



Sponsors



2014 HYDROGEN STUDENT DESIGN CONTEST

DEVELOPMENT OF DESIGN FOR A DROP-IN HYDROGEN FUELING STATION TO SUPPORT THE EARLY MARKET BUILD-OUT OF HYDROGEN INFRASTRUCTURE

OFFICIAL RULES AND DESIGN GUIDELINES

v.1.1

January 8, 2014

--Changes to previous document marked up in red--

Any revisions will be posted at www.hydrogencontest.org.

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(Please start the subject line with "HEF Contest")

The Hydrogen Student Design Contest is managed by the Hydrogen Education Foundation, a 501(c)(3) charitable organization. For more information on the Hydrogen Education Foundation, go to www.hydrogeneducationfoundation.org. All donations and sponsorships are tax-deductible.



TABLE OF CONTENTS

AT A GLANCE	4
REGISTRATION.....	4
ELIGIBILITY.....	4
IMPORTANT DATES.....	4
1. INTRODUCTION	5
1.1. THE CHALLENGE	5
1.2. BACKGROUND.....	5
1.3. ABOUT THE CONTEST	5
1.4. JUDGING	6
1.5. PRIZE SUMMARY	6
2. RULES	6
2.1. ELIGIBILITY AND TEAM STRUCTURE.....	6
2.2. CITATIONS AND QUESTIONS.....	7
2.3. TEAM REGISTRATION AND MEMBER LIST.....	7
2.4. REPORT FORMAT SUBMISSION AND SCORING.....	8
<i>Abstract.....</i>	<i>8</i>
<i>Full Entry.....</i>	<i>8</i>
2.5. PRIZES	9
<i>General Information.....</i>	<i>9</i>
<i>Grand Prize.....</i>	<i>10</i>
<i>Honorable Mentions.....</i>	<i>10</i>
2.6. CONTEST SCHEDULE	10
2.7. TIPS	11
<i>Time Management.....</i>	<i>11</i>
<i>Learn From Successful Teams.....</i>	<i>11</i>
3. GUIDELINES	11
3.1. ABSTRACTS.....	11
3.2. FULL ENTRY	12

3.2.1.	<i>Cover Sheet, Executive Summary & Table of Content</i>	<i>12</i>
3.2.2.	<i>Design Data and Equipment Drawings</i>	<i>12</i>
3.2.3.	<i>Cost and Economic Analysis</i>	<i>15</i>
3.2.4.	<i>Safety Analysis</i>	<i>15</i>
3.2.5.	<i>Siting</i>	<i>16</i>
3.2.6.	<i>Operation and Maintenance</i>	<i>16</i>
3.2.7.	<i>Environmental Analysis</i>	<i>17</i>
3.2.8.	<i>Interface Design / Customer Education</i>	<i>17</i>
3.2.9.	<i>Optional Features.....</i>	<i>18</i>
4.	ADDITIONAL RESOURCES.....	18
5.	LIABILITY	18

AT A GLANCE

REGISTRATION

Register your team via the [Hydrogen Energy Foundation \(HEF\) Contest website at www.hydrogencontest.org/register.asp](http://www.hydrogencontest.org/register.asp) by January 15, 2014 or by January 31, 2014 for the Late Submission Deadline. You will be asked to provide the name of your Institution, your name and email, and your faculty advisor's name and email address.

ELIGIBILITY

The Contest is open to undergraduate and graduate students worldwide. All team members must have been enrolled in a college or university by October 15, 2013 but do not have to be enrolled full-time.

IMPORTANT DATES

January 15, 2014	Team Registration and Team Roster Due
January 15, 2014	Submission Deadline for Abstracts
January 31, 2014	Late Team Registration and Team Roster Due
January 31, 2014	Late Submission Deadline for Abstracts
March 21, 2014	Submission Deadline for Final Entry
April 15, 2014	Announcement of Contest Winners
May 5-9, 2014	Trip to ACT Expo 2014, Long Beach, CA

1. INTRODUCTION

Each year, the **Hydrogen Education Foundation's** Hydrogen Student 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, urban planning, marketing, and entrepreneurship. Undergraduate and graduate students worldwide are eligible to participate.

