

NRC Publications Archive Archives des publications du CNRC

IRC/NRC residential heating, ventilation and indoor air quality research facility Ouazia, B.

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version.
/ La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version acceptée du manuscrit ou la version de l'éditeur.

Publisher's version / Version de l'éditeur:

7th Canada-Japan Housing R&D Workshop Proceedings, 2006-10-03

NRC Publications Archive Record / Notice des Archives des publications du CNRC :
<https://nrc-publications.canada.ca/eng/view/object/?id=5650d5f8-1012-4b89-934a-490b7406a68>
<https://publications-cnrc.canada.ca/fra/voir/objet/?id=5650d5f8-1012-4b89-934a-490b7406a688>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at
<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site
<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at
PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.



<http://irc.nrc-cnrc.gc.ca>

IRC/NRC Residential Heating, Ventilation and Indoor Air Quality Research Facility

Ouazia, B.

NRCC-49206

A version of this document is published in / Une version de ce document se trouve dans: 7th Canada-Japan Housing R&D Workshop, Ottawa, ON., Oct. 3-6, 2006, 1-33



National Research
Council Canada

Conseil national
de recherches Canada

Canada



NRC-CNRC

*Institute for
Research in
Construction*

IRC/NRC Residential Heating, Ventilation, and Indoor Air Quality Research Facility

Boualem Ouazia

Indoor Environment Research Program

Canada-Japan Workshop October 03 & 04, 2006



National Research
Council Canada

Conseil national
de recherches Canada

Canada

Introduction

One focus of IRC research is aimed to improve Canadian housing in terms of:

- better quality construction,
- healthy indoor air quality,
- comfortable indoor thermal environment,
- energy-efficiency and durability.

IRC/NRC Vision

- residential HVAC systems
- innovative building envelopes designs,
- indoor environments contained by those envelopes and created by the HVAC systems,
- interaction between those indoor environments, the building envelope and real Canadian weather.
- improved moisture management strategies for houses to avoid mould problems.

V&IAQ Research House

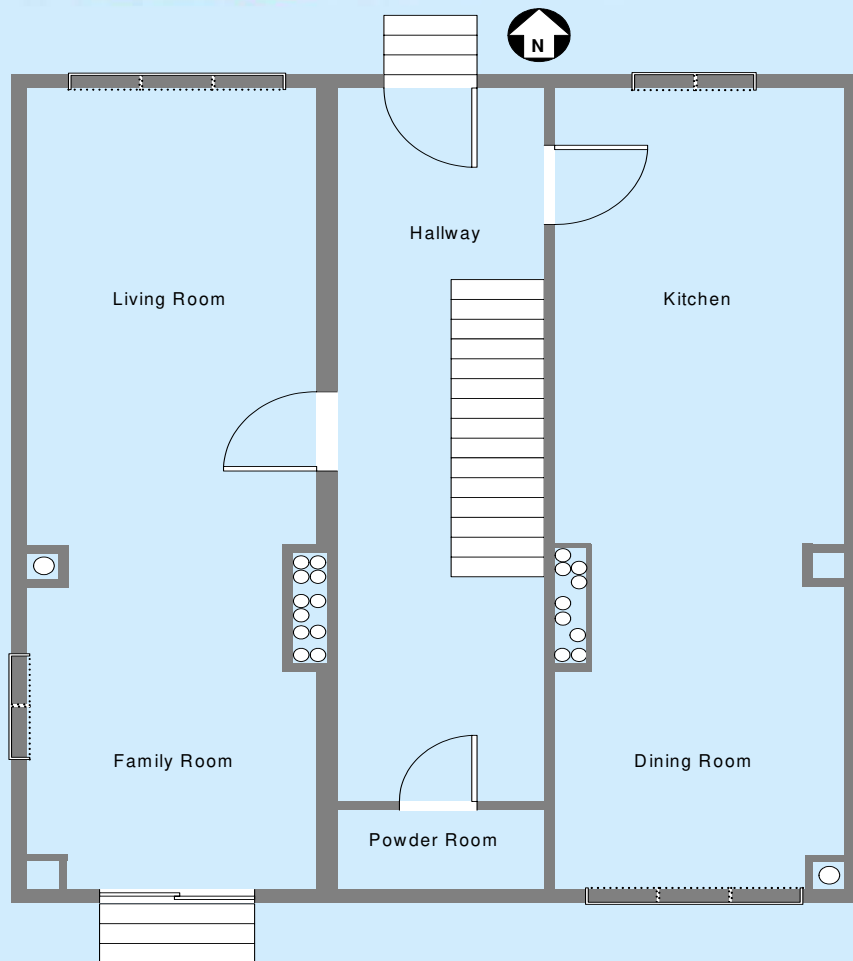
- Ventilation
- Air infiltration
- Space heating & cooling
- Efficient energy use
- Indoor air quality
- Thermal comfort



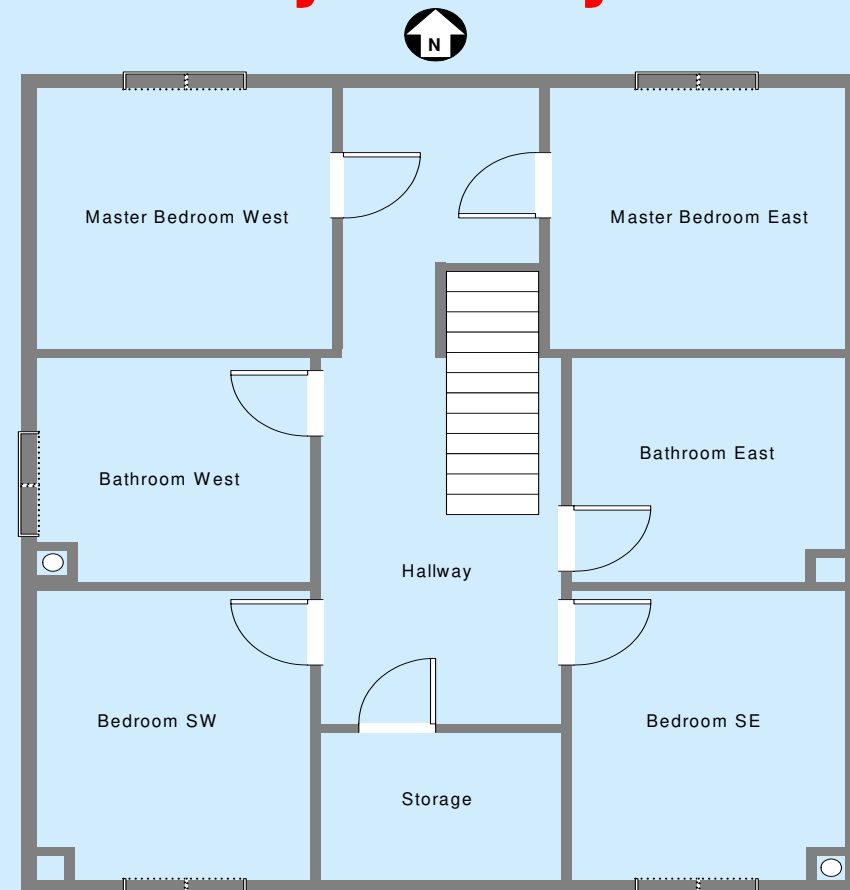
Research House Description

- Completely flexible room configuration
- Forced-air heating system now fully-zoned, configured for east-west symmetry and connections for two furnaces
- Automated zone-by-zone control for radiant floor and forced-air heating
- Fully-zoned automated tracer gas sampling & dosing system with multiple tracer gas capability.

