WHITE PAPER

Maximizing Production Amid Regulatory Constraints with the ColdStream Energy Refrigeration Unit (CRU) System

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The Challenge: Regulatory restrictions on gas flaring and pipeline capacity constraints combine to impact production potential

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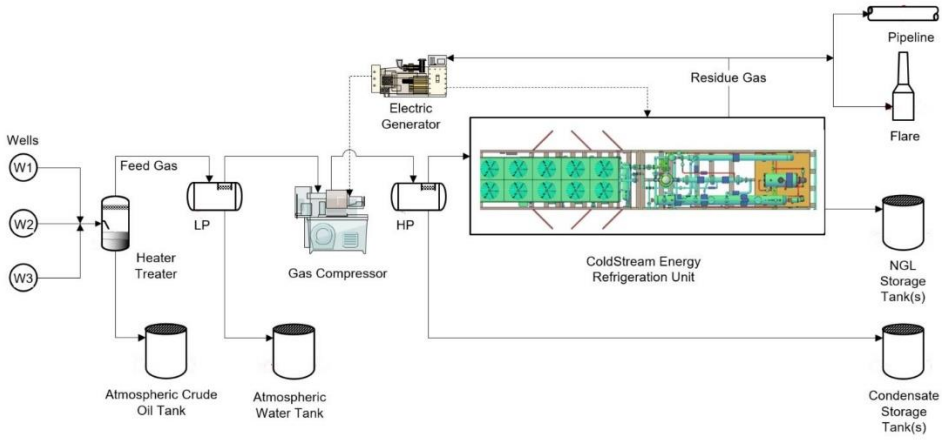
Many states have increased their regulatory limits on flaring at oil and gas production facilities, and it is expected that the trend will continue. Recent examples, such as Colorado's Reg 7 and the North Dakota Flare Capture rules, have resulted in production impacts and expenses to maintain operations. There are multiple measures that state and federal regulations use to limit gas flaring from oil and gas production facilities. These metrics may include mass of VOCs emitted, volume of gas flared, percentage of VOC recovered, and/or heat content of flared gas (Btu); various combinations may apply depending on location. These are typically applied by both the state environmental regulatory agency and the oil and gas agency with overlapping jurisdictions. Where the environmental agency is focused on minimizing total mass of emissions to the atmosphere, typically with VOC mass emission limits, the oil and gas regulator has the role of maximizing the commercial benefit and overall conservation of natural resources. This limits the amount of saleable gas that is sent to flare based on volume, Btu content or total percentage of gas flared.

As an example, North Dakota has VOC emissions thresholds that trigger increasing levels of permitting and gas capture goals for aggregated statewide operations that require a significant percentage of produced natural gas and/or natural gas liquids (NGLs) be recovered for sale or beneficial use rather than flared[i]. Curtailing production to reduce gas volumes is the worst case response from a business standpoint. Utilizing an NGL recovery unit to lower the VOC content (and all controlled metrics) of a flared gas stream can allow for greater facility production without triggering new permit limits.

The ColdStream Energy's CRU offers a modular micro midstream solution for processing low to medium volumes of rich natural gas using mechanical refrigeration. These portable and rapidly deployable CRU designs are especially applicable in shale oil plays with rich associated gas and constrained (or absent) takeaway capacity. ColdStream Energy's CRU provides an alternative method for reducing flared emissions along with the opportunity to increase production while remaining below various regulatory thresholds. NGL and condensate produced from these units can be transported and sold resulting in additional revenue to the operator.

Figure 1: Process Flow Diagram of typical ColdStream Energy Refrigeration Unit Installation



To assist producers in visualizing the full economic gains of CRU installation, ColdStream Energy worked with Zephyr Environmental Corporation to develop a Regulatory Economic Calculator that provides a more complete picture of CRU benefits for facility-specific situations. (Data Input/Financial Results page for WPX Energy (WPX) shown as Figure 1.) Taking into account state-specific environmental permitting emission limitations, state-specific natural resource agency flaring requirements, the potential for increased facility throughput, and the direct sales of recovered NGL and condensate, ColdStream Energy can provide immediate financial analysis of placing their CRU at a client's facility.

