Glasgow City Council

Net Zero and Climate Progress Monitoring City Policy Committee

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Item 3

8th August 2023

UPDATE ON DEEP GEOTHERMAL FEASIBILITY STUDY

Purpose of Report:

To provide Committee with an update on the feasibility study into deep geothermal energy recovery.

Recommendations:

The Committee is asked to:

1) Note the contents of this report, and
2) Request a further update on the next steps no later than 12 months hence.

Ward No(s):	Citywide: ✓
Local member(s) advised: Yes ☐ No ☐	consulted: Yes ☐ No ☐

1. Introduction

1.1 Increasing the amount of district heating and renewable energy generation in the City has been a long-held ambition of Glasgow City Council. This ambition, and the tangible projects that have been delivered in the city, coalesced into the creation of the Sustainable Glasgow Plan (2010) and were developed further in the Glasgow City Council Carbon Management Plans (1 & 2, 2010, 2014 respectively) the Energy & Carbon Masterplan (2014), and the Glasgow Climate Plan 2020.

1.2 This work has included the predominant use of gas combined heat and power engines for district heating, with solar panels and wind turbines for renewable energy generation. Most recently, we have seen the introduction of air-source and ground-source heat pumps being utilised instead of gas CHP for district heating as a renewable heating provision.

1.3 The Glasgow Climate Plan contains a specific action (#15) on geothermal - “Deliver projects that utilise the recovery of heat from geothermal sources”. This action stems from previous work funded by the Scottish Government Low Carbon Infrastructure Transition Programme to investigate deep geothermal energy as a renewable source of heat and power in the East of the City. This work has utilised to inform the work summarised in this report.

1.4 The former feasibility for deep geothermal heat recovery was broadly positive, however the original location was not being progressed. As a result of COP 26 taking place at the SEC, a decision was subsequently taken to work with the SEC on a feasibility study into deep geothermal using the SEC as potential site for its location.

1.5 Haliburton were appointed by the SEC with funding support from Glasgow City Council to undertake the feasibility. The content of the Haliburton feasibility report is the intellectual property of Haliburton. This report provides a summary of the technical feasibility report, gratefully shared with permission of Haliburton.

2 Summary of Findings

2.1 The detailed feasibility report assessed the potential viability of a deep geothermal system for combined heat and power at the SEC or other nearby site within the city boundary. The undertaking of such detailed feasibility work was predicated on an evaluation of known similar geothermal systems and encouraging developments of these systems in the UK. **The objective of this report is to assess the technical feasibility of such a system in Glasgow and to quantify its potential contribution to the City’s Net Zero Carbon by 2030 target.**

2.2 The work included:

- a detailed assessment of the local subsurface environment, to determine development considerations such as the number of wells required.

- A high-level surface facility plan, including turbine selection for power generation.

2.3 Some key factors considered in the design of the system were as follows:
- Limited space available on site for hosting of the system on surface. This limited the number of wells and sizing of the equipment on surface
- The considerable amount of local demand for heat and power
- The apparent lack of conventional geothermal conditions (fluid, temperature and pressure) needed for convection-based systems to drive a commercial turbine
- Sparsity of data due to the lack of subsurface exploration/development activity in relative proximity to the site.

2.4 It was found that Glasgow does not have the required subsurface conditions to operate a conventional Geothermal system. In environments such as that in Glasgow, Enhanced Geothermal Systems (EGS) are needed for access to deeper and hotter formations to create 'Unconventional' Geothermal reservoirs through stimulation of natural fractures. It should be noted that this is not the same process as fracking as the natural fractures would be stimulated through some water pressure, where fracking injects much larger volumes of pressure to create new fractures to release fossil fuels. These Deep Geothermal systems can produce power and heat in the MW[1] range.

2.5 To generate power, significant volumes of a working fluid are transferred between an injection well and a production well. The injector well sends the working fluid, capable of extracting heat from the hot rock as it travels from the injection point to the extraction point, where it is transported to the surface and into a heat exchanger or power generating turbine.

2.6 The type of working fluid used has an impact upon the output of the geothermal system and can be chosen based upon the operational aims of the system. This study focused on two carriers, H_2O/Brine and CO_2.

2.7 The study also considered a ‘heat only’ scenario which is an alternative option should initial drilling indicate that enhanced geothermal system isn’t viable. In other words, it would bring useable heat for a district heating system but not sufficient heat to generate power.

