COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY COLLEGIATE WIND COMPETITION 2021

Preface

The U.S. Department of Energy Collegiate Wind Competition 2021 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.

While teams work on their deliverables, 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 feasibility of their concept. Teams are highly encouraged to pursue mentorships and sponsorships early in the course of the competition beyond the guidance received throughout the Connection Creation Contest as it will provide immense benefit to the learning and overall competition experience. However, only undergraduate student team members may take an active role in any competition event. It is the role of the nonstudent team members to provide a supportive environment and the educational background necessary for the students to achieve success in the competition. **It is not appropriate for anyone other than an undergraduate student to be actively working on a turbine or making decisions.**

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 if they are feasible and are intended to improve the competition, its rules, measurable outcomes, fairness, or precision.

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Revision History

This is the original version, issued October 09, 2020.

1 Introduction

1.1 Background

According to the U.S. Department of Energy's (DOE's) *Wind Vision* report, wind energy could supply 20% of the nation's electricity by 2030 and 35% by 2035.[1] As more wind energy is incorporated into the U.S. 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, CWC, or competition). The competition contributes to the creation and maintenance of American leadership in the transition to a global clean energy economy. 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, and business and sales forces. Wind-energy-specific advanced degrees are not required for many of these jobs but having wind-related experience is considered to be highly valuable.[2]

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 energy industry. The Collegiate Wind Competition 2021 challenge is to:

> **Research, design, and build a turbine for deployment in highly uncertain times (with a great degree of unknown risks and delays)**.

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.
- A site plan and cost of energy analysis for a 100-megawatt (MW) wind farm.
- A presentation on wind energy careers, community engagement, and outreach.

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

Planning projects in the face of uncertainty teaches us the importance of active risk management and ensures that we understand the probability of occurrence and the consequences. The theme this year requires teams to take risks into account to the extent possible in the schedule and budget, for example, to ensure project success. Proactive risk management is fundamental for any line of employment—a critical skill the organizing team is fortifying alongside the teams this year. The rules are written to ensure maximum learning in the event of a final in-person or virtual competition.

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[1] http://www.energy.gov/eere/wind/maps/wind-vision
[2] https://www.nrel.gov/docs/fy19osti/73908.pdf

2 Competition, Contests, Products, and Awards

The Collegiate Wind Competition 2021 consists of all 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.

During the event, teams compete in four contests: the Project Development contest, the Turbine Prototype contest, the Turbine Testing contest, and the Connection Creation contest. Within each contest, teams' submissions (hereafter referred to as products) receive points toward winning the contest. An overview of which product contributes to the scoring of each of the contests is in Figure 1. How many points a product contributes to the overall score is covered in Appendix A.

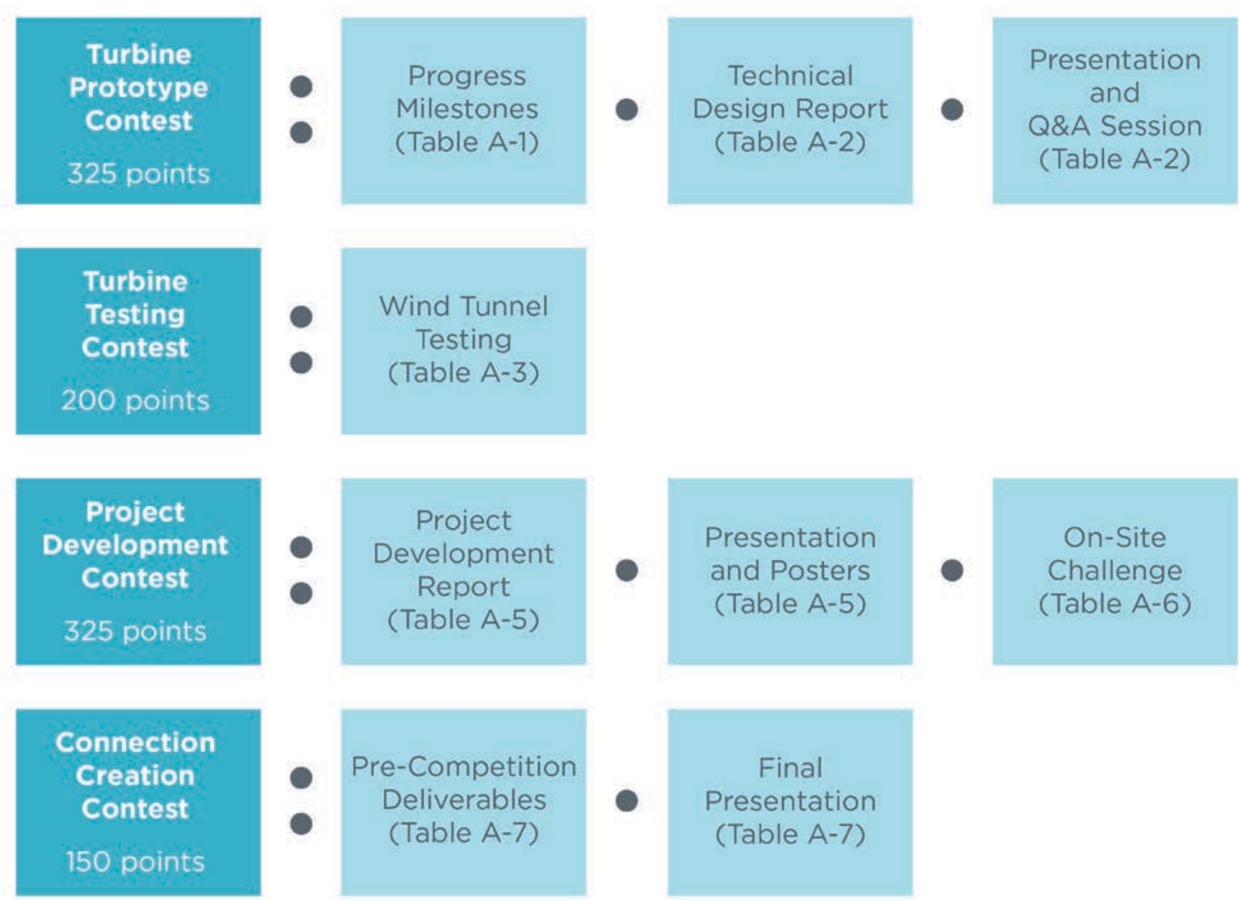

Figure 1. Contests and products overview. Further information available on the point breakdown available in Appendix A. Rubrics.

2.1 Overview of Product Submission Deadlines

This section gives an overview of when products should be delivered. The competition will run from Monday, June 7, through Thursday, June 10, 2021, at the American Wind Energy Association (AWEA) CLEANPOWER Conference in Indianapolis, Indiana. As stated, this rules document is written to ensure that learning will occur in the event that the in-person competition must become virtual. See Appendix H. Alternative Competition Structure for more details. Refer to each product section and H for format requirements and submission instructions.

Table 1. Product Deadlines

Product	Submission Deadline
PRIOR TO COMPETITION:	
Initial list of wind industry contacts	Sunday October 4, 2020, 11:59 p.m. MT
Conceptual design milestone	Sunday November 1, 2020, 11:59 p.m. MT
Distributed manufacturing plan milestone	Sunday December 6, 2020, 11:59 p.m. MT
Outreach plan and team story	Sunday January 10, 2021, 11:59 p.m. MT
Subsystem assembly and testing milestone	Sunday April 4, 2021, 11:59 p.m. MT
Project development report	Sunday May 23, 20/21, 11:59 p.m. MT
Turbine design report	Sunday May 23, 2021, 11:59 p.m. MT
DURING COMPETITION:	
Project development poster(s) (digital)	Bring to presentation
Turbine design question and answer (Q&A) supporting materials (optional)	Bring to presentation
Test turbine and load system	During safety inspection

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 Prototype contest winner—the team that earns the highest combined score from all design products
- Turbine Testing contest winner—the team that earns the highest combined score from all turbine testing products
- 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 Prototype Contest

The Turbine Prototype contest will comprise three basic components: a series of midyear milestones, a technical design report, and a prototype 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 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, and loads analyzed to withstand continuous winds of up to 22 meters per second (m/s) but no testing will be done beyond 13 m/s. Each turbine prototype must be designed for testing inside the Collegiate Wind Competition wind tunnels (further designated as “tunnel[s]” or “wind tunnel[s]”). The basic wind tunnel configuration is shown at the end of this section.

