Request for Proposals

The 2005 International

Future Energy Challenge

A student competition sponsored by the

Institute of Electrical and Electronics Engineers (IEEE) Power Electronics Society, Industry Applications Society, Power Engineering Society, and Industrial Electronics Society
&
by the National Renewable Energy Laboratory
&
other sponsors

Summary of Competition and Proposal Requirements

General Information

Competition Title: 2005 International Future Energy Challenge Student Competition

Topic areas: (A) Single-Phase Adjustable Speed Motor Drive and (B) Utility Interactive Inverter System for Small Distributed Generation.

Period of Competition: May 15, 2004 to August 15, 2005

Challenge Award: At least US$10,000 (and more based on sponsorship) will be awarded for highest score among entries meeting all minimum requirements as confirmed through reports and hardware tests.

Program Awards (actual number depends on availability): Best in specific topic areas (engineering design, reports, presentations, and others); expected levels are $1,000 to $5,000 each. The final amounts are subject to the recommendations of the judges.

Intellectual Property and Use of Prize Money:

The International Future Energy Challenge does not restrict the use or protection of inventions or other intellectual property produced by participating teams. There are no special licenses or rights required by the sponsors. However, the Final Test Events that begin August 15, 2005 will include public disclosure of each team’s technology. Teams interested in securing protection for their inventions should be aware of this date when making arrangements.

The prizes provided to schools are intended to benefit the team members and student team design project activities. There is a Letter of Support (Attachment II) required for submission with the proposal, and it should outline the plans of the school in the event that a prize is received.

Outside Support:

Individual schools should solicit project funding from companies, foundations, utilities, manufacturers, government agencies, or other sources. There is no limitation for the sources of project funding.

Eligibility Information:

- **Eligible schools must:** Have an accredited or similarly officially recognized engineering program (through the Accreditation Board for Engineering Technology (ABET) or equivalent); Be a college or university with engineering curricula leading to a full first degree or higher; Have the support of the school’s administration; Establish a team of student engineers with an identified faculty advisor; Demonstrate the necessary faculty and financial support commitments; and Demonstrate a strong commitment to undergraduate engineering education through their proposal.

- **University Eligibility Limit: <u>Each university is limited to one topic area; each school can support only one team.</u>**

To confirm eligibility, potential participating schools must submit a Letter of Support (Attachment II) together with a Preliminary Team Information Form (Attachment I) when they submit the proposal.

How to Participate: Participation is on a proposal basis. Those schools that are interested must submit a proposal no later than April 10, 2004. Proposals will be judged by a distinguished panel of volunteer experts from the IEEE and from industry. Schools with successful proposals will be notified by May 15, 2004. Student teams will then carry out the work and prepare hardware prototypes and reports. First and second progress reports are due November 1, 2004 and February 1, 2005, respectively. Final progress reports are due May 1, 2005. The reports will be judged by a similar expert panel. By May 15, 2005, the panel will select a group of teams as Finalists. These teams will be invited to a competition event that will begin August 15, 2005. A Final Report will be due at the competition event. The team achieving the best overall results that meet all the requirements will receive a Challenge Award of no less than US$10,000 (and more based on sponsorship levels). The best results in individual categories, including engineering design, engineering report quality, technical presentation, innovation, and other categories to be determined, will win special monetary prizes of approximately $1,000 to $5,000 each.

Please be aware that each of the two topic areas of the 2005 International Future Energy Challenge will be judged separately, against a separate specification set. Each team proposal must address a single topic area.

Judging Panels

Experts from IEEE Power Electronics Society, Industry Applications Society, Power Engineering Society (and others to be announced), and representatives from manufacturers, national labs, independent test labs, utilities, and R&D engineers.

Judging

Student team project results will be judged based on cost effectiveness, performance, quality of the prototype and other results, engineering reports, adherence to rules and deadlines, innovation, future promise, and related criteria. Each aspect of judging will be scored according to a point list and Test Protocol published in the 2005 International Future Energy Challenge Rules.

