Strategies for Achieving Optimal Gasoline Blending

By: David S. Seiver (Valero) & Brian Stefurak (Honeywell)

ABSTRACT

Solomon issued a report on Gasoline and Diesel Quality Analysis in 2010 that showed that the *"monetized difference in gasoline property give-away between the average refiner worldwide and the top 25% is estimated to be more the $0.55/bbl."* This translates into millions of dollars of clean product blending optimization opportunity for the average refinery.

Several strategies exist around control method, certification method, waiver methodology, blend flexibility, blend frequency, and analytical equipment used, not to mention specific techniques within these strategies that can be used to move your refinery closer to optimal gasoline blending. These strategies and some techniques and the rationale behind each of them will be examined.

BIOGRAPHIES

Dave S. Seiver, P.E. has over 20 years experience in the Petrochemical & Industrial Gas industries. Dave currently is the Manager of Blending APC Technology for Valero. Prior to coming to Valero, Dave spent four years specialized in Gasoline & Diesel Blend Optimization for ConocoPhillips at their Wood River Refinery as well as providing technical project assistance to some of their other sites. Dave has extensive expertise in APC, Blending Optimization, NIR modeling, and has two U.S. patents in the APC field and one patent-pending for RBOB Gasoline Optimization using Chemometric Methods. Dave is a registered professional engineer in the State of Texas.

Brian Stefurak, P.E. has over 20 years experience in Process Automation. Brian currently is the Blending and Movement Automation Business Consultant for Honeywell's Advanced Solutions. In Brian's years with Honeywell, he has been involved in all aspects of Honeywell's offsites automation solutions, from project to support to development to consulting. Brian has been involved in over a dozen major offsite automation projects and has a perspective on blending from on-site discussions with more than 50 refineries. Brian is a registered professional engineer in the Province of Ontario.

In June 2010, Solomon & Associates issued a report entitled, "North and South America Gasoline and Diesel Quality Analysis" outlining a comprehensive look at quality give-away by refiners for clean products gasoline and diesel. Minimizing the difference between a measured physical property and a critical specification on a tactical level can have a significant impact on refinery profitability. According to the report *"the monetized difference in gasoline property give-away between the average refiner worldwide and the top 25% is estimated to be more the $0.55/bbl, with the difference between the bottom 25% and the best performing 25% being more than $1.30/bbl."* In a highly competitive, low margin, and currently low refinery utilization market, this could mean the difference in keeping a refinery running or shutting it down. Refinery blending typically consists of gasoline and diesel product blending and can be considered the "cash register" of the refinery. It is the last chance to optimize composition and to get as close to product specification as possible without excessive giveaway. If there is specification give-away at blending, it is truly lost revenue and cancels out benefits gained in upstream unit process areas. At a typical refinery, optimized blending could represent more than 50% of the total Advanced Process Control (APC) savings, and may exceed $20 million/year in bottom-line savings. Bear in mind that a small reduction in give-away yields impressive results through scale-up.

As shown in **Figure 1**, there are five (5) basic elements of refinery blending complexity that defines a refinery's overall product blending strategy. They are **Blend Frequency**, **Blend Flexibility**, **Waiver Methodology**, **Certification Method**, and **Control Method**.

In practice, there are several permutations that span the continuum from optimal to undesirable. A pragmatic starting point for optimization of refinery blending would begin by locating a profile matching your refinery's operations in the table. Throughout this discussion, we will work from the optimal (green in **Figure 1**) starting profile, stepping backwards towards the least preferred profile, thereby illustrating some cost or benefit impacts associated with each profile bifurcation. The intention is for blending and APC engineers to identify where they are in their current product blending strategy, and then determine the next logical step(s) to a more optimal blending strategy. The examples in this article will hopefully help when justifying a move in that direction. It is not necessary to implement all of the steps from the current to the optimum, but rather the step(s) most cost effective to the local situation.

