

Creating Energy-Efficient Communities in California: A Technical Reference Guide to Building and Site Design



Prepared by the National Energy Center
for Sustainable Communities



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Executive Summary

This document is a building and site design technical reference guide for energy-efficient community development in California. The guide's contents are derived from a research initiative to determine how advanced building energy technologies and land use, transportation, and urban design features can be integrated to produce energy-efficient development projects in California. Known as the Chula Vista Research Project (CVRP), the initiative entailed performance modeling of these technologies and features on two development sites in Chula Vista, California, and an assessment of their impact on the environment and the existing electric and gas utility infrastructure.

The CVRP findings suggest use of these technologies and features can reduce aggregate energy consumption and CO₂ emissions of a large-scale development project by as much as 45 percent and 33 percent, respectively, compared to a project designed for minimum compliance with California's Title 24 energy efficiency standard. This guide contains details on these building technologies and a set of site design features for consideration by development practitioners designing energy-efficient community-scale projects.

A companion document entitled: *Sustainable Community Energy Planning in California: New Challenges & Roles for Government Agencies, Utilities & the Development Industry*, contains complementary public policies and incentives that state and local government agencies and utilities can use to facilitate this form of development in the State.

1.0 Introduction

Within the next 20 to 25 years, the United States will design, construct, and remodel more than half of all structures in the country. This equates to 213 billion square feet of built space, half of it in new homes, which have yet to be designed and constructed.¹ This presents an unprecedented opportunity to design and build homes, offices, public facilities and whole communities to a new level of energy and resource efficiency.

Although technologies exist that can improve the energy efficiency of individual buildings and processes, little research has been conducted on how to optimize the efficiency of these technologies in relation to one another or in the aggregate to achieve community-scale energy efficiency. Further, little or no research has sought to determine how to maximize the performance of energy efficiency, demand response, renewable energy, and distributed energy technologies and strategies through energy-efficient community planning, design, and development.

Historically California has been one of the leading states promoting energy efficiency and resource conservation. It has now become the lead state in the emerging national effort to reduce greenhouse gas emissions and global warming. The *California Energy Action Plan*, the *Integrated Energy Policy Report of 2007*, the *Global Warming Solutions Act of 2006 (AB 32)*, *Executive Order S-3-05* and *California's*

1. Nelson, Arthur C. 2004. *Toward A New Metropolis: The Opportunity to Rebuild America*. A Discussion Paper Prepared for The Brookings Institution Metropolitan Policy Program Virginia Polytechnic Institute and State University.

Strategic Plan for Energy Efficiency all contain strategies and goals that will continue to move the state forward in each of these areas of sustainable energy management and toward realization of zero-net-energy structures. However, if the state is to reach the ambitious goals contained in these documents, it must determine how to optimize energy-efficient community development. It must also engage the private sector, in particular the development industry, in pursuit of this supporting objective.

1.1. Recent Research

The goal of the Chula Vista Research Project (CVRP) was to determine which actions and technologies in the California loading order could be combined with enabling community design features to increase the energy efficiency and air quality of California communities.²

To achieve the goal, researchers modeled the application of a number of building energy technologies and community design features on two large development sites on the eastern side of Chula Vista, California. Site A, the more urban of the two sites, was planned to be a predominantly commercial

mixed-use development on 206 acres of land; Site-B was planned to be a predominantly residential mixed-use development on 418 acres of land.

Researchers created three alternative development options for each distinct building prototype on each site. These included use of advanced, highly efficient building envelope features and appliances and space conditioning equipment (EE option); the EE option with the addition of solar photovoltaic panels (EE-PV option); and the EE option with the addition of distributed generation technologies (EE-DG option).

For the advanced community design features, four alternative options were modeled for the two development sites. These included the use of moderate-density/mixed-use/smart-growth development; stormwater runoff mitigation measures; carbon sequestration measures; and urban heat island mitigation measures. Passive solar building orientation was also modeled for the predominantly residential development site. The researchers referred to the collective use of these advanced energy technologies and community design features as *Energy-Efficient Community Development* (EECD).

Once they determined the incremental costs of the energy technology options, researchers conducted online surveys with developers, builders, and brokers to determine if they were deemed acceptable in today's marketplace. Additionally, researchers surveyed capital market and development industry practitioners to determine the perceived barriers and risks associated with use of these technologies and design features in large-scale projects. They also determined what financial and

2. The California Energy Action Plan, adopted in 2003 by the California Energy Commission, the Public Utilities Commission, and the Consumer Power and Conservation Financing Authority, envisioned a "loading order" of energy resources to guide decisions made by these same agencies. This loading order is as follows:

1. Optimize all strategies for increasing conservation & energy efficiency to minimize increases in electricity & natural gas demand;
2. Meet generation needs first by renewable energy resources & distributed generation;
3. Support additional clean, fossil fuel, central-station generation.

business models and public policy incentives would accelerate adoption of new energy technologies..

The following section summarizes key findings of the energy technology and community design modeling. Detailed findings are available in the full technical report entitled *Energy-Efficient Community Development in California: The Chula Vista Research Project*. Key findings of the market and policy analysis can be found in the companion document entitled *A Public Policy Reference Guide to Energy-Efficient Community Development in California*. Both documents are available from the California Energy Commission.

1.2. Key Findings

The CVRP modeling results indicated use of advanced building energy technologies and community design features in a large-scale development project can reduce aggregate electric energy consumption (kWh) by about 43%; peak demand (kW) by 45%; and CO₂ emissions by 35% compared to a project designed for minimum compliance with California's Title 24 energy efficiency standard. The key component findings include the following:

- Strategic integration of EE, EE-PV, and EE-DG building energy technologies would produce significant reductions in aggregate energy consumption, peak demand, and emissions compared to the builder's proposed baseline approach.
- Central power plant emission reductions achieved through use of

the EE-DG option would significantly increase local emissions.

- Utility infrastructure impacts associated with use of the EE and EE-PV options were deemed relatively insignificant. Use of the EE-DG option would result in a significant reduction of necessary electric distribution facilities to serve a large-scale project.
- The mixed-use/moderate density option also would facilitate cost-effective performance of combined cooling heat and power technologies and district cooling systems and significantly reduce vehicular petroleum consumption and emissions and increase land use efficiency.
- Mixed-use/moderate density development, stormwater runoff mitigation, and carbon sequestration and urban heat island mitigation measures all would produce significant reductions in energy consumption and energy-related emissions in large-scale development projects.

1.3. Performance Profiles and Technical Assumptions

The performance profiles presented in the next two chapters contain the optimal mix of alternative energy-efficient building materials and advanced energy technologies for 40 building types and space uses common to urban and residential development

projects in California. This includes 15 distinct urban building prototypes and 5 district residential building prototypes. The applicable construction types for these buildings are as follows:

- Type I Structural steel frame with exterior metal studs skinned with stone tiles on cement plaster system. Mineral fiber batts are placed between the framing studs and Gypsum board for the interior. Roofs are flat lightweight concrete poured into metal decking with a 3-ply BUR over the concrete.
- Type II Reinforced poured-in-place concrete exterior walls with plaster exterior finish. Steel framing is attached to the inside of the concrete walls with mineral fiber batts between the studs and Gypsum board on the interior. Roofs are flat 3-ply BUR over 2" rigid insulation boards over metal decking.
- Type III Wood framed walls with lath/plaster and brick veneer exterior. The walls are filled with mineral fiber batts between the studs and Gypsum board on the interior. Roofs are flat wood trusses with rigid insulation over plywood decking. A 3-ply built-up-roof covers the rigid insulation.
- Type V Wood framed with plaster exterior finish, fiberglass batts within the framing, and Gypsum interior. Roofs are flat wood trusses with fiberglass batt insulation below the wood decking. A 3-ply built-up-

roof covers the wood decking. If the roofs are pitched with an attic, fiberglass batt insulation is placed at the attic floor and flat concrete tiles cover the roof exterior.

Performance profiles for each prototype begin with a description and a dimensional drawing or photograph. Next, a black and white table presents a description of building materials, design configurations and energy technologies common for each prototype (referred to as the builder's baseline) and a set of alternative energy-efficient building materials, configurations, and energy technologies for three different scenarios. A set of three tables containing information on energy savings, installation costs, and paybacks for each alternative follows. The tables also provide information on total energy consumption and an assessment of the alternative relative to California's building energy efficiency standard.³ The specific content of the three tables includes:

- Utility and Installation Costs and Paybacks for each Energy-Efficient Alternative
 - Annual electric utility costs
 - Annual natural gas costs
 - Annual combined electricity and natural gas utility costs
 - Alternative energy efficiency measure installation costs
 - Payback period for each alternative measured in years
- Annual Electric, Gas and Total Energy Consumption for each Alternative

3. Paybacks = < than useful life of the alternative (material, equipment, feature) being implemented.

- Electricity consumption in annual kWh
 - Electricity consumption expressed as a thousand, thousand British thermal units (MMbtu)
 - Natural gas consumption expressed in MMBtu
 - Total combined consumption of electricity and natural gas in MMBtu
 - Total energy saved in MMBtu from the use of the alternative over the use of conventional building materials and energy technologies (builder's baseline approach)
- Electric TDVI energy consumption
 - Natural Gas TDVI energy consumption
 - Total combined electricity and natural gas TDVI energy consumption
 - Amount of TDVI units saved from the use of the alternative over the use of conventional building materials and energy technologies
- Annual Electricity and Natural Gas Consumption and Savings Expressed in Time Dependent Valuation Inclusive (TDVI) Units for each Alternative⁴
 - Total square feet of each prototype

The tables enable the reader to determine the performance impact of each alternative for each building prototype and each use (e.g. residential, office, retail building) and to determine which proved economically feasible (yellow shading) on a simple payback basis and which was not feasible (unshaded).

The first three rows of each table indicate what the building energy costs, consumption, and TDVI performance would be under the following three scenarios: (1) use of conventional building materials and equipment (the builder's baseline approach), (2) use of all the economically feasible energy-efficient alternatives (the EE option), and (3) use of the EE option with the addition of photovoltaic onsite power generation. Tables for several commercial building prototypes contain an additional row to show the performance impact of onsite fossil-fueled distributed generation technologies.⁵ The performance information under all three scenarios is shaded in green.

4. Time Dependent Valuation (TDV) is the new method for valuing energy under the performance approach in the 2005 Building Energy Efficiency Standard known as Title 24. Under TDV the value of electricity differs depending on the time-of-use (hourly, daily, seasonal), and the value of natural gas differs depending on season. TDV is based on the cost for utilities to provide the energy at different times. TDVI is an enhanced version of the performance approach for valuing energy consumption and savings that accounts for all energy consumption in a building including those not specifically included under the Title 24 residential standard such as energy consumed by appliances, plug-in loads and lights. It should however be noted that the Title 24 commercial building TDV method does however account for lights and receptacles load.

5. However, it should be noted that given a recent change in

Modeling Assumptions Results of the Chula Vista Research Project determined the performance profiles. The profiles were based on the technical modeling assumptions contained in Appendix A and Appendix B.

Key Qualifier Models assumed atmospheric conditions for Climate Zone 10 to determine the performance profiles in the next two chapters and the information contained chapter four. Performance of these alternative building materials, advanced energy technologies, and community design alternatives will vary by climate zone.

The next two chapters provide the specific performance characteristics for alternative energy-efficient building materials and technologies for 40 common building prototypes and space uses and for the advanced community site design options modeled in the research project. The following chapter provides preliminary planning and design guidelines for community-scale district energy systems and the final chapter provides additional information resources public and private development practitioners and utility personnel may consider in the design and development of more energy-efficient community development projects.



San Diego Gas and Electric's Self-Generation Incentive Program (SGIP), distributed generation technologies are no longer being incentivized and thus become economically infeasible to consider. The performance data is nonetheless included here as they may once again be incentivized with rebates in the future.

2.0 Alternatives for 28 Urban-Site Building Types and Spaces

2.1. Freestanding Full-Service Restaurant

Type III construction, approximately 7,400 sf single-story slab on grade, typical of a national-chain casual full-service restaurant with three independently controlled zone types (Dining Room, Kitchen, and Hood). The floor-to-floor height is 13'-0" and 50% of the roof area is available for solar cells.

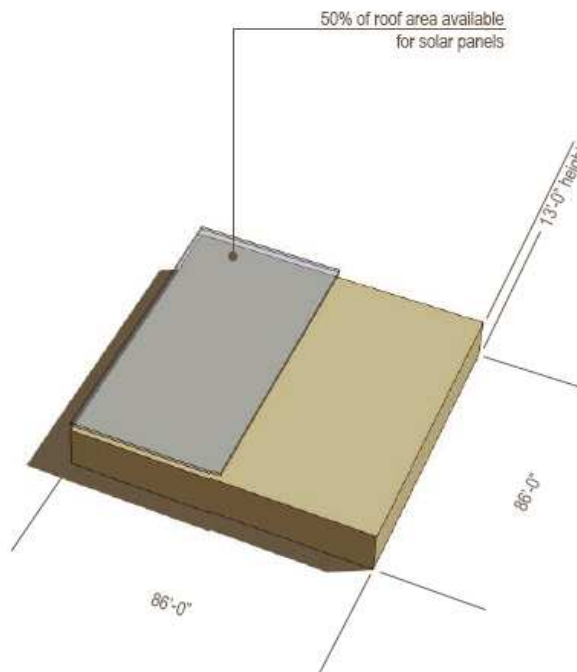


Figure 1. Freestanding Full-Service Restaurant

Table 1. Freestanding Full-Service Restaurant (FFSR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=80%	Heating - AFUE=94%	None	None	Alternative 1
Space Cooling	HVAC - EER 9.5	HVAC - EER 10.5	HVAC - EER 11.5	HVAC - EER 12.5	Alternative 3
Photovoltaics	No PV	PV - 3698 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 1
DG	No DG	DG - 30kW microturbine	None	None	No Alternative

Table 2. FFSR - Alternatives Impact on Utility Costs and Paybacks

Prototype #1 Freestanding Full-Service Restaurant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$48,946	\$25,480	\$74,426	-	-
Package - Optimum EE	\$46,975	\$23,286	\$70,260	\$23,084	5.5
Package - Optimum EE + PV	\$39,858	\$23,286	\$63,144	\$206,937	19.0
CoolRoof - Abs=0.25	\$48,812	\$25,542	\$74,354	\$2,441	33.9
DHW - EF=0.640	\$48,946	\$24,362	\$73,308	\$620	0.6
DHW - EF=0.823	\$48,946	\$23,936	\$72,882	\$741	0.5
Heating - AFUE=94%	\$48,946	\$24,856	\$73,802	\$1,000	1.6
HVAC - EER 10.5	\$48,195	\$25,480	\$73,675	\$16,098	21.4
HVAC - EER 11.5	\$47,578	\$25,480	\$73,058	\$18,007	13.2
HVAC - EER 12.5	\$47,063	\$25,480	\$72,543	\$19,178	10.2
PV - 3698 sqft	\$41,793	\$25,480	\$67,272	\$183,853	25.7
Roof - U=R15 rigid	\$48,943	\$25,429	\$74,372	\$1,849	34.2
Roof - U=R20 rigid	\$48,940	\$25,419	\$74,359	\$3,328	49.7
Walls - R19 batt	\$48,916	\$25,488	\$74,403	\$394	17.1
Walls - R21 batt	\$48,908	\$25,485	\$74,393	\$537	16.3
Walls - R21 batt + R5 rigid	\$48,881	\$25,477	\$74,358	\$1,431	21.0
Windows - U=0.43, SHGC=0.39	\$48,928	\$25,463	\$74,390	\$733	20.4
Windows - U=0.26, SHGC=0.37	\$48,911	\$25,424	\$74,335	\$2,191	24.1
Windows - U=0.22, SHGC=0.22	\$48,788	\$25,504	\$74,293	\$6,690	50.3
DG - 30kW microturbine	\$43,966	\$29,033	\$73,336	\$44,709	59.4

Table 3. FFSR - Alternatives Impact on Energy Consumption

Prototype #1 Freestanding Full-Service Restaurant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	334,010	1,140	1,875	3,015	-
Package - Optimum EE	323,160	1,103	1,679	2,782	233
Package - Optimum EE + PV	262,936	897	1,679	2,577	438
CoolRoof - Abs=0.25	333,244	1,137	1,880	3,017	-2
DHW - EF=0.640	334,010	1,140	1,775	2,915	100
DHW - EF=0.823	334,010	1,140	1,737	2,877	138
Heating - AFUE=94%	334,010	1,140	1,819	2,959	56
HVAC - EER 10.5	329,874	1,126	1,875	3,000	15
HVAC - EER 11.5	326,458	1,114	1,875	2,989	26
HVAC - EER 12.5	323,588	1,104	1,875	2,979	36
PV - 3698 sqft	273,785	934	1,875	2,809	206
Roof - U=R15 rigid	334,140	1,140	1,871	3,011	4
Roof - U=R20 rigid	334,226	1,140	1,870	3,010	5
Walls - R19 batt	333,900	1,139	1,876	3,015	0
Walls - R21 batt	333,879	1,139	1,876	3,015	0
Walls - R21 batt + R5 rigid	333,742	1,139	1,875	3,013	2
Windows - U=0.43, SHGC=0.39	333,853	1,139	1,873	3,013	2
Windows - U=0.26, SHGC=0.37	333,685	1,139	1,870	3,008	7
Windows - U=0.22, SHGC=0.22	333,202	1,137	1,877	3,014	1
DG - 30kW microturbine	300,342	1,025	2,192	3,217	-202

Table 4. FFSR - Alternatives Impact on TDVI

Prototype #1 Freestanding Full-Service Restaurant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	7,396	848	278	1,126	-
Package - Optimum EE	7,396	817	249	1,066	60
Package - Optimum EE + PV	7,396	652	249	901	225
CoolRoof - Abs=0.25	7,396	847	279	1,126	0
DHW - EF=0.640	7,396	848	263	1,112	14
DHW - EF=0.823	7,396	848	258	1,106	20
Heating - AFUE=94%	7,396	848	270	1,118	8
HVAC - EER 10.5	7,396	836	278	1,114	12
HVAC - EER 11.5	7,396	826	278	1,104	22
HVAC - EER 12.5	7,396	818	278	1,096	30
PV - 3698 sqft	7,396	683	278	961	165
Roof - U=R15 rigid	7,396	849	277	1,126	0
Roof - U=R20 rigid	7,396	849	277	1,126	0
Walls - R19 batt	7,396	848	278	1,126	0
Walls - R21 batt	7,396	848	278	1,126	0
Walls - R21 batt + R5 rigid	7,396	848	278	1,126	0
Windows - U=0.43, SHGC=0.39	7,396	848	278	1,126	0
Windows - U=0.26, SHGC=0.37	7,396	848	277	1,125	1
Windows - U=0.22, SHGC=0.22	7,396	846	278	1,125	1
DG - 30kW microturbine	7,396	747	326	1,073	53

2.2. Multi-Tenant Retail Building – Corner Tenant

Type III construction, approximately 20,000 sf single-story slab on grade, accommodating 14 individual tenants averaging 1,400 sf each. The floor-to-floor height is 13'-0". 60% of the roof area is available for solar cells.

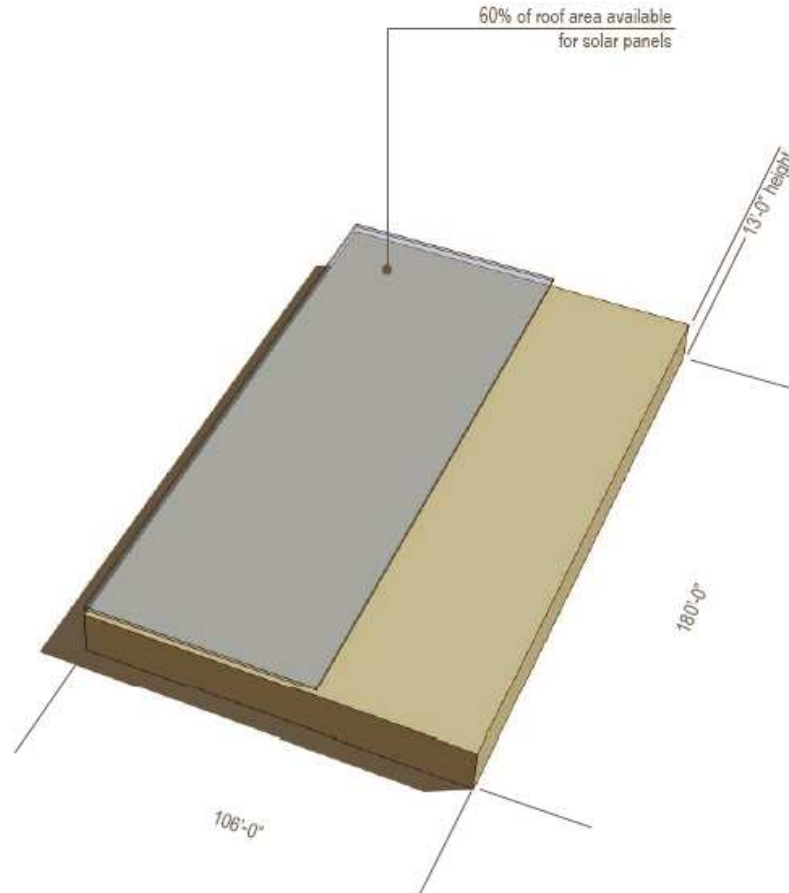


Figure 2. Multi-Tenant Retail Building

Table 5. Multi-Tenant Retail Shop (MTRS) - Corner Tenant Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 1
Photovoltaics	No PV	PV - 842 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 2
DG	None	None	None	None	No Alternative

Table 6. MTRS - Corner Tenant Alternatives Impact on Utility Costs and Paybacks

Prototype #2 Multi-Tenant Retail Shop - Corner Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,081	\$1,698	\$5,779	-	-
Package - Optimum EE	\$3,912	\$1,629	\$5,541	\$2,984	12.5
Package - Optimum EE + PV	\$2,165	\$1,629	\$3,794	\$44,402	22.9
CoolRoof - Abs=0.25	\$4,061	\$1,698	\$5,759	\$463	23.2
DHW - EF=0.640	\$4,081	\$1,678	\$5,759	\$310	15.5
DHW - EF=0.823	\$4,081	\$1,629	\$5,710	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$4,002	\$1,698	\$5,700	\$443	5.6
HVAC - EER 12.06, COP 3.48	\$4,021	\$1,698	\$5,719	\$1,328	22.1
HVAC - EER 12.80, COP 3.66	\$3,980	\$1,698	\$5,678	\$2,213	21.9
PV - 842 sqft	\$2,371	\$1,698	\$4,069	\$41,881	21.4
Roof - U=R15 rigid	\$4,070	\$1,698	\$5,768	\$351	31.9
Roof - U=R20 rigid	\$4,063	\$1,698	\$5,761	\$632	35.1
Walls - R19 batt	\$4,072	\$1,698	\$5,770	\$192	21.4
Walls - R21 batt	\$4,071	\$1,698	\$5,769	\$262	26.2
Walls - R21 batt + R5 rigid	\$4,067	\$1,698	\$5,765	\$699	49.9
Windows - U=0.43, SHGC=0.39	\$4,041	\$1,698	\$5,739	\$272	6.8
Windows - U=0.26, SHGC=0.37	\$4,040	\$1,698	\$5,738	\$813	19.8
Windows - U=0.22, SHGC=0.22	\$3,989	\$1,698	\$5,687	\$2,483	27.0

Table 7. MTRS - Corner Tenant Alternatives Impact on Energy Consumption

Prototype #2 Multi-Tenant Retail Shop - Corner Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	23,388	80	18	98	-
Package - Optimum EE	22,531	77	13	90	8
Package - Optimum EE + PV	8,282	28	13	41	57
CoolRoof - Abs=0.25	23,227	79	18	98	0
DHW - EF=0.640	23,388	80	17	97	1
DHW - EF=0.823	23,388	80	13	93	5
HVAC - EER 12.19, COP 3.52	23,028	79	18	97	1
HVAC - EER 12.06, COP 3.48	23,069	79	18	97	1
HVAC - EER 12.80, COP 3.66	22,863	78	18	96	2
PV - 842 sqft	9,517	32	18	51	47
Roof - U=R15 rigid	23,356	80	18	98	0
Roof - U=R20 rigid	23,331	80	18	98	0
Walls - R19 batt	23,342	80	18	98	0
Walls - R21 batt	23,328	80	18	98	0
Walls - R21 batt + R5 rigid	23,317	80	18	98	0
Windows - U=0.43, SHGC=0.39	23,076	79	18	97	1
Windows - U=0.26, SHGC=0.37	23,130	79	18	97	1
Windows - U=0.22, SHGC=0.22	22,790	78	18	96	2

Table 8. MTRS - Corner Tenant Alternatives Impact on TDVI

Prototype #2 Multi-Tenant Retail Shop - Corner Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	317	14	331	-
Package - Optimum EE	1,404	302	10	312	19
Package - Optimum EE + PV	1,404	98	10	109	222
CoolRoof - Abs=0.25	1,404	314	14	329	2
DHW - EF=0.640	1,404	317	13	330	1
DHW - EF=0.823	1,404	317	10	327	4
HVAC - EER 12.19, COP 3.52	1,404	310	14	325	6
HVAC - EER 12.06, COP 3.48	1,404	311	14	325	6
HVAC - EER 12.80, COP 3.66	1,404	307	14	322	9
PV - 842 sqft	1,404	117	14	131	200
Roof - U=R15 rigid	1,404	316	14	330	1
Roof - U=R20 rigid	1,404	316	14	330	1
Walls - R19 batt	1,404	316	14	330	1
Walls - R21 batt	1,404	316	14	330	1
Walls - R21 batt + R5 rigid	1,404	316	14	330	1
Windows - U=0.43, SHGC=0.39	1,404	312	14	326	5
Windows - U=0.26, SHGC=0.37	1,404	313	14	327	4
Windows - U=0.22, SHGC=0.22	1,404	307	14	322	9

2.3. Multi-Tenant Retail Shop – Internal Tenant

Table 9. Multi-Tenant Retail Shop (MTRS) - Internal Tenant Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Photovoltaics	No PV	PV - 842 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3
DG	None	None	None	None	No Alternative

Table 10. MTRS - Internal Tenant Alternatives Impact on Utility Costs and Paybacks

Prototype #2 Multi-Tenant Retail Shop - Internal Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,025	\$1,698	\$23,018	-	-
Package - Optimum EE	\$3,632	\$1,629	\$20,580	\$5,241	11.3
Package - Optimum EE + PV	\$1,982	\$1,629	\$7,379	\$46,659	19.8
CoolRoof - Abs=0.25	\$3,983	\$1,698	\$22,740	\$463	11.0
DHW - EF=0.640	\$4,025	\$1,678	\$23,018	\$310	15.5
DHW - EF=0.823	\$4,025	\$1,629	\$23,018	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$3,935	\$1,698	\$22,654	\$388	4.3
HVAC - EER 12.06, COP 3.48	\$3,940	\$1,698	\$22,691	\$1,163	13.7
HVAC - EER 12.80, COP 3.66	\$3,904	\$1,698	\$22,420	\$1,939	16.0
PV - 842 sqft	\$2,378	\$1,698	\$9,700	\$41,881	22.1
Roof - U=R15 rigid	\$3,999	\$1,698	\$22,922	\$351	13.5
Roof - U=R20 rigid	\$3,972	\$1,698	\$22,759	\$632	11.9
Walls - R19 batt	\$4,006	\$1,698	\$22,950	\$206	10.8
Walls - R21 batt	\$4,005	\$1,698	\$22,940	\$281	14.0
Walls - R21 batt + R5 rigid	\$4,004	\$1,698	\$22,943	\$748	35.6
Windows - U=0.43, SHGC=0.39	\$3,982	\$1,698	\$22,746	\$171	4.0
Windows - U=0.26, SHGC=0.37	\$3,964	\$1,698	\$22,652	\$510	8.4
Windows - U=0.22, SHGC=0.22	\$3,928	\$1,698	\$22,474	\$1,556	16.0

Table 11. MTRS - Internal Tenant Alternatives Impact on Energy Consumption

Prototype #2 Multi-Tenant Retail Shop - Internal Tenant				
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total I
Baseline	23,018	79	18	9
Package - Optimum EE	20,580	70	13	8
Package - Optimum EE + PV	7,379	25	13	3
CoolRoof - Abs=0.25	22,740	78	18	9
DHW - EF=0.640	23,018	79	17	9
DHW - EF=0.823	23,018	79	13	9
HVAC - EER 12.19, COP 3.52	22,654	77	18	9
HVAC - EER 12.06, COP 3.48	22,691	77	18	9
HVAC - EER 12.80, COP 3.66	22,420	76	18	9
PV - 842 sqft	9,700	33	18	5
Roof - U=R15 rigid	22,922	78	18	9
Roof - U=R20 rigid	22,759	78	18	9
Walls - R19 batt	22,950	78	18	9
Walls - R21 batt	22,940	78	18	9
Walls - R21 batt + R5 rigid	22,943	78	18	9
Windows - U=0.43, SHGC=0.39	22,746	78	18	9
Windows - U=0.26, SHGC=0.37	22,652	77	18	9
Windows - U=0.22, SHGC=0.22	22,474	77	18	9

Table 12. MTRS - Internal Tenant Alternatives Impact on TDVI

Prototype #2 Multi-Tenant Retail Shop - Internal Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	311	14	325	-
Package - Optimum EE	1,404	278	10	288	37
Package - Optimum EE + PV	1,404	85	10	96	229
CoolRoof - Abs=0.25	1,404	306	14	321	4
DHW - EF=0.640	1,404	311	13	324	1
DHW - EF=0.823	1,404	311	10	321	4
HVAC - EER 12.19, COP 3.52	1,404	304	14	318	7
HVAC - EER 12.06, COP 3.48	1,404	305	14	319	6
HVAC - EER 12.80, COP 3.66	1,404	300	14	315	10
PV - 842 sqft	1,404	117	14	132	193
Roof - U=R15 rigid	1,404	309	14	323	2
Roof - U=R20 rigid	1,404	307	14	321	4
Walls - R19 batt	1,404	310	14	324	1
Walls - R21 batt	1,404	310	14	324	1
Walls - R21 batt + R5 rigid	1,404	310	14	324	1
Windows - U=0.43, SHGC=0.39	1,404	306	14	321	4
Windows - U=0.26, SHGC=0.37	1,404	305	14	319	6
Windows - U=0.22, SHGC=0.22	1,404	302	14	317	8

2.4. Major Retailer

Type III construction, approximately 32,500 sf free standing single-story slab on grade, typical of a larger department store with 25'-0" floor height and 75% of the roof area available for solar panels.

