RENEWABLE NATURAL GAS FEASIBILITY FOR QUALCO ENERGY

AN ANAEROBIC DIGESTER CASE STUDY FOR ALTERNATIVE OUTTAKE MARKETS

A REPORT TO WASHINGTON STATE DEPARTMENT OF COMMMERCE

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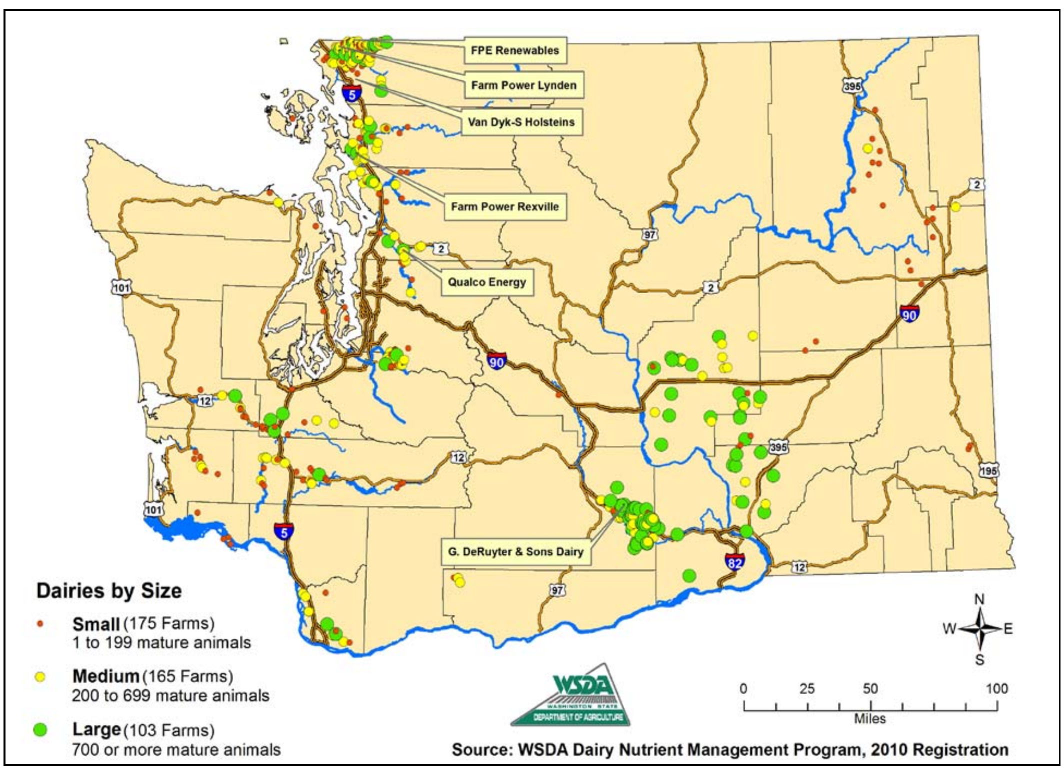
INTRODUCTION

Washington State has 443 commercial dairy farms, totaling more than 250,000 dairy cows. Roughly 100 of these dairies, or 23 percent of the total, can be considered large production facilities comprising 700 or more mature animals. Thanks to commercial developmental support, both in the form of loan/grant opportunities (USDA Rural Development) and industry sponsorship (EPA AGSTAR), U.S. farms, particularly dairies, began to show, during 1990-2000, increased interest in and installation of emerging anaerobic digestion (AD) technology—technology that had previously been mostly exclusive to either municipal wastewater or European agriculture sectors.

Due to historically low received electrical sale prices, Washington State, and the entire Pacific Northwest (PNW), was late in this development cycle, only installing its first digester in 2004 near Lynden, Washington in Whatcom County. Figure 1.1 details the location and herd size of the state's dairy farms and the six operating AD projects. A seventh project, Rainier Biogas, near Enumclaw, Washington, is expected to start operating in late summer 2012.

Figure 1.1: Washington State dairies and anaerobic digester installations (WSDA 2011)



Developing a sustainable business model is critical for wider adoption of anaerobic digestion involving the state's dairies. This report uses one of the five AD projects in western Washington – Qualco Energy – to examine the feasibility of producing renewable natural gas at an existing dairy manure-based anaerobic digester in western Washington. A companion report, Renewable Natural Gas and Nutrient Recovery Feasibility for DeRuyter Dairy, assesses the potential for renewable natural gas production and enhanced nutrient recovery for an existing anaerobic digester in the Yakima Valley.

The Qualco Energy feasibility project was authorized and funded by the Washington State Department of Commerce. Specifically, the study was to:

- Generate a baseline economic model for Qualco Energy.
- Develop a detailed techno-economic analysis offering a new business model approach for Qualco focused not on electric production and sales but renewable natural gas (RNG) production and sales, with discussion on opportunities and hurdles.

While the project is site specific, focusing on techno-economic details for an existing and retrofitted Qualco Energy, it is anticipated that outputs can be applied to potential project development elsewhere.

HIGHLIGHTS/KEY FINDINGS

While the ensuing chapters detail the assumptions and findings of the project and its two main objectives, this section summarizes key findings from the body of the report. In line with the objectives, the summary is divided into two sections: (1) present techno-economic reality for Qualco and its combined heat and power (CHP) AD operation, and (2) potential of alternative business plans associated with conversion of combined heat and power production to RNG, both in regard to technical approach and markets.

Baseline CHP

Qualco Energy has positive cash flow primarily because it receives tipping fees in addition to its electricity and anticipated compost sales and because it has had access to low interest financing. Tipping fees generate 57% of Qualco's gross revenue in 2012, electricity sales and associated credits generate 40% and fiber compost sales generate 2%. In 2014, with the expiration of its existing Power Purchase Agreement and current Renewable Energy Credit agreements, Qualco will receive less revenue from electricity sales because Puget Sound Energy's existing tariff for such purchases is at a substantially lower rate and the value of credits is anticipated to decrease. As a result, tipping fees will increase to 64% of Qualco's gross revenue, fiber sales to 10% and electricity prices to 26% of gross revenue. Qualco has also benefited from access to low-interest financing through a 15-year Clean Renewable Energy Bond that carries a 1% management fee.

Qualco does not have a contract for carbon credits, which are more complex to receive when a digester receives substrates. The consultant team recommends that Qualco reconsider the carbon credit opportunity in light of anticipated increasing prices.

RNG Markets and Off-Takes

Two important RNG supporting factors delineated by the team include:

- Use of RNG within a digester-based "integrated systems approach" producing multiple revenues, including tipping fees and fiber products.
- The rise in the cost of petroleum, the growing availability of compressed natural gas (CNG) and natural gas vehicles (NGVs) and conversions for popular heavy-duty truck engines, and the resulting national shift to methane fuels in the high-value transportation fuels market.

RNG was evaluated under three scenarios (commodity, commodity plus RIN, and Retail Fast Fuel Sales) and compared to the current CHP operation.

1. Commodity natural gas pricing: If sold at low wholesale prices for pipeline gas ($3.87/MMBTU or $0.44/gas gallon equivalent (GGE)), RNG produces less cash flow than the CHP model. This remains the case even if the interest rate is reduced to 1% from the 7% rate assumed in the analysis. If biogas production is increased to 500 cfm (cubic feet per minute) from the current 400 cfm by the introduction of additional substrates, the resulting RNG revenue is about the same as the current CHP operation. The addition of more substrates would require Qualco to get a Solid Waste Handling Permit.
2. Commodity plus "green premium" (RIN): When renewable credits are added to the commodity price of gas, RNG generates less net revenue than CHP through 2023 if the RIN prices are lower than the current RIN price. At the current RIN value, Qualco must receive at least 50 percent of the value of the RINs to generate more cash flow than the CHP operation. If interest rates are decreased to 1 percent or if biogas production is increased to 500 cfm, the lower RIN value generates more revenue than the CHP operation.
3. Retail CNG plus RIN: If producers take RNG to the retail CNG market, where CNG is now selling for $1.85 and up, it generates more revenue than CHP, especially if RIN credits are added. Even if credits are not added, this scenario still generates more cash flow than the current CHP model. Lowering the interest rate or increasing biogas production improves the retail CNG plus RIN cash flow.

Conclusions

The logistics needed to access these markets – gas cleaning and compression, pipeline injection, tube trailers, fueling facilities – are capital intensive and, although they offer profitable scenarios, the scale of debt, unreliability of green credits, and operational risk can impede adoption of the model. These impediments can be addressed by:

- Reducing the debt burden through equity partners/developers and/or non-recourse loans or grants;
- Sharing the cost of common infrastructure through a cooperative, a public “host,” or private development; and
- Diversifying AD-related revenue streams and developing an integrated systems approach that, based on site-specific factors, can include revenue from energy, fiber, and tipping fees.

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Chapter Two — Baseline Qualco CHP

Qualco Energy

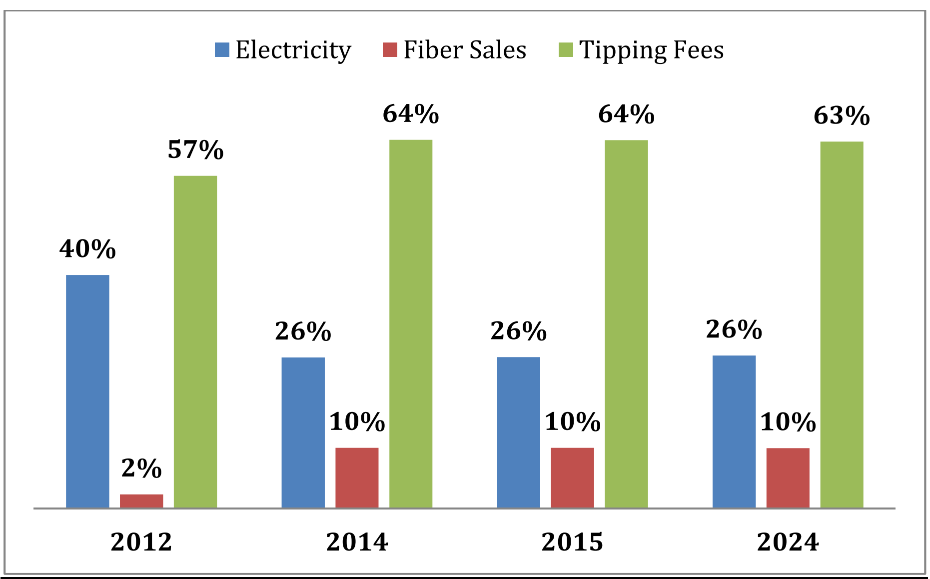
Qualco Energy is a nonprofit partnership made up of Northwest Chinook Recovery, a nonprofit working to restore and improve salmon habitat; the 3,500-member Native American Tulalip tribes; and the Sno/Sky Agricultural Alliance, which is directed by five local dairymen and one cattle farmer.

The Anaerobic Digester

Qualco's anaerobic digester is a GHD/Andgar hybrid plug flow-complex mix digester. It is fed by 1,400 dairy cows generating 60,000 gallons per day of manure and an additional 25,000 gallons per day of pre-consumer organic waste substrate, which is the maximum substrate allowable under RCW 70.95.330 without obtaining a solid waste handling permit. Qualco receives tipping fees from the waste.

The digester was installed in 2008 and is experiencing stable operation, producing an average of 400 cfm (cubic feet per minute) of biogas. Biogas from the digester is sent to a Guascor engine and generator set for production of electricity and recovered heat. A portion of the recovered heat is used to maintain the temperature of the digester while the rest is released without value via a dump radiator. The electrical power is sold via Puget Sound Energy to the grid. Separated solids have been used as compost.

Figure 2.1: Fraction of Net Revenue from Three Components



The Qualco project has three general sources of revenue: (1) electrical sales and associated credits/incentives; (2) fiber sales and (3) tipping fees. (Figure 2.1).

Electrical sales and associated credits/incentives

Qualco's 450 kW generator operates at 91.7% of capacity generating an average of 413 kW, or 3.6 million kWh per year, of which 6 percent is used to operate the anaerobic digester, biogas and fiber screening systems and 3.4 million kWh of electrical power are sold to Puget Sound Energy. The federal Public Utility Regulatory Policies Act (PURPA) adopted in 1978 requires electric utilities to purchase the output of qualifying small power production facilities that have a production capacity of no more than 80 MW. Power Purchase Agreement (PPA) rates are subject to the review and approval of the Washington State Utilities and Transportation Commission (WUTC) which requires that utilities purchase power on "terms that do not exceed the utility's avoided costs for such electric energy" (WAC 480-107-095).

Qualco's five-year Power Purchase Agreement (PPA) with Puget Sound Energy expires in 2013. Under the existing agreement, Qualco is paid $0.0983 per kWh in 2012 and will be paid $0.1019 per KWh in 2013. Puget Sound Energy's Schedule 91 Cogeneration and Small Power Production establishes the rates for the purchase of power from facilities that generate 5MW or less. Prices under the current approved tariff are lower than the prices in effect when Qualco entered into its PPA. This reflects Puget Sound Energy's reduced avoided costs.

Table 2.1 Puget Sound Energy Schedule 91 tariff rates (2012)

	Payment $/kWh
2012	$0.0561
2013	$0.0575
2014 (New contract)	$0.0590
2015	$0.0604
2016	$0.0619
2017	$0.0635
2018	$0.0651
2019	$0.0667
2020	$0.0684
2021	$0.0701
2022	$0.0718
2023	$0.0736
2024	$0.0755
2025	$0.0774
2026	$0.0793

The Schedule 91 rates (Table 2.1) were used to project electricity sales revenues through 2021. To project Schedule 91 rates through 2032, the consultants assumed a 2.5 percent per year increase from 2022 to 2032 which is the same rate of increase in the current Schedule 91 rates from 2014 to 2021.

The minimum term for a Puget Sound Energy PPA is five years and the maximum is ten years. If Qualco enters into a new PPA with Puget Sound Energy, the new rates at the point of renewal will be applicable.

The Qualco project, as currently designed, also has the opportunity to realize additional electricity revenue from the sale of ***Renewable Energy Certificates (RECs)***. Under the existing contract, which expires in 2013, Qualco RECs are being sold at $.00665 per kWh. A recently study, completed for the State of Oregon, reviewed the value of Oregon RECs generated by wastewater treatment plants. The study, noting that REC pricing is not a consolidated market and significant pricing variation can be anticipated, identified three prices: a low price of $1.00/MWh based on the voluntary market; a medium price of $4.00/MWh based on current and near-future California REC prices; and a high price of $23/MWh based on the potential for higher California prices if Oregon RECs are treated the same as California generated RECs. This financial analysis assumes that in 2014, the price paid for Qualco RECs drops to the mid-point of the Oregon study, or $0.004 per kWh, with the rate increasing 10 percent every five years.

RCW 82.16.120 authorizes "*a* ***customer investment cost recovery incentive payment***" to help offset the costs associated with the purchase and use of renewable energy systems located in Washington state that produce electricity (WAC 4568-20-273). The incentive, which is paid by the participating utility, allows a maximum annual payment of $5,000 through 2020.

Figure 2.2 is a 20-Year Pro Forma (2012-2032) showing net income for Qualco. Electricity sales and associated credits and incentive payments total $306,000 in 2012. These revenues are anticipated to drop in 2014 with a decline in electricity sales prices and reduced revenue from renewable energy credits. Total revenue from electricity sales, credits and incentives is $186,000 in 2014.

Operation and maintenance costs were identified through consultation with Qualco. In 2011 Qualco's operation expenses were $550,000 of which $170,000 were extraordinary expenses for installation of a separator and for digester modifications. A base of $380,000 for 2012 on-going operations expense was assumed, with annual inflation of two percent from 2013 forward. Digester modifications are anticipated to cost $35,000 in 2012 and 2013 in addition to the on-going operations expenses. An additional allowance for potential digester improvements is assumed at a rate of two percent of operating expenses between 2014 and 2032. Other expenses include:

- ***Property Tax.*** Qualco pays real and personal property tax of $50,000 per year. Inflation is assumed at two percent per year on the property tax.
- ***State and local business and occupation (B&O) tax*** expense is included in Qualco's operating expenses.

Qualco has ***debt service payments*** on a 15-year Clean Renewable Energy Bond (CREB) issued in January 2008. The annual payment includes a 1.2 percent management fee which is applied to the balance owed. Annual debt service payments are $196,000 in 2012, ending in 2022 with a final payment of $175,000.

Fiber Sales

Qualco has experienced some difficulties producing quality compost. This results from the introduction of fats and grease to boost biogas production, which in turn result in a more greasy fiber product. To date, Qualco has not sold compost, but rather has used the material as a local soil supplement.

Qualco plans to initiate compost sales in the last quarter of 2012. The average annual production is anticipated to be 7,300 cubic yards to be sold at $10.00 per cubic yard. Prices are assumed to remain constant through 2014 and then grow at an annual inflation rate of two percent. There are effectively no marginal operating costs associated with fiber sales. All trucking and loading fees will be charged to, or borne by, the purchaser.

Tipping Fees

Qualco derives a significant portion of its revenue from tipping fees. In 2011, 9.2 million gallons of substrate were received. Five percent (5%) of the substrate were not charged tipping fees and the remaining 8.7 million gallons were charged $0.05 per gallon and generated $436,000 in 2011 revenue. This analysis assumes a two percent annual inflation rate on tipping fee revenue.

Baseline Pro Forma Specifics

Figure 2.2 and Table 2.2 are graphical and tabular representations of the changing cash flow for the project based on the above discussion, which is anticipated to be $99,000 in 2012. As shown in the chart below, cash flow drops in 2014 to $68,000 then stabilizes and increases in 2023 to $312,000 after which it rises to $385,000 in 2032. The changes in cash flow result from:

- **Revenues from electrical sales decreasing**. Electrical sales revenue is anticipated to drop by 42 percent from 2013 to 2014 and is anticipated to remain relatively low throughout the 20-year period. This reflects changes in the avoided cost calculation that underlies the regulated prices paid by Puget Sound Energy.

- **Revenues from renewable energy credits decreasing.** Revenue from renewable energy credits is anticipated to drop by 38 percent with the expiration of the current contract in 2014, reflecting changed market conditions.
- **Revenues from fiber sales increasing.** Qualco is initiating fiber sales in 2012 with this revenue source accounting for a larger percentage of revenue in the future.

  Debt service. Qualco's debt service payments end in 2022. This pro forma does not include additional debt service that may be incurred to reinvest in the digester.

CONCLUSION

Qualco, located in northwestern Washington, has different opportunities and challenges than projects developed in eastern Washington. The primary benefits are the higher prices and abundant substrates that generate significant tipping fees. However, the addition of substrate has made it more difficult to generate fiber of a quality suitable for composting. Qualco has also not been able to sell carbon credits, the sale of which are complicated by the addition of substrate. The consultant team recommends that Qualco re-consider the carbon credit opportunity in light of anticipated increasing prices. (See DeRuyter report for specifics.)

