Unhealthy Energy Conservation Practices

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INTRODUCTION

"Today's problems come from yesterday's solutions." Systems thinker Peter Senge wrote this introductory passage in his best seller *The Fifth Discipline* to illustrate the futility of simplistic solutions. Systems dynamics predict that the most obvious solutions are too narrowly focused; they may improve matters in the short term, but only make things worse for the future.[1] Environmental design has demonstrated this maxim several times from the Department of Transportation's freeway campaign in the 50's to Corbu inspired high-rise slums. In examining energy practices over the last 25 years it is clear that the building industry and the academy too narrowly defined and attacked the energy crisis at the expense of broader health and welfare issues. ASHRAE guidelines, passive energy recommendations and typical planning and building efficiencies have significantly deteriorated indoor light, air and views.

ASHRAE'S CONTRIBUTION TO THE PROBLEM

In the late 70's and 80's, ASHRAE responded to the crisis by taking the most direct route by lowering ventilation standards. Since ventilation represents 20 to 40 percent of a building's thermal load, ASHRAE looked at the most obvious solution and cut ventilation in office buildings from 15cfm in 1977 to 5cfm in 1982.[2, 3] Seven years later, after a number of press releases and articles on sick building syndrome, the *ASHRAE, 1989 Fundamentals Handbook* still wrote the following on ventilation, "Outdoor air introduced into a building constitutes part of the space-conditioning load which is one reason to *limit air exchange* rates in buildings to the minimum required."[4] The *1997 ASHRAE Handbook Fundamentals* contains this same sentence which demonstrates that efficiency is of central importance while human health is on the periphery.

But air quality appears to be a fraction of the problem. In addition to respiratory illness, simplistic efficiency strategies have lowered the quality and quantity of indoor light. Within the last 20 years, medical studies have found that today's low levels of light may significantly contribute to depression[5] inattentiveness,[6] stress[7] and compromised immunity.[8] Additionally, restricted access to outdoor spaces that provide a plenitude of full-spectrum light may significantly increase rates of osteoporosis[9] and cancers of the breast and prostate.[10] For hospital patients, poor views due to smaller energy saving windows may slow recovery time and increase pain.[11]

MODERN ARCHITECTURE'S TIE TO HEALTHY DESIGN

Recent environmental medical findings have roots back to ancient times and more recently to the mid 19th century. Florence Nightingale was one amongst many who strongly recommended light — in particular sunlight—and fresh air in hospital and house designs in her influential 1860 book *Notes on Nursing*. In 1903, the therapeutic use of light gained considerable validity when the Nobel Prize was given to Niels Finson for discovering the curative effects of light on tuberculosis.[12] These findings inspired building and city designs to access more light and air. According to Ph.D. candidate James Ross of Brown University, modern architecture and its health conscious use of light and air was deeply influenced by late 19th century medical findings and theories.[13] From this era emerged the health inspired work of Frank Lloyd Wright, Irving Gill, Rudolph Schindler, Richard Neutra and Alvar Aalto.[14] All promoted their designs as healthy. Most used glass liberally and blurred the distinction between inside and outside for natural views, fresh air and light. Today however, to designers who still see windows as an energy drain and outdoor spaces as superfluous, modern architecture's use of glass and outdoor rooms could be seen as wasteful.

PROBLEMS WITH VERNACULAR PRECEDENTS

By breaking cultural traditions, modern architecture's use of glass appeared culturally blind. A void of traditional forms and practices resulted which vernacular architecture may have filled. In addition to the comfort of tradition, the vernacular is often touted as both energy efficient and healthy. However, this is not always the case with cold weather examples like the igloo, wigwam and the early New England home. Although thermally responsive due to limited windows and low exterior wall to space ratios, rooms are typically oriented inward which may compromise basic health needs for light, air and view. For example, the early colonial Capen house

in Massachusetts is considered a climate responsive design because it's rooms gather around a dark centralized mass of fireplaces to conserve heat.[15] Colonialists could take comfort in this type of heat, but in latitudes that rank the highest percentages of clinical winter depression (from 10 to 29 percent of the population depending on latitude) orienting spaces away from natural light in the winter most likely exacerbated depression.

