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Magazine of the Institution of Civil Engineers **19 September 2002**

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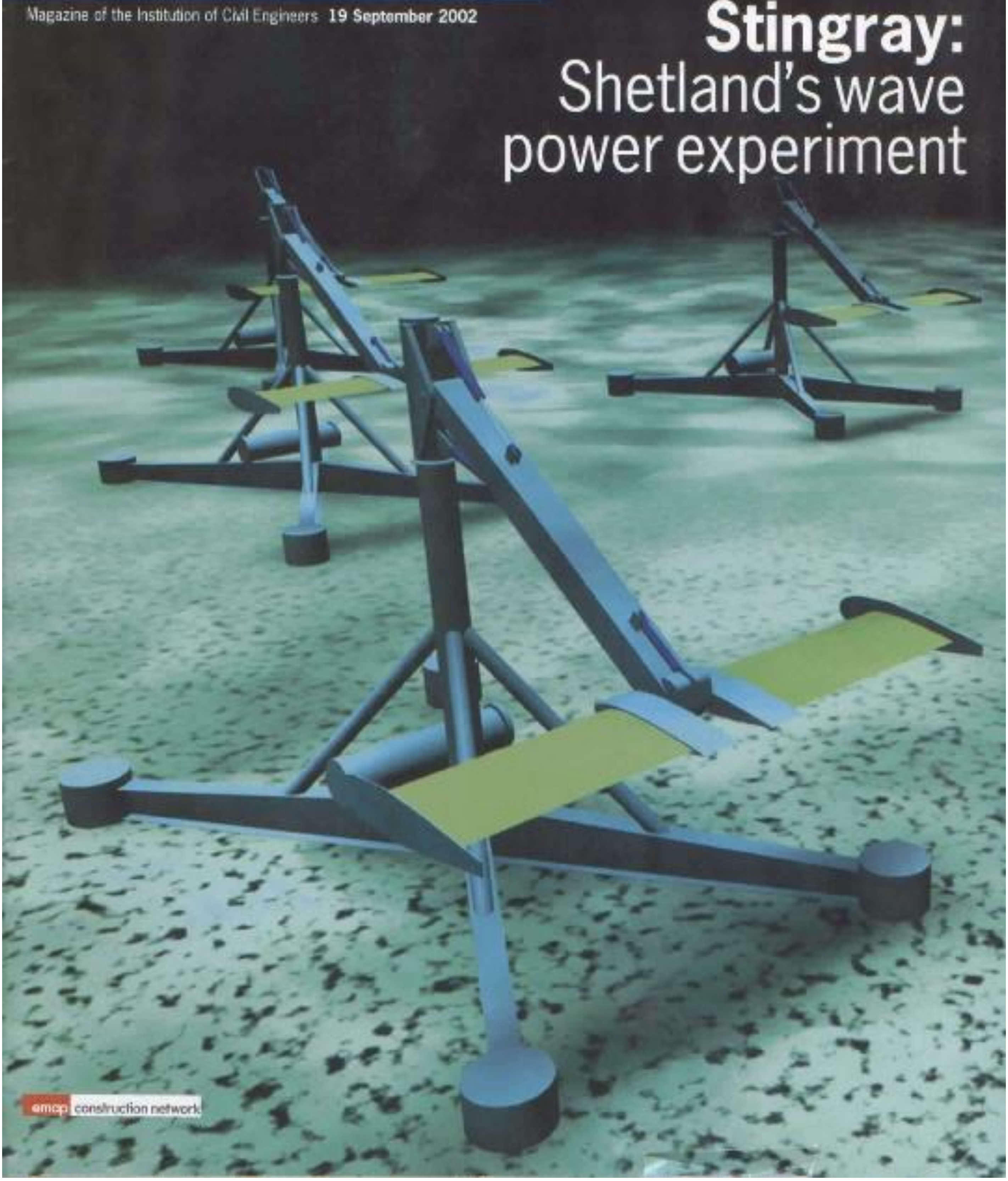
Stingray:
Shetland's wave power experiment



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Technical

Wave power

Call of the running tide

Wave energy could help the government meet its commitment to produce 10% of electricity from renewable sources by 2010 and 20% by 2020. Andrew Mylius looks at a radical new approach to harnessing tidal currents.

Otters and seals diving in the racing currents of Shetland's Yell Sound will be among the few witnesses to a radical £1.8M wave power experiment this month.

Shetland is already a focal point for finns keen to generate power using the winds that lash the islands. But it was the enormous tidal energy surging up and down the coastline that grabbed the attention of Tony Trapp, managing director of Nort.humberland marine engineering specialist The Engineering Business (EB).

