Automated Landfill Gas Collection Increases Uptime and Revenue for Landfill in Lawrence, KS

Technical Paper

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THE LEADER IN AUTOMATED LANDFILL GAS COLLECTION

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Update: Automated Landfill Gas Collection Increases Uptime and Revenue for Landfill in Lawrence, KS

Results through March 2019

Overall, MMBTU/Deks sold has increased by 52% from October 1, 2018 – March 31, 2019, compared to the same six months in the prior year, of which 10-20% is attributed to landfill gas automation. The plant downtime due to landfill gas quality delivered to the plant not meeting specifications has been reduced by 93%.

Sales Gas Increased by 52% with 10-20% attributable to landfill gas automation

The total sales gas to pipeline during the Oct-Jan period increased by 52% in 2018-19 as compared to the prior year, with 10-20% of this increase attributed to landfill gas automation. In *Figure 1*, we show the increase in sales gas.

During the same period, downtime due to gas quality was reduced by 93%, from an average of 73 hours per month to less than 6 hours per month. Loci Controls launched an update to the algorithm in November of 2018, and since the roll-out of this update the average number of hours per month of downtime due to gas quality is less than 1 hour. In *Figure 2*, we show the downtime due to gas quality to show that gas quality-related downtime has been essentially eliminated.

Benefits of landfill gas automation include (1) increase uptime due to gas quality stabilization in weather events, (2) increased flow after a weather event, (3) increased flow in the afternoon and evening resulting from a system that can tune to changing diurnal conditions, and (4) other synergistic effect from full wellfield visibility, rapid troubleshooting, and 24/7/365 automated tuning. Sales gas fully accounts for these benefits, but also captures benefits from other initiatives at the plant. The other major contributor to the sales gas increase was the replacement of the CO2 membrane system with a new system that reduced parasitic consumption of CH4 from a rate of 25% to near-zero.

Figure 1: Sales gas increased by 52% over prior year. Sales gas from Oct 2017- March 2018 shown in grey; sales gas for Oct 2018- March 2019 shown in green. Over this period, the average increase in gas production is 52%. Y-axis scales with dekatherms of sales gas; exact figures are confidential.

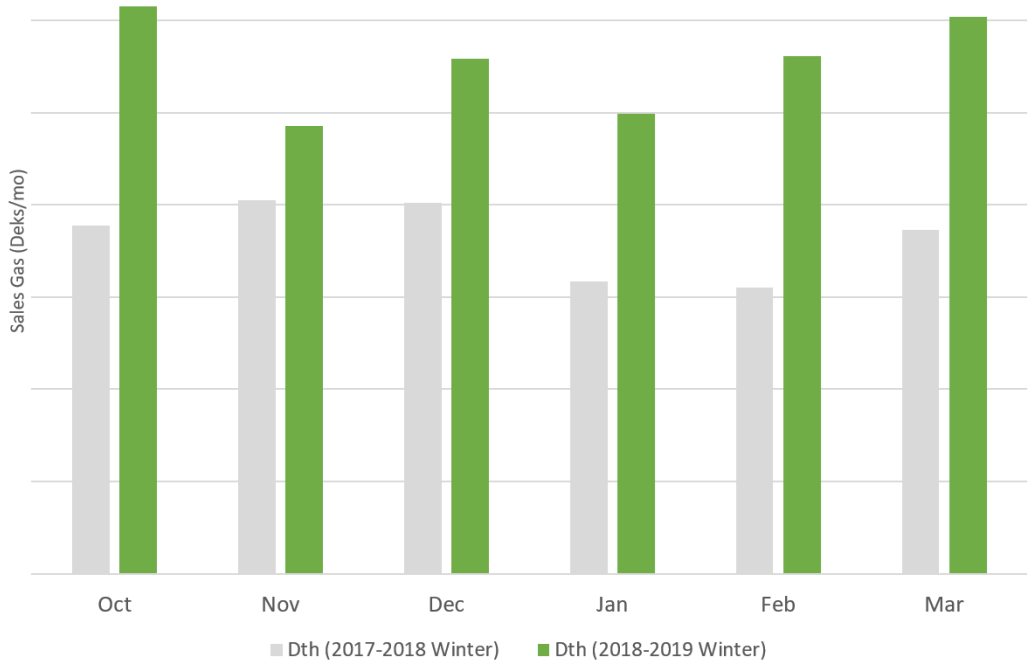
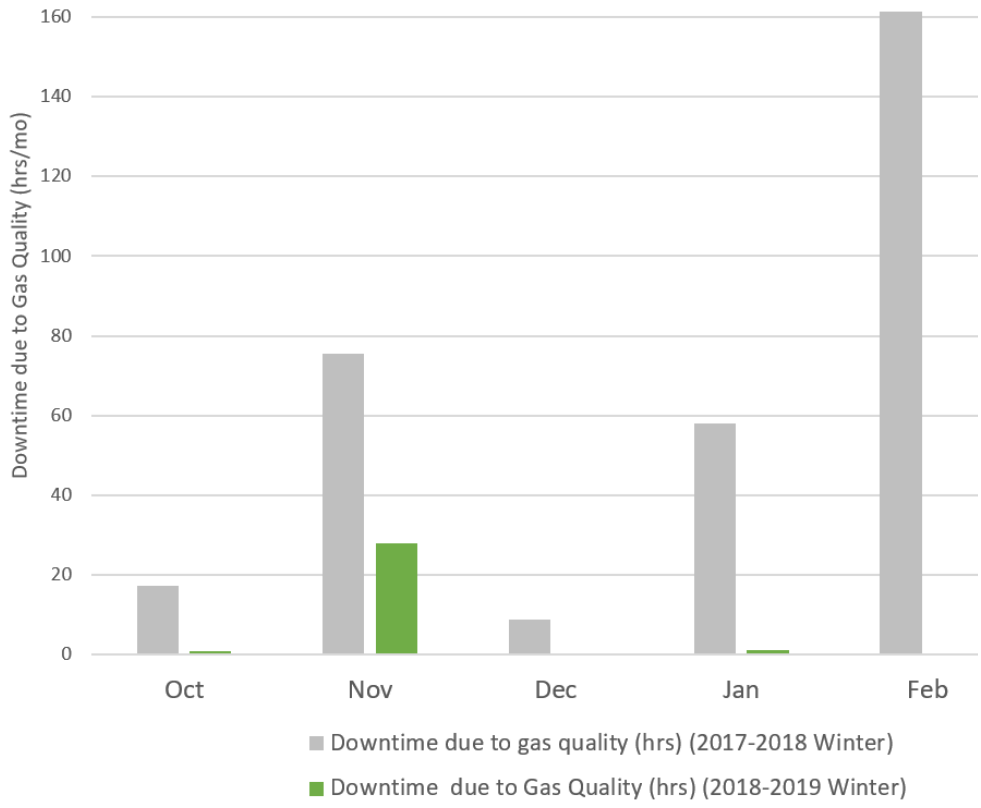


Figure 2: Downtime due to gas quality reduced by 93% over prior year. Hours of downtime from Oct 2017- March 2018 shown in grey; hours of downtime for Oct 2018- March 2019 shown in green. Over this period, the average decrease in downtime from gas quality is 93%. Improved Loci algorithm rolled out in November 2018 and since then downtime due to gas quality has been essentially eliminated.



Abstract

Enerdyne Power Systems (“Enerdyne”) is a market leader in the North American Landfill Gas sector. Enerdyne works on all aspects of project development, including construction, operations, consulting and ownership. Enerdyne has been involved with more than 50 projects over the last 28 years.

Loci Controls (“Loci”) is the leader in automated landfill gas collection. Loci’s products and services provide remote wellfield control through cloud-based software applications that maximize landfill gas collection. Loci products have been installed at over 20 sites, including landfill gas-to-electricity projects and landfill gas-to-high-BTU operations.

