# Benefits and Costs of
# Building Code Green Amendments

## *Executive Summary*

The intent of the benefit cost analysis of the building code green amendments is to consider benefits and costs related to owners/occupants, the building sector and the community/ecosystem. Results show:

- The green amendments align with Fort Collins community goals embodied in the *Energy Policy* (2009), *Water Conservation Plan* (2009) and the *Climate Action Plan* (2008), while providing a variety of benefits for building owners and occupants.
- Costs incurred at the individual, building sector or community/ecosystem levels can produce benefits at multiple levels.
- Near-term cost increases, associated with the design and construction of a building project, are balanced by recurring benefits delivered over the life of the building. Other community-level benefits improve the economic picture.
- Initial cost increases projected for building projects are not insignificant but represent relatively small percentage increases (one to four percent); these are within typical variance ranges for construction. It is anticipated that increased design and construction costs incorporated in this analysis will decrease as contractors gain experience and infrastructure matures. There are exemplary green, high-performance buildings in Fort Collins that deliver a strong array of benefits with little or no cost increase compared with conventional construction.
- Reductions of energy, water and carbon are projected on the order of five to ten percent for residential projects and on the order of 20% to 30% for commercial projects.
- The green amendments do not provide a quick "payback" for building owners, based on a traditional view of utility savings compared with increased design and construction costs.
- Increases in code enforcement time are estimated on the order of 45% for residential projects and 25% for commercial projects, requiring additional staffing.

Using generally conservative assumptions and the elements quantified to date, total benefits are projected to exceed total costs. A benefit-to-cost ratio of 1.3 is projected.

## *1. Introduction*

Staff has developed building code green amendments for City Council consideration. City Council adopted the green amendments on March 22, 2011. One package of amendments addresses residential buildings, the other addresses commercial buildings. Staff worked with a consultant, The Brendle Group, to develop a benefit cost analysis for the amendments.

The charge from City Council to staff regarding "greening" the Fort Collins building code was to develop amendments that align with City goals around reducing energy use, water use and carbon emissions, while also addressing other green building opportunities such as improved indoor air quality.

Buildings complying with the green amendments will deliver additional benefits compared with buildings complying with the current code. The changes also will, for many projects, mean higher initial costs. This analysis was prepared to support Council's decision-making process by outlining and quantifying, where feasible, the range of benefits and costs associated with each amendment package.

Benefits and costs are approached from a "triple-bottom-line" perspective, reflecting social, economic and environmental impacts.

This report describes categories of benefits and costs related to green building, the analysis methodology and results. Appendices provide additional detail. "Amendments-at-a-Glance" summaries of the packages and in-depth descriptions of each individual amendment (including benefits and costs) are available on the Building Code Green Amendments web page at www.fcgov.com/gbp.

There are many ways to design and build buildings. Tabulating benefits and costs is an imprecise science. In developing the analysis, a generally conservative approach was taken so that benefits would not be overstated and costs would not be understated.

