2010-2011 Hydrogen Student Design Contest: Residential Fueling with Hydrogen

Official Rules and Design Guidelines v 1.2

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Version 1.2 – Section 3.1.5 updated
Version 1.1 – Changed deadline for registration and abstract submission to November 1, 2010
Version 1.0 – Original version

1 Introduction

Each year, the Hydrogen Education Foundation's Hydrogen Design Contest ("the Contest") challenges teams of university-level students from around the world to develop and design hydrogen applications for real-world use.

Established in 2004 by the Hydrogen Education Foundation, the Contest showcases the talents of students in many disciplines, including engineering, architecture, marketing, and entrepreneurship. Undergraduate and graduate students worldwide are eligible to participate.

1.1 The Challenge: Residential Fueling with Hydrogen

The 2010-2011 Hydrogen Student Design Contest will challenge university-level students to plan and design a residential hydrogen fueling system. As a part of their entry, teams will develop a technical design; conduct an economic analysis; and develop business, marketing, and public education plans for their systems.

Systems should be able to be integrated into a home, apartment complex, dorm, or other single residential building. Students must choose one type of residential building for their design and determine the specific characteristics of the hydrogen production, compression, storage, and delivery elements of the system. The use of renewable resources to produce the hydrogen is highly encouraged. <u>Students must also consider all relevant codes and standards when siting the fueling unit.</u>

1.2 Background

For years, hundreds of companies around the globe have been working hard to make hydrogen-powered technologies a more common reality. In the transportation sector, major auto manufacturers and energy companies have invested billions of dollars in the development of hydrogen fuel cell vehicles and commercial hydrogen fueling stations.

The transition to using hydrogen as a fuel is underway, but there are still many key questions to be answered, including the well-known challenge of fueling infrastructure development. According to the Electric Power Research Institute, "the primary obstacle to [hydrogen vehicle] implementation is the perceived infrastructure investment cost associated with building and operating hydrogen fueling stations during the early market penetration years of hydrogen vehicles." [1] In other words, which should come first—the hydrogen vehicles or the stations to fuel them?

Some are offering an innovative answer: residential fueling. In residential fueling, the hydrogen vehicle owner fuels the vehicle each evening using equipment installed at his or her residence. Developing residential hydrogen fuelers would mitigate the considerable investment needed for a commercial facility while providing early adopters in areas with no stand-alone station with a convenient option for their fueling needs.

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[1] Rastler, Dan. <u>Feasibility of Electrolyzer Based Home Refueling System for Advanced Plug-In Hydrogen Vehicle Applications</u>. Electric Power Institute, April 2008.

This type of distributed fueling network is in the beginning stages but shows great promise. Several companies are exploring residential applications of both reformer- and electrolyzer-based hydrogen fueling equipment. For this Contest, we are inviting students to get involved in this exciting new frontier of hydrogen technology development.

1.3 About the Contest

Since 2004, the HEF Hydrogen Student Design Contest has challenged multi-disciplinary teams of university students to apply their creativity and academic skills in the areas of design, engineering, economics, environmental science, business and marketing to the hydrogen and fuel cell industries.

The Contest is open to undergraduate and graduate students worldwide. Multiple teams from one institution are permitted.

Although the Contest designs are concepts when submitted, the Grand Prize winning teams from 2004 and 2005 each attracted the funding necessary for actual development and implementation: a new hydrogen fueling station and power park, respectively. The station designed in 2004 had its grand opening at Humboldt State University on September 9, 2008. The winning design in 2008, which included a back-up and portable power system powered by hydrogen for airports, has generated a great deal of interest for implementation at the Columbia International Airport in Columbia, South Carolina.

1.4 Judging

Submissions will be evaluated by a diverse panel of judges that include industry representatives and officials at U.S. Department of Energy.

1.5 Prize Summary

For this Contest, winning teams can receive:

- Expenses-paid trip to present design to thousands in a keynote session of 2011 National Hydrogen Association (NHA) Hydrogen Conference and Expo, February 13-16 in Washington, DC. Package includes $5,000 travel stipend and complimentary hotel rooms and conference registrations for team. (Grand Prize winner only)

- Priority consideration for summer internships at participating sponsor organizations (Grand Prize and Honorable Mention winners)

- Invitation to the NHA Members Only and Opening Receptions at the 2011 NHA Conference (Grand Prize and Honorable Mention winners)

- Invitation to present design in the poster presentations component of the 2011 NHA Conference. Complimentary hotel accommodations and conference registrations included as a part of the prize. (Honorable Mention winners)

For more details on contest prizes, please see Section 2.4.

