



COLLEGIATE
WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY COLLEGIATE WIND COMPETITION 2023

Rules and Requirements

August 31, 2022

Preface

The U.S. Department of Energy Collegiate Wind Competition 2023 will be governed and adjudicated by this manual, which is intended to establish fair contest rules and requirements. In case of a discrepancy with other competition materials or communication, this document takes precedence. The organizers reserve the right to change contest criteria, rules, and measurable outcomes as needed.

While teams work on their deliverables, faculty advisors, graduate student advisors, and members of industry secured by each team for support can provide feedback about the team's design so the students can identify mistakes, prove technical rigor, or demonstrate feasibility of their concept. Teams are highly encouraged to pursue mentorships and sponsorships early in the competition year beyond any guidance received throughout the Connection Creation Contest. However, only undergraduate student team members may take an active role in any competition event. It is the role of the nonstudent team members, including mentors and sponsors, to provide a supportive environment and the educational background necessary for the students to achieve success in the competition. The Faculty Advisor advises, provides input, and coaches the students on the skills necessary to compete in the various aspects of the competition. **It is not appropriate for anyone other than an undergraduate student to be actively working on a wind turbine or making decisions.**¹

In addition, teams are encouraged to communicate rules that are unclear, misguided, or in need of improvement. The organizers will seriously consider suggestions if they are feasible and intended to improve the competition, its rules, measurable outcomes, fairness, or precision.

¹ Any student who was an undergraduate student member of the team during the competition year may continue to act in that role throughout the competition year.

List of Acronyms

A	ampere
cm	centimeter
CWC	Collegiate Wind Competition
DOE	U.S. Department of Energy
GW	gigawatt
m	meter
mm	millimeter
m/s	meters per second
NREL	National Renewable Energy Laboratory
PCC	point of common coupling
Q&A	question and answer
RPM	revolutions per minute

Table of Contents

Preface.....	i
List of Acronyms	iii
Revision History	vi
1 Introduction	1
2 Competition, Contests, Products, and Awards.....	2
2.1 Overview of Product Submission Deadlines.....	3
2.2 Awards	4
3 Turbine Design and Testing Contests	5
3.1 Turbine and Load Design Requirements.....	5
3.2 Midyear Project Milestones.....	20
3.3 Technical Design Report.....	22
3.4 Presentation and Question and Answer Session.....	23
3.5 Wind Turbine Testing	23
4 Project Development Contest	27
4.1 Part A: Research and Develop a Plan for an Offshore Wind Farm.....	27
4.2 Part B: Design a Wind Farm During the Competition	31
5 Connection Creation Contest.....	33
5.1 Contest Elements.....	33
5.2 Final Metrics Report.....	36
5.3 Final Presentation and Q&A	37
Glossary.....	38
Appendix A. Rubrics	39
Appendix B. Deliverable Requirements.....	47
Appendix C. Sample Safety and Technical Inspection.....	51
Appendix D. Roles and Responsibilities	53
Appendix E. Learn-Along Schools	56
Appendix F. Funding Requests	58
Appendix G. Logistics	59
Appendix H. Safety and Conduct.....	61
Appendix I. Dispute Resolution.....	64
Appendix J. Communications and Contest Details	65
Appendix K. Alternative Competition Structure.....	68
Appendix L. Virtual Conference Participation Etiquette	73

List of Figures

Figure 1. Overview of contests and products.....	2
Figure 2. The configuration of the Collegiate Wind Competition wind tunnel. <i>Image created by Jason Roadman, NREL.....</i>	5
Figure 3. Allowable turbine volume. <i>Image created by Jason Roadman, NREL.....</i>	6
Figure 4. Offshore simulation tank underneath the competition wind tunnel. <i>Image created by Jason Roadman, NREL.....</i>	7
Figure 5. Offshore simulation tank. <i>Image created by Jason Roadman, NREL.....</i>	8
Figure 6. (a) Turbine, structure, and anchorage allowable volumes and (b) tank layout. <i>Image created by Jason Roadman, NREL</i>	8
Figure 7. Organizer-provided transition piece (stub) between the student tubing and turbine. <i>Image created by Jason Roadman, NREL</i>	10
Figure 8. A bubble level (similar to the one shown here) will be provided to help align the foundation during installation (Link to Rongpro level).....	11
Figure 9. Electrical cable from the wind turbine base through the foundation to the point of common coupling and load. <i>Image created by Jason Roadman, NREL</i>	12

Figure 10. Base flange dimensions for wind turbine attachment to tunnel (dimensions in centimeters). <i>Image created by Jason Roadman, NREL</i>	13
Figure 11. Load, turbine, and point of common coupling arrangement. <i>Image created by Lee Jay Fingersh, NREL</i>	14
Figure 12. Wiring layout of the point of common coupling and student load display table. <i>Image created by Jason Roadman, NREL</i>	16
Figure 13. Proper Anderson Powerpole polarity to match tunnel wiring	17
Figure 14. Team-provided connection to the manual shutdown interface	18
Figure 15. Competition-provided connector for manual shutdown interface	18
Figure 16. Laser tachometer used to measure turbine revolutions per minute	18
Figure 17. Laser tachometer sensors (circled in white) used to measure turbine RPM.	19
Figure 18. Map of offshore Port Furchon auction area.....	28
Figure A-1. Score weighting based on power ratio for control of rated power task	42
Figure A-2. Score weighting based on revolutions per minute ratio for control of rated rotor speed task	43

List of Tables

Table 1. Product Deadlines.....	3
Table A-1. Scoring Rubric for the Overall Competition.....	39
Table A-2. Scoring Rubric for the Midyear Progress Milestones for Turbine Design and Testing.....	39
Table A-3. Scoring Rubric for the Technical Design Report and Question and Answer Session.....	40
Table A-4. Scoring Rubric for Wind Turbine Performance Testing.....	40
Table A-5. Weighting for the Power Curve Performance Task.....	41
Table A-6. Scoring Rubric for the Midyear Progress Milestone for Project Development.....	44
Table A-7. Project Development Contest Part A: Develop Plan for 100-Megawatt Wind Farm	44
Table A-8. Project Development Contest Part B: On-Site Design Challenge	45
Table A-9. Scoring Rubric for the Midyear Progress Milestones for the Connection Creation Contest .	45
Table A-10. Scoring Rubric for Connection Creation Contest Deliverables.....	45
Table B-1. Team Names and Abbreviations.....	49
Table B-2. Product Names, Contests, and Abbreviations.....	50
Table C-1. Sample Inspection Sheet for Evaluating Test Turbines	51
Table D-1. Roles and Responsibilities	53
Table H-1. Suggested Hazards and Controls for Testing Prototype Wind Turbines	62
Table K-1. Updated Submission Timelines	69

Revision History

This document is the first draft version, issued August 31, 2022.

1 Introduction

The U.S. Energy Information Administration projects that the share of renewables in the U.S. electricity generation mix will increase from 21% in 2020 to 42% in 2050 with wind and solar generation playing a significant role² The U.S. Department of the Interior, DOE, and U.S. Department of Commerce also announced a shared goal to deploy 30 gigawatts (GW) of offshore wind energy in the United States by 2030, which could support more than 44,000 jobs by 2030 and nearly 33,000 additional jobs in communities supported by offshore wind activity.³ As more wind energy is incorporated into the U.S. power generation mix, qualified workers are needed to fill jobs at all levels.

To support these goals, DOE and the National Renewable Energy Laboratory (NREL) created the Collegiate Wind Competition in 2014 (hereafter referred to as the Collegiate Wind Competition, CWC, or the competition). The competition contributes to renewable energy job preparedness and energy equity in the transition to a global clean energy economy. Specifically, the CWC's objective is to prepare students from multiple disciplines to enter the wind energy workforce by providing real-world experience for researchers, scientists, engineers, educators, project managers, and business and sales forces. Wind-energy-specific advanced degrees are not required for many of these jobs but having wind-related experience is highly valuable.⁴

Each year, the competition identifies a new challenge and set of activities that address real-world research questions, thus demonstrating skills that students will need to work in the wind or wider renewable energy industries. The Collegiate Wind Competition 2023 challenge is to:

Address challenges in siting, outreach, and development of offshore, fixed-bottom wind turbines.

Specifically, competition participants will need to create:

- An effective mechanical, electrical, and aerodynamic wind turbine and load design with a fixed-bottom sea foundation that is safe and reliable for testing in an on-site wind tunnel with a sea simulation tank
- A site plan and cost-of-energy analysis for an offshore wind farm
- A presentation on wind energy careers, community engagement, and outreach.

The competition does not prescribe a power system market (i.e., <https://www.ferc.gov/electric-power-markets>) or wind regime.

Proactive risk management in the face of uncertainty remains fundamental for any line of employment. The same is true for this event. As a result of the COVID-19 pandemic, the rules are written in a way that ensures readers will clearly understand all aspects of the CWC in case the in-person event should become a virtual competition.

² [EIA Annual Energy Outlook, 2021](https://www.eia.gov/outlooks/aeo/) <https://www.eia.gov/outlooks/aeo/>

³ <https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/>

⁴ <https://www.nrel.gov/docs/fy19osti/73908.pdf>

2 Competition, Contests, Products, and Awards

The Collegiate Wind Competition 2023 comprises all of the aspects and activities leading up to, during, and following the event. During the event, teams compete in four contests: Turbine Design, Turbine Testing, Project Development, and Connection Creation. Within each contest, teams’ submissions (hereafter referred to as “products”) receive points toward winning the contest. An overview of which products contribute to the scoring of each of the contests is in Figure 1. The number of points a product contributes to the overall score is covered in 0.

The competition will be held in two phases that determine a team’s level of participation. Phase 1 teams will participate through the fall semester, completing several milestones. CWC organizers will use those milestones to determine which 12 of the Phase 1 teams will compete in Phase 2 during the spring 2023 semester. Refer to Section 2.1 for details on which milestones will be evaluated and when they are due. The remaining Phase 1 teams who are not selected for Phase 2 are encouraged to continue their involvement throughout the spring semester as learn-along schools and receive virtual feedback from judges. These schools will choose which events they want to focus on during the spring semester. More details can be found in Appendix F.

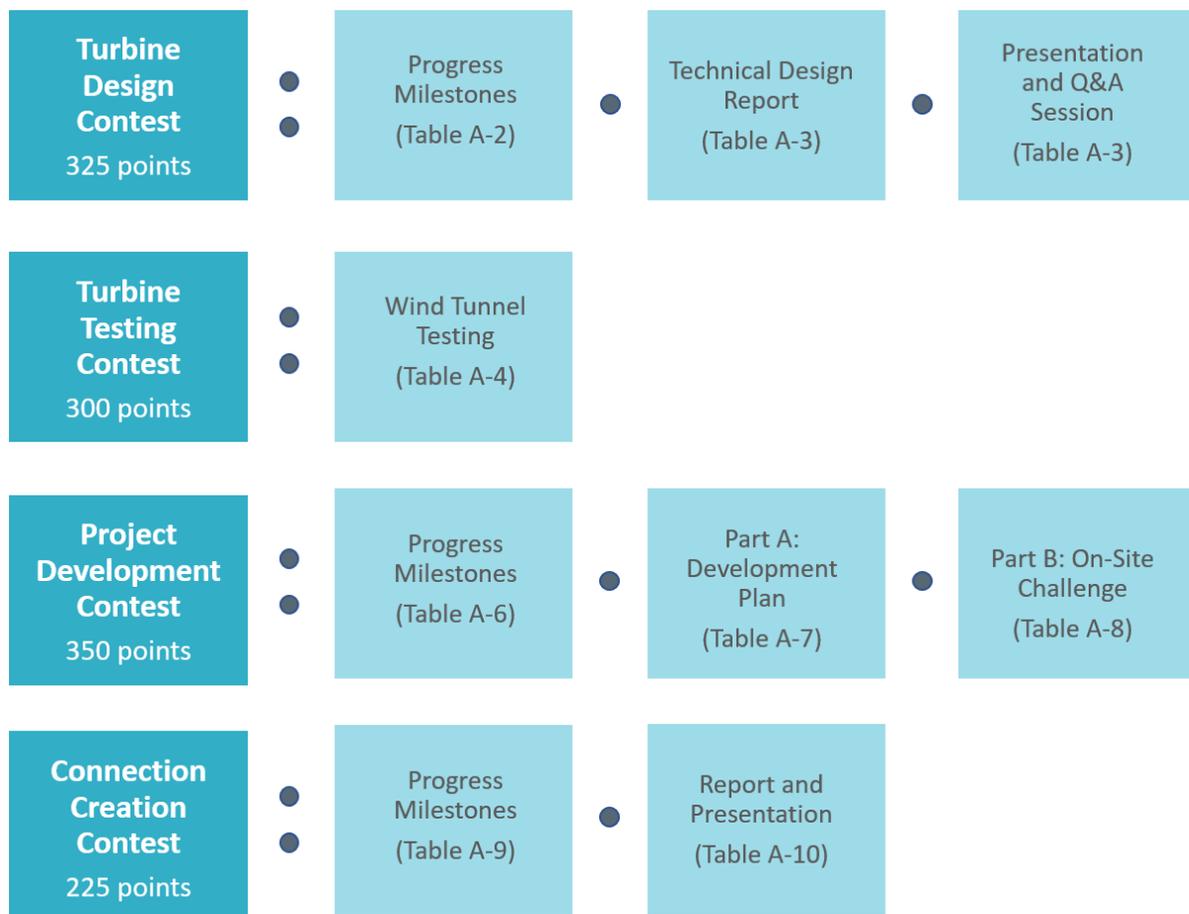


Figure 1. Overview of contests and products

2.1 Overview of Product Submission Deadlines

This section provides an overview of when products should be submitted. The competition is expected to run from Sunday, May 21, through Wednesday, May 24, 2023, at the American Clean Power Association’s CLEANPOWER 2023 Conference & Exhibition in New Orleans, Louisiana, or a similar venue and timeline.⁵ Should the venue change, an announcement will be made during fall semester. Refer to each product section and Appendix B for format requirements and submission instructions. Teams are strongly encouraged to submit early in case of technical difficulties or similar submission challenges.

Table 1. Product Deadlines

Product	Down-Select	Contest	Submission Deadline
PRIOR TO THE COMPETITION:			
Conceptual design milestone	✓	Turbine Design	Thurs., 10/27/22, 11:59 p.m. mountain time (MT)
Outreach plan milestone	✓	Connection Creation	Thurs., 10/27/22, 11:59 p.m. MT
Preliminary design report milestone	✓	Turbine Design	Thurs., 12/8/22, 11:59 p.m. MT
Preliminary site design milestone	✓	Project Development	Thurs., 12/8/22, 11:59 p.m. MT
Understanding the wind industry milestone	✓	Connection Creation	Thurs., 12/8/22, 11:59 p.m. MT
Team story		Connection Creation	Thurs., 1/26/23, 11:59 p.m. MT
Subassembly assembly and testing milestone		Turbine Design	Thurs., 4/13/23, 11:59 p.m. MT
Identify events to continue competing in		Learn-Along	Thurs., 4/6/23, 11:59 p.m. MT
Turbine design report		Turbine Design	Thurs., 5/4/23, 11:59 p.m. MT
Project development report		Project Development	Thurs., 5/4/23, 11:59 p.m. MT
Metrics report		Connection Creation	Thurs., 5/4/23, 11:59 p.m. MT
Technical inspection prior to competition		Turbine Design	Thurs., 5/4/23, 11:59 p.m. MT
DURING THE COMPETITION:			
Project development poster(s)		Project Development	Upload to Box and bring to presentation
Turbine design question and answer (Q&A) supporting materials (optional)		Turbine Design	Upload to Box and bring to presentation
Connection Creation presentation		Connection Creation	Upload to Box and bring to presentation
Test turbine and load system		Turbine Testing	During safety inspection

⁵ Should the venue change from CLEANPOWER, a decision will be announced by 12/31/22.

2.2 Awards

Awards will include, but not necessarily be limited to, the following:

- First-place winner: The team that earns the highest combined score.
- Second-place winner: The team that earns the second-highest combined score.
- Third-place winner: The team that earns the third-highest combined score.
- Turbine Design contest winner: The team that earns the highest combined score from all Turbine Design contest products.
- Turbine Testing contest winner: The team that earns the highest combined score in the Turbine Testing contest.
- Project Development contest winner: The team that earns the highest combined score from all Project Development products.
- Connection Creation contest winner: The team that earns the highest combined score from all industry and community engagement products.

3 Turbine Design and Testing Contests

The Turbine Design and Testing contests comprise three basic components: a series of midyear milestones, a technical design report, and a prototype wind turbine. Additionally, at the competition, teams will present their design to a panel of technical judges, who will then conduct a brief turbine design question and answer (Q&A) session to clarify any questions they have after reading the reports and before finalizing scores.

This section will describe the requirements for turbine design and the details of each of the contest elements. Detailed scoring algorithms and rubrics can be found in Appendix A.

3.1 Turbine and Load Design Requirements

Each team will design and build a prototype wind turbine. The turbine must be designed to withstand continuous winds of up to 22 meters per second (m/s) at sea level. Each turbine prototype must be designed for testing inside the Collegiate Wind Competition wind tunnels (further designated as “tunnel[s]” or “wind tunnel[s]”).

3.1.1 Specifications for Competition Tunnel

A digital rendering of the competition tunnel is shown in Figure 2. The dimensions of the test chamber are 122 centimeters (cm) wide by 122 cm high by 244 cm long. There are inlet and outlet components of the wind tunnel that extend beyond the test chamber. The tunnel has a drawdown configuration; that is, the air is sucked through the test section—entering at the left, exiting at the right—with the drawdown being induced by the fan on the right side of the tunnel. A honeycomb flow straightener at the inlet of the wind tunnel provides for near-uniform mixing of the incoming air. There is a debris filter upstream of the fan section. The screen is made of wire mesh to prevent wind turbine pieces from getting sucked into the fan unit.

