VerdErg
Green by Design™

VerdErg

Spectral Marine Energy Converter
"SMEC"

Presentation to:

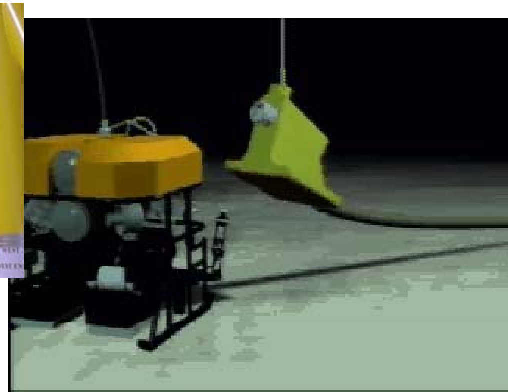
UKTI Marine Energy Opportunities

5th November 2009

VerdErg: Operating for 30 years in hostile marine environments

Gaskets

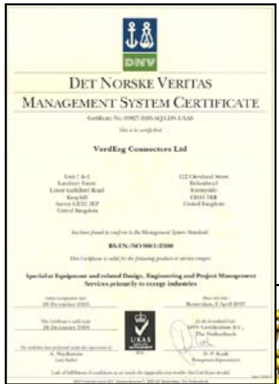
Diverless
Subsea Connectors

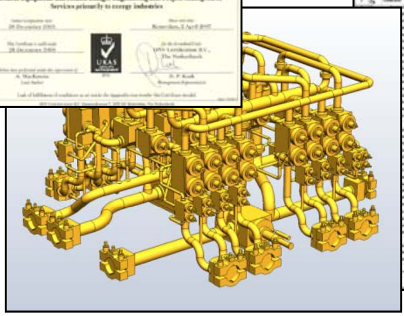


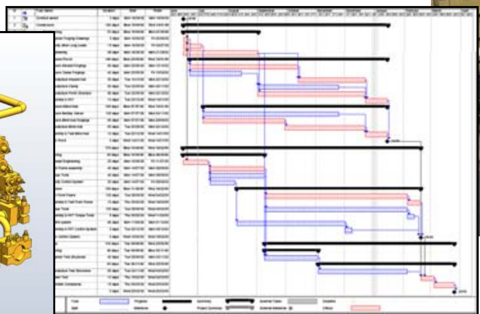
Remotely-Operated Tooling

Compact Manifolds

….and services







Design, Planning,
Supply Chain and
Project Management

Assembly & Test

Installation Supervision

1979 to 2009:

- Offshore and Subsea specialist Engineering and Project Management:
  - FUEL Ltd., was spun out of Vickers, Barrow from the team providing Engineering Support to manned submersibles.
  - 30 years working in the harsh West of Shetlands environment, more recently in USA and offshore West Africa. Developed full Supply Chain Management System to build in-house designs.
  - Vertically Integrated Business by 1997 for Design, Procurement, Fabrication Management, in-house Assembly and Test and Installation/Maintenance Management of subsea systems.
  - Small Oil & Gas Field Development undertaken 2001/02 with Land & Marine Engineering, Wirral, when both owned by SMIT.
  - Sold to INTEC Engineering of Houston in 2002 as INTEC was acquired by Heerema Group of Leiden. Investment frozen.

- Management Buy-Out of business in 2005: renamed "VerdErg" to show commitment to reducing the Carbon Footprint of the Energy Industries. Product development re-started.
- Turnaround to profitable growth of Core Business with extended product range and new clients, 2007/8.
- Developed a unique tidal energy technology called “SMEC” standing for Spectral Marine Energy Converter which was patented in 2006 and 2008. £400,000 invested in completing Phase 1 development which established technical feasibility and showed prospects of possible eventual economic parity with Fossil Fuels.
- VerdErg claims expertise in the complete product development and commercialization life-cycle for marine hardware. Focused on "Design for Installation" and testing for the high Reliability and Availability essential for inaccessible marine environments.

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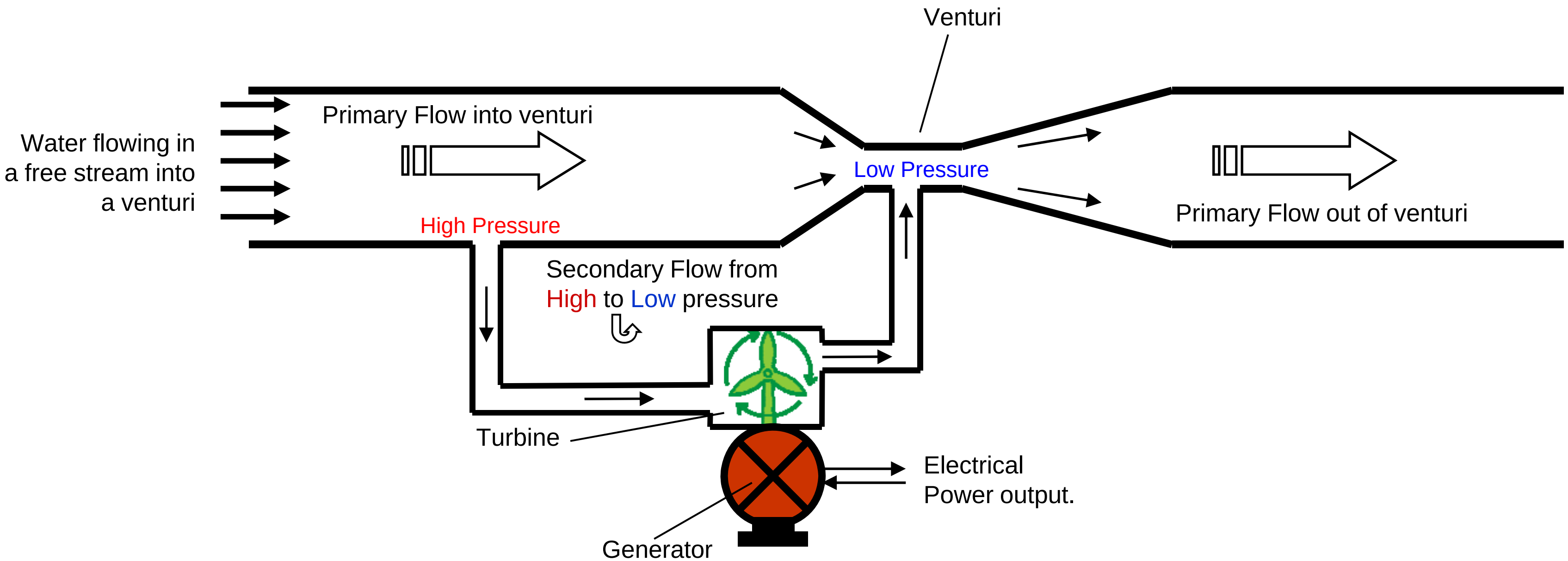
how SMEC works - Theory



- The pressure of water flowing through a venturi falls in accordance with Bernoulli's Theorem causing a head difference from the upstream flow.
- Useful work can be extracted from a turbine, driven by the head difference, placed in a Secondary Flow from upstream into the venturi.
- The head difference created across the turbine and the water velocity in the Secondary Flow can both be significantly higher than in other renewable energy devices.