1.1. THE CHALLENGE

The theme of the 2014 Hydrogen Student Design Contest is **"Development of a Drop-in Hydrogen Fueling Station."**

The Contest will challenge undergraduate and graduate students to design a **stand-alone, standardized** hydrogen fueling module that fulfills the requirements of low-cost, easy permitting, low-maintenance, mass-production, and transportability in order to create a model for a reliable, convenient and reasonably priced refueling experience for all hydrogen fuel cell vehicle customers.

1.2. BACKGROUND

Hydrogen infrastructure development is one of the most important challenges for the rapid commercialization of zero-emission fuel cell electric vehicles (FCEVs). Drivers of FCEVs need to know that they can rely on available fueling stations in their area to reduce range-anxiety.

Hydrogen fuel suppliers need to be able to react to increasing fueling demand and may be interested in expanding early stations modularly or moving early smaller stations to new start-up markets and rebuilding on early sites. One way to address the problem is the development of low-cost drop-in fueling stations that require minimal set-up, operation and expense to meet the initial demand for fueling in areas that do not have a well-developed hydrogen fueling infrastructure.

The development of a fueling station module that provides a positive fueling experience while being able to be mass produced could potentially have a game-changing effect on traditional hydrogen fueling station development plans.ⁱ

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.

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 of 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 attention at the Columbia International Airport in Columbia, South Carolina.

The Contest is open to undergraduate, graduate and Ph.D. students worldwide. Multiple teams from one institution are permitted, but students may not belong to more than one team, and teams must work independently.

1.4. JUDGING

A panel of expert judges from federal agencies, sponsors, industrial gas companies, hydrogen fuel cell manufacturers, system integrators, and academia will be grading the student teams' submissions.

The contest submissions will be evaluated; each judge will be assigned a random set of entries. The scores from the judges' set will then be normalized using standard deviation formulas to account for individual bias. For the final entry, the top 5 entries will be reviewed a second time by a select panel of judges to identify the winning teams.

1.5. PRIZE SUMMARY

For this Contest, the Grand Prize winning team will receive a travel stipend to attend and present their design at the ACT Expo 2014 in Long Beach, California.ⁱⁱ

Honorable mentions (awards depend on available funding) will receive waved conference registration, accommodations for the ACT Expo 2014, an invitation to present the design in a poster presentation component of the event.

All winning teams' designs are also planned to be published in the International Journal for Hydrogen Energy (IJHE), a major industry publication. Sponsors may also consider students for internship positions.

For more details on contest prizes, please see Section 2F.

2. RULES

2.1. ELIGIBILITY AND TEAM STRUCTURE

The Contest is open to undergraduate and graduate (including Ph.D.) students worldwide. Team members must be enrolled in a college or university at the time of abstract submission but do not have to be enrolled full-time. Students who are working or researching part-time in the field or a related field of the Contest topic may participate.

Students who are enrolled at a university at the time of abstract submission, but will graduate before August 31, 2014, may still participate.

Given the multi-disciplinary nature of this competition, teams are highly encouraged to include students with various expertise, including: 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. A

team with students from diverse backgrounds will help address non-technical sections much better than a homogenous team.

Each team is limited to a maximum of two faculty advisors. The faculty advisors must be faculty members of a college or university. 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 ensuring that the teams work independently to maintain a fair competitive atmosphere for all participants.

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 ewagner@ttcorp.com. Teams with students from more than three schools are not allowed.

A team of about 8 students is recommended, although teams with no less than 3 or up to 12 students are allowed. **Teams may not exceed 12 students at any time.** In cases where more than 12 students are interested in participating in the Contest, students are encouraged to split into two separate teams.

Please send an updated team roster to ewagner@ttcorp.com if any changes to your team roster are made during the course of the contest (i.e. additions at the beginning of a new semester).

