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Programme Area: Marine

Project: Tidal Modelling

Title: The CSM Web User Interface: User Guide

Abstract:

This document contains the supporting information required by a qualified tidal resource analyst to remotely use the Coarse or Detailed Continental Shelf Model through a Web User Interface. It provides a summary of the inputs required to run the Continental Shelf Model assuming the User has experience in specifying the underlying tidal modelling and tidal technology parameters.

Context:

Launched in October 2011 this project involved Black & Veatch, in collaboration with HR Wallingford and the University of Edinburgh to develop a model of the UK Continental Shelf and North European Waters, 100 times more accurate than existing marine data. This has been used to assess the tidal energy potential around the UK (tidal range and tidal streams), to inform the design of energy harnessing schemes, to assess their interactions, and to evaluate their impact on European coasts. It can also be used to renew and inform flood defences, coastal erosion and aggregate extraction. Now completed, the project has been launched to market under the brand of SMARTtide. This is available to the marine industry under licence from HR Wallingford.

Energy Technologies Institute

MA1009

Tidal Modelling

(Modelling Tidal Resource Interactions around the UK)

PM02.06c

Technical Documentation for the UK Continental Shelf Model

Part C – The CSM Web User Interface: User Guide

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Version 2.0

Participant Lead – HR Wallingford

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CONTENTS

1 EXECUTIVE SUMMARY

The *Energy Technologies Institute* (ETI) is developing a *Continental Shelf Model* (CSM) of the UK waters to assess the tidal energy potential around the UK, to inform the design of energy harnessing schemes and to evaluate their impact on European coasts. *Black & Veatch* (B&V), in collaboration with *HR Wallingford* (HRW) and the *University of Edinburgh* (UoE), is providing support with regard to the development of this model and subsequent use by the tidal power industry. This report has been led by HRW and is part of the *Tidal Resource Modelling* (TRM) scope of work delivered by B&V as prime contractor.

B&V has been consulting on tidal energy since 1975 (B&V was previously Binnie & Partners in the UK until 1995). B&V has a very broad and in-depth experience of both tidal range and tidal current projects, including resource assessment and project development, technology development, due diligence, cost of energy and policy development. Through working on these projects, it has gained a deep technical and commercial understanding of tidal energy projects in addition to simply resource assessment.

HR Wallingford has vast experience of numerical modelling of free surface flows using the TELEMAC system and has been instrumental in its continued development. The TELEMAC system is a state-of-the-art free surface flow suite of solvers developed by a kernel of European organisations including HR Wallingford and other partners such as Electricité de France and the Federal Waterways Engineering and Research Institute of Germany (pertinent information related to the TELEMAC system and, in particular, to the 2D module used in this project is given in the D02 – CSM Requirements Specification document). HR Wallingford's expertise is acknowledged within the UK tidal modelling community as the only entity with an in-depth experience of TELEMAC and its tailoring to specific problems.

The UoE is one of the largest and most successful universities in the UK with an international reputation as a centre of academic and research excellence. The Institute for Energy Systems (IES) is one of five multi-disciplinary research groupings within the School of Engineering at the University. In the most recent UK-wide Research Assessment Exercise (RAE 2008), the School was ranked third in the UK for combined research quality and quantity.

The aim of the TRM scope of work is to address the following fundamental questions:

How will the impacts of tidal range and tidal current energy schemes positioned around the UK combine to form an overall effect?
Will the extraction of tidal energy resources in one area affect the tidal energy resources at distant sites around the UK and Europe?
What constraints might these interactions place on the design, development and location of future systems?

This is achieved through a series of work packages and, ultimately, 10 deliverables outlined below.

D01 – Tidal resource characterisation
D02 – Continental Shelf Model (CSM) requirements specification document
D03 – Scenarios modelling
D04 – Cost of Energy Model and supporting documentation
D05 – Interface specification for detailed tidal current model with CSM
D06 – CSM (coarse and detailed versions) with supporting documentation
D07 – Interactions (analysis and conclusions report)
D08 – Interface specification for detailed tidal range model and the CSM
D09 – Tidal Range model and supporting documentation
D10 – Project dissemination

This report forms part of the D06 deliverables. D06 is comprised of 3 parts:

- Part A – The TELEMAC system: Installation Guide,
- Part B – The CSM Functional and Testing Report,
- Part C – The CSM Web User Interface: User Guide.

