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PMEC Cost Calculation Report - Newport

Stuart Baird & John Griffiths

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1. Introduction

The site that the PMEC test centre will be installed is at Newport as it is a geographically well suited location that had both economical and social advantages to the local area.

The cost of procuring and installing sufficient infrastructure required to support a WEC test site was calculated in detail. This includes offshore subsea cables and substation and visitor centre as required. The methodology of calculating the costs for these stages is explained in this report, along with any assumptions or allowances that were deemed necessary.

The offshore distance that would be required is up to a water depth of 50m. The distance to this depth at Newport is 11.1km out to sea. The buildings are on a sandy location and, as stated by the Feasibility Study the ground may need improvement and or the buildings may need to rest on piles.

No allowance has been made for decorative external walls, roofing or surroundings to the facilities as EMEC has not been provided with any specifications for these things which are all matters for detailed planning permission.

2. Method of Estimating

Cables can be purchased by international competitive tender and can be sourced from Korea, Japan or possibly in USA, South America or Europe.

Cable capex was calculated based on prices submitted to EMEC for past cable purchases. Cable transportation was assumed to be by freighter to a US port (San Francisco) to be picked up by the cable lay vessel - assuming a Vancouver base. Global Marine seem to keep a suitable vessel in the area. A day rate has been assumed based on UK experience. Other aspects of cable lay such as the pull ashore, connection to onshore cables and the onshore cable runs are based on EMEC experience. Contingencies will be added as this is an ''un-engineered'' estimate. The estimate should be revised by carrying out at least basic engineering of the facilities and the contingerncies revised as necessary.

At the Newport site, a Visitor Centre and a Substation is required. A floor plan for the outline of these buildings was designed including external and internal walls as well as and doors. In addition an outside layout of roadway, turning area, parking and equipment laydown has been included. All of the equipment, civils and facilities for this design had their cost calculated using www.get-a-quote.net (this provides labour, equipment and material costs specfic to Oregon at 2013 prices).

A contingency factor was also calculated for the various items. This was for a number of reasons:

- Prices may vary from those of Get-a-quote.net
- To allow for items that may have been omitted from the estimate.
- To allow for the approximate nature of the measurements of sizes and distances.

More details of these contingencies can be found in Section 5.

Land within the fence line that was not used for building or road ways was assumed covered by a crushed rock finish.

Table 2 (below) summarises the main groups of cost for onshore and offshore supply and services from the estimate.

2. Summary of Results

Newport **Case Item**	**Cost $**	**Contingency added %**
Visitor Centre Structure (e.g. walls, doors, roof)	176,542	15
Visitor Centre and Fit out (e.g. electricity, CCTV)	77,113	15
Visitor Centre Facilities (e.g. furniture, fittings)	39,224	15
Substation Building structure (e.g. walls, doors, roof)	70,517	15
Substation equipment and bulks (e.g. power cables, lighting)	349,842	15
External areas (e.g. civils landscaping, roads, trenching)	72,902	15
Onshore overheads (e.g. engineering and mobilisation)	172,101	10
General overheads Onshore (e.g. insurance and corporate profit and overheads)	156,353	-
Ground Improvement	482,152	30
Total Onshore cost (incl. contingency)	2,014,897	16.4 incl.
Offshore works cost (incl. contingency)	11,668,800	11
Offshore overheads (e.g. insurance and engineering etc.) included in the above total.	1,114,541	10
TOTAL ESTIMATED COST ($)	**15,636,224**	5

Table 1 - Summary of offshore and onshore infrastructure costs

Having estimated material, labour plant and services costs, various overheads have been added that would normally be incurred by a contractor. These include project management and engineering, using factors that are similar to EMEC's experience; insurance – much greater for offshore than onshore and an allowance for corporate overghead and profit. The uncertainties here, covered by the contingency, include differences between UK and US contract pricing methods.

It should be noted that offshore contingency has been allowed in the estimate partly as waiting-on-weather (WoW) and partly as additional cable cost, which reduces the contingency added overall. The sum of these contingencies and the for the offshore work is close to 20% of the total offshore costs.

Allowance has been made to order 5% more cable than the stated lengths as well as adding an overall 5% contingency to the total of on and offshore costs.