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 using common citation styles.
- Teams may contact professionals in the hydrogen and fuel cell industry as desired, and are encouraged to do so. If information from industry experts 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 (ewagner@ttcorp.com). Please include "HEF Contest" in the subject line for a timely response.

2.3.TEAM REGISTRATION AND MEMBER LIST

- Each team must register your team via the HEF Contest website at www.hydrogencontest.org/register.asp by January 15, 2014. You will be asked to provide the name of your Institution, your name and email, and your faculty advisor's name and email address.
- **A late team registration and team roster and late submission deadline for abstracts is due by January 31, 2014. Teams submitting late submissions will receive feedback at a later date than the submissions received by the January 15 deadline.**
- Registered teams will be made public on the contest website and may be included in contest announcements.
- Teams must submit their member roster with their abstract. The list needs to be in an Excel spreadsheet format. This list shall include the following:
 - Name and email address of Faculty Advisor(s)

- Name and email address of Team Leader, alternative Team Leader and all participating students
- Teams are encouraged to submit additional information that could be shared via social media, e.g. team photos, short team description or even motivational videos. This information will be posted on the Hydrogen Student Design Contest Website and/or the HEF Facebook site (www.facebook.com/Hydrogen.Education.Foundation). Students agree that the information that the Contest receives may be shared in the ways described above (excluding name and email address).

2.4.REPORT FORMAT SUBMISSION AND SCORING

- All submissions must be in English. The **metric system** must be used throughout the entry. Currency must be U.S. dollars. Where conversions are required, the exchange rate from October 15, 2013 shall be used.ⁱⁱⁱ

ABSTRACT

- A 4-page preliminary design study of a fueling station (Section 3.1) must be submitted **by 11:59 PM ET January 15, 2014**. Each evaluation will be shared with the respective team and added to the final score.
- The submissions will be reviewed by the judges and feedback will be given within two weeks.
- **A late deadline for abstract submissions is January 31, 2014. Abstracts until then will be accepted, but review by judges and thus feedback to student teams may not be as timely as teams which submit by Jan 15.**

FULL ENTRY

- Your team's final entries must be submitted **by 11:59 PM (ET), March 21, 2014**. Late entries will be penalized.
- The entire report, including graphics and citations, should appear as a single PDF file. The electronic copy of the report must be emailed to ewagner@ttcorp.com. Please include "**HEF Contest Entry – [Your school name]**" in the subject line of the email. Please be cautious about the file size of the document.
- You may set up a Dropbox account or FTP site if the attachments exceed 5MB.
- All materials must be submitted electronically. Mailings will no longer be accepted.

PAGE LIMITS

The following page limits have been recommended for each section. You may distribute the pages as you see fit provided that the final report does not exceed **35** pages, not including references and citations. Report pages must include 1 inch (2.5 cm) margins and be written using a font no smaller than 11 point size, single spaced.

Section	Page Max (Recommended)
Cover Page	(Not included in page count)
Executive Summary	1
Table of Content	1
Design Data and Equipment Drawings	10
Cost and Economics	5
Safety Analysis	4
Regulations, Codes and Standards	4
Siting, Operation and Maintenance	4
Environmental Analysis	3

Interface Design / Customer Education
References/Citations

3
As necessary (not included in page count)

Max. No. Pages

35 plus references/citations

Entries that exceed the maximum total page limit will be deducted **5 POINTS** for **each page** that exceeds the limit, excluding references and citations.

Entries that are received after the official deadline will be deducted **5 POINTS** for **each day** that it is late. However, the Hydrogen Education Foundation reserves the right not to accept late entries.

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, 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	Topic
60	Station Design
30	Cost and Economics
20	Safety Analysis
20	Siting
10	Operation and Maintenance
15	Environmental Analysis
15	Interface Design/Customer Education
15	Accuracy, Graphics, Readability
10	Innovative Approaches
200	TOTAL

Teams are encouraged to copyright their submissions. By submitting a design in this contest, however, teams agree to allow their papers to be published professionally in participating media partners' publications and archived on the Contest website. 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.

