H2Os Prize

Hydropower Operations Optimization Prize

OFFICIAL RULES

July 2022

Preface

The U.S. Department of Energy (DOE) Hydropower Operations Optimization (H2Os) Prize will be governed by this Official Rules document, which establishes the rules and requirements for the H2Os Prize. This rules document applies to all phases of the H2Os Prize. The Prize Administrator and DOE reserve the right to modify this Official Rules document and will publicly post any such notifications as well as notify prize participants.

Date	Modification
May 6, 2022	• Typographical corrections in Appendix C, Power System Evaluation.
July 7, 2022	• New figure 3: Example power system network. • Hydropower Generation Benefits Scoring updates related to Phase 2 data set. • Addition of reservoir type in Appendix B Water System Data including updated guidance for Phase 2 data set. • Updates to Appendix C Power System Evaluation to reflect additional challenges presented by Phase 2 data set. • Updates to Appendix D Water System Evaluation to reflect Phase 2 data set added complexity.
July 27, 2022	• Typographical corrections in equations referenced in Appendices C and D.

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Acronym List and Uncommon Terms

AF	volume of water in acre-feet
CSV	comma-separated value
DOE	U.S. Department of Energy
H2Os	Hydropower Operations Optimization
LMP	locational marginal electricity prices
NREL	National Renewable Energy Laboratory
OPF	optimal power flow
PSH	pumped storage hydropower
RoR	run of river
WPTO	Water Power Technologies Office

1. Executive Summary

The Hydropower Operations Optimization (H2Os) Prize, supported by the U.S. Department of Energy's (DOE) Water Power Technologies Office (WPTO) as part of the Hydropower and Water Innovation for a Resilient Energy System Initiative,[1] is offering up to $75,000 in a cash prize pool to help solve some of the most near-term challenges in optimizing the value of hydropower in the grid. The prize will be made up of three competition phases of increasing difficulty, each 6 weeks in length with a unique dataset, during which competitors can continuously submit solutions to gauge their performance. New competitors can enter at any phase, and this rules document and the associated evaluation criteria will apply to all three phases of the prize.

H2Os Prize Awards

Phase 1:

- Prize pool up to $10,000
- One grand prize of $3,000
- $1,000 prizes for up to seven other winners

Phase 2:

- Prize pool up to $15,000
- One grand prize of $7,500
- $1,500 prizes for up to five other winners

Phase 3:

- Prize pool up to $50,000
- One grand prize of $30,000
- $10,000 for second and third place winners

Competition Overview

In each phase, competitors will be asked to act as a hydropower manager responsible for a water system consisting of a river network connecting one or more hydropower-producing reservoirs. The reservoirs will be connected by river reaches and will have associated inflows, such as surface runoff from rain events, and outflows, such as water withdrawals from municipal and agriculture uses. The water system should be managed to produce hydropower corresponding to anticipated grid needs while also respecting general water management constraints and needs.

The competitors will also have to integrate the power produced by their water system into a regional electrical grid (power system). The complexity of the power system configuration will increase in each phase of the competition but will generally include several other power generating facilities in addition to the hydropower generation from the water system. Other facilities connected to this power system will potentially include fossil fuel, solar, and wind power generation facilities, and industrial-scale batteries. The price of electricity generated by each of these facilities will fluctuate throughout each competition scenario based on the operating (fuel, start-up, shut down, etc.) costs of each facility. Competitors will have to decide when to generate hydropower and will be scored on the amount of economic and environmental benefits. Since the price of electricity is variable and dependent on the operating status of all system generators, competitors will need to determine when to generate hydropower to optimize power system benefits.

1 Water Power Technologies Office. 2022. "HydroWIRES Initiative" U.S. Department of Energy. https://www.energy.gov/eere/water/hydrowires-initiative.

The main task of the competitor is to create a reservoir release schedule for all reservoirs in the system. Successful schedules will avoid violating water system constraints and will endeavor to generate power when it is most economically and environmentally beneficial.

The competitor will be scored based on their management of the water system and benefits to the grid. This scoring criteria is outlined in Section 5.3 with additional details in Appendix C and Appendix D.

To encourage competitors to create an innovative and commercially-relevant work product, competitors are expected to create their reservoir release schedules with an automated process that can accept a variety of inputs describing different water and power system conditions and automatically generate an optimized reservoir release schedule. The competition problems are intended to be sufficiently complex to require the implementation of computational approaches to generate release schedules. As part of their submission package, competitors will have to provide a technical narrative describing their computational approach. The technical narrative will be evaluated against the scoring criteria, outlined in Section 5.3.2.

Each phase of the competition will be open for 6 weeks and will begin with a dataset posted on Topcoder. Competitors will be able to submit a reservoir release schedule to Topcoder and receive a score at any time during the open period of each phase.[2] The score is generated by an evaluation platform consisting of a water system simulation and power system simulation. The competitor's release schedule is first simulated in a water system model to determine resulting hydropower production. The resulting hydropower production is passed to the power system simulation. Both water and power system simulations will generate the actual outputs that are scored per the scoring criteria. See Figure 1 for a graphical representation of how submissions will be evaluated. A live, public leaderboard will track submitted solutions throughout the time the prize is open.

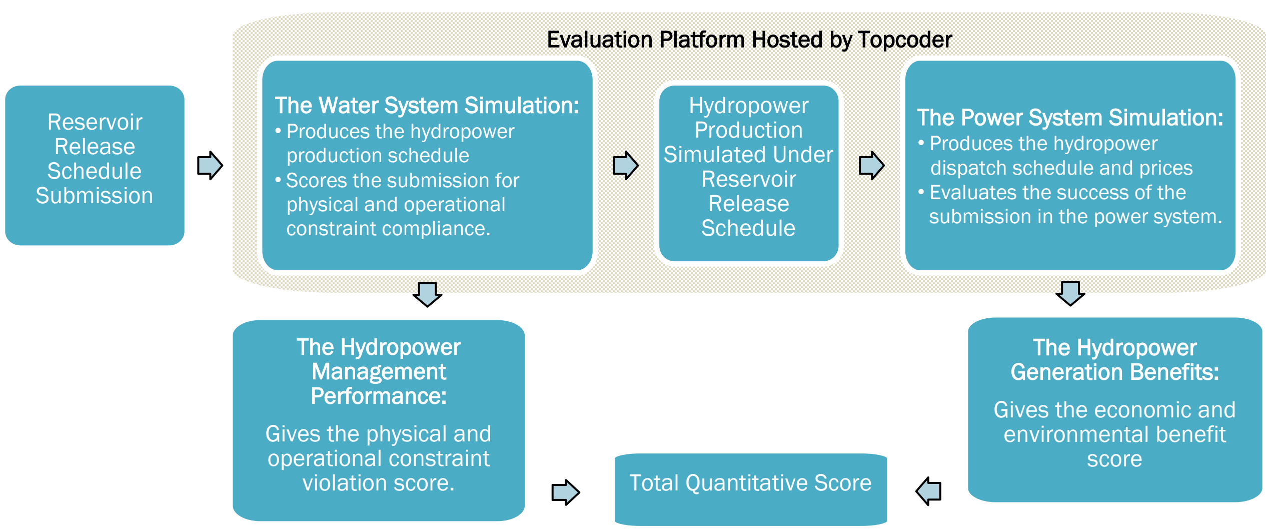

Figure 1. Illustration of evaluation platform hosted on Topcoder

[2] Competitors will be limited to a maximum daily number of submissions. This limit will be posted on the Topcoder website. This number may change at each phase of the competition due to problem complexity, computing requirements, and available computing resources.

2. Important Dates

The three phases of the H2Os Prize will align with the following anticipated timeline in which:

- **Phase One Opens: April 6, 2022**
- Phase One Submission Closes: May 20, 2022
- **Phase One Winner Announcement and Phase Two Opens: July 7, 2022**
- Phase Two Submission Closes: August 19, 2022
- **Phase Two Winner Announcement and Phase Three Opens: September 2022 (anticipated)**
- Phase Three Closes: November 2022 (anticipated)
- **Phase Three Winner Announcement: December 2022 (anticipated).**

All dates outlined for the Prize phases are anticipated and subject to change. Final dates will be posted on the Topcoder website.

3. Technology Development Goals

This prize is specifically designed to incentivize innovative approaches to optimize hydropower operations in a realistic, simulated scenario with respect to physical and environmental constraints of the water system, revenue, emissions, and other goals. Competitor submissions will be scored against three key metrics that will feed into a final score:

1. **Hydropower Management Performance:** Hydropower scheduling solutions that respect the water system's physical and operational constraints.
2. **Hydropower Generation Benefits:** Economic and environmental benefits resulting from hydropower generation based on feasible hydropower output and electricity market energy prices.
3. **Novel, Scalable, and Broadly Applicable Hydropower:** Unique, innovative, and flexible solutions that apply to a variety of facilities within a range of modeling and institutional workflows.

4. Background and Purpose

As the U.S. grid evolves and integrates more variable resources, like wind and solar, hydropower management can be adapted to support changing grid conditions and enhance the reliability and resiliency of the grid. WPTO is looking for contributions from current hydropower professionals and new innovators alike. WPTO hopes this prize will attract a diverse group of competitors from multidisciplinary backgrounds who are interested in putting their expertise in machine learning, data science, optimization, and everything in between to work to help solve some of the most near-term challenges in optimizing the value of hydropower on the grid. By increasing hydropower's ability to operate flexibly and integrate variable energy resources, solutions funded by this competition support the Biden administration's goal of a decarbonized power sector by 2035.

Hydropower technologies are versatile in that they can provide flexibility, reliability, sustainability, controllability, and inertia, including fast frequency response. However, the hydropower resources offered in the power system scheduling process are often limited, reflecting conservative restrictions on hydropower availability and water management practices. This prize supports WPTO's Hydropower and Water Innovation for a Resilient Energy System Initiative by focusing on hydropower's complementary role as an integrator of variable renewables, like wind and solar, and best leveraging hydropower's benefits for planning daily grid operations. The H2Os Prize incentivizes competitors to develop solutions to help hydropower systems coordinate with existing grid scheduling practices to apply the full set of hydropower's benefits and capabilities. The Prize Administration Team has developed a phased approach to the challenge problem and vetted the scoring criteria with a federal stakeholder review committee comprised of hydropower operations and planning experts, including representatives from the U.S. Bureau of Reclamation. Each successive phase of the prize phase will add complexity to encourage innovation, value extraction, and support commercialization of the proposed optimization solution.

