Request for Proposals (RFP)

The 2018 International Future Energy Challenge (IFEC'18)

A student competition sponsored by the

The Institute of Electrical and Electronics Engineers (IEEE)

May 26th, 2017

Summary of Competition and Proposal Requirements

General Information

Competition Title: 2018 International Future Energy Challenge (IFEC) Student Competition

Topic: ***High Efficiency and High Power Density Isolated Bidirectional Dc-dc Converter for Residential Energy Storage Systems***

Period of Competition: July 18th, 2017 to July 18th, 2018

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 in each topic area 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 2018 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. The panel will select a group of teams as Finalists based on the qualifying reports. These teams are invited to present their progress to the panel at IEEE APEC conference on March 4-8, 2018, in San Antonio, Texas, USA. Feedback will be given to the team to improve the system. The team will be invited to a competition event in July of 2018. 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 2017 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 2018 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 **Nov 15, 2017** for full consideration.

Proposal Submission

The electronic copy of the proposal in PDF format must be sent to IFEC2018@tsinghua.edu.cn by e-mail, with a copy to the chairs of IFEC'18 below:

General Chair:

Zhengming Zhao, Professor
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Information

The volunteer Organizing Committee for the 2017International 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

Oct.01-05, 2017	IFEC'18 Information Session at ECCE2017
Nov. 15, 2017	Proposals Due
Dec. 15, 2017	Schools informed of acceptance into the competition
Feb. 28, 2018	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.04-08, 2018	Workshop at APEC 2018, San Antonio, TX, USA. All accepted qualified teams must give an oral presentation.
Mar.20, 2018	Finalists notified (Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all the challenge objectives).
Jun.30, 2018	Final reports due (Final reports are limited to 50 single-column pages total, including all diagrams, attachments, and appendixes)
Jul. 16-17, 2018	Final competition

2018 International Future Energy Challenge
Organizing Committee

General Chair: Prof. Zhengming Zhao, *Tsinghua University*

General Co-chairs: Prof. Kai Sun, *Tsinghua University*

Prof. Qiang Li, *Virginia Tech*

Webmaster: Prof. Jin Wang, *The Ohio State Univ.*

IEEE Inter-Society Associate: Donna Florek, *IEEE*

Treasurer: Prof. Yaow-Ming Chen, *National Taiwan Univ.*

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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 will be held on July 24-25 at Virginia Tech, USA.

The detailed technical specification of the 2018 competition is listed in the following page.

Competition Topic

High Efficiency and High Power Density Isolated Bidirectional Dc-dc Converter for Residential Energy Storage Systems

Background

During past decades, distributed generation by renewable energy is one of the most significant growing component of the electric grids around the world due to its low pollutant emission, high energy utilization efficiency and long term energy security. Most renewable energy sources are location-dependent and feature intermittency, such wind energy and solar energy. Hence, energy storage systems are inevitably operated with the distributed renewable generation systems. This could smooth the power generation of renewable sources, which enables the utility grid to accommodate more renewable power without increasing the system stability risks. Thanks to the new developments of battery technologies, the cost of energy storage systems decreases gradually, which brings more commercial opportunities for residential energy storage systems. The residence could gain economic returns by installing and operating the renewable generation and energy storage systems at their houses.

Residential energy storage systems consist of batteries, battery manage system (BMS) and power conversion system (PCS). PCS interfaces the batteries and the utility grid, and typically comprises dc-dc converters and dc-ac converters. Isolated bidirectional dc-dc converters are employed to step up the lower voltage level at battery side to the higher voltage level at dc bus side and implement bidirectional power flow for charging and discharging. As well, the dc bus is connected with the ac utility grid through the bidirectional dc-ac converters. In order to promote the economic values of residential energy storage systems, the isolated bidirectional dc-dc converters are required to have higher efficiency, higher power density and lower cost.

This main objective of this competition is to develop a high efficiency and high power density isolated bidirectional dc-dc converter for residential energy storage systems. It should be able to charge and discharge the batteries with good steady-state and dynamic performances. The students are encouraged to propose and implement new and cost-effective solutions for these dc-

dc converters by developing new circuit topologies, using power devices properly and optimizing magnet design.

