City of Boulder

# CITY OF BOULDER, COLORADO

## COMMERCIAL ENERGY CODE CONSULTATION

FINAL – February 2013

PREPARED FOR CITY OF BOULDER BY

brendle GROUP

Engineering Sustainable Change

COLORADO CODE CONSULTING

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Jim Appel, Coburn Development

Sean Beilman, BCER Engineering

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James Dixon, Tebo Development

Julie Herman, Colorado Green Building Guild

J.C. Martel, Southwest Energy Efficiency Project

C.J. McCray, RK Mechanical

Andrew McVay, Tebo Development

Jerry Oglesbee, 2020 Engineering

Stacy Rogers, Rogers & Sons

John Wyatt, Wyatt Construction

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# EXECUTIVE SUMMARY

The City of Boulder continues to be proactive in its approach to green building standards even as national standards evolve. With the goal of adopting an updated building code in April of 2013 that exceeds the current standards of the 2012 International Energy Conservation Code (IECC) by 20 percent and the 2012 International Green Construction Code (IGCC) thermal envelope standards by 10 percent, the City of Boulder wants to define through engineering analysis what the premium cost of these updates will be to building owners involved in new construction and major renovations. This information will serve to inform the content of the update such that the goals are achieved and the minimum cost premium is defined. The City also will be gathering public input in early 2013 and has reached out to the commercial construction, development, and real estate industry as part of this analysis for a view of cost impacts.

Brendle Group and its partner, Colorado Code Consulting, conducted research and developed a methodology for estimating energy savings and costs for a variety of code measures and scenarios. The team engaged community and industry stakeholders to inform cost estimating parameters and vet measures. On the basis of this background effort, the team identified, analyzed, and prioritized measures to achieve the desired 20 percent energy efficiency improvements for two baseline building types.

The analysis indicates that exceeding 2012 IECC by 20 percent has an associated cost premium of 1 to 2 percent of project cost for commercial and mixed use building owners. The associated cost savings to building owners is 33 to 35 percent of annual utility energy costs, for an average payback of 7 to 8 years, depending on building type. These estimates are the results of energy savings analyses for building efficiency improvement measures and cost analyses that included direct feedback from local industry representatives.

# OUTCOMES

## Bottom Line for Building Owners

Higher performing buildings increase property value, command higher lease prices, cost less to operate, and improve occupant comfort in addition to contributing to community goals for reducing greenhouse gases in Boulder. However, first costs to construct these buildings are higher than those for meeting minimum energy efficiency requirements.

This analysis considered two base building models – a commercial office space and a mixed use space - that comply with minimum 2012 IECC standards and compared the energy use and costs (both energy and construction) with energy use and costs for exceeding the 2012 IECC by 20 percent. Exceeding the 2012 IECC requirements by at least 20 percent is projected to cost buildings owners 1 to 2 percent over baseline building first costs. Using the commercial office space model described in this report, the building efficiency improvements reflected by the cost premium will yield 33 percent in energy savings and have an overall payback of 8 years. Similarly, for the mixed use building modeled, the efficiency improvement will yield 35 percent in energy savings and 7 years for the overall payback.

## Combination of Measures

Using a tiered analysis that prioritized energy measures based on energy savings and first costs, the combination of measures presented in the list below is estimated to achieve or exceed 2012 IECC building performance standards by 20 percent and represents the base case for determining the cost premium for commercial buildings constructed to this standard:

- Plug loads
- Reduced lighting power density and daylighting
- Parking garage ventilation controls
- Building automation system - ventilation
- Exterior LED lighting and controls
- Building automation system - HVAC mechanical equipment

While building commissioning is not explicitly included, it is a measure that is considered to be required to achieve the savings potential of each of the listed measures. Additionally, as detailed later in the Measures section, other measures evaluated provided nearly similar results (of first costs and savings) and are considered likely options for achieving the 20 percent improvement.

# BACKGROUND AND METHODOLOGY

## Understanding Code Evolution in Boulder

The City of Boulder's current commercial building energy code requires new construction and/or building additions to exceed the 2006 IECC by 30%. For context on the efforts of this analysis, the chart below compares Boulders current energy code to various editions of other energy related codes – namely IECC and ASHRAE 90.1. For example, Boulder's current code is 15 percent more efficient than 2009 IECC and 2007 ASHRAE 90.1 standards.