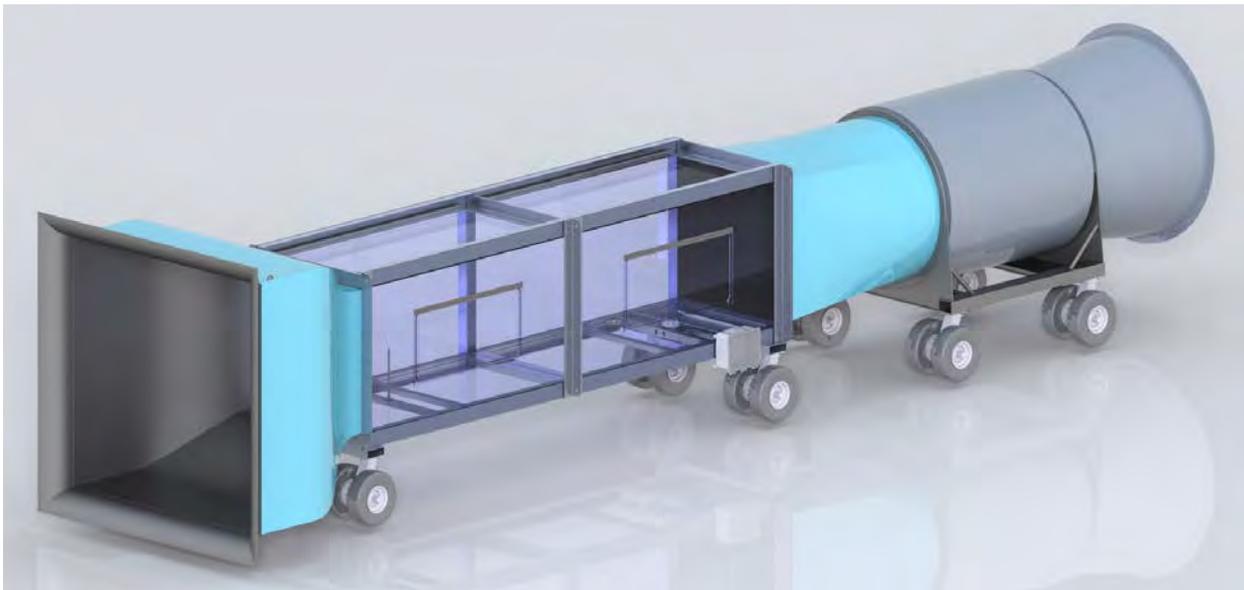


Figure 2. The configuration of the Collegiate Wind Competition wind tunnel. *Image created by Jason Roadman, NREL*

3.1.2 Physical Design Constraints Within the Tunnel

At zero yaw angle, the entire turbine must fit within the volume specified and shown in Figure 3. The turbine must have the following maximum geometry:

- Rotor and nonrotor turbine parts must be contained in a 45-cm-by-45-cm-by-45-cm cube. This cube may be shifted as much as 10 cm aft of the tower centerline when the turbine is aligned with the flow.
- A 15-cm-diameter cylinder centered on the mounting flange extending from the tunnel floor to the bottom of the previously mentioned cube can contain only nonrotor turbine parts. For this purpose, these parts will be defined as anything that does not capture energy from the moving air, including the mounting flange.
- All turbines must fit through the 61-cm-by-122-cm turbine door in one assembly with no additional assembly occurring inside the tunnel other than attachment to the base flange and connection to external electrical components. Electrical connections should not be made in the nacelle during installation.

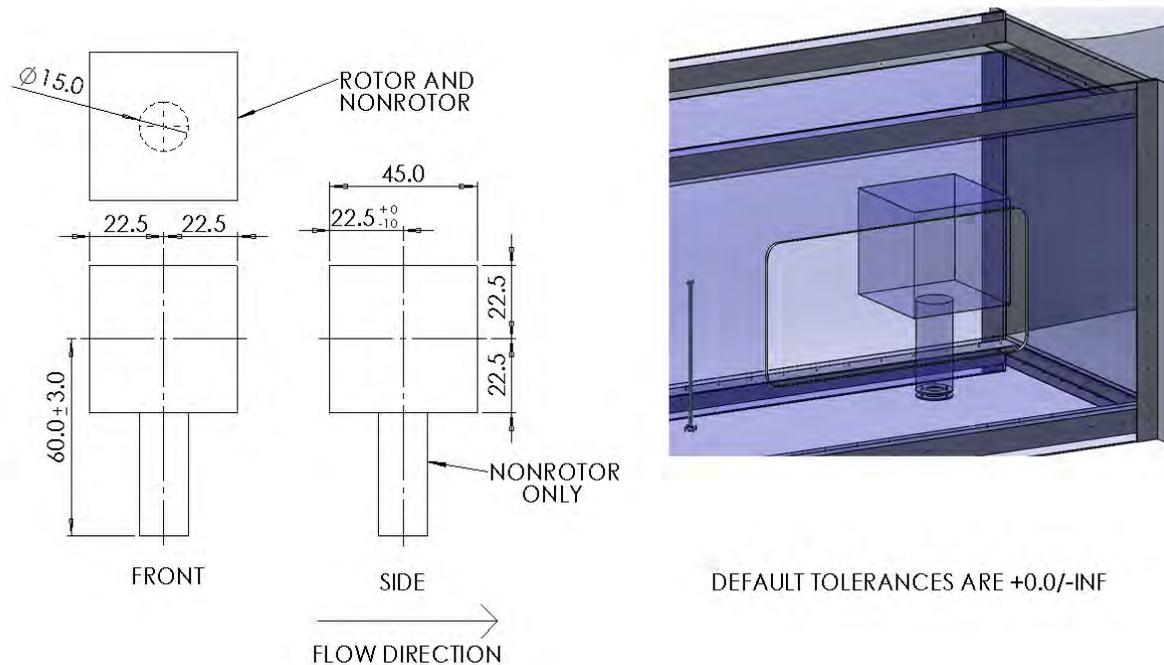


Figure 3. Allowable turbine volume. Image created by Jason Roadman, NREL

The foundation of the wind turbine system must adhere to the following:

- **The foundation structure and anchorage will be a primary focus of the competition and its theme.** Students must design a structure to be installed into a water tank with a sand bed to simulate shallow-water, fixed-bottom offshore foundations. This foundation structure will be the sole source of support for the wind turbine. See Figure 4, Figure 5, and Figure 6.

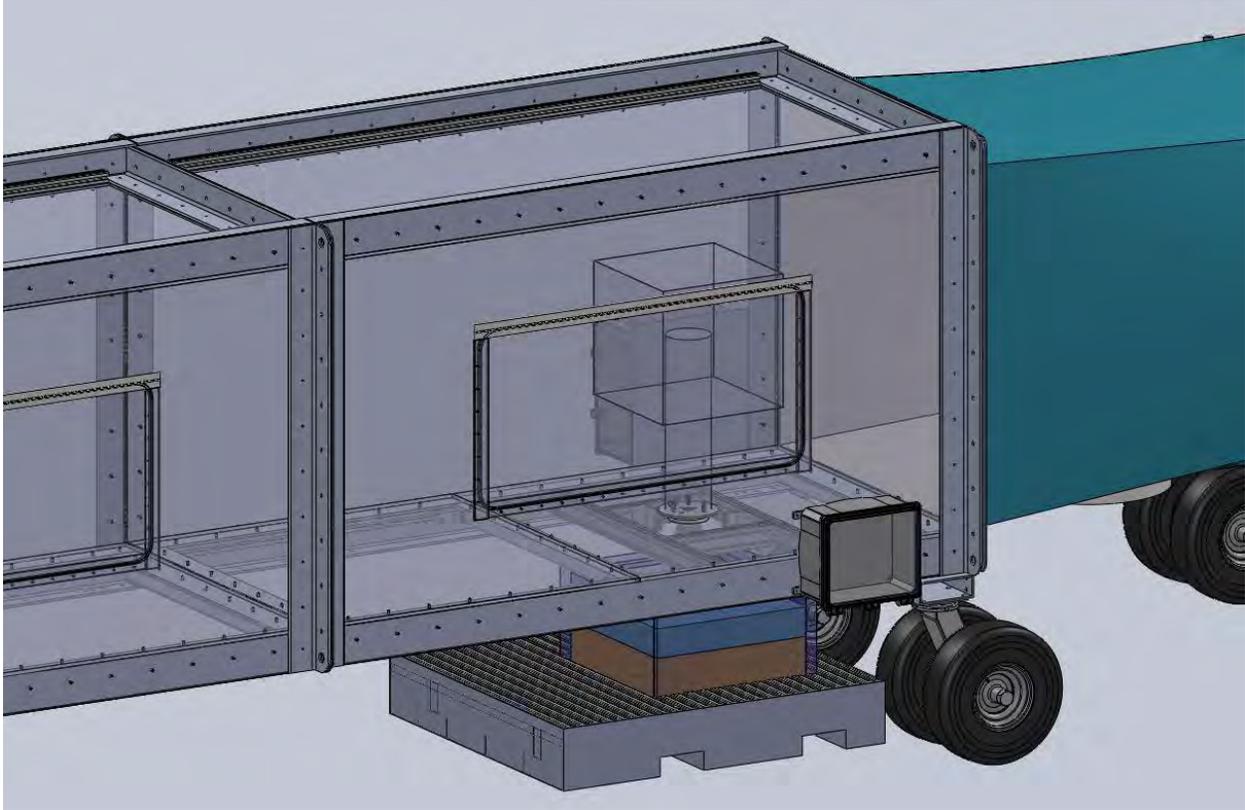


Figure 4. Offshore simulation tank underneath the competition wind tunnel. *Image created by Jason Roadman, NREL*

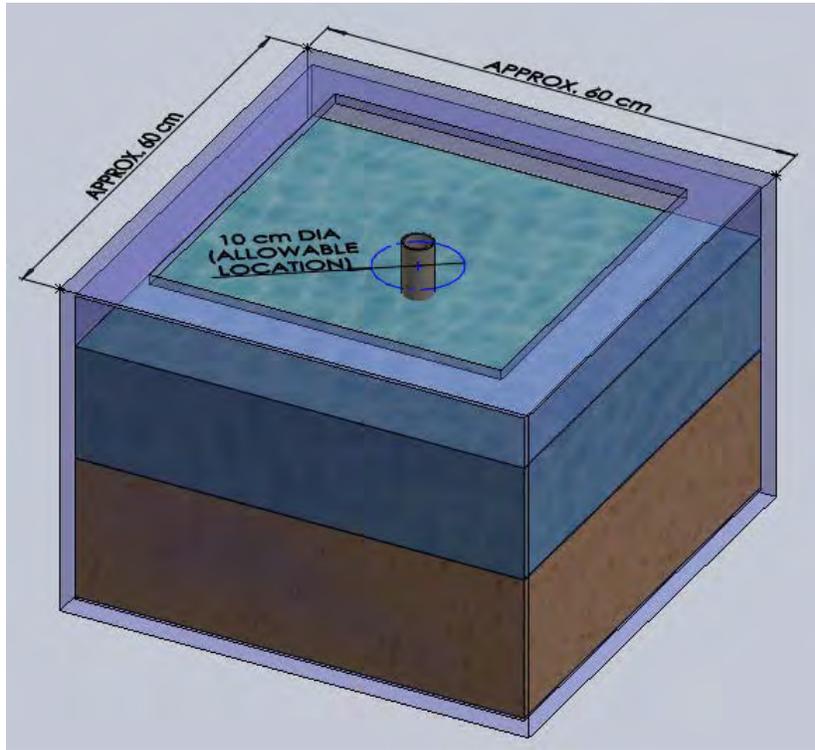


Figure 5. Offshore simulation tank. Image created by Jason Roadman, NREL

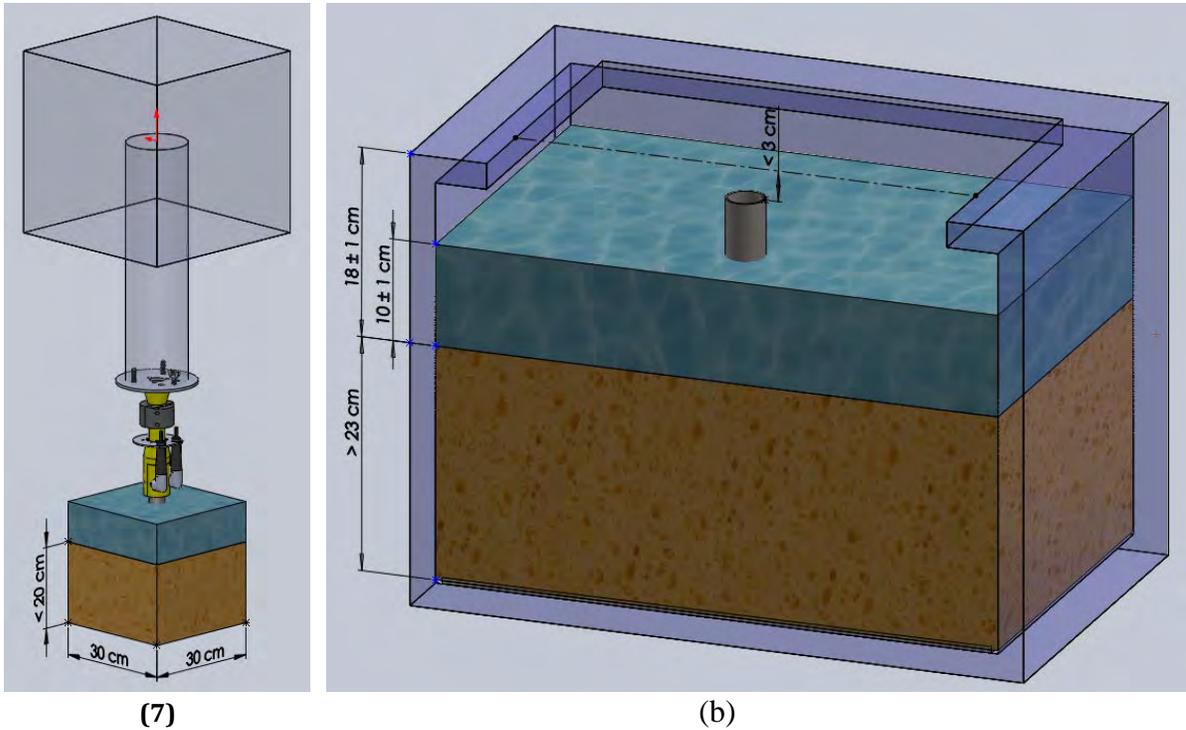


Figure 6. (a) Turbine, structure, and anchorage allowable volumes and (b) tank layout. Image created by Jason Roadman, NREL

- The bottom of the tank will be filled with play sand (Lowe’s item #293326 or equivalent). **Anchors shall penetrate the sand no more than 20 cm.**
- Water depth will be $10\text{ cm} \pm 1\text{ cm}$.
- For design considerations, students can assume the distance from the tunnel centerline to the top of the sand will be roughly 95 cm.
- The top of the team-designed foundation structure must include nominal 1.5-inch-outside-diameter tubing at the location where it attaches to the stub. This tubing (and any paint) must have an outer diameter of 1.500 ± 0.015 inches and an unmodified section at least 8 cm long. Students can source this tubing in various wall thicknesses from McMaster ([89955K389](#) through [8305T22](#)) or an equivalent source.
- The maximum horizontal dimensions of the structure and anchorage shall not exceed a projected square area of 30 cm on each side, as shown in Figure 6. **Note that this area is centered on the foundation structure top tube.** These dimensions will be verified during the safety and tech inspection portion of the competition by placing the assembled structure with anchor(s) in their deployed position entirely within a box of these dimensions. The box will be centered on the foundation tubing using a hole in its top.
- **New for this year, there will be a no-excavation rule.** As a result, the teams are not permitted to move the sand aside during installation and then back-fill nor are they allowed to shovel or otherwise lift the sand up and put it back down with tools. The foundation system must engage the sand from the sand surface. The foundation structure is allowed to penetrate the sand, subject to the dimensions shown in Figure 6a and tools can be used to drive that engagement. However, the design must be consistent with engaging the sand rather than with excavation. A foundation that violates this rule will not be permitted to be used in a scoring run. Teams are encouraged to reach out to the judges early in the design process with any questions about their specific design and its compliance.
- The entire structure must be made of a ferrous metal (iron, steel, or stainless steel). No part of the structure may be made of aluminum, titanium, other metals, or any type of polymer or composite. Thin coatings are excluded from this rule (e.g., the structure may be painted, plated), but thick coatings (e.g., rubberized) are not allowed.
- The competition organizers will provide a “stub” or “transition piece” that will connect the top of the foundation structure to the place in the wind tunnel where the mounting plate was located in previous years. Figure 6a, Figure 7, and Figure 10 and show depictions of the stub and interface method for the student turbines. The bolt pattern of Figure 10 matches the small tunnels and previous competitions. The stub weighs 4.6 pounds.

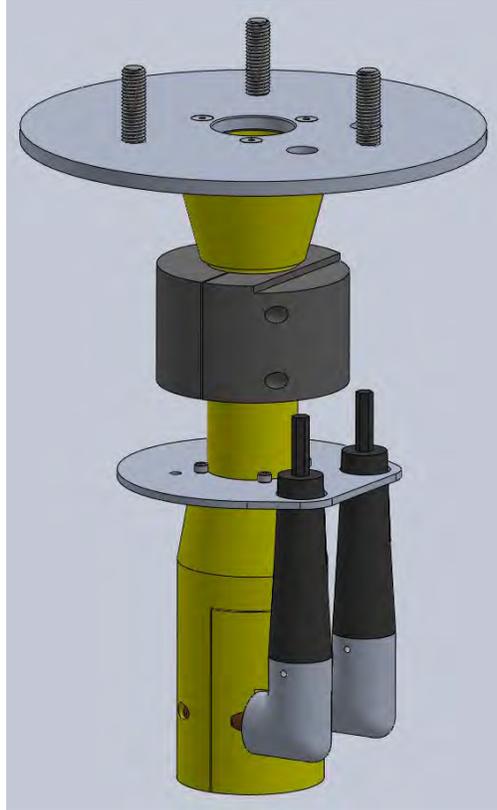


Figure 7. Organizer-provided transition piece (stub) between the student tubing and turbine. *Image created by Jason Roadman, NREL*

- Students should install their foundation structure and anchorage such that the top of the standardized tubing is flush with the top of the tank. It cannot stick out above the top and must be within 3 cm of the top (see Figure 6b). Note that the tolerance between the top of the tank and the top of the sand shown in Figure 6a will make the actual tolerance of the foundation height quite small. Teams are encouraged to consider ways for their foundation to adapt to meet the 3-cm specification.
- Students must assemble their foundation structure and anchorage such that the tubing at the top falls horizontally within a specified 10-cm circle within the tank (see Figure 5).
- During the period immediately before a team’s testing slot, the students will be given at least 25 minutes to install their foundation structure into the water tank at a location adjacent to the tunnel. This task will be supervised by the organizers. **The students will at no time be allowed to touch the water surface with any part of their bodies during installation.** Only tools will be allowed to enter the water and no alternating current power will be provided for this task. This approach is to simulate installation of the device similarly to the way full-scale structures of this type are installed at sea. At the end of the testing period, students will be given 5 minutes to remove their foundation structure from the tank and may touch the water during removal only.
- To ensure that the turbine is plumb during installation and prevent leaning at the start of testing, students will be provided with a magnetic bubble level, similar to one shown in Figure 8.