Detailed Specifications and Requirements

- Low voltage side (for battery) V_{low}: 35~50 Vdc
- High voltage side (for dc bus) V_{high}: 400 Vdc
- Output power P_{out}: 1000W
- Current ripple at low voltage side during battery charging <3% @100% load
- Voltage ripple at high voltage side during battery discharging <2% @100% load
- Efficiency requirements:

  higher than 96% at 100% load (both charging and discharging modes)

  higher than 94% at 50% load (both charging and discharging modes)

  higher than 92% at 25% load (both charging and discharging modes)
- Power density: >1.5 W/cm^3

  (Note: The converter can be built with open frame. The volume will be calculated as Volume=Length*Width*Height.)
- Weight: less than 1.5 kg
- Operation modes:

  The isolated bidirectional dc-dc converter is intended for use as an interfacing converter between battery and high voltage dc bus in the residential energy storage systems, which can achieve smooth transition between charging and discharging modes.
- Control functions:

  1) Charging mode: a Programmable dc Power Source will be provided at the high voltage side to feed the dc-dc converter and four series-connected 12 V 40 Ah batteries will be provided at the low voltage side as loads; The dc-dc converter is required to operate at constant-power charging mode for batteries, and if the batteries are fully charged the dc-dc converter should shift to constant-voltage charging mode to protect the batteries.

  2) Discharging mode: four series-connected 12 V 40 Ah batteries will be provided at the

low voltage mode as power sources and resistors will be provided at the high voltage side as loads; The dc bus voltage (400 V) should be regulated by the dc-dc converter.

3) Switching between charging mode and discharging mode: two buttons should be equiped with the dc-dc converter, in which one is used to control the connection switch between the converter and the Programmable dc Power Source and the other one is used to control the connection switch between the converter and the resistor load; During the charging/discharging mode switching test, the dc-dc converter should be disconnected with the Programmable dc Power Source first and then connected to the resistor load by clicking the button manually; The reverse test (discharging to charging) should have the similar manual operation procedure.

- Power supplies:

Besides four 12 V 40 Ah batteries and the Programmable dc Power Source, no auxiliary power supplies will be provided.

- Battery:

The battery type (lithium-ion battery or lead-acid battery) used in the final test will be announced before the final competition.

- User interface:

Each design should include a clear user interface, which provides status monitoring and programming capability to support "battery-friendly" operation. The following interface settings are required:

Modes: "Battery mode" or "Power supply mode" or "Test mode"

1) In "Battery mode", settings must include

Maximum voltage (within the allowed range) in charging mode and in discharging mode

Minimum voltage (within the allowed range) in discharging mode and in charging mode

Current or power limit (consistent with 0-1 kW) in charging mode

Current or power limit (consistent with 0-1 kW) in discharging mode

If the operation outside voltage limit is attempted, the current should be 0

Current or power limit always enforced

2) In "Power supply mode", the converter shall be constrained to unidirectional operation. The output voltage is considered to be set externally. Current or power limit settings are required.

3) In "Test mode", the converter will enforce voltage and current or power limits into a resistive load on either side, or will enforce bidirectional limits given a fixed externally connected voltage.

During the operation in any mode, the voltage, current and power of the converter are required to be displayed on the interface in real time.

- Protection:

  Over current, over voltage, short circuit and open circuit. The system should shut down if the high voltage side current exceeds 5A (instantaneous value). No damage caused by output short circuit and open circuit.

- 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. After the dc-dc converter shut down, the dc bus voltage should decrease to be less than 60 V within 5 seconds.

- Thermal consideration: The operating temperature range -20 to 50 °C.
- Cooling: Natural convection is encouraged. The fan for cooling is used or not will be determined by the teams, but it will be considered in the power density measurement.
- Acoustic noise: No louder than conventional domestic refrigerator. Less than 50 dBA, measured 1.5 m from the unit.
- 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/.

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 Tsinghua University, Beijing, China.

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

2018 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:

Kai Sun, Associate Professor
Department of Electrical Engineering
Tsinghua University
2-305, West Main Building
Beijing, 100084, China
Tel: 86-10-62796934, Fax: 86-10-62783057
Email: sun-kai@mail.tsinghua.edu.cn

Dear International Future Energy Challenge Coordinator,

Our university has organized a student team to participate in the 2018 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 15, 2017. 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)