Marine Current Turbines: an update

Peter Fraenkel - Technical Director - MCT Ltd

© Marine Current Turbines Ltd, 2007
The Court, The Green,
Stoke Gifford, Bristol BS34 8PD, UK.
www.marineturbines.com
MCT’s Progress

1993: DTI Tidal Stream Review pessimistic results: DTI relegates sector to “watching brief” status

1994-5: MCT’s parent develops World’s first tidal turbine - 10kW - tested on Loch Linnhe at Corran Narrows

2000: MCT formed as independent entity and lobbies DTI

2001: DTI agrees to support Tidal Stream following positive findings of consultant's review of MCT Seagen Concept

2003-7: MCT installs and tests Seaflow, 300kW experimental test rig 3km off Lynmouth in Bristol Channel

2007: MCT designs, builds and is ready to install 1.2MW Seagen Commercial Demonstrator in Strangford Narrows

2007: MCT starts work on 10MW Seagen Array project
Background: 15kW Tidal Current Turbine (1994-5)

PROOF OF CONCEPT PROJECT
(IT Power. Scottish Nuclear & NEL)
Loch Linnhe, Scotland

World’s first tidal current turbine
Seaflow installed
30 May 2003
rotor dia. 11m
rated power 300kW
pile dia. 2.1m
water depth 24m ± 5m

operational
raised for access
Seaflow: what has ‘worked’

the basic concept

- Axial flow rotor
- Marinised drive train
- Surface breaking monopile
- Structural integrity
- Low cost intervention
- No significant environmental impact
SeaGen Prototype

Some key features:-

◆ 2 x 600kW rotors: 16m diameter
◆ installed on steel pile
◆ rotors and nacelles raised above sea level for maintenance
◆ transformer and electrical connection to grid in accessible and visible housing at top of pile
◆ deployment in arrays or “farms”. of hundreds of turbines
Assembly at H&W - cross arm (above) pile (below)
Gearbox, hub and generator
Marine Current Turbines™ Ltd

Rotor blades - carbon/glass epoxy composite

Fully optimised geometry - expected free-stream $C_p > 0.45$
Marine Current Turbines™ Ltd

Rotor assembly at H&W - 16m diameter - 600kW
Both 600kW rotors test-assembled at H&W Belfast
Seagen - complete and ready for installation at Harland & Wolff, Belfast - April 2007
SeaGen 1.2MW Commercial Demonstrator

- soon to be tested in Strangford Narrows, NI
- will be used as testbed for SeaGen technology
- will have continuous environmental monitoring
- mean max current 7.8kt
  water depth 25m ± 2m
Seacore Jackup-rig Excalibur visits Strangford 16-19 April 2005, to complete SeaGen geotechnical survey
Key Project Costs - short-term cost trend

Note £1 ≅ Euro 1.50 (or US$ 1.9)

- **2003**: £4340/kW for Seaflow 0.3MW
- **2007**: £2830/kW for SeaGen 1MW
- **2009**: £1900/kW for SeaGen Array 10MW

Bar chart showing installed unit costs (£/kW) for different projects and years, with grid connection, installation costs, and manufacturing costs indicated.
<table>
<thead>
<tr>
<th>Location</th>
<th>Rated Power (MW)</th>
<th>Capital cost (£k/MW)</th>
<th>Life Cycle Unit cost (p/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strangford</td>
<td>1.2</td>
<td>5,191</td>
<td>16.8</td>
</tr>
<tr>
<td>Anglesey Skerries demo</td>
<td>10.5</td>
<td>2,537</td>
<td>11.7</td>
</tr>
<tr>
<td>Anglesey Skerries Commercial</td>
<td>51.0</td>
<td>1,489</td>
<td>7.9</td>
</tr>
<tr>
<td>Anglesey Skerries if developed fully (after 500MW installed)</td>
<td>30.0</td>
<td>923</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Cost projections from due diligence report by Black & Veatch in an independent assessment
Driving down costs

Note 1p = £0.01 ≅ Euro 1.5c

1st Generation MCT technology

Electricity Cost (p/kWh)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>R&amp;D Phase 1</td>
</tr>
<tr>
<td>B</td>
<td>R&amp;D Phase 2</td>
</tr>
<tr>
<td>C</td>
<td>R&amp;D Phase 3</td>
</tr>
<tr>
<td>D</td>
<td>Project #1 15MW</td>
</tr>
<tr>
<td>E</td>
<td>Project #2 50MW</td>
</tr>
<tr>
<td>F</td>
<td>Project #3 150MW</td>
</tr>
<tr>
<td>G</td>
<td>Project #4 500MW</td>
</tr>
</tbody>
</table>

- A: 18
- B: 16
- C: 14
- D: 12
- E: 10
- F: 8
- G: 6

2005 2006 2007 2008 2009 2010 2011 2012

competitors 2003 costs
- Biomass
- Off-shore Wind
- Nuclear
- On-shore Wind
- CCGT

Improved 1st Generation MCT

?
Niche Market? Turbine Bridge
Route towards Second Generation Technology

1. develop a reliable power unit based on Seagen

2. Scale it up and down within reasonable limits

<table>
<thead>
<tr>
<th>Diameter (ft)</th>
<th>Rating (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>110</td>
</tr>
<tr>
<td>12</td>
<td>270</td>
</tr>
<tr>
<td>16</td>
<td>525</td>
</tr>
<tr>
<td>20</td>
<td>880</td>
</tr>
<tr>
<td>24</td>
<td>1350</td>
</tr>
</tbody>
</table>

3. Deploy suitably sized array of rotors across current

6 rotors of 8m dia give rating of 0.66MW

…but we need to develop a suitable structure to hold them
MCT 2nd Generation - horizontal array structure
Comparisons:
how many kW per tonne of equipment?

MCT Seaflow tidal turbine ~ 2.3 kWe per tonne
130t & 300kWe

MCT Seagen prototype ~ 3.1 kWe per tonne
390t & 1200kWe

Vestas V80 windturbine offshore at North Hoyle
~ 3.4 kWe per tonne
590t & 2000kWe

MCT 2nd Gen Technology ~ 4.5 kWe per tonne
1100t & 5000kWe
world leader in tidal turbine development

Marine Current Turbines Ltd
http://www.marineturbines.com
tel: (+44 or 0) 117 979 1888