H2 Refuel H-Prize Technical Data Collection Requirements

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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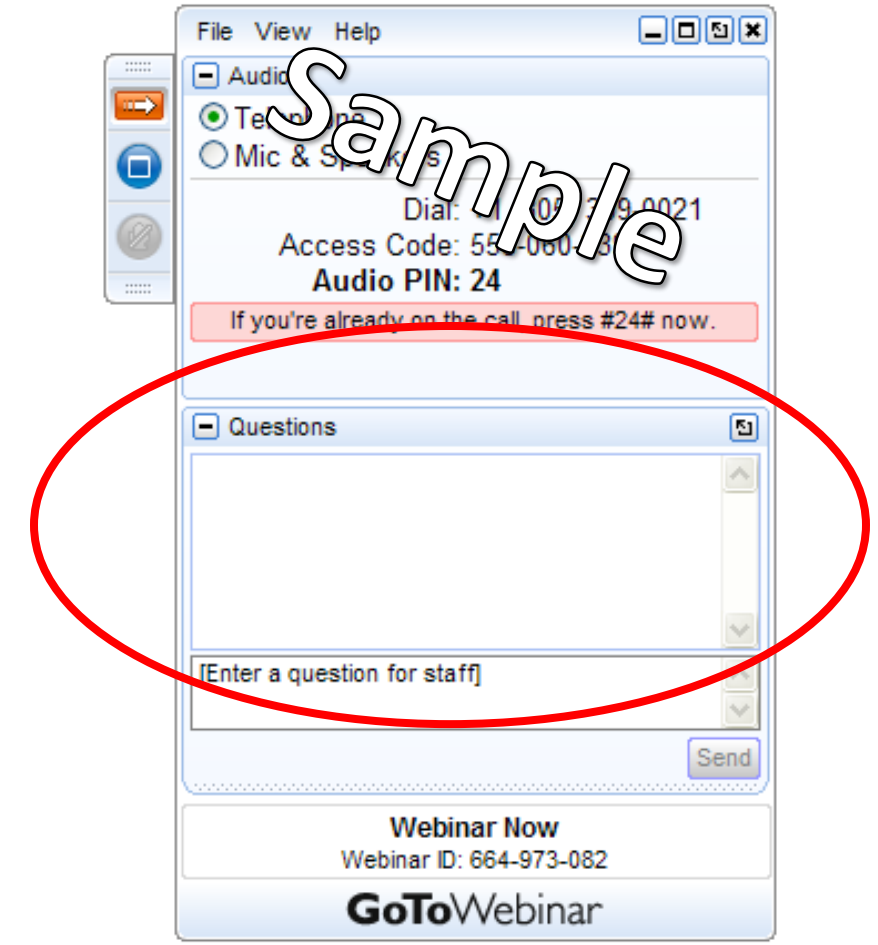
Fuel Cell Technologies Office

Question and Answer

- Please type your question into the question box



hydrogenandfuelcells.energy.gov

2014-2016 H-Prize competition

Two-year competition opened October 29, 2014

H2refuel
U.S. Department of Energy

Challenging America's innovators to develop on-site systems to generate and dispense hydrogen to fuel vehicles at homes, community centers or small businesses.

The Best Entry Wins $1 Million!

Year One Teams form, develop plans, and submit designs by October 29, 2015.

Year Two Finalists are announced in December 2015, and will prepare their entries, and start testing in June 2016. Open houses will let the public get a peek!

Beyond The competition closes October 31, 2016. Technical and cost data will be analyzed to select the $1 million winner.

Want to compete? Interested in seeing what teams are doing? Looking to join a team? For more information, to sign up for updates, or register, visit http://hydrogenprize.org/

Timeline

The Goal: Deploy an on-site hydrogen generation system that uses electricity or natural gas and can be used in homes, community centers, retail sites or similar locations to fuel hydrogen vehicles. The best entry, based on technical and cost criteria, wins $1 million!

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The Competition:

2014

October
- Competition opens: Contestants have one year to find partners, design a system, test components, find a place to install the system, and register for the prize

2015

October
- Contestants submit data and designs, and a team of independent judges selects finalists to enter the testing phase

December
- Finalists are announced and they have 7 months to build, install, and prepare systems for testing

2016

June-October
- Remote and on-site testing data collection for the technical criteria
- Independent financial experts evaluate the cost criteria
- Open house to let the public get a peek at the entries!

