

DD IEC/TS 62600-1:2011



BSI Standards Publication

Marine energy — Wave, tidal and other water current converters

Part 1: Terminology

bsi.

...making excellence a habit.™

National foreword

This Published Document is the UK implementation of IEC/TS 62600-1:2011.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

This Technical Specification provides terminology for marine energy converters but is not exhaustive in its scope. It is expected that future IEC publications will develop further terminology and this Technical Specification will be updated accordingly.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than three years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of Update Standards.

According to the replies received by the end of the review period, BSI Committee PEL/114 will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of BSI Technical Committee PEL/114 at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee PEL/114, Marine energy - Wave, tidal and other water current converters.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2012

ISBN 978 0 580 75298 8

ICS 27.140

Compliance with a British Standard cannot confer immunity from legal obligations.

This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 29 February 2012.

Amendments issued since publication

Amd. No.	Date	Text affected
----------	------	---------------



TECHNICAL SPECIFICATION

Marine energy – Wave, tidal and other water current converters – Part 1: Terminology

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE

U

ICS 27.140

ISBN 978-2-88912-829-7

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Terms and definitions	6
Bibliography.....	26
Figure 1 – Six degrees of freedom – Floating device.....	9
Figure 2 – Six degrees of freedom – Submerged device	9
Figure 3 – Wave height and wave period	23

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MARINE ENERGY – WAVE, TIDAL AND OTHER WATER CURRENT CONVERTERS –

Part 1: Terminology

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62600-1, which is a technical specification, has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
114/65/DTS	114/76/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This Technical Specification has been developed as a tool for the international marine energy community, to assist in creating clarity and understanding. The wave, tidal and water current energy industry has recently experienced a period of rapid growth and sector development. With this expansion, it became apparent that a glossary of terms for the sector was required. The aim of this Technical Specification is to present clear and consistent language that will aid the development of programs, projects, and future standards.

This Technical Specification lists the terms that the marine energy industry commonly uses. It is an evolving document that will change as new terms and symbols are added. The terminologies herein have been harmonized with IEC 60050 and other IEC documents as far as possible.

MARINE ENERGY – WAVE, TIDAL AND OTHER WATER CURRENT CONVERTERS –

Part 1: Terminology

1 Scope

This part of IEC 62600 defines the terms relevant to ocean and marine renewable energy. For the purposes of this Technical Specification, sources of ocean and marine renewable energy are taken to include wave, tidal current, and other water current energy converters.

Terms relating to conventional dam and tidal barrage, offshore wind, marine biomass, ocean thermal and salinity gradient energy conversion are not included in the scope of this Technical Specification.

This Technical Specification is intended to provide uniform terminology to facilitate communication between organizations and individuals in the marine renewable energy industry and those who interact with them.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

added mass

extra mass associated with the additional force necessary to accelerate a body through a fluid compared to the same acceleration in a vacuum

NOTE 1 In general, added mass is a variable that depends on the state of the unsteady motion and is not a constant.

NOTE 2 In a viscous (real) fluid, the added mass would include kinetic energy of a fluid layer entrained by the accelerating body.

2.2

added mass at infinity

limit of the mass corresponding to the added mass as the frequency tends to infinity

NOTE The value of added mass at infinity is normally necessary for time domain modelling of wave-body interaction.

2.3

added mass coefficient

ratio between added mass and the mass of the water displaced by the submerged body

2.4

amplitude control

method to obtain the optimum oscillatory motion amplitude to capture a maximum of wave energy

NOTE For a simple oscillating system, the object of amplitude control is to obtain a given oscillatory velocity amplitude that should be related with the wave excitation force.

2.5

annual energy production (marine energy converter)

estimate of total energy production of a marine energy converter system during a one-year period obtained by applying its power performance assessment to a prospective marine energy resource characterization and assuming 100 % availability

NOTE Actual annual energy production is unlikely to exceed this estimate.

[IEC 60050-415:1999, 415-05-09, modified]

2.6

array (marine energy)

farm of marine energy converters arranged specifically so as to enhance energy capture

NOTE Array spacing is dictated by hydrodynamic considerations and may be very closely packed so as to constitute a single platform or an arrangement of identical devices.

2.7

attenuator device

energy converter which is aligned parallel to the predominant direction of wave incidence

2.8

availability (marine energy converter)

ability of a marine energy conversion system to be in a state to perform a necessary function under given conditions at a given instant of time or over a given duration, assuming that the necessary external resources are provided

NOTE 1 For continuously running equipment availability equates to: $\text{uptime}/(\text{uptime} + \text{downtime})$.

NOTE 2 Where reliability is specified in Mean Time Between Failures (MTBF) and maintainability in Mean Time To Repair (MTTR), availability also equates to: $\text{MTBF}/(\text{MTBF} + \text{MTTR})$.

