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MULTI-DISCIPLINARY RISK IDENTIFICATION AND EVALUATION FOR THE TIDAL INDUSTRY

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ABSTRACT

With tidal industry still having not achieved high Technology Readiness Levels (TRL), it becomes a pertinent task for developers, investors and operators to develop a widely agreed risk register in order to efficiently control residual risks towards further development. Scarcity and sensitivity of available data and limited synergy between industry agents constitute the task of stakeholder and risk identification quite difficult with relevant studies performed so far focusing specifically on individual sectors of the industry. This paper adopts a PESTLE approach to categorise the different sectors of the tidal industry, identifying key stakeholders and listing the risks considered most relevant. Outputs of this analysis stand as a basis for a targeted survey among stakeholders highlight the most critical risks through multi-criteria assessment in order to establish effective mitigation strategies that allow focus to be placed upon the most critical risks as perceived by the industry cumulatively.

INTRODUCTION

Currently installed capacity of in-stream tidal energy within the UK is estimated at 9MW [1], with theoretical resources predicted to total 32GW [2]. With the industry still being in an early stage of maturity, many potential risks and hazards have yet to be encountered and addressed by developers; however, there is not much publically available data on tidal energy risks, as they remain propriatory and hence particularly sensitive. Among available literature, RenewableUK [3] highlights four main aspects as critical for further development; finance, technology, grid connection and consenting.

Despite there being numerous reports focusing on individual or a limited number of risk assessment, there is a lack of a comprehensive risk register covering all of the PESTLE (Political, Economic, Social, Technological, Legal, and Environmental) sectors. This paper aims to bridge this gap, identifying the possible risks faced by the in-stream tidal energy industry in the UK, highlighting the most critical risks through MCDM (Multi-Criteria Decision Making methods) assessment, allowing further use for establishing mitigation strategies placing focus upon the most critical risks as perceived by the whole industry.

METHODOLOGY

The methodology followed in this study can be summarized in five distinct steps:

- *Stakeholder Identification:* Employing a PESTLE approach, stakeholders are identified and classified in one or more categories.
- *Risk Identification:* From the categories and stakeholders identified, a comprehensive risk register is built following experts' consultation.
- *Stakeholder Survey:* Using questionnaires, a targeted survey will collect data regarding the severity of individual risks, as well as the perceived importance for each sector.
- *Multidisciplinary Risk Assessment:* Data collected will form input for a multidisciplinary risk assessment with scores from each industry sector to be considered as criteria.
- *Risk Prioritisation:* Results of the risk assessment will allow prioritisation of risks for consideration of efficient risk control strategy.

STAKEHOLDER IDENTIFICATION

As part of the risk identification process, the key stakeholders of the UK tidal energy industry, which was the primary focus of this study, were identified. Tidal energy involves many different stakeholders and by categorizing the responses according to the PESTLE sector they fit into, individual analysis of the groups was possible and overall comparisons were made. In [4] and [5] a detailed categorisation of the key stakeholder groups and organizations by PESTLE categorization can be found. This literature, contains a comprehensive list of organizations that were approached for the survey, however not all of them could take part due to various reasons.

MULTI-DISCIPLINARY RISK ASSESSMENT

This study initially identified all possible risks applicable to tidal energy developments, followed by ranking. PESTLE analysis normally identifies the main risks only; however this study thoroughly identifies all risks and relevant stakeholders. Figure 1 presents in a flow diagram form the steps followed for risk prioritisation. A parallel study was targeted to industrial and academic stakeholders.

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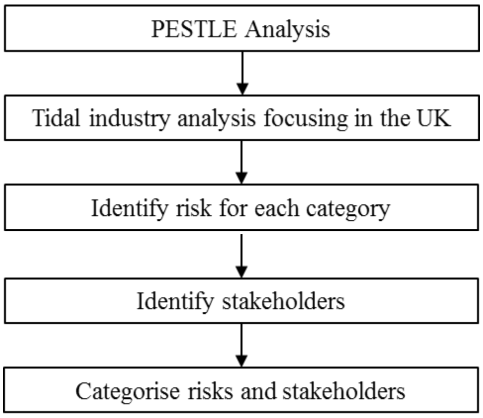

Figure 1 Stages for PESTLE Analysis

In total there were 68 responses to the survey; 30 industrial and 38 academics stakeholders. A response rate of around 15% was achieved across both academics and industrial stakeholders, with academics having a slightly higher response rate than industrial stakeholders. Industry showed an even spread of responses across all PESTLE sectors (with the exception of legal stakeholders). The majority of academic responses were technological, with sufficient responses from environmental and economic stakeholders. The absolute number of responses is considered to be sufficient considering that the key number of specialized stakeholders is limited and the number obtained allows effective statistical processing of the results obtained.

Once the results were collected, the individual response data from each sector of stakeholders was averaged forming a decision criterion for each of the risks. Data have also been collected from the stakeholders based on their opinions for the importance of each of the sectors to the development of the industry in order to form a weight vector for the process to follow. For the assessment of this decision matrix TOPSIS MCDM method was employed. Technique for Order of Preference by Similarity to Ideal Solution was first developed by Hwang & Yoon [6] and is based on the concept that the optimum alternative or the "closeness" should have the shortest distance from the positive ideal solutions and the longest distance from the negative ideal solution [7]. Figure 2 summarises the computational steps of the method.

