

# IEEE International Future Energy – A Bit of History

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# What is IFEC?

- The International Future Energy Challenge (IFEC) is 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 world wide.
- In general, the competition addresses two broad topic areas:
  - Motor and Motor Drives.
  - Power Electronics.

# History

- 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.
- This competition was originally open to schools in North America with accredited engineering programs.

# IFEC: Vision

- To Incorporate practicability, potential manufacturability, and affordability into the competition assessment process.
- To 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.

# IFEC Previous Editions

- **FEC'01**
- **IFEC'03**
- **IFEC'05**
- **IFEC'07**
- **IFEC'09**

# FEC 2001

- One Topic:
  - Low-Cost inverter.
  
- Development Period: 11 months
  - From: September 2000.
  - To: August 2001.

# FEC 2001 Chair

- General Chair:
  - Prof. Jason Lai.
  - Virginia Polytechnic Institute.

# FEC'01 – Topic Specs

## ■ Low-Cost Inverter

- 10 kW continuous, 20 kW for 1 minute.
- Single-phase 120V/240V, 60 Hz output suitable for domestic applications.
- 48 Vdc Input Supply (tolerance range 42 V to 72 V).
- Not less than 90% Overall energy efficiency for 10 kW resistive load.
- THD: Less than 5%.
- Low Cost – no more than US\$500 when scaled to a 10 kW design in high-volume production.



# FEC'01 – Participating Schools

- Colorado School of Mines
- Drexel University
- Gonzaga University
- Texas A&M University
- University of Central Florida
- University of Illinois – Urbana
- University of Minnesota
- University of Nevada -- Las Vegas
- University of South Carolina
- University of Tennessee – Knoxville
- University of Texas -- El Paso
- University of Wisconsin – Madison
- Virginia Polytechnic Institute
- West Virginia University

# FEC'01 – Final Event and Winner

- Date: August 6, 2001.
- Place: National Energy Technology Laboratory - Morgantown, WV / USA.
- First Prize: ***Texas A&M University.***

# FEC'01: Photo Gallery



# IFEC 2003

- TwoTopics:
  - Topic A: Fuel cell energy conversion.
  - Topic B: Single-phase adjustable-speed motor.
  
- Period for development: 11 months.
  - From: August, 2002.
  - To: July, 2003.

# IFEC 2003 Chairs

- General Chair:
  - Prof. Jo Howze.
  - Texas A&M University.
- Vice-Chair:
  - Prof. Fang Peng.
  - Michigan State University.

# IFEC'03 – Topic A Specs

## ■ Fuel cell Energy Conversion

- Output voltage 120 V/240 V (60Hz) nominal (split-phase).
- Output power capability – nominal 5 kW continuous.
- Output power capability – Overload 10 kW overload for 1 minute.
- Input Source: 22-41 Vdc, 29 Vdc nominal, 275 A max. from fuel cell.
- Protection: Over current, over voltage, short circuit, over temperature, and under voltage. No damage caused by output short circuit.
- Low Cost: Less than US\$40/kW for the 10 kW design in high-volume production.

# IFEC'03 – Topic B Specs

## ■ **Single-Phase Adjustable Speed Motor Drive.**

- Output power capability and speed range: 500 W at 1500 RPM up to 5000 RPM.
- At least 3.18 N-m at speeds from 150 RPM to 1500 RPM.
- 120/240V (50-60Hz) Input Supply.
- 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.
- Low Cost: Manufacturing cost no more than US\$40 when scaled to high-volume production (approximately 1 million units/year).