Figure 8. A bubble level (similar to the one shown here) will be provided to help align the foundation during installation. Image from Amazon.com

- The installation of the electrical cable between the turbine and the electrical components outside the tunnel (e.g., point of common coupling [PCC], load) must be made through the top tube of the foundation structure. To facilitate this connection without placing connectors in the water, the student-provided cables from the outside electrical components to the turbine base must be installed through the foundation structure top tube during structure installation into the water/sand tank. At least 1 meter (m) of extra cable must be available above the top of the foundation structure top tube to facilitate installation of this cable through the stub and to the connectors in the turbine tower base during turbine installation (see Figure 9). The connectors at the turbine base must be able to support the weight of the cable that passes down through the stub and into the water. Those connectors must always be kept dry, including during installation.

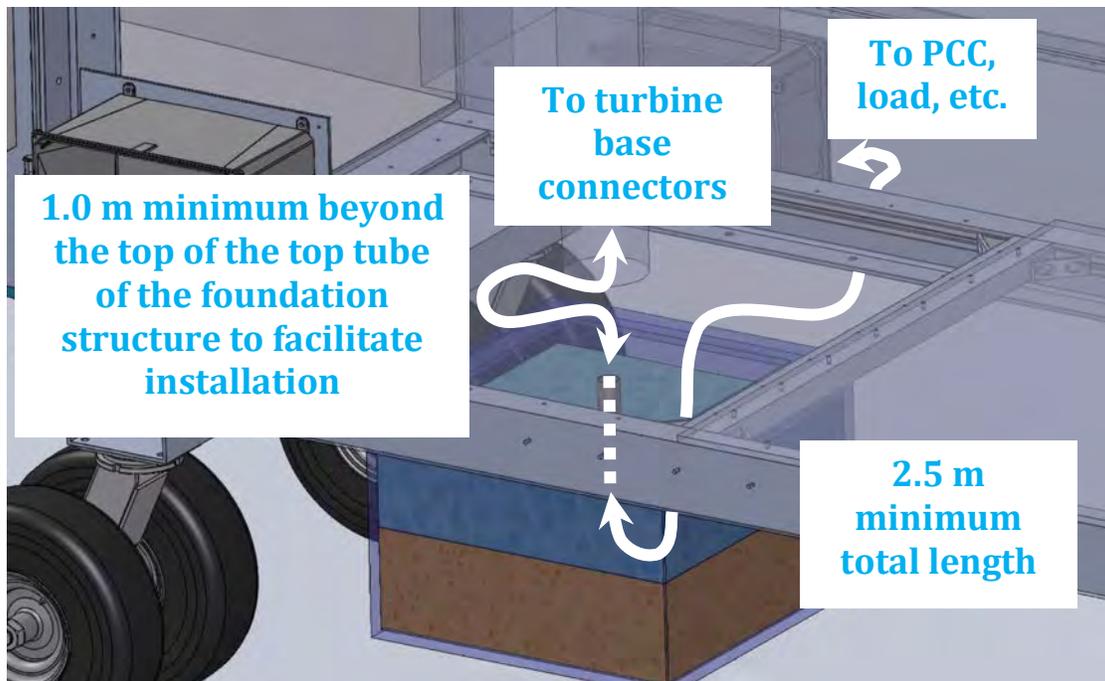


Figure 9. Electrical cable from the wind turbine base through the foundation to the point of common coupling and load. *Image created by Jason Roadman, NREL*

- A portion of the points awarded in this competition will be based on how much a team's structure weighs, with lighter structures yielding more points. The structure and all the elements to be installed inside the tank will be weighed dry by the organizers. The scores will not be absolute but rather based on a ranking relative to the other teams (see Appendix A).
- The stub's horizontal displacement between the beginning and end of testing will be measured at a location just below the tunnel floor for scoring purposes. **This displacement should not exceed 25 millimeters (mm).**
- If the structure experiences excessive movement, sliding, twisting, tilting, or sinking in the sand during testing, the tunnel will be immediately stopped, and no further points will be awarded.
- Three tunnels will be available in this year's competition: two small tunnels and the larger competition tunnel. The smaller tunnels will have the existing base plates as in previous years (see Figure 10). The student-provided foundation structure will not be used in the smaller practice tunnels. It is for this reason that a consistent mounting pattern is used between all three tunnels for the turbine baseplate.
- No yaw turntable will be incorporated into this competition; however, students are still required to incorporate yaw capabilities into their turbine to align it with the predominant wind direction after installation.
- The turbine base plate must be constructed of material no thicker than 16.1 mm. It should be designed and constructed with adequate tolerances to smoothly fit over three studs, where it will be secured to the tunnel base flange/mounting stub with wingnuts. Figure 10 shows the bolt pattern and sizing of this flange and the dimension for the hole in this base flange to allow cables and connectors to pass through.

- Teams are free to apply their engineering judgment to their own base plate design, keeping in mind that the turbine base must be designed to withstand the tension of the mounting studs. Torque values could be up to 50 newton-meters.

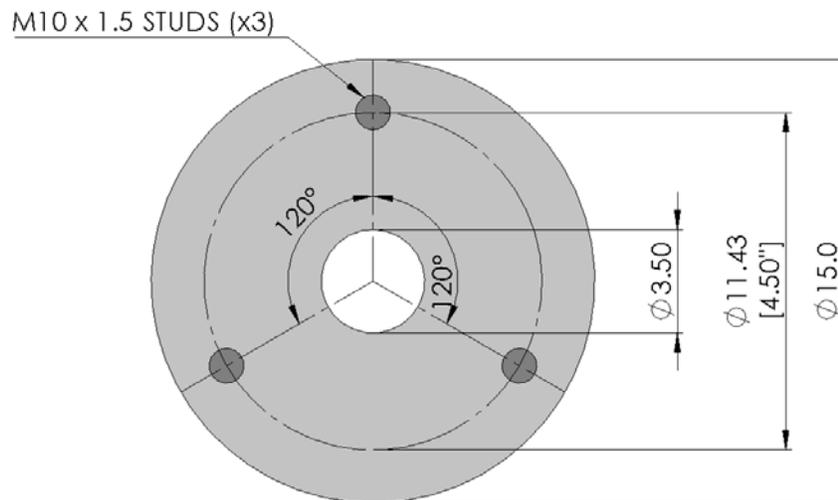


Figure 10. Base flange dimensions for wind turbine attachment to tunnel (dimensions in centimeters).
Image created by Jason Roadman, NREL

3.1.3 Physical Design Constraints Outside the Tunnel

Within practical limits, there is no size restriction for components located outside the tunnel. These components must be incorporated into closed enclosures that are firesafe and meet or exceed a National Electrical Manufacturers Association Type 1 rating. All components must be electrically insulated from the enclosures. Teams should also pay careful attention to the standards for ventilating these enclosures, which include:

- National Electrical Manufacturers Association Type 1 characteristics. Enclosures are constructed for indoor use to provide a degree of protection for personnel against access to hazardous parts as well as a degree of protection for the equipment inside the enclosure against ingress of solid foreign objects (should not be able to insert fingers or tools through the enclosure when closed). It is important that the intent of the National Electrical Manufacturers Association Type 1 rating be preserved once all connectors and/or passthrough devices are installed.
- All cable passthroughs in enclosures must use cable glands or other similar devices that provide both strain and chafe protection.
- Tape is not considered adequate sealing of penetrations or passthroughs in the enclosure.
- All electrical cables leading from the turbine to the electronic components located outside the tunnel must be in cable form (no individual strands) and include connectors. Individual strands or bare wires will result in disqualification from testing until remedied. Twisting two or more strands together is permissible if the resulting multistrand cable has a connector on the end. Multistrand cables are encouraged when used in a logical way. For example, there could be one cable for all power wires and one for all control wires.

- Cables must be continuous and unbroken in the vicinity of the tank. No connectors may be in any position that would allow them to be submersed (Figure 9).
- Neither screw terminals nor spade- or fork-type lugs are considered acceptable connectors outside of enclosures. Each cable connection from turbine to enclosure should employ a quick-attach connector. Ideally, teams should be able to connect all their cables in a few seconds.
- All electrical components must be mechanically secured to the enclosure.

3.1.4 Electrical Requirements

Figure 11 illustrates the electrical configuration of the prototype turbine, competition data acquisition system, and PCC, which is the point of electrical measurement for the competition. Electrical requirements are as follows:

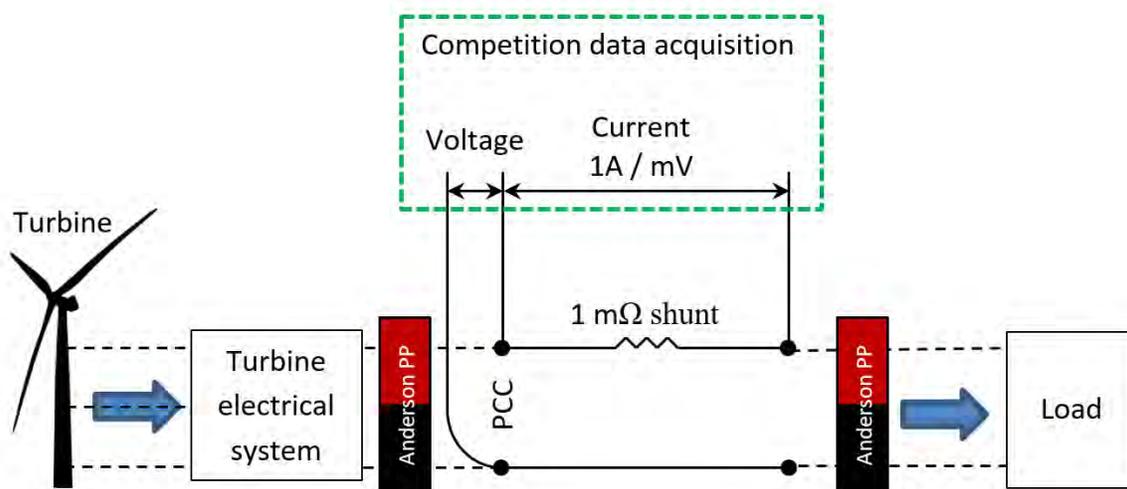


Figure 11. Load, turbine, and point of common coupling arrangement. Image created by Lee Jay Fingersh, NREL

- Voltage must be direct current at the PCC and is required to be at or below 48 volts at all times.
- The turbine base plate must be tied to earth ground. To prevent overvoltage of the tunnel data acquisition system, turbine electrical system ground(s) must be electrically tied to this base plate with a 100-kiloohm or lower resistance connection.
- Teams are expected to choose their own generator and design their own wind turbine and load system. Off-the-shelf components may be used, but the turbine and load system should be designed and built by the teams. All components must meet safety requirements including, but not limited to, proper wiring practices, shielding of hazardous components, and proper heat rejection.
- The turbine electronics must be in separate enclosure(s) from the load to clearly differentiate load and control during inspection by judges, as shown in Figure 11. The turbine nacelle may also contain turbine electronics, if desired.

3.1.5 Specifications for the Turbine Side of the PCC

Specifications for the turbine side of the PCC are as follows:

- Energy storage elements, such as capacitors and/or inductors, may be used in both the turbine and load, but not for bulk energy storage on the turbine side of the PCC.
- No batteries of any type, capacitors, or combinations of capacitors with nameplate voltage and capacitance ratings corresponding to over 10 joules of energy storage ($E = \frac{1}{2}CV^2$) will be permitted.
- Turbine components may draw from the load but must register a zero state of charge at the beginning of the test.
- Wired connections between the turbine and load external to the PCC are allowed but must be optically isolated. The amount of power transferred through this connection must only be enough to facilitate communication, and that power may only be used for that purpose, not to power any other turbine systems.

3.1.6 Specifications for the Load Side of the PCC

Specification for the load side of the PCC are as follows:

- Bulk energy storage is allowed in the load, provided it is used in a safe and reliable manner.
- To run the load, 120-volt alternating current will be provided, if desired.

3.1.7 Interfacing With the Competition Data Acquisition System

Protocol for interfacing with the competition data acquisition system are as follows:

- Wires should exit the tunnel at the wind turbine base through the center of the stub. As shown in Figure 12, a table will be provided to display the load on the side of the tunnel and hold any turbine electronics enclosures external to the tunnel. Rough distances are shown in the figure, but teams should provide adequate lengths of wire to run from the PCC to accommodate their desired enclosure arrangement on the table.

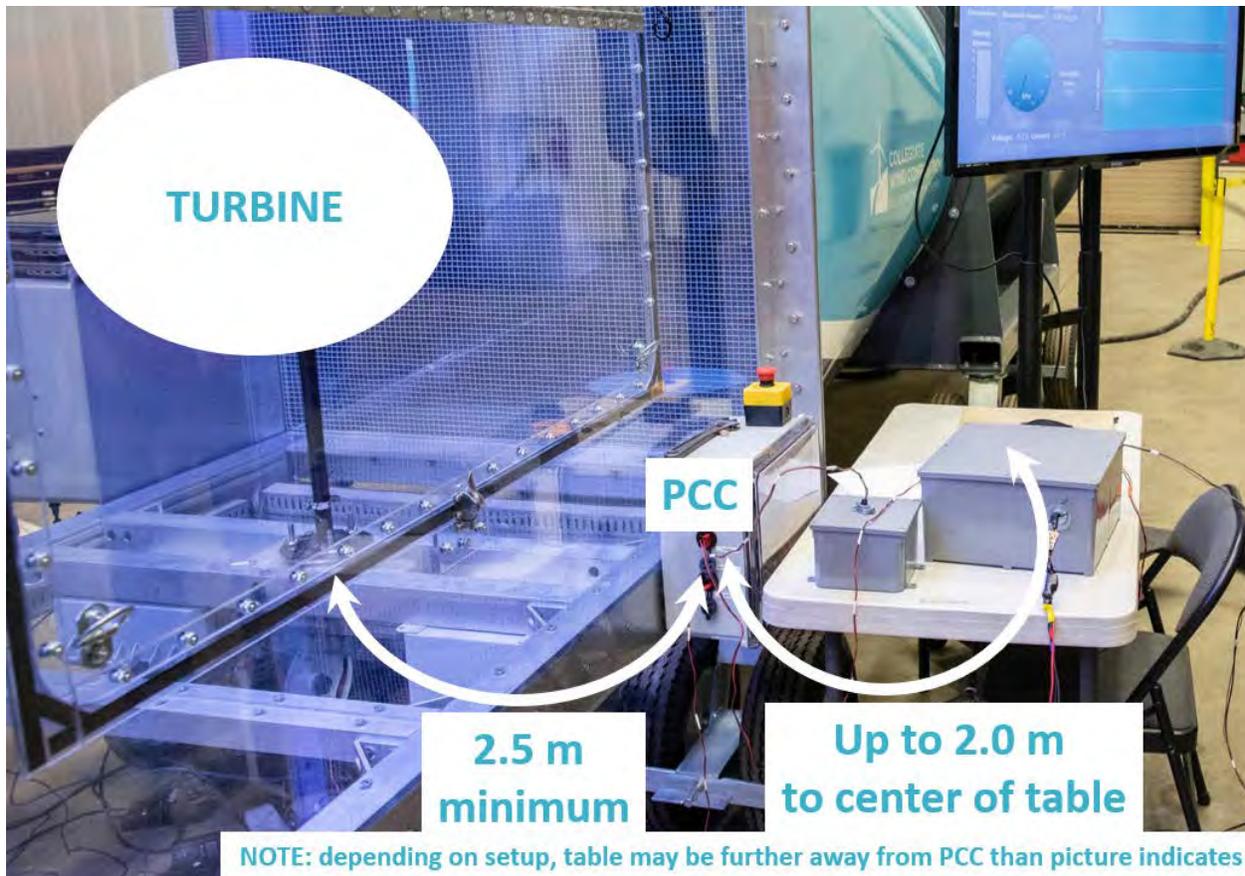


Figure 12. Wiring layout of the point of common coupling and student load display table. *Image created by Jason Roadman, NREL*

- To interface with the PCC, wires should be terminated with Anderson Powerpole connectors, PP15-45 (a red and a black for positive and negative, respectively). See Figure 13 for correct polarity. Incorrect polarity must be corrected before testing.
- Teams are expected to provide their own Powerpole connectors of an appropriate size—15 amperes (A), 30 A, or 45 A—that are specified to handle wire gauges from 10–20 American wire gauge. Each team can choose the wire size it wants to use in this range as long as the appropriate current-carrying capacities are considered. All three pin sizes fit into the same housing (PP15-45), as stated previously.

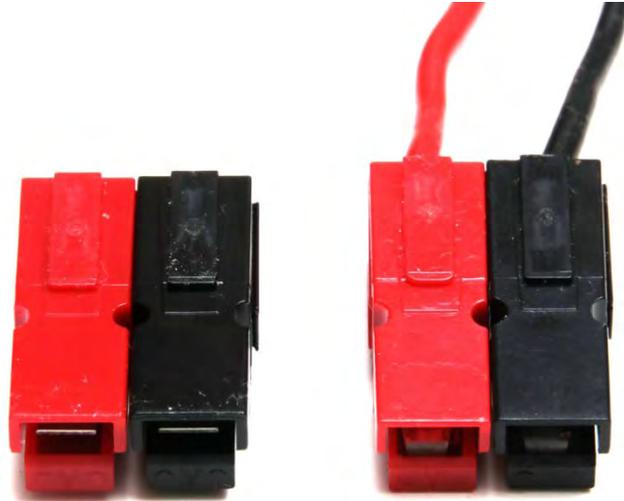


Figure 13. Proper Anderson Powerpole polarity to match tunnel wiring

- Turbines must be capable of shutting down on command through an emergency-stop button, as well as when electrically disconnected from the load.
 - The emergency-stop button will be located outside the tunnel. It operates in the same manner as an industrial emergency stop chain. That is, it is closed during normal turbine operation and opened during an emergency stop when the button is depressed.
 - In industry, emergency-stop systems use this switch logic so that multiple switches in and around a piece of hardware, such as a wind turbine, can be wired in series in a single wiring loop. In this configuration, opening any switch or a fault in the wiring will cause the whole circuit to open. Thus, an entire emergency-stop system can be monitored by a single channel input. If the switches used the opposite logic, the system would have to monitor each switch individually.
 - The emergency-stop connector and wiring is rated for 3 A, thus it is intended to carry a low-current control signal—not high-current power. Teams must describe their emergency-stop system during the safety and tech inspection and explain how this design uses a signal that can never carry more than the rated 3 A.
 - Each team must provide a cable containing two wires (no smaller than 28 American wire gauge) that reaches the PCC, as labeled in Figure 12. This cable must be terminated, prior to the competition, with a standard JST RCY female receptacle housing connector (Manuf. P/N: SYR-02T housing using SYM-001T-P0.6(N) for the corresponding male pin contacts) (Figure 14).



Figure 14. Team-provided connection to the manual shutdown interface

- The competition switch will be terminated with the corresponding polarity JST RCY male plug (Manuf. P/N: SYP-02T-1 plug housing using SYF-001T-P0.6[LF][SN] socket contacts) (Figure 15).