December
- Data analyzed and H-Prize winner announced

For more information and to sign up, visit http://hydrogenprize.org/

Finalists Scoring Criteria

- Entries must meet the basic criteria (e.g., safety requirements), and will be scored based on both Financial and Technical criteria
- Because some of the criteria are considered more critical, the criteria have different weights adding up to a total of 50 points

Criteria	Weight
Dispensing pressure	3
Dispensing time	1
Standard fills per day	1
Tested availability	2
Installed system cost	2
Direct user cost per kg	1

Cost criteria

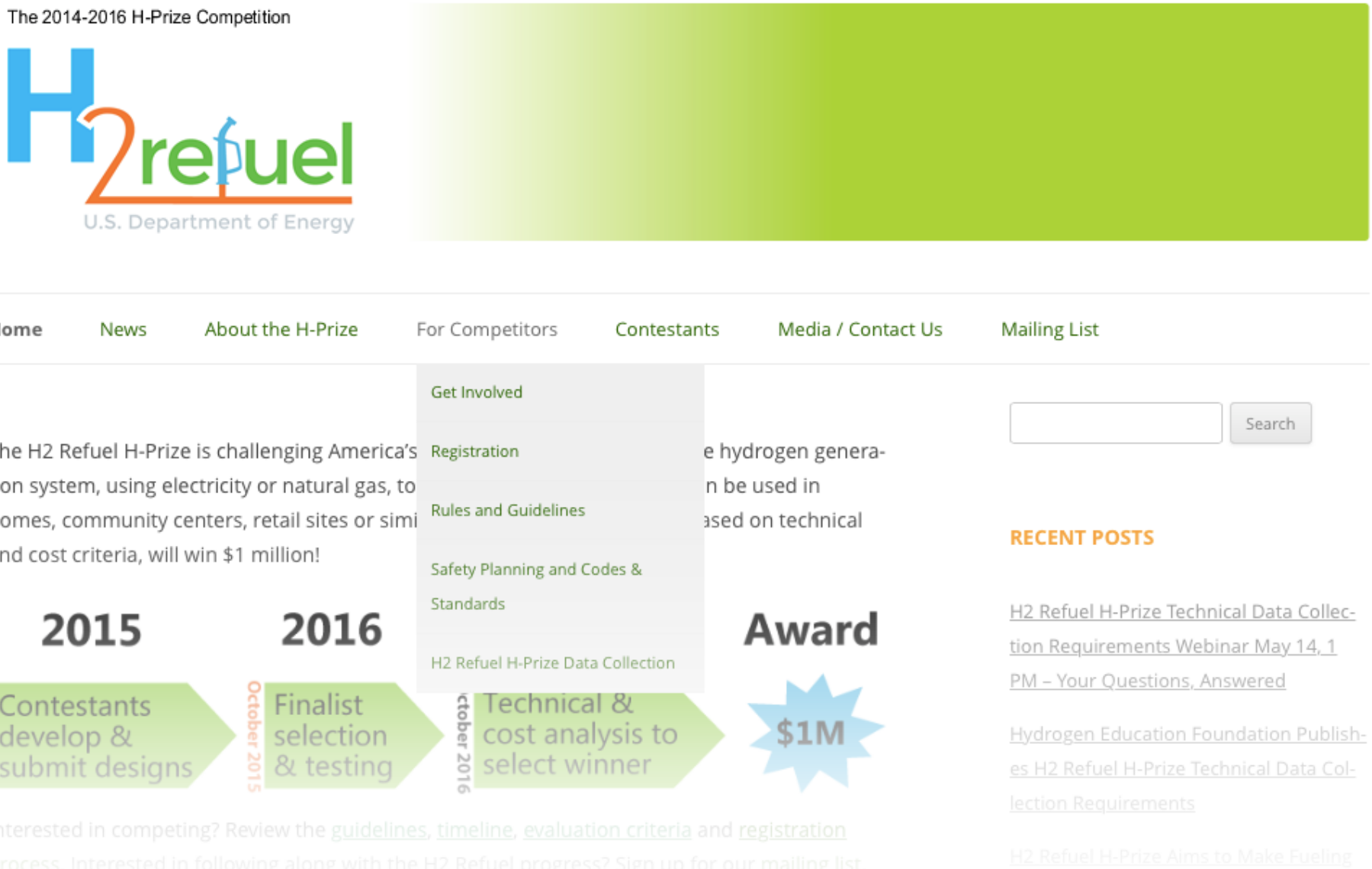
	Installed system cost (Includes capital costs)		Direct user cost per kg (Does not include capital costs)
Score	Home	Community	Home & Community
1	$25k/kg or less	$15k/kg or less	$20 or less
2	$20k/kg or less	$12.5k/kg or less	$17 or less
3	$15k/kg or less	$10k/kg or less	$14 or less
4	$10k/kg or less	$7.5k/kg or less	$11 or less
5	$5k/kg or less	$5k/kg or less	$8 or less

