DENVER’S SUSTAINABILITY GOALS AND STRATEGY
• What do we mean by “sustainability”?

Ensure a high quality of life for everyone in Denver now and in the future.

“Generations we will never meet.”
Basic Resources

• Air Quality
• Climate Stability
• Energy
• Materials
• Water Quality
• Water Quantity

• Food
• Health
• Housing
• Land Use
• Mobility
• Workforce

Available → Affordable → To Everyone → Now and Tomorrow
### 2020 Sustainability Goals

<table>
<thead>
<tr>
<th>Category</th>
<th>Goal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Quality</strong></td>
<td>Attain all National Ambient Air Quality Standards</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Reduce Denver CO2 emissions to below 1990 levels</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>Hold total energy usage below 2012 levels, while cutting fossil fuels by 50%</td>
</tr>
<tr>
<td><strong>Food</strong></td>
<td>Grow and/or process at least 20% of food purchased in Denver in Colorado</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td>Increase the % of youth in Denver at a healthy weight from 69% to 74%</td>
</tr>
<tr>
<td><strong>Housing</strong></td>
<td>Ensure 80% of neighborhoods are rated as affordable</td>
</tr>
<tr>
<td><strong>Land Use</strong></td>
<td>Move Denver’s Walk Friendly rating to Platinum from Gold</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td>Increase the citywide recycling rate to 34% or greater</td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>Reduce trips in single-occupant vehicles to no more than 60% of commutes</td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
<td>Make all Denver creeks and rivers swimmable and fishable</td>
</tr>
<tr>
<td><strong>Water Quantity</strong></td>
<td>Reduce water usage by 22%</td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td>Help at least 40% of workers living in transit deserts get to work without driving alone</td>
</tr>
</tbody>
</table>
2020 Sustainability Goals

More Impact

- Climate: Reduce Denver CO2 emissions to below 1990 levels
- Energy: Hold total energy usage below 2012 levels, while cutting fossil fuels by 50%
- Water Quality: Make all Denver creeks and rivers swimable and fishable

Less Impact

- Food: Grow and/or process at least 20% of food purchased in Denver in Colorado
Climate ACTION Plan Goals

• 2020 Goal: Absolute reduction of GHG emissions to 1990 levels by 2020 – would require a 10 percent reduction of GHGs from 2005 levels

• 80% reduction in greenhouse gas emissions by 2050

• Tree Canopy: 18% goal; 19% per Executive Order 123
Climate ADAPTATION Plan Goals

• Buildings and Energy Sector
  – Goal 1: Reduce vulnerability to building energy supply disruptions
  – Goal 2: Reduce vulnerability of buildings to extreme weather

• Urban Natural Resources Sector
  – Goal 1: Enhance and preserve existing urban forest resources
  – Goal 2: Ensure all Denver streams are fishable and swimmable

• Food and Agriculture sector
  – Increase food security
• Goal: 18% goal
• Executive Order 123: preserve 19%
• Non-City-Led Strategies Enacted
  – Clean Air Clean Jobs
  – Colorado Renewable Portfolio Standard
  – Demand-Side Management
  – Corporate Average Fuel Economy (CAFE) standards
City-Led Strategies Enacted

- Updated energy code to 2015 IECC
- Joining into State’s New Energy Improvement District to allow PACE financing
- Energize Denver – existing building energy efficiency
  - Benchmarking requirement
  - Education and outreach, including promotion of PACE
- Adoption of Greywater Ordinance allowing use
• Xcel’s Colorado Energy Proposal
  – 55% Renewable Electricity by 2026
• 80x50 Plan in final development
  – 100% Renewable Electricity Goal, date to be set
• Exploring Voluntary Stretch Code
Plans to Achieve Goals

• Sustainability Plan
• Climate Action Plan
• Climate Adaptation Plan
• 80x50 Plan (in development)
• Game Plan (in development)
# Climate ACTION Plan
## Long-Term Strategies

## Building Strategies

<table>
<thead>
<tr>
<th>Category</th>
<th>Strategy/Activity</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building and energy codes</td>
<td>Phase in net-zero energy/carbon-neutral building codes.</td>
<td>High</td>
</tr>
<tr>
<td>District energy</td>
<td>Expand the use of district heating and cooling systems and decrease their carbon intensity through combined heat and power and distributed generation.</td>
<td>High</td>
</tr>
<tr>
<td>Finance</td>
<td>Develop meter-based financing programs to incentivize long-term efficiency upgrades and/or create incentives for renters.</td>
<td>High</td>
</tr>
<tr>
<td>Finance</td>
<td>Encourage and develop innovative financing programs for energy efficiency and onsite renewables (i.e., Property Assessed Clean Energy, revolving loan funds, and bond facilities).</td>
<td>High</td>
</tr>
<tr>
<td>Fuel switching</td>
<td>Incentivize switching away from natural gas heating to renewable electricity, geothermal or solar thermal.</td>
<td>High</td>
</tr>
<tr>
<td>Strategy</td>
<td>Description</td>
<td>Importance</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Grid improvements</td>
<td>Expand high-efficiency transmission lines City-wide to reduce transmission and distribution losses.</td>
<td>High</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>Implement shared renewable power purchasing programs.</td>
<td>High</td>
</tr>
<tr>
<td>Energy innovation</td>
<td>Support clean energy entrepreneurship and use City facilities for demonstration of new solutions.</td>
<td>Medium</td>
</tr>
<tr>
<td>Engagement and incentive programs</td>
<td>Expand advertising and outreach and set targets to increase residential energy efficiency programs in currently underserved communities.</td>
<td>Medium</td>
</tr>
<tr>
<td>Engagement and incentive programs</td>
<td>Structure permit fees to incentivize energy efficiency.</td>
<td>Medium</td>
</tr>
<tr>
<td>Demand side management</td>
<td>Incentivize use of “smart home” energy management systems.</td>
<td>Medium</td>
</tr>
<tr>
<td>Waste heat recapture</td>
<td>Create incentives for waste heat recovery in industrial processes, data centers, and new buildings; investigate waste heat recovery from sewer lines.</td>
<td>Medium</td>
</tr>
</tbody>
</table>
### Urban and Natural Resources Strategies

<table>
<thead>
<tr>
<th>Category</th>
<th>Strategy/Activity</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green infrastructure</td>
<td>Use green stormwater infrastructure when designing, building, or upgrading infrastructure.</td>
<td>High</td>
</tr>
<tr>
<td>Water conservation</td>
<td>Incentivize rainwater harvesting and conservation practices for residents.</td>
<td>High</td>
</tr>
<tr>
<td>Trees and open space</td>
<td>Protect existing tree canopy resources.</td>
<td>High</td>
</tr>
<tr>
<td>Trees and open space</td>
<td>Expand open space and green development projects.</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### Food Strategies

<table>
<thead>
<tr>
<th>Category</th>
<th>Strategy/Activity</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban farming</td>
<td>Reduce regulatory barriers to urban agriculture and increase acceptable zones for food production.</td>
<td>Medium</td>
</tr>
<tr>
<td>Urban farming</td>
<td>Promote development of rooftop gardens (e.g., on large commercial buildings).</td>
<td>Medium</td>
</tr>
<tr>
<td>Indicator</td>
<td>Measure(s)</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| 1. Socioeconomic      | • Families in poverty  
                        • Educational attainment                                              |
| 2. Built Environment  | • Access to full service grocery stores                                    |
|                       | • Access to parks or open space                                            |
| 3. Access to Care     | • 1st Trimester care during pregnancy                                       |
| 4. Morbidity          | • Children and youth overweight and obese                                  |
| 5. Mortality          | • None – TBD                                                               |
Neighborhood Equity Index

Neighborhood Health Index

1. Social Determinantes of Health: measured by a) % of High School graduates or the equivalent for those 25 years of age and older and b) % of families below 1.0 of the Federal Poverty Line

2. Built Environment: measured by a) Food Access: % of residents within 1/4 mile walk to a full service grocery store, and b) Park Access: % of living units within 1/4 mile walk to a park or open space.

