REBECCA TRUJILLO BROWN
Regulatory Compliance
Tel: 503.721.2459
Fax: 503.220.2579
Email: rebecca.brown@nwnatural.com

NW Natural
220 NW 2ND AVENUE
PORTLAND, OR 97209
TEL 503.226.4211
www.nwnatural.com

January 10, 2020

VIA ELECTRONIC FILING

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street SE, Suite 100
Post Office Box 1088
Salem, Oregon 97308-1088

Re: LC 71—NW Natural's 2018 Integrated Resource Plan (IRP)—Revised Appendix H

Northwest Natural Gas Company, dba NW Natural (NW Natural or the Company), files herewith a Revised Appendix H to the Company's 2018 IRP. The Public Utility Commission of Oregon (Commission) issued Order No. 19-043 in NW Natural's 2018 IRP on March 4, 2019 (Order). Within that Order, Staff's Recommendation No. 14 requested that we update and submit a Revised Appendix H. NW Natural has been working with Commission Staff to address Staff's stated concerns.

Staff requested several changes including: updated greenhouse gas (GHG) policy expectations; use of a zero or low-price carbon price path beginning as late as 2030; updated inputs, assumptions and forecasts to methodology; and provide a detailed description of the SENDOUT renewable natural gas (RNG) modeling process. In response, NW Natural agreed to file a Revised Appendix H and the following points:

- Assumptions regarding GHG policy should be updated.
- Include a zero-price carbon price path in the stochastic analysis.
- Use the best knowledge available at the time of evaluating a potential RNG project.
- File a more detailed description of the SENDOUT RNG modeling process in the Revised Appendix H.

NW Natural did not agree with Staff's proposal to allow a carbon price to begin as late as 2030. Staff was amenable to keeping NW Natural's original assumption that a carbon price will begin by 2026. However, this assumption may be revisited in the future if a carbon price begins to look less probable in Oregon and Washington.

NW Natural addresses Staff's requests by making the following changes to the Revised Appendix H:

- Including a zero-price carbon path as a potential policy in the stochastic analysis.
- Changing language to indicate "most recent update" rather than "most recent acknowledged IRP."

- Providing a table outlining the frequency of updating primary inputs and forecasts.
- Including a more detailed description of SENDOUT and how RNG is modeled within the optimization software.

In addition to addressing Staff's requests NW Natural also made a few general changes that include:

- Adapting language to be non-specific to the 2018 IRP assumptions, but references the 2018 IRP where appropriate as an example.
- Adapting language in the flow chart for the Project Evaluation and Procurement Process for consideration of a project under SB 98, SB 844, a pilot program, and other voluntary options if the project is not cost-effective using traditional least cost and least risk planning. If these options are not appropriate, NW Natural will not procure the RNG project.
- Adding a table outlining potential contract structures. This table is not an exhaustive list of contract structures.

NW Natural presented slides at the UM 2030 December 13th, 2019 workshop. After the workshop there were a few minor changes made to information presented in those slides and in this revised appendix, including:

- Table H.3 outlining potential contract structures includes:
  - An additional row describing an RNG environmental attributes-only purchase structure.
  - Additional clarifying language in the cost basis for consideration for cost-effectiveness.
- Table H:4 Update Frequency for Inputs and Forecast included further clarifying language:
  - "The GHG compliance cost assumptions will be updated each year after the legislation sessions in each state or when legislation is signed into law."
  - Relabeled "Supply Resource Costs" to "Gas Supply Capacity Costs."
  - Relabeled "Distribution Avoided Costs" to "Distribution System Capacity Costs."

Please address correspondence on this matter to me with copies to the following:

eFiling
NW Natural
Rates & Regulatory Affairs
220 NW Second Avenue
Portland, OR 97209
Fax: (503) 220-2579
eFiling@nwnatural.com

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Please contact me at (503) 721-2459 if you have any questions.

Sincerely,

NW NATURAL

/s/ Rebecca T. Brown

Rebecca T. Brown
Regulatory Compliance
503-721-2459

Enclosure

REVISED APPENDIX H

RENEWABLE GAS SUPPLY RESOURCE EVALUATION METHODOLOGY

1. PURPOSE AND OVERVIEW

This appendix details and expands upon the evaluation of resources in the IRP process and presents an application of the existing least cost and least risk resource planning framework to evaluate low carbon gas resources on an apples-to-apples basis against conventional gas resources. As stated in our action plan, NW Natural is seeking acknowledgment to use this methodology to evaluate, and if supportable, secure potential renewable natural gas (RNG) resources.

Enabled by new information and expertise gained since completing its last IRP, NW Natural evaluated low carbon gas resources in a much more detailed and comprehensive manner in the 2018 IRP. This methodology applies the current least cost and least risk planning standard to RNG resources; it is not meant to expand the scope of integrated resource planning or serve as a policy statement regarding RNG.

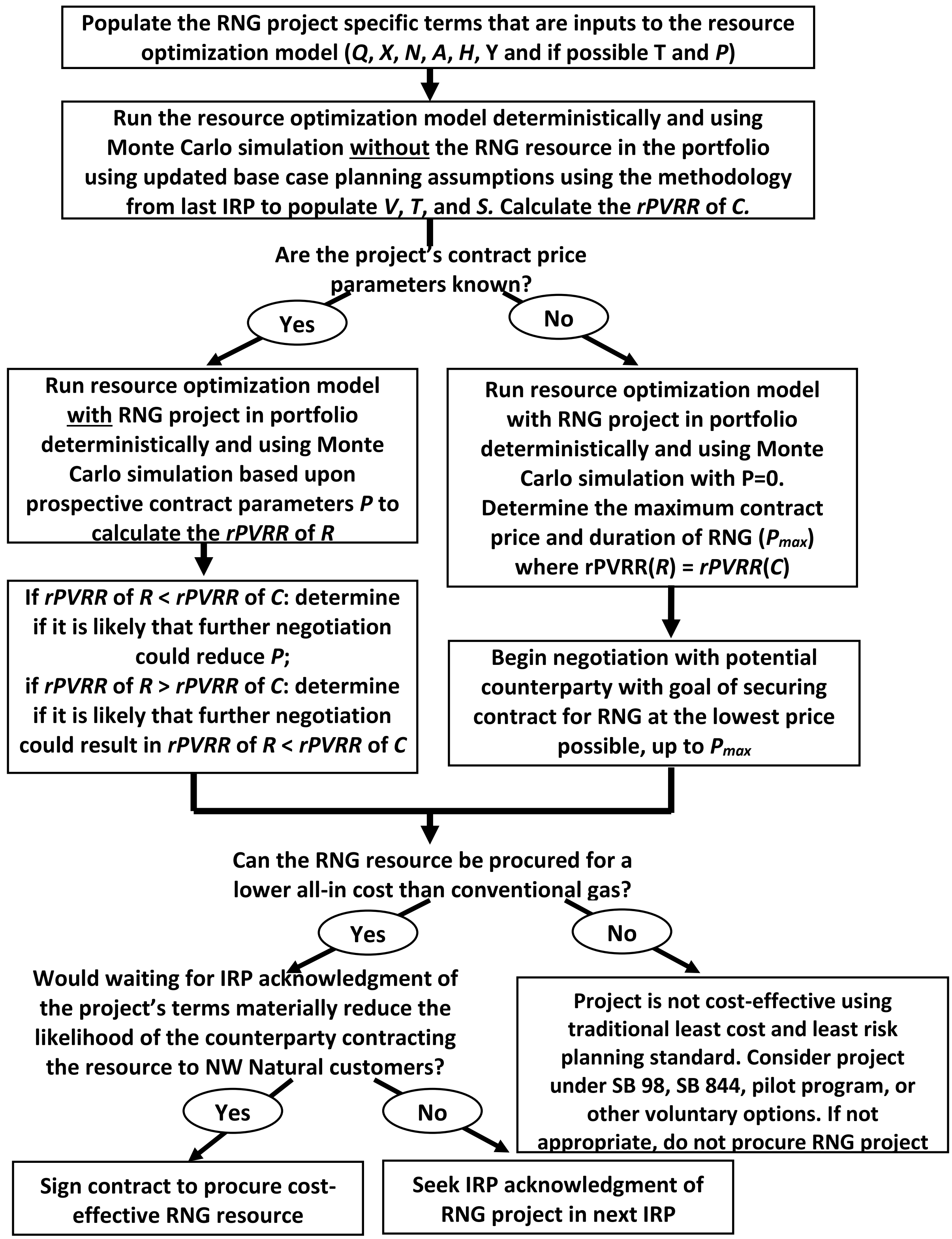
The methodology and process presented in this appendix is meant to be flexible so that as new policies are enacted they can be incorporated into the analysis. While the RNG resources evaluated in the 2018 IRP are representative projects rather than actual resource options, their parameters are based upon the best available information and show RNG resources have the potential to be cost-effective resources for customers in both the near- and long-term. This result — and the potential for missed opportunities to procure cost-effective RNG resources for our customers — serves as the motivation for the inclusion of Action Item 2 in the 2018 IRP.

