CERIN
Canadian Emissions Reduction Innovation Network

# CANADA EMISSIONS REDUCTION INNOVATION NETWORK (CERIN) PUBLIC REPORT

## 1. PROJECT INFORMATION:

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| **Project Title:** | Electrical Generation Technology Demonstration – Phase 3 |
| **Emissions Reduction Scope/Description:** | Electricity generation to reduce methane emissions |
| **Applicant (Organization):** | Saskatchewan Research Council |
| **Project Completion Date:** | March 2023 |

## 2. EXECUTIVE SUMMARY:

Four gas-to-power (electrical generation) technologies were instrumented as part of Phase 3 of the Electrical Generation Demonstration project, to provide operational data over an extended time. The units have been operated by their owners continuously for over a year. The gas-to-power units were instrumented in early 2023 by SRC to collect process data for this report, although only three units supplied data within sufficient time for this report. Gas-to-power technologies can reduce greenhouse gas (GHG) emissions in the oil and gas sector by combusting methane-rich gas streams, which may otherwise be directly vented to atmosphere. Methane will combust to carbon dioxide while generating power which can be used for any appropriately sized application. Oftentimes it is used to power a compressed air system or instrumentation/pumps and further reduces overall emissions by preventing pneumatic venting of methane. This electrical generation demonstration was a joint effort by the Saskatchewan Research Council (SRC), and the producers: Cenovus Energy, Ovintiv, and Tourmaline Oil. Electrical production performance and process parameters were measured. The data was analyzed to determine methane destruction efficiencies and to observe how external weather conditions affected the electrical production performance or process parameters. In addition, qualitative observations on the function of the gas-to-power technologies, as described by the producers, are presented as part of this report.

Based on the data collected thus far, it was found that the gas-to-power units investigated were capable of uninterrupted operation as no downtime was observed during the period while data was collected. Methane destruction efficiency ranges from 98.7 to 100% for the gas-to-power units and electrical efficiency remained relatively consistent despite a large variation in temperatures over the course of this study. The choice in gas-to-power technology depends upon the site's gas flow rates, electrical demand, and preferred methodology to reduce emissions. The units can reduce pneumatic venting of methane by providing electric power for equipment or by powering air compressors and converting pneumatic equipment to air operation. The inlet gas flow was widely cycled at sites where the primary load was an air compressor (GPT M5 and Westgen EPOD AP6 Hybrid) and did not show an impact on the continuous operation. It has been concluded that the gas-to-power units are a viable methane mitigation option for long-term operation in variable climates and can be used as a reliable source of power.

## 3. KEY WORDS:

Methane mitigation, electrical generator, emissions reduction, well site, pneumatic, compressed air, gas-to-power

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## 4. APPLICANT INFORMATION:

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| **Applicant (Organization):** | Saskatchewan Research Council |
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| **Applicant Representative Name:** | Carolyn Mortensen |
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## 5. LEAD CONTRIBUTING PARTNER INFORMATION:

| | |
|---|---|
| **Organization:** | N/A |
| **Address:** | |
| **Representative Name:** | |
| **Title:** | |

## 6. PROJECT PARTNERS:

Funding for this project is made possible through PTAC's CanERIC program, funded by Alberta Innovates and NRCan, and by the Saskatchewan Ministry of Energy and Resources, and Innovation Saskatchewan. In-kind contributions are provided by Cenovus Energy, Tourmaline Oil, Ovintiv, and the Saskatchewan Research Council (SRC).

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SRC gratefully acknowledges the help and in-kind contributions, coordination and field support provided by Cenovus Energy, Tourmaline Oil, and Ovintiv during instrument installation and testing.

# A. INTRODUCTION

## *Sector Introduction*

Gas is vented routinely in the upstream oil and gas sector, when the gas cannot be recovered economically and the gas does not contain volatile organic compounds, sulphurous, and malodorous components which exceed regulated limits or best practices. It is common that gas from oil and gas sites generally contains high amounts of methane. Methane is vented during emergencies, equipment leaks, as part of installation and maintenance activities, or due to equipment design. A molecule of emitted methane contributes more to global warming than a molecule of carbon dioxide. The 100-year global warming potentials of methane and carbon dioxide are 25 and 1 on a mass basis, respectively (ECCC, 2020). Thus, combustion of methane to carbon dioxide and water can result in a reduction of GHG emissions.