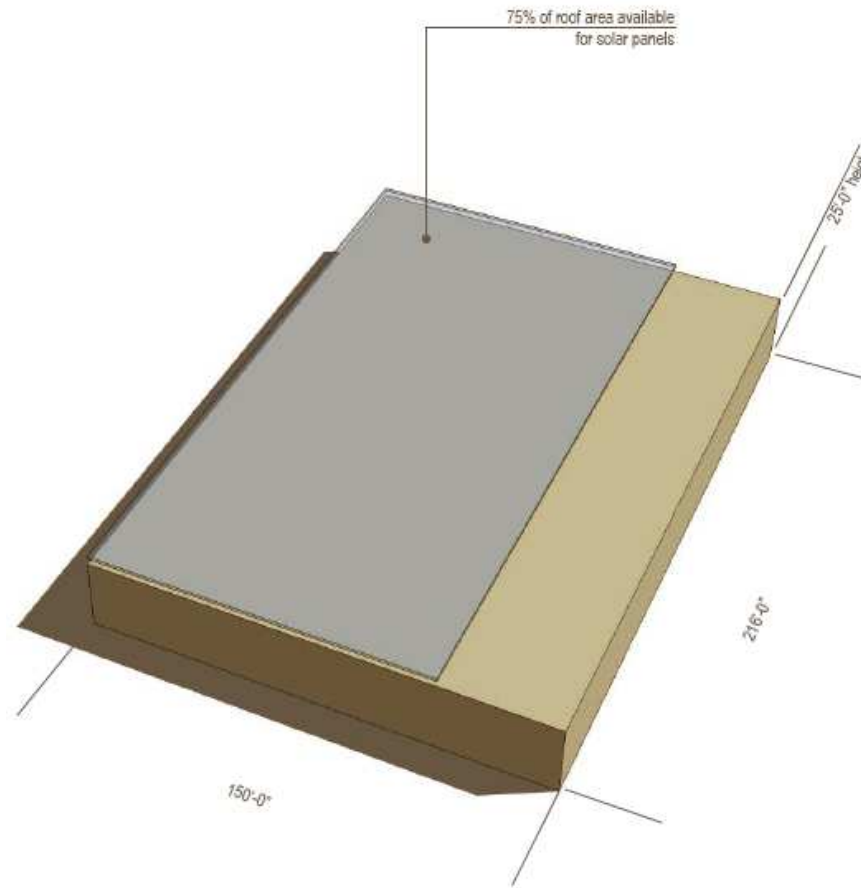


Figure 3. Major Retailer

Table 13. Major Retailer (MR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 4.90	HVAC - COP 6.13	None	None	Alternative 1
Photovoltaics	No PV	PV - 24300 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3
DG	None	DG - 60kW MT w/ 32 ton absorb	None	None	No Alternative
Thermal Strg	None	TS - 70% of max daily cooling load	None	None	No Alternative

Table 14. MR - Alternatives Impact on Utility Costs and Paybacks

Prototype #3 Major Retailer					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$101,893	\$7,292	\$109,184	-	-
Package - Optimum EE	\$91,124	\$5,668	\$96,793	\$50,415	4.1
Package - Optimum EE + PV	\$51,555	\$5,663	\$57,218	\$1,247,840	21.9
CoolRoof - Abs=0.25	\$99,992	\$7,289	\$107,281	\$10,692	5.6
DHW - EF=0.640	\$101,893	\$6,876	\$108,769	\$310	0.7
DHW - EF=0.823	\$101,893	\$5,680	\$107,572	\$371	0.2
Heating - AFUE=85%	\$101,893	\$7,285	\$109,178	\$482	80.3
HVAC - COP 6.13	\$96,201	\$7,292	\$103,493	\$4,496	0.8
PV - 24300 sqft	\$57,935	\$7,299	\$65,234	\$1,208,117	24.6
Roof - U=R15 rigid	\$101,264	\$7,307	\$108,572	\$8,100	13.2
Roof - U=R20 rigid	\$100,889	\$7,306	\$108,195	\$14,580	14.7
Walls - R19 batt	\$101,694	\$7,295	\$108,989	\$1,812	9.3
Walls - R21 batt	\$101,645	\$7,295	\$108,940	\$2,471	10.1
Walls - R21 batt + R5 rigid	\$101,384	\$7,302	\$108,686	\$6,588	13.2
Windows - U=0.43, SHGC=0.39	\$101,045	\$7,293	\$108,338	\$1,501	1.8
Windows - U=0.26, SHGC=0.37	\$101,140	\$7,298	\$108,438	\$4,484	6.0
Windows - U=0.22, SHGC=0.22	\$100,417	\$7,298	\$107,715	\$13,688	9.3
DG - 60kW MT w/ 32 ton absorb	\$83,776	\$20,102	\$104,551	\$106,237	26.8
TS - 70% of max daily cooling load	-	-	\$104,542	\$62,878	13.5

Table 15. MR - Alternatives Impact on Energy Consumption

Prototype #3 Major Retailer					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	669,102	2,283	426	2,709	-
Package - Optimum EE	608,177	2,075	308	2,383	326
Package - Optimum EE + PV	282,626	964	308	1,272	1,437
CoolRoof - Abs=0.25	657,589	2,244	426	2,670	39
DHW - EF=0.640	669,102	2,283	396	2,679	30
DHW - EF=0.823	669,102	2,283	309	2,592	117
Heating - AFUE=85%	669,102	2,283	426	2,709	0
HVAC - COP 6.13	635,823	2,169	426	2,596	113
PV - 24300 sqft	317,321	1,083	427	1,510	1,199
Roof - U=R15 rigid	666,808	2,275	427	2,702	7
Roof - U=R20 rigid	665,328	2,270	427	2,697	12
Walls - R19 batt	668,316	2,280	426	2,707	2
Walls - R21 batt	668,131	2,280	427	2,706	3
Walls - R21 batt + R5 rigid	666,985	2,276	427	2,703	6
Windows - U=0.43, SHGC=0.39	663,956	2,265	426	2,692	17
Windows - U=0.26, SHGC=0.37	664,780	2,268	427	2,695	14
Windows - U=0.22, SHGC=0.22	660,277	2,253	427	2,680	29
DG - 60kW MT w/ 32 ton absorb	556,236	1,898	1,421	3,319	-610
TS - 70% of max daily cooling load	Not Reported				

Table 16. MR Alternatives Impact on TDVI

Prototype #3 Major Retailer					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	32,400	398	14	412	-
Package - Optimum EE	32,400	359	10	369	43
Package - Optimum EE + PV	32,400	114	10	124	288
CoolRoof - Abs=0.25	32,400	391	14	405	7
DHW - EF=0.640	32,400	398	13	411	1
DHW - EF=0.823	32,400	398	10	408	4
Heating - AFUE=85%	32,400	398	14	412	0
HVAC - COP 6.13	32,400	377	14	391	21
PV - 24300 sqft	32,400	149	14	164	248
Roof - U=R15 rigid	32,400	396	14	411	1
Roof - U=R20 rigid	32,400	395	14	410	2
Walls - R19 batt	32,400	397	14	412	0
Walls - R21 batt	32,400	397	14	412	0
Walls - R21 batt + R5 rigid	32,400	396	14	411	1
Windows - U=0.43, SHGC=0.39	32,400	395	14	409	3
Windows - U=0.26, SHGC=0.37	32,400	395	14	410	2
Windows - U=0.22, SHGC=0.22	32,400	392	14	407	5
DG - 60kW MT w/ 32 ton absorb	32,400	322	49	371	41
TS - 70% of max daily cooling load			Not Reported		

2.5. Office Building – Low-Rise

Type III construction, approximately 30,000 sf two-story slab on 15,000 sf grade, typical of a suburban office park. The floor-to-floor height is 13'-0" and 60% of the roof area is available for solar cells.

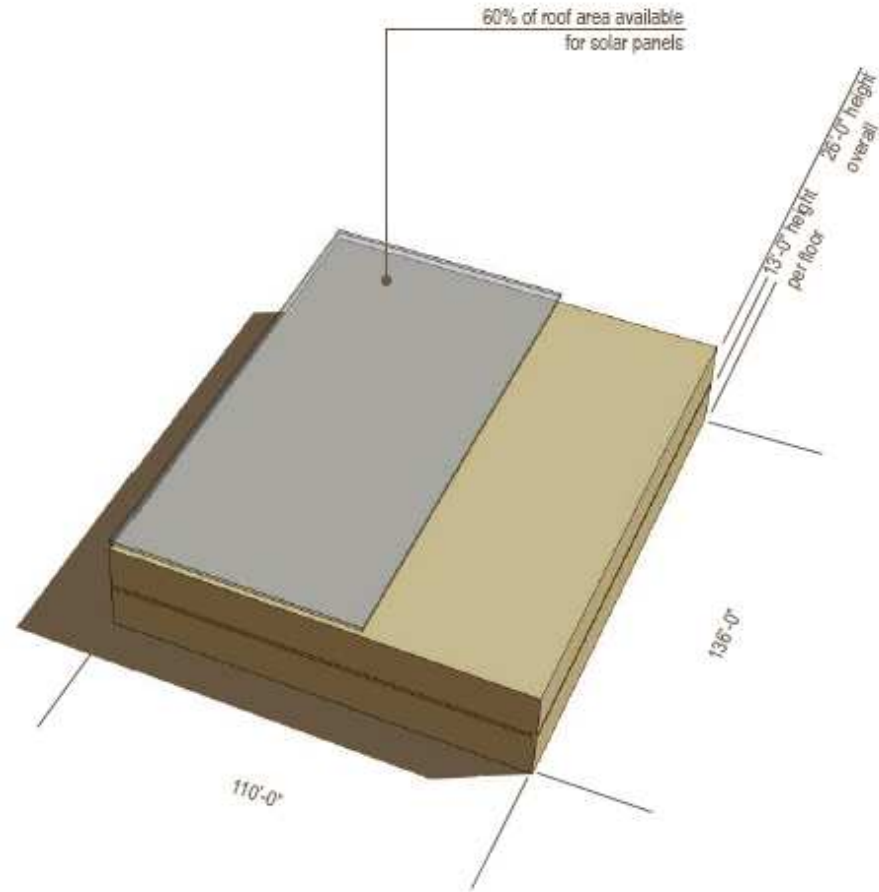


Figure 4. Office Building – Low-Rise

Table 17. Office Building - Low-Rise (OBLR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 8976 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 18. OBLR - Alternatives Impact on Utility Costs and Paybacks

Prototype #4 Office Building - Low-Rise					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$57,790	\$3,179	\$60,969	-	-
Package - Optimum EE	\$48,904	\$2,727	\$51,631	\$90,874	9.7
Package - Optimum EE + PV	\$29,187	\$2,727	\$31,914	\$532,195	17.2
CoolRoof - Abs=0.25	\$57,303	\$3,179	\$60,482	\$4,937	10.1
DHW - EF=0.640	\$57,790	\$3,065	\$60,855	\$620	5.4
DHW - EF=0.823	\$57,790	\$2,727	\$60,517	\$741	1.6
HVAC - EER 12.19, COP 3.52	\$55,995	\$3,179	\$59,174	\$7,807	4.3
HVAC - EER 12.06, COP 3.48	\$56,159	\$3,179	\$59,338	\$23,422	14.4
HVAC - EER 12.80, COP 3.66	\$55,163	\$3,179	\$58,342	\$39,037	14.9
Lighting - 0.90 watts/sf	\$54,017	\$3,179	\$57,196	\$0	0.0
PV - 8976 sqft	\$37,216	\$3,179	\$40,395	\$446,258	19.4
Roof - U=R15 rigid	\$57,633	\$3,179	\$60,812	\$3,740	23.8
Roof - U=R20 rigid	\$57,507	\$3,179	\$60,686	\$6,732	23.8
Walls - R19 batt	\$57,743	\$3,179	\$60,922	\$844	18.0
Walls - R21 batt	\$57,735	\$3,179	\$60,914	\$1,151	20.9
Walls - R21 batt + R5 rigid	\$57,709	\$3,179	\$60,888	\$3,070	37.9
Windows - U=0.43, SHGC=0.39	\$57,807	\$3,179	\$60,986	\$4,196	Never
Windows - U=0.26, SHGC=0.37	\$57,715	\$3,179	\$60,894	\$12,537	167.2
Windows - U=0.22, SHGC=0.22	\$55,447	\$3,179	\$58,626	\$38,275	16.3

Table 19. OBLR - Alternatives Impact on Energy Consumption

Prototype #4 Office Building - Low-Rise					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	332,469	1,134	249	1,384	-
Package - Optimum EE	285,304	973	215	1,188	196
Package - Optimum EE + PV	140,418	479	215	694	690
CoolRoof - Abs=0.25	330,023	1,126	249	1,375	9
DHW - EF=0.640	332,469	1,134	241	1,375	9
DHW - EF=0.823	332,469	1,134	215	1,349	35
HVAC - EER 12.19, COP 3.52	324,079	1,106	249	1,355	29
HVAC - EER 12.06, COP 3.48	324,940	1,109	249	1,358	26
HVAC - EER 12.80, COP 3.66	320,072	1,092	249	1,341	43
Lighting - 0.90 watts/sf	311,084	1,061	249	1,311	73
PV - 8976 sqft	186,338	636	249	885	499
Roof - U=R15 rigid	332,158	1,133	249	1,383	1
Roof - U=R20 rigid	331,336	1,131	249	1,380	4
Walls - R19 batt	332,247	1,134	249	1,383	1
Walls - R21 batt	332,188	1,133	249	1,383	1
Walls - R21 batt + R5 rigid	332,098	1,133	249	1,382	2
Windows - U=0.43, SHGC=0.39	332,691	1,135	249	1,384	0
Windows - U=0.26, SHGC=0.37	332,701	1,135	249	1,384	0
Windows - U=0.22, SHGC=0.22	320,189	1,092	249	1,342	42

Table 20. OBLR - Alternatives Impact on TDVI

Prototype #4 Office Building - Low-Rise					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	29,920	214	9	223	-
Package - Optimum EE	29,920	182	8	190	33
Package - Optimum EE + PV	29,920	84	8	92	131
CoolRoof - Abs=0.25	29,920	212	9	221	2
DHW - EF=0.640	29,920	214	9	223	0
DHW - EF=0.823	29,920	214	8	222	1
HVAC - EER 12.19, COP 3.52	29,920	208	9	217	6
HVAC - EER 12.06, COP 3.48	29,920	209	9	218	5
HVAC - EER 12.80, COP 3.66	29,920	205	9	214	9
Lighting - 0.90 watts/sf	29,920	200	9	209	14
PV - 8976 sqft	29,920	115	9	124	99
Roof - U=R15 rigid	29,920	214	9	223	0
Roof - U=R20 rigid	29,920	213	9	222	1
Walls - R19 batt	29,920	214	9	223	0
Walls - R21 batt	29,920	214	9	223	0
Walls - R21 batt + R5 rigid	29,920	214	9	223	0
Windows - U=0.43, SHGC=0.39	29,920	214	9	223	0
Windows - U=0.26, SHGC=0.37	29,920	214	9	223	0
Windows - U=0.22, SHGC=0.22	29,920	205	9	215	8

2.6. Office Building – Mid-Rise

Type II construction, approximately 100,000 sf four-story slab on 25,000 sf grade, typical of a suburban office park. The floor-to-floor height is 13'-0" and 60% of the roof area available for solar cells.

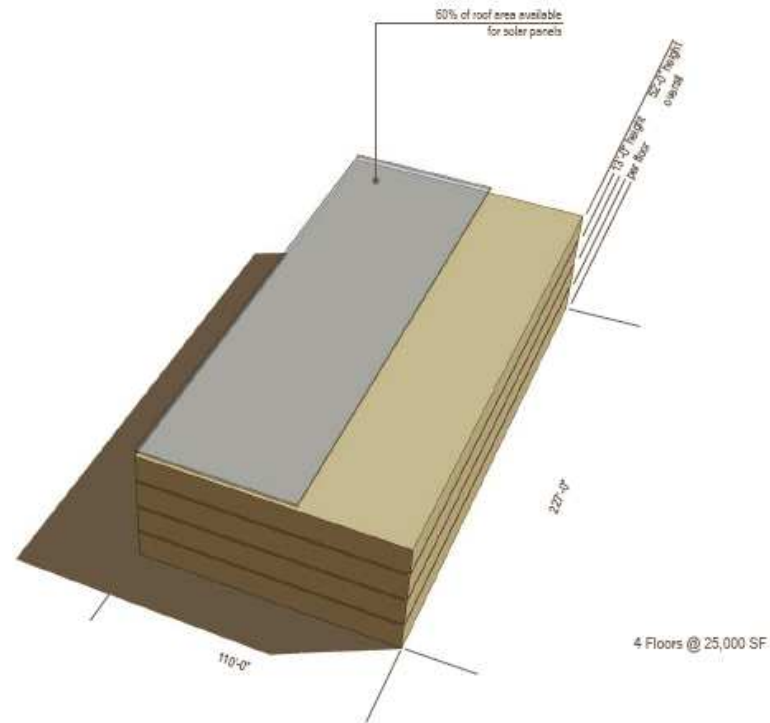


Figure 5. Office Building – Mid-Rise

Table 21. Office Building - Mid-Rise (OBMR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 4.90	HVAC - COP 6.13	None	None	Alternative 1
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 14982 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - R15 rigid	Roof - R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3
DG	None	DG - 180 kW MT w/ 78 ton absorb	None	None	No Alternative
Thermal Strg	None	TS - 65% of max daily cooling load	None	None	No Alternative

Table 22. OBMR - Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Office Building - Mid-Rise					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$219,910	\$13,085	\$232,995	-	-
Package - Optimum EE	\$181,419	\$11,385	\$192,805	\$136,780	3.4
Package - Optimum EE + PV	\$147,838	\$11,383	\$159,221	\$873,397	11.7
CoolRoof - Abs=0.25	\$218,164	\$13,088	\$231,252	\$8,240	4.7
DHW - EF=0.640	\$219,910	\$12,677	\$232,586	\$620	1.5
DHW - EF=0.823	\$219,910	\$11,509	\$231,419	\$741	0.5
Heating - AFUE=85%	\$219,910	\$13,056	\$232,966	\$3,113	107.3
HVAC - COP 6.13	\$208,294	\$13,085	\$221,379	\$5,602	0.5
Lighting - 0.90 watts/sf	\$205,226	\$13,116	\$218,341	\$0	0.0
PV - 14982 sqft	\$183,667	\$13,085	\$196,752	\$744,856	19.5
Roof - R15 rigid	\$219,254	\$13,040	\$232,294	\$6,243	8.9
Roof - R20 rigid	\$218,762	\$13,008	\$231,769	\$11,237	9.2
Walls - R19 batt	\$219,697	\$13,060	\$232,757	\$2,313	9.7
Walls - R21 batt	\$219,676	\$13,056	\$232,733	\$3,154	12.0
Walls - R21 batt + R5 rigid	\$219,498	\$13,034	\$232,532	\$6,098	13.2
Windows - U=0.43, SHGC=0.39	\$219,753	\$13,030	\$232,783	\$11,496	54.2
Windows - U=0.26, SHGC=0.37	\$219,348	\$12,965	\$232,314	\$34,347	50.4
Windows - U=0.22, SHGC=0.22	\$208,107	\$13,012	\$221,119	\$104,862	8.8
DG - 180 kW MT w/ 78 ton absorb	\$104,987	\$102,209	\$212,077	\$267,538	17.8
TS - 65% of max daily cooling load	-	-	\$221,873	\$138,483	12.5

Table 23. OBM - Alternatives Impact on Energy Consumption

Prototype #5 Office Building - Mid-Rise					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	1,255,518	4,284	849	5,133	-
Package - Optimum EE	1,049,509	3,581	724	4,305	828
Package - Optimum EE + PV	828,819	2,828	724	3,552	1,581
CoolRoof - Abs=0.25	1,245,931	4,251	849	5,100	33
DHW - EF=0.640	1,255,518	4,284	819	5,103	30
DHW - EF=0.823	1,255,518	4,284	734	5,018	115
Heating - AFUE=85%	1,255,518	4,284	847	5,131	2
HVAC - COP 6.13	1,196,117	4,081	849	4,930	203
Lighting - 0.90 watts/sf	1,171,319	3,997	851	4,848	285
PV - 14982 sqft	1,028,241	3,508	849	4,357	776
Roof - R15 rigid	1,252,773	4,274	846	5,120	13
Roof - R20 rigid	1,250,958	4,268	843	5,111	22
Walls - R19 batt	1,254,671	4,281	847	5,128	5
Walls - R21 batt	1,254,584	4,281	847	5,128	5
Walls - R21 batt + R5 rigid	1,253,766	4,278	845	5,123	10
Windows - U=0.43, SHGC=0.39	1,255,808	4,285	845	5,130	3
Windows - U=0.26, SHGC=0.37	1,255,242	4,283	840	5,123	10
Windows - U=0.22, SHGC=0.22	1,192,964	4,070	843	4,914	219
DG - 180 kW MT w/ 78 ton absorb	525,098	1,792	8,630	10,422	-5,289
TS - 65% of max daily cooling load			Not Reported		

Table 24. OBM - Alternatives Impact on TDVI

Prototype #5 Office Building - Mid-Rise					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	99,880	244	9	253	-
Package - Optimum EE	99,880	202	8	210	3
Package - Optimum EE + PV	99,880	153	8	161	12
CoolRoof - Abs=0.25	99,880	242	9	251	5
DHW - EF=0.640	99,880	244	9	253	2
DHW - EF=0.823	99,880	244	8	252	0
Heating - AFUE=85%	99,880	244	9	253	107
HVAC - COP 6.13	99,880	232	9	241	0
Lighting - 0.90 watts/sf	99,880	228	9	237	0
PV - 14982 sqft	99,880	194	9	204	20
Roof - R15 rigid	99,880	243	9	253	9
Roof - R20 rigid	99,880	243	9	252	9
Walls - R19 batt	99,880	244	9	253	10
Walls - R21 batt	99,880	244	9	253	12
Walls - R21 batt + R5 rigid	99,880	243	9	253	13
Windows - U=0.43, SHGC=0.39	99,880	244	9	253	54
Windows - U=0.26, SHGC=0.37	99,880	244	9	253	50
Windows - U=0.22, SHGC=0.22	99,880	231	9	240	9
DG - 180 kW MT w/ 78 ton absorb	99,880	103	96	198	18
TS - 65% of max daily cooling load	99,880		Not Reported		12

2.7. Office Building – High-Rise

Type I construction, approximately 225,000 sf nine-story at 25,000 sf per floor, two floors of subterranean parking. The floor-to-floor height is 13'-6" and 25% of the roof area is available for solar cells.

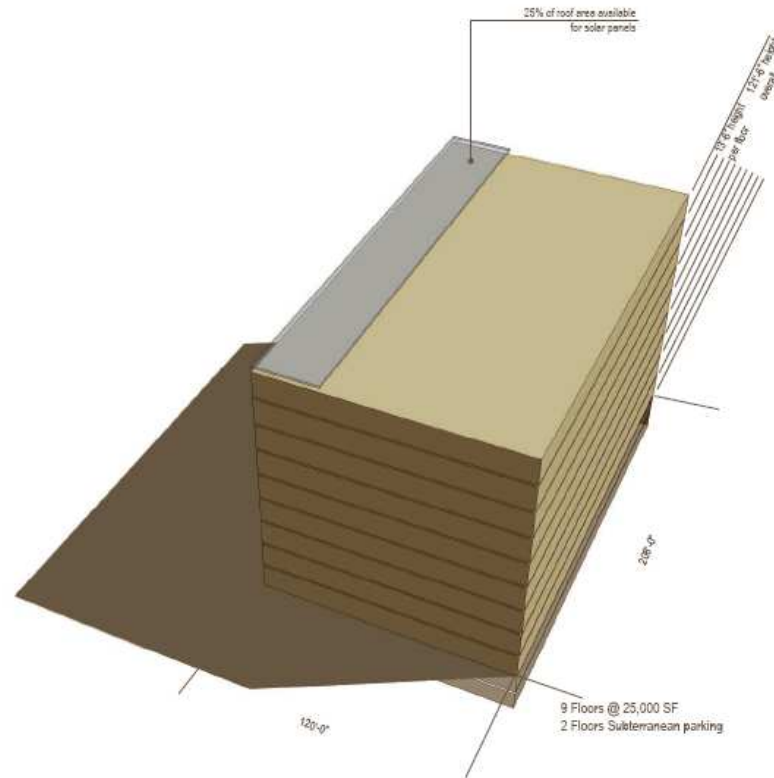


Figure 6. Office Building – High-Rise

Table 25 Office Building - High-Rise (OBHR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 6.10	HVAC - COP 7.63	None	None	Alternative 1
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 5616 sqft	None	None	Alternative 1
Roof Insulation	Roof - Light wt. Concrete	Roof R5 rigid	Roof R10 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3
DG	None	DG - 800 kW Eng w/ 177 ton absorb	None	None	Alternative 1
Thermal Strg	None	TS - 55% of max daily cooling load	None	None	No Alternative

Table 26. OBHR Alternatives Impact on Utility Costs and Paybacks

Prototype #6 Office Building - High-Rise					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$536,318	\$26,576	\$562,894	-	-
Package - Optimum EE	\$462,457	\$22,968	\$485,426	\$281,601	3.6
Package - Optimum EE + PV	\$448,746	\$22,851	\$471,597	\$553,397	6.1
Package - Optimum EE + DG	\$135,471	\$248,886	\$384,356	\$1,099,699	6.2
CoolRoof - Abs=0.25	\$534,868	\$26,685	\$561,553	\$7,413	5.5
DHW - EF=0.640	\$536,318	\$25,830	\$562,149	\$1,239	1.7
DHW - EF=0.823	\$536,318	\$23,693	\$560,011	\$1,483	0.5
Heating - AFUE=85%	\$536,318	\$26,431	\$562,750	\$5,587	38.8
HVAC - COP 7.63	\$516,287	\$26,576	\$542,863	\$33,308	1.7
Lighting - 0.90 watts/sf	\$507,155	\$26,690	\$533,845	\$0	0.0
PV - 5616 sqft	\$519,585	\$26,576	\$546,160	\$279,209	16.7
Roof R5 rigid	\$536,530	\$26,370	\$562,900	\$5,616	Never
Roof R10 rigid	\$536,689	\$26,330	\$563,019	\$10,109	Never
Walls - R19 batt	\$535,625	\$26,439	\$562,064	\$4,990	6.0
Walls - R21 batt	\$535,393	\$26,390	\$561,783	\$6,805	6.1
Walls - R21 batt + R5 rigid	\$533,781	\$26,134	\$559,915	\$13,157	4.4
Windows - U=0.43, SHGC=0.39	\$535,700	\$26,223	\$561,923	\$24,802	25.5
Windows - U=0.26, SHGC=0.37	\$535,638	\$25,823	\$561,461	\$74,103	51.7
Windows - U=0.22, SHGC=0.22	\$512,457	\$25,908	\$538,365	\$226,240	9.2
DG - 800 kW Eng w/ 177 ton absorb	\$150,079	\$275,477	\$425,555	\$818,098	7.4
TS - 55% of max daily cooling load	-	-	\$548,060	\$264,297	17.8

Table 27. OBHR Alternatives Impact on Energy Consumption

Prototype #6 Office Building - High-Rise					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	3,167,371	10,807	1,972	12,779	-
Package - Optimum EE	2,750,753	9,386	1,651	11,036	38
Package - Optimum EE + PV	2,667,247	9,101	1,640	10,741	45
Package - Optimum EE + DG	684,148	2,334	21,807	24,141	0
CoolRoof - Abs=0.25	3,159,191	10,779	1,982	12,761	0
DHW - EF=0.640	3,167,371	10,807	1,906	12,713	0
DHW - EF=0.823	3,167,371	10,807	1,715	12,522	1
Heating - AFUE=85%	3,167,371	10,807	1,960	12,767	0
HVAC - COP 7.63	3,064,212	10,455	1,972	12,427	9
Lighting - 0.90 watts/sf	2,997,716	10,228	1,983	12,211	14
PV - 5616 sqft	3,065,739	10,460	1,972	12,433	9
Roof R5 rigid	3,167,991	10,809	1,954	12,763	0
Roof R10 rigid	3,168,821	10,812	1,950	12,762	0
Walls - R19 batt	3,165,485	10,801	1,960	12,761	0
Walls - R21 batt	3,165,240	10,800	1,956	12,756	0
Walls - R21 batt + R5 rigid	3,161,814	10,788	1,933	12,721	1
Windows - U=0.43, SHGC=0.39	3,168,383	10,811	1,941	12,752	0
Windows - U=0.26, SHGC=0.37	3,180,638	10,852	1,905	12,757	-1
Windows - U=0.22, SHGC=0.22	3,022,895	10,314	1,913	12,227	12
DG - 800 kW Eng w/ 177 ton absorb	794,409	2,711	24,203	26,914	102
TS - 55% of max daily cooling load	Not Reported				

Table 28. OBHR Alternatives Impact on TDVI

Prototype #6 Office Building - High-Rise					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	224,640	271	10	280	-
Package - Optimum EE	224,640	234	8	242	38
Package - Optimum EE + PV	224,640	227	8	235	45
Package - Optimum EE + DG	224,640	50	107	158	0
CoolRoof - Abs=0.25	224,640	270	10	280	0
DHW - EF=0.640	224,640	271	9	280	0
DHW - EF=0.823	224,640	271	8	279	1
Heating - AFUE=85%	224,640	271	10	280	0
HVAC - COP 7.63	224,640	261	10	271	9
Lighting - 0.90 watts/sf	224,640	256	10	266	14
PV - 5616 sqft	224,640	262	10	271	9
Roof R5 rigid	224,640	271	10	280	0
Roof R10 rigid	224,640	271	10	280	0
Walls - R19 batt	224,640	271	10	280	0
Walls - R21 batt	224,640	271	10	280	0
Walls - R21 batt + R5 rigid	224,640	270	9	279	1
Windows - U=0.43, SHGC=0.39	224,640	271	9	280	0
Windows - U=0.26, SHGC=0.37	224,640	271	9	281	-1
Windows - U=0.22, SHGC=0.22	224,640	259	9	268	12
DG - 800 kW Eng w/ 177 ton absorb	224,640	59	119	178	102
TS - 55% of max daily cooling load	224,640	0	0	0	0

2.8. Large Hotel – Hotel Space

Type II construction, approximately 171,000 sf, six-story slab on 54,000 sf grade. First floor at 16,000 sf includes a 7,400 sf restaurant and meeting rooms. Five upper floors at 16,000 sf each are guest rooms. Two-story adjacent sports club at 37,500 sf per floor. The floor-to-floor height is 14'-0" except guest rooms are 9'-6". 45% of the roof area is available for solar panels.