Proposals

Proposals will be judged on the quality of plans, the likelihood that a team will be successful in meeting the International Future Energy Challenge objectives, technical and production feasibility and degree of innovation. Other key criteria are evidence of the school's commitment, capability, experience, and resources to implement their design over the one-year span of the competition. Commitment to excellence in undergraduate education is important, and acceptable proposals will involve undergraduate students as the primary team members. Interdisciplinary teams are encouraged. Graduate students are not excluded, but the impact on undergraduate education is a critical judging criterion. **Proposals are limited to 12 double-spaced pages total, including all diagrams, attachments, and appendixes.** Schools that are invited to participate in 2005 International Future Energy Challenge are expected to adhere to the basic plans described in their proposals. Approval of the competition organizers must be sought for significant changes in plans or engineering designs. **Only one proposal will be considered for each school. Electronic copies of the proposals in PDF format are due, to be received by April 10, 2004, at the address provided below.**

A. Proposal Objectives

Respondents should express their ideas and plans relevant to their interested topic area. The project should include the construction and operation of a complete hardware prototype. The proposal must address both technical and organizational issues for each phase of the prototype's development and testing. It must contain a realistic project budget, along with a plan to secure the necessary funding. The educational goals, including any course credit provided for work related to 2005 International Future Energy Challenge, and how the project relates to other efforts within the school and at the regional or national level should be addressed. A Letter of Support from an official of the school confirming a commitment to participate in the competition, and stating the type(s) and level of support for the team's participation in the competition should be attached, and is not counted toward the 12-page limit. Refer to the attachments at the end of this document for a sample.

B. Administrative Considerations and Limitations

This section describes the limitations placed on the proposal. Compliance is mandatory.

Language	Proposals must be written in English.
Length	Proposals are limited to 12 single-sided double-spaced pages of text, figures, and appendixes. The page size must be 8.5" x 11" or A4 and the font size must be no smaller than 10 point. Margins should be at least 25 mm. The Preliminary Team Information Form (Attachment I in this RFP), Support Letter (Attachment II in this RFP) from the school, government entities, or private sector organizations will not count in the proposal length.
Authors	Proposals are to be prepared by the student team in collaboration with the faculty advisors.

Signatures — Proposals must be signed by all authors of the proposal (or the student team leader) and the faculty advisor.

Letter of Support — Proposals must be accompanied by a letter of support from an appropriate Dean, Department Chair, or other authorized school official. The letter must confirm the school's commitment to participate. It must also state the type(s) and value of support from the institution. School support should match the value of cash and in-kind support from the team's principal sponsors. Additional letters of support from other team sponsors are optional. A sample letter is provided as Attachment II.

Preliminary Team Data — Submit one copy of the Preliminary Team Information Form (Attachment I) with the proposal, then an updated copy with the progress reports to the address below. This form does not count in the 12-page limit.

Due Date — All proposals must be received at the address below by close of business on April 10, 2004 for full consideration.

Proposal Submission — The electronic copy of the proposal in PDF format must be sent to the following topic coordinators via email. The electronic copy of the proposal can also be delivered on floppy disk (IBM format), Zip disk (IBM format), or CD.

Coordinator for Topic (A) Single-Phase Adjustable Speed Motor Drive:

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Coordinator for Topic (B) Utility Interactive Inverter System for Small Distributed Generation

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For Information

Non-technical or administrative questions should be directed to Mr. Robert Myers:

Robert Myers Administrative Secretary IEEE Power Electronics Society IEEE Industry Applications Society 799 North Beverly Glen Los Angeles, CA 90077, USA	Phone: +1/(310)446-8280 Fax: +1/(310)446-8390 E-mail: bob.myers@ieee.org

Technical questions should be directed to the 2005 International Future Energy Challenge Organizing Committee. The Chair is Prof. Steven D. Pekarek, University of Missouri-Rolla, pekarek@ece.umr.edu. Topic coordinators are Prof. Ali Emadi, Illinois Institute of Technology, emadi@iit.edu, for Topic (A) and Prof. Marcelo G. Simoes, Colorado School of Mines, mgsimoes@ieee.org. The competition website is http://www.energychallenge.org; this final version of this RFP and updates will be posted on the website.