There are several gas-to-power electrical generation technologies capable of using gas from the upstream oil and gas sector to generate electricity. Most gas-to-power technologies involve combustion, and therefore they reduce direct GHG emissions by combusting methane to carbon dioxide. In addition, these technologies can reduce GHG emissions further when they replace existing energy sources which have higher GHG intensities such as grid electricity from coal or on-site electricity generation from diesel. Electric generators are a solution to pneumatic venting of methane by either enabling the use of electric equipment or powering air compressors to feed air instead of methane-rich gas to pneumatic equipment. When combustion technologies are used to mitigate GHG emissions, the amount of methane destroyed by the technology is an important parameter to consider. The current study will compare technologies based on their methane destruction efficiency, simply defined as the mass percentage of methane removed from the feed stream to the unit. It will also comment on the practicality of long-term operation in a location with variable climate conditions.

## *Project Specific Information*

This project involves instrumenting four gas-to-power (electrical generation) technologies which are used for reducing greenhouse gas (GHG) emissions from upstream oil and gas sites. This technology demonstration is a joint effort by the Saskatchewan Research Council (SRC) and three producers (Cenovus Energy, Ovintiv, and Tourmaline Oil). The project was initiated by CanERIC to fulfill its mandate to encourage the deployment of technologies which reduce GHG emissions, specifically methane, in the oil and gas sector. The purpose of Phase 3 of this project is to demonstrate the reliable operation of these systems in a "real-world" application of the technology.

Each unit was previously installed by the owner and was in use for at least one year. The systems were instrumented by SRC for monitoring over extended time periods. During the technology trials, electrical production, ambient conditions, and process variables are measured and recorded continuously. It is important to emphasize that each of the generation units have been installed at different sites and are subject to a range of unique operating conditions, fuel source characteristics, average electrical loads, and load fluctuations. The data is analyzed to observe each system's individual performance in their site specific application with respect to performance and reliability. In addition, exhaust (stack) testing is completed at each site to measure inlet and outlet gas composition and process parameters. The exhaust testing data is analyzed to determine methane destruction efficiencies of each unit.

## B. METHODOLOGY

The test sites chosen for Phase 3 had electrical generation units already installed by the producers. In order to collect data for long-term system monitoring, SRC provided instrumentation to monitor inlet air temperature, inlet gas flowrate, exhaust gas temperature, electrical parameters of each unit, and ambient conditions, along with a data logging device to store the data records.

On the same day which data logging equipment was installed at each unit by an SRC Research Technologist, the technologist completed stack testing over 2 to 6 hours at the existing operating conditions (as found the day of testing). During stack testing, inlet and outlet gas compositions and process conditions were measured.

*Table 1 - Electrical Generation Demonstration Phase 3 Technologies and Test Start Date*

| Equipment Manufacturer and Model | Technology type | Rated power (and heat[1]) generation (W) | Rated natural gas feed rate ($m^3/d$)[2] | Stack Testing |
|---|---|---|---|---|
| **Qnergy PowerGen 600** | Stirling Engine (CHP) | 600<br>(1500 - 2100 heat) | 15.6 | Jan 23, 2023 – 12:15 PM to 2:55 PM |
| **Global Power Technologies (GPT) M5** | CHP | 5,000<br>(10,000 heat) | 21 to 43 | Feb 23, 2023 – 9:30 AM to 2:55 PM |
| **EPOD AP6 Hybrid** | Internal combustion engine | 6,000 | 75 | Mar 29, 2023 – 12:45 PM to 3:07 PM |

[1] Heat generation for combined heat and power unit.
[2] Gas flowrate at standard conditions of 15°C and 101.3 kPa.