3. Access to Care: % of pregnancies without 1st trimester prenatal care

4. Morbidity: % of overweight or obese children

5. Mortality: no indicator included
Net Zero Energy Case Study
Discovery Elementary School
630 students

Pre-K to 5th grade

$32.3 M construction cost

98,000 gsf / 15.5 acres

$273 / sf building only
$289 / sf building with PV

PV = 4% of construction cost

$264,900 / acre sitework

$3+ million of County req’d site amenities included
What is Net Zero Energy?
Energy Use Index (EUI) =

Energy use per square foot over one year

\[ \text{kBTU} / \text{s.f.} / \text{yr.} \]
A Net Zero Energy school returns as much energy to the power grid as it uses in a year.
Energy Use

<table>
<thead>
<tr>
<th></th>
<th>HVAC</th>
<th>Lighting</th>
<th>Plug/ Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE 90.1</td>
<td>72</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td>AEDG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NES #1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost of PV array to get to NZE

<table>
<thead>
<tr>
<th></th>
<th>Millions of Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE 90.1</td>
<td>$5.0M</td>
</tr>
<tr>
<td>AEDG</td>
<td>$2.5M</td>
</tr>
<tr>
<td>NES #1</td>
<td>$1.5 M</td>
</tr>
</tbody>
</table>
HVAC 27%  
Lighting 20%  
Plugs 15%  
Kitchen 24%  
IT 8%  

Plugs / Kitchen / IT 23%  
Lighting 28%  
HVAC 49%  
IT 8%  
Total EUI: 60

Total EUI: 23

C O N S U M P T I O N  B R E A K D O W N
Roof Design
black roof,
white roof,
green roof,
blue roof.
PRIME SOLAR REAL ESTATE
496 kW ARRAY – ALL ON THE ROOFTOP
Exterior Wall Design
INSULATED CONCRETE FORMS
ICF: THERMAL MASS + ACOUSTICS
ICF offers high R-Value + Thermal Mass

Windows sized for views and quality of interior space – not harvesting

Reduce number of mullions & increase glass size

Trade-off method of energy code compliance
Cost Shifting

Daylight Harvesting
Controls

Added Roof Insulation
R40 to R30

Triple Pane Windows
PV system cost: $1,535,000
Bond rate: 2.63%
Year 1 Energy rate: $0.109 kWh
Energy Inflation: 3%
2014 SREC value: $35

6.34% Annualized Return on Investment

$99,679 bond payment
PROJECT EXAMPLES
February 2018

Prologis: Sustainable Design Overview

Jeannie Renne-Malone, LEED AP
VP, Sustainability
About Prologis

- **19 Countries**
- **687M Square Feet**
- **1500+ Employees**
- **3,307 Buildings**
- **5,200 Customers**
- **7,000+ Leases**

- **U.S.**
  - 379M SF
  - 2,024 Buildings

- **Europe**
  - 187M SF
  - 750 Buildings

- **Other Americas**
  - 57M SF
  - 250 Buildings

- **Asia**
  - 64M SF
  - 107 Buildings

Data as of September 30, 2017
Prologis Has an Integrated Approach to Sustainability

- Commitment to minimizing the environmental impact of our operations and development activity to deliver long-term value to our investors, customers, employees and communities

- We track and report progress against our goals through reputable reporting standards including GRI, CDP and GRESB

- Our management policies, including those on sustainability, apply to all properties, whether held by a co-investment venture or directly by Prologis
Environmental Goals and Progress

<table>
<thead>
<tr>
<th>Goals</th>
<th>Progress</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% of new development is designed with a goal of certification</td>
<td></td>
<td>87 MSF of sustainable building certifications</td>
</tr>
<tr>
<td>100% energy-efficient lighting across our operating portfolio</td>
<td></td>
<td>233 projects</td>
</tr>
<tr>
<td>200 MW solar by 2020</td>
<td></td>
<td>165 MW total solar generating capacity</td>
</tr>
<tr>
<td>20% reduction of corporate GHG emissions by 2020 from a 2011 baseline</td>
<td></td>
<td>22% reduction in Scope 1 and 2 GHG emissions since 2011</td>
</tr>
</tbody>
</table>

Note: Chart shows 3 years of data, as of year-end 2016
Key Sustainability Considerations for a Typical Prologis Building

• All new buildings are designed and developed with a goal of certification (e.g., LEED, BREEAM)

• We aim to retrofit existing buildings with LED lighting, cool roofs, smart meters and water-saving solutions

• Our industry-leading, energy-efficient buildings are designed to cost less to operate, reducing overall occupancy costs for our customers
Prologis Rooftop Solar Program

These solar installations generate enough electricity annually to power 2,500+ California homes

Global Solar Goal
• 200 MW solar by 2020
• As of year-end 2017, 175 MW of solar in 9 countries
• Equates to clean power for 25,900 average homes each year
• 87.5% towards goal

PROPERTY DETAILS

<table>
<thead>
<tr>
<th>Location</th>
<th>Inland Empire, CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>1,740,451 SF</td>
</tr>
<tr>
<td>Solar Capacity</td>
<td>11.22 MWp dc</td>
</tr>
<tr>
<td>Customer</td>
<td>Southern California Edison</td>
</tr>
</tbody>
</table>
Prologis Cool Roofing Initiative

Goal: 100% cool roofing in new development and property improvement where feasible, given climate restrictions

- The term cool roof refers to a roofing product with high solar reflectance and thermal emittance properties, i.e. a roof that is made from a white and/or reflective material
- 40% of global portfolio currently has cool or reflective roofing

Benefits:
- Customer: Energy savings
- Prologis: Reduced roof maintenance cost and replacement cost; no cost premium for cool roof material
- Community: Reduce urban heat island effect, community health benefits
Rooftop Options: Structural Challenges and Costs

• Structural Challenges to Green Roofs for Industrial Real Estate
  • “Adding a green roof system to an existing warehouse would probably not be possible based on the weights that I have seen. I am seeing that it would add 30-35 psf to a roof that is only designed for 45 psf total including snow. It is simply not possible to reinforce roof joists for a 66% increase in loads. You would have to tear off all of the roof deck, joists and girders and rebuild. The columns could be reinforced by welding new plates on for the full height, but the footings would be over loaded so the slab would have to be cut out so that the footings could be enlarged. The wall panels could also be a problem. Steel tubes could be bolted on to reinforce the panels at great expense. I have no idea what it would cost but probably much more than building a new building.”
  • -John Hart, P.E., S.E. (AZ, CO, HI, ID, IL, NE, NV, UT, WA), President, Peak Engineering