2.5. PRIZES

GENERAL INFORMATION

All prizes are dependent on available funding and may change accordingly throughout the Contest. One grand prize winning team and one or more honorable mention teams will be selected.

The Hydrogen Education Foundation will notify winning teams around April 15, 2014. Teams are required to refrain from publicly announcing their achievements until the award ceremony. Contest winners will be announced publicly at the ACT Expo 2014 in Long Beach, CA. All winning teams will receive awards at the

conference. Winning designs will be published online at www.HydrogenContest.org and the IJHE, a leading industry trade publication.

For winning teams outside of the United States, passport and visa arrangements must be made by the individual team members to attend the ACT Expo. The travel stipend will not be increased for teams outside of the U.S.

Depending on opportunities provided, some of the winning teams may be invited to present their design or meet sponsors or decision makers at events not identified in the prize description.

GRAND PRIZE

The grand prize winning team will receive:

- An invitation to present their design to industry leaders in a session of the ACT Expo 2014
- A stipend of up to \$5,000 to cover airfare, meals, accommodation and incidental trip expenses (must be documented) and ACT Expo 2014 registration for up to eight team members and their faculty representative
- Publication of their design in an issue of the International Journal for Hydrogen Energy (IJHE)
- Priority consideration for summer internships at sponsor organizations

Important Information:

The winning team must send at least one representative to present the team's design at the ACT Expo 2014. However, the team is **strongly** encouraged to use the stipend to allow the maximum number of team members to attend and participate in the conference.

The team must send a 15-minute PowerPoint presentation (maximum of 15 slides) with highlights of the project plan, to be given by the team representative(s) during a session of the ACT Expo 2014. Presentation is due via email to ewagner@ttcorp.com by **May 1, 2014**.

HONORABLE MENTIONS

The honorable mention teams will receive:

- An invitation to give a poster presentation or short presentation at the ACT Expo 2014
- Conference registration for up to four team members and their faculty representative ACT Expo 2014
- Publication of their design in an issue of the International Journal for Hydrogen Energy (IJHE)
- Priority consideration for summer internships at participating sponsor organizations

2.6.CONTEST SCHEDULE

DUE: Team Registration and Team Roster Due	1/15/2014
DUE: Submission Deadline for Abstracts (Section 3.1)	1/15/2014
DUE: Late Team Registration and Team Roster Due	1/31/2014
DUE: Late Submission Deadline for Abstracts	1/31/2014
DUE: Submission Deadline for Full Entry	3/21/2014
Announcement of Contest Winners to Winning Teams	4/15/2014
DUE: Grand Prize team presentation for ACT Expo 2014 to HEF Staff	5/1/2014

2.7.TIPS

TIME MANAGEMENT

It is important for your team to start Contest work early to be able to adhere to the deadlines of the Contest. Previous teams found the most challenging part of the Contest to finish on time. Connect with researchers and industry from the start; they can help you to refine your approach and ideas and help save time. Be aware that many companies may not give you all the information you may desire.

LEARN FROM SUCCESSFUL TEAMS

Review previous winning entries and see how they approached the contest. All winning entries are archived on the Contest website.

3. GUIDELINES

For this year's Contest, student teams are challenged to plan and design a **stand-alone, standardized** hydrogen fueling module that fulfills the requirements for advancing the hydrogen fueling infrastructure by providing a fueling station solution that combines low-cost, low-maintenance, mass-production, and transportability.

Student teams should strive to create a model for a reliable, convenient and reasonably priced refueling experience for all hydrogen fuel cell vehicle customers.

The technologies and systems participating teams select for their design must be commercially available and feasible to implement for practical, real-world use by October 15, 2013. Participants should clearly state any assumptions used in their entries.