Technical criteria

	Dispensing pressure	Dispensing time		Standard fills per day		Tested availability
Score	Home & Community	Home	Community	Home	Community	Home & Community
1	350 bar or higher	10 hours or less	60 minutes or less	1 or more	5 or more	80% or higher
2	400 bar or higher	8 hours or less	30 minutes or less	2 or more	10 or more	85% or higher
3	500 bar or higher	5 hours or less	15 minutes or less	3 or more	20 or more	90% or higher
4	600 bar or higher	2 hours or less	10 minutes or less	4 or more	40 or more	95% or higher
5	700 bar or higher (*ultimate target*)	30 minutes or less	3 minutes or less	5 or more	50 or more	98% or higher

Website

http://www.hydrogenprize.org



Joining a team

http://www.hydrogenprize.org/how-to-compete/join-a-team/

Home | News | About the H-Prize | **For Competitors** | Contestants | Media / Contact Us | Mailing List

Get Involved

If you are interested in joining a team, you can fill out the form to the right. Submissions for people or groups looking to join a team appear below.

Please note that neither the Hydrogen Education Foundation (HEF) nor the U.S. Department of Energy (DOE) endorses any member of the list, or provides guarantees about their suitability. This information is only provided as a resource to facilitate potential contestants to find other possible team members and resources. This website is operated and maintained by the Hydrogen Education Foundation (HEF) under a cooperative agreement with DOE. It is not a government website. DOE's Privacy Policy does not apply to HEF.

If you want to keep up on any news and updates, you can sign up for the mailing list.

FULL-NAME	SPECIALTY	EMAIL
Milan Krupa	We can build one of our three ultra-efficient rotary compressor/pump concepts to cost effectively compress hydrogen to any pressure. We are developing the designs for use as detonation cycle engines.	memilan@yahoo.com
Lane Shar-	Intermittent energy (solar, wind, solar-thermal) and electrolysis for the production of hydro-	lane@solanaener-

INTERESTED IN JOINING A TEAM?

Fill out the form below to let others know your areas of expertise. Submissions will be listed in a table to the left.

Full Name (required)

Email (required)

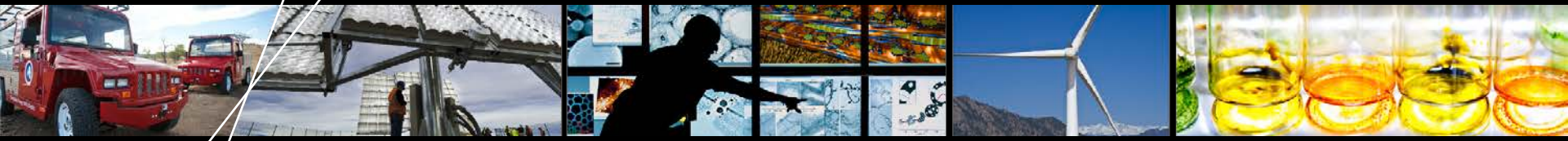
Phone number (required)

Affiliation

Website

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

H_2 Refuel H-Prize

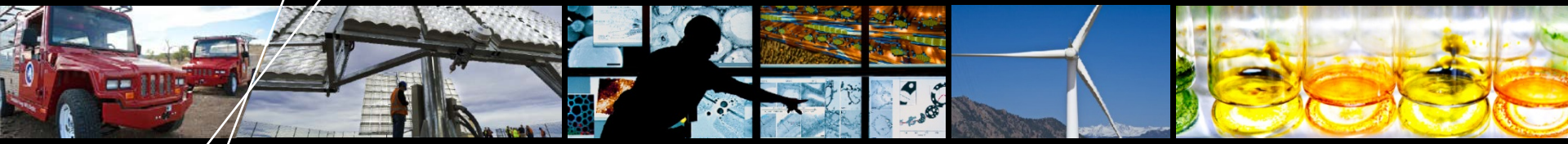


Technical Data Collection Requirements

Chris Ainscough, P.E.

May 14, 2015

NREL
NATIONAL RENEWABLE ENERGY LABORATORY



Judging Criteria

Judging Criteria

- **Official Guidelines and Data Requirements**
  - http://www.hydrogenprize.org/how-to-compete/rules-and-guidelines/
  - http://www.hydrogenprize.org/wp-content/uploads/2015-03-26-Data-requirements-v5.pdf
- **The official guidelines and data requirements govern in any apparent or actual contradiction or omission in the writings or spoken words of this presentation, express or implied.**

