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Geothermal Heat with Every Beat: The BODYHEAT Project Three Years into Operation

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ABSTRACT

This paper presents BODYHEAT, an innovative geothermal system built at SWG3, an arts and events venue in Glasgow that captures body heat from audiences of up to 2,300 people. The body heat is then stored as thermal energy in 12 closed-loop boreholes. The paper documents the complete system operation from heat extraction via air handling units, to underground storage and subsequent recovery for heating throughout the year. Beyond technical implementation, the paper examines BODYHEAT's journey from initial concept in 2019 to a fully functioning system that has been operating successfully for over 3 years at time of writing. The project gained extraordinary media traction, with coverage in over 350 publications from BBC News to The New York Times, reaching audiences far beyond the geothermal community. Three years of operational monitoring reveal the system behaviour during events and across yearly heating and cooling cycles. Detailed analysis examines temperature profiles, heat and coolth delivered, and electrical requirements across both short-term events and long-term seasonal periods, demonstrating peak coefficients of performance approaching 10 during high-occupancy events when cooling requirements are maximised. BODYHEAT demonstrates that geothermal technology and entertainment venues can work hand in hand to achieve net-zero targets by transforming audiences from passive consumers into active participants. BODYHEAT provides an innovative model for venue decarbonisation worldwide and in doing so captures the imagination of millions of people around the world.

1 INTRODUCTION

Entertainment venues present a unique energy challenge: high occupant densities generate substantial cooling loads during events, followed by heating demands during off-peak periods. Traditional approaches waste the rejected heat from cooling systems whilst burning gas for heating, creating an inefficient cycle, yet an exciting opportunity.

SWG3, a multi-disciplinary arts space in Glasgow's West End, committed to achieving net-zero carbon emissions, recognised this inefficiency as a solvable problem. The venue recruited TownRock Energy (TRE) and Harley Haddow, who devised and installed BODYHEAT, an innovative geothermal system that transforms this waste into a resource.

This paper explores the project's journey from initial concept through to its current status after three years of continuous operation, examining technical implementation, why it captured global attention, and operational performance with implications for other venues.

2 BODYHEAT – THE INSTALLED SYSTEM

2.1 System Design and Technical Specifications

The system works by supplying cool air and drawing rejected warm air from the dancing crowd into air handling units where heat is extracted from the air and transferred to the carrier fluid. The rejected heat, instead of being vented to the atmosphere, is then circulated around closed-loop boreholes, where it is stored in the surrounding rock mass, as illustrated in Figure 1. When the venue requires heating (e.g. during the day, prior to events), the same process can be used to extract the heat from the boreholes, boost the temperature with heat pumps, and deliver it to the venue.

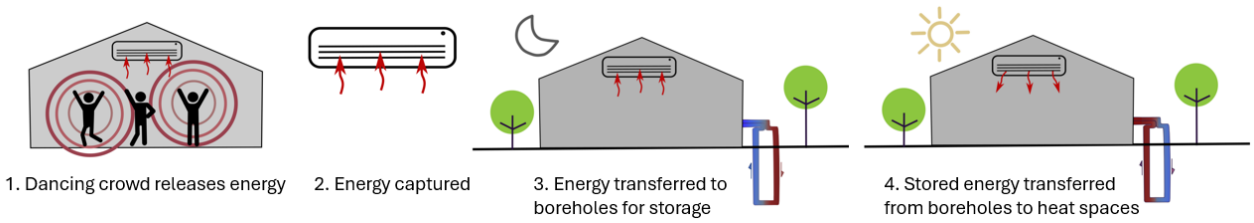
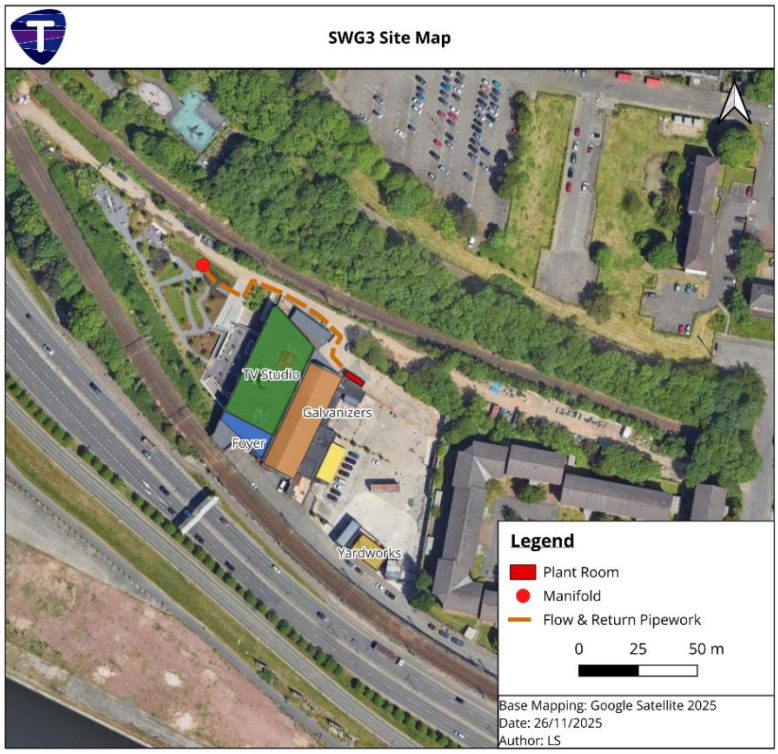


