U.S. Department of Energy
Request for Information (RFI)
Potential Prize titled "Water Security Grand Challenge Thermoelectric Cooling Prize"

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SUMMARY: The U.S. Department of Energy (DOE) invites public comment providing information and feedback on the design of a potential prize competition with a goal of lowering water use in existing thermoelectric power plants and enabling near zero water use in new power plants (i.e., reduce water intensity of thermoelectric power generation). Through this potential prize, DOE would seek novel equipment designs (including materials and methods of manufacture), for both wet and dry cooling systems and combinations thereof, as well as for those with alternative working fluids, that enable the achievement of the prize goal. Specifically, the intent is to encourage innovators, engineering and design firms, manufacturers and utilities to develop solutions that will be subjected to rigorous testing to demonstrate their potential. Input from this RFI may be used to further develop the competition objectives, rules, metrics, and incentives.

BACKGROUND: The DOE-led Water Security Grand Challenge ("the Challenge") aims to advance transformational technology and innovation to meet the global need for safe, secure, and affordable water using a coordinated suite of prizes, competitions, early-stage research and development, and other programs.[1] The Challenge consists of five goals; this RFI focuses on the goal of reducing water intensity of thermoelectric power generation by 2030.

Thermoelectric plants use a variety of different process schemes (see attached figures) that require water as a cooling medium.[2] Due to this dependence on water, power plants are faced with the prospect of curtailing their production (often at times when that power is needed the most) as cooling water supply is not adequate, or in some instances incoming cooling water temperatures are too high, limiting maximum power production to keep outlet temperatures within environmental limits.[3]

[1] *https://www.energy.gov/eere/water-security-grand-challenge*
[2] *Consumptive Water Use for US Power Production, NREL/TP-550-33905*
[3] *Water-Related Power Plant Curtailments: An overview of incidents and contributing factors, NREL/TP-6A20-67084, December 2016*

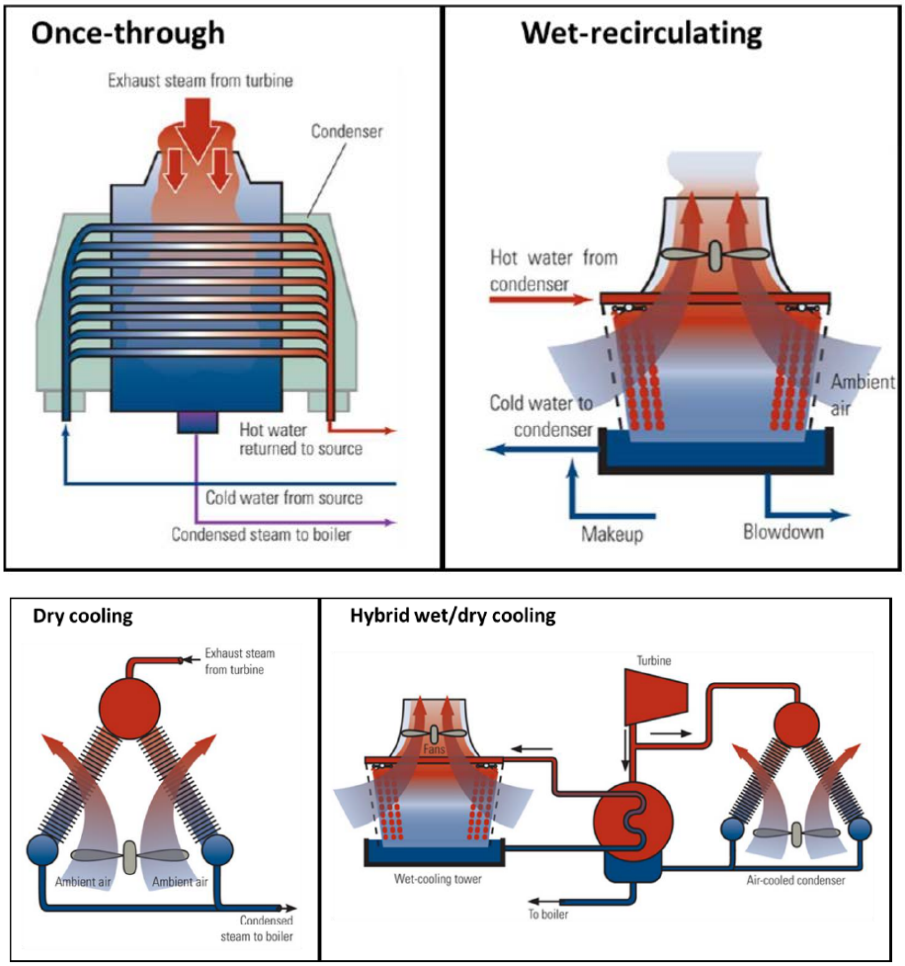

Figure 1. Schematic representation of different cooling systems (Source: EPRI. Water Use for Power Generation. 2008)

In addition, consumptive losses associated with recirculating cooling systems (drift) and cooling ponds (evaporative losses) increase quantities of water use for cooling. As an alternative, dry cooling systems have been developed, but need to address issues such as overall cost and parasitic losses. Information on the utilization of different cooling systems in US power plants is provided by the EIA at this link.

