Standardization Risks in Wind and Ocean Power

Study conducted for

CANADIAN STANDARDS ASSOCIATION

Study sponsored by

Natural Resources Canada

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Overview

- Context of Wind & Ocean Power
- Existing Standards
- Proposed Standards
- Risk Methodology
- Risk Registry
- Technical Commentary
- Industry Risk Ranking

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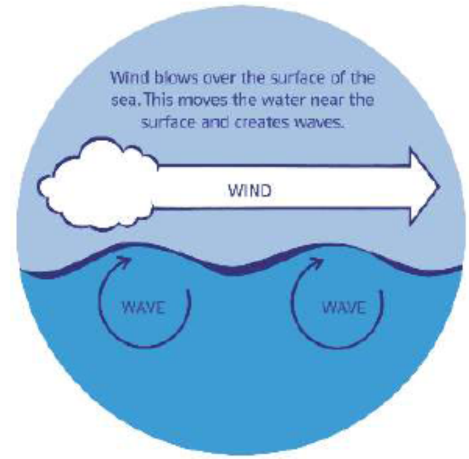
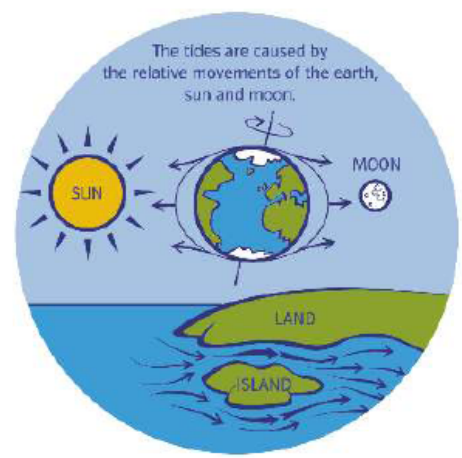
Context

Ocean Power

- Wave Power
- Tidal – Ocean Current
- Kinetic – “Zero Head”
- At present<~200 MW world wide commercial





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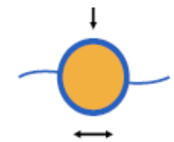
Context

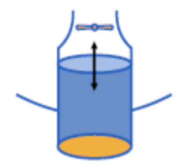
Wave Power Device Classification

BUOYS - floating structures which are carried up and down and/or pushed side to side by the waves and convert that movement into power to drive a generator.

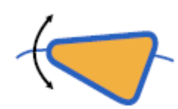


SURFACE FOLLOWING - floating structures hinged together following the surface movement of passing waves using the motion of the parts against each other to drive a generator.

OSCILLATING WATER COLUMN - enclosed column of air which rises and falls with the motion of the waves, pushing out and sucking back through a turbine which drives a generator.



TERMINATORS - line of floating structures placed facing the oncoming waves and forced to move against each other using the power to drive a generator.



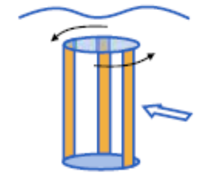
OVERTOPPING - an offshore reservoir is created as waves flow up a ramp into the structure, then flow back out through a turbine that drives a generator.

Source: OREG

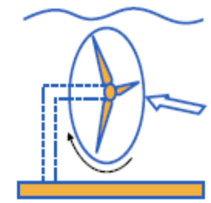
Context

Tidal Power Device Classification

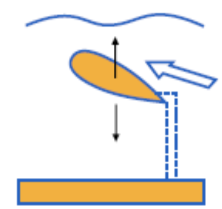
CROSS-FLOW OR VERTICAL AXIS TURBINES - the turbine is placed in the tidal stream flow, as the water flows past the vertical turbine blades rotate to drive a generator producing power.



AXIAL OR HORIZONTAL AXIS TURBINES - these turbines are similar to modern wind turbines; as the tidal stream flows past, the turbine blades rotate producing power through a generator.



