Congleton Hydro
Connecting the Power to the Customer

Q - What has Congleton Hydro's grid connection cable got in common with The Jam?

A – They are both 'Going Underground'!

If you've been in the vicinity of Havannah Weir or the Siemens factory recently you may have seen temporary traffic lights and roadworks for a short period. Sorry, that was us! We've been installing the electrical cable that will connect the hydro generator to the user of its electricity. This short article explains more.

Why a Cable?

Firstly, why are we not connecting to the nearest point on the local utility supply, on the other side of Havannah Bridge? The answer to that is economics. During the development phase we considered a range of possibilities for how to best utilise the power from our turbine, such as a local 'mini-grid' for the nearby residential area, connection to the public grid or connection to a site with sufficient load to easily absorb our power. After careful analysis and comparison, we found that it was most economically efficient to install a private cable directly from the hydro to a suitably large customer, this being Siemens who have also been a very generous supporter of our project. A minor detail is that there is a distance of around 1km from hydro to user! To bridge this gap, we are using a long underground electric cable. More specifically almost 1000 metres of what our supplier calls "4x300mmAL BS5467 XLPE SWA". Read on to find out what this all means.

Cable Technology

The purpose of the cable is to act as a conduit to take the electricity produced by the hydro to the user. In an ideal world it would be lossless and cost nothing, but, we have to contend with losing some of the power to heat as the electric current passes through the cable's resistance. As low voltage cables go, ours is on the large side, being four aluminium conductors each with a cross sectional area of 300mm^2 surrounded by XLPE (a type of polyethylene) insulation, wrapped in a strong steel wire armour (SWA) to protect it from physical damage. The overall diamete5rr is almost 75mm (3") and each metre of it weighs a mere 7.2kg. It is made to British Standard BS5467 and designed to operate at a maximum continuous temperature of 90°C. Under these conditions it is good for carrying 460A of current, although our generator won't put out more than around 120A, which can easily be handled by a much smaller cable.

So why does our cable need to be so much larger? For two reasons, voltage regulation and to minimise the loss of power within it and hence lost revenue. Our generator operates at a nominal voltage of 400V, as does the switchboard we are connecting to at the Siemens factory. When we generate and send power down the cable our voltage goes up (some of you may remember Ohm's Law from long-ago physics lessons). If the voltage goes too high, it would be out of the tolerable range for our generator to operate and the way to minimise this voltage rise is to use a larger cable with lower electrical resistance. A lower resistance also means lower losses in the cable, so we gain there too. More on this later.

And why aluminium conductors when copper is a far better conductor? It is true that for a given size of cable, copper will have a much lower electrical resistance than aluminium. However, it is significantly heavier and, crucially for us, much more expensive. In a nutshell, a fat aluminium cable is much less than half the cost of a thinner copper cable that can do the same job. That is the most important consideration for us. So, we chose a fat aluminium cable which we purchased from Eland Cables, a major supplier to utilities. It arrived as two 500m sections, each wound onto a large wooden cable drum of 1.8m diameter, weighing 4000kg. Special cable joints are used to connect the two 500m sections together to make the 1000m we need.

Route and Laying

Our cable runs from the Power House to the Siemens factory via the grounds of Eaton Bank Academy and Eaton Bank Farm. Legal agreements are in place with both landowners to allow the cable to be buried under their land. These are known as 'wayleave agreements' and are closely modelled on those routinely used by gas and electricity utilities.

The cable crosses roads under Havannah Lane, Eaton Bank and Jackson Road (remember the traffic lights?). At all points it is deep enough to keep it safe from damage or disturbance and to ensure safety. How deep is 'deep enough'? It depends. The law is not particularly helpful in this respect as the Electricity Safety, Quality and Continuity Regulations 2002 tell us (Reg 14(1)) that

> "Every underground cable shall be kept at such depth or be otherwise protected so as to avoid, so far as is reasonably practicable, any damage or danger by reason of such uses of the land which can be reasonably expected."

We can, more helpfully, refer to the standard practices of utility companies as these have thousands of miles of cables underground (in Cheshire alone!). Beneath footways 450mm is deep enough, under roads 600mm and 1050mm beneath normal agricultural land. There are examples of all of these on our route. Wherever it is

laid, there is a band of warning tape laid 100mm or so above the cable to give a final warning to anyone digging that deep!

