Advantage Insight Group Inc.

Condensate Equalization Density Model Review

Prepared for the

Equalization Steering Committee

By

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Condensate Equalization Density Model Review

1 Executive Summary

This report summarizes the findings of the Condensate Equalization Density Model Review, conducted at the request of the Equalization Steering Committee. Initiated from discussions in 2023, the review was formally scoped, funded, and approved in 2024 as a desktop study, with no additional laboratory work required. This review focused on the Condensate Equalization Density Model, with the objective of confirming whether the current model continues to support fair and equitable pricing for varying condensate qualities under current market conditions. The review also aimed to identify potential adjustments to improve transparency, simplification, and long-term stability.

Current Condensate Density Penalty Model: The Condensate Density Penalty model calculates a monthly density adjustment and is the combination of two components: (1) blending efficiency and (2) bitumen blend value. Key inputs into the calculation include the thermal/conventional ratio of heavy crude volumes, Enbridge reference temperature, average Enbridge CRW condensate density, and monthly allowance prices. It incorporates coefficients derived from laboratory testing of heavy crude blends with various condensates, capturing density blending, viscosity and volumetric shrinkage effects. A key assumption is that bitumen realization remains constant regardless of the condensate used. The model is updated monthly to reflect market conditions and provide relative value adjustments based on quality.

Condensate Density Model Review: The review assessed the components of the Condensate Density Model using available historical data on heavy crude volumes, condensate quality, and model input and pricing. Detailed crude price data were obtained from Argus Media (Houston close) for available delivery locations. Seasonal variations and the impact of each model component were also evaluated.

Discussion and Key Findings:

Thermal/Conventional Ratio:

Conventional production has remained relatively steady while thermal production has grown, shifting the thermal/conventional ratio to 86%/14% in 2024 from 84%/16% in 2018. Although the updated ratio did not have a statistically significant effect on the density penalty during the evaluated period, updating it is recommended as it better reflects current market conditions.

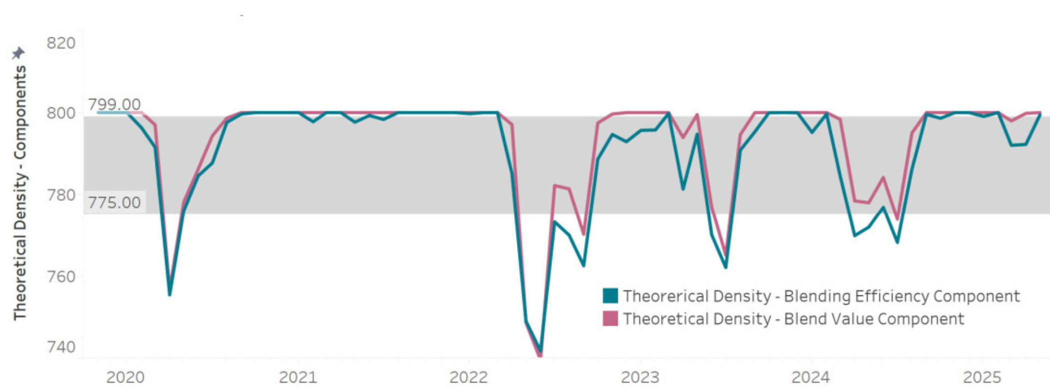
Condensate content and heavy crude blend pricing: seasonal variation in blend density is attributable to changes in condensate content. Regression analysis of Blend Value against condensate (diluent) percentage and Nymex CMA showed a tendency for higher condensate content to reduce Blend Value. The association was statistically significant for AWB and CDB blends, but not for CL and LLB blends, making the overall results inconclusive. Other factors, including supply/demand dynamics and transportation constraints, also influence pricing.

Component evaluation: A total of four model components were evaluated with key insights for each model component summarized below:

- *<u>Blending Efficiency</u>*– (current model component)
    - Assuming bitumen realization and blend value remain constant, while condensate value varies according to blending efficiency. Based on laboratory data, it remains a robust and reliable method for assessing the relative value of condensates.
- *<u>Bitumen Blend Value</u>* – (current model component) –
    - Assumes bitumen realization and condensate value remain constant, effectively implying that higher condensate usage (heavier condensates) would increase blend value. Regression analysis using actual market pricing data from Argus Media showed a negative association between condensate content and market Blend Value across all blends, although this was statistically significant only for AWB and CDB. While heavier condensates can contain more valuable components, the overall findings remain inconclusive.

- *Variable Bitumen Realization assumption*:
    - Assumes that blend value and condensate prices remain constant while bitumen realization varies. The committee concluded that it does not reflect observed market behavior; as a result, it was rejected.
- *Transportation component*:
    - Assumes higher condensate usage increases total transportation costs due to additional bitumen blend volume. Evaluation used the Enbridge Canadian Mainline heavy crude tariff from Edmonton to the International Boundary. Although sensitive to assumed tariff values, it has minimal impact on the overall condensate density adjustment and was therefore excluded from the model.

Theoretical Density: this metric represents the density at which a stream would be indifferent between contributing to the CRW or MSW pools. Although it does not account for quality compatibility, it provides insight into potential impacts on pool volumes. Compared to the CRW-MSW price differential, Blending Efficiency produces lower theoretical densities than Blend Value, reinforcing that the Blend Value component favors heavier streams. The following chart compares Blending Efficiency and Blend Value components.



Final thoughts: A general observation is that most refineries do not purchase condensates for direct processing. In practice, condensate is primarily acquired for blending with heavy bitumen to facilitate transportation, with demand driven by heavy oil producers rather than refineries.

To conclude the study, in October 2025, the committee coordinated a vote to finalize its recommendation to industry. Following the vote, and by majority, the committee recommended:

- Update *Thermal/Conventional Factor* ***(86%/14%)***
- Removal of the **Blend Value** component.

Using the inputs described above, the density slope implied by the recommendation was compared with the current density slope. Key results are presented on the table below.

Month	Condensate Allowance Price, $Cdn/m3	Heavy Allowance Price, $Cdn/m3	Ref Temp, °C	Average Condensate Density, kg/m3	Published Density Slope $/m3 per kg/m3	Density Slope w/ Proposed Recommendation $/m3 per kg/m3
Sep-23	734.14	619.31	17.75	738.5	0.26	**0.36**
Oct-23	723.14	569.90	14.73	739.9	0.37	**0.52**
Nov-23	666.17	479.36	11.50	737.7	0.45	**0.66**
Dec-23	576.20	375.48	8.98	744.4	0.51	**0.76**
Jan-24	602.94	447.78	7.74	743.3	0.38	**0.57**
Feb-24	614.06	483.64	7.50	743.3	0.31	**0.47**
Mar-24	642.78	513.73	7.50	740.4	0.30	**0.45**
Apr-24	701.26	582.95	8.00	741.5	0.27	**0.40**
May-24	636.91	559.74	10.53	734.6	0.16	**0.23**
Jun-24	647.46	572.43	14.00	740.1	0.16	**0.22**
Jul-24	660.47	577.17	16.52	738.9	0.18	**0.25**
Aug-24	611.95	522.13	18.26	739.1	0.20	**0.28**
Sep-24	563.93	473.12	17.75	744.5	0.21	**0.29**
Oct-24	616.20	497.02	14.73	745.9	0.29	**0.41**
Nov-24	611.65	501.15	11.50	738.8	0.25	**0.37**
Dec-24	628.18	511.80	8.98	745.1	0.28	**0.41**
Jan-25	674.85	562.25	7.74	741.8	0.26	**0.38**
Feb-25	631.11	528.76	7.50	741.8	0.23	**0.35**
Mar-25	586.83	485.21	7.50	745.7	0.24	**0.36**
Apr-25	532.55	442.89	8.00	747.0	0.21	**0.31**
May-25	523.58	446.18	10.53	747.1	0.18	**0.26**
Jun-25	599.99	496.58	14.00	741.8	0.24	**0.34**
Jul-25	573.53	497.50	16.52	744.2	0.17	**0.23**
Aug-25	533.03	460.93	18.26	748.6	0.16	**0.23**
Sep-25	537.03	444.45	17.75	748.5	0.22	**0.31**
Oct-25	508.40	423.20	14.73	749.4	0.20	**0.29**
Nov-25	503.29	427.04	11.50	745.1	0.17	**0.25**
Dec-25	483.48	398.66	8.98	752.3	0.21	**0.30**
Jan-26	522.51	402.80	7.74	753.4	0.31	**0.45**
Feb-26	545.33	426.11	7.50	743.7	0.29	**0.43**
Mar-26	774.99	647.15	7.50	744.4	0.30	**0.44**

2 Introduction

This section provides an overview of the condensate equalization process and outlines the objectives of the current review.

The Canadian condensate equalization process is based on the principle that the value difference of condensates blended in a common stream can be determined by three key parameters: density, sulphur, and deemed butane content.

- **Density penalty:** calculated monthly using an industry approved generalized model. The **Condensate Equalization Model,** which produces this adjustment, is the focus of the current review initiative.
- **Sulphur:** The adjustment for condensates is equal in value to that used for the industry accepted equalization process for light and medium crude oil.
- **Deemed butane:** defined in the *Equalization Procedures Guide* as a calculated value based on the volumetric content of butane and C3- (propane and lighter). A penalty is currently applied when the Deemed butane exceeds a 5% threshold.

Given these parameters, the present review focuses on reviewing the density penalty calculation to ensure it remains appropriate under current market conditions.

2.1 Background and Objectives

As outlined in Appendix A - Context, in 2024 the Equalization Steering Committee defined the scope and approved a third-party review of the Condensate Equalization Density Model. This initiative was proposed to ensure the model continues to support fair and equitable pricing under current market conditions. This review focuses exclusively on the model used to calculate the density penalty. Other elements of the Condensate Equalization process are outside the scope of this initiative.

The review aims to evaluate the adequacy of the current Condensate Equalization (EQ) model. The specific objectives as approved by the Committee are to:

- Confirm whether the current Condensate Equalization model is adequate.
- If the current Condensate EQ model is not adequate, identify adjustments that will improve the model with emphasis on:
    - **Simplification** – ensuring simplified calculation and inputs to stay within the public domain to maintain transparency.
    - **Stability** – ensuring the model remains robust over the long term.

