

dti

**PRELIMINARY TIDAL CURRENT
ENERGY DEVICE PERFORMANCE
PROTOCOL**

**CONTRACT NUMBER:
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dti

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PRELIMINARY
**TIDAL CURRENT ENERGY:
DEVICE PERFORMANCE PROTOCOL**

Version 1.3 - February 2007

**Commissioned by
The Department of Trade and Industry**

**MRF/02/00006/00/00
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**Prepared by
The University of Edinburgh**

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Disclaimer

This report is submitted in good faith only. The University of Edinburgh will not accept responsibility or liability for third party use or interpretation of the findings.

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Definitions

The following definitions describe terminology as it is used within this document.

- “Acceptance Date” The date on which the Grant offer acceptances duly signed by the Scheme participant are returned to the Secretary of State, accompanied if a condition of grant offer by evidence that all necessary private sector finance for the Project has been secured and is unconditional.
- “Acoustic Doppler (AD) device” An instrument which generates a 3-dimensional current profile by analyzing the Doppler-shift of fixed-frequency acoustic echoes. The instrument measures the Doppler-shifted, fixed-frequency echoes backscattered from scatterers (plankton and sediment) in the water and converts the echoes to north/south, east/west, and vertical velocity components. Velocity profiles are determined by range gating echoes so that velocities are determined at pre-set intervals along the acoustic path (called bins).
- “Bathymetry” The underwater equivalent of topography. Bathymetry describes the spatial variations of water depth measured from the sea surface to the sea-bed.
- “Centroid” the point that may be considered as the centre of a one- or two-dimensional figure, the sum of the displacements of all points in the figure from such a point being zero.
- “Chart datum” The height of water at the lowest astronomical tide (LAT).
- “Commissioning date” The date on which the Scheme participant has declared the Eligible Facility to be commissioned, being
- (i) No earlier than the date on which the first kWh of Metered Energy has been delivered to the Distributor.
 - (ii) No later than 2 years after the Acceptance Date.
- “COP standard” Code of practice for the metering of energy transfers for settlement purposes. The appropriate COP standard to apply is determined by the rated capacity of the facility.
- “Device performance envelope” Device performance is not characterised by a single value or criterion, a power curve, annual energy production and continuous record of the operational status of each device is utilised. Together, these performance criteria describe the ‘device performance envelope’.

- “Distributor” The UK Public Electrical Supplier or the UK Transmission Line Operator that operates the electrical network into which electrical energy generated by the Facility is distributed.
- “Eligible Facility” The part of the Facility that is eligible for Capital Grant and Revenue Support from the Scheme.
- “Ensemble average” Terminology used by AD device manufacturers to describe the processed output produced by an AD device. The ensemble average encompasses various internal processing typically including time averaging over a series of measurement samples (pings) and manipulation of the output from the various beams of the device to produce a co-located ‘geographical’ output.
- “Facility” The generating station, comprising of multiple generator units and any associated infrastructure, which is capable of the metered export of electrical energy.
- “IHO Order 1” States the Standards recommended for the scale of surveys and the density of soundings; accuracy of horizontal position; accuracy of depth and other various measurements. Issued by the International Hydrographic Organisation.
- “Metered Energy” Electrical energy generated by the Eligible Facility and delivered to the Distributor net of any electrical energy imported into the Eligible Facility.
- “Metering System” An electrical metering system compatible with the requirement specified in clause 5.
- “MRDF” Marine Renewable Deployment Fund.
- “Performance surface” The area of resource that the operational part of the device impinges upon. In the case of a ducted, shrouded, vaned or similar device operation, the performance surface is defined as the cross-sectional area of the inlet. In the case of a horizontal axis turbine, the performance surface is defined as the cross-sectional area swept by the turbine blades. In the case of a vertical axis turbine, the performance surface is defined as the vertical cross-sectional area swept by the turbine blades (i.e. the swept area perpendicular to the horizontal flow).
- “Power curve” The Power curve is a graphical representation depicting the performance of a converter device at a measured current velocity (metres per second) relative to the power produced (kilowatts).

