

Marine Energy

Wave, tidal and other water converters



INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

Purpose of Document

This document is intended to serve as a reference for TC 114 documents, and contains summaries, status, and links to each. This reference may be used by any interested party. As the work of TC 114 is rapidly progressing, this document will be updated twice per year at a minimum, and feedback from document users is welcome to make the document as useful as possible. Please send all feedback to Arielle.Cardinal@nrel.gov.

- **Chair:** Jonathan Colby (U.S.)
- **U.S. Technical Advisor:** Bill Staby
- **Secretary:** Danny Peacock (U.K.)
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- **Technical Officer:** Anson Chiah (IEC)
- **U.S. Secretary:** Arielle Cardinal

TC114 Scope

To prepare international standards for marine energy conversion systems. The primary focus will be on conversion of wave, tidal, and other water current energy into electrical energy, although other conversion methods, systems, and products are included. Tidal barrage and dam installations, as covered by TC 4, are excluded.

The standards produced by TC 114 will address the following, as guided by the **Strategic Business Plan**:

- Terminology
- Management plans for technology and project development
- Performance measurements of marine energy converters
- Resource assessments
- Design and safety, including reliability and survivability
- Deployment, commissioning, operation, maintenance, retrieval, and decommissioning
- Electrical interface, including array integration and/or grid integration
- Testing laboratory, manufacturing, and factory acceptance
- Additional measurement methodologies and processes.

