
# OFFICIAL RULES AND DESIGN GUIDELINES

## FOR THE

# 2005 H2U DESIGN CONTEST: POWER PARKS

*Presented by the National Hydrogen Association, ChevronTexaco and the U.S. Department of Energy*

Last Revised: 15 October 2004

# 1 Rules

The H2U Design Contest intends to engage university students from a variety of disciplines in the design of a hydrogen power park – a hydrogen production facility serving a multitude of hydrogen loads (stationary power plants, fueling stations, individual buildings) within the vicinity. Power park examples include industrial parks, office and commercial areas, shopping malls, or residential neighborhoods. The H2U Design Contest aims to create a competitive forum for students studying a variety of disciplines to apply their academic learning and creativity in the areas of design, engineering, economics, environmental science, and business and marketing to the developing hydrogen economy.

## *1.1 Eligibility and Team Structure*

- The contest is open to college and university, undergraduate and graduate students. Team members must be enrolled in a college or university at the time of the contest but do not have to be enrolled full-time. Each member must be enrolled in the same university as other team members.
- Multiple teams from a single school are welcome, but each team must work independently.
- Teams can have up to 10 students.
- Given the multi-disciplinary nature of this competition, teams are recommended to include members from the following interdisciplinary fields: engineering (all types), economics, business, environmental science, policy, chemistry, architecture, industrial design, marketing, education or any other field of study relevant to the project.
- Teams must register by the deadline (in Section 1.5) as an "undergraduate-only" or "graduate-only/mixed" team.

- Each team must have a faculty advisor. The advisor must be a faculty member of the college or university of the students on the team. Adjunct or emeritus faculty are welcome to serve as advisors. Advisors may give guidance and suggestions but cannot perform actual design work.

## *1.2 Information Sourcing and Questions*

- Teams may use any source of data or materials: journals, computers, software, references, web sites, books, etc., however all sources used **MUST** be credited.
- Teams may contact hydrogen professionals, as desired. Any and all contacts that provide information used in the design **MUST** be documented.
- An electronic public bulletin board is available on the contest web site to post answers to frequently asked questions: http://www.H2UContest.org
- Teams may submit questions concerning the contest by email and they will be answered in a timely fashion by an appropriate expert. All questions and answers will be posted on the bulletin board for the duration of the contest for all competitors.

## *1.3 Report Format Submission and Scoring*

- All entries are due by 5:00 PM EST on January 14, 2005; entries received afterwards will not be considered (If in doubt, get in your entry early!). Entries must be submitted in hardcopy (2 copies; see page requirements below) and on disk/CD (see format requirements below) to the National Hydrogen Association:

  **2005 H2U Design Contest**
  **ATTN: Patrick Serfass**
  **National Hydrogen Association**
  **1800 M Street, NW Suite 300-North**
  **Washington, DC 20036-5802**
- Entries will take the form of a proposal responding to the requirements given in the following sections.
- Hardcopies (2): Pages should have 1" margins, with single spacing, and should use Times 12 point font. Bound hardcopies are appreciated, but will not be judged differently.
- Electronic copy: The entire report, including graphics and references should appear on the CD as a single *.pdf file. Reports submitted as multiple files will not be judged, however, students are encouraged to include high resolution graphics in a separate folder on the same CD for exposure at the Annual Hydrogen Conference (see Prizes, Section 1.4, below). Only the electronic, *.pdf file will be sent to the judges and scored.
- The following page limits will be assigned to the following sections:

| **Section** | **Page Limit** |
|---|---|
| Cover Page | 1 |
| Executive Summary | 1 |
| Data Table | 1 |
| Technical Design | 10 |
| Safety Analysis | 3 |
| Economic Analysis | 4 |

| | |
|---|---|
| Environmental Analysis | 4 |
| Marketing/Education | 2+1(ad) |
| Appendix | 5 |
| References | as necessary |
| Entry Form | 1 |

- Entries that exceed the stated page limits will be deducted **3 POINTS** for each page that exceeds the limit.
- The executive summary and summary table should summarize the main features and operation of the power park.
- Each section should concisely fulfill the specific requirements and provide any other relevant information.
- The marketing ad should appear in the body of the design, however teams are encouraged to include a high-resolution version of the ad and any other graphics (design drawings, site plot, etc.) separately on the submitted CD.
- An appendix of up to 5 additional pages is allowed for teams to include information, calculations and background material if needed.
- Judging criteria will be based on the requirements for the design and other qualities including technical accuracy, completeness, clarity of writing and presentation, professionalism, economic viability, environmental performance, and realism and creativity of the design.
- All teams must register online at: http://www.H2Ucontest.org (click on Team Registration) BEFORE submitting their design.
- Teams are encouraged to copyright their designs. By submitting a design in this contest, however, teams agree to have their papers published; the National Hydrogen Association and the U.S. Department of Energy assert the right to publicize the design concepts for their own purposes. All work will be given due credit to its authors.

