U.S. DEPARTMENT OF ENERGY
SOLAR DISTRICT CUP
COLLEGIATE DESIGN COMPETITION

Solar District Cup 2020 Rules

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U.S. DEPARTMENT OF ENERGY
U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE
NREL Transforming ENERGY

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Acronyms and Abbreviations

BSU	Ball State University division
CP	Crystal Parks division
DOE	U.S. Department of Energy
DSS	distribution system simulator
MACRS	modified accelerated cost recovery system
NMSU	New Mexico State University division
NREL	National Renewable Energy Laboratory
PPA	power purchase agreement
PV	photovoltaic
SAM	System Advisor Model
SCADA	supervisory control and data acquisition

Summary of Changes to this Edition

1. Changed finalist presentation and winner announcement dates.
2. Changed conference location references to video conference.
3. Added to Table 2. Final Deliverable Package Content and Judging Statements, section 5. Optimization Strategy, right-side column.
4. Corrected "How Entries are Scored" section, Item 4.
5. In "Travel for Competition" section, deleted content that no longer applies.
6. Changed Appendix D., Sections 2.A. and 2.B.
7. Added Appendix D., Section 2.C.

Summary of Changes to the January 28, 2020 Edition

1. Changed deadline of Final Deliverable Package from Saturday, April 11 to Tuesday, April 7, 2020.
2. Indicated that only students are allowed to present to judges at the finalist event.
3. Added date of Thursday, April 16, 2020, for teams to submit a revised presentation PPTX file in Table 2. Section 5. Optimization Strategy.
4. Replaced all references to Solar Power Southeast with Solar and Energy Storage Southeast.
5. Added a note referencing Appendices B & D for Final Deliverable Package content and formatting requirements to Table 2.
6. Added file format references to Table 2 for alignment with Appendix D.
7. Changed Table 2. Section 4. Judging Statements to "Proposed building, site, construction, and development plans…" for alignment with Table 2. Section 4. Content items A. and B.
8. Changed How Entries Are Scored section, item 6. to "a 15-minute live presentation" and "Ten minutes will be provided for judges to ask questions of each team."
9. Changed How Entries Are Scored section, item 9. to "present an 8-minute project story to industry attendees."
10. Changed Figure 1 for district use case partner names and the maximum number of finalist teams in each division.

11. Added information indicating that a maximum of five student team members may present to judges and a maximum of 10 team members per team may attend the final event.
12. Added a Partners section following the Competition Authority and Administration section.
13. Added a reference to the HeatSpring Solar District Cup Training Course to the Appendix A. Written Resources section.
14. Added a reference to the HeatSpring Solar Executive MBA Financial Model Template to the Appendix A. Models and Software Tools section.
15. Renamed Appendix C to Progress Deliverable Package Requirements and moved the Final Deliverable Package Requirements section to the new Appendix D.
16. Added a requirement to each section of the Final Deliverable Package Requirements appendix that clarifies expectations around proofreading and file naming.

Competition Overview

Welcome to the U.S. Department of Energy (DOE) Solar District Cup Collegiate Design Competition!

To support DOE's ongoing work addressing structural employment gaps for professionals in the energy industry, the Solar District Cup challenges multidisciplinary collegiate student teams to develop forward-thinking designs for optimized campus or urban district distributed energy systems that inspire students and professionals alike—and then design and model those systems.

The competition engages students across engineering, finance, urban planning, sustainability, and other disciplines or degree programs to reimagine how electric energy is generated, managed, and used in urban areas. Students assume the role of a solar-plus-storage developer to produce a proposal and analyze electric distribution grid interactions for a district use case. For the purposes of this competition, "campus" and "urban district" are distinct areas of developed land containing a group of mixed-use buildings served by a distribution feeder. The competition organizers provide the teams with district use cases—including energy use data for multiple buildings, electrical infrastructure, and the district master plan—to serve as the basis for the solutions the teams develop in the challenge.

Each team competes against other teams in one of multiple divisions. Each division is structured around a single district use case, consisting of an existing defined set of buildings and land area, for which several teams develop solutions. Judges select winning teams after the teams present their designs in via live video conference. Judges identify the top three teams for each division and select an industry choice winner from amongst each of the division first-place teams. The strongest submissions provide innovative solutions that offset the highest amount of the district's annual energy and power consumption while integrating economic, aesthetic, and community considerations.

The Solar District Cup is designed to inspire students to consider new career opportunities, learn new industry-relevant skills, engage with the professional marketplace, and prepare to lead the next generation of distributed solar energy. As competitors, students:

- Build experience with innovative renewable energy design
- Develop real-world solutions that shape the future of solar energy
- Engage with industry professionals to forge relationships and connections that aid participating students' transition to the solar energy workforce upon graduation
- Compete to earn national recognition upon winning a Solar District Cup and/or being selected as an industry choice winner.

The Solar District Cup invites participation by teams comprising at least three students enrolled in accredited U.S.-based collegiate institutions. In this case, "collegiate institution" refers to any school of secondary or higher education, including but not limited to community colleges, colleges, and universities. There is no cost to register or attend the fall workshop or the final competition event, and participating teams receive complimentary passes to conferences associated with the competition. After they register, teams will receive notification of acceptance on a rolling basis.

Competition organizers support student team effort through educational webinars on system design, modeling, and techno-economic analysis topics available free of charge to all student teams. Learn more at www.energy.gov/solardistrictcup.

Register to compete at www.herox.com/solardistrictcup.

Summary Timeline

The Solar District Cup 2020 is a two-semester (or three-academic-quarter) project, starting in fall 2019 and culminating in spring 2020.