WPTO recognizes a wealth of capabilities emerging through the advancement of the mathematic programming, data science, and machine learning fields. This competition seeks to identify some of those capabilities that hold the most promise to address some of the challenges faced by the hydropower industry. WPTO welcomes competitors both from the hydropower industry as well as those that have no previous experience in power system or water system management.

4.1. Water System

Competitors will manage a water system that includes several hydropower dams and associated reservoirs, reaches of river, and drainage basins. Each aspect of the system has its own unique physical and operational constraints, such as maximum reservoir capacity and minimum environmental stream flow requirements. Constraints include (but are not limited to):

- **Physical constraints, such as:**
  - Minimum and maximum storage capacity in reservoirs
  - Maximum turbine capacity (outlet capacity)
- **Operational constraints, such as:**
  - Minimum environmental flow requirements
  - Flooding thresholds in river reaches
  - Meeting water demands.

Physical constraints are impossible to violate in a real-world setting. While it is physically possible to violate operational constraints, it is highly discouraged in real water system management. Fines or legal consequences may occur if operational constraints are violated. In this competition, violations of either set of constraints will reduce the score consistent with the severity of the violation.

In this competition, competitors must manage the system to meet a range of competing objectives. These objectives include managing reservoir storage for present and future generation capacity, domestic and agricultural water supply demands, recreation, or downstream constraints (e.g., water demands, flooding concerns, and minimum flow requirements). Competitors will be required to submit operations in the form of reservoir releases that account for all water inflows, outflows, and movement within the system. The competitor's reservoir release schedule will be evaluated for compliance with physical and operational constraints and scored accordingly (see Appendix C).

An example of a water system is shown in Figure 2. As shown, two storage reservoirs with associated hydropower facilities and an intermediate run-of-river (RoR) hydropower facility are found in a cascading system along a river reach with two identified inflow points. Physical constraints are defined for the storage reservoirs and hydropower facilities. Operational constraints to prevent flooding below Reservoir 1 and minimum fish flows below the RoR facility are also included in the system.

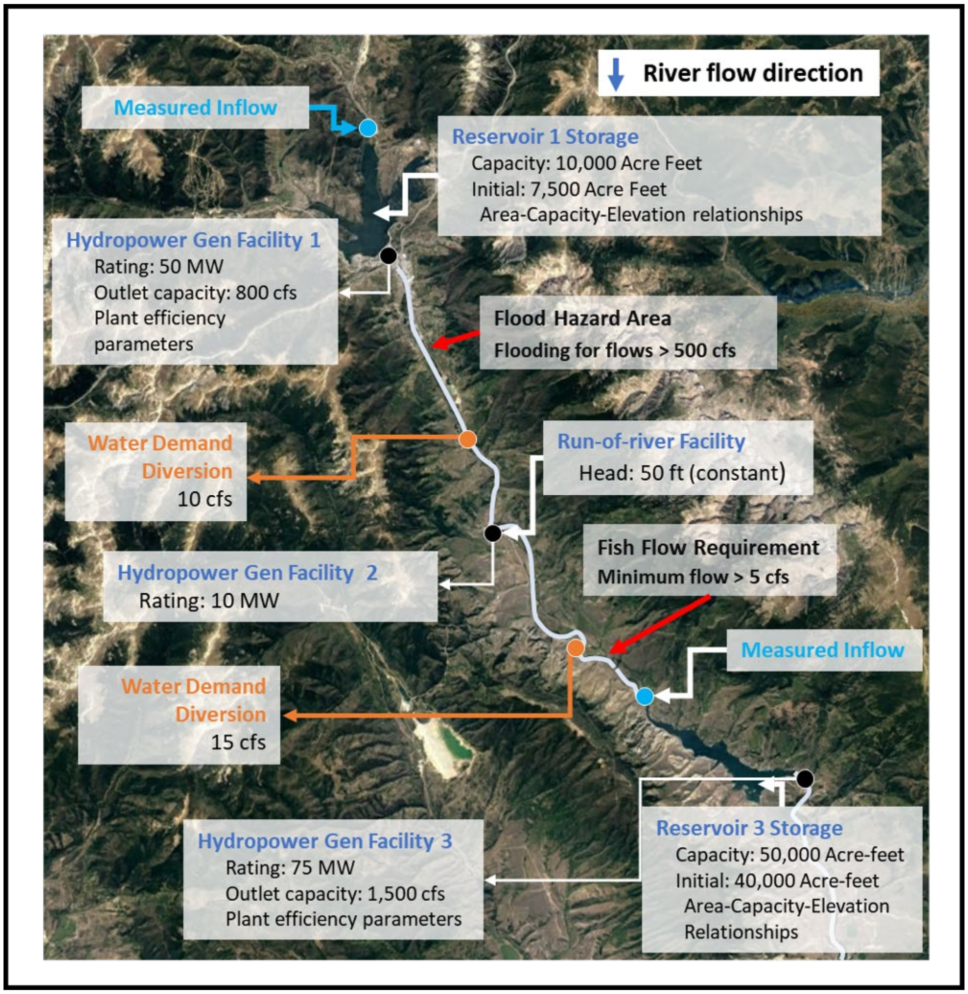

Figure 2. Example water system network using a screen capture from Google Earth to illustrate water system elements

Although the water system includes a complex set of physical and operational constraints, the reservoir release schedule is the only variable that is controlled by the competitor.

4.2. Power System

Power system optimization seeks to minimize total system generation costs, while respecting generation facility and transmission constraints at both unit and system levels. Costs include units' operation, startup, and shutdown costs. Individual generation facility constraints include (but are not limited to) generating units' minimum and maximum output levels; the capabilities needed to ramp up and ramp down power production; the minimum time that units must run after starting, or the minimum time units must be off before they can be started again. Figure 3 below shows an example power system (with some unit-level constraints) that describes maximum generator capacities and peak demand levels. Appendix D provides an illustrative model formulation of how the grid managers schedule generators.

In this competition, the competitor will submit a reservoir release schedule. The release schedule will yield a proposed hydropower production schedule. The simulation will take the hydropower production into consideration with the rest of the producers on the regional grid and create an optimal power system dispatch schedule to meet load requirements. The optimized production schedule for all generators will also determine the price each producer is paid for the power they contribute to the grid.

Competitors will be scored on their ability to maximize the economic benefit produced by hydropower facilities, which is defined as the product of hydropower generation and electricity price in each time period. To maximize economic benefit, competitors must understand that their release schedule will have an impact on the prices paid to all generators for their electricity.

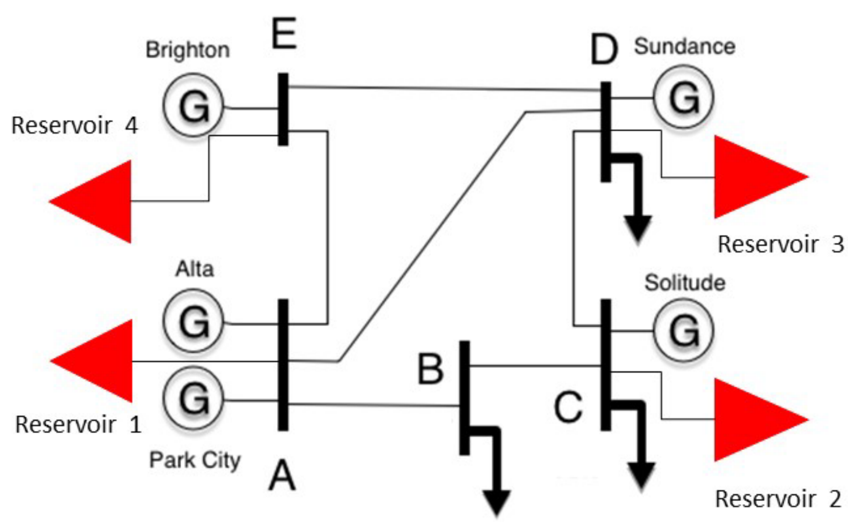

Figure 3: Example power system network in megawatts (MW) adapted from Li and Bo 2010[3]

[3] Li, F. and R. Bo. 2010. "Small Test Systems for Power System Economic Studies," *IEEE PES General Meeting*: 1–4. doi: 10.1109/PES.2010.5589973.

Determining Which Generators Will Provide Power to the Grid (and How Much They Will Get Paid)

To understand how to optimize the hydroelectric power revenue, competitors should understand how grid operators determine the price that producers will receive at every time step in the competition.

For each time step in the competition period, all power generators, except the hydropower operators, will offer an amount of electricity. For simplicity, all hydropower generation is offered at zero price. All other generators will offer their full operating capabilities at a price based on their operating costs. For traditional fossil fuel generation, the price these generators offer is influenced by the cost of their fuel and the cost to start and stop their generation equipment. For renewable energy producers, like solar and wind, their energy is also offered at zero price.

The power system operator selects the cheapest power from each producer until the entire load for the system is met. For any given time step, the power generators selected to meet the load will be included in the dispatch stack. Hydroelectricity is generally offered at a near-zero price, so it will usually be included in the dispatch stack at the metaphorical bottom of the stack. Power generators that offer power at a high price and are not needed to meet the load in a given time step will not produce power during that time step.

According to this method of determining price, the price of electricity paid to the generators in this system is the cost of delivering the next marginal unit of energy in any given time step. In other words, generators are all paid based on the most expensively priced generator that is scheduled to produce in any given time step and location.

One strategy to maximize income from hydropower may be to maximize hydropower production when demand and variable prices are the highest. However, offering hydropower production at these times can potentially displace more expensive generation and can drive down the price, which is set by the most expensive generator in the stack. To put it another way, the price will be set by the cheapest offered generator that still has generation capacity after the power demand is met. Because the cost of hydropower production is zero, adding hydropower to the dispatch stack may drive down the price of electricity because it will put low-cost generation at the bottom of the dispatch stack and displace high-cost generation.

Prices may vary between locations due to transmission-capacity constraints. For example, although there may be cheaper power available in the system, such power may not be usable because there are transmission bottlenecks that limit the ability to deliver that power to the load. In the first phase of this competition, the transmission system will impose no constraints (i.e., there will be no transmission bottlenecks), and by definition, electricity prices will be uniform across all locations in the system. However, subsequent phases may introduce transmission bottlenecks to diversify locational prices and increase the problem complexity.

5. H2Os Prize Rules and Requirements

5.1. How To Enter

Follow the instructions for registering and submitting all required materials before the deadline in the following Important Dates section or as displayed on the Topcoder website. Competitors also have the ability to form teams or find partners through the platform.