Total contingency allowance for Newport: $1.88 million

3. Cable Design

The best suited cable size was worked out by establishing what was the smallest cable size that could be used within an acceptable level (3%) voltage drop. This was to reduce power losses as far as practicable.

The voltage drops for the three different voltages (6600V, 1100V and 3300V) were calculated for the length of cable. The formula employed was

volt drop = Sqrt3*I*L*[AC resistance*Power Factor + AC reactance*Sin^{-1}(PF)]

where: I is the current (Amps); L is the cable length (km); AC resistance from tables; Power Factor taken as 0.95 which gives the Sin of the lag angle to be 0.3122.

Should the voltage drop fall within 4% of the total voltage of the cable then this was deemed an acceptable drop and therefore that size of cable and voltage level could be considered for the site. Should the voltage drop be much greater that 4%, this was deemed not suitable for the site. Below is a summary table the minimum 6.6kV cable size and voltage that was considered appropriate for this site.

	Location	**Newport**
	Length by PMEC (km)	11.13
6.6kv	Conductor size (mm^2)	150
	Total Capacity (MW)	1.004

Table 2 - Summary of cable conductor size for the Newport PMEC location.

For further information on these calculations see the PMEC Conceptual Guide Report.

Cable prices were determined by updating past bids to EMEC for cable to 2013 prices to provide benchmarks. EMEC's previous graphs of cost v cable conductor size for 3 core armoured cables were adjusted to meet the benchmarks.

The price of copper was taken from the London metal exchange on Feb 20th 2013 at $8215/t and a differential calculated against the price at the time of the quotes. The cost of copper/m for each conductor size (from 50mm2 to 630 mm2) has been calculated.

The cost for both onshore and offshore cables was calculated and applied to Newport to find a total cost. Onshore over head cables are quoted as $50k dollars per kilometer[1]. A cost double this would need to be used throughout the calculations in this paper if the onshore link to the grid was to be by underground cable. An 6.6kV/33kV transformer has been included to supply the link.

This was incase of a drastically uneven surface under the sea that was not known about before, or in case of spare cable needed. A summary table of these costs can be seen in the next section.

11kV was chosen by EMEC as the standard operating voltage. It is EMEC's experience that technology developers do operate at lower voltages (eg 6.6kV) which is why those costs have been noted in the estimate. This is a matter to be discussed with the potential client developers and an allowance for a significant price increase made in the project estimate if it seems necessary.

Cable Procurement and Installation

The case for procuement and installation includes, single cables to each of four berths and a single larger cable (70-150mm2 conductors) connecting to a passive subsea hub with tails of 50mm2 conductor size to the four berth positions.

Note that onshore cable link to the grid has been included with the offshore cable procurement estimate.

No account has been taken of charges that may be levied by the district grid network operator and any such costs should be added to the estimate as a separate item.

The tables below summarise the costs for offshore cables purchase , transportation and installation together with the procurement and installation of the onshore link to the grid

[1] Hyline Engineering. http://www.woodpoles.org/documents/MARA.pdf

Procurement

	Unit Cost ($000)	Length (km)	No Of	Total Cost ($000)	Remarks
Single cables (150mm2 conductors)	235	11.69	4	9461	Includes 5% contingency
Cable joints	60	-	4	240	Hub calculated from 4 way hub and cost scaled to 50% size
Grid Cable to 115kV substation	50	1.34	1	67	Based on distances in feasibility study +5% for 33kV cables
Transformer 11/33kV	68		1	68	
Subtotal Procurement				**9836.6**	

Freight cost for cables

	Unit Cost ($000)	Usage t/day	No Off	Total Cost ($000)	Remarks
Freighter hire	9	-	12	108	Assumes 5000t freighter using 7.5t/d fuel
Fuel (cost/t)	0.7	7.5	12	63	Assumes Intermediate Fuel Oil at $700/t
Subtotal Freight				**266.3**	

Offshore Installation

	Unit Cost ($000)	Usage t/day	No Of	Total Cost ($000)	Remarks
Cable-Lay vessel hire mob/demob	95	-	12	9000	Based on Global Marine 'Pacific Guardian' and Vancouver base mob to San Francisco
Fuel (cost/t)	0.7	12.5	12	105	From vessel spec.
Port Dues	5		3	15	Allowance
Cable-Lay vessel operations	95	-	6	570	Assumes 2 days dry runs and 2 days lay
Fuel	0.7	12.5	6	52.5	From vessel spec
Cable-Lay vessel WoW	97	-	3	291	Assumes anchored in sheltered location (fuel 3t/d)
Subtotal Cable Lay				**1551**	

