Clean Technology Development Final Report

Grants Coordinator Comments

> Note: as of February 7th, 2022, the notes left below will be copied to the Grant notes when the status of this Final Report changes to Approved.

Jk June 3/24: PA cannot move the report for approval. GC flipped status back to GC Admin check and back to reviewer.
Jk Feb 8/24: GC updated report due date to May 1/2024 as per new schedule

Grant Type: Clean Technology Development
Project Title: CTD 2018-027 Razor Energy Geothermal Co-production from an Active Oil Field in Swan Hills, Alberta

Legal Name: Swan HIlls Geothermal Power Corp.
Trade Name:
Address 1: 500 5 Avenue Southwest
Address 2: #800
City: Calgary
State/Province: Alberta
Country: Canada
Postal Code: T2P 3L5

Applicant Representative Name: Lisa Mueller
Phone Number: 403-816-0675
Email: lmueller@futerapower.com

AI Recommendation/Approval

Approved

Amount Approved For Payment On This Report

$100,000.00

ALBERTA INNOVATES

AI Reviewer Comments to Applicant

Please provide copies of the same production/GHG emissions reports you will submit to Emissions Reductions Alberta (ERA) for the next five years, in accordance with ERA's requirements.

We look forward to seeing this facility coming into uninterrupted operation once current challenges are overcome, and wish you success in your future geothermal projects.

Value	Date Time	By
Approved	2024-06-03 14:40:38	Susan Carlisle

ARRA

1. Schedule And Budget

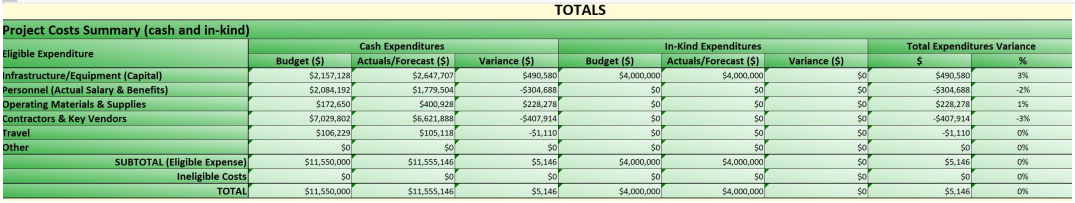
> Discuss if the work is on schedule and if there are any significant variances.
>
> Discuss significant variances between the Original Budget and the Actuals & Forecast.
>
> Discuss if any amendments to the agreement are expected or have been completed.

There were four amendments during the project due to a variety of challenges: Assignment - Change of Applicant from Razor (original applicant) to Swan Hills Geothermal Corp.; Delays - one year delay in construction (2022-->2023) due to delayed AESO in-service date, postponement of construction to avoid higher cost of working through winter, of winter construction; temporary evacuation due to wildfire (no damage); pandemic-related supply chain challenges; a critical mechanical failure (2023) after commissioning due to manufacturer error.

Two recent disruptions have prevented achieving 6 months of operations by the end of Milestone 4 (01-Apr-2024): (a) damage to the waste heat recovery system during cold weather re-start in winter of 23/24 - incident was insured but the replacement/repair of equipment will take about 18 months (late 2025); and (b) well owner (Razor) going into bankruptcy (notice of intent filed Jan 31/24) causing natural gas production to be shut until until new well ownership well operations to be suspended to due receivership. From discussions with project co-funder ERA, both ERA and the AI Clean Technology Executive Director agreed it is not in the best interests of the funding organizations to extend the project and delay project payment by an additional two years (2026). The proponent has verbally committed to share production and GHG reports after project completion. Risk of failure to report is low: the proponent has reporting obligations as an electricity supplier to the grid and under the carbon offset program, and has demonstrated their willingness to share information through wide sharing of start-up experience with funding partners and stakeholders, including a Carbon Copy podcast set up by ERA (see Final report).

Despite delays and challenges, the budget has a very minor variance of ~$5K (over) against a budget of ~$12M. The nominal variance was a result of expenditures being higher than budgeted for Infrastructure/Equipment (3% variance) and Operating Materials & Supplies (1% variance) and lower for Personnel (-2% variance) and Contractors (-3% variance). Strategies for staying on budget included alternative procurement (purchasing surplussed equipment) and excluding additional unforeseen system optimization from Project Scope.

Upload an image of the budget tables from the AI Work Plan and Budget Workbook – Budget Performance tab.



TOTALS

Project Costs Summary (cash and in-kind)								
Eligible Expenditure	Cash Expenditures			In-Kind Expenditures			Total Expenditures Variance	
	Budget ($)	Actuals/Forecast ($)	Variance ($)	Budget ($)	Actuals/Forecast ($)	Variance ($)	$	%
Infrastructure/Equipment (Capital)	$2,157,128	$2,647,707	$490,580	$4,000,000	$4,000,000	$0	$490,580	3%
Personnel (Actual Salary & Benefits)	$2,084,192	$1,779,504	-$304,688	$0	$0	$0	-$304,688	-2%
Operating Materials & Supplies	$172,650	$400,928	$228,278	$0	$0	$0	$228,278	1%
Contractors & Key Vendors	$7,029,802	$6,621,888	-$407,914	$0	$0	$0	-$407,914	-3%
Travel	$106,229	$105,118	-$1,110	$0	$0	$0	-$1,110	0%
Other	$0	$0	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expense)	$11,550,000	$11,555,146	$5,146	$4,000,000	$4,000,000	$0	$5,146	0%
Ineligible Costs	$0	$0	$0	$0	$0	$0	$0	0%
TOTAL	$11,550,000	$11,555,146	$5,146	$4,000,000	$4,000,000	$0	$5,146	0%

2. Results

Discuss the key results of this project to date.

The two most recent challenges identified in Section 1 (Razor's bankruptcy, and damage during cold weather re-start) prevented Futera's 6 month demonstration of operations during the most recent time extension of M4 to 01-Apr-2024. While the hybrid facility was commissioned in December 2023 and briefly fully operational in early 2023, only a few weeks of geothermal production (1,777 MWh) have been achieved. Production was stopped due to a system failure (manufacturer error - incorrect alloy). Futera claims that they operated at sub-economic electricity market prices in order to get the requested data.

As a result of delays, production (and GHG reductions) forecasts are as follows:
2024 - Nil
2025 - 8,946 MWh (4,741 tCO2e)
2026-2033 - Full production 35,785 MWh (11,122 tCO2e).
After 2033, while production levels are expected to continue to the end of plant life (assumed to be 20-25 years) the net GHG benefit is expected to be reduced due to future reductions to regulated GHG baseline values, such as continued reductions in the grid emission factor due to further greening of the Alberta electricity grid.

3. Learnings

Discuss the key learnings from the results of this project to date.

This project has been a demonstration of a key attribute for a successful startup: persistance. Challenges encountered included project leadership change, tight financial resources, equipment procurement (supply chain, cost, logistics), and armslength challenges between the former parent/well owner (Razor) and third parties. Part of the project's success has been Futera's ability to attract AIMCo

as a primary investor -- this can partly be attributed to the conceptual derisking of geothermal production by co-production at a natural gas production facility and the opportunity to supplement the mid-temperature geothermal resource with waste heat from natural gas operations. However, the communication and marketing skills of Futera senior leadership have also likely been a key factor in attracting AIMCo.

Managing complex partner and supplier relationships were a key to keeping the project moving forward. The project illustrates risks associated with partners, including Razor, that can create delays/challenges outside the control of the proponent. Fortunately, AIMCo became the majority shareholder of Futera Power on May 25/23, essentially separating Futera Power from Razor, its original parent company. As a result, Razor's bankruptcy did not impact the corporations, Futera Power nor its subsidiary Swan Hills Geothermal Corp. However, the bankruptcy did cause natural gas production to be shut in until the receivership process allows production to resume, presumably under a new well owner.

Due to the time needed to repair the damaged equipment (insured) Futera's plans for full, uninterrupted commercial production operations has been further delayed to late 2025 .High electricity prices create the best opportunity to achieve the projected cumulative emissions reductions of ~350,000 tCO2e by 2050. By the time they resume production, with several large NG assets coming onto the grid in 2024 (e.g., Edson Cascade 900 MW NG plant), they anticipate electricity prices will be low. If this proves true, Futera is more likely to operate geothermal generation intermittently as a slow response peaker and years with low electricity pricing are not likely to see the full production level of 35,785 MWh.