*Figure 1 - Qnergy PowerGen 600*

*Figure 2 - GPT M5*

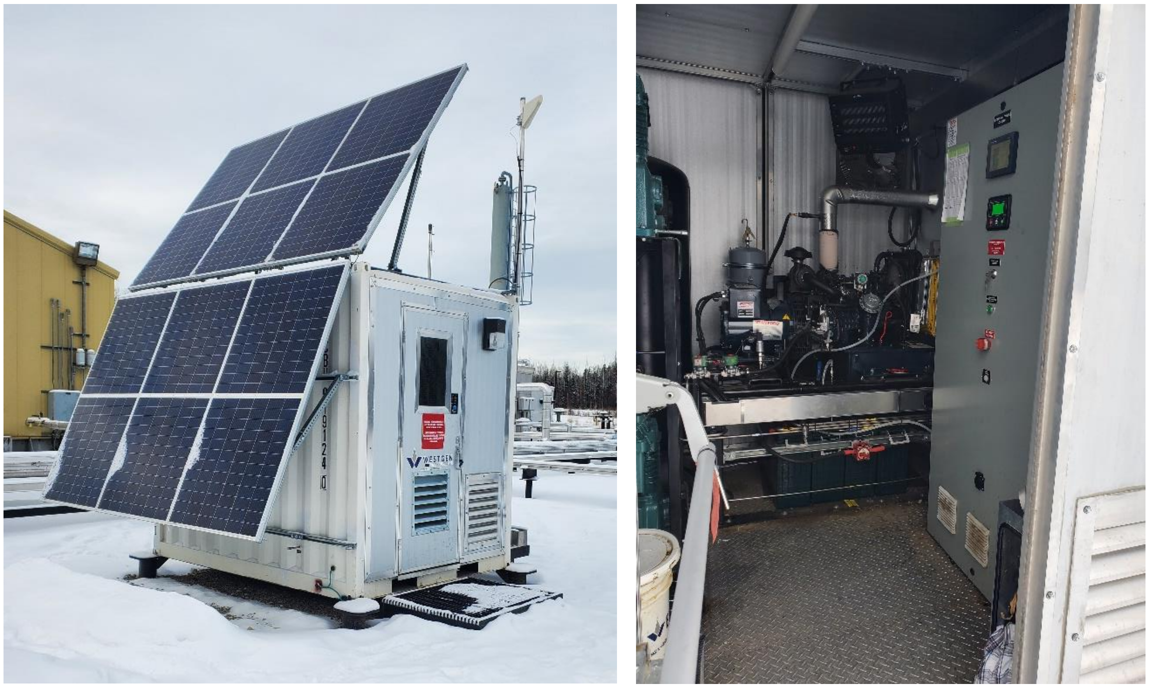

*Figure 3 - Westgen EPOD AP6 Hybrid*

## C. PROJECT RESULTS AND KEY LEARNINGS

Over the course of data collection, all of the gas-to-power units operated continuously over a range of operating and environmental conditions.

***PowerGen 600, Qnergy***

The Qnergy PowerGen 600 is consistently supplied an inlet flow rate at near its maximum rated value of 15.6 $m^3$/d. It supplies power to a load at 196.8 W which is only 32.8% of its maximum rated value of 600 W. Since the PowerGE 600 cannot turn down below 600 W, the unused power is turned into heat and shed in the Heat Rejection Unit (HRU). This operation results in a consistently low electrical efficiency due to the unused power. This system remains operating at a constant state of efficiency, despite significant variation in ambient temperatures, as is demonstrated in Figure 4.

