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A 10 year installation program for wave energy in Ireland: A case study sensitivity analysis on financial returns

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ABSTRACT

This paper is a case study which examines the finances of a proposed installation schedule of 500 MW of a wave energy device type in Ireland. The novel aspects of the analysis were the modelling of the combined influence of learning curves, supply and demand rates as well as future cost of cash on the phased deployment over the 10 years. There are many studies which have examined the economics of renewable energy project installations, including wave energy. However, there is lack of research in the impact and implications of phased installations over time, especially when using a feed-in tariff (FIT) revenue mechanism. The goal of the study was twofold. The first goal was to assess the viability of the current Irish feed-in tariff within the context of a phased installation program for the wave energy device chosen for the study, and measures required to produce a positive rate of return. The second aim was to assess the impact of learning curve, supply/demand curves and future cost of cash on phased project installations. The wave energy device chosen for the study was the Pelamis P1 and the economic model used was NAVITAS, created by HMRC. The assessment was based on net present value and internal rate of return. The wave energy data for the study was 2007 from M4 of the west coast of Ireland, obtained from Marine Institute, Ireland. Results from the case study indicated that the high initial costs for the case study wave energy device had a significant impact on financial returns. Results of the case study indicate that higher tariffs may be required than the current Irish, static, nonindex linked, FIT to foster positive returns for future wave energy projects, especially if phased installations are considered, which are susceptible to future cash and supply/demand factors. The large range of sensitivity factors assessed in the case study demonstrates the vulnerable nature of these large scale projects when estimating financial returns. Further studies will be required to assess multiple device types, update initial costs for wave energy devices, provide reliable power matrices, as well as appropriate learning curve and supply demand rates.

1. Introduction

This paper examines the phased installation of a total of 500 MW of a wave energy device (Pelamis P1) over a period of 10 years in Irish waters.

The goal of the study was twofold:

- To assess the viability of the current Irish feed-in tariff, and measures required to produce a positive rate of return using the case study device.
- To assess the impact of learning curve, supply/demand curves and future cost of cash on phased project installations.

The 500 MW Irish installation target is quoted as an 'ambition' by DCENR [1], or that 'at least' 500 MW would be the desired installation minimum. The 500 MW target is an increase from that originally set in the 2005 strategy paper [2] of 84 MW installed by 2020 and 485 MW for 2025. The white paper also sets a short range target of 75 MW for 2012. This target was cancelled in Sept 2009 by the Ocean Energy Development Unit[1] (OEDU) in consultation with the Marine Renewable Industry Association (MRIA),[2] as it was deemed unattainable considering current progress in device development at the time. 500 MW is the target set in the 2010 released Renewable Energy Action Plan (NREAP) [3] and is

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[1] http://www.sustainableenergyireland.com/Renewables/Ocean_Energy/Ocean_Energy_Development_Unit/?print=1.
[2] http://www.mria.ie/, personal communication with Peter Coyle, chairman MRIA.

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considered a stepping stone to large scale deployment by 2050. The 500 MW capacity chosen for this paper is thus a case study example of a possible deployment schedule for 2020. It assumes that all the relevant technical problems, including supply chain logistics, have been solved for each deployment year examined.

The model used for the analysis in this paper was NAVITAS, which is a Microsoft Excel [4] tool developed at the Hydraulics and Maritime Research Centre. The outputs of the study were the profit (net present value (NPV)) in present value terms derived from the 10 year project for a developer and internal rate of return (IRR minimum 10%). The cost of electricity (COE) was not assessed in this paper, as COE does not account for revenue creation from tariffs, and it was concluded in a study by Dalton et al. [5] that it is not the best metric to consider when profits generated from tariffs are the main focus of the study.

The wave energy device chosen for analysis in this report was the Pelamis P1, as it is the only WEC to date that has a published power performance matrix. It is also the only device which has provided some preliminary initial cost estimates, which were used in the 2004 EPRI study [6]. A further study by EPRI was reported in 2006 by Bedard [7].