Control method	Certification method	Waiver methodology	Blend flexibility	Blend frequency	Benefit impact
On-line	On-line	In-line blending (direct to pipeline)	Many grades and/or recipe types	Short duration blends (small batches)	Optimal
				Long duration blends (large batches) only	Commercial "small sales" opportunities penalty
			Few grades and/or recipe types	Short duration blends	Same as above + limits markets / customers one can sell product to
				Long duration blends only	
	Off-line	In-line blending	Many grades and/or recipe types	Short duration blends	Same as above + must account for primary method reproducibility => automatic giveaway
				Long duration blends only	
			Few grades and/or recipe types	Short duration blends	Throughput penalty associated with blend "fix-ups" & more on-site tankage
		Tank blending		Long duration blends only	
*Off-line	Off-line	In-line blending	Many grades and/or recipe types	Short duration blends	*Same as above + more spot samples needed meaning more lab analysis / personnel & limits minimum blend duration
				Long duration blends only	
		Tank blending	Few grades and/or recipe types	Short duration blends	
				Long duration blends only	Least desirable

Figure 1 Refinery blending complexity / optimization matrix

Cost of Blend Frequency

As a general rule, shorter-in-time (smaller-in-volume) blends generally allow for more commercial opportunities than longer blends (think premiums). However, pragmatic limitations exist, such as minimum time to get the blend on-spec, equipment stabilized and spot samples taken and analyzed. Less than eight hours is generally regarded as risky considering the criteria mentioned earlier. However, this usually would facilitate blends as small as 20 000 bbls (at rates of 2500 bbls/hr), which could lead to more niche or spot commercial sales opportunities than those refineries restricted to, say, 100 000 bbls minimum blends. The main challenge to being able to make smaller blends is ensuring a quality system around the blending controls/systems that will enable you to minimize specification.

Cost of Blend Flexibility

Some refineries are limited, or limit themselves, to very few products. This simplifies blending to keep the number of recipe types or grades low, at a high opportunity cost with regard to markets and customers. A typical, complex refinery can easily produce 50% or more reformulated and/or oxygenated gasoline these days. Blend flexibility leads to many more recipe types; 50 unique recipe types might be common, which is advantageous commercially yet more challenging from a standpoint of blend execution – reformulated and oxygenated blends are typically more challenging to produce than conventional gasolines.

Why might 50 unique recipe types be considered such a challenge? First of all, it is not hard to envision 50 recipes types if you are making both regular and premium grades; producing conventional, sub-grade and reformulated and/or oxygenated gasolines; have customers with unique RVP-class specifications; sell VOC-limited blends; and have targeted near-infrared (NIR) or RAMAN calibration models for various blending seasons, including summer, early/late winter and the blend-down and blend-up intermediate seasons. The permutations of these different recipe types can easily reach 50 or more. If you utilize NIR, RAMAN or other similar model based spectroscopic technology to control the blenders online, typically 12–15 (or more) primary properties can be determined for each product, including, but not limited to, RON, MON, D86 properties (eight or so might be typical, including IPB, T10, T20, T50, T90, FBP, E200, E300), %Benzene, %Olefins, %Aromatics and API and specific gravity. Elemental concentrations like %Sulfur are not analyzed with spectroscopy, though using the API or specific gravity from the spectrometer is useful for converting from volumetric to mass percentage %Sulfur as needed for blending. The challenge of using model based spectroscopy becomes clear when considering the modeling, organizational, and coordination challenges associated with 50 possibly unique recipe types, each needing calibration models to characterize 12–15 properties. One could end up with several hundred models to create and maintain. In order to keep the calibration models properly organized, a model catalogue should be considered to spell out specifically which targeted calibration models for each recipe type are currently in use, and any relevant modeling data such as biases, model goodness of fit, number of latent variables used (if partial least squares, or PLS, is used), number of spectra in the model and model range.

It is also a good practice to match up final blend recipe data associated with the spectra and lab data. This is particularly useful for outlier detection. Remember, targeted spectroscopic calibration models minimize giveaway in various blending seasons; for instance, winter blending requires different blend components and recipe mixes compared to summer blending. Therefore, the spectroscopic models should be unique (split-out) to capture these recipe-type specificities, without sacrificing model robustness.

