BUILDING ENERGY MODELING SUMMARY

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1. PURPOSE OF THIS DOCUMENT AND INTRODUCTION

This document is a summary and explanation of building energy studies prepared during the fall of 2008 for East Valley Partnership for the planning study are known as Superstition Vistas. They are preliminary in nature with findings based on the evaluation of a limited array of generic building types anticipated to be constructed in the project. General conclusions are noted in the last section but specific recommendations are not made as it would be premature to do so given the rapidly moving regulatory, energy cost, and technology context for decision making. It is suggested that the findings of the study are used as a general guide for strategy development and that more detailed modeling occurs as the preferred vision plan, master plan and initial phases of development are identified.

BACKGROUND

According to the US Department of Energy, buildings consume approximately 37% of the energy and 68% of the electricity produced in the US annually. Electricity generated from oil and coal impact the environment adversely from their initial extraction, through transportation, refining process and distribution. The generation of electricity through conventional fossil-based processes releases significant amount of carbon dioxide, which in turn contributes to poor air quality and ultimately global climate change.

Other electricity generation methods such as natural gas, nuclear fission and hydro-based have adverse environmental impacts as well. Natural gas is a major source of greenhouse gas emissions. Nuclear power causes significant waste transportation and disposal issues and potential catastrophic accidents. Hydroelectric generation strategies could disrupt natural water flows, resulting in disturbance of habitat and depletion of fish and other wildlife population.

As a result, building energy strategies are critical in improving our air quality, protecting natural habitat, reducing greenhouse gas emissions and minimizing carbon footprint caused by the project. There are three main approaches to reducing the energy required to operate and condition buildings: 1) utilize passive design techniques to make a more efficient shell, 2) use more efficient mechanical systems, and 3) generate electricity or heat water using renewable energy technologies. All three of these strategies have been tested in various combinations to find the most efficient means to achieve specified levels of source energy demand reduction. The building energy analysis should assist in achieving the following:

- Demonstrate that substantial energy reductions are possible within reasonable cost parameters consistent with the marketplace.
- Generally indicate which combinations of measures achieve the greatest efficiency at the lowest cost
- Provide data that can be used in a community wide analysis to show which combination of building and non-building energy strategies can achieve the lowest carbon footprint at an acceptable cost.
- Provide guidance on peak demand for power so that base generation and distribution facilities can be reduced on a per capita basis.
- Cost/benefit analysis on all above components so that development guidance can be realistic and acceptable to the marketplace.

- Assist in correlating a program to meet potential national and/or state carbon reduction requirements.

In summary, the Superstition Vistas energy program is envisioned as a multi-step process utilizing the latest modeling and cost/benefit analysis techniques to construct a sound, defendable and affordable energy and carbon reduction strategy. This analysis provides data for the building energy portion of such a process with a reasonable level of defensibility and accountability given the cost and time parameters of the analysis.

2. METHODOLOGY AND PROCESS

The building energy reduction analysis has occurred in two steps, first to reduce energy demand through building and mechanical systems design and secondly, to supplement conventional sources with cleaner, renewable energy.

Initially, a set of energy reduction targets were set in the first sustainability charette which occurred in early 2008 and used in the study for comparison purposes.

Alternative 1 (Alt 1): 30% total building energy reduction
Alternative 2 (Alt 2): 50% total building energy reduction
Alternative 3 (Alt 3): 80% total building energy reduction

Each of these targets were relative to a BaU energy demand defined as Business as Usual (BaU). The same targets were used for both residential and non-residential building types.

The building energy team explored reductions in energy requirements by modeling a variety of Energy Conservation Measures (ECMs) and identifying the potential energy savings associated with each. This includes ECMs associated with:

- Improved Building Envelope Standards
- Improved HVAC Efficiency Standards
- Improved Facility Lighting Control Standards
- Improved Hot Water Heating Standards

The proposed ECMs are tested for effectiveness in achieving each target. Adjustments to the ECMs are made to achieve the targets at the lowest possible cost. Specific focus has been to seek the combined passive, mechanical and renewable strategy that achieves a net positive cash flow for the end user to the extent possible.

The building energy team modeled six residential building types and six non-residential building types. The energy model provides output in the form of anticipated annual electrical and gas consumption which is then converted into total KWhrs per annum for comparison purposes. Several monetary comparisons are made including a cost/benefit analysis which will indentify the percentage of both energy and GHG reduction per $1,000 invested for each of the three target packages.

Because of the different construction type and market parameters, the modeling was done in two groupings: 1) residential buildings, and 2) non-residential buildings. The ensuing sections outline the details of the modeling process in these two different categories.

2.1. Building Types

Residential Building Types

Six residential building types were used in the evaluation. These were selected in concert with the VISION master plan simulation process and represent building types with high probability of occurring in the Superstition Vistas site. The building types analyzed are small single family homes, large single family homes, townhouse product, condominium, mixed use buildings and higher density multifamily buildings. Specific building forms assumed for each building types are as follows (see Table 1).

Table 1: Residential Building Type Summary

	Bldg GFA	FAR	Floors	Ave. Unit Size	Units/ Bldg	Du/Ac
Large SFD	3,714	0.57	2	3,714	1	2.9
Small SFD	2,153	0.67	2	2,153	1	4.8
Townhouse	9,786	0.52	3	1,583	6	12
Low-Rise Condo	10,208	0.54	3	1,240	8	18.5
Low-Rise Mixed Use	51,750	0.77	3	983	44	28.4
Mid-Rise Tower	174,970	2.23	7	1,478	93	51.7

Non-residential Building Types

Six non-residential building types were identified based on a high probability of being representative of those most likely to occur in the project. The building types analyzed are: low rise commercial offices; high rise commercial office; industrial buildings; mid-rise commercial offices; mixed use buildings (combining retail and commercial space) and standalone retail buildings. The assumed building characteristics for each were as follows (see Table 2):

Table 2: Non-Residential Building Summary

	Bldg GFA	FAR	Floors	Ave. Floor Size	Empl. per 1000 sf
Low-Rise Office	75,000	0.45	3	25,000	4
Mid-Rise Office	292,500	1.37	10	29,250	4
High-Rise Office	558,000	2.70	20	29,250	4
Office/Retail Mixed Use	120,000	0.51	4	30,000	4
Industrial	53,300	0.44	1 + mez.	40,000	2
Retail - Suburban	25,000	0.26	1	25,000	0.5

It is understood that many more variations of both residential and non-residential buildings will occur in the project. However those selected for modeling are considered to be broadly enough representational that potential variations can be averaged into these types without loosing a level of magnitude of accuracy in the results.

2.2 Modeling Assumptions

Residential Modeling

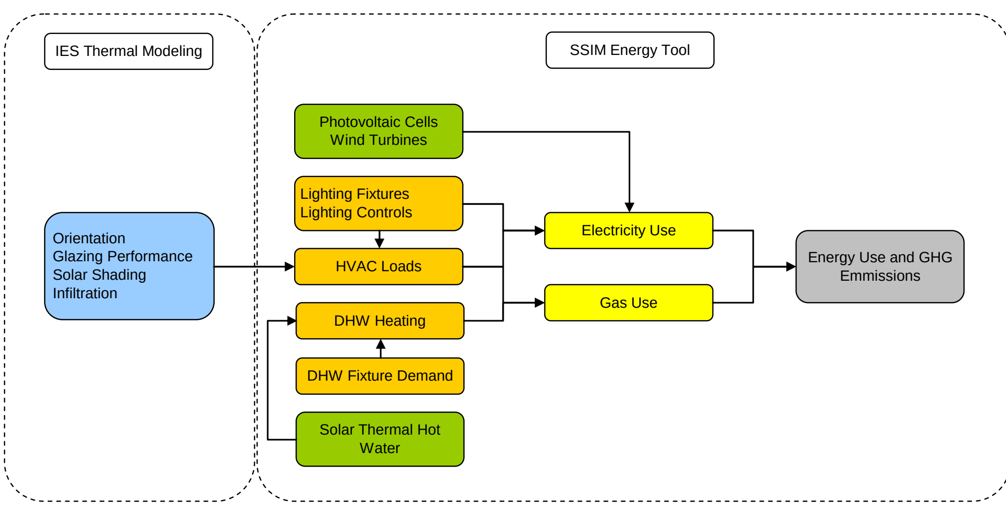
For the single family detached home, townhome and condominium, annual energy use was estimated using EnergyGauge 2.7 (DOE2.1E) for both HVAC and non-HVAC end uses. Photovoltaic (PV) production values are also calculated in EnergyGauge assuming south-facing roof-mounted systems. For the townhome and condominium designs, the modeling was run on three different unit configurations each.

For mid-rise and mixed-use residential products, annual energy use was estimated using EQuest (DOE2.2). PV production values are based on hourly production profiles for flat roof-mounted arrays based on the system size. The Mixed-Use building model also includes the non-residential portion of the building on the first floor.

Non-Residential Modeling

For non-residential building types, a different modeling process is applied which has been designed to meet the unique needs of commercial, retail and industrial building types and to interface with EDAW/AECOM's Sustainable Systems Integration Model (SSIM), **Error! Reference source not found.** shows a flowchart outlining the analysis process used to assess the various combinations of energy efficient measures that could be utilized to reduce the overall grid-energy usage of each building type. The overall analysis strategy was to investigate the energy benefit and cost effectiveness of various combinations of passive, active and renewable energy strategies, from which the three alternative target scenarios were determined.

Figure 1: Flowchart Describing the SSIM Non-Residential Energy Analysis Process



A two phase approach was used to analyze the various combinations of energy efficient measure that could reduce the energy usage of each building type. This process is described below:

Phase 1: IES Thermal Modeling

The first phase involved the development of an individual DOE2 energy model of each building type utilizing the IES Virtual Environment software, upon which dynamic thermal modeling (DTM) analysis was undertaken.

IES Virtual Environment is an integrated suite of applications based around one 3D geometrical model. The modules used for solar shading, thermal simulation, bulk airflow and thermal design load calculations are noted below. Phoenix TMY2 weather data was used for the analysis; being the closest available TMY weather data for the Superstition Vistas site.

- **SunCast** generates shadows and internal solar insulation from sun positions defined by date, time, orientation, and site latitude/longitude. This shading information is stored in a database and used to take account of shading from surroundings in subsequent thermal simulation calculations.
- **Apache-Sim** is a dynamic thermal simulation program based on first-principles mathematical modeling of the heat transfer processes occurring within and around a building. The program provides an environment for the detailed evaluation of building and system designs, allowing them to be optimized with regard to comfort criteria and energy use.
- **MacroFlo** is a program for analyzing bulk air movement in buildings, driven by buoyancy and wind induced pressures.
- **Apache-Loads** is a thermal simulation program based on first-principles mathematical modeling of the heat transfer processes occurring within and around a building. The program provides an environment for the assessment of peak heating and cooling loads based on ASHRAE approved weather data.

Depending on the building type being analyzed, up to sixteen thermal models were created to provide BaU energy loads for the four different passive measures assessed using the DTM process; namely orientation, glazing thermal performance, solar shading and infiltration.

Phase 2: SSIM Non-Residential Energy Tool

Following the DTM analysis, the results from the DOE2 models were inputted into the SSIM Non-Residential Energy Module, an Excel based "post processor" analysis and selection tool developed by AECOM for use in sustainable master planning design. For each of the six non-residential building types analyzed as part of the Superstition Vistas assessment, the following passive and active energy reduction measures were compared in order to determine packages of measures which could best meet the three predetermined targets for energy performance while optimizing cost effectiveness. It is noted that the purpose of this analysis was not to provide a prescriptive criteria or set of measures to be implemented across all projects, but to demonstrate possible solutions that would achieve the recommended minimum performance criteria in a cost effective manner.

- Building orientation
- Infiltration rate
- Building envelope alternatives
- Lighting strategy alternatives
- HVAC alternatives
- Hot water usage
- Hot water heating alternatives
- Photovoltaics
- Wind energy

The module allowed ‘Business as Usual’, 30% reduction, 50% reduction and 80% reduction scenarios for each building type to be assessed. Throughout the analysis process, the primary goal was to achieve a balance between energy reduction and cost with a payback period, either through increased rental premiums or energy savings, of less than 10 years.

2.3 Energy Reduction Measures Considered

Residential Buildings

In addition to BaU, which represents minimum code compliant building practice, three building design targets were used to conduct the design optimization studies. These targets were compared against homes built to the current local code: 2006 International Energy Conservation Code (IECC). The target savings are based on *source energy* use, which accounts for efficiency losses due to generation, transmission, and distribution. Table 3 summarizes the goals for each building design based upon the performance comparison with the 2006 IECC as the standard. Modeling was conducted for each building design in four cardinal orientations assuming worst orientation. Both the Alt 1 and Alt 2 cases use conventional and proven efficiency strategies to meet the proposed performance goals. The Alt 2 case also assumes some orientation optimization. The Alt 3 case includes the Alt 2 features along with 100% energy efficient lighting, additional passive solar strategies, and active solar technologies such as photovolatics.

Table 3: Residential Building Design Standards

Case	Description
Base	2006 IECC Code
Alt 1	30% better than IECC
Alt 2	50% better than IECC
Alt 3	80% better than IECC

Table 4 through Table 7 summarize the energy efficiency features for each package. The PV systems are sized in the Alt 3 cases to bring total source energy savings to the 80% target.