THE SEDUCTIVE EFFICIENCY OF MINIMIZED EXTERIOR WALLS AND WINDOWS

Taking a clue from cold weather vernaculars, Victor Olgyay recommends in *Design With Climate* that designs in northern latitudes should be nearly square because of the high space to low exterior wall ratio.[16] Using graphic tables he demonstrates how BTU efficiency slumps when building shapes become more thin. However, this strategy not only limits natural light, but the design can have a multitude of interior rooms which rely solely on the air conditioning system for fresh air. If the system is contaminated or broken, windows cannot be opened to temporarily relieve the problem. Additionally, rooms near the core have views of walls instead of stress reducing views of nature.

Gideon in his book *Mechanization Takes Command* noted the machinelike efficiency of this compaction strategy in Belfast's 1900 Royal Victorian Hospital. In contrast to the Royal Victorian, most contemporary hospital designs sported winged pavilions with natural light and patient access to garden courtyards. Air quality was assured through cross ventilation. However, the Royal Victorian eliminated inefficient patient centered courtyards and pavilion wings by compressing the scheme into a single rectangular block minimizing energy wasting exterior walls and windows. Gideon showcased this more efficient arrangement because it greatly minimized heat distribution ducts which the engineers utilized to reduce heat loss.[17]

While the Royal Victorian reduced duct runs, it also reduced circulation space saving nurses and doctors steps. This circulation efficiency was later used frequently in hospital designs due in part to administrative efficiency and the demise of environmental therapies which were replaced by more controllable biochemical drugs.[18]

In 1978, the ASHRAE Applications Handbook also endorsed a similar compaction strategy while discouraging the use of windows. In '78 it recommended that "since the exterior load varies from 30 –60% of the total air-conditioned load when fenestration ranges from 25 – 75 percent, it is desirable to keep the perimeter area to a minimum."[19] Energy tables graphically reinforced the idea.

But beyond the seduction of thermal and administrative efficiency, minimizing exterior walls and windows is profitable for all climates because of its ease of planning and assembly. Compared to interior walls, exteriors require more detailing, building time, and energy intensive materials due to the extra effort needed to waterproof, insulate and integrate windows and doors. In short, it takes more human and material energy to build exterior walls.

MEDICAL EVIDENCE AGAINST BUILDINGS THAT MINIMIZE EXTERIOR WALLS AND WINDOWS

However, the health risks of limiting exterior walls and windows could be substantial. In 1984 Roger Ulrich's landmark study demonstrated that window views to nature may accelerate healing and decrease pain medication in hospital patients.[20] These views appear to relax patients. Research has found that a relaxed body increases the amount of white blood cells in the bloodstream helping to strengthen the immune system.[21] Ulrich's studies are significant because the benefits of stress-reducing views can crossover to other stressful settings like schools and offices.

The importance of windows and light is demonstrated in Lisa Heschong's 1999 study of classrooms where she found a link with higher test performance levels in rooms with windows and skylights. In this study, she evaluated 21,000 children from 2nd to 5th grade from three different climates in Seattle, Ft. Collins, and San Juan Capistrano.. All three showed similar results, but the most promising study found that students whose classrooms were exposed to the largest window areas progressed 15% faster in math and 23% faster in reading than those with the least amount of window area. [22]

Heschong's studies could tie into recent sleep disorder and depression research.[23] Inadequate indoor light as it relates to sleep disorders and anxiety could lead to higher levels of stress which raises the body's hormonal levels of cortisone and epinephrine. Both hormones compromise the immune system's white blood cell counts.[24] Inadequate levels of light as it relates to depression[25] can conceivably contribute to other types of immune problems. Studies conducted on depressed patients have shown that certain immune system regulators like immunoglobulins and lymphocytes can be compromised making the depressed more vulnerable to illness[26] and conceivably to building related illness.

