MAXIMIZING GAS PLANT PROFITABILITY IN TURBULENT PROCESSING ENVIRONMENTS

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ABSTRACT

Operating natural gas processing plants under fluctuating commodity pricing, inlet conditions, and equipment performance capabilities is challenging. Midstream natural gas processors typically address fluctuating economic conditions by operating their gas plants in either full ethane recovery or full ethane rejection mode.

In early 2000, Enable Midstream Partners, LP (Enable Midstream) began deploying gas plant optimization technology to its cryogenic plants and discovered that there is actually a continuum of optimal operating points within each mode. Rigorous gas plant optimization technology is used to determine where to operate along the continuum so that profitability is maximized under all operating and economic conditions.

The optimization solution is currently deployed at seven of Enable Midstream's gas processing complexes. An additional plant optimizer is scheduled to come online when the new McClure Plant in western Oklahoma is commissioned.

This paper describes the non-intuitive, and often counter-intuitive, guidance that the optimization solution provides to maximize plant profit margins on a daily basis. A case study will be presented that demonstrates how the non-intuitive move guidance is delivering substantial value for Enable Midstream's Wheeler gas processing facility in the Texas Panhandle. The paper will contrast optimization move guidance at Wheeler versus optimization move guidance at the South Canadian facility – an identical plant with the same economics - where the optimizer guided the plant to maximize profit using exactly the opposite move strategy.

A detailed study was performed to describe this optimization move guidance differential. The study describes the non-linear optimization move response to fluctuations in inlet GPM and economic conditions. Results will be overviewed and a 12-month pro forma example will be presented that shows the profit opportunity associated with optimizing physical and economic interactions for cryogenic assets.

The case for optimizing gas plants

The optimization solution has added value differently under varying economic environments. Figure 1.0 shows the ethane margin at Mt. Belvieu and Conway since 2000.