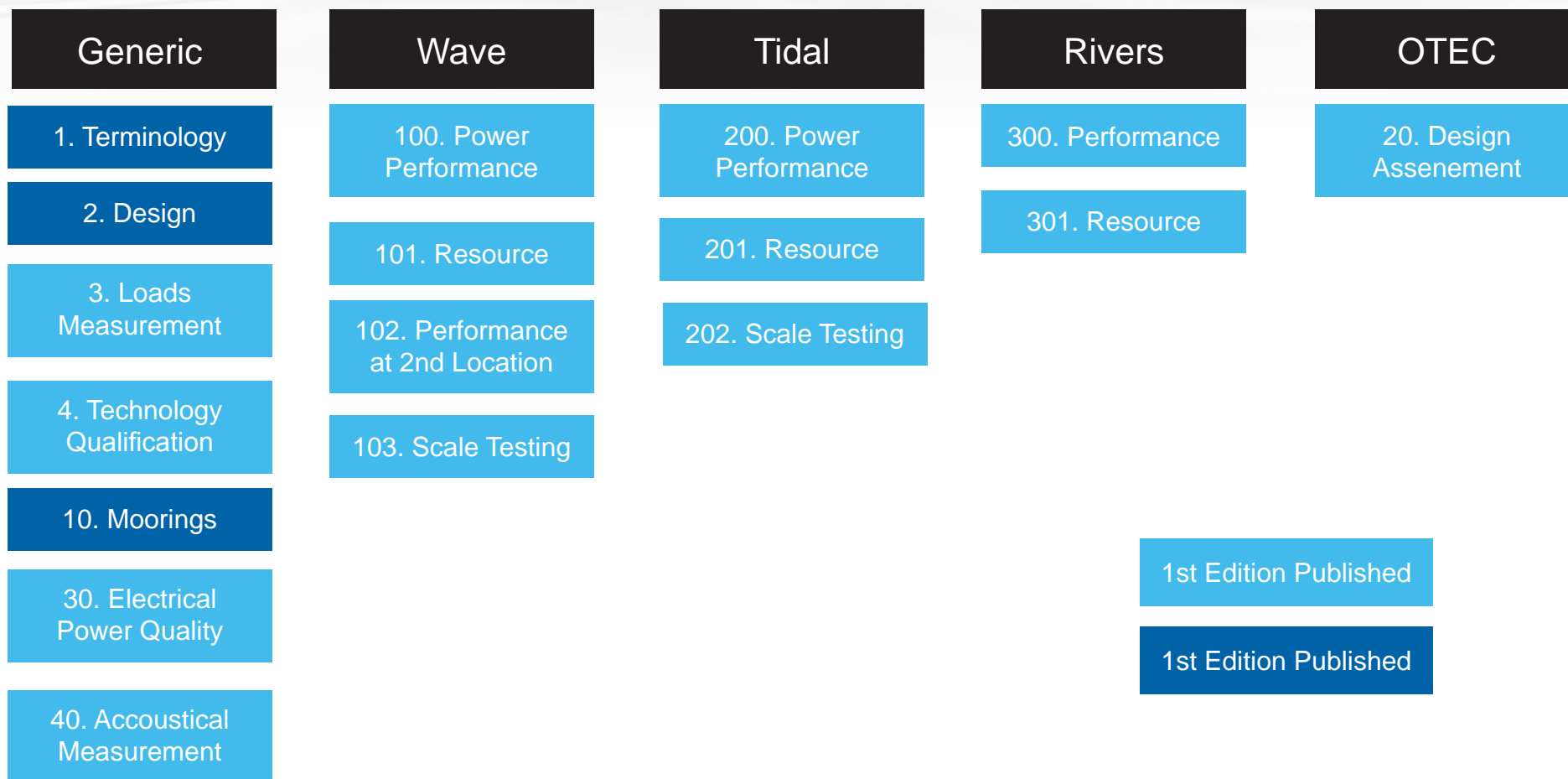
Glossary

- **Technical Specification**—A technical specification approaches an international standard in terms of detail and completeness but has not yet passed through all approval stages, either because consensus has not been reached or because standardization is seen to be premature.
- **International Standard**—An international standard is a document that has been developed through the consensus of experts from many countries and is approved and published by a globally recognized body. It comprises rules, guidelines,

processes, or characteristics that allow users to achieve the same outcome time and time again.

- **Committee Draft**—The Committee Draft (CD) is submitted to all IEC Members: those who participate actively in IEC work, and those who have observer status only (P- and O-members) for comment and approval.

- **Draft Technical Specification**—The Draft Technical Specification (DTS) is submitted to all IEC Members: those who participate actively in IEC work, and those who have observer status only (P- and O-members) for comment and vote to approve publication.



Document	Title	Document Status	Topics Covered
62600-2	Design requirements for marine energy systems	TS Edition 2.0 published in 2019 Next edition ETA: 2022	<p>This document provides requirements to ensure the engineering integrity of wave, ocean, tidal, and river current energy converters, collectively referred to as Marine Energy Converters (MECs). Its purpose is to provide an appropriate level of protection against damage from all hazards that may lead to catastrophic failure of the MEC structural, mechanical, electrical, or control systems. Figure 1 illustrates the scope of this document and critical interfaces with other elements of a marine energy converter installation.</p> <pre> graph TD subgraph MEC [Marine Energy Converter] S[Structural Primary structure Fixed foundation Interface to mooring] M[Mechanical Rotating components Oscillating components Power take-off system] E[Electrical Power generation system Umbilical interface] C[Control Control and monitoring Telemetry system] end MS[Mooring system] <--> Load exchange S S <--> Load exchange Env[Environmental Corrosion Marine growth Violent weather] S <--> Load exchange M M <--> Load exchange R[Resource Waves Tidal current River current] E <--> Electrical SSI[Sea-based and shore-based infrastructure] FT[Facility telemetry] <--> Electrical C </pre>

