COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY COLLEGIATE WIND COMPETITION 2019

Revision 2: 1/4/2019

Preface

The U.S. Department of Energy Collegiate Wind Competition 2019 will be governed and adjudicated by this manual, which is intended to establish fair contest rules and requirements. In the 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.

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

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Revision History

This document is a revision of the original. Specific changes are detailed below.

Version 1: Original document issued 8/9/2018

Version 2: Issued 1/4/2019

- Specified exact deadlines for written reports, Section 3.3
- Section 5.1: Fixed errata, PCC is now located on student side of tunnel.
- Section 5.2: Provided submission email for task selection and default case if no selection is made by the deadline.
- Revised verbiage explaining how a stable power reading will be evaluated in the power curve performance task, Section 5.2.2.
- Appendix A: Revised description of safety task to make scoring algorithm clearer.
- Appendix B: Specified number of attendees allowed from each team
- Revised submission instructions for products due prior to competition in Appendix D by removing references to Dropbox and instead using Box.com.

1 Introduction

1.1 Background

According to the U.S. Department of Energy's (DOE's) *Wind Vision* report, wind energy could supply 10% of the nation's electricity needs by 2020, 20% by 2030, and 35% by 2035.[1] As more wind energy is incorporated into the United States' power generation mix, qualified workers are needed to fill related jobs at all levels.

To help facilitate this process, DOE and the National Renewable Energy Laboratory (NREL) created the Collegiate Wind Competition in 2014 (hereafter referred to as the Collegiate Wind Competition or competition). The competition directly aligns with DOE's overall goals: to create and sustain American leadership in the transition to a global clean energy economy. Its vision is a strong and prosperous America powered by clean, affordable and secure energy.[2] Specifically, the competition's objective is to prepare students from multiple disciplines to enter the wind energy workforce by providing real-world technology experience. Positions in the workforce that require development include researchers, scientists, engineers, educators, project managers, business and sales forces, and many others. Wind-energy-specific advanced degrees are not required for many of these jobs, but having wind-related experience is considered to be highly valuable.[3]

Each year the competition identifies a new challenge and set of activities to address real world research questions, thus demonstrating skills students will need working in the wind or wider energy industry. The Collegiate Wind Competition 2019 challenge is to:

> **Research, design, and enhance a turbine for a grid scenario with a high contribution of renewables and be able to operate in an islanded mode.**

Specifically, competition participants will need to create:

- An effective mechanical, electrical, and aerodynamic wind turbine and load design that is safe and reliable for testing in an on-site wind tunnel.
- An electrical control system that can maintain a constant voltage into a competition-provided variable-resistance load during the durability portion of the turbine testing, utilizing a competition-provided storage element to balance source and load energy.
- A cost of energy analysis for the site plan developed in 2018.

The competition does not prescribe a power system market or wind regime.

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[1] Source: http://www.energy.gov/eere/wind/maps/wind-vision; accessed 7/27/18.
[2] Source: https://energy.gov/eere/about-us/mission; accessed 7/21/17
[3] Source: Leventhal, M. and Tegen, S. A National Skills Assessment of the U.S. Wind Industry in 2012. NREL Technical Report TP-7A30-57512. June 2013.

1.2 Roles and Responsibilities

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

Table 1. Roles and Responsibilities

Role	Individual(s) Assigned	Definition
Collegiate Team	Multiple	Collegiate teams execute the will of their team members, principal investigator (PI), and co-principal investigators within the rules and requirements of the competition. Teams consist of 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.
Collegiate Team Lead Principal Investigator	One per team	Serves as the lead faculty member and primary representative of a participating school in the project. This person also provides guidance to the team throughout the project and ensures that the student team leader disseminates information received from the competition organizers. The PI teaches, advises, and coaches the students on the skills necessary to compete in the various aspects of the competition. Some teams may specify multiple PIs who are contacts for the team, but in this case, one person should be identified as the lead.
Collegiate Team Student Leader	One per team	Attends informational sessions with the PI, 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 Google Group that is discussed later in this manual) during the event.
Collegiate Team Co-Principal Investigator(s) or Supporting Faculty	Multiple	Supports the PI in the above duties but typically does not directly engage with DOE/NREL Collegiate Wind Competition staff.
Competition Manager	Amber Passmore, DOE	Represents the U.S. Department of Energy and has the final decision-making authority in all aspects of the competition.

Role	Individual(s) Assigned	Definition
Competition Operations Manager	Elise DeGeorge, NREL	Leads correspondence with the collegiate teams regarding contracts, 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 head rules official. Reports to the competition manager.
Operations Coordinator	Bethany Straw, NREL	Coordinates competition logistics including registration, lodging, overall event schedule, individual team schedules, and related topics. Key point of contact for questions related to engagement with the judges, individual competition contests, and protocol. Leads correspondence with teams regarding contest questions and event feedback. Supports collegiate teams, judges, head rules official, and operations manager.
Competition Safety Point of Contact	Ian Baring-Gould, NREL	Point of contact for questions or issues related to safety.
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 as to the wording or intent of these rules, the decision of the rules panel shall prevail.
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 of whether a turbine can be tested or not in the tunnel due to safety concerns.
Communications and Outreach Point of Contact	Mim Mirsky	Coordinates all aspects of media representation, website management, publications, signage, and outreach.
Core Competition Staff	NREL KidWind	Performs 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.

1.3 Safety and Conduct

The 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 be a fun learning experience and a professional growth opportunity. Each team is responsible for the safety of its operations in accordance with the subcontract agreement. Each team member shall work in a safe manner at all times 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 (see NREL/university subcontract, Appendix B Clause 8: Worker Safety and Health Requirements, for more information). Organizers may issue a stop work order at any time during the project if a hazardous condition is identified.

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 for use during wind tunnel testing and other potentially hazardous activities at the competition:

- Safety glasses (student provided)
- Hard hats[4] (competition provided)
- Steel-toe boots if expecting to handle heavy loads[5] (student provided)
- Electrical personal protective equipment if electrical voltage demands it (student provided)
- Hearing protection for use in areas that are in close proximity to the wind tunnel during operation. (student provided)

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.

As part of DOE's and NREL's culture, 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, re-using packaging materials that were used in transporting items to the competition, and eliminating the use of non-recyclable 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.

[4] The number of teams members working with the turbine will be restriced within the cordoned area in front of the tunnel for testing. Spectators are encouraged outside the PPE boundary.

[5] Teams should use their judgement 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.

1.4 Dispute Resolution

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

- Be submitted to the competition operations manager by the collegiate team PI.
- Be submitted via email and be accompanied by an in person notification of the email
- 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 amongst 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 DOE/NREL 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 Google Group site (discussed further in Appendix C) within 24 hours. If the dispute is being handled during the competition event, an announcement at the next major address to teams (opening or closing remarks for the day, lunch, and so on) may be substituted for the Google Group post.

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

2 Competition, Contests, Products, and Awards

The Collegiate Wind Competition 2019 consists of all of the aspects and activities leading up to, during, and following the event. It includes the subcontract project agreement between the competitively selected collegiate teams and NREL, as well as the contests, products, and event.

At the event, teams compete in three contests; technical design, turbine testing, and siting and project development. Products receive points toward winning a contest. An overview of which product contributes to the scoring of each of the contests is in Table 2. How many points a product contributes to the overall score is covered in Appendix A.

Table 2. Contests and Products Overview

Competition Contests	Technical Report and Q&A	Siting and Project Development: Report, Presentation & Posters	Turbine and Load
Technical Design	✓	-	-
Turbine Testing	-	-	✓
Siting and Project Development	-	✓	-

This manual is arranged by contest. For all contests, products include two written reports, one on-site oral presentation, a siting and project development poster, and a wind turbine and load combination for testing in an on-site wind tunnel. Teams will also meet with the design judges during the event (see 4.2), however there is no distinct associated deliverable. This session is meant only to provide additional feedback to students and final clarification prior to finalization of technical report scores.