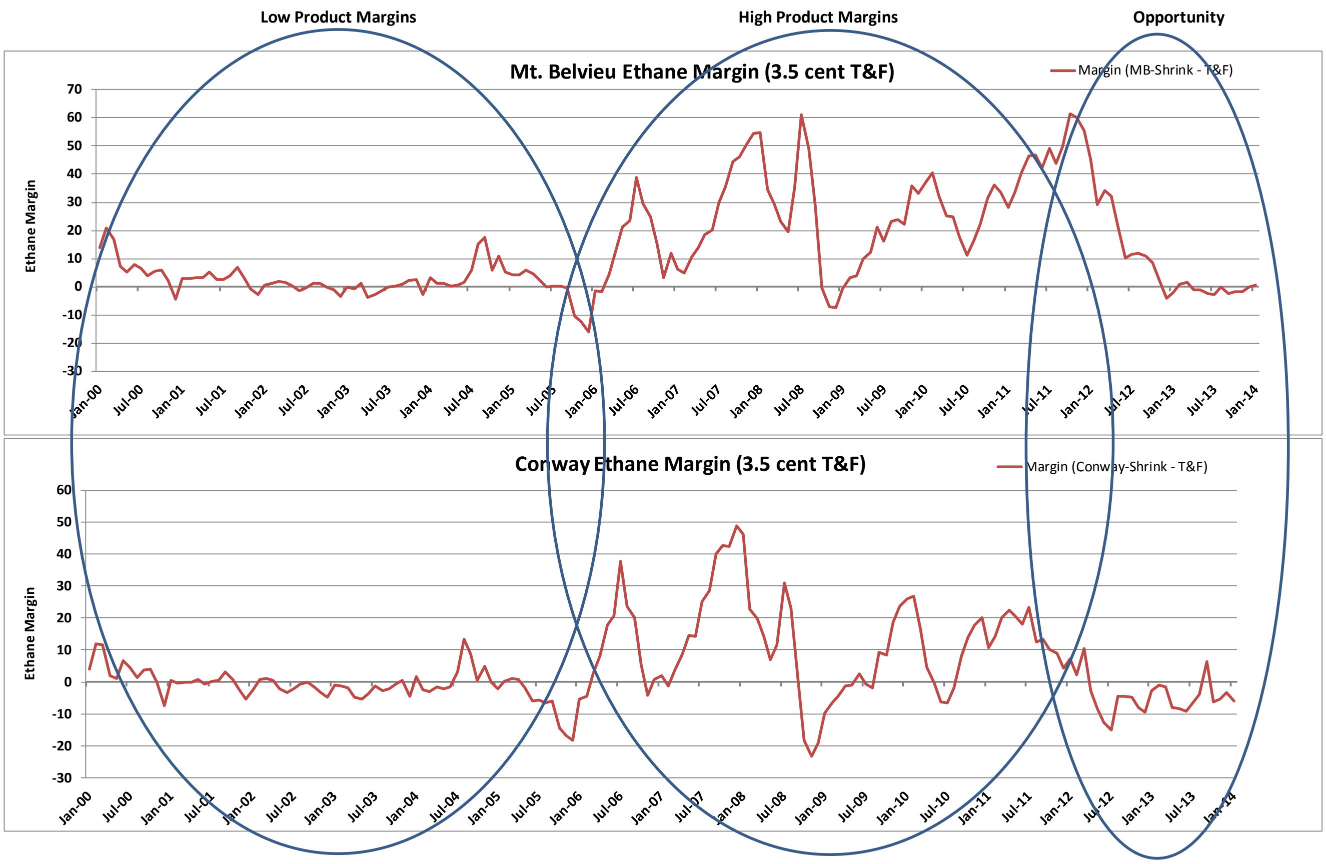

Figure 1 – Ethane Margins at Mt. Belvieu and Conway (2000 – Jan 2014)

Between 2000 and mid-2005, ethane margins were fluctuating between low and negative values. In ethane recovery mode, the optimization system often guided Enable Midstream's operators to reduce ethane recovery targets to improve energy efficiency. When ethane margins were negative, and plants were operating in ethane rejection mode, the optimization system modulated ethane recovery targets to maximize propane production (typically) and to optimize energy efficiency.

Between mid-2005 and mid-2012, ethane margins were strong and the optimization solution guided operators to maximize ethane recoveries. The solution also guided operators to manage constraints associated with midstream asset build-outs (i.e. reduce recoveries to allow processing of excess gas, manage natural gas liquids takeaway constraints to make heavier liquids, and manage to "provide or pay" liquids contracts).

Mid-2012 through November 2013 brought back low and negative ethane margins. The optimization system once again provided non-intuitive guidance to maximize value at Enable Midstream's gas plants - - especially in rejection mode.

According to industry publications and presentations at the 2013 GPA meeting in San Antonio, these periods of natural gas liquids (NGL) product imbalances, low product margins, and ethane rejection operation will be prevalent over the next five-year period as the petrochemical industry builds out to take advantage of abundant NGL supplies from the shale basins. In these turbulent processing environments, it is important to have an optimization solution in place to maximize profitability under all economic and processing conditions.

Wheeler Gas Plant Optimization Case Study

Determining optimal operating targets for gas plants requires consideration of several key factors: ethane margin, propane margin, producer contract structures, inlet volume, inlet GPM, ambient conditions, compression energy, and the processing equipment's ability to perform given current fouling, efficiencies, and processing constraints. The optimization solution deployed at Enable Midstream's gas plants utilizes a rigorous, non-linear, thermodynamic model that calculates the cost of extracting the next gallon of NGL's (given current equipment fouling/efficiencies/constraints) and balances that against the revenue generated given current commodity prices and producer contract structures. The resulting optimization targets (column pressure, column temperature, sub-cooled reflux flow, etc…) are updated every two hours for operator implementation.