Time Schedule

December 1, 2003:	Request for proposals (RFP) posted
April 10, 2004:	Proposals due
May 15, 2004:	Schools informed of acceptance into the competition
November 1, 2004:	1st summary progress reports due (Progress reports are limited to 10 double-spaced, single-column pages total, including all diagrams, attachments, and appendixes.)
February 1, 2005:	2nd summary progress reports due (Progress reports are limited to 10 double-spaced, single-column pages total, including all diagrams, attachments, and appendixes.)
May 1, 2005:	Final progress reports due (Final progress reports must include preliminary experimental results; final progress reports are limited to 25 single-column pages total, including all diagrams, attachments, and appendixes.)
May 15, 2005:	Finalists notified (Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all the challenge objectives.)
August 15, 2005:	Final reports and working units due (Final reports are limited to 50 single-column pages total, including all diagrams, attachments, and appendixes.)
August 15-19, 2005:	Final competition

2005 International Future Energy Challenge Organizing Committee

Chair: Dr. Steven D. Pekarek – University of Missouri-Rolla
Vice-Chair: Dr. Antonello Monti – University of South Carolina
Secretary: Dr. Ali Emadi – Illinois Institute of Technology
Coordinator Topic A: Dr. Ali Emadi – Illinois Institute of Technology
Coordinator Topic B: Dr. Marcelo G. Simoes – Colorado School of Mines
Future Planning: Dr. Philip Krein – University of Illinois at Urbana-Champaign
Industry Liaison: Dr. John M. Miller – J-N-J Miller Design Services, P.L.C.
Webmaster: Dr. Ali Emadi – Illinois Institute of Technology
Sponsor Liaison: Dr. John M. Miller – J-N-J Miller Design Services, P.L.C.
European Liaison: Dr. Francesco Profumo – Politecnico di Torino
Australia Liaison: Dr. Grahame Holmes – Monash University
South America Liaison: Dr. Marcelo G. Simoes – Colorado School of Mines
IEEE Inter-Society Associate: Robert Myers – IEEE

Competition Description

Scope: An international student competition for innovation, conservation, and effective use of electrical energy. The competition is open to college and university student teams from recognized engineering programs in any location. Participation is on a proposal basis.

Introduction: In 2001, the U.S. Department of Energy (DOE), in partnership with the National Association of State Energy Officials (NASEO), the Institute of Electrical and Electronics Engineers (IEEE), the Department of Defense (DOD) and other sponsors, organized the first Future Energy Challenge competition. The objective was to build prototype, low-cost inverters to support fuel cell power systems. This competition was originally open to schools in North America with accredited engineering programs. The 2001 Future Energy Challenge focused on the emerging field of distributed electricity generation systems, seeking to dramatically improve the design and reduce the cost of dc-ac inverters and interface systems for use in distributed generation systems. The objectives were to design elegant, manufacturable systems that would reduce the costs of commercial interface systems by at least 50% and, thereby, accelerate the deployment of distributed generation systems in homes and buildings. The 2001 Challenge was a success, and is now the first in a biannual series of energy-based student team design competitions.

To continue and expand the 2001 success, the 2003 Future Energy Challenge was organized as a worldwide student competition. The theme of the 2003 Future Energy Challenge was "Energy Challenge in the Home." The objective was to introduce engineering design innovations that can demonstrate dramatic reductions in residential electricity consumption from utility sources or that can lead to the best use of electricity in newly connected homes in developing nations.

Topics and Descriptions: The 2005 competition addresses two broad topic areas: (A) Single-Phase Adjustable Speed Motor Drive and (B) Utility Interactive Inverter System for Small Distributed Generation, respectively described as follows:

A. **Single-Phase Adjustable Speed Motor Drive:** Innovations in motors and motor drive systems that produce deep cuts in losses and costs for home (appliance) use, or that could replace "universal motor" brush machines in residential applications. For example, use three-phase motors and motor drives that operate from single-phase power, reduce appliance in-rush currents associated with motor starting, and enhance motor efficiency across a wide load range are of interest. Target hardware costs are US$40 for a combination of motor, power electronic driver, and controller that can operate from a single-phase residential source, deliver rated shaft load of 3/4 HP (or 500 W) at 1500 RPM, exhibit a useful speed control range of at least 150 RPM to 5000 RPM, and provide power efficiency of at least 70% for loads ranging from 50 W to 500 W at a specified speed. The hardware prototypes judged as best will be tested. The school with the most cost-effective design and that can meet or exceed the aggressive cost target, and that provides a fully functional prototype, will be awarded with a large prize.
B. **Utility Interactive Inverter System for Small Distributed Generation:** The objective of this competition is to improve and foster innovation in the design of flexible utility interactive inverter systems for small distributed generation. The inverter must be efficient

and comply with requirements for harmonic control, interconnection, and safety standards. The inverter must be capable to operate in typical voltage and frequencies, grid-connected or stand-alone. Target hardware costs are US$200 for an inverter that can operate from a dc input voltage varying from 30 volts to 60 volts, under constrained input power varying from 250W to 1000W, to a single-phase utility line 110/240V either 50Hz/60Hz, with efficiency of at least 90%. The inverter will be able to work grid-connected (at unity power factor) or stand-alone (providing power for a resistive load). The inverter will have to provide galvanic isolation, compliance with IEEE Standards 519 and 1547 as well as FCC Class A Part 18 for conducted and radiated EMI. The inverter must draw all its internal power from the input side. Hardware prototypes capable to meet the specifications will be tested. The school with the most cost-effective design and that can meet or exceed the cost target, and that provides a fully functional prototype, will be awarded with a large prize.

