Green Amendment Information Packet

Fort Collins Building Code Green Amendments: Overview

Introduction

While Fort Collins building codes include many elements that support green building, this building code amendment proposal represents next steps along the path of integrating green building practices into mainstream construction.

Background

Areas commonly included under the "green building" umbrella include:

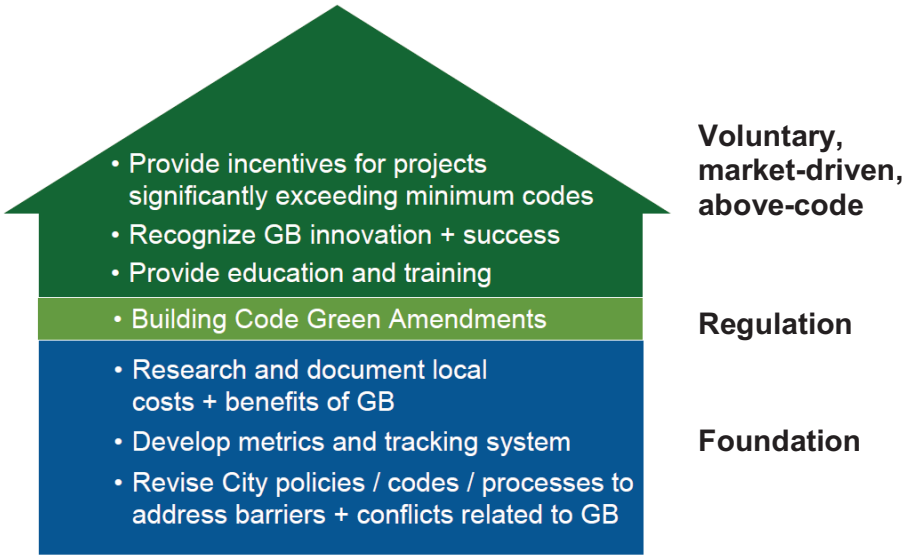
- Site and lot development
- Resource efficiency
- Energy efficiency
- Water efficiency
- Indoor environmental quality (healthy indoor air, thermal and visual comfort, acoustics)
- Operations and maintenance / owner education

Implementation of a Green Building Program (GB Program) was identified as a City Council priority during the 2010 – 2011 budget process. The Utilities department is leading the effort in close collaboration with other departments. Green building has a strong policy basis with the 2008 Climate Action Plan, 2009 Energy Policy and 2009 Water Conservation Plan.

The goal of an ongoing Green Building Program is to increasingly align Fort Collins' built environment with community goals of reduced carbon emissions, reduced energy use and reduced water use.

The GB Program will incorporate both code and market-driven elements, as shown in Figure 1. Council's direction to consider a code amendment ordinance during the first quarter of 2011 focused the efforts of GB Program work in 2010. Other aspects of the GB Program will continue to be developed throughout 2011.

Figure 1: Green Building Program Elements



Green Amendments

Building codes represent the minimum acceptable community standards for design and construction of new buildings and renovations or additions to existing buildings. The City recently adopted the 2009 International Building Codes. Rather than adopting a standalone "green building code," the direction of this project has been to update the Fort Collins building code with "green amendments."

Staff has developed, through a comprehensive stakeholder process, two packages of green building practices for adoption by Council: one each for residential and commercial construction. The applicability of individual green building practices to new construction, additions and renovations varies, and is described in the proposal documents outlined below.

The following information about the green amendments is available on the GB Program web pages (www.fcgov.com/gbp):

- This overview document of the Green Building Program and Building Code Green Amendments.
- "Amendment-package-at-a-glance." These summary documents, one each for the residential and commercial amendments, list all of the green building practices with brief descriptions.
- Benefits and Costs Summary. This document summarizes the benefits and costs for the residential and commercial amendment packages, based on prototypical projects for each sector. A triple-bottom-line approach is used that reflects social, economic and environmental impacts.
- Green Building Practice Summaries. These documents, currently under development, will provide additional information about each of the practices. Topics addressed include applicability to new construction and existing buildings, benefits and costs, implementation issues, current practice, and context

As an integral part of the amendment package, staff is estimating the resources required to effectively implement the green amendments. City responsibilities will include:

- Development of necessary verification procedures
- Development of support materials
- Training (contractors, inspectors, public)
- Day-to-day implementation (plan review, field inspections, training)
- Monitoring and evaluation of the implementation process and results

These resource needs will be reflected in the Benefits and Costs Summary.

Themes of the Green Building Amendments

A number of cross-cutting themes drove the selection of measures reflected in the green building amendments:

- Broad scope of green building. City Council directed staff to investigate practices that provide a range of benefits, not just those directly tied to City goals (energy, water, carbon) or that have the most favorable economic benefit for the building owner. The green amendments will improve health and safety of construction workers and occupants, save energy, save water, divert construction waste from the landfill, improve occupant comfort and enhance durability of buildings.

- Leadership. The intent is for Fort Collins to delineate the next steps in the process of integrating green building practices into mainstream construction. This involves accelerating the normal process by which new building practices become part of the building codes.
- Refine current codes. The 2009 International Code package, adopted in September 2010, includes important new elements as well as innovative local amendments adopted in previous code cycles. The green amendments will augment the recently adopted codes and address any gaps that will forward more sustainable construction. .
- Installed performance. The green amendments focus on ensuring that components and systems operate at rated performance. The amendments emphasize critical installation details and testing to verify that performance standards are met.
- Systems approach. Buildings operate as systems. The performance of one component may influence a number of others, positively or negatively. Several of the green amendments are based on important interrelationships and only make sense as a package.
- Lost opportunities. Many aspects of buildings are relatively easy and inexpensive to address during construction and difficult and expensive to address after completion. Several measures are designed to capture these opportunities.
- Reasonable steps. For several measures, the amendment targets achievable steps based on the available infrastructure. The objective of these changes is to catalyze infrastructure growth and, in turn develop capacity to support additional future steps.
- Residential and commercial alignment. Where possible, the amendments align requirements across the residential and commercial codes.

Green Building Program Development Process

The formal Fort Collins Green Building Program development process began in late 2009. The basic program approach received City Council support in a January 2010 Work Session.

The core green building staff team coordinated the formation of stakeholder and advisory committees:

- The Green Building Program Advisory Committee is comprised of a broad spectrum of community stakeholders, such as the Fort Collins Chamber of Commerce, Fort Collins Board of Realtors and Northern Colorado Chapter of the US Green Building Council. This committee serves as a sounding board as the GB Program is developed. Members are asked to help with two-way communication with their constituencies about the effort. The advisory committee will be kept up to date on the development process as part of the continued public outreach in 2011.
- Two Technical Review Advisory Committees (TRAC), one each for residential and commercial sectors, have been closely involved with code development. Members were invited based on their technical and market expertise. Each TRAC typically has met twice a month from May through December 2010. TRACs will be kept up to date on the development process as part of continued public outreach in 2011.

Initial direction was for the City to adopt a “green building code” as a supplement to the City’s existing building codes. The intent was to review and potentially adapt one or more of the national model GB codes or standards. Staff and the TRACs reviewed the National Green Building Standard (residential buildings) and International Green Construction Code (commercial buildings) for

potential adaptation and adoption in Fort Collins. This review suggested this would not be an appropriate solution because of the multiplicity and complexity of optional combinations that would be available as "compliance paths" to applicants.

In mid-2010, staff recommended to City Council that the effort shift from adopting model GB codes to instead develop a strategic selection of effective amendments to further "green" the existing building codes. Council members supported the recommendation.

In parallel, the Building Services Department led an effort for City adoption of the 2009 editions of the International Code Council's "International Codes" (I-Codes). The 2009 I-Codes package was adopted by Council in September 2010 and became effective in October 2010. The 2009 I-Code requirements serve as the baseline for the green amendments.

Green Building Program – Continued Development

The green amendments are one key element of the overall Green Building Program. GB Program development will continue in 2011-2012 yet are dependent upon appropriate resources and will be focused on the following:

- Implementation of the green amendments (training and enforcement)
- Development of above-code incentive and recognition program elements for projects which demonstrate high performance outcomes.
- Development of the metrics to track results related to the GB Program.
- Review and consideration of green development practices and processes to augment the Land Use Code.

Residential Code Green Building Amendments (Prescriptive)

These amendments apply to single-family detached housing, duplexes, townhomes and low-rise (one- to three-story) multifamily housing.

3/10/2011

#	GB Practice	Description *	Intent	Applicability**	Type***
	RESOURCE EFFICIENCY				
1	**Construction waste recycling**	• Submit recycling plan (who, what, where, how) before project begins • Implement recycling (non-landfill) for wood, metal, concrete and cardboard	Divert construction waste from landfill	New: Yes Addition: No Alteration: No	New
2	**Certified wood**	Sustainable forestry certification required for all tropical hardwoods	Support sustainable forestry practices	New: Yes Addition: Yes Alteration: Yes	New
3	**Windows, skylights, doors: installation**	Increased detailing regarding integration of fenestration with exterior drainage plane	Reduce potential for exterior moisture damage	New: Yes Addition: Yes Alteration: No	Refine
	ENERGY EFFICIENCY				
4	**Building envelope: thermal specifications for electric-heat buildings**	More rigorous insulation and air sealing specifications for electric-heat buildings (beyond 2009 International Residential Code requirements)	Save energy and reduce peak electrical demand	New: Yes Addition: Yes Alteration: Yes	Reinstate + Refine
5	**Basement windows: thermal specifications**	Basement windows with comparable performance to windows on main living levels	Set stage for energy-efficient, comfortable living space when basement is finished	New: Yes Addition: Yes Alteration: No	Refine
6	**Air sealing: tight construction**	• Whole-building air leakage: 4.0 ACH50 maximum • Increased focus on effective sealing between living space and attached garage • Performance testing required	Capture energy, comfort, durability and health benefits	New: Yes Addition: Part Alteration: Part	Reinstate + Refine
7	**Insulation: installation**	Insulation installed to the Residential Energy Services Network (RESNET) Grade I standard Exceptions for which RESNET Grade II is acceptable: • Rim joists • Exterior walls with continuous rigid insulating sheathing, R-5 minimum.	Install insulation so it delivers rated energy performance	New: Yes Addition: Yes Alteration: Yes	Refine
8	**Heating + cooling systems: design**	Added requirements for permit application: • Heating + cooling design load calculations include room-by-room loads • Air-Conditioning, Heating, and Refrigeration Institute (AHRI) matched evaporators, condensing units and furnaces (AHRI certificate required) • Document key design parameters	Design heating and cooling systems that satisfy comfort needs and perform in accordance with manufacturer specifications	New: Yes Addition: Yes Alteration: Part	Refine
9	**Heating, ventilation, air conditioning (HVAC) systems: commissioning**	Performance testing of heating, cooling and ventilation systems, aligned with Air Conditioning Contractors of America (ACCA) 5 "Quality Installation" procedures. Systems operating out of tolerance compared with design specifications will be adjusted and re-tested until they pass.	Verify that HVAC systems perform as designed	New: Yes Addition: Yes Alteration: Part	Refine + New
	WATER EFFICIENCY				
10	**Water-efficient fixtures**	Toilets, showerheads and faucets must meet Environmental Protection Agency (EPA) WaterSense® standards for maximum flow rate or consumption.	Save water and energy	New: Yes Addition: Yes Alteration: Yes	New
	INDOOR ENVIRONMENTAL QUALITY (IEQ)				
11	**Safer combustion appliances: new construction**	Natural draft combustion appliances (furnaces, boilers, water heaters, fireplaces) must be placed outside the building's pressure boundary and pass combustion safety test. (This requirement may also be met with safer combustion appliances: power-vented, sealed-combustion or direct-vent.)	Eliminate potential health and safety hazard of combustion products spilling into building	New: Yes Addition: Yes Alteration: No	New

12	**Safer combustion appliances: existing buildings**	When combustion appliances are replaced, all natural draft combustion appliances must pass combustion safety test under "natural conditions."	Reduce potential health and safety hazard of combustion products spilling into building	New: No Addition: No Alteration: Yes	New
13	**Low-Volatile Organic Compound (VOC) materials**	Interior materials meet maximum VOC emissions standards: • Sealants + adhesives • Resilient flooring • Carpeting • Paints, stains, varnishes and other site-applied finishes • Structural wood panels, hardwood veneer plywood, particle board, and fiber board • Insulation	Improve indoor air quality for construction workers and occupants	New: Yes Addition: Yes Alteration: Part	New
14	**Whole-building ventilation**	Provide whole-building, controlled, mechanical ventilation system, designed to meet ASHRAE 62.2 requirements. Air handlers used to move ventilation air must be equipped with efficient blower motors.	Improve indoor air quality	New: Yes Addition: No Alteration: No	New
	OUTDOOR ENVIRONMENTAL QUALITY (OEQ)				
15	**Exterior lighting: fixture design**	Install "dark-sky friendly" exterior lighting fixtures	Increase security Reduce light pollution and light trespass	New: Yes Addition: No Alteration: No	New
	OPERATIONS + MAINTENANCE + EDUCATION				
16	**Building owner education**	Provide operations and maintenance manual for building owner	Educate owners about their home and other "green" choices they can make	New: Yes Addition: Part Alteration: Part	New

* Visit the City of Fort Collins Green Building Program web site (www.fcgov.com/gbp) for more information:
  - **Fort Collins Building Code Green Amendments** - context for this evolving proposal
  - **Expanded descriptions of each green building practice**
  - **Benefits and Costs of Building Code Green Amendments**

** Indication of how amendment applies to new buildings, additions and alterations to existing buildings. In general, amendments apply in same manner as any code provision, when a building permit is required. See expanded description of each green building practice (www.fcgov.com/gbp) for more detail about applicability.

*** Classifies how the amendment relates to the existing building code:
New: not previously addressed in Fort Collins code
Refine: already addressed in Fort Collins code; the amendment provides more detail or takes it further
Reinstate: similar provision existed in the Fort Collins code prior to fall 2010 update.

Residential Green Building Practice Summaries

Green Building Practice Summary 11/21/10

Sector: Residential and Commercial

Category/Practice: Resource Efficiency / Construction Waste Recycling

Proposed GB Practice

Description

Builder must complete a construction waste management (CWM) plan before the project begins.

At minimum, concrete, wood, metal and cardboard must be recycled rather than landfilled.

The plan must be posted on the job site and implemented.

Applicability

New Construction: Applies

Existing Buildings/Additions: Does not apply (address with education, encourage recycling)

Existing Buildings/Alterations: Does not apply (address with education, encourage recycling)

Intent

Divert construction waste from landfill

Benefits and Costs

Triple Bottom Line Benefits

People: N/A

Economic:

- The direct, first cost impact on the project may be a small savings, neutral, or a small increase.
- Long-term savings to the community related to extending the life of the landfill.
- Support local business by expanding the market for recycled-materials haulers and providing materials for local composting and scrap metal recycling facilities.

Environment:

- Reduced demand for virgin materials
- Reduced resource use for processing by reusing what has already been made
- Reduced greenhouse gas (methane, carbon dioxide) emissions due to fewer organic materials (wood, cardboard) decomposing in the landfill. GHG emissions from hauling and reprocessing materials will, to some degree, offset those gained from keeping them out of the landfill.

Costs Passed to Owner

As noted above, the direct first cost of construction waste recycling is anticipated to be minimal; the net disposal cost impact might be a small added cost, a small savings, or neutral compared with landfill disposal.

Lost Opportunity

Construction materials dumped in the landfill are much less economically feasible to recover in the future.

Implementation

Availability of Products and/or Services

Several local haulers currently provide customized recycling services for Fort Collins construction projects. Local drop-off sites exist for recycling metals, wood, concrete, and cardboard, should builders wish to self-haul these materials.

Practicality

This measure can be relatively easily implemented. Initially, builders will have to spend time to train employees and subcontractors about the recycling protocol. This will get easier with each project. Smaller projects may have to self-haul materials, requiring additional time and resources. However, the reduction in the cost of trash service for the project and financial returns for recycling metals will ease implementation cost impacts on the builder. The proposed requirement is designed to put minimal paperwork and tracking burden on the builder.

Certification Issues

None

Enforcement Procedures

Permit application/plan review: Plan reviewers check the waste management plan

Field inspection: Building inspectors verify that recycling is being done onsite during all inspection visits On-site inspection will include visual verification of recycling to confirm that containers are on-site, appropriately labeled and not contaminated with trash.

Certificate of Occupancy: N/A

Support Materials Needs

City will develop a template for the CWM plan. Minimum information likely required in the plan includes:

- Materials to be recycled
- How recycling will be handled: sizes of containers, who will haul materials to recycling sites
- When recycling containers will be on site (e.g. concrete recycling from washout following pour of the footings and foundation)
- How contamination of the recycling containers will be avoided

Example signage would be helpful.

Training Needs - Industry
Training will be provided as part of mandatory training for all contractors on the recently adopted Fort Collins building codes and green amendments.

Training Needs - Staff
Staff training will be needed for consistent enforcement.

Background

Current Practice
Most construction waste is hauled to the landfill.

Context
In 2006, City Council approved a community waste diversion goal of 50% by 2010. As of 2010, the City has a diversion rate of 38% (not including concrete/asphalt). In 2009, over 25% of the material going into the landfill was waste from construction and demolition. Diverting construction waste will help extend the life of the landfill, reduce carbon emissions, and help the City reach its diversion goals.

Some builders in the community who are working on green building and LEED-certified projects have been able to recycle 75-95% of construction waste. That includes recycling more types of material than the four included in this proposed amendment.

Several communities throughout the country require solid waste diversion for both residential and commercial construction projects.

This proposal intentionally sets no specific target for the percentage of construction waste diverted from the landfill. It sets requirements only for materials for which a local recycling infrastructure already exists. It is intended to include an educational component. Developing a CWM plan raises awareness about recycling opportunities. Implementing the plan provides experience and supports further development of local infrastructure.

Related Green Building Practices
N/A

Known Objections
- Lack of space on some construction sites to accommodate recycling containers
- A quantified recycling goal (e.g. volume % of total job waste) is needed for this proposal to be meaningful.
- Training and administration costs for the builder
- Time lost training staff and contractors

Green Building Practice Summary 3/17/2011

Sector: Residential and Commercial

Category/Practice: Resource Efficiency / Certified Tropical Hardwood

Proposed GB Practice

Description

All tropical hardwoods used in a project are required to have a sustainable forestry certification from the Forest Stewardship Council, or other agency approved by the Building Official.

Certification demonstrating compliance shall be required with delivery of such materials and shall be available for inspection.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to addition portion only

Existing Buildings/Alterations: Applies only to materials within scope of the alteration requiring a permit.

Intent

Support sustainable forestry practices.

Benefits and Costs

Triple Bottom Line Benefits

People: People benefit from many aspects of the environmental benefits listed below. Examples include cleaner water, improved fisheries, and reduced chance of property damage due to mudslides.

Economic: As noted below in "Costs Passed to Owner," this measure represents increased costs rather than savings for the builder and owner. There is the potential for long-term economic benefit from sustainable forestry practices, particularly as demands on this resource increase.

Environment: Sustainable forest management practices provide many benefits where timber grows and is harvested:

- Improved wildlife habitat
- Reduced soil erosion
- Reduced pollution
- Healthier ecosystem

This measure in unique among the proposed green amendments in that direct benefits accrue upstream, where timber is grown and harvested, rather than to Fort Collins.

Costs Passed to Owner

Cost impacts are difficult to quantify due to differing sources, pricing practices and availability of hardwood certified under different certification systems. For example, Forest Stewardship Council (FSC) certified tropical hardwood is generally about 10-15% more expensive than conventional lumber. However, some Colorado suppliers say that the cost impacts are minimal.

The cost of tropical hardwoods – certified or non-certified – is usually higher than that of non-tropical species. They are rarely used in entry-level or production buildings. In most cases where the consumer is asking for tropical hardwoods, the choice is made primarily based on aesthetics or durability before costs are considered.

Implementation

Availability of Products and/or Services

FSC-certified tropical hardwoods are difficult to obtain. Several Northern Colorado and Denver area suppliers stock FSC-certified tropical hardwoods or are willing to make special orders upon demand. Other hardwood suppliers are unfamiliar with the certification and why it was developed.There is a potential that some species of tropical hardwoods may not be available as certified products.

Several of the vendors interviewed said that customer demand drives the products that are carried in stock. It is realistic to expect that, if the demand for certified tropical hardwoods increases, availability would also increase.

Practicality

This would not be a difficult measure for builders or owners. They would need to plan ahead to make sure the certified lumber is ordered and arrives to the job site when it is needed.

Enforcement Procedures

Permit application/plan review: Where tropical hardwood is specified in construction documents, it must be identified as being certified by FSC or other approved agency.

Field inspection: Certification demonstrating compliance available for inspection.

Certificate of Occupancy: Builder/owner must submit documentation showing that all tropical hardwoods used in project comply with requirement.

Support Materials Needs

A fact sheet with background on certified wood and a description of what species and sources of wood are subject to the proposed requirement would be helpful for builders and owners. A resource list, with information about what local suppliers can provide, would also be useful.

Training Needs – Industry

Requirement will be covered as mandatory training for all contractors on the recently adopted Fort Collins building codes and green amendments. Outreach to suppliers should also be conducted.

Training Needs – Staff

Minimal training will be needed.

Background

Current Practice

Anecdotal evidence suggests that many builders and building owners do not know the original source of their lumber, how the material is harvested or how the resource is managed. Sustainable forestry certification is currently not a significant factor in the Fort Collins market.

The main uses for tropical hardwood in Colorado are for decks and hardwood flooring. Currently, there is not a big demand for tropical hardwoods, though some vendors report that about 50% of their customers ask for it for flooring.

Context

The term "certified wood" applies to lumber that comes from forests that are sustainability managed and harvested. Forest certification programs have been created by several non-profit groups to address issues of illegal logging, clear-cutting, and rapid deforestation in many parts of the world. Part of the mission of these groups was to create certification programs that consumers could use to make environmentally responsible purchasing decisions.

Current certification programs include:

American Tree Farm System (ATFS)	Focused on education and certification for private forest owners. Certified over 24 million acres of forest land.	http://www.treefarmsystem.org
Canadian Standards Association's Sustainable Forest Management System Standards (CSA)	Develops standards for sustainable forest management. Focused on operations in Canada.	http://www.csa.ca/cm/ca/en/home
Forest Stewardship Council (FSC)	International organization that certifies forests in the U.S. and worldwide.	http://www.fscus.org
Program for Endorsement for Forest Certification System (PEFC)	Endorses forest certification systems that are developed and tailored to local conditions. Currently endorses 34 national certification systems and 220 million hectares of certified forests.	http://www.pefc.org
Sustainable Forestry Initiative Program (SFI)	Certification system focused on operations and forest management in North America.	http://www.sfiprogram.org/

In 2008, the Federal Government amended the Lacey Act to include illegal timber and paper products. This act prohibits the importation and trade of wildlife, fish, and plants that have been illegally taken, transported or sold. This act requires that companies importing wood products practice due diligence and know the entire supply chain of their products. While the Lacey Act took a big step in the right direction, third-party certification programs like FSC help to ensure that wood products are coming from sources that are not only legal but sustainable.

Green building standards and rating systems recognize the benefits of using certified wood in construction projects. In the residential sector, LEED for Homes and the National Green Building Standard both award points for using materials from sustainable sources. Commercial green building standards including LEED and the International Green Construction Code also support sustainable forestry in their requirements.

In looking into this green building opportunity as a potential building code green amendment, the initial suggestion was to require certification for a wider array of wood products. However, due to the potential for higher first cost for certified wood and the upstream nature of the benefits, it was felt that tropical hardwoods represented an appropriate regulatory first step. This is an opportunity for the City of Fort Collins to be a leader and to "think globally and act locally."

Related Green Building Practices
None

Known Objections

- FSC-certified wood is not always readily available.
- Perception that lumber yards are already only selling wood from sustainable sources.