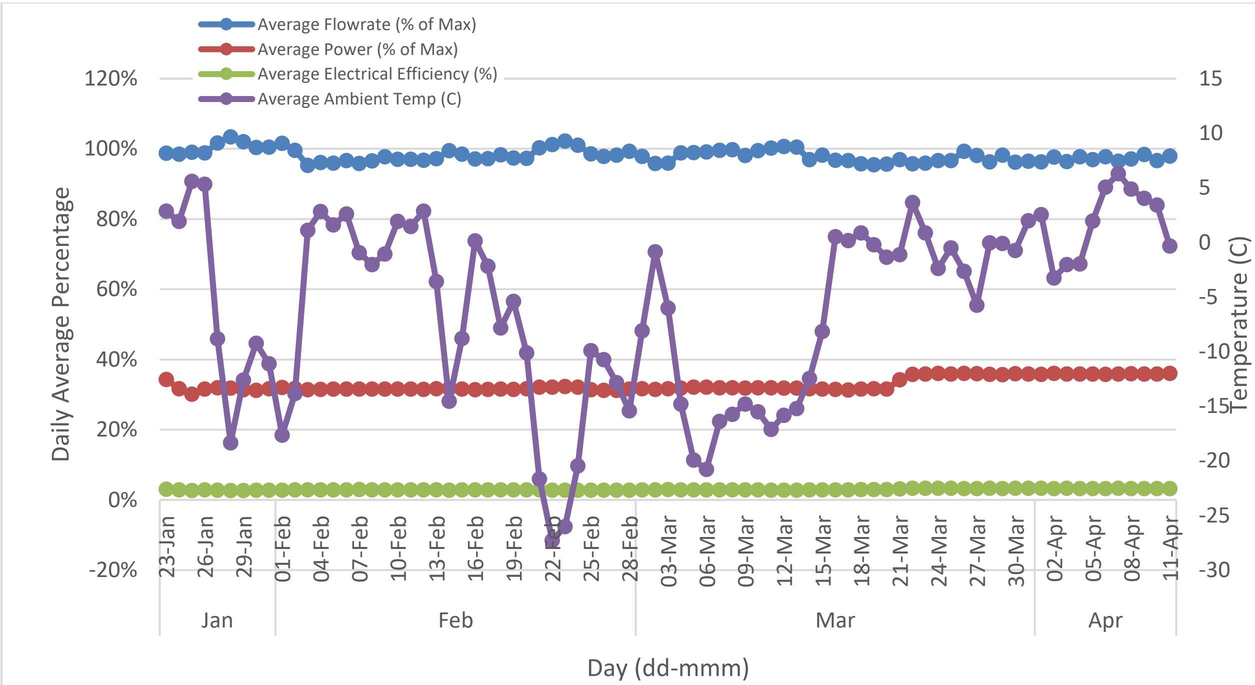


*Figure 4 – Qnergy PowerGen 600 Performance*

***M5, Global Power Technologies***

The GPT M5 sees significant variation in power demand, as the air compressor turns off and on, with an overall standard deviation in power at 798.4 W. The electrical load on this system is drawn by the air compressor, which feeds air to the pneumatic devices, as well as two catalytic heaters within the M5. It is believed that the heaters may have turned on in the period from March 5 to 7, where an increase in average flowrate is observed that corresponds with a drop in temperature. The electrical efficiency has a slight dip, as expected, after this period where the power demands drops but is otherwise relatively consistent. Note that GPT's current model, the MX, does not use catalytic heaters.

