Florida Energy Systems Consortium

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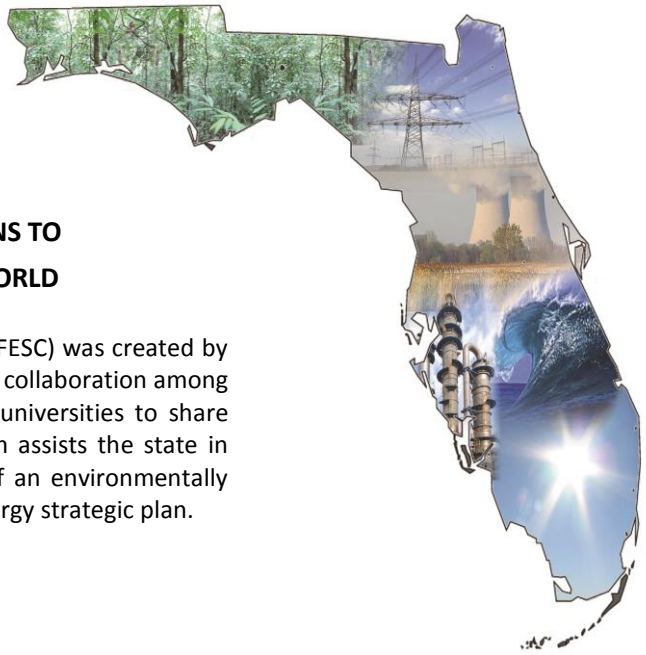

FESC BRINGING ENERGY SOLUTIONS TO FLORIDA, THE NATION AND THE WORLD

The Florida Energy Systems Consortium (FESC) was created by the Florida State government to promote collaboration among the energy experts at its 12 supported universities to share energy-related expertise. The consortium assists the state in the development and implementation of an environmentally compatible, sustainable, and efficient energy strategic plan.

Florida Energy Systems Consortium

AGENDA

MONDAY, MAY 12

7:00 - 8:00 am REGISTRATION
POSTER SET-UP for Session I
BREAKFAST

GENERAL SESSION: ***Century Ballroom A***
MODERATOR: JENNIFER CURTIS

8:00 - 8:10 am WELCOME
David Norton, Chair, FESC Oversight Board, VP Research, University of Florida

8:10 - 8:20 am WELCOME
Patrick Sheehan, Director, Florida Office of Energy

8:20 – 9:20 am SESSION I: BIOMASS AND SMART GRID PANEL SESSION
MODERATOR: CHRIS FOUNTAS, PARTNER, ARSENAL VENTURE PARTNERS, FESC ADVISORY BOARD MEMBER

Biomass: U.S. Biofuels - Technical, Economic, and Regulatory Status Update - Paul Bryan, Professor at UC Berkeley and former Program Manager for US-DOE Efficiency and Renewable Energy's Biomass Program

Smart Grid: Electric Energy Systems of the Future - Visions, Challenges, and Opportunities - Pramod P. Khargonekar, Head of Engineering Directorate, National Science Foundation

9:20 – 9:30 am BREAK

9:30 – 10:40 am SESSION I SHORT ORAL PRESENTATIONS (5 min each)

Track I: Biomass - *Century Ballroom B*
Chair: George Philippidis, Associate Professor, Sustainable Energy, USF

- *Potential for Oilseed Crops in the Southeast-David Wright, James Marois, Sheeja George, University of Florida - IFAS*
- *Pongamia - An Oilseed Tree Crop for Florida's Lost Citrus Acreage - David Harry, Claire Kinlaw, TomSchenk, Naveen Sikka, Terviva Inc.*
- *Evaluating eTuber and Energy beets as Feedstocks for Biofuels and Biogas in South Florida-Brian Boman, Edward Evans, Ann Wilkie, University of Florida- IFAS*
- *Commercial Production of Terpene Biofuels from Existing Slash Pine Plantations-Gary Peter, Jennifer Lauture, Alan Hodges, University of Florida- IFAS*
- *Environmentally and economically sustainable production of fuels and chemicals from sweet sorghum- Wilfred Vermerris, John Erickson, Lonnie Ingram, University of Florida- IFAS*
- *Engineering Bacillus Subtilis Biocatalysts for Production of Biofuels and Chemical Feedstocks and Biochemicals for Pharmaceutical and Nutraceutical Applications-James Preston, Mun Su Rhee, Lusha Wei, University of Florida- IFAS*

- *Biomass Treatment with Supercritical Fluids for high Throughput and Yield to Fuels- Aydin Sunol, Kyle Cogswell, Aaron Driscoll, and Zachary Cerniga University of South Florida*
- *Oxygen-blown Gasification for Efficient Conversion of Woody Biomass to Liquid Hydrocarbon Fuels- Ali T-Raissi, Florida Solar Energy Center*
- *Dual pretreatment Strategy for Enhanced Biomass Hydrolysis- John Telotte, Subramanian Ramakrishnan, Florida State University*
- *Floating Cultivation System for Low-cost Production of Algae- Dr. Ioannis Dogaris,* George Philippidis, Ph.D., Michael Welch, University of South Florida, Andreas Meiser, Ph.D., Lawrence Walmsley, Culture Fuels, Inc.
- *Dealing with Heterogeneity: The Central Problem with Using Agroindustrial Waste as a Feedstock for Heterotrophic Algae-Thomas Lyons, Eudes de Crecy, BioTork*
- *Landfill Gas to Liquid Fuel - Ryan Kent, Ali Gardezi, Dr. Babu Joseph, Dr. John Kuhn, University of South Florida*
- *An Experimental Evaluation and Thermochemical Modeling of High Temperature Steam Gasification of Municipal Solid Waste (MSW)-Uisung Lee, J.N. Chung, H.A. Ingley, University of Florida*

Track II: Smart Grid - *Century Ballroom C*

Chair: William S. Oates, Associate Professor, Mechanical Engineering, FSU

- *Power Quality Impact Study For Interconnection of Heterogeneous Distributed Energy Resources-Ali Hariri, Omar Faruque, FSU Center For Advanced Power Systems*
- *Recent Fuel Cell Research Activities at FSEC-Ali T-Raissi, Florida Solar Energy Center*
- *Ultra-Compact Portable Power: Direct Methanol Fuel Cell Open-Cathode System-Willaim Lear, Fenner Colson, Matt Inman, University of Florida*
- *Microstructure Effects on the Capacity, Power, and Energy Density of Metal-air Batteries for Large Grid Storage Applications- Petru Andrei, Vamsci Bevara, Florida State University*
- *Nanomaterials for Enhancing Electrochemical Energy Storage-Wolfgang Sigmund, Rui Qing, University of Florida*
- *The Effects of the Discharge Product on the Discharge Characteristics of Li-air Batteries- Vamsci V. Bevara, Petru Andrei, Florida State University*
- *Non-Destructive Testing and Quality Control Technologies. Ensuring High Quality, Safety and Reliability of New Generation Batteries-Volodymyr Redko, Elena Shembel, Enerize Corp.*
- *Power Quality Improvement of Electric Vehicle DC Charging Stations Utilizing UPQC and SFCL- M.H. Amini, Arif Sarwat, A.H. Moghadasi, M. Jamei, Florida International University*
- *Buildings as Batteries: Inexpensive Ancillary Service to the Grid from HVAC Systems- Yashen Lin, Prabir Barooah, Sean Meyn, University of Florida*
- *Hydrogen Energy Storage for On-Board Fuel Cells, Concentrated Solar Power and Secondary Batteries- Sesha Srinivasan, Tuskegee University, D. Yogi Goswami, Elias K. Stefanakos, Dervis Emre Demirocak, University of South Florida, Sarada Kuravi, Florida Institute of Technology, Ryan Integlia, Jorge Vargas, Florida Polytech University*
- *Development and Characterization of Novel Metal Chloride Thermal Storage Media with Enhanced Heat Transfer - Philip D. Myers, D. Yogi Goswami, Elias Stefanakos, University of South Florida*
- *Encapsulation of the Phase Change Materials and Its Application in Thermal Energy Storage System - Tanvir E Alam, Jaspreet Dhau, D. Y. Goswami , E. Stefanakos, University of South Florida*

10:40 – 11:40 am SESSION I POSTER REVIEW AND DISCUSSIONS

11:40 - 12:45 BUFFET LUNCH
REMOVAL OF SESSION I POSTERS and SET-UP of SESSION II POSTERS

12:45 - 1:45 pm SESSION II: SOLAR ENERGY AND ENERGY EFFICIENCY PANEL SESSION
MODERATOR: J.L. MARTINEZ, SR. DIRECTOR OFFICE OF CLEAN ENERGY, FPL, FESC ADVISORY BOARD MEMBER

***Solar Energy:* Solar Energy: What's Next? - Dr. Ryne Raffaelle, Vice President for Research and Associate Provost, Rochester Institute of Technology**

***Energy Efficiency:* DOE Building Technologies Office: Energy Efficiency R&D - Patrick Phelan, Supervisor, Building Technologies Program, US-DOE, Energy Efficiency and Renewable Energy**

1:45 - 2:00 BREAK

2:00 - 3:10 pm SESSION II ORAL PRESENTATIONS (5 min each)

Track I: Solar Energy - *Century Ballroom B*
Chair: D. Yogi Goswami, Distinguished University Professor, USF

- *Advances in Micro-inverter Technologies-Issa Batarseh, Ahmadreza Amirahmadi, Lin Chen, University of Central Florida*
- *Photomechanics of Liquid Crystal Polymer Networks-William Oates, Florida State University*
- *Distributed & Mobile Solar Electricity Generation with Energy Storage Devices and Application to PrePaid (PPD) Technology for the Latin America marketplace-Albert Rodriquez, ATI Energia LLC ATI Companies Group*
- *Nanostructured Transparent Polymer for Encapsulation of PV Modules and Optical Devices. Breakthrough in Design and Properties of Solar Cells-Elena Shembel, Enerize Corporation*
- *Effective Doping of CdTe Towards High Efficiency Thin Film Solar Cell- M. I. Khan, S. Collins and C. Ferekides, University of South Florida*
- *Cooling Channel Analysis to Enhance the Efficiency of Photovoltaic Panels- Obiechina Abakporo, Dr. Juan Ordonez, Dr. Alejandro Rivera, Florida A&M University*
- *Integration of Transparent Insulation Materials into Solar Collection Devices-Sam Yang, Alejandro Rivera, Juan Ordonez, FSU Center for Advanced Power Systems*
- *Air-Processed Polymer-Fullerene Bulk Heterojunction Solar Cells With Higher Than 6% Efficiency- Iordania Constantinou, John R. Reynolds, Franky So, University of Florida*
- *Development of Novel Water Splitting Materials for the Production of Renewable Hydrogen-Samantha Roberts, Helena E. Hagelin-Weaver, University of Florida*
- *Kinetic and Material Analysis for Solar Fuel Production-Michael Bobek, Nathan Rhodes, David Hahn, University of Florida*
- *Energy Glass - The Next Generation in Solar Energy Production with Enhanced Building Physical Security-Theron Colbert, TiRC Energy Engineering, International Professional LLC*
- *A Mathematical Model for Performance Prediction of a Hybrid PV/T Module for Hot and Humid Climates - Cheng-Xian Lin, Francisco Emilio Zevallos*, Florida International University
- *Solar Water Heating as a Green House Gas Reduction and Energy Conservation Strategy-Thomas Lane, Colleen Kettles, ECS Solar and Florida Solar Energy Center/UCF*

Track II: Energy Efficiency - *Century Ballroom C*

Chair: John Leeds, Senior Management Analyst, Office of Energy

- *Thermal Simulation of FSU's Off-Grid Zero Emissions Building-Juan Ordonez, Florida State University*
- *Low Cost Building Energy Efficiency Solution Based on Real-Time Occupancy Based Control-Jonathan Brooks, Prabir Barooah, University of Florida*
- *Moisture and Energy Consequences of a Tight Residential Envelope- Robin Vieira, Danny Parker, Philip Fairey III, John Sherwin, Chuck Withers, David Hoak, Florida Solar Energy Center/UCF*
- *An Overview of Building America Partnership for Improved Residential Construction (BA-PIRC) Activities in Hot Humid Climates-Eric Martin, Florida Solar Energy Center/UCF*
- *My Florida Home Energy Interactive Web tool- Lesly A. Jerome, Harold S. Knowles, III, Nicholas W. Taylor, University of Florida*
- *Florida Energy Efficiency Loan (FEEL): A New Residential Lifestyle Literacy and Leveraged Lending Program-Craig Miller, Hal Knowles, University of Florida - Program for Resource Efficient Communities*
- *Targeting Utility Customers to Improve Energy Savings From Conservation and Efficiency Programs - Nicholas W. Taylor, Pierce H. Jones, M. Jennison Searcy, University of Florida*
- *Exploring the Market for Multifamily Energy-Efficiency Retrofits in Florida- M. Jennison Searcy, Pierce H. Jones, Nicholas W. Taylor, University of Florida*
- *Side by Side Evaluation of Residential Hot Water Heating Systems in Florida-Carlos Colon, Florida Solar Energy Center/UCF*
- *A Program for Energy Efficient and Environmentally Sustainable Laboratories - Philip J. Wirdzek, International Institute for Sustainable Laboratories (I2SL)*
- *Permanent Magnet for Energy Efficiency Systems- Ke Han, FSU Mag Lab*
- *Energy Efficiency and NRCE: A Needed, Country, State and Industrial Policy/Program-Cristian Cardenas-Lailhacar, Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador*
- *Energy Efficient Transportation-John Nuszkowski, University of North Florida*
- *Energy-Aware Database Disk Storage System- Yicheng Tu, Bo Zeng, Peyman Behzadnia , Wei Yuan, University of South Florida*

3:10 – 4:10 pm SESSION II POSTER REVIEW AND DISCUSSIONS

4:10 – 4:15 pm REMOVAL of SESSION II POSTERS and SET-UP of ADDITIONAL POSTERS

4:15 – 5:15 pm ROUNDTABLE DISCUSSION – *Century Ballroom A, B, C, Dogwood, Azalea and Hickory*

1- **Energy Efficiency – Dogwood**
   Moderator: Robin K. Vieira, Director, Buildings Research Division, Florida Solar Energy Center
2- **Biomass – Century Ballroom A**
   - **Algae - *Moderator: George Philippidis, Associate Professor, Sustainable Energy, USF***
   - **Biochemical Conversion - *Moderator: Lonnie O. Ingram, Director, Florida Center for Renewable Chemicals and Fuels, Microbiology and Cell Science, UF***
   - **Thermo-chemical Conversion - *Moderator: Janan Balaban, Associate Director, FESC***
   - **Waste to Energy - *Moderator: John N. Kuhn, Assistant Professor, Chemical & Biomedical Engineering, USF***

3- **Energy Crops- Hawthorne**
   Moderator: David L. Wright, Professor of Agronomy, UF
4- **Solar – Century Ballroom B**
   - **Solar PV- *Moderator: Issa Batarseh, Professor, ECE, UCF***
   - **Solar Thermal - *Moderator: D. Yogi Goswami, Distinguished University Professor, USF***
5- **Smart Grid and Storage – Century Ballroom C**
   - **Grid - *Moderator: Sean Meyn, Director Florida Institute for Sustainable Energy, Professor of ECE, UF***
   - **Energy Storage - *Moderator: Charles A. Weatherford, Chairman Department of Physics and Director of the NSF CREST, FAMU***
6- **Natural Gas – Azalea**
   Moderator: J. R. Mclelland, Director Gas Supply & Wholesale Origination at TECO Peoples Gas
7- **Education – Hickory**
   Moderator: Jennifer Sinclair Curtis, Interim FESC Director

5:15 - 6:15 pm ADDITIONAL POSTER SESSION

The list of posters is given at the end of the agenda.

6:15 - 7:15 pm RECEPTION – *Century Ballroom A*

7:15 pm REMOVAL OF ADDITIONAL POSTERS – SET-UP of SESSION III POSTERS

7:15 pm DINNER ON YOUR OWN

TUESDAY, MAY 13

7:00 – 8:00 am BREAKFAST

GENERAL SESSION: ***Century Ballroom A***

8:00 – 9:00 am ROUNDTABLE REPORTS (5 min)

9:00 – 10:30 am SESSION III: NATURAL GAS, MARINE ENERGY, AND EDUCATION PANEL SESSION
MODERATOR: TOMMY BOROUGHS, HOLLAND & KNIGHT, PARTNER, FESC ADVISORY BOARD MEMBER

Natural Gas: ***Natural Gas: Serving Florida's Energy Needs Today and in the Future - John R. Mclelland, Director Gas Supply and Wholesale Origination, TECO Peoples Gas***

Marine Energy: ***Blue Energy: The Southeast National Marine Renewable Energy Center - Camille Coley, Assistant Vice President for Research, Associate Director for the Southeast National Marine Renewable Energy Center, Florida Atlantic University***

Education: ***Trends in Energy Education and Workforce Development - Dr. Dean Evasius, Vice President and Director of Science Education Programs, Oak Ridge Associated Universities***

10:30 – 10:45 am BREAK

10:45– 11:25 am SESSION III ORAL PRESENTATIONS (5 min each)

Track I: Natural Gas and Marine Energy - *Century Ballroom B*
Chair: Janan Balaban, Associate Director, FESC

- *The Direct Use of Natural Gas - Scott Ranck, Florida Public Utilities Company*
- *Natural Gas As A Transportation Fuel - Mark Thompson, Florida Public Utilities Company*
- *So Natural Gas Motor Fuels are Cheaper than Oil: Does This Solve Our Energy Problem? - David E. Bruderly, Bruderly Engineering Associates, Inc.*
- *Crew Member Training Standards for Natural Gas-Fueled Ships - Dennis L. Bryant, Bryant's Maritime Consulting*
- *Evaluation of Viability of Combined Heat and Power Projects in Florida – David Richardson, Mark Cutshaw, Florida Public Utilities Company*
- *Performance Evaluation and Field Testing of Gas Heat Pump - Rajeev Kamal, D. Yogi Goswami, University of South Florida*
- *Scaling Relations for the Model Scale Testing of Hydrokinetic Ocean Renewable Energy Systems- Karl Von Ellenrieder, Valentine W., Florida Atlantic University*
- *Water Energy for Florida and the USA-George Meyer, Engineer & Energy Invest. Consultants*

Track II: Education - *Century Ballroom C*

Chair: Jennifer Curtis, Interim FESC Director

- *Renewable Energy Education Program at USF's Patel College of Global Sustainability- George Philippidis, University of South Florida*
- *"Buildings and Energy: Design and Operation vs. Sustainability" an Energy Engineering Course for Florida-specific Building Design & Operation – Prabir Barooah, University of Florida*
- *Educating on Economic Realities of Sustainable Energy- Mark Jamison, University of Florida*
- *Introducing Specialization in "Sustainable Energy Systems" for Under-Graduate Students in Engineering at the University of West Florida.- Bhuvaneswari Ramachandran, University of West Florida*
- *Industrial Energy Efficiency Education-Nina Stokes, M Barger, Dr. Richard Gilbert, FLATE at Hillsborough CC*
- *Sustainable Floridians Program - Strengthening Your Sense of Place-Kathleen C. Ruppert, University of Florida*
- *Two Alternative Fusion Energy Confinement Concepts: Spheromaks and Laser-Assisted Muon Catalyzed Fusion-Charles A. Weatherford, Florida A&M University*
- *Challenges in Quantifying Optimal CO_2 Emissions Policy-Theodore J. Kury, University of Florida- Public Utility Research Center*

11:25 – 12:10 SESSION III POSTER REVIEW AND DISCUSSIONS

12:10 REMOVAL OF POSTERS

12:15 BUFFET LUNCH

ADJOURN

ADDITIONAL POSTER SESSION

List of Posters

BIOMASS

1. Biodiesel Production from Waste Oils using Non Catalytic Supercritical Alcohols -*Zachary Cerniga, Aydin Sunol, George Philippidis*, University of South Florida
2. Supercritical Gasification of Wet Biomass such as Citrus Solid Waste for Hydrogen Generation- *Aydin K. Sunol*, *Kyle Cogswell*, University of South Florida
3. Intragenic Precision Breeding Supports Targeted Modification of Lignin Biosynthesis in Sugarcane - *Jung JH, Dermawan H, Altpeter F*, University of Florida -IFAS
4. Breeding Elephantgrass for Elevated Biomass Yield and Biosafety - *Baskaran Kannan, Marco Sinche, Carlos Corsato, Fredy Altpeter*, University of Florida-IFAS
5. Emulsion of Lignin-co-butyl Acrylate as a Biobased Polymer System - *Suguna Jairam, Zhaohui Tong, Fei Wang*, University of Florida - IFAS
6. Development and Management of Brassica carinata (Ethiopian Mustard) as a "Drop-in" Biofuel - *Ramdeo Seepaul*, Sheeja George, Ed Coppola, David L. Wright, Jim J. Marois, University of Florida University of Florida - IFAS
7. Sunflower Genotype Evaluation for Bio-oil Production in Florida -*Fedenko, JR, Ann C. Wilkie*, *Erickson, JE*, University of Florida - IFAS
8. Bioenergy Plant: Efficient Method For Disposing Biodegradable Materials - *Jose Sifontes,* Sigarca
9. Anaerobic Digestion of Food Waste from Alachua County Schools - *Ryan E. Graunke*, *Ann C. Wilkie*, University of Florida-IFAS
10. Renewable Energy Production through Organic Waste Recycling at Christianville, Haiti - *Reginald Toussaint, Ann C. Wilkie*, University of Florida-IFAS
11. Methane Productivity of Organic Waste Treatment by Two-Phase Anaerobic DigestionVictoria Cortés, Ann C. Wilkie, Zamorano Agricultural University and university of Florida-IFAS
12. Co-production of Astaxanthin and Biofuels - *Alec. S. Shoelson, Ann C. Wilkie*, University of Florida-IFAS
13. Characterization of Cellulosic Ethanol Stillage and Use as an Algal Growth Medium - *Tommie B. Lovato, Ann C. Wilkie,* University of Florida-IFAS
14. Reuse of Cellulosic Bioethanol Residuals - *Jianru Shi, George O'Connor, Ann C. Wilkie,* University of Florida-IFAS
15. Evaluation of Energy Recovery Potential From Sweet Potato Stillage - *Wendy Mussoline, Ann C. Wilkie*, University of Florida-IFAS
16. Anaerobic Co-Digestion of Swine Manure and Microalgae for Biogas Production - *Meng Wang, Eunyoung Lee, Qiong Zhang and Sarina Ergas*, University of South Florida
17. Bioprospecting for Oleaginous Microalgae and/or Cyanobacteria From Wastewater Holding Tanks - *Devin Alvarez, Lowell Collins, Ashvini Chauhan,* Florida A&M University
18. Wastewater Nutrient Sequestration and Production of Lipid-biofuels from a Newly Isolated Cyanothece sp. strain SGAC1 - *Lowell Collins, Devin Alvarez, Ashvini Chauhan,* Florida A&M University
19. A Kinetic Model for Microalgae Growth in Wastewater - *Eunyoung Lee & Qiong Zhang*, University of South Florida
20. Indigenous Algal Growth on Municipal Sludge Centrate and a Simple Irradiance-based Model for Predicting Biomass Production in the System - *Trina Halfhide, Kofi Dalrymple, Ann Wilkie, Sarina Ergas*, University of South Florida
21. Alternative Sources of Nutrients for Production of Microalgae Biomass - *Kassiana Ribeiro dos Santos, Juan C. Ordonez*, Florida State University

22. Searching for the Lipid Trigger in Biofuel Green Algae - *Elton Carvalho Goncalve, Jin Kho, Sixue Che, Bala Rathinasabapathi*, University of Florida
23. Development of a Production System for Natural Renewable Gas Using Synechococcus sp. BG0011, a Unique Cyanobacterium, as a Feedstock - *Bailey E. Trump, Cesar M. Moreira, Edward J. Phlips, Pratap Pullammanappallil, Spyros A. Svoronos,* University of Florida -IFAS
24. Comparison of pretreatment methods to enhance methane production from microalgae Nannochloropsis oculata - *Pratap Pullammanappallil, Samriddhi Buxy, Robert Diltz, Tushar K. Goswami, Weihua Yang,* University of Florida

SMART-GRID & STORAGE

25. Renewable Energy Investment and Operational Decision Model - *Alireza Ghalebani, Tapas K Das*, University of South Florida
26. Using Electrochemical Impedance Spectroscopy to Study the Reaction Rates and Diffusion Coefficients in Li Batteries - *Mohit Mehta, Petru Andrei*, Florida State University
27. Experimental Study of Heat Transfer Improvement in Phase Change Materials for Thermal Energy Storage - *Abhinav Bhardwaj, Elias Stefanakos, D.Y. Goswami,* Clean Energy Research Center, University of South Florida
28. Studying Stress Relaxation at Polymer Interfaces Using FTIR-ATR Spectroscopy - *Onyekachi Oparaji, Daniel Hallinan*, Florida State University
29. Designing Composite Polymer Electrolyte Interfaces for Stable Electrodes - *Guang Yang, Daniel Hallinan*, Florida State University
30. Optimal Dispatch of Energy Storage Systems in Real-time Digital Simulation - *Lingling Fan, Zhixin Miao,* University of South Florida

SOLAR

31. *Laser Processing for the Formation of Ohmic Contacts to CdTe Solar Cells-Vasilios Palekis, Prasad Banel, Christos Ferekides, University of South Florida*
32. Investigation of TiO2 Annealing and TiCl4 Treatment on the Performance of Dye-Sensitized Solar Cells - *Shamara Collins, Arash Takshi, Chris Ferekides,* University of South Florida
33. A New Solar Radiation Interpolation Technique- *Cristian Cardenas-Lailhacar,* Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador
34. Cost Effectiveness of Energy Generating Solar Plant Using Sea Water - *Sarah Rajkumari Jayasekaran, Essy Tari, Hamid Shoraka, Fazil T Najafi*, University of Florida

Addition:

Functional APCVD Oxide Films for c-Si Solar Cells- *Kristopher O. Davis, Kaiyun Jiang, and Winston V. Schoenfeld*

ENERGY EFFICIENCY

35. Analysis and Optimization of Combined Flash Binary Cycle for Geothermal Power Generation - *Mehdi Zeyghami, Yogi D Goswami*, University of South Florida
36. Cryogenic Thermal Modeling of Helium Gas-Cooled Superconducting Cable System Components - *Nick Suttell*, Center for Advanced Power Systems
37. Flat Plate Fins Shape Optimization - *Julian Osorio*, Florida State University
38. Modeling and Simulation of a Vapor Compression Refrigeration System - *T. K. Nunes, J. C. Ordonez, and J. V. C. Vargas*, Florida State University - Center for Advance Power Systems

EDUCATION

39. The Development of an Interactive Software as a Secondary Learning Tool for Undergraduate Fuel Cell Courses - *Amjad Aman, Yunjun Xu, Nina Orlovskaya, Haiyan Bai*, University of Central Florida

Addition:

TBD- *Luisa Amelia Dempere*

POLICY

40. Key Factors Influencing Energy Intensity in Developed and Emerging Countries - *Priscila Delfino, University of Florida* -Public Utility Research Center

WIND

41. A New Wind Power Forecasting Technique - *Cristián Cárdenas-Lailhacar*, Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador

OTHER

42. Comparison of Emerging Ground Propulsion Systems for Electrified Aircraft Taxi Operations - *Rui Guo, Yu Zhang, Qing Wang*, University of South Florida
43. Organic Rankine Cycle (ORC) For Decentralized Applications - *Arun Kumar Narasimhan, Rajeev Kamal, D. Yogi Goswami,* University of South Florida
44. Stochastic Economic Dispatch via Point Estimation Method and Particle Swarm Optimization- *Luna Gloria, Thais Araújo*, *Wadaed Uturbey,* Florida Atlantic University.

