LONGEST TUNNEL IN IRELAND REACHES ITS DESTINATION

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The longest tunnel ever built in Ireland has just been completed in Co. Mayo. The 4.9km tunnel, (which is 300m longer than Dublin's Port Tunnel) has been under construction since January 2013. The tunnel runs under Sruwaddacon Bay, a special area of conservation (SAC) and will house a key onshore section of the Corrib gas pipeline. The tunnel will be used to connect the previously laid 83km offshore pipeline from the Corrib Field to the Bellanaboy Bridge Gas Processing Terminal.

Excavation of the Corrib tunnel started in January 2013 using a German designed tunnel boring machine (TBM) called 'Fionnuala'. The 140 metre long TBM and its crew have been working around the clock drilling through rock, sand and clay at depths of between 5.5m and 12m under Sruwaddacon Bay.

Construction of the tunnel was undertaken by a joint venture between BAM Civil and Wayss & Freytag, both operating companies of Royal BAM Group. As the TBM advanced, over 25,000 concrete ring segments, which were prefabricated in Ireland were installed to line the tunnel.

Speaking after the TBM had broken through the final metres of rock at the Glengad landfall site in North Mayo, Michael Crothers, Managing Director of Shell E&P Ireland, said, "On behalf of the Corrib partners Shell, Statoil and Vermilion, we congratulate the entire team on a remarkable achievement. The completion of the Corrib tunnel brings us a step closer to producing First Gas in 2015 and to improving security of supply for the Irish energy market."

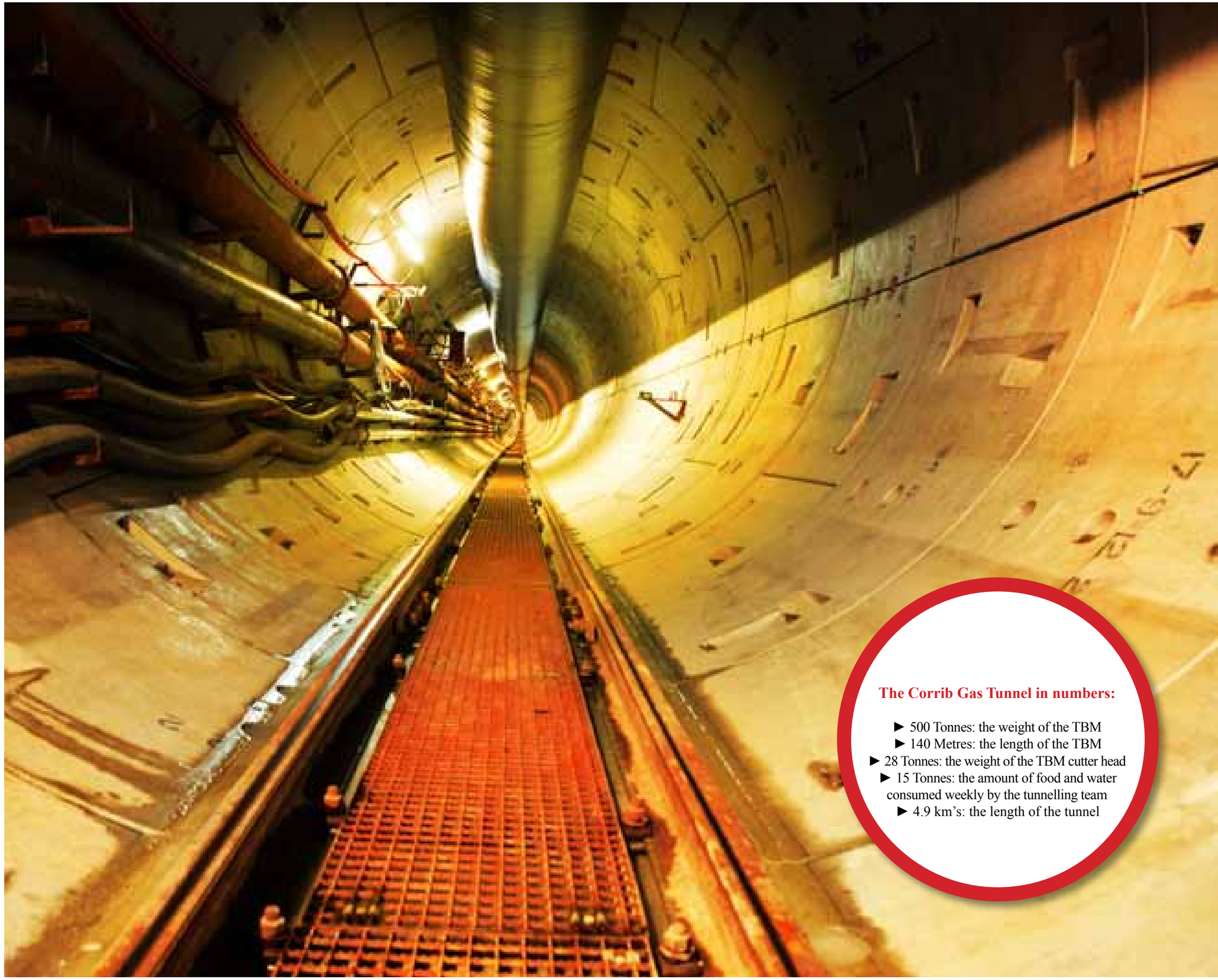
Reflecting on this important milestone, Corrib Project Director, Roeland Borsboom commented: "The innovative work that has been undertaken in successfully building the tunnel in an SAC is a remarkable example of engineering excellence. Our tunnelling team has, at every stage, adopted measures to minimise risks, as well as construction and environmental impacts on the local community."

