AMERICAN MADE

U.S. DEPARTMENT OF ENERGY

Official Rules: Data-Driven Distributed (3D) Solar Visibility Prize

THESE RULES ARE EFFECTIVE JUNE 27, 2024

Preface

The U.S. Department of Energy's American-Made Data-Driven Distributed (3D) Solar Visibility Prize will be governed by 15 U.S.C. §3719 and this Official Rules document. This is not a procurement under the Federal Acquisitions Regulations and will not result in a grant or cooperative agreement under 2 CFR 200. The prize administrator reserves the right to modify this Official Rules document if necessary and will publicly post any such notifications as well as notify registered prize participants.

Contents

Modification Summary

Date	Modifications
Revision 1 5/24/2024	Page 13: Modified the text around metrics with respect to changes made to the metrics. Page 17: Modified the text around metrics with respect to changes made to the metrics. Page 21: Updated the metrics that will be used in the competition to make them simpler.
Revision 2 6/127/2024	Page 6: Added the deadline to upload the executables. Page 18: Added more details about the network model format. Page 19: Added more details for the bad data that will be present in the historical measurement sets. Page 20: Modified the measurement temporal granularity. Provided more detail about the measurements at the same location. Page 22: Updated the lower limits for calculating the M_1 metric.

1 Introduction

The American-Made 3D Solar Visibility Prize is designed to incentivize innovators to develop models and algorithms that can provide accurate and real-time information about distributed solar generation in electric power distribution networks. The goal of the prize is to enhance the reliability and resilience of electric power distribution networks that have large amounts of solar generation. This prize is a continuation of American-Made Solar Forecasting Prize and Net Load Forecasting Prize.

Building a clean energy economy and addressing the climate crisis are top priorities of the Biden administration. This prize will advance the Biden administration's goals to achieve carbon-pollution-free electricity by 2035, to "deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050"[1] to the benefit of all Americans. The U.S. Department of Energy (DOE) is committed to pushing the frontiers of science and engineering; catalyzing clean energy jobs through research, development, demonstration, and deployment; and ensuring environmental justice and the inclusion of disadvantaged communities.

The activities incentivized by this prize will support the governmentwide approach to the climate crisis by promoting innovation and early deployment of clean energy technologies resulting in wider adoption, which is critical for climate change mitigation. Specifically, the Solar Energy Technologies Office (SETO) in DOE's Office of Energy Efficiency and Renewable Energy is launching 3D Solar Visibility Prize to:

1. Increase stakeholder awareness of the state of the art in data-driven models and algorithms that provide accurate understanding of the electricity voltage, load, and power generation amounts (known as state estimation) including the contribution from distributed solar energy resources.
2. Demonstrate the feasibility of fair, transparent, and uniform evaluations of computation models and algorithms using the publicly available, open-source data and software platform, Open Energy Data Initiative Solar Integration (OEDI SI).[2] OEDI SI, a collaboration among multiple national labs with support from SETO, will serve as the benchmarking platform.
3. Promote the adoption and use of these models and algorithms by researchers and industry practitioners to evaluate distribution network modeling and analysis algorithms using transparent and uniform metrics and specifications.

Institutions, companies, nonprofit organizations, and individuals based in the United States are eligible to compete. This prize offers a total of $175,000 in cash prizes, with two (2) anticipated winners and three anticipated runners-up. DOE expects to select two (2) winners that will receive $50,000 (first place), and three (3) runners-up that will receive $25,000 each, in cash, based on the performance of their distribution state estimation algorithms.

Throughout the competition, competitors will have access to support from the American-Made Network, a diverse and powerful community of incubators, investors, philanthropists, fabrication facilities, and seasoned industry leaders who provide technical insight, business development expertise, product validation, and more.

Competitors will submit their state estimation calculation results to the OEDI SI platform. which is designed to enable reproducible, robust, replicable, and scalable simulations of distribution and

[1] Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad" (Jan. 27, 2021).
[2] https://openei.org/wiki/OEDI-SI/Overview

transmission networks with high solar generation resources. Historical and daily real-time measurements for two synthetic networks will be published on the OEDI SI website. The OEDI SI platform will be also used to assess distribution system state estimators' performance and to audit the results submitted by the competitors.

Currently, the solar industry and its associated research community do not reflect the diversity of the United States. Women and minorities are underrepresented in the solar industry and in science, technology, engineering, and math (STEM) fields. STEM fields also lack diversity in geographical origin, with U.S. rural areas underrepresented relative to large population centers. Because STEM students and graduates support research and development activities, which can often result in the formation of companies, the lack of diversity in that pipeline adversely affects opportunities and potential outcomes in scientific and economic output. To achieve the administration's energy justice goals, SETO is working to ensure that the work SETO funds will support more equitable participation in the solar energy community. SETO recognizes the inherent advantages of diverse teams and encourages competitors to consider diversity and inclusion when developing their teams. Additionally, the American-Made Network will support SETO in the recruitment of diverse applicants for the prize.

2 Background

As of October 2023, solar accounted for about 5.5% of U.S. electricity produced on an annual basis.[3] This means that to combat climate change, the nation's solar capacity would need to grow by hundreds of gigawatts in the next 15 years, with an annual rate of deployment three to four times higher than today's rate. Analysts expect that installed capacity of solar photovoltaics will surpass that of coal by 2027.[4] The *Solar Futures Study,*[5] released by SETO and the National Renewable Energy Laboratory (NREL) in September 2021, found that with aggressive cost reductions, supportive policies, and large-scale electrification, solar could account for as much as 40% of the nation's electricity supply by 2035 and 45% by 2050.

Integrating large amounts of variable energy resources, such as solar and wind, is a challenge for a power grid that was designed and built around central-generation thermal plants and unidirectional power flows. SETO's Systems Integration subprogram supports targeted technology research, development, and demonstration that addresses the technical goals identified in the Grid Modernization Multi-Year Program Plan,[6] SETO's previous efforts focused on distribution power network analysis, targeting several technical areas such as distribution state estimation and optimal power flow,[7] solar forecasting,[8] increasing the cyber-physical resilience of electric power,[9] and interoperability of grid-forming inverters.[10]

The 3D Solar Visibility Prize aims to incentivize the development and adoption of distribution system state estimation (DSSE) tools to improve visibility of distribution systems and their operating conditions. This will enable utilities and grid operators to make better operational decisions and optimize the use of distributed solar energy, which in turn will help address SETO's goal of accelerating the deployment of solar energy technologies. This prize is designed as a continuation of the American-Made Solar Forecasting[11] and Net-Load Forecasting[12] prizes.

Distribution System State Estimation

Distributed solar energy systems typically lack readily available near real-time monitoring data, creating a blind spot in network planning and operations for distribution network operators. DSSE involves calculating system operating conditions in near real time through sensor data.[13] It is a new concept in advanced distribution management systems that developers can use to ensure the reliability and resilience of the power grid as the amount of distributed solar energy on the grid increases.

