Request for Proposal (RFP)

The 2019 International Future Energy Challenge (IFEC'19)

A student competition sponsored by the

The Institute of Electrical and Electronics Engineers (IEEE)

Aug, 2018

Summary of Competition and Proposal Requirements

General Information

Competition Title: 2019 International Future Energy Challenge (IFEC) Student Competition

Topic: E-drive for a bicycle

Overall Specifications:

- Input: 48V dc nominal from specified 10Ah battery pack.
- Output: 3-phase BLDC motor drive; V_{out}: 36V; P_{out}: 500W; variable speed.
- Power Density: >1.5 W/cm^3 without fan.
- Converter temperature rise < 40°C with 500W @ 25°C Ambient Temperature.
- Judgment criteria will include energy consumption for a typical drive cycles.

Period of Competition: Aug 1st, 2018 to July 31th, 2019

Challenge Program Awards: There will be a Grand Prize of $10,000 and three additional awards granted at $1,000, $3000 and $5,000 each.

Prize requirements: US$10,000 will be awarded as Grand Prize for highest score among entries meeting all minimum requirements as confirmed through reports and hardware tests. The remaining prizes will be awarded to the teams who have scored the highest in categories such as Best Undergraduate Educational Impact, Best Innovative Design of Power Electronics Converters, etc.

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 in July 2019 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: Each university is limited to support only one team.**

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 before the proposal deadline. Proposals will be judged by a distinguished panel of volunteer experts from the IEEE and the industry. Schools with successful proposals will be notified two months after the proposal deadline. Student teams will then carry out the work and prepare hardware prototypes and reports. Deadline for the qualification reports are also listed in the attachment and will be posted on the IFEC website. The reports will be judged by a similar expert panel. These teams are invited to present their progress to the panel at IEEE APEC conference on March 17-21, 2019, in Anaheim, California, USA. The panel will select a group of teams as Finalists based on their progress. Feedback will be given to the team to improve the system. The team will be invited to a competition event in July of 2019. A Final Report will be due at the competition event.

Judging Panels

Experts from IEEE Power Electronics 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.

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. For each team, the **minimum** undergraduate student number is **three** to qualify for the competition. Interdisciplinary teams are encouraged. Graduate students are not excluded, but are limited to graduate advisor role in the team. The upper limit of graduate student participants is **two** for each team.

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 2019 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. Proposals must be submitted electronically in PDF format.**

A. Proposal Objectives

Respondents should express their ideas and plans relevant to the competition 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 the 2019 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 by close of business on **Oct 19, 2018** for full consideration.

Proposal Submission The electronic copy of the proposal in PDF format must be uploaded to the secure e-mail address TBD.

Information The volunteer Organizing Committee for the 2019 International Future Energy Challenge maintains a web site at http://www.energychallenge.org/. The site will include the most recent schedule and rule updates, frequency-asked questions, details about judging and scoring, and other team information. It should be checked regularly.

Time Schedule

Sept 25, 2018	IFEC'19 Information Session at ECCE 2018
Oct. 19, 2018	Proposals Due
Dec. 21, 2018	Schools informed of acceptance into the competition
Mar. 1, 2019	Qualification reports due (Qualification reports must include preliminary experimental results. It is limited to 25 single-column pages total, including all diagrams, attachments, and appendixes).
Mar. 17, 2019	Workshop at APEC 2018, Anaheim, CA, USA. All accepted qualified teams must give an oral

	presentation.
Apr. 22, 2019	Finalists notified (Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all the challenge objectives).
Jul. 1, 2019	Final reports due (Final reports are limited to 50 single-column pages total, including all diagrams, attachments, and appendixes)
Jul. 29-31, 2019	Final competition

2018 International Future Energy Challenge Organizing Committee

Steering Committee Chair: Qiang Li, Virgina Tech, USA (Chair)

General Chair: Giri Venkataramanan, UW-Madison, USA

Publicity Chair: Bulent Sarlioglu, UW-Madison, USA

General Co-chair: Kyle Hanson, UW-Madison, USA

Finance Chair: Ching-Jan Chen, National Taiwan University, Taiwan

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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. Final events were conducted at the National Energy Technology Laboratory (NETL) in Morgantown, WV, USA. Speakers from IEEE, DOE, and DOD introduced the competition and interacted with students during the event week. Hardware was tested with an experimental fuel cell at the NETL site. 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 International Future Energy Challenge (IFEC) was organized as a worldwide student competition. The 2003 IFEC had two topics, a revised topic on fuel cell power conditioning, and a topic for high-efficiency motor drive systems suitable for home appliances. Major sponsors included three IEEE societies, DOE, and DOD. Fuel cell inverter events were again held at NETL. Motor system events were held at Advanced Energy in Raleigh, NC, USA.