Minimum/Maximum Criteria

Minimum/Maximum Criteria Table

Criteria	Home	Community
Minimum dispensing pressure	350 bar	
Maximum dispensing time (standard fill)	10 hours	60 minutes
Min. hydrogen dispensed per day	1 kg	5 kg
Hydrogen purity	Meets SAE J2719 (Hydrogen Fuel Quality for Fuel Cell Vehicles)	
Fill method	Compliant with relevant codes (for automobiles, SAE J2601 Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles) and ensures that delivered hydrogen does not exceed the pressure and temperature limits of the vehicle storage tank.	
Safety	Meets relevant safety codes and standards for installation in target location	

Scoring Criteria

- Dispensing Pressure
- Dispensing Time
- Number of Standard Fills (1-kg) per day
- Tested Availability
- Total installed system cost
- Direct cost per kg

NOT COVERED IN THIS WEBINAR. WILL BE COVERED IN A FUTURE WEBINAR

Dispensing Pressure

Dispensing Pressure		
Score	**Home**	**Community**
1	350 bar or higher	
2	400 bar or higher	
3	500 bar or higher	
4	600 bar or higher	
5	700 bar or higher (ultimate goal)	

Dispensing Time

Dispensing time		
Score	**Home**	**Community**
1	10 hours/kg or less	60 minutes/kg or less
2	8 hours/kg or less	30 minutes/kg or less
3	5 hours/kg or less	15 minutes/kg or less
4	2 hours/kg or less	10 minutes/kg or less
5	30 minutes/ kg or less	3 minutes/kg or less

Fills Per Day

Number of standard fills per day		
Score	**Home**	**Community**
1	1 or more	5 or more
2	2 or more	10 or more
3	3 or more	20 or more
4	4 or more	40 or more
5	5 or more	50 or more

Tested Availability

Tested Availability		
Score	**Home**	**Community**
1	80% or higher	
2	85% or higher	
3	90% or higher	
4	95% or higher	
5	98% or higher	

- Availability will be tested over a period of two to three months, during which time system usage will need to be at least 50% of the planned capacity per week.
- Any time spent on repairs or non-routine maintenance during the testing period will count as non-available, even if compensated for (e.g., repairs done during scheduled down-time, or using stored hydrogen).

Tested Availability Defined

$$A = (168 - Tr - Td) / 168$$

(for weekly calculations, 24hours/day X 7 days=168 hours)

Tr = repair time (time (h) between when a repair or non-planned maintenance intervention is initiated and the system is returned to operational status).

Td = delay time (time (h) between when a failure occurs [system can no longer fill or generate hydrogen] and a repair is initiated).

Finalists will be required to collect detailed maintenance logs. A template will be provided at a future date.

Scoring

Criteria Category	Score multiplier
Dispensing pressure	3
Dispensing time	1
Standard fills per day	1
Tested Availability	2
System installation cost	2
Direct user cost per kg	1

A bonus score of up to 3 points will be awarded for integrated systems in order to offset the additional costs associated with adding heat and/or power, based on how much heat or power is provided.

Bonus points	
Points	**Heat or power supplied**
1	Supply at least 35 gallons of hot water per day
1	Supply at least 25,000 BTU/hr of space heating
1	Supply at least 10 kWh electricity per day

Scoring Examples

Example A: Makes all the lowest scores

Criteria Category	Result	Category Score	Score multiplier	Total scores
Dispensing pressure	360 bar	1	3	3
Dispensing time	8 hours	1	1	1
Standard fills per day	1	1	1	1
Tested Availability	81%	1	2	2
System installation cost	$23k/kg	1	2	2
Direct user cost per kg	$19/kg	1	1	1
Bonus categories	None	0	0	0
Total	--	--	--	10

Example B: Mixture of scoring levels

Criteria Category	Result	Category Score	Score multiplier	Total scores
Dispensing pressure	475 bar	2	3	6
Dispensing time	3 hours	3	1	3
Standard fills per day	3	3	1	3
Tested Availability	88%	2	2	4
System installation cost	$18k/kg	2	2	4
Direct user cost per kg	$11/kg	4	1	4
Bonus categories	Supplies hot water	1	--	1
Total	--	--	--	25

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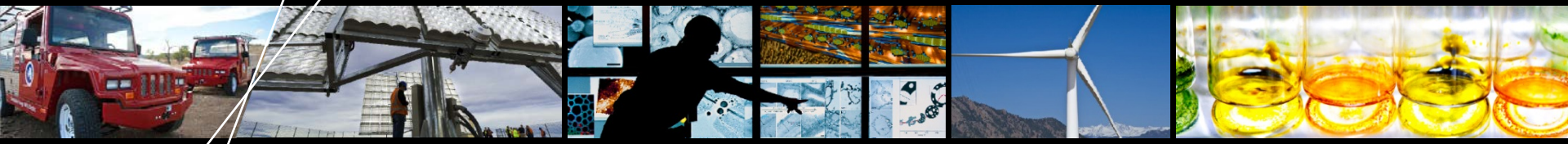


Data Collection Details

Why We Collect Data

- We collect data to allow for accurate assignment of points to finalist contestants competing in the H-Prize competition, ensuring fair judging of all systems.

