MSc SES. TSE Assessment 2 - Part A (Tidal Energy)

Version 1.3

Part B on Integration and Storage will follow.

PAGE-LIMITS:

SECTION: Types of Tidal Turbine & Understanding the Resource: Sensors, comprising Q1 to Q4.

[2 Pages including Figures, minimum font size of 11, minimum margins 1cm]

SECTION: Tidal Energy Yield, comprising Q5 to Q8.

[4 Pages including Figures, minimum font size of 11, minimum margins 1cm]

SECTION: Operations and Maintenance

[2 Pages including Figures, minimum font size of 11, minimum margins 1cm]

REMINDER: You should reference any used materials in a sensible and clear way.

Types of Tidal Turbines

Q1)

The most commonly commercially deployed type of tidal turbine, to date, is the seabed-mounted Horizontal Axis Tidal Turbine. Name 3 alternate design concepts. Pick one concept and list 2 advantages, and two disadvantages when compared to a seabed-mounted HATT.

Understanding the Resource: Sensors

Table 1. A selection of candidate tidal sites

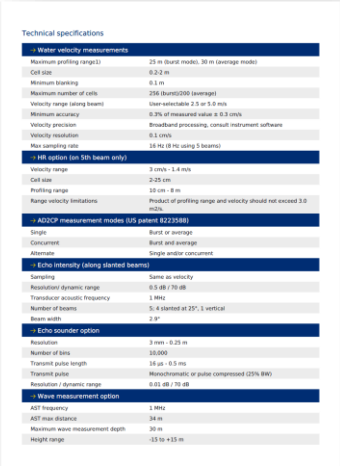
Site Number	Water Depth	Flow-speed Range Ebb tide: negative values Flood tide: positive values	Channel Width	Flood / Ebb Misalignment Angle (deg)
1	45m	-2.0m/s to 2.5m/s	800m	10
2	20m	-2.0m/s to 2.5m/s	100m	5
3	20m	-2.0m/s to 2.5m/s	100m	40
4	45m	-3.9m/s to 4.2m/s	800m	10
5	45m	-3.9m/s to 4.2m/s	100m	10

Q2)

From the three Acoustic Doppler Current Profiler (ADCP) datasheets provided on Learn, select a product (also listed below) that you think would be most suitable for use in a resource measurement campaign for Site #4 in Table 1. Briefly justify your answer.

Assumptions: The instrument will be seabed-mounted.

Instrument 1- Nortek Signature 1000
Instrument 2 – Origin 600
Instrument 3 – RDI Workhorse II – 300KHz



Nortek Signature 1000 **Origin 600** **RDI Workhorse II – 300kHz**

The IEC TS 62600-200 [2] requires current velocities to be measured with an Acoustic Doppler Current Profiler (ADCP) during the power performance assessment. Among many configurations, the most common current profiler used in the tidal industry is a diverging beam ADCP in pairs of opposing beams. The position of instruments is to be placed at a large enough distance so that the flow is undisturbed from the operating TEC but not too far to ensure a true representation of the flow characteristics around the TEC location is observed. The position of these current profilers is clearly defined in the technical specification, and the initial influence of these positions has been analysed in Ref. [15]. It recommended further analysis to fully understand the impact of ADCP placement on the power curve.

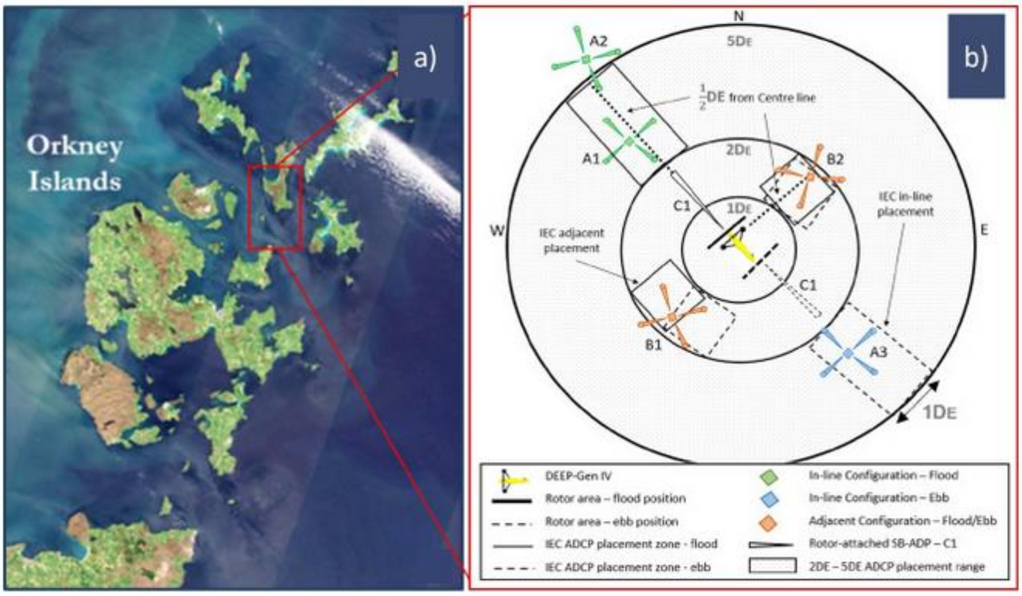


Fig. 1. Map showing (a) the Orkney Islands, Scotland, and the location of the European Marine Energy Centre (EMEC) tidal energy test site (red rectangle). The plan view of the measurement campaign is presented in (b), where the IEC TS 62600-200 highly influences the instrument placement and is placed relative to the DEEP-Gen IV [2]. A1, A2, A3, B1 and B2 are seabed current profilers, and C1 is a rotor-attached current profiler.

