1099 Osage Apartments (now known as Tapiz at Mariposa)
1099 Osage Street, Denver, CO 80204
Denver Housing Authority

A. Project Narrative:

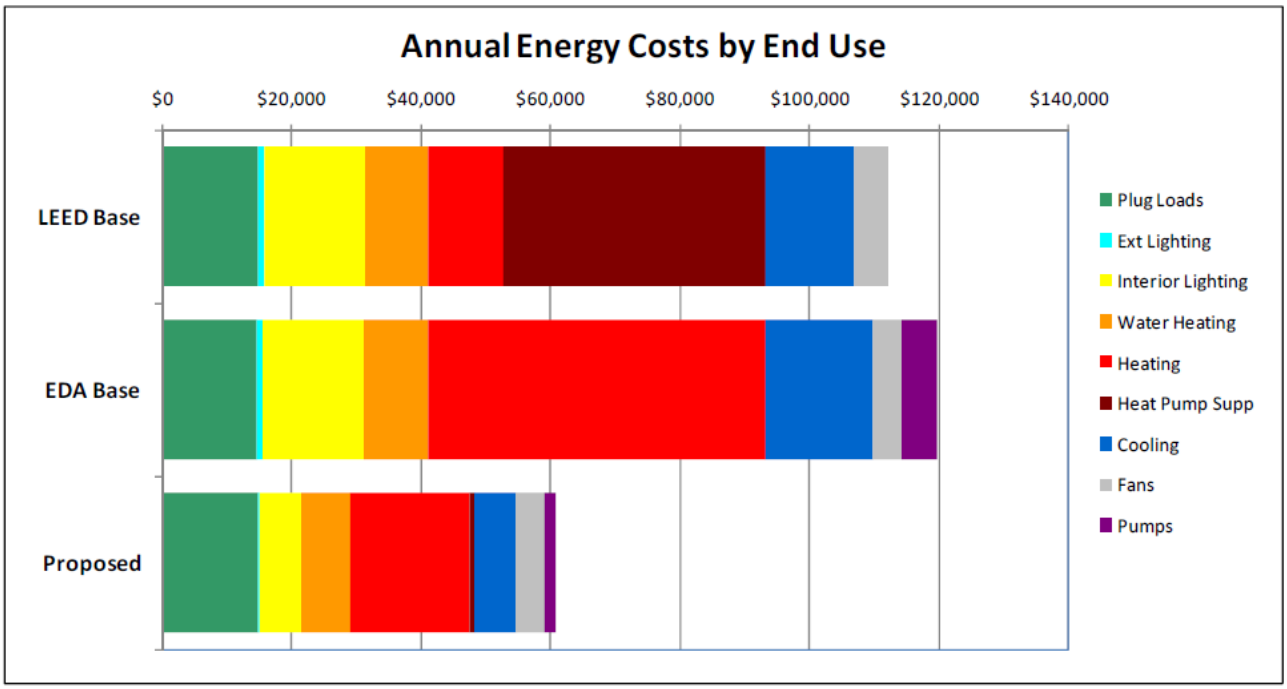
The Tapiz at Mariposa Apartments project evaluated a wide variety of energy saving options during the design phases and subsequent implementation of the project. Tapiz at Mariposa delivers exceptional environmental efficiency and energy performance with reduced energy costs for residents and a 50% reduction in overall energy consumption[1]. This has been accomplished by implementing a comprehensive energy efficiency package as was specified in the Construction Documents and ultimately constructed. The building opened in January 2012, complies with Enterprise Green Communities Criteria and is tracking LEED Platinum. Energy efficiency features to note include a 50 kilowatt solar PhotoVoltaic system, geothermal system that utilizes the ground temperature to heat and cool all the residential units, pilot grey water system to reuse shower water in toilet, and enhancements to the lighting/electrical systems, building envelope, daylighting features, windows and plumbing systems.

Tapiz at Mariposa was constructed on a Brownfield's site, previously occupied by the adjacent rail yard users (BNSF and the Regional transportation District in Denver); adjacent to the 10th & Osage light rail station in central Denver. By 2008, while owned by the City and County of Denver, the site was remediated using an EPA Brownfield's assessment grant along with CDBG funds from the City and County of Denver as well as their economic incentive fund-grant match. Following environmental abatement, the City of Denver sold the land to Denver Housing Authority, an adjacent land owner, to ensure DHA's South Lincoln Homes revitalization activity was feasible (and to follow the "build first, demolish second" approach to public housing redevelopment).

