CABLE Conductor Manufacturing Prize

Conductivity-enhanced materials for Affordable, Breakthrough Leapfrog Electric and thermal applications (CABLE) Conductor Manufacturing Prize
Stage 2 Informational Webinar

May 17, 2022

Housekeeping

This webinar is being recorded and will be made available later

Questions:

There will be a Q&A session at the end of the presentation

- **To submit a question, type it into the "Q&A Box"**

Technical Issues:

If you experience technical issues, *please check your audio settings under the "Audio" tab*

- **A recording will be posted following the webinar**

This Webinar Will Be Recorded

Agenda

1. Overview of U.S. DOE Advance Manufacturing Office and American-Made Challenges and Network
2. CABLE Initiative and Innovation Ecosystem
3. Overview of CABLE Conductor Manufacturing Prize and Stage 1 Recap
4. CABLE Conductor Manufacturing Prize Stage 2 Deep Dive
5. HeroX Live Demo
6. Q&A

Today's Speakers

Tina Kaarsberg, Ph.D.
CABLE Team Lead, Technology Manager at the U.S. Department of Energy (DOE)

Christopher Oshman, Ph.D., P.E.
DOE Science, Technology and Policy Fellow

Cameron Bordinat M.S.
DOE On-Site Contractor—Energetics Inc.

Mai (Kimmai) Tran, PhD
DOE Science, Technology and Policy Fellow

Emily Evans
National Renewable Energy Laboratory (NREL)
American-Made Prize Administrator

Advanced Manufacturing Office

DOE's Advanced Manufacturing Office (AMO) is dedicated to improving energy efficiency and reducing carbon emissions of the industrial sector while delivering innovations to drive manufacturing of next-generation energy technologies.

Industrial Efficiency and Decarbonization

- Reducing greenhouse gas emissions from industries through new manufacturing technologies.

Clean Energy Manufacturing

- Solving key manufacturing challenges for clean energy technology that are critical for achieving economy-wide decarbonization.

Material Supply Chains

- Developing secure and sustainable supply chains and high-performance materials.

Technical Assistance and Workforce Development

- Providing technical assistance to develop the manufacturing workforce of the future.

BUDGET

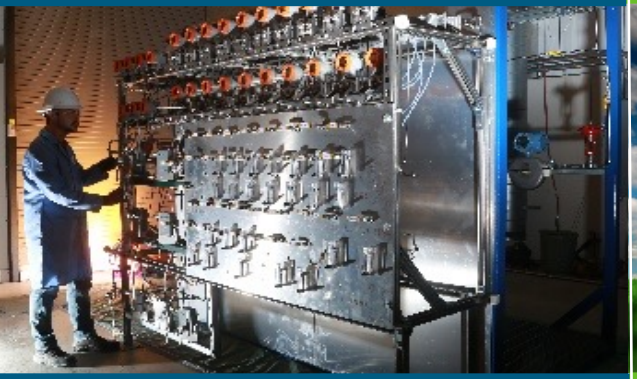
$416 million

Fiscal Year (FY) 2022

AMO's Priorities and CABLE

INDUSTRIAL EFFICIENCY AND DECARBONIZATION

Reducing greenhouse gas emissions from industries through new manufacturing technologies.



- R&D and demonstrations for energy-intensive industries
- Clean process heat
- National Alliance for Water Innovation.

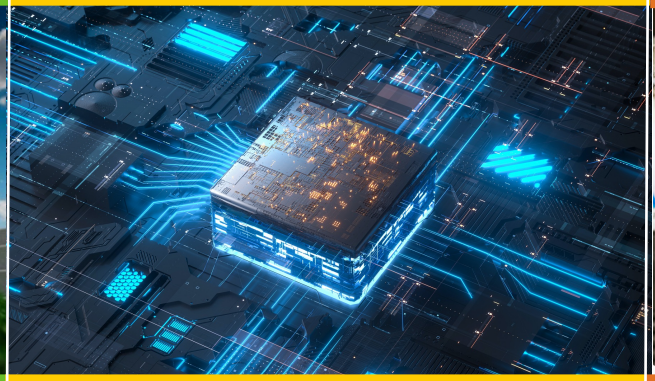
CLEAN ENERGY MANUFACTURING

Solving key manufacturing challenges for clean energy technology that are critical for achieving economywide decarbonization.

- Manufacturing Demonstration Facility/Carbon Fiber Technology Facility at Oak Ridge National Laboratory
- Collaborations across the Office of Energy Efficiency and Renewable Energy (e.g., battery R&D with VTO, hydrogen R&D with HFTO, wind turbine R&D with WETO).

MATERIAL SUPPLY CHAINS

Developing secure and sustainable supply chains and high-performance materials.



- Critical materials consortium
- Circular economy
- Materials for harsh environments
- **Increased conductivity materials.**

TECHNICAL ASSISTANCE AND WORKFORCE DEVELOPMENT

Providing technical assistance for the implementation of energy- and water-efficiency programs and making tools and training opportunities accessible to develop the manufacturing workforce of the future.

- Better plants
- Industrial assessment centers
- Lab Embedded Entrepreneurship Program (LEEP).

Overview of American-Made Challenges and Network

AMERICAN MADE
U.S. DEPARTMENT OF ENERGY


Your
fast track
to the clean
energy
revolution.
AMERICAN
MADE
U.S. DEPARTMENT OF ENERGY