This paper highlights a case study where Loci provided full-field automated landfill gas collection to Enerdyne at the Hamm Landfill, a landfill gas-to-high-BTU project in Lawrence, Kansas. The project started in July 2018, and this paper presents results for the winter months which have the most variability in weather. From October 2018, through January 2019, Loci Controls reduced downtime due to gas quality not meeting specifications by 85% and increased gas delivered to the pipeline by 10-15% compared to the prior year.

Background

Automated Landfill Gas Collection

Loci Controls is the first company to provide automated landfill gas collection and was founded in 2013 by MIT engineers. Loci uses patent-pending technology and control algorithms to monitor and control the landfill gas collection process. Through continuous monitoring and control of the landfill gas collection system, Loci increases methane collection, gas quality, and profits for landfill gas to energy project operators. Through the use of wellhead monitoring and automated control, both plant and employee productivity are improved and there is a significant reduction in man-hours spent in the wellfield with commensurate safety benefits. Increasing gas collection efficiency also has the benefit of reducing fugitive emissions and odors from landfills.

The landfill gas collection system uses a large number of interconnected collection wells. Loci continuously monitors all collection wells and makes continuous, incremental valve adjustments to maximize the collection of methane from the whole wellfield. In addition, Loci uses aggregate gas composition measurement equipment, such as Gas Chromatographs, and/or precision gas meters, as top-level automation control variables. This ensures that aggregate gas collection meets the plant processing requirements. While each landfill has a unique operating environment, Loci's automated gas collection system has proven to increase gas collection by 10% or more — while improving the productivity of plant and personnel on location, and reducing the environmental, health and safety risks, and associated costs.

Loci's products and services use wellhead and header mounted hardware, connected via cellular networks to our WellWatcher® user interface and analytics platform. Working with personnel on site, Loci gas collection analysts provide remote oversight of the landfill gas collection process. In addition, Loci provides onsite support to help our customers optimize the overall gas collection and gas to energy process.

Loci Controllers and Guardians are wellhead-mounted products with an onboard sensor package that remotely monitors pressure, temperature, system vacuum, flow, oxygen, carbon dioxide, methane, and balance gas (calculated). The Controller units are designed for high flow wells (>15 scfm) at LFG to high-BTU projects where the performance requirements and value of incremental gas collection is greatest, and required precision with all measurements is down to tenths of a percent. The Guardian product is designed for lower flowing wells at high-BTU projects or for collection wells on electricity sites where the performance requires precision down to the percentage point. Both the Controller and the Guardian include an automated flow valve that regulates the flow at each individual well. Algorithms are used to make fine tuning adjustments on individual collection wells on an ongoing basis. Automation is also used to make simultaneous adjustments to multiple collection wells in response to changing gas composition as measured at the plant. In addition, Loci uses monitoring only Sentry devices which are mounted on individual headers to provide aggregate gas composition from sectional areas of the landfill.

Renewable Power Partners, Lawrence, Kansas

The Hamm Landfill in Lawrence, Kansas began accepting waste in 1981, is an open site, and has over 10 million tons of waste in place. The landfill is privately owned by Hamm Waste Services. Renewable Power Producers ("RPP"), a subsidiary of Enerdyne, owns the gas rights, and in 2017, designed and built a landfill gas-to-high-BTU pipeline injection project. This project generates Renewable Identification Numbers (RINs) as part of the Renewable Fuel Standards Program from the methane injected into the pipeline.

The Hamm Landfill has 100 collection wells, with average LFG collection of 1550 SCFM of landfill gas. The landfill has been manually tuned historically, with typical gas composition of the landfill gas at the inlet of 55% methane. To meet pipeline injection requirements, a minimum of 950 BTU, <2.000 ppm O_2, and <1% CO_2 is required."

The RPP plant does not have a Nitrogen Rejection Unit, so nitrogen must be controlled in the wellfield through the collection process. RPP's CO_2 removal equipment was upgraded in June of 2018, which increased the recovery efficiency for methane by 25%. Oxygen is burned off and H_2O is removed through a series of processes, including gravity drains and knockout pots. All equipment has been designed, manufactured, and operated by RPP/Enerdyne.

In the first year of operations at the high-BTU facility, it became clear that rapidly changing weather which is common in this part of the United States has a significant effect on gas composition and the overall gas collection process. Rapidly rising barometric pressure increased the intrusion of nitrogen and oxygen into the landfill gas collection system and frequently resulted in gas compositions which did not meet pipeline specifications. From October, 2017 – January, 2018, RPP experienced an average of 40 hours of downtime per month from the landfill gas collection system not meeting gas processing specifications. In addition, it was often necessary during the winter months to substantially reduce overall gas flow, especially during rising pressure events that typically accompany a cold weather front.

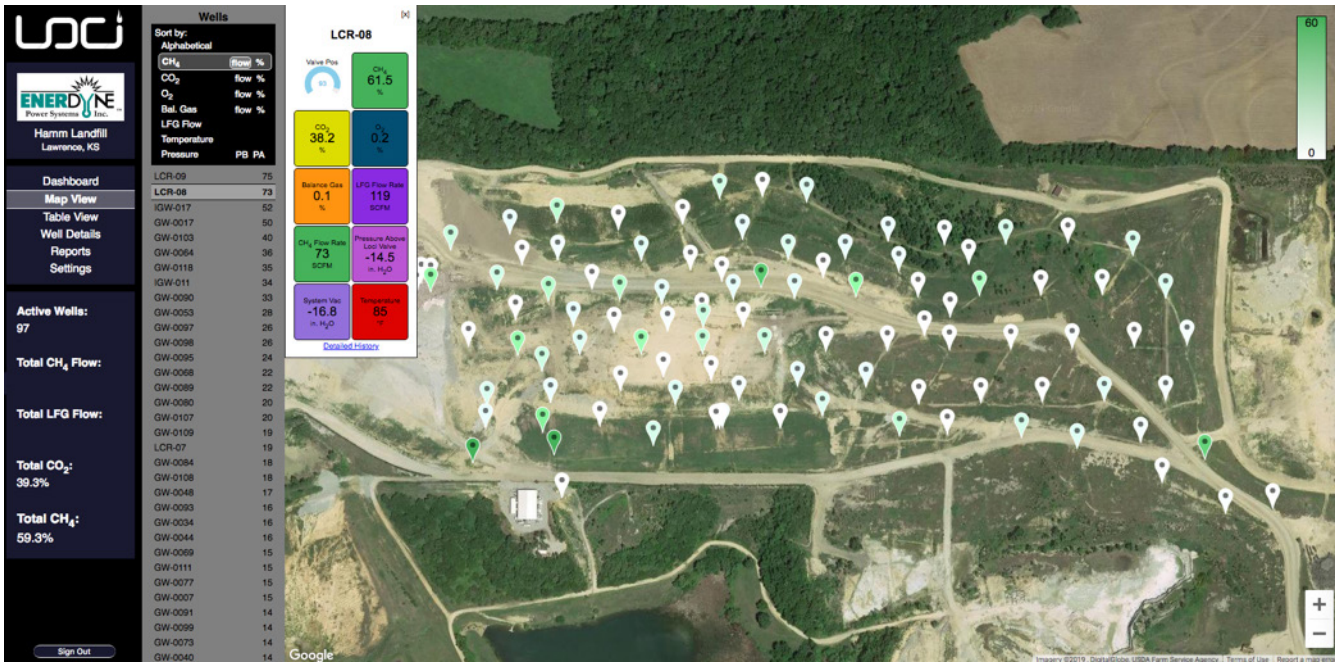
Project

Full-Field Automated Landfill Gas Collection

In the summer of 2018, Loci and Enerdyne worked together to deploy an automated landfill gas collection system at the Hamm Landfill in Lawrence, KS. Loci deployed 35 Controllers, 65 Guardians, and 1 Sentry unit to provide full-field coverage with the automated gas collection system. Controllers were deployed to wells with historical performance above 15 scfm of flow, and Guardians were installed on all other wells. The Sentry unit monitored inlet gas. The Sentry was used to make a direct connection to the ABB Gas PGC 1000 Gas Chromatograph ("GC") at the RPP plant to monitor aggregate gas quality at the plant as a top-level control. In November 2019, Loci also integrated an Advanced Micro Instruments 4010 BR precision O_2 meter into a serial port on the Sentry. This was necessary because the sales gas specification required a maximum of 2,000 ppm of O_2, which was too small a measurement to be accurately measured with the GC. The integration with the GC and precision O_2 meter provided Loci high-precision values for the gas inlet BTU, N_2, and O_2. Installation on 100% of collector locations, plus the data connection to the GC and Precision O_2 meter at the RPP plant, allowed for optimal operation of the automated landfill gas collection system.