[IEC 60050-191:1990, 191-02-05, modified]

2.9

capture area (tidal)

equal to the power captured by the hydrodynamically functional part of a TEC divided by power per square metre of the incident tidal stream

2.10

capture length (wave)

capture width

equal to the power captured by the hydrodynamically functional part of a WEC divided by power per metre of the incident wave field

2.11

centre of buoyancy

centroid of the submerged volume

2.12

centre of flotation

point coinciding with the centroid of the water-plane area

NOTE The water-plane area is the cross-sectional area of the floating body at mean water level in calm water.

2.13

chart datum

reference level of water, typically from a selected phase of the tide at a specific location

NOTE Different hydrographic organizations have differing conventions for defining chart datum.

2.14

conversion efficiency (resource to wire)

measure of the overall effectiveness of a marine energy converter calculated as the ratio of electrical power output in relation to the incident power in the water resource

NOTE 1 For WECs, conversion efficiency (resource to wire) is sometimes referred to as wave-to-wire conversion efficiency.

NOTE 2 Conversion efficiency (resource to wire) is normally calculated over extended periods (e.g. tidal cycle, years, etc.).

2.15

current profile

variation in velocity throughout the water column, typically displayed as a function of height above the sea bed

2.16

deep water (offshore)

spatial location where the depth of the water is greater than or equal to half the wave length

NOTE The deep water (offshore) spatial location is based on the kinematic properties of waves. The dispersion equation is

$$L = \frac{gT^2}{2\pi} \tanh \frac{2\pi d}{L}$$

where

L is the wave length;

d is the water depth;

T is the period;

g is the gravitation acceleration.

In deep water, the dispersion equation may be simplified to

$$L = \frac{gT^2}{2\pi} = 1,56 T^2$$

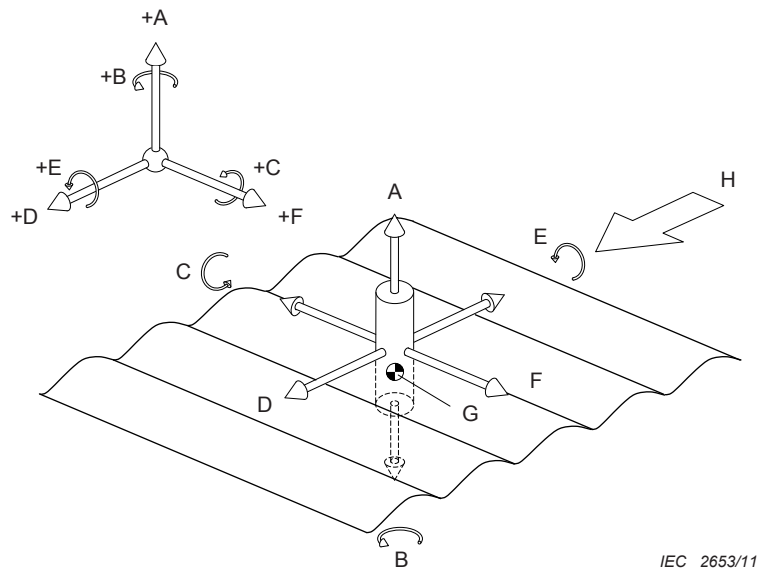
2.17

degree of freedom

independent displacements and/or rotations that specify the orientation of a body or system

NOTE 1 A marine body may experience three linear and three rotational motions as depicted in Figures 1 and 2.

NOTE 2 The principal axis is parallel to the mean water surface and aligned with the direction of incident energy, and the rotations act about the centre of gravity.