While our eyes and bodies have evolved with very high levels of outdoor light, ranging between 5,000 to 10,000-lux, it isn't until recently where we began to spend the majority of our time in darker inside spaces of 100 to 500-lux. According to sleep researcher Dr. Daniel Kripke of the University of California in San Diego, humans function normally in the wake/sleep cycle, when exposed regularly to light conditions of 1500 to 2,500-lux. Today's typical indoor light measurements are 3 to 25 times lower. According to Kripke, these low levels do not fully activate the production of serotonin.[27]

Serotonin is a crucial neurotransmitter which gives the brain a sense of well being. Without it, depression can result. This could also explain why Heschong's school children received higher scores in the daylit schools. Studies also show that alcoholics, violent offenders, sex offenders and suicide victims demonstrate marked deficiencies of serotonin. With this evidence, the psychiatric community spawned a new breed of serotonin activators like Prozac, Paxil, Zoloft and light boxes....all significantly more effective than its predecessors Valium and Xanax.[28] When light turns to dark, the pineal gland converts serotonin to its chief metabolite, melatonin which is crucial for inducing sleep. Both neurotransmitters are essential for accommodating stress.

For those who suffer from Seasonal Affective Disorder (SAD), high intensity lamps of 10,000-lux adequately relieve winter depression. However, these lamps along with typical interior lights lack the full spectrum of daylight. Incandescent light lacks outside levels of blue while cool white fluorescent lack red and less than optimal amounts of blue. Both light sources are foreign to what our brain evolved with which is high levels of outdoor full-spectrum light. Some researchers have deemed this imbalance as "mal-illumination" referring to the different color spectrums as essential nutriants.[29] Blue light, which is lacking in both incandescent and many fluorescent lights is known to activate the para-sympathetic nervous system which helps the body to relax.[30] This is congruent with further studies that shows that the color blue lowers blood pressure and heart rates[31] . Additionally, blue light is also linked with the suppression of melatonin which makes us drowsy.[32] From this evidence, it appears that the higher levels of blue light found in the sky not only relaxes the body, but also keeps the mind alert. This evidence could also explain why Heschong's schoolchildren performed better with larger windows.

Task lighting standards may also contribute to anxiety and depression. Task lighting currently focuses on minimum light levels for *visual comfort* and task efficiency. These numbers range from 300-lux for classrooms and computer stations to 500-lux for offices,[33] which is not the vastly higher levels of 1500 –2500-lux that are recommended for normal bodily function and serotonin production.

THE HEALTH BENEFITS OF OUTDOOR LIGHT

In addition to the high levels of outdoor light, medical research is now claiming that the *lack* of outdoor full-spectrum light could be responsible for a number of maladies that go far beyond sleep disorders and depression. Because lifestyles today are typically spent indoors, studies are showing a relationship between a lack of outdoor light and higher incidences of osteoporosis, jaundice, breast cancer, ovarian cancer, colin cancer, large bowel cancer and prostate cancer. Most of this research is sponsored by science based foundation grants and is reported in hard scientific medical journals.[34,35] Sunlight induced ultraviolet B light and its production of vitamin D3, a sunshine not dietary induced vitamin, helps bones and the immune system absorb calcium. Although dietary vitamin D can be metabolized into vitamin D3, the process is only 60% as effective as outdoor light exposure.[36] The combination of calcium and vitamin D 3 not only helps form strong bones and teeth, but also may help to regulate the body's immune system for which bones play an integral part.[37] This contribution to the immune system has resulted in a multitude of promising studies since the '80's that show strong links to ultraviolet light and its role in combating heart disease and cancer (breast, prostate and bowel).[35,36] Reinforcing this research is a number of surprising studies that show lower incidences of both cancer and heart disease in global areas and times of the year where the sun shines strongest. (higher altitudes, lower latitudes and summer time)[38,39,40] Although windows block out most ultraviolet light, thus eliminating Vitamin D3 production, this prompts the need for more accessible and comfortable outside areas.