Photo 1: Loci Controller unit on well at the Hamm Landfill in September, 2018.

Photo 2: Loci WellWatcher® Map of Enerdyne wellfield with data shown for a sample well.

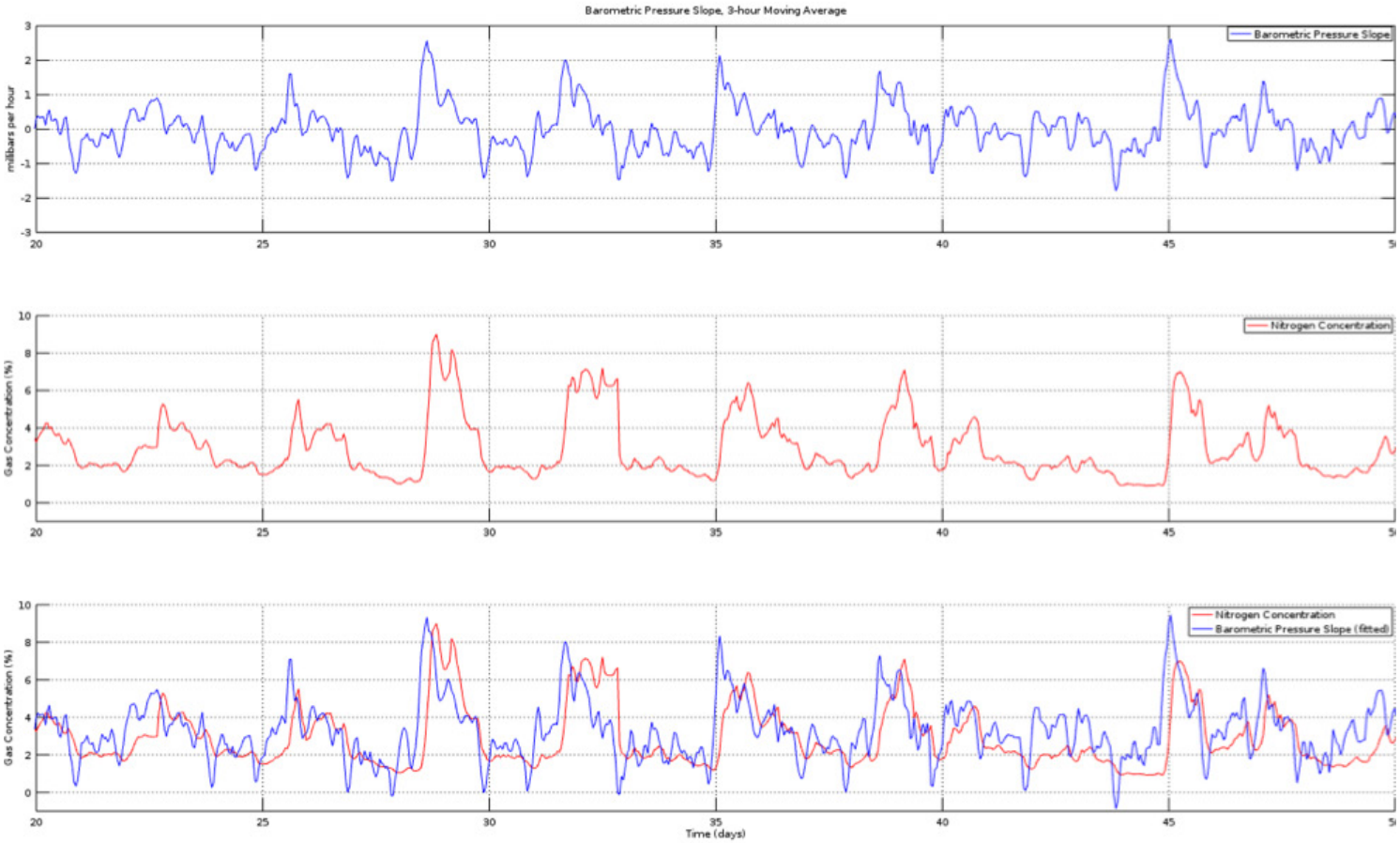


Barometric Pressure and Gas Quality

Figure 3 below illustrates the consistent and strong correlation between nitrogen concentration and the rate of change of barometric pressure before the landfill gas automation system was operating. Measurement of nitrogen is based on the Gas Chromatograph used on the pipeline injection point (sales gas) for this project. There is also a consistent time constant between when barometric pressure changes, and when the effect is measured at the plant. It takes approximately 4 hours from the time that barometric pressure starts to rise or fall before the effect is seen at the sales point. The correlation between nitrogen and barometric pressure change, with the 4 hour correction applied, has a very strong statistical significance as shown in *Figure 8*.

This effect is also consistent, but opposite, with rising or falling pressure. In a rapidly rising barometric pressure (normally associated with a cold front and clearing weather), nitrogen concentration in the sales gas can more than double in a matter of hours. Conversely, in falling pressure, typically following bad weather or storms, nitrogen concentration falls rapidly (and hence BTU of the sales gas increases), providing an opportunity where flow can be increased to capture more CH_4 flow.

Figure 3: Nitrogen concentration in sales gas is proportional to the rate of barometric pressure change. For a 30-day period pre-automation, a 3-hour moving average of barometric pressure, with a 4-hour shift applied, is shown in blue. Nitrogen concentration in the sales gas is shown for the same period. Strong visual correlation observed; statistics for the full winter period pre-automation are shown in *Figure 8*.