This report, Part C, contains the supporting information required by a qualified tidal resource analyst to get acquainted with the remote use of (either the coarse or detailed version of) the CSM through a Web User Interface.

The principal goal of the work carried out by HRW in the organisation of the remote access to the CSM was to provide a simple functional tool to operate the CSM irrespective of the chosen resolution. The CSM is nevertheless a sophisticated hydrodynamic model, based on the mathematically advanced TELEMAC system, which requires suitably qualified personnel to access and operate directly.

This report provides a summary of the inputs required to run the CSM at this stage of development, however, the web user guide will be developed as the project develops. In particular during the next milestone to incorporate more description about the inputs (including a diagram) and definition of the outputs from scenarios modelling which are to be agreed during the work for milestone 3 (D07 – Interactions).

The report assumes that the user has suitable experience in the underlying tidal modelling and tidal technology and, therefore, the nature of the input requirements. For less experienced users, advice should be sought (from those with tidal modelling/tidal technology expertise) to ensure that the inputs are correctly supplied and the resulting outputs are valid.

References to the technical details of the parameterisation of tidal current and tidal range energy schemes are provided in this report. Explanation of the technical parameterisation for incorporation into the TELEMAC source code can be found in Deliverable D02 – CSM Requirements Specification document.

General information about the TELEMAC system, upon which the CSM is based, can be found on the official website hosted and managed by HR Wallingford: http://www.opentelemac.org/. Tidal resource analysts interested in the use of the CSM, or model developers, can refer to Part A of deliverable D06 – The TELEMAC system: Installation Guide, which describes how to install the required software for the CSM to be run (subject to the models being obtained from the ETI and bathymetry data being licensed appropriately). The Installation Guide contains a comprehensive source of references with respect to all practical, technical and theoretical aspects of TELEMAC-2D. This information can be used to investigate and understand how the CSM operates.

HR Wallingford, as a primary distributor of the TELEMAC system for the last 20 years, strongly recommends that new users register for training courses. Interaction with an expert in the system is invaluable and is something that a technical report does not replace. Suitably experienced users of TELEMAC should be in a position to modify the programming of the CSM's operating rules and options if required.

2 INTRODUCTION

In accordance with the acceptance criteria for deliverable D06, a coarse and detailed version of a UK Continental Shelf Model (called the CCSM and DCSM respectively, or CSM together) have been set up based on the open source, industry-driven TELEMAC system.

Further, and still in keeping with the acceptance criteria for deliverable D06, a Web User Interface has been put in place by HRW. Its principal goal is to provide users with a simple functional tool to operate the CSM irrespective of the chosen resolution. Users can upload tidal energy schemes, which automatically trigger submission on the appropriate high performance computers. The CSM is a sophisticated hydrodynamic model, based on the mathematically advanced TELEMAC system, which requires suitably qualified personnel to access and operate directly.

TELEMAC is open source. Access to the source code and documentation is granted through a website following a registration process (http://www.opentelemac.org/). The CSM is accessible to users registered through the same website, but following an additional step specific to the CSM. A separate link on the website takes the user to a special branch of the TELEMAC system which has been created to: (a) host all source codes specific to the CSM implementation under a source-control repository; and (b) keep track of major updates of the standard TELEMAC system for future updates of the CSM. Therefore, the CSM Web User Interface is part of the official TELEMAC website, but is only visible to authorised users of the CSM (see Section 4.1 for details on the authorisation procedure).

It is noted that the CSM Web User Interface is, at this stage of the project, a prototype version in preparation for the tidal energy scenarios modelling work to be carried out in D07. As such, the web interface will be developed further to allow the implementation of all variations in tidal energy scenarios envisaged for D07.

Tidal resource analysts interested in the use of the CSM, or model developers, can refer to Part A of deliverable D06 – The TELEMAC system: Installation Guide, which describes how to install the required software for the CSM to be run (subject to the models being obtained from the ETI and bathymetry data being licensed appropriately). The document also contains a comprehensive source of references with respect to all practical, technical and theoretical aspects of TELEMAC-2D. This information can be used to investigate and understand how the CSM operates if required.

HR Wallingford, as a primary distributor of the TELEMAC system for the last 20 years, strongly recommends that new users register for training courses. Interaction with an expert in the system is invaluable and is something that a technical report does not replace. Qualified and experienced users of TELEMAC are in a position to modify the programming of the CSM's operating rules and options.