While Futera considers the overall technical and business concept to be sound, the project had inherent technical risk as a first-of-its kind. Lessons learned include:
- Mechanical malfunction during start up the ORC in cold weather: will be replacing their water-glycol circulating fluid with oil to survive cold temperatures.
- Manufacturer specifications: ensure that metallurgy is suitable for operating conditions (i.e., corrosive environment). Fortunately, under the terms of the contract with the third party contractor, the contractor replaced the defective equipment at their own expense.
- Performance and optimization of heat exchangers has been a key challenge.

This project is subject to both natural resource/mineral and electricity rules and regulations. The project commenced without a regulatory pathway, but with Futera's advocacy and input, the Geothermal Resources Act became law in time for this project. While this legislation addressed key regulatory gaps, there will likely be opportunities to improve geothermal regulations. As this facility becomes operational, their next challenge is the market system. As mentioned above, new natural gas generating capacity is expected to cause a drop in electricity price in the energy only market, which negatively affects project

economics. Furthermore, the Government of Alberta has commenced an electricity market review which creates market uncertainty.

4. Metrics

> Generally, discuss how the project is advancing towards the Clean Resources, Program and Project Metrics as laid out in Schedule C of the agreement and the AI Work Plan and Budget Workbook – Performance Metrics tab.

As discussed above, full sustained production and associated GHG reductions has yet to be achieved, nor have they achieved the 90-95% run time. The facility did not impact existing gas operations, although shut in natural gas operations did impact the geothermal facility's operations. The facility advanced from TRL 7 to 9 (commissioned and nominal production achieved.) The project involved eight collaborators (1 PSI; 7 private sector), trained 4 UofA students, and created 50 project jobs (largely construction related) and 13 full time Futera jobs. The project achieved delivery of 1 commercial renewable and alternative energy facility. There is potential for wider deployment by Futera or its competitors, as this project did not generate any proprietary IP -- Futera's competitive advantage is their experience.

5. Quality

> Discuss the quality of work and if the project progress has been shared with the appropriate stakeholders. Comment on the quality of the progress reports and/or deliverables for this reporting period (e.g. stakeholder engagement, discussion of results and/or outcomes, project management, etc.)

Despite the numerous challenges that arose during this project, the overall quality of work has been high. Futera has been persistent, prompt in filing reports and strong in their communications on the design concept, project progress, lessons learned, and the benefits of geothermal energy to Alberta. Throughout the project, Futera has been proactive and available to the Project Advisor.

222301905

GEOTHERMAL CO-PRODUCTION FROM AN ACTIVE OIL FIELD IN SWAN HILLS, ALBERTA

Alberta Innovates File #222301905

Final Financial Report

Submitted on: May 3, 2024

Prepared for:

Alberta Innovates, Susan Carlisle

Prepared by:

Swan Hills Geothermal Power Corp.
(a wholly owned subsidiary of FutEra Power Corp.)

Lisa Mueller, President, and Chief Executive Officer

403-816-0675, lmueller@futerapower.com

ALBERTA INNOVATES

CLEAN ENERGY FINAL FINANCIAL REPORT

Please submit the Final Financial Report as a separate document from the Final Public Report as the Final Financial report will be kept confidential. The Final Financial Report consists of updating and submitting the *Work Plan, Budget and Metrics* template in pdf form and completing the sections below.

Alberta Innovates is governed by FOIP. This means Alberta Innovates can be compelled to disclose the information received under this Application, or other information delivered to Alberta Innovates in relation to a Project, when an access request is made by anyone in the general public.

In the event an access request is received by Alberta Innovates, exceptions to disclosure within FOIP may apply. If an exception to disclosure applies, certain information may be withheld from disclosure. Applicants are encouraged to familiarize themselves with FOIP. Information regarding FOIP can be found at http://www.servicealberta.ca/foip/. Should you have any questions about the collection of this information, you may contact the Manager, Grants Administration Services at 780-450-5551.

1. PROJECT INFORMATION

Project Title:	**Geothermal Co-production from an Active Oil Field in Swan Hills, Alberta**
Alberta Innovates Project Number:	222301905
Submission Date:	May 3, 2024
Total Project Cost:	$15,555,146
Alberta Innovates Funding:	$2,000,000
AI Project Advisor:	Susan Carlisle

2. APPLICANT INFORMATION

Applicant (Organization):	**Swan Hills Geothermal Power Corp.**
Address:	900-500 5th Ave SW Calgary AB T2P3L5
Applicant Representative Name:	Lisa Mueller
Title:	President & CEO
Phone Number:	403-816-0675
Email:	lmueller@futerapower.com

A. PROJECT COSTS

Minimal variance of $5,146 compared to the project budget. The project scope only included the purchase, installation, and initial commissioning of the geothermal equipment. The additional costs incurred to optimize the geothermal turbine for long-term operations post commissioning were not included in the project scope.

CASH

Project Costs (Cash) - Original Budget						
Eligible Expenditure	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Cash Expenditures	% of Total
Infrastructure/Equipment (Capital)	$54,248	$0	$1,658,135	$444,745	$2,157,128	14%
Personnel (Actual Salary & Benefits)	$383,830	$534,424	$615,938	$550,000	$2,084,192	13%
Operating Materials & Supplies	$111,421	$0	$31,517	$29,713	$172,650	1%
Contractors & Key Vendors	$1,082,029	$1,037,589	$1,130,237	$3,779,947	$7,029,802	45%
Travel	$12,294	$82,876	$7,922	$3,137	$106,229	1%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$1,643,822	$1,654,889	$3,443,748	$4,807,542	$11,550,000	74%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$1,643,822**	**$3,309,778**	**$6,887,495**	**$9,615,083**	**$11,550,000**	**74%**

Project Costs (Cash) - Actuals and Forecast						
Eligible Expenditure	Milestone 1 Actual	Milestone 2 Actual	Milestone 3 Actual	Milestone 4 Actual	Cash Expenditures	% of Total
Infrastructure/Equipment (Capital)	$54,248	$0	$1,658,135	$935,324	$2,647,707	17%
Personnel (Actual Salary & Benefits)	$383,830	$534,424	$615,938	$245,313	$1,779,504	11%
Operating Materials & Supplies	$111,421	$0	$31,517	$257,990	$400,928	3%
Contractors & Key Vendors	$1,082,029	$1,037,589	$1,130,237	$3,372,033	$6,621,888	43%
Travel	$12,294	$82,876	$7,922	$2,027	$105,118	1%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$1,643,822	$1,654,889	$3,443,748	$4,812,687	$11,555,146	74%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$1,643,822**	**$1,654,889**	**$3,443,748**	**$4,812,687**	**$11,555,146**	**74%**

Project Costs (Cash) - Variance (Actuals & Forecast - Budget)						
Eligible Expenditure	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Cash Variance ($)	Cash Variance (%)
Infrastructure/Equipment (Capital)	$0	$0	$0	$490,580	$490,580	23%
Personnel (Actual Salary & Benefits)	$0	$0	$0	-$304,688	-$304,688	-15%
Operating Materials & Supplies	$0	$0	$0	$228,278	$228,278	132%
Contractors & Key Vendors	$0	$0	$0	-$407,914	-$407,914	-6%
Travel	$0	$0	$0	-$1,110	-$1,110	-1%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$0	$0	$0	$5,146	$5,146	0%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$0**	**$0**	**$0**	**$5,146**	**$5,146**	**0%**

IN-KIND

Project Costs (In-kind) - Original Budget						
Eligible Expenditure	Milestone 1	Milestone 2	Milestone 3	Milestone 4	In-Kind Expenditures	% of Total
Infrastructure/Equipment (Capital)	$4,000,000	$0	$0	$0	$4,000,000	26%
Personnel (Actual Salary & Benefits)	$0	$0	$0	$0	$0	0%
Operating Materials & Supplies	$0	$0	$0	$0	$0	0%
Contractors & Key Vendors	$0	$0	$0	$0	$0	0%
Travel	$0	$0	$0	$0	$0	0%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$4,000,000	$0	$0	$0	$4,000,000	26%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$4,000,000**	**$0**	**$0**	**$0**	**$4,000,000**	**26%**

Project Costs (In-kind) - Actuals and Forecast						
Eligible Expenditure	Milestone 1	Milestone 2	Milestone 3	Milestone 4	In-Kind Expenditures	% of Total
	Actual	Actual	Actual	Actual		
Infrastructure/Equipment (Capital)	$4,000,000	$0	$0	$0	$4,000,000	26%
Personnel (Actual Salary & Benefits)	$0	$0	$0	$0	$0	0%
Operating Materials & Supplies	$0	$0	$0	$0	$0	0%
Contractors & Key Vendors	$0	$0	$0	$0	$0	0%
Travel	$0	$0	$0	$0	$0	0%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$4,000,000	$0	$0	$0	$4,000,000	26%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$4,000,000**	**$0**	**$0**	**$0**	**$4,000,000**	**26%**

