County of Los Angeles
CHIEF EXECUTIVE OFFICE
713 KENNETH HAHN HALL OF ADMINISTRATION
LOS ANGELES, CALIFORNIA 90012
(213) 974-1101
http://ceo.lacounty.gov

WILLIAM T FUJIOKA
Chief Executive Officer

Board of Supervisors
GLORIA MOLINA
First District

YVONNE B. BURKE
Second District

ZEV YAROSLAVSKY
Third District

DON KNABE
Fourth District

MICHAEL D. ANTONOVICH
Fifth District

May 19, 2008

To: Supervisor Yvonne B. Burke, Chair
Supervisor Gloria Molina
Supervisor Zev Yaroslavsky
Supervisor Don Knabe
Supervisor Michael D. Antonovich

From: William T Fujioka
Chief Executive Officer

REPORT TO THE BOARD ON THE FEASIBILITY OF ESTABLISHING A "HEALTHY BUILDING AND ENERGY SAVINGS CERTIFICATE" OR OTHER BUILDING BENCHMARK IN EXISTING COMMERCIAL AND RESIDENTIAL BUILDINGS

On October 23, 2007, your Board directed the Chief Executive Office (CEO) and County Counsel, working in concert with the Energy & Environmental Policy Team (Team) to determine the feasibility and need for establishing a "Healthy Building and Energy Savings Certificate" or other building benchmark based on a model developed in 2007 under the United Kingdom's Energy Efficiency Action Plan (U.K. Plan).

The requested feasibility report was also to address: descriptions of specific implementation elements of the proposed program, an assessment of the long-term health impacts, a plan to work with industry participants to maximize effectiveness and scope, any recommendations for legislative advocacy, and investigation of possible financial incentives.

This report provides background information on the feasibility of home energy performance certification and commercial building benchmarking and specific recommendations for County actions. Attachment A includes a more detailed description of the U.K. Plan and other local building energy performance programs. A report by the Department of Public Health on the Green Buildings and Public Health is included as Attachment B.

Background on Building Energy Performance Programs

A Countywide program to establish a "Healthy Building and Energy Savings Certificate," or equivalent, is feasible based on the U.K. Plan and on the results of other pilot programs implemented elsewhere in California. However, it is recommended at this time that the County work in conjunction with the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) in developing any type of pilot program to ensure it is consistent with the goals of Statewide programs for existing residential performance certification and existing commercial building benchmarking that are currently being implemented.

The CEC and the CPUC programs to develop residential energy performance certificates and commercial building benchmarks are similar to the U.K. Plan for existing, residential and commercial buildings and meet the objectives of the U.K. Plan's Energy Performance Certificates. The State programs being implemented are: the Residential Time-of-Sale Information Disclosure Program for existing residential buildings and the Commercial Building Benchmarking Program for existing commercial buildings.

Residential Time-of-Sale Information Disclosure Program Summary

The State's Residential Time-of-Sale Information Disclosure Program is, for now, an optional program that has been available to homeowners for several years. The Program's services that have already been developed are described below:

- A Home Energy Rating Service (HERS) evaluation protocol;
- A Certification Program managed by the State which qualifies private companies to conduct the HERS evaluations;
- A Certifier Training Program which helps private companies become HERS Certified evaluators;
- An online directory of Certified HERS providers;
- Marketing materials which provide information about HERS, HERS Certification, HERS Training to both homeowners and private companies;

- Education materials which provide information about Energy Efficient Mortgages (EEMs), utility incentives, and savings benefits of improving home energy efficiency (EEMs are Federally sponsored home financing programs that allow lenders to provide additional funds to recognize savings from energy efficiency measures; they can be applied to conventional and "Jumbo" financing or for FHA, VA, Fannie Mae, Freddie Mac, and other loans).

These are valuable and worthwhile programs and should be utilized under any County pilot or other County action. The Residential Time-of-Sale Information Disclosure Program strategy includes a scope and timeline for developing additional local pilot programs and working with industry constituents to investigate mandatory certification and mandatory implementation of home energy efficiency measures. All of the program's details are described in Attachment A (Other Energy Performance Program Details). The County's Green Building Team should work with the CEC to assist in further developing the program strategy and in developing a potential Los Angeles County pilot program.

Commercial Building Benchmarking Program Summary

The CEC has similarly developed a strategy to benchmark the energy performance of existing commercial buildings. The strategy includes development of a automated tool to provide information to building owners so they may compare their energy performance against similar buildings. The strategy has resulted in adoption of legislation which requires commercial building owners to obtain energy benchmarking information at certain ownership milestones. AB 1103, which was signed into law in November of 2007, implements the CEC strategy by requiring the State's utilities to provide an online tool which allows commercial building owners to automatically benchmark their buildings by comparing their energy usage information against other buildings from a central database. This automated tool is to be available by January of 2009. Under the law, by January of 2010 commercial building owners are to provide this benchmarking information to prospective buyers or tenants. The next step in the CED strategy is to investigate legislation for program improvements and possible mandatory building upgrades.

The benchmarking tool to be used is the U.S. Department of Energy's Energy Star Portfolio Manager (Energy Star). Energy Star uses building information (e.g., size, occupancy, climate zone, annual energy consumption, building use) and provides a building owner with an energy consumption comparison against similar buildings on a per square foot basis.

The County has already utilized the Energy Star program to achieve an Energy Star Certification award for five County courthouses which were recognized as being in the top percentile of benchmarked buildings for energy performance. In support of AB 1103 and the CEC's strategy, the County will develop a program scope and schedule for benchmarking all appropriate County-owned commercial buildings using Energy Star. Under AB 1103, any building that is not used for residential purposes is considered commercial. The County operates in about 4,000 facilities that would be considered commercial so some level of planning is needed to determine the appropriate scope and schedule.

The County, through the Internal Services Department (ISD), is also currently collaborating with the Building Owners and Management Association (BOMA) of Greater Los Angeles to develop an Energy Star Portfolio Manager training program and to promote facility benchmarking as an ongoing best practice for building managers.

CPUC's Energy Efficiency Strategic Plan – Local Government Role for Existing Buildings

The CPUC is working to develop a California Energy Efficiency Strategic Plan (Plan); a preliminary draft of the Plan is complete. The Plan specifically identifies areas where local governments are expected to play a valuable role in helping the State achieve its overall energy efficiency goals:

- Implementing and enforcing Statewide building energy performance ratings for residential and commercial buildings as discussed above;

- Developing model building ordinances for higher building energy efficiency design in new development;

- Providing energy efficiency technical assistance to building developers and owners;

- Promoting greater peer-to-peer exchange between local governments on energy efficiency.

The County's ISD, and other local governments have existing energy efficiency partnership agreements with investor owned utilities to implement energy efficiency projects both in government facilities and for constituents; these current partnerships run through calendar year 2008. ISD will work with its utility partners (Southern California Edison and Southern California Gas Company) to include development of existing building energy performance rating programs in the current partnership. ISD anticipates continuing its utility partnership through the next program cycle – 2009

through 2011. To date, the utilities and the CPUC have not made it clear that utility partnerships can include resources to assist local governments in implementing more stringent building codes and standards or other regional building programs. The County and other local governments will continue to work with the CPUC and the utilities so that greater building energy efficiencies in these areas can be achieved through the partnerships.

Reference Documents

Attachment A (Other Energy Performance Program Details) provides further information about the Residential Time-of-Sale Information Disclosure Program and the Commercial Building Benchmarking Program. The State's timeline and implementation plan for these programs serve as an action plan for County involvement and support and allows for coordination and development of any County pilot program in coordination with the CEC and the CPUC. Attachment A also includes a description of the U.K. Plan Energy Performance Certificates and other local government building performance rating pilot programs.