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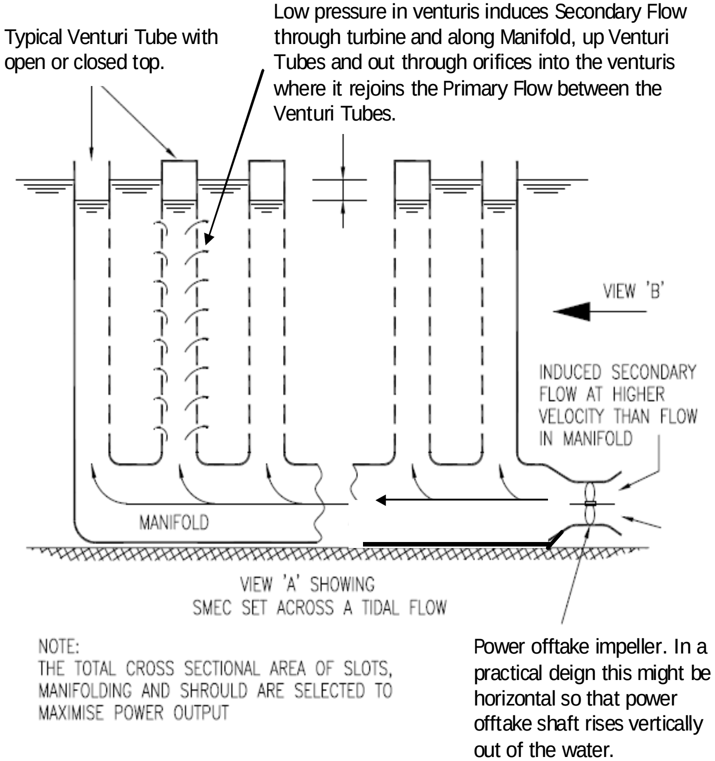
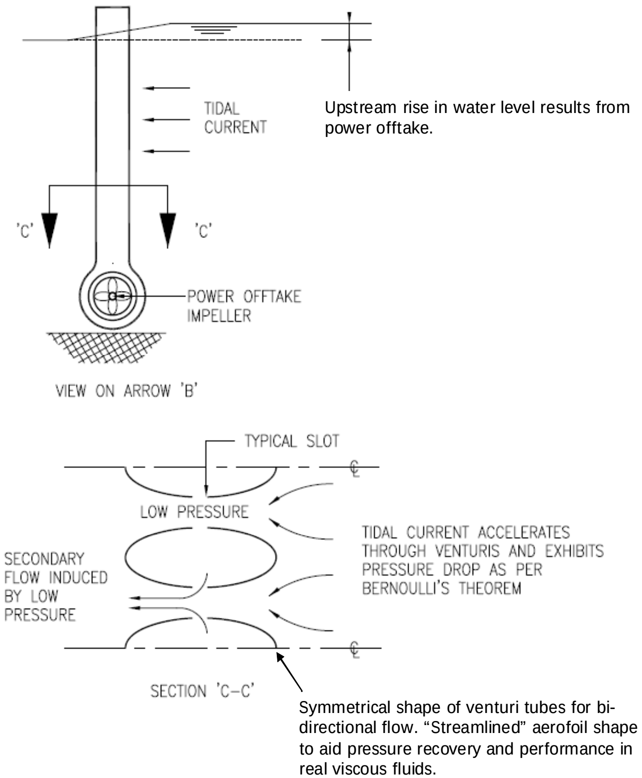
how SMEC works - Application

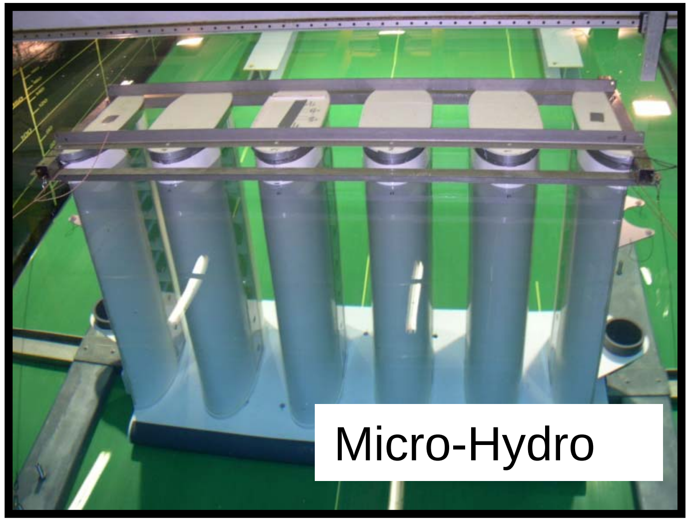


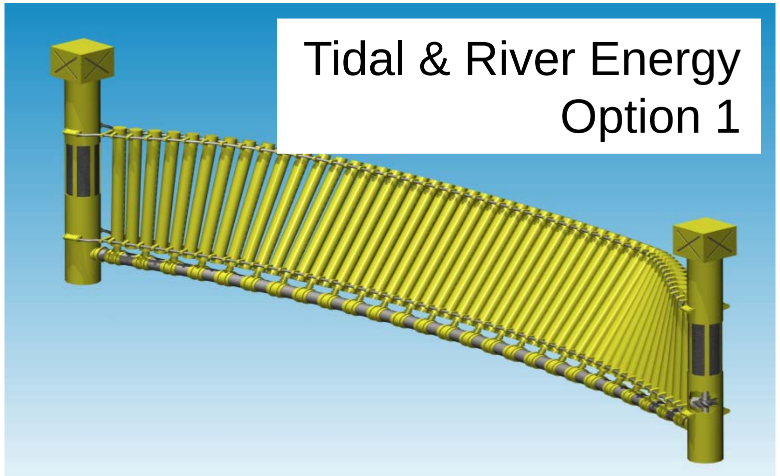


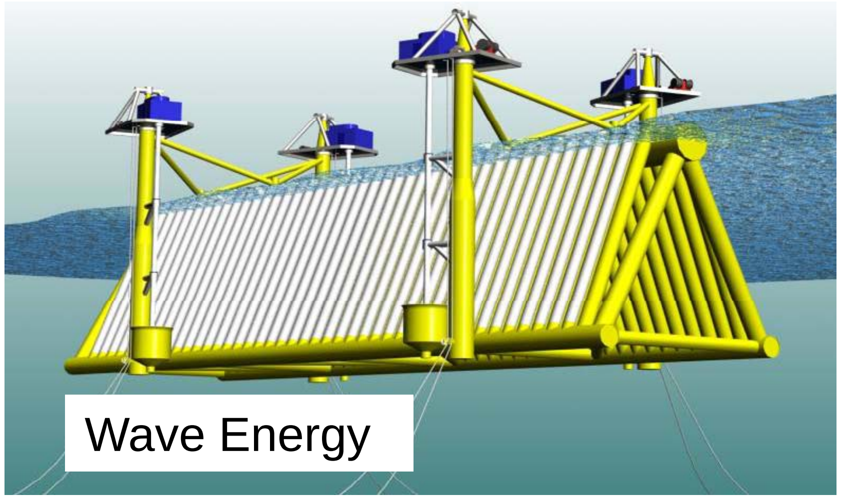
- SMEC concentrates the inaccessible energy of a large body of slow, low-head water into a smaller quantity of fast-moving, high-head water inside a manifold, from which useful energy can be extracted efficiently.
- SMEC is analogous to an electrical transformer which turns wasteful low-voltage high current power into useful high-voltage, low current power.