Figure 15. Competition-provided connector for manual shutdown interface



Figure 16. Laser tachometer used to measure turbine revolutions per minute

- The competition data acquisition system uses a laser tachometer to measure wind turbine revolutions per minute (RPM) (Figure 16). This system works by placing a piece of retro-

reflective tape on a spinning portion of the turbine and pointing the tachometer's laser at this tape during operation. The tachometer measures the frequency of the tape's passing and converts this to an RPM. This measurement is critical for scoring the tasks related to turbine RPM. As such, turbines must have an area of shallow curvature at least 4 mm wide and 20 mm in spanwise length to place a piece of reflective tape in a location that is clearly visible by at least one of the two laser tachometers shown in Figure 17.

- o Typical locations for reflective tape include spinners or blade roots. For vertical-axis wind turbines, tape is often placed on a blade at midspan. Wind turbines with active pitch should provide a location for the tape that does not pitch out of view of the laser. The tachometer is on a movable mount and pointing can be varied during the test if the motion is small, slow, or otherwise easily tracked but large or quick deviations can be hard to track.
- o **Failure to provide a location sufficient to measure RPM could result in a zero score for the tasks requiring RPM measurement as the judges have no way to verify turbine rotational speed.** Students who are concerned about their specific application are encouraged to reach out to the judges in advance for guidance.

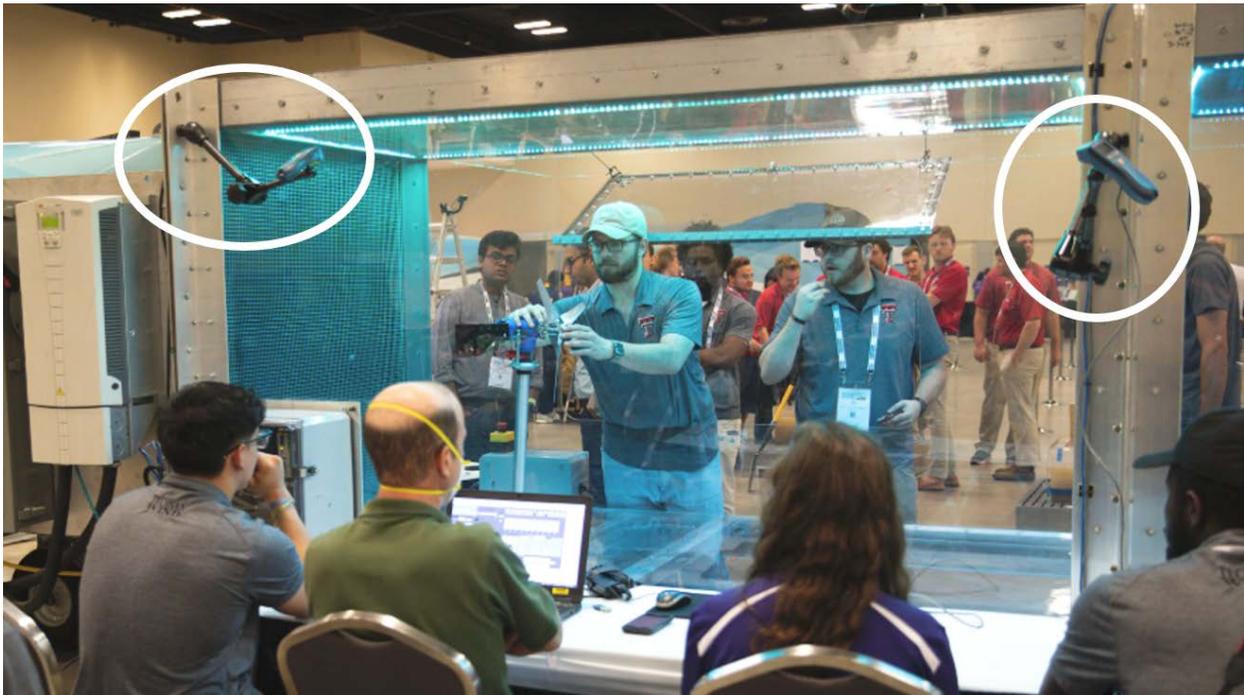


Figure 17. Laser tachometer sensors (circled in white) used to measure turbine RPM.

Note: only one tachometer is used at a time.

3.1.8 Safety Specifications

Competition staff will perform a safety inspection of the wind turbine and load system, which must be passed before they can be installed in the wind tunnel. Appendix C contains a draft version of the safety and inspection sheet used to evaluate the turbines. The turbine safety officials make the final and official determination about whether a turbine may be tested in the wind tunnel.

3.2 Midyear Project Milestones

The competition will include a series of scored milestones throughout the academic year to monitor the student teams' progress leading up to the final event and incentivize key aspects of the design. Milestones are scored based on the quality of content delivered, with details given in each of the following subsections.

Write-ups should follow the same formatting requirements as the reports, detailed in Appendix B. Each section lists page limits, restrictions on length of video that can be submitted (where relevant), and number of supplemental images (where relevant) that will be accepted for each milestone. Anything beyond the limits will not be considered during scoring. Scoring details are in Appendix A.

3.2.1 Conceptual Design

A crucial part of designing and building any new system is having a viable concept that will meet the needs of the task. Finding such a concept involves having a deep understanding of the task to be accomplished and the physics of accomplishing that task along with a review of available resources (e.g., Open-EI, rules, webinars, past reports/designs). Brainstorming, high-level trade studies, and other methods can be used to narrow in on a concept that could be viable at this early stage. Teams' thought process should consider scoping out and ordering components to support prototype construction and testing during the preliminary design milestone. During the rest of the design process, additional challenges may be identified that require further adaptation.

Deliverables and Scoring

- Submit a two-page write-up plus up to five images that describe the concept the team has selected during the conceptual design process. The write-up must explain the basic operation of all the major subsystems of the design, how they work together to accomplish the task, why these methods were chosen, and initial scoping of prototype construction and testing. A summary of resources consulted should be included along with a short description of prototype components ordered. However, the teams are reminded that this is a conceptual design; details are not needed at this stage.
- Scores will be based on how clear the concept is articulated, how likely it is to work for the tasks presented, and how well the team articulates their understanding of the task and deliverables.

3.2.2 Preliminary Turbine Design Report

Once a concept has been created it must be investigated through initial analysis and testing. This process may involve such things as design trade-offs, evaluations of materials, possible control methods, interfaces between parts and the outside environment, and manufacturability. Teams should plan and execute component testing to help further refine their design and discuss how these individual components will integrate into the larger design. Students will also be evaluated on whether the required fabrication and testing is within the scope of their skill set. Students are expected to test designs throughout the process and failure is expected. Should a design fall short of expectations, students must include a detailed explanation of how they plan to remedy the situation, again demonstrating how that remedy is within the skill sets their team possesses.

Deliverables and Scoring

- Submit a three-page write-up (simple or outline form) plus up to 10 images that describe and illustrate the preliminary design and the thought processes that led to that design.
- Scores will be based on how well the teams have thought through the design process and describe their designs and design intentions, including trade-offs, limitations, prototype construction and testing, and manufacturability along with the degree to which students demonstrate turbine potential for success and their ability to fabricate a design within their skill set. Details of design testing should be included.

3.2.3 Construction, Assembly, and Testing of Subassemblies

Teams are encouraged to develop a robust and redundant method to construct and test their systems during fabrication. Teams are also strongly encouraged to design a wind turbine that requires minimal assembly time when installing in the wind tunnel. Teams should divide up the process of construction of the turbine into its subsystems and acquire or construct the parts to build those subsystems. Good design, even when combined with good manufacturing, does not guarantee working systems. Each subsystem should then be tested before assembly of the complete turbine begins. Note, this writeup's scope includes a description of the manufacturing construction processes used during fabrication as well as the steps necessary to assemble the turbine when testing in the wind tunnel.

Deliverables and Scoring

- Submit a three-page write-up (simple or outline form) plus up to 20 images and optional video up to 3 minutes long that describes how each of the critical subassemblies was fabricated, tested, and assembled for final testing as a complete system. The teams are encouraged to define what and how many subsystems are critical for their design. Two examples might be the system that converts the kinetic energy of the wind into mechanical energy and the system that converts that mechanical energy into electrical energy.
- Scores will be based on how well the teams identify critical subassemblies, how well they were tested, and how the fabrication and testing process along with final component assembly procedures for wind tunnel testing was outlined in the milestone write-up. Scores will not be based on how well the subsystems performed during the testing. A failure found during testing is every bit as valuable as a success. However, any failures should be accompanied by a plan to remedy the results before competition.

3.2.4 Technical Inspection Prior to Competition

To make the tech inspection process as smooth as possible, student teams should go through an inspection prior to the competition, working with someone who is as qualified to interpret the rules and understand the competition as best as possible. Ideally, this person should be someone other than the faculty advisor to provide a fresh perspective at the end of the year. Teams need not pass the tech inspection to complete this milestone.

Deliverables and Scoring

- Submit a short write-up summarizing the qualifications of the inspector, certify that both the student team and inspector have read Section 3.1, and include a complete, signed tech inspection sheet from Appendix C.

- Detail any deficiencies and plans on how to remedy them before competition.
- Scores will be based on the completeness of this inspection, not on whether the system passes all elements. The purpose of the inspection is to identify areas that would not pass technical inspection at the competition, thus giving the teams time to correct these deficiencies before the competition begins.

3.3 Technical Design Report

The technical design report explains the turbine concept development process from an engineering perspective. The report should detail the complete design process as it relates to the turbine being tested in the competition wind tunnel, as well as the foundation structure and its installation approach.

At a minimum, the report must include the following sections:

- **A cover sheet.** Teams should begin the report with a one-page cover sheet that includes their affiliation and contact information. It should indicate the team roles/hierarchy and approximately how many students, faculty, and others (e.g., sponsors, volunteers, and family members) are involved in the project.
- **A table of contents.**
- **An executive summary.** The executive summary discusses components from all sections of the report and includes a short, high-level description of the team project. Teams should use their judgment when deciding how long to make the executive summary; however, one page is often sufficient.
- **The technical design.** Teams should provide detail that is adequate for an engineering review of the baseline and operating properties of the turbine and its subsystems, including mechanical loading requirements, operational limits, control algorithms, and software. At a minimum, the following topics should be included in the prescribed order:
 - A description of the design objective and how the design components support this objective.
 - A clear and concise list of what is the same as previous years and why. Demonstrate an understanding of how previous research and design decisions have shaped the team's approach. If a team's school did not compete in the previous year's competition, they should write about how the information in last year's winning design report influenced their own design.
 - A basic static performance analysis (e.g., CP-Lambda report) of the turbine design that contains the annual energy production over a range of operational parameters.
 - A basic engineering diagram of all mechanical systems and an analysis of the expected mechanical loads and associated safety factors within the design, both for operational and parked conditions.
 - A basic engineering diagram of the foundation and a civil and structural analysis of the foundation and its anchoring system.
 - An electrical, one-line diagram of the overall system and electrical analysis comprising the generator model, power electronics (e.g., canonical model and one-line diagram), electrical load model, and operating voltage, including how the team plans to regulate voltage.
 - A control model analysis of the operational modes (i.e., the control states diagram and a description of primary operational modes).

- Documentation of associated software architecture (e.g., data acquisition, turbine control, safety systems, states and state diagram, outputs to the turbine actuators, and data archiving) and its development. Note that this is about the development of the software itself, not the turbine control methodologies described previously.
- A description of the final assembly of the wind turbine's subsystems. Where relevant, include how a distributed team environment was managed.
- An assembly and commissioning checklist that can be followed during installation of the turbine in the wind tunnel to ensure it is functioning as expected before starting the scoring portion of the test. Note that this list should extend beyond a simple step-by-step assembly, and students should think carefully about how to ensure proper functionality of their turbine before commencing testing.
- The results of laboratory and/or field testing of turbine prototypes.

This report should be no more than 20 pages in length and formatted according to the specifications laid out in Appendix B. Pages submitted beyond this limit will not be reviewed.

Scoring criteria for the design report are provided in Appendix A. At the conclusion of the competition, team reports will be posted to the CWC website for reference during future events.

3.4 Presentation and Question and Answer Session

In addition to the written report, each team will present their design to a panel of judges followed by a question and answer (Q&A) session to answer any remaining questions that the judges may have from their review of the written report. This presentation should begin with a brief overview that conveys the most important details of the technical design and clearly communicates the team's approach to design and development.

Presenters should showcase their wind turbine prototype and have the option to use posters, charts, PowerPoint slides, or other visual aids to engage with the judges. Please note visual aids will not be scored but can be used, if necessary, to help clarify any questions the judges may have after reading the written report. Please bring necessary files on a USB drive along with any drivers needed to support presentation animation. Presentations are limited to 10 minutes, which will be followed by a 15-minute Q&A period with the competition judges. Additional attendees are allowed in the feedback session at the discretion of the student lead.

The judges will use the content from this project overview and Q&A period to make final adjustments to the technical design report score. Answers provided during the Q&A session will also be evaluated to gauge the depth of students' technical understanding of wind turbine design.

3.5 Wind Turbine Testing

The wind turbine testing portion of the turbine prototype contest comprises several individual turbine tasks. This section describes the requirements of the individual tasks in which the turbine is expected to perform and the parameters of the testing conditions. Details on scoring algorithms and point allocations between individual tasks can be found in Appendix A.

Testing provides teams with the opportunity to demonstrate their turbine's performance through objective tasks, and the testing outcomes help determine if they have succeeded in developing a

durable, safe, high-performing machine (performance is a strong indicator of a turbine's ability to compete successfully in the marketplace).

Each turbine, along with its corresponding load system, will be tested in the competition wind tunnel. The contest will include the following tasks: turbine performance, controllability, safety, and durability over a range of wind speeds along with foundation performance. Students will use their load for all tasks. Although the prescribed order will be the same for each team, the exact amount of time at each set point could vary between schools. Thus, teams are expected to design their turbines to sense the local conditions within the tunnel and react accordingly for each task.

Exceeding the voltage limit set in Section 3.1.4 will result in an immediate abort of the testing sequence, with all points gathered to that point retained but no more points earned after the abort. Teams may then attempt to fix the cause of the overvoltage and use their retest, if available.^{6,7}

Verification of zero energy at the start of the test will be accomplished using the competition data acquisition system to measure zero current flow into the load at the PCC. Any questionable elements are subject to additional verification of zero energy by the testing team with a multimeter or similar device before the testing begins.

Only one team's wind turbine will be tested at a time. Teams are limited to 10 members (students and faculty advisors) within the testing area. Other members can act as spectators. Each team will have 25 minutes of tunnel time to install their turbine, commission it, test it, and uninstall. Note that this does not include the separate time provided to each school to construct their foundation structure in the tank before testing, which is discussed in Section 3.1.2. Teams will be provided with a period of commissioning time prior to the scoring tasks, during which the teams may ask for any wind speed from 5–11 m/s and do any work on their turbine or electronics they deem necessary to get their systems up and running. Teams may use as much of their tunnel time for commissioning as they would like, keeping in mind that the testing tasks will be stopped promptly 5 minutes prior to the end of the team's allotted period to allow time to remove the turbine. Students are encouraged to minimize install and commissioning time as much as possible because the complete series of testing tasks are expected to require upward of 15 minutes to complete, depending on how fast the turbine stabilizes during testing conditions.

Additionally, teams may signal at any time during the test that they would like to turn the session into a practice session. In this case, the score for this attempt will be zeroed, and the team can use their remaining time to troubleshoot and learn about their turbine's performance in preparation for an additional session, if they have one available.

If there are unforeseen delays caused by the organizers (e.g., a wind tunnel issue or power outage), the time spent rectifying the problem will not be included as part of the team's allowable minutes. Team members will only be allowed to touch their turbine electronics or controls during the following phases of testing: commissioning and manually restarting their turbine if they fail to restart after a safety shutdown task. Turbine failure is defined as anything out of the ordinary, such as excessive displacement, cracking, breaking, pieces falling off,

⁶ https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9880&p_table=STANDARDS

⁷ <https://www.mouser.com/pdfdocs/Why-are-Power-Designs-Moving-to-48V.pdf>

smoking, sparking, or failure to produce an electrical current, and will be cause for immediate stoppage of testing.

If a team wants to retest their wind turbine for any reason, they may request a single retest during the provided makeup sessions later in the competition. The retest will be a full test, and all scores from the first test will be replaced, regardless of the turbine's performance in the retest. Teams must confirm their desire to retest with the organizers by 5:00 p.m. on the first day of testing. If the organizers do not hear from a team by this time, it will be assumed that team does not want a retest.

Students are encouraged to bring spare components and/or assemblies and design their turbines so that damaged parts or assemblies can be easily replaced. However, it is important to keep in mind that the turbine configuration throughout the entire competition should remain substantially the same as what is documented in the written report. For example, the number of blades, rotor axis, configuration, and operating voltage must remain the same. Teams with questions about any changes or altered turbine components or assemblies are encouraged to discuss their situation with the organizers well ahead of the competition to ensure they are adhering to this requirement.

3.5.1 Power Curve Performance Task

The objective of this task is to test each wind turbine over a range of wind speeds to determine a power curve. It is meant to be a direct comparison of power performance between turbines, which is one factor by which real turbines are judged.

Each turbine will be tested at integer wind speeds between 5 and 11 m/s inclusive for a duration of 60 seconds (s) or less, with the stated intent of obtaining a "stable" power reading. A "stable" power reading is defined as stable rotations per minute and stable power per electronic testing device during the test period. As power output may fluctuate, for the purposes of this task, the allowable power outputs to be included in the maximum average power (per electronic testing device) during any 5-s interval will be defined as $\pm 10\%$ of the maximum average power.

This stability criterion will also consider any noise that the data acquisition system measures. The system samples at 50 kilohertz using a filter with a cutoff frequency of 22.5 kilohertz. These samples are then block-averaged down to 200 hertz. In order to meet the specified stability tolerance, teams should ensure that any noise in the power their turbine produces is adequately filtered and that the combination of power variation and measured noise is within the specified tolerance when read by the competition data acquisition system. One way to reduce noise is to implement an LC filter (inductor-capacitor filter) on the power output lines to filter noise coming from the switching of power electronics.

3.5.2 Control of Rated Power and Rotor Speed Task

Wind turbines must withstand high winds without damaging their mechanical or electrical components. Because wind power is proportional to the cube of wind speed, the energy available in the wind quickly becomes very high as wind speed increases. To control rising mechanical and electrical loads, turbines must be able to limit their rotational speed and output power in these high-wind conditions. Proper controls can also be used to limit rotor thrust and, therefore, the moment applied to the tower and foundation system.