## *1.4 Prizes*

- One grand-prize winning team and four honorable mention teams are expected to be selected. The winning teams will be announced (to winning teams only) on February 25, 2005; awards will be announced publicly March 29-April 1, 2005 at the 2005 Annual Hydrogen Conference in Washington, DC (for more information on the conference, visit: www.HydrogenConference.org
- Two of the four honorable mentions are expected to be given to undergraduate-only teams and two honorable mentions will be given to graduate-only or mixed teams.
- All five winning teams (one grand-prize team plus four honorable mentions) will receive awards in a ceremony at the 2005 Annual Hydrogen Conference. Winning designs will be published in the conference proceedings and online at www.H2Ucontest.org. Five members from all winning teams will receive complimentary registration to the conference in addition to complimentary hotel accommodations. All other attendees must register through www.HydrogenConference.org.
- The grand-prize winning team:
    - will receive a stipend of up to $5,000 to cover airfare, meals, and incidental expenses during the trip (must be documented) as well as

complimentary hotel rooms and complimentary registration for five team members to the conference. Reservations will be made and paid for the winners at the Marriott Wardman Park Hotel in Washington, DC (see www.hydrogenconference.org for more information);
    - must send at least 1 representative to present the team's design at the 2005 Annual Hydrogen Conference, however the whole team is **strongly** encouraged to use the stipend to allow the maximum number of team members to attend; and
    - must send via email a 20-minute PowerPoint presentation of its design to the NHA (serfassp@HydrogenAssociation.org) by March 15, 2005.
- The four honorable mention teams:
    - will be invited to give poster presentations at the 2005 Annual Hydrogen Conference; and
    - will receive complimentary hotel rooms and complimentary registration for five team members to the conference. Reservations will be made and paid for at the Marriott Wardman Park Hotel in Washington, DC (see www.hydrogenconference.org for more information);

### *1.5 Contest Schedule*

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|---|---|
| • Early announcement to alert universities: | **August 15, 2004** |
| • Rules review meeting (open to all interested) | **September 2, 2004** |
| • Rules finalized | **September 15, 2004** |
| • Contest Begins | **September 15, 2004** |
| • **DUE: Team Registration (www.H2Ucontest.org)** | **October 15, 2004** |
| • **DUE: Entries due to NHA** | **January 14, 2005** |
| • Contest Committee reviews judges' scores | **February 24, 2005** |
| • Announcement of winners to winning teams | **February 25, 2005** |
| • **DUE: Winning team submits presentation to NHA** | **March 15, 2005** |
| • Announcement and presentation of winning designs | **Mar. 29-Apr. 1, 2005** |

# 2 Design Guidelines

The NHA and US DOE request proposals for the design of a hydrogen power park to produce hydrogen and hydrogen-fueled electrical power to serve light duty hydrogen fuel cell vehicles and various electrical loads. Conforming to the power park requirements listed below, the students will be judged on their ability to provide hydrogen and electrical power safely, cleanly and affordably. Specific judging criteria include technical accuracy, completeness, clarity of writing and presentation, operational safety, economic viability, environmental performance and realism of the design. Additional consideration will be given for innovative and creative designs.

### *2.1 General Hydrogen Power Park Requirements*

The hydrogen power park design must include hydrogen production, purification (if necessary), dispensing (to vehicles) and electrical power production. The project team will

have to provide a detailed description of the hydrogen production system used to produce hydrogen at the power park. Teams that use renewable energy technologies for hydrogen production and/or electrical loads can receive up to 5 bonus points.

The power park design should include the following:

- Hydrogen cost and overall efficiency should be a strong design consideration for the hydrogen, production, storage, delivery, and power system design. The hydrogen must be generated on-site and stored.
- As part of the design, teams should plan to open their power park for service in January of 2010 with a 10-year service life to 2020.
- Designs must include appropriate safety measures to ensure safe operation (see Section 2.3)
- Teams should use today's commercially-available components. Vendor specs for the components and sub systems must be used in evaluating performance and cost.
- The maximum footprint for the power park must not exceed 21,000 square feet.
- The power park must be publicly visible and accessible.

Fueling Requirements –

- The power park must have the daily capacity to refuel a minimum of 50 kg/day (10 vehicles at 5 kg/vehicle) at the station opening. The daily capacity should increase to 250 kg/day (50 vehicles/day) by 2020.
- The power park must be able to handle a single peak vehicle fueling period of 30 kg in 1 hour.
- At a minimum, on-site production, compression and storage capabilities must adequately support the fueling loads.

Power Requirements –

- The power park must have the capacity to provide a minimum of 100 kilowatts of electrical power from a stationary fuel cell, internal combustion engine, turbine or other hydrogen-fueled power system on-site. This power can be provided to serve any number of loads including (but not limited to) –
    - Uninterruptible Power Supply (UPS)
    - Back-up power (BUP) for local building loads or for multiple (minimum of 10) homes*
    - Peak shaving or load leveling for local building loads or multiple homes*
    - Baseload power for local building loads or multiple homes*
    - Normalize power supply from intermittent resources like renewables (e.g. wind, geothermal, biomass or biomass waste, solar power, etc.).