How We Collect Data

- Finalists will be required to have a data collection system (DCS), installed by NREL.
- Data will be collected primarily through the use of a Modbus TCP/IP interface.
- Finalists must provide a Programmable Logic Controller (PLC) or similar controller configured as a Modbus server.
- DCS will be configured as a client.

How Much Data We Collect

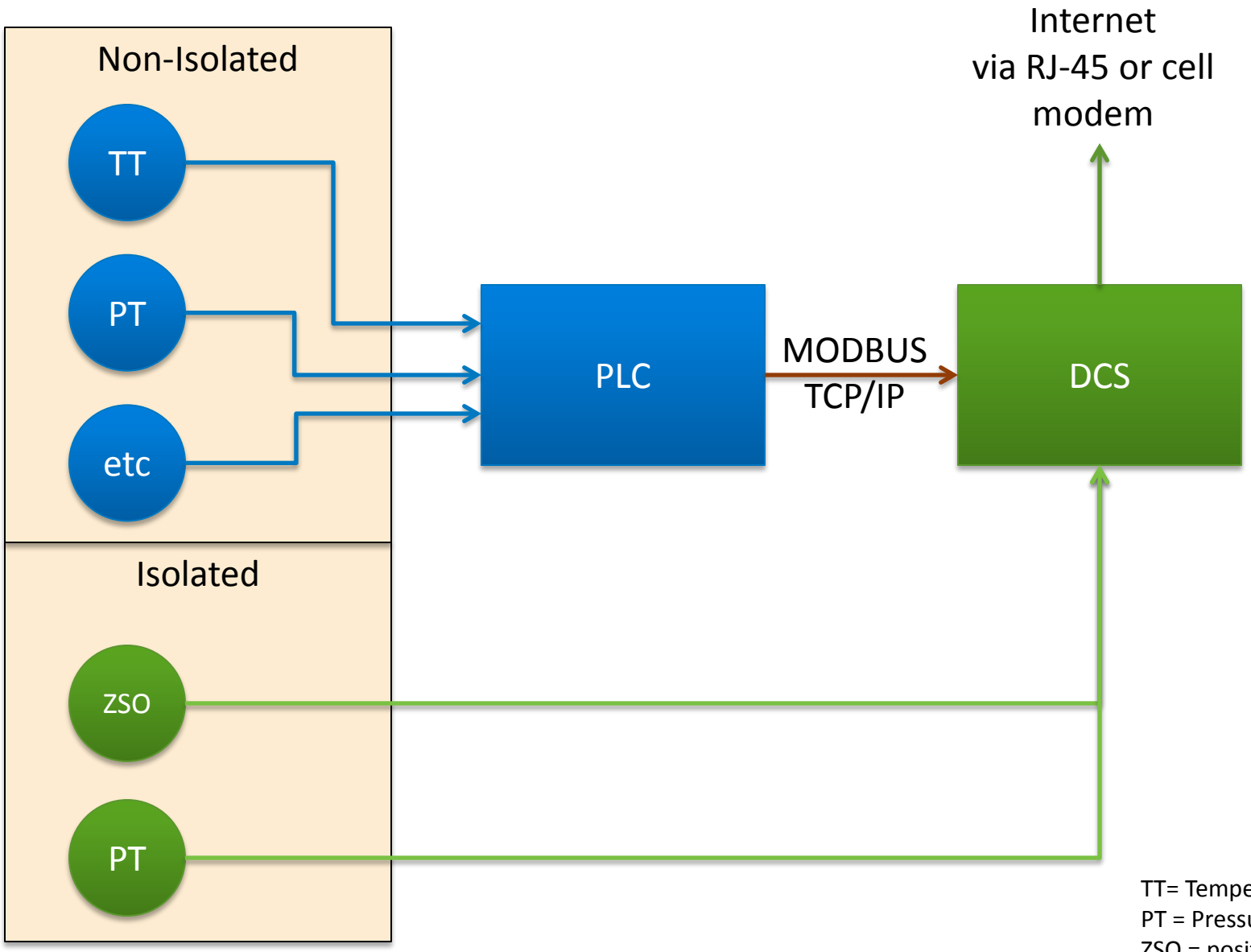
- The DCS must collect a minimum of 60 days worth of operational data.
- Operation need not be 60 continuous days.

Types of Sensors

- The sensor package provided by the contestant must, at its expense, include sensors in two broad categories:

1. Isolated – signal connects electronically ONLY to the DCS.
2. Non-Isolated – connected to contestant's system and provides data to DCS over Modbus.

