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# REVIEWS

**Wave Energy – A Design Challenge.** By RONALD SHAW. Wiley, 1982, £18.50 (cloth). Ellis Horwood £8.50 (paper). 202 pp.

Although the first recorded patent on a wave-energy device dates back to 1799, it was not until the oil crisis of 1974 that the UK Government began to think seriously about using wave-energy-generated electricity to perserve costly fossil fuels. Programmes of research in other countries began at about the same time. Now that the oil crises appears to be over, for the short term at least, it is perhaps understandable that the Department of Energy (DOE) in the UK should cut back sharply on funding the wave-energy research programme in Britain. The book *Wave Energy – a Design Challenge*, by Ronald Shaw, arrives on the scene at an appropriate time to take stock of what has been achieved in Britain and elsewhere over the last eight years, although, because of inevitable delays in publication, the book contains no mention of the DOE decision or the latest costing figures for UK devices arrived at early in 1982. There have been other books on the subject in the last few years – all of them rapidly being dated by the speed of developments in the field. They range from the racy, campaigning *Energy from the Waves* by journalist David Ross, now in its second edition published by Pergamon in 1980, to the esoteric *Power from Sea Waves*, edited by Brian Count and published by Academic Press in 1980, which is a collection of papers presented at an IMA Conference on Ocean Wave Energy in Edinburgh in 1979 – and which was reviewed in this journal by F. Ursell: *J. Fluid Mech.* **112** (1981), 498–499. In the present book the author has attempted to provide a broad coverage of background information on topics as diverse as wave theory, dimensional analysis, turbomachinery, hydraulic pumps and motors, as well as including an extensive treatment of wave-energy theory and a detailed description of many of the current devices. Thus most readers will find something of interest here, but at the same time in a book of barely 200 pages it is clearly not possible to do justice to any specific topic.

Any book dealing with renewable energy sources must of necessity include a section describing the various scenarios for future energy demand. It is a difficult task in which the author, in limiting the discussion to just over six pages in chapter 1, is not wholly successful. Packed into those few pages are three figures and five tables containing statistics from such acronymic organizations as WAES, IEA, ERG and DOE. What emerges is that predictions of future energy demand and cost can vary greatly and are particularly vulnerable to unforeseen events. For instance the figure indicating the anticipated energy 'gap' is taken from a DOE report of 1979 and takes no account of the world recession now being experienced. It is also significant that, up to 1981, lowest estimates of world growth rates, essential parameters in estimating energy demand, are about 3 %, a figure which seems rather optimistic in the current world recession. Faced with a bewildering mass of statistics it is not surprising then that the author's conclusion is somewhat tentative: 'It is clear that *some* scenarios suggest that there will be problems in matching supply and demand early in the next century. Furthermore since the real cost of primary energy will *almost certainly* rise, it follows that *some* current uneconomic sources of energy *may* become viable' (my italics). Later in the chapter, following a consideration of the environmental effects of both nuclear and fossil fuels, the author gains conviction, suggesting that the shortfall in energy early in the next century will require the employment of fast or

fusion reactors or the use of renewable energy resources. A mild note of censure is implicit in the contrast between UK investment in nuclear energy and the 'renewables' for the year 1977/78, although it is conceded that the greater spending on the latter since then indicates some small increase in the commitment to these resources. Maps showing the power available at different sites worldwide and in particular in the UK make it clear that wave energy could provide a significant proportion of energy demands in the UK as well as Norway and Japan. The author goes on to suggest that costs of 5p/kW h are attainable from wave-energy power stations, a figure which has since been confirmed and improved upon by at least two device groups in the UK.

Chapter 1 continues with a survey of devices, past and present. Reference is made to a little-known paper by Stahl in 1892 in which an enormous variety of possible mechanisms for converting wave energy to mechanical energy are described, many of them showing a strong resemblance to more recent ideas. There follows a good concise description of all the devices that have received support in the UK, together with others from Norway and the US. The weight given to each is about right, and this section will be of considerable interest to a reader wishing to gain a brief overview of the wave-energy field and the diversity of device types. The chapter concludes with an estimate of costs for the latest UK designs. It is an illustration of the strange world in which we live that the lowest cost estimate of 3.5–4.7p per unit in 1981 was enjoyed by the Lancaster Flexible Bag device, which by 1982 had shot up to 10p, whilst at the bottom of the list of 1981 cost estimates languished the oscillating-water-column device (OWC) currently being supported by the Department of Industry, together with a consortium of private companies, and which has been developed by the National Engineering Laboratory since the start of the UK programme.