Table 4: Package Description and Specifications – Small & Large SFD

	Base	Alt 1	Alt 2	Alt 3
Reduction Target	**2006 IECC**	**30%**	**50%**	**80%**
Walls	R-13	R-13 + R-4	R-19 + R-4	R-19 + R-4
Ceiling	R-30	R-38	R-49	R-49
Radiant Barrier	No	No	Yes	Yes
HERS Insulation Inspection	No	No	Yes	Yes
Window U-Factor/SHGC	0.75 / 0.40	0.34 / 0.31	0.31 / 0.23	0.31 / 0.23
AC SEER/EER	13	13	15 / 12.5	15 / 12.5
TXV	No	No	Yes	Yes
Furnace AFUE	0.78	0.80	0.92	0.92
Duct Insulation	R-4.2	R-4.2	Ducts Cond.	Ducts Cond.
Duct Leakage	No test	Tested (<6%)	Tested (<6%)	Tested (<6%)
House Leakage	No test	No test	Tested (3.5 SLA)	Tested (3.5 SLA)
Water Heater (EF)	Storage (0.575)	Storage (0.60)	Tankless (0.82)	Tankless (0.82)
Solar Thermal	No	No	No	Active
Energy Star Appliances	No	Yes	Yes	Yes
CFL Lighting	10%	10%	90%	100%
PV Installed	n/a	n/a	n/a	3.28 kW Small 5.125 kW Large
Production (kWh/yr)	n/a	n/a	n/a	5,759 Small 8,522 Large

Table 5: Package Description and Specifications – Townhome, Condominium

	Base	Alt 1	Alt 2	Alt 3
Reduction Target	**2006 IECC**	**30%**	**50%**	**80%**
Walls	R-13	R-13 + R-4	R-19 + R-4	R-19 + R-4
Ceiling	R-30	R-38	R-49	R-49
Radiant Barrier	No	No	Yes	Yes
HERS Insulation Inspection	No	No	Yes	Yes
Window U-Factor/SHGC	0.75 / 0.40	0.34 / 0.31	0.31 / 0.23	0.31 / 0.23
AC SEER/EER	13	13	15 / 12.5	15 / 12.5
TXV	No	No	Yes	Yes
Furnace AFUE	0.78	0.80	0.92	0.92
Duct Insulation	R-4.2	R-4.2	Ducts Cond.	Ducts Cond.
Duct Leakage	No test	Tested (<6%)	Tested (<6%)	Tested (<6%)
House Leakage	No test	No test	Tested (3.5 SLA)	Tested (3.5 SLA)
Water Heater (EF)	Storage (0.575)	Storage (0.60)	Tankless (0.82)	Tankless (0.82)
Solar Thermal	No	No	Batch (ICS)	Active
Energy Star Appliances	No	Yes	Yes	Yes
CFL Lighting	10%	10%	90%	100%
PV Installed	n/a	n/a	n/a	17.22 kW TH 19.68 kW Condo
Production (kWh/yr)	n/a	n/a	n/a	29,154 TH 33,064 Condo

Table 6: Package Descriptions and Specifications – Mid-Rise Residential

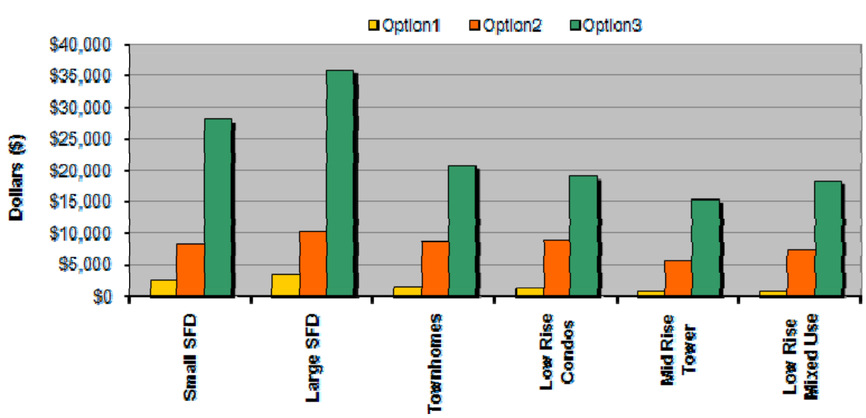
	Base	Alt 1	Alt 2	Alt 3
Reduction Target	**2006 IECC**	**30%**	**50%**	**80%**
Walls	R-19 + R-1	R-19 + R-4	R-19 + R-4	R-21 + R-4 - 24"oc
Ceiling	R-30	R-30	R-30	R-42
Cool Roof	No	No	No	Yes
Insulation Inspection	No	No	Yes	Yes
Window U-Factor/SHGC	0.65 / 0.47	0.58 / 0.40	0.58 / 0.32	0.58 / 0.32
AC SEER	11	15	15	WLHP
Heat Pump HSPF	7.70	8.50	8.50	WLHP
Duct Leakage	Not Tested	Tested (<6%)	Tested (<6%)	Tested (<6%)
Water Heater (EF)	Storage (0.575)	Storage (0.575)	Cond. (0.95)	Cond. (0.95)
Window Shading	No	No	South Overhangs	Overhangs S/W/E
Solar Thermal	No	No	No	No
Energy Star Appliances	No	No	Yes	Yes
CFL Lighting	None	75%	75%	100%
PV Installed	n/a	n/a	86 kW	260 kW
Annual PV Production (kWh/yr)	n/a	n/a	13,300	403,000

Table 7: Package Descriptions and Specifications – Mixed Use Residential

	Base	Alt 1	Alt 2	Alt 3
Reduction Target	**2006 IECC**	**30%**	**50%**	**80%**
Walls	R-19	R-19	R-19 + R-4	R-21 + R-4 24" oc
Ceiling	R-30	R-30	R-49	R-49
Cool Roof	No	No	No	Yes
Insulation Inspection	No	No	Yes	Yes
Window U-Factor/SHGC	0.65 / 0.47	0.58 / 0.40	0.58 / 0.32	0.35 / 0.32
AC SEER	11	15	15	WLHP
Heat Pump HSPF	7.70	8.50	8.50	WLHP
Duct Leakage	Not Tested	Tested (<6%)	Tested (<6%)	Tested (<6%)
Water Heater (EF)	Storage (0.575)	Storage (0.575)	Cond. (0.95)	Cond. (0.95)
Window Shading	No	No	South Overhangs	Overhangs S/W/E
Solar Thermal	No	No	No	No
EnergyStar Appliances	No	No	Yes	Yes
CFL Lighting	None	75%	75%	100%
PV Installed	n/a	n/a	50 kW	150 kW
Annual PV Production (kWh/yr)	n/a	n/a	77,500	232,500

Incremental capital costs per square foot for each building type and performance target is summarized in Figure 2 below. These are net costs and include any applicable utility and state incentives for PV, solar thermal, and energy efficiency.

Figure 2: Incremental Capital Costs per Dwelling Unit



Non-Residential Building Measures and Targets

Consistent with the residential analysis, three packages of energy reduction measures each with respective increasing levels of efficiency were selected for each of the six building types, with the goal of maximizing the reduction in energy use compared to the BaU case with a reasonable financial payback.

Table 8 to Table 13 show the BaU, Alt 1, Alt 2, and Alt3 scenarios for each building type. The packages of options selected for each type are highlighted and the energy and carbon emissions reductions relative to the Business as Usual case are also given.

Table 8: Package Description and Specifications – Low Rise Commercial

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per	0.25 Air Changes per	0.25 Air Changes per
Building Envelope	ASHRAE 90.1-2004	High Performance	ASHRAE 90.1-2004	High Performance
Lighting	ASHRAE 90.1-2004	ASHRAE 90.1-2004	High Efficiency Lighting +	High Efficiency Lighting +
HVAC	ASHRAE 90.1-2004	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation –	Energy Policy Act: 1992	20% Reduction	30% Reduction	50% Reduction
DHW Generation –	ASHRAE 90.1-2004	High Efficiency Gas Fired	Solar Water Heater	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	0% of Roof available for PV	25% of Roof available for PV	Best +: 75% of Roof available
Rooftop Wind Generation	No Wind Energy	No Wind Energy	No Wind Energy	2,500 sq ft of roof area / kW
Parking Lot PV Generation	0% of parking lot area	0% of parking lot area	25% of parking lot area	Best +: 75% of parking lot area
Parking Lot Wind	No Wind Energy	No Wind Energy	No Wind Energy	No Wind Energy
Energy Reduction	**-**	**24.0%**	**39.0%**	**71.7%**
Carbon Emissions	**-**	**24.4%**	**39.6%**	**69.3%**
Green investment	**-**	**$2.97**	**$10.16**	**$17.95**
Simple payback period	**-**	**8.2**	**17.5**	**20.7**

Table 9: Package Description and Specifications – Retail

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per	0.25 Air Changes per	0.25 Air Changes per
Building Envelope	ASHRAE 90.1-2004	High Performance	ASHRAE 90.1-2004	High Performance
Lighting	ASHRAE 90.1-2004	ASHRAE 90.1-2004	High Efficiency Lighting	High Efficiency Lighting +
HVAC	ASHRAE 90.1-2004	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation –	Energy Policy Act: 1992	20% Reduction	30% Reduction	50% Reduction
DHW Generation –	ASHRAE 90.1-2004	High Efficiency Gas Fired	High Efficiency Gas Fired	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	0% of Roof available for PV	25% of Roof available for PV	Best +: 75% of Roof available
Rooftop Wind Generation	No Wind Energy	No Wind Energy	2,500 sq ft of parking lot area	2,500 sq ft of roof area / kW
Parking Lot PV Generation	0% of parking lot area	0% of parking lot area	25% of parking lot area	Best +: 75% of parking lot area
Parking Lot Wind	No Wind Energy	No Wind Energy	2,500 sq ft of parking lot area	2,500 sq ft of roof area / kW
Energy Reduction	**-**	**31.1%**	**48.1%**	**91.5%**
Carbon Emissions	**-**	**31.7%**	**48.8%**	**90.9%**
Green investment	**-**	**$4.07**	**$17.45**	**$36.93**
Simple payback period	**-**	**4.7**	**13.2**	**16.0**

Table 10: Package Description and Specifications – High Rise

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per	0.25 Air Changes per	0.25 Air Changes per
Building Envelope	ASHRAE 90.1-2004	High Performance	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Lighting	ASHRAE 90.1-2004	ASHRAE 90.1-2004	High Efficiency Lighting	High Efficiency Lighting +
HVAC	ASHRAE 90.1-2004	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation –	Energy Policy Act: 1992	20% Reduction	30% Reduction	50% Reduction
DHW Generation –	ASHRAE 90.1-2004	High Efficiency Gas Fired	High Efficiency Gas Fired	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	0% of Roof available for PV	0% of Roof available for PV	Best +: 75% of Roof available
Rooftop Wind Generation	No Wind Energy	No Wind Energy	No Wind Energy	No Wind Energy
Parking Lot PV Generation	0% of parking lot area	10% of parking lot area	0% of parking lot area	Best +: 75% of parking lot area
Parking Lot Wind	No Wind Energy	10,000 sq ft of parking lot area	No Wind Energy	No Wind Energy
Energy Reduction	-	**23.1%**	**28.2%**	**54.9%**
Carbon Emissions	-	**23.7%**	**28.5%**	**51.3%**
Green investment	-	**$3.30**	**$5.19**	**$9.17**
Simple payback period	-	**9.6**	**13.1**	**16.7**

Table 11: Package Description and Specifications – Light Industrial

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per	0.25 Air Changes per	0.25 Air Changes per
Building Envelope	ASHRAE 90.1-2004	High Performance	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Lighting	ASHRAE 90.1-2004	ASHRAE 90.1-2004	High Efficiency Lighting	High Efficiency Lighting +
HVAC	ASHRAE 90.1-2004	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation –	Energy Policy Act: 1992	20% Reduction	50% Reduction	50% Reduction
DHW Generation –	ASHRAE 90.1-2004	High Efficiency Gas Fired	High Efficiency Gas Fired	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	10% of Roof available for PV	Best :50% of Roof available	Best +: 75% of Roof available
Rooftop Wind Generation	No Wind Energy	No Wind Energy	No Wind Energy	No Wind Energy
Parking Lot PV Generation	0% of parking lot area	0% of parking lot area	0% of parking lot area	Best +: 75% of parking lot area
Parking Lot Wind	No Wind Energy	10,000 sq ft of parking lot area	No Wind Energy	No Wind Energy
Energy Reduction	**-**	**24.5%**	**38.8%**	**79.5%**
Carbon Emissions	**-**	**24.9%**	**39.8%**	**77.9%**
Green investment	**-**	**$6.24**	**$17.64**	**$35.35**
Simple payback period	**-**	**9.5**	**16.4**	**19.2**

Table 12: Package Description and Specifications – Mid Rise

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per	0.25 Air Changes per	0.25 Air Changes per
Building Envelope	ASHRAE 90.1-2004	High Performance	ASHRAE 90.1-2004	ASHRAE 90.1-2004
Lighting	ASHRAE 90.1-2004	ASHRAE 90.1-2004	High Efficiency Lighting	High Efficiency Lighting +
HVAC	ASHRAE 90.1-2004	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation –	Energy Policy Act: 1992	20% Reduction	30% Reduction	50% Reduction
DHW Generation –	ASHRAE 90.1-2004	High Efficiency Gas Fired	High Efficiency Gas Fired	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	10% of Roof available for PV	0% of Roof available for PV	Best +: 75% of Roof available
Rooftop Wind Generation	No Wind Energy	No Wind Energy	5,000 sq ft of roof area / kW	2,500 sq ft of roof area / kW
Parking Lot PV Generation	0% of parking lot area	0% of parking lot area	0% of parking lot area	Best +: 75% of parking lot area
Parking Lot Wind	No Wind Energy	10,000 sq ft of parking lot area	5,000 sq ft of parking lot area	2,500 sq ft of parking lot area
Energy Reduction	-	**24.5%**	**28.2%**	**57.8%**
Carbon Emissions	-	**24.7%**	**28.5%**	**54.5%**
Green investment	-	**\$3.23**	**\$5.29**	**\$10.62**
Simple payback period	-	**9.3**	**13.3**	**17.6**

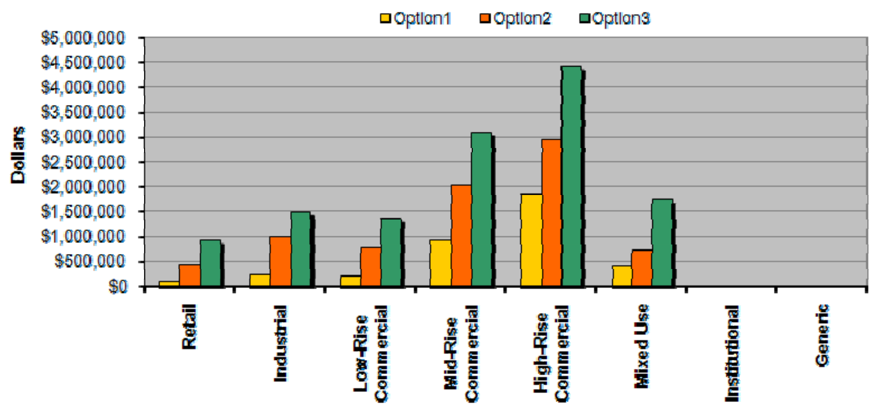
Table 13: Package Description and Specifications – Multi Use