Given the low visibility of distributed solar generation (residential, commercial, and industrial solar installations) and its variable nature, distribution state estimation is a powerful tool for accurate planning and real-time dispatch of those generation resources. Having accurate and real-time knowledge of their state would enable grid operators to optimize planning and operations.

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[3] Electric Power Monthly - U.S. Energy Information Administration (EIA)
[4] https://www.iea.org/energy-system/renewables/solar-pv
[5] *Solar Futures Study*
[6] https://energy.gov/downloads/grid-modernization-multi-year-program-plan-mypp
[7] https://www.energy.gov/eere/solar/funding-opportunity-announcement-enabling-extreme-real-time-grid-integration-solar-energy
[8] https://www.energy.gov/eere/solar/funding-opportunity-announcement-solar-forecasting-2
[9] Funding Opportunity Announcement: Advanced Systems Integration for Solar Technologies (ASSIST) | Department of Energy
[10] https://www.energy.gov/eere/solar/solar-energy-technologies-office-fiscal-year-2021-systems-integration-and-hardware
[11] American-Made Solar Forecasting Prize | Department of Energy
[12] American-Made Net Load Forecasting Prize | Department of Energy
[13] "A Review on Distribution System State Estimation", A Primadianto and C-N. Lu, https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7779155

Deployment of distributed solar energy resources on distribution networks is increasing exponentially, which poses challenges as well as opportunities. The two major challenges are their lack of near real-time visibility and their variable nature. On the other hand, distributed solar generation can provide grid services much faster and can mitigate potentially negative impacts of power system events better than their traditional large power generation counterparts. To exploit this and other advantages that distributed solar generation resources can provide, the distribution network operators need to have an accurate knowledge of their state, i.e., their voltage magnitudes, phase angles, and generation amounts as well as the net load at their installation point in the network.

For this purpose, a numerical analysis method used for the transmission network operators needs to be deployed at advanced distribution management systems as well. Power system state estimation is defined as solving for *n* number of unknowns (states) in *m* number of equations (measurements), where *m* is larger than *n*. Having more measurements than the number states provides the redundancy to eliminate the errors in measurements, thereby improving the accuracy required in the calculation of the states. These states, in turn, can be used in all the numerical analysis tools used in advanced distribution management systems. Power system state estimation has become a salient power systems analysis tool and an integral part of the energy management systems used by independent system operators for transmission network operations and planning. However, until recently, distribution networks have not had enough redundancy due to the lack of visibility of distributed solar generation resources and loads. As grid operators deploy more distributed solar generation each year, there is a need to incorporate DSSEs into advanced distribution management systems as an essential tool for operators and planners at distribution network operators. Having an accurate knowledge of the distribution system operating conditions in near real time (every 15 minutes or so) through sensor data[14] is essential for ensuring the reliability, resilience, and quality of the electricity delivered to consumers.

Open Energy Data Initiative Solar Integration Platform

To facilitate robust and scalable power system research on operating the distribution systems with high deployment of distributed solar generation more reliably and cost-effectively, SETO also initiated the development of the OEDI SI platform under the SETO FY2019-21 Lab Call.[15] OEDI SI is an open-source, cloud web portal that will serve as a single public data repository for integrating publicly available test systems and anonymized field data coming from multiple sources. Reference power systems analysis algorithms are also posted at OEDI SI so that power system analysis researchers can test, benchmark, and validate new approaches for power system analysis to support the integration of distributed solar generation.

The 3D Solar Visibility Prize will help increase awareness of the state of the art in distribution state estimators for distributed solar generation; demonstrate the data warehousing and computational capabilities of a public open-source platform, OEDI SI; promote wider adoption of DSSE methods by grid operators; and establish trust in transparent and uniform benchmarking metrics.

[14] "A Review on Distribution System State Estimation", A Primadianto and C-N. Lu, https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7779155
[15] https://www.energy.gov/eere/solar/solar-energy-technologies-office-lab-call-fy2019-21

3 Prize Overview

Every day for 14 consecutive days, competitors will submit their DSSE solutions for two distribution system networks through the OEDI SI platform. The submitted solutions must have a 15-minute resolution. Time-series composite input measurement data with a resolution of 15-minute snapshots will be provided on OEDI SI each day of the competition for a 12-hour period. The competitors are encouraged to read the input data and process details in Appendix 1.

The OEDI SI will compare the state estimator's performance against a set of industry standard metrics[16] (see Appendix 2 for more details).

The 3D Solar Visibility Prize offers a total prize pool of $175,000 in cash. The following table provides funding details.

	Number of Prizes Awarded	Prizes
Winners	Up to two (2) anticipated cash prizes	$50,000 each
Runners-Up	Up to three (3) anticipated cash prizes	$25,000 each

SETO anticipates making a total of up to five awards (two winners and three runners-up) but may or may not award winners and runners-up, depending on the performance of the competitors and the discretion of the evaluation process. However, the total prize purse will not exceed $175,000.

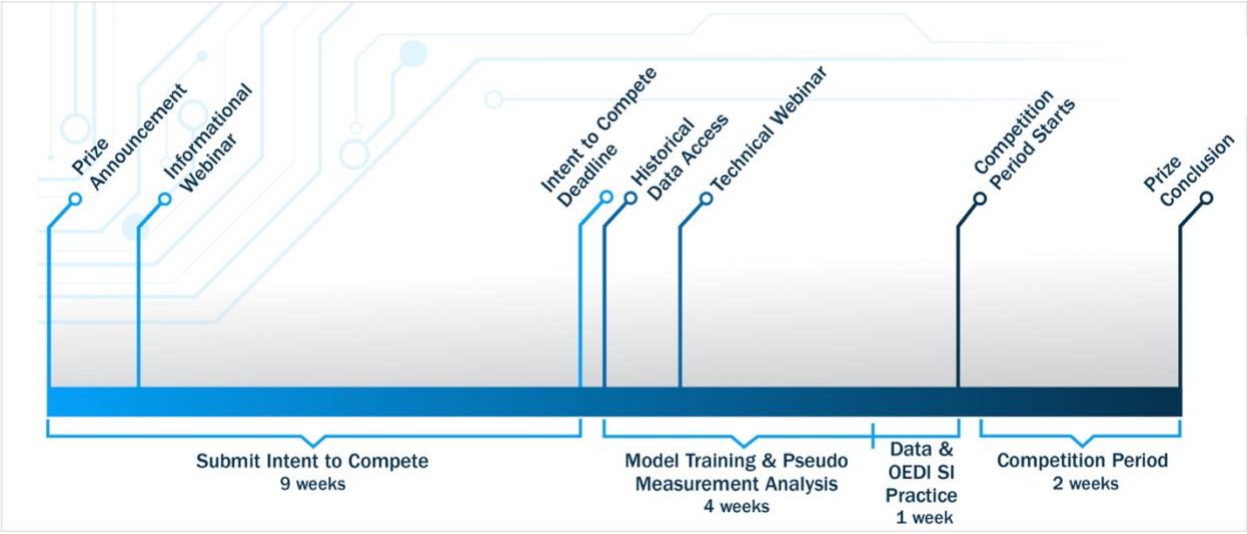
To learn more and sign up, go to https://www.herox.com/3D-Solar-Visibility-Prize.