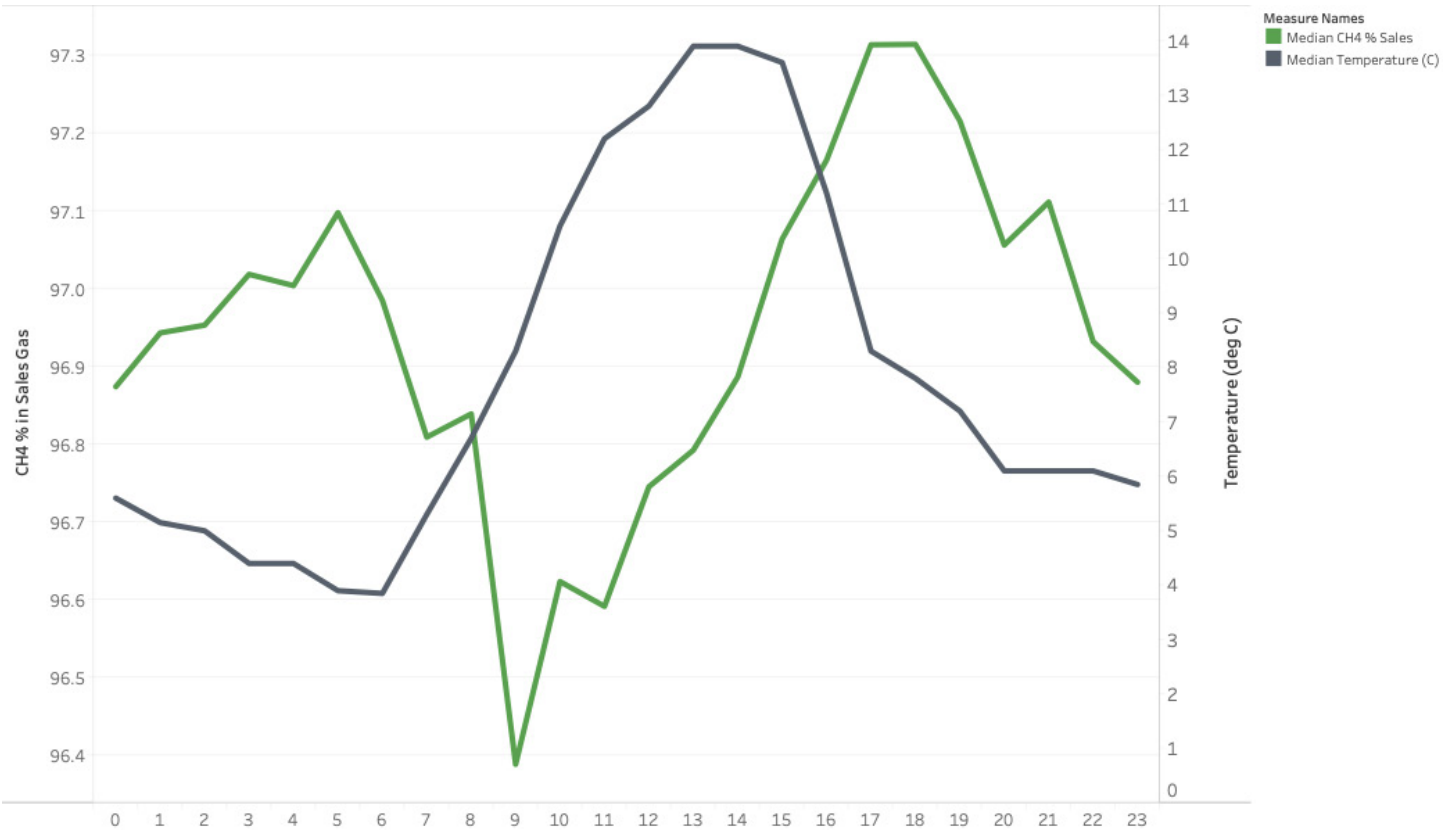


Diurnal Temperature Changes and Gas Quality

The concentration of nitrogen, or BTU of the sales gas, also varies diurnally, with rising and falling ambient temperature if landfill gas automation is not in use to correct for this effect. Typically, early in the morning when ambient temperature is the lowest, gas quality and BTU of the sales gas is generally lower than at any other point in a 24 hour daily cycle. As the temperature increases throughout the day, gas quality improves. The improvement in gas quality lags behind the ambient temperature by 3-4 hours as shown in *Figure 4* below.

This effect is smaller at the Lawrence, KS landfill during the winter months when rapid changes in barometric pressure can overshadow daily fluctuations of gas quality due to temperature. Still, this provides an example of additional opportunities to use small, frequent collection well valve adjustments to increase overall landfill gas collection system efficiency. *Figure A* in Supplemental Information shows the increases in gas flow that an automated landfill gas collection system can harvest from these changes, with a 4% increase in collection in the afternoon and evening relative to morning.

Figure 4: Hourly ambient temperature vs. CH_4% in sales gas, medians for Oct-Dec 2017. As ambient temperature (black) rises, it causes methane % in sales gas (green) to rise, with a 3-4 hour delay. Median values are given on an hourly basis over the Oct-Dec time period in 2017.



Almost all experienced LFG to high-BTU operators are familiar with these effects, but Loci's automated gas collection system is ideally suited to increase gas collection efficiency by compensating for external variables that change on hourly to daily timescales and are beyond the control of plant operators.

Landfill Gas Control Algorithms to Maximize the Collection System Performance

In order to not only mitigate the negative effects of rapidly changing weather, but also to fully capitalize on the opportunities for increased CH_4 flow created by these same conditions, Loci worked in coordination with Enerdyne technical and operating personnel to develop and implement enhanced algorithms at this project.

The following provides an overview of the automation algorithms that Loci has deployed for RPP at this site.

Fine Tuning Algorithm

Loci's original automated gas collection algorithm, launched in 2017, uses frequent (hourly) gas composition and flow measurements at each collection well to make small incremental valve adjustments. This automatic "fine tuning" of each collection well results in optimized CH_4 flow, while maintaining individual well gas composition requirements within balance gas (N_2) and O_2 thresholds.

Loci's fine tuning automation is a continuous "process cycle" that optimizes individual well and overall gas collection. The Loci Controllers or Guardians are used to take individual collector readings (gas composition, flow, LFG temperature, ambient pressure, pressure above and below Loci's automated valve, and valve position). In stable environmental conditions, automation is used to make small, incremental valve adjustments (less than 1% open or closed based on the last measurement). Subsequent gas composition readings will be compared to prior readings, and if the last valve adjustment resulted in a positive improvement in CH_4 flow while continuing to meet well specific gas composition thresholds, then an additional valve adjustment will be made in the same direction. If the last valve adjustment produced a negative result, a valve adjustment will be made in the opposite direction to seek the optimum. Loci's fine tuning algorithm is the equivalent of having a full time wellfield technician on each collection well manually measuring and adjusting each well according to this protocol.

This process is very effective when overall conditions external to the landfill are relatively stable. However, at a site like the Hamm landfill in Lawrence Kansas, external changes to temperature and weather can have a very rapid and large impact on gas composition and quality. As a result, a more dynamic algorithm was required to mitigate the effects of these rapid changes on the whole wellfield.

Threshold Gas Composition Algorithm 1.0

To respond to rapidly changing gas composition due to atmospheric conditions, Loci launched an enhanced control algorithm on October 1, 2018, that uses the plant GC data on aggregate gas composition from the entire wellfield, along with individual collection well readings, to optimize the landfill gas collection process. Beginning in October, 2018, Loci connected directly to RPP's GC at the plant using the Sentry product, to use real time gas composition and energy content (BTU) of the sales gas to ensure that the measured nitrogen and oxygen levels meet process set points and allow the operator to stay in the pipeline.