The following represents the methodology and procurement process of which NW Natural is seeking acknowledgment:

- NW Natural Renewable Natural Gas Project Evaluation and Procurement Process
- NW Natural Renewable Natural Gas Project Evaluation Criteria and Calculations
- NW Natural Renewable Natural Gas Project Evaluation Component Descriptions
- NW Natural Renewable Natural Gas Project Evaluation Component Definition Fill-in Sheet

The remainder of this appendix (Sections 2 through 5) provides a detailed explanation of terms, a rationale for the proposed evaluation process, and an example project to demonstrate the calculations and process proposed to evaluate RNG projects.

NW Natural Renewable Natural Gas Project Evaluation and Procurement Process



NW Natural Renewable Natural Gas Project Evaluation Criteria and Calculations

Annual all-in cost of RNG (R) =
Cost of methane (M) + Emissions compliance costs (E) – Avoided infrastructure costs (I)

Or: $R_T = M_T + E_T - I_T$

Where:

$$M_T = X_T + \sum_{t=1}^{365} [P_{T,t} + Y_{T,t}^{RNG}] Q_{T,t}$$

$$E_T = \sum_{t=1}^{365} N^{RNG} G_T Q_{T,t}$$

$$I_T = S_T A_T + DH_T$$

Substituting leaves the annual all-in cost of RNG as:

$$R_T = X_T - S_T A_T - DH_T + \sum_{t=1}^{365} \left[P_{T,t} + Y_{T,t}^{RNG} + N^{RNG} G_T\right] Q_{T,t}$$

Where the annual all-in cost of the conventional natural gas alternative (C) is:

$$C_T = \sum_{t=1}^{365} \left[V_{T,t} + Y_{T,t}^{CONV} + N^{CONV} G_T\right] Q_{T,t}$$

The present value of revenue requirement of all relevant years is used for evaluation where:

$$PVRR(R) = \sum_{T=k}^{T=k+z} \frac{R_T}{[1+d]^T}$$

$$PVRR(C) = \sum_{T=k}^{T=k+z} \frac{C_T}{[1+d]^T}$$

This is risk-adjusted to account for uncertainty in long-term forecasting where:

$$rPVRR(R) = 0.75 * \text{deterministic } PVRR(R) + 0.25 * \text{95th Percentile Stochastic } PVRR(R)$$

$$rPVRR(C) = 0.75 * \text{deterministic } PVRR(C) + 0.25 * \text{95th Percential Stochastic } PVRR(C)$$

The RNG project is a least cost/least risk resource to acquire if:

$$rPVRR(R) \leq rPVRR(C)$$

Table H.1: NW Natural Renewable Natural Gas Project Evaluation Component Descriptions[1]

Term	Units	Description	Source	Project Specific?	Input or Output of Optimization?	Treated as Uncertain?
R	$/Year	Annual all-in cost of prospective renewable natural gas (RNG) project	Output of RNG evaluation process	Yes	Output	Yes
C	$/Year	Annual all-in cost of conventional natural gas alternative	Output of RNG evaluation process	Yes	Output	Yes
M	$/Year	Annual costs of natural gas and the associated facilities and operations to access it	Output of RNG evaluation process	Yes	Output	Yes
E	$/Year	Annual greenhouse gas emissions compliance costs	Output of RNG evaluation process	Yes	Output	Yes
I	$/Year	Annual infrastructure costs avoided with on-system supply	Output of RNG evaluation process	Yes	Output	Yes
Q	Dth	Expected or contracted daily quantity of RNG supplied by project	Project evaluation or RNG supplier counterparty	Yes	Input	If no contractual obligation
P	$/Dth	Contracted or expected volumetric price of RNG	Project evaluation or RNG supplier counterparty; Max cost-effective price determined by methodology if NWN initiating negotiations	Yes	Input if responding to offer, Output if NWN making offer	If no contractual obligation
T	Year	Year relative to current year, where the current year T = 0, next year T = 1, etc.	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN making offer	If no contractual obligation
k	Year	When the RNG purchase starts in # of years in the future; k = RNG start year - current year	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN making offer	If no contractual obligation
z	Years	Duration of RNG purchase in years	Project evaluation or RNG supplier counterparty	Yes	Input if responding to offer, Output if NWN making offer	If no contractual obligation
t	Days	Day number in year ***T*** from 1 to 365	N/A	No	Input	No
V	$/Dth	Price of conventional gas that would be displaced by RNG project	Average price of last ***Q*** quantity of conventional gas dispatched without RNG project	Yes	Output	Yes
Y	$/Dth	Variable transport costs to deliver gas to NWN's system	*For off-system RNG* - based upon geographic location of project; *For conventional gas* - determined from the marginal unit of gas dispatched to meet demand	Yes	Output	No
X	$/Year	Annual revenue requirement of capital costs to access resource	Engineering project evaluation or RNG supplier counterparty	Yes	Input	If no contractual obligation
N	TonsCO_2e /Dth	Greenhouse gas intensity of natural gas being considered	Based on expected policy treatment of carbon intensity of for reported emissions from RNG resources	Yes	Input	No
G	$ /TonCO_2e	Volumetric Greenhouse gas emissions compliance costs/price	Expected greenhouse gas compliance costs from the most recent update	No	Input	Yes
S	$/Dth	System gas supply capacity cost to serve one Dth of peak DAY load	Based upon marginal supply capacity resource that is being deferred using Base Case resource availability from the most recent update	No	Output	Yes
A	Dth	Minimum natural gas injected on to NWN system during a peak DAY by project	Project evaluation or contractual obligation from RNG supplier counterparty	Yes	Input	If no contractual obligation
D	$/Dth	Distribution system capacity cost to serve one DTH of peak HOUR load	Distribution system cost to serve peak hour load from avoided costs in most recent update	No	Input	No
H	Dth	Minimum natural gas injected on to NWN system during a peak HOUR by project	Project evaluation or contractual obligation from RNG supplier counterparty	Yes	Input	If no contractual obligation
d	% rate	Discount Rate	Discount rate from most recent update	No	Input	No

[1] Most recent update is defined as the updated inputs and forecasts as outlined by Table H.4.

Table H.2:

NW Natural Renewable Natural Gas Project-Specific Component Definition Fill-In Sheet

Term	#	Question	Project Parameter	
Q: RNG Output	1	How much RNG is the project expected to sell to NW Natural annually?		Dth
	2	Is this volume expected to vary by season, day of the week, or any other factor? If so, provide the expected variation on a separate spreadsheet		
	3	Is there a minimum daily, monthly, or annual quantity included/expected to be included in the prospective contract? If so, what is the minimum daily volume?		Dth per
***T*:** Timing of RNG Purchase	4	Is the duration and timing of the RNG purchase known?		
	5	If Yes, when does the RNG purchase begin?	Date	
	6	If Yes, when does the RNG purchase end?	Date	
	7	If No, when does the RNG purchase begin?	Date	
P: Price of RNG	8	Is the volumetric pricing arrangement for the RNG known?		
	9	If Yes, and it is it a fixed price arrangement, what is the proposed price NW Natural will pay for the RNG? If fixed, but varying through time attach separate spreadsheet and enter average for duration of contract to the right:	$	per Dth
	10	If Yes and it is not a fixed price arrangment, please provide the formula for pricing on a separate spreadsheet and enter average expected price for the duration of the contract to the right:	$	per Dth
***X*:** Required Capital Investment	11	What (if any) is the total annual revenue requirement of any equipment and facilities in which NW Natural needs to invest to access the RNG from the project?	$	per Year
	12	If there is a fixed non-volumetric payment to the RNG supplier as part of the contract, what is the annual payment?	$	per Year
***N*:** GHG Emissions Intensity	13	If the project has already been assessed a greenhouse gas intensity from the EPA or ODEQ, what is the carbon intensity of the RNG?		Metric Tons CO2e/Dth
	14	If the project has not already been assessed a carbon intensity, what is the average GHG intensity for the projects biogas type from the Low Carbon Fuel Standards work done by the California Air & Resources Board		Metric Tons CO2e/Dth
On-System?	15	Will the project inject the RNG onto NW Natural's distribution system?		
	16	Where will NW Natural take custody of the RNG?		
If the answer to *Question 15* is **YES** fill-in **Zero** on *Question 17*				
***Y*:** Variable Transport	17	What are the total variable volumetric transport charges that would be required to bring the off-system RNG to NW Natural's system?	$	per Dth
If the answer to *Question 15* is **NO** fill in **Zero** for the remaining questions				
***A*:** Peak Day Supply	18	What is the mininum daily amount of methane the project would inject into NW Natural during a cold weather event?		Dth per Day
	19	Is this amount a contractual obligation?		
***H*:** Peak Hour Supply	20	What is the minimum amount of methane the project would inject into NW Natural's system during the 7am hour of a cold weather event?		Dth per Hour
	21	Is this amount a contractual obligation		