| | |
|-------------------------------|---|
| “Principal current direction” | The u- and v- velocity components of a tidal current record make up a bivariate data set. The principal angle for a bivariate data set can be calculated as described by Presendorfer (1988). This principal angle defines the principal current direction. Mathematically, the principal covariance of basis vectors parallel and perpendicular to the principal current direction is 0. |
| “Project” | The work, costs, funding, payments, timeline and deliverables for the construction and operation of the Eligible Facility that is supported by the DTI under the Scheme. |
| “Project monitoring officer” | The individual who is monitoring the Project on behalf of the Secretary of State. The Project monitoring officer acts as the arbiter in determining a course of action that meets the ‘fit-for-purpose’ remit of the protocol to ensure that the solution neither advantages nor disadvantages the individual Scheme participant affected under circumstances when deviation from the protocol procedures is unavoidable. |
| “Scheme” | The Wave and Tidal Stream Energy Demonstration Scheme. |
| “TEC” | Tidal Energy Converter. A device used to convert energy from tidal currents to electrical power. |
| “Test-site” | Location of the TEC array. |
| “Test-site envelope” | An area the extent of the proposed array footprint plus a minimum extent of 1km up and downstream and 100 metres either side, perpendicular to the flow direction. |
| “WGS 84” | World Geodetic System 1984. The datum used for GPS positioning and adopted by the protocol as the universal positioning specification. |

Symbols & Units

| | |
|-------------------|---|
| “m” | metres. |
| “m/s” | metres per second |
| “V” | velocity magnitude |
| “ ρ ” | density (kg/m ³). |
| “A” | Area (of the performance surface). |
| “U” | In the case of a fixed (e.g. non-yawing) TEC device, the velocity component perpendicular to the device performance surface. In the case of a TEC device capable of orientating to present the performance surface into the principal current direction, the velocity vector magnitude. |
| “ $U_{perf(i)}$ ” | the averaged representative current velocity in bin <i>i</i> (m/s). |

| | |
|-----------------|--|
| $P_{(i)}$ | the averaged measured power output in bin i (Watts). |
| $U_{perf(i,j)}$ | the representative current velocity of data set j in bin i . |
| $P_{(i,j)}$ | the measured power output of data set j in bin i . |
| $N_{(i)}$ | the number of 10 minute data sets in bin i . |

Background

The DTI's Wave and Tidal Stream Energy Demonstration Scheme, part of the Marine Renewable Deployment Fund (MRDF) supports the development of full-scale, grid-connected, multi-device wave and tidal-current energy demonstration facilities. An important objective of the Scheme is the production of transparent, unambiguous, consistent and meaningful assessments of the performance of tidal devices and arrays of tidal devices. This will enable the performance of devices to be effectively validated and, consequently, enable government, industry and the finance/investment community to form soundly based judgements of the commercial prospects of the technologies being demonstrated. To ensure that the performance of different devices is assessed on a consistent basis, there is a need for an explicit written protocol, which will form part of the contract between MRDF Scheme Participants and the Secretary of State. The protocol sets out in detail how performance assessment should be conducted.

This document proposes a preliminary Protocol for the performance testing of tidal current energy devices/arrays. Feedback on the initial draft Protocol document has been compiled, and where deemed appropriate, incorporated into the finalised preliminary protocol. This exercise is detailed in the accompanying "Response to feedback" document. It is acknowledged at this stage that knowledge gaps exist which impact on the proposed Protocol. These knowledge gaps have been identified in the accompanying documentation. Research to address the key knowledge gaps will inform the content of the final Protocol document adopted by the DTI for the MRDF Scheme.

1 Scope

1.1 Overview

There are currently no recognised or common procedures for assessing and comparing the performance of full scale tidal energy converter (TEC) devices at sea. The need for a clearly defined performance testing protocol is however obvious as proposed device technologies reach the stage of full-scale, grid-connected operation. It is acknowledged that significant ‘grey’ areas of fundamental understanding restrict the present development of a hard and fast procedure for performance testing at the level of a British or International Standard as exists for more mature technologies.

1.2 Objectives

The purpose of this document is to outline a preliminary protocol that is fit-for-purpose within the limitations of current understanding, and therefore ready for immediate application within the confines of the MRDF Scheme. Fit-for-purpose in this context is defined as obtaining an effective balance between quality and quantity of data collection, processing and delivery and operational achievability without being overly burdensome on the Scheme participants. The protocol must meet the needs of the TEC developer community while providing reliable data to inform the relevant governmental, planning and financial stakeholders. The overall objective of the protocol is therefore to provide a robust and auditable procedure for determining the performance characteristics of an individual TEC or array of similar TEC devices.