The CEC December 2005 Report, "Options for Energy Efficiency in Existing Buildings" (57 pages) can be found at:

http://www.energy.ca.gov/2005publications/CEC-400-2005-039-CMF.PDF

The CPUC's January 2008 Draft Report, "California Energy Efficiency Strategic Plan" (130 pages) can be found at:

http://www.californiaenergyefficiency.com/docs/IOU%20Supplemented%20Draft%20EE%20Strategic%20Plan%203.06.08.pdf

The Department of Public Health's report, "Green Buildings and Public Health" is included as Attachment B.

Recommendations

It is recommended that:

- The County Green Building Team (with representatives from Regional Planning, Public Works' Building and Safety, and ISD Energy Management Division) should coordinate development and implementation of a Countywide pilot program, or other County activity, with the CEC's Residential Time-of-Sale Information Disclosure Program.

- Specific implementation elements of a County pilot should include:

  - Enhancing the education, marketing, and outreach of voluntary services already developed by the CEC;

  - Utilizing the State's existing Home Energy Rating Service, Rating Certification Program, and Certifier Training Program to enhance voluntary home energy certification and under a County pilot program that may be implemented in collaboration with the CEC and CPUC;

  - Working with the County's local utilities and the CPUC to develop enhanced incentive and rebate programs as part of a County pilot program under the County's proposed utility partnership for 2009-2011;

  - Developing an outreach program to increase the utilization of Energy Efficient Mortgages which already exist to finance energy efficiency measures, but are not well known;

  - Utilizing the Strategic Development Group already assembled by the CEC consisting of the Department of Real EState (DRE), California Association of Realtors (CAR), utilities, California Real EState Inspection Association (CREIA), Office of Real EState Appraisers (OREA), and others to discuss the feasibility of a local, mandatory home energy performance rating certification.

- The Green Building Team should participate in the development of legislation or building code changes, as coordinated by the CEC, which seek to enhance the Residential Time-of-Sale Information Disclosure and Commercial Building Benchmarking Programs Statewide.

- The CEO should develop a legislative policy which will guide the County's advocacy on a variety of other "green building" bills which will be considered by the legislature in current and future legislative sessions.

- ISD's Energy Management Division should develop a program and schedule to benchmark the County's commercial facilities using the Energy Star Portfolio Manager and report back to the Board in the next Energy & Environmental Policy Team update report due around August of 2008.

Progress on these recommendations shall be reported back to the Board as a part of the regular, comprehensive report to the Board on the status of all energy and environmental related programs ongoing within the County. If you have any questions, please contact Howard Choy of ISD at (323) 881-3939.

WTF:LS
HWC:os

Attachments (2)

c: Executive Officer, Board of Supervisors
County Counsel
All Department Heads **[Via Electronic Mail]**

OTHER ENERGY PERFORMANCE PROGRAM DETAILS

Feasibility and Need

The viability of an energy performance certificate program for the State and the County is feasible as shown by the implementation of the United Kingdom Energy Efficiency Action Plan (U.K. Plan), local pilot programs and work conducted by California regulatory agencies. In the U.K. the requirement for energy performance certificates is already implemented for new and existing, residential and commercial buildings and is a key element of meeting a national energy efficiency goal. The State of California is developing programs similar to the U.K. Plan which includes the development of energy performance certificates for existing buildings.

U.K. Plan Description

The United Kingdom's 2007 U.K. Plan was created as a result of the European Union's (EU) Policy developed in response to the Kyoto Protocol and the fact that nearly half the carbon emissions in the EU are from buildings. The EU Policy was adopted in January 2003 and included an Energy Performance of Buildings Directive which had two primary goals: improve the energy performance of buildings in the EU through cost-effective measures; and bring the building energy standards throughout the EU towards those of member States that already adopted building performance goals.

The EU Policy required members, by January 2006, to set minimum energy performance standards for new and retrofit work, in both commercial and residential buildings. There is provision for a three-year implementation extension. For almost all buildings, the building owner must provide a prospective buyer or tenant with an energy performance rating, or energy certificate. The rating or certificate may include an indication of how much carbon dioxide (CO2) the building generates. The rating or certificate also must include recommendations for energy efficient building improvements, although there is not a legal obligation for the purchaser or tenant to carry out the recommendations.

In response to the EU Policy, the UK developed its energy rating program in the 2007 Energy Action Plan. The U.K. Plan establishes a package of policies and measures to deliver improvements in energy efficiency to meet national climate and energy policy objectives and to double a 9 percent national energy savings target by 2016 established under the EU Policy.

The U.K. Plan includes programs to lower energy consumption in the households (residential), business and public, and transport sectors through increases in energy efficiency technology and through changes in consumer behavior.

A specific measure to assist building owners and tenants includes a requirement for Energy Performance Certificates (EPCs) which provide information on the energy efficiency of homes and businesses and indicate how to improve energy efficiency. EPCs provide an energy rating - "A" (best) through "G" (worse) for buildings and must be presented whenever buildings are constructed, sold, or rented. EPCs are required when homes and buildings are constructed, sold, or rented out. The requirement to produce an EPC at time of home construction, sale, or rent will be phased in between mid-2007 and early 2009.

In the U.K., the EPCs also include an environmental impact rating from "A" through "G". This environmental impact rating measures the building's impact on the environment in terms of CO2 emissions. In the U.K., outside parties perform the energy rating, and there are many companies that offer this service.

California's Energy Efficiency Plan for Existing Buildings

In California, the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) recognize that substantial opportunities remain to cost effectively improve the efficiency of existing buildings, particularly in existing, older homes and commercial buildings, and especially those built before 1982 when specific building codes targeting energy efficiency were first adopted.

About three-quarters of California's homes and apartments (more than 8 million residences) were built prior to these 1982 building standards. Although many have since been upgraded through existing energy efficiency programs and through progressive code requirements, the State concludes that considerable, untapped energy savings potential remains. In addition, half of the square footage of commercial buildings in California was built prior to 1982 and similar, untapped energy savings exist.

The CEC has prepared a collaborative action plan, similar to the U.K. Plan, which seeks to increase energy efficiency in all building sectors through a combination of enhanced technologies, stricter building codes, increased consumer education, and awareness, and a program of financial incentives. This Plan also includes development and implementation of residential and commercial building energy performance ratings or benchmarks through two programs described below: the Residential Time-of-Sale Information Disclosure Program and the Commercial Building Benchmarking Program.

California's Recommendations for Residential and Commercial Buildings

The CEC's December 2005 Commission Report: Options for Energy Efficiency in Existing Buildings (CEC Report), includes a recommendation that by 2010, the State should begin requiring the disclosure of home energy efficiency ratings and suggested improvements when a house is sold. The Residential Time-of-Sale Information Disclosure Program for existing residential buildings is being developed to accomplish this. The CEC has been working with the real estate and home building industries to develop a standard rating system, a directory of energy efficiency information materials, and training programs for private certifiers. The CEC's goal is to seek passage of legislation requiring all homes to be rated at time of sale or implement the requirement in building codes sometime in the 2010 timeframe.

The CEC Report also recommends that the State establish a California-specific benchmarking requirement for all commercial buildings at the time a building is financed or refinanced. The Commercial Building Benchmarking Program will automatically provide energy consumption information in a form that commercial building owners and operators can use to compare their building's performance to similar buildings. In December of 2007, AB 1103 was signed into law which requires the utilities to maintain building utility information and provide a tool to building owners so that the benchmark analysis can be performed at the owner's request. This tool is to be available by January of 2009. The benchmarking tool to be used, per AB 1103, is the Energy Star Portfolio Manager (Energy Star). Building owners will be required to provide Energy Star benchmark information to prospective buyers or tenants. The CEC, utilities and others are currently working to develop the detailed mechanism of automating this tool, as well as promoting and marketing the benefits and use of commercial building benchmarking.