2.8 The scenarios considered include the following:

Scenario	**Geothermal System**	**Working Fluid**	**Surface System**
Deep Geothermal ~6km depth [Base case]			
1	2 injectors, 1 producer (ESP[2] potential)	H_2O/Brine	Binary cycle turbine
2	2 producer, 1 inj	CO_2	Direct turbine
Deep Geothermal ~4km depth			

[1] MegaWatt, a unit of power equal to one million watts
[2] ESP – Electric Submersible Pump

3	2 injectors, 1 producer	H_2O/Brine	Binary cycle turbine
4	2 producer, 1 injectors	CO_2	Direct turbine
Alternative scenario – Shallow Well – Heat only [<3km depth)			
5	1 producer, 1 injector or 1 well closed loop	H_2O/Brine	District Heating only

Table 1 – Geothermal scenarios

2.9 Due to a lack of data beyond around 1km in depth, best assumptions were made based on available data and literature on conditions at the targeted levels of 4km and 6km.

3 Feasibility Study Conclusions and Outputs

3.1 The report concludes that, even when taking account of the known uncertainties, the drilling of a geothermal well to a depth of 4 – 6km in Glasgow is technically feasible, although challenging, and likely to incur significant cost due to the need for drilling through hot, dry rock at the deeper depths.

3.2 The report states that the wells would cost approx. £20-25M if drilling the full depth and take in the region of 166 days per well to drill based on the data available for similar systems and technical analysis done. If circulating CO_2 as the working media, additional consideration needs to be given to ensure effective ongoing operation of the system, which could add ~5% additional cost to the program.

3.3 Assumptions had to be made on the temperature of the subsurface environment and the potential success of artificially enhancing the reservoir due to the lack of porosity/permeability of the rock. The detail behind these assumptions is made clear within the technical report.

3.4 Table 2 below shows the potential outputs from each scenario. It should be noted that these are based on assumptions and further work is required to confirm these.

Scenario	Geothermal System	Working Fluid	Surface System	Wells & Facility cost estimate	Annual output estimate power GWh	Annual output estimate heat GWh
Deep Geothermal ~6km depth [Base case]						
1	2 injectors, 1 Producer (ESP potential)	H_2O/Brine	Binary cycle turbine	~£100M	~29 GWh	60GWth @77°C
2	2 producer, 1 injectors	CO_2	Direct turbine	~£110-£120M (Chrome Casing)	~52 GWh	76GWth @ 75°C
Deep Geothermal ~4km depth						
3	2 injectors, 1 producer	H_2O/Brine	Binary cycle turbine	~£80M	~12 GWh	~31 GWth @59°C
4	2 producer, 1	CO_2	Direct	~£95-	~43 GWh	~19 GWth

	Injectors		turbine	£105M (Chrome casing)		@ 45°C
Alternative scenario – Shallow Well – Heat only [<3km depth)						
5	1 producer, 1 injector or 1 well closed loop	H_2O/Brine	District Heating Only	Insufficient data available to complete at this stage		

Table 2: Geothermal outputs by scenario

3.5 Based on the data available, the example the H_2O/Brine system could drive a turbine on the surface that could generate 3-4MW of power. Although more work needs to be done to fully understand the heat potential from a heat only model, the raw heat potential is estimated at 7MWth.

3.6 The example can be improved by utilising CO_2 as the working fluid. This is due to being able to inject larger volumes of CO_2 into the well due to its lower density, therefore accommodating 2 producer wells to the one injector. This however, is an emerging technology and requires further exploration, with indicative costs also being higher. The project can start as a H_2O/Brine system and potentially, should CO_2 be developed enough, switch across during delivery.

4 Summary

4.1 Both water/brine and CO_2 systems are capable of circulating a sufficient volume of fluid to return high temperatures from the sub-surface to surface at sufficient flow rates to drive a turbine on surface, provided sub-surface assumptions made in the study are valid.

4.2 Both systems are potentially capable of generating significant heat volume at surface that can potentially be used for district heating systems. Water/brine is the optimum working fluid due to existing infrastructure considerations and heat capacity to store and transport the heat in comparison to the CO_2 system.

4.3 In the CO_2 case, it is expected waste heat from the direct turbine would need some form of further heat transfer to a district heating system on surface where an efficiency factor could reduce output.