This protocol specifies two separate procedures. Both procedures specify a field based measurement program, data analysis methodology and standardised reporting format, which are as follows:

- The first procedure specifies a methodology for characterising the resource available at the intended location of the test site.
- The second procedure specifies a methodology for characterising the device performance envelope. Device performance is characterised using a measured power curve, measured annual energy production and a continuous record of operational status.

These points outline the major requirements of the MRDF Scheme protocol. Individual developers may wish to conduct more rigorous monitoring and analysis of the resource and device performance than that specified in this protocol. This falls outside the scope of the MRDF Scheme protocol and is therefore at the individual developer’s discretion.

2 Normative References

IEC 61400-12-1 Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines

IEC 60044-1: 1996, Instrument transformers – Part 1: Current transformers.

IEC 60186:1987, Voltage transformers (amended 1988 and 1995).

IHO S44: 1998, IHO Standards for Hydrographic Surveys, 4th edition.

3 Procedure to characterise the local resource

3.1 Rationale

TEC device power production is fundamentally limited by the magnitude of the resource available for harvesting. Site selection is therefore a key design consideration. Matching of an efficient device with an appropriate resource will optimise device performance. It is therefore necessary to adequately characterise the local resource to enable long-term performance assessment, and predictions of energy production prior to deployment.

The tidal current resource at a particular location can be reliably predicted based upon harmonic analysis of the in-situ current measured across a defined period. A 30-day continuous record prior to device deployment is acceptable for meeting the requirements of the MRDF Scheme, as this enables accurate distinction between 23 of the major tidal constituents using harmonic analysis. These tidal constituents will then be used to predict the tidal current and the associated kinetic energy across the lifetime of the intended device deployment for that particular site.

3.2 Data Collection

Site and resource data are to be obtained prior to any site development taking place. If the data specified in clause 3.2.1 or 3.2.2 already exist, are accessible, and meet or exceed the standard specified in the protocol, submission of these data supersedes the requirement for further data collection to characterise the local resource at the discretion of the project monitoring officer.

3.2.1 Test site

The test-site envelope shall be surveyed in accordance with the minimum requirements of IHO “Order 1” standard as prescribed by the 4th edition of the IHO Standards for Hydrographic Surveys (1998). The purpose of the IHO standard relates to navigation, a similar level of accuracy and resolution is suitable for adoption within the protocol. The requirements of sections 4.1 and 4.3 of the IHO

standard are not deemed necessary and hence not required in order to comply with this protocol.

3.2.2 Resource measurement - pre deployment

The current resource at the test-site should be measured using an Acoustic Doppler (AD) device suitable for measuring the variation of the horizontal current velocity profile vertically through the water column. The AD device should have a minimum of three acoustic beams. The AD device should also have a pressure sensor capable of recording the variation in depth due to the tidal cycle. The manufacturer guaranteed error associated with the selected AD device must be less than $\pm 2.0\%$ of the measured current velocity. The AD device must have a velocity range of at least ± 5 m/s and resolution better than ± 0.01 m/s. The AD device shall be bottom mounted within the test-site envelope, orientated to capture a vertical snapshot, and located at the centroid of the intended array, or nearest position which meets the following requirement. The difference in depth between the AD and nearest intended TEC deployment position must be established from the pre-installation site survey data to be less than $\pm 15\%$ of the depth to chart datum. The AD device should obtain discrete samples at a minimum resolution of 20 seconds between samples. The AD device recording period should be set as a minimum resolution of 10-minute time-stamped ensemble average data (i.e. 10 minute ensemble average or less). If the recording period is shorter than 10 minutes, the period should be a suitable multiple of 10 minutes. The AD record should be binned at a minimum resolution of 2 metres. The minimum required measurement period is 30 days. A contiguous record should be obtained across the measurement period. Any deviation from this methodology must be agreed in writing with the project monitoring officer prior to the inception of data collection.

3.2.3 Time-keeping

Time shall be universally set throughout all record keeping to Greenwich Mean Time (GMT).