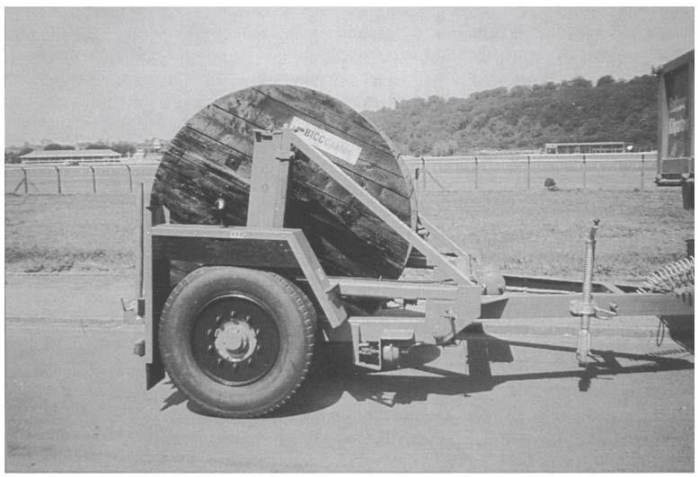
Throughout the laying process many photographs were taken, and the route was accurately recorded and notified to the relevant agencies. This minimises the risk that the cable will be damaged by future excavations or developments. It is also invaluable in the unlikely event of a fault which requires the cable to be exposed and repaired.

The photograph below was taken in mid-August when our contractors, Duttons, were digging the trench in the footway to accommodate the cable. After leaving our land close to Havannah Bridge the cable turns right and remains under the footway for 50 metres or so before crossing under the road and entering the grounds of Eaton Bank Academy. To minimise disruption, this section of the cable is installed in ducts, allowing the roadworks to be in place for the minimum possible time. Ducts are just red plastic pipes, with appropriate markings, laid in sections around 3m long and joined. As they are laid a length of rope is run through the centre of the duct, from one end of the line of ducts to the other – this rope has an especially important role, as we will soon see. Once the ducts are laid, the roadway and footpath above them can be reinstated immediately, minimising the length of open trench, and allowing the roadworks to be over as fast as possible.

Havannah Lane – Cable Duct Installation

No ducts are used under the fields between Havannah Lane and Jackson Road as here the cable is laid directly in a deep trench, which is normal practice in such land. But how do we get the cable into the duct and safely in place under the road? Remember that rope? Well, now it comes in very handy. A mechanical winch is taken to one end of the duct and a trailer holding the cable is taken to a convenient location beyond the other end of the duct.
The rope is carefully tied to the winch wire and then gently pulled from the other end as the winch is slowly unspooled, bringing the winch wire to the power cable. Special fittings are used to securely attach the winch wire to the power cable.

Finally, the winch is wound back in, drawing the power cable through the trench, into the duct and out the other side. Simple really!



Typical Cable Carrying Trailer

Losses and Metering

Alas, physics dictates that a portion of the electrical energy flowing through a cable is lost in heating it up. This happens to all cables, irrespective of size and duty, but is normally imperceptible and of no consequence. Our export cable is no different in this respect and experiences some power loss in carrying out its duties.

The expected maximum power export of the Congleton Hydro is 65kW. At this level, the total power lost to heat in the 1km of our export cable is 2.88kW, or about the same as a fan heater on its highest setting. How this translates to lost income is a little more complex and depends of the operating profile over the year, which is of course rainfall dependent. In a typical year, the lost energy is estimated to be around 5000kWh, or about 2% of the scheme's total generation and this has been taken into account in the financial modelling.

A further factor is that our income is from two sources and these have their respective energy meters at opposite ends of the cable. The Feed-in-Tariff meter is located at the generator, so does not get reduced by the (small) cable losses. At the other end of the cable a separate meter records the energy passing from the hydro scheme into the Siemens factory, which is net of losses within the cable. Again, this has been factored into the scheme's financial calculations. Our site control cabinet will be fitted with a MID certified meter, which we can read remotely via the 3G connection to the plc. The meter will be registered with OFGEM then we'll report the readings monthly for FIT payments. There will be a separate MID approved meter fitted in the Siemens substation which will report figures to their Building Management System, which will be used for monthly billing of their payments. There will be a slight discrepancy between the readings due to the cable losses.

A Hidden Gem?

In conclusion, the cable is an essential, but hardly glamorous, component of the Congleton Hydro development. All the hydro's electricity is exported through it and, hence, all its income flows through it. Maybe it is glamorous after all!

Sept 2020