# Oil (and Oil-Related Products) Monte Carlo Simulation Summary

## WTI Forecasting

Ornstein-Uhlenbeck Process Monte Carlo.

### Source Data

WTI forecasting is based on historical pricing volatility of the nominal WTI price series. The nominal price series is calculated from the U.S. Federal Reserve Series real WTI “OILPRICE” (monthly) and “DCOILWTICO” (daily – for the most recent month average) and the U.S. Federal Reserve Series Consumer Price Index (CPI) “CPILEGSL.”

### Forecast Methodology

WTI forecasting uses the Ornstein-Uhlenbeck Process. Nominal returns are fitted with a Gaussian distribution.

Mean Reversion values must pass two statistical tests. The first is the Augmented Dickey-Fuller Test (ADF Test) null hypothesis. The ADF test must produce a DF-statistic less than -1.931 or a 95% confidence level to reject the null hypothesis of a unit root. The second is the ADF P-value. The ADF P-value tested needs to be less than 0.1 to reject the null hypothesis of a unit root.

The Mean Reversion time used in the process is 4.5 years. The Mean Reversion calculations are not perfect and sometimes produce values that deviate significantly from the real trend. To minimize these deviations, a moving average of the same 4.5 year interval is calculated. Mean Reversion values are rejected if they are with a +/-20% band of the 4.5 year moving average.

With each time time-step forecast, a new mean reversion value is calculated (meanwhile adhering to the +/-20% band of the 4.5 year moving average).

### File Locations

Two separate WTI Monte Carlo models exist, though fundamentally they are the same:

* “WTI Volatility & Monte Carlo (Optimatized V2.0).R”
  + Work Directory Path: [P:\Pricing Volatility\WTI Pricing](file:///P:\Pricing%20Volatility\WTI%20Pricing)
  + Work Output Path: [P:\Pricing Volatility\WTI Pricing\CSV Files\50 Years](file:///P:\Pricing%20Volatility\WTI%20Pricing\CSV%20Files\50%20Years)
* “WTI Volatility & Monte Carlo (Optimized V2.0) – Hedging.R”
  + Work Directory Path: [P:\Pricing Volatility\WTI Pricing](file:///P:\Pricing%20Volatility\WTI%20Pricing)
  + Work Output Path: [P:\Pricing Volatility\WTI Pricing\CSV Files\Hedging](file:///P:\Pricing%20Volatility\WTI%20Pricing\CSV%20Files\Hedging)

## Consumer Price Index (CPI) Forecasting – US and Canada

Simple Monte Carlo.

### Source Data

CPI forecast is based on historical volatility of the monthly returns of the US CPI. The US CPI data is sourced from the U.S. Federal Reserve Series Consumer Price Index (CPI) “CPILEGSL.”

### Forecasting Methodology

CPI forecasting uses a simplistic Monte Carlo forecast where the monthly CPI volatility is walked forward. The CPI time series does not appear to show an obvious mean-reversion process. Monthly returns can be fitted with logistic distribution.

The US CPI was chosen as the deflator for WTI prices because both are a function of the same general market. It could be argued that real WTI prices should be converted to nominal prices with an aggregate/composite world CPI because WTI is a world-leading crude benchmark and its prices reflect macro-economic world events. Since the purpose of this paper is to test the impacts of commodity volatility on a company’s reserves and revenue and not to predict future WTI prices, WTI is only deflated using US CPI.

Canada’s CPI is forecast independently of the US CPI. Canada’s CPI will be used in forecasting the inflationary pressures local to Canada as the paper will be focusing on Canadian-based companies with Canadian-based assets that generally utilize Canadian-sourced labour and materials.

### File Locations

Two separate US CPI Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “US CPI – Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI](file:///\\calfas01b\users$\Don.Mikalson\Pricing%20Volatility\CAD%20US%20CPI)
  + Work Output Path: C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI
* “US CPI – Monte Carlo – Hedging.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI](file:///\\calfas01b\users$\Don.Mikalson\Pricing%20Volatility\CAD%20US%20CPI)
  + Work Output Path: C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI

Two separate US CPI Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “CAD CPI – Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI](file:///\\calfas01b\users$\Don.Mikalson\Pricing%20Volatility\CAD%20US%20CPI)
  + Work Output Path: C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI
* [not converted yet]
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI](file:///\\calfas01b\users$\Don.Mikalson\Pricing%20Volatility\CAD%20US%20CPI)
  + Work Output Path: C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US CPI

## USD-CAD Exchange Rate Forecasting

Ornstein-Uhlenbeck Process Monte Carlo.

