EDITORIAL
Building Performance Simulation: The Now and the Not Yet

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Simulation of building thermal performance using digital computers has been an active area of investigation since the 1960s, with much of the early work[1] focusing on load calculations and energy analysis. Over time, the simulation domain has grown richer and more integrated, with available tools integrating simulation of heat and mass transfer in the building fabric, airflow in and through the building, daylighting, and a vast array of system types and components. At the same time, graphical user interfaces that facilitate use of these complex tools have become more and more powerful and more and more widely used.

Yet, at present, there are many questions that are still difficult to answer with available simulation tools, and progress in this direction can be frustratingly slow. It is to some degree a case of "the now and the not yet"—while building simulation tools are widely used, they are not universally used; while they can adequately model many scenarios, there are many scenarios for which they cannot give an adequate answer; while they have been validated extensively, the infinite variety of building and system designs preclude complete validation; and while they offer great promise for improving design and operation of buildings and their systems, much of this promise is, at the present, unrealized.

In February 2006, the US National Science Foundation blue ribbon Panel on Simulation-Based Engineering Science released its report, subtitled "Revolutionizing Engineering Science through Simulation."[2] Although building performance simulation may have been far from the minds of the authors, they nevertheless addressed many of the issues relevant to the current state of the art:

- "The development of models is very time consuming, particularly for geometries of complex engineering systems…."[3] Indeed, this is one of the primary challenges for application of building simulation in practice.
- Dynamic data-driven applications systems (DDDAS) integrate systems for gathering archival and dynamic data, algorithms that blend simulation models and data and software infrastructure to support "model execution, data gathering, analysis prediction, and control algorithms."[4] The model-based control systems presented in two of the papers here are partial realizations of the DDDAS concept. Another aspect of DDDAS, not yet realized in building simulation, involves steering and control of the data-gathering process.
- Multiscale methods are needed "that can deal with large ranges of time and special scales and link various types of physics."[5] In building simulation, time scales can go from seconds for control actuation to many years for ground-coupling. Integration of different models linking different simulation domains has been an ongoing research and development activity in building performance simulation for a number of years.

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- Optimization methods are needed “that can deal with complex integrated systems, account for uncertainties, and provide robust designs.”[6] Optimization of building and system designs remains a research topic rather than a design activity—both new methods and improvements in computational speed are needed to bring optimization to practice.
- “While verification and validation and uncertainty quantification have been subjects of concern for many years, their further development will have a profound impact on the reliability and utility of simulation methods in the future.”[7] Verification and validation of building simulation models continue to be active areas of research.

The above issues have been the subject of research presented at the biennial series of conferences organized by the International Building Performance Simulation Association since 1989. This special issue of *HVAC&R Research* contains expanded versions of papers first presented at Building Simulation ’05, held in Montreal last August. The papers were selected by the Executive Scientific Committee, then subjected to an additional review process.

Two of the papers focus on the use of building simulation for controls. The first, “Comparing Control Strategies Using Experimental and Simulation Results: Methodology and Application to Heating Control of Passive Solar Buildings” by Kummert et al., utilizes model-based control but focuses on the use of building simulation to complement physical evaluation of the control system performance. The second, “Model-Based Control of Renewable Energy Systems in Buildings” by Hanby and Zhang, looks at the use of model-based control to optimize performance of multiple renewable energy systems in a novel building.

Two of the papers focus on integration of simulation domains, linking more than one type of physics. The first, “An Integrated Approach to Indoor Contaminant Modeling” by Samuel and Strachan, shows the importance of linking the thermal and airflow domains in order to get reliable prediction of contaminant transport. The second, “Distributed Building Performance Simulation—A Novel Approach to Overcome Legacy Code Limitations” by Trcka-Radosevic et al., addresses one practical approach to the linking of simulation domains involving inter-process communication.

The three remaining papers describe recent developments in building performance simulation that allow for modeling of new system types. Interestingly, each involves multi-domain physics. The first, “A Proposed System-Level Model for Simulating the Thermal and Electrical Production of Solid-Oxide Fuel Cell Residential Cogeneration Devices within Whole-Building Simulation” by Beausoleil-Morrison et al., includes chemical reaction modeling as well as integrating the various thermal transfers with the rest of the building simulation. “Building Thermal Performance Simulation with Direct Evaporative Cooling by Water Spray Vaporization” by Silva et al., integrates droplet-level analysis of evaporation with the building model. The third paper, “Implementation and Validation of Ground-Source Heat Pump System Models in an Integrated Building and System Simulation Environment” by Fisher et al., integrates the long-time-scale multi-dimensional conductive heat transfer simulation of the ground-loop heat exchanger with the building simulation.

Building performance simulation faces the same challenges as other areas of simulation-based engineering science identified by the National Science Foundation report. These seven papers individually represent various approaches to meeting these challenges. Taken together, they provide a diverse sample of current research. As may be inferred from the NSF report, there is ample opportunity for additional contributions, and much effort is needed to more fully realize the potential of building performance simulation.

ENDNOTES

[1] For a first person account, see Kusuda, T. 1999. Early history and future prospects of building system simulation. *Proceedings of the Sixth International IBPSA Conference, Kyoto*, pp. 3–15.

[2] NSF. 2006. Simulation-based engineering science: Revolutionizing engineering science through simulation. Report of the National Science Foundation Blue Ribbon Panel on Simulation-Based Engineering Science, Chair J.T. Oden. Available at http://www.ices.utexas.edu/events/SBES_Final_Report.pdf.

[3] Ibid, p. 25.

[4] Ibid, p. 38.

[5] Ibid, p. 26.

[6] Ibid, p. 26.

[7] Ibid, p. 38.