• Sample Roof Material Costs
  • Green roof: $30-35 SF (+ annual maintenance costs: $18,000)
  • Cool roof: $11-12 SF (annual maintenance costs: $1,450)
  • BUR: $14-15 SF (annual maintenance costs: $2,500)
  • Black Roof EPDM (A): $9-10 SF (annual maintenance costs: $4,000)
  • Black Roof EPDM (B): $8-9 SF (annual maintenance costs: $29,200)
Solar Costs and Issues

• Base Solar Calculation per 80% Mandate:
  • 150,000 sf x 80% = 120,000 sf stated solar requirement
  • 120,000 sf ÷ 125,000 sf/MWpDC = 0.960 MWpDC solar plant
  • 960,000 WpDC x $1.50/WpDC = $1,440,000 installed cost
  • 1,550 kWh/kWpDC x 960 kWpDC = 1.488 million kWh produced by solar per year (estimated)
  • 1.488 million kWh/yr. ÷ 150,000 SFT = 9.92 kWh/sf/yr. or > 2x typical warehouse energy consumption
  • Rooftop PV system would cost approximately $9.60/sf in addition to roofing cost
  • PV system output would far exceed local consumption; grid off-take may not be viable

• Adhering to the language in the Green Roof Ordinance relative to rooftop solar may not be possible (for utility grid management and interconnection reasons) and would be costly compared to costs of the roof or building.
  • Oversizing a PV plant is often not allowed by local utilities for technical and safety reasons. This is separate from potential limitations with the load capacity of existing roof structures and the compatibility of a rooftop PV plant with certain roofing systems and designs.
  • Sizing for behind-the-meter power plants normally considers current and future consumption alongside applicable utility rate structures and net metering rules to conclude a technically-feasible and economically-viable solution.
  • We foresee a likely timing disconnect: behind-the-meter PV plant approvals are typically granted by utilities after a lengthy process (often with technical and commercial components) based on information about the electricity consumption of the building, which would not be available well in advance of applying for a building permit, especially not in the case of a new building.

• And more....
Conclusions and Recommendations

• Real Estate companies already taking action to address climate change and mitigate environmental impacts should have flexible options for compliance or exemptions
  • Cool roofs
  • LEED certifications
  • Other design features that minimize impacts on energy, water, waste
  • Commitment to sustainability and public goals
PROJECT EXAMPLES
**Living in a High-Performance Green Building:**

**The Story of EPA’s Region 8 Headquarters**

<table>
<thead>
<tr>
<th>Cost Tradeoffs: Vegetated Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs:</strong></td>
</tr>
<tr>
<td>◆ Typical roof costs: approximately $4 psf</td>
</tr>
<tr>
<td>◆ Green roof premium: approximately $12 psf</td>
</tr>
<tr>
<td>◆ EPA green roof premium: approximately $240,000.</td>
</tr>
<tr>
<td><strong>Offset Savings:</strong></td>
</tr>
<tr>
<td>◆ Reduced detention vault: $150,000</td>
</tr>
<tr>
<td>◆ Parking revenues: 12 spaces × $25,000/yr = $300,000</td>
</tr>
<tr>
<td>◆ Additional savings:</td>
</tr>
<tr>
<td>▶ Roof temperature moderation = reduced energy costs</td>
</tr>
<tr>
<td>▶ Lower stormwater utility fees assessed by local utility</td>
</tr>
<tr>
<td>▶ Protects roof membrane from ultraviolet rays and hail, prolonging roof lifespan.</td>
</tr>
</tbody>
</table>
EPA Green Roof Research


Solar + Green Roof Conclusions

• Cooler beneath PV than the exposed area
• Temperature variation was less too
  • Winter – less “in and out” of dormancy
• More plants overwintered near PV
• PV protection = increase in plant cover
• Substrate moisture ↑ in the protected area
PROJECT EXAMPLES
Denver Housing Authority and Sun Valley EcoDistrict
Sustainability Approach
DHA Solar Initiatives

- Solar Garden (2 Megawatts)
- Other Roof Top Solar (Approx. 1 Megawatt)
- Roof Top PPA (2.5 Megawatts)
- Remaining Demand for Solar (10 to 15 Megawatts)

1 Megawatt = 1,000 kilowatts

- Reduction of Operating Costs
- 10,000 sf of roof space generates $10,000 annual savings or greater
Solar/Water Quality and Detention
DHA / Roof top Solar Program – Mariposa District 2015
DHA Community Revitalization and Healthy Food Access

In recent years DHA development has had a direct link to health outcomes.

• Health Impact Analysis
  • Significant Lack of Access to Healthy Food
  • No Healthy Market/Farmers Market
  • Childhood Obesity

• Looking to development for direct solutions
Solar Thermal Food Production
Green Roofs: Test these Design Assumptions

• Roof top detention, controlled flow
• Require no additional land area for detention?
• Increased roof life? (White roof versus Black roof)
• Lower Energy Costs?
• Water Quality/ Beauty/ Food production
• Calculate 0.7 soft (green) to hardscape ration- user friendly still with value for water quality/capture
## Preferred Option