Figure 2.2: Graphical representation of changing cash flow to Qualco Energy

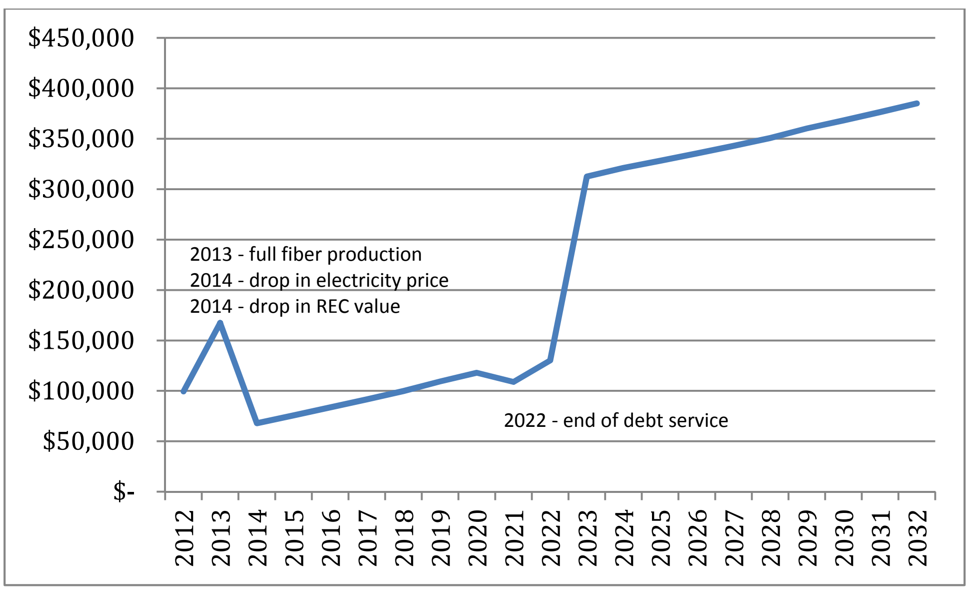


Table 2.2: Baseline Qualco Pro Forma

	2012	2013	2014	2015	2020	2025	2030
Revenue							
Electricity Produced/Rate							
Electricity Generation (kWh)	3,614,814	3,614,814	3,614,814	3,614,814	3,614,814	3,614,814	3,614,814
Electricity Used in Digester & Generator	216,638	216,638	216,638	216,638	216,638	216,638	216,638
Net Electricity	3,398,176	3,398,176	3,398,176	3,398,176	3,398,176	3,398,176	3,398,176
Electricity Purchase Price (per kWh)	$ 0.0983	$ 0.1019	$ 0.0590	$ 0.0604	$ 0.0684	$ 0.0774	$ 0.0875
Fee Snohomish County PUD	16.50%	16.50%	16.50%	16.50%	16.50%	16.50%	16.50%
Renewable Energy Certificate Price (per kWh)	$ 0.0065	$ 0.0065	$ 0.0040	$ 0.0040	$ 0.0044	$ 0.0048	$ 0.0053
Projected Revenue Electricity							
Electricity Sales	$ 278,981	$ 289,025	$ 167,298	$ 171,469	$ 193,998	$ 219,507	$ 248,340
Renewable Energy Certificates	$ 22,088	$ 22,088	$ 13,593	$ 13,593	$ 14,952	$ 16,447	$ 18,092
Washington State Renewable Energy Incentive	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000		
Sub-total Electricity Revenues	*$ 306,069*	*$ 316,114*	*$ 185,890*	*$ 190,061*	*$ 213,950*	*$ 235,954*	*$ 266,432*
Fiber Sales							
Cubic Yards Per Year	1,825	7,300	7,300	7,300	7,300	7,300	7,300
Price per cubic yard - Compost	$ 10.00	$ 10.00	$ 10.20	$ 10.40	$ 11.49	$ 12.68	$ 14.00
Sub-total Fiber Revenues	*$ 18,250*	*$ 73,000*	*$ 74,460*	*$ 75,949*	*$ 83,854*	*$ 92,582*	*$ 102,218*
Tipping Fees							
Gallons per Year	9,200,000	9,200,000	9,200,000	9,200,000	9,200,000	9,200,000	9,200,000
Price per Ton	$ 0.047	$ 0.048	$ 0.049	$ 0.050	$ 0.056	$ 0.061	$ 0.068
Sub-total Tipping Fees	$ 436,350	$ 445,077	$ 453,979	$ 463,058	$ 511,254	$ 564,465	$ 623,215
Total Revenue	**$ 760,669**	**$ 834,191**	**$ 714,329**	**$ 729,069**	**$ 809,058**	**$ 893,001**	**$ 991,865**
Expenses							
Operations							
On-going operation cost	$ 380,000	$ 387,600	$ 395,352	$ 403,259	$ 445,231	$ 491,571	$ 542,734
Equipment Repair & Replacement - planned	$ 35,000	$ 35,000					
Equipment Repair & Replacement - reserve			$ 7,907	$ 8,065	$ 8,905	$ 9,831	$ 10,855
Sub-total Operations Cost	*$ 415,000*	*$ 422,600*	*$ 403,259*	*$ 411,324*	*$ 454,135*	*$ 501,402*	*$ 553,588*
Real & Personal Property Tax	*$50,000*	*$50,000*	*$51,000*	*$52,020*	*$57,434*	*$63,412*	*$70,012*
Total Expense	**$ 465,000**	**$ 472,600**	**$ 454,259**	**$ 463,344**	**$ 511,569**	**$ 564,814**	**$ 623,600**
Net Income	**$ 295,669**	**$ 361,591**	**$ 260,070**	**$ 265,725**	**$ 297,488**	**$ 328,187**	**$ 368,264**
Debt Service	($196,282)	($194,202)	($192,121)	($190,040)	($179,636)	$0	$0
Net Cash Flow	**$ 99,387**	**$ 167,389**	**$ 67,949**	**$ 75,684**	**$ 117,852**	**$ 328,187**	**$ 368,264**
Pro Forma does not include replacement of digester and equipment in 2028 (20 year life)							

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Chapter Three — RNG Market Analysis

INTRODUCTION

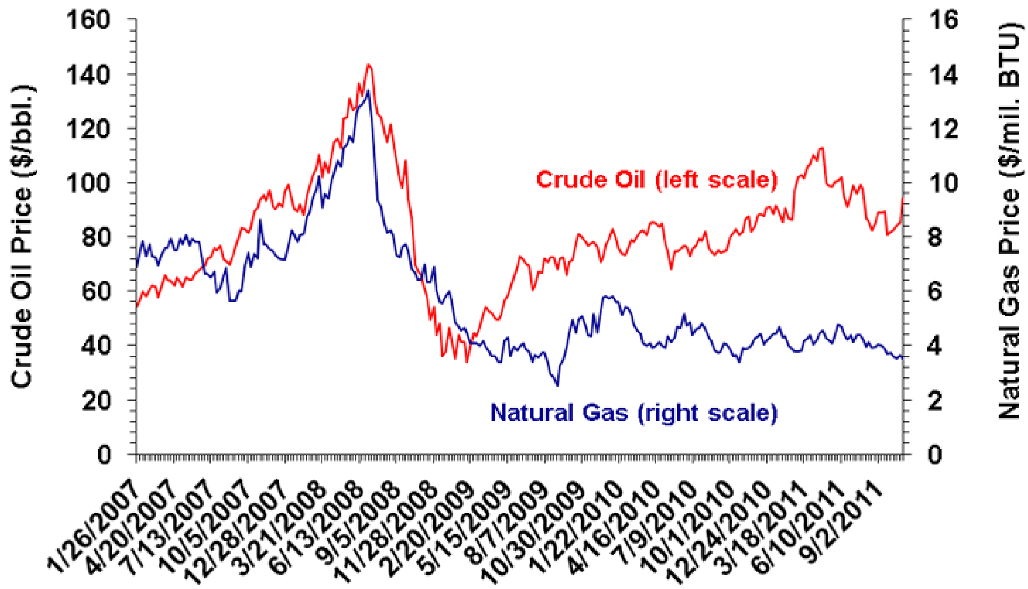
The purpose of this section is to evaluate the opportunity to sell RNG produced at Qualco, describing the potential RNG market – RNG price and terms – and identifying potential purchasers. It includes an analysis of several RNG pricing scenarios: as commodity natural gas; commodity value plus a "green premium" (i.e., plus RIN value); and retail CNG plus "green premium." These RNG pricing scenarios are compared to the Qualco CHP baseline in the Economic Analysis section of this report. Also described in this section are the logistics associated with several RNG delivery pathways and potential RNG purchasers.

NATURAL GAS MARKET REVIEW

The United States is beginning an "historic shift" to natural gas with recent production breakthroughs that, for the first time in history, have given the U.S. decades of low-priced natural gas (Novak 2012). Until recently, natural gas has been a relatively volatile commodity, fluctuating with supply and demand swings from less than $2/MMBTU to $15/MMBTU over the last two decades, closely aligned to petroleum price swings. In the last several years, natural gas exploration and production associated with mammoth shale gas plays provides unprecedented reserves and the promise of relatively low, stable prices for gas and a "decoupling" from increasingly costly petroleum products (Figure 3.1). This dynamic is driving shifts to natural gas for heating, manufacturing, and electricity production, and to methane fuels – CNG, LNG, and, perhaps, RNG – for transportation.

The absence of three factors has impeded a tip from petroleum to methane transportation fuels: 1) price and supply stability; 2) fueling infrastructure; and 3) availability of natural gas vehicles (NGVs) that can use CNG or LNG. With new assurance of vast domestic gas supplies and CNG retailing for about half the price of gasoline and diesel, price and long-term supply strongly favor methane fuels. The scarcity of CNG/LNG fueling infrastructure and NGVs, however, has presented a chicken and egg impediment that has only recently begun to yield to the economic, environmental, and energy security advantages of methane-based transportation fuels.

Figure 3.1: Decoupling of gas and petroleum pricing



Recent progress reducing these impediments is seen in the growing availability of new cars, trucks, and ship propulsion systems that can use methane fuels, combined with recent EPA certification of conversions for popular light-duty and heavy-duty truck engines. For example, the project team took note of the newly-approved EcoDual conversion for the Cummins ISX 15-liter engine that is widely used in the mountainous west; runs on either diesel or a mix of natural gas and diesel (displacing approximately 70% of the diesel); can be installed for $25-$35,000 by Seattle-based World CNG, and is anticipated to have an ROI of less than 12-months for heavy fuel users at current CNG and diesel prices. In addition, several CNG retailers are building out fueling station networks on major truck routes and interstate highways, which will reduce this remaining impediment over the next several years. Although problems associated with hydraulic fracturing of gas-producing shale (“fracking”) and fugitive methane emissions have generated environmental and other concerns, industry practices, regulation, and maturing technologies are focusing on these concerns, with a general expectation that broad-scale shale gas production will continue.

RNG, as a member of the methane fuels family, should benefit from the tip to methane fuels. The question is whether there is an economically viable place for RNG along with low-cost CNG and LNG from geologic sources. Can RNG compete with natural gas at the commodity or retail levels? After discussions with fleet operators and industry observers, the project team developed and evaluated the following three RNG pricing scenarios:

Scenario 1: Commodity Price. RNG is priced at the commodity value of natural gas with no “green premium” (e.g., REC or RIN value).

Scenario 2: Commodity plus “green premium” (RIN). RNG is sold as transportation fuel generating RIN values in addition to the commodity value. Two RIN values are analyzed:

current RIN ($0.74 per 77,000 BTUs or $1.10 GGE) and a lower RIN ($0.25 per 77,000 BTUs or $0.37/GGE).

Scenario 3: Retail CNG price plus RIN. The RNG is dispensed at a fast fuel station as transportation fuel at CNG prices, while also generating RIN values.

Scenario 1: Commodity Price

The base case (lowest value) scenario for the price of RNG is the commodity (pipeline wholesale) value of natural gas from geologic sources. National forecasts by the U.S. Energy Information Administration (EIA) project growing reserves of domestic natural gas supply at relatively low and stable prices. This is largely due to the discovery and production of new supplies of shale gas in the Mountain West of U.S. and Canada, the South, and throughout the Northeast's Appalachian Basin. This unprecedented development opens the door for greater use of methane fuels, including RNG, in the high-value transportation fuels market, but it also makes it difficult for RNG to compete with low-cost natural gas as a commodity product.

This analysis assumes that Qualco receives the Sumas Cascade commodity price (i.e. the wholesale price for gas at the Washington/Canada border) for its gas. The Sumas Cascade price was estimated based on the March 2012 EIA forecast for prices at the Henry Hub reduced by the projected difference between the Henry Hub price and the Sumas Cascade Price in the Cascade Natural Gas 2011 Integrated Resource Plan. Under this analysis, the Sumas Cascade price forecast is $3.87 per MMBTU ($0.44/GGE) in 2014 increasing to $6.07 per MMBTU ($0.69/GGE) in 2032. It assumes RNG is injected into the pipeline grid and is purchased at that point (Table 3.1).

Table 3.1: Projected price of commodity natural gas and retail CNG, 2014 - 2032

$/MMBTU	2014	2016	2018	2020	2022	2024	2026	2028	2030	2032
Henry Hub	$4.16	$4.30	$4.59	$4.80	$5.29	$5.64	$5.98	$6.18	$6.19	$6.67
Sumas Discount	7%	9%	12%	10%	13%	11%	11%	10%	10%	9%
Total	$3.87	$3.91	$4.04	$4.32	$4.61	$5.02	$5.33	$5.58	$5.57	$6.07
% Change		0.43%	2.51%	0.97%	4.93%	4.80%	5.54%	0.27%	-0.03%	3.61%
CNG Retail Price	$1.85	$1.87	$1.93	$2.06	$2.21	$2.40	$2.55	$2.67	$2.66	$2.90

Source: U.S. EIA Early Outlook 2012 and Cascade 2011 Integrated Resource Plan Projections

Scenario 2: Commodity plus "green premium" (RIN)

If RNG can be injected into the pipeline grid, it can be distributed locally or "wheeled" to distant purchasers, offering a vast potential market for RNG. As a renewable fuel, RNG can in some cases qualify for Renewable Energy Credits if the RNG is used to produce electricity[1], or for

[1] Different state Renewable Portfolio Standards have different rules around if and how RNG put into a pipeline to be used at a power plant can generate RECs. The California Energy Commission, for example,

Renewable Identification Numbers (RINs, under the Renewable Fuel Standards (RFS) program) if the RNG is used as transportation fuel.[2] This analysis focuses on the RIN as the green premium, noting regional utilities have an oversupply of renewable power, primarily from wind farms, and RECs are considerably lower in value than RINs, at least for the time being.

The RIN value is realized at the point the compressed RNG is put into motor vehicles. If RNG is put into the pipeline at Qualco, and then compressed and used for fuel off-site, the RIN is generated off-site. A portion of the value of this RIN, however, should be reflected in the price that Qualco is paid for the gas it injects. The ability for RIN revenue to be realized downstream should effectively increase the value of the RNG at pre-delivery stages as well. Two RIN values were evaluated: the current value of $0.74 per 77,000 BTUs (which equates to $1.10/GGE) and a projected lower RIN value of $0.25 ($0.37/GGE). Commodity plus green premium pricing appears to be a viable approach in selling RNG to gas utilities, gas brokers, and CNG/LNG retailers, noting they will likely require some sharing of the RIN or REC value. Under this scenario, the sale of RNG from Qualco to a gas utility in 2014 would include the Sumas Index price of natural gas ($3.87/MMBTU or $0.44/GGE) plus an agreed percentage of the RINs. If the producer of the fuel were to split 50% of the RIN revenue with Qualco, this green premium would add $0.55/GGE at the current RIN rate or $0.19/GGE at the lower RIN rate, providing Qualco with a total of $0.99/GGE at the current RIN value or $0.64/GGE at the lower RIN rate.

Scenario 3: Retail CNG price plus RIN

The current retail price of CNG in the Seattle area is between $1.85 and $2.14/GGE. This analysis assumes that the price is $1.85/GGE in 2014 and changes at the same rate as changes in the Sumas Cascade commodity prices. Actual retail prices will be affected by the rate of introduction of CNG vehicles into the U.S. fleet, which may have a substantial affect on CNG prices. The potential of a "concerted U.S. policy effort to shift the transportation sector away from oil toward natural gas would significantly increase demand, and thus natural gas prices" (PacifiCorp IRP 2011, pg. 29). Based on the combination of the retail price of CNG ($1.85/GGE – paid by the RNG customer) plus the applicable RIN rate (paid through the RFS program), the sale of RNG as a retail product with RINs would garner an estimated $2.94/GGE at the current RIN rate or $2.22/GGE at the lower RIN value in 2014. In this scenario, because the project itself cleans, compresses gas, and fuels trucks, it realizes 100% of the RIN revenue. As noted in the Economic Analysis and Environmental Credit sections below, the RINs and other "green premiums" are young markets, based largely on government policies, subject to fluctuations and uncertainties.

recently decided that projects whose gas is not injected into a dedicated pipeline that serves California power plants cannot for now generate RECs in California.

[2] The RIN market is described in detail in the Environmental Credit section of the report.

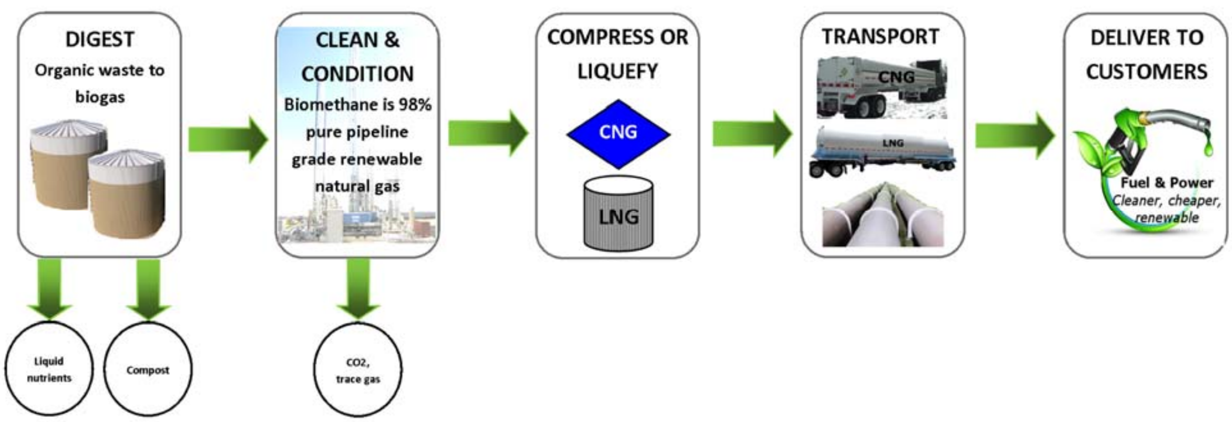
Potential RNG Purchasers and Delivery Logistics

Under the three RNG pricing scenarios, potential RNG purchasers fall into two categories: wholesale RNG buyers who resell the gas, and retail customers who are the end user of the RNG. Each category has associated delivery logistics that are described briefly in this section and factored into the RNG conversion design section and the *Pro Forma* in the Economic section.

