REDUCE, REUSE,

A public-private partnership converts two cities' biogas into transportation fuel

Anna Schroeder and Becky Luna

In October 2019, South Platte Renew (SPR) commissioned its new gas recovery facility, the first system in Colorado to convert raw biogas to high-standard renewable natural gas (RNG) and inject that product into a natural gas pipeline for downstream use as transportation fuel. Constructed as part of the pipeline injection project, this facility is expected not only to improve environmental sustainability and local air quality but also to generate valuable revenue streams for the utility, which is jointly owned by the cities of Littleton and Englewood.

While the boons of an RNG-to-pipeline project are attractive and achievable, SPR's endeavor had few precedents. Yes, the technology used to convert biogas to RNG is established, but pipeline injection projects remain few and far between in the U.S. Thus, any such project requires stakeholder buy-in and extensive coordination with other agencies that may similarly lack experience in delivering such efforts. This meant that SPR's project team faced novel and delicate challenges that, to solve, required close communication between multiple partner firms, the right project delivery approach, patient follow-through, and, most of all, an attitude toward continual learning.

The following advice has been sifted from the obstacles overcome, lessons learned, and close calls during the Colorado project. By keeping these key points in mind, other utilities may also pursue similar efforts that not only contribute positively to their water resource recovery facilities (WRRFs) and communities but also generate long-term revenue through resource recovery — both of which were achieved by this innovative installation in Colorado.

Stakeholder Support Is Key

The vast majority of capital projects undertaken at WRRFs are driven by aging infrastructure, capacity limitations, and permit compliance. Because RNG-to-pipeline projects are

The gas conditioning and interconnect facilities work together to clean, compress, and inject biogas into Xcel's natural gas pipeline. Randall Erkelens/Philosophy Communication Inc.

REFUEL

focused on resource recovery, garnering buy-ins from stakeholders and local governments may take some time, diligent negotiations, and finesse.

For this reason, some WRRFs choose to pay for their pipeline injection projects via a third-party developer, who covers the financing, while the WRRFs receive a royalty or lease payment for the contracts' duration. While this financing method eliminates the need for a utility to invest capital, its control over the project becomes limited and, because its revenue stream is now shared with the developer, its return also is significantly diminished.

To maximize revenue potential and maintain project control, SPR pursued a cash-financed option, requesting a 50% split in capital investment from the cities of Littleton and Englewood. Garnering project approval and buy-ins from both city councils was a year-long effort that included presenting the project concept, discussing financing and delivery methods, and addressing a myriad of project uncertainties.

Several concerns were raised regarding the valuation of such a project, given how unstable renewable identification number (RIN)-generated revenue streams can be: traded on the open market, these "green credits" can experience price fluctuations related to supply and demand. In addition, the U.S. Environmental Protection Agency (EPA) set mandated quantities of renewable fuel volumes, which obligated parties are required to purchase, only through 2022. Beyond that period, there are more unknowns.

Understanding these valid concerns, the SPR project team took time to address each, running different sensitivity analyses on project payback and educating stakeholders on the U.S. EPA Renewable Fuel Standard (RFS) program's viability. The team also incorporated time to market as a critical project success factor and accordingly worked to shorten the project timeline and begin earning revenue as soon, and as securely, as possible. Ultimately, both city councils approved and supported this project through design and construction, so much so that both mayors spoke at the project's ribbon-cutting ceremony.

Project Delivery Structure Counts

The pipeline injection project constructed three primary assets to make up the gas recovery facility:

- A skid-mounted gas-conditioning system designed by Unison Solutions (Unison; Dubuque, Iowa) to remove hydrogen sulfide, moisture, siloxanes, volatile organic compounds, and carbon dioxide from biogas to produce RNG. This system is housed in an acoustic and weather-proof enclosure.
- An interconnect facility owned by Xcel Energy (Xcel; Minneapolis) that measures gas flow and quality and injects a mercaptan odorant prior to the RNG's injection into Xcel's 500-mm

The gas conditioning system is carefully set into place by Filanc during construction. Matt Crozier/Filanc

(20-in.) natural gas pipeline.

- A 100-mm (4-in.) diameter, 600-m (2,000-ft) long RNG pipeline that conveys pressurized, treated biogas to Xcel's pipeline.