- April 1, 2019—Competition announced and team registration opened.
- July 31, 2019—Rules published.
- September 12, 2019, 5:00 p.m. ET—Deadline for registration of participating teams.
- September 19, 2019—Participating teams announced.
- September 23–24, 2019—Competition introduction and networking workshop at the Solar Power International conference in Salt Lake City, Utah. Attendance is optional but recommended. Information presented will also be available to teams that cannot attend.
- November 21, 2019, 5:00 p.m. ET—Deadline for receipt of Progress Deliverable Package from all participating teams.
- December 12, 2019—Finalist teams announced.
- April 14, 2020, 5:00 p.m. ET—Deadline for receipt of Final Deliverable Package from finalist teams.
- April 23, 2020, 5:00 p.m. ET – Deadline for receipt of final presentation file from finalist teams.
- April 26–27, 2020—Finalists present projects online; winners announced. Live video attendance and presentation by at least one student team member from each finalist team is required. Only students may present to judges at the finalist event.

Background

Advancements in solar electric generation and battery electric storage technologies have resulted in decreasing costs and increasing rates of deployment. At the same time, preparation for professional careers in these technology applications—particularly at the nexus between the two—has limited existing post-secondary curricula.

As indicated in Chapter 5 of the Quadrennial Energy Review: Transforming the Nation's Electricity System, published by DOE:

> Workforce retirements are a pressing challenge. Industry hiring managers often report that lack of candidate training, experience, or technical skills are major reasons why replacement personnel can be challenging to find—especially in electric power generation.

Although the solar industry has matured significantly over the last decade, additional opportunities exist to integrate solar-plus-storage solutions at the district scale. With innovation and careful integration, property owners and utilities alike can realize benefits of a more resilient, cost-effective, and sustainable distributed energy source.

DOE has a history of supporting workforce development through competitions focused on project-based learning (e.g., Solar Decathlon, Collegiate Wind Competition, EcoCAR, Cleantech University Prize). Competitors gain experience solving relevant industry challenges that prepare them for successful careers in solar and related energy fields, benefiting from mentorship, training, collaboration, and networking. The competition supports DOE's ongoing work to help industry address structural employment gaps through comprehensive workforce development activities that simultaneously provide innovative solutions for partner districts' consideration and district-level ideas that inspire industry members.

The Solar District Cup encourages collaboration between academia and industry. The program seeks to establish public-private partnership, and demonstrate corporate and nonprofit industry cosponsorship.

For the purpose of this competition, the organizers develop district use cases based on existing campuses or urban areas. Each team develops its solution for its division's district use case, which enables students to work on real-world projects and access actual energy, site, and utility rate data while developing district distributed-energy solutions. These use cases are developed using input from district partners to provide real-world constraints and considerations. The solutions the teams develop provide insights that could inform the partner districts for future development of distributed energy systems.

To raise industry awareness and recognition of the student work, the competition organizers host a workshop that includes free team member access to the Solar Power International conference, part of North America Smart Energy Week, where students have access to industry networking. At the conclusion of the competition, student teams present their solutions to industry leaders and judges on a video conference, where winners are announced.

Competition Process

Introduction

The Solar District Cup challenges multidisciplinary collegiate student teams to design and model optimized distributed energy systems for a campus or urban district. A campus or district is a defined area of developed land containing a mixed-use group of buildings served by a local electrical distribution feeder. The systems proposed by students integrate solar photovoltaic (PV) generation, battery electric storage, and other distributed technologies and capabilities within the district's existing energy sources, uses, and infrastructure.

The winning teams in each division of the Solar District Cup 2020 receive a trophy and national recognition. Additionally, one team is identified as the industry choice winner. All student competitors gain valuable experience with real-life examples of innovative renewable energy design. Competitors learn to use leading industry software, present to nationally respected judges, and engage with industry mentors.

Goal

The goal for each team is to design a solar-plus-storage system for a campus or district that maximizes energy offset and financial savings over 20 years. Competition teams analyze electric distribution grid interactions and assume the role of renewable energy systems developers to produce a power purchase agreement (PPA) proposal for their division's district.

How To Enter

1. Go to the Challenge page at www.herox.com/solardistrictcup.
2. Create a HeroX account if you don't already have one, or sign in and then choose "Accept Challenge." This indicates your interest in competing; it is not a commitment.
3. By the registration deadline, one person on each team shall submit a "Registration" entry on HeroX to complete registration. This step is when you identify your collegiate institution and expected team makeup.
4. Registration entries received by the deadline are deemed participating teams.
5. Divisions are assigned by the competition organizers upon receipt of a complete registration entry. Assignments are ordered and cycled to ensure an equal number of teams in each division.
6. Multiple teams from a single school may enter, but only one team may compete per division.

7. Only one person per team may submit a registration entry. Other members join the team via HeroX. Team members may be added or removed from a team at any time. Once you have created a team, you can invite additional members using HeroX.

How To Win

A team competes against all other teams in a division, each with a single district use case. Competition organizers assign teams to divisions upon registration. Each team designs its own solution for the district use case. The strongest team concepts are those that provide the highest offset of annual energy and power and illustrate financial viability through a techno-economic analysis. A team wins based on its total score as determined by a panel of three to five judges who evaluate the competition entries through review of written deliverables and presentations. The first-place winners of each division compete against each other to determine an industry choice winner.

Divisions and District Use Cases

The Solar District Cup has three divisions. Each division has at least six teams competing against each other.

Each division has a distinct use case of an existing mixed-use urban district or campus interested in pursuing increased distributed energy development. The competition organizers provide each team with the details of the district use case for the division in which the team is competing.

A district use case is a defined area served by an electrical distribution feeder with a collection of buildings, open space, parking, and infrastructure. The use case for each district includes the following data set, at a minimum:

- A map designating the boundaries of the campus or district in which student teams are confined to designing their systems, and GIS coordinates locating the center of this map.
- Twelve consecutive months of 15-minute interval load (energy consumption) data for several of the buildings that are within the district and connected to the feeder.
- Location of the electric utility meters at each building (i.e., where PV systems interconnect).
- Location and rating of the substation transformer serving the district.
- Size and length of the distribution wires serving the district.
- Electric utility rate schedule.
- A development master plan, land ownership information, local zoning codes, and permitting requirements for land use.