Potential Wholesale RNG Buyers

Wholesale purchasers of RNG will usually require pipeline delivery of the gas so it can be delivered to customers in various locations on the natural gas pipeline grid. As noted above, values for wholesale RNG are set by the applicable index price for natural gas (e.g., Sumas or Henry Hub) plus the green premium (RIN or REC) minus a negotiated share of the total for the reseller (Scenario 2 above). A possible exception to the pipeline requirement would be direct delivery of RNG in tube trailers to gas/electric utility combustion turbines and supply-constrained industries and residential or commercial service areas (which would still require injection into that part of the grid using a utility-supplied injection point) (Figure 3.2).

Figure 3.2: RNG Production and Delivery



For pipeline delivery of RNG to wholesale customers, the **logistical requirements** include:

- **Gas cleaning equipment that meets applicable pipeline specifications:** RNG must meet rigorous gas quality standards ("tariff"), and real-time monitoring, to be injected into the pipeline system. Sensitivity to gas quality increases with distance, and reduction in gas volume, from the main transmission pipeline. At the end of a gas distribution system where volumes are low, the injected gas must closely match the ambient gas. The gas-cleaning unit evaluated in this feasibility study (Flotech's Rimu model) is capable of producing 98% pure methane and removing potentially problematic contaminants from biogas. However, pure methane has a heating value of 1000 BTUs/cubic foot, while the typical gas in central and western Washington has a heating value of approximately 1030 BTUs/cubic foot due to the presence of high-BTU constituents, such as propane, ethane, and butane. This does not present a problem if the gas is injected into the Williams NW pipeline, which requires gas entering the pipeline to have a heating value of at least 985 BTUs/cubic foot. It could present an issue if the RNG is injected into low flow areas, potentially requiring supplementation with propane to boost the BTU value of the RNG to closely match the gas in the pipeline.

- **Compression of the RNG for pipeline or tube trailer delivery:** A compressor at the back end of the gas cleaning unit is required to transport RNG through a pipe to the pipeline injection point and to pressurize the RNG for injection into the Williams pipeline (to approximately 700 psi). Alternatively, a larger compressor system would pump the RNG into tube trailers to pressures of up to 3600 psi. Delivery by pipeline is not an option to Qualco because of permitting issues.
- **Tube trailer delivery to the pipeline or fueling station:** A state-of-the-art jumbo tube trailer can hold approximately 280,000 cubic feet of gas at 3600 psi, requiring two trips a day at the expected RNG production rate of more than 3500 GGEs/day. Tube trailer delivery also provides the option to deliver RNG directly to a fueling station or to other customers. This would have the advantage of avoiding the cost of an injection point and meter station, as well as taking advantage of the gas pressure in the tube trailer to reduce the cost of compressing gas from the pipeline (at 600-700 psi) to high pressure holding tanks (4700 psi) for fast fill dispensing at the fueling station. If there is not an injection point at the fueling station, however, additional storage at the fueling station and Qualco would be necessary and there would not be the option to serve other customers via the natural gas grid.
- **Injection point/meter station:** Getting RNG into the pipeline requires both a tap (injection point) into the pipeline and metering and monitoring equipment to assure the RNG meets pipeline specifications. This package of equipment typically includes a gas chromatograph, flow meter, filter, valves, telemetry for real-time reporting, and other features. The injection point/meter station is an expensive piece of infrastructure – approximately $1.0 million depending largely on land acquisition costs. A meter station typically has a 100’ x 100’ footprint and a small metal shed to house components. The cost of a meter station is not greatly influenced by size -- a meter station for a single small user, such as Qualco, would not cost much less than a meter station for five times that amount of gas. The high capital cost and ability of others to use it at little additional cost make it a candidate for a public, co-op, or third-party hosted model.
- **Fueling Station:** Ideally, a CNG/RNG fueling station is in a location that can serve a number of fleets that consume hundreds or even thousands of gallons a day. The ideal facility would be on or near a high-flow gas transmission pipeline — with both a meter station for injection of RNG and the ability to withdraw natural gas — as well as high pressure storage tanks (4700 psi), booster compressor, and dispensers for fast fueling of CNG vehicles. Such a station reduces the need for expensive storage systems, is able to blend RNG and CNG, and provides certainty of supply. It would also likely cost $1.5 to $2 million. A more modest fueling station (used in this analysis), with pipeline access but

without injection capability, is estimated to cost less than $300,000. Down the road, as LNG becomes the preferred fuel for long-haul trucking, it would include cryogenic tanks and dispensers for LNG fueling.

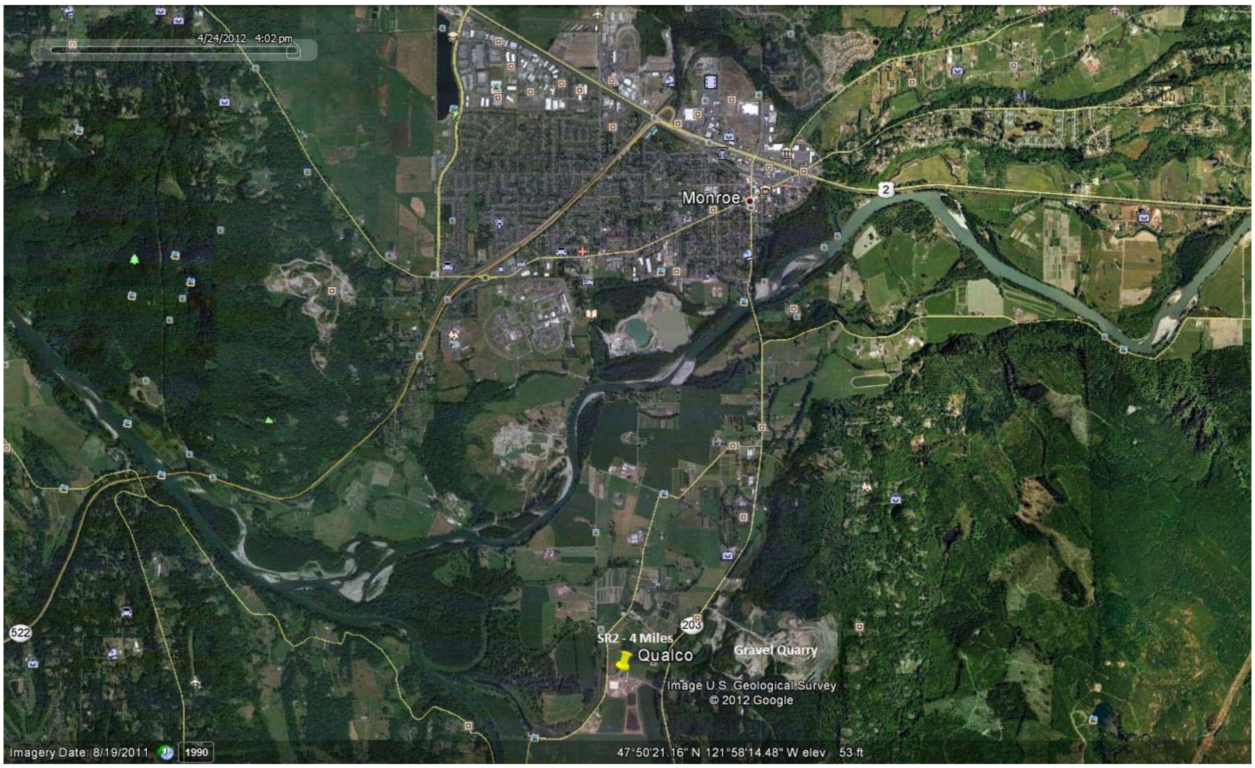
Potential **wholesale purchasers and terms** include:

- **Gas utilities:** Puget Sound Energy has expressed interest in purchasing RNG from these types of projects. It would sell the renewable gas with the potential to produce RECs or RINs to renewable energy brokers, retailers, or large end-use customers. It already participates in the RNG market through its involvement with the Cedar Hills landfill gas project. Another Pacific Northwest utility, FortisBC, recently launched programs to market RNG to residential and commercial gas customers at a premium price which, combined with Canadian carbon pricing, enables it to purchase RNG from dairy farmers for $15.25 a gigajoule (approximately 1MMBTU, or more than $1.70/GGE). Fortis will purchase either pipeline-quality RNG or raw biogas, which Fortis will purchase at a lower rate and upgrade on-site for pipeline injection. Fortis indicated the purchase of Washington State RNG could be a possibility in cases of local supply shortage. Northwest utilities are considering similar RNG marketing programs.
- **Gas Brokers:** Project team members have been in contact with several national gas brokers who would be interested in discussing RNG purchase agreements on terms similar to those outlined for the gas utilities above.
- **Commercial CNG Retailers:** As Clean Energy, Pilot-Flying J truck stops, Marathon, and other CNG/LNG retailers build new natural gas fueling stations along major trucking routes, the demand for RNG is expected to increase. Transportation of food products for retailers such as Safeway, Wal-Mart, and Costco is a sector increasingly sensitive to its carbon footprint. RNG from dairy manure can significantly reduce agricultural and transportation-related greenhouse gas (GHG) emissions. These purchasers may be willing to pay a few Cents more for CNG or LNG blended with RNG. Clean Energy is already marketing blended CNG/RNG as RNG10 and RNG20. Terms for the sale of RNG to these retailers are expected to be similar to the terms for sale of RNG to utilities (Scenario 2).
- **Military and other Government Purchasers:** To meet the military's "net zero" requirement by 2020, the Defense Logistics Agency (DLA) and the General Services Administration (GSA) are potentially major wholesale purchasers of RNG for vehicles as well as for other natural gas and propane applications. The same is true for other government agencies that have carbon emission reduction or renewable energy goals, such as the Department of Energy at Hanford, Washington. Terms for sales to the DLA, GSA, and other federal, state, and local agencies would be similar to gas utilities (Scenario 2) unless they contracted for fueling services, in which case the retail CNG plus RIN model (Scenario 3) would likely apply.

Potential Retail Purchasers of RNG

Qualco is located several miles south of the City of Monroe (population 17,000) and is near major metropolitan centers. It is 34 miles from downtown Seattle and 17 miles from the City of Everett. Qualco is 4 miles from US Highway 2, an important east-west freight corridor for Washington, and just off SR 203, which has a significant amount of truck traffic, including locally stationed cement trucks and milk trucks.

Figure 3.3 Location of Qualco and major highways



There are potentially hundreds of fleets within a 50-mile radius of Qualco that could be candidates for retail RNG fueling, and many more regional users if Qualco injects RNG into the gas pipeline grid. Examples of several potential retail customer fleets are discussed below.

<u>Existing CNG stations</u>

There are two public CNG fueling stations in Seattle and six within 50 miles, including one in Bellevue and one in Everett. Fleets using these existing fueling stations include Pierce County Transit, Sound Transit, taxis, and Allied Waste refuse trucks. In addition to the public stations, there are a growing number of private fueling stations for major CNG users, such as Waste Management. These stations typically have connections to major natural gas transmission or distribution pipelines and could receive RNG to blend with CNG either through the pipeline grid or delivered in tube trailers.

Less-than-truckload (LTL) and small parcel fleets

LTL carriers differ from typical long-haul trucking operators in that they pickup and deliver to multiple customers in a region every day from a fleet of trucks and then aggregate that freight at a local terminal for distribution to points across the country via long-haul trucks and other distribution centers. These trucks are potential end users for natural gas because they return to a central location daily and are not as sensitive to needing a wide fueling network like a typical long haul carrier. Pilot projects for CNG powered LTL trucks are scheduled to begin this year in the Chicago and Houston areas. LTL carriers that serve the greater Seattle area include: Roadway Express, USF Reddaway, Saia Motor Freight, R&L Carriers, Oak Harbor, and Peninsula. Parcel delivery companies such as Fedex and UPS are another potential user. UPS has experience operating CNG delivery vehicles in the US since 1997 and announced plans in 2011 to convert 48 of its long-haul tractors to LNG.

Long-haul truck fleets

World CNG, located in Kent, is about to begin a pilot project to retrofit trucks in the drayage fleet at the Port of Seattle and trucks in large long-haul contract fleets. LTI, which is a subsidiary of Lynden Transport and is the milk hauler for Darigold in Washington State, is an attractive candidate for this effort and is evaluating the opportunity to shift to CNG. Vertical integration of this type within the milk industry has already been demonstrated by the Fair Oaks Farms in Indiana, who fuel a fleet of Ruan Transport milk delivery trucks on two stations - one standard CNG station on the pipeline, and one that uses both pipeline gas and RNG produced by dairy farms. The project team also had conversations with Puget Sound truck maker Paccar regarding options for new CNG/LNG powered trucks. Paccar reported that there are only two options on the market right now - a 9 Liter engine that can be run on CNG or LNG but is underpowered for heavy freight loads in mountainous areas, and an LNG-only 15 Liter engine that has been thought of as cost-prohibitive by many fleets. This should change within the next year with the introduction of a Cummins Westport 12 Liter option that will have more power than the 9 Liter engine and be more cost effective than the 15 Liter LNG engine. Paccar is estimating the new 12 Liter engine will cost $40-50,000 more than a similarly powered diesel platform. These developments, combined with the existing fueling infrastructure in the greater Seattle area and new natural gas stations being built along freight corridors nationwide at Pilot-Flying J, Clean Energy, and other retailers, will support increased use of CNG and LNG by local truck operators.

Private fleets

Many large retailers, such as Safeway, Costco and Wal-Mart, and food distributors such as United Natural Foods, Coca-Cola, and Sysco, among other large corporations, manage their own fleets of trucks in addition to using contract carriers. These potential CNG/RNG customers could potentially have a better opportunity to directly market the environmental benefits of RNG as a transportation fuel than a contract carrier that moves freight for a wide variety of customers and may not place as much importance on sustainability or “being green.”

<u>Government users</u>

The Washington State Ferry system is actively pursuing the use of LNG in up to six conversions of existing vessels and future new builds. The ferry system is already required to use a certain percentage of biodiesel and the legislature could potentially mandate the use of a percentage of natural gas from renewable sources. Other potential government customers to approach include: school districts, local municipalities, counties, and transit agencies, the Department of Transportation, and the Washington State Fleet Operations division that manages vehicle procurement for state agencies. Within the federal government, the General Services Administration is the government’s procurement center, including vehicles and fueling systems. The GSA Regional Administrator is working closely with the EPA Regional Administrator on federal leadership in clean fuels, including CNG/RNG, which could create RNG marketing opportunities across the Pacific NW region. The Hanford Nuclear Reservation and military installations are currently engaged in discussions regarding the use of RNG.

<u>Local industry</u>

Qualco is located across SR 203 from the Cadman quarry and concrete plant. This operation is energy intensive in both production and transportation, is not connected to a gas distribution line, and could be a purchaser of locally-produced RNG as a fuel source. Other potential industrial markets include, data centers (“server farms”) with huge arrays of diesel generator sets for companies such as Yahoo and Microsoft, and other industries that are either off the pipeline grid or are seeking to reduce their carbon footprint, support local agriculture and renewable energy production, or become more sustainable.

References

Montague (2012)
PacifiCorp (2012)

Puget Sound Energy Letter of Interest

References

Novak, A. (2012). The tectonic shift of new oil and gas technologies has only just begun, in Forbes Magazine, electronic version, February 16, 2012.

PSE PUGET SOUND ENERGY
The Energy To Do Great Things
Puget Sound Energy
P.O. Box 97034
Bellevue, WA 98009-9734
PSE.com

April 30, 2012

Daniel Evans, Principal
Promus Energy LLC
1201 Third Avenue, Suite 320
Seattle, Washington 98101

Re: Letter of Interest in Renewable Natural Gas - Washington State Dairy Farm Anaerobic Digesters

Dear Mr. Evans:

We understand that a state/federal funded study is evaluating the feasibility of converting anaerobic digesters at Qualco Energy- near Monroe, WA and at the George DeRuyter and Sons Dairy- near Sunnyside, WA from combined heat and power (CHP) operation to production of pipeline quality renewable natural gas (RNG). Puget Sound Energy ("PSE") is interested in purchasing RNG from these digesters, subject to the negotiation of a purchase and sale agreement. Our financial terms would include:

- Purchase Price of the RNG would include a current natural gas market value component (First of the Month Sumas Index) and a premium for the environmental attribute.
  - The premium would be based on a negotiated sharing of the market value of the environmental attributes (e.g. when the RNG is sold as biogas for renewable compliance, used to generate RECs and/or used as a transportation fuel to create RINs).
- A negotiated term of at least 5 years with the potential of up to a 20 year agreement.
- Consideration of a floor and ceiling price arrangement that may support financing requirements in the initial years of the project.

The RNG must meet all pipeline quality standards. All capital and operating costs, including costs of interconnection and injection into the pipeline, would be borne by the producer. PSE has gained valuable experience as the result of making arrangements for the purchase of RNG produced from the Cedar Hills Regional Landfill (King County, WA) and thus may be able to assist in establishing interconnections and operating procedures with Northwest Pipeline.

Our commitment to the provision of renewable energy for our customers would be enhanced by this opportunity and could extend to additional farms producing RNG in Washington State. Thank you for the opportunity to express our interest in these projects.

Sincerely,

Bill Donahue

Bill Donahue
Manager, Natural Gas Resources

Chapter Four — RNG Design

While Chapter 3 was a summary of the RNG markets, opportunities/hurdles, and potential downstream infrastructure required for sales of produced RNG under various scenarios, this chapter focuses on on-site infrastructure and operation necessary to produce a relatively pure methane gas product at flow rates appropriate for effective scaling of identified technologies.

Design Alternatives

Scrubbing Technology

After biogas is produced from the AD process, it contains numerous non-methane containments, including water, carbon dioxide, and hydrogen sulfide. Depending on the composition of the substrate, the biogas could contain nitrogen, oxygen, ammonia, siloxanes, and other impurities that must all be removed from the methane to achieve pipeline quality gas. Table 4.1 compares the different technologies we evaluated for achieving pipeline quality gas, with specific details of the varying approaches summarized after the table. Raw biogas must be purified to meet the quality standards that are specified by major pipeline transmission and distribution companies. This standard fluctuates from 90% on up, depending on the company. For Qualco it was assumed that 95% pure methane is needed to achieve pipeline quality gas. It can contain up to two percent by volume of carbon dioxide and cannot contain more than three percent by volume of combined non-hydrocarbon gases.