GUEST SPEAKERS

Dr. Paul Bryan, Lecturer, Berkeley and Consultant

Paul Bryan is currently a Lecturer in Chemical Engineering at the University of California – Berkeley and an Independent Consultant in the fields of Bio-Based and Conventional Fuels and Chemicals. From 2010 – 2011, he served as Program Manager for Biomass (now "BETO" – the Bio-Energy Technology Office) at the U.S. Department of Energy. He remains active with the DOE as a BETO Peer Reviewer, a member of the Biomass R&D Board's Technical Advisory Committee, and in other advisory / reviewer roles.

Prior to his time at the DOE, he worked for 15 years for Chevron in Northern California and Western Australia, the last 4 of which as Vice President – Biofuels Technology. Prior to that he founded and managed Chevron's Western Australian Alliance for Advanced Energy Solutions in Perth, Australia, as well as Chevron's Long-Range Research Program in Separations Technology in the U.S. Earlier positions included stints as a Research Engineer with Chevron in California and with Union Carbide in West Virginia, and academic positions in Chemical Engineering at MIT and the Colorado School of Mines.

Paul's educational background is in Chemical Engineering, with a B.S. from Penn State, a Ph.D. from the University of California – Berkeley, and post-doctoral work at the École des Mines – Paris.

Dr. Pramod P. Khargonekar, Assistant Director for the Directorate of Engineering, National Science Foundation

Dr. Pramod P. Khargonekar was appointed by the National Science Foundation (NSF) to serve as Assistant Director for the Directorate of Engineering (ENG) in March 2013. In this position, Khargonekar leads the ENG Directorate with an annual budget of more than $800 million. The ENG Directorate invests in frontier engineering research and education, cultivates an innovation ecosystem, and develops the next-generation of engineers. He is a member of the senior leadership team at NSF and thereby involved in setting priorities and policies at NSF.

Khargonekar received B. Tech. Degree in electrical engineering from the Indian Institute of Technology, Bombay, India, in 1977, and M.S. degree in mathematics and Ph.D. degree in electrical engineering from the University of Florida in 1980 and 1981, respectively. He has held faculty positions at the University of Florida, University of Minnesota, and The University of Michigan. He was Chairman of the Department of Electrical Engineering and Computer Science from 1997 to 2001 and also held the position of Claude E. Shannon Professor of Engineering Science at The University of Michigan. From 2001 to 2009, he was Dean of the College of Engineering and is currently Eckis Professor of Electrical and Computer Engineering at the University of Florida. He also served briefly as Deputy Director of Technology at ARPA-E, U. S. Department of Energy in 2012-13.

Khargonekar's research and teaching interests are centered on theory and applications of systems and control. His early work was on mathematical control theory, specifically focusing on robust control analysis and design. During the 1990's, he was involved in a major multidisciplinary project on applications of control and estimation techniques to semiconductor manufacturing. His current research and teaching interests include systems and control theory, machine learning, and applications to smart electric grid and neural engineering. He has authored more than 130 refereed journal publications and 150 conference publications.

He has supervised 32 doctoral students. He has been recognized as a Web of Science Highly Cited Researcher. He is a recipient of the NSF Presidential Young Investigator Award, the American Automatic Control Council's Donald Eckman Award, the Japan Society for Promotion of Science fellowships, the IEEE W. R. G. Baker Prize Award, the IEEE CSS George Axelby Best Paper Award, the Hugo Schuck ACC Best Paper Award, and the Distinguished Alumnus and Distinguished Service Awards from the Indian Institute of Technology, Bombay. He is a Fellow of IEEE and IFAC. At the University of Michigan, he received the Arthur F. Thurnau Professorship. In the past, he has served as Associate Editor for IEEE Transactions on Automatic Control, SIAM Journal of Control, Systems and Control Letters, and International J. of Robust and Nonlinear Control.

Dr. Ryne Raffaelle, VP for Research and associate Provost, Rochester Institute of Technology

Dr. Ryne P. Raffaelle is the Vice President for Research and Associate Provost at Rochester Institute of Technology (RIT). He is the former Director of the National Center for Photovoltaics at the National Renewable Energy Lab of the U.S. Department of Energy. Prior to serving at NREL, he was the Academic Director for the Golisano Institute for Sustainability and Director of the NanoPower Research Laboratory at RIT. He has worked as a visiting scientist at the NASA-Glenn Research Center, NASA Kennedy Research Center, and Oak Ridge National Laboratory. He is the author of over 200 refereed publications and is the Managing Editor of Progress in Photovoltaics, published by Wiley Interscience. He has a Ph.D. in Physics from University of Missouri-Rolla, and B.S and M.S. in Physics from Southern Illinois University.

Dr. Patrick (Pat) Phelan, Program Manager for Emerging Technologies in the Building Technologies Office, Energy Efficiency and Renewable Energy, US Department of Energy

Patrick Phelan received his BS degree from Tulane University in New Orleans, his MS degree from MIT, and his PhD from UC Berkeley, all in mechanical engineering. Following a two-year post-doctoral fellowship at the Tokyo Institute of Technology, he started his academic career as an Assistant Professor at the University of Hawaii in 1992. In 1996 he moved to Arizona State University (ASU), where he is a Professor of Mechanical & Aerospace Engineering, and a Senior Sustainability Scientist. While on leave from ASU he served as the Director of the NSF Thermal Transport Processes Program from 2006 to 2008. He is again on leave from ASU, and is now the Program Manager for Emerging Technologies in the Building Technologies Office, Energy Efficiency and Renewable Energy, US Department of Energy.

Camille Coley, JD, Associate VP, Division of Research and Associate Director for the Southeast National Marine Renewable Energy Center at Florida Atlantic University

Camille E. Coley, J.D., is an Associate Vice President for the Division of Research and Associate Director for the Southeast National Marine Renewable Energy Center at Florida Atlantic University (FAU). For Research, Ms. Coley oversees the internal awards programs for the Division and the reporting by the University to external research sponsors. She has been actively engaged in the University community as a member of several strategic planning committees, the University's accreditation review and a co-chair of a University task force on meeting community needs and unique institutional responsibilities. In her role Associate Director of FAU's Southeast National Marine Renewable Energy Center in the College of Engineering and Computer Science, she manages the permitting and licensing

activities for the center as well as the education and outreach programs. Ms. Coley was a member of the Governor's 21-member Action Team on Energy and the Environment, and a member of the technical working group on adaptation. Presently she is a member at the Federal Advisory Committee on the U.S. Global Change Program. Ms. Coley came to FAU from the University of Rhode Island's (URI) Coastal Resources Center in the Graduate School of Oceanography, where she was Project Manager and a Marine Resource Specialist in East Africa from 1999 to 2001. Ms. Coley worked with governments in East Africa to develop coastal management policies, new programs and initiatives for the protection, preservation and wise use of coastal resources as well as capacity development programs for local coastal managers. She also developed and implemented a cutting-edge training program for emerging coastal managers in the region. Ms. Coley has authored several publications on Coastal Management in developing countries. Prior to her employment at URI, she was the Program Administrator for the Florida Coastal Management Program where she coordinated local, state and federal agency activities using existing laws to ensure that Florida's coast remained a valuable asset to the state of Florida. She received her law degree from the University of Maryland – School of Law and she completed her undergraduate work at Towson State University in Communications and University of Virginia in Chemical Engineering.

John R. "J.R." Mclelland, Managing Director Fuels Management, TECO Gas Services

J.R. Mclelland is Managing Director, Fuels Management and is responsible for leading the natural gas, coal, oil, and wholesale power origination and trading activities for Tampa Electric, Peoples Gas, TECO Gas Services, and SeaCoast Gas Transmission.

Previously, J.R. served as Director, Gas Supply and Wholesale Origination where he was responsible for gas acquisition strategies and day-to-day supply activities. Prior to joining TECO in 2002, J.R. served in gas supply related management functions with Calpine Eastern, Florida Power Corporation, and Lykes Energy.

J.R. sits on the Board of Directors of the Florida Natural Gas Association and is a member of the Southern Gas Association. He holds a Bachelor of Science degree in Marketing from Florida State University. J.R., his wife Randi, and daughter Allison reside in Sarasota Florida.

Dr. Dean Evasius, Vice President and Director of Science Education programs at Oak Ridge Associated Universities

Dr. Dean Evasius is Vice President and Director of Science Education programs at Oak Ridge Associated Universities (ORAU). In this role, Dr. Evasius is responsible for providing leadership, oversight and direction for ORAU's portfolio of science education programs. He previously served as Senior Adviser for science at the National Science Foundation (NSF), and also served as a program director in the Division of Mathematical Sciences at NSF.

Prior to his time at NSF he was a research mathematician for the National Security Agency. He holds a B.S. and Ph.D. in mathematics.

ABSTRACTS

Monday, May 12- 10:40-11:40 am
SESSION I: BIOMASS AND SMART GRID PANEL SESSION

Track I : Biomass

Potential for Oilseed Crops in the Southeast - David Wright, James Marois, Sheeja George, University of Florida - IFAS

Oilseed crops are important biofuels. Florida has the potential to grow many different types of crops for energy production. Years of research with canola showed the potential for oilseed crops and the fit into current cropping systems of the Southeast. However, for an industry to develop, it is important for the crops to fit into current systems and having infrastructure to plant, manage, harvest and store the crop. Oilseed crops fit these criteria with the exception that we need earlier maturing crops that can be planted in the fall after cotton, soybean or peanut and be harvested by late April or early May at the latest so that these summer crops can be planted timely. Recent research with camelina and carinata show the potential of these crops and cooperative work with Agrisoma BioSciences and Applied Research Associates has allowed an expanded vision of the potential for the crops for "drop in fuel" and evaluation of cultivars that may be more adapted to conditions in the Southeast. This talk will focus on recent work on oilseed crops and the viability for Florida growers.

Pongamia - An Oilseed Tree Crop as a Profitable Replacement for Florida's Lost Citrus Acreage - David Harry, Claire Kinlaw, Tom Schenk, Naveen Sikka, Terviva Inc.

Rule #1: For any renewable fuels crop to be successful, it has to make economic sense for landowners to grow it.

Corollary #1: It has to be better than other crop choices the grower has.
Corollary #2: It needs to fit within a grower's existing equipment and infrastructure.
Rule#2: There needs to be already existing (and deep) downstream market demand for the output.
Rule#3: The lower the capital costs to process the crop, the greater the probability it will scale.

Over the last two years, TerViva has deployed successful trials with major citrus growers in southern Florida in planting a hardy leguminous tree crop called pongamia. Pongamia produces a generous nut crop that can be mechanically harvested. The seed looks like a large lima bean and its properties are extremely similar to soybeans. However, the tree produces over 10x what soybeans can produce and can crow on a footprint where soybeans generally cannot. The nuts are shelled with a peanut sheller and crushed with conventional soybean crushers - all low-capex items. The end products are: a valuable oil (high in oleic and palmetic acid) and a seedcake which can be used as a high-protein (27%) animal feed or a high-nitrogen (4%) slow-release, low-nitrification fertilizer for Florida's sandy soils. The oil is a C 18:1 molecule making it valuable for a drop-in feedstock for biodiesel, lubricants, surfactants and other biochemicals. The oil also has bio-pesticidal properties and can be a substitute for the mineral oil that is mixed in almost all conventional crop sprays.

The tree has been grown as an ornamental in south Florida since the 1920's. The tree thrives in tropical/subtropical tree suited to growing zones no cooler than 9b which is generally from Orlando and southward. Pongamia is planted at the same field density as citrus, but requires much less water than citrus, minimal fertilizer, and little or no pesticides which can help the problems being addressed throughout the Everglades watershed. Financially, the crop can be a very close income replacement for lost citrus and can make 3x-4x more than other biomass crops.

Exceptionally successful trials have been deployed with major agricultural landowners such as US Sugar, Evans Properties, Graves Brothers, and even on Mosaic's challenging phosphate reclamation and heavy clay soils. TerViva has more new growers this year and is sold out of tree stock for 2014. Pongamia could be the best crop to restore lost value to tens of thousands of acres of abandoned citrus land, and brings life back to the rural economies in the southern half of Florida.

Evaluating eTuber and Energy beets as Feedstocks for Biofuels and Biogas in South Florida- Brian Boman, Edward Evans, Ann Wilkie, University of Florida- IFAS

This project takes an innovative approach to developing the biofuel and biogas industry in the state of Florida using an eTuber and Energy Beet rotation system. The eTuber sweet potato, developed by CAREnergy, has 50% more dry matter than current leading varieties of sweet potatoes grown in Florida. As a result, it has a greatly increased ethanol producing potential and the eTuber's starch can be processed with the technology used in a corn ethanol plant. The crop tolerates heat, requires little irrigation, and has been shown to produce 4 to 5 times as much starch per acre as corn. The 'energy beet' is a non-edible biomass crop that is "Generation 1.5" simple sugar crop – does not need to be converted from starch and can produce twice as much sugar per acre as corn. In addition, Energy Beets ferment without the need for enzymes. The by-products can be used as a livestock feed supplement. A major goal of this project is to conduct field trials with eTuber and Energy Beer to develop protocol for growing the crop which can be developed into recommended practices. In addition, these trials will allow us to document potential yields and to collect the data on fossil fuels inputs for growing and processing the crop and construct a greenhouse gas (GHG) analysis to support an application for certification of the crop as an Advanced Biofuel Feedstock (ABF). The trials will include experiments on planting density, rotation crops, fertilizer and irrigation rates, pest & disease control, and planting and harvest times. Another goal will be to develop procedures to process the eTuber™ into ethanol fuel, by-products and syrup. Once the techniques to process the eTuberTM into syrup has been accomplished it will be tested as a putative ABF for e-coli, algae, and yeast to make biodiesel and jet fuel, etc. Studies will also be undertaken to determine the potential to use biogas to run the processing of eTuber™ sugar into biofuels using biogas through anaerobic digestion. A very important part of the project will be the economic analysis of the market potential and the impact of the commercialization of the eTuber™ for fuel and energy in Florida. The establishment of the eTuber™ ethanol industry has the potential to significantly benefit regional and local communities and to provide enormous gains for agriculture, especially in areas where diseases have taken out citrus groves.

Commercial Production of Terpene Biofuels from Existing Slash Pine Plantations - Gary Peter, Jennifer Lauture, Alan Hodges, University of Florida- IFAS

North Florida has a long history of collecting and processing pine terpenes into renewable chemicals. Recovering terpenes from live pine trees is actively done globally, but died out in the

south because of high labor costs and the harvesting of older stands of slash and longleaf pine. Today the pine chemicals industry obtains terpenes from crude tall oil and turpentine collected in chemical pulp mills. However, the recent strong commercial interest in drop-in biofuels has dramatically increased interest in pine terpenes as a source of readily available hydrocarbon precursors for jet fuel. We propose to reinvigorate commercial collection of terpenes from live pine trees by developing new methods to boost production and decrease collection costs from stands of young planted slash pine. Planted slash pine stands cover over 3 million acres in North Florida and we estimate that tapping 200,000 acres can annually produce >100 million gallons of gum turpentine valued at >$400 million, without detrimental effects on the existing forest products industry. Cost effective collection of gum turpentine is expected to greatly improve economic returns to forestland owners while increasing jobs in the collection and processing industries.

Existing pine chemical markets and the new US military and commercial aviation industry markets for jet fuels made from renewable sources have increased demand for pine terpenes. The cost of terpene recovered from live pine trees depends on individual tree production rate or yield and per tree collection costs. To recover gum turpentine for <$800/tonne we will complete the following aims: 1) increase terpene production from live trees by developing and testing cost effective chemical inducers of resinosis in young slash pine trees, 2) further develop methods that reduce the per tree collection costs, and 3) evaluate the impact of terpene collection on pine tree growth potential. A replicated factorial experiment with inducers, tree sizes, tree ages, and previous silvicultural treatments will be conducted. Trees treated with resinosis inducers will be tapped with borehole method and terpene yields and costs compared. Because landowners can still harvest trees for traditional wood and paper products, we will quantify the impact of resinosis inducers and live tree collection methods on tree growth. Overall, we expect to develop a cost effective system to collect large amounts of terpenes for renewable chemicals and biofuel production.

The second objective for this research is to test methods to produce drop-in jet fuels from pine terpenes, including gum turpentine, diterpene mixes and crude sulfated turpentine and crude tall oil. We have partnered with Applied Research Associates to test their proven catalytic hydrothermolysis and upgrading processes. Yields, chemical composition and fuel properties of processed gum turpentine or other pine terpene fractions will be analyzed. The third objective is to assess the economic impact of expanding gum turpentine collection and terpene based biofuels production in Florida.

Environmentally and economically sustainable production of fuels and chemicals from sweet sorghum- Wilfred Vermerris, John Erickson, Lonnie Ingram, University of Florida- IFAS

Sweet sorghum is a tall (4-6 m) grass that grows well in hot and dry environments and that accumulates large amounts of soluble sugars in its stem juice. Given the large amount of bagasse (crushed stems) that remains after the extraction of the juice, sweet sorghum is an ideal crop to transition from first-generation sugar-based biofuels and chemicals to second-generation biomass-based fuels and chemicals. We have developed new sweet sorghum cultivars that perform better in Florida and neighboring states than currently available germplasm. Further improvements in yield can be made by using germplasm that is resistant to anthracnose, the most prevalent fungal disease in the region that can reduce crop yields by 70%. We have identified the genetic basis of anthracnose resistance, so that this useful trait can be introduced more efficiently in new cultivars. Through a better understanding of the catalytic mechanisms of enzymes involved in cell wall biosynthesis, we are working on the development of sorghums with stems that are more amenable

to biomass processing. In addition, we are investigating the genetic basis of root system architecture to enable more efficient use of water. We are also developing novel, high-value nanomaterials from the lignin-rich waste stream of the biorefinery, with the goal of off-setting some of the operating costs of the biorefinery. We have shown that some of these nanomaterials show promise in biomedical applications, specifically as delivery vehicles for DNA and therapeutic agents into human cells. Commercial-scale application of this comprehensive approach to sweet sorghum improvement will enable regional production of fuels and chemicals in an environmentally and economically sustainable manner. Supported by USDA-BRDI project 2011-10006-303508.

Engineering Bacillus subtilis biocatalysts for production of biofuels and chemical feedstocks and biochemicals for pharmaceutical and nutraceutical applications-James Preston, Mun Su Rhee, Lusha Wei, University of Florida- IFAS

Different forms of lignocellulosic biomass represent major renewable resources derived from solar energy via photosynthesis as major sources of fuels and chemicals. Energy crops, poplar and switchgrass, and agricultural residues, sugarcane and sorghum bagasse, are candidates for bioconversion to targeted products. The hemicellulose fraction, representing 20 to 30% of these resources, may be efficiently converted, via secreted xylanolytic enzymes, to sugars for intracellular metabolism and conversion to biofuels and chemicals by fermentative bacterial biocatalysts. With a sequenced and annotated genome, genetically malleable Bacillus subtilis strain 168 has become an attractive candidate for developing strains for bioconversion of xylans in hemicellulosic biomass to alternative biofuels and chemicals. Through deletion of its existing GH11/GH30 xylanase system and introduction of genes encoding a GH10/GH67 system B. subtilis strains have been engineered for efficient and complete conversion of xylans to targeted products, e.g. lactic acid for bioplastic production. Alternatively the B. subtilis can be genetically engineered to secrete either the GH11 or the GH30 xylanase for the conversion xylans to acidic xylooigosaccharides that have immunomodulating activities. With only the GH30 xylanase the B. subtilis strain MR44 produces acidic XOS that can serve as precursor for pentosan polysulfate (PPS) with pharmaceutical activities, including treatment of interstitial cystitis in humans and osteoarthritis in animals. B. subtilis biocatalysts allow the conversion of agricultural residues, e.g. bagasse derived from sugarcane and other crops, as well as dedicated energy crops, e.g. poplar, eucalyptus, switchgrass and sweet sorghum, mitigating consumption of fossil energy sources for transportation fuels and chemical feedstocks. Other B. subtilis biocatalysts may be used for production of high value specialty products for applications in nutrition and medicine.

Biomass Treatment with Supercritical Fluids for high throughput and yield to fuels-Aydin Sunol, Kyle Cogswell, Aaron Driscoll, and Zachary Cerniga University of South Florida

Supercritical Fluid Treatment of Biomass results selective removal of lignin hemi cellulose or cellulose as well as modifying the chemical structure of the biomass for subsequent treatments including biological and thermal. Effective Supercritical fluids range from water at the high pressure and temperature end to carbon dioxide ethanol mixtures for tunable temperatures. The effective list includes ammonia and amines as well. The gasification of the treatment residue can also be accomplished through supercritical gasification and this particular route avoids the drying step of the conventional gasification processes. The presentation will highlight our thirty years of experience in such treatments and novel processing concepts.

Oxygen-blown Gasification for Efficient Conversion of Woody Biomass to Liquid Hydrocarbon Fuels- Ali T-Raissi, UCF- Florida Solar Energy Center

Biomass conversion to carbon-neutral fuels is a subject of intense research due to concerns over diminishing resources and negative environmental impact of fossil fuel usage. In this poster presentation, we demonstrate a cost effective process for thermochemical conversion of biomass to a hydrogen-rich gas fit as a feedstock for the production of liquid hydrocarbon fuels. The process consists of gasification of biomass to syngas with subsequent Fisher-Tropsch synthesis to diesel range clean sulfur-free hydrocarbons. The focus of this presentation is on steam-oxygen gasification of pinewood charcoal in an updraft moving-bed reactor. The data show that the oxygen flow rate and $[H_2O]/[O_2]$ feed ratio profoundly affect the efficiency of the conversion process. Data suggest that higher input of oxygen increases H_2/CO ratio without affecting the CO/CO_2 ratio in the output gas composition. This appears to be due to higher reaction temperatures across the board as a result of increased oxygen flow rates that permit higher rates of water gas and water-gas shift reactions. Increasing the $[H_2O]/[O_2]$ ratio results in higher H_2/CO ratio in the product gas with slight decrease in the rate of biomass consumption. The rate at which water is consumed by the reactions drops significantly at high $[H_2O]/[O_2]$ ratios. This is due to the water-gas shift reaction due to cooling down of the reduction zone.

Dual pretreatment Strategy for Enhanced Biomass Hydrolysis- John Telotte, Subramanian Ramakrishnan, Florida State University

Cellulosic biomass is a renewable, carbon neutral resource that can be used to generate chemicals that replace petroleum products. Optimal processes for biomass utilization separate the raw material into its constituent parts: hemicellulose, cellulose and lignin, and then offer effective strategies to utilize the chemical components of each part. Dilute acid pretreatment is an effective pretreatment for removal of the hemicellulose component but the remaining cellulose - lignin mixture is still difficult to utilize. In this work we show that a second stage of pretreatment with N-Methyl Morpholine N-Oxide (NMMO) both helps to separate the cellulose and lignin and makes the cellulose more readily digestible by cellulase enzymes. This allows for a near complete fractionation of the biomass into streams that can be easily converted into sugars and other high value chemicals. Specific work accomplished so far has examined the treatment of corn stover and sugar cane bagasse. The corn stover was initially subjected to dilute acid treatment with a sulfuric acid solution and the bagasse was treated with phosphoric acid. The resultant material was then dissolved in NMMO solution and then reprecipitated as an amorphous material. This mass was then reacted with a commercial cellulase enzyme mixture to generate glucose. In both cases, the materials treated with both acid and NMMO, showed the same final conversion to sugars in 24 hours that took 72 hours with acid treatment alone. In this presentation we will show the details of the treatment strategy, compare the reactivity of materials with different treatments and show the overall mass balance for biomass fractionation.

Harvest Power-Christopher Balfe, Molly Bales, Harvest Power Inc.

Harvest Power is an organics recycling and composting company. We build, own, and operate anaerobic digestion and composting facilities in America and Canada. Harvest has partnered with a municipality in Central Florida to anaerobically digest the town's biosolids, food waste, and grease interceptor sludge and produce on-site, renewable energy for the adjacent wastewater treatment

plant. This project is groundbreaking in its mix of feedstocks and system components and has recently started to accept organic materials. Perhaps most importantly, it is an excellent example of a closed-loop organics system: the entire municipality's organics are now being recycled to produce renewable energy and natural fertilizers. The renewable energy powers the treatment plant while the natural fertilizers return nutrients to the municipality's soil. This project is helping the municipality achieve zero waste and energy independence. Harvest's presentation will highlight the Florida project described above while providing some information on Harvest's business model and several of its operating facilities.

Floating cultivation system for low-cost production of algae- Ioannis Dogaris, Ph.D., George Philippidis, Ph.D., Michael Welch, University of South Florida, Andreas Meiser, Ph.D., Lawrence Walmsley, Culture Fuels, Inc.

Algae can potentially revolutionize the manufacturing of bioproducts, including renewable transportation fuels and a variety of chemicals. However, important techno-economic challenges should first be addressed. Productivity and yield under real-world outdoor conditions need to be boosted and water and energy usage needs to be minimized. In pursuit of those goals we have developed a floating algae cultivation platform that is scalable and cost-effective, as it is modular in design and is manufactured from inexpensive plastic film. Its design reduces water usage by 4-fold compared to conventional outdoor systems. In addition, it is engineered to improve CO2 mass transfer and nutrient uptake for enhanced algae cell growth. The cultivation of Nannochloris sp., known as a promising lipid producer, in the floating platform was successfully demonstrated outdoors. Algae growth was monitored to assess the effect of important process variables, such as nutrients and CO2 levels, on biomass productivity. Consistently high biomass productivities and yields have been achieved in semi-continuous outdoor operations over 14 months with no contamination problems. We have recently begun constructing a scale-up facility to demonstrate commercial feasibility and confirm the projected financial performance of the technology.

Dealing with Heterogeneity: The Central Problem with Using Agroindustrial Waste as a Feedstock for Heterotrophic Algae-Thomas Lyons, Eudes de Crecy, BioTork

The major limiting factor for the economic viability of processes involving heterotrophic algae is the cost of feedstock. Expensive feedstocks, such as refined carbohydrates, are far too expensive to allow for the viable production of low-margin chemicals. Consequently, there has been a concerted effort to develop algal fermentation processes that utilize low-cost agroindustrial wastes, such as biodiesel-derived crude glycerol. While this prospect is enticing, the heterogeneity of these substrates presents significant problems. First, these substrates are complex mixtures often containing a host of inhibitory chemicals. Microbes grow less robustly on agroindustrial wastes than they do on refined substrates,which profoundly effects the capex and opex of a proposed biorefinery. Second, the composition of agroindustrial wastes varies from production facility to production facility. For example, the composition of crude glycerol varies greatly depending upon the oil feedstock and the transesterification process, a fact that also profoundly affects the capex and opex of a proposed biorefinery. Thus, the idea of developing a one-size-fits-all alga for crude glycerol—or any other class of agroindustrial waste—is naïve. The only viable approach is to develop a catalogue of algae that are adapted for specific agroindustrial waste streams. A second major key to economic success is robustness, or the ability of an alga to produce the desired chemical fast enough on the feedstock to facilitate an economically competitive process. Robustness is not a

property that can be engineered and even if it could, genetic engineering is not ideal for industrial purposes where an end product (or co-product) is designed for feed markets. Rather, the best way to ensure robustness is through the use of evolution. Herein, we demonstrate the principles of this concept using different samples of biodiesel-derived waste glycerol as substrates for an oil producing heterotrophic alga.