RECIPROCATING HYDROFOILS - working like a fish's tail and controlled by pitch, the hydrofoils are forced up and down by the stream flow capturing power to drive a generator.



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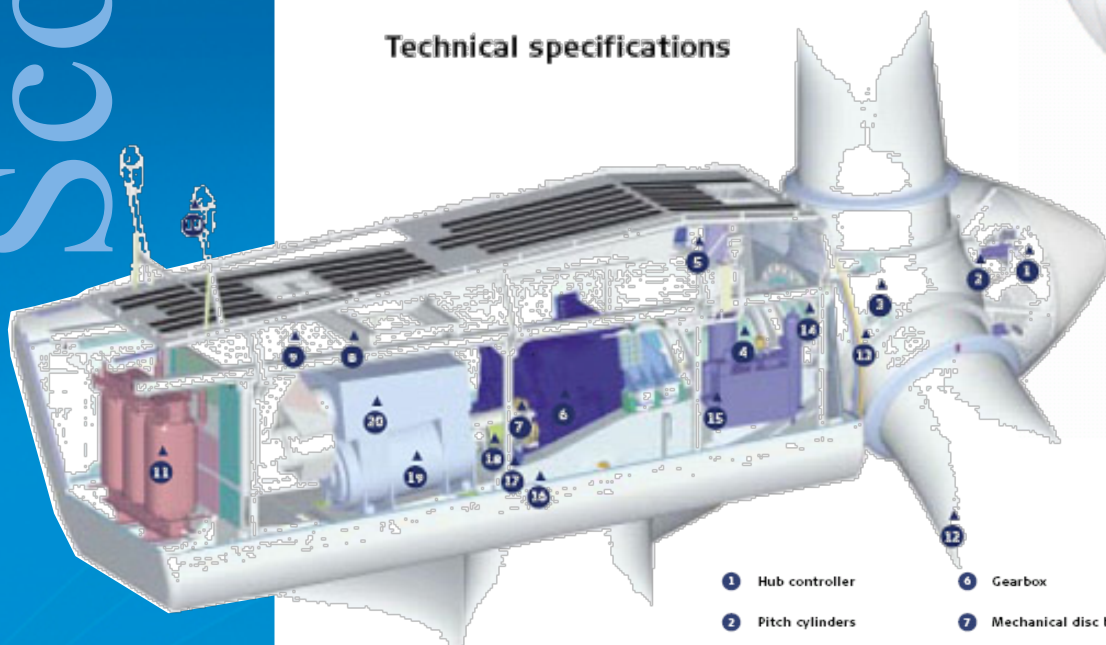
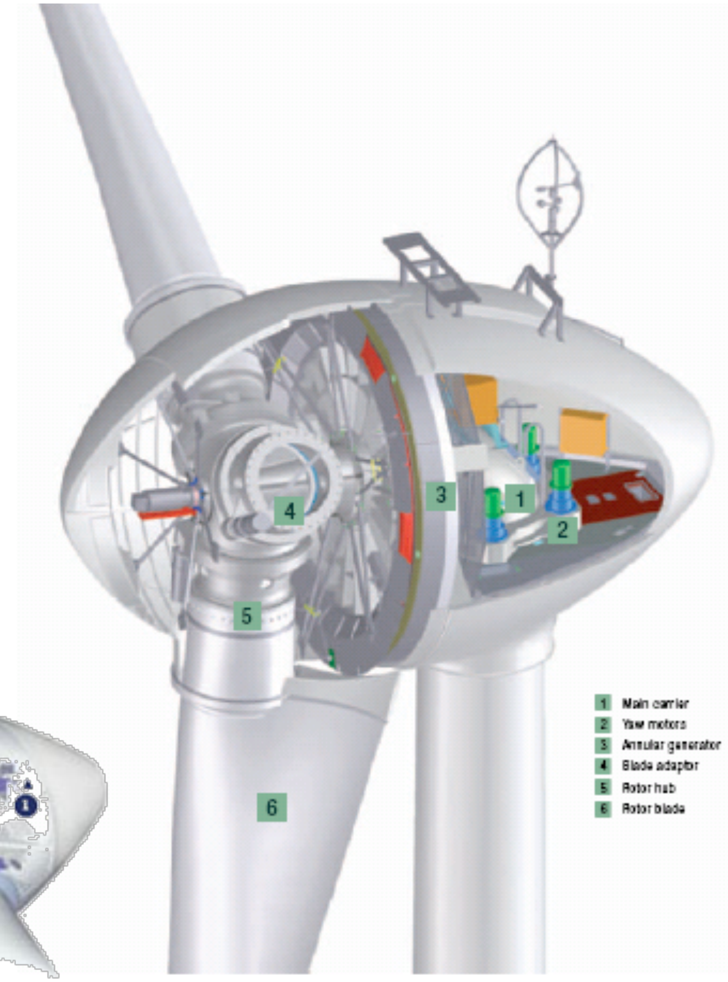
Scope