2 Rules

2.1 Eligibility and Team Structure

- The Contest is open to undergraduate and graduate students worldwide. Team members must be enrolled in a college or university by September 1, 2010 but do not have to be enrolled full-time.
- Given the multi-disciplinary nature of this competition, teams are encouraged to include members with various expertises, including: architecture/planning, industrial design, engineering (all types), economics, business, environmental science, policy, chemistry, marketing, education, or any other field of study relevant to the team's design.
- Each team must have a faculty advisor. The faculty advisor must be a faculty member of a college or university with at least three students on the team. Adjunct and emeritus faculty are welcome to serve in this capacity. Faculty advisors may give guidance and suggestions but cannot perform actual design work. Faculty advisors can advise more than one team, but they must assist in making sure the teams work independently to keep competition fair to other schools with one team.
- Multiple teams from one institution are permitted. However, each team must work independently to keep the competition fair for other teams.
- Teams are encouraged to include members from only one school. If collaboration between different schools is desired, the team leader and designated faculty advisor must request approval by submitting the team registration form with a cover letter to the address in Section 2.3 or by email to jlieberman@ttcorp.com. Teams with students from more than three schools are not allowed.
- A team of about 10 students is recommended, although teams with fewer or more members are allowed.

2.2 Citations and Questions

- Teams may use any source of data or materials: journals, computers, software, references, web sites, books, etc. All sources used **MUST** be cited.
- Teams may contact professionals in the hydrogen and fuel cell industry, as desired, and are encouraged to do so. If information from them is used to develop the design, teams **MUST** cite all sources. Only open source data are allowed. No proprietary or confidential information should be included in any design or presentation.
- Teams may submit any questions about the contest by email (jlieberman@ttcorp.com).

2.3 Report Format Submission and Scoring

- Each team must submit an abstract of less than 300 words to jlieberman@ttcorp.com by **November 1st, 2010.** Please include "**Hydrogen Contest Abstract – [Your**

school name]" in the subject line of the email. The abstract should provide an overview of the team's project, highlighting the main features and goals of its design. The abstract does not need to be included in the final submission. This information will assist the contest organizers in planning for the rest of the contest.

- All final entries must arrive at the location below **by 5 PM (ET), January 3, 2011.** Late entries will not be considered.
- Entries may be submitted in electronic or hardcopy. If you would like to send a hardcopy, please send a printed copy and a CD/DVD with the electronic files to:

  Hydrogen Student Design Contest
  ATTN: Josh Lieberman
  Hydrogen Education Foundation
  1211 Connecticut Ave., NW
  Suite 600
  Washington, DC 20036
- **Electronic copy**: The entire report, including graphics and citations, should appear as a single PDF file. Electronic entries should be emailed to jlieberman@ttcorp.com. Please include "**Hydrogen Contest Entry – [Your school name]"** in the subject line of the email.
- The following page limits have been recommended for the following sections. You may distribute the pages as you see fit provided that the final report does not exceed 34 pages + references and citations. Report pages must include 1 inch margins and minimum 11 point font.

Section	Page Max (Recommended)
Cover Page	1
Executive Summary	1
Fueling System Technical Designs	15 (including drawings)
Safety Analysis	2
Economic/Business Plan Analysis	4
Environmental Analysis	3
Marketing and Education Plan	3 (2+1 for the advertisement)
Appendix	5
References/citations	as necessary (not inc. in page count)
Max. No. Pages	**34 + references/citations**

- Entries that exceed the maximum total page limit will be deducted **3 POINTS** for each page that exceeds the limit.
- The final submission must include an executive summary that reviews the main features of the project in language that a general audience can understand. For the other sections, as you describe your design, keep in mind that the judging panel will include both technical and non-technical experts.
- Each section of the final project plan should concisely and completely fulfill the specific requirements in the design guidelines (Section 3) and provide any other relevant information.
- Judging criteria:
  Points:
  20 Technical accuracy

20 Realism, ability to be effectively implemented and/or installed
20 Effective uses of renewable resources/energy efficiency
20 Practicality/usefulness
20 Value per dollar spent
20 Overall impact on community
20 Originality/Creativity
20 Safety and code compliance
20 Comprehensive nature of the design
20 Clarity of writing
200 Total

- Teams are encouraged to copyright their designs. By submitting a design in this contest, however, teams agree to have their papers professionally published in the proceedings for the NHA Conference and Expo. The Hydrogen Education Foundation and Contest sponsors assert the right to publicize the design concepts for their own purposes. All work will be given due credit to its authors.

2.4 Prizes

General Information

- One grand prize winning team and up to two honorable mention teams are expected to be selected.
- On **January 14, 2011** the Hydrogen Education Foundation will notify winning teams (teams are expected to refrain from publicly announcing their achievements until the public announcement date at the NHA Hydrogen Conference and Expo in February 2011).
- Contest winners will be announced publicly at the NHA Hydrogen Conference and Expo in Washington, DC, February 13-16, 2011 (for more information on the conference, visit: www.HydrogenConference.org). All winning teams will receive awards at the conference.
- Winning designs will be published in the proceedings of the NHA Hydrogen Conference and Expo and also online at www.HydrogenContest.org.
- For teams outside of the United States, passport and visa arrangements must be made by the individual team members.

