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CANADA EMISSIONS REDUCTION INNOVATION NETWORK (CERIN) PUBLIC REPORT

1. PROJECT INFORMATION:

Project Title:	**Electrical Generation Technology Showdown, CanERIC**
Alberta Innovates Project Number:	N/A
Submission Date:	June, 2022
Total Project Cost:	$115,237.35
CanERIC Alberta Innovates Funding:	$80,222.38
AI Project Advisor:	Brian Spiegelmann, PTAC

2. APPLICANT INFORMATION:

Applicant (Organization):	Saskatchewan Research Council
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Applicant Representative Name:	Erin Powell
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3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

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 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. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes, and benefits.

RESPOND BELOW

Six gas-to-power technologies were demonstrated as part of the Electrical Generation Showdown 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 waste gas streams to convert methane to carbon dioxide. This electrical generation “showdown” 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.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

Sector Introduction:

There are several gas-to-power electrical generation technologies capable of using waste 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 waste gas production and on-site electrical demand. The scoping study identified the most suitable gas-to-power units to include in a technology showdown, 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 showdown tests units which are either active or entering the market, capable of utilizing waste gas from oil and gas wells. The project evaluates the performance of several gas-to-power technologies, operated almost continuously, fed with sales natural gas, at up to five different electrical loading levels.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Knowledge or Technology Description:

The project objectives are to:

- Test electrical generation technologies which are either active or entering the market, with a focus on options which utilize associated gas from oil wells.
- Properly instrument a test site to monitor and analyze process and ambient conditions, electrical generation output, and methane destruction efficiencies of each electrical generation technology.
- Gain an appropriate understanding of the real-world operation and the overall system efficiency of each electrical generation technology.
- Investigate performance of the electrical generation technologies at varying electrical load levels to better understand turn-down abilities.
- Facilitate access to the test site by CanERIC industry representatives to allow prospective adopters to view the technologies during operation.
- Provide vendors with live data and useful feedback to review and possibly improve electrical generation technologies.
- Provide oil and gas producers with real-world operation and performance data to help adopt electrical generation technologies, and to remove both real and perceived barriers to implementing electrical generation technologies in the oil and gas sector.

Updates to Project Objectives:

When this project was proposed, it was planned to test 8 units, including a solid oxide fuel cell and two Stirling Engines. The solid oxide fuel cell technology was excluded because it was not ready for field testing. The vendor of both Stirling Engine units was only able to supply one of the units for field-testing.

Performance Metrics:

Metric	Project Target	Values so far	Commercialization / Implementation Target	Comments (as needed)
# field pilots/ demonstrations	8	6	5	5 of these gas-to-power units are suitable for further field-testing
# of Publications	1	1	1	A long-form final report will be shared with the CanERIC members

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

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 – OilPro PowerGen 5650

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

Figure 2 – Global Power Technology M1.5

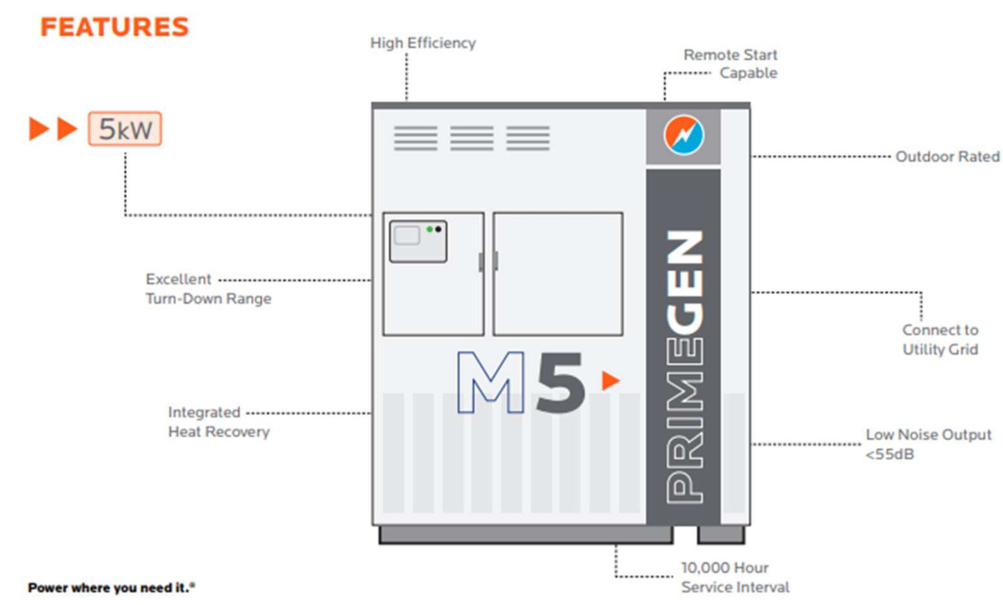

Figure 3 – Global Power Technology M5 (www.globalte.com)

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 – Horizon Power Systems Capstone C65

The AISIN COREMO unit from ATCO is a CHP unit with an internal combustion engine, rated for 1,500 W of electricity production:

Figure 6 – ATCO COREMO

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project's milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

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 at approximately 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 energy efficiencies when heat produced by the units is used for on-site heating such as heat tracing or tank heating. All models (except 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. The COREMO unit 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. Methane destruction efficiency is generally higher when the units are operated near their design electrical load (Table 1). During stack testing of the EPOD 6XL, 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 EPOD might be even higher than the calculated values.

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 (%)
PowerGen 5650	30.7	43.0	0.817	5.29E-05	99.99
	117.2	74.1	3.13	0.000132	100.00
M1.5	7.4	6.78	0.194	0.00994	94.86
	13.8	9.12	0.366	0.00971	97.30
M5	25.1	44.6	0.658	0.0568	91.36
	41.4	105.5	1.08	0.131	87.90
EPOD 6XL	65.5	56.3	1.70	0.051	96.95
	81.1	53.1	2.02	0.042	97.99
C65	223	686.4	5.81	0.00327	99.94
	535	1223	14.2	0.000999	99.99
COREMO	16.2	18.6	0.421	0.0069	98.37
	15.1	22.0	0.394	0.0182	95.34

Operability and Safety:

Sometimes waste 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 ºC. 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.

F. KEY LEARNINGS

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes

RESPOND BELOW

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 waste 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 waste 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 waste 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 waste 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.

G. RECOMMENDATIONS AND NEXT STEPS

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

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	OilPro, 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 waste gas, to see how the units operate on gas, containing impurities and liquids, 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 any fugitive methane emissions from the gas-to-power units.
- 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.
- Measure sound levels of each unit.