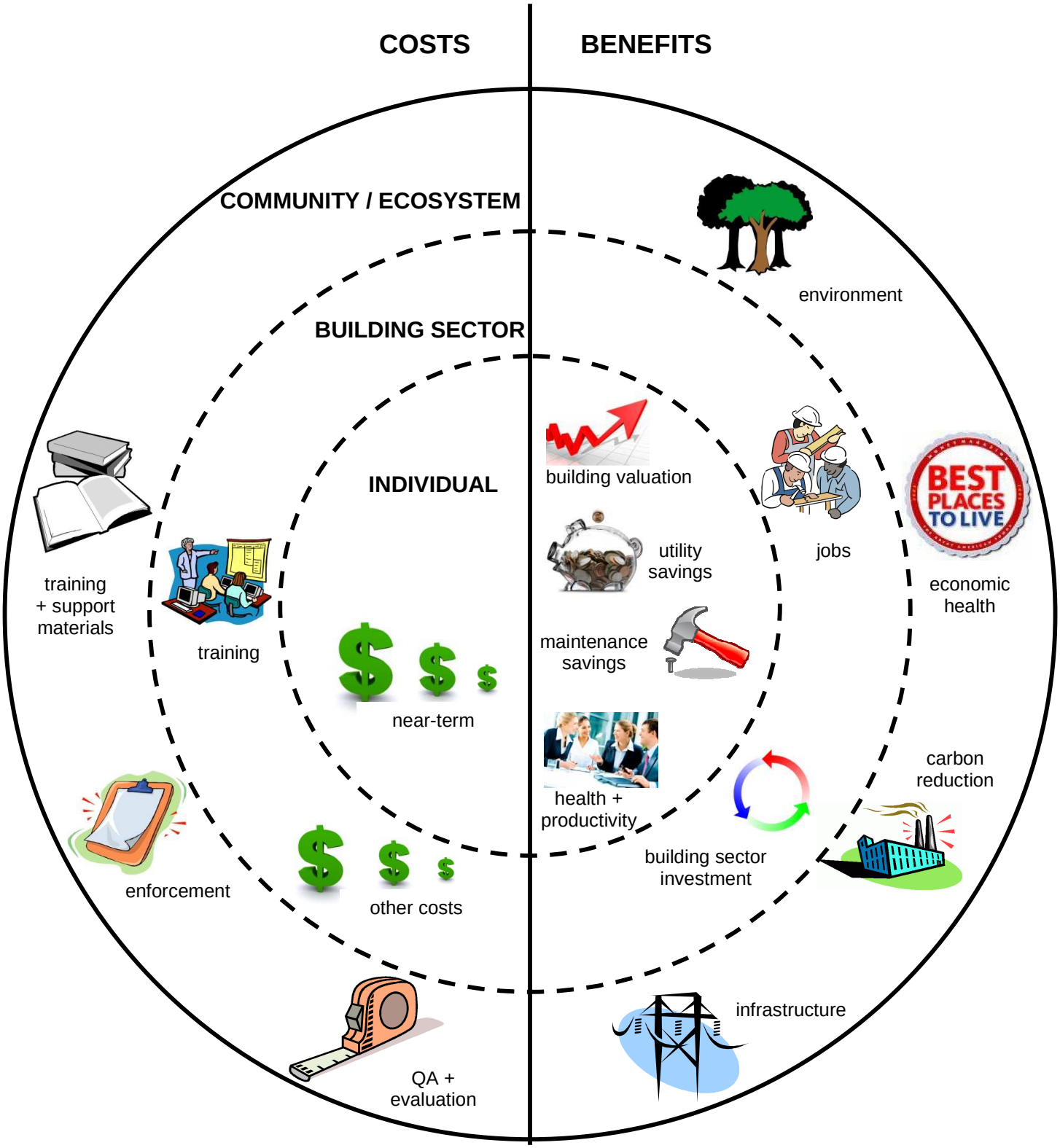
## *2. Benefit Cost Categories*

Figure 1 illustrates categories of benefits and costs related to green building. They occur at three inter-related scales, represented by concentric circles:

- Individual. A specific project, where the impacts are traced to an owner or tenant.
- Building Sector. The building services industry, which includes design and construction professionals and product suppliers.
- Community/Ecosystem. Local, regional or global costs or benefits.

Costs are shown on left-hand side of the diagram, benefits on the right-hand side. Each category is described below.

**Figure 1: Benefit Cost Categories**



**Cost Categories (see Figure 1)**

- Individual, Near-term. Increased, one-time cost to design/build a building. The "$" signs get smaller in the graphic to represent decreasing costs as the industry moves along a prototypical learning curve. The varying size of the "$" signs also represents the range of initial cost increases, depending on the starting point of the construction team.
- Building Sector, Training. Building sector costs related to training on new construction techniques and compliance requirements. These are near-term costs that will be amortized over many projects.
- Building Sector, Other. Other building sector costs, such as buying new tools or obtaining and maintaining new certifications. These are primarily near-term costs that will decrease over time based on market development, competition and adaptation.
- Community, Training + Support Materials. Pre-implementation phase (prior to the January, 2012 effective date of the green amendments in) costs borne by the City cover the development of support materials, staff training and subsidization of industry training.
- Community, Enforcement. Increased implementation costs related to the City's day-to-day enforcement of the green amendments. These could be borne by building owners (through building permit fees) or by the community as a whole or a combination.
- Community, Quality Assurance + Evaluation. Implementation costs, borne by the City, for on-going quality assurance and program evaluation.

**Benefit Categories (see Figure 1)**

- Individual, Utility Savings. Lower utility costs for electricity, natural gas, water and wastewater.
- Individual, Maintenance Savings. Some green amendments will result in reduced maintenance costs, which will accrue to the occupant and/or owner of the building.
- Individual, Building Valuation. Green buildings are expected to command an increased value in the marketplace compared with conventional buildings.
- Individual, Occupant Health + Productivity. The green amendments will lead to improvements in indoor environmental quality (improved thermal comfort, improved indoor air quality). These, in turn, will improve occupant health and productivity.
- Building Sector, Jobs. The building sector will realize an increase in job activity for a given amount of construction activity. The green amendments support the expansion of related infrastructures, higher-level contractor skills, increased demand for green services and increased demand for green products.
- Building Sector, Investment. The building sector will realize increased investment through the supply chain development cycle. Beyond the direct job impact described above, direct suppliers, indirect suppliers, products and materials vendors will develop and mature, resulting in reduced cost premiums over time.
- Community, Economic Health. The green amendments support the community's values, pride and identity as a vibrant, environmentally conscious place to live. The community's reputation as such also supports economic health as by attracting outside investment and local economic development. Progressive public policy has been shown to increase activity in many instances related to green building and clean energy.