Detailed Description, Proposal Preparation, and Specifications of Each Topic

Request for Proposals – Topic (A) Single-Phase Adjustable Speed Motor Drive

Topic Description

The information provided in the following is for the single-phase adjustable speed motor drive topic. The objective is innovations in motors and motor drive systems that produce deep cuts in losses and costs for home (appliance) use, or that could replace “universal motor” brush machines in residential applications. For example, use three-phase motors and motor drives that operate from single-phase power, reduce appliance in-rush currents associated with motor starting, and enhance motor efficiency across a wide load range are of interest.

Target hardware costs are US$40 for a combination motor and motor controller that can operate from a single-phase residential source, deliver rated shaft load of 3/4 HP (or 500 W) at 1500 RPM, exhibit a useful speed control range of at least 150 RPM to 5000 RPM, and provide power efficiency of at least 70% for loads ranging from 50 W to 500 W at a specified speed. The hardware prototypes judged as best will be tested. The school with the most cost-effective design and that can meet or exceed the aggressive cost target, and that provides a fully functional prototype, will be awarded with a large prize. Substantial funding for this topic is provided by the IEEE Power Electronics Society, the IEEE Industry Applications Society, and the IEEE Power Engineering Society. Total prize money will depend on the number of schools engaged in this topic, and is expected to exceed US$25,000.

Vision

- Encourage the development of technologies to bring dramatic improvements to low-cost single-phase motor systems for home use.
- Incorporate practicality, potential manufacturability, and affordability into the competition assessment process.
- Demonstrate technical progress toward and potential of advanced technologies that may help achieve the goals of this competition.
- Improve engineering education and foster practical learning through the development of innovative team-based engineering solutions to complex technical problems.

Goal

Construct an adjustable speed motor drive system that will:

- reduce the manufacturing cost to less than US$40 for a 500 W unit;
- achieve maximum efficiency and operating requirements; and,
- maintain acceptability in the areas of performance, reliability, and safety.

Motor System Specifications

The motor system proposed will be judged against a set of objective specifications based on the example design targets shown below. The design concept is a 500 W motor system, and teams are asked to construct a complete hardware prototype to demonstrate their accomplishments. The target design requirements for the system given below are minimums that need to be reached to win the Challenge Award. Design concepts are expected to be validated with working prototypes. Scoring will be set up such that improvements beyond the minimums are beneficial to the team.

Design Concept/Function	*Minimum* Target Requirement
1. Manufacturing cost	No more than US$40 when scaled to high-volume production (approximately 1 million units/year).
2. Complete package size	A convenient shape with volume less than 4 L. (Motor maximum dimensions are given below.)
3. Complete package weight	Mass less than 8 kg for the complete system.
4. Output power capability and speed range	500 W continuous shaft output power at a nominal speed of 1500 RPM, and also at higher speeds up to 5000 RPM. Continuous output torque of at least 3.18 N-m at speeds from 150 RPM to 1500 RPM.
5. Input source	Single-phase source at 50 Hz or 60 Hz. Teams may select either to design for nominal 120 V at these frequencies or for nominal 240 V at these frequencies.
6. Overall energy efficiency	Higher than 70% for shaft loads ranging from 50 W to 500 W. Efficiency will be tested at a nominal speed of 1500 RPM and also for the entire speed range from 150 RPM to 5000 RPM.
7. Power factor	Power factor measured at the electrical input should be at least 80% when tested under a 500 W shaft load at 1500 RPM. Current waveform should conform to requirements in IEC1000-3-2 standards.
8. Safety	The system is intended for safe use in a home appliance or household HVAC system.
9. Speed control	Speed is to be controlled from start to the full 5000 RPM with a linear 0-10 V analog signal, referenced to the unit case. Except for starting, no testing will be performed below 150 RPM.
9. Speed regulation and accuracy	The actual operating speed should remain within ±5% of the voltage command setting (2 V/1000 RPM) from no-load to full-load.
10. Acoustic noise	Low noise. Less than 50 dBA sound level measured 0.5 m from the unit.
11. Electrical noise	Able to meet FCC Class A—industrial

