CERIN
Canadian Emissions Reduction Innovation Network

CANADA EMISSIONS REDUCTION INNOVATION NETWORK (CERIN) PUBLIC REPORT

1. PROJECT INFORMATION:

Project Title:	**Electrical Generation Technology Demonstration - Phase 2**
Emissions Reduction Scope/Description:	Electricity generation to reduce methane emissions
Applicant (Organization):	Saskatchewan Research Council
Project Completion Date:	May 2022

2. EXECUTIVE SUMMARY:

Six gas-to-power technologies were demonstrated as part of the Electrical Generation Demonstration project. The units were operated almost continuously, over approximately one week each, at ATCO’s Peigan Trail Gate Station in Calgary. Gas-to-power technologies can reduce greenhouse gas (GHG) emissions in the oil and gas sector by combusting methane gas streams to convert methane to carbon dioxide. This electrical generation demonstration was a joint effort by ATCO, Southern Alberta Institute of Technology (SAIT), the Saskatchewan Research Council (SRC), and the technology vendors: OilPro, Global Power Technology, Westgen, Horizon Power Systems, and ATCO. Electrical production performance and process parameters were measured. The data was analyzed to determine methane destruction efficiencies and to compare gas feed rates at various electrical loads. In addition, qualitative observations on operability of the technologies are presented as part of this report. These gas-to-power technologies can generate varying electrical loads.

3. KEY WORDS

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

Natural Resources Canada / Ressources Naturelles Canada

Canada

ALBERTA INNOVATES

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

4. APPLICANT INFORMATION:

Applicant (Organization):	Saskatchewan Research Council
Address:	Bay 2D, 820 51st Street East, Saskatoon, SK, S7K 0X8
Applicant Representative Name:	Erin Powell
Title:	Manager, Process Development, Energy Division
Applicant Contact Information:	306-933-5400

5. LEAD CONTRIBUTING PARTNER INFORMATION:

Organization:	See below
Address:	
Representative Name:	
Title:	

6. PROJECT PARTNERS

Funding for this project is made possible through PTAC's CanERIC program, funded by Alberta Innovates and Natural Resources Canada (NRCan), and by the Saskatchewan Ministry of Energy and Resources, and Innovation Saskatchewan. In-kind contributions are provided by ATCO, Southern Alberta Institute of Technology (SAIT), and the Saskatchewan Research Council (SRC). SRC gratefully acknowledges the help provided by Michael Leung of ATCO for coordinating this project. SRC would also like to thank all field staff representing ATCO for their assistance during testing. In addition, SRC would like to acknowledge the expert stack testing and analysis provided by Senior Technologist James Ravenhill and the team at the SAIT Environmental Technologies Applied Research and Innovation Services group.

A. INTRODUCTION

Sector Introduction:

There are several gas-to-power electrical generation technologies capable of using associated gas from the upstream oil and gas sector to generate electricity. Some of these units generate useful heat. Most gas-to-power technologies involve combustion, and therefore they reduce direct GHG emissions by combusting methane to carbon dioxide. In addition, they indirectly prevent GHG emissions when they replace existing energy sources which have higher GHG intensities such as grid electricity from coal or on-site electricity generation from diesel. In March 2021, SRC completed a scoping study of electrical generation technologies for CanERIC. The study examined oil and gas production areas in Saskatchewan and Alberta to determine typical associated gas production and on-site electrical demand. The scoping study then identified the most suitable gas-to-power units to include in a technology demonstration, based on design inlet gas flowrates and electrical outputs.

Knowledge or Technology Gaps:

This current project addresses technology and knowledge gaps of gas-to-power technologies by testing them in a field setting. This technology demonstration tests units which are either active or entering the market, capable of utilizing associated gas from oil and gas wells. The project evaluates the performance of several gas-to-power technologies, fed with sales natural gas, at up to five different electrical loading levels.

B. METHODOLOGY

Field Test Site and Plan:

ATCO provided the Peigan Trail Gate Station for the demonstration of six electrical generation technologies. The ATCO site is a regulating station of sales natural gas, which feeds into the Calgary distribution system. The ATCO site is equipped with a feed gas line with pipe, valves, regulators, and instrumentation to provide and monitor clean gas to the gas-to-power units during the demonstration. SRC provided instrumentation to monitor inlet air temperature, exhaust gas temperature, and electrical parameters of each unit, along with data logging to record both the SRC and ATCO parameters.

The technologies were trialed consecutively in time. Generally, the units were operated almost continuously between the start and end dates, for at least one week. The units are tested at up to five different inlet gas flow rates. Stack testing was conducted by The Southern Alberta Institute of Technology Environmental Technologies group (SAIT ET) one day per technology at two different electrical loads and resulting flowrates to measure exhaust parameters such as composition and velocity.

