Reliability of Tidal Stream and Ocean Current Energy Converters

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Work Stream 8: WS 8.1 Reliability

This research focuses on developing a methodology to assess the reliability of tidal stream or ocean current energy generation converters for the assessment of most reliable architecture

Introduction: More than 50 Tidal Stream Device (TSD) designs have been identified around the world. Most are at the conceptual design phase. In the absence of in-service reliability data it is currently impossible for developers or investors to critically evaluate the prospective reliability of different technologies. An established system-reliability methodology is proposed as the basis for the evaluation of different systems design approaches in order to determine which design has potentially the most reliable architecture.

Case Studies: 4 horizontal axis turbine, 1.2 MW nominal rated Devices were chosen for reliability & technology comparison. These Devices are examined to find a generalized reliability approach.

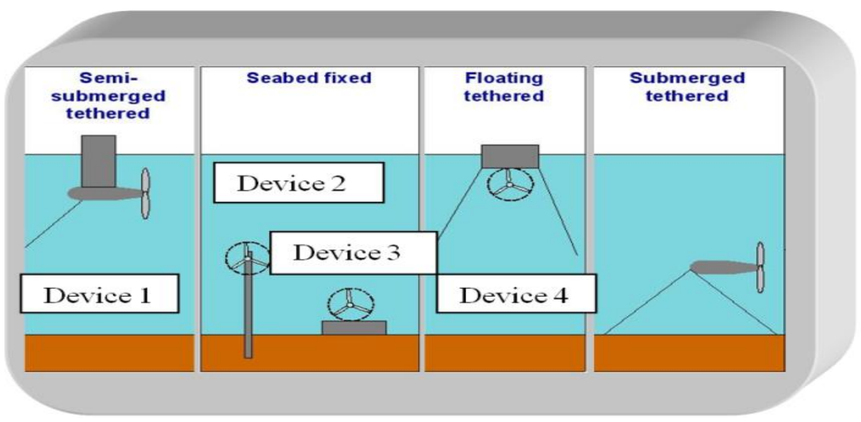
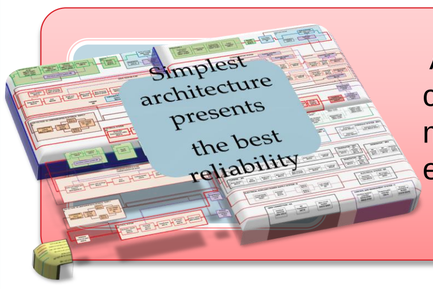


Figure adapted from [1]: Types of horizontal axis tidal stream devices.

Method: The Reliability Modelling and Predictions Analysis using Reliability Block Diagrams (RBD) and Parts Count Prediction technique, based on surrogate data from wind, marine and other generic databases, was used to quantitatively evaluate device design reliabilities.

Results , Discussion, Conclusion



A Functional Block Diagram (FBD) shows that TSD incorporate complex systems which require advanced methods of reliability modelling for analysis. However, during the concept of exploration phase the system can be analysed as a series model in RBD.

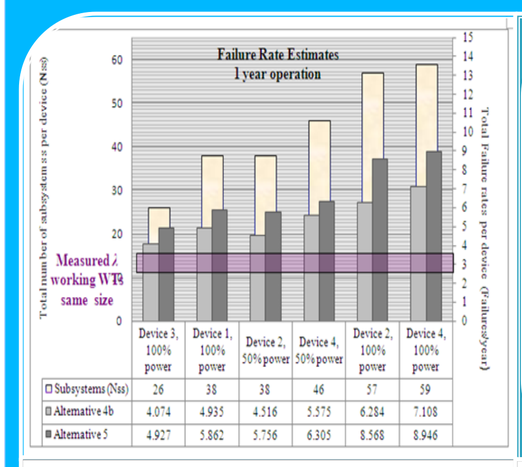
Environmental Adjustment Factors π_E for λ_i adapted from [6]

Environment	Navy unsheltered (NU)[6]	Navy sheltered (NS)[6]
Surrogate data source	π_E	π_E
LWK ,WMEP [2][3]	3.3	1.7
OREDA [4]	2	1
NPRD-95 [5]	3.3	1.7
MIL-HDBK217F [6]	3.3	1.7

Surrogate failure rates data collected from wind , MIL-HDBK 217F and NPRD -5 databases have been adjusted most closely to 'tidal environment''. The Annual Failure Rates $\sum\lambda$ for total power production and Reliability Survivor Function R(t) have been calculated based on Alternative 1: highest collected surrogate failure rate data; Alternative 2: surrogate data adjusted by considering environmental factors of MIL-HDBK217F for electronic/electrical components.