The district use cases might have select details simulated or otherwise changed by the competition organizers for the purposes of the competition. Information provided to teams is intended to be used only by the team members. The data provided is not for redistribution to the public or for use outside of the competition.

What To Submit

Teams submit two deliverable packages: a Progress Package and a Final Package. These packages are described in Table 1 and Table 2 below and are discussed in greater detail in the appendices. All competition deliverables are submitted via HeroX.

Progress Deliverable Package—Solar PV System

A complete submission for the progress deliverable is the design and techno-economic analysis of interconnected solar PV systems that maximize energy offset and savings over a 20-year PPA for the division district use case.

The competition organizers evaluate the Progress Deliverable Package using the evaluation statements in Table 1. Competition organizer staff reviewers evaluate the degree to which they "agree" or "disagree" with the individual evaluation statements. Teams advance as finalists if the reviewers agree (on average) with the evaluation statements more than they disagree with the statements. Teams do not compete against each other to become finalists.

Table 1 comprises the content requirement summaries and corresponding evaluation statements for the Progress Deliverable Package. The required file format of each component of the Progress Deliverable Package is indicated in brackets. Each deliverable must use the information provided in the district use case and the assumptions and resources cited in Appendix A. Additional details on the required components of the deliverable package are provided in Appendix C. Additionally, the submission form on the HeroX platform asks teams to answer a few short questions about team makeup, approach to work done to date, and planned work for winning the competition in the next stage. These additional questions are not judged, but they are used to enable continuous program improvement by the organizers.

Table 1. Progress Deliverable Package Content and Evaluation Statements

Content	Evaluation Statement
1. Conceptual System Design	
A. Layout and specifications for the solar electric PV systems proposed within the district on one or more rooftops, parking lots, or ground areas [PDF].	A. Conceptual system design is complete and reasonable for PV system location and specifications.
B. Average hourly energy production output for each system over annual period [Excel spreadsheet].	B. Energy output is complete, based on a reasonable yield factor, and accounts for climatic variables.
2. Distribution System Impact Analysis	
A. Descriptive approach to power flow model [PDF], including: i. Irradiance profiles for the proposed PV systems ii. Load profiles for the connected buildings iii. Size of PV systems to comply with utility code iii. Control settings for the PV systems, capacitor banks, and voltage regulators.	A. Approach document provides clear explanation of input choices.
B. Power flow model [OpenDSS[1] input and output]: i. Demonstrating all network elements satisfy loading and voltage constraints ii. Demonstrating active elements have realistic settings, responses, and dead times.	B. Power flow model voltage analysis shows operation within expected bandwidth and with reasonable inputs.
3. Financial Analysis	
A. A project financial model that uses the production data and other inputs to generate a PPA price for a 20-year term and that achieves a net present value of $0 [Excel spreadsheet].	A. Financial model has a complete set of reasonable inputs, models cash flows competently, and has a PPA price output that conforms to market benchmarks.
4. Development Plan	
A. Building and site plan for conceptual system design, including applicable local ordinances [PDF].	A. Building and site plan demonstrates compliance with district master plan, zoning, and other land use building restrictions.
B. Construction plan to procure necessary permits and comply with local codes [PDF].	B. Development plan demonstrates compliance with permitting and relevant codes.

[1] OpenDSS is an electric power distribution system simulator (DSS) for supporting distributed resource integration and grid modernization. It is available free of charge at http://smartgrid.epri.com/SimulationTool.aspx.

Final Deliverable Package—Solar PV Plus Battery Electric Storage System

The Final Deliverable Package includes a complete conceptual design and techno-economic analysis of a proposed **interconnected solar PV plus battery electric storage system for the division district that maximizes energy offset and savings over a 20-year PPA for the division district,** given the following parameters and conditions.

The competition gives student teams an optimization challenge of how to schedule the battery charge and discharge cycles in coordination with the solar PV system to net the greatest value for the district. This practice—known as "value stacking"—involves optimizing battery charge and discharge cycles for a set of use cases (e.g., load shifting, peak shaving, resilience) for the maximum economic benefit to the district. Battery-storage economics are driven by the dispatch strategy, ensuring that the value derived is greater than the cost incurred to charge the battery. To maximize value, a developer must identify what applications a battery should serve and when to serve each.[2] The two primary parameters[3] for which students can optimize the charge and discharge cycle of the battery are:

- Time-of-use bill management (i.e., load shifting).
- Demand charge reduction (i.e., peak shaving).

In addition to these parameters, the final deliverable should reflect the following conditions:

- System design changes and financial implications of meeting the specific district goals as provided by the organizers at the beginning of the competition.
- A proposed value of resilience.

The Final Deliverable Package requires student teams to update their Progress Deliverable Package to reflect their approach to the value-stacking optimization challenge, as well as to add three new components:

- A savings analysis to be included with the financial model.
- A narrative describing the team's optimization strategy and how this strategy is reflected in the sub-deliverables.
- Two presentations summarizing the Final Deliverable Package.

Table 2 provides a content requirement summary of the Final Deliverable Package. The required format for each component of the final deliverable is indicated in brackets. Additional details on the required components of the deliverable package are provided in Appendices C and D. Judges evaluate the Final Deliverable Package using a scale from 1 to 6 to agree or disagree with the assigned statements listed in Table 2, as shown in Table 3.

[2] *Optimizing Energy Storage Economics*, NREL, https://www.nrel.gov/docs/fy16osti/66967.pdf.
[3] *The Economics of Battery Storage*, Rocky Mountain Institute, https://rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf.

Table 2. Final Deliverable Package Content and Judging Statements

See Appendices B and D for Final Deliverable Package content and formatting requirements.