Room Layout Reconfigured for E-W Symmetry



First Floor



Second Floor

Heating and Cooling Systems

- High-efficiency propane or electrical furnace for forced-air system
- Central air-conditioning with R-410A, 13 SEER
- Instantaneous water heaters for radiant system

Dual Forced-Air Furnace Connections



East-West Split Configuration



*Fully-zoned Reconfigured Forced-
Air System Capable of East-West
Split Operation*

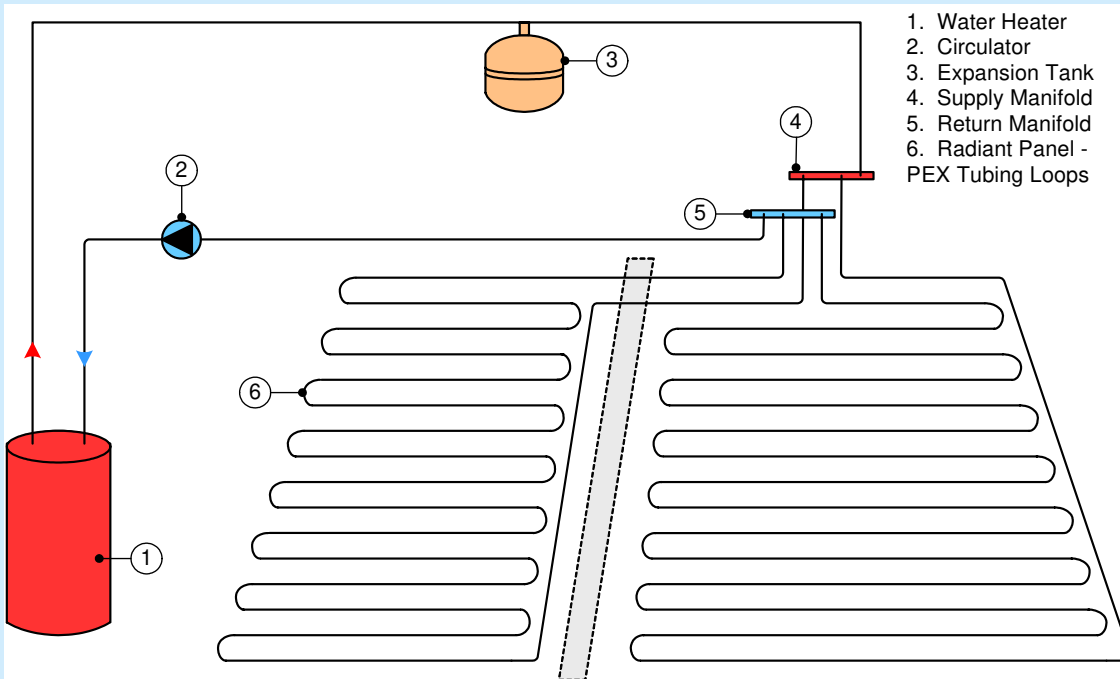
Ducts, Flow Meters & Actuators



High-Efficiency 13 SEER R-410A Air Conditioning

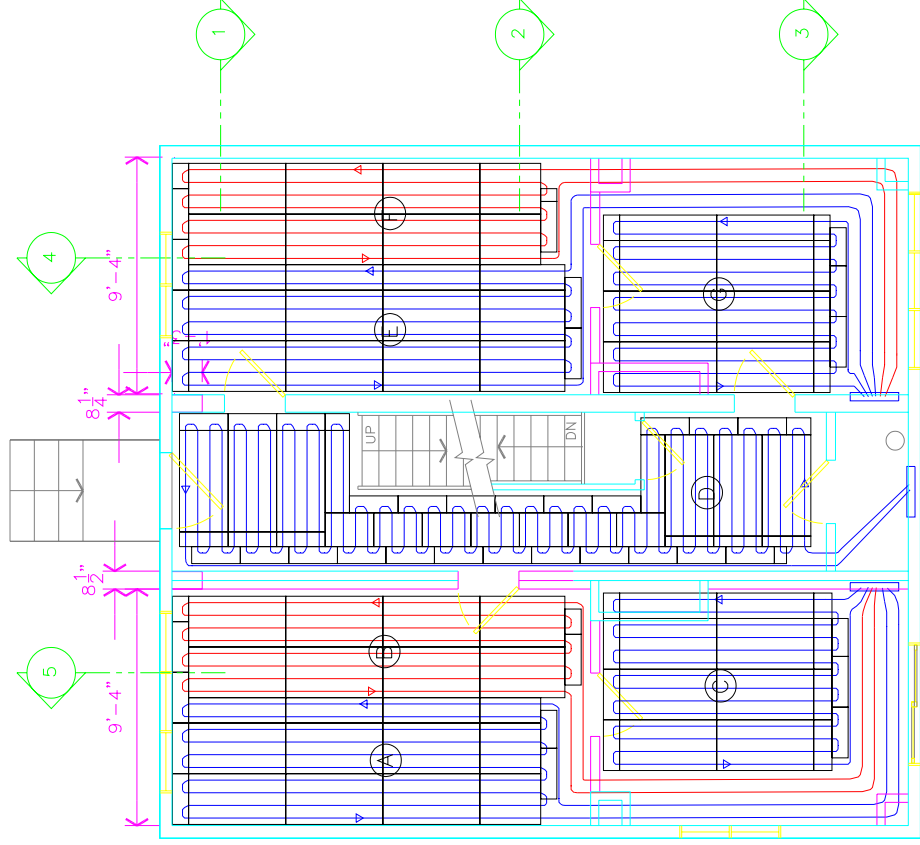