	Option			
Element	**BaU**	**Alt 1**	**Alt 2**	**Alt 3**
Orientation Mix	25%N / 25% S / 25% E / 25% W	30%N / 30% S / 20% E / 20% W	35%N / 35% S / 15% E / 15% W	40%N / 40% S / 10% E / 10% W
Building Leakage	0.5 Air Changes per Hour	0.25 Air Changes per Hour	0.25 Air Changes per Hour	0.25 Air Changes per Hour
Building Envelope	ASHRAE 90.1-2004 Prescriptive Glazing	High Performance Glazing	ASHRAE 90.1-2004 Prescriptive Glazing + Solar Shading	ASHRAE 90.1-2004 Prescriptive Glazing + Solar Shading
Lighting	ASHRAE 90.1-2004 Prescriptive Lighting	ASHRAE 90.1-2004 Prescriptive Lighting + Lighting Control	High Efficiency Lighting	High Efficiency Lighting + Lighting Control
HVAC	ASHRAE 90.1-2004 Prescriptive Packaged Units	High Efficiency Packaged Units	High Efficiency Packaged Units	Ground Source Heat Pumps
DHW Generation – Requirements	Energy Policy Act: 1992	20% Reduction	30% Reduction	50% Reduction
DHW Generation – Heating Efficiency	ASHRAE 90.1-2004 Prescriptive Efficiency Gas Fired Water Heater	High Efficiency Gas Fired Water Heater	High Efficiency Gas Fired Condensing Water Heater	Solar Water Heater
Rooftop PV Generation	0% of Roof available for PV	0% of Roof available for PV	10% of Roof available for PV	Best +: 75% of Roof available for PV
Rooftop Wind Generation	No Wind Energy	No Wind Energy	10,000 sq ft of roof area / kW wind generation	No Wind Energy
Parking Lot PV Generation	0% of parking lot area available for PV	10% of parking lot area available for PV	0% of parking lot area available for PV	Best +: 75% of parking lot area available for PV
Parking Lot Wind Generation	No Wind Energy	10,000 sq ft of parking lot area / kW wind generation	No Wind Energy	No Wind Energy
Energy Reduction from BaU (%)	-	**25.9%**	**31.4%**	**65.0%**
Carbon Emissions Reduction from BaU (%)	-	**26.5%**	**31.8%**	**62.6%**
Green investment ($/sq ft)	-	**$3.45**	**$6.19**	**$14.61**
Simple payback period (years)	-	**7.4**	**11.5**	**16.0**

Incremental capital costs per building for each building type and performance target is summarized in

Figure 3 below. These are net costs and include the utility and state incentives for PV, solar thermal, and energy efficiency.

Figure 3: Incremental Capital Costs per Building



3. FINDINGS

3.1 Residential Buildings

Electric Energy Analysis

Estimated annual electrical and gas energy for each building type and performance package are summarized in Figure 4 through Figure 10. The results include all appliance and plug load energy uses, as well as PV generation if applicable.

The Alt 3 cases all include a PV system sized for achieving the 80% energy reduction performance goals. Achieving the performance targets was more challenging for the multifamily models than the single family detached models. Both Mixed-Use and Mid-Rise residential models include on-site renewable generation in both the Alt 2 and Alt 3 cases to meet the performance targets.

Figure 4: Total Annual Electric Use – Small and Large SFD

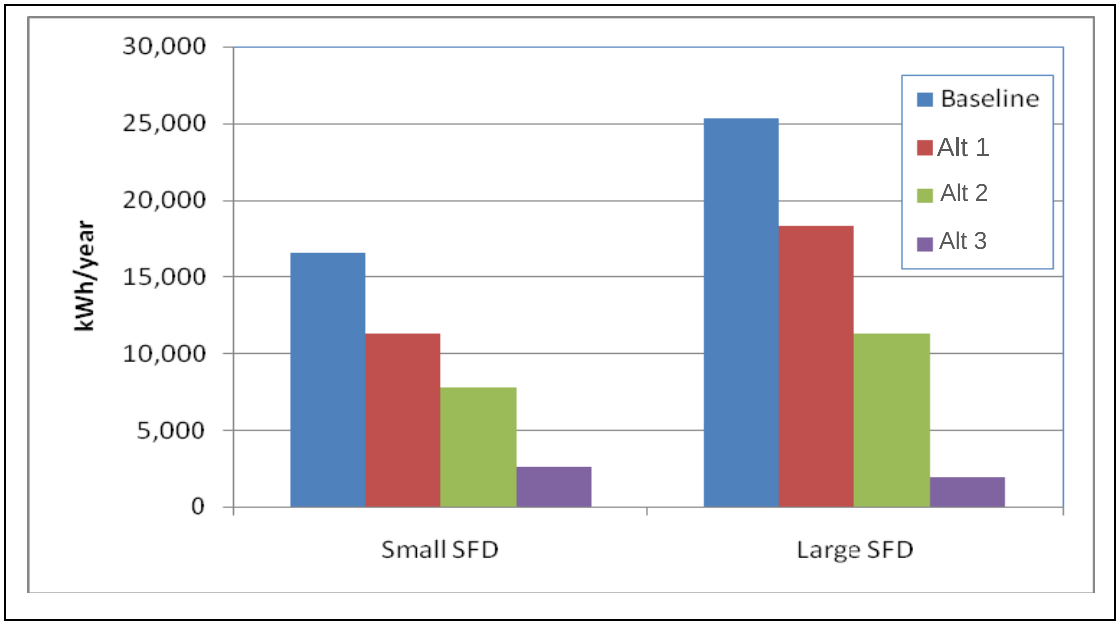


Figure 5: Total Annual Electric Use – Townhomes and Low-Rise Condos

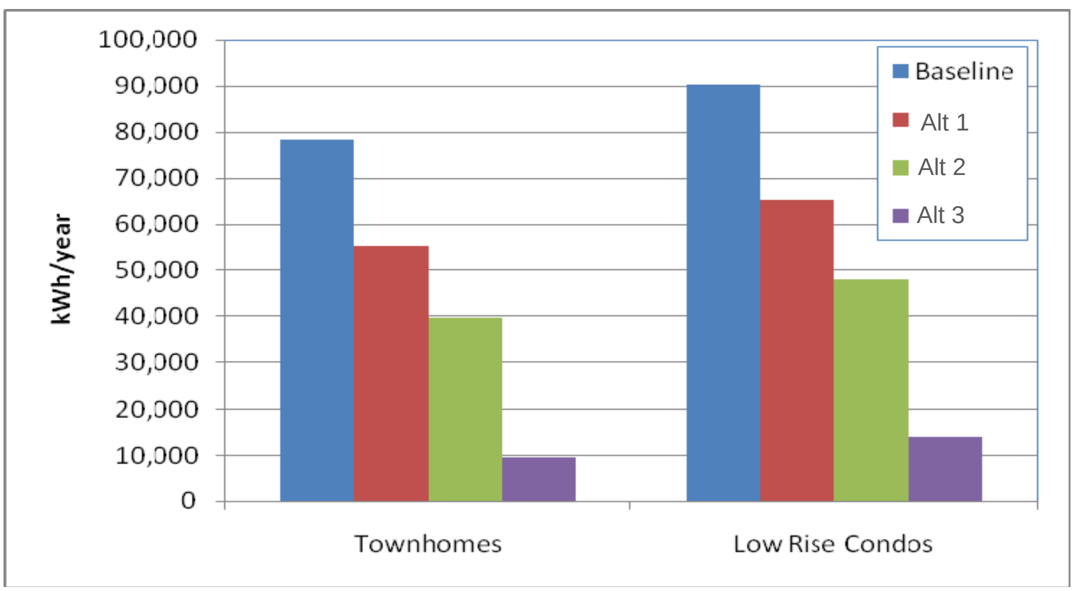


Figure 6: Total Annual Electric Use – Mid-Rise

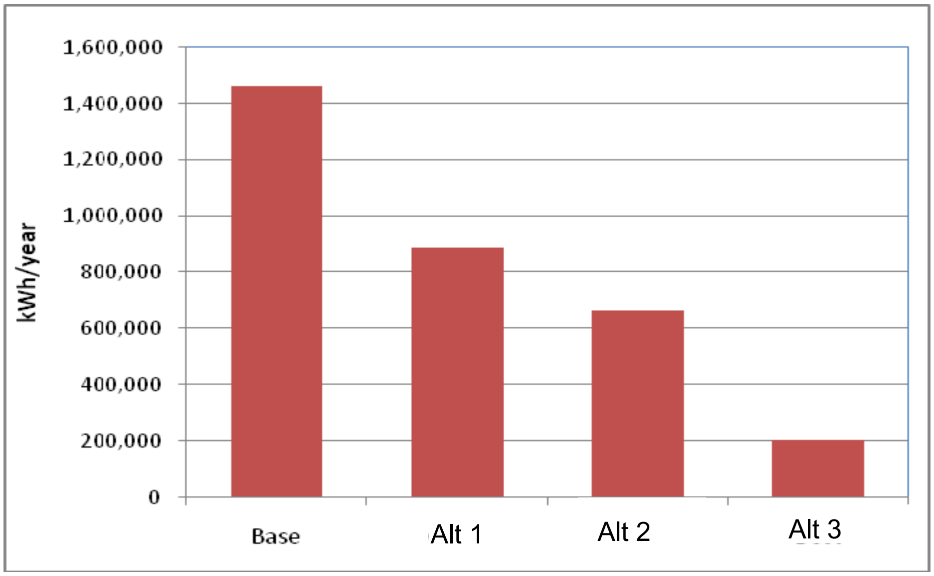
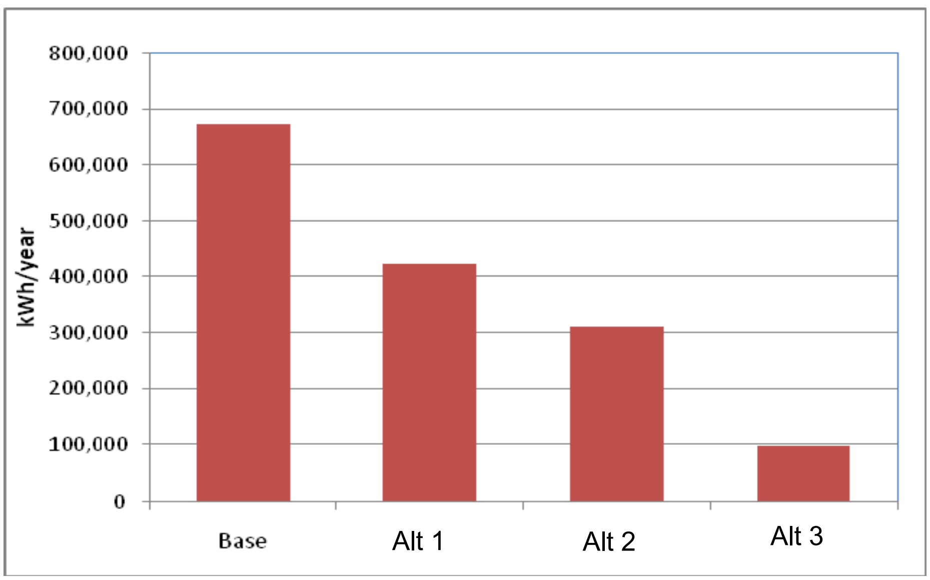


Figure 7: Total Annual Electric Use – Mixed Use Residential



Gas Energy Analysis

Gas water and space heating was assumed for the single family detached, townhome and condominium models. The gas savings between Alt 2 and Alt 3 cases in the single family detached models are due to solar water heating. There is little or no Alt 3 case savings in Townhomes and Condo because solar water heating is also included in the Alt 2 case. Mid-Rise and Mixed-Use models assume electric heat pumps for space heating, so all gas savings are due to higher efficiency gas water heating.