Residential Time-of-Sale Information Disclosure Program

The action plan for the CEC's proposed Residential Time-of-Sale Information Disclosure Program is described below. It is recommended the County coordinate with the agencies below, as well as other regional entities in considering how to support the program, develop a modified local program, or provide some other role.

- Department of Real Estate (DRE), CEC, California Association of Realtors (CAR), utilities, California Real Estate Inspection Association (CREIA), Office of Real Estate Appraisers (OREA), and others from a Strategic Development Group (completed).

- Utilities provide and administer pilot programs during 2006-08 (completed).

- The CEC completes a proceeding to adopt regulations establishing Home Energy Rating Service (HERS) for homes and develops a booklet describing the rating system (completed).

- CAR, HERS providers, DRE, CREIA, OREA conduct training. (Ongoing through 2008-09)

- CEC, HERS providers, DRE, CEC, CREIA, OREA design and conduct further Pilot Programs (planned for 2008-09; the CEC is convening a task force to re-address this).

- CEC assesses the Pilot Program(s) and delivers a report to the Legislature (2009).

- CEC, CAR, utilities, CREIA, OREA design and launch a Phase I mandatory program (implemented by code or legislation) for homes built prior to 1982 (2010).

- CEC, CAR, utilities, CREIA, OREA design and launch a Phase II mandatory program (implemented by code or legislation) for all homes (2011).

The Residential Time-of-Sale Information Disclosure Program only covers the rating of a residence. It would still be the buyer's decision to pursue upgrades. The CEC anticipates that legislation or building code changes will be developed sometime after 2009 proposing that certain upgrades to homes be required after the home rating. The County should participate in the development of any legislation or Building Code change.

The current voluntary program administered CEC does not provide incentives or rebates for the rating. Raters are trained to provide information about existing utility rebates and incentives that apply for the upgrades. A potential County pilot program may include incentives for the rating; discussions with the utilities will be necessary. Data from the CEC Report indicates that the home inspections under this program costs, on average, about $70 per home.

Training materials already developed by the Department of Real Estate, CEC, real estate industry and others are readily available from the CEC's website (www.energy.ca.gov) and from the California Professional Builders and Contractors Association website (www.cpbca.org). They are currently being used throughout the State under existing programs which provide optional home energy ratings. They are adequate for use in a County pilot.

HERS provides an appropriate level of information and is already incorporated into the State's program. HERS establishes several categories in which a building is evaluated: space heating, space cooling, and water heating. Under HERS, each home is rated on scale of 0 to 100. The individuals that perform the rating must be certified. There are several organizations that certify HERS raters, including California Home Energy Efficiency Rating Services (CHEERS), the Residential Energy Services Network (RESNET, a national organization), the California Certified Energy Rating & Testing Services (CalCERTS), and California Building Performance Contractors Association (CBPCA). Other groups such as Build It Green and the U.S. Green Building Council have developed their own building rating systems and provide similar training and certification. Build It Green has developed a Green Point Rated system, while the U.S. Green Building Council has recently introduced a Leadership in Energy and Environmental Design program for homes. The Green Building Team will further investigate the pros and cons of each rating system.

Commercial Building Benchmarking Program

The CEC's action plan for commercial building benchmarking is described below. As indicated earlier, AB 1103 requires the utilities to develop the automated benchmarking tool and make building consumption information available for the benchmarking at the owners initiation. Building owners will be required to provide this information to prospective buyers or tenants.

- CEC, Department of Energy (DOE), Environmental Protection Agency (EPA) form an expert panel to guide program development and direction (completed).

- CEC, Building Owners Management Association (BOMA), International Facilities Management Association (IFMA), and the Real Estate Leadership Industry Council (RELIC) work with industry to promote benchmarking as an industry best practice (completed).

- CEC and Flex Your Power design and market a benchmarking outreach and education program (ongoing in 2008).

- CPUC and CEC require utilities to develop benchmarking referral and marketing programs (ongoing in 2008).

- Utilities to develop automated benchmarking tools (ongoing 2008).

- Legislature to require benchmarking of all commercial building during financing and refinancing (accomplished under AB1103).

- Private firm to evaluate program and modify as needed (2010)

AB 1103 requires the utilities to develop an automated program which building owners may access to determine the energy performance of their building compared to similar buildings using the Energy Star Portfolio Manager database and protocol. This benchmark procedure is required to be available to all commercial building owners in the State by January of 2009. Beginning January of 2010, all building owners will be required to provide the building benchmarking information to prospective buyers or tenants.

The utilities are developing the automated interface between the owner and the Energy Star Portfolio Manager Tool and database. In order to develop the benchmark, Energy Star requires utility bill information (for 12 months) and information about the building (e.g., location, type of use, square footage, occupancy, etc.).

Energy Star Portfolio Manager will provide the owner with a rating comparing the energy performance of the building to other buildings in the State and other buildings in the same classification.

The U.K. Plan requires all public buildings to be certified, or benchmarked, before 2009 and the certification shall be highlighted within the building. The County should similarly move to benchmark its facilities and encourage other public building owners to do the same within an agreed upon schedule.

Other Building Energy Rating Programs in California

In the U.S., a few cities have adopted energy performance certificate programs. In California, these include Berkeley and San Francisco. While there are not many mandatory requirements for rating the energy performance of buildings, most rating systems in California are used on a voluntary basis. Because home energy ratings are not mandatory statewide, there are no requirements for the entity that conducts the study to take any particular action. One of the requirements under a mandatory program would be to require that energy efficiency upgrades be completed after a home is rated. There is grassroots interest among trade groups, policy makers, and staff from more sustainably oriented jurisdictions to develop statewide and/or national energy rating programs.

An option for a government entity that establishes an energy rating program ordinance would be to provide the verification through its staff. One example might be to add this responsibility to a building inspection department. Very few of the jurisdictions in Europe or the U.S. have opted to provide in-house rating services. Most appear to prefer the third-party verification process. In California this is because the CEC has already developed the rating service, rating certification program, and certifier training program.

An ancillary goal for some of the energy rating organizations is to help property owners find lenders for energy mortgages. These mortgages roll the cost of energy efficiency upgrades to an existing home or energy efficient features in a newly built home into the mortgage. In the case of upgrades, the energy savings help finance the mortgage payments. Many lenders provide energy efficient mortgages, but they are not well publicized or utilized.

Mandatory Energy Rating Programs in California

In California, the cities of Berkeley and San Francisco have adopted residential energy conservation ordinances ("RECOs"). All the RECOs require that an energy rating be performed by a certified evaluator when a building is being sold or remodeled. The building inspection division is responsible for ensuring that the RECO requirements have been met.

The Berkeley program evaluates the home's:

- wiring,
- toilets,
- showerheads,
- faucets,
- water heaters,
- hot and cold water piping,
- weather stripping,
- furnace duct work,
- fireplace chimneys,
- attic insulation, and
- common area lighting (in multi-unit buildings).

The Berkeley program establishes limits on the amount that a property must spend in order to comply with the ordinance. Residents also can hire their own contractor. In either case, the building is inspected by the City before it is deemed compliant.

Because San Francisco has a high percentage of multi-family units, its ordinance applies to those buildings as well, including residential hotels. Whether a building must comply when it is being remodeled, as opposed to sold, depends on the value of the improvements being made. The San Francisco program looks at:

- attic insulation,
- weather stripping,
- water heaters,
- showerheads,

- openings in building exterior,
- heating and cooling ducts,
- faucets,
- toilets.