2.2 Scope of Review

The condensate density model review was completed as a desktop analysis. During scope development in 2024, it was determined that existing laboratory data for blends of dry heavy crudes (thermally and conventionally produced) with condensates, along with viscosity properties supporting the current model, remained sufficient for the review. As a result, additional laboratory work was deemed unnecessary.

Recognizing that an open-ended analysis of the condensate equalization model would be too broad to deliver results useful to industry, the review proceeded through structured steps to assess the magnitude and direction of potential refinements:

- **Heavy crude volumes**: Historical production in Alberta and Saskatchewan was reviewed, and changes in the thermal/conventional ratio were assessed for their impact on the current model.
- **Condensate quality review:** Condensate quality characteristics were also assessed to provide additional context.
- **Component review:** Historical comparison analysis was conducted to identify major differences and evaluate the contribution of each term in the model.

- **Variable Bitumen realization**: An additional assumption of variable Bitumen realization was included alongside the assessment of each term in the existing model.
- **Transportation component:** The transportation component was assessed for heavy blends along the route from Edmonton to the international boundary. Heavier condensates result in higher transportation costs because larger volumes are required to move the same amount of bitumen compared with lighter condensates.
- **Theoretical density:** The density at which a producer would be indifferent between sending volume to a condensate or a light crude commingled stream was estimated. This theoretical density served as a reference point to evaluate the potential impact on volumes entering the condensate pool.

With the scope and evaluation steps defined, the following sections present the analysis, findings, and recommendations arising from the review of the condensate density model.

3 Condensate Density Model Review

Building on the scope and structured evaluation steps defined in the previous section, this section presents the results of the review. Each component of the condensate density model was analyzed to assess its contribution and understand the behaviour of the model. The analysis draws on pricing data, historical heavy crude production data, condensate quality characteristics, and model term assessments to provide a clear understanding of the model under current conditions.

3.1 Current Model

The current Condensate Density Model calculates the density adjustment for condensates commingled in a common stream. Since its initial approval in 2001 and implementation in 2002, the model has evolved to reflect changes in heavy crude production trends, incorporate new laboratory data (2007), update the volumetric shrinkage equation, implement a revised heavy allowance pricing calculation, and address negative pricing scenarios that occurred during the COVID-19 pandemic. The following figure illustrates the timeline of these changes, each proposed by the Equalization Steering Committee and approved through an industry vote.

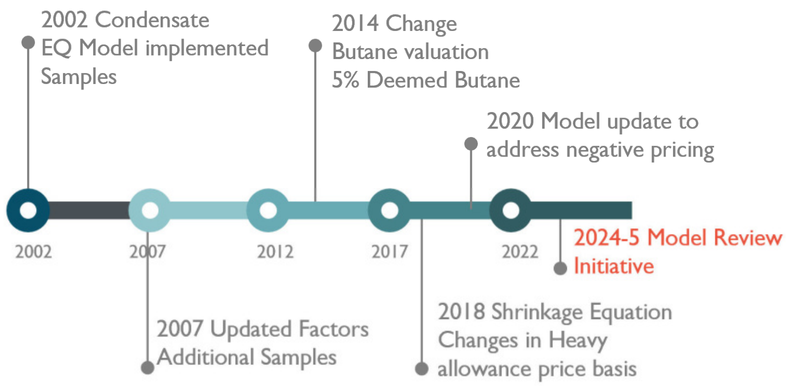


Figure 3-1– Approved Updates to the Condensate Density Model Since 2002

The current model incorporates key inputs to determine the monthly density penalty including

- **Thermal/Conventional ratio,** currently 84% thermal and 16% Conventional used in:
  - Model factors calculation
  - Heavy Allowance Price calculation
- **Enbridge Reference Temperature**, °C at which a heavy blend has a viscosity of 350cSt.
- **Average Condensate Density**, Kg/m3 is the weighted average density for all condensate volumes received by Enbridge at Edmonton.
- **Allowance Prices, $Cdn/m3**: Condensate and Heavy Allowance Price provided monthly to the Equalization Steering Committee by Enbridge. The pricing is calculated as per Enbridge's "Practice Applicable to Automatic Balancing"[1].
  - HEAVY ALLOWANCE OIL PRICE Thermal: the volume weighted price for AWB, BHB, CDB, KDB, SH, and WDB.
  - HEAVY ALLOWANCE OIL PRICE Conventional: the volume-weighted average of the allowance oil price for the LLB, LLK, and Fosterton streams.
- **Heavy Allowance Price,** $Cdn/m3 =

  (HEAVY ALLOWANCE OIL PRICE Thermal) ∗ 0.84 + (HEAVY ALLOWANCE OIL PRICE Conventional) ∗ 0.16

[1] Current document refers to section 9 (d) Automatic Balancing Price Determination. Section number may change from time to time.

The current model also incorporates factors developed from laboratory testing of a series of blends. Four unblended heavy crude samples (two conventionally produced and two thermally produced) were blended with fifteen different condensates, resulting in ninety blends and approximately three hundred viscosity measurements. Three target density blends were prepared for each of the heavy crude and diluent pairings (912 kg/m3, 930 kg/m3 and 940 kg/m3). The viscosity for each one of the blends was measured at different temperatures ranging from 7°C to 40°C. These samples were collected in 2001 and in 2006[2].

The model applies a series of calculations to represent how condensates interact with heavy crude streams. It calculates a target heavy oil blend density representing the minimum density required to achieve 350 cSt at the reference temperature. This target is a function of condensate density and reference temperature, with coefficients derived from the laboratory data, ensuring that viscosity characteristics are explicitly embedded in the model formulation. A shrinkage factor, which varies with diluent density, is then calculated to account for volumetric effects during blending.

The key assumption of the Condensate Density Penalty model is that the primary interest of the heavy oil/bitumen producer is to achieve a similar bitumen realization regardless of which condensate is used as a blend stock. From this perspective, the model calculates the slope of the relative value between condensates in commingled streams, accounting for both their market value as a stream and the adjustment based on quality. Two model components are calculated:

- **Blending Efficiency**: The value of the condensate varies with its blending efficiency while maintaining the Bitumen realization and the Blend price constant.
- **Blend Value**: The blend price varies while maintaining the Bitumen realization and the Condensate price constant.

[2] https://www.industryeq.ca/eq-documentation/ AIG, Condensate Density Penalty Modification Study 2001 and AIG Analysis of Blending Data Used in the Condensate EQ Model – 2007

The Density Penalty Model combines these components into a single slope, which offsets the effects of each: Blending Efficiency favours lighter condensates, which require less volume to achieve the same blending specifications, while Blend Value favours heavier condensates. The following figure illustrates the key considerations for each component of the current model.

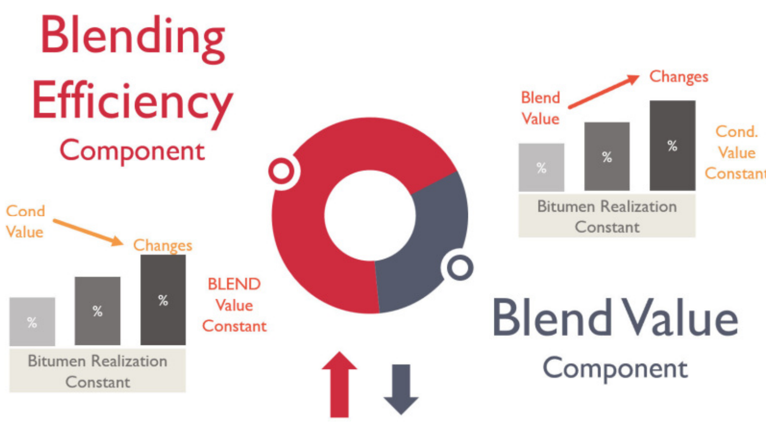
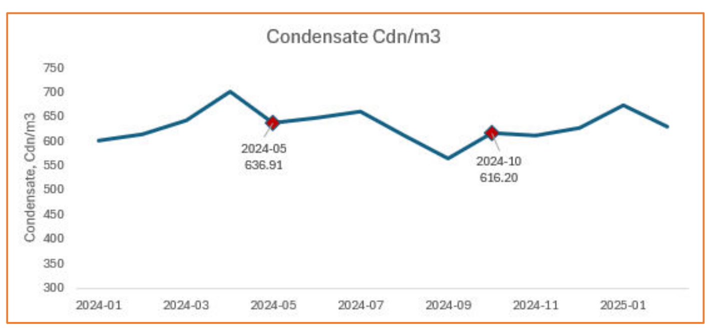


Figure 3-2 Assumptions of Current Condensate Density Penalty Model Components

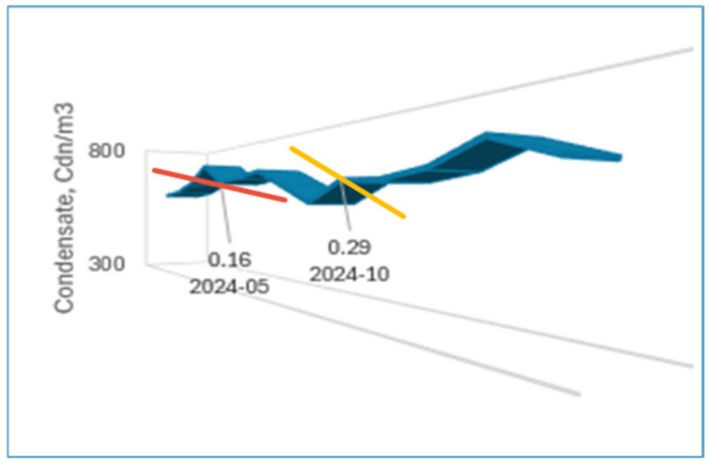
The scales are calculated monthly reflecting the market conditions providing a relative value adjustment based on quality. The following illustrates the adjustment.

This chart shows market value of the CRW stream over time. For this example, two dates are highlighted.



This chart illustrates the density penalty calculated using the inputs provided for each respective month, for the two dates in the example.

This 3D chart shows the CRW price surface with the slopes for the two example dates superposed, illustrating the relative value of a condensate stream based on its quality.



The following chart illustrates how the two components have behaved over time.

