VRGE Technology Overview + Comparison to Other Fracturing Systems

Confidential Information

Part 1: VRGE Overview

VRGE as a Replacement for Water-Based Fracturing

Expansion Energy LLC (XE), in cooperation with several large E&P companies, has recently conducted extensive evaluations of VRGE as a replacement for water-based fracturing (slickwater or cross-linked). A summary of preliminary conclusions is presented below.

Cost Reductions

- **Completion costs per stage can be *reduced* dramatically vs. water-based fracs—50% or more**
- Water consumption reduced by 85% (or more)
- Proppant consumption reduced by 50% or more
- Water-related savings per stage (interval) for Marcellus wells: $49,000 (low) to $88,000 (high)
- Water-related savings per stage (interval) for Bakken wells: $20,000 (low) to $34,000 (high)
- **Typical Marcellus well's total completion costs reduced by up to $100,000 per stage**
- **Typical Bakken well's total completion costs reduced by up to $100,000 per stage**
- **Typical Marcellus well's total completion costs reduced by up to $1.7 million per well**
- **Typical Bakken well's total completion costs reduced by up to $2 million per well**
- All numbers shown above include Operating Costs and Capital Cost charges
- Equipment CAPEX for VRGE fracing spreads is comparable to standard water-based fracing spreads (excluding the LNG plant to produce VRGE's CCNG (cold compressed natural gas) frac fluid onsite).

Increased Production

In addition to the compelling cost savings that VRGE will deliver for E&P companies, as an "energized" (i.e., foam-based) fracturing process, **VRGE will likely increase oil & gas production substantially vs. water-based fracturing—up to 1.5 or 2 X as much—depending on the type of formation, formation pressure, etc.** (Note that non-gas-energized versions of VRGE can also be deployed, as discussed in subsequent sections of this memorandum.) See the recent article linked here from the Society of Petroleum Engineers' *Journal of Petroleum Technology* (June 2014) titled "Shale Revolution Revisits the Energized Fracture," which discusses a trend toward renewed interest by US producers to use gas-energized/foam fracturing (and expanded use by Canadian producers): http://www.spe.org/jpt/article/6439-shale-revolution-revisits-the-energized-fracture/

Another compelling SPE-published study on the production benefits of gas-energized fracs can be obtained here: https://www.onepetro.org/conference-paper/SPE-168632-MS Quote from this study*: "In summary, all possible production metrics show superiority of foam-based fracturing fluids over slickwater... When production is normalized with respect to the proppant pumped, foamed fluid wells are 2 times more efficient; and when normalized on water pumped, foamed fluid wells are 7.2 times more efficient."*

Despite the similarities of VRGE to CO2- and N2-based energized fracturing, VRGE has several important advantages over CO2 and N2 fracturing, including:

- CO2 and N2 needs to be "imported" to the well site at substantial cost and logistical complexity, and is usually not available from a nearby source. In contrast, VRGE's CCNG fracturing fluid is produced onsite at/near the wellhead.
- CO2 and N2 contaminates the oil & gas stream, and needs to be separated from the oil & gas at the surface. Often the initial production from gas wells using N2 or CO2 fracs must be flared or vented for several weeks before the gas is clean enough to sell to the market, which can cost tens- or hundreds-of-thousands of dollars of lost production value.

VRGE avoids both of these drawbacks, plus most of the natural gas used as VRGE's fracturing fluid eventually resurfaces from the formation and can then be sold to the market or re-used for further VRGE fracturing or EOR.

Through VRGE, XE intends to capitalize on the E&P industry's growing interest in energized fracturing.

VRGE for Enhanced Oil Recovery (EOR)

XE has also been evaluating the use of VRGE as a new enhanced oil recovery (EOR) system. Based on our preliminary findings, the use of VRGE for EOR appears to be "low-hanging fruit" and an exceptionally large global opportunity. As such, **XE suggests that E&P companies explore how VRGE can substitute for CO2 in EOR applications within their operations, and begin EOR field trials in the near term**.

"Traditional" EOR using CO2 is limited, because the CO2 source is usually too far from the well site to be economical, and usually needs to be transported via a fixed CO2 pipeline. EOR can be more universally accomplished with NG using VRGE than with CO2. Related to this, XE has identified recent EOR research showing that using NG as an EOR working fluid can be more effective for EOR than CO2. **Indeed, VRGE may have a bigger potential impact on worldwide oil & gas production as an EOR tool than as a fracturing tool.**

Most significantly, the demonstrated use of VRGE for EOR would open a very large worldwide market opportunity, substantially increasing the estimated recoverable reserves in unconventional and conventional oil & gas basins. These enhanced reserves would be accessible without the need to drill and complete new wells, and without the need for new pipelines (for CO2 "import" or for oil & gas transport) or other infrastructure.

Part 2: VRGE Equipment + Layout & Footprint

VRGE Equipment vs. Other Fracturing Systems

Pre-completion steps (i.e., drilling, well-casing, etc.) are the same for VRGE as for the other unconventional wells. Also, the surface monitoring equipment will be similar. Therefore, no additional equipment is required for any pre-completion steps when using VRGE.