Figure 1 - BODYHEAT system diagram

The process of transferring heat between the demand-side carrier fluid and the borehole-side carrier fluid occurs in the plant room, which is housed in a shipping container in the SWG3 yard. The plant room contains two, twin Mitsubishi WR2 series heat pumps, which provide 170kW cooling and 190 kW heating capacity to the busiest spaces within the venue: TV Studios, Galvanizers and the Foyer (Figure 22). A plate heat exchanger provides passive heating by means of thermal transfer to water pipes which run through the building and under the car park to serve Yardworks (via another Mitsubishi heat pump) and the Galvanizers (via underfloor heating).

The BODYHEAT geothermal system comprises 12 boreholes, each drilled to 199 m depth in an open-U configuration with 8 m spacing between boreholes. Located in the community garden at SWG3 with minimal visual impact (Figure 3), each borehole is 115 mm in diameter with steel casing installed to bedrock at c. 17 m below ground level. Each borehole has flow and return header pipes installed in trenches to the central manifold. The manifold contains balancing valves, air vents and isolation valves on all 24 header pipes.



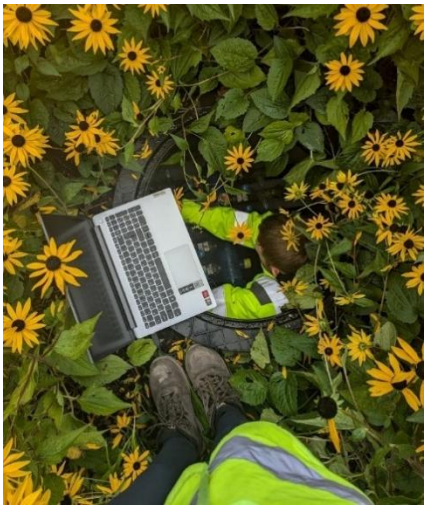


Figure 2 - The SWG3 site layout.

Figure 3 - Collecting data from the BODYHEAT borehole manifold, summer 2024.

3 TURNING UP THE HEAT: THE STORY OF BODYHEAT

3.1 FROM CONCEPT TO CONSTRUCTION

In late 2019, SWG3 started to investigate potential solutions to decarbonise their operations. A key component of this was reducing emissions associated with heating and cooling the venue. During an initial site walk over, David Townsend, TRE Founder & CEO, proposed a radical concept to Andrew Fleming-Brown, the venue's Managing Director: capturing body heat from audiences and storing it underground using geothermal technology, transforming crowds from energy consumers into energy sources. The Guardian reported in 2022 that Fleming-Brown saw the project as recognition that "our audiences could be our source of energy."