While teams work on these products, principal investigators, co-principal investigators, 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 fatal flaws, prove technical rigor, or demonstrate certification of concept. Teams are highly encouraged to pursue mentorships and sponsorships early in the course of the competition as it will provide immense benefit to the learning and overall competition experience. However, only student team members may take an active role in any competition event.

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

- Overall 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.
- Siting and project development winner—the team that earns the highest combined score from all siting and project development products.

- Technical design contest winner—the team that earns the highest combined score from all technical design products.
- Turbine testing contest winner—the team that earns the highest combined score from all of the turbine tasks.

3 Overview of Products

This section gives an overview of when products should be delivered. The competition will run from Monday, May 6th through Thursday, May 9th, 2019. Refer to each product section and Appendix C for format requirements, and submission instructions. Information on scoring and penalties can be found in Appendix A.

3.1 Products in Advance of Competition Event

The written reports must be completed and digitally submitted according to the deadlines below, so that the judges can review them prior to arriving on-site. See Appendix C for information on submission.

3.2 Products at the Competition Event

The printed poster(s) and PowerPoint (if used) must be submitted upon check in at the event. The test turbine and load must be formally presented during the safety and technical inspection prior to testing at the event. See Appendix D for a draft version of the sheet that will be used for this inspection.

3.3 Overview of Product Deadlines

Product	**Submission Deadline**
Siting and project development report	Sunday 4/21/19, 11:59pm MT
Technical design report	Sunday 4/21/19, 11:59pm MT
Siting and project development poster (printed)	Upon check in
Q&A supporting presentation (optional)	Upon check in
Test turbine	During safety inspection
Load system	During safety inspection

4 Turbine Design Contest

For the turbine design contest, there is one formal deliverable: a written report. Teams must also be prepared to participate in a brief Q&A session focusing on the turbine design report, as described in the section below, but there is no formal deliverable for that session.

4.1 Technical Design Written Report

The technical design report explains the turbine concept development process from an engineering perspective. The design report should detail the complete design process as it relates to the turbine being tested in the competition wind tunnel. Teams should provide detail that is adequate enough 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:

- A description of the design objective and how the design components support this objective.
- A basic static performance analysis (e.g., C_P-Lambda Report) of the turbine design that contains the annual energy production over a range of operational parameters.
- An analysis of the expected mechanical loads and associated safety factors within the design.
- A description and analysis of the turbine's yaw system (if included)
- An electrical analysis comprised of the generator model, power electronics (e.g., canonical model), electrical load model, and operating voltage including how the team plans to regulate voltage into the load during the durability task.
- A control model analysis of the operational modes (i.e., the control states diagram and a description of primary operational modes) including any associated systems used to balance energy from the turbine and the storage element during the durability task.
- Documentation of associated software (e.g., control and/or logging) and its development including any specific elements related to the storage element.
- Results of laboratory and/or field testing of turbine prototypes.
- Engineering diagrams with at least a basic mechanical drawing of all components and an electrical one-line diagram.

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

- **Cover sheet -** Teams should begin the report with a 1-page cover sheet that includes their affiliation and contact information. 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.

- **Table of contents**
- **Executive summary** - The executive summary discusses components from all sections of the report and includes a short description of the team project. Teams should use their judgement

when deciding how long to make the executive summary, however, one page is often sufficient.

- **Technical design**

The technical design report should not exceed 20 pages in length including cover, table of contents and appendices. Pages submitted beyond this limit will not be reviewed. References are not required to fit within the page limit.

Scoring criteria for the written report is provided in Appendix A. Report formatting requirements are provided in Appendix C. At the conclusion of the competition, team reports will be posted to the competition website for reference during future events.

4.2 Private Q&A Session

In addition to the written report, each team will spend 20 minutes with a panel of judges to answer any remaining questions that the judges may have from their review of the written report. This question and answer period should begin with a brief overview which conveys the most important details of the technical design, clearly communicating the team's intended application and overall approach.

Presenters should showcase their 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. Project overviews are limited to 5 minutes, which will be followed by 15 minutes of questioning from the competition judges. Additional attendees are allowed in the feedback session at the discretion of the students and their PI.

The scoring criteria for this project overview and question and answers period is included within the design contest written report rubric as shown in Appendix A.

5 Test Turbine Design and Evaluation

Each turbine prototype must be designed for testing inside the Collegiate Wind Competition wind tunnels, further designated as the “tunnel(s)” or “wind tunnel(s).” The basic wind tunnel configuration is shown in Figure 1. Relevant interfaces to the tunnel are described in Section 5.1. The dimensions of the test chamber are 122 cm x 122 cm x 244 cm. There are inlet and outlet components of the wind tunnel that extend beyond the test chamber. The tunnel has a “draw down” configuration. That is, the air is “sucked through” the test section—entering at the left, exiting at the right—with the draw down 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 composed of wire mesh to prevent turbine pieces from getting sucked into the fan unit.

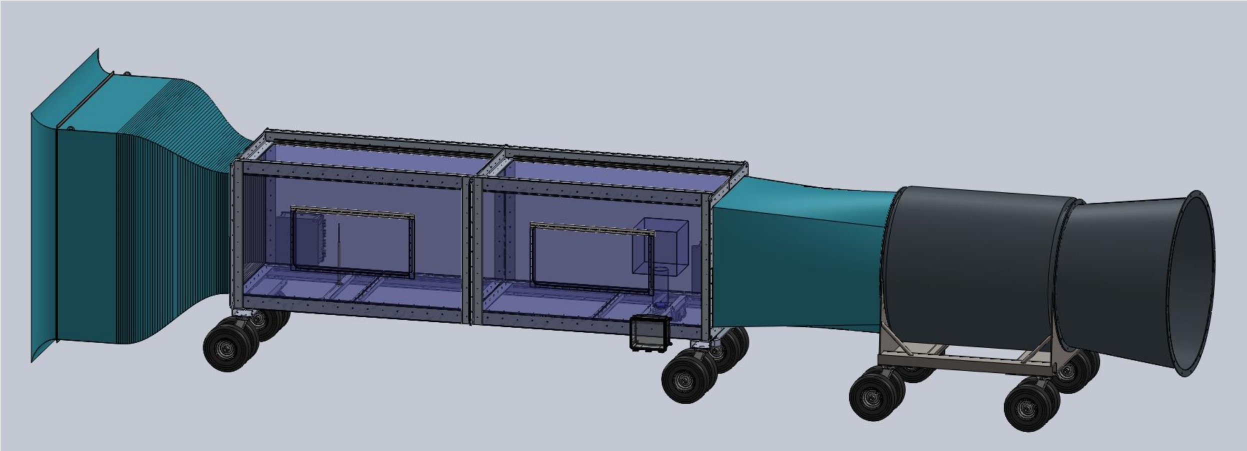

Figure 1. Collegiate Wind Competition wind tunnel basic configuration

Teams are expected to choose their own generator and design their own turbine and load system. This load system will be used for all tasks except durability, in which a competition-provided load will be used. Off-the-shelf components may be used, but the turbine and load system should be designed and built by the teams. Both components must meet safety requirements including, but not limited to, proper wiring practices, shielding of hazardous components, and proper heat rejection. A safety inspection of the wind turbine and load system will be performed by the competition staff and must be passed before the wind turbine and load system are installed in the wind tunnel. Appendix D contains a draft version of the safety and inspection sheet used to evaluate the turbines. The turbine safety official will make the final and official determination about whether a turbine may be tested in the wind tunnel.

5.1 Turbine and Load Design Requirements

For the testing contest:

- The turbine must be designed to withstand continuous winds of up to 20 m/s.
- The tunnel base flange, where the turbine is mounted, will be subjected to yaw rates of up to 180° per second with a maximum of two full rotations from the initially installed position.