Figure 8: Total Annual Gas Use – Small and Large SFD

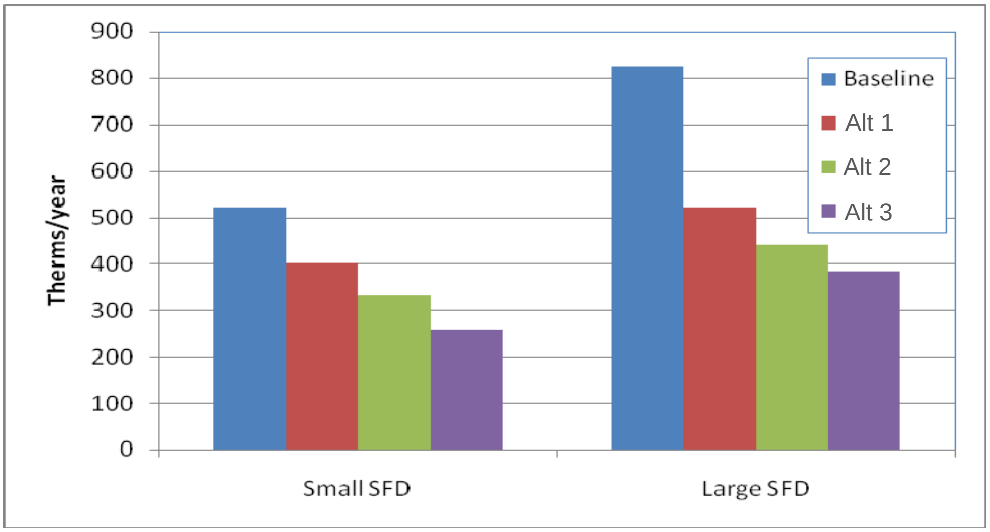


Figure 9: Total Annual Gas Use – Townhomes and Low-Rise Condos

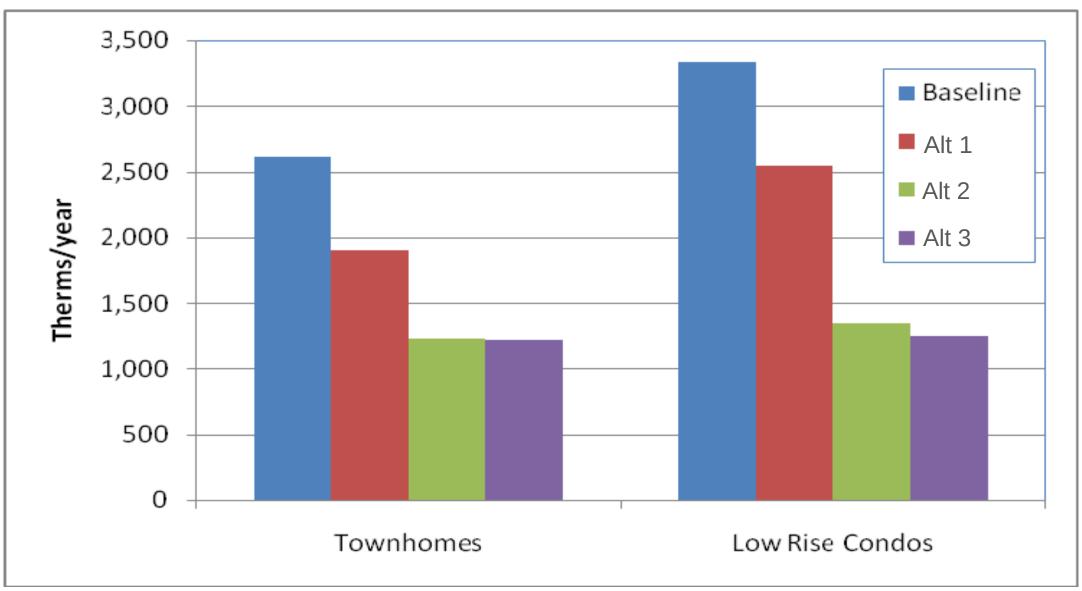
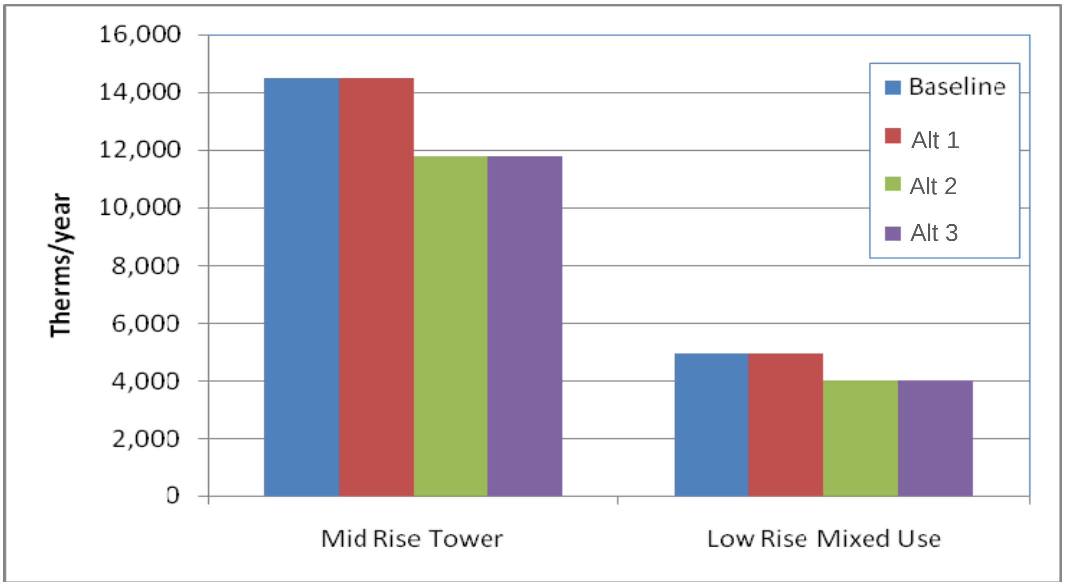


Figure 10: Total Annual Gas Use – Mid-Rise and Mixed Use Residential



Cost Analysis

Estimated annual utility cost for each building type and performance package are summarized in Figure 11 throughFigure 13. Figure 14 summarizes the percent energy cost savings when compared to the Base case. Percent energy cost savings are close to the source energy savings goals of 30%, 50%, and 80%.

Figure 11: Annual Utility Cost Comparison – Small and Large SFD

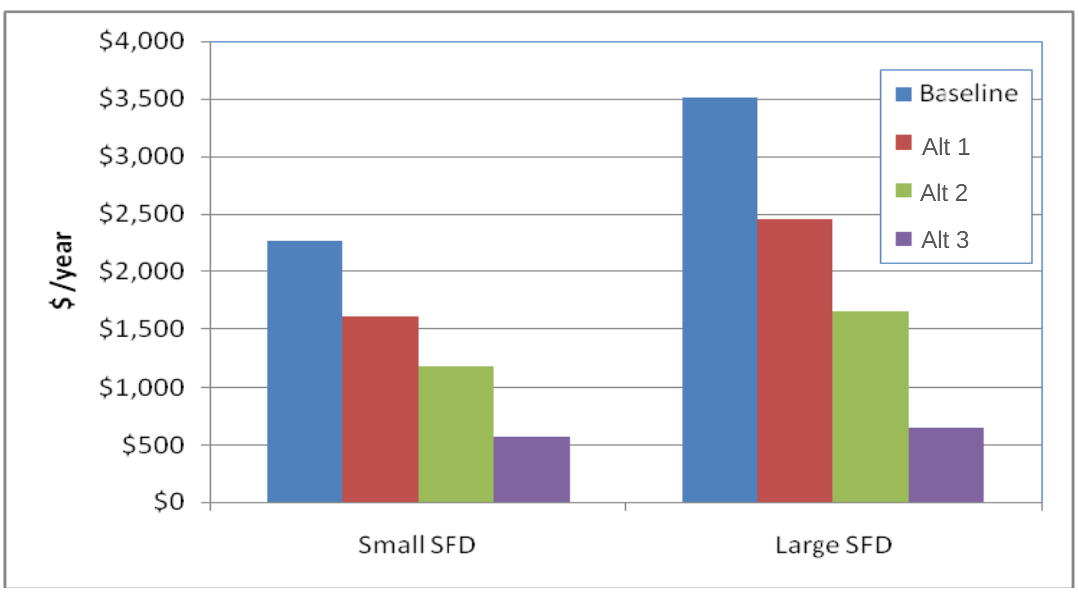


Figure 12: Annual Utility Cost Comparison – Townhomes and Low-Rise Condos

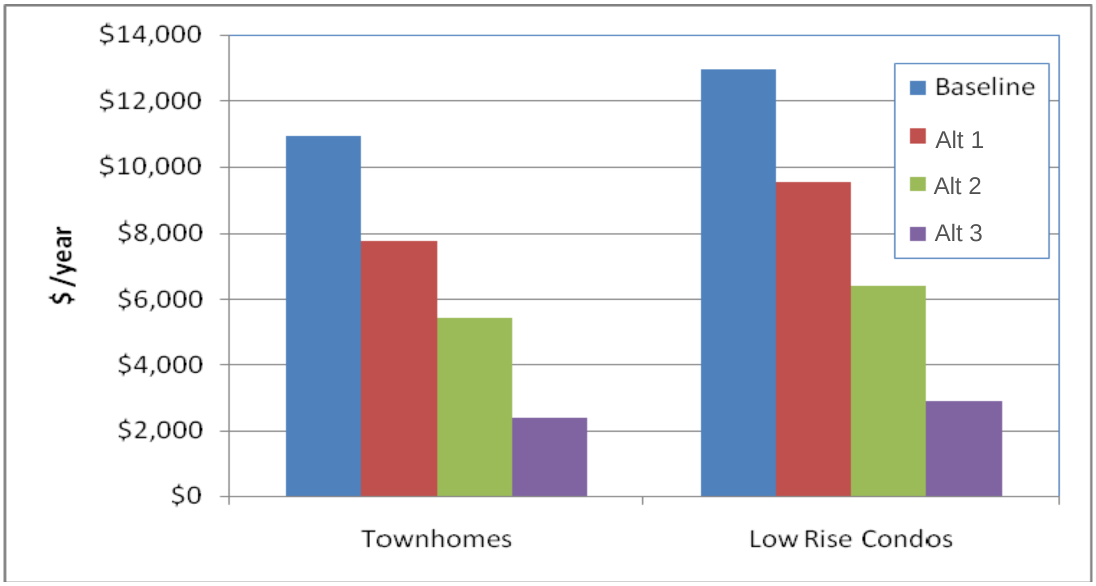


Figure 13: Annual Utility Cost Comparison – Mid-Rise and Mixed Use Residential

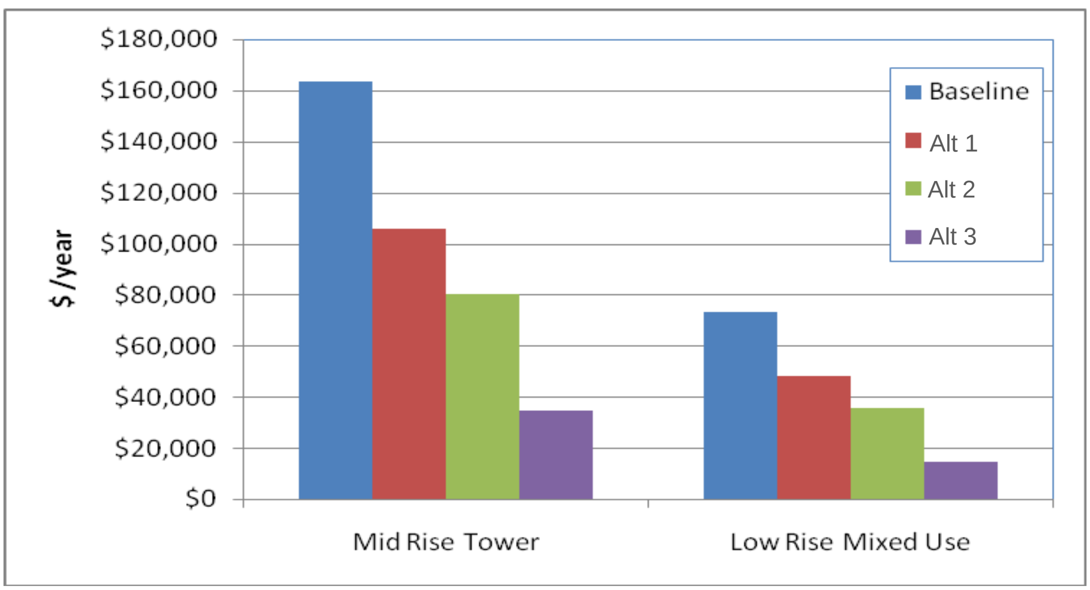
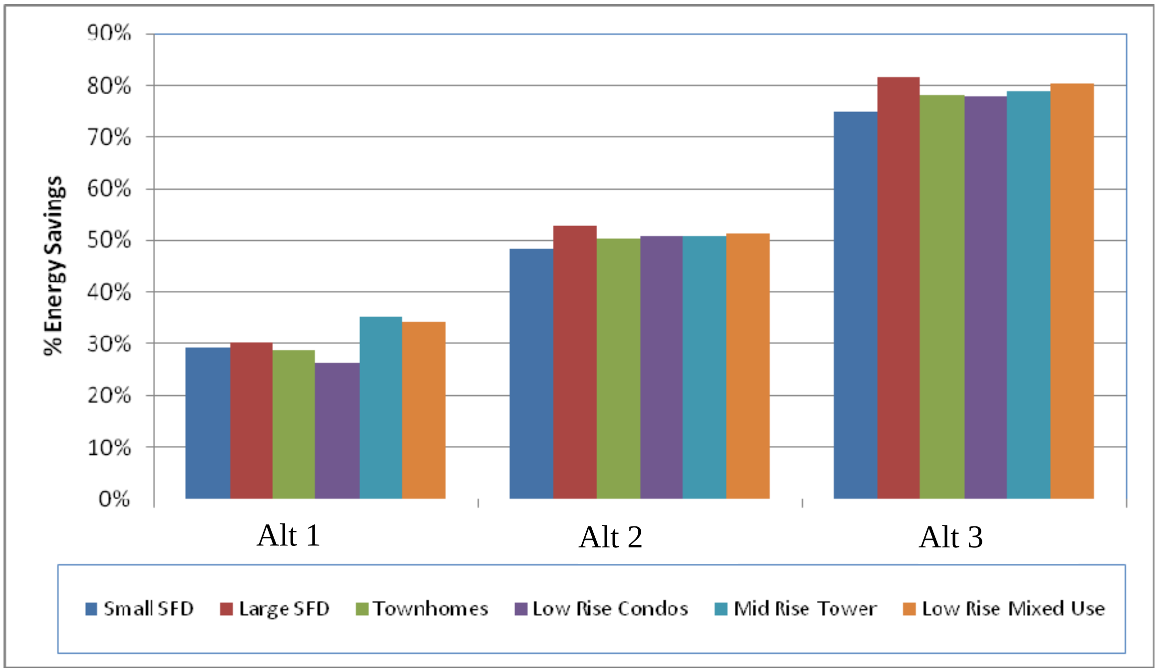


Figure 14: Percent Energy Cost Savings Compared to the Base Case



Carbon Analysis

The carbon impacts for each building type and performance target have been calculated and summarized in Figure 15 and Figure 16. The conversion factors of 13.160 lbs CO_2 per therm as supplied by a National Renewable Energy Laboratory report[i] (NREL, 2007) and 1.240 lbs per kWh as supplied by the EPA[ii] (EPA, 2008) were used in order to calculate total carbon impacts. Figure 17 through Figure 22 summarize the carbon impacts based by component for each building type. PV contribution is shown as negative and should be subtracted from the total positive values to get net CO_2 contribution.

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[i] NREL, 2007, "NREL Source Energy & Emmission Factors for Energy Use in Buildings", NREL/TP-550-38617, M. Deru, P. Torcellini, June 2007.

[ii] EPA, 2008, "Clean Power Profiler", U.S. Environmental Protection Agency, based on energy mix of Salt River Project utility, http://www.epa.gov/cleanenergy/powerprofiler.htm.