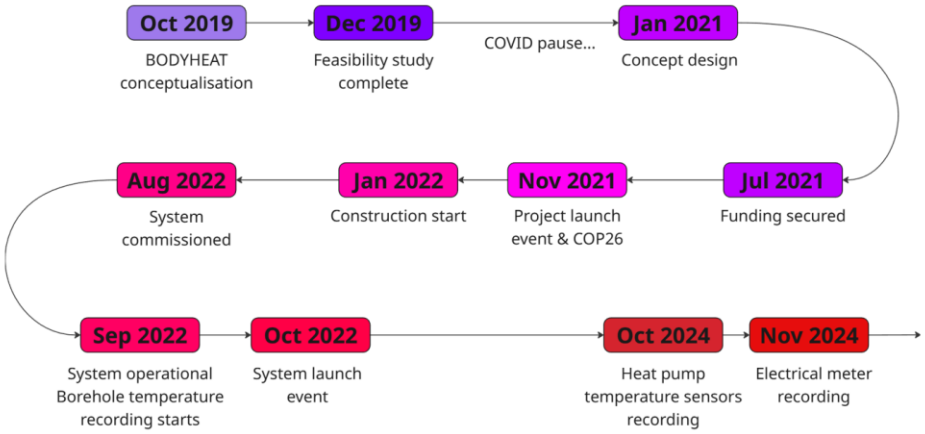


Figure 4 - Journey of BODYHEAT

The initial concept was developed during the feasibility study, completed in December 2019, which confirmed technical viability (Figure 4). However, progress slowed considerably with the onset of COVID-19 and associated lockdowns, creating immense uncertainty for venues such as SWG3. By early 2021, confidence was building in a post-COVID event industry, and the project was back on track with a detailed concept design completed in January 2021 by TRE, with Harley Haddow (HH) providing M&E engineering consultancy throughout design. Funding was secured by July 2021 through the Scottish Government's Low Carbon Infrastructure Transition Programme, District Heating Loan Fund, William Grant Foundation, and UK Community Renewal Fund.

The project was officially announced on 7 November 2021, coinciding with COP26, the UN Climate Change Conference hosted in Glasgow. SWG3 partnered with The New York Times to host their Climate Hub at the venue, welcoming some of the world's most influential voices in climate action including Nobel Peace Prize laureate Malala Yousafzai, renowned artist Oliver Jeffers, and Dr. Katharine Wilkinson. The launch event featured DJ and activist Honey Dijon headlining to a sold-out crowd in a venue filled with 150 living trees, many of which were later planted in the community garden.

Construction commenced in January 2022, with drilling of the 12 boreholes. All construction completed over the following months was done with zero interruption to the busy venue operations. By August 2022, the system was commissioned with switch on in September of the same year. On the 5th of October 2022, the system was officially inaugurated at a celebration event covered by the BBC featuring a specially choreographed Slosh, a traditional Scottish line dance, with Townsend presenting the first three weeks of operational data which showed temperature changes in the boreholes corresponding to music events. The BBC reported that Fleming-Brown described the £600,000 investment as "a leap of faith" but emphasised that "someone has to be that first investment."

3.2 Local Innovation to International Headlines

Media interest began in August 2021 with a pre-launch press release attracting widespread attention, before the launch event during COP26 elevated it to an international audience. COP26 brought unprecedented attention to Glasgow's climate solutions, providing a global platform for what the World Economic Forum (2021) called "a number of creative environmental initiatives and solutions," with BODYHEAT as a flagship example.

The venue's operations manager told EcoWatch (2021): "The thing I love most about BODYHEAT is that it's all existing technology. Innovations aren't limited to inventing something new." The appeal was straightforward: audiences could contribute to climate action simply by dancing, as BODYHEAT turned the familiar heat of a crowded room into environmental action. Fleming-Brown told SBS Dateline (2023) that the approach "really

struck a chord" because people were "participating in the system" rather than observing distant environmental schemes "conjured up by scientists." By coming to the venue and enjoying themselves, they were "contributing to a net-zero heating and cooling system."

Townsend told the BBC (2021) that “the clubbing generation right now are very enlightened with regards to climate change”, reinforcing the idea that sustainability and nightlife culture can meaningfully support one another. His vision is for "different clubs in different cities competing to be the most green" and the idea has already attracted interest from venues in Berlin and international music festivals, with potential anywhere there are crowds, including venues, gyms and offices.

Many of the early media headlines were however misleading, insinuating or even directly stating that BODYHEAT was generating power for the speakers and lighting. Questions came from reporters asking how many iPhones could be charged, or kettles boiled. The projects PR officer quickly sought to address this by compiling and distributing a technical Q&A 1-pager to mitigate any further misrepresentations. However, as is the way with public discussion on social media, these inaccuracies still caused several sceptical commentators decrying that the way the system was being described defied the laws of physics, and that journalists should be required to study physics before reporting on technologies such as this.

Coverage continued with BODYHEAT winning the 2022 UK Geothermal Symposium Innovation Award at the Geological Society in London, recognising it as the most innovative UK geothermal project before Members of Parliament and the geothermal community. The award from the British Geological Survey, was selected by a judging panel composed of experts from the UK geothermal energy community, celebrated the headline grabbing success of the projects design.