3.1.1 Physical Design Constraints Within the Tunnel

At zero yaw angle, the entire turbine must fit within the volume specified as follows and shown in Figure 2. The turbine may have the following maximum geometry:

- Rotor and nonrotor turbine parts must be contained in a 45 centimeter (cm)-by-45-cm-by-45-cm cube. This cube may be shifted as much as 10 cm aft of the yaw table 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 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, including the mounting flange.
- 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. Electrical connections should not be made in the nacelle during installation.

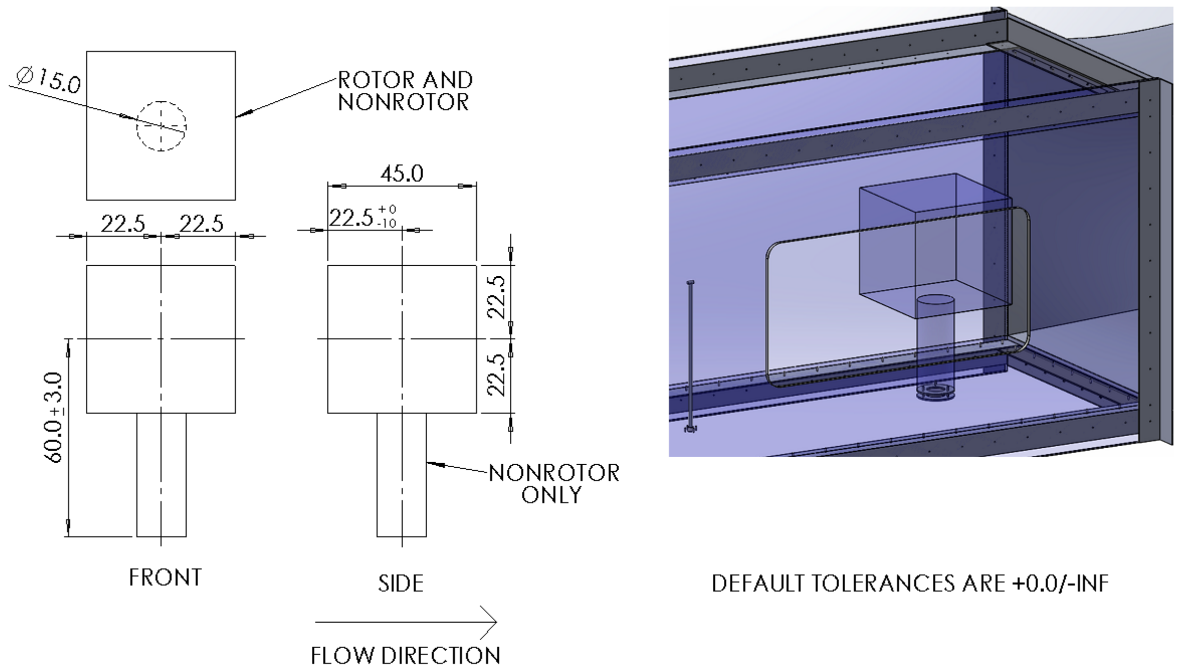

Figure 2. Allowable turbine volume

The wind turbine system must be mountable on the test stand within the wind tunnel as follows:

- The turbine base plate must be constructed of material no thicker than 16.1 millimeters. 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 wingnuts. Figure 3 shows the bolt pattern and sizing of the flange and the dimension for the hole 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.
- The tunnel base flange incorporates a turntable to generate yawed flow. This 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.

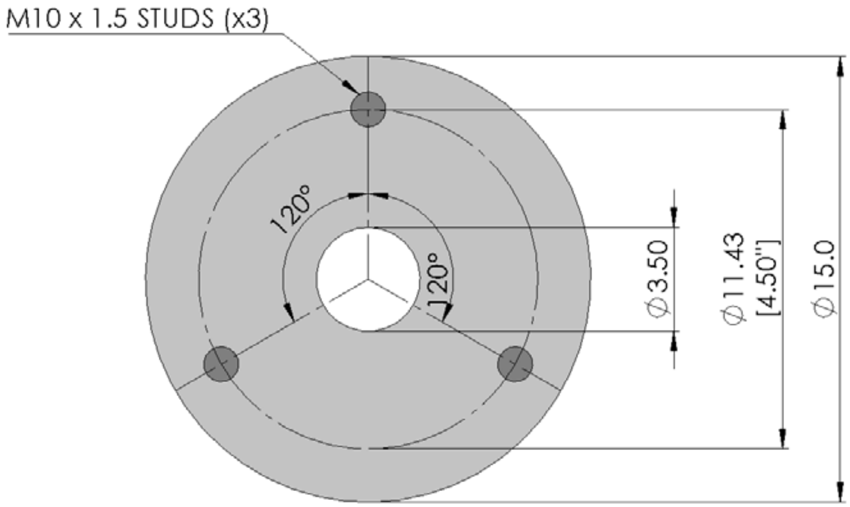

Figure 3. Base flange dimensions for turbine attachment to tunnel (dimensions in cm)

3.1.2 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 (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, which include the following:

- NEMA 1 characteristics: Enclosures are constructed for indoor use to provide a degree of protection for personnel against access to hazardous parts and to provide 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 NEMA 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 have connectors. Individual strands or bare wires will result in disqualification from testing until remedied. Twisting two or more strands together is permissible as long as 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 cable for all control wires.
- 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 shall be mechanically secured to the enclosure.

3.1.3 Electrical Requirements

Figure 4 illustrates the electrical configuration of the prototype turbine, competition data acquisition system, and point of common coupling (PCC), which is the point of electrical measurement for the competition.

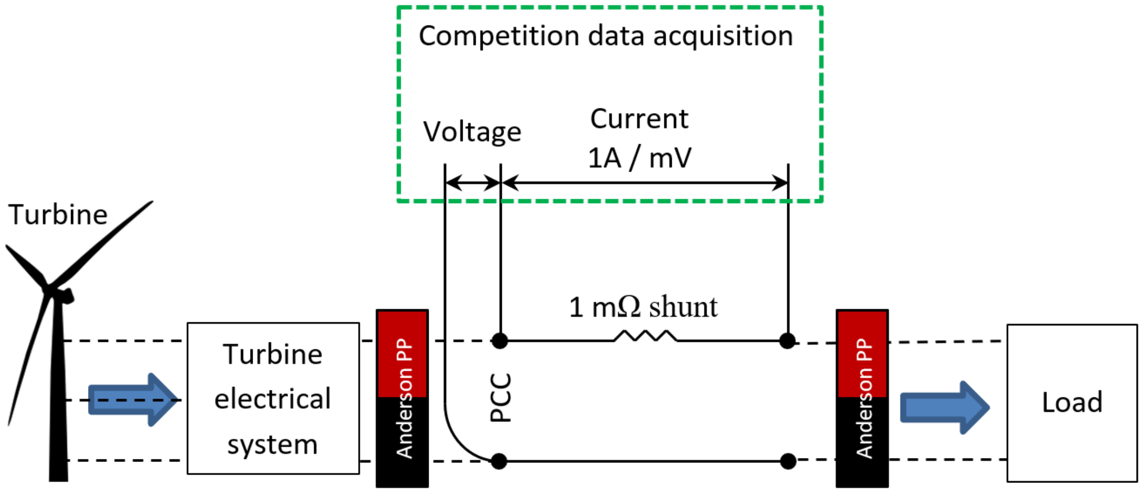

Figure 4. Load, turbine, storage element, and point of common coupling arrangement

- Voltage must be direct current (DC) at the PCC and is required to be at or below 48 volts (V) at all times.
- The turbine base plate shall 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.
- Teams are expected to choose their own generator and design their own 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. Both 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 a separate enclosure(s) from the load to clearly differentiate load and control during inspection by judges, as shown in Figure 4. The turbine nacelle may also contain turbine electronics, if desired.

3.1.4 Specifications for the Turbine Side of the PCC

- 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.

- No batteries of any type or capacitors or combinations of capacitors with nameplate voltage and capacitance ratings corresponding to over 10 joules (J) 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 of the PCC are allowed but must be optically isolated.

