SEES “You Choose” Award Application

Wangda Zuo

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Department of Civil, Architectural and Environmental Engineering
College of Engineering
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Office: 305-284-5993

11/16/2013
Abstract:
Funding is sought to foster scientific collaboration between Dr. Zuo and Dr. Michael Sohn, a Staff Scientist and Deputy Group Leader at the Department of Energy’s Lawrence Berkeley National Laboratory (LBNL) in California. The SEEDS fund will be used to allow for two meetings, one each at the UM and LBNL. The purposes of the visits are to plan, draft and finalize jointly written journal publication and external proposal on model-based fault detection and diagnostic for the energy efficient building system operation. Collaboration in person would enhance the quality of the resulting research paper and proposal because we can discuss, can meet with respect research teams and their facilities. It will also harden the potential long term professional relationship between the two institutions. It will also enable Dr. Zuo to extend his research, enforce his collaboration with national laboratories and potentially bring external research funding to the UM.

Activity Goals:
Buildings account for more than 40% of primary energy usage in the US and building energy efficiency is of great interests to our nation. Automated Fault Detection Diagnostics (FDD) can prevent much of the energy waste resulting from poor maintenance and improper control of building HVAC systems. The estimated energy savings for commercial buildings alone is between 15% to 30%. While FDD is well established in the aerospace, automotive, and manufacturing industries it is still in its infancy in commercial buildings. Current research of automated building FDD has focused on individual components. Whole-building, or system level, fault detection has been underexplored and is still labor-intensive because it is performed manually. The proposed research is to develop a model-based FDD algorithm that can be used for automated, system-level, building FDD by capitalizing on Dr. Zuo’s expertise in building modeling and Dr. Sohn’s expertise in FDD.

To model the fast transient operation of building energy system, we will use Modelica that is an equation-based objective-oriented modeling language for modeling of multi-physics multi-domain dynamic systems. The Modelica-based models can simulate the fast transient process during the building operation that cannot be modeled using conventional building simulation tools. We will use a Bayesian statistical approach for FDD to compute the probability that a fault may be occurring, and highlight what components or schedules are likely to be faulting. To do so, the algorithm compares energy data and sensor measures (such as temperature) to the expected energy use from the Modelica model. When they differ substantially, the algorithm will call for hundreds to thousands of model simulations of normal building operations and possible faults, and then compute the statistical likelihood of each simulation explaining the difference.

During his visit to the UM in January or February, Dr. Sohn will give a seminar about his research in building FDD. He and Dr. Zuo will also develop a research plan. Afterwards, Dr. Zuo’s graduate student will conduct the research and draft a paper under the supervision of Dr. Zuo. Dr. Zuo’s team will conduct regular tele-conferences with Dr. Sohn to discuss the research progress. In May, Dr. Zuo will visit LBNL to present the research findings and finalize a joint paper and an external research proposal with Dr. Sohn.
Dr. Zuo’s UM group is actively working on Modelica-based modeling for the design and optimization of energy efficient building systems. This research will provide the UM team with an opportunity to extend our research to the building FDD that is an emerging area for building energy efficiency. Collaborating with a sensor scientist and group leader in a DOE national laboratory will increase the exposure of the UM to national laboratories who can be our collaborator and sponsors.

**Personal Goals:**
Collaboration with experts that complement my own skills and interests has been a cornerstone of my career. Dr. Sohn is a well-known scholar in building FDD and indoor environment analysis. He has published 30 journal papers and 30 additional reports that are cited 588 times. I first met Dr. Sohn when I joined LBNL in 2010. After I joined the UM, we have had several brainstorming sessions on mutually beneficial research ideas. As the result of these discussions, the proposed research perfectly combines our strengths. The success of the project will enable me to expand my research profile to an emerging area, build a long-term collaboration with a sensor researcher, and seek federal funding for further research.

As the Deputy Leader of the Sustainable Energy Systems Group and former Leader of the Airflow and Pollutant Transport Group at the LBNL, Dr. Sohn is extremely experienced in developing externally funded projects and interacting with sponsors from various federal agencies, including Department of Energy, Department of Defense and Environmental Protection Agency. As a junior professor, I will greatly benefit from the research collaboration and proposals development with Dr. Sohn.