Chapter 2, on the characteristics of waves, leads the reader gently through classical linear water-wave theory, supplemented by an extended version in appendix A, to the statistical representation of a seaway and the ideas of power-spectral density functions. A brief description of methods of wave measurement and analysis is given, showing how scatter diagrams can be drawn from which the number of occurrences of waves of given significant height and period can be determined and the power estimated.

The final paragraph of chapter 2 seems rather misplaced, dealing as it does with power capture efficiency of rows of heaving buoys, and describing how favourable interactions between them can improve the efficiency of power absorption. This discussion is curious on two counts. First the author chooses to 'reiterate here that there is an interaction between point absorbers in a row', although there has been no previous mention of the fact. Secondly a graph is presented of interaction factors against device spacing, together with experimental data, taken from a paper by the Norwegian Wave Group in Trondheim, who are investigating heaving-buoy devices, which is then presented again in chapter 3. This extravagent duplication in such a short book is surely unwarranted, especially as in neither case does the author inform the reader as to what the different experimental points actually mean.

The main part of the long chapter 3 is concerned with the theory of the response of various devices to incident waves. The treatment here is most uneven and incomplete, and this section on device–wave interaction must be regarded as a major weakness in the book. For instance the chapter begins in a pedestrian style for twelve pages on the elementary mathematics of the simple harmonic oscillator with a harmonic forcing term, including a digression on the idea of 'added mass', and concludes that the maximum power that can be absorbed by a vertically oscillating

device is $P_{max} = |F|^2/8D$, where $F$ is the forcing and $D$ the total damping, a result that Lighthill (*J. Fluid Mech.* **91** (1979), 253–317) is content to quote. In contrast, seven pages of advanced mathematics taken from Lighthill's paper appear later in the chapter to show that for a two-dimensional upward-facing duct $|F|$ may be in excess of what would be experienced in the absence of the duct. The reader who struggles through this theory will be disappointed to find that this is only a simplified 'local' model and that the theoretical basis for the resulting curves must be sought in the original paper.

More serious than this unevenness is the failure to recognize the importance of the connection between $|F|^2$ and $D$. Having stated the connection, equation (3.4) on p. 99, it is left to the reader to discover that, by substitution, $P_{max}/P_w = \lambda/2\pi$, where $P_w$ is the mean power per unit crest length of the incident wave, and $\lambda$ is the incident wavelength, a remarkable result which has been known since 1975 and which has prompted much of the fundamental work both in the UK and Norway on small isolated devices.

A brief section on the theory of OWC-type devices leads into a useful section on turbomachinery, where it is clear that the author is on more familiar territory. Of particular interest is the description of the ingenious symmetrical Wells turbine specifically designed for coping with the reversing flows occurring in OWC devices.

Later in chapter 3 the author considers devices that operate in more than one mode, and a full description of Salter's duck, the work of Haren and Mei on Cockerell's rafts, and the theoretical and experimental work on the Bristol cylinder is given. A brief section on hydrostatic transmission and a more extended look at gyroscopic conversion systems as intended for Salter's duck leads to a final section on other devices and techniques for wave-energy conversion. The Lancaster flexible bag receives a brief treatment, as do the Norwegian wave-focusing ideas.

There follow two perfunctory chapters on conversion and transmission systems and on construction and mooring of devices, taking up barely eighteen pages in total, whilst the final five pages constitute chapter 6 on environmental, social and industrial considerations. Appendices include further elementary linear wave theory, some dimensional analysis, and a summary of SI and Imperial units, together with relevant conversion tables.