3 PROJECT DESIGN / METHODOLOGY

3.1 Definition of a tidal scheme

In accordance with the deliverable D02 of the CSM specification document, (PM01.02), each tidal scheme is defined by:

- A reference name or alphanumeric user-defined ID;
- Parameters defining how the CSM should respond to the presence of the scheme; and
- A geographical extent and location, defined as a polygon or polyline.

The following sections detail the minimum information required for a qualified tidal resource analyst to define a tidal scheme.

3.1.1 Tidal scheme parameters

The characteristics of each tidal scheme are defined by a long list of parameters. In order to assist the user, HRW has produced an MS Excel spreadsheet summarising the required parameters. This spreadsheet is provided to any new user of the CSM upon registration (see Section 4.1).

The MS Excel spreadsheet contains several examples of tidal scheme parameters, defined for the scenarios identified in deliverable D01 and to be tested within deliverable D07. These example parameters can be adopted by users if they wish or replaced by their own alternative parameters. In the spreadsheet, each tidal scheme is defined in a separate column and is identified by a reference ID.

3.1.1.1 Tidal range energy scheme parameters

A tidal range scheme is characterised by a mode (Ebb, Flood or Dual) and 57 numerical parameters as defined in D02 Appendix B (PM01.02). They include parameters defining polynomial functions which represent head-discharge-power characteristics, as well as various other turbine characteristics and turbine operating rules for two different types of turbines. Thus, while the number of parameters (57) is significant, not all the parameters are required for a particular scenario.

For example, the following parameters, developed by B&V, were implemented in the CSM for the La Rance tidal power plant. This parameterisation was used as an example application, from which the code specific to the CSM was developed in TELEMAC-2D in preparation of the work to be carried out in D07.

Site: La Rance – Mode: Ebb		
Sluice input data		
Nsluice	6	Number of sluices
A1sluice	150	Sluice throat area
A0sluice	274	Sluice exit area
CWsluice	19	Sluice caisson width
αebb	1.6	Sluice discharge coefficient on ebb tide
αflood	1.6	Sluice discharge coefficient on flood tide
Turbine input data		
Nturbine	24	Number of turbines
D	5.35	Turbine diameter
A0turbine	80.6	Turbine exit area
CWturbine	13.9	Turbine caisson width
βebb	1.62	Turbine discharge coefficient on ebb tide
βflood	1.62	Turbine discharge coefficient on flood tide
Hrated	5.65	Rated head
Pmax	10	Turbine power at rated head / generator capacity including turbine and shaft (gearbox) losses

Hmin	1.20	Minimum operating head
Hint	4.33	Intermediate head (used for head-discharge characteristic)

Turbine head-discharge-power characteristics							
B1	8.8009	C1	338.4373	E1	944.0334	F1	-0.5387
B2	114.6330	C2	-61.2289	E2	-205.0735	F2	0.2685
B3	-21.3395	C3	14.0552	E3	17.6662	F3	0.4552
B4	1.8536	C4	-1.0082	E4	-0.5285	F4	-0.0306
Turbine start conditions							
Tstart	5						
L1	-7.36	H1	3.50				
L2	-5.89	H2	4.25				
L3	-4.42	H3	5.00				
L4	-3.68	H4	5.25				
L5	-2.94	H5	4.50				
L6	-1.47	H6	2.75				
L7	1.47	H7	2.75				
L8	2.94	H8	4.50				
L9	3.68	H9	5.25				
L10	4.42	H10	5.00				
L11	5.89	H11	4.25				
L12	7.36	H12	3.50				

A screen capture of the MS Excel spreadsheet storing the above case of La Rance and other examples of tidal range energy schemes is provided in Appendix A.

3.1.1.2 Tidal current energy scheme parameters

Rather more simply, a tidal current scheme is characterised by: (a) a packing density; (b) a structural drag coefficient, which depends on the technology; and (c) a power curve for extracted energy, which also depends on the technology.

A screen capture of the MS Excel spreadsheet storing examples of tidal current energy schemes is provided in Appendix A.

3.1.2 Tidal scheme extent and location

The extent of a tidal range scheme is defined by a polyline (generally called a shape) representing the barrage or lagoon alignment along which embankment, turbines and sluices lie. In contrast, the extent of a tidal current scheme is defined by a closed polygon (also generally called a shape) representing the area within which the turbines are to be installed.