Landfill Gas to Liquid Fuel-Ryan Kent, Ali Gardezi, Dr. Babu Joseph, Dr. John Kuhn, University of South Florida

Landfill gas can be captured, converted, and used as an energy source. Approximately 234 MM tons/year of municipal solid waste is produced in United States, with the average landfill collecting 2800 ft3/min of landfill gas (LFG). Most of this gas is wasted by flaring while landfills spend $8,000 per day on diesel fuel for their vehicle fleet. Using LFG helps to reduce odors and other hazards associated with LFG emissions. Collecting LFG also helps prevent methane and NMOC's from migrating into the atmosphere and contributing to local smog and global climate change. The process involves two specialized catalysts, Ni-Mg supported on Ce0.6Zr 0.4O2 for use in a Tri-reforming reactor, turning CO2 and CH4 into hydrogen and carbon monoxide (syngas). The syngas is converted using a silica eggshell catalyst in the Fischer-Tropsch reactor (FTSR). Using both the tri-reforming and the FTS reactors in tandem enables conversion of the landfill gas directly into a tailored fuel cut of middle distillates (diesel and jet fuel). The catalysts combat current issues of coke formation and formation of less valuable heavier hydrocarbon waxes, lowering the cost of synthetic fossil fuels.

An experimental evaluation and thermochemical modeling of high temperature steam gasification of municipal solid waste (MSW)-Uisung Lee, J.N. Chung, H.A. Ingley, University of Florida

Microalgae have received much attention as a potential energy resource because they contain 250 times more oil per pound of biomass compared to other energy crops, such as soybeans (Hossain et al., 2008). In addition, microalgae do not compete for arable land since they are cultivated in ponds or photobioreactors (Rosch et al., 2012). Despite these benefits, life cycle assessment studies have shown that microalgae biofuel has higher environmental impacts than first generation biofuels due to the nutrient requirements for microalgae cultivation (Clarens et al., 2010). Thus, sustainable microalgae biofuel production system will need to integrate with wastewater as nutrient resources (Guest et al, 2013). A key obstacle of this integration is a lack of understanding of microalgae growth in wastewater which is necessary to improve microalgae productivity. Therefore, the goal of the overall study is to develop a new kinetic model of microalgae growth using wastewater as nutrient resources. The framework of the model was based on the combination of threshold and multiplicative theories. In the model, nitrogen, dissolved carbon dioxide concentrations, and light intensity were selected as major growth factors. The current study and results presented focused on the determination of a rate expression for nitrogen based on existing models.

In this study, Chlorella sp., collected from Howard F. Curren Advanced Wastewater Treatment Plant in Tampa, Florida was used and performed in batch photobioreactors (1L) for 7 days. Synthetic wastewater with a similar composition to centrate from anaerobically digested swine manure was used for the cultivation. The experiment was conducted at a controlled temperature (22±1°C). During the experiment, 5% CO2-air mixture was injected through a fine bubble diffuser in the

reactors (with the flow rate 400ml/min). The reactors were illuminated by 13W and 20W fluorescent lamps (24:0 h light-dark cycles) to provide the desired light intensity (5000lux).

Microalgal biomass concentrations were measured with time for different initial concentrations of nitrogen (0-308ml/L) with/without organic carbon in synthetic wastewater. The Haldane–Andrews model was found to fit best to the experimental data. Kinetic parameters of the Haldane–Andrews models were determined by fitting the experimental data to the relationship between specific growth rate (μ) and initial nitrogen concentration obtained from the growth curves. The parameters for microalgae growing in the wastewater (without organic carbon) were μmax = 2.32 d-1, Ks=140 mg/L as N, and Ki= 25 mg/L as N (R2=0.8014), while the parameters in the wastewater containing organic carbon were μmax = 17.12 d-1, Ks=229 mg/L as N, and Ki= 12.9 mg/L as N (R2=0.7694). The results showed that the μmax and Ks values in wastewater containing organic carbon were high because the organic carbon is readily bioavailable so that it stimulates the microalgae growth (Liang et al., 2009; Ogawa & Aiba, 1981). It indicated that the Haldane-Andrews model can describe the growth kinetic in terms of N with inhibition of NH3. Thus, the Haldane-Andrew model is an appropriate rate expression for nitrogen in the new model.

Track II: Smart Grid

Power Quality Impact Study For Interconnection of Heterogeneous Distributed Energy Resources-Ali Hariri, Omar Faruque, FSU Center For Advanced Power Systems

In this work, we will investigate the combined impact on power quality due the interconnection of multiple Distributed Generators (DG) on a distribution utility feeder. Our objective is to investigate power quality issues such as voltage sag/swell followed by transient events, harmonics or dc injection due to the interconnection of power electronic based converters, the effects of injection of low frequency (different from power frequency) anti-islanding signal injection, flicker issue due to the variability in wind velocity and solar irradiation. Literature review suggests that some work has been done in this area where either a single source of DG is connected to a small scale test system or multiple DG of same technology (PV or wind) were used to investigate the impacts. However, our approach will use the model of a real (a Florida based utility feeder) test system with multiple DG plant models using heterogeneous technologies such as inverter based and rotary machine based applications (induction generator and synchronous generator) found in various DG technologies. In addition, we would also conduct the impact of low-frequency harmonic injection (used for anti-islanding detection) on voltage and current THDs (Total harmonic Distortion). We will leverage the available data from a DOE sponsored project conducted at the Center for Advanced Power Systems (CAPS).

Recent Fuel Cell Research Activities at FSEC-Ali T-Raissi, UCF-Florida Solar Energy Center

Fuel cells are viable means to meet future energy demands. However, significant research must be accomplished in several key areas in order to achieve economic feasibility. Some of these research areas include membrane stability and catalyst performance. This poster will highlight the use of FESC funding to provide the framework for several follow-on projects obtained through alternate funding sources. The success of the follow-on projects was a direct result of the initial investment by FESC.

Ultra-Compact Portable Power: Direct Methanol Fuel Cell Open-Cathode System-Fenner Colson, Matt Inman, University of Florida

Researchers at the University of North Florida and the University of Florida have developed a novel Direct Methanol Fuel Cell (DMFC) for powering portable electronics in the 10-100 W power class. DMFCs represent a promising alternative to traditional batteries for long-duration operation, but until recently were marginally suited for mobile applications due to their bulky architecture, mostly attributed to the cathode exit water recovery system required to continuously re-supply the anode reaction. By utilizing a patented Liquid Barrier Layer (LBL) in the fuel cell, the DMFC system presented here performs this task passively, eliminating many bulky, water-related components. A prototype of this simplified architecture has been tested for long-duration performance in CERDEC labs and has shown remarkable energy density characteristics, far exceeding those of current, top-of-the-line Li-Ion batteries and other commercially available DMFCs in the same power class. Ongoing research at UF is geared towards further optimizing the LBL to expand the operational envelope of the DFMC to higher ambient temperatures.

Microstructure effects on the capacity, power, and energy density of metal-air batteries for large grid storage applications- Petru Andrei, Vamsci Bevara, Florida State University

The penetration of renewable energy sources in our national grid is estimated to increase dramatically in the near future. It is estimated that the current national grid can support penetration levels of 10%-15% but needs major modifications in planning and operational practices in order to support penetration levels larger than 20%. Among the most important such modifications is the introduction of energy storage elements distributed across the grid to smooth the fluctuations of the power created by renewable sources. The new energy storage devices need to be scaled up to power ratings over 10 GW and energy capacities over 10 GW·h per device in order to compensate for the power fluctuations. In this presentation we discuss the effects of particle and pore size distributions on the specific capacity, power density, and energy density of metal-air batteries. The presentation will mostly focus on the effects of the microscopic structure of the cathode of Li-air and Li-metal batteries on the above mentioned quantities, but will also include a discussion of other types of batteries such as batteries based on sodium metal, LiCoO2, etc. Methods to improve the energy density of Li-based batteries will also be presented. The presentation will also give an overview of modeling and simulation efforts on energy storage devices (including batteries, fuel cells, and super capacitors) in our research group and will present the features of our in-house developed simulator for electrochemical systems, RandFlux [2]. The simulator can be used to model the discharge characteristics (including the power and energy densities) of most batteries (including Li-ion, Li-air, Li-oxygen, other metal batteries), fuel cells, and super capacitors.

Nanomaterials for enhancing electrochemical energy storage-Wolfgang Sigmund, Rui Qing, University of Florida

Large scale electrochemical energy storage requires several key aspects to be enabled. One of them is to make the materials as safe as possible, i.e. reducing thermal stresses, electrochemical induced stresses as well as removing reactive compounds. For mass application cost is also a major concern. We reported and patented several novel electrode materials over the past years. This talk and poster will highlight some of them. For example titania (pigment found in paint) is a low cost electrode material that we tailored into an attractive anode for lithium ion batteries. It removes carbon from the anode and has almost no volume change from fully charging to discharging. The

poster will also highlight other materials that were designed and realized for highest energy densities, i.e. enabling better batteries for plug in vehicles

The Effects of the Discharge Product on the Discharge Characteristics of Li-air Batteries- Vamsci V. Bevara, Petru Andrei, Florida State University

Growing greenhouse gas emissions and degrading air quality, mainly in cities, due to automobiles powered by fossil fuels has resulted in a shift in interest towards renewable energy sources and storage technologies. Lithium based battery technologies like Li-ion and Li-air batteries have relatively high energy densities and so have received more attention. Li-air batteries in particular have a theoretical energy density approximately 5-10 times that of Li-ion batteries and comparable to that of gasoline. This relatively high specific energy density in Li-air batteries is due to the fact that one of the reactants, oxygen, is not stored in the cathode but is taken from the atmosphere. Despite, the high theoretical energy density, Li-air batteries face a major challenge, which is, limited practical capacity during discharge. The net electrochemical reaction during discharge in a Lithium-air battery with organic electrolyte results in the formation of lithium peroxide (Li_2O_2) due to the reversible reaction between Li metal and oxygen. This reaction/discharge product (Li_2O_2) is insoluble in the organic electrolyte and forms solid layers in the porous carbon cathode. It can be argued that the limited capacity of Li-air batteries is due to pore clogging in the cathode and the inability of oxygen to diffuse into the cell for the electrochemical reaction to take place. The discharge characteristics of a Li-air battery obtained using finite-element simulations shows a sudden drop in cell voltage from around 2.5 V to a potential less than 2 V. This sudden death of the battery might be the result of various phenomenon occurring in the battery. One theory as discussed above suggests that discharge product formation is more at the battery surface resulting in low oxygen transport into the cathode. The electrochemical reaction can no longer proceed due to a lack of oxygen, resulting in very limited formation of lithium peroxide inside the cathode and very ineffective use of the porous volume of the battery. This explains the limited capacity of the batteries as compared to the theoretical possible capacity given by the pore volume. Catalysts have therefore been used to improve reaction dynamics inside the battery for an effective utilization of pore volume. Another theory is that the discharge product has a very high resistance which increases with the thickness of the deposited Li_2O_2. This resistance results in an increasing voltage drop across the deposit layer as the discharge progresses, thereby reducing the battery potential as observed. The discharge product layer can also be treated as a barrier for the electron to tunnel through to participate in the electrochemical reaction. A few studies describe a critical tunneling length, beyond which tunneling can no longer be possible. The critical tunneling length according to those studies is usually 5-10 nm. Thus, the sudden death of the battery, in this case can be attributed to, thickness of the discharge product formed exceeding the critical tunneling length. The last two models for the discharge product provide simulated discharge curves of the battery which are comparable to the experimental discharge characteristics.

Non-Destructive Testing and Quality Control Technologies. Ensuring High Quality, Safety and Reliability of New Generation Batteries - Volodymyr Redko, Elena Shembel, Enerize Corp.

For ensuring high quality, safety and reliability of new generation Li-ion batteries Enerize developed proprietary non-destructive non-contact electromagnetic, holographic interferometry, gas discharge visualization, and combined methods and devices. These methods could be used for evaluation of the properties of nano-structured powder of electrode materials, polymer and solid inorganic electrolytes, interface of multi-layered electrode structures, semi-product and final product during new generation

battery production. The safety and reliability of the final product are determined mainly by its basic technology, design and materials. However, without adequate quality control during manufacture, defects in even the best designs can lead to inconsistent performance and early failure. Deployment of automated quality assurance technology at every stage of the manufacturing and assembly process will increase the reliability and safety of batteries while lowering overall manufacturing costs by reducing wastage and preventing defective components from being incorporated into the finished product. The list of the non-destructive & non-contact methods and devices developed by Enerize includes but not limited the following:

- Holographic interferometry for non-destructive testing of battery components during production.
- Electromagnetic non-destructive non-contact testing of dry multi-layer structure and hidden defects evaluation.
- Non-destructive non-contact combined electromagnetic & ultrasonic systems for determination of bulk conductivity & electromagnetic properties of powdered materials, including nanostructured. Electromagnetic non-destructive capacitance method for testing electromagnetic properties and chemical composition of materials during synthesis.
- Electromagnetic eddy-current testing for determination of the interface resistance between current collector and active electrode mass.
- High voltage gas discharge visualization method for quality assurance of hermetically sealed devices
- Non-contact electromagnetic measurement of thickness and electro-physical parameters electrodes during coating.
- Non-destructive non-contact testing of the conductivity of thin film polymer and solid inorganic electrolytes.
- Non-destructive non-contact detection of hidden faults in collector welding of batteries and ultracapacitors;

These methods are based on the interaction of different vector and scalar fields with the test article:

- Wave acoustic fields of different polarization;
- Potential electrical and magnetic fields;
- Vector eddy magnetic fields;
- Gradient heat fields (infra-red spectrum);
- Electron emission fields;
- Glow fields of high voltage pulse discharges.

Mathematical constructs are used for process description and modeling. They provide indications of main analytical dependences between the parameters of the excitation / probe fields and geometric and electro-physical characteristics of the test article. Describing the wave process of elastic waves in isotropic and anisotropic media; Maxwell and Laplace equations; Mathematics of spectral transformations in different orthogonal bases; Theory of wave diffraction processes; Methods of defection of identification and treatment of images using fuzzy logic and artificial neural networks;
Noise resistant method of the wavelet Noise resistant method of the wavelet.

Developed non-destructive testing methods & devices enable to optimize the technology, and quality of initial materials, components, and final product, including in-line control during battery production. Enerize owns 12 US patents, and 1 UK patent in the area of non-destructive testing.

Power Quality Improvement of Electric Vehicle DC Charging Stations Utilizing UPQC and SFCL- M.H. Amini, Arif Sarwat, A.H. Moghadasi, M. Jamei, Florida International University

Electric transportation is an inevitable element of the Smart Grid (SG). High penetration of Electric Vehicles (EVs) may disturb the power quality. In this paper, firstly a comprehensive model of EV parking lots based on the probabilistic behavior of the drivers will be obtained. Among different charging modes, DC charging station (DCCS) is selected for the simulation purposes. This fast and direct charge of electricity recharges the battery in a considerably short time interval, giving EV drivers exceptional freedom. DCCS connection to the power grid will be established by rectifier. Hence, it causes current harmonics and disturbances for the power quality. Unified Power Quality Conditioner (UPQC) is utilized to the integration of series and shunt active filters and analysis of the combination of UPQC and superconducting fault current limiter (SFCL) are presented to satisfy the power quality requirements of the DCCS. SFCL aids on reduction in Volt-Ampere rating of the UPQC with limiting the excessive current when fault occurs. The analyses and simulations will be carried out by PSCAD/EMTDC to demonstrate the considerable effect of the control by SFCL on rating reduction of the UPQC.

Buildings as batteries: inexpensive ancillary service to the grid from HVAC systems-Yashen Lin,Prabir Barooah, Sean Meyn, University of Florida

Automated demand response can be a valuable resource for ancillary services in the power grid. This talk/poster illustrates this value with the first experimental demonstration of frequency regulation from commercial building Heating Ventilation and Air Conditioning (HVAC) systems. The experiments were conducted in a 40,000 sq. ft. commercial building located at the University of Florida campus. Detailed are the steps required to make this possible, including control architecture, system identification, and control design. Experiments demonstrate: 1. Satisfactory frequency regulation service can be provided by the HVAC system without noticeable effect on the indoor climate, and 2. The ancillary service provided by this system passes the qualification criteria for participating in PJM Interconnection's frequency regulation market. The system is easy and inexpensive to deploy since it doesn't involve any equipment change, it is merely a software add on to existing HVAC systems. The ancillary service provided by HVAC systems can span the time scale of from a few seconds to an hour or more, depending on the level of control available. The combined capacity of the commercial buildings in the U.S. with the necessary HVAC equipment in place is estimated to be around 6 GW.

Hydrogen Energy Storage for On-Board Fuel Cells, Concentrated Solar Power and Secondary Batteries- Sesha Srinivasan, Tuskegee University, D. Yogi Goswami, Elias K. Stefanakos, Dervis Emre Demirocak, University of South Florida, Sarada Kuravi, Florida Institute of Technology, Ryan Integlia, Jorge Vargas, Florida Polytech University

Hydrogen is not a primary source of alternative energy like solar and wind. But hydrogen can be derived via various processes such as solar PV, biomass, photo-electrochemical etc. Once produced, an atomic hydrogen behaves like a lean burning fuel in (IC) combustion engines or an active ingredient source for PEM type fuel cells. Usage of hydrogen for stationary and mobile applications not only mitigate the carbon footprints from our atmosphere but also enables energy efficient processes. The role of hydrides because of their temperature swing properties, are currently

employed to replace thermochemical energy storage in a concentrated solar power plants. For an electrochemical batteries such as Ni-MH, an added strength of developing light weight hydride electrodes lead for improving the available energy density and the overall battery life as well. Based on the rationale discussed above, this presentation is focused to highlight the salient features of hydrogen based research for fostering project based learning for STEM education and applied research.

Development and characterization of novel metal chloride thermal storage media with enhanced heat transfer- Philip D. Myers, D. Yogi Goswami, Elias Stefanakos, University of South Florida

Molten inorganic salts hold a great deal of promise as high-temperature heat transfer fluids and thermal storage media in renewable energy applications, and they have found use in nuclear and solar thermal power. As phase-change materials (PCMs) for thermal storage, chloride salts are especially promising—high latent heat of fusion and resistance to supercooling allow for high energy storage density and consistent energy delivery at design temperature. They are, however, hampered by relatively low thermal conductivity (less than 1 W/m-K in the molten state).

This study describes the development and characterization of novel high-temperature storage media, based on inclusion of transition metal chlorides in the potassium-sodium chloride eutectoid, (K-Na)Cl (melting temperature of 657°C, latent heat of 305 J/g). At the melting temperature of (K-Na)Cl, infrared (IR) radiation can play a major role in the overall heat transfer process—90 percent of spectral blackbody radiation falls in the range of 2 to 13 µm. Inclusion of small amounts (0.5 wt %) of IR-active transition metal chlorides can greatly improve heat transfer rates.

Determining the degree of improvement requires measurement of the absorption coefficient in the spectral range of interest. Unfortunately, traditional spectroscopic methods are ill-suited for work with molten salts: direct transmittance measurements overestimate absorption if they do not capture backscattering, and window materials (e.g., quartz) are prone to corrosion by these molten salts. A new IR reflectance apparatus was constructed to allow for determination of the spectral absorption coefficient of the newly formulated PCMs in the molten state. The apparatus consisted of an alumina crucible coated at the bottom with a reflective platinum surface, a ceramic heating element housing the crucible, and appropriately chosen window materials for containment of the salt and allowance of inert purge gas flow. Using this apparatus, infrared spectra were obtained for

various transition metal chloride additives in (K-Na)Cl, and improved infrared activity and radiative transfer properties were quantified.

Encapsulation of the Phase Change Materials and Its Application in Thermal Energy Storage System- Tanvir E Alam, Jaspreet Dhau, D. Y. Goswami , E. Stefanakos, University of South Florida

Thermal energy storage (TES) is a key solution to the long standing issue of the intermittency of the renewable energy resources. The sensible heat storage is being widely used for TES systems. However, the low energy storage density of the sensible storage materials makes these systems large and expensive. Since the phase change materials (PCMs) have larger specific storage capacity, it reduces the overall storage cost by ensuring a more compact, efficient and economical TES system. The large volumetric expansion of the PCM during phase transition coupled with its low

thermal conductivity makes the implementation of these systems quite challenging. A number of methods have been proposed to address the low conductivity of the PCMs. One of the most promising ways is to increase the surface area to volume ratio of the PCM. This can be achieved by the encapsulation of the PCM. We have developed an innovative technique to encapsulate the PCMs that melt in the 120oC-400oC temperature range which include; sodium-, potassium- and lithium nitrate, and their eutectics. The encapsulation process is a two-step approach. In the first step, the PCM pellet is coated with a benign polymer layer, and in the second step a layer of metal is deposited by electroless and electroplating techniques. The tested capsules have survived more than 2000 thermal cycles which is equivalent to more than 6 years of working environment. The thermo-physical properties of the PCMs were investigated by DSC/DTA, IR and weight change analysis at various stages of thermal testing. No significant change in the thermo-physical properties was noticed. The fabricated capsules are being tested in a lab-scale packed bed in order to test the storage capacity, and charging-discharging time at different flow rate of the heat transfer fluids.

Monday, May 12- 3:10-4:10 pm
SESSION II: SOLAR ENERGY AND ENERGY EFFICIENCY PANEL SESSION

Track I: Solar Energy

Advances in Micro-inverter Technologies-Issa Batarseh, Ahmadreza Amirahmadi, Lin Chen, University of Central Florida

Distributed solar energy systems, which take granularity of large-scale solar farms down to tens kilowatts per unit or even further down to a single PV panel, will be a tendency for future solar PV deployment because of the remarkable merits such as: Easy modularization and scalability; Elimination of single point failure; Simple installation and maintenance, High efficiency and low cost. Micro-inverters, one of typical distributed PV systems, are small grid-tie inverters of 150-400W that convert the output of a single PV panel to AC. The micro-inverters AC outputs are connected in parallel and routed to a common AC coupling point. No series or parallel DC connections are made leaving all DC wiring at a relatively low voltage level of a single panel. Micro-inverters can be further integrated into PV modules to realize a true Plug-and-Play solar AC PV generation system. AC PV modules with integrated micro-inverters have significant advantages over traditional PV systems since they allow Maximum Peak Power Tracking (MPPT) on each solar panel to maximize energy harvesting, and offer distributed and redundant system architecture. Previous approaches for the PV micro-inverters are mainly in the form of single-phase grid connected and they aim at the residential and commercial rooftop applications. It would be advantageous to extend the micro-inverter concept to large size PV installations such as MW-class solar farms where three-phase AC connections are used. Unlike single-phase systems, where a bulky power decoupling capacitor is required to buffer the fluctuated injected power, balanced three-phase system draws constant power from the proposed three-phase micro-inverter, which will minimize the DC link capacitance and allow for the long lifetime capacitors to be used. A soft-switched two-stage architecture for the three-phase micro-inverter is implemented. It aims at standard PV panels with low output voltage and nearly 83% market share. More specifically, the proposed three-phase distributed AC micro-inverter architecture would offer the following advantages: No mismatch losses due to parallel connection of PV modules: Micro-inverters effectively connect all the panels in parallel eliminating any mismatch losses between panels; Ease of installation through flexible and modular solar farm design: Micro-inverters would greatly reduce installation costs associated with wiring, cabling, DC

bus disconnections, and large size inverters since each micro-inverter would generate AC power that could be directly coupled to the grid; Possible cost reduction due to mass production: Due to the large potential volumes of micro-inverters, economies of scale could be realized resulting in potential cost reduction to meet cost targets; Improved reliability by effectively reducing the number of components per watt compared to that of equivalent single-phase AC modules; Reduced in dollars per watt since one inverter is now amortized over higher level of power; and finally eliminated the need of an expensive custom AC cable that is required to balance the number of single phase inverters per phase.

Photomechanics of Liquid Crystal Polymer Networks-William Oates, Florida State University

The ability to directly convert visible light into mechanical work provides many opportunities in the field of smart materials and adaptive structures ranging from biomedical applications to control of heliostat mirrors for solar harvesting. The complexities associated with coupling time-dependent Maxwell's equations with linear momentum is discussed by introducing a set of optical mode order parameters that govern the coupling between electromagnetic radiation and mechanics of a photodeformable solid. Numerical examples are given illustrating how this methodology is applied to a special class of liquid crystal polymer networks containing azobenzene. The dynamics associated with light absorption and its effect on deformation of the polymer are solved in three dimensions using finite difference methods and compared to experimental results. Particular emphasis is placed on the effect of polarized light on microstructure evolution and stresses that occur during photoisomerization of the optically active microstructure.

Distributed & Mobile Solar Electricity Generation with Energy Storage Devices and Application to PrePaid (PPD) Technology for the Latin America marketplace-Albert Rodriguez, ATI Energia LLC ATI Companies Group

The ATI Energia approach to Solar Electricity Generation focuses on Distributed-Community-Mobile Generation and is developing a PPD application for the Latin American Marketplace.

The ATI Solar Lounge is a prototype of a demonstrable “Modular and Scalable” system that can operate On or Off Grid 24 hours a day supplying low cost alternate energy. This technology can be applied to power Off-Grid Communities in Latin America and the outlying villages with a Prepaid (PPD) Technology application. In Latin America as in all developing countries, Prepaid Wireless Services is the norm and was the leading driver of the expansion of telecommunications provisioning as it employed a pay as you go financial model. A similar market opportunity can be expected for PPD Solar Electricity that will bring reliable power to the entire continent and propel LATAM into a new era of growth and improvement of quality of life.

Wireless Communications in Latin America was a Transformational Technology. In the year 2000, 5 years after BellSouth initiated operations in Latin America, Wireless Activations surpassed Wire-line connections (Figure 1). This was possible thanks to Technology that was NOT dependent on the existing infrastructure. The same can and will occur with Electricity Generation: Leapfrogging Infrastructure Development from a Fixed-line Centralized Electric Power generation to a Distributed Power Generation. ATI Energia is continuing to develop this concept using an initial applications of this model for Back-up Power and Cost Reduction in various locations. ATI Energia OFF Grid System Technical Description. The demo model for this system is available in the ATI Solar Trailer. The actual trailer was manufactured by GT Express Enterprises and is 16 feet long. It has been converted

to a Solar System Demonstration trailer by ATI-Energia. The trailer is a self-contained "apartment" or office complete with air conditioning, seating, work area(s) and communications as well as WiFi and cable access.