  *Local building loads may be located on-site or in the immediate vicinity of the power park.
- The power park may provide process heat and/or waste heat used for other purposes such as space or water heating or cooling (i.e., "combined heat and power") for local building loads.
- Designs are allowed to feed power back into the grid if it can be bought, and be compensated for power sales at the prevailing rate for the power park location.

## 2.2 Technical Design

Technical designs must include the following:

- Definition of the park location, zoning, and occupancy in compliance with existing codes. Teams will receive 8 bonus points if they seek, receive and document approval to build from local fire marshals (in concept only). Teams unable to obtain approval may receive up to 2 bonus points if the team's interaction is well documented. Teams should include their documentation in the Appendix.
- Site (plot) plan. The plot should be "plan-view" and show the location of equipment, refueling pumps, building(s), ingress/egress, any auxiliary equipment, and any other items the project team wishes to include.
- Detailed three-dimensional drawing or computer rendering of the power park design including all major hardware and structures.
- Description of major components for fuel production and use with specifications and rationale for the choice of component.
- Description of the equipment used for on–site electrical power production, power conditioning, and interconnection with the load. Include a plot of net efficiency vs. load, specifications and rationale for the choice of the type of generation equipment (e.g., fuel cell).
- Detailed description of the characteristics of the electrical load served by the power park and load profile (power vs. time).
- Description of the process heat load served by the power park, if any, including any potential heat load-fuel cell system interface.
- Explanation of the control of major systems and processes and major control issues, such as power plant response to load fluctuations and other load dynamics.
    - For vehicle re-fueling: Process schematic from production to dispensers, including all major equipment and flow paths.
    - For electrical power production: Process schematic from production to electricity production including a basic electrical schematic including the electrical power distribution and major controls.

## 2.3 Safety Analysis

The goal of this section is to prove that the power park will operate safely. In the design, students must insure that safety is comprehensively addressed as a paramount issue during station operation. This section will be judged on the safety of the entire design and the documentation provided to prove that the station will operate safely. Due to time and page limitations, the following requirements are listed to assist the design team in making its case. To document the ability of the students' power park to address safety, the following minimum requirements must be met in this section:

- Students must identify the most significant (at least four) major failure modes (leakage, rupture, accidents, equipment failure, etc.).
- Failure modes must be ranked from highest probability to lowest probability.
- The highest probability failure mode must be analyzed. Students will explain how their design will either mitigate the risk of failure or cope with the result.
- Students must design their power park to address the other failure modes in addition to any other major anticipated risks.

- Mitigation of safety hazards should consider appropriate levels of redundancy to minimize the probability of a safety-related event.

## 2.4 Economic/Business Plan Analysis

The project team must complete a detailed economic analysis of the entire power park design and its major components (e.g. electricity production, waste heat recovery, hydrogen production, compression, storage, and dispensing). The analysis may also consider additional economic benefits associated with the overall power park "value proposition," such as the value of UPS or BUP in providing high reliability power. The economic analysis should include capital costs, operational and maintenance costs, and avoided costs, and use a 10% internal rate of return (IRR). For all costing analyses, teams must use documented sources.

The analysis should include the following:

- Capital costs for all equipment sited at power park, depreciated using "straight line" depreciation.
- Operation and maintenance costs.
- Balance of energy use for power park operation overall and major systems individually (production, delivery, compression, power system, etc.), shown in kW.
- The utility rate structures used at your power park location. The rate structures should include all tariffs (e.g. for electricity, natural gas, etc.) that affect the economics of your design. Seasonal variation in electricity charges may be included, and note that commercial customers often have electricity tariff schedules with three or more components (e.g. fixed monthly charges, energy charges, and peak load demand charges).
- Comparison of the price the utility will pay for electricity sold back to the grid to the cost of producing that electricity ($/kWh).
- Production cost and selling price of hydrogen in each year of the analysis, based on a discounted cash flow analysis with an after tax internal rate of return of 10% for a 10 year analysis.
- Overall and annual net cost/revenue from all systems in the power park.

## 2.5 Environmental Analysis

Using the balance of energy use from Section 2.4, each team will perform an energy input/output and emissions ($CO_2$ only) analysis. At a minimum, the analysis should include the following:

- Using the energy balance and process schematics from Section 2.2, quantify the emissions produced overall and from major systems as listed in 2.4.
- The emissions analysis should quantify:
    - Grams $CO_2$/ kg hydrogen produced;
    - Grams $CO_2$/ kWh electricity produced at the power park;
    - Grams $CO_2$/kWh for the local grid electrical power.

For all emissions analyses, teams must document their sources.

## *2.6 Public Awareness/Marketing and Education Plan*

Public acceptance of hydrogen is a challenge and needs to be developed through long term education and outreach efforts, just like introduction of other fuels. How will you build support for your planned power park, allay public safety fears or reduce potential resistance, and raise community awareness of the benefits of hydrogen technologies? For this section, teams must produce a realistic public awareness and education plan to support the planned hydrogen power park. The plan must include a one-page (8.5" x 11") advertisement that will be distributed through local media. Teams must include marketing costs in the economic analysis.