- At zero yaw angle, the entire turbine must fit within the volume specified below and shown in Figure 2.

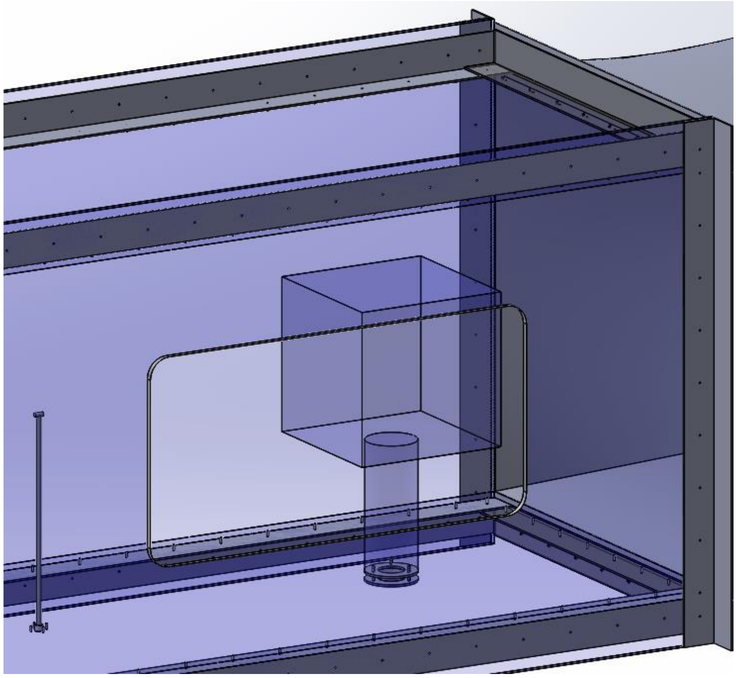

Figure 2. Allowable turbine volume

  - Rotor and nonrotor turbine parts must be contained in a 45 cm by 45 cm by 45 cm cube centered horizontally on the flange axis with its horizontal midplane located 60 cm ± 3 cm above the mounting flange top plane.
  - A 15-cm diameter cylinder around the vertical centerline of the mounting flange extending from the tunnel floor to the bottom of the cube can contain only nonrotor turbine parts. For this purpose, nonrotor turbine parts will be defined as anything that does not capture energy from the moving air.
  - Other electronic components may also be located outside the tunnel. Within practical limits, there is no size restriction for these components. These components must be incorporated into closed enclosures that are fire safe and meet or exceed a NEMA type 1 rating. All components must be electrically insulated from the enclosures. Teams should also pay careful attention to the standards for ventilation of these enclosures. It is important that the intent of the NEMA 1 rating be preserved even once all connectors and/or pass-through devices are installed.
  - NEMA 1 Characteristics: Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt). Note that tape will not be considered adequate sealing of penetrations 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 have

connectors. Neither screw terminals nor spade or fork type lugs are considered acceptable connectors. Individual strands or bare wires will result in disqualification for testing until remedied. Two or more individual strands twisted together is permissible as long as the resulting multi-strand cable has a connector on the end. Multi-strand cables are encouraged, used in a logical way. For example, one cable for all power wires and one cable for all control wires, each with its own quick-attach connector would be considered good practice. Ideally, teams should be able to connect all their cables in a few seconds.

  - All turbines must fit through the turbine door (61 cm by 122 cm) in one assembly with no additional assembly occurring inside the tunnel other than attachment to the base flange and connection to external electrical components.

- The wind turbine system must be mountable on the test stand at the specified location within the wind tunnel:
  - 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 with nuts. Figure 3 shows the bolt pattern and sizing of this flange.
  - The tunnel base flange incorporates a turntable to generate yawed flow. Figure 3 details 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 when torqued to approximately 50 Newton-meters.

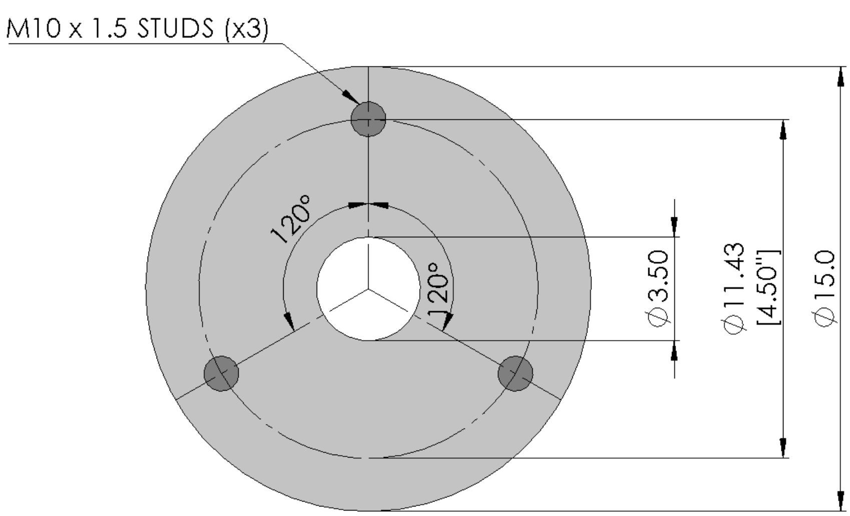

Figure 3. Base flange dimensions for turbine attachment to tunnel (dimensions in cm)

The turbine base plate will 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 kΩ or lower resistance connection.

- Wires should exit the tunnel at the turbine base through the center of the turntable. From this point, each team must provide a length of wire approximately 1 meter in length to reach the point of common coupling (PCC) on the student side of the tunnel, where they will join with the load connectors from either of the two loading systems. The competition instrumentation will be inserted at this point (Figure 4). A table will be provided to display the load on the opposite side of the tunnel from the judges and the PCC. Teams should provide adequate lengths of wire to run from the PCC to the load to accommodate their desired load display arrangement on the table.