### Green Roof Performance

**SUN VALLEY REDEVELOPMENT | GREEN ROOFS: INTEGRATED ULTRA-URBAN GREEN INFRASTRUCTURE 2.5**

Yan Meter Williams Pollack

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>SQ. FT.</th>
<th>ACRES</th>
<th>10 YEAR D+WQ 1.54*/AC</th>
<th>BLDG HT</th>
<th>BLDG AREA (sf)</th>
<th>ROOF AREA</th>
<th>GARAGE BLDG AREA (sf)</th>
<th>GARAGE HT</th>
<th>GARAGE ROOF AREA (sf)</th>
<th>GARAGE ROOF UTILIZATION at .70 OF GARAGE</th>
<th>GARAGE GREEN ROOF UTILIZATION at .70 OF GARAGE</th>
<th>GARAGE GREEN ROOF cu. ft.</th>
<th>% of 10yr D+WQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>92,700</td>
<td>2.13</td>
<td>at 0.85 imperm = 10,112 cu. ft.</td>
<td>3.0</td>
<td>5 story</td>
<td>216,060</td>
<td>43,612</td>
<td>60,990</td>
<td>2 story</td>
<td>30,495</td>
<td>21,347</td>
<td>14,943</td>
<td>479</td>
</tr>
<tr>
<td>2</td>
<td>74,000</td>
<td>1.70</td>
<td>at 0.85 imperm = 8,872 cu. ft.</td>
<td>3.3</td>
<td>5 story</td>
<td>200,050</td>
<td>40,010</td>
<td>42,300</td>
<td>2 story</td>
<td>21,150</td>
<td>14,805</td>
<td>10,364</td>
<td>332</td>
</tr>
<tr>
<td>3</td>
<td>81,000</td>
<td>1.66</td>
<td>at 0.85 imperm = 8,836 cu. ft.</td>
<td>2.9</td>
<td>5 story</td>
<td>164,794</td>
<td>36,959</td>
<td>50,300</td>
<td>2 story</td>
<td>25,150</td>
<td>17,065</td>
<td>12,324</td>
<td>395</td>
</tr>
<tr>
<td>4</td>
<td>52,700</td>
<td>1.21</td>
<td>at 0.85 imperm = 5,740 cu. ft.</td>
<td>2.5</td>
<td>5 story</td>
<td>108,680</td>
<td>21,736</td>
<td>24,710</td>
<td>2 story</td>
<td>12,355</td>
<td>8,649</td>
<td>6,054</td>
<td>194</td>
</tr>
<tr>
<td>5</td>
<td>59,100</td>
<td>1.36</td>
<td>at 0.85 imperm = 6,447 cu. ft.</td>
<td>2.5</td>
<td>5 story</td>
<td>120,930</td>
<td>24,186</td>
<td>29,180</td>
<td>2 story</td>
<td>14,590</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>76,250</td>
<td>1.75</td>
<td>at 0.85 imperm = 8,318 cu. ft.</td>
<td>3.0</td>
<td>5 story</td>
<td>168,990</td>
<td>33,798</td>
<td>58,500</td>
<td>2 story</td>
<td>29,250</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>81,700</td>
<td>1.68</td>
<td>at 0.22 imperm = 2,307 cu. ft.</td>
<td>0.7</td>
<td>2&amp;3 story</td>
<td>53,140</td>
<td>N/A</td>
<td>6,400</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td>60,800</td>
<td>1.40</td>
<td>at 0.85 imperm = 6,632 cu. ft.</td>
<td>2.2</td>
<td>5 story</td>
<td>103,200</td>
<td>20,640</td>
<td>28,510</td>
<td>2 story</td>
<td>14,255</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>78,500</td>
<td>1.80</td>
<td>at 0.85 imperm = 8,563 cu. ft.</td>
<td>2.7</td>
<td>5 story</td>
<td>154,170</td>
<td>30,834</td>
<td>54,620</td>
<td>2 story</td>
<td>27,310</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>94,950</td>
<td>1.95</td>
<td>at 0.36 imperm = 4,143 cu. ft.</td>
<td>0.8</td>
<td>2&amp;3 story</td>
<td>48,920</td>
<td>N/A</td>
<td>20,880</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>55,500</td>
<td>1.51</td>
<td>at 0.85 imperm = 7,156 cu. ft.</td>
<td>2.4</td>
<td>5 story</td>
<td>123,940</td>
<td>24,788</td>
<td>34,680</td>
<td>2 story</td>
<td>17,340</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>47,050</td>
<td>1.08</td>
<td>at 0.85 imperm = 5,132 cu. ft.</td>
<td>3.4</td>
<td>5 story</td>
<td>121,800</td>
<td>24,360</td>
<td>38,400</td>
<td>2 story</td>
<td>19,200</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>32,300</td>
<td>0.74</td>
<td>at 0.85 imperm = 3,523 cu. ft.</td>
<td>2.9</td>
<td>5 story</td>
<td>66,700</td>
<td>13,340</td>
<td>27,600</td>
<td>2 story</td>
<td>13,800</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>49,800</td>
<td>1.14</td>
<td>at 0.85 imperm = 5,432 cu. ft.</td>
<td>2.3</td>
<td>5 story</td>
<td>94,920</td>
<td>18,804</td>
<td>21,200</td>
<td>2 story</td>
<td>10,600</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>57,950</td>
<td>1.56</td>
<td>at 0.85 imperm = 7,412 cu. ft.</td>
<td>2.4</td>
<td>5 story</td>
<td>131,310</td>
<td>26,252</td>
<td>28,840</td>
<td>3 story</td>
<td>9,613</td>
<td>5,729</td>
<td>4,711</td>
<td>151</td>
</tr>
<tr>
<td>16</td>
<td>68,300</td>
<td>1.57</td>
<td>at 0.60 imperm = 5,250 cu. ft.</td>
<td>2.6</td>
<td>8 story</td>
<td>154,520</td>
<td>19,315</td>
<td>25,200</td>
<td>3 story</td>
<td>8,400</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>94,200</td>
<td>2.16</td>
<td>at 0.30 imperm = 3,627 cu. ft.</td>
<td>0.3</td>
<td>1 story</td>
<td>29,420</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>18</td>
<td>74,850</td>
<td>1.72</td>
<td>at 0.60 imperm = 5,763 cu. ft.</td>
<td>2.6</td>
<td>8 story</td>
<td>163,440</td>
<td>20,430</td>
<td>34,500</td>
<td>3 story</td>
<td>11,500</td>
<td>8,050</td>
<td>5,635</td>
<td>181</td>
</tr>
</tbody>
</table>
Sun Valley P1 Green Roof
Options:

Option 1
On-Site Conventional Detention, Water Quality, and Conveyance Alternative

Option 2
Off-Site Detention and Water Quality: Green Streets and Ponds

Option 3
On-Site Detention and Water Quality: Blue Roof, Green Roof, and Green Streets

Preferred Option
Off-Site Detention and Water Quality: Integrated Ultra-Urban Green Infrastructure
Integrated Ultra-Urban Green Infrastructure

- Stormwater infrastructure system within the public ROW
- Consider Green Roofs
  (roof top detention on top of the structured parking facilities, semi-public space)
- 2 Green Alleys
  (service private development blocks)
- District(project)-scale stormwater management strategy in place
  (development parcels do not need to meet requirements)
Sun Valley Master Plan
Beginning to Populate the Framework

WATER QUALITY
GREEN ROOFS

Water Quantity and Quality Benefits

Part 2
Questions from Last Meeting

- How Do Green Roofs Compare to Other Water Quality BMPs?
  - Bioretention
    - Trees or plants on the ground
    - Trade impervious parking for green space at ground level
  - Pervious Pavement
    - Trade impervious surface for pervious surface at grade
  - Retention
    - Holding tank for stormwater

Limited Information Comparing Relative Effectiveness of Green Roofs to Other Practices for Improving Water Quality

More Appropriate to Compare Green Roofs to Other Types of Roofs
Water Quality Capture Volume

- Water Quality Capture Volume (WQCV) - The volume of runoff that a water quality BMP is designed to capture and treat prior to release to receiving waters.
  - Applies to water quality and runoff volume
    - Based on site imperviousness, size of tributary area, and stormwater retention time
    - Treatment targets storm events of up to 0.6 inches precipitation

- Requirements for Stormwater Detention are also Based on the Water Quality Capture Volume
Green Roof Benefits

• Primary Benefit - Delay of Peak Flows and Runoff Volume Reduction
  • Benefit varies with storm size, duration, and time between storms
  • Benefit depends on green roof construction

• Secondary Benefit - Water Quality Improvement
  • May be helpful in managing volume for water quality storm events
    • Reduced rooftop runoff = reduced volume treated by in-ground BMPs
  • Green roofs are highly effective at managing typical roof-top pollution
    but don’t provide treatment for other surfaces
## Comparison of Two Green Roofs