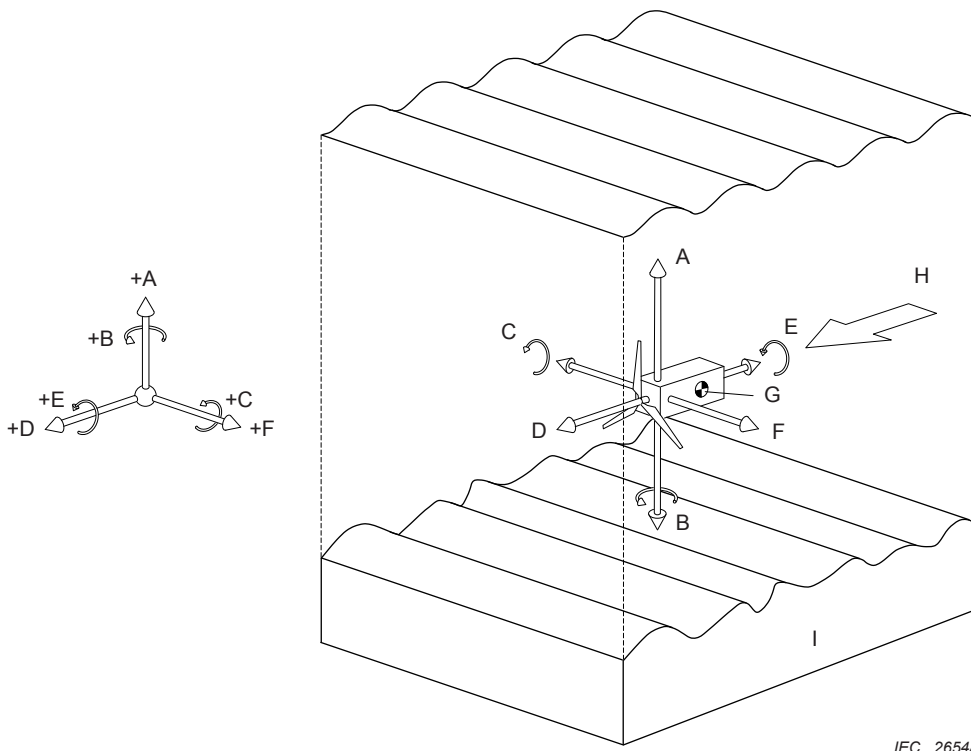


IEC 2653/11

Key

A	Heave	D	Surge	G	Centre of gravity
B	Yaw	E	Roll	H	Incident energy
C	Pitch	F	Sway		

Figure 1 – Six degrees of freedom – Floating device



IEC 2654/11

Key

A	Heave	D	Surge	G	Centre of gravity
B	Yaw	E	Roll	H	Incident energy
C	Pitch	F	Sway	I	Seabed

Figure 2 – Six degrees of freedom – Submerged device

2.17.1

heave

motion in a direction perpendicular to the mean water surface

2.17.2

pitch

rotation about the sway axis

2.17.3

roll

rotation about the surge axis

2.17.4

surge

motion parallel to the principal axis

2.17.5

sway

motion perpendicular to the principal axis and parallel to the mean water surface

2.17.6

yaw

rotation about the heave axis

2.18

directionally resolved power (wave)

distribution of wave power in a given sea state as a function of the angle of incidence

2.19

directional spreading function

normalized distribution of wave energy, D , for a given frequency, f , over the angle of incidence, θ

NOTE Since $\int_0^{2\pi} D(\theta, f) d\theta = 1$ it may be considered to be a probability density function over direction.

2.20

directional wave spectrum

distribution of the spectral density as a function of incident wave frequency and direction

NOTE The directional wave spectrum is calculated as the product of the spectral density, as a function of incident wave frequency, multiplied with the directional spreading function.

2.21

diurnal tides

occurrence of only one high water and one low water in each tidal day

NOTE A tidal day is equal to 24,8 h.

2.22

energy period (wave)

T_e

characteristic wave period associated with energy propagation expressed as the group velocity weighted mean period of the frequency spectrum

NOTE 1 A monochromatic wave in deep water, whose variance and period match the variance and energy period of a specified polychromatic sea state, will also have the same wave power.

NOTE 2 In accordance with IAHR, the spectral estimate of the energy period is preferred.

$$T_e = \frac{m_{-1}}{m_0}, \text{ where } m_{-1} \text{ and } m_0 \text{ are the minus-one and zero spectral moments.}$$

2.23 energy storage capacity

measure of the amount of energy a storage device can store and deliver, within established design limits and maintenance interval conditions

NOTE The energy storage capacity is specified in terms of energy units such as kJ, MJ, kWh or MWh (i.e. the kinetic energy stored in a flywheel, the hydraulic energy stored in accumulators or potential energy stored in a water reservoir).

2.24 excitation force (wave)

force which an incident wave exerts on a static body

2.25 extreme significant wave height

significant wave height (H_{m0}) of the most severe sea state expected at a site over a specific return period or design life

NOTE This definition provides for extreme wave heights to be defined in terms of a 50/100 year storm condition.

2.26 farm

group of similar marine energy converters of the same type (either WECs or TECs) sharing a connection to the electric grid

NOTE Farm spacing will normally be dictated by installation, mooring and access requirements.

2.27 fast tuning

adaptive control of a device over a typical wave period

NOTE Adaptive tuning, real-time control, or complex conjugate control is examples of fast tuning.

2.28 fetch

unobstructed distance of water surface over which the wind has acted

2.29 focusing absorber device

energy converter that uses a method to concentrate waves onto a central converter to enhance energy production

2.30 free surface

interface between the air and a body of water

2.31 group velocity (wave)

propagation velocity of water wave groups and the wave energy

NOTE The group velocity of a water wave is the velocity that the energy associated with the wave disturbance travels in the direction of wave propagation. In deep water using linear wave theory this is one half the wave phase velocity. In shallow water it is equal to the wave phase velocity.

2.32

harmonic analysis of tides

representation of tidal elevations and velocities by the summation of components whose amplitudes and periods describe astronomical processes

2.33

highest astronomical tide

HAT

highest sea level due to an astronomical tide that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions

NOTE The highest astronomical tide is not an extreme sea level, as certain meteorological conditions can cause a higher sea level. The sea level under these circumstances is known as a storm surge. HAT is determined by inspecting predicted sea levels over a number of years.

[National Oceanography Centre – Natural Environment Resource Council (NERC), 2011]

2.34

in-stream generation

capture and conversion of the energy of flowing water

NOTE In-stream generation includes tidal, ocean current, and flowing river environments.