2. WHY SEEK ACKNOWLEDGMENT OF A METHODOLOGY?

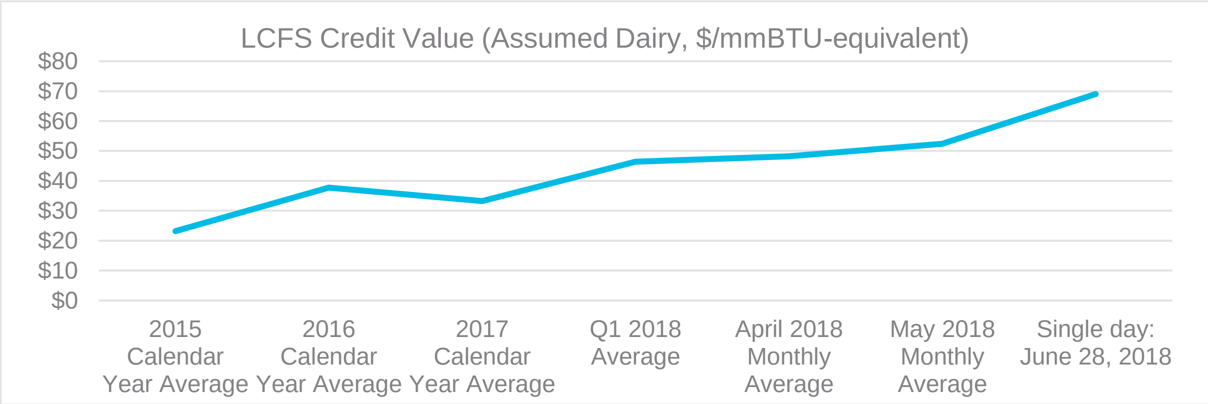
This section provides background on the salient factors driving the RNG market today as well as an explanation for why NW Natural would need to be able to make decisions on RNG projects along a timeframe more compressed and uncertain than the biennial schedule of IRPs. NW Natural prefers that RNG opportunities be reviewed on a project-by-project basis through the IRP process. However, RNG market characteristics dictate that waiting for IRP acknowledgement for specific projects may lead to lost cost-effective RNG procurement opportunities for NW Natural's customers. Consequently, NW Natural is seeking acknowledgement of an evaluation methodology and process that would allow us to use the key assumptions detailed and reviewed in the most recent IRP to evaluate and procure cost-effective RNG within a timeframe acceptable to RNG suppliers.

2.1 THE CURRENT MARKET FOR RNG

The RNG market has seen tremendous growth over the past few years, due mostly to the strong economic incentive associated with developing RNG for use in the compressed natural gas (CNG) market. Under a federal program (the Renewable Fuel Standard) and two state programs (California's Low-Carbon Fuel Standard and Oregon's Clean Fuels Program) RNG resources that are ultimately sold for use in CNG vehicles can command prices much higher than that of conventional natural gas. Under these programs, parties with compliance obligations, including petroleum product refiners and producers, purchase the credits (the "green attributes" of the renewable resource) to meet annual obligations set by the program administrators.

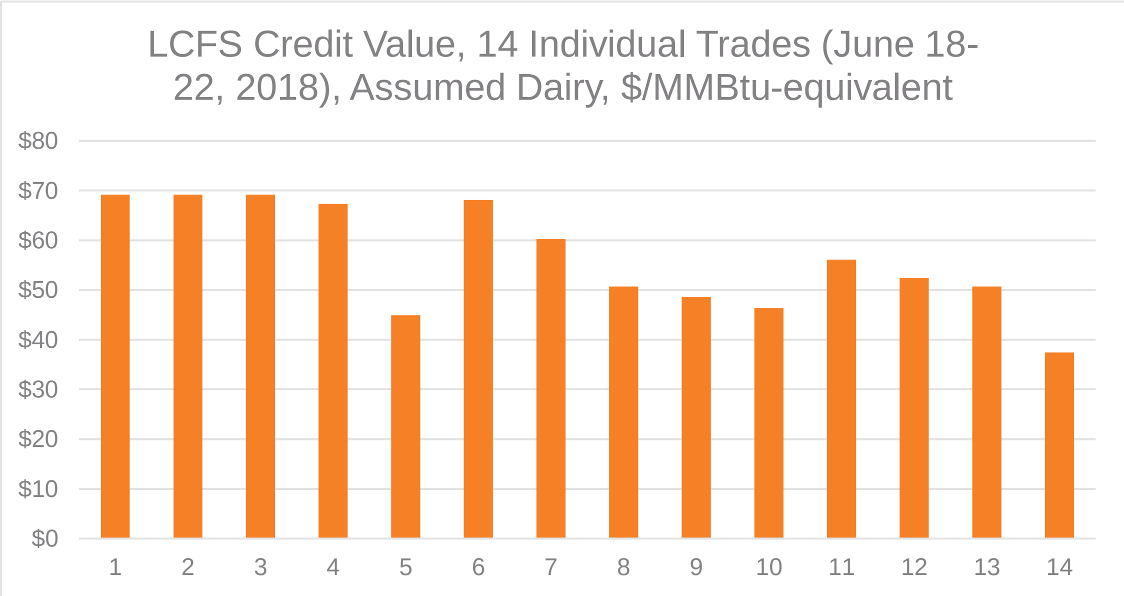
To illustrate the significance of these credit values to the RNG industry, Figure H.1 shows the trend in the value of credits derived from dairy-based RNG sold into the California market for CNG vehicle fuel. In 2015 the average value for such a credit was $23.20 per MMBtu-equivalent sold. The value of these credits has steadily risen in the past few years, and currently is trading near historically peak prices. Throughout June 2018, the value of the credits continued to rise, reaching $69/MMBtu-equivalent. This credit is one component of the overall revenue stream available to RNG sold into the market today and would be coupled with both a revenue associated with the federal Renewable Fuel Standard as well as the sale of the underlying gas commodity.

Figure H.1: Historical dairy-based RNG Low-Carbon Fuel Standard credit value[2]



It is clear that the value of selling RNG into these markets is significant. However, these markets are highly volatile and the value of credits can change dramatically from day to day. For instance, Figure H.2 shows 14 different individual trades within the Low-Carbon Fuel Standard over the course of five days in June 2018. One contract traded at $37.41/MMBtu-equivalent price, while another the day before traded at $68.09/MMBtu-equivalent. Additionally, all of these environmental credit programs are potentially subject to political changes and are not guaranteed in perpetuity.

Figure H.2: Low Carbon Fuel Standard Credit 5 Day Trading Value[3]



[2] Figure data source: California Air Resources Board
[3] Figure data source: California Air Resources Board

A typical contract structure for these environmental credits will be a multiyear (1-3 years) off-take by a party that is obligated to acquire these credits within the program. Payment under these contracts will typically be some percentage of the credit trading price, adjusted to reflect daily or monthly trading values. The longer the contract term, the lower the percentage paid to RNG producers, to reduce the exposure of the obligated parties or other third-party marketers to rising credit prices.