In apartment buildings, the San Francisco RECO also looks at boilers and furnaces, and steam and hot water pipes and tanks, in addition to the requirements for single family homes. San Francisco establishes maximum amounts that a building owner must spend to be deemed "compliant" with the RECO ordinance.

Green Buildings and Public Health

Prepared By: Los Angeles County Department of Public Health
Toxics Epidemiology Program

March 13, 2008

EXECUTIVE SUMMARY

Los Angeles County would benefit from positive health impacts of a comprehensive Green Building program, in which design, construction, and maintanence focus upon sustainable development, environmental stewardship, and the public's health. Green buildings improve energy and water efficiency; reduce municipal waste; conserve natural resources; reduce indoor air pollutants; and improve occupant productivity, comfort, and health. Cost-benefit analyses suggest that green buildings increase worker productivity by an estimated 1.0-1.5%, translating into a cost savings of nearly $1000 per employee per year among those working in the State of California government system.

Green buildings use an average of 35% less energy than conventional buildings, thus significantly reducing air pollutants, acid rain production, and climate-changing emissions. Green buildings also incorporate cool roofs and vegetation to mitigate the urban 'heat-island effect,' further reducing peak energy demand and the formation of smog.

Energy-efficient lighting and enhanced daylighting not only conserve energy and money, but also improve worker productivity by reducing eye strain, enhancing safety, and improving emotional well-being and cognitive function. Green buildings conserve water with water-saving devices and Low Impact Development (LID). LID reduces storm water runoff and encourages shade-providing trees near buildings to sequester water evaporation, prevent soil erosion, capture air pollutants, and reduce air-cooling energy demands by up to 25%.

Green buildings generally have "tighter" physical construction for improved energy efficiency, allowing fewer air leaks, and potentially preventing indoor air pollutants from escaping. Air quality in green buildings is optimized through high-performance ventilation and moisture control, use of building materials and cleaning products with minimal emissions, and integrative pest management practices, resulting in significantly fewer health complaints among occupants. Green buildings also divert at least 50% of building waste from landfills through solid waste management and promotion of recycling. County purchasing of 'Energy-Star' electronic equipment reduces so-called "e-waste", which accounts for 70% of toxic waste in municipal landfills.

Green buildings promote smart growth principles that support compact development, reduce urban sprawl, stimulate growth around urban centers, encourage transit-oriented, walkable, bicycle-friendly land use, reduce reliance on cars, and increase pedestrian and mass transit use. These measures reduce traffic accidents and vehicular injuries, increase physical activity, reduce obesity, and lower rates of high blood pressure.

The initial cost of green building construction or renovation may be offset by increased worker productivity and improved health as well as the financial gain from lower energy and water usage, reduced waste, reduced environmental emissions, and decreased maintenance and operational costs.

Green Buildings and Public Health

The built environment can have a significant impact on human health. The buildings where we live, work and play are also where we spend 90% of our time.[1] Few standards exist regarding construction, renovation, or operation of commercial buildings to maintain optimal health for the occupants and the environment. Historically public health departments have not generally been involved in decisions on building design, use of materials, or construction methods. Instead, public health departments have typically played a more reactionary role, investigating workplace-associated health complaints. However, the public's health can be better served by incorporating preventive health considerations into building practices and all aspects of the built environment. For example, the high costs of lead paint abatement, urea-formaldehyde insulation replacement, and asbestos removal show that these materials cost more to remedy than is suggested by their initial savings, and may cost the public unrecoupable health damages.

Green buildings minimize negative impacts of the built environment on human health and the natural environment; improve energy and water efficiency; reduce municipal waste; conserve natural resources; reduce indoor air pollutants; and improve occupant productivity, comfort, and health. Although the scientific literature is limited on the long-term health benefits of green buildings, there is good evidence of short-term benefits. Los Angeles County and its residents stand to benefit from the positive economic, social, and health impacts of a comprehensive green building program – where design, construction, and maintanence center around sustainable development, environmental stewardship, and the public's health.

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system is the national standard for green buildings. The Los Angeles County Board of Supervisors has proposed 53 projects for its sustainable design program and 20 new County buildings to be at least LEED-Silver certified. A LEED Existing Building (EB) certification program is also being considered, as well as a Green Building Program requiring LEED or Low Impact Development (LID) certification for private development in the unincorporated County areas.

The cost benefits of green buildings in California is estimated to be a 1% increase in productivity per employee per year for LEED Certified or Silver levels and a 1.5% increase for LEED Gold and Platinum levels.[2] These percentages translate into large health and productivity gains for employees. An increase in productivity of 1-1.5% equates to a cost savings of $600- $1,000 per employee per year among employees working in the State of California's government system.

Positive Human Health Benefits of Green Buildings

Energy Efficiency

The County has set the goal of a 20% reduction in energy and water usage in its facilities by 2015, via energy-efficient retrofits and retrocommissioning. Green buildings use an average of 35% less energy than conventional buildings, and can thus help achieve the County's goal.[3]

Energy-efficient buildings may also directly improve the public's health. Occupants of certified, energy-efficient homes report significantly improved health during the first year, and fewer

symptoms of throat irritation, cough, fatigue, and irritability compared to occupants of similarly priced, non-certified homes built in the same year and location.[4]

Green buildings reduce important environmental emissions. Commercial and residential buildings consume 72% of the nation's electricity and generate more greenhouse gas emissions than transportation or industry.[5] Addressing greenhouse gas emissions will align with state goals and legislation such as the California state Assembly Bill 32 (AB32) which targets the reduction of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NOx), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.[6] Los Angeles County also aims to reduce local greenhouse gas emissions to 80% of current levels by 2050 as a member of the National Cool Counties Initiative.

Buildings generate 39% of the U.S's total CO_2 emissions,[7] 52% of SO_2 emissions, 19% of NOx emissions, 12% of $PM_{2.5}$, 5% of VOCs, 4% of PM_{10}, and 3% of CO emisions.[8] Table 1 lists notable air pollutants, their main contributing sources, and the known health effects. NOx and VOCs react in the presence of sunlight to form ozone, the main component of smog. Ground-level ozone leads to short-term health effects such as difficulty breathing, shortness of breath, coughing, and irritation of the eyes, nose and throat; aggravates heart disease,[9,10] bronchitis,[11] emphysema, asthma, and other respiratory diseases; and contributes to new cases of childhood asthma.[12] Southern California children living in regions with higher levels of NOx and PM have decreased lung function, decreased lung growth, and increased respiratory symptoms.[13,14,15] Air pollution is also associated with increased emergency room and hospital visits, student and worker absences,[16] preterm birth,[17,18] and premature death.[19,20]

Los Angeles County ranks as having the worst air quality in the nation, consistently exceeding state and federal air quality standards for ozone and particulate.[21] According to the California Air Resources Board (CARB), the annual health impact of exceeding state standards for ozone and particulate matter are 8,800 premature deaths, 8,200 hospitalizations for respiratory disease, 3,000 hospitalizations for cardiovascular disease, 340,000 asthma attacks, 800,000 cases of respiratory illness in children, 500,000 cases of adult respiratory illness in adults, 4.7 million school absences, and 2.8 million lost workdays across the state or in LA County?.[22]

Energy reduction not only decreases smog-related pollutants, but also curtails SO_2, NOx, and CO_2 emissions, which contribute to acid rain and climate change.[23, 24] Acid rain affects human health indirectly by damaging agricultural crops, acidifying lakes and streams so that fish cannot survive in them, and disrupting soil ecosystems. Reducing emissions from SO_2, NOx, and CO_2 would lead to fewer cases of respiratory disease, cardiovascular disease, and premature death.[25]

Los Angeles County may additionally lower its building energy needs by addressing the urban 'heat-island effect.' The heat-island effect increases the demand for cooling energy and accelerates the formation of smog. Green buildings that incorporate highly-reflective materials such as cool roofs, and replace paved surfaces with shade trees and vegetation, can mitigate this effect.[26,27]