5.2. Important Dates

New datasets for the three phases of the H2Os Prize will be released in alignment with the following anticipated timeline:

- **Phase One Opens: April 6, 2022**
- Phase One Submission Closes: May 20, 2022
- **Phase One Winner Announcement and Phase Two Opens: July 7, 2022**
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All dates outlined for the Prize phases are anticipated and subject to change. Final dates will be posted on the Topcoder website.

5.3. Submission Elements

The following items (see Figure 4 and Table 1) constitute the submission package and must be submitted through the Topcoder platform for each phase.

Submission Elements

- Reservoir Release Schedule
- Technical Narrative
- Software
- Submission Summary Slide

Figure 4. Submission elements for each phase

Table 1. Submission Elements Required

Submission Elements
❑ **Reservoir Release Schedule** ○ This includes the time series of scheduled releases from reservoirs ○ This is scored, and the schedule will be made public. ○ See Section 5.3.1. ❑ **Technical Narrative** ○ This document describes the technical approach and novelty. ○ This is scored and the narrative will not be made public. ○ See Section 5.3.2. ❑ **Software** ○ This is the software used to produce the reservoir release schedule submissions. ○ This is not scored, and the software will not be made public. ○ See Section 5.3.3. ❑ **Submission Summary Slide** ○ This is the summary presentation slide. ○ This is not scored, and the slide will be made public. ○ See Section 5.3.4.

Competitors' reservoir release schedule will receive an automated score. The technical narrative will be scored qualitatively by expert reviewers. The reservoir release schedule accounts for 80% of the final score and the Technical Narrative accounts for 20% (see Section 5.3.5).

Please refer to Appendix C and Appendix D for more background on the Hydropower Management Performance scoring process and Hydropower Generation Benefits scoring and see detailed scoring examples below. This, paired with the scores assigned to the Technical Narrative submission, will constitute a total final score.

5.3.1. Reservoir Release Schedule

The reservoir release schedule submission will be used to calculate the Hydropower Management Performance score based on the feasibility of the solution in the water system. The corresponding generated hydropower will yield economic and environmental benefits and will result in the Hydropower Generation Benefit score. The scoring specifications defined below provide an overview of the scoring calculations.

Table 2. Reservoir Release Schedule Submission Requirements

Reservoir Release Schedule (Scored, To Be Made Public)
Required Content Competitors Provide Competitors must submit a CSV file that contains one column identifying the text time step of the beginning of the period (format of YYYY-MM-DD:HH:MM:SS) with header label "DateTime" along with columns of floating point values (precision of three decimal places) identifying the acre-feet release scheduled during the associated time step for each reservoir with header labels following the naming convention: "[ReservoirName]_InputRelease". See Appendix E for an example of a reservoir release schedule submission. Specific formatting requirements will be available on Topcoder and may change between the three phases of this competition.

5.3.1.1. Hydropower Management Performance Scoring

The competitors' reservoir release schedules will be scored based on meeting physical and operational constraints.

In a situation where the competitor does not violate any constraints, the competitor will receive a perfect score for water management.

Physical Constraint Violations

Physical constraint violations represent fundamental errors in the accounting of water throughout the water system over the simulation period. Physical constraint violations will occur if releases contain more or less water than is physically available. Examples of violations include releasing more water than exists in the reservoir or not releasing enough water to keep the reservoir below its maximum capacity.

In the evaluation process, these physical constraint violations are identified, scored, and corrected to ensure both that all water is accounted for and that hydropower production is a result of physically possible releases. If a competitor's release is too small (e.g., causes the reservoir to exceed its maximum volume) or too big (e.g., calls for a release beyond the existing reservoir volume), then the evaluation will update the release to correct the physical constraint violation, and the competitor will be penalized. Physical violations in the release schedule may cause cascading errors for the remainder of the simulation period due to misrepresentation of water availability and movement. There are two types of physical constraint violations:

- Inadequate Release wherein the competitor's release schedule for a given time step is too small, causing a reservoir to exceed its maximum capacity, which will be corrected, and the competitor's score will be reduced
- Excess Release wherein the competitor's submission for a given time step is too large, calling for a release of water that does not exist at that time, which must be corrected, and the competitor's score will be reduced.

This competition considers meeting physical constraints and avoiding these violations to be extremely important, because energy production must only be based on feasible (physically possible) energy generation; therefore, physical constraint violations are penalized heavily. Each competition dataset will be comprised of one or more reservoirs. For each reservoir in the competition dataset, an Inadequate Release score and Excess Release score will be calculated and a single lumped physical constraint violation score will be computed for the entire dataset.

A physical constraint violation is a serious violation of water system physics; therefore, a binary value is assigned to this type of violation for the entire time series. If one or more time steps of physical constraint violation occurs, the resulting score is a 0. If every time step release satisfies physical constraints, the resulting store is a 10. Example scoring calculations are included in Figure *5*.

Operational Constraint Violations

Operational constraint violations include various water management requirements, such as avoiding flooding, meeting environmental minimum flow requirements, and meeting municipal, industrial, and agricultural water demands.

Operational constraint violations are evaluated by computing the average violation for time steps when the violation occurs over the simulation period. The calculation ignores all timesteps when the operational constraint was satisfied, and instead only calculates the average violation for timesteps when a violation occurred. The purpose of the calculation is to discourage severe operational constraint violations. Each violation is given a score between 0 and 10 for the category. For each category of operational constraint violations, a value that represents the theoretical maximum potential violation is determined first. This value will be used to scale the violation of a competitor submission between 0 and 10 with 10 being no violation and 0 being the maximum violation possible. In the case that a violation is less than 0, a score of 0 will be given. Example scoring calculations are included below.

Figure 5 shows the hierarchy of potential water system violations. Each competition dataset will define constraints for each feature of the system. For each feature of the system, a score will be calculated, and a single lumped operational constraints score will be computed for the entire dataset.

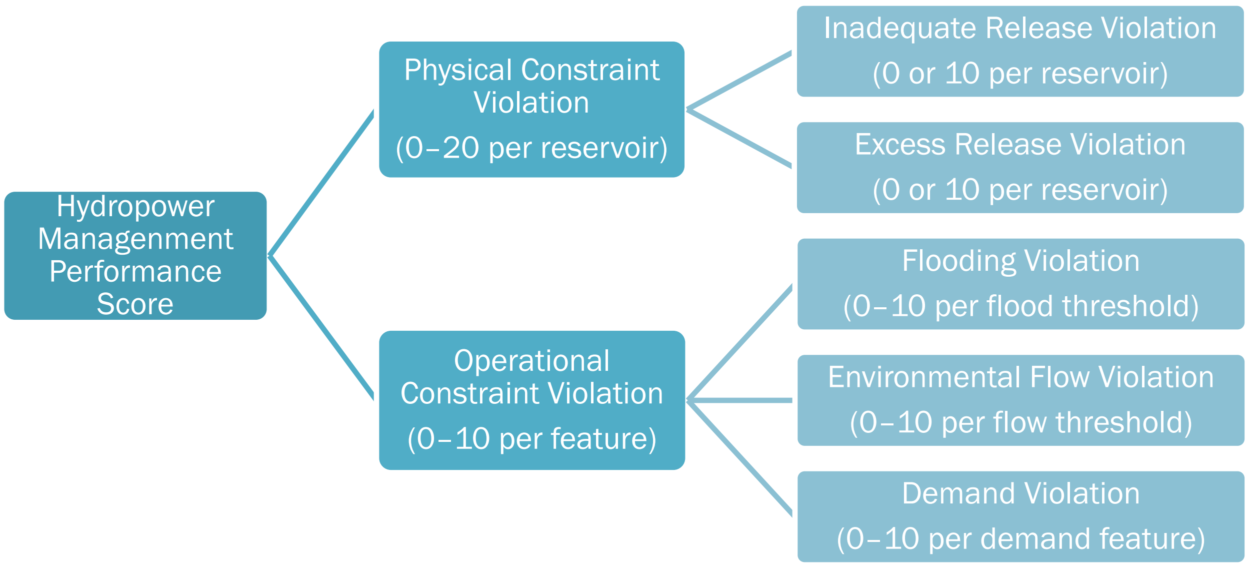

Figure 5. Hydropower Management Performance scoring

Lastly, the scores are summed over all subcategories of water system violations, and the aggregate score is scaled between 0 and 60 using the following formula:

$$\text{Scaled hydropower management performance score} = 6 \times \left(\frac{\text{summed score of subcategories of water system violations}}{\text{total number of subcategories of water system violations}}\right)$$

This metric produces a score between 0 and 60 with 0 being the worst possible violation of water system operations and 60 being no violation at all.

Table 3. Calculation of Hydropower Management Performance Scores

Metrics		Weights
Hydropower Management Performance Score (0–60)	Physical Constraint Violation (0 or 10 per reservoir)	6 / total number of subcategories of water system violations
	Operational Constraint Violation (0–10 per operational constraint)	

Hydropower Management Performance Scoring Example

The following example illustrates how a competition submission will be scored with respect to water system scoring categories. Consider a water system with two cascading power-producing reservoirs, as shown in Figure 6. The reservoir system has a 10 acre-feet per hour (AF/hr) water supply demand requirement below Reservoir 1 and above Reservoir 2. Below Reservoir 2, there is an environmental minimum flow requirement of 20 AF/hr. Reservoir 1 is a headwater reservoir; therefore, the local inflow represents the total inflow to the reservoir. The total inflow into Reservoir 2 equals the release from Reservoir 1 plus the Reservoir 2 local inflows minus the Reach 1 demand. The black arrows on the diagram represent water flow movement. For this example, a competitor will be required to submit two time series: releases from Reservoir 1 and releases from Reservoir 2.