supercharge

A REVOLUTION OF **BOLD IDEAS**

Fast track your ideas for the clean energy revolution

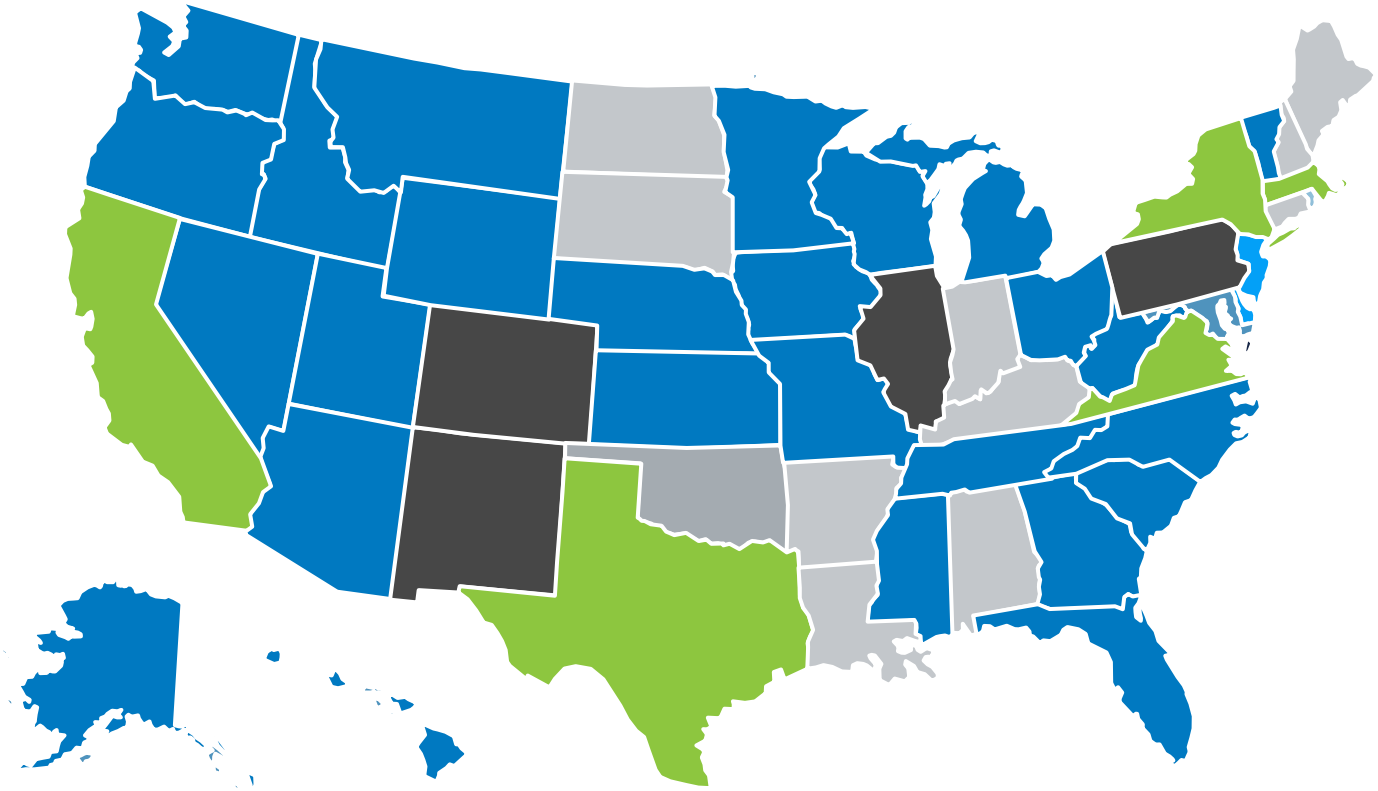
$100M
in cash prizes and support

30+
prizes

250+
Network members

AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

American-Made NETWORK



None 1-5 6-10 10+

250+ Connectors

- Outreach
- Recruiting innovators and Connectors
- Mentoring
- Technical support
- Business support
- Financial support

American-Made Challenges: U.S. Department of Energy

CABLE Initiative and Innovation Ecosystem

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A BIG Idea: The CABLE Initiative

DOE's AMO launched the Conductivity-enhanced materials for Affordable, Breakthrough Leapfrog Electric and thermal applications (CABLE) Initiative in 2021 to help supercharge U.S. energy and manufacturing industries. The CABLE Conductor Manufacturing Prize is a key part of the Initiative.

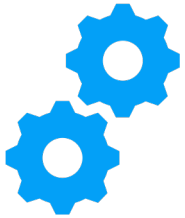
The $4.5 million CABLE Conductor Manufacturing Prize encourages researchers and inventors to develop and manufacture breakthrough conductivity-enhanced materials. Competitors must make affordable conductors that demonstrate significant enhancements in conductivity and enable U.S. manufacturers to leapfrog to next-generation materials.

https://americanmadechallenges.org/challenges/cable https://cable-bigidea.anl.gov/ Cable.Bigidea@hq.doe.gov

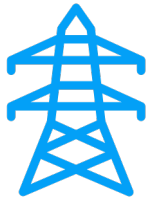
A Big Idea Contest Winner: CABLE Supports All Office of Energy Efficiency and Renewable Energy Budget Priorities

ENERGY.GOV
Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

The CABLE Initiative supports **decarbonization** of:

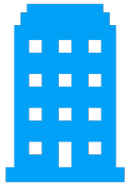


The Industry
by lowering the cost and enhancing the conductivity to increase efficiency and performance in wiring, motors, heat exchangers, heat pumps, and controls for electrification .

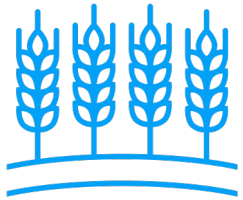


The Grid
by lowering the cost and impact of electrical delivery systems and renewable technology components from generators to interconnects.

Transportation
by lowering the cost and weight and increasing the performance and efficiency of wiring, charging stations, and components for electric vehicles.



Buildings
by decreasing the footprint and increasing the energy efficiency of HVAC, including heat pumps, appliances, and lighting.



Agriculture
by making increasingly electrified agricultural vehicles and equipment lower cost and more energy efficient.

CABLE materials manufacturing is a key element of AMO's **clean energy manufacturing** goal.

CABLE SBIR Prize Winners & SBIR Awardees

10 Prize Stage 1 Finalists by Material

Metal with nanocarbon

- MetalKraft Technologies, Albany, OH
- VT Materials, Blacksburg, VA
- Team NAECO
- GE Research, Niskayuna, NY

Metal without nanocarbon

- NanoAL Lightning, Ashland, MA

Nonmetal with metal

- Selvamanickam, Houston, TX
- Tehrani, Austin, TX

Nonmetal without metal

- 59701 Nano Innovations
- Clean Carbon Conductors, Houston, TX
- SuperWire, Burlington, MA

10 FY21 SBIR Phase I Awardees

- Directed Vapor Technologies Internat'l, Charlottesville, VA
  - Metal Carbon Composite Manufacturing
- Mainstream Engineering Corporation, Rockledge, FL
  - Copper-Encapsulated Carbon Nanotubes to Enhance Copper Transmission Cable Properties
- QuesTek Innovations LLC, Evanston, IL
  - Enhanced Aluminum Conductor for Overhead Electrical Transmission Application
- Energy Wall, Lancaster, PA
  - Non-Metallic Heat Exchangers - Ceramic Polymer Hybrid Microchannel
- T2M Global, LLC, DANBURY, CT
  - High-performance Lower-cost Plastic Heat Exchangers
- Technology Assessment & Transfer, Inc., Annapolis , MD
  - High Payoff 3D Printed Ceramic Heat Exchangers for HVAC
- Triton Systems, Inc., Chelmsford, MA
  - Plastic Heat Exchangers with High Conductance
- Mainstream Engineering Corporation, Rockledge, FL
  - Ice-Storage and Other Thermal Storage-Related Systems (CABLE)
- Greenpath Systems LLC, Norman, OK
  - Highly Conductive Nano-engineered Geopolymer Cements for Geothermal Applications
- NAECO, LLC, Peachtree City, GA
  - Fabrication and Evaluation of EV Charging System subcomponents made from Enhanced Conductivity Copper