Table 1. Toxic Air Pollutants in Los Angeles County

Pollutants	Source	Health Effects	Environmental Effects
Carbon Monoxide (CO)	Automobile emissions (motor vehicle exhaust), fossil fuel burning	Decrease in blood's ability to transport oxygen to necessary cells, exacerbated cardiovascular diseases, damage to central nervous system, increased mortality	Colorless, odorless gas contributing to air pollution (including greenhouse gases and ozone)
Mercury	Power plants, solid waste incineration, hazardous waste, chlorine production plants	High levels can affect the central nervous system, impairing coordination and causing seizures, brain damage and possibly death.	Contaminates soil, plants, and water. Accumulates in plants and aquatic life, leading to higher levels in animals higher up the food chain
Nitrogen Dioxide (NO_2)	Power plants, oil refineries, automobile emissions	Airway injury, decreased lung function, exacerbation of respiratory illnesses and existing heart disease	Large contributor to ozone smog (smog/pollutant at ground vs. atmospheric level);major element of particulate matter and acid rain
Ozone (O_3)	Automobile emissions, ozone generators, aircraft cabins	Respiratory tract damage, exacerbation of asthma symptoms such as coughing, tightness in chest, inflammation	Damaging to trees and other plants; important contributor to smog
Particulate Matter (PM_{10} and $PM_{2.5}$)	Industrial activity, combustion of fuels, mobile sources	Acute respiratory disease, decreased lung function, increased mortality rate, bronchitis *children at high risk	Particulate matter remains as one of the main sources of pollution; creates large amount of pollution in air
Sulfur Dioxide (SO_2)	Oil refineries, coal or oil burning power plants, wood, coal, and kerosene-burning stoves	Acute bronchoconstrictive effects, increase in airway resistance, chronic airway obstruction, overall reduced lung function *especially effects individuals with asthma	Undergoes chemical reaction once released in atmosphere to form aerosols; mixture of SO_2 and other fossil-fuel combustion products form smog, acidic aerosols, and acid rain
Carbon Dioxide (CO_2)	Coal burning power plants	Indirect health effects associated with climate change including increased heat-related illness, spread of infectious disease, and higher ozone levels in the atmosphere	
Ultra Fine Particulate Matter ($\leq PM_{0..1}$)	Mostly from automobile emissions (motor vehicle diesel vehicles), fossil fuel combustion	Causes oxidative stress, inflammation in the lungs and heart, chronic obstructive lung disease; may have adverse effects on neurological conditions as well	Higher carbon content, larger potential for carrying toxic compounds; create the most reactive oxygen species (leads to oxidative stress)
Volatile Organic Compounds (VOCs)	Burning fuel (gasoline, natural gas, wood, oil), paints, glues, and other household products, motor vehicles	Damage to liver, kidneys, damage to central nervous system; nose, throat, and eye irritation, nausea, headaches, dizziness	Large contributor to smog, harmful to plants; higher concentrations typically found indoors vs. outdoors

Natural Lighting

Energy-efficient lighting improves luminescence, reduces the risk of eye strain, and improves the safety in underlit areas such as stairwells. Incorporation of more natural lighting into a building increases occupant productivity and overall sense of well-being. In one study, the addition of skylights in retail stores led to a 40% increase in sales, reportedly due to customer perception that the store was cleaner and better lit.[28]

Daylighting, views of the outdoors and the visual presence of green vegetation improve emotional well-being and cognitive function.[29] Worker performance in a 100-worker office building in Sacramento, California improved 13% with increased daylighting, and memory recall and mental function increased 10-25% when workers had the best window views versus no views at all.[30] Increased natural daylighting in classrooms, with pleasant window views, significantly improved performance among students as well.[31] Window glare; lack of blinds or curtains to control glare or solar heat gain; and direct sunlight from east or south-facing windows negatively affect performance. Green building strategies that reduce glare and heat from direct sunlight include planting shade-providing trees close to buildings, incorporating external overhangs into building design, and using blinds and solar-control glaze on windows.

Water Stewardship

Buildings consume 12.2% of the total water used in the U.S. each day.[32] The Southern California Association of Governments estimates that most of the region's water is imported, and that only 25-30% of water is derived locally from ground, surface, or reclaimed water sources. [33] Demand for California's limited freshwater supplies may exceed capacity as soon as 2020.[34]

Green buildings minimize water consumption through the use of water-saving appliances, low-flow toilets and shower heads, and recycled or reused materials. Green buildings encourage site development and landscape strategies that conserve water entering the site and prevent untreated waste water from leaving it. In most urban areas, storm waters typically land on impervious surfaces such as paved roads and parking lots, where they entrain surface pollutants and carry them off to nearby waterways. Green site design allows rain water to infiltrate the soil, replenish the depleted groundwater sources, and reduce storm water runoff.

Storm water runoff threatens the water quality in Los Angeles County with pollutants such as pesticides, fertilizers, animal waste, pathogens, trash, fuels, oils, solvents, grease, and heavy metals. Public health advisories and beach closures are often issued to warn the public of contamination from storm runoff. In 2006, 2,072 health advisories were issued for Los Angeles County beaches.[35] Health risks include direct risk to swimmers in waters near storm drains and indirect health risks from contamination of ocean waters, sediments, and aquatic life. [36] This contamination kills fish, damages habitats, and concentrates pollutants in fish intended for human consumption. The EPA considers storm water runoff to be one of the most important sources of contamination of the nation's waters.[37]

Low impact development (LID) may guide the development of new green buildings for LEED certification. LID decreases stormwater runoff, protects wildlife habitat and native vegetation,

prevents soil erosion, minimizes non-porous landscape surfaces, uses less water, energy, and natural resources, avoids toxic chemicals, and prevents air and water pollution. Grey water collection systems and green roofing can conserve water while curtailing polluted waste water runoff.

LID development requires the planting of on-site trees to prevent soil erosion and to sequester water evaporation from the soil and other plants, leading to a reduction in the ambient temperature surrounding a building.[38] Planting large, shade-providing trees near buildings can reduce the energy demand for cooling the building by up to 25%, while improving air.[39] This cooling effect mitigates the urban heat-island effect, and resulting increased demand for air conditioning. Trees improve air quality by capturing CO_2 and other air pollutants such as CO, NOx, ozone, and SO_2. One shade tree planted in Los Angeles can sequester 18,000g of carbon each year, potentially helping to curb climate change as well as local air pollution.[40]

Indoor Air Quality

According to the U.S. Environmental Protection Agency (EPA), the air inside homes and buildings may be 2-5 times more polluted than outdoor air (in extreme cases 100 times more polluted), even in the most industrialized cities. Green buildings promote improved indoor ventilation, minimize moisture, incorporate integrative pest management practices, and use products with minimal emissions.

Building materials and furnishings; cleaning and maintenance products; central heating and cooling systems; and outdoor sources such as radon, pesticides, and outdoor air contaminants contribute to indoor air pollution. Inadequate ventilation and filtration, and higher temperatures and humidity levels worsen indoor air quality. Green buildings generally have "tighter" building construction for improved energy efficiency, allowing fewer air leaks, and potentially preventing indoor air pollutants from escaping. Thus, high-performance ventilation, high efficiency particulate air (HEPA) filters, and materials with fewer emissions are staples of green building design.