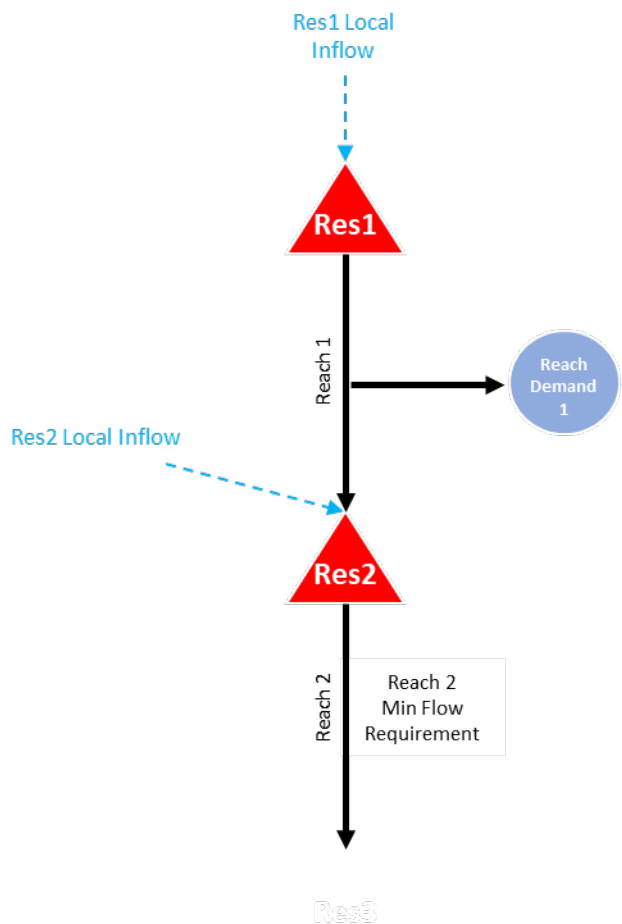

Figure 6. Example water system diagram with reservoirs (Res)1 and 2

Assume that the competition horizon is five time steps and the competitor submitted the following releases.

Table 4. Example Reservoir Release Schedule for Scoring Demonstration

Time Step	Reservoir 1 Release (AF/hr)	Reservoir 2 Release (AF/hr)
1	20	20
2	5	25
3	5	7
4	5	20
5	15	21

Physical Constraint Violation Check

For the example problem described, there are several physical constraints, including the:

- Minimum and maximum volume of Reservoir 1
- Maximum outlet capacity out of Reservoir 1
- Minimum and maximum volume of Reservoir 2
- Maximum outlet capacity out of Reservoir 2.

The evaluation process will check whether the competitor's reservoir release schedule submission obeys these water system physical constraints. If not, a physical constraint violation will occur. Recall that there are two categories of physical constraint violations: Inadequate Release (competitor release is too small, causing a reservoir to overtop) and Excess Release (competitor release is too big, releasing water that does not exist in the reservoir). For each reservoir, all types of physical constraint violations are captured by either Excess Release or Inadequate Release. Each scheduled release is checked at every simulation time step for every reservoir. Each individual subcategory is scored either 0 (at least one time step of violation) or 10 (no time steps of violation) with a maximum total score of 20 for a schedule with a physical constraint violation at a reservoir. The possible violations are:

- Reservoir 1 Inadequate Release
- Reservoir 1 Excess Release
- Reservoir 2 Inadequate Release
- Reservoir 2 Excess Release.

If there were additional reservoirs for which a competitor submitted releases as part of a competition problem, there would an additional Inadequate Release score and Excess Release score per reservoir added.

As shown in

Table 5, if the competitor-scheduled releases for time steps 4 and 5 for Reservoir 1 are too low, then an Inadequate Release violation occurs. This means that these releases cause the maximum storage in Reservoir 1 to be exceeded, which is physically impossible. Therefore, a larger release is forced out of the reservoir to prevent overtopping. Even though only two time steps were erroneous, the Inadequate Release violation score is a binary score of either 0 (at least one time step is in violation) or 10 (no errors; perfect score). For this case, the resulting score is 0 for the Inadequate Release violation and 10 for the

Excess Release violation (no errors). The total physical constraint violation score for Reservoir 1 is therefore 10. Please note that in the evaluation simulation, the additional releases required in time step 4 and time step 5 cascade throughout the system. This means that errors at Reservoir 2 could occur as a result of physical constraint violations upstream.

If, in the same simulation, the competitor-desired release for time step 5 at Reservoir 2 is too high, then an Excess Release violation occurs. In this case, the release has to be reduced to satisfy physical constraints. In this example, the competitor-desired release caused the reservoir storage to be less than the minimum allowable storage, which is physically impossible. The evaluation model releases the exact amount required to maintain the minimum allowable storage. Since at least one time step results in an Excess Release violation and no time steps result in an Inadequate Release violation, the total physical constraint violation score for Reservoir 2 is 10.

The total physical constraint violation score for this example is 20 out of 40.

Table 5. Example of Tabulated Physical Constraint Violations for Scoring Demonstration

Timestep	Reservoir 1				Reservoir 2			
	Release	Evaluation	Inadequate Release	Excess Release	Release	Evaluation	Inadequate Release	Excess Release
1	20	Can be satisfied	No	No	20	Can be satisfied	No	No
2	5	Can be satisfied	No	No	25	Can be satisfied	No	No
3	5	Can be satisfied	No	No	7	Can be satisfied	No	No
4	5	Release too low – reservoir exceeds max capacity.	Yes	No	20	Can be satisfied	No	No
5	15	Release too low – reservoir exceeds max capacity.	Yes	No	21	Release too high; reservoir is less than minimum storage.	No	Yes
At least one error?			Yes	No			No	Yes
Score			0	10			10	0

Operational Constraint Violation Check

In the example problem, there are two operational constraints. There is a single water demand point, requesting 10 AF/hr on every time step of the simulation period, and a single minimum environmental flow, requiring 20 AF/hr on every time step of the simulation period. Each subcategory is scored from 0 to 10.

Because operational constraint violations represent “soft” system constraints, the evaluation will not force any changes to competitor releases but rather will allow the violations to occur. Additionally, operational constraint violations are scored more aggressively if a violation is a larger deviation from a desired value. For example, if there is a nuisance flooding threshold, a small deviation above the threshold more often is less egregious than a single time step of extreme flooding.

Each operational constraint (i.e., minimum flows for a specific reach or each municipal or agricultural demand) will receive a single final score for the entire Reservoir Release Schedule. The final score for each operational constraint will be determined by calculating the average violation when the violation (the deviation from the operational constraint) occurs throughout the simulation then dividing by the maximum theoretical violation. This value is scaled from 0 to 10. The final operational constraint score is calculated as 10 (best possible score) minus the scaled average deviation divided by the maximum theoretical violation.

For this example problem, the theoretical maximum violation in a given time step is 10 AF/hr for the water demand subcategory, and the theoretical maximum violation in a given time step is 20 AF/hr for the minimum flow requirement subcategory. If a competitor submission sends 5 AF/hr for 3 time steps but otherwise meets the full demand throughout the simulation period, then the average violation when the violation occurs is

$$\frac{(5\ AF/hr + 5\ AF/hr + 5\ AF/hr)}{3\ time\ steps} = 5\ AF/hr \text{ (Equation 1)}$$

resulting in a score of

$$10 - 10 \times \left(\frac{5\ AF/hr}{10\ AF/hr}\right) = 5 \text{ (Equation 2)}$$

for the demand of the specific constraint.

If the competitor’s Reservoir Release Schedule submission results in a flow of 7 AF/hr for a single time step in the minimum flow reach but otherwise meets the minimum flow requirements throughout the simulation period, then the average violation when the violation occurs is

$$\frac{(20\ AF/hr - 7AF/hr)}{1\ time\ step} = 13\ AF/hr \text{ (Equation 3)}$$

resulting in a score of

$$10 - 10 \times \left(\frac{13\ AF/hr/}{20\ AF/hr}\right) = 3.5 \text{ (Equation 4).}$$

The total operational constraint score is the sum of the individual operational constraint violations (which, in this case, includes two features). Table 6 represents the calculations.

Table 6. Example of Tabulated Operational Constraint Violations for Scoring Demonstration

Time Step	Demand Below Reservoir 1 (10 AF/hr)			Min Flow Requirement below Reservoir 2 (20 AF/hr)		
	Upstream Release	Evaluation	Violation	Upstream Release	Evaluation	Violation
1	20	Demand satisfied	Not applicable	20	Minimum flow requirement satisfied	No
2	5	Demand short by 5 AF/hr	$10 - 5 = 5$	25	Minimum flow requirement satisfied	No
3	5	Demand short by 5 AF/hr	$10 - 5 = 5$	7	Minimum flow requirement short by 13 AF/hr	$20 - 7 = 13$
4	5	Demand short by 5 AF/hr.	$10 - 5 = 5$	20	Minimum flow requirement satisfied	No
5	15	Demand satisfied	Not applicable	21	Minimum flow requirement satisfied	No
Average Violation			5			13
Theoretical Maximum Violation			10			20
Score			$10 - 10 \times \frac{5}{10} = 5$			$10 - 10 \times \frac{13}{20} = 3.5$

Final Hydropower Management Performance Score

The final hydropower management performance score is calculated by summing all subcategories of the water system. This score is then averaged according to the number of subcategories then scaled by 6 for a final score between 0 and 60 with 0 being the lowest score possible and 60 being a perfect Hydropower Management Performance score. Note that the final scaled score is rounded to the nearest integer (following IEEE Standard 754 standards[4]).

[4] IEE. 2008. "IEEE-754, Standard for Floating-Point Arithmetic. 2008. https://www.researchgate.net/publication/236944299_IEEE-754_Standard_for_Floating-Point_Arithmetic.

Table 7. Example of Tabulated Hydropower Management Performance for Scoring Demonstration

Hydropower Management Performance Score		
Category	**Subcategory**	**Score**
Physical Constraint Violation	Reservoir 1 Inadequate Release	0
	Reservoir 1 Excess Release	10
	Reservoir 2 Inadequate Release	10
	Reservoir 2 Excess Release	0
Operational Constraint Violation	Demand Violation	5
	Minimum Flow Requirement Violation	3.5
Total Score		**28.5**
Average Score		**4.75**
Integer-Rounded Score		**29**

5.3.1.2. Hydropower Generation Benefits Scoring

A benefit metric will be calculated to measure the sum of economic benefits that hydropower generation facilities earn from wholesale energy markets and the environmental benefits of hydropower, illustrated below.

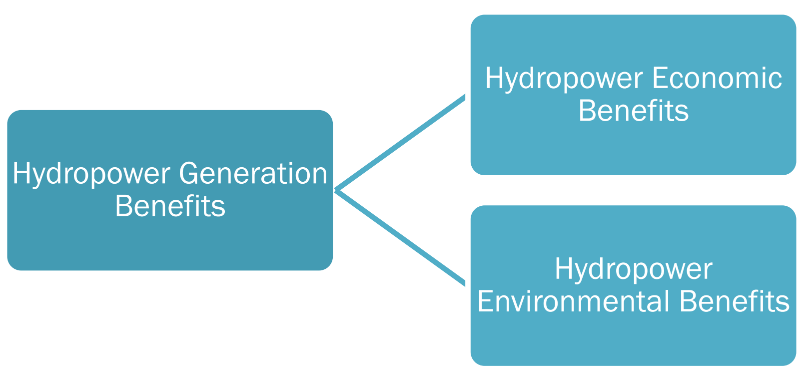

Figure 7. Hydropower Generation Benefits scoring

A Hydropower Economic Benefits score from regional grid scheduling is calculated as the sum of the product of hydropower generation resulting from the reservoir release schedule and the electricity price at the location of each hydropower generator (*i*) for each time step (*t*) in the simulation period. Electricity prices, or locational marginal prices (LMPs), are derived from the regional grid scheduling results. LMP is a representation of the price of power when considering transmission constraints of power producers in different locations on the regional grid. In the first phase, there will be no representation of transmission, so LMPs will be the same across the system, calculated as

$$Hydropower\ Economic\ Benefits\ =\ \sum_{i,t}(scheduled\ hydropower\ production_{i,t} \times LMP_{i,t})$$ (Equation 5).