Figure 2: ColdStream Energy Regulatory Economic Calculator Summary

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WPX Energy Regulatory Economic Calculator

regulatory analysis by zephyr

(simulation run on 11-21-2017)

Inputs to Simulation

Client	WPX Energy	
Facility		
State	North Dakota	
Oil Production Known?	No	
Gas Throughput	4	MMscf/day
Gas-Oil Ratio	1,800	ft^3 of Vapor/bbl Liquid
Oil Production Current *(calculated)*	2,222	bbl/day
Wellpad Oil Maximum Production Goal *(if known)*		bbl/day
Gas-Water Ratio *(if known)*		ft^3 of Vapor/bbl Liquid
Water Production *(if known)*		bbl/day
Analytical Data	1500 Btu	
Oil Price	$45.00	$/bbl
Condensate Price	$40.00	$/bbl
NGL Price	$0.50	$/gal
Site Non-Flare VOC Emissions (fugitives, loading,...)	5	TPY
Produced Gas to Flare	4,000,000	scf/day
Input Vapor MW	25.40	lb/lb-mol
Input Vapor VOC Content (C3+)	34.54	wt% VOC
VOC to Flare	92,524	lb/day
Flare Efficiency	98%	% destruction
CRU Removal Efficiency	12%	% gas volume removed from input gas total stream
CRU Sitewide C3+ (VOC) Reduction	73%	wt% C3+ (VOC) removed from input gas VOC
CRU Condensate Recovery	9.18	bbl condensate recovered per MMscf of input gas
CRU NGL Recovery	3,323	gal NGL recovered per MMscf of input gas
Net Shrinkage Inlet Gas to Flare	81%	% gas volume removed from input gas total stream, including gas used for CRU combustion fuel

Assuming 85% current flare capture statewide.

Color Key:
below current oil prod
above actual oil prod

Economic Benefit of ColdStream CRU

	Maximum Oil Production to Remain Below Applicable Limit				Condensate Recovered		NGL Recovered		Net Total	
	without CRU bbl/d	with CRU bbl/d	Delta bbl/d	Delta $/day	bbl/d	$/day	gal/d	$/day	$/month	$/year
ND IC Restriction on Gas Flaring	n/a	n/a	0	$ -	37	$ 1,469	13,293	$ 6,647	$ 106,858	$ 1,282,301
Federal Title V Trigger	648	2,283	1,635	$ 73,561	64	$ 2,550	23,072	$ 11,536	$ 2,525,939	$ 30,311,263
Federal PSD Trigger	1,621	5,708	4,087	$ 183,903	104	$ 4,172	37,739	$ 18,870	$ 6,154,559	$ 73,854,707

Net of amortized mobilization and demobilization cost and monthly service fee.

Simplifying a Complicated Payback Model

The initial review of a NGL recovery system often relies solely on the value of recovered NGLs balanced against the cost of operating the unit. What this fails to include is the effect of additional regulatory or pipeline restrictions that can curtail oil and gas production in active production areas. This lost (or deferred) production has a net present value that often exceeds the value of recovered NGLs by an order of magnitude. While several states have levels of minor source air permitting with increasing compliance burdens, all states are subject to the federal Title V and Prevention of Significant Deterioration (PSD) permitting programs. Title V permitting is not uncommon at larger oil and gas production sites, but is never desired due to significant additional permitting costs and self-reporting burdens. In addition, most operators consider PSD permitting a hard stop as the process typically takes 12-18 months with associated costs that can range from $100,000 to greater than $250,000 for application preparation, emission impacts modeling, and agency permitting fees.

In the WPX North Dakota example above and Figure 2 below, we see in red the max throughput of 648/1,621 barrels per day (bbl/d) that would stay below Title V and PSD is well below the desired production rate of 2,222 bbl/d, but in green we see that with the CRU the desired production can stay below thresholds. In other words, at the desired oil production rate of 2,222 bbl/d the facility will exceed both the Title V, 100 ton per year (TPY) VOC emission threshold, and the PSD, 250 TPY VOC emission threshold. This was not acceptable for WPX as they were potentially required to constrain oil production at the site prior to CRU installation.

Using WPX specific stream data, the ColdStream Energy Regulatory Economic Calculator documented the potential to achieve the desired production without increasing the environmental permitting burden. The Calculator shows that oil production would be limited to 648 bbl/d but with the installation of a CRU, WPX can increase production by 1,635 bbl/d at the facility without triggering Title V, for an associated daily return of $73,561. When combined with CRU recovered NGL and Condensate sales, the daily available return on the CRU is up to $83,044 net equipment cost while maintaining minor source permit status.