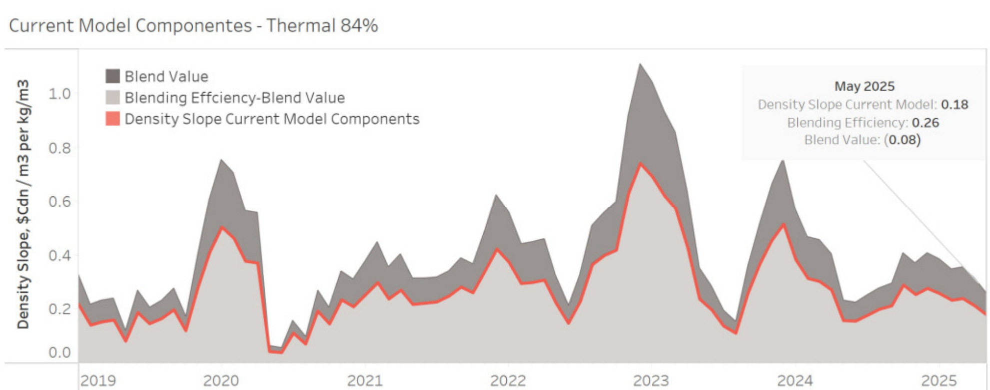


Figure 3-3Current model components – Thermal/Conventional ratio 84%/16%

3.2 Thermal/Conventional Ratio – Heavy Crude Volumes

The Thermal/Conventional ratio, currently 84% thermal and 16% conventional, is used in two calculations within the model. First, it is incorporated into the coefficients derived from laboratory data that underpin the model factors. Second, it is used in the calculation of the Heavy Allowance Price, ensuring that the price adjustment reflects the composition of heavy crude production.

Since condensate is primarily used for heavy crude production, a detailed assessment was carried out using production data from Alberta and Saskatchewan. Historical records were analyzed to evaluate the thermal/conventional split in heavy crude output as well as overall production volumes.

Thermally produced crude, with its higher viscosity and distinct blending characteristics, can significantly affect the relative value of condensates in commingled streams compared with conventionally produced crude. This distinction is important, as the thermal/conventional ratio directly influences both the coefficients used in the model and the calculation of the Heavy Allowance Price.

The following figure shows Alberta non-upgraded crude oil production, distinguishing between thermal (oil sands) and conventional heavy crude. The data[3] illustrates that conventional production has remained relatively steady over time, while thermal production has increased significantly.

[3] Data Source: Alberta Energy Regulator ST3 Reports - Supply and Disposition of Crude ST3 | Alberta Energy Regulator

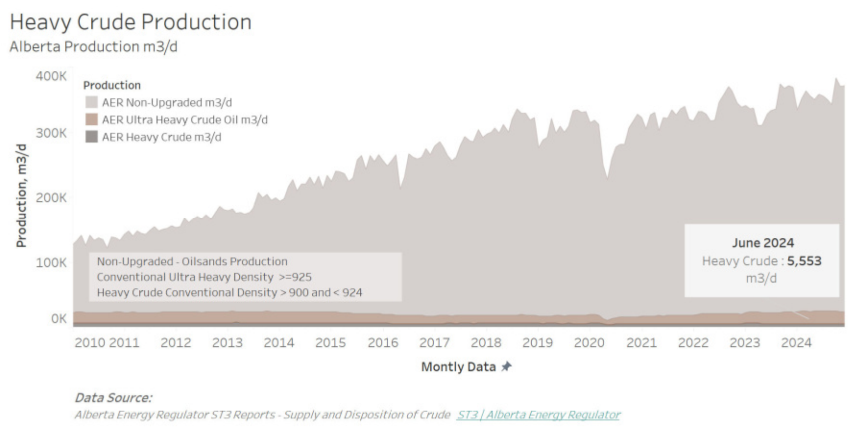


Figure 3-4 Alberta Heavy Crude Oil Production

Saskatchewan's heavy crude production[4] has also shown a slight increase, contributing a steady share of overall supply, largely from conventional sources. The following chart shows the historical production trends for Saskatchewan.

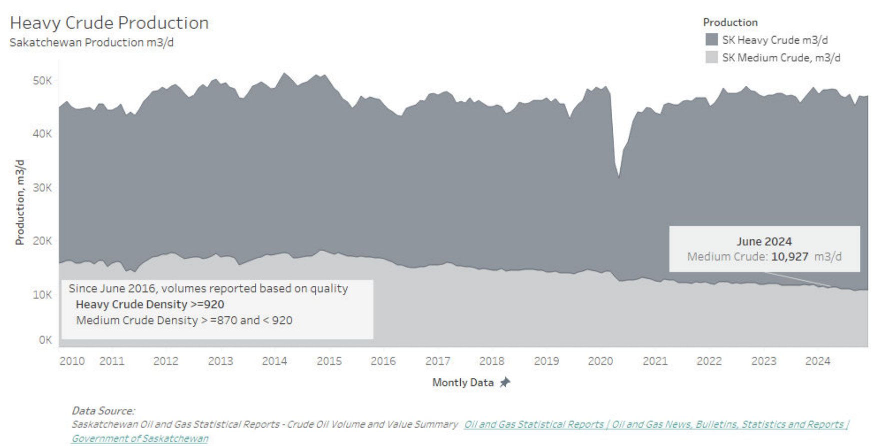


Figure 3-5 Saskatchewan Heavy Crude Oil Production

The Canadian condensate market is driven by heavy crude production in Alberta and Saskatchewan. For this analysis, the volumes considered to calculate the thermal/conventional ratio includes Alberta non-upgraded oil sands and conventional ultra-heavy crude (density ≥925 kg/m3), together with Saskatchewan's heavy conventional crude (density ≥920 kg/m3). The following chart shows historical production trends for these categories.

[4] Data Source: Saskatchewan Oil and Gas Statistical Reports - Crude Oil Volume and Value Summary Oil and Gas Statistical Reports | Oil and Gas News, Bulletins, Statistics and Reports | Government of Saskatchewan

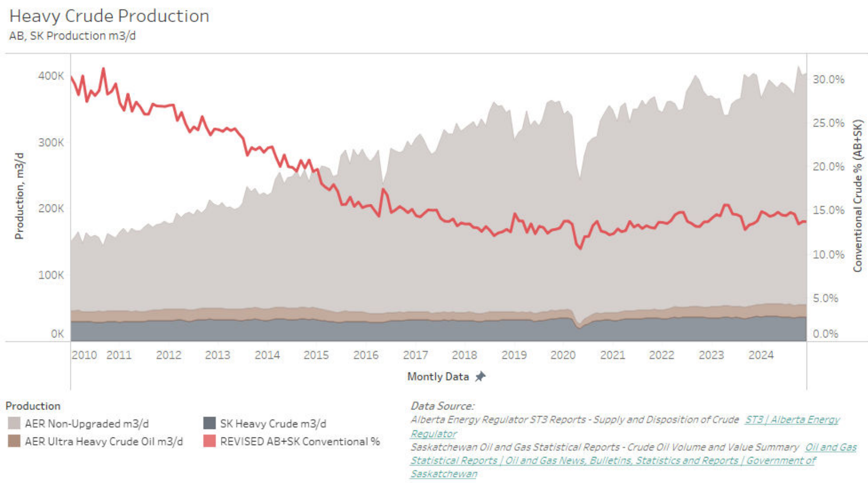


Figure 3-6 Therma/Conventional Production Ratio

Based on this revised data, the 2024 average thermal/conventional ratio is 86%/14%, compared with the 84%/16% ratio used in the current model.

Using the current Condensate density model, the following table compares the density slope and target density calculated with the current thermal/conventional ratio of 84% with the revised value of 86%. The comparison was completed for the period starting on Jan 2019 to May 2025 equivalent to 77 data points.

	Revised Thermal ratio 86% Mean	Current Thermal ratio 84% Mean	Δ	|t Stat| < t Critical	p-value (two-tail)	Conclusion – p<0.05?
Density Slope	0.276	0.278	0.002	Yes	>0.05	No Statistically Significant difference
Target Density	925.60	925.77	0.17	Yes	>0.05	No Statistically Significant difference

Although the revised ratio has no statistically significant effect on the density penalty calculation over the evaluated period, it is recommended to update it. This updated ratio better reflects current market conditions and serves as the basis for the model's related coefficients and heavy allowance price, as discussed in the following section.

3.3 Reference Temperature

The Enbridge Reference Temperature is an input to the model, used in the monthly calculation of condensate density penalty. It represents the temperature at which the pipeline specification for viscosity of 350 cSt must be met to ensure efficient transportation through the system. The model uses the reference temperature, together with laboratory derived properties of condensates and heavy crudes, to calculate blend densities that meet the 350 cSt target. The following chart illustrates how the Enbridge Reference Temperature changes throughout the year, reflecting seasonal adjustments applied in the pipeline system.

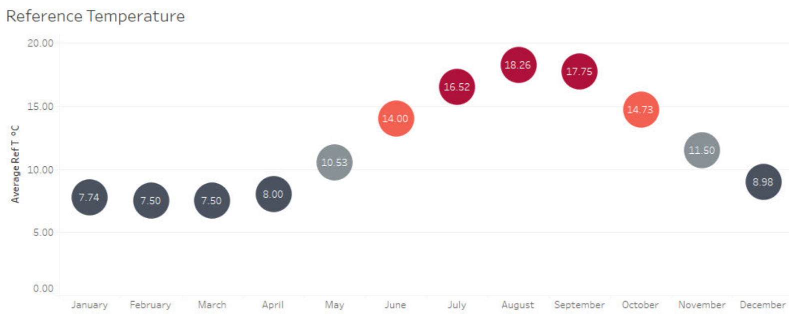


Figure 3-7 Enbridge Reference Temperature - Monthly Weighted Average

Along with viscosity, the pipeline is also subject to a density specification. The following chart illustrates how seasonal variation in reference temperature affects condensate requirements for heavy blends, with darker bars indicating heavier blend densities. Higher summer densities correspond to lower diluent requirements, while lighter winter densities require more condensate.