It has a 1750 watt solar system that can stand on its own or tied to the grid. This PV array is subdivided into 2 components. The first sub-array is a 6 panel system rated at 1050 watts at ~70 volts, mounted on the roof of the display trailer with a UniRac hybrid track. The second sub-array is a 4 module system rated at 700 watts at ~70 volts on a portable UniRac hybrid rack that travels inside the trailer. A complete Technical Description will be part of the presentation at Go Solar Fest. The ATI Off and On-Grid PV System was designed with the developing countries as a model but is can also be used as a project and construction site trailer. It is a modular system that can be adapted to any size requirement (with a minimum of 1.5 KW). The concept was developed after meetings with the FIS (Fondo de Inversion Social) in Panama and defining the basic needs of Darien, a community in Panama. This system is designed to also plug into the grid to charge the battery array, run the devices in the trailer, or feed power back into the grid. All of these devices are connected through the Switchgear Module, which handles the current flow with breakers and hard connections within the unit.

Overall, this is an excellent example of the power of the sun and of man to harness and use its power. This application can be scaled up or down in size and it can be used on construction sites, rural areas and remote underdeveloped regions of the world or anywhere where there is a need for conventional operations with no conventional infrastructure.

Nanostructured Transparent Polymer for Encapsulation of PV Modules and Optical Devices. Breakthrough in Design and Properties of Solar Cells - Elena Shembel, Enerize Corporation

Enerize Corporation presents nano structured transparent polymer technology for encapsulation of different type of photovoltaic modules, including silicon based, flexible non silicon based (for example CIGS), organic and DSSC modules, organic light-emitting diodes (OLED), and other applications for optical devices.

Enerize novel technology includes patent pending nano structured transparent polymer, which is flexible, durable, has high level of adhesion for various materials, provides high level of hermetic sealing (waterproof) and UV protection, and contains nanostructured clusters with sizes from 20 to 100 nanometers, and micro-domains from 15 to 120 microns. Such composition of nanostructured clusters and micro-domains, located in a certain order in the volume of the polymer, results in micro lensing which increases the concentration of light reaching the semiconductor layer. As a result, the performance of PV modules encapsulated with one layer of Enerize nano structured transparent polymer improves as compared with PV modules laminated with glass or encapsulated with multilayer structure of other polymers.

Enerize single film nano structured transparent polymer materials are coated directly on the surface of solar cells or modules, and do not need any additional lamination with glass or polymer layers to deliver durable encapsulation.

Combination of the high efficiency PV modules for energy generation, and high energy Li-ion battery for energy storage is one of the key factor of the successfully using the solar energy.

We will present results of the investigation the structure and evaluation the properties of the nanopolymer and PV modules encapsulated with nanopolymer. We will present also the properties of high energy solid state Li-ion battery for energy storage.

The key component of the PV module is a single layer nano-structured optical polymer enabling solar modules of all types to be cheaper, lighter and deliver higher efficiency via encapsulation vs. glass or multilayer polymer coating. The key components of solid state Li-ion battery: leading-edge cathode, anode based on the composition of graphite and silicon, and solid high ionic conductive electrolyte.

Effective Doping of CdTe towards High Efficiency Thin Film Solar Cell- M. I. Khan, S. Collins and C. Ferekides, University of South Florida

Over the past two decades Cadmium Telluride (CdTe) based thin film photovoltaic technology has proven itself as a promising contender in the ever-growing renewable energy industry. Laboratory efficiencies of CdTe solar cells have reached the 20% mark, yet a lot more is to be achieved considering its much higher theoretical efficiency limit. At the current developmental stage, the bottleneck towards higher efficiency is the doping concentration which directly influences the attainable open-circuit voltage (VOC). However, conventional approach of increased doping is associated with poor carrier lifetime which negatively affects the current output of the solar cell. This study investigates a path towards attaining good VOC while simultaneously maintaining a decent carrier lifetime. CdTe is a group II-VI defect semiconductor with bipolar intrinsic doping capability. Excess Cd yields n-type conductivity in CdTe while excess Te produces p-type. A system has been developed with the capability of controlling the stoichiometry (hence the intrinsic doping) of CdTe films by varying the gas phase ratio of Cadmium (Cd) and Tellurium (Te), known as the Elemental Vapor Transport (EVT) process. EVT mechanism allows in situ control over the concentration of the native defects in a compound material deposition. For CdTe in photovoltaic device applications, this means enhanced intrinsic doping and opportunity for incorporation of extrinsic dopants by creating suitable vacancies. The study of the electronic properties of the deposited films and fabricated solar cells suggested variation of the native intrinsic defects as a function of gas phase Cd to Te ratio. This would allow creating the favorable conditions that need to be met to effectively introduce external dopants towards a higher efficiency solar cell.

Cooling Channel Analysis to Enhance the Efficiency of Photovoltaic Panels- Obiechina Abakporo, Dr. Juan Ordonez, Dr. Alejandro Rivera, Florida A&M University

The efficiency and lifespan of sustainable energy technologies can significantly decrease due to the overheating of cells in the device. Theoretically, it is known that temperature influences power degradation by approximately 0.5% per degree Celsius in photovoltaic systems. The primary objective of this project is to develop improvements to current solar panel prototypes currently being used by reducing the operating temperature of the device. To accomplish this goal, heat sinks designed with cooling channels for photovoltaic panels were simulated under various circumstances using COMSOL Multiphysics to thoroughly analyze the methods that will maintain and/or achieve the optimum power output. The emphasis of this project is the heat transfer analysis of the cooling methods that is examined through simulation. The focus is placed on forced convection cooling by way of a propeller fan, but natural convection will also be considered and accounted for in the future. Optimized power production by the PV is calculated as a function of fin spacing, and air flow

velocity of the attached heat sink and fan, respectively. The primary fluid used for cooling is air due to both natural availability and abundance. Heat transfer analysis is essential to the successful development and implementation of sustainable energy technologies on a global scale. The results acquired from the data of this project illustrate that photovoltaic panel energy conversion efficiency can be increased by about 11% with an effective cooling system applied. In principle, Fuel cells and potentially other alternative energy technologies can be cooled in the same manner, reinforcing the versatility, longevity, and dependability of these applications.

Integration of Transparent Insulation Materials into Solar Collection Devices-Sam Yang, Alejandro Rivera, Juan Ordonez, FSU Center for Advanced Power Systems

Rapid growth in solar thermal energy research (i.e. flat-plate, parabolic trough, solar tower, etc.) has sparked the demand for a heat transfer fluid (HTF) achieving high stagnation temperatures. In parallel to such demand, material and geometric optimizations for these collectors have become forefront research topics. In terms of material optimization, advanced glazing materials from products like plastics, polymer sheets, capillaries and cellular profiles have been broadly investigated to be used as effective thermal insulations. These glazing materials, also referred as transparent insulation materials (TIM), are solar transparent while providing good thermal insulation, and their fundamental physical principle lies in the wavelength difference between the absorbed solar radiation and the emitted infrared (IR) radiation. A review of related studies of different geometries and material configurations of TIM shows that a general mathematical model describing the thermal performance of a solar collector with any material and geometric configuration of TIM is lacking, however. Additionally, no research and development in integrating TIM into a parabolic trough receiver (PTR) has been performed yet. Hence in this research, a general model for a flat-plate (FPC) and for a parabolic trough solar collectors (PTC) equipped with TIM are derived, comparative studies of each system is performed, and their overall performance and potential to improve the collector efficiency are evaluated. Simulation results show that TIM integrated collectors achieve higher thermal efficiencies compared to conventional ones, with larger thermal resistance between the absorber and the outer cover using commercialized materials like glasses.

Air-Processed Polymer-Fullerene Bulk Heterojunction Solar Cells With Higher Than 6% Efficiency- Iordania Constantinou, John R. Reynolds, Franky So, University of Florida

Organic photovoltaic (OPV) cells have been a topic of research focus in recent years as they are a low cost renewable energy source due to their compatibility with large scale, flexible and high throughput roll-to-roll production. Even though power conversion efficiencies over 10% have been reached for polymeric solar cells, most reported high efficiency results are based on solar cells processed in a nitrogen atmosphere in order to avoid oxygen and moisture - the main causes for degradation. For this technology to be commercialized, polymers that can withstand oxygen and moisture without significant degradation during processing are desirable.
In this report, polydithienogermole-thienopyrrolodione (PDTG-TPD) was used to demonstrate good air processability while maintaining high efficiency. A bulk heterojunction device was made with P(DTG-TPD) as the donor and PC70BM as the acceptor. Comparing devices made in air and in nitrogen atmosphere, only a 7% decrease in device performance was observed for the devices with the bulk heterjunction film processed in air. Power conversion efficiencies over 6% were achieved

with an open circuit voltage of 0.83 V and a short circuit current of 12.6 mA/cm2, which to our knowledge is the highest efficiency reported for OPV cells with an active layer processed in air.

Development of Novel Water Splitting Materials for the Production of Renewable Hydrogen-Samantha Roberts, Helena E. Hagelin-Weaver, University of Florida

Thermochemical water splitting offers a unique alternative to the demand for alternative hydrogen energy to replace fossil fuels. This process produces hydrogen from water using renewable solar energy. Direct water splitting occurs unfavorably at extremely high temperatures (2300 °C) and requires product gas separation. Utilizing the iron oxide two-step reaction cycle allows for water splitting to be safely separated into two reactions (water splitting and thermal reduction) and lowers the operating temperature significantly (1500 °C). In this project, water is passed over a reduced iron oxide material to generate hydrogen while the oxygen is taken up by the oxygen-deficient iron oxide. In the second reaction, the resulting iron oxide is heated to release oxygen and regenerate the reduced reactive material to close the cycle.

Under high temperature operating conditions, reactive materials can undergo detrimental sintering effects that can limit diffusion transport and severely reduce the surface area available for reaction. Our novel reactive material development approach makes use of high temperature ceramic oxide powder supports, such as nanoparticle zirconia and yttria-stabilized zirconia (YSZ), which can be implemented to increase thermal shock resistance. This research investigates the hydrogen production activity and stability of iron oxides on these types of oxide supports and how these reactive materials improve oxygen mobility, lower operating temperatures, and improve the water splitting reaction. These studies are intended to develop reactive materials with increased activity and limited sintering effects for multiple reaction cycles.

Kinetic and Material Analysis for Solar Fuel Production-Michael Bobek, Nathan Rhodes, David Hahn, University of Florida

A solar fuels generation research program is focused on solar fuels production by means of reactive metal CO2 splitting in a cyclic metal oxide redox process. Ceria oxides are explored as an intermediary reactive material to dissociate CO2 molecules. In order to exploit the unique characteristics of highly reactive materials and ultimately achieve the potential efficiency gains at the solar reactor scale, laboratory scale TGA has been used to explore the redox cycle at temperatures ranging from 1373-1723 K for up to 2000 cycles. The extent and stability of reactive potential over these cycles are qualified with resultant TG data. Using high resolution SEM and electron dispersive X-ray spectroscopy (EDS), the oxide morphology and the oxide state are quantified; including spatial distributions and the stability of the porous structure is examined over the many cycles.

Energy Glass - The Next Generation in Solar Energy Production with Enhanced Building Physical Security-Theron Colbert, TiRC Energy Engineering, International Professional LLC

Next to the economy – energy is the biggest concern to most citizens – safe, reliable service at a reasonable price which conserves natural resources and protects the environment. National leaders are looking for innovative ways to reduce energy consumption and carbon footprint, while developing more efficient methods of power generation. This is especially a vital realization, considering that electricity demand will increase considerably over next several years (and for decades to come), while growth in power generation capacity is precarious at best, and the certainty

that fuel and electrical generation costs are also set to increase substantially. Energy Glass™ is the world's only patented optically clear building-integrated photovoltaic (BIPV) window system that produces continuous energy from sunlight, diffused or ambient light and ground reflectance. Power intensive buildings now have the ability to be transformed into solar energy farms. Unlike conventional photovoltaic or thin-film applications which generate energy for only 4-6 hours per day at peak efficiency, Energy Glass™ produces 1-2 watts per square-foot per hour 10-12 hours/day and 3-4 watts at peak. Energy Glass™ also does not degrade from infrared solar radiation like typical PV cells. Energy Glass™ consists of a sheet of polycarbonate laminate infused with nano-particles, sandwiched between two pieces of glass. The nano-particles direct light into the window frame, where solar cells at the perimeter convert the light into electricity. Energy Glass™ is an extremely practical and common-sense solution to the challenges growing countries faces in desiring to increase renewable energy production, yet at the same time, it resolves the dilemma of the lack of space for roof-top solar PV panels in the highly populated modern cities, by taking advantage of the obvious abundant tall vertical office building space. Buildings quite obviously already need to have structural glass installed, so the added benefit of solar energy production is makes Energy Glass™ such a far superior product, that it actually would not make any sense to install anything else, given its inherent energy producing properties. Energy Glass™ answers the requirement for both enhanced physical security and energy cost savings, as it is also available in high-grade bullet resistant, blast resistant, physical attack resistant (prison glass), natural disaster resistant (earthquake, tornado, hurricane) and fire resistant glass designs.

In U.S. states and territories with a "net-energy" electric bill metering system, businesses and citizens receive a credit applied towards their utility company's account for surplus energy generated by the facility's renewable power system. Energy Glass™ can also supply power to renewable battery energy storage systems, which can augment building power with stored renewable energy during high energy usage operational times when kWh energy charges peak. For a fraction of the economic and environmental price of constructing a power plant, renewable energy technologies such as Energy Glass™ can substantially aid industrialized nations in controlling energy costs – minus the pollution, environmental damage, natural resources depletion, and recurring operating, labor and fuel costs. When additionally factoring in its inherent energy cost savings properties, the decision to install Energy Glass™ windows is as clear as glass.

A Mathematical Model for Performance Prediction of a Hybrid PV/T Module for Hot and Humid Climates - Cheng-Xian Lin, Francisco Emilio Zevallos, Florida International University

In this study, the performance of an integrated solar photovoltaic and thermal (PV/T) liquid (water) collector for hot and humid climates is investigated. A detailed thermal model is formulated to calculate and correlate the thermal parameters a standard PV/T collector, including solar cell temperature, back surface temperature, outlet water temperature, as well as the electrical parameters including open-circuit voltage, short circuit current, maximum power point voltage, and maximum power point current. An analytical expression for the overall energy efficiency of the PV/T collector is derived in terms of thermal, electrical, design and climatic parameters. A computer simulation program is developed to calculate both the thermal and electrical performance of the PV/T collector. The results of the computational simulation are found in good agreement with the experimental results reported in the literature. Furthermore, the authors made corrections to previous thermal and electrical models, which allowed us to observe that the thermal simulation results are more precise than those previously reported in the published papers. Based on the energy balance of each component of the system, an analytical expression for the temperature of the PV module and the water have also been derived.

Solar Water Heating as a Green House Gas Reduction and Energy Conservation Strategy- Thomas Lane, Colleen Kettles, ECS Solar and Florida Solar Energy Center/UCF

Historically solar energy was the only method in Florida to heat water for homes in the early 1900s. There was over 70,000 solar water heaters in Florida by 1950. Cheap electric safe water heaters promoted by utility companies eliminated solar water heating from the Florida market from the early 1950s to the mid '70s. There was a resurgence from 1978 to 1985 as a result of the 40% federal tax credit, utility rebates and the rapid rise in utility rates in Florida. In 1986 the Federal IRS 40% tax credit ended and electric utility rates remained stable until 2006. There was virtually no market until 2006 when there was a new 30% federal tax credit, new state and utility rebates and rapid electric utility increases that created a resurgences in solar water heating.

One SHW systems creates the equivalent of 2800 kwh per year or it can be viewed as an energy generation device or energy conservation device. Each solar water heater installed offsets 4046 pounds of carbon dioxide, 12 pounds of carbon dioxide, and 7 pounds of nitrogen oxide besides eliminating mercury in Florida's habitat. Solar water heaters have a design life of over 20 years. Florida residents installed 136,000 SHW systems from 1978 to 2006 creating a $500 million dollar industry eliminating 100 tons of Greenhouse gases. Solar water heating in utility DSM/ RPS programs (demanded side management and renewable portfolio standards) could result in a significant increase in installations. If 263,000 SHW were installed over the next twelve years it would result in 4 billion KHW saved and 400 million saved in utility bills. The results would include 400,000 kwh demand reduction, with 3 million tons of greenhouse gas reductions. This would create 5,000 jobs and a 1billion dollar industry. Solar water heating is new residential construction with 150,000 home states assuming 1,440,000 systems would be installed. (This does not include the retrofit market with a 4.4 single family housing inventory.) New residential construction would result in 26 thousand kwh saved, $3 billion utility savings, 2.2 6w demand reduction, 19 million tons GHG reduction, creating 30,000 jobs a year, and a 6 million dollar industry.

Recommendations
- Encourage solar in new construction
- Create a dedicated fund to provide financial incentives
- Eliminate the RNA test for utility SHW systems
- Establish goals with ad RPS program
- Require SHW on state buildings and public educational facilities.
- Require SHW in state funded or administered affordable housing, programs.
- Provide dedicated budget for solar demonstrated programs
- Increase the commercial sector funding for solar water heating

There is great potential for solar water heating in the state of Florida. This could be a boon to employment in the solar industry both in manufacturing and contracting. Besides helping Florida homeowners' utility bills, it is urgent that we do everything possible to lower greenhouse gasses.

Track II: Energy Efficiency

Thermal Simulation of FSU's Off-Grid Zero Emissions Building - Juan Ordonez, Florida State University

The poster presents a volume element model based simulation of the thermal response of the off-grid zero emissions building at the Florida State University Energy and Sustainability Center. The model results are in good agreement with preliminary experiments. The poster describes the OGZEB and its energy systems, presents the model and the experimental results used for initial model verification.

Low cost building energy efficiency solution based on real-time occupancy based control- Prabir Barooah, University of Florida

A large fraction of energy used in buildings is due to HVAC (heating, ventilation, air conditioning) systems. In this research we have developed a mostly software-based retrofit solution for reducing energy used by commercial building HVAC systems. The system employs a low cost wireless sensor network to detect which rooms/zones of the building are occupied, and control algorithms use that information to dynamically decide appropriate set points (flow rate, cooling/heating applied to the zones) that can ensure thermal comfort and indoor air quality while reducing energy use to near minimum. A software middleware is developed for commanding equipment to follow the computed commands. The entire system has been tested in a LEED silver certified building in the University of Florida campus that demonstrated that the first version of the system has the potential for easily saving 35% energy use. Extensive simulation studies have been carried out on with the second version of the technology that shows the potential for 50-70% savings over a well-tuned baseline (depending on weather). Since the only cost of the technology is the cost of the wireless sensors, the first cost of deployment is small. The payback period is estimated to be less than a year.

Moisture and Energy Consequences of a Tight Residential Envelope- Robin Vieira, Danny Parker, Philip Fairey III, John Sherwin, Chuck Withers, David Hoak, Florida Solar Energy Center/UCF

As part of a long-term experiment exploring retrofit measures, the savings from reducing air infiltration, with and without the addition of mechanical ventilation, are being studied. In 2011–2012, two identical laboratory homes designed to model existing Florida building stock were sealed and tested to 2.2 ACH50. Then, one was made leaky with 70% leakage through the attic and 30% through the windows, to a tested value of 8 ACH50. Reduced energy use was measured in the tighter home (2.2 ACH50) in the range of 15.8%–18.6% relative to the leaky (8 ACH50) home.

Internal moisture loads resulted in higher dew points inside the tight home than in the leaky home. Window condensation and mold growth occurred inside the tight home. Even cutting internal moisture gains in half to 6.05 lb/day, the dew point of the tight home was more than 15°F higher than the outside dry bulb temperature. The homes have single-pane glass representative of older central Florida homes. There are factors that may limit the representation of the moisture results:

• The laboratory homes have very little moisture capacitance, as they contain no interior walls, no furnishings, and no carpeting (slab is exposed).
• The homes were only one year old when the testing took place. There is likely still some drying out of the slab and concrete block walls typical of new homes, not existing homes.

A second winter of testing was conducted in 2012–2013 with the tight home alternating between two-week periods with mechanical ventilation (63 CFM supply air continuously) and not having ventilation. The leaky east building remained the same with no ventilation. Both buildings used a schedule of 11 lb/day of internal moisture generation. Winter condensation was observed again when the supply ventilation fan was off. Inside window temperatures (measured for the second winter collection period) were lower than the inside dew point on cold winter nights. However, condensation was not observed when the ventilation fan was on, or in the leaky home. Heating energy use in the tight but ventilated home was 15% higher than in the leaky home with natural air infiltration only.

Cooling energy increased by 20-38% or about 4 kilowatt hours (kWh) per day in the mechanically ventilated unit in summer. Part of this increase resulted from the mechanical ventilation system fan itself, which added 1.8 kWh per day of energy use to the cooling system energy use. The mechanical ventilation system also contributed measurable increases to the building moisture levels.

Acknowledgement: Funding for the lab buildings was provided from the Florida Energy Systems Consortium and funding for the experiments was provided by the Department of Energy's Building America program which archives the full September 2013 report, "Flexible Residential Test Facility: Impact of Infiltration and Ventilation on Measured Heating Season Energy Loads."

An overview of Building America Partnership for Improved Residential Construction (BA-PIRC) Activities in Hot Humid Climates-Eric Martin, Florida Solar Energy Center/UCF

The U.S. Department of Energy's (DOE) Building America program has been a source of innovations in residential building energy performance, durability, quality, affordability, and comfort for more than 15 years. This world-class research program partners with industry to bring cutting-edge innovations and resources to market. The Building America Partnership for Improved Residential Construction (BA-PIRC), led by the Florida Solar Energy Center, focuses on developing and implementing innovations for both new and existing housing in the hot humid climate. This poster introduces the viewer to research conducted in the areas of low-load HVAC; high performance water heating systems; scalable, deep energy retrofits; and technical and business solutions for zero net-energy ready new construction.

My Florida Home Energy Interactive Web tool- Lesly A. Jerome, Harold S. Knowles, III, Nicholas W. Taylor, University of Florida

The My Florida Home Energy tool is designed specifically for Florida homeowners. With some basic information about your home, this tool can analyze your present energy situation and identify potential energy efficient products and services that may reduce your energy usage and therefore utility bills. You can also find helpful support from an extensive home energy education library and read advice on how to select a good contractor, when to apply for financing, and where to search for incentives. The site was created through collaboration with the Program for Resource Efficient Communities (PREC) and the Florida Department of Agriculture and Consumer Services Office of

Energy (FDACS OOE) in order to address the requirement specified by the legislature in Section 377.703(2)(k) F.S. and HB 7117.

Florida Energy Efficiency Loan (FEEL): A New Residential Lifestyle Literacy and Leveraged Lending Program-Craig Miller, Hal Knowles, University of Florida - Program for Resource Efficient Communities

Objectives: To date, residential energy efficiency financing programs sell themselves as cash flow neutral pathways toward improved home comfort to borrower households. In reality, these programs are more often cash flow negative and, when poorly designed, can serve as an additional burden on families. This session describes the Florida Energy Efficiency Loan (FEEL), an innovative and alternative residential energy efficiency financing program recently launched in seven Central Florida counties. The program is jointly administered and enabled through a 10-year contract between the UF/IFAS Program for Resource Efficient Communities and FAIRWINDS Credit Union.

Methods: Initial financial support for FEEL program development was provided by US DOE ARRA grant funds directed through the Osceola County government to UF and its collaborators. Ongoing financial support for FEEL program administration comes through revenues associated with the loan structure and Participating Independent Contractor membership and project fees. The FEEL program is currently in beta testing with a full public alpha release in the late winter/early spring of 2014. It leverages and tailors existing UF/IFAS Cooperative Extension Service programs to improve household financial and utility service literacy; to improve access to credit for underserved households; to increase probability of timely loan repayment; to reduce risk of loan default; and to increase the depth and persistence of home energy efficiency.

Results: Beyond the FEEL program design, UF/IFAS plans to undertake the long-term administration, refinement, and expansion of the FEEL program into other cities, counties, and utility service territories statewide. Both qualitative and quantitative approaches will be used in the monitoring, measurement, and verification of the FEEL program from individual household utility bill savings and lifestyle behavior changes…to home improvement contractor performance and overall achievement of program goals.

Conclusions: The FEEL program provides a living laboratory and an evolving case study of the public/private sector partnerships possible in the effort to improve consumer lifestyles through awareness-based, action-focused outreach on household budgeting of energy, water, and finances.

Targeting utility customers to improve energy savings from conservation and efficiency Programs - Nicholas W. Taylor, Pierce H. Jones, M. Jennison Kipp, University of Florida

Electric utilities, government agencies, and private interests in the US have committed and continue to invest substantial resources – including billions of dollars of financial capital – in the pursuit of energy efficiency and conservation through demand-side management (DSM) programs. While most of these programs are deemed to be cost effective, and therefore in the public interest, opportunities exist to improve cost effectiveness by targeting programs to those customers with the greatest potential for energy savings. This article details an analysis of three DSM programs offered by three Florida municipal electric utilities to explore such opportunities. First, we estimate programs' energy savings impacts; second, we measure and compare energy savings across subgroups of program participants as determined by their pre-intervention energy performance,

and third, we explore potential changes in program impacts that might be realized by targeting specific customers for participation in the DSM programs. All three programs resulted in statistically significant average (per-participant) energy savings, yet average savings varied widely, with the customers who performed best (i.e., most efficient) before the intervention saving the least energy and those who performed worst (i.e., least efficient) before the intervention saving the most. Assessment of alternative program participation scenarios with varying levels of customer targeting suggests that program impacts could be increased by as much as 80% for a professional energy audit program, just over 100% for a high-efficiency heat pump upgrade program, and nearly 250% for an attic insulation upgrade program. Findings are directly relevant for utility program administrators seeking to improve program outcomes.

Exploring the Market for Multifamily Energy-Efficiency Retrofits in Florida- M. Jennison Searcy, Pierce H. Jones, Nicholas W. Taylor, University of Florida

In the U.S., and particularly in Florida, multifamily housing represents a significant untapped opportunity for advancing energy efficiency and conservation and reducing associated adverse environmental impacts. Attempts to capture this potential are complicated, however, by inherent market uncertainties, financing constraints, and "split incentives" whereby property owners incur the costs of multifamily retrofits yet tenants receive the direct benefits, primarily via reduced utility bills. Overcoming these challenges to grow the Florida market for multifamily energy retrofits demands on-the-ground projects coupled with applied research and performance evaluations that document project details and generate reliable and practical information about retrofit costs, benefits, and overall effectiveness. UF's Program for Resource Efficient Communities (PREC) is playing a key role in several such projects to fill information gaps related to the market for energy efficiency in Florida's multifamily housing. The objective of this poster and presentation is to introduce three of these PREC projects, highlighting their goals, partners, synergies and applied value.