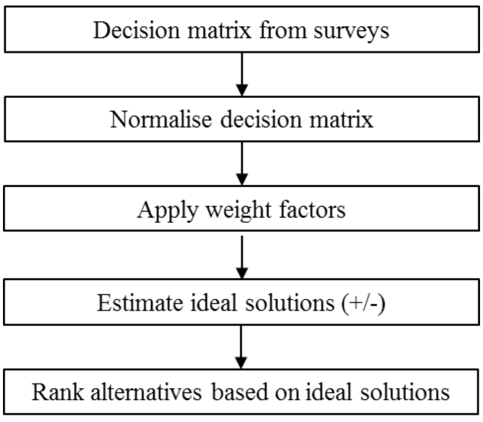

Figure 2 TOPSIS MCDM process

OBSERVATIONS AND DISCUSSIONS

Risk analysis ranked 'private investment', 'investment pay off period' and 'reliability' as the most critical risks in the sector. Top 10 of risks comprised of 4 economic, 5 technological and 1 political risk. The overall results of TOPSIS for industry highlight the importance of economic and technological risks. It is also particularly interesting to note that no legal or social issues were regarded as critical risks (top 10) with the majority of these three categories of risk featuring in the bottom half of the ranking.

- *Political* stakeholders identified 'grid connection' as most critical, as well as 'public acceptance' and 'support' alongside technological and economic risks.
- *Economic* stakeholders identified 'UN support' as most critical.
- *Social* stakeholders identified legal, social and environmental risks as the most critical. The most critical risks were 'international legislation'.
- 'Support structure' was the critical risks for *technological* stakeholders with technological, economic and political factors making up the remaining top 10 risks.
- *Environmental* stakeholders ranked 'International legislation' as the most critical risk.

The *legal* stakeholder group were omitted from this part of the analysis as there were only 2 responses from this stakeholders' group. This low response rate for legal stakeholders could possibly be for a number of reasons; the legal firms were too busy (as mentioned in survey request responses on numerous occasions) or there was not enough expertise in the sector (response from a multinational law firm).

The survey revealed the importance of economic and technological risks to industrial stakeholders, with political risks to follow. It was also seen that environmental only featured low down in the top 10 of risks, with legal and social risks not ranking at all (most of the results make up the bottom half of the rankings), highlighting the fact that a lot of focus is being placed on technological and economic risks which is normally associated with engineering projects. Future work should test further the sensitivity of the results towards the PESTLE weighting. The current average of PESTLE sectors weighting factors marked political as 25%, economic 26%, social 6%, technological 26% and environmental 13%. From this it can be observed that economic, technological and political risks have the highest weighting which reflects the results but with political risks deemed lower on the risk scores.

For the survey among academics, TOPSIS ranked 'cut backs in spending', 'maintenance' and 'true cost' highest with 5 economic risks, 4 technological risks and 1 environmental on the top 10. Due to the majority of the responses coming from technological academics, it was not possible to conduct a valid analysis for each individual category. This lack of participation of different stakeholder groups was down to the fact that the majority of academic work in the tidal energy industry is focusing on technological aspects (with a number of environmental also), with many engineers currently working with tidal energy developers and not many having expertise in the other sectors.

Overall it can be seen that economic and technological risks are deemed most critical over both sets of academic and industrial results, with the academics placing more emphasis on economic risks. Both sets ranked political risks third, environmental fourth and social and legal risks the least critical.

Many high profile organisations with significant expertise participated in the survey, with several individual industry experts among these responses. The average industry expertise score stood at 5.2, perhaps not reflecting the true knowledge and expertise of the stakeholders who participated, as this type of self-assessment remains subjective. It is interesting to note that the highest expertise weighting group overall were the technological stakeholders, with the lowest comprising of the social and legal stakeholders. This expertise rating could explain the relatively low scores for the legal and social groups as either the experts from those groups did not respond to have their true input on risks, or simply that there isn't much expertise in these sectors as the industry have already assessed risks in those areas as very low.

The corresponding overall average weighting for academics was lower than that of industry at only 4.0. This score suggests that either the participants were too modest to express themselves as having higher expertise, or that as a lot of the individuals have not truly been exposed to the industry yet they feel their overall expertise is low.

Table 1, summarises the results of this analysis both for the academic and for the industrial stakeholders.

Table 1. Prioritised Risks

Risk ID	Industrial Stakeholders	Academic Stakeholders
Risk 1	Public sector investment	Cut Backs
Risk 2	Private Capital	Maintenance
Risk 3	Investment pay off	True cost (CAPEX & OPEX)
Responses	30	38

CONCLUSIONS

Tidal energy industry faces a number of challenges currently, with many posing as potential risks towards further development. This study has looked into the stakeholder perception of these risks that the industry faces through a thorough PESTLE analysis carried out to identify key relevant risks and stakeholders. Through a survey risks were ranked based on their respective criticality as well as the importance of each sector.

TOPSIS multi-criteria analysis revealed overall the economic and technological factors to be the highest priority for both academics and industry. Political risks remained close to the top, with environmental, legal and social risks making up the least critical risks sectors. Within the industrial stakeholders, individual analysis revealed that 4 of the 6 groups agree with the overall critical risk categories (but not for the top individual risk). The biggest difference between industry and academic stakeholders was that academics gave more of an overall score to the environmental, social and legal risks.

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