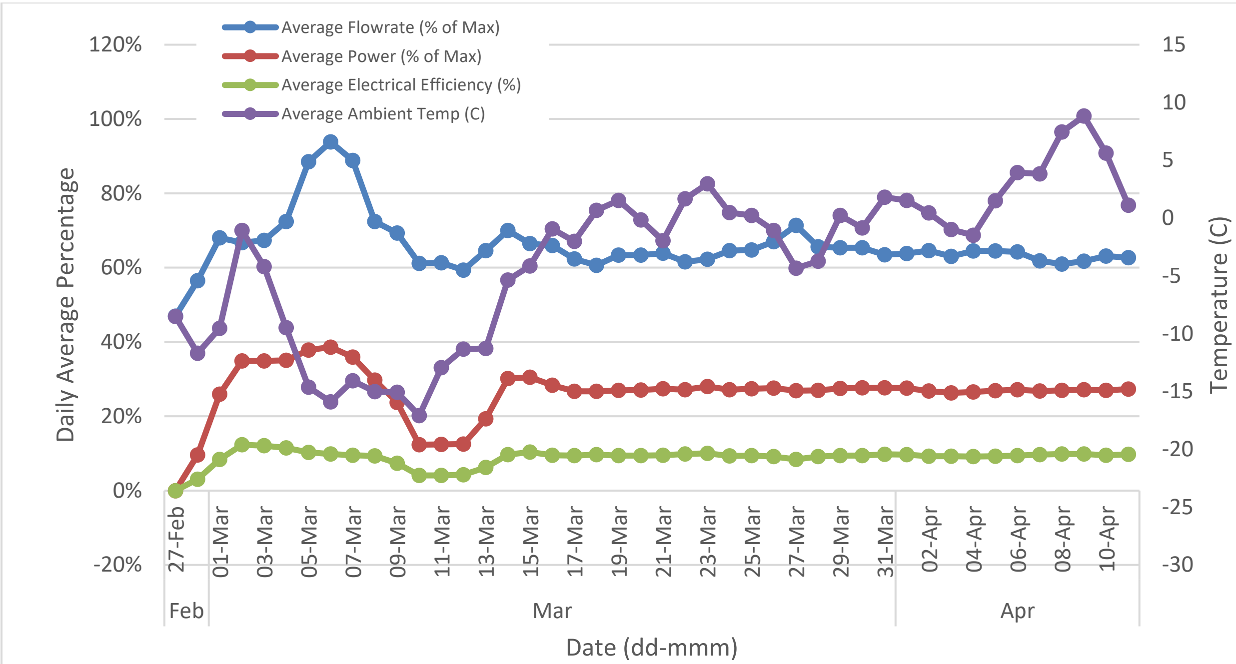


*Figure 5 – GPT M5 Performance*

***EPOD AP6 Solar Hybrid, Westgen***

The EPOD AP6 Solar Hybrid has a steady flowrate and correspondingly steady power consumption. The average electrical efficiency is 15% and operates at approximately 50% of the maximum rated flow rate and power. This is in part due to the inclusion of additional electrical load via battery energy storage which allows the generator to operate higher on its electrical efficiency curve. Note that this system has also been monitored for a shorter time period and in more temperate conditions.

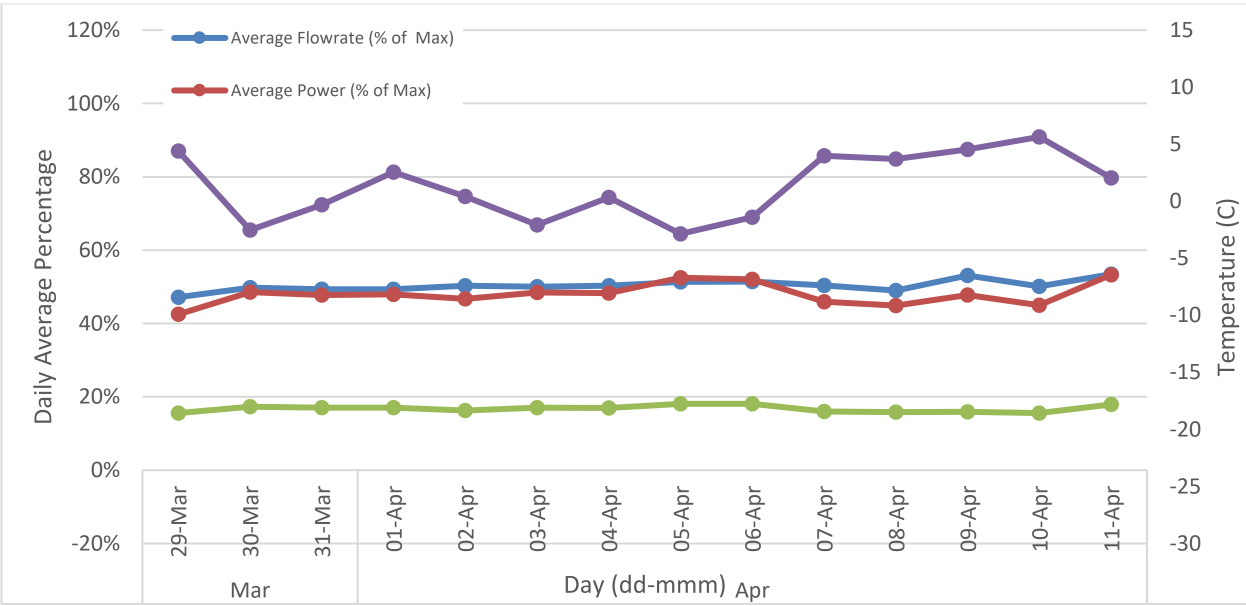


*Figure 6 – WestGen EPOD AP6 Performance*

Methane destruction efficiency (Table 2) is determined from stack testing results for each gas-to-power unit. Inlet gas and exhaust testing was completed on each unit at its operating condition, as found on the day of testing. No hydrogen sulphide was detected in the inlet gas, and liquids content is relatively low. The field test results were used to calculate how much methane was consumed in the units. Methane destruction efficiency (Table 2) is very high in all units and well above 95% (98.7 to 100%). These results demonstrate that the units are viable methane mitigation options at upstream oil and gas sites.

