An investigation of the Knowledge Base of the UK Marine Renewable Sector

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Abstract

This Supergen Marine study highlights the issues facing the UK marine renewables energy industry in conjunction with identifying, investigating and discussing the pertinent issues surrounding this fledgling sector.

A review of technology forecasting methods has identified the "Delphi Interview Method" as providing a suitable mechanism to facilitate the investigation of a forward direction for the sector. The use of this method has provided a robust and auditable set of results from a series of 22 interviews with leading academics in the marine and renewable energy fields. The analysis of the results from the interviewees has facilitated the presentation of the qualitative interview results in quantitative terms, thereby allowing the identification of a unique set of technology trends.

The outcomes of the investigation have in turn been fed into the population of the UK Energy Research Centre (UKERC) Marine Renewables Research Roadmap (where there has been close collaboration) in order to forecast an efficient and effective route forward for the sector. The results from the road-mapping work are discussed in the companion paper presented by Dr Markus Mueller: "UKERC Marine Renewable Energy Technology Roadmap".

Keywords: Knowledge base, Technology forecasting, Marine renewables, Knowledge gaps, UKERC.

Introduction

As part of the Supergen Marine [1] "Engineering Guidance" work package, an investigation has been conducted to establish the knowledge base within the Supergen Marine academic community and the influence it has on the way forward for the Marine Renewables sector. Additionally Supergen has identified a theme of a lack of design consensus in the wave and tidal energy sectors. In conjunction with this, a DTI sponsored gap analysis (DTI Renewable Supply Chain Gap Analysis 2004) [2] states within its SWOT analysis for wave and tidal power that the UK is amongst the world leaders in wave and tidal power research due to the technical competence of several of its universities. Additionally, the SWOT analysis states that this position provides the UK with the opportunity of developing the "*winning design*" [2] and thus allowing the development of a UK centred supply base. However, it also states that, at present, "*there is no stable design*" [2], hampering efficient technology development. In order to add clarity to this situation an investigation was conducted within Supergen utilising a Delphi interview technology forecasting technique to add clarity to the future direction and requirements of the marine renewables sector. The interviews were conducted with 22 academics from the following UK organisations: *University of Edinburgh, Heriot Watt University, Lancaster University and The Robert Gordon University.* The interview results were analysed using an inductive coding technique to allow the identification of trends and themes.

Additionally, the study has investigated possible future directions and shape of the sector and related technology requirements. As well as forming the underpinnings for "Engineering Guidance" the outcomes of the investigation have in turn been fed into the population of the UKERC[3] Marine Renewables Research Roadmap in order to forecast an efficient and effective route forward for the sector.

The implicit theme of this investigation has been to take the tacit knowledge held within selected interviewees and turn that into explicit information. This paper will display the merged results from the 22 one to one interviewees from the 4 UK academic research institutions involved in this investigation. Additionally the paper will discuss the use of inductive codings that have facilitated the presentation of the highly qualitative interview results in quantitative terms. This has allowed the identification of a unique set of trends and themes surrounding the marine renewables sector

The paper will culminate by displaying and discussing the pertinent interim results of this study, predominantly those surrounding information on "knowledge gaps" and "technology direction and requirements".

Overall Methodology

The overall approach in this investigation has been to integrate the experience and skills of all Supergen Marine

consortium partners and others in the research community in order to establish the position of the knowledge base within the marine renewables research sector.

This has been conducted in the first instance via a high level investigation to evaluate where the Supergen knowledge base fits the needs to develop the sector. To this end, a program of work was designed that would identify the current position, gaps in the current understanding, barriers to the progression of the sector and potential opportunities.

In order to most effectively conduct this investigation an extensive review of technology forecasting techniques has been undertaken. This has highlighted the Delphi method, which is a process of gathering and distilling knowledge and information [4] while facilitating the formation of group judgment [5] as providing a suitable mechanism to enable the establishment of a knowledge base and the identification of possible forward directions of the sector. The Delphi method has the advantage of efficiently gaining consensus of a group of expert individuals. The group of experts does not meet, but give their opinions through an iterative series of questionnaires or interviews, from which a direction can be derived. Furthermore the Delphi interview method which has been successfully used in energy technology investigations in Finland [6] has been ultimately selected for use in this study.