Boulder is now proposing to be 20 percent more efficient than the 2012 IECC and ASHRAE 90.1 2010 standards, bringing the City in line with proposed levels for the 2015 IECC, which will be 50 percent more efficient than the 2006 IECC. ASHRAE currently has Advanced Energy Design Guidelines that would provide a 50 percent energy savings over the 2006 IECC. Actual adopted levels will not be certain for the 2015 IECC until fall of 2013 because of the IECC code cycle. ASHRAE 90.1 is referenced within the IECC as an alternate path of compliance for commercial buildings. The Department of Energy has issued a statement that the 2009 IECC and ASHRAE 90.1 2007 are equivalent in efficiency. The IGCC is an "above code" option to the IECC, whereas ASHRAE 189 is an "above code" option to ASHRAE 90.1. The energy requirements found in the 2012 IGCC have been determined to be 10 percent greater in efficiency than the 2012 IECC.

| Percent Efficiency Above 2006 IECC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 50% | | | | | | | | | |
| 40% | | | | | | | | | |
| 30% | | | Boulder's 2006 Energy Code | | | Boulder's Proposed 2012 Energy Code | ASHRAE Advanced Energy Design Guides | | Proposed 2013 ASHRAE 90.1 |
| 20% | | | | | 2010 ASHRAE 90.1 | | | | |
| 15% | | 2007 ASHRAE 90.1 | | 2012 IECC | | | | Proposed 2015 IECC | |
| 10% | 2009 IECC | | | | | | | | |
| Base Code | 2006 International Energy Conservation Code | | | | | | | | |

Starting with the minimum requirements for IECC 2012 included in Appendix A, the consultant team developed a baseline from which to begin its evaluation of potential measures to achieve the target of exceeding 2012 IECC by 20 percent.

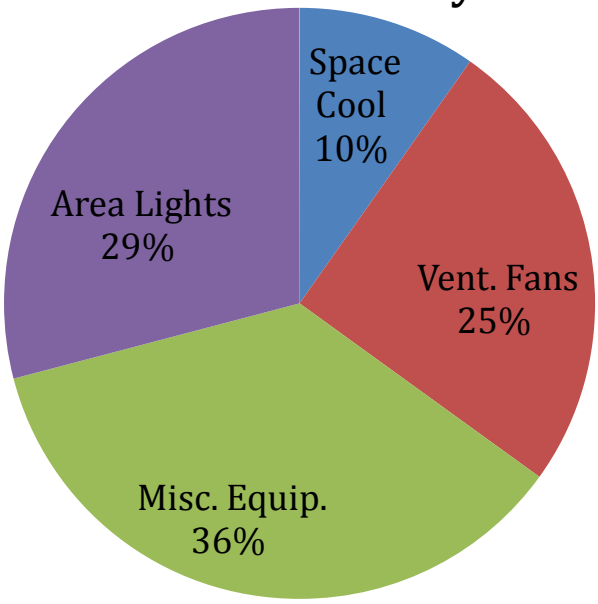
## Defining Baseline Buildings

With baseline efficiency requirements defined, two buildings types were established on the basis of input from City staff, members of an industry working group, and data relative to current development patterns in Boulder. These two building types are intended to represent the typical type of new construction in Boulder. One building is a 40,000-square-foot office building with basement parking and the other is a 50,000-square-foot mixed use building that includes residential, office, retail, and restaurant spaces. Additional details about the baseline buildings and their occupancy and operation are included in Appendix B. The estimated baseline construction cost used in this analysis is $175 per square foot for core and shell plus a tenant finish cost of $80 to $100 per square foot.

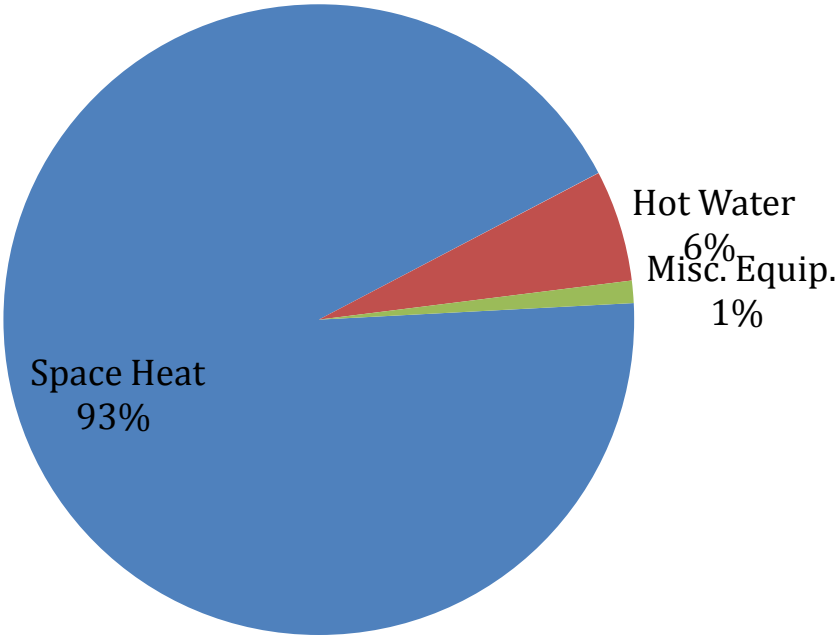
| | Commercial Office | Mixed Use |
|---|---|---|
| **Building Size** | 40,000 (including basement parking) | 50,000 (including basement parking)<br>• Residential 20,000<br>• Office 10,000<br>• Retail 8,000<br>• Restaurant 2,000 |
| **Floors** | 3 (not including basement) | 4 (not including basement) |
| **Parking** | Basement – vented only | Basement – vented only |
| **Notes** | Metal framed (2B) | Concrete floor, metal framed (2B) |