Project Costs (In-kind) - Variance (Actuals & Forecast - Budget)						
Eligible Expenditure	Milestone 1	Milestone 2	Milestone 3	Milestone 4	In-kind Variance ($)	In-kind Variance (%)
Infrastructure/Equipment (Capital)	$0	$0	$0	$0	$0	0%
Personnel (Actual Salary & Benefits)	$0	$0	$0	$0	$0	0%
Operating Materials & Supplies	$0	$0	$0	$0	$0	0%
Contractors & Key Vendors	$0	$0	$0	$0	$0	0%
Travel	$0	$0	$0	$0	$0	0%
Other	$0	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expenses)	$0	$0	$0	$0	$0	0%
Ineligible Costs	$0	$0	$0	$0	$0	0%
TOTAL	**$0**	**$0**	**$0**	**$0**	**$0**	**0%**

TOTALS

Project Costs Summary (cash and in-kind)					
Eligible Expenditure	Cash Expenditures			In-Kind Expenditures	al Expenditures Varia
	Budget ($)	Actuals/Forecast ($)	Variance ($)	Budget ($)	%
Infrastructure/Equipment (Capital)	$2,157,128	$2,647,707	$490,580	$4,000,000	3%
Personnel (Actual Salary & Benefits)	$2,084,192	$1,779,504	-$304,688	$0	-2%
Operating Materials & Supplies	$172,650	$400,928	$228,278	$0	1%
Contractors & Key Vendors	$7,029,802	$6,621,888	-$407,914	$0	-3%
Travel	$106,229	$105,118	-$1,110	$0	0%
Other	$0	$0	$0	$0	0%
SUBTOTAL (Eligible Expense)	$11,550,000	$11,555,146	$5,146	$4,000,000	0%
Ineligible Costs	$0	$0	$0	$0	0%
TOTAL	$11,550,000	$11,555,146	$5,146	$4,000,000	0%

Table 1: Project Costs Summary Tables

B. CONTRIBUTING PARTNERS

From the *Work Plan, Budget and Metrics* template:

- Copy and paste an image of the **Contributing Partners** tables from the *Final Contributing Partners* below. A blank example image is included for reference and should be replaced with the completed image.
- Provide a narrative as to the reasons for any variance between project's initial contributions and the final contribution.

RESPOND BELOW

Project Revenues - Budget					
Name	Cash	Cash (% of Total)	In-kind	In-kind (% of Total)	Total Contribution
Alberta Innovates	$2,000,000	0%			$2,000,000
Applicant	$4,550,000	0%	$4,000,000	0%	$8,550,000
Co-Applicant	$0	0%	$0	0%	$0
Government	$5,000,000	0%	$0	0%	$5,000,000
Industry	$0	0%	$0	0%	$0
Academic	$0	0%	$0	0%	$0
Not-for-Profit	$0	0%	$0	0%	$0
Other	$0	0%	$0	0%	$0
TOTAL	$11,550,000	0%	$4,000,000	0%	$15,550,000

Project Revenues - Actuals					
Name	Cash	Cash (% of Total)	In-kind	In-kind (% of Total)	Total Contribution
Alberta Innovates	$2,000,000	13%			$2,000,000
Applicant	$4,555,146	29%	$4,000,000	35%	$8,555,146
Co-Applicant	$0	0%	$0	0%	$0
Government	$5,000,000	32%	$0	0%	$5,000,000
Industry	$0	0%	$0	0%	$0
Academic	$0	0%	$0	0%	$0
Not-for-Profit	$0	0%	$0	0%	$0
Other	$0	0%	$0	0%	$0
TOTAL	$11,555,146	74%	$4,000,000	35%	$15,555,146

Project Revenues - Variance (Actuals - Budget)					
Name	Cash	Cash (% of Total)	In-kind	In-kind (% of Total)	Total Variance
Alberta Innovates	$0	13%			$0
Applicant	$5,146	29%	$0	35%	$5,146
Co-Applicant	$0	0%	$0	0%	$0
Government	$0	32%	$0	0%	$0
Industry	$0	0%	$0	0%	$0
Academic	$0	0%	$0	0%	$0
Not-for-Profit	$0	0%	$0	0%	$0
Other	$0	0%	$0	0%	$0
TOTAL	$5,146	74%	$0	35%	$5,146

Table 2 – Project Contribution Summary Tables

FutEra Power Corp. a/o Swan Hills Geothermal Power Corp.

DocuSigned by:

per _____ 45B09D2F9A51455...

Lisa Mueller, President and CEO

222301905

GEOTHERMAL CO-PRODUCTION FROM AN ACTIVE OIL FIELD IN SWAN HILLS, ALBERTA

Alberta Innovates File # 222301905

Final Public Report

Submitted on: May 3, 2024

Prepared for:

Alberta Innovates, Susan Carlisle

Prepared by:

Swan Hills Geothermal Power Corp.
(a wholly owned subsidiary of FutEra Power Corp.)

Lisa Mueller, President, and Chief Executive Officer

403-816-0675, lmueller@futerapower.com

222301905

ALBERTA INNOVATES

CLEAN RESOURCES FINAL PUBLIC REPORT

1. PROJECT INFORMATION:

Project Title:	**Swan Hills Geothermal Co-production from an Active Oil Field**
Alberta Innovates Project Number:	222301905
Submission Date:	May 3, 2024
Total Project Cost:	$15,555,146
Alberta Innovates Funding:	$2,000,000
AI Project Advisor:	Susan Carlisle

2. APPLICANT INFORMATION:

Applicant (Organization):	**Swan Hills Geothermal Power Corp.**
Address:	900-500 5th Avenue SW, Calgary, Alberta T2P 3L5
Applicant Representative Name:	Lisa Mueller
Title:	President and Chief Executive Officer
Phone Number:	403-816-0675
Email:	lmueller@futerapower.com

3. PROJECT PARTNERS

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

RESPOND BELOW

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be specifically mentioned. Their contributions are sincerely appreciated and gratefully acknowledged. However, FutEra would like to express its deep appreciation and indebtedness particularly to the following:

To our funding partners Alberta Innovates, Emissions Reduction Alberta, and NRCan, and their personnel: you helped advocate for our project, provided high risk capital, and were a general delight to work with.

To Razor Energy Corp. and Doug Bailey, who was our parent company and its President and Chief Executive Officer: you backed the early vision and the final Project, and provided moral, financial, and physical support.

To AIMCo, your support of Razor Energy and now, FutEra Power, was instrumental in completing the project and now is foundational to the FutEra growth plan.

To the FutEra Team: you are the backbone of the Project and your blood, sweat, and tears, brought an idea to life.

A. EXECUTIVE SUMMARY

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

RESPOND BELOW

FutEra Power Corp. (“FutEra”, parent company of Swan Hills Geothermal Power Corp.) has successfully designed, financed, constructed, and is now operating the first geothermal power plant in Alberta, and Canada. The Project uses a hybrid approach to allow a practical, economic ‘first’ geothermal heat to power design demonstrating that it is possible to use geothermal earth heat to generate power in legacy oil and gas assets. The Swan Hills Geothermal Natural Gas Hybrid power project includes a 15 MW NGT integrated with a 7.5 MW binary ORC, which can produce an average annual power output of 17.3 MW, with a peak of over 19 MW in cold ambient conditions. The Project includes a 21 MW capacity grid connect to allow merchant sales of all generated power to the Alberta grid. The Project has demonstrated its economic, technical, environmental, and social objectives. As with any new technology startup, there continues to be debugging and optimization efforts needed to achieve long term operational specifications.

However, the data from 2023 represents the achievement of design metrics and 'full operation of the plant as per design'. It is important to note that this pilot, like all pilot projects, has not been without its setbacks, with a significant engineering error that has been resolved by December 2023. The performance is also reliant on the productivity of the oil and gas operator for battery 3-19; i.e. higher production means more geothermal resource available, which is the basis of higher economic return due to the co-production design.

Environmental benefits: The key environmental benefit is the reduction of GHG emissions. By leveraging geothermal heat and waste heat, the ORC power generated demonstrates a notable advantage over equivalent grid-based power, as it has no associated emissions. This emissions reduction is documented to be 18,966 tCO2 per annum. With a project life expectancy of 25+ years, the Project will reduce emissions by 346,952 tCO2 by 2050. Another environmental benefit is the utilization of existing infrastructure. By co-locating in an existing oil and gas facility, the re-use of developed surface lease, roads, wells, pipelines, and processing equipment equates to significantly less environmental impact than a similar project created on a greenfield site.