Green Building Practice Summary 12/13/2010

Sector: Residential

Category/Practice: Energy Efficiency / Fenestration Installation

Proposed GB Practice

Description

Require increased attention to detail regarding integration of windows, skylights and door flashings with the exterior drainage plane, by requiring installation in accordance with the American Architectural Manufacturers Association (AAMA) Installation Master Standards. All fenestration installations shall be supervised and inspected by an individual certified by AAMA Installation Master or other approved agency.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies only to addition portion

Existing Buildings/Alterations: Does not apply (address with education)

Intent

Reduce potential for exterior moisture damage.

Benefits and Costs

Triple Bottom Line Benefits

People: None

Economic:

- No annual operational cost savings are anticipated.
- Increase building durability and avoid large maintenance/repair costs by reducing the potential for water leakage into building cavities

Environment: Environmental benefits of enhanced durability

Costs Passed to Owner

"Medium" cost

Incremental cost is estimated at no more than $25 per window (additional flashings that may be required plus increased time for installation). 10 windows @$25 = $250.

Lost Opportunity

Meeting these requirements is much less expensive than repairing water damage later.

Implementation

Availability of Products and/or Services

Materials to implement this requirement are readily available. There are a reasonably large number of AAMA Installation Masters-certified installers in the Fort Collins replacement window market. In the new construction market, a significant number of framing contractors will need to be trained and certified.

Practicality

No obstacles have been identified. Certification requirements could potentially be phased in as framers renew their licenses.

Certification Issues

Inspections must be performed by individuals certified by AAMA Installation Masters (or other credential approved by the Building Official). Inspection may be performed by the same company that installed the windows; i.e. third-party inspection is allowed but not required.

Cost of certification is estimated at $300 to $600. The lead framer is the logical candidate to become certified.

Certification requirements could potentially be phased in as framers renew their licenses.

Enforcement Procedures

Permit application/plan review: N/A

Field inspection: N/A

Certificate of Occupancy: Applicant must turn in signed affidavit documenting compliance. The document will include the certified inspector's certification number and expiration date.

The Building Department is contemplating adding a pre-siding inspection to be able to check compliance with other drainage plane requirements. If this occurs, inspection responsibility for this proposed amendment would be transferred to building inspectors and no documentation would be required before the Certificate of Occupancy is issued.

Support Materials Needs

Compliance form

Training Needs – Industry

Additional training opportunities should be made available to those wishing to become certified.

Window installation training is periodically being offered by Fort Collins Utilities as a requirement to be listed as a participating window installation contractor in the Home Efficiency Program (for existing homes). Installation Masters certification could be offered as an extension of this training or separately for framers, focusing on new construction installations.

Training Needs - Staff

If the Building Department adds a pre-siding inspection, inspectors will need training in fenestration installation inspection.

Background

Current Practice

Many different methods are being used to install windows, doors and skylights. New construction and retrofit installations can be very different and each contractor thinks the method they use is correct. Comparing the contractors' methods with window manufacturers' installation instructions or other nationally recognized installation standards, in many cases there is a significant difference. Unless these installation standards are followed closely, there can be no guarantee that the windows, doors, or skylights will not leak.

In new construction, windows are typically installed by framers. Replacement windows in existing buildings are typically installed by window installers working for, or contracted by, the window vendor.

Staff is aware of expensive moisture-related problems caused by leakage around windows and skylights in relatively new Fort Collins buildingss. No data has been collected regarding the frequency of such problems.

Context

The root cause of many building failures is water. Wood and other cellulose-based building materials that get wet and can't dry quickly enough decay. Part of the challenge of building a durable building is to keep the water out of the structure. This is accomplished through a systems approach, addressing both exterior and interior moisture sources (see "Related Green Building Practices" below).

Some key exterior moisture control measures have been missed in Fort Collins in the past, likely due to perceptions around the semi-arid climate. Since the 1997 Uniform Building Code, a "weather-resistive barrier" (WRB) been required in the model codes. The WRB is a membrane layer, exterior to the wall and roof sheathing, that provides secondary protection for the building structure against exterior moisture intrusion (primary protection is provided by exterior finish materials like siding and stucco). Since 2005, with the adoption of the 2003 IRC, this requirement been enforced in Fort Collins.

Windows, skylights and doors are installed in openings in the building structure. The edges of these components are prime locations for moisture intrusion. To complete an effective exterior "drainage plane," these components must be carefully integrated with the surrounding WRB; installation details for these elements are critical.

The 2009 IRC provides general requirements for the flashing of window, door and skylight penetrations in the building exterior. These flashings must extend out to the finish or to the WRB on the exterior. However, specific guidance regarding the proper installation of these flashings is not provided. The proposed amendment would reference installation details developed by AAMA, a trade association of window manufacturers. It would eliminate contention about which contractor's installation method is correct.

Related Green Building Practices

Exterior moisture protection requires a systems approach. Elements that work together to keep exterior moisture out of the building include:

- Roofing

- Roof overhangs
- Gutters and downspouts, with downspout terminations a minimum distance from the building
- Exterior siding
- Flashings
- WRB and fenestration installation details
- Finish grading adequately sloped from the building
- Permeable backfill adjacent to the building
- Foundation drains

Known Objections

- Another certification required, with the associated cost to obtain and maintain it

Green Building Practice Summary 3/17/2011

Sector: Residential

Category/Practice: Energy Efficiency / Electric-Heat Envelope Specifications

Proposed GB Practice

Description

Electrically heated buildings must meet the following building envelope thermal specifications, which are more energy-efficient than the recently adopted 2009 *International Residential Code* (IRC) and 2009 *International Energy Conservation Code* (IECC):

- Air sealing: 3.0 ACH50 (maximum)
- Windows: 0.30 U-factor (maximum)
- Ceilings: R-49 (minimum)
- Exterior frame walls: R-20 cavity + R-5 continuous (minimum)
- Mass walls: R-15/R-19 (minimum)
- Basement walls: R-15 continuous / R-19 cavity (minimum)
- Crawl space walls: R-15 continuous / R-19 cavity (minimum)
- Slab-on-grade perimeter: R-10 to 4 feet below grade (minimum)

Assemblies with equivalent U-Factors will also comply.

Applicability

Heating System Type: Applies to buildings with electric heat as primary heat source.
Exception: Primary heat source is a ground-source electric heat pump designed by a licensed design professional to operate without the use of supplemental electric resistance heat.

New Construction: Applies

Existing Buildings/Additions: Applies to addition portion when addition uses electric heat (whether existing portion of building uses gas or electric heat)

Existing Buildings/Alterations: Does not apply

Intent

Energy savings and peak electrical demand reduction

Benefits and Costs

Triple Bottom Line Benefits

People: Increased thermal comfort

Economic:

- Electric bill savings for prototype home approximately $300 to $400 per year (energy modeling)

- Peak demand reduction and associated deferral of electrical system capacity expansion

Environment: Benefits associated with decreased energy use

Costs Passed to Owner

Estimated cost increases for prototype home (including builder margin):

- Windows. Assuming no change in frame material, the cost increase for a lower U-factor, dropping from 0.35 to 0.30, is low. Assuming 16 windows, total increase is approximately $450.
- Ceiling insulation. Increase from R-38 to R-49 is approximately $475, for either blown fiberglass or cellulose insulation.
- Exterior frame walls. Increase for lowest cost approach is approximately $750. This assumes the base case is a 2x6 wall with R-20 cavity insulation and OSB sheathing. The lowest cost upgrade to meet the proposed requirement is to sheath the exterior with rigid, one-inch, R-5 extruded polystyrene foam board. Meet sheer bracing requirements with half-inch OSB, overlaid with half-inch foam, at corners and as needed elsewhere. Door jambs are extended.
- Basement walls. Increase for lowest cost approach is approximately $550. This assumes the base case is an unfinished basement insulated with vinyl-faced, R-11 interior fiberglass drape, ungraded to a similar product rated R-19.
- Air leakage reduction. Approximately $100 increase. Minimal cost for this based on 2007 new home performance study observations (see "Context" below).
- Total cost increase for the prototype building, with a basement, is estimated in the range of $2200 to $2500 ("Very high" cost).

Cost increases for the other two foundation types:

- Crawl space walls. Increase from R-11 continuous blanket to R-19 continuous blanket is approximately $270. (Note: few new Fort Collins homes have crawl spaces; when they do, the crawl space is frequently a small portion of the total foundation.)
- Slab-on-grade perimeter. Increase from R-10 rigid insulation board, extending 2' below grade to the same product, extending 4' below grade, is approximately $475.

Lost Opportunity

The components addressed in this proposed amendment include some that will likely never be altered once the building has been built (air sealing, frame walls, slab-on-grade perimeter), others that will be very infrequently addressed (windows, typical service life 20+ years, high replacement cost) and others that could be modified, at higher cost, at any time (attics, crawl space walls). The situation varies for basement walls depending on whether the basement is finished or unfinished.

Implementation

Availability of Products and/or Services

The only potential obstacle appears to be that few, if any, wood-framed windows meet the 0.30 U-factor specification. This requirement can be met with vinyl-framed and some composite-framed windows. It is anticipated that more choices will be available soon, as ENERGY STAR has adopted this window specification.

Practicality

The most challenging proposed change is liable to be the frame walls requirement; it will require exterior foam sheathing (currently used by a small number of builders) with alternative methods

used to meet shear requirements, framed walls of 2x8 construction or alternative building systems (e.g. structural insulated panels, double-frame-wall).

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Plan reviewer will check thermal specifications for these building components. (No change from current procedures)

Field inspection: Building inspectors will check that specified materials have been installed. (No change from current procedures)

Certificate of Occupancy: Nothing additional.

Support Materials Needs
None

Training Needs - Industry
No training specific to this proposed amendment is needed. These changes will be addressed in mandatory training on building code updates and comprehensive building envelope training.

Training Needs – Staff
None

Background

Current Practice
In previous versions of the Fort Collins building code, new Fort Collins electrically heated buildings were required to meet more rigorous thermal specifications than gas-heated buildings (see table in "Context" below).

No field surveys of electrically heated buildings have been performed to confirm that these specifications were followed. In recent years, most builders chose to comply with energy code using the Simulated Performance Alternative path, which provided many tradeoff opportunities.

According to Building Department records, no new electrically heated single-family homes have been built in Fort Collins for at least six years (with the exception of a very small number of ground-source heat pumps, exempted from this proposed requirement). Electric heat is used on occasion in remodels and additions.

Context
Since at least the 1996 energy code, Fort Collins has locally amended the model codes to require electrically heated buildings to meet more stringent building envelope thermal specifications than for gas-heated buildings. This reflected the substantially higher cost of delivered energy for electric heat compared with gas heat. Currently, delivered energy from electric heat at 100% efficiency is approximately 2.5 times more expensive than delivered energy from gas heat at 80% efficiency.

The 2009 IRC, adopted by City Council in September 2010, makes no distinction between requirements for buildings with electric versus gas heating systems. The recently adopted code reduces envelope thermal specifications for electric heat. The proposed amendment will restore the approach used in the past. The following table compares requirements in the 2005 Fort Collins code versus the 2009 IECC and this proposed amendment.

	Building Envelope Thermal Specifications		
Component	**2005 FC Code (electric heat)**	**2009 FC Code (any heating system)**	**Proposed green amendment (electric heat)**
Air sealing	ACH 5.0 (blower-door compliance path)	ACH 7.0 (1)	ACH 3.0
Windows	0.35 U-factor	0.35 U-factor	0.30 U-factor (5)
Ceilings	R-49	R-38	R-49 (2,3,4)
Wood frame walls	R-21	R-20 or R-13+R-5	R-20+R-5
Mass walls	R-15	R-13 / R-17 (R-17 applies if more than half the insulation is on interior of mass wall)	R-15 / R-19 (R-19 applies if more than half the insulation is on interior of mass wall) (2,3)
Basement walls	R-10 continuous or R-13 cavity in frame construction	R-10 continuous or R-13 cavity in frame construction	R-15 continuous or R-19 cavity in frame construction (3)
Crawl space walls	R-19	R-10 continuous or R-13 cavity in frame construction	R-15 continuous or R-19 cavity in frame construction
Slab-on-grade perimeter	R-10 to 4' below grade	R-10 to 2' below grade	R-10 to 4' below grade (2,3)

(1) Another proposed green amendment would lower this to ACH 4.0 (see Air Sealing amendment)
(2) Matches 2005 Fort Collins code electric heat requirement
(3) Matches specification in 2009 International Energy Conservation Code, Climate Zone 6.
(4) Matches specification in draft 2012 International Energy Conservation Code, Climate Zone 5 (which is not tied to type of heating fuel)
(5) Matches ENERGY STAR window requirement for this climate zone. Draft 2012 International Energy Conservation Code (which is not tied to type of heating fuel) specifies 0.32 U-factor.

If any of the proposed component requirements is an obstacle for a particular project, alternative code compliance options (UA tradeoff, Simulated Performance Alternative) provide flexibility.

Related Green Building Practices

Installation details for building envelope components are critical in achieving installed performance that matches rated performance. These details are addressed with other proposed amendments (Air Sealing, Insulation Installation, Fenestration Installation).

Known Objections

- Higher first cost for electrically heated buildings

Green Building Practice Summary 3/10/2011

Sector: Residential

Category/Practice: Energy Efficiency / Basement Windows

Proposed GB Practice

Description

Require basement windows to provide performance comparable to windows used in other living areas, by setting U-Factor = 0.40 maximum for any window when area-weighted U-Factor tradeoffs are used to comply with code.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies only to addition portion

Existing Buildings/Alterations: Does not apply.

Intent

Set stage for energy-efficient, comfortable living space when basement is finished.

Benefits and Costs

Triple Bottom Line Benefits

People:

- Improved thermal comfort in basement
- Reduced winter condensation on basement windows

Economic:

- Energy savings (very low)
- Avoided cost for window replacement when basement is finished (approximately $500 per window)
- Less maintenance related to condensation on windows

Environment:

- Fewer discarded building materials
- Environmental benefits associated with energy savings (small)

Costs Passed to Owner

"Very low" to "low" cost ($75 maximum). The maximum cost will be the difference in cost between a vinyl-framed, low-e insert or window versus a vinyl-framed, clear-glass insert or window (times the number of basement windows). Since the 2009 IRC prescriptive window U-factor requirement is more stringent than the U-factor specified in this amendment (see "Context" below), it is questionable whether any cost should be assigned to this item.

Lost Opportunity
It is much less expensive to initially install a higher quality window than to replace a lower quality window later.

Implementation

Availability of Products and/or Services
Products and qualified contractors are readily available.

Practicality
No obstacles foreseen

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Plan reviewer will check thermal specifications for basement windows, submitted with plans. (Slight change from current procedures)

Field inspection: Building inspectors will check that basement windows with qualifying specifications have been installed. (Slight change from current procedures)

Certificate of Occupancy: N/A

Support Materials Needs
None

Training Needs - Industry
No specific training on this requirement is needed; it will be covered in mandatory training on building code updates.

It may be useful to offer contractor training on installation approaches for basement windows, with an objective of reducing the practice of using pour-in-place metal bucks.

Training Needs – Staff
None

Background

Current Practice
The following observations were made in a 2007 field survey of new Fort Collins homes:

- In all homes with garden level or walkout basements, windows installed in the frame portions of basement walls were of the same style and properties as windows in the main and upper living levels.
- Windows set in basement foundation walls followed a different pattern:
  > Low-e, solar-control windows (U-Factor 0.35 to 0.39) in about 40% of homes
  > Conventional, uncoated windows (U-Factor 0.49 to 0.50) in about 60% of homes
- Basement windows in foundation walls were installed in a variety of ways:
  > Direct set to concrete foundation: about 50%
  > Set into metal bucks poured into concrete foundation: about 50%

> Set into timber frame built into insulated concrete form foundation: one home

Context

Most Fort Collins homes have basements. In most new homes, these spaces are unfinished but some preparations are typically made during construction with the expectation that home owners will finish the basement as living space. For example, plumbing is roughed in so that a bathroom can be relatively easily added.

High-performance windows with low-e coatings had reached almost 100% market penetration in Fort Collins 2007 new construction. However, as noted above in "Current Practice," basement windows in the majority of homes incorporated conventional, clear, uncoated glass. Compared with the low-e coated windows, conventional windows have higher heating and cooling loads, compromise comfort and are more vulnerable to condensation. When basements are finished as living space, owners will either put up with these disadvantages or replace the windows with units comparable to the rest of the house. Installing windows with comparable performance when the house is built avoids this problem.

The 2009 IRC prescriptive path requires windows to have an area-weighted average U-Factor of 0.35 or below. It also specifies that the maximum U-Factor allowed in an area-weighting tradeoff equals 0.48. This proposed amendment drops the latter to U-Factor = 0.40 maximum (equal to the 2009 IRC specification for Climate Zone 6).

A related issue, probably best addressed via training, is the basement window installation approach. As noted above in "Current Practice," about half the homes surveyed in 2007 used metal bucks, part of the concrete formwork that is left in place after the foundation is poured. These bucks serve as thermal short-circuits that undermine the rated performance of the window.

Related Green Building Practices

N/A

Known Objections

None identified

Green Building Practice Summary 3/10/2011

Sector: Residential

Category/Practice: Energy Efficiency / Air Sealing

Proposed GB Practice

Description

Comprehensive air sealing to meet a moderately tight measured performance standard (4.0 ACH50 maximum) and provide an effective air barrier between living space and attached garage.

Performance testing will be performed by certified contractors.

Note: another proposed amendment lowers the whole-building leakage requirement to 3.0 ACH50 for electric-heat building (see "Electric-Heat Envelope Specifications").

Applicability

New Construction: Applies, performance testing required (blower-door test of whole-building air leakage and zonal isolation between conditioned space and garage).

Existing Buildings/Additions: Prescriptive air sealing requirements apply to the addition but not the existing building (visual inspection, no testing required)

Existing Buildings/Alterations: Prescriptive air sealing requirements apply to portions of the building being modified, when access permits (visual inspection, no testing required)

Intent

Capture energy, comfort, durability and health benefits by reducing uncontrolled air leakage and isolating a common source of pollutants from the living space.

Benefits and Costs

Triple Bottom Line Benefits

People:

- Improve indoor air quality by isolating conditioned space from exterior pollutant sources
- Enhance thermal comfort by reducing drafts and improving insulation performance
- Improve comfort by providing more occupant control over indoor humidity levels
- Improve indoor air quality by reducing moisture condensation that can support mold growth

Economic:

- Save energy by reducing the heating and cooling load associated with infiltration (Modeled savings by decreasing air leakage from ACH50=7.0 to ACH50= 4.0 ~$100/yr for gas heat, $250/yr for electric resistance heat. However, as noted below in "Context," ACH50=7.0 is a hypothetical baseline.)

- Save energy by reducing thermal bypasses through insulation (i.e. reducing air leakage helps insulation perform at its rated R-value)
- Improve building durability by preventing air-transported moisture from entering building cavities

Environment: Environmental benefits associated with lower energy use

Costs Passed to Owner

Builders should incur no new construction costs to meet this air sealing target, since 2007 Fort Collins practice averaged considerably tighter than the proposed requirement.

For new construction, blower-door testing costs are estimated to be "low"($200 maximum for third-party testing, if this is the only reason the testing contractor is making a site visit and this is the only performance testing being performed). In many cases, costs will be lower.

Lost opportunity

It is much easier and less expensive to meet tightness targets during initial construction.

Implementation

Availability of Products and/or Services

Air sealing materials, the expertise to effectively install them and certified blower-door testing contractors are widely available.

Practicality

No practical obstacles have been identified.

Certification Issues

RESNET or BPI Building Analyst certification (or other credential approved by the Building Official) required to conduct performance testing. Testing may be performed by the same company that provided air-sealing services; i.e. third-party testing is allowed but not required.

To be completed: do these certifications include training re garage isolation testing?

Enforcement Procedures

Permit application/plan review: Building conditioned volume must be included on plans.

Field inspection: Building inspectors will visually verify prescriptive air-sealing requirements have been completed. (Higher level of detail than current procedures)

Certificate of Occupancy: For new construction, applicant must turn in signed performance-testing results documenting compliance. The document will include the testing contractor's certification number and expiration date. (Little change from current procedures, since most new homes in recent years have met air-sealing requirements via a blower-door test result.)

Support Materials Needs

- A field guide, illustrating required building envelope details (including acceptable and unacceptable products and techniques for air sealing, by location), would be very useful for contractors and enforcement staff.

- Reference needed for full details of garage isolation test
- Blower-door testing compliance form
- A City-maintained list of certified performance-testing contractors may prove useful

Training Needs - Industry
Since this proposed requirement is commonly exceeded in new construction (see "Current Practice," below), there is not a strong need for specific air sealing training. However, comprehensive contractor training on building envelope details will be useful, ideally supported with a field guide illustrating required and recommended techniques (see "Support Materials Needs" above).

Training on garage isolation testing may be needed for contractors conducting the performance testing.

Training Needs – Staff
Building inspectors will need training to consistently identify air barrier problems. This can be covered in more general training about inspection of building envelope details. Training will be needed to review compliance documents submitted by contractors.

Background

Current Practice
A 2007 survey of new Fort Collins homes showed that tightness averaged 3.0 ACH50, with a range from 1.9 to 4.2 ACH50 (air changes per hour at the standard test pressure of 50 Pascals). The testing sample included 12 single-family detached homes. Visual inspection showed that the large holes observed in earlier surveys were generally being effectively sealed, though many smaller opportunities to further tighten the building envelope remained. The survey also tested the separation between living spaces and attached garages and generally found it quite effective.

Context
New homes have gradually become tighter over several decades, due to customer expectations of greater thermal comfort (fewer drafts and cold spots), increasing use of sheet goods in construction, increasing energy costs, availability of specialized air sealing tools and products, increasing awareness of where buildings leak and how to seal the holes, increasing use of blower-door testing to quantify performance and provide feedback, and increasing building code attention to this topic. However, until recently, model code air-sealing language left wide latitude for interpretation.

Building scientists have been stressing the benefits of a complete "air barrier" since the early 1980s. Fort Collins has provided builder training about building a quality building envelope since the late 1980s. The City was a leader when it developed the 1996 energy code. This code allowed builders to either follow a detailed prescriptive checklist of air-sealing locations or demonstrate compliance with the air sealing requirement with a blower-door test result of 5.0 ACH50 or less. Since then, builders have increasingly used the performance-testing option.

A survey of Fort Collins homes built in the mid- to late-1990s showed moderately tight construction. The average leakage rates for homes built before and after the code change were 5.6 and 4.7 ACH50, respectively. The overall range of tightness was more than a factor of four, from 2.4 to 11.4 ACH50. Large "thermal bypasses" were frequently observed.

The City of Fort Collins Builder's Guide to Energy Efficient Construction, published in 1997, reinforced required and recommended building envelope practices, including tight construction.

A tight construction fact sheet, developed by the City and E-Star Colorado, has been widely distributed since 2003.

In 2006, the U.S. EPA introduced the "Thermal Bypass Checklist," with accompanying field guide, as part of its ENERGY STAR New Homes program guidelines. The checklist addresses important air sealing and insulation details and provides a systematic inspection approach.

Since the Fort Collins code was updated in 2005, builders have largely used the "Simulated Performance Alternative" path to demonstrate compliance with the energy code as a whole. This has led to a close working relationship between builders and third-party energy raters. This, in turn, has provided ongoing educational opportunities in the field, as energy raters spot building envelope problems and coach builders and trade partners on effective details to plug leaks. The "Thermal Bypass Checklist" was informally used in this process. The 2007 new home survey results, reported in "Current Practice," illustrates the progress that has been made since the 1990s survey: an approximately 40% reduction in average air leakage and much more consistency in house tightness.

The 2009 IRC is the first edition of the model codes to reference "air barrier" and include an air-leakage testing option to document code compliance. However, it takes a big step back in performance, setting a requirement of 7.0 ACH50 in all climate zones, i.e. 40% greater than the 1996 Fort Collins code benchmark and more than twice the average measured leakage of new Fort Collins homes built in 2007. Though no explanation is given in the code documents about how this level was chosen or why it does not vary with climate, it is almost certainly related to long-held misperceptions about the relationship of air tightness and indoor air quality (that are referenced in widely published standards). The City's current code includes the 2009 IRC tightness standard.

The City's green amendment proposals support a systems approach to improving indoor air quality; a tight building envelope is a key component (see "Related Green Building Practices" below).