Figure 1. An excerpt from [Evans et al. 2023] - DOI: https://doi.org/10.1016/j.renene.2023.05.031

Q3)

Describe the important factors to consider when performing a high quality Tidal Turbine Power Performance Assessment (PPA) (e.g., IEC62600-200) when using Acoustic Doppler Current Profilers (ADCP)s. Figure 1 provides some useful information.

Q4)

List three sources of uncertainty in the measurements and/or processed datasets that arise from using ADCPs to characterise tidal channels.

Tidal Energy Yield

On Learn there is a link to a folder within the *Datasync* file-sharing platform where multiple data files have been generated.

The files are of the following format:

1. ADCP Files in ASCII format:

[Student Name]_Data_Tidal_Flow_ADCP_[XXXXX]_Velocity_East.csv,
[Student Name]_Data_Tidal_Flow_ADCP_[XXXXX]_Velocity_North.csv
,where elements in square brackets are variables. Each dataset is unique.

Rows: time-series data comprising 10-minute average flow speeds covering time period 17-Sep-2014 07:00:00 to 13-Dec-2014 16:20:00. The flow speeds are either the East component of velocity, or the North component of velocity (as this is what this class of instruments generate).

Columns: Each column contains the 10-minute average data as recorded by a seabed-mounted ADCP with Column 1 = Instrument data bin (cell) 1…. Column n = Instrument data bind (cell) n.

2. Tidal Turbine Power Curve Datasheets

   MSC_SES_Tidal_Power_Curves_v1.xlsx

Use the data provided to:

Q5)

Calculate the Energy Yield for the given data duration for the two variants of a tidal turbine (see below), using a calculation of the Power Weighted Rotor Average (PWRA) as an intermediate step. Clearly explain your methodology and summarise any assumptions and/or limitations of your approach.

Assume that:

1) it is acceptable in this implementation of the PWRA method to use the supplied 10-minute averaged datasets (as opposed to raw original data sampled at 1Hz),
2) you should calculate and use *velocity magnitude* in your PWRA step (and ignore vertical velocities as these are not provided).
3) That each data bin/cell is 1 m in depth

NOTE: You may want to review, re-use, and/or build upon the supplied spreadsheet from the Tidal Seminar.

Machine Variant 1) 20 m Diameter Single Rotor Floating HATT with hub-height of 15 m above sea-bed.
Machine Variant 2) 16 m Diameter Single Rotor Floating HATT with hub-height of 20 m above sea-bed.

The area sections of these rotors, (1 m deep sections) have been provided in the excel sheet below. The values are the scaled individual areas of each rotor "strip" i.e., they are the area of each strip divided by the Total Area of the rotor.

MSC_SES_Tidal_Power_Curves_v1.xlsx

Q6)

For both turbine variants calculate the capacity factor for the time period covered by the data.

The capacity factor is an example of a performance metric of a tidal turbine. List two other performance metrics related to energy production of a tidal turbine that you think could be important and briefly explain why.

Q7)

Briefly describe an outline of a method that *could be used in the future* to estimate (i) total annual energy yield and (ii) life-of-operation energy yield and discuss its limitations and any assumptions you have made. (Calculations are not required)

Q8)

Produce a clear figure (or figures) of the timeseries of the flow speeds derived from the "East" and "North" velocities provided in your dataset and comment on three key features of the flow's dynamics that the figure helps to reveal.

Part B – Operations and Maintenance

The XLS spreadsheet from the Tidal Seminar has an updated tab/sheet labelled "Thresholding Data". It provides a means of checking whether or not a threshold in a given parameter has been exceeded in a corresponding dataset (timeseries) and shows resulting frequency of occurrences of these thresholded events. Use the spreadsheet tab "Thresholding Data" as a starting point to answer the following question:

Q9)

For each of the following two different operations and maintenance (O&M) activities find the total number of individual occurrences where these could take place - for the short duration of the data supplied – given the provided constraints in Table 2. Explain concisely and clearly your methodology.

O&M Activity 1 – an emergency manual checking of an alarm, job duration, 20 minutes.
O&M activity 2 – a full inspection of various sub-systems, job duration, 12 hours.

Table 2. O&M activities

Activity ID	Description	Constraint 1	Constraint 2	Constraint 3
1	"quick check on a sensor using small low-capability vessel"	Hm0* < 0.5 m	U < 1.00m/s	Time required: 20mins
2	"long-duration repair with large vessel"	Hm0 < 1.5 m	U < 1.75m/s	Time required: 12 hours

*Hm0 is "significant wave height", measured in metres, and is a statistical description used in engineering related to average wave heights within a specified timeframe (e.g., 10 minutes).

Q10)

Concisely list 3 other constraints - beyond the simple constraints listed in Table 2 - that might play a role in the management of the Operator's access to their the tidal turbines.