In this task, each turbine will be subjected to one wind speed bin chosen by the organizers between 12 m/s and 14 m/s (inclusive) and turbine performance in that bin will be compared to the performance in the 11-m/s bin. The turbines are expected to keep the RPM at or below the RPM determined at 11 m/s and to keep the power at the same level as is determined at 11 m/s.

3.5.3 Safety Task

Safety is of the utmost importance to wind turbine designers and manufacturers. To be certified, turbines must be able to safely shut down rapidly and with a fail-safe shutdown capability. Turbines must shut down when disconnected from the grid, as well as manually upon command, as described in Section 3.1. Each team may choose to address these shutdown scenarios with one or two systems or mechanisms.

In this task, the turbine will be required to safely shut down at two different times during the testing period at any wind speed—up to the maximum continuous operational wind speed specified in Section 3.1. For each turbine, the shutdown process will be initiated once “on command” and separately by disconnecting the load from the PCC. It is important to note that the open-circuit voltage of the wind turbine will be monitored during this shutdown and not exceed the limit provided in Section 3.1. The wind turbine must also be able to restart at any wind speed above 5 m/s. For the purposes of this task, “shutdown” is defined as dropping below 10% of the maximum 5-s bin average rotations per minute achieved during power performance testing. This reduction in RPM must occur within 10 s and remain below the limit indefinitely. If the turbine fails to successfully restart, the team may work on their electronics to manually restart their turbine, resulting in a zero score for the restart portion of the task.

3.5.4 Durability and Foundation Success Tasks

Wind turbines are expected to perform over the long term and will be subjected to a wide variety of weather conditions. Producing power effectively and over the course of the turbine’s lifetime are desirable design qualities.

In this task, each turbine will be subjected to the same prescribed variable wind speed. Speeds will never be less than 6 m/s or greater than 22 m/s over a 5-minute test period. This test helps verify that the turbine can function over a wide range of operating conditions.

The scoring for these tasks will, in part, be based on the turbine system’s ability to produce positive power using the student load. Turbines should be designed to stay running and producing power throughout the entire range of wind speeds encountered during the first 3 minutes of this test. Additionally, the support structure should not allow the location of the top of the stub to drift in position during the testing, as that will also be evaluated and scored (see Section 3.1.2 and Appendix A).

4 Project Development Contest

The Project Development contest has two main elements. Part A is a yearlong effort to investigate key aspects of wind farm siting and project development activities. Part B will be conducted during the on-site competition and build on the experience gained in Part A.

It will be beneficial to develop a basic understanding of siting elements prior to beginning Part A. This could include understanding wind resource data and performance estimation, factors that affect project economics, bathymetry, environmental issues, transportation constraints, transmission design, permitting requirements, turbine technology, and performance variables (e.g., wakes, turbine availability, and site-specific losses).

The output of these efforts will include a written report delivered prior to the competition and a presentation at the competition with two posters as visual aids. These deliverables are described in further detail in Section 4.1.2.

4.1 Part A: Research and Develop a Plan for an Offshore Wind Farm

Teams must assess wind farm development opportunities within the defined auction area, create a rough development plan, and prepare a bid for a lease area (one or more lease blocks) within the auction area. Team members must be prepared to explain their process to judges at the competition.

4.1.1 *Develop a Site Plan and Conduct Financial Analysis*

The following describes the procedure for developing the site plan and conducting financial analysis:

1. Select a specific lease area (one or more lease blocks) within the auction area, which is defined on the map in Figure 18. This auction area is available via a shape file in the CWC Box folder named “Project Development Data.” Teams may site their project in any of the lease blocks within the auction area and should reference their chosen lease blocks according to the numbers in the shape file. In addition:
 - Be prepared to explain how and why this lease area was chosen.
 - Some considerations may include wind resource, bathymetry, geotechnical data, lease boundary, access to transmission, transportation access, and environmental factors.
 - Please note that this auction area is for Collegiate Wind Competition purposes only and should not be misconstrued as an official auction area that is under development by the Bureau of Ocean Energy Management or NREL for commercial purposes. This auction area has not gone through the formal vetting process by BOEM, so bear in mind there may be lease blocks that are not suitable for wind farm development.
2. Develop a preliminary wind farm design. This should include:
 - Research site characteristics, such as:
 - Collect wind resource information, bathymetry data, roughness, and so on
 - Bathymetry, water depth, wind resource, geotechnical data, significant wave height, hurricane impacts, port infrastructure, and ocean activities (e.g., fishing, shipping, military).
 - Sensitive species in the area, sensitive ecosystems, impacts to wildlife, and mitigation options—if relevant.

- A draft preliminary design that includes:
 - Turbine type, hub height, rotor diameter, and number of turbines
 - Foundation type
 - Interconnection site on the coast
 - Staging, construction, and operations and maintenance ports
 - Survey, installation, and operations and maintenance vessels
 - The project boundary.



Figure 18. Map of offshore Port Furchon auction area

3. Conduct a cost-of-energy and cash flow analysis for the 20-year expected life of the project. It should, at a minimum, consider each of the following elements in the cost-of-energy analysis.
 - **Initial capital cost.** This covers costs associated with development, turbine procurement/installation, and balance-of-station costs. Costs include, but are not limited to, site preparation, wind turbines, foundations, electrical hardware, electric collection system and transmission lines, substation equipment, wind farm control and monitoring equipment, operations and maintenance facilities and equipment, shipping, resource assessment, preconstruction environmental monitoring, surveying, legal counsel, project management, permits, construction insurance, title insurance,

lease payments, engineering services, sales and use tax, and so on. Costs must be expressed in dollars and dollars per kilowatt.

- **Annual operating expenses.** Key cost categories here include operations and maintenance costs (including preventative maintenance, corrective maintenance, and spare parts), lease costs, asset management, operational insurance, and scheduling fees. Teams should consider the potential of increased costs year over year. Costs should be expressed in dollars and dollars per kilowatt per year.
- **Annual energy production.** The total amount of electrical energy the wind farm expects to make in a year, expressed in megawatt-hours.
- **Market conditions.** The team should research what the market is willing to pay for the megawatt-hours produced and compare this with the cost of energy.
- **Financing plan.** Some elements the team should consider include construction financing, tax equity, sponsor equity, permanent (long term) debt, financing fees, debt and equity return requirements, depreciation, and income tax.
- **Incentives.** This includes national incentives, tax credits, and any regional incentives. The team should research potential abatements sales and use tax.

Note: Steps 2 and 3 may require several iterations to balance financial and technical elements.

4. Finalize detailed design of the site plan, including the following steps:
 - Finalize wind turbine locations, turbine type, rotor diameter, and foundation type
 - Finalize transmission design from project to point of interconnection
 - Plan port activities
 - Plan submerged land leases

The final design does not need to remain the same as the preliminary design proposed in the milestone.

5. Propose a bid price, as follows:
 - Teams should propose a maximum bid price they would be willing to pay for their chosen lease area. This bid should be based on the cost of energy and cash flow analysis developed in Step 3.

Preliminary Project Development Report

- The midyear milestone should describe activities completed in Steps 1 and 2 in a short report that is no more than 5 pages and formatted according to the specifications laid out in Appendix B. The deadline is listed in Section 2.1. The report should describe which lease area the team has chosen and why the team chose it over the other options. The report should also describe the preliminary site design, including information about the wind resource, site layout, turbine type, bathymetry, foundation type, transmission plan, and sensitive environmental regions and species. This report may also be used as part of the final report for this contest.
- Students should not plan to conduct any stakeholder outreach or engagement during their project development activities. While community and stakeholder engagement are imperative parts of any development process, they are outside the scope of the competition this year, and students should not conduct any such activities. The organizers are soliciting creative feedback to better incorporate this idea alongside the technical feasibility that is outlined here for the 2023 competition.

4.1.2 Deliverables

Project Development Written Report

The project development written report is the primary means for a team to provide detailed information about the project to the judges, given that the judges have a limited opportunity at the competition event to evaluate the yearlong project development activities. At a minimum, the report must include the following sections in the prescribed order:

- **A cover sheet.** Teams should begin the report with a one-page cover sheet that includes school affiliation, contact information, project name, team roles/hierarchy, and approximately how many students, faculty, and others (e.g., mentors, sponsors, or other volunteers) are involved in the project.
- **A site description and energy estimation.** This should include information about the wind resource, site layout, turbine type, foundation, sensitive environmental regions and species, reason as to why this site was selected, and risks and fatal flaws (i.e., fatal flaw being circumstances that can lead to the project's demise).
- **Financial analysis.** This section should outline the financial potential of the project, noting required capital, financing, and key assumptions (e.g., project marginal costs). The team should demonstrate the path to solvency and outline the project's potential through cash flow analysis. Full pro formas (pro formas being financial statements forecasted for future periods typically used for Security and Exchange Commission filing) are not required; however, it is recommended that higher-level, longer-term summaries be included to communicate the attractiveness of the project for investment.
- **Discussion of optimization process.** This section should describe the iterative process of optimization that occurred between the preliminary site design and the financial analysis.
- **An auction bid.** The team should suggest the maximum bid they would be willing to pay for their chosen lease area.

The report should be no more than 15 pages in length and formatted according to the specifications laid out in Appendix B. Pages submitted beyond this limit will not be reviewed.

Scoring criteria are provided in Appendix A. At the conclusion of the competition, team reports will be posted to the competition website for reference during future events.

Presentation and Posters

Each team must submit their posters digitally according to the schedule in Section 2.1. Printed posters should match the submitted digital version. If the event is executed virtually, posters should be replaced with digital slides.

At the competition, teams will present their proposed wind farm site plan during an assigned presentation session with the judges who will represent potential project owners or investors. This presentation should convey the most important details of the project, which may include items from the project development written report. The report and posters, however, would ideally be complementary rather than redundant.

The teams will have 15 minutes to present their project and another 10 minutes for questions from the judges. Teams may use up to two posters to represent the project; each poster should be

no larger than 3 feet by 4 feet. Teams are expected to have their posters on display at their team booth for the duration of the competition. Two easels and poster backboards will be provided for this purpose.

The scoring criteria are provided in Appendix A. At the conclusion of the competition, team posters will be posted to the CWC website.

4.2 Part B: Design a Wind Farm During the Competition

Teams will complete a siting activity at the competition. This task will be similar to elements of both the preliminary and detailed design activities conducted prior to the competition. The site will be set up within the software prior to the competition and computers will be provided for the teams to work on. The site will represent a real location and will be the same area for all teams. The objective is to balance competing priorities of maximizing power production while minimizing costs, as well as other relevant constraints. The scoring criteria are provided in Appendix A. The challenge will likely use the Furow software; however, this will not be finalized until we get closer to the live competition. While it can be helpful to be familiar with the software platform, it is not necessary—industry experts will be available throughout the challenge to ensure that all students are able to successfully complete the contest activity.

The contest will run as follows:

- **On-site contest preparation, including the following:**
 - Teams will be given a siting challenge packet of the site area with detailed topography, the wind regime, and instructions for the challenge during the competition check-in. This information will be reviewed during a project development briefing on the first day of the official competition, at which time teams will have the opportunity to ask questions.
 - Specific timing on the briefing will be provided as part of the overall competition schedule.
 - The provided materials will clearly identify all pertinent elements that should be considered. Teams will have a full day to sketch a draft solution to the problem—this is the preliminary design layout.
 - Teams should also detail environmental and community elements that were considered, as well as any other competing priorities that the team was attempting to balance. This information should be recorded on a single 8.5-by-11 paper that will be turned in at the end of the on-site contest time slot each team is assigned to.
- **On-site contest execution, including the following:**
 - Teams will have 40 minutes to place wind turbines on the site which will be setup on the computer, followed by 5 minutes to share a summary of the team’s approach with the on-site evaluator. Time slots for each team will be assigned and provided along with all other contest events in the competition scheduling platform.
 - Teams will select the precise location of each turbine for their proposed wind farm using industry-accepted wind power plant siting software. This siting tool will evaluate project energy produced and economics.
 - Teams will hand in their preliminary design layout and a single 8.5-by-11 paper describing the environmental and community considerations at the end of the session.

- **Scoring, including the following:**
 - The combination of the preliminary design work shown on the paper copy of the site, the justification detailed on the 8.5-by-11 paper, and the final siting layout will be the basis for the final submission. Siting judges will evaluate the siting contest using the defined scoring criteria laid out in Appendix A.

5 Connection Creation Contest

The Connection Creation Contest is designed to forge stronger connections between competition participants, the wind industry, students, and the team's local community.

This contest is broken up into four elements: Outreach Plan & Execution, Team Story, Understanding the Wind Industry, and Community Engagement. The deliverables required throughout the contest will build on each other and inform other Connection Creation Contest activities.

In alignment with expectations in a professional setting, the team will be required to present and summarize the purpose and impact of their work. This contest is designed, in part, to develop this skill set. Specific requirements are defined in the following contest segments, and deadlines are included in Section 2.1.

5.1 Contest Elements

5.1.1 Outreach Plan and Execution

Teams will develop an outreach timeline chronicling the team's accomplishments and associated announcements throughout the year. An outreach plan is an industry best practice to help keep announcements on track and serve as an activity road map.

Sharing the team's progress will also help employers understand the skills the team has developed through involvement with the CWC and prepare members for the final event presentation.

This outreach plan should include:

- High-level goals the team aims to achieve with their outreach activities. Goals could include, but are not limited to:
 - Raising student and local community awareness of wind energy
 - Inspiring and recruiting new students to participate in the CWC and diversifying the team
 - Educating and exciting young students about opportunities in wind energy
 - Highlighting skills developed during the competition.
- A timeline for the contest elements, including:
 - Development of the team story and dissemination plan
 - Listing of initial contacts and a timeline for career interviews
 - Proposed outreach events
 - Planned outreach announcements and social media posts, at least two of which should be in the spring semester.
- A recruitment strategy, including how the team will connect with students in majors other than engineering
- Relationships developed with the team's school newspaper, local media outlets, and existing or new social media accounts
- Any social media content or photos that have been developed for outreach purposes.

This outreach plan is required in the first half of the year. An explanation of this plan and how it was executed should be included in the team’s final presentation to the judges.

Outreach plans should not exceed three pages (photos not included in the page count). Formatting details can be found in Appendix B.

5.1.2 Understanding the Wind Energy Industry

For this contest element, teams are asked to explore multiple sectors of the wind energy industry and learn about career opportunities. The goal of this activity is to learn more about the industry and create outreach materials to educate and inspire younger students. Teams must interview at least four industry professionals to learn about their role and produce four slides highlighting insights from the interviews (see requirements listed below). The professionals interviewed may be alumni that have gone into the wind energy industry or other industry contacts. Teams are responsible for making their own connections to professionals in the industry.

Returning teams may not interview any individuals that team has previously interviewed in past competition years. Any teams in need of support developing new contacts can begin their search using LinkedIn, webinars on wind energy topics, or bios from wind energy conferences.

Teams should ask questions that will help them develop a clear and compelling presentation covering specific details about each job that they are highlighting, what is interesting about it, and requirements needed for each job identified. Details on other entry-level positions, internships, scholarships, or fellowships available within each organization are also of interest.

Please note that these industry professionals will be volunteering their time. Be mindful of their availability and ensure team members are fully prepared, professional, and concise with their interactions.

Teams should choose professionals in four different sectors of the industry. The following are some examples of industry sectors:

- Offshore, land-based, or distributed wind energy
- Project development, manufacturing, research and development, or operations
- Wind turbines or components (e.g., gearboxes, generators, blades)
- Stakeholder engagement, communications, or marketing.

‘Understanding the Wind Industry’ Milestone

Teams must submit four slides—one for each of the four required interviews—and details about each contact. The timing for this deliverable is shown on Table 1. Teams must use the slide template provided by NREL organizers. Slides should be submitted in .pptx format.

As part of the midyear milestone, teams need to include a slide containing a list of completed interviews along with contact info for each interviewee. The contact details must include the interviewee’s:

- Full name
- Company affiliation

- Origin of the relationship (i.e., professional or alumni)
- Sector in the wind energy industry
- Email address
- Response regarding if this person would be open to continued participation in future CWC events.

The four interview slides developed in this contest element will be part of the final presentation along with the deliverables from the other contest elements. The slides should also be shared during the team's community engagement event outlined in Section 5.1.4 to illustrate opportunities in the wind industry. More details on requirements for the final presentation are included in Section 5.3.

5.1.3 Team Story

A Team Story that details the project, goals, and background will be required along with any information on the work completed for the competition to date. Organizers will provide detailed guidance in late 2022, but teams should plan to include the following in their team story:

- Name of team, name of school, location of school, team contacts
- The team's history and structure
- Lessons learned from previous years, or how new teams got involved and initiated
- If it is a club team, capstone, or other: include some core classes or activities the team partakes in
- Student leadership structure/roles
- Industry involvement (including mentors, alumni, speakers, and sponsors)
- The reason students are participating in the Collegiate Wind Competition this year
- How members are recruited and what steps have been taken to ensure diversity and inclusivity on the team
- The team's strengths and strategies for success
- Team social media accounts with hyperlinks
- A team photo, including the names of the team members in the order in which they appear. Students in the photo should be following practices consistent with local social distance and mask guidelines when the picture is taken.

Organizers may edit the story for consistency between teams and to meet necessary web standards on [energy.gov](https://www.energy.gov).

Teams are encouraged to promote their team stories through their social media channels and media connections once they are live on the CWC website.

5.1.4 Student and Local Community Engagement

Considering the high-level goals outlined in the outreach plan, each team must organize and run at least one educational event with middle school, high school, or college students. These engagement events may be done virtually or in person. Events could include but are not limited to:

- A KidWind event organized with the CEO of the KidWind Project Michael Arquin (<https://www.kidwind.org>; michael@kidwind.org)

- An event at a local school or the team’s university
- An event within the team’s local community.

Teams are encouraged to describe their project and share highlights from their story. Teams should also share what they have learned about wind energy and include some discussion about career opportunities in the wind industry. Teams should draw from elements learned through the Understanding the Wind Industry contest element and through other work on the competition to date.

During each event, teams are encouraged to capture high-quality photos and videos to present during the final presentation and to aid in the Outreach Plan and Execution element of the contest (described in Section 5.1.1).

Teams should provide a photo release form (see [KidWind’s release form](#) as an example) to any event attendees they take photos or videos of, especially at events where minors are present.

Events must occur **prior to the final competition date** so teams can speak to these experiences during their presentation to the judges. An explanation of the goals of the event, the planning process, estimated number of attendees, and an impact assessment should be included in the final presentation.