<table>
<thead>
<tr>
<th>Downtown Building – 100% Impervious Site</th>
<th>Industrial Facility – 67% Impervious</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building Footprint</strong></td>
<td><strong>Site</strong></td>
</tr>
<tr>
<td>2.4 acres</td>
<td>5.75 acres</td>
</tr>
<tr>
<td><strong>Lot Size</strong></td>
<td><strong>Other Impervious Surfaces</strong></td>
</tr>
<tr>
<td>2.4 acres</td>
<td>4.7 acres</td>
</tr>
<tr>
<td><strong>% Imperviousness</strong></td>
<td><strong>Lot Size</strong></td>
</tr>
<tr>
<td>100%</td>
<td>15.4 acres</td>
</tr>
<tr>
<td><strong>Required Runoff Retention</strong></td>
<td><strong>% Imperviousness</strong></td>
</tr>
<tr>
<td>4,450 sq ft</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Available Space</strong></td>
<td><strong>Required Runoff Retention</strong></td>
</tr>
<tr>
<td>0</td>
<td>14,825 sq ft</td>
</tr>
<tr>
<td><strong>40% Green Roof Coverage</strong></td>
<td><strong>Available Space</strong></td>
</tr>
<tr>
<td></td>
<td>5 acres</td>
</tr>
<tr>
<td><strong>Site Imperviousness</strong></td>
<td><strong>10% Green Roof Coverage</strong></td>
</tr>
<tr>
<td>61%</td>
<td></td>
</tr>
<tr>
<td><strong>100% Green Roof Coverage</strong></td>
<td><strong>Site Imperviousness</strong></td>
</tr>
<tr>
<td></td>
<td>64%</td>
</tr>
<tr>
<td><strong>Site Imperviousness</strong></td>
<td><strong>100% Green Roof Coverage</strong></td>
</tr>
<tr>
<td>1%</td>
<td></td>
</tr>
<tr>
<td><strong>Site Imperviousness</strong></td>
<td><strong>Site Imperviousness</strong></td>
</tr>
<tr>
<td></td>
<td>30%</td>
</tr>
</tbody>
</table>
Important Points to Take Away

• Water Quality Benefits from Green Roofs are Secondary to Delay of Peak Flows and Reduction in Volume of Runoff
  • Focus should be on delay of peak runoff and volume reduction
  • Water quality should be considered site-wide and integrate green roofs with in-ground BMPs

• Green Roof Stormwater Benefits May Prove Most Useful in Neighborhoods with
  • Higher Building Density
  • Nuisance Flooding
  • Existing, or planned, high imperviousness (60-70%+)
QUESTIONS?

Jon Novick
Environmental Administrator – Water Quality
Denver Department of Public Health and Environment
200 W. 14TH Ave
Dept. 310
Denver, CO 80204
jon.novick@denvergov.org
Denver’s Stormwater Capture / Treatment Requirements

• §56-111 DRMC:
  (a) ... each developer of land within the city has a duty to provide on his/her property all reasonably necessary drainage and detention facilities to ensure the adequate drainage and control of ... stormwaters which fall or develop on his/her property or which contribute runoff to his/her property.

  (b)... each developer/redeveloper of land conducting projects that disturb one (1) or more acres of soil, including projects less than one (1) acre that are part of a larger common plan of development or redevelopment, has the duty to prevent or minimize water quality impacts from the completed project.
Perviousness/Imperviousness

- Pervious surfaces allow water soak into the ground, impervious surfaces do not, instead creating runoff.

<table>
<thead>
<tr>
<th>Pervious Surfaces</th>
<th>Impervious Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass</td>
<td>Roads and Sidewalks</td>
</tr>
<tr>
<td>Dirt, Sand, or Gravel</td>
<td>Roofs</td>
</tr>
<tr>
<td></td>
<td>Parking Lots and Driveways</td>
</tr>
</tbody>
</table>
Downtown Building

Industrial Facility

Note: Photos are not at the same scale.
Other Types of Water Quality BMPs

• Traditional
  • Extended Detention Basin
  • Constructed Wetlands (Pond or Channel)
  • Permeable Pavement
  • Sand Filter
  • Retention Pond
  • Underground Treatment

• Green Infrastructure
  • Bioretention (Rain Gardens or Porous Landscape Detention)
  • Grass Buffer
  • Grass Swale
  • Curb-Side Planters

Assessment of WQ BMP Effectiveness

Studies conducted by the International Stormwater BMP Database

- Most recent summary report available at:
  
  http://www.bmpdatabase.org/Docs/03-SW-1COh%20BMP%20Database%202016%20Summary%20Stats.pdf
Imperviousness Statistics for Denver

- Buildings Make Up 30% of Impervious Surfaces in Denver
  - Remaining 70% are roads, driveways, parking lots, and sidewalks
- Approximately 40% of Surfaces in Denver are Impervious (2010 data, includes DIA)
- Amount of Impervious Surfaces in Denver are Projected to Increase by 30% - 40% by 2040 (CU Boulder, unpublished data)
Beginning to Populate the Framework

SOLAR
Renewable Energy Choices

Your guide to renewable energy choices through Xcel Energy

Kevin Cray – Solar Trade Relations Manager
Wide Array of Renewable Options

On-Site

Solar* Rewards

Net Metering

Subscription

Windsource

Solar* Rewards Community

Renewable* Connect (coming soon)
Renewable Energy Certificates (REC’s)

A REC serves as “proof” that 1 MWH of renewable energy was generated and can be purchased separate from electrical service.

Source: Intermountain Rural Electric Association
https://www.irea.coop/customer-tools/recs/
RECs can be used to reach sustainability goals, achieve green certification, and strengthen customer brands as they promoting their commitment to using clean energy. Some of our programs include RECs, while others do not.

When RECs are Yours to Claim

RECs with RECs:
- Windsource
- Renewable* Connect
- Net Metering Only

RECs without RECs:
- Solar*Rewards Community
- Solar*Rewards
## On-Site Options

<table>
<thead>
<tr>
<th>Solar*Rewards (+ Net Metering)</th>
<th>Net Metering Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Xcel Energy retains the REC</td>
<td>• Customer keeps the REC</td>
</tr>
<tr>
<td>• Net metering</td>
<td>• Net metering</td>
</tr>
<tr>
<td>• Must use new equipment</td>
<td>• Can use existing/used equipment</td>
</tr>
<tr>
<td>• System can be sized up to 120% of customers history usage</td>
<td>• System can be sized up to 120% of customers history usage</td>
</tr>
<tr>
<td>• 20 year contract term</td>
<td>• Open enrollment: no application expiration</td>
</tr>
<tr>
<td>• Small program (up to 25kW)</td>
<td></td>
</tr>
<tr>
<td>• Medium program (25 -500kW)</td>
<td></td>
</tr>
<tr>
<td>• Large program (&gt;500kW)</td>
<td></td>
</tr>
</tbody>
</table>
## Subscription Options

<table>
<thead>
<tr>
<th>Solar*Rewards Community®</th>
<th>Windsource®</th>
<th>Renewable*Connect</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 3rd party subscriptions</td>
<td>• 100% local wind to offset your energy use</td>
<td>• Approved by PUC</td>
</tr>
<tr>
<td>• Gardens are owned and maintained by private companies</td>
<td>• Sold in 100 kWh blocks</td>
<td>• Coming in late 2018</td>
</tr>
<tr>
<td>• Xcel Energy retains the RECs</td>
<td>• Customer keeps the REC</td>
<td>• 100% large scale solar that will be locally sourced</td>
</tr>
<tr>
<td>• Monetary bill credit on Xcel Energy bill</td>
<td>• Up to 100% of energy use</td>
<td>• Customer keeps the REC</td>
</tr>
<tr>
<td>• Subscribe up to 120% of historic usage</td>
<td>• Net cost = 1.5¢ / kWh</td>
<td>• Cost TBD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Contract directly with Xcel Energy</td>
</tr>
</tbody>
</table>
Questions?
Third Party Community Solar Model

Xcel Energy

All Customers

$ Avoided costs (ECS, riders, etc.)