Not only is the outdoors a source of high amounts of full-spectrum light, but in many cases, fresh air. Compared to outside air, recycled indoor air in most sick buildings has higher concentrations of fungus. According to asthma researcher Dr. Cynthia Jumper of Texas Tech's Health Science Center, sick indoor air conditions have been linked to upper and lower respiratory illnesses. Asthma in children has risen dramatically since the 70's energy crisis where today 1 in 20 children are afflicted. Dr. Jumper speculates that tightly sealed buildings and lower ventilation standards are a major contributor, if not the main cause.[41] As pointed out by Dr. Jumper's colleagues, Dr. Danny Cooley and Dr. David Strauss in their research of 94 buildings in 48 states, the fungi which is responsible for building related illnesses, and sick building syndrome has significantly higher concentrations inside. As a result, these researchers use outdoor air as a baseline for measuring normal fungus levels.[42] Because outside air is continuously moving, it can in most cases easily disperse harmful fungus and gasses to near harmless concentration levels.

The relative freshness of outdoor air, the opportunity to view natural scenes and the anticancer properties of sunshine vitamin D-3 overshadow the danger of outdoor light's link with melanoma. Although abusive exposure to ultraviolet light (as demonstrated in the 1970's suntan fad) has been linked with melanoma, there is contrary evidence that significant *lack* of sunlight may also contribute to skin cancer.[43] Additionally, the hands and face which are regularly exposed to the sun, seldom develop melanoma; it is the torso and legs which are not normally exposed, that develop melanoma.[44] Melanoma researcher Dupont Guerrt, MD admits in his book *Melanoma Prevention , Detection and Treatment* that: "mild exposure to the sun is not harmful to most people. Indeed, it may have beneficial effects... it has been reported that the sort of mild continual sun exposure that produces a bit of a tan, but no burn may even protect you from melanoma."

CONCLUSION

It is often written in sustainability literature that energy efficiency *is* healthy. Sometimes the writing appears as if the two are interchangeable. This is not the case for health needs and energy efficiency is frequently at odds. Although sustainability intends to be health conscious, the first priority still appears to be energy efficiency. Although sustainable practices aim to incorporate natural light, the formulas dwell more on energy efficiency and minimum task levels. Higher circadian light levels do not enter the formula because task levels are assumed to be enough. Although it is considered sustainable to reuse existing buildings, how healthy is it to re-occupy deep space buildings that are designed with a multitude of interior rooms with no access to views, light and air? Because a home is made of straw bale in a humid climate does not guarantee that a person with allergies or asthma can live in it. This is *not* to say sustainable practices and ASHRAE guidelines have

ignored health concerns, but it appears that basic human biological needs are secondary to efficient energy usage.

If a new energy crisis emerges, new regulations are inevitable. If again, energy standards are too narrowly focused, then history may repeat itself in the form of unhealthy building design. From a biological point of view, recent light, air and view research suggests that the rules of thumb and tools of sustainable design be re-examined to include more basic human needs. Through this re-assessment, perhaps a more balanced vision of sustainability can emerge.

NOTES

[1]Peter Senge, *The Fifth Discipline.* (New York, Doubleday 1990)

[2]*ASHRAE Hand book. 1977 Fundamentals.* (Atlanta, ASHRAE 1977)

[3]*ASHRAE Handbook. 1982 Fundamentals.* (Atlanta, ASHRAE 1982)

[4]*ASHRAE Handbook. 1989 Fundamentals.* (Atlanta, ASHRAE 1989)

[5]Norman Rosenthal, *Seasons of the Mind.* (New York, Bantam, 1989)

[6]Lisa Heschong, "Daylighting In Schools: An Investigation into the Relationship between Daylighting and Human Performance. (Condensed Report submitted to the Pacific Gas and Electric Company, 1999)

[7]R. Kuller and C. Lindstern, "Health and Behavior of Children in Classrooms with and without Windows," *Journal of Environmental Psychology* 12, (1992) pp 305-317