3.1.ABSTRACTS

All teams **are required** to develop an up to 4-page preliminary station design for review and commentary by the judges. This entry will **NOT** be graded, but rather provides participating teams with the feedback needed to either continue to pursue their design or to amend their design and incorporate the judges' comments. To improve the feedback from judges, teams should strive to provide a detailed submission.

Submissions must include:

- Narrative of the team's approach to their fueling system, outlining the key challenges and solutions for their system design.
- Description of major system components with specifications and rationale for their choice. Major components include:
 - Production/Delivery System
 - Compression
 - Storage
 - Dispensing

- Safety Equipment
- HVAC System
- Telecommunication Equipment
- Preliminary system design schematics of the hydrogen fueling system. Schematics must include all key components referenced above and any auxiliary equipment or other items the project team wishes to include.

3.2. FULL ENTRY

For the full entry, the teams must submit a complete station design based on the following criteria.

3.2.1. COVER SHEET, EXECUTIVE SUMMARY & TABLE OF CONTENT

The submission needs to feature a cover sheet, including the title of their proposal, list the members of the team and contact information.

Teams are required to provide a one-page executive summary outlining the key components, challenges and solutions included in their design.

The submission needs to include a Table of Content with page numbers for easy reference. If submitted in electronic form, a linked TOC to the specific sections is highly recommended.

3.2.2. DESIGN DATA AND EQUIPMENT DRAWINGS

In this section, all components of the system need to be described in detail, including their interconnection, supported by detailed high-resolution schematics. A blueprint and schematics of the entire systems with specs on key data, including footprint, weight, and interconnection requirements needs to be included.

KEY COMPONENTS

HYDROGEN PRODUCTION/DELIVERY

There are two ways to provide hydrogen: On-site production and delivery. Teams should develop their own approach on which of these two approaches they prefer, both have clear benefits and disadvantages over the other. From a design perspective, the submission needs to clearly define the team's approach and account for the specific equipment used in the design.^{iv}

The system should initially be able to distribute at least **100 kg** of hydrogen per day, enough to fully refuel **25** vehicles per day, thus serve at least **100** cars in the area. The system should also be able to refuel up to **6** cars per hour **per nozzle**.

While producing hydrogen from renewable sources is the end goal for a clean hydrogen economy, students are not required to use renewable sources due to the considerable premium cost associated with renewable hydrogen. However, students are encouraged to consider ways to incorporate renewable energy sources, if possible.

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.

STORAGE

While hydrogen needs to be stored, the amount needed for storage may differ depending on the ability to produce additional hydrogen on-site. Be sure to explain in detail all major characteristics of the storage unit(s).

On-site hydrogen storage should to accommodate a 48 hour shutdown.

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 J2601 (2013) compliant connections and tank systems as described in Appendix A of SAE TIR J2601. **The system must meet a 5 minute refueling target, from pulling the fueling trigger to full, assuming a 5 kg fill to 700 bar. The hydrogen may require to be precooled prior to dispensing, and thus a precooling component may need to be integrated in the system design.**

In this section, detail all major characteristics of the dispensing system, including fill rate and pressure(s). All major vehicle OEMs are developing their vehicles for 700 bar fueling, thus the design must incorporate that specific fueling pressure. Teams may add other fueling pressures. Be sure to explain the rationale for your choices. **The dispensing system must have flexibility to expand from one to two simultaneous fuelings.**

COMMUNICATIONS

Since the station is unmanned, in this section teams need to describe how the system will communicate key information, e.g. refueling needs, electrical outage, error messaging, user feedback, etc. This includes system internal as well as external communication. For example, the storage system needs to be able to send a signal to the refueler when it is running low on hydrogen, or signal to the production equipment if its storage has reached maximum, thus shutting off production until further demand is signaled again.

Since a wired connection cannot be guaranteed, a wireless communication system that data to a third party needs to be incorporated in the design. The communications system also needs to be able to allow the user to verbally communicate with the remote operator and via video, thus must support transfers of large amounts of data.