Interview Methodology

The following section displays and describes the process that was utilised when conducting the one to one Delphi interviews and that of the subsequent processing of the information that followed. The process was as follows:

1. An interview template was constructed comprising of semi-structured, but open-ended questions/topics that were designed to elicit the following information from the interviewee:
    - Fully establish the interviewee's background and assess their overall experience in the sector.
    - Establish what their current activities within the sector are and how they see the way forward for their work, while identifying any knowledge gaps or barriers to this being realised.
    - Establish what they consider to be the way forward for marine renewables, identify specific areas for technology development and identify knowledge gaps and barriers that may hinder this progress.
2. 22 interviewees where selected across four UK academic institutions with expertise covering the whole sector, i.e., from the resource assessment of the energy available in the sea through to network integration of the generated power into the grid.
3. The interviews were arranged with academic experts in the marine renewable energy sector.
4. The interviews were then conducted with the author (who has an extensive background in marine renewables from both an academic and commercial perspective) guiding the interviewee through the interview topics. Although the same topics and format was used in each interview the author would probe deeper into any areas where the participant displayed a particular strength. This flexible approach allowed additional pertinent topics to be identified and explored. At the end of each interview the participants were asked if they had anything else they wanted to add, thanked for their time and told what would happen with the results. Additionally they were also asked if they could be contacted again with supplementary questions as the study progressed.
5. As each interview was conducted more pertinent information came apparent and this was used to "feed forward" into the next interview, not to change the structured format but to change the angle or emphasis put on questions, so as draw out themes and trends that evolved as the interviews progressed.
6. Analysis of this predominantly qualitative data from the interviews was conducted using the following methods to process and reduce the data:
    - An interim analysis was performed on the data. This consisted of arranging the data into distinct but broad headings or codings. To make the data manageable, this process was initially performed on an institute-by-institute basis.
    - The interim analysis documents were then further sorted into more detailed inductive coding areas to allow the identification of trends and themes to emerge [7]. This was also conducted on an institute-by-institute basis.
    - The four institute results were then compared and amalgamated to display the overall themes, directions and trends.

Analysis of Interview Data

In summary, the raw interview responses were transformed into meaningful results via the following route:

1. The raw interview discussions were fully transcribed.
2. The interim analysis was performed on the interview transcripts where the responses were sorted into appropriate categories on an institute-by-institute basis.
3. The inductive coding tables were constructed from the interim analysis and produced separately for each question and each institute.
4. Finally the merging of the coding tables were produced in bar chart format to identify trends

and themes which are displayed and discussed in the following section.

Results and Discussion

Bar chart analysis technique: In order to consistently and methodically perform analysis of the merged results from the four intuitions the following technique was adopted to identify and characterize an area of interest. The following bullet points describe the conditions that were applied for when using the technique:

- Topics with a high frequency of occurrence
- Topics with a high level of agreement across institutes
- Topics with a high level of disagreement across institutes

The following section uses this technique to facilitate the analysis and discussion of the "Identified gaps in knowledge" and the "Technology direction and requirements" which are now displayed and discussed.

Figure: 1, Identified gaps in knowledge

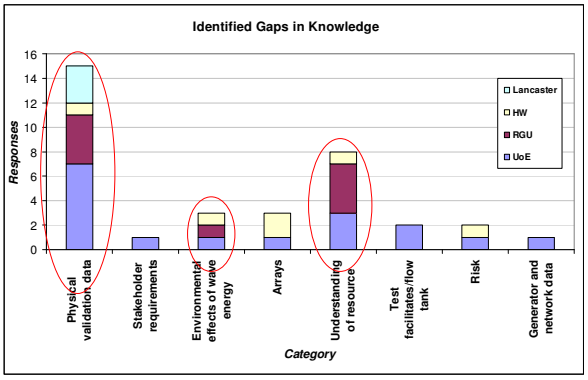

Figure 1 displays the results of question/discussion area, where the interviewee were asked to explain the current gaps in the scientific knowledge that are present in their area of work which are hampering scientific research and, possibly, subsequent progression of marine renewable technology. Using the analysis technique the following areas of interest were identified and are:

Lack of physical validation data: A broad range of interviewees, from those involved in modelling of the wave and tidal resource, through to those modelling of electricity networks and the economics of the industry all highlighted lack of physical validation data as hampering the progress of their work and hence the progression of knowledge feeding into the overall sector.