4.4 The key factor in power output is the volume of working fluid for circulation and the effective area of naturally porous/stimulated rock that can be accessed as a heat exchange mechanism for the working fluid. In the case of CO_2 vs water/brine, a higher volume of CO_2 can be injected and produced with lower injection pressures required and thus is potentially more optimal for power generation assuming that volume can be sourced.

4.5 If successful, there is high potential to enhance the output of the system or increase its longevity beyond an expected 20-30 year profile with minimal further investment using the existing infrastructure.

4.6 Assumptions made in this study are in absence of tangible comparable data and need to be validated and revisited after the drilling of an appraisal well.

4.7 Successful projects in Cornwall such as the Eden Project and United Downs give some confidence to the potential for geothermal heat and power recovery in Glasgow and the ongoing progress in these projects will be informative. Furthermore, the British Geothermal Society's work will also continue to be informative. Glasgow City Council is working with Haliburton to allow sharing of information under an NDA to ensure learning from the project shared at an academic level.

5 Next Steps

5.1 Several steps need to be taken to progress this work to an investable and deliverable proposition. These include the following:

- Build the commercial model – This work is required to assess the economic viability of the project based on the outputs presented in the technical feasibility study.
- District Heating Study – Build detailed feasibility and business case for a district heating network based on heat recovered from the deep geothermal well proposed.
- Undertake more detailed feasibility on heat only scenario – to review heat potential should an appraisal well not be successful beyond 3km and explore closed loop potential.
- Drill appraisal well – This will provide better data and allow for optimisation of design around the following;
  - Drilling program
  - Reservoir properties
  - Stimulation requirements
  - Well spacing/design
  - Revised subsurface model

5.2 This work shows the potential for geothermal in Glasgow to provide significant volumes of renewable power and heat and contribute to our target of being a net zero carbon city. However, it is not without risk and the preliminary drilling is required to quantify that risk. The preliminary drilling is in itself a risk and, at an expected cost of ~£25M, consideration needs to given to how this risk be managed given that the preliminary drilling could result in a heat only option, or worst case, no viable option.

5.3 This work will be considered in the Local Heat and Energy Efficiency Strategy that will be presented to committee in November. This work will also be considered in relation to the developing Climate Finance Framework.

5.4 GCC will now work with the SEC to cost these next steps and review funding options, as well as review potential placement of a geothermal well and consider potential approaches to investors before returning to committee with a further update, no later than 12 months hence.

6. Policy and Resource Implications

Resource Implications:

Financial:	Progressing this work will need investment. Its is expected that this investment will be through a combination of grant funding and private sector investment. Options may be presented for capital investment by GCC, to be considered as the project develops.
Legal:	Legal support will be required when assessing private sector involvement in the project development.
Personnel:	The further development of this work will be managed through existing resource within Glasgow City Council
Procurement:	Procurement resources may be required to support further development of stages of the business case and potential private sector investment.
Council Strategic Plan:	Contributes to Grand Challenge 3 - *Fight the Climate Emergency in a Just Transition to a Net Zero Glasgow* and Mission 2 - *Become a net zero carbon city by 2030*

Equality and Socio-Economic Impacts:

Does the proposal support the Council's Equality Outcomes 2021-25? Please specify.	The project does not have any impact on equality impacts at this stage. Should the project develop further and be successfully delivered, it has the potential to support the Council's equality outcomes. This will be explored at each stage of the project development.
What are the potential equality impacts as a result of this report?	No significant impact.
Please highlight if the policy/proposal will help address socio-economic disadvantage.	The project has the potential to deliver renewable heat and power into the city and insulate against energy price fluctuations in future, thus having the potential to address elements of socio-economic disadvantage in relation to energy costs.

Climate Impacts:

Does the proposal support any Climate Plan actions? Please specify:	This project provides a specific response to action 15 of the Climate Plan. Also contributes to many of the actions within the Climate Plan, including actions 14, 16, 17, 34, 42, 44, and 50.
What are the potential climate impacts as a result of this proposal?	This project has the potential to generate significant and dependable volumes of renewable power and heat, thus further decarbonising these energy systems in the City.
Will the proposal contribute to Glasgow's net zero carbon target?	By increasing the volume of renewable energy in the City, there will be a direct reduction in CO_2 emissions generated through energy consumption, thus contributing to Glasgow's Net Zero Carbon target.

Privacy and Data Protection Impacts:	Not directly applicable to this report.

7. Recommendations

7.1 The Committee is asked to:

1) Note the contents of this report, and
2) Request a further update on the next steps no later than 12 months hence.