Hydronic Radiant Floor Heating system

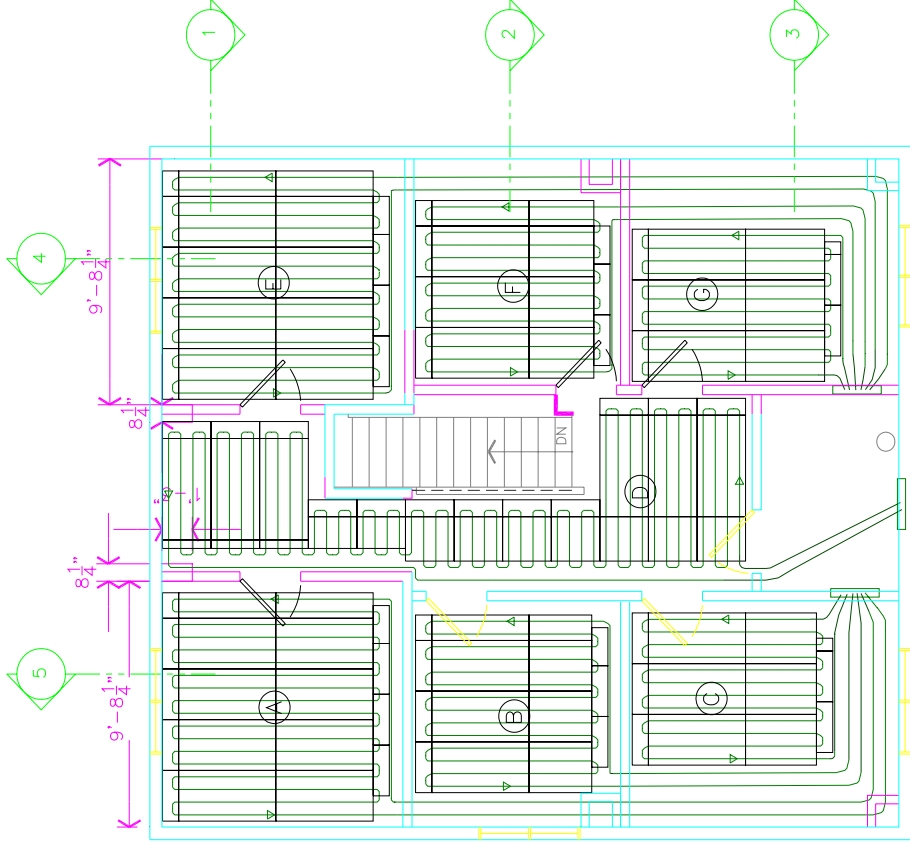


Boiler Circuit

Fully-Zoned Radiant Floor Heating System

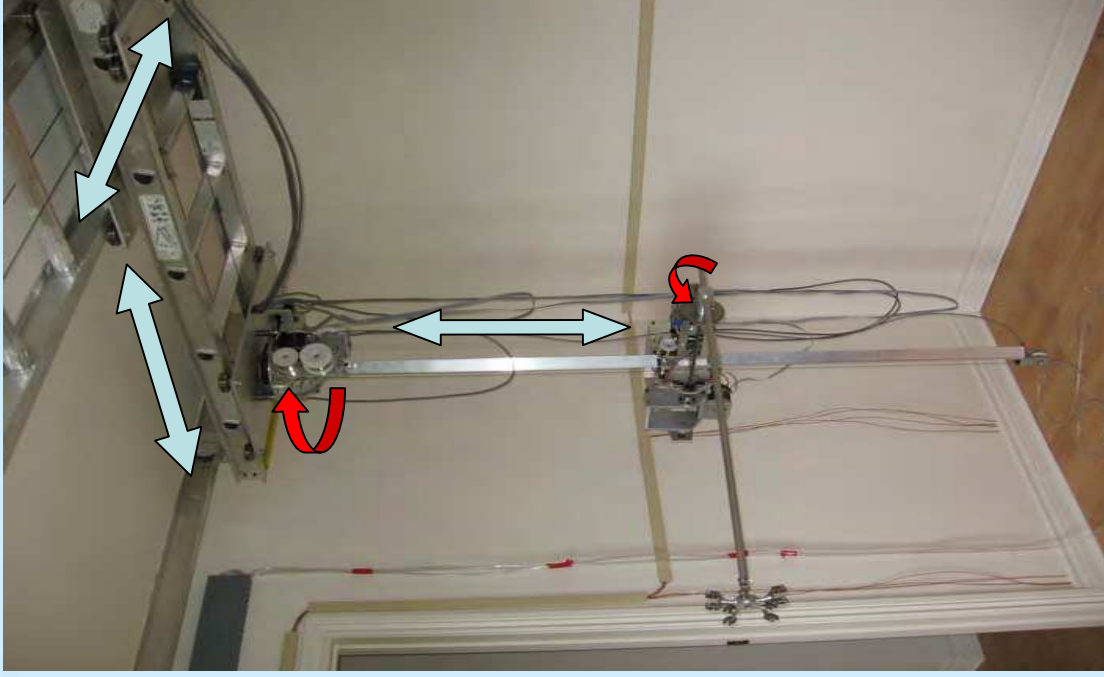


GROUND FLOOR PLAN



SECOND FLOOR PLAN

Automated 3-D System & IR Camera



- Relative humidity
- Air speed
- Dry bulb
- Mean radiant and,
- Operative temperature

Current Research Projects in Research House Facility

Project 1 - Energy-efficient Hybrid Heating

(IRC/NRC, PERD, NRCan, Roth Canada & Flexco)

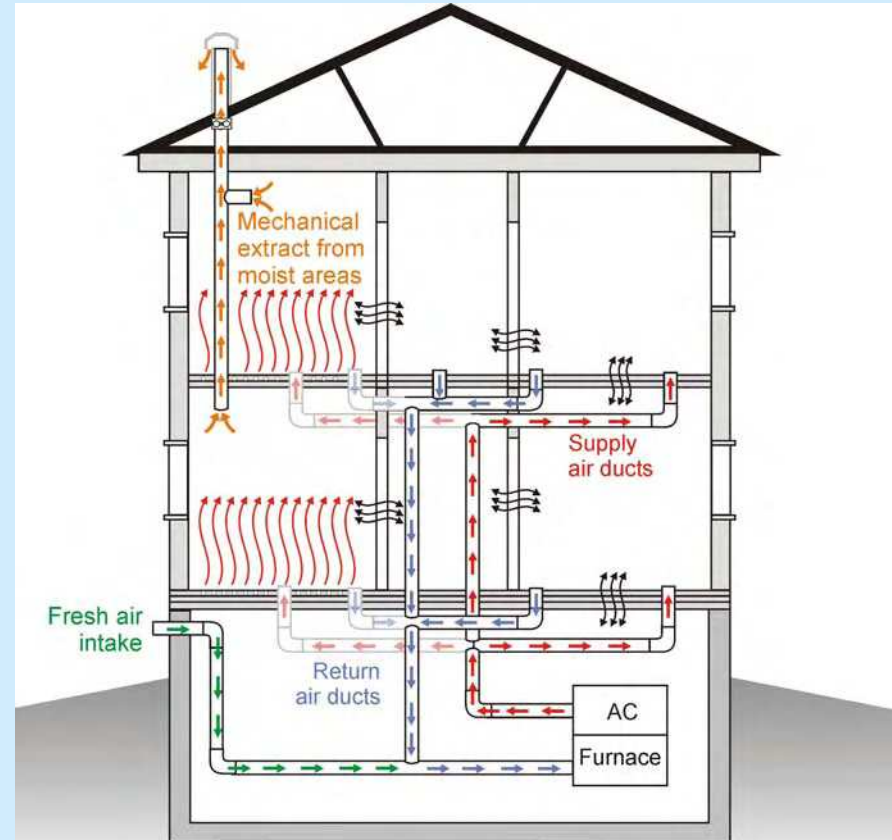
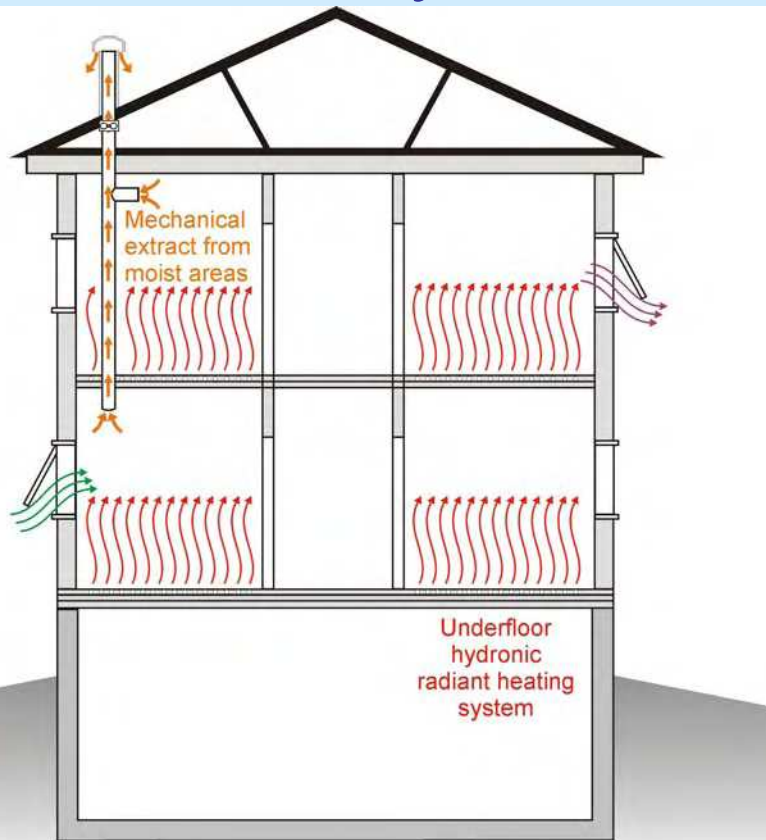
Project 2 - Energy-efficient Hybrid Ventilation Systems