Content	Judging Statements for Evaluation
1. Conceptual System Design	
A. Layout and specifications for PV system(s) with battery electric storage system(s) added, including summary description of results and underlying assumptions used in the analysis [PDF]. B. Average hourly energy production output over annual period, including battery charge and discharge cycles [Excel spreadsheet].	Conceptual system design proposes creative and innovative solution that demonstrates excellent site analysis, alignment with partner district goals, and optimal battery use.
2. Distribution System Impact Analysis	
A. Descriptive approach to power flow modeling, including summary description of results and underlying assumptions used in the analysis [PDF]. B. Rationale for sizing and siting the battery, including: i. Explanation and selection of operating mode (e.g., peak shaving, self-consumption, capacity firming) and corresponding input settings for the battery system. ii. Assumptions made to model the battery, including round-trip efficiency parameters. iii. Justification for any changes to the distribution system infrastructure either needed or avoided as a result of adding the PV and battery systems [PDF]. C. Power flow model demonstrating the proposed solar PV plus battery systems can operate without voltage violations [OpenDSS input and output].	Power flow modeling approach demonstrates sophisticated strategy to integrate a reliable solution into the distribution system while operating within voltage and loading restrictions.

Table 2. Final Deliverable Package Content and Judging Statements (cont.)

See Appendices B and D for Final Deliverable Package content and formatting requirements.

Content	Judging Statements for Evaluation
3. Financial Analysis	
A. Financial narrative including [PDF]: i. Expected system operation within utility rate structure ii. Value stacking of battery use cases iii. Valuation of resilience premium. B. Financial model comprising i. Project financial model that uses the production data, battery operation, and other inputs to generate a PPA price or prices (reflecting both the solar and battery systems) for a 20-year term. Net present value of the system should be $0 to reflect breakeven economics for the system owners [Excel spreadsheet]. ii. Customer savings model that demonstrates annual cash flows for the PPA offtakers (i.e., the district) and provides a net present value of savings over the term of a 20-year PPA contract [Excel spreadsheet].	Financial analysis communicates a compelling solution integrating thoughtful approach to renewable energy project finance, justifiable input assumptions, proper calculations, sound battery-operation strategy, and a creative methodology for value stacking.
4. Development Plan	
A. Building and site plan for conceptual system design, including any proposed rezoning [PDF]. B. A construction and development plan to implement the design [PDF], including: i. Necessary construction and land use permits. ii. Compliance with applicable local codes. iii. Potential risks to successful deployment. iv. Approach to address potential concerns and questions of district decision makers and surrounding community members.	Proposed building, site, construction, and development plans with any rezoning adds significant value in a comprehensive, actionable, and feasible approach for the entire district and surrounding community.
5. Optimization Strategy	
A. Written narrative that describes the team's structure, approach to system design, strategy for optimization, final solution, and progress toward meeting district goals [PDF]. B. Presentations on the team's approach to the system design, operation, optimization, and innovation [PPTX & live presentations].	• The team's approach to system design, optimization, and innovation demonstrates substantial progress toward meeting district goals. • The team communicates its solution effectively, clearly demonstrating why it should win.

How Entries Are Scored

A qualified panel of three to five judges, comprising subject-matter experts and representatives from the partner district use cases selected by the competition organizers, score finalist submissions according to the judging statements listed in Table 3.

Table 3. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

The following is a list of steps and actions the judges take to ensure each finalist entry receives fair and equal consideration.

1. Judges review Final Deliverable Packages submitted by each team.
2. Each statement listed in the "Judging Statements for Evaluation" receives a preliminary score between 1, "strongly disagree," and 6, "strongly agree" (on the scoring scale shown in Table 3), based on the professional determination of the judges.
3. The statements have equal weight, so it is critical that teams successfully complete each component of the deliverable package while maintaining a comprehensive and innovative optimization strategy overall.
4. The scores from each judge for each statement are averaged, and the averages are summed to determine the team's total preliminary score. The maximum score a team can receive is 36. (There are 6 judging statements for evaluation, each worth a maximum of 6 points.)
5. The preliminary scores for all teams in the division yield a preliminary ranking of teams.
6. The judges witness a 15-minute live presentation by each team to inform final scores and determine the winners of the competition. Each division will present in parallel. Ten minutes will be provided for judges to ask questions of each team. A maximum of five students per team may present.
7. The judging panel convenes following the video conference presentation to review preliminary scores, discuss and agree upon final scores for each statement, and determine the winners of the competition.
8. First-, second-, and third-place winners are identified and announced. Individual scores for each team are not released. No ranking is completed beyond third place. The judges' feedback is provided to each team individually.
9. The first-place winner of each division presents an 8-minute project story to industry attendees at the final event. Final event attendees select an industry choice winner from among the presenting teams. The presentations are open to all conference participants, increasing the recognition of the top teams. The division and competition process is illustrated in Figure 1.