To date over 350 stories have appeared across written and video publications from engineering journals to lifestyle magazines, local newspapers to state media organisations, maintaining visibility across diverse audiences, countries and languages. This combination of innovation and participation explains why headlines like The New York Times' online in 2021 "Harnessing an Unusual Kind of Natural Energy: Dancers' Body Heat" and in print January 2nd 2022 “The Literal Power of Dance” gained such traction, generating widespread coverage, ticket sales, and public awareness. Margaret Fuhrer of the New York Times said it well, “There is poetry in the idea: the power of dance, made literal” following which she quoted David Townsend, “Conversations about sustainability can be pretty abstract, but if you can connect it to something people love to do – everyone loves a dance – that can be very meaningful”. She goes on to quote Andrew Fleming-Brown, “We did not initially think that dance would be such a big part of this project, but you need a visual language to communicate an idea, and it quickly became apparent that the emotional connection people have with live music and dance was a winning streak.”

Geothermal energy is abstract and many people, even with technical backgrounds, often confuse and conflate between different types of geothermal energy, making it a challenging technology / natural resource to promote accurately, simply and with conviction. The key learning from BODTYHEAT is that people and their emotional connection to life affirming activities should be at the core of geothermal energy messaging to gain the most traction with media.

4 THE FIRST 3 YEARS OF OPERATION

The original January 2021 budget estimate of £350,000 was made with a degree of uncertainty. By mid-2022 when the system construction was complete, the total budget had expanded to £600,000 due to:

- local and global supply chain challenges associated with COVID and volatile commodity and shipping prices;
- complex nature of extensive retrofit plumbing throughout the ex-industrial building;
- no principal contractor appointed (due to budgetary constraints) resulting in no central budget oversight.

The funders were understanding, stretching their support to meet the budget requirements, but a core component was not installed due to lack of budget: a central building management system and associated electrical, heat and temperature sub-metering and controls (est. cost £100-200,000). A such, whilst the system has been successfully operational, its granular technical performance has not been measurable. To ensure the performance of the geothermal system can be tracked, TRE took it upon themselves to invest in and implement a minimum viable monitoring solution, prior to the start of operation.

4.1 Monitoring and Installed Sensors

The initial monitoring solution consisted of temperature sensors, measuring the temperature of the return line from each individual borehole (Figure 5), as well as the temperature of the main flow and return lines in the plant room.

The installed sensors are Tinytag TGP-4520 data loggers and use probes installed beneath the pipe insulation, to measure the borehole return temperatures at 30-minute intervals.



Figure 5 - Tinytag temperature sensors installed on return line for each borehole within the manifold.

The sensors have been recording continuously since the start of operation and are a useful form of basic instrumentation, which can give a high-level overview of borehole and system performance. However, temperature sensors alone cannot give a comprehensive overview of overall system performance, which requires system load data to understand the heat and coolth provided by the BODYHEAT system. Comparing the impact of actual heating and cooling loads on borehole temperatures and comparing this with the original modelled impact would permit a better understanding of system performance.

A further set of non-invasive instrumentation was installed by TRE in late 2024, in an attempt to obtain a more thorough understanding of system performance and efficiency. Ideally, this would have been achieved by installation of an in-line, flow meter with pocket temperature probes for each heat pump and for the plate heat exchanger. However, as there was no budget for mechanical and electrical work to shut down the system and install in-line metering: only clamp-on, non-invasive flow and temperature metering could be considered. An attempt was made to instal clamp-on heat meters in the plant room, but it was found that except at very low circulation rates, the flow profiles in the flow and return pipe legs were unstable: as a result, heat readings from the clamp on heat meters were unavailable or unreliable. An alternative approach was therefore used: a more robust ultrasonic flow meter was used to take a set of one-off flow rate measurements on all the flow and return legs at a given invertor setting (circulation pump rate). The invertor setting was then changed and a new set of flow rate readings taken. A look-up table was thus created for a range of invertor settings. By installing Tinytag temperature sensors on all flow and return legs, and referring to the look up table, the heat and coolth from each heat pump and from the plate heat exchanger could be estimated.

The final aspect required to assess system performance is an understanding of the electrical requirements to run the system. This allows the assessment of the system Coefficient of Performance (COP) and means that the carbon intensity of the system can be tracked throughout operation. To achieve this, a Tinytag AC current data logger (TV-4810) was installed on the BODYHEAT system switchboard, located in the plant room.

4.2 Operational Data Analysis

Data analysis has been ongoing since each of the respective sensors were installed.

4.2.1 Temperature

Whilst temperature data alone cannot provide details on the quantity of heat and coolth stored in the subsurface, it does provide useful insights into system and borehole temperature trends. Collected data can be analysed at different levels:

- **Long-term analysis**: Collation and analysis of temperature data throughout the operation lifetime of the system can be used to observe seasonal trends, along with any long-term changes.
- **Short-term analysis**: Temperature data can be analysed over shortened periods (e.g. weeks or days) to assess the impact of specific events on system temperatures.