[16] "A Review on Distribution System State Estimation Algorithms", Fotopoulou et al., Applied Sciences | Free Full-Text | A Review on Distribution System State Estimation Algorithms (mdpi.com)

4 Important Dates

- **Program Announced and Registration Opens:** May 8, 2024.
- **3D Solar Visibility Prize—General Informational Webinar:** May 29, 2024, 3:00 p.m. ET.
- **Intent to Compete HeroX Submission Package Deadline:** July 10, 2024, 5:00 p.m. ET.
  - **Note:** Competitors can only gain access to training data after they have submitted their Intent to Compete package. The competitors will have *9 weeks* to submit their packages**,** May 8 to July 10, 2024.
- **Access to Historical Data**: No later than July 15, 2024, 4 p.m. ET.
- **Technical Webinar for Registered Competitors**: July 17, 1:00 p.m. ET.
  - **Note**: The registered team are encouraged to thoroughly read the competition and the input data details in Appendix 1 and come prepared with any questions they may have.
- **Model Training on Historical Data and Pseudo-measurement Analysis**: From the date of access to historical data to the start date of the Competition Period (*four weeks*, July 15 through August 11).
- **Distribution State Estimation Practice Week (via OEDI SI platform):** August 5, 2024, through August 9, 2024.
  - **Note:** The Test Week is meant to give an opportunity to competitors to test their submission process with the OEDI SI platform before the actual competition begins. Participation is entirely optional but highly encouraged.
- **Deadline to Upload Algorithm Executables:** August 10, 2024, 5:00 p.m. ET.
- **Distribution State Estimation Competition Period (via OEDI SI platform):** August 12, 2024, through August 25, 2024.
- **Winners and Awards Announced:** October 2024 (anticipated).

For the most up-to-date information on prize deadlines and events, please visit our website: https://www.herox.com/3D-Solar-Visibility-Prize.



5 Prize Administrator

The NREL Prize Team will support competitors by cultivating resources and building connections through the American-Made Network that enhance, accelerate, and amplify their efforts. The objective is to link competitors with potential new team members as well as the resources, financing, perspectives, and relevant industry expertise necessary for long-term success.

NREL Technical Team will support the distribution network analysis, setting up the time-series data for two different distribution power network models, setting up the user accounts on OEDI SI, and monitoring the daily activities during the competition.

6 Eligibility Requirements

The competition is open only to individuals; private entities (for-profits and nonprofits); non-federal government entities such as states, counties, tribes, and municipalities; and academic institutions subject to the following requirements:

- An individual prize competitor (who is not competing as a member of a group) must be a U.S. citizen or permanent resident.
- A group of individuals competing as one team may win, provided that the online account holder of the submission is a U.S. citizen or permanent resident. Individuals competing as part of a team are eligible to participate if they are legally authorized to work in the United States.
- Private entities must be incorporated in and maintain a primary place of business in the United States.
- Academic institutions must be based in the United States.
- DOE employees, employees of sponsoring organizations, members of their immediate families (e.g., spouses, children, siblings, or parents), and persons living in the same household as such persons, whether or not related, are not eligible to participate in the prize.
- Individuals who worked at DOE (federal employees or support service contractors) within six months prior to the submission deadline of any contest are not eligible to participate in any prize contests in this program.
- Federal entities and federal employees are not eligible to participate in any portion of the prize.
- DOE national laboratory employees cannot compete in the prize.
- Entities and individuals publicly banned from doing business with the U.S. government such as entities and individuals debarred, suspended, or otherwise excluded from or ineligible for participating in federal programs are not eligible to compete.
- Individuals participating in a foreign government talent recruitment program[17] sponsored by a country of risk[18] and teams that include such individuals are not eligible to compete.
- Entities owned by, controlled by, or subject to the jurisdiction or direction of a government of a country of risk are not eligible to compete.
- To be eligible, an individual authorized to represent the competitor must agree to and sign the following statement upon registration with HeroX:

  > I am providing this submission package as part of my participation in this prize. I understand that the information contained in this submission will be relied on by the federal government to determine whether to issue a prize to the named competitor. I certify under penalty of perjury that the named competitor meets the eligibility requirements for this prize competition and complies with all other rules contained in the Official Rules document. I further represent that the information contained in the submission is true and contains no misrepresentations. I understand false statements or misrepresentations to the federal

[17] Foreign Government-Sponsored Talent Recruitment Program is defined as an effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to U.S. entities. Compensation could take many forms including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

[18] DOE has designated the following countries as foreign countries of risk: Iran, North Korea, Russia, and China. This list is subject to change.

government may result in civil and/or criminal penalties under 18 U.S.C. § 1001 and § 287 and 31 U.S.C. §§ 3729-3733 and 3801-3812.

In keeping with the goal of growing a community of innovators, competitors are encouraged to form diverse, multidisciplinary teams while developing their concepts. The HeroX platform provides a space where parties interested in collaboration can post information about themselves and learn about others who are also interested in competing.

6.1 Number of Submission Packages Allowed

Multiple submissions are not allowed. Each applicant is allowed one submission.

7 Program Goal Requirements

Only submissions relevant to the goals of this program are eligible to compete. DOE will review all submissions to ensure that the following statements are true:

- The submitted results' sets are for distribution state estimation for the data published on OEDI SI platform and are submitted in a manner compliant with the submission requirements of the OEDI SI platform.
- The proposed solution is based on fundamental technical principles and is consistent with a basic understanding of the U.S. market economy.

8 Additional Requirements

Please read and comply with additional requirements in Appendix 3.

COMPETITORS WHO DO NOT COMPLY WITH THESE REQUIREMENTS MAY BE DISQUALIFIED.

9 Rules

9.1 Introduction

The 3D Solar Visibility Prize is a single-contest program with $175,000 in cash prizes. This competition focuses on three key areas:

- Identifying the best-performing distribution system state estimators
- Demonstrating fair and transparent evaluation of DSSE using a publicly available open-source platform
- Promoting the adoption of DSSE by end users, such as independent system operators, integrated utilities, and other balancing authorities.