OMC NIR MODEL CATALOG						Gasoline Properties Measured				
						RON	MON	T10	T20	T50
Model CSV	Blend Recipe Type	Blend Class	Octane	D86	TVL Calc	Res Octane #	Mtr Octane #	degF @10%	degF @20%	degF @50%
RECNO1	RU_7.2	CONV_S	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO2	RU_7.8	CONV_S	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO3	RU_8.0	CONV_S	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO4	RU_9.0	CONV_S	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO5	RU_11.5	CONV_WL	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO6	RU_11.5_4	CONV_WL	Neat	Neat	Linear	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO7	RU_13.5	CONV_WC	Neat	Neat	Computer	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO8	RU_13.5_5	CONV_WC	Neat	Neat	Computer	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO9	RU_15.0	CONV_WC	Neat	Neat	Computer	CRRONL01	CRMONL01	WRT10DS	WRT20DS1	CRT50L01
RECNO10	P3_7.2	CONV_S	Neat	Neat	Linear	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO11	P3_7.8	CONV_S	Neat	Neat	Linear	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO12	P3_9.0	CONV_S	Neat	Neat	Linear	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO13	P3_11.5	CONV_WL	Neat	Neat	Linear	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO14	P3_11.5_4	CONV_WL	Neat	Neat	Linear	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO15	P3_13.5	CONV_WC	Neat	Neat	Computer	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO16	P3_13.5_5	CONV_WC	Neat	Neat	Computer	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO17	P3_15.0	CONV_WC	Neat	Neat	Computer	CPRONL01	CPMONL01	WRT10C2	WRT20CP2	CPT50S01
RECNO18	10_RB_V1	BOB10SS	Blended	Blended	Linear	BRRONM01	BRMONM01	BRT10M01	BRT20MS1	BRT50MS1
RECNO19	10_RB_V2W	BOB10SS	Blended	Blended	Linear	BRRONM01	BRMONM01	BRT10M01	BRT20MS1	BRT50MS1
RECNO20	10_RB_7.8	BOB10NS	Blended	Neat	Linear	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01
RECNO21	10_RB_9.0	BOB10NS	Blended	Neat	Linear	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01
RECNO22	10_RB_11.5	BOB10NWL	Blended	Neat	Linear	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01
RECNO23	10_RB_11.5_4	BOB10NWL	Blended	Neat	Linear	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01
RECNO24	10_RB_11.5S	BOB10SWL	Blended	Blended	Linear	BRRONM01	BRMONM01	BRT10M01	BRT20MS1	BRT50MS1
RECNO25	10_RB_11.5S_4	BOB10SWL	Blended	Blended	Linear	BRRONM01	BRMONM01	BRT10M01	BRT20MS1	BRT50MS1
RECNO26	10_RB_13.5	BOB10NWC	Blended	Neat	Computer	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01
RECNO27	10_RB_13.5_4	BOB10NWC	Blended	Neat	Computer	BRRONM01	BRMONM01	RRT10M01	RRT20M01	RRT50M01

Figure 2 Spectroscopic Analyzer Model Catalog

Currently there is an ASTM industry sub-team working on a *Standard Test Method for Infrared Determination of Properties of Spark-Ignition Engine Fuels Using Direct Match Comparison Technique.*

Another way to maximize blend flexibility would be to increase the number of blend components, in essence increasing the degrees of freedom the optimizer has at its disposal. If there is a way to segregate a mixed or multi-component stream further into different blend components, say with similar octane values but drastically different RVP values, this will be advantageous in optimizing product blending. So, for example, if your refinery has some mixed or multi-component streams with low octane and high RVP, you might consider re-routing one of the streams that might be similarly low octane but low RVP as a separate component that could be utilized in summer reformulated blending, where the octane specification is often easier to achieve than RVP. This is a common optimization strategy used with mixed-cat naphtha streams where the heavy naphtha stream is segregated from the lighter stream(s).