Table 4.1: Summary of approaches and parameters

Parameter	PSA	Water Scrubbing	Organic Scrubbing	Chemical Scrubbing
Pre-cleaning needed	Yes	No	No	Yes
Working pressure (bar)	4 - 7	4 - 7	4 - 7	No Pressure
Methane loss	< 3 % / 6-10%	< 1 % / < 2%	2-4%	< 0.1%
Methane content in upgraded gas	> 96%	> 97%	> 96 %	> 99%
Electricity consumption (kWh/Nm3)	0.25	< 0.25	0.24-0.33	< 0.15
Heat requirement (C)	No	No	55 - 80	160
Control to nominal load	+/- 10-15%	50-100%	10-100%	50-100%

When the raw biogas exits the digesters it is saturated with water vapor. This vapor can be corrosive and can cause mechanical wear if the gas scrubbing system is not designed to handle the water. Water vapor may be removed prior to gas scrubbing using various condensation techniques, or depending on the technology, during the scrubbing process.

Hydrogen sulfide can be dealt with in two ways. First there is the option to add precipitation to the digester. A historically common approach, with considerable operating and maintenance cost, is to add Fe^{+2} or Fe^{+3} ions, in certain forms, to the digester, however there are other technologies, besides precipitation, that can also be used to clean hydrogen sulfide from the biogas. Active carbon, chemical absorption, and biological treatment are among these processes that were analyzed to remove hydrogen sulfide. *Active carbon* is often used when hydrogen sulfide content is less than 1 ppm. The carbon filter is impregnated with other elements to speed up the process and produce a higher quality gas. The filters must be replaced when saturated with hydrogen sulfide and, although this method is extremely simple, the cost is high due to the replacement of filters. *Chemical absorption* is the use of sodium hydroxide to clean biogas. This is a very technical process and requires a great deal of management due mainly to the use of a caustic solution. This method is only used when very large quantities of gas are being cleaned or when there is a high level of hydrogen sulfide. Even under these conditions, chemical absorption is not used widely in small-scale applications due to high-risk potential and high cost of the process. This method was widely used in sewage sludge treatment plants before precipitation became the standard. *Biological treatment* is the addition of *Thiobacillus* and *Sulfolobus* microorganisms for aerobic conversion to elemental sulfur. This process can be added to the digester or added as a filter after the digester. This method is widely used in other applications but not for pipeline quality gas due to the unsuitable traces of oxygen left behind by the microorganisms.

Pressure Swing Absorption

Another technology, Pressure Swing Absorption (PSA), uses a carbon-absorbing material. This process uses four to nine vessels that work in parallel. One vessel is filled and pressurized with raw gas and the carbon dioxide and hydrogen sulfide are absorbed into the carbon material. At that time the clean gas is released and the pressure is then dropped to release the carbon dioxide from the ion-absorbed material. Each vessel takes its turn to produce a relatively steady flow of gas. Once the hydrogen sulfide is absorbed in these filters it cannot be reversed. Absorption material must be replaced on a regular basis due to the hydrogen sulfide and the destruction of the material by water. Water vapor must be removed from the gas before it is treated in the PSA system.

Water Scrubbing

Water scrubbing is another form of gas upgrading. This technology is based on the principle that carbon dioxide has a higher solubility in water than methane. The raw gas is run against the flow of water, in a scrubbing vessel, which absorbs the carbon dioxide and all the other contaminates. The water containing the carbon dioxide and contaminates is run through a stripping vessel which allows the contaminating material to be stripped out of the water and released. Water scrubbing has been widely used in the industry and comes in a broad array of capacities and suppliers.

Organic Scrubbing
Organic scrubbing uses the same method as the water scrubbing with one major difference. Instead of water, organic solvent, such as polyethylene glycol, is used to absorb the contaminating material. Carbon dioxide has a higher solubility rate in polyethylene glycol than in water, which means that gas-cleaning plants can be smaller in size compared to water scrubbing. On the other hand, water is cheaper and more readily available than polyethylene glycol.

Chemical Scrubbing
Chemical scrubbing uses specific chemicals to absorb contaminates and has the lowest methane loss of all the technologies. This method can absorb the hydrogen sulfide but it is recommended to remove it before the chemical scrubbing process. This is done because of the added complexity of regenerating the chemicals to reuse for gas cleaning. This process is usually used in large-scale plants and must have highly trained individuals that work with the chemicals.

Membranes
Membranes are another form of gas upgrading technique. These membranes are permeable to carbon dioxide, water and ammonia. Hydrogen sulfide must be taken out before the membrane by using a carbon filter. This is considered the classic technique for gas upgrading but has the highest methane loss compared to other systems.

Transportation
Transportation, storage and the construction of a pipeline were all assessed to see which option was more feasible for getting RNG to market. There were two types of storage that were considered: onsite permanent storage and tube trailers. Onsite storage would be expensive, take up space, and another storage tank would be needed at the receiving end of the gas distribution. Tube trailers on the other hand have more advantages than disadvantages. Some advantages are mobility, storage, and the creation of a virtual pipeline. The only disadvantage is that one tube trailer cannot store as much methane as an onsite storage tank possibly could, but more than one tube trailer could be purchased.

American Strategies Group supplied Promus Energy with information on several different types of trailers, as well as the compression equipment specifications and filling options. The Titan module from Lincoln Composites and the ISO Container C340 from Integrated Compressed Natural Gas (ICNG) are composite tube trailers that use composite tanks instead of steel tanks. Composite tanks weigh less and have a much higher capacity than steel tanks. Although composite tanks are much more expensive than traditional steel tanks, their lack of weight makes them the more efficient choice, if the gas must be transported by truck. Table 5.4 provides a comparison of traditional steel tanks and the new composite tanks.

Table 4.2: Summary of transportation equipment

Storage Method	Number of tanks/trailer	Weight (Tanks, Frame, Trailer)	CNG Capacity	CNG Weight
50 bar TITAN module	**4**	**19,500 kg**	**10,064 SCM**	**7,380 kg**
3AAX-2900 (12.2 m)	10	35,930 kg	5,677 SCM	4,070 kg
Type II tank (12.2 m)	3	28,500 kg	6,700 SCM	4,913 kg
Type II tank (125 L)	162	33,750 kg	6,235 SCM	4,570 kg

ISO Container C340

Product	40-foot Three Tube ISO Container	
Length	40 feet	12.192 m
Width	8 feet	2.438 m
Height Container	8 feet	2.438 m
Weight of Container	~ 80,416 pounds	~ 36.5 MT
Tare Weight	~ 63,916 pounds	~ 29.0 MT
Net Weight (Payload)	~ 16,500 pounds (gas)	~ 7.5 MT (gas)
Operating Pressure	3600 psi	250 bar
Operating Temperature	-40F to 112F	-40C to 45C
Volume Gas (STP - CNG)	~ 280,000 ft^3 (975 ft^3 water volume)	~ 8,000 m^3 (27,600 L water volume)

Certifications - Pressure Vessels
Designed to ISO 11119-1:2002 Gas cylinders of composite construction -- Specification and test methods -- Part 1: Hoop wrapped composite gas cylinders and ASME Section VIII, Div 3 and Section X and Code Case 2390. Certified by American Bureau of Shipping (ABS).

Certifications - Container
Open tank container designed and manufactured to ISO Standards (*1496-3-4th Edition – 1995-03-01 Tank Containers)*, and certified by ABS or equivalent for international use under the Convention for Safe Container guidelines (CSC).

(ICNG, Scott Peterson)

Titan Module

Property	SI Units	English Units
Water Volume (@250 bar)	8530 L	2253 gallons
Operating Pressure	250 bar (@ 15C)	3600 psi (@ 59F)
Weight	2400 kg	5291 pounds
Diameter	1.08 m	42.6 in
Length	11.6 m	38 feet
Gas Capacity	2516 SCM	88,860 SCF
Tanks/module	4	4
Total water Volume	34,220 L	9,013 gallons
Operating Pressure	259 bar (@15C)	3600 psi (@ 59F)
Max Fill Pressure	325 bar (@15C)	4500 psi (@59F)
Module Dimensions	2.44m x 2.44m x 12.2m	8' x 8 ' x 40'
Module Weight (1bar)	14,500 kg	31,970 pounds
Gas Capacity	10,064 SCM	355,440 SCF
Gas Mass	7,380 kg	16270 pounds

(Lincoln Composites)

Dispenser (Filling) Station

American Strategies Group (ASG) specializes in the development of virtual pipelines and fueling stations for compressed natural gas. This company has done extensive research on the different technologies for refueling stations, decompression cabinets for pipeline insertion, and compressors for the refueling stations. After the technology was analyzed, ASG supplied Promus Energy with detailed information on suppliers and different technologies, and recommended SAFE Technologies. SAFE has high-quality equipment at a competitive cost, and has more than 31 years of operational history and manufacturing, which allows them to have products that will fit any customer’s needs. The equipment is also extremely efficient and well tested.

CONCLUSION

Scrubber

After extensive research and consideration of all the factors for this feasibility study, water-scrubbing technology comes to the top of the list, with the second choice being PSA scrubbing.

Water scrubbing was selected for many reasons. These include a longer life with less maintenance with few high-wear parts that must be replaced, and the fact that the technology takes care of all the contaminants without having to add other mechanisms to achieve pipeline quality gas. Although this is not the cheapest technology when it comes to capital cost, lower operation and maintenance costs over the life span of the project gave this choice the edge for this dairy application. Another factor that influenced the decision was the safety and reliability that water scrubbing supplies. No harsh chemicals or specific liquids must be bought, which is key when rural areas are the location of the gas-cleaning units.

Once the water scrubbing technology was chosen, the next task was to identify a supplier. Flotech Greenlane was one of the first to commercialize an extremely efficient product and has had the best track record with the technology. Although the company is based out of Sweden, all of the parts required are manufactured in the USA, which makes shipping cheaper and faster. The units are also modular and self-contained. This means it can be assembled and hooked up without any major engineering designs. Greenlane supplies everything that is needed to take raw biogas to pipeline quality, from the compressor to the flash tank. The units supply a heat recovery option that is efficient enough to heat the digester in place of the CHP engines that previously supplied heat. Not only do they supply a spare parts package, they also check assembly and make sure that the unit was assembled properly to make gas production efficient with as little down time as possible. They also offer a remote monitoring system, where they monitor the system to make sure gas is in spec and that all the pieces are working together. Greenlane has systems that are sized for small- to large-scale operations. This is critical because there is not a custom setup for each dairy that must be designed for the scrubber and all of its components. These units are complete and do not require a large amount of space to install. Greenlane has also been the quickest to respond with information and has had the best customer service record available.

The Greenlane unit named Rimu fits the Qualco digester best. It has an inlet condition that ranges from 155 cfm to 500 cfm, thus allowing for the projected flow as well as fluctuations. Table 4.3 provides a summary of the Rimu system.

Table 4.3: Summary of Rimu system

Rimu	Max Input	500 SCFM
Numbers are based on following assumptions		
1) Inlet Condition- 15.3 psia, 86 degrees F	a=Atmospheric Pressure	
2) Standard Conditions are defined as 60degF @ 14.7 psia		
Operation hours per Year	8350	Hours
Gas Produced per year	*150,801,000*	*SCF/year*
	1,190,502.88	*GGE/year*
	158,341,050,000	*BTU/year*
	158,341	*MMBTU/year*
Separated Gas: typical composition is 56% N_2, 29% CO_2, 14% O_2, 1% H_2O+H_2S. (Based off of 60/40 Methane to CO_2 ratio)		

Heat recovery = 144.1 Horsepower (Boiler) which is 4,819,510 BTU/hour

(Flotech)

Transportation

For the transportation, and gas-dispensing unit, American Strategies Group led Promus Energy in the right direction. Out of the tube trailers that were supplied, the ISO container was chosen over the Titan container. The ISO was the cheaper of the two composite tank companies and gave it the edge over Titian since the companies have the same composite technology. SAFE was the company of choice for the gas dispenser unit, decompression cabinet, and the compressor. Their technologies were designed to work together which eliminates most of the engineering risk that would come with piecing these technologies together from different companies. The model of compressor chosen from SAFE is the S963. This compressor will be able to process 360,000 cubic feet of biogas per day. SAFE paired this compressor with a dispenser that has two hoses set up for fast fill applications. Along with choosing the compressor and filling station, a decompression cabinet was chosen to take the 3600 psi biogas and decompress it down to pressures suitable for pipeline injection. After analyzing the performance, cost, and support of the different companies and technologies, we selected the best-fit applications for the Qualco project.

References

Websites for various technology providers were accessed for summary and technical information.

Acrona-Systems PSA (www.acrona-systems.com)
Air Liquide Membrane (http://www.airliquide.com)
CarboTech PSA, chemical absorption (http://www.carbotech.de)
Cirmac PSA, Chemical absorption, membrane (www.cirmac.com)
Flotech Sweden AB Water scrubber (www.flotech.com)
Gasrec PSA/Membrane (www.gasrec.co.uk)
GtS Cryogenic (www.gastreatmentservices.com)
HAASE Organic physical scrubbing (www.haase-energietechnik.de)
Läckeby Water Group AB Chemical absorption (www.lackebywater.se)
Malmberg Water scrubber (www.malmberg.se)
MT-Energy Chemical absorption (www.mt-energie.com/)
Prometheus Cryogenic (www.prometheus-energy.com)
Terracastus Technologies Membrane (www.terracastus.com)
Xebec (QuestAir) PSA (www.xebecinc.com)

Chapter Five — RNG Economic Analysis

INTRODUCTION

Chapter 3 and Chapter 4 have described in detail the market opportunities as well as technology choices and assumptions related to the Qualco conversion from CHP to RNG. In this chapter, all of the information is put together to develop a Pro Forma for the RNG Options identified in Chapter 3. Key assumptions made during development of the cash flow Pro Forma (2012-2032) include:

- **Renewable Fuel Standards Credits (RINs).** RNG revenues are maximized if the RNG is distributed as transportation fuel generating RINs. This analysis assumes that Qualco controls the RNG and receives 100 percent of the RIN value. A sensitivity analysis is provided for reduced capture of the RIN value.
- **Biogas.** The analysis assumes that Qualco continues to produce 400 cfm of biogas. A sensitivity analysis is provided for production of 500 cfm.
- **RNG Production.** RNG production is assumed to commence in 2014, allowing for project development, although discussion on this timeline is given in more detail in Chapter 6.
- **Financing.** This analysis assumes a 20-year loan at 7 percent interest. Although the dairy had 1 percent financing for its digester project, this may not be available for this additional investment. A sensitivity analysis is provided for lower interest rate financing.
- **RNG Transport.** A pipeline had previously been assessed by Qualco and found to be impractical given permitting challenges. It is assumes that Qualco will transport the RNG by tube trailer.

Biogas Production

The digester produces approximately 400 cfm of biogas resulting in 799,000 GGE per year/106,000 million MMBTU of RNG per year. This assumes that none of the gas is used to generate power for operation of the digester or scrubber. All RNG is pipeline quality.

Table 5.1 Qualco RNG production

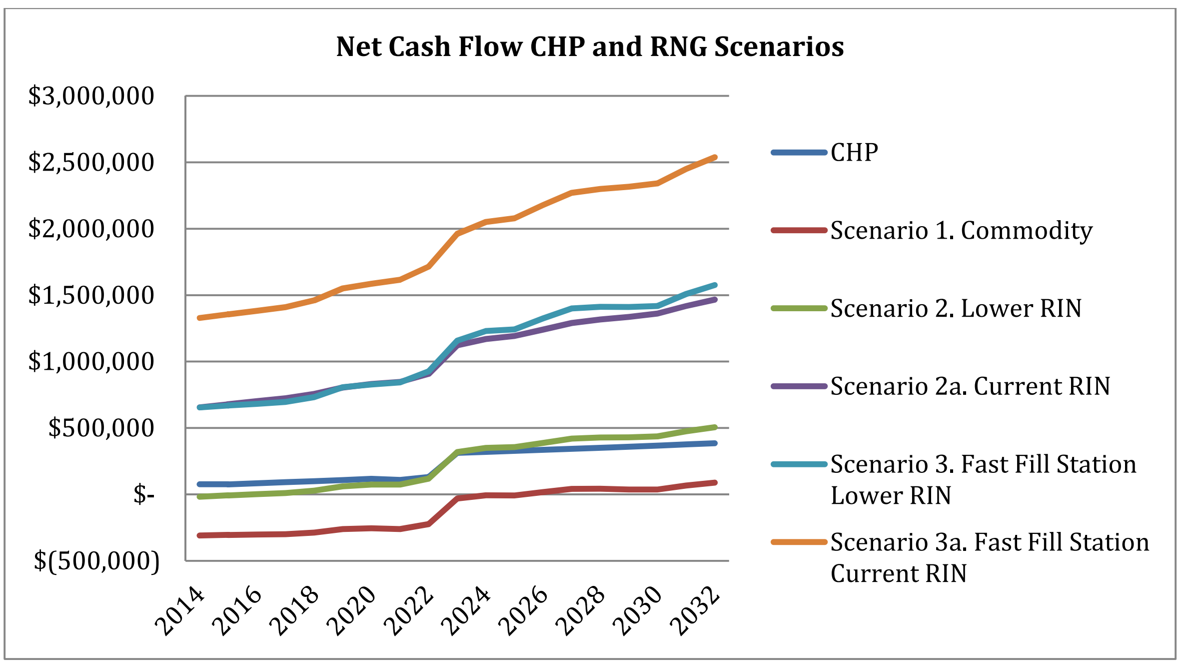
RNG Production Per Year (No Parasitic Use)	
100,701,000	SCF/year
799,214	GGE/year
105,736,050,000	BTU/year
105,736	MMBTU/year

Revenue Alternatives. Three revenue scenarios were reviewed:

- **Scenario 1 Commodity Value.** Qualco receives the commodity price of natural gas with no RIN value. This results in pre-tax cash flow that is less than the pre-tax cash flow from the existing CHP operation.
- **Scenario 2 RIN Value.** The RNG is sold as transportation fuel generating RIN values in addition to the commodity value.
- **Scenario 3 Fast Fuel Station.** The RNG is used as transportation fuel generating RIN values and is dispensed at a fast fuel station operated by Qualco.

Figure 5.2 below shows the cash flow from the current CHP operation and the RNG scenarios. Revenues in all scenarios are the same for fiber sales and tipping fees.

Figure 5.1: Comparison of the RNG scenarios with baseline CHP



Specific details and quantitative conclusions from the cash flow summaries for the respective scenarios are:

- **Scenario 1 Commodity Value**. Cash flow under this scenario is negative until 2026 when it generates cash flow of $18,000. Annual cash flow increases to $89,000 in 2032 which is lower than the projected cash flow of $385,000 in 2032 with CHP operation.
- **Scenario 2 RIN Value**. With the lower RIN value, cash flow is negative until 2016 when it generates cash flow of $2,000. Annual cash flow increases to $506,000 in 2032 which is higher than the projected cash flow of $385,000 in 2032 with the CHP

operation. With the current RIN value, cash flow is $587,000 higher in 2014 and in 2032 it is $1.1 million higher than the CHP projection.