### Source Data

The US dollar – Canadian dollar exchange rate forecast is based on the historical volatility of the monthly returns of the USD-CAD exchange rate. The USD-CAD exchange rate data is sourced from the U.S. Federal Reserve Series: monthly exchange rate “EXCAUS” and daily exchange rate “DEXCAUS.”

### Forecasting Methodology

USD-CAD exchange rate forecasting uses the Ornstein-Uhlenbeck Process. Nominal returns are fitted with a Gaussian distribution.

Mean Reversion values must pass two statistical tests. The first is the Augmented Dickey-Fuller Test (ADF Test) null hypothesis. The ADF test must produce a DF-statistic less than -1.931 or a 95% confidence level to reject the null hypothesis of a unit root. The second is the ADF P-value. The ADF P-value tested needs to be less than 0.1 to reject the null hypothesis of a unit root.

The Mean Reversion time used in the process is 3.0 years. The Mean Reversion calculations are not perfect and sometimes produce values that deviate significantly from the real trend. To minimize these deviations, a moving average of the same 3.0 year interval is calculated. Mean Reversion values are rejected if they are with a +/-10% band of the 3.0 year moving average.

With each time time-step forecast, a new mean reversion value is calculated (meanwhile adhering to the +/-10% band of the 3.0 year moving average).

### File Locations

Two separate US CPI Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “CAD US EX – Monte Carlo with Mean Reversion V2.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US EX](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\CAD%20US%20EX)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US EX\CSV Files](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\CAD%20US%20EX\CSV%20Files)
* “CAD US EX – Monte Carlo with Mean Reversion V2 - Hedging.R”
  + Work Directory Path[C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US EX](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\CAD%20US%20EX)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\CAD US EX\CSV Files](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\CAD%20US%20EX\CSV%20Files)

## Edmonton Light Differential Forecasting

Simple Monte Carlo based on linear fit of historical WTI and Edmonton Light.

### Source Data

The differential between Edmonton Light and WTI is actually not a true differential and is instead a linear fit between the two prices.

Both Edmonton Light and WTI data are pulled from The Kent Group (<http://www.kentmarketingservices.com/dnn/PetroleumPriceData.aspx>). Monthly data is calculated from the average price in each month. In the nearest month where only partial daily data exist, an average is calculated from the posted data. The Kent Group usually posts daily data approximately one to two weeks behind the current date. At the moment, this is the most current free data set available of the major Canadian benchmark prices. The Kent Group posts WTI and Edmonton Light prices in Canadian Dollars.

### Forecasting Methodology

Prior to the Edmonton Light price forecasts, the WTI output file is, first, transformed from nominal prices into real prices (US dollars) by the US CPI forecasts. Secondly, the real prices are again transformed from US dollars into Canadian dollars by the US-Canada Exchange Rate forecasts.

The WTI to Edmonton Light differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future WTI prices (quoted in real, Canadian dollars).

### File Locations

Two separate Edmonton Light Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Prices](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Prices)
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Prices](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Prices)

## Hardisty Heavy Differential Forecasting

Simple Monte Carlo based on linear fit of historical WTI and Hardisty Heavy.

### Source Data

The differential between Hardisty Heavy and WTI is actually not a true differential and is instead a linear fit between the two prices.

Both Hardisty Heavy and WTI data are pulled from The Kent Group (<http://www.kentmarketingservices.com/dnn/PetroleumPriceData.aspx>). Monthly data is calculated from the average price in each month. In the nearest month where only partial daily data exist, an average is calculated from the posted data. The Kent Group usually posts daily data approximately one to two weeks behind the current date. At the moment, this is the most current free data set available of the major Canadian benchmark prices. The Kent Group posts WTI and Hardisty Heavy prices in Canadian Dollars.

### Forecasting Methodology

Prior to the Hardisty Heavy price forecasts, the WTI output file is, first, transformed from nominal prices into real prices (US dollars) by the US CPI forecasts. Secondly, the real prices are again transformed from US dollars into Canadian dollars by the US-Canada Exchange Rate forecasts.