Solar Energy

$ Bill Credits

Subscriber

Subscriber Organization

Solar Energy

REC(s)

$ REC Payment

$ Buyers Shares
# Programs at a Glance

<table>
<thead>
<tr>
<th></th>
<th>Renewable*Connect</th>
<th>Windsource</th>
<th>Solar*Rewards Community</th>
<th>Solar*Rewards</th>
<th>Net Metering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable Energy Source</strong></td>
<td>50 MW of additional competitively bid Colorado solar</td>
<td>Colorado wind</td>
<td>Competitively bid up to 2 MW per project</td>
<td>On-site personal solar</td>
<td>On-site solar or wind</td>
</tr>
<tr>
<td><strong>Sustainability Claims</strong></td>
<td>Claim renewable energy benefits</td>
<td>Claim renewable energy benefits</td>
<td>No claims to renewable energy benefits</td>
<td>No claims to renewable energy benefits</td>
<td>Claim renewable energy benefits</td>
</tr>
<tr>
<td><strong>Impact to all Customers</strong></td>
<td>No cost to non-participants</td>
<td>No cost to non-participants</td>
<td>Low cost to non-participants</td>
<td>Highest cost to non-participants for incentive + net metering benefits</td>
<td>Moderate cost to non-participants for net metering benefits</td>
</tr>
<tr>
<td><strong>Cost Savings</strong></td>
<td>Potential for cost savings</td>
<td>Cost savings not likely</td>
<td>Potential for cost savings*</td>
<td>Potential for cost savings*</td>
<td>Potential for cost savings*</td>
</tr>
<tr>
<td><strong>Program Charge</strong></td>
<td>Monthly charge on utility bill approved by PUC; locked-in during contract</td>
<td>Monthly charge on utility bill approved by PUC; subject to change</td>
<td>Negotiated with developer; not regulated by PUC</td>
<td>Negotiated with installer; not regulated by PUC</td>
<td>Negotiated with installer; not regulated by PUC</td>
</tr>
<tr>
<td><strong>Financial Credit</strong></td>
<td>Fuel cost credit on Xcel Energy bill</td>
<td>NA</td>
<td>Average Retail Rate + REC incentive</td>
<td>Net metering benefits plus REC incentive</td>
<td>Net metering benefits</td>
</tr>
<tr>
<td><strong>Contract Terms</strong></td>
<td>Xcel Energy contract with flexible terms and modest termination fee</td>
<td>Xcel Energy contract with monthly term and no termination fee</td>
<td>Third-party long-term contract termination clause</td>
<td>System contract with third-party solar installer; interconnect and incentive agreements with Xcel Energy</td>
<td>System contract with third-party solar installer; interconnect agreement with Xcel Energy</td>
</tr>
</tbody>
</table>

*Cost savings is dependent upon individual costs negotiated with developer/installer*
Net Metering
Install on-site solar and keep the RECs

Features
Ownership - Generate clean energy with solar or wind installed on your home or business.

Use what you need - Fulfill your energy needs with what your system produces.

Green energy - RECs are yours to keep, allowing you to make claims on the use of renewable energy.

Get Started
Net Metering allows you to generate your own energy and retain the renewable attributes that your system produces.

Learn more about how to apply and interconnect to our grid by visiting xcelenergy.com/Solar.
Solar*Rewards
Install on-site solar and receive incentives

Features
Ownership- Generate clean energy through solar panels installed on your home or business

Use what you need- Fulfill your energy needs with what your system produces.

Energy credit- Receive a production based incentive to offset costs.

Net metering- Use the kWh you produce each month, and if you generate more energy than you need, you can sell the excess back to us

Get Started
Installing on-site solar is a great way to invest in renewable energy. Your system will still be integrated with our grid to ensure you receive reliable power even when the sun isn’t shining.

Find out about availability and how to apply for incentives by visiting xcelenergy.com/Solar.
Windsource
Add more Colorado wind to your energy mix

Features

Low cost- No upfront fee, just a minimal monthly charge on your electric bill.

Choice- Choose how much wind power you want to purchase, from one 100 kWh block up to 100 percent of your usage.

Green energy- RECs are retired on your behalf, allowing you to make claims on the use of renewable energy.

Get Started

Windsource is an easy, inexpensive way to support green energy, and you can subscribe today. Just complete an online application or speak with your account manager for help enrolling.

Visit xcelenergy.com/Windsource to learn more.
Solar*Rewards Community
Support a solar garden and get paid for solar energy production

Features

Third-party provider- Contract terms defined by provider; and no installation is required.

Consistency- You still receive electric service and billing from Xcel Energy.

Bill credit- Subscribers receive an Xcel Energy bill credit as payment for your portion of the garden’s solar energy production.

Get Started
Subscribe to a solar garden to get paid for the solar energy produced with nothing on your roof. Contact a provider to request a subscription to a nearby garden. The solar garden operator is your advisor to potential savings, as well as subscription terms and conditions.

View the list of solar gardens by visiting xcelenergy.com/Solar.
Renewable*Connect
Subscribe to local solar energy

Features

Flexible terms- Choose from monthly, five-year or 10-year subscriptions.

Choice- Decide how much renewable energy you want to subscribe to.

Locked-in pricing- Enjoy more certainty with set price schedules for the contract term.

Green energy- RECs are retired on your behalf, allowing you to make claims on the use of renewable energy.

Get Started

Renewable*Connect is our newest program coming to Colorado in 2018 that can deliver clean, local and reliable energy to your business or organization.

Enrollment begins in 2018. Please visit xcelenergy.com/RenewableConnect to check availability and learn more.
Beginning to Populate the Framework

COOL ROOFS. CERTIFICATION SYSTEMS.
Cool Roofs Overview
Impact:

1. Cooling energy savings

2. Lower roof surface temperatures reduce heat island effect

3. Improved thermal comfort in spaces immediately below roof

4. Heating energy penalty
Summer Roof Temperatures

Roof Temperature (°F)

Time of Day

- Conventional Roof
- Green Roof
- Cool Roof
Winter Heating Energy Penalty

- Heating loads are typically higher in evenings, whereas the benefit of a darker roof in winter is mostly realized during daylight hours.

- Many commercial buildings require space cooling all year because of human activity or equipment usage, thereby negating the little—if any—heating benefit achieved by a dark roof.