The office building baseline model had a combined energy use intensity (EUI), including electricity and natural gas, of 58.5 kBtu/square foot. Existing small offices in this climate zone are estimated to have an EUI of about 100 kBtu/square foot according to the Commercial Building Energy Consumption Survey (CBECS). The baseline model's EUI seems reasonable with respect to the existing stock considering the stringency of the 2012 IECC code. The following two charts present the portion of electric and natural gas energy going to each end use in the office building baseline. Miscellaneous equipment for electricity includes plug loads (e.g., computers, copiers, etc.) and for gas includes snowmelt for the parking garage ramp and cooking in the restaurant (mixed-use building only).

## Office Baseline Electricity End Uses

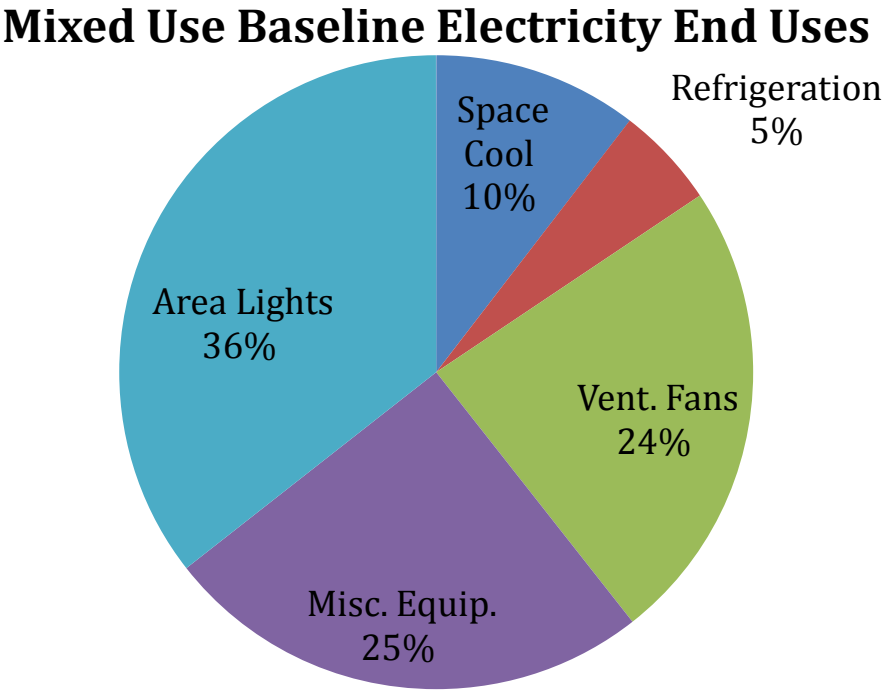


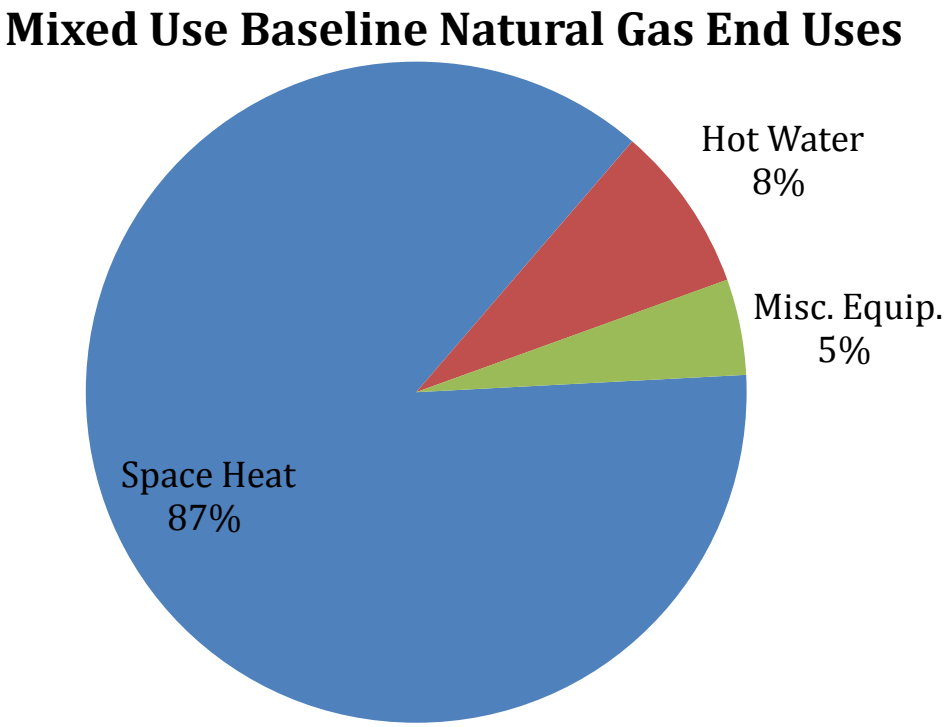

## Office Baseline Natural Gas End Uses




The mixed use building baseline model has an EUI of 76.5 kBtu/square foot. While there is no CBECS equivalent for this particular breakdown of building uses – the building is similar to the office building except for the increased lighting density in the retail and restaurant spaces, and the cooking loads and

longer hours in the restaurant – the baseline model's EUI seems reasonable with respect to the office building with increased intensities in the expected end uses. The following two charts present the portion of electric and natural gas energy going to each end use in the mixed use baseline.






## Identifying and Selecting Measures

A variety of resources were used to identify potential measures for analysis. The consultant team considered existing best practices and research relative to going above and beyond existing standards from the following:

- ASHRAE 50 Percent Advanced Energy Design Guides for Small and Medium Offices
- Oregon Reach Code (based on 2012 International Green Construction Code)
- Fort Collins Green Building Code amendments
- Northwest Energy Codes Group, Global Cool Cities Alliance, and International Association of Lighting Designers 2015 IECC proposed changes
- Pacific Northwest Laboratory 50 percent Code Development and Analysis
- Preliminary information for ASHRAE 90.1 2013
- Utility rebates

Information from these resources was used in tandem with industry stakeholder input, professional experience, and knowledge of regional buildings and efficiency best practices to build a list of 43 potential measures to consider that would result in energy savings. It is important to note that measures that would primarily results in energy cost savings (e.g., demand control) were not analyzed given that energy savings itself is the primary parameter for this analysis. All 43 measures are outlined later in the report and provided with descriptions and relevant notes in Appendix C.

