wood.

Flexcom Wave

Engineering optimisation software for wave energy systems

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WELCOME

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Flexcom Product Manager

I am pleased to announce the release of Flexcom Wave.

Although traditionally used in offshore oil and gas, Flexcom is a versatile application which also has applications in the renewable energy sector. As far back as 2009 in fact, Flexcom 7.9 saw the introduction of the *Floating Body* coupled analysis feature, which enabled the analysis of floating devices. Since then Flexcom has been successfully utilised in the optimisation of wave energy devices, and results from our numerical simulations have been validated with empirical data derived from experimental test facilities. In response to the growing interest in wave energy, Flexcom 8.9 sees the launch of a dedicated module, Flexcom Wave.

User feedback is an essential part of our software development process. We invite you to join the conversation and welcome your opinions and suggestions which will in turn help guide future development. Feel free to call me at the number below, or simply email any suggestions to software.support@woodgroup.com

We hope you enjoy Flexcom Wave.

Best regards,
Aengus.

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Flexcom Wave

Flexcom Wave is Wood's dedicated simulator package for wave energy conversion devices. It provides enhanced insights into power generation capabilities and structural designs of wave energy converters.

It's quick and easy to build models using the new user-friendly interface. Inputs are defined in engineering terms and logically grouped into familiar components, such as floating body, mooring and power take-off etc. As a designer, you have access to wave resource data at your fingertips, via a direct import from a global database of metocean information.

Detailed engineering analysis facilitates design optimisation for improved efficiency. It enables the exploration of potential advances in energy generation, and assists in the identification of opportunities for cost reduction.

Flexcom Wave presents 3D surface plots of electrical power, as a function of wave height and period. It also predicts device motions, mooring line tensions, anchor loads, and stresses in power cables.

OptiWave

Flexcom Wave is complemented by 'ExceedenceFinance', a financial appraisal product which examines commercial feasibility, to form a fully-integrated design environment known as OptiWave.

ExceedenceFinance provides financial indicators like levelised cost of energy, internal rate of return and net present value. It also supplies Flexcom Wave with access to environmental conditions from open metocean datasets from locations around the globe. Sensitivity analyses may be run to determine where the major risks are in a project.

While both Flexcom Wave and ExceedenceFinance are available as standalone offerings, the OptiWave product bundle represents the complete assessment suite for wave energy designers. The platform helps to unlock investment by de-risking projects, ensures complete transparency of the design process, and provides financial information in an investor's language.

For further information, please contact OptiWave@woodgroup.com or view the product brochure online.

Software Installation

Flexcom Wave is a specialised module which forms part of the overall Flexcom 8.9 installation pack. The software is available for download from our website.

Download Flexcom

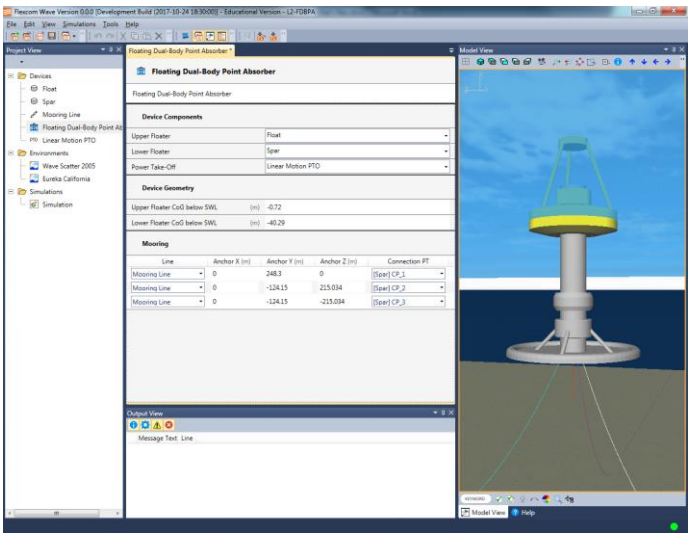
To install the upgrade, save the ZIP file to a temporary folder on your hard drive, unzip the contents, run 'InstallFlexcom.exe' to launch the Setup Wizard, and then simply follow the on-screen instructions.

Should you have any questions, refer to our Software Installation Guide, or Contact our Technical Support Team.

Contents

User Interface

Flexcom Wave may be launched from the *Tools* menu in the main Flexcom user interface. The user experience is somewhat different to the mainstream Flexcom package (there are no keywords!). The module is effectively aimed at software users who would have a background in marine renewable energy, but no prior experience of working with Flexcom. The user interface is sub-divided into three main windows, namely the *Project View*, the *Component View* and the *Model View*.