[8]F. Holwich and B. Dieckhues, "The Effect of Natural and Artificial Light via the Eye on the Hormonal Metabolic Balance of Animal and Man," *Ophthalmologica* 180, No. 4 pp188-197

[9]Michael Holick, "The Role of Sunlight in Providing Vitamin D for Bone Health," in M. Holick and E. Jung's *Biologic Effects of Light 96.* (New York, Walter D. Gruyter and Co, 1997)

[10]Michael Holick, "Historical and New Perspectives in M. Holick and E. Jung (eds) *The Biologic Effects of Light 98.* (Norwell Mass, Kluwer Academic Publishers, 1999)

[11]Roger Ulrich, "View Through a Window May Influence Recovery from Surgery, *Science* 224 (1984) pp 420-21

[12]Michael Holick, "The Biological Effects of Light, Historical and New Perspectives" in M. Holick and E. Jung (eds) *The Biologic Effects of Light 98.* (Norwell Mass, Kluwer Academic Publishers, 1999)

[13]James Ross, "The Impact of the 19th Century Public Health Movement on American Architecture." (Unpublished paper delivered at the 1995 Annual Meeting of the S Society of Architectural Historians, Seattle)

[14]F.L. Wright, *The Natural House.* (New York, Horizon Press, 1954) Wright scorned the unhealthful qualities of basements due to lack of fresh air and light. Irving Gill,

"New Ideas About Concrete Floors" *Sunset Magazine* December (1915) Gill wrote about the sanitizing qualities of his concrete floors. R. M. Schindler, "Care of the Body" *Los Angeles Times* March 14 and April 11, (1926) Schindler wrote in place of Dr. Lovell on air quality issues. Richard Neutra, *Survival Through Design.* (New York, Oxford Press, 1954). Neutra wrote on various health related design issues. Alvar Aalto's Pamio Sanitarium included design features that allowed beds and easy therapeutic access to outdoor sun, air and views of nature. Aalto also designed splash minimizing sinks and chairs that allowed for patients to sit at such an angle as to make breathing easier.

[15]C. Moore, G. Allen and D. Lyndon. *The Place of Houses.* (New York, Holt, Rinehart and Winston, 1974) p. 71

[16]Victor Olgyay, *Design With Climate* (Princeton, NJ. Princeton Univ. Press, 1973) pp. 88-89

[17]S. Giedion, *Mechanization Takes Command.* (New York, Norton 1948)

[18]Marni Barnes and Clare Cooper-Markus, "Research Report Applying the Therapeutic Benefits of Gardens" *Journal of Healthcare Design.* (Vol. VIII, 1996)

[19]*ASHRAE Handbook 1982 Applications,* (Atlanta, ASHRAE) p. 6.3

[20]Roger Ulrich, "View Through a Window May Influence Recovery From Surgery"

[21]Hans Selye, *The Stress of Life.* (New York, McGraw Hill. 1956)

[22]Lisa Heschong, "Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance," (Report submitted to: The Pacific Gas and Electric Company, August 20 1999) p. 2

[23]Daniel Kripke, "The Uses of Bright Light in an Office Practice" in S. Poceta and M. Mitler (eds) *Sleep Disorders: Diagnosis and Treatment.* (Totowa, NJ, Humana Press. 1998)

[24]R. Parsons, "The Potential Influences of Environmental Perception on Human Health

Journal of Environmental Psychology. 11 (1991) pp 1-23

[25]N. Rosenthal, D. Sack, J Gillin, et al: "Seasonal Affective Disorder: A Description of the Syndrome and Preliminary Findings with Light Treatment," *Arch Gen Psychiatry 41* (1984) pp 72-80

[26]Fredric Goodwin and Kay Redfield Jamison, *Manic Depressive Illness* (New York, Oxford Univ. Press, 1990) Reports that depression studies have shown that one of the immune systems regulation devices, Prostaglandin, is shown to be elevated in depressed patients. T. Kronfolz and W. Nascallah, "Leukocyte Regulation in Depression and Schizophrenia." *Psychiatry Res 13:* (1984), pp. 13-18 Research finds that depressed patients have less circulating lymphocytes. Delist e al., A. King and S. Targum, "Serum Immunoglobulin Concentration in Patients Admitted to an Acute Psychiatric In-Patient Service." *British Journal of Psych. 145* 1984) pp 661-665 Research finds that the level of immunoglobulins are lower in those suffering from depression than in normal people.