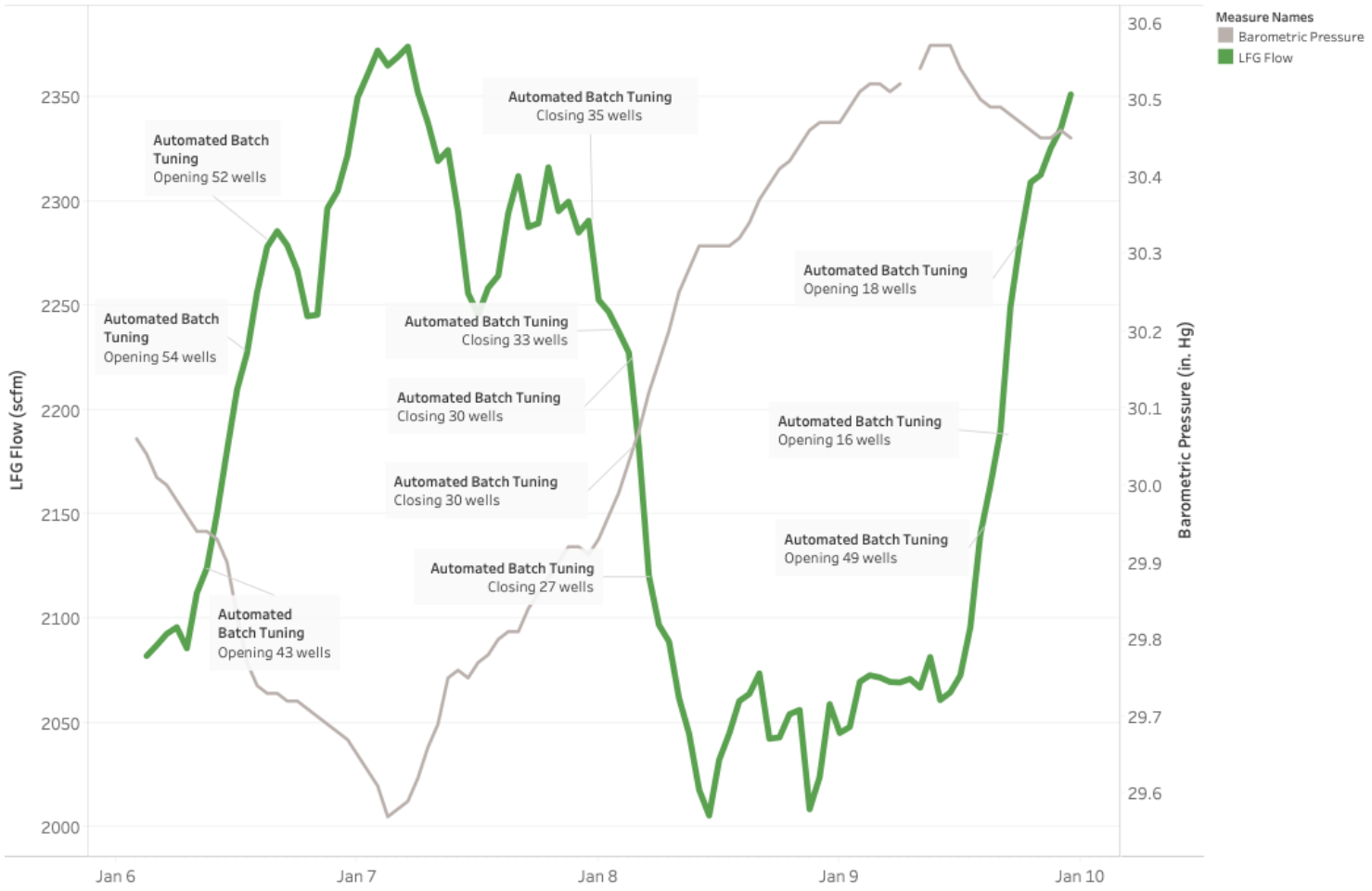
When the BTU value at the GC approaches either the high or low limits of a desired range, or process set points, Loci's automated system makes batch valve adjustments in the wellfield to stabilize the BTU values and maintain them within the optimal range.

Adjustments to valve positions on each individual collection well are weighted by gain factors which reflect how responsive an individual well's gas composition is to a given valve adjustment. For some collection wells, small valve adjustments have a large impact on gas composition; for other collection wells, larger valve adjustments are required to change the gas quality.

For example, in a rising pressure event, where nitrogen concentration is increasing in the sales gas and the BTU/energy content of the sales gas begins to fall rapidly, Loci's Threshold Gas Composition Algorithm sorts wells that are producing the lowest quality gas, and makes a significant (5% or more), simultaneous valve adjustment to reduce vacuum on these wells. Each collection well is subject to minimum and maximum valve positions to ensure that no well is adjusted above or below a set point when a Threshold Gas Composition batch valve adjustment is applied.

Figure 5 below illustrates a series of batch valve adjustments in response to changing barometric conditions in order to maintain gas composition and BTU, and to keep the gas treatment plant in the pipeline. Following a barometric pressure event, the Threshold Gas Composition Algorithm will rapidly resume a strong vacuum on the site in order to harvest additional gas.

Figure 5: Threshold Automation batch adjustments to meet gas composition thresholds. The Threshold Gas Composition Algorithm automatically adjusts batches of well simultaneously to rapidly respond to changing environmental conditions. As discussed below in the Results section below, Jan 6-10 2019, provides a case study for Loci's response to a barometric pressure swing. During this period, the control algorithm maintained all gas composition thresholds and maximized flow by batch tuning to increase flow when barometric was falling, and batch tuning to decrease flow and stabilize quality when barometric data was rising. Flow data (green) and barometric pressure (grey) shown below.



The manual well tuning method only relies upon data at each individual well, and generally, adjustments can be made only one well at a time; at a maximum the number of simultaneous adjustments possible is limited by the number of wellfield technicians deployed. In contrast, Loci's automated landfill gas collection system can make simultaneous changes on a large number of wells in response to changing gas composition as measured at the plant.

Threshold Gas Composition Algorithm 2.0

After approximately 6 weeks of positive results from Loci's newly introduced Threshold Gas Composition Algorithm 1.0, which used sales gas BTU as a top-level control variable, the site experienced several weather events that required the integration of precision oxygen readings. On November 15, 2018, Loci launched an update to the algorithm. In early November, there were several events when the BTU of the sales gas stayed well above the required set-point (consistently above 960 BTU), but gas composition failed on the 2,000 ppm (0.2%) oxygen outlet specification.

RPP had previously installed a precision O_2 meter with resolution of 1 part per billion O_2 concentration, as the Gas Chromatograph which was effective for measuring nitrogen concentration and calculating sales gas energy content (BTU's), was not sufficiently accurate to control O_2 to the 2,000-ppm maximum sales gas specification.

At that time, Loci leveraged a serial port available on the Sentry product to integrate the precision O_2 meter readings in real time, directly into Loci's control system. As a result, the Loci Threshold Gas Composition Algorithm was enhanced to allow multiple plant measurements, such as Sales or inlet gas BTU, nitrogen limits into or out of plant, O_2 limits, and others, as part of Loci's control algorithm.

During the month of November, there were 26 hours of downtime due to the gas composition from the landfill gas collection system. Since Loci implemented both sales gas BTU and precision meter O_2 feedback and control, during the months of December and January combined, there was less than 1 hour when gas composition from the collection system did not meet processing specifications.

Results

Full-field automation of landfill gas has been in continuous operation since October 1, 2018. The primary goals of the project for Enerdyne are to minimize plant downtime due to landfill gas collection system not meeting gas composition specifications, and to increase overall CH_4 flow and MMBTU/sales. The results have been significant and compelling. Overall, MMBTU/Deks sold has increased by 44% from October 1, 2018 – January 31, 2019, compared to the same four months in the prior year, of which 10-15% is attributed to landfill gas automation. The plant downtime due to landfill gas quality delivered to the plant not meeting specifications has been reduced by 85%.

Gas Composition during a Weather Event: Manual vs. Automated Landfill Gas Collection

Manual Wellfield Tuning

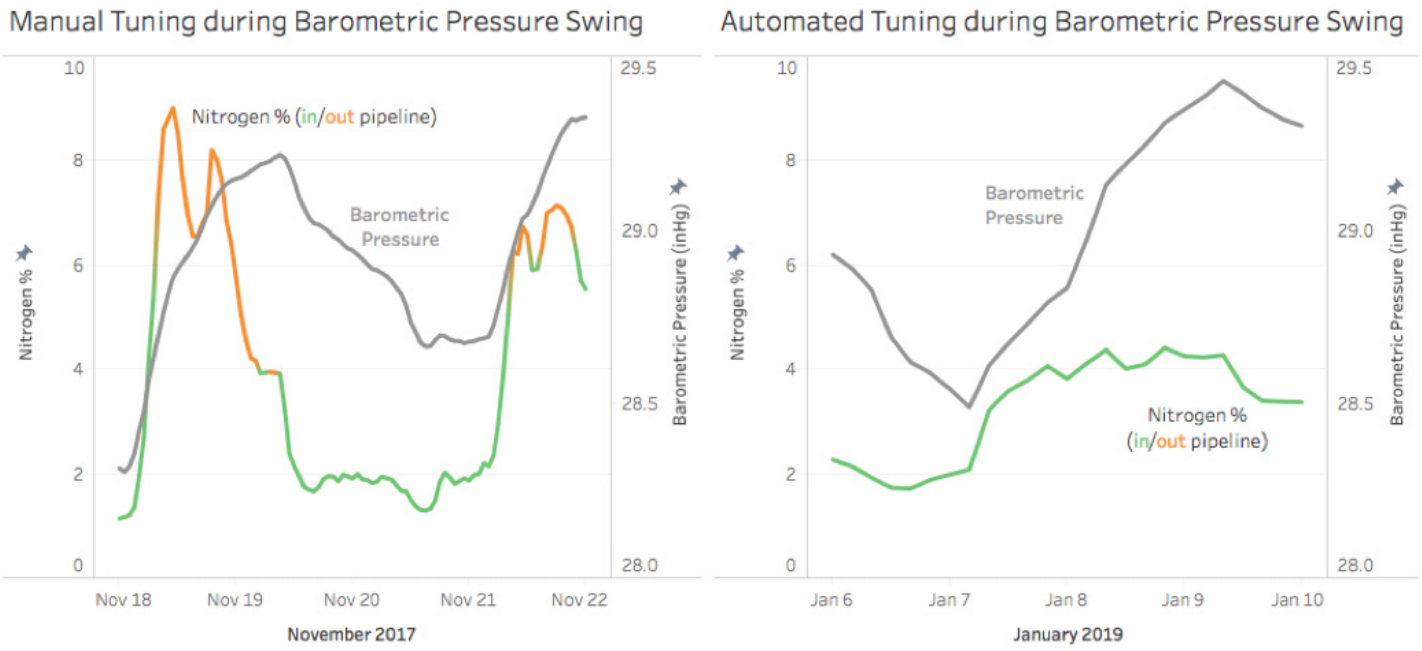
On Nov 18-22, 2017, a significant barometric pressure swing took place in Lawrence, KS which resulting in N_2 levels nearly 2x that of pipeline specifications and 50 hours of flaring associated with the event. In response to the barometric pressure event, site personnel attempted to tune down the area of the wellfield with the lowest quality gas, which at times meant doing so at night in very cold, hazardous conditions. For several days, staff sampled headers and targeted areas with the poorest quality. Still, with the whole field affected,