The proposed tightness standard (4.0 ACH50) represents a readily achievable level; through training, the City will encourage even tighter buildings. (See another proposed amendment that would require new buildings with electric resistance heat to achieve a lower leakage rate: 3.0 ACH50 maximum.)

National voluntary energy efficiency and green building rating systems encourage tighter construction as part of a systems approach. The proposed tightness standard matches the ENERGY STAR New Homes Version 3 guideline for this climate zone (to be fully effective in January 2012). LEED/Homes sets a maximum leakage rate of 5.0 ACH50 and awards points for leakage reduction to 3.5 and 2.5 ACH50; NGBS awards points for air leakage rates from 5.0 to 1.0 ACH50.

The draft 2012 International Energy Conservation Code includes a tightness requirement of 3.0 ACH50 in this climate zone, with a mandatory blower-door test.

The requirement for an effective air barrier between living space and garage recognizes that the garage is a frequent source of pollutants: automobile exhaust, gasoline, other chemicals stored in the garage. The 2009 IRC provides an explicit requirement that "walls and ceilings separating a garage from conditioned spaces" be sealed. The proposed code measure reinforces that with required performance testing to verify the intent of this requirement is being met.

Related Green Building Practices

A tight envelope is a key part of a systems approach to buildings that are comfortable, durable, energy efficient and have healthy indoor air. These practices go hand-in-hand:

- Tight construction
- Insulation thermal specifications and installation practices
- Safer combustion appliances
- Controlled ventilation

Known Objections

- Some feel that tighter buildings have poorer indoor air quality.

Green Building Practice Summary 03/17/2011

Sector: Residential

Category/Practice: Energy Efficiency / Insulation Installation

Proposed GB Practice

Description

All insulation must be installed to Residential Energy Services Network (RESNET) Grade I standard, except as follows:
RESNET Grade II will be accepted for cavity insulation in two locations:

1. Exterior walls which include continuous rigid insulating sheathing, insulated siding or combination of the two, R-5 minimum; and
2. Rim joists.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies only to the addition portion

Existing Buildings/Alterations: Applies to building envelope components for which insulation is being altered

Intent

Install insulation so it delivers rated energy performance

Benefits and Costs

Triple Bottom Line Benefits

People: Enhance thermal comfort by improving insulation performance.

Economic: Save energy by improving the effective R-value of insulation.
Energy savings are estimated to be in the range of $30 to $60 per year.

Environment: Environmental benefits associated with lower energy use.

Costs Passed to Owner

"Medium" cost ($200 to $350). As described in "Context" below, this proposed measure effectively represents a continuation of insulation installation requirements that have been part of the Fort Collins code since 1996. Cost increases represent an elimination of low-bid practices that have slipped by in the past.

Lost Opportunity

There are many components for which time of construction is the only opportunity to effectively install insulation.

Implementation

Availability of Products and/or Services
A wide variety of insulation products is available in the Fort Collins market. Local contractors are able to install insulation to meet the proposed requirements.

Practicality
Some types of insulation are easier to effectively install than others.

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Insulation details must be provided.

Field inspection: Visual inspection of all installed insulation will be performed by City building inspectors. At final inspection, access into attic, including ladders, will be required to inspect attic insulation.

Certificate of Occupancy: See above.

Support Materials Needs
A field guide, illustrating required building envelope details (including insulation installation techniques that meet and don't meet the proposed RESNET grade), would be very useful for contractors and enforcement staff.

Training Needs - Industry
Training is needed, for builders, insulation contractors and building inspectors, to set common expectations about installation requirements. This can be handled as part of comprehensive contractor training on building envelope details, ideally supported by a field guide.

Training Needs - Staff
Building inspectors will need training to consistently grade installed insulation. This can be covered in more general training about inspection of building envelope details.

Background

Current Practice
A 2007 survey of new home construction in Fort Collins yielded the following observations about insulation installation:

- In framed exterior walls, where blown insulation products were used (about 50% of those surveyed), Grade I installation was typical. When fiberglass batts were used, there was a lot of variation; most walls were rated Grade II.
- Flat attics, insulated with blown insulation products, were generally rated Grade I (note: though the installation quality was quite good, the installed R-value in the majority of attics was significantly below the claimed R-value).
- Vaulted sections of attics, typically insulated with fiberglass batts, were generally rated Grade III. Problems were often observed at the edges of vaulted ceilings meeting flat ceilings.

- In a very small sample of cathedral ceilings (i.e. ceilings with no attic), installations ranged from Grade I to Grade III.
- Problems were repeatedly observed at rim joists, cantilever floors and knee walls. These were quite consistently rated Grade III or below.

Context

Insulation is an example of a product that will not deliver its manufacturer-specified R-value if it is not properly installed. Performance will be compromised if there are gaps, voids, compression or opportunities for air to move through, past or around the insulation (thermal bypass). To perform as expected, all these problems must be avoided with careful installation and coordination of insulation and air barrier.

The performance degradation with improper installation has been increasingly recognized since the 1980s. Fort Collins has provided builder training about detailing a quality building envelope since the late 1980s. The City was a leader when it developed the 1996 energy code. Referenced in the code were the *Fort Collins Insulation Guidelines*, a detailed set of requirements for insulation installation for each building envelope component.

The City of Fort Collins Builder's Guide to Energy Efficient Construction, published in 1997, reinforced required and recommended building envelope practices including proper insulation installation.

A survey of Fort Collins homes built in the mid- to late-1990s showed wide variation in insulation installation practices, with many consistent problem areas. Infrared images showed how insulation installation flaws affected performance.

An insulation fact sheet, developed by the City and E-Star Colorado, has been widely distributed since 2003. It includes an emphasis on proper insulation installation.

In 2006, the Residential Energy Services Network, more commonly known as RESNET, published an insulation installation grading system as part of its Mortgage Industry National Home Energy Rating Systems Standards. The system assigns a Grade I (best), II, or III to insulation in each component. The specifications for even Grade III are fairly stringent.

The practices observed in new Fort Collins homes in 2007 (see "Current Practice," above), compared with the late 1990s, showed significant improvement in certain areas, particularly when blown or spray foam insulation products were used.

National voluntary energy efficiency and green building rating systems have gradually placed increasing emphasis on proper insulation installation and have begun to reference the RESNET grading system. EPA's ENERGY STAR New Homes "Thermal Bypass Checklist," published in 2006, addresses important air sealing and insulation details and provides a systematic inspection approach. ENERGY STAR Version 3 guideline for this climate zone (to be fully effective in January 2012), require RESNET Grade I practices, with only minor exceptions. LEED/Homes has a prerequisite of Grade II, with points awarded for Grade I. NGBS awards points for third-party inspections of Grade I or II.

The 2009 IRC also places increasing emphasis in this area than earlier model codes, providing more detailed requirements for insulation installation in specific locations. However it does not

take a comprehensive approach and could be interpreted as a step backward from the *Fort Collins Insulation Guidelines*. It does not reference the RESNET grading system. It is fuzzy on the need to fully encapsulate insulation to prevent thermal bypasses in common problem areas. This proposed amendment restores the intent of those guidelines by referencing an increasingly well-known standard.

Two exceptions are proposed for which Grade II would be accepted. The first, for frame walls with exterior insulation, mirrors the exception in ENERGY STAR New Homes Version 3. It recognizes that rigid foam board insulation (which must be applied to RESNET Grade I standards) mitigates problems with cavity insulation. The second exception, for rim joists, reflects the reality that an improvement from current practice to Grade II is a large step up from typical current practice.

Related Green Building Practices

A properly insulated envelope is a key part of a systems approach to high-performance buildings. These requirements go hand-in-hand with tight construction.

Known Objections

None

Green Building Practice Summary 3/10/2011

Sector: Residential

Category/Practice: Energy Efficiency / Heating + Cooling System Design

Proposed GB Practice

Description

Add these provisions to code requirements for heating and cooling system design:

- Design load calculations must include room-by-room heating and cooling loads.
- Central air conditioner evaporator coils, central air conditioner condensing units and air handlers (furnaces) must be matched; an Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certificate must be submitted.
- Key design parameters must be documented.

Applicability

New Construction: Applies in full

Existing Buildings/Additions:

- Applies in full when the addition work scope includes a new heating/cooling system serving the addition alone
- Applies in full when the existing building's heating/cooling system is extended to serve the addition and the heating/cooling equipment must be resized to meet the loads.
- Applies in part when the existing building's heating/cooling system is extended to serve the addition and the existing heating/cooling equipment is adequate to meet the loads; room-by-room load calculations are not required.

Existing Buildings/Alterations: Applies in part to heating/cooling equipment replacement. Exceptions: Room-by-room heating and cooling load calculations and AHRI-matched components are not required.

Intent

Design heating and cooling systems that satisfy comfort needs and perform in accordance with manufacturer specifications.

Benefits and Costs

Triple Bottom Line Benefits

People:

- Improved thermal comfort
- Improved sense of control over heating and cooling of living spaces

Economic:

- Potential for savings due to reduced size of "right-sized" equipment (reflected in "Costs Passed to Owner," below)

- Energy savings due to improved installed efficiency of heating and cooling equipment operating correctly in conjunction with the distribution system.
  Savings estimate for the combination of more careful design and commissioning (i.e. this amendment + HVAC Commissioning amendment): 5% to 10% reduction in heating + cooling energy use, ~$30-60 per year.
- Enhanced durability of heating/cooling equipment operating within manufacturer specifications.

Environment: Environmental benefits associated with reduced energy use.

Costs Passed to Owner
"Low" cost ($200 maximum). The proposed changes are small refinements to current practice and code requirements. Little additional time will be required on the part of the HVAC contractor. There are potential first cost savings if more careful design results in smaller equipment and/or ductwork. There may be some increased material cost associated with lower-pressure-drop duct transitions.

Lost Opportunity
Quality performance begins with quality design. It can be difficult and expensive to try to improve performance of a poorly designed system after the fact.

Implementation

Availability of Products and/or Services
Many local HVAC contractors are capable of meeting these additional requirements or are already doing so as a matter of practice.

Practicality
The proposed requirements are a small refinement of existing code requirements; see "Context" below.

Certification Issues
None

Enforcement Procedures

Permit application/plan review: The additional information required by the proposed amendment (including the AHRI certificate) will be submitted by the builder or HVAC contractor with heating/cooling design information required by the existing code.

Field inspection: Building inspectors will check to see that specified components have been installed.

Certificate of Occupancy: N/A

Support Materials Needs
Form to document submittal requirements.

Training Needs – Industry

Training will be needed by some HVAC contractors on heating/cooling system design, installation and commissioning; the training will cover the details addressed by these proposed requirements.

Training Needs – Staff

A small amount of training will be required to be able to review the submitted documentation.

Background

Current Practice

HVAC contractors complete and submit whole-building design load calculations and duct designs for new construction, in accordance with code requirements. The calculations often include room-by-room design loads.

When heating/cooling equipment is replaced in existing buildings, the Building Department does not require design load calculations. Some HVAC contractors perform these calculations, others do not.

Matched heating and cooling equipment components have not been required by code. It is unknown what proportion of systems use matched components.

Context

In the past, heating and cooling system design was largely based on rules-of-thumb that have proven to be unacceptable. Results have included oversized equipment, poor matches between equipment and distribution systems, equipment that doesn't operate within manufacturer specifications, poor thermal comfort and, among many occupants, a sense that they have little control over their heating and cooling systems. These observations were documented in a survey of Fort Collins homes built in the mid- to late-1990s. They are not exclusive to Fort Collins; similar issues have been observed nationally.

Awareness of these issues has markedly increased in the past decade with information and training. Code revisions have gradually tightened requirements for heating/cooling system design. The 2009 IRC requires that heating + cooling equipment be sized in accordance with design building loads calculated with ACCA Manual J and ACCA Manual S and that ductwork be designed in accordance with ACCA Manual D or equivalent procedures (ACCA is the Air Conditioning Contractors of America, a national trade association of HVAC contractors). The City has sponsored design load calculation training.

Since 2002, contractors designing systems for new construction have submitted Manual J design load calculations and a Manual D ductwork design as part of the permit application. Building Department staff has limited expertise to review the submittals.

The same issues experienced locally have been observed nationally. Research has gradually improved understanding of effective design, installation and testing procedures to improve the installed performance of heating and cooling systems. The Consortium for Energy Efficiency and ACCA worked together to develop an ANSI-approved national standard: *HVAC Quality Installation Specification*, ANSI/ACCA 5 QI-2007. It follows a systems approach, from design through installation, performance testing, documentation and owner education.

ENERGY STAR New Homes Version 3 guidelines (which will be fully effective by January 2012), include an approach in alignment with the ACCA Quality Installation standard. ENERGY STAR's new checklists for HVAC contractors and energy raters provide a practical, organized means for fulfilling the standard's requirements. The contractor checklist documents design parameters on one side; on the back side, performance measurements are documented, the contractor answers pass/fail questions about meeting the standard and signs the form. The City could choose to use or adapt this public domain model.

Other voluntary green building rating systems, such as LEED/Homes and NGBS, include subsets or variations of these requirements.

The proposed requirements add some relatively minor provisions to the code so that it more closely matches the ACCA Quality Installation standard.

Related Green Building Practices

This proposal ties closely to the HVAC Commissioning proposal.

Known Objections

None identified

Green Building Practice Summary 12/13/2010

Sector: Residential

Category/Practice: Energy Efficiency / HVAC Commissioning

Proposed GB Practice

Description

Add more specific language to the code to:

- Require testing of heating, cooling and ventilation systems to compare installed performance versus design specifications
- If a system is operating out of tolerance, the problems must be addressed and the system must be retested.
- Repeat this cycle until the system passes all tests.
- Document results.

Commissioning will be performed by certified contractors.

Applicability

New Construction: Applies in full

Existing Buildings/Additions: Applies when the addition work scope includes a new heating/cooling system.

Existing Buildings/Alterations: Applies with a more limited commissioning scope (reflecting inaccessibility of ductwork in many buildings). Likely limitations:

- No requirement to test duct leakage
- No requirement to seal ductwork
- No requirement to test and match room-by-room flows
- Greater tolerances for elevated static pressure and low air flow

Intent

Verify that HVAC systems perform as designed, meeting comfort needs and performing in accordance with manufacturer specifications.

Benefits and Costs

Triple Bottom Line Benefits

People:

- Improved thermal comfort
- Improved sense of control over heating and cooling
- Healthier indoor air

Economic:

- Energy savings due to improved installed efficiency of heating and cooling equipment operating correctly in conjunction with distribution system.
  Savings estimate for the combination of more careful design and commissioning (i.e. this amendment + HVAC Commissioning amendment): 5% to 10% reduction in heating + cooling energy use, ~$30-60 per year.
- Enhanced durability of HVAC equipment operating within manufacturer specifications.

Environment: Environmental benefits associated with reduced energy use.

Costs Passed to Owner

"Medium" cost ($200 to $300). Full-service HVAC contractors already provide these services. Contractors installing low-bid HVAC systems probably are not. They will need to attend training, purchase equipment and spend more time performance-testing the installed systems.

No additional time is assumed for addressing problems identified with the testing. Experience with other quality assurance processes suggest short learning curves when contractors begin receiving quantitative feedback on their work.

Lost Opportunity

Access to address ductwork problems is typically very limited after initial construction.

Implementation

Availability of Products and/or Services

Some local HVAC contractors are already offering these services. Others do not have the equipment or experience. A contractor certification process must be formalized to implement this proposed requirement.

Practicality

The proposed requirements are a small adjustment to existing code requirements; see "Context" below. Tolerances for passing specific testing requirements in the proposed approach are generous, providing a good step toward better performance while not setting an unreasonably high hurdle. The City may choose to more tightly define allowed testing procedures.

A practical challenge to be addressed is that the test for air conditioner refrigerant charge typically may only be performed when outdoor temperature is 55^{o}F or above. This limits testing of one parameter during colder months.

Certification Issues

Contractor certification requirements must be established; i.e. who will be allowed to perform or oversee the testing and sign off on the commissioning form. This could be based on approaches developed for the City's Home Efficiency Program or, more likely, a newly developed credential from the Air Conditioning Contractors Association in support of the ANSI/ACCA *HVAC Quality Installation Specification* (see "Context" below).

Testing may be performed by the same company that installed the HVAC system; i.e. third-party testing is allowed but not required.

Enforcement Procedures

Permit application/plan review: N/A

Field inspection: N/A

Certificate of Occupancy: Applicant will submit completed, signed commissioning form documenting compliance with requirements. The document will include the testing contractor's certification number and expiration date.

Challenge: Air conditioner refrigerant charge generally cannot be tested when outdoor temperature is below 60 F. This may be addressed through temporary Certificate of Occupancy or by allowing this test to be bypassed if the AC equipment includes a Thermal Expansion Valve (which compensates to some degree for improperly charged equipment).

Support Materials Needs
Commissioning documentation form

Training Needs – Industry
Some local contractors are already familiar with all of the procedures embodied in this proposed requirement, through industry training, training offered recently through the City's Home Efficiency Program or the regional Select HVAC program. Comprehensive training will be needed by some contractors on HVAC system design, installation and commissioning. All contractors wishing to become certified will need some training.

One particular area in which training will be needed is accurate measurement of air flow through registers.

Training Needs – Staff
Building Department needs additional expertise to review submittals.

Background

Current Practice
With some exceptions, there is little evidence that most HVAC systems receive more than a cursory start-up test after installation. Many systems operate outside of manufacturer specifications. Many residents complain that their HVAC systems don't meet comfort needs and that they feel they have little control over them.

Context
According to the Building Commissioning Association, commissioning is defined as documented confirmation that building systems function in compliance with criteria set forth in the project documents to satisfy the owner's operational needs.

In the past, heating and cooling system design and installation was largely based on rules-of-thumb that have proven to be unacceptable. Ductwork was often laid out on the job site rather than following a carefully planned design. Little performance testing was conducted after systems were installed. Results have included oversized equipment, poor matches between equipment and distribution systems, equipment that doesn't operate within manufacturer specifications, poor thermal comfort and, among many occupants, a sense that they have little control over their heating and cooling systems. These observations were documented in a survey

of Fort Collins homes built in the mid- to late-1990s. They are not exclusive to Fort Collins; similar issues have been observed nationally.

The City has provided contractor training on these issues since the early 1990s. Awareness of these issues has markedly increased in the past decade with information and training. Code revisions have gradually tightened requirements for heating/cooling system design, installation and testing. The 2005 City code required that:

- Heating + cooling equipment is sized in accordance with the building load calculated with ACCA Manual J and that ductwork be designed in accordance with ACCA Manual D. ACCA is the Air Conditioning Contractors of America, a national trade association of HVAC contractors.
- "All heating and cooling equipment shall be tested to ensure such equipment is operating within the manufacturer's recommended operating parameters and standards, including within such parameters and standards for sufficient combustion, according to the applicable protocols established by the building official and in accordance with the mechanical code adopted by the City."
- Prior to receiving a Certificate of Occupancy, HVAC contractors submit signed mechanical systems disclosure forms listing installed equipment and stating that the installations were in compliance with code.

Though a large amount of local progress has been made in HVAC system design and installation, there is still little evidence that most systems are performance tested after installation. A 2007 survey of new Fort Collins homes documented wide ranges for HVAC performance parameters and systems operating out of specification for static pressure and air flow.

The 2009 IRC adds requirements that:

- Equipment be sized in accordance with ACCA Manual S procedures
- Duct systems in which any portion is located in unconditioned space must be leak-tested and meet maximum leakage requirements.

The disclosure requirement from past Fort Collins codes was not carried over to the recently adopted building code.

The proposed requirement provides a more comprehensive and specific framework addressing system installation and testing, tied back to documented design parameters. The intent is to base the details on the *HVAC Quality Installation Specification*, ANSI/ACCA 5 QI-2007, developed by the Consortium for Energy Efficiency and ACCA. This standard takes a systems approach, from design through installation, performance testing, documentation and owner education. This approach provides the HVAC contractor invaluable feedback about how well the installed system operates. A manual, *Technician's Guide for Quality Installations*, is also available from ACCA to support the standard. Updates to the quality installation standard have recently been issued for public review; the updated standard should be available by first quarter 2011.

ENERGY STAR New Homes Version 3 guidelines (which will be fully effective by January 2012), include an approach aligned with the ACCA quality installation standard. It extends the ACCA 5 approach to ventilation systems. ENERGY STAR's new checklists for HVAC contractors and energy raters provide a practical, organized framework for fulfilling the standard's requirements. The contractor checklist documents design parameters on one side of a page. The other side documents performance measurements and pass/fail questions about

meeting the standard, and includes a contractor signature block. This is a model the City could choose to use or adapt.

Other voluntary green building rating systems, such as LEED/Homes and NGBS, include subsets or variations of these requirements.

Related Green Building Practice

This proposed amendment ties closely to:

- Heating and cooling system design
- Whole-building ventilation

Known Objections

Higher first cost

Green Building Practice Summary 3/21/2011

Sector: Residential

Category/component: Water Efficiency / Water-Efficient Fixtures

Proposed GB practice

Description

Plumbing fixtures must meet these maximum water flow or consumption limits:

- Lavatory faucets: 1.5 gpm at 60 psi
- Shower heads: 2.0 gpm at 80 psi
- Sink faucets: 1.8 gpm at 60 psi
- Toilets: 1.28 gallons per flushing cycle, with minimum MaP threshold of 350 grams

Such fixtures shall be Environmental Protection Agency (EPA) WaterSense® labeled fixtures or fixtures which provide the equivalent maximum flow rates.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies only to the addition portion

Existing Buildings/Alterations: Applies to fixtures being replaced

Intent

Save water and energy

Benefits and Costs

Triple Bottom Line Benefits

People: None

Economic: The proposed standards compared to the current water-efficiency standards are intended to reduce water use by approximately 20%. Lower water, wastewater and energy bills for the homeowner. Estimated annual savings of approximately $50, split approximately equally between the three components.

Environment: Environmental benefits associated with lower water and energy use

Costs Passed To Owner

Just as with conventional plumbing fixtures, depending on the style and quality selected there is a wide range of costs for WaterSense® labeled fixtures. Approximate starting price points are:

- Lavatory faucets: under $30
- Toilets: $100

- Showerheads: $10

Information from the EPA WaterSense web site: WaterSense® labeled toilets are not more expensive than regular toilets. MaP testing results have shown no correlation between price and performance. Prices for toilets can range from less than $100 to more than $1,000. Much of the variability in price is due to style, not functional design. Toilets that could potentially bear the WaterSense® label are currently in the low to middle range of about $200. There is a lot of competitive pressure on manufacturers to lower prices; therefore, it can be expected that as more toilets become certified, the average price should fall.

The incremental cost associated with the proposed amendment, assuming 2 bathrooms and a kitchen, is estimated to be "very low" ($0 to $50) to "low" ($50 to $200).

Lost Opportunity
These fixtures last for 20 years or more. Although replacement is relatively easy, fixtures are rarely replaced until they fail.

Implementation

Availability of Products and/or Services
WaterSense® labeled lavatory faucets and high efficiency toilets are widely available from major plumbing manufacturers, plumbing supply distributors and builder supply warehouses, in a wide variety of brands, styles and price points. Products are labeled and readily identified.

Showerheads began to be WaterSense® labeled in mid-2010 and aren't currently as available as the toilets and faucets.

WaterSense® labeled products are listed on the WaterSense website at www.epa.gov/WaterSense/product_search.html .

Practicality
No practical obstacles have been identified. WaterSense® labeled fixtures require essentially the same basic installation procedures as conventional plumbing fixtures.

Certification Issues
Products are labeled through the national EPA WaterSense® process. There are no local certification issues.

Enforcement Procedures

Permit application/plan review: Application specifies that WaterSense® labeled fixtures or fixtures with equivalent maximum flow rates will be installed.

Field inspection: Building inspectors verify that specified products are installed. WaterSense® labels are found on fixtures.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
None.

Training Needs-Industry
No special skills are required to install WaterSense® fixtures. Requirement will be covered as part of mandatory training for all contractors on the recently adopted Fort Collins building codes and green amendments.

Training Needs-Staff
Minor.