	requirements for conducted and radiated EMI.
12. Protection	Self-protection against continuous stall conditions, over temperature, or loss of input source with no damage caused by any of these (up to the maximum storage temperature).
13. Environment	Open drip proof motor construction is acceptable. Ambient temperature -20°C to +40°C. Suitable for indoor or outdoor domestic applications.
14. Lifetime	The system should function for at least ten years with no maintenance needs when subjected to normal use in a 20°C to 30°C ambient environment.
15. Technical report	Design, simulation, experiment results, lifetime analysis, and cost study.

Additional Hardware Specifications	
1. Inrush and starting current	Operating current shall not exceed 150% of the nominal full-load current under any conditions, including power-on inrush and motor starts.
2. Phases and motor phasing	The input power source is single phase. There are *no restrictions* on the motor technology or motor phase count as long as the system operates from single-phase power.
3. Motor dimensions	The motor itself must be no larger than NEMA Frame Size #48. Radius from shaft center to mounting points not to exceed three inches or 76.2 mm. Overall length (not including shaft extension) not to exceed 7.75 inches or 197 mm.
4. Coupling and mount	Motor is to be provided with a footed or cradle mount with base holes corresponding to NEMA Frame #48 (width spacing 108 mm or 4.25 in, length spacing 70 mm or 2.75 in), located 76.2 mm (3 in) below the shaft center. Motor shaft diameter is to be 0.50 in (12.7 mm), or the team can provide a suitable adapter to achieve this diameter. The shaft should extend at least 38 mm beyond the motor case.
5. Safety	The final rules will contain detailed safety information. No live electrical elements are to be exposed when the system is fully configured.
6. Connection	The complete unit is to be provided with an IEC 320 input connection, with a clear label stating the voltage requirement.
7. Storage temperature range	-20 to 60°C

8. Bearings	Any choice of bearings is acceptable, provided no lubrication or maintenance will be needed during a ten-year normal duty operating life.
9. Handling	The unit must be robust enough for normal handling by a technician with no special training.
10. Shipping environment	Can be shipped by conventional air freight or truck freight.
11. Displays and data	No displays or data capability are required, although a digital display of running speed is encouraged. A control dial with markings is required, as stated above.
12. Command signal	Access to the speed control voltage signal is to be provided either through a conventional BNC jack or a pair of screw terminals. The input should be protected against accidental polarity reversal. The speed must return to zero if no signal is connected.
13. Switch	The unit must include an on/off switch. When the switch is off, the input power must not exceed 1 W.
Prototype Test Considerations	
1. Inspections	All prototypes of approved Finalist teams must pass safety inspection prior to operation. All prototypes must function correctly during a 15-minute initial operation check before proceeding.
2. Test energy source: voltage	Prototypes will be tested with available power consistent with the selected voltage rating. Either 50 Hz or 60 Hz may be used.
3. Test duration	An automated load sequencing operation will be tested for up to 24 hr continuous.
4. Typical operation tests	Tests for steady-state performance, protection, robustness to stalls, acoustic noise, electromagnetic noise may be conducted.
5. Source interface tests	Tests for transient loads may be conducted, within the allowed torque, speed, and power range.

Specification Intent

The specifications are intended to provide guidance rather than an exhaustive list of requirements. All teams are encouraged to develop novel solutions and test a wide range of ideas. The long-term purpose is to develop cost-effective technologies that will bring major advances in motors for homes. Judges will be encouraged to consider the spirit, innovation, and future promise of each team’s work when reviewing entries.

Design Restrictions

In general, any electrical, electronic, energy, mechanical, or other component may be used and any motor technology is permitted. Keep in mind the cost considerations and the intended safe use in domestic applications. Both factors will limit the feasible range of component choices.

Funding Sources

IEEE and other sponsors provide the Challenge Award as well as the Program Awards.

Individual schools should solicit project funding from local, national, or international sources. There is no limitation for the sources of project funding.