- **Scenario 3 Fast Fuel Station**. Cash flow under this alternative is greater than under any other scenario. With the lower RIN value, cash flow is $579,000 better in 2014 than the current CHP operation and $1.2 million better in 2032. With the higher RIN value, cash flow is $1.3 million better in 2014 and $2.2 million better in 2032 than the current CHP operation.

REVENUES

RNG revenues are more difficult to estimate than electricity sales revenue because under existing federal law, natural gas utilities, unlike electrical utilities, are not required to purchase gas from small producers and such sales are not subject to regulation by the WUTC. RNG revenues are estimated as: commodity prices, RINs, and retail fast fill station prices.

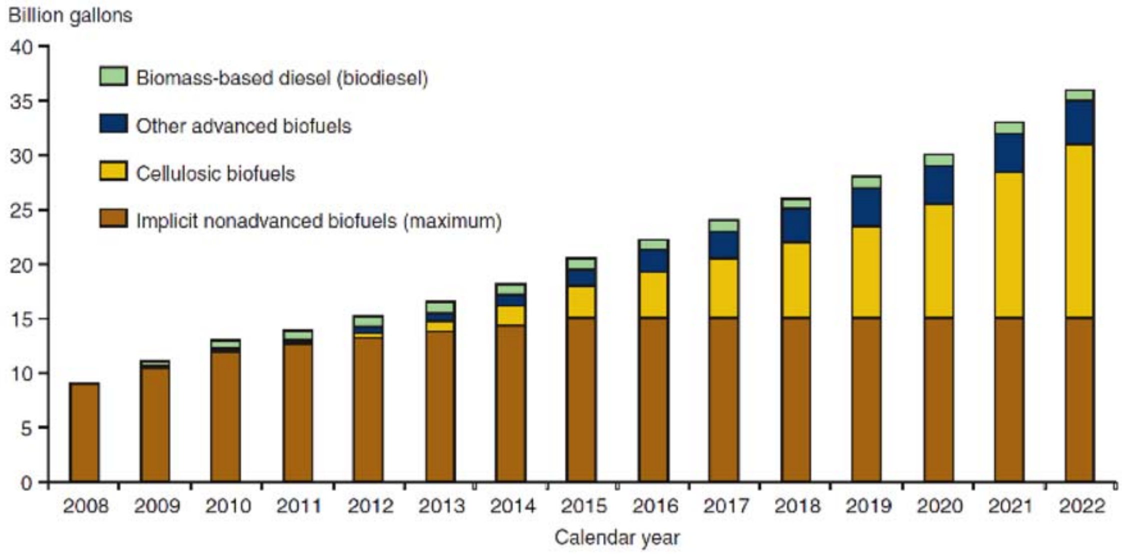
Commodity Price

National forecasts by the U.S. Energy Information Administration (EIA) project a stable and growing source of domestic natural gas supply with relative price stability, largely as the result of the discovery of substantial new supplies of shale gas in the Mountain West, the South and throughout the Northeast's Appalachian Basin. This results in relatively low projected commodity prices for natural gas. This analysis assumes that Qualco receives the Sumas Cascade commodity price (i.e. the wholesale price for gas at the border between Washington and Canada) for its gas. The Sumas Cascade price was estimated based on the March 2012 EIA forecast for prices at the Henry Hub reduced by the projected difference between the Henry Hub price and the Sumas Cascade Price in the Cascade Natural Gas 2011 Integrated Resource Plan. Under this analysis, the Sumas Cascade price forecast is $3.87 per MMBTU in 2014 increasing to $6.07 per MMBTU in 2032, resulting in revenues of $613,000 in 2014 increasing to $961,000 in 2032.

Renewable Fuel Standard Credits/RINs

The 2005 Energy Policy act created the first Renewable Fuel Standard (RFS). RFS2, the current version of this standard, requires 15.2 billion gallons of renewable fuel be created or imported into the United States by 2012, and 36 billion gallons by 2022 when the mandates expire. Specific carve-outs for the amount of advanced biofuels (renewable fuel other than ethanol from corn starch), cellulosic biofuels (from cellulose, hemicelluloses or lignin from renewable biomass) and biodiesel (fuel from renewable biomass) are included. These fuels must make up a greater portion of the renewable fuel in the United States over time, as illustrated in Figure 5.2.

Figure 5.2: RFS mandate 2008-2022 (McPhail et al, 2011)



Biogas that is captured at manure digesters, landfills and sewage and waste treatment plants, cleaned, compressed and used to fuel vehicles qualifies as an "advanced biofuel" under the RFS2 (blue bar in Figure 5.2). Just as digester projects that make electricity can sell the renewable benefit of this electricity, digester projects that make transportation fuel can sell the biofuel benefit of this fuel to producers and importers that have to demonstrate that a certain portion of their fuel qualifies as an "advanced biofuel" under the RFS2.

In electricity projects, Renewable Energy Certificates (RECs) are used to ensure compliance with Renewable Portfolio Standards. For transportation fuel projects, Renewable Identification Numbers (RINs) are used to track compliance with the RFS2. When advanced biofuels are produced and used, RINs remain a separate commodity from the fuel itself. The Qualco project has the potential to earn RINs in the scenarios in which the project owns the equipment that cleans and compresses biogas and fuels vehicles. In the scenarios in which Qualco does not own this equipment, the project will not generate RINs directly. With appropriate contracts and monitoring systems in place, however, the owner of the fueling equipment who purchases the RNG from Qualco could generate RINs. In these scenarios, the project has instead been modeled to charge a "green premium" on the RNG sales to reflect the increased value the purchaser of the gas can realize.

Revenue from the sale of RINs depends upon the following three factors:

1. The price at which these RINs are sold;
2. The number of RINs generated by the project; and
3. The transaction costs associated with monitoring, verifying, and commercializing the RINs.

Data on the current price of Advanced Biofuel RINs was gathered from the Oil Price Information Service. In 2011, Advanced Biofuel RINs sold for between $0.69-$0.74/RIN, with an average price of $0.715/RIN. In 2012, prices have been very similar, between $0.69-$0.75/RIN, with an average price of $0.72/RIN. Market participants, however, warn that RIN prices are extremely volatile and difficult to predict; these historically high prices are a result of skepticism that the requirements for advanced biofuel can be met in the short term. If larger quantities of advanced biofuel were made available, prices would likely drop quickly. Ethanol production has greatly exceeded the requirements of the RFS2, so RINs from “non-advanced biofuels” like ethanol are currently trading for as low as $0.02/RIN.

Given this historic volatility, current RIN prices for advanced biofuels were modeled under two pricing scenarios: the current RIN value and a more conservative value of $0.25/RIN. This is similar to “mid” RIN price of $0.20/RIN used by a recent Oregon study of bio-methane from wastewater treatment plants (Oregon Department of Energy, 2012). Market participants confirmed that this is likely a best guess for the long-term value of Advanced Biofuel RINs.

Qualco is anticipated to generate 100,701,000 SCF of bio-methane for transportation fuel per year; this is equivalent to 105,736 MMBTUs per year. As set out in the RFS2, every 77,000 BTUs of bio-methane is equivalent to 1 RIN. The project is therefore anticipated to generate 1,373,195 RINs per year. Although there is no mandate for purchasing RINs under the RFS after 2022, this analysis assumes if the RFS2 sunsets, another renewable fuel incentive will exist after 2022 and its value is assumed to be at least equivalent to the value of RINs. The project Pro Forma therefore includes RIN revenue over the entire project lifetime through 2032.

Transaction costs for generating RINs have been included in this analysis. To create a RIN the facility producing renewable fuel must be registered in the EPA Moderated Transaction System by a third-party engineer. On this EPA system, RINs are screened, registered and traded. Each RIN must be registered within four days from the time the fuel is created. While no third-party verification is required of each registered RIN facilities can be audited by the EPA. After discussions with a variety of market participants and brokers, the project Pro Forma estimates that the transaction costs associated with registering facilities, registering RINs, and contracting to sell the RINs will be equal to 10% of the value of the RINs under the “Conservative Price” scenario.

Putting it all together in the Pro Forma, RINs under both pricing options are assumed to inflate at a rate of 2 percent per year. Transaction costs start at $51,000 per year and also increase at 2 percent per year. RIN revenue net of transaction costs under the current advanced biofuel RIN pricing is $965,000 million in 2014 growing to $1.4 million in 2032. Under the lower pricing, revenue is $292,000 in 2014 growing to $417,000 in 2032.

Retail CNG Station Price

The current retail price of CNG in the Seattle area is $1.85/GGE. This analysis assumes that the price remains at $1.85/GGE in 2014 and changes at the same rate as changes in the Sumas Cascade commodity prices. Actual retail prices will be affected by the rate of introduction of CNG vehicles into the U.S. fleet, which may have a substantial affect on CNG prices. The potential of a "concerted U.S. policy effort to shift the transportation sector away from oil toward natural gas would significantly increase demand, and thus natural gas prices" (PacifiCorp IRP 2011, pg. 29). Retail revenues under this scenario are $1.7 million in 2014, increasing to $2.7 million in 2032 at the lower RIN value or $2.4 million to $3.7 million with the current RIN value.

OPERATION COSTS

RNG Production Operating Expenses

The operating expenses include repair and maintenance, power, other scrubber costs, on-going operation cost ($300,000 of the $380,000 CHP operation expense is estimated to be on-going costs), and property taxes.

As shown in the Table 5.1 below, total operating expenses in 2014 are $528,000. Annual operating expenses are projected to increase by 2 percent per year for inflation.

Table 5.2: Operating costs of RNG

RNG Scrubber and Digester Operation Cost, 2014		
		%
Maintenance & Repair		
Digester reserve	$7,907	
Maintenance Agreement - Gas Cleaning Unit	$17,675	
Sub-total maintenance & repair	*$25,582*	5%
Electricity		
Gas Cleaning Unit	$114,634	
Digester	$16,833	
Sub-total electricity cost	*$131,467*	25%
Other Scrubber Costs		
Water	$ 1,772	
Lubrication Oil	$ 2,132	
Remote Monitoring	$ 16,200	
Sub-total Other Scrubber Costs	*$ 20,104*	4%
Other Operations Cost	*$300,000*	57%
Property Tax	*$51,000*	10%
Total Cost Operations Cost	**$528,153**	

RNG Transportation Off-Site Operation Costs

Operation costs assume $1.00 per mile cost of transporting gas with a round-trip of 30 miles per day to an injection point on the Williams pipeline. An additional $5,000 per year is allowed for maintenance expenses on the compressor and tube trailers. Costs are inflated at 2 percent per year.

Fast Fill Station Operation Costs

Operating costs of 25 percent of revenue are assumed to cover ground lease, staffing, and repair and maintenance of the station.

CAPITAL COSTS AND DEBT SERVICE

Capital costs include:

- **Gas Cleaning Infrastructure**. Capital costs are offset by the sale of the 450 kW generator currently owned by Qualco.
- **Tube Trailers.** The cost of tube trailers to transport the gas to the injection point.
- **Injection Point.** The cost of the injection point for injecting pipeline quality gas into the grid.
- **Fast Filling Station.** The cost of construction of a fast filling station on leased property.

Assumptions for the capital costs are:

- **Gas Cleaning Unit**. The cost estimate is based on a Flotech RIMU biogas upgrading system. Construction and installation include an allowance for on-site supervision by the supplier ($120,000); and contractor installation (20 percent), and mobilization and insurance costs (4 percent). A design allowance of 5 percent is provided for any drawings that may be needed.
- **Sale of Existing Generators**. The generators cost $450,000 new and are estimated to have a resale value of 10 percent.
- **Tube Trailer**. This cost estimate is for two floating pipeline trailers. Used trailers may be significantly less expensive, but pricing is time dependent. The trailers are USDOT approved with a capacity of 280,000 ft^3 at 3600 psi. A used tractor to pull the trailers is included.
- **Injection Point**. This cost estimate is based on Williams Northwest estimated cost of adding an injection point.
- **Fast Fill Station.** The cost estimate includes additional compression and construction of the station.
- **Contingency.** A 10 percent contingency is included.

- **Project Management.** A 4 percent cost of project management is included.

Capital costs are shown in Table 5.2 below. Total capital costs for Scenario 3 with the additional cost of a fast fill station. Capital costs range from $5.7 million to $4.9 million with debt service between $462,000 and $540,000 per year assuming 20-year 7 percent financing.

Table 5.3: Capital costs of RNG

	Gas Cleaning Infrastructure	Tube Trailer	Injection Point	Fast Fill Station
Gas Cleaning Equipment	$1,500,000			
Construction & Installation	$432,000	$43,125		$30,750
Spare Parts	$70,700			
Sale of Existing Generators	-$45,000			
Tube Trailers		$640,000		
Tractor		$10,000		
Compression On-Site		$287,500		
Injection Point			$1,000,000	
Fast Fill Station				$30,000
Fast Fill Compression				$175,000
Project Management 4%	$80,108	$46,046	$47,440	$11,184
Sales Tax	$172,232	$83,474	$86,000	$20,275
Design Allowance (5%)	$96,600			
Contingency (10%)	$200,270	$97,063	$100,000	$23,575
Total	**$2,506,910**	**$1,207,208**	**$1,233,440**	**$290,783**

	Capital Cost	Debt Service/Year
Scenario 1 & 2 - Commodity and RIN Value	$4,947,558	$468,000
Scenario 3 - Fast Fill Station	$5,238,341	$495,000

SENSITIVITY ANALYSIS

RIN Value

The Pro Forma assumes that Qualco captures 100 percent of the RIN value. This sensitivity analysis shows the impact if the RIN values are retained by Qualco at 0 percent, 25 percent, 50 percent, and 75 percent of their value. The charts (Figure 5.6 as landscape set) show that:

Scenario 2 RIN Value

- **Lower RIN Value – 100 percent of the RIN Value.** At the lower value of $0.25 per RIN, Qualco must receive all of the RIN value to generate greater cash flow than the

CHP operation by 2032. Scenario 2 with the lower RIN value does not generate as much cash flow as the CHP operation until 2023.

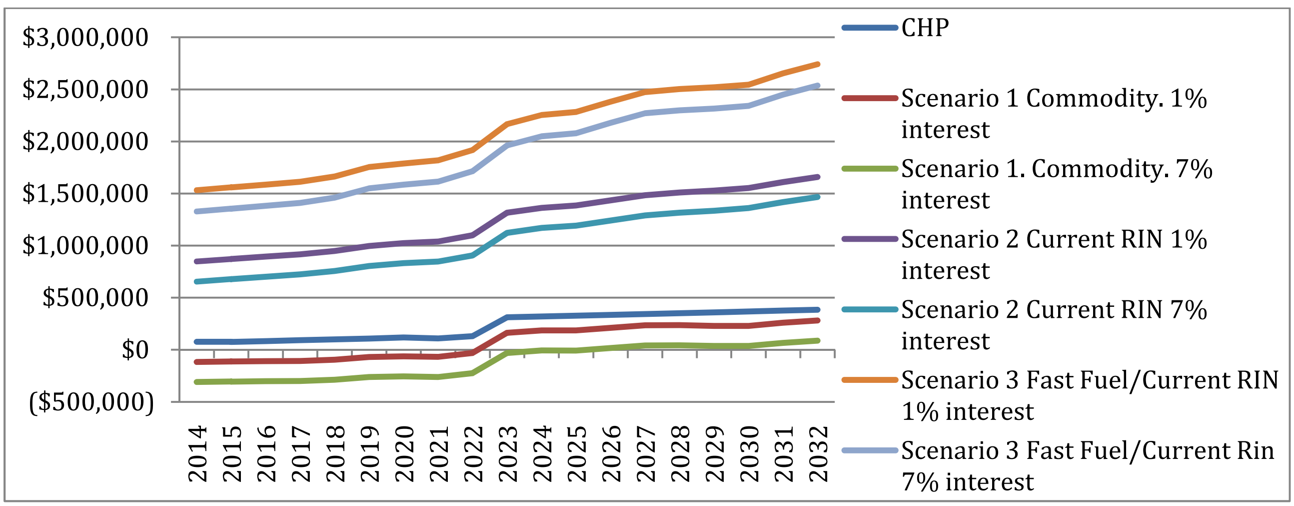
- **Current RIN Value – 50 percent RIN Value Needed.** At the current value of $0.74 per RIN, Qualco has greater cash flow with the RIN scenarios if at least 50 percent of the RIN value is retained by Qualco.

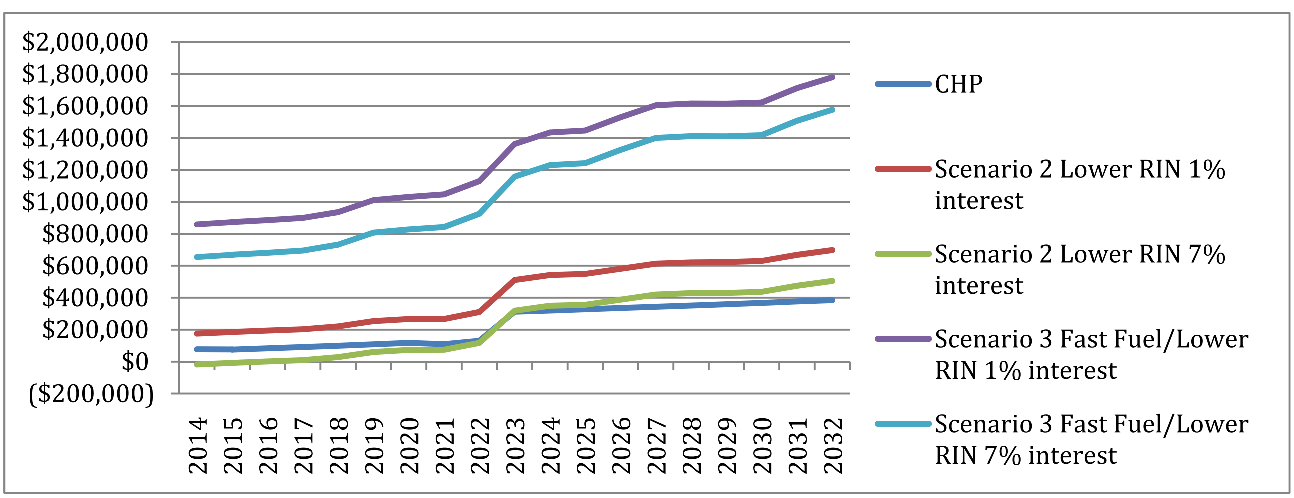
Scenario 3 Fast Fill Station – No RIN Value Needed. At the lower and the current RIN value, the fast fill station scenario generates greater cash flow even if Qualco does not have any RIN revenue.

Interest Rate

The Pro Forma assumes a 7% interest rate on a 20-year loan. This analysis shows the impact if Qualco is able to secure the same 1% interest it had on the original digester investment. The change in rate would reduce expenses by ~$200,000 per year (Figure 5.3).