## Evaluating Savings

Energy savings – the primary parameter for this analysis – for each measure identified was estimated using either eQuest modeling software or engineering calculations. Cost savings associated with the

energy savings also were identified. eQuest models were built for each of the baseline buildings described earlier and the consultant team ran an independent parametric run for each modeled measure against the baseline to estimate savings. Both costs and savings estimates are considered to be high-level for a variety of reasons. For example, many assumptions were made to create the energy models for the two building types. Also, variations of the assumptions related to plug loads (e.g., office equipment, appliances, etc.), lighting loads, and temperature setpoints influenced results significantly.

For the combination of measures outlined earlier, the parametric runs for individual measures were combined in another run to more accurately indicate savings when systems operate together and affect each other. This produces a different result than simply adding savings of individual runs together.

Results from this exercise informed efforts for the cost analysis. For example, those measures that indicated little or no savings were not carried through to the cost analysis and those that exhibited the greatest savings were raised in priority to determine the most reasonable combination of measures to achieve the 20 percent target.

## Evaluating Costs

Building on the results from the savings analysis, the list of measures was refined and prioritized and costs were developed for those measures that indicated reasonable savings. In order to develop reasonably accurate regional costs for priority measures, the consultant team convened an industry working group consisting of local developers, construction professionals, commercial property management organizations, and green building experts. The primary objective of the working group was to confirm or cross-check cost assumptions with actual industry costs. The working group confirmed base costs per square foot for core and shell as well as tenant finish (presented earlier), and also indicated a need for high, medium, and low ranges of costs per square foot per measure.

Feedback from this working group, combined with the consultant team's professional experience and other industry costing resources, such as contractors and RS Means (a division of Reed Construction Data), formed the basis for establishing reasonable cost estimates for priority measures.

