Marine Current Turbines
A Siemens Business

SeaGen-S 2MW

Proven and commercially viable tidal energy generation

The SeaGen Advantage

The generation of electricity from tidal flows requires robust, proven, available, and cost effective technology. SeaGen-S 2MW is the most advanced, field proven tidal generation system available. As the pioneer and first mover in tidal the energy sector, MCT have developed and patented key features, that deliver commercially viable electricity generation.

These system features have been field-proven since installation in 2008, of the commercial scale, SeaGen - S 1.2 MW grid connected system. By 2012, SeaGen - S had delivered ten times the amount of electricity to the grid than all other tidal devices combined.

Following MCT's acquisition by Siemens, SeaGen-S 2MW is being developed and tested to the highest production standards, benefitting from Siemens world class, delivery of renewable energy technology to global utilities. SeaGen-S 2MW is designed around the principles of; Cost-Effectiveness, Availability, Proven Engineering and Environmental Responsibility.

Cost-Effectiveness

Each SeaGen-S 2MW device consists of twin 1MW powertrains, delivering 2MW of grid conditioned electricity to the substation. This configuration reduces the cost per MW by minimising cabling and associated distribution infrastructure. The pitch-controlled blades and high efficiency powertrains, extract the maximum energy from the available tidal resource.

Availability

Building upon 1000's of generating hours from SeaGen –S 1.2MW, SeaGen-S 2MW has matured its engineering for greater reliability. With its unique raising mechanism allowing low cost and rapid access to the powertrains, and power conditioning and control systems in its tower, SeaGen-S provides unparalleled maintainability and unbeatable availability.

Proven Engineering

With 3GWh generated by 2012 and the system continuing in 24-7 operation, SeaGen-S has proven its' engineering way beyond any competing device. Not only is the concept fully demonstrated, but the detailed engineering design including longer-term fatigue characteristics are now proven.

Environmental

In addition to producing zero-carbon electricity, MCT is committed to ensuring minimal impact on the environment from installation and operation in sensitive coastal waters. An independent environmental monitoring programme was commissioned to study the installation and first three years of operation of SeaGen 1.2 MW. In 2012 the studies concluded that, with the mitigation in place, there had been "no significant environmental impact".

Technical Description

SeaGen-S 2MW

The SeaGen-S 2MW tidal generation system evolves the highly successful 1.2MW SeaGen S device that has been operational in Strangford Lough since 2008. With the insight and experience gained from this project, MCT has been able to optimise the system design to deliver 2MW with greater availability and at lower cost.

Rotor

The SeaGen S tidal turbine incorporates twin horizontal axis rotors. The rotors utilise an active blade pitching system which limit structural forces during high flow conditions. This allows the use of blades that are highly efficient over the full range of tidal velocities, from initial cut-in through to rated flow. Energy capture is further enhanced by variable speed operation which allows the turbine to operate at its optimum tip speed ratio (all the way up to up to rated power) and also minimises the dynamic loads on the transmission system. In summary, the variable speed and active pitch features allow efficient energy capture over the full range of tidal velocities and minimise structural loading, weight and cost.

Blades

The highly efficient rotor blades are constructed from composite materials and are the most advanced and tested blade technology used in tidal generation. The 2MW design blades are being verified by static and dynamic testing, building upon 25,000+ blade operating hours gained during the 1.2MW SeaGen and SeaFlow projects .

Rotor hub

The rotor hub houses the blade pitch actuators, slew bearings and automatic greasing system in a compact and easily maintainable configuration.

Blade pitch system

The blade pitch arrangement is used to optimize and regulate power output throughout the operating range. The blades can be feathered to minimize hydrodynamic loads during extreme wave or tidal conditions.

Main shaft and bearing

The main shaft is forged in alloy steel and is hollow for the transfer of power and signals to the blade pitching system via slip rings.

Gearbox

The efficient and lightweight planetary gearbox allows a very compact and light power train to be realised. This simplifies maintenance operations and support logistics as well as reducing overall structural weight and cost.

The intermediary and high speed stages are normal helical stages arranged with an offset of the high-speed shaft, allowing the passage of power and control cables to the pitch systems. The gearbox is equipped with large capacity filtering systems that ensure optimum operating conditions and up to 12 months of operation between filter changes. The gearbox is fully sealed and is cooled by the tidal flow.