8 FY22 SBIR Phase I Awardees

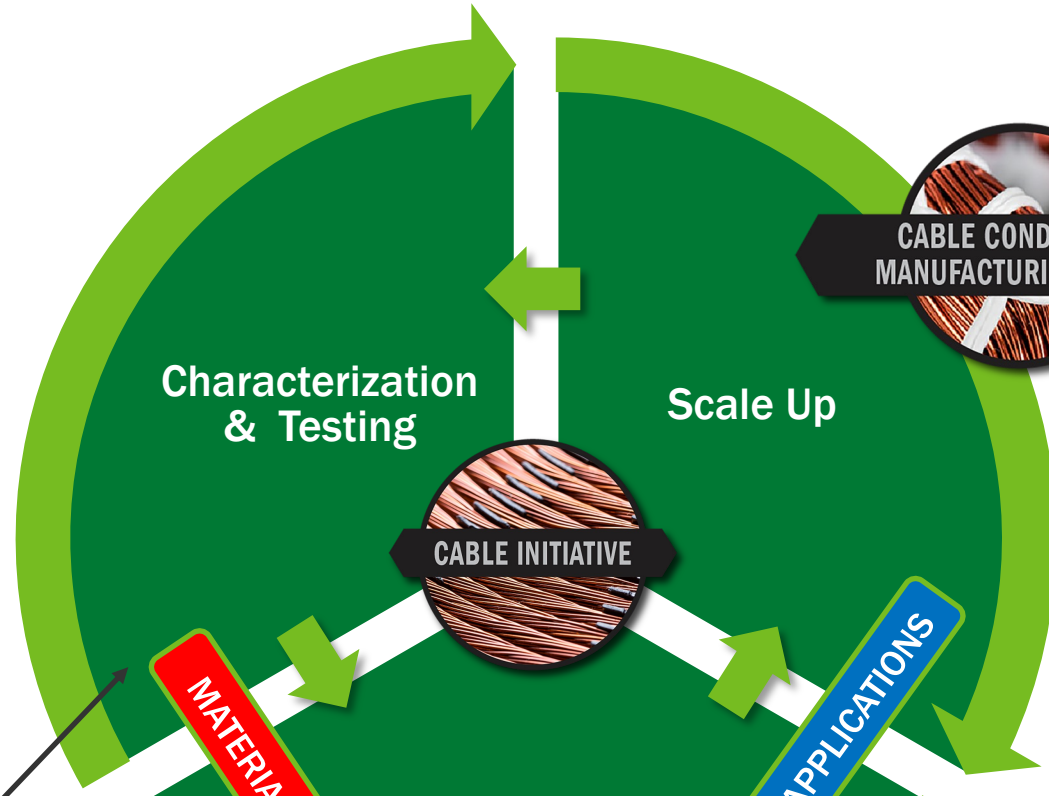
- Electric Conductivity of Metals
  - NAECO, LLC, Peachtree City, GA
  - QuesTek Innovations LLC, Evanston, IL
  - MetalKraft Technologies, LLC, Albany, OH
  - The Enabled Manufacturing LLC, Blacksburg, VA
  - Shear Form, Inc., BRYAN, TX
- Thermal Conductivity of Non-Metals
  - Giner, Inc., Newton , MA
  - DexMat, Inc, Houston, TX
  - Tessellated, Inc., South Bend, IN

Just posted at:
https://science.osti.gov/sbir/Awards

CABLE Innovation Ecosystem 2022

FY 2022 Topic 9
CABLE CHARACTERIZATION & MODELING FOR FABRICATION

a. Metals/electrical
b. Nonmetals/thermal
May 2022



January 2023

FY 2021 Topic 20
CABLE MATERIALS & APPLICATIONS

May 2021

SBIR: Covetics

Pacific Northwest National Laboratory Seedling

October 2021

April 7–9, 2021

July 20–21, 2022

SBIR: Al, Cu cables

SBIR: Nonmetallic heat exchangers

SBIR: Electric vehicle cables

SBIR: Ice storage

SBIR: Geothermal

2nd Annual CABLE (Hybrid) Workshop

July 20—21, 2022 @Argonne National Laboratory, Chicago, Il

Invitees include:

- Prize Inventors & Small Business Innovators
- Scientists (incl. theorists)
- Metallurgists
- Product Developers
- Manufacturers
- Market Experts

DRAFT AGENDA

Wednesday	Thursday
Optional Lab Tour	Electrical Conductor Materials
Opening Welcomes & Plenary	Thermal Conductor Materials
Testing & Characterization (SBIR & Prize Focus)	Thin Film/Wire/Tape Superconductors
AMC (Lab) Showcase	Theory and Modeling
Networking Event	Accelerating Commercialization
Reception	Concluding Remarks

Register for the Virtual part of the workshop at https://yesevents.com/AMO_CABLE;
Sign up to receive notice when in-person registration is open by writing to Cable.BigIdea@hq.doe.gov or follow the CABLE Prize on HeroX

Overview of CABLE Conductor Manufacturing Prize and Stage 1 Recap

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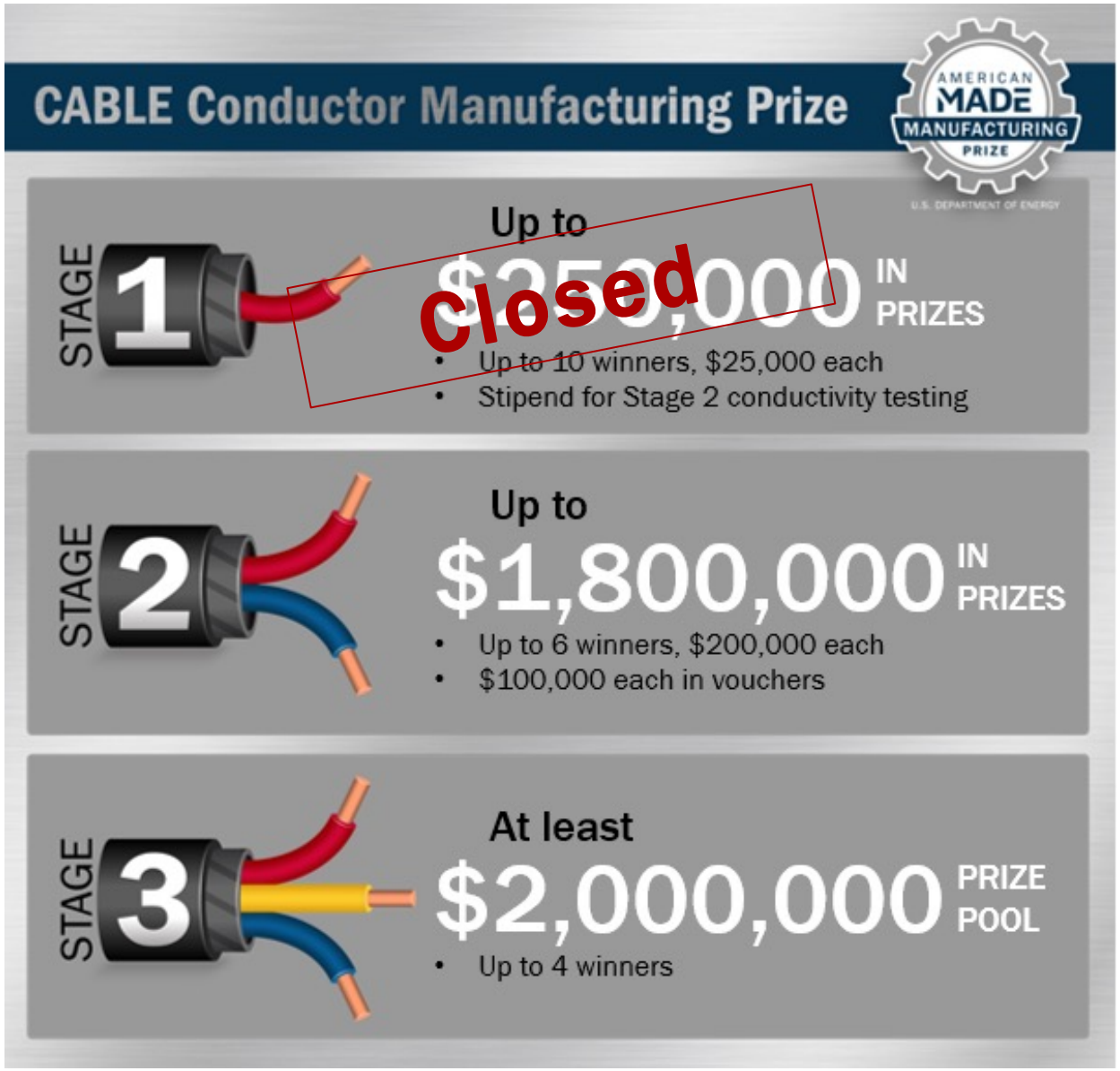
CABLE Conductor Manufacturing Prize Video

The CABLE Conductor Manufacturing Prize will push the frontiers of science and engineering and drive American innovation for materials that can lead to the deployment of clean energy technologies that are critical for climate solutions.