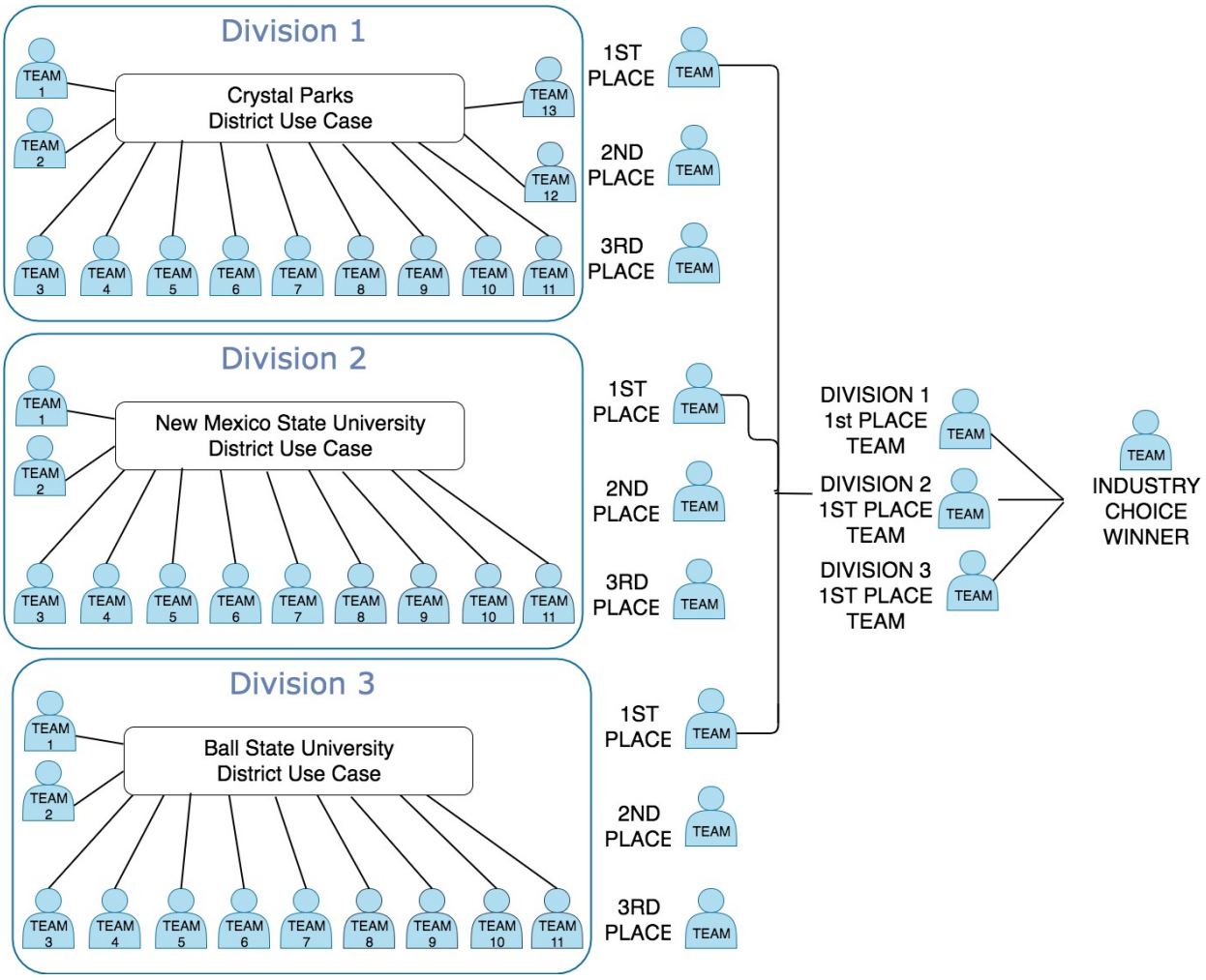

Figure 1. Division and competition process

Judges may not have personal or financial interests in; be an employee, officer, coordinator, or agent of any entity that is a registered participant in; or have a familial or financial relationship with an individual who is a registered competitor in this contest.

Who Can Enter

The Solar District Cup invites participation of teams composed of at least three students enrolled in accredited U.S.-based collegiate institutions. Students must be enrolled in at least one class and be pursuing a degree for the duration of the competition. Students and faculty advisors are not required to be U.S. citizens but must be legally residing in the United States at the time of the competition. Members of the judging panels, competition organizer staff, and DOE and national laboratory employees are ineligible to compete.

Although any level of collegiate student is eligible to compete, the challenge scope is intended for multidisciplinary teams of upper-level undergraduate students. Student participation may be integrated into senior design or capstone work, count as elective or independent study course credit, be added to the curriculum of existing classes, or be considered an extracurricular student activity.

Each team is encouraged to have at least one faculty advisor, but this is not required for participation. If a team of students needs assistance in identifying a faculty advisor, it can contact the competition organizers for help.

By uploading a deliverable package, a team certifies that it is in compliance with the eligibility requirements. If the organizers become aware that a team or individual is not eligible, that team may be disqualified from competition.

Travel for Competition

Workshop at Solar Power International (optional)

The competition organizers host a free workshop and competition event at Solar Power International in Salt Lake City, Utah, in September 2019. At this optional but highly recommended event, teams have an opportunity to engage with industry leaders, meet with district use case partners, and receive training from the competition organizers. Workshop and conference registration is free to team members. Teams are responsible for their travel and lodging expenses.

Final Competition Event on Video Conference

The competition organizers host the final competition event as a video conference in April 2020. At this event, teams present their projects to industry judges and the winners of each division are announced. The first-place winners of each division present to video conference attendees, who then select an industry choice winner. Live video conference attendance and presentation by at least one student team member from each finalist team is required. A maximum of 10 team members per team are allowed to attend.

Curriculum Support

Students and faculty who participate as a team may participate as part of a class, a design project, or a curricular activity. The team effort is supported by a series of optional online educational webinars presented by the competition organizers on the techno-economic analysis topics. The webinar topics relate specifically to the required elements of the deliverable packages. Faculty advisors are expected to provide guidance to teams toward successful completion and, where feasible, may integrate activities into existing coursework or curriculum.

Competition Authority and Administration

The Solar District Cup is organized by DOE and the National Renewable Energy Laboratory (NREL), which is managed and operated by the Alliance for Sustainable Energy, LLC, for DOE. Funding is provided by the DOE Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed herein do not necessarily represent the views of DOE or the U.S. government.

The Solar District Cup 2020 is governed and adjudicated by this rules document, which is intended to establish fair contest rules and requirements. The competition is designed and administered by a team of competition organizers consisting primarily of DOE and NREL staff. In the case of a discrepancy with other competition materials or communication, this document takes precedence. The latest release of these rules takes precedence over any prior release. The organizers reserve the right to change contest criteria, rules, and outcomes as needed. Additionally, competitors are encouraged to bring to the organizers' attention rules that are unclear, misguided, or in need of improvement. For the purposes of competition evaluation, a violation of the intent of a rule will be considered a violation of the rule itself. Questions on these rules or the program overall can be directed to solardistrictcup@nrel.gov.