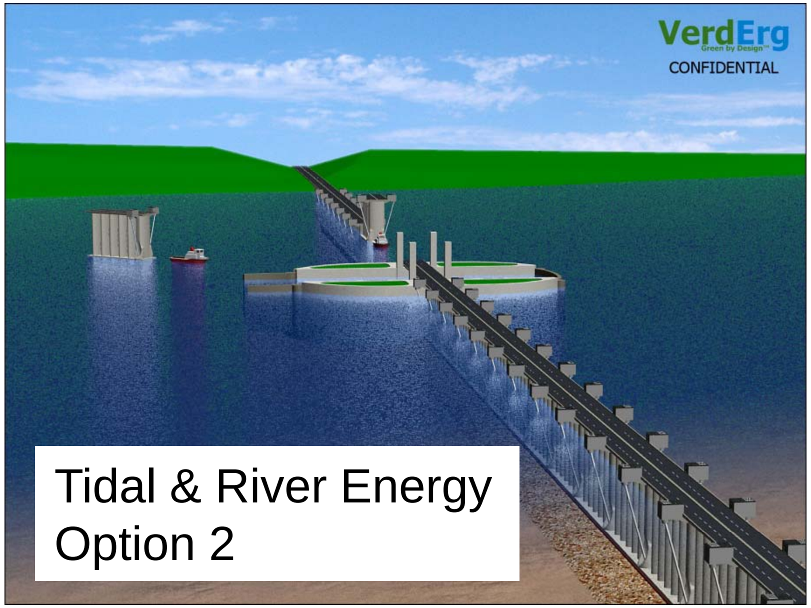
SMEC technology has 4 main applications.

Tidal and River energy applications have been chosen for initial development.









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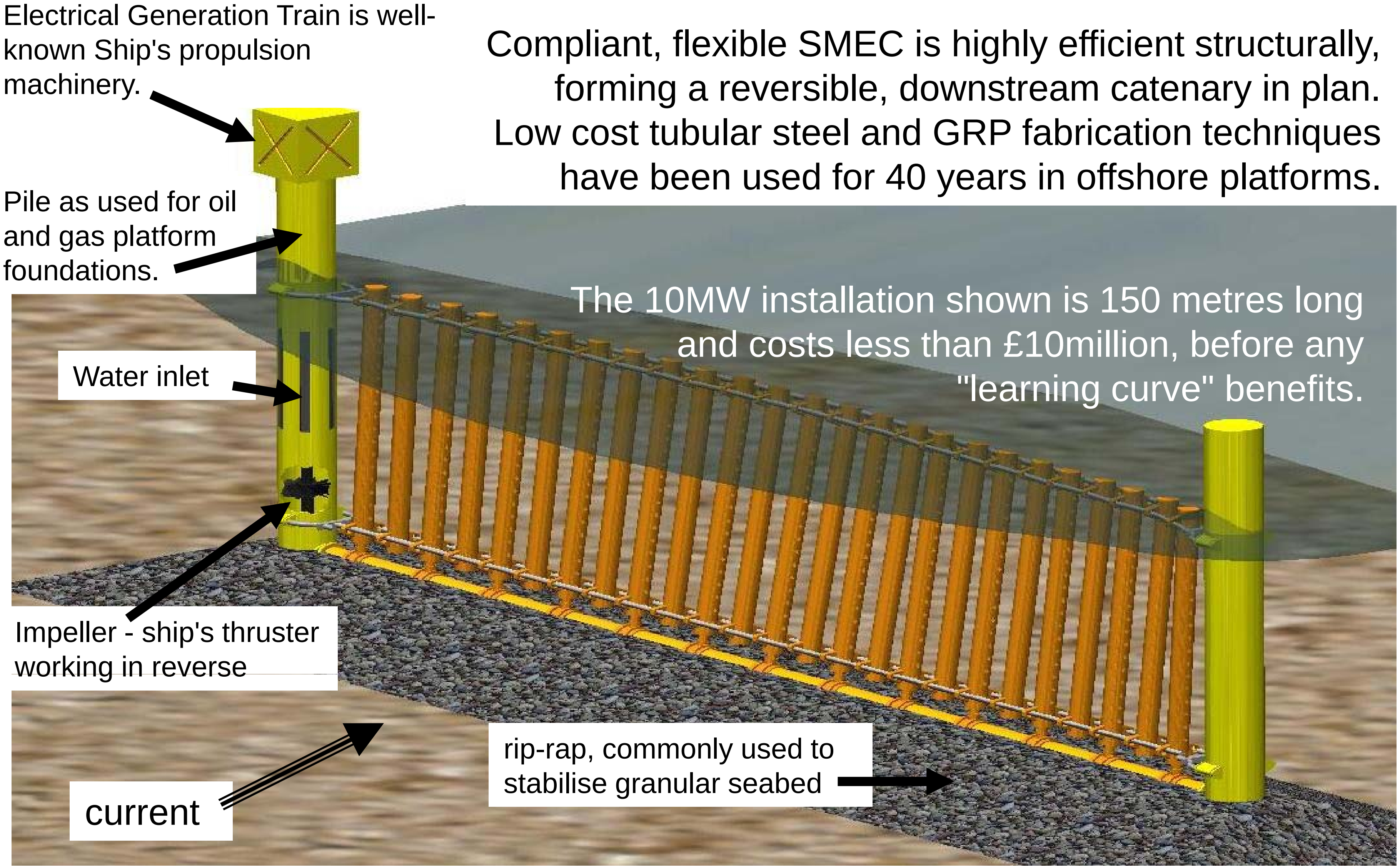
Option 1 – SMEC Tidal or River Fence – one module.

Compliant, flexible SMEC is highly efficient structurally, forming a reversible, downstream catenary in plan. Low cost tubular steel and GRP fabrication techniques have been used for 40 years in offshore platforms.