The cryogenic pumping units required to pump VRGE's CCNG frac fluid to a high pressure are similar to the Liquid CO2/Liquid N2 pumps currently used for other gas-energized foam fracturing methods, but with two distinctions. First, the VRGE pumps must either be connected to the diesel engine prime movers through extended drive shafts (to keep combustion a safe distance away from the CCNG) or they must be electric-drive motors (avoiding combustion in the pumping units entirely). Therefore, if VRGE's pumping units are electric-drive, a VRGE frac site will need to have a modest-sized gen set to produce power. This is not a requirement for most other types of fracing systems. Second, because they pump methane (a greenhouse gas), the pumps must have robust and resilient seals, valves, etc.—just like LNG pumps used for midstream applications have.

VRGE's blending of the proppant with a liquid foaming agent (which includes surfactant and, optionally, can include a modest amount of water) takes place in a special (but not technically complex) blending vessel(s) which have already been designed by XE and its US-based fracing equipment vendors. Following proppant + surfactant blending, methanol is introduced via a "Y-valve" connection. That slurry then enters a slurry pumping unit(s), following which the high-pressure slurry meets the high-pressure CNG stream (from the CCNG pumping units) through another Y-valve connection. From there, the high-pressure foamed CNG + proppant is sent downhole to fracture the formulation and place the proppant.

If methanol is used as a foaming agent (optional), VRGE captures and regenerates methanol that re-surfaces at the wellhead, and reuses that methanol for further VRGE fracturing. Therefore, VRGE's site footprint may also include a trailer-mounted methanol regeneration unit plus one or more methanol storage trailers.

Because energized fracturing systems such as VRGE greatly reduce the amount of proppant required per stage (e.g., reduction of 50% or more), fewer proppant storage tanks are needed onsite.

The most significant equipment difference between VRGE and other fracturing systems is that VRGE utilizes an LNG/CCNG plant at or near the well site (preferably a plant using XE's efficient and lower-CAPEX "VX Cycle" LNG/CCNG production technology) to produce the cryogenic CCNG fracturing fluid. Water-based, CO2-based, and N2-based fracturing do not require an onsite frac fluid production system because they "import" those fluids to the well site from off-site (often distant) sources.

VRGE produces little (if any) flowback water, and therefore virtually eliminates the need to store flowback water in ponds or tanks, and greatly reduces the need to dispose of flowback water in injection wells, etc.

Optionally, if the VRGE user (or its client) chooses to keep a VX Cycle plant at the well site to separate natural gas liquids (NGLs) from the produced hydrocarbon streams, to produce LNG, and to recover a portion of the methanol (and optionally water) that were used as the liquid portion of the energized foam, then the VX plant plus NGL and LNG storage would be additional equipment versus other fracturing systems. However, that equipment would be supporting a stream of additional revenues that would not otherwise be available to the well owner or a midstream company that serves them. Moreover, when the NGL stripping and LNG production stage begins, fracturing activities will already be completed, and therefore the NGL-related equipment and the NGL/LNG storage tanks should not be considered part of the fracturing spread itself, and will not interfere with fracing operations or require a larger frac spread footprint.

VRGE Layout & Footprint

A typical VRGE frac layout diagram is presented on the following page. Layout diagrams for certain other types of fracturing systems are also presented below for comparison.

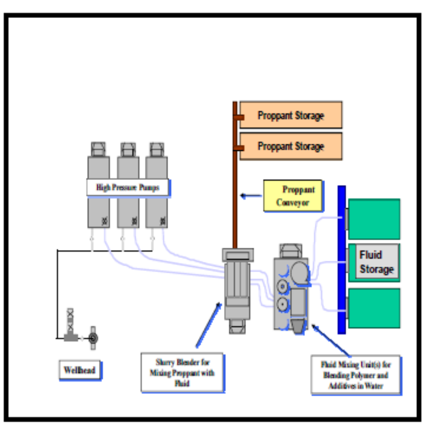
Regarding the production of VRGE's CCNG frac fluid, XE recommends utilizing mobile VX Cycle CCNG production plants that are deployable in 100,000 gallons/day (GPD) modules. For long-lateral frac jobs that require large volumes of frac fluid (e.g., 200,000 gallons per frac stage) such as Marcellus gas wells, a 300,000 GPD mobile VX Cycle plant (3 modules) may be required, which is then converted into ~ 800,000 GPD of methane-based foamed frac fluid. A 300,000 GPD plant is sufficient to frac 4 Marcellus stages per day. Smaller wells and/or wells which require less frac fluid (such as Bakken wells) could utilize smaller VX Cycle plants (e.g., 100,000 GPD), or they could perform more stages of fracing per day.

Each 100,000 GPD VX Cycle module requires ~ 20 skid-mounted or trailer-mounted shipping container-sized "boxes" which are connected to each other. Each 100,000 GPD plant requires ~ 10,000 square feet and ~ 1,500 square feet for storage tanks. If necessary, the skids can be "stacked" to shrink the plant's footprint.