Background

Current Practice
Fixtures typically installed meet the federal Energy Policy Act of 1992 standards:
- Toilets = maximum 1.6 gallons per flush (gpf), no performance requirement
- Showerheads = maximum 2.5 gallons per minute at 80 psi
- Lavatory faucets = maximum 2.2 gallons per minute at 60 psi

This mandate was lifted by the Department of Energy (DOE) and is no longer applicable as of December 22, 2010.

Context
Indoor water use averages about half of total water consumption in Fort Collins homes.

Toilets are by far the main source of water use in the home, accounting on average for nearly 30 percent of indoor consumption.

Reducing showerhead flow rates reduces both water and energy use for water heating.

WaterSense® labeled fixtures are the next step in the evolution toward water-efficient fixtures. Lessons learned in previous steps have been brought to bear so that earlier performance problems are avoided. For example, the move in the 1990s from 3.5 gpf to 1.6 gpf toilets was not well conceived. Manufacturers didn't have time to redesign models to provide acceptable performance. This resulted in many dissatisfied users. Since then, a Maximum Performance test (MaP test) protocol has been developed that provides a useful metric for toilet performance. The WaterSense® criteria include a MaP requirement.

According to the EPA:
- WaterSense® specifications include performance criteria to ensure that consumers won't need to sacrifice a good shower in order to achieve water savings.
- Unlike some first-generation, 'low-flow' toilets, WaterSense® labeled toilets combine high efficiency with high performance. Design advances enable WaterSense® labeled toilets to save water with no trade-off in flushing power. In fact, many perform better than standard toilets in consumer testing.

The City currently offers City water customers rebates of $35 for the purchase of WaterSense® labeled toilets and $15 for recycling the old toilet. These rebates are available for toilets replaced in conjunction with existing home alterations, not for new construction.

WaterSense® fixtures are encouraged in voluntary green building rating systems, including LEED/Homes and the National Association for Home Builders National Green Building Standard™.

Related Green Building Practices
None

Known objections

- Concerns about flush performance for WaterSense® toilets.

Sources

WaterSense water savings calculator:
http://www.epa.gov/WaterSense/calculate_your_water_savings.html

DOE - Federal Energy Management Program
http://www1.eere.energy.gov/calculators/buildings.html

Faucets/Showerheads calculator
http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html

Green Building Practice Summary 3/10/2011

Sector: Residential

Category/Practice: IEQ / Safer Combustion Appliances: New Construction

Proposed GB Practice

Description

Most natural draft combustion appliances (furnaces, boilers, water heaters) must be located outside the pressure boundary of the building, in a mechanical room that is sealed from the rest of the building and connected to outdoors via code-required combustion air openings. A self-closing, gasketed door is required. No other exhaust appliances may be located in the mechanical room. Performance testing is required to document that:

- the mechanical room is decoupled from pressure changes within the building;
- natural draft combustion appliances pass the Building Performance Institute (BPI) combustion safety test under "worst-case" conditions.

Natural draft fireplaces, located anywhere in the building, must pass the Building Performance Institute (BPI) combustion safety test under "worst-case" conditions.

All testing will be performed by certified contractors.

When other types of combustion appliances are used that are less vulnerable to spillage of combustion products (power-vented, sealed-combustion or direct-vent appliances), there are no new restrictions on their location and no testing is required to document compliance with this amendment. All appliances designed to operate as sealed-combustion must be installed with hard-piped outdoor combustion air supply and sealed exhaust.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to combustion appliances located in the addition.

Existing Buildings/Alterations: Does not apply (see companion proposed amendment: "Safer Combustion Appliances: Existing Buildings)

Intent

Eliminate potential health and safety hazard of combustion products spilling into building.

Benefits and Costs

Triple Bottom Line Benefits

People: Health and safety for occupants is the primary benefit of this proposed change. Installing combustion equipment more safely or using equipment less vulnerable to spillage of combustion products addresses the root cause of potential health and life safety concerns.

If all combustion appliances are sealed-combustion or direct-vent, with 100% of combustion air directly drawn from outside through sealed ducts, open combustion air ducts can be eliminated; this, in-turn, eliminates a common source of cold drafts and improves occupant comfort.

Economic: By isolating or eliminating the need for open combustion air ducts, a sizable uncontrolled air leak is reduced or eliminated, providing a small reduction in heating and cooling energy use and costs ($10 to $15 per year).

When builders will choose to meet the requirement by selecting sealed-combustion furnaces, there will be savings associated with increased efficiency; virtually all sealed-combustion furnaces are rated at 90+ AFUE, whereas code-minimum furnaces are rated at 80 AFUE. Savings from this change are approximately $50 to $60 per year.

Environment: None

Costs Passed to Owner

The incremental cost estimate to meet the proposed requirement, using code-minimum-efficiency, natural draft space and water heating equipment, is "high" ($1,200 to $1,500). This represents the cost of building a sealed mechanical room and hiring a contractor to perform the testing to document compliance.

Alternatively, compliance can be achieved using combustion appliances that aren't required to be isolated from the building. The aggregate cost increase is "high" ($2000 max) to "very high" (greater than $2000), based on the following appliances:

- Water heater incremental cost: The least expensive water heater option applicable in most new buildings will be power-vented storage units: $500 to $1500 cost increase compared with a conventional, natural draft storage water heater.
- Furnace incremental cost: The increased cost of a basic, single-stage, 90 AFUE sealed-combustion furnace compared with a basic, single-stage, 80 AFUE furnace (code-minimum) is approximately $1000. (Note that 90+ AFUE sealed-combustion furnaces have been installed in most new Fort Collins homes in recent years, so it might be argued the incremental furnace cost is zero.)
- Fireplace incremental cost: No cost. Direct-vent units that meet this requirement are current practice in Fort Collins new construction.

Lost Opportunity

The City encourages installation of safer combustion appliances. Doing so at time of construction avoids lost opportunities associated with support details including gas piping, venting and electrical layout.

Implementation

Availability of Products and/or Services

Products and services are readily available to build mechanical rooms; however, see "Practicality" below regarding the challenge of effectively sealing a mechanical room from the building. Experience will be needed to be able to do so with a reasonable amount of labor.

Combustion appliances not required to be isolated from the building are readily available from all major equipment manufacturers. Local contractors have extensive experience installing sealed-combustion furnaces and direct-vent fireplaces, less so with compliant water heater options. It is anticipated that more widespread use of these products will, over time, decrease their incremental cost versus conventional combustion appliances.

Practicality

To comply with the proposed requirement by using atmospheric appliances will be a challenge. (see "Examples of Compliant Approaches" below). It is considerably more difficult to isolate the mechanical room from the building than one might expect, due to the many duct, plumbing and electrical penetrations between the mechanical room and building, and leakage in the furnace cabinet itself.

If the requirement is instead met by choosing types of equipment that don't need to be isolated from the building, other considerations are relevant:

- Furnaces and water heaters that are not natural draft cannot be commonly vented, as has been common practice with conventional equipment. This means two separate vents and vent terminations rather than one, which could be a challenge with some building designs (the vent terminations must meet minimum separation requirements from air intakes and operable windows; and minimum clearance requirements above grade). In some buildings, though, separate vents that terminate at different sidewall locations are much easier to accommodate than running a common vent up through an open floor plan (this is especially true in multi-story buildings).
- Direct-vent combustion appliances (e.g. water heaters and fireplaces) typically must be located near exterior walls to meet venting requirements.
- Some power-vented and sealed-combustion water heaters require a dedicated electrical circuit, which can add cost. Tankless, sealed-combustion water heaters require a larger gas supply pipe than conventional water heaters, an added cost.

Certification Issues

BPI Building Analyst certification is likely to be the most appropriate credential for performing the testing associated with this proposed requirement. This credential requires both blower-door testing (required to document isolation of the mechanical room) and combustion safety testing skills. Testing may be performed by a certified individual working for the company installing the mechanical equipment or for the builder; third-party testing may also be utilized.

Enforcement Procedures

Permit application/plan review: Submitted plans must include information describing how this requirement will be met. If atmospheric appliances are to be used, details regarding mechanical room isolation from the building must be provided.

Field inspection: If this requirement is to be met using combustion appliances that don't need to be isolated from the building, building inspectors check that the specified equipment has been installed to meet manufacturer installation requirements (current practice).

Certificate of Occupancy: If natural draft appliances are used, applicant will submit a signed performance testing form documenting compliance with requirements. The document will include the testing contractor's certification numbers and expiration date.

Support Materials Needs

- Compliance form
- Information for building owners or occupants of buildings in which natural draft appliances are located in a mechanical room, instructing them how not to defeat the purpose of the requirement.

Training Needs – Industry

For builders planning to meet the proposed requirement with natural draft appliances in a sealed mechanical room, training will be needed regarding the details needed to meet the testing standards.

For builders choosing to meet the proposed requirement by using combustion appliances that don't need to be isolated from the building, training regarding installation of these appliances is provided by manufacturers and product suppliers.

Training Needs – Staff

Building Department staff should receive training to understand the performance testing and the compliance documentation submitted by contractors.

Background

Current Practice

- In new Fort Collins construction, for more than 15 years, almost all fireplaces have been direct-vent units.
- In new Fort Collins construction, since 2005, almost all furnaces and boilers have been sealed-combustion units, with rated efficiencies of 90 AFUE and above. (In a survey of new homes built in 2007, about one-third of these were installed to draw house air for combustion rather than outside air.)
- In new Fort Collins homes surveyed in 2007, about two-thirds of the water heaters were conventional, natural draft; one-sixth were power-vented; one-sixth were sealed-combustion or direct-vent. Sealed-combustion, higher-efficiency tankless water heaters were provided as standard equipment by a small number of Fort Collins builders.
- Furnaces, boilers and water heaters are most often located in basements, the majority of which are unfinished when the building is sold. When basements are later finished, the equipment is typically walled off into a mechanical room.
- Code-required "combustion air ducts," open ducts from outdoors or the attic that terminate near the equipment, are installed whenever appliances that draw indoor air for combustion are installed. One or two ducts, from four-inch to eight-inch diameter, are typical.
- In the 2007 new home survey, in a finished home that had just received its Certificate of Occupancy, two natural draft water heaters and a natural draft fireplace continuously spilled combustion products into the living space whenever the vented kitchen range hood was operated.

Context

Natural draft appliances draw indoor air for combustion; the buoyancy of hot combustion gases is intended to vent combustion products out of the building. This venting process relies on very small pressure differences to push the gases out the chimney. These pressures are easily disrupted by many factors: "stack effect" air leakage, exhaust fans (kitchen and bath fans, clothes dryers, radon vent systems, whole-house fans), other chimneys, leaks in the return ductwork, unbalanced supply and return air flows to different parts of the building, wind, varying outdoor temperatures.

These factors can act alone or in combination. When pressure imbalances exist, combustion products – potentially including carbon monoxide (CO) – can spill into the living space. The potential for this problem increases with tighter construction, which more readily supports pressure imbalances than leaky construction.

CO poisoning, in relatively low concentration, can be fatal. Lower doses can cause chronic illnesses which mimic other conditions. Other combustion products include oxides of nitrogen (a respiratory irritant) and water (which can lead to excess humidity, mold, building damage).

The two most common natural draft combustion appliances installed in Fort Collins today are:

- Conventional gas water heater. This is the appliance most vulnerable to spillage at low pressure imbalances. This type of water heater was installed in about two-thirds of new Fort Collins homes in 2007.
- Induced-draft gas furnace. Though this type of furnace is natural draft, it does not incorporate a "draft hood." A pressure sensor on the exhaust is designed to shut down the appliance when venting problems occur. These units have rated efficiency of approximately 80 AFUE, meeting code-minimum efficiency requirements. However, as noted above, the new construction market has largely moved beyond these to sealed-combustion, 90+ AFUE furnaces.

With few exceptions, building code requires that outside combustion air ducts are installed whenever combustion appliances that draw indoor air for combustion are specified. The minimum sizes for these ducts are based on the installed combustion capacity of the equipment. It is often assumed that one function of these ducts is to provide pressure relief to mitigate imbalances in the combustion appliance zone. In reality, these ducts can exacerbate pressure imbalances; air flow out through the combustion air duct can contribute to a spillage scenario.

Combustion air ducts also blur the line between "inside" and "outside," providing a direct connection between the two environments. This contributes to uncontrolled air leakage. Cold drafts through combustion air ducts often trigger comfort complaints. Despite code-required warning labels, it is not unusual to find combustion air ducts plugged by occupants who don't understand their intended function and want to stop the source of cold air.

Building scientists have long recognized the potential for combustion safety failures with atmospheric appliances. The City has provided training and education to builders, trades and consumers, addressing combustion safety concerns, since the early 1990s. Combustion safety was addressed in the City's report on a survey of Fort Collins homes built in the mid- to late-1990s. A combustion safety fact sheet, developed by Fort Collins Utilities and E-Star Colorado, recommends safe combustion appliances in new buildings. The fact sheet has been widely distributed since 2005.

Green building rating systems, including LEED for Homes and the National Green Building Standard, award points for safer combustion appliances. NGBS does not allow points to be claimed for tight construction unless safer combustion appliances are installed.

ENERGY STAR New Homes Version 3 guidelines (which will be fully effective by January 2012), require safer combustion appliances in all homes that earn the ENERGY STAR label.

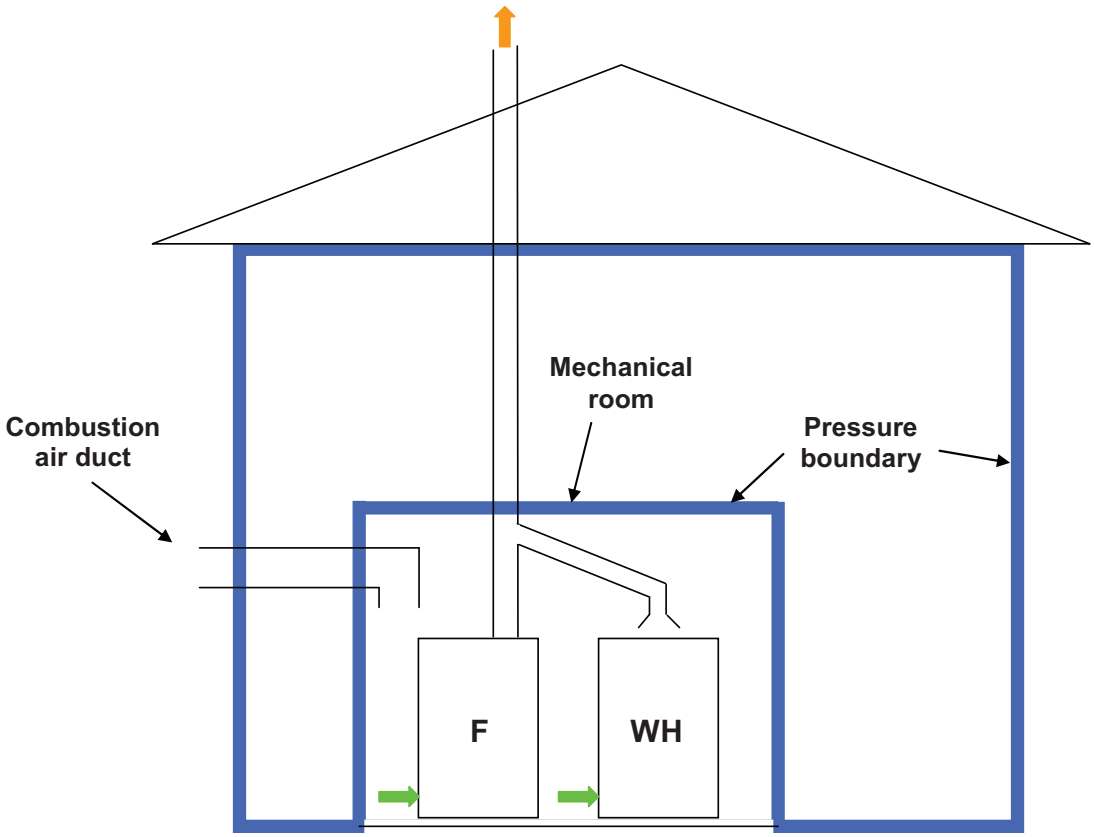
Gas ovens are unvented combustion appliances that often produce high levels of CO. In response, Fort Collins building code requires that vented range hoods are installed when gas ovens are installed. As noted above ("Current Practice"), vented range hood operation, drawing air out of the building, can cause other natural draft appliances to spill combustion products into the building.

State law prohibits the installation of other unvented combustion appliances.

By state law, CO detectors are required in new construction. These detect one symptom of combustion problems.

Examples of Compliant Approaches

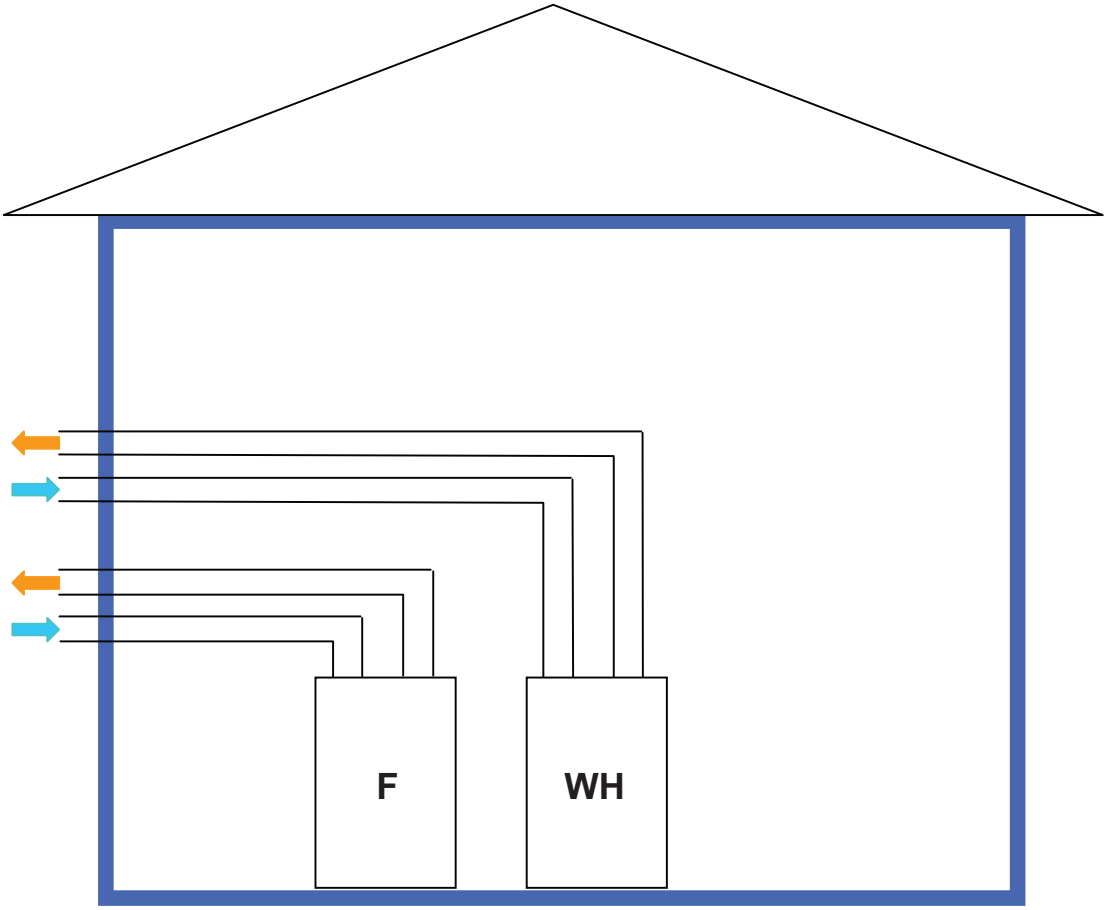
The following drawings illustrate three examples of approaches that would comply with the proposed requirement



OPTION 1

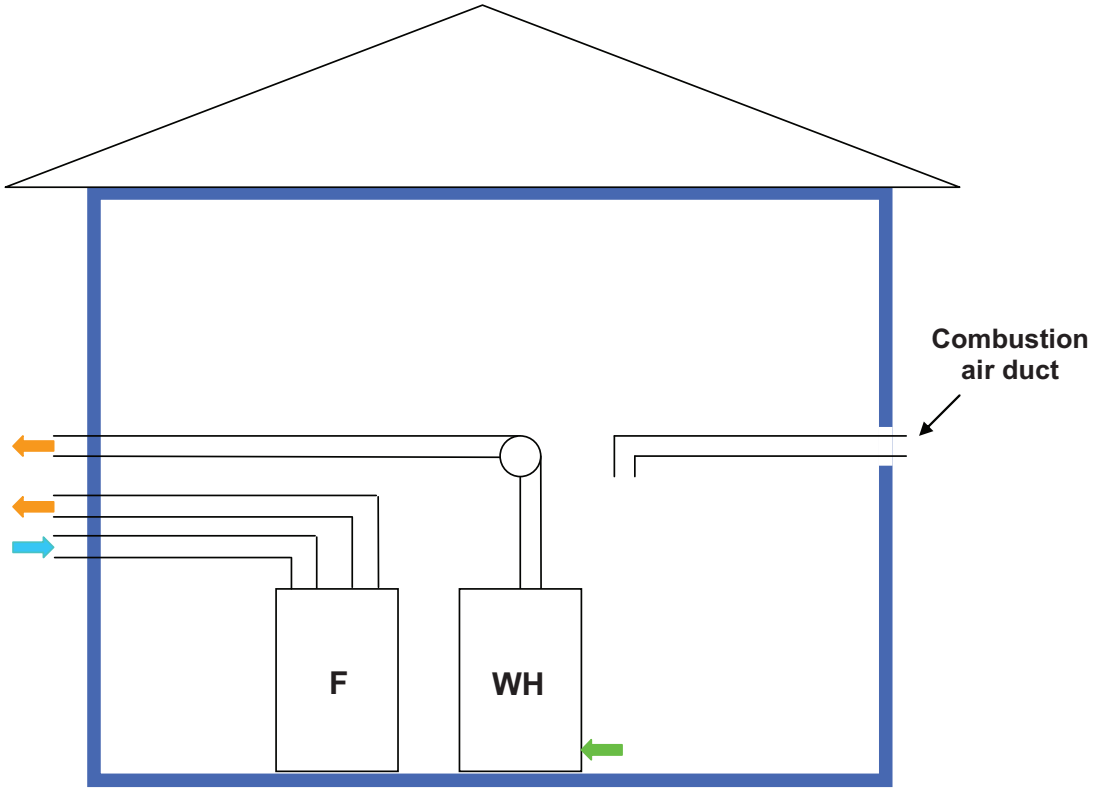
Natural draft appliances. These are located in a mechanical room that is sealed from the rest of the building, connected to the outside by an open combustion air duct. This effectively places the combustion appliances outside the pressure boundary, as shown. The combustion air duct is sized based on the total input combustion capacities of the furnace and water heater.

The isolation of the mechanical room from the building must be demonstrated with a differential pressure test. The appliances must pass a worst-case combustion safety test.



OPTION 2

Sealed-combustion appliances. Because they have hard-piped combustion air intakes and combustion product exhausts, these appliances are not vulnerable to pressure imbalances in the building. Mechanical room, open combustion air ducts, performance testing are not required.



OPTION 3

Sealed-combustion furnace and power-vented water heater. The furnace has hard-piped combustion air intake and combustion product exhaust, so is fully isolated from pressure changes in the building. The water heater uses indoor air for combustion air; combustion products are fan-forced out of the building. A (small) open combustion air duct typically is required, sized based on the input combustion capacity of the water heater. The small combustion air duct represents a breach in the pressure boundary.

Neither a mechanical room nor a performance test is required.

Related Green Building Practices

Safer combustion appliances are a key part of a systems approach to healthier indoor air and other aspects of improved performance. These practices go hand-in-hand:

- Tight construction
- Healthy indoor air
- Exhaust-only ventilation approaches can only safely be used with safer combustion approaches.
- Eliminate uncontrolled leakage through open combustion air duct

Known Objections

- Higher first cost versus current approach.
- There aren't many deaths from CO poisoning.
- State law requires CO detectors in new homes.
- Builders may locate combustion appliances in garages; this approach introduces other problems.