Technology: The key technology employed is a binary Organic Rankin Cycle ("ORC") turbine which uses heat to spin a turbine where the spinning of the turbine generates electricity. The ORC works in conjunction with four heat exchangers which collect and exchange the heat from the hot reservoir fluid and the heat from the exhaust of the natural gas turbine to feed heat into the ORC. A binary ORC uses a more efficient working fluid, with better heat transfer qualities, to increase extraction of geothermal heat from the produced water and the waste heat.

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

The Project contributes to the energy and clean tech sector and addresses the diversification strategy needed in Alberta to create an emerging geothermal energy industry with a geothermal resource development strategy that can be replicated. The science and technology of geothermal development is well known as there is a vibrant and growing geothermal industry worldwide. This Project is innovative in that it is progressing the Albertan and Canadian energy story by adding geothermal energy to the renewable energy mix. Wind, solar, and hydro have established a credible footprint in Canada, and

Alberta. Geothermal energy, despite its global protocols and successes, has yet to establish itself on the Canadian landscape.

The challenge and gap for this project can be described as taking what is well known and common practice in the incredible resource development best practices from Alberta, and other Canadian jurisdictions, and apply it to geothermal development. The opportunity is to harness the trillions of dollars of infrastructure and historical production data and human capital that could advantage geothermal energy among its renewable peers. Retraining our workforce and retooling our drilling capacity and service industries to add geothermal development is a natural progression of existing talent and business infrastructure.

By way of background, Razor's Swan Hill assets have operated since 1960 as an enhanced oil recovery waterflood scheme gathering produced emulsion from existing vertical wells to a main battery. The oil, water and gas are separated into their constituent streams at the battery and processed. The co-produced water is re-injected back into the same formation through high-pressure injection pipelines/wells. The assets are in a high thermal gradient area with 2,400-meter deep, vertical wells exhibiting consistent and homogeneous reservoir bottom hole temperatures of 110-120 degrees Celsius. Razor has in place one of the major components of a successful geothermal project; namely, the established hydro-geological loop.

FutEra designed, and piloted, a co-production process to remove thermal heat carried by co-produced fluids and to convert that geothermal heat to electrical power through a geothermal binary Organic Rankine Cycle (“ORC”) power plant. FutEra constructed and operates the co-production process which takes advantage of this existing infrastructure and hot reservoir, augmented by waste heat capture from a co-located natural gas-fired turbine (“NGT”). The Project has a nameplate capacity of 21 MW, of which 4 to 6 MW is generated from renewable geothermal heat and waste heat recovery, resulting in a GHG emissions reduction of up to 346,952 tCO2 eliminated by 2050 through the expected plant operation life. The project has met or exceeded expectations established at the approval stage of Alberta Innovates (“AI”) funding.

Knowledge or Technology Gaps

This Project was the design, construction, and operation of the co-produced geothermal natural gas hybrid power plant. The objective was to prove out the following technical components to demonstrate the economic viability of a novel co-production process, including:

- Harvest geothermal heat from an existing oil and gas waterflood operation taking advantage of the hydrogeological loop developed through decades of upstream production/injection, using the existing infrastructure to advantage the high cost of geothermal power development, and de-risk geothermal development using decades of oil and gas development expertise and production data.
- Use the 90-100 degrees Celsius production brine at surface as the ‘preheat’ in the heat recovery loop that feeds the binary ORC system.

- The NGT duct heat is used as a second heat supply to the system to 'superheat' the binary ORC system motive fluid to 120+ degrees Celsius to ensure efficient, and thus commercial, electricity generation from lower enthalpy geothermal brines, using off the shelf ORC technology.

The Project design deliberately employs co-production as a means to enhance the geothermal energy outcomes, back-stop the hybrid plant economics, and shore up the efficiencies of operating a binary ORC, which is required for commercial outcomes in Alberta. Conventional geothermal power plants require high temperature geothermal resources, often above 200 degrees Celsuis. The South Swan Hills waterflood battery operates to produce hot water in the range of 110-120 degrees Celsius, which by Alberta geothermal resource standards, is on the higher end of the temperature scale.

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

FutEra has developed a first-of-its-kind Co-produced Geothermal Natural Gas Power Project. Situated in the greater Swan Hills area, the Project directly tackles the diversification needed to create an emerging geothermal energy industry with a development strategy that can be replicated. The Project has a nameplate capacity of up to 21 MW, of which 4-6 MW will be generated from renewable heat recovery, resulting in approximately 346,952 tCO2 to 2050. FutEra delivers sustainable power to the Alberta grid and has transition end of life oil and gas wells to green energy.

Knowledge or Technology Description

FutEra has selected a 'functioning co-production geothermal site' to host the demonstration project. The project was built on safe waterflood operations, decades of data, proven reservoir conditions, relatively benign chemistry, and a cost/timeline advantaged brownfield site. The South Swan Hills waterflood battery, owned and operated by Razor Energy, produces significant hot water and hydrocarbon production at surface daily. Prior to implementation, this Project had already solved the riskiest of the front-end technical unknowns for geothermal development, which are attached to highest risk capital. In a typical geothermal development project, 40% of the overall project costs are targeted at finding a hot, wet reservoir with good porosity and permeability. Exploration data, seismic, modelling and then drilling

is used to find a favorable reservoir, and then establish that water communicates between the injection and production well. Razor's assets are fully drilled, and the battery is pipeline connected to all the hot wells. Daily waterflood operations sweep the reservoir and bring the expected hot fluids to surface. The relationship between injected fluids and production volumes and temperatures is well known. The production brine chemistry is predictable and relatively benign, due to previous decades of freshwater injection into the reservoir. Razor's waterflood has a plethora of evidence to show that the geothermal loop is established and repeatable. This advanced the typical geothermal project timeline significantly, while reducing capital risk in a material way. This asset was the 'best, first test case' for geothermal energy production in Alberta.

FutEra partnered with Razor Energy to capitalize on its existing well-trained staff and safe operations as well as a satisfactory regulatory compliance rating to manage daily activity, project planning and execution. FutEra has all the necessary permits to operate and understands how to manage or expand the parameters of existing regulatory permits and policy. Razor's internal expertise in understanding the reservoir, the infrastructure and the geochemistry was assisted by experts in geothermal technology and development.

Preliminary modelling by our partners at the University of Alberta confirmed that the reservoir conditions at South Swan Hills could support sustained geothermal production in excess of 10 MWe. In addition, the University of Alberta published a paper outlining the Swan Hills area reservoirs as highly favorable to geothermal development which is called, "Deep Dive Analysis of Best Geothermal Reservoirs for Commercial Development". FutEra used 'off the shelf' technology wherever possible, therefore, no Intellectual Property ("IP") development was identified. There is, however, 'process IP' which is not necessarily patentable but certainly lends commercial advantage to FutEra. Learning how to adapt a waterflood operation to a commercial geothermal outcome is a first in Alberta, and Canada. The geo-chemistry, the heat exchange system, and the changes to infrastructure are the technical challenges that FutEra had solved. There is a competitive advantage to a differentiated oil and gas development strategy that includes use of waste heat. FutEra believes in developing a complete energy story, using the most commercial outcomes available to harvest all energies inherent to our asset base.

The science and technology of geothermal development is well known as there is a vibrant and growing geothermal industry worldwide. This project is innovative in that it has progressed the Albertan and Canadian energy story by adding geothermal energy to the renewable energy mix. Wind, solar, and hydro have established a credible footprint in Canada, and Alberta. Geothermal energy, despite its global protocols and successes, occupies little space on the Canadian renewable energy landscape. It is not because the geology or expertise is unavailable in Canada, quite to the contrary, as the United States has the largest geothermal footprint, and the geology and available resource does not stop at the border.

The challenge, and gap, is taking what is well known and common practice within the incredible resource development potential of Alberta, and other Canadian jurisdictions, and finding the process to achieve geothermal development. The opportunity is to harness the trillions of dollars of infrastructure and historical production data, and human capital that could advantage geothermal energy among its

renewable peers. Retraining our workforce and retooling our drilling capacity and service industries to add geothermal development is a natural progression of existing talent and business infrastructure.