Generator

The generator is a fully-enclosed asynchronous machine with squirrel-cage rotor, which does not require slip rings and is very robust. In addition to variable speed operation, the use of frequency converters enables the generator to achieve high part-load efficiency, allowing the turbine to achieve high system efficiency across the range of tidal flow velocities. The generator is cooled naturally by the water flow.

Mechanical brake

The system incorporates a hydraulically realised brake which serves as a parking brake for crossbeam lifting and maintenance operations, and is also used to ensure safe shut-down under some theoretical fault conditions.

Controller

The turbine utilises a standard wind turbine control system provided by a leading supplier. The controller is compatible with turbine safety requirements, is self-diagnosing and includes a keyboard and display for easy status readout and adjustment of settings. The system allows; remote interrogation, the reset of turbine alarms and provides comprehensive data logging functionality.

Power conversion

The power conversion system allows the rotor to operate at optimal speed over the range of tidal velocities (from initial cut-in to rated power) whilst supplying grid compatible electrical power at a frequency and voltage to match the local distribution network. The power conversion system is a modular arrangement for easy maintenance.

The frequency converter output is interfaced to the grid via an onboard transformer, protection switch and standard grid protection relay. Each SeaGen device is a self-contained power station, requiring minimal onshore infrastructure and permitting multiple machines to use a common subsea cable.

Grid compliance

The SeaGen system complies with current grid code requirements and due to the use of modern frequency converters, can be adapted to meet emerging standards and network requirements associated with tidal arrays.

Operation

The tidal turbine operates automatically, self-starting when the tide reaches an average speed of about 1 m/s. During operation below rated power, the pitch angle and rotor speed are adjusted to maximize the hydrodynamic efficiency. Rated power is reached at a tidal speed of about 2.5 m/s. At higher tidal speeds the output is regulated at rated power and rated rotational speed.

Remote control

The tidal turbine is equipped with a web based SCADA system. This system offers; remote control, a variety of status views and useful reports from a standard internet web browser. The status views present; electrical, mechanical, meteorological and tidal data, as well as operation, fault and grid status.

Turbine Condition Monitoring

In addition to the Web SCADA system, the turbine is equipped with a web-based Turbine Condition Monitoring (TCM) system. The TCM system carries out precise, continuous, real time, condition diagnostics on main turbine components. The TCM system has various alarm levels, from informative through alerting level to turbine shutdown.

Support Structure

The twin 1MW tidal turbine drive trains are mounted at each end of a crossbeam which in turn is supported by a surface piercing tubular steel tower. The cross beam can be raised, as required above the sea surface to maintain the drive trains, avoiding the cost and delay associated with expensive marine vessels. MCT can provide support to array developers to design foundations to meet local site conditions.

Specifications

Rotor

Diameter	20 m
Swept area	628 m^2 for 2 rotors
Rotor speed	4 –11.5 rpm
Power regulation	Active blade pitch regulation

Transmission System

Gearbox type	Planetary
Gearbox cooling	Direct to passing sea water

Mechanical brake

Type	Hydraulically released

Generator

Type	Asynchronous
Nominal power	rated to provide 1,000kW into grid export cable
Voltage	690 V
Cooling system	direct to passing sea water

Monitoring system

SCADA system	Web based
Remote control	Full turbine control

Tower

Type	Cylindrical tubular steel
Hub height	Tailored for water depth/navigation constraint issues