# MEASURES

More than 40 individual energy efficiency improvements (measures) were considered as part of the analysis. These measures are presented, along with their individual estimated savings and costs, in Appendix C and are organized by these building themes:

- Renewables
- Controls
- HVAC
- Process
- Lighting
- Electrical
- Envelope

Of the 43 original measures, some were filtered out because they offered little to no savings for the additional cost.

## Prioritizing Measures to Achieve Target

The process of estimating total energy savings was a true discovery. From the outset, the team did not know if 20 percent savings could be achieved with the measures identified. As development continued, it was determined that the list of gathered measures, in fact, exceeded the required energy savings. As a result, the team developed a process to prioritize the measures in order to determine a minimum cost premium to achieve the 20 percent target. The results for each individual measure were sorted first according to greatest savings and then by least cost to determine the top tier measures for further consideration.

Once the top tier list was established, the consultant team analyzed the data associated with each measure to determine the combination of measures that would most reasonably and consistently achieve the 20 percent target. It is important to note that three additional measures (listed below) that are not included in the combination that produces the cost premium estimate provide nearly similar results related to first costs and savings and can be considered likely options to exceed 2012 IECC by 20 percent.

- Windows
- Building envelope
- Centralized plug load control

# NEXT STEPS

Using this analysis as a starting point, the City of Boulder can evaluate its options for best translating the outcomes into related code language. In addition, given the pending update schedules for IECC 2015 and ASHRAE 90.1, the City may opt to delay its own update to incorporate any significant changes that may arise as a result of those processes. As the code allows both a prescriptive and a performance compliance path, we have provided sample amendments for the prescriptive path in Appendix D to illustrate representative changes. Performance amendments could be as simple as '20% more energy efficient than a prescriptive building'.

Regardless of the compliance path, enforcement of energy code compliance is challenging at best. While building departments today often have a wide variety of expertise, the majority do not have energy code expertise. This expertise is critical to any 'above code' energy program such a Boulder is exploring. One particular benefit of this capability is the capacity to train plans examiners and field personnel. The more comfortable the plans examiners and field inspectors are with energy code requirements and related construction details, the better they will be in supporting the builders and designers with code compliance. In today's buildings, the majority of energy savings results from building systems integration. To achieve projected energy savings, the full performance and operation of this integration must be realized. Well trained and educated building department personnel can help in achieving this integration and the related energy savings.

Finally, the objective of this effort was to determine the premium cost of exceeding energy efficiency requirements of 2012 IECC code by 20 percent and 2012 IGCC thermal envelope code by 10 percent. The combination of measures presented in this report achieves this target. However, now that the groundwork of achieving the target has been established, greater resolution relative to cost effectiveness of various scenarios may be an appropriate next step. That is, any number of additional measures (e.g., wholesale mechanical system changes) also could achieve the 20 percent energy

improvements and also would increase the first cost premium. However, other measures may also yield more energy savings and prove to be more cost effective in the long run. Any additional analysis should incorporate therelated practicality (e.g., availability of related products) of measures for this region.

# APPENDIX A: 2012 IECC MINIMUM REQUIREMENTS

- Envelope
  - Roof R-25 c.i.
  - Walls R-13+R-3.8c.i. or R-20
  - Continuous air barrier
  - Window-to-wall ratio: 30%
  - Fenestration U-0.38 and solar heat gain coefficient (SHGC) 0.4
- HVAC Packaged Roof-top Units (RTUs)
  - Less than 65 Mbtu/h: 15.0 SEER, 12.0 EER
  - 65 to 240 Mbtu/h: 12.0 SEER, 12.4 EER
  - Economizers
  - Restaurant makeup air unit with evaporative cooling
- Interior Lighting
  - Parking: 0.2 watt per square foot
  - Retail: 1.6 watts per square foot
  - Office: 1.0 watt per square foot
  - Family dining: 1.4 watts per square foot
  - Occupancy sensors in many spaces greater than 300 square feet
  - No daylighting
- Exterior Lighting: Current Boulder Code
- Service Hot Water: 80 percent efficient
- Plug loads/controls: no requirements

# APPENDIX B: BASE BUILDING ENERGY MODELING DEFINITIONS

All items the same for both buildings unless otherwise noted.