Request for Proposals – Topic (B) Utility Interactive Inverter System for Small Distributed Generation

Topic Description

The objective of this competition is to improve and foster innovation in the design of flexible utility interactive inverter systems for small distributed generation. Alternative energy solutions such as photovoltaic and fuel cell sources as well as generator based systems with rectifiers provide a variable dc voltage. Such variable voltage is power constrained and often limited by other environmental factors leading to instantaneous limitations in maximum voltage and/or current. The inverter must be efficient and comply with requirements for harmonic control, interconnection, and safety standards. The inverter must be capable to operate in typical voltage and frequencies, grid-connected or stand-alone.

Target hardware costs are US$200 for an inverter that can operate from a dc input voltage varying from 30 volts to 60 volts, under constrained input power varying from 250W to 1000W, to a single-phase utility line 110/240V either 50Hz/60Hz, with efficiency of at least 90%. The inverter will be able to work grid-connected (at unity power factor) or stand-alone (providing power for a resistive load). The inverter will have to provide galvanic isolation, compliance with IEEE Standards 519 and 1547 as well as FCC Class A Part 18 for conducted and radiated EMI. The inverter must draw all its internal power from the input side. This does not preclude the use of small internal batteries for nonvolatile memory or similar functions as long as the inverter meet a ten-year lifetime. When abnormal grid conditions exist or a disconnection signal is relayed to the inverter, it should disconnect itself from the utility grid in accordance to IEEE 1547 and keep a stand-alone mode to support some local loads. Hardware prototypes capable to meet the specifications will be tested. The school with the most cost-effective design and that can meet or exceed the cost target, and that provides a fully functional prototype, will be awarded with a large prize. Substantial funding for this topic is provided by the IEEE Power Electronics Society, the IEEE Industry Applications Society, and the IEEE Power Engineering Society. Total prize money will depend on the number of schools engaged in this topic, and is expected to exceed US$25,000.

Vision

- Encourage the development of technologies to bring dramatic improvements to low-cost utility interactive inverters for small distributed generation applications suitable for improving weak grids and use in developing countries.
- Encourage the development of technologies to bring dramatic improvements to alternative energy systems for homes in the developing world.
- Address lifestyle impacts of electrification at modest power levels,\ and focus on those loads most likely to improve quality of life.
- Incorporate practicality, potential manufacturability, and affordability into the competition assessment process.
- Demonstrate technical progress toward and potential of advanced technologies that may help achieve the goals of this competition.

- Improve engineering education and foster practical learning through the development of innovative team-based engineering solutions to complex technical problems.

Goal

Construct a utility interactive inverter system that will:

- Reduce the manufacturing cost to less than US$200 for a 1 kW unit;
- Achieve maximum efficiency, operating requirements, and compliance to IEEE relevant standards;
- Reduce the manufacturing and operating costs of alternative energy systems, as related to the power electronics unit, into the range of US$0.10 to US$0.20 per kilowatt-hour;
- Provide load flexibility to bring significant lifestyle enhancements to remote areas in the developing world;
- Provide reliability necessary for effective operation over many years of household use; and,
- Maintain acceptability in the areas of performance, reliability, and safety.

Inverter System Specifications

The inverter system proposed will be judged against a set of objective specifications based on the example design targets shown below. The design concept is for a 1 kW rated system, and teams are asked to construct a complete hardware prototype to demonstrate their accomplishments. The target design requirements for the system given below are minimums that need to be reached to win the Challenge Award. Design concepts are expected to be validated with working prototypes. Scoring will be set up such that improvements beyond the minimums are beneficial to the team.

Design Item	Minimum Target Requirement 1 kW System
1. Manufacturing cost	Less than US$200/kW when scaled to high-volume production (approximately 100,000 units/year)
2. Complete package size	A convenient shape with volume less than 7.5 dm^3 (7.5 liters).
3. Complete package weight	Mass less than 3 kg.
4. Output power capability	Must deliver energy into a grid with automatic detection. The ranges that will be tested are 110 V +15% -20%, at 60 Hz ± 2% and 240 V +15% -20%, at 50 Hz ± 2%. The unit must disconnect automatically from the utility grid and keep a stand-alone emergency load (maximum 250 W) if an external blackout or abnormal operating conditions occur with the grid interconnection. The unit will also be tested in stand-alone for powering a 1 kW resistive load. The voltage tolerance should be ±10% for all power range.