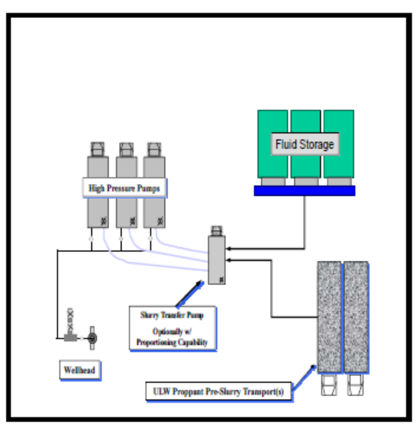
When methanol is used as one of VRGE's foaming agents, 1-3 methanol tanker trucks are required for each frac stage, depending on the volume of frac fluid needed and the foam quality selected.

Offsetting the space that VRGE's CCNG plant needs are a number of positive factors that reduce VRGE's total footprint versus other types of fracturing. For example, VRGE's use of CCNG produced at/near the well site eliminates (or greatly reduces) the need for trucks to transport water (or other fracing fluids such as CO2 or N2) to the well site and the need for truck parking and turn-around space on the well site. Similarly, VRGE also greatly reduces the amount of frac fluid storage tanks (or ponds) and flowback storage tanks (or ponds) that need to be onsite. VRGE also reduces the number of proppant tanks and chemicals tanks at the well site. Therefore, VRGE's footprint may be smaller than water-based frac spreads.

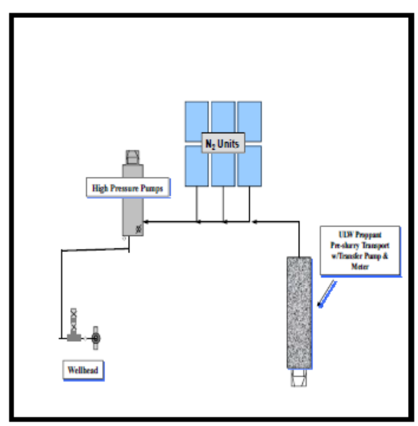
Sample Layouts for Other (Non-VRGE) Types of Fracturing Systems