A Hydropower Environmental Benefits score reflecting the CO_2-reduction benefits of hydropower is quantified as the monetary value of avoided CO_2 emissions due to hydropower generation, which is calculated as the product of scheduled feasible hydropower and a benefit factor, summed over the time steps of the evaluation period, expressed as

$$Hydropower\ Environmental\ Benefits\ =\ \sum_{i,t}(scheduled\ hydropower\ production_{i,t} \times benefit\ factor)$$ (Equation 6)

The environmental benefit factor is calculated using the following formula:

$$benefit\ factor\ =\ heat\ rate\ of\ Gas\ Turbine^{5} \times emission\ rate\ of\ natural\ gas^{6} \times social\ cost\ of\ carbon^{7}$$ (Equation 7)

or

$$benefit\ factor = \frac{11{,}098\ British\ thermal\ units}{kilowatt\text{-}hour} \times \frac{116.65\ pounds\ CO_2}{metric\ million\ British\ thermal\ unit} \times = \frac{\$29.948}{megawatt\text{-}hour}$$ (Equation 8).

The sum of the Hydropower Economic Benefits and Hydropower Environmental Benefits is the competitor's Power System Benefit score (in U.S. dollars). To weight this score accordingly, the sum of the Hydropower Economic Benefits and Hydropower Environmental Benefits scores is multiplied by 60 and divided by a value that represents the largest possible Power System Benefit score, expressed as

$$Scaled\ Hydropower\ Generation\ Benefit\ score\ =\ 60 * (Hydropower\ Economic\ Benefit\ + Environmental\ Benefit)\ /\ largest\ possible\ power\ system\ benefits$$ (Equation 9).

The largest possible Power System Benefits score is calculated as the largest possible hydropower dispatch (minimum of hourly demand and hydropower capacity) multiplied by the sum of largest possible electricity prices and the environmental benefit factor, summed over the time steps of the evaluation periods. The largest possible hourly electricity prices are calculated by running the production cost model

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[5] Heat rate of natural gas turbine (11,098 British thermal units per kilowatt-hour): U.S. Energy Information Administration. 2021. Form EIA-860, Annual Electric Generator Report. Washington, D.C.: U.S. Energy Information Administration. https://www.eia.gov/electricity/annual/html/epa_08_02.html.

[6] Emission rate of natural gas 116.65 pounds CO2 per metric million British thermal unit: U.S. Energy Information Administration. 2021. "Carbon Dioxide Emissions Coefficients." U.S. Energy Information Administration. https://www.eia.gov/environment/emissions/co2_vol_mass.php

[7] Social cost of carbon: $51 per metric ton of CO2:
Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Washington, D.C.: U.S. White House. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

without any hydro generation. In phase 1, the largest possible electricity prices were obtained from the marginal cost of the most expensive unit.

Table 8. Calculation of Hydropower Generation Benefits Score

Metrics		Weights
Hydropower Generation Benefits (0–60)	Hydropower Economic Benefits ($)	60 / largest possible Power System Benefits score
	Hydropower Environmental Benefits ($)	

5.3.1.3. Total Quantitative Scoring Calculation

The Hydropower Management Performance and Hydropower Generation Benefits scores are combined with equal weight to come up with the quantitative score (see Table *9*), equating to 80% of the total score a competitor can receive. The remaining 20% of the score is based on qualitative scoring criteria defined in Section 5.3.

Table 9. Calculation of Total Quantitative Score

Metrics		Score
Time Series Quantitative Score (0–120)	Hydropower Management Performance	0–60
	Hydropower Generation Benefits	0–60

5.3.2. Technical Narrative

The scored Technical Narrative, describing the solution approach, should provide a clear description of the methods used to generate the Reservoir Release Schedule and provide responses to the evaluation statements outlined in

Table *10*. Competitors can use up to 2,500 words and up to five supporting images, figures, or graphs to populate the template available on Topcoder. The document should describe the methods used, show a clear understanding for how the approach will function within hydropower facilities and an interdependent system, show the potential for more generalized use, include a plan for how it may be implemented, and indicate an understanding of diversity, equity, and inclusion considerations. The document should clearly highlight the novelty of the approach and give a description of how the approach will advance the state of the art. The Technical Narrative should also include a description of the team members and their backgrounds.

Table *10* suggests content for you to provide and the statements used to evaluate the Technical Narrative. The content bullets are only suggestions to guide responses; competitors decide where to focus their responses.

Table 10. Scored Technical Narrative Requirements

Technical Narrative (Scored, Not To Be Made Public)	
Suggested Content Competitors Provide Competitors should provide: ● A clear and concise description for how the approach will function in the hydropower industry ● A clear and concise description for how the approach can be modified for other hydropower generation applications ● A description of how the approach can be easily modified to apply to other hydropower operations beyond the competition datasets used in these prizes ● A comparison of the submitted approach to the current state of the art ● A description of the team composition, team member backgrounds, and relevant experience ● Diversity, equity, and inclusion goals using SMART[8] milestones supported by metrics to measure the success of increasing diversity and inclusion as a result of the proposed actions.	**Each Statement Is Scored on 1–6 Scale** Scores evaluate whether: ● The competitor demonstrates a clear understanding for how the approach can be used in the hydropower industry ● The competitor demonstrates a clear understanding of the approach, any limitations, and how it can be generalized and applied to different datasets ● The approach is scalable such that it can address large system applications and alleviate computational performance concerns ● The approach is unique and novel in comparison to the current state of the art in the hydropower industry ● The competitor demonstrates how diversity, equity, and inclusion objectives will be incorporated into their solution.

Each statement for the Technical Narrative requirements from

Table *10*, will be scored based on a 1–6 scale, as shown in Table *11*.

Table 11. Technical Narrative Scoring Scale

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

[8] SMART goals are defined as specific, measurable, achievable, relevant, and time-bound.

5.3.3. Software

The goal of this prize is to incentivize competitors to develop an approach to produce the reservoir release schedule in a rapid and replicable manner without human intervention. Judges seek to understand competitors' approaches. Competitors should provide a description of the software execution steps, the software source code, and/or instructions on how to build and run the software, along with descriptions of any proprietary- or license-restricted dependencies and other details. As this will not be scored, providing this portion of the submission is optional but encouraged.

Table 12. Optional Software Submission Requirements

Software (Not Scored, Not To Be Made Public)
Competitors should provide the software or other information used to produce the reservoir release schedule. This can consist of any combination of details about the: • Algorithm, which is written prose in English describing the steps the software takes to produce the reservoir release schedule • Source code, documented in human readable and sharable text. • Build/run steps with instructions for how to build and run the software, including descriptions of proprietary or license restricted dependencies, version numbers, and other details required for a reproducible build. The prize administrator will take no rights in this information, which will only be used for purposes of evaluation of the submission package.

5.3.4. Submission Summary Slide

The Submission Summary Slide is a slide describing the competitor's approach and the anticipated impact of the submission. The Submission Summary Slide will not contribute to the overall score but is a required submission.

Table 13. Submission Summary Slide Requirements

Submission Summary Slide (Not Scored, Will Be Made Public)
The competitor must make a public-facing, one-slide submission summary that contains technically specific details but can be understood by most people. There is no template, so competitors are free to present the information in any layout in a PDF format. Any text must be readable in a standard printout and conference room projection.

5.3.5. Final Score

Final scores for each submission will be calculated using scores from each of the aforementioned categories in accordance with Table *14*.

Table 14. Calculation of the Final Score

Scoring Item	Total Possible Points
Technical Narrative	30
Hydropower Management Performance ● Physical Constraint Violation ● Operational Constraint Violation	60
Hydropower Generation Benefits ● Hydropower Economic Benefits ● Environmental Benefits	60
Total	**150**

5.4. Dataset Specification

The datasets informing each phase of the competition will be made available on the Topcoder platform at the start of each phase. A description of the regional grid and water network data is included in tables in Appendix A and Appendix B. These tables describe the data that may be provided in each phase and may be slightly modified between phases. If additional dataset information is provided for a specific phase, the data will be described in similar detail to the tables provided in those appendices.

5.5. How Winners Are Determined

The Prize Administrator screens all completed submissions and, in consultation with DOE, assigns reviewers to independently score the applicable content of each submission. The reviewers will be composed of federal and nonfederal subject-matter experts with expertise in relevant areas. Reviewers will review submissions in each phase according to the described evaluation criteria. The Prize Administrator will tally the scores based on the scoring criteria described.

The Prize Administration Team has identified the following additional processes that may be used in the determination of winners. Outcomes from these processes are optional but can be used in the consideration of winner selection. These processes include:

- **Virtual interviews.** WPTO, at its sole discretion, may decide to hold virtual interviews with a subset of competitors in each phase. Selected finalists will be invited to present, explain, and answer questions pertaining to the functionality of their approach. This will be done in a virtual format. The interviews will be held prior to the announcement of winners and will serve to help clarify questions the reviewers or judges may have.

- **Final determination.** The director of WPTO is the judge of the competition and will make the final determination. Final determination of winners by the judge will take the reviewers' scores, any interview findings, and the judge's review and program policy factors in 0 into account.

Approximately 45 days after the contest closes, the Prize Administrator will notify winners and request the necessary information to distribute cash prizes. The Prize Administrator will then publicly announce winners.

5.6. Additional Terms and Conditions

See Appendix F for additional requirements. COMPETITORS THAT DO NOT COMPLY WITH THE ADDITIONAL REQUIREMENTS IN APPENDIX F MAY BE DISQUALIFIED.