**Budget and Budget Justification:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Budget</th>
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<tr>
<td>Travel</td>
<td>Round-trip flight Ticket for Dr. Sohn to visit the UM in Jan./Feb.</td>
<td>$600</td>
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<td>Round-trip flight Ticket for Dr. Zuo to visit LBNL in May</td>
<td>$600</td>
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<tr>
<td>Lodging</td>
<td>Dr. Sohn’s 4-days lodging in Holiday Inn Coral Gables at $100/day</td>
<td>$400</td>
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<td>Dr. Zuo’s 4-days lodging in LBNL’s Guest House at $100/day</td>
<td>$400</td>
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<td>Food</td>
<td>Dr. Sohn’s food for 5 days at $50/day</td>
<td>$250</td>
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<td>Dr. Zuo’s food for 5 days at $50/day</td>
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<td><strong>Total</strong></td>
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<td><strong>$2,500</strong></td>
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</table>
Wangda Zuo

Department of Civil, Architectural, and Environmental Engineering
University of Miami
Coral Gables, FL 33124

Date: November 15, 2013

Research Interests
Building Energy and Control Systems, Sustainable Building Design, Computational Fluid Dynamics

Education
Ph.D. (05/2010) Mechanical Engineering, Purdue University, USA
M. Eng. (06/2003) Automation, Chongqing University, China
B. Sc. (07/2000) Automation, Chongqing University, China

Research Experience
Assistant Professor, University of Miami, USA 01/2013 – Present
Research Scientist, Lawrence Berkeley National Laboratory (LBNL), USA 03/2011 – 12/2012
Post Doctoral Fellow, Lawrence Berkeley National Laboratory (LBNL), USA 05/2010 – 03/2011
Graduate Research Assistant, Purdue University, USA 08/2006 – 04/2010
Researcher, German Aerospace Center, Germany 09/2005 – 08/2006
Research Assistant, University Erlangen-Nuremberg, Germany 05/2004 – 02/2005
Intern, Automation and Drives Group, Siemens AG, Germany 07/2003 – 10/2004
Intern, Automation and Drives Group (A&D), Siemens Ltd., China 12/2001 – 07/2002

Teaching Experience
CAE 690-01 Data Analysis and Visualization for Building Systems, University of Miami 08/2013 – 12/2013
CAE 690T Advanced Modeling of Hybrid Systems in Buildings, University of Miami 08/2013 – 12/2013
CAE 560 Sustainable Construction, University of Miami 01/2013 – 05/2013
Teaching Assistant, Chongqing University, China 09/2000 – 01/2001

Publications

Journal Papers
Applications of Computational Fluid Mechanics, 6(2), 234-247.


Conference Proceedings


Posters


2. W. Zuo, Q. Chen 2008. "Real time simulation of indoor airflow on graphic processing units (GPU),” the 3rd National Conference of IBPSA-USA (SimBuild 2008), Berkeley, CA.


Invited Talks


10. W. Zuo 2013. “Recent breakthroughs in building simulations”, Department of Automation, Xiamen
University, Xiamen, China, May 13.


Other Major Publications/Presentations


Guest Lectures

Sponsored Research

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Sponsor</th>
<th>Role</th>
<th>Amount ($)</th>
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<tbody>
<tr>
<td>Implementation and validation of Modelica based models for a large chiller plant system (Part of the ESTCP project “Optimizing operational efficiency: integrating energy information systems and model-based diagnostics”, Subcontract from LBNL, 01/13-08/31)</td>
<td>DoD</td>
<td>PI</td>
<td>50,000</td>
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<tr>
<td>Coupling fast fluid dynamics and Modelica Buildings library for integrated simulation of indoor environment and HVAC systems (Subcontract from LBNL, 01/2013-09/2013)</td>
<td>DoE</td>
<td>PI</td>
<td>30,100</td>
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</table>
5. Modular modeling in support of rapid prototyping and control design  
   DoE  Co-Author  300,000

4. Demonstration of a Modelica-based tool chain for rapid prototyping and evaluation of integrated building controls (subcontract from Purdue University) (02/12-01/13)  
   GPIC  Co-PI  188,700

3. Enabling tools for system-level design and operation of energy-efficient building systems (10/11-06/13)  
   California Energy Commission  Co-Author  395,731