Cash Prizes
• Up to two (2) anticipated winners • Up to three (3) anticipated runners-up • Each winner receives 50,000 • Each runner-up receives $25,000

The following rules are for potential and actual competitors for the 3D Solar Visibility Prize.

9.2 Prizes to Win

The prize offers cash prizes of $50,000 for two anticipated winners (first and second) and $25,000 for three anticipated runners-up (third, fourth and fifth).

9.3 How to Enter

Competitors must submit an Intent to Compete submission package on HeroX by the submission deadline. After the competitor submits an Intent to Compete submission package and is verified as eligible, competitors will be asked to create a profile on the OEDI SI platform before receiving access to the composite distribution state estimation data.

See Section 4 ("Important Dates") for information regarding submission deadlines and Section 9.4 for more information on the overall prize process.

9.4 Prize Process

The prize requires the following steps:

1. **Sign Up to Compete**. To sign up and prepare for the prize, competitors are asked to complete the following steps by July 10, 2024, at 5 p.m. ET:

    1A: **Create a HeroX account** and follow the prize on HeroX for updates and notifications.

    1B (optional): If desired, determine appropriate partners for competitors' team.

    1C: **Submit an Intent to Compete submission package** via the HeroX platform before the registration deadline. The submission can be accessed after creating an account on HeroX by clicking "Solve this Challenge" and then "Begin Entry" on the HeroX prize website.

    1D: **Receive OEDI SI platform log in credentials**. After creating an account in HeroX and submitting an Intent to Compete submission form, the prize administrator will confirm eligibility and will register the competitor on the OEDI SI platform. OEDI SI platform log-in details will then

be sent to the competitor along with instructions on how to access the network model topologies, parameters, and training data.

2. **Distribution State Estimation Practice Week (via OEDI SI platform).** There will be a week provided (anticipated to last from August 5 to August 9, 2024) for competitors to test uploading their DSSE results to the OEDI SI platform. Competitors may use this week to ensure understanding of any OEDI SI-related tasks for the prize. The test week will be led by the NREL Technical Team, who will serve as the OEDI SI platform operator.

3. **DSSE Results Submission.** For each of the 14 days of the distribution system state estimators' evaluation period (anticipated to last from August 12 to August 25, 2024), competitors must upload to the OEDI SI platform their daily state estimation results, per Section 9.5.2 of this document. Reports will be generated regularly to allow competitors to understand their performance as the competition progresses.

   Please note:

   - The competitors need to thoroughly read and understand the details in Appendix 1 on the 3D Solar Visibility Prize process, its details, and the data that will be provided.
     - The competitors will have to upload their algorithms either as open-source code or as executable as docker containers[19] prior to the start of the competition. DOE and NREL prize and technical teams reserve the right to audit a submitted results set using these containers.
     - The competitors will have three (3) hours to submit their results once the measurement sets for the following day are posted on OEDI SI platform.

4. **Ranking.** All competitors' scores will be displayed with their assigned *anonymized* pseudonyms on the HeroX website. The general rules for ranking are given in Section 10. The scores will be calculated based on the metrics defined in Appendix 2. The benchmark will be done using the original power flow network data. At the end of the competition, the prize administrator will make public the team names and/or team organization names of the winning and runner-up teams.

5. **Evaluation.** Competitors will be evaluated on the accuracy of their state estimations compared to actual state values, using four (4) different industry standard metrics. Competitors with the highest scores are eligible to win a prize. Section 10 describes how the scores are calculated. The metrics are defined in Appendix 2. Within the first five (5) business days after the end of the distribution state estimation competition, the OEDI SI platform operator will generate a final report for each competitor with the calculated metrics for the submitted state estimation results. Competitors will receive a copy of their report.

6. **Announcement.** Approximately two (2) months after the competition closes, the prize administrator will notify winners and runners-up and request the necessary information to distribute cash prizes. The prize administrator will then publicly announce winners and runners-up. Winners and runners-up may be invited to present at a stakeholder workshop (to be organized by DOE and NREL) following the winner announcement.

[19] https://www.docker.com/

9.5 What to Submit

Competitors will need to complete a HeroX Intent to Compete submission package as well as uploading daily result sets during the competition period via the OEDI SI platform as summarized in the table below.

Item	Content	Will Be Made Public	Scored
Intent to Compete HeroX Submission Package	Cover page	No	No
	One summary PowerPoint slide	Yes	No
	Intellectual property licensing agreements (if applicable)	No	No
OEDI SI DSSE Results Set Submissions	See Section 9.5.2 for details	No	Yes

Note: Portions of the submission package will be made available to the public. These have been denoted as such, and DOE does not intend to release the remaining parts of the submission to the public. See Appendix 3 for additional details.

All documents must be uploaded as a PDF.

9.5.1 HeroX Intent to Compete Submission Package

Competitors are required to submit the items in the table below.

Cover Page—List basic information about your submission (public)
• Team name • Key team members (names, contact information, and links to their professional websites or LinkedIn profiles) • Competitor's city, state, and nine-digit zip code • Statement of whether the competitor's organization currently provides distribution state estimation algorithm(s) commercially • The partners and affiliates who significantly helped competitors develop their model (if applicable).

Submission Summary Slide—A PowerPoint slide as a PDF (public)
Make a public-facing, one-slide submission summary containing technically specific details about the competitor's DSSE algorithm (i.e., DSSE approaches and techniques used) that can be understood by most people. There is no template, so competitors should feel free to present the information as they see fit. Please make any text readable in a standard printout and conference room projection. *Submission Summary Slide will be made public after the competition ends.*

Intellectual Property Licensing Agreements (required if applicable, as a PDF)
Provide documentation showing that competitors have secured access to the intellectual property underlying their distribution state estimation algorithm(s) from the relevant institution where it was originally developed, where applicable.

9.5.2 Open Energy Data Initiative Solar Integration Submission Package Details

Competitors must submit their distribution state estimator's results to the OEDI SI that meet the following requirements:

- State estimation results for each snapshot at 15-minute intervals of the 12-hour time-series. The results will include the following:
  - The estimated state variables. State variables are voltage magnitudes and phase angles, x_i. *i* runs *1* through *2n-1*, where *n* is the number of nodes in the distribution network.
  - Measurement residuals for *1* through *m*. *m* is the total number of measurements.
  - Measurement residual is defined as: $res_i = y_i - y_i^e$, where y_i is a measurement, and y_i^e is the estimated measurement, calculated as $y_i^e = h_g\,(x_i^e)$. x_i^e is the estimated value of state variable and h_g denotes a specific type of measurement function, g.
  - Any bad data detected.
  - Any distribution network topology change detected.

- The competitors must upload their results by 5 p.m. ET.

See Appendix 1 for more details on how the competition will be run, what the composite input data sets will include each day of the competition, and additional information on competition prizes.