The geographic extent and location are stored within binary geospatial files referred to here as "*shp-files*". The format of the shp-file is here assumed to be the standard ESRI shapefile format, which is produced by many *geographic information systems* (GIS) and by analysis and visualisation software often used by engineers. It is developed and regulated by ESRI as a (mostly) open specification for data interoperability between ESRI and other software products.

Alternatively, the software BlueKenue, already identified in PM02.06a as a means to analyse and visualise results from the TELEMAC system, can also be used to draw and create shapefiles. BlueKenue is developed by the Canadian Hydraulics Centre, National Research Council. The software and its documentation can be downloaded from the following link:
http://www.nrc-cnrc.gc.ca/eng/ibp/chc/software/kenue/blue-kenue.html

3.2 Preparation of a tidal scenario

One tidal energy scenario is defined by one or more tidal range and/or tidal energy current schemes. The CSM is designed to apply a group of schemes based on their respective parameterisation and geographical definitions, and to predict the impact of these as one scenario.

As discussed previously (see Sections 3.1.1 and 3.1.2), the parameterisation and the geographical definition of tidal range and tidal current are quite different, and these schemes may or may not be used together. Therefore, tidal range and current schemes are stored in separate pairs of files. Each pair is made of a parameter file and a shape file.

The following explains how to prepare these input files defining a scenario for submission to the CSM.

3.2.1 Preparation of the scheme parameters' files

Because the software MS Excel comes in different versions and formats on different systems, it is not possible for the CSM to directly interpret it. Instead, a single export button has been added to the MS Excel spreadsheet to automatically create a maximum of two "csv-files" (one for all tidal range schemes and another for all tidal current schemes), which form part of the CSM user input files.

The csv-file format is an ASCII text file containing columns of values and names, where columns are delimited by comma. As such, the csv-file is generic, independent of how it was created and can be interpreted by the CSM more simply.

As the user clicks on the export button, a limited number of automated checks are also carried out on the parameter values within the MS Excel spreadsheet for example, a negative number of turbines. The user is, however, responsible for checking that all values are exact and coherent with the definition and the intended characteristics of the tidal energy scheme to be tested.

3.2.2 Preparation of the scheme extent and location files

Similarly to the two csv-files, a maximum of two shp-files are required: one for tidal range schemes and one for tidal current schemes.

The shp-file table should contain a column heading "scheme" associating each shape to the name or reference ID of the scheme. Each shape represents a single tidal scheme.

Finally, given the overall coverage of Northern Europe continental shelf by the CSM, the geospatial coordinate system is assumed to be *Latitude and Longitude ellipsoid WGS84* (LatLong), which means that the shapefile projection has to be defined. If the projection is not defined in the shp-file, LatLong will be assumed.

3.2.3 Further considerations

In the CSM, only one technology can be defined for each tidal scheme. If the user wishes to define a tidal farm and structure with different technologies, it is necessary to create a separate scheme for each device type. In this case, the polygons or polylines for each should not overlap.

In addition, it is important to note that the ID of each tidal energy scheme defined in the csv-file must be the same as that given in the corresponding shp-file. If they are different, the simulation will not be submitted and the user will receive an email indicating that the input files are not consistent.

3.2.4 Packaging of a tidal scenario

To summarise, the user has to produce a minimum of two input files (a pair made of one csv-file and one shp-file, representing a scenario of either a set of tidal current or tidal range energy schemes) and a maximum of four input files (two pairs, each made of one csv-file and one shp-file, the combination of which represents a scenario with sets of both tidal current and tidal range energy schemes).

The final step before submission through the web interface is for the user to zip the csv-files and shp-files into one file, which then contains all the information required to define the tidal energy scenario.

4 RESULTS, THE CSM WEB USER INTERFACE

As mentioned in the introduction, the principal goal of the work carried out by HRW in the organisation of the remote access to the CSM was to provide a simple functional tool to operate the CSM. To achieve this, a Web User Interface has been put in place allowing tidal energy schemes to be uploaded before submission on the appropriate high performance computers.

The following describes the user registration process and the procedure put in place from the time the user uploads a packaged tidal scenario (see Section 3.2)

4.1 User registration and authorisation

The Web User Interface is part of the official TELEMAC website, but is only visible to authorised users of the CSM. Because users of the CSM are also users of the TELEMAC system, access credentials are common. Users of the CSM are part of a privileged group of TELEMAC users, the ETI-CSM group.