Wind Power

- On-shore / Off-shore
- Utility scale / Small wind

Technical specifications





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Standards

Wind Power

- Existing IEC standards (TC-88):
  - IEC 61400-1* Wind Turbine Design (1993)
  - IEC 61400-2*Small Wind Turbine Safety (1994)
  - IEC 61400-3 Off-shore (Final Draft 2008)
  - IEC 61400-11* Noise Measurement (1998)
  - IEC 61400-12* Power Performance (1998)
  - IEC 61400-13 Mechanical Loads (1999)
  - IEC 61400-21 Power Quality (1999)
  - IEC 61400-22 Wind Turbine Certification (1999)
  - IEC 61400-23 Blade Structural Testing (1999)
  - IEC 61400-24 Lightning Protection (2008)
  - IEC 61400-25 Communication (2008)

* Adapted by CSA as National Standards in Canada

Standards

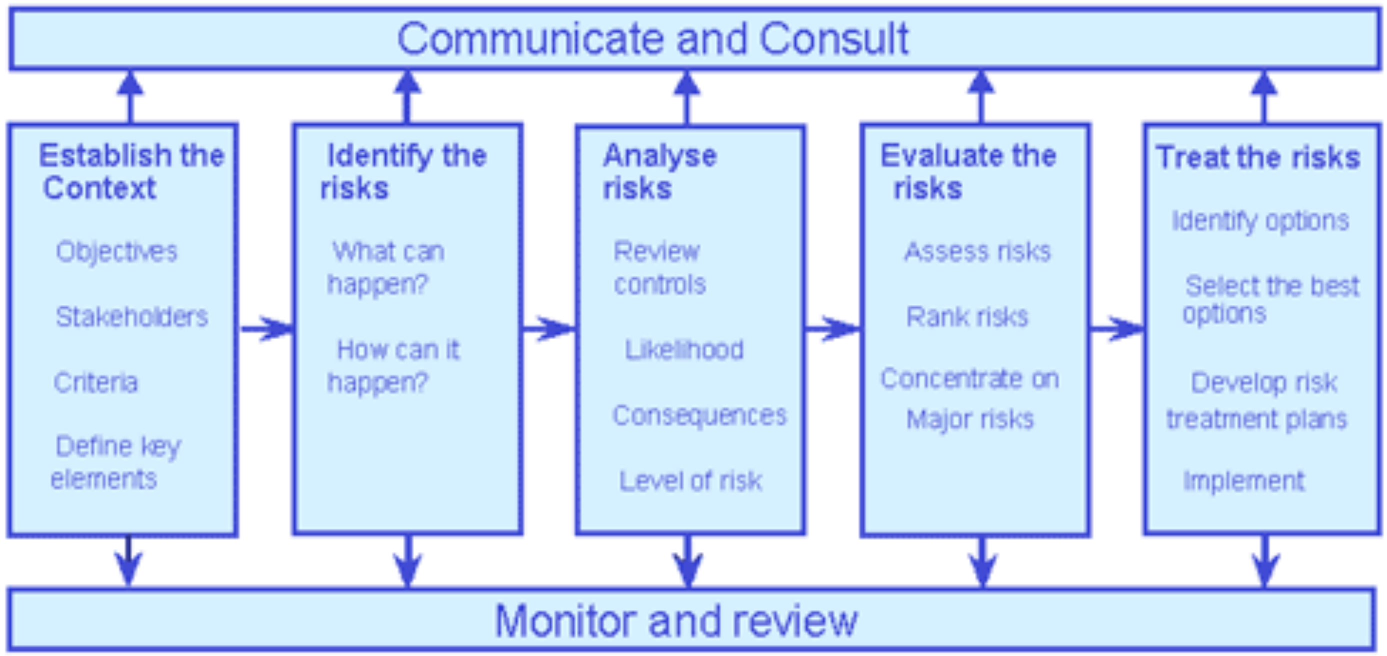
Ocean Power

- None existing
- IEC TC 114 Formed in 2007
  - 14 Member Countries
  - Mandate to develop standards for marine energy conversion systems (focus on electricity generating, excluding barrage)
- IEC TC 114 will address
  - Terminology*
  - Performance measurement of wave, tidal and water current energy converters*
  - Resource assessment requirements, *
  - Design and safety requirements*
  - Power quality
  - Manufacturing and factory testing
  - Evaluation and mitigation of environmental impacts

  * Identified as priority

Risk Methodology

Phases of Risk Management



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Risk Methodology

Risk Identification

- Technical categories ->triggers:
  - customer requirements
  - resource availability and skill mix
  - technical expertise
  - development level or technological maturity
  - size and/or complexity
  - integration requirements and potential
  - maintenance concerns
  - availability of parts and sourcing of components

Risk Methodology

Likelihood

Rating	Likelihood Description and Indicative Frequency	Indicative Probability
A – 5	Almost Certain: Very high probability of occurrence could occur several times per year. Has occurred several times on similar projects at this location.	>0.8
B – 4	Likely: High probability, likely to approximately once per year. Similar event has occurred several times per year on similar projects for this organisation.	0.5 to 0.8