For each project, the methods used to assess impacts require access to large sets of complete and reliable data: from utility partners, property appraisers, and others. Since 2006, PREC has been building relationships with utility staff (e.g., from Gainesville Regional Utilities, Orlando Utilities Commission (OUC) and JEA) to collect and analyze energy consumption data for a wide range of applied purposes. These partnerships and datasets are foundational elements of the multifamily retrofit projects described here, grounding the analysis and performance evaluations with actual, rather than modeled, data.
The first project involved energy retrofits of five apartment complexes (over 230 units) in Orlando. PREC partnered with OUC and secured ARRA funding through the Florida Department of Agriculture & Consumer Services (FDACS) Office of Energy to coordinate project design and implementation, offset property owners' capital investments (via utility rebates), and perform post-retrofit evaluation of impacts. PREC estimates that the upgrades led to an average first-year energy savings of 23% (2,260 kWh) per treatment unit. Findings are valuable for use in the development of rebates and incentive structures for OUC's future multifamily retrofit programs.

The second project is a research study in partnership with UF's Shimberg Center for Housing Studies and funded through an award from the John D. and Catherine T. MacArthur Foundation. This project builds on the OUC project to include in-depth interviews with property owners about retrofit costs and benefits, comparative assessments of the energy consumption of multifamily households, and estimates of tenant stability as a function of energy cost burdens. Results will be directly

relevant to a wide range of energy and housing policy stakeholders, such as state financing agencies and affordable housing authorities.

The third PREC project, also in partnership with UF's Shimberg Center, involves performance evaluation of a Multifamily Energy Retrofit Project. This effort is funded by the FDACS Office of Energy through the Florida Housing Finance Corporation (FHFC). PREC will play a key role in the selection of participating properties/owners and evaluation of retrofit effectiveness.

Side by Side Evaluation of Residential Hot Water Heating Systems in Florida-Carlos Colon, Florida Solar Energy Center/UCF

The Hot Water Systems (HWS) laboratory at the Florida Solar Energy Center (FSEC) in Cocoa, FL is now in its fourth year in operation. It has evaluated over eighteen residential hot water systems since it began operating in 2009. The laboratory undertakes testing of seven side-by-side water heating systems simultaneously delivering hot water at 120 ^{o}F. Two systems of minimum code efficiency serve as electric and natural gas baseline during each year-long testing rotation. To date, standard storage water heaters, electric heat pumps, solar electric and tankless natural gas systems have been evaluated as single units and in tandem hybrid operation. Ultra-high efficiency hybrids such as heat pump with passive solar thermal have demonstrated a 77% electric reduction over the electric baseline providing hot water at an average of 1.75 kWh/day. In the natural gas category a hybrid solar thermal with tankless condensing heater demonstrated a 75% energy reduction providing hot water at an average consumption of 8.5 cubic feet of natural gas per day. Two alternating and distinctive hot water draw schedules – ASHRAE 90.2 and NREL/Building America load profiles are used every month as loads. The first draw profile imposes the average residential hot water load (64.3 gal./day) while the latter changes dynamically per month providing a better representation of a typical residential seasonal hot water load. Because of varying seasonal water temperature conditions, data analysis leads to determination of efficiency penalties which are shown to vary from the stated equipment energy factor (EF) rating. Currently, the minimum efficiency standards for residential water heaters are being revised and implementation is scheduled to begin in 2015. In June 2013, the HWS laboratory upgraded the storage type natural gas water heater used as baseline to meet the 2015 minimum standards (i.e., EF=0.62, 40 gallon). Preliminary results indicate that a modest efficiency increase from thicker tank insulation leads to a 9% savings in natural gas reduction. Researchers have also experimented with intellectual property concepts related to water heating energy efficiency leading to one insulation apparatus patent applicable to hot water storage tanks. The HWS laboratory is funded by the Department of Energy (DOE) under the Building America Program in consultation with and administered by the National Energy Renewable Laboratory (NREL). The project also received funding from the Florida Natural Gas Association (FNGA).

A Program for Energy Efficient and Environmentally Sustainable Laboratories - Philip J. Wirdzek, International Institute for Sustainable Laboratories (I2SL)

The International Institute for Sustainable Laboratories (I2SL) is devoted to the principles of sustainable laboratories and related high technology facilities, from design to engineering to operation. Through world-wide partnerships that provide an exchange of technical expertise, I2SL will encourage the development of high-technology facilities that address the rapid pace of science, medicine, research and development in an ever-changing and dynamic environment. I2SL's mission addresses three key elements: promotion, implementation and education. Promotion – to raise

awareness within the specialized and niche building sector for creating resource-effective and environmentally responsible facilities of science, science education, testing, medicine, research and development. Implementation – to encourage the creation of technologically advanced, energy-efficient, and environmentally responsive laboratories throughout the world through collaboration. Education – to facilitate the application of a sustainable "whole-building" approach in designing, engineering, constructing, operating and using laboratories and other advanced facilities.

The challenge for architects, engineers, and other building professionals is to design and construct the next generation of laboratories with energy efficiency, renewable energy sources, and sustainable construction practices in mind, and to do so while maintaining — and even advancing — high contemporary standards of comfort, health, adaptability, security and safety. By expanding upon a former US DOE and EPA program called Laboratories for the 21st Century (Labs21), I2SL maintains that the laboratory and related high technology facilities demand concentrated attention. What the cathedral was to the 14th century, the train station was to the 19th century, and the office building was to the 20th century, labs and related high technology facilities are to the 21st century. In short, it is the building type that embodies, in both program and technology, the spirit and culture of our age and attracts some of the greatest intellectual and economic resources of our society.

With their extensive requirements for health and environmental management, security, flexibility, adaptability and resource consumption, the design, construction, operation and use of these facilities will continue to present significant challenges to the building sector. Unlike other more conventional building types, these facilities are sophisticated machines with parts and functions that must interrelate at the highest level of life-cycle performance, a fact that cannot be ignored or deferred. If whole-building design and sustainability are truly goals for the built environment, these facilities provide the greatest opportunities and justification for such outcomes which therefore demands a high level of attention.

Permanent Magnet for Energy Efficiency Systems- Ke Han, FSU Mag Lab

In Florida, it is almost impossible for a building to operate without a center air system. In hot weather seasons, the system uses air-conditioning to cool the building and in cold seasons, it warms the building. Such system or similar is usually referred to as heating, ventilating, and air conditioning (HVAC). HVAC systems in Florida create significant electricity demand, particularly in summer. HVAC with both magnetic bearings and a variable speed permanent magnet motor creates a sustainable energy efficient system that is compact, lightweight and quiet. The system needs very strong permanent magnets. In fact, strong permanent magnets play an important role not only in enhancement of the efficiency of HVAC, but also in development of many new technologies that can help us to use energy efficiently. These magnets underlie the operation of alternators and generators. Permanent magnets provide essential components for improvement of the energy efficiency in many products including computers, mobile phones, electric cars and wind turbines [1]. It is clear that we rely heavily on strong permanent magnets and they will be an integral part to the advancement of technology. Currently the strongest Nd2Fe14¬B type or SmCo5 type permanent magnet contains rare earth metals, such as Nd, Dy and Sm because of the high energy product and coercivity. However, the constraints of rare earth suppliers, the environmental impact of the refining process, and price volatility call for research on using of rare earth metals more efficiently in development of permanent magnet. We will present our work on rare earth containing permanent magnets and how we can use rare earth metal efficiently in such magnets by application of high field magnet annealing.

We also pursue research on non-rare earth containing bulk permanent magnet materials that have potential to achieve similar magnetic strength and energy product as its rare earth counterpart. Materials with a magnetic anisotropy have been given much attention as a possible alternative to rare earth permanent magnets. I will present some of our work on permanent magnet model composites made of FePt and FePd. The systems have magnetic anisotropy and high coercivity and application of high magnetic field during the fabrication can enhance the magnetic properties. In addition to Fe based permanent magnet materials, we also studied Mn based permanent magnets. In this system, we can make the magnet materials with neither rare earth nor noble metals. A simplest model magnet material is Mn-Ga alloy. This system has many intermetallic compounds that show high coercivity, therefore can be used as permanent magnets. In my presentation, I will report that we were able to prepare bulk Mn-Ga permanent magnet alloys using new approaches. The new Mn-Ga materials have coercivity 30% higher than previous achievable values in bulk Mn-Ga.

Energy Efficiency and NRCE: A Needed, Country, State and Industrial Policy/Program-Cristian Cardenas-Lailhacar, Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador

The world dependence on energy, particularly on fossil fuels, is an addiction that is having a tremendous impact all over the globe. How much is being used, how much is left, and the consequences of its use are every day questions. A healthy economy certainly relies not only on the abundance of energy resources, but on their kind, quality, and on how efficiently they are used. It is clear then that the path to follow should be energy efficiency and the use of nonconventional renewable energy (NCRE) sources. Solar Energy is one these. In this paper we show a new mathematical interpolation technique which, by using historical and current solar radiation (SR) data, for a given period and region, provides a pretty accurate SR forecast for the next period considered. The algorithm is based on a mathematical expansion around a minimum of SR in the catchment region of the cycle considered. Future solar radiation profile values depend on some variables and past radiation. The purpose of this research is to have an insight into the amount of SR available in a given region, area, surface, etc., and new expressions and variables for the SR. Among them are the associated force constants, the maximum SR, when it will occur, etc. The algorithm provides new expressions for current SR techniques. Preliminary results of the interpolation technique are shown, with encouraging results.

Energy Efficient Transportation - John Nuszkowski, University of North Florida

Energy is a vital part of society. We use energy in industry, transportation, and our modern way of life. Continual innovation is required to reduce emissions and increase fuel efficiency to displace foreign oil importation in the transportation and heavy-duty vehicle sectors. The transportation industry currently consumes 30% of the U.S. energy. This is a local, state, country, and global issue.

Vehicle Efficiency - Operating a vehicle's engine and transmission at their highest efficiency point can provide opportunities for complete powertrain strategies to reduce fuel consumption while maintaining adequate vehicle performance. An onboard GPS device allows future road grades to be calculated from GPS coordinates and topographical maps. This generates a

prediction of the road grade ahead for the moving vehicle that can then be used to estimate the power required and deliver only the necessary power to propel the vehicle through the upcoming terrain. The knowledge of future road grade through predictive calculations provided a cycle weighted fuel economy benefit of 0.1-0.2% compared to only knowing the current road grade. Real time information about changes in aerodynamic drag due to wind can be a useful in look-ahead control systems. With the reduction of the aerodynamic drag experienced by vehicles, a lower aerodynamic drag force results in lower engine power demands and therefore lower fuel consumption. It was seen that the vehicle required up 30% more power to overcome aerodynamic drag from wind gusts just under 5m/s and the average power to overcome aerodynamic drag was approximately 10% greater than that needed in zero wind. Advanced Combustion (AC) - The need to reduce engine emissions while retaining high engine efficiencies has fueled AC engine research and development. Each of these advanced combustion regimes essentially follow the same principle in which a homogeneous or near-homogeneous air and fuel mixture combusted at low temperatures can provide reductions in oxides of nitrogen, soot and fuel consumption while observing increased brake-thermal efficiency. The primary objective of this project was to characterize five specifically blended fuels during AC operation focusing on which fuels best facilitate AC and more specifically reduce emissions, while increasing fuel efficiency in comparison to the engine's OEM operation. Natural Gas (NG) Transportation - With the high cost of diesel (~$4.00/gal), low cost of NG (~$1.75/diesel gallon equivalent), reduced dependence on petroleum imports (55% of the petroleum consumed by the U.S. in 2011 was domestic), and increased dependence on domestic NG reserves (92% of the NG consumed by U.S. in 2011 was domestic), NG utilization as a transportation fuel is economically viable. Conversions of existing diesel ships and locomotives to dedicated or dual fuel applications require fundamental understanding of combustion from these types of engines due to the larger displacement and lower operating speeds as compared to existing on-road engines. NG conversion systems allow individuals to use NG in place of conventional diesel within a vehicle or engine they already own have become increasingly appealing. In general, these dual fuel conversion kits have been targeted towards legacy era engines without exhaust after-treatment.

Energy-Aware Database Disk Storage System- <u>Yicheng Tu,</u> Bo Zeng, Peyman Behzadnia, Wei Yuan, University of South Florida

Energy consumption has become the first-class optimization goal in design and implementation of the computing systems. The database storage system is the major consumer of the energy in the modern data centers. In this talk, we present results of our recent research funded by FESC and NSF on designing energy-aware database storage systems. Given that the dynamic power management

(DPM) techniques are the most common methods used to save energy in disks, we integrate our DPM model into the data management policy of the database management system (DBMS) in order to minimize the power consumption of the database disk storage while satisfying the given performance bound. We evaluate our proposed ideas through running experimental simulations. Our preliminary results clearly show promising energy savings in this context.

Tuesday, May 13- 11:25-12:10 pm
SESSION III ORAL PRESENTATIONS (5 min each)

Track I: Natural Gas and Marine Energy

The Direct Use of Natural Gas - Scott Ranck, Florida Public Utilities Company

This brief presentation will propose increasing the direct use of natural gas to commercial and residential consumers will have very positive benefits for the entire state of Florida. This is a much more conservation friendly vehicle to use natural gas energy. Currently, Florida's electric generation uses 64% natural gas. It can be argued as a nation shifting to natural gas for a primary fuel for electric generation is the major cause of our carbon emissions being reduced.

In the process of electric generation and distribution 68% of the total energy is lost, only delivering 32% to the home or business. On the contrary from well head to the home or business the direct use of natural gas delivers 92% of the original energy. As a result, costs, emissions, the need for new electric generation, and peak demand issues are reduced.

There are hurdles to overcome. With cooling the dominant energy user, there needs to be a viable natural gas residential (3-5 ton) heat pump developed. Small commercial (8-30 ton) units need to have lower first costs to compete. Affordable natural gas heat pump units would be a game changer. The best all round water heaters on the market today are natural gas condensing units coming in as high as 96% efficient. Another challenge is the need for natural gas infrastructure throughout the state. Currently, there is only approximately 10% saturation.

If only 50% of people who currently have natural gas available converted water heating, cooking, clothes drying and heat, a Black & Veatch study showed at minimum we would remove 60 million tons of CO_2.

Natural Gas as a Transportation Fuel - Mark Thompson, Florida Public Utilities Company

Natural gas vehicles have been around for a long time but not until recently have we seen a true interest in the use of natural gas as a transportation fuel and the conversion of commercial fleets, buses, waste trucks become a reality. In addition, there seems to be a push in the market for in-home fueling units for private vehicle users.

There are obviously many benefits to increasing the use of natural gas from a societal standpoint. Ninety seven percent of America's natural gas is produced in North America. This means that every gallon of natural gas used in a vehicle equals one less gallon of petroleum that needs to be imported. Using natural gas as an alternative fuel can help reduce the billions the US spends on foreign oil every week. Every new NGV fueling station creates 45 new jobs within a 5-mile radius and every 1% increase in natural gas production can create 35,000 jobs. Although these are nice statistics, most fleet operators' interest in natural gas stems from the fact that natural gas can significantly reduce their operating costs and the more miles their fleet drives, the greater the savings. There are also savings in the maintenance of natural gas vehicles because natural gas burns cleaner than diesel. Manufacturers have also started to produce natural gas vehicles and there are currently 200 fleet options available in the US. Currently there are more than 50 different manufacturers producing 150 models of light, medium and heavy-duty Natural Gas Vehicles and engines. Also, fleets typically can take advantage of central fueling facilities which are

more applicable to slow fill stations. These slow fill stations fill vehicles overnight making them ideal, and less costly to install, for fleets that are parked over night at a central location. One concern that many fleet operators have had in the past is the servicing of natural gas vehicles. However, mechanics can be quickly and easily trained to support both vehicles & infrastructure .NGVs use similar engine designs, body structures, etc., than gasoline or diesel fueled cars and trucks.

There are currently 30 Natural Gas Vehicle fueling stations in Florida. Although this is a considerable increase from previous years, it is probably the number one concern of the industry. Most fleet operators prefer to own their own fueling stations and more public access stations are needed. When fueling stations are available throughout the state, more people will be willing to purchase natural gas vehicles without being concerned about where to fuel. This will definitely make a difference in the private users' willingness to switch to natural gas.

The state has created an incentive program to increase the use of natural gas as a transportation fuel and encourage the conversion of private and governmental agency fleets. Many may not be aware of the availability of this funding and this presentation will focus on educating the audience on what is available.

So Natural Gas Motor Fuels are Cheaper than Oil: Does This Solve Our Energy Problem? - David E. Bruderly, Bruderly Engineering Associates, Inc.

The movement to low-cost, low-carbon natural gas motor fuels could be a major step towards solving Florida's Oil Problem if implemented in ways that achieve environmental and security objectives that are not formally recognized by existing public policy goals or market forces. Jacksonville based businesses in the logistics sector are actively developing both compressed natural gas (CNG) and liquefied (LNG) natural gas motor fuel infrastructure to power cars, trucks, locomotives and ships. In spite of Florida's long history as a pioneer in compressed and cryogenic gaseous fuels, project developers are being forced, out of necessity, to look out-of-state to develop and procure the technology and equipment needed to use this flammable, combustible gas. To date, there has been little, if any, support from the State of Florida to support RDD&D by Florida energy researchers.

For example, CSX has partnered with GE to develop / demonstrate / evaluate the use of LNG fuels to power locomotives. Two shipping companies, Crowley and Sea Star / Tote Marine, have committed billions to build at least four ocean going dual-fuel LNG powered ships to serve the Jacksonville – Puerto Rico trade routes. At least two companies, a Sempra / JEA partnership and Clean Energy, have announced plans to build cryogenic plants in Jacksonville to produce LNG to serve this emerging market demand. The methane could come from renewable sources, such as Florida biomass, in addition to fossil natural gas delivered to Jacksonville via pipeline. The Jacksonville Port Authority, Transportation Planning Organization and Transit Agency are each sponsoring aggressive market development and public outreach and education programs.

This activity could position Florida to leap-frog into a global energy leadership position with respect to the use of gaseous motor fuels. This sudden commercial interest in natural gas motor fuels could be the beginning of a paradigm shift; it could create opportunities for RDD&D to produce, distribute, store and use low-carbon methane and hydrogen much more efficiently and in ways that complement increased use of renewable energy sources. It could create outreach and education opportunities to help consumers regain control of motor fuel markets. While private capital has

been earmarked to develop these initial ventures, the focus has been on proven, off-the-shelf technologies and business strategies. The opportunity for investment in RDD&D to support continued improvement in these technologies, not to mention approaches to deployment of infrastructure, has not yet been recognized by Florida academics or policy makers.

Crew Member Training Standards for Natural Gas-Fueled Ships - Dennis L. Bryant, Bryant's Maritime Consulting

Currently, there are no international or federal requirements establishing training standards for crew members on ships using natural gas as fuel. The International Maritime Organization (IMO) has drafted special training requirements for such personnel, but those requirements have yet to be finalized and it will be some time thereafter before they come into force. The United States Coast Guard (USCG) has issued draft guidelines for training personnel on vessels using natural gas as fuel. Even when finalized, those guidelines will not be directly enforceable. USCG regulations on this topic are at least two years away. Drawing on the current draft documents and related material, my presentation will provide an outline of the expected training standards for crew members on ships using natural gas as fuel. The presentation will provide owners and operators of such ships, as well as training providers, with needed guidance, allowing them to move forward now, while minimizing duplicative training requirements in the future.

Evaluation of Viability of Combined Heat and Power Projects in Florida – David Richardson, Mark Cutshaw, Florida Public Utilities Company

Florida Public Utilities is interested in getting feedback on the potential for establishing a research project on the economic viability of combined heat and power generation in Florida. Of particular interest is the application and feasibility of micro or small scale CHP systems.
Micro CHP systems are designed to do two things, generate hot water and produce electricity. Hot water is produced with a liquid cooled internal combustion engine that generates heat which is then pumped through a heat exchanger. The excess heat of this process is then used to spin a generator to produce electricity (up to 4.7 kWh). There are many benefits associated with using micro CHP technology as well as drawbacks. Benefits include lower carbon emissions, lower electric bills, long maintenance intervals (4, 000 hours), 93% efficient v. 42% efficient from typical power plants, great fit for LEED and other “green” buildings and more. Drawbacks include first cost ($25K to $40K depending on configuration of the system), required spark spread between electric utility cost and natural gas costs, and applications typically require high heat load requirement. There is data available on micro CHP systems in other areas of the country but we are not aware of any studies that have been done in Florida.

Performance Evaluation and Field Testing of Gas Heat Pump - Rajeev Kamal, D. Yogi Goswami, University of South Florida

Background: According to the U.S. Energy Information Administration, 87% of American households are equipped with air-conditioning. US expends about 185 billion kWh of energy annually on residential cooling. A Gas Heat Pump (GHP) provides efficient heating and cooling option with decentralized production of mechanical work for powering the cooling/heating cycle. GHP works

similar to any other air-source heat pump, except that it relies on natural gas based internal combustion engine instead of electricity. Objective: This study aims to test GHP units installed at commercial buildings and a high school in Florida and evaluate their energy performance.

Methodology: This is a yearlong energy performance study based on actual measurements and computer modeling. The buildings and GHP units will be instrumented to measure the operating parameters including (i) capturing space and ambient temperatures, humidity, energy consumption of air handling units (AHU's) and (ii) High Pressure (HP), low pressure (LP), HP side temperature, LP side temperatures, gas consumption and refrigerant flow rate etc. at different sections of the GHP units. A computer based model will then be used to project the performance of similar units at a third location of Okaloosa Gas Building in Santa Rosa Beach. Expected outcomes: This study will provide the avoided electric kWh demand, based on measured performance and projected energy use calculated for the test period for all three locations. These results will be compared to a conventional electric heat pump for the three locations using the validated computer model. An economic analysis of the operational costs of the two options will also be conducted.

Scaling relations for the model scale testing of hydrokinetic ocean renewable energy systems-Karl Von Ellenrieder, Valentine W., Florida Atlantic University

A non-dimensional dynamic scaling procedure that can be applied to subsurface and deeply moored systems, such as hydrokinetic ocean renewable energy devices is presented. Numerical simulations of prototype systems moored in 400 m of water are performed. Systems studied include: subsurface spherical buoys moored in a shear current and excited by waves; a subsurface ocean current turbine excited by waves; and a deeply submerged spherical buoy in a shear current excited by strong current fluctuations. The corresponding model systems are scaled based on relative water depths of 10 m and 40 m. For each test case studied the response of the model system closely matches the scaled response of the corresponding full-sized prototype system. The results suggest that laboratory-scale experimentation of complete ocean current renewable energy systems moored in a current is possible and should be pursued as a cost effective way of evaluating system performance.

Water Energy for Florida and the USA-George Meyer, Engineer & Energy Invest. Consultants

Electricity generated in our waters and electric vehicles are the only way to American recovery, energy independence and economic growth while keeping the air and water clean and global warming at a minimum. Water is the most abundant resource on our planet. The ocean's energy is mainly caused by gravitation between the sun, earth, moon and solar heat. Rivers flow by gravity from mountains to the sea. A tiny fraction of the water's usable power is sufficient to supply all mankind with electricity. Hydroelectric power is superior, lasts forever and is free to use. Modern technology suggests modular submerged Hydroelectric Power Plants (HPP's) anchored on the ocean floor or in the riverbeds. They do not exist to the eye, are barely audible over the natural noise of

the water and do not occupy precious land. Pump storage plants supply peak power. Phase I: We shall be independent from foreign energy within 10 years. Phase II: We shall only use clean renewable domestic water energy within 30 years. Florida has the longest coastline of all the states with tides on its gulf and Atlantic coasts. The Gulf Stream flows at an average speed of 4-6 mph, the continental shelf extends wide into the ocean. Water energy is predictable, providing a reliable source for electric power. Phase I: The goal of this phase is to reduce and eventually eliminate petroleum imports. In 2009, we paid approximately $500 billion to foreign nations for imported oil,

which is mostly used for transportation. The industry must concentrate on infrastructure from power plants to distribution, power storage and plug stations. Rules must be changed. The auto industry is ready to sell fully electric vehicles (EV). It costs about 1/5 to drive an EV, even with electricity from conventional power plants. What stops us from using EVs? There is no infrastructure to charge and service EVs. However, the existing installations, services and supply network of oil companies can be used and extended to suit EV needs. The petroleum industry can use hydropower to their advantage. Phase II: The goal is to generate enough hydropower to cover 95% of all energy needs. Subsidies should be completely eliminated. Tax incentives may be given only for sellable power, i.e. MWh produced and usable. Monies like the $14.7 billion spent in 2010 will be used as pay for work done, not as subsidies. Florida's population is growing rapidly. The desired hydropower by 2050 is 90-115GW. The expected annual consumption is 400-500 TWh. Five thousand jobs are assumed to be needed per $1 billion capital expenditure (1 job=$200,000 capital). Two thousand jobs are required for operation, maintenance, repair, etc. per 1 GW installed capacity. Capital cost for power plants is expected to be $1.2 billion/GW. Operation and maintenance will become routine. Petroleum, coal and gas will be here for generations. Water energy can make oil companies sell less and become more profitable for generations. They can get wealthier than ever by selling hydropower now and oil much longer. They want their share of the long-term future. Now there is a chance to own HPPs like oil wells and plug stations like gas stations. Fossils are too precious to be burned, they can come to new life as plastics, drugs, fertilizers and even food.

Track II: Education

Renewable Energy Education Program at USF's Patel College of Global Sustainability - George Philippidis, University of South Florida

At the heart of sustainable economic growth lies renewable energy production, which is expected to quadruple by 2050 creating significant employment, investment, and tax revenue opportunities. Given Florida's rich natural assets of year-round warm weather, sunshine, and biomass, the State has a unique opportunity to become a national leader in the development of sustainable power and fuels. A key component of such an undertaking is the specialized education required to prepare a workforce capable of running and managing a green economy that will be increasingly dependent on solar, wind, biomass, and other forms of renewable energy. With the financial support of FESC and the Energy Office at the Florida Department of Agriculture and Consumer Services, the Patel College of Global Sustainability at the University of South Florida is developing a new concentration in Renewable Energy as part of the College's existing M.A. in Global Sustainability. The program's goal is to place Florida in a position to educate, train, and prepare students for the green jobs of today and tomorrow. The new concentration area will consist of two graduate courses (6 credit hours) that address the two constituents of renewable energy, transportation fuels and power. The courses are "Renewable Transportation Fuels" and "Renewable Power Portfolio". The goal of the former is to educate students in the technology and business aspects of green fuel production for vehicles and the aviation sector, whereas the goal of the latter is to educate students in the technology and business aspects of the various forms of renewable power generation. The courses will be taught by renewable energy experts and will involve invited speakers from the private sector, from USF's Clean Energy Research Center, and from other Florida and national Universities. Assessment and evaluation that include review by subject matter experts, student assessments tools, and summative evaluation will be performed to ensure the development of high quality content at the onset and to disseminate valuable feedback from students for continuous quality improvement.

"Buildings and Energy: Design and Operation vs. Sustainability" An Energy Engineering Course for Florida-specific Building Design & Operation - Prabir Barooah, University of Florida

The building sector is the largest consume of energy in the US and the State of Florida, ahead of transportation and industry. A typical energy use by Florida households is 40% higher than the U.S. average. As energy is resources are dwindling, it is crucial to proactively seek ways to improve new and existing buildings' energy efficiency. To achieve higher standards in building design and operation, a solid foundation of energy engineering and sustainability principles is essential. Currently, there are no courses offered to students or industry professionals with a distinct focus on energy in built environment, specifically for the design and operation in Florida's distinct climate conditions. Another limitation of existing courses is that they are focused on either design or operation, while they impact energy use in an intertwined manner. This course therefore emphasizes operation of buildings as much as their design. The course is planned to be offered starting Fall 2014 in a distance education format through the University of Florida's EDGE (Electronic Delivery of Gator Engineering) program. Course material will also be made available through FESC website.