"I stood onshore of Yell Sound and watched several terrawatts of energy flowing past," he says. "The tide hardly stops as it turns around. No one could fail to be impressed."

EB has developed a prototype power generator that rethinks fundamentally the process of harnessing ocean currents to produce electricity

Forget tidal barrages, which work in the same way as hydroelectric dams, holding back a head of water to drive turbines. Trapp says they are difficult and costly to build and have huge environmental obstacles to overcome.

The high cost of installing, and eventually removing, monopiled foundations in the sea bed has also steered EB away from hydraulic turbines – beefed-up, submarine equivalents of wind turbines.

Resting under its own weight on the ocean floor, EB's "Stingray" uses a giant 172m^2 hydroplane to drive an oscillating ann up and down in sweeping 20m, 15 second cycles.

Stingray's action mimics that of a whale's tail, says Trapp. But where the whale puts energy into driving itself through the water, Stingray's hydroplane extracts energy from the fast-moving tidal stream. Movement of the arm and hydroplane pumps six hydraulic rams connected to a DC generator. This is mounted on the sturdy base which supports the moving parts.

Lifting the oscillating arm to 24m tall at full stretch, Stingray's hydroplane is composed of 3m long injection-moulded plastic sections that are sleeved onto a pair of tubular steel beams. The hydroplane is equipped with a spoiler at each end to prevent potentially destabllising vortex shedding.

By contrast with the sleek hydroplane, Stingray's base is unsophisticated. It is heavily built in standard steel sections, accounting for 160t of a total 180t weight; the hydroplane and arm weigh lOt apiece. Trapp admits the machine as a whole is heavily over constructed – it will be producing a nominal 150kW of electricity but EB estimates it is robust enough to deliver 500kW.

Unlike a wind or marine current turbine, Stingray will be invisible. In Yell Sound, even at the lowest tides, there will be 7m of water above it. With no need to worry about Stingray's looks, EB has been able to concentrate on optmiising the balance between cost and efficiency

"We started off by designing our own box sections, but dropped those for standard I-sections," recalls EB technical director Tim Grinsted. There was little significant increase in the amount of drag and turbulence generated as most of the structure lies below the hydroplane's operating area.

"For stability we had to make the base heavy – there was no point in building an efficient structure and then adding ballast," he adds.

EB reasoned that it was better to focus on making the base easy; quick and cheap to construct and put the savings towards reducing the cost of the resulting electricity.

EB's roots are in designing and fabricating plant for offshore cable laying and pipeline trenching – largely winches and ploughs. Projects are nearly always driven by tight deadlines.

it is a refined branch of engineering, but with a distinctly agricultural flavour, says Trapp.

The firm employs a mix of civil, geotechnical, mechanical and agricultural engineers to develop its deep sea equipment. Part of its ethos involves cracking on with the job, Trapp says.

Stingray was developed in an incredibly tight five month period, underpinned by hydraulic modelling of Yell Sound by Robert Gordon University; hydroplane studies at Galbraith University Glasgow, tow tank tests at Newcastle University and research on linear drive trains by Durham University

Barging it

A specially modified barge has been equipped to launch and recover Stingray. A pair of gantries have been cantilevered from the back of the barge. These are fitted with strand jacks which support Stingray's base at each corner.

Launching the generator requires a calm sea and needs to be carried out as the tide turns, when currents are slow. Lowering it into 35m of water takes about an hour.

"We could have hired Halliburton to drop this for several hundreds of thousands of pounds, but we may want to take it out and modify it. Ultimately we'll decommission it," Trapp says.

The barge works out a fraction of the price and, before Stingray was even in the water, EB was fielding inquiries from clients in the oil and gas sector who saw scope for saving cash on lifting jobs