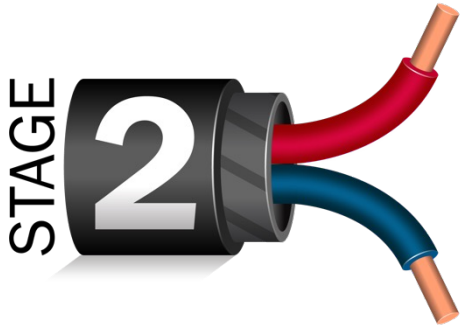
A Tiered Prize Structured for Success

Three years, three stages, up to **$4.5 million** in prizes and vouchers.

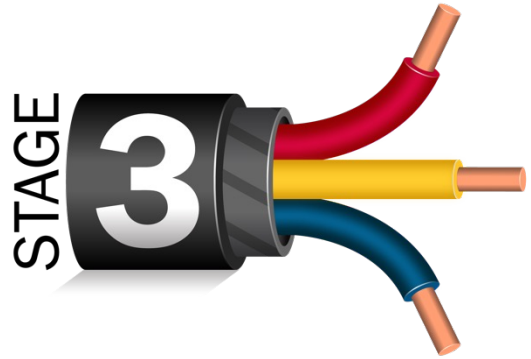


Prize Structure

Stage 1 sought concepts to develop and manufacture conductors with bulk electric conductivity enhanced significantly more than today's best commercial copper and aluminum. Judging is based on written proposals only.



Stage 2 will test lab-scale samples for electrical conductivity and will require proposals describing other high-performance properties and manufacturability, including how to leverage the American-Made Network to scale up from lab scale. Judging is based on written proposals and testing.



Stage 3 will evaluate manufacturing-scale samples for conductivity and other properties and examine the documented manufacturing process, scale-up plans, and cost. Judging is based on written proposals and comprehensive testing results.

Stage 2 Overview

- Stage 2 is now open for competitors to take their materials from concept to reality, producing a microscale sample of their material for evaluation by CABLE Conductor Manufacturing Prize-approved testing labs.
- Stage 2 is open to new and returning competitors; however, you must win Stage 2 to compete in Stage 3.
- If you intend to compete, be sure to **read the new Stage 2 Rules document at this URL:**

Stage 2 Contest Prizes

- **Up to 6 winners**
- **$1,200,000 in cash prizes ($200,000 per winner)**
- **$600,000 in technical assistance vouchers ($100,000 per winner)**
- **Stage 3 testing stipends**

https://americanmadechallenges.org/challenges/cable/docs/rules/CABLE_Prize_Official_Rules.pdf

Stage 3 Overview

- Competitors will be evaluated based on their manufacturing-scale samples' conductivity and other properties, documented manufacturing process, scale-up plans, and cost.
- Three testing organizations will evaluate each material sample for conductivity and other characteristics.
- Scores will be based, in part, on the conductivity enhancement (size and extent of breakthrough), other important material characteristics (e.g., strength, corrosion resistance, temperature resistance), life cycle impacts, manufacturability, and economic competitiveness.

Stage 3 Contest Prizes

- **Up to four competitors will split a total prize pool of at least $2 million.**

Co-sponsors are needed to make the prize pool BIGGER!

CABLE Conductor Manufacturing Prize

STAGE 3: TIMELINE

*Anticipated

Competitors will submit their proposals for breakthrough concepts to develop and manufacture a new conductivity-enhanced material suitable for electrical and/or thermal applications. Stage 1 competitors will be invited to a virtual CABLE workshop on April 5–7, 2022, to enable networking with the CABLE research ecosystem before Stage 1 applications are due.

CABLE Conductor Manufacturing Prize
Stage 2 Deep Dive

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Stage 2 Prizes

Stage 2 Contest Prizes

- **Up to 6 winners**
- **Up to $1,200,000 in cash prizes ($200,000 per winner)**
- **Up to $600,000 in technical assistance vouchers ($100,000 per winner)**
- **Stage 3 testing stipends**

Stage 2 is open to all competitors;

However, you must win Stage 2 to compete in Stage 3!

AMC Network Vouchers

- Stage 2 winners will receive a $100,000 voucher for technical assistance that they may use to fund work at national laboratories and other facilities to accelerate the production, testing, improvement, and/or validation of their conductive materials for the Stage 3 competition.
- The Prize Administrator will provide competitors with opportunities to meet with potential voucher providers (including at this year's CABLE Workshop) ahead of the Stage 2 submission deadline. Competitors must identify voucher provider(s) and include a high-level overview of proposed work provided in the final Stage 2 submission.

How to get connected with lab researchers:

- Competitors can meet Voucher Providers in person at the July 20-21 2022 CABLE Workshop
- Competitors can finalize Voucher plans after the Final Virtual Meetup Event to be held August 18--Register here: https://nrel.zoomgov.com/meeting/register/vJItcOuvrzsqHMScbjBDDorOOQhVomMDf7c

Stage 2 Request for Information (RFI)

We issued an RFI Request for Information in November 2021 that proposed specific testing requirements and sought input on other aspects of the Stage 2 contest, such as:

- The inclusion of superconductors and "Room Temperature Equivalent Conductivity" (RTEC) calculation
- Stage 2 Documentation including Overall Conductivity Goals, Material/Manufacturing Cost Documentation, etc.
- Stage 2 Schedule
- Testing logistics and Potential Vendors
- Overall/General feedback

A copy of the full RFP can be found on HeroX: https://www.herox.com/cable/resource/929

This RFI is closed for responses.

Request for Information (RFI)

Electrical Conductivity Testing for New Conductor Materials

December 6, 2021

Purpose

The National Renewable Energy Laboratory (NREL) is issuing a request for information (RFI) on behalf of the U.S. Department of Energy (DOE). This RFI is intended for the CABLE Conductor Manufacturing Prize community and broader material testing industry to provide feedback on CABLE Prize Stage 2 documentation, testing requirements, and specifications as well as on potential vendors for the testing itself. CABLE is an acronym for Conductivity-enhanced materials for Affordable, Breakthrough, Leapfrog Electric and thermal applications, wherein the letters C, A, B, and L represent CABLE goals. In Stage 2, the focus will be on quantitative verification of electrical conductivity enhancement (or the equivalent) through testing and detailed documentation of costs and affordability.

Introduction

The CABLE Conductor Manufacturing Prize is made up of three stages and includes up to $4.5 million in cash prizes and vouchers for testing and technical assistance to competitors.

In Stage 1, 22 teams submitted their breakthrough concepts for development and manufacture of a new, affordable, electrical conductivity-enhanced material. In Stage 1, an "electrical-conductivity-enhanced material" was defined as exceeding the minimum standard (10 MS/m) and potentially could be enhanced to or above the levels of the aspirational electrical conductivity enhancement goals: exceeding 65 MS/m conductivity or 14 kSm^2/kg conductivity by density.[1] In October of 2021, DOE selected and announced 10 winners who each received $25,000 in cash awards and a stipend for third-party testing of their material in Stage 2 of the prize.