[27]N. Okudaira and D. Kripke. "Naturalistic Studies of Human Light Exposure" *American Journal of Physiology 245:* R613-R615

[28]Michael Norden, *Beyond Prozac. Brain-Toxic Lifestyles. Natural Antidotes and New Generation Antidepressants.* (New York, Regan Books,1996)

[29]John Ott, *Light and Health.* (Old Greenwich, Conn. Devin-Adir Co. 1973)

[30]S. Krakov, "Color Vision and the Automatic Nervous System." *Journal of the Optical Society of America.* June (1942)

[31]H. Woolfarth, "Psychological Evaluation of Experiment to Assert the Effects of Color Stimuli Upon the Automatic Nervous System," *Exerpta Medica Neurology and Psychiatry 2* no. 4 (1958)

[32]R. Reiter. "Action Spectra Dose Response Relationships and Temporal Aspects of Light's Effects on The Pineal Gland." *Annals of the New York Academy of Science 453.* (1985) pp. 215-230

[33]Benjamin Stein and John Reynolds, *Mechanical and Electrical Equipment for Buildings* (New York, John Wiley and Sons, 2000)

[34]Full-spectrum light deprivation (in particular UVB light deprivation) and its detrimental effects on breast, ovarian, prostate and colon cancer can be found in medical journals as early as 1980 in the *International Journal of Epidemiology.* Similar studies have appeared consistently through the 90's in journals such as *Cancer Research. Lancet* and *Cancer Causes and Control.*

[35]Michael Holick, *The Biologic Effects of Light 98*

[36]Michael Holick, *The Biologic Effects of Light 95*

[37]F. Holwich and B. Dieckhues, "The Effect of Natural and Artificial Light via the Eye on the Hormonal Metabolic Balance of Animal and Man." *Ophthalmologica 180* No. 4, (1980) pp. 188 – 197

[38]R. Scragg, *Int. Journal of Epidemiology 10* pp. 337-341

[39]C. Garland, G. Comstock, F. Garland, K. Helsing, E. Shaw and E. Gorham. "Serum 25-Dihydroxyvitamin D and Colin Cancer: Eight Year Prospective Study." *Lancet* (1989) pp. 1176-1178

[40]J. Waterhouse, C. Muir and P. Shanmugarantnam: "Cancer Incidence in Five Continents" Vol. IV IARC Sci Publ. Lyon (1982) Follow-up studies tracked immigrants who moved from lower to higher latitudes and visa versa and found the subjects appeared to take-on the risks associated with the new location.

[41]Dr. Cynthia Jumper and the author have taken part in three, day long indoor air quality roundtable discussions between 1997 and 1999 at the Texas Tech Health Science Center where Dr. Jumper has given the results of her asthma research and her views on Building Related Illnesses.

[42]David Strauss, J. Danny Cooley, Wing C. Wong and Cynthia A Jumper "Correlation Between the Prevalence of Certain Fungi and Sick Building Syndrome" *Occupational Environmental Medicine 55* (1998) pp. 579-584

[43]F. Garland, M. White and E. D. Gorman. *Arch Environmental Health 45.* (1990), pp 261- 267 Melanoma and other skin cancers have been linked with UV B light, but this research has shown that those whose jobs that take place mostly inside can have a higher risk of skin cancers than those whose jobs that are outside.

[44]M. Braun and M. Tucker, "Do Photoproducts of Vitamin D Play a Role in the Etiology of Cutaneious Melanoma," In M. Holick and E. Jung (eds) *Biologic Effects of Light 95*