The WTI to Hardisty Heavy differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future WTI prices (quoted in real, Canadian dollars).

### File Locations

Two separate Hardisty Heavy Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Prices](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Prices)
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Prices](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Prices)

## SCO at Edmonton Differential Forecasting

Simple Monte Carlo based on linear fit of historical Edmonton Light and SCO at Edmonton.

### Source Data

The differential between SCO at Edmonton and Edmonton Light is actually not a true differential and is instead a linear fit between the two prices.

Both SCO at Edmonton and Edmonton Light data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Edmonton Light and SCO at Edmonton prices in Canadian Dollars.

### Forecasting Methodology

The Edmonton Light to SCO at Edmonton differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Edmonton Light prices (quoted in real, Canadian dollars).

### File Locations

Two separate SCO at Edmonton Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## Cromer LSB Differential Forecasting

Simple Monte Carlo based on linear fit of historical Edmonton Light and Cromer LSB.

### Source Data

The differential between Cromer LSB and Edmonton Light is actually not a true differential and is instead a linear fit between the two prices.

Both Cromer LSB and Edmonton Light data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Edmonton Light and Cromer LSB prices in Canadian Dollars.

### Forecasting Methodology

The Edmonton Light to Cromer LSB differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Edmonton Light prices (quoted in real, Canadian dollars).

### File Locations

Two separate Cromer LSB Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## WCS Differential Forecasting

Simple Monte Carlo based on linear fit of historical Hardisty Heavy and Western Canadian Select (WCS).

### Source Data

The differential between WCS and Hardisty Heavy is actually not a true differential and is instead a linear fit between the two prices.

Both WCS and Hardisty Heavy data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Hardisty Heavy and WCS prices in Canadian Dollars.

### Forecasting Methodology

The Hardisty Heavy to WCS differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Hardisty Heavy prices (quoted in real, Canadian dollars).

### File Locations

Two separate WCS Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## Hardisty Bow River Differential Forecasting

Simple Monte Carlo based on linear fit of historical Hardisty Heavy and Hardisty Bow River.

### Source Data

The differential between Hardisty Bow River and Hardisty Heavy is actually not a true differential and is instead a linear fit between the two prices.

Both Hardisty Bow River and Hardisty Heavy data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Hardisty Heavy and HARDISTY BOW RIVER prices in Canadian Dollars.

### Forecasting Methodology

The Hardisty Heavy to Hardisty Bow River differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Hardisty Heavy prices (quoted in real, Canadian dollars).

### File Locations

Two separate Hardisty Bow River Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## Propane Differential Forecasting

Simple Monte Carlo based on linear fit of historical Edmonton Light and Propane.

### Source Data

The differential between Propane and Edmonton Light is actually not a true differential and is instead a linear fit between the two prices.

Both Propane and Edmonton Light data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Edmonton Light and Propane prices in Canadian Dollars.

### Forecasting Methodology

The Edmonton Light to Propane differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Edmonton Light prices (quoted in real, Canadian dollars).

### File Locations

Two separate Propane Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## Butane Differential Forecasting

Simple Monte Carlo based on linear fit of historical Edmonton Light and Butane.

### Source Data

The differential between Butane and Edmonton Light is actually not a true differential and is instead a linear fit between the two prices.

Both Butane and Edmonton Light data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Edmonton Light and Butane prices in Canadian Dollars.

### Forecasting Methodology

The Edmonton Light to Butane differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Edmonton Light prices (quoted in real, Canadian dollars).

### File Locations

Two separate Butane Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

## Pentane/Condensate Differential Forecasting

Simple Monte Carlo based on linear fit of historical Edmonton Light and Pentane/Condensate.

### Source Data

The differential between Pentane/Condensate and Edmonton Light is actually not a true differential and is instead a linear fit between the two prices.

Both Pentane/Condensate and Edmonton Light data are pulled from Sproule Petroleum Consultants (<http://www.sproule.com/system/resources/W1siZiIsIjIwMTQvMDEvMDcvMTcvMjQvMjkvMzk4LzIwMTMxMl9Fc2NhbGF0ZWQueGxzeCJdXQ/201312-Escalated.xlsx>). Only monthly data are posted (within the *History* tab). Sproule posts monthly data up until the last full month. At the moment, this is the most current free data set available of the smaller Canadian benchmark prices. Sproule posts Edmonton Light and Pentane/Condensate prices in Canadian Dollars.