3.2.4 Data analysis

For the purposes of characterising the local resource, the record spanning the measurement period at the centroid of the performance surface should be extracted (e.g. at the depth of the rotor axis in the case of a horizontal-axis turbine). The record should be suitably manipulated to provide a 10-minute resolution data set. The data should be analysed to determine the principal current direction. The data set should then be processed along the principal current direction using a recognised, referenced method of harmonic analysis capable of determining a minimum resolution of 20 tidal constituents, including the 10 most significant constituents as defined in standard order (see table 1).

| Common name | Speed (degrees/hour) | Rank in standard order |
|-------------|-------------------------|------------------------|
| M2 | 28.9841042 | 1 |
| S2 | 30.0000000 | 2 |
| N2 | 28.4397295 | 3 |
| K1 | 15.0410686 | 4 |
| M4 | 57.9682084 | 5 |
| O1 | 13.9430356 | 6 |
| M6 | 86.9523127 | 7 |
| MK3 | 44.0251729 | 8 |
| S4 | 60.0000000 | 9 |
| MN4 | 57.4238337 | 10 |

Table 1: Tidal constituents in standard order

The determined constituents are then to be used as the bases for a tidal prediction spanning the lifetime of the intended deployment within the MDRF Scheme remit at a minimum resolution of 30 minutes. The data should be processed using a recognised, referenced method of tidal prediction capable of incorporating all the tidal constituents derived from the preceding harmonic analysis. The tidal prediction data should then be used to determine the variation of the kinetic energy flux over the performance surface of the participants’ intended TEC device throughout the predicted time period using equation (1).

$$P_{KE} = \frac{1}{2} \rho A U^3 \quad [1]$$

The analysis in section 3.2.4 should be conducted by a competent individual with suitable experience in performing tidal prediction and harmonic analysis.

3.2.5 Reporting

At the conclusion of the measurement and analysis process (which must be completed prior to inception of device installation), the following outputs should be reported to the project monitoring office acting on behalf of the DTI:

- Site survey report detailing the output from clause 3.2.1, and the intended position of each intended TEC device (in latitude and longitude coordinates (WGS 84) specifying degrees as a decimal number to five decimal places after the point).
- Specification of the AD device deployed and the user defined settings employed.
- A spreadsheet detailing the measurement record from the AD device output throughout the period used to derive the tidal constituents (current velocity components in units of mm/s), including the signal-to-noise ratio and standard deviation where this data is available. The output from the pressure sensor will also be reported at the same recording interval.
- The principal current direction of the AD data measurement record derived from the 30-day measurement period in degrees to one decimal place after the point. The principal current direction can also be defined as the major

principal axis, with the minor principal axis lying at right angles to the major principal axis.

- The amplitude (to 4 decimal places after the point) and phase (degrees to 4 decimal places after the point) of each tidal constituent determined in clause 3.2.4.
- The annual summed value of the kinetic energy flux (kWh per year) available across the performance surface of the participant's intended TEC device (assuming orientated perpendicular to the principal current direction in the case of a fixed (e.g. non-yawing device)) using a prediction of the resource variability based upon the harmonic analysis of the site. Predictions for each year of the project lifetime within the MRDF scheme should be returned.

4 Procedure to characterise the TEC device performance envelope

4.1 Rationale

The performance envelope of an individual TEC device will be characterised using a power curve produced using measured in-situ data, analysis of the operational status of each device, and annual energy produced by the eligible facility (described in sections 4 and 5 respectively). The power curve relates the variation of electrical power produced by a particular TEC device to the variation in the magnitude of the incident resource (characterised as the current velocity). **The Scheme participants are responsible for *providing the data necessary for the production of a power curve*.** The DTI or its designated representative will independently utilise this data to produce a power curve representative of that participant's device performance. The intended procedure for production of the power curve is detailed in section 4.4 for reference purposes. The data provided by each Scheme participant to the DTI for power curve production is generated by collecting simultaneous measurements of current velocity and power output of an individual device for a 15-day period during device operation. This ensures that a fully representative range of tidal current velocities and associated power outputs will be captured. The data required to produce a power curve as detailed in section 4.3 must be submitted within 18 months of the commissioning date of the eligible facility. It is the prerogative of each individual Scheme participant to repeat the data collection procedure to inform the production of an updated power curve as and when appropriate after the initial submission, to be submitted as being representative of an improved version of the technology deployed. The most recently derived power curve is deemed to be representative of the current state-of-the-art performance of the developers TEC device technology, and will be incorporated in the annual review released by the DTI.

4.2 Data collection

The data collection procedure in clause 4.2.1 must be conducted simultaneously with the data collection procedure in clause 4.2.2. The data collection fulfilling clauses 4.2.1 and 4.2.2 must relate to the same individual TEC device within the array. The data collection covers a 15-day continuous measurement period. Time shall be universally set throughout all data collection to Greenwich Mean Time

(GMT). Time synchronisation between the incident resource and delivered power measurement record bins is required.