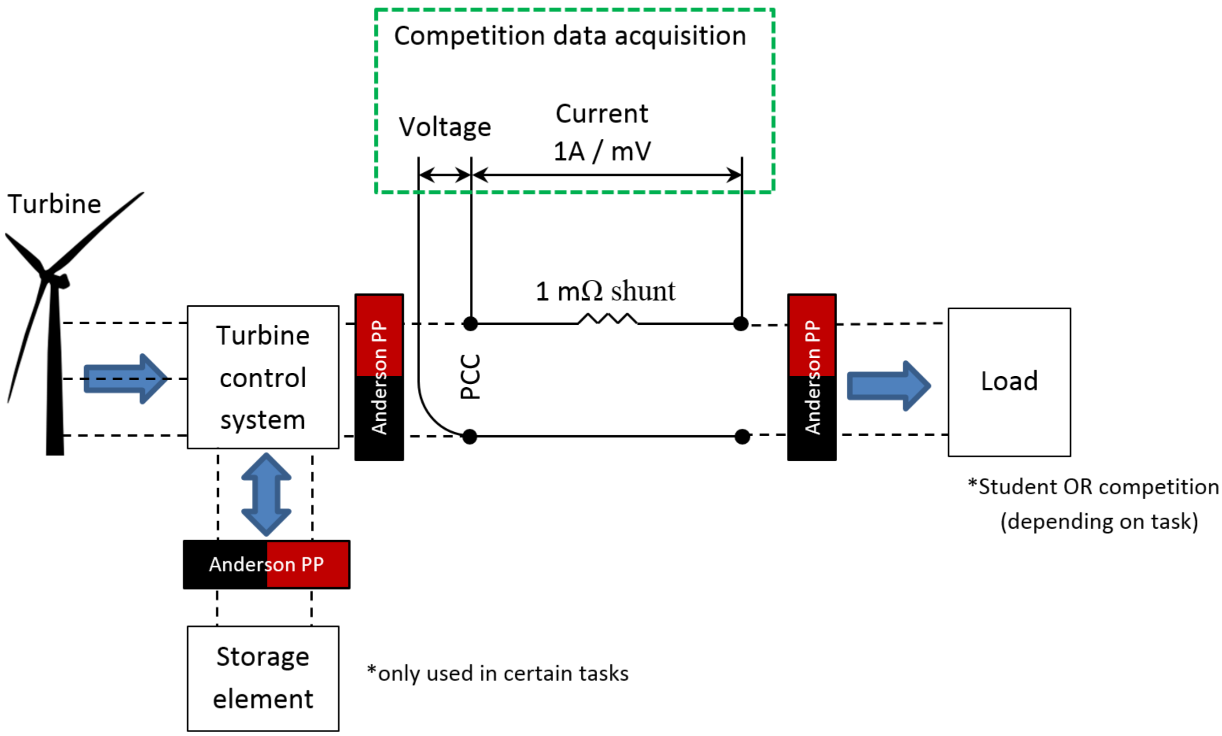

Figure 4. Load, turbine, storage element, and point of common coupling arrangement

- Voltage must be direct current (DC) at the PCC and is required to be at or below 48 volts at all times. Exceeding this voltage limit 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 re-test if available.
- Energy storage elements, such as capacitors and/or inductors, may be used in both the turbine and the load but not for bulk energy storage on the turbine side of the PCC.
    - Additionally, for the turbine side of the PCC:

    - No batteries of any type or excessively large capacitors[6] will be permitted, except for the storage element provided by the competition organizers.
    - Turbine components may draw from the load but must register a zero state of charge at the beginning of the test.
    - Verification of zero energy at the start of the test will be accomplished by the use of 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 through the use of a multimeter or similar device before the testing begins.
    - Teams must show that all components utilized to control the turbine reside on the turbine side of the PCC. During the safety inspection, students must adequately demonstrate to the judges through verbal explanation, wiring diagrams, software architecture, and similar tools that the load is not controlling the turbine.
    - Wired connections between the turbine and load external of the PCC are allowed, but must be optically isolated. Teams must show that any connection external of the PCC, either wired or wireless, is being used for monitoring or logging only—not active command and control.
  - For the load side of the PCC:
    - Bulk energy storage is allowed, provided it is utilized in a safe and reliable manner.
    - To run the load, 120 VAC will be provided, if desired.
- The storage element, provided by the judges, is detailed in Figure 5. It consists of a Maxwell Technologies' 16-V small cell ultracapacitor module (Manuf. P/N: BMOD0058 E016 B02). If a team exceeds the 16V rating of this module as measured by the competition data acquisition system, the tunnel controls will immediately disconnect it from the PCC.

Figure 5. Competition-provided ultracapacitor storage element

[6] No single capacitor (or electrical combination thereof) can have a storage capability of greater than 10 Joule, calculated as $\frac{1}{2}CV^2$, where C is capacitance in farads and V is the rated voltage of the capacitor.

- A fuse (Manuf. P/N: Bussmann ABC-30-R) will be placed in series with the capacitor to protect it.

- The competition will provide a variable-resistance load to be used during the durability portion of the test.
- To interface with the PCC, the competition load, and the storage element, wires should be terminated with Anderson Powerpole connectors, PP15-45 (a red and a black, for positive and negative, respectively). See Figure 6 for correct polarity. Incorrect polarity must be corrected before testing. Teams are expected to provide their own Powerpole connectors of appropriate size: 15A, 30 A, or 45 A, which are specified to handle wire gauges from 10 American wire gauge (AWG) through 20 AWG. Each team can choose the wire size it wants to use in this range as long as the appropriate current-carrying capacities are taken into consideration. All three pin sizes fit into the same housing (PP15-45), as stated above.

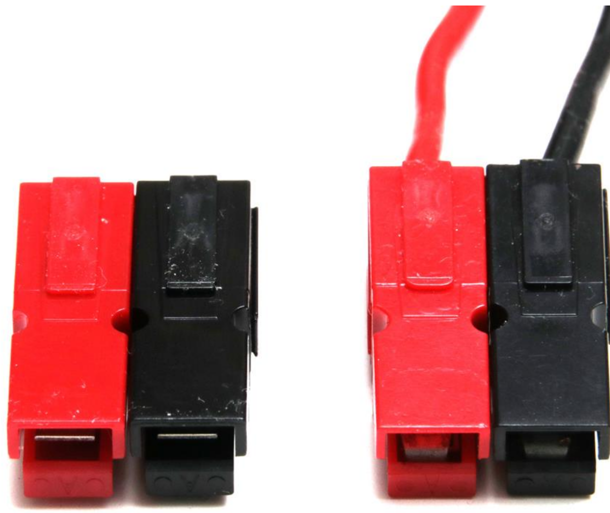

Figure 6. Proper Anderson Powerpole polarity to match tunnel wiring

- Turbines must be capable of shutting down on command as well as when electrically disconnected from the load. During the contest:
  - The judges will initiate an electrical shutdown by signaling the students to disconnect the load connection to the PCC.
  - Manual shutdown will be triggered by a competition-provided, normally closed switch that is typical of industrial emergency stop circuits and will be located outside the tunnel. Judges will initiate a manual shutdown by signaling the students to depress the switch, causing the circuit to open. To connect to this circuit:
    - Each team must provide a cable containing two wires (22–28 AWG) that is at least 2 meters in length from the tunnel base flange to reach this switch. 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 7.[7]

Figure 7. 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 8.[7]

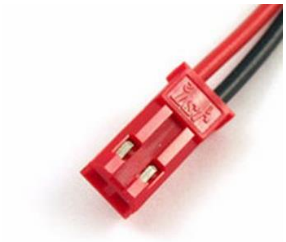

Figure 8. Competition-provided connector for manual shutdown interface

5.2 Testing Procedure

The turbine-testing contest consists of a number of 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, turbine-rated rpm and power control, cut-in wind speed, turbine durability over a range of wind speeds and yaw positions, and turbine safety. Students will use their load for all tasks except durability, wherein a competition-provided load and storage element, described in Section 5.1, will be used.

The teams will be able to choose if they want to design to accomplish all the tasks or a reduced set. The control tasks (section 5.2.4) are optional as is the durability task (section 5.2.5). Teams

[7] Note: in the remote-control aircraft community, these connector pairs are commonly referred to as "JST BEC" connectors and are available from a variety of sources, including Digi-Key.

that are newer to the competition, teams with fewer returning members and teams who are feeling behind schedule by the last day in March are strongly encouraged to focus on fewer tasks by foregoing one or both of these optional tasks. Eliminating control of rated rpm and power will reduce the need for turbine control hardware and software. Eliminating durability will alleviate the need for the turbine to accept yaw motion and to interface with the competition provided load and capacitor. This reduction in complexity could substantially reduce some of the burden on the engineering teams at the cost of some potential points. By 11:59 PM, Mountain Time on March 31, 2019, teams will have to formally commit to which tasks they will attempt to accomplish during the competition by communicating with the competition organizers via email to Jason.Roadman@NREL.gov. Teams may make a task selection as early as they want and change their selection up to the deadline if needed. However, if no selection is received from the team by the deadline, a default selection of attempting all tasks will be assigned. No changes in selection will be allowed after the deadline.