The *Project View* acts as a container for all of the simulation components, and provides a good overview of the project workspace. It has a tree-like structure and is divided into separate sub-folders for convenience. You can define as many sub-components as you like, even if you do not intend to use all of them immediately. In this way, the project view effectively serves as a library for both current and future projects.

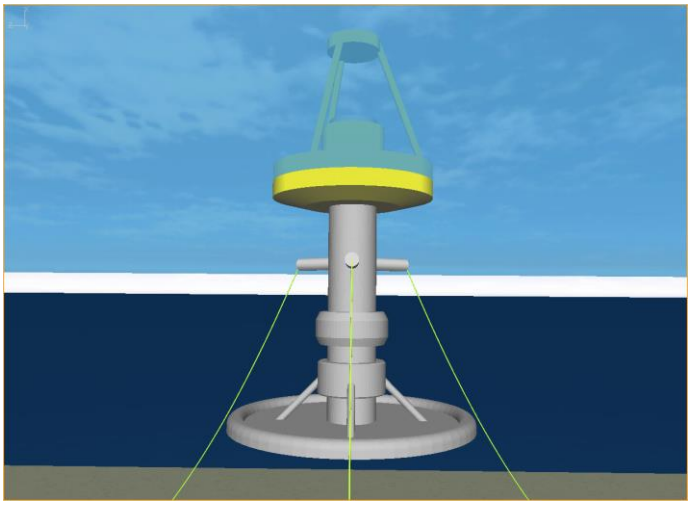
The *Component View* allows the user to specify all the inputs associated with the selected component. Sample components include floating bodies, power take-offs, mooring lines etc. You can assemble a particular device using any of the sub-components already defined. When you are ready to perform a simulation, you nominate a wave energy converter and choose the environmental conditions to which it is subjected. Each component has context sensitive help which may be brought on screen at any time by pressing the F1 button.

The *Model View* provides both a structure preview during model building, and a way of viewing an animation of the structure response after a simulation has completed. During model building, as new components are added to the model, the structure preview is continuously and automatically updated. The Model View provides a control system capable of allowing precise inspection of models, allowing you to move freely and examine any region of the model in detail.

Sample Devices

Floating Dual-Body Point Absorber

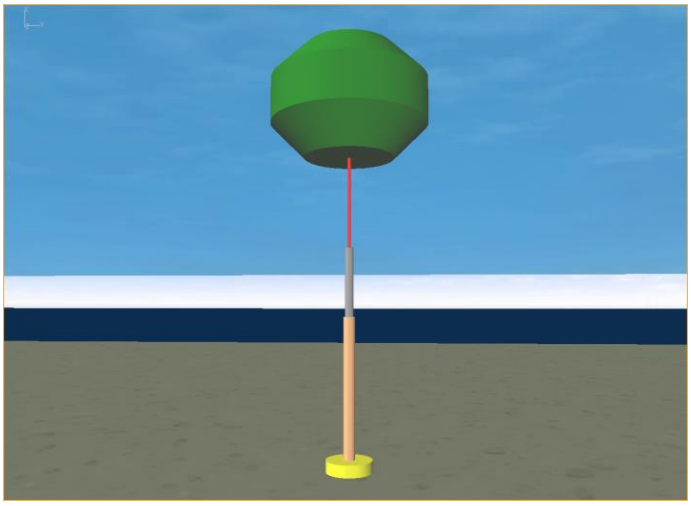
Example No. 1 was inspired by a device known as 'PowerBuoy' (Ocean Power Technologies, 2017), which is a two-body floating point absorber design. The device consists of a surface float which moves in response to wave motion, relative to a vertical column spar buoy which is attached to a large reaction plate submerged at a considerable depth below the mean water line. Generation of electrical power occurs predominately by harnessing oscillations of the surface float in the heave direction (the device is designed to accommodate relative heave motions of up to 4 metres along the shaft). Stability of the device is ensured via a spread mooring configuration, and it is designed to operate in water depths of between 40 and 100 metres.



Another similar device is 'Wavebob', which uses a submerged volume rather than a damping plate for stability.

Submerged Tether-Moored Point Absorber

Example No. 2 was inspired by a device known as 'CETO5' (Carnegie Clean Energy, 2017), which is a bottom-referenced point absorber design. It consists of a cylindrical buoy which is submerged a couple of metres below the still water line. The device is tethered to a hydraulic pump-based power take-off mechanism which is located on the seabed.