Thermoelectric power plants will continue to be used well into the future despite the growth of renewable sources of power. Installation of carbon capture systems could increase the power load by as much as 30%.[4] It is critical, therefore, to ensure efficient and responsible water use of these plants. Guidelines are available, and standards have been established to facilitate water savings via operational best practices; however, to date there has been little innovation in the realm of equipment design that could achieve a step change reduction in water use.

DOE has, through its various offices and agencies, previously funded multiple activities directed at this goal:

[4] *Water Use at Pulverized Coal Power Plants with Postcombustion Carbon Capture and Storage, H. Zhai, E. Rubin, P. Versteeg, Environ. Sci. Technol. 2011, 45, 6, 2479-2485.*

- Energy Efficiency and Renewable Energy (EERE) Advanced Manufacturing Office (AMO): Materials in Harsh Environments, Additive Manufacturing
- Advanced Research Projects Agency-Energy: Advanced Research Program in Dry Cooling
- Office of Fossil Energy: Water Management R&D
  - Modeling Existing Coal Plant Challenges Using High-Performance Computing
  - Coal Power Plant Cooling Technology
- Office of Nuclear Energy: Integrated Hybrid Energy Systems

To build from recent work and make progress towards the goal of lowering water intensity of thermoelectric power generation, DOE is considering a potential prize competition that seeks to develop and test novel equipment designs for improved cooling. This prize is intended to target both existing and proposed new build power plants. The envisioned outcome of this prize competition is the development of new equipment designs that have low capital and operating expense, and achieve the desired goal of lower water usage. It is also envisioned that the prize competition will benefit from recent advances in materials science and manufacturing techniques.

Competition participants are expected to be multi-disciplinary teams of stakeholders that will develop novel equipment designs (including novel materials and methods of manufacture). Teams are likely to be comprised of innovators in both industry (e.g., equipment manufacturers, engineering and design firms and utilities) and academia.

As currently envisioned, the prize would consist of two phases. In the first phase, teams would submit a proposed equipment design with sufficient detail to confirm lower water usage (through actual testing or computer modeling). Successful designs would demonstrate superior performance over existing state of the art designs and have the potential to be deployed broadly. Designs would also be judged on their innovation, performance and cost. At the end of phase one, DOE anticipates selecting a small number of teams for awards in the range of 250-500k$ to facilitate the construction of equipment proposed in their design. DOE may also publish selected teams' plans on a DOE website. DOE expects to provide teams about six months from prize announcement until phase one applications are due.

In phase two of the competition, teams would construct their equipment at a specified scale which would then be tested at a designated facility such as the Water Research Center founded jointly by Southern Research Institute, Georgia Power and EPRI. All equipment selected for demonstration will be subjected to the same testing protocol, and several metrics will be recorded to assess performance. The top performing design(s) in phase two would be eligible for the prize amount(s), as well as public recognition with the goal of incentivizing deployment by the private sector. DOE expects to provide teams approximately 1 year from phase one selection to submit final phase two hardware.

Quantitative metrics would play a critical role in the judging process of both phases of the competition. DOE envisions applicants will need to demonstrate a superior (i.e. lower) water usage as compared with existing technology at a specified cooling load (power production). Additional metrics or guidance would be developed to assess submissions on other criteria, including energy efficiency, innovation, replicability, and technical and engineering rigor.

The envisioned competition will focus on design of cooling equipment that uses water, air, or possibly other media for cooling. For the purposes of this competition, DOE is not interested in algorithm-based solutions for measurement/control of water consumption, or on improvements in

secondary systems such as heat recuperators. In addition, DOE is not interested in advancements in power production that require less cooling, as DOE is pursuing these advancements through other programs.

REQUEST FOR INFORMATION CATEGORIES AND QUESTIONS:

Category 1: Overall Prize Concept and Objectives

a) Can a prize-based approach contribute to achieving the goal of reducing water usage at thermoelectric power plants through cooling system improvements? If so, what aspects of a prize in particular can help achieve this goal? If not, what other approaches could be considered? Are there other complementary activities that can be pursued to increase the impact of the prize?

b) Are there other, similar initiatives that could help inform this prize?

c) What cooling technologies do you believe are most promising in the context of this prize, and what challenges exist in integrating these technologies into existing power plants? Are there configurations that incorporate multiple technologies? Which power plants/geographic locations would benefit the most from improvements to cooling systems with regards to water consumption and/or remaining life of the plant?