2.35

intermediate depth water

spatial location where the kinematics properties of the waves are such that the water depth is less than half the wave length but equal to or greater than a twentieth of the wave length

NOTE In intermediate water, the dispersion equation is

$$L = \frac{gT^2}{2\pi} \tanh \frac{2\pi d}{L}, \text{ where } L = \text{wave length, } d = \text{water depth, } T = \text{period and } g = \text{gravitation acceleration}$$

2.36

latching

restraining the motion of the primary interface at the extremes of its range of motion to improve power capture

NOTE Latching is sometimes referred to as phase control because latching is often used to align the excitation (force or pressure) and response (velocity or flow rate), and this can be understood as reducing the phase difference between the principal frequency components of these parameters.

2.37

lowest astronomical tide

LAT

lowest sea level due to an astronomical tide that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions

NOTE The lowest astronomical tide is not an extreme sea level, as certain meteorological conditions can cause a lower sea level. The sea level under these circumstances is known as a negative surge. LAT is determined by inspecting predicted sea levels over a number of years. LAT is commonly used as the datum point from which sea level is measured.

[National Oceanography Centre – NERC, 2011]

2.38

maintainability

probability that a given active maintenance action, for an item under given conditions of use, can be carried out within a given duration, when the maintenance is performed under stated conditions and using stated procedures and resources

[IEC 60050-191:1990, 191-13-01, modified]

2.39
marine current

persistent flow of seawater produced by natural physical processes, including the gravitational pull of celestial bodies

2.40
maximum average power

time-averaged power produced by a device under peak operating conditions over a given interval

NOTE 1 For a wave device, peak operating conditions represent the maximum operating sea conditions.

NOTE 2 For a tidal device, peak operating conditions would be the maximum flow rates.

2.41
maximum individual wave height

H_{\max}

statistical measure of the largest individual wave heights which can be observed or expected in a given sea state for a stated probability of exceedance

NOTE Maximum individual wave height is normally calculated from a Rayleigh distribution for wave heights in deep water for an exceedance probability of one per thousand, for which a $H_{\max} = 1,86 H_{m0}$.

2.42
mean annual wave power

long-term average of the directionally unresolved wave energy flux per unit width, calculated as an arithmetic mean over all sea states occurring at a given location

NOTE Typically mean annual wave power units are expressed in kilowatts per metre.

2.43
mean high water neaps
MHWN

annual average height (when the average maximum declination of the moon is 23,5 degrees) of two successive high waters during those time intervals of 24 h when the range of the astronomical tide is at its least

NOTE The values of mean high water neaps vary from year to year with a cycle of approximately 18,6 years.

[National Oceanography Centre – NERC, 2011, modified]

2.44
mean high water springs
MHWS

annual average height (when the average maximum declination of the moon is 23,5 degrees) of two successive high waters during those time intervals of 24 h when the range of the astronomical tide is at its greatest

NOTE The values of mean high water springs vary from year to year with a cycle of approximately 18,6 years.

[National Oceanography Centre – NERC, 2011, modified]

2.45
mean low water neaps
MLWN

annual average height (when the average maximum declination of the moon is 23,5 degrees) of two successive low waters during those time intervals of 24 h when the range of the astronomical tide is at its least

NOTE The values of mean low water neaps vary from year to year with a cycle of approximately 18,6 years.

[National Oceanography Centre – NERC, 2011, modified]

2.46

mean low water springs

MLWS

annual average height (when the average maximum declination of the moon is 23,5 degrees) of two successive low waters during those time intervals of 24 h when the range of the astronomical tide is at its greatest

NOTE The values of mean low water springs vary from year to year with a cycle of approximately 18,6 years.

[National Oceanography Centre – NERC, 2011, modified]

2.47

mean neap range

difference between mean high water neaps (MHWN) and mean low water neaps (MLWN)

[National Oceanography Centre – NERC, 2011]

2.48

mean spring peak velocity

Vmsp

annual average (when the average maximum declination of the moon is 23,5 degrees) of four successive maximum flow speeds during those time intervals of 24 h when the range of the astronomical tide is at its greatest

NOTE Mean spring peak velocity should be calculated at a depth 5 m below the surface as the average over 30 min of the four peak speeds occurring during the two ebb and the two flood tides, associated with the largest spring tide.

2.49

mean spring range

difference between mean high water springs (MHWS) and mean low water springs (MLWS)

[National Oceanography Centre – NERC, 2011]

2.50

mean water level

surface level of a body of water with motions such as wind waves and/or changes due to the tides averaged out

NOTE When considering tides, the mean water level is normally measured at a tidal gauging station over a period of several years. When considering waves, the sea level is generally averaged over a much shorter time period (e.g. 1 h).

2.51

mean zero crossing period (see Figure 3)

average time interval between down crossings of the mean water level during a given sea state

NOTE The spectral estimate of the mean zero crossing period, T_{02} , is calculated as

$$T_{02} = \sqrt{\frac{m_0}{m_2}}$$

2.52

met-ocean

meteorological and oceanographic environment typically described using wind, wave, tidal characteristics, etc.

2.53

mixed tides

occurrence of relatively large diurnal inequality in the high or low waters or both

2.54

ocean current

large scale and persistent flow of seawater produced by mechanisms other than the gravitational forces of celestial bodies

NOTE Ocean currents result from processes such as wind, density gradients, salinity gradients, Coriolis forces, etc.

