

# PUMPED-STORAGE OF HYDROELECTRICITY IN IRELAND FOR 2020

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## Project Outline

### BACKGROUND

The Ireland in line with Europe and many other developed countries is facing a number of challenges in the energy generation sector which is predominantly brought about by various governments' aim to reduce greenhouse gas emissions, increase energy security and to move generally towards a more sustainable, low carbon economy. The government's focal point for achieving these aims is an introduction of large-scale off-shore wind development programme which are now well underway. To support these developments and to link the new generation facilities on the Irish East Coast, the Irish Sea and elsewhere with the large areas of consumption in the North West, the upgrade of the transmission network is planned through the Grid21 investment programme. It is furthermore essential to link the large-scale intermittened generators (off-shore and on-shore wind farms) with balancing plants many of which are still in planning or construction.

The upgrade of Ireland's transmission network is hampered by the need to obtain way leaves, planning and to overcome local objections to HVC routes.

The proposed Pump-Storage Hydroelectric (PSH) system can address some of these issues and partially avoid the need for the transmission network to be built to peak demands.

## PUMPED-STORAGE HYDROELECTRICS PLANT DESCRIPTION

The pumped-storage hydroelectric plant uses the hydrostatic water pressure at sea levels in the Irish Sea at a depth of 500 m. The plant could be fed from excess electricity generated by off-shore or, depending on the grid connection point and where available on-shore wind farms. A typical plant will have the following structure:

- air, inspection and access pit coast side (initial vertical cavity)
- storage tunnel or gallery below sea level in a solid geological layer (cretaceous, marl or chalk)
- intake, outlet, air, inspection and access shaft in the sea near off-shore wind farms (vertical cavity at the outer end of the cavern)
- cavern for electric generating equipment (turbine) below the intake and outlet pits (this will also serve as the turning basin for the tunnel drilling equipment during cavern construction)
- one or more horizontal cavern for water flooding in during generation or pumped empty during charging operations
- discharge closure devices
- hydroelectric generating set with pump turbine, generator und electrical connection plant

The storage will be provided by separate caverns (tunnels) dug in a solid geological layer deep under the sea bed. The (typically) twin tunnels will be drilled at a depth of 400 to 500 m. The tunnels will have a diameter of 12 to 15 m. The tunnel drilling machine will be taken through the inspection and access shaft coast side. The tunnel drilling machine will be used to dig the tunnels over a length of approx. 50 km below the off-shore wind farms. The turning cavern for the drilling equipment will be built at the end of the storage tunnels sea side. This cavern will later house the electricity generating equipment, the room for the electrical connection plant and the stilling basin below the intake, outlet, air, inspection and access shaft.

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The intake, outlet, air, inspection and access shaft sea side will be built in parallel with drilling the coast side shaft using a pressurised caisson for deep-sea work

After the completion the PSH plant, sea water will be allowed into storage tunnels through the inlet shaft and passes through the electricity generating turbines, filling the storage tunnels. The pressurised air is discharged through the coast side air shaft. At times of excess wind capacity, the turbines work in reverse and pump out the storage tunnels again taking in air from the coast side air shafts.

As an example, the supply shaft on the island of Helgoland (in the North Sea off Germany) is used for air in and outlet. Furthermore, a factory workshop is built on top of the coast side shaft which contains a crane for supply of equipment to the turbine hall. The coast side shaft is separated from the storage tunnels by an air-tight access hatch.

The storage tunnels off Helgoland will also be used as HV cable routes for connection of the off-shore wind farm. It will only be necessary to lay undersea cables from Helgoland to the shore.

The PSH facility will have a minimum capacity of 2,180MW with a storage volume of 12m<sup>3</sup>. This is comparable to pump storage facilities built in mountain areas (e.g. Goldisthal, Germany). The capacity can generally be increased by adding additional storage tunnels.