These wide variations in credit value and the risk that these programs are not renewed mean that many RNG producers are interested in hedging their bets on environmental credit markets and reducing their risk exposure. Thus, many are interested in securing long-term contracts for all or part of their RNG, perhaps after a period during which they hope to benefit from high credit prices. For instance, NW Natural has observed RNG projects that enter into an off-take for environmental credits at 80% of the credit value price over three years, and then in year four enter into contracts with a guaranteed floor price that is well below the trading price of the credits.

Despite the environmental credit volatility and inherent risk in investing in major capital projects predicated on future political support of the programs, the RNG industry has seen rapid growth in the last few years, and especially the last year. The environmental credits available to RNG project developers have been significant enough to drive major capital investment around the country. Between 1982 and 2014, 41 individual RNG projects were built in the U.S. and Canada. Today there are 77 RNG projects operating in the U.S. and Canada, with at least 40 additional projects now in development. The environmental credits available to RNG projects are the clear driver for this tremendous growth, and have helped the RNG market both grow and mature significantly in recent years. This growth and maturation is reflected in the different treatment of RNG in this IRP compared to the IRP developed just two years ago.

2.2 THE NEED FOR A FLEXIBLE RNG PROCUREMENT PROCESS

As the RNG market grows and develops, the markets for gas purchases and environmental credit purchases are becoming more sophisticated. RNG producers typically ask for bids from a variety of potential RNG and environmental credit purchasers as the project is being developed, before the project is operating but after the projected volume and carbon intensity of the gas has been finalized. They then consider the multiple bids received during one “off-taker” contract evaluation process. A typical time period between when a request for bid is issued and when the offers are evaluated is about 30-60 days. This means that for any given RNG project, there is a short window during which any bid to purchase the RNG produced will be evaluated. RNG producers will evaluate the risk, revenue opportunities, and other characteristics of each bid during that time. As NW Natural considers its interest in potentially acquiring RNG for our customers, we recognize that there are regional RNG projects that will ask us to bid for their RNG within such a window. Indeed, NW Natural has already been approached by several Oregon-based RNG project developers to indicate our interest in offering a bid for the RNG from projects they are developing.

To date we have only offered the price we pay for conventional gas resources to RNG project developers given the uncertainty in the prudency criteria for evaluating on-system and/or lower carbon intensity sources of natural gas. This lower price is usually of little interest to RNG project developers who can command ten times — or greater — that price in the current market. The work in this IRP shows that NW Natural could pay more for RNG than the price of conventional natural gas depending on how environmental policy treats emissions from RNG for compliance costs and whether it would be injected directly into our distribution system grid, though the cost-effective price for NW Natural customers is still much below what can be obtained in the transportation incentive market in the near term. However, after about 2021, when the uncertainty around incentives in the transportation market grows, RNG suppliers may find the price shown as cost-effective by the methodology laid out in this appendix to be high enough to make sense to them on a risk-adjusted basis.

An approach that allows NW Natural to apply this methodology on a project-specific basis by evaluating the volume, carbon compliance costs, location, and other aspects of in-development RNG resources to quickly determine the price we could pay for such resources would allow us to adequately respond to requests for offers to bid for RNG and potentially be competitive to procure the renewable resources our customers prefer at a lower expected price than conventional gas resources. The methodology discussed herein would establish a “ceiling” price, reflecting the highest price we could pay before the RNG becomes not cost-effective for our customers. However, NW Natural recognizes its duty to procure resources for its customers at the lowest price possible, so we would offer/bid a price lower than the ceiling price if we believe that price may be attractive to the RNG producer.

As new RNG projects are developed, NW Natural will need to be nimble to act on potential opportunities to procure RNG. As a practical matter, we will need to make decisions at the pace that the RNG market dictates, which is likely faster than we could bring individual projects for acknowledgment in the IRP. As a result of these market dynamics, NW Natural is proposing to utilize this methodology and process plan to evaluate projects so that we can quickly respond to potential cost-effective resources. In the event that our methodology or process changes, we will update the Commission so that there is full transparency into our decision-making process around these resources.

2.3 POTENTIAL CONTRACT STRUCTURES

RNG producers could potentially benefit from setting up a fixed price contract to sell their gas to NW Natural, especially for producers — such as publicly-owned entities – that are trying to reduce their overall risk exposure in their RNG project development. These contracts can take several different forms and will be unique to each project. For example, an RNG producer may wish to interconnect with NW Natural’s distribution system to take advantage of the lucrative renewable identification number (RIN) market. As long as this producer is participating in the RIN market, and selling to CNG vehicles somewhere in the U.S., NW Natural does not receive the green attributes associated with the RNG. The RNG producer may wish to plan to sell into the RIN and LCFS credit markets for four years. However, beginning in year 5, they may wish to “lock in” a long-term fixed-price contract that is not susceptible to the volatility of the environmental credit markets. NW Natural could offer a long-term fixed price contract for delivery of RNG beginning in year 5, at which point the RNG producer would sell the RNG —

including all of its environmental attributes — to NW Natural. NW Natural would then claim the emissions savings associated with that project's RNG production. A fixed price contract can offer price certainty for these producers, while providing a low-carbon intensive resource for NW Natural's customers.

Table H.3 shows the possible contract structures that NW Natural could engage in acquiring RNG. This table shows various types of structures, but is not meant to be an exhaustive list of the potential combinations. The methodology for evaluating RNG is designed to be flexible enough to accommodate different types of ownership structures and the environmental attributes associated with RNG resources and its cost impacts to NW Natural customers.

Table H.3 Possible Contract Structures

Type of Structure	Ownership of biogas production	Ownership of conditioning and cleanup equipment and/or pipeline interconnection	Cost basis for consideration of cost-effectiveness
RNG environmental attributes-only purchase	3rd party	3rd party	$/MMBtu contract for delivery of RNG's environmental attributes over a set period of time
RNG commodity-only purchase	3rd party	3rd party	Flat $/MMBtu contract for delivery of RNG over a set time period
Investment in gas conditioning and/or pipeline interconnection	3rd party	NW Natural	Capital costs of investment in gas cleanup/ interconnection, and some payment to 3rd party for raw biogas
Investment in full RNG project development	NW Natural	NW Natural	Capital costs of gas production and gas clean up/ interconnection; potentially a payment to the owner of the feedstock
Full acquisition of operational RNG project	NW Natural	NW Natural	Asset purchase price, plus any existing contractual obligations, and operating costs

3. "ALL-IN" COST COMPONENTS

The all-in cost refers to the total cost to deliver a unit of natural gas to a customer on NW Natural's system, inclusive of infrastructure requirements to deliver that gas and emissions compliance costs. All-in costs can be substantially more or less than the cost of the commodity itself. The calculation for all-in costs that is provided in Section 1 of this appendix, where this section will describe in more detail the components that make up the all-in cost of gas for both RNG and the conventional gas alternative. This section is organized into three subsections based upon the three broad components that make up all-in costs (commodity costs, infrastructure costs, and emissions compliance costs) and details all the components in the equations in Section 1.

3.1 COST OF THE NATURAL GAS COMMODITY (METHANE (M))

For the conventional natural gas alternative, this is the price of natural gas (***V***) plus the variable costs associated with transporting the gas to our pipeline network (Y^{CONV}).[4] The variable costs are quite small relative to the price of natural gas paid at the supply basins where NW Natural purchases gas and include variable payments to interstate pipeline operators and line losses (the amount of gas that is used to deliver gas from where it is purchased to where it is consumed by a NW Natural customer).

$$M_T^{CONV} = X_T + \sum_{t=1}^{365}[V_{T,t} + Y_{T,t}^{CONV}]Q_{T,t}$$

On any given day (***t*** in Year ***T***) in the timeframe over which the RNG project is expected to be part of NW Natural's gas supply the gas and transport costs of the conventional alternative represent the average cost of the last (***Q***) units of gas expected to be procured during that particular day,[5] as this is the amount of gas that would be displaced if the RNG project were in the portfolio. This daily gas price and the associated transport costs come from the SENDOUT® optimization run without the potential RNG project in the portfolio and are therefore the result of production cost modeling dispatch. These units of potentially displaced gas are from a spot purchase at one or more of the supply hubs NW Natural purchases gas or from a storage withdrawal (or a combination thereof) depending on the load that needs to be served and gas prices on that day (and throughout the year).