All teams will follow the same prescribed schedule for testing in the wind tunnel as described in Section 5.2.6, except if one or both optional tasks are not chosen. Only one team's turbine will be tested at a time. Teams are limited to 10 members (students and PIs) within the testing area. More can act as spectators. Each team will have 35 minutes of tunnel time to install the turbine, commission it, test it, and uninstall. Teams will be provided with a period of "commissioning time" prior to the scoring tasks starting during which the teams may ask for any wind speed from 5 m/s to 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 as the complete series of testing tasks are expected to require upwards of 20 minutes to complete, depending on how fast the turbine stabilizes at certain 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 turbines or controls during the following phases of testing: commissioning, to manually restart their turbine if they fail to restart after a safety shutdown task, and at the start of the durability task. Turbine failure is defined as anything out of the ordinary such as cracking, breaking, pieces falling off, 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 turbine for any reason, team members 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.

Students are encouraged to bring spare components and/or assemblies and to 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, turbine 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 particular situation with the organizers well ahead of the competition to ensure they are adhering to this requirement.

5.2.1 Cut-In Wind Speed Task

Cut-in wind speed—the lowest wind speed at which a turbine produces power—is one of the characteristics that can differentiate one turbine as being better suited to lower wind-speed regimes than others. Lower wind speed is generally deemed more desirable in the small turbine market.

In this task, each turbine will be subjected to slowly increasing wind speeds, from 2.5 m/s to 5 m/s, to determine the cut-in wind speed. For this task, “producing power” is defined as achieving a positive current average over a 5-s interval at a steady wind speed.

5.2.2 Power Curve Performance Task

The objective of this task is to test each 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 maximum duration of 60 seconds (s) or less, with the stated intent of obtaining a “stable” power reading, which is defined as stable in rpm and power per electronic testing devices during the test period. As power output may fluctuate, for purposes of this task, the allowable power outputs to be included in the maximum average power (per electronic testing devices) during any 5-s interval will be defined as +/-10% of the maximum average power. **New for 2019, this stability criterion will also take into account any noise the competition data acquisition system measures up to 100Hz. Teams should ensure that any noise at a frequency higher than 100 Hz is adequately filtered out to prevent aliasing by the data acquisition system and ensure that the combination of power variation and measured noise is within the specified tolerance.** One way to reduce noise is to implement an LC filter on the power output lines to filter noise coming from the switching of the power electronics.

5.2.3 Safety Task

Safety is of utmost importance to 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 5.1. 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 wind speed specified in Section 5.1. For each turbine, the shutdown process will be initiated once “on command” and separately by disconnecting the load from the PCC. It is important that the load is disconnected from the PCC and not the turbine as to ensure that the competition data acquisition system can continue to monitor the open circuit voltage of the wind turbine. The turbine must also be capable of restarting 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 rpm achieved during the 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.

5.2.4 Control of Rated Power and Rotor Speed Task (Optional)

Wind turbines have to withstand high winds without damage to 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.

In this task, each turbine will be subjected to two wind speed bins chosen by the organizers between 12 m/s and 20 m/s and turbine performance in those two bins will be compared to the performance in the 11m/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.

5.2.5 Durability Task (Optional)

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 and direction function. Speeds will never be less than 6 m/s or greater than the maximum continuous wind speed specified in Section 5.1 over a 5-minute test period. Yawed flow will be achieved using the tunnel's turntable governed by the limits set in Section 5.1. This test helps verify that the turbine can function over a wide range of operating conditions.

The scoring for this task will be based on the turbine system's ability to maintain a constant 5 V output into a competition-provided variable-resistance load, using the output from the turbine and the storage capacity of the competition-provided storage element, described in Section 5.1. Maximum load demand will be 40W. The storage element will start at a discharged state. The first minute of wind will be provided so that energy can be stored in the storage element. No yaw motion or load will be used during this minute, and no score will be generated. After the end of the first minute, 2 minutes of variable wind and variable load with no yaw will be scored. The fourth and fifth minutes will be similar to the previous 2 minutes but with yaw motion added.

To summarize:

- Minute 1: no load, no yaw, no scoring, allowing time to charge the storage element.
- Minutes 2 and 3: variable load, no yaw, scores generated, charge and discharge the storage element as needed.

- Minutes 4 and 5: variable load, yaw motion, scores generated, charge and discharge the storage element as needed.

5.2.6 Prescribed Testing Task Order

Turbines tasks will be tested in the following order. While the prescribed order will be the same for each team, the exact amount of time at each setpoint 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. Prior to durability, the turbine, load, and associated software should be designed to react to any situation given in any order, just like a commercial turbine must be able to do when deployed in the field.

1. Cut-in Wind Speed Task
2. Power Curve Performance Task
3. Control of Rated Power and Rotor Speed Task (Optional)
4. Safety Task
5. Durability Task (Optional)

Teams should note the following with respect to the initiation of the durability task and the load changeover.

- After the final safety task, teams will have a chance to "work on their electronics to manually restart their turbine" per Section 5.2.3. Wind will remain on during this restart attempt.
- The wind will be turned off and the turbine allowed to come to a stop.
- The judges will plug in the capacitive storage element at 0 VDC and the competition provided load connections will be switched out with the student load at the PCC. However, due to the nature of the competition load design, it will appear as open circuit at the PCC during the charging portion of the task. Students will be allowed to touch their electronics outside the tunnel to reconfigure the controller if necessary prior to the start of the durability task. Teams are reminded that any time spent reconfiguring will still count toward the total allotted testing time.
- The 5 minute timer for the durability task period will start and the wind will immediately ramp to 6 m/s and remain at or above 6 m/s for the remainder of the task. Rest assured there will be adequate energy in the wind profile during this first 60 second charging period that teams with a moderate Cp value will be able to sufficiently charge the capacitor.
- The remainder of the task will proceed as described in Section 5.2.5. At the start of the second minute, the competition provided load will switch from open circuit to variable resistance.

6 Siting and Project Development Contest

The siting and project development contest is a yearlong effort to investigate key aspects of wind farm siting and project development activities. The output of these efforts will include a written report delivered prior to competition and a presentation at competition with two posters as visual aids. These deliverables are described in further detail below.

6.1 Financial Analysis

Last year, your team investigated your local area and developed a detailed site plan. This year you will continue evaluating your site from last year by completing a thorough 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:

- **Financing.** Some elements the team should consider include: construction financing, financing fees, return on debt and equity, depreciation, income tax, property tax and insurance.
- **Initial capital cost.** This covers the wind project balance of station. Costs may include foundations, control/electrical hardware, site preparation, electric collection system and transmission lines, substation, windfarm control and monitoring equipment, O&M facilities and equipment, shipping, resource assessment, surveying, legal counsel, project management, permits, construction insurance, engineering services, etc.
- **Net annual energy production.**
- **Annual operating expenses**. Key cost categories here include land lease costs, levelized O&M costs and levelized replacement/overhaul costs.
- **Incentives.**

Other items the team may wish to balance include: triple bottom line opportunities (social, environmental, financial), restoring the site at the end of the project life, asset disposal/recycling or other.

If an economically viable project is not feasible at this time discuss economic developments (e.g. incentives, novel financing mechanisms, market changes, PPA pricing) and/or technology developments that would be required to make the project viable.

6.2 Prior work (for reference only): Research and Develop a Plan for a 100-MW Wind Farm in the Team's Home Region

As a reminder, last year you were asked to conduct a regional assessment of wind farm development opportunities within your region and create a rough development plan. **This effort does not need to be repeated again this year.** The challenge was as follows:

1. Select the top three development sites within 100 miles of the team's school.
    a. This site cannot be offshore nor can it be an existing land-based site.

   b. Be prepared to explain how these sites were chosen. Some considerations may include wind resource, terrain, landowners, vegetation, access to transmission, transportation access, environmental, and community factors.
2. Choose one of the three proposed sites and develop a preliminary wind farm design.
   a. Draft preliminary design:
      i. Choose turbine type, hub height, rotor diameter, number of turbines.
      ii. Define project boundary
   b. Conduct a site visit:
      i. Record observations about terrain, vegetation, wildlife, and so on.
   c. Permitting:
      i. Research local ordinances.
      ii. Research sensitive species in the area, sensitive ecosystems, impacts to wildlife, and mitigation processes that have been successfully implemented in the past.
3. Finalize detailed design of the site plan.
   a. Collect wind resource information, contour data, roughness, and so on.
   b. Pick turbine locations.
   c. Plan site access roads.
   d. Plan transmission to nearest substation.
   e. Plan land leases.