Cost of Waiver Methodology

There are two general methodologies associated with where refiners blend their products: in-line or pipeline blending, and tank blending. Typically, in-line blending requires a regulatory blend waiver that specifies the refiner's systems to produce on-spec products directly into a pipeline. The obvious risk/reward proposition with in-line blending is the lack of "buffer to fix-up" blends that tank blending allows, with the obvious benefit of less tankage and higher refinery product throughput. The effect on throughput can be illustrated in the following example to the right:

Basis: 100 000 bbl blends both cases; 5000 bbl/hr product pumps both cases

Case 1: In-Line blending
100 000 bbl pipeline blend @
5000 bbl/hr =   20 hours

Case 2: Tank blending

95 000 bbl initial tank blend @ 5000 bbl/hr =	19 hours
Tank testing and analysis	2 hours
Creation of "fix-up" blend based on test results	1 hour
5000 bbl "fix-up" tank blend @ 5000 bbl/hr =	1 hour
	23 hours

The outcome with finished product tank blending is 15% additional time to move the same barrels of product, or a reduction in throughput of 15%.

Further impacting this imbalance is the systemic giveaway inherent to tank (batch) blending. In the above example, it is assumed that the two cases yield exactly the same final result in product quality and reduced giveaway. In fact, Case 2 almost always involves expected giveaway in the "fix-up" or correction blend because of the need to be on-spec in just one iteration. The same throughput restrictions prevent a blending scenario where after an 90 000 bbl initial blend where the first correction blend is 5000 bbl, another set of testing and analysis is done, a second correction blend of 3000 bbl is done, another set of testing and analysis is done, a third correction blend of 1000 bbl is done, and so on. The repeated and hopefully smaller correction blends are done until the tank is 'just right'. Since no actual refiner can wait on repeated correction blends, the first correction blend targets a giveaway on critical properties to ensure the blend is on-spec or better after only one correction. By comparison, Case 1 with online analysis and recipe adjustment performs correction blends with each cycle of the blend optimizer and accurately measuring actual blend results long prior to blend completion. In a sense, the inline example is allowed to continuously play with the blend until it is 'just right', often long before the end of the blend volume.

Cost of Certification Method

The blend certification method can be the most financially significant option for optimization available to most refineries. The two blend certification methods are: traditional off-line (or lab) certification, where ASTM (or other governing bodies') primary testing methods are applied to the blended products; and on-line certification (in the U.S. – this normally would only apply to non-EPA regulated properties like octane which is a performance specification), where product properties are tested as the blend is being produced and these properties are certified against (that is, no additional laboratory testing is required beyond what is needed to maintain the on-line blend analyzers). Clearly, on-line certification has advantages in terms of product throughput (by eliminating the need to wait for additional testing at end-of-blend) and laboratory personnel (because fewer testers are generally needed). But, most important of all, it enables the control system to target closer to the actual product specifications without the need for an on-line target bias to ensure the reproducibility of off-line results is still on-spec.

On-line certification requires a greater commitment to maintenance and quality control for on-line analyzers and instrumentation. Some corporate cultures find the concept of on-line certification uncomfortable. In order to capture the benefits associated with not needing a bias between the on-line control system and the off-line testing results, consider choosing an on-line system proxy for the primary laboratory methods that has good reproducibility and repeatability. This is why most refiners choose NIR, RAMAN, or similar spectroscopic variants over on-line knock engines and online D86 analyzers. Spectroscopic analyzers have markedly better repeatability (basically very few if any moving parts) and, when properly calibrated, their reproducibility can be better than the primary methods for which they are a proxy. Spectroscopic repeatability for RON & MON is measured in hundredths of an octane number, where primary method (knock engines) repeatability is measured in tenths. Mechanical methods such as knock engines have an inherent disadvantage in repeatability over spectrometers with few or no critical moving parts. In all cases, analysis with an spectroscopic analyzer is much faster and significantly less labor-intensive than with primary methods such as Knock Engines, D86 Distillizers, Gravitometers, and Gas Chromatographs.