Example



TT= Temperature Transmitter
PT = Pressure Transmitter
ZSO = position switch, open

DCS Facilities requirements

- Safe location protected from weather.
- 120-VAC power ~50-W (regular 15-amp circuit).
- Ethernet internet connectivity OR
- Access to a GSM cellular data network of sufficient strength to retrieve data.

Traceability

- The contestant must supply NIST[1] traceable certificates of calibration for all sensors relied upon by the DCS.
- All sensors must remain within their scheduled calibration window, based on manufacturer's recommendations, while the DCS is collecting data.

1. http://www.nist.gov/calibrations/

Site visits

- The contestants shall arrange for at least one site visit by NREL personnel (travel at NREL/DOE's expense) to install and verify operation of the DCS and the candidate system through at least one test fill.

- DCS installation must be completed by 7/31/16. Earlier is OK and encouraged.

- We will not book travel based on anticipated system operation dates. It must be actually operating before the visit is scheduled.

Site visits

- If the candidate system is not operational during the site visit, such that the DCS cannot be installed and/or its operation, along with operation of the candidate system, cannot be verified, additional site visits may be required, at the contestant's expense.

- Alternately, the contestant may withdraw from the competition.

Purity

- The contestant must contract, at its expense, with an independent chemistry lab capable of verifying compliance with the SAE J2719[1] purity standard.
- The lab must collect samples according to ASTM D7606[2].
- Samples shall only be in the custody of the contracted laboratory personnel and not handled by the contestants.
- The lab must mail a notarized copy of the purity results directly to NREL. The results may not come via the contestant.

Hydrogen & Fuel Cell Systems Eng. Group: H-Prize, ESIF 302
National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401-3305

1. SAE International, *Hydrogen Fuel Quality for Fuel Cell Vehicles*, J2719, 2011, http://standards.sae.org/j2719_201109/
2. ASTM International, *Standard Practice for Sampling of High Pressure Hydrogen and Related Fuel Cell Feed Gases*, D7606, 2011, http://www.astm.org/Standards/D7606.htm

Whose data is it anyway?

- The DCS remains the property of the U.S. Department of Energy and must be disconnected by the finalist contestant, and returned to NREL at the end of the logging period, at the contestant's expense.
- Data collected by the DCS remains the property of the U.S. Department of Energy, and will be stored, analyzed, and archived at the National Fuel Cell Technology Evaluation Center at NREL in accordance with the then current revision of its security procedures.
- Contestants will receive a copy of the results provided to the judges for their system. These results will not be made public, unless mutually agreed to after the competition.
- Final results for scoring criteria will be made public.

Data Integrity

Finalist contestants are forbidden from adulterating or falsifying, concealing, or covering up by any trick, scheme, or device a material fact; or making any materially false, fictitious or fraudulent statement or representation; or making or using any false writing or document regarding the candidate system operation. This includes providing adulterated or false signals to DCS with the aim of gaining an advantage in the competition. The DCS shall not be opened or tampered with in any way, except as expressly directed in writing by NREL staff. Failure to comply with these requirements will result in immediate disqualification from the H-Prize competition and may constitute a false statement under 18 U.S.C. § 1001, which can carry a penalty of up to five years in prison.

Data Requirements

H2 Refuel Testing Data Requirements

Performance Metric	System Type	Signal Range	Units	Physical Measurement	Logging Period (s)	Location	Minimum Accuracy	Signal Type	Scaling for Modbus Signals	Modbus Data Type	Modbus Data Location	Preferred Modbus Address*
Required Data Collection												
Due to the potential variation among possible system configurations, additional measurements, at the candidate team's expense, may be required to measure H-Prize criteria												
Time	All	n/a	UTC	Real time, 24-hour clock, UTC, reported as Epoch time (elapsed seconds since midnight Jan 1, 1970)	30 sec	n/a	precision to seconds	Modbus TCP/IP	n/a	32-bit unsigned int, straight endian	Holding Register	4x00015-4x00016
Dispensing Pressure		125% of system design maximum dispensing pressure	bar	Pressure		As close to the dispensing nozzle as practical	0.25% of span	4-20mA				
Dispensing Time		Binary	on/off	Open/closed dry contacts (one of each) on dispenser valve		As appropriate	n/a	Dry contacts				
Hydrogen Dispensed	Home	1	kg dispensed**	Mass total for each fill			10% of fill amount	Modbus TCP/IP	kg*1000	16-bit unsigned int	Holding Register	4x00001
		0.03 to 1.5	grams/min**	Mass flow rate averaged over 30 seconds			10% of max flow rate		grams/min*10000			4x00002
	Community	1	kg dispensed**	Mass total for each fill, at least 5 fills per day			10% of fill amount		kg*1000			4x00003
		15 to 350	grams/min**	Mass flow rate averaged over 30 seconds			10% of max flow rate		grams/min*1000			4x00004
Ambient Temperature	All	-40 to 50	˚C	Ambient temperature		Shaded area out of direct sunlight/precipitation.	+/-1 ˚C		transmit as Kelvin			4x00005
Hydrogen Gas Temperature		-40 to 80		Gas temperature		As close to the dispensing nozzle as practical		See RTD Spec				4x00006
Availability		Whether the system is up and ready to fill.	Yes/No	Binary Yes/No		n/a	n/a	Modbus TCP/IP	n/a	1-bit	Status Coil	4x00007
Volume of the Tank Being Filled		as appropriate	L	Water filled volume of tank being filled for each fill	manual	n/a	in accordance with tank manufacturer's manufacturing tolerances	manual collection				1x00000

