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colour inside

Marine energy – Wave, tidal and other water current converters – Part 100: Electricity producing wave energy converters – Power performance assessment

INTERNATIONAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 100: Electricity producing wave energy converters – Power performance assessment

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 62600-100:2012. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TS 62600-100 has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Incorporation of IEC TS 62600-102 as a series of annexes in this document
b) Removal of the computation of annual energy production. This has been moved to IEC TS 62600-101.
c) Modification to the list of terms definitions, symbols and units.
d) Modification of the reporting section to align with IEC TS 62600-200

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
114/537/DTS	114/554/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62600 series, published under the general title *Marine Energy – Wave, tidal and other water current converters*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 62600, which is a Technical Specification, provides performance assessment methods for wave energy ~~Conversion Systems (WECS)~~ converters. A wave energy converter is a device which generates electricity using the action of water waves and delivers electricity to an electrical load.

Wave energy industry development is transitioning from preliminary stages to commercial production stages. Validated data gathering and processing techniques are important to improve existing technologies. This document will be subject to changes as data are collected and processed from testing of wave energy converters.

The expected users of the document include:

- Device developers who want to validate the performance of their wave energy converter.
- Investors who want to assess the performance of a device developer's wave energy converter.
- Project developers who want to assess the performance of their project against manufacturer's claims.
- Surveyors contracted to carry out the assessment.
- Conformity assessment, test laboratories, and certification.
- Project developers – income, return on investment
- Device developers – performance of device
- Utilities and investors – reliability/predictability of supply, return on investment
- Policy-makers and planners – usage of seascape, optimisation of resource, power supply issues
- Consultants to produce resource data/due diligence – compatible/readable data format

An essential element for any published Technical Specification or International Standard is to allow an opportunity to provide feedback on its contents to the appropriate TC 114 Working Group. TC 114 utilizes a standard methodology to allow this.

To submit feedback such as proposed changes, corrections and/or improvements to this document, please send an email to the TC 114 Chair using the Contact TC 114 Officers feature on the IEC TC 114 Dashboard, accessible at www.iec.ch/tc114. On the right side of the Dashboard under Further information select the link to contact the TC 114 Officers. On the subsequent page find and select the Send Email link for the Chair to access the email tool.

Complete all the required elements within the email pop-up. For the Subject field please include the document title and edition you are providing feedback for (ex: feedback for TS 62600-1 ED2). In the Message field, include text which summarizes your feedback and note if further information can be made available (note attachments are not allowed). The Chair may request added information as needed before forwarding the submission to the remaining TC 114 Officers for review and then to the appropriate Working Group for their consideration.

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

Part 100: Electricity producing wave energy converters – Power performance assessment

1 Scope

Wave Energy Converters (WEC) are designed to operate efficiently at different locations. Systematic methods are used to evaluate the power performance of a WEC at a second location (hereinafter Location 2) based on power performance assessment at a first location (hereinafter Location 1). The degree of similarity of the measured WEC (WEC 1) and the metocean conditions at Location 1 to the secondary WEC (WEC 2) at Location 2 determine the methodology and the applicability of this document.

~~This part of IEC 62600, which is a Technical Specification, provides a method for assessing the electrical power production performance of a Wave Energy Converter (WEC), based on the performance at a testing site.~~

This document applied in conjunction with the IEC Technical Specification on wave energy resource assessment and characterization (IEC TS 62600-101), provides a method for estimation of the mean annual energy production of a WEC, assessing the electrical power production performance of a single, non-array, wave energy converter, at Location 2 based on the performance at Location 1.

The scope of this document includes:

a) All wave energy converters that produce electrical power from wave energy.
b) All sea resource zones (near and offshore, deep and shallow water).
c) Capture width matrix transposition from one location to another.
d) Limitation on the changes that are allowed to the WEC and the specification of the location.
e) Wave data required at Location 2, as a minimum the requirements found in IEC TS 62600-101.
f) Development of the capture width matrix at Location 2.
g) Validation of the capture width matrix at Location 2.
h) Assessment of uncertainties in the derived performance parameters at Location 2.
i) Requirements for the allowable power performance transfer by geometric, kinematic and dynamic similarity.
j) Requirements for the allowable incorporation of additional empirical model data.
k) Requirements for the allowable incorporation of additional numerical model data.
l) The document applies to commercial scale wave energy converters that are:
    1) compliantly moored.
    2) tautly moored.
    3) bottom mounted.
    4) shore mounted.