5.2 Final Metrics Report

Teams will submit a final report detailing the metrics of their Connection Creation Contest activities throughout the year. This report should include the following:

- Recruitment plan outcomes, including:
 - Metrics on team breakdown and recruitment
 - Team numbers and growth
 - Grade levels of team members
 - Composition of the team’s university overall and of the team (e.g., race, gender)
 - Breakdown of majors in the team
 - Reflection on the team’s original recruitment plans versus results attained
- Social Media, including:
 - Metrics on social media account growth
 - List each platform with number of followers, number of posts and likes, and how this grew throughout the year
 - Reflection on the team’s original social media plan versus results attained
- Interviews, including:
 - Metrics on interview attendance by the team
 - Metrics on industry connections made (from interviews or otherwise)
 - Reflection on the value (or lack thereof) that the team gained from the industry connections; how they helped the team in the competition, did they result in jobs, and so on

- Outreach Events, including:
 - Number and types of events
 - Metrics on team and participant attendance
 - Reflection on how these events met the team’s high-level goals for the year.

This report should be no more than four pages in length. Formatting details can be found in Appendix B.

5.3 Final Presentation and Q&A

Teams must develop a final PowerPoint presentation to share their progress on each competition element throughout the year. This presentation must include the following:

- Details on the outreach plan, including the team’s initial high-level goals, execution of activities from the plan, and an assessment of activity impact
- Details on the development and dissemination of the team story
- Four slides covering the four industry interviews using the template distributed by the organizing team
- Each community engagement event that the team holds.

Teams should emphasize the quality and visual appeal of each slide and the accompanying presentation by the speaker. Slides should include high-resolution photos to represent each contest element. Teams may use videos, but this is not required. See Appendix B for instructions on submission and formatting details.

Each team will have 10 minutes to present to a panel of judges and to the public. This will be followed by 10 minutes of questions from the judges. Teams will be scored on the professional and clear structure of the presentation, use of effective storytelling techniques and visual elements, and their completion of each of the required deliverables. The full scoring criteria are included in Appendix A. Final presentations from each of the teams will be published on the competition website, used for reference for future events, and could be used to develop future competition deliverables.

Glossary

competition	All aspects and activities leading up to, during, and following the event. It is the subcontract project agreement between the competitively selected collegiate teams and the National Renewable Energy Laboratory, the contests, products, and event, collectively referred to for a given year as the U.S. Department of Energy Collegiate Wind Competition.
contests	The competition comprises several contests with multiple products.
event	When and where the teams compete in the contests.
learn-along school	A team that was selected for Phase 1, but not Phase 2. This team is encouraged to continue following the rules and requirements throughout the spring semester and choose which events to separately showcase to judges. See Appendix G for more details.
products	What the team builds, writes, submits, and brings to compete in the competition.
task	Each individual achievement goal of the test turbine that will be scored during the wind tunnel testing period.
team booth	An assigned area provided to each team to use as a central location throughout the competition to work on their wind turbines, prepare for various contests, regroup, and showcase their hard work to spectators.
test	The overall time period in the wind tunnel during which each team's turbine is subject to various wind speeds and scored on the testing tasks.

Appendix A. Rubrics

Overall Competition

Table A-1. Scoring Rubric for the Overall Competition

Description	Possible Points
Turbine Design Contest	325
Turbine Testing Contest	300
Project Development Contest	350
Connection Creation Contest	225
Total	1,200

Turbine Design Contest

Table A-2. Scoring Rubric for the Midyear Progress Milestones for Turbine Design and Testing

Description	Possible Points
Conceptual design	20
Preliminary design report	25
Assembly and testing of subassemblies	20
Technical inspection prior to competition	15
Total	80

Table A-3. Scoring Rubric for the Technical Design Report and Question and Answer Session

Description	Possible Points
Concise, readable, and descriptive with logical flow and clear communication	15
Design objective description for test turbine and foundation	15
Clear and concise enumeration of what is the same as last year and why ^a	15
Static performance analysis	15
Mechanical loads analysis and associated safety factors of structures	15
Description and analysis of the underwater structure and anchoring system	15
Electrical analysis	15
Engineering diagrams including mechanical and electrical drawings	15
Controls analysis including states and algorithms, as applicable	15
Software implementation and testing description	15
Documentation of final assembly	15
Commissioning checklist	15
Results from laboratory and/or field testing	15
Subtotal	195
Demonstrated understanding of technical design during question and answer session	50
Subtotal	50
Total	245

^a Teams whose schools did not compete last year should write a few sentences about how the winning design report from last year influenced their design decisions instead.

Turbine Testing Contest

Table A-4. Scoring Rubric for Wind Turbine Performance Testing

Description	Possible Points
Power curve performance task	50
Control of rated power and rotor speed task	50
Safety task	50
Foundation success task	50
Durability task	60
Structure weight	40
Total	300

Scoring algorithms for each testing task are described in the following sections.

Power Curve Performance Task

A total score for this task will be calculated according to Table A-5 by multiplying each power measurement in watts in 1 meter per second (m/s) wind speed intervals from 5–11 m/s by the factor given. If power is not stable within the specified tolerance in Section 3.5.1, the score for the bin will be zero.

Table A-5. Weighting for the Power Curve Performance Task

Wind Speed (meters/second)	Factor
5	0.7
6	0.8
7	0.8
8	0.7
9	0.4
10	0.3
11	0.1

Control of Rated Power and Rotor Speed Task

Scores for power will be calculated according to the following:

$$r_p \equiv \frac{\text{measured power in bin of interest}}{\text{measured power at 11 m/s}}$$

$$\text{Bin Score} = 25 \frac{[\tanh(-20 * |r_p - 1| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

In Figure A-1, a ratio, r_p , of 1.000 represents perfect power control at the same value that was measured in the 11-m/s bin. The weighting shown will be multiplied by 25 for the selected bin to obtain a score.

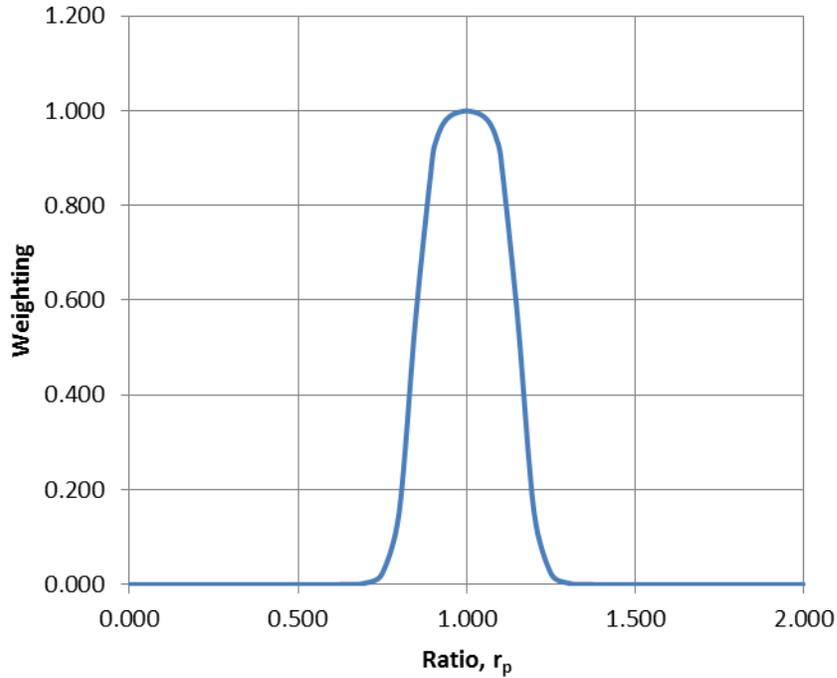


Figure A-1. Score weighting based on power ratio for control of rated power task

Scores for rotor speed control will be calculated according to the following:

$$r_s \equiv \frac{\text{measured speed in bin of interest}}{\text{measured speed at 11 m/s}}$$

$$0 < r_s < 1.03 \rightarrow \text{Bin Score} = 12.5$$

$$r_s \geq 1.03 \rightarrow \text{Bin Score} = 25 \frac{[\tanh(-20 * |r_s - 1.03| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

In Figure A-2, a ratio, r_s , of 1.000 represents the perfect rotor speed control at the same value that was measured in the 11-m/s bin. The weighting shown includes a 3% buffer above and infinite buffer below that speed to obtain full points. The weighting shown will be multiplied by 25 for the selected bin to obtain a score.

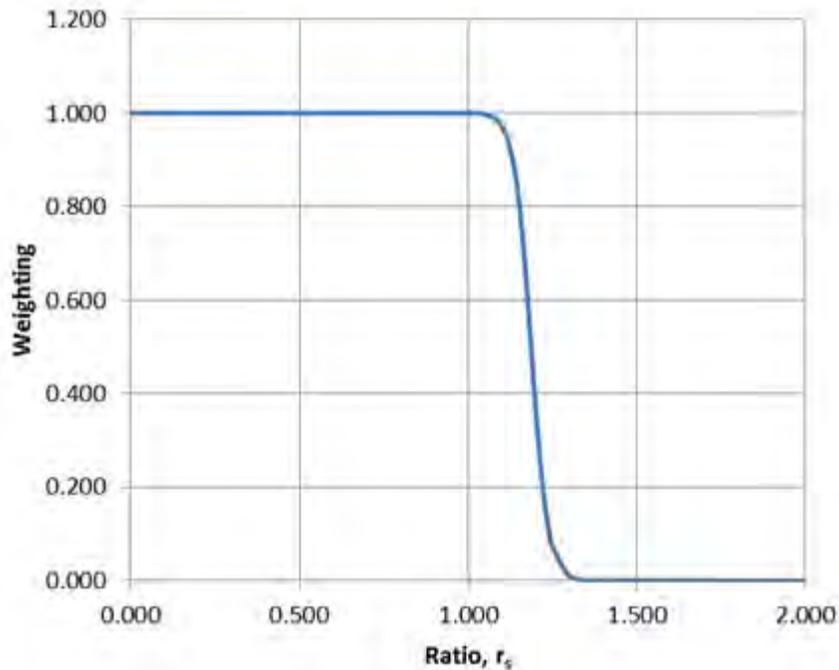


Figure A-2. Score weighting based on revolutions per minute ratio for control of rated rotor speed task

Safety Task

The safety task is scored on a pass/fail basis in two parts, which is governed by the limits set forth in the safety task description (see Section 3.5.3). If the wind turbine achieves a successful shutdown upon manual initiation, the team will receive 15 points. If it automatically restarts, the team will receive an additional 10 points. If the team must manually restart the turbine, they will receive zero points for the restart. If the turbine achieves a successful shutdown when disconnected from the load system, the team will receive an additional 15 points. If the turbine automatically restarts when reconnected, the team will receive an additional 10 points. If the team must manually restart the turbine, they will receive zero points for the restart.

Foundation Success Task

The foundation’s purpose is to keep the turbine stationary during the entire period of testing. However, the wind tunnel does have a “hard stop” that will prevent the top of the stub from moving beyond a certain point. If the foundation fails to keep the turbine stationary, it will usually fall all the way to the hard stop.

This task will be scored according to whether the foundation tips beyond a set limit during testing (see Section 3.1.2), taking into account the highest wind speed that was experienced before tipping occurs. Points will be awarded linearly from 0 to 50 based on the maximum wind speed attained from 5 m/s to 20 m/s, with 20 m/s being worth 50 points and 5 m/s being worth 0 points. No more than 50 points or less than 0 points can be earned for this task.

Durability Task

The 5-minute testing period for this task will be divided into two parts. The first part will encompass the first 3 minutes, during which the wind speed will be kept between 6 m/s and 14 m/s. The second part will encompass the final 2 minutes, during which the wind speed will be kept between 8 m/s and up to a maximum of 22 m/s. Teams have the option to “opt out” of the second period of the testing; however, opting-out will result in lower scoring potential for the foundation success task because the highest wind speeds are experienced in part two.

This portion of the task will be scored on a second-by-second basis for the first 3 minutes. Each 3-second period during which the turbine system produces positive power for the first 3 minutes of the task will result in 1 point being awarded for a maximum of 60 points. The turbine need not produce power during the second portion of this task; no score will be awarded for power production, but it will be subjected to higher wind speeds, allowing teams to gather more points in the foundation success task.

Structure Weight

This portion of the competition will be scored based on the weight of the in-water support structure as it relates to the weights of the structures of the other teams. All structures will be weighed dry, including all necessary installation hardware (not including tools), and the results will be ranked. The following formula will be used to calculate each team’s point total for this section of the contest:

$$Score = 40 - 2 \times (rank - 1)$$

Project Development Contest

Table A-6. Scoring Rubric for the Midyear Progress Milestone for Project Development

Description	Possible Points
Preliminary site selection and down-select, including identifying potential siting challenges and opportunities associated with options	45
Total	45

Table A-7. Project Development Contest Part A: Develop Plan for 100-Megawatt Wind Farm

Description	Possible Points
Final Deliverables	
Written report: concise, readable, and descriptive with logical flow; communicates technical information clearly	20
Presentation: professional, clear project pitch	20
Posters: well-designed, illustrative, and appropriate use of text and graphics	20
Subtotal	60
Analysis	
Wind farm design: detailed layout and resource assessment	30
Articulation of environmental impacts and mitigation approaches	25
Levelized cost of energy (cost/kilowatt-hour) is realistic	20
Depth and thoroughness of balance-of-station elements considered in the financial analysis (capital expenditures)	25

Description	Possible Points
Evaluation of annual operational costs (operational expenditures)	25
Bankability of financial plan and bid price	30
Understanding of market opportunities and constraints (e.g., power markets, equipment supply chains, ownership structures, taxes, policies, and incentives)	15
Subtotal	170
Total	230

Table A-8. Project Development Contest Part B: On-Site Design Challenge

Description	Possible Points
Lowest cost of energy	45
Environmental and community impact (e.g., habitat impacted, conflicting interests)	30
Total	75

Connection Creation Contest

Table A-9. Scoring Rubric for the Midyear Progress Milestones for the Connection Creation Contest

Description	Possible Points
Quality and creativity of outreach plan	15
Engaging summaries of career interviews on Understanding the Wind Industry slides and complete interviewee information	15
Quality of team story; engaging storytelling	15
Total	45

Table A-10. Scoring Rubric for Connection Creation Contest Deliverables

Description	Possible Points
Final Metrics Report	
Written report: concise, readable, and descriptive with logical flow; communicates information clearly	15
Quality of recruitment plan metrics and demonstrated understanding of impact	15
Quality of social media metrics and demonstrated understanding of impact	15
Quality of interview metrics and demonstrated understanding of impact	10
Additional industry connections made beyond the four required interviews	5
Quality of outreach event metrics and demonstrated understanding of impact	15
Subtotal	75
Final Presentation	
PowerPoint is concise and visually engaging, and presentation to judges is professional and clear, uses effective storytelling techniques	20
Demonstrated execution of outreach plan and team goals and the associated impact throughout the year, including improvement in digital public engagement (social media or other news outlets)	15
Execution and demonstrated impact of an engaging educational event, virtual or in person	20
Successful recruitment and inclusion of a multidisciplinary team with diverse backgrounds	15
Demonstrated understanding of wind energy industry career opportunities	15
Inspirational or creative description of career opportunities	10

Description	Possible Points
Diversity of outreach methods and creativity in tactics used	10
Subtotal	105
Total	180

Scoring Penalties

- No points will be awarded for a milestone that is late.
- Ten percent will be deducted for each day deliverables other than milestones are late (e.g., reports, and so on)
- Five percent will be deducted for each incorrectly named file
- Formatting requirements are in place to ensure an equal amount of space for all teams to tell their stories to the judges. Reports not formatted to the requirements in Appendix B that are deemed to be utilizing more than the allotted space will be penalized at the discretion of the judges proportional to the infraction.
- Pages in excess of the page limit will be ignored.

Appendix B. Deliverable Requirements

Submittals and Submission Locations

Submittals are considered on time if they are received by the competition manager by the respective due date stated in this document. Teams are encouraged to submit early and update their submission as necessary up until the deadline to prevent unexpected issues at the last minute during submission. **Penalties will apply for late submissions and no resubmittals will be accepted after the deadline if a product has already been submitted.**

All products must be saved in the formats indicated.

Products due ahead of the competition must be delivered to the competition Box.com repository. A folder for each team will be created, and it will be the team's responsibility to provide email addresses for each student that needs upload access to the account. A link will be provided to these students via email.

Written Deliverable Formatting Requirements

The following format requirements apply to the midyear milestones and written reports:

- Reports must adhere to the page limits detailed in the respective sections. Cover pages and bibliographies do not count against the page limits, but any table of contents, executive summaries, and appendices do. See the following sections on milestone and written reports for how figures, tables, and equations are treated in each case.
- Pages should be 8.5-by-11 inches, paginated, and have 1-inch margins at a minimum.
- References should begin on a new page with a distinct page number format from that used for the body of the report.
- Content should be single-spaced.
- The body of the report must use an 11-point font size at a minimum.
- Captions for figures and tables must be numbered for easy navigation.
- The final documents must be submitted as an Adobe PDF file, adhering to the following criteria:
 - Report sections must be bookmarked.
 - Fonts must be embedded.
 - All images must have a minimum resolution of 300 dots per inch.
 - *Do not* create a PDF from scans or by outputting the content into a raster image format (e.g., .jpg, .tiff, .png, or .gif) and then creating a PDF from the images.
 - *Avoid* all-raster PDFs. Although they are large files at 300 dots per inch, they are of unacceptable quality at lower resolutions and are not scalable without degradation.

Midyear Milestone Requirements

- Students may include images up to the number specified in the respective milestone section.
- Images should be placed at the end of the document to make it easy for judges to determine page limit compliance in milestones.

- Equations and tables should be placed within the text and count against the page limit.

Written Report Requirements

- Images, tables, equations, and so on should all be included within the text and count against the page limit for written reports.

Audiovisual Presentation Requirements

Audiovisual presentations are not required for all contests, but if used should follow the following format requirements. The final presentation must be delivered digitally to the team's Box folder in advance of their presentation during the competition. Teams should also bring the file on a USB drive to their presentation slot.

- Videos should be recorded in a 1,920-by-1,080 frame size with a frame rate of at least 30 frames per second.
- Videos should be recorded horizontally rather than vertically.
- Teams may use any video recording software and file format they prefer.
- If the video includes narration, please include a transcript.
- No background music that violates U.S. copyright laws is allowed; all incorporated music must be an original or royalty-free composition, and proof of licensing must be submitted with the final file and transcript.

Electronic File-Naming Instructions

The required file-naming convention for all electronic files is:

[TEAM ABBREVIATION]_[SUBMISSION DATE (YYYY-MM-DD)]_[CONTEST ABBREVIATION]_[PRODUCT ABBREVIATION].[EXTENSION]

Table B-1 presents a list of team names and abbreviations. Table B-2 lists product names and abbreviations.

Example: A design report submitted by California Maritime Academy on April 23, 2023, would have the following file name: CALMARITIME_2023-04-23_TD_Design Report.PDF.