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62600-3	Measurement of mechanical loads	TS Edition 1.0 published in 2020 Next edition ETA: TBD	<p>This part of IEC 62600 describes the measurement of mechanical loads on hydrodynamic marine energy converters such as wave, tidal, and other water current converters (including river current converters) for the purpose of load simulation model validation and certification. This document contains the requirements and recommendations for the measurement of mechanical loads for such activities as site selection, measurand selection, data acquisition, calibration, data verification, measurement load cases, capture matrix, post-processing, uncertainty determination and reporting.</p> <p>Informative annexes are also provided to improve understanding of testing methods. The methods described in this document can also be used for mechanical loads measurements for other purposes such as obtaining a measured statistical representation of loads, direct measurements of the design loads, safety and function testing, or measurement of subsystem or component structural loads.</p> <p>Through a technology qualification process, the test requirements can be adapted to the specific marine energy converter.</p> <p>This document also defines the requirements for full-scale structural testing of subsystems or parts with a special focus on full-scale structural testing of MEC rotor blades and for the interpretation and evaluation of achieved test results. This document focuses on aspects of testing related to an evaluation of the structural integrity of the blade. The purpose of the tests is to confirm to an acceptable level of probability that the whole installed production of a blade type fulfills the design assumptions.</p>
62600-4	Standard for establishing qualification of new technology	TS Edition 2.0 published in 2020 Next edition ETA: 2/2022	<p>This part of IEC 62600 specifies the requirements of the technology qualification process for marine renewable technologies. Technology Qualification is a process of providing evidence and arguments to support claims that the technology under assessment will function reliably in a target operating environment within specific limits and with an acceptable level of confidence.</p> <p>The Technology Qualification process is also assumed in IEC TS 62600-2: 2019.</p> <p>The objective of this document is to provide the necessary practices and technical requirements regarding technology qualification methodology to support the needs of the IECRE certification process for marine renewables energy systems. Technology Qualification may be performed at the beginning of the certification process to identify the uncertainties, novelties, and modes of failure, mechanisms of failure, risks and risk control measures. In addition, Technology Qualification will identify the standards that are applicable, to what extent, and what adaptation to the technology is required to address the risks. The Technology Qualification Plan is the deliverable arising from this process and it will provide all necessary actions to achieve certification.</p>
62600-10	Assessment of mooring systems for marine energy converters	TS Edition 2.0 published in 2021 Next edition ETA: TBD	<p>The purpose of this Technical Specification is to provide uniform methodologies for the design and assessment of mooring systems for floating MECs (as defined in TC114 scope.) It is intended to be applied at various stages, from mooring system assessment to design installation and maintenance of floating MEC plants.</p> <p>This Technical Specification is applicable to mooring systems for floating MEC units of any size or type in any open water conditions. Some aspects of the mooring system design process are more detailed in existing and well-established mooring standards. The intent of this technical specification is to highlight the different requirements of MECs and not duplicate existing standards or processes.</p> <p>While requirements for anchor holding capacity are indicated, detailed geotechnical analysis and design of anchors are beyond the scope of this Technical Specification.</p>

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62600-20	Guideline for design assessment of Ocean Thermal Energy Conversion (OTEC) system	TS Edition 1.0 published in 2019 Next edition ETA: TBD	<p>This part of IEC 62600 establishes general principles for design assessment of OTEC plants. The goal is to describe the design and assessment requirements of OTEC plants used for stable power generation under various conditions. This electricity may be used for utility supply or production of other energy carriers. The intended audience is developers, engineers, bankers, venture capitalists, entrepreneurs, finance authorities, and regulators.</p> <p>This document is applicable to land-based (i.e. onshore), shelf-mounted (i.e. nearshore seabed mounted) and floating OTEC systems. For land-based systems the scope of this document ends at the main power export cable suitable for connection to the grid. For shelf-mounted and floating systems, the scope of this document normally ends at the main power export cable where it connects to the electrical grid.</p> <p>This document is general and focuses on the OTEC-specific or unique components of the power plant, particularly marine aspects of the warm and cold water intake systems. Other established standards are referenced to address common components between the OTEC system and other types of power plans and floating, deep water oil and gas production vessels, such as FPSOs and FLNG systems. Relevant standards are listed within this document as appropriate.</p>
62600-30	Electrical power quality requirements for wave, tidal, and other water current energy converters	TS Edition 1.0 published in 2018 Next edition ETA: TBD	Identifies power quality issues and parameters (non-device specific and prescriptive) for single/three-phase, grid-connected/off-grid (including micro-mini grid) marine wave, tidal, and other water current converter-based power systems. Also establishes the measurement methods, application techniques and result-interpretation guidelines.
62600-40	Acoustic characterization of marine energy converters	TS Edition 1.0 published in 2019 Next edition ETA: TBD	Provides uniform methodologies to consistently characterize the sound produced by the operation of marine energy converters that generate electricity, including wave, current, and OTEC. Does not include the characterization of sound associated with installation, maintenance, or decommissioning of these converters, nor does it establish thresholds for determining environmental impacts. Guidance is given for instrumentation calibration, deployment methods around specific types of MECs, analysis procedures, and reporting requirements.

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62600-100	Power performance assessment of electricity producing wave energy converters	TS Edition 1.0 published in 2012 Next edition ETA: 12/2022	<p>The scope of this Technical Specification includes: All Wave Energy Converters (WECs) that produce electrical power from wave energy; all sea resource zones (near and offshore, deep and shallow water); and commercial scale WECs that are:</p> <ul style="list-style-type: none"> • Compliantly moored • Tautly moored • Bottom mounted • Shore mounted <p>The scope of this Technical Specification does not include: WECs that produce other forms of energy unless this energy is converted into electrical energy; resource assessment; 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; power quality issues; environmental issues; and power matrix transportation from one location to another.</p> <p>This Technical Specification provides a systematic method which includes: Measurement of WEC power output in a range of sea states; WEC power matrix development; an agreed framework for reporting the results of power and wave measurements.</p>