# IFEC'03 – Topic A Participating Schools

- Seoul National University of Technology
- Texas A&M University
- Virginia Polytechnic Institute and State University
- West Virginia University
- University of Wisconsin
- University of Akron
- Colorado School of Mines
- Drexel University
- Michigan State University



# IFEC'03 – Topic B Participating Schools

- Illinois Institute of Technology
- University of Illinois
- University of South Carolina
- University of Wisconsin
- Bangladesh University of Engineering and Technology

# IFEC'03 –Final Events and Winners

## Topic A:

- Date: May 19 – 22, 2003.
- Place: NETL – National Energy Technology Laboratory Morgantown, WV, USA.
- FirstPrize: ***Seoul National University of Technology.***

## Topic B:

- Data: May 21 – 24, 2003.
- Local:NETL – National Energy Technology Laboratory Morgantown, WV, USA
- FirstPrize: ***Illinois Institute of Technology***

# IFEC'03 – Photo Gallery



# IFEC 2005

- Two topics:
  - Topic A: Single-Phase Adjustable Speed Motor Drive
  - Topic B: Utility Interactive Inverter System for Small Distributed Generation
  
- Period for development: 15 months
  - From: May, 2004
  - To: August, 2005

# IFEC 2005 Chairs

- General Chair:
  - Prof. Steven D. Pekarek
  - University of Missouri-Rolla
- Topic A Coordinator:
  - Prof. Ali Emadi,
  - Illinois Institute of Technology.
- Topic B Coordinator:
  - Prof. Marcelo G. Simoes
  - Colorado School of Mines

# IFEC'05 – Topic A Specs

## ■ **Single-Phase Adjustable Speed Motor Drive**

- Output power capability and speed range: 500 W at 1500 RPM up to 5000 RPM.
- At least 3.18 N-m at speeds from 150 RPM to 1500 RPM.
- 120/240V (50-60Hz) Input Supply
- 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.
- Low Cost: Manufacturing cost no more than US\$40 when scaled to high-volume production (approximately 1 million units/year).

# IFEC'05 – Topic B Specs

## ■ **Utility Interactive Inverter System for Small Distributed Generation.**

- Automatic grid parallel operation.
- Output Power: 1kW.
- Output Voltages: 110 V +15% -20%, at 60 Hz  $\pm$  2% and 240 V +15% -20%, at 50 Hz  $\pm$  2%.
- Low Cost: Manufacturing cost less than US\$200/kW when scaled to high-volume production (approximately 100,000 units/year).
- The unit must disconnect automatically from the utility grid and keep a stand-alone emergency load (maximum 250 W).

# IFEC'05 – Topic A Participating Schools

- University of Akron, USA
- University of Belgrade, Serbia
- University of Illinois at Urbana-Champaign, USA
- University of South Carolina, USA



# IFEC'05 – Topic B Participating Schools

- Bangladesh University of Engineering & Technology, Bangladesh
- Federal University of Mato Grosso do Sul, Brazil
- Federal University of Rio Grande do Norte – UFRN, Brazil
- Institute for Power Electronics and Electrical Drives of the RWTH (Aachen) and Institute for Automation of the University of Applied Sciences Cologne (FH Köln), Germany
- Krishna Institute of Engineering & Technology, India
- Memorial University of Newfoundland, Canada
- Michigan State University, USA
- Monash University, Australia
- Nanjing University of Aeronautics and Astronautics, China
- Seoul National University of Technology, South Korea
- State University of Campinas, Brazil
- Texas A&M University, USA
- University of Central Florida, USA
- University of Illinois at Chicago, USA
- University of Wisconsin-Madison, USA

# IFEC'05 – Final Events and Winners

## Topic A:

- Date: August 15 – 19, 2005
- Place: MPC Products Corporation, Chicago, IL, USA
- FirstPrize: ***University of Belgrade, Serbia***

## Topic B:

- Date: August 15 – 19, 2005
- Place: NREL – National Renewable Energy Laboratory, Golden, CO, USA
- FirstPrize: ***Monash University, Australia***

# IFEC'05 – Photo Gallery



# IFEC 2007

- Two Topics:
  - Topic A: Universal Adapting Battery Charger
  - Topic B: Integrated Starter/Alternator - Motor Drive for Automotive Applications
  
- Period for development: 14 months
  - From: June, 2006
  - To: August, 2007

# IFEC 2007 Chairs

- General Chair:
  - Prof. Ali Emadi,
  - Illinois Institute of Technology.
- Topic A Coordinator:
  - Prof. Philip Krein
  - University of Illinois at Urbana-Champaign
- Topic B Coordinator:
  - Prof. Babak Fahimi
  - University of Texas at Arlington