If spectroscopic technology is chosen for one's on-line certification method, it is important to understand that full redundancy is critical, since this analyzer system will be replacing numerous analyzers in the blending system. Care should be taken in the design of the on-line analysis system, including sample systems, so that there are no single points of failure that could jeopardize blending operations availability. Also, success using spectroscopic analyzers for on-line certification requires a commitment from the analyzer maintenance group as well as the APC group that is often asked to perform calibration or modeling.

On-line certification requires a more focused approach to analyzer diagnostics. Fortunately, most spectroscopic analyzers come equipped with powerful, and often ignored or under-utilized, on-line diagnostic capabilities that should be exploited to ensure a robust on-line certification system. On-Line blending feedback based on the status of the spectroscopic analyzer's real-time diagnostics for each inferred property such as the Residual Ratio (RR) and/or the Mahalanobis Distance (M-Dist) should be built into the blending control system, and appropriate standard operating procedures (SOPs) developed so that blending operators know how to react (i.e. take additional spot samples within the blend) when the on-line analyzers are telling them that the confidence of the inferred property(s) is questionable (i.e. high RR and/or M-Dist values). Long-term historical trends of these valuable on-line diagnostic tools should be analyzed in the routine QC meetings that are part of a robust on-line certification system. A typical spectroscopic analyzer analysis display is shown below in **Figure 3**. Examples of performance data are contained in the display. The left quadrant property data includes both red highlighting for off-spec results and red and orange underlining of results to indicate questionable quality of results as determined by the analyzer itself (spectral inconsistencies between measured and modeled, etc.). Data to the bottom and right of the display shows overall performance and fault information for the analyzer based on flows or physical faults. Where the off-spec results are commonly used to correct a given blend, the parallel analyzer performance numbers should be used to correct the model and analyzer dynamics.
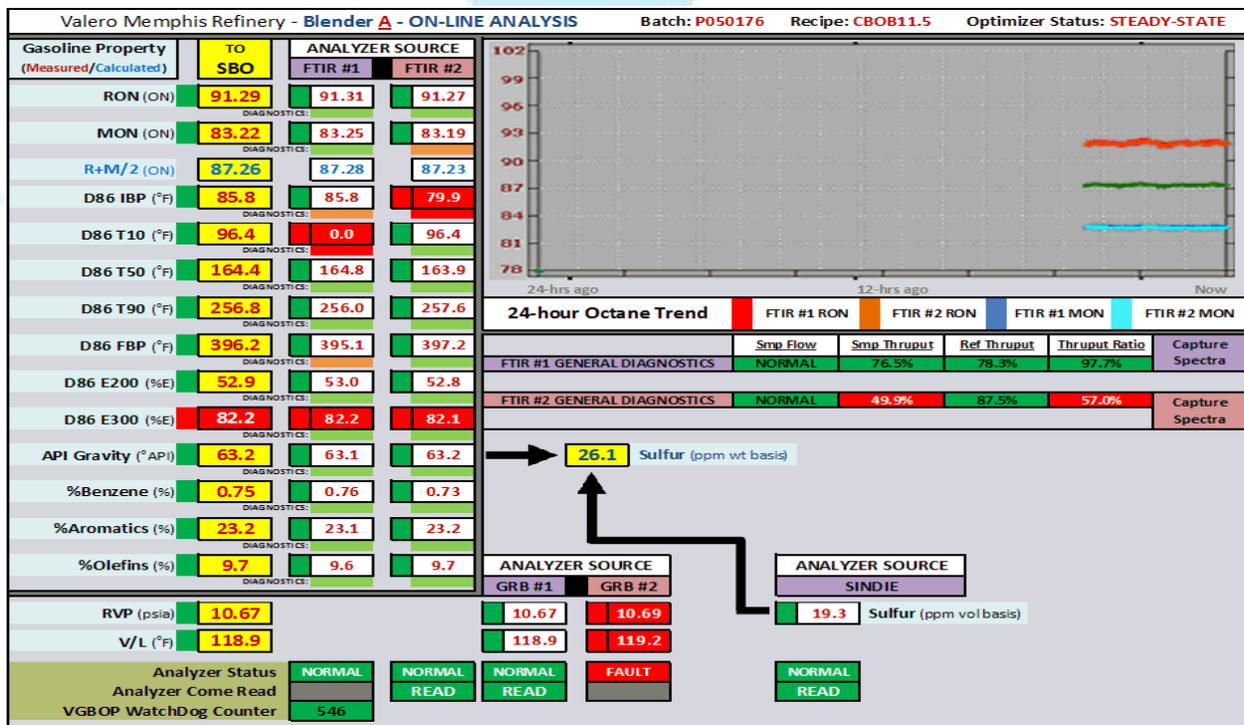
Figure 3 Spectroscopic Analyzer Diagnostics Control System Graphic