Good progress continues to be made on other significant elements of the Corrib project. Approximately 1,000 construction workers are currently employed putting the finishing touches to the project in Mayo, Donegal, Dublin and offshore at the Corrib field. "An extensive schedule of offshore work has begun with the arrival of the 'Ocean Guardian' drilling rig at the Corrib field to prepare and test wells ahead of first gas production," said Mr. Borsboom.

At the same time, the Bellanaboy Bridge Gas Terminal, which is 98% complete, is preparing to use 'backfeed' gas from the national grid to test the newly constructed terminal facilities in the autumn.

In the coming weeks, work will commence inside the completed tunnel, on the welding and installation of the 20-inch diameter gas pipeline, control umbilical and related services. Testing of the pipeline will then take place before the tunnel is backfilled with a grout mix to completely seal it. The finished pipeline will then be ready to transport gas from the Corrib field to the Bellanaboy Bridge Gas Terminal for processing.

The Corrib Gas Partners are Shell E&P Ireland Limited (45% and operators), Statoil Exploration Ireland Limited (36.5%) and Vermilion Energy Ireland Limited (18.5%). The Corrib gas field contains an estimated 1 trillion cubic feet of gas. At peak production, Corrib has the potential to meet up to 60% of Ireland's gas needs.



The Corrib Gas Tunnel in numbers:

- ▶ 500 Tonnes: the weight of the TBM
- ▶ 140 Metres: the length of the TBM
- ▶ 28 Tonnes: the weight of the TBM cutter head
- ▶ 15 Tonnes: the amount of food and water consumed weekly by the tunnelling team
- ▶ 4.9 km's: the length of the tunnel

THE RECORD BREAKER

Ireland's longest tunnel is now in Co Mayo, and this is a project of big numbers. It is one of the most complex and intricate engineering projects in Ireland. bE talks to Paul Hughes, Tunnel Construction Manager at Shell Ireland about this engineering achievement.

bE: ***The 4.9km long tunnel, linking the 83km offshore pipeline from the Corrib Field to the Bellanaboy Bridge gas processing terminal in north-west Mayo, was a key piece of infrastructure needed to bring the natural gas ashore. From an engineering, construction and regulatory perspective, the tunnel has also been one of the most challenging projects. Could you tell us what construction methodologies have been used? What are the unique engineering and innovative engineering solutions that have been adopted?***

Paul Hughes: When Shell E&P Ireland Limited (SEPIL) made the decision to proceed with a tunnel a comprehensive ground investigation was undertaken along the proposed route in Sruwaddacon Bay. This investigation included a combination of boreholes and cone penetration tests, the results of which provided an understanding of the ground conditions along the proposed route, which was integral to the design of the tunnel and the tunnel boring machine (TBM) that would be used. A mixed shield, slurry TBM was identified as the most appropriate machine for the ground conditions.