3.1.5 Specifications 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.

3.1.6 Interfacing with the Competition Data Acquisition System

- Wires should exit the tunnel at the turbine base through the center of the turntable. As shown in Figure 5, a table will be provided to display the load on the student side of the tunnel and hold any turbine electronics enclosures external of 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.

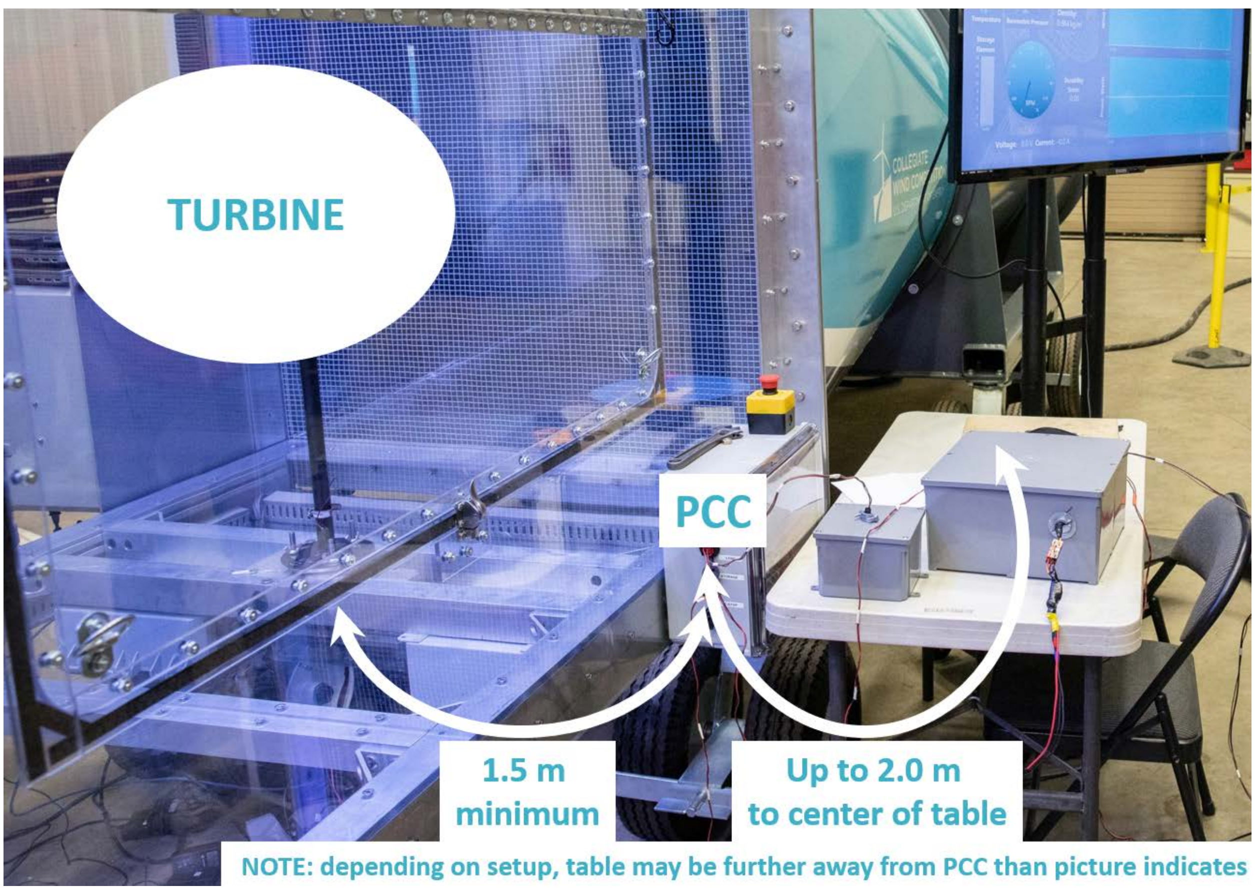

Figure 5. Wiring layout of PCC and student load display table

- 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 6 for correct polarity. Incorrect polarity must be corrected before testing.
- Teams are expected to provide their own Powerpole connectors of an appropriate size: 15 ampere (A), 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 earlier.

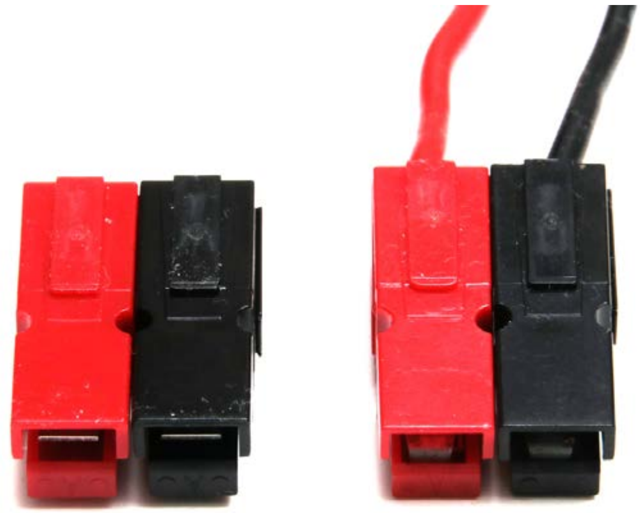

Figure 6. Proper Anderson Powerpole polarity to match tunnel wiring

- 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 switch 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 is opened during an emergency stop when the button is depressed.
    - In industry, emergency stop systems use this switch polarity 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 utilized the opposite polarity, the system would have to monitor each switch individually.
  - The emergency stop connector and wiring is rated for 3 A and thus is intended to carry a low current control signal—not high current power. Teams must describe their emergency stop system during safety and tech inspection and explain how this design utilizes 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 AWG) that reaches the PCC, as labeled in Figure 5. 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]. See Figure 7.[3]

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]. See Figure 8.[3]

Figure 8. Competition-provided connector for manual shutdown interface

3.1.7 Specifications for Competition Tunnel

A digital rendering of the competition tunnel is shown in Figure 9. The dimensions of the test chamber are 122 cm by 122 cm by 244 cm. 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 comprises wire mesh to prevent turbine pieces from getting sucked into the fan unit.

[3] 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.

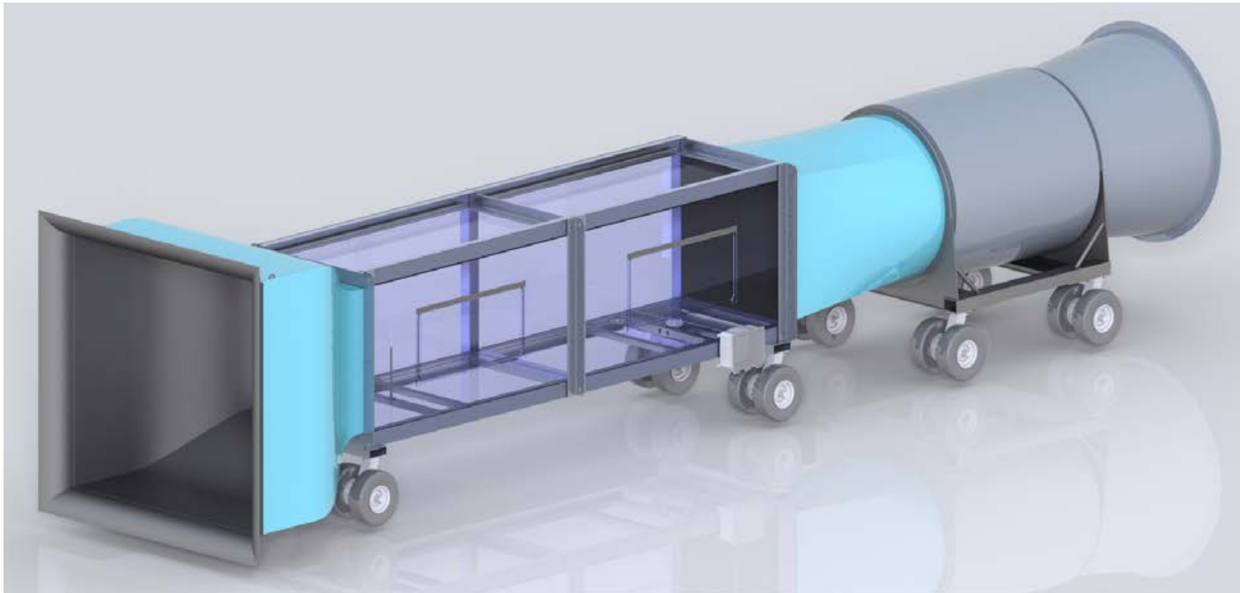

Figure 9. Collegiate Wind Competition wind tunnel basic configuration

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 are installed in the wind tunnel.
Appendix B 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, midyear milestones to monitor the student teams' progress leading up to the final event and incentivize key aspects of the design. Milestones are scored based on quality of content delivered with details given in each of the following subsections. Writeups should follow the same formatting requirements as the reports, detailed in Appendix G. 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.

