Storing heat underground

UTES and ATES systems can help developments meet UK government renewable-energy targets

Aerial view of Riverlight and other nearby development sites

Reverse-circulation drilling with a Conrad rig

Underground thermal energy storage (UTES) is a system that uses inter-seasonal heat storage, storing excess heat from the summer for use in winter heating, and the cooling potential from winter for cooling in summer.

A cost-effective, low-energy and low-risk proven renewable technology, UTES reduces carbon emissions by up to 60% and is becoming an increasingly popular choice for residential, commercial, educational and community complexes where heating and cooling of 250kw and upwards are required.

Installing a UTES system helps to meet the current energy criteria required by UK planning authorities, which is difficult to achieve with conventional systems when building large-scale developments.

The UK is legally committed to meeting 15% of its energy demand from renewable sources by 2020 and the National Planning Policy Framework, published by the government in March 2012, makes it clear that local authorities must design their policies to maximise renewable and low-carbon energy development.

The London Plan goes further, stating in section 4A.7 that boroughs should in their development plan document adopt a presumption that developments will achieve a reduction in carbon dioxide emissions of 20% from onsite renewable energy generation.

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The COP experiment

With the ability to produce low-energy 'direct cooling' without using heat-pump energy, the requirement for conventional chiller plant can be eliminated. A higher system COP (co-efficient of performance) is achieved on heating due to the efficient utilisation of the 'warm store' water.

As an example of the potential COP that can be achieved, measurements were carried out at an ATES installation in Hoogstraten (Belgium) in 2012. The measurements were completed on the basis of an approved measurement plan and focused on measuring the COP of the HP, the groundwater circuit, and the overall ATES/HP installation under various load conditions.

The ATES/HP system in Hoogstraten has an HP with scroll compressors. Larger systems with a screw-compressor HP will have a higher HP COP. When comparing a conventional system, a base case of gas boilers is used with an efficiency of 90%. This translates into a COP of 0.9.

The cooling season is yet to be monitored but data from various other projects leads to seasonal system cooling COPs of between 10 and 15 and often higher depending on the percentage of 'direct' cooling utilised. As a comparison, a conventional chiller may have a system COP of 3-4.

How UTES works

The best-value UTES system is an open-loop system where a suitable aquifer exists. Aquifer thermal energy storage (ATES) systems make use of an underground water-bearing layer to store heat or cold. Groundwater is pumped in the winter period from one or more warm wells, with the stored heat in the groundwater used for space heating purposes in the building by linking to heat pumps (HP). The cooled groundwater from the HP refrigeration process is returned in the aquifer by way of injecting into cold wells. In the summer the process is reversed – cold groundwater is pumped from the cold wells and used directly for cooling in the building. Then the warmed-up groundwater is injected again into the warm wells.

There are a number of considerations when installing an ATES system, including site-specific hydrogeology, aquifer characteristics, the number and depth of boreholes and space between, optimum flow rates, the thermal loads of the buildings and field pipework routes from the boreholes to the mechanical plant room.

IFTech has been installing UTES systems across Europe since 2006, utilising the technology and systems developed by IF Technology, which has designed and implemented over 1,000 UTES systems in the Netherlands alone since 1998. IFTech is currently working on 10 major UTES systems across the UK. One of the company's largest projects is the installation of an open-loop reversible ATES system in London.

By the Thames

The Riverlight scheme is a large residential project in Nine Elms, south-west London, overlooking the river Thames. A 2.9MW cooling and heating ATES system is being installed for five mixed-use buildings including over 200 luxury apartments, affordable apartments and commercial space. The completely reversible system will comprise eight wells, four warm and four cold, 130m deep and delivering a planned peak groundwater flow rate of 50m^3/hr per well.

The geology of London presents its own challenges and it is usual to have to drill through 50-70m of clay before reaching the chalk aquifer. The drilling method and use of casing is critical to ensure this stage of the process is trouble-free and to achieve the appropriate flow rate.

A drilling report was initially produced using geological and hydrogeological data about the area together with data provided from a test borehole drilled at the site and local borehole and water table information.

The well construction consisted of the drilling and installation of a Boode 330 x 292mm PVC casing through the tertiary deposits of the London Basin to depths of approximately 70m to the water-bearing chalk formation. The holes were started off at circa 450mm diameter and were drilled with mud rotary reverse circulation to the top of the chalk. A mud programme was implemented using soda ash as a water conditioner to reduce excess calcium and to maintain an optimum pH of 8.5–9.5 and to enhance yield, hydration and performance of the polymeric additives, plus a dry PHPA polymer for enhanced stabilisation and inhibition of the water-sensitive London clay.

The PVC casing was then grouted in place using high-quality pelletised bentonite grout. The hole was completed using R/C water flush techniques within the chalk aquifer to the completion depth ranging from 95m to 125m.

Conventionally, carbon-steel casing is used at the 'conductor' stage as a support to the drilling operations, preventing soft formations near the surface from caving in and conducting drilling mud from the bottom of the hole to the surface when drilling starts. However, steel casing is heavy, which can make access more difficult in the early stages of drilling, and it must be either welded on site or threaded, requiring a greater wall thickness and therefore more expensive steel to be sourced. The Water Industry Specifications (1985) state that the carbon steel conductor casing should usually be bitumen-coated to protect the steel from corrosion. Inevitably, some of this coating (or alternative approved coatings) will be removed during the onward drilling phase once the conductor casing has been set. With the advent of DWI Regulation 31, any coating applied to casing must be DWI approved, so uncoated steel may be used but corrosion issues are inherent at welded joints.

IFTech has instead chosen to use Boode's 330mm OD x 292mm, 19.5mm wall-thickness (heavy-wall) PVC casing, which deals with the grouting and onward-drilling phase without issue. PVC is comparatively light, easing on-site handling, and can be supplied threaded or, as at Riverlight, with strong (2,072kN) solvent weld connections.

Boode PVC casing is corrosion free and approved by KIWA, WRAS and the Secretary of State under Regulation 31. Approval under Regulation 31 of the Water Supply (Water Quality Regulations) means that, should the wells ever be required for potable water abstraction, they are already compliant. The cylindrical perfection of Boode's PVC casings, achieved due to the slowest possible rate of extrusion, simplifies the drilling and installation process and avoids potential costly delays due to material stripping through poor connections associated with inferior tolerances in some PVC material. It is for these reasons that IFTech uses Boode PVC casings, and screens where required, in most of its projects across Europe.

It is anticipated that the drilling stage of the Riverlight project will be completed by the end of March and the ATES system for the first building will be commissioned in September. The rest of the buildings will come on line within the next 12 months.

Elsewhere in the UK, IFTech is currently working on the installation of systems for the new South West wing at the National Maritime Museum in Greenwich, a large residential development in Wandsworth, Trafford's historic town hall in Manchester, a new visitor centre at Stonehenge and the rebuilding of the Library of Birmingham. It is a challenging range of projects and demonstrates the breadth of interest in installing renewable-energy systems that harness thermal energy.

Nick Boid of IFTech and Scott Dronsfield of Boode at the St James site

Despite being a relatively new technology in the UK, UTES is part of a growing global interest in thermal energy storage and is seen as an increasingly effective solution to meet the government's 2020 target for renewable-energy generation. According to a recent report from Pike Research, worldwide sales of thermal energy storage will grow steadily over the remainder of this decade, reaching US$3.6 billion by 2020.

One of the completed well pairs

This article was written by Nick Boid, director of IFTech, and Scott Dronsfield, managing director of Boode Waterwell Systems