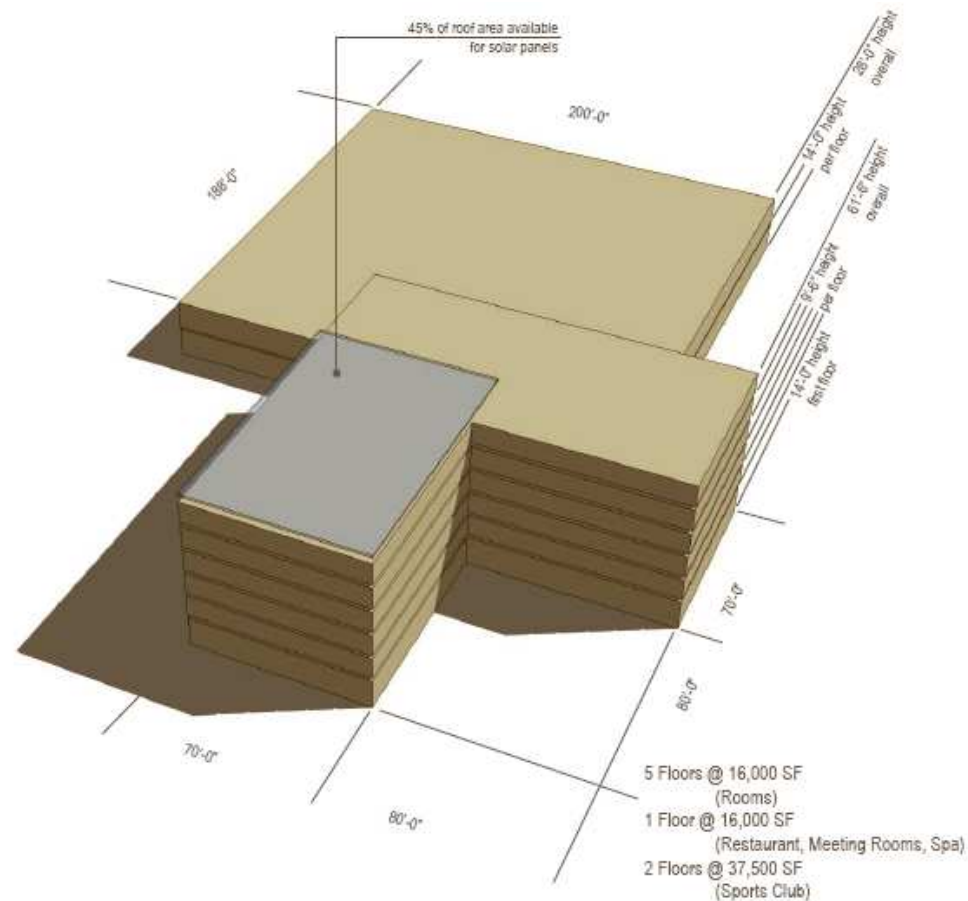


Figure 7. Large Hotel

Table 29. Large Hotel - Hotel Space (LHHS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	Alternative 1
Space Cooling	HVAC - COP 6.10	HVAC - COP 7.63	None	None	Alternative 1
Lighting	Lighting - 1.40 watts/sf	Lighting - 1.19 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 7199 sqft	None	None	Alternative 1
Roof Insulation	Roof - R20 rigid	Roof - R25 rigid	Roof - R30 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	None	No Alternative
DG	None	DG - 120 kW MT w/ 35 ton absorb	None	None	No Alternative
Thermal Strg	None	TS - 20% of max daily cooling load	None	None	No Alternative

Table 30. LHHS Alternatives Impact on Utility Costs and Paybacks

Prototype #7 Large Hotel - Hotel Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$202,183	\$57,107	\$259,289	-	-
Package - Optimum EE	\$186,438	\$47,260	\$233,698	\$74,975	2.9
Package - Optimum EE + PV	\$172,118	\$47,260	\$219,378	\$432,868	11.0
CoolRoof - Abs=0.25	\$202,386	\$58,223	\$260,609	\$5,279	Never
DHW - EF=0.640	\$202,183	\$54,924	\$257,107	\$2,168	1.0
DHW - EF=0.823	\$202,183	\$48,653	\$250,836	\$2,594	0.3
Heating - AFUE=85%	\$202,183	\$55,709	\$257,892	\$1,157	0.8
HVAC - COP 7.63	\$196,088	\$57,107	\$253,194	\$11,374	1.9
Lighting - 1.19 watts/sf	\$192,293	\$57,117	\$249,409	\$59,850	6.1
PV - 7199 sqft	\$185,145	\$57,107	\$242,252	\$357,894	21.0
Roof - R25 rigid	\$202,164	\$57,108	\$259,272	\$3,999	235.3
Roof - R30 rigid	\$202,158	\$57,110	\$259,267	\$7,199	327.2
Walls - R19 batt	\$202,255	\$57,051	\$259,306	\$2,511	Never
Walls - R21 batt	\$202,286	\$57,032	\$259,318	\$6,620	Never
Walls - R21 batt + R5 rigid	\$202,364	\$56,967	\$259,331	\$6,620	Never
Windows - U=0.26, SHGC=0.37	\$202,392	\$57,002	\$259,394	\$35,726	Never
Windows - U=0.22, SHGC=0.22	\$196,913	\$57,289	\$254,202	\$109,073	21.4
DG - 120 kW MT w/ 35 ton absorb	-	-	\$252,597	\$107,971	60.4
TS - 20% of max daily cooling load	-	-	\$256,470	\$43,791	15.5

Table 31. LHHS Alternatives Impact on Energy Consumption

Prototype #7 Large Hotel - Hotel Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	1,472,537	5,024	4,698	9,722	-
Package - Optimum EE	1,366,154	4,661	3,819	8,480	1,242
Package - Optimum EE + PV	1,248,903	4,261	3,819	8,080	1,642
CoolRoof - Abs=0.25	1,474,051	5,029	4,797	9,826	-104
DHW - EF=0.640	1,472,537	5,024	4,503	9,527	195
DHW - EF=0.823	1,472,537	5,024	3,943	8,967	755
Heating - AFUE=85%	1,472,537	5,024	4,573	9,597	125
HVAC - COP 7.63	1,431,645	4,885	4,698	9,582	140
Lighting - 1.19 watts/sf	1,405,196	4,795	4,699	9,493	229
PV - 7199 sqft	1,332,956	4,548	4,698	9,246	476
Roof - R25 rigid	1,472,607	5,025	4,698	9,722	0
Roof - R30 rigid	1,472,681	5,025	4,698	9,722	0
Walls - R19 batt	1,473,413	5,027	4,692	9,720	2
Walls - R21 batt	1,473,740	5,028	4,691	9,719	3
Walls - R21 batt + R5 rigid	1,474,734	5,032	4,685	9,717	5
Windows - U=0.26, SHGC=0.37	1,476,249	5,037	4,688	9,725	-3
Windows - U=0.22, SHGC=0.22	1,435,843	4,899	4,714	9,613	109
DG - 120 kW MT w/ 35 ton absorb	Not Reported				
TS - 20% of max daily cooling load	Not Reported				

Table 32. LHHS Alternatives Impact on TDVI

Prototype #7 Large Hotel - Hotel Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	114,266	233	45	278	-
Package - Optimum EE	114,266	215	37	252	26
Package - Optimum EE + PV	114,266	195	37	231	47
CoolRoof - Abs=0.25	114,266	233	46	279	-1
DHW - EF=0.640	114,266	233	43	276	2
DHW - EF=0.823	114,266	233	38	271	7
Heating - AFUE=85%	114,266	233	44	277	1
HVAC - COP 7.63	114,266	226	45	271	7
Lighting - 1.19 watts/sf	114,266	222	45	267	11
PV - 7199 sqft	114,266	208	45	253	25
Roof - R25 rigid	114,266	233	45	278	0
Roof - R30 rigid	114,266	233	45	278	0
Walls - R19 batt	114,266	233	45	278	0
Walls - R21 batt	114,266	233	45	278	0
Walls - R21 batt + R5 rigid	114,266	233	45	278	0
Windows - U=0.26, SHGC=0.37	114,266	233	45	278	0
Windows - U=0.22, SHGC=0.22	114,266	227	45	272	6
DG - 120 kW MT w/ 35 ton absorb			Not Reported		
TS - 20% of max daily cooling load			Not Reported		

2.9. Large Hotel – Restaurant Space

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=80%	Heating - AFUE=94%	None	None	Alternative 1
Space Cooling	HVAC - EER 9.5	HVAC - EER 10.5	HVAC - EER 11.5	HVAC - EER 12.5	Alternative 3
Photovoltaics	No PV	PV - 3698 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 1
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	No Alternative

Table 33. Large Hotel – Restaurant Space (LHRS) Alternatives

Table 34. LHRS Alternatives Impact on Utility Costs and Paybacks

Prototype #7 Large Hotel - Restaurant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	332,563	1,135	1,867	3,002	-
Package - Optimum EE	322,385	1,100	1,675	2,775	227
Package - Optimum EE + PV	262,161	894	1,675	2,569	433
CoolRoof - Abs=0.25	331,885	1,132	1,872	3,004	-2
DHW - EF=0.640	332,563	1,135	1,831	2,966	36
DHW - EF=0.823	332,563	1,135	1,729	2,864	138
Heating - AFUE=94%	332,563	1,135	1,812	2,947	55
HVAC - EER 10.5	328,551	1,121	1,867	2,988	14
HVAC - EER 11.5	325,236	1,110	1,867	2,977	25
HVAC - EER 12.5	322,452	1,100	1,867	2,967	35
PV - 3698 sqft	272,338	929	1,867	2,796	206
Roof - U=R15 rigid	333,078	1,136	1,858	2,994	8
Roof - U=R20 rigid	333,342	1,137	1,855	2,992	10
Walls - R19 batt	332,503	1,135	1,867	3,002	0
Walls - R21 batt	332,496	1,134	1,868	3,002	0
Walls - R21 batt + R5 rigid	332,504	1,135	1,868	3,002	0
Windows - U=0.43, SHGC=0.39	332,450	1,134	1,867	3,002	0
Windows - U=0.26, SHGC=0.37	332,337	1,134	1,863	2,997	5
Windows - U=0.22, SHGC=0.22	332,997	1,136	1,883	3,019	-17

Table 35. LHRs Alternatives Impact on Energy Consumption

Prototype #7 Large Hotel - Restaurant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$48,644	\$25,387	\$74,030	-	-
Package - Optimum EE	\$46,811	\$23,238	\$70,049	\$21,313	5.4
Package - Optimum EE + PV	\$39,688	\$23,238	\$62,927	\$205,166	19.1
CoolRoof - Abs=0.25	\$48,525	\$25,446	\$73,971	\$2,441	41.4
DHW - EF=0.640	\$48,644	\$24,989	\$73,632	\$620	1.6
DHW - EF=0.823	\$48,644	\$23,844	\$72,488	\$741	0.5
Heating - AFUE=94%	\$48,644	\$24,775	\$73,419	\$1,000	1.6
HVAC - EER 10.5	\$47,924	\$25,387	\$73,311	\$16,098	22.4
HVAC - EER 11.5	\$47,329	\$25,387	\$72,716	\$18,007	13.7
HVAC - EER 12.5	\$46,830	\$25,387	\$72,217	\$19,178	10.6
PV - 3698 sqft	\$41,486	\$25,387	\$66,872	\$183,853	25.7
Roof - U=R15 rigid	\$48,696	\$25,288	\$73,984	\$1,849	40.2
Roof - U=R20 rigid	\$48,734	\$25,254	\$73,988	\$3,328	79.2
Walls - R19 batt	\$48,623	\$25,393	\$74,016	\$394	28.1
Walls - R21 batt	\$48,621	\$25,394	\$74,016	\$537	38.3
Walls - R21 batt + R5 rigid	\$48,612	\$25,398	\$74,009	\$1,431	68.1
Windows - U=0.43, SHGC=0.39	\$48,615	\$25,396	\$74,011	\$733	38.6
Windows - U=0.26, SHGC=0.37	\$48,593	\$25,343	\$73,935	\$19,178	201.9
Windows - U=0.22, SHGC=0.22	\$48,740	\$25,574	\$74,314	\$19,178	Never

Table 36. LHRs Alternatives Impact on TDVI

Prototype #7 Large Hotel - Restaurant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	7,396	844	277	1,121	-
Package - Optimum EE	7,396	815	248	1,063	58
Package - Optimum EE + PV	7,396	650	248	898	223
CoolRoof - Abs=0.25	7,396	843	278	1,120	1
DHW - EF=0.640	7,396	844	272	1,116	5
DHW - EF=0.823	7,396	844	256	1,101	20
Heating - AFUE=94%	7,396	844	269	1,113	8
HVAC - EER 10.5	7,396	833	277	1,110	11
HVAC - EER 11.5	7,396	823	277	1,100	21
HVAC - EER 12.5	7,396	815	277	1,092	29
PV - 3698 sqft	7,396	679	277	956	165
Roof - U=R15 rigid	7,396	846	276	1,121	0
Roof - U=R20 rigid	7,396	846	275	1,122	-1
Walls - R19 batt	7,396	844	277	1,121	0
Walls - R21 batt	7,396	844	277	1,121	0
Walls - R21 batt + R5 rigid	7,396	844	277	1,121	0
Windows - U=0.43, SHGC=0.39	7,396	844	277	1,121	0
Windows - U=0.26, SHGC=0.37	7,396	844	276	1,120	1
Windows - U=0.22, SHGC=0.22	7,396	846	279	1,126	-5

2.10. Small Hotel – Hotel Space

Type III construction, approximately 152,000 sf three-story slab on 102,600 sf grade. Guest rooms and commercial space are located at upper two levels. The first level includes a 7,400 sf restaurant, retail and the hotel lobby. Interior floor space demised to accommodate 19 individual retail tenants at street level averaging 2,700 sf each. The first level floor-to-floor height is 20'-0". The guest room levels are 9'-6". 60% of the roof area is available for solar cells. Adjacent to the hotel complex is a two-story parking structure, approximately 68,000 sf.

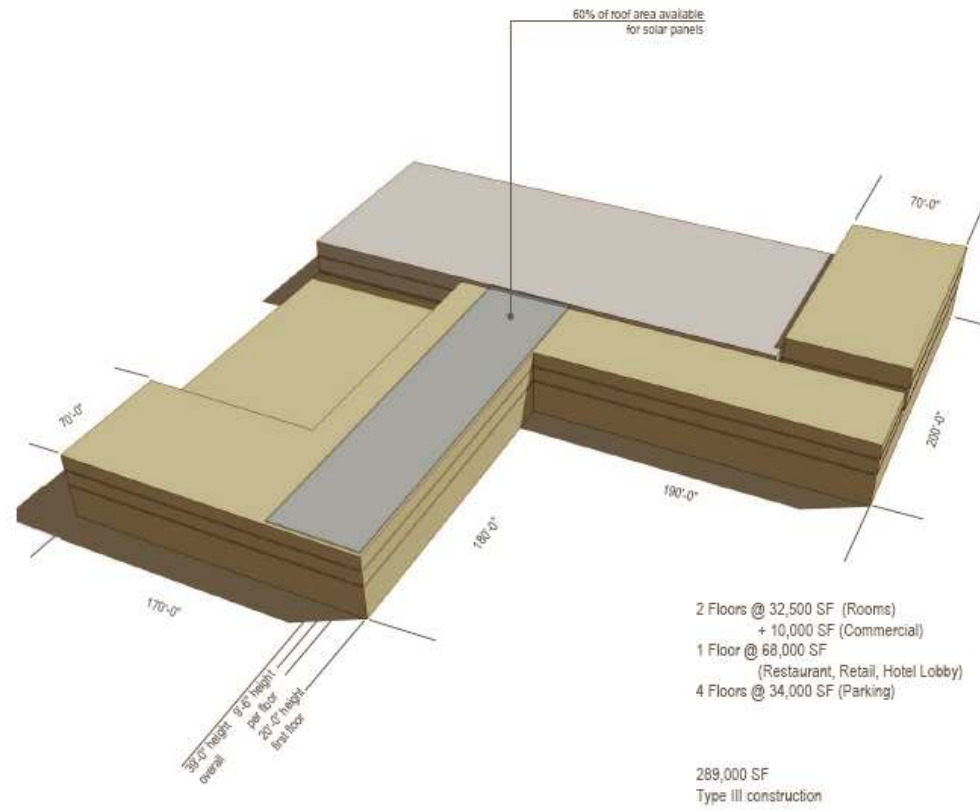


Figure 8. Small Hotel

Table 37. Small Hotel – Hotel Space (SHHS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	Alternative 1
Space Cooling	HVAC - COP 6.10	HVAC - COP 7.63	None	None	Alternative 1
Lighting	Lighting - 1.40 watts/sf	Lighting - 1.19 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 11391 sqft	None	None	Alternative 1
Roof Insulation	Roof - R20 rigid	Roof - R25 rigid	Roof - R30 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	None	No Alternative

Table 38. SHHS Alternatives Impact on Utility Costs and Paybacks

Prototype #8 Small Hotel - Hotel Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$131,231	\$45,478	\$176,710	-	-
Package - Optimum EE	\$121,210	\$37,570	\$158,780	\$68,415	3.8
Package - Optimum EE + PV	\$98,960	\$37,570	\$136,530	\$634,753	16.2
DHW - EF=0.640	\$131,231	\$43,750	\$174,981	\$1,859	1.1
DHW - EF=0.823	\$131,231	\$38,789	\$170,021	\$2,224	0.3
Heating - AFUE=85%	\$131,231	\$44,251	\$175,483	\$953	0.8
HVAC - COP 7.63	\$127,378	\$45,478	\$172,856	\$7,964	2.1
Lighting - 1.19 watts/sf	\$124,915	\$45,483	\$170,398	\$48,600	7.7
PV - 11391 sqft	\$103,249	\$45,478	\$148,728	\$566,339	20.1
Roof - R25 rigid	\$131,219	\$45,479	\$176,699	\$6,329	575.3
Roof - R30 rigid	\$131,404	\$45,476	\$176,880	\$11,391	Never
Walls - R19 batt	\$131,203	\$45,412	\$176,615	\$2,385	25.1
Walls - R21 batt	\$131,183	\$45,399	\$176,582	\$3,253	25.4
Walls - R21 batt + R5 rigid	\$131,091	\$45,350	\$176,441	\$8,674	32.2
Windows - U=0.26, SHGC=0.37	\$131,394	\$45,380	\$176,773	\$22,584	Never
Windows - U=0.22, SHGC=0.22	\$127,922	\$45,641	\$173,562	\$68,951	21.9

Table 39. SHHS Alternatives Impact on Energy Consumption

Prototype #8 Small Hotel - Hotel Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	952,639	3,250	3,660	6,910	-
Package - Optimum EE	885,766	3,022	2,954	5,976	934
Package - Optimum EE + PV	700,295	2,389	2,954	5,344	1,566
DHW - EF=0.640	952,639	3,250	3,506	6,756	154
DHW - EF=0.823	952,639	3,250	3,063	6,314	596
Heating - AFUE=85%	952,639	3,250	3,551	6,801	109
HVAC - COP 7.63	927,470	3,165	3,660	6,825	85
Lighting - 1.19 watts/sf	909,740	3,104	3,660	6,764	146
PV - 11391 sqft	719,217	2,454	3,660	6,114	796
Roof - R25 rigid	952,947	3,251	3,660	6,911	-1
Roof - R30 rigid	953,927	3,255	3,660	6,915	-5
Walls - R19 batt	953,033	3,252	3,654	6,906	4
Walls - R21 batt	953,062	3,252	3,653	6,904	6
Walls - R21 batt + R5 rigid	952,927	3,251	3,648	6,900	10
Windows - U=0.26, SHGC=0.37	955,394	3,260	3,651	6,911	-1
Windows - U=0.22, SHGC=0.22	929,388	3,171	3,675	6,846	64

Table 40. SHHS Alternatives Impact on TDVI

Prototype #8 Small Hotel - Hotel Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	72,327	238	55	294	-
Package - Optimum EE	72,327	221	45	266	28
Package - Optimum EE + PV	72,327	169	45	214	80
DHW - EF=0.640	72,327	238	53	291	3
DHW - EF=0.823	72,327	238	46	285	9
Heating - AFUE=85%	72,327	238	54	292	2
HVAC - COP 7.63	72,327	231	55	287	7
Lighting - 1.19 watts/sf	72,327	228	55	283	11
PV - 11391 sqft	72,327	172	55	228	66
Roof - R25 rigid	72,327	238	55	294	0
Roof - R30 rigid	72,327	239	55	294	0
Walls - R19 batt	72,327	238	55	294	0
Walls - R21 batt	72,327	238	55	294	0
Walls - R21 batt + R5 rigid	72,327	238	55	293	1
Windows - U=0.26, SHGC=0.37	72,327	239	55	294	0
Windows - U=0.22, SHGC=0.22	72,327	232	55	288	6

2.11. Small Hotel – Office Space

Table 41. Small Hotel - Office Space (SHOS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 5005 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R20 rigid	Roof - R25 rigid	Roof - R30 rigid	None	No Alternative
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 42. SHOS Alternatives Impact on Utility Costs and Paybacks

Prototype #8 Small Hotel - Office Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$38,018	\$2,092	\$40,110	-	-
Package - Optimum EE	\$32,729	\$1,787	\$34,516	\$46,157	8.3
Package - Optimum EE + PV	\$21,478	\$1,787	\$23,265	\$294,989	16.8
CoolRoof - Abs=0.25	\$37,868	\$2,092	\$39,960	\$3,303	22.0
DHW - EF=0.640	\$38,018	\$2,015	\$40,033	\$620	8.0
DHW - EF=0.823	\$38,018	\$1,787	\$39,805	\$741	2.4
HVAC - EER 12.19, COP 3.52	\$36,841	\$2,092	\$38,933	\$4,845	4.1
HVAC - EER 12.06, COP 3.48	\$36,962	\$2,092	\$39,054	\$14,534	13.8
HVAC - EER 12.80, COP 3.66	\$36,318	\$2,092	\$38,410	\$24,224	14.2
Lighting - 0.90 watts/sf	\$35,445	\$2,092	\$37,537	\$0	0.0
PV - 5005 sqft	\$26,362	\$2,092	\$28,454	\$248,832	19.4
Roof - R25 rigid	\$38,014	\$2,092	\$40,106	\$2,503	625.6
Roof - R30 rigid	\$38,122	\$2,092	\$40,214	\$4,505	Never
Walls - R19 batt	\$38,002	\$2,092	\$40,094	\$2,385	149.1
Walls - R21 batt	\$37,985	\$2,092	\$40,077	\$3,253	98.6
Walls - R21 batt + R5 rigid	\$37,975	\$2,092	\$40,067	\$8,674	201.7
Windows - U=0.43, SHGC=0.39	\$38,044	\$2,092	\$40,136	\$2,323	Never
Windows - U=0.26, SHGC=0.37	\$37,957	\$2,092	\$40,049	\$6,941	113.8
Windows - U=0.22, SHGC=0.22	\$36,634	\$2,092	\$38,726	\$21,191	15.3

Table 43. SHOS Alternatives Impact on Energy Consumption

Prototype #8 Small Hotel - Office Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	218,013	744	167	911	-
Package - Optimum EE	190,128	649	144	792	119
Package - Optimum EE + PV	108,668	371	144	514	397
CoolRoof - Abs=0.25	217,215	741	167	908	3
DHW - EF=0.640	218,013	744	161	905	6
DHW - EF=0.823	218,013	744	144	888	23
HVAC - EER 12.19, COP 3.52	212,482	725	167	892	19
HVAC - EER 12.06, COP 3.48	213,048	727	167	894	17
HVAC - EER 12.80, COP 3.66	210,046	717	167	883	28
Lighting - 0.90 watts/sf	203,336	694	167	861	50
PV - 5005 sqft	136,390	465	167	632	279
Roof - R25 rigid	218,062	744	167	911	0
Roof - R30 rigid	218,518	746	167	912	-1
Walls - R19 batt	218,058	744	167	911	0
Walls - R21 batt	217,947	744	167	910	1
Walls - R21 batt + R5 rigid	217,978	744	167	911	0
Windows - U=0.43, SHGC=0.39	218,390	745	167	912	-1
Windows - U=0.26, SHGC=0.37	218,150	744	167	911	0
Windows - U=0.22, SHGC=0.22	210,882	720	167	886	25

Table 44. SHOS Alternatives Impact on TDVI

Prototype #8 Small Hotel - Office Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	20,020	209	9	218	-
Package - Optimum EE	20,020	181	8	189	29
Package - Optimum EE + PV	20,020	99	8	107	111
CoolRoof - Abs=0.25	20,020	208	9	218	0
DHW - EF=0.640	20,020	209	9	218	0
DHW - EF=0.823	20,020	209	8	217	1
HVAC - EER 12.19, COP 3.52	20,020	203	9	213	5
HVAC - EER 12.06, COP 3.48	20,020	204	9	213	5
HVAC - EER 12.80, COP 3.66	20,020	201	9	210	8
Lighting - 0.90 watts/sf	20,020	195	9	204	14
PV - 5005 sqft	20,020	127	9	136	82
Roof - R25 rigid	20,020	209	9	218	0
Roof - R30 rigid	20,020	210	9	219	-1
Walls - R19 batt	20,020	209	9	218	0
Walls - R21 batt	20,020	209	9	218	0
Walls - R21 batt + R5 rigid	20,020	209	9	218	0
Windows - U=0.43, SHGC=0.39	20,020	209	9	219	-1
Windows - U=0.26, SHGC=0.37	20,020	209	9	218	0
Windows - U=0.22, SHGC=0.22	20,020	202	9	211	7