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 a deep understanding of the task to be accomplished and the physics of accomplishing that task. 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. However, 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 settled on 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, and why these methods were chosen. However, the teams are reminded that this is a conceptual design; details of the design are not needed at this stage.
- Scoring will be based on how clear the concept is articulated, how likely it is to work well for the tasks presented, and how well the team articulates their understanding of the task and the physics of the problem.

3.2.2 Distributed Manufacturing Plan

In the modern world, it is common for design and manufacturing to be distributed around the country or even the world. Systems may be designed in different places and parts manufactured in different facilities, and design often occurs at separate locations from manufacturing. Ultimately, everything may come together in a single assembly factory (such as with cars or aircraft) or final assembly may not occur until installation at the field site (such as with wind turbines).

Given the current uncertainty around in-person meetings and access to shared laboratory space, developing a cohesive design and manufacturing plan while working collaboratively with team members in other locations is a valuable experience for team members moving into the employment market. Furthermore, as we have seen with recent interruptions to the supply chain, having backup plans is crucial when circumstances prevent normal operations.[4]

Deliverables and Scoring:

- Submit a two-page write-up plus up to 10 images that:
    1. Details how the team plans to design the turbine systems whether or not the team is able to be co-located. This process should include design for distributed manufacturing and should take a strong look at where precision tooling, complex processes, instrumentation, and test apparatus are needed and ways to design for less critical requirements. Should backups not be feasible, teams must include discussion on how they have derisked that portion of the design as much as possible.
    2. Further, a conceptual-level distributed manufacturing and testing plan, including backups and potential timeline impacts, should be outlined. The teams are encouraged to think about ways to obtain or manufacture and assemble the needed parts with limited or no access to well-equipped labs, laboratory personnel, or even to each other and to explain that thinking in the report. Outsourcing subcomponent manufacturing may be incorporated, but details on how the identified vendor is managing risk should also be included.

[4] The organizers have come up with a way to design, construct, and test a competitive turbine in separate garages/basements/workshops without any direct contact with each other using nothing but low-precision tooling from local hardware stores and components readily available locally or via mail order.

- Scores will be based on the thoroughness of the thought processes articulated for the plan and how well it is likely to work in an uncertain environment.

3.2.3 Subsystem Assembly and Testing

As in the previous milestone, teams are encouraged to develop a robust and redundant method to assemble and test their turbine in a distributed environment. Teams should divide up the process of building the turbine into its subsystems and acquire or construct the parts to assemble 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.

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 assembled and tested. 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 assembly and testing process was outlined in the milestone writeup. 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.

3.3 Technical Design 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 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, both for operational and parked conditions.
- 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 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 that were described earlier.
- A description of the final assembly of the turbine's subsystems. Where relevant, include how a distributed team environment was managed.
- A commissioning checklist that can be followed during installation of the turbine in the wind tunnel allowing no steps to be forgotten or executed in the wrong order.
- The 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.
- **New for 2021:** A clear and concise enumeration 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 decisions. If a team's school did not compete in the previous year's competition, they should write a few sentences about how the information in last year's winning design report influenced their own design.

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

- **Cover sheet**. Teams should begin the report with a one-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 judgment 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. Pages submitted beyond this limit will not be reviewed. The cover sheet and references are not required to fit within the page limit, but a table of contents and appendices are.

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

3.4 Presentation and Q&A Session

In addition to the written report, each team will present their design to a panel of judges followed by a Q&A 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, clearly communicating the team's approach to design and development.

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. 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 students and their principal investigator.

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 turbine design, as shown in Table A-2.

4 Turbine Testing Contest

The Turbine Testing 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, turbine-rated revolutions per minute (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. 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.

Exceeding the voltage limit set in Section 3.1.3 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.[5,6]

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.

All wind tunnel testing tasks at competition will be optional. The teams will be able to choose if they want to design to accomplish all the tasks or a reduced set. Note that teams must attempt at least one task. Teams that are newer to the competition, teams with fewer returning members, and teams who are feeling behind schedule are encouraged to focus on fewer tasks. Teams may find it strategic to focus their efforts and maximize their points on a subset of tasks instead of spreading themselves too thin. Additionally, since each team will be tested in the same sequence in the wind tunnel, opting out of a task will allow a team to effectively skip over one that could have catastrophic effects on their system in order to score additional points on the later tasks. There is no penalty for opting out of a task beyond losing the points for that task. All teams will be ranked solely based on points and not on which teams attempted more tasks.

When installing the turbine in the tunnel, a team representative should be prepared to identify to the judges which tasks, if any, the team chooses to opt out of. If desired, teams may choose a different selection of tasks during their retest.

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

[6] https://www.mouser.com/pdfdocs/Why-are-Power-Designs-Moving-to-48V.pdf

Only one team's turbine will be tested at a time. Teams are limited to 10 members (students and principal investigators) within the testing area. Other members can act as spectators. Each team will have 35 minutes of tunnel time to install their turbine, commission it, test it, and uninstall. 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 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 because the complete series of testing tasks are expected to require upward of 20 minutes to complete, depending on how fast the turbine stabilizes during 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.

4.1 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-second interval at a steady wind speed.

4.2 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 m/s and 11 m/s inclusive for a duration of 60 seconds or less, with the stated intent of obtaining a “stable” power reading, which is defined as stable rpm and 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-second interval will be defined as +/-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 (kHz) with a filter with a cutoff frequency of 22.5 kHz. These samples are then block-averaged down to 200 Hz. In order to meet the specified stability tolerance, teams should ensure that any noise in the power their turbine produces is adequately filtered and ensure 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 on the power output lines to filter noise coming from the switching of the power electronics.

4.3 Control of Rated Power and Rotor Speed Task

Wind turbines must 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 at 12 m/s and 13 m/s. Turbine performance in those two bins 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. The stability criterion defined in Section 4.2 will be applied to speed and power in this task.

4.4 Safety Task

Safety is of the 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 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 that the load is disconnected from the PCC and not the turbine to ensure that the competition data acquisition system can continue to monitor the open circuit voltage of the wind turbine, which must not exceed the limit provided in Section 3.1. 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-second bin average rpm achieved during power performance testing. This reduction in rpm must occur within 10 seconds 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.

4.5 Durability Task

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 13 m/s during a 5-minute test period. Yawed flow will be achieved using the tunnel's turntable governed by the limits set in Section 3.1. 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 produce positive power using the student load.

5 Project Development Contest

The Project Development contest has two main elements. Part A is a year-long effort to investigate key aspects of wind farm siting and project development activities. Part B will be conducted during the on-site competition and will 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 economics, setbacks, terrain effects, environmental issues, transportation constraints, transmission design, permitting requirements, turbine technology, and performance variables (i.e., wakes, inflow, availability, and site-specific losses).

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 in Section 5.1.

5.1 Part A: Research and Develop a Plan for a 100-MW Wind Farm in Western South Dakota

Teams must assess wind farm development opportunities within the defined region and create a rough development plan. Team members must be prepared to explain their process to judges at the competition.

5.1.1 Develop a Site Plan and Conduct Financial Analysis

1. Select a site within the area highlighted on the map in Figure 10.
    a. This site cannot be on an existing wind farm or one that is under development.
    b. Be prepared to explain how this site was chosen. Some considerations may include wind resource, terrain, landowners, vegetation, access to transmission, transportation access, and environmental and community factors.