Enable Midstream chose to extend their optimization program to manage the new Wheeler Plant in Wheeler, Texas. The plant is designed to process 200 mmscfd of gas coming from the Granite Wash shale play. The optimizer was commissioned in January 2013 while the plant was being operated in ethane rejection mode.

Prior to the optimization commissioning effort, the operational objectives were to keep ethane recovery low (10 -12%) while maximizing propane recovery (>90%). This was achieved by running the demethanizer bottoms temperature at approximately 116 deg F, the overhead pressure at around 215 psig, and the gas sub-cooled process (GSP) ratio at 0.38.

Interestingly, the optimization system guided the operators to increase ethane recoveries and to achieve those targets using exactly the opposite move strategy as was currently employed. The optimizer guided the plant operators to increase the demethanizer pressure to 235 psig, lower the demethanizer bottoms temperature to 100-102 deg F, and lower the GSP ratio to 0.33. These moves increased ethane recovery to above 25%, provided a 1%-2% increase in propane recovery, and reduced the load on the residue compressors (saving energy consumption) because less ethane was being recompressed. Figure 2, 3 and 4 illustrate the changes in recovery and power consumption over a 24-hour period.

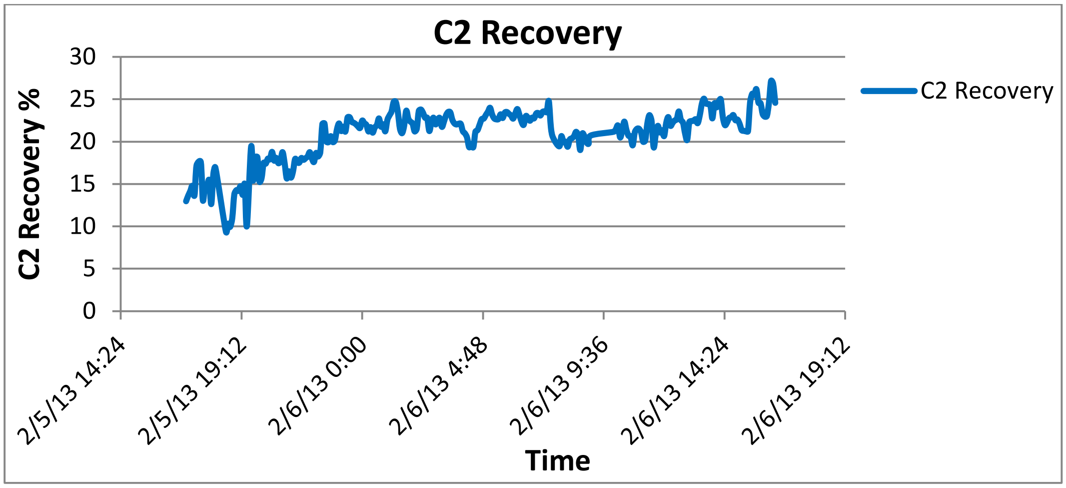

Figure 2 - C2 recovery change over time

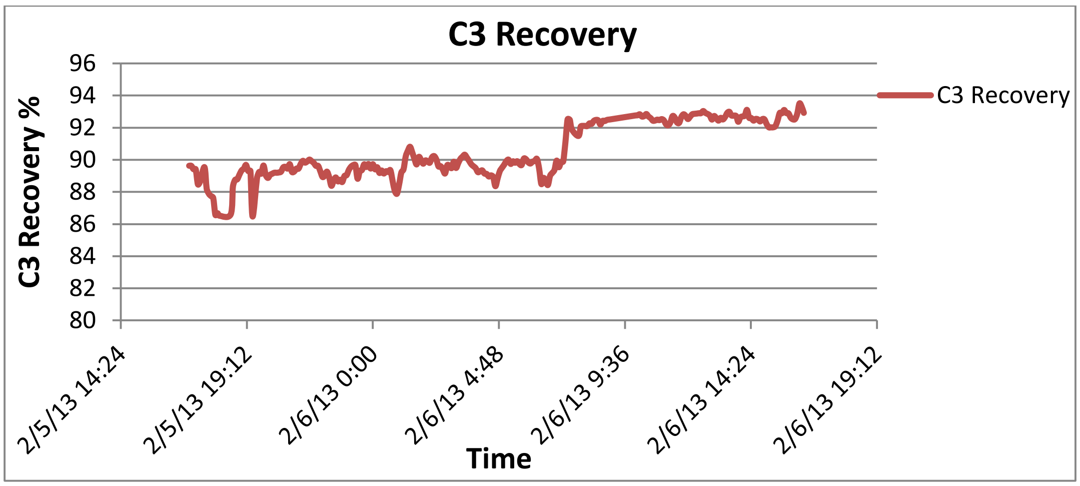

Figure 3 - C3 recovery change over time

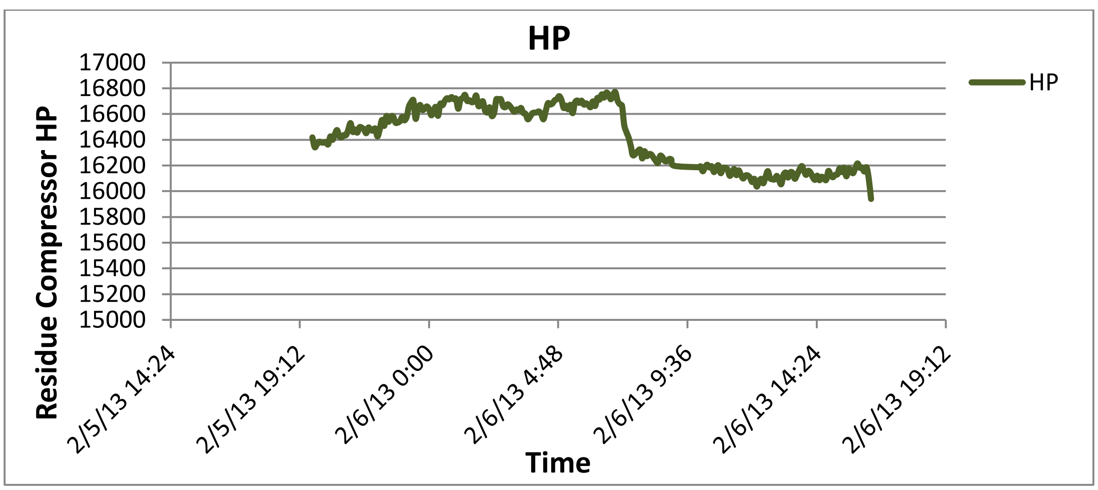

Figure 4 - Residue compressor HP change over time

The resulting changes in plant operation were compared to the pre-optimization baseline to evaluate performance improvements (Table 1):

Performance Improvement - The resulting change in plant performance is as follows (measured by actual performance variances, not model results):					
Change in C2 Production vs Baseline (gal/day)	Change in C3 Production vs Baseline (gal/day)	Change in Fuel Usage (MMSCFD/day	Change in Power Usage (KWH)	Profit Uplift vs Baseline ($/day)	Profit Uplift vs Baseline (cents/mcf)
51,161	**7,198**	**0.035**	**-32,926**	**$2,678**	**1.37**

Table 1 – Gas Plant Performance Improvements during Commissioning

Table 2 summarizes how the optimization system guided operators to maximize gas plant profitability when comparing optimized performance vs baseline (i.e. how the plant was running at time of optimizer commissioning):