HVAC

The design needs to incorporate the effect of the elements, seasons and temperature levels on the system. If components utilized are prone to efficiency reduction due to excessive heat, cold or humidity, the design needs to show how an HVAC system provides a safe operating environment and temperature. That may require cooling or heating equipment, as well as ventilation.

SAFETY EQUIPMENT

In case of severe failure, the system needs to feature a fire suppression system and emergency communications protocol. A breaker to cut off the electrical interconnection is also required. Acoustical warning sounds as well as

warning lights must be featured as well. The station needs to provide artificial lighting for fueling after sunset as well as video recording equipment.

KEY FEATURES

TRANSPORTABILITY

A key feature of the station design is its easy transportability. The design of the system shall be such that it can be easily disconnected, prepared for transport via truck and rail, and reconnected. The system shall be entirely re-locatable over a period of not more than 1 week. This time shall include the time required to disconnect from the local interface, re-configure the equipment for transport, load onto transport conveyances, unload and reconnect at the destination, and bring on line. That excludes the actual transport time and the destination site preparation time.

The system must meet standard ISO container limitations, when installed or shipped, shall be fully containerized. That is, all components (including all auxiliaries such as HVAC and fire suppression systems, etc.) and tools shall be enclosed in (or on) containers that are capable of being “drop-shipped” onto a properly prepared pad or foundation (e.g., compacted soil, concrete pad or platform, etc.). This requirement is further described, as follows:

- The container(s) shall be of a size and weight such as to be capable of being transported on city streets. Dimensions must account for both horizontal as well as vertical (e.g., overhead utility lines or infrastructure) clearance. While not required, a 40-foot standard ISO container would meet this requirement
- Containers shall incorporate standard lugs or other means for lifting by crane and/or be properly palletized for movement with fork-lift trucks.
- All containers shall be suitable for land or sea transport, including offering suitable protection of the equipment inside against damage from weather and vibration or shock from transportation.
- The system and its shipping containers installed and/or shipped within the United States or its Possessions shall meet all U.S. Department of Transportation (USDOT) and U.S. Marine Goods (USMG) requirements. Units shipped within the United States shall meet the requirements of 74 FR 2200 - Hazardous Materials.

MODULARITY

While the fueling station needs to be transportable, the design may feature a modular approach, starting with one or more ISO containers, but allow for add-ons if demand increases until a stationary fueling station can substitute for the drop-in fueling station. System components may be placed in separate containers provided an interconnection between containers can be easily established.

LOW COST

Current stationary hydrogen fueling stations cost between \$2 and \$4 million. With an uncertain demand in many areas, these are unreasonably high costs and produce an enormous risk for station owners. A modular station, for a fraction of the price, would be able to bridge the risk of low demand. Therefore, the system needs to be designed to be of low cost for the station owner. Measures to reduce construction and operation and maintenance costs should be taken.

MASS PRODUCTION

The design should **be simplified to allow a** highly automatized production process, reducing the need for specialty components and labor as much as possible.

APPEARANCE/ATMOSPHERE

Unlike gasoline, hydrogen does not smell and does not spill and accumulate in puddles or stains the ground. Therefore, stations should be developed in a clean, appealing way that attracts FCEV drivers and provide them with a positive, “clean” fueling experience, and improves acceptance of nearby residents. **Teams should supply a picture of how one of the stations may look (Page not part of page count).**

FOOTPRINT

The design should make the footprint and associated space for driving lanes and potential hydrogen distribution as compact as possible. **Teams need to identify and clearly label minimum set-back distances of the station.**

Teams should assume water and electricity connections are available on-site.

3.2.3. COST AND ECONOMIC ANALYSIS

In this section, the teams will determine the costs of their proposed hydrogen fueling system. Using a line-itemization chart, this comprehensive analysis should include all fixed costs associated with the team’s station design. Furthermore, the teams need to estimate the operating costs of the station as well as estimate costs for replacements of parts.