Long-term Temperature Analysis

The system flow and return temperature over the entire operational period is shown in Figure 6**Fehler! Verweisquelle konnte nicht gefunden werden.**. This graph shows seasonal variation, with overall temperature increasing during the summer months and overall temperature decreasing through the winter months. This indicates the variation in BODYHEAT system use throughout the year, with the system being cooling dominated during the summer months, with many events requiring cooling and therefore more heat being stored in the subsurface. During the winter months, heat is extracted from the subsurface to provide heating to the venue with only a small cooling demand from events.

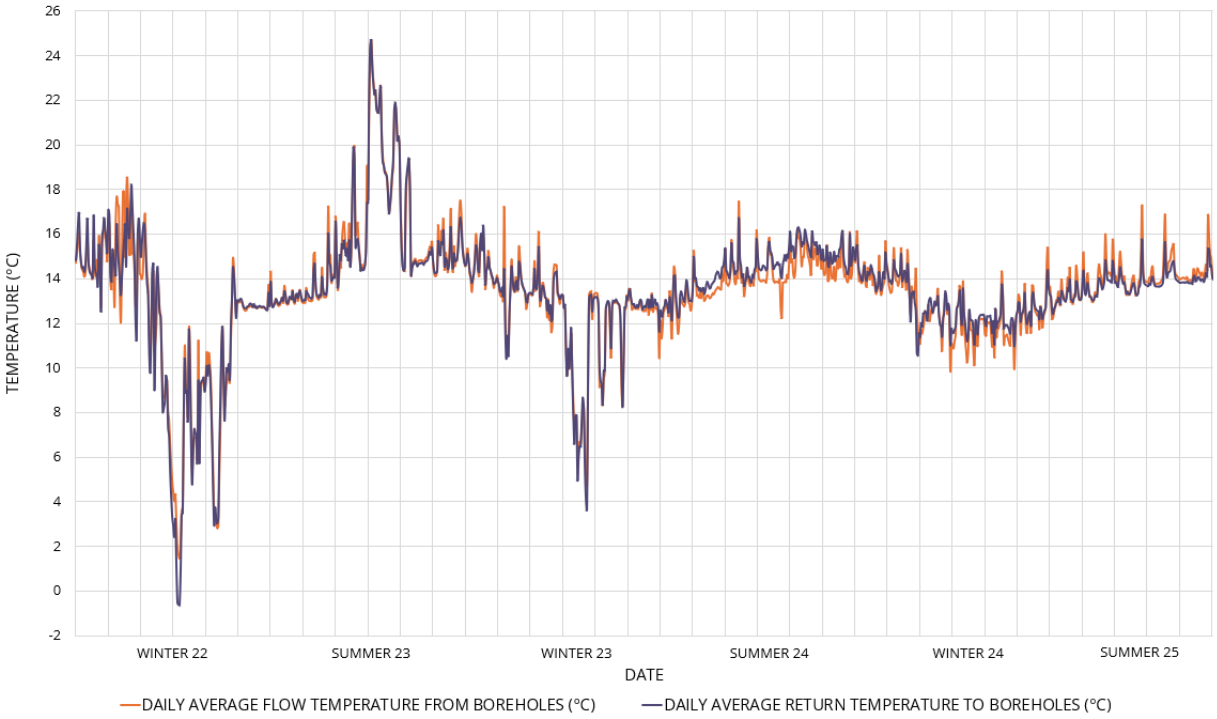


Figure 6 - Temperature data from entire BODYHEAT operational period.

This summer "subsurface heating" effect and winter "subsurface cooling" effect are most obvious during the first year of operation, with the lowest temperatures observed during the first winter of operation. This is expected, due to the cooling dominant nature of the BODYHEAT system and the expectation of a steady increase in subsurface temperatures throughout the system lifetime.

A large "charging up" period of increased temperature is also observed during the first summer of operation. Without load data, it is not possible to determine whether this "charging up" is a result of:

- High ambient temperatures requiring greater cooling;
- High system usage, which is later decreased;
- A combination of both of the above.

Whilst the following summers do show the same trends, they are less significant than those observed during the first year of operation.

Short-term Temperature Analysis

Temperature data can also be assessed on shorter timescales, to assess the impact of specific events on the borehole temperatures. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows a snapshot of flow and return temperatures over a 2-week period in August 2024. Daily temperature fluctuations can be observed in the low-amplitude waves, reflecting the diurnal temperature changes. Annotations on Figure 7 highlight more drastic temperature fluctuations linked to system operation during specific events. The size of these “spikes” can be qualitatively correlated to the scale of cooling required.