C – 3	Moderate: Possible, reasonable probability that it may occur at least once in a 1 to 10 year period. A similar event has occurred at some time on other similar projects for this organisation	0.1 to 0.5
D – 2	Unlikely: Plausible, unlikely to occur during the project, could occur over the next 10 to 40 years. A similar event has occurred on other similar projects in this industry	0.02 to 0.1
E – 1	Rare: Very low likelihood but not impossible, unlikely to occur during the next 40 years. A similar event has occurred elsewhere in the world in this industry.	<0.02

Risk Methodology

Consequence

Rating	Technical Performance	Project Cost	Project Schedule	Health & Safety	Environment
E - 5 (Catastrophic)	60% of design capacity not achieved Increase in operating costs	Greater than 30% cost overrun	Greater than 50% delay in project completion	Multiple fatalities	Long term environmental damage – 5 years or more requiring > $5M to remediate, study and/or penalties
D - 4 (Major)	Cannot achieve 80% of design capacity without significant capital expenditure Increase in operating costs	16% to 30% cost overrun	17% to 50% delay in project completion	Fatality Injury relating in permanen t disabilities	Medium term – 1 to 5 years environmental damage requiring $1 to $5M to remediate, study and/or penalties
C - 3 (Significant)	Cannot achieve 100% design capacity without significant capital expenditure 10% to 30% increase in operating costs	6% to 15% cost overrun	8% to 17% delay in completion of the project	Serious injuries Extended lost time	Short-term < 1 year environmental damage requiring up to $1M to remediate, study and/or penalties
B - 2 (Moderate)	Cannot achieve 100% design capacity without some capital expenditure <10% increase in opex	0.5% to 5% overrun	3% to 8% delay in the completion of the project	Significant injury Limited lost time	Environmental damage requiring up to $250K to remediate, study and/or penalties
A - 1 (Minor)	Minor Difficulties	Less than 0.5% Within budgeted costs	Less than 3% delay	Minor injuries or near miss	Negligible environmental impact, managed within budgets