even targeted manual tuning was ineffective, and as a result the gas had to be flared. After the barometric pressure peaked and declined, high quality gas was available, but flow was greatly reduced due to the manual tune-down of the field. Therefore, recovering production took several days.

Loci Automated Gas Collection

In contrast, on Jan 6-10, 2019, there was a similar extreme barometric swing, but this event was managed using Loci's automated gas collection system and newly developed algorithms. During this period, Loci and RPP staff communicated closely and used the automated system to manage the gas quality. The nitrogen did rise, but the automated system maintained it below the gas quality threshold so that the gas stayed in the pipeline throughout the event. The automated system, with some remote human oversight, managed the whole event with no need for any manual tuning on site. Results from these two events are shown below in *Figure 6*.

Figure 6: Manual tuning during a barometric pressure swing event results in flaring vs. Automated tuning maintains pipeline specifications. Manual tuning during a barometric pressure event was associated with N_2 levels up to 9% and 50 hours of downtime. Automated turning maintained N_2 at the pipeline specification to stay in pipeline throughout the event.



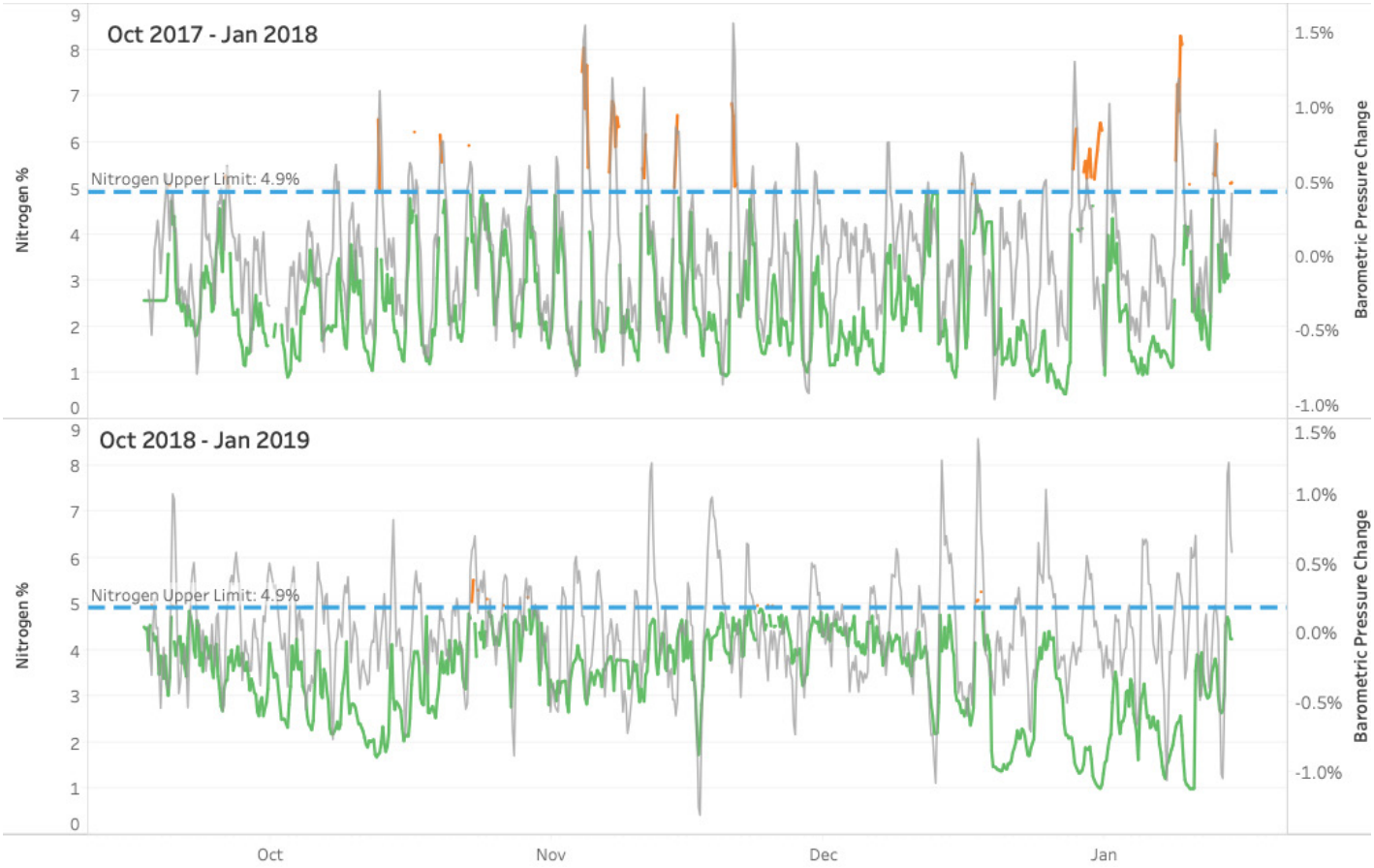
Reducing Downtime due to poor gas quality by 85%

Over the period of October to January in 2018-19, the number of hours of downtime resulting from weather-related events dropped by 85% relative to this period a year ago. As shown in *Figure 7*, the number of events when the nitrogen content of the gas exceeded the 4.9% pipeline specification was reduced dramatically.

There were 160 total hours of downtime last year compared to 26 hours this year, or an overall collection system uptime of over 99% with Loci from October 2018 – January 2019, vs. a 95% gas collection system uptime using manual wellfield tuning a year ago.

Figure 7 also shows a strong correlation between gas quality and barometric pressure swings in 2017, whereas in 2019, the automated landfill gas collection system was able to de-couple this relationship and deliver high quality gas even during an extreme barometric pressure swing. Barometric pressure is shown as percent change over a 12-hour period because the change in barometric pressure, not the absolute pressure, is the primary driver for gas quality variations. Barometric pressure data is shifted by 4 hours to coincide with gas quality events, as there is a delay in the change in ambient conditions and the impact on the wellfield.

Figure 7: 85% Reduction in hours of system flaring (orange) in 2017 versus 2018. Nitrogen percent shown in green below 4.9% and in orange above 4.9% to show flaring events. Percent change in barometric pressure over 12-hour period.