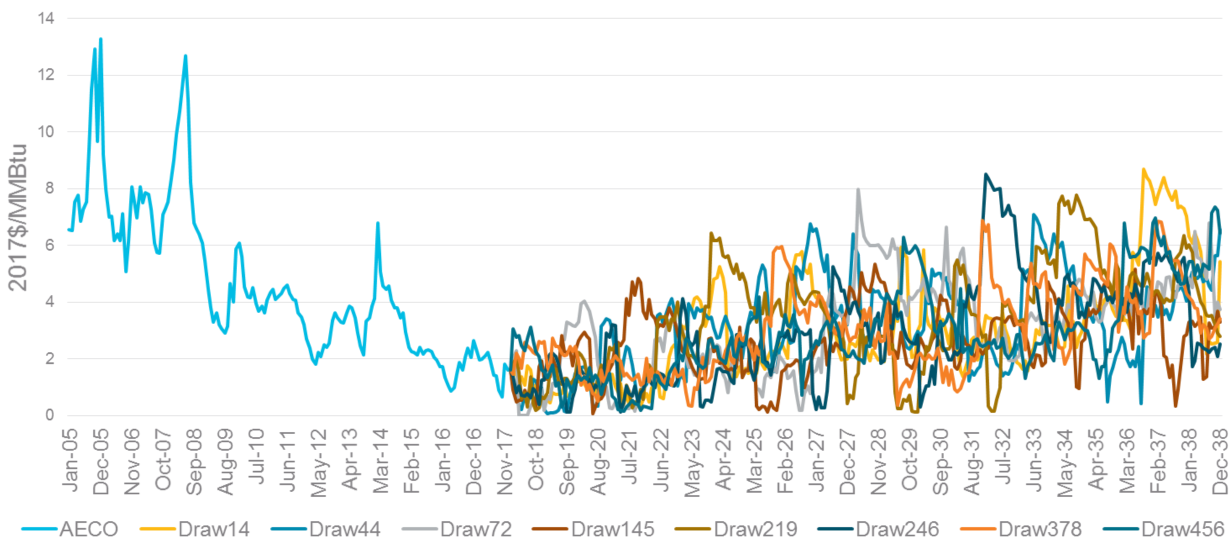
The deterministic resource optimization run for this evaluation will use the most recent forecast from NW Natural's third-party consultant. Additionally, given that gas prices are uncertain they are varied in the risk analysis. As such, the process to determine the commodity costs of the conventional alternative will use the Monte Carlo simulation process. Figure H.3 shows eight representative stochastic draws for AECO gas prices. Simulations for weather, resource costs, and GHG compliance costs as described in the most recent IRP are also applied within this

[4] Variable costs for transporting gas on interstate pipelines include fuel charges and variable charges. For example, NW Pipelines charges 1% in fuel charges and 0.8 cents ($0.008) per dekatherm in variable charges. In comparison these variables costs are very small compared to the commodity cost.

[5] Which by cost minimization protocols is the most expensive unit of gas purchased that day.

methodology and will impact the commodity portion of the conventional gas alternative's costs in each of the draws in the simulation.

Figure H.3: Stochastic Commodity Price Forecast (AECO)



For the prospective RNG project the commodity cost portion of all-in costs is more complex and may be unknown when beginning the analysis process. If it is known (the typical situation for this would be NW Natural responding to a contract offer) each of the components that make up the commodity cost portion of all-in costs will be inputs to the optimizations described in the next section. More likely, however, these costs will be unknown (the typical situation when NW Natural is responding to a bid solicitation or is approaching a biogas supplier with an offer for RNG), making the process more involved. In this case the primary purpose of the analysis is to determine the breakeven RNG commodity price where the prospective renewable project becomes more expensive than the conventional gas alternative, i.e., to determine the maximum price where RNG is a least cost/ and least risk resource for customers (***P^{MAX}***).

$$M_T^{RNG} = X_T + \sum_{t=1}^{365} [P_{T,t} + Y_{T,t}^{RNG}] Q_{T,t}$$

Additionally, for RNG projects the total commodity costs (***M***) can also include the net revenue requirement associated with constructing and maintaining the equipment owned by NW Natural that allows the project to be accessed and connected to our system (***X***) in addition to the RNG commodity contract price (***P***). While for on-system RNG equipment it will always be necessary to process, connect, and inject RNG into our distribution system, NW Natural could own all, part, or none of that equipment depending on the arrangement. Typically, when this equipment is owned and operated by the counterparty these costs will be included in the commodity price of RNG, whereas it will need to be added if there is additional revenue requirement from NW Natural ownership and maintenance of assets to access the RNG. In addition to the capital outlay, variable costs (e.g., operating and maintenance expenses), financing costs, taxes and other loadings are incorporated into a net annual revenue requirement that is levelized over an asset's depreciable life.

The contract price for the RNG commodity could take many different forms as it could be fixed over some time frame (be it monthly, yearly, or multiyear), determined by a formula, a combination of both, and many other setups.

Additionally, if the prospective RNG project will not be injecting gas directly onto NW Natural's distribution system it is necessary to utilize our interstate pipeline capacity to bring the gas to our system. In this case, the RNG project will have variable transport costs ($\boldsymbol{Y^{RNG}}$), where the exact amount is dependent upon the location NW Natural will need to transport the gas from.

3.2 EMISSIONS COMPLIANCE COSTS (OR BENEFITS)

The per unit emissions compliance costs are net GHG emissions intensity (***N***) multiplied by the cost of GHG emissions compliance (otherwise referred to as the "carbon price") (***G***).

$$\boldsymbol{E_T = \sum_{t=1}^{365} N G_T Q_{T,t}}$$

The policy driven expected emissions compliance price (***G***) is constant across all sources of gas, though can vary through time. For the deterministic case the base case carbon price from the most recent update (as discussed in more detail in Table H.4) will be used.[6] There is currently significant uncertainty about what emissions compliance costs will be for the direct use of natural gas going forward in Oregon, though there is a growing likelihood that Oregon will implement GHG reduction policies that include compliance obligations for natural gas LDCs. However, the policy tool in Oregon is currently unknown and even if a policy is implemented the actual compliance price in any given year may not be known. The Washington legislature has given direction to use the social cost of carbon for resource planning.[7]

NW Natural will take the same approach as presented in the most recently filed IRP where the carbon price is an input into the stochastic modeling when the price is uncertain. Figure H.4 illustrates potential carbon price sensitivities that were be included in the stochastic risk analysis.[8] Each path is assigned a probability of starting within a given year.[9] Once a policy starts it begins on the trajectory path starting at year 1 cost levels.

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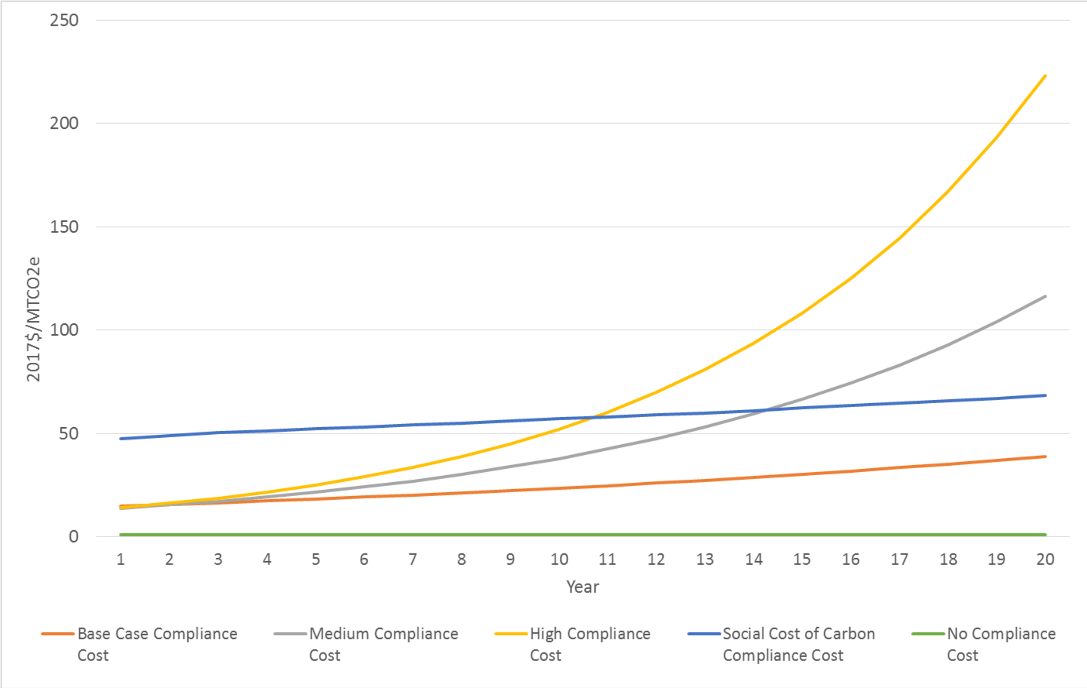
[6] The 2018 IRP details the base case compliance cost in Chapter Two.