Following this work we engaged with the tunnelling industry to provide a machine that was suitable to our requirements.

In relation to innovation, technology in the tunnelling industry is always evolving however there are countless examples across the tunnelling site, where innovation and best available technology has been used. This includes the use of BIM techniques and 3D AutoCAD during the development of the tunnel compound, real time noise and geotechnical monitoring.

bE: ***Could you tell us more about the design stage and was it possible to make all reliable predictions at that stage?***

Paul Hughes: As with any large infrastructural development, successful delivery is dependent on the quality of the design, which in turn is related to the quality of the ground investigation information. For the first part of the Corrib tunnel the rock encountered by the TBM proved to be particularly challenging. The TBM was able to advance through the rock, albeit a bit slower than was anticipated. This was a challenge however by working closely as a team we were able to resolve any issues that arose. It is at times like this that you rely on the competence and experience of the contractor and the quality and expertise of the wider tunnelling team.

The Final Breakthrough - The Corrib Gas tunnel boring machine (TBM) completed its 4.9km journey to Glengad, in Co Mayo. Pictured beside "Fionnuala" are Shell's Tunnelling Manager Paul Hughes and Wayss & Freytag Project Manager Holger Joneleit as the TBM gets a well earned wash down.

bE: ***A specially constructed TBM named Fionnuala, was used to excavate the tunnel. Could you tell us more about Fionnuala, what it did and how it worked? What were the most significant excavation challenges?***

Paul Hughes: The TBM that was selected was a mixed face machine so it was able to go through rock and sand. The cutting wheel, with a diameter of 4.3m, had a variety of tools including 21 cutting discs, which are predominately suited to full rock conditions. These disks were interchangeable and were replaced with scrapers, which are more suited to overburden material. In tunnelling the selection of the appropriate tools for the ground conditions is very important to the success of the tunnel drive.

Pressure was applied to the front of the machine to balance the earth and water pressures during advancement. These pressures are carefully selected during the design process based upon the knowledge of the ground and groundwater conditions together with the depth of cover above the crown of the tunnel.
As the TBM advanced forward, the excavated material was transported back to the Aughoose tunnelling site via pipe work that carried 'bentonite' slurry. Once above ground the material passed through a separation plant which separated material into sand, gravel and filter cake (clay).

The bentonite slurry was then re-circulated to the front of the machine where the excavation and transport process continued. Some of the excavated rock material was reused on the project and the rest was sent to local quarries in the area. Any wastewater generated from bentonite slurry change out was taken to a local County Council treatment plant for disposal.
Bentonite is naturally occurring clay and is commonly used in tunnelling and construction industries. During tunnelling, it was imperative that the 140m long tunnel boring machine was continually supplied with tunnel segments, cables, pipe work and rail lines to advance further towards the reception pit at Glengad. Each advance forward required the positioning of 6 concrete segments to form a 1.2m long ring.
Overall tunnelling is a very repetitive process and in many instances it is like a factory production line!

bE: ***As Fionnuala was progressing, what was going on to ensure the supply of personnel and materials?***

Paul Hughes: Every time 'Fionnuala' advanced 6 meters the pipe work had to be extended. This included bentonite pipes, which were 250mm pipes, fire water pipes and compressed air pipes. A 20 kV cable was installed every 100 metres due to the huge power required to operate the motors. In addition a 1kV cable was installed every 200 metres to ensure temporary back up for the emergency lighting system.

We also had to extend the railway track inside the tunnel so that the 20 tonne locomotive would be able to transport the segments, pipe work, grouting and personnel required to operate the TBM.

bE: ***What was it like to work underground?***

Paul Hughes: It was very warm for the tunnellers to work in so we had fresh air pumped in to the tunnel all the time.