The Solar District Cup is collegiate design competition. There is no expectation that any of the submitted entries will be built or implemented by the students or partner districts.

Partners

The Solar District Cup depends on partnerships to be successful. We would like to thank the following organizations for their impactful support of the competition and the student teams:

Aurora Solar

This software company has created a one-stop, cloud-based solution to streamline the solar design and sales process. It is providing all competing teams free accounts and access to its solar software, offering customized training, and staffing "Office Hours" sessions throughout the competition.

HeatSpring LLC

This technology firm has developed a platform that helps knowledge leaders better reach knowledge seekers. It offers online courses led by industry experts for professionals in renewable energy industries, including solar and green building. HeatSpring is providing a training platform and solar industry training content for all competing students and staff "Office Hours" with solar business experts Keith Cronin and Chris Lord.

Solar Power Events

This group is behind North America's largest solar and storage events and is owned by the Solar Energy Industry Association and Smart Electric Power Alliance. The organization provided space, promotion, and amenities for the Solar District Cup at Solar Power International 2019 and will do the same at Solar and Energy Storage Southeast 2020.

District Use Cases

The Solar District Cup 2020 has three divisions to which teams have been randomly assigned. Each division centers on a distinct use case of a real-world mixed-use urban district or campus interested in pursuing distributed energy solutions.

The Solar District Cup would not be able to provide access to these districts and campuses without the collaboration of our 2020 Solar District Cup use case partners and their willingness to organize and provide valuable data about their districts to the student teams:

- Ball State University
- JBG SMITH
- New Mexico State University.

These organizations have generously given their time and data to ensure that their districts were accurately represented and provided the student teams with robust challenges to drive competition.

Appendix A. Resources for Model Input Assumptions

A series of assumptions and resources are provided to serve as the baseline of input to all teams' design and analysis. NREL and other organizations regularly publish cost benchmarks and industry-analysis documentation that estimate the cost for system technologies and components, development strategies, value-stacking opportunities, and other related figures. Teams are encouraged to research and select all elements, but approximate starting values are provided here. Should a team choose to use a different value, an explanation should be provided and a publicly available source for the value cited. Although teams are encouraged to discuss the competition and their proposed solution with industry professionals, costs or assumptions not publicly available to all teams are not to be used in calculations. Unless qualified alternates are used following the previously described process, all teams should use the input values listed under the two "Assumptions" sections.

Note that, in addition to providing system production output, NREL's System Advisor Model (SAM) also includes default assumptions for many of the input values required to run the financial model. Students may use any resources or tools desired to derive their financial modeling inputs, study modeling mechanics, or validate their results, but teams must develop their own financial models to be submitted in the deliverable packages. The NREL SAM tool and materials specified below can be used as a baseline for successful analysis. Submissions of SAM Excel exports in lieu of a student-constructed financial model will not be accepted. Student manipulation and development of financial models based in part on other resources is acceptable. The link for SAM is provided below (users are required to register when using SAM for the first time, but registration is free).

Written Resources

- NREL PV System Cost Benchmark provides data points for PV system and component costs. Additional unitized balance of system costs are available in the "Financial Model Assumptions" section.
- NREL Financing Terms and Trends provides data points for PV cost of capital (debt, tax equity, and partner equity inputs).
- Emerging Opportunities and Challenges in Financing Solar provides general information on how PV projects are financed using tax incentives in the United States.
- Best Practices for Operation and Maintenance of Photovoltaic and Energy Storage Systems (3rd Edition) provides cost figures for operations and maintenance.
- Database of State Incentives for Renewables and Efficiency provides information on state and local incentives for PV and PV-plus-storage systems.
- Solar District Cup Training Course on HeatSpring provides free videos and written resources relating specifically to the required activities of the Solar District Cup.

Models and Software Tools

- Aurora Solar—Can be used to create 3D site layouts, design PV systems, perform shading analysis, and estimate PV system performance.
- SAM—Can be used for PV systems production modeling and financial model validation.
- REopt™ Lite—Can be used for battery operations analysis.
- OpenDSS—Can be used for distribution system voltage analysis.
- Cost of Renewable Energy Spreadsheet Tool—Can be used as a reference or instructive tool in designing Excel-based renewable energy financial models.
- NREL Annual Technology Baseline and levelized cost of energy calculator—Can be used to source data points and validate the inputs/outputs of other models.

- ArcGIS Online—Can provide parcel, zoning, and other information for plan development.
- HeatSpring Solar Executive MBA Financial Model template – Can be used as a template financial model for the system(s) proposed by competing teams. Note: must be logged in to the free HeatSpring course to access.

Financial Model Assumptions

- Property tax: Assume $0 over the course of the PPA.
- Sales tax: Assume all sales tax already is expressed in the total system cost.
- Corporate tax rate: Assume 27% for state plus federal total rate.
- Developer margin: Assume 0% margin (this is a different figure from partner internal rate of return); that is, all systems will be modeled as breakeven.
- Assume a construction timeline of six (6) months. All systems in the district should have the same commercial operation date.
- PV useful life is 30 years.
- PPA contract term is 20 years.
- System degradation is 0.5% per year.
- Inflation is 2% per year.

Open DSS Information To Be Provided To Teams Specific To Each District Use Case

Topological Data

- Line lengths.
- Line codes.
- Conductor layout configuration.
- Substation and distribution transformer parameters.
- Load configuration (peak load, phase configuration, power factor).
- PV systems (phase configuration, inverter settings, AC-DC ratio, PV rating).

Loading Profiles

Fifteen-minute resolution advanced metering interval data for select buildings, or modeled data using substation loading profile supervisory control and data acquisition data combined with load allocation using peak load to develop synthetic profiles for individual loads.

Appendix B. Deliverable Package Submission Requirements

Deliverable packages are considered to be on time if they are received by the respective due date and time as indicated on HeroX. Late submissions may be considered on a case-by-case basis but are marked as such with guidance given accordingly by the reviewers or judges.