4.2.1 Incident resource measurement

Incident resource measurement should be conducted using an Acoustic Doppler (AD) device suitable for measuring the current profile variation vertically through the water column. The AD device should have a minimum of three acoustic beams. The AD device should also have a pressure sensor capable of recording the variation in depth due to the tidal cycle. The manufacturer guaranteed error associated with the selected AD device must be less than $\pm 2.0\%$ of the measured current velocity. The AD device must have a minimum velocity range of at least ± 5 m/s and resolution better than ± 0.01 m/s. The AD device should obtain discrete samples at a minimum resolution of 20 seconds between samples. The AD device recording period should be set as a minimum resolution of 10-minute time-stamped ensemble average data (i.e. 10 minute ensemble average or less). If the recording period is shorter than 10 minutes, the averaging period should be a suitable multiple of 10 minutes. The AD record should be binned at a minimum resolution of 2 metres. The required measurement period is 15 days. A contiguous record should be obtained throughout the measurement period.

The project developer has two options for AD device placement as follows:

1. One AD device should be deployed at the TEC to be monitored. The AD device should be deployed perpendicular to the TEC along the minor principal axis of the tidal resource (as reported in clause 3.2.5). The AD device should be bottom mounted, positioned no more than 60 metres away from the centre-line of the TEC device and orientated to capture a vertical snapshot. The difference in depth between the TEC and AD device positions must be established from the pre-installation site survey data to be less than $\pm 15\%$ of the depth to chart datum.
2. Two AD devices should be deployed at the TEC to be monitored. The AD devices should be deployed immediately up- and down-stream of the TEC along the major principal axis of the tidal resource (as reported in clause 3.2.5). The AD devices should be positioned no less than 3 performance surface widths (e.g. 3 diameters in the case of a horizontal axis turbine) from the TEC device, and no more than 120 metres from the TEC device. Both devices should be bottom mounted and orientated to capture a vertical snapshot. The difference in depth between the TEC and AD device positions must be established from the pre-installation site survey to be less than $\pm 15\%$ of the depth to chart datum.

Any deviation from this methodology must be agreed in writing with the project monitoring officer prior to the inception of data collection

4.2.2 Power production measurement

A similar approach is adopted as prescribed by the IEC 61400-12-1 International standard for wind turbine performance assessment.

The net electric power of the TEC device selected for monitoring shall be measured using a power measurement device (e.g. power transducer) and be based on measurements of current and voltage on each phase.

The class of the current transformers shall meet the requirements of IEC 60044-1 and the class of the voltage transformers, if used, shall meet the requirements of IEC 60186. They shall be of a minimum accuracy class of 0,5.

The accuracy of the power measurement device, if it is a power transducer, shall meet the requirements of IEC 60688 with a minimum accuracy class of 0,5. If the power measurement device is not a power transducer then the accuracy should be equivalent to class 0,5 power transducers. The operating range of the power measurement device shall be set to measure all positive and negative instantaneous power peaks generated by the TEC device. The power transducer shall be calibrated to traceable standards. The power measurement device shall be mounted between the TEC device and the electrical connection to ensure that only the net active electric power (i.e. reduced by self-consumption) is measured. If a separate cable is used for importing of electricity, this also needs to be separately monitored to the same standards. It shall be stated whether the measurement devices are located on the TEC device side or the network side of the transformer.

The voltage and current shall be reported as an ensemble average recorded over the same averaging period as adopted for reporting resource characteristics in section 4.2.1. It will be the responsibility of the TEC operator to supply this power production data in a time stamped format over a 15-day period corresponding with the 15-day incident resource measurement to enable direct comparison and performance assessment. To facilitate the auditing of this power production the TEC operator shall also provide copies of the accredited meter operator, contiguous 30-minute sampled data record over the same 15-day period. In the situation where multiple eligible facilities utilise a common grid connection point, metering meeting the relevant COP standard must be installed at a point before the facilities output combines in order to produce the same standard of data specific to each eligible facility.

4.3 Reporting

Upon completion of the data collection procedure outlined, the following outputs should be reported to the project monitoring officer acting on behalf of the DTI:

- Specification of the AD device deployed and the user defined settings employed.
- A spreadsheet detailing
 - the 15-day recorded measurement record obtained from the AD device output throughout the period necessary to produce a

representative power curve (current velocity components in units of mm/s), including the signal-to-noise ratio and standard deviation if this data is available. The output from the pressure sensor should also be reported at the same recording interval.