[7] Washington SB 5116 – 2019-20

[8] Figure H.4 shows the compliance carbon price sensitivities used in the 2018 IRP. The Social Cost of Carbon price forecast is pulled from EPA's mid-price of the social cost of carbon based on a 2% discount rate. The three ramping price paths are allowance price forecasts for the cap-and-trade market administered under the California Air and Resource Board. Low, medium and high forecasts are produced by the California Energy Commission through 2030. The low price path is used for NW Natural's base case assumptions. A "no compliance cost" path was added to the figure per Staff's recommendation No. 14 in Order No. 19-073.

[9] For the 2018 IRP each policy had an equal probability of being chosen. Additionally for the 2018 IRP, once a policy path was chosen it had an equal probability of starting in any year leading up to 2026, but must be started by January 2026. The assumptions regarding the potential carbon price sensitivities will be updated according to Table H.4.

Figure H.4 Potential Carbon Price Paths



Forecasting both the type of policy and timing of the policy is very difficult and uncertain. NW Natural assesses the possible policy outcomes to develop these compliance cost uncertainties. The stochastic analysis simulates 500 draws from these possible paths. The combination of start date and selection of a price path creates a wide ranges of possible compliance prices over the planning horizon to evaluate policy uncertainty risk.

RNG resources have a different carbon intensity than that of conventional natural gas. The carbon intensity (***N***) used for resource evaluation will be dependent on the outcome of how policy and legislation measure emissions from RNG, and how those emissions are reported for GHG compliance cost purposes. The company will periodically update its expectations of these policy outcomes as we learn more about the treatment of RNG under legislative directive.

3.2 AVOIDED INFRASTRUCTURE CAPACITY COSTS

Infrastructure needs are driven by peak loads. On-system resources that supply gas during peak periods reduce the amount that needs to be supplied from off-system and avoids infrastructure costs (***I***).[10] In order to estimate infrastructure costs avoided for any resource there are two pieces that need to be calculated:

1) The incremental cost of serving additional peak load (***S*** and ***D***)
2) The amount of energy that would be saved or supplied during peak (***A*** and ***H***)

[10] For off-system resources there are no avoided infrastructure capacity costs (i.e., $\boldsymbol{I_T = 0}$).

Note that the incremental cost of serving additional peak load is the same for all resources but the energy supplied or saved on peak is resource specific. There are two infrastructure related avoided costs components — supply capacity avoided costs and distribution system avoided costs.

$$\boldsymbol{I_T = S_T A_T + D H_T}$$

Supply capacity resources are the resources NW Natural uses to get gas onto our system of pipelines and are primarily interstate pipeline capacity and storage resources. Distribution system resources are the assets, primarily smaller pipelines, on NW Natural's system that distribute the gas that arrives at NW Natural's system via its supply resources to customers as it is demanded.

As peak load grows we must increase the deliverability of gas onto our system and the best currently available option is Mist Recall. Each guaranteed dekatherm supplied from RNG on a peak day contributes to NW Natural's portfolio of capacity resources it holds to ensure it can meet customers' peak daily needs and avoids having to recall a dekatherm of Mist Recall. Once Mist Recall is exhausted, an on-system RNG project would avoid the cost of the next best alternative.[11] This avoided cost is a benefit that is determined within the supply resource planning optimization (i.e., SENDOUT).

The avoided distribution capacity costs (***D***) applied to on-system supply resources (in this instance RNG) will be consistent with the methodology used for energy efficiency in the most recently filed IRP[12]. As load within its service area grows NW Natural must reinforce its distribution system to alleviate bottlenecks where we see pressure drops or other indications of insufficient pressure.[13]If these on-system resources inject gas on the correct side of the bottleneck on the peak hour the additional gas supports pressurization of distribution system, which can delay or avoid system reinforcement projects.

If the amount of RNG that is injected during a peak hour (***H***) or day (***A***) can be estimated, or better yet contractually guaranteed, these volumes will be used for evaluation. If this is not estimated or guaranteed, NW Natural will assume RNG supply is constant across all hours in a year.

4. PORTFOLIO EVALUATION PROCESS

The decision to execute RNG projects accounts for uncertainties related to natural gas prices, weather, carbon policies, and capital expenditure cost estimates. Using the stochastic analysis described in the most recently filed IRP, NW Natural can incorporate these uncertainties into the decision process.

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[11] The term "best" is used instead of "cheapest" since the marginal resource might be selected based on its deliverability profile and not strictly based on its costs.
[12] For the 2018 IRP, please see the discussion in Chapter Four
[13] For the 2018 IRP, please see the discussion in Chapter Six

If NW Natural were presented with specific contract terms from an RNG producer, we would evaluate the proposal through the following process:

1. Run deterministic and Monte Carlo simulations for two portfolios using supply resource planning model (SENDOUT):
    a. Portfolio 1: with proposed RNG project
    b. Portfolio 2: without proposed RNG project
2. Compare cost distributions of the two portfolios using risk-adjusted present value of revenue requirement (rPVRR)

The PVRR result of the deterministic portfolio runs are weighted by 0.75. The 95th percentile is estimated from the stochastic simulations and is weighted by 0.25. The proposed RNG contract terms could be accepted if the rPVRR of the RNG portfolio is less than or equal to a portfolio without the RNG.

Alternatively, NW Natural may proactively approach RNG producers with terms and conditions, which will be negotiated with the counter-party. In this circumstance the process requires a third step to find the maximum contract price we can offer where the project is still considered cost-effective for customers.

3. Based on equating the rPVRR between portfolio 1 (with proposed RNG project) and portfolio 2 (without proposed RNG project); determine the maximum risk-adjusted commodity contract price customers would be willing to pay for the RNG resource under consideration.

This process for resource evaluation uses the most recent updates at the time of evaluating a potential RNG project. As a practical matter the inputs and forecast required must be updated periodically. Table H.4 lists the major inputs and forecasts used for resource decisions, and the frequency with which they are updated. These updates are not specific to RNG, but are consistent for all resources. Furthermore, Table H.4 is a guideline for the input and forecast update frequency, however; NW Natural will update input assumptions and forecasts at any time if unforeseen changes occur that would have a material impact on the evaluation since the previous update.

Table H.4: Update Frequency for Inputs and Forecast

Inputs and Forecasts	Frequency of Update	Additional Explanation
Resource Under Evaluation	Most Current Estimate	For example, if an RNG project requires any capital costs, the most current estimate of those costs will be run through the cost-of-service model and used for the evaluation.
Gas Prices (Deterministic and Stochastic)	Twice a year	Our third-party consultant provides long term gas price forecasts twice each year in August and February.
Peak Day & Annual Load Forecast	Once a year	These forecasts are updated spring/summer to include data from the most recent heating season.
GHG Compliance Cost Expectations (Deterministic and Stochastic)	Once a year	The GHG compliance cost assumptions will be updated each year after the legislation sessions in each state or when legislation is signed into law.
Design, Normal, and Stochastic Weather	Each IRP	Resources are planned based on design weather, but are evaluated on cost using normal and stochastic weather.
Gas Supply Capacity Costs (Deterministic and Stochastic)	Each IRP	For the 2018 IRP base case this included the cost of a pipeline uprate, a local pipeline expansion, and representative.
Distribution System Capacity Costs	Each IRP	NW Natural will calculate and present the avoided distribution avoided costs through the IRP process.

5. SENDOUT

This section offers a more in-depth description of SENDOUT and how RNG resources can be modeled within the cost-minimization model. Although this section describing SENDOUT is included in this RNG evaluation methodology appendix, SENDOUT is a tool NW Natural uses to evaluate all resources and the model is not specific to RNG. The methodology described in this appendix for evaluating RNG should be considered independent of the tool used to complete calculations and evaluation. In other words, SENDOUT can be adapted to fit the methodology; the methodology is not dependent on SENDOUT.