Educating on Economic Realities of Sustainable Energy- Mark Jamison, University of Florida

Energy sustainability is a popular topic, but fact based and analytically rigorous discussions of the economic realities are rare. Florida students and other Floridians need to understand these realities so that they can make sound business and career decisions and to be informed citizens. FESC has provided funding to UF's Public Utility Research Center to create a class "Energy Sustainability" for upper level undergraduates on the economics of energy sustainability. The class is funded for two offerings and will be video recorded so that it can be made available for Continuing Education.

Introducing Specialization in "Sustainable Energy Systems" for Under-Graduate Students in Engineering at the University of West Florida - Bhuvaneswari Ramachandran, University of West Florida

The objective of this proposal is to introduce a specialization in "Sustainable Energy Systems" for Undergraduate Engineering students at the University of West Florida that could also be used to educate industry professionals towards workforce development. The courses have been designed from the perspective of energy system planning, a subject that has always been complex and evolving rapidly during the past 10-15 years to accommodate dramatic changes in the industry. These changes include the ongoing transformation of the nation's generation portfolio from being heavily dependent on fossil fuels to one that is heavily dependent on renewables (especially wind and solar) and the need for operating competitive electricity markets. The courses designed under this specialization will assist professionals in understanding the limits of our present energy systems and lead us to a future in which we can continue to provide reliable and secure energy resources for improved human quality of life. The proposed specialization program focuses on electrical engineering sources and systems that are non-polluting, conserving of energy and natural resources, economically viable and safe for workers, communities and consumers. Coursework takes a systems level and interdisciplinary approach to solving seemingly intractable sustainable energy problems, as opposed to single disciplinary and locally optimized approaches destined to yield marginal positive impacts. Students will be able to create study programs suited to their interests and aspirations

through their choice of electives and design projects. The course is electrical engineering-based but also covers a wider range of topics including economics, sustainability and environmental studies.
The University of West Florida (UWF) is a public university based in Northwest Florida with multiple instructional sites and a strong virtual presence. UWF is committed to planning and investing strategically to enhance student access and educational attainment, to build on existing strengths and develop distinctive academic and research programs and services that respond to identified regional and state needs in the complex 21st Century global society. UWF offers over 500 fully accredited online course sections each semester that lead to undergraduate and graduate degrees as well as credit-earning certificates. The Department of Electrical and Computer Engineering at UWF offers Undergraduate degrees in Electrical and Computer Engineering (ABET accredited) and professional development courses in Power and Energy Engineering to Gulf Power, an electric utility owned by Southern Company. The management and supervisors at Gulf Power are very pleased with the technical content and delivery of these courses and are eager to partner with UWF on this venture in sustainable energy systems engineering.

With UWF's strong network of area partners in technology, military and other educational institutions, and with an expanding regional presence, the impact of this proposed program will be widely felt. The program will cater to the needs of working professional in the public or private sector, including public agencies, utilities involved with energy conservation, energy consultants, business owners and sustainability managers. The program is also ideal for better understanding of sustainable energy management. Upon successful completion of the program, the students will have gained knowledge about the principles of sustainability management and the impact of climate change law on businesses and government, have the necessary skills and knowledge to make assessments and analyze and manage issues related to energy use, climate change and sustainability, and focus their career on clean energy.

Industrial Energy Efficiency Education - Nina Stokes, M Barger, Dr. Richard Gilbert, FLATE at Hillsborough CC

In 2008, Florida's legislature directed, via FESC, the Florida Energy Systems Consortium, the State's University and College system to develop applied research and specific technical education pathways to allow Florida to meet its 2020 energy generation and demand criteria. The current strategy is entertaining a mix of conventional, nuclear, solar and bio-fuels for generation and a range of options to make Florida "green" within a "smart" grid. In that same legislative action, FLATE, the National Science Foundation Advanced Technological Education Center of Excellence for Florida, was commissioned to partner with FESC to prepare and execute a technician workforce plan that will put that energy workforce into place on time. The new Industrial Energy Efficiency specialization track and college credit certificate (CCC) for the AS/AAS degree in Engineering Technology, comes at a time when green job sectors such as energy efficiency, are flourishing. Interest in reducing operating costs through energy efficiency maximization is growing significantly, both in Florida and throughout the nation. Collaboration with industry subject matter experts has allowed the energy efficiency specialization curriculum to be tailored to match training directly to industry needs.

Sustainable Floridians Program - Strengthening Your Sense of Place-Kathleen C. Ruppert, University of Florida - Program for Resource Efficient Communities

Objectives: This session describes the Sustainable Floridians[SM] (SF) program, an innovative Extension educational effort with the mission of guiding Floridians on how to take individual responsibility for protecting Earth's limited resources and strengthening their sense of place. The program is currently jointly administered and enabled through UF/IFAS' Program for Resource Efficient Communities and Florida Cooperative Extension Service County Faculty in the counties participating in the program.

Methods: Initial financial support for program development originated with a US DOE ARRA grant fund in UF/IFAS' Department of Family, Youth and Community Sciences. UF/IFAS' Program for Resource Efficient Communities, using partial support from FESC, assisted in program development and has taken on the role of statewide coordination. The SF program itself, offered through individual UF/IFAS Cooperative Extension Service offices, offers citizens, business people and government officials training about green and sustainable practices. Operated as a teaching program in some counties and a volunteer program in others, this interactive class brings in local knowledge, creates group discussion and promotes lasting behavioral change. PowerPoint presentations, evaluation tools, along with other educational materials are available to County Extension faculty through a SharePoint site. Topics include: Why Should You Care?, Consumerism, Energy, Food Systems, Water: Florida's Lifeblood, Landscaping and Community Leadership and Engaging Others. Other topics under development including: Transportation (revised), Sea Level Rise and Climate Change, Biodiversity and Economics. Ongoing financial support for statewide program development and coordination is being sought to continue the program.

Results: Through a discussion-to-action format, the program educates participants about making wise use of resources, making households and communities more resilient and financially sound, and understanding the impact of individual lifestyle choices. All of this revolves around Florida-appropriate targeted information that motivates participants to implement conservation and efficiency actions while creating opportunities for community-level leadership. Both quantitative (decreased energy, water and transportation fuel use) and qualitative approaches (leadership opportunities and efforts) will be used in the monitoring, measurement, and verification of the SF program.

Conclusions: Primary program goals are: improved environmental and financial resilience for participants and communities; providing information that identifies Florida-appropriate targeted actions for conserving resources, including energy and water; motivating participants to implement conservation and efficiency actions that save resources and money; and providing a forum that promotes sustainability leadership within the community. Those completing the Sustainable Floridians program become active participants in the mission of the Florida Extension Service to transform societies through lifestyle choices and behaviors while strengthening their sense of place.

Two Alternative Fusion Energy Confinement Concepts: Spheromaks and Laser-Assisted Muon Catalyzed Fusion - Charles A. Weatherford, Florida A&M University

Almost all of the US investment in fusion energy is flowing into the ITER (International Thermonuclear Experimental Reactor) tokamak (Cadarache, France) and the NIF (National Ignition Facility) laser facility (Lawrence Livermore National Laboratory). ITER continues to experience cost

over-runs and the break-even is constantly being pushed into an indefinite future. NIF uses 192 laser beams to compress deuterium and tritium pellets inside a gold hohlraum to produce fusion. There has been significant progress on NIF towards break-even, but substantial problems remain and the plans for a fusion reactor using NIF technology appear to the author to be uncertain. Another technology receiving sizable US investment is the Sandia Z-pinch which produces X-rays with exploding wires. The position taken by the author is that we may not currently know the science and technology which will lead to a working fusion reactor--much fundamental science needs to be studied in the field of nuclear fusion and it is very dangerous to close-off funding for alternative confinement concepts. This paper will describe two alternative confinements concepts (acc) under study at the Center for Plasma Science and Technology (CePaST) at Florida A&M University (FAMU): Spheromaks, and Laser-Assisted Muon Catalyzed Fusion (LAMCF). FAMU-CePaST has an operational Spheromak called the STPX. The STPX stands four meters high and is two meters wide at the vacuum vessel. The STPX achieves plasma temperatures of 300 electron volts (3.5 million degrees Kelvin) and electron currents of 600 kiloamps. The STPX does not achieve plasma confinement by external magnetic fields, but rather by a self-confining Taylor state which lasts for several microseconds. Disruptive plasma phenomena such as magnetic re-connections are being studied on the STPX. These types of alternative designs for a fusion reactor are much less expensive than the extremely large and expensive ITER. Instead of large-scale centralized fusion devices like ITER, Spheromak reactors would provide distributed power sources and several of them could provide energy to power a small town. Another acc being studied at FAMU-CePaST is LAMCF--in fact, the "laser-assisted" component is an original concept proposed by the author. LAMCF confines deuterium and tritium by using a muon (elementary particle with the same charge as an electron but 200 times the mass) to form a molecule. The laser will be used to speed up the catalyzes cycle using the science of Quantum Control (QC). The basic ideas of LAMCF will be described.

Challenges in Quantifying Optimal CO2 Emissions Policy - Theodore J. Kury, University of Florida- Public Utility Research Center

Implementing public policy without understanding its economic impacts can be costly and unproductive. This problem is paramount when a price of carbon dioxide (CO2) emissions is considered as a vehicle for abatement. The United States Congressional Budget Office, Environmental Protection Agency, and Department of Energy's Energy Information Administration have all released their estimates of the macro-economic impact of various proposals for environmental legislation. The focus of these studies is on the level of output variables such as the amount of CO2 emissions, the cost of emissions allowances, and the broad impact of increased electricity prices, rather than on the marginal effects of policy change. This paper utilizes a model that simulates the dispatch of electric generating units in the state of Florida and demonstrates how incremental cost of abatement curves may intersect with a the marginal benefits of CO2 reduction at many levels of abatement, allowing for different characterizations of the 'optimum'. Therefore, agreement on the marginal costs and the marginal benefits of CO2 abatement can be seen as a necessary condition for the determination of an optimal level of abatement, but not a sufficient one.

ADDITIONAL POSTER SESSION

Monday, May 12- 5:15-6:15 pm

BIOMASS (POSTER SESSION)

Biodiesel Production from Waste Oils using Non Catalytic Supercritical Alcohols -Zachary Cerniga, Dr. Aydin Sunol, Dr. George Philippidis, University of South Florida

A novel sustainable biodiesel manufacturing process has been developed. The continuous process produces biodiesel from waste oils and waste alcohols collected from the local community. It aims at powering the University bus system using a portable plant with a capacity of several hundred thousand gallons a year. The process is intensified by utilizing supercritical alcohols in transesterification reactions with residence times of a few minutes and minimal separation requirements compared to conventional biodiesel production methods. Moreover, the process is very tolerant to water in the waste oil, unlike the conventional alternatives, and incorporates heat integration to minimize utility requirements. Although alcohol cost is minimal, efforts to utilize alcohol waste from University hospitals and laboratories is expected to further reduce the cost of raw materials and boost the sustainability of the technology. With this intensified process wastewater generation is virtually eliminated compared to conventional production methods, which generate 30 gallons of wastewater for every 100 gallons of biodiesel produced. The glycerol by-product is significantly purer than that from conventional methods and can serve as precursor in high-value pharmaceuticals production or soap production for local use. An orthogonal experimental design has been implemented to identify the effects of important process variables, including reaction temperature, residence time, and molar ratio of alcohol to oil. The temperature of operation ranges from 250 C to 350 C and the pressure from 1,500 to 2,000 psia, while the excess alcohol is about 2-8 times the stoichiometric amount and is recycled. Moreover, optimal conditions have been identified by means of response surface methodology. The biodiesel yield is determined by ester content, which is measured via gas chromatography. The presentation will report on the pilot plant operation, process scale up, transportation system powering implications, and life cycle considerations.

Supercritical Gasification of Wet Biomass - Aydin K. Sunol, University of South Florida

The biomass resources can be organized into four groups, as forest residues, agricultural residues, municipal solid waste, and residual industrial waste. Citrus is the leading crop cultivated in Florida, over 800,000 acres and about 100 million citrus trees. Ninety percent of the citrus is processed into juice and the remainder is sold as fresh fruit. The pelletized peel is primarily used as cattle feed and the cost is 60-155 $/ton per Florida Citrus Association. The only possible large scale utility of biomass is its utility as energy source, possibly by producing hydrogen which is the clean energy future of the world. The only waste generated from citrus crops that is large enough for hydrogen production is citrus peel. One million tons/yr citrus waste residue is generated in Florida. The moisture content is 60-80% while hydrogen content is about 6-8%.

The hydrogen produced will find immediate and sustainable use in NASA space programs as well as providing renewable and clean fuel for other applications. Evaluation of hydrogen conversion potential of citrus peel is well overdue. Various biomass conversion technologies have matured over the last three decades and there is a very intense work in Europe, Japan, as well as USA on this technology. The most promising technology for high moisture content biomass is supercritical water

gasification. This technology is also compatible with recovery and fractionation of oils from orange peel. The typical commercial facility may be 30 metric ton/day for which there will be more than sufficient citrus peel. The typical hydrogen production is expected to be 10 grams hydrogen for 100 gram feed.

The presentation will focus on several comparisons of biomass energy conversion technologies in terms of efficiency and carbon dioxide emissions. The objective is to evaluate the position of supercritical water gasification in biomass technologies from the viewpoint of life-cycle evaluation. As for electricity generation, efficient processes are thermal gasification combined cycle, supercritical water gasification combined cycle, and direct combustion in order of efficiency for low moisture content biomass.

However, Supercritical water gasification combined cycle is the most efficient for high moisture content biomass which is the case for citrus peel. The tradeoff between carbon dioxide emissions and total cost of technologies is analyzed so that the most cost-effective technology can be determined for different CO2 emissions constraints. Computed results show that biomass is mainly consumed for electricity and heat generation so as to utilize finite biomass resources efficiently. Transportation fuels are generally made from fossil fuels. Cost-effective processes for CO2 reduction are thermal gasification and reforming when the present efficiency and prices are assumed. Supercritical water gasification is also one of the optimal processes when the relative cost to fuel cell decreases. Improving heat exchange efficiency also contributes toward enhancing the position of supercritical water gasification in biomass technologies

Intragenic Precision Breeding Supports Targeted Modification of Lignin Biosynthesis in Sugarcane - Jung JH, Dermawan H, Altpeter F, University of Florida –IFAS

Sugarcane (Saccharum sp. hybrids) is a highly productive C4 grass used as the main source of sugar and more recently to produce bioethanol. Biofuel production from the abundant lignocellulosic sugarcane residues is expected to not only improve the production rate per unit land area, but also promote green cane harvesting and minimize the open air burning of sugarcane leaf litter. However, bioconversion of lignocellulosic biomass to biofuel is highly limited due to the presence of lignin in plant cell walls. Down-regulation of lignin biosynthetic enzymes has been proven to be a promising strategy to increase the efficiency of bioconversion from lignocellulosic biomass. In the lignin biosynthetic pathway, 4-coumarate-CoA ligase (4CL) is one of the key enzymes, which catalyzes the formation of CoA thiol esters of 4-coumarate. In this study, 4CL gene was isolated and suppressed to reduce lignin content in sugarcane. In order to facilitate regulatory approval, an intragenic approach was used to suppress 4CL. The entire DNA expression cassettes that were used for the generation of the lignin reduced sugarcane were derived from sugarcane and/or sexually compatible sorghum. A total of 60 intragenic sugarcane lines was generated suppressing the 4CL gene up to 97%. Intragenic sugarcane lines with high level of 4CL suppression exhibited brown coloration in the basal internodes and vascular bundle cells. Data describing the total lignin content in the stem biomass will be described.

Breeding Elephantgrass for Elevated Biomass Yield and Biosafety - Baskaran Kannan, Marco Sinche, Carlos Corsato, Fredy Altpeter, University of Florida-IFAS

Elephantgrass (Pennisetum purpureum) also known as napiergrass is one of the best adapted warm season perennial grasses for production of large amounts of high quality forage biomass. The biofuels industry has identified elephantgrass as one of the most productive feedstocks for lignocellulosic biofuel production in the southern US. However, the currently available cultivars and naturalized populations can produce large amounts of wind dispersed seeds, which contribute to their potential for invasiveness. Elephantgrass can be propagated through stem cuttings for new plantings. Hence, seed production is not required for establishment and its suppression will significantly reduce its potential for invasiveness.

In order to enhance the biosafety of elephantgrass, interspecific hybridizations were made between elephantgrass (2n=4x=28) and pearl millet (2n=2x=14), which results in genotypes that display male and/or female sterility due to their triploid (2n=3x=21) nature. We produced more than 3000 triploid, interspecific hybrids between elephantgrass and pearl millet. Phenotypic variability present in these hybrids allowed selecting lines which produced similar or higher biomass amounts than the seed producing elephantgrass cultivar Merkeron. We will present data describing the biomass yield and the sterility of interspecific hybrids evaluated in replicated field trials.

Flowering in elephantgrass is induced by shortening day length. Genotypic differences were observed in different elephantgrass accessions regarding the the beginning and duration of their flowering period. This offers the opportunity for the enhancement of biosafety by genetic hybridization and selection of late-flowering, non-lodging accessions with high biomass yield. Therefore, five genetically distant accessions were crossed to produce around 1600 F1 hybrids. The 50 highest yielding hybrids and 183 hybrids from the two most contrasting parents were vegetatively propagated in replicated row plots for evaluation during two years and four harvest cycles with a commonly used elephantgrass cultivar Merkeron as a control. Phenotypic data were recorded to correlate different traits with biomass yield. Late-flowering, non-lodging F1 hybrids were identified with significantly higher biomass yield than Merkeron. Multi-location testing in larger plots is being carried out to confirm the superior accessions for the development of high-yielding, late-flowering cultivars.

Emulsion of Lignin-co-butyl Acrylate as a Biobased Polymer System - Suguna Jairam, Zhaohui Tong, Fei Wang, University of Florida – IFAS

Stable waterborne latex polymers are gaining a lot of importance due to their various advantages in environment-friendly production, ease in manipulation and a variety of application areas including packaging, paints and coatings, polymer foams and films. For instance, latexes involved in packaging and coating applications tend to focus on the use of styrene and acrylic based copolymers in emulsion and miniemulsion polymer systems. This blend is used to provide strength and flexibility in polymer films hence formed. However, these systems are entirely based on materials sourced from petroleum products. Due to their large-scale use and the vastly diminishing petroleum resources available, sustainability in the synthesis of polymers has become an essential aspect of material synthesis and research. With this issue in mind, the current research is focused on using lignin as a co-monomer in the synthesis of a sustainable emulsion polymer system. Lignin is a bio-based poly-phenolic material that forms 15% of all plant material providing support to the plant structure. It is also known to possess anti-UV and anti-microbial properties apart from high mechanical strength and thermal properties. In the bio-ethanol process, lignin is extracted from the biomass as waste and is discarded. This makes lignin a highly useful and abundant waste resource. The objective of the current research was to modify lignin as a monomer to replace styrene in the styrene-co-butyl

acrylate system and to assess the properties of the polymer formed. Organosolv lignin was modified to its acrylic hydrophobic form resulting in a lignin based monomer. This monomer was then copolymerized with butyl acrylate via emulsion polymerization resulting in a novel lignin based latex. The latex was cast and air-dired to form films used for characterization. Characterization of the modified monomer and polymer included H1NMR, SEM imaging, thermo gravimetric analysis, tensile testing and molecular weight estimation via GPC. H1NMR profile indicated the successful grafting of polymerizable acrylic group on lignin structure. SEM images of the polymer indicate growth of the polybutyl acrylate particles along lignin cores as templates. Analysis of the results indicated that increase in modified lignin monomer (even in low concentrations) in the emulsion system improved the mechanical and thermal properties of films formed. Based on current results, lignin can be a feasible candidate for sustainable and green polymer synthesis in a variety of application areas.

Development and Management of Brassica carinata (Ethiopian Mustard) as a "Drop-in" Biofuel - Ramdeo Seepaul, Sheeja George, Ed Coppola, David L. Wright, Jim J. Marois, University of Florida - IFAS

Producing biofuel crops while preserving land committed to growing food/feed/fiber crops is crucial in the light of the urgent need for U.S. independence from first generation fuels while meeting agriculture's mandate to feed an increasing world population. Florida in particular, being one of the highest consumers of petroleum fuels in the region, could benefit tremendously by using its underutilized (12 million acres of warm season perennial grass pastures) and 500,000 acres of winter fallowed row crop acreage for renewable biofuel production. We propose to use Brassica carinata, an oilseed crop, as a feedstock for biofuels. B. carinata is superior to other Brassica species and oilseed crops in terms of seed size, drought and heat tolerance, and low rates of seed shattering. B. carinata is also better adapted under low input systems and tolerant to weather extremes (low rainfall, high temperature) especially during the grain filling period. B. carinata has considerably higher yields (2500-3000 kg/ha) and higher oil content (above 40%) than other members of the Brassicaceae or other oilseed crops. Because B. carinata is not a food crop, can potentially be grown on marginal land with minimal input, does not compete with traditional row crops, can be used as a feedstock for biofuel production, and can tolerate warm climates, production of this species in Florida may provide an additional economic means to agricultural producers, especially those with small and medium-sized farms that may not be on prime agricultural land. Moreover since only the seed is being harvested and crop residues are being returned to the soil it is a more sustainable option to conventional biomass based feedstock development.

At the UF-IFAS North Florida Research and Education Center, we have been evaluating B. carinata germplasms to identify regionally adapted varieties for cultivation in the Southern United States. In our current project we are looking at optimum planting dates, row spacing, seeding rates, nitrogen fertilizer rates, fungicide and herbicide effect etc. We are also evaluating the potential of B.carinata to be used in a crop rotation system and also examining soil physico-chemical characteristics under the influence of this crop. Data from these trials will be presented at this workshop.

Sunflower Genotype Evaluation for Bio-oil Production in Florida -Fedenko, JR, Wilke, AC, Erickson, JE, University of Florida – IFAS

Sunflower is widely cultivated in the United States and globally as an oil crop, with 1.3 million US acres harvested in 2013 for oil. Sunflower is commercially cultivated primarily in North and South Dakota, and has recently received renewed interest as a rotational cash crop for the Southeastern US. Research has indicated that optimal yields of sunflowers in the Southeast can be produced with early spring planting, potentially allowing production of a second summer crop, such as sweet sorghum, depending on sunflower days to maturity. While yields of hybrid oil sunflowers have recently been documented in Mississippi, most cultivars have been optimized for production in Northern regions, and several studies have examined seed and oil characteristics of native, wild sunflowers in the Southeast. The current research quantified the growth habit and oil content of 10 sunflower genotypes with potential as oilseed crops in Florida. Oil content varied between cultivars from 184 to 381 g oil seed, and total seed yields were heavily affected by cultivar. Seed oil content was not correlated with stem biomass, and cultivars varied significantly in morphology, number of heads produced, total height, and resistance to disease. As a component of the research, a group of undergraduate interns were involved in the planting, management and harvest of the experiment, and throughout the process were provided practical and theoretical knowledge about biofuels and renewable energy. The research suggests that sunflower production may produce comparable oil seed concentrations in the Southeast compared with current production regions if intensively managed.

Bioenergy Plant: Efficient Method for Disposing Biodegradable Materials - Jose Sifontes, Sigarca

The Bioenergy Plant is a unique system that provides an economic and sustainable solution to the management of biodegradable waste, renewable energy and agri-business to rural and urban communities. It handles a wide variety of wastes such as municipal solid waste (MSW), waste activated sludge (WAS), animal waste, agricultural waste, food waste, industrial waste, energy crops, etc. The system provides communities the option to more cost effectively manage waste and save on energy costs through the production of distributed power and production of valuable organic soil conditioners.The Plant is compact, modular and flexible to locate, mobilize, and expand; safe, state of the art and passive with no production of runoff, noise, noxious odors, scum, and silt common to most digesters. Waste generated is loaded in specially-designed containers which are then placed inside bioreactors where it is digested in a heated and moist environment. Byproducts from processing include biogas and organic soil conditioners. Additional benefits include: lowering the greenhouse effect, complying with laws and regulations, improving the hygiene and aesthetics, generating employment and political stability and reducing the threat of waste to communities and the environment. The Bioenergy Plant was a winner on the 2008 Farm to Fuel Program and it is endorsed by University of Florida, TRDA, Florida Department of Agriculture and Marion County. The technology has been tested, verified and demonstrated to the equine community for several years at the Southeastern Livestock Pavilion in Marion County.

Anaerobic Digestion of Food Waste from Alachua County Schools - Ryan E. Graunke, Ann C. Wilkie, University of Florida-IFAS

As society quickly realizes that fossil fuel is a finite resource and recognizes the many problems associated with procuring and combusting fossil fuels, it is inevitable that humans must find

alternative energy solutions. In this effort, every potential resource must be tapped. One such potential resource is food waste. Food waste can become usable energy through the process of anaerobic digestion. In anaerobic digestion, naturally-occurring microorganisms consume organic matter and produce biogas through a series of metabolic processes. In its natural state, biogas is approximately 60% to 80% methane and can be used in much the same way as natural gas (e.g. as a direct-combustion fuel or to produce electricity using modified generators). Also, biogas can be refined into biomethane, which is 100% methane and is identical to natural gas; it can even be injected into the existing natural gas infrastructure to offset fossil natural gas. While many types of organic matter can be converted into methane, food waste is an increasingly growing problem, especially in Florida's urban and suburban areas. By tapping into food waste as a resource, many of the problems associated with the current landfill disposal of approximately 2.3 million tons of food waste each year in Florida can be alleviated. There are many sources of food waste including grocery stores, restaurants, schools, prisons, food manufacturers, farms, and residential areas. Because anaerobic digestion is a scalable technology, a centralized digester can be constructed to collect food waste from a community or, alternatively, individual digesters can be set up at food-waste-generating locations to digest food waste and utilize the resulting biogas on-site. This study examined the potential of food waste digestion at schools. Schools are not only a major source of food waste in Florida, but by spearheading food waste digestion at schools, students can also learn important lessons on the roles of waste and renewable energy in the larger context of sustainability. For this study, waste audits were conducted at 3 local schools in Alachua County during which all waste was collected, categorized, and sorted from the schools' cafeterias over 1 to 2 weeks. Daily-collected food waste from each school was homogenized and representative samples were obtained to measure the physicochemical parameters of the food waste and estimate the daily methane potential from each school. The data were normalized on a per student basis in order to extrapolate the potential energy production from all of Alachua County's schools.