5.7. Participant Eligibility

Eligible Competitors

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

- Individuals can compete alone or as a group. A representative of a private entity can also register the entity to compete by itself or as the lead organization of a group of entities. Teams can also be comprised of a mix of individuals and entities or organizations.
- An individual prize competitor (who is not competing as a member of a group) must be a United States citizen or a legal permanent resident.
- A group of individuals competing as one team may win, provided the team captain and Topcoder account holder for the team submission is a United States citizen or a legal permanent resident.
- Individuals competing as part of a team may participate if they are legally allowed to work in the United States.
- Private entities must be incorporated in and maintain a primary place of business in the United States with majority domestic ownership and control. If an entity seeking to compete does not have majority domestic ownership and control, DOE's Office of Energy Efficiency and Renewable Energy may consider issuing a waiver of that eligibility requirement where (1) the entity otherwise meets the eligibility requirements; (2) the entity is incorporated in and maintains a primary place of business in the United States; and (3) the entity submits a compelling justification. DOE's Office of Energy Efficiency and Renewable Energy may require additional information before making a determination on the waiver request. See Appendix F for more information on the waiver process.
- Academic institutions must be based in the United States.

Ineligible Competitors

Those interested in participating should consider that:

- 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 6 months prior to the submission deadline of any contest are not eligible to participate in any prize contest in this program.
- Federal entities and federal employees are not eligible to compete 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.
- Entities and individuals identified as a restricted party on one or more screening lists of Department of Commerce, State and the Treasury are not eligible to compete. See Consolidated Screening Lists.
- Individuals participating in foreign government talent recruitment programs[9] of foreign countries of risk are not eligible to compete. Further, teams that include individuals participating in foreign government talent recruitment programs of foreign countries of risk[10] are not eligible to compete. Participation in a foreign government talent recruitment program could conflict with this objective by resulting in unauthorized transfer of scientific and technical information to foreign government entities.

To be eligible, the team captain 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 I am providing this submission to the Federal Government. 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.

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[9] Foreign government talent recruitment program is defined as an effort directly or indirectly organized, managed, or funded by a foreign government to recruit science and technology professionals or students (regardless of citizenship or national origin, and 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 physically relocate to the foreign state for the above purpose. Some programs allow for or encourage continued employment at U.S. 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.

[10] Currently, the list of countries of risk includes Russia, Iran, North Korea, and China

5.8. Applications of Interest

The Prize Administrator must conclude that all the following statements are true when applied to a submission to be considered:

- The proposed solution represents an advancement in the hydropower industry beyond the current state
- The proposed solution is based on sound fundamental technical principles, following the laws of physics
- The proposed solution does not involve the lobbying of any federal, state, or local government.

If your proposed solution does not meet the above requirements, it will not be subjected to additional review, will not receive scores from the reviewers, and will not be considered for a prize under this program.

The competitor will retain all ownership of the intellectual property contained in their submission. The prize administrator will not utilize any proprietary information without first obtaining a license from the competitor.

5.9. Diversity, Equity, and Inclusion

It is the policy of the Biden Administration that:

> [T]he Federal Government should pursue a comprehensive approach to advancing equity[11] for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. Affirmatively advancing equity, civil rights, racial justice, and equal opportunity is the responsibility of the whole of our Government. Because advancing equity requires a systematic approach to embedding fairness in decision-making processes, executive departments and agencies must recognize and work to redress inequities in their policies and programs that serve as barriers to equal opportunity.
>
> By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone.[12]

As part of this whole of government approach, this prize seeks to encourage the participation of underserved communities[13] and underrepresented groups. Applicants are highly encouraged to include individuals from groups historically underrepresented[14,15] in STEM on their project teams. As part of the

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[11] The term "equity" means the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality.

[12] The White House. 2021. "Executive Order 13985, Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" Jan. 20, 2021. *The White House*. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/.

[13] The term "underserved communities" refers to populations sharing a particular characteristic, as well as geographic communities, that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, as exemplified by the list of in the definition of "equity." E.O. 13985. For purposes of this prize, as applicable to geographic communities, applicants can refer to economically distressed communities identified by the Internal Revenue Service as Qualified Opportunity Zones; communities identified as disadvantaged or underserved 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 definition of "underserved communities" stated above.

[14] According to the National Science Foundation's 2019 report titled "Women, Minorities and Persons with Disabilities in Science and Engineering", women, persons with disabilities, and underrepresented minority groups—blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives—are vastly underrepresented in the science, technology, engineering and mathematics (STEM) fields that drive the energy sector. That is, their representation in STEM education and STEM employment is smaller than their representation in the U.S. population.
National Center for Science and Engineering Statistics. 2019. *Women, Minorities and Persons with Disabilities in Science and Engineering*. Alexandria, Virginia: National Science Foundation. https://ncses.nsf.gov/pubs/nsf19304/digest/about-this-report.
For example, in the U.S., Hispanics, African Americans and American Indians or Alaska Natives make up 24% of the overall workforce, yet only account for 9% of the country's science and engineering workforce. DOE seeks to inspire underrepresented Americans to pursue careers in energy and support their advancement into leadership positions.
Erin R. Pierce. 2013. "Introducing the Minorities in Energy Initiative." *U.S. Department of Energy*. Sept. 25, 2013. https://www.energy.gov/articles/introducing-minorities-energy-initiative

[15] Note that Congress recognized in section 305 of the American Innovation and Competitiveness Act of 2017, Public Law 114-329: "(1) [I]t is critical to our Nation's economic leadership and global competitiveness that the United States educate,

application, applicants are required to describe how diversity, equity, and inclusion objectives will be incorporated in the project. These objectives should include SMART (Specific, Measurable, Assignable, Realistic and Time-Related) milestones supported by metrics to measure the success of the proposed actions. This criterion will be evaluated as part of the technical review process.

Further, Minority Serving Institutions[16], Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, Veteran Owned Businesses, or entities located in an underserved community that meet the eligibility requirements are encouraged to apply as the prime applicant or participate on an application as a proposed partner to the prime applicant. The Selection Official may consider the inclusion of these types of entities as part of the selection decision (See Appendix F).

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

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train, and retain more scientists, engineers, and computer scientists; (2) there is currently a disconnect between the availability of and growing demand for STEM-skilled workers; (3) historically, underrepresented populations are the largest untapped STEM talent pools in the United States; and (4) given the shifting demographic landscape, the United States should encourage full participation of individuals from underrepresented populations in STEM fields."

[16] Minority Serving Institutions (MSIs), including Historically Black Colleges and Universities/Other Minority Institutions) as educational entities recognized by the Office of Civil Rights (OCR), U.S. Department of Education, and identified on the OCR's Department of Education U.S. accredited postsecondary minorities' institution list. See U.S. Department of Education. 2011. "Lists of Postsecondary Institutions Enrolling Populations With Significant Percentages of Undergraduate Minority Students." U.S. Department of Education. https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html.

Appendix A. Power System Data

Table *15* describes power system datasets that will be provided to the competitors

Table 15. Power System Datasets

Component	Name	Description
Generator	ID	Unit identification (ID) of the generator
	Bus ID	ID of the bus the generator is connected to
	Unit Type	Type of the generating unit
	Fuel	Fuel of the generating unit
	PMax	Maximum capacity of the generator in megawatts (MW)
	PMin	Minimum operating capacity of the generator in MW
	Min Down Time	Minimum down time of the generator in hour (hr)
	Min Up Time	Minimum up time of the generator in HR
	Ramp Rate	Ramp rate of the generator MW/minute
	Start Cost	Start-up cost of the generator $/startup
	Shutdown Cost	Shut-down cost of the generator $/shutdown
	Variable Cost	Variable operations costs $/mw
Bus	ID	ID of the bus in the system
Branch	UID	ID of the branch in the system
	From Bus	Bus ID from end of the branch
	To Bus	Bus ID to end of the branch
	R	Resistance of the branch in per unit
	X	Reactance of the branch in per unit
	B	Susceptance of the branch in per unit
	Flow Limit	Rated MW limit of the branch (line capacity)
Reserve	ID	ID of reserve product
	Requirement	Requirement of reserve product in MW
	Qualifying Facilities	Generator IDs of qualifying facilities
	Saturation time	Maximum response time of provisioned resources
Demand	ID	Load ID
	Bus ID	ID of the bus the demand is connected to
	MW	MW Demand

Appendix B. Water System Data

The water system dataset will include information about the water system features and connectivity, physical constraints, and operational constraints. The dataset can be used by the competitors to inform their modeling process. Table *16* describes the data that could be provided to competitors to define the water system.

Table 16. Water System Datasets

Component	Name	Description
Network	Connectivity	River network connectivity, i.e., flow direction, ordering and topology of reservoirs (including cascading effects), river reaches, demands, constraints, etc., which will be defined as a table
Reservoirs	Storage Capacity	Minimum and maximum reservoir volumes
	Initial Storage	Initial reservoir storage at the start of the simulation
	Area-Capacity-Elevation Table	A table containing area-capacity-elevation relationships (which will be linearly interpolated)
	Net Evaporation Rates	Rates of gains/losses to the exposed water surface of the reservoir
	Outlet Capacity	Maximum reservoir outlet flow capacity
	Guide Curves	Any operational reservoir storage guide curve that is used to define the operational storage targets throughout the simulation period[17]
	Measured Inflows	A time series of measured, local inflows from contributing watershed(s) and the infrastructure of imported water
	Reservoir Type	Designates the setup of the reservoir as either on-channel or off-channel
	Max Power Capacity	Maximum power generation

[17] Guide curves referenced could vary throughout time.

Component	Name	Description
Hydropower Generators	Power Plant Elevation	Plant elevation, which defines the tailwater elevation for hydropower generation
	Efficiency Table	A power plant energy efficiency table, defined as a function of flow and head
Operational Constraints	Water Demands and Water Rights	A time series of water demands at point locations along a river reach with priority date and flow entitlement
	Minimum Flow Constraints	A time series of minimum flow constraints along a river reach, which could mimic environmental flows, recreational flows, etc.
	Maximum Flow Constraints	A time series of maximum flow constraints along a river reach, which could mimic flooding constraints or hazards

In addition to the datasets, simplifying assumptions will be made about the water system problem. The following is a list of general assumptions that are true for all competition phases. Additional assumptions may be provided for specific problem sets, if necessary. Assumptions can include that:

- Measured inflows are assumed to be additional inflows into the system at a specific point. These could represent local flows from the surrounding watershed(s) or imported flows from neighboring basins. Total inflows to a reservoir would be calculated as local flows plus any releases from upstream reservoirs. If there are no reservoirs upstream, the total inflow is equivalent to the measured inflows. In a cascading reservoir system, downstream reservoirs will have to account for measured inflows plus any instream contributions from upstream reservoirs.

- Reservoir release schedules will be assumed to go through the reservoir outlet (with a maximum capacity). Any water that goes through the reservoir outlet is assumed to go through the turbine and generate energy.