SENDOUT is the software application NW Natural uses for its supply resource planning model and is developed and licensed by ABB Group.[14] SENDOUT is a capacity expansion model, which has the ability to choose among potential resource options to minimize costs while still meeting demand over a planning horizon. Given specified inputs and constraints (e.g., pipeline

[14] See website for detailed product description: https://new.abb.com/enterprise-software/energy-portfolio-management/commercial-energy-operations/sendout

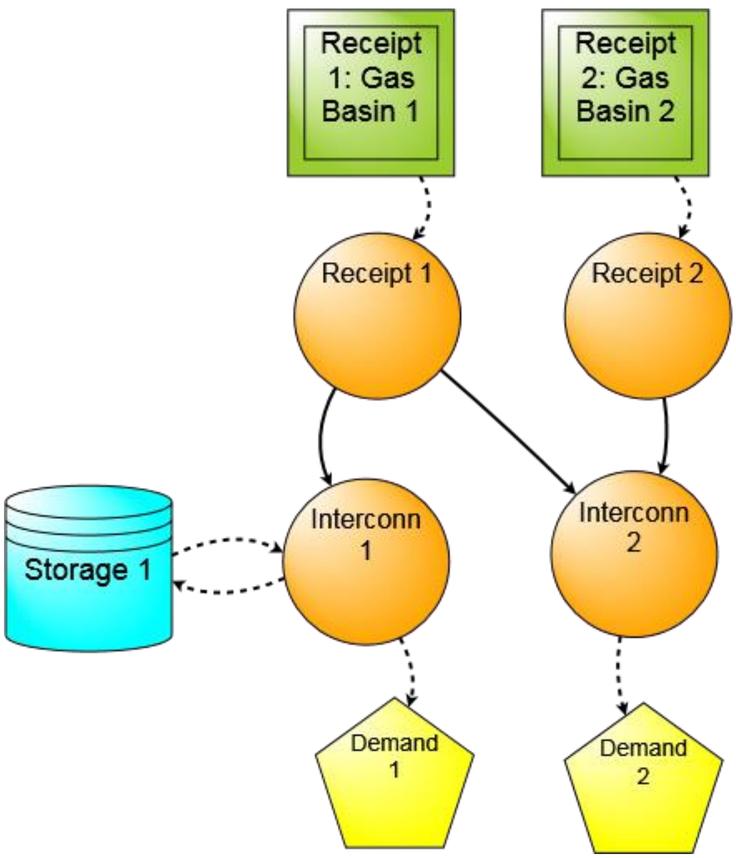
capacity, demand, costs) the software implements a linear program (LP) algorithm, which minimizes costs over a planning horizon while still meeting demand requirements. The main inputs that SENDOUT requires are demand forecasts, capacity constraints as well as costs associated with gas supplies, interstate pipeline contract details, and storage.

Figure H.5 is a simple visual diagram of how SENDOUT interconnects the four primary input categories:

- supply (green squares)
- demand (yellow pentagons)
- storage (blue cylinder)
- transport (solid black arrows)

The orange circles in Figure H.5 are receipt and interconnection points. Interconnection points are not input categories, but link two or more of the aforementioned input categories. Generally, interconnections can be thought of as physical locations within the system. The black dashed arrows associate supply, storage or demand with a specific interconnection point. The solid black arrows are transport resources (e.g., pipeline) between two interconnections.

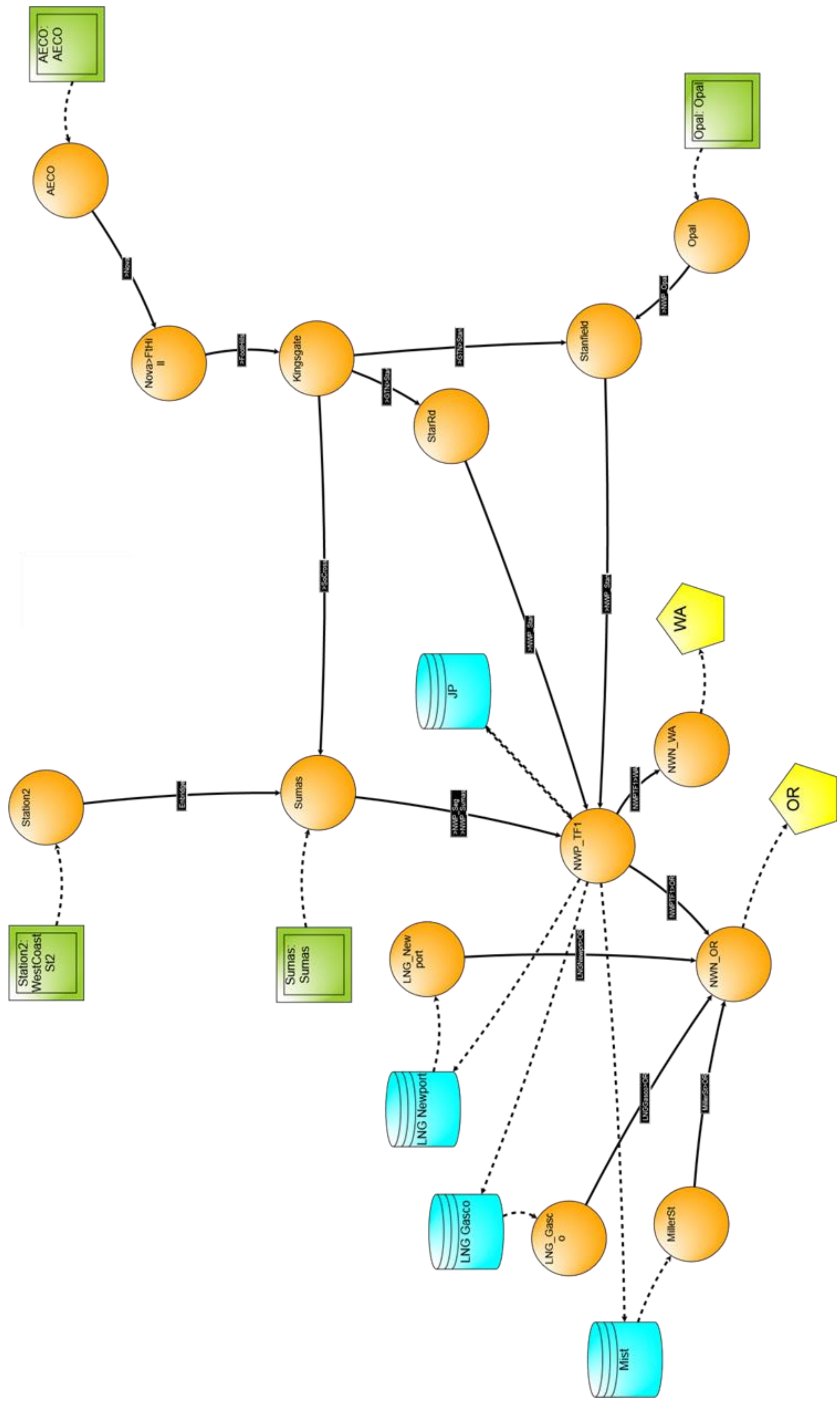
Figure H.5: Simple Diagram – 2 Supply Basins, 2 Demand Area, 1 Storage



In this simple diagram there are two supply basins, two demand areas, and a single storage facility. There are pipelines that connect Gas Basin 1 to both demand areas, but gas from Gas Basin 2 can only flow to demand area 2. There are two dashed arrows between Storage 1 and Interconnect 1; indicating that gas from Interconnection 1 can flow both in an out of the storage facility.