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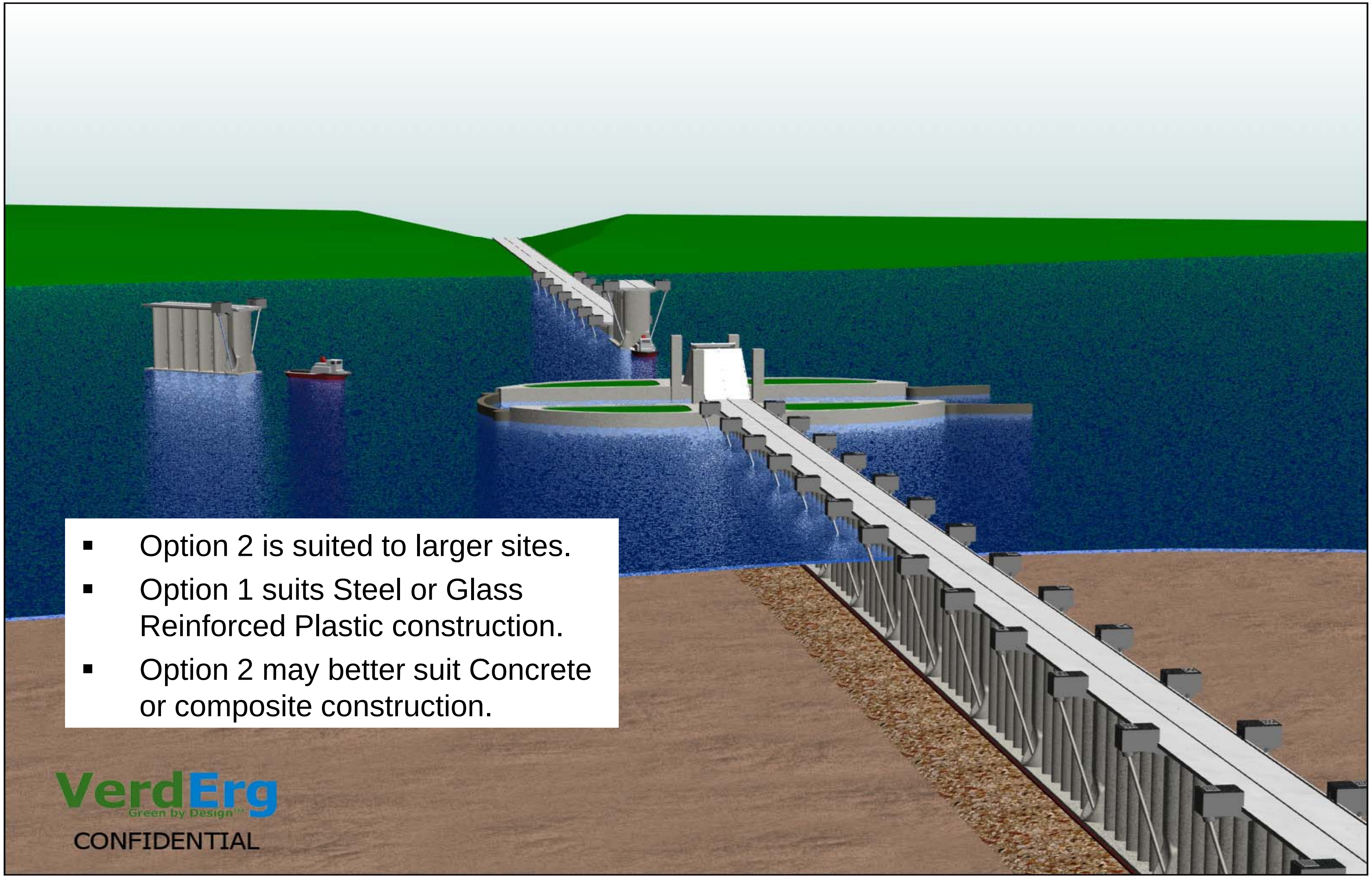
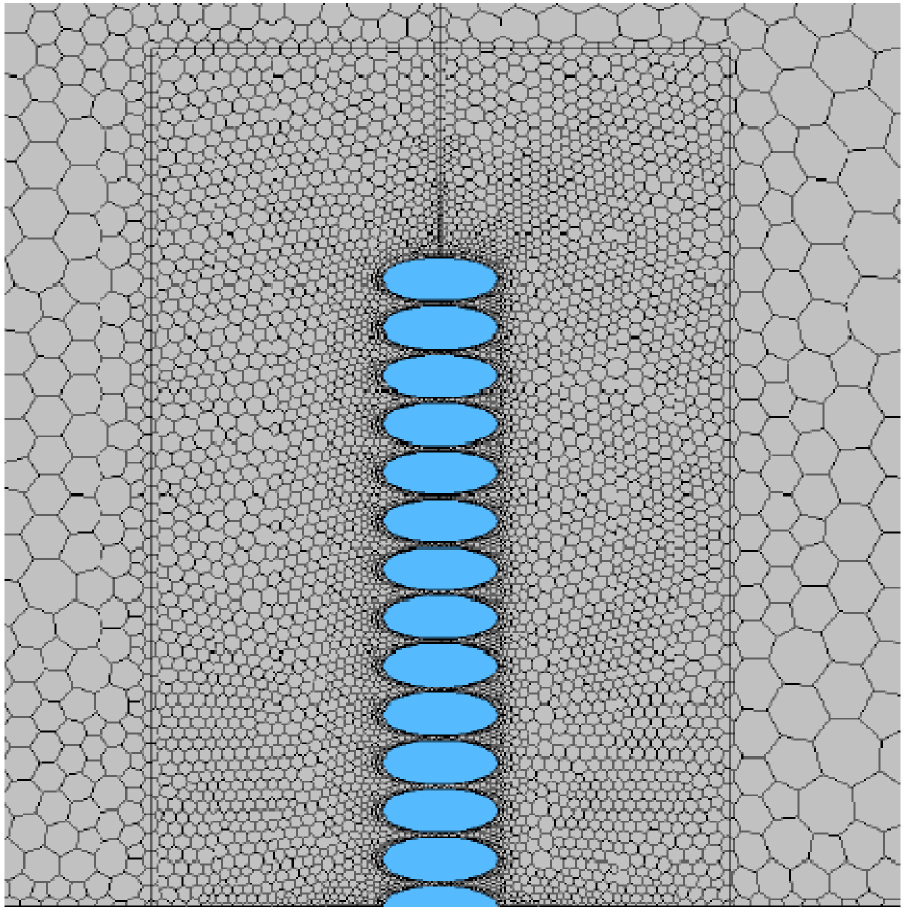
Option 2 – Large Tidal or River fence with Shipping Lock. Installation of a typical module shown.

