

Review of Sustainable Heat in the Glasgow Subway Tunnels



Hytiris N^{1*}, Ninikas K², Aaen B¹ and Emmanuel R¹

¹Department of Geotechnics and Environmental Geotechnolgy, Glasgow Caledonian University, UK

²University of Thessaly, Greece

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***Corresponding author:** Hytiris N, Department of Geotechnics and Environmental Geotechnolgy Glasgow Caledonian University, UK

Introduction

Glasgow Caledonian University (GCU) commenced April 2014 looking into the potential for heat energy recovery from the water present within the Glasgow's Subway tunnel system. Glasgow Subway is owned, operated and maintained by Strathclyde Partnership for Transport (SPT). The opportunity came about due to GCU's involvement in an academic project looking the potential for district heating systems being fed from energy recovered from water in mine workings in and around Glasgow City Centre. This was of interest to the Strathclyde Partnership Transport (SPT) owing the Glasgow Subway, currently manages and removes (via pumping) large volumes from water that ingresses into the tunnels on a daily basis [1,2]. The water ingress causes dampness, corrosion and defects making it a major contributor to on-going expensive infrastructure maintenance. As well as trying to prevent the water from entering the tunnels (through tunnel repair works), SPT were keen to establish if there was a beneficial use for the water to counter balance the cost of its removal and the maintenance impacts to the surrounding infrastructure.

Feasibility Study

Early into the data capture stage it was established that water ingress varies throughout the system and in some areas there was little potential. As such, a common approach to energy recovery across the system would be a challenge. However, given the depth of the tunnels, the ambient air temperature was established to remain above 14° through the year. As such, the use of air for heat recovery was then also included in the scope of the project. As data and analysis progressed, it became evident that the potential for heat recovery from the water and air resources within the Subway tunnels was significant and greater than the basic heating needs of the local Subway stations and land. However, exploitation trials to prove the scale of potential were infeasible within the timescales of the GCU-SPT project programme, as wide scale implementation trials, would require significant third party involvement and buy

in, not to mention significant additional funding [3,4]. As such it was agreed to undertake a staged approach to proving the potential and the technology, such that the trials were contained within SPT land and sphere of influence and also to establish a 'quick hit' outcome for the project.

Pilot Study

The project therefore worked towards establishing two trial sites in Subway stations – one with a water source heat recovery system (water source heat pump - WSHP) and one with an air source heat recovery system (air source heat pump - ASHP) [5,6]. The sites selected were St Georges Cross station for the water system and Bridge Street station for the air system. The trial sites were installed in October 2015 & November 2015, followed by a period of commissioning and monitoring. At the St. Georges Cross Station for example, almost a quarter of the overall water flux, instead of being discharged to the local sewers, is being used through the heat pump resulting in a reduction in the current pumping system operational hours.

Energy Savings

For each kW that is spent as energy input, there is a heat energy output of 2.75 kW. This means that the energy cost for this station has been reduced accordingly and also the carbon footprint has also been reduced from 0.47 kg/kW to 0.14 kg/kW. The payback period for this heating system, taking under consideration the actual equipment and installation cost is expected to be 12 years. At the Bridge Street station, an air source heat pump (ASHP) has been positioned below the stairs at platform level. The air from the tunnels is being absorbed from the unit (ASHP). An air draft with stable temperature between 14 to 17 degrees Celsius feed the unit. The "compact heating system" has been positioned at the station's canteen room. This provides the station's hot water and also feed with hot water the four radiators (fan coil units). The ASHP is

currently operating with higher air temperatures compared to a unit which is positioned in an outdoor environment. This means less energy input to reach the desired temperature of 45 degrees Celsius, therefore higher output. At the Bridge Street Station there is 3.6kW heat output for every 1kW energy input. This means that the energy cost for this station has been reduced accordingly and also the carbon footprint has also been reduced from 0.47 kg/kW to 0.17 kg/kW. The payback period for the Bridge Street Station heating system, taking under consideration the actual equipment and installation cost is expected to be 9 years. Through this project a data base has been created with water readings for each sump for a period of 18 months. The maximum heat energy output using the water and the air in each station has been identified. Through the design and implementation of the two trial installations, one for water and for air, the energy input reduction for heating and domestic hot water has been proven. The carbon footprint has been reduced by 2/3 at both trials. This project has engaged the SPT's Stakeholders showing them a smart use of their resources through an environmental friendly approach [7-12].

Limitations

There are some limitations, barriers and opportunities to extensively apply shallow geothermal heat harvesting to the whole Subway network and elsewhere. The continuity of water is one of them. Out of the fifteen stations, a heating system based on the water can be assumed only in few sites due to different water ingress at each location. This waste resource has not been fully exploited due to some constraints mentioned previously.

Further Installations

Meanwhile, the ASHP approach has driven the SPT to further roll out this heating system to 5 more stations within its network reducing the energy input with regard to the stations needs for heating and domestic hot water. The WSHP hasn't been implemented in other stations due to the minimum water presence in various Subway stations and also due to the complexity of the overall installation.

Opportunities

However, a number of implementations have to be acknowledged and developed to transform such opportunities into real applications and viable projects. The heat map is one, but

not the only necessary tool. Other European companies operating underground metro systems with a similar setup (existence of wastewater in large quantities or warmed air) should proceed with specific steps through feasibility studies to identify key characteristics of the water and/or air within their systems with a view to commercialize this resource. A year round survey is necessary with regards to the following: quantity, quality and temperature of water. These three, are essential to assess the real potentials for heat recovery and afterwards to seek for customers to provide this secondary energy source. On the other hand, developers and businesses have to seek for new ways of exploiting available resources in close proximity to their properties based on key factors such as sustainability and waste resource management towards energy.

Awards / Prizes

Winner of SCOTTISH TRANSPORT AWARDS 2016 for contribution to Sustainable Transport Strathclyde Partnership for Transport -Ground Water and Air Source Heat System on the Subway. <https://www.transporttimes.co.uk/news.php/THE-SCOTTISH-TRANSPORT-AWARDS-2016-WINNERS-ANNOUNCED-130/>.

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