***Envelope**:* Tapiz at Mariposa Apartments is a 97,000 square foot, eight story building steel-frame multi-family residential building with 100 units for senior and disabled households. The ground floor consists of a Neighborhood Networks Center computer lab, community meeting space, a creative-industries job training office, and a Youth Culinary Academy training kitchen. There is non-enclosed parking on the ground level, but the building does not have a parking garage.

Building Energy Goals
The project is tracking LEED 2009 certification and was designed as a showcase project for sustainability and energy efficiency, and was constructed to meet a 47% energy cost savings relative to ASHRAE 90.1-2007 (the LEED Baseline model) and has a total electric demand reduction of 116 kW. The final design, incorporating the efficiency strategies listed above, saves $56,424 annually in energy costs relative to the EDA Base as shown in the chart below:

[1] based on ASHRAE 90.1-2004, existing building survey data, and energy consumption calculation procedures, energy models.



B. Key Building Energy Efficiency Measures

The energy efficiency strategies included in the building include:

- Roof with R-20 minimum continuous roof insulation
- Exterior rain-screen wall construction with R-21 batt
- Ground level concrete walls insulated with R-21 batt insulation in metal stud cavity and 1" rigid polystyrene (R-5) with face brick (total construction U-0.063/R-15.8)
- Double pane low-e, low-SHGC glass with center-of-glass (U-0.29, SHGC-0.28) in thermally broken aluminum framing systems for residential windows.
- Center-of-glass (U-0.29, SHGC-0.28) in thermally broken aluminum framing systems for storefront window system at ground level.
- Center-of-glass (U-0.29, SHGC-0.28) in thermally broken aluminum framing systems for curtain wall at 'Connectors'.
- Non-residential area lighting power density reduced to 0.57 W/SF
- Occupancy sensors to control the lighting systems in corridors and most common areas
- Average residential unit lighting power density of 0.33 W/SF
- Stepped daylighting controls in the connector spaces
- 1.38 kW installed exterior lighting
- Low flow sinks and lavatories
- Energy Star residential appliances (refrigerators, dishwashers, toilet room exhaust fans)
- Traction elevators
- Ground source heat pump system with the following details:
  a. One CW loop pump with variable speed drive, 63% efficiency, 90' head, 236 gpm
  b. 15.3 EER, 3.3 COP average rated heat pump efficiencies

c. Well field parameters: 36 boreholes, 440' deep, 1.22 ground conductivity (Btu/hr-ft-F˚, 0.039 ft*ft/hr diffusivity, 10% methanol, 1-1/4" pipe

- Direct evaporative cooling with 0.90 effectiveness for corridor make-up air (MUA) unit
- 95% peak efficiency condensing boilers for domestic water heating
- Corridor pressurized make-up air units with direct evaporative cooling with .90 effectiveness
- Community resource center space with 11.5 EER packaged heat pump system with run-around loop energy recovery

Equipment: The mechanical system utilizes a geothermal heat pump system for heating and cooling. Domestic Heating water is supplied by two 95% efficient condensing boilers. For the first floor the system is completely different, with multiple air cooled heat pump systems providing both heating and cooling through multiple direct refrigerant exchange fan coils. These heat pumps have an EER of 11.5 and a COP efficiency of 3.5. To enhance the efficiency, the exhaust air is used with a run-around loop to pre-treat the outside ventilation air.

Renewables: In addition to the Envelope, equipment and ventilation improvements described above, the building will supple renewable energy through a 50kw roof-mounted photo voltaic system.

Summary comparison: The final design, incorporating the efficiency strategies listed above, saves $56,424 annually in energy costs (47%) relative to the EDA Base, and has a total electric demand reduction of 116 kW.

C. Description of Differences Between the Baselines Measured

The energy analysis used for Tapiz at Mariposa used three different base building models to compare to energy efficiency strategies. These are defined as follows.

1. **EDA Base:** This is the basis of analysis used to calculate kW electric demand and dekatherm (10 therms) natural gas savings for incentives from Xcel Energy. It is for the most part an ASHRAE 90.1-2004-compliant baseline building energy model developed following Appendix G energy modeling requirements in the standard. This Base model will match the space heating energy source of the Proposed Building: either electricity or fuel. If the design team is considering scenarios with all electric heating as well as scenarios with natural gas or hybrid heating, two different EDA Base models will be required to calculate energy and cost savings for the different Proposed Buildings. IN some cases, the EDA Base model will have a difference HVAC system than the ASHRAE 90.1 Baseline used for the LEED Base model.

2. **LEED Base:** This model is very similar to the EDA Base, but follows ASHARE 90.1-2007 energy standard more precisely. It is the baseline model used for a LEED 2009 analysis to calculate points under EA credit 1.