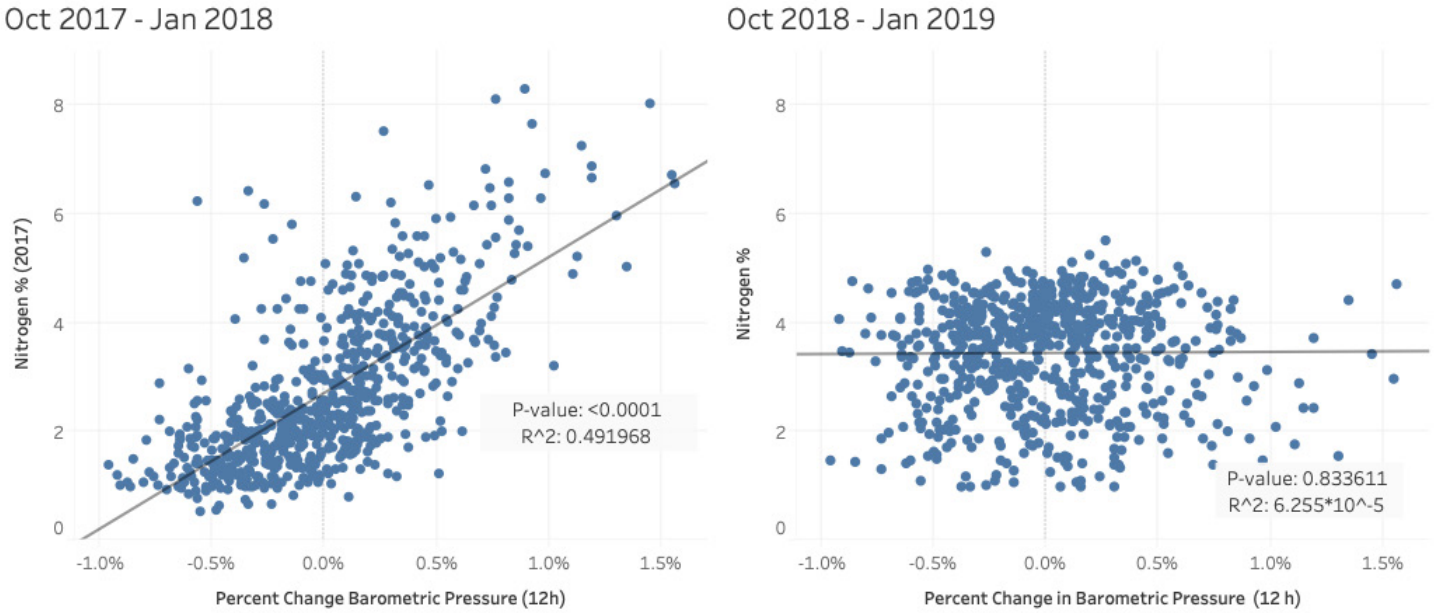


Using this same dataset, we ran a regression to examine the relationship between nitrogen content and barometric pressure, shown in *Figure 8*. We display the p-value and R_2 values for each regression. The p-value is used to determine if there is a statistically significant relationship between the two variables; the relationship is generally considered significant if the p-value is below 0.05. The R_2 value shows how much of the total variation in the dependent variable (here, nitrogen %) can be explained by the independent variable (here, barometric pressure).

In Oct 2017- Jan 2018, we found a p-value of <0.0001, well above the standard threshold for significance; thus, our p-value demonstrates substantial significance between the nitrogen content and barometric pressure change. The R_2 value in 2017-2018 was 0.49, indicating that the rate of change of barometric pressure alone is responsible for about 50% of the total variation in nitrogen percent in this dataset. In contrast, the Oct 2018 – Jan 2019, dataset has a high p-value and a very low R_2, indicating that there is no correlation between nitrogen and barometric pressure change.

In summary, this data illustrates that with manual wellfield operations, operators had little or no control over nitrogen levels in landfill gas because of the strong dependence on weather conditions. With automated gas collection, nitrogen concentration in the sales gas, and barometric pressure change dependence has been virtually eliminated, and it has been demonstrated that it is possible to maintain near constant gas collection system uptime, regardless of barometric pressure swings.

Figure 8: Strong relationship between barometric pressure change and nitrogen content with manual vs. No relationship with automated control. Regression analysis shows highly statistically significant relationship between rate of barometric pressure change in 2017, and no relationship in 2018. Also note the absence of very high nitrogen content readings in 2018 as compared to 2017. On average, N_2 levels were lower in 2017 than 2018, but despite the lower average, more values fell above the threshold. The lower N_2 average also resulted from a "tuning down" of the field in 2017 relative to 2018, which yielded lower flows without automation.



Sales Gas Increased by 44% with 10-15% attributable to landfill gas automation

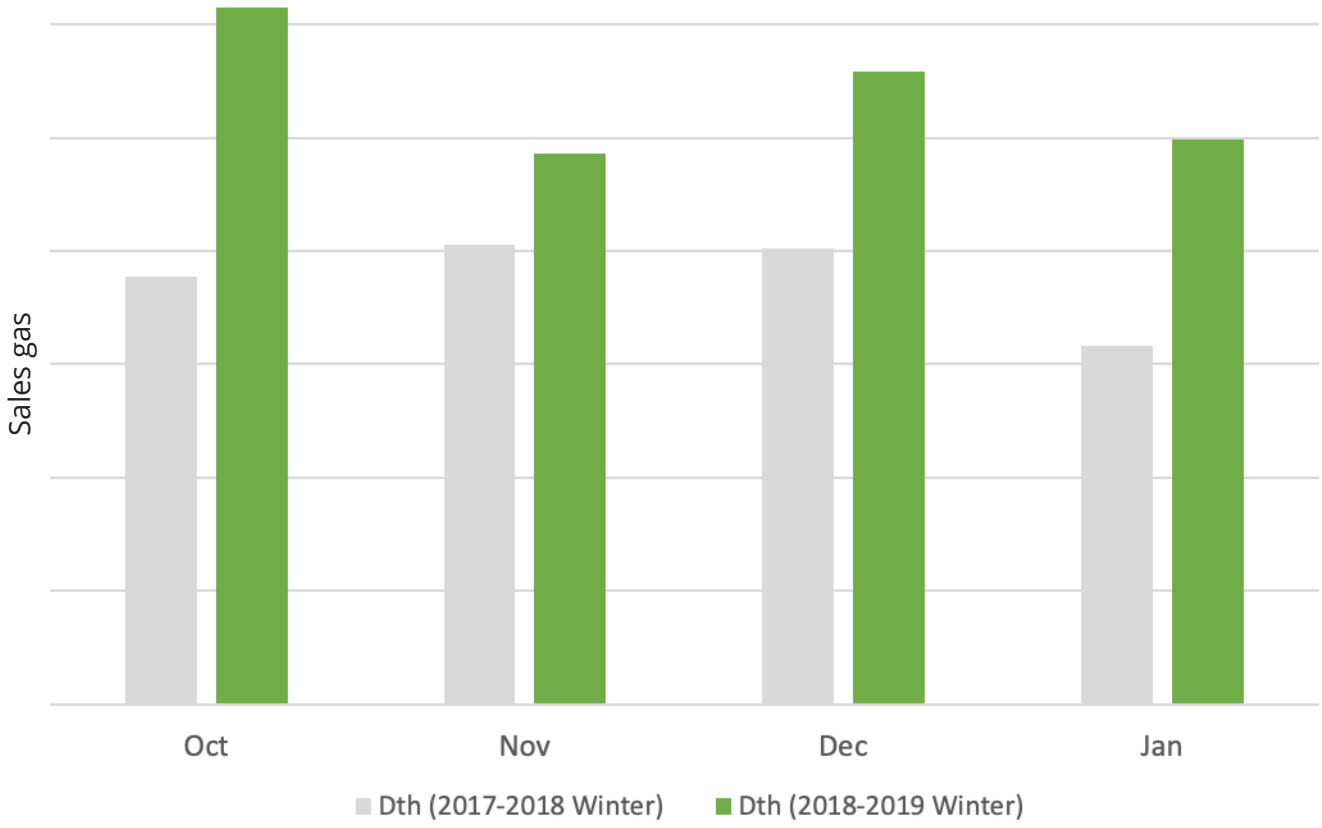
The total sales gas to pipeline during the Oct-Jan period increased by 44% in 2018-19 as compared to the prior year, with 10-15% of this increase attributed to landfill gas automation. In *Figure 9*, we show the increase in sales gas.