2. Building systems for net zero energy buildings (10/10-09/11)  
   LBNL  Co-PI  120,000

1. Fast simulation of contaminant transportation in buildings (07/09-06/10)  
   Chongqing University  PI  8,823

Ph.D. Theses Supervised

<table>
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<tr>
<th>Student</th>
<th>Title of Thesis</th>
<th>Completion Date</th>
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<tr>
<td>Wei Tian</td>
<td>Integrated Simulation of Building Energy and Environment Systems</td>
<td>05/2016 Expected</td>
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<tr>
<td>Sen Huang</td>
<td>Modular Modeling for the Design and Optimization of Building Energy System</td>
<td>12/2015 Expected</td>
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<tr>
<td>Reymundo J. Miranda</td>
<td>Equation Based Modeling for Hybrid Systems in Buildings</td>
<td>05/2015 Expected</td>
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Internal Examiner of Ph.D. Theses
- Song Luo, University of Miami, “Lateral current distribution in proton exchange membrane fuel cells with interdigitated flow field”, ongoing.

External Examiner of Ph.D. Theses
- Donghun Kim, Purdue University, ongoing.

Professional Membership
- Corresponding Member of ASHRAE Technical Committee 1.4 Control Theory and Application, 4.7 Energy Calculations, 4.10 Indoor Environmental Modeling
- Associate Member of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- Member of IBPSA-USA (International Building Performance Simulation Association – USA Branch)

Awards
- ASHRAE GIA Honorarium for presentation of research work in ASHRAE, 2010.
- Best Poster Award, The 1st OMEGA Annual Research Exhibition, Purdue University, 2010.
- ASHRAE Graduate Student Grant-In-Aid Award 2009-10, 2009
- Best Poster Award, IBPSA-USA Winter Meeting, Chicago, IL, 2009
- The 3rd Place in Poster Competition, The 3rd National Conference of IBPSA-USA (SimBuild 2008), Berkeley, CA, 2008
- Student Scholarship, The 3rd National Conference of IBPSA-USA (SimBuild 2008), Berkeley, CA, 2008
- Graduate School Incentive Grant, Purdue University, 2008
- Scholarship for attending U.S. Foreign Policy Colloquium, 2007
• Travel Award for Doctoral Student, School of Mechanical Engineering, 2007
• Siemens Scholarship, Siemens AG, Germany, 2004

Professional Committees & Services
Peer Reviewers
Journals
• Annals of Occupational Hygiene
• Applied Energy
• ASHRAE Transactions
• ASME Journal of Energy Resources Technology
• Building and Environment
• Building Simulation
• Energy and Buildings
• Engineering Applications of Computational Fluid Mechanics
• HVAC&R Research
• Indoor and Built Environment
• Journal of Architectural Engineering
• Journal of Building Performance Simulation
• Simulation Modelling Practice and Theory

Conferences
• The 13th International Conference of IBPSA (Building Simulation 2013), Chambery, France, 2013.
• The 5th National Conference of IBPSA-USA (SimBuild 2012), Madison, WI, 2012.
• The 12th International Conference of IBPSA (Building Simulation 2011), Sydney, Australia, 2011.
• The 4th National Conference of IBPSA-USA (SimBuild 2010), New York, NY, 2010.
• The 6th International Symposium on Heating, Ventilating and Air Conditioning, Nanjing, China, 2009.

<table>
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<tr>
<th>Conference</th>
<th>Function</th>
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<tr>
<td>Building Simulation 2013, Chambery, France</td>
<td>Session Chair</td>
<td>Aug. 25-28, 2013</td>
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<tr>
<td>ASHRAE 2013 Winter Conference, Dallas, TX</td>
<td>Session Chair</td>
<td>Jan. 26-30, 2013</td>
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<tr>
<td>Energy and Environment (COBEE2012), Boulder,</td>
<td>Committee Member</td>
<td></td>
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<tr>
<td>CO.</td>
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<tr>
<td>ASHRAE 2012 Winter Conference, Chicago, IL</td>
<td>Session Chair</td>
<td>Jan. 21-25, 2012</td>
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<tr>
<td>ASHRAE 2011 Annual Conference, Montreal, Canada</td>
<td>Session Chair</td>
<td>June 25-29, 2011</td>
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<tr>
<td>The 4th National Conference of IBPSA-USA</td>
<td>Session Chair</td>
<td>Aug. 11-13, 2010</td>
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<tr>
<td>(SimBuild2010), New York, NY</td>
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<tr>
<td>The 19th International Compressor Engineering</td>
<td>Session Vice-chair</td>
<td>July 14-17, 2008</td>
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<tr>
<td>Conference, West Lafayette, IN</td>
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The 12th International Refrigeration and Air Conditioning Conference, West Lafayette, IN  
Session Vice-chair July 14-17, 2008

