Renewable Energy 88 (2016) 120–129

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Creation of investor confidence: The top-level drivers for reaching maturity in marine energy

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ARTICLE INFO

Article history:
Received 27 October 2014
Received in revised form
30 October 2015
Accepted 8 November 2015
Available online 5 December 2015

Keywords:
Marine energy commercialisation
Strategic drivers
Investor confidence
System dynamics

ABSTRACT

Electricity generation by tidal current and wave power arrays represents a radical innovation and is confronted by significant technological and financial challenges. Currently, the marine energy sector finds itself in a decisive transition phase having developed full-scale technology demonstrators but still lacking proof of the concept in a commercial project environment. After the decades-long development process with larger than expected setbacks and delays, investors are discouraged because of high capital requirements and the uncertainty of future revenues. In order to de-risk the technology and to accelerate the commercialisation process, we identified stakeholder-wide balanced and realisable strategic targets. The objective is to name the top-level drivers for facilitating technology maturation and thus achieving market acceptance. Our analysis revealed that the two major risks for multi-megawatt projects (funding and device performance) are directly interlinked and that co-ordinated action is required to overcome this circular relationship. As funding is required for improving device performance (and vice-versa), showcasing an "array-scale success" was identified as the interim milestone on the way towards commercial generation. By this game-changing event, both mentioned risk complexes will be simultaneously mitigated. We observed that system dynamics modelling is appropriate for an unbiased analysis of complex multi-level expert interview data. The applied research model was found to be efficient and allows a regular re-assessment of the strategic alignment thus supporting the adaptation to a complex and continuously changing socio-technical environment.

1. Introduction

Marine energy is arising in an era of global interest in low-carbon electricity generation and is confronted with a market environment in which other renewables are struggling to be cost competitive with non-renewable sources. Even though there are significant public support programmes, the commercialisation of marine energy represents a major technical and financial challenge. Since 2003, the European Commission has allocated up to €140 m towards marine energy development and industry investment of more than €700 m in the last 8–10 years has triggered significant progress [1].

To become recognised as a mature generation alternative, marine energy needs to prove a range of referenceable application cases in commercial project environments. Managing the market entry process represents an ambitious undertaking that requires the unbiased identification and stakeholder-wide application of harmonised strategic principles. To tackle this problem, comprehensive expert interviews and system dynamics techniques were used to identify the top-level drivers. Representative interview statements, correlating with the determined strategic drivers, are put into context.

It was identified that, drawing on expert interviews, the two top-ranked risks for multi-megawatt tidal current and wave power array projects are "achieving funding" and "device performance". Both are interlinked and will be mitigated simultaneously when achieving the "array-scale success". As investor confidence mainly depends on proof of continuous grid-connected operation, attainment will represent a major turning point for the global marine energy business and is expected to finally trigger new investment required for large-scale deployment.

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http://dx.doi.org/10.1016/j.renene.2015.11.033
0960-1481/

To efficiently pass the present "pre-profit" phase and to head towards commercial-scale projects, coordinated interaction within and between the stakeholder groups is required. A conclusive strategy to orientate the marine energy development process must integrate the dynamic and complex interplay between the different stakeholders.

The focus of the research is on de-risking the technological concept and thus attracting investment to finally establish marine energy as a competitive generation alternative with commercially viable projects implemented on a regular basis.

2. Literature review

2.1. Investors' attitudes towards wave and tidal

Leete et al. [2] report that investors engaged in marine energy venture capital funding were unlikely to make any future investments in early stage device development. They found that venture capital investors are not closed to the industry completely, but the current level of risk and uncertainty of future revenues are discouraging them from investing. It is underlined that a track record of continuous device operation of at least 6 months is a pre-requisite for further engagements. Investors profiled by Masini and Menichetti [3] showed a clear preference for more mature, proven technologies with only 3 of 93 investors analysed having any exposure to wave and tidal energy. Given the relatively small scale of today's marine energy developments, investors are able to achieve similar or greater returns on larger developments of more proven energy technologies. Magagna and Uihlein [4] describe that high costs associated with marine energy, combined with the unproven status of the technologies, hinder investors' confidence.