- Location: Boulder, CO
- Weather File: BoulderCOTMY2
- Building Description:
  - Office building
    - Three-story office building
    - Underground parking
    - 30,000 square feet (sq ft) occupied space
    - 100' x 100' footprint
  - Mixed-use building
    - Three-story building
    - Underground parking
    - 8,000 sq ft retail and 2,000 sq ft restaurant on first floor
    - Office space on second and third floors
    - 30,000 sq ft occupied space
    - 100' x 100' footprint
  - 13' floor to floor height, 9' floor to ceiling height
  - Two zones per floor, east and west, split down the center of the building
  - Schedule: 8 AM – 6 PM, Mon-Fri, closed weekends and holidays. Restaurant 6 AM – 12 AM every day.
- Envelope:
  - Slab below grade (parking garage)
  - Roof: metal frame, 24" o.c; R-25c.i.
  - Walls: 2x6 metal frame, 24" o.c.; R-13 + R-7.5c.i. (R-20 equivalent)
  - Infiltration: 0.1 CFM/ sq ft of wall area (ASHRAE Handbook of Fundamentals value for a "tight" building)
  - Windows: 30% gross wall area on all sides, U-value = 0.38, SHGC = 0.40
  - Doors: glass, assembly U-value of 0.77
- Loads:
  - Interior lighting (10% reduction in spaces requiring occupancy sensors per ASHRAE 90.1 Appendix G)
    - Office: 1 watt/ sq ft
    - Parking garage: 0.2 watt/ sq ft
    - Retail: 1.6 watt/ sq ft
    - Restaurant: 1.4 watt/ sq ft
  - Exterior lighting: Done separately from model in a spreadsheet
  - Office equipment: Average 0.75 watt/sq ft for applicable office areas and 0.35 watt/sq ft in applicable retail areas, cooking loads extrapolated from typical food preparation energy use intensity of 400 kBtu/sq ft/year (Advanced Energy Design Guides for small office, retail, and restaurant)

- HVAC:
  - Six packaged single zone RTU's with DX cooling (11.8 EER per minimum requirement of 2012 IECC Section 406) and natural gas furnaces (0.78 efficiency)
  - Constant speed supply air fans
  - Temperature setpoints:
    - Occupied: 74°F cooling and 72°F heating
    - Unoccupied: 79°F cooling and 67°F heating
  - Design temperatures:
    - Cooling: 75°F indoor and 55°F supply
    - Heating: 72°F indoor and 120°F supply
  - Minimum design airflow: 0.5 CFM/sq ft
  - Supply fan: 1.25" WG, standard efficiency motor
  - Night fan cycling on, controlled by each zone, minimum outdoor air at night + economizer
  - Economizer: dry-bulb outdoor air with 75°F dry-bulb high limit
- DHW:
  - Natural gas, storage type, no recirculation
  - 1 gallon/person/day
  - 0.97 energy factor
  - 120°F supply temperature
  - Additional system for DHW in restaurant, ~500 gallon/day

# APPENDIX C: MEASURE DETAILS

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **Renewables** | | | | | | | | | | |
| Solar electric PV | Solar electric PV system on building | | | | | | | | | Added first cost, not needed for savings |
| Solar thermal - domestic hot water | Solar thermal system on building for domestic hot water | | | | | | | | | Added first cost, not needed for savings |
| **Controls** | | | | | | | | | | |
| Building automation system (BAS) | Central computer based control of HVAC mechanical equipment and settings, no schedule savings, only more aggressive setbacks/ups | $60,000 | 19,342 | 1,739 | 239,845 | 13.5% | $554 | $1,060 | $1,614 | |
| Commercial office building BAS - ventilation | Outside air ventilation controls such as closing OA dampers at night and during morning warm up and demand controlled ventilation (DCV) | $22,500 | 7,122 | 1,060 | 130,310 | 7.3% | -$50 | $646 | $596 | |
| Mixed-use building BAS - ventilation | Outside air ventilation controls such as closing OA dampers at night and during morning warm up and demand controlled ventilation (DCV) | $30,000 | -3,590 | 4,075 | 395,291 | 17.2% | -$450 | $2,486 | $2,036 | Majority of savings in restaurant and retail space |
| BAS - lighting (control, scheduling, sweeps) | Low voltage lighting controls, can be integrated with BAS | | | | | | | | | Intent already required by code |
| BAS - plug load control 50% of outlets (schedule, occupancy) | Central control of 120V wall outlets designated for equipment to be turned off during unoccupied | $9,000 | 34,422 | -719 | 45,558 | 2.6% | $1,026 | -$439 | $587 | |