### Forecasting Methodology

The Edmonton Light to Pentane/Condensate differential is forecast by fitting the linear regression residuals with a logistic distribution. The residual logistic distribution is walked forward and used to offset the linear model applied to the future Edmonton Light prices (quoted in real, Canadian dollars).

### File Locations

Two separate Pentane/Condensate Monte Carlo models exist; fundamentally, the only difference is the length of the projected time series:

* “Canadian Differentials w Sproule Differentials - Oil - Monte Carlo.R”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]
* “”
  + Work Directory Path: [C:\Users\don.mikalson\Dropbox\Pricing Volatility\Pricing Volatility CEC\Canadian Price Differentials](file:///C:\Users\don.mikalson\Dropbox\Pricing%20Volatility\Pricing%20Volatility%20CEC\Canadian%20Price%20Differentials)
  + Work Output Path: [needs to be created]

# Natural Gas (and NG-Related Products) Monte Carlo Simulation Summary

## Henry Hub (HH) Forecasting

Ornstein-Uhlenbeck Process Monte Carlo.

### Source Data

Henry Hub forecasting is based on historical pricing volatility of the nominal Henry Hub price series. The nominal price series is calculated from the U.S. Federal Reserve Series real Henry Hub “GASPRICE” (monthly) and from Quandl/Wall Street Journal “WSJ/NG\_HH” (daily – for the most recent month average) and the U.S. Federal Reserve Series Consumer Price Index (CPI) “CPILEGSL.”

### Forecast Methodology

HH forecasting uses the Ornstein-Uhlenbeck Process. Nominal returns are fitted with a Gaussian distribution.

Mean Reversion values must pass two statistical tests. The first is the Augmented Dickey-Fuller Test (ADF Test) null hypothesis. The ADF test must produce a DF-statistic less than -1.931 or a 95% confidence level to reject the null hypothesis of a unit root. The second is the ADF P-value. The ADF P-value tested needs to be less than 0.1 to reject the null hypothesis of a unit root.

The Mean Reversion time used in the process is 9.0 years. The Mean Reversion calculations are not perfect and sometimes produce values that deviate significantly from the real trend. To minimize these deviations, a moving average of the same 9.0 year interval is calculated. Mean Reversion values are rejected if they are within a +/-20% band of the 9.0 year moving average when the mean reversion price is above $7.50/mcf or within a +/-50% band of the 9.0 year moving average when the mean reversion price is below $7.50/mcf.

With each time time-step forecast, a new mean reversion value is calculated (meanwhile adhering to the +/-20% band or +/-50% band of the 9.0 year moving average).

### File Locations

Two separate HH Monte Carlo models exist, though fundamentally they are the same:

* “HH Volatility & Monte Carlo (Optimatized V2.0).R”
  + Work Directory Path: [P:\Pricing Volatility\WTI Pricing](file:///P:\Pricing%20Volatility\WTI%20Pricing)
  + Work Output Path: [P:\Pricing Volatility\WTI Pricing\CSV Files\50 Years](file:///P:\Pricing%20Volatility\WTI%20Pricing\CSV%20Files\50%20Years)
* “”
  + Work Directory Path: [P:\Pricing Volatility\WTI Pricing](file:///P:\Pricing%20Volatility\WTI%20Pricing)
  + Work Output Path: [P:\Pricing Volatility\WTI Pricing\CSV Files\Hedging](file:///P:\Pricing%20Volatility\WTI%20Pricing\CSV%20Files\Hedging)

## AECO Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical HH and AECO

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## Ethane Differential Forecasting

Unable to source historical Ethane prices. Sproule uses a fixed ratio to AECO.

### Source Data

Source: Sproule History

### Forecasting Methodology

For lack of alternatives at the moment, a fixed ratio will be used to forecast Ethane prices.

### File Locations

## Alberta Reference Price Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## Alliance Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## BC EMP Wellhead Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## BC West Coast Station 2 Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## BC 30 Day Spot Price Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations

## Dawn Differential Forecasting

Simple Monte Carlo based on linear fit(????) of historical Alberta Reference Price and AECO.

\*\*\*\* Need to build entire script\*\*\*\*

### Source Data

Source: Sproule History

### Forecasting Methodology

### File Locations