The North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division (NDIC) also has statewide gas capture requirements that can result in gas flaring restrictions at isolated or pipeline-constrained sites. These flare capture requirements are scheduled to ratchet down over time. However, an acceptable alternative is to recover the majority of propane and heavier NGLs (VOCs) from the gas stream prior to flaring, exactly as the CRU is designed to operate. Similar benefits can be realized in other states based on their specific capture/recovery metrics.

Figure 3: ColdStream Energy Regulatory Economic Calculator (Details)

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WPX Energy Regulatory Economic Calculator

regulatory analysis by zephyr

(simulation run on 11-21-2017)

Emissions Scenarios with and without ColdStream CRU

	VOC		Produced Gas		
	lb/day	TPY	SCF/day	MMBtu/hr	MMSCF/yr
Site Non-Flare Baseline (fugitives, loading, …)	-	5	-	-	-
Uncontrolled Produced Gas	92,524	16,886	4,000,000	249	1,460
Emissions without ColdStream CRU					
Baseline + Flared Produced Gas	**1,850**	**343**	**4,000,000**	**249**	**1,460**
ND IC Restriction on Gas Flaring	-	-	none uncontrolled	none uncontrolled	none uncontrolled
Federal Title V Trigger	-	100	-	-	-
Federal PSD Trigger	-	250	-	-	-
Emissions with ColdStream CRU					
Baseline + Flared Produced Gas Post-CRU	**506**	**97**	**3,237,869 ***	**173**	**1,182**
ND IC Restriction on Gas Flaring	-	-	(controlled)	(controlled)	(controlled)
Federal Title V Trigger	-	100	-	-	-
Federal PSD Trigger	-	250	-	-	-

Color Key:
emissions exceed rule threshold
emissions below rule threshold

□ *system does not intake ≥ 75% of the gas and NGL volume from the well for beneficial consumption*
□ *system does not separate and collect ≥ 50% of the propane and heavier hydrocarbons*

■ *system intakes ≥ 75% of the gas and NGL volume from the well for beneficial consumption*
■ *system separates and collects ≥ 50% of the propane and heavier hydrocarbons*

Impact of ColdStream CRU on NOx/CO Emissions

	Produced Gas Flared *	CRU Glycol Reboiler	CRU Compressor Engine	CRU Generator Engine	Overall Impact
Difference (Δ) in Emissions with ColdStream CRU					
Annual NOx Emissions (TPY)	-46	0.17	18.25	5.12	-22
Annual CO Emissions (TPY)	-91	0.14	16.43	10.24	-64

**Volume of produced gas flared discounted by volume of gas used as fuel for ColdStream CRU combustion equipment and volumes of extracted liquids.*

Emissions estimates for a 945 hp Cat 3512 LE @ 100% load compressor engine and an EPA certified 530 hp Doosan D183TIC generator engine. Actual emissions pending design.

Upstream production facilities are often throughput limited due to VOC emission limits, flaring restrictions, or third-party takeaway restraints. Using the ColdStream Energy CRU to lower the VOC content of a flared gas stream, the total VOC emissions and flared volume are reduced allowing for greater facility production without triggering or exceeding new permit limits.

Summary

The ColdStream Energy Economic Calculator allows for fast and simple analysis for a customer facility that is faced with restrictive flaring regulations that constrain production. An operator can provide ColdStream Energy with a limited amount of production and gas analysis data and receive their potential payback numbers within days or hours. In most cases, the benefits go beyond the company to external stakeholders and include the following:

- Neighbors and landowners see an environmental benefit as emissions of both VOCs and the products of flare combustion are reduced.
- Mineral right holders, states, producers, and consumers benefit as additional oil and NGLs are recovered and sent to market maximizing the beneficial use of natural resources and their associated revenues.
- Producers realize both greater operational flexibility and revenues with oil production rates that can increase based on business decisions rather than constrained by regulatory restrictions.

[i] https://www.dmr.nd.gov/oilgas/GuidancePolicyNorthDakotaIndustrialCommissionorder24665.pdf