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62600-101	Wave energy resource assessment and characterization	TS Edition 1.0 published in 2015 Next edition ETA: 12/2022	<p>This part of IEC 62600, which is a Technical Specification, establishes a system for estimating, analysing, and reporting the wave energy resource at sites potentially suitable for the installation of WECs. This Technical Specification is to be applied at all stages of site assessment (from initial investigations to detailed project design) and in conjunction with the IEC Technical Specification on WEC performance (IEC TS 62600-100) enables an estimate of the annual energy production of a WEC or WEC array to be calculated. This Technical Specification is not intended for estimation of extreme wave conditions.</p> <p>The wave energy resource is primarily defined using hydrodynamic models that are successfully validated against measurements. The framework and methodologies prescribed in this Technical Specification are intended to ensure that only adequate models are used, and that they are applied in an appropriate manner to ensure confidence and consistency in the reported results. Moreover, the document prescribes methods for analyzing metocean data (including data generated by modelling) in order to properly quantify and characterize the temporal and special attributes of the wave energy resource, and for reporting the results of a resource assessment in a comprehensive and consistent manner.</p>
62600-102	Wave energy converter power performance assessment at a second location using measured assessment data	TS Edition 1.0 published in 2016 TS will be merged into an Annex of -100 in 2021	<p>This part of IEC 62600 specifies data requirements needed from the original measurements at Location 1 including an assessment of the uncertainty involved (if based on limited/incomplete data material) in addition to those specified in IEC TS 62600-100 and IEC TS 62600-101. It also specifies:</p> <ul style="list-style-type: none"> • Limitation on the changes that are allowed to the WEC and the specification of the location • Wave data required at Location 2, as a minimum the requirements found in ICE TS 62600-101 • Development of the power matrix at Location 2 • Validation of the power matrix at Location 2 • Assessment of uncertainties in the derived performance parameters at Location 2 • Requirements for the allowable power performance transfer be geometric, kinematic, and dynamic similarity • Requirements for the allowable incorporation of additional empirical model data • Requirements for the allowable incorporation of additional numerical model data. <p>The Technical Specification does not cover the following items: The original data measurement at Location 1 (see IEC TS 62600-100); environmental concerns; operation and maintenance.</p>
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62600-103	Guidelines for the early stage development of Wave Energy Converters: Best practices and recommended procedures for the testing of pre-prototype scale devices	TS Edition 1.0 published in 2018 Next edition ETA: 12/2022	<p>This part of IEC TS 62600 is concerned with the sub-prototype scale development of WECs. It includes the wave tank test programmes, where wave conditions are controlled so they can be scheduled, and the first large-scale sea trials, where sea states occur naturally and the programmes are adjusted and flexible to accommodate the conditions. A full-scale prototype test is not covered in this document. Bench tests of Power Take-Off (PTO) equipment are also not covered in this document.</p> <p>This document describes the minimum test programmes that form the basis of a structured technology development schedule. For each testing campaign, the prerequisites, goals, and minimum test plans are specified. The document addresses:</p> <ol style="list-style-type: none"> Planning an experimental programme, including a design statement, technical drawings, facility selection, site data, and other inputs as specified in Clause 5 Device characterisation, including the physical device model, PTO components, and mooring arrangements where appropriate Environment characterization, concerning either the tank testing facility or the sea deployment site, depending on the stage of development Specification of specific test goals, including power conversion performance, device motions, device loads and device survival. <p>Guidance on the measurement sensors and data acquisition packages is included but not dictated. Providing that the specified parameters and tolerances are adhered to, selection of the components and instrumentation can be at the device developer's discretion.</p> <p>An important element of the test protocol is to define the limitations and accuracy of the raw data and, more specifically, the results and conclusion drawn from the trials. A methodology addressing these limitations is presented with each goal so the plan always produces defensible results of defined uncertainty.</p>
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62600-200	Power performance assessment of electricity producing tidal energy converters	TS Edition 1.0 published in 2012 Next edition ETA: 12/2022	<p>This Technical Specification provides: A systematic methodology for evaluating the power performance of Tidal Current Energy Converters (TECs) that produce electricity for utility-scale and localized grids; a definition of TEC rated power and rated water velocity; a methodology for the production of the power curves for the TECs in consideration; and a framework for the reporting of results.</p> <p>Exclusions from the scope of this Technical Specification are as follows:</p> <p>TECs that provide forms of energy other than electrical energy unless the other form is an intermediary step that is converted into electricity by the TEC; resource assessment. This will be carried out in the tidal energy resource characterization and assessment Technical Specification (future IEC/TS 62600-201); scaling of any measured or derived results; power quality issues; any type of performance other than power and energy performance; and the combined effect of multiple TEC arrays.</p>