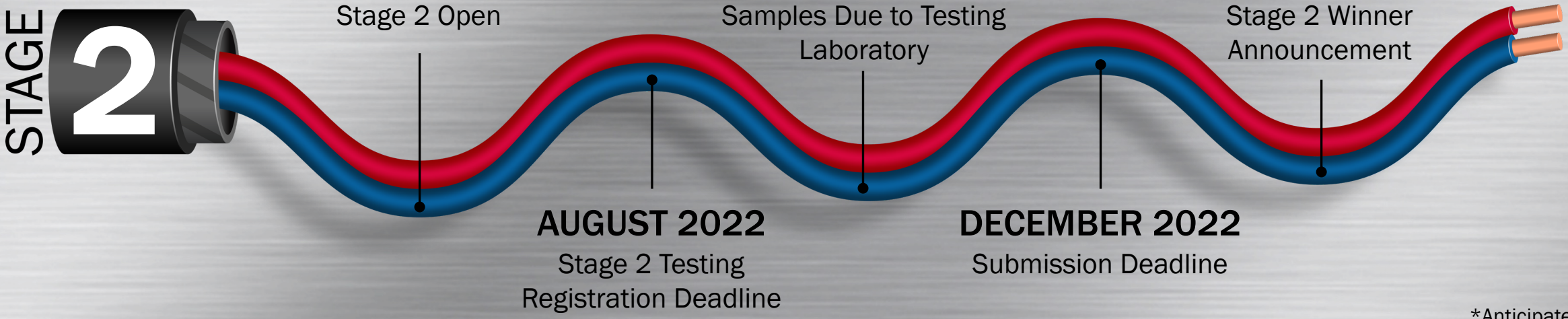
In Stage 2, competitors will be asked to submit a sample of their material to an approved laboratory for electrical conductivity testing according to prize requirements. Although the Stage 1 rules stated there would be a 1 gram minimum for these samples, the proposed dimension requirements provided in this document would imply a somewhat heavier sample, and we also are proposing multiple samples be produced. At the conclusion of Stage 2, DOE anticipates up to six awards of $200,000 each.

Through the prize DOE aims to identify, verify, and reward new materials and manufacturing methods that have the potential to achieve the aforementioned electrical conductivity enhancement goals that would indicate a breakthrough material that would be affordable and have widespread energy applications.

[1] MS is 10^6 Siemens, kS is 10^3 Siemens, m is meters, m^2 is square meters, and kg is kilogram

CABLE Conductor Manufacturing Prize

STAGE 2: TIMELINE



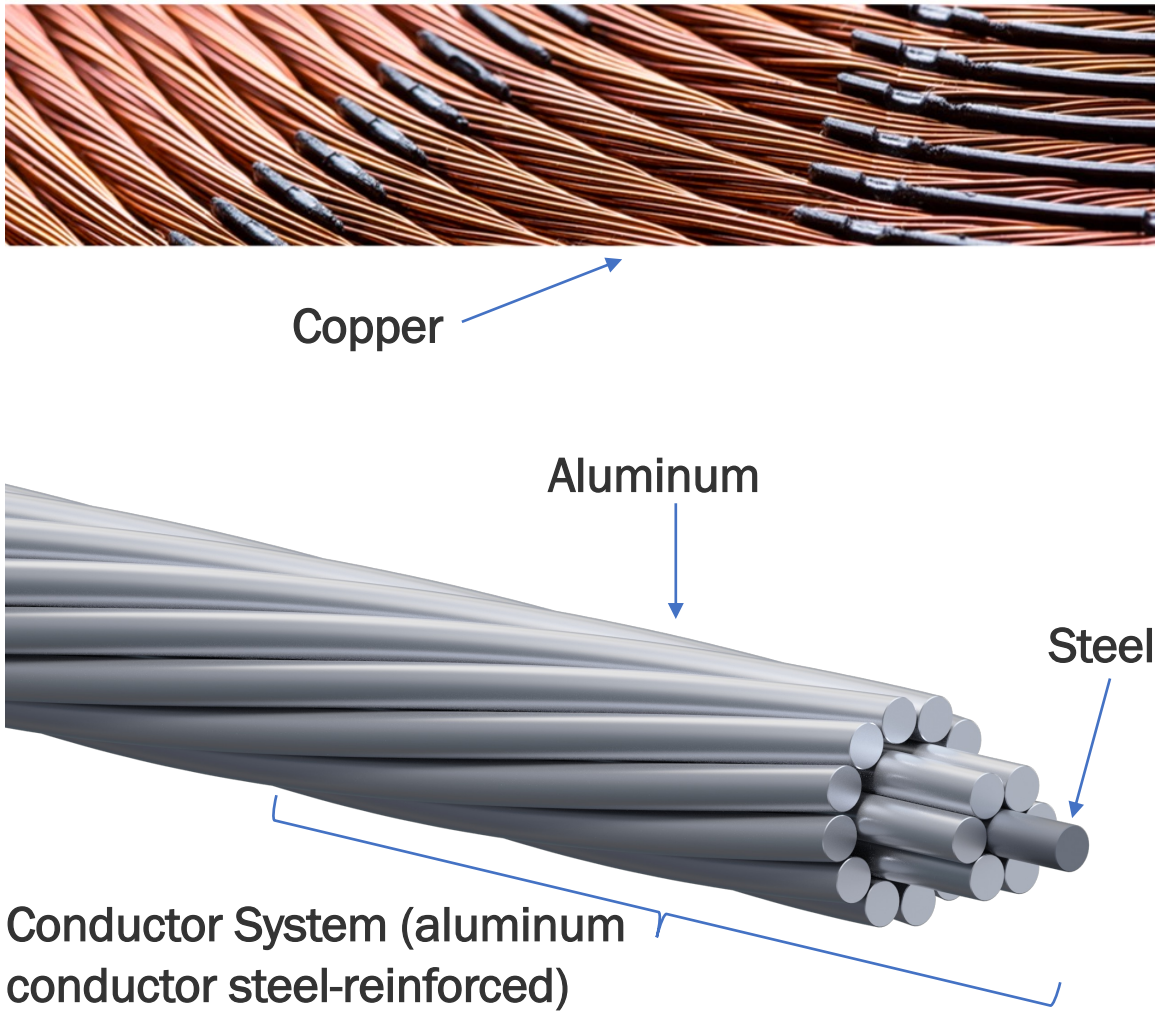
*Anticipated

Other Important Milestone Events:
May 17, 2022: Stage 2 Informational Webinar
July 20–21, 2022: CABLE Workshop

Stage 2 Contests and Conductivity Thresholds

Contest 1: Beat Copper!
Conductivity measured is >59.3 megasiemans (MS)/meter (m), or 102% International Annealed Copper Standard (IACS).
Contest 2: Beat Aluminum!
Conductivity measured is >37.7 MS/m or 65% IACS + Density <2,710 kilograms/cubic meter.
Contest 3: Beat a Conductor System!
Conductivity measured is > a conductor system comprising the primary conductor from Rules Appendix A.

IACS
was set in 1913 as 100% IACS = 58.1 X10^6 siemens/meter at 20°C.



Stage 2 Scoring Goals

1. **Affordability**: The extent to which competitors enable conductivity-enhanced materials that will be economically competitive with the copper, aluminum, and other conductor systems that they would replace.

2. **Breakthrough conductor material**: The extent to which a competitor's conductor material represents a breakthrough technology as well as the results from conductivity testing.

3. **Life cycle energy, resource and climate impact**: This assesses the impacts on cost and economic competitiveness as well as life cycle impacts other than cost savings.

4. **Manufacturability**: Competitors will be evaluated according to the reasonableness and credibility of their scale-up path/scenario as well as the results from conductivity testing.

5. **Commercialization**: This is the extent to which a competitor has developed a reasonable, credible, and high-quality scenario or pathway for commercializing their material and demonstrating economic competitiveness in a widespread application within 10 years of deployment.

Stage 2 Material Classifications

- **Metal-based non-superconductor**: These are enhanced-conductivity materials whose bulk material comprises a composite or alloy that is predominantly metal.
  - These may include metals whose conductivity is enhanced by nanocarbons, such as graphene, carbon nanotubes, or other carbon allotropes, or enhanced by nonmetal elements or dopants, such as rare earth elements.
  - They may also include metal-based materials whose conductivity is enhanced through process innovations.