It can be observed that, during this two-week period, the techno night generated much more heat than the band nights later in the week. Townsend told the BBC that whilst "dancing medium pace, to the Rolling Stones", this generates around 250W per person, whereas high-energy events with "slamming basslines" can produce 500-600W of thermal energy per person, accounting for the more pronounced temperature spike observed during techno nights.

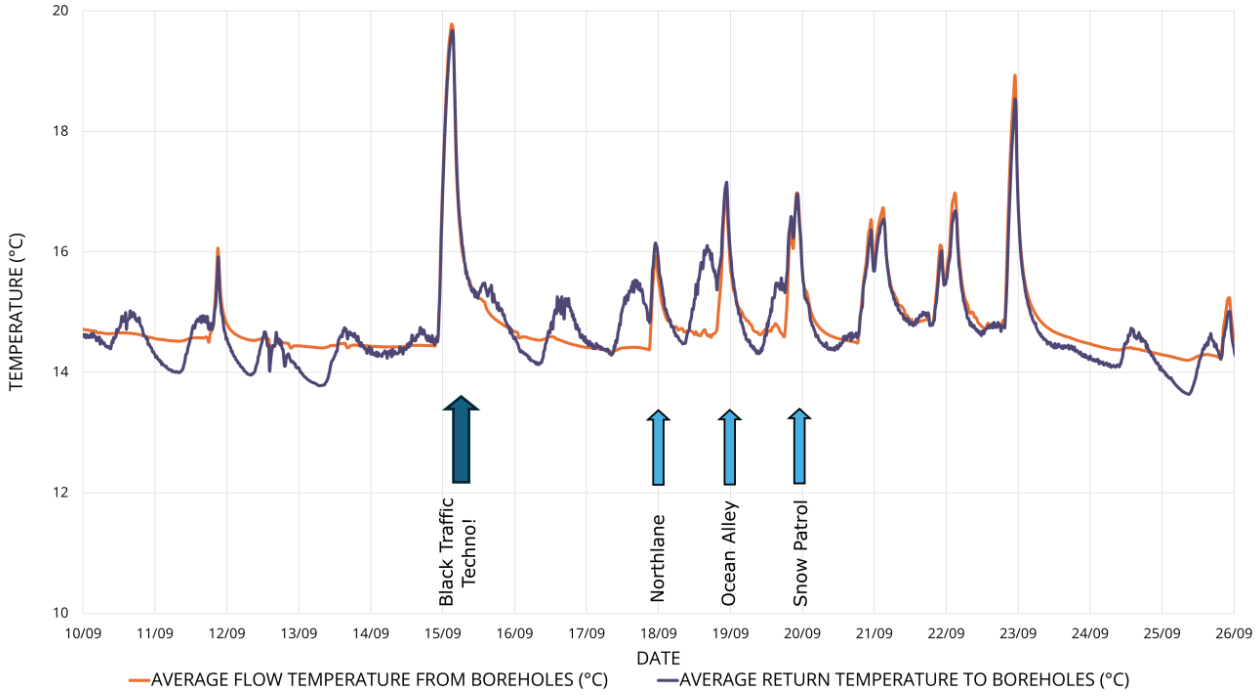


Figure 7 - Average flow and return temperatures over a c. 2 week over in August 2024.

Using temperature data alone, these observations are purely qualitative. To assess the actual cooling provided during these events, analysis of load data must be performed.

4.2.2 Heat and Coolth

To date, the heat and coolth data analysis has primarily been focused on assessing the load for specific events. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows an example of coolth data recorded on the 2nd of November 2024, just after the installation of the sensors on the heat pump. The graph illustrates a period of cooling, predominantly provided by one of the twin heat pump sets (HPU1 and HPU2), which supply the Galvanisers.