- the recorded measurement record of net electrical power produced by the monitored turbine spanning the required 15-day measurement period.
- A copy of the 30-minute record of power production from the facility produced by the accredited meter operator coincident with the 15-day measurement period. In the situation where multiple eligible facilities utilise a common grid connection point, metering meeting the relevant COP standard must be installed at a point before the facilities output combines in order to produce the same standard of data specific to each eligible facility.

4.4 Production of the power curve

This section details the approach intended to be adopted by the DTI for analysing the data collected by the Scheme participants in order to produce a power curve representative of the measured TEC device performance. Production of this power curve is not the Scheme participants responsibility. The power curve is produced by plotting the incident current resource record (x-axis) against the power production record (y-axis). A similar methodology to that used by the wind industry (IEC Standard 61400-12-1) is adopted. The spatial dislocation between the AD and TEC devices is deemed insignificant when considering a record averaged over any more than a few seconds, and therefore no correction is required.

4.4.1 Data analysis

The incident current resource record obtained by the AD device(s) provides a time-averaged representation of the horizontal velocity variation with depth. The record should be suitably manipulated to provide a 10-minute resolution data set. For the purposes of producing a power curve, the average current across the performance surface has to be derived. Each vertical data bin is considered to be representative of the resource in that vertical layer across the whole performance surface width. The vertical variation of the current record in each measurement record then has to be integrated across the performance surface area to produce a representative averaged velocity acting across the performance surface for plotting on the power curve. In the case of a fixed TEC device, only the component of velocity perpendicular to the performance surface should be considered. For a TEC device capable of orientating the performance surface into the principal current direction, the recorded velocity vector magnitude irrespective of direction is to be analysed. Equation (2) should be used for integrating the velocity record across the performance surface

$$U_{perf} = \left(\frac{1}{A} \int_A U^3 dA \right)^{1/3} \quad (2)$$

Where A is the performance surface

4.4.2 Determination of the measured power curve

The measured power curve is determined by applying the method of bins to the data set using 0.05 m/s bins (e.g. 0.00 – 0.05, 0.05 – 0.10, etc.), and by calculation of the mean values of current resource acting across the performance surface and device power output for each current resource bin according to the equations:

$$U_{perf(i)} = \frac{1}{N_{(i)}} \sum_{j=1}^{N_i} U_{perf(i,j)} \quad (3)$$

$$P_{(i)} = \frac{1}{N_{(i)}} \sum_{j=1}^{N_i} P_{(i,j)} \quad (4)$$

4.4.3 Presentation of the measured power curve

When publishing data relating to the measured power curve, the DTI will present the data both in tabular and graphical form. For each current velocity bin the table shall list:

- Velocity bin;
- Averaged current velocity ($U_{perf(i)}$);
- Averaged power output ($P_{(i)}$);
- Number of data sets in the bin ($N_{(i)}$);

The graphic representation of the power curve will show the averaged power output as a function of the averaged current velocity.

5 Procedure for reporting TEC operational status and annual energy production

5.1 Rationale

In order fully assess TEC device operation, performance data relating to net annual electrical power production and operational status are required. The following section outlines the procedure for recording and reporting of this information. The data requested is to be submitted annually to the project monitoring office acting on behalf of the DTI.

5.2 Measuring operational status

The operational status of the TEC shall be monitored by the devices own controller in order to provide sufficient auditable status signals to meet the reporting requirements of clause 5.3.

5.3 Reporting

In order to assess the annual performance of each individual TEC device in the eligible facility, Scheme participants shall provide the following data on an annual basis measured from the commissioning date:

- Copies of the statements received from the accredited meter operator detailing the overall power produced by the eligible facility throughout the preceding 12-month period. In the situation where multiple eligible facilities utilise a common grid connection point, metering meeting the relevant COP standard must be installed at a point before the facilities output combines in order to produce the same standard of data specific to each eligible facility.
- An auditable report constructed from the output of each individual TEC device's control system spanning the preceding 12-month period which indicates:
 - Number of hours each device was available for production.
 - Number of hours each device was unavailable for production because of a device fault
 - Number of hours each device was unavailable for production due to planned maintenance as outlined in the MRDF Scheme grant application.
 - Number of hours each device was unavailable due to external factors mandated by an independent third-party (e.g. grid faults). This will only be deemed acceptable when accompanied by appropriate supporting documentation supplied by the relevant third-party detailing the external factors involved and the length of time that these conditions impacted on the Eligible Facility. Unsubstantiated claims of device unavailability due to external factors will be re-allocated as unavailability due to a device fault.

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