2.55

oscillating hydrofoil

energy converter in which force is induced due to a pressure difference on the foil section caused by the relative motion of the fluid over the foil inducing oscillatory motion

[University of Strathclyde, Energy Systems Research Unit, 2011, modified]

2.56

oscillating water column device

OWC

energy converter with an enclosed air volume excited by waves causing reciprocating air to flow through a turbine

2.57

oscillating wave surge converter

OWSC

device which responds to the predominantly horizontal fluid motions in shallow and intermediate depth water

2.58

overtopping device

energy converter with a reservoir filled by wave overtopping, which typically discharges through a low head turbine

2.59

park (marine energy)

designated geographical region containing one or more marine energy farms

2.60

peak operating conditions

met-ocean and/or river conditions under which a machine operates so as to generate its maximum power output

2.61

peak period (wave)

T_p

inverse of the peak frequency (wave), $T_p = 1 / f_p$

2.62

peak frequency (wave)

f_p

frequency corresponding to the maximum value of the omni-directional wave spectrum

2.63

phase velocity (water wave)

celerity

speed at which the shape of the wave propagates

2.64

point absorber device

WEC that is small relative to the wave length and typically absorbs wave energy independent of the direction of wave incidence

2.65

power matrix

tabular description of power capture as a function of relevant met-ocean parameters

NOTE 1 For a wave energy converter, the power matrix should be described using at least wave height and energy period.

NOTE 2 For a tidal energy converter, the power matrix should be described using at least flow speed and direction.

2.66

power curve

power surface

graphical description of the power capture as a continuous function of relevant met-ocean parameters

NOTE 1 For a wave energy converter, the power curve should be described using at least wave height and energy period.

NOTE 2 For a tidal energy converter, the power curve should be described using at least the flow speed.

2.67

power take-off

PTO

mechanism that converts the motion of the prime mover into a useful form of energy such as electricity

2.68

prime mover

physical component that acts as the interface between the marine resource and the energy converter from which energy is captured

NOTE For wave energy converters the prime mover may be a heaving buoy, a hinged flap, an OWC runner, etc., and for tidal energy converters the prime mover is typically the runner.

2.69

rated capacity (system)

designated power output of a marine energy converter

NOTE The term capacity can refer to the output of a single device, an array of devices, or an entire marine farm.

2.70

reliability

probability that an item can perform a necessary function under given conditions for a given time interval

[IEC 60050-191:1990,191-12-01, modified]

2.71

resource assessment (marine energy)

collection and processing of met-ocean data required for determining the performance of a marine energy converter or farm

NOTE Resource assessment may be conducted in three distinct stages including theoretical resource assessment, technical resource assessment, and practical resource assessment.

2.71.1

practical resource assessment

proportion of the technical resource that is available after consideration of external constraints

NOTE 1 External constraints may include grid accessibility, competing use, environmental sensitivity, etc.

NOTE 2 Practical resource assessment is one of three distinct stages in a resource assessment. The remaining two stages include theoretical resource assessment and technical resource assessment. The value of the theoretical resource assessment is greater than the technical resource assessment, which in turn is greater than the practical resource assessment.

[Legrand, 2009, modified]

2.71.2

technical resource assessment

proportion of the theoretical resource that can be captured using existing technology options without consideration of external constraints

NOTE Technical resource assessment is one of three distinct stages in a resource assessment. The remaining two stages include practical resource assessment and theoretical resource assessment. The value of the theoretical resource assessment is greater than the technical resource assessment, which in turn is greater than the practical resource assessment.

[Legrand, 2009, modified]

2.71.3

theoretical resource assessment

energy contained in the entire resource

NOTE Theoretical resource assessment is one of three distinct stages in a resource assessment. The remaining two stages include practical resource assessment and technical resource assessment. The value of the theoretical resource assessment is greater than the technical resource assessment, which in turn is greater than the practical resource assessment.

[Legrand, 2009, modified]

2.72

resource characterization

parameterization of met-ocean data to enable determination of the performance of a marine energy converter or farm

2.73

scatter diagram

tabular representation of the frequency of occurrence for given met-ocean conditions at a specific site

NOTE 1 For wave energy converters, the met-ocean conditions typically used are significant wave height and a characteristic wave period.

NOTE 2 A scatter diagram is sometimes referred to as a joint occurrence table.

2.74

sea state

stationary condition of the wind waves and swell at a site, characterized by relevant parameters such as the significant wave height and energy period (wave)

2.75

sea trial

evaluation of a device's performance and properties in the natural environment

2.76

semi-diurnal tides

occurrence of two high waters and two low waters of approximately equal height each tidal day

NOTE A tidal day is equal to 24,8 h.

**2.77
 shallow water**

spatial location defined by the kinematic properties of waves where the water depth is less than a twentieth of the wave length

NOTE In shallow water, the dispersion equation is

$$L = \frac{gT^2}{2\pi} \tanh \frac{2\pi d}{L}$$

where

L is the wave length;

d is the water depth;

T is the period;

g is the gravitation acceleration.