Value Improvement vs Commissioning Conditions	Change in Product Value ($/day)	Change in Shrink Value ($/day)	Change in Fuel Usage ($/day)	Change in Power Usage ($/day)	Value Increase ($/day)	Value Increase (cents/mcf)	Profit Delivered ($/month)
Feb-13	$ 17,631	$ 17,251	$ 194	$ (2,172)	$ 2,358	1.29	$ 66,037
Mar-13	$ 16,087	$ 15,534	$ 197	$ (2,714)	$ 3,070	1.64	$ 95,165
Apr-13	$ 13,615	$ 13,463	$ 721	$ (2,097)	$ 1,528	0.75	$ 45,849

Table 2 – Value Generation over First Three Months vs Baseline Operation

Table 3 shows the effect of comparing optimized performance vs design recoveries:

Value Improvement vs Commissioning Conditions	Change in Product Value ($/day)	Change in Shrink Value ($/day)	Change in Fuel Usage ($/day)	Change in Power Usage ($/day)	Value Increase ($/day)	Value Increase (cents/mcf)	Profit Delivered ($/month)
Feb-13	$ 31,401	$ 31,979	$ 155	$ (1,679)	$ 946	0.52	$ 26,495
Mar-13	$ 11,774	$ 10,900	$ 100	$ (2,526)	$ 3,300	1.77	$ 102,303
Apr-13	$ 9,273	$ 8,656	$ (41)	$ (1,906)	$ 2,563	1.26	$ 76,897

Table 3 – Value Generation over First Three Months vs Design

Key learning points from the Wheeler Plant optimization effort:

- The optimal ethane recovery target was significantly higher than the full ethane rejection target. This allows for a higher level of propane recovery which made sense in the economic conditions present when the optimizer was commissioned.
- There was a significant reduction in power usage at the higher ethane recoveries. This is counter-intuitive. Usually, higher ethane recoveries require more residue compression horsepower (HP) to recompress the residue gas to pipeline conditions. In this case, there was significantly less ethane in the gas stream that had to be recompressed resulting in lower power requirements.
- The optimization solution drives significant value for gas processing assets and use of this tool maximizes Enable Midstream's revenue. *The project more than paid for all deployment costs and three years of optimization service in the first three months after commissioning!*

Enable Midstream's engineering group asked the question: "Why are operational targets at Wheeler exactly the opposite of the South Canadian optimal targets?"

Enable Midstream operates two relatively new gas plants about 100 miles apart (Wheeler and South Canadian). The plants are of the same design and operated with the same economics. The Wheeler plant's optimal targets led to higher than design C2 recovery of approximately 25% while the optimization solution installed at the South Canadian plant was guiding operators to run at approximately 10% C2 recovery. Enable Midstream's engineers asked why?

An offline case study was run to analyze the impact of operating the South Canadian plant using the Wheeler plant optimization moves. The analysis showed that if the South Canadian plant was run using the optimal targets for the Wheeler plant, the South Canadian plant would lose $1,700/day.

The offline analysis identified that there was a different inlet composition at South Canadian with lower propane concentration versus Wheeler. The propane value upgrade from running at the higher ethane recovery at South Canadian would not offset the ethane losses at higher recovery rates.

During this period, the ethane margin was closer to breakeven, and propane margins were attractive. Therefore, the optimizer sacrificed ethane losses to go after the propane at the Wheeler plant. The analysis demonstrated that small changes in inlet composition can cause major operational shifts. These are the types of opportunities that Enable Midstream would not have taken advantage of without a rigorous optimization solution.

The results demonstrate why it is important to have optimizers in place all the time: Conditions change, and it is not predictable when conditions will occur where non-intuitive moves are required to maximize profits.