Figure 15: CO_2 Impacts Based on Energy Use – Small, Large SFD, Townhomes, and Condo

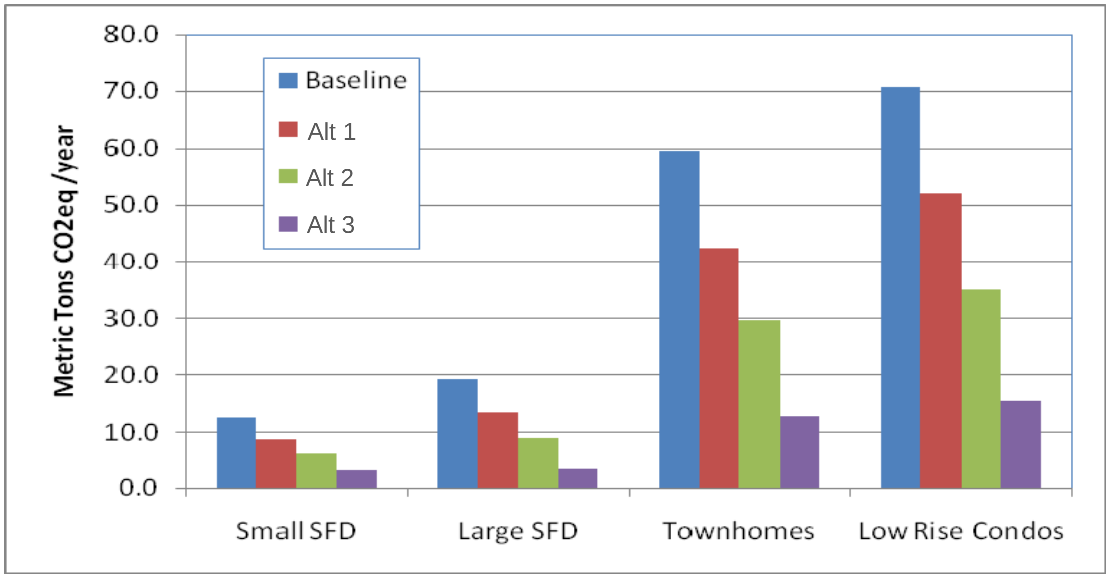


Figure 16: CO_2 Impacts Based on Energy Use – Mid-Rise and Mixed Use Residential

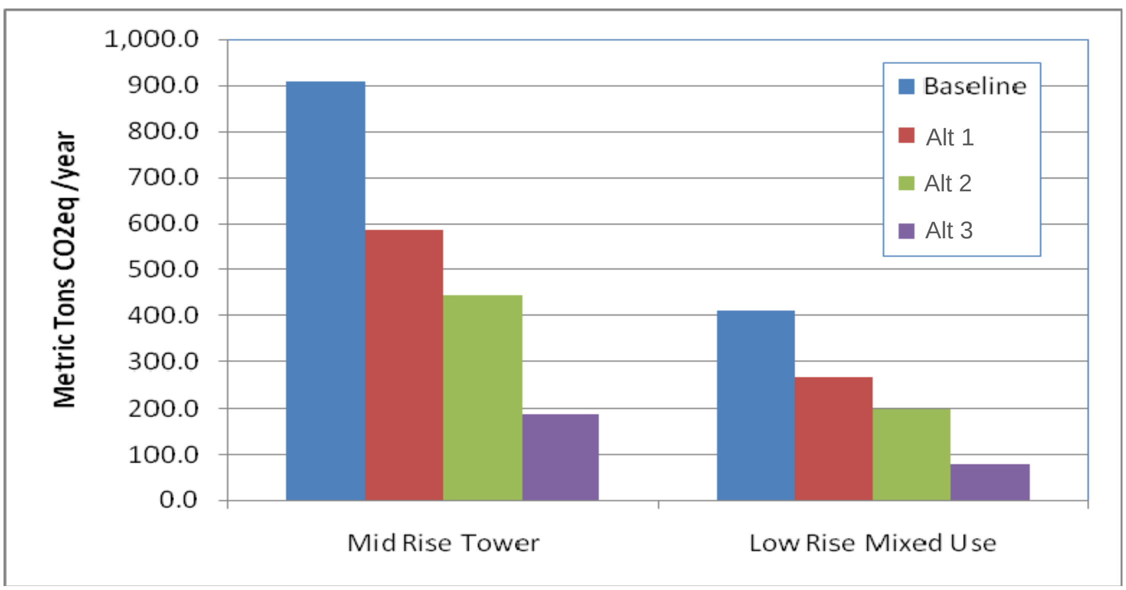


Figure 17: Carbon Impacts by Component – Small SFD

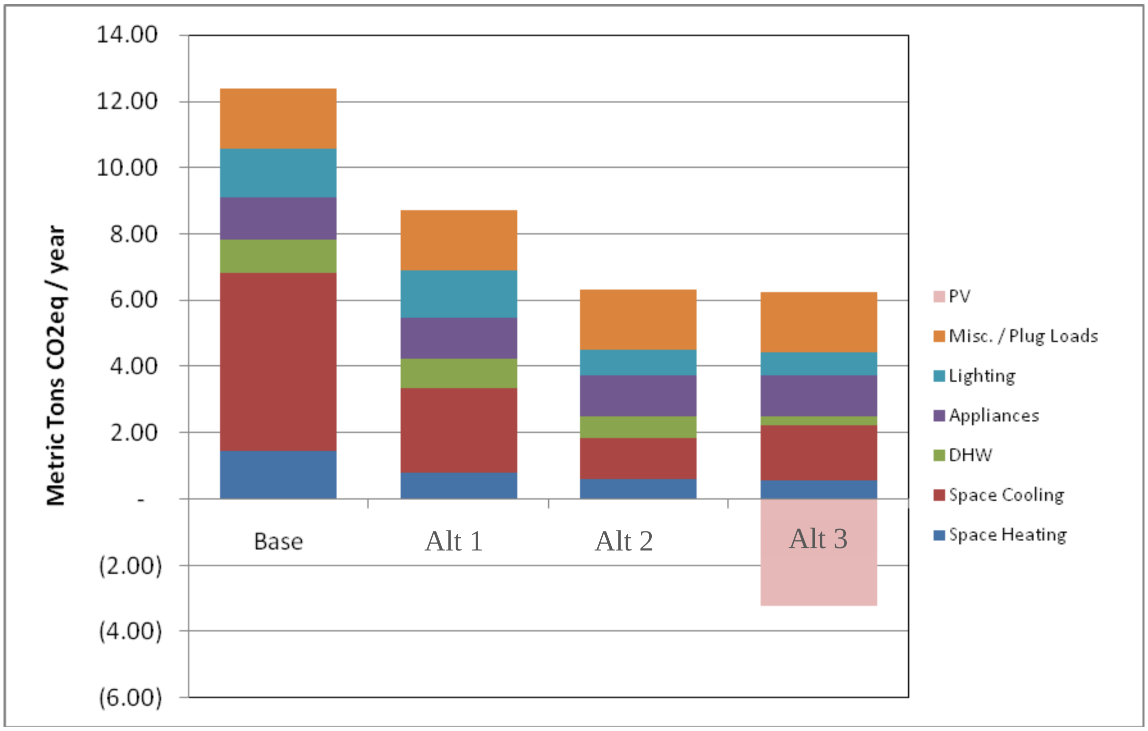


Figure 18: Carbon Impacts by Component – Large SFD

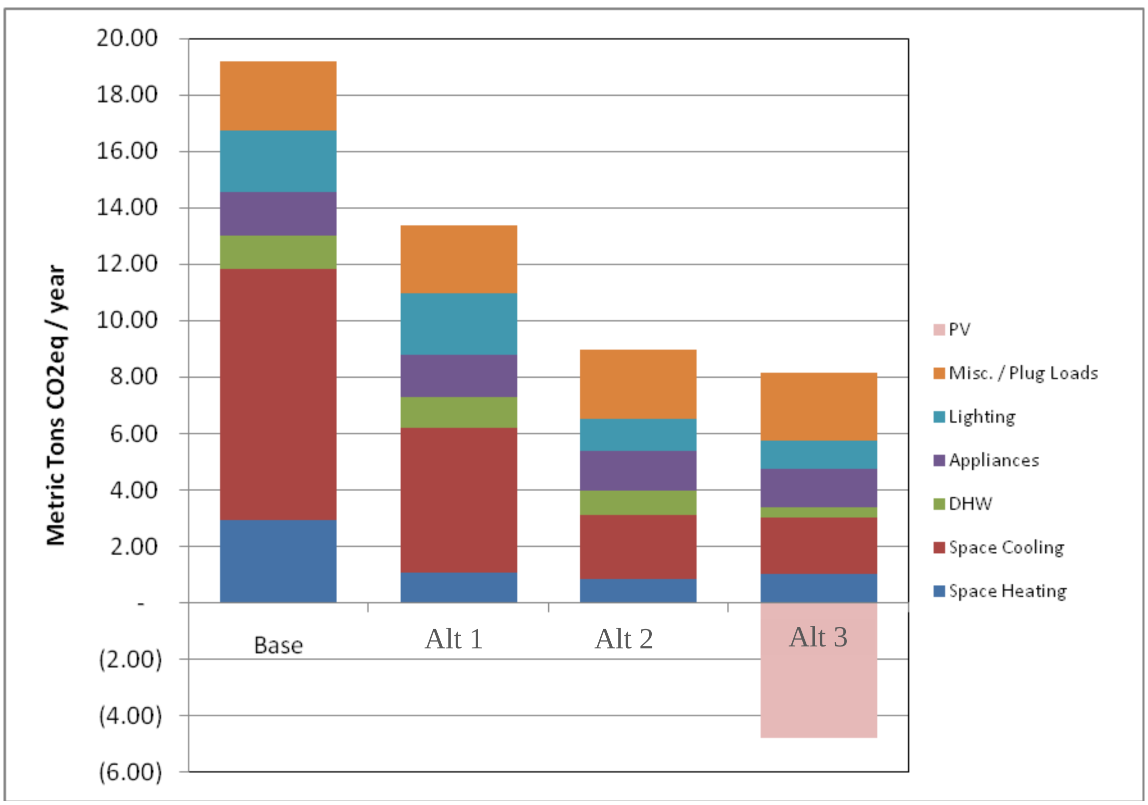


Figure 19: Carbon Impacts by Component – Townhome

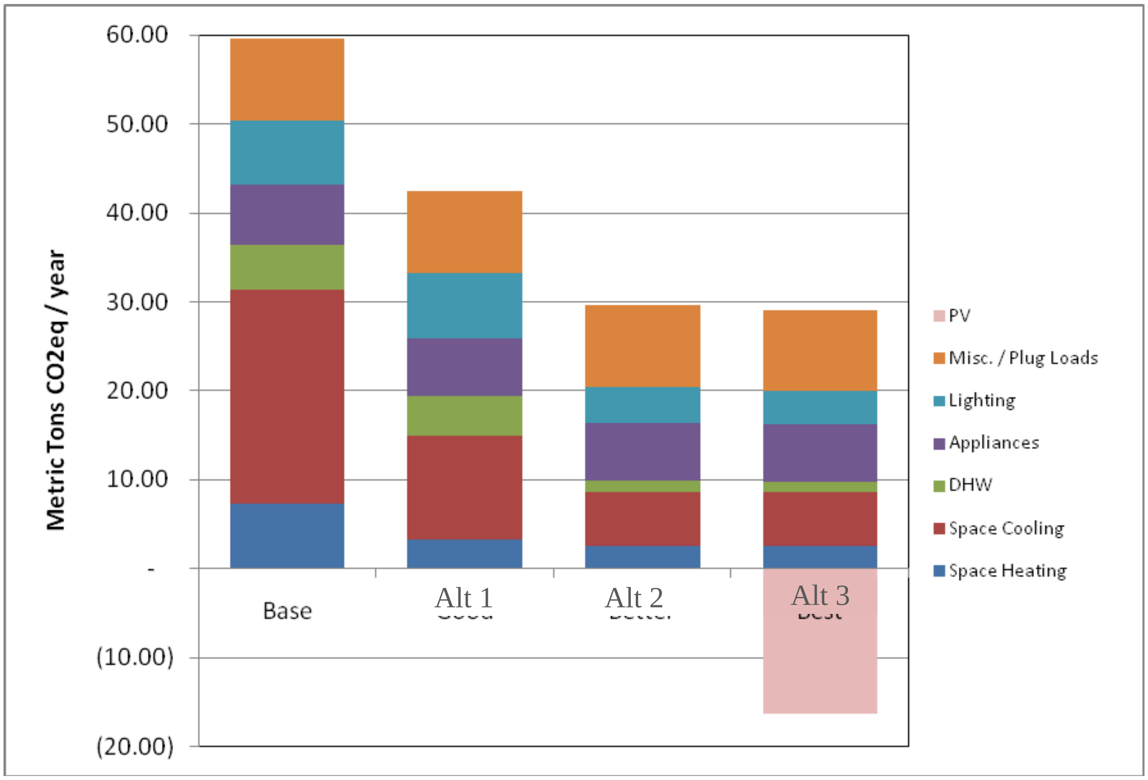


Figure 20: Carbon Impacts by Component – Low-Rise Condos

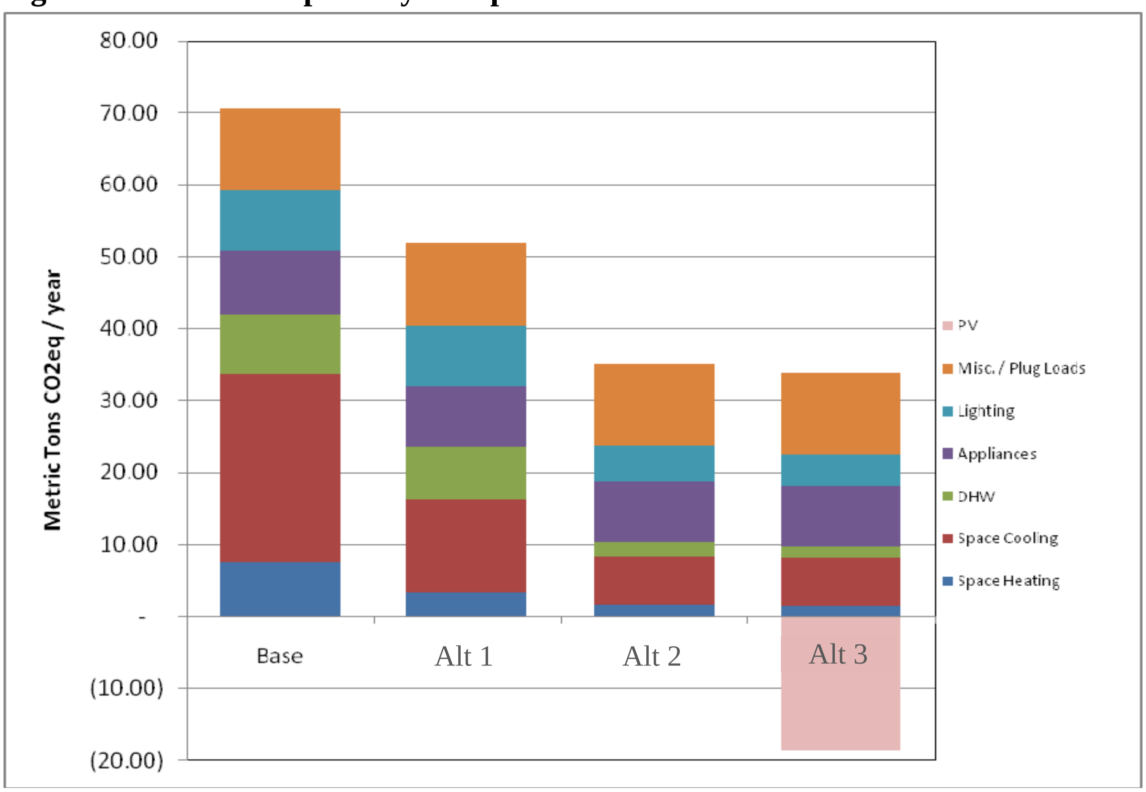


Figure 21: Carbon Impacts by Component – Mid-Rise Tower

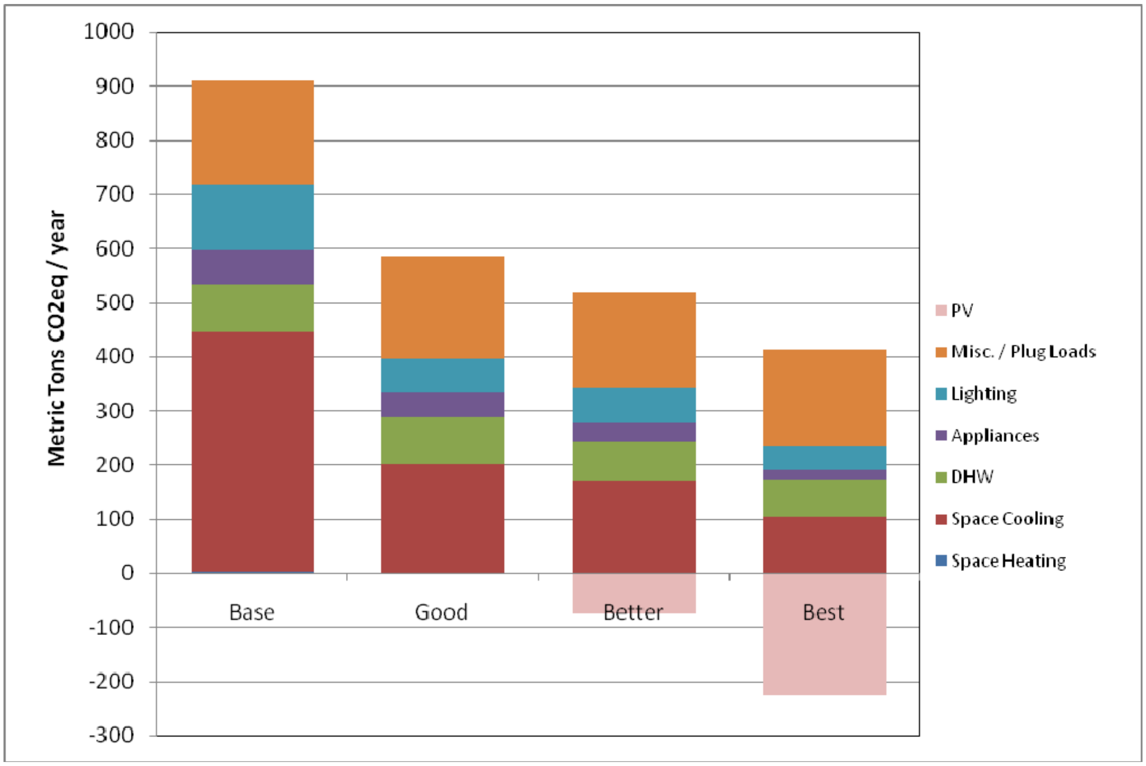
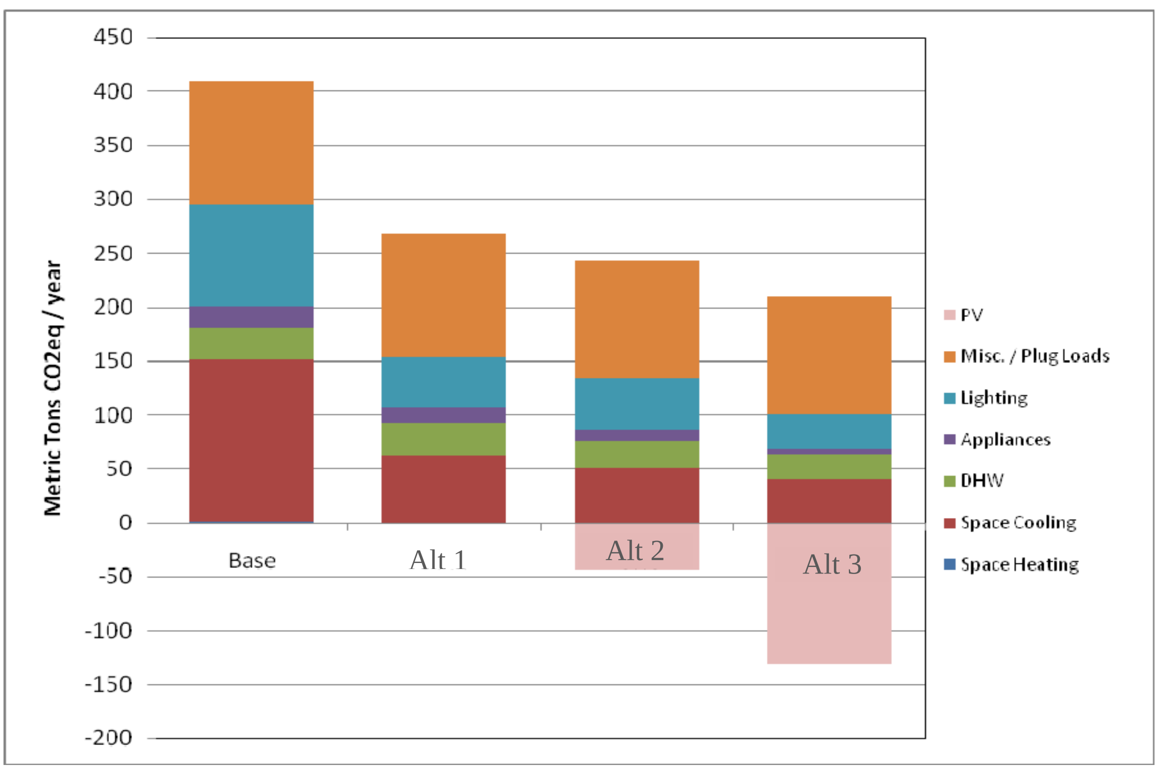


Figure 22: Carbon Impacts by Component – Mixed-Use Residential



3.2 Non-Residential Findings

Based on the BaU, Alt 1, Alt 2 and Alt 3 packages outlined for each building type in the previous section, the following conclusions can be drawn from the SSIM analysis of the non-residential building types at Superstition Vistas.

Energy Analysis

Analysis of the data indicates that the reductions in energy performance and carbon emissions for each building type vary significantly, depending on the building type and the specific packages chosen for the Alt 1, Alt 2 and Alt 3 options. Figure 23 shows the annual total energy savings relative to BaU performance, for each building type.

Figure 23: - Annual Total Energy Savings by Building Type

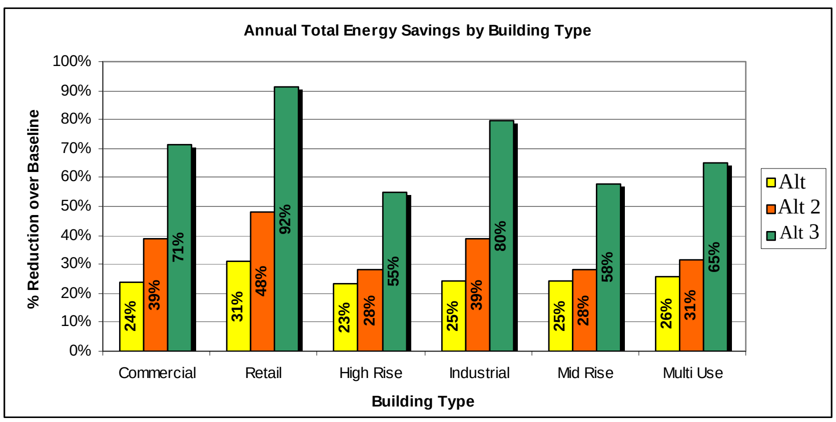


Figure 23 indicates that, for all building types, energy savings in excess of 20% over BaU are likely to be yielded for all building types, based on the Alt 1 package of options. In particular, significant energy savings are likely to be made through the use of high efficiency HVAC equipment. Primarily this is due to the high space conditioning loads likely to be experienced at the site compared to similar buildings in more temperate climates. At Superstition Vistas, space conditioning and in particular space cooling, is likely to make up a greater proportion of the total building energy demand, therefore improvements in the energy performance in this area will yield higher overall building energy reductions. In all building types, both the Alt 1 and Alt 2 solutions utilize high efficiency packaged HVAC equipment, compared to the ASHRAE 90.1-2004 "code minimum" packaged HVAC solution used in the BaU scenario.

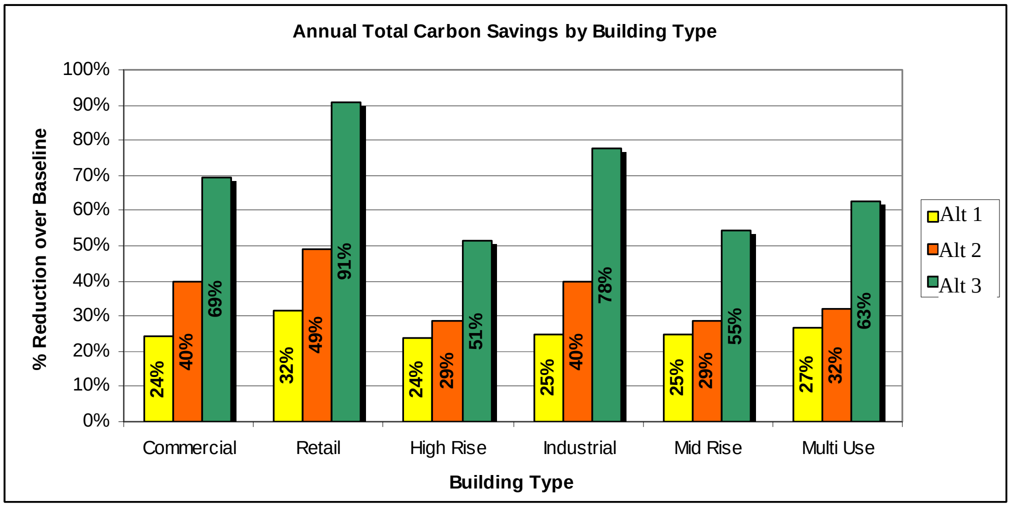