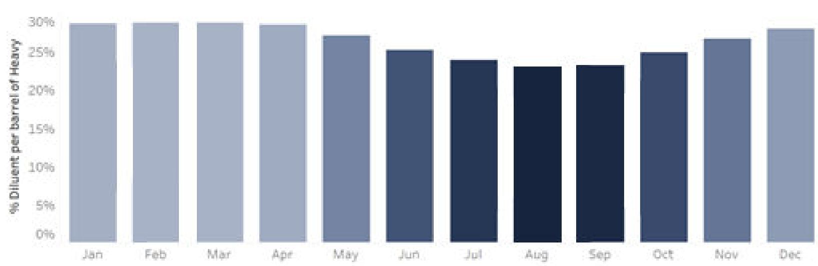


Figure 3-8 Illustrative Seasonal Variation in Condensate Requirements

3.4 Heavy Blend Density

As noted earlier, seasonal changes in reference temperature also influence the density of heavy crude blend. Laboratory data from historical heavy crude blends[5] show that the density of heavy blends varies over the course of the year, reflecting both seasonal effects and changes in crude quality over time.

The following charts illustrate seasonal changes from 2018 to 2025. The top chart shows density changes throughout the year, driven by varying condensate requirements to meet the density and viscosity at reference temperature. The bottom chart shows the condensate CRW pool volumes for the same period.

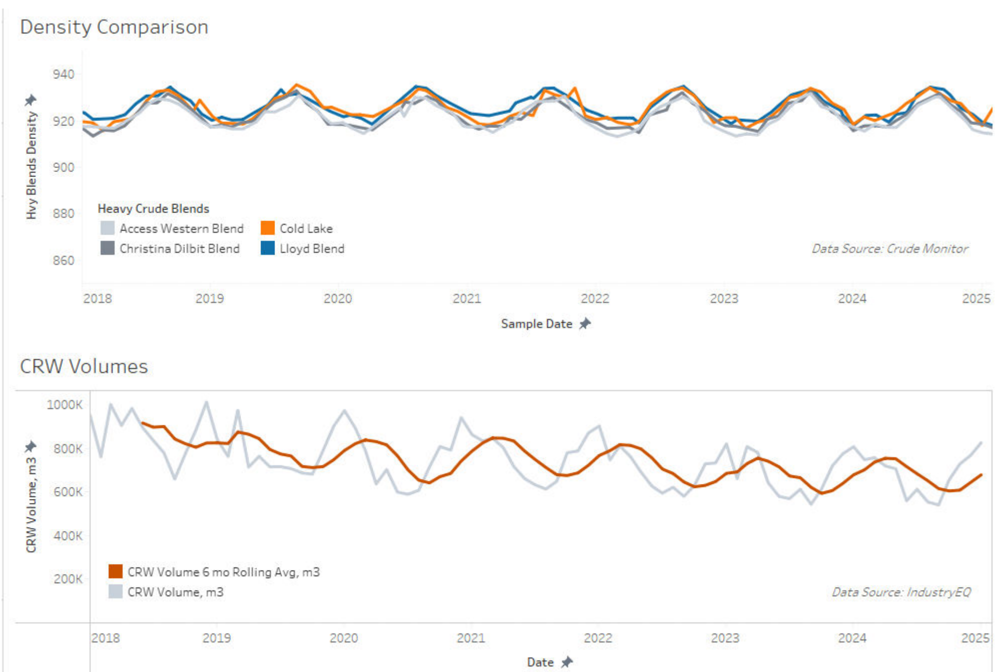


Figure 3-9 Seasonal Variation Heavy Blends Density

[5] Data Source: Crude Monitor: https://www.crudemonitor.ca/

The table below summarizes the average heavy crude density for Q1 and Q3, along with the corresponding p-values from two-sample t-tests, highlighting the statistical significance of seasonal density differences.

Table 3-1 Heavy Blend Q1 and Q3 Density Comparison

	Qtr1 Mean, kg/m3	Qtr3 Mean, kg/m3	Δ (kg/m3)	P-value
LLB	921.2	931.9	↑ 10.7	~ 0
CDB	917.2	929.0	↑ 11.8	~ 0
AWB	916.4	927.5	↑ 11.1	~ 0
CL	920.1	931.8	↑ 11.7	~ 0

As shown above, the density of all four heavy crudes is higher in Q3 compared with Q1, with p-values indicating that the seasonal differences are statistically significant.

3.5 Condensate quality

For the purpose of this review, condensate quality was examined in terms of density and composition. The following subsections present historical changes in these characteristics using publicly available laboratory data. While the current model only incorporates condensate density, reviewing composition provides additional insights into how the condensate pool has evolved over time.

3.5.1 Condensate Density

Over the past two decades, the density of the CRW condensate pool has increased, while the historical seasonal gap between winter and summer densities has narrowed. These changes may be linked to increased condensate demand driven by the growth of heavy crude production. The entry of heavier condensates into the CRW pool would explain both the overall rise in average density and the reduced seasonal variation. The following chart illustrates the trend in condensate density over time.

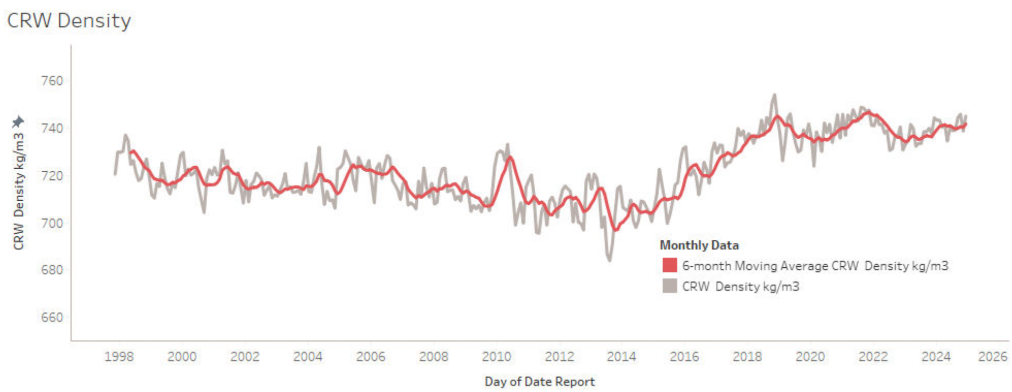


Figure 3-10 CRW Density over time

The table below quantifies seasonal differences by comparing mean densities for Q1 and Q3 across two periods. Results show a statistically significant decrease in density from winter (Q1) to summer (Q3) during 1998–2015. In contrast, the more recent period (2016–2024) exhibits minimal variation, indicating a narrowing gap between winter and summer pool density.

Table 3-2 Seasonal Differences in CRW Condensate Density, 1998–2024

Year	Q1 Mean (kg/m3)	Q3 Mean (kg/m3)	Δ (kg/m3)	p-value (two-tail)	Conclusion – p<0.05?
1998-2015	717.3	710.8	↓ 6.5	~ 0	Statistically Significant decrease
2016-2024	736.1	735.9	↓ 0.2	>0.05	No Statistically Significant difference in the means

3.5.2 Condensate Composition

From 2009 to 2025, CRW condensate pool composition[6] exhibited notable seasonal variation, consistent with the trends observed in pool density. The following chart illustrates these changes over time.

[6] Data Source: Crude Monitor: https://www.crudemonitor.ca/

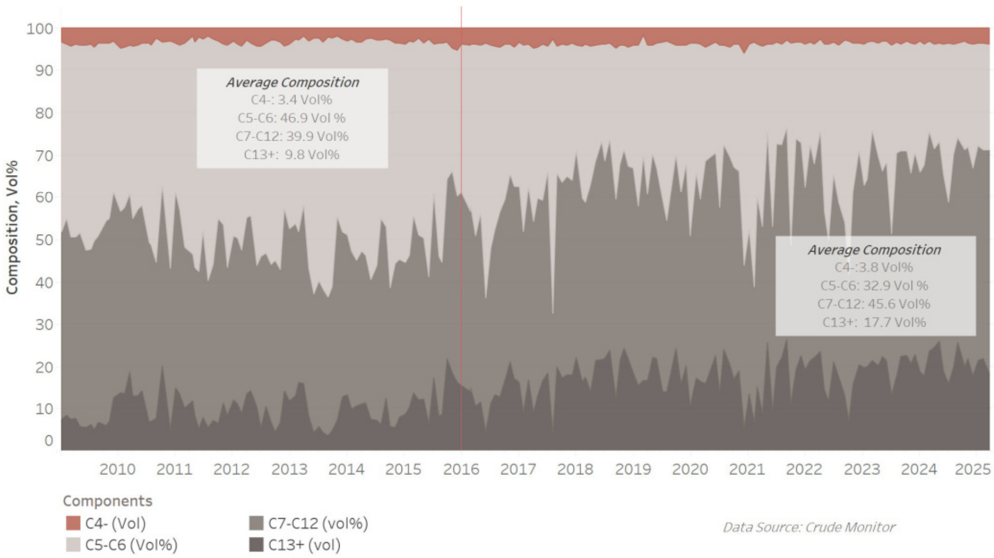


Table 3-3 Historical CRW Composition

For the data prior to 2016, results indicate seasonal differences in composition between winter and summer months. During the winter, the composition was shifted toward heavier components, consistent with the previously noted density observations. The following table summarizes the statistical comparison of Q1 and Q3 mean volumetric fractions for the major hydrocarbon components.

Table 3-4 Average Condensate Composition Before 2016

Component	Q1	Q3	Δ (Vol%)	|t Stat| < t Critical	p-value (two-tail)	Conclusion – p<0.05?
C4-	3.7	3.3	(0.43)	No	<0.05	Statistically Significant decrease
C5-C6	44.3	50.1	5.75	No	<0.05	Statistically Significant increase
C7-C12	40.2	39.2	(1.04)	Yes	>0.05	No Statistically Significant difference
C13+	11.7	7.5	(4.28)	No	<0.05	Statistically Significant decrease

In contrast, for data from 2016 onward, results show no statistically significant seasonal differences in composition between winter and summer months. The following table summarizes the comparison of Q1 and Q3 mean volumetric fractions for the major hydrocarbon components.