Optimization Study Results

Enable Midstream's engineers were having trouble explaining the non-intuitive optimized move guidance to management as conditions changed. A detailed study was performed using an actual online optimization model taken offline to examine the impact of fluctuating inlet GPM and economic conditions on optimal plant operation. The detailed analyses – resulting from over 100 case studies – are summarized as follows (detailed results available):

Effect of inlet GPM fluctuations on optimal ethane recovery and profit opportunity

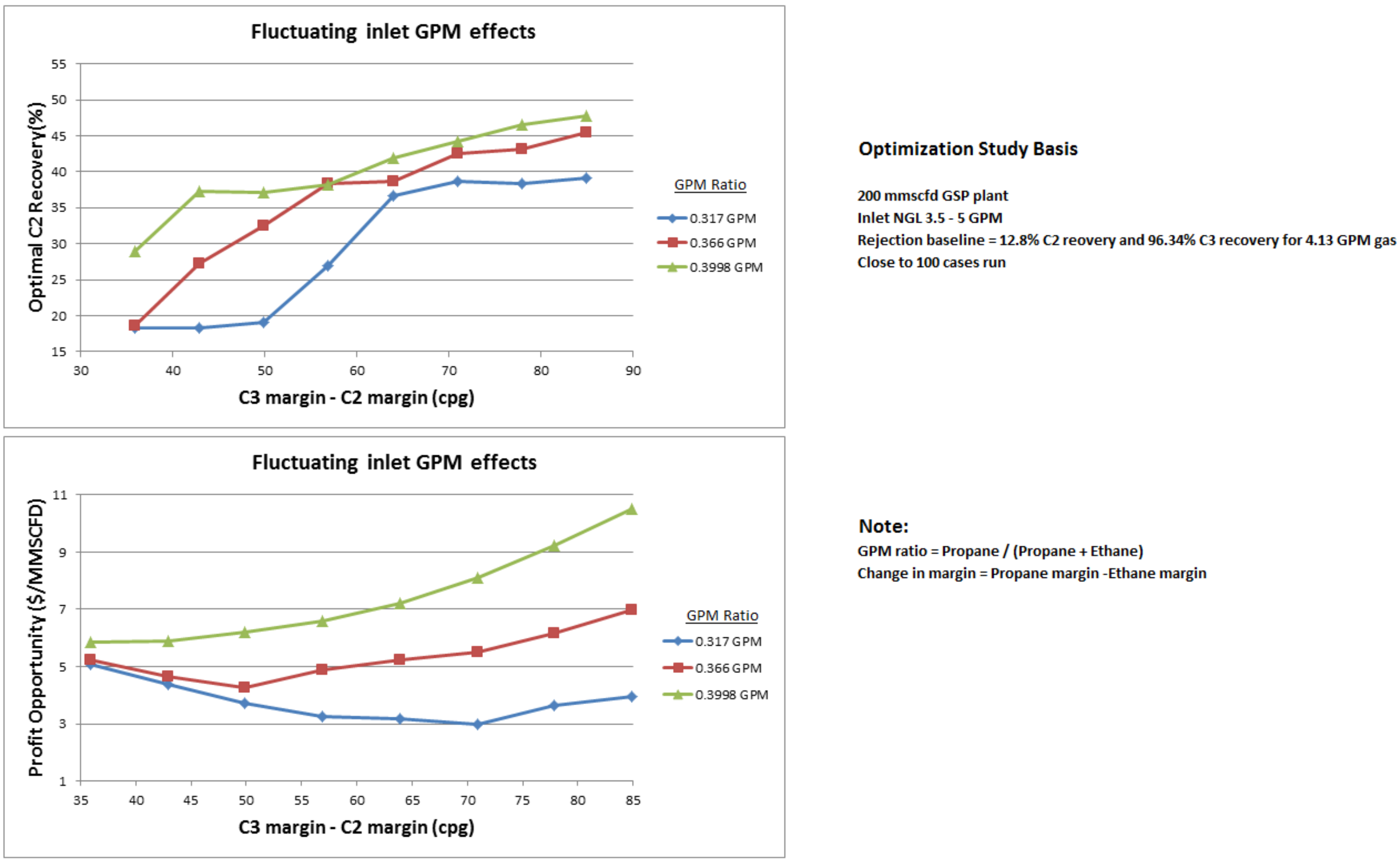

Figure 5 – Optimal response to inlet GPM fluctuations

Effect of <u>ethane margin fluctuations</u> on optimal ethane recovery and profit opportunity