4. Conduct community education and outreach, which should include one of the following:
   a. Pitch project to planning and zoning commission, **or**
   b. Interview a county commissioner or planning board member, **and** present at a:
      i. Town hall meeting.
      ii. Public open house.
      iii. Lions or rotary club.

   For this exercise, be sure to emphasize that this is a project for a collegiate competition and there will be no real wind development so there is no confusion for the audience or unwanted feedback.

6.3 Deliverables

6.3.1 Written Report

The siting and 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 siting and project development investigation. At a minimum, the report must include the following sections:

- **Cover sheet**. Teams should begin the report with a 1-page cover sheet that includes their affiliation and contact information. Indicate the team roles/hierarchy and approximately how many students, faculty, and others (e.g., sponsors, volunteers, and family members) were involved in the project.

- **Brief site description**. This year the focus is the financial analysis, however teams should provide an overview of the 2018 site design to provide context for the financial analysis.
- **Design changes**. Explanation of any design changes from the 2018 plan and a brief justification for the change or why the site remained unchanged.
- **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 outlining the project's potential through cash flow analysis. Full pro formas are not required, however, it is recommended that higher level, more long-term, summaries be included to communicate the attractiveness of the project for investment.

The report should be no more than 10 pages in length including cover, table of contents and appendices. Pages submitted beyond this limit will not be reviewed. References are not required to fit within the page limit.

Scoring criteria for the written report is provided in Appendix A. Report formatting requirements are provided in Appendix C. At the conclusion of the competition, team reports will be posted to the competition website for reference during future events.

6.3.2 Presentation and Posters

Each team must submit their posters digitally, upon checking in at competition. Printed posters should match the digital version provided.

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 written report however, the report and posters would ideally be complementary rather than redundant. The presentation should touch on the site design but focus primarily on the financial analysis.

The teams will have 15 minutes to present their project with 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 by 4 feet. Teams are expected to have their posters on display at their team booth for the duration of the competition.

The scoring criteria is provided in Appendix A. At the conclusion of the competition, team posters will be posted to the competition website for reference during future events.

Glossary

Team booth	Each team is provided an assigned area, known as a team booth, to use as a central location throughout the competition to work on their turbines, prepare for various contests, regroup, and showcase their hard work throughout the year to the public.
Competition	The competition is all aspects and activities leading up to, through, 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 consists of several contests with multiple products.
Event	The event is when and where the teams compete in the contests.
Products	Products are what the team builds, writes, submits, and brings to compete in the competition.
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.
Task	Each individual achievement goal of the test turbine that will be scored during the wind tunnel testing period.

Appendix A. Rubrics

Products

Table A-1. Scoring Summary for the Competition Products (1,000 Points Total)

Competition Contests	Total Scores	Technical Report and Q&A (250)	Project Development: Report, Presentation & Posters (350)	Turbine and Load (400)
Technical Design	250	250	-	-
Turbine Testing	400	-	-	400
Project Development	350	-	350	-

Technical Design Written Report

Table A-2. Scoring Rubric for the Written Report (250 Points Total)*, **

Description	Possible Points	Score
Technical Design (250 points)		
Concise, readable and descriptive with logical flow.	20	
Presents and communicates technical information clearly, intelligently	20	
Design objective description for test turbine	25	
Static performance analysis	25	
Mechanical loads analysis and associated safety factors (including yaw system if present)	25	
Electrical analysis (including both loads and storage element)	25	
Controls analysis (including storage element)	25	
Software documentation and description (including storage element if app.)	25	
Results from laboratory and/or field testing	30	
Engineering diagrams including mechanical and electrical drawings	30	
	Total	

*** 5% of total allowable points, distributed evenly across each contest section, will be deducted for each day the report is late.**

****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 C that are deemed to be utilizing more than the allotted space will be penalized at the discretion of the judges proportional to the infraction. Furthermore, extra pages will be ignored.**

Siting and Project Development

Table A-3. Siting Project Development Contest Rubric (350 Points Total)

Description	Possible Points	Score
Quality of Deliverables (100 points)		
Written report: concise, readable and descriptive with logical flow.	25	
Written report: communicates technical information clearly	35	
Presentation: professional, clear project pitch and presentation of financial analysis	25	
Posters: well designed, illustrative, appropriate use of text and graphics	15	
	Subtotal	
Analysis (250 points)		
Creativity and bankability of financial plan and evaluation of alternatives.	80	
Risk assessment: evaluation of project risks and mitigation strategies.	60	
Understanding of market opportunity and constraints.	30	
Discussion of 2018 site plan and justification for choice to modify or not.	30	
Depth and thoroughness of balance of station elements and annual operational costs	50	
	Subtotal	
	Total	

*** 5% of total allowable points, distributed evenly across each contest section, will be deducted for each day the report is late.**

****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 C that are deemed to be utilizing more than the allotted space will be penalized at the discretion of the judges proportional to the infraction. Furthermore, extra pages will be ignored.**

Turbine Performance Testing

Table A-4. Scoring Rubric for Turbine Performance Testing (400 Points Total)

Description	Possible Points	Score
Cut-in wind speed task (10 points for each half m/s bin below 5 m/s)	50	
Power curve performance task (Table A-5)	100	
Control of rated power – Optional task A (Figure A-1)	25	
Control of rated speed – Optional task A (Figure A-2)	25	
Safety task (50 points for each task divided into 30 for shutdown and 20 for restart)	100	
Durability task – Optional task B (Figure A-3)	100	
	Total	

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

Cut-In Wind Speed Task

A team will earn ten points for each half m/s bin below 5 m/s, inclusive of the lower bound and exclusive of the upper bound in which they can produce power, as defined in the cut-in wind speed task description (Section 5.2.1), up to the maximum score of 50 points for this task. The team receives one score based on its cut-in wind speed.

Power Curve Performance Task

A total score for this task will be calculated according to Table A-8 by multiplying each power measurement in watts in 1-m/s wind speed intervals from 5 m/s to 11 m/s by the factor given. If power is not stable within the specified tolerance in Section 5.2.1, the score for the bin will be zero.

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

Wind Speed (m/s)	Factor
5	1.3
6	1.5
7	1.5
8	1.3
9	0.9
10	0.5
11	0.3

Control of Rated Power and Rotor Speed Task – Optional task A

Scores for power will be calculated according to the following:

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

$$Bin\ Score = 12.5\frac{[\tanh(-20 * |r_p - 1| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

In Figure A-1, a ratio, r_p, of 1.000 represents perfect power control at exactly the same value as was measured in the 11-m/s bin. The weighting shown will be multiplied by 12.5 for the two selected bins to obtain scores for each bin.