d) What technologies are currently being used in power plants for cooling purposes? Please describe in detail the specific equipment/manufacturer. Is there a specific target for overall water use/consumption? What challenges/opportunities arise when deploying these in existing plants versus new builds?

e) What is the experience with development and utilization of wet/dry cooling technologies as well as alternative working fluids? Please elaborate on specific barriers that might prevent new technologies/designs from being proposed for the prize concept.

f) What materials of construction and methods of manufacture are currently used for cooling equipment? Are there opportunities to improve the performance through using novel materials, new manufacturing techniques such as additive manufacturing, or new system concepts? What barriers exist to doing so?

g) What is the typical capex for cooling equipment (new installs and retrofits) ($/kw)? Please also give the physical size of the equipment. What are the major drivers for the difference in cost?

h) What are the typical operating costs for cooling systems? (please identify the type of system: $/kWh$_{\text{plant output}}$/year, kWh$_{\text{cooling system power consumption}}$/year)

i) What current state and local policies are driving plants to consider updating/replacing existing cooling systems? What are the promising retrofit solutions already available on the market?

j) What R&D needs are there in the area of traditional wet cooling systems? What R&D needs are there in the area of dry cooling?

k) Is fouling a significant burden for cooling units and how is it handled? Do technologies exist that can reduce the fouling burden and improve the overall cooling performance, including water efficiency? Are there other operational factors that can affect water consumption?

l) What is the typical operational life of cooling equipment? What is a typical maintenance schedule and the cost ($/kWh$_{\text{plant output}}$/year) of performing that maintenance? How does the cooling equipment typically affect the overall efficiency of the plant?

m) What is the decision-making process for replacement/purchase of cooling equipment? What criteria are important and please provide order of magnitude numbers that would constitute a major benefit for the sector (both capex/opex)?

n) How do environmental factors such as air temperature, water temperature, and humidity affect system performance and how should this be factored into the competition?

o) How should the competition consider different power generation systems (fuel and power cycle)? What factors significantly affect the optimal design of a cooling system?

p) What recent advances in materials science and manufacturing techniques may be valuable for this competition?

q) Who are important stakeholders to engage as partners or competitors in this competition?

Category 2: Prize Design

a) Is the proposed two-phase prize concept the most effective way of ensuring actionable ideas emerge from broad stakeholder teams? Is the proposed timeline (i.e., about six months for phase one and a year for phase two) sufficient to ensure DOE receives thoughtful, well-crafted application materials?

b) What scale (kWh) is appropriate for the phase 2 demonstration to provide sufficient assurance that the results would translate to deployment at a larger scale?

c) Are the proposed incentive levels [i.e., $250,000-500,000 prizes for teams selected in phase one; $1-2M prizes for the best design(s)] sufficient to incent participation?

d) How can the prize competition be structured such that the lessons learned from the projects that are selected through the competition can be generalized and replicated?

e) A key objective of the prize is to develop designs that can be scaled up and deployed in the private sector. What can DOE do as part of the prize structure or process to facilitate such an outcome?

f) Please share any other perspectives on details of the prize design.

Category 3: Criteria and Metrics

a) As currently envisioned, the prize focuses on measuring the water intensity of new equipment (gallons used per kWh power production) as the key determinant of success.

Secondary metrics include capital cost and energy efficiency of the design. Are there other metrics that should be considered/not considered?

b) What are ambitious but achievable targets for the metrics identified in question one in this section at an individual plant level that would distinguish applicants from state-of-the-art?

c) What metrics are appropriate to assess the financial viability of a submission as part of phase two judging?

d) How should DOE assess the innovativeness of prize applications?

e) Are there significant differences in the scalability of technologies?

f) What is the typical temperature range that is relevant for testing new designs?

g) What are methodologies that may be used to evaluate different designs e.g., different source temperatures?

h) How should the overall (future) impact of a new technology concept be assessed?

SUPPLEMENTARY INFORMATION:

Request for Information Response Guidelines:
Responses to this RFI must be submitted electronically to WSGC-Thermoelectric@netl.doe.gov with the subject line "Water Security Grand Challenge Thermoelectric Cooling Prize RFI" no later than 8:00pm (ET) on June 11, 2020. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. ***Responses must be provided as an Adobe Acrobat PDF (.PDF) attachment to the email, and no more than 20 pages in length, 12-point font, 1- inch margins. Only electronic responses will be accepted.***

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

This RFI document is located at here. On behalf of DOE, thank you in advance for providing your input on this important topic and contributing to DOE's success in achieving its objectives.

Confidential Business Information
Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information

believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) a description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person that would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

Disclaimer and Important Notes:

DOE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed. This is solely a request for information and not an announcement for a prize competition. DOE is not accepting applications or submissions for a potential prize competition. If DOE pursues the potential prize competition, it would be announced through a separate solicitation.