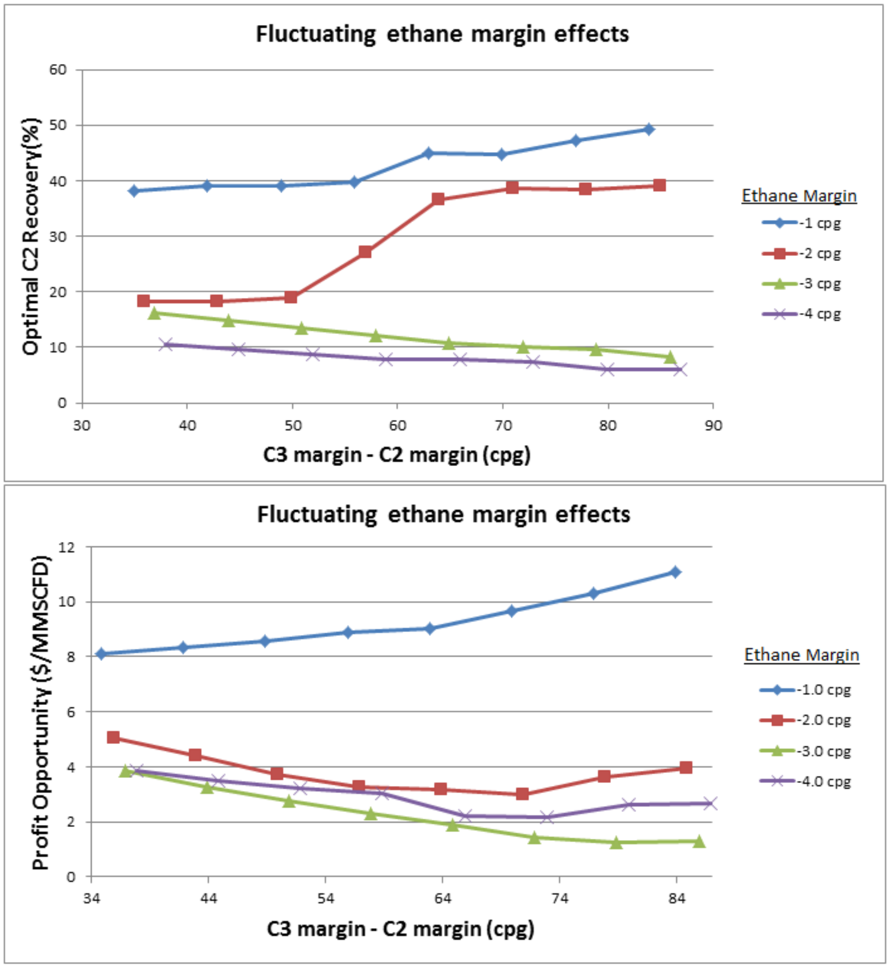

Figure 6 – Optimal response to ethane margin fluctuations

Pro Forma Analysis

A pro forma analysis was performed whereby the optimization opportunity over a 12-month period was quantified. The methodology included the following steps: to load baseline conditions into the model, run it at each month's prices, and then run an optimization case to see where the model would move the plant to maximize profitability at that month's prices. Baseline rejection operation was as follows:

<u>Basis / Baseline</u>

- Inlet rate = 207mmscfd
- GSP plant
- 9.00% C2 recovery
- 96.32% C3 recovery
- 4.22 GPM
    - Ethane Mole% = 8.997
    - Propane Mole% = 3.639
    - GPM Ratio = 0.294   (GPM ratio = Propane / (propane + ethane))
- Midcontinent economics
- Mt Belvieu NGL delivery

The resulting 12-month pro forma is as follows:

Mt Belvieu Pricing		**Baseline**	**Dec-12**	**Jan-13**	**Feb-13**	**Mar-13**	**Apr-13**	**May-13**	**Jun-13**	**Jul-13**	**Aug-13**	**Sep-13**	**Oct-13**	**Nov-13**
Conditions														
Ethane Margin	cpg		(5.12)	(5.75)	(3.86)	(4.99)	(5.62)	(5.48)	(6.99)	(7.10)	(4.57)	(6.94)	(6.34)	(6.33)
Propane Margin	cpg		38.82	44.67	47.27	46.06	48.21	48.68	44.88	49.06	63.22	70.11	70.73	77.02
Difference in Margin (C3-C2)	cpg		43.93	50.43	51.13	51.04	53.83	54.16	51.87	56.16	67.79	77.05	77.08	83.35
Electricity	cents/kwh		6.51	6.51	3.95	3.63	3.63	3.53	3.23	6.36	5.04	5.04	5.04	5.18
Key Optimization Moves														
Tower Pressure	psig	230	300	300	270	233	222	221	215	276	282	231	238	239
Bottoms Temp	deg F	130	135	135	135	135	135	135	135	135	135	135	135	135
Cold Sep Temp	deg F	-4.00	4.23	4.23	3.24	2.01	1.62	1.58	1.40	3.44	3.28	1.91	2.17	2.18
Impact														
Ethane Recovery	%	9.00%	**17.30%**	**17.30%**	**12.91%**	**8.17%**	**6.72%**	**6.58%**	**5.90%**	**13.76%**	**14.66%**	**7.83%**	**8.78%**	**8.82%**
Propane Recovery	%	96.32%	95.04%	95.04%	95.37%	95.81%	95.96%	95.97%	96.04%	95.30%	95.25%	95.85%	95.75%	95.75%
Change in Fuel Usage	$/day	1870	(9.29)	(9.32)	(4.44)	0.90	2.88	3.02	3.68	(5.86)	(6.42)	1.26	0.14	0.08
Change in Power Usage	$/day	21114	(6,529)	(6,529)	(2,836)	(1,163)	(631)	(561)	(270)	(4,951)	(4,203)	(1,447)	(1,909)	(1,982)
Result														
Profit Uplift ($/Month)			**$107,322**	**$ 95,632**	**$ 36,881**	**$ 35,233**	**$ 35,842**	**$ 35,986**	**$ 42,071**	**$ 78,206**	**$ 55,775**	**$ 47,309**	**$ 47,498**	**$ 46,276**

Annual Pro-Forma Value	**$ 664,030**
Estimated profit uplift (NPV, 40 mo. @ 7%)	**$ 1,630,199**
Estimated ROI (non-disc)	**681%**

Figure 7 – Pro Forma Results

Typical operational directives in ethane rejection mode are to minimize ethane recovery while attempting to maintain as high of propane recovery as possible. Note that the pro forma analysis puts this strategy in question:

- Optimal ethane recoveries fluctuate significantly versus the full ethane rejection baseline. Simply holding the target at minimum is only valid if ethane margin is highly negative.
- Propane recovery is relatively flat, maybe even slightly less than the baseline.
- The real value driver in this analysis was recompression energy. This learning point was not expected since recompression energy is not typically considered in the ethane rejection strategy.

Conclusion

The decision to go into ethane rejection and the optimal level of ethane rejection is dependent on product prices, gas prices, energy consumption, process capability, and inlet volume/composition – not simply ethane margin. All of these variables must be analyzed in a comprehensive fashion to determine the best way to run the plant. The process is highly non-linear and requires a rigorous model-based optimization system to determine the appropriate recovery levels on a 24/7 basis. Optimal move response to operational and economic fluctuations is non-linear, non-intuitive, and offers strong profit opportunities.

Enable Midstream has invested in the rigorous optimization infrastructure required to identify and capitalize on market opportunities as they become available. The solution has been shown to provide value to Enable Midstream under all processing conditions.