Request for Proposals (RFP)

(Updated on Jun 7, 2021)

The 2022 International Future Energy Challenge (IFEC2022)

http://energychallenge.weebly.com/ifec-2022.html

A student competition sponsored by the
The Institute of Electrical and Electronics Engineers (IEEE)
March, 2022
University of Tennessee, Knoxville, USA

IFEC2022 Organizing Committee and Time Schedule

Organizing Committee

General Chair:
Kevin Bai, University of Tennessee

General Co-chair:
Daniel Costinett, University of Tennessee

Publicity Chairs:
Helen Cui, University of Tennessee

Finance Chair:
Ching-Jan Chen, National Taiwan University

Steering Committee

Steering Committee Chair:
Giri Venkataramanan, University of Wisconsin-Madison

Time Schedule

Oct. 30, 2020	**Final Rules Announcement**
Oct. 31, 2021	**Proposals Due (with letter of support)**
Nov. 30, 2021	**Schools informed of acceptance into the competition**
Mar. 20, 2022	**Workshop at ECCE 2022 (accepted teams present their results).**
Mar. 27, 2022	**Notification of final teams**
July (TBD), 2022	**Final competition**

IFEC Introduction

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, reduce the cost of dc-ac inverters, and interface systems for use in distributed generation systems. The objectives were to design elegant, manufactural 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.

To continue and expand the success of 2001 and other 11 IFECs along the years, the 2022 International Future Energy Challenge (IFEC) will be organized with the topic of "Smart, Efficient and Light Solar Microgrid Inverter". In the 2022IFEC, the students will be asked to design the solar inverter, where providing the grid service becomes crucial.

Awards and Financial Support

There will be a Grand Prize of $10,000 and three additional awards granted at $5,000, $3000 and $1,000 each. The detailed technical specification of the 2022 competition is listed in the following page. A travel support of $1000 for teams with a distance less than 5000 km and $2000 for distance of 5000 km and above will be provided, which is applicable for the final competition.

IFEC2022 Topic: Smart, Efficient and Light Solar Microgrid Inverter

Background of the Topic

The past decade has witnessed a surge in the use of solar inverter in power grid and microgrid applications. In the past 40 years, solar energy has grown from a niche technology powering satellites in space to a technology that powers homes and businesses in every state. According to the U.S. Energy Information Administration (EIA), solar supplied nearly 2.5% of U.S. electricity demand in the first 11 months of 2018. In some states, solar represented up to 15% of total annual electricity generation. There are nearly 2 million solar installations in increasingly diverse climates, policy environments, and commercial markets across the country. Some of America's biggest companies, including Walmart, Apple, Target, and Amazon, lead corporate adoption of solar and help mobilize demand for solar in new regions.

Integrating renewable and distributed energy resources, such as photovoltaics (PV) and energy storage devices, into the electric distribution system requires advanced power electronics, or smart inverters, that provide grid services such as voltage and frequency regulation, ride-through, dynamic current injection, and anti-islanding functionality. The U.S Department of Energy has been sponsoring all major research institutes and grid companies to push the solar inverter and related technology to reach marketability for years. Since 2010, solar costs have declined 70% to 80%, making solar one of the most economical ways to add new electricity generation to the grid. It is estimated that solar will grow to account for 5% of U.S. electricity by 2030.

The main goal of this topic is to develop high efficiency high power density smart solar inverter for microgrid applications. Currently, grid-tied solar inverter topology has been widely used in residential roof, ranging 3~10kW [1]. However, the solar inverters still have great potential to provide the grid services, such as providing frequency regulation by managing active power generation, exchanging reactive power between the solar inverter and the electric grid in order to improve the reliability and resilience of the grid, reduce the cost of energy, and ease the planning and maintenance of the grid.

Another cost reduction driver is the installation cost. U.S. residential and commercial PV systems are 89% and 91% toward achieving 2020 electricity price targets. With further efficiency increment, the system loss related heatsink weight and size can be further reduced, which yields in lower installation cost. This high efficiency and high power density can be achieved through innovations in new circuit topologies, optimizations of circuit parameters, optimization of the passive components, and possible implementations of highly efficient wide-bandgap (WBG) devices. WBG devices, such as Silicon Carbide (SiC) Metal Oxide Field Effect Transistors (MOSFET) and Gallium Nitride (GaN) High-Electron-Mobility Transistor (HEMT), are expected to have lower on-resistance, lower switching loss and higher junction temperature than their Silicon (Si) based counterparts. The lower power loss and higher junction temperature can bring in the size and cost reduction in the cooling system, whereas the higher switching frequency can result in smaller passive components. At this time, SiC MOSFETs and GaN HFET from various vendors are already available in the market. For this topic competition, all the teams are encouraged to use active WBG devices in their circuits.