Table 3-5 Average Condensate Composition After 2016

Component	Q1	Q3	Δ (Vol%)	|t Stat| < t Critical	p-value (two-tail)	Conclusion – p<0.05?
C4-	3.7	3.8	0.11	Yes	>0.05	No Statistically Significant difference
C5-C6	33.3	33.5	0.24	Yes	>0.05	No Statistically Significant difference
C7-C12	45.7	45.0	(0.75)	Yes	>0.05	No Statistically Significant difference
C13+	17.3	17.7	0.40	Yes	>0.05	No Statistically Significant difference

Further analysis of the CRW condensate pool shows that the C5–C6 fraction has decreased, while heavier hydrocarbon components (C7–C12 and C13+) have increased. These changes are consistent with previous observations and help explain the overall increase in condensate pool density over time. The table below summarizes the volumetric changes in major hydrocarbon components between the periods 2009–2015 and 2016–2025.

Table 3-6 Changes in Condensate Composition Over Time

Component	2009-2015	2016-2025	Δ (Vol%)	p-value (two-tail)	Conclusion – p<0.05?
C4-	3.4	3.8	↑ 0.4	~ 0	Statistically Significant **increase**
C5-C6	46.9	32.9	↓ 14.0	~ 0	Statistically Significant **decrease**
C7-C12	39.9	45.6	↑ 5.7	~ 0	Statistically Significant **increase**
C13+	9.8	17.7	↑ 7.9	~ 0	Statistically Significant **increase**

3.6 Heavy Crude and Condensate Pricing

As per the current Equalization Procedures Guide, condensate and heavy allowance prices are provided by Enbridge and calculated according to Enbridge's "Practice Applicable to Automatic Balancing." As model inputs, the individual crudes are grouped into thermal (CLK, AWB, BHB, CDB, KDB, SH, WDB) and conventional (LLB, LLK, Fosterton) categories, which are then used to calculate the heavy allowance price.

For this analysis, detailed crude price data were sourced from Argus Media. Market available data included CL[7] and CDB at Hardisty, AWB at Edmonton, and LLB at Hardisty. BHB, KDB, SH, WDB, LLK, and Fosterton were not readily available. The monthly allowance prices used in the model are consistent with the Argus data, which provide higher frequency market observations. Accordingly, no further price data sources were considered necessary.

The following charts show how the acquired data compares with the monthly allowance prices used in the model for both thermal and conventional crudes, supporting due diligence and confirming a close alignment between the datasets.

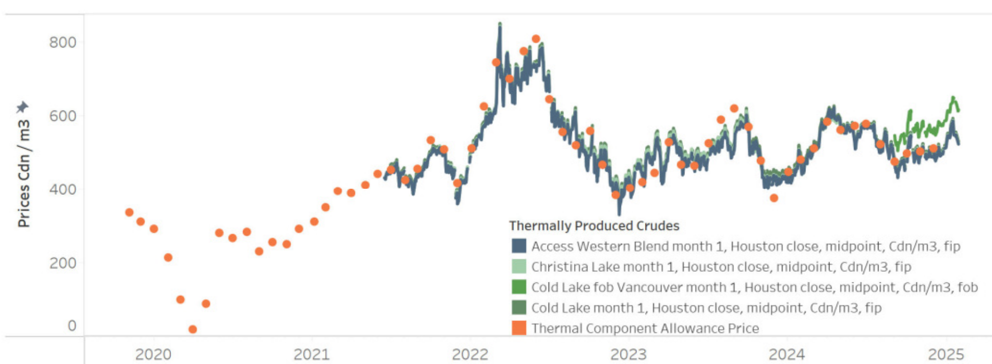


Figure 3-11 Thermally produced Crude Pricing Comparison

[7] Cold Lake price Vancouver is shown for reference only, not used in the analysis.

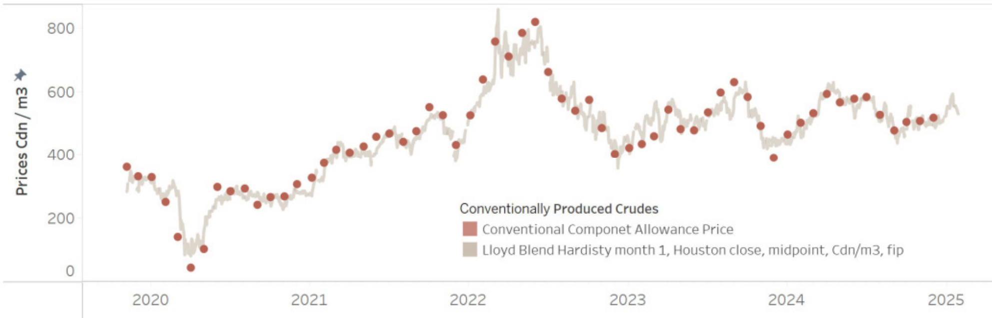


Figure 3-12 Conventionally produced Crude Pricing Comparison

The same analysis was also performed for the condensate allowance price. Market available data for this purpose included CRW at Edmonton, which was compared to the monthly allowance prices used in the model to support due diligence and confirm consistency. The following chart illustrates this comparison.

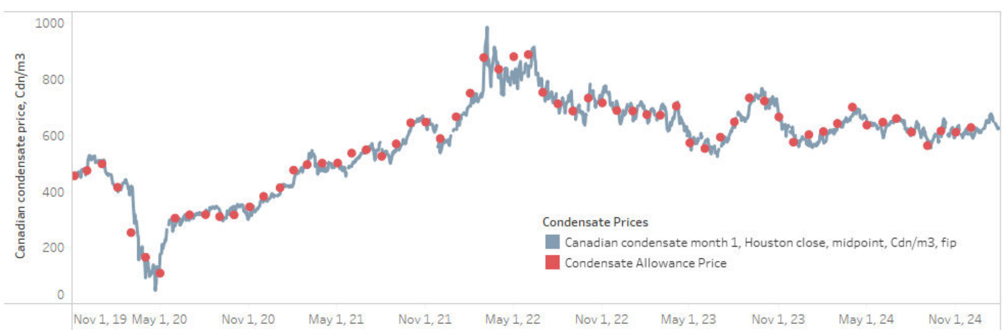


Figure 3-13 Condensate Pricing Comparison

3.6.1 Heavy Crude Pricing and Condensate Content

Building on the earlier discussion of seasonal variation in heavy crude quality driven by changing condensate requirements, this section examines how condensate content influences the value of heavy crude blends.

The following charts compare heavy crude pricing trends with blend density and the corresponding estimated condensate content, for thermally produced crudes, CDB, CL, AWB and Conventionally produced LLB crudes[8]. The condensate estimates are intended to provide a high-level view rather than a detailed calculation, and serve to frame the regression analysis that follows, which quantifies the association between condensate requirements on relative blend value.

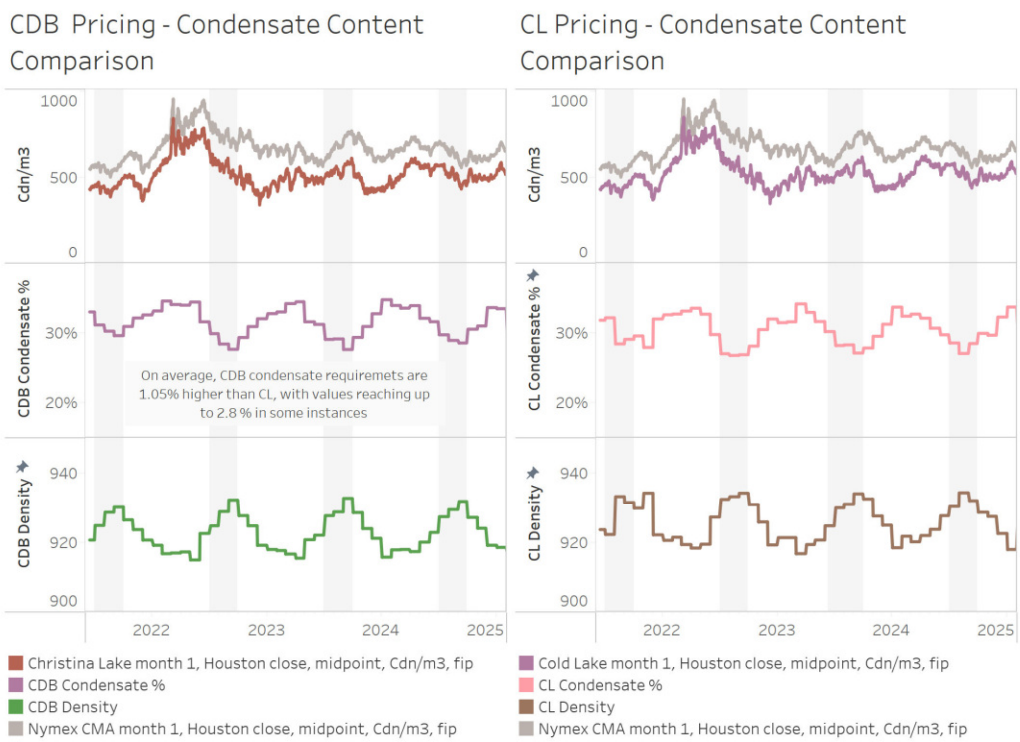


Figure 3-14 CDB, CL Pricing and Condensate Content Comparison

[8] Pricing data source: Argus Media, Quality data source: Crude monitor: https://www.crudemonitor.ca/

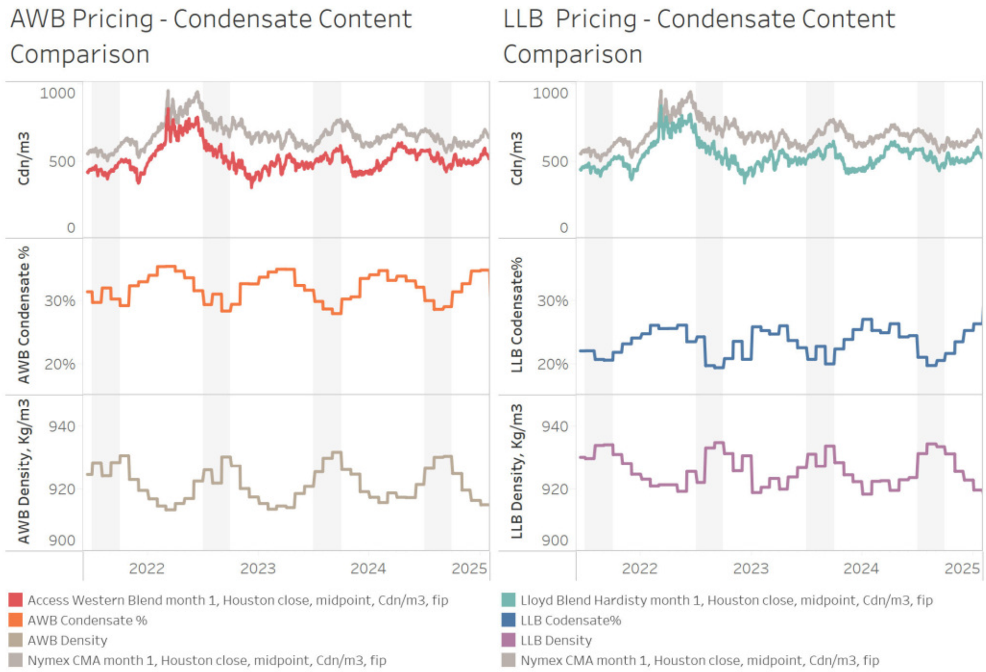


Figure 3-15 AWB, LLB Pricing and Condensate Content Comparison

To assess how condensate content influences heavy crude pricing, the Blend Value was regressed against the percentage of diluent in the blend, with Nymex CMA included as a control to account for overall market changes.