Table B-1. Team Names and Abbreviations

Lead University Name	Team Abbreviation
Brigham Young University	BYU
California Polytechnic State University	CALPOLY
California State University Maritime Academy	CALMARITIME
California State University San Marcos	CSUSM
Iowa State University	ISU
James Madison University	JMU
Johns Hopkins University	JHU
Kansas State University	KSU
Manhattan College	MC
Massachusetts Maritime Academy	MMA
Northern Arizona University	NAU
Oklahoma State University	OSU
Rice University	RICE
Rutgers University	RUTGERS
Texas A&M University	TAMU
Texas A&M University Corpus Christi	TAMUCC
Texas Tech University	TTU
The Pennsylvania State University	PSU
The University of Oklahoma	OU
The University of Texas at Dallas	UTD
Universidad Ana G. Mendez	UAGM
University of California Los Angeles	UCLA
University of Colorado at Boulder	CU
University of Delaware	UD
University of Massachusetts Lowell	UML
University of North Carolina at Charlotte	UNCC
University of Wisconsin-Madison	UWM
University of Wyoming	UWYO
Virginia Polytechnic Institute and State University	VT
Washington State University-Everett	EVERETT

Table B-2. Product Names, Contests, and Abbreviations

Product Name	Contest Abbreviation	Product Abbreviation
Conceptual Design Milestone	TD	Conceptual Design
Outreach Plan Milestone	CC	Outreach Plan
Preliminary Design Report Milestone	TD	Preliminary Design
Preliminary Site Design Milestone	PD	Preliminary Site Design
Understanding the Wind Industry Milestone	CC	Wind Industry Pres
Team Story	CC	Team Story
Subassembly Assembly and Testing Milestone	TD	Subassembly Milestone
Turbine Design Report	TD	Design Report
Project Development Report	PD	Project Development Report
Metrics Report	CC	Metrics Report
Technical Inspection Prior to Competition	TD	Tech Inspection
Project Development Poster(s)	PD	Poster
Connection Creation Presentation	CC	Final Pres

Appendix C. Sample Safety and Technical Inspection

A sample of the sheet used to evaluate test wind turbines prior to competition is provided in Table C-1. Teams are required to work through this process in advance of the competition with a qualified research technician, advisor, or similar university personnel as part of the final midyear project milestone. **If a team makes a change to their system after passing tech inspection that could affect anything evaluated during that inspection, they must notify a judge and undergo a revised inspection. Failure to do so may lead to disqualification.**

Table C-1. Sample Inspection Sheet for Evaluating Test Turbines

CWC 2023 Safety and Tech Inspection Sheet	
Team Name: _____	
SAFETY – Cannot practice or test if noncompliant	
<input type="checkbox"/>	Wiring is deemed safe and uses adequate gauges—no electrocution or overheating hazard
<input type="checkbox"/>	Droop cable is continuous and unbroken between turbine and point of common coupling (PCC); connectors capable of being kept dry during install
<input type="checkbox"/>	Electrical systems are tied to earth ground with 100 kilohms or lower resistor
<input type="checkbox"/>	Energized electrical components are adequately shielded—both electrically and mechanically (National Electrical Manufacturers Association Type 1 is preserved)
<input type="checkbox"/>	Proper heat rejection
<input type="checkbox"/>	Voltage is ≤ 48 Volts (V) direct current at PCC at all times
<input type="checkbox"/>	Turbine mounting flange fits over studs without having to be forced (test fit to tunnel flange)
<input type="checkbox"/>	Top of foundation has tubing 1.500 ± 0.015 inches at least 8 centimeters (cm) long (test fit competition provided stub)
<input type="checkbox"/>	Team load runs on 120 V alternating current maximum
<input type="checkbox"/>	For the team load: all charging or bulk energy storage follows industry-accepted best practices (i.e., safe circuitry overvoltage/undervoltage protection, flame/spill containment)
NON-SAFETY – Can practice but must fix prior to official testing	
General	
<input type="checkbox"/>	All electrical components outside the tunnel are contained in enclosures meeting National Electrical Manufacturers Association type 1 or greater (no tape)
<input type="checkbox"/>	Cable passthroughs in enclosures provide strain and chafe protection (e.g., cable glands)
<input type="checkbox"/>	Turbine electronics and load electronics are in separate enclosures
<input type="checkbox"/>	All external wiring is in cable form and utilizes commercial connectors (no screw terminals or spade- or fork-type lugs)
<input type="checkbox"/>	All electrical components are mechanically secured to the enclosure
Wind Turbine	
<input type="checkbox"/>	Turbine for testing is substantively the same as in the report
<input type="checkbox"/>	Turbine side of PCC: no batteries or excessively large capacitors (individual or combination ≤ 10 Joules)
<input type="checkbox"/>	Turbine is capable of fitting through the door in one assembly

CWC 2023 Safety and Tech Inspection Sheet

Structure and anchorage

- Constructed exclusively of ferrous metal and paint
- Capable of being assembled with only tools touching water
- Measure dry weight of all foundation structure and anchorage components: _____ grams

Volume

Rotor and nonrotor components are:

- Within a 45-cm cube centered horizontally on the flange axis, shifted at most 10 cm aft
- Vertically, the rotor midplane is 60 cm \pm 3 cm above the flange top plane to center it in the test section

Nonrotor parts only:

- Base plate is \leq 16.1-millimeters thick and tower is less than a 15-cm-diameter cylinder from the base of the cube to the tunnel floor

Foundation and anchorage:

- Fits within a projected area 30 cm on a side when assembled (test fit in competition provided box)
- Anchors penetrate sand no more than 20 cm (test fit in competition provided box)
- When assembled, mounting tube is at or below the lip of the tank by no more than 3 cm

Wiring

- Wiring will reach PCC (test fit)
- Emergency stop terminated with standard JST *female* receptacle with *male* pins (test fit to data acquisition system)
- Emergency-stop signal (JST connector wiring) never draws more than 3 amperes and uses normally closed logic during turbine operation (students to describe)
- Anderson Powerpole polarity is correct (test fit to PCC)

Load

- Team-supplied load

INSTALL

- Reflective tape for revolutions per minute

Inspecting Judge Signature: _____

Date and time: _____

*Noncompliance checkboxes should be circled above

Reinspecting judge – Initial compliancy above with date and time of reinspection

Reinspecting judge signature when complete: _____

Date and time: _____

Reinspecting judge – Initial compliancy above with date and time of reinspection

Reinspecting judge signature when complete: _____

Date and time: _____

Appendix D. Roles and Responsibilities

Table D-1 shows the competition roles, who is performing in each role, and what the role entails.

Table D-1. Roles and Responsibilities

Role	Individual(s) Assigned	Definition
Collegiate Team	Multiple	Collegiate team members are led by the student lead and subteam leads under the mentorship of faculty advisors within the rules and requirements of the competition. Teams comprise undergraduate students only, but graduate students may be involved as mentors or advisors. There is no limit to team size. However, the number of students that teams may bring to the competition will be limited based on space requirements. Interdisciplinary teams are encouraged in the following areas of study: engineering, business, marketing, environmental science, communications, policy, and social sciences.
Student Lead(s)	One or more	The student lead should take on the primary leadership and organizing responsibilities for the team under simple mentorship from the faculty advisor. In addition, the student lead attends informational sessions, represents the team when communicating with competition organizers, and disseminates information received from the competition organizers over the course of the entire project, including monitoring communications (i.e., the Slack channel that is discussed later in this document) during the event. The collegiate team student lead is effectively the leader of their collegiate team in all aspects of the competition.
Faculty Advisor	One per team	Serves as the lead faculty member of a participating school in the project. This person provides mentorship to the team throughout the project and provides a supportive environment for student team leads to thrive in. The faculty advisor teaches, advises, and coaches the students on the skills necessary to compete in the various aspects of the competition. Some teams may specify multiple faculty advisors who are contacts for the team, but in this case, one person should be identified as the lead.
Student Mentors	Multiple	Because of their unique perspective, students who have completed their undergraduate degree or graduate students are encouraged to act as mentors to the collegiate team. Similar to the faculty advisors, mentors should provide a supportive environment and the educational background necessary throughout the contest without making active decisions themselves.

Role	Individual(s) Assigned	Definition
Supporting Faculty	Multiple	Supports the faculty advisor in the previously mentioned duties but typically does not directly engage with U.S. Department of Energy (DOE)/National Renewable Energy Laboratory (NREL) Collegiate Wind Competition staff.
Competition Manager	Alex Lemke, DOE	Represents DOE and has the final decision-making authority in all aspects of the competition.
Competition Operations Manager	Elise DeGeorge, NREL	Leads correspondence with the collegiate teams regarding contracts (if applicable) and team expectations. During the competition, the operations manager is the primary point of contact for dispute resolution. Tasks include collating scores and supporting the testing team, collegiate teams, judges, competition manager, and the head rules official. Reports to the competition manager.
Competition Operations Coordinator	Christa Nixon, NREL	Coordinates competition logistics including registration, lodging, the overall event schedule, and individual team schedules. Leads correspondence with teams and event feedback. Supports collegiate teams, judges, the head rules official, and operations manager.
Contest and Industry Engagement Lead	Heidi Tinneland, NREL	Coordinates all activities related to the contests and engagement with industry members. Key point of contact for questions related to engagement with the judges, individual competition contests, and protocol. Organizes all industry-related events and webinars.
Head Rules Official and Turbine Safety Official	Jason Roadman, NREL	The head rules official and chair of the rules panel. The only official authorized to write and modify the rules. This individual reports to the competition manager. The turbine safety official makes the final decision about whether or not a turbine can be tested in the tunnel because of safety concerns.
Electrical and Technical Lead	Lee Jay Fingersh, NREL	Coordinates primary electrical and technical aspects of the competition.
Rules Panel	See definition	Rules panel members, a subset of the competition organizers and/or contest judges, are solely authorized to interpret the rules. If there is any doubt or ambiguity about the wording or intent of these rules, the decision of the rules panel shall prevail.
Communications and Outreach Point of Contact	Tara McMurtry, NREL	Coordinates all aspects of media representation, website management, publications, signage, and outreach.
Competition Safety Points of Contact	Jason Roadman, NREL Lee Jay Fingersh, NREL	Points of contact for questions or issues related to safety.

Role	Individual(s) Assigned	Definition
Core Competition Staff	NREL, KidWind	Perform all duties to ensure a safe, effectively communicated, and fair competition. The competition organizers, including the competition manager and operations manager, will work to ensure a seamless event.
Contest Judges	To be announced prior to the competition	Conduct and evaluate each individual contest at the competition.

Appendix E. Learn-Along Schools

All teams should submit the relevant deliverables outlined in Section 2.1 during Phase 1. Teams should submit all deliverables in accordance with the deadlines and procedures outlined in this document.

Teams that are not selected for Phase 2 are still encouraged to keep learning along, but no additional deliverables are expected beyond the final reports and final presentations. No deliverables after the Phase 2 selection will be scored or reviewed. Students will receive valuable, real-time feedback during a feedback session with industry experts at the end of the competition year based solely on final presentations in any contest.

Learn-along teams are welcome to participate in some or all of the competition contests; however, a selection will need to be made by the deadline in Section 2.1 so that the organizers can plan for the final event properly. Students who do not make a selection by this deadline are encouraged to continue involvement but will not receive feedback from the industry experts. Note that because of scheduling and tunnel availability, only the learn-along schools with the best Phase 1 testing milestone scores will be offered a chance to test in the small wind tunnels.

Teams that are new and building institutional knowledge are encouraged to participate in milestones but consider electing to be a learn-along school and build a simpler turbine. That turbine should focus on rotor design, power electronics, and basic reliability. The best-performing learn-along schools will be given a chance to test this simpler turbine in the small wind tunnels without the need for an offshore foundation.

This activity does not require that a team builds a small wind turbine, though they are encouraged to do so, and find alternative ways to test the wind turbine's performance. Students are encouraged to develop a testing protocol to validate their turbine on their own and utilize resources beyond wind tunnels. Competition organizers and judges are available on Slack to help brainstorm ideas and provide advice on how to get worthwhile results safely.

Learn-along teams will receive:

- Access to all the resources provided to competing teams
- Feedback sessions with industry experts for each contest that the team elected to complete.
 - This feedback session will begin with a team presentation as described for each contest mentioned previously. The presentation will be followed by a question-and-answer session so that students can learn from industry experts.
- A shared space amongst the team bullpens to work during the competition if the team has selected to participate in the turbine design challenge and have been selected to test in one of the National Renewable Energy Laboratory tunnels
- Two easels to display contest posters near the team bullpen area, if attending and have participated in at least two of the contests
 - This display will provide learn-along teams the chance to demonstrate their work to industry during the networking hour.

All learn-along teams will have access to all the general resources provided to competing collegiate teams to support contest activities, including:

- Rules and requirements
- Box folder with all available Collegiate Wind Competition (CWC) resources (e.g., educational webinars, papers, other educational resources)
- CWC Slack channel access for students to get answers to rules questions
- Access to the CWC LinkedIn group for students to build connections with current CWC participants, CWC alumni, and wind energy professionals
- Student rate for conference attendance
- Invitation to all educational webinars.

Learn-along teams will not receive:

- Testing time in any of the National Renewable Energy Laboratory wind tunnels, unless specifically notified based on Phase 1 scores
- Space in the bullpens with the rest of the competing teams, if not testing a turbine
- Opportunity to do the on-site challenge for project development.

The feedback session with industry experts will be held virtually approximately 2 weeks after the competition and will be facilitated by a National Renewable Energy Laboratory representative. The schedule for presentations will be shared with learn-along teams along with the communications for all competing teams.

It is important to note that primary interaction with competition staff will be through the 1-day feedback session and answering questions on the Slack channel. Participation as a learn-along school is primarily an independent activity in which schools are encouraged to use the framework of the CWC rules to shape an educational program for academic growth. Additionally, participating teams will have a chance to provide feedback to organizers at the end of the year.

Appendix F. Funding Requests

Teams can submit Phase 1 funding requests beginning August 1, 2022, through 11:59 p.m. Mountain Time (MT) on September 30, 2022, through a funding request form provided by National Renewable Energy Laboratory organizers. Funding requests can be up to \$5,000 per team. Teams will need to submit a description of how funds will be used and a timeline for when the funds are needed.

Some examples of appropriate funding uses include:

- Funding for incorporating wind-related coursework into program curricula
- Funding for hardware associated with incorporating wind-related coursework into program curricula
- Funding to secure space for machine work or similar to support long-term curricula enhancement to include wind energy
- Funding to foster student engagement with the wind energy industry
- Funding to enhance wind energy education in their community (as part of the Connection Creations Contest)
- Other similar requests that achieve the Collegiate Wind Competition (CWC) goals of providing students with real-world experience as they prepare to enter the wind industry (or renewable energy) workforce and encouraging students to consider wind energy in their career planning.

Funds should not be used for things like food, swag (e.g., clothing, custom merchandise), or marketing materials.

Phase 2 selected teams may request up to \$15,000 to support ongoing CWC project needs in the spring semester. National Renewable Energy Laboratory organizers will provide a funding request form to the selected teams, and requests can be submitted until 11:59 p.m. MT on January 31, 2023. Teams will need to submit a description of how funds will be used and a timeline for when the funds are needed. It is expected that this will include:

- Funding to buy equipment and materials for wind turbines and/or turbine testing
- Funding to attend the CWC.

Appendix G. Logistics

Many logistical details will be provided throughout the course of the academic year, leading up to the event. Although organizers will make concerted efforts to inform teams, teams are responsible for familiarizing themselves with the details provided and proceed accordingly. Some of these topics are detailed in the following subsections.

Event Schedule

The event schedule will be provided to participating teams once it has been finalized. When organizers draft the schedule, slots will be assigned to letters A through L. Each letter will ultimately be assigned to a team through a lottery. Teams may send requests for special consideration regarding scheduling; however, organizers are not obligated to accommodate them. Organizers will not accept requests for schedule adjustments after the lottery has been completed. Assigned slots will include:

- A check in
- A safety and technical inspection
- Contest slots, which teams should not expect to receive until they check in at the event, including:
 - Tunnel testing practice
 - Tunnel testing and makeup testing
 - A Project Development presentation
 - A Turbine Design question-and-answer session
 - A Connection Creation presentation.

Event Registration

All individuals attending the event will be required to register with the organizers. The number of individuals that can attend from each team will be limited based on constraints such as event space. This limit will apply to all attendees from each university, including students, faculty advisors, and mentors. The limit for attending participants for the 2023 event will be provided closer to the competition date.

Lodging

CWC organizers will coordinate with the conference organizers to provide information to teams on desirable, cost-effective lodging options. It is up to each team to ultimately book appropriate accommodations.

Local Resources

Each team is responsible for considering what local resources may be needed and identifying reasonable options near the event. These resources may include:

- Printing shops
- Shipping services

- Hardware stores
- Machine shops
- Electronic supply stores.

Team Booths

Teams will be provided with a space to use as their home base during the competition. There will be electrical outlets in the team booth area to allow students to operate tools, test equipment, or use computers. Appropriate personal protective equipment should be worn in the team booths when working on the wind turbines (see Appendix I for more details). Posters are encouraged to be displayed within the team booth throughout the event (easels and backboards will be provided). Additional materials that display the team's hard work and school spirit are also encouraged.

Shipping

It is each team's responsibility to transport their turbine and all supplies to the event safely and on time. It is also each team's responsibility to arrange return transport of these items. It is advised that teams consider how to ensure access to these items quickly upon arrival at the event and the safest way to transport fragile items, minimizing risk of damage.

Storing Items at the Event

Organizers are not responsible for the security of supplies stored at the event space. If teams wish to avoid transport of supplies to and from the event each day, they are advised to explore reasonable options to store and secure these items appropriately. Gear that could aid in this might include lockable totes.

Feedback

Throughout the organization and execution of the event, organizers will request feedback from participating teams, judges, volunteers, and others. This feedback is taken very seriously both during the year and for future competitions as we work to improve the organization and execution of the event. To support that continued improvement, it is crucial that participating teams seriously consider and convey both positive and critical feedback. All participants should expect and plan to provide feedback at the conclusion of the event. Consider opportunities to capture and provide individual and/or team feedback to organizers throughout the year as well.

Appendix H. Safety and Conduct

The Collegiate Wind Competition is a forum for students with an interest in wind energy to showcase their innovative ideas and demonstrate their knowledge. The event is designed to be safe, fair, and competitive, as well as a fun learning experience and professional growth opportunity. Each team is responsible for the safety of its operations in accordance with the subcontract agreement. Each team member must always work in a safe manner during the competition. Participants are expected to conduct themselves in the spirit of the competition by being team players both within their own teams and amongst competitor teams.

Teams must follow Occupational Safety and Health Administration rules for safety equipment based on expected activities. Organizers may issue a stop work order at any time during the project if a hazardous condition is identified.