* Because Modbus slaves may differ in their address space allocation, other addresses are acceptable if comminucated in writing in the design package. However, if possible please use the specified addresses to reduce data transmission issues.

** Both values are required, but one may be calculated from a physical sensor measuring the other

RTD Spec: RTD Pt (α = 0.00385, 0.00392), Ni (α = 0.005001), Cu (α = 0.0039) 10 Ohm to 10 kOhm. 2.5mA Max

Data Requirements

H2 Refuel Testing Data Requirements

Performance Metric	System Type	Signal Range	Units	Physical Measurement	Logging Period (s)	Location	Minimum Accuracy	Signal Type	Scaling for Modbus Signals	Modbus Data Type	Modbus Data Location	Preferred Modbus Address*
Optional Bonus Points												
Due to the potential variation among possible system configurations, additional measurements, at the candidate team's expense, may be required to measure H-Prize criteria												
Hot Water	Optional	35	gallons per day	Water volume	30 sec	At point of delivery to the thermal load	+/- 1% of reading	Modbus TCP/IP	gal/day*10	16-bit unsigned int	Holding Register	4x00008
		1.5	gallons/hour	Water flow rate gph averaged over 30 seconds					gal/hour*100			4x00009
		1 to 250	°C	Water Temperature			+/-1 °C	See RTD Spec				
Space Heating		25,000	SCFH	Air flowrate SCFH*** averaged over 30 seconds			+/- 1% of reading	Modbus TCP/IP	no scaling, transmit directly	16-bit unsigned int	Holding Register	4x00010
		1 to 250	°C	Air Temperature			+/-1 °C	See RTD Spec				
Electricity		10 kWh/day	Hz	Power Frequency		At the point of delivery to the electrical load	+/- 1% of reading	Modbus TCP/IP	Hz*10	16-bit unsigned int	Holding Register	4x00011
			n/a	Power factor					power factor *100			4x00012
			V (RMS)	Line-line Voltage (RMS)					Voltage (RMS) * 100			4x00013
				Line-neutral voltage (RMS)					Voltage (RMS) * 100			4x00014
			A (RMS)	Current (RMS)				4-20 mA				

* Because Modbus slaves may differ in their address space allocation, other addresses are acceptable if comminucated in writing in the design package. However, if possible please use the specified addresses to reduce data transmission issues.

*** SCFH = standard cubic feet per hour of dry air at 20°C and 1 atm

RTD Spec: RTD Pt (α = 0.00385, 0.00392), Ni (α = 0.005001), Cu (α = 0.0039) 10 Ohm to 10 kOhm. 2.5mA Max

Data Requirements

Performance Metric	System Type	Signal Range	Units	Physical Measurement	Logging Period (s)	Location
Required Data Collection						
Due to the potential variation among possible system configurations, additional measurements, at the candidate						
Time	All	n/a	UTC	Real time, 24-hour clock, UTC, reported as Epoch time (elapsed seconds since midnight Jan 1, 1970)	30s	n/a
Dispensing Pressure		125% of system design maximum dispensing pressure	bar	Pressure		As close to the dispensing nozzle as practical

Minimum Accuracy	Signal Type	Scaling for Modbus Signals	Modbus Data Type	Modbus Data Location	Preferred Modbus Address*
te team's expense, may be required to measure H-Prize criteria					
precision to seconds	Modbus TCP/IP	n/a	32-bit unsigned int, straight endian	Holding Register	4x00015-4x00016
0.25% of span	4-20mA				

Data Requirements

Performance Metric	System Type	Signal Range	Units	Physical Measurement	Logging Period (s)	Location
Dispensing Time		Binary	on/off	Open/closed dry contacts (one of each) on dispenser valve	30 sec	As appropriate
Hydrogen Dispensed	Home	1	kg dispensed**	Mass total for each fill		
		0.03 to 1.5	grams/min**	Mass flow rate averaged over 30 seconds		
	Community	1	kg dispensed**	Mass total for each fill, at least 5 fills per day		
		15 to 350	grams/min**	Mass flow rate averaged over 30 seconds		