Equipment layout for typical slickwater frac with sand proppant

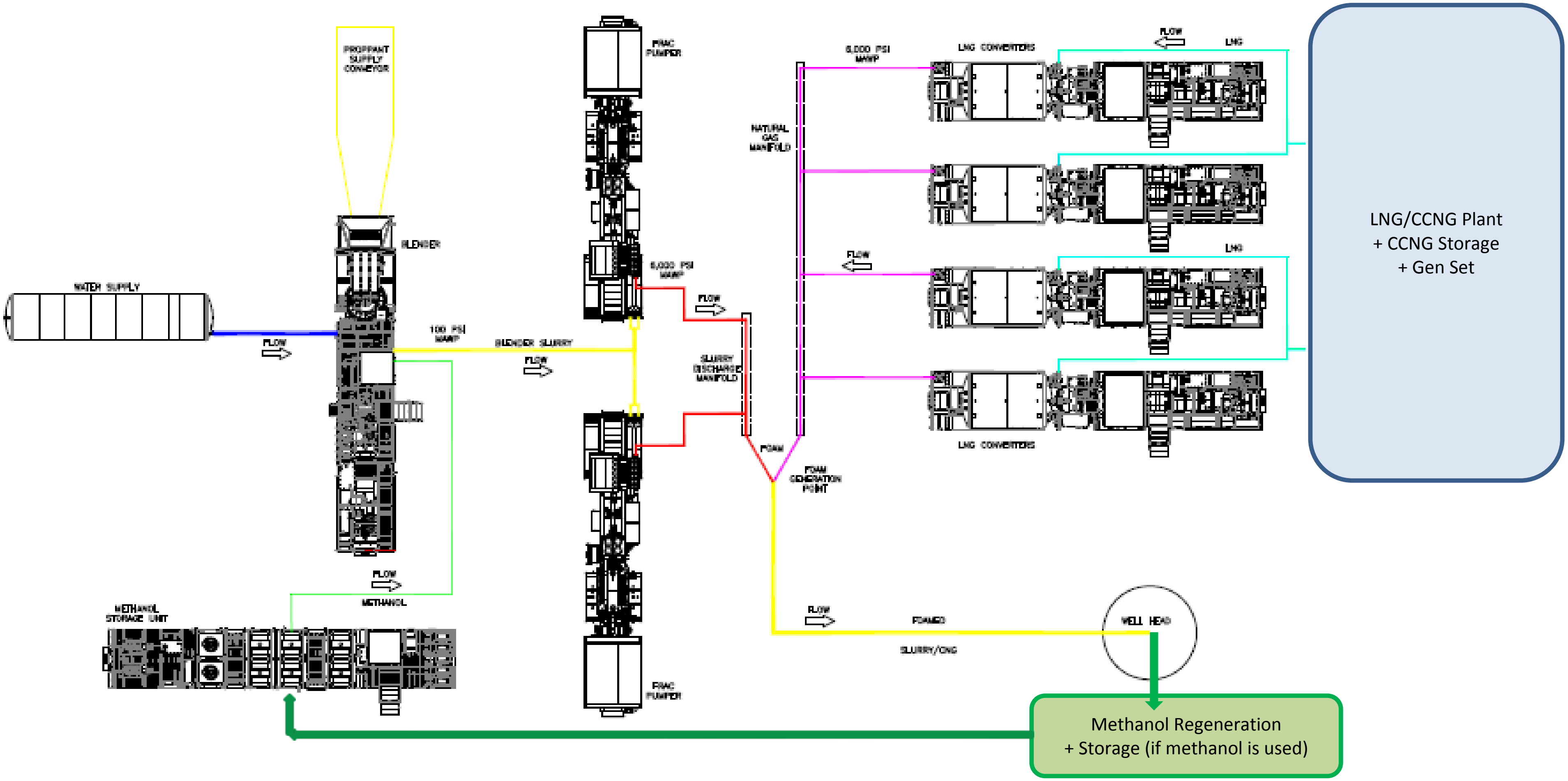


Equipment layout for pre-slurried ULW-1.05 proppant slickwater frac



Equipment layout for pre-slurried ULW-1.05 UHQ foam frac

Sample Layout for a Typical VRGE Frac Spread



** **Note:** VRGE preferably uses CCNG instead of LNG as its frac fluid. Therefore, in the diagram above, the term “CCNG” may replace “LNG”.*

Part 3: Health, Safety & Environment (HSE)

Health

VRGE has health advantages over other fracturing systems, particularly water-based fracturing systems. Water-based frac fluids require a substantial amount of chemical additives to counter-act the negative effects that water has on hydrocarbon formations. In contrast, VRGE requires very few chemical additives, limited primarily to non-toxic surfactants and the methanol that is utilized in VRGE's foaming process.

VRGE typically uses primarily clean-burning natural gas as the fuel source for its equipment instead of diesel fuel which releases a substantial amount of harmful air emissions, which can affect the health of workers and of residents in the nearby area.

Safety

Because VRGE virtually eliminates the consumption of water and the disposal of flowback water, both of which are typically shipped by tanker truck, VRGE greatly reduces truck traffic, resulting in reduced risk of road accidents for workers and for residents near the oil & gas field.

Because a VRGE frac spread has fewer equipment components and fewer "moving parts" overall versus other fracturing systems, the risk of accidents from any of that equipment is proportionately reduced.

VRGE's main safety risk is its use of methane as a working fluid. Of course, methane is flammable under ambient conditions, and therefore requires additional safety precautions to be taken in order to avoid combustion of methane onsite. Included in these precautions is the use of extended-shaft drives or electric motor drives for the pumping equipment to avoid the possibility of CNG combustion. It should be noted, however, that a majority of oil & gas wells already handle methane as their main hydrocarbon product or as a by-product (i.e., "associated gas"). Therefore, VRGE's safety protocols are quite similar to those already required at most oil & gas well sites.

Environment

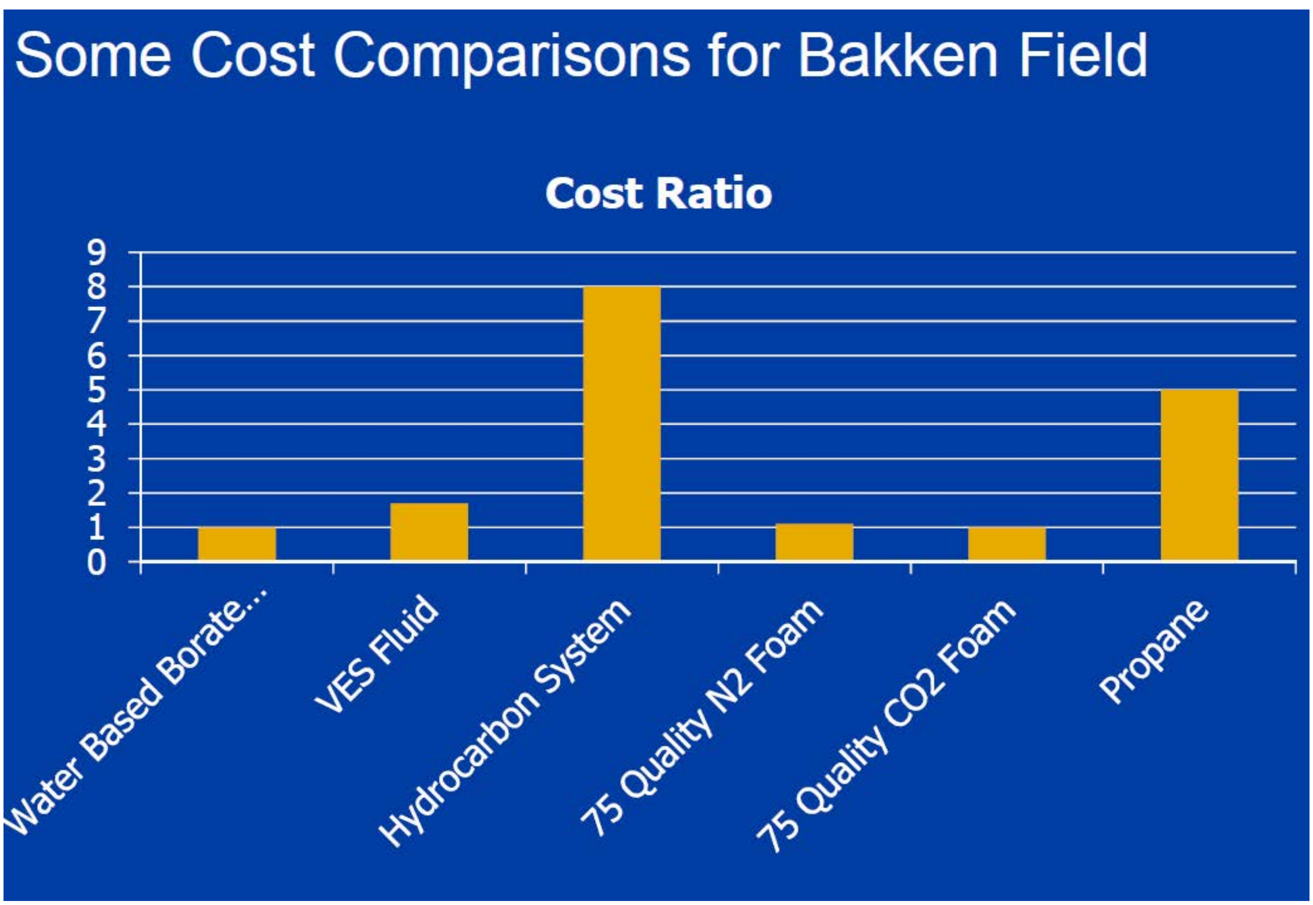
Environmental improvements are among VRGE's greatest strengths compared to water-based fracturing systems and fracturing systems that utilize other fluids (e.g., CO2, N2, propane, etc.). VRGE eliminates or greatly reduces the consumption of water, the disposal of flowback water, and the need for flaring. VRGE also eliminates hundreds of truck trips to/from a typical well site by greatly reducing the amount of water, proppant and chemicals required. This means less energy (e.g., diesel fuel) is consumed for truck shipments and also results in other environmental benefits, such as reduced emissions and reduced dust, which improves air quality in the nearby area. Overall, VRGE is a more resource-efficient process than other fracturing approaches.