In order to achieve the highest levels of energy savings achieved by the Alt 3 solution, for all building types, ground source heat pumps have been utilized to meet the annual heating and cooling demands, which helps high levels of energy reductions compared to the BaU case to be achieved. It is noted that in doing this, it has been assumed that sufficient ground area for ground source wells is available to meet the total peak space conditioning load and that the performance of the ground source heat pumps will not deteriorate over time due to increasing ground temperatures, caused by the imbalance between heating and cooling at the Superstition Vistas site. As such, it is recognized that, ground source heating and cooling may not be suitable for all building types all of the time.

In addition to reducing energy use actively, through, for example, the use of high efficiency HVAC systems, scrutiny of the results indicates that significant reductions in energy use are likely to be achieved through passive means. For Superstition Vistas, it is noted that a high performance glazing solution including solar shading can, if incorrectly specified, increase, rather than decrease annual energy use. In particular, where HVAC systems are cooling load lead, high performance glazing systems can trap heat in the building during the summer; thus increasing the cooling loads and therefore cooling energy in the building. Higher reductions in energy use against the BaU package may be achieved through the use of lower efficiency, BaU glazing and solar shading; the combination of which will help to reduce annual cooling energy by minimizing the amount of heat trapped in the building during summer months whilst also reducing summertime solar gain.

Carbon Analysis

Figure 24 shows the total annual carbon savings, relative to the BaU building carbon emissions, for each building type. For all buildings, the reduction in carbon emissions is in line with the annual energy savings shown in Figure 23. For the Alt 3 package for each building, the annual carbon savings are marginally lower than that corresponding reduction in energy use. This is because, in utilizing ground source heating and cooling, the annual heating energy is transferred from a natural gas based system (using conventional boilers) to an electricity based system (heat pumps). For the Superstition Vistas site, the carbon factor of electricity (0.236kgCO_2/kWh) is in the order of 1.3 times greater than that of natural gas (0.181kgCO_2/kWh).