Figure 5.3: Sensitivity of interest rate



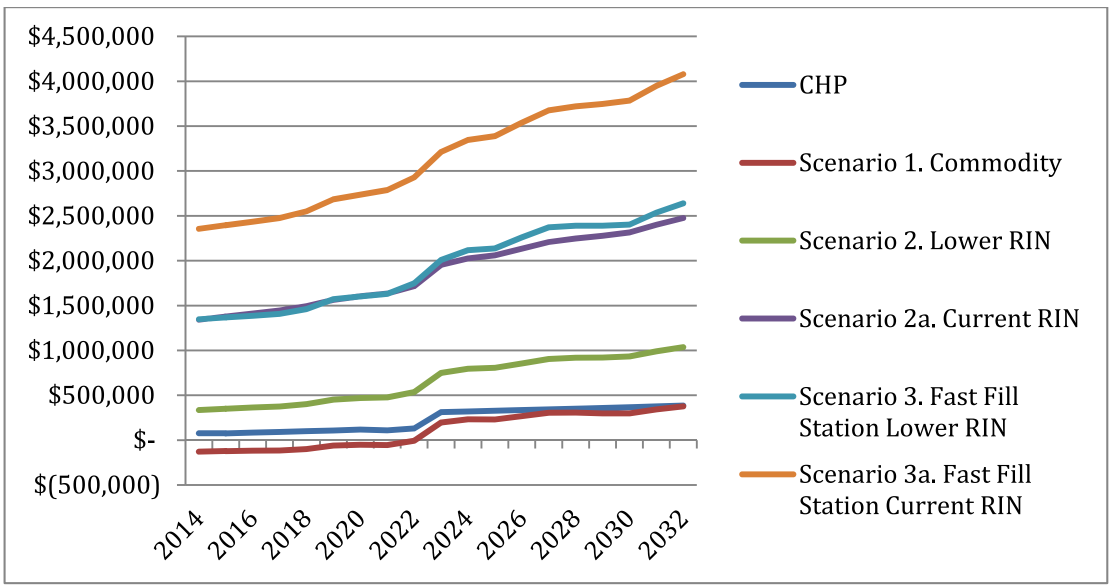


- **Commodity Value Scenario.** Even with 1 percent interest the commodity scenario does not generate more cash flow than the current CHP operation.
- **Scenario 2. Rin Value.** At 1 percent interest, cash flow is higher under Scenario 2 than with the CHP operation, which is not the case until 2023 at 7 percent interest.

Biogas Production

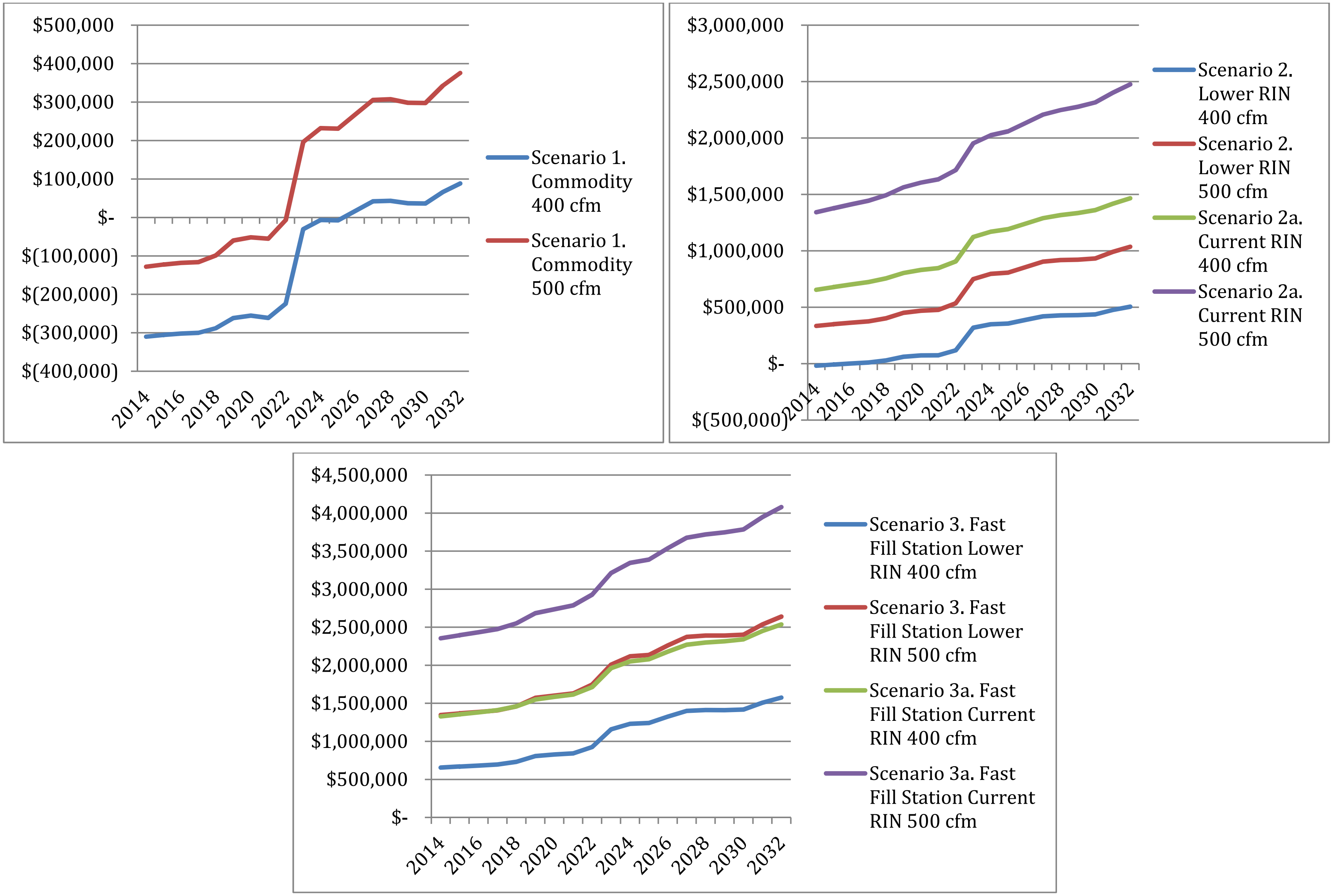
- Increasing biogas production to 500 cfm could be obtained by increasing the amount of substrate to greater than 30 percent, which would require a solid waste handling permit. For the purposes of this analysis, it is assumed that any additional tipping fees from the additional substrate would equal the cost of the solid waste handling permit.
- Under that assumption, revenues for RNG would be higher reflecting a more efficient operation of the Rimu gas scrubber unit which is designed to handle 500 cfm, higher RNG sales, and additional RIN values. The impact as shown in Figure 5.4 is that the Scenario 1, the commodity value, generates the same revenue as the current CHP operation. Scenario 2, when RIN values are added to the commodity price, produces more revenue than the CHP operation from the first year of operation even with the lower RIN value.

Figure 5.4 Current CHP compared to RNG scenarios at 500 cfm of biogas



As shown in Figure 5.5, cash flow under each RNG scenario is higher than with the 400 cfm operation.

Figure 5.5 Cash flow RNG scenario biogas sensitivity



CONCLUSION

The RNG analysis is driven by two questions: at what price can RNG be sold and what are the logistics needed to get the RNG to high-value markets? A shift to natural gas also opens the door for RNG to displace petroleum in high-value motor fuel markets. RNG pricing was evaluated under three scenarios and compared to the current CHP model:

1. Commodity natural gas pricing: If sold at low wholesale prices for pipeline gas ($3.87/MMBTU or $0.44/GGE), RNG produces less cash flow than the CHP model. This remains the case even if the interest rate is reduced to 1 percent from the 7 percent rate assumed in the pro-forma. If biogas production is increased to 500 cfm, the resulting RNG revenue is about the same as the current CHP operation.
2. Commodity plus "green premium" (RIN): When renewable credits are added to the commodity price of gas, RNG generates less net revenue than CHP through 2023 if the RIN prices are lower than the current RIN price. At the current RIN value, Qualco must receive at least 50 percent of the value of the RINs to generate more cash flow than the CHP operation. If interest rates are decreased to 1 percent or if biogas production is increased to 500 cfm, the lower RIN value generates more revenue than the CHP operation. Gas utilities, brokers, and CNG retailers are potential purchasers.
3. Retail CNG plus RIN: If producers take RNG to the retail CNG market, where CNG is now selling for $1.85 and up, it generates much more revenue than CHP, especially if credits are added. Even if credits are not added, this scenario still generates more cash flow than the current CHP model. Lowering the interest rate or increasing biogas production improves the retail CNG plus RIN cash flow.

The logistics needed to access these markets – gas cleaning and compression, pipeline injection, tube trailers, fueling facilities – are capital intensive and, although they offer profitable scenarios, the debt, unreliability of green credits, and operational risk can impede adoption of the model. These impediments can be addressed by:

- Reducing the debt burden through equity partners/developers and/or non-recourse loans or grants.
- Sharing the cost of common infrastructure through a cooperative, a public "host," or private development.

Table 5.4: Natural gas only pro forma – excludes other revenue sources

	2014	2015	2016	2017	2018	2025	2030
Scenario 1. Commodity							
Revenue							
Natural Gas	$ 409,098	$ 411,446	$ 413,223	$ 416,768	$ 427,224	$ 534,159	$ 588,941
RIN							
Total Revenue	**$ 409,098**	**$ 411,446**	**$ 413,223**	**$ 416,768**	**$ 427,224**	**$ 534,159**	**$ 588,941**
Operations Expense							
Scrubber & Digester	$ 528,153	$ 538,363	$ 549,130	$ 560,112	$ 571,315	$ 656,261	$ 724,565
Tube Trailer Transportation	$ 15,950	$ 16,269	$ 16,594	$ 16,926	$ 17,265	$ 19,832	$ 21,896
Injection (Delivery Charge)	$ 43,352	$ 43,352	$ 43,352	$ 46,820	$ 46,820	$ 54,611	$ 63,698
Fast Fill Station							
Total Operations Expense	**$ 587,455**	**$ 597,983**	**$ 609,076**	**$ 623,859**	**$ 635,399**	**$ 730,703**	**$ 810,159**
Net Income	**$ (178,357)**	**$ (186,537)**	**$ (195,853)**	**$ (207,091)**	**$ (208,175)**	**$ (196,545)**	**$ (221,218)**
Debt Service							
Scrubber & Digester	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)
Tube Trailer Transportation	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)
Injection	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)
Fast Fill Station							
Total Debt Service	**$ (468,000)**	**$ (468,000)**	**$ (468,000)**	**$ (468,000)**	**$ (468,000)**	**$ (468,000)**	**$ (468,000)**
Net Cash Flow	**$ (646,357)**	**$ (654,537)**	**$ (663,853)**	**$ (675,091)**	**$ (676,175)**	**$ (664,545)**	**$ (689,218)**
Scenario 2. RIN							
Revenue							
Natural Gas	$ 409,098	$ 411,446	$ 413,223	$ 416,768	$ 427,224	$ 534,159	$ 588,941
RIN (Lower RIN Value)	$ 291,889	$ 297,727	$ 303,682	$ 309,755	$ 315,950	$ 362,928	$ 400,701
Total Revenue	$ 700,987	$ 709,174	$ 716,904	$ 726,523	$ 743,174	$ 897,086	$ 989,642
Natural Gas	$ 409,098	$ 411,446	$ 413,223	$ 416,768	$ 427,224	$ 534,159	$ 588,941
RIN (Current RIN Value)	$ 964,755	$ 984,050	$ 1,003,731	$ 1,023,805	$ 1,044,282	$ 1,199,551	$ 1,324,401
Total Revenue	**$ 1,373,853**	**$ 1,395,496**	**$ 1,416,954**	**$ 1,440,573**	**$ 1,471,505**	**$ 1,733,710**	**$ 1,913,342**
Operations Expense							
Scrubber & Digester	$ 528,153	$ 538,363	$ 549,130	$ 560,112	$ 571,315	$ 656,261	$ 724,565
Tube Trailer Transportation	$ 15,950	$ 16,269	$ 16,594	$ 16,926	$ 17,265	$ 19,832	$ 21,896
Injection (Delivery Charge)	$ 43,352	$ 43,352	$ 43,352	$ 46,820	$ 46,820	$ 54,611	$ 63,698
Fast Fill Station							
Total Operations Expense	**$ 587,455**	**$ 597,983**	**$ 609,076**	**$ 623,859**	**$ 635,399**	**$ 730,703**	**$ 810,159**
Net Income Lower RIN	**$ 113,533**	**$ 111,190**	**$ 107,828**	**$ 102,665**	**$ 107,775**	**$ 166,383**	**$ 179,483**
Net Income Current RIN	**$ 786,398**	**$ 797,513**	**$ 807,878**	**$ 816,715**	**$ 836,106**	**$ 1,003,006**	**$ 1,103,183**
Debt Service							
Scrubber & Digester	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)
Tube Trailer Transportation	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)
Injection	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)
Fast Fill Station							
Total Debt Service	$ (468,000)	$ (468,000)	$ (468,000)	$ (468,000)	$ (468,000)	$ (468,000)	$ (468,000)
Net Cash Flow (Pre-Tax) Lower RIN	**$ (354,467)**	**$ (356,810)**	**$ (360,172)**	**$ (365,335)**	**$ (360,225)**	**$ (301,617)**	**$ (288,517)**
Net Cash Flow (Pre-Tax) Current RIN	**$ 318,398**	**$ 329,513**	**$ 339,878**	**$ 348,715**	**$ 368,106**	**$ 535,006**	**$ 635,183**

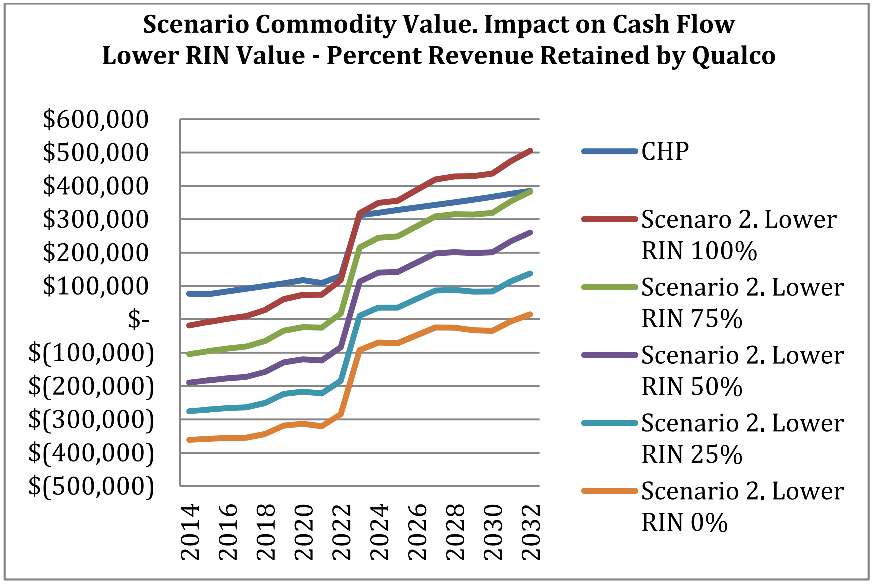
	2014	2015	2016	2017	2018	2025	2030
Scenario 3. Fast Fill Retail Station							
Revenue							
Natural Gas	$ 1,478,546	$ 1,487,034	$ 1,493,454	$ 1,506,267	$ 1,544,057	$ 1,930,536	$ 2,128,527
RIN Lower	$ 291,889	$ 297,727	$ 303,682	$ 309,755	$ 315,950	$ 362,928	$ 400,701
Total Revenue	$ 1,770,436	$ 1,784,761	$ 1,797,136	$ 1,816,022	$ 1,860,007	$ 2,293,464	$ 2,529,229
Revenue							
Natural Gas	$ 1,478,546	$ 1,487,034	$ 1,493,454	$ 1,506,267	$ 1,544,057	$ 1,930,536	$ 2,128,527
RIN Current	$ 964,755	$ 984,050	$ 1,003,731	$ 1,023,805	$ 1,044,282	$ 1,199,551	$ 1,324,401
Total Revenue	$ 2,443,301	$ 2,471,084	$ 2,497,185	$ 2,530,072	$ 2,588,338	$ 3,130,087	$ 3,452,929
Operations Expense							
Scrubber & Digester	$ 528,153	$ 538,363	$ 549,130	$ 560,112	$ 571,315	$ 656,261	$ 724,565
Tube Trailer Transportation	$ 15,950	$ 16,269	$ 16,594	$ 16,926	$ 17,265	$ 19,832	$ 21,896
Injection (Delivery Charge)	$ 43,352	$ 43,352	$ 43,352	$ 46,820	$ 46,820	$ 54,611	$ 63,698
Fast Fill Station	$ 369,637	$ 371,759	$ 373,364	$ 376,567	$ 386,014	$ 482,634	$ 532,132
Total Operations Expense	$ 957,091	$ 969,742	$ 982,439	$ 1,000,425	$ 1,021,413	$ 1,213,337	$ 1,342,291
Net Income Lower RIN	$ 813,344	$ 815,020	$ 814,696	$ 815,597	$ 838,594	$ 1,080,126	$ 1,186,938
Net Income Current RIN	$ 1,486,210	$ 1,501,342	$ 1,514,745	$ 1,529,647	$ 1,566,925	$ 1,916,750	$ 2,110,638
Debt Service							
Scrubber & Digester	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)	$ (237,000)
Tube Trailer Transportation	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)	$ (114,000)
Injection	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)	$ (117,000)
Fast Fill Station	$ (28,000)	$ (28,000)	$ (28,000)	$ (28,000)	$ (28,000)	$ (28,000)	$ (28,000)
Total Debt Service	$ (496,000)	$ (496,000)	$ (496,000)	$ (496,000)	$ (496,000)	$ (496,000)	$ (496,000)
Net Cash Flow (Pre-Tax) Lower RIN	**$ 317,344**	**$ 319,020**	**$ 318,696**	**$ 319,597**	**$ 342,594**	**$ 584,126**	**$ 690,938**
Net Cash Flow (Pre-Tax) Current RIN	**$ 990,210**	**$ 1,005,342**	**$ 1,018,745**	**$ 1,033,647**	**$ 1,070,925**	**$ 1,420,750**	**$ 1,614,638**