Personal Protective Equipment

All team members must wear appropriate personal protective equipment when working on, testing, and operating wind turbines. Teams are expected to use the following appropriate protective equipment during wind tunnel testing and other potentially hazardous activities at the competition (note that all of these items must be student-provided):

- Safety glasses
- Steel-toed boots if expecting to handle heavy loads⁸
- Electrical personal protective equipment if electrical voltage demands it
- Hearing protection in areas that are near the wind tunnel during operation.

Testing Hazards

Teams may encounter hazardous conditions while testing their turbines. Some examples of these conditions and safety controls that teams should follow are listed in Table H-1.

⁸ Teams should use their judgment for steel/composite safety-toed shoes. If there is any danger of foot injuries due to a falling or rolling object or objects piercing the sole, safety shoes should be worn. Steel toes are usually rated for 50 pounds dropped from 18 inches.

Table H-1. Suggested Hazards and Controls for Testing Prototype Wind Turbines

Hazard	Control
<p>Inexperience with potentially destructive testing (Testing a rotor to failure can be hazardous to people nearby.)</p>	<ul style="list-style-type: none"> • Work with the faculty advisor to determine appropriate safety measures for reducing the potential for injury. • Consult the local safety department to determine appropriate hazards and safety control strategies specific to the team’s campus and testing area that meets the school’s requirements.
<p>Electrical shock (A shock from contact with energized conductors)</p>	<ul style="list-style-type: none"> • Follow the team’s campus electrical safety requirements. • Only work on de-energized systems. • Lock the system so that it cannot be turned on or start moving inadvertently while someone is in contact with the rotor and test equipment.
<p>Noise (A rotor assembly coming apart can create a loud, sudden burst of sound.)</p>	<ul style="list-style-type: none"> • Wear appropriate hearing protection, such as approved ear plugs or earmuffs, in the test area. • Follow manufacturers’ recommendations for proper usage.
<p>Hazards to the eyes, face, and head (Projectiles could be thrown with great force from a rotor or component undergoing testing, injuring a person’s eyes, face, or head [if debris takes a parabolic trajectory].)</p>	<ul style="list-style-type: none"> • Wear eye protection marked with a Z87+ symbol around the rotor and test area. • Information regarding eye protection can be found here: https://www.grainger.com/content/qt-personal-protective-equipment-requirements-125 • Wear hard hats if there is potential for injury to the head from falling objects; for more information, visit: https://www.grainger.com/content/qt-241-hard-hat-requirements.
<p>Thrown debris (A rotor assembly will come apart with great force, sending projectiles into the surrounding test area.)</p>	<ul style="list-style-type: none"> • Check the area to ensure it is clear before moving into the test phase; notify everyone involved that testing is about to begin. • Keep people away from the rotor during testing at what the team has determined to be a safe distance with appropriate barriers to keep others out; the barriers should have signage describing the hazard. • Station spotters around the perimeter of the area where the test is being conducted to prevent someone unfamiliar with the hazards of the test to inadvertently enter into a hazardous area. • Develop controls that allow testing to be done remotely at a safe location and to safely shut down the test. • Determine if equipment in the area could be damaged and protect it accordingly. • Determine if there are pressurized gas cylinders, hydraulic systems, or chemical storage containers that could be damaged during the test and if they need to be moved or protected. • Create housing surrounding the plane of rotation that is able to withstand the forces of the rotor coming apart. <ul style="list-style-type: none"> ○ The National Renewable Energy Laboratory uses 0.5-inch-thick polycarbonate. • Keep the area downwind and upwind clear of people where debris could be thrown with the direction of airflow or from sudden ricochets.

Shipping

Each team is responsible for the transport of its wind turbine and all necessary tools and equipment, as well as for any damage to or loss of such items. Shipping information will be provided before the competition event.

Sustainability

As part of the U.S. Department of Energy's and National Renewable Energy Laboratory's cultures, renewable energy and sustainability go hand in hand. It is a common public perception as well. As a result, the competition is about renewable wind energy, and we expect that participants will embrace and showcase sustainability, where possible, during all aspects of the event (e.g., reducing waste in packaging for shipping, reusing packaging materials that were used in transporting items to the competition, and eliminating the use of nonrecyclable materials such as foam packing peanuts). In addition, we encourage team members to engage in common sustainable activities such as recycling paper and beverage containers. Team creativity to support this mission is encouraged.

Appendix I. Dispute Resolution

Disputes are a serious matter and will be treated as such. Disputes must:

- Be submitted to the competition operations manager by the student team lead
- Be submitted via personal message on Slack and be accompanied by an email or in-person notification
- Include a clear description of the action being protested, referencing the appropriate section of this rules document.

Once submitted, the competition operations manager will meet with the head rules judge and initiate an internal review of the dispute. Disputes will be discussed among at least three judges and/or competition organizers who will gather appropriate information through interviews or other means, and a final ruling will be issued. If it is concluded that the issue has a broader impact on the entire competition, the head rules official will consult with all necessary members of the U.S. Department of Energy/National Renewable Energy Laboratory organizing team to determine next steps.

If the head rules official makes a decision that may directly or indirectly affect the strategies of some or all of the teams, the decision will be recorded in the “Decisions on the Rules” section of the Slack channel (discussed further in Appendix L) within 24 hours. If the dispute is being handled during the competition event, an announcement at the next major address to teams (e.g., opening or closing remarks for the day, lunch) may be substituted for the Slack channel post.

In all cases, the head rules official has the final say in all disputes.

Appendix J. Communications and Contest Details

External Communications

Organizers will use the Collegiate Wind Competition website, energy.gov/cwc, to showcase the various elements of the competition, ongoing collegiate team engagement, and information about how to participate in future competitions. The website will feature important documents, such as this manual and [identity guidelines](#), that provide information about the competition itself and how the competition name, logo, and visual identity can be used.

Teams are expected to manage external communications.

Internal Communications

It is each team's responsibility to stay abreast of the latest competition communications from the organizers. Communication between the teams and the organizers occurs via one or more of the following:

- **The Slack channel.** Official communications suitable for viewing by all team members and organizers will be posted on the Slack message board. Instructions for joining the Slack channel will be provided by the National Renewable Energy Laboratory to the teams following each team's commitment to participate. Students should reference specific sections of this document when posting questions and search past threads to find out if their topic has already been addressed. When creating a new question, structure the question as a new thread within the appropriate channel.
- **The Box.com repository.** This tool is used by the organizers and teams to transfer large files such as competition products. Notification of or requests for file transfers are made via the Slack channel or email.
- **Virtual meetings.** Teams are strongly encouraged to participate in scheduled virtual meetings with the organizers. Invitations and instructions for participation in virtual meetings are provided by the competition operations manager via email until the Slack channel has been established, but provided via the Slack channel thereafter.
- **Meetings during the event.** Meetings will be held daily throughout the event.
- **Email.** For expediency and to protect confidentiality, organizers may choose to communicate with teams via team members' email addresses as listed in the Slack database; however, most official communications occur via the Slack channel.

Branding

Teams are encouraged to develop an online presence and branding platform for their team to showcase their work throughout the year. This platform may include web pages, social media, outreach material, and team T-shirts. Regular updates and engagement with school and external media are recommended, and efforts will be shared by National Renewable Energy Laboratory and U.S Department of Energy channels as allowed. The use of the competition logo or name as part of individual school/team branding and platform is covered by the [identity guidelines](#).

To get teams started, examples of good team branding and an engagement toolkit will be provided prior to the competition. All branding and social outreach should conform to the

aforementioned safety and conduct provisions and be of high quality for a national-scale industry event.

Teams are expected to set up a professional space in their booths to highlight their branding. This can include the turbine design, project development posters, team logo, and school information. The team booths are a chance to showcase all the work each team has put into their project over the course of the year, and are the best way to communicate their efforts to the industry, especially at the final industry networking event.

Confidentiality and Intellectual Property

There are portions of the competition that are decidedly open to the public for purposes of generating interest and providing general information. Team members should keep in mind that various media outlets may be present during the competition. Any information made known and/or discussed should be expected to receive widespread and uncontrolled dissemination. Teams should consider in advance what level of information regarding all aspects of their turbine and turbine design they desire to have publicly available versus information that provides a competitive advantage, is critical to their performance in the competition, or is of a proprietary nature and essential to potential future business endeavors.

Team members agree to the use of their names, likenesses, content, graphics, and photos in any communication materials issued by the organizers, event sponsors, and attending media.

Content, images (graphics and photos), and any publications in which the content and images appear may be viewed and made available to the general public via the websites of the U.S. Department of Energy, National Renewable Energy Laboratory, and event sponsors with unrestricted use.

The organizers and event sponsors will make all reasonable efforts to credit the sources of content and images. To ensure proper usage of and credit for images, teams should submit photos and graphics through the competition Box.com repository.

Judging and Scoring

Panels of judges are responsible for scoring team performance in each contest. The judges will have detailed expertise related to the content they are responsible for evaluating. Each panel will also include diverse backgrounds that allow the judges to evaluate performance from a variety of angles.

Competition organizers will ensure that, to the extent possible, judges will not:

- Have personal or financial interests in or be an employee, officer, director, or agent of any entity that is a registered participant in the competition
- Have a familial or financial relationship with an individual who is a registered participant
- Provide advice to teams, although they can provide clarification on the judging process
- Discuss team performance with other teams or their advisors.

Names of the selected judges will be announced prior to the 2023 Collegiate Wind Competition.

Judging Rubrics

Judges will use detailed scoring rubrics to evaluate team performance in each of the categories. These rubrics give all participants a clear idea of what they will be evaluated on in each contest.

Products submitted prior to the event will be thoroughly reviewed and evaluated by the judges. Each judge will complete a rubric independently as the team is competing or based on the review of submitted products. At the completion of each event segment, judges will discuss each team's performance before finalizing the rubrics. The team of judges will submit one unified rubric to the competition manager for scoring purposes.

Team Feedback

In an effort to provide as much feedback as possible, teams will receive copies of the scored rubrics, which will be provided after the competition. Teams will receive a short narrative derived from the judges' deliberations after each team's presentation. Teams will also receive copies of notes that judges have written on the individual rubric forms.

Appendix K. Alternative Competition Structure

In the event the in-person conference is cancelled, the following updates to the competition structure will go into effect and are listed in reference to their respective sections of the main document. Should there be extenuating circumstances for some but not all teams, a hybrid solution between a standard contest and what is described in this appendix will be developed and further communicated to the teams with as much advanced notice as feasible.

The following modifications are designed to accommodate the possibility that the competition may not occur in person. In that case, if any team is unable to complete any of the deliverables because of extenuating circumstances, please reach out to the organizers. The primary goal of the competition is to maximize learning, and the organizers will work with each team to determine what is possible.

Background

Competition requirements for the wind turbine will be updated to reflect an effective, **digital-only**, mechanical, electrical, and aerodynamic wind turbine design that is safe and reliable for testing in an on-site wind tunnel. (The turbine need not actually be tested but should be designed as if it were going to be and subcomponents built and tested to the best of the teams' abilities according to the milestones.)

Competition, Contests, Products, and Awards

All references to the in-person competition presentations and question-and-answer (Q&A) sessions will shift to virtual execution. There will be no in-person turbine testing or designing of a wind farm during the competition. The planned scores for those sections will not be part of the competition scoring.

Submission Deadlines

The virtual competition sessions will be held in May or June 2023, and specific dates will be selected based on team and judge availability. If any team is unable to make the available dates or complete the deliverables as outlined, they must reach out to the organizing team to work out an alternative.

The expected deliverables and the associated timeline will remain the same, except as shown in Table K-1.

Table K-1. Updated Submission Timelines

Product	Submission Deadline
PRIOR TO COMPETITION:	
Unchanged	
DURING COMPETITION:	
Project Development PowerPoint presentation (digital)	Presented on virtual meeting platform
Turbine design question-and-answer supporting materials (optional)	Presented on virtual meeting platform
Connection Creation PowerPoint presentation (digital)	Presented on virtual meeting platform

Awards

Awards will shift to include:

- **A first-place winner.** This is the team that earns the highest combined score (not including the Turbine Testing contest).
- **A second-place winner.** This is the team that earns the second-highest combined score (not including the Turbine Testing contest).
- **A third-place winner.** This is the team that earns the third-highest combined score (not including the Turbine Testing contest).
- **A Project Development contest winner.** This is the team that earns the highest combined score from all Project Development products.
- **A Turbine Digital Design contest winner.** This is the team that earns the highest combined score from the digital design and milestones.
- **A Connection Creation contest winner.** This is the team that earns the highest combined score from all industry and community engagement products.

Note: There will be no Turbine Testing contest, but there will still be an overall competition winner.

Final scores and rankings for the modified project development and design contests will be shared with all participants.

Turbine Digital Design Contest

The Turbine Design Contest will remain unchanged except that presentations will move to a virtual format. Presentation dates may change.

Midyear Project Milestones

All milestones and due dates will remain unchanged. They are designed to be conducted in an entirely remote learning environment, if necessary.

Private Q&A Session

The Q&A session will continue as planned, albeit in a virtual format.

Presenters should showcase their wind turbine prototype as it exists, if possible, and have the option to use PowerPoint slides or other visual aids to engage with the judges. Note that visual aids will not be scored but can be used, if necessary, to help clarify any questions the judges may have after reading the written report. See Appendix L for virtual presentation best practices and to ensure it will function as intended in advance of presentation time.

Turbine Testing Contest

This contest will become optional remote testing, and wind turbines will not be tested in the competition wind tunnel. Testing will not be scored. Teams are encouraged to test their turbines remotely, using their own facilities, and to document their testing in a short video and present their results via an informal, unscored, public-facing webinar to celebrate this year's student accomplishments. Participating teams will have the option to:

- Conduct remote turbine testing. Teams should attempt to replicate as many of the tasks per Section 3.5 as they can, including:
 - Power performance
 - Controllability
 - Safety
 - Durability.
- Use the data they collect from their work on the milestones as a start on the remote testing.
- Reach out to judges and organizers via Slack for advice on experimental design and instrumentation selection.
- Conduct testing at a time most convenient for members, taking into consideration schedules, when resources are available, and the required submission deadline.
- Document turbine testing results using photos, video, screenshots, and real-time data logging compiled into a single, edited video no longer than 5 minutes in length, detailing the:
 - Turbine components
 - Experimental setup and instrumentation
 - Testing procedures
 - Results.
- Optional: submit a bloopers reel, which does not count as part of the time limit, in a separate file(s).

Final submission deadline for the video will be provided during the transition to the virtual event but will be shortly before the event itself to balance time for teams to test with time for judges to review.

Teams who submit a video summary of their turbine testing results will have the option to present their video summary in an interactive, public-facing webinar session as part of the Collegiate Wind Competition. These virtual sessions are designed to foster deeper learning among participants through direct feedback from the judging panel on the performance of their wind turbine, as well as through interaction with other competitors and the public. Each webinar session will include:

- A review of the submitted video
- Questions from the judges about the team's testing approach as well as feedback on the execution of testing and results
- A brief Q&A with the team, judges, and audience.

Project Development Contest

The Project Development contest, initially structured as two parts, will now only include Part A. Requirements associated with Part B will be removed from the competition.

Poster requirements will be replaced by a PowerPoint presentation, which must be delivered on a virtual meeting platform. Each team must submit their written report and PowerPoint presentation digitally.

Connection Creation Contest

This contest will remain unchanged except that presentations will move to a virtual format. It has been designed to be completed in an entirely remote learning environment. Presentation dates may change.

Rubrics

The rubrics will remain unchanged except for removing the scoring of the Turbine Testing contest and designing a wind farm during the competition as part of the Project Development contest.

Logistics

The most up-to-date logistics information will be provided to the teams directly from competition organizers.

Event Schedule

The event schedule will be provided to participating teams once it has been finalized. Slots will be determined based on preferences provided by each team in a poll, and organizers will do their best to accommodate those preferences based on judge availability. These slots are not guaranteed. Assigned slots will include:

- A project development presentation
- A turbine digital design session and Q&A
- A remote testing review session
- A connection creation presentation
- A final awards ceremony.

Virtual Event Login

For teleconferencing best practices, all individuals participating in the virtual presentations should review Appendix L.

Any members of the team, including faculty advisors, and mentors are welcome to attend their team's presentation sessions and the final awards ceremony.

Virtual login information for private presentation sessions, access to the event app, and the awards ceremony will be provided closer to the assigned competition date.

Virtual Networking and Career Development

In lieu of attending an in person conference, upon request, organizers will set up virtual meet-and-greet activities and informational interviews with industry representatives for any interested students. If any team members are interested in this opportunity, connect with the organizing team to schedule a time prior to the assigned virtual presentation slot.

Organizers will also develop a video montage to feature each team's successes this year. We encourage everyone's involvement so we can highlight the wind energy experience gained, the breadth of students involved, and the continued dedication to learning in an unprecedented situation. This will be shared on available channels to wind energy professionals, where possible; students will be able to share it as well. It is designed to highlight the skills each team developed over the course of this academic year. More information on scheduling, best recording practices, and specific questions will be provided directly from organizers.

Dispute Resolution

Dispute resolution procedures are unchanged.

Communications and Contest Details

Meetings will no longer be held during the event at the start and end of each day.

Teams will have the opportunity to set up virtual meet-and-greets and informational interviews with industry experts by coordinating with competition organizers. Requests for these meetings must be submitted via the Slack channel or email at least 5 days prior to the virtual competition date selected.

Given the shift to a virtual competition, teams can sign up for individual virtual interviews with organizers so they will have the opportunity to share their story of how they continued working on the competition and what they learned during the competition year. Those interviews will be recorded and disseminated after the conclusion of the competition to share the teams' accomplishments with the industry.

Appendix L. Virtual Conference Participation Etiquette

The following best practices are highly recommended for remote participation in any event. Teams should:

- Be responsible for knowing their meeting point of contact and ensuring that connections and technology all work prior to their start time. Test the internet connection, audio and video capabilities, and ability to use the virtual meeting program before the presentation time. The organizers have built in transition time, but it is limited.
- Use a hard-wired internet connection (i.e., ethernet cord). Wi-Fi connections can be used but are not ideal because they are prone to more connection issues.
- Mute the audio connection (phone and/or computer) when the speaker is not intending to speak. The organizers will mute participants with excessive background noise.
- Ensure there is only one audio connection being used. Connect to audio via phone or computer, but not both. Connecting with two audio connections results in electrical feedback that is very uncomfortable for all involved.
- Feel encouraged, but not required, to use the team's webcam for presenting. Audio narration of slides is also acceptable.
- Ensure there is a clean background while streaming video (e.g., no inappropriate or offensive images in the background, or people walking around).
- Avoid window backdrops because of lighting.
- Be sure to dress and speak professionally during the presentation.
- Refrain from distracting behavior while sharing the video and/or audio, such as drinking or eating.