2.12. Small Hotel – Restaurant Space

Table 45. Small Hotel – Restaurant Space (SHRS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=80%	Heating - AFUE=94%	None	None	Alternative 1
Space Cooling	HVAC - EER 9.5	HVAC - EER 10.5	HVAC - EER 11.5	HVAC - EER 12.5	Alternative 3
Photovoltaics	No PV	PV - 3698 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 2

Table 46. SHRS Alternatives Impact on Utility Costs and Paybacks

Prototype #8 Small Hotel - Restaurant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$48,864	\$25,055	\$73,919	-	-
Package - Optimum EE	\$46,888	\$22,823	\$69,711	\$26,976	6.4
Package - Optimum EE + PV	\$39,749	\$22,823	\$62,572	\$210,828	19.2
CoolRoof - Abs=0.25	\$48,667	\$25,111	\$73,777	\$2,441	17.2
DHW - EF=0.640	\$48,864	\$24,656	\$73,520	\$620	1.6
DHW - EF=0.823	\$48,864	\$23,511	\$72,375	\$741	0.5
Heating - AFUE=94%	\$48,864	\$24,492	\$73,357	\$1,000	1.8
HVAC - EER 10.5	\$48,132	\$25,055	\$73,187	\$16,098	22.0
HVAC - EER 11.5	\$47,537	\$25,055	\$72,591	\$18,007	13.6
HVAC - EER 12.5	\$47,032	\$25,055	\$72,087	\$19,178	10.5
PV - 3698 sqft	\$41,687	\$25,055	\$66,742	\$183,853	25.6
Roof - U=R15 rigid	\$48,844	\$24,985	\$73,830	\$1,849	20.8
Roof - U=R20 rigid	\$48,814	\$24,946	\$73,760	\$3,328	20.9
Walls - R19 batt	\$48,839	\$25,046	\$73,885	\$394	11.6
Walls - R21 batt	\$48,834	\$25,048	\$73,881	\$537	14.1
Walls - R21 batt + R5 rigid	\$48,817	\$25,055	\$73,872	\$1,431	30.4
Windows - U=0.43, SHGC=0.39	\$48,832	\$25,043	\$73,876	\$733	17.1
Windows - U=0.26, SHGC=0.37	\$48,738	\$24,984	\$73,722	\$2,191	11.1
Windows - U=0.22, SHGC=0.22	\$48,616	\$25,222	\$73,837	\$6,690	81.6

Table 47. SHRS Alternatives Impact on Energy Consumption

Prototype #8 Small Hotel - Restaurant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	333,775	1,139	1,837	2,976	-
Package - Optimum EE	323,017	1,102	1,638	2,740	236
Package - Optimum EE + PV	262,792	897	1,638	2,534	442
CoolRoof - Abs=0.25	332,627	1,135	1,842	2,977	-1
DHW - EF=0.640	333,775	1,139	1,801	2,940	36
DHW - EF=0.823	333,775	1,139	1,699	2,838	138
Heating - AFUE=94%	333,775	1,139	1,787	2,925	51
HVAC - EER 10.5	329,740	1,125	1,837	2,962	14
HVAC - EER 11.5	326,407	1,114	1,837	2,951	25
HVAC - EER 12.5	323,606	1,104	1,837	2,941	35
PV - 3698 sqft	273,550	933	1,837	2,770	206
Roof - U=R15 rigid	333,801	1,139	1,831	2,970	6
Roof - U=R20 rigid	333,739	1,139	1,827	2,966	10
Walls - R19 batt	333,648	1,138	1,836	2,975	1
Walls - R21 batt	333,624	1,138	1,836	2,975	1
Walls - R21 batt + R5 rigid	333,538	1,138	1,837	2,975	1
Windows - U=0.43, SHGC=0.39	333,667	1,138	1,836	2,975	1
Windows - U=0.26, SHGC=0.37	333,152	1,137	1,831	2,967	9
Windows - U=0.22, SHGC=0.22	332,126	1,133	1,852	2,985	-9

Table 48. SHRS Alternatives Impact on TDVI

Prototype #8 Small Hotel - Restaurant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	7,396	847	272	1,120	-
Package - Optimum EE	7,396	816	243	1,059	61
Package - Optimum EE + PV	7,396	651	243	894	226
CoolRoof - Abs=0.25	7,396	844	273	1,117	3
DHW - EF=0.640	7,396	847	267	1,114	6
DHW - EF=0.823	7,396	847	252	1,099	21
Heating - AFUE=94%	7,396	847	265	1,112	8
HVAC - EER 10.5	7,396	836	272	1,108	12
HVAC - EER 11.5	7,396	826	272	1,098	22
HVAC - EER 12.5	7,396	818	272	1,090	30
PV - 3698 sqft	7,396	682	272	954	166
Roof - U=R15 rigid	7,396	847	271	1,119	1
Roof - U=R20 rigid	7,396	847	271	1,118	2
Walls - R19 batt	7,396	847	272	1,119	1
Walls - R21 batt	7,396	847	272	1,119	1
Walls - R21 batt + R5 rigid	7,396	847	272	1,119	1
Windows - U=0.43, SHGC=0.39	7,396	847	272	1,119	1
Windows - U=0.26, SHGC=0.37	7,396	846	271	1,117	3
Windows - U=0.22, SHGC=0.22	7,396	843	275	1,118	2

2.13. Small Hotel – External Retail Tenant

Table 49. Small Hotel – External Retail Tenant (SHERT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 50. SHERT Alternatives Impact on Utility Costs and Paybacks

Prototype #8 Small Hotel - External Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$8,112	\$1,939	\$10,051	-	-
Package - Optimum EE	\$6,954	\$1,802	\$8,756	\$9,556	7.4
DHW - EF=0.640	\$8,112	\$1,904	\$10,016	\$310	8.9
DHW - EF=0.823	\$8,112	\$1,802	\$9,914	\$371	2.7
HVAC - EER 12.19, COP 3.52	\$7,830	\$1,939	\$9,769	\$1,172	4.2
HVAC - EER 12.06, COP 3.48	\$7,873	\$1,939	\$9,812	\$3,517	14.7
HVAC - EER 12.80, COP 3.66	\$7,740	\$1,939	\$9,679	\$4,593	12.3
Walls - R19 batt	\$8,103	\$1,939	\$10,042	\$452	50.2
Walls - R21 batt	\$8,102	\$1,939	\$10,041	\$616	61.6
Walls - R21 batt + R5 rigid	\$8,099	\$1,939	\$10,038	\$1,642	126.3
Windows - U=0.43, SHGC=0.39	\$7,754	\$1,939	\$9,693	\$503	1.4
Windows - U=0.26, SHGC=0.37	\$7,718	\$1,939	\$9,657	\$1,504	3.8
Windows - U=0.22, SHGC=0.22	\$7,418	\$1,939	\$9,357	\$4,593	6.6

Table 51. SHERT Alternatives Impact on Energy Consumption

Prototype #8 Small Hotel - External Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	48,403	165	36	201	-
Package - Optimum EE	42,027	143	26	169	32
DHW - EF=0.640	48,403	165	33	198	3
DHW - EF=0.823	48,403	165	26	191	10
HVAC - EER 12.19, COP 3.52	47,256	161	36	197	4
HVAC - EER 12.06, COP 3.48	47,367	162	36	198	3
HVAC - EER 12.80, COP 3.66	46,775	160	36	195	6
Walls - R19 batt	48,495	165	36	201	0
Walls - R21 batt	48,474	165	36	201	0
Walls - R21 batt + R5 rigid	48,525	166	36	201	0
Windows - U=0.43, SHGC=0.39	46,439	158	36	194	7
Windows - U=0.26, SHGC=0.37	46,472	159	36	194	7
Windows - U=0.22, SHGC=0.22	44,857	153	36	189	12

Table 52. SHERT Alternatives Impact on TDVI

Prototype #8 Small Hotel - External Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,752	340	14	354	-
Package - Optimum EE	2,752	293	10	303	7
DHW - EF=0.640	2,752	340	13	353	9
DHW - EF=0.823	2,752	340	10	350	3
HVAC - EER 12.19, COP 3.52	2,752	330	14	344	4
HVAC - EER 12.06, COP 3.48	2,752	331	14	345	15
HVAC - EER 12.80, COP 3.66	2,752	326	14	340	12
Walls - R19 batt	2,752	340	14	354	50
Walls - R21 batt	2,752	340	14	354	62
Walls - R21 batt + R5 rigid	2,752	340	14	354	126
Windows - U=0.43, SHGC=0.39	2,752	325	14	339	1
Windows - U=0.26, SHGC=0.37	2,752	325	14	339	4
Windows - U=0.22, SHGC=0.22	2,752	313	14	327	7

2.14. Small Hotel – Internal Retail Tenant

Table 53. Small Hotel – Internal Tenant (SHIRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 54. SHIRT Alternatives Impact on Utility Costs and Paybacks

Prototype #8 Small Hotel - Internal Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$7,838	\$1,939	\$9,777	-	-
Package - Optimum EE	\$6,850	\$1,802	\$8,652	\$8,881	7.9
DHW - EF=0.640	\$7,838	\$1,904	\$9,742	\$310	8.9
DHW - EF=0.823	\$7,838	\$1,802	\$9,640	\$371	2.7
HVAC - EER 12.19, COP 3.52	\$7,572	\$1,939	\$9,511	\$996	3.7
HVAC - EER 12.06, COP 3.48	\$7,603	\$1,939	\$9,542	\$2,988	12.7
HVAC - EER 12.80, COP 3.66	\$7,490	\$1,939	\$9,429	\$4,980	14.3
Walls - R19 batt	\$7,841	\$1,939	\$9,780	\$467	-155.8
Walls - R21 batt	\$7,841	\$1,939	\$9,780	\$637	-212.4
Walls - R21 batt + R5 rigid	\$7,830	\$1,939	\$9,769	\$1,699	212.4
Windows - U=0.43, SHGC=0.39	\$7,553	\$1,939	\$9,492	\$387	1.4
Windows - U=0.26, SHGC=0.37	\$7,446	\$1,939	\$9,385	\$1,156	3.0
Windows - U=0.22, SHGC=0.22	\$7,099	\$1,939	\$9,038	\$3,531	4.8

Table 55. SHIRT Alternatives Impact on Energy Consumption

Prototype #8 Small Hotel - Internal Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	47,488	162	36	198	-
Package - Optimum EE	41,746	142	26	168	30
DHW - EF=0.640	47,488	162	33	195	3
DHW - EF=0.823	47,488	162	26	188	10
HVAC - EER 12.19, COP 3.52	46,220	158	36	194	4
HVAC - EER 12.06, COP 3.48	46,338	158	36	194	4
HVAC - EER 12.80, COP 3.66	45,787	156	36	192	6
Walls - R19 batt	47,535	162	36	198	0
Walls - R21 batt	47,534	162	36	198	0
Walls - R21 batt + R5 rigid	47,558	162	36	198	0
Windows - U=0.43, SHGC=0.39	45,866	156	36	192	6
Windows - U=0.26, SHGC=0.37	45,105	154	36	190	8
Windows - U=0.22, SHGC=0.22	42,996	147	36	183	15

Table 56. SHIRT Alternatives Impact on TDV

Prototype #8 Small Hotel - Internal Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,752	331	14	346	-
Package - Optimum EE	2,752	290	10	300	46
DHW - EF=0.640	2,752	331	13	345	1
DHW - EF=0.823	2,752	331	10	342	4
HVAC - EER 12.19, COP 3.52	2,752	321	14	336	10
HVAC - EER 12.06, COP 3.48	2,752	322	14	337	9
HVAC - EER 12.80, COP 3.66	2,752	318	14	332	14
Walls - R19 batt	2,752	331	14	346	0
Walls - R21 batt	2,752	331	14	346	0
Walls - R21 batt + R5 rigid	2,752	332	14	346	0
Windows - U=0.43, SHGC=0.39	2,752	319	14	334	12
Windows - U=0.26, SHGC=0.37	2,752	314	14	329	17
Windows - U=0.22, SHGC=0.22	2,752	300	14	314	32

2.15. Retail/Commercial Mixed-Use Building – Office Space

Type II construction, approximately 105,000 sf three-story slab on 35,000 sf grade, mixed use building with street level retail shops and two floor levels of service commercial or office space above. Interior floor space demised to accommodate 24 individual retail tenants at street level averaging 1,400 sf each. The floor-to-floor height is 13'-6" and 50% of the roof area is available for solar cells.

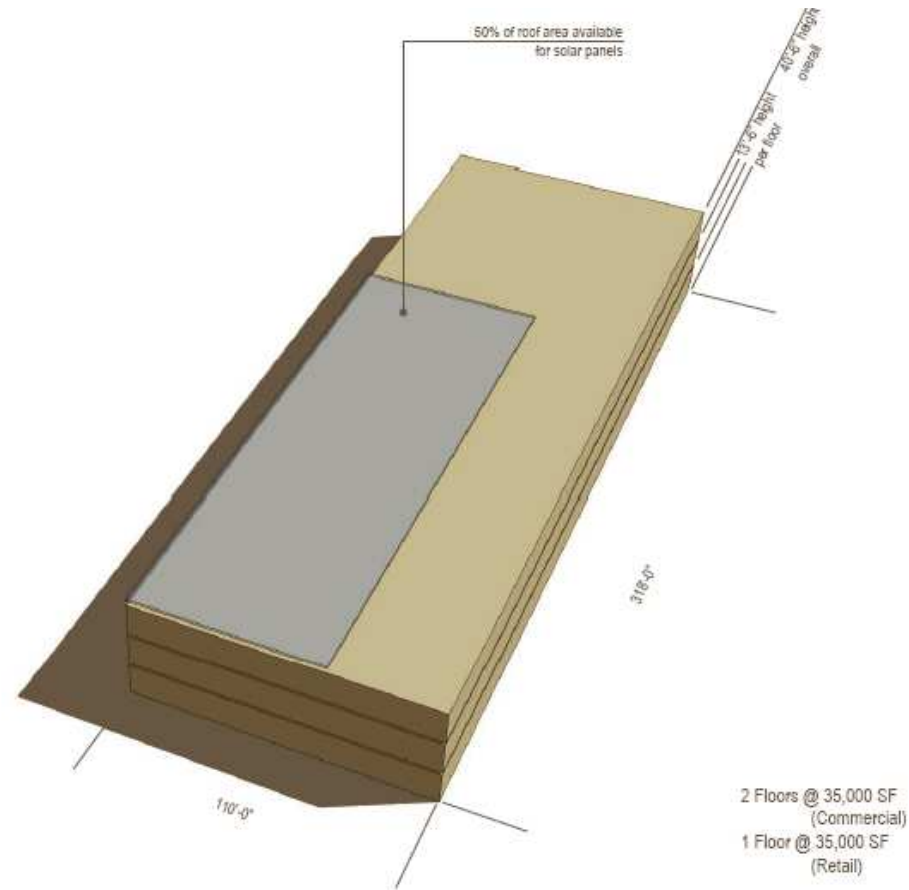


Figure 9. Retail/Commercial Mixed-Use Building

Table 57. Retail/Commercial Mixed Use: Office Space (R/CMUOS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 4.90	HVAC - COP 6.13	None	None	Alternative 1
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 8424 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 58. R/CMUOS Alternatives Impact on Utility Costs and Paybacks

Prototype #9 Retail/Commercial Mixed Use - Office Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$147,134	\$9,468	\$156,602	-	-
Package - Optimum EE	\$120,197	\$8,204	\$128,402	\$102,694	3.6
Package - Optimum EE + PV	\$101,180	\$8,196	\$109,376	\$510,388	10.8
CoolRoof - Abs=0.25	\$144,836	\$9,487	\$154,323	\$11,120	4.9
DHW - EF=0.640	\$147,134	\$9,194	\$156,328	\$620	2.3
DHW - EF=0.823	\$147,134	\$8,406	\$155,540	\$741	0.7
Heating - AFUE=85%	\$147,134	\$9,430	\$156,564	\$2,199	57.9
HVAC - COP 6.13	\$139,279	\$9,468	\$148,747	\$3,865	0.5
Lighting - 0.90 watts/sf	\$137,272	\$9,542	\$146,814	\$0	0.0
PV - 8424 sqft	\$109,766	\$9,468	\$119,234	\$418,814	10.2
Roof - U=R15 rigid	\$146,145	\$9,352	\$155,496	\$8,424	7.6
Roof - U=R20 rigid	\$145,462	\$9,316	\$154,778	\$15,163	8.3
Walls - R19 batt	\$146,999	\$9,434	\$156,433	\$1,497	8.9
Walls - R21 batt	\$146,975	\$9,430	\$156,406	\$2,041	10.4
Walls - R21 batt + R5 rigid	\$146,804	\$9,394	\$156,197	\$3,946	9.7
Windows - U=0.43, SHGC=0.39	\$146,994	\$9,397	\$156,392	\$7,439	35.4
Windows - U=0.26, SHGC=0.37	\$146,510	\$9,320	\$155,830	\$22,226	28.8
Windows - U=0.22, SHGC=0.22	\$139,316	\$9,387	\$148,703	\$67,859	8.6

Table 59. R/CMUOS Alternatives Impact on Energy Consumption

Prototype #9 Retail/Commercial Mixed Use - Office Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	836,700	2,855	585	3,440	-
Package - Optimum EE	694,112	2,368	493	2,861	579
Package - Optimum EE + PV	570,561	1,947	492	2,439	1,001
CoolRoof - Abs=0.25	823,975	2,811	587	3,398	42
DHW - EF=0.640	836,700	2,855	566	3,420	20
DHW - EF=0.823	836,700	2,855	508	3,363	77
Heating - AFUE=85%	836,700	2,855	583	3,437	3
HVAC - COP 6.13	797,070	2,720	585	3,305	135
Lighting - 0.90 watts/sf	779,800	2,661	591	3,252	188
PV - 8424 sqft	593,592	2,025	585	2,611	829
Roof - U=R15 rigid	832,565	2,841	577	3,417	23
Roof - U=R20 rigid	829,782	2,831	574	3,405	35
Walls - R19 batt	836,285	2,853	583	3,436	4
Walls - R21 batt	836,207	2,853	583	3,436	4
Walls - R21 batt + R5 rigid	835,462	2,851	580	3,430	10
Windows - U=0.43, SHGC=0.39	836,818	2,855	580	3,435	5
Windows - U=0.26, SHGC=0.37	835,553	2,851	574	3,425	15
Windows - U=0.22, SHGC=0.22	795,397	2,714	579	3,293	147

Table 60. R/CMUOS Alternatives Impact on TDVI

Prototype #9 Retail/Commercial Mixed Use - Office Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	67,392	241	10	251	-
Package - Optimum EE	67,392	198	8	206	45
Package - Optimum EE + PV	67,392	158	8	166	85
CoolRoof - Abs=0.25	67,392	237	10	247	4
DHW - EF=0.640	67,392	241	9	250	1
DHW - EF=0.823	67,392	241	8	249	2
Heating - AFUE=85%	67,392	241	10	251	0
HVAC - COP 6.13	67,392	229	10	238	13
Lighting - 0.90 watts/sf	67,392	225	10	234	17
PV - 8424 sqft	67,392	158	10	168	83
Roof - U=R15 rigid	67,392	240	9	249	2
Roof - U=R20 rigid	67,392	239	9	248	3
Walls - R19 batt	67,392	241	10	250	1
Walls - R21 batt	67,392	241	10	250	1
Walls - R21 batt + R5 rigid	67,392	241	9	250	1
Windows - U=0.43, SHGC=0.39	67,392	241	9	250	1
Windows - U=0.26, SHGC=0.37	67,392	240	9	250	1
Windows - U=0.22, SHGC=0.22	67,392	228	9	238	13

2.16. Retail/Commercial Mixed-Use Building – Corner Retail Tenant

Table 61. Retail/Commercial Mixed Use - Corner Retail Tenant (R/CMUCRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 62. R/CMUCRT Alternatives Impact on Utility Costs and Paybacks

Prototype #9 Retail/Commercial Mixed Use - Corner Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,514	\$1,698	\$6,212	-	-
Package - Optimum EE	\$3,971	\$1,629	\$5,600	\$5,745	9.4
DHW - EF=0.640	\$4,514	\$1,678	\$6,192	\$310	15.5
DHW - EF=0.823	\$4,514	\$1,629	\$6,143	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$4,394	\$1,698	\$6,092	\$557	4.6
HVAC - EER 12.06, COP 3.48	\$4,401	\$1,698	\$6,099	\$1,672	14.8
HVAC - EER 12.80, COP 3.66	\$4,326	\$1,698	\$6,024	\$2,786	14.8
Walls - R19 batt	\$4,525	\$1,698	\$6,223	\$200	Never
Walls - R21 batt	\$4,524	\$1,698	\$6,222	\$272	Never
Walls - R21 batt + R5 rigid	\$4,531	\$1,698	\$6,229	\$526	Never
Windows - U=0.43, SHGC=0.39	\$4,298	\$1,698	\$5,996	\$284	1.3
Windows - U=0.26, SHGC=0.37	\$4,279	\$1,698	\$5,977	\$848	3.6
Windows - U=0.22, SHGC=0.22	\$4,072	\$1,698	\$5,770	\$2,588	5.9

Table 63. R/CMUCRT Alternatives Impact on Energy Consumption

Prototype #9 Retail/Commercial Mixed Use - Corner Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	25,640	87	18	106	-
Package - Optimum EE	22,908	78	13	91	15
DHW - EF=0.640	25,640	87	17	104	2
DHW - EF=0.823	25,640	87	13	101	5
HVAC - EER 12.19, COP 3.52	24,968	85	18	103	3
HVAC - EER 12.06, COP 3.48	25,045	85	18	104	2
HVAC - EER 12.80, COP 3.66	24,477	84	18	102	4
Walls - R19 batt	25,694	88	18	106	0
Walls - R21 batt	25,708	88	18	106	0
Walls - R21 batt + R5 rigid	25,750	88	18	106	0
Windows - U=0.43, SHGC=0.39	24,172	82	18	101	5
Windows - U=0.26, SHGC=0.37	24,221	83	18	101	5
Windows - U=0.22, SHGC=0.22	23,417	80	18	98	8

Table 64. R/CMUCRT Alternatives Impact on TDVI

Prototype #9 Retail/Commercial Mixed Use - Corner Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	350	14	364	-
Package - Optimum EE	1,404	308	10	318	46
DHW - EF=0.640	1,404	350	13	363	1
DHW - EF=0.823	1,404	350	10	361	3
HVAC - EER 12.19, COP 3.52	1,404	339	14	354	10
HVAC - EER 12.06, COP 3.48	1,404	341	14	355	9
HVAC - EER 12.80, COP 3.66	1,404	332	14	346	18
Walls - R19 batt	1,404	351	14	365	-1
Walls - R21 batt	1,404	351	14	365	-1
Walls - R21 batt + R5 rigid	1,404	351	14	366	-2
Windows - U=0.43, SHGC=0.39	1,404	329	14	343	21
Windows - U=0.26, SHGC=0.37	1,404	329	14	343	21
Windows - U=0.22, SHGC=0.22	1,404	317	14	331	33

2.17. Retail/Commercial Mixed-Use Building – Internal Retail Tenant

Table 65. Retail/Commercial Mixed Use - Internal Retail Tenant (R/CMUCRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 66. R/CMUCRT Alternatives Impact on Utility Costs and Paybacks

Prototype #9 Retail/Commercial Mixed Use - Internal Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,293	\$1,698	\$5,991	-	-
Package - Optimum EE	\$3,837	\$1,629	\$5,466	\$4,200	8.0
DHW - EF=0.640	\$4,293	\$1,678	\$5,971	\$310	15.5
DHW - EF=0.823	\$4,293	\$1,629	\$5,922	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$4,178	\$1,698	\$5,876	\$443	3.8
HVAC - EER 12.06, COP 3.48	\$4,184	\$1,698	\$5,882	\$1,328	12.2
HVAC - EER 12.80, COP 3.66	\$4,088	\$1,698	\$5,786	\$2,213	10.8
Walls - R19 batt	\$4,292	\$1,698	\$5,990	\$214	Never
Walls - R21 batt	\$4,290	\$1,698	\$5,988	\$292	Never
Walls - R21 batt + R5 rigid	\$4,291	\$1,698	\$5,989	\$564	Never
Windows - U=0.43, SHGC=0.39	\$4,105	\$1,698	\$5,803	\$177	0.9
Windows - U=0.26, SHGC=0.37	\$4,099	\$1,698	\$5,797	\$529	2.7
Windows - U=0.22, SHGC=0.22	\$3,997	\$1,698	\$5,695	\$1,616	5.5

Table 67. R/CMUCRT Alternatives Impact on Energy Consumption

Prototype #9 Retail/Commercial Mixed Use - Internal Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	24,373	83	18	101	-
Package - Optimum EE	21,837	75	13	88	13
DHW - EF=0.640	24,373	83	17	100	1
DHW - EF=0.823	24,373	83	13	96	5
HVAC - EER 12.19, COP 3.52	23,955	82	18	100	1
HVAC - EER 12.06, COP 3.48	23,996	82	18	100	1
HVAC - EER 12.80, COP 3.66	23,777	81	18	99	2
Walls - R19 batt	24,393	83	18	101	0
Walls - R21 batt	24,402	83	18	102	-1
Walls - R21 batt + R5 rigid	24,424	83	18	102	-1
Windows - U=0.43, SHGC=0.39	23,733	81	18	99	2
Windows - U=0.26, SHGC=0.37	23,679	81	18	99	2
Windows - U=0.22, SHGC=0.22	23,014	79	18	97	4

Table 68. R/CMUCRT Alternatives Impact on TDVI

Prototype #9 Retail/Commercial Mixed Use - Internal Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	330	14	345	-
Package - Optimum EE	1,404	293	10	304	41
DHW - EF=0.640	1,404	330	13	344	1
DHW - EF=0.823	1,404	330	10	341	4
HVAC - EER 12.19, COP 3.52	1,404	323	14	338	7
HVAC - EER 12.06, COP 3.48	1,404	324	14	338	7
HVAC - EER 12.80, COP 3.66	1,404	320	14	335	10
Walls - R19 batt	1,404	330	14	345	0
Walls - R21 batt	1,404	331	14	345	0
Walls - R21 batt + R5 rigid	1,404	331	14	345	0
Windows - U=0.43, SHGC=0.39	1,404	321	14	335	10
Windows - U=0.26, SHGC=0.37	1,404	320	14	335	10
Windows - U=0.22, SHGC=0.22	1,404	310	14	325	20

2.18. Retail/Residential Mixed-Use Mid-Rise Building: Residential Space

Type III construction, approximately 136,000 sf six-story mixed use slab on 33,000 sf grade. Interior floor space demised to accommodate 24 individual retail tenants at street level averaging 1,400 sf each. Five floor levels of residential apartments above the first floor totaling approximately 103,300 sf. Residential floor space demised to accommodate 110 individual units; 47 Studios, 34 2BR and 29 3BR units ranging from approximately 600 to 1,300 sf each. The floor-to-floor height for the first floor retail is 14'-0" and 10'-0" for the residential levels above. 50% of the roof area is available for solar cells.