2. Develop a preliminary wind farm design.
    a. Draft preliminary design:
        i. Choose turbine type, hub height, rotor diameter, and number of turbines. The total project size should be less than or equal to 100 MW.
        ii. Define project boundary.
    b. Research site characteristics:
        i. This investigation may include terrain, vegetation, general wind resource, wildlife, and land ownership.
    c. Collect information for 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. 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:

a. **Initial capital cost**. This covers costs associated with development, turbine procurement/installation and balance-of-station costs. Costs include site preparation; turbines; foundations; electrical hardware; electric collection system and transmission lines; substation; wind farm control and monitoring equipment; operation and maintenance facilities and equipment; shipping; resource assessment; surveying; legal counsel; project management; permits; construction insurance; title insurance; lease payments during construction; engineering services; sales and use tax, and so on. Costs should be expressed in dollars and in dollars per kilowatt ($/kW).
b. **Annual operating expenses**. Key cost categories here include O&M costs (including preventative maintenance, corrective maintenance, and spare parts), land lease costs, annual property tax, 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 in $/kW per year ($/kW/yr).
c. **Net annual energy production**.
d. **Market conditions**. The team should research what the market is willing to pay for the megawatt-hour's produced and compare this with the cost of energy.
e. **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.
f. **Incentives**. This includes national incentives, like the production tax credit, and any regional incentives. The team should research potential abatements for property tax and sales and use tax.

4. Develop a risk management plan to consider the unknowns, uncertainties, and delays in alignment with the theme of this years' competition. Teams should demonstrate their understanding of how this risk management approach (including probability of occurrence and consequence of each identified risk) can affect their schedule including financing and manufacturability of their proposed project development plan.

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, and asset disposal/recycling.

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

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

5. Finalize detailed design of the site plan, including the following steps:
   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.

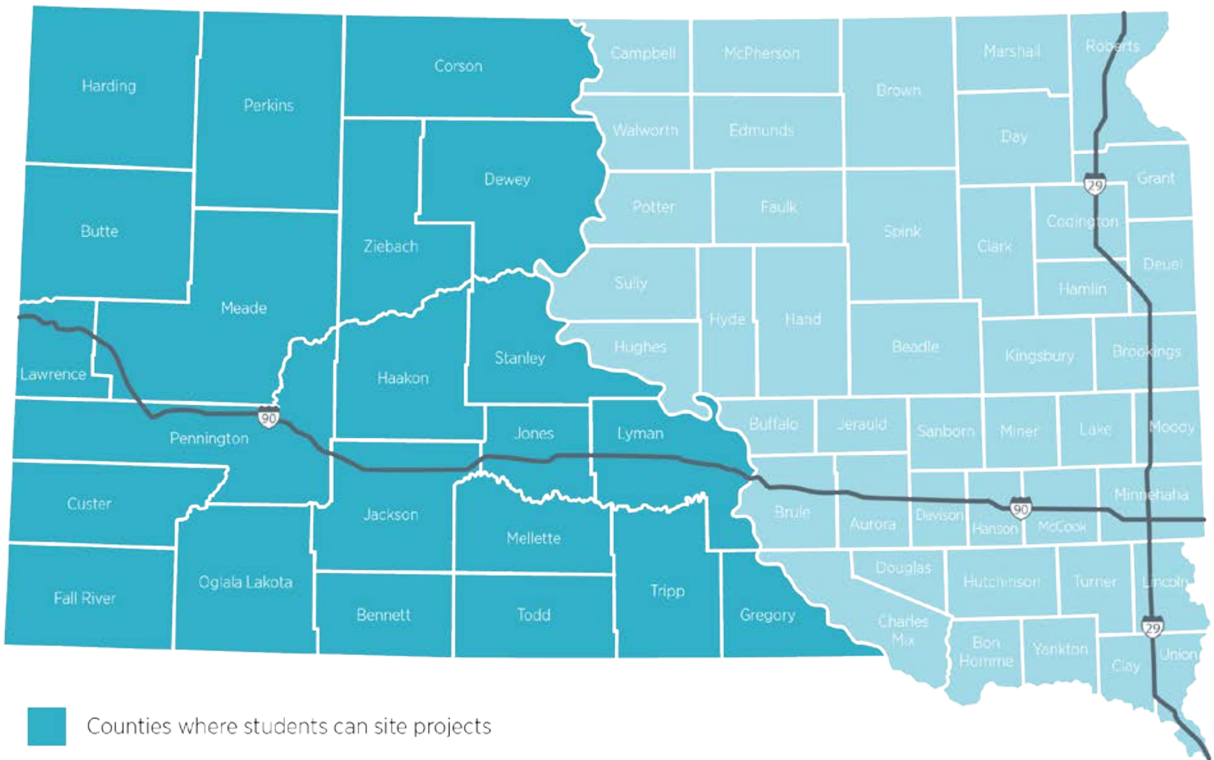

Figure 10. Map of South Dakota

5.1.2 Deliverables

5.1.2.1 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 year-long project development activities. At a minimum, the report must include the following sections:

- **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., sponsors, volunteers, and family members) involved in the project.
- **Site description and energy estimation**. This could include information about the wind resource, site layout, sensitive environmental or community regions, why this site was selected, and risks and fatal flaws.
- **Financial analysis**. This section should outline the financial potential of the project noting required capital, financing, potential financial impacts from risks based on the risk management plan described in Section 5.1.1, 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 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.

- **Discussion of optimization process**. This section should describe the iterative process of optimization that occurred between the preliminary site design and the financial analysis.

The report should be no more than 15 pages in length including the 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 G. At the conclusion of the competition, team reports will be posted to the competition website for reference during future events.

5.1.2.2 Presentation and Posters

Each team must submit their posters digitally, upon checking in at competition. Printed posters should match the digital version provided. In the case where 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 written report. The report and posters, however, would ideally be complementary rather than redundant.

The teams will have 15 minutes to present their project with 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 is provided in Appendix A. At the conclusion of the competition, team posters will be posted to the competition website.

5.2 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 represent a real location and will be the same area for all teams but will not be within any of the competition teams' local areas. The winner of the on-site siting challenge will balance competing objectives of maximizing power production while minimizing costs and environmental and community impact. The scoring criteria is provided in Appendix A, Table A-6.

The contest will run as follows:

- **Day 1**. Teams will be given a siting challenge packet of the site area with detailed topography, wind regime, and instructions for the challenge during the competition sign-in. This information will be reviewed during a project development briefing on the first day, at which time teams will have the opportunity to ask questions. Specific timing on the briefing will be provided on the competition schedule via the app. The provided materials will clearly identify all environmental and community 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.

- **Day 2**. Teams will hand in their preliminary design layout, indicating proximity to communities, residences, and sensitive habitat, for example. Teams will then 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. The combination of the preliminary design work shown on the paper copy of the site 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.

6 Connection Creation Contest

This is a new contest for the 2021 competition designed to forge stronger connections between competition participants, the wind industry, and local communities.

This contest is broken up into three elements: Understanding the Wind Industry, Community Engagement, and Outreach Plan & Execution. The deliverables required throughout the contest will build on each other and inform the requirements for the next event through both public-facing outreach and a final presentation to the judges during the competition.

Because the team will often be required to present and summarize the purpose and impact of its work in a professional setting, this contest is designed to align with this expectation. Specific requirements are defined in the following contest segments and deadlines are included in Table 1.

6.1 Contest Elements

6.1.1 Understanding the Wind Industry

Teams must do an assessment of the professional environment within the wind industry. This assessment will serve as the basis for the rest of the contest deliverables.

Each team must deliver a list of wind industry contacts to organizers. These contacts (for organizer reference only) may be alumni that have gone into the wind industry, existing professional relationships, or others, that the team has engaged with. Should a team not have any existing relationships in the wind industry, the team must send an email confirming this information to the organizing team by the noted deadline. There will be no penalty for not providing any wind industry contacts. Organizers will provide contacts for all teams that do not have existing relationships to leverage.

The contacts list must include the following information:

1. Full name
2. Company affiliation
3. Origin of the relationship (i.e., professional or alumni)
4. Sector in the wind industry
5. A response regarding if this person would be open to continued participation in future CWC events.

Following the delivery of the contacts list, organizers will partner each team with a wind industry professional representing each of the following industry sectors. Teams with existing relationships in any of the sectors will be paired with their existing contacts, and those without existing relationships will receive an introduction. These partnerships will be critical to the development of the team’s deliverables, and it is important to note that these industry professionals are volunteering their time. Be mindful of their availability and ensure team members are fully prepared, professional, and concise with their interactions.