# IFEC'07 – Topic A Specs

## ■ **Universal Adapting Battery Charger**

- Input Source: 48 Hz to 440 Hz and 95 V to 270 V RMS.
- Output Voltage: 2 to 28Vdc.
- Charging currents up to 1 A must be possible at all voltages.
- Adaptive Operation: Device must adapt (automatic) and successfully charge any of the following battery combinations without external settings, switches, or other user intervention.
  - Lead-acid cells (up to nine cells); Nickel-cadmium cells (two to fifteen cells); Nickel-metal-hydride cells (two to fifteen cells); Lithium-ion cells, (up to five cells)

# IFEC'07 – Topic B Specs

## ■ **An Integrated Starter Alternator (ISA) system.**

- Provides 30 Nm for Startup Torque
- Speed Should be Controllable (Motor mode only)
- 200 Vdc Input Supply
- Generates 1 kW of Power at 3000 rpm
- Not exceed NEMA Frame 56
- Not less than 75% overall efficiency at 3000 rpm
- Safe enough to be used in automobile applications
- Low Cost – Less than \$100 per unit (1 million per year)

# IFEC'07 – Topic A Participating Schools

- Bangladesh University of Engineering and Technology, Bangladesh
- Federal University of Mato Grosso do Sul, Brazil
- HuaZhong University of Science and Technology, China
- Institute for Power Electronics and Electrical Drives of the RWTH Aachen, Germany, and Institute for Automation of the University of Applied Sciences Cologne (FH Köln), Germany
- Monash University, Australia
- Seoul National University of Technology, Korea
- Texas A&M University, USA
- University of Central Florida, USA
- University of Peradeniya, Sri Lanka
- University of Texas-Arlington, USA
- University of Wisconsin-Madison, USA
- Virginia Tech, USA



# IFEC'07 – Topic B Participating Schools

- Consortia of the University of Colorado at Boulder Electrical and Computer Engineering Department, USA, and the Indian Institute of Technology at Delhi Electrical Engineering (Power), India
- Sharif University of Technology, Iran
- University of Padova, Italy
- University of South Carolina, USA, and University of Nebraska at Lincoln, USA

# IFEC'07 – Final Events and Winners

## Topic A:

- Date: August 20 – 22, 2007
- Place: TI - Texas Instruments , Dallas, TX, USA
- First Prize: ***Federal University of Mato Grosso do Sul, Brazil***

## Topic B:

- Date: August 20 – 22, 2007
- Place: MPC Products Corporation, Chicago, IL, USA
- First Prize: ***University of Colorado at Boulder, USA, and Indian Institute of Technology at Delhi, India***

# IFEC'07 – Photo Gallery



# IFEC 2009

- Two Topics:
  - Topic A: Integrated Starter/Alternator-Motor Drive for Automotive Applications
  - Topic B: Low Power Wind Turbine Energy Maximizer
  
- Period for development: 14 months
  - From: May, 2008
  - To: July, 2009

# IFEC 2009 Chairs

- General Chair:
  - Prof. Babak Fahimi
  - The University of Texas at Arlington
- Topic A Coordinator:
  - Prof. Antonello Monti
  - University of South Carolina
- Topic B Coordinator :
  - Prof. Grahame Holmes
  - Monash University

# IFEC'09 – Topic A Specs

## ■ **An Integrated Starter Alternator (ISA) system.**

- Provides 30 Nm for Startup Torque
- Speed Should be Controllable (Motor mode only)
- 200 Vdc Input Supply
- Generates 1 kW of Power at 3000 rpm
- Not exceed NEMA Frame 56
- Not less than 75% overall efficiency at 3000 rpm
- Safe enough to be used in automobile applications
- Low Cost – Less than \$100 per unit (1 million per year)