- **Nonmetal-based non-superconductor**: These conductors are primarily nonmetal (e.g., nanocarbon such as graphene and carbon nanotubes). They may also contain metal, such as nanoparticles or coatings of metallic elements, but cannot include bulk metal.

- **Superconductor**: These are materials capable of achieving zero electrical resistance below T_c. For comparison with metals and nonmetals, a room-temperature-equivalent (RTEC) conductivity is calculated based on T_c and manufacturing cost (refer to Rules Appendix A and Appendix D) compared to copper.

Comparing High-Temperature Superconductors to Normal Conductors

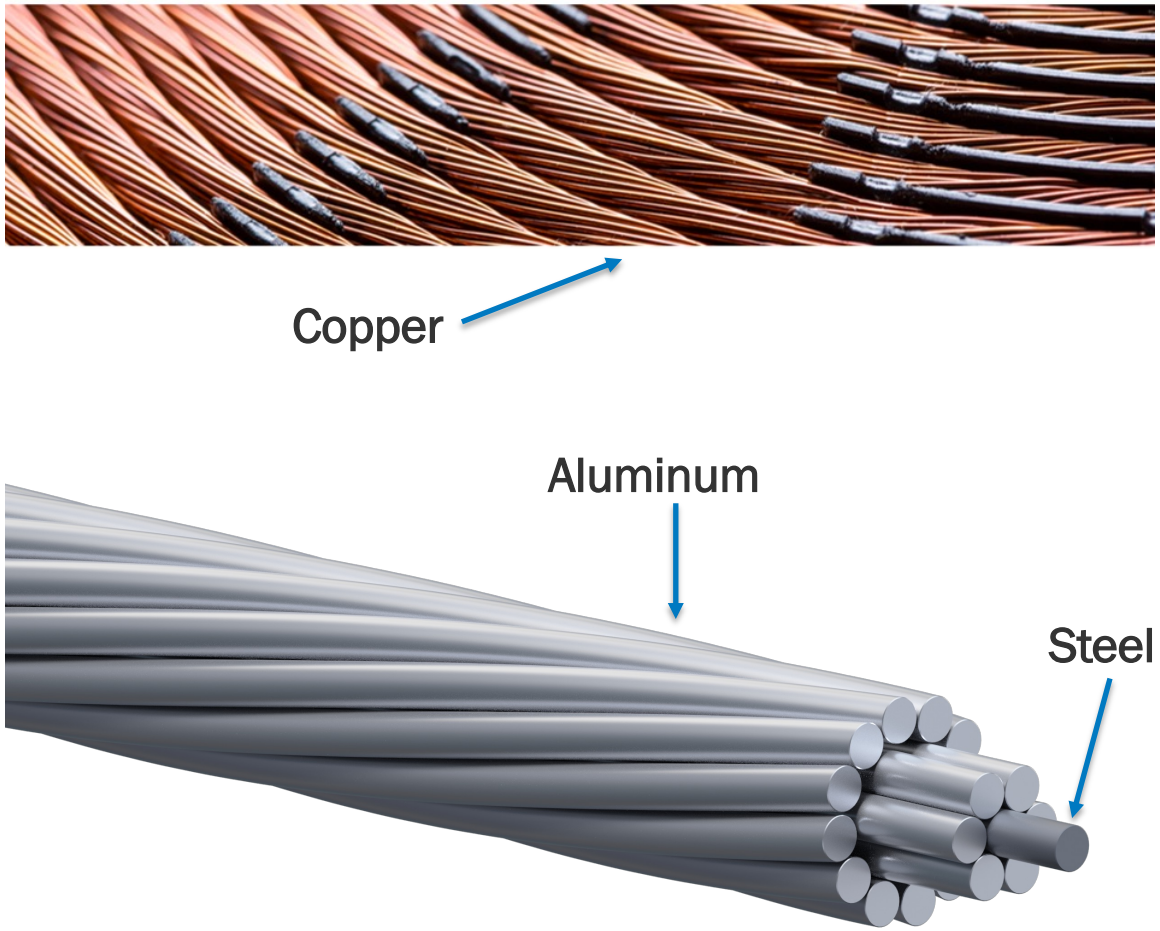
Given that a key requirement of Stage 2 is laboratory testing of a sample material's conductivity and superconductors have infinite conductivity, this prize has developed an RTEC equation that includes a linear-cooling penalty and manufacturing-cost parameter for superconductors so that they can compete fairly with general-purpose conductors (i.e., copper).

Superconductor RTEC Equation

$$RTEC = 72.55 + \left(26 \times (1 - f)\right) - (\Delta T \,/\, 11.1)$$

Stage 2 Contests and Conductivity Thresholds

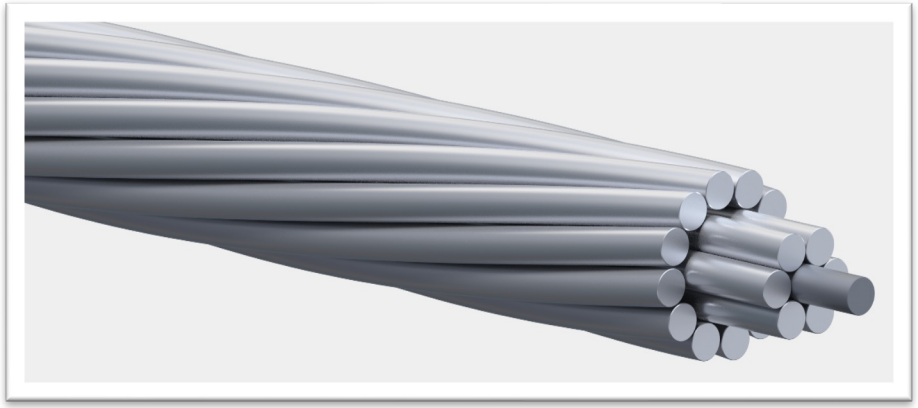
Contest 1: Beat Copper!
Conductivity measured is >59.3 MS/m, or 102% IACS. + no Ag + pathway to economic competitiveness with Cu + parity or better Cu nonconductivity properties.
Contest 2: Beat Aluminum!
Conductivity measured is >37.7 MS/m or 65% IACS + Density < 2,710 kg/m^3 + no Au + pathway to economic competitiveness with Al1350 + parity or better Al1350 nonconductivity properties.
Contest 3: Beat a Conductor System!
Conductivity measured is > conductor system comprising primary conductor in Rules Appendix A + parity or better primary conductor non-conductivity system properties + material would replace an existing conductor system in a major market (refer to the example in Rules Figure 2) involving conductor(s) in Rules Appendix A.



Reminder: IACS
was set in 1913 as 100% IACS = 58.1 X10^6 siemens/meter at 20°C.

Contest 3 Example

Beat a Conductor System Market (Contest 3) Example: An aluminum conductor steel-reinforced (ACSR) cable is commonly used for overhead power transmission and as a primary and secondary distribution cable. As shown in the image, ACSR comprises varying concentric layers of Al1350 wires around a steel core. The overall conductivity (using 62% IACS for Al1350 and 8% IACS for steel) of the highest conductivity type of ACSR is 43.7% IACS. Top manufacturers include Nexans, Southwire Company, LLC, and General Cable. ACSR has widespread energy applications with an estimated global market of ~$30 billion in 2022. A competitive CABLE Conductor Manufacturing Prize material would have a conductivity of >44% IACS, equivalent strength and sag resistance (for part or all of ACSR), and a path to cost competitiveness in this widespread conductor application.