- For off-channel reservoirs, it should be assumed that there is a single bottom outlet structure for reservoir releases and no other additional controlled or uncontrolled outlet structures. Therefore, spills/bypass may not consist of stored water. Spills/bypass can occur, in any timestep, if:

    - the reservoir outlet capacity is fully utilized then the available inflows can be bypassed (non-generation flow).

    - the reservoir is full and the release schedule is greater than the outlet capacity, the available inflows will be bypassed.

- For on-channel reservoirs, it should be assumed that there is a single bottom outlet structure for reservoir releases and an uncontrolled spillway at the maximum elevation defined for the reservoir. Therefore, spills/bypass may only occur when the reservoir is full. Uncontrolled spills/bypass (non-generation flow) will occur, in any timestep, if given the current timestep inflow, the reservoir outlet capacity is fully utilized and the reservoir storage exceeds the reservoir's maximum capacity.

- Any spill/bypass included in a reservoir release schedule that does not meet the outlined spill/bypass requirements defined above for on-channel and off-channel reservoirs will result in a physical violation.

- Unless otherwise specified for a particular dataset, river flow routing is ignored; therefore, there is no lag or attenuation of water flow between network objects.

- Units will be provided for all dataset components (i.e., volume: acre-feet or cubic meters (m^3); flow: acre-feet/day, cubic feet per second (CFS), m^3/day, or cubic meters per second (CMS); rates: feet (ft)/day, or m/day).

- For power calculations, it can be assumed there are no head losses during the transit of water through the reservoirs and turbine. It is also assumed that there is a constant tailwater elevation based on the power plant elevation provided. Lastly, hydropower production for each time step is calculated based on average hydraulic head over the time step, calculated from the corresponding simulated initial and ending volumes of the reservoir in the time step.

Appendix C. Power System Evaluation

The job of the regional grid operator is to manage the supply of power generation to meet the demands of the grid at the lowest cost. To do this the operators make power generation scheduling decisions for every hour of the following day. In order to provide electricity to the grid, individual generation facilities must submit a schedule of possible power production every day for the following day. Regional grid operators take the production offers from each individual generator and use it to create a generation schedule for all generators for the following day. This schedule must balance the expected supply and demand for the entire system for each hour.

$$\min \sum_{g,t} p_{g,t} * C_g^{variable} + v_{g,t} * C_g^{startup} + w_{g,t} * C_g^{shutdown} \quad (10)$$

$$\sum_g p_{g,t} = \sum_l p_{l,t}, \forall t \quad (11)$$

$$p_{g,t} \geq P_g^{min} * u_{g,t}, \forall g, t \quad (12)$$

$$p_{g,t} \leq P_g^{max} * u_{g,t}, \forall g, t \quad (13)$$

$$p_{g,t} - p_{g,t-1} \leq R_g^{up} + P_g^{min} * v_{g,t}, \forall g, t \quad (14)$$

$$p_{g,t-1} - p_{g,t} \leq R_g^{down} + P_g^{min} * w_{g,t}, \forall g, t \quad (15)$$

$$\sum_{i=t-\Gamma_g^{up}}^{t} u_{g,i} \geq w_{g,t} * \Gamma_g^{up}, \forall g, t \quad (16)$$

$$\sum_{i=t-\Gamma_g^{down}}^{t} (1 - u_{g,i}) \geq v_{g,t} * \Gamma_g^{down}, \forall g, t \quad (17)$$

$$u_{g,t} = u_{g,t-1} + v_{g,t} - w_{g,t}, \forall g, t \quad (18)$$

$$v_{g,t} + w_{g,t} \leq 1, \forall g, t \quad (19)$$

$$u, v, w \in \{0, 1\} \quad (20)$$

$$f_{k,t} = \sum_j PTDF_{j,k} * (\sum_g p_{g \in j,t} - \sum_l p_{l \in j,t}), \forall k, t \quad (21)$$

$$T_k^- \leq f_{k,t} \leq T_k^+, \forall k, t \quad (22)$$

Typically grid operators solve a mathematical program to determine the optimal schedule of production for each generator. For this competition, the represented grid operator will use a formulation that follows a similar structure to those solved in common day-ahead grid scheduling processes, described in (10)-(22). Each step in the simulation process represents a set of periods, ($t \in T$), and each step is simulated in sequence by incrementally updating T to represent successive scheduling windows and initializing each problem with results obtained from previous solutions.

In a typical day-ahead scheduling simulation each problem will include 48 1-hour periods, T is incremented by 24 hours to represent subsequent problems, and the results of the first 24 hours of each problem are used to inform Equations (14)-(20). For example, the first problem in a day-ahead simulation sequence would represent $T_1 = \{t_1, t_2, \ldots, t_{48}\}$ and the second problem in the sequence would represent $T_2 = \{t_{25}, t_{26}, \ldots, t_{72}\}$ where the initial conditions of the problem representing T_2 are informed by the $t_1, \ldots, t_{24}$ results from the first problem.

The objective (10) of each sequential optimization problem is to minimize the total fixed and variable cost of generating electricity. The system balance constraint (11) requires the sum of generation (p_g) from each generator ($g \in G$) and the sum of demand (p_l) from each load ($l \in L$) to be equal all times ($t \in T$). Equations (12)-(20) govern the operation of each generator. Specifically, the on/off status (u) is determined by the occurrence of startup (v) and shutdown (w) events in (18), and startup and shutdown events are restricted by minimum up (Γ_g^{up}) and down time (Γ_g^{down}) in constraints (16) and (17). The power output of each generator is constrained by the minimum (P_g^{min}) and maximum (P_g^{max}) output capabilities in (12) and (13), and the ramping limitations (R_g^{up}, R_g^{down}) in (14) and (15). Equation (21) defines the relationship between power injections and network flow. The power flow on each line ($k \in K$) at each period ($t \in T$) (denoted by ($f_{k,t}$) is equal to the product of power transfer distribution factor (PTDF[18]) from node *j* on line *k* and the net injection at node *j*, summed across all nodes ($j \in J$). $p_{g \in j,t}$ and $p_{l \in j,t}$ denote generation and load from generator *g* and load *l* at node *j*, respectively. $PTDF_{j,k}$ represents the amount of power flow on $line_k$ for each unit of power injection at node *j*. Equation (22) imposes transmission capacity constraints on power flows to be between a lower bound T^-_k and an upper bound T^+_k.

For the purposes of this competition, the Hydropower Economic Benefits of each generator is calculated as the product of the generation (p_g) and locational marginal prices (LMPs). LMP is calculated using the equation (23), where λ_t and $\mu_{k,t}$ are shadow price of equation (11) and (22), respectively.

$$LMP_{j,t} = \lambda_t + \sum_k (\mu_{k,t} * PTDF_{j,k}), \forall j,t \qquad (23)$$

In other words, by scheduling generation using the above simulation, the regional grid operator calculates the generator production schedules ($p_{g,t}, \forall t \in T, g \in G$) and the electricity prices at each time period. Each generator produces Economic Benefit by getting paid the price for the amount of energy it produces in each hour.

Appendix D. Water System Evaluation

The competitor's reservoir release schedule is the only variable that the competitor may control to determine water movement in the water evaluation model. All other values are either fixed or directly determined by the release schedule. The schedule will be evaluated based on compliance with the physical and operational constraints and corrected accordingly in the water system evaluation model (if necessary) (see Section 5.3.1.1). The resulting hydropower production will be passed to the power system evaluation and combined will all other production schedule offers from all other electricity producers in the regional power grid. See power system scoring in Appendix C.

The water system evaluation model calculates hydropower for each reservoir based on the flow through the turbine outlet, the mean effective head in the reservoir (neglecting head losses), and turbine efficiencies as shown in equation (24):

$$P_t = Q_h \times \overline{H}_t \times e_t(Q_t, \overline{H}_t) \leq P_{max} \text{ (Equation 24).}$$

Where for a given single reservoir: P_t is the power output during period t; $\overline{H}_t$ is mean effective head for period t; and $e_t(Q_t, \overline{H}_t)$ is the plant efficiency, interpolated from an efficiency table (provided to the competitor) as a function of discreate release rates Q and heads H, and P_{max} is the maximum power capacity.

For this competition, a constant tailwater is assumed at all hydropower facilities (as noted in Appendix B). Based on this assumption, the mean effective head is calculated using equation (25):

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[18] Many power system and energy modeling textbooks cover PTDF calculation. For example, see Appendix C of Gabriel, S. A., Conejo, A. J., Fuller, J. D., Hobbs, B. F., & Ruiz, C. (2012). Complementarity modeling in energy markets (Vol. 180). Springer Science & Business Media

$$\overline{H}_t = 0.5 \times \left(E(S_t) + E(S_{t+1})\right) - EP \text{ (Equation25)}$$

Where for a given single reservoir: $\overline{H}_t$ is mean effective head for period t; $E(S_t)$ is the water surface elevation at the beginning of period as interpolated from the area-capacity-elevation table, and $E(S_{t+1})$ is the water surface elevation at the end of period as interpolated from the area-capacity-elevation table; and EP is the power plant elevation. As noted in Appendix B, power plant elevation and area-capacity-elevation tables will be provided to the competitor in the dataset for each reservoir in the water system.

It should be assumed that all reservoir releases (scheduled by the competitor) will pass through the turbine and generate power unless releases exceed turbine flow capacity. For off-channel reservoirs, if scheduled water releases exceed the turbine's maximum capacity, then available inflows will be passed through a spill-bypass construct and will not generate power. For off-channel reservoirs this can occur even when the reservoir storage is not at the maximum capacity. For on-channel reservoirs, any scheduled water releases that exceed the turbine's maximum capacity when the reservoir is at maximum capacity will be passed through a spill-bypass construct and will not generate power. Physical violations will occur If the scheduled reservoir releases do not consider the necessary bypass/spill flow. Any spill/bypass included in a reservoir release schedule that does not meet the outlined spill/bypass requirements discussed above and defined in Appendix B for on-channel and off-channel reservoirs will result in a physical violation. If a physical violation(s) occurs, the release schedule will be corrected and the competitor will lose points for that time period.

Appendix E. Reservoir Release Schedule Example

Table 17 below provides an example of a competitor's reservoir release schedule and how it will appear in a CSV file. The first column, with header label "DateTime," identifies the text time step of the time series (in the format of YYYY-MM-DD:HH:MM:SS). The remaining columns record the release scheduled in acre-feet per hour as floating point with a precision of three decimal places during the associated timestep for each reservoir with header labels following the naming convention: "[ReservoirName]_InputRelease". In this example, there are three reservoirs, named "Reservoir1", "Reservoir2", and "Reservoir3", with 10.000, 20.000, and 30.000 acre-feet releases scheduled per time step for each corresponding reservoir.