Cost of Control Method

In common with certification methodology, control methodology for refinery blending also falls into one of two general classifications: on-line or off-line. As on-line control is the de facto standard in refining, it is the only methodology to be discussed here. The control method is the mechanism by which the tender is created. This mechanism includes the process control hardware and software, and the interface with the refinery planning cycle.

The control method has a choice of objectives. Most on-line Single-Blend Optimizers, or SBO, have several optimization objective functions to choose from, including minimum cost, minimum giveaway or minimum blend recipe deviation. Minimum blend recipe deviation should ideally be a refinery's optimum strategy if the multi-period recipe planning is extremely accurate and optimum over the entire multi-period plan. In practice, this is **rarely**, if ever, the case, or correct for a fleeting period of time and thus unrealizable, due to commercial or logistical reasons or refinery dynamics. Changing unit conditions, tank layering of components, and the age of component property data all combine to create different initial blend conditions to those expected in the plan. Generally the APC engineer is left to choose between the minimum cost and minimum give-away objective functions.

Some optimizers, such as Honeywell's BPC and OpenBPC blend optimizers, can use a combination of multiple objective functions. **Figure 2** shows how the original starting recipe, while valid, can still be non-optimal. A hierarchical optimizer running Minimum Giveaway would select from within the range of valid, On-Spec recipes yielding minimum giveaway. However, where there is more than one recipe that can achieve the same minimum giveaway, the optimizer will select some mathematical reason, and not an economic reason, to select within that range. By using a 3rd optimizer selection pass (1st On-Spec, 2nd Minimum Giveaway, 3rd Minimum Cost), it can select amongst the valid giveaway recipes based on minimizing cost. Similarly, an optimizer running only on Minimum Cost, would select the best Minimum Cost recipe, but this would not also provide the least giveaway.

Starting Recipe				
All recipes				
On-spec recipes	Off-Spec	On-Spec Recipe Range		Off-Spec
Minimum Giveaway			Range of recipes that yield the same (best acheivable) giveaway	
Minimum Cost		Area of best cost recipe solution	Area of 2nd best cost recipe solution	
Recipe Options		Lowest Cost / Original Recipe	Lowest Giveaway Range / Lowest Cost of Lowest Giveaway	
Selected Recipe			Optimal Overall Recipe	

Figure 4 Recipe results through combined objective functions

However, deviation of the recipe from plan should be tracked and minimized where possible. Ideally, the multi-period planning software should download suitable min/max recipe percentages that the single-blend optimizer should stay within, so as not to force the multi-period plan infeasible.