The 2005 IFEC had two topics. The inverter topic was revised to incorporate photovoltaic sources and grid interaction, while the motor topic was revised only slightly. Major sponsors included three IEEE societies and DOD, with more modest sponsorship from DOE. Inverter events were held at the National Renewable Energy Laboratory (NREL) in Golden, CO, USA. Motor events were held at MPC Products in Skokie, IL, USA.

The 2007 IFEC had two topics. An integrated starter/alternator and a Universal battery charger system were chosen as the two topics. Major sponsors included IEEE Power Electronics society, and Power Supply Manufacturer Association (PSMA). The final competitions were held at MPC Products in Skokie, IL and Texas Instrument in Richardson, TX.

The 2009 IFEC, similar to the previous editions, had two topics. The Integrated Starter/Alternator-Motor Drive for Automotive Applications topic was repeated, a new topic, the Power Wind Turbine Energy Maximizer was included. Major sponsors included IEEE Power Electronics society, Industrial Electronics Society, MPC Products, Monash University, IEEE Power Electronics Society, IEEE Industrial Electronics Society, and Power Sources Manufacturers Association (PSMA). The final competitions were held at Illinois Institute of Technology in Chicago, IL, USA, and in Monash University, VIC, Australia.

The 2011 IFEC had two topics. Topic A focused on low cost lithium ion battery chargers. The final competition of Topic A was held at University of Michigan-Dearborn. And Virginia Tech University of USA won the Grand Prize and the Outstanding Performance Award. Topic B focused on Low Power Induction Motor Drive System Supplied from a Single Photovoltaic Panel for an Emergency Water Treatment Device Maximizer. The final competition of Topic B was held at Federal University of Maranhao, Brazil. Federal University of Maranhao won the Grand Prize and Outstanding Performance Award as well as the Best Technical Presentation Award. Sponsors of this year's competition include IEEE Power Electronics Society, IEEE Industrial Electronics Society, and Power Sources Manufacturers Association (PSMA).

The 2013 IFEC Competition also had two topics. Topic A focused on highly efficient micro inverter for photovoltaic panels. The final competition was held on July 18-19. National Taiwan University of Science and Technology won the Grand Prize and the Best Efficiency Award, Nanjing University of Aeronautics and Astronautics won the Best Engineering Achievement

Award, University of Kassel of Germany won the IEEE IES Best Innovative Design of Power Electronic Converters Award, and Beijing Jiaotong University won the Best Presentation Award. Topic B was focused on Low power off-line light-emitting diode (LED) driver with long lifetime. And the final competition was held at Zhejiang University on July 29-30. Zhejiang University won the Grand Prize and the Best Efficiency Award; National Cheng-Kung University won the Best Engineering Achievement Award; North China University of Technology won the Best Engineering Design Award. Sponsors of the 2013 IFEC competition include IEEE Power Electronics Society, IEEE Industrial Electronics Society, IEEE Industry Applications Society, IEEE Power and Energy Societyand Power Sources Manufacturers Association (PSMA).

The 2015 competition addressed two topic areas: Topic A is "High-efficiency wireless charging system for electric vehicles and other applications; and Topic B is "Battery energy storage with an inverter that mimics synchronous generators.

In 2014, the IFEC steering committee proposed to the Power Electronics Society to make IFEC an annual event from 2016. A single technical topic will be addressed by each competition. The 2016 IFEC Competition topic is ultra-high power density AC-DC converter. The final competition was held on July 18-20 at National Taiwan University, Taiwan. Nanjing University of Aeronautics and Astronautics won the Grand Prize Award, National Cheng-Kung University won the Second Price Award, University of Belgrade won the Best Education Impact Award, National Taiwan University of Science and Technology won the Best Presentation Award, University of Illinois Urbana-Champaign won the Best Innovation Award, and University of Michigan-Dearborn won the Best Report Award. Sponsors of the 2016 IFEC competition include IEEE Power Electronics Society, IEEE Industry Applications Society, IEEE Power and Energy Societyand Power Sources Manufacturers Association (PSMA).