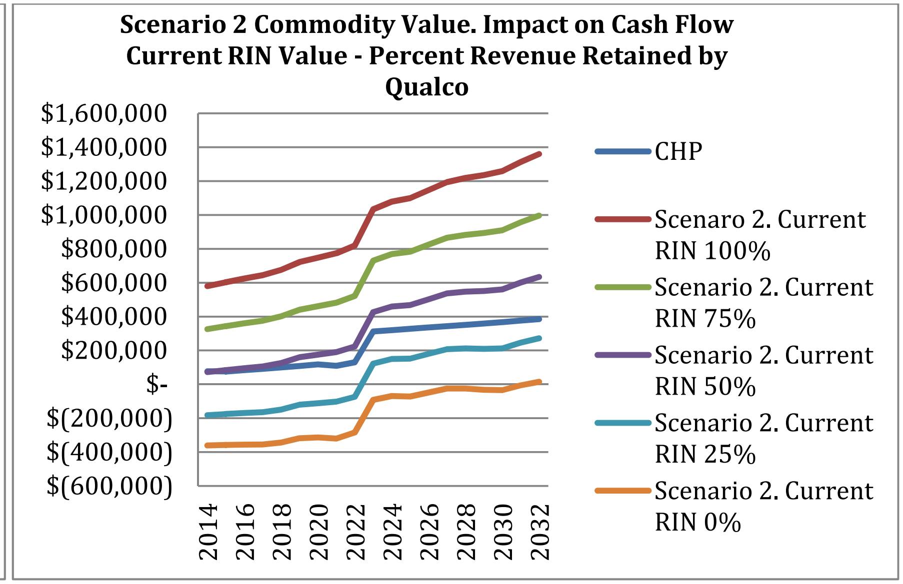
References

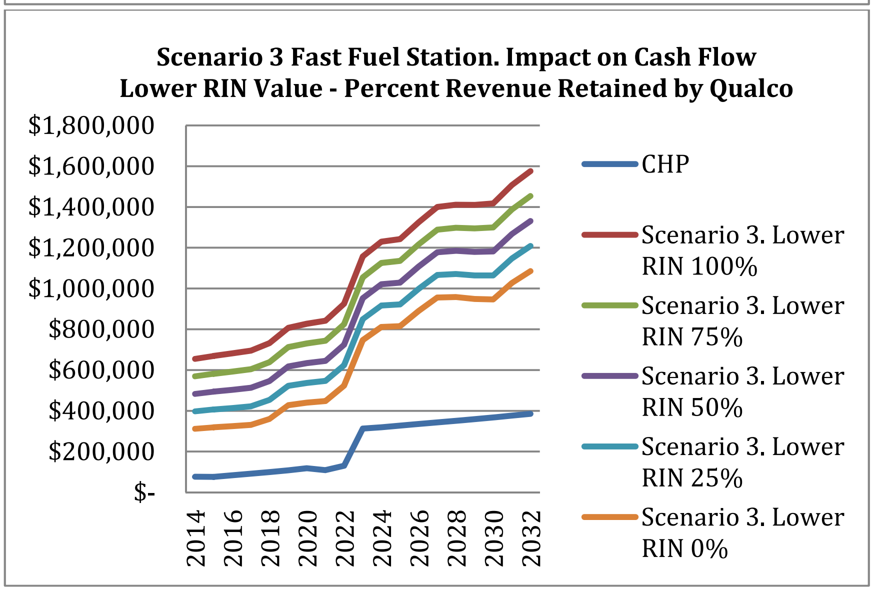
McPhail, Lihong et al. (2011). The Renewable Identification Number System and U.S. Biofuel Mandates. United States Department of Agriculture, Economic Research Service. BIO-03. November 2011.

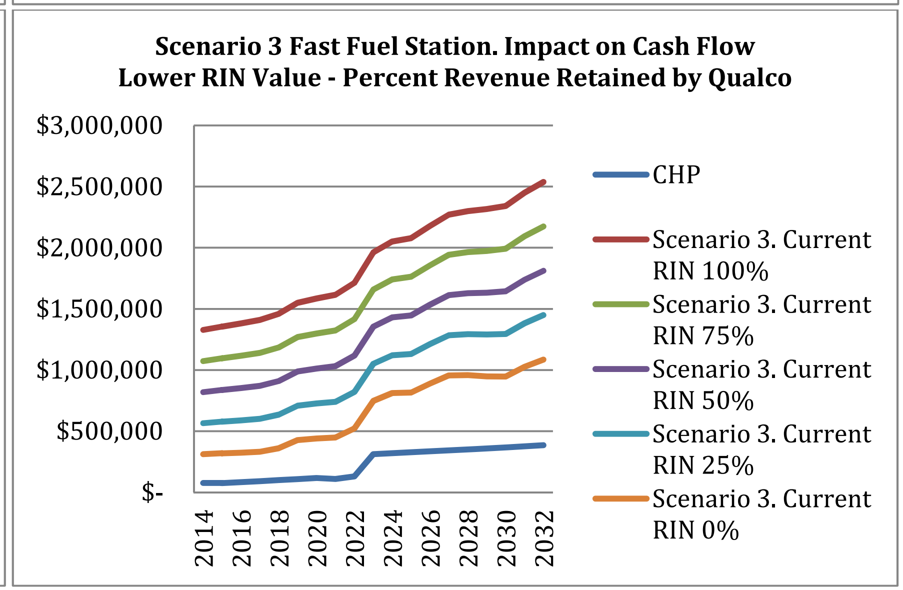
Oregon Department of Energy (2012) Bioenergy Optimization Assessment at Wastewater Treatment Plants. Oregon Department of Energy. March 20, 2012.

Figure 5.6: Sensitivity of RIN









Chapter Six — Project Permitting and Timeline

The purpose of this section is, in collaboration with the Governor's Office of Regulatory Assistance (ORA), to list the permits necessary to convert the Qualco CHP operation to RNG production, identify important permitting timelines, and highlight potentially complex or problematic permitting issues. The intent is to provide a permitting framework for the Qualco project developer, and potentially other RNG projects, and to provide policymakers and agencies with a clearer sense of any regulatory impediments to the adoption of the model and support that could facilitate its application. ORA, which hosted an AD working group (including the dairy community and agency stakeholders), provided much of the following permitting information and guidance. The following permitting summary uses excerpts of several ORA products as well as interviews with regional air quality and federal, state, and local permitting experts.

Overview of Digester-Related Permitting Needs and Issues

The Qualco digester was permitted and constructed more than three years ago to generate electricity. The emphasis here is on the process of converting the current Qualco CHP operation to production of marketable RNG, fiber, environmental credits, and potentially other products. However, if a viable and solidly profitable model is identified, there is sufficient manure from another dairy and high-energy substrate to justify a second digester. This chapter will therefore also permitting for a new digester, for the benefit of Qualco as well as to inform others who might consider digestion of organic wastes. Permitting for dairy ADs primarily includes complying with state and regional environmental regulations and local building, zoning, and development codes. Noting that Qualco is located within the flood plain, a new AD would require a flood plain development permit from Snohomish County PDS that could trigger federal involvement through FEMA, an Endangered Species Act consultation, and environmental review under the National Environmental Policy Act (NEPA). Each local jurisdiction has its own process for permitting new construction, in this case, Snohomish County, Puget Sound Clean Air Agency, and any other jurisdiction (e.g., City of Monroe) in which project facilities may be constructed.

Current state and regional environmental permitting requirements for dairy ADs

The primary state and regional environmental regulations affecting the construction and operation of dairy ADs are in the areas of solid waste, air quality, water quality and dairy nutrient management. Collaboration between agencies and stakeholders has significantly simplified the environmental permitting process for the existing dairy ADs (Figure 6.4).

<u>Solid Waste</u>

Initially, dairy ADs in Washington were conceived as "manure only" ADs, meaning they did not plan to use any additional organic substrates, such as food processing waste. This business model quickly changed, however, when the economics of dairy AD operations became clearer. The digestion of manure alone does not create nearly as much biogas as manure combined with additional organic material. The additional biogas means that more electricity or RNG can be produced, generating additional revenue. If this extra income is combined with tipping fees received for accepting the waste, the economic boost to the dairy AD operations can be significant. All dairy ADs currently operating in waste-rich western Washington add pre-consumer organic waste and consider it essential to economic success.

What does the addition of other organic material to dairy ADs mean for environmental permitting? It normally would trigger state solid waste regulations; the AD accepting organic wastes along with manure would be required to obtain a Solid Waste Handling Permit (SWHP). Under this situation, the liquid and solid effluents from the digester, at least from a regulatory perspective, would then no longer be considered manure but solid waste and would require permitting/handling as such. Without the addition of other substrates, the dairy AD operation would not need a SWHP, and the effluents would be considered manure. Dairy AD operators were concerned about needing a SWHP and raised the issue with state legislators. In response, in 2009, a law was passed providing an exemption from the SWHP for dairy digesters that accept off-farm organic waste and meet certain conditions (RCW 70.95.330). State agencies, including the departments of Agriculture, Health, and Ecology, worked together with stakeholders to develop guidelines for the exemption, which were published in 2009. As a result of the co-digestion exemption:

- No solid waste permit is required for dairy ADs meeting the conditions of RCW 70.95.330.
- Dairy ADs must submit a *Notice of Intent to Operate* and annual reports to the Department of Ecology (or the local jurisdictional health department) and allow regular inspections.

Air Quality

Because dairy ADs burn biogas in their engines or boilers, they are new or modified sources of air pollution. As such, the owner of an AD must contact either the Department of Ecology or the appropriate regional air quality authority to go through the new source review process and to determine if an air permit will be required. Air permits regulate pollutants such as particulates, ammonia, nitrogen dioxide, and sulfur dioxide. All AD projects currently operating in Washington have required a Notice of Construction/Order of Approval permit. To simplify the air permitting process for dairy ADs that are exempt from solid waste permitting, the Department of Ecology's Air Quality Program, the Northwest Clean Air Agency, the Puget Sound Clean Air Agency, and the Yakima Regional Clean Air Agency worked with stakeholders to develop a new General Order of Approval (GO) specifically for dairy ADs meeting the solid waste exemption. It applies to CHP operations but not to RNG operations because there is not yet any operational experience with RNG production at dairy ADs. A GO is essentially a pre-written permit that includes clearly defined emission criteria, best available control technology, and other requirements. ADs that meet the applicability criteria have a significantly streamlined air permitting process and lower permit fees. Ecology issued GO No. 12 AQ-GO-01 in April 2012.

It is assumed that RNG production would require a *Notice of Construction/Order of Approval* (NOC) permit, although if there is no significant adverse change in emissions, the applicant could seek an *Applicability Determination* ("*b (10) exemption*"), which could exempt the project from the NOC program. Air quality permitting therefore would be conducted either through:

- The *General Order of Approval* (GO for CHP only);
- Notice of Construction/Order of Approval (NOC for CHP or RNG), or;
- NOC Applicability Determination establishing emissions are "*de minimis*" and therefore exempt from NOC program.

Although nutrient recovery is not part of the scope of this feasibility study, it is noteworthy that the WSU's combined nutrient recovery system being proposed as a potential nutrient recovery system for consideration in the DeRuyter project does strip gases, ammonia and carbon dioxide, from the manure and passes these gases through an acid contact tower. Nearly 99% of the stripped ammonia is absorbed through the acid contact process with the remaining carbon dioxide and water vapor exited from the tower. Although not a regulated gas, quantification of the carbon dioxide release is needed for reporting purposes.

Water Quality

State Waste Discharge Permits (SWDP) are generally required for discharges to surface or ground water in Washington State. If a dairy chooses to operate without a SWDP, the operator is responsible for ensuring that no discharges occur. A properly designed manure storage lagoon is considered non-discharging and can be constructed without a SWDP. When manure from the lagoon is land applied, state law requires that it be applied at agronomic rates and that there is minimal leaching below the root zone. State law also requires that a plan be developed which describes how the material will be applied to prevent surface and groundwater pollution. These plans are commonly referred to as "nutrient management plans." The state's Dairy Nutrient Management Act (Chapter 90.64 RCW) requires all commercial dairy farms to develop and implement nutrient management plans to protect surface and ground water quality. A SWDP is generally not issued. The Dairy Nutrient Management Plan (DNMP) outlines how much and when solid and liquid nutrients can be applied to fields. If a plan is updated as conditions change (such as the addition of a digester or off-farm substrates) and followed properly, it can be an effective tool to prevent discharges to ground or surface water.

The DNMP is developed by the dairy and approved by the local Conservation District. Inspections are conducted by the Washington State Department of Agriculture. Thus, in terms of water quality permitting:

- No water quality permit is required if there are no discharges to ground or surface water.
- Dairies must develop a Dairy Nutrient Management Plan, register with the Washington State Department of Agriculture, and allow regular inspections.

The State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) would apply to the overall project environmental review if the project creates significant adverse environmental effects, and, in the case of NEPA, if there is a federal nexus, such as a federal permit or funding. SEPA and NEPA consider overall project impacts and are conducted or overseen by a lead agency (typically the agency with initial or primary permit decisions). These environmental reviews can include:

- SEPA Checklist: County, PSCAA, or Ecology (based on first permit decision)
- NEPA Environmental Assessment or EIS: federal agency with jurisdiction (if nexus)

Flood Plain Development Permit and Federal Approvals

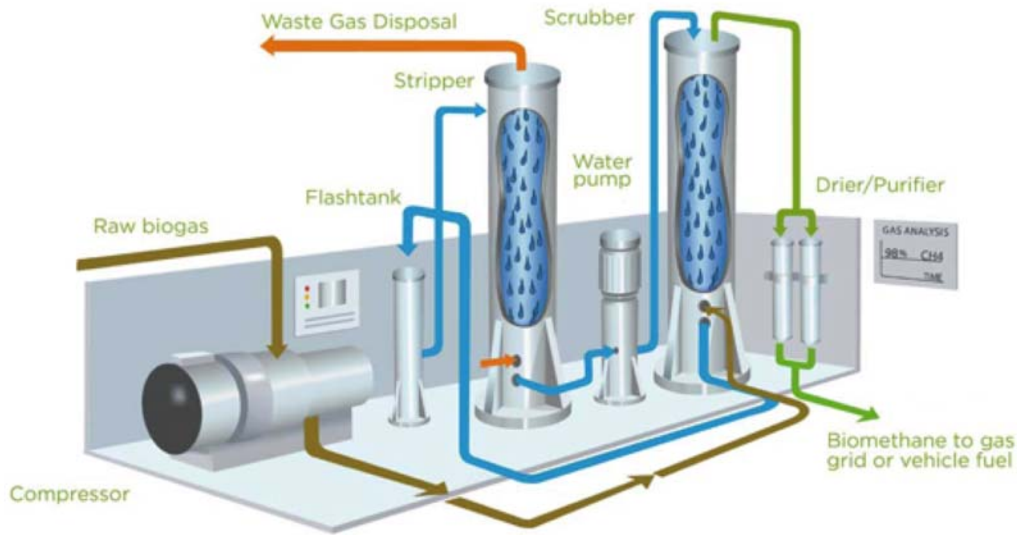
Because the Qualco digester, powerhouse, and related facilities are within the flood plain, modifications and new facilities would require a flood plain development permit from Snohomish County's Department of Planning and Development Services (PDS). This could also trigger review, and possible mitigation, by the Federal Emergency Management Agency (FEMA) as well as issues regarding insurance for capital investments under the National Flood Insurance Program. Construction of additional facilities in the flood plain, such as a second digester, could also trigger a Corps of Engineers 404 (dredge and fill in wetlands or navigable waterways) permit and consultation under Section 7 of the federal Endangered Species Act (ESA), which includes the development of a Biological Assessment (BA) and a Biological Opinion (BiOp) that ensures the action (combined with mitigation) will not jeopardize ESA-listed salmon. If, as would be likely in the case of replacing the generator set with a gas-cleaning unit as part of an RNG conversion project, it is determined by PDS that the project would not adversely affect listed species, no consultation (and no BA or BiOp) would be required. If PDS is uncertain as to whether the project would adversely affect ESA-listed species, it could seek counsel from the ESA Services (NMFS and USFWS).

Summary of RNG and Nutrient Recovery Project Elements

Gas Cleaning Unit and Compressor

A Flotech Greenlane gas-cleaning unit (Rimu) is an example of the type of equipment that would be used to convert raw biogas from the existing AD to pipeline quality RNG (Figure 6.1).

Figure 6.1: Flotech Greenlane Rimu



Emissions from the unit are primarily CO_2, some of which could be used in greenhouses or industrial processes, and significantly less NO_2 and SO_2 than the emissions from the current engine sets. No significant releases of hydrogen sulfide are expected. The gas cleaning unit (GCU) fits on a 40’ skid and has two towers approximately 45’ high. The unit, and compressor, could utilize the footprint of the existing powerhouse or an area adjacent to it.

Permitting for the GCU and compressor could include:

- Air Quality Notice of Construction, Applicability Determination: Puget Sound Regional Clean Air Agency
- Building permit: Snohomish County PDS
- Shorelines permit: Snohomish County PDS
- Land Disturbing Activity (LDA): Snohomish County PDS
- Potential ESA Section 7 consultation and biological assessment (if ESA-listed specifies possibly adversely affected): ESA services (NMFS, USFWS)
- Electrical permit: Washington State Department of Labor & Industries

RNG transport to Williams pipeline or fueling station

The Qualco digester is several miles and a river crossing from the Williams NW transmission pipeline or a major Puget Sound Energy distribution line, making the construction of a feeder pipeline to an interconnect with the natural gas grid cost-prohibitive. The most practical to ways to distribute Qualco RNG are therefore:

- Shuttling compressed RNG in tube trailers from Qualco to a meter station and injection point; or,

- Permitting for transportation of RNG from Qualco would therefore likely include:

Permitting for transportation of RNG from Qualco could include:

- Tube trailers: certification by DOT; connections and valves must meet fire and safety codes (see National Fire Protection Association Code, Title 52: standards for CNG vehicular systems).

Meter station and injection point

A meter station, with a fenced 100' x 100' footprint (see photo of example meter station in Sunnyside), would be built (or an existing station adapted, such as the Snohomish pump/meter station) at or near a selected interconnection point with the Williams pipeline. The meter station and injection point ("interconnect") would include gas monitoring and management equipment in a shed (approx. 10' x 15'). If tube trailers are used as the RNG delivery method, space would be needed for tube trailer unloading and turnaround. Potential locations for a meter station include: 1) the existing Snohomish compressor / meter station on the Williams pipeline near Highway 2 and Westwick Road; 2) the Echo Lake compressor station; or 3) the meter station at Elliott Road just north of SR 522 on the west bank of the Skykomish River; and 4) a new meter station on commercial or industrial property in the City of Monroe combined with a fueling station. Permitting for meter station and injection point, which would be accomplished by or in close coordination with Williams Gas Pipeline, could include:

- Local construction permit: Snohomish County PDS or Monroe Planning & Permitting
- Electrical permit: Wash. Department of Labor & Industries

Figure 6.2 Example meter station in Sunnyside (9390 Emerald Road)

Fueling station

A CNG fueling station, likely located on commercial or industrial property, or existing facilities owned by Williams or PSE (if private fleet fueling) would include the following infrastructure:

- Connection to the Williams pipeline (which runs under the property)
- Compressor
- An array of high pressure storage tubes
- Dispensers (gas pumps)

If RNG is delivered directly to the station, space would be needed for tube trailer unloading and a connection to the compressor and storage tubes. Permitting for RNG/CNG fueling station, which would be accomplished by or in close coordination with PSE and Williams, could include:

- Local construction permit: Snohomish County PDS or Monroe Planning & Permitting
- Electrical permit: Washington State Department of Labor & Industries

Focus on Potentially Complex, Problematic Permit Issues

Although it does not appear that any of the likely permitting requirements for the CHP to RNG project are potential "show stoppers," air quality permitting for the conversion from CHP to RNG – namely, the gas cleaning unit -- has some complexity and uncertainty that warrants special attention here. When Qualco applied to the Puget Sound Clean Air Agency (YRCAA) for its CHP air quality permit more than three years ago, it went through the *New Source Review* process and was issued a *Notice of Construction/Order of Approval permit*. Today, a new dairy-based AD in the area with a CHP operation could be permitted under the streamlined General Order that was recently promulgated by Ecology. Although the conversion of a CHP operation to RNG should result in significantly reduced emission of criteria pollutants, its new status means that the GO shortcut is not available. Although RNG production could result in lower emissions of most pollutants, the appearance of a new pollutant, such as hydrogen sulfide (H_2S), could trigger the new source review. It all depends on whether PSCAA is provided with sufficient information to conclude that there would be no significant increase in a key pollutant, such as H_2S that would have been combusted to form SO_2 under the CHP design but could emerge as a new pollutant under the RNG operation unless it is effectively controlled (e.g., through filtration, adding controlled amounts of air to the digester, and/or flaring).