- Community, Infrastructure. Direct benefits of green building (reduced energy use, water use and waste) have indirect impacts on community infrastructure requirements, such as extending the life of existing investments in power supply, water supply and landfills.
- Community, Carbon Reduction. The direct results of green building (reduced energy use, water use and waste) contribute directly to the community's goals to reduce carbon emissions.
- Community/Ecosystem, Environment. In addition to carbon reduction, the green amendments reduce environmental impacts associated with construction (resource use, waste, outdoor environmental quality).

## *3. Analysis and Results*

Benefits and costs have been quantified where feasible. They were assigned value using either of two approaches:

- Component analysis. The impacts of each amendment were analyzed to develop building-specific benefits and costs, and code enforcement costs.
- Community-scale analysis. This approach, which included applying the results of research performed elsewhere to Fort Collins, was used to estimate benefits related to building valuation, occupant health and productivity, economic health and carbon reduction.

Other types of costs and benefits have not been quantified. Tables 1 and 2 show generally how each category was handled in the analysis. More information follows in Sections 3.1 and 3.2.

The quantified elements have been compared to develop a benefit-to-cost ratio. It must be emphasized that the benefit cost analysis is approximate, reflecting uncertainties in accurately quantifying both benefits and costs.

The analysis focused on new construction. Existing building scenarios (alterations and additions, from minor to very large) are too varied to be analyzed with this approach and timeframe. Also, many of the amendments do not apply to existing buildings or apply only in part (see "Applicability" information in the "Amendments-at-a-Glance" summaries and the detailed description of each practice at www.fcgov.com/gbp).

**Table 1: Quantified Benefits and Costs**

| Benefit Cost Category | Analysis Approach |
|---|---|
| COST: Individual, Initial | Component analysis |
| COST: Community, Training + Support Materials | Estimated |
| COST: Community, Code Enforcement | Component analysis |
| BENEFIT: Individual, Utility Savings | Component analysis |
| BENEFIT: Individual, Building Valuation | Community-scale analysis; national studies applied |
| BENEFIT: Individual, Occupant Health + Productivity | Quantified in part using community-scale analysis; national studies applied to estimate part of the benefit |
| BENEFIT: Building Sector, Jobs | Community-scale analysis; these three categories are represented as part of "economic impact" multiplier. |
| BENEFIT: Building Sector, Investment | |
| BENEFIT: Community, Economic Health | |
| BENEFIT: Community, Carbon Reduction | Community-scale analysis; calculated based on utility savings |

**Table 2: Non-Quantified Benefits and Costs**

| Benefit Cost Category | Notes |
|---|---|
| COST: Building Sector, Training | Primarily near-term costs amortized over many projects. |
| COST: Building Sector, Other | Primarily near-term costs that will decrease over time. |
| COST: Community, Quality Assurance + Evaluation | Quality assurance and evaluation plans to be developed |
| BENEFIT: Individual, Maintenance savings | Larger maintenance costs are episodic and challenging to quantify. Savings could be significant over life of building. |
| BENEFIT: Individual, Occupant Health + Productivity | Non-quantified "people" benefits related to health and productivity have been tabulated for certain amendments; see detailed description of each amendment at www.fcgov.com/gbp. |
| BENEFIT: Community, Infrastructure | Incremental benefits from greener building add to benefits from other conservation / efficiency / renewables efforts for potentially significant cumulative impact. |
| BENEFIT: Community/Ecosystem, Environment | Non-quantified "environment" benefits have been tabulated for each amendment; see detailed description of each amendment at www.fcgov.com/gbp. |

## 3.1 Quantified Elements

Costs and benefits quantified via component analysis and community-scale analysis are described in the Subsections 3.1.1 and 3.1.2, respectively. Results are summarized and combined to calculate the benefit-to-cost ratio in Subsection 3.1.3.

#### 3.1.1 Component Analysis

Primary benefits and costs of the green amendments for typical projects were quantified via component analysis. Primary benefits are the reduced utility costs (electricity, natural gas, water and wastewater). Primary costs are increased design and construction costs. The analysis reflected each amendment.

Important aspects of the analysis include:

- Benefits and costs are generally presented as ranges. This reflects that, for each code amendment, there are often multiple ways to comply; different contractors have a range of experience and a range of costs for products and labor; there is uncertainty in estimating benefits and costs of building projects.
- It is assumed that all increased first costs are passed directly to the owner of the building.
- "Cost" represents retail cost
- Data sources included architects, builders, trade specialists, product suppliers, staff experience, energy modeling, other studies and analyses.
- Generally, conservative values have been chosen so as to not overstate benefits or understate costs.

Building-specific benefits and costs were developed for two prototypical buildings to which the majority of the amendments could be applied:

- Residential
  - 1,600 square foot ranch over full basement (3,200 sf conditioned area)
  - Natural gas heat
  - $250,000 sales price, financed with a 6%, 30-year mortgage
  - $2,600 annual utility cost
- Commercial
  - 15,000 square foot office building, two stories
  - Natural gas heat
  - $162 per square foot construction cost ($2.4 Million)
  - $14,000 annual utility cost

The team recognizes that these are limited examples of the many types and sizes of buildings in the market. These were developed to provide a more tangible reference for benefits and costs.