Failure to upload the daily result or results for one or more snapshot by the daily submission deadline will result in lower scores, because the daily and final scores will be averaged assuming all snapshots and daily results were provided by the competitors.

If the OEDI SI is offline during the submission period, the corresponding evaluation period will not be included in the scores, and an additional day will be added to the competition.

The OEDI SI will reject DSSE results uploaded after the daily submission deadline. Competitors may, however, upload their results for future days even if they miss deadlines for some evaluation periods.

The OEDI SI will use the state variables values from a standard power flow algorithm, OpenDSS, for every 15-minute snapshot of the daily 12-hour time-series data using the original network data. The results from this algorithm will be used to benchmark the competitors' results. The metrics that are used and how they are calculated are given in Appendix 2. These metrics will be calculated at the end of each day.

Competitors will receive daily a performance report that includes the reference results, and the metrics for each. The report will not include the results of other competitors.

The OEDI SI will provide an example script to help users become acquainted with using the application programming interface for operational evaluations.

10 How We Score

The scoring of distribution state estimation results will proceed as follows:

- We will first calculate the metrics. See Appendix 2 for more details.
    - M_1 is the mean absolute error for the state variables.
    - M_2 is the bonus for the number of bad data correctly detected and identified (if any).
    - M_3 is the bonus for number of topology changes correctly detected and identified (if any).

- Then we will calculate a score for each day as the simple average of the $State\ Estimation\ Skill_i$, calculated at 15-minute time intervals as the following:
    - $State\ Estimation\ Skill_i = M_1 + M_2 + M_3$
      for each snapshot at 15-minute intervals of the 12-hour time-series for each day. The daily state estimation skill will be a simple average of the 15-minute state estimation skills for that day.

- Next, we will calculate the final average state estimation skill for the competition period (14 days) as:
    - $Final\ Average\ State\ Estimation\ Skill = {}^{1}/_{14} * \sum_{1}^{14} Daily\ State\ Estimation\ Skill_i$
    - Final average state estimation skill will be the competitor's total score.
- Interviews: The prize administrator, at its sole discretion, may decide to hold a short interview with the winners. Interviews would be held after the announcement of winners and would serve as further discussion about the winners' distribution state estimation algorithms. Attending interviews is not required.

- The judge's final determination of winners will take into account total scores and the program policy factors listed in Appendix 3. DOE is the judge and final decision maker and may elect to award all, none, or some of the submissions accepted.

Appendix 1: Details on the Input Data and Process for the Prize

This prize is designed to verify the robustness and the scalability of the competitors' distribution system state estimation (DSSE) algorithms. Here are the general high-level requirements for DSSEs and details about the composite input data that will be posted on the Open Energy Data Initiative Solar Integration (OEDI SI) platform throughout the competition period.

1. The competitors should be able to handle *multi-phase unbalanced distribution state estimation* input data and its format.

2. Competitors can use physics-(network model-) based, machine learning, or hybrid algorithms.

3. The competition will use two network models to test the scalability of the algorithms.
    i. One relatively small distribution network model will be used during the first week of the competition, and one relatively large distribution network model will be used during the second week.
    ii. The two network models will be chosen from Smart-DS network repository, hosted by the National Renewable Energy Laboratory.
    iii. The network model data will be published in OpenDSS format on OEDI SI. The network model data will include the initial network model topology, device, and line parameters. In addition, a JSON file that contains the necessary topology information, such as admittance matrix, incidence matrix showing the connectivity, and switch locations, will also be provided.
    iv. Locations of the rooftop photovoltaic panels on the network and their nameplate capacities will also be published in the network model data.

4. Composite input measurement data will be calculated based on power flow solutions assuming different load and solar generation profiles at each node for snapshots with snapshots every 15 minutes for *12* hours each day of the competition.
    i. Gaussian errors will be added to these power flow-based measurements to mimic field conditions.
    ii. The actual load profiles and solar generation at the nodes will *NOT* be published to ensure a fair competition for different types of DSSE algorithms.
    iii. There may be *unbalanced conditions* in the distribution network(s) as they will be implied in the measurement data sets.

5. Composite input measurement data during the competition period will include different types of measurements.
    i. Composite input measurement data will be published in comma-separated-value [CSV] format. The format of this data will be posted on OEDI SI platform.
    ii. Composite input measurement data will include:
        a. Traditional remote terminal unit (RTU) (supervisory control and data acquisition [SCADA]) data, such as power flows and injections (if any).
        b. Smart meter (advanced metering infrastructure) data (if any). Typical smart meter data will be included, simulating the measurement types, their availability, temporal granularity, and random error characteristics of such sensors.

c. Smart inverter data (if any). Typical smart meter data will be included, simulating the measurement types, their availability, temporal granularity, and random error characteristics of such sensors.
d. Higher temporal data from a phase measurement unit (PMU), and PMU-like devices. Typical PMU and PMU-like data will be included, simulating the measurement types, their availability, temporal granularity, and random error characteristics of such sensors.
e. The competitors will have to decide on how to average measurements with high temporal granularity for each 15-minute snapshot.
f. The competitors will be responsible for calculating data imputation of missing measurements or not using them if they are missing.
g. Locations for pseudo measurements will be predefined (see historical data details below for more information). *Competitors cannot use more pseudo measurements at locations not specified by the Technical Team.*

iii. Redundancy of the composite input measurement data will change from day to day, and from one snapshot to the next one.
a. Observability of the composite input measurement data will not be guaranteed for each snapshot.
b. There may be some missing measurements from one snapshot to the next one to simulate missing data from the sensors.

iv. If a competitor's approach cannot handle a certain type of measurement, then their algorithm will have to provide results based on the remaining measurements.

6. There may be network topology changes from one snapshot to next. These changes will be simulated through normally closed switches.
i. These topology changes will NOT be posted.
ii. The DSSE algorithms will need to take them into account by using different approaches, e.g., identification by topology estimation using (normalized) measurement residuals, or the time-series information, etc.
iii. The historical training data will include sufficient time-series snapshots that will simulate these switching conditions.

7. There may be occasionally gross error (aka bad data) in the measurements. If not detected and eliminated, these are expected to increase the mean absolute error for the state variables.
i. The mean absolute error for the state variables will be calculated using the estimate state variables and original power solution.
ii. The DSSE algorithms will need to identify them by using different approaches, e.g., using (normalized) measurement residuals, etc.
iii. The historical training data will include sufficient time-series snapshots that will simulate these bad data conditions. Physics-based traditional DSSE algorithms may use these in recognizing the bad data in the daily competition measurement sets.
iv. It is expected that the state estimation process would be recalculated after the bad data detected are eliminated from the measurement set. Any measurement identified as bad data will need to be reported in the results.