We deployed binary-cycle geothermal technology, in which the thermal energy (heat) from the co-produced fluid is transferred via a heat exchanger to a low-boiling point 'working' fluid, whose evaporation and recondensation drives a turbine to produce electrical power. The most common binary-cycle engine is the ORC. ORC technology is commercially proven in international markets.

Updates to Project Objectives

The key goals of the project have been substantially achieved:

- Proving the technical and commercial viability of co-produced geothermal natural gas hybrid power project, demonstrating a novel co-production process
- Harvesting geothermal heat from an oil and gas waterflood operation using the existing infrastructure to advantage the high cost of geothermal power development, and de-risk geothermal development using decades of oil and gas expertise and production data.
- Proving that using the existing flow and temperature of production brine at surface as the 'preheat' in the heat recovery loop that feeds the binary ORC system, and adding recovered duct heat as a second heat supply will ensure efficient electricity generation.
- Reducing emissions by up to 31,000tCO2 in the project's first years, and 500,000 tCO2 reduced from operations to 2050. *

*Further to the last objective, it is important to note that the project's green energy outcome in MWhs has not been reduced, but the standard/benchmark for emissions against which it is compared has been lowered from 31,000 tCO2 to 18,966 tCO2 in the project's first year, and 500,000 tCO2 to 346,942 tCO2 by 2050. This is largely driven by legislated emissions reduction targets and prescribed grid emissions factors used in calculating emissions reductions. The significant GHG reduction is therefore viewed as a success.

Performance Metrics

Below are copies of the success metrics identified in previous reporting to AI.

Note: References to "Razor" should be replaced with "Swan Hills Geothermal Power Corp.". The original Investment Agreement was between Alberta Innovates and Razor Energy Corp. ("Razor"). On August 30, 2021, the Investment Agreement was subsequently assigned to Swan Hills Geothermal Power Corp.

Clean Resources Metrics (Select the appropriate metrics from the drop down list)

Metric	Project Target	Commercialization / Implementation Target	Comments (as needed)
Investment in 4 Core Strategic Technology Areas	Yes		Clean Technology
TRL advancement	2		TRL 7 to 9
Future Capital Investment	$15,000,000	~$100MM CAD	$15M was attracted for this project and ~$100MM CAD is expected to develop the future target of 43 MW of installed geothermal power via future similar projects
Field pilots/demonstrations	1		There is an embedded pilot project ongoing that forms a data input to the larger demonstration project.
Collaborators	8		Research - University of Alberta, Technical - Scovan Engineering, Fluid Intelligence, Third Bay, Lionstooth Energy, Ormat Technologies, Britt Land, Clear Stream Environmental
Publications	2		The University of Alberta has developed a scope of work that includes publications of research associated with this demonstration project and will be undertaken upon successful completion of the demonstration project.
Students Trained (Msc., PhD, Postdoc)	4		The University of Alberta has a dedicated geothermal team which consists of at least some masters and PhD candidates that have intimately worked on the project. Razor has paid the U of A to be involved in this project.
Jobs: Acutal new jobs created from project	50		During construction this project could have as many as 50 FTE people working on the demonstration project full time at any given time. Razor has 60+ staff that have at least intermittent to full time work created and sustained by the project. The operating power plant, in existence as a result
Jobs: Projected new jobs created from future deployment		100+	Razor intends to replicate a successful outcome of this project at other locations, creating at least 100 full time jobs as the company grows capacity in the geothermal industry.
GHG emissions: Actual reductions from project	31,000 tCO2e/year		Facility expected to operate for a minimum project life of 20 years, resulting in 600,000 tCO2 emissions reduction accumulated
GHG emissions: Projected reductions from future deployment (to 2030)		5,700,000 t CO2 per 20 year project life	GHG reduction can be calculated using this project as a proxy for evalution of GHG emissions reduction. A future buildout of 43 MW, and similar project life spans of at least 20 years per project, would result in 5,700,000 tCO2 emissions reduction for Razor's geothermal energy development plan.

Program Specific Metrics (Select the appropriate program metrics from the drop down list)

Metric	Project Target	Commercialization / Implementation Target	Comments (as needed)
# of alternative energy technologies deployed	1		Co-produced Geothermal Natural gas Hybrid Power System
# of renewable energy technologies deployed	1		Co-Produced Geothermal Energy to Power

Project Success Metrics (Metrics to be identified by Applicant)

Metric	Project Target	Commercialization / Implementation Target	Comments (as needed)
IRR/Simple Payback	IRR > 10% (cost of capital), Simple payback above industry standard of 6-8 years		Razor understood through investor/capital discussions that these metrics were the minimum needed to attract external funding
Carbon Credit Revenue	$50/tCO2		The economic model has includes a revenue stream earned for GHG emissions reductions.
% Run Time	90-95%		This run time would be the average run time of 18 MW of the nameplate 21 MW during a calendar year.
No impact to existing operations	No change or improvement to oil cut		Razor will baseline oil and gas production prior to operation of the power plant. The metric will be that this project does not impair the operation of the oil and gas business, measure by barrels of oil produced per barrel of total fluid produced.

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

Experimental Procedures/Methodology

The experimental procedures and methodology for the Project were designed to evaluate the feasibility and performance of the heat recovery heat exchangers in transferring heat from the produced water to the ORC working fluid for electricity generation. The primary objective was to recover as much geothermal energy as possible from the oil and gas operation produced water flow, while considering potential fouling and scaling issues. The experimental procedures and methodology employed in the pilot test provided valuable insights into the performance of the heat recovery heat exchangers and tube materials. The results demonstrated the feasibility of effectively transferring heat from the produced water to the ORC working fluid while minimizing fouling and scaling. The current system demonstrates that scaling and fouling is a manageable operation with the design implemented. However, it is evident the corrosion impacts shown in the pilot were underestimated in the final design.

Technology Development

The development of the co-produced hybrid geothermal power project involved evaluation of the geothermal resource, the heat recovery system and then selection of a suitable power generation technology. Figure 1 shows the overall view of the project processes. The process starts by harnessing geothermal heat from the produced water available at surface and located at the Swan Hills field main battery. Then, the geothermal heat is upgraded by the additional of captured and waste heat from the duct heat produced by the NGT. This collected heat is then directed into ORC system, which is designed to convert thermal energy into mechanical work. Within the ORC system, the heat drives a working fluid. As the heat transfers to the working fluid, which causes it to evaporate and form a high-pressure (“HP”) vapor. The high-pressure vapor is then sent to the turbine section of the ORC system. In the turbine, the pressurized vapor expands and undergoes adiabatic expansion, converting its thermal energy into mechanical work. The turbine's mechanical work drives an electrical generator, which produces electricity from the rotational energy. After the expansion in the turbine, the now low-pressure and low-temperature vapor exits and enters the condenser section. The condensed liquid is then pumped back to the evaporator section, where the cycle restarts as the fluid is heated again by geothermal and waste heat sources.

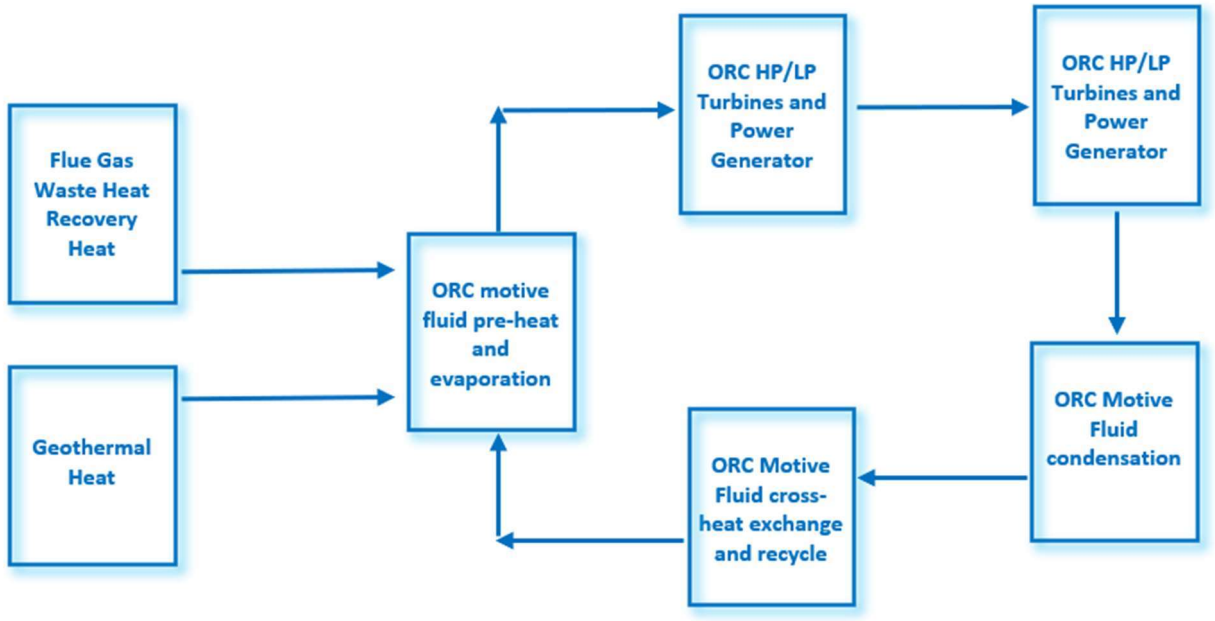


Figure 1 The Project Power Production Process

Therefore, geothermal heat at surface, coupled with decades of reservoir and operating data, ensured that there was a low technical risk to harness the significant heat energy present from the reservoir in Swan Hills. This identification, combined with the knowledge of utilizing heat for power generation and the need to reduce emissions from the Alberta oil and gas industry and electrical grid, led to the vision of creating low-emission electrical power from existing infrastructure.