In shallow water, the dispersion equation may be simplified to $L = T\sqrt{gd}$.

**2.78
 significant wave height**

statistical measure of the average of the largest one-third of wave heights in an irregular sea state

NOTE 1 From time domain analysis the significant wave height, H_s , is calculated based on zero down crossing analysis.

NOTE 2 The spectral estimate of the significant wave height is to be preferred and is estimated by $H_{m_0} = 4\sqrt{m_0}$ where m_0 is the zeroth spectral moment of the wave energy spectrum. m_0 is the variance of the sea state and can be calculated directly from the surface elevation time series. If the individual wave heights are Rayleigh distributed then $H_s = H_{m_0}$. In most realistic sea states this is not completely true and H_{m_0} is therefore often slightly larger than H_s .

**2.79
 spectral density**

limit of the variance of the free surface elevation as the frequency bin width tends to zero

**2.80
 spectral moment**

n^{th} spectral moment, m_n , about zero frequency, is given by

$$m_n = \int_0^{\infty} f^n S(f) df$$

where $S(f)$ is the spectral density.

NOTE For discrete data the following estimate may be used

$$m_n = \sum_i f_i^n S_i \Delta f_i$$

**2.81
 submerged pressure differential device**

immersed WEC which converts pressure variations into some other form of energy, typically electricity

2.82

survivability (functional)

probability that a converter will continue to operate without a forced outage over the stated operational life

[Legrand, 2009, modified]

2.83

survivability (safety)

probability that a converter will remain as installed over the stated operational life

[Legrand, 2009, modified]

2.84

survival mode

operation mode for a device that reduces the likelihood of damage being sustained during extreme/uncommon environmental conditions such as storms

2.85

tank testing

evaluation of device performance and properties under controlled hydrodynamic conditions

NOTE Tank tests may be performed in wave flumes, towing tanks, wave basins, and other types of facilities.

2.86

terminator device

energy converter which is aligned perpendicular to the predominant direction of wave incidence

2.87

tidal current

tidal stream

flow of water induced by the gravitational forces of celestial bodies

2.88

tidal current constituents

complex amplitudes and phases of the components of the harmonic description of tidal velocities at a specified location

2.89

tidal current ellipse

polar plot of the tidal velocities at spring and neap tide

NOTE Typically the depth averaged velocities are used to create the plot.

2.90

tidal current turbulence

unsteady fluctuation of the flow velocity in a tidally induced current

2.91

tidal eddy

circular movement of water present in a tidally induced current

2.92

tidal energy

energy present in the movement of water created by the gravitational forces of celestial bodies

2.93

tidal energy converter

TEC

device which captures energy from tidal currents and converts it into another form

2.94

tidal height constituents

amplitudes and phases of the components of the harmonic description of tidal elevations at a specified location

2.95

tidal range

difference between consecutive high and low tides

2.96

turbine

rotating device that converts kinetic energy of flowing fluid to mechanical energy

2.96.1

axial flow turbine

kinetic energy conversion device in which the fluid moves in a direction parallel to the axis of rotation

[IEC 60050-811:1991, 811-22-04, modified]

2.96.2

bulb turbine

hydraulic reaction type kinetic energy conversion device set with its casing containing the generator and turbine immersed in the water flow

[IEC 60050-602:1983, 602-02-16]

2.96.3

counter-rotating turbine; contra-rotating turbine

set of kinetic energy conversion devices placed close together with their blades rotating in opposite directions

2.96.4

cross-flow turbine

kinetic energy conversion device in which the fluid moves in a direction perpendicular to the axis of rotation

2.96.5

Darrieus turbine

type of cross-flow turbine with non-helical blades in line with the axis of rotation

2.96.6

Francis turbine

hydraulic reaction type kinetic energy conversion device with fixed runner blades usually operating from a medium or low head source with medium flow rate

[IEC 60050-602:1983, 602-02-14, modified]

2.96.7

Gorlov turbine

type of cross-flow turbine with helical blades

2.96.8

horizontal axis tidal turbine

kinetic energy conversion device whose rotor axis is substantially parallel to the fluid flow

[IEC 60050-415:1999, 415-01-04, modified]

2.96.9

Kaplan turbine

axial hydraulic reaction type kinetic energy conversion device with adjustable runner blades operated with a high flow rate

[IEC 60050-602:1983, 602-02-15, modified]

2.96.10

Pelton turbine

hydraulic impulse type kinetic energy conversion device usually operated from a high head source with small flow rate

[IEC 60050-602:1983, 602-02-13, modified]

2.96.11

propeller turbine

kinetic energy conversion device with non-adjustable runner blades suitable for non-varying head sources

[IEC 60050-602:1983, 602-02-17, modified]

2.96.12

pit turbine

type of bulb type kinetic energy conversion device in which the gearbox is used to reduce the size of the generator and the bulb

2.96.13

rim turbine

type of axial flow type kinetic energy conversion device in which the power take-off is taken from the perimeter of the turbine