Therefore, users of the CSM have to register first as users of the TELEMAC system. This process does not require special authorisation from the ETI or HRW. The official website for access to TELEMAC hosted and managed by HR Wallingford can be found at: http://www.opentelemac.org/.

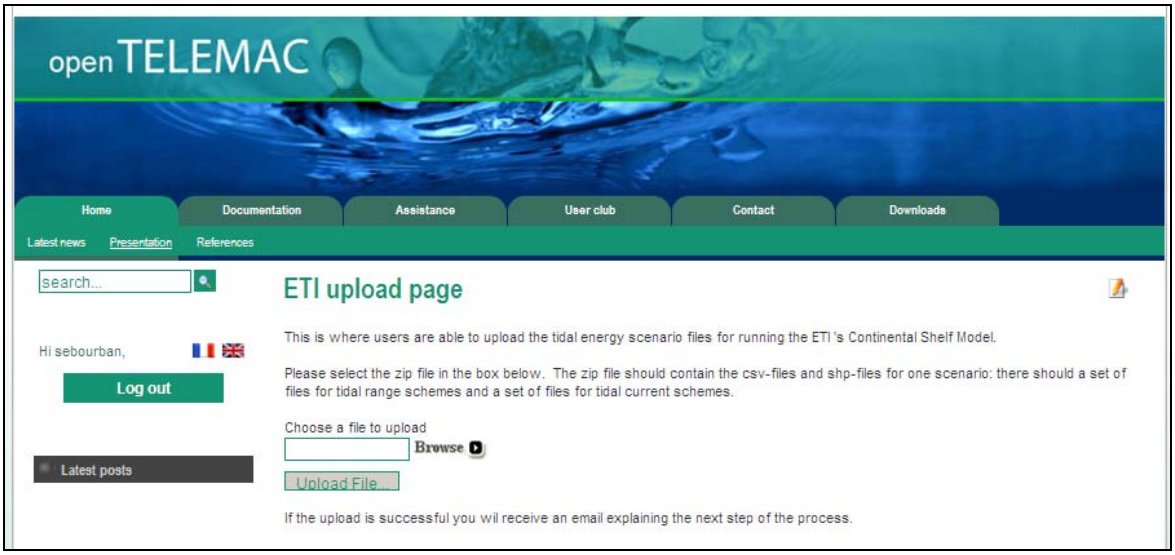
Then, users of the CSM should contact HRW, with the username employed to register to the TELEMAC system, for it to be added to the ETI-CSM group. Licensing agreement and invoicing details will be organised by HRW during this process.

4.2 The webpage(s)

Because of their respective resolutions, the CCSM and the DCSM target different high performance computers, rented at different rates. Thus, two webpages have been put in place, one to submit a tidal energy scenario to the CCSM and the other to the DCSM. It should be noted that the packaged user inputs can be submitted to either version of the CSM.

As a prototype at this stage, the CSM submission webpage can be found either by entering ETI-CSM into the search tool or at:
http://www.opentelemac.org/index.php?option=com_content&view=article&id=117&Itemid=2&lang=en

It should be remembered that a single zip file, containing all the input files (one or two csv-files and one or two shp-files) should be created before uploading on the above website. A snapshot of the webpage on which the data can be uploaded is illustrated below.



4.3 Procedure from user inputs to CSM outputs

The submission of a tidal energy scenario follows three stages:

- As a front end, users should upload individual tidal energy scenarios (one at a time), as a single, self-contained zip file per scenario (see Section 3.2.4). This is done using the “Browse” button to select the file on the user’s system, and the “Upload File” button to start the scenario submission process.

- The CSM then carries out a series of procedural scripts to check the reference ID of each pair of csv- and shp-files, to transform these into files that the TELEMAC code can understand, to submit the user simulation having selected the appropriate remote high performance computers, and to process the results of the simulation into a number of outputs, which are then posted on a FTP site for the user to download. It is noted that smaller outputs (less then 2Mb) are sent via e-mail.

- The user receives an e-mail including either a link to a secure FTP site from which to download the CSM outputs, or the output files themselves (when less then 2Mb). These form the results of the uploaded tidal energy scenarios.

A series of 3 to 6 e-mails is sent to the user, throughout the process, to inform of progress from initial notification of receipt of the simulation to completion.