Standard CO2- and N2-based fracturing equipment often loses substantial volumes of CO2 or N2 in the blending and pumping of those frac fluids. In contrast, VRGE will not release any significant amount of frac fluid, in part because that practice is wasteful and costly, but also because methane is a greenhouse gas that should not be "vented" into the atmosphere. To achieve this, VRGE's blending vessels, interconnections, valves and pumping units are designed to have tight and robust seals, which requires a modest amount of additional capital cost, but which pays for itself through avoiding losses of valuable methane and methanol from the frac fluid. VRGE frac spreads will also use methane sensors to detect leaks and to improve safety.

Part 4: Cost Comparisons

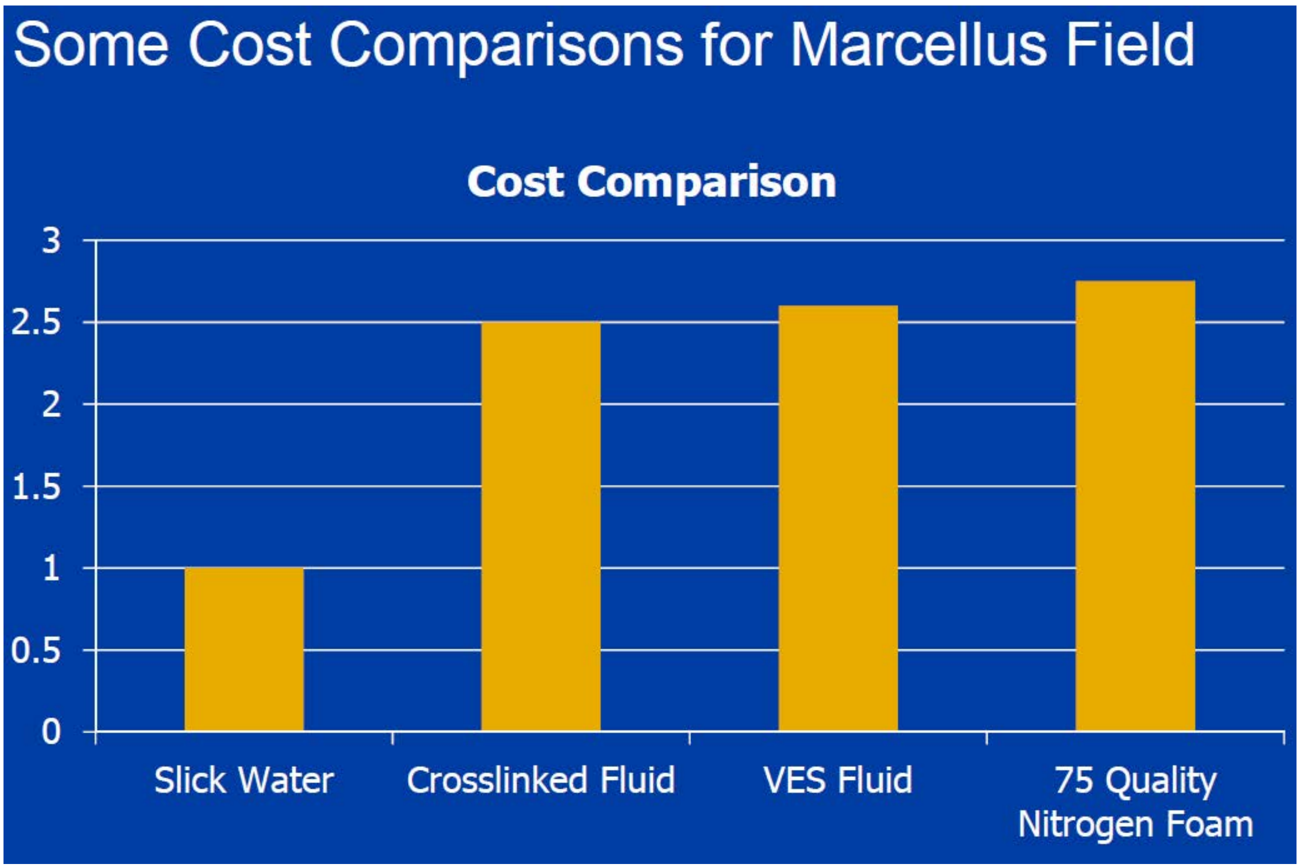
One of the global E&P companies interested in utilizing VRGE for various completion applications provided XE with the following chart comparing the costs of various Bakken fracturing systems as a ratio to each other. Compared to standard water-based fracs, VRGE can reduce total completion costs by more than 50%. Therefore, if the “all-in” costs are considered, VRGE has substantially lower costs than any of the fracturing systems in the Bakken chart below, as follows:

- VRGE = ~ 50% of the cost of Water-Based Borate
- VRGE = ~ 50% of the cost of 75 Quality N2 Foam
- VRGE = ~ 50% of the cost of 75 Quality CO2 Foam
- VRGE = ~ 30% of the cost of VES Fluid
- VRGE = ~ 10% of the cost of Propane
- VRGE = ~ 6% of the cost of Hydrocarbon System



Again, if the "all-in" costs are considered, VRGE also has substantially lower costs than any of the fracturing systems in the Marcellus chart below, provided by the same global E&P company:

- VRGE = ~ 50% of the cost of Slick Water
- VRGE = ~ 20% of the cost of Crosslinked Fluid
- VRGE = ~ 19% of the cost of VES Fluid
- VRGE = ~ 18% of the cost of 75 Quality Nitrogen Foam



Part 5: Comparison of VRGE vs. Sample Frac Jobs (provided by potential VRGE users)

VRGE vs. CO2 Emulsions or N2-Energized Foam

The energized (foamed) version of VRGE shares many of the potential benefits of other types of gas-energized fracturing approaches such as CO_2 emulsions and N_2 foams, including avoiding (or greatly reducing) the consumption & disposal of water, greatly reduced consumption of proppant, and high potential for increased oil & gas production—as much as 1.5 to 2 X. However, by utilizing CCNG produced at/near the well site, VRGE avoids the main drawbacks of CO_2 and N_2 foam fracturing systems—most importantly the high cost and logistical complexity of importing CO_2/N_2 to the well site and the need to separate the CO_2/N_2 from the hydrocarbon production stream or to flare/vent the entire CO_2/N_2 + hydrocarbon stream until the CO_2/N_2 has been purged.

Because of its use of CCNG produced at/near the well site as its fracing fluid instead of fluids imported to the well site, VRGE has the inherent ability to be scaled up or down dramatically—from small vertical wells to the largest/deepest horizontal wells, such as Bakken and Marcellus wells. VRGE also has the inherent flexibility to utilize a wide range of pressures and pumping rates, depending on the needs of the job, type of formation, type of well, etc. VRGE's foam quality can also be adjusted up or down, to maximize proppant placement, lower overall proppant consumption, minimize the amount of liquid foaming agents used, etc.

In summary, VRGE should be able to deliver all of the key advantages that CO_2 and N_2 energized fracturing offers, but with substantially lower operating costs and greater flexibility.