8. *The competitors can NOT use any other inputs, or measurements, or inequality constraints that are not posted on OEDI SI*. In fact, if, for example, power flow limits, such as 5% voltage tolerances, are used as inequality constraints, those may be detrimental to accurate solutions

when in fact there are voltage magnitudes higher than 1.05 per unit due to the high penetration of solar in some instances.

9. Prior to the competition, a comprehensive 3-month historical data set for 12 hours with 15-minute interval granularity will be posted on OEDI SI.
    i. The network models, solar generation, and load profiles, with topology changes that typically occur under certain loading conditions.
    ii. The main purpose of these data is for training machine learning-based and hybrid DSSE algorithms.
    iii. However, these data will be available for all competitors, and can be used for pre-state estimation for creating pseudo measurements and/or measurement preprocessing for gross error detection. If used, such preprocessing will have to be explained in the summary slide. That algorithm will also have to be included in the source code that will be uploaded to the OEDI SI platform.
    iv. The competitors with machine learning-based DSSE algorithms will have up to four (4) weeks to train their models.
    v. Composite input measurement data will include:
        a. Traditional remote terminal unit (RTU) (supervisory control and data acquisition (SCADA) data, such as power flows and injections (if any).
        b. Smart meter (advanced metering infrastructure) data (if any).
        c. Smart inverter data (if any).
        d. Higher temporal data from a phase measurement unit (PMU) and PMU-like devices.
        e. Typical measurement data, representing the actual device characteristics, will be included, simulating the measurement types, their availability, ~~temporal granularity~~, and the random error characteristics of such sensors.
        ~~f. The competitors will have to decide on how to average measurements with high temporal granularity for each 15-minute snapshot.~~
        f. The 15-minute snapshots are discrete. There will be not any transition data from one snapshot to the next. As such, the competitors will not need to have to average out measurements which would have different temporal granularity in the field. However, the competitors may need to assign different weights (trust) to different types of measurements.
        g. Some of these different types of measurements may overlap in their location. As an example, a measurement set can contain RTU voltage magnitude, smart inverter voltage magnitude, PMU voltage magnitude and smart meter voltage magnitude at the same node for a snapshot (as an extreme case). It is left to the competitors to decide if they want to use all these measurements to keep the redundancy high (maybe using different measurement weights), or keep only one, if their algorithms cannot handle multiple measurements at the same location simultaneously.
        h. The competitors will be responsible for calculating data imputation of missing measurements or not using them if they are missing.
        i. Pseudo measurements and their locations. The competitors cannot use more such measurements at other locations than specified in the input set.
    vi. The actual state variable values are for each snapshot.

10. The competitors will have to upload their algorithms either as open-source code or as executable docker containers[20] prior to the start of the competition. The U.S. Department of Energy and National Renewable Energy Laboratory prize and technical teams reserve the right to ***audit*** submitted results set using these containers.

[20] https://www.docker.com/

Appendix 2: Prize Metrics

In this appendix, the metrics that will be used to calculate competitors' final scores are defined.

As mentioned before, the *15-minute State Estimation Skill* will be calculated as the following:

- $Skill_i = M_1 + M_2 + M_3$

1. How M_1 is calculated:

M_1 is the mean absolute error for the state variables; M_2 is the normalized number of bad data detected and correctly identified (if any); and M_3 is the normalized number of topology changes detected and correctly identified (if any).

There will not be bad data and topology changes *simultaneously* in the measurement set. In other words, there may be only bad data *OR* only topology change(s) in any of the measurement set. A particular measurement set will not flag any of these prior to the submission of results. The competitors are responsible for detecting and identifying them. They will be penalized for falsely reporting bad data or topology changes as explained below.

X_{MAE} is the mean absolute error [MAE] for the estimated state variables. It is calculated as the following:

$$X_{MAE} = \frac{1}{N}\sum_{i=1}^{N} |x_i - x_i^e|$$

Where x_i^e are the estimated state variables for x_i, defined by voltage magnitudes (*in per unit*) and phase angles (*in radians*) at distribution network nodes. $N = 2n - 1$, where *n* is the number of nodes (buses). M_1 is calculated as the following for *voltage magnitudes (in per units)*:

- $M_1 = 1.00$ if $X_{MAE} \leq 0.001$
- $M_1 = -1.00$ if $0.02 \leq X_{MAE}$
- $M_1 = f(x)$ where f(x) is calculated as a linear function for $0.001 < X_{MAE} < 0.02$.

And, M_1 is calculated as the following for *voltage angles (in radians)*:

- $M_1 = 1.00$ if $X_{MAE} \leq 0.0017$
- $M_1 = -1.00$ if $0.09 \leq X_{MAE}$
- $M_1 = f(x)$ where f(x) is calculated as a linear function for $0.0017 < X_{MAE} < 0.09$.

2. How M_2 is calculated:

M_2 results in bonus points for the number of bad data correctly detected and identified (if any). It is calculated as the following.

- $M_2 = 0.2$ if 100% correctly detected and identified,
- $M_2 = 0.15$ if 75% correctly detected and identified.
- $M_2 = 0.1$ if 50% correctly detected and identified.
- $M_2 = 0.05$ if 25% correctly detected and identified.

This metric will be calculated by the prize administrator, because the actual number of bad data and their locations will not be known by the competitors. The competitors will also need to provide the measurement identity and location for the bad data measurement(s) they identified, and the prize administrator will ensure the measurement(s) identified as bad matches the actual bad data measurements.

The bad data detection and identification will need to be general and scalable. The competitors will have to define how they detect and identify bad data. Manual or arbitrary detection of measurements with gross errors (bad data) will not be acceptable.

3. How M_3 is calculated:

M_3 results in bonus points for the number of topology changes correctly detected and identified (if any). It is calculated as the following.

- $M_3 = 0.2$ if 100% correctly detected and identified,
- $M_3 = 0.15$ if 75% correctly detected and identified.
- $M_3 = 0.1$ if 50% correctly detected and identified.
- $M_3 = 0.05$ if 25% correctly detected and identified.

This metric will be calculated by the prize administrator, because the actual number of topology changes and their locations will not be known by the competitors. Topology changes will include only on/off status changes at the switches provided in the network topology file. The competitors will also need to provide the switch number and location for the topology change(s) they identified, and the prize administrator will ensure the topology change(s) identified matches the actual topology change(s).

The topology change detection and identification algorithm will need to be general and scalable. The competitors will have to define how they detect topology changes. Manual or arbitrary detection of topology changes will not be acceptable.