Cost Evaluation
Representative Buildings

**Apartment**
5 flrs, 55,000 ft² total building area, 11,000 ft² roof area
Green Roof Coverage requirement: 30% or 3,300 ft²

**Industrial or Retail**
1 flr, 150,000 ft² total building area, 150,000 ft² roof area
Green Roof Coverage requirement:
- 10% for Industrial or 15,000 ft²
- 50% for Retail or 75,000 ft²

**Office**
15 flrs, 300,000 ft² total building area, 6,000 ft² roof area
Green Roof Coverage requirement: 60% or 3,600 ft²
## Cool Roof Replacement Costs

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
<th>Building 1: Apartment</th>
<th>Building 2a: Industrial</th>
<th>Building 2b: Retail</th>
<th>Building 3: Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Consultant #1</td>
<td>Life Expectancy: 25 years</td>
<td>$144,500</td>
<td>$1,589,300</td>
<td>$1,589,300</td>
<td>$91,500</td>
</tr>
<tr>
<td>Roof Consultant #2</td>
<td>Life Expectancy: 20 years</td>
<td>$132,000</td>
<td>$1,500,000</td>
<td>$1,500,000</td>
<td>$114,000</td>
</tr>
<tr>
<td><strong>Average Capital Cost ($)</strong></td>
<td></td>
<td>$138,250</td>
<td>$1,544,650</td>
<td>$1,544,650</td>
<td>$102,750</td>
</tr>
<tr>
<td>Roof Consultant #1</td>
<td><strong>Annual Maintenance Costs ($)</strong></td>
<td>$2,200</td>
<td>$30,000</td>
<td>$30,000</td>
<td>$1,200</td>
</tr>
</tbody>
</table>
# Existing Building
## First Costs & Premiums

<table>
<thead>
<tr>
<th>Description</th>
<th>Building 1: Apartment</th>
<th>Building 2a: Industrial</th>
<th>Building 2b: Retail</th>
<th>Building 3: Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Roof Replacement Cost ($)</td>
<td>$137,700</td>
<td>$1,539,900</td>
<td>$1,539,900</td>
<td>$101,250</td>
</tr>
<tr>
<td>Additional Green Roof Replacement Cost ($)</td>
<td>$140,636</td>
<td>$490,089</td>
<td>$2,224,759</td>
<td>$132,300</td>
</tr>
<tr>
<td>Green Roof Cost Increase vs Black Roof (%)</td>
<td>102</td>
<td>32</td>
<td>144</td>
<td>131</td>
</tr>
<tr>
<td>OR Additional Green Roof + PV Replacement Cost ($)</td>
<td>$134,634</td>
<td>$533,554</td>
<td>$2,548,439</td>
<td>$139,833</td>
</tr>
<tr>
<td>PV + Green Roof Cost Increase vs Black Roof (%)</td>
<td>98</td>
<td>35</td>
<td>165</td>
<td>138</td>
</tr>
<tr>
<td>OR Additional Cool Roof Replacement cost ($)</td>
<td>$550</td>
<td>$4,750</td>
<td>$4,750</td>
<td>$1,500</td>
</tr>
<tr>
<td>Cool Roof Cost Increase vs Black Roof (%)</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>1.5</td>
</tr>
</tbody>
</table>
# New Construction Cost Evaluation

## First Costs & Premiums

<table>
<thead>
<tr>
<th>Description</th>
<th>Building 1: Apartment</th>
<th>Building 2a: Industrial</th>
<th>Building 2b: Retail</th>
<th>Building 3: Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Building Floor Area (ft²)</td>
<td>50,000</td>
<td>150,000</td>
<td>150,000</td>
<td>300,000</td>
</tr>
<tr>
<td>Cost per ft² ($/ft²)</td>
<td>$139.81</td>
<td>$130.95</td>
<td>$100.00</td>
<td>$186.69</td>
</tr>
<tr>
<td>New Building Total Construction Costs ($)</td>
<td>$6,990,500</td>
<td>$19,642,500</td>
<td>$15,000,000</td>
<td>$56,007,000</td>
</tr>
<tr>
<td>Additional Green Roof Cost per ft² ($)</td>
<td>$2.81</td>
<td>$3.27</td>
<td>$14.83</td>
<td>$0.44</td>
</tr>
<tr>
<td>Additional Green Roof Cost ($)</td>
<td>$140,636</td>
<td>$490,089</td>
<td>$2,224,759</td>
<td>$132,300</td>
</tr>
<tr>
<td>Cost Increase for Green Roof (%)</td>
<td>2.0</td>
<td>2.5</td>
<td>14.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Additional Green Roof + PV Cost per ft² ($)</td>
<td>$2.69</td>
<td>$3.56</td>
<td>$16.99</td>
<td>$0.47</td>
</tr>
<tr>
<td>Additional Green Roof + PV Cost ($)</td>
<td>$134,634</td>
<td>$533,554</td>
<td>$2,548,439</td>
<td>$139,833</td>
</tr>
<tr>
<td>Cost Increase for Green Roof + PV (%)</td>
<td>1.9</td>
<td>2.7</td>
<td>17.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Additional Cool Roof Cost per ft² ($)</td>
<td>$0.01</td>
<td>$0.03</td>
<td>$0.03</td>
<td>$0.01</td>
</tr>
<tr>
<td>Additional Cool Roof Cost ($)</td>
<td>$550</td>
<td>$4,750</td>
<td>$4,750</td>
<td>$1,500</td>
</tr>
<tr>
<td>Cost Increase for Cool Roof (%)</td>
<td>0.008</td>
<td>0.024</td>
<td>0.032</td>
<td>0.003</td>
</tr>
</tbody>
</table>
# Cool Roof Benefits vs Green Roofs

<table>
<thead>
<tr>
<th>Cool Roof</th>
<th>Green Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically fast payback, lower first costs</td>
<td>Additional benefits beyond direct financial investment:</td>
</tr>
<tr>
<td>Cooling energy savings, associated GHG emissions savings</td>
<td>• Amenity Value</td>
</tr>
<tr>
<td>Minimal maintenance</td>
<td>• Aesthetic Benefits</td>
</tr>
<tr>
<td>Easily implemented on existing buildings</td>
<td>• Biodiversity</td>
</tr>
<tr>
<td></td>
<td>• Increased PV Efficiency</td>
</tr>
<tr>
<td></td>
<td>• Stormwater</td>
</tr>
<tr>
<td></td>
<td>• Revenue source (food garden)</td>
</tr>
<tr>
<td>Glare risk</td>
<td>Higher installation costs, long-term maintenance costs</td>
</tr>
</tbody>
</table>

Smart Surfaces Study

- Suite of Resilient Strategies to manage Sun and Rain
  - Green Roofs
  - Solar PV
  - Cool Roofs
  - Reflective Pavement
  - Permeable, Porous Pavement

- **Integrated cost-benefit** analysis for all strategies
  - Urban Heat Island
  - Energy & Greenhouse Gas Emissions
  - Financial Incentives
  - Health
  - Stormwater
  - Employment
  - Summer Tourism

- **Specific benefits for addressing urban low-income communities**

Swapping a square foot of dark, low albedo roof for a higher albedo generates nearly $4/ft^2$ in net energy and health benefits (lower energy bills, improved health due to better air quality, lower heat stress and cooler indoor conditions).