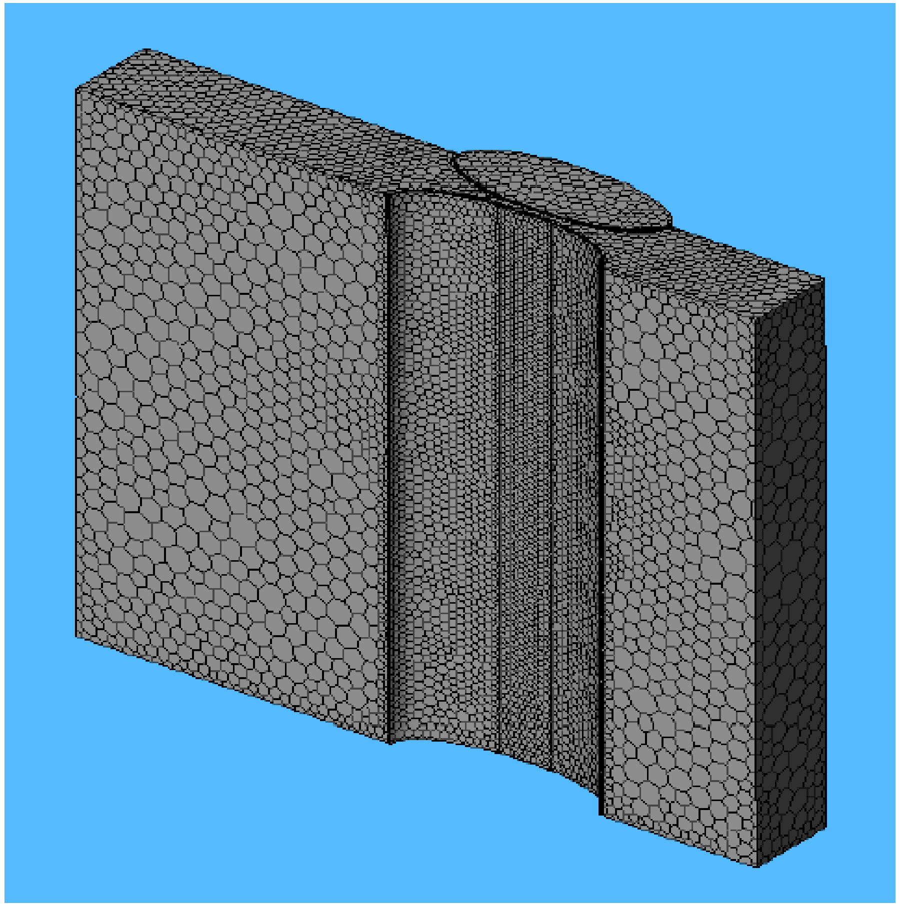


Phase 1. concept development

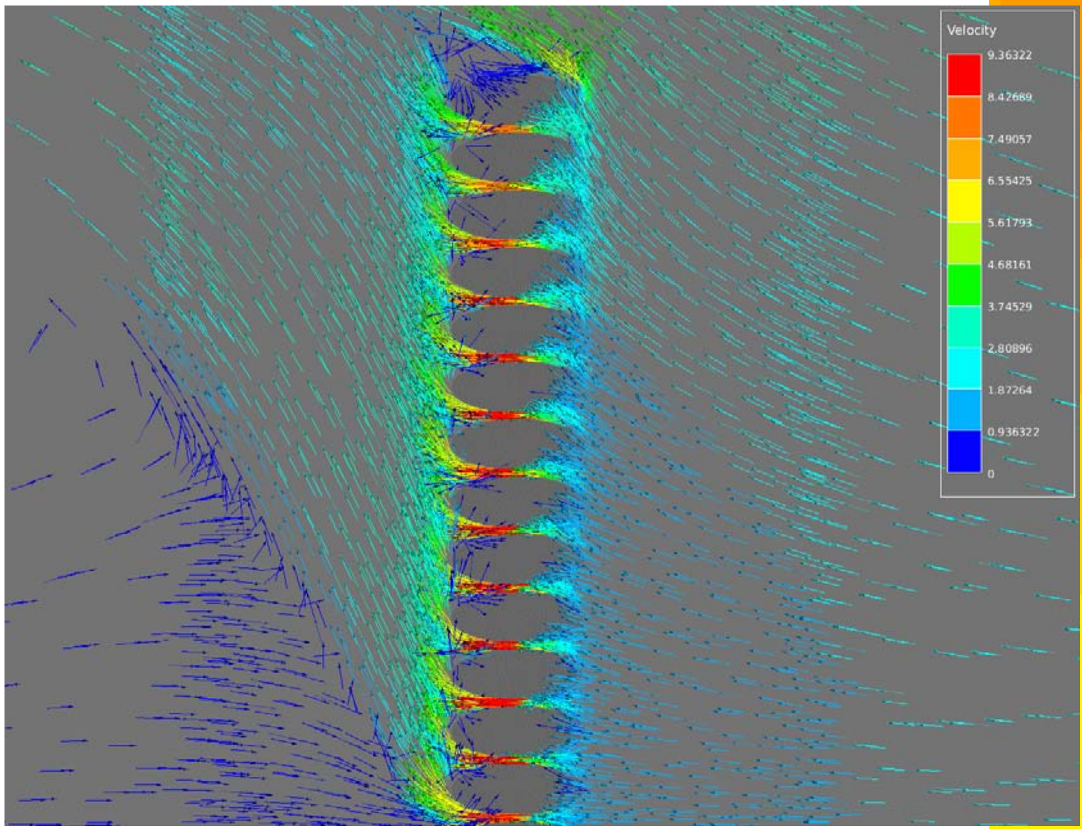
- Apply for general patent - focus on tidal design
- CFD (Computational Fluid Dynamics) model
- Predict economic performance
- Preliminary tank test at IFREMER (METRI II)
- Analyse test results
- Venturi tests
- Final tank tests
- Theoretical validation
- £400,000 sunk cost – limit of VerdErg spending

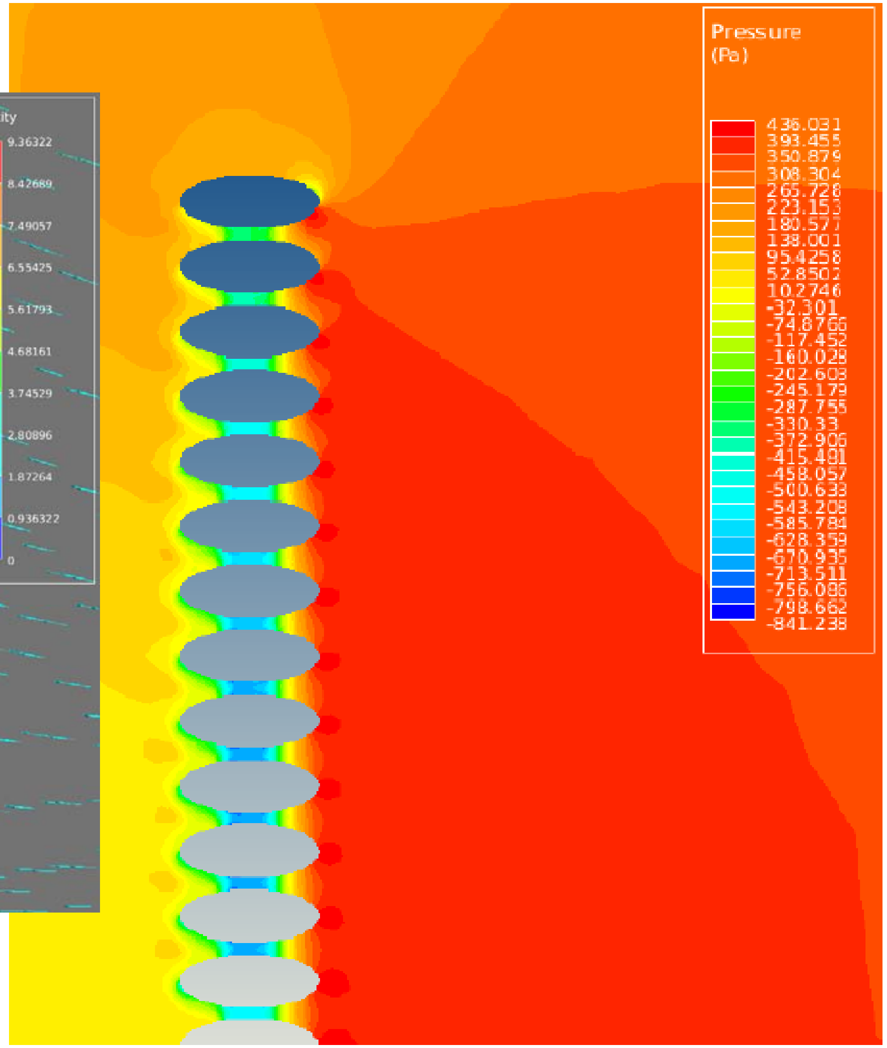
CFD models (CFD = Computational Fluid Dynamics)