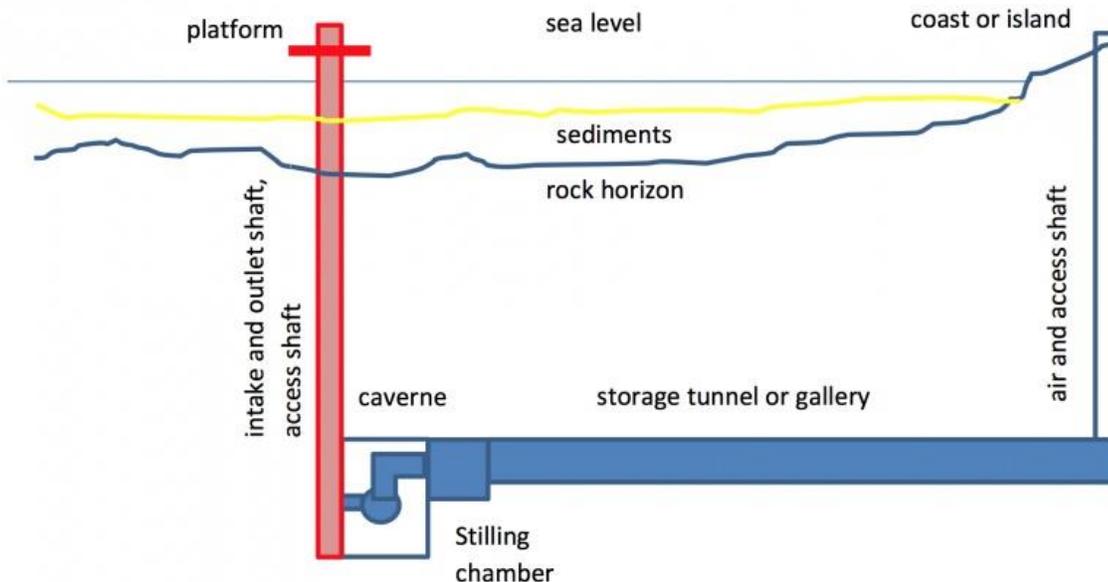


FIGURE 1 CROSS SECTION OF PSH PLANT

# PROPOSED PSH PLANT FOR ARKLOW WINDFARM IN THE IRISH SEA

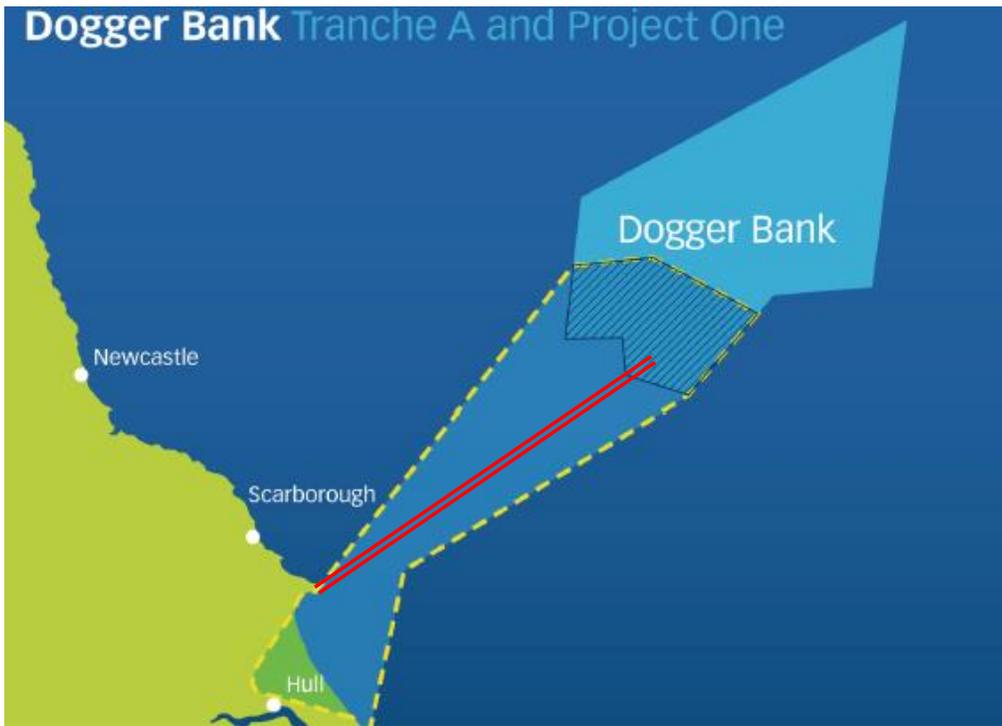


FIGURE 2 PROPOSED LOCATION OF A PSH PLANT LINKING THE COAST AT HULL/SCARBOROUGH WITH THE DOGGER BANK OFFSHORE WIND FARM

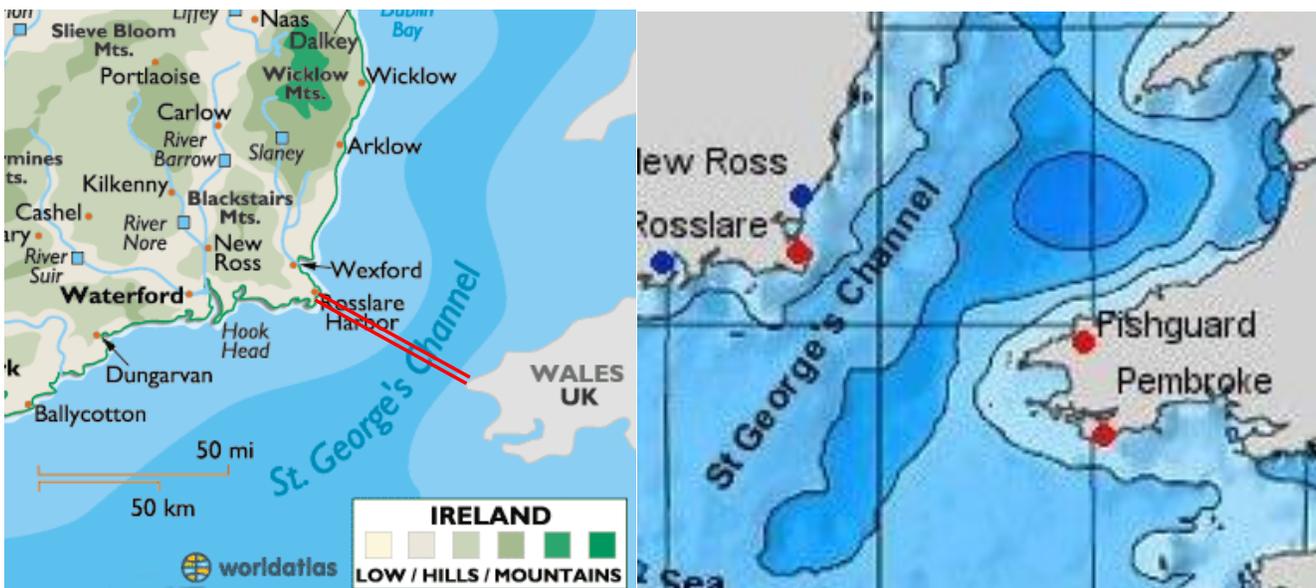


FIGURE 3 PROPOSED LOCATION OF A PSH PLANT LINKING THE COAST NEAR ARKLOW

## Pumped-Storage of Hydroelectricity in Ireland for 2020

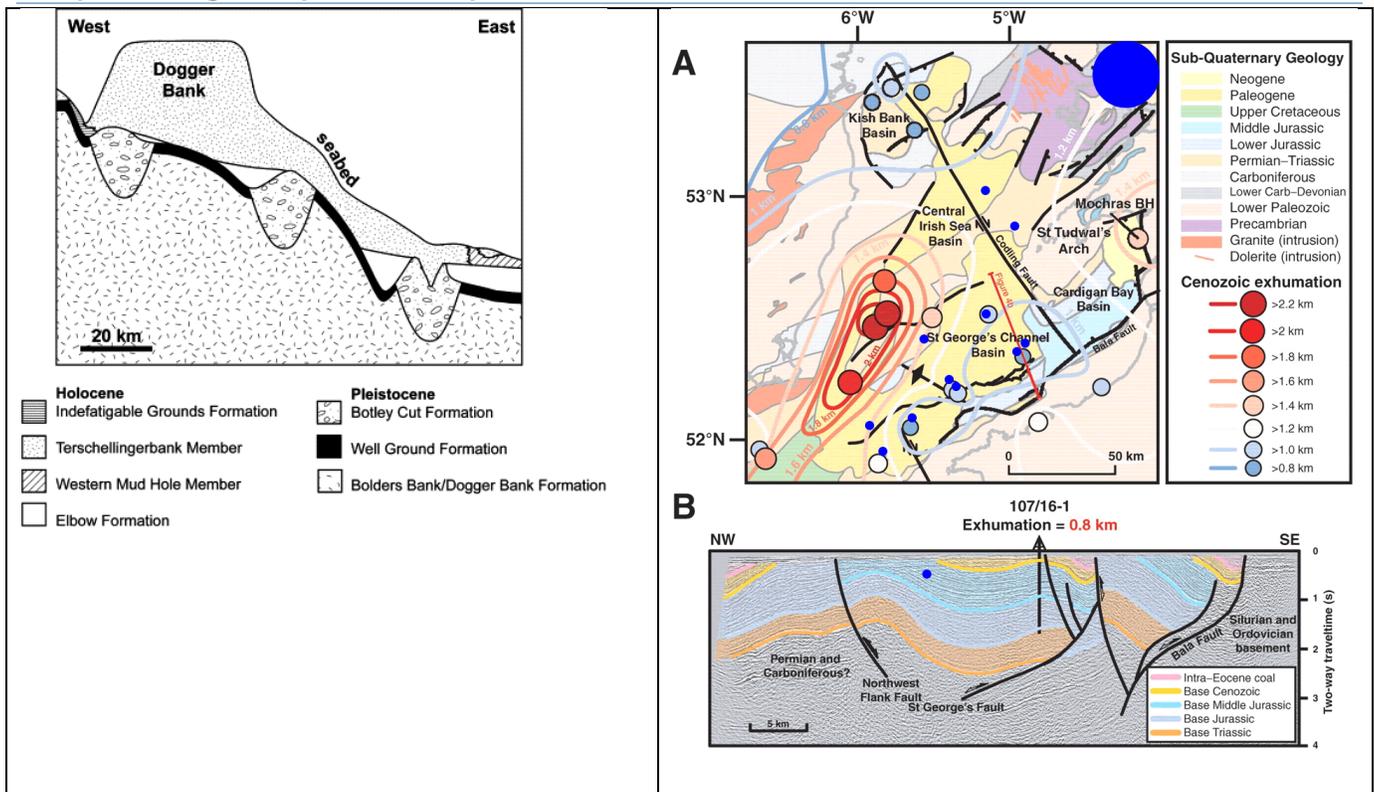


FIGURE 3 GEOLOGICAL PROFILE OF DOGGER BANK AND COAST NEAR ARKLOW

## PROPOSED PLANNING PROCESS

We have secured the international patent (for the EU region and world-wide PCI) for the construction of a PSH plant. The patent is based on a feasibility study covering technical and economic issues. The next step will be a location study and the investigation of the opportunities in the Ireland market place. This needs to include cover an investigation of the regulatory environment under which a PSH plant will have to operate, the type of corporate entity that will be able to operate the facility and an assessment of the impact on the market. It will also be necessary as part of the market analysis for Ireland to assess the potential for savings in the transmission network upgrade necessary over the next decade to link the planned off- and on-shore wind farms on the East Coast of Ireland and in the Irish Seas.