Health effects resulting from poor indoor air quality can include headaches, dizziness, fatigue, and eyes, nose, and throat irritation. Long-term health effects are not fully understood; however, some indoor air pollutants are linked to respiratory disease and cancer. Illnesses like Legionnaires' disease, hypersensitivity pneumonitis, and humidifier fever may be caused by a contaminated ventilation system.[41,42,43] Health departments are often called upon to investigate non-specific, building-related complaints known as Sick Building Syndrome (SBS). Non-environmental factors such as job stress play a significant role in SBS; however building factors such as ventilation, cleaning practices, levels of chemical and biological pollution, indoor temperature, and humidity often contribute to the severity of SBS.[44] Just improving ventilation rates and reducing indoor CO_2 concentrations is expected to yield a 70-85% decrease in SBS symptoms.[45]

Building-related triggers most commonly linked to asthma and allergy symptoms, SBS, and respiratory infections are moisture problems, dust mites, molds, animal dander, and cockroach infestation.[46,47,48] Green buildings ensure effective ventilation and proper water drainage to

maintain optimal indoor humidity and use electrostatic filters to reduce dust mites and particle pollution; and may result in fewer complaints among occupants.[49, 50,51]

An intervention study was attempted in a building that received frequent complaints from occupants concerning the indoor air quality.[52] Renovations were made to the heating and ventilation system in one part of a German office building. In a different part of the building, carpet was replaced with low-emission vinyl flooring in addition to ventilation system renovation. Improved ventilation plus low-emission flooring significantly reduced occupants' environmental complaints and health symptoms, and improved performance, compared to improved ventilation alone, with a significant positive effect on the occupants' perception of health. Replacement of carpet with vinyl flooring correlated with a significant reduction of indoor dust particles.

The U.S. Occupational Safety and Health Administration (OSHA) estimates a 3% loss in worker productivity from indoor air quality (not including health care costs); this cost is equivalent or greater than the cost of maintenance and operation of a building.[53] According to the World Health Organization, 30% of new or remodeled buildings worldwide may have unusually high rates of health and comfort complaints related to indoor air quality.[54] The potential yearly savings in the U.S. from reduced medical bills and lost worker productivity from poor indoor air quality is $6-$14 billion from reduced respiratory illness, $1-4 billion from reduced asthma and allergies, $10-$30 billion from reduced Sick Building Syndrome, and $20-$60 billion from improved worker performance.[55]

Environmentally Preferable Building Materials and Specifications

The County Environmentally Preferable Purchasing Policy supports future purchases of environmentally-preferable computers, energy-savings devices for vending machines, and power savings control features for desktop computers.

Building materials considered "green" include products that may contain recycled content, included cradle-to-cradle design, give off low or no emissions, use non-toxic alternatives, or have wood certified sustainably-managed forests. Green cleaning and maintenance supplies attempt to limit potential exposure to certain toxic air pollutants such as formaldehyde and volatile organic compounds (VOCs). Many building materials and products in indoor environments emit VOCs, including insulation, paint, adhesives, vinyl flooring, carpeting, drywall, and furniture. Over 300 VOCs are typically found in the indoor environments of commercial buildings.[56] Some VOCs cause no known health effects while others can cause damage to the liver, kidney, central nervous system. Formaldehyde, methylene chloride, and perchloroethylene are suspected carcinogens, while benzene is known to cause cancer in humans. Short-term health effects may include skin rashes, eye, nose and throat irritation, headaches, nausea, dizziness, fatigue, shortness of breath, and asthma symptoms.[57]

Composite wood products are often bonded with urea-formaldehyde-containing resins, which may then be released in the air. Exposure to airborne formaldehyde may irritate the eyes, noses and throat, exacerbate asthma,[58] and cause nasopharyngeal cancer.[59] Formaldehyde is estimated to cause 86 to 231 per million excess cases of cancer in adults and 23 to 63 per million excess

cases in children nationwide.[60] According to the California Air Resources Board, there is no established safe exposure level of formaldehyde.

Other possible sources of VOCs are air fresheners, office equipment, pesticides, biological contaminants, and cleaning and maintenance products. Improved ventilation or "airing out" new products outdoors before installation may decrease occupant exposure to VOCs; however, exposure reduction to indoor air pollutants is most effective by removing the source of pollution. Many building materials and products are marketed as "green," and undergo emissions testing with labeling such as "zero-VOC" or "low-VOC."

Infestations of cockroaches and rodents, as well as pesticide sprays, can trigger allergy and asthma symptoms. Integrated pest management strategies reduce the need for chemical pesticides. Green buildings insulate and seal structures for energy efficiency, thereby decreasing gaps for pest entry. Integrated pest management makes areas less attractive to pests, by reducing water leaks and keeping areas clean and clutter-free.[61]

Waste Reduction

The Los Angeles County Environmental Stewardship Programs aim to reduce waste produced by County facilities and divert waste from landfills through recycling and re-use efforts. The Department of Water and Power reports that most large, County facilities routinely recycle paper and toner cartridges. About one-third of those facilities also recycle beverage containers. Green buildings incorporate solid waste management and recycling programs to reduce the waste stream of construction crews as well as occupants. Diverting waste from landfills may subsequently reduce the amount of methane released into the air that contributes to global climate change.

In the U.S. about 135.5 million tons construction, renovation, and demolition waste (e.g. lumber, drywall, metals, concrete, brick, carpeting, landscape waste) make up 24% of total municipal solid waste. As much as 95% of this waste is recyclable.[62] Metals are the most commonly recycled materials, while lumber makes up most of the waste sent to landfills. Green buildings divert at least 50% waste from landfills through recycling efforts and promote the use of products from recycled materials.

Electronic waste accounts for 70% of toxic waste found in landfills.[63] Electronic waste contains mercury, lead, cadmium, chromium, beryllium, nickel, zinc, and brominated flame retardants. According to the EPA, only about 5.5% of the 1.9 million tons of discarded electronics were properly recycled.[64] The County now requires new office computing products to be Energy-Star compliant, which reduces the amount of hazardous materials it contains, uses recycled materials and packaging when possible, and is designed for recycling and proper disposal at the end of its life cycle. Currently, there is no County-wide program for business hazardous waste disposal; however residents may go to a local hazardous waste round-up. Proper disposal prevents exposure to hazardous waste, by keeping it out of the trash, landfills, storm waters, and the environment.

Decreasing the amount of waste and encouraging proper disposal of hazardous waste (e.g. batteries) reduces pollution from mercury emissions. Although mercury occurs naturally in the

environment, solid waste incineration and fossil fuel combustion account for 87% of mercury emissions in the U.S.[65] Mercury falls from the air onto land and into neighboring waters where it accumulates in plants and fish. Human health is impacted by consumption of contaminated fish and meat. Mercury contamination of fish is so widespread that it is recommended that adults consume only two servings of fish per week; and that children and pregnant women consume only one weekly serving.[66] Mercury can affect the central nervous system, leading to impaired vision and coordination, loss of feeling, and, at high doses, seizures, brain damage, and death, and is especially harmful to children and pregnant women.

Smart Growth and Sustainable Development

Greening the built environment includes developing new sites using sustainable practices and contributing to smart growth principles of urban planning, including designing landscapes to preserve land, air, and water quality, re-using previously developed land when possible, and protecting public health. Smart growth principles support compact development, avoid urban sprawl, stimulate growth around urban centers, and encourage transit-oriented, walk able and bicycle-friendly land use. Smart growth has a positive impact on the local environment and overall public health.[67]

Conclusions

LEED-certified green buildings have comprehensive indoor air environment standards, which may translate into health benefits for occupants as well as long-term financial savings. The initial cost of green building construction or renovation may be offset by a subsequent 10-fold financial gain from lower energy and water usage, reduced waste, reduced environmental emissions, decreased maintenance and operational costs, and increased worker productivity and health.