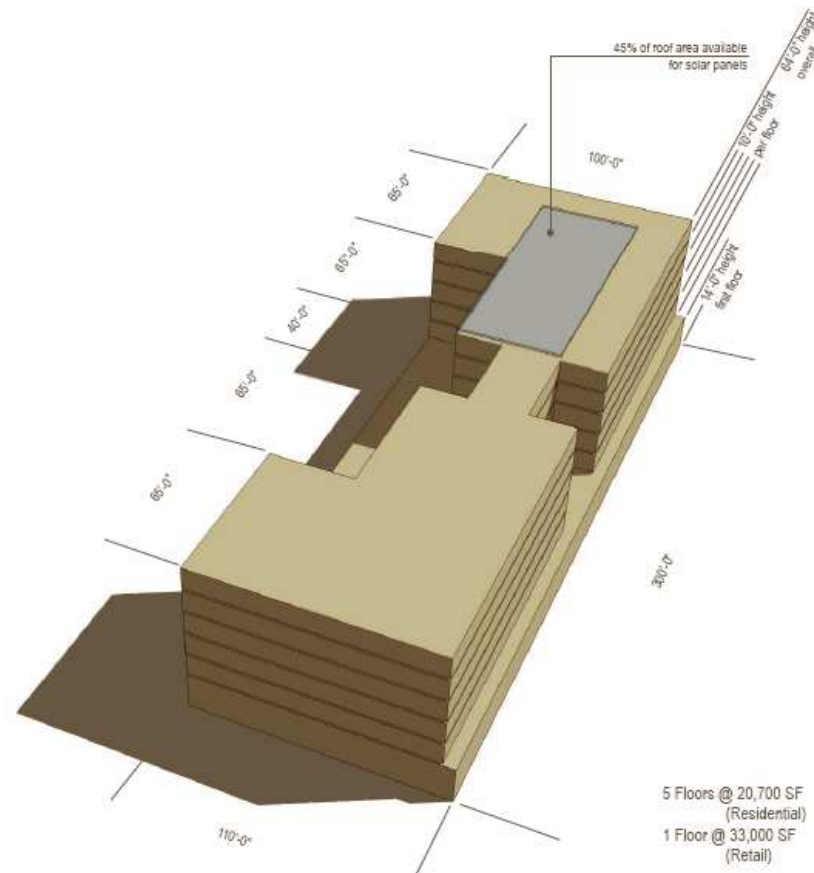


Figure 10. Retail/Residential Mixed-Use Mid-Rise Building

Table 69. Retail/Residential Mixed Use Mid-Rise - Residential Space (R/RMUMRRS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliance	Dish EF=.46, Clothes MMEF=1.26	Dish EF=.64, Clothes MMEF=2.0	Dish EF=.64, Clothes MMEF=2.2	None	Alternative 1
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 6.10	HVAC - COP 7.63	None	None	Alternative 1
Lighting	Lighting - 0.713 watts/sf	Lighting - 0.674 watts/sf	None	None	No Alternative
Photovoltaics	No PV	PV - 9301 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - U=R15 rigid	Roof - U=R20 rigid	None	No Alternative
Wall Insulation	Walls - R13 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.48, SHGC=0.47	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 70. R/RMUMRRS Alternatives Impact on Utility Costs and Paybacks

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Residential Space						
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs	
Baseline	\$166,804	\$25,058	\$191,862	-	-	
Package - Optimum EE	\$154,484	\$21,093	\$175,577	\$112,688	6.9	
Package - Optimum EE + PV	\$119,468	\$21,091	\$140,559	\$568,264	11.2	
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	\$164,271	\$25,057	\$189,328	\$29,110	11.5	
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	\$164,116	\$25,057	\$189,173	\$39,450	14.7	
CoolRoof - Abs=0.25	\$165,107	\$25,057	\$190,164	\$6,820	4.0	
DHW - EF=0.640	\$166,804	\$24,037	\$190,841	\$34,075	33.4	
DHW - EF=0.823	\$166,804	\$21,104	\$187,908	\$40,770	10.3	
Heating - AFUE=85%	\$166,804	\$25,048	\$191,852	\$1,000	100.0	
HVAC - COP 7.63	\$162,643	\$25,058	\$187,701	\$4,809	1.2	
Lighting - 0.674 watts/sf	\$162,857	\$25,058	\$187,915	\$99,000	25.1	
PV - 9301 sqft	\$129,686	\$25,058	\$154,744	\$462,396	12.2	
Roof - U=R15 rigid	\$166,778	\$25,053	\$191,831	\$5,167	166.7	
Roof - U=R20 rigid	\$166,616	\$25,048	\$191,664	\$9,301	47.0	
Walls - R19 batt	\$166,673	\$25,056	\$191,729	\$2,723	20.5	
Walls - R21 batt	\$166,610	\$25,053	\$191,663	\$3,934	19.8	
Walls - R21 batt + R5 rigid	\$166,181	\$25,052	\$191,233	\$11,498	18.3	
Windows - U=0.43, SHGC=0.39	\$165,786	\$25,058	\$190,844	\$2,157	2.1	
Windows - U=0.26, SHGC=0.37	\$165,866	\$25,054	\$190,920	\$6,446	6.8	
Windows - U=0.22, SHGC=0.22	\$163,042	\$25,056	\$188,098	\$19,680	5.2	

Table 71. R/RMUMRRS Alternatives Impact on Energy Consumption

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Residential Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	683,630	2,333	1,912	4,244	-
Package - Optimum EE	633,886	2,163	1,610	3,773	471
Package - Optimum EE + PV	491,935	1,678	1,610	3,289	955
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	673,315	2,297	1,912	4,209	35
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	672,685	2,295	1,912	4,207	37
CoolRoof - Abs=0.25	676,752	2,309	1,912	4,221	23
DHW - EF=0.640	683,630	2,333	1,834	4,167	77
DHW - EF=0.823	683,630	2,333	1,611	3,944	300
Heating - AFUE=85%	683,630	2,333	1,911	4,244	0
HVAC - COP 7.63	666,931	2,276	1,912	4,187	57
Lighting - 0.674 watts/sf	667,562	2,278	1,912	4,190	54
PV - 9301 sqft	533,163	1,819	1,912	3,731	513
Roof - U=R15 rigid	683,580	2,332	1,911	4,244	0
Roof - U=R20 rigid	682,951	2,330	1,911	4,241	3
Walls - R19 batt	683,133	2,331	1,912	4,243	1
Walls - R21 batt	682,892	2,330	1,911	4,241	3
Walls - R21 batt + R5 rigid	681,185	2,324	1,911	4,235	9
Windows - U=0.43, SHGC=0.39	679,505	2,318	1,912	4,230	14
Windows - U=0.26, SHGC=0.37	679,850	2,320	1,912	4,231	13
Windows - U=0.22, SHGC=0.22	668,390	2,281	1,912	4,192	52

Table 72. R/RMUMRRS Alternatives Impact on TDVI

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Residential Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	103,339	98	20	117	-
Package - Optimum EE	103,339	90	17	107	10
Package - Optimum EE + PV	103,339	67	17	84	33
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	103,339	96	20	116	1
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	103,339	96	20	116	1
CoolRoof - Abs=0.25	103,339	97	20	116	1
DHW - EF=0.640	103,339	98	19	116	1
DHW - EF=0.823	103,339	98	17	114	3
Heating - AFUE=85%	103,339	98	20	117	0
HVAC - COP 7.63	103,339	95	20	115	2
Lighting - 0.674 watts/sf	103,339	95	20	115	2
PV - 9301 sqft	103,339	74	20	93	24
Roof - U=R15 rigid	103,339	98	20	117	0
Roof - U=R20 rigid	103,339	97	20	117	0
Walls - R19 batt	103,339	98	20	117	0
Walls - R21 batt	103,339	97	20	117	0
Walls - R21 batt + R5 rigid	103,339	97	20	117	0
Windows - U=0.43, SHGC=0.39	103,339	97	20	117	0
Windows - U=0.26, SHGC=0.37	103,339	97	20	117	0
Windows - U=0.22, SHGC=0.22	103,339	95	20	115	2

2.19. Retail/Residential Mixed-Use Mid-Rise Building: Corner Retail Tenant

Table 73. Retail/Residential Mixed Use Mid-Rise - Corner Retail Tenant (R/RMUMRCRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 74. R/RMUMRCRT Alternatives Impact on Utility Costs and Paybacks

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Corner Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,514	\$1,698	\$6,212	-	-
Package - Optimum EE	\$3,946	\$1,629	\$5,575	\$5,482	8.6
DHW - EF=0.640	\$4,514	\$1,678	\$6,192	\$310	15.5
DHW - EF=0.823	\$4,514	\$1,629	\$6,143	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$4,391	\$1,698	\$6,089	\$487	4.0
HVAC - EER 12.06, COP 3.48	\$4,414	\$1,698	\$6,112	\$1,460	14.6
HVAC - EER 12.80, COP 3.66	\$4,318	\$1,698	\$6,016	\$2,434	12.4
Walls - R19 batt	\$4,517	\$1,698	\$6,215	\$207	Never
Walls - R21 batt	\$4,516	\$1,698	\$6,214	\$282	-141.2
Walls - R21 batt + R5 rigid	\$4,520	\$1,698	\$6,218	\$753	-125.5
Windows - U=0.43, SHGC=0.39	\$4,298	\$1,698	\$5,996	\$294	1.4
Windows - U=0.26, SHGC=0.37	\$4,299	\$1,698	\$5,997	\$877	4.1
Windows - U=0.22, SHGC=0.22	\$4,093	\$1,698	\$5,791	\$2,678	6.4

Table 75. R/RMUMRCRT Alternatives Impact on Energy Consumption

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Corner Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	25,609	87	18	106	-
Package - Optimum EE	22,730	78	13	91	15
DHW - EF=0.640	25,609	87	17	104	2
DHW - EF=0.823	25,609	87	13	101	5
HVAC - EER 12.19, COP 3.52	24,861	85	18	103	3
HVAC - EER 12.06, COP 3.48	24,949	85	18	103	3
HVAC - EER 12.80, COP 3.66	24,570	84	18	102	4
Walls - R19 batt	25,655	88	18	106	0
Walls - R21 batt	25,643	87	18	106	0
Walls - R21 batt + R5 rigid	25,691	88	18	106	0
Windows - U=0.43, SHGC=0.39	24,254	83	18	101	5
Windows - U=0.26, SHGC=0.37	24,289	83	18	101	5
Windows - U=0.22, SHGC=0.22	23,387	80	18	98	8

Table 76. R/RMUMRCRT Alternatives Impact on TDVI

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Corner Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	350	14	364	-
Package - Optimum EE	1,404	306	10	316	48
DHW - EF=0.640	1,404	350	13	363	1
DHW - EF=0.823	1,404	350	10	360	4
HVAC - EER 12.19, COP 3.52	1,404	338	14	352	12
HVAC - EER 12.06, COP 3.48	1,404	339	14	354	10
HVAC - EER 12.80, COP 3.66	1,404	333	14	348	16
Walls - R19 batt	1,404	350	14	365	-1
Walls - R21 batt	1,404	350	14	364	0
Walls - R21 batt + R5 rigid	1,404	350	14	365	-1
Windows - U=0.43, SHGC=0.39	1,404	330	14	345	19
Windows - U=0.26, SHGC=0.37	1,404	330	14	344	20
Windows - U=0.22, SHGC=0.22	1,404	317	14	331	33

2.20. Retail/Residential Mixed-Use Mid-Rise Building: Internal Retail Tenant

Table 77. Retail/Residential Mixed Use Mid-Rise - Internal Retail Tenant (R/RMUMRIRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 78. R/RMUMRIRT Alternatives Impact on Utility Costs and Paybacks

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Internal Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,274	\$1,698	\$5,972	-	-
Package - Optimum EE	\$3,832	\$1,629	\$5,461	\$4,020	7.9
DHW - EF=0.640	\$4,274	\$1,678	\$5,952	\$310	15.5
DHW - EF=0.823	\$4,274	\$1,629	\$5,903	\$371	5.4
HVAC - EER 12.19, COP 3.52	\$4,133	\$1,698	\$5,831	\$395	2.8
HVAC - EER 12.06, COP 3.48	\$4,156	\$1,698	\$5,854	\$1,184	10.0
HVAC - EER 12.80, COP 3.66	\$4,077	\$1,698	\$5,775	\$1,973	10.0
Walls - R19 batt	\$4,273	\$1,698	\$5,971	\$90	Never
Walls - R21 batt	\$4,273	\$1,698	\$5,971	\$122	122.4
Walls - R21 batt + R5 rigid	\$4,274	\$1,698	\$5,972	\$326	Never
Windows - U=0.43, SHGC=0.39	\$4,100	\$1,698	\$5,798	\$184	1.1
Windows - U=0.26, SHGC=0.37	\$4,106	\$1,698	\$5,804	\$549	3.3
Windows - U=0.22, SHGC=0.22	\$3,994	\$1,698	\$5,692	\$1,676	6.0

Table 79. R/RMUMRIRT Alternatives Impact on Energy Consumption

Prototype #10 Retail/Residential Mixed Use Mid-Rise - Internal Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	24,434	83	18	102	-
Package - Optimum EE	21,803	74	13	88	14
DHW - EF=0.640	24,434	83	17	100	2
DHW - EF=0.823	24,434	83	13	97	5
HVAC - EER 12.19, COP 3.52	23,854	81	18	100	2
HVAC - EER 12.06, COP 3.48	23,903	82	18	100	2
HVAC - EER 12.80, COP 3.66	23,552	80	18	99	3
Walls - R19 batt	24,445	83	18	102	0
Walls - R21 batt	24,445	83	18	102	0
Walls - R21 batt + R5 rigid	24,456	83	18	102	0
Windows - U=0.43, SHGC=0.39	23,517	80	18	98	4
Windows - U=0.26, SHGC=0.37	23,571	80	18	99	3
Windows - U=0.22, SHGC=0.22	23,002	78	18	97	5

Table 80. R/RMUMRIRT Alternatives Impact on TDVI

Prototyp #10 Retail/Residential Mixed Use Mid-Rise - Internal Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	331	14	345	-
Package - Optimum EE	1,404	293	10	303	42
DHW - EF=0.640	1,404	331	13	344	1
DHW - EF=0.823	1,404	331	10	341	4
HVAC - EER 12.19, COP 3.52	1,404	322	14	337	8
HVAC - EER 12.06, COP 3.48	1,404	323	14	338	7
HVAC - EER 12.80, COP 3.66	1,404	318	14	332	13
Walls - R19 batt	1,404	331	14	345	0
Walls - R21 batt	1,404	331	14	345	0
Walls - R21 batt + R5 rigid	1,404	331	14	345	0
Windows - U=0.43, SHGC=0.39	1,404	318	14	333	12
Windows - U=0.26, SHGC=0.37	1,404	319	14	333	12
Windows - U=0.22, SHGC=0.22	1,404	310	14	324	21

2.21. Retail/Residential Mixed-Use Low-Rise: Residential Space

Type II construction at ground level and type V construction above, approximately 76,000 sf three-story mixed use slab on 33,000 sf grade. Interior floor space demised to accommodate 24 individual retail tenants at street level averaging 1,400 sf each. Two floor levels of residential apartments above the first floor totaling approximately 44,000 sf. Residential floor space demised to accommodate 46 individual units; 18 Studios, 16 2BR and 12 3BR units ranging from approximately 600 to 1,300 sf each. The floor-to-floor height for the first floor retail is 14'-0" and 10'-0" for the residential levels above. 45% of the roof area is available for solar panels.

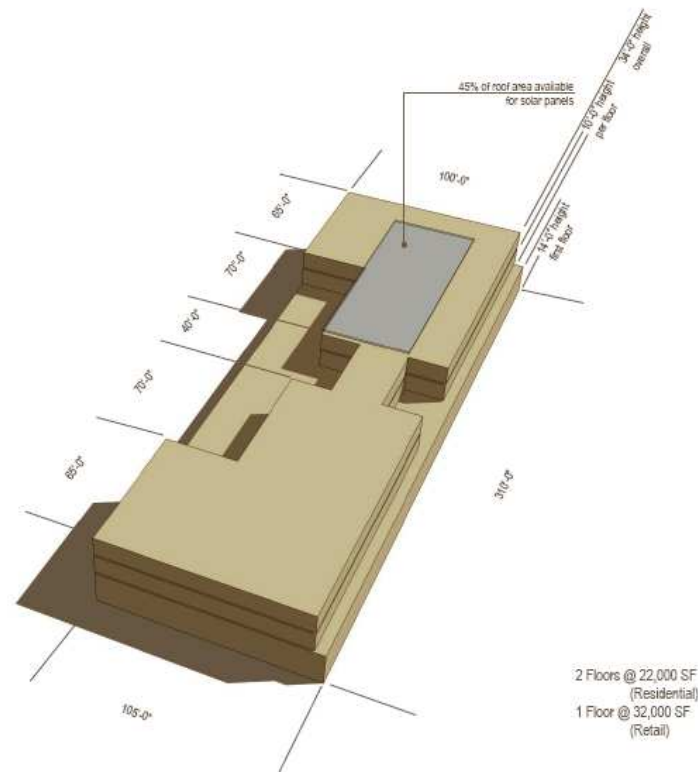


Figure 11. Retail/Residential Mixed-Use Low-Rise Building

Table 81. Retail/Residential Mixed-Use Low-Rise: Residential Space (R/RMULRRS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliance	Dish EF=.46, Clothes MMEF=1.26	Dish EF=.64, Clothes MMEF=2.0	Dish EF=.64, Clothes MMEF=2.2	None	Alternative 1
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Lighting	Lighting - 0.713 watts/sf	Lighting - 0.667 watts/sf	None	None	No Alternative
Photovoltaics	No PV	PV - 9904 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R30 batt	Roof - R38 batt	Roof - R49 batt	None	No Alternative
Wall Insulation	Walls - R13 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 82. R/RMULRRS Alternatives Impacts on Utility Costs and Paybacks

Prototype #11 Retail/Residential Mixed Use Low-Rise - Residential Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$58,486	\$10,460	\$68,946	-	-
Package - Optimum EE	\$55,127	\$8,808	\$63,935	\$53,550	10.7
Package - Optimum EE + PV	\$15,750	\$8,808	\$24,558	\$580,062	11.8
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	\$57,392	\$10,460	\$67,852	\$12,173	11.1
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	\$57,319	\$10,460	\$67,779	\$16,497	14.1
CoolRoof - Abs=0.25	\$57,901	\$10,460	\$68,361	\$7,263	12.4
DHW - EF=0.640	\$58,486	\$10,034	\$68,520	\$14,249	33.4
DHW - EF=0.823	\$58,486	\$8,808	\$67,294	\$17,049	10.3
HVAC - EER 12.19, COP 3.52	\$57,535	\$10,460	\$67,995	\$2,844	3.0
HVAC - EER 12.06, COP 3.48	\$57,643	\$10,460	\$68,103	\$8,532	10.1
HVAC - EER 12.80, COP 3.66	\$57,251	\$10,460	\$67,711	\$14,220	11.5
Lighting - 0.667 watts/sf	\$56,821	\$10,460	\$67,281	\$41,400	24.9
PV - 9904 sqft	\$18,684	\$10,460	\$29,144	\$492,375	10.2
Roof - R38 batt	\$58,516	\$10,460	\$68,976	\$4,182	Never
Roof - R49 batt	\$58,662	\$10,460	\$69,122	\$14,525	Never
Walls - R19 batt	\$58,535	\$10,460	\$68,995	\$1,112	Never
Walls - R21 batt	\$58,584	\$10,460	\$69,044	\$1,606	Never
Walls - R21 batt + R5 rigid	\$58,542	\$10,460	\$69,002	\$4,695	Never
Windows - U=0.43, SHGC=0.39	\$58,577	\$10,460	\$69,037	\$1,002	Never
Windows - U=0.26, SHGC=0.37	\$58,710	\$10,460	\$69,170	\$2,994	Never
Windows - U=0.22, SHGC=0.22	\$57,559	\$10,460	\$68,019	\$2,844	3.1

Table 83. R/RMULRRS Alternatives Impacts on Utility Costs and Paybacks

Prototype #11 Retail/Residential Mixed Use Low-Rise - Residential Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	240,792	822	803	1,624	-
Package - Optimum EE	227,239	775	677	1,452	172
Package - Optimum EE + PV	67,612	231	677	908	716
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	236,341	806	803	1,609	15
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	236,045	805	803	1,608	16
CoolRoof - Abs=0.25	238,416	813	803	1,616	8
DHW - EF=0.640	240,792	822	770	1,592	32
DHW - EF=0.823	240,792	822	677	1,499	125
HVAC - EER 12.19, COP 3.52	236,996	809	803	1,611	13
HVAC - EER 12.06, COP 3.48	237,417	810	803	1,613	11
HVAC - EER 12.80, COP 3.66	235,856	805	803	1,607	17
Lighting - 0.667 watts/sf	234,028	799	803	1,601	23
PV - 9904 sqft	79,448	271	803	1,074	550
Roof - R38 batt	240,932	822	803	1,625	-1
Roof - R49 batt	241,550	824	803	1,627	-3
Walls - R19 batt	241,003	822	803	1,625	-1
Walls - R21 batt	241,212	823	803	1,626	-2
Walls - R21 batt + R5 rigid	241,080	823	803	1,625	-1
Windows - U=0.43, SHGC=0.39	241,171	823	803	1,625	-1
Windows - U=0.26, SHGC=0.37	241,722	825	803	1,627	-3
Windows - U=0.22, SHGC=0.22	237,054	809	803	1,611	13

Table 84. R/RMULRRS Alternatives Impacts on TDVI

Prototype #11 Retail/Residential Mixed Use Low-Rise - Residential Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	44,017	81	19	100	-
Package - Optimum EE	44,017	76	16	92	11
Package - Optimum EE + PV	44,017	17	16	33	12
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	44,017	79	19	99	11
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	44,017	79	19	99	14
CoolRoof - Abs=0.25	44,017	80	19	99	12
DHW - EF=0.640	44,017	81	19	99	33
DHW - EF=0.823	44,017	81	16	97	10
HVAC - EER 12.19, COP 3.52	44,017	80	19	99	3
HVAC - EER 12.06, COP 3.48	44,017	80	19	99	10
HVAC - EER 12.80, COP 3.66	44,017	79	19	98	12
Lighting - 0.667 watts/sf	44,017	79	19	98	25
PV - 9904 sqft	44,017	21	19	41	10
Roof - R38 batt	44,017	81	19	100	-139
Roof - R49 batt	44,017	81	19	100	-83
Walls - R19 batt	44,017	81	19	100	-23
Walls - R21 batt	44,017	81	19	100	-16
Walls - R21 batt + R5 rigid	44,017	81	19	100	-84
Windows - U=0.43, SHGC=0.39	44,017	81	19	100	-11
Windows - U=0.26, SHGC=0.37	44,017	81	19	100	-13
Windows - U=0.22, SHGC=0.22	44,017	80	19	99	3

2.22. Retail/Residential Mixed-Use Low-Rise: Corner Retail Tenant

Table 85. Retail/Residential Mixed Use Low -Rise - Corner Retail Tenant (R/RMULRCRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 86. R/RMULRCRT Alternatives Impact on Utility Costs and Paybacks

Prototype #11 Retail/Residential Mixed Use Low-Rise - Corner Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,514	\$1,698	\$6,212	-	-
Package - Optimum EE	\$3,948	\$1,629	\$5,577	\$5,629	9
DHW - EF=0.640	\$4,514	\$1,678	\$6,192	\$310	15
DHW - EF=0.823	\$4,514	\$1,629	\$6,143	\$371	5
HVAC - EER 12.19, COP 3.52	\$4,381	\$1,698	\$6,079	\$516	4
HVAC - EER 12.06, COP 3.48	\$4,390	\$1,698	\$6,088	\$1,548	12
HVAC - EER 12.80, COP 3.66	\$4,326	\$1,698	\$6,024	\$2,581	14
Walls - R19 batt	\$4,523	\$1,698	\$6,221	\$207	Never
Walls - R21 batt	\$4,522	\$1,698	\$6,220	\$282	Never
Walls - R21 batt + R5 rigid	\$4,512	\$1,698	\$6,210	\$546	Never
Windows - U=0.43, SHGC=0.39	\$4,301	\$1,698	\$5,999	\$294	1
Windows - U=0.26, SHGC=0.37	\$4,301	\$1,698	\$5,999	\$877	4
Windows - U=0.22, SHGC=0.22	\$4,085	\$1,698	\$5,783	\$2,678	6

Table 87. R/RMULRCRT Alternatives Impact on Energy Consumption

Prototype #11 Retail/Residential Mixed Use Low-Rise - Corner Retail Tenant					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	25,696	88	18	106	-
Package - Optimum EE	22,746	78	13	91	15
DHW - EF=0.640	25,696	88	17	105	1
DHW - EF=0.823	25,696	88	13	101	5
HVAC - EER 12.19, COP 3.52	24,857	85	18	103	3
HVAC - EER 12.06, COP 3.48	24,923	85	18	103	3
HVAC - EER 12.80, COP 3.66	24,516	84	18	102	4
Walls - R19 batt	25,761	88	18	106	0
Walls - R21 batt	25,782	88	18	106	0
Walls - R21 batt + R5 rigid	25,722	88	18	106	0
Windows - U=0.43, SHGC=0.39	24,224	83	18	101	5
Windows - U=0.26, SHGC=0.37	24,265	83	18	101	5
Windows - U=0.22, SHGC=0.22	23,434	80	18	98	8

Table 88. R/RMULRCRT Alternatives Impact on TDVI

Prototype #11 Retail/Residential Mixed Use Low-Rise - Corner Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	351	14	365	-
Package - Optimum EE	1,404	306	10	317	48
DHW - EF=0.640	1,404	351	13	364	1
DHW - EF=0.823	1,404	351	10	361	4
HVAC - EER 12.19, COP 3.52	1,404	338	14	353	12
HVAC - EER 12.06, COP 3.48	1,404	339	14	354	11
HVAC - EER 12.80, COP 3.66	1,404	333	14	347	18
Walls - R19 batt	1,404	352	14	366	-1
Walls - R21 batt	1,404	352	14	366	-1
Walls - R21 batt + R5 rigid	1,404	351	14	365	0
Windows - U=0.43, SHGC=0.39	1,404	330	14	344	21
Windows - U=0.26, SHGC=0.37	1,404	330	14	344	21
Windows - U=0.22, SHGC=0.22	1,404	317	14	332	33

2.23. Retail/Residential Mixed-Use Low-Rise Building: Internal Retail Tenant

Table 89. Retail/Residential Mixed Use Low -Rise - Internal Retail Tenant (R/RMULRIRT) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.57, SHGC=0.61	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 90. R/RMULRIRT Alternatives Impact on Utility Costs and Paybacks

Prototype #11 Retail/Residential Mixed Use Low-Rise - Internal Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,293	\$1,698	\$5,991	-	-
Package - Optimum EE	\$3,834	\$1,629	\$5,463	\$5,125	9.7
DHW - EF=0.640	\$4,293	\$1,678	\$5,971	\$310	15
DHW - EF=0.823	\$4,293	\$1,629	\$5,922	\$371	5
HVAC - EER 12.19, COP 3.52	\$4,151	\$1,698	\$5,849	\$415	3
HVAC - EER 12.06, COP 3.48	\$4,169	\$1,698	\$5,867	\$1,246	10
HVAC - EER 12.80, COP 3.66	\$4,084	\$1,698	\$5,782	\$2,076	10
Walls - R19 batt	\$4,296	\$1,698	\$5,994	\$222	Never
Walls - R21 batt	\$4,285	\$1,698	\$5,983	\$302	Never
Walls - R21 batt + R5 rigid	\$4,300	\$1,698	\$5,998	\$585	Never
Windows - U=0.43, SHGC=0.39	\$4,119	\$1,698	\$5,817	\$294	2
Windows - U=0.26, SHGC=0.37	\$4,126	\$1,698	\$5,824	\$877	5
Windows - U=0.22, SHGC=0.22	\$3,999	\$1,698	\$5,697	\$2,678	9

Table 91. R/RMULRIRT Alternatives Impact on Energy Consumption

Prototype #11 Retail/Residential Mixed Use Low-Rise - Internal Retail Tenant					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$4,293	\$1,698	\$5,991	-	-
Package - Optimum EE	\$3,834	\$1,629	\$5,463	\$5,125	9.7
DHW - EF=0.640	\$4,293	\$1,678	\$5,971	\$310	15
DHW - EF=0.823	\$4,293	\$1,629	\$5,922	\$371	5
HVAC - EER 12.19, COP 3.52	\$4,151	\$1,698	\$5,849	\$415	3
HVAC - EER 12.06, COP 3.48	\$4,169	\$1,698	\$5,867	\$1,246	10
HVAC - EER 12.80, COP 3.66	\$4,084	\$1,698	\$5,782	\$2,076	10
Walls - R19 batt	\$4,296	\$1,698	\$5,994	\$222	Never
Walls - R21 batt	\$4,285	\$1,698	\$5,983	\$302	Never
Walls - R21 batt + R5 rigid	\$4,300	\$1,698	\$5,998	\$585	Never
Windows - U=0.43, SHGC=0.39	\$4,119	\$1,698	\$5,817	\$294	2
Windows - U=0.26, SHGC=0.37	\$4,126	\$1,698	\$5,824	\$877	5
Windows - U=0.22, SHGC=0.22	\$3,999	\$1,698	\$5,697	\$2,678	9

Table 92. R/RMULRIRT Alternatives Impact on TDVI

Prototype #11 Retail/Residential Mixed Use Low-Rise - Internal Retail Tenant					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,404	331	14	345	-
Package - Optimum EE	1,404	293	10	303	42
DHW - EF=0.640	1,404	331	13	344	1
DHW - EF=0.823	1,404	331	10	341	4
HVAC - EER 12.19, COP 3.52	1,404	322	14	337	8
HVAC - EER 12.06, COP 3.48	1,404	324	14	339	6
HVAC - EER 12.80, COP 3.66	1,404	319	14	334	11
Walls - R19 batt	1,404	331	14	345	0
Walls - R21 batt	1,404	331	14	345	0
Walls - R21 batt + R5 rigid	1,404	331	14	346	-1
Windows - U=0.43, SHGC=0.39	1,404	320	14	335	10
Windows - U=0.26, SHGC=0.37	1,404	321	14	335	10
Windows - U=0.22, SHGC=0.22	1,404	310	14	325	20

2.24. Civic/Commercial Mixed-Use Building: Library Space

Type II construction, approximately 110,000 sf five-story slab on 27,000 sf grade, mixed use building with 1.5 levels of civic (library) space and 3.5 levels of office space above. Interior floor space demised to accommodate 43,500 sf of library and 66,600 sf of office space. The ground level floor-to-floor height is 18'-0" and 14'-0" for the four levels above. 45% of the roof area is available for solar cells.