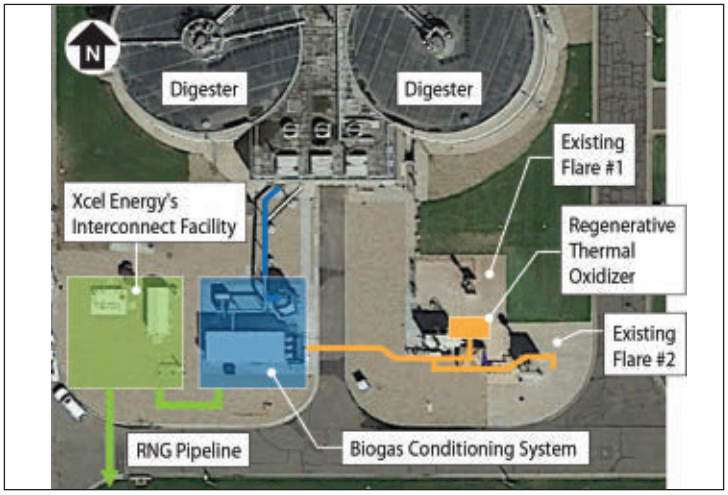
To efficiently manage these moving parts, SPR opted to use a construction manager/general contractor structure: compared to a traditional design–bid–build (DBB), this alternate delivery format allows for accelerated schedules and more control over costs. SPR selected Carollo Engineers (Carollo; Walnut Creek, California) as the design engineer and J.R. Filanc Construction Co. Inc. (Filanc; Escondido, California) as the contractor, who then assisted SPR with the early procurement of critical equipment, which typically has a lead time of 40 to 50 weeks, before the final design was completed.

Furthermore, unlike a DBB project whose bid price is unknown until the bid opening, this alternative delivery format gave SPR transparency regarding price estimations and equipment costs, with which it could cut, adjust, and develop project costs before being contractually bound to a final guaranteed maximum price. The project remained within budget from start to finish. In fact, SPR returned $129,000 of its contingency funds from the contractor after project completion.

Communicate, Communicate, Communicate

The pipeline injection project would not have succeeded on time and under budget had it not been for open, honest, and persistent communication between all parties involved. This was never more critical than during the startup and commissioning phase when each project element was verified, tested, and integrated into a single system. During this critical time, every team member attended daily meetings to remain abreast of changes to the schedule, issues to resolve, and task lists.

In particular, the team faced



SPR's gas recovery facility is located in a compact footprint adjacent to the existing digesters and is made up of the gas conditioning system, interconnect facility, regenerative thermal oxidizer, and RNG pipeline. Courtesy of Carollo

two notable challenges: 1) integrating complex systems into one cohesive facility and 2) cross-training experts in two distinctive industries — water and natural gas — on crucial aspects of each other's engineering and operations.

Piecing It Together

For the gas-conditioning system, the project team set out to develop a facility that not only generates RNG but also communicates with a regenerative thermal oxidizer (RTO) — two separate systems, each with distinct abilities and constraints, integrated into one.

WRRFs typically use candlestick-style flares to combust biogas produced in the anaerobic digestion process. However, tail gas generated through the membrane separation of carbon dioxide biogas does not contain enough methane to meet the methane-to-air ratio required by such a flare's design; therefore, SPR decided to install an RTO, which, unlike a standard thermal oxidizer, does not require additional natural gas to heat and combust the gas-conditioning system's tail gas. To function properly, the RTO relies on the gas-conditioning system's signals and accurate gas-quality readings.

To coordinate the two systems, the project's contractor managed discussions between the gas-conditioning system's designer and the RTO manufacturer, consulting with SPR and the design engineer at every turn. As a result of this teamwork, both manufacturers worked together and developed a single system tailored to the needs and conditions of SPR's WRRF.

In addition, the gas-conditioning system's manufacturer spent multiple weeks onsite to support the system's startup and commissioning and fine-tune its programming and mechanical components. Even later, when additional adjustments were required, the manufacturer's technicians communicated remotely with the contractor and guided them on how to tune various aspects of the system. This valuable partner will remain in contact with SPR to resolve any issues that may arise with the system and offer troubleshooting assistance.

Crosstrain the Workforce

In addition to being the first pipeline injection system at a WRRF in Colorado, this project was also Xcel's first RNG-to-pipeline endeavor. As such, everything from deciding on reasonable gas quality requirements to establishing contingencies, insurance, payment, and testing requirements had to be negotiated and finalized before Xcel could begin their design work.

At the start of the project, SPR and Xcel entered an agreement for Xcel to design and construct the interconnect facility and RNG pipeline, located on an easement provided by SPR. Therefore, SPR had to coordinate closely with its design engineer, contractor, and equipment manufacturers to design, construct, and commission the gas-conditioning system while also keeping track of Xcel and its own contractor's progress on the interconnect facility.

