



Rolls-Royce

Tidal Generation

Sustainable, clean, predictable power



The case for renewable energy

Exploiting the natural power of tidal stream flows is a sustainable, predictable and potentially profitable way to enhance the use of renewable energy for tomorrow's world.

Rolls-Royce believes the time is right to explore tidal stream technology more thoroughly and to gain greater understanding of its challenges and its potential for commercial application on a broad scale, to reduce emissions of carbon dioxide worldwide.

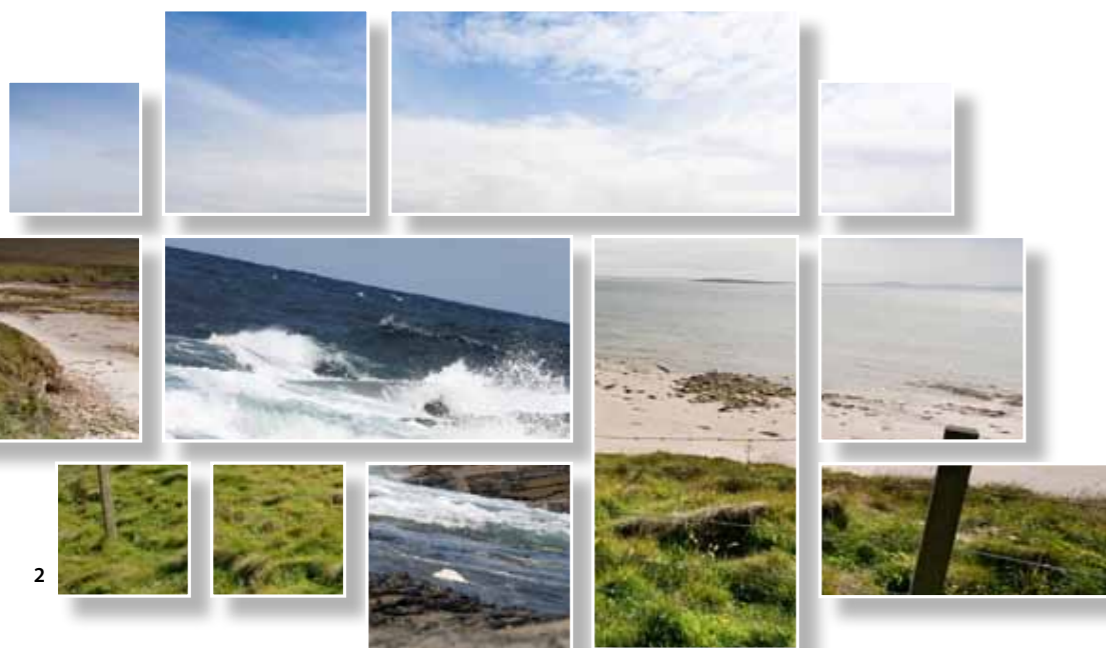
The European Union has set 2020 as the year by which 20 per cent of member states energy should come from renewable resources.

And in the UK, which is taking the lead in tidal stream initiatives, the national Renewable Energy Strategy proposes that by 2020 as much as 30 per cent of the country's electricity consumption could come from wind, tidal, wave, hydro and sustainable biomass technologies. This is set against the background of the UK's Climate Change Act of 2008, which requires a legally-binding reduction of at least 80 per cent in greenhouse gas emissions by 2050.

Market forces alone, however, will not achieve the necessary changes towards a low-carbon energy mix quickly and radically enough. These changes need key incentives from governments through enhanced tariffs and capital investment.