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<th>Professional Services</th>
<th>Function</th>
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<tr>
<td>ASHRAE Technical Committee 4.7 Energy Calculation</td>
<td>Voting Member</td>
<td>07/2013</td>
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<tr>
<td>ASHRAE Technical Committee 4.10 Indoor Environment Modeling</td>
<td>Research Subcommittee Chair</td>
<td>07/2013</td>
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<tr>
<td>ASHRAE Technical Committee 4.10 Indoor Environment Modeling</td>
<td>Voting Member</td>
<td>07/2012</td>
<td>06/2016</td>
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<td>IEA Annex 60 &quot;New generation computational tools for building and community energy systems based on the Modelica and Functional Mockup Unit standards”</td>
<td>Participants</td>
<td>09/2011</td>
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<td>ASHRAE Student Congress, Chicago, IL</td>
<td>Representative</td>
<td>01/2009</td>
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<th>Other Activities</th>
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<td>Activities</td>
<td>Chair</td>
<td>02/2012</td>
<td>05/2012</td>
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<td>Search Committee for Scientist, Environmental Energy Technologies Division, LBNL</td>
<td>Mentor</td>
<td>01/2012</td>
<td>06/2012</td>
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<tr>
<td>Mentoring Program , Environmental Energy Technologies Division, LBNL</td>
<td>Mentor</td>
<td>08/2009</td>
<td>12/2009</td>
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<tr>
<td>OMEGA Mentorship Program, School of Mechanical Engineering, Purdue University</td>
<td>Representative of Purdue University</td>
<td>06/2007</td>
<td>06/2007</td>
</tr>
</tbody>
</table>
Michael D. Sohn
Lawrence Berkeley National Laboratory
One Cyclotron Road, Mail Stop: 90R3058
Berkeley, California 94720 U.S.A
510-486-7610; MDSohn@lbl.gov

Education and Licensure

- PhD, Civil and Environmental Engineering, 1998, Carnegie Mellon University
- MS, Engineering and Public Policy, 1997, Carnegie Mellon University
- MS, Mechanical Engineering, 1992, University of California, Los Angeles
- BS, Mechanical Engineering, 1991, University of California, Los Angeles
- Registered Professional Engineer, Civil, California License Number C65633

Employment

- ChemRisk Environmental Consulting, Burbank, CA (1992 to 1993)
- Environmental Science & Technology, Inc., Irvine, CA (1992)

Service

- Member of the Technical Panel 9 Working Group for The Technical Cooperation Program (TTCP) on Chemical, Biological, and Radiological Defense. TTCP is a government-supported international scientific panel to review methods for predicting atmospheric transport of hazardous materials. (2003 to 2012).


LBNL Invention Disclosures


Students Mentored or Supervised

- Travis Walter: 3rd year PhD student, UC Berkeley, Civil Engineering, with AJ Gadgil UCB advisor.
- Cheol-Yong Shin, Kookmin University, South Korea. Three month training program to support PhD degree research.
- Undergraduate interns lasting longer than two months: Steffenie Tomlin (Millsaps College), Pamela Reynolds ( Cabrillo College & UC Berkeley), Navteg Singh (CSU, Fresno & U. of Hawaii)

Consulting Services


Journal Publications

1. Sohn MD, Price PN, Black DR, Najafi M. Local occupancy-based HVAC control will not likely produce large energy savings in most office buildings. Submitted to PLOS One, November 2013.


3. Shin HM, McKone TE, Sohn MD, Bennett DH. Tracking contributions to human body burden of environmental chemicals by correlating environmental measurements with biomarkers. Submitted to PLOS One, October 2013.


7. Herrmann IT, Mauschild MZ, Sohn MD, McKone TE. Confronting uncertainty in LCA used for decision support. Journal of Industrial Ecology, Accepted June 2013.


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