(IRC/NRC, PERD, NRCan & CMHC)

Project 1

Energy-efficient Hybrid Heating

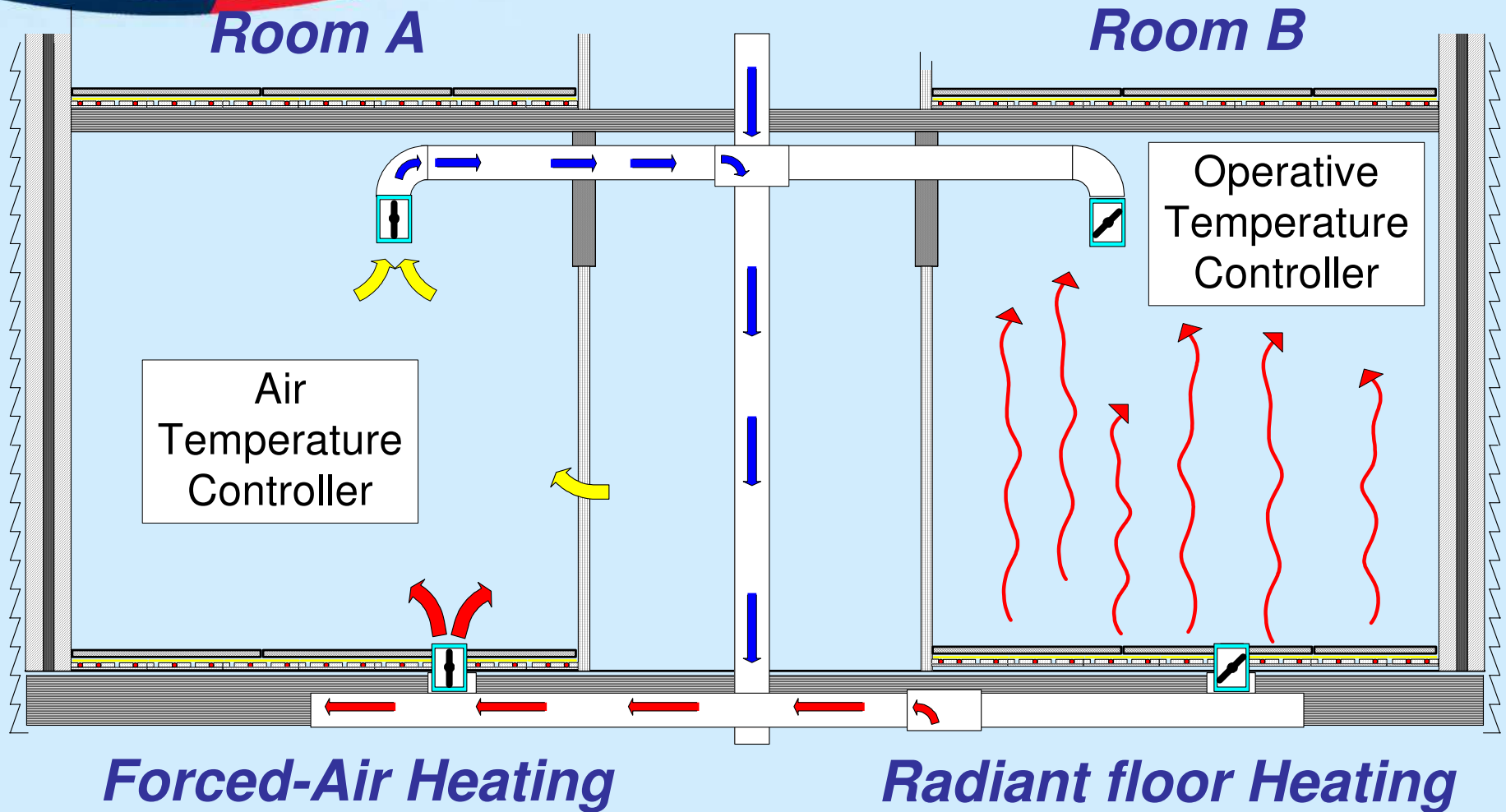
Compare radiant floor heating vs. forced-air heating & examine hybrid combinations of both



Experimental Approach

- Compare total energy consumption for whole house heating by each of forced-air and radiant floor systems.
- Assess thermal comfort quality delivered by each heating system.
- Determine energy required by each system's components to deliver the thermal comfort achieved.
- Investigate influence of required supplemental ventilation on overall energy consumption.
- Assess envelope transmission losses for each heating system.
- Assess control strategies and potential further system optimization.

Comparative System Analysis



Side-by-Side Comparison

Thermal Comfort / Acceptability Criteria

International standards and guidelines
(ISO 7730 1994, CR 1752 1998, ASHRAE 55-1994)

General thermal comfort

- Operative temperature (air temperature & mean radiant temperature)
 - Winter (heating season)
20°C - 24°C for people at 1.2 met & 1.0 clo

Local thermal comfort

- Floor surface temperature range 19°C – 29°C
- Vertical air temperature difference (head-feet < 3°C)
- Air speed < 0.2 m/s