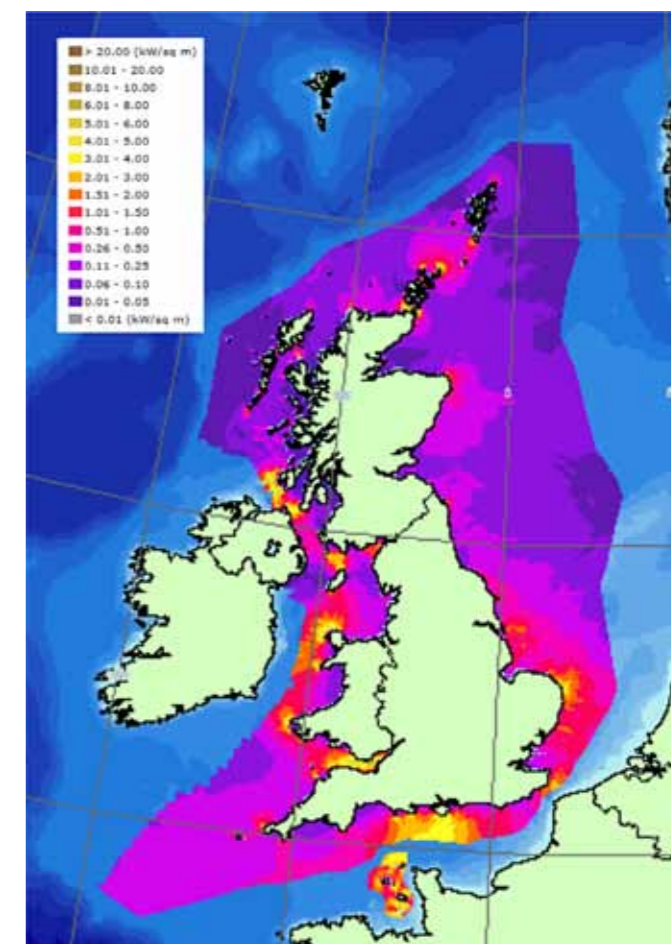
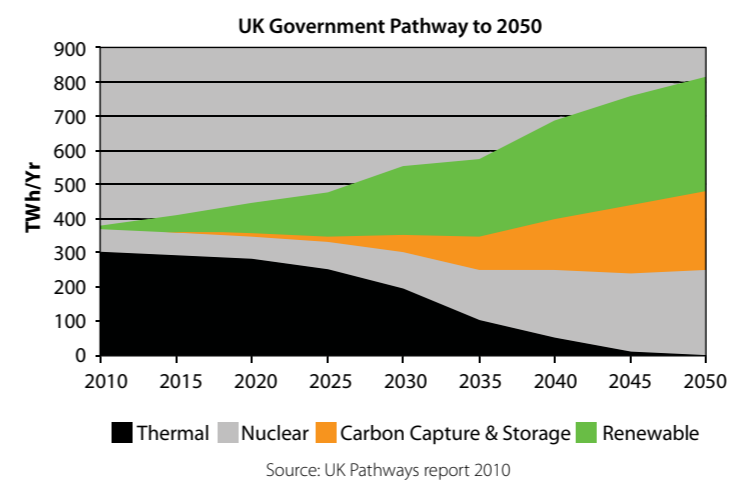
There is currently no commercial tidal stream energy industry and how it evolves and develops will depend on the actions of technology leaders such as Rolls-Royce and on others, including governments.

Rolls-Royce, as a leading global power systems business, aims to be one of the leading OEMs in a market where there is potential to generate more than 20GW of electricity worldwide. Today we are researching and developing our knowledge and expertise. This brochure outlines our capability-backed approach and our plans to progress the potential of tidal stream power generation for long-term worldwide benefit.



Key benefits of tidal generation

- Tidal generation can make a valuable contribution to the electricity demand of the UK and many other industrialised nations. Crucially, tidal power is reliable and predictable.
- Tidal forces are produced by the moon and the sun in combination with the earth's rotation. The tides that result are predictable for many years into the future.
- Tidal power comes in two forms: tidal range, which exploits the size of tides; and tidal stream, which uses the speed of tidal currents.
- Water is 800 times denser than air, which gives it huge potential for power extraction.
- Tidal generators cannot be seen or heard from the shore.
- Tidal stream generation represents an enormous opportunity, with between 20GW - 30GW available globally.



- UK Electricity demand to double with electrification
- 300TWh renewables equivalent on installed base of 103GWe (Today 6.7GWe)
- Tidal forecast 0 to 21GWe by 2050
- 250TWh nuclear equivalent to an installed base of 30GWe (Today 10GWe)
- Current winter peak 62GWe, summer peak 40GWe
- Night demand 25GWe

The Rolls-Royce approach

Rolls-Royce, as a leading global power systems business, is well placed to offer innovative tidal stream generation and other renewable energy technologies. Rolls-Royce does this by bringing together its existing portfolio of technologies, products and services.