Green Building Practice Summary 3/10/2011

Sector: Residential

Category/Practice: IEQ / Safer Combustion Appliances: Existing Buildings

Proposed GB Practice

Description

All natural draft combustion appliances must pass the Building Performance Institute (BPI) combustion safety test, including carbon monoxide (CO) production and spillage, under "natural conditions."

Exception: Induced-draft furnaces

Combustion safety testing will be performed by certified contractors.

When appliances meet this requirement but fail a BPI "worst-case" depressurization test, the contractor must provide, and the building owner must sign, a City-provided disclosure form describing the risks.

Applicability

New Construction: Does not apply (see companion proposed amendment: "Safer Combustion Appliances: New Construction")

Existing Buildings/Additions: Applies (companion proposed amendment – "Safer Combustion Appliances: New Construction" – may also apply)

Existing Buildings/Alterations: Applies when combustion appliances (furnace, water heater, fireplace) are replaced

Intent

Reduce potential health and safety hazard of combustion products spilling into building.

Benefits and Costs

Triple Bottom Line Benefits

People: Health and safety for occupants.

Economic: No direct benefit. Improved health can potentially reduce health care costs.

Environment: None

Costs Passed to Owner

"Low" cost

Approximately $75 to $150 if only the combustion safety test is required. If an appliance fails the test, costs for mitigating the problem could range from "low" to "very high."

Implementation

Availability of Products and/or Services

A number of local HVAC and home performance contractors have recently received BPI Building Analyst certification through the City's Home Efficiency Program training.

Practicality

Conducting the combustion safety test is practical. The "natural conditions" qualifier for the test is intended to screen out the appliances most liable to cause health and safety hazards. If an appliance fails the test, mitigation may be easy and low cost in some cases, challenging and expensive in other scenarios.

Residents will face some risk when replacing their combustion appliances. They won't know until the initial work is completed whether or not their natural draft appliances will pass. If they don't, the resident could face significant expense to mitigate the problem. This risk must be weighed against the risk of significant health problems related to combustion appliance spillage and CO poisoning.

Certification Issues

BPI Building Analyst certification (or other credential approved by the Building Official) is required to conduct combustion safety testing. Testing may be performed by the same company performing the other retrofit work that triggers this proposed requirement; i.e. third-party testing is allowed but not required.

Enforcement Procedures

Permit application/plan review: Applicant provides information describing the combustion appliances that will remain in place after equipment replacement. Building Department will notify applicant which appliances must meet this requirement.

Field inspection: Applicant must turn in signed affidavit documenting compliance. The document will include the testing contractor's certification number and expiration date. If an appliance passes the natural conditions test but fails the worst-case depressurization test, applicant must also submit a copy of the disclosure form.

Support Materials Needs

- Compliance form
- Disclosure form

Training Needs – Industry

Additional training opportunities should be made available to those wishing to become certified.

Training Needs - Staff

Building Department enforcement staff should receive training to understand combustion safety testing and how to interpret results submitted by contractors.

Background

Current Practice

The majority of furnaces, water heaters and fireplaces in existing Fort Collins homes are natural draft natural gas appliances.

Combustion safety testing is not routinely conducted in the situations that would trigger this proposed requirement.

Context

Natural draft appliances draw indoor air for combustion; the buoyancy of hot combustion gases is intended to vent combustion products out of the building. This venting process relies on very small pressure differences to push the gases out the chimney. Existing vent conditions may lead to insufficient pressure difference due to poor design, degradation or "orphaning" of commonly vented appliances. Further, venting pressures are easily disrupted by many factors: "stack effect" air leakage, exhaust fans (kitchen and bath fans, clothes dryers, radon vent systems, whole-house fans), other chimneys, leakage in the return ductwork, unbalanced supply and return heating and cooling flows to different parts of the building, wind, varying outdoor temperatures – acting alone or in combination. When this happens, combustion products, including potentially harmful levels of carbon monoxide (CO), can spill into the living space. The potential for this problem increases as buildings are tightened; a tighter envelope more readily supports pressure imbalances than a leaky one.

CO poisoning, in relatively low concentration, can be fatal. Lower doses, over time, can cause chronic illnesses which mimic other conditions. Other combustion products include nitrogren oxides (a respiratory irritant) and water (which can lead to excess humidity, mold, building damage).

Even when combustion appliances have been safely operating in a building, many factors can tip the pressure balance to unsafe operation. Small problems with the combustion process can create high levels of CO in the flue gases. Changes to the building or the way it is operated can easily change the pressure balance enough to create venting problems. Examples include installation of new or larger exhaust fans, radon mitigation systems, additions, air sealing (intentionally or through other energy improvements such as blowing insulation into exterior walls), ductwork modifications.

A range of combustion appliances are found in the Fort Collins housing stock:

- Furnaces. The oldest units are low efficiency, natural draft furnaces with "draft hoods," vulnerable to spillage. These frequently share a common vent with atmospheric water heaters. For about the last two decades, higher federal efficiency requirements meant that the typical furnaces installed in new construction or as replacement units have been induced-draft designs (approximately 80 AFUE). Though still natural draft, these have no draft hood. A pressure sensor in the exhaust is designed to shut down the furnace when venting problems occur; compared with the draft hood units, a significantly higher pressure imbalance is necessary for induced-draft furnaces to spill combustion products. Sealed-combustion furnaces first became widely available about two decades ago. In these designs, combustion products are fully isolated from the living space and are pushed out of the building by a blower; they virtually eliminate the chance of combustion product spillage. Sealed combustion furnaces are now commonly installed in new construction and many have been installed as replacement units by

building owners as energy efficiency upgrades. They cannot be commonly vented with a water heater; a dedicated vent is required.

- Boilers. The situation is analogous to furnaces. (Boilers constitute a very small part of the Fort Collins market.)
- Water heaters. Typical practice in buildings of all vintages is the conventional storage water heater. These are natural draft with draft hoods, vulnerable to spillage with small pressure imbalances. These units frequently share a common vent with atmospheric furnaces. Only in very recent years have safer water heater designs – power-vented, direct-vent, sealed-combustion – begun to make significant inroads in new construction. In a 2007 new home survey in Fort Collins, about one-third of the sample had safer gas water heaters.
- Fireplaces. Older fireplaces are natural draft, including masonry and sheet metal designs, wood- or natural gas-fired. They are vulnerable to combustion product spillage. When burning, wood-fired fireplaces draw large amounts of air from the building and can create significant pressure imbalances that can cause water heaters or furnaces to spill. Most fireplaces installed in the last two decades have been direct-vent units that are fully sealed from the living space and virtually immune to spillage.

A common scenario is the "orphan" water heater. The starting point is a natural draft water heater commonly vented with a natural draft furnace. The furnace is replaced with a high-efficiency, sealed combustion unit, using a new, dedicated vent. The water continues to use the original vent, which was sized based on the size of the furnace and water heater together and is now much too large for the water heater alone. Because the relatively small heat output of the water heater doesn't heat the flue to the same temperature that it did when the furnace was commonly vented, this situation increases the likelihood of spillage and flue damage due to condensation of combustion products. To mitigate these problems, the existing flue should be "lined" with a smaller vent. This is done in some cases, not others; building code provides mixed guidance.

Building scientists have long recognized the potential for combustion safety problems with conventional appliances. They recommend performance testing rather than prescriptive approaches. In the last decade, the Building Performance Institute's combustion safety testing protocol has been increasingly referenced. This test evaluates pressure imbalances in the zones in which combustion appliances are located, draft in the vent, CO production and spillage of combustion products into the building. It defines testing under "natural" conditions (normal building operation) and "worst-case depressurization" conditions (building operated in a manner most likely to cause spillage problems).

The City has provided training and education to builders, trades and consumers, addressing combustion safety concerns, since the early 1990s.

When combustion appliances are replaced, the building code requires contractors to follow manufacturer instructions and that "all heating and cooling equipment be tested to ensure such equipment is operating within the manufacturer's recommended operating parameters and standards, including within such parameters and standards for sufficient combustion, according to the applicable protocols established by the building official and in accordance with the mechanical code adopted by the City." There are several other provisions in the code that rely on prescriptive approaches to aid combustion safety; none explicitly require testing to be performed to document that the equipment operates safely. The code also includes provisions addressing pressure imbalances caused by exhaust fans. These provisions have rarely been enforced in the past. There are no code provisions regarding combustion safety that are triggered by other

changes to the building. As noted in "Current Practice," combustion safety testing has not routinely been conducted.

The City's Home Efficiency Program (HEP) for existing homes includes a strong emphasis on combustion safety. All program audits, for homes with appliances that can potentially spill combustion products, include a BPI combustion safety test.

In the HEP, disclosure forms must be provided by the auditor or contractor, for the customer to sign, when an appliance fails the combustion safety test under either natural or worst-case conditions. The City provides a CO detector for homes without one.

Related Green Building Practices

Summarizing some of the information in "Context," above, there are four ways to approach combustion safety:

- Install safer combustion appliances. This gets at the root of the problem.
- Install vulnerable combustion appliances, following prescriptive instructions, and assume they will operate safely.
- Install combustion appliances, following prescriptive instructions, and test them to see if they produce low amounts of CO and safely vent all combustion products out of the building under a range of operating conditions.
- Install CO detectors.

Known Objections

- Higher costs for combustion appliance replacement due to testing costs
- Potential for higher costs to mitigate when appliances fail combustion safety tests
- This will pose a particular challenge for emergency replacements of furnaces and water heaters.
- May drive more equipment replacement work underground; i.e. non-licensed contractors installing equipment without a building permit
- There aren't many deaths from CO poisoning.
- CO detectors are an alternative, lower cost solution for combustion safety.

Green Building Practice Summary 03/17/2011

Sector: Residential

Category/Practice: IEQ / Low-VOC Materials

Proposed GB Practice

Description

Construction materials, floor coverings and site-applied finishes (including sealants and adhesives), resilient flooring, carpeting and pad, site-applied paints, stains and varnishes, structural wood panels, hardwood veneer plywood, particle board and fiber board building products, and insulation are required to meet specified volatile organic compound (VOC) emissions limits in accordance with California Department of Public Health (CDPH) 01350; GREENGUARD Environmental Institute GGPS.001 standard for building materials and finishes; and, Green Seal® standards.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to addition portion only

Existing Buildings/Alterations: Applies with limited scope:

- Only to new construction within alteration
- Only to sealants and adhesives, resilient flooring, paints, stains, varnishes and other site-applied finishes.

Intent

Improve indoor air quality for construction workers and occupants.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved health for construction workers and occupants.

Economic: No direct economic benefits. Improved health can potentially reduce health-care costs.

Environment:
- Improved outdoor air quality.
- Fewer toxic compounds purchased likely leads to reduced pollution at the manufacturer level

Costs Passed to Owner
Incremental costs for compliant low-VOC materials versus conventional materials appears to be quite low, per each material. Cumulatively, the incremental cost is estimated to be "Medium" ($200 to $400).

Lost Opportunity
- Construction worker exposure to VOCs during application may have long-term health consequences.
- Many construction materials used when the building is built are with the building over its life.

Implementation

Availability of Products and/or Services
Availability of compliant low-VOC materials is as follows:
- Sealants and adhesives: readily available
- Resilient flooring: readily available
- Carpeting: readily available
- Paints, stains, varnishes and other site-applied finishes: readily available
- Structural wood panels, hardwood veneer plywood, particle board, and fiber board building products: readily available (see Engineered Wood Association, www.apawood.org)
- Insulation: Low VOC fiberglass insulation from several major manufacturers readily available; cellulose insulation; and bio-based GREENGUARD certified polyurethane spray foam all readily available.

Practicality
It has been difficult to locate data regarding the relative durability of low-VOC materials compared with conventional materials they replace. There is a chance that some of the healthier materials may not hold up as well, meaning more maintenance may be required.

Certification Issues
None. The referenced standards are developed and administered elsewhere by state governments and industry trade associations.

Enforcement Procedures

Permit application/plan review: Require initial documentation via standardized checklist form developed by the City.

Field inspection: Documentation demonstrating compliance is required with delivery of materials and must be available for inspection.

Certificate of Occupancy: See above.

Support Materials Needs
- Standardized checklist form for initial submittal
- Form for documenting compliance

Training Needs – Industry
Training should cover health impacts and compliant material sources, costs, performance and identification.

Training Needs – Staff
Submittal review

Background

Current Practice
A wide variety of materials are used in construction. Low-VOC materials are used on a voluntary basis by informed citizens and contractors who have health concerns. There is no data regarding VOC levels in Fort Collins housing.

Context

People in the US spend an average of 65 percent of their time at home and as much as 90 percent of their time indoors, according to a May 1999 national survey conducted by the American Lung Association. Additionally, 90 percent of owners questioned in this survey were not aware that poor indoor air could be a problem. Another national survey conducted in 2000 found that about 95 percent of people who responded to that survey said they thought the quality of air in their homes was either somewhat or very important.

The increase in awareness is due in part to educational efforts by the US Environmental Protection Agency (EPA) and other public interest groups. The US Department of Health and Human Services and the Surgeon General's Office, for example, established a Healthy People Initiative. Their conference report estimated that 25 percent of preventable illness worldwide can be attributable to poor environmental quality, and that air pollution alone is associated with 50,000 premature deaths and more than $40 billion dollars in health-related costs. Indoor air pollution is one of the environmental causes of these illnesses.

Source: http://www.aerias.org/DesktopDefault.aspx?tabindex=3&tabid=79

VOCs include a variety of chemicals, some of which may have short-and long-term adverse health effects, emitted as gases from certain solids or liquids. VOCs are emitted by a wide array of products numbering in the thousands. Examples include paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers and photographic solutions.

Tighter construction practices and the lack of controlled ventilation with outdoor air contribute to higher average indoor VOC levels. Concentrations of many VOCs are consistently higher indoors than outdoors (up to ten times higher), particularly during construction and renovation projects.

The health impacts of exposure to VOCs include eye, nose and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some VOCs can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness (see www.epa.gov/iaq/voc.html#Health%20Effects).

There is much more data on health effects of VOCs in commercial environments than residential because there are so many variables in residential buildings and their occupants.

The biggest emitters of VOCs are formaldehyde-based products. Formaldehyde is classified as a "Group 1 Carcinogen" which is defined as an agent that "is definitely carcinogenic to humans" by the International Agency for Research on Cancer (IARC), and "a complete carcinogen" in the words of the Occupational Safety and Health Administration (OSHA). The National Toxicology Program also recently revised its characterization of formaldehyde to that of "known human carcinogen." Formaldehyde is one of the few indoor air pollutants that can be readily measured.

California has been the leader in regulating VOCs in many consumer products. A number of northeastern states also regulate VOCs with the goal of improving indoor air quality. The EPA and a number of trade associations have developed standards for particular materials.

The proposed requirement references standards from several sources, including:
- California Department of Public Health (CDPH) Standard Practice 01350 for VOC testing.
- GREENGUARD: an ISO-IEC accredited third-party environmental organization that certifies products and materials for low chemical emissions and provides a resource for choosing healthier products and materials for indoor environments.
- Green Seal: a non-profit organization that uses science-based programs for consumers, purchasers and companies to utilize more environmentally-sustainable products.
- Carpet and Rug Institute (CRI) Green Label Plus Indoor Air Quality Program: an independent testing program that identifies carpet with very low emissions of VOCs to help improve indoor air quality.

In national green building rating or labeling programs, use of low-VOC materials is required (EPA Indoor Air Plus program) and/or rewarded (LEED/Homes, National Green Building Standard).

The proposed requirement is based on standards regarding the VOCs in materials themselves rather than occupant decisions. VOCs would still be subject to occupants' lifestyles, items brought into the living space such as dry cleaning, fabrics, cleaning agents, and decisions on furnishings.

Related Green Building Practices

Healthy indoor air is the result of a systems approach. These practices go hand-in-hand:
- Tight construction
- Pollutant source control
- Spot ventilation
- Whole-building ventilation

Known Objections

- Construction materials meeting referenced standards may not perform as well (initial application, durability) as products currently in use.
- Some of these materials may have health impacts for applicator but not for the residents, because the off-gassing is largely complete when the material is cured.

- Any gains in indoor air quality gained with this proposal may be outweighed by furnishings and other materials brought into the living space by the residents after final inspection and/or Certificate of Occupancy.
- Compliance could be difficult to verify.

Sources

- NAHB Toolbase – residential low voc paints
  www.toolbase.org/Technology-Inventory/Interior-Partitions-Ceilings/low-voc-paints
- "Building Codes and IAQ" by the Cadmus Group, September 2010 prepared for the EPA
  www.epa.gov/iaq/pdfs/building_codes_and_iaq.pdf
- CRI – GREEN LABEL PLUS
  www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/
- CALIFORNIA DEPARTMENT OF PUBLIC HEALTH
  www.calrecycle.ca.gov/greenbuilding/Specs/Section01350/
- CALIFORNIA AIR RESOURCES BOARD (Indoor Air Quality)
  www.arb.ca.gov/research/indoor/indoor.htm
- GREEN GUARD ENIRONMENTAL INSTITUTE (testing for all interior finishing products)
  www.greenguard.org
- AIR QUALITY SCIENCES IAQ RESOURCE CENTER (up-to-date information about IAQ and other occupant health issues)
  www.aerias.org/DesktopDefault.aspx?tabindex=5&tabid=97 .
- "Building Healthy Hospitals" (2007 cost data from four hospital projects)
  www.epa.gov/region9/waste/p2/pdf/IAQFinalOct12.pdf

Green Building Practice Summary 12/13/2010

Sector: Residential

Category/Practice: IEQ / Whole-building Ventilation

Proposed GB practice

Description

A whole-building, controlled, mechanical ventilation system, designed to meet ASHRAE Standard 62.2 requirements, must be provided. Key design parameters must be documented. The installed system must be commissioned.

Air handlers used to move ventilation air must be equipped with efficient blower motors. Exception: Motors rated at one-quarter horsepower or below.

Applicability

New Construction: Applies

Existing Buildings/Additions: Does not apply (address with education)

Existing Buildings/Alterations: Does not apply (address with education)

Intent

Improve indoor air quality

Benefits and Costs

Triple Bottom Line Benefits

People: Improved health due to better indoor air quality.

Economic: Potential for indirect benefits due to improved health. As noted under "Costs Passed to Owner," below, controlled ventilation represents an energy cost rather than a benefit.

Environment: N/A

Costs Passed to Owner

There are several types of ventilation systems that can satisfy this proposed requirement. Each has first costs associated with design and installation, plus operating costs.

The least expensive system to install uses an exhaust-only approach based on an upgraded bath fan engineered to operate quietly and continuously. The incremental first cost of a system like this, with no other changes, is estimated at "low" to "medium" ($150-400).

For the prototype house, the operational cost of an exhaust-only system like this, running continuously, year-round, in a gas-heated house, is approximately $120 per year, due to increased

fan electricity use (~10%) and energy for heating and cooling the make-up air (~90%). The cost will go down proportionately if the owner chooses not to operate the system year-round.

Other system types – exhaust-only based on fans with more sophisticated controls, exhaust-only using a remote fan with more pickup points, supply-only, balanced with heat recovery – will all have a higher first cost, ranging from "Medium" to "Very high" cost. Operating costs may be higher or lower than the simple exhaust-only system, depending upon the fan(s) and whether or not the system includes heat recovery.

Lost Opportunity

It is less expensive to install a whole-building ventilation system at time of construction than to retrofit it later.

Implementation

Availability of Products and/or Services

Though whole-building ventilation has not been extensively used in the Fort Collins market, equipment is available. Increased market penetration is anticipated to improve the local product supply infrastructure. Relatively few local HVAC contractors have much experience installing whole-building ventilation systems.

Practicality

No obstacles have been identified.

Certification Issues

Contractor certification requirements must be established; i.e. who will be allowed to perform or oversee the testing and sign off on the commissioning form (the ventilation system commissioning is a subset of the proposed "HVAC Commissioning" amendment).

Enforcement Procedures

Permit application/plan review: Applicant submits a whole-building ventilation system design as part of permit application.

Field inspection: Building inspectors visually verify presence of system components.

Certificate of Occupancy: Applicant will submit completed, signed commissioning form documenting compliance with requirements. The document will include the testing contractor's certification number and expiration date. (The ventilation system commissioning is a subset of the proposed "HVAC Commissioning" amendment)

Support Materials Needs

- Template for the ventilation system design submittal
- Commissioning form (the ventilation system commissioning is a subset of the proposed "HVAC Commissioning" amendment)

Training Needs – Industry

Training regarding design, installation and testing of whole-building ventilation systems will be needed for builders and HVAC contractors. This can be offered as a subset of comprehensive training on HVAC system design, installation and commissioning.

Training Needs - Staff

Enforcement staff will need at least introductory training about whole-building ventilation systems, with an emphasis on inspection requirements.

Background

Current Practice

A very small proportion of Fort Collins buildings, including new buildings, are equipped with whole-building ventilation systems.

Context - Ventilation

Building scientists have long advocated a systems approach to healthy indoor air, of which controlled, whole-building ventilation is one component. The City has sponsored builder training supporting this approach since the early 1990s. The availability of high-quality, quiet, low-power ventilation fans and innovative controls has increased over that period.

A fact sheet addressing a systems approach to healthy indoor air, including whole-building ventilation, developed by Fort Collins Utilities and E-Star Colorado, has been widely distributed since 2005.

Controlled ventilation in most Fort Collins buildings is provided by windows operated by occupants (less so than in the past with increasing use of air conditioning and increased security concerns), bath fans and, in a minority of buildings, vented kitchen range hoods (bath fans and kitchen hoods have been used for intermittent, user-controlled, spot ventilation). These are augmented by uncontrolled air leakage through holes and cracks in the building envelope, which is highly variable with weather conditions and building operation. Very few whole-building ventilation systems have been installed.

A national standard, *Ventilation and Acceptable Indoor Quality in Low-Rise Residential Buildings*, ASHRAE 62.2, published in 2003, addresses both whole-building and local exhaust ventilation. It specifies required ventilation rates (which are quite low), controls, maximum sound ratings for fans and related "building-as-a-system" practices.

The ASHRAE ventilation standard allows a number of whole-building ventilation strategies, including low-cost approaches such as using bath fans, double-duty, for spot and whole-building ventilation. It recognizes the importance of duct sizing and system testing to ensure that the system is meeting design specifications.

National voluntary energy efficiency and green building rating systems are increasingly referencing this standard: it is a mandatory element of both LEED/Homes and ENERGY STAR New Homes, Version 3 (to be fully effective in January 2012). It has not yet been referenced in the national model codes.

The *HVAC Quality Installation Specification*, ANSI/ACCA 5 QI-2007, developed by the Consortium for Energy Efficiency and Air Conditioning Contractors of America (a national trade association of HVAC contractors) supports a systems approach, from design through installation, performance testing, documentation and owner education. The 2007 edition of this standard did not address ventilation systems; updates currently underway may extend the standard to ventilation.

Context – Efficient Air Handler Blower Motors

Conventional, permanent-split-capacitor (PSC) air handler unit (AHU) motors represent one of the largest end uses of electricity in homes with forced-air heating/cooling. Few people are aware of this "invisible" load, which is estimated by the Appliance Standards Awareness Project to average 1100 kWh per year, on the order of 10% to 15% of total electricity use in a gas-heated home. At current FC Utilities rates, this costs about $80/yr. The energy use in a given home depends on the motor size, the resistance to air flow presented by the ductwork and how the AHU is controlled.

Average energy use of these motors has markedly increased in recent decades, with:

- Larger homes with larger heating and cooling loads and, therefore, larger AHU blower motors
- Rapidly increasing market penetration of central air conditioning; AC systems require higher air flow rates than heating systems and operate during the summer.
- Increase in number of owners who operate AHU fans continuously, for a variety of reasons: air filtration, humidification, attempts to mix the air and equalize temperatures in different parts of the building.

AHU blowers are sometimes also used to move air for whole-building ventilation. In this scenario, the AHU is liable to operate considerably more hours than when only used to meet heating and cooling needs.