62600-201	Tidal energy resource assessment and characterization	TS Edition 1.0 published in 2015 Next edition ETA: 12/2022	<p>This part of IEC 62600 establishes a system for analysing and reporting, through estimation or direct measurement, the theoretical tidal current energy resource in oceanic areas including estuaries (to the limit of tidal influence) that may be suitable for the installation of arrays of TECs.</p> <p>It is intended to be applied at various stages of project lifecycle to provide suitably accurate estimates of the tidal resource to enable the arrays' projected annual energy production to be calculated at each TEC location in conjunction with IEC 62600-200.</p>
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62600-202	Scale testing of tidal stream energy systems	TS edition 1 published in 2021	<p>The document describes the minimum test programs that form the basis of a structured technology development schedule. For each testing campaign, the prerequisites, goals, and minimum test plans are specified. The document addresses:</p> <ol style="list-style-type: none"> Planning an experimental program, including a design statement, technical drawings, selection of scale and facility based on physical laws, site data, and other inputs; Device representation and characterization, including the physical device model, power take-off components, foundation and mooring arrangements where appropriate; Energy resource and environment characterization, concerning either the tank testing facility or the open-water deployment site, depending on the stage of development; Specification of explicit test goals, including power conversion performance and device loads. <p>Guidance on the measurement sensors and data acquisition packages is included but not dictated. Providing the specified parameters and tolerances are adhered to, the device developer is free to select the components of instrumentation.</p> <p>An important element of testing is to define the limitations of accuracy of the raw data and, more specifically, the results and conclusions drawn from the trials. A methodology of addressing these limitations is presented with each goal so the plan always produces defensible results of defined uncertainty.</p> <p>It is anticipated that this document will serve a wide audience of tidal energy stakeholders, including device developers and their technical advisors; government agencies and funding councils; test centers and certification bodies; private investors; and environmental regulators and non-governmental organizations.</p>
62600-300	Power performance assessment of electricity producing river current energy converters	TS Edition 1.0 published in 2019 Next edition ETA: TBD	<p>The document provides a systemic methodology for evaluating the power performance of river current energy converters (RECs) that produce electricity for utility-scale and localized grids; a definition of river energy converter rated capacity and rated water speed; a methodology for the production of power curves for the river energy converters in consideration; and a framework for the reporting of results.</p> <p>Exclusions from the scope of this document are as follows: RECs that provide forms of energy other than electrical energy unless the other form is an intermediary step that is converted into electricity by the river energy converter; resource assessment that will be addressed separately in the River Energy Resource Assessment Technical Specification; scaling of any measured or derived results; power quality issues; any type of performance other than power and energy performance; and the combined effect of multiple river energy converter arrays.</p>
Document	Title	Document Status	Topics Covered

<p>62600-301</p>	<p>River energy resource assessment and characterization</p>	<p>TS Edition 1.0 published in 2019</p> <p>Next edition ETA: TBD</p>	<p>This part of IEC 62600 provides:</p> <ul style="list-style-type: none"> • Methodologies that ensure consistency and accuracy in the determination of the theoretical river energy resource at sites that may be suitable for the installation of RECs; • Methodologies for producing a standard current speed distribution based on measured, historical, or numerical data, or a combination thereof, to be used in conjunction with an appropriate river energy power performance assessment; • Allowable data collection methods and/or modelling techniques; and • A framework for reporting the results. <p>The document explicitly excludes:</p> <ul style="list-style-type: none"> • Technical or practical resource assessments; • Resource characterization; • Power performance assessment of RECs; and • Environmental impact studies, assessments, or similar.
<p>Upcoming new work item proposals</p>			<p>The National Committee of TC114 identified the following as the top priorities for the TC114:</p> <ul style="list-style-type: none"> • Guidelines—I,O&M procedures • O&M principles • Design guidelines—connections to minigrids • Design guidelines—subsea cables • Cable lay guidelines