RNG project design and control equipment can address such air quality issues and must be presented to PSCAA to avoid difficult and protracted air quality permitting. There are two ways to secure a timely air quality permit:

- Notice of Construction review process: If the application is complete and there are no significant questions, the process can take 30-60 days; the application reviews should be on the order of $2,000 - $3,000; or

- NOC Applicability Determination ("b(10) exemption"): If information is provided sufficient to support the conclusion that the emissions are "*de minimis*" and that the technology proposed is consistent with that conclusion; timeframe is typically 30-45 days from submission of a complete application ($1,000 filing fee).

The information requirements for the two options are virtually the same:

- Description of the project process;
- All emission information;
- An evaluation of the emission control technologies available for the proposed equipment, and;
- Information to the agency sufficient to determine that the proposal:
  - Operates within existing emission limits;
  - Will employ best available control technology (BACT); and
  - Will not create an adverse air quality impact offsite.

In addition, the fact that the Qualco project is located in the flood plain creates several complexities, especially if an ESA Section 7 consultation is triggered because it might "jeopardize" the viability ESA-listed salmon. Unless a second digester is part of the design, the replacement of the CHP operation with RNG production is highly unlikely to trigger a Section 7 consultation requirement, something the ESA Services (NMFS and USFWS) could provide counsel on if the Corps of Engineers or Snohomish County have questions about whether such an action would require an ESA consultation.

Safety Issues

The RNG system operates equipment under pressure. OSHA regulations will need to be met in regard to safety involved with pressure equipment

PROJECT PERMITTING AND TIMELINE CONCLUSIONS

As long as the Qualco project developer provides sufficient information in a timely and professional manner, project permitting should be fairly straightforward. The permits sought have reasonable timelines and costs in light of the size of the project, there does not appear to be any significant opposition to the project or threat of litigation or appeal, and the regulatory agencies with jurisdiction have been collaborating with AD stakeholders and agencies to facilitate AD projects (Figure 6.4).

The project timeline estimates that it will take approximately one year to complete the RNG portion of the project. This timeline is based on private sector funding; if public funding is used, the timeline would probably be extended by at least six months. Overall, it is expected that there would be five discreet phases or steps in the full transformation of the Qualco digester from the existing CHP operation to RNG:

1. **Baseline CHP operation plus tipping fees**: Although power revenues will drop after the current rate contract expires, the operation is financially viable due to the robust revenue generated by tipping fees for high-energy substrate.
2. **Transitional period:** Between the current CHP operation and the potential switch to RNG production, Qualco is generating and flaring surplus biogas – more than it is using for the current CHP operation (upwards of 250 cfm on average); during this interim period, as it is evaluating future options, it could make use of the biogas to generate additional electricity, dry chicken manure, heat and add CO2 to green houses, etc. Each option, of course, could involve additional permitting.
3. **RNG Conversion Funding and Agreements**. Consideration should be given to increasing biogas from 400 cfm to 500 cfm by obtaining a solid waste handling permit. Private and/or public funding partnerships should be explored and secured to reduce the risk for the RNG conversion. Most critically, firm long-term sales agreements should be agreed to before committing to RNG.
4. **RNG conversion:** The highest value for RNG is taking it as vehicle fuel at a retail fueling station, plus RINs and other incentive payments. Combined with revenue from fiber, tipping fees, and potentially other revenue-generating measures, the RNG model promises to be a profitable use of AD biogas and an important part of the Qualco AD-based waste-to-revenue system. Securing public or cooperative support for common infrastructure – injection point / meter station, fueling stations, transportation to the pipeline or fueling stations – can further enhance the attractiveness of the RNG model and encourage broader application.

Combining these stages or steps, even with some overlap, is likely to take two years or more to be fully implemented. However, within each step, important components, strategies, markets, and systems can be tested and demonstrated. Figure 6.3 summarizes this staged approach and its decision making steps.

Figure 6.3 RNG project phases

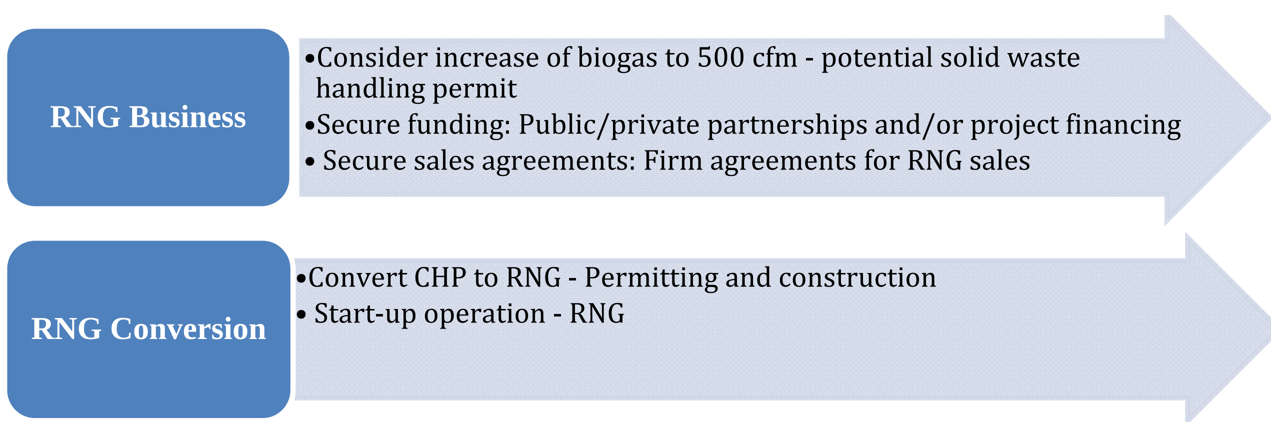


Table 6.1: Permitting Process Table

Promus Energy – Qualco Digester

- Table below is for reference purposes only. Applicants are advised to consult with local, state, and federal authorities since permit requirements vary based on site-specific conditions.
- The term "permit" in the table below is a synonym for process, permit, authorization, license, requirement, certificate, and approval.
- Federal funding may trigger additional review under the National Environmental Policy Act (NEPA) and Section 106 National Historic Preservation Act.
- More complete information regarding permits may be found at www.ora.wa.gov.

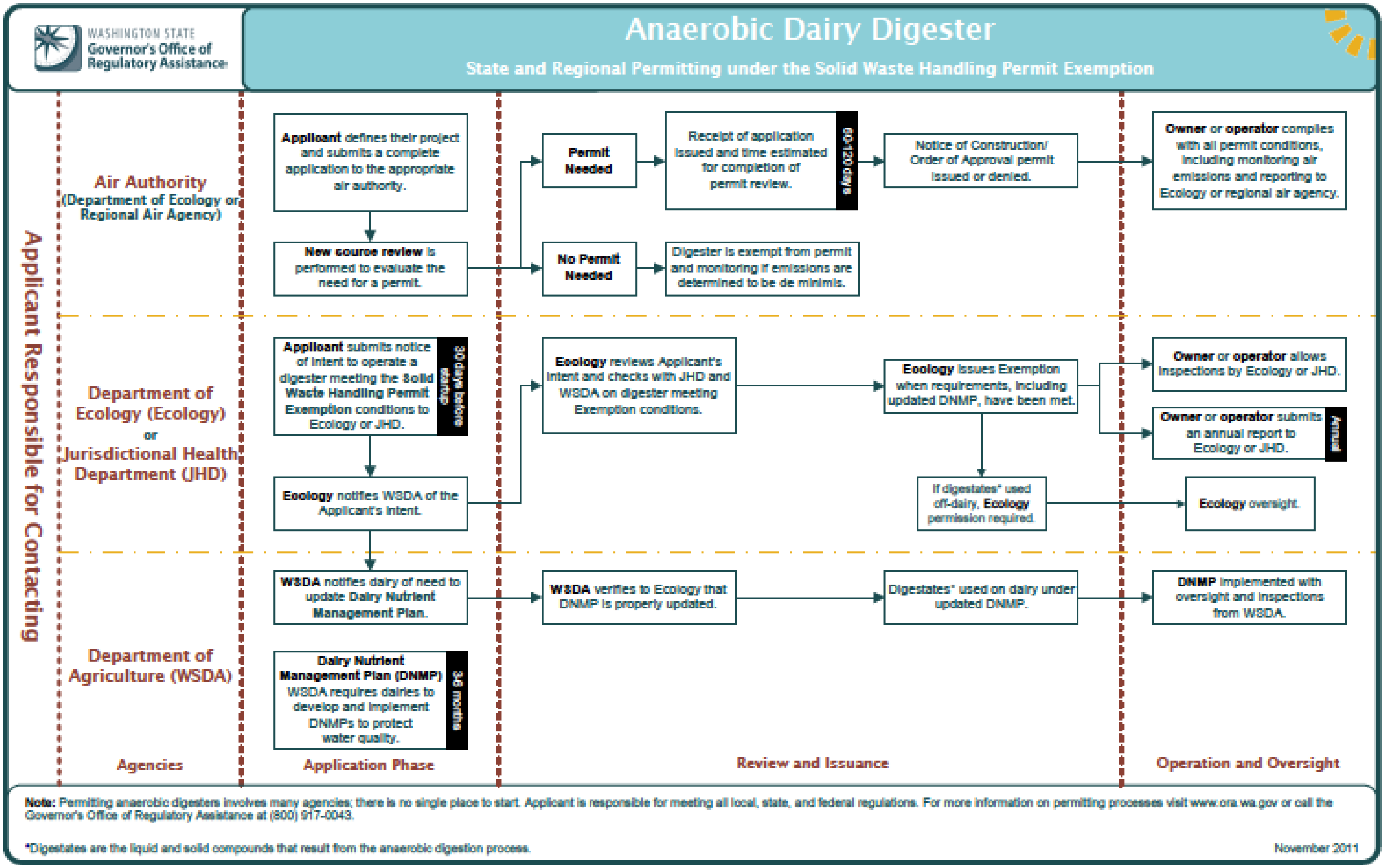
Local Permits			
Permit	**Lead Agency**	**Contact**	**Comments**
Notice of New Construction	Puget Sound Clean Air Authority	Steve Van Slyke, Compliance Manager, (206) 689-4052 stevev@pscleanair.org	• Time for review – 30 to 60 days • Fees - $1000 to $3000
Building Permit	Snohomish Co, Planning and Development Services	Roxanne Pilkenton, (425) 388-3311, ext 2731 http://www1.co.snohomish.wa.us/Departments/PDS/Contact/ *NOTE: for local permits, request a pre-application meeting with the county.*	• Existing Conditional Use Permit would most likely have to be modified
Flood Hazard Permit	Snohomish Co, Planning and Development Services	Roxanne Pilkenton, 425-388-3311, ext 2731 http://www1.co.snohomish.wa.us/Departments/PDS/Contact/	• Unless "no adverse effect," may need biological assessment if project needs Section 7 Consultation through Corps of Engineers.
Substantial or Condition Use Permit	Snohomish Co, Planning and Development Services	Roxanne Pilkenton, 425-388-3311, ext 2731 http://www1.co.snohomish.wa.us/Departments/PDS/Contact/	• Because development is in floodplain

Local Permits			
Permit	**Lead Agency**	**Contact**	**Comments**
Land Disturbing Activity (LDA) Permit	Snohomish Co, Planning and Development Services	Roxanne Pilkenton, 425-388-3311, ext 2731 http://www1.co.snohomish.wa.us/Departments/PDS/Contact/	• If any digging is done to complete project or new impervious surfaces are created

State Permits			
Permit	**Lead Agency**	**Contact**	**Comments**
Electrical Permit	Labor & Industries	Jim Hinrichs, Electrical Inspections Supervisor, (425) 290-1320 hinr235@lni.wa.gov L & I, Everett Office, 729 100th Street SE, Everett, WA 98208.	• Process: www.lni.wa.gov/TradesLicensing/Electrical/FeePermInsp/PermitInspect/default.asp#1 • Fees vary depending on size: www.lni.wa.gov/TradesLicensing/Electrical/FeePermInsp/PermitInspect/default.asp#4
Construction Storm water Permit	Ecology	Bryan Neet, Construction Stormwater Permit Manager (509) 575-2808 Bryan.neet@ecy.wa.gov	• If 3 miles of trenching, this permit is triggered

Federal Permits			
Permit	**Lead Agency**	**Contact**	**Comments**
NEPA	Funding agency or permitting agency		If federal funding or other federal nexus.

Figure 6.4: Summary of the permitting requirements



Chapter Seven — Conclusions

After compilation of the data and analysis of the project outputs, the project team can highlight key conclusions as well as make future project planning suggestions. Each of the main conclusions is summarized in order of display within the report, starting with the baseline CHP and continuing through to a staged implementation plan for RNG production.

Baseline CHP

Qualco Energy has positive cash flow primarily because of the receipt of tipping fees in addition to its electricity and anticipated compost sales and because it has had access to low interest financing. Tipping fees generate 57% of Qualco's gross revenue in 2012, electricity sales and associated credits 40% and fiber compost sales 2%. In 2014, with the expiration of its existing Power Purchase Agreement and current Renewable Energy Credit agreements, Qualco will receive less revenue from electricity sales because Puget Sound Energy's existing tariff for such purchases is at a substantially lower rate and the value of credits is anticipated to decrease. As a result, tipping fees will increase to 64% of Qualco's gross revenue, fiber sales to 10% and electricity prices to 26% of gross revenue. Qualco has also benefited from access to low-interest financing through a 15-year Clean Renewable Energy Bond that carries a 1% management fee.

Qualco does not have a contract for carbon credits, which are more complex to receive when a digester receives substrates. The consultant team recommends that Qualco re-consider the carbon credit opportunity in light of anticipated increasing prices.

- <u>*Policy Suggestions*</u>*— To replicate the Qualco model to other dairy manure-based AD projects in the region, it is suggested that the state continue to identify ways project developers can gain access to grants and low-interest loans. As carbon credits and RECs do play a small but important part within revenues, the state should amend the Energy Independence Act so that carbon credits and RECs are guaranteed of their market de-coupling while also ensuring regional support to emerging California carbon markets. The legislature and the WUTC should consider amendments to current RCWs and/or WACs that would provide greater stability and better pricing under the investor-owned utility standard PURPA contracts and rates, such as Puget Sound Energy's Schedule 91. Specifically, the WUTC should consider mandating a longer-term standard contract and further consider the potential for feed-in or other tariff structures that would allow utilities to pay more than avoided costs for renewable energy.*

RNG Markets and Off-Takes

Identification and securing of long-term market off-take agreements is essential to development of an RNG model for Qualco.

<u>Policy Suggestions</u> – Public-private partnerships, involving ports, economic development organizations, and other general and special purpose local governments, should be formed to tap public financing mechanisms that could provide infrastructure necessary for capital expenditure structures and business plans. Federal, state and local government fleets, as well as regional greenhouse gas mitigation and energy programs (power back-up), could be instrumental as first-stage end-user markets. Market-setting policies, such as bid preferences for renewable fuels in government contracts for transportation services (e.g., waste hauling), should be encouraged. In addition, federal policies that add certainty and long-term value to the RIN market would reduce RNG investor risk.

RNG Model

Two important opportunities delineated by the team include:

- Use of RNG within a digester-based "integrated systems approach" producing multiple revenues including tipping fees and fiber products.
- The rise in the cost of petroleum, the growing availability of CNG and NGVs and conversions for popular heavy duty truck engines, and the resulting national shift to methane fuels in the high-value transportation fuels market;

More specifically, RNG was evaluated under three scenarios (commodity, commodity plus RIN, and Retail Fast Fuel Sales) and compared to the current CHP operation.

1. Commodity natural gas pricing: If sold at low wholesale prices for pipeline gas ($3.87/MMBTU or $0.44/GGE), RNG produces less cash flow than the CHP model. This remains the case even if the interest rate is reduced to 1 percent from the 7 percent rate assumed in the pro-forma. If biogas production is increased to 500 cfm, the resulting RNG revenue is about the same as the current CHP operation.
2. Commodity plus "green premium" (RIN): When renewable credits are added to the commodity price of gas, RNG generates less net revenue than CHP through 2023 if the RIN prices are lower than the current RIN price. At the current RIN value, Qualco must receive at least 50 percent of the value of the RINs to generate more cash flow than the CHP operation. If interest rates are decreased to 1 percent or if biogas production is increased to 500 cfm, the lower RIN value generates more revenue than the CHP operation. Gas utilities, brokers, and CNG retailers are potential purchasers.
3. Retail CNG plus RIN: If producers take RNG to the retail CNG market, where CNG is now selling for $1.85 and up, it generates much more revenue than CHP, especially if credits are added. Even if credits are not added, this scenario still generates more cash flow than the current CHP model. Lowering the interest rate or increasing biogas production improves the retail CNG plus RIN cash flow.

<u>Policy Suggestions</u> – While extensive private opportunity exists, governments could help demonstrate and accelerate adoption of AD-based RNG systems by implementing policies that:

- *Reduce the risk of RNG infrastructure through grants and non-recourse loans.*
- *Facilitate cost sharing of common infrastructure through cooperatives, public "hosts," or similar public-private partnerships.*
- *Provide regulatory flexibility and clarity that supports diverse AD-related revenue streams, including an integrated systems approach, based on site-specific factors, that allows for revenue from energy, nutrients, fiber, carbon dioxide, environmental and carbon credits, and other waste-to-revenue products.*
- *Support the RNG market through government purchases of RNG and contract provisions that incentivize RNG use by government contractors.*