Environmental effects of wave energy: To a lesser extent the was an area where there was agreement between interviewees that had been overlooked. In general, comments surrounded the fact that the environmental effects of tidal energy is an area that attracts a lot of attention and that wave energy had been overlooked in this area.

Understanding of the wave and tidal resource: Finally, there was a high degree of agreement that there were substantial gaps in the fundamental understanding in this area which would require to be filled in order to take the sector forward.

Figure: 2, Technology direction and requirements

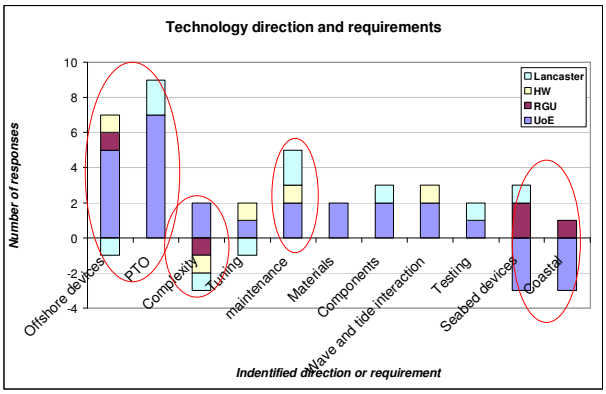

Figure 2 displays the results of question/discussion area, where the interviewee was asked to provide details of where they felt marine renewable energy technology was headed and what were the breakthroughs required to facilitate effective progression of the technology. Using the analysis technique the following areas of interest were identified and are as follows:

Interviewees from three separate institutions promoted offshore devices as opposed to near shore or shoreline devices as the technology that would move the wave energy sector forward. In connection with this power take offs (PTO) was identified as a area requiring development that could make a step change forward possible to the development of devices.

Complexity was considered an area of interest due to the disparity in agreement, with some interviewees promoting complexity in design being required to drive technology forward whilst others stating the opposite, that simplification was required to promote survivability. Additionally, in connection with this, the complex area of the tuning of marine energy technologies is seen by some as an area that could improve efficiencies of devices, while others believe that this type of development is premature, promoting the idea that there are more fundamental areas requiring attention before tuning would be necessary.

Maintenance was highlighted as an area requiring focus, with concern amongst the interviewees that without

effective maintenance strategies being designed into the development of marine energy devices. their operation would never be efficient.

The topic of seabed mounted wave energy devices was raised by some interviewees who saw the survivability merits of this approach, whilst others described the concept as being fundamentally flawed in its operation

Conclusion

The implicit theme of this investigation has been to take the tacit knowledge held within selected interviewees and turn that into explicit information. The Delphi method, executed via an interview survey of an appropriate section of the UK marine renewable energy academic sector, has provided a successful mechanism to do this and thus produced a robust and auditable set of results. The interview method has facilitated valuable inaction between the interviewee and interviewer facilitating results to be based on intelligent discussion rather than on a basic questionnaire.

The analysis of these results from the interviewees from the four institutions, incorporating the use of inductive codings, have facilitated the presentation of the highly qualitative interview results in quantitative terms, hence allowing the identification of a unique set of trends and themes that otherwise would not have been possible.

It is recognized this investigation is limited in its consultation group, thus to address this, work is presently ongoing to include other stakeholders including other academics and device developers. However the trends and themes discussed in the paper have already started to provide clarity regarding present knowledge gaps and future direction and requirements of the marine renewables sector. In addition the results have helped to underpin the direction and detail of the UKERC Marine Renewable Energy Technology Roadmap.

Further work

This work is on going with work already underway extending the interview process within UK academic community. In parallel with this there is also a study undertaking a identical process with Marine Renewable development community which will allow comparison. Additionally it is intended on completion of this UK study to expand the investigation to both European and international academics and developers**.** Throughout this work Supergen Marine will continue to collaborate with UKERC at its road mapping activity.

Acknowledgments

The authors would like to thank Supergen Marine, UKERC & EPSRC for funding and the University of Edinburgh for providing facilities. A special thanks must also go to the interviewees whose time and willingness to be involved, has made this investigation possible

References

[1] Supergen Marine: Part of the EPSRC SUPERGEN program The academic partners within the consortium are: The University of Edinburgh, The Robert Gordon University, Heriot Watt University, Lancaster University and the University of Strathclyde. The industrial collaborators include more than 20 national and international marine energy and electricity supply companies.

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