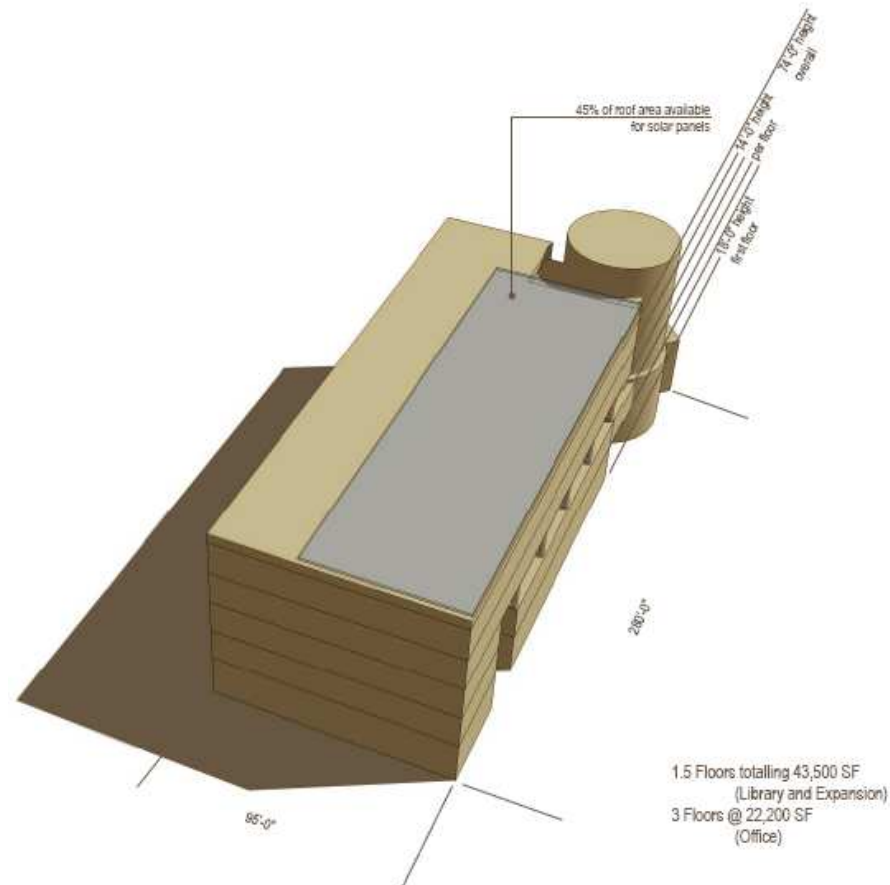


Figure 12. Civic/Commercial Mixed-Use Building

Table 93. Civic/Commercial Mixed Use: Library (C/CMUL) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 4.90	HVAC - COP 6.13	None	None	Alternative 1
Lighting	Lighting - 1.10 watts/sf	Lighting - 1.02 watts/sf	None	None	Alternative 1
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 94. C/CMUL Alternatives Impact on Utility Costs and Paybacks

Prototype #12 Civic/Commercial Mixed Use - Library					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$69,637	\$5,333	\$74,970	-	-
Package - Optimum EE	\$54,935	\$4,669	\$59,604	\$45,404	3.0
DHW - EF=0.640	\$69,637	\$5,169	\$74,806	\$310	1.9
DHW - EF=0.823	\$69,637	\$4,701	\$74,338	\$371	0.6
Heating - AFUE=85%	\$69,637	\$5,322	\$74,959	\$889	80.8
HVAC - COP 6.13	\$65,721	\$5,333	\$71,054	\$3,426	0.9
Lighting - 1.02 watts/sf	\$61,752	\$5,370	\$67,122	\$0	0.0
Walls - R19 batt	\$69,557	\$5,320	\$74,877	\$891	9.6
Walls - R21 batt	\$69,542	\$5,320	\$74,862	\$1,215	11.3
Walls - R21 batt + R5 rigid	\$69,469	\$5,310	\$74,778	\$40,392	210.4
Windows - U=0.43, SHGC=0.39	\$69,540	\$5,311	\$74,851	\$4,428	37.2
Windows - U=0.26, SHGC=0.37	\$69,247	\$5,281	\$74,527	\$13,230	29.9
Windows - U=0.22, SHGC=0.22	\$64,893	\$5,304	\$70,198	\$40,392	8.5

Table 95. C/CMUL Alternatives Impact on Energy Consumption

Prototype #12 Civic/Commercial Mixed Use - Library					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	393,633	1,343	283	1,626	-
Package - Optimum EE	314,390	1,073	235	1,308	318
DHW - EF=0.640	393,633	1,343	272	1,615	11
DHW - EF=0.823	393,633	1,343	237	1,580	46
Heating - AFUE=85%	393,633	1,343	283	1,626	0
HVAC - COP 6.13	373,678	1,275	283	1,558	68
Lighting - 1.02 watts/sf	348,339	1,189	286	1,475	151
Walls - R19 batt	393,261	1,342	282	1,624	2
Walls - R21 batt	393,175	1,342	282	1,624	2
Walls - R21 batt + R5 rigid	392,909	1,341	282	1,622	4
Windows - U=0.43, SHGC=0.39	393,623	1,343	282	1,625	1
Windows - U=0.26, SHGC=0.37	392,768	1,340	279	1,619	7
Windows - U=0.22, SHGC=0.22	368,113	1,256	281	1,537	89

Table 96. C/CMUL Alternatives Impact on TDVI

Prototype #12 Civic/Commercial Mixed Use - Library					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	26,600	288	12	300	-
Package - Optimum EE	26,600	228	10	238	62
DHW - EF=0.640	26,600	288	11	299	1
DHW - EF=0.823	26,600	288	10	298	2
Heating - AFUE=85%	26,600	288	12	300	0
HVAC - COP 6.13	26,600	273	12	284	16
Lighting - 1.02 watts/sf	26,600	255	12	267	33
Walls - R19 batt	26,600	288	12	299	1
Walls - R21 batt	26,600	288	12	299	1
Walls - R21 batt + R5 rigid	26,600	287	12	299	1
Windows - U=0.43, SHGC=0.39	26,600	288	12	299	1
Windows - U=0.26, SHGC=0.37	26,600	287	12	298	2
Windows - U=0.22, SHGC=0.22	26,600	268	12	280	20

2.25. Civic/Commercial Mixed-Use Building: Office Space

Table 97. Civic/Commercial Mixed Use - Office Space (C/CMUOS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 4.90	HVAC - COP 6.13	None	None	Alternative 1
Lighting	Lighting - 1.10 watts/sf	Lighting - 0.90 watts/sf	None	None	Alternative 1
Photovoltaics	No PV	PV - 11970 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 rigid	Roof - R15 rigid	Roof - R20 rigid	None	Alternative 2
Wall Insulation	Walls - R11 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 2
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 98. C/CMUOS Alternatives Impact on Utility Costs and Paybacks

Prototype #12 Civic/Commercial Mixed Use - Office Space					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$237,414	\$13,894	\$251,308	-	-
Package - Optimum EE	\$194,821	\$12,062	\$206,883	\$157,498	3.5
Package - Optimum EE + PV	\$166,552	\$12,058	\$178,609	\$743,829	10.2
CoolRoof - Abs=0.25	\$235,610	\$13,897	\$249,506	\$8,778	4.9
DHW - EF=0.640	\$237,414	\$13,456	\$250,870	\$929	2.1
DHW - EF=0.823	\$237,414	\$12,209	\$249,623	\$1,112	0.7
Heating - AFUE=85%	\$237,414	\$13,858	\$251,272	\$3,424	95.1
HVAC - COP 6.13	\$224,331	\$13,894	\$238,225	\$6,194	0.5
Lighting - 0.90 watts/sf	\$221,850	\$13,940	\$235,790	\$0	0.0
PV - 11970 sqft	\$207,332	\$13,894	\$221,226	\$595,110	19.2
Roof - R15 rigid	\$236,782	\$13,849	\$250,631	\$6,650	9.8
Roof - R20 rigid	\$236,319	\$13,816	\$250,135	\$11,970	10.2
Walls - R19 batt	\$237,236	\$13,865	\$251,101	\$2,772	13.4
Walls - R21 batt	\$237,212	\$13,863	\$251,075	\$3,780	16.2
Walls - R21 batt + R5 rigid	\$236,956	\$13,841	\$250,798	\$7,308	14.3
Windows - U=0.43, SHGC=0.39	\$237,266	\$13,840	\$251,106	\$13,776	68.2
Windows - U=0.26, SHGC=0.37	\$236,700	\$13,736	\$250,436	\$41,160	47.2
Windows - U=0.22, SHGC=0.22	\$223,378	\$13,810	\$237,188	\$125,664	8.9

Table 99. C/CMUOS Alternatives Impact on Energy Consumption

Prototype #12 Civic/Commercial Mixed Use - Office Space					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	1,355,741	4,626	908	5,533	-
Package - Optimum EE	1,125,886	3,842	774	4,616	917
Package - Optimum EE + PV	945,252	3,225	774	3,999	1,534
CoolRoof - Abs=0.25	1,345,463	4,591	908	5,499	34
DHW - EF=0.640	1,355,741	4,626	876	5,502	31
DHW - EF=0.823	1,355,741	4,626	785	5,411	122
Heating - AFUE=85%	1,355,741	4,626	905	5,531	2
HVAC - COP 6.13	1,288,801	4,397	908	5,305	228
Lighting - 0.90 watts/sf	1,266,044	4,320	911	5,231	302
PV - 11970 sqft	1,168,899	3,988	908	4,896	637
Roof - R15 rigid	1,353,171	4,617	904	5,521	12
Roof - R20 rigid	1,351,279	4,611	902	5,512	21
Walls - R19 batt	1,354,931	4,623	906	5,529	4
Walls - R21 batt	1,354,817	4,623	905	5,528	5
Walls - R21 batt + R5 rigid	1,353,640	4,619	904	5,522	11
Windows - U=0.43, SHGC=0.39	1,356,307	4,628	904	5,531	2
Windows - U=0.26, SHGC=0.37	1,355,163	4,624	896	5,520	13
Windows - U=0.22, SHGC=0.22	1,280,186	4,368	901	5,269	264

Table 100. C/CMUOS Alternatives Impact on TDVI

Prototype #12 Civic/Commercial Mixed Use - Office Space					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	106,400	248	9	257	-
Package - Optimum EE	106,400	204	8	212	45
Package - Optimum EE + PV	106,400	167	8	175	82
CoolRoof - Abs=0.25	106,400	246	9	255	2
DHW - EF=0.640	106,400	248	9	257	0
DHW - EF=0.823	106,400	248	8	256	1
Heating - AFUE=85%	106,400	248	9	257	0
HVAC - COP 6.13	106,400	235	9	244	13
Lighting - 0.90 watts/sf	106,400	231	9	241	16
PV - 11970 sqft	106,400	210	9	220	37
Roof - R15 rigid	106,400	247	9	256	1
Roof - R20 rigid	106,400	247	9	256	1
Walls - R19 batt	106,400	247	9	257	0
Walls - R21 batt	106,400	247	9	257	0
Walls - R21 batt + R5 rigid	106,400	247	9	256	1
Windows - U=0.43, SHGC=0.39	106,400	247	9	257	0
Windows - U=0.26, SHGC=0.37	106,400	247	9	256	1
Windows - U=0.22, SHGC=0.22	106,400	233	9	242	15

2.26. Residential Multi-Family/Town Home (20-dua)

Type V construction, two parallel town home buildings approximately 9,800 sf each. Three-story structure with tuck-under parking. Interior floor space demised to accommodate 7 individual units; three 2BR, three 3BR, and one 4 BR units ranging from approximately 1300 sf to 1,600 sf each. The floor-to-floor height is 10'-0" and 45% of the roof area is available for solar cells.

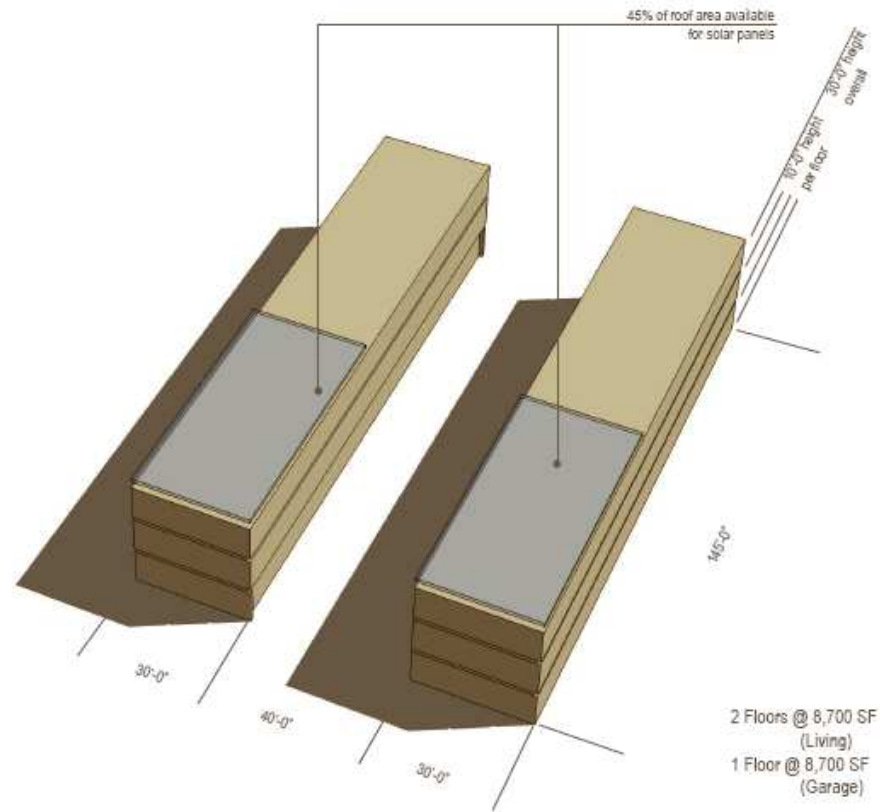


Figure 13. Residential Multi-Family/Town Home

Table 101. Residential Multi-Family/Town Home (RMF/TH) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliance	Dish EF=.46, Clothes MMEF=1.26	Dish EF=.64, Clothes MMEF=2.0	Dish EF=.64, Clothes MMEF=2.2	None	No Alternative
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Lighting	Lighting - 0.706 watts/sf	Lighting - 0.657 watts/sf	None	None	No Alternative
Photovoltaics	No PV	PV - 2205 watts/sf	None	None	Alternative 1
Roof Insulation	Roof - U=R30 batt	Roof - R38 batt	Roof - R49 batt	None	No Alternative
Wall Insulation	Walls - R13 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3
Solar Thermal	No Solar Thermal	ST - 441 sqft, 840 gal	None	None	No Alternative

Table 102. RMF/TH Alternatives Impact on Utility Costs and Paybacks

Prototype #13 Residential Multi-Family/Town Home						
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs	
Baseline	\$11,384	\$2,117	\$13,501	-	-	
Package - Optimum EE	\$10,929	\$1,698	\$12,627	\$13,644	15.6	
Package - Optimum EE + PV	\$2,291	\$1,698	\$3,989	\$132,089	11.6	
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	\$11,305	\$2,117	\$13,422	\$1,852	23.4	
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	\$11,305	\$2,117	\$13,422	\$2,510	31.8	
DHW - EF=0.640	\$11,384	\$2,007	\$13,391	\$4,337	39.4	
DHW - EF=0.823	\$11,384	\$1,698	\$13,082	\$5,189	12.4	
HVAC - EER 12.19, COP 3.52	\$11,237	\$2,117	\$13,354	\$736	5.0	
HVAC - EER 12.06, COP 3.48	\$11,254	\$2,117	\$13,371	\$2,209	17.0	
HVAC - EER 12.80, COP 3.66	\$11,149	\$2,117	\$13,266	\$3,682	15.7	
Lighting - 0.657 watts/sf	\$11,078	\$2,117	\$13,195	\$8,820	28.8	
PV - 2205 sqft	\$2,692	\$2,117	\$4,809	\$109,625	10.3	
Roof - R38 batt	\$11,366	\$2,117	\$13,483	\$931	51.7	
Roof - R49 batt	\$11,325	\$2,117	\$13,442	\$3,234	54.8	
Walls - R19 batt	\$11,384	\$2,117	\$13,501	\$464	Never	
Walls - R21 batt	\$11,386	\$2,117	\$13,503	\$671	Never	
Walls - R21 batt + R5 rigid	\$11,374	\$2,117	\$13,491	\$1,961	196.1	
Windows - U=0.43, SHGC=0.39	\$11,393	\$2,117	\$13,510	\$523	Never	
Windows - U=0.26, SHGC=0.37	\$11,421	\$2,117	\$13,538	\$1,563	Never	
Windows - U=0.22, SHGC=0.22	\$11,092	\$2,117	\$13,209	\$4,772	16.3	
ST - 441 sqft, 840 gal						Not Reported

Table 103. RMF/TH Alternatives Impact on Energy Consumption

Prototype #13 Residential Multi-Family/Town Home					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	49,337	168	169	337	-
Package - Optimum EE	47,521	162	137	299	38
Package - Optimum EE + PV	11,820	40	137	177	160
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	49,028	167	169	336	1
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	49,018	167	169	336	1
DHW - EF=0.640	49,337	168	160	329	8
DHW - EF=0.823	49,337	168	137	305	32
HVAC - EER 12.19, COP 3.52	48,750	166	169	335	2
HVAC - EER 12.06, COP 3.48	48,816	167	169	335	2
HVAC - EER 12.80, COP 3.66	48,392	165	169	334	3
Lighting - 0.657 watts/sf	48,103	164	169	333	4
PV - 2205 watts/sf	13,639	47	169	215	122
Roof - R38 batt	49,268	168	169	337	0
Roof - R49 batt	49,101	168	169	336	1
Walls - R19 batt	49,335	168	169	337	0
Walls - R21 batt	49,344	168	169	337	0
Walls - R21 batt + R5 rigid	49,299	168	169	337	0
Windows - U=0.43, SHGC=0.39	49,373	168	169	337	0
Windows - U=0.26, SHGC=0.37	49,486	169	169	337	0
Windows - U=0.22, SHGC=0.22	48,179	164	169	333	4
ST - 441 sqft, 840 gal	Not Reported				

Table 104. RMF/TH Alternatives Impact on TDVI

Prototype #13 Residential Multi-Family/Town Home					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	9,800	75	18	93	-
Package - Optimum EE	9,800	72	15	87	6
Package - Optimum EE + PV	9,800	13	15	27	66
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	9,800	75	18	93	0
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	9,800	75	18	93	0
DHW - EF=0.640	9,800	75	17	92	1
DHW - EF=0.823	9,800	75	15	90	3
HVAC - EER 12.19, COP 3.52	9,800	74	18	92	1
HVAC - EER 12.06, COP 3.48	9,800	74	18	92	1
HVAC - EER 12.80, COP 3.66	9,800	73	18	92	1
Lighting - 0.657 watts/sf	9,800	73	18	91	2
PV - 2205 watts/sf	9,800	16	18	34	59
Roof - R38 batt	9,800	75	18	93	0
Roof - R49 batt	9,800	75	18	93	0
Walls - R19 batt	9,800	75	18	93	0
Walls - R21 batt	9,800	75	18	93	0
Walls - R21 batt + R5 rigid	9,800	75	18	93	0
Windows - U=0.43, SHGC=0.39	9,800	75	18	93	0
Windows - U=0.26, SHGC=0.37	9,800	75	18	93	0
Windows - U=0.22, SHGC=0.22	9,800	73	18	91	2
ST - 441 sqft, 840 gal	9,800	0	0	0	0

2.27. Residential Low-Rise (30-40+ du)

Type II construction at ground level parking and type V construction above, approximately 63,000 sf three-story residential above 44,000 sf parking structure. Residential floor space demised to accommodate 62 individual units; 19 Studios, 24 2BR and 19 3BR units ranging from approximately 600 to 1,300 sf each. The floor-to-floor height is 10'-0" for the residential levels. 45% of the roof area is available for solar cells.

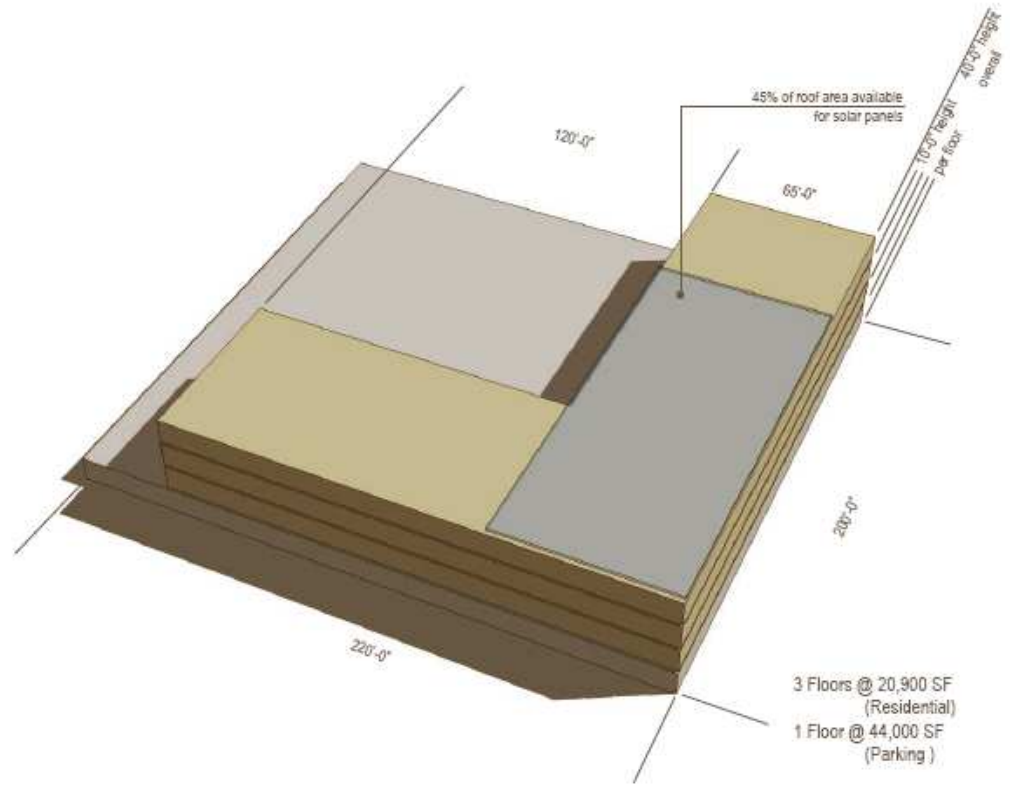


Figure 14. Residential Low-Rise

Table 105. Residential Low-Rise (RLR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliance	Dish EF=.46, Clothes MMEF=1.26	Dish EF=.64, Clothes MMEF=2.0	Dish EF=.64, Clothes MMEF=2.2	None	Alternative 1
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Htg/Clg	HVAC - EER 11.07, COP 3.28	HVAC - EER 12.19, COP 3.52	HVAC - EER 12.06, COP 3.48	HVAC - EER 12.80, COP 3.66	Alternative 3
Lighting	Lighting - 0.711 watts/sf	Lighting - 0.648 watts/sf	None	None	No Alternative
Photovoltaics	No PV	PV - 9375 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R30 batt	Roof - R38 batt	Roof - R49 batt	None	No Alternative
Wall Insulation	Walls - R13 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	No Alternative
Windows	Windows - U=0.56, SHGC=0.42	Windows - U=0.43, SHGC=0.39	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	Alternative 3

Table 106. RLR Alternatives Impact on Utility Costs and Paybacks

Prototype #14 Residential Low-Rise					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$84,776	\$14,469	\$99,245	-	-
Package - Optimum EE	\$80,010	\$12,243	\$92,253	\$62,740	9.0
Package - Optimum EE + PV	\$42,669	\$12,243	\$54,912	\$584,627	12.0
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	\$83,400	\$14,469	\$97,869	\$16,408	11.9
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	\$83,346	\$14,469	\$97,815	\$22,236	15.5
CoolRoof - Abs=0.25	\$84,432	\$14,469	\$98,901	\$6,875	20.0
DHW - EF=0.640	\$84,776	\$13,894	\$98,670	\$19,206	33.4
DHW - EF=0.823	\$84,776	\$12,243	\$97,019	\$22,980	10.3
HVAC - EER 12.19, COP 3.52	\$83,337	\$14,469	\$97,806	\$3,925	2.7
HVAC - EER 12.06, COP 3.48	\$83,559	\$14,469	\$98,028	\$11,776	9.7
HVAC - EER 12.80, COP 3.66	\$82,601	\$14,469	\$97,070	\$11,676	5.4
Lighting - 0.648 watts/sf	\$82,566	\$14,469	\$97,035	\$55,800	25.2
PV - 9375 sqft	\$47,153	\$14,469	\$61,622	\$466,087	11.0
Roof - R38 batt	\$84,850	\$14,469	\$99,319	\$3,958	Never
Roof - R49 batt	\$85,046	\$14,469	\$99,515	\$13,750	Never
Walls - R19 batt	\$84,900	\$14,469	\$99,369	\$1,420	Never
Walls - R21 batt	\$85,016	\$14,469	\$99,485	\$2,051	Never
Walls - R21 batt + R5 rigid	\$85,103	\$14,469	\$99,572	\$5,996	Never
Windows - U=0.43, SHGC=0.39	\$84,861	\$14,469	\$99,330	\$1,280	Never
Windows - U=0.26, SHGC=0.37	\$85,135	\$14,469	\$99,604	\$3,824	Never
Windows - U=0.22, SHGC=0.22	\$83,835	\$14,469	\$98,304	\$11,676	12.4

Table 107. RLR Alternatives Impact on Energy Consumption

Prototype #14 Residential Low-Rise					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	347,832	1,187	1,107	2,294	-
Package - Optimum EE	328,556	1,121	938	2,059	235
Package - Optimum EE + PV	177,176	605	938	1,543	751
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	342,215	1,168	1,107	2,275	19
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	341,995	1,167	1,107	2,274	20
CoolRoof - Abs=0.25	346,445	1,182	1,107	2,289	5
DHW - EF=0.640	347,832	1,187	1,064	2,250	44
DHW - EF=0.823	347,832	1,187	938	2,125	169
HVAC - EER 12.19, COP 3.52	342,034	1,167	1,107	2,274	20
HVAC - EER 12.06, COP 3.48	342,942	1,170	1,107	2,277	17
HVAC - EER 12.80, COP 3.66	339,075	1,157	1,107	2,264	30
Lighting - 0.648 watts/sf	338,826	1,156	1,107	2,263	31
PV - 9375 sqft	195,328	666	1,107	1,774	520
Roof - R38 batt	348,148	1,188	1,107	2,295	-1
Roof - R49 batt	348,972	1,191	1,107	2,298	-4
Walls - R19 batt	348,371	1,189	1,107	2,296	-2
Walls - R21 batt	348,857	1,190	1,107	2,297	-3
Walls - R21 batt + R5 rigid	349,239	1,192	1,107	2,299	-5
Windows - U=0.43, SHGC=0.39	348,197	1,188	1,107	2,295	-1
Windows - U=0.26, SHGC=0.37	349,335	1,192	1,107	2,299	-5
Windows - U=0.22, SHGC=0.22	344,037	1,174	1,107	2,281	13

Table 108. RLR Alternatives Impact on TDVI

Prototype #14 Residential Low-Rise					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	62,498	82	19	101	-
Package - Optimum EE	62,498	77	16	93	8
Package - Optimum EE + PV	62,498	38	16	54	47
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	62,498	81	19	100	1
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	62,498	81	19	99	2
CoolRoof - Abs=0.25	62,498	82	19	100	1
DHW - EF=0.640	62,498	82	18	100	1
DHW - EF=0.823	62,498	82	16	98	3
HVAC - EER 12.19, COP 3.52	62,498	81	19	99	2
HVAC - EER 12.06, COP 3.48	62,498	81	19	100	1
HVAC - EER 12.80, COP 3.66	62,498	80	19	99	2
Lighting - 0.648 watts/sf	62,498	80	19	99	2
PV - 9375 sqft	62,498	42	19	61	40
Roof - R38 batt	62,498	82	19	101	0
Roof - R49 batt	62,498	82	19	101	0
Walls - R19 batt	62,498	82	19	101	0
Walls - R21 batt	62,498	82	19	101	0
Walls - R21 batt + R5 rigid	62,498	82	19	101	0
Windows - U=0.43, SHGC=0.39	62,498	82	19	101	0
Windows - U=0.26, SHGC=0.37	62,498	82	19	101	0
Windows - U=0.22, SHGC=0.22	62,498	81	19	100	1

2.28. Residential Mid-Rise (60-75+ du)

Type III construction, approximately 130,000 sf six-story residential above parking structure. Residential floor space demised to accommodate 135 individual units; 19 Studios, 48 2BR and 36 3BR units ranging from approximately 600 to 1,300 sf each. The floor-to-floor height is 10'-0" for the residential levels. 45% of the roof area is available for solar cells.