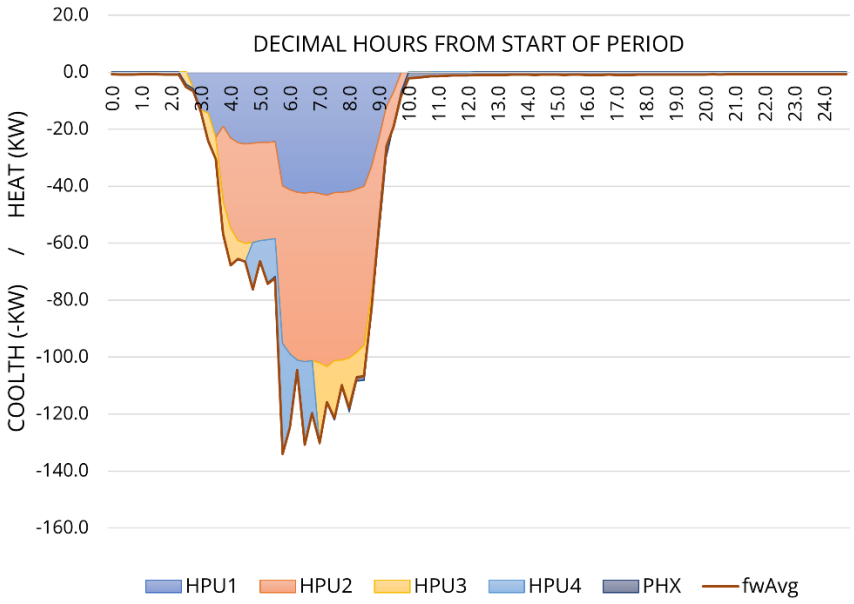


Figure 8 - Coolth delivered during an event on the 2nd of November 2024.

Fehler! Verweisquelle konnte nicht gefunden werden. shows an example of a prolonged heating period, where heating is being provided to the Foyer/TV Studio by the other heat pump set (HPU3 and HPU4). It can be observed that the heat provided in this example is much lower (c. 25 kW) than the cooling provided (c. 120 kW) in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

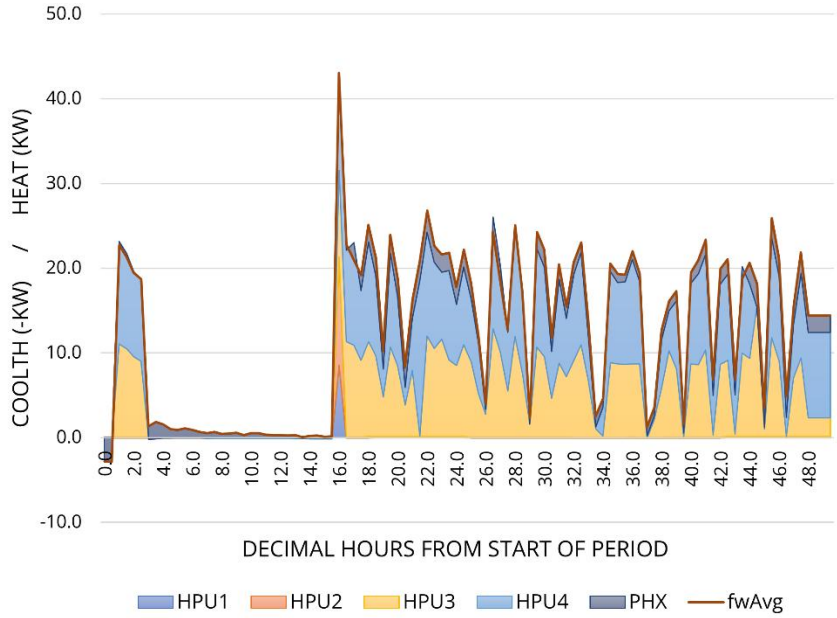


Figure 9 - Heat delivered across a two-day period, starting on the 19th of November.

4.2.3 Electrical use

The final instrumentation to be added to the BODYHEAT system was the current logger, which records the current supplied to the equipment within the plant room. It is not a fully reliable estimate of the electrical usage of the system as a whole, for two reasons: firstly, the power factor is not recorded; and secondly, the heat recovery system installed in the TV Studio / Foyer is capable of sending refrigerant locally to supply heat and coolth simultaneously to those areas and only demanding the net heat / coolth requirement from the plant room. The approach employed estimates the heat / coolth supplied by the plant room, but the heat / coolth delivered to the venue may be greater (due to the local heat recovery), so the COP figures reported here will understate the true performance during those periods.

In addition, current data would ideally be recorded for individual system components, such as each heat pump and the circulating pumps, to understand component efficiency and assess overall system performance. However, due to the plant room electrical configuration, this was not possible to implement. Instead, the current logger records the overall current provided to the BODYHEAT heat pumps and circulating pumps and therefore the electrical power consumption of the overall system. This monitoring enables more detailed performance analysis than previously and provides initial opportunities for potential system operation refinements.

From analysing power consumption for the first month of the current data recording, it can be observed that the system has a baseline power consumption of c. 1.1 kW. This is a result of the circulation pump which currently runs 24/7. The system power consumption could be improved if automation of circulation pump was included in the BMS.

As for the temperature data, it is possible to look at a shorter period to observe the impact of single events on the power consumption. Combining the power consumption data with the heat and coolth output data, it is possible to estimate the COP of the BODYHEAT system for specific events. Figure 10 shows the filtered COP data for a specific event which took place in December 2024. It can be observed that COPs up to 10 are obtained during the event peak. General analysis of COP data across the period of logging indicates COP values during events are typically between 8 and 10. This indicates that when operating at capacity, BODYHEAT is up to 5 times more efficient than a typical air conditioning system.