The reliability of the Pelamis P1 power matrix has never been fully verified since it was first published in 2003, and unfortunately, there has been no update of the matrix since. There have also been no revised initial costs estimates for the Pelamis P1 device, nor has the company volunteered to provide up-to-date costs. Therefore, the Pelamis P1 device, its matrix and costings, are only used in the context of a case study and provide a platform methodology to examine this paper's research aims. The 500 MW assessed in the paper is modelled as if located in one location. This is not representative of reality where multiple farms will be located along the west coast. Current research work carried out by the author (yet to be published) will investigate whether the wave energy climate along the west coast of Ireland substantially varies or is similar. Thus the total energy resultant from the one location chosen for this present study can be taken as indicative of the sum of energy from a range of other possible locations. The modelling for this case study paper uses only one year of data from 2007. Further research work carried out by the author (yet to be published) will compare energy output over a range of years. Other relevant research work carried out by the author (yet to be published) will include financial returns of multiple device types in one location. Results extracted from this study must be taken as indicative, keeping in mind that the main focus of the paper is an analysis of the impacts of learning curve and future cost of cash on phased installations.

2. Background literature review

This study is an extension on an initial study published by Dalton et al. [5] which modelled the performance and economics of Pelamis devices at M4 deployed all in one year. An extensive literature review was conducted on the state of the art of the wave energy industry, which will not be repeated here. Results from the study recommended the cautious use of cost of electricity, and that future research is needed to assess the impact of learning curves on final net present value results as well as feed-in tariff (FIT) required to produce positive net present value (NPV). Net present value results indicated that a positive return could be attained for large Pelamis wave farms over 100MW at the Irish tariff rate if all the devices were deployed in one year.

The cost per kW is an easy costing method to compare prices of different technologies. Offshore wind is the closest technology to wave energy and thus will be the comparison technology. Average cost/kW for offshore wind ranges from €1500 to €3000/kW (Table 1). Snyder and Kaiser [8] observe that costs are greater for larger farms than for smaller ones despite bulk discount rates; no explanation is provided in the paper for this observation.

Table 1
Cost per kW for various offshore wind and wave energy studies (€1 = $1.4US, €1 = £0.82).

Technology	Author	Year	Reference	Turbine or farm size	Euros/kW
Offshore wind	Snyder and Kaiser	2009	[8]	1–2 MW turbines	€1500–€3000
				2–5 MW turbines	€2000–€3000
				1–50 MW farms	€1500–€3000
				50–200 MW farms	€2000–€3000
	Fingersh et al.	2006	[10]	3 MW	€1500 ($2100)
	DETI (quoted in SEI)	2002	[11]	Not quoted	€1400–€2000
	Horns Reef (quoted in SEI)	2002		160 MW	€1700
	Barthelmie et al.	2008	[12]	Not quoted	€1650
	Luypaert et al.	2008	[13]	Not quoted	€2500
Wave energy	Weiss et al.	2007	[14]	90 MW	€1800 ($2600)
	Carbon trust and Callaghan	2006	[9]	Commercial	€1400–€3500
	Previsic (calculated from report by the author)	2004	[6]	1 MW	€5350 ($7500)
				105 MW farm	€1900 ($2600)
	Dunnett and Wallace	2009	[15]	Not quoted	€2500 ($3500)

Costs reported for wave energy farms vary substantially with size, ranging from a high of approx €5300/kW [6] for small wave farm developments to €1400 for larger ones [9]. It must be noted that the €5400/kW cost is from 2004, and costs may have increased substantially since that time.

2.1. Learning curve

There have not been many studies examining the impacts of learning curves (sometimes referred to as progress ratios) on project profitability. The term 'learning curve' has been defined by Neij [16] as the cost reductions of a standardized product within a single firm, while an 'experience curve' may also describe cost reductions of non-standardized products on a national or global level. He observed a number of problems with using experience

Table 2
Research papers which have included 'learning curve rates' or 'progress ratios' in their evaluations. Rates based quoted are based on cost reduction only not COE.

Author	Reference	Technology	Learning curves rate or progress ratios
Batten and Bahaj	[17]	Wave	85–90%
Carbon Trust and Callaghan	[9]	Wave	Scenario A 90%, Scenario B 85%
Hoffmann	[19]	PV	82–80%
Junginger et al.	[20]	Offshore wind	23%[a]
Junginger et al.	[21]	Wind (review of 20 studies)	88–90%
IEA	[22]	PV Wind	82% 92%
McDonald and Schrattenholzer	[23]	Wind	92–96%

[a] Referred to time rather than cost reduction.