The analysis should include:

- **Capital costs** for all equipment, including installation costs.
- **Operating costs** of all resources necessary for operation (i.e., water for electrolysis, natural gas for on-site reformers, electricity for compressors and controls, costs for delivery of hydrogen^v). Justify costs for water and electricity (when needed) using average U.S. utility prices.^{vi}
- **Maintenance requirements and costs.**
- Determined **market price** for the prototype fueling system, based on analysis of above factors, and by applying standard cost reduction estimates, the market price for the 5th, 100th, and 500th station.^{vii}

To allow for a fair comparison, the price for delivered hydrogen is fixed.^{viii} Additionally, students will need to develop a matrix for the price of hydrogen (\$/kg) for sale. This will be based on the cost of the station and different estimates for fueling demand. With those results, a return on investment analysis needs to be developed **with a payback period no longer than 10 years.**^{ix} In general, students should consider different approaches in order to reduce costs, e.g. off-peak hydrogen production using real-time pricing for electricity or developing additional value streams for the system or its products. See “Optional Features” section for details.

3.2.4. 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 and standards 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:

- Perform a Failure Mode and Effects Analysis (FMEA) by identifying the most significant safety risks in the design. In determining the failure modes that need to 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) The majority of hydrogen codes and standards are safety related, such as National Fire Protection Association (NFPA) codes 2 and 55, as well as the Society of Automotive Engineers (SAE) codes relating to connections between dispenser nozzles and fuel cell electric vehicles. However, not all codes, standards and regulations relate to safety, e.g. standards relating to hydrogen fuel quality^x.

Resources for hydrogen related codes and standards are:

- Hydrogen and Fuel Cell Safety - <http://www.hydrogenandfuelcellsafety.info/>
- Fuel Cell Standards - <http://www.fuelcellstandards.com/>
- National Fire Protection Association - <http://www.nfpa.org/>
- International Code Council - <http://www.iccsafe.org/>

Other good resources include the DOE Hydrogen Permitting website^{xi}, SAE hydrogen standards, and the corresponding regulatory agencies for the states and counties in which the students plan to construct hydrogen sourcing and refueling stations.

Final submissions for this section must include:

Show that the team's design addresses the issues identified in FMEA and provides solutions, and meets all the necessary codes, standards and regulations. Ensuring these codes, standards and regulations are met will demonstrate a high level of reliability, safety and quality of the design. Teams must document their sources as necessary.

3.2.5. SITING

In this section, the teams are required to identify one specific site in the United States to site their fueling station. Teams should contact the site owner to determine local conditions and requirements. A site plan needs to be provided, which outlines the interconnection of the system to electric and water infrastructure. It shall outline local requirements, certifications and permits that need to be met, and if their system would meet them.

3.2.6. OPERATION AND MAINTENANCE

The station needs to operate autonomously over long periods of time, thus the remote operator needs to be able to receive all system data and run diagnostics remotely. The station thus needs to be able to collect performance data on all key system components.

The system shall be designed to facilitate rapid and easy replacement of most parts to minimize potential downtime. Teams are required to identify the ability to conduct repairs and maintenance of the system, e.g. accessibility of key systems.

Consideration should be given to minimum operational levels of equipment when usage is low and to the cycling of systems as hydrogen delivery varies. Teams should also provide information of life expectancy of the components used.

3.2.7. ENVIRONMENTAL ANALYSIS

The impact of the station on the surrounding is a key component in siting a station. Teams must provide a narrative of the environmental impacts of the design. This should include considerations of how residents may be impacted, e.g. if hydrogen deliveries need to be made at any hour of the day.

RESOURCE ANALYSIS

The resource analysis needs to address all required fuels and resources the system needs to operate. That needs to include an **energy balance** for all major components (production, delivery, compression, etc.) of the system. It needs to include an **efficiency factor** determining the efficiency of converting the feedstock to dispensed hydrogen. Other resources could include water use if the design produces hydrogen through electrolysis. Overall, it should be considered how to minimize energy needs and losses throughout the system.

