# 2009 BFRL Project Description

## Project Title: Ventilation and Indoor Air Quality in High-Performance Buildings

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**BFRL Program:** Healthy and Sustainable Buildings

**Objective:** To improve ventilation and IAQ in high performance buildings through the development and application of building airflow measurement science and technical recommendations.

**Problem:**

***What is the problem?*** One of the key functions of buildings is to provide a place for people to live, work and learn, and it is critical that high-performance buildings continue to serve these functions and actually improve the health, comfort and productivity of the occupants relative to current practice. The connection of indoor air quality and ventilation to occupant health and performance has been noted in a number of key studies and research plans, including the report of a 2005 Surgeon Generals workshop on healthy indoor environments[1], key EPA planning documents [2] [3]. and an ASHRAE roadmap to net zero energy buildings[4]. These documents all note the importance of good indoor air quality, supported through ventilation, in efforts to achieve high-performance buildings and the need to consider the IAQ impacts of building energy technologies. In particular, the Surgeon General's workshop noted a range of research needs including a better understanding of the IAQ impacts of energy savings technologies.

***Why is it hard to solve?*** High performance buildings must meet demanding energy and IAQ requirements that include innovative building designs and ventilation and IAQ control technologies. Design and analysis of these buildings and systems requires advanced modeling tools, such as coupled whole-building thermal and airflow modeling to properly account for the coupled physical heat transfer, airflow and contaminant transport phenomena, as well as metrics that capture the relevant performance attributes of different designs and systems. Non-technical barriers include overly prescriptive requirements in existing building standards and green

[1] U.S. Department of Health and Human Services. 2005. Report of the Surgeon General's Workshop on Healthy Indoor Environment
[2] EPA. 2005. Program Needs for Indoor Environments Research (PNIER), U.S. EPA, 402-B-05-001.
[3] EPA. 2001. Healthy Buildings, Healthy People: A Vision for the 21st Century. U.S. EPA 402-K-01-003.
[4] ASHRAE. 2008. ASHRAE Vision 2020. Producing Net Zero Energy Buildings.

building programs and the lack of specific performance requirements or design procedures for alternative ventilation systems.

***How is it solved today, and by whom?*** There are significant programs in the U.S. to promote high-performance buildings, but these efforts do not focus specifically on ventilation and IAQ. Similarly, there are international programs (e.g., the International Energy Agency's Air Infiltration and Ventilation Centre[5]) in ventilation and IAQ technology, however they are not specifically concerned with U.S. buildings practice, codes and programs. Specifically, U.S. buildings and HVAC systems use different equipment than in other countries, must comply with different building codes and participate in sustainability programs specific to state governments and federal agencies.

The measurement science problem exists largely because current green building program crediting is based more on individual design engineer's experience rather than formal technical analysis or measured performance. Also, analysis tools and performance requirements are lacking for innovative ventilation options. BFRL has developed such tools in the past, which are currently used by designers, but they have not been updated to reflect recent advances in modeling capability and to address the range of new technologies available.

***Why NIST?*** BFRL is currently the leading source for building ventilation and IAQ measurement science. This project is aligned with the Measurement Science for Net Zero Energy, High Performance Buildings Strategic Priority as it will apply and extend this knowledge to promote U.S. innovation and competitiveness by meeting the IAQ measurement science needs of the high performance building field. Through this project, BFRL will continue to be the source of critical solution-enabling tools to the U.S. building industry by providing the required modeling tools, technical evaluation of ventilation and IAQ control technologies and input to relevant building standards and high performance building programs. The impact of this work will employ existing relationships between BFRL and key government agencies and industry organizations.

**Approach:**

***What is the new technical idea?*** This project will further develop existing ventilation and IAQ measurement science capability including multizone airflow and IAQ modeling, building thermal simulation, and computational fluid dynamics. The primary focus of this development will be the integration of these different simulation capabilities enabled by recently developed fundamental airflow modeling knowledge as needed to support the design and analysis of the complex building and ventilation system designs being applied in high performance, sustainable buildings. This will include the development of these integrated tools in forms that are accessible to building and ventilation system designers.

These advanced tools will also be applied to study the potential energy and IAQ performance of some of the key, but challenging building and ventilation design approaches including natural and hybrid ventilation, particularly their use in building atria. Current analysis of high performance buildings focuses almost exclusively on energy performance but this project will emphasize the important IAQ aspects of green buildings. Additionally, these existing and

[5] www.aivc.org

new simulation capabilities will be used to conduct rigorous technical evaluations of the ventilation and IAQ requirements and options included in widely used building standards and rating programs.

***Why can we succeed now?*** Demand for high performance buildings is soaring as evidenced by higher occupancy and rental rates for LEED and Energy Star buildings. As a result, the bodies that write and maintain the relevant standards and programs need improved technical justification for ventilation and IAQ requirements. Additionally, designers of high performance buildings are seeking advanced tools for design and analysis of innovative technologies. Past work by BFRL developed basic technical knowledge in the areas of coupled thermal/airflow/contaminant analysis and computational fluid dynamics (CFD) that will serve as a basis for the proposed work. Additionally, previous BFRL projects on advanced ventilation and IAQ control technologies provide the required expertise to support this project.

***What is the research plan?***

This project will create new engineering tools by developing and integrating multizone airflow and IAQ modeling, building thermal simulation, and CFD analysis. These tools will also be used to support technical requirements and options in ventilation and IAQ standards and green building programs. . BFRL will conduct a needs assessment for advanced simulation and design tools based on a review of existing tools and their capabilities and discussions with high performance building designers and system manufacturers. A plan for tool development will then be generated to meet these needs, which is expected to include collaboration between NIST and the developers of the TRNSYS simulation program to improve upon the existing coupled multizone thermal and airflow modeling capabilities. As such, a second task is the establishment of a CRADA between these organizations. Additional formal collaborations will be established as needed to achieve the project goals.

BFRL will produce a natural ventilation climate suitability tool for assessing the potential application of natural ventilation to buildings during the pre-design phase. In addition, a proposal for design requirements for alternative residential ventilation systems such as natural ventilation will be prepared and submitted for consideration to the ASHRAE committee maintaining Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. BFRL will also complete a review of IAQ and ventilation requirements and criteria for high performance buildings. Finally, NIST will take a leadership role in the development of an IAQ Guide by ASHRAE in collaboration with AIA, BOMA, EPA, SMACNA and USGBC. This document is intended to provide improved IAQ in commercial and institutional buildings and will focus on advanced ventilation and IAQ design and construction practices.

In future years, other enhanced engineering design and analysis tools will be developed, including a new version of LoopDA and a coupled thermal/airflow analysis tool integrating capabilities of CONTAM and TRNSYS. The new version of LoopDA[6], a tool for natural ventilation system design and component sizing, will implement a more diverse set of airflow components, simple thermal coupling, a more robust user interface and inclusion of mechanical components for hybrid systems. These simulation capabilities will be used to perform technical

[6] Dols, W.S. and Emmerich, S.J. 2003. LoopDA: Natural Ventilation Design and Analysis Software, NISTIR 6967.

evaluations of the ventilation and IAQ requirements and options in existing building standards and rating programs and to study the potential energy and IAQ performance of some of the more challenging building and ventilation features such as natural ventilation approaches that employ building atria.

**Recent Results:** None (new project).

**Standards and Codes:** This project will provide input to ASHRAE ventilation and sustainable building standards (62.2, 62.1 and 189.1) and green building programs such as LEED and EPA Energy Star to enable their consideration of reward innovative and effective options. Emmerich chairs ASHRAE 62.2, and Persily chairs the committee developing the ASHRAE IAQ Guide.