The following are some examples of entry-level positions within each category:

- Project development. For example, positions may include GIS/geospatial analyst, financial analyst, geologist, environmental scientist, project manager, public relations, and computer science.
- Original equipment manufacturer. Related positions might include gearbox, blades, foundations, towers, balance of station, grid interconnection, and supervisory control and data acquisition.
- Owner/operations. Positions may include maintenance and repair professionals, financial analyst, or public relations.
- Research and development. Related positions might include modeling, design, construction, field verification, cybersecurity, and digital twin.

Once partnerships are established, teams must conduct interviews with the representatives in each category and build an understanding of a career that is of the most interest and available within that career path. Teams should ask questions that will help them develop a clear and compelling presentation covering specific details about each job, what is interesting about it, and requirements to enter the field. Details on other entry-level positions, internships, scholarships, or fellowships available within each organization will also be of interest.

These conversations will form the basis of the final presentation and deliverables within the other two contest elements. The final deliverable will be presented to a panel of judges and a school selected in the Community Engagement element of the contest.

Students are encouraged to use this opportunity to get feedback on the other elements of the competition. This feedback can be used to guide some of the team's decisions and can be shared with Project Development and Technical Design judges as a part of their final deliverables. Refer to the preface for appropriate levels of feedback from industry representatives.

More details on requirements for the final presentation are included in Section 6.2.

6.1.2 Community Engagement

Teams will share what they have learned, both in the Understanding the Wind Industry contest element, and in the other three contests (Project Development, Turbine Prototype, and Turbine Testing), with the local community. Each team will:

1. Organize and run a community outreach event to share information beyond the team
    - Events could include, but are not limited to, a KidWind event organized with Mike Arquin, an event at the participants' school to engage other students in the CWC team, or an event within the local community to share the importance of wind energy.
2. Present to a local middle or high school on career opportunities in wind energy. This can be completed concurrently with Part 1.

Students should organize or attend each event with a specific goal in mind (i.e., educate and excite younger students interested in the wind industry, inspire underclassmen to join future CWC teams, mentor younger students on the importance of wind, raise awareness in their community about wind, and so on) and report on how they achieved that goal in the final presentation.

Both 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 planning process, estimated number of attendees, and the impact should be included in the final deliverable.

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 & Execution element of the contest (described in Section 6.1.3).

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.

These engagement events may be done as in-person or virtual events.

6.1.3 Outreach Plan and Execution

Teams will develop an outreach timeline chronicling the team's accomplishments and associated announcements throughout the year. Sharing the team's progress will help local employers understand the skills the team has developed throughout the year and prepare members for the final presentation during the competition.

An outreach plan is an industry best practice to help keep announcements on track and will serve as a guide through the year. Teams should use their judgment when deciding how long to make the outreach plan; however, one page is sufficient.

This outreach plan should include:

- High-level goals the team aims to achieve with the outreach plan. Goals could include, but are not limited to, community awareness of wind energy, inspiring new students or teams to participate, highlighting entry-level skills developed during the competition to hiring managers, and more.
- Outreach announcement dates. At least two should be included in the spring semester.
- Relationships developed with the team's school newspaper, local media outlets, and existing or new social media accounts.
- Any content, photos, or videos that have been developed for the purpose of outreach.

This outreach plan will be developed in the first half of the year. An explanation of this plan and a representation of its execution should be included in the team's final presentation to the judges.

Teams will also submit a team story that details their project, goals, and background. Any information on the work completed for the competition to date is also of interest. When developing the story, teams can use the following as a guide:

1. School and team name
2. Why are you participating in the Collegiate Wind Competition?

3. Describe your project and your goals
4. What is your team's plan for achieving your goals?
5. Team strengths
6. Team hurdles
7. What do you hope to achieve in the competition this year?

Submission of the story must also include a high-resolution photo of the team or screenshot from a virtual meeting. Organizers may edit the story for consistency between teams and to meet necessary web standards on energy.gov.

Teams are encouraged to include their stories in the outreach plan and promote them on their own channels once they are live.

6.2 Final Presentation and Q&A

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

1. Four slides covering the four defined wind industry sectors
2. Strategy behind recruitment efforts for the competition to support all individual contests
3. A slide for each of the community engagement events
4. Details on the outreach plan, including the team's initial high-level goals, the execution, and metrics detailing the impact of the plan.

Emphasis should be placed on the quality and visual appeal of each slide and the accompanying presentation by the speaker. Each slide should include a high-resolution photo to represent each contest element. Teams may use videos, but this is not required. See Appendix G for instructions on formatting and submission.

Each team will have 10 minutes to present their presentation to a panel of judges. 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 is included in Appendix A. Rubrics.

Final presentations from each of the teams will be published on the competition website, used for reference for future events, and could be used in the development of future competition deliverables.

Glossary

Competition	The competition is 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 U.S. Department of Energy's 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	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.
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 to spectators.

Appendix A. Rubrics

Turbine Prototype Contest

Table A-1. Scoring Rubric for the Midyear Progress Milestones (75 Points Total)*

Description	Possible Points	Score
Midyear Progress Milestones (75 points)		
Conceptual design	20	
Distributed manufacturing plan	20	
Subsystem assembly and testing	35	
Total		

*** No points will be awarded if a milestone is late.**

Table A-2. Scoring Rubric for the Technical Design Report and Q&A (250 Points Total)*, **

Description	Possible Points	Score
Technical Design Report (200 points)		
Concise, readable, and descriptive with logical flow	15	
Presents and communicates technical information clearly and intelligently	15	
Design objective description for test turbine	15	
Static performance analysis	15	
Mechanical loads analysis and associated safety factors (including yaw system if present)	15	
Electrical analysis (including both loads and storage element)	15	
Controls analysis (including storage element)	15	
Software documentation and description (including storage element if applicable)	15	
Documentation of final assembly	20	
Commissioning checklist	15	
Engineering diagrams including mechanical and electrical drawings	15	
Results from laboratory and/or field testing	15	
Clear and concise enumeration of what is the same as last year and why***	15	
Subtotal		
Private Q&A Session (50 points)		
Demonstrated understanding of technical design during Q&A	50	
Subtotal		
Total		

*** 20 points 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.**

***** 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-3. Scoring Rubric for Turbine Performance Testing (200 Points Total)

Description	Possible Points	Score
Turbine Performance Testing (250 points)		
Cut-in wind speed task	25	
Power curve performance task	50	
Control of rated power	25	
Control of rated speed	25	
Safety task	50	
Durability task	25	
	Total	

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

Cut-In Wind Speed Task

A team will earn 5 points for each half meter per second (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 4.1), up to the maximum score of 25 points for this task.

Power Curve Performance Task

A total score for this task will be calculated according to Table A-4 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 4.1, the score for the bin will be zero.

Table A-4. Weighting for the Power Curve Performance Task

Wind Speed (m/s)	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:

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

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

In Figure A-1, a ratio, r_p, of 1.000 represents perfect power control at 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.

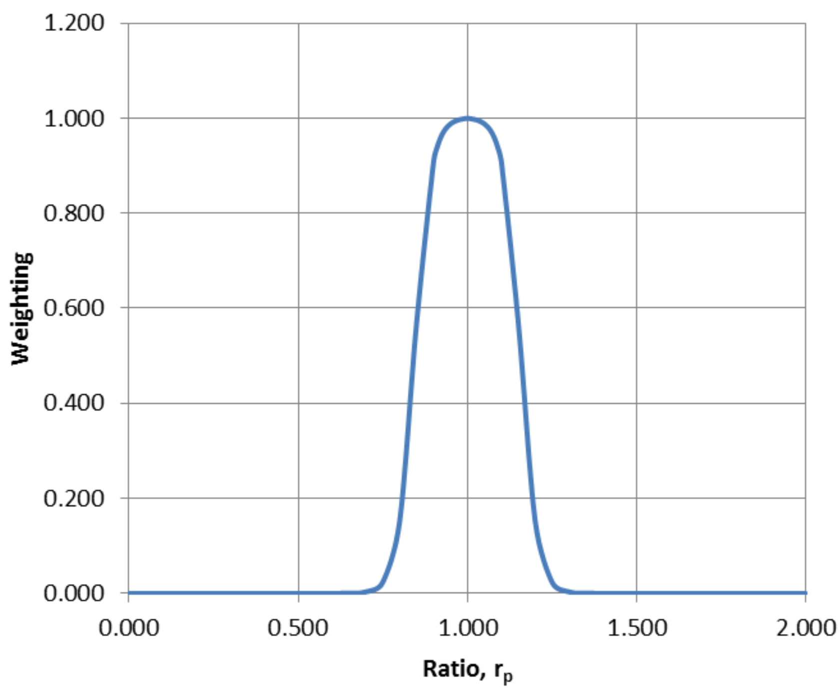

Figure A-1. Score weighting based on power ratio for control of rated power task

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 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.