Here, Blend Value is the dependent variable, while the independent variables are the diluent percentage and Nymex CMA. As previously shown, heavy crude quality exhibits lower density in Q1 and higher density in Q3, while statistical analysis indicates that condensate quality does not differ significantly between these periods. This suggests that the seasonal variation in blend density is primarily attributable to changes in condensate content.

A summary of the regression results is provided in the table below.

Table 3-7 Regression Analysis of Blend Value and Condensate Content

Blend	R Square	Coefficient for % Diluent	P-value	Statistic Significance (p<0.05?)
AWB Blend Value	0.9928	-0.97899	0.005	Statistically significant
CDB Blend Value	0.9934	-0.83321	0.015	Statistically significant
CL Blend Value	0.9938	-0.53883	0.101	Trend consistent, not statistically significant
LLB Blend Value	0.9943	-0.49019	0.229	Trend consistent, not statistically significant

The regression results indicate that the negative association between diluent content and Blend Value, statistically significant for the AWB and CDB blends, but not for CL and LLB blends (significant at the 5% level). While these results indicate a tendency for higher condensate content to reduce Blend Value, other factors, including supply/demand dynamics and transportation constraints, also influence pricing. Therefore, the regression reflects a correlation between condensate content and Blend Value rather than a definitive causal effect.

3.7 Analysis of Model Components

This section presents an evaluation of the four components examined during the committee's initiative review of the Condensate Density Model. It examines the two existing components, Blending Efficiency and Blend Value, and introduces analysis of two additional components: a Transportation Component and an Alternative Variable Bitumen Realization Component. The purpose of this section is to assess how each component contributes to the overall condensate density adjustment and to explore potential refinements to the model.

Each component is evaluated using the mechanics as the current model ensuring the results are comparable. Using monthly inputs, condensate allowance price, heavy allowance price, Enbridge reference temperature, average CRW pool density, and the thermal/conventional ratio (revised value thermal/conventional of 86%/14%), the model estimates a target density at which the blend achieves 350 cSt at the reference temperature. It also calculates the amount of diluent required, accounting for the shrinkage factor that varies with condensate density. The evaluation is performed over a range of condensate densities from 680 kg/m3 to 800 kg/m3. The slope of each curve is the value of the component that is evaluated. The following chart illustrates the contribution of each of the components in the density factor.

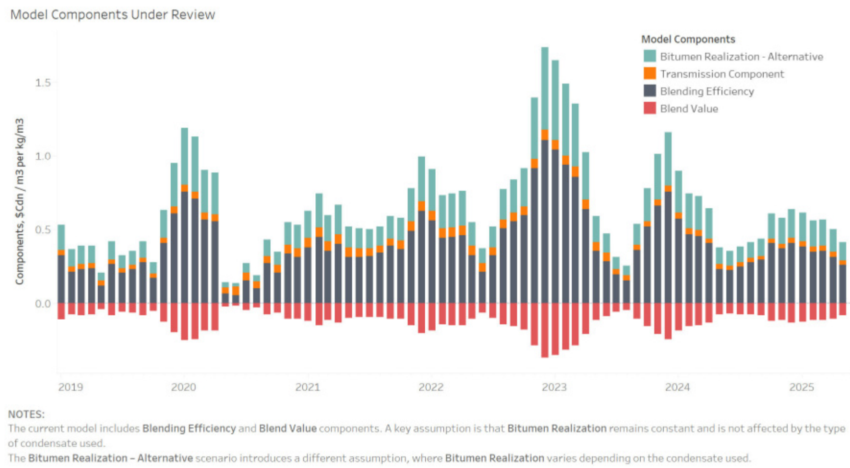


Figure 3-16 Effect of Each Model Components Under Review

3.7.1 Variable Bitumen Realization Assumption

This component was proposed by the Equalization Steering Committee for further analysis during the review. Under the same market conditions, for different condensate densities, the underlying assumptions are as follows:

- Bitumen realization per barrel is variable.
- Blend value remains constant.
- Condensate pricing remains constant.

As a result, bitumen realization decreases as the proportion of condensate in the blend increases. The following schematic illustrates this relationship. Lighter condensates require less diluent than heavier condensates. In the schematic below on the left, each bar represents a blend of bitumen and condensate. The light beige portion indicates the bitumen realization, while the gray portion represents the condensate fraction. From left to right, the proportion of condensate increases, with the darker gray bar on the right representing a heavier condensate that requires a larger percentage. The chart below on the right illustrates the relative contribution of each component to the overall density factor, highlighting the Variable Bitumen Realization component, based on monthly input data. This model component favours lighter condensates.

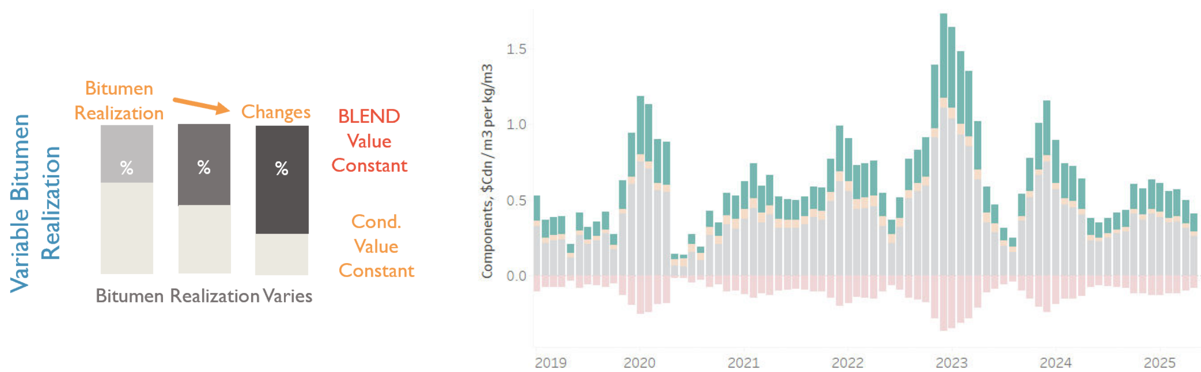


Figure 3-17 Bitumen Realization Varying Assumption

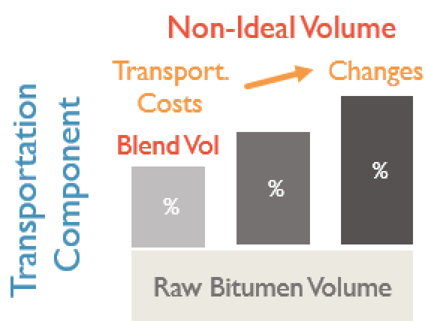
As part of the due diligence undertaken during the review initiative, the committee concluded that this assumption does not reflect actual market behaviour and therefore should not be included in the model.

3.7.2 Transportation Component

The Transportation Component evaluates the relative value of condensates by accounting for additional transportation costs associated with heavier condensates. The key assumptions for this component are:

- The same volume of unblended heavy crude is being transported.
- Transportation from Edmonton to the International Boundary using the Enbridge tariff on Canadian Mainline / Local Tolls for heavy crude oils.

Under these assumptions, heavier condensates result in higher transportation costs, as a greater volume of condensate is required in the blend to transport the same amount of bitumen. This component favours lighter condensates. The following schematic illustrates this relationship. The chart below on the right illustrates the relative contribution highlighting the Transportation component, based on monthly input data.



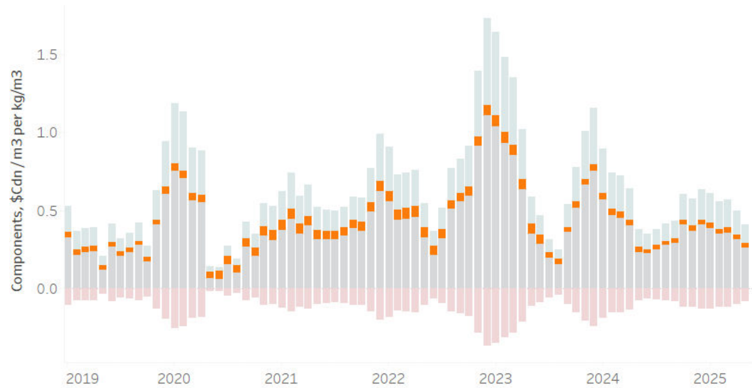


Figure 3-18 Transportation Component

The Transportation Component contributes only a small effect to the overall condensate density adjustment. Its value is sensitive to the assumed tariff, and based on the review, it may not be a relevant factor for inclusion in the model.

3.7.3 Blending Efficiency – Current Component

This is a component of the current model. The key assumption is that bitumen realization and blend value remain constant. Under this assumption, the value of the condensate varies depending on its blending efficiency derived from laboratory data. In summary, under the same market conditions, for different condensate densities

- Bitumen realization per barrel is constant.
- Blend value remains constant.
- Condensate value varies.