For systems operated many hours, the electrical bill impact is much higher than the average noted above. For example, a ¾ HP PSC AHU motor operating 24/7 throughout the year will use about 6,000 kWh per year of electrical energy, costing the homeowner about $450 per year at current electric rates.

Because these motors are part of the heating and cooling systems, they virtually always operate during the electric utility's peak system electrical demand both winter and summer, increasing the cost of electricity for all residents.

Most AHUs incorporate conventional PSC motors. These have a relatively high power draw and, when operating many hours, use a substantial amount of electricity. In a sample of new Fort Collins homes surveyed in 2007, all AHUs used PSC motors with power draws ranging from 400 to 1000 Watts.

Motor sizes observed in the new home survey:

- 27%: 1/3 HP (typical with 3-ton AC system)
- 40%: ½ HP (typical with 3.5- to 4-ton AC system)
- 27%: ¾ HP (typical with 4- to 5-ton AC system)
- 7%: 1 HP (occasional with 4-ton and 5-ton AC systems)

Efficient AHU motors – powered by direct current (DC) rather than alternating current – have been available for at least two decades. The best known is the "Electrically Commutated Motor" (ECM) from General Electric. In addition to lower power draw and energy use, ECMs offer other advantages such as variable speed control and the ability to move more air through restrictive duct systems. To date, HVAC manufacturers have offered the DC motors primarily in higher-end, variable-speed, high-efficiency (AFUE 94+) furnaces. The incremental cost for such

furnaces is approximately $1000 to $1300 compared with a basic, sealed-combustion, 90 AFUE furnace, or $2000 to $2300 compared with a code-minimum, induced-draft, 80 AFUE unit.

Efficient DC motors have recently become available as drop-in replacements for blower motors in existing AHUs. They are currently available from two manufacturers in a limited range of sizes. Though these can be retrofit into new AHUs with PSC motors, this voids the AHU manufacturer's equipment warranty, so few owners or contractors choose this option.

Depending on motor size and the way in which the heating/cooling/ventilation system is controlled, annual savings by using the more efficient motor may range from:

- Low-end: Approximately $30 (1/3 HP motor operating an average 25% of the time)
- High-end: Approximately $300 (1 HP motor continuously operated year-round)

The City offers incentives for efficient AHU blower motors in existing homes, through the CheckMe! and Home Efficiency Programs. CheckMe! provides a rebate for retrofit of PSC motor to DC motor in an existing AHU. The Home Efficiency Program also provides rebates for installation of a new AHU with DC motor and retrofit of PSC motor to DC motor in an existing AHU.

Federal tax incentives are available for very high efficiency replacement furnaces in existing homes; the 95 AFUE criteria can only be met by variable capacity units.

To date, AHU blower motor efficiency has not been addressed by federal standards or the model energy code. However, U.S. Department of Energy rulemaking on AHU motors must be completed by the end of 2013.

ENERGY STAR New Homes Version 3 guidelines, which will be fully effective in January 2012, require an efficient DC motor if the whole-building ventilation system uses the AHU blower.

The proposed exemption encourages right-sizing of equipment (which is usually smaller than when sized using rules-of-thumb). Entry level buildings tend to be smaller, with smaller loads and smaller heating/cooling equipment.

Related Green Building Practices

Whole-building ventilation is just one part of a systems approach to healthy indoor air. Other, closely related practices include:

- Pollutant source control, including safer combustion appliances that can't spill combustion products into the living space, attached garage isolation from the living space and radon-resistant construction.
- Tight construction
- Spot ventilation
- Efficient motors for blowers used in the whole-building ventilation system
- Proper duct design and installation
- HVAC system commissioning ("V" is for ventilation)
- Buyer education about the ventilation system and how the items they bring into their living spaces affects indoor air quality

Known objections

- Higher first cost
- Higher operating cost
- Occupants open windows when they need more fresh air

Green Building Practice Summary 12/13/2010

Sector: Residential

Category/Practice: OEQ / Exterior Lighting Fixture Design

Proposed GB Practice

Description

Exterior lighting fixtures must have the "Fixture Seal of Approval" from the International Dark-Sky Association, or meet equivalent criteria approved by the Building Official.

Exception: This provision doesn't apply if the fixture location provides equivalent shielding.

Applicability

New Construction: Applies

Existing Buildings/Additions: Does not apply

Existing Buildings/Alterations: Does not apply

Intent

Reduce light trespass and light pollution; help to preserve view of the night sky

Benefits and Costs

Triple Bottom Line Benefits

Economic: No direct benefit. Potential for small electrical energy savings; compliant fixture directs light where it's needed, meaning it may be possible to use a lower wattage bulb to provide the same amount of useful light.

People:

- Improve safety by reducing nighttime glare and directing light to where it is needed.
- Reduction of intrusive light trespass
- Improved view of the night sky

Environment: Outdoor lighting can negatively impact wildlife

Costs Passed to Owner

Incremental costs are expected to be "very low" ($0 to $50) to "low" cost (maximum four fixtures @$30 maximum = $120). Some of the lowest-cost fixtures may not be available in a compliant equivalent.

Implementation

Availability of Products and/or Services
A wide variety of compliant fixtures are readily available at little or no additional cost.

Retrofit kits and shields can be purchased to bring some types of conventional fixtures into compliance.

Practicality
See "Known Objections" below.

Certification Issues
To increase the range of choice, the Building Department may establish local criteria for compliance.

Enforcement Procedures

Permit application/plan review: N/A (lighting fixtures are rarely selected by this stage of the design/building process)

Field inspection: At final inspection, inspectors will visually check fixtures for compliance.

Certificate of Occupancy: N/A

Support Materials Needs
A fact sheet regarding compliant lighting would be helpful for builders, home buyers and lighting retailers.

Training Needs – Industry
In new construction, the home buyer often selects lighting fixtures. Education will be needed to ensure that owners and builders understand the requirement. This education should extend to local lighting retailers.

Training Needs – Staff
Staff will need to understand the compliance criteria to answer questions and consistently enforce the proposed requirement.

Background

Current Practice
A wide range of exterior fixture designs is in use. Some are well-shielded while others have no shielding.

Context
Exterior lighting can be a source of glare (making it difficult to see), light pollution (lighting the sky) and light trespass (lighting on one property intruding on adjoining properties). These attributes can cause safety problems, disrupt wildlife, reduce the view of the night sky and annoy neighbors.

The International Dark Sky Association has worked to raise awareness about these issues and the advantages of using more carefully designed fixtures. Fully shielded (or "full cutoff") fixtures

direct light where it is needed, providing quality lighting without the problems noted above. The IDSA has developed the "Fixture Seal of Approval" program to identify dark sky-friendly fixtures.

Some major lighting retailers identify "dark sky-compliant" fixtures in their product line.

The City addresses exterior lighting design – including glare, light pollution and light trespass – in the Land Use Code. These regulations apply to site lighting and do not regulate exterior lighting on buildings.

Known Objections

- Restriction of choice
- The City should first revamp its street lighting guidelines to meet Dark Sky criteria.
- Reducing light pollution from new construction is a drop in the bucket compared with light pollution from existing development.
- Owners may remove compliant light fixtures on a new building and replace them with the fixtures they really wanted.

Notes

- Provide education to owners of existing buildings to raise awareness about glare, light pollution, light trespass. Encourage fixture change-out to Dark Sky-friendly products.

Green Building Practice Summary 12/13/2010

Sector: Residential

Category/component: Operations & Maintenance/Owner Education

Proposed GB practice

Description

Builder will provide building owner with an operations and maintenance manual, including information on other "green" opportunities.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to new systems, equipment and major appliances installed in the addition

Existing Buildings/Alterations: Applies to new systems, equipment and major appliances installed as part of the job scope

Intent

Educate owners about their home and other "green" choices they can make.

Benefits and Costs

Triple Bottom Line Benefits

People: Improve owner/occupant satisfaction by making it easier for them to operate the building as intended and avoid problems caused by incorrect operation or maintenance

Economic:

- Increase likelihood that building's green attributes will provide operations and maintenance benefits over the lifetime of the building. If utility costs are reduced 0.5% to 1% per year, this represents about $10 to $20 in annual savings. Maintenance savings would be additional.
- Reduce builder callbacks

Environment: Educated owners are more likely to be aware of protecting the natural environment in their care.

Costs Passed to Owner

It is challenging to estimate cost because the specifics of the proposal are not yet defined. City-supported development work should provide a big head start for builder: an easy-to-use template plus boilerplate where possible. For this requirement to be feasible, the cost target must be quite low.

Builders are already providing some of this information to buyers. Most of the work associated with this proposal can be performed by staff with lower hourly costs.

An estimated range of costs, until the requirement is better defined, is $150 to $300.

Lost Opportunity
This proposal represents a front-end chance to set the owner on the course of proper operation of the building, including preventive maintenance practices, rather than the owner dealing on the back end with preventable problems and maintenance costs.

Implementation

Availability of products and/or services
There are a number of models upon which owner's manuals that meet the proposed requirement could be patterned (see "Context" below).

Practicality
No obstacles foreseen

Certification Issues
N/A

Enforcement Procedures

Permit application/plan review: Applicant receives checklist and/or template for items needed in owner's manual.

Field inspection: Verify at final inspection that manual is on the premises and meets the code requirement.

Certificate of Occupancy: N/A

Support Materials Needs
The minimum content and potentially the allowable formats of owner's manuals that meet the proposed requirement must be developed. This will likely be accomplished by staff working with a small group of contractors. This effort could also develop boilerplate to streamline the builder's process of meeting this proposed requirement.

Training Needs – Industry
No specific training on this requirement is needed; it will be covered in mandatory training on building code updates.

Training Needs – Staff
None.

Background

Current practice

Some builders provide materials meeting some aspects and the intent of this requirement. Virtually all builders provide the owner with operation manuals for major appliances installed in the building.

Context

The impact of the building on the natural environment continues well past the completion of construction. Proper operation and maintenance of the building and the equipment and systems within it are essential to maintain efficiency and long-term durability. This translates into resource and economic savings over the life of the structure. Unfortunately, often O+M procedures are not well-implemented and unnecessary problems result. Accessible information and education of the owner can help increase the chances of a positive outcome.

There are many other choices that the owners/occupants can make to further "green" their lifestyle.

The recently adopted Fort Collins building code includes a requirement for a permanent certificate attached to electrical panel, listing R-values, window U-factors and SHGC, and efficiencies of heating, cooling and water heating equipment. This provides some useful information for the owner and future occupants. The proposed requirement takes this several steps further. Minimum contents for manuals meeting the proposed requirement have not been established. They might include, for example:

- product manuals and data for major equipment, fixtures and appliances
- photo record of framing with utilities installed prior to insulation
- information on energy- and water-conserving operation
- tips on maintaining healthy indoor air
- location of main shutoffs for water, gas, electricity
- information for maintaining gutters and downspouts
- recommended preventive maintenance schedule
- information on native landscape materials
- a directory of local recycling options

It is anticipated that staff will work with a group of interested contractors to develop the specific criteria. The City may develop a template that makes it easier for builders to comply with the proposed requirement. Ideas can be drawn from similar requirements in voluntary green building rating systems such as the US Green Building Council's LEED for Homes program and the National Green Building Standard.

Builders will be encouraged, but not required, to conduct in-depth walkthroughs with buyers to reinforce the information contained in the owner's manual.

Related Green Building Practices

None

Known objections

- Time required to assemble the manual
- No assurance that the owner will take advantage of the manual

- No assurance that the manual will stay with the building as occupancy changes

Commercial Code Green Building Amendments (Prescriptive)

These amendments apply to commercial buildings and high-rise (four-story and more) multi-family housing.

2/11/2011

#	GB Practice	Description*	Intent	Applicability
	RESOURCE EFFICIENCY			
1	**Construction waste recycling**	• Submit recycling plan (who, what, where, how) • Implement recycling (non-landfill) for wood, metal, concrete and cardboard	Divert waste from landfill. Potential disposal cost savings	New: Yes Addition: Yes Alteration: No
2	**Certified wood**	Sustainable forestry certification required for all tropical hardwoods	Support sustainable forestry practices	New: Yes Addition: Yes Alteration: Yes
	ENERGY EFFICIENCY + CONSERVATION			
3	**Energy distribution design**	Each electrical panel supplies only one of the following electricity use types - Heating, Ventilation, and Air Conditioning (HVAC), Lighting, miscellaneous loads, plug loads, & process loads.	Provides means for measurement and verification leading to potential energy savings	New: Yes Addition: Part Alteration: No
4	**Building envelope: air barrier**	Require continuous air and thermal barrier per The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 189.1. Appendix B	Saves energy, improves occupant comfort, improves building durability, reduces pest problems	New: Yes Addition: Yes Alteration: No
5	**Building envelope: electrically heated buildings**	Higher specifications for electric-heat buildings beyond 2009 International Energy Conservation Code (IECC) requirements	Save energy, reduce peak electrical demand, improve occupant comfort	New: Yes Addition: Yes Alteration: No
6	**Building envelope: installed insulation standards**	Stud cavity insulation installed to Residential Energy Services Network (RESNET) Grade I standard. Grade II allowed if exterior insulation installed to Grade I.	Improves performance of insulation - energy savings, better occupant comfort, better building durability	New: Yes Addition: Yes Alteration: Yes
7	**Control of loads in hotel/motel guest rooms**	Lighting, switched outlets, and televisions will be controlled when guest rooms are unoccupied. HVAC set point will be relaxed by at least 5℉ when room is unoccupied.	Energy savings, operations and maintenance savings through increased equipment life	New: Yes Addition: Yes Alteration: Yes
8	**Outdoor lighting controls**	Reduce outdoor lighting by 50% 2 hours after business closes	Electricity savings, CO2 reduction	New: Yes Addition: Part Alteration: No
9	**Occupancy sensor controls**	Occupant sensor controls to automatically reduce connected lighting power by at least 50% in corridors, enclosed stairwells, storage and stack areas not open to the public, and parking garages when unoccupied.	Electricity savings, CO2 reduction	New: Yes Addition: Part Alteration: No
10	**Energy assessments for alterations**	Energy assessments required prior to building alterations. No-cost assessment provided by Fort Collins Utilities.	Identify energy efficiency opportunities	New: No Addition: No Alteration: Yes
	WATER EFFICIENCY + CONSERVATION			
11	**Water Efficient Fixtures**	See table (based on Water Sense standard)	Water savings	New: Yes Addition: Part Alteration: Part

(continued on other side)

#	GB Practice	Description*	Intent	Applicability
	INDOOR ENVIRONMENTAL QUALITY (IEQ)			
12	**HVAC IAQ Design**	Protect ducts from contamination during construction Air handling system access & ability to clean and maintain No friable materials in air plenums	Avoid introducing contaminants into supply air and provide means for maintaining air quality.	New: Yes Addition: Yes Alteration: Yes
13	**Building flush-out**	Flush out building contaminants by operating at prescribed outside air setting for 14 days.	Remove pollutants generated from outgassing of new materials	New: Yes Addition: Part Alteration: Part
14	**Low-Volatile Organic Compound (VOC) materials**	Interior materials meet maximum VOC emissions standards: • Sealants + adhesives • Resilient flooring • Carpeting • Paints, stains, varnishes and other site-applied finishes • Structural wood panels, hardwood veneer plywood, particle board, and fiber board	Improve indoor air quality for construction workers and occupants	New: Yes Addition: Part Alteration: Part
15	**Acoustical control**	Requirements for exterior-to-interior sound transmission, interior sound transmission, and background sound levels.	Reduce noise disturbances for occupants	New: Yes Addition: Part Alteration: No
	COMMISSIONING / OPERATIONS + MAINTENANCE			
16	**Commissioning**	Provide Fundamental Commissioning with addition of commissioning building envelope materials and assemblies.	Ensure that building systems are installed and operate per owner's intent	New: Yes Addition: Part Alteration: No

*Visit the City of Fort Collins Green Building Program web site (www.fcgov.com/gbp) for more information:

- **Fort Collins Building Code Green Amendments**
- **Expanded descriptions of each green building practice**
- **Benefits and Costs of Building Code Green Amendments**

Commercial Green Building Practice Summaries

Green Building Practice Summary 3/17/2011

Sector: Residential and Commercial

Category/Practice: Resource Efficiency / Construction Waste Recycling

Proposed GB Practice

Description

Builder must submit a construction waste management (CWM) plan before the project begins that includes recycling of concrete, wood, metal and cardboard.

The plan must be implemented and conspicuously posted on the construction site.

Applicability

New Construction: Applies

Existing Buildings/Additions: Does not apply (address with education, encourage recycling)

Existing Buildings/Alterations: Does not apply (address with education, encourage recycling)

Intent

Divert construction waste from landfill

Benefits and Costs

Triple Bottom Line Benefits

People: N/A

Economic:

- The direct, first cost impact on the project may be a small savings, neutral, or a small increase.
- Long-term savings to the community related to extending the life of the landfill.
- Support local business by expanding the market for recycled-materials haulers and providing materials for local composting and scrap metal recycling facilities.

Environment:

- Reduced demand for virgin materials
- Reduced resource use for processing by reusing what has already been made
- Reduced greenhouse gas (GHG)—methane , carbon dioxide—emissions due to fewer organic materials (wood, cardboard) decomposing in the landfill. GHG emissions from hauling and reprocessing materials will, to some degree, offset those gained from keeping them out of the landfill.

Costs Passed to Owner

As noted above, the direct first cost of construction waste recycling is anticipated to be “very low;” it net be a small added cost, a savings, or neutral impact compared with landfill disposal.

Lost Opportunity
Construction materials dumped in the landfill are much less economically feasible to recover in the future.

Implementation

Availability of Products and/or Services
Several local haulers currently provide customized recycling services for Fort Collins construction projects. Local drop-off sites exist for recycling metals, wood, concrete, and cardboard, should builders wish to self-haul these materials.

Practicality
This measure can be relatively easily implemented. Initially, builders will have to spend time to train employees and subcontractors about the recycling protocol. This will get easier with each project. Smaller projects may have to self-haul materials, requiring additional time and resources. However, the reduction in the cost of trash service for the project and financial returns for recycling metals will ease implementation cost impacts on the builder. The proposed requirement is designed to put minimal paperwork and tracking burden on the builder.

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Plan reviewers check the waste management plan

Field inspection: Building inspectors verify that recycling is being done onsite during all inspection visits On-site inspection will include visual verification of recycling to confirm that containers are on-site, appropriately labeled and not contaminated with trash.

Certificate of Occupancy: N/A

Support Materials Needs
City will develop a template for the CWM plan. Minimum information likely required in the plan includes:
- Materials to be recycled
- How recycling will be handled: sizes of containers, who will haul materials to recycling sites
- When recycling containers will be on site (e.g., concrete recycling from washout following pour of the footings and foundation)
- How contamination of the recycling containers will be avoided

Example signage would be helpful.

Training Needs - Industry
Training will be provided as part of mandatory training for all contractors on the recently adopted Fort Collins building codes and green amendments.

Training Needs - Staff
Staff training will be needed for consistent enforcement.

Background

Current Practice
Most construction waste is hauled to the landfill.

Context
In 2006, City Council approved a community waste diversion goal of 50% by 2010. As of 2010, the City has a diversion rate of 38% (not including concrete/asphalt). Diverting construction waste will help extend the life of the landfill, reduce carbon emissions, and help the City reach its diversion goals.

Some builders in the community who are working on green building and LEED-certified projects have been able to recycle 75-95% of construction waste. That includes recycling more types of material than the four included in this proposed amendment.

Several communities throughout the country require solid waste diversion for both residential and commercial construction projects.

This proposal intentionally sets no specific target for the percentage of construction waste diverted from the landfill. It sets requirements only for materials for which a local recycling infrastructure already exists. It is intended to include an educational component. Developing a CWM plan raises awareness about recycling opportunities. Implementing the plan provides experience and supports further development of local infrastructure.

Related Green Building Practices
N/A

Known Objections
- Lack of space on some construction sites to accommodate recycling containers
- A quantified recycling goal (e.g., volume percentage of total job waste) is needed for this proposal to be meaningful.
- Training and administration costs for the builder
- Time lost training staff and contractors

Green Building Practice Summary 3/17/2011

Sector: Residential and Commercial

Category/Practice: Resource Efficiency / Certified Tropical Hardwood

Proposed GB Practice

Description

All tropical hardwoods used in a project are required to have a sustainable forestry certification from the Forest Stewardship Council, or other agency approved by the Building Official.

Certification demonstrating compliance shall be required with delivery of such materials and shall be available for inspection.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to addition portion only

Existing Buildings/Alterations: Applies only to materials within scope of the alteration requiring a permit.

Intent

Support sustainable forestry practices.

Benefits and Costs

Triple Bottom Line Benefits

People: People benefit from many aspects of the environmental benefits listed below. Examples include cleaner water, improved fisheries, and reduced chance of property damage due to mudslides.

Economic: As noted below in "Costs Passed to Owner," this measure represents increased costs rather than savings for the builder and owner. There is the potential for long-term economic benefit from sustainable forestry practices, particularly as demands on this resource increase.

Environment: Sustainable forest management practices provide many benefits where timber grows and is harvested:

- Improved wildlife habitat
- Reduced soil erosion
- Reduced pollution
- Healthier ecosystem

This measure in unique among the proposed green amendments in that direct benefits accrue upstream, where timber is grown and harvested, rather than to Fort Collins.

Costs Passed to Owner

Cost impacts are difficult to quantify due to differing sources, pricing practices and availability of hardwood certified under different certification systems. For example, Forest Stewardship Council (FSC) certified tropical hardwood is generally about 10-15% more expensive than conventional lumber. However, some Colorado suppliers say that the cost impacts are minimal.

The cost of tropical hardwoods – certified or non-certified – is usually higher than that of non-tropical species. They are rarely used in entry-level or production buildings. In most cases where the consumer is asking for tropical hardwoods, the choice is made primarily based on aesthetics or durability before costs are considered.

Implementation

Availability of Products and/or Services

FSC-certified tropical hardwoods are difficult to obtain. Several Northern Colorado and Denver area suppliers stock FSC-certified tropical hardwoods or are willing to make special orders upon demand. Other hardwood suppliers are unfamiliar with the certification and why it was developed.There is a potential that some species of tropical hardwoods may not be available as certified products.

Several of the vendors interviewed said that customer demand drives the products that are carried in stock. It is realistic to expect that, if the demand for certified tropical hardwoods increases, availability would also increase.

Practicality

This would not be a difficult measure for builders or owners. They would need to plan ahead to make sure the certified lumber is ordered and arrives to the job site when it is needed.

Enforcement Procedures

Permit application/plan review: Where tropical hardwood is specified in construction documents, it must be identified as being certified by FSC or other approved agency.

Field inspection: Certification demonstrating compliance available for inspection.

Certificate of Occupancy: Builder/owner must submit documentation showing that all tropical hardwoods used in project comply with requirement.

Support Materials Needs

A fact sheet with background on certified wood and a description of what species and sources of wood are subject to the proposed requirement would be helpful for builders and owners. A resource list, with information about what local suppliers can provide, would also be useful.

Training Needs – Industry

Requirement will be covered as mandatory training for all contractors on the recently adopted Fort Collins building codes and green amendments. Outreach to suppliers should also be conducted.

Training Needs – Staff

Minimal training will be needed.

Background

Current Practice

Anecdotal evidence suggests that many builders and building owners do not know the original source of their lumber, how the material is harvested or how the resource is managed. Sustainable forestry certification is currently not a significant factor in the Fort Collins market.

The main uses for tropical hardwood in Colorado are for decks and hardwood flooring. Currently, there is not a big demand for tropical hardwoods, though some vendors report that about 50% of their customers ask for it for flooring.

Context

The term "certified wood" applies to lumber that comes from forests that are sustainability managed and harvested. Forest certification programs have been created by several non-profit groups to address issues of illegal logging, clear-cutting, and rapid deforestation in many parts of the world. Part of the mission of these groups was to create certification programs that consumers could use to make environmentally responsible purchasing decisions.

