HEALTH PERFORMANCE CRITERIA FRAMEWORK FOR HOMES BASED ON "WHOLE HOUSE" AND "LEED" APPROACHES

Summary of Research Report and M.S. Thesis

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INTRODUCTION

- Indoor air may be more polluted than outside air (DoH, Washington 1999).
- Americans often spent most of their time indoors (Klepeis et al. 2001).
- Indoor Environment Quality (IEQ) and Occupant Health have received much attention lately.

GOAL OF THIS RESEARCH

Analyze health effects associated with Indoor Environmental Quality in relation to the physical, chemical and biological processes involved; and develop a framework for the design and construction of healthy homes by utilizing the "Whole House" approach and the "LEED" criteria.

INDOOR ENVIRONMENT AND HUMAN HEALTH

Attributes of Indoor Environment Quality (IEQ)	Examples of Health effects
1. Presence of Indoor Air Pollutants	Allergic reactions, Asthma, Hypersensitivity pneumonitis
2. Temperature	Discomfort and secondary health impacts
3. Humidity	Discomfort and secondary health impacts
4. Ventilation	Discomfort and secondary health impacts
5. Lighting	Eyestrain, headache
6. Acoustics	Discomfort, hearing problems, safety issues
7. Ergonomic conditions	Body strain, safety issues

PHYSICAL-CHEMICAL-BIOLOGICAL INTERACTIONS IN INDOOR ENVIRONMENT

- Various physical, chemical and biological processes determine the fate of IEQ.
- Air flow, air mixing, energy transfer, sorption, volatilization and dissolution processes, hydrolysis, photolysis, redox reactions, condensation process, microbial growth etc. (ESP 2005, Arens & Baughman 1996).

"WHOLE HOUSE" AND "LEED" APPROACHES

- IEQ problems can be attributed to negative interactions between building systems.

- "Whole House" approach promotes the idea that the home be viewed as a system composed of different components which work together, so that negative interactions between various building systems can be avoided (Swarup 2005).
- External environment is inextricably connected to the indoor environment.
- The "LEED" green building criteria utilizes the whole system approach, with the intent to minimize environment damage attributable to buildings; while enhancing occupant health, safety and comfort (LEED 2005).
- Therefore, the LEED criteria for homes was used as a starting point for the research on healthy homes and health impact matrices were developed (Figure 1).

HEALTH PERFORMANCE CRITERIA FRAMEWORK

- Based on the above studies, a set of Health Performance Goals and Building Systems Design/Construction/Integration Strategies were developed (Figure 2).
- The strategies were then scored for their resemblance to an ideal "Whole House" situation.
- This ideal "Whole House" epitomizes the situation where all involved building systems work synergistically, thereby enhancing the health performance of the home and avoiding any negative interactions.
- Each strategy was scored for performance and interaction.
- Performance score of a strategy denotes its ability to deliver the required health performance. Interaction score denotes the degree of synergism of that particular strategy in combination with other strategies (Figures 3, 4 and 5).

LEED checklist item	LEED Intent & Rationale	Health Effects and Supporting literature		LEED broad guidelines	LEED: Interaction Scenarios	Systems integration aspects
		Direct Effects	Indirect Effects			
Credit 3: Humidity Control	**Intent**: Provide a comfortable thermal environment in the home. **Rationale**: Occupant comfort may be adversely affected by very high or very low humidity levels in the home. High humidity levels may also foster mold growth.	▪ **No direct health effects from humidity per se.** BUT ▪ Known health effects related to high humidity are primarily caused by the growth and spread of biotic agents under elevated humidities, and humidity interactions with non-biotic pollutants, such as formaldehyde (Arens & Baughman 1996). ▪ A few pathogens causing infectious diseases can colonize abundantly within moist environments outside the human body and become airborne given proper conditions (Flánnigan 1992). ▪ The majority of patients suffering from asthma are allergic to dust mites, mold, and/or animal dander (Berglund et al. 1992). ▪ Non-allergic immunologic responses like hypersensitivity pneumonitis can be triggered by fungi and bacteria. They occur as a result of repeated pollutant exposures (Burge 1988).	▪ Humidity significantly affects local thermal comfort. Local thermal discomfort can be due to the insufficient cooling of the mucous membrane in upper respiratory tract, resulting from high temperature and humidity of air (Toftum et al. 1998). ▪ Humidity affects the perception of indoor air quality (Fang et al. 1998). ▪ Low humidity can result in the drying out of nasal and throat membranes, leading to discomfort. ▪ Dehumidification can result in static electricity in buildings which can be hazardous.	▪ Analyze moisture loads and need for a central humidity control system. Install humidity control system where needed to maintain humidity ratios below 0.012 (lb. water vapor / lb. dry air) per Section 5.2.2 of ASHRAE Standard 55-2004.	▪ Water leakage through building envelopes can be another major cause of indoor environmental problems (e.g., mold). The LEED points for improved foundation, exterior wall, and roof water management water are included in *Materials and Resources* credit 4, *Durability plan.*	▪ Humidity control equipment should be selected to maintain maximum humidity levels based on the summer indoor air temperature. ▪ Studies show that moisture transfer between indoor air and the hygroscopic structure significantly reduces the peak indoor humidity. Hygroscopic structure with a permeable interior coating is able to significantly improve warm respiratory comfort and perceived air quality (PAQ) during occupation (Simonson et al. 2002).