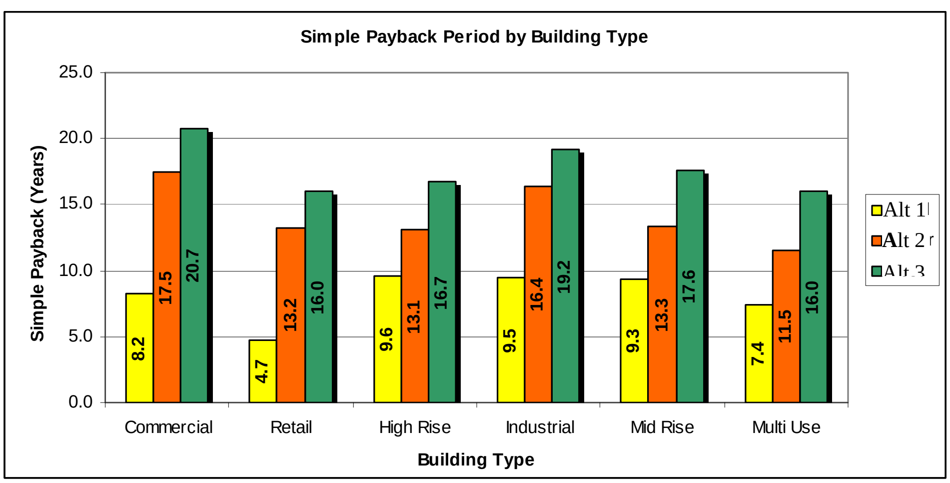
Figure 24 - Annual Total Carbon Savings by Building Type



Cost Analysis

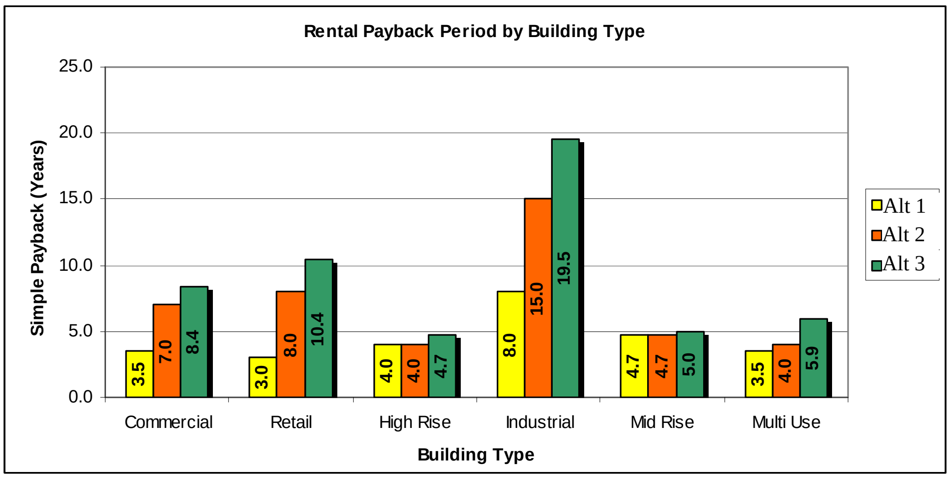
For all buildings, packages have been selected to ensure that at least the Alt 1 option achieves payback within a 10 year period. In all cases except the retail building, the Alt 1 package yields energy and carbon emissions reductions in the order of 25%. For the retail building, high internal loads, primarily from overhead and display lighting, mean that higher energy and carbon emissions reductions can be achieved through the use of high efficiency HVAC equipment. For the retail building, the Alt 1 package yields savings of over 30%, with payback in the region of 5 years. The high cost of ground source heating and cooling equipment means that for the Alt 3 packages, simple payback is unlikely to be achieved until after between 15 and 20 years, depending on building type. Simple payback periods for the Alt 1, Alt 2 and Alt 3 packages for each building type are shown in Figure 25.

Figure 25: Simple Payback Periods by Building Type



If potential rental income for each building type is taken into consideration, the payback periods of each option are likely to be significantly reduced, due to the rental premiums associated with green buildings. Payback periods including rental income (based on rental premium assumptions of 2.5%, 5% and 7.5% for the Alt 1, Alt 2 and Alt 3 cases for all building types) are shown in Figure 26. In doing this, it is recognized that determining rental premiums associated with green building is a difficult process. Numerous studies have been undertaken on the subject; however the actual rental premium green buildings can achieve will vary significantly depending on local, national and international location, as well as the specifics of the building type being assessed. The figures used in this assessment, 2.5%, 5% and 7.5% are based on local and national anecdotal evidence, as well as taking into account that in addition to commanding an increased rental income, green buildings are likely to be let quicker than standard buildings, thus yielding an increase in total rental income over the period under analysis.

Figure 26: Payback Periods by Building Type with Rental Premiums



It is noted that, whilst payback are periods generally significantly reduced when rental income and rental premiums are considered, significant reductions in payback period are not seen for the industrial building. This can be attributed to the low rental costs associated with industrial buildings, assumed to be in the region of $7/sq ft, compared to around $20/sq ft for commercial office space. For the commercial, high rise office, mid rise office and multi use building types, higher rental rates help to reduce the payback period for the Alt 3 case to less than 10 years.

4. IMPLICATIONS

4.1 Residential Implications

The following are the key implications derived from the modeling findings and summarize the building energy analysis for Superstition Vistas prepared by EDAW and sub consultants during the fall of 2008.

Residential Implication #1 – Moderate Levels of Efficiency Increase (30%) are Affordable Today

Up to a 32%, Alt 1, reduction in residential building energy source demand is possible with reasonable building design techniques and the application of available mechanical systems technology (see Figure 27 and Figure 28). All Alt 1 Scenarios (27-32% reductions) showed both day-one positive cash flow and a positive ROI (see Figure 29 and Figure 32). The additional direct construction costs for this range of demand reduction were under 2% for all residential building types with simple payback durations of from only 1.5 to 4.2 years and all with net positive cash flows when financing the incremental costs on a conventional 30 year mortgage (see Figure 30 and Figure 31).

Residential Implication #2 – More Aggressive Levels of Efficiency (50%) are also Possible in the Near Term with Effective Marketing and Communication
Alt 2 indicates that a 40-50% energy demand reduction is possible on most residential building types (see Figure 28) with only a 4-5% increase in direct construction costs (see Figure 30). Although simple paybacks for this level of efficiency range from 5.6 to 10 years, a day-one positive cash flow is maintained on all building types (see **Error! Reference source not found.**). The ability to half total energy cost while maintaining a positive cash flow is a strong marketing proposition in any market. On most building types, photovoltaics are not required to achieve this target, indicating that good passive design and high performance mechanical systems, when combined properly, can achieve impressive efficiency gains.

Residential Implication #3 – Very Aggressive Levels of Efficiency (80%) are Technically Possible but Require Land Trust Subsidy or Breakthroughs in Financing or Incentives.
The most aggressive reduction target was achieved on all residential building types, but not without thermal solar water heating, photovoltaics and water loop heat pumps which add considerable cost to building construction. Simple paybacks range from 10 to 15 years with a range in initial cost increase from 10-18% (see Figure 30 and Figure 31) and Figure 30). It should be noted that the energy savings are so considerable on the simple building types (small and large detached homes) that even at the considerable cost they still show a break even or slight positive monthly cost impact based on a conventional 30 year mortgage.

Residential Implication #4 – Not All Building Types are Created Equal
Although the cost to achieve high efficiencies on the lower density housing types is more than higher density building types, the energy savings in on larger dwellings is disproportionately more so that the monthly cash flow impact is superior. That means

that guidelines may be different for single family vs. attached housing in order to get the most effective reductions at the lowest relative cost.

Figure 27: Annual Total Energy Use Per Dwelling Unit

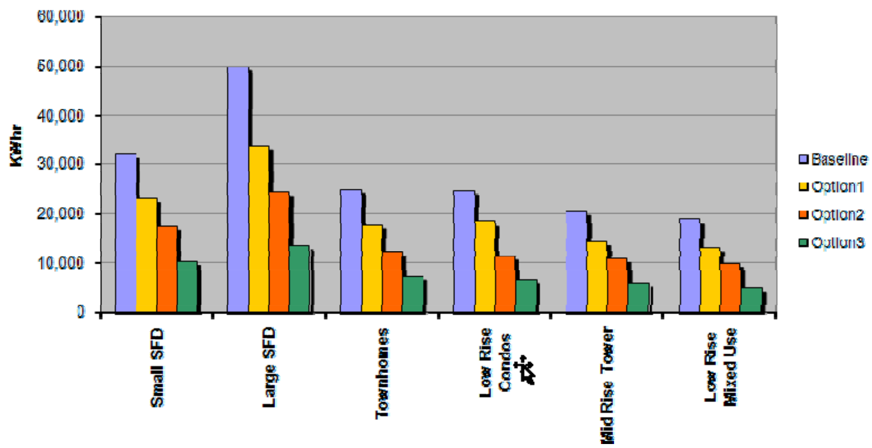


Figure 28: Annual Total Energy Savings

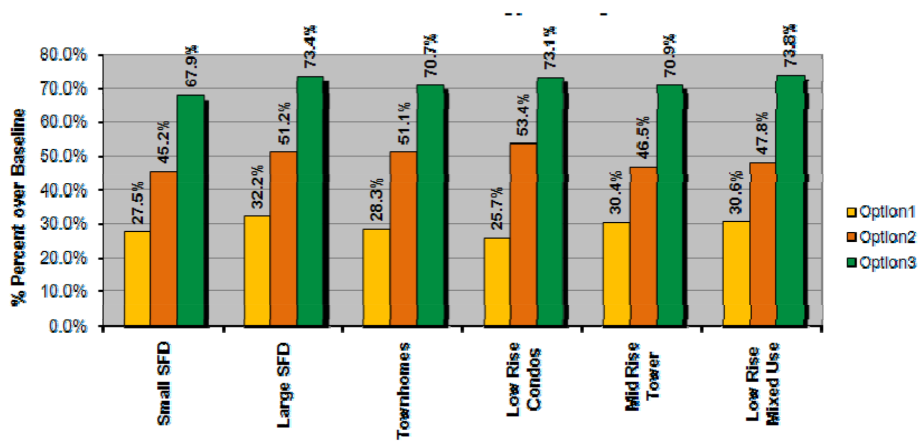


Figure 29: Operating Cost Evaluation

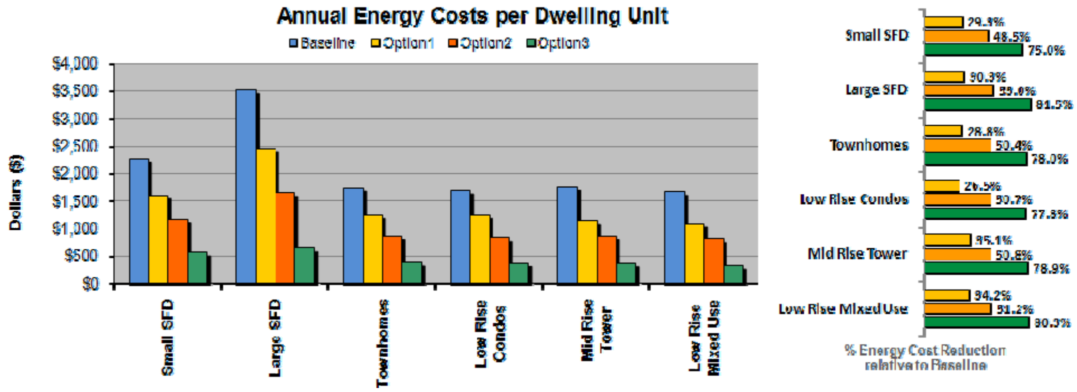


Figure 30: Capital Cost Evaluation

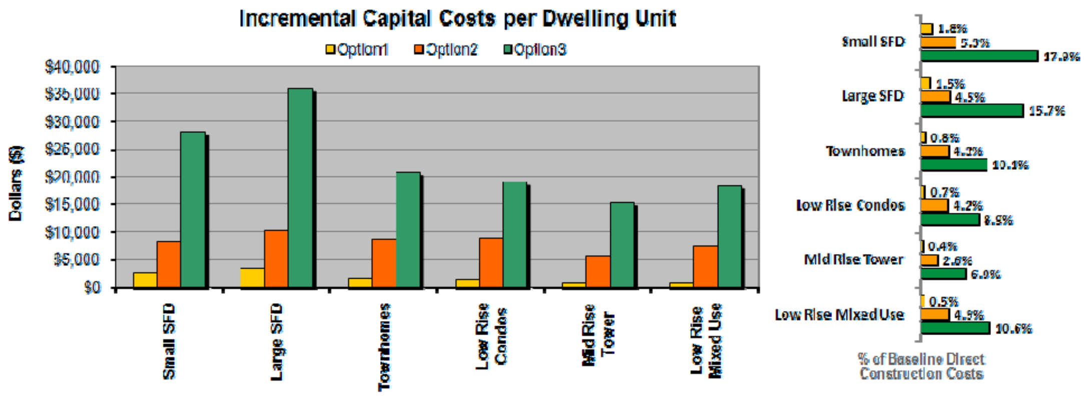


Figure 31: Payback Evaluation

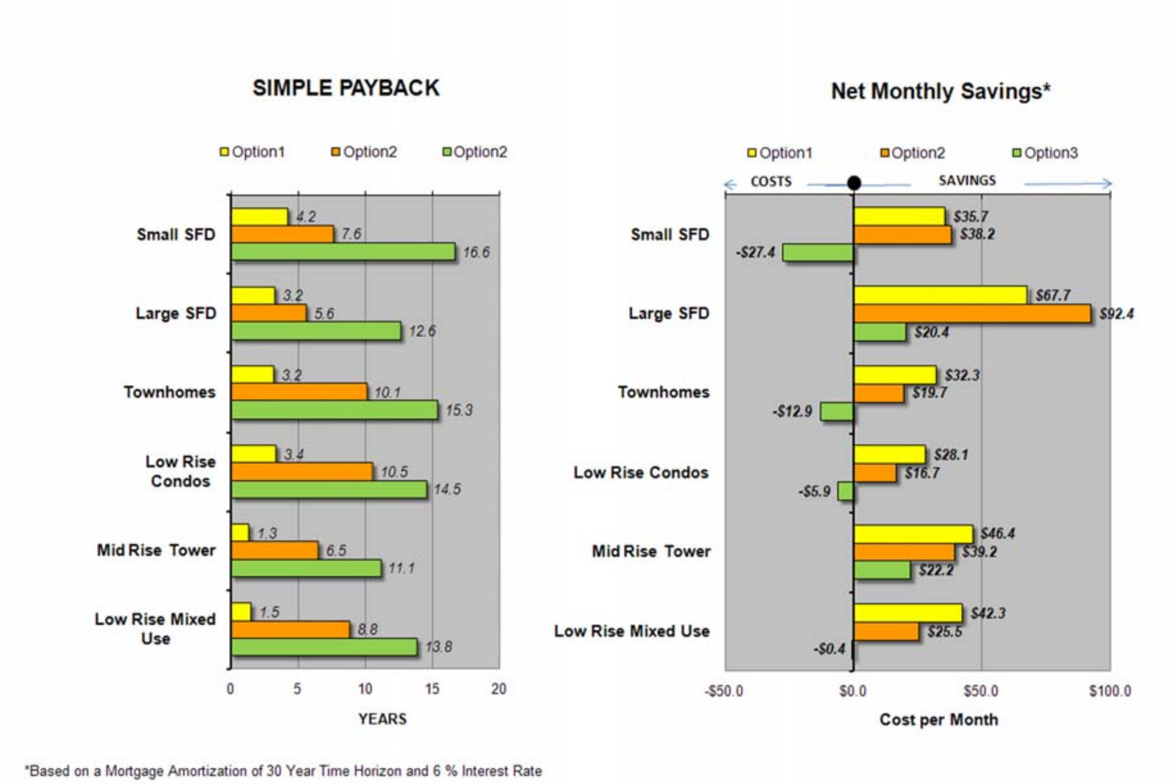
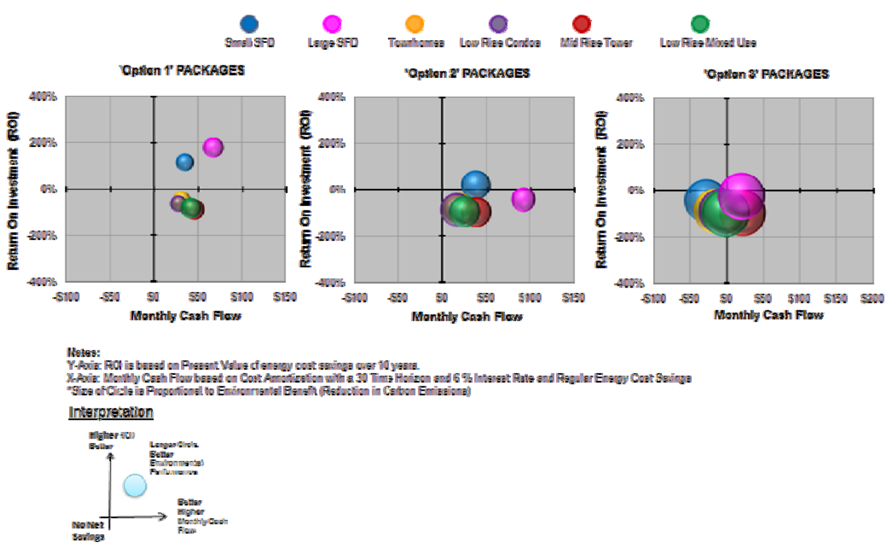