5. Peak power rating	3000 W peak for a 1000 W continuous rating.
6. Improved overall efficiency curves	Should be included in the final report showing efficiency higher than 90% for power level varying from 5% to 100%.
7. Stand-by (tare) losses, i.e., when the inverter is on, but not producing power (low load).	Less than 3% of full rating.
8. Harmonic quality	In accordance to IEEE 519 and IEEE 1547.
9. Input source	30 VDC to 60 VDC under programmable power. The input source is unidirectional and not capable to absorb any power back.
10. Load	The inverter will be tested in grid-connected mode and will have to be able to provide all the output power range at unity power factor. The inverter has to automatically detect blackout, disconnect from the grid and keep an auxiliary load of up to 250 W operating normally. The inverter will also be tested in stand-alone. In stand-alone, it has to generate either 50 Hz or 60 Hz (maybe configured by jumpers) and capable to power a resistive load of 1000 W.
11. Battery storage	There is no technical need to provide battery storage in this system. However, additional scoring points will be awarded for teams that incorporate battery storage circuitry under the cost limit.
12. Overall energy efficiency	Higher than 90% for a 1.0 kW resistive load. Additional scoring points will be awarded for efficiencies higher than 90%.
13. Protection	Over current, over voltage, short circuit, over temperature, under voltage. No damage caused by output short circuit. The inverter will be surely tested against short circuit. The inverter must shut down if the input voltage dips below the minimum input. IEEE Std. 929 is a useful reference.
14. Electromagnetic interference	Per FCC 18 Class A -- industrial requirements for conducted and radiated EMI.
15. Acoustic noise	No louder than conventional domestic refrigerator. Less than 50 dBA sound level measured 1.5 m from the unit.
16. Safety	The final rules will contain detailed safety information. No live electrical elements are to be exposed when the unit is fully configured. The system is intended for safe, routine use in a home, rural or small business by non-technical customers. Industry safety standards will be required, such as UL 1741-2000.

17. Grid and source interaction	In accordance to IEEE 1547.
18. Environment	Suitable for outdoor installation under ambient temperature. Case should be resistant against water droplets, as in case of a light rain.
19. Storage temperature range	-20°C to +75°C
20. Operating ambient temperature range	-20°C to +50°C
21. Ambient humidity	Humidity less than or equal to 95% up to 25 °C Less than or equal to 75% at temp. above 25 °C up to 40 °C.
22. Enclosure type (suggested)	NEMA 3R
23. Cooling	Air cooled
24. Shipping environment	Must be shipped by conventional air or truck freight.
25. Lifetime	The system should function for at least 10 years with routine maintenance when subjected to normal use in ambient environment.
26. Technical report	Design, simulation, experimental results, overall efficiency, lifetime analysis, and cost study. The report must include reliability and cost analysis to demonstrate that the design can meet the ten-year lifetime requirement and the life-cycle cost objectives.
27. Galvanic isolation	Galvanic isolation must be provided as a safety requirement. A grounding connection must be available.

Additional Scoring

Any intelligent function to make the system operation in stand-alone mode or connected to other types of renewable energy sources may render additional scoring points. Battery storage and capabilities to provide user with net-metering features are also other ideas for additional points. Teams are encouraged to analyze the manufacture and utility of their design. Technical reports that include manufacturing plans based on facilities in developing nations will receive extra merit during judging. Designs best suited for use in a wide range of locations will also receive extra merit. In the event that multiple teams are able to meet all the target specifications, the designs with the best promise for wide application and reports that address manufacturing plans in developing nations will be favored.

Specification Intent

The specifications are intended to provide guidance rather than an exhaustive list of requirements. All teams are encouraged to develop novel solutions and test a wide range of ideas. The long-term purpose is to develop cost-effective technologies that will bring major advances in energy sources for homes in developing nations. Judges will be encouraged to consider the spirit, innovation, and future promise of each team’s work when reviewing entries.

Final Testing

Final testing of the winning designs will be conducted August 15-19, 2003 at the Distributed Energy Resource (DER) Test Facility at the National Renewable Energy Laboratory.

Funding Sources

IEEE and other sponsors provide the Challenge Award as well as the Program Awards.

Individual schools should solicit project funding from local, national, or international sources. There is no limitation for the sources of project funding.

References

[1] NREL/TP-560-32063 "Distributed Power Program DER Pilot Test at the Nevada Test Site"

[2] NREL/SR-200-28053 "Making Connections – Case Studies of Interconnection Barriers and Their Impact on Distributed Power Projects"

[3] NREL/SR-560-32459 "Distributed Energy Resources Interconnection Systems: Technology Review and Research Needs"

[4] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems IEEE Std 1547-2003

[5] IEEE Standard 1547-2003, "Standard for Standard for Interconnecting Distributed Resources with Electric Power Systems"

[6] IEEE Standard (Draft) P1547.1, "Standard Conformance Test Procedures for Interconnecting Distributed Energy Resources with Electric Power Systems."