Comparison: CO2/N2 Foam Frac vs. VRGE Foam Frac

Category/Description	VaporFrac	VRGE
	Equipment	
Blending	Usually a batch mixer + ultra-light-weight proppant	Standard Proppant + Liquid Foaming Agent blender (already sourced/designed by XE)
Fluid tanks	Cryogenic CO2 or N2 tanks	Cryogenic LNG tanks or CCNG tanks[1,2]
Proppant vessel	Sized per amount of proppant needed/chosen	Sized per amount of proppant needed/chosen (See "Proppant concentration" below)
Pressure pumping	CO2 or N2 cryogenic pump units	LNG/CCNG cryogenic pump units
	Working Fluid	
Source	CO2 or N2 must be purchased and trucked in from an offsite plant. Costs can be high. Transport logistics add complexity to operations.	LNG/CCNG is sourced from a "VX Cycle" LNG/CCNG plant at/near the well site. A properly sized "VX Cycle" LNG/CCNG plant can supply as much CCNG as needed, and at low-cost/gallon (e.g., < $0.50/gal).
Foam quality	95% (average)	VRGE "Base Case" is 75% foam quality. However, higher or lower foam quality can be selected depending on needs of the job.
	Proppant	
Proppant concentration	0.1 to 0.25 ppa (e.g., Liteprop 105)	0.75 psa (Base Case; standard sand proppant) VRGE ppa can be lower with lightweight synthetic proppant or different foam quality.
	Treatment Details	
Wells	3000 to 4000 ft	VRGE is applicable for wells of virtually any depth—vertical or horizontal
Pumping pressure	4000 psi	VRGE pumps can easily achieve 4000 psi[3]
Rate	76 bpm	VRGE can easily achieve 76 bpm with ~ 4 CCNG pump units + 1 slurry pump unit

[1] LNG has approx. the same density as CO2, and therefore requires tanks of about the same volume. Approx. 20% more CCNG is required vs. N2, due to different densities.

[2] It is more economical to use CCNG vs. LNG, because CCNG requires less energy to produce. CCNG requires tanks capable of storing at temperatures colder than -160 F and at pressures higher than 700 psi. A somewhat higher volume of CCNG is required vs. LNG.

[3] LNG/CCNG pumps sourced by Expansion Energy can achieve pressures as high as 15,000 psi.

Pumping time	As little as 1 minute per stage or longer as needed. Pumping time is reduced or increased linearly based on amount of frac fluid needed/stage.	As little as 1 minute per stage or longer as needed. Pumping time is reduced or increased linearly based on amount of frac fluid needed/stage.
Footprint		
	Smaller than water-based frac spreads due to avoidance of water holding tanks & flowback water storage; fewer pumping units; and less proppant storage.	Similar footprint as foamed CO2 or N2 frac spreads for pumping, blending, foaming and proppant storage equipment. The main exception is the footprint of the skid-mounted CCNG plant (if CCNG is produced at the well site), which will require ~ 10,000 ft2. VRGE will require ~ 20% more CCNG vs. N2. However, production of CCNG on site will reduce amount of storage tanks required. If VRGE's NG pumps are electric-drive, a trailer-mounted power gen set will be needed onsite at a safe distance from the CCNG.

VRGE vs. N2 Lifting

Purpose: *Bring an over-balanced well back to production by circulating N2 at certain depth in order to reduce the hydrostatic pressure. VRGE, using CCNG, would be a replacement.*

This application of VRGE is similar to the potential use of VRGE by a large US independent producer XE is working with to potentially replace N2 fracs in the Appalachia region. For the lifting application, there is no need for proppant delivery and no need to foam VRGE's CCNG with methanol or any other liquid. Lifting can be done by merely producing CCNG, pumping it to the required pressure and sending it into the previously completed well. Therefore, **there is low risk in using VRGE for lifting applications, and it would require the lowest amount of capital of any VRGE application.**

In most contexts, and especially in remote production regions, N2 is either not available or is available only at high cost. By contrast, lifting with VRGE can rely on locally available NG as the feed gas source for producing VRGE's CCNG. The cost of the CCNG will be lower than any N2 "imported" to the well site (if such imported N2 is available at all). XE has verified (using cost data from US E&P companies) that the cost to produce CCNG onsite with VRGE is only a fraction of the cost of trucking L-N2 to the well site—even in the USA, where N2 prices are relatively low.

Also, the CCNG used in VRGE's frac fluid does not contaminate the produced hydrocarbon stream, and eventually resurfaces as NG, and can then be sold to the market or used for additional VRGE treatments. By contrast, the N2 used for well cleaning needs to be flared off (causing a loss of NG at the same time) or vented along with valuable NG (which is also environmentally harmful). The venting and/or flaring of NG contaminated with N2 is a major problem for one of the US producers who is currently evaluating VRGE as an alternative to N2. The US Environmental Protection Agency will begin preventing the practice of venting or flaring such N2 + NG streams in 2015. Moving away from N2 and toward VRGE is a solution for this problem.

Comparison: N2 Lifting vs. VRGE Lifting

Category/Description	N2	VRGE
Equipment		
Fluid transfer to wellbore	Coiled tubing	Coiled tubing[4]
Pumping	N2 cryogenic pump unit	LNG/CCNG cryogenic pump unit[5]
Fluid tanks	2 x 2000 gal N2 tanks	1 x 5000 gal LNG or CCNG tank[6,7]
Working Fluid Sourcing		
	N2 must be purchased and trucked in from an offsite air separation plant. Costs can be high. Transport logistics add complexity to operations.	1 onsite 6000 gal/day "LNGo" LNG plant from Dresser-Rand (using XE's "VX Cycle" technology) is sufficient to supply CCNG for 3 lifting jobs per day. Produced at low-cost per gallon.
Job Parameters		
Surface pumping pressure	2000 psi	2000 psi[8]
Rate	300 scf/min	300 scf/min
Volume	1500 gal	1800 gal
Pumping time	6 hours	As little as 2 hours (if pumping is constant).
Footprint		
	No change to drilling pad.	No significant change to drilling pad. VRGE's footprint would be virtually the same as the N2 spread. VRGE's tanks are ~ 20% larger. 4 container-sized skids for an LNGo plant. If LNG/CCNG pumps are electric-drive, a trailer-mounted power gen set will be needed onsite at a safe distance from the CNG.