EMISSION ANALYSIS

Each team will be required to perform a **Well-to-Wheels analysis, including an** emissions (CO₂ and common particulates [NO_x, Sox]) analysis, including emissions from producing the fuel (off-site).^{xii}

NOISE ANALYSIS

Teams need to describe all acoustic sources and estimate the resulting noise level.

3.2.8. INTERFACE DESIGN / CUSTOMER EDUCATION

In this section, students need to develop an interface for the customer. The interface needs to be a self-explanatory, modern interactive interface (e.g. touch screen), explaining the refueling process and provide an automated error resolve, and establish a connection with a remote operator. The interface needs to be able to process payments and provide or directions on nearby operational refueling stations in case of a downtime of the station. The station should also have an emergency option, allowing the contacting of local policy and or fire department. **The teams need to develop a one-pager illustrating the steps of the refueling process (not in page count).**

In addition, teams need to develop a one-page high-resolution advertisement (scaled to fit on a 8.5" x 11" page) **(not in page count)** for inclusion in a local publication or as an on-site poster at fueling stations, announcing the station. It should be designed to:

- Build support for your design and understanding of the used hydrogen technologies;
- Address the safety of the system and thus alleviate public safety fears; and
- Raise awareness of the benefits of hydrogen technologies so the station can be sited with maximum acceptance.

Students are welcome to use any advertising method they see fit as long as it meets the assigned page limits.

This section will be graded for clarity, creativity, quality and thoughtfulness of the advertising message and design.

3.2.9. OPTIONAL FEATURES

Teams may think about additional features for their system that may increase the profitability and usability of the system. E.g., since hydrogen is an energy storage medium, the fueling stations may be able to provide back-up power during outages, either to feed back into the grid or to provide electricity for emergency services.

Teams may support their entry by developing a video of no more than 5 minutes, which either features or explains the station, or supports the marketing and education on the station to the public.

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.

5. LIABILITY

The Hydrogen Student Design Contest, the Hydrogen Education Foundation and any sponsoring or supporting organization assume no liability or responsibility for accidents or injury related to the Contest.

ⁱ Rastler, Dan. Feasibility of Electrolyzer Based Home Refueling System for Advanced Plug-In Hydrogen Vehicle Applications. Electric Power Research Institute, April 2008.

ⁱⁱ Prizes are subject to change and depend on number of sponsors.

ⁱⁱⁱ Students shall use www.xe.com for currency conversions.

^{iv} For gaseous hydrogen delivery, assume the pressure at 200 bar. For liquid delivery pressure, if via a trailer truck to a ground cryogenic storage tank, assume 5 bar. The purity of the delivered hydrogen meets the 5 9s (99.999%) purity requirement for vehicle fuel.

^v For comparison, use <http://www.ttcorp.com/pdf/marketReport.pdf>, page 11 for costs of delivered hydrogen in the U.S. Note that these prices do not include sales tax. Do not calculate the distance from the production facility.

^{vi} For electricity, use 10.58ct/kWh (http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a)

^{vii} For cost reduction scenarios, use http://www.hydrogen.energy.gov/pdfs/progress12/iii_2_elgowainy_2012.pdf

^{viii} Teams should assume a cost of \$7/kg for delivered gaseous H₂.

^{ix} Useful information on station cost can be gleaned from this NREL Paper: <http://www.nrel.gov/docs/fy13osti/56412.pdf>

^x Ensuring fuel quality is of particularly high importance to the reliability of PEMFC technology.

^{xi} <http://www.hydrogen.energy.gov/permitting/index.cfm>

^{xii} To develop a well to wheels analysis, use http://www.hydrogen.energy.gov/well_wheels_analysis.html. For delivered hydrogen from natural gas, use www.hydrogen.energy.gov/docs/cs_distr_steam_methane_reform.doc. For electrolysis, use data of the U.S. standard grid mix at <http://www.epa.gov/cleanenergy/energy-resources/refs.html>