[7] IEEE Standard (Draft) P1547.2, "Application Guide for IEEE Standard 1547: Interconnecting Distributed Resources with Electric Power Systems."

[8] IEEE Standard (Draft) P1547.3, "Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems."

[9] IEEE Standard 519-1992 "IEEE recommended practices and requirements for harmonic control in electrical power systems"

[10] IEEE Std 929-2000 "IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems"

[11] UL 1741 "Static Inverters and Charge Controllers for use in Photovoltaic Power Systems"

[12] "Application Guide for Distributed Generation Interconnection: 2003 Update The NRECA Guide to IEEE 1547," Resource Dynamics Corporation, April 2003

[13] National Electrical Code (NEC) 1999 (or NFPA 70)

ATTACHMENT I

2005 INTERNATIONAL FUTURE ENERGY CHALLENGE
PRELIMINARY TEAM INFORMATION FORM
TOPIC (X)
Submit with Proposal

NAME OF UNIVERSITY:

CORRESPONDING ADDRESS (PLEASE INCLUDE NAME):

TELPHONE:
FAX:
EMAIL:

FACULTY ADVISOR(S):

Name	Department	E-Mail
____________________	____________________	____________________
____________________	____________________	____________________

PRELIMINARY TEAM MEMBERS:

Name	Major Field of Study	Degree and Expected Graduation Date
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________

ATTACHMENT II
LETTER OF SUPPORT
Submit with Proposal

[The letter below is a typical sample and should not simply be copied. Please send a letter with similar content on your university letterhead.]

For Topic (A) Single-Phase Adjustable Speed Motor Drive:

To: Prof. Ali Emadi
Illinois Institute of Technology
Electrical and Computer Engineering Department
3301 S. Dearborn Street
Chicago, IL 60616-3793, USA

For Topic (B) Utility Interactive Inverter System for Small Distributed Generation:

To: Prof. Marcelo G. Simoes
Colorado School of Mines
Engineering Division
1500 Illinois Street
Golden, CO 80401-2887, USA

Dear International Future Energy Challenge Coordinator,

Our university has organized a student team to participate in the 2005 International Future Energy Challenge. Our proposal for the topic (X) is enclosed. A Preliminary Team Participation Form is attached, listing our contact person, the faculty advisor(s), and some of the students who plan to be involved. The team will keep an eye on the Energy Challenge web site for detailed rules and other information. We understand that we will be notified whether we have been accepted to participate by May 15, 2004. If we are accepted, we agree to have our student team perform the design tasks and prepare the reports and hardware prototypes required for the competition. Our school is prepared to support the team with the following resources:

- A final year project course, XXX, has been authorized to provide engineering students across several disciplines with the opportunity to include this project in their curricula. Laboratory space has been arranged for this course.
- A faculty advisor, Prof. XXX, has been identified, and has been formally assigned to teach the project course and to advise the student team as a portion of her regular duties.
- A graduate student assistant has been identified to help manage the student team and to supervise direct laboratory activity. This student is supported with a Teaching Assistantship, which represents a funding commitment of our university of approximately $X.
- The student team will be provided with an appropriate level of technician and machine shop support to assist them with package preparation and assembly. This assistance

represents a funding commitment of approximately $X, and we consider this as a matching commitment for any in-kind support received from external sponsors.

- In addition, we will provide limited funds to help secure special parts and equipment, with a total commitment of up to $X.
- The student team will be encouraged to secure outside sponsorship. Our university strongly supports all these efforts, and will match any outside cash support 1:1 up to an additional total of $X.

In the event that our school receives prizes from the competition, we are committed to using approximately X% of this money for scholarships for the student team members. The remainder of the funds will be added to our Team Design Program fund, which supports this and similar projects through sponsorship matching, travel funds for participation in competition events, and other direct costs of large team design projects. In the event that our team creates new inventions in the topic area, our university also provides the possibility of assisting with organization of a start-up company.

We understand the importance of student team projects in the engineering curriculum and look forward to our participation in the 2005 International Future Energy Challenge.

Sincerely,

(Head of Department, Dean of Engineering or similar school official)