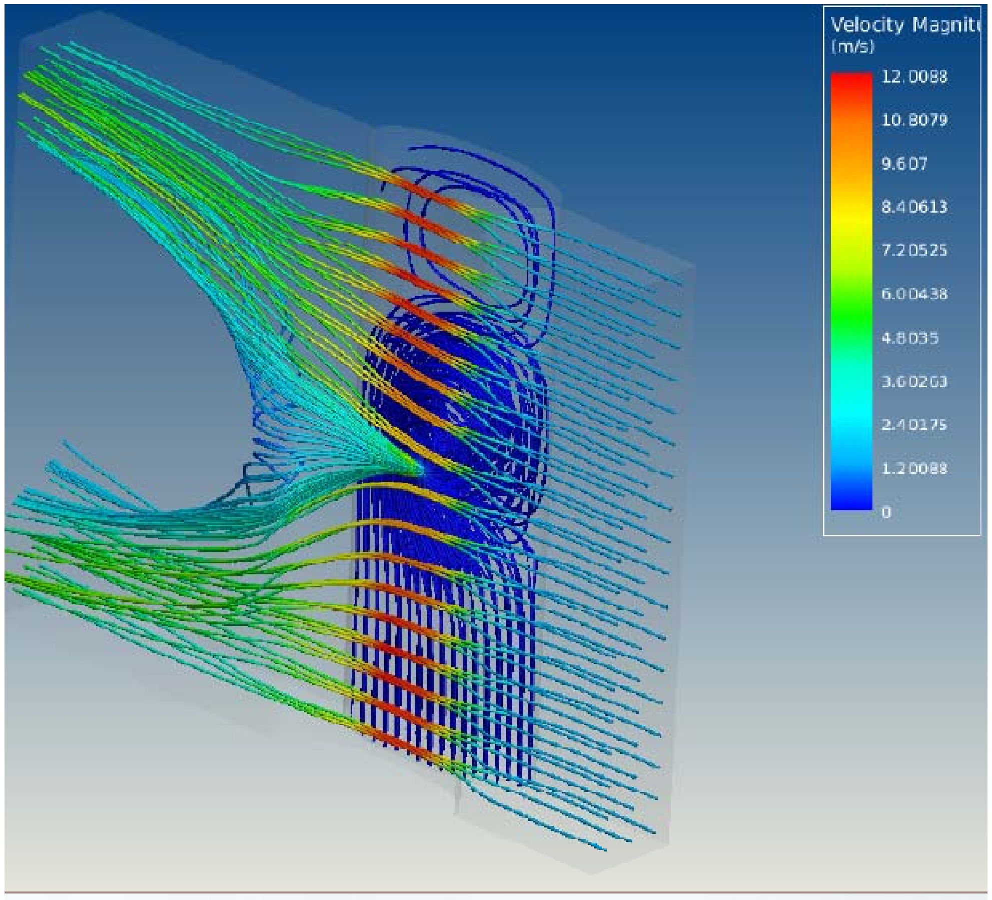


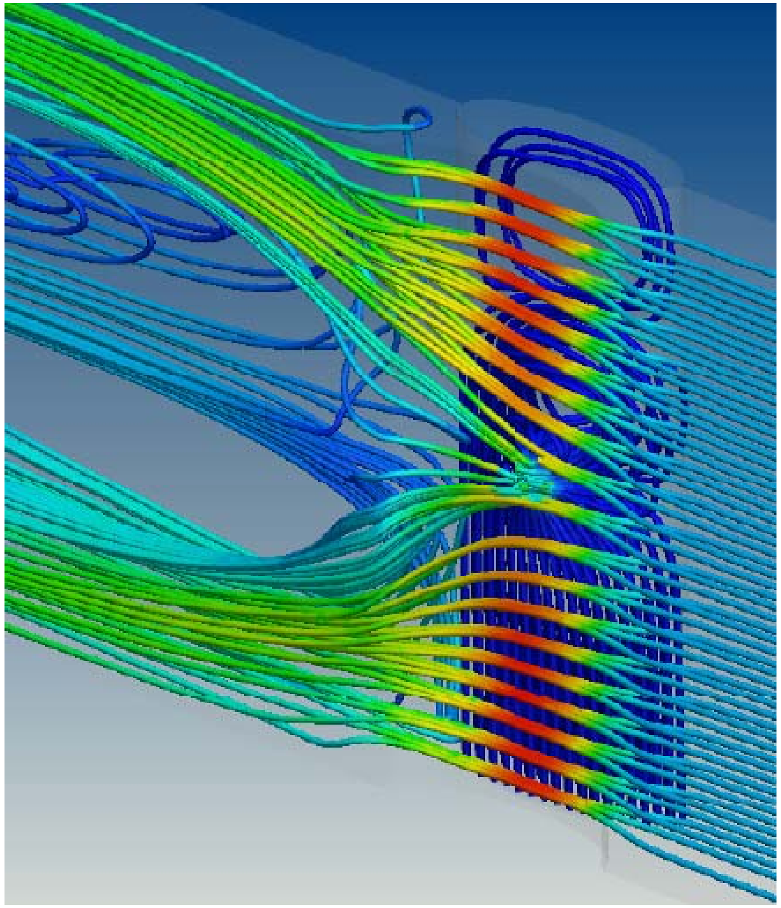
flow and pressure regimes





turbulent orifice flow





CFD model results

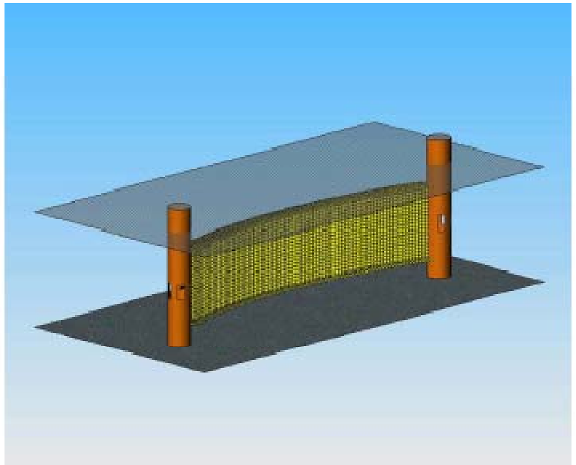


Figure 33 - foundation drawing of a 150m long 86 section 3400 venturi screen

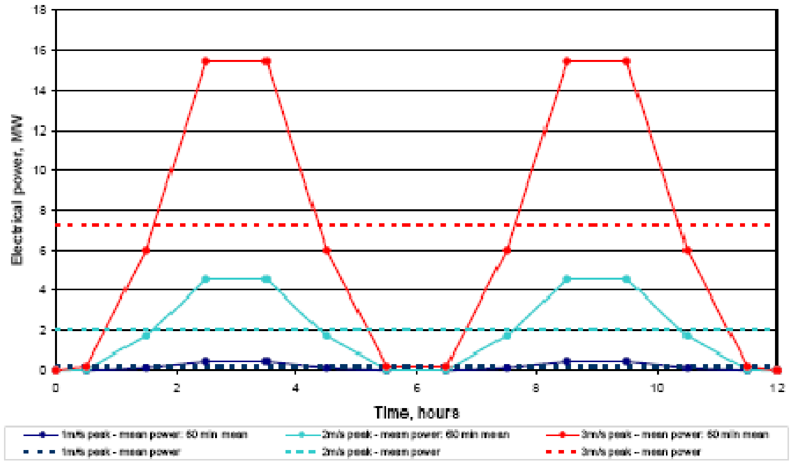


Figure 38 - case 3: power generation over three tidal cycles with peak flows of 1m/s, 2m/s and 3 m/s

	Peal tidal velocity	Peak velocity Speed in Knots	Mean Yield MW	Installed capacity KW	Tidal Yield MWh	Annual yield MWh	Life yield (25 yrs) GWh	Annual revenue @ £75/MWh
Case 3	1	1.94	0.2	500	2.4	1,752	43.8	£117,900
	2	3.88	2.09	4.750	25.08	18,308.4	457.71	£1,373,130
	3	5.83	7.22	16,000	86.64	63,247.2	1581.18	£4,743,540

Table 6 – electrical power generation, installed capacity and annual yield

SMEC - reliable, large scale, tidal and river flow renewable energy.

- VerdErg designed SMEC to be robust, simple, reliable and very large. The intent was to achieve low unit energy cost through practical features based on experience rather than through elegant hydrodynamics.
- SMEC features proven technologies, all currently used offshore.
- SMEC is simple to build, install, maintain and operate. The only moving part below water is a conventional impeller resembling a ship's propeller.
- SMEC delivers economies of scale - commercial and technical. The bigger it is the better it works, ideally intersecting the whole flow to avoid the "Betz Limit".
- Individual renewable energy devices located in a river or tidal flow can only access the Kinetic Energy in a small proportion of the cross-section of the flow. A SMEC across the whole cross-section of the flow will in practice take more energy from any given site than by installing an array of, for example, multiple free-stream turbines.

SMEC - high availability.