## Certifications: Multi-Attribute

<table>
<thead>
<tr>
<th>USGBC LEED</th>
<th>WELL Building Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addresses overall environmental impact</td>
<td>Focused on the impact of indoor spaces on human health &amp; wellbeing</td>
</tr>
<tr>
<td>Weighted towards energy efficiency, and proximity to dense urban core with public transit</td>
<td>Weighted towards indoor air quality, water quality, healthy food choices, active lifestyles</td>
</tr>
<tr>
<td>Industry familiarity, lower cost impact, greater emphasis on documentation</td>
<td>More stringent criteria, higher cost impact, greater emphasis on performance verification</td>
</tr>
<tr>
<td>Pre-requisites and optional credits</td>
<td>Pre-conditions and optional optimizations</td>
</tr>
</tbody>
</table>
Certifications: Multi-Attribute

USGBC LEED
- Integrative Design Process
- Location + Transportation
- Sustainable Sites
  - Protect & Restore Habitat
  - Open Space
  - Rainwater Management
  - Heat Island
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation
- Regional Priority Credits
  - Resiliency Pilot Credits

WELL Building Standard
- Air
- Water
- Nourishment
  - Food Production
- Light
- Fitness
  - Exterior Active Spaces
- Comfort
- Mind
  - Biophilia
Certifications: Single-Attribute

Verified Net-Zero Energy

Living Building Challenge Zero Energy Certification
(note restrictions on combustion)

One Water
LEED Cost Premiums

**USGBC LEED**

- LEED Silver: 1-2%
- LEED Gold: 3-5%
- LEED Platinum: Variable

Cost is highly contingent on:

- Proximity to public transit, dense urban fabric, diverse uses
- Achieving significant energy cost savings vs code baseline
- Funding mechanism for on-site renewables
Predicted energy cost savings

<table>
<thead>
<tr>
<th>New Bldg. Type</th>
<th>2009</th>
<th>2015</th>
<th>Certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel (11)</td>
<td>20%</td>
<td>18%</td>
<td>5</td>
</tr>
<tr>
<td>MOB (9)</td>
<td>21%</td>
<td>20%</td>
<td>4</td>
</tr>
<tr>
<td>Mixed Use (11)</td>
<td>27%</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Multifamily (80)</td>
<td>27%</td>
<td>22%</td>
<td>60</td>
</tr>
<tr>
<td>Office (26)</td>
<td>32%</td>
<td>19%</td>
<td>20</td>
</tr>
<tr>
<td>Recreation (8)</td>
<td>24%</td>
<td>22%</td>
<td>2</td>
</tr>
<tr>
<td>K-12 (7)</td>
<td>35%</td>
<td>23%</td>
<td>5</td>
</tr>
<tr>
<td>Higher Ed (4)</td>
<td>25%</td>
<td>27%</td>
<td>3</td>
</tr>
<tr>
<td>Total Bldgs (156)</td>
<td>26%</td>
<td>22%</td>
<td>109</td>
</tr>
</tbody>
</table>

- Under 2009 IECC, average energy cost savings are 26%.
- Under 2015 IECC, average energy cost savings are 22%.
- Less than 10% of total buildings sampled were under 2015 IECC.
- To meet 2015 IECC using the whole building energy model approach, building must show at least 15% savings.
Multifamily
## Energy Cost Savings

<table>
<thead>
<tr>
<th>Category</th>
<th>Average SF</th>
<th>Energy Cost Savings ($/sf)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel (11)</td>
<td>161,300</td>
<td>$0.24</td>
</tr>
<tr>
<td>MOB (9)</td>
<td>81,603</td>
<td>$0.30</td>
</tr>
<tr>
<td>Mixed Use (11)</td>
<td>247,297</td>
<td>$0.31</td>
</tr>
<tr>
<td>Multifamily (80)</td>
<td>181,940</td>
<td>$0.26</td>
</tr>
<tr>
<td>Office (26)</td>
<td>199,225</td>
<td>$0.47</td>
</tr>
<tr>
<td>Recreation (8)</td>
<td>56,361</td>
<td>$0.87</td>
</tr>
<tr>
<td>K-12 (7)</td>
<td>73,932</td>
<td>$0.60</td>
</tr>
<tr>
<td>Higher Ed (4)</td>
<td>95,500</td>
<td>$0.35</td>
</tr>
</tbody>
</table>

*normalized over whole building

- This set of data is based on Group14’s experience, which tends to be higher-performing new projects that go through green certification.

- Energy cost savings represent all the buildings in a category under both energy codes.

- Energy cost savings are not related to green roofs (fewer than 1% of buildings have a green roof in this sample).

- On average, simple payback on investment in energy efficiency is 8-12 years for new construction.
  - Existing buildings, which are not represented here, simple payback on investment averages 2-5 years.
Green Roof Costs vs Energy Cost Savings

<table>
<thead>
<tr>
<th>Category</th>
<th>Average SF</th>
<th>Energy Cost Savings from other EE Measures $/SF</th>
<th>Average Green Roof Cost ($/SF) of building area*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel (11)</td>
<td>161,300</td>
<td>$0.24</td>
<td>$2.02</td>
</tr>
<tr>
<td>MOB (9)</td>
<td>81,603</td>
<td>$0.30</td>
<td>$3.43</td>
</tr>
<tr>
<td>Mixed Use (11)</td>
<td>247,297</td>
<td>$0.31</td>
<td>$3.41</td>
</tr>
<tr>
<td>Multifamily (80)</td>
<td>181,940</td>
<td>$0.26</td>
<td>$3.77</td>
</tr>
<tr>
<td>Office (26)</td>
<td>199,225</td>
<td>$0.47</td>
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<tr>
<td>Recreation (8)</td>
<td>56,361</td>
<td>$0.87</td>
<td>$4.05</td>
</tr>
<tr>
<td>K-12 (7)</td>
<td>73,932</td>
<td>$0.60</td>
<td>$8.04</td>
</tr>
<tr>
<td>Higher Ed (4)</td>
<td>95,500</td>
<td>$0.35</td>
<td>$4.81</td>
</tr>
</tbody>
</table>

*based on square footages indicated in the ordinance.

- Average green roof cost is based on $25/sf of green roof. Higher costs occur on 1 and 2 story buildings.
- The investment in energy efficiency for a new building is generally in the order of the cost of a green roof.
- It takes approximately 10yrs of energy savings from other EE measures in a new building to pay for a green roof.
- Can never show payback from a strictly energy cost savings for a green roof.
- If project invests in a green roof, will it invest in energy efficiency beyond the energy code? Will it invest in green certification?
Considerations

• Ensure ordinance requirements are not deterring from investment in energy efficiency and green certifications.

• Offer alternative compliance pathways, such as:
  • New Construction projects achieving 25% better than code
  • Existing Buildings achieving Energy Star Certification (75+)
  • Green Building Certifications (LEED Gold/Platinum, Enterprise Green Communities, etc.)
  • Include menu of options that considers energy savings in addition to the application of green infrastructure for stormwater management, vegetated open space, and cool roofs.
Beginning to Populate the Framework

ENERGY EFFICIENCY IN EXISTING BUILDINGS
Quick Payback EE Upgrades (1-3 year payback)

- Lighting Upgrades and Controls
- Tuning Controls (Recommissioning)
- Matching Supply to Demand
  - Variable Frequency Drives
  - Variable-Air-Volume Systems, Demand Control Ventilation
  - Scheduling
- Taking advantage of natural conditions
  - Air economizer
  - Temperature reset values
  - Heat recovery
Longer Payback EE Measures (3-15+ years)

- Controls upgrades
- Heating, Ventilation, Cooling (HVAC) System Upgrades
- Windows
- Insulation
- Ground Source
- Cool Roofs
- Vegetated Roofs
Energize Denver Task Force recommendation:
Flexible options to help low performers improve

Once every 5-years

Performance
Demonstrate a sufficiently high ENERGY STAR score or else improve EUI by 15% from a 2016 baseline. (EUI weather adjusted)

-or-

Retrocommissioning
Building “tune-up”. RCx study plus implementation.
Base building systems only in multi-family

-or-

Audit and Upgrade
Owner completes an audit and implements measures from the audit with <3 year payback OR implements other upgrades with similar savings