The selected geothermal power generation technology for this project was the binary Organic Rankine Cycle turbine, which utilizes a working fluid to transform heat energy into electrical energy through a rotating turbine.

In conjunction with the ORC turbine, heat exchangers were employed to collect and exchange heat from both the hot reservoir fluid and the exhaust heat from the gas turbine, effectively maximizing heat utilization and enhancing overall power generation equipment efficiency.

Installation

The installation phase of the Project involved the construction and assembly of the ORC plant infrastructure, the NGT power plant, and all the necessary integration and operations associated components. The power plant used a unique process suitably named the 'Swan Hills Geothermal Hybrid Power Plant.'

All the power generated by the power plant is being sold to the grid which involved working with the Alberta Electrical System Operator ("AESO") and ATCO to build the interconnection infrastructure with the necessary safety and communications equipment. The grid is highly managed to keep balance and

reliability. As such, Urica Technologies has been contracted to manage all communications and compliance with the AESO, on an hourly basis.

Additionally, the Project is situated in an existing oil and gas battery which required the integration of the geothermal power plant with the existing oil and gas infrastructure, which is comprised of wells, pipelines, process equipment, surface leases, and roads, to minimize environmental impact, to lower overall capital costs and to leverage the available resources including geothermal heat at surface.

Commissioning

The commissioning phase marked the operational readiness and testing of the ORC plant. The layout of the plant can be seen in Figure 2, Project plant site with aerial view of major installed equipment. This involved a series of comprehensive checks, tests, and fine-tuning procedures to ensure the seamless integration and proper functioning of the entire system. The gas turbine, which provided the waste heat, was started up in September 2022, followed by the full operation of the ORC turbine for geothermal and exhaust heat power generation in January 2023. Through rigorous testing and optimization, the plant was brought to most of its operating conditions, ready for long-term operation. Final and ongoing optimization efforts are underway, given the novelty of the power plant. It is foreseen that it could take a full year to achieve optimal results that meet or exceed design conditions. The AESO has previously allowed plants a full year to achieve design outcomes.

In December 2023, the ORC achieved ‘design’ output and was running stable. Razor Energy was embroiled in a gas processing dispute beginning December 24, 2023, which resulted in the geothermal heat and produced water being shut in, with an undefined restart date.

Figure 2 Project plant site with a view of major installed equipment

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

Milestone 1

Progressed to FEED level project design including geothermal systems modelling, geochemistry modelling, and project FEED level engineering design (including procurement, installation, and test of heat exchanger and all asset modifications for testing. This included heat exchangers design, heat transfer model, and geochemistry solution. Also, included heat customer pilot installation/operations. All of which supported the economic modelling of the Project.

Milestone 2

Continued work from Milestone 1 to further progress FEED level engineering design. The completed FEED allowed a project "Go/No Go" decision on the 5MWe geothermal power plant, based on technical and economic feasibility. Regulatory support was also pursued to progress Project activities.

Milestone 3

Continued work from Milestones 1 and 2 and completed detailed engineering design and procurement activities for the 5 MWe geothermal power plant. This included securing an ORC, which was decommissioned from original site, tested, and transported for refurbishment. Field construction activities for grid connect and site preparation for the ORC were also prosecuted in anticipation of the power plant installation.

Milestone 4

Field construction activities completed, and start-up and commissioning of geothermal power plant. Project Impact Assessment and Final Report, including impact on reservoir and pipeline integrity and audit of project design models (comparing forecasts to actuals for both technical and commercial impacts), prepared to report to AI on successes.

Performance Metrics

The performance metrics, as described above, have remained the same since the grant application was made with two exceptions: (1) GHG reductions, and (2) target output and run-time.

The GHG reductions were originally calculated by a third party, Cap-Op, and agreed to by AI and AI's funding partner, Emissions Reduction Alberta ("ERA"). ERA has since provided a different methodology which results in new GHG reduction calculations, on which we are reporting.

The price of carbon was $50/tCO2 when the project was initiated. The federal government has legislated, and Alberta has accepted, that the price of carbon will rise to $170/tCO2 in 2030 in increments of $15/tCO2 per year, with today's price at $80/tCO2.

It is important to note that the target output and run time of the project remains unchanged, but due to a metallurgy issue in the design and damage suffered by the waste heat recovery unit during commissioning, it will take more time to optimize the system to achieve a standard industry run time of 90-95%, and the average annual output of 4.3 MW from the ORC per annum. The plant life is at least twenty-five years, the time to repair the waste heat recovery unit and optimize the plant performance will not be detrimental to the lifetime achievement of emissions reduction.

NOTE: There is a clerical error in the previous Clean Resource Metrics table indicating projected GHG reduction of 5,700,000 tCO2, it should read 570,000 tCO2. However, under the new methodology prescribed by the ERA, the expected GHG reduction is now 346,942 tCO2; this number takes into account repair time for the waste heat recovery unit.

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

The primary lesson learned is associated with the challenge of raising capital for the 'first of its kind' geothermal power project. The Project was always 'undercapitalized' and forced to make some decisions to keep capital budgets competitive. Some surplus equipment was purchased to drive costs lower, but this equipment came with additional construction and operational risks. Critical equipment, such as the heat exchangers, were always higher risk components. Both the brand-new heat exchanger, and the surplus heat exchangers, have metallurgy challenges as they operate under hot temperatures and pressures, and their performance, reliability and safety are essential for the success of the Project. The heat exchangers are mostly responsible for achieving design criteria. The ongoing commissioning and optimization issues are related to the underperformance of the various heat exchangers. The ORC and

NGT turbines and generators are performing very well. The lesson learned is that the overall design of the plant is solid, but the engineering firms underestimated the corrosion issues, and the metallurgy selections were substandard.

Another lesson learned was the need for effective project management and coordination among various stakeholders. FutEra was a fledgling entity with a very tight budget. Early in the construction cycle, the lead and very senior project manager left due to health reasons. Finding a suitable replacement was a significant challenge resulting in a temporary, external project manager who was eventually replaced by a permanent, but external project manager. The Project involved multiple partners, and key suppliers, which made for a complex execution strategy. Each partner had distinct roles, responsibilities, expectations, and interests in the Project. Without the continuity of a senior internal project manager from start to finish to manage multiple project partners, there were some execution errors, and related budget overruns, during the project lifecycle. Despite the challenges, the broader project team had established clear communication channels, regular meetings, reporting protocols and conflict resolution mechanisms to ensure better collaboration and alignment among all parties which helped mitigate the impact of changing project management.

A third lesson learned was the challenge of managing the supply chain, project costs and project logistics. The Project required specialized equipment and materials that were not readily available in the local market, made worse by supply chain interruption during COVID. The project team had to source them from different suppliers across the country and internationally, which increased the cost and complexity of procurement. Moreover, the Project faced some delays and disruptions due to transportation issues, such as road closures, weather conditions, customs clearance, and COVID-19 restrictions. The Project team had to plan, monitor the delivery status, secure alternative options, and mitigate any other potential risks. During operations, other complications occurred that could be considered unusual. A force majeure in January that ran until late March forced the plant to shut down. This event affected the north of the province and meant that no fuel gas was available to the plant. Then, spring hit and an usually extreme wildfire season hit the plant. Swan Hills was evacuated for several weeks with, again, an effect on the ability to operate the plant.