*Table 2 - Methane Destruction Efficiency*

| Technology | Inlet Gas Flow ($m^3/d$)[3] | Exhaust Flow ($m^3/d$) | Inlet Methane (kg/h) | Outlet Methane (kg/h) | Methane Destruction Efficiency (%) |
|---|---|---|---|---|---|
| Qnergy 600 | 14.7 | 151.1 | 0.380 | 0.0000 | 100.0* |
| GPT M5 | 26.9 | 132.1 | 0.634 | 0.0081 | 98.72 |
| Westgen EPOD6 | 32.2 | 740.7 | 0.7438 | 0.0060 | 99.20 |

*Methane stack emissions were below detectable limits

[3] All flows at Standard Conditions, 15°C, 101.325 kPa

Based on the information gathered during the Phase 3 of the electrical demonstration, the following key findings were established:

1. Methane destruction efficiency ranges from 98.7% to 100% for the gas-to-power units tested in this phase and are a viable methane mitigation option for long-term use.
2. The GPT M5 and EPOD AP6 include an electrical air compressor in the system for powering pneumatic devices on-site. Therefore, pneumatic devices which are currently venting methane to atmosphere can directly be converted to air operation.
3. Electrical generation units can treat methane while producing electricity for on-site or off-site use. Also, the units can reduce pneumatic venting of methane.
4. The most common application for gas-to-power generators that were instrumented in this phase was to reduce methane emissions, generating power for instrument air/pneumatics. The inlet gas flow was widely cycled at sites where the primary load was an air compressor (GPT M5 and Westgen EPOD AP6 Hybrid) and did not show an impact on the continuous operation.
5. The choice in gas-to-power technology depends upon the site's well or produced gas flow rates and/or electrical demand. If sized appropriately, backup power is not required. Note: For the Westgen EPOD AP6, the solar battery was the main source of power, with the gas-to-power generator operating as backup.
6. The gas-to-power units investigated are capable of uninterrupted operation – no downtime was observed while data was collected. Note: The Westgen EPOD AP6 Hybrid will run solely on battery when supplemental power from generator is not required.
7. Electrical efficiency for all gas-to-power units remained relatively consistent despite large variation in temperatures over the course of this study.

## D. PROJECT AND TECHNOLOGY KEY PERFORMANCE INDICATORS

| Organization: | Current Study | Commercial Deployment Projection |
|---|---|---|
| **Project cash and in-kind cost ($)** | $371,899 | N/A |
| **Technology Readiness Level (Start / End):** | 8 to 9 | 9 |
| **GHG Emissions Reduction (kt $CH_4$/yr):** | 0.03/unit | Up to 0.25/unit |
| **Estimated GHG abatement cost ($/kt $CH_4$)** | 130,000 | 80,000 |
| **Jobs created or maintained:** | N/A | N/A |

## E. RECOMMENDATIONS AND NEXT STEPS

Recommendations are as follows:

1. GHG reductions from use of heat in CHP units were not measured because the sites either did not have an application or had not yet implemented it. Future testing should include measurement of the heat, if possible.
2. None of the four Phase 3 study sites had generators that were operating on stranded gas at oil sites. Future studies should demonstrate the long-term operability of gas-to-power units at these sites.
3. Ideally, instrumented sites should collect data for a minimum of one year to observe a full weather cycle with updated data being included in a report.
4. If maintenance records and downtime are logged by producers, this information may be useful to include in future analysis and reporting.
5. Future studies should analyze GHG reductions and economics when using gas-to-power units for treating vented methane and for avoiding pneumatic venting of methane. It is important to have an overall understanding of the value in reducing emissions.