# The Green Scale Research Project
## Quantifying Truly Sustainable Design

Office of the Vice President of Research
**Faculty Research Support Program 2011**
Initiation Grant

**Final Report**
Submitted: April 2, 2012
PI: Aimee P. C. Buccellato

**Motivation:**

The future of the Green Scale Research Project (GSRP) and its ability to expand current methods for making informed building design and material decisions is in the development of a dynamic digital modeling tool that will enable the user to accurately evaluate and effectively weigh the use of specific materials and methods of building assembly simultaneously with site and context-specific design decisions from the very earliest stages of design, leading ultimately to widespread adoption of *truly* sustainable building practices. The GreenScale Digital Design and Analysis Tool will provide a reliable and accessible quantitative methodology for holistically measuring and evaluating building practices, from the commencement of the design process to the selection of materials, the methods of their assembly, and the long term implications of one's design on the environment associated with building operation, efficiency, maintenance, and the overall lifespan of the project.

**Project Method and Timeline:**

Per the proposal submitted in November 2010, the 2011 Faculty Research Support Program Initiation Grant supported the conclusion of four case studies already underway as part of The GSRP; enabled the development of two additional case studies; and facilitated further development of the GreenScale method in the context of Professor Buccellato's Special Research in Sustainable Design and Building Technologies course (ARCH 67611, offered fall and spring), as well as the incorporation of the GreenScale method into Professor Buccellato's 4th year undergraduate design studio (ARCH 41121) in the spring of 2011 and 2012.

**Since the Initiation Grant Award in January 2011, the Green Scale Research Project has supported the following student research participation**:

- 5 undergraduate research assistants
- 3 graduate research assistants
- 3 undergraduate thesis investigations, including one honors thesis (Glynn Family Honors Program)
- 2 graduate thesis investigations, including a Commercialization Thesis by a candidate in the Colleges of Engineering and Business' ESTEEM program
- 2 independent research projects that have yielded undergraduate authored or co-authored papers and conference presentations:

  Kaitlin Veenstra, "Case Studies in Sustainable Campus Design." To be included in the proceedings of the *9th Annual Greening the Campus Conference* at Ball State University. March 21, 2012.

  Whitley Esteban and Aimee P. C. Buccellato, "Building Tomorrow: A Sustainable Future Starts in the Classroom." To be included in the proceedings of the *Sustainable Futures: Architecture and Urbanism in the Global South* Conference. July 2012.

- Cross-institutional research collaboration with Professor Ryan Smith from the University of Utah College of Architecture & Planning and Director of the Integrated Technology in Architecture Center (ITAC).
- Student Engineers Reaching Out (SERO), co-advising with Paul Brenner (CRC) 3 engineering students (Civil, AME, and Chemical) on community outreach project(s) involving the GreenScale.

Development of the prototype dynamic modeling and analysis tool began in the summer of 2011and involved close collaboration with the University's Center for Research Computing. Beginning in the fall of 2011, students involved in Professor Buccellato's Special Research in Sustainable Design and Building Technologies course began testing and validation of the prototype GreenScale tool/ calculation engine. This collaboration yielded important, early-user feedback about the prototype that has been immediately useful in subsequent refinements to the prototype and planning for the next generation of the Tool (on-going).

**Since the Initiation Grant Award in January 2011, the Green Scale Research Project has produced the following publications, presentations, and funding proposals** (list does not include output prior to FRSP 2011 Award, January 2011):

Refereed publications and conference presentations:

Buccellato, A. "Case Studies in Sustainable Design and the Motivation for Enhanced Methods and Tools to Measure Environmental Impact." To be included in the Proceedings of the *2012 Association of Collegiate Schools of Architecture (ACSA) International Conference, Change: Architecture, Education, Practices.* Barcelona, Spain: June 2012 (pending publication).

Buccellato, A. (primary author), Vardeman, C., "Material Matters." To be included in the *Proceedings of the 4th CIB International Conference on Smart and Sustainable Built Environments*. Sao Paolo, Brazil: June 2012 (pending publication).

Buccellato, A., "Quantifying Sustainable Design: Select Case Studies." *Proceedings of the 2011 Building Enclosure Sustainability Symposium.* California Polytechnic University, Pomona: April 2011.

Citations/ Interviews:

Kirkwood, E. "Integrating pine beetle kill material into building design." *Outdoor Elements* on WNIT-South Bend (featured in TV segment to air in 2013).