Risk Methodology

Risk Matrix

Likelihood	Consequences				
	A – 1 Minor	**B – 2 Moderate**	**C – 3 Significant**	**D – 4 Major**	**E – 5 Catastrophic**
A – 5 Almost Certain	Moderate 11	High 16	High 20	Extreme 23	Extreme 25
B – 4 Likely	Moderate 7	Moderate 12	High 17	High 21	Extreme 24
C – 3 Moderate	Low 4	Moderate 8	Moderate 13	High 18	High 22
D – 2 Unlikely	Low 2	Low 5	Moderate 9	Moderate 14	High 19
E – 1 Rare	Low 1	Low 3	Moderate 6	Moderate 10	High 15

Risk Registry

Definition “successful”:

- **“Select the suitable location, energy capture, constraints, development status and technology for a wind or ocean power renewable energy project and implement the project within scope, schedule and budget for operation at projected reliability and electricity output performance levels over the design life of the project without harm to health, safety, environment or community.”**

Risk Registry

Wind – Extreme Risks

Issue	Risk	Standard	Likelihood	Consequence
Training and Qualifications	No accredited programs for engineers and technicians exist specific to RE devices and installations. Risk of under-qualified staff in construction and maintenance.	n/a	5	4 Health & Safety Technical Performance
Fabrication & Manufacture	Fabrication and manufacturing experience as well as QA procedures specific to RE devices and installations are lacking. Risk of poor quality of RE devices.	CSA 61400-1 61400-2 IEC 61400-3	5	4 Health and Safety Technical Performance
Installation & Construction	Construction and installation experience as well as QA procedures specific to RE devices and installations are lacking. Risk of poor quality of RE structures.	CSA 61400-1 61400-2 IEC 61400-3	5	4 Health and Safety Technical Performance
Management	Unavailability or inexperience of qualified management team: project managers, construction managers, operations managers & financers	n/a	5	4 Technical and Financial Performance

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Risk Registry

Ocean – Extreme Risks

Issue	Risk	Standard	Like-lihood	Consequence
Extent of R&D effort completed	Development efforts vary greatly between the large number of different ocean RE devices, which range from conceptual design to lab testing complete or to prototype/demo unit, from temporary to permanent anchorage. Risk of deployment of unproven technology with potential for adverse environmental impact or, unsatisfactory reliability and electricity output performance	n/a	5	4 Financial, H&S Environmental Impact
Training and qualifications	No accredited programs for engineers and technicians exist specific to RE devices and installations. Risk of under-qualified staff in construction and maintenance.	n/a	5	4 H&Safety Technical Performance
Fabrication & manufacture	Fabrication and manufacturing experience as well as QA procedures specific to RE devices and installations are lacking. Risk of poor quality of RE devices.	CSA-ISO 1990I to 19905	5	4 H&Safety Technical Performance
Installation & construction	Construction and installation experience as well as QA procedures specific to RE devices and installations are lacking. Risk of poor quality of RE structures.	Idem	5	4 H&Safety Technical Performance
Management	Unavailability or inexperience of qualified management team: project managers, construction managers, operations managers & financers.	n/a	5	4 Technical & Financial Performance
Satisfy reliability, strength, stability & dependability criteria	Criteria are not established. Applicable design safety factors (or load factors for limit states design) are not established. Risk of equipment failure.	n/a	5	4

Commentary

General

- Wind power
  - relatively mature technology
  - converged to widely uniform design features
  - strong foundation in international standards issued by IEC – TC88
  - standards are actively applied in design, certification and verification
- Ocean power
  - wide variety of technologies in various stages of development
  - no body of standards exists that is specific
  - harsh operating environment
  - IEC – TC 114 has been recently established
  - In the interim standards from other industries are being adopted
- Maintenance of wind and ocean power
  - practises from the power industry at large
  - specific training needs are recognized
  - No activity on standardization in this area has been identified.