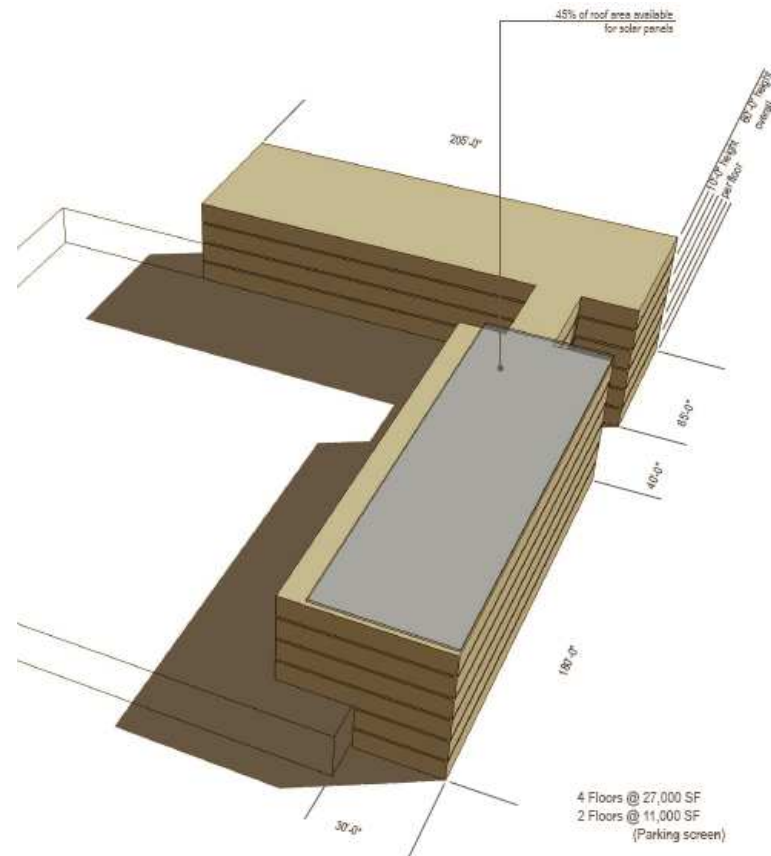


Figure 15. Residential Mid-Rise

Table 109. Residential Mid-Rise (RMR) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliance	Dish EF=.46, Clothes MMEF=1.26	Dish EF=.64, Clothes MMEF=2.0	Dish EF=.64, Clothes MMEF=2.2	None	No Alternative
Roof Material	CoolRoof - Abs=0.40	CoolRoof - Abs=0.25	None	None	Alternative 1
Water Heating	DHW - EF=0.594	DHW - EF=0.640	DHW - EF=0.823	None	Alternative 2
Space Heating	Heating - AFUE=75%	Heating - AFUE=85%	None	None	No Alternative
Space Cooling	HVAC - COP 6.10	HVAC - COP 7.63	None	None	Alternative 1
Lighting	Lighting - 0.703 watts/sf	Lighting - 0.664 watts/sqft	None	None	No Alternative
Photovoltaics	No PV	PV - 9763 sqft	None	None	Alternative 1
Roof Insulation	Roof - U=R10 batt	Roof - U=R15 rigid	Roof - U=R20 rigid	None	Alternative 2
Wall Insulation	Walls - R13 batt	Walls - R19 batt	Walls - R21 batt	Walls - R21 batt + R5 rigid	Alternative 3
Windows	Windows - U=0.48, SHGC=0.47	Windows - U=0.26, SHGC=0.37	Windows - U=0.22, SHGC=0.22	None	Alternative 2

Table 110. RMR Alternatives Impact on Utility Costs and Paybacks

Prototype #15 Residential Mid-Rise					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility	Alt Cost \$	Payback yrs
Baseline	\$181,789	\$48,919	\$230,709	-	-
Package - Optimum EE	\$168,877	\$44,007	\$212,885	\$106,601	6.0
Package - Optimum EE + PV	\$131,077	\$44,004	\$175,081	\$584,814	10.6
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	\$179,739	\$48,922	\$228,661	\$35,726	17.4
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	\$179,616	\$48,922	\$228,538	\$48,416	22.3
CoolRoof - Abs=0.25	\$180,046	\$48,922	\$228,968	\$7,159	4.1
DHW - EF=0.640	\$182,651	\$47,563	\$230,214	\$41,819	84.5
DHW - EF=0.823	\$181,789	\$44,064	\$225,853	\$50,036	10.3
Heating - AFUE=85%	\$181,789	\$48,909	\$230,698	\$1,000	90.9
HVAC - COP 7.63	\$176,440	\$48,919	\$225,360	\$5,671	1.1
Lighting - 0.664 watts/sqft	\$176,990	\$48,925	\$225,915	\$121,500	25.3
PV - 9763 sqft	\$142,691	\$48,919	\$191,611	\$485,372	12.4
Roof - U=R15 rigid	\$181,671	\$48,909	\$230,580	\$5,424	42.0
Roof - U=R20 rigid	\$181,467	\$48,894	\$230,362	\$9,763	28.1
Walls - R19 batt	\$181,659	\$48,914	\$230,573	\$2,967	21.8
Walls - R21 batt	\$181,580	\$48,913	\$230,493	\$4,285	19.8
Walls - R21 batt + R5 rigid	\$181,117	\$48,900	\$230,017	\$12,527	18.1
Windows - U=0.26, SHGC=0.37	\$178,474	\$48,914	\$227,388	\$7,024	2.1
Windows - U=0.22, SHGC=0.22	\$175,595	\$48,918	\$224,513	\$21,445	3.5

Table 111. RMR Alternatives Impact on Energy Consumption

Prototype #15 Residential Mid-Rise					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	744,371	2,540	3,725	6,264	-
Package - Optimum EE	692,345	2,362	3,351	5,714	550
Package - Optimum EE + PV	539,100	1,839	3,351	5,191	1,073
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	736,021	2,511	3,725	6,236	28
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	735,522	2,510	3,725	6,234	30
CoolRoof - Abs=0.25	737,301	2,516	3,725	6,240	24
DHW - EF=0.640	745,095	2,542	3,622	6,164	100
DHW - EF=0.823	744,371	2,540	3,356	5,896	368
Heating - AFUE=85%	744,371	2,540	3,724	6,263	1
HVAC - COP 7.63	722,879	2,466	3,725	6,191	73
Lighting - 0.664 watts/sqft	724,843	2,473	3,725	6,198	66
PV - 9763 sqft	585,882	1,999	3,725	5,724	540
Roof - U=R15 rigid	743,934	2,538	3,724	6,262	2
Roof - U=R20 rigid	743,132	2,536	3,723	6,258	6
Walls - R19 batt	743,872	2,538	3,724	6,262	2
Walls - R21 batt	743,558	2,537	3,724	6,261	3
Walls - R21 batt + R5 rigid	741,716	2,531	3,723	6,254	10
Windows - U=0.26, SHGC=0.37	730,946	2,494	3,724	6,218	46
Windows - U=0.22, SHGC=0.22	719,268	2,454	3,724	6,179	85

Table 112. RMR Alternatives Impact on TDVI

Prototype #15 Residential Mid-Rise					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	130,171	85	30	115	-
Package - Optimum EE	130,171	78	27	106	9
Package - Optimum EE + PV	130,171	59	27	86	29
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 1.26	130,171	84	30	114	1
Appliance - Dishwasher EF=0.64, Clothes Washer MMEF = 2.00	130,171	84	30	114	1
CoolRoof - Abs=0.25	130,171	84	30	114	1
DHW - EF=0.640	130,171	85	29	114	1
DHW - EF=0.823	130,171	85	27	112	3
Heating - AFUE=85%	130,171	85	30	115	0
HVAC - COP 7.63	130,171	82	30	112	3
Lighting - 0.664 watts/sqft	130,171	82	30	113	2
PV - 9763 sqft	130,171	65	30	95	20
Roof - U=R15 rigid	130,171	84	30	115	0
Roof - U=R20 rigid	130,171	84	30	115	0
Walls - R19 batt	130,171	85	30	115	0
Walls - R21 batt	130,171	84	30	115	0
Walls - R21 batt + R5 rigid	130,171	84	30	115	0
Windows - U=0.26, SHGC=0.37	130,171	83	30	113	2
Windows - U=0.22, SHGC=0.22	130,171	82	30	112	3

3.0 Alternatives for 12 Residential-Site Building Types & Spaces

3.1. Residential Single-Family Detached Home (6 -dua)

Type V construction, Colonial style approximately 2,540 sf. 2-story structure with 2-car attached direct-access garage parking. Interior floor space demised to accommodate 4 BR and 3 BA. The floor-to-floor height is 11'-0" and 45% of the roof area is available for solar cells.



Figure 16. Residential Single-Family Detached Home

Table 113. Residential Single-Family Detached Home (RSFDH) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	0.35193 w/sqft, 0.54043 Btu/hr/sqft	0.34694 w/sqft, 0.54043 Btu/hr/sqft	0.34663 w/sqft, 0.54043 Btu/hr/sqft	None	No Alternative
CHP	None	None	None	None	No Alternative
Roof Material	100% of roof at Abs=0.70	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.56, SHGC=0.42	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	AFUE=94%	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	SEER 14, EER 11.99	SEER 15, EER 12.72	SEER 18, EER 13.37	Alternative 2
Lighting	0.554 watts/sqft	0.508 watts/sqft	None	None	No Alternative
Photovoltaics	None	None	None	None	No Alternative
Roof Insulation	R30 batt	R38 batt	R49 batt	None	Alternative 1
Solar Thermal	None	42 Sqft of panels, 84 Gal tank	None	None	No Alternative
Thermal Storage	None	None	None	None	No Alternative
Wall Insulation	R13 batt	R19 batt	R21 batt	R21 batt + R5 rigid	Alternative 2

Table 114. RSFDH Alternatives Impact on Utility Costs and Paybacks

Prototype #1 Luminara Residential					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	11,091	38	33	71	0
Baseline + EE Package	10,078	34	29	63	8
Baseline + High Efficiency Appliances, 0.34694 w/sqft, 0.54043 Btu/hr/sqft	11,009	38	33	70	1
Baseline + High Efficiency Appliances, 0.34663 w/sqft, 0.54043 Btu/hr/sqft	11,004	38	33	70	1
Baseline + High Efficiency Domestic Hot Water, EF=0.823	11,091	38	28	65	6
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	11,100	38	31	69	2
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	10,242	35	36	70	1
Baseline + High Efficiency Heating, AFUE=94%	11,091	38	32	70	1
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	10,986	37	33	70	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	10,912	37	33	70	1
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	10,853	37	33	70	1
Baseline + High Efficiency Lighting, 0.508 watts/sqft	10,891	37	33	70	1
Baseline + Envelope Insulation - Roof, R38 batt	11,071	38	33	70	1
Baseline + Envelope Insulation - Roof, R49 batt	11,044	38	33	70	1
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	11,091	38	22	60	11
Baseline + Envelope Insulation - Walls, R19 batt	11,060	38	32	70	1
Baseline + Envelope Insulation - Walls, R21 batt	11,048	38	32	69	2
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	11,012	38	31	68	3

Table 115. RSFDH Alternatives Impact on Energy Consumption

Prototype #1 Luminara Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,540	66	14	80	0
Baseline + EE Package	2,540	59	12	71	9
Baseline + High Efficiency Appliances, 0.34694 w/sqft, 0.54043 Btu/hr/sqft	2,540	66	14	80	0
Baseline + High Efficiency Appliances, 0.34663 w/sqft, 0.54043 Btu/hr/sqft	2,540	66	14	79	1
Baseline + High Efficiency Domestic Hot Water, EF=0.823	2,540	66	11	78	2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	2,540	66	13	79	1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	2,540	61	15	75	5
Baseline + High Efficiency Heating, AFUE=94%	2,540	66	13	80	0
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	2,540	66	14	79	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	2,540	65	14	78	2
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	2,540	64	14	78	2
Baseline + High Efficiency Lighting, 0.508 watts/sqft	2,540	65	14	79	1
Baseline + Envelope Insulation - Roof, R38 batt	2,540	66	14	80	0
Baseline + Envelope Insulation - Roof, R49 batt	2,540	66	13	80	0
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	2,540	66	9	75	5
Baseline + Envelope Insulation - Walls, R19 batt	2,540	66	13	79	1
Baseline + Envelope Insulation - Walls, R21 batt	2,540	66	13	79	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	2,540	66	13	78	2

Table 116. RSFDH Alternatives Impact on TDVI

Prototype #1 Luminara Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,540	66	14	80	0
Baseline + EE Package	2,540	59	12	71	9
Baseline + High Efficiency Appliances, 0.34694 w/sqft, 0.54043 Btu/hr/sqft	2,540	66	14	80	0
Baseline + High Efficiency Appliances, 0.34663 w/sqft, 0.54043 Btu/hr/sqft	2,540	66	14	79	1
Baseline + High Efficiency Domestic Hot Water, EF=0.823	2,540	66	11	78	2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	2,540	66	13	79	1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	2,540	61	15	75	5
Baseline + High Efficiency Heating, AFUE=94%	2,540	66	13	80	0
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	2,540	66	14	79	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	2,540	65	14	78	2
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	2,540	64	14	78	2
Baseline + High Efficiency Lighting, 0.508 watts/sqft	2,540	65	14	79	1
Baseline + Envelope Insulation - Roof, R38 batt	2,540	66	14	80	0
Baseline + Envelope Insulation - Roof, R49 batt	2,540	66	13	80	0
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	2,540	66	9	75	5
Baseline + Envelope Insulation - Walls, R19 batt	2,540	66	13	79	1
Baseline + Envelope Insulation - Walls, R21 batt	2,540	66	13	79	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	2,540	66	13	78	2

3.2. Residential Multi-Family Town Home (15+ du)

Type V construction, approximately 2,980 sf total. 2-story structure with 2-car attached direct-access garage parking per unit. Interior floor space demised to accommodate 2 individual units at approximately 1490 sf each, 3 BR and 2.5 BA. The floor-to-floor height is 11'-0" and 45% of the roof area is available for solar cells.



Figure 17. Residential Multi-Family Town Home

Table 117 - Residential Multi-Family Town Home (RMFTH) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	0.39347 w/sqft, 0.93 Btu/hr/sqft	0.38497 w/sqft, 0.93 Btu/hr/sqft	0.38444 w/sqft, 0.93 Btu/hr/sqft	None	No Alternative
CHP	None	None	None	None	No Alternative
Roof Material	100% of roof at Abs=0.70	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.56, SHGC=0.42	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	AFUE=94%	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	SEER 14, EER 11.99	SEER 15, EER 12.72	SEER 18, EER 13.37	Alternative 1
Lighting	0.592 watts/sqft	0.542 watts/sqft	None	None	No Alternative
Photovoltaics	None	None	None	None	No Alternative
Roof Insulation	R30 batt	R38 batt	R49 batt	None	Alternative 1
Solar Thermal	None	42 Sqft of panels, 84 Gal tank	None	None	No Alternative
Thermal Storage	None	None	None	None	No Alternative
Wall Insulation	R13 batt	R19 batt	R21 batt	R21 batt + R5 rigid	Alternative 2

Table 118. RMFTH Alternatives Impact on Utility Costs and Paybacks

Prototype #2 Chambray Residential					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$2,238	\$601	\$2,839	\$0	NA
Baseline + EE Package	\$2,036	\$484	\$2,520	\$3,213	10.1
Baseline + High Efficiency Appliances, 0.38497 w/sqft, 0.93 Btu/hr/sqft	\$2,204	\$602	\$2,806	\$529	16.0
Baseline + High Efficiency Appliances, 0.38444 w/sqft, 0.93 Btu/hr/sqft	\$2,201	\$602	\$2,803	\$717	19.9
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$2,238	\$493	\$2,731	\$741	6.9
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$2,244	\$586	\$2,830	\$331	36.8
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$2,091	\$625	\$2,716	\$990	8.0
Baseline + High Efficiency Heating, AFUE=94%	\$2,238	\$590	\$2,828	\$2,000	181.8
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	\$2,215	\$601	\$2,816	\$400	17.4
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	\$2,197	\$601	\$2,798	\$800	19.5
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	\$2,185	\$601	\$2,786	\$2,001	37.7
Baseline + High Efficiency Lighting, 0.542 watts/sqft	\$2,182	\$602	\$2,784	\$2,700	49.1
Baseline + Envelope Insulation - Roof, R38 batt	\$2,231	\$598	\$2,829	\$250	25.0
Baseline + Envelope Insulation - Roof, R49 batt	\$2,225	\$598	\$2,823	\$1,148	71.8
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	\$2,238	\$371	\$2,609	\$18,224	98.8
Baseline + Envelope Insulation - Walls, R19 batt	\$2,233	\$592	\$2,825	\$450	32.2
Baseline + Envelope Insulation - Walls, R21 batt	\$2,231	\$588	\$2,819	\$831	41.6
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$2,223	\$577	\$2,800	\$5,266	135.0

Table 119. RMFTH Alternatives Impact on Energy Consumption

Prototype #2 Chambray Residential					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	13,612	46	53	99	0
Baseline + EE Package	12,710	43	43	86	13
Baseline + High Efficiency Appliances, 0.38497 w/sqft, 0.93 Btu/hr/sqft	13,450	46	53	99	0
Baseline + High Efficiency Appliances, 0.38444 w/sqft, 0.93 Btu/hr/sqft	13,440	46	53	99	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	13,612	46	44	90	9
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	13,634	47	52	98	1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	12,954	44	55	99	0
Baseline + High Efficiency Heating, AFUE=94%	13,612	46	52	99	0
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	13,511	46	53	99	0
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	13,439	46	53	99	0
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	13,381	46	53	98	1
Baseline + High Efficiency Lighting, 0.542 watts/sqft	13,359	46	53	99	0
Baseline + Envelope Insulation - Roof, R38 batt	13,587	46	53	99	0
Baseline + Envelope Insulation - Roof, R49 batt	13,553	46	52	99	0
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	13,612	46	33	80	19
Baseline + Envelope Insulation - Walls, R19 batt	13,584	46	52	98	1
Baseline + Envelope Insulation - Walls, R21 batt	13,576	46	52	98	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	13,539	46	51	97	2

Table 120. RMFTH Alternatives Impact on TDVI

Prototype #2 Chambray Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,982	69	19	87	0
Baseline + EE Package	2,982	63	15	79	8
Baseline + High Efficiency Appliances, 0.38497 w/sqft, 0.93 Btu/hr/sqft	2,982	68	19	87	0
Baseline + High Efficiency Appliances, 0.38444 w/sqft, 0.93 Btu/hr/sqft	2,982	68	19	87	0
Baseline + High Efficiency Domestic Hot Water, EF=0.823	2,982	69	16	84	3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	2,982	69	18	87	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	2,982	65	19	84	3
Baseline + High Efficiency Heating, AFUE=94%	2,982	69	19	87	0
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	2,982	68	19	87	0
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	2,982	68	19	86	1
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	2,982	67	19	86	1
Baseline + High Efficiency Lighting, 0.542 watts/sqft	2,982	67	19	86	1
Baseline + Envelope Insulation - Roof, R38 batt	2,982	69	19	87	0
Baseline + Envelope Insulation - Roof, R49 batt	2,982	68	19	87	0
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	2,982	69	12	80	7
Baseline + Envelope Insulation - Walls, R19 batt	2,982	68	18	87	0
Baseline + Envelope Insulation - Walls, R21 batt	2,982	68	18	87	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	2,982	68	18	86	1

3.3. Retail/Residential Mixed-Use Low-Rise Building Residential Space (20-dua)

Type V construction for retail and residential space, approximately 10,110 sf three-story mixed use slab on grade building. Interior floor space demised to accommodate 2 individual retail tenants at street level averaging 510 sf each. Two and a half floor levels of residential apartments on or above the first floor totaling approximately 9,090 sf. Residential floor space demised to accommodate 5 individual 2BR, 2BA units ranging from approximately 1220 to 1,970 sf each. The floor-to-floor height for the first floor retail is 14'-0" and 11'-0" for the residential levels above. 45% of the roof area is available for solar cells.



Figure 18. Residential Multi-Family Town Home

Table 121. Retail/Residential Mixed-Use Low-Rise Building – Residential Space (R/RMULRB-RS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	0.37556 w/sqft, 0.75563 Btu/hr/sqft	0.36858 w/sqft, 0.75563 Btu/hr/sqft	0.36815 w/sqft, 0.75563 Btu/hr/sqft	None	Alternative 1
CHP	None	None	None	None	No Alternative
Roof Material	75% of roof at Abs=0.70	75% of roof at Abs=0.25	None	None	Alternative 1
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.56, SHGC=0.42	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	AFUE=94%	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	SEER 14, EER 11.99	SEER 15, EER 12.72	SEER 18, EER 13.37	Alternative 2
Lighting	0.643 watts/sqft	0.587 watts/sqft	None	None	No Alternative
Photovoltaics	None	1640 Sqft @ 0 deg pitch	None	None	Alternative 1
Roof Insulation	R30 batt	R38 batt	R49 batt	None	Alternative 2
Solar Thermal	None	42 Sqft of panels, 84 Gal tank	None	None	No Alternative
Thermal Storage	None	None	None	None	No Alternative
Wall Insulation	R13 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 122. R/RMULRB-RS Alternatives Impact on Utility Costs and Paybacks

Prototype #3 Artisan Residential					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$8,712	\$1,556	\$10,268	\$0	NA
Baseline + EE Package	\$8,127	\$1,273	\$9,400	\$8,144	9.4
Baseline + EE Package + Photovoltaics	\$4,701	\$1,273	\$5,974	\$89,680	16.2
Baseline + High Efficiency Appliances, 0.36858 w/sqft, 0.75563 Btu/hr/sqft	\$8,609	\$1,558	\$10,167	\$1,323	13.1
Baseline + High Efficiency Appliances, 0.36815 w/sqft, 0.75563 Btu/hr/sqft	\$8,604	\$1,558	\$10,162	\$1,793	16.9
Baseline + Cool Roof, 75% of roof at Abs=0.25	\$8,574	\$1,563	\$10,137	\$900	6.9
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$8,712	\$1,269	\$9,981	\$1,853	6.5
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$8,724	\$1,550	\$10,274	\$400	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$8,486	\$1,563	\$10,049	\$1,196	5.5
Baseline + High Efficiency Heating, AFUE=94%	\$8,712	\$1,541	\$10,253	\$5,000	333.3
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	\$8,631	\$1,556	\$10,187	\$891	11.0
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	\$8,574	\$1,556	\$10,130	\$1,781	12.9
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	\$8,527	\$1,556	\$10,083	\$4,453	24.1
Baseline + High Efficiency Lighting, 0.587 watts/sqft	\$8,478	\$1,559	\$10,037	\$8,910	38.6
Baseline + Photovoltaics, 1640 Sqft @ 0 deg pitch	\$5,028	\$1,556	\$6,584	\$81,535	16.9
Baseline + Envelope Insulation - Roof, R38 batt	\$8,677	\$1,550	\$10,227	\$655	16.0
Baseline + Envelope Insulation - Roof, R49 batt	\$8,670	\$1,547	\$10,217	\$1,091	21.4
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	\$8,712	\$917	\$9,629	\$45,560	86.8
Baseline + Envelope Insulation - Walls, R19 batt	\$8,708	\$1,550	\$10,258	\$754	75.4
Baseline + Envelope Insulation - Walls, R21 batt	\$8,709	\$1,547	\$10,256	\$1,392	116.0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$8,704	\$1,543	\$10,247	\$8,819	419.9

Table 123. R/RMULRB-RS Alternatives Impact on Energy Consumption

Prototype #3 Artisan Residential					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	41,274	141	126	267	0
Baseline + EE Package	38,948	133	104	237	30
Baseline + EE Package + Photovoltaics	24,612	84	104	188	79
Baseline + High Efficiency Appliances, 0.36858 w/sqft, 0.75563 Btu/hr/sqft	40,865	139	126	265	2
Baseline + High Efficiency Appliances, 0.36815 w/sqft, 0.75563 Btu/hr/sqft	40,840	139	126	265	2
Baseline + Cool Roof, 75% of roof at Abs=0.25	40,730	139	126	265	2
Baseline + High Efficiency Domestic Hot Water, EF=0.823	41,274	141	104	245	22
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	41,335	141	125	267	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	40,383	138	127	264	3
Baseline + High Efficiency Heating, AFUE=94%	41,274	141	125	266	1
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	40,955	140	126	266	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	40,729	139	126	265	2
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	40,548	138	126	264	3
Baseline + High Efficiency Lighting, 0.587 watts/sqft	40,332	138	126	264	3
Baseline + Photovoltaics, 1640 Sqft @ 0 deg pitch	26,021	89	126	215	52
Baseline + Envelope Insulation - Roof, R38 batt	41,148	140	125	266	1
Baseline + Envelope Insulation - Roof, R49 batt	41,112	140	125	266	1
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	41,274	141	77	218	49
Baseline + Envelope Insulation - Walls, R19 batt	41,258	141	126	266	1
Baseline + Envelope Insulation - Walls, R21 batt	41,272	141	125	266	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	41,258	141	125	266	1

Table 124. R/RMULRB-RS Alternatives Impact on TDVI

Prototype #3 Artisan Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	9,091	68	15	83	0
Baseline + EE Package	9,091	64	12	76	7
Baseline + EE Package + Photovoltaics	9,091	16	12	28	55
Baseline + High Efficiency Appliances, 0.36858 w/sqft, 0.75563 Btu/hr/sqft	9,091	67	15	82	1
Baseline + High Efficiency Appliances, 0.36815 w/sqft, 0.75563 Btu/hr/sqft	9,091	67	15	82	1
Baseline + Cool Roof, 75% of roof at Abs=0.25	9,091	67	15	82	1
Baseline + High Efficiency Domestic Hot Water, EF=0.823	9,091	68	12	80	3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	9,091	68	15	83	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	9,091	66	15	81	2
Baseline + High Efficiency Heating, AFUE=94%	9,091	68	15	82	1
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	9,091	67	15	82	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	9,091	67	15	81	2
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	9,091	66	15	81	2
Baseline + High Efficiency Lighting, 0.587 watts/sqft	9,091	66	15	81	2
Baseline + Photovoltaics, 1640 Sqft @ 0 deg pitch	9,091	20	15	35	48
Baseline + Envelope Insulation - Roof, R38 batt	9,091	68	15	82	1
Baseline + Envelope Insulation - Roof, R49 batt	9,091	68	15	82	1
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	9,091	68	9	77	6
Baseline + Envelope Insulation - Walls, R19 batt	9,091	68	15	83	0
Baseline + Envelope Insulation - Walls, R21 batt	9,091	68	15	82	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	9,091	68	15	82	1

3.4. Retail/Residential Mixed-Use Low-Rise Building – Small Corner Retail Shop

Table 125. R/RMULRB – Small Corner Retail Shop (R/RMULRB – SCRS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	No Alternative
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 3
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	Alternative 3

Table 126. R/RMULRB – SCRS Alternatives Impact on Utility Costs and Paybacks

Prototype #3 Artisan Retail Corner Small Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$1,812	\$1,536	\$3,348	\$0	NA
Baseline + EE Package	\$1,593	\$1,536	\$3,129	\$2,525	11.5
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$1,812	\$1,512	\$3,324	\$371	15.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$1,769	\$1,536	\$3,305	\$168	3.9
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$1,700	\$1,536	\$3,236	\$503	4.5
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$1,766	\$1,536	\$3,302	\$209	4.6
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$1,743	\$1,536	\$3,279	\$419	6.1
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$1,732	\$1,536	\$3,268	\$1,047	13.1
Baseline + Envelope Insulation - Walls, R19 batt	\$1,790	\$1,536	\$3,326	\$83	3.8
Baseline + Envelope Insulation - Walls, R21 batt	\$1,789	\$1,536	\$3,325	\$154	6.7
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$1,776	\$1,536	\$3,312	\$975	27.1

Table 127. R/RMULRB – SCRS Alternatives Impact on Energy Consumption

Prototype #3 Artisan Retail Corner Small Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	7,044	24	7	31	0
Baseline + EE Package	5,927	20	7	27	4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	7,044	24	5	29	2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	6,929	24	7	30	1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	6,379	22	7	28	3
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	6,815	23	7	30	1
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	6,698	23	7	29	2
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	6,633	23	7	29	2
Baseline + Envelope Insulation - Walls, R19 batt	7,008	24	7	31	0
Baseline + Envelope Insulation - Walls, R21 batt	7,000	24	7	30	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	6,927	24	7	30	1

Table 128. R/RMULRB – SCRS Alternatives Impact on TDVI

Prototype #3 Artisan Retail Corner Small Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	510	275	14	289	0
Baseline + EE Package	510	227	14	241	48
Baseline + High Efficiency Domestic Hot Water, EF=0.823	510	275	11	285	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	510	271	14	285	4
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	510	250	14	264	25
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	510	264	14	279	10
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	510	259	14	273	16
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	510	256	14	270	19
Baseline + Envelope Insulation - Walls, R19 batt	510	273	14	287	2
Baseline + Envelope Insulation - Walls, R21 batt	510	273	14	287	2
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	510	270	14	284	5

3.5. Retail/Residential Mixed-Use Low-Rise Building – Residential Space (30-dua)

Type II construction for the ground floor and Type V construction for the residential space above. Approximately 19,800 sf three-story mixed use slab on grade building. Interior floor space demised to accommodate 5 individual retail tenants at street level averaging 510 sf each. Two floor levels of residential apartments above the first floor totaling approximately 17,250 sf. Residential floor space demised to accommodate five 3BR, 3BA and five 4BR, 3BA units ranging from approximately 1600 to 1,850 sf each. The floor-to-floor height for the first floor retail is 14'-0" and 11'-0" for the residential levels above. 45% of the roof area is available for solar cells.