Benefits of landfill gas automation include (1) increase uptime due to gas quality stabilization in weather events, (2) increased flow after a weather event, (3) increased flow in the afternoon and evening resulting from a system that can tune to changing diurnal conditions, and (4) other synergistic effect from full wellfield visibility, rapid troubleshooting, and 24/7/365 automated tuning. Sales gas fully accounts for these benefits, but also captures benefits from other initiatives at the plant.

The other major contributor to the sales gas increase was the replacement of the CO_2 membrane system with a new system that reduced parasitic consumption of CH_4 from a rate of 25% to near-zero.

Figure B in Supplemental Information provides one other view of the impact of automation sales gas. There, we show that production of gas in 2017 was relatively flat when the plant was online, but in 2018 production ramps up to harvest additional gas when available.

Figure 9: Sales gas increased by 44% over prior year. Sales gas from Oct 2017- Jan 2018 shown in grey; sales gas for Oct 2018- Jan 2019 shown in green. Over this period, the average increase in gas production is 44%. Y-axis scales with dekatherms of sales gas; exact figures are confidential.



Labor efficiencies

In addition to the quantifiable benefits of landfill gas discussed above, RPP has also realized productivity gains, through labor efficiencies by implementing the Loci automated landfill gas collection system. RPP has been able to re-allocate staff away from wellfield operations in order to focus on plant operations, where they have been able to drive additional benefits.

Automated landfill gas collection has also unlocked the ability to monitor at a rate that would not be feasible with manual collection. For example, Loci takes a minimum of one reading every 3 hours, or 8 readings per day. For a wellfield with 100 wells, this is 800 readings per field per day, or nearly 300,000 readings per year. Assuming an efficiency of 6 wells per hour for a wellfield technician, one technician working an 8-hour shift could reach 48 wells a day, or 12,000 wells per year on a standard work schedule. So, to achieve the coverage that Loci provides, operators would have to hire at least 24 technicians and station them in the wellfield all day and night. While this is clearly not economically viable, even in this thought experiment, the technicians would be unable to tune instantaneously at multiple locations or use data from across the field to optimize collection. With automated collection, Loci delivers the value of more than 24 technicians operating the field 24/7/365 and provides high ROI economics on the service through improved operations, sales gas to pipeline, and uptime.

Conclusion

Landfill gas collection automation provides operators with full control over gas quality even during extreme weather events that have historically resulted in flaring with manual wellfield tuning operations. Using automation, Loci and Enerdyne have been able to drive an 85% reduction in downtime from landfill gas not meeting plant gas composition requirements. During the same period, sales gas to pipeline increased by 44%, with 10-15% of this attributable to landfill gas automation. With higher quality gas delivered to the plant and reduced variability in gas quality, RPP has the ability to devote existing resources to the highest impact areas, maximize production of gas to pipeline, and realize the full benefits of improved operations.

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As the landfill gas collection manager for Loci Controls, Inc., Jack Rowbottom is responsible for daily oversight of Loci's systems across the U.S. and has been instrumental in paving the way for remote and automated landfill gas collection and control. Mr. Rowbottom implements strategies for energy providers and waste companies to increase gas collection, improve quality, and reduce fugitive emissions. Mr. Rowbottom has eight years of experience associated with landfill gas management at many sites throughout the United States. He holds a Bachelor's degree in environmental studies and biology from St. Lawrence University.

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Site Manager
Enerdyne Power Systems

Kyle Caton is a site manager for Enerdyne Power Systems, a Landfill Group company. In his 18-year career, Kyle has managed five landfill gas to high-BTU treatment facilities, including the landfill gas collection systems associated with each project. He has been involved in the construction, startup and successful day-to-day operations of three different treatment technologies: physical solvent (Selexol), pressure swing adsorption, and membrane separation. Kyle now oversees Enerdyne's Renewable Power Producers facility in Lawrence, Kansas.

Supplemental Information

Figure A: Increased gas collection in afternoon and evening due to diurnal changes in automated collection. We observe higher quality gas in the afternoon as the site warms up and gas production increases. To harvest this additional gas, Loci's automated gas collection system increases vacuum across the site in the afternoon, resulting in a 4% boost in afternoon production. Averaged over the full 24-hour day, this increases production at the site by an estimated 1.7%. Y-axis scales with methane flow; exact figures are confidential.

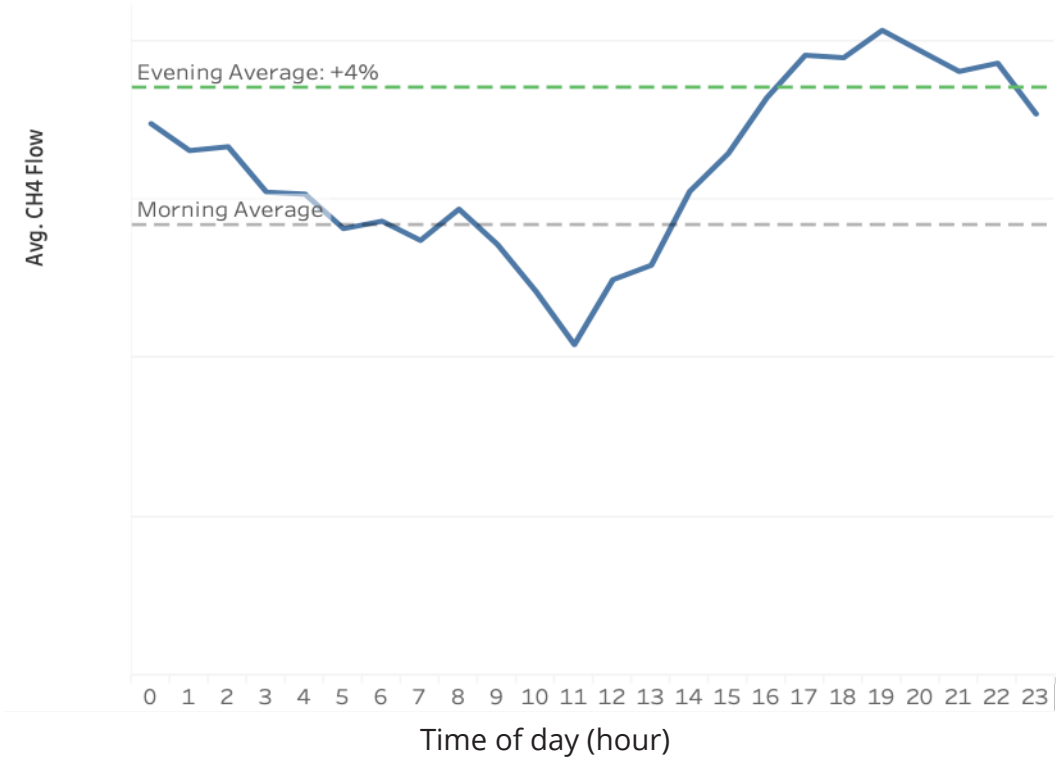

Figure B: Automated tuning increases sales gas opportunistically to deliver more dynamic profile of gas to pipeline than manual tuning. Oct-Dec gas production shown with flaring events excluded, with 2018 in green, 2017 in blue, and barometric pressure change in grey. 2017 is lower than 2018 production and output is fairly flat when on-pipeline. In contrast, 2018 sales gas is more dynamic in nature, with sharp increases in sales gas following a barometric pressure event and other signatures of an opportunistic, dynamic harvesting system. Y-axis scales with sales gas, with consistent axes across all graphs; exact numbers are confidential.