Appendix 3: Additional Terms and Conditions

A3.1 Universal Prize Requirements

Each competitor's submission for the 3D Solar Generation Visibility Prize is subject to the following terms and conditions:

- If any team member is actively receiving funding from the U.S. Department of Energy (DOE) Solar Energy Technologies Office (SETO) at the submission deadline, SETO will review any potential prize awards as well as other DOE funding and make a decision as to whether awarding a prize to individuals or entities already receiving funding is in line with the program policy factors stated later in these rules (Section A3.13).
- Competitors must post the final content of their submission or upload the submission form online at https://www.herox.com/3D-Solar-Visibility-Prize before the prize closes. Late submissions or any other form of submission do not qualify.
- The summary slide will be made public.
- The cover page, narrative, and letters of commitment/support are not intended to be made public; however, see Section A3.10 regarding the Freedom of Information Act.
- Competitors must include all the required submission elements. The prize administrator may disqualify a competitor's submission after an initial screening if the competitor fails to provide all required submission elements. Competitors may be given an opportunity to rectify submission errors due to technical challenges.
- Competitors' submissions must be in English and in a PDF readable and searchable format. Scanned handwritten submissions will be disqualified.
- Competitors will be disqualified if any engagement during the 3D Solar Visibility Prize—including but not limited to the submission, the online forum, emails to the prize administrator, or other forms of communication—contains any matter that, in the discretion of DOE, is indecent, lacking in professionalism, or demonstrates a lack of respect for people or life on this planet.
- If competitors click "Accept" on the HeroX platform and proceed to register for the competition described in this document, these rules will form a valid and binding agreement between competitors and DOE that is in addition to the existing HeroX Terms of Use for all purposes relating to this competition. Competitors should print and keep a copy of these rules. These provisions apply only to the competition described here and no other competitions on the HeroX platform or anywhere else.
- The prize administrator, when feasible, may give competitors an opportunity to fix nonsubstantive mistakes or errors in their submission packages.
- As part of your submission to this prize, you will be required to sign the following statement:

  > I am providing this submission package as part of my participation in this prize. I understand that the information contained in this submission will be relied on by the federal government to determine whether to issue a prize to the named competitor. I certify under penalty of perjury that the named competitor meets the eligibility requirements for this prize competition and complies with all other rules contained in the Official Rules document. I further represent that the information contained in the submission is true and contains no misrepresentations. I understand false statements or misrepresentations to the federal

government may result in civil and/or criminal penalties under 18 U.S.C. § 1001 and § 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812.

A3.2 Verification for Payments

The prize administrator will verify the identity and the role of a participant entity potentially qualified to receive the prizes. Receiving a prize payment is contingent upon fulfilling all requirements contained herein. The prize administrator will notify winning competitors using provided email contact information after the date that results are announced. Each competitor (or parent/guardian if under 18 years of age) will be required to sign and return to the prize administrator, within 30 days of the date the notice is sent, a completed National Renewable Energy Laboratory (NREL) request for Automated Clearing House [ACH] banking Information form and a completed W-9 form (https://www.irs.gov/pub/irs-pdf/fw9.pdf). At the sole discretion of the prize administrator, a winning competitor will be disqualified from the competition and receive no prize funds if: (i) the person/entity cannot be contacted; (ii) the person/entity fails to sign and return the required documentation within the required time period; (iii) the notification is returned as undeliverable; or (iv) the submission or person/entity is disqualified for any other reason.

A3.3 Teams and Single-Entity Awards

The prize administrator will award a single dollar amount to the business entity designated by the primary submitter, whether consisting of a single entity or multiple entities. The winning business entity is solely responsible for allocating any prize funds among its member competitors as it deems appropriate.

A3.4 Submission Rights

By making a submission and consenting to the rules of the competition, a competitor is granting to DOE, the prize administrator, and any other third parties supporting DOE in the competition, a license to display publicly and use the parts of the submission that are designated as "public" for government purposes. This license includes posting or linking to the public portions of the submission on the prize administrator's or HeroX's applications, the competition website, DOE websites, and partner websites as well as the inclusion of the submission in any other media, worldwide. The submission may be viewed by DOE, the prize administrator, and reviewers for purposes of this competition, including, but not limited to, screening and evaluation purposes. The prize administrator and any third parties acting on their behalf will also have the right to publicize on the competition website indefinitely the competitors' names and, as applicable, the names of competitors' team members and organizations that participated in the submission.

By entering, the competitor represents and warrants that the competitor is the sole, original author and copyright owner of the submission or that the applicant has acquired sufficient rights to use and to authorize others, including DOE, to use the submission as specified throughout the rules; that the submission does not infringe upon any copyright, trade secret, trademark, nondisclosure agreement, patent, or any other third-party rights; and that the submission is free of malware.

A3.5 Copyright

Each competitor represents and warrants that the competitor is the sole author and copyright owner of the submission; that the submission is an original work of the applicant, or that the applicant has acquired sufficient rights to use and to authorize others, including DOE, to use the submission, as specified throughout the rules; that the submission does not infringe upon any copyright or upon any other third-party rights of which the applicant is aware; and that the submission is free of malware.

A3.6 Prize Subject to Applicable Law

This competition is subject to all applicable federal laws and regulations. Participation constitutes each participant's full and unconditional agreement to these official rules and administrative decisions, which are final and binding in all matters related to the competition. This notice is not an obligation of funds; the final awards are contingent upon the availability of appropriations.

A3.7 Resolution of Disputes

DOE is solely responsible for administrative decisions, which are final and binding in all matters related to the competition.

In the event of a dispute, the authorized account holder of the email address used to register will be deemed to be the competitor. The “authorized account holder” is the natural person or legal entity assigned an email address by an internet access provider, online service provider, or other organization responsible for assigning email addresses for the domain associated with the submitted address. Competitors and potential winners may be required to show proof of being the authorized account holder.

The prize administrator will not arbitrate, intervene, advise on, or resolve any matters between team members or any disputes between competitors.

A3.8 Publicity

The winners of these prizes (collectively, "Winners") will be featured on DOE’s and NREL’s websites.

Except where prohibited, participation in the competition constitutes each winner’s consent to DOE’s and its agents’ use of each winner’s name, likeness, photograph, voice, opinions, and/or hometown and state information for promotional purposes through any form of media, worldwide, without further permission, payment, or consideration.

A3.9 Liability

Upon registration, all participants agree to assume and, thereby, have assumed any and all risks of injury or loss in connection with or in any way arising from participation in this competition or development of any submission. Upon registration, except in the case of willful misconduct, all participants agree to and, thereby, do waive and release any and all claims or causes of action against the federal government and its officers, employees, and agents for any and all injury and damage of any nature whatsoever (whether existing or thereafter arising; whether direct, indirect, or consequential; and whether foreseeable or not) arising from their participation in the competition, whether the claim or cause of action arises under contract or tort.

In accordance with the delegation of authority to run this competition delegated to the director of SETO, the director has determined that no liability insurance will be required of competitors to compete in this competition, per 15 USC 3719(i)(2).

A3.10 Records Retention and Freedom of Information Act

All materials submitted to DOE as part of a submission become DOE records. Any confidential commercial information contained in a submission should be designated at the time of submission.