Renewable Energy Production through Organic Waste Recycling at Christianville, Haiti - Reginald Toussaint, Ann C. Wilkie, University of Florida-IFAS

Recovery of renewable energy and valuable nutrients from recycling of agricultural waste has become very critical in the transition from a fossil-based to a bio-based farming system. With the increase of agricultural activities as a response to unprecedented population growth, the amount of organic wastes generated from agricultural production, livestock, and food processing is continuously increasing and their disposal poses serious environmental, economic and logistical challenges. Christianville is a non-profit organization that has been involved in providing long-term sustainable solutions for more than a decade in Haiti. Christianville has an orphanage with 300 children and are feeding more than 1000 other students every day. As a result, Christianville is a net food and energy consumer in a country where food and energy production is very scarce. Sustainable farming systems, fish farms, livestock, and food processing are among the diverse ongoing activities being operated to feed the Christianville community, with plans in place for expansion. With the anticipated increase of agricultural activities at the beginning of the coming year, organic waste production is consequently expected to increase significantly and therefore provides justification for the implementation of a farm-scale biodigester for environmentally sustainable waste handling as well as energy and plant-nutrient recovery. This project aims at implementing biodigestion at Christianville as a sustainable technology for handling organic wastes generated from diverse ongoing activities while providing a clean-burning renewable energy in the form of biogas, as well as an enriched-fertilizer source to enhance food production and food security for this Haitian community.

Methane Productivity of Organic Waste Treatment by Two-Phase Anaerobic DigestionVictoria Cortés, Ann C. Wilkie, Zamorano Agricultural University and university of Florida-IFAS

Two-phase anaerobic digestion methodology has a positive impact on the conditions required for the groups of microorganisms involved in the process. Using this methodology, we can obtain a reduction of the hydraulic retention time (HRT) and higher efficiency of organic matter removal. The efficiency of anaerobic digestion was evaluated by comparing the methane production in 250 mL one and two-phase anaerobic batch reactors using the organic wastes of coffee pulp and boreal waste, as substrates with seasonal availability, and the separated fiber from swine waste as a substrate with continuous availability. Organic loads of 1.00, 2.00, 3.00, 4.00, 6.00 and 8.00 kg VS/m3 were applied to one-phase reactors and to the methanogenic phase of the two-phase reactors, using biol as inoculum for these reactors and a mixture of facultative bacteria from waste stabilization pond effluent as inoculum for the acidogenic phase of the two-phase reactors. The biol used as inoculum was the effluent from active anaerobic biodigesters operated with dairy manure. The tests were performed at mesophilic range of 33–35 °C. The setup of the hydrolytic-acidogenic phase reactors required a HRT of two days, run within an organic loading range of 14–20 kg VS/m3. The effluent from this reactor was analyzed to calculate the organic load needed for the methanogenic reactor setup. One-phase reactors were also set up at the same organic loads to obtain the HRT required for the degradation of the substrate and the organic load which causes failure in the process. The one-phase reactors operated at loading rates between 1-3 kgVS/m3 were also used to obtain the maximum yield of methane for each substrate through a methane index production assay (MIP). The MIP values obtained were 0.67, 0.35 and 0.49 m3 CH4/kg VS for coffee pulp, boreal waste and fiber from swine manure, respectively. The maximum operating loads in methanogenic phase reactors were 2.50, 7 and 8 kg VS/m3 for coffee pulp, boreal waste and fiber from swine manure, respectively. Values higher than this were followed by a system failure. The optimal operational load for the methanogenic phase reactor was found to be 2.00 kg VS/m3 when the coffee pulp substrate was fed at pH values lower than 4, without adding alkali reagents. The HRTs required for the degradation of the substrates in one-phase reactors were 28, 35, and 40 days for coffee pulp, boreal waste and fiber from swine manure, respectively. In addition, the HRT required by the two-phase anaerobic reactors in all assays to obtain the same amount of methane produced in one-phase reactors was reduced by at least 30%. The ultimate yield of methane obtained with the two-phase anaerobic reactors was comparable to the results obtained with the one-phase reactors, but at lower HRTs.

Co-production of Astaxanthin and Biofuels - Alec. S. Shoelson, Ann C. Wilkie, University of Florida-IFAS

Cultivation of algae can yield a diversity of high-value bioresources, which mitigate the cost of biofuel production. Microalgae are currently cultivated for such high-value compounds as astaxanthin, beta-carotene, lutein, etc. Haematococcus pluvialis is a freshwater species of Chlorophyta from the Haematococcaceae family. When stressed, the cells encyst into immobile aplanospores and accumulate astaxanthin, a carotenoid pigment. Astaxanthin has strong antioxidant properties and offers a wide range of health benefits. It is therefore highly sought after and is used heavily in the aquaculture and pharmaceutical industries. However, because it can be difficult to obtain from natural sources, synthetic substitutes are often used that lack many of the benefits natural astaxanthin provides. The objective of this study was to optimize the growing

conditions of Haematococcus along with stressing the cells to produce astaxanthin and determine a way to extract it. Haematococcus pluvialis was cultivated using a variety of techniques and conditions. An orbital shaker with volvox media proved to have the most optimal conditions of those tested. Haemoatococcus cells were stressed into producing astaxanthin by being put under high light and low nutrient conditions. Due to astaxathin's popularity and high price, Haematococcus could be grown and sold to supplement algal biofuel production. If Haematococcus is grown at a biofuel facility, the profits from the sale of astaxanthin could be used to offset other costs. The residual biomass after astaxanthin extraction could be anaerobically digested to produce methane-rich biogas, an alternative to natural gas, which could be used to produce electricity for algal production or processing facilities. Burning methane produces carbon dioxide, which can be recycled back into growing more algae. Also, carbon dioxide produced from bioethanol fermentation processes can be directed towards algal cultivation. If able to be grown and harvested in an efficient and affordable way, Haematococcus and astaxanthin may have wide-reaching implications for integrated biofuel refineries.

Characterization of Cellulosic Ethanol Stillage and Use as an Algal Growth Medium - Tommie B. Lovato, Ann C. Wilkie, University of Florida-IFAS

Cellulosic ethanol is a potential alternative to petroleum-based fuels and, because it is created from lignocellulose found in woody plant materials, it does not compete directly with food production, unlike corn-based ethanol. One obstacle in cellulosic ethanol production is dealing with the stillage by-product that is typically high in nutrients and chemical oxygen demand. Growing algae for biofuels and high-value pigments like β-carotene or astaxanthin requires high nitrogen inputs to sustain growth and produce more biomass, providing a possible bioremediation option for stillage. Various treatment options exist for stillage including anaerobic digestion that has been shown to substantially reduce chemical oxygen demand. In addition, algae can serve as a potential feedstock for anaerobic digestion and the subsequent creation of biogas introducing a conceivable link between multiple bioenergy prospects. The objective of this study was to cultivate algae using stillage as a nutrient source. Sugarcane bagasse stillage from the UF-IFAS Stan Mayfield Biorefinery Pilot Plant was characterized, measuring pH, electrical conductivity, light transmission, total nitrogen, total ammoniacal nitrogen, total and soluble phosphorus, and total and soluble chemical oxygen demand. A strain of the microfilamentous cyanobacterial algae Spirulina sp. was isolated using a modified Spirulina standard culture medium replacing nitrate ion with ammonium as the nitrogen source. This culture was then inoculated into flasks with 2% dilutions of stillage supplemented with Spirulina nutrients using Spirulina's preferred sodium bicarbonate as a carbon source. The experimental group using the 2% stillage dilutions produced more biomass than the control under the same conditions, as measured by optical density absorbance readings. Lipid analysis using nuclear magnetic resonance based against a triolein standard showed that the algae biomass had low neutral oil content and was not ideal for algal biodiesel production. However, the biomass growth under experimental conditions points towards a potential use of stillage as a nutrient source in algae production. The algal biomass can be utilized as feedstock for biogas production via anaerobic digestion.

Reuse of Cellulosic Bioethanol Residuals - Jianru Shi, George O'Connor, Ann C. Wilkie, University of Florida-IFAS

Increasing demand for fossil fuels, coupled with diminishing fossil fuel reserves, create an urgent need to develop renewable energy sources as a replacement for fossil fuels. Biofuel systems have emerged as one such alternative to fossil fuels. First-generation biofuels are made from sugary or starchy plants and have generated food security concerns. The development of second-generation biofuels emphasizes the use of non-edible (cellulosic) feedstocks and green chemical technologies. However, the commercialization of second-generation biofuel is held up by technical as well as economic issues. Many studies focus on enhancing technology to improve ethanol productivity, while very few studies recognize the importance of the byproducts associated with cellulosic ethanol production. Beneficial reuse of these residues could provide cost savings as well as lessen the negative environmental impacts imposed by chemical fertilizers. An estimated 20 liters of stillage byproduct is generated for every liter of ethanol produced, so an effective solution for byproduct treatment is necessary when considering large-scale production of cellulosic ethanol in the future.

This study critically evaluates the possible treatments for residues from cellulosic ethanol production and discusses the potential environmental and economic impacts of byproduct land application. The first step is to characterize and compare the stillage from different types of feedstocks. Treatments applied to first-generation bioethanol residues may or may not work on cellulosic ethanol residuals. Different initial chemical components of cellulosic feedstock, combined with the various pretreatment processes, may also result in byproducts that require different types of treatment prior to reuse management.

Land application has been considered as one of the possible approaches for final disposal of cellulosic ethanol byproduct. Several studies have reported positive effects of land application such as improving soil structure, reducing soil erosion, increasing soil organic matter content, and reducing nutrient leaching. These potential benefits as well as the effects of these residuals on crop yields, especially biofuel feedstocks, are being evaluated as part of this research.

Evaluation of Energy Recovery Potential from Sweet Potato Stillage - Wendy Mussoline, Ann C. Wilkie, University of Florida-IFAS

Sweet potatoes, or eTubers, have recently emerged as a potential non-grain feedstock for bioethanol production. More than 80% of the global sweet potato production occurs in China where it is mainly used for processed food, animal feed or alcohol. In Florida, however, marginal land from former citrus groves is being utilized by CAREnergy to grow high-starch eTubers for bioethanol production. The crop tolerates heat, requires little irrigation, and has been shown to produce 4 to 5 times as much starch per acre as corn.

The waste residues from the conversion process remain a concern, however, as approximately 20 liters of stillage can be generated for every liter of ethanol produced. The sweet potato stillage contains relatively high concentrations of organic compounds (25,000 to 60,000 mg COD/L), total nitrogen (1000 to 6000 mg/L) and total phosphorus (500 to 1000 mg/L). Anaerobic digestion is an effective means of reducing the chemical oxygen demand (COD) in the stillage and converting it to biogas, while still conserving the nutrients for soil enrichment.
The focus of this research is to evaluate the biogas potential of sweet potato stillage by conducting baseline biogas index tests under mesophilic conditions. The tests will be conducted using both stillage and culled sweet potatoes. Characterization of the feedstock will include parameters such as total solids, volatile solids, COD, total nitrogen, ammonia nitrogen and total phosphorus. Biomass

reduction, biogas yields and retention times will be measured to assess the feasibility of this approach and to quantify the overall improvement of process efficiency by using biogas rather than fossil fuels for steam generation. Higher COD reduction (89% versus 78%) has been previously documented for potato stillage under mesophilic as opposed to thermophilic conditions.

Waste characterization of the digestate will also be evaluated to ensure that sufficient macro- and micro- nutrients are available to return to the eTuber crops as fertilizer. A recent life cycle analysis that evaluated bioethanol production from sweet potatoes concluded that replacing coal with a cleaner fuel and eliminating chemical fertilizers could effectively increase net energy gain by nearly 50% and decrease the environmental impact from eutrophication by nearly 40%. Though the eTuber™ ethanol industry has the potential to benefit local communities and agriculture in Florida, the market potential and environmental sustainability of the industry are clearly dependent upon energy recovery from the stillage and recycling of the digestate.

Anaerobic Co-Digestion of Swine Manure and Microalgae for Biogas Production - Meng Wang, Eunyoung Lee, Qiong Zhang and Sarina Ergas, University of South Florida

Anaerobic digestion has been widely used to stabilize livestock wastes and produce energy. However, centrate produced after anaerobic digestion contains large amounts of nitrogen (N) and phosphorous (P), and additional nutrient removal processes are required before discharge. Microalgae have gained a lot of attention as an alternative biofuel source, due to their high growth rates, independence from arable land usage and ability to remove nutrients from various wastewaters. This study investigates the integration of nutrient recovery and on-site energy production into farms by applying algae cultivation and anaerobic digestion technology. In this system, nutrients are removed from the anaerobic digester centrate by algae growth and the harvested algae biomass is co-digested with swine manure for on-site energy generation. Previous studies have found that centrate from digested swine manure is a good medium for algae cultivation. However, there is limited research on anaerobic co-digestion of swine manure and microalgae.

In this study, six treatments with different proportions of indigenous Chlorella sp. grown on synthetic swine waste (A) and swine manure (SM) were performed in batch anaerobic digesters. The combinations of wastes based on volatile solids content in the six treatments were: T1 (100% SM), T2 (6% A+94% SM), T3 (16% A+84% SM), T4 (43% A+57%SM), T5 (75% A+25% SM), T6 (100% A). Biogas production from the algae only treatment (250 mL CH4/g VSfed) was the lowest compared with all other treatments. The cellulose or hemicellulose structure of the algal cell wall, which is hard to degrade under anaerobic conditions, mostly likely inhibited biogas production. Co-digestion of algae with swine manure improved biogas production. Treatments with up to 16% algae addition resulted in similar biogas yields as swine manure alone (317 mL CH4/g VSfed). Moreover, the addition of 6% algae significantly improved the biogas yield of the swine manure (348 mL CH4/g VS). A case study will be presented for a medium sized confined animal feeding operation (CAFO) showing the potential to increase biogas production and treat wastewater as well as the economic benefits of using this strategy.

Bioprospecting for Oleaginous Microalgae and/or Cyanobacteria From Wastewater Holding Tanks - Devin Alvarez, Lowell Collins, Ashvini Chauhan, Florida A&M University

Biofuel generation coupled with wastewater remediation has been proposed as a viable, environmentally sustainable technology. We used Fluorescent Automatic Cell Sorting (FACS) as a high throughput method to isolate native algal cells from secondary treated wastewater holding tanks. Two sample preparation methods were employed to concentrate the native algal biomass; a) centrifugation (sample 1) and enrichment in Chu10 or BG11 media (sample 2). Prior to FACS, both sample 1 and sample 2 were stained with 1µM of BODIPY 505/515, a microalgal cell lipid fluorescence enhancement method. FACS was run on a BD FACSAria machine using all possible combinations of excitation lasers and filters, and those that showed the highest resolution between bands were chosen for sorting. We isolated approximately 83 fluorescent strains from 768 wells sorted from sample 1. Most of the isolates were characteristic of the green pigmentation shown by microalgae but we also found some with brown and golden pigmentation. From the enriched sample, 82 cultures were isolated from 4800 wells sorted possessing brown, yellow, gold or red pigmentation but no green colored cells were found; this likely occurred because the enrichments permitted for the green algae to be outcompeted by brown algae. The isolates produced from samples 1 and 2 are being analyzed by Automated Ribosomal Intergenic Spacer Analysis (ARISA) and/or Restriction Fragment Length Polymorphism (RFLP) using the 18S gene and/or the internal transcribed spacer region (ITS1-5.8S-ITS2) genes to determine purity and diversity of the isolated strains. In addition, we are also comparing the lipid production abilities of the isolated strains and correlate their ability to sequester wastewater nutrient

Wastewater Nutrient Sequestration and Production of Lipid-biofuels from a Newly Isolated Cyanothece sp. strain SGAC1 - Lowell Collins, Devin Alvarez, Ashvini Chauhan, Florida A&M University

The production of value added products from microalgae on the commercial scale is generally successful, but large scale outdoor production is restricted mainly because of fluctuating temperature. Larger scale systems have yet to become economically feasible and the obstacle of seasonal or diurnal temperature fluctuation is an industry barrier. Growth of an isolate throughout the annual cycle is a prerequisite of commercial biomass production. In investigating this, a local Cyanobacteria sp. was isolated from wastewater holding ponds in Tallahassee, FL. Cyanobacteria represent a widespread group of photosynthetic prokaryotes serving not only as primary producers in aquatic environments but also contributing significantly to carbon sequestration, O2 production and nitrogen cycle. Efficient photosynthetic capability, faster growth rates, and ease in genetic modifications are some of the major advantages of cyanobacteria relative to microalgae for the production of next-generation biofuels. Using 16S rRNA gene taxonomy, strain SGAC1 was found to be 85% similar to Cyanothece sp. strain PCC8802, which was isolated from rice fields in Taiwan. Our ongoing studies are demonstrating seasonal durability of the newly isolated Cyanothece strain SGAC1 in a range of temperatures that are being correlated to the production of lipids and nutrient sequestration efficiency for obtaining environmentally sustainable algal technologies specifically customized for growth at North-Florida facilities.

A Kinetic Model for Microalgae Growth in Wastewater - Eunyoung Lee & Qiong Zhang, University of South Florida

Microalgae have received much attention as a potential energy resource because they contain 250 times more oil per pound of biomass compared to other energy crops, such as soybeans (Hossain et

al., 2008). In addition, microalgae do not compete for arable land since they are cultivated in ponds or photobioreactors (Rosch et al., 2012). Despite these benefits, life cycle assessment studies have shown that microalgae biofuel has higher environmental impacts than first generation biofuels due to the nutrient requirements for microalgae cultivation (Clarens et al., 2010). Thus, sustainable microalgae biofuel production system will need to integrate with wastewater as nutrient resources (Guest et al, 2013). A key obstacle of this integration is a lack of understanding of microalgae growth in wastewater which is necessary to improve microalgae productivity. Therefore, the goal of the overall study is to develop a new kinetic model of microalgae growth using wastewater as nutrient resources. The framework of the model was based on the combination of threshold and multiplicative theories. In the model, nitrogen, dissolved carbon dioxide concentrations, and light intensity were selected as major growth factors. The current study and results presented focused on the determination of a rate expression for nitrogen based on existing models.

In this study, Chlorella sp., collected from Howard F. Curren Advanced Wastewater Treatment Plant in Tampa, Florida was used and performed in batch photobioreactors (1L) for 7 days. Synthetic wastewater with a similar composition to centrate from anaerobically digested swine manure was used for the cultivation. The experiment was conducted at a controlled temperature (22±1°C). During the experiment, 5% CO2-air mixture was injected through a fine bubble diffuser in the reactors (with the flow rate 400ml/min). The reactors were illuminated by 13W and 20W fluorescent lamps (24:0 h light-dark cycles) to provide the desired light intensity (5000lux).

Microalgal biomass concentrations were measured with time for different initial concentrations of nitrogen (0-308ml/L) with/without organic carbon in synthetic wastewater. The Haldane–Andrews model was found to fit best to the experimental data. Kinetic parameters of the Haldane–Andrews models were determined by fitting the experimental data to the relationship between specific growth rate (μ) and initial nitrogen concentration obtained from the growth curves. The parameters for microalgae growing in the wastewater (without organic carbon) were μmax = 2.32 d-1, Ks=140 mg/L as N, and Ki= 25 mg/L as N (R2=0.8014), while the parameters in the wastewater containing organic carbon were μmax = 17.12 d-1, Ks=229 mg/L as N, and Ki= 12.9 mg/L as N (R2=0.7694). The results showed that the μmax and Ks values in wastewater containing organic carbon were high because the organic carbon is readily bioavailable so that it stimulates the microalgae growth (Liang et al., 2009; Ogawa & Aiba, 1981). It indicated that the Haldane-Andrews model can describe the growth kinetic in terms of N with inhibition of NH3. Thus, the Haldane-Andrew model is an appropriate rate expression for nitrogen in the new model.

Indigenous Algal Growth on Municipal Sludge Centrate and a Simple Irradiance-based Model for Predicting Biomass Production in the System - Trina Halfhide, Kofi Dalrymple, Ann Wilkie, Sarina Ergas, University of South Florida

An indigenous algal consortium was cultivated on municipal sludge centrate in a semi-continuous photobioreactor, operated with a mean cell residence time of seven days under natural light conditions. Centrate from dewatering anaerobically digested municipal sludge is of particular concern in wastewater treatment, as it contains high ammonia concentrations, and is often recycled to the head of the plant, reducing efficiency. The research goals included: (1) to enrich an algal consortium capable of growth on sludge centrate, (2) observe and measure biomass productivity, including lipid production, and nutrient removal efficiencies, and (3) apply a simple irradiance-based model to predict biomass production in the photobioreactor. The model was developed from the fundamental Michaelis-Menten photosynthesis-irradiance (PI) response for photosynthetic

organisms. A good fit to the experimental data was obtained with the irradiance-based model (R2=0.96), indicating that the system was light. Chlorella sp. was the dominant species (95%) in the consortium. The mean biomass productivity was 5.2 g m-2 d-1. Observed mean removal efficiencies for total nitrogen, total phosphorus, ammonia and chemical oxygen demand were 65, 71.5, 77.5 and 8%, respectively. Lipid production was low, comprising only 10% of total biomass and could be used as a feedstock for anaerobic digestion for methane production.

Alternative Sources of Nutrients for Production of Microalgae Biomass - Kassiana Ribeiro dos Santos, Juan C. Ordonez, Florida State University

The high cost of production in the cultivation of microalgae in photobioreactors is a barrier to be overcome, therefore is necessary to search to reduce the cost of cultivation. The objective of this work is to compare the growth of the microalge Scenedesmus sp. being cultivated in CHU medium and in an alternative medium composed mainly of fertilizer. The research approach consisted on growing the microalgae in Erlenmeyer type photobioreactors and producing the growth curves for both media. The comparisons between the two were made based upon three parameters: dry biomass, absorbance, and total lipid quantity. The experiments were made in triplicates in order to quantify the uncertainty in the measurements. The comparison of the cultivation in both media suggests that the modification of the chemical nutrients by fertilizer did not produce significant changes in the number of cells, dry biomass and lipids. In spite of that, the modification resulted in 20% reduction in the growth medium. In this way, the substitution of conventional nutrients by fertilizers, constitute an interesting alternative for the production of biomass from microalgae leading to a cost reduction.

Searching for the Lipid Trigger in Biofuel Green Algae - Elton Carvalho Goncalves, Jin Kho, Sixue Che, Bala Rathinasabapathi, University of Florida

Algal lipids as a source of biofuels represent superior alternatives to cellulosic and corn-based ethanol for energy use. Algal storage lipid triacylglycerol (TAG) can readily be converted to high quality fuel via transesterification of TAG, yielding biofuel and glycerol. In our recently published study, we used the green algae Chlorella sp. as a model to investigate storage lipid synthesis and accumulation in response to nitrogen starvation using radiotracer labeling, lipid analyses using mass spectrometry, and ultrastructure. Two of the most striking findings were that Chlorella cells start accumulating TAG as early as 3 hours of nitrogen starvation and that acyl groups from membrane lipids are remodeled into oil bodies during this stress. A special proteomic method called the isobaric tagging for relative and absolute quantitation of proteins (ITRAQ) was used to identify soluble and membrane proteins modulated in the early stages of nitrogen starvation. Out of 1736 soluble proteins identified, 208 were differentially expressed under nitrogen starvation. Several transcription factors were found among the top up-regulated proteins, suggesting possible transcriptional mechanisms controlling this metabolic shift in green algae. Validation of the proteomics data is currently in progress. The mechanism of oil accumulation in response to this stress is still poorly understood and not easily applicable in large-scale production systems. Moreover, such stress condition is not conducive to high growth rates and biomass productivities. Our goal is to reveal the main regulatory steps involved this stress response in order to develop an alternative approach that mimics N starvation, maintaining oil production without compromising culture growth. Therefore, the outcome of this project can be expected to have a direct impact in speeding up the process of making algal biofuels a competitive product in the market.

Development of a Production System for Natural Renewable Gas Using Synechococcus sp. BG0011, a Unique Cyanobacterium, as a Feedstock - Bailey E. Trump, Cesar M. Moreira, Edward J. Phlips, Pratap Pullammanappallil, Spyros A. Svoronos, University of Florida

Three University of Florida labs are collaborating to develop an innovative new technology for the production of renewable natural gas, by combining a unique strain of cyanobacteria (i.e. blue-green algae) with an anaerobic digester technology. The overall system is designed to address two critical challenges facing the successful application of algal feeds for biofuels production: 1) The availability of species capable of sustained biomass production over a wide range of environmental conditions, and 2) A pathway for converting algal feedstocks to biofuels which avoids costly harvesting and processing procedures. Synechococcus sp. BG0011, the feedstock species, is unique because it is capable of excreting viscous polysaccharides, surviving in hypersaline conditions, and fixing nitrogen. The algal and carbohydrate solution will be fed directly (with or without co-feedstock like manure) into anaerobic digesters for the generation of methane gas. The methane gas will then be converted to electrical power, and some of the byproducts utilized for other value-adding purposes. In order to develop this production system, the ecophysiology of BG0011 will be evaluated, its genome sequenced, its extra-cellular material characterized, and its biochemical potential of digestion will be investigated. The convertibility of BG0011 biomass and polymers to methane has been demonstrated in preliminary experiments at the University of Florida. The proposed system is unique because it diverges from most existing technologies in bypassing one of the most costly aspects of existing approaches; the separation, concentration and conversion of algal biomass into liquid fuels.

Comparison of pretreatment methods to enhance methane production from microalgae Nannochloropsis oculata - Pratap Pullammanappallil, Samriddhi Buxy, Robert Diltz, Tushar K. Goswami, Weihua Yang, University of Florida

Microalga is an ideal feedstock for biofuel production as it is rich in lipids and carbohydrates. Nannochloropsis oculata (N.oculata), is a spherical autotrophic unicellular microorganism with thick cell wall. Anaerobic digestion eliminates the need of dewatering, extraction or economical separation, which is required in other biofuel production from algae. N.oculata is not rich in lipids but contain predominantly cellulose and other carbohydrates, which makes it a good feedstock for anaerobic digestion. Anaerobic digestion of microalgae faces numerous challenges due to complex structure and thick cell wall of algae cells. One of the main challenges is to breakdown the cell wall. Pretreatment helps in overcoming this obstacle. Different pretreatment studies like acid hydrolysis, sonication, freezing, microwave irradiation etc. done on algae are indicative of resulting cell wall disruption which in turn would improve anaerobic digestibility of algal biomass and enhance the rate and extent of methane production. Biomethane potential of marine microalgae N.oculata was determined in a 5-L batch digestion setup. N.oculata was grown in an open raceway pond at 25ºC, with 1% CO2 and 99% air supplied. N.oculata was grown for 2-3 weeks to final concentration of 600-800 mg/L, and then harvested in a 30-gallon batch by adding base and concentrating algae to 3.15% volatile solids.

In the present study, different pretreatment techniques such as, thermal, acid catalyzed thermal, ultrasonication and enzyme hydrolysis were investigated to improve anaerobic digestibility of N.oculata. Biogasification of N.oculata was optimized in terms of duration and intensity of pretreatment. Thermal hydrolysis (at 160ºC for 90 minutes) was done prior to enzyme hydrolysis with and without acid catalyst (2% phosphoric acid). Commercial enzyme (Cellic CTec2, Novozymes)

developed for hydrolysis of lignocellulosic biomass was used in present experiments. The average biomethane potential of untreated N.oculata was 0.225 LCH_4 STP/g VS. The highest methane yield was achieved by thermal treatment without acid addition + enzymatic saccharification (0.5 L CH_4 STP/g VS). Simple thermal treatment of N.oculata (at 160ºC for 90 minutes) followed by anaerobic digestion without an enzymatic saccharification step (0.26 L CH4 STP/g VS) did not show any considerable improvement in methane yield from control. Thermal treatment with addition of acid as catalyst (at 160ºC for 90 minutes) produced 0.39 LCH_4 STP/g VS and ultrasonication pretreatment produced 0.286 LCH_4 STP/g VS. These were 1.7 times and 1.2 times higher methane yield than methane yield from untreated microalgae.