During the summer of 2019, in the midst of constructing the interconnect facility, discussions began between SPR and Xcel regarding the appropriate sampling requirements to check the RNG's gas quality. Xcel initially set forth stringent sampling conditions that could not be completed without hiring a third party to collect samples and a certified laboratory to analyze them. SPR quickly realized that Xcel's proposed testing plan for the first year of operation was too extensive and would place a prohibitive financial burden on the project.

To find a reliable middle ground, SPR, the design engineer, and Xcel reduced the frequency of

Fueling Finances

SPR operates a 190-million-L/d (50-million-gal/d) WRRF, the third largest in Colorado, whose anaerobic digesters produce approximately 14,000 m^3 (500,000 cu ft) of biogas every day. Before this project, this WRRF, like many others in the U.S., used only a portion of its biogas to heat its anaerobic digesters while the remaining 60% was flared. Almost 200 million BTUs of energy was wasted each day, thus spurring facility personnel to explore more opportunities for the sustainable reuse of their facility's biogas.

Today, over 95% of the WRRF's generated biogas is recaptured as RNG and injected into the natural gas pipeline owned by SPR's project partner and local natural gas utility, Xcel. This reuse method offsets the equivalent of 7,600 L (2,000 gal) of gasoline per day and over 22 million petroleum-fueled passenger vehicle kilometers (13.5 million miles) per year, reducing fossil-fuel-based carbon dioxide emissions by more than 5 million kilograms (5,000 metric tons) per year.

Beyond its environmental and community benefits, this pipeline injection system is anticipated to collect a significant return on investment.

In recent years, biogas recovery has become increasingly popular amongst utilities who've been incentivized by the U.S. EPA RFS program, a federal effort that requires fossil-fuel refiners, importers, and producers to purchase RIN credits from renewable fuel producers. Utilities selling RNG in California's natural gas market may also qualify for the state's low-carbon fuel standards (LCFS), which established the nation's first performance-based, fuel-neutral standard in 2007.

SPR qualified to receive credits from both programs, thus establishing new revenue streams. SPR's 20-year net revenue, just from RFS credits and assuming a RIN value of $1.78 (the historical three-year average at the time of this project's evaluation), is anticipated at $17 million. In 2020 alone, the gas recovery facility is projected to produce $1.8 million at current RIN and LCFS values. Accounting for these revenue sources, the project cost of $7.8 million, the project's payback period is approximated at five to seven years.

A regenerative thermal oxidizer is used to combust the low BTU tail gas produced by the gas conditioning system. Becky Luna/Carollo

testing to a level that would duly confirm the RNG quality but demand fewer trips to the site by a specialized testing firm. The discussions also led to the elimination of costly tests for components, such as hydrocarbons and biologicals, that would not be present in the final RNG. The end product was a testing and sampling protocol that was agreeable to and cost-effective for all parties.

Over a month after startup on the rest of the pipeline injection system, construction of Xcel's interconnect facility was completed and startup began on the complete system. The project team faced some roadblocks during this stage as well, one in particular being that the interconnect facility's design turned out to generate too much head loss, preventing the compressed RNG from flowing into Xcel's pipeline. Once again, steady communication between all parties led to a rapid and effective response: The gas-conditioning system's designer worked with the contractor to re-tune its system and increase the discharge pressure while Xcel procured and installed a pressure control valve with significantly lower head loss. These two actions allowed all system components to work together in conditioning and injecting WRRF-produced biogas into the natural gas pipeline.

To this day, SPR and Xcel continue to analyze these project-specific complications and educate each other about the nuances and requirements of their respective fields.

Keep Working

While the pipeline injection system's ribbon-cutting ceremony was cause for much celebration, SPR's work was far from complete. For several months after startup, SPR continued to work with the equipment manufacturers, in coordination with the design engineer and contractor, to adjust instrumentation set points and refine communication pathways between system components.

During this process, the project team discovered discrepancies in the gas quality measured at different points in the system. In particular, the methane analyzer in the gas conditioning system registered a different British thermal unit (BTU) concentration in the tail gas than what was measured by the RTO's analyzer; as such, the RTO, instead of oxidizing the methane in the tail gas as intended, kept re-routing it to be combusted by the WRRF's existing candlestick flare. To avoid frequent recalibrations and firmware updates and to streamline programming, the project team disabled the RTO's methane analyzer and configured the gas-conditioning systems' analyzer to run for both systems.