Based on the results of the location studies and the analysis of the Irish market place, a number of outline designs will be produced as the basis for a planning application. This will go in parallel with necessary public consultations which are not expected to be

controversial due to the near invisibility of the plant, the lack of any impact on the transport system and the non-invasive nature of the plant to the coast line and the sea bed. The feasibility study will then be completed by a financial appraisal of the project.

## PPROPOSED DEVELOPMENT PROCESS

The overall development is split into three phases. They are:

- A) Feasibly Stage
- B) Planning Stage and
- C) Construction and commissioning.

We expect that the location study and Ireland market analysis can be carried out over the next six months. This will be followed by the preparation and submission of planning application, the conduct of the public consultation process and the decision process. This process is expected to take another 18 to 24 months.

The construction of the storage tunnels will be carried out using similar tunnelling drilling equipment used for building the Eurotunnel, the London Jubilee Line and other comparable engineering projects. The twin-storage tunnels could be built either in parallel or in sequence depending on the available finance. As a comparative the Channel Tunnel consists of three bores with two 7.6-metre (25 ft.) diameter rail tunnels, 30 metres (98 ft.) apart is 50 kilometres (31 miles) in length and took 2 years to be built.

In addition, the construction of the service shafts, the turbine hall as well as commissioning of the plant is expected to take another 2-3 years. Thus the overall construction programme from completion of the feasibility stage to commissioning is expected to take 6-7 years depending on specifics of the rock formation found in the various potential locations.

There are options to optimise the build programme by building some of the tunnels in parallel. This could allow the commissioning of 50% of the capacity after only 4-5 years which would assist greatly in the financing of the projects.

## PROJECT FINANCING

Typical construction cost estimates for traffic tunnels are €20,000 per tunnel meter. Here the fit out and equipment is estimated at approx. 15–20% of the total cost. Under this assumption the cost of the tunnel construction would be between €12–14,000 per tunnel meter. Based on a German project, headline total construction costs have been estimated at approximately €2bn.

The cost of the project development phase is estimated at approx. 2–3% of the total costs.

Contact:

Dr R Trottnow

Network Economy Ireland Ltd.

19 Heddon Street

London W1B 4BG

Tel: +44 (0) 777 468 888

[Ralf.Trottnow@Network-Economy.com](mailto:Ralf.Trottnow@Network-Economy.com)