These studies clearly describe the present investment climate and investor attitudes based on experience. As improvement measures are rarely proposed, this paper intends to name effective strategies to overcome the present locked-in situation and to provide arguments for investors to direct their financial engagements. The required efforts for putting corresponding measures into practice can be justified by the long-term benefits after the market breakthrough.

2.2. Can marine energy compete on cost?

According to the UK Department of Energy & Climate Change [5], the projected levelised cost of electricity generation (LCOE[1]) for marine energy in the year 2020 will range between 20 and 42 c€/kWh. Spain expects LCOE for that period of time of 21–33 c€/kWh [6]. Previsic et al. [7] have similarly suggested commercial opening costs of electricity for wave power between 20 and 30 c€/kWh. LCOE for onshore wind in the UK are projected of 9–15 c€/kWh by 2020 and for offshore wind of 13–22 c€/kWh [5]. RenewableUK [8] believes that the current LCOE for leading tidal current devices is around 36 c€/kWh, compared with 48 c€/kWh for wave power devices. As onshore wind energy represents the reference for cost-competitive renewable power, it shall be noted that the global average LCOE dropped from 19 c€/kWh in 1992 to 6 c€/kWh in 2014 [9]. Offshore wind farms at very good locations currently achieve LCOE of 11–19 c€/kWh [10]. Presently, the kWh-costs in marine energy are far too high to compete with other renewable or even non-renewable generation options [11]. Taking into consideration the projected LCOE in the UK for 2020, the cost for tidal current might touch the upper end of the offshore wind range. For the forthcoming years, governmental support programs will be indispensable to further drive research and development [12]. In offshore wind – with a global installed capacity of 5.4 GW [13] – it is expected that a further 15 years of subsidies will be required [14].

Although there is the perspective for continuously decreasing LCOE for marine energy, we see the need to concentrate on rapidly achieving a multi-company based market breakthrough. If the first commercial array projects do not deliver good returns for investors, the significant industry investment of the last years might not be compensated and the focus of interest would finally move to other technologies. It is evidently in the interest of all engaged stakeholders to make use of the available window of opportunity in order to overcome the current pre-profit phase and to establish a new and innovative industry.

2.3. Protected spaces for innovation

Carlsson et al. [15] identified in the course of innovation studies, that market-linked technological systems are not static but need to evolve continuously to be able to survive. Due to regular transformations in the embedding socio-technical system, which encompasses the co-evolution of technology and society, the lines of technology development need to be regularly re-adjusted [16]. Alkemade et al. [17] explain from an innovation studies perspective, that new technology often has difficulty in competing with embedded technologies and suggests that most inventions are relatively inefficient at the date when they are first recognised as constituting a new innovation. Negro et al. [18] hereto formulated more specifically, that renewable energy technologies find it hard to breakthrough in an energy market dominated by fossil fuel technologies that reap the benefits from economies of scale, long periods of technological learning and socio-institutional embedding. If the gap between new and established technology is very large and if there is a "paucity of nursing" or missing "bridging segments" that allow for a gradual generation of increasing returns, a new technology may never have the chance to rectify the initial disadvantages [19]. Scholars in evolutionary economics have highlighted the importance of "niches" that act as "incubation rooms" for radical novelties, shielding them from mainstream market selection. Such protected environments are enabled to overcome conventional organisational (i.e. socio-technical) inertia (e.g. Refs. [20,21]). Bergek et al. [22] confirm that technology development can best take place within specially created learning spaces that allow a new technology to develop a technical trajectory (for reaching maturity or even a dominant design). Erickson and Maitland suggest that "nursing markets" need to be created to support the technology breakthroughs, taking advantage of windows of opportunity that drive adjustments in the socio-technical regime [23,24].

For a decade, we have seen that significant development in the marine energy sector is taking place within such "protected incubation rooms" in the form of marine energy test facilities or subsidised pilot projects. Research, however, recognises an underlying time pressure, as artificially created learning environments can be maintained only for a limited time.

3. Objective of the research

The referenced primary literature describes the difficulties which the marine energy sector faces and makes investors' restraint evident. Although ideas for improving the investment climate are outlined, the presentation of a conclusive set of measures that can be implemented by the stakeholders in order to

[1] LCOE is defined as the ratio of the net present value of total capital and operating costs of a generic plant to the net present value of the net electricity generated by that plant over its operating life.