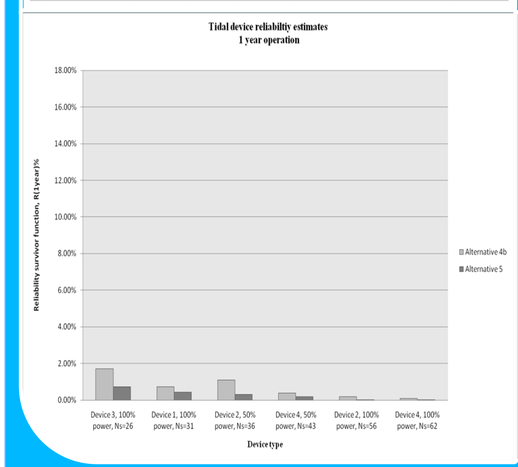
Total failure rates, λ_{tot} (Failures/year)

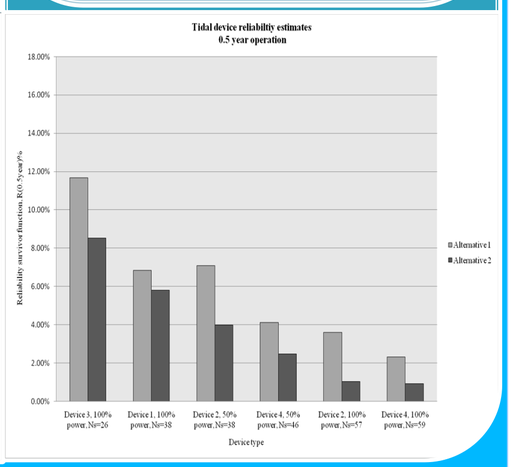
	Device 3, 100% power	Device 1, 100% power	Device 2, 50% power	Device 4, 50% power	Device 2, 100% power	Device 4, 100% power
Alternative 4b	4.074	4.935	4.516	5.575	6.284	7.108
Alternative 5	4.927	5.862	5.756	6.305	8.568	8.946
Subsystems (Nss)	26	38	38	46	57	59



At this preliminary stage, failure rates are relatively high and survivor functions low compared to the availability of offshore wind turbines.

These calculations have been done on the basis of one year's operation as a non-repairable system, with no maintenance. However, a six month maintains interval improves device reliability.





Results show that the Reliability Modelling & Prediction Analysis with adjusted surrogate failure data (wind, OREDA , MIL-HDBK217F and NPRD-95) adjusted for the tidal environment is an appropriate methodology for quantitatively evaluating the reliability of competing TSD designs. However, due to novelty of TSD technology and of the use of the Parts Count Reliability Prediction Technique for this analysis, the calculated reliability characteristics probably present lower reliability estimates compared to prospective operating reliability results. Reliability simulation will be required when detail design and stress data become available.

References

1. G. Mackie. Development for Evopod tidal stream turbine. Proceedings of the International Conference *on* Marine Renewable Energy, The Royal Institute of Naval Architects, London, 2008, pp 9-17.
2. B. Hahn, M. Durstewitz, K. Rohrig. 'Reliability of Wind Turbines' in Wind Energy- Proceedings of the Euromech Colloquium 464b 2005 Oldenburg, Springer Berlin Heidelberg New York, 2007, pp. 329-332.
3. F. Spinato, P. J. Tavner, G. J. W. van Bussel, E. Koutoulakos. 'Reliability of wind turbine subassemblies', IET Renewable Power Generation, 2009, vol. 3, Iss. 4, pp.1-15.
4. OREDA, Offshore Reliability Data Handbook. SINTEF Industrial Management. Det Norske Veritas, Norway, 1984-2002.
5. NPRD-95, Non Electronic Parts Reliability Data, published by Reliability Information and Analysis Center (RAC), Utica, New York, USA.
6. MIL-HDBK-217F, Notes 2. Military Handbook. Reliability Prediction of Electronic Equipment, 1991.

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