Figure 32: Cost Value Analysis



4.2 Non-Residential Implications

The following are the key implications derived from the non-residential building modeling findings:

Non-Residential Implication #1 – Office Buildings Have Different Investment and Payback Characteristics than Retail and Industrial
As a rule the modeling showed that similar energy reductions cost slightly more initially for retail and industrial buildings but that the savings offset the higher costs similarly to office on a simple payback basis (see Figure 35 and Figure 34). When rent premiums are included, office pays back significantly sooner for the same level of efficiency reduction. If investments were to be strategically focused, more aggressive policy and guidelines relating to office vs. retail/industrial may want to be considered.

Non-Residential Implication #2 – Moderate Levels of Efficiency Increase (25%) are Affordable Today
An average of 25%, Alt 1, reduction in non-residential building energy source demand is possible with reasonable building design techniques and the application of available mechanical systems technology (see Figure 35 and Figure 36). All Alt 1 Scenarios showed a less than 10 year simple payback and positive, if modest, ROI. The additional direct construction costs for office buildings were below 3% and for industrial and for retail below 6%.

Non-Residential Implication #3 – Office Buildings and Mixed Use Provide and Opportunity for More Aggressive Levels of Efficiency (28-40%)
Alt 2 indicates that a moderately aggressive level of energy demand reduction is possible for office buildings and mixed use office over retail buildings within the outer bounds of market acceptance. These building types exhibit only a 4-8% increase in direct construction costs (see Figure 33). Although simple paybacks for this level of efficiency exceed 10 years, their payback when assuming industry average rent premiums for green building shorten the payback to 4 to 7 years (see Figure 34). The down side is that a combination of photovoltaics, and in some cases, on-building wind generation, are required to achieve these results which may be daunting to the general market even if the economics look attractive assuming rent premiums.

Non-Residential Implication #4 – Some Measures are More Effective than Others at Superstition Vista
At the lower energy savings levels, significant energy savings are likely to be made through the use of high efficiency HVAC equipment. Primarily, this is due to the high space conditioning loads likely to be experienced at the site compared to similar buildings in more temperate climates. At Superstition Vistas, space conditioning and in particular space cooling, is likely to make up a greater proportion of the total building energy demand, therefore improvements in the energy performance in this area will yield higher overall building energy reductions. In order to achieve the highest levels of energy savings achieved by the best solution, for all building types, ground source heat pumps have been utilized to meet the annual heating and cooling demands, which helps high levels of energy reductions compared to the BaU case to be achieved.

Non-Residential Implication #5 – Start with Passive Design

In addition to reducing energy use actively, through, for example, the use of high efficiency HVAC systems, scrutiny of the results indicates that significant reductions in energy use are likely to be achieved through passive means. For Superstition Vistas, it is noted that a high performance glazing solution including solar shading can, if incorrectly specified, increase, rather than decrease annual energy use due to summertime heat capture. The right combination of passive measures needs to be identified to achieve the greatest gains.

Figure 33: Capital Cost Evaluation

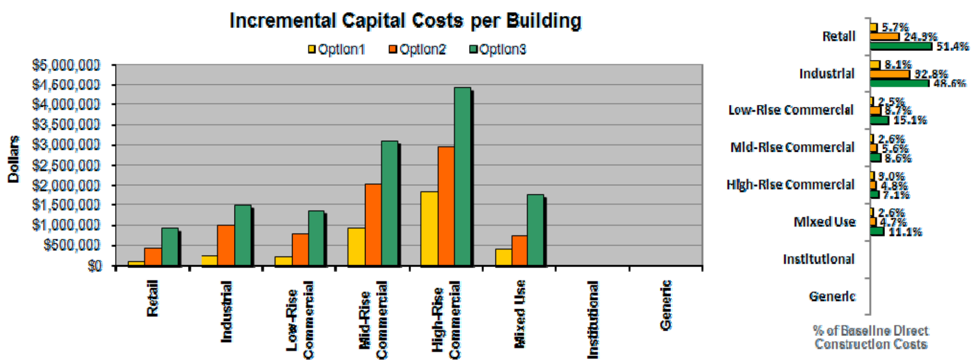


Figure 34: Payback Evaluation

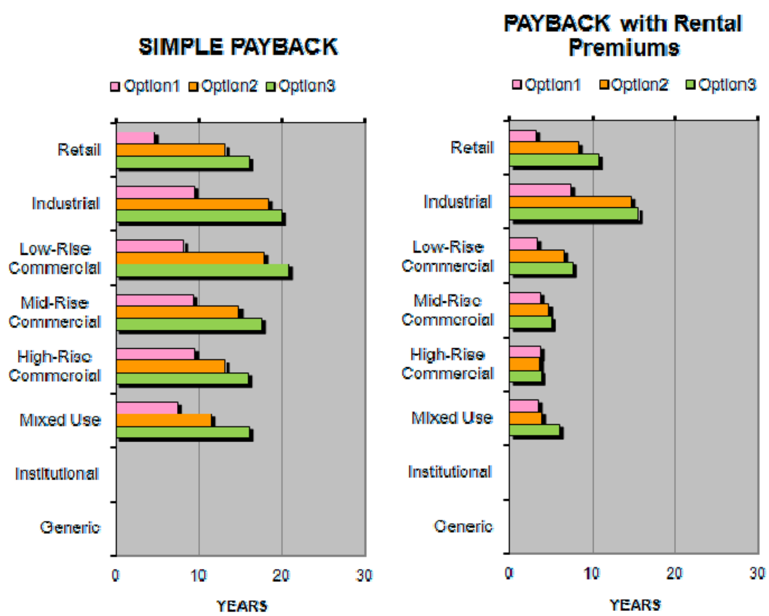


Figure 35: Annual Total Energy Use Per Building

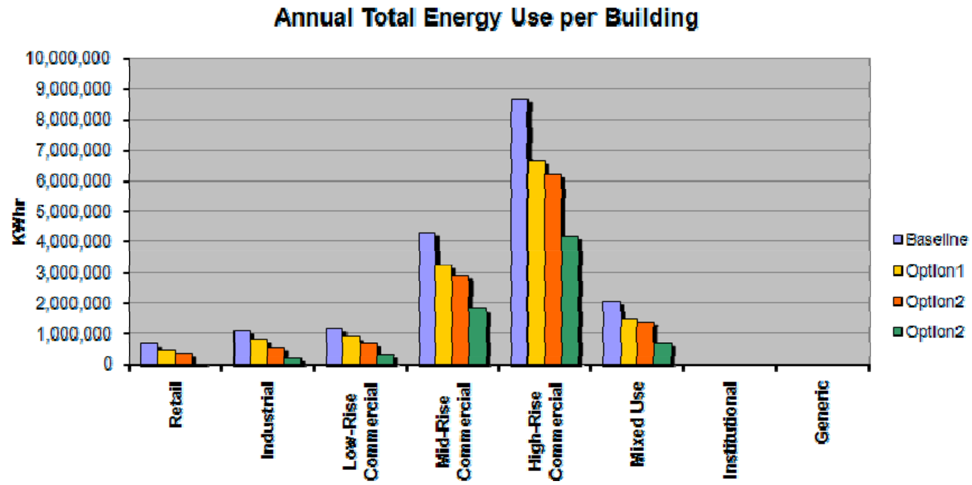


Figure 36: Annual Total Energy Savings

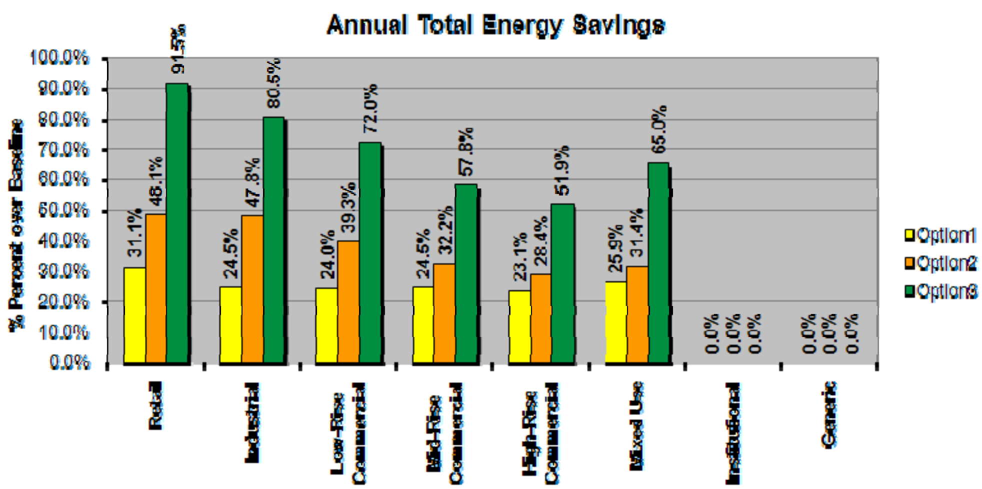
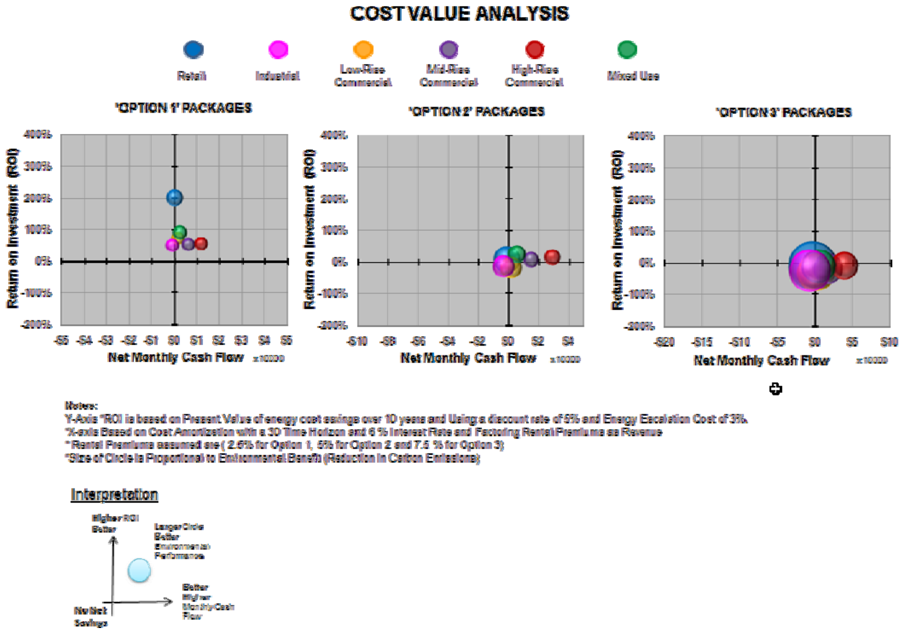


Figure 37: Cost Value Analysis



4.3 General Implications

General Implication #1 – Increased Energy Efficiency Can and Should be a Integrated of Superstition Vistas Policy and Guidelines.

Overall the modeling team felt there was an expansive opportunity for energy reduction in both residential and non-residential building stock within general market and financial parameters. The study shows that all building types are not equal. Being more aggressive on detached housing and office buildings will achieve greater energy reductions with less push back from the marketplace. All building types however can accept a moderate level of policy and guideline guidance to increased efficiency with nominal market and financial resistance.

General Implication #2 – Peak Load Issues Require Further Study

During the modeling process discussions and peer review occurred with Salt River Project (SRP). The relationship of incremental building energy reductions to peak load requirements for the generation and distribution system was raised and a disconnect identified; that is, even if you reduce energy demand substantially from the building stock, if that energy demand reduction does not align with the period of peak demand, then the benefit to the utility is in reduced emissions but not in reduced cost. A pre-demand reduction sizing for distribution and source generation is still required and maintained and therefore reduced demand only ultimately results in increased cost per KWh. Should a second phase of building energy evaluation be initiated, a key question should be the impact of selected measures, such as increasing thermal mass, on the manipulation of peak load.

General Implication #3 – Energy Targets can be Phased Over Time – Crawl
Opportunities for energy reduction should expand in the future. As technology improves, costs decrease and the price of energy increases. Given the long term development horizon of SV, more aggressive targets than those indicated in current modeling can be set with reasonable expectations of achievement. The concept of "crawl, walk, run" is used by many developers invoking sustainability strategies. This would allow, for instance, a 50% energy reduction to be achieved in a long term project by striving for 30% in the first set of phases, 50% in the second and 80% during the final stages.