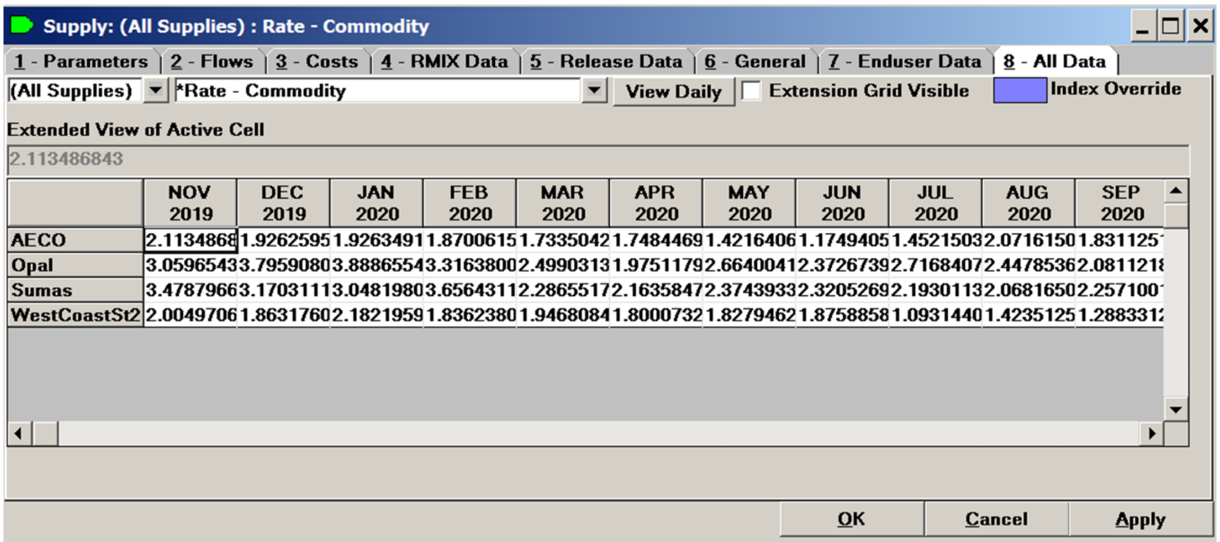
NW Natural's System is more complex. Figure H.6 shows a visual for NW Natural's interstate pipeline capacity and storage resources as it is configured today and depicts the both Oregon and Washington as the two demand areas. The SENDOUT model used for the IRP and resource evaluation (e.g., RNG resources) is more complex with several more demand areas representing load areas throughout NW Natural's service territory with a high-level model of the distribution system interconnecting those load areas.

Figure H.6: NW Natural's Simplified SENDOUT Network Model



All four input categories have numerous parameters which specify various costs, capacity constraints, maximum deliverability, usage factors, etc. Generally, SENDOUT allows each parameter to vary by month over the entire planning horizon. Some parameters can be specified daily. Figure H.7 shows a spreadsheet for the commodity cost parameters for the four basins where NW Natural purchases gas.[15]

Figure H.7: SENDOUT Screenshot of Gas Price Forecasts



	NOV 2019	DEC 2019	JAN 2020	FEB 2020	MAR 2020	APR 2020	MAY 2020	JUN 2020	JUL 2020	AUG 2020	SEP 2020
AECO	2.1134868	1.9262595	1.9263491	1.8700615	1.7335042	1.7484469	1.4216406	1.1749405	1.4521503	2.0716150	1.831125
Opal	3.0596543	3.7959080	3.8886554	3.3163800	2.4990313	1.9751179	2.6640041	2.3726739	2.7168407	2.4478536	2.081121
Sumas	3.4787966	3.1703111	3.0481980	3.6564311	2.2865517	2.1635847	2.3743933	2.3205269	2.1930113	2.0681650	2.257100
WestCoastSt2	2.0049706	1.8631760	2.1821959	1.8362380	1.9468084	1.8000732	1.8279462	1.8758858	1.0931440	1.4235125	1.288331

The number of parameters that can be entered within SENDOUT is extremely large, however; not all parameters are necessary. Table H.5 shows the key parameters NW Natural considers in each input category.

[15] Note that the prices shown are examples for illustrative purposes and not the actual forecasts from NW Natural's third-party consultant.

Table H.5: Key SENDOUT Parameters

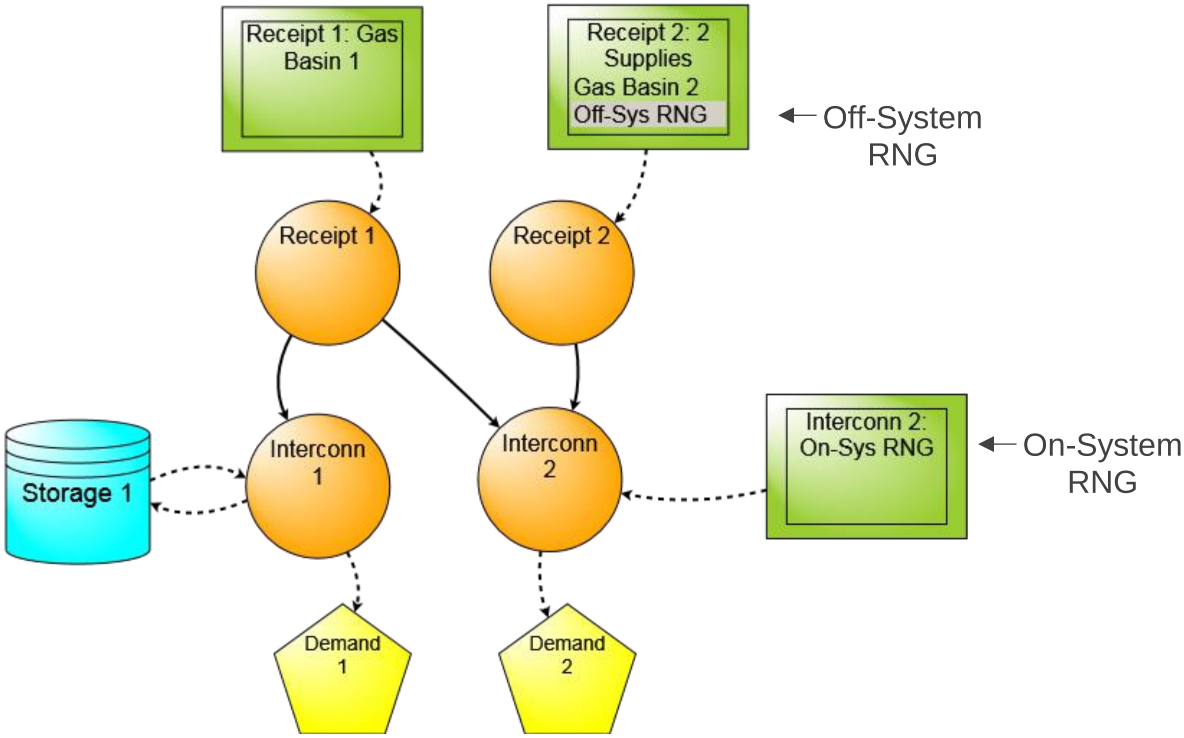
Input Category	Key Parameters
Supply	• Maximum Daily Quantity (MDQ), • Commodity Prices
Demand	• Customer Counts • Usage Factors (Commercial & Residential) • Daily Demand (Industrial) • Weather (Temperature) • Cost of Unserved Demand
Storage	• Maximum Capacity • MDQ – Injection • MDQ – Withdrawal • Fuel Cost • Carry Rate • Storage Ratchets • Starting Layer Volume • Inventory Targets
Transport	• Daily MDQ • Fuel Cost • Demand Charge • Variable Charge

The large number of parameters available in SENDOUT allows for great flexibility within the program to model various scenarios and circumstances. For example, NW Natural is able to incorporate its industrial recall agreements into the model, which are modeled as additional supply resources, but are constrained to be available only during a peak event.

Despite this wide flexibility in the model, SENDOUT is still limited by the parameters that can be entered. For example, SENDOUT was not designed to incorporate carbon policies and evaluate resources with different carbon intensities. We work around this limitation by adding a carbon price adder based on the appropriate carbon intensity to the gas price parameters within the supply input category.

RNG resources can be modeled as additional supply (green squares) that can transport gas to our system. RNG can potentially be on-system (behind the gate station) or off-system which requires upstream pipeline capacity to bring the gas to NW Natural's service territory. Using the simple diagram, Figure H.8 illustrates the difference of how on-system and off-system RNG are model within SENDOUT.

Figure H.8: On-system vs Off-system RNG



The off-system RNG is modeled as being injected onto the interstate pipeline at Receipt 2 interconnect. Interstate pipeline capacity (solid black arrows) would still be needed to deliver the off-system RNG from Receipt 2 to Interconn 2 and sequentially into Demand 2. This off-system RNG would incur both the fuel, variable, and demand charges associated with transporting it to demand area 2. The on-system RNG however, is injected directly onto the Interconn 2 and thus avoids the interstate pipeline (solid black arrows). Any associated costs of interconnecting RNG projects (either on-system or off-system) can be included within SENDOUT.