Minimum Accuracy	Signal Type	Scaling for Modbus Signals	Modbus Data Type	Modbus Data Location	Preferred Modbus Address*
n/a	Dry contacts				
10% of fill amount	Modbus TCP/IP	kg*1000	16-bit unsigned int	Holding Register	4x00001
10% of max flow rate		grams/min*10000			4x00002
10% of fill amount		kg*1000			4x00003
					4x00004
10% of max flow rate		grams/min*1000			4x00005

NREL
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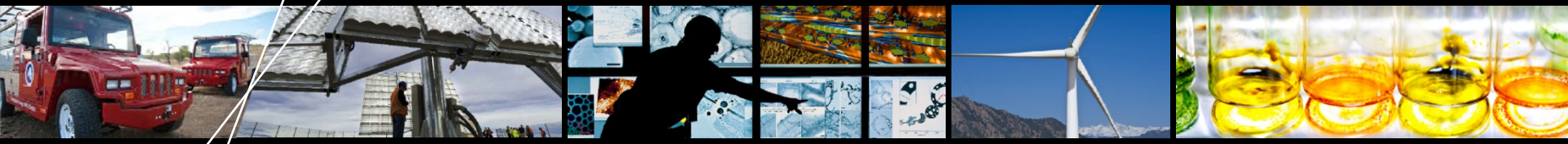
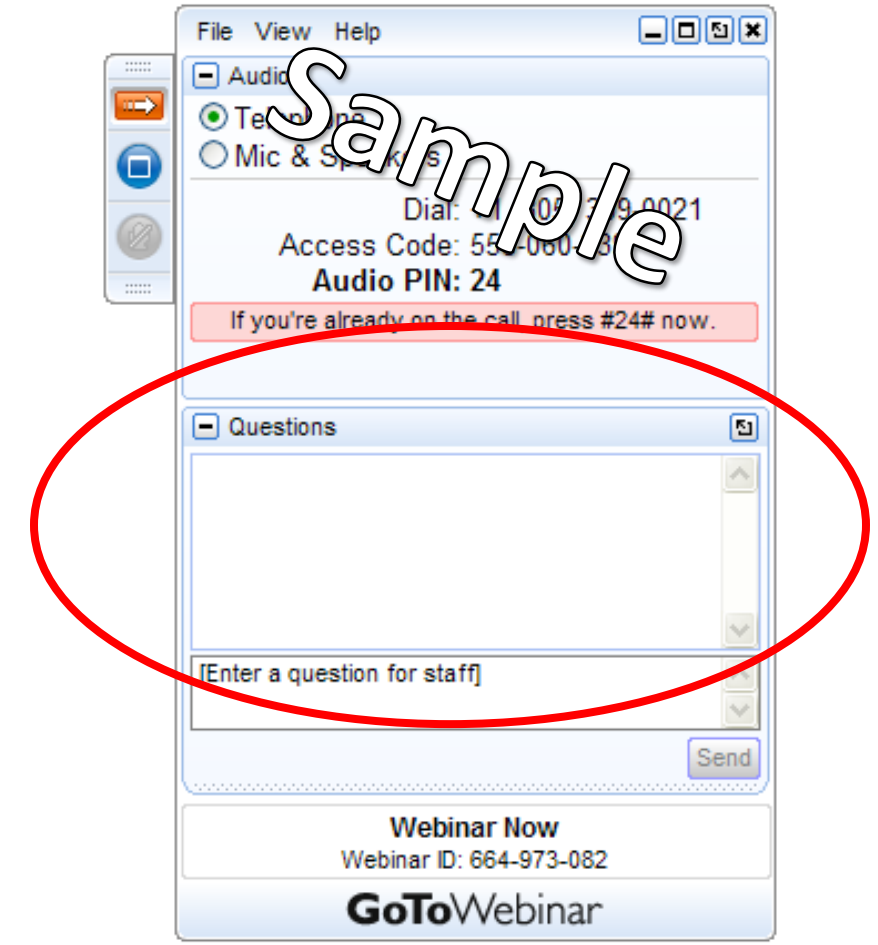


Questions

Question and Answer

- Please type your question into the question box.



hydrogenandfuelcells.energy.gov

Other Questions?

Ways to send in questions after this webinar:

- email Hprize@ee.doe.gov
- Submit a question on the H-Prize website FAQ page http://www.hydrogenprize.org/about-the-h-prize/faqs/
- Tweet to @H2Refuel

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