The scope of this document does not include:

~~a) WECs that produce other forms of energy unless this energy is converted into electrical energy;~~

a) Wave energy converters that produce nonelectrical energy.

b) Resource assessment.

c) Scaled devices in test facilities (tank or scaled sea conditions) where any scaling would ~~need to~~ be carried out to extrapolate results for a full-scale device.

d) Power quality issues.

e) Environmental issues.

~~f) power matrix transposition from one location to another.~~

f) Operation and maintenance.

g) Annual energy production (AEP).

This document provides a systematic method which includes:

- measurement of WEC ~~power output~~ capture width in a range of sea states.
- ~~WEC power matrix development;~~
- transposition of capture width from one location to a second location.
- an agreed framework for reporting the results of ~~power~~ capture width and wave measurements.
- estimate of the capture width of a modified WEC at Location 2. This work would include the development of parameters for the modified WEC for the second location.

This document provides:

- guidance on the use of observations from Location 1.
- methods for assessing and reporting the validity of numerical and physical models.
- limits on the permissible changes to the WEC between Locations 1 and 2.
- limits on the use of data fitting techniques, and
- requirements for reporting.

The wave power industry is at an early stage of development. There is little practical experience with field-scale WECs deployment. Because of this, the present document will be subject to change as more data is collected and experience with wave energy converters develops.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60044-1, *Instrument transformers – Part 1: Current transformers*~~

IEC 60688, *Electrical measuring transducers for converting AC and DC. electrical quantities to analogue or digital signals*

~~IEC 61000-3 (all parts), *Electromagnetic compatibility (EMC) – Part 3: Limits*~~

IEC 61869-1, *Instrument transformers – Part 1: General requirements*

IEC 61869-2, *Instrument transformers – Part 2: Additional Requirements for current transformers*

IEC 61869-3, *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*

IEC TS 62600-3, *Marine energy – Wave, tidal and other water current converters – Part 3: Measurement of mechanical loads*

IEC TS 62600-101:2015, *Marine energy – Wave, tidal and other water current converters – Part 101: Wave energy resource assessment and characterization*

IEC TS 62600-103, *Marine energy – Wave, tidal and other water current converters – Part 103: Guidelines for the early stage development of wave energy converters – Best practices and recommended procedures for the testing of pre-prototype devices*

ISO/IEC Guide 98-1~~:2009~~, *Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement*

ISO/IEC Guide 98-3~~:2008~~, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement* (GUM:1995)

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ISO 19901-1, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 1: Metocean design and operating considerations*

~~*EquiMar: Protocols for the equitable assessment of marine energy converters, Part II,* Chapters I.A.1 through I.A.5., Editors: David Ingram, George Smith, Claudio Bittencourt Ferreira, Helen Smith. European Commission 7th framework programme grant agreement number 213380, First Edition 2011~~

~~NDBC:2009, Technical Document 09-02, *Handbook of automated data quality control checks and procedures.* National Data Buoy Center, August 2009~~

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TECHNICAL SPECIFICATION

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Marine energy – Wave, tidal and other water current converters – Part 100: Electricity producing wave energy converters – Power performance assessment



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

Part 100: Electricity producing wave energy converters – Power performance assessment

FOREWORD

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IEC TS 62600-100 has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Incorporation of IEC TS 62600-102 as a series of annexes in this document
b) Removal of the computation of annual energy production. This has been moved to IEC TS 62600-101.

c) Modification to the list of terms definitions, symbols and units.

d) Modification of the reporting section to align with IEC TS 62600-200

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
114/537/DTS	114/554/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62600 series, published under the general title *Marine Energy – Wave, tidal and other water current converters*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 62600, which is a Technical Specification, provides performance assessment methods for wave energy converters. A wave energy converter is a device which generates electricity using the action of water waves and delivers electricity to an electrical load.

Wave energy industry development is transitioning from preliminary stages to commercial production stages. Validated data gathering and processing techniques are important to improve existing technologies. This document will be subject to changes as data are collected and processed from testing of wave energy converters.

The expected users of the document include:

- Device developers who want to validate the performance of their wave energy converter.
- Investors who want to assess the performance of a device developer's wave energy converter.
- Project developers who want to assess the performance of their project against manufacturer's claims.
- Surveyors contracted to carry out the assessment.
- Conformity assessment, test laboratories, and certification.
- Project developers – income, return on investment
- Device developers – performance of device
- Utilities and investors – reliability/predictability of supply, return on investment
- Policy-makers and planners – usage of seascape, optimisation of resource, power supply issues
- Consultants to produce resource data/due diligence – compatible/readable data format

An essential element for any published Technical Specification or International Standard is to allow an opportunity to provide feedback on its contents to the appropriate TC 114 Working Group. TC 114 utilizes a standard methodology to allow this.