As a result, this component favours lighter condensates. The value of heavier condensates decreases because their blending efficiency is lower, requiring a larger amount of condensate in the blend as density increases. The following schematic below on the left illustrates this relationship. The chart below on the right illustrates the relative contribution highlighting the Blending efficiency component, based on monthly input data.

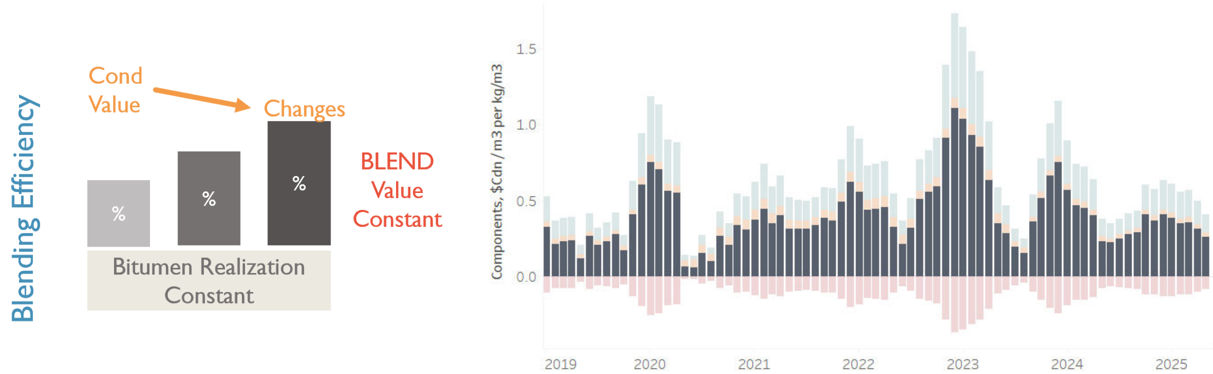


Figure 3-19 Blending Efficiency Component

As a result of the review, this component continues to provide a robust methodology for assessing the relative value of condensates based on their blending efficiency.

3.7.4 Blend Value Component – Current Component

This is a component of the current model. The key assumption is that bitumen realization and condensate value remain constant, making it indifferent to diluent density. Under the same market conditions, for different condensate densities

- Bitumen realization per barrel is constant.
- Condensate value remains constant.
- Blend value varies.

Under these assumptions, the value of the heavy blend increases as the amount of condensate increases in the blend. The following schematic below on the left illustrates this relationship. The chart below on the right illustrates the relative contribution highlighting the Blend value component, based on monthly input data.

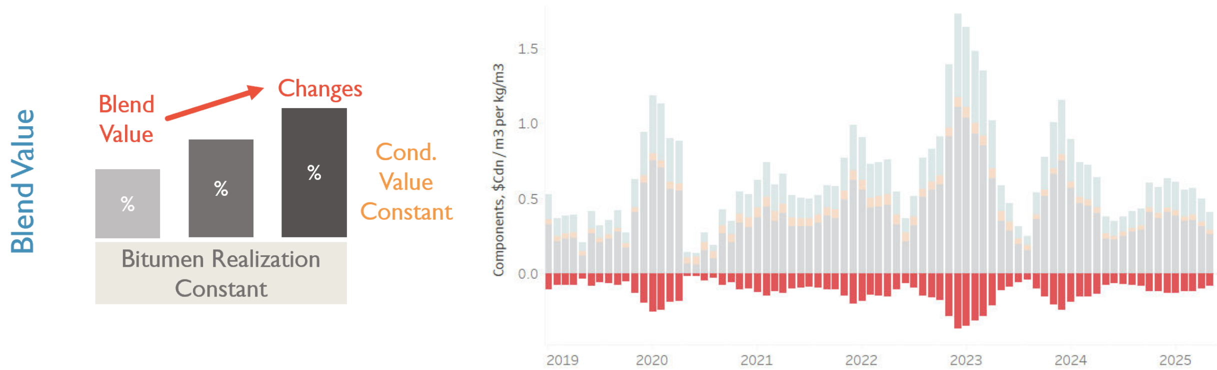


Figure 3-20 Blend Value Component

This model component favours the addition of heavier condensate into the various condensate streams instead of it being blended into the Western Canadian Light Crude production (MSW) maximizing the availability of local condensate.

3.8 Summary of Model Components Reviewed

The table below summarizes the four model components evaluated during the Condensate Model review initiative. It shows how each component affects the overall density slope and outlines the assumptions for bitumen realization, blend value, and condensate relative value, along with key observations from the review.

Table 3-8 Condensate Model Components: Summary of Review

Component	Blend Value	Bitumen Realization	Condensate Relative Value	Comments
Blending Efficiency	Constant	Constant	Changes	Favours lighter condensates
Bend Value	Changes	Constant	Constant	Provides incentive for heavier condensates
Variable Bitumen Realization	Constant	Changes	Constant	Not Recommended
Transportation Component	Constant	NA	NA	Sensitive to the assumed tariff, start and end points, impact low, not relevant

Based on the review, of the four components initially analyzed, only the Blending Efficiency and Blend Value components were retained for further analysis. The Variable Bitumen Realization and Relative Transportation components were discarded from further consideration.

The next section examines the theoretical density at which a stream is indifferent between contributing to the condensate pool or the light crude pool.

3.9 Theoretical Density Analysis

As noted in the previous section, the Blending efficiency and the Blend Value components offset each other. The chart below illustrates the combined effect of these two terms and its resulting Condensate density penalty using the updated thermal/conventional ration of 86%/14%.

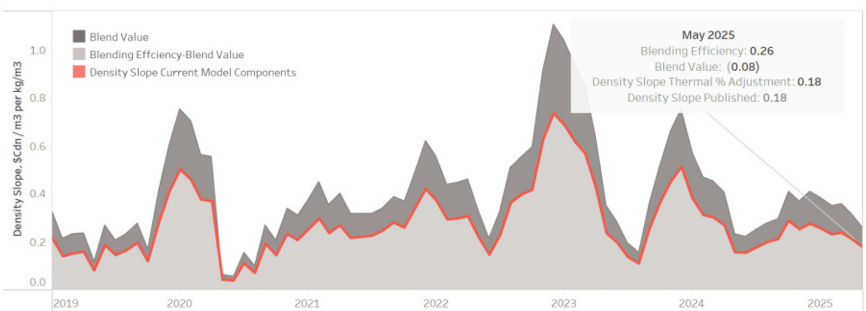


Table 3-9 Combined Effect Model Components: Blending Efficiency and Blend Value, Thermal/Conventional ratio 86%

Using these two components, this section examines the theoretical density at which a stream would be indifferent between contributing to the CRW or MSW pools. The theoretical density calculation does not consider quality compatibility; rather, it provides an indication of the potential impact on pool volumes. Crude compatibility refers to the solubility and stability of blended crude oils, with asphaltene stability being a key concern, since asphaltene precipitation can create challenges in transportation and refining.

The value of a stream in the light crude pool will be valued with the current light and medium crude density penalties. The following chart illustrates the comparison between the density scales for Condensate and Light crude.

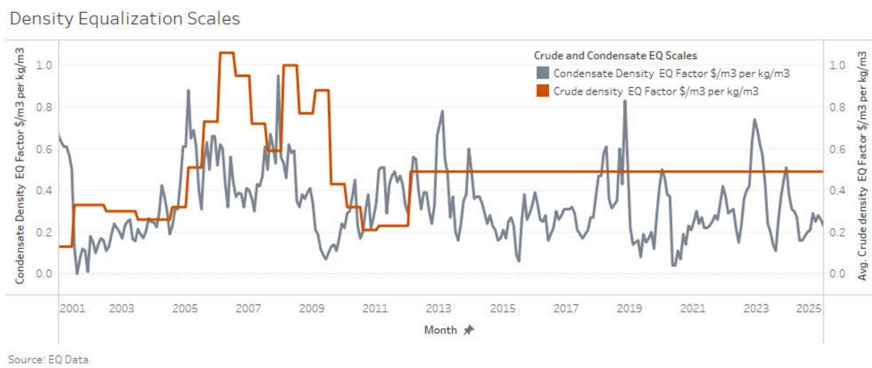


Figure 3-21 Condensate and Light Crude Density EQ Scales comparison

The following chart shows the theoretical density at which a stream will be indifferent if it goes to the CRW or the MSW pools. The Condensate density specification ranges from 600 kg/m3 to 775 kg/m3, while light crude (MSW) ranges from 799 kg/m3 to 876 kg/m3. Streams with densities 775 kg/m3–799 kg/m3 could potentially contribute to either pool, subject to a compatibility assessment. This range is highlighted as the gray band in the chart. The bottom chart presents the corresponding CRW–MSW price differential.

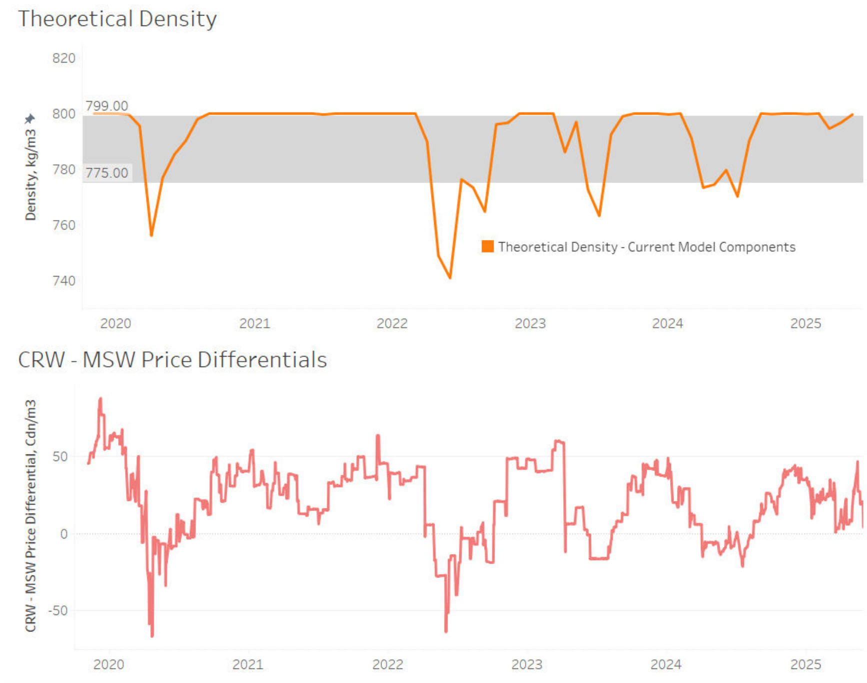


Figure 3-22 Theoretical Density – Combined model components

The following chart illustrates the theoretical density for each of the two model components evaluated independently. When compared to the CRW–MSW price differential, the theoretical density calculated using the Blending Efficiency component is lower than that calculated using only the Blend Value component. This reinforces the earlier observation that the Blend Value component favour heavier streams entering the condensate pool.