3. **Cost Base:** This model represents the base starting point design for the project, with proposed HVAC system and envelope constructions that would have been built as standard practice in the absence of this energy analysis. Results from this base model are meant to be used by the design team to calculate energy cost savings and paybacks for various energy efficiency strategies.

D. Comparison of Design versus Design Energy Case

As shown by the table below, the "Proposed Building" meets or exceeds the ASHRAE baseline within all the design elements.

Element	Baseline (ASHRAE 90.1 - 2007)	Proposed Building
Floor Area	97,000 SF (100 residential units)	
Above Grade Stories	8	
Below Grade Stories	0	
Floor-to-Ceiling Height	11'-0" ground level; 8'-0" upper levels	
Floor-to-Floor Height	14'-0" ground level; 9'-6" upper levels	
	Roof	
Construction Type	insulation above metal deck	insulation above metal deck
Insulation	R-20 continuous	R-20 continuous
Total U-Factor	U-0.048	0.048
	Exterior Walls	
Construction Type	steel frame	steel frame 16" o.c. with face brick rainscreen
Insulation	R-13.0 batt + R-7.5 continuous	R-21 batt in framing cavity
Total U-Factor	U-0.064	0.090
	Ground Floor	
Construction Type	slab-on-grade	slab-on-grade
Insulation	R-10 down 24"	R-10 down 24"
Total F-Factor	F-0.540	F-0.540
Interior Finish	tile	tile
	Floor Above Unconditioned Space	
Construction Type	steel frame	8" slab
Insulation	R-30 batt	R-15 continuous
Total U-Factor	U-0.038	U-0.045
Interior Finish	tile	tile
	Below Grade Walls	
Construction Type	NA	NA
	% Window Area	***% Window Area***
Building Average	28%	28%
	Fenestration	
Fenestration Type	double pane clear	double pane low-e clear
Fenestration U-Factor	0.55	0.35
Fenestration SHGC	0.40	0.25
Center-of-Glass Properties	U-0.47, SHGC-0.45, Tvis-0.60	U-0.29, SHGC-0.28, Tvis-0.63
Frame Type	aluminum	thermally-broken aluminum
Frame U-Factor	3.00	1.00
Shading Devices	none	none

Element	Baseline Building (ASHRAE 90.1 - 2007)	Proposed Building
Primary System Type (residential spaces)	Appendix G System 2: Packaged terminal heat pump	Packaged terminal ground source heat pumps
Secondary System Type (Make-up Air)	Natural gas 'preheat' for MUA	Natural gas MUA 'preheat' units
	Air-Side	
Supply Fan Control	intermittent (residential)	intermittent (residential)
Residential Fan Parameters	0.85 TSP, 33% total efficiency (0.300 W/cfm)	0.60 TSP, 33% total efficiency
Minimum Outdoor Air	same as Proposed	80 cfm per unit toilet exhaust; 6,000 cfm for corridor MUA + 2,000 cfm ground level CRC
Economizer Control	NA	NA
Demand Control Ventilation	none	In CRC
Energy Recovery	none	none
Humidity Control	none	none
	Heating	
Space Setpoints	same as Proposed	70° F w/64° setback in non-residential spaces
Heating Equipment	electric heat pump	ground source heat pumps
Max Heating SA Temperature	95° F	95° F
Heating Efficiency	2.8 COP	varies from 3.2 to 3.4 COP
	Cooling	
Space Setpoints	same as Proposed	75° F w/81° setup in non-residential spaces
Min SA Temperature	55° F	45° F
Cooling Equipment	packaged DX	ground source heat pumps
Cooling Efficiency	9.8 EER	varies from 14.9 to 15.7 EER
	Heat Rejection	
Heat Rejection Equipment	air cooled	ground field: 42 wells, 440' deep each, 1.16 conductivity, 0.037 diffusivity, 0% glycol, grout-filled wells
	Lighting	
Lighting Power (peak W/ft^2)	1.70 in residential units	0.38 in residential units
Daylighting Controls	none	stepped dimming in 'link' spaces
Occupancy Sensors	none	in most common area spaces
Exterior Lighting (peak kW)	4.00	1.49
	DHW/ Equipment/ Process Loads	
DHW Equipment	natural gas water heater	natural gas water heater
DHW Load Modeled	same as Proposed	4,300 gal/ day
DHW Heating Efficiency	80%	condensing water heaters
DHW Loop Temperature	120° F	120° F
Elect. Equipment (peak W/ft^2)	0.80	0.80