Demonstrating the potential of tidal stream generation

Rolls-Royce began trials of a 500kW tidal stream turbine in 2010 and during initial trials produced over 50MWh of electrical power in total, averaging 12 hours of operation each day, demonstrating extended running at base load.

Development of a 1MW tidal stream generator began in October 2010 and manufacture is now under way in readiness for a two-year test programme. Experience gained will benefit a 10MW demonstration array scheduled for 2013/14.

Main Features:

The project's key features include:

- A three-bladed rotor operating at 14 rpm coupled to an epicyclic gearbox to increase the speed, then to an induction generator and power converter
- Rotor diameter 18m
- Turbine length 21m
- Service life of 30 years with minor maintenance every 2 years
- Turbine weight: 135 tonnes (not including seabed support structure)
- Turbine width: 2.6m to 3.5m
- Turbine height: 5m
- Installed water depth 35m to 80m
- Water speed at rated power: 2.7m/s
- Cut-in velocity: 1m/s
- Maximum operating water speed: 3.4m/s
- Power exported via subsea cable to grid at 6.6kV



The challenge

The challenge for the emerging tidal stream power generation industry over the next decade is to increase the scale, prove the reliability, demonstrate environmental acceptability and reduce the costs of the technology to ensure electricity can be generated at a commercially competitive price.

One key to meeting this challenge is the rapid deployment and retrieval system created by Rolls-Royce. It allows the turbine to be installed or uninstalled in just 20 minutes, maximising the time it spends producing electricity and minimising the cost of deployment and maintenance to its operator. We achieve this by making the turbine buoyant. It can be towed to its point of operation.

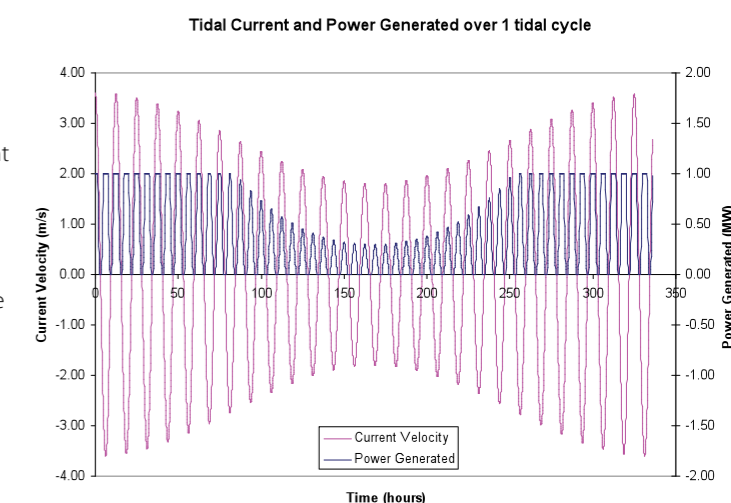
On site, it uses a patented winch and clamp design that winches the nacelle down to its seabed support structure and locks it in place.

Simple and efficient, the system avoids the need for specialist high-capacity lift vessels and for divers.

Another major competitive advantage stems from the way the system yaws. Tidal streams do not always turn through 180 degrees. As the tide turns, four times each day, the turbine turns with it, positioning itself to face directly into the flow at the optimum angle to extract the maximum energy potential. At the same time it withstands the powerful forces the flows exert on the structure.