Onshore

	Unit Cost ($000)	Usage t/day	No Of	Total Cost ($000)	Remarks
Set-up for pull ashore				40	Allowance
Onshore Crew	3		7	21	Four labour and supervisor
Trenching/backfill up beach (labour)	10	0.3	1	3	Assume 200m above high water and 100m from low water mark
Cables into trench (200m)	2	0.3	4	2.4	
Connections 4 cables (in pit)	1.6		8	12.8	4 cable ends 3 core plus fibre connections 2 days per connection for 2 man crew
Connections 4 cables (to switchgear)	1.2		6	7.2	4 cable ends 3 core plus fibre connections 1.5 days per connection for 2 man crew
Misc tools etc	0.01		680	6.8	At $10/manhour assuming 10hr days
Misc transport	0.3		10	3	Van
Plant hire	0.8		5	4	Excavator
Crane hire	1		10	10	Small mobile crane
Subtotal Onshore				**110.2**	

TOTAL COST ($000)=$11,668.8

Table 3 - – Build Costs

4. Summaries of cost of cables at site

Costs for the site allows for the minimum acceptable size of cable conductor and this does include the cost of the hubs and the onshore link to the local 115kV substation. Note there is no offshore installation cost in this comparison.

Option	$ (millions)	Remarks
4 Single 11kv	7.079	with onshore link
4 Single 6.6kv	9.837	with onshore link
2 doubles with 2 tails each	10.628	with onshore link

Table 4 – Cable Configuration Costs
(All figures in $millions. Onshore, Offshore and joint cost only)

5. Contingencies

Different percentages were applied for different purposes. The overall contingency of this estimation is under 20% .

Contingencies requierd for cable length (in this case 5% has been added on). The distance onshore between the sites ranges from as low as 25m and as much as 1600 m from high water mark to the proposed substation location.

Below is a table of the contingency allowances that have been quantifed and added onto the total cost of the project:

Reason	Allowance	Remarks
Procurement	5%	This for the purchase of cable length. Estimate taken from feasibility study but cannot be certain of length accuracies and therefore an extra 5% cable should be procured.
Freight	10%	Locations and distances required for freight hire are not certain or fixed within this report and therefore a contingency is required.
Installation (Waiting on weather)	3 days vessel hire	High uncertainty of offshore environment. Allowance of three days for bad weather. It has also been assumed that the vessel will be anchored in a sheltered location to use minimum fuel.
Onshore	16.4%	Allowances are required in case of uncertain labour costs or equipment costs. The estimate has not been engineered.

Table 5 - Contingencies quantified and explained

6. Substation Ground Improvement

An assumption has been made for the substation being located 200m from high water mark. The ground which is sand, requires stabilising in order to support the structure of the substation and visitor centre. It has been assumed that the buildings will stand on piles and the ground for vehicular movements and equipment laydown will be improved.

Ground preparation and piling

The assumptions made here are that the substation and ground preparations have taken place on the beach within 200m of the high water mark. The ground here would require improvement and the buildings need to rest on piles in order to be structurally sound. It is assumed that the ground at this site is sand based and therefore ground reinforcement will have to be factored in to cost calculations.

	Cost $000	**Contingency %**
Total Additional Civils	360	
Over heads e.g. engineering, management	176	
Total (including contingencies)	145	30

Table 6 - Ground preparation and piling additional costs (Additional to costs of buildings and site)

7. Conclusions

1. The total estimated cost of the Newport site is $ 15.636 million.
2. A summary of the cost breakdown for the Newport site can be seen in the table below:

Item	$millions	Notes
Onshore Works costs	1,268	Supply and install
Onshore O/H Profit etc	0.462	Incl.Eng & Constrn. management
Offshore installation cost	1.661	Includes WoW
Offshore procurement cost	10.007	Includes freight for cables
Offshore Overheads	1.117	Incl: Proj Mgt, Eng and Insurance
Contingencies	1,120	In addition to cable and WoW
TOTAL	**15,636**	

Table 7 - Summary of the break down of costs at the Newport site