The 2017 IFEC Competition topic is high-efficiency high-density isolated DC-DC converter. The final competition was held July 24-25 at Virginia Tech, USA. The winners in the various categories were: The Grand Prize: Kunming University of Science and Technology; The Best Innovation Award: Zhejiang University; The Best Education Impact Award: National Taiwan

University of Science and Technology; The Best Report Award: Beijing Insititute of Technology; The Best Presentation Award: University of Maryland.

The 2018 IFEC Competition was held at Tshinghua University, Beijing, China, on the topic of High Efficiency and High Power Density Isolated Bidirectional Dc-dc Converter for Residential Energy Storage Systems in July 2018. The winners in the various categories were: The Grand Prize ($10k): Xi'an Jiaotong University; The Outsdanding Performance Award ($5k): Tsinghua University; The Innovation Award ($3k): Beijing Jiaotong University; The Educational Impact Award ($1k): University if Belgrade; The Outstanding Technical Report Award ($500): National Taiwan University of Science and Technology; The Outstanding Presentation Award ($500): The Ohio State University.

The 2019 IFEC Competition topic is e-drive for an electric bicycle. The final competition will be hosted at the University of Wisconsin-Madison, USA.

The detailed technical specification of the 2019 competition is listed in the following page.

Competition Topic: E-Drive for a Bicycle

During the recent decades electric drive for bicycles have become widely used to assist pedal operation. The power level of the drive motor is usually at the fractional horse power level, and the battery energy capacity is in the order of few hundred watt hours. The drives are usually gear and/or chain driven from brushless dc type of permanent magnet three phase ac machine, with discrete hall-sensor for magnetic rotor position sensing. The user interface generally quite simple, with a throttle command that regulates the motor torque, and an on-off switch. The competition for the challenge consists of the design and prototype of a battery-three phase output drive including the motor control and user interface design. The detailed technical specifications of the drive as listed below:

Detailed Specifications and Requirements

- Maximum output power P_{out}: 500W
- Input: 48V nominal dc from battery
- 3-phase output: 0-36 V line-neutral fundamental component, 0-5A rms line current, 0-300Hz
- Phase and frequency to be synchronized to 3-phase Hall-effect sensor feedback from motor (Detailed motor specifications will be provided)
- Motor waveform: Trapezoidal
- Motor number of pole pairs: 6
- Shaft integrated planetary gear speed reduction ratio: 1:6
- Maximum battery current: 15A (will be fused externally)
- Current ripple at the battery <3% @100% output
- Power terminal leads: Anderson connector for battery and three phase output (Details will be provided)
- Power density: >1.5 W/cm^3
- Weight: less than 1.5 kg
- Mounting: Connection bracket to connect to bicycle frame (Details will be provided)

- Control functions:
  1) An on-off signal switch to enable and disable the drive
  2) A 0 to 5V throttle input that regulates the motor torque
- Battery: Lead-acid battery. (Detailed battery specifications will be provided)
- Protection:

  Over current, under-voltage over voltage, short circuit and thermal. (Detailed protection settings will be provided)
- Safety:

  No live electrical elements are to be exposed when the unit is fully configured. The system is intended for safe, routine use by non-technical customers.
- Thermal consideration: Case should be touch-safe for prolonged operation (<48°C)
- Cooling: Natural convection.
- Cost: The final technical report should include the description of the basic principles, design of the system, simulation results, experimental results and cost study for mass production of 1000 units, using the price information on http://www.digikey.com/.
- Test conditions: Hardware test conditions including drive cycle testing will be published in due-course.

Final Competition Prototype Testing

The detailed test protocol will be presented to the teams prior to the competition. The final test will be carried out at the University of Wisconsin-Madison, USA.

Team Composition

For each team, the minimum undergraduate student number is **three** to qualify for the competition. Graduate students can only participate as graduate advisors. Up to **two** graduate students are allowed per team.

Financial Support

Each team will receive travel support of $1000 for distance less than 5000 km and $2000 for distance of 5000 km and above.

ATTACHMENT I

2019 INTERNATIONAL FUTURE ENERGY CHALLENGE
PRELIMINARY TEAM INFORMATION FORM

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.]

To:

Giri Venkataramanan
Professor
Department of Electrical and Computer Engineering
University of Wisconsin-Madison
Madison, WI, 53711, USA
Ph: 608-262-4479
Fx: 608-62-5559
E-mail: giri@engr.wisc.edu

Dear International Future Energy Challenge Coordinator,

Our university has organized a student team to participate in the 2019 International Future Energy Challenge. Our proposal 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 December 21, 2018. 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 his/her regular duties.

- A graduate advisor 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 2018 International Future Energy Challenge.

Sincerely,

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