Current certification programs include:

American Tree Farm System (ATFS)	Focused on education and certification for private forest owners. Certified over 24 million acres of forest land.	http://www.treefarmsystem.org
Canadian Standards Association's Sustainable Forest Management System Standards (CSA)	Develops standards for sustainable forest management. Focused on operations in Canada.	http://www.csa.ca/cm/ca/en/home
Forest Stewardship Council (FSC)	International organization that certifies forests in the U.S. and worldwide.	http://www.fscus.org
Program for Endorsement for Forest Certification System (PEFC)	Endorses forest certification systems that are developed and tailored to local conditions. Currently endorses 34 national certification systems and 220 million hectares of certified forests.	http://www.pefc.org
Sustainable Forestry Initiative Program (SFI)	Certification system focused on operations and forest management in North America.	http://www.sfiprogram.org/

In 2008, the Federal Government amended the Lacey Act to include illegal timber and paper products. This act prohibits the importation and trade of wildlife, fish, and plants that have been illegally taken, transported or sold. This act requires that companies importing wood products practice due diligence and know the entire supply chain of their products. While the Lacey Act took a big step in the right direction, third-party certification programs like FSC help to ensure that wood products are coming from sources that are not only legal but sustainable.

Green building standards and rating systems recognize the benefits of using certified wood in construction projects. In the residential sector, LEED for Homes and the National Green Building Standard both award points for using materials from sustainable sources. Commercial green building standards including LEED and the International Green Construction Code also support sustainable forestry in their requirements.

In looking into this green building opportunity as a potential building code green amendment, the initial suggestion was to require certification for a wider array of wood products. However, due to the potential for higher first cost for certified wood and the upstream nature of the benefits, it was felt that tropical hardwoods represented an appropriate regulatory first step. This is an opportunity for the City of Fort Collins to be a leader and to "think globally and act locally."

Related Green Building Practices
None

Known Objections

- FSC-certified wood is not always readily available.
- Perception that lumber yards are already only selling wood from sustainable sources.

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy / Electricity Distribution Design Requirements

Proposed GB practice

Description

An electric distribution system serving a building with a floor area of 15,000 sq. ft. or more must be designed such that each primary electric panel supplies only one electricity use type for the following:

- HVAC system total energy use.
- Lighting system total energy use.
- Plug loads.
- Process loads.
- Miscellaneous loads.

Buildings designed and constructed where each load is measured through the use of sub-meters or other equivalent methods are exempt.

Applicability

New construction: Applies to buildings 15,000 SF and larger
Additions: Applies to new panels for additions 15,000 SF and larger
Alterations: Does not apply

Intent

Provide the space for meters and segregate energy loads for easier sub-metering of building energy use. This facilitates measurement and verification activities and continuous commissioning and monitoring of building energy use.

Meters are not an energy efficiency/energy conservation technology per se; instead, meters and their supporting systems are devices that provide building owners and operators with data that can be used to:

- Reduce energy/utility use
- Reduce energy/utility costs
- Improve overall building operations
- Improve equipment operations.

How the metered data are used is critical to a successful metering program. Depending on the type of data collected, it can enable the following practices and functions:

- Verification of utility bills

- Comparison of utility rates
- Proper allocation of costs or billing of reimbursable tenants
- Demand response or load shedding when purchasing electricity under time-based rates
- Measurement and verification of energy project performance
- Benchmarking building energy use
- Identifying operational efficiency improvement opportunities and retrofit project opportunities
- Usage reporting and tracking in support of establishing and monitoring utility budgets and costs, and in developing annual agency energy reports.

This practice does not require sub-metering, only providing the capability to do it.

Benefits and Costs

Triple Bottom Line Benefits

People: Better information on building energy use can make diagnosing building problems easier for building managers.

Economic: According to the *Federal Building Managers O&M Best Practices Guide,* installing sub-meters and utilizing the data to verify utility billing, identify problems with equipment, manage peak demand periods, and identify efficiency opportunities can lead to energy savings as high as 20 percent. The guide recommends estimating 2 percent savings for determining the economic case for a sub-meter.

Note that these savings only apply if sub-meters are installed and the data used to actively manage energy use. This measure as it stands alone does not produce energy savings.

Environment: Reduced energy consumption and CO_2 emissions (~400 pounds of CO_2/square foot/year)

Costs passed to owner

Assuming an additional panel must be added, the cost would be $1,750 per structure for buildings less than 35,000 square feet. Larger buildings will likely have a sufficient number of electrical panels to segregate loads without adding additional equipment. Note that the proposed practice does not require sub-metering and no savings will result without sub-metering. Each sub-meter is estimated to cost at least $1,500 according to the Federal O&M guide.

Lost Opportunity

This is a lost opportunity if not done at the time of construction. Without this in place it would likely be difficult and/or expensive to monitor discrete building systems.

Implementation

Availability of products and/or services

Readily available.

Practicality
No significant obstacles.

Certification Issues
N/A

Enforcement Procedures

Permit application/plan review: Submit design details with construction documents.

Field inspection: City building inspector performs standard compliance inspection.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
Documentation of requirements

Training Needs – Industry
Minor training needs for ME firms, electricians

Training Needs – Staff
Minor training for plan reviewers and inspectors

Background

Current practice
No current requirement.

Context
The value of sub-metering building loads is increasingly being recognized in the building community. Awareness of energy consumption by system can help to verify utility billing, understand utility rates and costs, measure and verify energy project performance, manage peak demand, and identify efficiency opportunities. Furthermore, displaying building energy consumption information for occupants can be a useful tool in promoting behavior change.

Under current practices, sub-metering at the electrical panel can be difficult due to mixed and sometimes poorly labeled loads on each panel.

Related GB practices
- Increasing levels of measurement and control in building automation systems will be supported by physically separating types of energy consumption and clearly labeled loads.
- ENERGY STAR and LEED-EB certifications can be supported with sub-metering data

Known objections
- Space may be limited at the point of installation for electrical panels
- Additional cost
- Requires the use of temporary or permanent sub-metering and the analysis of that data to reveal energy saving opportunities

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy Efficiency & Conservation / Building Thermal Envelope - Continuous Air Barrier

Proposed GB practice

Description

The building thermal envelope must be designed and constructed with a continuous air barrier that limits air leakage into, or out of, the conditioned space.

Applicability

New construction: Applies
Additions: Applies
Alterations: No

Intent

Improve energy efficiency, comfort, and building durability.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved comfort, fewer pest problems

Economic: Energy cost savings, reduced maintenance cost through building durability (avoid water damage, mold). Potentially, smaller HVAC systems are needed.

Environment: Reduced CO_2 emissions. Longer building durability equates to less material use in the long run.

Costs Passed to Owner

$0.75 - $2.00/SF of above-ground building envelope:
($6k - $15k for example building)
*$0.75/SF for commercial fabric wrap (e.g. Tyvek)
*$1.00/SF for incremental cost between fiberglass batt insulation and closed-cell foam insulation
*$1.25/SF for single-coat, fluid applied
*$2.00/SF for self-adhering rubberized asphalt membrane

*

Lost Opportunity

Yes. There is only one chance to get this right.

Implementation

Availability of products and/or services
Products and services are available in the Front Range, but not necessarily in Fort Collins. Local market will respond to demand for resources, materials and technical expertise.

Practicality
This is a well-accepted practice in some parts of the country.

Certification Issues
Certification will be required for assembly and whole-building testing

Enforcement Procedures
Permit application/plan review: All air barrier components of each envelope assembly shall be clearly identified on construction documents with details about the joints, interconnections, and penetrations of the air barrier components.
Field inspection: City building inspectors visually inspect installed air barrier, spot checking only.
Third party testing: Required.
Certificate of Occupancy:

Support Materials Needs
Resource guides on material selection and proper design and installation of air barriers.

Training Needs – Industry
Substantial training needed for architects, builders, trades. Continuous technical assistance needed.

Training Needs – Staff
Training needed for plan reviewers and inspectors

Background

Current practice
Continuous air barriers are not currently required by code. Analysis of existing building stock shows substantial energy loss through building envelope systems. A 2007 paper by the National Institute of Standards (NIST) and ASHRAE show heating and cooling energy savings ranging from 9%-36% from increasing the air tightness of commercial buildings.

Context
It has been traditionally assumed that energy loss through commercial building enclosures is minimal and as a result they have been given little attention. Work in Canada, Europe and the United States over the last 30 years has demonstrated the value to energy savings, occupant comfort and building durability of a well-designed and implemented continuous air barrier system.

Related GB practices
The tightness of the building envelope can affect HVAC system sizing. A tighter building requires less of a safety factor to assure occupant comfort.

A continuous air barrier is one component of a wall system that includes thermal, vapor, and weather barrier layers. It is important that these are integrated for optimum performance of the envelope.

Commissioning the air barrier system ensures that it was installed and performs as designed.

Known objections

- Higher building first cost
- Potential lack of local expertise for design and implementation

Sources

Emmerich, S.; McDowell, T.; Anis, W. “Simulation of the Impact of Commercial Building Envelope Airtightness on Building Energy Utilization” (http://www.nist.gov/customcf/get_pdf.cfm?pub_id=905031)

Air Barrier Association of America (www.airbarrier.org - numerous articles.

"Air Barriers in Building Construction: Understanding Costs, Meeting Performance Standards and Exceeding Codes" (Honeywell white paper).

"Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use" NIST, 2005.

Green Building Practice Summary 3/17/2011

Sector: Commercial

Category/Practice: Energy Efficiency / Electric-Heat Envelope Specifications

Proposed GB Practice

Description

Electrically-heated buildings must meet increased building envelope requirements for exterior insulation, door insulation and window U-values based on ASHRAE 189.1 as specified in Table 502.2(3) of the 2009 *International Energy Conservation Code* (IECC) as amended .

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies

Existing Buildings/Alterations: Does not apply

Intent

Reduce energy use and associated upstream carbon emissions in buildings heated with electric heat.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved comfort

Economic: Energy cost savings for utility customers. Reduction in utility peak demand.

Environment: Reduced CO_2 emissions through reduction of fuel use associated with heating and cooling.

Costs Passed to Owner

The increased cost for increased insulation and improved windows is approximately $0.15 - $0.25 per SF of floor space for the reference building depending on insulation and glazing type.

Lost Opportunity

Once construction is complete the opportunity is for improvement is limited.

Implementation

Availability of Products and/or Services

Products are readily available.

Practicality
Requirements would not affect standard insulation and window installation practices.

Enforcement Procedures

Permit application/plan review: Plans must include details on type of electric heating system used, verification of insulation values and specifications of required electrical panels solely dedicated for such use.

Field inspection: City building inspectors will visually inspect electric heat system and verify increased insulation installed.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
City to provide information on higher R-value insulation and higher U-value windows.

Training Needs – Industry
Education on new requirements

Training Needs – Staff
No additional

Background

Current Practice
IECC 2009 does not require additional thermal performance for building enclosures in electrically heated buildings.

Context
Buildings that use electric resistance heat use a large amount of electric energy in the winter. Increasing insulation level requirements would cut down on heating costs as well as improving occupant comfort. Insulation improvements are only cost effective at the time of construction; retrofits are rarely a viable option.

Related Green Building Practices
Continuous air barrier, insulation installation standards

Known Objections

- Increased cost of construction
- Possible increase lead times on insulation procurement

Green Building Practice Summary 3/17/2011

Sector: Commercial

Category/Practice: Energy / Installed Insulation standards

Proposed GB practice

Description
All insulation must be installed to Residential Energy Services Network (RESNET) Grade I standard, except RESNET Grade II will be accepted for cavity insulation in exterior walls that include continuous exterior insulation as specified in 2009 *International Energy Conservation Code* Table 502 .2 (1) installed to RESNET Grade I standard.

Applicability
New construction: Applies
Additions: Applies
Alterations: Applies

Intent
Ensure as-designed insulation performance through proper installation.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved comfort.

Economic: Energy cost savings. Getting what you pay for.

Environment: Reduced CO2 emissions through reduction of fuel use associated with heating and cooling.

Costs Passed to Owner
No additional cost for builder. Negligible cost for inspector training/certification.

Lost Opportunity
Once this insulation is encapsulated the opportunity to correct it is gone. Construction is the only time to get it right.

Implementation

Availability of products and/or services
Not an issue. This is just ensuring that existing products are installed as designed.

Practicality
Very practical.

Certification Issues
RESNET certification for insulation inspection

Enforcement Procedures
Permit application/plan review: Insulation details must be provided.

Field inspection: Visual inspection of all installed insulation will be performed by City building inspectors. At final inspection, access into attic, including ladders, will be required to inspect attic insulation.

Certificate of Occupancy: See above.

Support Materials Needs
Insulation installation guides for all types of insulation.

Training Needs – Industry
Builders will need to be trained as to proper installation.

Training Needs - Staff
Inspectors will need to be trained for insulation installation inspection.

Background

Current practice
There is no current system for grading insulation installation in commercial buildings.

Context
Often, in commercial buildings, insulation is installed in such a way that performance is substantially diminished. Fiberglass insulation in stud cavities is often installed with gaps, voids, and/or compression. Rigid insulation is often installed with gaps between sheets, not firmly attached to sheathing underneath, and/or with damaged edges. Polyurethane spray foam is often installed unevenly and/or with voids.

Related GB practices
Continuous air barrier

Known objections

- Possible construction delay waiting for inspection.

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy / Control of Loads in Hotel/Motel Guest Rooms

Proposed GB practice

Description

In hotels and motels with over 20 guest rooms, lighting switched outlets, permanently wired lighting fixtures, television and HVAC equipment serving each guest room will be automatically controlled to shutoff or adjust heating and cooling modes to conserve energy when the guest room is unoccupied.

Applicability

New construction: Applies
Additions: Applies
Alterations: To be determined

Intent

Conserve energy when guest rooms are not occupied.

Benefits and Costs

Triple Bottom Line Benefits

People: Convenient, guests don't have to be as vigilant about turning off equipment.

Economic: Energy cost savings (~$0.17/square foot/year) for guest rooms. There is also reduced maintenance cost due to lower equipment operating time.

Environment: Reduced CO_2 emissions (~7 pounds of CO_2/square foot/year), more efficient use of materials by making equipment last longer.

Costs Passed to Owner

$300-$500 per hotel/motel guest room depending on the scale of the installation and the selected technology.

Lost Opportunity

This is less expensive to install in new construction compared to retrofitting.

Implementation

Availability of products and/or services

These control products currently have moderate availability. The market is growing but it is still unclear which types of automation will remain in the market.

Practicality
No significant obstacles. Most of the automation technologies are not much more difficult to install and setup than traditional thermostats and occupancy sensors.

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Controls specified in construction documents.

Field inspection: City building inspector performs standard compliance inspection.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
Provide information on acceptable types of controls.

Training Needs – Industry
Minor training needs for architects, builders, trades and inspectors. Facility maintenance staff, housekeeping, and front-of-house staff will need to be trained in the maintenance, operation, and guest interface on these technologies.

Training Needs - Staff
Minor training for plan reviewers and inspectors

Background

Current practice
According to 2009 IECC, a master switch is required at each room entrance or main entrance for hotels, motels, or other similar properties. If room is a suite, master switch must control all permanently wired luminaries or switched receptacles. Specific control of televisions and HVAC set points is not required.

Context
Relatively recent applications of networked thermostats, occupancy sensors, and/or key card enabled room systems can reduce a significant amount of room and hotel-wide energy consumption by preventing lights, televisions, HVAC, and other amenities from operating when a guest room is unoccupied. Studies have shown (ACEEE, CEC) that occupancy based controls in hotel and motel guest rooms can lead to annual energy savings of 25 to 44% of total energy use.

Related GB practices
May relate or integrate with lighting control strategies in guest rooms.

Known objections

- Higher building controls costs
- Challenges of effectively implementing some control technologies
- Room may be too warm/cold on initial guest arrival - before systems respond to occupancy - with some technologies
- Training staff and managing guest expectations about controls

Resources

IGCC Public Version 1.0
ASHRAE 189.1
Esource - Resource Guide on Hotel Room Automation, By Peter Criscione and Ira Goldschmidt

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy Efficiency & Conservation / Exterior Lighting Controls

Proposed GB practice

Description

Exterior lighting of building façades, parking lots, garages, canopies (sales and non-sales) and all outdoor sales areas require automatic controls to reduce lighting power consumption by a minimum of 50 percent two hours after normal business closing and to turn off outdoor lighting within 30 minutes after sunrise.

Applicability

New construction: Applies
Additions: Applies
Alterations: No

Intent

Conserve energy at night by turning off lighting that is not essential for safety or security. The 50 percent reduction threshold provides flexibility in selecting fixtures that are not essential for safety, security, or sales.

Benefits and Costs

Triple Bottom Line Benefits

People: Reduced light trespass and light pollution.

Economic: Energy cost savings of ~$0.015/square foot/year and reduced maintenance cost due to lower equipment operating time.

Environment: Reduced CO_2 emissions of ~0.5 pound of CO_2/square foot/year.

Costs Passed to Owner

About $400 per structure depending on the type of control technology and the number of circuits that need to be controlled to achieve the required reduction.

Lost Opportunity

If this is not done during construction, it may difficult and expensive to create that would enable this type of control later.

Implementation

Availability of products and/or services

Timer controls with a photo sensor or astronomical clock for adjusting to seasonal changes in night-time hours are readily available.

Practicality
No significant obstacles. Designing outdoor lighting circuits so that desirable fixtures for control are on the same circuit is probably the biggest challenge.

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Controls specified in construction documents.

Field inspection: City building inspector performs standard compliance inspection.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
None

Training Needs – Industry
Minor training needs for designers to assure circuits are conducive to desired control scheme.

Training Needs - Staff
Minor training for plan reviews and inspectors

Background

Current practice
The 2009 IECC requires outside lighting to be on from dusk-to-dawn and controlled by an astronomical time switch or photo sensor. Other outside lighting applications—those that are not on from dusk-to-dawn—are also required to have a clock timer in addition to astronomical or photo sensor control. This proposed approach assumes that an additional clock timer is needed above the current practice to achieve the 50 percent reduction in lighting load.

Context
Outdoor lighting is often left on from dusk-to-dawn at businesses where there is little or no activity from shortly after the close of business until after dawn. By selecting appropriate fixtures for control the safety and security of the occupants and structure can be maintained with significantly less lighting left on for the entire night.

Related GB practices
This practice will support other efforts to reduce light trespass and pollution such as the implementation of cut-off lighting fixtures.

Known objections
- Concerns about safety, security, and/or sales.

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy Efficiency / Occupancy Sensors in Corridors & Stair Wells

Proposed GB Practice

Description

Occupant sensor controls are required to automatically reduce connected lighting power by at least 50% in corridors, enclosed stairwells, storage and stack areas not open to the public, library stack areas, and parking garages when unoccupied.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies

Existing Buildings/Alterations: Does not apply

Intent

Energy efficiency by limiting lighting that is often on for long periods of time (in some cases, 24 hours per day) when these spaces are mostly unoccupied while maintaining safety by controlling lights to 50% when areas are unoccupied.

Benefits and Costs

Triple Bottom Line Benefits

People: N/A

Economic: Electricity cost savings for utility customers. Potentially longer replacement cycles for lighting in controlled areas.

Environment: Reduced fuel use and CO_2 emissions at power plants.

Costs Passed to Owner

The installed cost for occupancy sensors is approximately $0.08 - $0.10 per square foot (about $1,200 to $1,500 for the example 15,000 sf office building).

Lost Opportunity

It would be more difficult and expensive to install the correct wiring and controls after the building has been constructed.

Implementation

Availability of Products and/or Services
Products are readily available.

Practicality
Very practical. This is currently done on more energy efficient buildings.

Enforcement Procedures

Permit application/plan review: Verify that controls are on construction documents.

Field inspection: Confirm occupancy sensors are installed.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
City to provide information on the types of controls that work well for these situations.

Training Needs – Industry
Education on new requirements

Training Needs – Staff
No additional

Background

Current Practice
Occupancy controls in these areas currently not required.

Context
Corridor and stairwell lights are often left on during all hours that a business is open or in some cases (e.g. multi-family) they are on 24-hours per day. This background electricity use adds to utility costs, shortens the replacement cycle of lamps, and contributes to unnecessary greenhouse gas emissions. These lights are primarily left on for safety and convenience. Controlling the lights only down to 50% insures that someone doesn't open the door into a dark hallway or stairwell. As soon as the space is occupied the lighting returns to 100%.

Related Green Building Practices
N/A

Known Objections
- Small increase in cost of construction

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Energy Efficiency / Energy Assessments for Alterations

Proposed GB Practice

Description

An energy analysis of the entire building is required prior to any alterations. Energy assessments are not required in the following cases:

- First-time interior finishes;
- Buildings that have had an energy assessment in the previous three years; and
- Alterations with a construction value of less than $30,000.

Applicability

New Construction: No

Existing Buildings/Additions: No

Existing Buildings/Alterations: Applies

Intent

Raise awareness about energy efficiency opportunities for which there may be opportunities to implement during renovations. Goal is to identify energy efficiency opportunities as early as possible.

Benefits and Costs

Triple Bottom Line Benefits

People: Raise awareness of energy efficiency.

Economic: Provides information that would allow an owner to reduce the energy cost of their building.

Environment: Potential to reduce energy consumption and associated environmental impacts.

Costs Passed to Owner

None – Fort Collins Utilities would cover the cost of the assessment.

Lost Opportunity

It could be more economical and cause less disruption to implement measures identified from the assessment during alterations than to implement them later.

Implementation

Availability of Products and/or Services
This is a service that Fort Collins Utilities currently provides. Additional resources may be required.

Practicality
Very practical

Certification Issues
Third party auditors will need to be certified by Fort Collins Utilities

Enforcement Procedures

Permit application/plan review: Assessment required to be scheduled and completed prior to work on alteration commencing. Copy of assessment to be submitted.

Field inspection: None required.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
Application and assessment forms

Training Needs – Industry
N/A

Training Needs – Staff
Minimal related to Utilities coordination with Building Department

Background

Current Practice
Energy assessments are not currently required for alterations

Context
Often during building alteration there are opportunities for energy efficiency upgrades. This practice would identify potential energy efficiency and/or conservation measures and raise owner awareness about energy use in their buildings. There is no requirement to implement identified measures.

The intention is to conduct assessments and associated paperwork in such a way that it does not delay or slow construction.

Related Green Building Practices
N/A

Known Objections

- Potential to slow down project

Green Building Practice Summary 3/17/2011

Sector: Commercial

Category/component: Water Conservation / Low-Water-Use Fixtures

Proposed GB practice

Description

Plumbing fixtures must meet these maximum water flow or consumption limits:

- Lavatory faucets, private: 1.5 gpm at 60 psi
- Lavatory faucets, public (metering): 0.25 gpm
- Lavatory, public (other than metering): 0.5 gpm at 60 psi
- Shower heads: 2.0 gpm at 80 psi
- Sink faucets: 1.8 gpm at 60 psi
- Toilets: 1.28 gpf with minimum MaP threshold of 350 grams
- Urinals: 0.5 gpf
- Pre-rinse spray valves (food service): Must meet federal requirements
- Bar sinks (food service): 2.2 gpm at 60 psi

Such fixtures shall be Environmental Protection Agency (EPA) WaterSense® labeled fixtures or fixtures which provide the equivalent maximum flow rates.

Applicability

New Construction: Applies throughout.

Existing Buildings/Additions: Applies to only those fixtures being replaced.

Existing Buildings/Alterations: Applies to only those fixtures being replaced.

Existing Buildings/Historic: Generally, same as alterations except when a qualifying historic building/structure is enlarged. In that case, the newly-constructed addition is subject to the "additions" criteria above.

Intent

To reduce water and energy consumption.

Benefits and Costs

Triple Bottom Line Benefits

People: Since these fixtures have been independently tested and must meet rigorous performance standards, they have high customer satisfaction. Using low-flow fixtures demonstrates a commitment to sustainability and a conservation ethic.

Economic:

- The proposed standards compared to the current water-efficiency standards are intended to reduce water use by approximately 20%.
- Reduced water use means less need for water distribution and treatment, and wastewater collection and treatment capacity.
- In addition to minimizing water consumption and wastewater collection and treatment capacity, water heating charges are also reduced.

- Customers use less water and save on their water bills and in foodservice applications can remain competitive with meal costs to their consumers.