Table 17. Table Example of Reservoir Release Schedule

DateTime	Reservoir1_InputRelease	Reservoir2_InputRelease	Reservoir3_InputRelease
2020-01-01T00:00:00.0	10.000	20.000	30.000
2020-01-01T01:00:00.0	10.000	20.000	30.000
2020-01-01T02:00:00.0	10.000	20.000	30.000
2020-01-01T03:00:00.0	10.000	20.000	30.000
2020-01-01T04:00:00.0	10.000	20.000	30.000
2020-01-01T05:00:00.0	10.000	20.000	30.000
2020-01-01T06:00:00.0	10.000	20.000	30.000
⋮	⋮	⋮	⋮

Appendix F. Additional Terms and Conditions

Universal Contest Requirements

Submissions are subject to following terms and conditions:

- Competitors must post the final content of their submission or upload the submission form on the Topcoder platform before the relevant contest closes. Any other form of submission will not be accepted. Late submissions will not be accepted.
- By clicking Submit in Topcoder, the competitor is agreeing to make their video and cover page public.
- The Technical Narrative and Software description are not intended to be made public. See the following section regarding the Freedom of Information Act.
- Competitors must include all the required Submission Elements. The Prize Administrator may disqualify a 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 or to fix nonsubstantive mistakes or errors in their submission packages.
- A competitor's Technical Narrative submission must be in English and in a format readable by Microsoft Word or a PDF viewer. Handwritten submissions will be disqualified.
- Submissions and competitors will be disqualified if any engagement with the H2Os Prize—included but not limited to the submission, the Topcoder forum, or emails to the Prize Administrator—contains any matter that, in the sole discretion of the U.S. Department of Energy (DOE) or National Renewable Energy Laboratory (NREL), is indecent, obscene, defamatory, libelous, lacking in professionalism, or demonstrates a lack of respect for people or life on this planet.
- If a competitor clicks Accept on the Topcoder platform and registers for any of the contests described in this document, they are agreeing to be bound by these rules in addition to the existing Topcoder Terms of Use for all purposes relating to these contests. Competitors should print and keep a copy of these rules. These provisions apply only to the contests described here and no other contests on the Topcoder platform or anywhere else.

Verification for Payments

The Prize Administrator will verify the identity and role of all competitors before distributing any 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 for the individual, team, or entity that was responsible for the submission. Each competitor will be required to sign and return to the Prize Administrator, within 30 days of the date on the notice, a completed NREL Request for ACH Banking Information form and a completed W-9 form (https://www.irs.gov/pub/irs-pdf/fw9.pdf). In 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/team/entity does not respond to notifications; (ii) the person/team/entity fails to sign and return the required documentation within the required time period; (iii) the notification is returned as undeliverable; (iv) the submission or person/team/entity is disqualified for any other reason as specified in eligibility section in the executive summary or universal content section above.

In the event of a dispute as to any registration, 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. All competitors may be required to show proof of being the authorized account holder.

Teams and Single-Entity Awards

The Prize Administrator will award a single U.S. dollar amount to the designated primary submitter, whether consisting of a single or multiple entities. The primary submitter is solely responsible for allocating any prize funds among its member competitors or teammates as they deem appropriate. The Prize Administrator will not arbitrate, intervene, advise on, or resolve any matters or disputes between team members or competitors.

Submission Rights

By making a submission and consenting to the rules of the contest, a competitor is granting to DOE, the Prize Administrator, and any other third parties supporting DOE in the contest, 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 or Topcoder applications, including the contest website, DOE websites, and partner websites, and the inclusion of the submission in any other media worldwide. The submission may be viewed by the DOE, Prize Administrator, and judges and reviewers for purposes of the contests, 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 competitors’ names and, as applicable, the names of competitors’ team members and organization, which participated in the submission on the contest website indefinitely.

By entering, the competitor represents and warrants that:

1. Competitor’s entire submission is an original work by competitor and competitor has not included third-party content (such as writing, text, graphics, artwork, logos, photographs, likeness of any third party, musical recordings, clips of videos, television programs or motion pictures) in or in connection with the submission, unless (i) otherwise requested by the Prize Administrator and/or disclosed by competitor in the submission, and (ii) competitor has either obtained the rights to use such third-party content or the content of the submission is considered in the public domain without any limitations on use.
2. Unless otherwise disclosed in the submission, the use thereof by Prize Administrator, or the exercise by Prize Administrator of any of the rights granted by competitor under these rules, does not and will not infringe or violate any rights of any third party or entity, including, without limitation, patent, copyright, trademark, trade secret, defamation, privacy, publicity, false light, misappropriation, intentional or negligent infliction of emotional distress, confidentiality, or any contractual or other rights;
3. All persons who were engaged by the competitor to work on the submission or who appear in the submission in any manner have:
    a. Given the competitor their express written consent to submit the submission for exhibition and other exploitation in any manner and in any and all media, whether now existing or hereafter discovered, throughout the world;
    b. Provided written permission to include their name, image, or pictures in or with the submission (or, if a minor who is not competitor’s child, competitor must have the permission of the minor’s parent or legal guardian) and the competitor may be asked by the Prize Administrator to provide permission in writing;

c. Not been and are not currently under any union or guild agreement that results in any ongoing obligations resulting from the use, exhibition, or other exploitation of the submission.

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 competitor or that the competitor 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 any other third-party rights of which the competitor is aware; and that the submission is free of malware.

Contest Subject to Applicable Law

All contests are subject to all applicable federal laws and regulations. Participation constitutes each participant's full and unconditional agreement to these Official Contest Rules and administrative decisions, which are final and binding in all matters related to the contest. This notice is not an obligation of funds; the final award is contingent upon the availability of appropriations.

Resolution of Disputes

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

Neither DOE nor the Prize Administrator will arbitrate, intervene, advise on, or resolve any matters between team members or among competitors.

Publicity

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

Except where prohibited, participation in the contest 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.

Liability

Upon registration, all participants agree to assume any and all risks of injury or loss in connection with or in any way arising from participation in this contest. 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 contest, whether the claim or cause of action arises under contract or tort.

In accordance with the delegation of authority to run this contest delegated to the director of DOE’s Water Power Technologies Office, the director has determined that no liability insurance naming DOE as an insured will be required of competitors to compete in this competition per 15 USC 3719(i)(2). Competitors should assess the risks associated with their proposed activities and adequately insure themselves against possible losses.

Records Retention and Freedom of Information Act

All materials submitted to DOE as part of a submission become DOE records and are subject to the Freedom of Information Act. The following applies only to portions of the submission not designated as public information in the instructions for submission. If a submission includes trade secrets or information that is commercial or financial, or information that is confidential or privileged, it is furnished to the Government in confidence with the understanding that the information shall be used or disclosed only for evaluation of the application. Such information will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act. Without assuming any liability for inadvertent disclosure, DOE will seek to limit disclosure of such information to its employees and to outside reviewers when necessary for review of the application or as otherwise authorized by law. This restriction does not limit the Government's right to use the information if it is obtained from another source.

Submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information and may use or disclose such information for any purpose.

The submission must be marked as follows and identify the specific pages containing trade secrets, confidential, proprietary, or privileged information:

> <u>Notice of Restriction on Disclosure and Use of Data:</u>
>
> Pages [list applicable pages] of this document may contain trade secrets, confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes. [End of Notice]

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Trade Secrets, Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, each line or paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double 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 FOIA representative prior to the release of materials.

Privacy

If a competitor chooses to provide Topcoder with personal information by registering or completing the submission package through the contest website, they 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 them in matters regarding your submission and/or the contest unless they choose to receive updates or notifications about other contests or programs from DOE on an opt-in basis. DOE and NREL are not collecting any information for commercial marketing.

General Conditions

DOE reserves the right to cancel, suspend, and/or modify the contest, 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 contests, as determined by DOE in its sole discretion, DOE may cancel the contest.

Although DOE may indicate that it will select up to several quarterfinalists, semifinalists, finalists, and winners for each contest, DOE reserves the right to only select competitors that are likely to achieve the goals of the program. If, in DOE's determination, no competitors are likely to achieve the goals of the program, DOE will select no competitors to be quarterfinalists, semifinalists, finalists, or winners and will award no prize money.

Program Policy Factors

While the scores of the expert reviewers will be carefully considered, it is the role of the prize judge to maximize the impact of contest 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 below program policy factors may be considered in determining winners:

- Geographic diversity and potential economic impact of projects
- Whether the use of additional DOE funds and provided resources are nonduplicative and compatible with the stated goals of this program and the DOE 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 funded efforts or projects, which, when taken together, will best achieve the goals and objectives of DOE
- The degree to which the submission expands DOE's funding to new competitors and recipients who have not been supported by DOE in the past
- 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.

National Environmental Policy Act (NEPA) Compliance

DOE's administration of the American Made Challenges: H2Os Prize is subject to NEPA (42 USC 4321, et seq.). NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website at http://nepa.energy.gov/.

Request To Waive the Domestic Ownership and Control Eligibility Requirement

If an entity seeking to compete as the registered competitor does not have domestic ownership and control, the entity should include a waiver request that addresses the following waiver criteria and content requirements below along with their submission. EERE may consider issuing a waiver of that eligibility requirement where the entity submits a compelling justification; the entity is incorporated in and maintains a primary place of business in the United States; and the entity otherwise meets the eligibility criteria. There are no rights to appeal EERE's decision on the waiver request.

Waiver Criteria

Entities seeking a waiver must demonstrate to the satisfaction of EERE that its participation: (1) has a high likelihood of furthering the objectives of this prize competition and (2) aligns with the best interest of the U.S. industry and U.S. economic development.

Content for Waiver Request

A waiver request must include the following information:

a) Entity's name and place of incorporation
b) The location of the entity's primary place of business
c) A statement describing the extent the entity is owned or control by a foreign government, agency, firm, corporation, or person who is not a citizen or permanent resident of the United States, including the applicable percentage of ownership/control
d) A compelling justification that addresses the waiver criteria stated above
e) A description of the project's anticipated contributions to the U.S. economy
f) A description of how the entity has benefitted U.S. research, development and manufacturing, including contributions to employment in the United States and growth in new U.S. markets and jobs
g) A description of how the entity has promoted domestic manufacturing of products and/or services.

Requests should be emailed to the H2OsPrize@nrel.gov.

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