[1] NREL, U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018

Specification of The Solar Microinverter

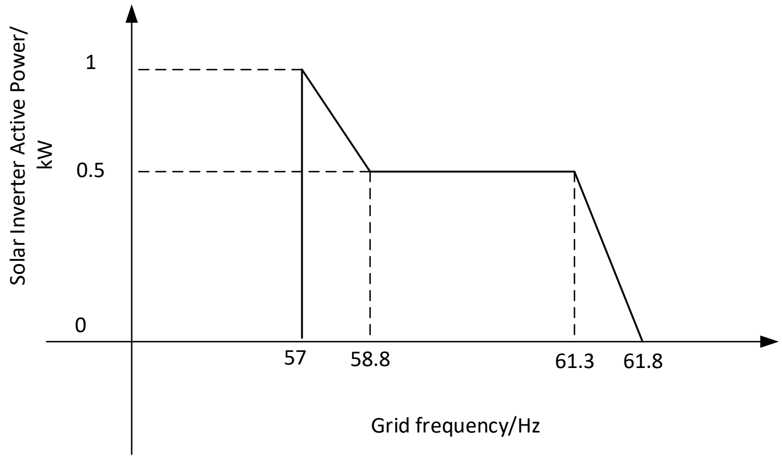
The proposed inverter will be judged against a set of objectives, requirements and characteristics given below.

- The design concept should target a 1kW (continuous) power generation system;
- The inverter should be able to receive a 48V PV input, with the voltage range of 36~60VDC;
- Modular or scalable circuit topologies are highly encouraged;
- Galvanic isolation is required between input and output;
- Utilizations of WBG devices are encouraged, however not a must;
- System switching frequency is not limited. However, teams need to provide the evaluation of the switching frequency to EMI performance;
- The designed inverter should adapt to the universal output, i.e., single-phase 120~230VAC, and three-phase 208~260VAC. Meanwhile the grid frequency can vary between 40~65Hz;

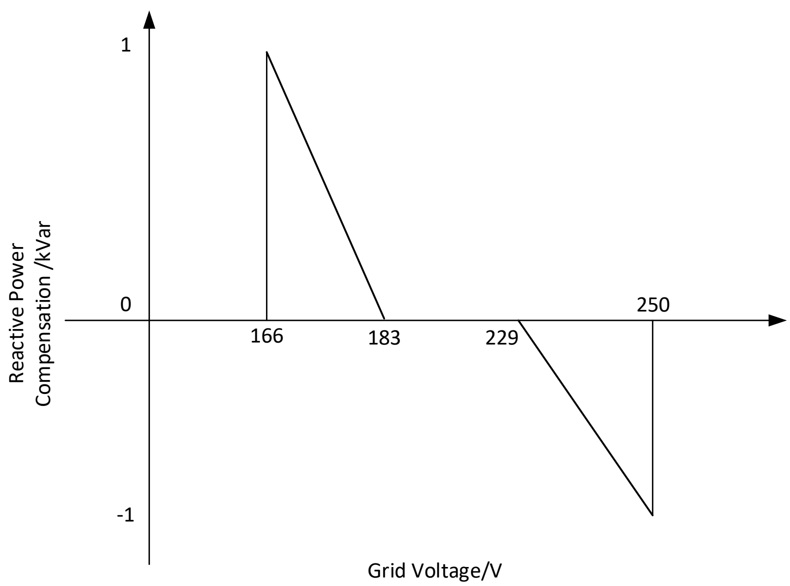
A programmable dc power supply and three-phase resistor load will be provided at the competition test site for debugging. In the final demo, a dc power supply to emulate the solar and hardware testbed (HTB) in CURENT acting as three-phase 208VAC 60 Hz source will be provided as the only power sources.