- SMEC is a scalable technology, not a device. A SMEC can be designed to suit a wide variety of site locations.
- SMEC, uniquely, is a zero to very low-head hydro-energy conversion technology. Suitable sites are commonly found in most coastal and many inland river locations.
- SMEC is bi-directional and delivers predictable power levels on both ebb and flow tides.
- Barrages need a high tidal range and tidal turbines need high currents to work properly. SMEC only needs a high volumetric flow rate, more frequently found, which lets SMEC be sited closer to grid and population centres than other marine renewable energy devices.
- SMEC is initially proposed for river and tidal flows, but with possible later application in waves, micro-hydro applications and subsea.

SMEC typically delivers electrical power for 6 -12p/kWh, even at present development status.

SMEC technology provides large scale, low unit cost renewable energy with high reliability and availability, using simple and conventional components. Additionally:

- There is an existing Supply Chain for every feature of SMEC's design, fabrication, operation and maintenance ensuring competitive procurement and manufacturing capacity.
- In a conventional barrage, all the water has to flow through inefficient low-head turbines to extract energy. With SMEC, the high-energy secondary flow induced by the primary flow through the "Venturi Pump" has a high head drop and high velocity, enabling large-scale power offtake from relatively few, high-efficiency Kaplan turbines (resembling ship's CP propellers, working in reverse.)
- A conventional barrage has to structurally withstand the maximum tidal range. A SMEC of equivalent capacity is porous, only resisting a low differential head, making it much lighter and cheaper to build.

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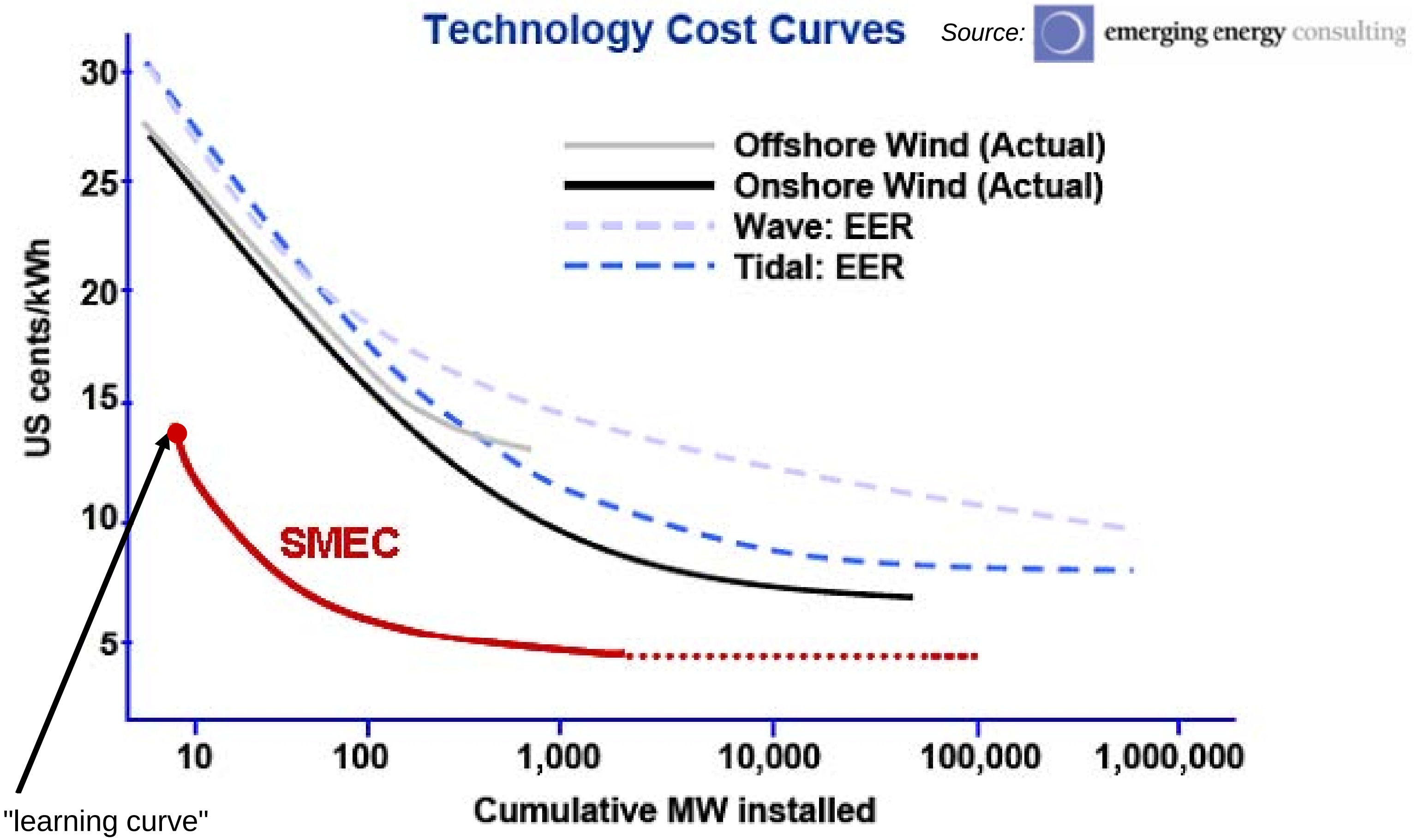
SMEC – possible future cost advantages