Joint public health and environmental regulatory efforts have paid off historically, as in the removal of lead from gasoline – blood lead levels in the United States have dropped dramatically since the 1970's.[68] The spectrum of benefits from green buildings may not be fully realized until full implementation of a comprehensive green building program; however, existing green buildings demonstrate a positive impact on health and cost. Further, the implementation of energy-efficient and waste-reducing workplace practices will have a positive effect on health and the environment in both the short term and the long term.

[1] U.S. Environmental Protection Agency. Indoor Air Quality (IAQ): About the Indoor Environments Division. Available from: URL: http://www.epa.gov/iaq/aboutus.html [Accessed: November 20, 2007].
[2] Kats G, Capital E. The Costs and Financial Benefits of Green Buildings: A report to California's Sustainable Building Task Force, October 2003. Available from: URL: http://www.usgbc.org/Docs/News/News477.pdf [Accessed January 14, 2008].
[3] U.S. Environmental Protection Agency. The Energy Star for Buildings & Manufacturing Plants. Available from: URL: http://www.energystar.gov/index.cfm?c=business.bus_bldgs [Accessed: December 13, 2007].
[4] Leech JA, Raizenne M, Gusdorf J. Health in occupants of energy efficient new homes. Indoor Air. 2004; 14:169-173.
[5] U.S. Department of Energy. 2007 Buildings Energy Data Book: 1.1 Buildings Sector Energy Consumption, September 2007. Available from: URL: http://buildingsdatabook.eere.energy.gov/?id=view_book#bookmark1-1 [Accessed: December 11, 2007].
[6] Legislative Council's Digest. Assembly Bill No. 32, CHAPTER 488 An act to add Division 25.5 (commencing with Section 38500) to the Health and Safety Code, relating to air pollution. [Approved by Governor September 27, 2006. Filed with Secretary of State September 27, 2006.] Available from: URL: http://www.climatechange.ca.gov/documents/ab_32_bill_20060927_chaptered.pdf [Accessed January 8, 2007].
[7] U.S. Department of Energy. 2007 Buildings Energy Data Book: 3.1 Carbon Emissions, September 2007. Available from: URL: http://buildingsdatabook.eere.energy.gov/?id=view_book#bookmark3-1 [Accessed: December 11, 2007].
[8] U.S. Department of Energy. 2007 Buildings Energy Data Book: 3.3 EPA Criteria Pollutants, September 2007. Available from: URL: http://buildingsdatabook.eere.energy.gov/?id=view_book#bookmark3-1 [Accessed: December 11, 2007]
[9] Kuenzli N, Jarrett M, Mack WJ, et al. Ambient air pollution and atherosclerosis in Los Angeles. Environmental Health Perspectives 2005;113(2):201-6.
[10] Miller KA, Siscovick DS, Sheppard L, et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. New England Journal of Medicine 2007;356(5):447-58.
[11] McConnell R, Berhane K, Gilliland F, et al. Air pollution and bronchitic symptoms in Southern California children with asthma. Environmental Health Perspectives 1999;107(9):757-60.
[12] McConnell R, Berhane K, Gilliland F, et al. Asthma in exercising children exposed to ozone: a cohort study Lancet 2002;359(9304): 386-91.
[13] Gauderman WJ, Gilliland GF, Vora H, et al. Association between air pollution and lung function in growth in Southern California children: Results from a second cohort. American Journal of Respiratory and Critical Care Medicine 2002;166(1):76-84.
[14] Gauderman WJ, Avol E, Gilliland F, et al. The effect of air pollution on lung development from 10 to 18 years of age. New England Journal of Medicine 2004;351(11):1057-67.
[15] McConnell R, Berhane K, Gilliland F, et al. Air pollution and bronchitic symptoms in Southern California children with asthma. Environmental Health Perspectives 1999;107(9):757-60.
[16] Gilliland FD, Berhane K, Rappaport EB, et al. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemiology 2001;12(1):43-54.
[17] Ritz B, Wilhelm M, Hoggatt KJ, Ghosh JK. Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles. American Journal of Epidemiology 2007;166(9):1045-52.
[18] Wilhelm M, Ritz B. Local variations in CO and particulate air pollution and adverse birth outcomes in Los Angeles County, California, USA. Environmental Health Perspectives 2005;113(9):1212-21.
[19] Bang KM, Gergen PJ, Kramer R, Cohen B. The effect of pulmonary impairment on all-cause mortality in a national cohort. Chest 1993;103(2):536-40.
[20] Hole DJ, Watt GC, Davey-Smith G, et al Impaired lung function and mortality risk in men and women: findings from the Renfrew and Paisley prospective population study. British Medical Journal 1996;313(7059):711-5.
[21] Ping Chang. Southern California Association of Governments: The State of the Region 2007. Available from: URL: http://www.scag.ca.gov/sotr/ [Accessed December 17, 2007].
[22] California Environmental Protection Agency Air Resources Board. Health effects of particulate matter and ozone air pollution, January 2004. Available from: URL: http://www.arb.ca.gov/research/health/fs/PM-03fs.pdf [Accessed December 3, 2007].
[23] U.S. Department of Energy. Carbon Dioxide Emissions from the Generation of Electric Power in the United States, July 2000. Available from: URL: http://tonto.eia.doe.gov/ftproot/environment/co2emiss00.pdf [Accessed

December 11, 2007].
[24] U.S. Environmental Protection Agency. Acid Rain Program 2006 Progress Report, Published November 2007. Available from: URL: http://www.epa.gov/airmarkets/progress/arp06.html [Accessed December 6, 2007].
[25] U.S. Environmental Protection Agency. The benefits and costs of the Clean Air Act 1990 to 2010. Report to Congress, November 15, 1999. EPA-410-R-99-001. Available from: URL: http://www.epa.gov/air/sect812/prospective1.html [Accessed December 13, 2007].
[26] U.S. Environmental Protection Agency. Heat-Island Effect. Available from: URL: http://www.epa.gov/heatisld/about/energysavings.html [Accessed March 3, 2008].
[27] U.S. Environmental Protection Agency. Air Pollution Prevention Through Urban Heat Island Mitigation: An Update on the Urban Heat Island Pilot Project. Available from: URL: http://www.ghcc.msfc.nasa.gov/uhipp/epa_doc.pdf [Accessed March 3, 2008].
[28] Heschong Mahone Group, Inc. Skylighting and retail sales. An investigation into the relationship between daylighting and human performance. Report for the Pacific Gas and Electric Company, Fair Oaks, CA 1999. Available from: URL: http://www.h-m-g.com/projects/daylighting/summaries%20on%20daylighting.htm [Accessed December 13, 2007].
[29] University of Washington, College of Forest Resources, Center for Urban Horticulture. Nature Experiences: Readings and References on Human Benefits Fact Sheet. Available from: URL: http://www.cfr.washington.edu/research.envmind/UF/Readings-FS6.pdf [Accessed January 16, 2007].
[30] Heschong Mahone Group, Inc. Windows and offices: A study of office worker performance and the indoor environment. Technical report for the California Energy Commission, October 2003 P500-03-082-A-9. Available from: URL: http://www.newbuildings.org/downloads/FinalAttachments/A-9_Windows_Offices_2.6.10.pdf [Accessed December 13, 2007].
[31] Heschong Mahone Group, Inc. (2003) Windows and classrooms: A study of student performance and the indoor environment. Technical report for the California Energy Commission, October 2003 P500-03-082-A-7. Available for download from: URL: http://www.h-m-g.com/projects/daylighting/projects-PIER.htm [Accessed December 13, 2007].
[32] U.S. Geological Survey. Estimated water use in the United States in 1995. Available from URL: http://www.water.usgs.gov/watuse/pdf1995/html [Accessed December 18, 2007].
[33] Ping Chang. Southern California Association of Governments: The State of the Region 2007: The Environment. p. 105. Available from: URL: http://www.scag.ca.gov/publications/pdf/2007/SOTR07/SOTR07_Environment.pdf [Accessed December 17, 2007].
[34] Legislative Analyst's Office. September 8, 1999. The Role of Water Transfers in Meeting California's Water Needs.
[35] Ping Chang. Southern California Association of Governments: The State of the Region 2007: The Environment. p. 109. Available from: URL: http://www.scag.ca.gov/publications/pdf/2007/SOTR07/SOTR07_Environment.pdf [Accessed December 17, 2007].
[36] Haile RW, Alamillo JS, Gold M. et al. The health effects of swimming in ocean water contaminated by storm drain runoff. Epidemiology 1999;10(4):355-363.
[37] U.S. Environmental Protection Agency. Source water protection practices bulletin: Managing storm water runoff to prevent contamination of drinking water, July 2001. EPA 816-F-01-020. Available from: URL: http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_stormwater.pdf [Accessed January 8, 2008].
[38] Akbari, H. Shade trees reduce building energy use and CO2 emissions from power plants. Environmental Pollution 2002;116:119-26.
[39] U.S. Environmental Protection Agency. Heat Island Effect: What Can Be Done. Available from : URL: http://www.epa.gov/hiri/strategies/index.html [Accessed January 15, 2008].
[40] Akbari, H. Shade trees reduce building energy use and CO2 emissions from power plants. Environmental Pollution 2002;116:119-26.
[41] Lee TC, Stout JE, Yu VL. Factors predisposing to Legionella pneumophila colonization in residential water systems. Archives of Environmental Health 1988;43(1):59-62.
[42] Engelhart S, Sennekamp J, Gilges S, et al. Workplace-related complaints due to exposure to contaminated humidifier water and the VDI guideline 6022. European Journal of Medical Research 2000;5(3):126.
[43] Ganier M, Lieberman P, Fink J, Lockwood DG. Humidifier lung. An outbreak in office workers. Chest 1980;77(2):183-7.
[44] Skyberg K, Skullberg KR, Eduard W, et al. Symptoms prevalence among office employees and associations to building characteristics. Indoor Air 2003;13(3):246-52.