Gas-to-Power Units:

The gas-to-power technologies are shown in the following figures. The PowerGen 5650 is a combined heat and power (CHP) Stirling Engine rated for 5,650 W of electricity production:

Figure 1 – Qnergy PowerGen 5650

The Global Power Technologies M1.5 and M5 are both CHP units, rated for 1,500 and 5,000 W of electricity production, respectively:

Figure 2 – Global Power Technology M1.5

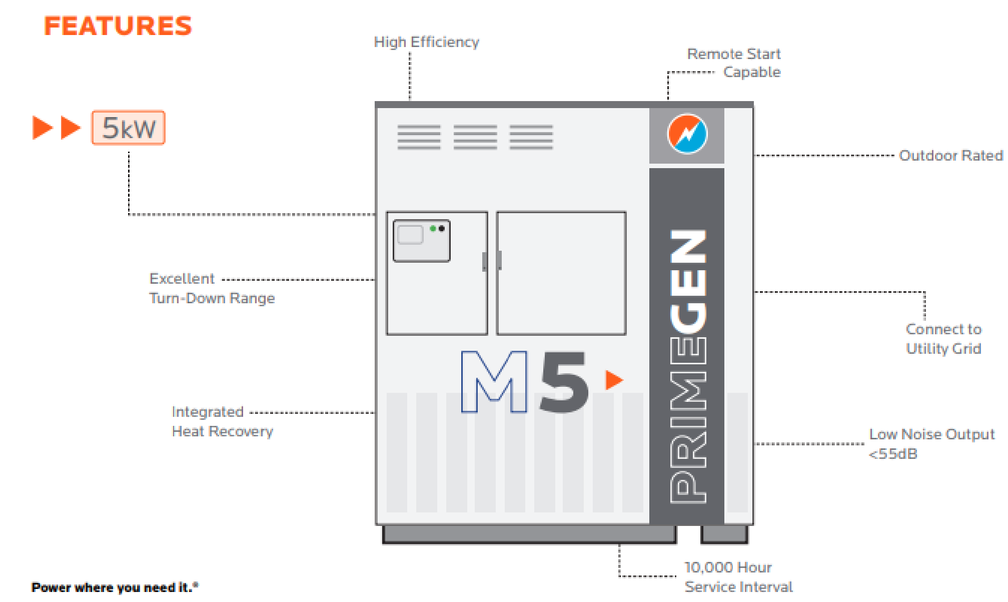

Figure 3 – Global Power Technology M5 (www.globalte.com)

The EPOD Air and Power 6XL Solar Hybrid, is a containerized unit, housing an internal combustion engine generator rated for 6,000 W of electricity production. Both the engine and solar cells mounted on the container charge a back-up uninterrupted power supply (UPS) battery. The container also houses an air compressor which can be used to power valves and chemical pumps:

Figure 4 – EPOD 6XL

The Horizon Power Systems Capstone C65 is a microturbine CHP units, rated for 65,000 W of electricity production:

Figure 5 –Capstone C65 Microturbine

The AISIN COREMO unit provided by ATCO is a CHP unit, rated for 1,500 W of electricity production:

Figure 6 – ATCO COREMO

C. PROJECT RESULTS AND KEY LEARNINGS

Measured and Calculated Parameters:

The gas-to-power units operated continuously at a variety of power generation capacities throughout each technology trial. The units achieved some level of inlet flowrate turndown. In general, the units are operated between 25% to 100% of their rated electrical generation (% of maximum) at the various test flowrates. The electrical efficiency is calculated, which is the electricity generated by the unit as a percentage of the power input available from the inlet natural gas. The electrical efficiency of the units was generally below 22% and was highest when the units operated near their rated capacity. The CHP units can achieve higher overall electrical efficiencies when heat produced by the units is used for on-site heating such as heat tracing or tank heating. All models, with the exception of the Capstone C65, produce 120/240 Volt, split phase power. The Capstone C65 produces 277/480 Volt, three-phase power.

Methane destruction efficiency is determined from stack testing results. Methane destruction efficiency ranged from 88 to over 99% and is generally highest when the units are operated near their design electrical load (Table 1). Reported results have been anonymized at PTAC's request. Unit 5 was only trialed at a high electrical load during stack testing as it was connected to the electrical utility grid and could not be controlled by SRC's programmable load bank to produce other loads.

Table 1 - Methane Destruction Efficiency

Technology*	Inlet Gas Flow (m^3/d)	Exhaust Flow (m^3/d)	Inlet Methane (kg/h)	Outlet Methane (kg/h)	Methane destruction efficiency (%)
Unit 1	30.7	43.0	0.817	5.29E-05	99.99
	117.2	74.1	3.13	0.000132	>99.99
Unit 2	7.4	6.78	0.194	0.00994	94.86
	13.8	9.12	0.366	0.00971	97.30
Unit 3	25.1	44.6	0.658	0.0568	91.36
	41.4	105.5	1.08	0.131	87.90
*Unit 4***	65.5	56.3	1.70	0.051	96.95
	81.1	53.1	2.02	0.042	97.99
Unit 5	223	686.4	5.81	0.00327	99.94
	535	1223	14.2	0.000999	99.99
Unit 6	16.2	18.6	0.421	0.0069	98.37
	15.1	22.0	0.394	0.0182	95.34

*Differences exist in technology type and intended application which results in operational tradeoffs. Technology unit anonymity is preserved for presenting test results in order to prevent direct comparison while maintaining ability to provide general learnings.
**During stack testing of Unit 4, the carbon monoxide concentrations in the exhaust were out of range of the FTIR analyzer. As a result, it is possible that the measured values of the exhaust methane concentration by the FTIR were in error, and that the actual methane destruction efficiency of the Unit could be higher than the calculated values.