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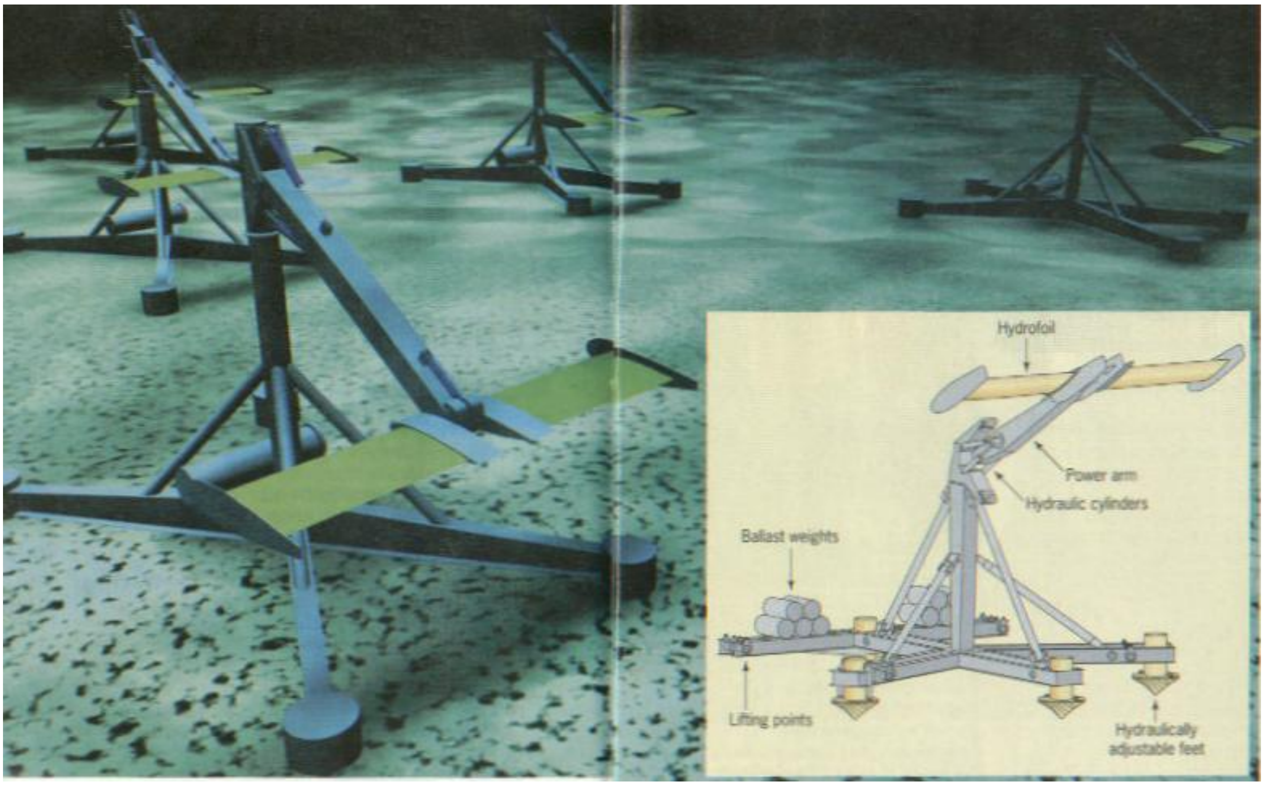

Designs incorporating two and three hydroplanes were scrapped: doubling or trebling the hydroplane area offered diminishing returns rather than delivering two or three times more lift. Again, EB weighed up cost and efficiency and calculated that a less efficient but mechanically more straightforward design would produce cheaper electricity. Stingray will be about 25% efficient, Grinsted says.

Stingray’s performance is being honed through a control system which borrows tecimology developed to manage the engines used for deep sea cable laying.

Generating power from an oscillating machine is, on the face of it., not easy” Trapp notes. It results in huge peaks which fall away to zero as the oscillating arm changes direction at the top and bottom of each cycle. Though these peaks and troughs cannot be eliminated, they can be moderated.

A decade ago the cable laying industiy started using computer controlled electric motors to compensate for the pitch, yaw and roil of ships to ensure that hugely expensive fibre optic cables were payed out at a constant tension. Power can be reduced, turning the motors into generators with huge braldng power, and switched back again in the blink of an eye.

Stingray will be marked with a buoy but, with 7m water above it at the lowest possible tide, it is no hazard to shipping.

A similar computer system will be used to turn Stingray’s generator momentarily into a motor, accelerating its hydroplane into its next phase each time it reaches the top or bottom of a cycle. The control system will be used to alter the hydroplane’s angle of attack, increasing it from 15 to 550 and back again. It will be used to moderate the amount of resistance offered by the generator, maximising energetic output.

Trapp predicts that the energy put into controlling Stingray will be a fraction of that gained. The control system will also enable ER to push Stingray’s limits.

Grmsted enthuses: “If we can generate 300kW rather than 150kW, great. We would also like to run it at significantly higher output for short periods.”

Over the next year the single 150kW Stingray is expected to produce between 300MW and 500MW enough to power up to 130 homes, at a cost of between 4p/kWh and l4p/kWh.

However, energy suppliers are penalised by industry regulator Ofgem for providing “bumpy” electricity. If Stingray proves itself in the coming months, Trapp envisages “co-operative” clusters of six to 10 Stingrays on the ocean floor. Coordinated by the same computer control system, they would work together to provide a constant, steady stream of power.

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