Similar devices include 'SeaBased' and 'CETO6' (where the relative positions of the tether and power take-off mechanism are reversed).

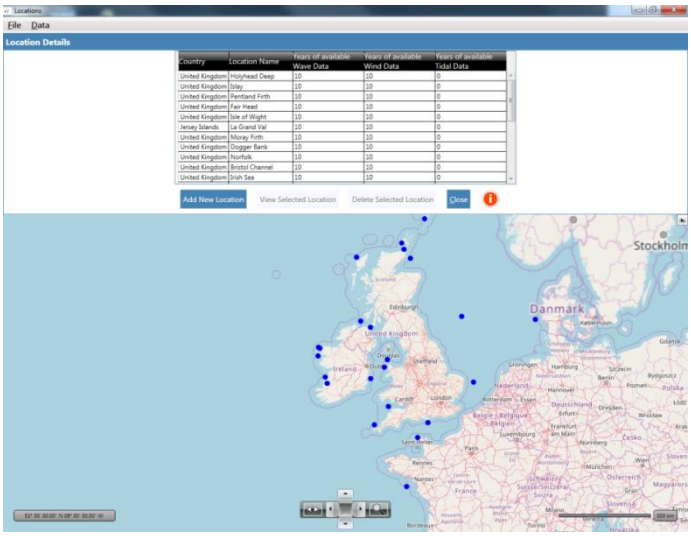
Custom Devices

The above devices were chosen as illustrative concepts, but Flexcom Wave is naturally capable of simulating other types of wave energy converter. If you have a specific device concept which is not currently accommodated by Flexcom Wave, you can always migrate to Flexcom itself.

Migrating is as easy as flicking a switch, you simply select the 'Open as Flexcom Project' from the *Simulations* menu. The wave energy module produces a well-structured, heavily parameterised keyword file which can be subsequently customised to meet your own individual requirements.

Wave Environment

Flexcom Wave interfaces directly with ExceedenceFinance, a third-party software package which contains databases of metocean data for various geographical locations around the world.



Two methods of data transfer between the software products are provided.

- **File Transfer**. This involves a software user working in the ExceedenceFinance environment, explicitly exporting data to an external file, then switching over to Flexcom Wave and manually requesting the retrieval of this data using an import command.
- **Cloud Transfer**. This approach allows a Flexcom Wave user to request and obtain the relevant information directly from within the engineering environment, without having to actually open the Exceedence software.

Both options may be invoked from the *File* menu within Flexcom Wave.

Running Simulations

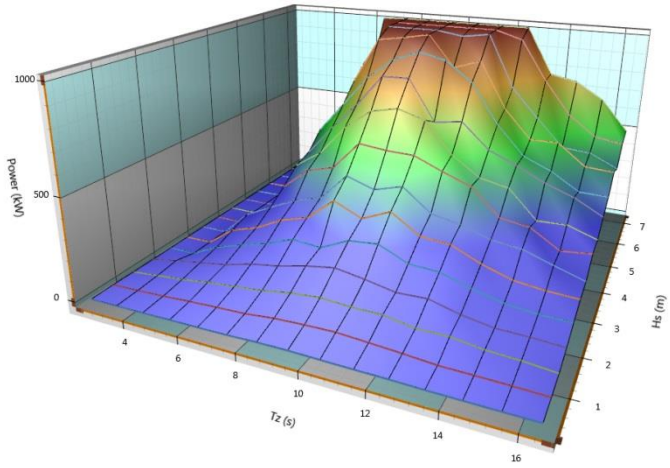
Overview

Once you are satisfied with your selection of device and environment, you can proceed to running a simulation. Flexcom Wave uses all the data which you have defined in the device component and uses it to create a Flexcom model in standard format.

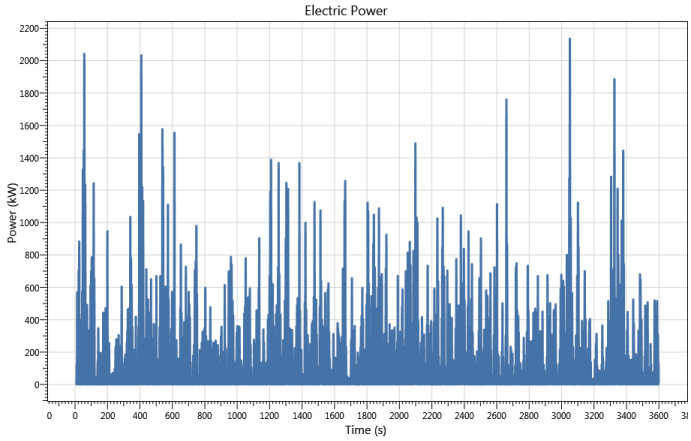
The ambient environment is characterised by a scatter diagram in the environment component. This provides Flexcom Wave with a large number of different combinations of Hs and Tz/Tp/Te. Each combination requires a separate numerical simulation, and the software automatically sets up the required input files, and neatly organises all the simulations into individual, appropriately named files within your project workspace.