A fourth lesson learned was during the operation of the ORC. Due to the specific properties of the oil and gas field where geothermal heat is extracted, corrosion and other metallurgical issues were significant factors that affected the performance and durability of the equipment. Despite spending significant money with external engineering ‘expertise,’ the corrosion risk was underestimated. FutEra feels that the external expertise ‘failed’ in selecting the right material for each component of the system which was crucial to ensure optimal operation and maintenance. The Project team had to conduct thorough analysis and research to identify the current underperformance issues. The external engineering firms re-engineered the heat exchangers at their cost. Repairs have been completed on most of the system and the plant was returned to service in August 2023. A replacement stainless steel heat exchanger was installed in November which will allow the ORC to meet or exceed its design criteria and capacity output for the duration of the 20-year plant life.

The final lesson learned is there was no regulatory pathway when the project began. The Geothermal Resource Act came into effect during plant construction, with considerable input from FutEra during stakeholder engagements sessions, and will provide clarity, regulatory oversight, and policy certainty. FutEra is complimentary that the policy makers and regulators took in stakeholder feedback to ensure that practical experience was embedded in new legislation and regulatory pathways.

G. OUTCOMES AND IMPACTS

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget, and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget, and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

Project Outcomes and Impacts

The Project demonstrates and proves that geothermal heat from a deep reservoir can be used to generate power and can be combined with waste heat from a turbine to generate meaningful and economic quantities of zero emission power. This system design also demonstrates that repurposing existing oil and gas infrastructure can improve economic outcomes for geothermal heat to power projects. This project relied on proven off the shelf technologies, combined in an innovative way, to lower the technology risk of the Project system and as such utilized widely used components in a novel way.

The commercialization pathway has been identified and underpinned with data and above FutEra's expected return on investment from the Project. In this way, FutEra is planning similar projects where 'design one, build many' improves the outcomes of future development. In addition, FutEra plans to optimize and improve geothermal energy outcomes by developing some intellectual property ("IP") required to scale the geothermal industry. Knowledge gained through the inaugural project will enhance the next natural steps of IP development. In addition, reservoir and economic risk are validated and virtually eliminated by the first project, so conventional geothermal extracting more pure green power from the same reservoir is another logical next step in the commercialization pathway.

During the Project, the Alberta Energy Regulator published the Geothermal Resource Act as a framework for geothermal energy development. FutEra participated in all stakeholder engagements requested by the AER, by other levels of government and by other stakeholders. FutEra was eager to share knowledge with all requestors to assist in the development of this policy.

Capital market support was gained in the later part of the Project. First mover projects often can have issues with capital market support as economic models are either unknown, unproven or both. FutEra experienced that feedback from multiple capital providers in Canada and the USA. However, grant support, and its de-risking properties, allowed FutEra to seek capital as needed. Now, the economic data will make the capital support of the subsequent and similar projects easier.

The Project is positioned to deliver tangible environmental benefits through the reduction of greenhouse gas emissions. By utilizing co-produced geothermal and recovered waste heat energy, the Project is expected to reduce emissions by up to 346,952 tonnes of CO2 to 2050. These emissions reductions will generate associated revenues through carbon pricing.

The Project had created thirteen full-time positions at FutEra. During construction, there were 40 - 100 construction workers at any given time. The Project also has gained much interest from job seekers, researchers, and other related parties, through various feedback networks, which allows FutEra to surmise that people would like to work in the geothermal industry. This includes high quality skilled people from the oil and gas industry seeking to transition from traditional energy production to a very relatable green geothermal energy industry. The people associated with this project development, and now operations, have been upskilled to work on future projects. With our early affiliation with the University of Alberta, and the newly minted relationship with University of Calgary, FutEra hopes to develop other avenues to train future employees and develop high quality skilled people.

It is important to note that this flagship project will give a boost to the nascent geothermal industry and to other projects started in Saskatchewan, British Columbia, and Alberta. These competitors have said that the fledgling industry will be buoyed by FutEra's success.

More detailed commentary on Project Metrics is captured in the tables below:

Clean Resources Metrics (Select the appropriate metrics from the drop down list)

Metric	Project Target	Commercialization / Mobilization Target	Comments (as needed)
Investment in 4 Core Strategic Technology Areas	YES		Clean Technology implemented.
TRL advancement	2		TRL 7 to 9 achieved.
Future Capital Investment	$15,000,000	~$100,000,000 CAD	$15M was attracted for this project. Though FutEra will now be pursuing next generation geothermal technology with an IP partner, FutEra expects to raise future capital of ~$100M CAD for future installations of geothermal power; particularly with capital partners like AIMCo standing behind FutEra.
Field pilots/demonstrations	1		The Co-produced Geothermal Power Plant has been fully commissioned since December 2023.
Collaborators	8		Research - University of Alberta ("UofA"), Scovan Engineering, Fluid Intelligence, Third Bay, Lionstooth Energy, Ormat Technologies, Britt Land, Clear Stream Environmental
Publications	2		The UofA has developed a scope of work that includes publications of research associated with this demonstration project.
Students Trained (M.Sc., Ph.D., Postdoc)	4		The UofA has a dedicated geothermal team which consists of at least some masters and PhD candidates that have intimately worked on the project. Swan Hills has paid the UofA to be involved in this project.
Jobs: Actual new jobs created from project	50		During construction of this project, staffing through affiliates at the time, Razor Energy Corp. and Blade Energy Services Corp., and subcontractors exceeded 50 full-time equivalent jobs at any given time.
Jobs: Projected new jobs created from future deployment		100+	Though FutEra has pivoted to exploit next generation geothermal technology to optimize geothermal outcomes with an IP partner, it maintains its expectation to create at least 100 full time jobs as the company grows capacity in the geothermal industry.
GHG emissions: Actual reductions from project	31,000 tCO2e/year		GHG reductions were originally calculated by a third party, Cap-Op. A different methodology was later implemented during project execution. The adjusted target is now 18,966 tCO2/year until 2033, thereafter 11,122 tCO2/year until 2050; the change is due to legislated emissions reduction targets.
GHG emissions: Projected reductions from future deployment (to 2030)		570,000 tCO2 per 20 year projected life	GHG reductions calculated to 2050, based on the new methodology as directed by AI and ERA, is 346,942 tCO2.

Program Specific Metrics (Select the appropriate program metrics from the drop down list)

Metric	Project Target	Commercialization / Mobilization Target	Comments (as needed)
# of alternative energy technologies deployed	1		The Co-produced Geothermal Power Plant has been fully commissioned since December 2023.
# of renewable energy technologies deployed	1		The Co-produced Geothermal Power Plant has been fully commissioned since December 2023.

Project Success Metrics (Metrics to be identified by Applicant Representative)

Metric	Project Target	Commercialization / Mobilization Target	Comments (as needed)
IRR/Simple Payback	IRR > 10% (cost of capital). Simple payback above industry standard of 6-8 years		Swan Hills expects the payback period to have been extended by 2 years due to sagging power prices, the requirement to optimize plant processes, and interruption of the supply of heat from Razor's oil and gas operation.
Carbon Credit Revenue	$50/tCO2		The plant is subject to an Offset program that scales with the existing carbon tax. The carbon tax for 2023 was $65/tCO2 and will go up $15 each year until 2030 when $170/tCO2.
% Run Time	90-95%		Due to commissioning difficulties, and the occasion of two Force Majeure events in February 2023 and then December 2023, the plant has been running at 14 MW on average. Ongoing plans to optimize equipment and plant processes are expected to yield designed production. However, due to forecasted power prices below marginal operating costs, Swan Hills plans to operate a peaker plant for a portion of the year.
No impact to existing operations	No change or improvements to oil cut		Razor's oil and gas production has not been impacted by plant operations.

H. BENEFITS

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

Economic

The Project has several economic impacts on the local, regional, and national level. Some of the impacts are:

- The Project generates tax revenues for the local, provincial, and federal government. The Project also pays fees for the use of existing infrastructure such as power lines and roads.
- The Project contributes investment into Alberta communities. The Project supports local businesses and entrepreneurs by purchasing goods and services. The Project will pay property tax to the municipality.
- The Project had created thirteen full time jobs both in Calgary and Swan Hills. Job creation during construction was higher at 40-100 full time equivalents over the multi-year construction process.
- There are no local First Nations attached to the Project however, every effort was made to inform the local populations and even distant First Nations were made aware of the Project. The Project is on crown land and 15 kms from any populated areas.
- The Project could reduce the cost of electricity for the consumers by providing reliable baseload and affordable power that is less emissions intensive than the grid average. The Project also enhances the energy security and diversity of the region by providing a firm, renewable resource.