PDF Requirements

Submitted PDF files shall meet the following criteria:

- Be written in complete, legible English.
- Have all fonts embedded.
- Maintain a minimum resolution of 300 dpi or be vector-based.
- Bookmarked.

Excel Requirements

Submitted Excel files shall meet the following criteria:

- Include all formulas used to calculate results.
- Explain any macros or associated internal scripts.
- Indicate where cells are using an input assumption versus a calculated result.
- Generate natively, if at all possible; imports from other programs should be carefully reviewed.

PowerPoint Requirements

Submitted PowerPoint (PPTX) files shall meet the following criteria:

- Use 16:9 aspect ratio.
- No embedded video or audio.
- Have all fonts and images embedded without external file references.

File Name Requirements

Submitted deliverable package files shall be named as follows:

- [DistrictUseCaseAbbreviation]_[SchoolShortName]_[DeliverableSection].[extension].
    - [DistrictUseCaseAbbreviation] is BSU, CP, or NMSU.
    - [SchoolShortName] is your collegiate institution commonly recognized and distinct short name or abbreviation.
    - [DeliverableSection] is given in the Appendix D. format requirements.
    - [extension] is PDF, XLSX, ZIP, or PPTX.

Appendix C. Progress Deliverable Package Requirements

Progress Deliverable Package

1. A. Conceptual System Design—Layout and Specifications

Format Requirements

☐	File type: single, bookmarked PDF.
☐	Up to 30 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.

Content Requirements

☐	System design summary of approach and solution (maximum 2 pages).
☐	Description of equipment selection and specifications, including process for optimization (maximum 2 pages).
☐	Site plan showing all proposed installations.
☐	Individual installation plans showing individual panels and location of associated equipment.
☐	Shading models for each proposed installation.

1. B. Conceptual System Design—Energy Production

Format Requirements

☐	Packaged into a single Excel file, multiple tabs allowed.

Content Requirements

☐	Hourly generation profile for each proposed solar installation over a year.
☐	Details of inputs and process used to calculate the hourly generation profile.
☐	Source of irradiance model used.

2. A. Distribution System Impact Analysis—Approach To Power Flow Model

Format Requirements

☐	File type: single, bookmarked PDF.
☐	Up to 12 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.

Content Requirements

☐	Summary of the methodology for sizing and siting PV systems and resulting impact of PV on the distribution system.
☐	Summary of the impact of PV system interconnection on the distribution system incorporating voltage/distance plots or voltage and loading heat maps.
☐	Summary of factors that impact PV system hosting capacity on the distribution system and the impact of using smart inverter control modes.
☐	Summary of systems operation detailing configurable settings used for the simulation study.
☐	Summary of the methodology used for any system upgrade detailing any component that was upgraded.

2. B. Distribution System Impact Analysis—Power Flow Model

Format Requirements

☐	File type: ZIP archive of OpenDSS and profiles.
☐	Simulation study should be carried out for at least a year at a minimum 15-minute temporal resolution.

Content Requirements

☐	Complete OpenDSS model.
☐	All dependencies (e.g., the profiles used to run the time series analysis).

3. A. Financial Analysis

Format Requirements

☐	File type: Excel file meeting the requirements listed in Appendix B.
☐	All formulas calculated, any macros explained, and all derived values highlighted in yellow.

Content Requirements

☐	PV system cost inputs and sources: • Modules, including type and quantity. • Balance of system elements. • Wiring. • Interconnection. • All other relevant element and construction costs.
☐	Financial performance inputs and sources: • Cost of capital and breakdown (e.g., tax equity versus debt). • Discount rate. • Solar investment tax credit (ITC) benefit assumed. • Modified accelerated cost recovery system (MACRS) schedule utilized. • PV system yield assumptions. • Construction loan interest and term. • Incentives available and benefits. • Property taxes. • Operation and maintenance assumptions. • Inflation assumptions. • PPA contract term. • System life and degradation. • Residual value assumption.
☐	Cash flows over 20-year PPA term.
☐	Offered PPA to district and justification.

4. A. Development Plan—Building and Site Plan

Format Requirements

☐	File type: single, bookmarked PDF.
☐	Up to seven pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.

Content Requirements

☐	Summary of proposed building and land utilization approach.
☐	Analysis of applicable land use and zoning ordinances compliance.
☐	Analysis of location suitability (roof, building, parking) and attractiveness for development.
☐	Demonstration of compliance with district master plan(s) provided as part of the district use case.
☐	Demonstration of compliance with other land-use or building restrictions or regulations.

4. B. Development Plan—Construction Plan

Format Requirements

☐	File type: Single, bookmarked PDF.
☐	Up to 5 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.

Content Requirements

☐	Summary of construction approach to procure necessary permits and comply with local codes.
☐	Proposed timeline for construction.

Appendix D. Final Deliverable Package Requirements

1. A. Conceptual System Design—Layout and Specifications

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 40 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_ConceptualDesign.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	System design summary of approach and solution (maximum 2 pages).
☐	Description of equipment selection and specifications, including total DC size of each system, total project size, and battery details, including process for optimization (maximum 2 pages).
☐	Site plan for entire district showing all systems.
☐	Individual system plans showing individual panels and location of associated equipment.
☐	One-line diagrams for each system and wiring required between systems.
☐	Shading models for each installation.

1. B. Conceptual System Design—Energy Production and Battery Cycles

Format Requirements

☐	File type: packaged into a single Excel file; multiple tabs allowed; see Appendix B.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_ConceptualDesign.XLSX.

Content Requirements

☐	Hourly generation profile for each solar system over a year.
☐	Details of inputs and process used to calculate the hourly generation profile.
☐	Source of irradiance model used and inputs for the battery charge/discharge strategy.