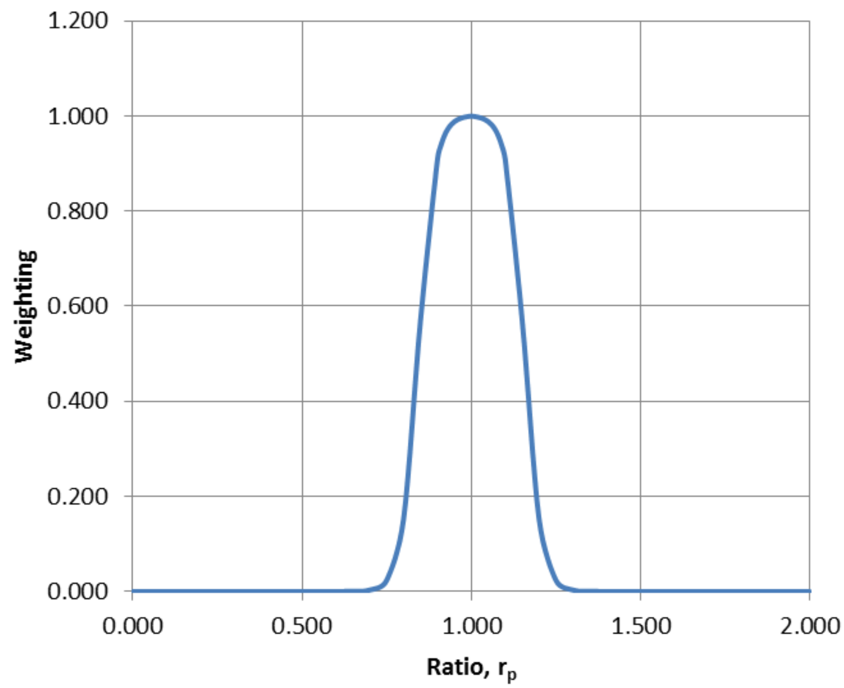

Figure A-1. Score weighting based on power ratio for control of rated power task

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

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

$$0 < r_s < 1.03 \rightarrow Bin\ Score = 12.5$$

$$r_s \geq 1.03 \rightarrow\ Bin\ Score = 12.5 \frac{[\tanh(-20 * |r_s - 1.03| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

In Figure A-2, a ratio, r_s, of 1.000 represents the perfect rotor speed control at exactly the same value as 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 12.5 for the two selected bins to obtain scores for each bin.

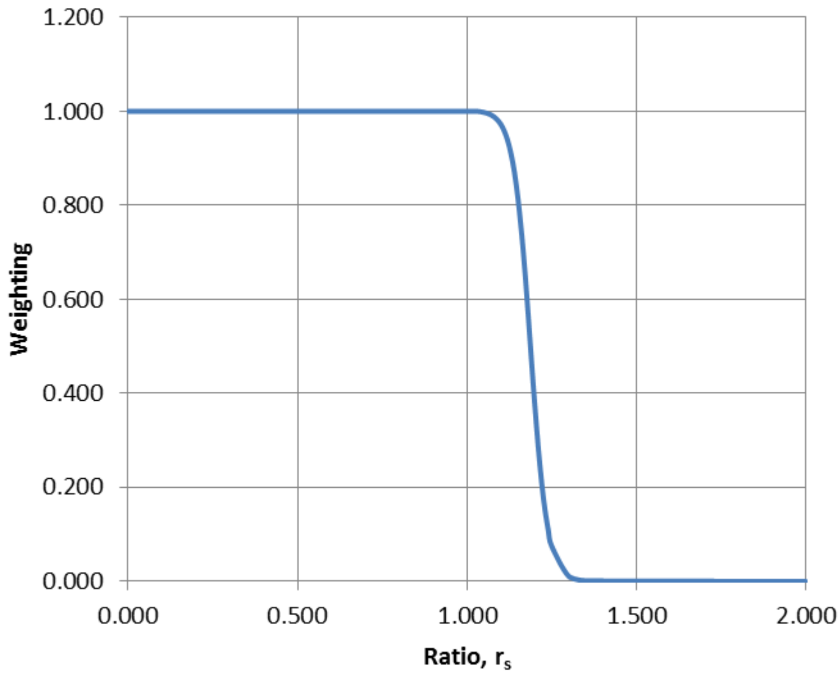

Figure A-2. Score weighting based on rpm ratio for control of rated rotor speed task

Safety Tasks

The safety task is scored on a pass/fail basis in two parts, governed by the limits set forth in the safety task description (see Section 5.2.3). If the turbine achieves a successful shutdown upon manual initiation, the team will receive 30 points. If the turbine automatically restarts, the team will receive an additional 20 points. If the team has to manually restart the turbine, the team 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 30 points. If the turbine automatically restarts when reconnected, the team will receive an additional 20 points. If the team has to manually restart the turbine, the team will receive zero points for the restart.

Durability Task – Optional task B

This portion of the competition will be scored on a second-by-second basis for minutes 2 through 5 of the task. Exceeding the rated voltage of the capacitive storage element will result in an immediate abort of the test and a zero score for the remainder of the durability task. Each second during minutes 2 through 5 will be scored according to the ratio between the measured average load voltage during that second and the 5 V target voltage according to the following:

$$r_v \equiv \frac{measured\ voltage}{5\,Volts}$$

$$0.95 < r_v < 1.05 \rightarrow Period\ Score = \frac{100}{4 * 60} = 0.41\overline{6}$$

$$r_v \geq 1.05 \rightarrow \ Period\ Score = 0.41\overline{6}\frac{[\tanh(-20 * |r_v - 1.05| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

$$r_v \leq 0.95 \rightarrow \ Period\ Score = 0.41\overline{6}\frac{[\tanh(-20 * |r_v - 0.95| + \pi) + 1]}{[\tanh(\pi) + 1]}$$

$$Task\ Score = \sum_{i=1}^{240}(Period\ Score)_i$$

The unscaled weighting function used in the equations provided here is shown in Figure A-3.

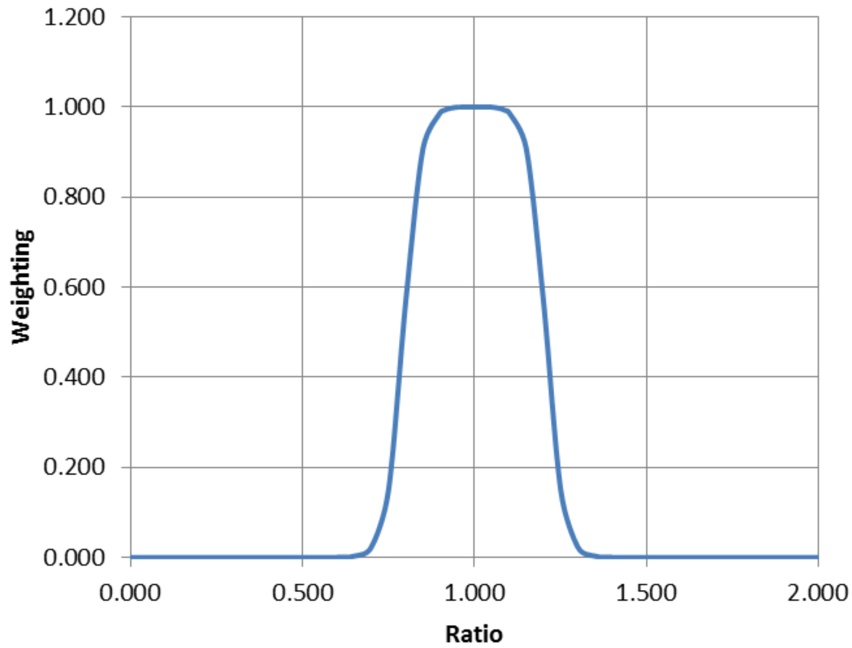

Figure A-3. Score weighting based on voltage for durability task

Appendix B. Logistics

Many logistical details will be provided throughout the course of the academic year, leading up to the event. While organizers will make concerted efforts to inform teams, teams are responsible for familiarizing themselves with the details provided and proceeding accordingly. Some of these topics include:

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 in regards to scheduling, however organizers are not obligated to accommodate. Organizers will not accept requests for schedule adjustments after the lottery has been completed. Assigned slots will include:

- Check in
- Technical inspection
- Contest slots
    - Tunnel testing practice
    - Tunnel testing
    - Siting and project development presentation
    - Design Q&A
    - Make-up tests (optional)

Teams should not expect to receive the balance of their assigned contest slots until check in at the event.

Event Registration

All individuals attending the event will be required to register. 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, PI's, Co-I's, advisors, and mentors. For the 2019 event, teams may bring no more than 7 attendees with a minimum of 1 faculty member.