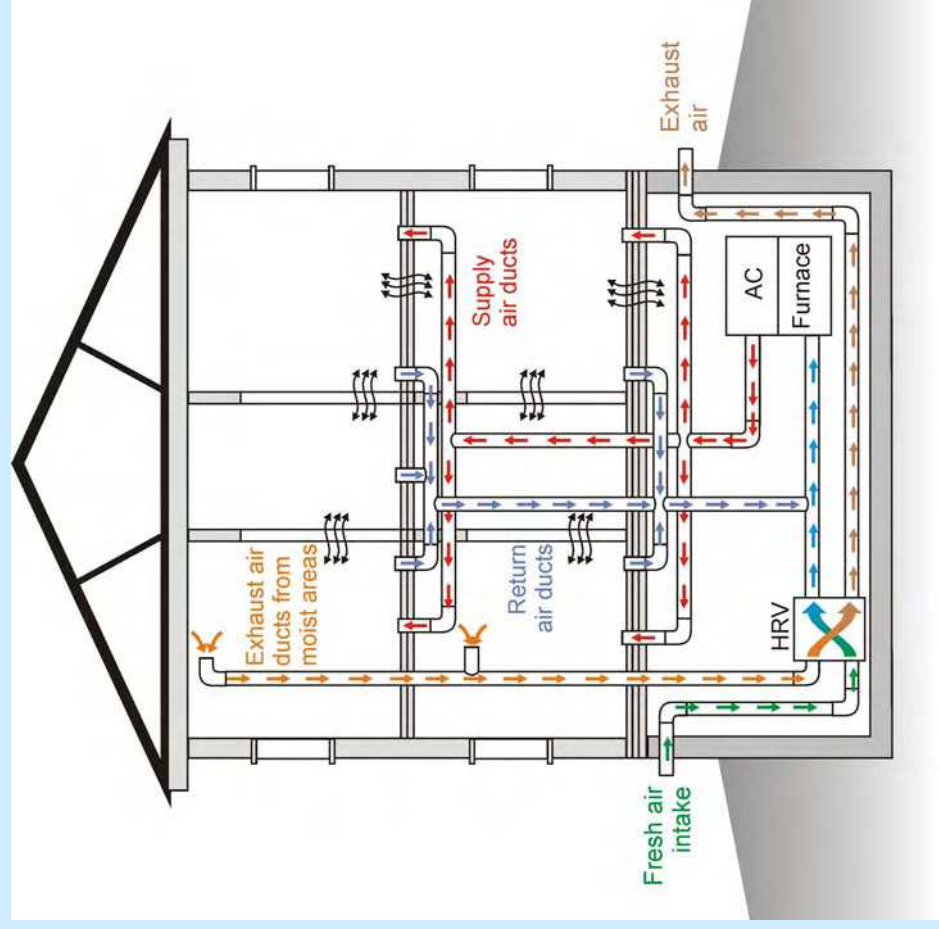
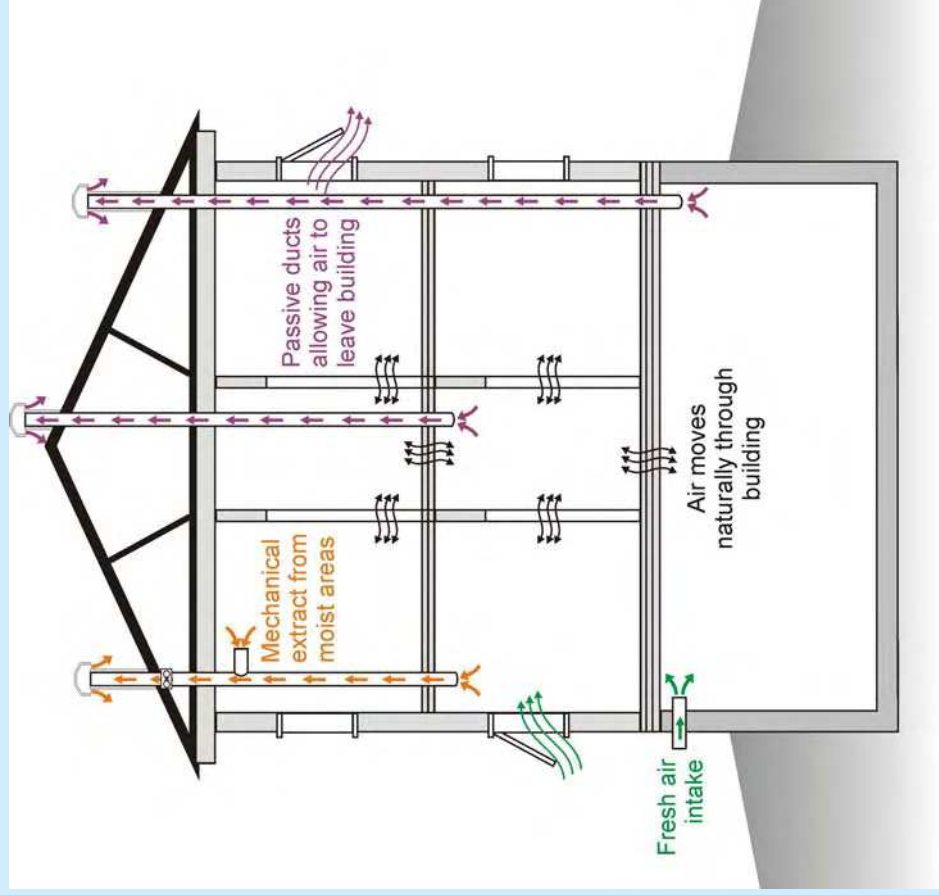
Project 2

Energy-efficient Hybrid Ventilation Systems

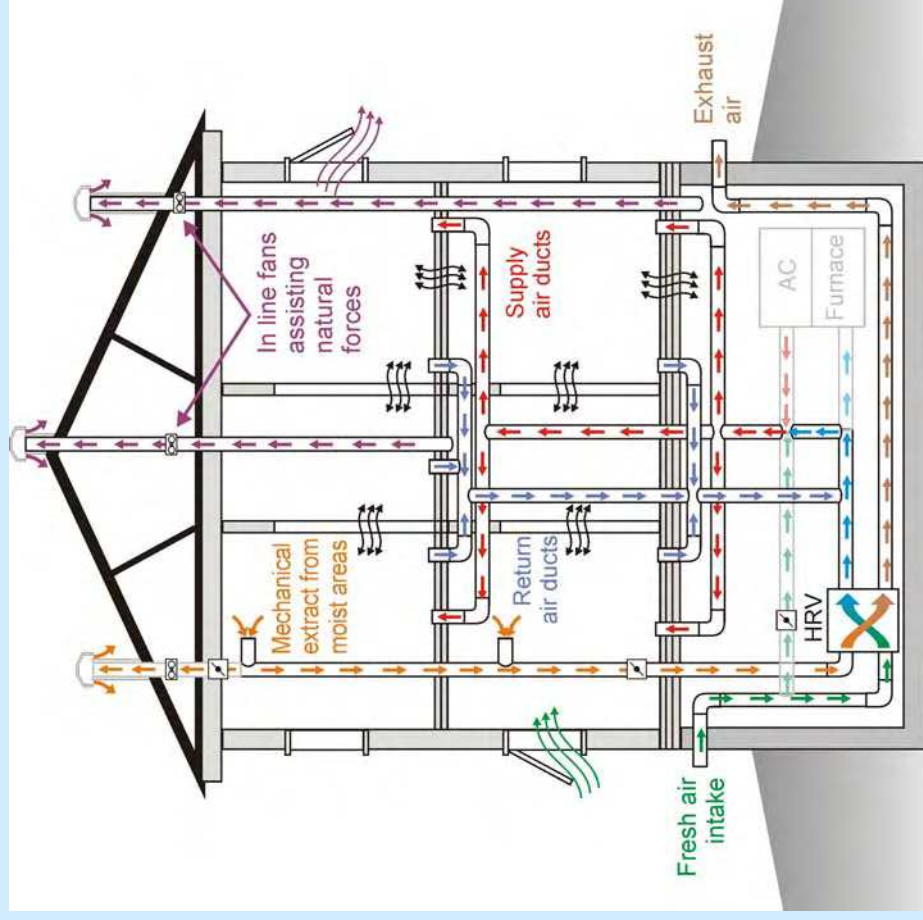
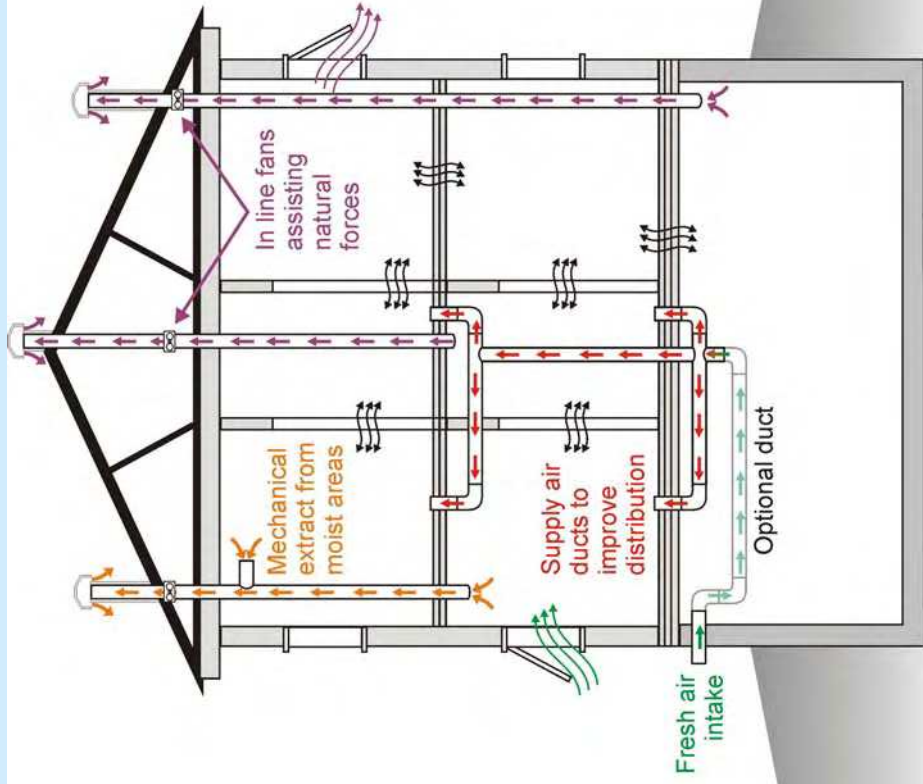
Comparison monitoring, for wide range of weather conditions:

- Mechanical ventilation system alone,
- Natural ventilation system alone, and
- Hybrid ventilation
 - mechanically-assisted natural
 - passive-supplemented mechanical

Passive Stack Ventilation Mechanical Ventilation



Mechanically-Assisted & Passive-Supplemented Mechanical Ventilation



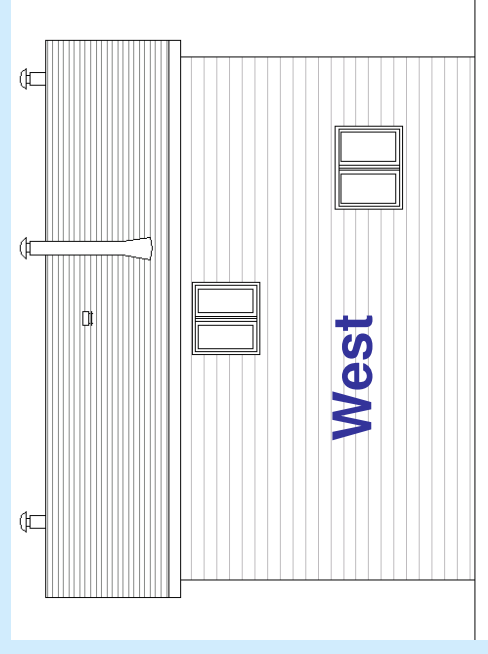
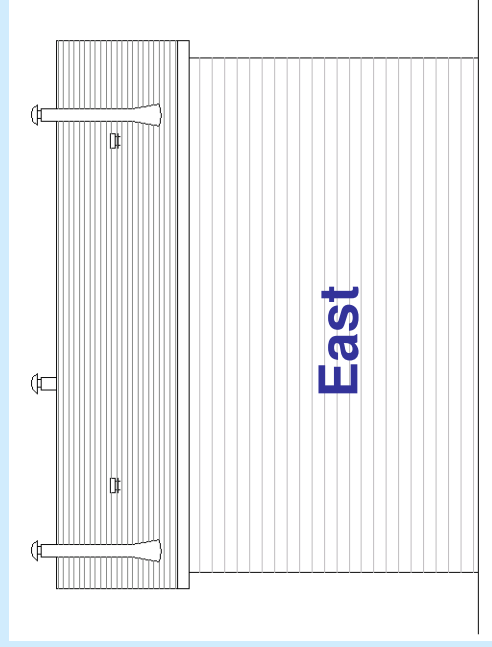
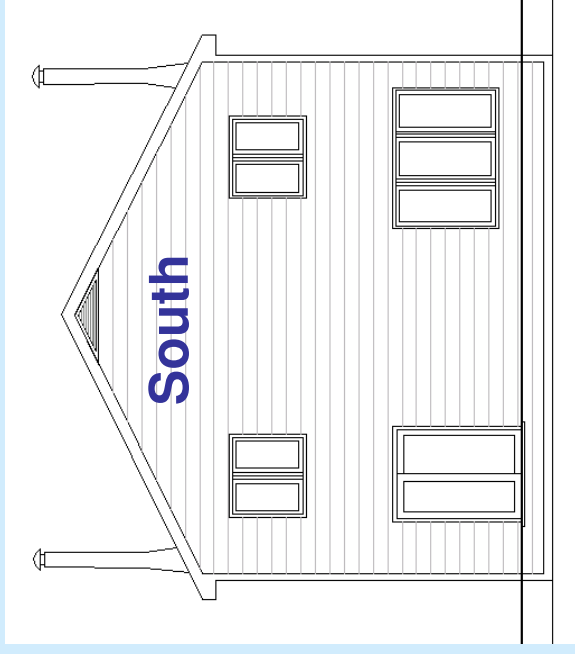
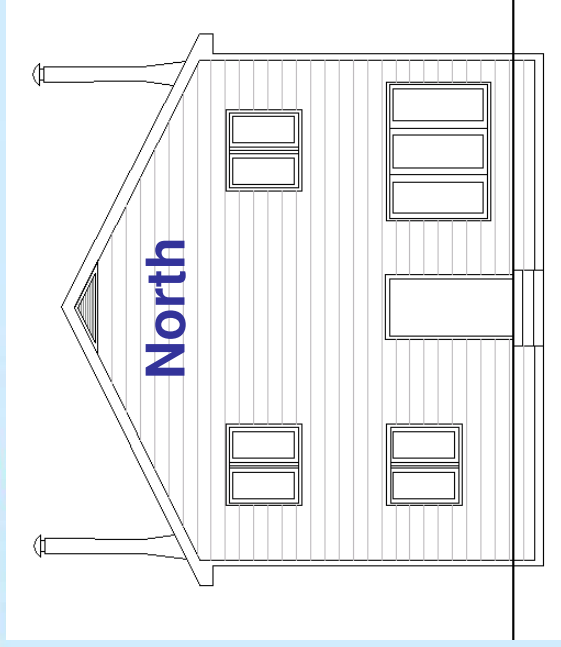
Experiments, Simulation & Expected Results

- Hybrid Heating - Fall, winter & spring 2006/2007
 - Experiments to evaluate performance of radiant floor heating system vs forced-air heating system.
- Hybrid Ventilation – Spring, summer & fall 2007 and Winter 2007/2008
 - Experiments to evaluate performance of providing ventilation for houses using hybrid approach (using mechanical assistance to supplement natural ventilation when required).
- Building Energy Simulation and CFD Modeling