Simulation Results

Flexcom Wave provides you with various options for examining key parameters typically associated with wave energy converters, such as electrical power, floating body motions and mooring fairlead tensions. Simulation of a scatter diagram results in a relatively large number of different combinations of Hs and Tz/Tp/Te being simulated. For your convenience, Flexcom Wave automatically collates all pertinent information for you to inspect at a high level.



You may seek further insight by examining results from any of the individual seastates. Simply select the relevant combination of Hs and Tz/Tp, and then view an animation of the wave energy converter in operation, or examine a time history plot of a parameter of interest.



Note also that Flexcom Wave allows you to estimate simulation results for seastate combinations which you have not actually simulated. Based on some selected 'reference seastates' in your scatter diagram, the software estimates results for adjacent seastates based on an extrapolation technique. The simulation of an entire scatter diagram in the time domain can be quite time consuming, so this is a highly efficient solution technique which can save you considerable computational time. However given the inherent approximation involved, caution is strongly advised regarding the user application of this feature.

This 'reference seastate' method can certainly be used during preliminary feasibility studies, and also during initial screening processes which consider various types of wave energy converter in a particular location. For computational efficiency, it may also be useful while you are fine-tuning a chosen device to suit the ambient environment. However once you are reasonably satisfied with a particular design configuration, it is strongly recommended that you explicitly simulate all seastate combinations in the scatter diagram. This will provide the most accurate estimate of a device's operation performance. A related benefit is that it will also allow you to quantify any inaccuracies associated with the 'reference seastate' method.

Hydrodynamic Data Importer

The *Hydrodynamic Data Importer* is a very helpful utility program which accompanies Flexcom Wave. It allows you to automatically import characteristic data relating to a floating body from a range of well-known hydrodynamic simulation packages, including WAMIT, ANSYS Aqwa and NEMOH. Prior to the simulation of floating bodies in Flexcom Wave, important hydrodynamic data is typically sourced externally from a radiation-diffraction program, and the importer aims to streamline the data transfer process, minimising both user effort and the potential for errors in data specification. Flexcom, like most other programs, has its own set of conventions regarding the specification of input data. The importer understands the output file formats and conventions used in several third-party software packages, and can automatically read in the relevant input data, perform the necessary conversions, and create output files which are readily accessible by Flexcom as standard input files.

Software Validation

Flexcom Wave

Verification centres on a floating point absorber which was designed by the U.S. Department of Energy as part of their reference model project 'RM3' (Neary et al., 2014). This is an internationally recognised project whose study objectives included the development of a methodology for design and economic analysis of marine energy technologies, and the application of this methodology to design and analyse open-source reference devices paired with reference marine energy resource sites.

The validation process for Flexcom Wave considers code-to-code benchmarks with other software, and comparisons with experimental data derived from model-scale tank test facilities. Several different scenarios are considered, beginning with simple response decay tests, before progressing to regular wave loading, and a full random seastate scatter diagram. Results of interest include floating body motions, mooring line tensions, and generated electrical power, all of which show close correlation with the reference data sources.

OptiWave

The OptiWave platform (i.e. the integration of ExceedenceFinance & Flexcom Wave) forms the focus of a case study which highlights its potential in the areas of design optimisation, improved efficiency, advances in energy generation, and opportunities for cost reduction. The study, to be published shortly, uses real-world data from a pre-commercial wave energy converter trialled at an offshore test facility.

Flexcom Wave performs the engineering simulation, computes the electrical power matrix, and passes this information over to ExceedenceFinance which subsequently performs a complete financial appraisal. Recommendations for design optimisation stemming from the commercial assessment are then validated by Flexcom Wave from a technical feasibility perspective.

References

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- Neary, V. S., Lawson, M., Previsic, M., Copping, A., Hallett, K. C., LaBonte, A., ... & Murray, D. (2014). "Methodology for design and economic analysis of marine energy conversion (MEC) technologies". Proceedings of the 2nd Marine Energy Technology Symposium, METS2014, Seattle, WA.
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