Lodging

Organizers will investigate desirable, cost effective lodging options and provide information to teams as an option to consider. 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
- Shipping
- Hardware stores
- Machine shops
- Electronics supplies

Team Booths

Teams will be provided with a space to use as their home base during competition. There will be electrical outlets in the team booth area to allow students to operate tools, test equipment, or computers. Appropriate PPE should be worn in the team booths when working on the turbines. Posters are also encouraged to be displayed throughout the event. Additional materials that can 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. It is also advised that teams consider 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, it is advised you explore reasonable options to store and secure these items appropriately. Gear that could aid in this might include lockable totes.

Feedback

Organizers take feedback from participating teams, judges, volunteers, and others very seriously. Feedback provided is taken under serious advisement as we work to improve the organization and execution of the event each year. In order to support that continued improvement, it is crucial that participating teams seriously consider and convey both positive and critical feedback. All participants should also expect, and plan to provide feedback at the conclusion of the event. Please also consider opportunities to capture and provide individual and/or team feedback to organizers throughout the year.

Appendix C. Communications and Contest Details

External Communications

The website will showcase the various elements of the competition, ongoing collegiate team engagement, and information about how to participate in future competitions. The website will also feature important documents such as this manual and the Collegiate Wind Competition identity guidelines. The identity guidelines provide information about how the competition name, logo, and visual identity can be used.

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:

- **Google Group**. Official communications suitable for viewing by all team members and organizers will be posted on the Google Group message board. Instructions for joining Google Group will be provided by NREL to the teams following each team's commitment to participate.
- **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 Google Group or email.
- **Conference calls**. Teams are strongly encouraged to participate in scheduled conference calls with the organizers. Invitations and instructions for participation in conference calls are provided by the competition operations manager via email until the Google Group has been established; then provided via the Google Group thereafter.
- **Meetings during event**. Meetings will be held daily throughout the event.
- **Email**. For expediency, and to protect confidentiality, the organizers may choose to communicate with teams via team members' email addresses as listed in the Google Group database; however, most official communications occur via the Google Group message board.

Branding

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

Content and 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, although they may be published without. To ensure proper usage of and credit for images, teams should submit photos and graphics through the competition Box.com repository.

Teams are encouraged to develop a brand and platform for their turbines and teams. This platform, which may include web pages, Facebook, or other social media, outreach material, and team T-shirts, are welcomed during the competition. The use of the competition logo or name as part of individual school/team branding and platform is covered by the identity guidelines provided. Examples of good team branding will be provided prior to the competition; however, all branding and social outreach should conform to the safety and conduct provisions described in this document. All team branding should be of high quality and be provided in a professional context fitting for a national scale industry event.

Teams are expected to set up a professional space in their team booths to highlight the team's branding. This can include the turbine design, siting and project development posters, team logo, and school information. The team booths are your chance to showcase all the work you have put into your project over the course of the year and the best way to communicate your 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. In addition, 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.

Judging and Scoring

Panels of judges are responsible for scoring team performance in each contest (e.g., technical design, turbine testing, and so on). 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 2019 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 following completion of the competition. Teams will also receive a short narrative that is derived from the judges' deliberations after each team's presentation. Teams will also receive copies of notes judges may have written on the individual rubric forms.

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.

All products must be saved in the formats indicated.

Products due ahead of competition must be delivered to the competition Box.com repository (a link will be provided in the Google Group). 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.

Teams can submit early copies and updated revisions until the deadline. Each folder will be closed, or "unshared," after the submission deadline. Revised products will not be accepted after the deadline.

Written Report Formatting Requirements

The following format requirements apply to the written reports:

- Adhere to page limits detailed in respective sections.
- Pages should be 8.5 x 11 inches, paginated, and with 1-inch margins at a minimum.
- Begin listing references on a new page with distinct page number format from that utilized for the body of the report.
- Content should be at a minimum single-spaced.
- The body of the report must use at a minimum an 11-point font.
- Captions for figures and tables must be numbered for easy navigation.
- The final documents must be submitted as a PDF file adhering to the following criteria:
    - Bookmarked report sections

- Embedded fonts
- Minimum resolution of 300 dpi on all images.
- *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. While they are large files at 300 dpi, they are of unacceptable quality at lower resolutions and are not scalable without degradation.

Audio Visual Presentation Requirements

Audio visual presentations are not required, but if utilized should follow the following format requirements:

- If used, videos should be of a .MOV or H.264 compressed.MP4 (MPEG-4) file type with a resolution of 720 x 480.
- Presentations should be of 16:9 aspect ratio.
- No background music that violates U.S. copyright laws; 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]_[PRODUCT ABBREVIATION]_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

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

Example: A report submitted by California Maritime Academy on April 23, 2019, would have the following file name: MARITIME_Report_2019-04-23.PDF.

Table C-1. Team Names and Abbreviations

Team Name	Team Abbreviation
California Maritime Academy	MARITIME
California State University, Chico	CHICO
Iowa State University	ISU
James Madison University	JMU
Kansas State University	KSU
Northern Arizona University	NAU
Pennsylvania State University	PSU
Seattle University	SU
Texas Tech University	TTU
Universidad del Turabo	TURABO
University of Wisconsin-Madison	UWM
Virginia Tech	VT

Table C-2. Product Names and Abbreviations

Product Name	Product Abbreviation
Written report	Design Report or Siting and Project Development Report
Presentation	Pres
Poster	Poster
Product zip before competition	Portfolio
Audio visual presentation (if applicable)	AV

Appendix D. Sample Safety and Technical Inspection

A sample of the sheet used to evaluate test turbines prior to competition is provided on the following page. Teams are strongly encouraged to work through this inspection sheet in advance of competition amongst themselves and even enlist the advice of a qualified research technician, advisor, or similar university personnel as an independent eye prior to competition to ensure compliance.

CWC 2019 Safety and Tech Inspection Sheet

Team Name: ____

SAFETY - cannot practice or test if noncompliant

- o Wiring is deemed safe and uses adequate gauges— no electrocution or overheating hazard
- o Electrical systems are tied to earth ground w/ 100 kohm or lower resistor
- o Energized electrical components are adequately shielded—both electrically and mechanically (NEMA 1 is preserved)
- o Proper heat rejection
- o Voltage is ≤ 48 VDC at PCC at all times
- o Turbine mounting flange fits over studs without having to be forced (test fit to tunnel flange)
- o Team load runs on 120 VAC max
- o 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

NONSAFETY - can practice but must fix prior to official testing

General

- o All electrical components outside the tunnel are contained in enclosures meeting NEMA type 1 or greater (no tape)
- o All external wiring is in cable form and utilizes commercial connectors (no screw terminals or spade/fork type lugs)

Turbine

- o Turbine for testing is substantively the same as in the report
- o Turbine side of PCC: no batteries, excessively large capacitors (indiv. or combo ≤ 10 Joule)
- o All turbine control components located on turbine side of PCC
- o Turbine is capable of fitting through the door in one assembly

Volume

Rotor and nonrotor components are:

- o Within a 45-cm cube centered horizontally on flange axis
- o Vertically the rotor midplane is 60 cm ± 3 cm above the flange top plane to center it in the test section

Nonrotor parts only:

- o Base plate is ≤ 16.1 mm thick and tower is less than 15-cm DIA cylinder from base of cube to tunnel floor

Wiring

- o Current carrying conductors from flange to PCC are >1m long
- o Estop wiring is > 2 m in length from tunnel base flange
- o E-stop terminated with standard JST *female* receptacle with *male* pins (test fit to DAS system)
- o Anderson PP polarity is correct (test fit to PCC)

Load

- o Team-supplied load

IF TIME ALLOWS, INSTALL:

- o Reflective tape for RPM

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: ____