Figure 1: LEED-H Health Matrix

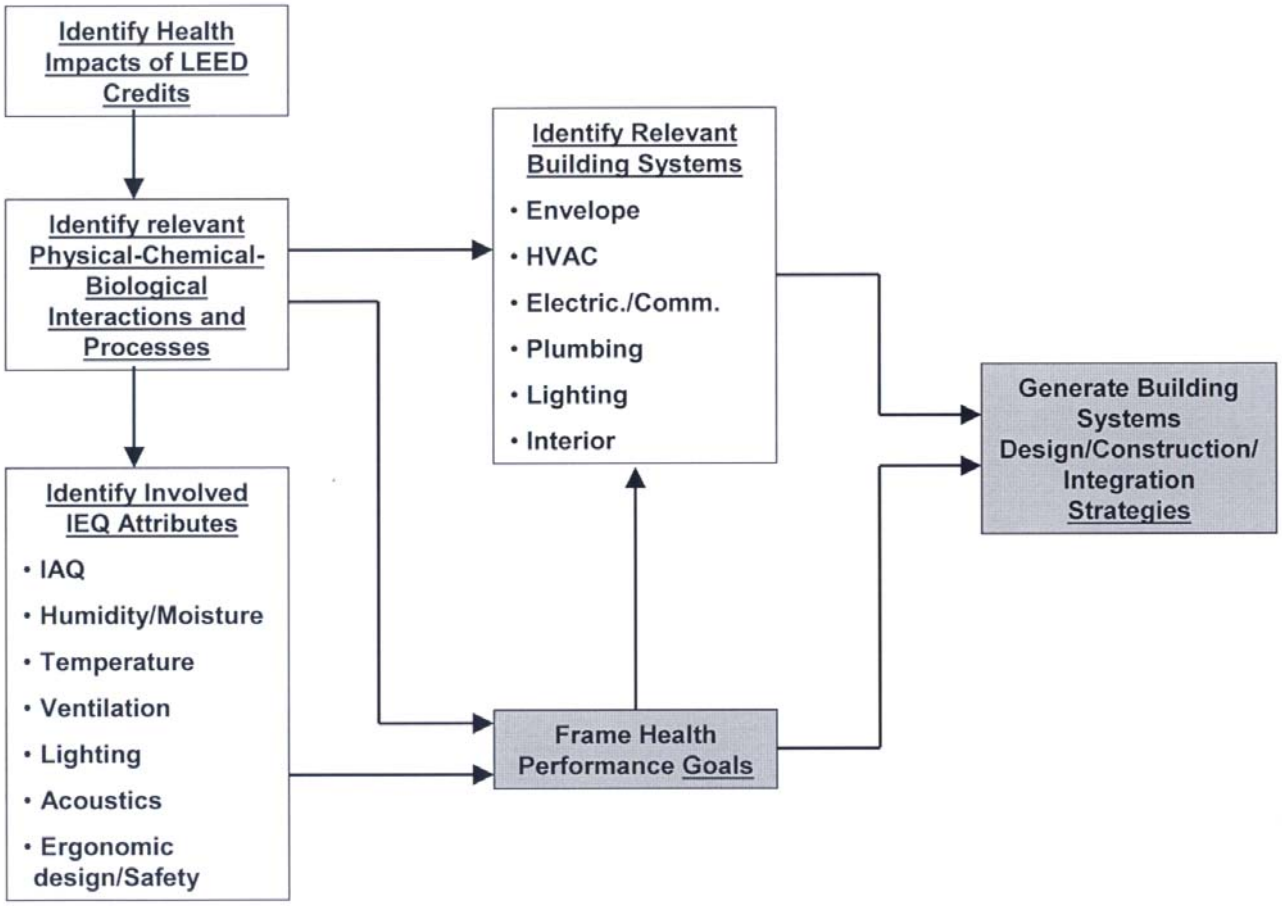

Figure 2: Model for generating building systems integration strategies

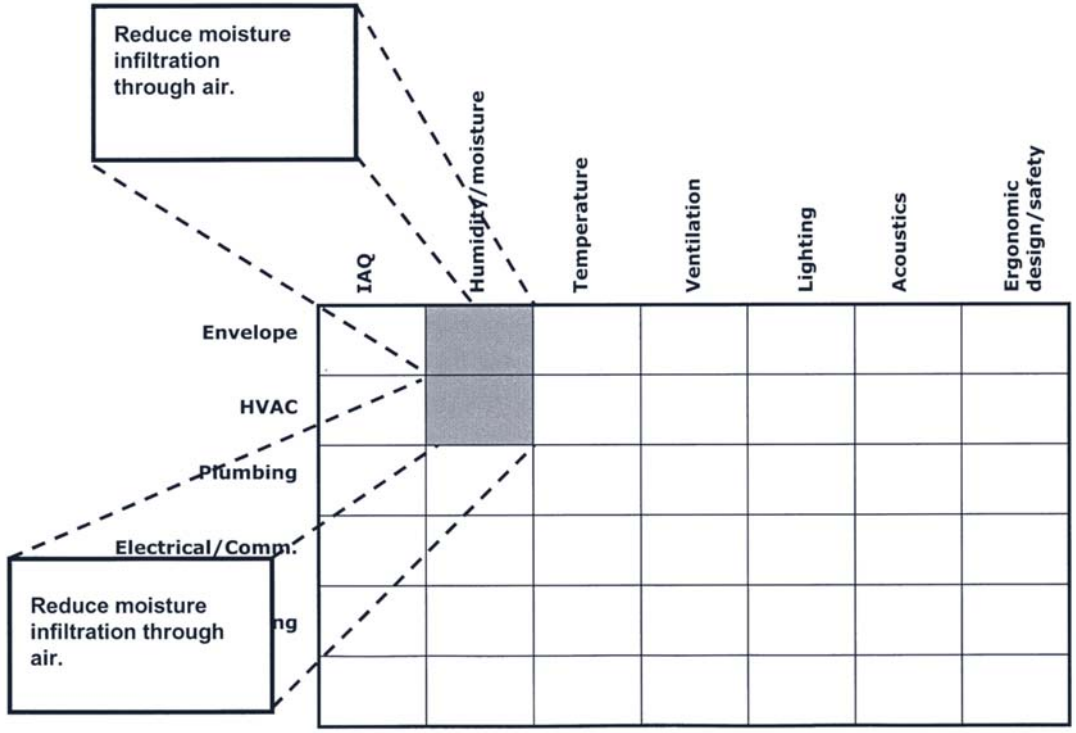

Figure 3: Health Performance Criteria Framework - Health Performance Goals

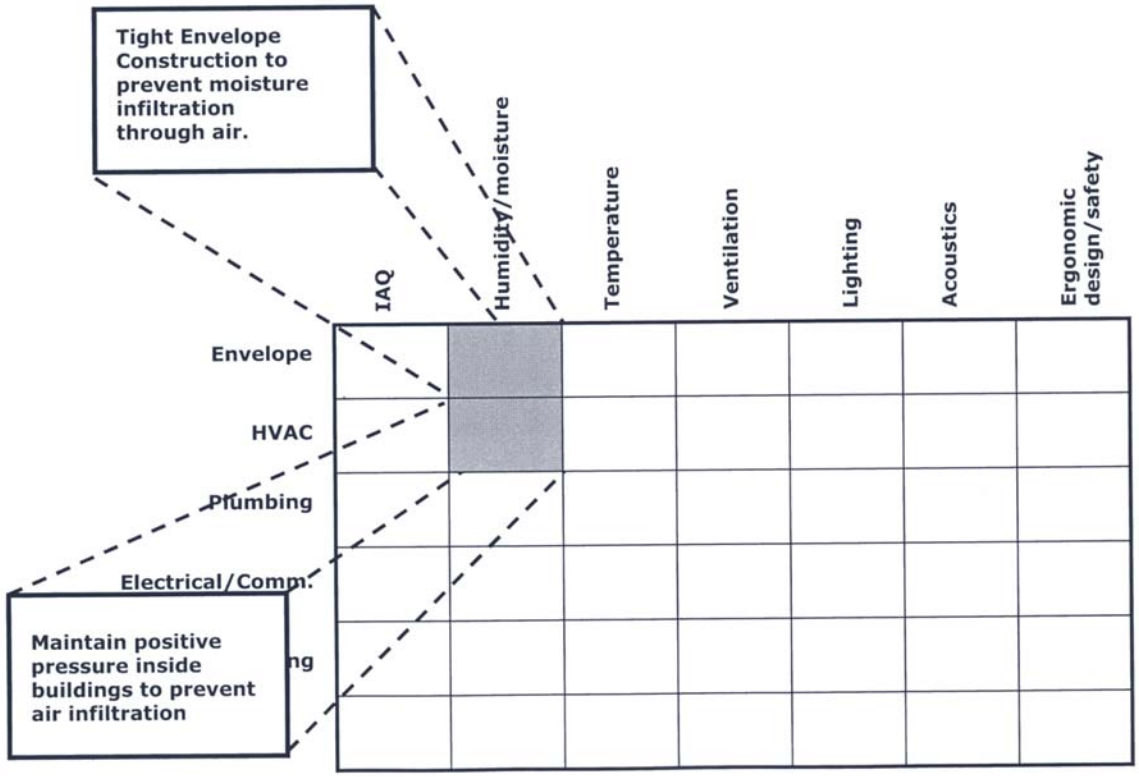

Figure 4: Health Performance Criteria Framework - Building Systems D/C/I Strategies

		1						2						
STRATEGIES														
		Attributes of Indoor Environmental Quality (IEQ)												
		IAQ - Presence of Indoor Pollutants		Performance Score **(x)**	Interaction Score **(y)**	Relevant Interactions	Performance Factor **(a*b*x)**	**Whole