Commentary

Pilot, Prototype or Demonstration Stage

- Inexperience leading to poor decisions, reactive risk management and a lack of anticipating relevant issues proactively. Technology and safety risks need to be identified before they can be managed
- Lack of sufficiently trained design and construction resources
- Immature technology that does not work or fails to meet minimum service level requirements
- Inappropriate resource assessment leading to device being incorrectly located resulting in under performance, difficult installation and/or stability issues.
- Device failure (sink, topple, collapse or generally does not achieve commissioning).
- Underfunding, insufficient to complete the device, or forcing short cuts that lead to technology inadequacy
- O&M or installation inexperience, leading to personal safety issues.

Commentary

Commercial Stage

- For proven technology the performance levels are generally known and the environmental issues have been identified.
- Challenge in realistically establishing and professionally managing the scope, budget and schedule.
- Resource assessment uncertainty and validation with actually measured field performance
- Array spacing and maximum extractable power from a significant resource needs to be established to avoid over- or under-development.
- Challenging site licensing/permit process
- Lack of experience in estimating long term O&M servicing requirements. O&M is a very high cost item for offshore work.
- Commodity price escalation (e.g. steel, copper) leading to alternative materials being developed with inherent short-term development risks.
- General financial & insurance risk

Commentary

Civil/Geotechnical

- Wind power
  - Well established standards & expertise in Canada and internationally
- Ocean power
  - Establish understanding of loading, in particular
  - Develop standards for design

Commentary

Construction

- Wind power
  - Construction in Canada is relatively well established
  - Structures relatively well accessible during construction
- Ocean power
  - Wide variety of device increases necessary efforts in development of standards
  - General offshore practises and standards from the oil and gas industry fill the gap.
  - Necessary to develop best practices
  - Challenging underwater quality control of civil and geotechnical structures

Commentary

Electrical

- technical standards in particular the Canadian Electrical Code are adequate for onshore installations
- There is currently work underway to add a new section to the Canadian Electrical Code Pt 1 - for the rules of installation for Wind and Ocean energy systems
- training need to be addressed through accrediting bodies at college and university level
- electrical interconnection is a provincial domain in Canada because of the ownership and operations for the electrical grid (outside national standards)

Commentary

Mechanical/Materials

- Standards on materials and testing are well established
- No experience on loading for the different ocean power technologies
- need instrumented field test to quantify loads for design purposes
- urgent to keep in step with the increasing quantity and size of planned installations

Commentary

Resource Assessment

- Wind Power
  - Internationally and in Canada a set of technical standards to guide the process of wind resource assessment does not exist
  - Risks are economic in nature rather than technical or safety issues, i.e. outside typical domain for CSA (but maybe in future)
- Ocean Power
  - Expert judgement prevail in evaluating the wave or current resource
  - IEC targets development of standard

Industry Rating

WIND POWER			
Overall Rating – Wind Power	**Average Likelihood : 2.79**	**Average Consequence : 2.83**	Average Risk: Low
Count of Risk Items	8.3%	4	Extreme
	12.5%	6	High
	56.3%	27	Moderate
	22.9%	11	Low
	100.0%	48	Total
OCEAN POWER			
Overall Rating – Ocean Power	**Average Likelihood : 3.17**	**Average Consequence : 3.04**	Average Risk: Moderate
Count of Risk Items	11.8%	8	Extreme
	27.9%	19	High
	44.1%	30	Moderate
	16.2%	11	Low
	100.0%	68	Total

Questions?

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