Grand Prize

The grand prize winning team will receive:

- Invitation to present design to thousands of industry leaders in a keynote session of the National Hydrogen Association's annual conference in February 2011 in Washington, DC.
- A stipend of up to $5,000 to cover airfare, meals, and incidental trip expenses (must be documented), as well as complimentary hotel rooms (double occupancy) and NHA conference registration for up to eight team members and their faculty representative.
- Priority consideration for summer internships at participating sponsor organizations

Important Information:

1. Teams must send at least 1 representative to present the team's design at the NHA conference. However, the team is **strongly** encouraged to use the stipend to allow the maximum number of team members to attend and participate in both conferences.
2. Teams must send a 20-minute PowerPoint presentation (maximum of 20 slides) with highlights of the project plan (presentation will be given by the team representative(s) referenced above during a keynote session of the NHA conference). Presentations are due via email to jlieberman@ttcorp.com by **February 4, 2011**.

Honorable Mentions

The honorable mention teams will receive:

- An invitation to give a poster presentation at the NHA Hydrogen Conference and Expo..
- Complimentary hotel rooms (double occupancy) and conference registration for up to four team members and their faculty representative.
- Priority consideration for summer internships at participating sponsor organizations.

2.5 Contest Schedule

• **DUE: Abstracts due (see Section 2.3)**	**November 1, 2010**
• **DUE: Entries due (see Section 2.3)**	**January 3, 2011**
• Announcement of winners to winning teams	**January 14, 2011**
• **DUE: Grand Prize team submits presentation for NHA Conference to HEF Staff**	**February 4, 2011**
• Announcement and presentation of all winning designs at NHA Hydrogen Conf. and Expo in Washington, DC.	**Feb. 13-16, 2011**

3 Guidelines

For this Contest, student teams are challenged to plan and design the basic elements of a residential hydrogen fueling system and installation. For their entry, teams will develop a technical design, address safety and code compliance, conduct an economic analysis; and develop business, marketing, and public education plans for their systems.

The hydrogen technologies and systems you select for your project plan must be commercially available and possible to implement for practical, real-world use by February 2011. Participants should clearly state any assumptions (if any) used in their entries.

3.1 Residential Hydrogen Fueling System Design

There are many elements to consider when designing a hydrogen fueling system for residential use at a home, apartment complex, dorm, or other single residential building. One must determine the specific characteristics of the hydrogen production, compression, storage, and delivery elements of the system. All relevant local, national, and model codes and standards should be taken into account when siting the fueling unit. For information on standards, visit www.fuelcellstandards.com.

The technical design will include:

1. Site plan. The plan should include a detailed diagram of the residential building and hydrogen fueling system. Plans shall include the hydrogen production equipment, dispenser(s), storage tanks (if necessary), safety equipment, basic equipment installation plan and elevations, and any auxiliary equipment or other items the project team wishes to include.

2. Description of major system components with specifications and rationale for their choice. Major components include:
    a. Production
    b. Compression
    c. Storage
    d. Dispensing
    e. Safety Equipment

3.1.1 Vehicle Parameters

Although your final design may take many forms, there are several parameters you must take into account when developing your plan. If you are planning to design a fueler for a single family home, size the equipment to accommodate a single light-duty hydrogen vehicle with the following characteristics:

Hydrogen Vehicle Requirements

Parameter	Value
Annual Mileage	12,000 miles
Daily Commute	35 miles total
Fuel Economy	44 miles per kg

If you are planning a fueling system for a larger residential building, use the above specification and multiply by the estimated numbers of vehicles at the building when developing your system design. Be sure to explain in detail your calculations and assumptions in either scenario.

3.1.2 Hydrogen Production

Although hydrogen is the most abundant element in the universe, pure hydrogen does not exist in appreciable amounts on Earth. For the most part, hydrogen is connected to other elements like carbon or oxygen. To produce pure hydrogen, you must break the chemical bond between hydrogen and its molecular partners.

For this Contest, there are two acceptable pathways for hydrogen production: natural gas reforming or water electrolysis. If reformation is chosen, describe the source of the natural gas (pipeline, biogas, etc.). For electrolysis, describe the source of the electricity (grid, on-site solar, etc.). The incorporation of renewable energy assets to generate at least a portion of the hydrogen supply is highly encouraged.

Your system design must include all major components of either system with specifications and rationale for their choice. For a single car home, your system should be optimized to meet the daily fueling needs of the vehicle profile included in section 3.1.1. If you are planning a fueling system for a larger residential building, use the above specification and multiply by the estimated numbers of vehicles in operation by residents at the building.