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | hours | | | | | | | | | |
| BAS - daylighting | Central daylighting controls, integrated with BAS | | | | | | | | | Combined with reduced LPD and daylighting measure |
| Energy monitoring, display - all energy types, publicly visible space or web based | Data logging of energy submetering and public display or accessible website | $45,000 | | | | | | | | Low confidence in direct energy savings |
| **HVAC** | | | | | | | | | | |
| Condensing SHW | Gas condensing water heater | | | | | | | | | Low potential for savings |
| More efficient constant volume rooftop unit | Higher EER rated RTU | | | | | | | | | Included in baseline building |
| VAV - variable air volume | Convert from constant volume single zone RTU system to VAV | $75,000 | 8,392 | -1 | 28,504 | 1.6% | $4 | -$1 | $3 | Added first cost |
| Evaporative cooling add-ons | Include evaporative cooling section in RTU, assume custom equipment | $33,750 | 9,492 | 0 | 32,387 | 1.8% | $295 | $0 | $295 | Not a viable mass market technology at this time |
| Evaporative condensing | Include evaporative condensing for RTU, assume custom equipment | $63,750 | 5,622 | 1 | 19,232 | 1.1% | | | | |
| VRF - Variable refrigerant flow | Convert from CV RTU to VRF system | $105,000 | | | | | | | | Added first cost |
| Dedicated evaporative cooling | Convert from DX cooling to evaporative cooling (direct, indirect, indirect-direct) | $33,750 | | | | | | | | Low system availability/potential impact on comfort |

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| ASHP - Air source heat pump | Convert from gas fired RTU to heat pump RTU | $45,000 | -64,918 | 7,139 | 492,390 | 27.6% | -$11,273 | $4,354 | -$6,919 | Electric fuel switch results in higher utility costs at current utility rates |
| GSHP - Ground source heat pump | Convert from RTU to ground source heat pump | $105,000 | | | | | | | | Added first cost |
| Condensing boiler | Convert from standard to condensing boiler | | | | | | | | | Boiler not used in savings package |
| Hot water system - air distribution | Convert from gas fired furnace to boiler | $75,000 | | | | | | | | Added first cost |
| Hot water system - radiant | Convert from forced-air distribution to radiant | $75,000 | | | | | | | | Added first cost |
| Chilled water system - air distribution | Convert from DX forced-air to chilled water system | $75,000 | | | | | | | | Added first cost |
| Heat recovery - air | Heat recovery from exhaust air to preheat outside ventilation air | $45,000 | | | | | | | | Not viable at modeled building system's scale |
| DOAS - Dedicated outdoor air system | Add stand alone system dedicated to meeting ventilation requirements | $63,750 | | | | | | | | Added first cost |
| Parking garage ventilation controls | Convert from constant operation to demand controlled ventilation with carbon monoxide sensors | $7,500 | 23,612 | 0 | 80,564 | 4.5% | $656 | $0 | $656 | |
| Server closet cooling requirements | Add cooling system that is independent from main space, provide economizer and heat recovery options for area heating | | | | | | | | | Low potential for savings |

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **Process** | | | | | | | | | | |
| Commissioning - 3rd party, functional testing, enhanced Cx (HVAC, lighting, envelope) | Commissioning is the quality assurance process for building design, construction, and performance | $49,500 | 20,864 | 722 | 143,386 | 8.0% | $1,043 | $505 | $1,549 | |
| RTU economizer fault detection and diagnostics | Controls that can self-diagnose and alert facility personnel | | | | | | | | | Direct energy savings unknown |
| **Lighting** | | | | | | | | | | |
| Daylighting building design - architectural definition | Architectural and interior design that incorporate daylighting into building design | | | | | | | | | Added first cost |
| Reduced lighting power density (LPD) and daylighting | Design for decreased LPD and daylighting according to IECC 2012 Section 406 lighting option | $15,300 | 63,552 | -515 | 165,319 | 9.3% | $7,325 | -$315 | $7,010 | |
| Reduce LPD by 20% below code | Design for decreased building lighting power density (LPD) | | | | | | | | | Combined with reduced LPD and daylighting measure |
| Exterior lighting - LEDs and controls | Convert exterior lighting to LED and reduce light power 50% one hour after business hours | $4,000 | 5,600 | 0 | 19,107 | 1.1% | $220 | $0 | $220 | |
| **Electrical** | | | | | | | | | | |
| Submetering ready - separate electric panels for HVAC, lighting, plug loads, process loads, renewables | Provide separate electric service panels for HVAC, lighting, plug loads, and process loads such that each panel only serves one load type | $1,700 | | | | | | | | No direct energy savings |