2.96.14

Savonius turbine

type of cross-flow kinetic energy conversion device with S-shaped scoops, which have an offset against each other so that a part of the fluid is diverted to the other concave blade

2.96.15

tubular turbine

type of axial flow kinetic energy conversion device in which the power take-off is taken from a long shaft connected to the runner

[Wave Energy Centre, 2007]

2.96.16

Turgo turbine

hydraulic impulse type kinetic energy converter operated from a medium head source in which the head range is where Pelton and Francis turbines overlap

2.96.17

vertical axis tidal turbine

kinetic energy conversion device whose rotor axis is vertical and perpendicular to the flow of water

[IEC 60050-415:1999, 415-01-05, modified]

2.96.18

Wells turbine

kinetic energy conversion device with symmetric fixed-pitch blades that rotates in a single direction regardless of the direction of fluid flow

[Carbon Trust, 2005, modified]

2.97

Venturi device

convergent-divergent duct section used to create a pressure difference that drives a turbine

2.98

water current measuring instrument

device used to measure water current properties

2.98.1

Doppler current meter

acoustic device which measures water current at only one level in the water column

2.98.2

Doppler current profiler

DCP

acoustic device which measures current speed and direction in multiple layers throughout the water column

2.98.3

Doppler velocimeter

acoustic device which produces high resolution measurement of the current speed and direction at a single point

2.99

wave climate

long-term statistical characterization of the wave properties at a location

NOTE Wave climate is a subset of met-ocean.

2.100

wave energy

total kinetic and potential energy associated with the propagation of surface waves, integrated from the sea floor to the surface

2.101

wave energy converter

WEC

device which captures energy from surface waves and converts it into another form

2.102

wave energy spectrum

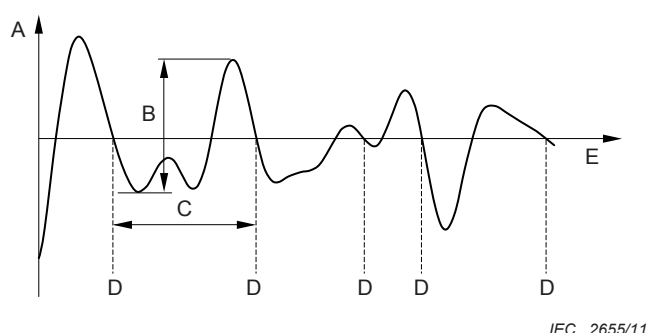
wave energy per unit area as a function of frequency, expressed as $\rho g S(f)$, where $S(f)$ is the spectral density

NOTE The wave energy spectrum may be expressed as a function of frequency and direction, and other parameters.

2.103

wave height

vertical distance between a consecutive wave trough and wave crest (see Figure 3)



Key

A	Surface elevation η	D	Zero downcrossing
B	Wave height H	E	Time t
C	Wave period T		

Figure 3 – Wave height and wave period

2.104
wave measuring instrument
WMI

device used to measure wave properties

2.104.1
acoustic wave profiler
AWP

inverted sonar device which uses the reflection of sound waves at the water surface to measure surface displacement

NOTE Acoustic wave profilers are often integrated into Doppler current profilers.

2.104.2
capacitance gauge

wavestaff constructed from a wire with a dielectric sheath to measure surface elevation

2.104.3
electromechanical probe

wave measuring instrument or staff constructed from a rigid insulated rod with a capacitance probe on the end which measures surface elevation by adjusting the vertical position of the rod to ensure the probe measures a constant capacitance

NOTE Electromechanical probes can only be used at small scale in laboratories.

2.104.4
laser wave gauge

laser system which uses an offset camera to measure the changing position of scattered light

NOTE Laser wave gauges have a high degree of accuracy but can only be used in laboratories and are unsuited for taking measurements where there are breaking waves.

2.104.5
optical altimeter

laser radar (lidar) system used to measure the distance between the instrument and the water surface

NOTE Optical altimeters are only useable for field measurements and are unreliable when there is significant wave breaking or spray.

2.104.6

resistance gauge

wavestaff constructed from two parallel wires, energized with an AC current, to measure surface elevation

2.104.7

shipborne wave recorder

device mounted within the hull of a ship, which accurately follows the rise and fall of each wave, combining the principles of the pressure recorder and the surface following buoy

2.104.8

sub-surface pressure recorder

pressure sensor placed at a fixed point below the water surface used to derive the surface displacement

2.104.9

surface following buoy

floating device using accelerometers to measure wave motions

2.104.10

wavestaff

surface piercing sensor that measures its own immersion depth

2.105

wave period

time between two consecutive zero down crossings of surface elevation

NOTE Refer to Figure 3 for a depiction of wave period.

2.106

wave phase velocity

velocity at which the phase of the wave is propagating

NOTE 1 The wave phase velocity is calculated in terms of the ratio between wave length and period.

NOTE 2 As water waves are dispersive, the wave phase velocity varies with period and is not necessarily the same as the group velocity of the wave.