- The first geothermal heat to power in Alberta, and Canada, has created an innovation pathway for others to follow, and has created a direct link to training the minds of the future to include geothermal in the renewable suite of energy sources. FutEra has done numerous, public engagement sessions to heighten the awareness of the Project, the geothermal industry and the strong partnerships with governments, funding agencies and regulators. The diversification of the energy industry to include geothermal energy is a significant project contribution.
- FutEra supports diversity and inclusion and has employed women and visible minorities in its workforce while maintaining a merit-based hiring format.

Environmental

We are projected to be able to reduce 18,966 tCO2 of GHG emissions from 2023 till 2033. With overall efforts to decarbonize the grid to meet legislated emissions reduction targets, we forecast that this will be 11,112 tCO2 of GHG reductions in Alberta between 2034 and 2050; thereafter, emissions reductions are expected to be lower.

The figures are determined based on the grid emissions factor, which represents the average GHG intensity of the electricity generated in Alberta. The grid emissions factor is 0.53 tCO2/MWh from 2023 till 2033 and then it will reduce to 0.3108 tCO2/MWh according to the Alberta Climate Plan. To calculate the GHG reductions from our project, we first calculate the net annual ORC electricity output in a year. This is calculated by multiplying the ORC output (4.3 MW) by the average estimated run time (95% post commissioning and optimization) and by the number of hours in a year (8760). The result is 35,785 MWh/year. Then, we multiply this by the grid emissions factor for each year to obtain the baseline emissions. For example, for 2026, the baseline emissions are 35,785 MWh/year x 0.53 tCO2/MWh = 18,966 tCO2/year. Since our project has zero emissions, the GHG reductions are equal to the baseline emissions. Therefore, for 2026, the GHG reductions are 18,966 tCO2/year. We repeat this calculation for each year until 2050 and sum up the results to get the total GHG reductions for the project period.

An additional advantage of the Project is that it does not create any other environmental impacts including air contaminants, land use, soil contaminants, water consumption. The system does not consume any water or additional water for its operation; it is a closed loop system therefore it does not use any fresh water. Further, this project does not require any land use change or expansion. The Project has been developed on land that has been in use since the 1960s, and no new land was required. It did not disturb any natural habitats or ecosystems, nor did it generate any waste or pollution that could harm the soil or groundwater.

FutEra believes that this project will help facilitate a low-carbon economy and secure Alberta’s success in a GHG-constrained future by 2050.

Social

The Project has several social impacts on the local community and the wider society. Some of the positive impacts are:

- The Project provides low emission power that reduces greenhouse gas emissions and contributes to climate change mitigation. According to the MMV protocol, the Project will have reduced emissions by a minimum of 346,952 tCO2 over the Project lifespan, up to and including at least 2050.
- The Project had created direct and indirect employment opportunities (direct: 13, indirect greater than 40), development, operation, and maintenance of the geothermal power plant. The Project also stimulates additional economic activities in the area, such as supply chain, services, and economic diversification.
- The Project will help to continue the high standard of living expected by Albertans by providing reliable, renewable, and possibly more affordable electricity.

Building Innovation Capacity

The Project had created thirteen full-time positions at FutEra. During construction, there were 40 - 100 construction workers at any given time. The Project also has gained much interest from job seekers, researchers, and other related parties, through various feedback networks, which allows FutEra to surmise that people would like to work in the geothermal industry. This includes high quality skilled people from the oil and gas industry seeking to transition from traditional energy production to a very relatable green geothermal energy industry. The people associated with this project development, and now operations, have been upskilled to work on future projects. With our early affiliation with the University of Alberta, and the newly minted relationship with University of Calgary, FutEra hopes to develop other avenues to train future employees and develop high quality skilled people ("HQSP").

It is important to note that this flagship project will give a boost to the nascent geothermal industry and to other projects started in Saskatchewan, British Columbia, and Alberta. These competitors have said that the fledgling industry will be buoyed by FutEra's success.

I. 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

FutEra has many strategic next steps planned in the next 2-5 years. It is important to note that recently FutEra became a standalone private entity, majority backed by the Alberta Investment Management Company ("AIMCO"). With a top tier capital partner, Futura has ambitious plans for both the short term and long term, which include but are not limited to:

1. Continue to optimize the current project plant to achieve design basis, plant power output.
2. Drill in the same location to get 'more, and hotter' water to the current ORC as its name plate is 7.5 MW and the average output of the plant is 4.3 MW. The grid connection has additional unused capacity to exploit.
3. Having avoided any technical risk in the Project, the next logical step is to improve geothermal outcomes by creating 'the new, or better' power generation equipment that surpasses the operational and capital efficiency of the traditional ORC power generation technology. ORC technology is good and used globally, but FutEra has found an improved approach to small geothermal power 'at the well head.' This IP addresses not only power generation at low enthalpy locations but the ability to harness the value of a drilled location. A successful pilot will allow FutEra to consider a global market for project development.
4. FutEra will develop a 'net zero' hybrid power plant process that combines several generation types, and machine learning, to export a net zero power product.

J. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

FutEra has been a leading voice and staunch advocate for geothermal in Alberta and Canada. FutEra has participated in various conferences, workshops, webinars, and other events related to geothermal energy, renewable energy, and oil and gas industry. Our President and CEO, Lisa Mueller, has been on countless panel presentations, numbering greater than 30 individual panels throughout Alberta and Canada, including geothermal workshops in Alberta, women in energy panels, public and stakeholder engagement on the Geothermal Resource Act, the annual Independent Power Producers Society of Alberta's annual conferences, geology and reservoir panels, to name a few.

The primary audience for these events is quite extensive given that Alberta is leading in all types of clean energy innovation. The audience would include capital investors, regulators, professional engineers, academic & student networks, potential collaborators and partners and many others. The Project team will also share the results and learnings from the Project at future events, which will always include acknowledgement of the funding and support from Alberta Innovates, Emissions Reduction Alberta, and NRCan.

The Project team has also created a company LinkedIn page as a useful social media platform to provide information about the company and its flagship geothermal project.

The Project team will continue to curate various communication tools and media to reach out to different audiences and convey information about FutEra and its cause in an effective and appropriate manner. Below is a table of some of the events to date:

Event Name	Date	Organizer	Subject
ERA Carbon Copy Podcast Episode 21	2023	Emissions Reduction Alberta (ERA)	Innovation at the Margins
EETiG 2024	2024	Canadian Energy Geoscience Association	Innovation - Co-Produced Geothermal Power
Scovan's Pathway to Net Zero	2022	Scovan Engineering	Transitioning the Energy Complex to Cleaner Power and Sustainable Infrastructure
Daily Oil Bulletin Feature	2022	Daily Oil Bulletin	The LEAD Project and Energy Transition Leadership
Co-Produced Geothermal Power Presentation	2023	Canadian Heavy Oil Association	Genesis of Canada's First Co-Produced Geothermal Power Plant
Calgary Geothermal Workshop	2023	University of Calgary	Innovation Behind First Geothermal Power Plant in Alberta

The Opportunities and Challenges of Geothermal Power	2023	SPE Young Professionals	Geothermal Power for Albertan Oil and Gas
Energy Security and Alberta's Market Design	2023	Independent Power Producers Society of Alberta	Alberta's Market Design
Potentials of Geothermal Energy in Alberta	2022	Alberta Innovates	Potentials of Geothermal Energy
The Lead Project	2023	Canadian Society for Unconventional Resources	Case History for a Cleaner Energy Future Canada's 1st Co-Produced Geothermal Power Project

K. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits, and next steps.

RESPOND BELOW

In conclusion, the analysis of the Project results indicates several achievements relative to the stated objectives and performance metrics. The Project has made significant strides in reducing GHG emissions, including a lifetime (to 2050) emissions reduction target of at least 346,952 tCO2. The higher-than-anticipated carbon prices have contributed to increased carbon credit revenue, further enhancing the Project's financial viability. The Project can claim to be the first grid connection geothermal power in the country which is a significant achievement. It should have been identified that running the ORC, as a first-of-its-kind, will require a longer commissioning and optimization timeline. Thus, to date the plant has not achieved its average design output or ORC run time. However, despite lower power output, the power plant has outperformed its economic modelling by a significant mark, achieving a higher rate of return on a higher capital cost than predicted due to higher than historical power (energy) commodity pricing and higher than predicted carbon prices. Overall, the Project has demonstrated successful outcomes in various aspects and has laid a solid foundation for future advancements and improvements.

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FutEra Power Corp. a/o Swan Hills Geothermal Power Corp.

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Lisa Mueller, President and CEO