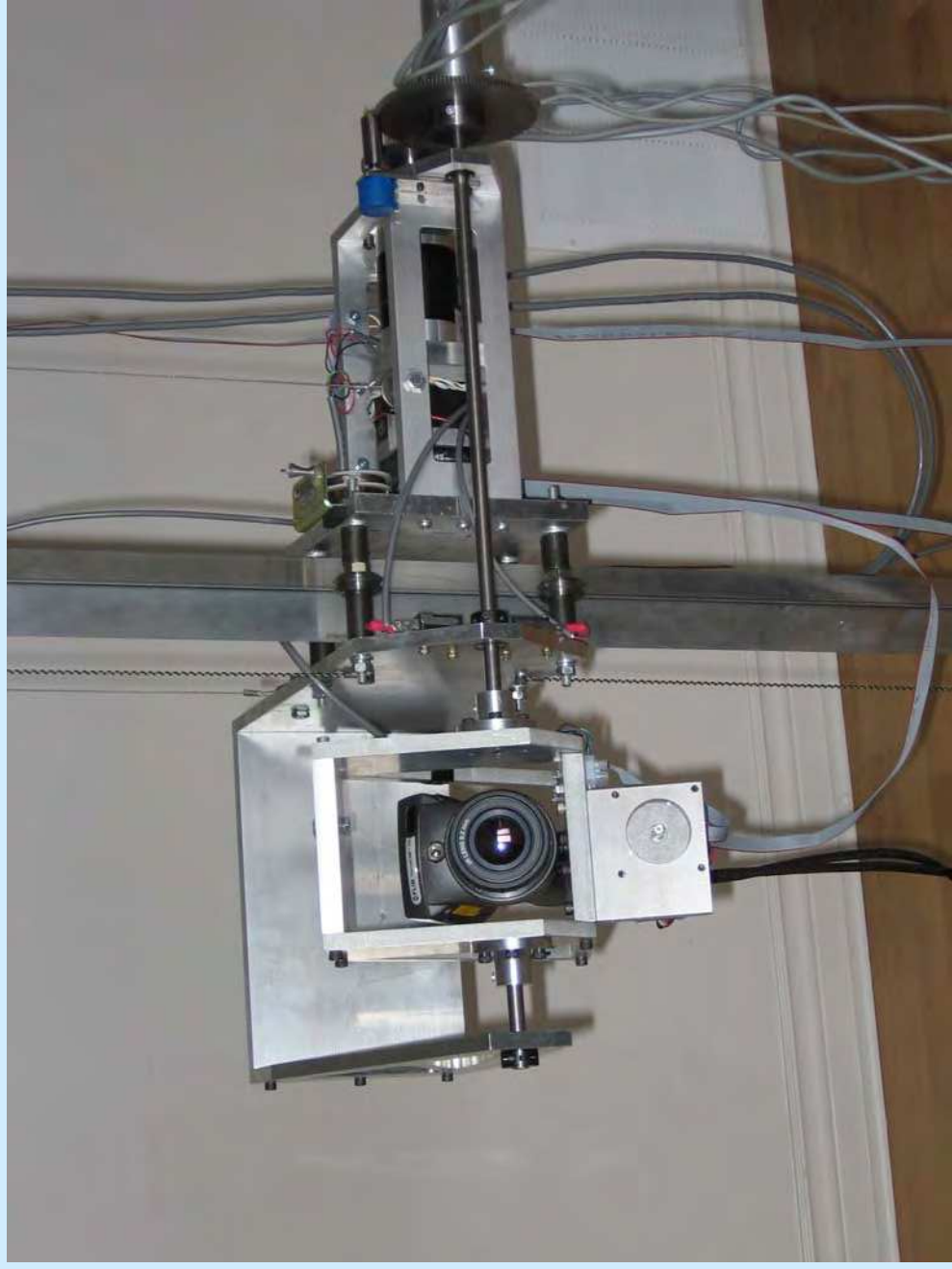


THANK YOU

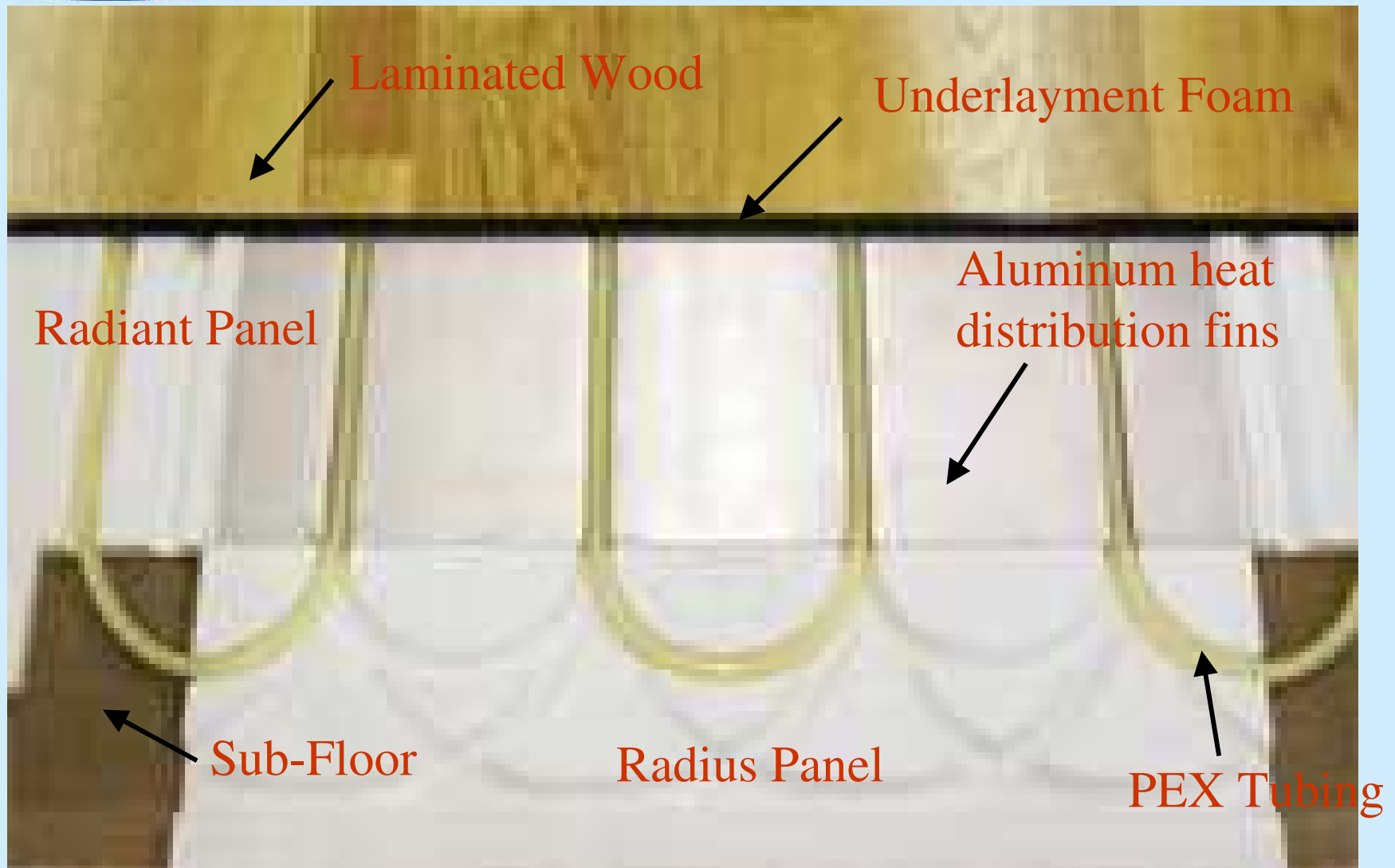
Facades



Infrared Camera for Thermographic Imaging



Roth Hydronic Radiant Panel System



Radiant Flooring Installation



Radiant Panel



PEX Tubing



Underlayment Foam



Laminated Wood

Issues Related to Radiant Floor Heating

- Thermal comfort delivered to zone demand
- Energy consumption to deliver thermal comfort
- Energy savings potential by reduced T_{DryBulb}
- Thermal mass impact on start-up, overheating, set-back
- Control strategies and sensor input
- Indoor environment impact of warm flooring
- Ventilation air distribution without forced-air ducts and circulation