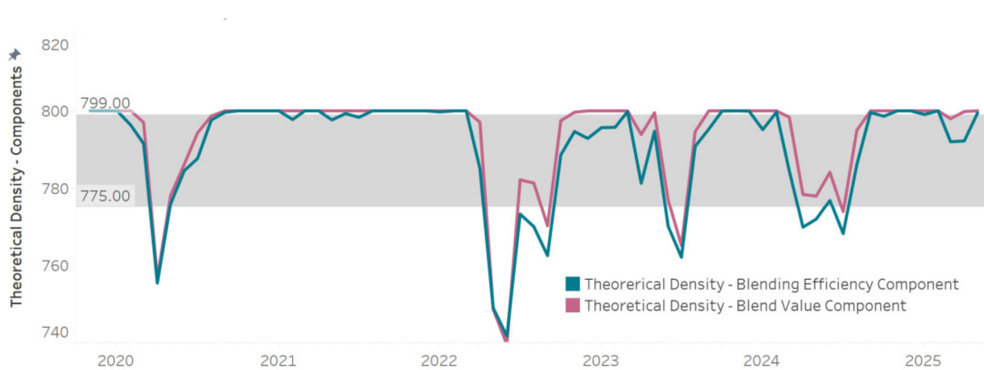


Figure 3-23 Theoretical Density by Model Component

The analysis indicates that the current model components, Blending Efficiency and Blend Value, capture the main drivers of condensate valuation. The Blend Value component may be justified primarily because it provides an incentive for heavier condensate streams to enter the pool. However, the assumptions underlying this component are weak and not strongly supported by the data review conducted in this initiative.

4 Key Findings

Thermal/Conventional Ratio: has increased overtime, the conventional production has remained relatively steady over time, while thermal production has increased significantly. For 2024 the average ratio increased to 86%/14% from 84%/16% implemented ratio in 2018.

Heavy Blend Density: the density of LLB, CDB, AWB and CL crudes is higher in Q3 compared with Q1. The seasonal differences are statistically significant.

Condensate density: Over the past two decades, the density of the CRW condensate pool has increased, while the historical seasonal gap between winter and summer densities has narrowed. From 1998 to 2015, the analysis shows a statistically significant decrease in density from Q1 to Q3. In the more recent period, 2016 to 2024, no statistically significant difference was observed between Q1 and Q3, suggesting that the seasonal density gap has largely diminished.

Condensate composition: When comparing 2009–2015 with 2015–2025, the CRW condensate pool shows a shift toward a heavier composition, with reduced C5–C6 content and a higher proportion of C7–C12 and heavier (C13+) components.

Condensate content and heavy crude blend pricing: seasonal variation in blend density is attributable to changes in condensate content. Regression analysis of Blend Value against condensate (diluent) percentage and Nymex CMA showed a tendency for higher condensate content to reduce Blend Value. The association was statistically significant for AWB and CDB blends, but not for CL and LLB blends, making the overall results inconclusive.

Component evaluation: The analysis highlights key insights for each model component:

- *Blending Efficiency,* this current model component assumes bitumen realization and blend value remain constant, while condensate value varies according to its blending efficiency. Based on laboratory data, it continues to provide a robust and reliable method for assessing the relative value of condensates.
- *Blend Value,* this current model component assumes bitumen realization and condensate value remain constant, which effectively implies that higher condensate usage, or heavier condensates, would increase blend value. As noted above, the regression analysis consistently showed a negative association between condensate content and Blend Value across all blends, although this relationship was statistically significant only for AWB and CDB. Heavier condensates can contain more valuable components; however, the findings are inconclusive.
- *Variable Bitumen Realization assumption*: This component assumes that blend value and condensate prices remain constant while bitumen realization varies. The committee reviewed the component and concluded that it does not reflect observed market behavior; as a result, it was rejected.
- *Transportation component*: Evaluated using the Enbridge Canadian Mainline heavy crude tariff from Edmonton to the International Boundary. While sensitive to assumed tariff values, this component contributes only a small effect to the overall condensate density adjustment and was therefore deemed not relevant for inclusion in the model.

Theoretical Density: This metric represents the density at which a stream would be indifferent between contributing to the CRW or MSW pools. While it does not account for quality compatibility, it provides insight into the potential impact on pool volumes. The analysis was performed for both the Blending Efficiency and Blend Value components. When compared to the CRW–MSW price differential, the theoretical density calculated using the Blending Efficiency component is lower than that from the Blend Value component, reinforcing that the Blend Value component tends to favour heavier streams entering the condensate pool.

5 Committee Recommendation

To conclude the study, in October 2025, the committee coordinated a vote to finalize its recommendation to industry. Following the vote, and by majority, the committee recommended:

- Update Thermal/Conventional Factor (86%/14%)
- Removal of the Blend Value component.

Appendix A - Context

This section provides the background and rationale for the Condensate Equalization Model Review initiative. It outlines the steps taken to assess the need for a review, scope development and the timeline of key activities leading up to the formal initiation of the process.

As part of the scope development, the condensate density model review was designated as a desktop study, with existing laboratory data and viscosity properties considered sufficient, making additional laboratory work unnecessary.

i. Background

In 2024, the Equalization Steering Committee approved the initiation of a third-party review of the Condensate Equalization Density model. This decision aims to ensure the model continues to reflect fair and equitable pricing for varying qualities of condensate under current market conditions.

The review initiative was prompted by a concern raised at the August 31, 2023, Equalization Steering Committee meeting. An analysis was shared in which a heavy crude was blended with two different condensates. The key concerns discussed:

- The density equalization model is over 20 years old as it was implemented in 2001
- Substantial increase in heavy oil production over time
- Increase in condensate imports
- In the case of heavier condensates. The current model does not account for transit costs when shipping more condensate and diluent volumes.

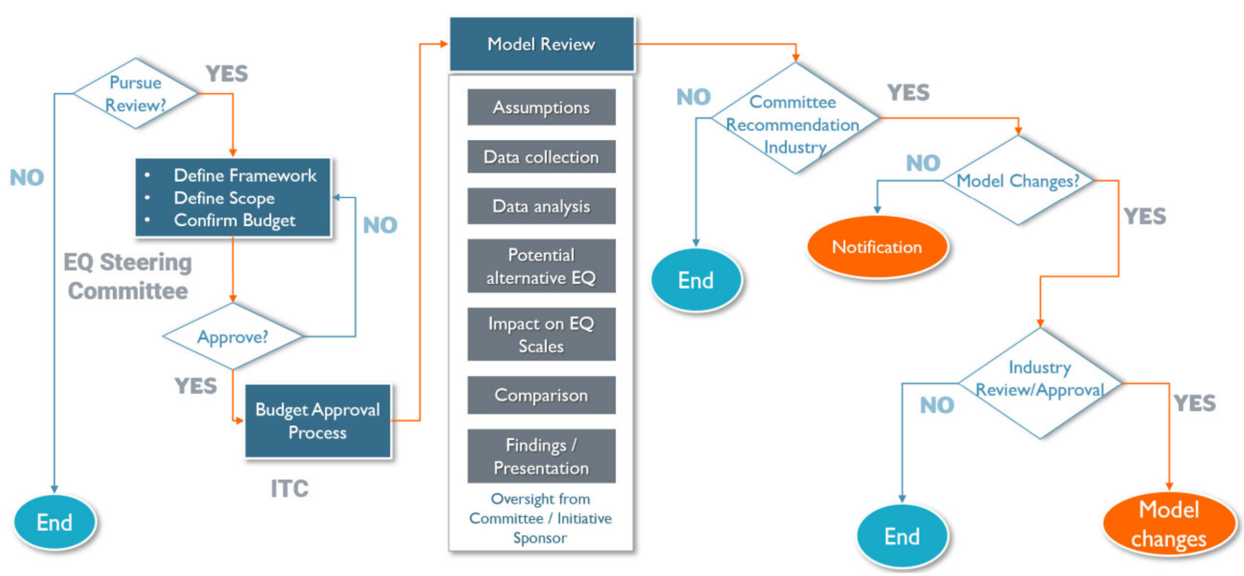
Following further discussion during the Equalization Steering Committee meetings on September 28 and October 26, 2023, a vote was coordinated to formalize the decision to pursue the review. Although the model has been reviewed and adjusted over time, a thorough review was considered. Between October 30 and November 28, 2023, Committee members submitted their votes, with the majority in favour of pursuing a review of the Condensate Equalization model.

In April 2024, a draft scope of work for the initiative was developed and presented to the Committee for discussion. This was followed in July by a presentation summarizing data challenges and preliminary cost estimates. In August, the Committee reviewed a tentative timeline, and key activities associated with the initiative. In September 2024, the Committee voted to proceed with the initiative and to submit a funding request to the Industry Technical Committee (ITC) for consideration at its October meeting. The funding request was subsequently approved.

ii. Review Process and Planning

The review of the Condensate Equalization Density model has followed a structured and deliberate process. The Equalization Steering Committee has taken focused steps to assess key concerns and define a clear path forward.

The following schematic provides a high-level overview of the decision-making process that has guided the initiative.



iii. Initiative Timeline

To support transparency and effective coordination, a high-level timeline was developed outlining key milestones and activities for the Condensate Equalization Model Review initiative. The following chart presents the sequence and timing of these activities.