Specifically,

1. Manufacturing cost: for the 1kW design in high-volume production, cost needs be less than $200, which includes the heatsink, control and auxiliary circuits. A brief cost analysis in the report is required;
2. Input voltage: 36 V~60 VDC;
3. Input current: limited to 20ADC, with ripple less than 10%;
4. Output voltage range: single-phase 120~230VAC, and three-phase 208~260VAC. In the test facility, we will only test three-phase 208VAC (nominal);
5. Output power capability: able to power the grid with the maximum power of 1kW. We will compare the efficiency at the nominal input (48VDC);
6. Grid current total harmonic distortion (THD): less than 2% @1kW;
7. Grid power factor: >0.99 when only 1kW active power is demanded;
8. Overall solar-to-grid power efficiency: higher than 95% at 1kW and higher than 94% at 500W;
9. Active power delivery: when the grid frequency is within (58.8Hz~61.3Hz), the inverter needs generate 500W active power. When the frequency drops, the inverter needs output more power to support the grid, and vice versa. When testing the active power curve, we will provide nominal 3-Φ 208VAC;



10. Reactive power compensation: when the grid voltage is within the normal range (205V~210V), the inverter needs generate 0 reactive power. When the voltage drops, the inverter needs compensate the reactive power to support the grid, and vice versa. When testing the reactive power curve, we will provide nominal 3-Φ AC grid, without requiring the inverter to provide active power.



11. Ambient temperature: the inverter will be tested at room temperature;
12. Cooling: natural or forced air convection. The fan size and heatsink will be included in the final prototype;
13. Lifetime: the system is expected to function for at least ten years with routine maintenance when subjected to normal use in a 0~40^{o}C ambient environment. A brief analysis of lifetime in the report is required;
14. Protections: the inverter needs to install some basic protections, such as over voltage, over current, over temperature protections. When fault happens, the inverter needs trigger the protection and gets off the grid.
15. Power density: while no power density is required, team with highest power density (kW/L and kW/kg) will win the competition, presumingly all items of 1~13 are accomplished.

Competition and Proposal Requirements

Competition Title
The 2022 International Future Energy Challenge (IFEC2022) Student Competition

Topic
Smart, Efficient and Light Solar Microgrid Inverter

Period of Competition
Nov, 2020 to March, 2022

Challenge Program Awards
A Grand Prize of $10,000 and three additional awards granted at $5,000, $3000 and $1,000 each.

Prize Requirements
US$10,000 will be awarded as Grand Prize for the 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 according to the highest scores in other aspects/categories, e.g., Best Hardware Design and Best Technical Report.

Intellectual Property and Use of Prize Money
The International Future Energy Challenge (IFEC) 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 2022 will include public disclosure of each team's technology. Teams interested in securing protection for their inventions should be aware of this date when planning.

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

External 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 campus is limited to support only one team**.
  To confirm eligibility, potential participating schools must submit a **Letter of Intention** (Attachment I) by October 31, 2021, to kevinbai@utk.edu and submit a **Letter of Support** (Attachment II) with the project proposal by October 31, 2021, to kevinbai@utk.edu.

- 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.

How to Participate

Participation is on a proposal basis. Interested universities 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 one month 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. All teams are invited to present their progress during the workshop in APEC, 2022. Afterwards, feedback will be given to the team. Up to 10 project teams will be invited to the final competition at Knoxville in July 2022. 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

Judging score schemes will be set up mainly based on grid services (active power delivery, and reactive power compensation), system efficiency and power density. Adoption of wide bandgap devices in innovative circuit topologies to achieve higher efficiency and size reduction is highly encouraged.

Proposals

Proposals will be judged on the quality of plans, the likelihood that a team will be successful in meeting the IFEC2022 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 two 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 the IFEC2022 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.

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 2022 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.

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 October 31, 2021 for full consideration.
Proposal Submission	The electronic copy of the proposal in PDF format must be sent to kevinbai@utk.edu by e-mail, with a copy to the IFEC2022 chairs. General Chair: Kevin Bai Department of Electrical Engineering and Computer Science University of Tennessee Knoxville, TN, USA 37996 Email: kevinbai@utk.edu General Co-Chair: Daniel Costinett Department of Electrical Engineering and Computer Science University of Tennessee Knoxville, TN, USA 37996 Email: daniel.costinett@utk.edu
Information	The Organizing Committee of IFEC2022 maintains the website at http://energychallenge.weebly.com/. The site will include the most recent schedule and rule updates, frequency-asked questions, details about judging and scoring, and other teams' information. It should be checked regularly.
Contact email	kevinbai@utk.edu

ATTACHMENT I

2022 INTERNATIONAL FUTURE ENERGY CHALLENGE
LETTER OF INTENTION

To be submitted by 31 December 2021

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

To be submitted by Oct.31 2021

[The letter below is an example, which should not be simply copied. Please send a letter with similar content on your university letterhead.]

Kevin Bai, Associate Professor
Department of Electrical Engineering and Computer Science
University of Tennessee
Knoxville, TN, USA 37996

Dear IFEC2022 General Chair,

Our university has organized a student team to participate in the 2022 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 November 30, 2021. 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 2022 International Future Energy Challenge.

Sincerely,

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