Competitors are encouraged to employ protective markings in the following manner:

- The cover sheet of the submission must be marked as follows and identify the specific pages containing trade secrets or commercial or financial information that is privileged or confidential: Notice of Restriction on Disclosure and Use of Data:
  Pages [list applicable pages] of this document may contain trade secrets or commercial or financial information that is privileged or confidential and is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source. [End of Notice]
- The header and footer of every page that contains trade secrets or privileged commercial or financial information must be marked as follows: "May contain trade secrets or commercial or financial information that is privileged or confidential and exempt from public disclosure."
- In addition, each line or paragraph containing trade secrets or commercial or financial information that is privileged or confidential must be enclosed in brackets.

Competitors will be notified of any Freedom of Information Act requests for their submissions in accordance with 29 C.F.R. § 70.26. Competitors may then have the opportunity to review materials and work with a Freedom of Information Act representative prior to the release of materials.

A3.11 Privacy

If competitors choose to provide HeroX with personal information by registering or completing the submission package through the competition website, competitors understand that such information will be transmitted to DOE and may be kept in a system of records. Such information will be used only to respond to competitors in matters regarding the competitor's submission and/or the competition unless competitors choose to receive updates or notifications about other competitions or programs from DOE on an opt-in basis. DOE and NREL are not collecting any information for commercial marketing.

A3.12 General Conditions

DOE reserves the right to cancel, suspend, and/or modify the competition, or any part of it, at any time. If any fraud, technical failures, or any other factor beyond DOE's reasonable control impairs the integrity or proper functioning of the competition, as determined by DOE in its sole discretion, DOE may cancel or modify the competition.

Although DOE indicates that it will select up to several winners for the competition, DOE reserves the right to only select competitors that are likely to achieve the goals of the prize. If, in DOE's determination, no competitors are likely to achieve the goals of the prize, DOE will select no competitors to be winners and will award no prize money.

DOE may conduct a risk review, using Government resources, of the competitor and project personnel for potential risks of foreign interference. The outcomes of the risk review may result in the submission being eliminated from the prize competition. This risk review, and potential elimination, can occur at any time during the prize competition. An elimination based on a risk review is not appealable.

ALL DECISIONS BY DOE ARE FINAL AND BINDING IN ALL MATTERS RELATED TO THE COMPETITION.

A3.13 Program Policy Factors

Although the scores of the expert reviewers will be carefully considered, it is the role of the prize administrator to maximize the impact of competition funds. Some factors outside the control of competitors and beyond the independent expert reviewer scope of review may need to be considered to accomplish this goal. The following is a list of such factors. In addition to the reviewers' scores, the following program policy factors may be considered in determining winners:

- Geographic diversity and potential economic impact of projects in a variety of markets.
- Whether the use of additional DOE funds and provided resources continue to be nonduplicative and compatible with the stated goals of this program and DOE's mission generally.
- The degree to which the submission exhibits technological or programmatic diversity when compared to the existing DOE project portfolio and other competitors.
- The level of industry involvement and demonstrated ability to accelerate commercialization and overcome key market barriers.
- The degree to which the submission is likely to lead to increased employment and manufacturing in the United States or provide other economic benefit to U.S. taxpayers.
- The degree to which the submission will accelerate transformational technological, financial, or workforce advances in areas that industry by itself is not likely to undertake because of technical or financial uncertainty.
- The degree to which the submission supports complementary DOE efforts or projects, which, when taken together, will best achieve the research goals and objectives.
- The degree to which the submission expands DOE's funding to new competitors and recipients that have not been supported by DOE in the past.
- The degree to which the submission exhibits team member diversity and the inclusion of underrepresented groups, with participants including but not limited to graduates and students of historically Black colleges and universities and other minority-serving institutions or members operating within Qualified Opportunity Zones or other disadvantaged communities.[21]
- The degree to which the submission enables new and expanding market segments.
- Whether the project promotes increased coordination with nongovernmental entities for the demonstration of technologies and research applications to facilitate technology transfer.

A3.14 Return of Funds

As a condition of receiving a prize, competitors agree that if the prize was awarded based on fraudulent or inaccurate information provided by the competitor to DOE, DOE has the right to demand that any prize funds or the value of other noncash prizes be returned to the government.

[21] DOE defines "disadvantaged communities" as areas that most suffer from a combination of economic, health, and environmental burdens, such as poverty, high unemployment, air and water pollution, and presence of hazardous wastes as well as high incidence of asthma and heart disease. Examples include but are not limited to: economically distressed communities identified by the Internal Revenue Service as Qualified Opportunity Zones; communities identified as disadvantaged communities by their respective states; communities identified on the Index of Deep Disadvantage referenced at https://news.umich.edu/new-index-ranks-americas-100-most-disadvantaged-communities/; and communities that otherwise meet the DOE definition of a disadvantaged community.

A3.15 Definitions

Prize administrator means both the Alliance for Sustainable Energy, operating in its capacity under the Management and Operating Contract for NREL and SETO. When the prize administrator is referenced in this document, it refers to staff from both the Alliance for Sustainable Energy and SETO. Ultimate decision-making authority regarding competition matters rests with the director of SETO.

Open energy data initiative solar integration (OEDI SI) operator means the technical team from NREL that will run and maintain the OEDI SI platform and also provide the synthetic network models and all the other competition data and processes.

Judge is the DOE official who makes the final decision for the winners and runners-up, taking into consideration total scores and the program policy factors listed in Appendix 3.

Competitor is an individual, organization, or team that registers to compete in the prize and submits the required items to be considered eligible for a cash prize.

System state estimation is typically defined as a statistical process of calculating (state) variables in measurements that describe a physical phenomenon. In **distribution system state estimation [DSSE]** the state variables are the voltage magnitudes and phase angles for each node in a distribution network.

Average state estimation skill will be calculated (see Section 10) based on the metrics defined in Appendix 2. It will be used to evaluate the performance of each competitor's distribution state estimation results. Average state estimation skill will be calculated for each snapshot in the time-series data on a daily basis.

Mean absolute error for estimated state variables is a metric used to evaluate the accuracy of each competitor's submitted distribution state estimation results (see Appendix 2).

Mean absolute error for measurement residuals is the average of the measurements' residuals for each snapshot of the time-series distribution state estimation analysis (see Appendix 2**Error! Reference source not found.**).

Normalized number of bad data detected is calculated as the ratio of the bad data (measurements with gross errors) detected and correctly identified by a competitor's DSSE algorithm to the number of bad data that may have been introduced to a snapshot measurement set.

Normalized number of topology changes detected is calculated as the ratio of the topology changes detected and correctly identified by a competitor's DSSE algorithm to the number of topology changes that may have been introduced to the original network topology.

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This is the end of the rules document; thank you for reading.