While the optimizations methods of minimum cost and minimum give-away appear very similar at first sight, there are subtle differences in their operation and in the results they produce. Minimum cost tries to create an on-spec blend using the least costly combination of blend components (i.e. cheapest blend), which does not ensure minimum specification giveaway, whereas minimum give-away tries to minimize specification giveaway without regard for utilizing the least costly blend components (though most modern SBO incorporate multi-level optimization which can combine the benefits of both strategies to some extent). An important distinction between the two strategies is that minimum giveaway is based on real costs that are outside the refinery's economic envelope, whereas minimum cost is based on internal shadow pricing of components that are not always correlated with actual costs. Therefore, it is generally advisable to set the primary optimization strategy to minimum giveaway, with a secondary optimization strategy of minimum cost, and most contemporary single-blend optimizers can be set up this way. Additionally, in the most common scenario, minimum giveaway captures some idea of cost, if only because the highest specification components are often either the most expensive or in the shortest supply.

Another important facet to optimal on-line blend control is the reliability of the blend recipe data, both initial recipe and blend values, which are obtained from the off-line blend recipe planning software, or Multi-Period Blend Optimizer (MPBO). Experience has shown that significant deviation from MPBO initial blend recipes often leads to sub-optimal final product blends (i.e. giveaway) and risks inventory control issues. This is especially true for blending systems that are designed to allow "barrel splitting" among product tenders (i.e. blend segment control is one common strategy), where poor quality initial recipes will lead to large deviations in product specifications early in the blend, which can never be recovered.

Often, the off-line blend recipe generation tool determines the blend values (roughly, the steady-state gains used by the optimizer if nonlinear blend equations are not used in the on-line optimizer) for each blend, and the accuracy of these blend values is important for good blend control. This is fairly obvious from a multivariable control perspective, where APC engineers are familiar with optimizer cycling associated with incorrect steady-state gains.

RBOB Recipe dependency of ethanol boost effect on octane			
Recipe	Neat octane	Blended octane	EtOH octane boost
High aromatics; low olefins blend	91.6	93.2	1.6
Low aromatics; high olefins blend	91.6	94.9	3.3

Table 1

If your refinery makes oxygenated gasoline, both the off-line blend recipe generation tool and the online blend optimizer should take into account the non-linear blending effect (aka "ethanol boost") that oxygenate induces in blend properties. Some oxygenates like ethanol (the most common in the U.S.) are not allowed in product pipelines because of corrosion problems (ethanol is hydrophilic); they are therefore typically added at product terminals. As a consequence, refineries typically blend neat reformulated/oxygenated gasoline (RBOB), and Conventional oxygenated gasoline (CBOB), sans ethanol. It is also well known that the so-called ethanol boost effect on the final blended gasoline's properties is both recipe-dependent and non-linear. The ratio of olefins to aromatics used in the neat blendstock significantly determines the final blended octane of oxygenated gasolines. An example of this is illustrated in Table 1.

This boost effect should be properly modeled to optimize RBOB/CBOB gasoline blends, and properly accounted for in both the off-line and on-line blending systems. Estimating the ethanol boost a priori as opposed to directly measuring "blended properties" throughout the blend will ultimately lead to either excessive give-away (i.e. you must target worse case low boost effect which will lead to give-away if the olefins/aromatics ratio deviates substantially throughout the blend), or in limited blend optimization flexibility (i.e. if you clamp down the olefins/aromatics ratio you might risk give-away or sub-optimal blends – more expensive blends). With oxygenated blends becoming more prevalent, this is an area ripe for optimization.

The ability to examine this effect by refiner is helped by the amount of raw data available. Each and every blend contains the information on how that particular recipe mix (based on final component volumes for the blend) behaved in generating the final property specifications. Regular KPI analysis of actual blend yields to initial starting recipes will show the accuracy of the current planning and modeling techniques.

Conclusions

Some basic elements of refinery blending complexity have been described in sufficient detail to enable blending and APC engineers to plan the next step(s) towards optimal refinery blending at their location. Furthermore, specific examples of implementable measures, techniques and technologies have been described, with some economic considerations presented where applicable.

Not all refineries will be able to get to the ideal refinery blending profile, but instead may only move incrementally towards that objective. It is the refinery's challenge to identify its unique place in the matrix of refinery blending complexity and to then to produce a project plan to reach the next step(s) towards a more optimal state.