To conclude, this book provides a disinterested description of most wave-energy devices that have merited serious consideration, and this will suffice for many readers. Where it fails is in providing a critical comparison between the various types of devices. Instead the author prefers to remain detached from his material – leaving the more interested reader to attempt the assessment himself – a task made virtually impossible by the uneven amount of material provided on the performance of the different devices. This arises not so much by design, but is due to the dearth of published information on some devices. Most of the research and development on engineering side is still in the form of DOE reports not yet published, which the author, who is not involved in the government programme, may have found difficulty in obtaining. A more serious consequence of this is the extremely brief accounts of the crucial areas of mooring, installation and power-conversion systems. It is in precisely these areas that the most serious problems in producing a viable wave-power station remain.

In contrast with the engineering R & D studies, a large number of theoretical papers on the hydrodynamics of wave-energy devices can be found in the open literature (see e.g. the references in D. V. Evans, 'Power from ocean waves', *Ann. Rev. Fluid Mech.* **13**, 157–187 (1981)). Despite this, the author has failed to present any of the

extremely simple, powerful analytical results which can be derived with relatively little effort, and which makes the field such an attractive one for theoreticians. Too often the author embarks on a piece of theory only to stop short of the main conclusions because they require mathematics 'outside the scope of the text'. Examples of this can be found on pp. 98 and 145. Where the theory is presented in full, the account tends to follow slavishly the original source. This uneven approach will frustrate the reader whose main interest is in the underlying hydrodynamic theory behind wave-energy devices.

In short, the author set himself an impossible task. It is just not possible to provide a balanced overview of all the technical aspects of a still developing field in 200 pages. Maybe in a few years, when the dust has finally settled, and when the UK government fulfils its promise to publish all the vast reports produced on the subject, or perhaps when the next oil crisis forces us to re-examine the potential of wave energy, the definitive version will be produced. But it will take more than 200 pages to do justice to all the efforts of the scientists and engineers who make up the wave-energy community and who sincerely believe in its future as an economic alternative energy source.

D. V. EVANS

**Wind Power Plants, Theory and Design.** BY D. LE GOURIERES. Pergamon, 1982. 300 pp. Hardback £25.00, Paperback £12.50.

Although in Britain wind energy has been the Cinderella of the alternatives since the oil crisis, it has recently moved into the lead position with the announcement of a range of technologically advanced projects over the last two years. In Britain, the U.S.A. and Canada, Denmark, Sweden, the Netherlands and Germany, there are now numerous wind generators of megawatt scale either in operation or under construction. Several of these projects together with a number of early post-war successful wind generators, are helpfully reviewed in the later sections of this book, presenting an impressive volume of evidence for both engineering excellence and for imaginative enterprise in this field over a wide international front. The main purpose and thrust of the book though lies elsewhere. The author has attempted to paint on a broad canvas a picture of remarkable detail. This policy is at once both the making and the downfall of the book. As an introductory text for the new recruit and as fascinating informative bedtime reading for the old hand, the author has made a superb provision. The book touches on all imaginable aspects of wind power calling on practical experience where it was available to the author (and he seems to have gained access to volumes of information requiring considerable effort for interpretation and reduction). On the other hand the treatment is so broad that the information presented is frequently too fleeting or elementary to have impact upon the real problems which would lie on a designer's desk today. The designer or project manager might find this a useful first level introduction to the breadth of problems and range of ideas in this field of knowledge. Specific help of greater technical depth would not, however, be forthcoming. Specialists should read this book for educational reasons but would gain little specific help from it. For example aerodynamic treatments (and surely aerodynamics must be vital to windmill design) fall far short of the best available in the recent literature. Neither do these treatments indicate the way ahead for R. and D. in this relatively new field of engineering endeavour. Thus, appended to the book is a series of elementary computer programs that might suit first level survey of designs but little else. One wonders how useful

these would be except as an entry for the newcomer. Quite useful aerodynamic data are also included but for such a broadly based book the selected bibliography is disappointing in the extreme, being dominated by unedited lists of the proceedings of a series of international conferences held since 1961. Despite these reservations this is an excellent popular level book which should be widely appreciated, and read by all windpower people.

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