O'Connell, K., "Spotlight on The GreenScale: Digital Design and Analysis Tool." *CRC Newsletter*, Issue 17. Center for Research Computing, University of Notre Dame. March 2012.

The University of Notre Dame, "Highlight on Teaching and Research," *Report on Catholic Mission 2011*. Notre Dame, Spring 2011.

"Divine Recycling: New York Church Moving to Atlanta – piece by piece," Mother Nature Network. June 23, 2010.

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Grants and Sponsored Programs:

**Harvesting Waste Heat from Computers for Sustainable Buildings ****
National Science Foundation: CBET – Environmental Sustainability
$305,177
Competitive; **in review**
PI: D. Go (AME); Co-PI: A. Buccellato; P. Brenner (CRC)

***The GreenScale Tool will be utilized in years 2 and 3 of this research program as a method to assess the broader impacts of deploying the energy conservation concept at the building scale.*

**The GreenScale: A New Digital Design and Analysis Tool for Sustainable Building**
Faculty Research Support Program: Regular Grant
**Award: $98,523/ 3 years**
Competitive
PI: A. Buccellato; Co-PI: S. Paolucci (AME); C. Vardeman II (CRC)

**The GreenScale: A New Digital Design and Analysis Tool for Sustainable Building**
The McCloskey Business Plan Competition
Gigot Center for Entrepreneurship, Mendoza College of Business, University of Notre Dame
Multiple Award Submission - Advanced to Round 2
Competitive
PI: A. Buccellato; Co-PI: C. Vardeman II (CRC); R. Duke (SoA 2013); M. Parker (ND-ESTEEM 2012)

**The GreenScale Research Project at the University of Notre Dame: Developing and Deploying a New Digital Design and Analysis Tool for Sustainable Building**
The Graham Foundation for the Arts
$20,000 (not awarded)
PI: A. Buccellato

Invited Lectures, Presentations, Workshops:

**Responsible Technology**
Presentation and Workshop Participant
Western Region Wood Building Workshop
Integrated Technology and Architecture Center, University of Utah
March 29-30, 2012

**Sustainable Design: It's Everybody's Business**
Speaker
ND Thinks Big Event
Jordan Auditorium, University of Notre Dame
March 22, 2012

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**The Placebo Effect and LEED**
Guest Lecture
Environmental Politics Seminar (AMST 30438, HESB 30518, POLS 30143, STV 30343)
Instructor: Prof. Matthew Doppke, University of Notre Dame
November 3, 2011

Commercialization:

Provisional Patent/ Invention Disclosure (internal document number: 12-033) submitted on 2/6/2012; to be filed on June 1, 2012 by the University's Office of Technology Transfer.

**The Green Scale Research Project in Progress:**

The GSRP and development of The GreenScale Tool continues apace in The GSRP Lab (G20 Bond Hall). With the recent award of a 2012 FRSP Regular Grant, development of the Next-Gen GreenScale Tool will involve faculty and both undergraduate and graduate-level research participation from multiple disciplines:

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|---|---|
| Sam Paolucci | Department of Aerospace and Mechanical Engineering |
| Charles Vardeman II | Center for Research Computing |

And will contribute to additional interdisciplinary research efforts underway at Notre Dame, including the development of a novel energy conservation concept, Environmentally Opportunistic Computing, with collaborators from the following disciplines:

| | |
|---|---|
| David Go | Department of Aerospace and Mechanical Engineering |
| Paul Brenner | Center for Research Computing |

In January 2012, The Green Scale Research Project requested – and was granted – a no-cost extension to the 2011 FSRP Initiation Grant so that Professor Buccellato could re-hire a critical graduate-level research assistant. Internal policies in the School of Architecture's Graduate Program prevent certain graduate students from participating in work-study, research, or employment (on or off campus) of any kind during the first 3 of their 6 semesters. The extension allowed Professor Buccellato to re-hire a graduate student from the summer of 2011 in the beginning of the spring 2012 semester, the student's 4th semester, in order to continue development of the novel graphic-user interface (GUI) for the dynamic modeling and analysis tool.

Meanwhile, Professor Buccellato is working hard with the administration of the School of Architecture to assess current policies in the Graduate Program (and Undergraduate Program) that pose significant challenges to faculty attempting to do (funded) research within the School of Architecture.

Respectfully and gratefully submitted,

Aimee Buccellato
Assistant Professor
University of Notre Dame
School of Architecture
abuccellato@nd.edu