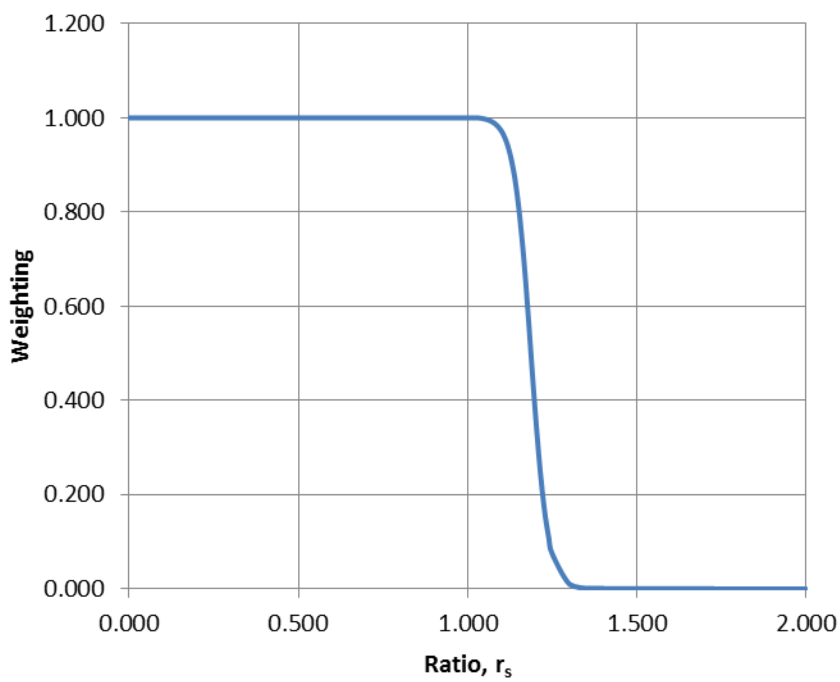

Figure A-2. Score weighting based on rpm ratio for control of rated rotor speed task

Safety Task

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 4.4). If the turbine achieves a successful shutdown upon manual initiation, the team will receive 15 points. If the turbine automatically restarts, the team will receive an additional 10 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 15 points. If the turbine automatically restarts when reconnected, the team will receive an additional 10 points. If the team has to manually restart the turbine, it will receive zero points for the restart.

Durability Task

This portion of the competition will be scored on a second-by-second basis for 5 minutes. Each 6-second period during which the turbine system produces positive power for the entire period will result in 0.5 points being awarded.

Project Development Contest

Table A-5. Project Development Contest Part A: Develop Plan for 100-Megawatt Wind Farm (250 Points Total)*, **

Description	Possible Points	Score
Quality of Deliverables (60 points)		
Written report: concise, readable, and descriptive with logical flow; communicates technical information clearly	20	
Presentation: professional, clear project pitch	20	
Posters: well-designed, illustrative, appropriate use of text and graphics	20	
	Subtotal	
Analysis (190 points)		
Preliminary site selection and down select, including identification of potential siting challenges and opportunities associated with options	20	
Wind farm design – detailed layout and resource assessment	30	
Articulation of community and environmental impacts and mitigation approaches (understanding local ordinances, such as setbacks, assessments, and permitting)	25	
Cost/kilowatt-hour	20	
Depth and thoroughness of balance-of-station elements considered in the financial analysis (capital expenditures [CapEx])	25	
Evaluation of annual operational costs (operational expenditures [OpEx])	25	
Bankability of financial plan and discussion of the team's evaluation of financial risks and alternatives (or mitigations strategies)	30	
Understanding of market opportunities and constraints (e.g., power markets, equipment supply chains, ownership structures, taxes, policies, and incentives)	15	
	Subtotal	
	Total	

*** 25 points 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. Pages in excess of page limit will be ignored.**

Table A-6. Project Development Contest Part B: On-Site Design Challenge (75 Points Total)

Description	Possible Points	Score
Lowest cost of energy	25	
Environmental and community impact (e.g., habitat impacted, sound, visual)	20	
Pre-work on paper	20	
Justification for turbine layout	10	
	Subtotal	
	Total	

Connection Creation Contest

Table A-7. Scoring Rubric for Connection Creation Contest Deliverables (150 Points Total)*

Description	Possible Points	Score
Precompetition Deliverables		
Delivery of initial wind industry contact list	10	
Delivery of outreach plan	10	
Delivery of team story	20	
	Subtotal	
Final Presentation		
Delivery of final presentation including all contest elements to organizers	20	
PowerPoint is concise and visually engaging, and presentation to judges is professional and clear, uses effective storytelling techniques	20	
Demonstrated understanding of potential wind industry career paths	20	
Demonstrated execution of outreach plan during the spring semester	20	
Metrics exhibiting improvement in digital public engagement	20	
Execution of a community event, virtual or in-person	20	
	Subtotal	
	Total	

*** The final presentation must be delivered digitally to the team's Box folder or shared in person on a USB in advance of a team's presentation during the competition.**

Appendix B. Sample Safety and Technical Inspection

A sample of the sheet used to evaluate test turbines prior to competition is provided in Table B-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 the final midyear project milestone.

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

CWC 2020 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 maximum
- 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 Cable passthroughs in enclosures provide strain and chafe protection (e.g., cable glands)
- o Turbine electronics and load electronics in separate enclosures
- o All external wiring is in cable form and utilizes commercial connectors (no screw terminals or spade/fork type lugs)
- o All electrical components are mechanically secured to the enclosure

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 J)
- 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, shifted at most 10 cm aft
- 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 Wiring will reach PCC (test fit)
- o E-stop terminated with standard JST *female* receptacle with *male* pins (test fit to DAS system)
- o E-stop signal (JST connector wiring) never draws more than 3 A and uses normally closed polarity during turbine operation (students to describe)
- o Anderson Powerpole polarity is correct (test fit to PCC)

Load

- o Team-supplied load

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: ______________________________

Appendix C. Roles and Responsibilities

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

Table C-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-PIs 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.
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 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 Slack channel that is discussed later in this document) during the event.
Student Mentors	Multiple	Because of their unique perspective, students having completed their undergraduate degree or graduate students are encouraged to act as mentors to the collegiate team. Similar to team PIs, mentors should provide a supportive environment and the educational background necessary throughout the contest without making active decisions themselves.

Role	Individual(s) Assigned	Definition
Collegiate Team Co-Principal Investigator(s) or Supporting Faculty	Multiple	Supports the PI 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	Amber Frumkin, 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 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 Coordinators	Christa Nixon and Jenny Wiegele, NREL	Coordinate competition logistics including registration, lodging, overall event schedule, and individual team schedules. Lead correspondence with teams and event feedback. Support collegiate teams, judges, the head rules official, and operations manager.
Contest Lead	Heidi Tinnesand, NREL	Coordinates all activities related to the contests. Key point of contact for questions related to engagement with the judges, individual competition contests, and protocol.
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 a turbine can be tested or not in the tunnel because of safety concerns.
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	Jenny Wiegele, NREL	Coordinates all aspects of media representation, website management, publications, signage, and outreach.
Competition Safety Point of Contact	Ian Baring-Gould, NREL	Point of contact for questions or issues related to safety.

Role	Individual(s) Assigned	Definition
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.

Appendix D. 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 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:

- Check-in
- Safety and technical inspection
- Contest slots
    - Tunnel testing practice
    - Tunnel testing
    - Project development presentation
    - Design Q&A
    - Connection creation presentation
    - 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 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, PIs, Co-PIs, advisors, and mentors. The limit for attending participants for the 2021 event will be provided closer to the competition date.

Lodging

Organizers will investigate desirable, cost-effective lodging options and provide information to teams for consideration. 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 turbines. 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 that they 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, 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 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 E. 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 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 shall 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 (see National Renewable Energy Laboratory [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 (competition provided)
- Steel-toe boots if expecting to handle heavy loads[7] (student provided)
- Electrical personal protective equipment if electrical voltage demands it (student provided)
- Hearing protection for use in areas that are near the wind tunnel during operation (student provided).