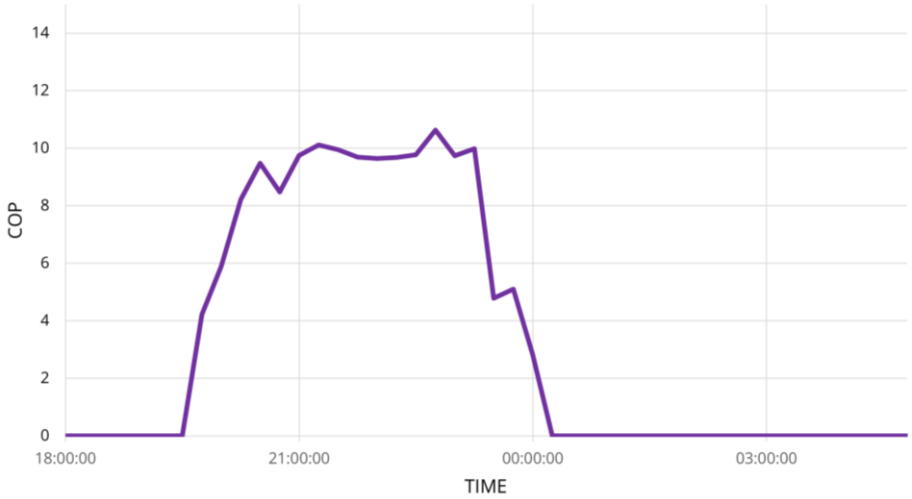


Figure 10 - Filtered COP data for a specific event on the 14th of December 2024.

With such a high COP the system is saving an estimated 8,401 kilowatt-hours of energy versus conventional air-conditioning, equivalent to powering a typical home for approximately one year. This small but significant saving is in a country, Scotland, that has typically low outside air-temperatures and little requirements for air-conditioning. In hotter climates the commercial case for geothermal cooling instead of air-source air-conditioning strengthens considerably.

5. CONCLUSION AND NEXT STEPS

5.1 Conclusion

BODYHEAT demonstrates that geothermal technology can successfully serve high-density entertainment venues whilst significantly reducing fossil fuel dependency. Three years of reliable operation validate the technical approach, with the system providing exceptionally efficient heating and cooling, with peak COPs approaching 10 during high-occupancy events.

Beyond technical performance, coverage in over 350 international publications reached audiences far beyond the geothermal community. The UK Geothermal Symposium Innovation Award recognised it as 2022's most innovative UK geothermal project, a prestigious endorsement by knowledgeable peers.

The project's appeal lay in making audiences active participants rather than passive consumers. By transforming the familiar experience of a crowded venue into climate action, BODYHEAT made sustainability tangible and immediate. This validated a "crazy dream" of combining geothermal technology with nightclub culture, proving

that creative energy systems thinking can produce solutions that are technically sound, economically viable, and culturally resonant.

5.2 Next Steps

BODYHEAT demonstrates a replicable model for venue decarbonisation. Enquiries from venues in Berlin, international music festivals, and diverse sectors show growing demand. The concept has applications wherever crowds gather, including venues, gyms, and offices, with various adaptations being explored for different contexts including temporary installations.

SWG3 is investigating expansion to supply heat to accommodation being constructed close to the venue. As the current system is cooling dominated, there is the opportunity to supply heat very efficiently to this or other buildings via expansion as a 5th generation heat network. The enhanced monitoring installed in late 2024 also helps to identify opportunities for potential system refinements and helps to make the case to install a more comprehensive building energy management system. Obvious opportunities include: improving efficiency by enabling automated circulation-pump control, reducing baseline power consumption, and expanding monitoring capabilities.

As entertainment venues worldwide face growing pressures to decarbonise, demand for proven solutions will accelerate. BODYHEAT provides both technical precedent and demonstration that geothermal technology can generate enthusiastic public support when applied in unconventional contexts.

As low-cost solutions are explored currently to increase monitoring across the system, greater customer engagement is also being discussed. One idea which is likely to be implemented in the coming months is for individual events to have thermal energy generation data shown in real time on a big screen in the foyer. This could enable stats for individual tracks within artists set lists to be quantified by energy generation. This level of monitoring means that different artists, events, or genres, could compete to generate the most heat. As Townsend quoted in an SBS video in dateline in 2023, “I think drum and bass generates the most heat”.

Acknowledgements

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