N.oculata harvesting rate was 9.64 g VS/m^2/d from pilot scale experiments conducted as part of this project. Using this information and the highest methane yield value obtained in this study (0.5 L CH4 STP/g VS), preliminary calculations show that potentially 166 BTU/ m^2/d of energy could be produced from biogasification of N.oculata which is 1.4 times higher than that produced from biogasification of high sugar content terrestrial energy crop like sugarbeet (114 BTU/m^2/d).

SMART-GRID & STORAGE (POSTER SESSION)

Renewable Energy Investment and Operational Decision Model - Alireza Ghalebani, Tapas K Das, University of South Florida

Higher level of distributed renewable energy generation and storage (microgrids) will lead to a significant reduction in carbon emission and also reduced cost of electricity in the grid, especially during peak times. Since the renewable green energy generation is still relatively expensive, there are federal, state and utility incentives to increase penetration of distributed renewable energy generation and storage for different regions in the country. In this research, we develop a decision support tool for the consumers to find an optimal level of investment in microgrids and an optimal operational strategy for microgrids participating in a smartgrid. Based on existing incentives, consumer characteristics, price of technologies and the weather forecast, a new Mixed Integer Programming (MIP) model is solved in order to find optimal level of investment in renewable energy generators and storages and their operational strategies to yield a minimum annual cost of energy.

We consider five main categories of incentives such as performance based incentives (PBIs), sales tax incentives, federal tax credit, rebates, and loan programs. PBIs and sales tax incentives are production based compensation. Rebate programs, federal tax credit and loan programs are incentives for installation. The two-level system model for investment and operation that we have developed will also serve as a tool for examining the impact of different incentive and rebate policies and thus serve as a policy design aid at the local, state, and federal government levels. Our “integrated decision support system of design and operation” can be used by households, business sectors or investors to decide the most profitable portfolio of renewable generators and batteries to invest and operate. This decision support tool aims to optimally benefit from the available incentives and tax credits for green energy, and reducing the share of current power supply from fossil fuels thus reducing carbon dioxide emission and increasing social welfare in the long run.

Using Electrochemical Impedance Spectroscopy to Study the Reaction Rates and Diffusion Coefficients in Li Batteries - Mohit Mehta, Petru Andrei, Florida State University

Over the last 10 years the progress of renewable energy technologies such as wind power and photovoltaics has been remarkable. The global solar power market has grown consistently by 37%/year on an average and wind energy by 21%/year. It is currently being forecast that by 2050 all our energy requirements could be fulfilled by renewable energy sources. The alternative sources are abundant and readily available but they are often not reliable. These sources are localized and often away from main power distribution centers. The electrical energy storage (EES) devices will become an important component for smoothing the intermittency of renewable energy storage and also to act as centralized base power stations. EES devices will not only be important in the power sector as grid storage units but also in the transport sector as fuel for electrical vehicles in the future. Electrochemical energy storage systems have a number of advantages over other electrical energy storage devices, namely they are cleaner, cheaper, faster to build, more responsive, and require less storage space.

Li-air electrochemical systems have received a lot of interest in the past few years mainly because of their high energy densities and specific capacities. Recently, we have developed an analytical model for studying the Electrochemical Impedance Spectroscopy (EIS) of Li-air batteries under d.c. discharge, in which the mass transport inside the cathode is limited by oxygen diffusion. The model takes into consideration the effects of double layer, faradaic processes, and oxygen diffusion in the cathode, but neglects the effects of anode, separator, conductivity of the deposit layer, and Li-ion transport. In this workshop we will demonstrate the use of our model to extract information such as the value of the effective oxygen diffusion coefficient and the reaction rate from the impedance spectra. The analytical model predicts that the effects of faradaic impedance can be hidden by the double layer capacitance. Therefore, we will consider two cases: 1) when the faradaic process and the double layer capacitance are separate and can be distinguished as two different semi-circles on the Nyquist plot and 2) when the faradaic process is shadowed by the double layer capacitance and shows up as only one large semi-circle on the Nyquist plot. The diffusion coefficient can be determined by using the resistances (real impedance intercept on the Nyquist plot) of both the semi-circles for the first case and by using the combined resistance for the second case. Once we find the effective oxygen diffusion coefficient, we can use it to estimate the value of the reaction constant. This method of extracting diffusion coefficient and the reaction constant can serve as a tool to study the material properties of the electrolyte. It can also serve as a noninvasive technique to identify and quantify the use of a catalyst to improve the reaction kinetics in the battery.

Experimental Study of Heat Transfer Improvement in Phase Change Materials for Thermal Energy Storage - Abhinav Bhardwaj, Elias Stefanakos, D.Y. Goswami, Clean Energy Research Center, University of South Florida

This paper reports an experimental study to determine improvement in heat transfer rates of optically enhanced high temperature phase change materials (PCMs) for thermal energy storage systems. At high temperatures, radiative heat transfer can be a significant part of the total heat transfer. For thermal energy storage at temperatures above 500 degrees C, salts, such as, Sodium Chloride are used as the PCMs which are transparent to infrared (IR) radiation. In these materials the radiant heat transfer can be improved by incorporation of absorptive additives. For this project, as a proof of concept, an experimental method was developed to study the improvement in heat transfer rates using absorbing additives in the PCMs.
The experimental temperature measurements were made with oxidation resistant high temperature thermocouple assemblies at different locations in the sample. The samples were held in ceramic containers and were tested at temperatures around the phase change temperature of the material. This data was used to determine the improvements in heat transfer rates on account of the

additives. The paper will describe the improvements in the heat transfer rates in the optically enhanced PCMs.

Studying Stress Relaxation at Polymer Interfaces Using FTIR-ATR Spectroscopy - Onyekachi Oparaji, Daniel Hallinan, Florida State University

Evolution of the structure of heterogeneous battery electrodes contributes significantly to the fade of battery capacity. Both conventional electrodes and polymer-electrolyte-based electrodes rely on polymer binder to maintain intimate mixing of components. Large volume changes inherent in the charge and discharge of a battery can lead to delamination of the components from the polymer binder rendering those components inaccessible. Therefore, our research focuses on studying the dissipation of stress at polymer interfaces. We use a model block copolymer and a selective solvent to preferentially swell one block. Time-resolved Fourier Transform Infrared - Attenuated Total Reflectance (FTIR-ATR) spectroscopy is then used to measure stress relaxation in the unswollen block. Better understanding of polymer stress relaxation as a function of temperature and the rate at which stress is applied will lead to better understanding of battery fade and to design of longer lasting electrode binders.

Designing Composite Polymer Electrolyte Interfaces for Stable Electrodes - Guang Yang, Daniel Hallinan, Florida State University

Polymer electrolytes are promising materials for high energy density rechargeable batteries. However, typical polymer electrolytes are not electrochemically stable at the charging voltage of advanced positive electrode materials, which is above 4 V. The initial goal of this project is to understand polymer electrolyte oxidation and design advanced composite electrolytes to prevent such oxidation. The polymer electrolyte used in this study comprises poly(ethylene oxide) (PEO) and lithium bis(trifluoromethanesulfonyl)imide salt (LiTFSI). We have chosen an inert metal electrode (gold) to measure PEO + LiTFSI electrochemical stability in the absence of reversible electrochemical reactions. Gold nanoparticles (AuNPs) have been used as probes in a heterogeneous electrode for the following reasons: AuNPs have large surface-to-volume ratio to provide sufficient contact area and signal; they are non-reactive with LiTFSI and PEO; surface modification is facile. The AuNP + PEO + LiTFSI composites are characterized using X-ray Diffraction (XRD) and small angle X-ray diffraction (SAXS). The electrochemical properties of AuNP + PEO + LiTFSI are studied using impedance spectroscopy and cyclic voltammetry. The effect of the AuNP/polymer interface composition on electrode stability will be presented.

Optimal Dispatch of Energy Storage Systems in Real-time Digital Simulation - Lingling Fan, Zhixin Miao, University of South Florida

In this paper, a high-fidelity microgrid model is developed in OPAL-RT's RT-lab. The microgrid consists of solar, wind, loads and a battery. The objective of this paper is to investigate the feasibility of a two-level system architecture for this microgrid: The upper level is responsible for system level optimization while the lower level is responsible for local feedback control. The upper level aims to collect measurements (including power from renewable energy sources, energy storage systems, and load demand), predict the next 24-minute solar/wind generation and load demand, and optimize the battery dispatch for the next 24 minutes. The upper-level control sends the dispatch

demand to the battery at every minute. The lower level control responds to the dispatch demand through the controls equipped in the interfacing converters of the battery. The24-minute time-domain dynamic performance of the system is presented in this paper. Real-time simulation-based tests validate the feasibility of the two-level control architecture in microgrids.

SOLAR (POSTER SESSION)

Laser Processing for the Formation of Ohmic Contacts to CdTe Solar Cells-Vasilios Palekis, Prasad Banel, Christos Ferekides, University of South Florida

For cadmium telluride (CdTe) solar cells one of the most important and difficult step is the formation of low resistance ohmic contact due to the high work function of CdTe. Surface preparation techniques including wet etches are typically used to produce a p+ surface through the formation of a Te-rich layer, followed by the deposition of a metallic contacting material. In this study laser annealing treatment is investigated in order to replace wet treatments for modifying the CdTe surface prior to contact formation. The laser anneals were carried out using a KrF excimer laser at 248nm with a 25ns pulse. X-Ray diffraction (XRD) and scanning electron microscopy (SEM) were used to study morphological changes on CdTe films laser treated under different incident laser fluences. CdTe surface melting point was observed near 80mJ/cm2 energy density. Current–voltage and spectral response measurements were used to analyze CdS/CdTe solar cells treated with laser annealing. Both open circuit voltage (Voc) and field factor (FF) were improved for laser treated samples versus samples with no laser treatment. The best cell fabricated to-date using all dry laser-based processing resulted in efficiency greater than 13%

Investigation of TiO_2 Annealing and TiCl4 Treatment on the Performance of Dye-Sensitized Solar Cells - Shamara Collins, Arash Takshi, Chris Ferekides, University of South Florida

Clean and cost effective electricity has been a long-term goal for governments and researchers around the world. Solar cells convert sunlight directly into electricity without any effluents and can provide a substantial fraction of the world's electricity needs if they can be produced cost effectively. The solar cell of interest for this investigation is the dye-sensitized solar cell (DSSC). In this type of solar cell, the charge generation occurs in a sensitizing dye by absorption of photons, and it has the potential to be fabricated using low cost manufacturing techniques. A wide band gap semiconductor, titanium dioxide (TiO2) and a sensitizing dye are responsible for charge generation while charge transport takes place using a liquid redox electrolyte. The structure and quality of the TiO2 is crucial for achieving high efficiencies in dye-sensitized solar cells. Therefore, this work investigates ways to improve the TiO2 composition. We have studied the effects of: annealing temperature, titanium tetrachloride (TiCl4) concentration and treatment time, and the number of TiO2 layers on the solar cell's performance. It is found that increasing the annealing temperature along with the treatment time of TiCl4 at a diluted concentration increases the devices efficiency. These modifications along with the inclusion of a bilayer semiconductor led to a 30% performance increase. Also, the diluted TiCl4 concentration decreases the damaging effects of the acidic solution without limiting the band edge improvement. Lastly, the bi-layer consisted of transparent and opaque TiO2 paste. The first comprises of 15-20nm particles and the latter of ~100nm particles. Each contributes to enhancement, as the dye and sunlight have greater absorption and scattering capabilities respectively within the solar cell.

A New Solar Radiation Interpolation Technique- Cristian Cardenas-Lailhacar, Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador

The world dependence on energy, particularly on fossil fuels, is an addiction that is having a tremendous impact all over the globe. How much is being used, how much is left, and the consequences of its use are every day questions. A healthy economy certainly relies not only on

the abundance of energy resources, but on their kind, quality, and on how efficiently they are used. It is clear then that the path to follow should be energy efficiency and the use of nonconventional renewable energy (NCRE) sources. Solar Energy is one these. In this paper we show a new mathematical interpolation technique which, by using historical and current solar radiation (SR) data, for a given period and region, provides a pretty accurate SR forecast for the next period considered. The algorithm is based on a mathematical expansion around a minimum of SR in the catchment region of the cycle considered. Future solar radiation profile values depend on some variables and past radiation. The purpose of this research is to have an insight into the amount of SR available in a given region, area, surface, etc., and new expressions and variables for the SR. Among them are the associated force constants, the maximum SR, when it will occur, etc. The algorithm provides new expressions for current SR techniques. Preliminary results of the interpolation technique are shown, with encouraging results.

Cost Effectiveness of Energy Generating Solar Plant Using Sea Water - Sarah Rajkumari Jayasekaran, Essy Tari, Hamid Shoraka, Fazil T Najafi, University of Florida

The objective of this study is to determine the marketability of the byproducts obtained from the sea water used for generating electricity. This study will show the economic impact of the production of water, hydrogen and oxygen in our existing solar plants. The other objective is to gain sufficient knowledge about the environmental impact because of the present process, particularly when we use sea water and then dump the brines into the sea which causes imbalance in the marine ecosystem.

The application of this study will render a long term beneficial effect on the environment. The biggest hurdle solar energy faces is that the competing energy sources available are cheaper when compared to solar.

The Technique involved is using electrolysis to break the bond of water to obtain hydrogen and oxygen in the available solar plants which is a promising route for the production of clean, carbon-free renewable fuel in the form of hydrogen gas (H2). Solar Electricity generation and electrolysis cell for hydrogen production will emerge as a potential technology for solar energy production.

During the course of the study we will develop an evaluation system which will foreshow the performance in terms of cost involved in a solar plant by incorporating our ideology. The marketability of the byproducts will help in reducing the cost involved in the operation of the solar plant. Finally the added benefit of the paper is to educate the public on issues related to the importance of solar energy and the methods to make it more cost effective.

Functional APCVD Oxide Films for c-Si Solar Cells- Kristopher O. Davis, Kaiyun Jiang, and Winston V. Schoenfeld

Atmospheric pressure chemical vapor deposition (APCVD) is a versatile process that offers much promise in enabling significant efficiency gains and cost reductions for crystalline silicon (c-Si) solar cells. In this presentation, we will share recent results on the deposition and subsequent processing of functional oxide films (AlOx, TiO2, SiO2 and doped SiO2) using an in-line, high throughput APCVD system. These oxide films and film stacks can be utilized for doping (e.g. emitter and surface field formation), surface passivation and light management on the front and rear side of c-Si solar cells. Experimental data regarding the microstructure, optical properties and electronic properties of the

films will be presented, along with the impact of these films on cell efficiency and other relevant cell parameters. Implications of these results for standard and novel c-Si cell architectures will be covered.

ENERGY EFFICIENCY (POSTER SESSION)

Analysis and Optimization of Combined Flash Binary Cycle for Geothermal Power Generation - Mehdi Zeyghami, Yagi D Goswami, University of South Florida

Due to limited supply and negative impacts of burning fossil fuels on environment, utilization of renewable energy resources has attracted more attention over the recent decades. Among renewable power generation systems, geothermal power plants can produce electricity with higher capacity factors. Introducing more efficient technologies and improving existing power generation systems would make geothermal power plants more competitive with conventional fossil fired power plants for base load power supply.

In this project the combined flash-binary geothermal power cycle is analyzed. A computer model has been developed to determine working fluid conditions in different parts of the cycle and performance of the system. One of the main design parameters is the flash separator pressure, which affects the power output of the cycle. Higher separator pressure results lower steam flow and lower power generation in steam cycle and at the same time higher brine temperature in binary cycle and higher power output in this part. Lower separator pressure has the opposite effect and results higher power generation in steam cycle and lower power output in binary cycle. Another important design parameter is the selection of binary working fluid which must be done with respect to brine temperature entering the boiler of the binary cycle. For different brine temperatures, optimum separator pressure and most appropriate working fluid will be presented. Organic working fluids R-22 (as a wet fluid), R-134a (as an isentropic fluid) and R-600 (as a dry fluid) will be considered as secondary working fluid options for each case.

Cryogenic Thermal Modeling of Helium Gas-Cooled Superconducting Cable System Components - Nick Suttell, Center for Advanced Power Systems

High temperature superconducting (HTS) power cables are being considered for a variety of electric power grid, naval, and aviation applications. A superconducting cable system is usually comprised of two terminations and a superconducting cable in a long cryostat. This study focuses on the modeling of the components for a gaseous helium cooled second generation HTS cable system. The termination cryostats are where the room temperature copper lead interfaces with the superconducting cable at cryogenic temperatures. Excessive temperature gradients in the termination cryostat reduce operating margins of the cables and increase the risks of damage. Therefore, the heat leak from the ambient and by Joule heating generated through current leads must be efficiently intercepted to minimize the heat load in the superconducting cable. The termination cryostat also includes a resistive joint that connects the current lead to the copper terminal of the superconducting cable. The cable system that is modeled in this study is for gaseous helium cooled cables. Significantly lower thermal capacity of gaseous helium compared to liquid nitrogen, typically used as the cryogen for HTS cables, necessitates detailed modeling of thermal and electrical behaviors of each component of the cable system. Optimal designs to minimize the size

and weight of superconducting cables and the required cryogenic systems require accurate estimations of heat load from the various components.

A helium gas cooled superconducting cable system has been designed, installed, and being tested at The Florida State University Center for Advanced Power Systems. Thermal map of this system under cryogenic helium circulation has been experimentally obtained with and without the load current through the cable system. However, the detailed heat transfer and thermodynamics of the system have not been modeled. In this study, models for the cable system using COMSOL have been developed in 2D and 3D and the temperature profiles from the model are compared with experimental data. This project is supported by the NEEC (Naval Engineering Education Center) and the Office of Naval Research.

Flat Plate Fins Shape Optimization - Julian Osorio, Florida State University

In this work, the optimum shapes of flat plate fins of constant thickness are studied in terms of the effectiveness and a set of three Biot (B_i) numbers: B_it, B_iw and √(B_iA), which characterize the ratio between conduction resistances through every direction and convection resistance at the fin surface. Different fin shapes composed by one (trapezoidal shape), two (rhomboidal shape) and three linear sections were analyzed. It was found that fins with higher effectiveness have shapes far from the convectional rectangular shape. Increments up to 6.0% were reached in fins constituted by three linear sections for B_iw=1- √(B_iA)=2. The effectiveness can be improved by relaxing the shape of the fin, i.e. adding more linear sections. It is expected that the optimal shape will resemble that of a leaf.

Modeling and Simulation of a Vapor Compression Refrigeration System - T. K. Nunes, J. C. Ordonez, and J. V. C. Vargas, Florida State University - Center for Advance Power Systems

This work introduces a simplified mathematical model of a vapor compression heating and refrigeration system, in order to optimize the system dynamic response. The model applies the mass and energy conservation principles to the components of compression vapor system, i.e., condenser, evaporator, compressor and expansion valve. The model assigns thermodynamic control volumes to each component, therefore uniform properties are assumed within them, which yield a system of ordinary differential equations with respect to time that is integrated explicitly and accurately with low computational time. Appropriate dimensionless groups are identified, and the results are presented in the form of normalized charts for general application to similar systems. As a result it is expected that the proposed model becomes a useful tool for simulation, control, design and optimization of vapor compression refrigeration system and that the model can be adapted in anyone HVAC-R system.

EDUCATION (POSTER SESSION)

The Development of an Interactive Software as a Secondary Learning Tool for Undergraduate Fuel Cell Courses - Amjad Aman, Yunjun Xu, Nina Orlovskaya, Haiyan Bai, University of Central Florida

Fuel cells are increasingly being used as sources of energy in power generation, automotive, and mobile applications, and as auxiliary or backup power units. Along with scientific and engineering

progresses, it is also important to train our next generation students in this area. Many universities have fuel cell related courses, but they are taught in the mechanical and/or chemical engineering departments, and those courses are more or less isolated. The purpose of the poster is to talk about the development of an interactive learning tool for undergraduate students to learn about fuel cells in the system perspective. The intended outcome is to provide students with an "outside of the classroom" approach to learning that would be effective, engaging, highly interactive, and non-threatening. The knowledge they can learn are interconnected from different levels of the fuel cells. Students are anticipated to be attracted to fuel cell systems, and have a better understanding of fuel cell concepts. Student retention through these fuel cell modules can be improved. A customized evaluation method is also under development. The software contents will be presented in terms of modules such that the earlier modules cover the system level fundamentals and applications of fuel cells, while the later modules cover the more detailed science and engineering concepts behind fuel cells. Modules will be interconnected so that students can learn and go in depth with a particular topic without having to complete an entire module before moving on to the next one; the interconnections between modules will be both ascending and descending in terms of the depth of the science and/or engineering understanding. For example, the following materials will be included in the Polymer Electrolyte Membrane Fuel Cell (PEMFC) learning modules: (i) the basic knowledge of a PEMFC system will be covered, (ii) applications of PEMFC in unmanned aerial vehicles (UAVs) will be illustrated including the connections between the fuel cell and the hybrid power system, (iii) understanding of the fuel cell at the sub-system level, (iv) understanding of the fuel cell at the cell and stack levels including different losses and efficiency. The course materials will be presented interactively as text and animations with the incorporation of sounds and video. The software will be connected to a database that would store the participation and progress of each student. The hardware and software requirements of the project are kept to a minimum such that computers with internet connection are sufficient. The intention is that once the software is developed and implemented at the University of Central Florida, it can then be made available to other interested universities.

POLICY (POSTER SESSION)

Key Factors Influencing Energy Intensity in Developed and Emerging Countries - Priscila Delfino, University of Florida -Public Utility Research Center

This project evaluates and compares how certain key factors (GDP explanatory variables) influenced and changed the energy intensity of different countries over a 30-year period. This study will examine developed countries such as the United States, Canada, Japan, and the UK as well as countries from emerging markets such as Brazil, India, China, and South Africa. The study seeks to determine what factors have the greatest impact on a country's energy efficiency. In addition, it seeks to identify which factors help countries become more energy efficient. Some variables were highly correlated, a total of seven regressions were run. The results of this study demonstrate that Net Energy Imports and Urban Population have a high impact on energy intensity in both emerging and developed countries. In addition, the results showed that the independent variable Industry % of GDP had a different impact between developed and emerging countries.

WIND (POSTER SESSION)

A New Wind Power Forecasting Technique - Cristián Cárdenas-Lailhacar, Universidad de Investigación de Tecnología Experimental YACHAY, Urcuquí, Ecuador

The world dependence on energy, particularly on fossil fuels, is an addiction that is having a tremendous impact all over the globe. How much is being used, how much is left, and the consequences of its use are every day questions. A healthy economy certainly relies not only on the abundance of energy resources, but on their kind, quality, and on how efficiently they are used. It is clear then that the path to follow should be energy efficiency and the use of renewable energy sources. The use of wind power is one these. In this paper we show a new forecasting, mathematical interpolation technique, which by using historical and current wind data for a given period and region, can be used to forecast wind speed for the next cycle period. The algorithm is based on an expansion around a minimum wind power point in the catchment regions of the cycle considered. Future wind speed values depend on some variables and past wind speed figures which are obtained from a meteorological station. The purpose of this research is to have an insight into the amount of wind available in a given region, and when high winds will occur, particularly before storms even start to form. The usefulness is mainly to provide alerts, better use of wind resources for wind harvesting, and for power generation through the use of a renewable energy source as is the wind. New mathematical expressions are derived, including associated force constants, periods for high wind speeds, and more This will allow having a better understanding of wind patterns and select dates for high wind speeds and power generation. Some preliminary results of the technique to predict wind power in Alachua County Florida are shown, with encouraging results.

OTHER (POSTER SESSION)

Comparison of Emerging Ground Propulsion Systems for Electrified Aircraft Taxi Operations - Rui Guo, Yu Zhang, Qing Wang, University of South Florida

Aviation is a mode with high fuel consumption per passenger mile and has significant environmental impacts. It is important to seek ways to reduce fuel consumption by the aviation sector, but it is difficult to improve fuel efficiency during the en-route cruise phase of flight because of technology barriers, safety requirements, and the mode of operations of air transportation. Recent efforts have emphasized the development of innovative Aircraft Ground Propulsion Systems (AGPS) for electrified aircraft taxi operations. These new technologies are expected to significantly reduce aircraft ground-movement-related fuel burn and emissions. This study compares various emerging AGPS systems and presents a comprehensive review on the merits and demerits of each system, followed with the local environmental impacts assessment of these systems. Using operational data for the 10 busiest U.S. airports, a comparison of environmental impacts is performed for four kinds of AGPS: conventional, single engine-on, external, and on-board systems. The results show that there are tradeoffs in fuel and emissions among these emerging technologies (e.g., some have a greater impact on reducing fuel burn and others on emissions).

Organic Rankine Cycle (ORC) For Decentralized Applications - Arun Kumar Narasimhan, Rajeev Kamal, D. Yogi Goswami, University of South Florida

The dependency of grid connectivity are in question when it comes to their reach in remote areas and overall losses that range from 7% in developed countries to more than 35% in developing countries. Coincidently most of the developing countries receive significantly high solar insolation of about 5.5-6.5 kWh/m2/day throughout the year. The need for energy supply in grid isolated regions backed with availability of high solar radiation presents an opportunity to harness this energy for production of electricity. For these areas, localized or decentralized power generation will help in meeting the daily energy needs of the local community. Organic Rankine Cycle (ORC),a modified steam Rankine Cycle, operating on working fluids like refrigerants and hydrocarbons instead of steam, can utilize solar energy to generate heat which can be converted to work using expansion devices. ORC broadly consists of evaporator, expanders, recuperator and condenser. Apart from expanders, rest of the components are practically heat exchangers. Due to its small scale application, there are no turbines available for this range and hence even though it's limiting, off-the-shelf compressors are reversed engineered to act like expanders. The objective of the study is in the modeling and design of scroll expanders to be used in ORC's. Equation based modeling is employed to design the scroll expanders, with the geometric design of the component being the first step. MATLAB environment will be used and other ORC components will be designed as well to suit the application. The final design choices will then be fabricated and tested by CERC.

Stochastic Economic Dispatch via Point Estimation Method and Particle Swarm Optimization- Luna Gloria, Thais Araújo, Wadaed Uturbey, Florida Atlantic University.

This work presents the results of the Point Estimation Method and Particle Swarm Optimization for solving the stochastic economic dispatch problem. The problem aim is to minimize the generation cost of thermal unit generators considering system uncertainties. In addition, demand dispatch is done throughout the time horizon. Stochastic loads are represented by a normal distribution and random values are generated by two different methodologies. In the first methodology, a particle swarm program performs several executions with random load values in a process similar to Monte Carlo Simulation (MCS). In another approach, a sampling procedure via Point Estimation Method (PEM) generates the loads. The applicability of PEM is notable in the solution of the problem. It is evident that the load randomness influences the generation costs, the slack generator generation and the power flow in the lines and it has little influence on the remaining generators and on the demand dispatch. The work highlights the great difference between the execution times of the algorithms based on PEM and MCS.