To submit feedback such as proposed changes, corrections and/or improvements to this document, please send an email to the TC 114 Chair using the Contact TC 114 Officers feature on the IEC TC 114 Dashboard, accessible at www.iec.ch/tc114. On the right side of the Dashboard under Further information select the link to contact the TC 114 Officers. On the subsequent page find and select the Send Email link for the Chair to access the email tool.

Complete all the required elements within the email pop-up. For the Subject field please include the document title and edition you are providing feedback for (ex: feedback for TS 62600-1 ED2). In the Message field, include text which summarizes your feedback and note if further information can be made available (note attachments are not allowed). The Chair may request added information as needed before forwarding the submission to the remaining TC 114 Officers for review and then to the appropriate Working Group for their consideration.

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

Part 100: Electricity producing wave energy converters – Power performance assessment

1 Scope

Wave Energy Converters (WEC) are designed to operate efficiently at different locations. Systematic methods are used to evaluate the power performance of a WEC at a second location (hereinafter Location 2) based on power performance assessment at a first location (hereinafter Location 1). The degree of similarity of the measured WEC (WEC 1) and the metocean conditions at Location 1 to the secondary WEC (WEC 2) at Location 2 determine the methodology and the applicability of this document.

This document applied in conjunction with the IEC Technical Specification on wave energy resource assessment and characterization (IEC TS 62600-101), provides a method for estimation of the mean annual energy production of a WEC, assessing the electrical power production performance of a single, non-array, wave energy converter, at Location 2 based on the performance at Location 1.

The scope of this document includes:

a) All wave energy converters that produce electrical power from wave energy.
b) All sea resource zones (near and offshore, deep and shallow water).
c) Capture width matrix transposition from one location to another.
d) Limitation on the changes that are allowed to the WEC and the specification of the location.
e) Wave data required at Location 2, as a minimum the requirements found in IEC TS 62600-101.
f) Development of the capture width matrix at Location 2.
g) Validation of the capture width matrix at Location 2.
h) Assessment of uncertainties in the derived performance parameters at Location 2.
i) Requirements for the allowable power performance transfer by geometric, kinematic and dynamic similarity.
j) Requirements for the allowable incorporation of additional empirical model data.
k) Requirements for the allowable incorporation of additional numerical model data.
l) The document applies to commercial scale wave energy converters that are:
    1) compliantly moored.
    2) tautly moored.
    3) bottom mounted.
    4) shore mounted.

The scope of this document does not include:

a) Wave energy converters that produce nonelectrical energy.
b) Resource assessment.
c) Scaled devices in test facilities (tank or scaled sea conditions) where any scaling would be carried out to extrapolate results for a full-scale device.
d) Power quality issues.

e) Environmental issues.

f) Operation and maintenance.

g) Annual energy production (AEP).

This document provides a systematic method which includes:

- measurement of WEC capture width in a range of sea states.
- transposition of capture width from one location to a second location.
- an agreed framework for reporting the results of capture width and wave measurements.
- estimate of the capture width of a modified WEC at Location 2. This work would include the development of parameters for the modified WEC for the second location.

This document provides:

- guidance on the use of observations from Location 1.
- methods for assessing and reporting the validity of numerical and physical models.
- limits on the permissible changes to the WEC between Locations 1 and 2.
- limits on the use of data fitting techniques, and
- requirements for reporting.

The wave power industry is at an early stage of development. There is little practical experience with field-scale WECs deployment. Because of this, the present document will be subject to change as more data is collected and experience with wave energy converters develops.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60688, *Electrical measuring transducers for converting AC and DC. electrical quantities to analogue or digital signals*

IEC 61869-1, *Instrument transformers – Part 1: General requirements*

IEC 61869-2, *Instrument transformers – Part 2: Additional Requirements for current transformers*

IEC 61869-3, *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*

IEC TS 62600-3, *Marine energy – Wave, tidal and other water current converters – Part 3: Measurement of mechanical loads*

IEC TS 62600-101:2015, *Marine energy – Wave, tidal and other water current converters – Part 101: Wave energy resource assessment and characterization*

IEC TS 62600-103, *Marine energy – Wave, tidal and other water current converters – Part 103: Guidelines for the early stage development of wave energy converters – Best practices and recommended procedures for the testing of pre-prototype device*s

ISO/IEC Guide 98-1, *Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement* (GUM:1995)

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ISO 19901-1, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 1: Metocean design and operating considerations*