[4] If the pressurized N2 is sent down at ambient temperatures, then VRGE's pumped-to-pressure CCNG would be warmed/vaporized by waste heat from VRGE's prime mover and/or from gas-fired heaters before it is sent down. In that regard, there would be no difference between the coiled tubing used for N2 or CNG (VRGE).

[5] VRGE LNG/CCNG pumps will have extended drive shafts or will be electric-drive, for safe use of NG.

[6] Approx. 20% more CCNG is required vs. N2, due to different densities. If preferred, 2 lower-volume LNG/CCNG tanks could be utilized instead of 1 x 5000 gal tank (e.g., 2 x 2400 gal tanks).

[7] It will be more economical to use CCNG vs. LNG, because CCNG requires less energy to produce. CCNG requires tanks capable of storing at temperatures colder than -160 F and at pressures higher than 700 psi.

[8] LNG/CCNG pumps sourced by Expansion Energy can achieve pressures as high as 15,000 psi.

VRGE vs. N2 Well Clean-Out after Frac

Purpose: *Circulate the well to clean debris by circulating N2 and fluid at certain depth. VRGE, using CCNG, would be a replacement.*

VRGE can be used for well cleaning applications in a similar manner as N2 is used. The only exception to this is where N2 is used because it is inert and non-flammable. (The CNG used in VRGE is, of course, flammable under certain conditions, and therefore requires adherence to safety protocols.)

This is another "low-hanging fruit" application for VRGE that can be considered for immediate demonstration/deployment. None of the equipment parameters/requirements for this application are particularly challenging for VRGE.

Because of its different density, the volume of CCNG needed by VRGE will be approximately 20% higher than the amount of N2 that would otherwise be used. However, because it is far less expensive to produce CCNG onsite with VRGE than to truck L-N2 to the well site, VRGE will still cost substantially less, despite the somewhat higher volume of cryogenic fluid (CCNG) used.

Also, the CCNG used in VRGE's frac fluid does not contaminate the produced hydrocarbon stream, and eventually resurfaces as NG, and can then be sold to the market or used for additional VRGE treatments. By contrast, the N2 used for well cleaning needs to be flared off (causing a loss of NG at the same time) or vented along with valuable NG (which is also environmentally harmful). The venting and/or flaring of NG contaminated with N2 is a major problem for one of the US producers who is currently evaluating VRGE as an alternative to N2. The US Environmental Protection Agency will begin preventing the practice of venting or flaring such N2 + NG streams in 2015. Moving away from N2 and toward VRGE is a solution for this problem.

Comparison: N2 Well Cleaning vs. VRGE Well Cleaning

Category/Description	N2	VRGE
Equipment		
Fluid transfer to wellbore	Coiled tubing	Coiled tubing[9]
Pumping	N2 cryogenic pump unit	LNG/CCNG cryogenic pump unit
Fluid tanks	3 x 2000 gal N2 tanks	1 x 7200 gal LNG tank[10,11]
Working Fluid Sourcing		
	N2 must be purchased and trucked in from an offsite air separation plant. Costs can be high. Transport logistics add complexity to operations.	1 onsite 6000 gal/day "LNGo" LNG plant from Dresser-Rand (using XE's "VX Cycle" technology) is sufficient to supply CCNG for 2 well cleaning jobs per day. Produced at low-cost/gal.
Job Parameters		
Surface pumping pressure	2000 psi	2000 psi[12]
Rate	500 scf/min	500 scf/min
Liquid volume per minute	0.7 bpm	0.84 bpm
Volume	3000 gal	3600 gal
Pumping time	6 hours	As little as 2 hours (if pumping is constant).
Footprint		
	No change to drilling pad.	No significant change to drilling pad. VRGE's footprint would be virtually the same as the N2 spread. VRGE's tanks are ~ 20% larger. 4 container-sized skids for an LNGo plant. If LNG/CCNG pumps are electric-drive, a trailer-mounted power gen set will be needed onsite at a safe distance from the CNG.

[9] If the pressurized N2 is sent down at ambient temperatures, then VRGE's pumped-to-pressure CCNG would be warmed/vaporized by waste heat from VRGE's prime mover and/or from gas-fired heaters before it is sent down. In that regard, there would be no difference between the coiled tubing used for N2 or CNG (VRGE).

[10] Approx. 20% more CCNG is required vs. N2, due to different densities. If preferred, 2 lower-volume LNG/CCNG tanks could be utilized instead of 1 x 7200 gal tank (e.g., 2 x 3600 gal tanks).

[11] It will be more economical to use CCNG vs. LNG, because CCNG requires less energy to produce. CCNG requires tanks capable of storing at temperatures colder than -160 F and at pressures higher than 700 psi.

[12] LNG/CCNG pumps sourced by Expansion Energy can achieve pressures as high as 15,000 psi.