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| Solar ready electrical systems, service panel | Reserve space on electric service panel for solar PV system | $1,000 | | | | | | | | No direct energy savings |
| ENERGY STAR restaurant equipment | Use ENERGY STAR rated food service equipment in restaurants | $7,600 | 1,990 | 9 | 7,690 | 0.3% | $192 | $5 | $197 | Restaurant in mixed-use building |
| Plug loads | Equipment power densities reduced by transitioning to higher % laptops, upgrading to ENERGY STAR equipment, adding localized timers and occupancy controls for daytime and unoccupied hours | $7,940 | 54,262 | -836 | 101,552 | 5.7% | $4,162 | -$3,825 | $337 | |
| **Envelope** | | | | | | | | | | |
| 10% thermal envelope improvement | Increased roof, wall, and floor insulation | $22,500 | 7,412 | 159 | 41,160 | 2.3% | -$76 | $97 | $21 | |
| Upgrade window U-value | Upgrade to higher performance windows - U-value less than 0.38 | $22,500 | 8,832 | 721 | 102,245 | 5.7% | -$23 | $440 | $417 | |
| Insulation installation guidelines | Higher quality installation standards to improve insulation uniformity and performance | | | | | | | | | Direct energy savings unknown |
| Roof reflectance | Higher solar reflectance roof | | 8,762 | -39 | 26,026 | 1.5% | $79 | -$24 | $55 | No energy savings |

| Name | Description | Cost | Electric Savings, kWh | Gas Savings, th | Total kBtu Savings | % Energy Savings | Electric Cost Savings | Gas Cost Savings | Total Cost Savings | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| Window exterior shading | Addition of exterior window shading | $45,000 | 12,892 | -166 | 27,378 | 1.5% | $700 | -$102 | $598 | Low energy savings |

# APPENDIX D: CODE LANGUAGE

The following are sample code amendments that are anticipated for the 2015 IECC, which is currently being revised and is anticipated to be complete in November 2013 with publication in the spring of 2014. The ASHRAE 90.1-2013 also is currently being revised. The goal for the 90.1 – 2013 as presented in the 2012 ASHRAE Winter meeting was to be 50 percent more energy efficient that the 90.1-2004

If the City of Boulder opts for a prescriptive route to achieve its goals, the amendments depicted below are representative of what could be applied to its existing code language. However, if a more performance-based route is selected, the code would simply state the desired level of performance beyond IECC 2012 and performance analysis would be required to confirm compliance.

1. Delete the exception to section **C402.4.1.1 Air barrier construction.**
   ~~Exception: Buildings that comply with Section C402.4.1.2.3 are not required to comply with Items 1 and 3.~~

2. Revise section C402.4.1.2 to read:
   **C402.4.1.2 Air barrier compliance. ~~options~~.**
   A continuous air barrier for the opaque building envelope shall comply with Section C402.4.1.2.1. ~~, C402.4.1.2.2, or C402.4.1.2.3.~~
3. Delete sections **C402.4.1.2.1 Materials** and **C402.4.1.2.2 Assemblies** in their entirety
4. Revise section **C402.4.1.2.3** Building test to read:
   **C402.4.1.2.~~3~~ 1 Building test.**
   The completed building shall be tested and the air leakage rate of the building envelope shall not exceed 0.40 cfm/ft2 at a pressure differential of 0.3 inches water gauge (2.0 L/s · m2 at 75 Pa) in accordance with ASTM E 779 or an equivalent method approved by the code official.
5. Delete Table **C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS** in its entirety and replace with:

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS

| Opaque Elements | Non-Residential |
|---|---|
| Opaque Elements | Commercial (Non-Residential) |
| Roofs | |
| Insulation entirely above deck | R-30.0 continuous insulation |
| Attic and other | R-49.0 |
| Metal building | R-19.0 + R-11.0 |
| Walls | |
| Wood framed and other | R-13.0 + R-10.0 Continuous Insulation |
| Steel framed | R-13.0 + R-15.6 Continuous Insulation |
| Mass (HC > 7 Btu/ft2) | R-13.3 Continuous Insulation |
| Metal building | R-0.0 + R-19.0 Continuous Insulation |
| Below-grade walls | R-7.5 Continuous Insulation |
| Floors | |
| Mass | R-14.6 Continuous Insulation |
| Steel joint | R-38.0 |
| Wood framed and other | R-38.0 |
| Slabs | |
| Unheated | R-15.0 for 24 in. |
| Heated | R-20.0 for 24 in. |
| Doors | |

| | |
|---|---|
| Swinging or Non-swinging | U-0.35 |
| Vestibules<br>Required at Building Entrance | <br>Yes |
| Windows<br>Nonmetal framing windows<br>Metal framing windows | <br>U-0.35<br>U-0.39 |