Benefits and costs associated with each amendment are provided in Appendix 1 (residential) and Appendix 2 (commercial). Totals are shown in Tables 3 and 4, representing the set of applicable green building practices for each project. The base case is the prototype project meeting current Fort Collins code requirements.

**Table 3: Quantitative Results – Residential Prototype (1,600 square foot ranch)**

| Description | Range ($) | Range (%) |
|---|---|---|
| Sales Price Increase | $2,800 to $5,600 | 1% to 2% of sales price |
| Monthly Mortgage Impact | $17 to $34 | 1% to 2% of monthly payment |
| Annual Utility Cost Savings | $65 to $171 | 3% to 7% of utility cost |
| Energy Savings | -- | 5% to 10% of annual use |
| Water Savings | -- | 5% to 10% of annual use |
| Carbon Savings | -- | 5% to 10% of annual emissions |

**Table 4: Quantitative Results – Commercial Prototype (15,000 square foot office building)**

| Description | Range ($) | Range (%) |
|---|---|---|
| Construction Cost Increase | $30,000 to $100,000 | 1% to 4% of construction cost |
| Annual Utility Cost Savings | $1,800 to $3,400 | 13% to 25% of utility cost |
| Energy Savings | -- | 24% to 36% of annual use |
| Water Savings | -- | 20% of annual indoor use |
| Carbon Savings | -- | 17% to 26% of annual emissions |

Enforcement costs were also estimated using component analysis. The Building Official evaluated the impact of each amendment on the time required for plan review, field inspection and administrative tasks. Estimated increases versus the workload associated with the existing codes are on the order of 45% for residential projects and 25% for commercial projects (see Appendix 3 for more detail). The increased workload translates to an additional 1.5 full-time equivalent positions in the Building Department, valued at approximately $158K annually for salary and benefits.

#### 3.1.2 Community-Scale Analysis

The consultant reviewed published regional and national studies of green building benefits and costs relative to individuals as well as communities, economies and ecosystems. The consultant also spoke with City economic development staff. This research indicates there are many benefits associated with green, high-performing buildings, including energy and environmental awareness, economic health, community pride and the opportunity to hedge against utility rate increases.

Based on the available information, the consultant quantified four benefits with sufficient confidence to inform the Fort Collins analysis. These are summarized here; additional information is provided in Appendix 4. Note that all of these analyses should be considered "order-of-magnitude" in nature. Because there are many uncertainties when applying the research to the green amendments, conservative assumptions were made.

- Building valuation. Studies show that labeled "green buildings" command higher value in the marketplace than their conventionally built counterparts. For this analysis, a one-percent increase in valuation was applied.
- Occupant health and productivity. Research has shown that occupants of green buildings tend, on average, to be healthier and/or more productive. The consultant extrapolated the research results to estimate the 20-year net present value of health cost savings for occupants of residential buildings

($28 per person) and increased productivity of commercial building occupants ($4.61 per square foot).

- Economic health. This term reflects increased local economic activity associated with increased construction spending. It ties to three of the benefit categories illustrated in Figure 1: Building Sector, Jobs; Building Sector, Investment; and Community, Economic Impacts. Based on conversations with City economic development staff, the consultant used an economic multiplier of 0.5 of the increased construction cost. In other words, 50% of the increased cost attributed to the green amendments is re-injected into the local economy
- Carbon reduction. Carbon savings are the only ecosystem benefit quantified in this analysis. Though carbon is not yet widely traded in the United States, a variety of research provides a basis to estimate the likely market value of savings. The consultant used a value of $20 per metric ton of carbon savings.

#### 3.1.3 Benefit-to-Cost Ratio

The benefits and costs that have been quantified can be totaled and compared. This was done using the following approach and assumptions:

- A net present value approach was used to account for the stream of future benefits (such as annual utility savings and improved occupant productivity) and compare them against costs incurred when the building is built. Consistent with many building analyses, a term of 20 years was used. A 7% discount rate, including 2% general inflation of goods and services, was assumed.
- Utility rates are assumed to stay constant at today's values.
- Construction activity is assumed to be 200 new homes and 10 new commercial office building projects per year (other commercial construction is not reflected in the analysis). Actual construction activity is difficult to predict; the analysis model is readily scalable.

Tables 5 and 6 summarize the data reported above, as extrapolated to the community scale using the construction activity assumptions in the previous bullet. These summaries represent the benefits and costs associated with one year of construction.

Table 6 includes a roughly estimated cost ($100K) associated with training and development of support materials prior to the effective date of the green amendments.

It is important to recognize that the quantitative analysis only tells part of the benefits and costs story. Non-quantified aspects are discussed in the next section.