Environment: Lower water demand lessens the amount of raw water supply needed. More water available to meet the potential increased needs with climate change. Lowers carbon emissions with lower energy use.

Lost Opportunity

These fixtures typically last for 5 to 20 years (spray-rinse valves to toilets/urinals). If maximum low flow models aren't installed at the time of new construction or renovation, the opportunity to reap water and energy savings won't come around until replacement. Although these fixtures can be replaced at any time, rarely are they replaced until they fail.

Costs Passed to Owner

Just as with conventional plumbing fixtures, depending on the style and quality selected there is a wide range of costs for WaterSense® fixtures, prices start as follows:

- Lavatory faucets for commercial start at $60
- High-efficiency toilets for commercial use start at $200
- Showerheads start at $10

The costs for low-flow pre-rinse spray valves:

- 1.2 gpm are approximately $70
- .65 gpm are approximately $47

Implementation

Availability of Products and/or Services

WaterSense® labeled lavatory faucets and high efficiency toilets are widely available from major plumbing manufacturers, plumbing supply distributors and builder supply warehouses, in a wide variety of brands, styles and price points. Products are labeled and readily identified. Showerheads began to be WaterSense® labeled in mid-2010 and aren't currently as available as the toilets and faucets.

WaterSense® labeled products are listed on the WaterSense website at www.epa.gov/WaterSense/product_search.html .

Low-flow pre-rinse spray valves are readily available through suppliers; 1.6 gpm models have been available since 2005. T & S Brass supplies low flow pre-rinse spray valves endorsed by the Green Restaurant Association www.dinegreen.com with flow rates as low as .64 gpm.

Practicality

No practical obstacles have been identified.

Certification Issues

None.

Enforcement Procedures

Permit application/plan review: Application specifies compliance with EPA Water Sense® labeled fixtures at specified flow rates or as otherwise noted for compliance.

Field inspection: Building inspectors verify that specified products are installed.

Enforcement resources: No additional resources required.

Support Material Needs
None.

Training Needs-Industry
Little to none needed. No special skills are required to install WaterSense or low-flow fixtures.

Training Needs-Staff
None, easily identifiable via WaterSense® labels on fixtures as specified in permit documents.

Background

Current Practice
The Energy Policy Act of 1992 mandated that fixtures manufactured in the U.S. meet the following maximum flow-rates: showers – 2.5 gpm; lavatory faucets – 2.2 gpm; and toilets - 1.6 gpf. This mandate was lifted by the Department of Energy (DOE) and is no longer applicable as of December 22, 2010.

The Energy Policy Act of 2005 (EPAct), in effect since January 1, 2006, states that all pre-rinse units and replacement spray valves used for ware washing must have a maximum flow of 1.6 gpm at 60 psi.

The Food Service Technology Center FSTC testing laboratory—the nation's leading resource for commercial foodservice energy efficiency information—recommends a pre-rinse spray valve with a flow rate of 1.6 gallons per minute or less, and cleaning performance of 26 seconds per plate or less, based on the ASTM *Standard Test Method for Performance of Pre-Rinse Spray Valves*.

The EPA WaterSense® and ENERGY STAR Programs are currently collaborating with American Society of Mechanical Engineers ASME and ASTM International to develop performance and efficiency criteria that will inform an EPA specification for Pre-Rinse Spray Valves (PRSVs).

Context
The WaterSense® Program is a U.S. Environmental Protection Agency (EPA) sponsored partnership program launched in 2006. The WaterSense® Program promotes water efficiency and enhances the market for water-efficient products, programs, and practices. The WaterSense® label for products helps consumers identify water-efficient products and programs that meet WaterSense® water efficiency and performance criteria. WaterSense brings together local water utilities and governments, product manufacturers, retailers, consumers, and other stakeholders to:

- Decrease indoor and outdoor non-agricultural water use through the adoption of more efficient products and practices.
- Help consumers make water-efficient choices, including differentiating between products and services in the marketplace and adopting simple daily activities that reduce water use.
- Encourage innovation in manufacturing
- Establish and standardize rigorous certification criteria that ensure product efficiency, performance, and quality

Initially the WaterSense® Program focused on residential products and services, but currently the program is expanding its focus to include the commercial sector. For example the WaterSense® Program recently released its specifications for commercial urinals which require that water use not exceed 0.5 gpf. This is important because according to WaterSense research, nearly 65

percent of the urinals in use today—approximately 7.8 million fixtures—exceed the maximum allowable flush volume set by federal standards of 1.0 gpf.

Fixtures meeting these specifications are encouraged in voluntary Green Building rating systems such as LEED.

Indoor water use averages about half of total water consumption in Fort Collins commercial applications.

Water and energy conservation are a primary concern in the foodservice industry. An average restaurant uses 11 gallons of water per meal. A water-efficient restaurant uses six to nine gallons of water per meal. The bulk of a restaurant's water usage—at 47 percent—is in the kitchen (with 33 percent water usage in the bathrooms).

Pre-rinse spray valves are used in commercial kitchens to remove food from dishes before being loaded into the dishwasher. About one-third of all water used in restaurants is consumed by pre-rinse sprayers, and in large commercial kitchens some older models can use as much as five gallons per minute.

A low-flow pre-rinse spray valve is one of the easiest and most cost effective water and energy saving devices available to the foodservice operator.

To calculate water savings, see the pre-rinse spray valve calculator:
www.fishnick.com/equipment/sprayvalves/

Nearly 65 percent of the urinals in use today—approximately 7.8 million fixtures—exceed the maximum allowable flush volume set by federal standards. While the current federal standard for commercial urinals is 1.0 gallon per flush (gpf), some older urinals use as much as five times that amount!

Replacing these inefficient fixtures with WaterSense® labeled flushing urinals can save between 1.0 and 4.5 gallons per flush, without sacrificing performance. The WaterSense® label helps purchasers easily identify high-performance, water-efficient products. Installing WaterSense ® labeled flushing urinals will help reduce water use in facilities and save money on water bills.

Related Green Building Practices
None

Known objections

- Contractor concerns about flush performance for 1.28 gpf toilets.

Green Building Practice Summary 3/17/2011

Sector: Commercial

Category/Practice: IEQ / HVAC Measures for Indoor Air Quality (IAQ)

Proposed GB Practice

Description
HVAC equipment and systems must be designed and protected to minimize the release and accumulation of debris prior to and during construction.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies

Existing Buildings/Alterations: Applies

Intent
Reduce contaminants introduced into HVAC systems during and after construction and construct HVAC system in such a way the Indoor Air Quality can be maintained.

Benefits and Costs

Triple Bottom Line Benefits

People: Healthier buildings

Economic: N/A

Environment: N/A

Costs Passed to Owner
If well designed, there should be no additional cost.

Lost Opportunity
Yes – just one chance to do this.

Implementation

Availability of Products and/or Services
Not an issue

Practicality
This is practical to do; only requiring attention to detail during design and construction

Certification Issues
None

Enforcement Procedures

Permit application/plan review: Required protective measures to be provided in construction documents.

Field inspection: City building inspectors visually inspect HVAC systems, surfaces and access.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
City to provide builder with applicable examples.

Training Needs – Industry
Minimal

Training Needs – Staff
Minimal

Background

Current Practice
These are all common-sense practices, but are not required in the current codes.

Context
Air handling equipment is sometimes installed in constrained spaces such that access is difficult for cleaning and maintenance. In some cases, materials are used that can introduce particulates (e.g. fiberglass in ceiling return air plenums). On some construction sites, ductwork is not covered and becomes contaminated with dust and debris, affecting initial indoor air quality of the building. These requirements provide the foundation for making corrections when these best-practices procedures are not followed.

Related Green Building Practices
Building Flush-out

Known Objections
- none

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: IEQ / Building Flush-Out

Proposed GB practice

Description

After all interior finishes are installed, the building must be flushed out with outside air for 14 days with either continuous ventilation or aggregate intermittent ventilation equivalent to 14 days as specified in the amended 2009 *International Building Code* (IBC). Occupancy is allowed one day after start of the flush-out.

Applicability

New construction: Applies
Additions: Applies if the addition can be isolated from the rest of building.
Alterations: No

Intent

Improve the indoor air quality by removing air contaminants that are caused by the construction process, construction materials, and interior design elements such as adhesives, carpeting, and paints.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved health and productivity of occupants

Economic: Flush-out period will result in greater energy costs. However, there can be economic benefit gained over long term as a result of improved health and productivity.

Environment: Greater energy costs from flush-out result in environmental impact.

Costs Passed to Owner

Costs include setup and monitoring (estimated at $500 - $1,500 per building to program and turn on/off flush) and energy to supply the air as well as to heat or cool the outside air to maintain safe indoor air temperatures. These latter energy costs vary depending on the season:

- Summer energy cost: ~$0.005/sf
- Winter energy cost: ~$0.012/sf
- Spring/Fall energy cost: ~0.008/sf

Implementation

Availability of products and/or services

Readily available.

Practicality
No significant obstacles. Potential obstacle would arise if HVAC system is not able to supply outside air at rate of 0.30 fm per square foot.

Certification Issues
Any qualified HVAC technician could perform this procedure.

Training needs
Limited.

Enforcement Procedures

Permit application/plan review: Applicant to submit specifics on compliance plan.
Field inspection: None; flush-out reports to be provided prior to approval.
Certificate of Occupancy: Nothing additional.

Support Materials Needs
City to develop materials detailing how to perform flush-out and compliance verification.

Training Needs – Industry
Minimal

Training Needs – Staff
Minimal

Background

Current practice
Not a current practice.

Context
US EPA reports that Americans spend an average of 90% of their time indoors, where pollutant levels may run 2 to 5 times higher than outdoor levels (USEPA, 2001). Sources of pollutants include construction activity, interior materials, and furniture. The intent of this measure is to create a high air exchange rate as the building is being occupied in order to remove as many VOCs as possible during the time that out-gassing is the highest.

Related GB practices
Activities designed to improve indoor environmental quality such as: improving air handing access and ability to clean and maintain equipment; eliminating use of fibrous insulating materials in air plenums; protecting ducts from contamination during construction; and minimizing VOCs in adhesives, paints, etc.

Known objections

- none

Sources:
US Environmental Protection Agency. "Healthy Buildings, Healthy People: A Vision for the 21st Century", 2001. http://www.epa.gov/iaq/hbhp/hbhptoc.html .

Green Building Practice Summary 3/17/2011

Sector: Commercial

Category/Practice: IEQ / Low-VOC Materials

Proposed GB Practice

Description

Construction materials, floor coverings and site-applied finishes (including sealants and adhesives), resilient flooring, carpeting and pad, site-applied paints, stains and varnishes, structural wood panels, hardwood veneer plywood, particle board and fiber board building products, and insulation are required to meet specified volatile organic compound (VOC) emissions limits in accordance with California Department of Public Health (CDPH) 01350; GREENGUARD Environmental Institute GGPS.001 standard for building materials and finishes; and, Green Seal® standards.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to addition portion only

Existing Buildings/Alterations: Applies with limited scope:

- Only to new construction within alteration
- Only to sealants and adhesives, resilient flooring, paints, stains, varnishes and other site-applied finishes.

Intent

Improve indoor air quality for construction workers and occupants.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved health for construction workers and occupants.

Economic: Improved health can potentially reduce health-care costs.

Environment:

- Improved outdoor air quality.
- Fewer toxic compounds purchased likely leads to reduced pollution at the manufacturer level.

Costs Passed to Owner

The best data for costs for low VOC sealants and adhesives; resilient flooring; and paints, stains, varnishes and other site-applied finishes comes from case studies in the health care industry. According to “Building Healthy Hospitals” an EPA P2 Project 2007

http://www.epa.gov/region9/waste/p2/pdf/IAQFinalOct12.pdf, noting the following cost premiums:

- Adhesives – 5 to 20%
- Carpeted flooring – 10-20% initially, but depending on the type can yield significant cost savings over useful life
- Caulk – 5-20%
- Finishes applied to woodwork, casing and other applications – 10-50%, but increasingly commonly available and cost competitive
- Interior paints – minimally more costly, paint quality is primary cost factor
- Sealants – 20-50%, but increasingly commonly available and cost competitive

Local suppliers of prefabricated cabinets with low VOC composite wood product materials have a higher cost impact; currently special order. Costs are 25%-40% more than standard cabinets due to low demand, demand thus far on LEED projects only.

Lost Opportunity

- Construction worker exposure to VOCs during application may have long-term health consequences.
- Many construction materials used when the building is constructed stay with the building throughout its life.

Implementation

Availability of Products and/or Services

Low VOC sealants and adhesives; resilient flooring; and paints, stains, varnishes and other site-applied finishes are readily available.

Low urea formaldehyde emissions plywood products are readily available; see Engineered Wood Association at www.apawood.org.

Documented low VOC composite wood product materials for cabinets are available through suppliers such as SkyBlend™; other resources through the ESP (Environmental Stewardship Program) by the Kitchen Cabinet Manufacturer's Association, see: www.greencabinetsource.org.

Practicality

Practical to require Low VOC sealants and adhesives; resilient flooring; and paints, stains, varnishes and other site-applied finishes.

As demand for low VOC cabinetry increases, costs are likely to decrease.

Certification Issues

None

Enforcement Procedures

Permit application/plan review: Require initial documentation via standardized checklist form developed by the City.

Field inspection: Documentation demonstrating compliance is required with delivery of materials and must be available for inspection.

Certificate of Occupancy: See above.

Support Materials Needs

- Standardized checklist form for initial submittal
- Certificate of compliance form

Training Needs – Industry

Training should cover health impacts and compliant material sources, costs, performance and identification.

Training Needs – Staff

Training should cover health impacts and compliant material sources, costs, performance and identification.

Background

Current Practice

Structural wood panels and plywood have been regulated for some time. Otherwise currently no maximum VOC limits required in construction by current building codes.

Context

Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short-and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.

The health impacts of exposure to VOCs include eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some VOCs can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include eye irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness. See: www.epa.gov/iaq/voc.html#Health%20Effects.

There is a lot more data on health effects of VOCs in commercial environments than residential environments because there are so many variables in homes and their occupants.

Industrial hygienists and environmental health professionals are currently very concerned about the trend toward green building and weatherization as some strategies create higher exposures to occupants. This is an issue that is gaining support and could lead to liability issues and other repercussions down the road.

The quest for energy efficiency—dating back to the 1970s—has often closed buildings off to fresh air, forcing reliance on building-ventilation systems for clean air. The EPA estimates that indoor VOC levels can grow up to 10-times higher than outdoor levels, especially during construction and renovation projects.

The biggest emitters of VOCs are formaldehyde-based products. Cabinetry is typically a major source of indoor formaldehyde exposure. Formaldehyde is classified as a "Group 1 Carcinogen" which is defined as an agent that "is definitely carcinogenic to humans" by the International Agency for Research on Cancer (IARC), and "a complete carcinogen" in the words of the Occupational Safety and Health Administration (OSHA). The National Toxicology Program also recently revised its characterization of formaldehyde to that of "known human carcinogen." Formaldehyde, one of the best known VOCs, is one of the few indoor air pollutants that can be readily measured.

Fiberglass insulation may contain urea or phenol formaldehyde binders. Recent studies indicate that phenol formaldehyde products expose occupants to emissions that exceed recognized standards. For alternatives that do not contain urea or phenol formaldehyde see: www.ecoblueinc.net; www.jm.com; and www.bondedlogic.com.

No federal standards have been set for VOCs in non industrial settings. OSHA regulates formaldehyde, a specific VOC, as a carcinogen. OSHA has adopted a Permissible Exposure Level (PEL) of .75 parts per million (ppm), and an action level of 0.5 ppm.

California has led the charge regulating VOCs in many consumer products—notably California Department of Public Health (CDPH) Section 01350. A number of northeastern states also regulate VOCs with the goal of improving indoor air quality.

The California Air Resources Board's (CARB) Airborne Toxic Control Measure (ATCM) to control formaldehyde emissions from composite wood specifically focuses on three products: hardwood plywood, particleboard, and medium density fiberboard.

Related Green Building Practices

Healthy indoor air is the result of a systems approach. These practices go hand-in-hand. Effective air-sealing building envelope creates healthy indoor air quality in combination with:

- Building Flush-out

Known Objections

- Construction materials meeting referenced standards may not perform as well (initial application, durability) as products currently in use.
- Some of these materials may have health impacts for applicator but not for the residents, because the off-gassing is largely complete when the material is cured.
- Any gains in indoor air quality gained with this proposal may be outweighed by furnishings and other materials brought into the building by occupants after final inspection and/or Certificate of Occupancy.
- Higher cost for compliant pre-fabricated cabinets.
- Compliance will be very difficult to verify.

Sources

"Building Codes and IAQ" by the Cadmus Group, September 2010 prepared for the EPA
http://www.epa.gov/iaq/pdfs/building_codes_and_iaq.pdf

CRI – GREEN LABEL PLUS
http://www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH
http://www.calrecycle.ca.gov/greenbuilding/Specs/Section01350/

CALIFORNIA AIR RESOURCES BOARD
Indoor Air Quality
http://www.arb.ca.gov/research/indoor/indoor.htm

GREEN GUARD ENIRONMENTAL INSTITUTE
www.greenguard.org
Institute does testing for all interior finishing products

AIR QUALITY SCIENCES IAQ RESOURCE CENTER.
http://www.aerias.org/DesktopDefault.aspx?tabindex=5&tabid=97 A well-respected resource for up-to-date information about IAQ and other occupant health issues.

SPRAY FOAM INSULATION CALCULATOR
http://foamboulder.com/calculator/spray-foam-energy-calculator.asp

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: IEQ / Acoustical Control

Proposed GB Practice

Description
This green building practice sets maximum sound levels for exterior and interior sound transmission as well as background sound.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to addition

Existing Buildings/Alterations: Does not apply

Intent
The intent of this measure is to improve indoor environmental quality for occupants by controlling noise pollution.

Benefits and Costs

Triple Bottom Line Benefits

People: Improved working environment resulting in increased productivity.

Economic: Increased worker productivity can improve bottom line for organizations.

Environment: Improved indoor environmental quality.

Costs Passed to Owner
Determined by building thermal envelope.

Lost Opportunity
It would be difficult and potentially costly to improve acoustics post-construction.

Implementation

Availability of Products and/or Services
Widely available.

Practicality
No significant issues.

Certification Issues
Verified by qualified commissioning technician.

Enforcement Procedures

Permit application/plan review: Design details submitted with construction documents.

Field inspection: Third party verification during building commissioning process.

Certificate of Occupancy: Nothing additional.

Support Materials Needs
Educational information about effects of noise pollution and appropriate acoustical control measures.

Training Needs – Industry
Part of commissioning education.

Training Needs – Staff
Part of commissioning education.

Background

Current Practice
None.

Related Green Building Practices
Commissioning.

Known Objections
- Added costs to construction.

Green Building Practice Summary 03/17/2011

Sector: Commercial

Category/Practice: Commissioning - Operations & Maintenance / Commissioning

Proposed GB practice

Description

New buildings and additions with a gross floor area of more than 15,000 sq. ft. must be "commissioned" to ensure that the building construction project and its components and systems comply with the construction documents.

The following activities/documents are required:

- Approved third party commissioning authority
- Commissioning plan to include all required forms and procedures for complete testing of equipment, systems and controls
- Owner's project requirements
- Basis of Design
- Installation verification
- Performance verification
- Final commissioning report

Applicability

New construction: Applies to all buildings 15,000 square feet and greater
Additions: Applies to all additions 15,000 square feet and greater
Alterations: No

Intent

To verify that the project's energy-related systems are installed, and calibrated to perform according to the owner's project requirements, basis of design and construction documents.

Benefits and Costs

Triple Bottom Line Benefits

People:

- For building occupants/owners, improved:
    - building environment, including thermal comfort, resulting in improved worker productivity.
    - facility and systems because all parties involved in the life cycle are focused on the end users' needs as the primary goal of the facility.
    - understanding of the purpose of the facility and the reason for its existence to serve the end user.

    - maintenance and reduced maintenance man-hours because of available documentation and training.
    - ability to correct problems with equipment.
- For design/construction team, improved:
    - coordination between the owner, engineer, and contractor resulting in appropriate costs, schedule, system operation and reduced change orders.
    - Reduced call-backs, and reduced claims and litigation because thorough acceptance tests were conducted, all systems were brought up to operate per design and performance was optimized.

Economic:

- 10% savings on electrical and natural gas usage. [For 15,000 square foot commercial office building, approximately $1,000 savings per year.]
- Reduced maintenance costs because of improved equipment life and reliability.
- Allows building owner/occupant to better quantify operating costs including identifying utility errors, problems with equipment, and peak demand monitoring.

Environment:

- Reduced energy consumption - 10% savings on electrical and natural gas usage – and associated greenhouse gas reductions.
- For 15,000 square foot commercial office building, savings are approximately:
    - 9,000-10,000 kWh per year
    - 400 – 500 therms per year
    - 7-8 tons of CO_2 per year

Costs Passed to Owner

- For new construction:
    - $1.16/SF is general number for new construction reported by Evan Mills' 2009 report for LBNL (Lawrence Berkley National Laboratory). However, this is across many different building types and sizes. Simple buildings (offices) that have energy management systems are on the low end. More complex buildings such as data centers are more costly, but have greater potential for savings. The economy of scale lowers the per square foot cost for larger buildings. [For 15,000 square foot commercial office building, $15,000 – 20,000]
    - $1.00 - $5.00/SF is the cost range for commissioning for new construction. Some studies quote lower values. However, to achieve the level of commissioning that would suffice for "Fundamental Commissioning" as defined by LEED, would cost at least $1.00/SF.
    - Note: Recent, local evidence suggests that even small buildings can achieve fundamental commissioning for about $1.00/SF, especially if they have energy management systems (Sieving, 2010).
    - $1.00 - $2.00/SF - Ron Major, Resource Conservation Manager with the General Administration of Washington State

Lost Opportunity
Buildings can be commissioned after occupancy, but it is much easier to do prior to occupancy and can avoid many comfort complaints and increased energy cost.

Implementation

Availability of products and/or services
While services are available across the Front Range, the number of Northern Colorado firms that offer them are limited.

Practicality
Commissioning is a common practice done on many local buildings.

Certification Issues
Need to have qualification criteria for commissioning agents.

Enforcement Procedures

Permit application/plan review: Commissioning documentation to be submitted

Field inspection: Performed by approved third party provider

Certificate of Occupancy: Final commissioning report to be provided.

Support Materials Needs
City to develop guidelines on the commissioning process

Training Needs – Industry
Training opportunity to expand number of service providers in Northern Colorado. Contractor training needed on how to effectively manage commissioning on a project.

Training Needs - Staff
Training on what commissioning is and isn't (e.g. compared to test and balance) and how to assess commissioning reports. Set up documentation procedures.

Background

Current practice
No current requirement.

Context
ASHRAE definition; ***Commissioning*** *is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.*

Washington State Department of General Administration's definition; ***Building Commissioning*** *is a systematic and documented process of ensuring that the owner's operational needs are met, building systems perform efficiently, and building operators are properly trained.*

Currently, the Fort Collins building code requires that building mechanical systems go through a test and balance process. That process is different from commissioning in several ways. Test and balance contractors work on air and water systems, measuring the quantities of air flow or water flow and setting them to where they should be. They are not as concerned with whether or not the equipment is performing optimally or the integrated controls of the equipment.

When should building commissioning start? Early involvement by the commissioning agent may not carry a cost premium. It will reduce project design problems and will introduce building commissioning expectations early.

Building systems commissioning is becoming a well-accepted practice on many projects. It is a standard for City of Fort Collins and Poudre School District building projects.

Related GB practices

- Building envelope: air barrier, electrically heated buildings, installed insulation standards

Known objections

- Increased construction cost.

Sources

"Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions" 2009 by Evan Mills at LBNL (summary at http://cx.lbl.gov/2009-assessment.html)

www.totalbuildingcommissioning.com (Dodd article)

Personal Communication with Julie Sieving of Brendle Group. She is working with Boulder on a commissioning project and has researched cost and savings potential.

Ron Major, Resource Conservation Manager with the General Administration of Washington State. www.energy.wsu.edu/Documents/**whatisinforyou.ppt**