5 CONCLUSIONS

A Web User Interface has been put in place by HRW to provide users with a simple functional tool to operate the CSM irrespective of the chosen resolution. Users can upload tidal energy scenarios through the interface. This automatically triggers submission on the appropriate high performance computers.

The Web User Interface is part of the official TELEMAC website, but is only visible to authorised users of the CSM. Because users of the CSM are also users of the TELEMAC system, access credentials are common. Users of the CSM are part of a privileged group of TELEMAC users, the ETI-CSM group.

Therefore, users of the CSM have to register first as users of the TELEMAC system, and then, should contact HRW for inclusion in the ETI-CSM group. Licensing agreement and invoicing details will be organised by HRW during this process.

To create a tidal energy scenario, users need to:

1. Use HRW's MS Excel spreadsheet to define the scheme parameters, and export as csv-files;
2. Use GIS software to define the scheme extent and location, and export as shp-files;
3. Create a single zipped file containing both the csv- and shp-files created in steps 1 and 2;
4. Upload the zipped file through the CSM Web User Interface.

The submission of a tidal energy scenario follows three stages:

1. The upload of the zipped file starts the scenario submission process.
2. The CSM then carries out a series of procedural scripts to check the reference ID of each pair of csv- and shp-files, to transform these into files that the TELEMAC code can understand, to submit the user simulation having selected the appropriate remote high performance computers, and to process the results of the simulation into a number of outputs, which are then posted on a FTP site for the user to download.
3. The user receives an e-mail including either a link to a secure FTP site from which to download the CSM outputs, or the output files themselves (when less then 2Mb). These form the results of the uploaded tidal energy scenario.

It is noted that a series of e-mails is sent to the user, throughout the process, to inform of progress from initial notification of receipt of the simulation to completion.

GUIDE TO APPENDICES

Appendix A – The MS Excel spreadsheet, scheme parameterisation

APPENDIX A – THE MS EXCEL SPREADSHEET, SCHEME PARAMETERISATION

The MS Excel user spreadsheet is designed to facilitate data entry for tidal energy schemes and automatically produce the relevant csv-files, which are used as inputs to the CSM. It is noted that the MS Excel spreadsheet can also be used to add calculations and plots as long as the templates for the principal sheets are not modified.

There are two principal sheets available to users, 'TidalRange' and 'TidalCurrent'. These hold the parameters for tidal range and tidal current energy schemes respectively. In these sheets, each column represents one tidal energy scheme, identified by a unique identifier 'SchemeID'.

A screen shot of the introductory page, the tidal range and tidal current inputs pages are provided below (see, Figure A1 and Figure A2). These will be developed further throughout the next deliverable D07 – Interactions (analysis and conclusions report) to ensure that the interface is suitable for use with scenarios.

Pre-defined tidal energy schemes can be automatically added as extra columns by selecting one of the available schemes in the drop-down menu at the top of the sheet, and then pressing the 'Add' button. The additional scheme is inserted to the right of the existing table. At present, only the La Rance scheme is available from the drop-down menu. To insert a new scheme, the user needs to insert the data in the relevant 'TidalRange_example' or 'TidalCurrent_example' pages. These will become available in the drop-down menu the next time the MS Excel spreadsheet is opened.

Once the data have been entered, it is strongly advised to save the MS Excel spreadsheet. Following this, users should click on the 'Export' button on the first sheet to create the csv-files in the same folder as the spreadsheet, and the spreadsheet will be closed.

The csv-files can then be uploaded along with the corresponding shp-files on the Web User Interface (see Section 4.2).