**Table 5: Community-scale Benefit Summary**
("K" = thousand, "M" = million, "NPV" = Net present value)

| Benefit | Commercial | Residential | Total | Notes |
|---|---|---|---|---|
| Individual, Utility Savings | $273K | $250K | $523K | NPV of recurring benefits |
| Individual, Building Valuation | $243K | $500K | $743K | One-time benefit at time of sale |
| Individual, Occupant Health + Productivity | $69K | $22K | $91K | NPV of recurring benefits |
| Community, Economic Health | $331K | $420K | $751K | One-time benefit at time of construction |
| Community, Carbon Reduction | $76K | $50K | $126K | NPV of recurring benefits |
| | | **Total benefits** | **$2.23M** | |

**Table 6: Community-scale Cost Summary**
("K" = thousand, "M" = million)

| Cost | Commercial | Residential | Total | Notes |
|---|---|---|---|---|
| Community, Training + Support Materials | | | $100K | One-time cost (mostly in 2011) |
| Individual, Initial | $662K | $840K | $1.50M | One-time cost at time of construction |
| Community, Enforcement | | | $158K | One-time cost at time of construction |
| | | **Total costs** | **$1.76M** | |

Given the many assumptions underlying the data presented in this section, the ratio of benefits to costs for the green amendments is $2.23 Million to $1.76 Million, equaling 1.3.

## 3.2 Non-Quantified Elements

As described above, not all benefits and costs have been quantified. Table 2 lists those that were not and includes brief comments for each. Some of these categories could be quantified with more information. Others are more inherently qualitative, such as the benefits of a darker night sky.

Non-quantified benefits associated with each amendment are listed under the "People" and "Environment" benefit headings in the detailed descriptions available at www.fcgov.com/gbp. Many of these benefits can be grouped into categories such as improved comfort (from improved building envelopes and better-performing heating and cooling systems), better indoor environmental quality (from building materials with lower pollutant emissions, safer combustion appliances, whole-house ventilation, building flush-out, acoustic requirements), improved outdoor environmental quality (Dark-Sky lighting fixtures), and conservation of resources for future generations (energy-efficiency measures and construction waste recycling). Some of these benefits will accrue to the individual owner or occupant while others are community benefits.

Non-quantified costs primarily reflect the process of change from conventional practices.

## 4. Discussion

The building code green amendments involve many types of benefits and costs. This analysis suggests:

- Benefits and costs can be associated with individuals, the building sector, the community and ecosystem. Costs incurred at one level can produce benefits at multiple levels.
- Near-term cost increases, associated with the design and construction of a building project, are balanced by recurring benefits delivered over the life of the building. Other community-level benefits improve the economic picture.
- Initial cost increases projected for building projects are not insignificant but represent relatively small percentage increases (one to four percent); these are within typical variance ranges for construction.
- The green amendments align with Fort Collins community goals embodied in the *Energy Policy* (2009), *Water Conservation Plan* (2009) and the *Climate Action Plan* (2008), while providing a variety of benefits for building owners and occupants.
- The green amendments do not provide a quick "payback" for building owners, based on a traditional view of utility savings compared with increased design and construction costs.
- The relative magnitude of utility savings and associated carbon reduction is considerably higher for commercial buildings than for the residential sector. The commercial opportunities are greater because building code has lagged in addressing key opportunities in the areas of building envelope and commissioning.
- The three largest projected benefits are utility savings, economic health gains and higher building valuation. Making this latter benefit a reality will require education of the market and progress in removing barriers in the appraisal and underwriting processes.

Based on the elements quantified to date, total benefits are projected to exceed total costs.

While there are uncertainties in accurately quantifying both benefits and costs, the intent of this analysis was to capture the essence of the benefits and costs within the scope, budget and timeframe of this project.

To avoid overstating benefits or understating costs, the analysis team has generally made conservative assumptions. For example, building cost increases used in the analysis generally reflect the current situation in Fort Collins, in which some of the amendments address practices for which many contractors have little experience and the infrastructure to efficiently implement the practices is not well developed. Experience with past code changes suggest that many costs are likely to significantly decrease over time, as contractors move up the learning curve and infrastructure matures. It should also be noted that there are exemplary green, high-performance buildings in Fort Collins that deliver a strong array of benefits with little or no cost increase compared with conventional construction.