Operability and Safety:

Sometimes gas sources at oil and gas sites, such as associated gas at oil wells, have low pressures, and it is important to know the allowable inlet pressures of the gas-to-power units technologies. In general, the PowerGen 5650, M1.5, M5, and EPOD 6XL units can operate at extremely low feed pressures. The C65 microturbine unit requires higher supply gas pressures.

When incorporating gas-to-power units into upstream oil and gas sites, designers should be aware of the exhaust temperatures of the units. Hot exhaust can be a potential hazard for sites where the exhaust plume can intersect a plume of natural gas from accidental releases or designed venting. The exhaust temperatures ranged from 31 to 362 ^{o}C. In general, the exhaust of combined heat and power (CHP) units will be cooled by using the waste heat for on-site heat demand.

One of the benefits of conducting the technology showdown at the ATCO site, was the opportunity for ATCO personnel including operators, an electrician, a pressure control operator, and an engineer-in-training to work directly with the gas-to-power units. In addition, oil and gas producers had the opportunity to visit the site during the showdown. Overall comments on the units are:

- All the electrical hookups from the technology manufacturers were very well thought out.
- Gas hookups were all straightforward as the ATCO test site was capable of delivering various gas inlet pressures.
- None of the technologies experienced much vibration.
- The COREMO unit requires an electrical utility connection to operate.

Key Learnings:

Key learnings from the project are as follows.

- The gas-to-power units are capable of uninterrupted operation at various electrical outputs.

- The gas-to-power units operate at significant turndown in flowrate, which is advantageous for variable flowrate associated gas sources from the oil and gas production sites.
- Electrical hook-ups of all gas-to-power units were straightforward.
- The mechanical and electrical design for incorporating gas-to-power units into existing and new oil and gas sites is expected to be straightforward.
- The choice in gas-to-power technology depends upon the site's gas flowrates and electrical demand, including voltage and phase requirements.
- Vibration of all the technologies is generally low.
- Several of the units are appropriate for gas sources with extremely low pressures (20.7 kPa_g or lower) such as associated gas from oil wells.
- The energy efficiency and GHG reductions are larger for combined heat and power (CHP) units.
- The EPOD 6XL further reduces GHG emissions by including battery storage, solar panels, and an electrical air compressor for powering any pneumatic devices on-site. Therefore, pneumatic devices which are currently venting methane to atmosphere can be converted to air operation.
- Methane destruction efficiency ranges from 88 to over 99% for the gas-to-power units and is higher when the units are operated at electrical loads closer to their design output.

D. PROJECT AND TECHNOLOGY KEY PERFORMANCE INDICATORS

Organization:	Current Study	Commercial Deployment Projection
Project cash and in-kind cost ($)	$224,350	
Technology Readiness Level (Start / End):	7-9	0
GHG Emissions Reduction (kt CH4/yr):	0.03/unit	Up to 0.25/unit
Estimated GHG abatement cost ($/kt CH4)	$130,000	$80,000
Jobs created or maintained:	N/A	N/A

E. RECOMMENDATIONS AND NEXT STEPS

SRC recommends a third phase of this project, field testing the following units:

Table 2– Electrical Generation Models Recommended for Testing

Model	Distributor / Manufacturer	Technology Type
PowerGen 5650	Qnergy	Stirling Engine (CHP)
M1.5	Global Power Technologies	CHP
M5	Global Power Technologies	CHP
EPOD Air and Power 6XL Solar Hybrid	Westgen	Internal combustion engine
C65	Horizon Power Systems, Capstone	Micro – turbine CHP

Other recommendations for a third phase of field testing are as follows:

- Test the gas-to-power units at upstream oil and gas sites, using associated gas, to see how the units operate on dirty gas with variable or cycling flows.
- Consider testing the Global Power Technologies model MX instead of M5, as the M5 model may be discontinued.
- Measure similar parameters as those measured in the current study, as well as the inlet pressure of the feed gas to each unit, downstream of any pressure regulating device.
- Consider capturing the heat from the combined heat and power (CHP) units for on-site use. The resulting GHG reductions and overall energy efficiency should be calculated and reported.
- Calculate GHG reductions from using the electric air compressor and solar/battery back-up power supply of the EPOD 6XL unit.
- Investigate non-exhaust methane emissions from the gas-to-power units (i.e., methane slip).
- Determine the need for a supplemental or back-up source of fuel gas to each gas-to-power unit.
- Test at both summer and winter temperatures.