Stage 2 Maximum Points—Testing impact

Goal	Criteria Points	Testing Points	Total Points	%
Affordability	24	0	24	10%
Breakthrough	6	60	66	27.5%
Lifecycle Impacts	12	0	12	5%
Manufacturability	18	60	78	32.5%
Commercialization	36	0	36	15%
Diversity	24	0	24	10%
Total	120	120	240	100%

How We Score – HeroX Package

- All items in the submission package, except for the cover page, will be considered when scoring each submission.
- After reviewing all elements of the submission package, expert reviewers will assign a score between 1 and 6 for each of the scoring criteria.

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

- Expert reviewers will score submissions based on the judging criteria (and judges will sign a nondisclosure agreement).
- The final score from an individual expert reviewer for a submission package equals the total sum of the scores for all the criteria.
- All expert reviewers' scores will then be averaged for a final score for the submission package.

HeroX Submission Materials

- Cover page
- Link to a 90-second video (publicly accessible online)
- Summary PowerPoint slide (which will be made public)
- Technical Narrative providing responses in five goal categories:
  - Affordability
  - Conductor Material Breakthrough
  - Life Cycle Impacts
  - Manufacturability
  - Commercialization
- Completed template for Appendix C in the Rules document: Quantitative Sample Data Commercialization Estimate Input
- Voucher Work Slide (refer to the Voucher Guidelines)
- Diversity, Equity, and Inclusion Plan
- Letters of commitment or support (optional).

Note: Content that exceeds any word, page, or time limit will not be reviewed.

Cover Page

Cover Page: List basic information about the submission. (One Page Maximum) (Editable Template)
Competitors should include: • Submission title • Competitor or team name • Official team address with nine-digit zip code • Team leader (point of contact) • Team leader phone number • Short description (e.g., slogan) • Material class of the team's conductor according to the three categories of the conductor material class (refer to Section 1.3) • Link to the 90-second video online • Key project members (names, contacts, and, if possible, links to online profiles/resumes) • <100-word abstract.

Video

Online Public Video: What is the innovation, in 90 seconds?
Competitors should make a 90-second (maximum) video showcasing their submission and emphasizing the novelty or advantage(s) of their idea and potential impact. Competitors should be creative and produce a video that conveys the information in exciting and interesting ways but not focus on time-consuming activities that only improve production value (i.e., technical elements, such as décor, lighting, and cinematic techniques). The video should be posted as "Unlisted" on YouTube, and the link should be included in the submission. Note: the video will be made public on HeroX after the submission deadline for Stage 2.
Competitors could include: • Their proposed idea • How their idea works • Why their idea is innovative • Show their sample preparation • Who they are and why they have a competitive edge.

Summary Slide

Public PowerPoint Summary Slide (One Slide) (Editable Template)
Competitors should make a public-facing, one-slide summary using PowerPoint that contains technically specific details that can be understood by most people. The slide will be made public and should include: • The competitor or team name and team leader • Submission title • Description of the conductor material, application market size, and which Table 1 contest the team is competing in • Sample fabrication approach • Material image • Potential impact. Competitors should make any text readable in a standard printout and conference-room projection. A summary slide template can be found at https://www.herox.com/cable/resources.

Technical Narrative

Competitors should respond to each of the five technical goals: Affordability, Conductor Material Breakthrough, Life Cycle Impacts, Manufacturability, and Commercialization.

The content bullets on the left side are only suggestions to guide their responses; competitors decide where to focus their answers.

Technical Narrative (Editable Template) Appendix C (Editable Template)	
Goal 1: Affordability 24 points possible (Note: Appendix C must also be complete)	
Competitors could: • Describe a scenario/pathway for how the sample preparation costs they provided in Appendix C will decrease as their fabrication process is scaled up to the industrial scale for commercialization; specifically, describe how much the cost must decrease from Stage 2 sample preparation to 10 years post-commercialization; describe how the manufacturing cost is reduced by learning,	Judging criteria (1–6 points per statement): • The extent to which the material's sample preparation cost-related data (Appendix C) support the competitor's estimate of their future manufacturing cost: Are future (industrial-scale) costs just a little (e.g., 10%) lower or a lot (e.g., 100 times) lower than sample fabrication costs?

Scoring Category	Points
Affordability	24
Conductor Material Breakthrough*	6
Life Cycle Impacts	12
Manufacturability*	12
Commercialization	36
Total Points	**90**

*Additional points from testing results

Appendix C: Quantitative Sample Data Commercialization Estimate Input

Appendix C in the Rules document is designed to ensure CABLE Conductor Manufacturing Prize competitors provide comprehensive and comparable commercialization forecasts and sample data to enable the Prize Administrator and Expert Reviewers to make fair comparisons among competitors for Stage 2 of the contest and to prepare them for Stage 3, which will ask for a much more detailed commercialization plan and forecasts.

3 Required Sections (Competitors must use template)

Section 1:

- ❑ Commercialization application statements (1A, 1B, 1C)

Section 2:

- ❑ Table 14, materials data
- ❑ Table 15, energy data
- ❑ Table 16, nonmaterial/nonenergy costs

Section 3:

- ❑ Selection of goal metric input questions (questions 1–7, as applicable)
- ❑ Table 17, material density
- ❑ Sample preparation data
- ❑ Superconductor critical current at 65 Kelvin

Appendix A

To enable comparisons among enhanced conductivity materials, these values are required to be used as a standard reference when completing the calculations required for Stage 2 submission.

Table 13. Electrical Conductivity and Densities of Common Conductors

Material	Conductivity (megasiemens per meter [MS/m])	International Annealed Copper Standard (IACS) %	Density (kilogram per cubic meter [kg/m³])
Silver	62.9	108%	10,490
Copper (Electrical)	58.6	101%	8,960
Copper (International Annealed Copper Standard) =100% IACS	58.1	100%	8,960
Gold	40.6	70%	19,320
Aluminum	37.7	65%	**2,710**
Al 1350	35.8	62%	**2,705**
Calcium	29.8	51%	**1,550**
Al 6061	24.6	42%	**2,700**
Magnesium	22.4	39%	**1,738**
Tungsten	17.9	31%	19,280
Zinc	16.9	29%	7,130
Brass, Yellow	15.7	27%	8,470
Nickel	14.3	25%	8,902
Lithium	10.8	19%	**534**
Carbon Nanotubes (CNT)	10.9	19%	**1,300**
Iron	10.4	18%	7,874
Carbon Fiber	1.06×10^{-4}	0.0002%	**1,750**

Voucher Work Slide

Competitors need to scope their potential Stage 3 voucher work for the Stage 2 submission package – use of template is encouraged but not required.

Scoring Category	Points
Manufacturability	6
Total Points	6

CABLE Conductor Manufacturing Prize

Prepared by:	*[Insert Team & Primary Submitter Names]*
Lab name:	
Anticipated cost:	
Work objective and how it would benefit your project:	

Tasks

•

Deliverables

•

Note: A statement of support from the relevant PI is required. This could be an email or short note confirming they agree with the proposed scope of work. If splitting your voucher between multiple vendors, please create 1 slide for each voucher provider.

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Competitors can meet Voucher Providers in person at the July 20-21 2022 CABLE Workshop—Information Here
Competitors can finalize Voucher plans after the Final Virtual Meetup Event to be held August 18--Register here,

Diversity, Equity and Inclusion Criteria & Plan

Competitors are asked to describe how diversity and inclusion objectives will be or have been incorporated in their project.