# Appendix 1
# Component Analysis Summary: Residential Prototype

| | 2/15/2011 | Direct Owner Financial Impact | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Initial Cost Impact Range | | | Net Utility Savings Range ($/yr) | | | Maintenance / Durability Impacts (1) |
| # | GB Practice | Notes | Low | High | Notes | Low | High | |
| 1 | **Construction waste recycling** | Net change = increased recycling cost less decreased landfill cost | $0 | $200 | | $0 | $0 | N/A |
| 2 | **Certified wood** | No tropical hardwoods used in entry level home | $0 | $0 | | $0 | $0 | N/A |
| 3 | **Windows, skylights, doors: installation** | | $250 | $350 | | $0 | $0 | Potential to avoid large maintenance/repair costs related to exterior water leakage at fenestration openings |
| 4 | **Building envelope: thermal specifications, electric-heat homes (2)** | N/A for gas-heated prototype home | $2,200 | $2,500 | N/A for gas-heated prototype home | $300 | $400 | N/A |
| 5 | **Basement windows: thermal specifications** | | $45 | $75 | | $3 | $6 | Avoid significant window replacement cost when basement is finished<br><br>Reduced maintenance costs related to condensation on windows |
| 6 | **Air sealing: tight construction** | Field study shows most new homes already tighter than proposed standard | $50 | $200 | Hypothetical savings vs 2009 IRC requirement (7.0 ACH50): $100/yr gas heat, $250/yr elec heat<br><br>Reality for most houses: $0 (already captured by even tighter construction) | $0 | $25 | Hypothetical: less maintenance / repairs to building due to moist air condensing in building cavities<br><br>Reality: Typically $0 (already captured by tight construction) |
| 7 | **Insulation: installation** | | $200 | $350 | | $30 | $60 | Minor savings possible |
| 8 | **Heating + cooling systems: design** | Evaluate benefits + costs for these two measures together | $400 | $500 | Evaluate benefits + costs for these two measures together | $30 | $60 | Equipment running within manufacturer spec will need less maintenance and last longer. |
| 9 | **Heating, ventilation, air conditioning (HVAC) systems: commissioning** | | | | | | | |
| 10 | **Water-efficient fixtures** | | $50 | $200 | Saves water, wastewater, natural gas | $40 | $60 | N/A |
| 11 | **Safer combustion appliances: new construction** | Low = sealed, tested mechanical room<br><br>High = safer furnace + water heater | $1,300 | $2,500 | Low = less air leakage<br><br>High = 90 AFUE furnace | $12 | $60 | Health benefits = maintenance savings |
| 12 | **Safer combustion appliances: existing buildings (2)** | N/A for new construction | $75 | $150 | N/A for new construction | $0 | $0 | Health benefits = maintenance savings |
| 13 | **Low-Volatile Organic Compound (VOC) materials** | | $200 | $400 | | $0 | $0 | Health benefits = maintenance savings<br><br>No info regarding durability of low-VOC products versus conventional. Higher or lower maintenance? |
| 14 | **Whole-house ventilation** | Exhaust-only system | $150 | $400 | Operating cost INCREASE rather than savings | ($60) | ($120) | Health benefits = maintenance savings |
| 15 | **Exterior lighting: fixture design** | | $40 | $120 | Assume no change in lamp wattage | $0 | $0 | N/A |
| 16 | **Building owner education** | | $150 | $300 | | $10 | $20 | Properly operated and maintained eqpt should yield maintenance savings. |

| **TOTALS for new construction, prototype home (2)** | **INITIAL COSTS** | | | **UTILITY SAVINGS BENEFIT (1)** | | |
|---|---|---|---|---|---|---|
| | **Low** | **High** | | **Low** | **High** | |
| | **$2,835** | **$5,595** | **Purchase price increase** | **$65** | **$171** | **Annual utility bill decrease** |
| 1,600 sq ft ranch over full basement (3,200 sq ft total)<br>Natural gas heat<br>$250,000 sales price, 6%, 30-yr mortgage<br>$2,600 annual utility cost | **$17** | **$34** | **Monthly mortgage payment increase** | **$5** | **$14** | **Monthly utility bill decrease** |
| | **1.1%** | **2.2%** | **Percent of base price or payment** | **2.5%** | **6.6%** | **Percent of base utility bill** |

(1) Savings due to reduced maintenance / enhanced durability are not quantified or reflected here. They would improve the economic case for the building owner.
(2) Two measures not applicable to new, gas-heated prototype home are not included in total costs or benefits.

