



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING

# Senior Design Newsletter

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## IEEE Senior Design Team wins 1<sup>st</sup> Place !

The Spring 2011 Smart Grid team won First Place in the student poster competition at the IEEE Power & Energy Society General Meeting in Detroit the last week of July. Their project continues this semester and you will be able to see the model of it at our Expo in December. Here's their winning poster:

### Renewable, Sustainable and Transportable Micro-Source for Smart Grid Applications

*Design Team: Preston Finnie, Matthew Bixler, Justin Shipley, Ryan Ricano, Sebastian Hayas*  
*Faculty Mentors: Dr. Valentina Cecchi and Dr. Sukumar Kamalasadana*

Power, Energy and Intelligent Systems Laboratory (PEISL), Department Electrical and Computer Engineering

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#### Abstract

The scope of the project is to design, test, and construct a modular, transportable, renewable, sustainable micro-source that retains plug-and-play capabilities. The power source should possess hybrid production capabilities via the implementation of photovoltaic array and PEM-hydrogen fuel cell. In addition, the source should be capable of generating and conditioning power suitable for use in stand-alone as well as grid-tie applications. Complementary to these design requirements, the system should have a fully integrated protection scheme and control algorithm to ensure optimized safety and efficiency during operation

#### Design Requirements

- Fuel cell and photovoltaic panels should serve as the primary renewable sources.
- Modular, transportable, and plug-and-play capabilities.
- Condition, store, and deliver generated power.
- Function in grid-tie and stand-alone applications.
- Sustain 500 Watt load.
- Integrated protection and safety scheme.

#### Design Concept

#### Research Goals

The Micro-Source will serve as a test bed for research in the following areas:

- Achieving 100% sustainable power generation via implementation of Electrolyzer Cells for hydrogen production.
- Load following studies for the purpose of improving grid penetration of renewable generated power.
- Development of a feedback loop for PEM-hydrogen fuel cell source.
- Development of protocol for communicating Micro-Source status and power quality parameters to local substations to improve the usability of distributed generation systems.

#### System Schematic

#### Fuel Cell Polarization Curves

#### Fuel Cell DC/DC Converter

#### PV Array

#### PV Array DC/DC Converter

#### DC Bus Characteristics

#### Relevant Equations

*Proton Exchange Membrane Fuel Cell Equations*

$$I = I_0 \left[ \exp\left(\frac{\alpha n F}{RT} V\right) - 1 \right] - I_{FC} \quad \text{(Fuel Cell Current)}$$

$$V = \frac{RT}{\alpha n F} \ln \left( \frac{I + I_0}{I_0} \right) + V_{act} \quad \text{(Act. cell overpotential)}$$

$$V_{act} = \frac{RT}{\alpha n F} \ln \left( \frac{I + I_0}{I_0} \right) \quad \text{(activation overpotential)}$$

$$V_{ohm} = I R_{ohm} \quad \text{(ohmic overpotential)}$$

$$V = V_{act} + V_{ohm} + V_{conc} \quad \text{(total cell overpotential)}$$

$$V_{conc} = \frac{RT}{\alpha n F} \ln \left( \frac{I + I_0}{I_0} \right) \quad \text{(concentration overpotential)}$$

#### Microcontroller Signal Routing

#### Ethernet Signal Routing

#### System Components

**Power Generation**

- MES DEA™ 1kW PEM Hydrogen Fuel Cell
- Suntrack™ 1.6kW Photovoltaic Array

**DC Power Conditioning**

- Outback™ Power FLEXmax 60 MPPT Charge Controller
- Outback™ Power FLEXmax 80 Buck Charge Controller

**AC/DC Power Inversion**

- Outback™ Power GTTX2524 Grid Tie Inverter

**Power Storage**

- Trojan™ SCS150 12V Deep Cycle Lead Acid Batteries (Two In Series)

**Controls**

- Arduino™ Mega2560 Microcontroller
- Outback™ MATE System Display and Control
- Outback™ HUB10 Ethernet Switch
- Outback™ FLEXnet Battery Management

**Protection**

- DC Breakers (6A, 60A, 80A, 125A)
- AC Breaker (20A)
- Ground Fault Circuit Interrupt (GFCI) Outlet 120V/50Hz
- EBM Papst™ DC Brushless Fan
- Synkers™ LIS101 Hydrogen Gas Sensors
- Omega™ RTD Temp Sensors
- Amplifier™ Current Sensors

#### System Management and Control

**Prioritized Protocol**

- Monitor hydrogen gas accumulation within system enclosure.
- Control fans for ventilation purposes.
- Monitor system temperature at critical locations.
- Control fans for the purpose of temperature regulation.
- Monitor State-Of-Charge (SOC) of the battery bank.
- Extract maximum power and efficiency from each source.
- Management of "Source-Load-Lag" interval.
- Data acquisition for modeling and load following.
- Startup and Shutdown Procedure.

#### Work Completed

- Conceptual Design.
- Equipment Selection and Procurement.
- Communication Network Design.
- Control Architecture Design.
- Simulation Model Design.
- Initialized Prototype Testing.
- Design of System Enclosure.
- Design of Printed Circuit Boards for Sensor Network.

#### Future Plans

- Balance Simulation Models.
- Simulation Model for Batteries and Inverters.
- System Management and Control Code Implementation.
- Real Time Testing.
- Model Validation.
- Case Studies and Analysis.
- Implementation of Micro-Source Module.
- Implementation of Electrolyzer Cells.

#### Acknowledgments

The authors would like to thank Dr. Valentina Cecchi and Dr. Sukumar Kamalasadana for providing their expertise and resources in support of this project

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## **2011 Call for Fall Projects Complete**

We expect to have over 300 students of Civil, Computer, Electrical, Mechanical and Systems Engineering disciplines available for projects this fall and we have over 30 company sponsored projects for them to choose and over 30 departmental ones as well. While our deadline for Fall 2011 is over, it is never too early to begin working on Project Descriptions for Spring. We have many great examples on our website [www.srdesign.uncc.edu](http://www.srdesign.uncc.edu) for the projects in process. If you need help in drafting a Project Description, please feel free to contact Bill Heybruck or look on the website under Company Information (<http://srdesign.uncc.edu/company-information.html>).

*The deadline for Project Description documents is November 1<sup>st</sup>*

The Next newsletter will have a list of all the staffed projects.

## **2011 Schedule of Events**

Here is the schedule of events for the 2011-2012 school year. Be sure to put the Expos on your calendar. They promise to be the biggest yet.

September 9, 2011 Kickoff Breakfast for Invited Sponsors, Mentors and Students

September 30, October 7, Project Design Review dates for Spring 2011 projects.

October 27-28, November 3-4, Conceptual Design Review dates for Fall 2011 projects.

December 9, FALL EXPO, Student Activity Center Arena, 11AM- 2PM OPEN TO PUBLIC

January 27th, Spring Kickoff Breakfast for Invited Sponsors, Mentors and Students

February 23,24 Project Design Review dates for Fall 2011 projects

March 16,23 Conceptual Design Review dates for Spring 2012 projects.

May 4, 2012 SPRING EXPO, Student Activity Center Arena, 11AM-2PM OPEN TO PUBLIC

## **For more information or questions**

Visit: [www.srdesign.uncc.edu](http://www.srdesign.uncc.edu) or contact Bill Heybruck at 704-687-2934 or [wfheybru@uncc.edu](mailto:wfheybru@uncc.edu).

*Please REPLY with "REMOVE" if you do not want to receive future issues.*