2.107

wave power

wave energy flux per unit width

wave energy transport rate per unit width from the sea floor to the surface, calculated as the product of the group velocity and the wave energy

NOTE Unless otherwise specified, wave power should be understood as omnidirectional, or directionally unresolved.

2.108

wave spectrum

distribution of the spectral density as a function of frequency

2.108.1

Bretschneider spectrum

theoretical two parameter spectrum for long fetch (oceanic) waves

NOTE Various parameterizations of the Bretschneider spectrum exist giving the spectrum as functions of typically H_{m0} and T_p .

2.108.2

JONSWAP spectrum

theoretical two parameter spectrum developed for the North Sea (fetch limited conditions), by the Joint North Sea Wave Project (JONSWAP) given as a function of wind speed and fetch length

NOTE 1 The JONSWAP spectrum is the Pierson-Moskowitz spectrum modified with a term involving a peak enhancement factor.

NOTE 2 Various parameterizations of the JONSWAP spectrum exist giving the spectrum as functions of typically H_{m0} and T_p .

[Hasselmann, Dunckel, & Ewing, 1980]

2.108.3

Pierson-Moskowitz spectrum

theoretical one parameter spectrum for fully developed sea states given as a function of wind speed

NOTE Various parameterizations of the Pierson-Moskowitz spectrum exist giving the spectrum as functions of typically H_{m0} and T_p .

2.109

wave steepness

ratio of wave height to wave length

NOTE Wave steepness is normally expressed as a percentage.

2.110

wave tank; wave flume; wave basin

facility that is able to reproduce controlled hydrodynamic conditions primarily waves and/or currents

Bibliography

Carbon Trust. (2005). *Marine energy challenge: Marine energy glossary*. Retrieved March 25, 2011 from <http://www.carbontrust.co.uk/SiteCollectionDocuments/Various/Emerging%20technologies/Technology%20Directory/Marine/Technical%20guidelines/MarineEnergyGlossary.pdf>.

Dean, R.G., & Dalrymple, R.A. (1991). *Water wave mechanics for engineers and scientists. World Scientific, Advanced Series on Ocean Engineering, 2.*

Earle, D.E., & Bishop, J.M. (1984). *A practical guide to ocean wave measurement and analysis*. Marion, MA: ENDECO Inc.

Falnes, J. (2002). *Ocean waves and oscillating systems*. Cambridge, England: Cambridge University Press.

Frigaard, P., Helm-Petersen, J., Harford, C., Klopman, G., Stanberg, C., Benoit, M., Briggs, M., Miles, M., Santas, J., Schaffer, H., & Hawker, P. (1997). *International Association for Hydraulic Research (IAHR) List of sea state parameters – an update for multidirectional waves*. Paper presented at the IAHR Conference in San Francisco, California.

Hasselmann, D., Dunckel, M., & Ewing, J. (1980). Directional wave spectra observed during JONSWAP 1973. *Journal of Physical Oceanography, 10*, 1264-1280.

International Association for Hydraulic Research (IAHR). (1986). *List of sea state parameters-Bulletin No. 52*. Retrieved March 25, 2011 from <http://www.iahr.org/assets/files/iahr-pianc%20sea%20state%20parame.pdf>.

IEC 60050 (all parts): *International Electrotechnical Vocabulary*

International Electrotechnical Commission (IEC). (2011). *Electropedia: The world's online electrotechnical vocabulary*. Retrieved March 25, 2011 from <http://www.electropedia.org/>.

Legrand, C. (2009). *European Marine Energy Centre Ltd. – Assessment of tidal energy resource: Marine renewable energy guides*. London, England: BSI.

National Oceanography Centre – Natural Environment Research Council. (2011). *Definitions of tidal levels and other parameters*. Retrieved March 25, 2011 from <http://www.pol.ac.uk/ntslf/tgi/definitions.html>.

University of Strathclyde, Energy Systems Research Unit. (2011). *Marine current resource and technology methodology – Technology: Oscillating hydrofoil*. Retrieved March 25, 2011 from http://www.esru.strath.ac.uk/EandE/Web_sites/05-06/marine_renewables/technology/oshydro.htm.

Wave Energy Centre. (2007). *Ocean energy glossary*. Retrieved March 25, 2011 from [http://www.iea-oceans.org/_fich/6/Ocean_Energy_Glossary_\(1\).pdf](http://www.iea-oceans.org/_fich/6/Ocean_Energy_Glossary_(1).pdf).

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards-based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

All the data, software and documentation set out in all British Standards and other BSI publications are the property of and copyrighted by BSI, or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI. Details and advice can be obtained from the Copyright & Licensing Department.

Useful Contacts:

Customer Services

Tel: +44 845 086 9001

Email (orders): orders@bsigroup.com

Email (enquiries): cservices@bsigroup.com

Subscriptions

Tel: +44 845 086 9001

Email: subscriptions@bsigroup.com

Knowledge Centre

Tel: +44 20 8996 7004

Email: knowledgecentre@bsigroup.com

Copyright & Licensing

Tel: +44 20 8996 7070

Email: copyright@bsigroup.com



...making excellence a habit.™