# Appendix 2
# Component Analysis Summary: Commercial Prototype

| | 2/16/2011 | Direct Owner Financial Impact | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Initial cost impact range | | | Net utility savings range ($/yr) | | | Maintenance / Durability Impacts (1) |
| # | GB Practice | Notes | Low | High | Notes | Low | High | |
| 1 | **Construction & Site waste recycling** | Net change = increased recycling cost, decreased landfill cost. | $0 | $600 | | $0 | $0 | N/A |
| 2 | **Certified Wood** | | $0 | $0 | | $0 | $0 | N/A |
| 3 | **Energy Distribution Design Requirements** | | $1,650 | $1,950 | Requires next step of installed monitoring equipment to realize savings | $0 | $0 | Allows monitoring of specific systems, potentially leading to maintenance savings. |
| 4 | **Building Envelope: Air Barrier** | | $11,250 | $22,500 | | $750 | $1,050 | Less infiltration and thus less moisture transport through building envelope resulting in better durability |
| 5 | **Building Envelope: electrically heated buildings (2)** | Does not apply to gas-heated building - not included in total | $2,250 | $3,750 | Does not apply to gas-heated building - not included in total | $450 | $600 | |
| 6 | **Building Envelope: Installed insulation standards** | | $0 | $0 | | $255 | $315 | May improve building durability by reducing condensation sites within the envelope. |
| 7 | **Control of loads in Hotel/Motel guest rooms (2)** | Assumes 15,000 SF of rooms. | $16,050 | $23,100 | Assumes 15,000 SF of rooms. | $2,250 | $2,850 | Longer life for lamps and equipement being controlled. |
| 8 | **Outdoor lighting controls** | Cost for controls | $450 | $600 | | $180 | $210 | Longer life for lamps being controlled. |
| 9 | **Occupancy sensor controls** | Utility incentives would reduce cost | $1,200 | $1,500 | | $60 | $75 | |
| 10 | **Energy assessments for alterations (2)** | Assessement cost covered by Fort Collins Utilities. | $0 | $0 | Savings result only if recommendations are implemented. | $0 | $0 | |
| 11 | **Water-efficient fixtures** | | $0 | $0 | Water savings only - does not include natural gas or stomrwater. | $30 | $330 | |
| 12 | **HVAC IAQ Design** | | $0 | $0 | | $0 | $0 | Potentially improves maintainability of HVAC equipement. |
| 13 | **Building flush-out** | Costs represent HVAC tech time to reprogram system. | $900 | $1,050 | Small one-time cost penalty for extra energy used to condition outside air. | $0 | $0 | |
| 14 | **Low-Volatile Organic Compound (VOC) materials** | | $0 | $1,500 | | $0 | $0 | Health benefits = maintenance savings<br><br>No info regarding durability of low-VOC products versus conventional. Higher or lower maintenance? |
| 15 | **Acoustical Control (2)** | Depends on baseline building envelope. | $0 | $25,500 | | $0 | $0 | A building envelope enhanced for acoustic purposes may also be more durable. |
| 16 | **Commissioning** | Based on complexity of systems to be commissioned. | $15,000 | $75,000 | | $585 | $1,455 | Improved operations & maintenance for commissioned systems. |

| **TOTALS for new construction, prototype commercial office building (2)** | **INITIAL COSTS** | | | **UTILITY SAVINGS BENEFIT (1)** | | |
|---|---|---|---|---|---|---|
| | **Low** | **High** | | **Low** | **High** | |
| 15,000 sq ft office building<br>Natural gas heat<br>$2.4 Million construction cost<br>$14,000 annual utility cost | **$30,450** | **$104,700** | **Construction cost increase** | **$1,860** | **$3,435** | **Annual utility bill decrease** |
| | **1.3%** | **4.4%** | **Percent of construction cost** | **13%** | **25%** | **Percent of base utility bill** |

(1) Savings due to reduced maintenance / enhanced durability are not quantified or reflected here. They would improve the economic case for the building owner.
(2) Some practices apply only to unique situations or specific buildling types and were not included in the totals for the representative building.

# Appendix 3
# Component Analysis Summary: Enforcement Costs

Enforcement costs were estimated using component analysis. The Building Official evaluated the impact of each amendment on the time required for plan review, field inspection and administrative tasks, for the same prototype buildings used to estimate building-specific benefits and costs. Results are summarized in Tables 1 and 2.

**Table 1: Residential Enforcement Time Impacts**

| Scenario | Plan Review | Field Inspection | Administrative | Total |
|---|---|---|---|---|
| Current codes | 6.0 to 8.0 hrs | 3.1 to 5.3 hrs | 2 hrs | 11 to 15 hours |
| Additional time for proposed green amendments | 1.6 to 2.8 hrs | 1.9 to 3.2 hrs | 1 hr | 5 to 7 hours |
| Total time with green amendments | 7.6 to 10.8 hrs | 5.0 to 8.5 hrs | 3 hrs | 16 to 22 hours |
| Approximate percentage time increase | 30% | 60% | 50% | 45% |

**Table 2: Commercial Enforcement Time Impacts**

| Scenario | Plan Review | Field Inspection | Administrative | Total |
|---|---|---|---|---|
| Current codes | 16 to 24 hrs | 5.9 to 9.1 hrs | 2 hrs | 24 to 35 hrs |
| Additional time for proposed green amendments | 2.3 to 3.8 hrs | 2.2 to 3.3 hrs | 1 hr | 6 to 8 hrs |
| Total time with green amendments | 18 to 28 hrs | 8 to 12 hrs | 3 hrs | 29 to 43 hrs |
| Approximate percentage time increase | 15% | 40% | 50% | 25% |

# Appendix 4
# Community-Scale Analysis

To provide insight to complement the component analysis approach, the consultant reviewed published regional and national studies of green building benefits and costs relative to individuals as well as communities, economies and ecosystems. The consultant also spoke with City economic development staff. This yielded additional information that supported the community-scale analysis.

The community-scale benefits and costs are challenging to quantify, given the range of variables and factors involved. Based on the available information, the consultant felt that four benefits could be quantified with sufficient confidence to inform the Fort Collins analysis: building valuation, occupant health and productivity, economic health, and carbon reduction. This appendix provides information about data sources and how the information they provided was applied to estimate each of these benefits.