# IFEC'09 – Topic B Specs

## ■ **Low Power WindTurbine Energy Maximizer**

- Output power capability 300W of for a 12V battery continuously.
- 900W of energy into a 12V battery for 60 seconds.
- Mass less than 3 kg.
- Less than 2 dm<sup>3</sup> (2 liters) maximum volume shape
- Not Less than 90% overall efficiency for power level varying from 5% to 100%
- Low Cost: Manufacturing cost less than US\$20 at high-volume production (approximately 100000 units/year)

# IFEC'09 – Topic A Participating Schools

- Consortia of the University of Colorado at Boulder (USA) and University of Tokushima, Japan
- Federal University of Mato Grosso do Sul, Brazil.
- United International University, Bangladesh



# IFEC'09 – Topic B Participating Schools

- University of Wisconsin at Milwaukee, USA.
- Cologne University of Applied Sciences, Germany.
- University of Central Florida, USA.
- Federal University of Ceará, Brazil.
- Consortia of Bangladesh University of Engineering and Technology and East West University, Bangladesh.
- University of Texas at Arlington, USA.
- Istanbul Technical University, Turkey.
- Universitaet Karlsruhe, Germany.
- HuaZhong University of Science and Technology, China.
- Northern Caribbean University, Jamaica.
- University of Macau, China.

# IFEC'09 – Topic Final Events and Winners

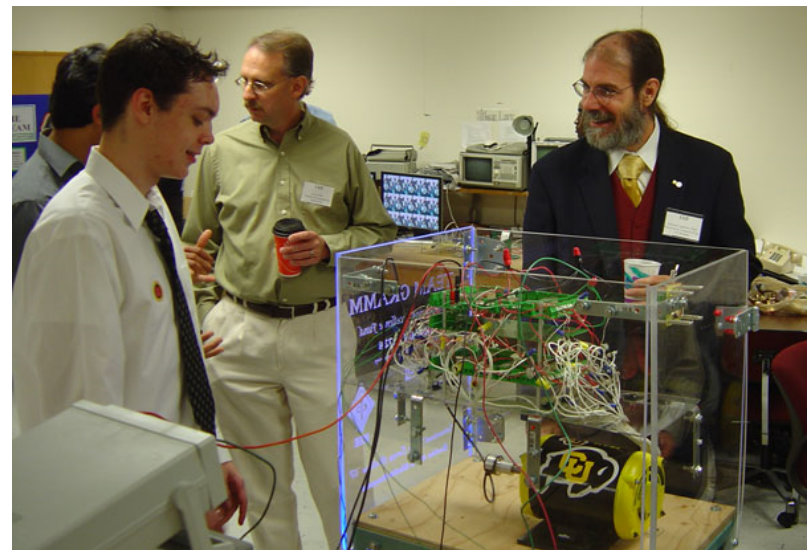
## Topic A:

- Date: July 20 – 22, 2009
- Place: IIT – Illinois Institute of Technology , Chicago, IL, USA
- FirstPrize: ***Federal University of Mato Grosso do Sul, Brazil***

## Topic B:

- Date: August 15 – 17, 2009
- Place: Monash University, Australia
- FirstPrize: ***University of Central Florida, USA***

# IFEC'09 – Photo Gallery



# IFEC 2011

# IFEC 2011

- Two Topics:
  - Topic A: Low Cost Lithium-Ion Battery Charger for Automotive and Renewable Energy Applications
  - Topic B: Low Power Induction Motor Drive System Supplied From a Single Photovoltaic Panel For an Emergency Water Treatment Device
  
- Period for development: 16 months
  - From: April, 2010
  - To: July, 2011

# IFEC 2011 Chairs

- General Chair:
  - Prof. João Onofre Pereira Pinto
  - Federal University of Mato Grosso do Sul - Brazil
- Topic A Coordinator :
  - Prof. Prof. Chunting (Chris) Mi
  - University of Michigan-Dearborn - USA
- Topic B Coordinator :
  - Prof. Maurício Beltrão de Rossiter Corrêa
  - Federal University of Campina Grande - Brazil

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