House Score (a*b*x*y*)**	**Humidity/ moisture**		Performance Score	Interaction Score	Relevant Interactions	Performance Factor	**Whole House Score**	**Final score**
		3.50							***2.00***							
		Envelope														
		(Weight.)	**2.00**						**2.50**							
A	***Building Systems***	Arch. Design Consideration	Garage-Living spaces interface.	Attached garage and hence there is threat from vehicle emissions.	2	2.88	A1-A4, A1-B2, A1-B4, A1-C1, A1-C6, A1-C7, A1-O1, A1-U1, A1-V7	14	40.32	Exterior water management systems.	Sloping roof has been provided. Design requirements followed for overhangs, gutters and downspouts are satisfactory.	4	3.57	A2-A5, A2-B1-T1-T2, A2-C4, A2-D2-E2-G2-D7, A2-E1, A2-E3, A2-O2-R2	20	71.4	
B			Material selection - environmentally preferable products	Low VOC products used for roof/ wall insulation.	3	4.5	A2-B1-T1-T2, B1-B3, B1-D2-E2-G2-H2-I4-LI, B1-H4, B1-C2-D2-E2-G2-H2-L1-O2-R2	21	94.5	Material selection - environmentally preferable products	Permeable materials and finishes used. Ease of maintenance been considered.	3	2.75	A1-B2, B2-D2-E2-G2-H2-I4-L1, B2-H4, B2-T1, B2-C2-D2-E2-G2-H2-L1-O2-R2	15	41.25	**235.50**
HEALTH PERFORMANCE SCORE BASED ON "WHOLE HOUSE" & "LEED" APPROACHES																**3467.06**

Figure 5: Sample Health Performance Criteria