[7] Teams should use their judgment for steel/composite safety-toed shoes. If there is any danger of foot injuries because of 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 E-1. Suggested Hazards and Controls for Testing Prototype Wind Turbines

Hazard	Control
Inexperience with potentially destructive testing Testing a rotor to failure can be hazardous to people nearby	• Work with the PI 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
Electrical shock Shock from coming into contact with energized conductors	• 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
Noise A rotor assembly coming apart can create a loud, sudden burst of sound	• Wear appropriate hearing protection, such as approved ear plugs or earmuffs, in the test area • Follow manufacturers' recommendations for proper usage
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)	• 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: https://www.grainger.com/content/qt-241-hard-hat-requirements

Hazard	Control
Thrown debris A rotor assembly will come apart with great force, sending projectiles into the surrounding test area	• Check the area to ensure its 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 has been 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 in order 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 shutdown 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 o NREL uses 0.5" 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

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 the U.S. Department of Energy'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, 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 F. 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 principal investigator
- Be submitted via email and 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 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 G) 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 G. Communications and Contest Details

External Communications

Organizers will use the 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:

- **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 (NREL) to the teams following each team's commitment to participate. Students should reference specific sections 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.
- **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.
- **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 Slack channel has been established but provided via the Slack channel thereafter.
- **Meetings during 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 NREL and U.S. Department of Energy (DOE) 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 safety and conduct provisions described 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 provide the chance to showcase all the work each team has put into their project over the course of the year and 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 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 DOE, NREL, 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 2021 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 receive a short narrative that is 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.

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 the competition must be delivered to the competition Box.com repository (a link will be provided in the Slack channel). 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:

- Reports should adhere to the page limits detailed in respective sections.
- 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:
    - 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 for all contests but if utilized should follow the following format requirements:

- 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 a 16:9 aspect ratio.
- 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]_[PRODUCT ABBREVIATION]_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

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

Example: A report submitted by California Maritime Academy on April 23, 2021, would have the following file name: MARITIME_Report_2021-04-23.PDF.

Table G-1. Team Names and Abbreviations

Team Name	Team Abbreviation
Brigham Young University	BYU
California Polytechnic State University	CALPOLY
California State University Maritime Academy	MARITIME
James Madison University	JMU
John Hopkins University	JHU
Kansas State University	KSU
Northern Arizona University	NAU
Pennsylvania State University	PSU
Texas Tech University	TTU
University of Maryland	UMD
University of Wisconsin-Madison	UWM
Virginia Polytechnic Institute and State University	VT
Washington State University-Everett with Everett Community College	EVERETT

Table G-2. Product Names and Abbreviations

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

Appendix H. Alternative Competition Structure

In the event of a cancellation of the in-person American Wind Energy Association (AWEA) CLEANPOWER conference, the following updates to the competition structure will go into effect, 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 enumerated 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 but if any team is unable to complete any of the deliverables because of extenuating circumstances, please reach out to 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 turbine will be updated to reflect:

- An effective mechanical, electrical, and aerodynamic wind turbine and load digital-only 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 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. The new high-level overview of contest deliverables is shown in Table H-1..

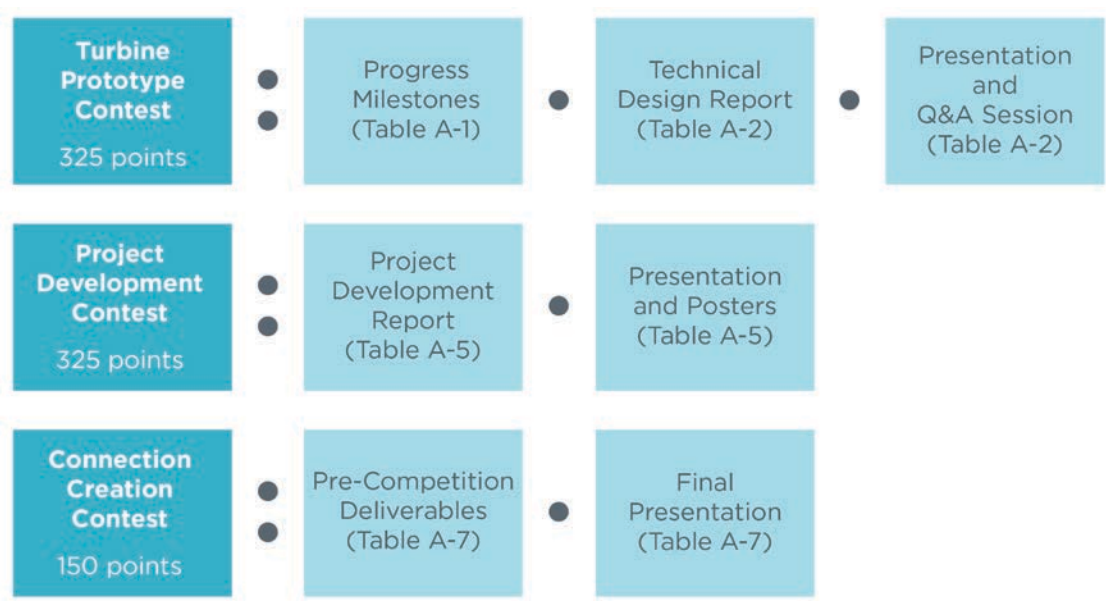

Figure H-1. Updated contest and product overview

Submission Deadlines

The virtual competition sessions will run over the course of three dates between May and June, which 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 H-1.

Table H-1. Updated Submission Timelines

Product	Submission Deadline
PRIOR TO COMPETITION:	
Unchanged	
DURING COMPETITION:	
Project development PowerPoint presentation (digital)	Present on virtual meeting platform
Turbine design Q&A supporting materials (optional)	Present on virtual meeting platform
Connection creation PowerPoint presentation (digital)	Present on virtual meeting platform

Awards

Awards will shift to include:

- First-place winner—the team that earns the highest combined score (not including the turbine testing contest)
- Second-place winner—the team that earns the second-highest combined score (not including the turbine testing contest)
- Third-place winner—the team that earns the third-highest combined score (not including the turbine testing contest)
- Project development contest winner—the team that earns the highest combined score from all project development products
- Turbine digital design contest winner—the team that earns the highest combined score from the digital design and milestones
- Connection creation contest winner—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 winner.

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

Turbine Digital Design Contest

The technical 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

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

Presenters should showcase their 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. For virtual presentation best practices and to ensure this will all function as intended in advance of presentation time, see Appendix I.

Turbine Testing Contest

This contest will be canceled, and turbines will not be tested in the competition wind tunnel. Teams are encouraged to develop ways to validate their turbines if able to do so. Organizers and judges will be available as resources to help develop a process.

Project Development Contest

The project development contest, initially structured as two parts, will now only include Part A. Requirements associated, with Part B 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.

In Table A-5, poster requirement will change to a PowerPoint presentation. Each line will be scaled equally so that the total points available in Table A-5 sum to 325. Table A-6 and task scoring for Part B of the project development contest will be removed from the competition.

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 doodle poll and organizers will do their best to accommodate based on judge availability. These slots are not guaranteed. Assigned slots will include:

- A project development presentation
- Turbine digital design and Q&A
- A connection creation presentation
- Final awards ceremony.

Virtual Event Login

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

Any members of each team and principal investigators, co-principal investigators, advisors, and mentors are welcome to attend both their team's presentation sessions and the final awards ceremony.

Virtual login information for both 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 AWEA CLEANPOWER, 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 as possible to highlight the skills each team developed over the course of this academic year despite the challenges, and students will be able to share it as well. More information on scheduling, best recording practices, and specific questions will be provided directly from organizers.

Dispute Resolution

Because of the virtual nature of the competition, in-person notification will not be required.

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 meet-and-greet meetings and informational interviews with industry experts virtually through coordination with competition organizers. Requests for these meetings must be submitted via the Slack channel or via 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 in how they continued working on the competition and what they learned during the competition year. These interviews will be recorded and disseminated after the conclusion of the competition to share those accomplishments with the industry.

Appendix I. Virtual Conference Participation Etiquette

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

- Teams are 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.
- Teams are encouraged, but not required, to use their 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 look professional in dress and speak professionally during the presentation.
    - Refrain from distracting behavior while sharing the video and/or audio, such as drinking or eating.