2. A. Distribution System Impact Analysis—Approach to Power Flow Model

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 12 pages; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_DistributionSystemAnalysis.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	The methodology, assumptions, and results for sizing of PV systems.
☐	The impact of PV system interconnection on the distribution system incorporating voltage/distance plots or voltage and loading heat maps.
☐	Sensitivity analysis for factors that impact PV system hosting capacity on the distribution system, including use of smart inverter control modes.

2. B. Distribution System Impact Analysis—Battery Rationale

Format Requirements

☐	File types: single, bookmarked PDF; see Appendix B.
☐	Up to 15 pages total in PDF; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_DistributionSystemBattery.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	The methodology and assumptions for sizing and siting battery storage systems.
☐	Battery systems operation detailing settings used for the simulation study.
☐	The methodology used for any system upgrade detailing any component that was upgraded.
☐	If the REopt Lite profile is used, the profile should also be provided.

2. C. Distribution System Impact Analysis—Power Flow Model

Format Requirements

☐	File types: ZIP archive of OpenDSS or other model.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_DistributionSystemModel.ZIP.

Content Requirements

☐	Model input and output files.
☐	The ZIP file should also contain all dependencies (e.g., the profiles used to run the time-series analysis).

3. A. Financial Analysis—Financial Narrative

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 10 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_FinancialNarrative.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	Summary of approach to financial modeling.
☐	Expected system operation within utility rate structure.
☐	Explanation of value stacking of battery use cases.
☐	Explanation of valuation of resilience premium.

3. B. Financial Analysis—Financial Model

Format Requirements

☐	File type: Excel file meeting the requirements listed in Appendix B.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_FinancialModel.XLSX.

Content Requirements—Project Financial Model Tab

☐	**Students are strongly encouraged to use one of the templates provided in Appendix A for their financial model, including the HeatSpring Solar MBA template, the Cost of Renewable Energy Spreadsheet tool.**
☐	For calculation of solar + battery savings to the district, students may choose to use one of NREL's free tools, including SAM and REOpt Lite (see Appendix A). Both tools will require an Excel export to present model inputs, calculations and outputs (e.g. cash flows, PPA price, etc.).
☐	PV system cost inputs and sources: • Modules, including type and quantity. • Balance of system elements. • Wiring. • Interconnection. • All other relevant element and construction costs.
☐	Financial performance inputs and sources: • Cost of capital and breakdown (e.g., tax equity versus debt). • Discount rate. • Solar ITC benefit assumed. • MACRS schedule used. • PV system yield assumptions. • Construction loan interest and term. • Incentives available and benefits. • Property taxes. • Operation and maintenance assumptions. • Inflation assumptions. • PPA contract term. • System life and degradation. • Residual value assumption. • Value-stacking assumptions.
☐	Cash flows over 20-year PPA term.
☐	Expected return on investment for developer calculation and results.
☐	Offered PPA to district and justification.
☐	Battery usage model and financial performance.

Content Requirements—Customer Savings Model Tab

☐	All inputs and assumptions from PPA model.
☐	Customer district financial analysis: • Cost of capital and breakdown (e.g., tax equity versus debt). • Use of land analysis. • Utility-rate analysis.
☐	Cash flows over 20-year PPA term for PPA offtakers (i.e., the district).
☐	Net present value of savings over term of PPA contract.
☐	Expected system operation within district rate structure.
☐	Value stacking opportunities.
☐	Valuation of resilience premium.

4. A. Development Plan—Building and Site Plan

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 20 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_BuildingSitePlan.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	Summary of proposed building and land utilization approach.
☐	Analysis of applicable land use and zoning code compliance.
☐	Analysis of location suitability (roof, building, parking) and attractiveness for development.
☐	Demonstration of compliance with existing zoning or proposed rezoning.
☐	Demonstration of compliance with district master plan.
☐	Demonstration of compliance with other land use or building restrictions or regulations.

4. B. Development Plan—Construction and Development Plan

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 10 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_ConstDevelopPlan.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.
☐	Summary of development plan.
☐	Analysis of permitting and relevant code requirements.
☐	Construction approach.
☐	Construction timeline.
☐	Strategy to engage partner district decision makers.
☐	Strategy to engage community members and achieve buy-in for project.
☐	Discussion of risks to successful deployment.
☐	Approach to addressing potential concerns of community members and district owners.
☐	Feasibility analysis.

5. A. Optimization Strategy Narrative

Format Requirements

☐	File type: single, bookmarked PDF; see Appendix B.
☐	Up to 10 pages total; any additional pages submitted will not be reviewed.
☐	ANSI A (8.5" x 11") paper size must be used.
☐	Minimum font size of 11 points, minimum ½" margin on all sides.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_OptimizationStrategy.PDF.

Content Requirements

☐	Title including names of school, team, district use case, and deliverable section.

☐	Summary of team structure, including team member names and degree program and level.
☐	Summary of final solution.
☐	Description of strategy for optimization.
☐	Approach to system design, including operation.
☐	Optimization and performance strategy.
☐	Alignment with district needs and interests.
☐	Innovation, as it relates to optimized design and operation of the system.

5. B. Optimization Strategy Presentation

Format Requirements

☐	File type: PowerPoint; see Appendix B.
☐	15 minutes for division presentation and 8 minutes for presentation by first-place winners of each division.
☐	Proofread document for spelling, grammar, legibility, and formatting.
☐	File named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_DivisionPresentation.PPTX.
☐	Optionally, a second, shorter presentation named as follows: [DistrictUseCaseAbbreviation]_[SchoolShortName]_IndustryPresentation.PPTX.

Content Requirements

☐	Title slide including names of school, team and district use case.
☐	Summary of team approach to: • Competition, including team structure and work effort. • System design. • Expected operation.
☐	Summaries of deliverable package sections 1–4.
☐	Summary of innovation as it relates to: • Optimized design. • System operation.
☐	Summary of the optimization strategy to result with a solution that best meets the needs and goals of the district.

U.S. DEPARTMENT OF ENERGY

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COLLEGIATE DESIGN COMPETITION

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