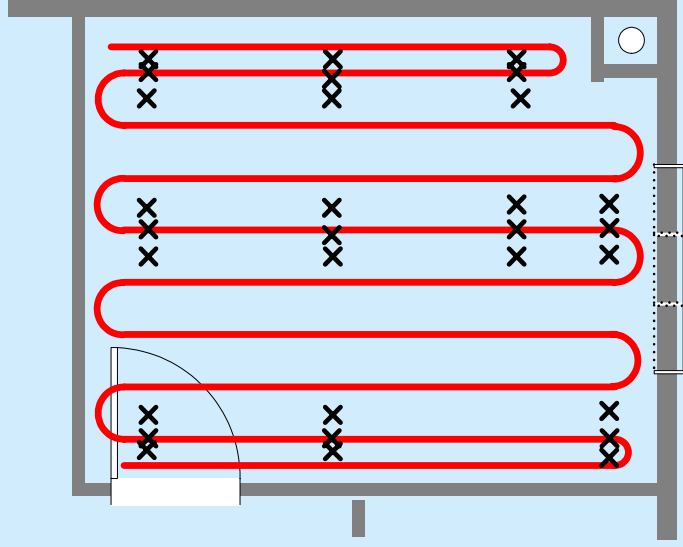
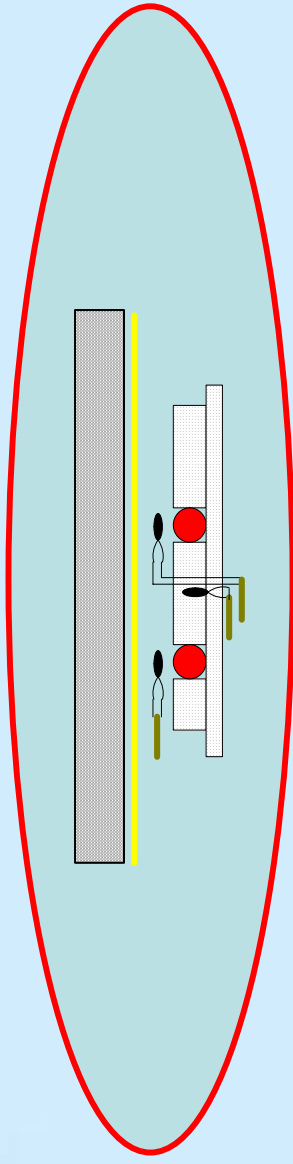
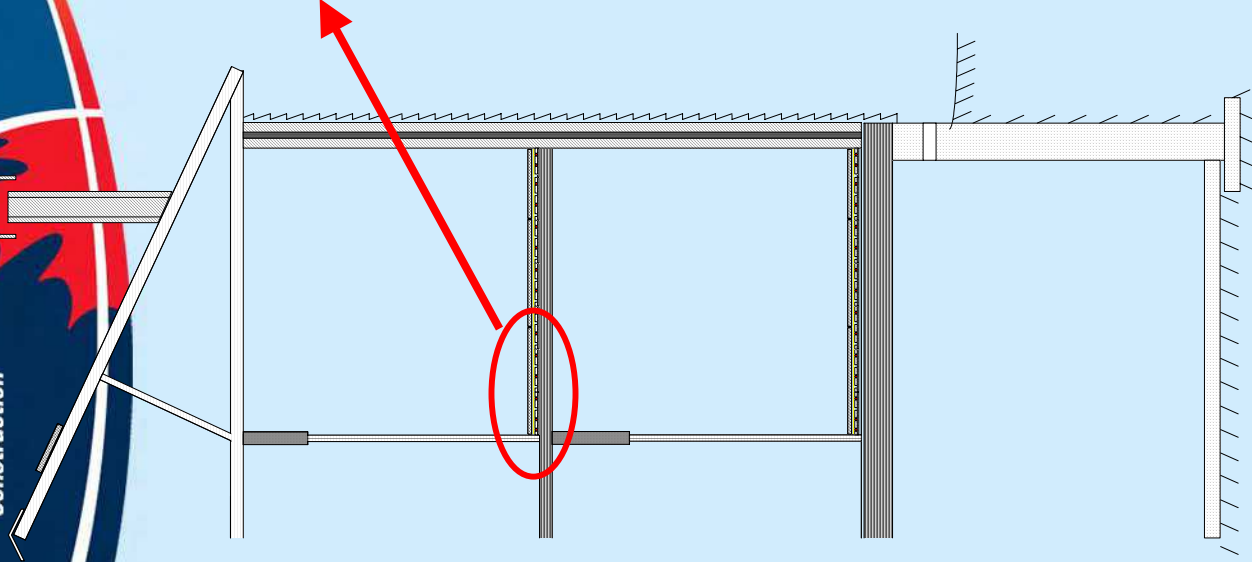
Multiple Tracer Gas System with Automatic Sampling & Dosing



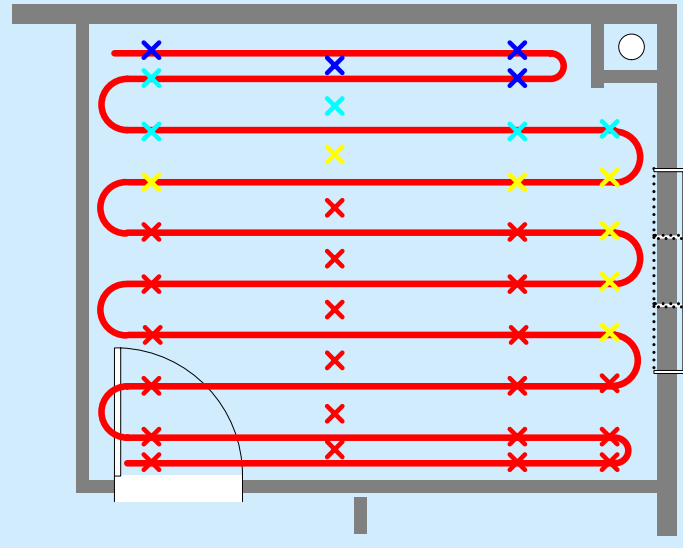
Data Acquisition System

- Flows and temperatures in radiant floor heating circuits and forced-air ducts.
- Water supply, propane supply and electrical supply rates for each system.
- External conditions including: wind velocity, humidity, temperature and solar radiation.
- Two robotic thermal environment measurement systems.
- Relative humidities and temperatures at air and surface locations.

Floor Temperature Distribution



Over the radiant panel



Over the laminate flooring

Air Temperature Distribution