The Rolls-Royce 1MW tidal stream generator also features:

- Low-speed, high-torque gearbox
- Pitching composite blades
- Autonomous operation and remote control
- Modular construction for easy maintenance and repair



The Rolls-Royce advantage

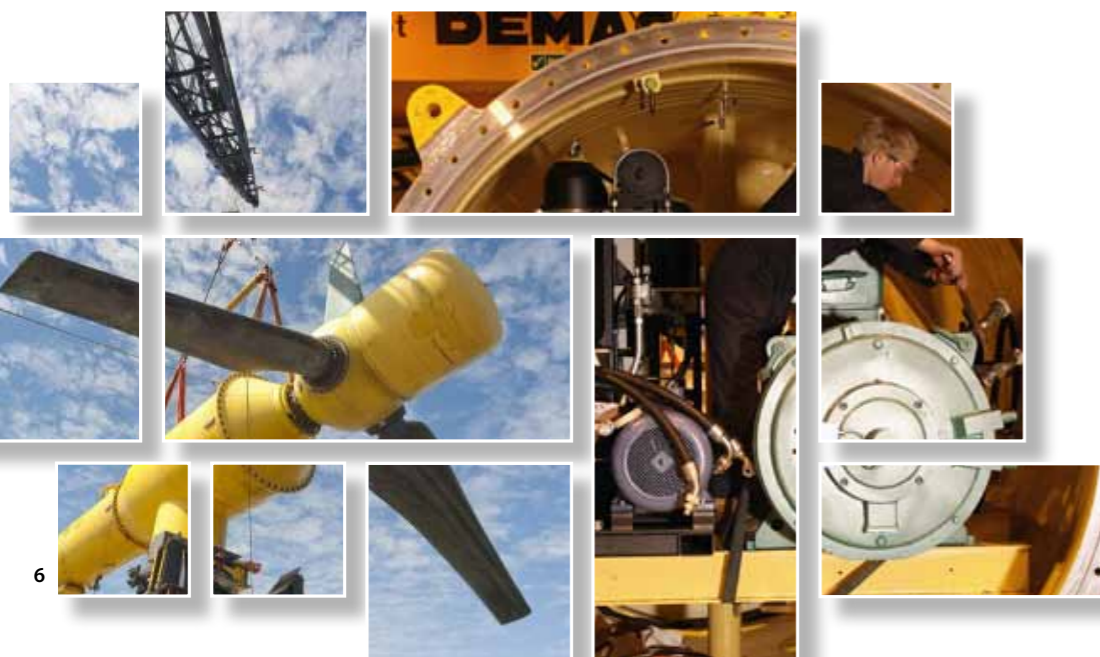
Working with turbines at low-speed, at high torque and at sea are all areas in which Rolls-Royce has extensive expertise through its substantial marine business. A key part of the turbine's power driver is core Rolls-Royce technology that draws on the company's powerful experience in marine propulsion and motion control systems.

The systems engineering approach Rolls-Royce uses throughout its energy and marine businesses integrates the company's extensive and well-proven experience in these sectors. Rolls-Royce has achieved a world-leading position in the design, development, supply and support of products and systems for commercial and naval customers around the world.

Products include electrical control systems, winches, thrusters, propulsors, gearboxes, controlled-pitch propellers, stabilisers, bearing and seals as well as the actual ship design. Rolls-Royce also brings to tidal stream generation its unparalleled degree of design and engineering expertise.



In addition, Rolls-Royce applies its extensive experience of operational maintenance and servicing and its unmatched expertise in equipment health monitoring.



Rolls-Royce: The global reach

As the leading global power systems and services company, Rolls-Royce is uniquely placed to develop the massive global opportunity tidal stream generation represents.

For optimum efficiency, tidal stream generators need to be placed in powerful marine currents. These occur where water, being moved by tidal forces, encounters a restriction such as a narrow passage between two land masses.

Some of the most promising sites are found around the western coastline of the British Isles, where Rolls-Royce will locate its 1MW tidal stream demonstrator.

Particularly interesting sites for further investigation also exist off Canada, South America, Western Europe and South Korea.

The entry into this marketplace of highly experienced and influential companies such as Rolls-Royce is essential to give governments and potential operators of tidal arrays the knowledge and confidence to support the technology's commercial potential.

Work now underway at Rolls-Royce will demonstrate the extent to which technologies can successfully be evolved, developed and adapted to create tidal stream generators that achieve this potential reliably and profitably – for the benefit of our future.





Tidal Generation Ltd (Part of the Rolls-Royce Group)

Venturers House
King Street
Bristol
BS1 4PB
Tel: +44 (0)117 325 7001
Fax: +44 (0)117 325 7002

www.rolls-royce.com
www.tidalgeneration.co.uk

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