SMEC "learning curve" extrapolated from auditable prototype performance estimate.

After further development, reductions in the cost of power from a SMEC should occur, perhaps to challenge fossil fuels directly.

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SMEC will have less environmental impact than other forms of renewable marine energy.

- A conventional barrage generally lets the rising tide flow freely through sluices then traps it upstream and lets it out through the turbines during the falling downstream tide, until the rising incoming level of the next tide equals the falling upstream reservoir level. The result is that much of the intertidal upstream wetland used by migratory birds is permanently flooded. SMEC is porous and preserves the tidal cycle which in turn preserves this vital habitat for migratory bird populations.
- The key factor in SMEC design is the "blockage ratio". When the venturi tubes are large, the gap between them is also large and can be sized to permit the largest local fish and marine mammals to pass through.
- SMEC is smaller and lighter than equivalent devices and easier to de-commission completely.
- SMEC can be located in areas of moderate tidal range and current velocity so considerable freedom is available to site SMEC installations away from environmentally sensitive areas, and shipping lanes.
- It is possible to design SMECs that also act as flood defences.

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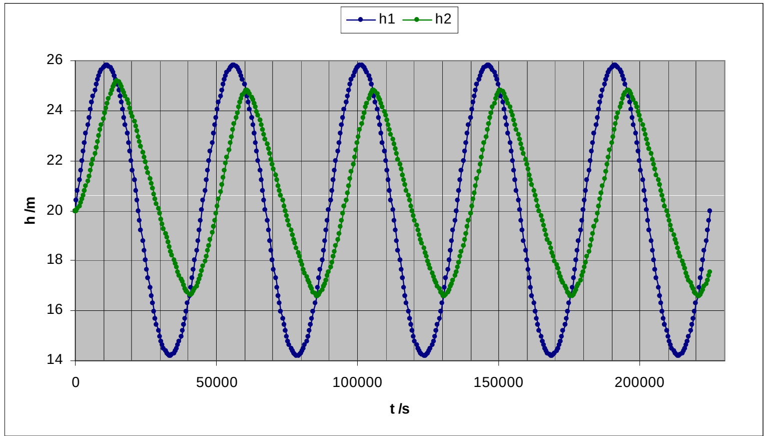
Case Study:
SMEC tidal fence across the Severn Estuary.

Attractive energy quantity at low cost with minimal environmental impact.

Criterion		
Option Variant	**Option 1**	**Option 2**
Annual Energy Output (TWh)	13.74TWh	13.74TWh
Total Capacity	1.57GW average 6.3GW installed	1.57GW average 6.3GW installed
Cost per Unit Energy (p/kWh): using 15% Discount Rate	7.83	12.39
CAPITAL COST (£bn)	6.5	9.9

Intertidal Area (ha)	No Barrier	Conventional Barrage	SMEC Tidal Fence (either option).
Spring tides	**18,898**	**4,469**	**14,232**
Neap tides	**9,881**	**4,039**	**7,217**

Blue - downstream Spring Tides Green - upstream



Device installed across River Severn	High Tide Sea Side (m)	High Tide Land side (m)	Low Tide Sea Side (m)	Low Tide Land side (m)
None	+5.8	+5.8	-5.8	-5.8
Conventional Barrage	+5.2	+5.2	-5.6	+0.44
SMEC	+5.8	+4.8	-5.8	-3.4

DECC report in December 2008 quotes for conventional barrage across the Severn Estuary an annual output of 16.8TWh/y at 27p/kWh for a CAPEX of £18.3bn. So:

- SMEC generates power at between **29% to 46%** of the cost/kWh, with an output of at least 80% and a CAPEX between **36% to 54%** of the conventional barrage.
- SMEC **preserves over 75%** of the intertidal mud flats. An equivalent conventional barrage permanently **floods over 75%** of this vital habitat for migrating birds.

what we need to commercialise SMEC:

MILESTONES

Phase 2a: Design Refinement – confirm inputs.

10 weeks

- Business model analysis and tidal application confirmation.
- Selective tank testing of a full scale section (typically 2 to 3 tubes).
- **£125,000** cost estimate. * 50% Public Funding obtained from SETS

De-risking

Phase 2b: Design Refinement – key details and risk assessment.

15 weeks

- Preliminary design: Foundations, Structural and Venturi Orifice optimization, Impeller, Generator and Power Offtake.
- Set up Risk Matrix: HAZID & FMECA: Wave tank test Phase 1 model.
- Recalculate costs & economics.
- **£75,000** cost estimate. * 50% Public Funding obtained from SETS

De-risking

2010

Phase 2c: Commercial Demonstrator

20 weeks

- Full scale test of a section of a SMEC module in the sea, generating power.
- **£2,500,000** cost estimate. *Possible partial Public Funding - TSB, ETF, EIT

Experience base

Power fee offsets

Phase 3: First Fully Commercial Operation

1 year

2 years

- Detailed design of prototype.
- Update Risk Matrix and mitigations.
- Check economics before CAPEX commitment.
- Manage manufacture of prototype at various sites.
- Assemble SMEC (possibly at VerdErg's Test & Assembly premises).
- Install prototype at test location.
- Prototype test program.
- **£10,000,000** cost estimate. *Possible partial Public Funding - ROCs

Power fee offsets

2013

Commercialised

Note: the Phase 3 prototype is intended to sell electrical power on a commercial basis.