3.1.3 Hydrogen Compression

Hydrogen gas has much lower energy density by volume than fossil-fuel based sources of energy. As a result, compression of the gas to improve its energy density is a commonplace practice. For this section, include all details on your hydrogen compression equipment and rationale for your choice.

3.1.4 Hydrogen Storage

Depending on your system, you may decide to store hydrogen on-site instead of production on-demand. If you choose to incorporate hydrogen storage tanks into your design, be sure to explain in detail all major characteristics of the storage unit(s), and location relative to the residence.

3.1.5 Hydrogen Dispensing

There are many factors to consider when optimizing the hydrogen dispensing system. Your system shall be designed to safely dispense gaseous hydrogen to a vehicle with SAE J2600 compliant connections and tank systems as described in Appendix A of SAE TIR J2601. In this section, detail all major characteristics of the dispensing system, including fill rate and pressure(s). Be sure to explain the rationale for your choices.

3.2 Safety Analysis

In this section, teams must show how their system design will operate safely and maintain the safety of the surrounding environment. Teams shall describe how safety concerns and applicable codes have been addressed for their fueling system. Safety equipment and operational safety, as well as public perception of safety, are included.

Judges will score the design according to how well they think safety has been addressed. Teams must address the following minimum requirements:

- Identify the most significant safety risks in their design. In determining which failure modes should be addressed, teams should consider both the magnitude of potential damage and frequency.
- Describe how their design mitigates the risk of any identified issues.

- List applicable codes and standards, show how the design is compliant, and describe how code requirements were used to ensure safety (visit www.fuelcellstandards.com for information on different relevant codes)

Teams must document their sources as necessary.

3.3 Economic/Business Plan Analysis

The project team will complete an economic analysis of the system that includes capital costs, operating costs, and maintenance costs. The project team should determine the cost of dispensed hydrogen ($/kg) based on the economic analysis. The team should also determine the market price of the residential fueler and develop projections for future market growth. For all costing analyses, teams must use documented sources.

The analysis should include:

- Capital costs for all equipment, including installation costs.
- Operating costs of all fuel, power, water or other resources necessary for operation (i.e., water for electrolysis, natural gas for reformers, electricity for compressors and controls). Justify costs for water, natural gas and electricity (when needed) using relevant local utility prices.
- Costs per kg of H_2 justified with a cost analysis of production and delivery systems.
- Maintenance requirements and costs.
- A comparison of annual fuel costs for the hydrogen vehicle in Section 3.1.1 compared to the annual fuel costs for a comparable conventional vehicle using gasoline with a fuel economy of 32.6 miles per gallon.
- Determined market price for the residential fueling system, based on analysis
- Projections for market growth for residential hydrogen fueling systems

Teams are encouraged to address any other issues that may affect the economic viability of the project plan (within the page limitations of this section). For example, teams may examine potential tax credits that could help reduce the total cost of the project.

3.4 Environmental Analysis

Teams should clearly explain the environmental impacts (positive and negative) of the design. For example, water use should be considered if your design produces hydrogen through electrolysis. Think about how to minimize energy losses throughout the system. Innovative energy efficiency will be rewarded.

Each team will also perform a well-to-tank energy and emissions (CO_2 only) analysis. The analysis should include:

- An energy balance for all major components (production, delivery, compression, etc.) of the system. The well-to-tank analysis should show the grams CO_2/ kg hydrogen produced compared to the amount of CO_2/gal gasoline produced. Assume that a 2010 gasoline-powered light duty passenger vehicle emits 422g CO_2/mi and that the average fuel economy is 32.6 miles per gallon[2]. Teams should take into account the production source of the hydrogen.

- An example of such a standard analysis for a baseline vehicle is the MIT study entitled "On the Road in 2020." (http://web.mit.edu/energylab/www/pubs/el00-003.pdf)
- For all emissions analyses, teams must use documented sources.

3.5 Marketing and Education Plan

To attract prospective customers, teams must create a realistic marketing plan and a one-page ad (scaled to fit on a 8.5" x 11" page) for inclusion in a local publication. The cost of implementing this plan must be included in the allowable overall project budget.

Note: Be creative with your marketing plan. Public acceptance is a key element in adopting hydrogen and fuel cell technologies.

The plan should:

- build support for your design and understanding of hydrogen and fuel cell technologies;
- attract new customers for residential hydrogen fueling;
- allay public safety fears or reduce potential resistance; and
- raise local awareness of the benefits of hydrogen and fuel cell technologies so your designs can be built and installed with maximum acceptance.

4 Additional Resources

For links to informative websites, presentations, and publications that may help with your project, please visit our website, www.hydrogencontest.org/resources.asp. We will update this page throughout the course of the Contest.

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[2] Source: http://www.epa.gov/oms/fetrends.htm