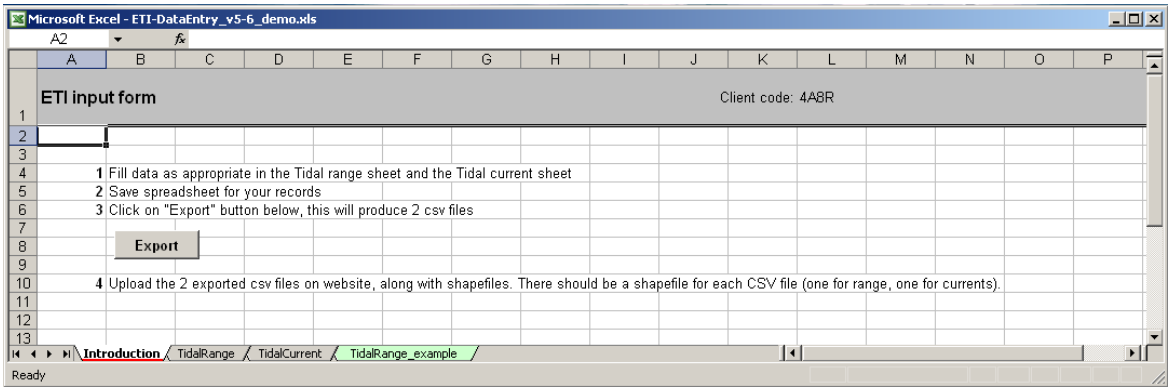


Figure A1 – Introduction sheet

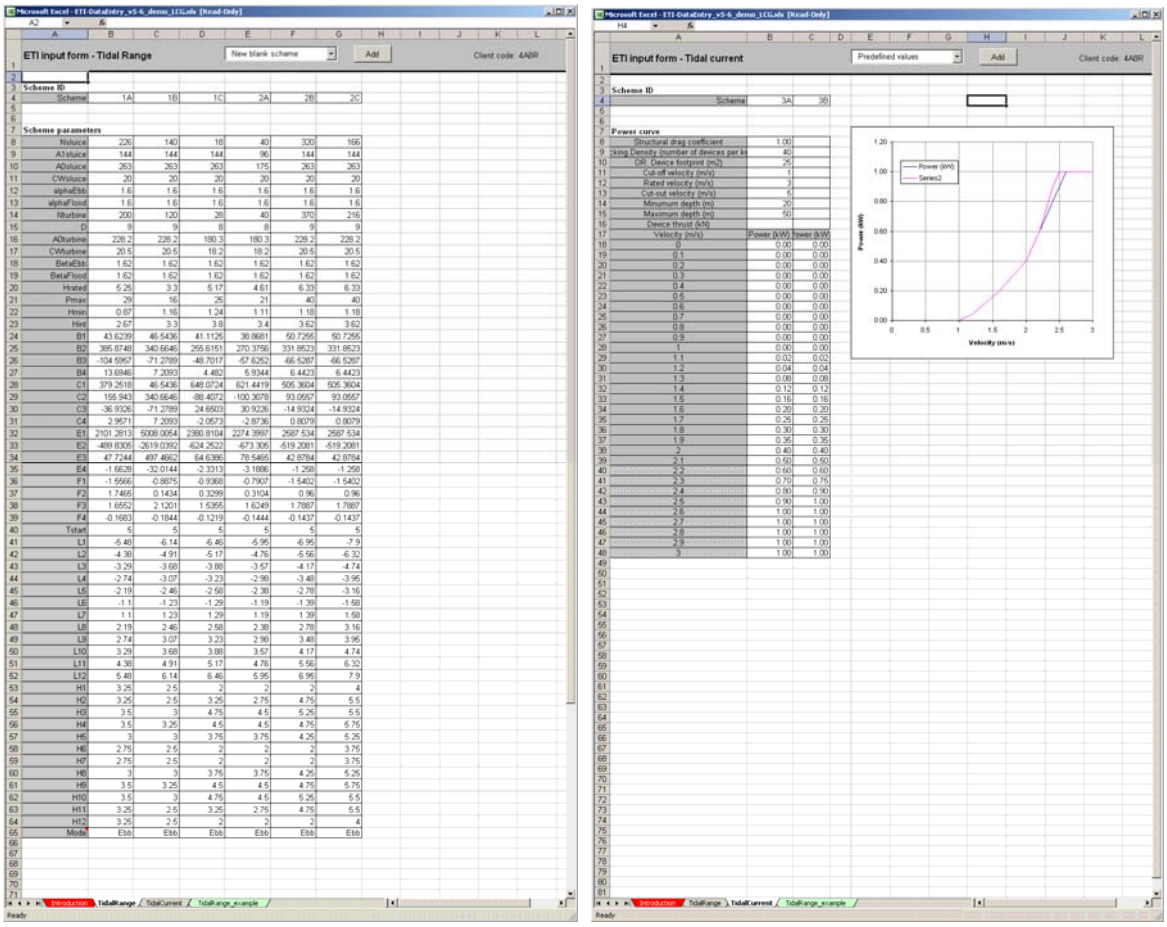


Figure A2 – Tidal Range and Tidal Current input sheets