Due to the ground conditions, we had to change out the cutter heads frequently which required inspections at the front of the cutter wheel. The TBM had 21 individual cutting discs and about 60 to 70 scrapers and knives and they had to be changed periodically. You just can't open a door at the front of the TBM if you want to go in and inspect the cutter head. This is because the area around the cutter head is pressurised so the bentonite had to be drained down and the working chamber around the cutter head had to be pressured with compressed air.

Those tunnellers who inspected the cutter head were required to enter a compression chamber similar to what is required for subsea diving. The chamber compressed the air pressure to 1.8 bar and they were then able to enter the front of the TBM through the double airlocks and work in a chamber. Work in this area would continue for a maximum of 4.5 hours before the tunnellers had to return to the main section of the TBM where they entered a decompressing chamber again. Medical personnel and paramedics were always on standby as decompression sickness can occur.

bE: ***What were the advanced technologies used in terms of mechanical and electrical systems in the tunnel?***

Paul Hughes: To operate 'Fionnuala' power was required so we had five generators generating 7.5 MW of power at the Aughoose site operating on the 24/7 basis.

Throughout the lifetime of the Corrib Gas Project Shell has applied very high environmental standards to the development work and we were required to adhere to similar standards in the construction of the tunnel.

It is normal to have noise on any construction site and we were required to operate within 60 dB during daytime and 40 dB at night. To make sure we could demonstrate compliance at all times, we installed our own unique central noise monitoring system consisting of 3 separate central systems that recorded noise levels around the site and we triangulated the site to check where the noise was coming from. We had designed the surface equipment within the compound so that we could satisfy a limit of 35 dB at night, and in the event of having a very calm night we could guarantee that we would not exceed the 40 dB noise limit. The noise requirements were challenging however we deliberately designed the Aughoose and Glengad sites to ensure that noise levels were kept to an absolute minimum. Up to approximately 2,000m^3 to 3,000m^3 of sand and gravel were required to be removed from the Aughoose site per week and front loaders were used to load the material on to trucks for removal. To operate within the requirements the front loaders had to be equipped with noise suppressions. We also ensured that we were mindful of lighting requirements as it was important that our sites at Aughoose and Glengad were properly lit for safe working conditions, but did not light up the Bay to the detriment of local residents or indeed the local environment. We therefore incorporated specific lighting requirements into the design of both sites.

At the outset of the tunnelling operation we were aware that Sruwaddacon Bay is a designated conservation site, and that the bay is particularly important for water birds which use the intertidal areas. In addition to the measures we took to minimise night time light spillage into the bay, and which included visual screens on the fences of the compounds, we had special green lights installed on high points including our cranes. These lights are designed to minimise any disturbance to migrating birds. We also covered the ponds on site with specially designed discs to discourage birds from using them.

There was a huge effort required to adhere to the commitments we had made in our licence applications, and we are very proud of our success in fully complying with the conditions of our consents and licences.

***bE:* As the tunnel is now built, what will happen next?**

Paul Hughes: The TBM broke through into the reception shaft on 19th May 2014. Since then the tunnel boring machine has been removed from the Glengad site and has been sent back to Germany where it is going to be refurbished and reused for another tunnelling project in Spain. The 14 trailers have also been removed from the site.

Over the next few months fit out of the tunnel will take place with the gas pipe umbilical and other service pipes being installed.

***bE:* What are the gas pipe characteristics?**

Paul Hughes: They are standard industry gas pipes but with a much greater wall thickness of 27 millimetres. It's a carbon steel pipe, used across Ireland's Bord Gais network and also across the UK, Europe, Russia and the USA.

***bE:* What is the significance of the project for Ireland?**

Paul Hughes: The development of the Corrib Gas Field is of huge significance for Ireland, Corrib will supply up to 60% of the country's gas needs during the initial years of production. The field is estimated to last for approximately 15-20 years.

Currently, Ireland is importing over 95% of its gas from the UK and further afield, so the Corrib gas field will help in terms of gas security.

As the Project has been continuing over recent years, much employment has been generated. At peak construction, over 1400 personnel were employed. Irish contractors have been able to develop new skills and they are now able to look for work across Ireland and overseas having developed these skills from working on the Corrib Gas Project. This can only be good for Ireland generally as the country emerges from recent economic hard times.