The DEI plan is scored (1-6) on four criteria:

Judging Criteria	Points Possible
1. The development of this technology will **benefit lower socioeconomic-status populations**, disadvantaged communities and other underrepresented populations	6
2. The **plan describes current and/or planned partnership** with Minority Serving Institutions, Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, or entities located in disadvantaged communities.	6
3. The team's plan for integrating DEI goals into the project is well-considered and effective, provides reasonable **SMART milestones and metrics**.	6
4. The degree to which the plan is likely to **lead to** increased opportunities and participation in clean energy and climate- smart job training and **job placement/hiring** within the industry.	6
Total	24

The Stage 2 DEI Plan is worth 10% of your overall score

Letters of Commitment

Letters of Commitment and Support (Optional)
Competitors may also attach one-page letters of support or intent from other relevant entities (e.g., potential users of the proposed innovation). Letters of support from partners or others that are critical to the success of their proposed solution will likely increase their score. General letters of support from parties that are not critical to the execution of a competitor's solution will likely not factor into their score. A Letter of Commitment must not exceed one page. All letters must be combined into a single PDF document.

Stage 2 Maximum Points… Again

Goal	Criteria Points	Testing Points	Total Points	%
Affordability	24	0	24	10%
Breakthrough	6	60	66	27.5%
Lifecycle Impacts	12	0	12	5%
Manufacturability	18	60	78	32.5%
Commercialization	36	0	36	15%
Diversity	24	0	24	10%
Total	120	120	240	100%

Testing – Approved Stage 2 Laboratories

All Stage 2 Competitors are required to submit samples of their material to an approved testing laboratory for electrical conductivity testing.

The CABLE Conductor Manufacturing Prize will provide a testing stipend to *all competitors*, regardless of if they won Stage 1 or not. This stipend will cover the cost of conductivity testing of **three samples** of their conductivity-enhanced material at the approved CABLE Conductor Manufacturing Prize laboratories.

The CABLE Conductor Manufacturing Prize is pleased to partner with the following laboratories for Stage 2:

NTS

Approved Testing Laboratory for Non-Superconductors (metal and nonmetal)

Argonne NATIONAL LABORATORY

Approved Testing Laboratory for Superconductors

Testing – Sample Requirements

Non-Superconducting (Metal and Nonmetal) Submissions

Sample size is required to:

- Be a minimum of 1.5 inches (in.) long (though greater lengths are more ideal) and a circular or rectangular cross section of, respectively, at least 0.21 in. diameter or dimensions of at least 0.18 in. wide by 0.18 in. thick
- Be a uniform cross section, where the cross-sectional area may not vary more than ±2% along the length
- Have a minimum electrical resistance of 20 microohms.

Superconducting Submissions

Sample size requirements:

The submission must be a round or square sample where one face of film is 5 square millimeters or less in area.

Competitors may submit their samples starting Sept. 1, 2022. **Early submission of samples is highly encouraged**, as sample submissions postmarked after the sample submission deadline of Oct. 17, 2022, will not be accepted.

Testing Results – Appendix D

Sample Testing Data and Calculations Score Card (To be filled in and used by Prize Administrator to rank/score submissions)	
Testing-Vendor-Provided Data	
For non-superconductors, the testing data will be the: • Average value of conductivity ± delta for highest and lowest.	For superconductors, the testing data will be the: • Average value of critical temperature, T_c, ± delta for highest and lowest • Average value of critical current, J_c, ± delta for highest and lowest at T_c.
Prize-Administrator-Calculated Values	
• There will be no calculated values for Goal 1. • For Goals 2 & 3, sample density will be calculated as a cross-check of the density submitted by competitor using density baseline from Appendix A and Equation (A.1)	• f is the ratio of the 10-year post-commercialization manufacturing cost of the superconductor (in $/kiloamphere-meter) to that for copper ($50/kiloampere-meter) • RTEC= _____MS/m based on f, T_c, and Appendix C Equation (C.2).
Prize-Administrator-Ranked Values	
• Ranking of all materials will be done by conductivity (or RTEC). • Either separate rankings by secondary goals or development of equations for "equivalent" conductivity for secondary goals will be depending on entries received.	

The completed Appendix D Score Card will be sent to competitors approximately 1 month following the sample submission deadline (about mid-November 2022).

Points for Testing

The number of points for qualifying entries will be determined by rank, with the top conductivity for contests 1 and 2 and the top market for Contest 3 receiving the maximum 120 points for testing.

To qualify for a prize, Stage 2 submissions must meet or exceed the requirements for one of the three contests (Beat Copper!, Beat Aluminum!, Beat a Conductor System!).

Goal	Criteria Points	Testing Points	Total Points	%
Affordability	24	0	24	10%
Breakthrough	6	60	66	27.5%
Lifecycle Impacts	12	0	12	5%
Manufacturability	18	60	78	32.5%
Commercialization	36	0	36	15%
Diversity	24	0	24	10%
Total	120	120	240	100%

Get Started in Stage 2

01

Get prepared when you:

- Create an account on HeroX
- Read the Rules
- Attend the CABLE Workshop, July 20–21, 2022.

02

Submit your Stage 2 registration form

no later than Aug. 25, 2022, 5 p.m. ET.

03

Submit (3) samples for conductivity testing

Sept. 1–Oct. 17, 2022.

04

Submit the final Stage 2 HeroX submission package

no later than Dec. 1, 2022, 5 p.m. ET.

05

Stage 2 winners are Announced

January/February 2023.

Stage 2 Important Dates

Date	Event
Jan. 18, 2022	CABLE RFI closes (Appendix E).
April 22, 2022[a]	CABLE Conductor Manufacturing Prize Stage 2 announcement: Stage 2 contest begins.
May 17, 2022[a]	Stage 2 Contest webinar.
July 20-21, 2022[a]	Second annual CABLE Big Idea Workshop and joint CABLE Conductor Manufacturing Prize and CABLE Small Business Innovation Research Showcase event with American-Made Network voucher matchmaking.
August 18, 2022	Virtual Voucher Networking Event (Register Here)
Aug. 25, 2022, 5:00 p.m. ET	CABLE Conductor Manufacturing Prize team HeroX registration deadline for Stage 2 testing.
Sept. 1, 2022	CABLE testing labs open for sample submissions.
Oct. 17, 2022	All sample material must be postmarked by this date and sent to an approved testing laboratory. Competitors must also email the Prize Administrator with shipping confirmation and tracking information.
Nov. 18, 2022[a]	Testing results are sent to competitors.
Dec. 1, 2022, 5:00 p.m. ET[a]	Stage 2 contest submission deadline (HeroX submission).
January/February 2023[a]	Stage 2 awards announcement.
April 2023[a]	Stage 3 contest begins.
Oct. 9, 2023[a]	Stage 3 contest submission deadline.
January 2024[a]	Stage 3 awards announcement.
[a] Date is anticipated	

HeroX Live Demo

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Get Started With Stage 2 of the CABLE Prize Challenge Today

You should:

1. Create an account and follow on HeroX:
   https://www.herox.com/cable

2. Mark your calendar for the CABLE Workshop (July 20–21, 2022):
   https://cable-bigidea.anl.gov/workshop/2022-workshop

3. Read the rules and review the FAQs:
   https://www.herox.com/cable/resource/665
   https://www.herox.com/cable/faq

4. Submit your team registration form by Aug. 25, 2022:
   https://www.herox.com/cable.

Partner With CABLE Conductor Manufacturing Prize

The CABLE Conductor Manufacturing Prize is seeking industry partners to provide sponsorship for Stage 2 and Stage 3.

Ways to partner with us:

- Provide competitors with mentorship or technical assistance
- Provide additional in-kind or financial awards to winners
- Help amplify the CABLE Conductor Manufacturing Prize and promote competitors

If your organization is interested in supporting one or more of our prizes and competitions, please reach out:
cableprize@nrel.gov

Thank You and Q&A

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Thank You

Webinar recording will be made available on herox.com/cable.