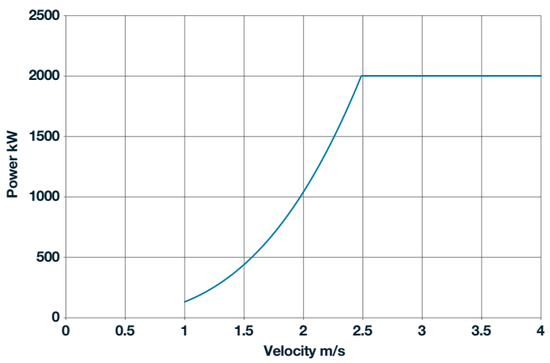
Operational data

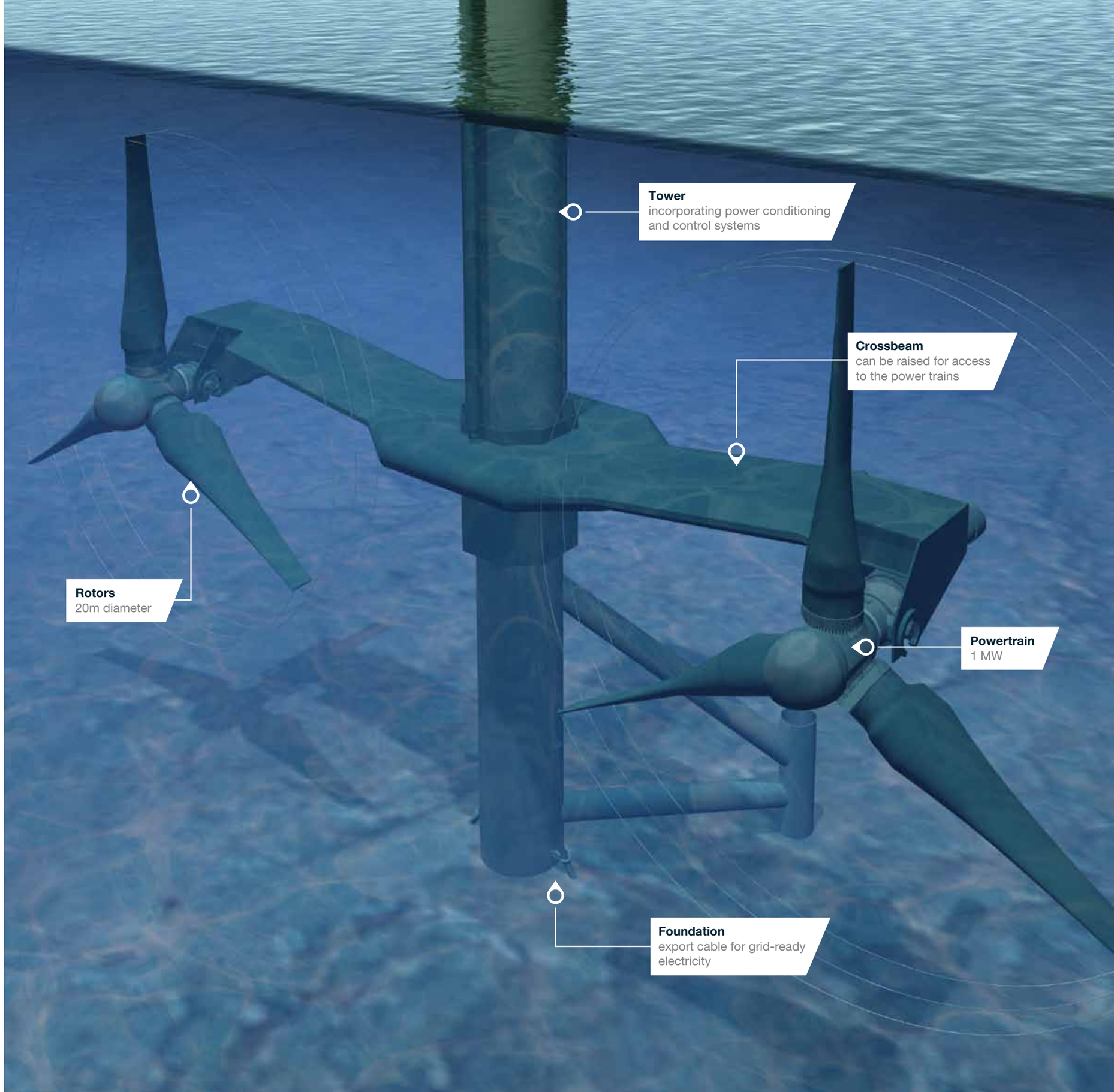
Cut-in tidal speed	1 m/s
Rated power at	2.5 m/s

Weights

Drive trains	60 tons
Tower	Site-specific

Power Curve for SeaGen -S 2MW





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