[45] Apte MG, Fisk WJ, Daisey JM. Associations between indoor CO2 concentrations and sick building syndrome symptoms in U.S. office buildings: An analysis of the 1994-1996 BASE study data. Indoor Air 2000;10:246-57.
[46] Breysse P, Farr N, Galke W, et al. The relationship between housing and health: Children at risk. Environmental Health Perspectives 2004;112(15):1583-7.
[47] Jaakkola MS, Nordman H, Piipari R, et al. Indoor dampness and molds and development of adult-onset asthma: A population-based incident case-control study. Environmental Health Perspectives 2002;110(5):543-7.
[48] Bornehag CG, Sundell J, Bonini S, et al. Dampness in buildings as a risk factor for health effects, EUROEXPO: a multidisciplinary review of the literature (1998-2000) on dampness and mite exposure in buildings and health effects. Indoor Air 2004;14(4):243-57.
[49] Wickman M, Emenius G, Eqmar AC, et al. Reduced mite allergen levels in dwellings with mechanical exhaust and supply ventilation. Clinical and Experimental Allergy: Journal of the British Society for Allergy and Clinical Immunology 1994;24(2):109-14.
[50] Bornehag CG, Sundell J, Hagerhed-Engman L, Sigsgaard T. Association between ventilation rates in 390 Swedish homes and allergic symptoms in children. Indoor Air 2005;15(4):275-80.
[51] Mendell MJ, Lei-Gomez Q, Mirer A, Seppanen O. Risk Factors in Heating, Ventilation, and Air-Conditioning Systems for Occupant Symptoms in U.S. Office Buildings: the U.S. EPA BASE Study. Lawrence Berkeley National Laboratory Indoor Environment Department. LBNL-61870. Available from: URL: http://repositories.cdlib.org/lbnl/LBNL-61870/ [Accessed January 10, 2008].
[52] Pejtersen J, Bronus H, Hyldgaard CE, et al. Effect of Renovating an Office Building on Occupants' Comfort and Health. Indoor Air 2001;17:9-25.
[53] U.S. Department of Labor. Occupational Safety and Health Administration. 29 CFR Parts 1910, 1915, 1926, and 1928 Indoor Air Quality; Proposed Rules 1994. Federal Register #: 59(65):15968-16039. Available from: URL: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=13369 [Accessed February 5, 2008].
[54] U.S. Environmental Protection Agency, Office of Air and Radiation. Indoor Air Quality: Indoor Air Facts No. 4 (revised) Sick Building Syndrome. Available from: URL: http://www.epa.gov/iedweb00/pubs/sbs.html [Accessed December 13, 2007].
[55] Fisk, WJ. Health and productivity gains from better indoor environments and their relationship with building energy efficiency. Annual Reviews of Energy and the Environment 2000;25:537-66.
[56] California Department of Health Services. Reducing occupant exposure to volatile organic compounds (VOCs) from office building construction materials: non-binding guidelines, October 1999. Available from: URL: http://www.cal-iaq.org/VOC/VOC.html [Accessed January 17, 2008].
[57] U.S. Environmental Protection Agency. Indoor Air Quality: Organic Gases (Volatile Organic Compounds - VOCs). Available from: URL: http://www.epa.gov/iedweb00/voc.html [Accessed December 4, 2007].
[58] Casset A, Merchand C, Purohit A, et al. Inhaled formaldehyde exposure: effect on bronchial response to mite allergen in sensitized asthma patients. Allergy 2006;61:1344-50.
[59] California Environmental Protection Agency Air Resources Board. Indoor Air Quality Guideline: Formaldehyde in the Home, August, 2004. Available from: URL: http://www.arb.ca.gov/research/indoor/formaldehyde.htm [Accessed January 14, 2008].
[60] California Environmental Protection Agency Air Resources Board. Fact Sheet: Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products. Available from: URL: http://www.arb.ca.gov/toxics/compwood/factsheet.pdf [Accessed January 14, 2008].
[61] U.S. Department of Housing and Urban Development. About Integrated Pest Management. Available from: URL: http://www.hud.gov/offices/lead/healthyhomes/ipm.cfm [Accessed January 17, 2007].
[62] U.S. Department of Energy. 2007 Buildings Energy Data Book: 3.4 Construction Waste, September 2007. Available from: URL: http://buildingsdatabook.eere.energy.gov/?id=view_book#bookmark3-1 [Accessed: December 11, 2007].
[63] Earth 911. E-Waste Harmful Materials. Available from: URL: http://earth911.org/electronics/e-waste-harmful-materials/ [Accessed January 17, 2008].
[64] U.S. Environmental Protection Agency. eCycying. Available from: URL: http://www.epa.gov/epaoswer/hazwaste/recycle/ecycling/index.htm [Accessed January 17, 2008].
[65] U.S. Environmental Protection Agency. Fact Sheet: Mercury Update: Impact on Fish Advisories, June 2001. EPA-823-F-01-011. Available from: URL: http://www.epa.gov/waterscience/fishadvice/mercupd.pdf [Accessed January 17, 2008].

[66] U.S. Environmental Protection Agency. What You Need to Know about Mercury in Fish and Shellfish. Available from: URL: http://www.epa.gov/waterscience/fishadvice/advice.html [Accessed January 17, 2008].
[67] U.S. Environmental Protection Agency. Environmental Benefits of Smart Growth. Available from: URL: http://www.epa.gov/dced/topics/eb.htm [Accessed January 18, 2008].
[68] Centers for Disease Control and Prevention. Blood Lead Levels – United States, 1999-2002. Morbidity and Mortality Weekly Report 2005;54(20):513-516. Available from: URL: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5420a5.htm [Accessed January 24, 2008].