Similar communication issues continue to be targeted and resolved today. This work is imperative not only to standardize units and monitor the entire pipeline injection system's health but also to collect pertinent data on gas quality and flow. This information must be reported to the EPA for the project to be certified into the RFS program, a key step in the revenue generation.

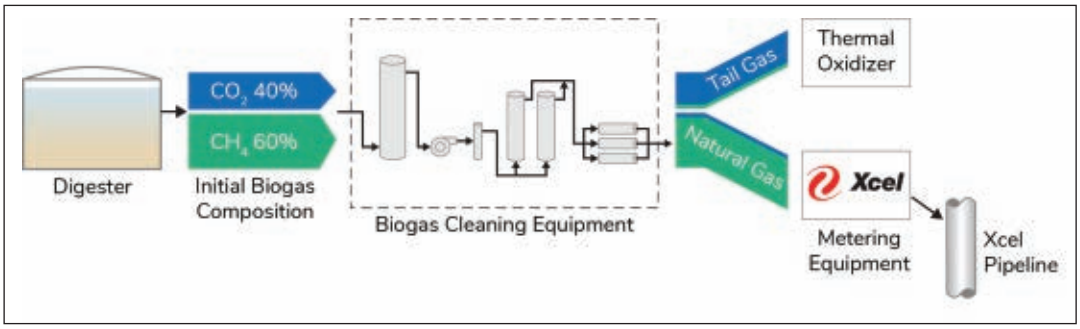
Play the Long Game

Because biogas-to-RNG projects can sell RIN credits and produce a revenue stream, their payback periods are typically less than 10 years, after which WRRFs can use their significant return on investment to plan future capital improvements projects they might not have otherwise been able to fund. The pipeline injection project's payback period is projected at five to seven years, with net-positive revenue being garnered after 2025.

That said, the path to revenue generation requires time and labor on the part of the WRRF. As was with SPR's project, these three steps are critical for revenue generation via a pipeline injection system:

1. **Hire a carbon broker.** On behalf of the utility, this third party sells both the RNG

Biogas Separation



About 96% of the methane generated in SPR's anaerobic digesters is recovered from the biogas and injected into Xcel's natural gas pipeline. The carbon dioxide present in the biogas and a small amount of residual methane is combusted in a regenerative thermal oxidizer. Courtesy of Carollo

(brown gas) and green credits (RINs and low-carbon fuel standards) associated with the injected gas to fossil-fuel refiners, importers, and producers.

2. **Obtain EPA registration as a new renewable fuel producer for the RFS program.** This is, at a minimum, a three-month process of proving system flow rates and RNG quality. As mentioned before, gathering this data for the EPA is also a good way to jump-start a proper operations and maintenance protocol for the gas-conditioning system's instrumentation. Ultimately, it takes time to gain a solid understanding of any new system's expected values.
3. **Be patient to start earning revenue.** EPA certification does not necessarily mean that money will immediately flow in the door. Generated RINs can be held for months at a time, bundled with RINs produced by other renewable fuel producers, and sold when the market is high to maximize revenue.

Case in point, SPR began injecting produced RNG into the natural gas pipeline in October 2019, received EPA certification in July 2020, and received its first check from the carbon broker in September 2020. So, it's important to remember that securing revenue streams with a pipeline injection system is a marathon, not a race.

Make the Trail

With so few installations across the country, RNG-to-pipeline projects are trailblazing efforts that set precedents and standards for others to follow. While any progressive project will have its share of pushback and obstacles, success will always be found in solid and well-defined visions, dependable partnerships, frequent communication, and selective decision-making.

Perhaps most vitally, any team pursuing a pipeline inject project, or any multidisciplinary project for that matter, must be humble to learning. The success of such a project does not lie in a single firm's competency or knowledge; it is earned through the collaborative effort of experts across a variety of fields who are willing to teach others what they do not yet know and be taught what they themselves seek to understand. Their ideas, synthesized together, are what lead to solutions not yet developed and innovations not yet achieved or seen.

This project exemplifies how such principles can lead to the construction of resource recovery systems at WRRFs that support the health and wealth of their communities, foster regional partnerships, and improve sustainable practices.

Anna Schroeder, P.E., is an engineer at South Platte Renew. ***Becky Luna****, P.E., is a vice president of Carollo Engineers (Denver).*

The SPR project team celebrate the startup of Colorado's very first WRRF gas recovery and pipeline injection system. Brenda Varner/SPR