The studies used in this analysis represent often-referenced sources (e.g., by U.S. Green Building Council) and/or sources referred through the green amendment development project (by members of the advisory committees and other stakeholders) on green building benefits and costs. They do not represent an exhaustive literature search.

Because there are many uncertainties when applying the research to the green amendment packages, conservative assumptions were made and the numbers generated through this approach should be considered "order-of-magnitude" in nature.

## *1. Building Valuation*

Two green building studies were used to inform the residential valuation analysis:

- ICF Incorporated (Nevin and Watson), *Evidence of Rational Market Values for Home Energy Efficiency*, The Appraisal Journal, October 1998.
- Earth Advantage Institute (Ann Griffin), *Certified Home Performance: Assessing the Market Impacts of Third-Party Certification on Residential Properties*, May 2009.

The first study's findings indicate a $20 increase in market value for every $1 in annual energy savings. The second study reports three to five percent higher selling price for homes with a third-party sustainable certification such as ENERGY STAR and LEED for Homes.

For the Fort Collins analysis, the method in the first study was used to calculate a one percent increase in home value based on the estimated utility savings. This method is more conservative than the second study and also reflects that no third-party certification is associated with the amendments.

Two green building studies were used to inform the commercial building valuation analysis:

- McGraw-Hill - *Business Benefits of Green Buildings SmartMarket Report: Building & Occupant Performance Driving Green Investment in Existing Commercial Buildings*, November 2010
- University of California Energy Institute (Eichholtz, Kok, and Quigley), *Doing Well by Doing Good – Green Office Buildings*, August 2006

These studies indicate that green high-performing buildings typically have increased value in the marketplace compared with their conventionally built counterparts. According to the first study, green buildings have a five percent higher valuation and occupancy rates, and one percent higher rental incomes. The second study reports two percent higher rents; when adjusted for occupancy-level, this translates into six percent higher effective rents.

Because the green amendments do not address all of the green attributes in the buildings studied and the regulatory approach does not include visible building labels, a conservative value of 1% was chosen to represent the increase in valuation.

Building valuation benefits tabulated in the benefit cost report were derived by applying the one percent increase to the values used for the prototype buildings, multiplied by numbers of projected new buildings. These benefits are considered one-time occurrences.

## *2. Occupant Health and Productivity*

These studies were used to value occupant health and productivity:

- US Green Building Council (Gregory Kats), *Greening America's Schools – Costs and Benefits*, October 2006.
- Gregory Kats, *The Costs and Financial Benefits of Green Buildings - A Report to California's Sustainable Building Task Force*, October 2003.

Overall, the studies were conducted on buildings that featured indoor air quality improvements related to ventilation and controls for temperature and pollutant sources.

The first study, for schools, was used to estimate the health benefits for the residential sector. The study indicates 20-year net present value (NPV) savings of $8 per square foot for reducing asthma and colds/flu. A conservative 10% proration of this benchmark, multiplied by an estimated 35 square feet per child (in a school setting), was used to calculate a dollar-per-person value that could be applied to the prototype home. This approach yields a 20-year NPV benefit of $28 per person, $112 per home, for health cost savings.

The second study, which indicates 20-year NPV productivity benefits of $37 to $55 per square foot for LEED-certified buildings, was used to value increased productivity in commercial buildings. Because the green amendments are not as extensive as LEED requirements, a conservative 10% proration to the average of the study findings, or $4.61 per square foot, was used. This rate per square foot was then multiplied by the prototype commercial building size to estimate a 20-year NPV of $6,900 per building for productivity gains.

## *3. Economic Health*

The economic health benefits of the code amendments were based on information provided by the City's Economic Advisor, Josh Birks, relative to a model used to assess the Mason Corridor. This information included multipliers for direct, indirect and induced benefits. Direct benefits represent the actual amount spent or invested. Indirect benefits (incremental) are defined in this model as increases in economic health, by local suppliers, necessary to support local impact. Induced benefits are defined as impacts on all local industries from wages derived from both direct and indirect impacts. The total multiplier for all three benefits is 1.5, based on 1.0 for direct and 0.5 for indirect and induced.

To ensure a conservative approach, only multipliers for indirect and induced benefits were used to value the local economic benefits of the incremental cost to implement the amendments for new buildings (both commercial and residential). The result is an economic benefit of $2,000 per home and $31,000 per commercial building. These benefits are considered one-time occurrences.

## *4. Carbon Reduction*

Projected utility savings (electricity and natural gas) were used to calculate carbon dioxide equivalent ($CO_2e$) emissions reductions for both residential and commercial buildings. Point Carbon's report, *Carbon 2010 Return of the Sovereign*, March 2010, indicates an expected carbon price of $10 to $20 per metric ton if trading is instituted in the United States. The *Stern Review of the Economics of Climate Change*, March 2007, estimates the social cost of carbon to be $85 per metric ton.

Based on these two reports, $20 per ton, or the high end of the range in the Point Carbon approach, was used to assign value to the carbon reduction benefit of utility savings. The annual value was then converted to a 20-year NPV.