Figure 19. Retail/Residential Mixed-Use Low-Rise Building

Table 129. Retail/Residential Mixed-Use Low-Rise Building – Residential Space (R/RMULRB-RS)

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	0.3801 w/sqft, 0.79647 Btu/hr/sqft	0.37273 w/sqft, 0.79647 Btu/hr/sqft	0.37228 w/sqft, 0.79647 Btu/hr/sqft	None	Alternative 1
CHP	None	30 kW, 0 Tons Abs	None	None	No Alternative
Roof Material	100% of roof at Abs=0.70	100% of roof at Abs=0.25	None	None	Alternative 1
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.56, SHGC=0.42	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	AFUE=94%	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	SEER 14, EER 11.99	SEER 15, EER 12.72	SEER 18, EER 13.37	Alternative 2
Lighting	0.576 watts/sqft	0.532 watts/sqft	None	None	No Alternative
Photovoltaics	None	3870 Sqft @ 0 deg pitch	None	None	Alternative 1
Roof Insulation	R30 batt	R38 batt	R49 batt	None	Alternative 2
Solar Thermal	None	42 Sqft of panels, 84 Gal tank	None	None	No Alternative
Thermal Storage	None	None	None	None	No Alternative
Wall Insulation	R13 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 130. R/RMULRB-RS Alternatives Impact on Utility Costs and Paybacks

Prototype #4 Studio Walk Residential					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$17,693	\$3,185	\$20,878	\$0	NA
Baseline + EE Package	\$16,256	\$2,623	\$18,879	\$18,225	9.1
Baseline + EE Package + Photovoltaics	\$9,215	\$2,623	\$11,838	\$210,629	16.7
Baseline + High Efficiency Appliances, 0.37273 w/sqft, 0.79647 Btu/hr/sqft	\$17,484	\$3,186	\$20,670	\$2,646	12.7
Baseline + High Efficiency Appliances, 0.37228 w/sqft, 0.79647 Btu/hr/sqft	\$17,470	\$3,186	\$20,656	\$3,586	16.2
Baseline + Combined Heat and Power, 30 kW, 0 Tons Abs	\$8,191	\$11,066	\$19,257	\$88,693	97.4
Baseline + Cool Roof, 100% of roof at Abs=0.25	\$17,156	\$3,210	\$20,366	\$2,840	5.5
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$17,693	\$2,615	\$20,308	\$3,706	6.5
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$17,744	\$3,171	\$20,915	\$882	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$17,080	\$3,203	\$20,283	\$2,634	4.4
Baseline + High Efficiency Heating, AFUE=94%	\$17,693	\$3,153	\$20,846	\$10,000	312.5
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	\$17,502	\$3,185	\$20,687	\$1,908	10.0
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	\$17,370	\$3,185	\$20,555	\$3,815	11.8
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	\$17,261	\$3,185	\$20,446	\$9,537	22.1
Baseline + High Efficiency Lighting, 0.532 watts/sqft	\$17,339	\$3,187	\$20,526	\$17,100	48.6
Baseline + Photovoltaics, 3870 Sqft @ 0 deg pitch	\$10,029	\$3,185	\$13,214	\$192,404	17.6
Baseline + Envelope Insulation - Roof, R38 batt	\$17,626	\$3,171	\$20,797	\$1,549	19.1
Baseline + Envelope Insulation - Roof, R49 batt	\$17,596	\$3,167	\$20,763	\$2,582	22.5
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	\$17,693	\$1,917	\$19,610	\$91,120	87.6
Baseline + Envelope Insulation - Walls, R19 batt	\$17,695	\$3,173	\$20,868	\$1,220	122.0
Baseline + Envelope Insulation - Walls, R21 batt	\$17,692	\$3,171	\$20,863	\$2,252	150.1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$17,682	\$3,161	\$20,843	\$14,263	407.5

Table 131. R/RMULRB-RS Alternatives Impact on Energy Consumption

Prototype #4 Studio Walk Residential					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	77,738	265	250	515	0
Baseline + EE Package	71,984	246	207	453	62
Baseline + EE Package + Photovoltaics	43,454	148	207	355	160
Baseline + High Efficiency Appliances, 0.37273 w/sqft, 0.79647 Btu/hr/sqft	76,885	262	250	512	3
Baseline + High Efficiency Appliances, 0.37228 w/sqft, 0.79647 Btu/hr/sqft	76,831	262	250	512	3
Baseline + Combined Heat and Power, 30 kW, 0 Tons Abs	33,414	114	849	963	-448
Baseline + Cool Roof, 100% of roof at Abs=0.25	75,592	258	252	510	5
Baseline + High Efficiency Domestic Hot Water, EF=0.823	77,738	265	207	472	43
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	77,941	266	249	515	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	75,282	257	251	508	7
Baseline + High Efficiency Heating, AFUE=94%	77,738	265	247	513	2
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	76,983	263	250	513	2
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	76,449	261	250	511	4
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	76,023	259	250	509	6
Baseline + High Efficiency Lighting, 0.532 watts/sqft	76,302	260	250	510	5
Baseline + Photovoltaics, 3870 Sqft @ 0 deg pitch	46,727	159	250	409	106
Baseline + Envelope Insulation - Roof, R38 batt	77,468	264	249	513	2
Baseline + Envelope Insulation - Roof, R49 batt	77,352	264	249	513	2
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	77,738	265	154	419	96
Baseline + Envelope Insulation - Walls, R19 batt	77,742	265	249	514	1
Baseline + Envelope Insulation - Walls, R21 batt	77,726	265	249	514	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	77,693	265	248	513	2

Table 132. R/RMULRB-RS Alternatives Impact on TDVI

Prototype #4 Studio Walk Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	17,215	68	15	83	0
Baseline + EE Package	17,215	62	13	75	8
Baseline + EE Package + Photovoltaics	17,215	3	13	15	68
Baseline + High Efficiency Appliances, 0.37273 w/sqft, 0.79647 Btu/hr/sqft	17,215	67	15	82	1
Baseline + High Efficiency Appliances, 0.37228 w/sqft, 0.79647 Btu/hr/sqft	17,215	67	15	82	1
Baseline + Combined Heat and Power, 30 kW, 0 Tons Abs	17,215	28	52	81	2
Baseline + Cool Roof, 100% of roof at Abs=0.25	17,215	66	15	81	2
Baseline + High Efficiency Domestic Hot Water, EF=0.823	17,215	68	13	80	3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	17,215	68	15	83	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	17,215	65	15	81	2
Baseline + High Efficiency Heating, AFUE=94%	17,215	68	15	83	0
Baseline + High Efficiency Cooling, SEER 14, EER 11.99	17,215	67	15	82	1
Baseline + High Efficiency Cooling, SEER 15, EER 12.72	17,215	66	15	82	1
Baseline + High Efficiency Cooling, SEER 18, EER 13.37	17,215	66	15	81	2
Baseline + High Efficiency Lighting, 0.532 watts/sqft	17,215	66	15	82	1
Baseline + Photovoltaics, 3870 Sqft @ 0 deg pitch	17,215	8	15	24	59
Baseline + Envelope Insulation - Roof, R38 batt	17,215	67	15	83	0
Baseline + Envelope Insulation - Roof, R49 batt	17,215	67	15	82	1
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	17,215	68	9	77	6
Baseline + Envelope Insulation - Walls, R19 batt	17,215	68	15	83	0
Baseline + Envelope Insulation - Walls, R21 batt	17,215	68	15	83	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	17,215	67	15	83	0

3.6. Retail/Residential Mixed-Use Low-Rise Building – Retail Small Corner Shop

Table 133. R/RMULRB – Retail Small Corner Shop (RSCS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	No Alternative
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 3
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	Alternative 3

Table 134. R/RMULRB- RSCS Impacts on Utility Costs and Paybacks

Prototype #4 Studio Walk Retail Small Corner Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$1,792	\$1,536	\$3,328	\$0	NA
Baseline + EE Package	\$1,595	\$1,536	\$3,131	\$2,493	12.7
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$1,792	\$1,512	\$3,304	\$371	15.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$1,764	\$1,536	\$3,300	\$168	6.0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$1,697	\$1,536	\$3,233	\$503	5.3
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$1,757	\$1,536	\$3,293	\$203	5.8
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$1,738	\$1,536	\$3,274	\$406	7.5
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$1,729	\$1,536	\$3,265	\$1,015	16.1
Baseline + Envelope Insulation - Walls, R19 batt	\$1,784	\$1,536	\$3,320	\$83	10.4
Baseline + Envelope Insulation - Walls, R21 batt	\$1,784	\$1,536	\$3,320	\$154	19.2
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$1,773	\$1,536	\$3,309	\$975	51.3

Table 135. R/RMULRB- RSCS Alternatives Impact on Energy Consumption

Prototype #4 Studio Walk Retail Small Corner Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	6,996	24	7	30	0
Baseline + EE Package	5,922	20	7	27	3
Baseline + High Efficiency Domestic Hot Water, EF=0.823	6,996	24	5	29	1
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	6,878	23	7	30	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	6,352	22	7	28	2
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	6,774	23	7	30	0
Baseline + High Efficiency Cooling, HSPF 8.8 ,EER 12.70, COP 3.74	6,654	23	7	29	1
Baseline + High Efficiency Cooling, HSPF 9.2 ,EER 12.88, COP 3.66	6,589	22	7	29	1
Baseline + Envelope Insulation - Walls, R19 batt	6,960	24	7	30	0
Baseline + Envelope Insulation - Walls, R21 batt	6,955	24	7	30	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	6,883	23	7	30	0

Table 136. R/RMULRB-RSCS Alternatives Impact on TDVI

Prototype #4 Studio Walk Retail Small Corner Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	510	273	14	287	0
Baseline + EE Package	510	226	14	241	46
Baseline + High Efficiency Domestic Hot Water, EF=0.823	510	273	11	283	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	510	269	14	283	4
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	510	248	14	263	24
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	510	262	14	277	10
Baseline + High Efficiency Cooling, HSPF 8.8 ,EER 12.70, COP 3.74	510	257	14	271	16
Baseline + High Efficiency Cooling, HSPF 9.2 ,EER 12.88, COP 3.66	510	254	14	268	19
Baseline + Envelope Insulation - Walls, R19 batt	510	271	14	285	2
Baseline + Envelope Insulation - Walls, R21 batt	510	271	14	285	2
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	510	268	14	282	5

3.7. Retail/Residential Mixed-Use Low-Rise Building – Retail Internal Small Shop

Table 137. R/RMULRB - Retail Internal Small Shop (RISS)

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	No Alternative
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 3
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	Alternative 3

Table 138. R/RMULRB-RISS Alternatives Impact on Utility Costs and Paybacks

Prototype #4 Studio Walk Retail Internal Small Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$1,667	\$1,536	\$3,203	\$0	NA
Baseline + EE Package	\$1,564	\$1,536	\$3,100	\$1,524	14.8
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$1,667	\$1,512	\$3,179	\$371	15.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$1,653	\$1,536	\$3,189	\$105	7.5
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$1,603	\$1,536	\$3,139	\$314	4.9
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$1,623	\$1,536	\$3,159	\$161	3.6
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$1,595	\$1,536	\$3,131	\$321	4.5
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$1,588	\$1,536	\$3,124	\$803	10.2
Baseline + Envelope Insulation - Walls, R19 batt	\$1,661	\$1,536	\$3,197	\$35	5.8
Baseline + Envelope Insulation - Walls, R21 batt	\$1,660	\$1,536	\$3,196	\$64	9.2
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$1,655	\$1,536	\$3,191	\$406	33.9

Table 139. R/RMULRB-RISS Alternatives Impact on Energy Consumption

Prototype #4 Studio Walk Retail Internal Small Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	6,233	21	7	28	0
Baseline + EE Package	5,794	20	7	26	2
Baseline + High Efficiency Domestic Hot Water, EF=0.823	6,233	21	5	26	2
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	6,178	21	7	28	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	6,024	21	7	27	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	6,017	21	7	27	1
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	5,942	20	7	27	1
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	5,912	20	7	27	1
Baseline + Envelope Insulation - Walls, R19 batt	6,213	21	7	28	0
Baseline + Envelope Insulation - Walls, R21 batt	6,203	21	7	28	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	6,175	21	7	28	0

Table 140. R/RMULRB-RISS Alternatives Impact on Impacts on TDVI

Prototype #4 Studio Walk Retail Internal Small Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	510	244	14	258	0
Baseline + EE Package	510	219	14	234	24
Baseline + High Efficiency Domestic Hot Water, EF=0.823	510	244	11	254	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	510	242	14	256	2
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	510	233	14	247	11
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	510	232	14	246	12
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	510	228	14	242	16
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	510	226	14	240	18
Baseline + Envelope Insulation - Walls, R19 batt	510	243	14	257	1
Baseline + Envelope Insulation - Walls, R21 batt	510	242	14	257	1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	510	241	14	256	2

3.8. Mixed- Retail/Residential Use Mid-Rise Building – Residential Space (85 dua)

Type III construction, approximately 134,000 sf five-story mixed use slab on grade building. Interior floor space demised to accommodate 12 individual retail tenants at street level averaging 1,050 sf each. Four floor levels of residential apartments above the first floor totaling approximately 121,300 sf. Residential floor space demised to accommodate 84 individual units; 12 @ 850 sqft, 8 @ 1,115 sqft, 14 @ 1450 sqft, 4 @ 1,580 sqft, 16 @ 1,545, 20 @ 1,645, and 10 @ 1,795. The floor-to-floor height for the first floor retail is 14'-0" and 11'-0" for the residential levels above. 50% of the roof area is available for solar cells.



Figure 20. Retail/Residential Mixed-Use Mid-Rise Building

Table 141. Retail/Residential Mixed-Use Mid-Rise Building – Residential Space (R/RMUMRB-RS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	0.39693 w/sqft, 0.94594 Btu/hr/sqft	0.38815 w/sqft, 0.94594 Btu/hr/sqft	0.3876 w/sqft, 0.94594 Btu/hr/sqft	None	Alternative 1
CHP	None	120 kW, 0 Tons Abs	None	None	Alternative 1
Roof Material	100% of roof at Abs=0.70	100% of roof at Abs=0.25	None	None	Alternative 1
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.56, SHGC=0.42	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	AFUE=75%	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 3
Lighting	0.623 watts/sqft	0.573 watts/sqft	None	None	No Alternative
Photovoltaics	None	13650 Sqft @ 0 deg pitch	None	None	Alternative 1
Roof Insulation	R30 batt	R38 batt	R49 batt	None	No Alternative
Solar Thermal	None	42 Sqft of panels, 84 Gal tank	None	None	No Alternative
Thermal Storage	None	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 142. R/RMUMRB-RS Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Gateway Residential					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$146,255	\$24,397	\$170,652	\$0	NA
Baseline + EE Package	\$138,714	\$19,977	\$158,691	\$112,274	9.4
Baseline + EE Package + Distributed Generation	\$42,303	\$68,927	\$111,230	\$350,098	6.2
Baseline + EE Package + Photovoltaics	\$83,874	\$19,977	\$103,851	\$790,908	11.1
Baseline + High Efficiency Appliances, 0.38815 w/sqft, 0.94594 Btu/hr/sqft	\$144,509	\$24,397	\$168,906	\$22,230	12.7
Baseline + High Efficiency Appliances, 0.3876 w/sqft, 0.94594 Btu/hr/sqft	\$144,354	\$24,397	\$168,751	\$30,126	15.8
Baseline + Combined Heat and Power, 120 kW, 0 Tons Abs	\$45,289	\$72,634	\$117,923	\$237,824	4.8
Baseline + Cool Roof, 100% of roof at Abs=0.25	\$145,522	\$24,397	\$169,919	\$10,008	13.7
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$146,255	\$19,977	\$166,232	\$31,134	7.0
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$146,678	\$24,397	\$171,075	\$2,027	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$144,724	\$24,397	\$169,121	\$6,056	4.0
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$143,871	\$24,397	\$168,268	\$8,570	3.6
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$143,052	\$24,397	\$167,449	\$17,139	5.4
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$142,604	\$24,397	\$167,001	\$42,847	11.7
Baseline + High Efficiency Lighting, 0.573 watts/sqft	\$143,217	\$24,397	\$167,614	\$111,420	36.7
Baseline + Photovoltaics, 13650 Sqft @ 0 deg pitch	\$91,451	\$24,397	\$115,848	\$678,634	11.7
Baseline + Envelope Insulation - Roof, R38 batt	\$147,006	\$24,397	\$171,403	\$5,459	never
Baseline + Envelope Insulation - Roof, R49 batt	\$147,246	\$24,397	\$171,643	\$9,098	never
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	\$146,255	\$14,313	\$160,568	\$765,408	93.7
Baseline + Envelope Insulation - Walls, R19 batt	\$146,514	\$24,397	\$170,911	\$3,856	never
Baseline + Envelope Insulation - Walls, R21 batt	\$146,672	\$24,397	\$171,069	\$7,118	never
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$146,665	\$24,397	\$171,062	\$45,083	never

Table 143. R/RMUMRB-RS Alternatives Impact on Energy Consumption

Prototype #5 Gateway Residential					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	597,864	2,040	1,861	3,901	0
Baseline + EE Package	567,363	1,936	1,526	3,461	440
Baseline + EE Package + Distributed Generation	256,594	875	5,245	6,120	-2,219
Baseline + EE Package + Photovoltaics	345,055	1,177	1,526	2,703	1,198
Baseline + High Efficiency Appliances, 0.38815 w/sqft, 0.94594 Btu/hr/sqft	590,752	2,016	1,861	3,877	24
Baseline + High Efficiency Appliances, 0.3876 w/sqft, 0.94594 Btu/hr/sqft	590,121	2,013	1,861	3,875	26
Baseline + Combined Heat and Power, 120 kW, 0 Tons Abs	275,030	938	5,527	6,465	-2,564
Baseline + Cool Roof, 100% of roof at Abs=0.25	594,892	2,030	1,861	3,891	10
Baseline + High Efficiency Domestic Hot Water, EF=0.823	597,864	2,040	1,526	3,566	335
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	599,637	2,046	1,861	3,907	-6
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	591,661	2,019	1,861	3,880	21
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	588,273	2,007	1,861	3,869	32
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	584,977	1,996	1,861	3,857	44
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	583,152	1,990	1,861	3,851	50
Baseline + High Efficiency Lighting, 0.573 watts/sqft	585,493	1,998	1,861	3,859	42
Baseline + Photovoltaics, 13650 Sqft @ 0 deg pitch	375,715	1,282	1,861	3,143	758
Baseline + Envelope Insulation - Roof, R38 batt	601,009	2,051	1,861	3,912	-11
Baseline + Envelope Insulation - Roof, R49 batt	602,017	2,054	1,861	3,915	-14
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	597,864	2,040	1,095	3,135	766
Baseline + Envelope Insulation - Walls, R19 batt	598,956	2,044	1,861	3,905	-4
Baseline + Envelope Insulation - Walls, R21 batt	599,618	2,046	1,861	3,907	-6
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	599,629	2,046	1,861	3,907	-6

Table 144. R/RMUMRB-RS Alternatives Impact on TDVI

Prototype #5 Gateway Residential					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	30,327	73	16	89	0
Baseline + EE Package	30,327	69	13	82	7
Baseline + EE Package + Distributed Generation	30,327	29	46	75	14
Baseline + EE Package + Photovoltaics	30,327	39	13	52	37
Baseline + High Efficiency Appliances, 0.38815 w/sqft, 0.94594 Btu/hr/sqft	30,327	72	16	88	1
Baseline + High Efficiency Appliances, 0.3876 w/sqft, 0.94594 Btu/hr/sqft	30,327	72	16	88	1
Baseline + Combined Heat and Power, 120 kW, 0 Tons Abs	30,327	31	48	80	9
Baseline + Cool Roof, 100% of roof at Abs=0.25	30,327	72	16	88	1
Baseline + High Efficiency Domestic Hot Water, EF=0.823	30,327	73	13	86	3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	30,327	73	16	89	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	30,327	72	16	88	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	30,327	71	16	88	1
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	30,327	71	16	87	2
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	30,327	71	16	87	2
Baseline + High Efficiency Lighting, 0.573 watts/sqft	30,327	71	16	87	2
Baseline + Photovoltaics, 13650 Sqft @ 0 deg pitch	30,327	43	16	59	30
Baseline + Envelope Insulation - Roof, R38 batt	30,327	73	16	89	0
Baseline + Envelope Insulation - Roof, R49 batt	30,327	73	16	89	0
Baseline + Solar Thermal, 42 Sqft of panels, 84 Gal tank	30,327	73	10	82	7
Baseline + Envelope Insulation - Walls, R19 batt	30,327	73	16	89	0
Baseline + Envelope Insulation - Walls, R21 batt	30,327	73	16	89	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	30,327	73	16	89	0

3.9. Retail/Residential Mixed-Use Mid-Rise Building – Retail Corner Large Shop

Table 145. R/RMUMRB – Retail Corner Larger Shop (RCLS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 3
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 146. R/RMUMRB-RCLS Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Gateway Retail Corner Large Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$6,518	\$1,898	\$8,416	\$0	NA
Baseline + EE Package	\$6,120	\$1,774	\$7,894	\$3,982	7.6
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$6,518	\$1,774	\$8,292	\$371	3.0
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$6,540	\$1,898	\$8,438	\$373	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$6,357	\$1,898	\$8,255	\$1,115	6.9
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$6,276	\$1,898	\$8,174	\$499	2.1
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$6,214	\$1,898	\$8,112	\$998	3.3
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$6,201	\$1,898	\$8,099	\$2,496	7.9
Baseline + Envelope Insulation - Walls, R19 batt	\$6,519	\$1,898	\$8,417	\$185	never
Baseline + Envelope Insulation - Walls, R21 batt	\$6,521	\$1,898	\$8,419	\$341	never
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$6,529	\$1,898	\$8,427	\$2,162	never

Table 147. R/RMUMRB-RCLS Alternatives Impact on Energy Consumption

Prototype #5 Gateway Retail Corner Large Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	39,644	135	33	168	0
Baseline + EE Package	36,884	126	24	150	18
Baseline + High Efficiency Domestic Hot Water, EF=0.823	39,644	135	24	159	9
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	39,865	136	33	169	-1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	38,223	130	33	163	5
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	37,871	129	33	162	6
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	37,541	128	33	161	7
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	37,420	128	33	161	7
Baseline + Envelope Insulation - Walls, R19 batt	39,672	135	33	168	0
Baseline + Envelope Insulation - Walls, R21 batt	39,679	135	33	168	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	39,735	136	33	168	0

Table 148. R/RMUMRB-RCLS Alternatives Impact on TDVI

Prototype #5 Gateway Retail Corner Large Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	2,528	300	14	314	0
Baseline + EE Package	2,528	279	10	289	25
Baseline + High Efficiency Domestic Hot Water, EF=0.823	2,528	300	10	310	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	2,528	301	14	316	-2
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	2,528	290	14	304	10
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	2,528	287	14	301	13
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	2,528	284	14	298	16
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	2,528	283	14	297	17
Baseline + Envelope Insulation - Walls, R19 batt	2,528	300	14	314	0
Baseline + Envelope Insulation - Walls, R21 batt	2,528	300	14	314	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	2,528	300	14	315	-1

3.10. Retail/Residential Mixed-Use Mid-Rise Building – Retail Corner Small Shop

Table 149. R/RMUMRB - Retail Corner Small Shop (RCSS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	Alternative 2
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	Alternative 1
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 150. R/RMUMRB-RCSS Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Gateway Retail Corner Small Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$2,897	\$1,625	\$4,522	\$0	NA
Baseline + EE Package	\$2,749	\$1,575	\$4,324	\$1,148	5.8
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$2,897	\$1,575	\$4,472	\$371	7.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$2,891	\$1,625	\$4,516	\$148	24.7
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$2,874	\$1,625	\$4,499	\$443	19.3
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$2,869	\$1,625	\$4,494	\$334	11.9
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$2,865	\$1,625	\$4,490	\$668	20.9
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$2,864	\$1,625	\$4,489	\$1,670	50.6
Baseline + Envelope Insulation - Walls, R19 batt	\$2,900	\$1,625	\$4,525	\$118	never
Baseline + Envelope Insulation - Walls, R21 batt	\$2,899	\$1,625	\$4,524	\$217	never
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$2,893	\$1,625	\$4,518	\$1,374	never

Table 151. R/RMUMRB-RCSS Alternatives Impact on Energy Consumption

Prototype #5 Gateway Retail Corner Small Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	14,831	51	13	64	0
Baseline + EE Package	13,733	47	9	56	8
Baseline + High Efficiency Domestic Hot Water, EF=0.823	14,831	51	9	60	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	14,929	51	13	64	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	14,768	50	13	63	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	14,731	50	13	63	1
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	14,706	50	13	63	1
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	14,688	50	13	63	1
Baseline + Envelope Insulation - Walls, R19 batt	14,863	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt	14,869	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	14,957	51	13	64	0

Table 152. R/RMUMRB-RCSS Alternatives Impact on TDVI

Prototype #5 Gateway Retail Corner Small Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,003	285	14	299	0
Baseline + EE Package	1,003	266	10	276	23
Baseline + High Efficiency Domestic Hot Water, EF=0.823	1,003	285	10	295	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	1,003	286	14	301	-2
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	1,003	283	14	298	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	1,003	282	14	297	2
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	1,003	282	14	296	3
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	1,003	282	14	296	3
Baseline + Envelope Insulation - Walls, R19 batt	1,003	285	14	299	0
Baseline + Envelope Insulation - Walls, R21 batt	1,003	285	14	300	-1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	1,003	287	14	301	-2

3.11. Retail/Residential Mixed-Use Mid-Rise Building – Retail Internal Large Shop

Table 153. R/RMUMRB - Retail Internal Large Shop (RILS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	No Alternative
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	No Alternative
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 154. R/RMUMRB-RILS Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Gateway Retail Internal Large Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$2,891	\$1,625	\$4,516	\$0	NA
Baseline + EE Package	\$2,891	\$1,575	\$4,466	\$371	7.4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$2,891	\$1,575	\$4,466	\$371	7.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$2,900	\$1,625	\$4,525	\$166	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$2,886	\$1,625	\$4,511	\$494	98.9
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$2,882	\$1,625	\$4,507	\$319	35.4
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$2,877	\$1,625	\$4,502	\$637	45.5
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$2,875	\$1,625	\$4,500	\$1,593	99.6
Baseline + Envelope Insulation - Walls, R19 batt	\$2,894	\$1,625	\$4,519	\$79	never
Baseline + Envelope Insulation - Walls, R21 batt	\$2,895	\$1,625	\$4,520	\$146	never
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$2,898	\$1,625	\$4,523	\$927	never

Table 155. R/RMUMRB-RILS Alternatives Impact on Energy Consumption

Prototype #5 Gateway Retail Internal Large Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	14,944	51	13	64	0
Baseline + EE Package	14,944	51	9	60	4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	14,944	51	9	60	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	15,027	51	13	64	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	14,898	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	14,855	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	14,833	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	14,822	51	13	64	0
Baseline + Envelope Insulation - Walls, R19 batt	14,968	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt	14,981	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	15,008	51	13	64	0

Table 156. R/RMUMRB-RILS Alternatives Impact on TDVI

Prototype #5 Gateway Retail Internal Large Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,242	286	14	301	0
Baseline + EE Package	1,242	286	10	297	4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	1,242	286	10	297	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	1,242	288	14	302	-1
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	1,242	285	14	300	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	1,242	284	14	299	2
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	1,242	284	14	298	3
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	1,242	284	14	298	3
Baseline + Envelope Insulation - Walls, R19 batt	1,242	287	14	301	0
Baseline + Envelope Insulation - Walls, R21 batt	1,242	287	14	301	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	1,242	287	14	302	-1

3.12. Retail/Residential Mixed-Use Mid-Rise Building – Retail Internal Small Shop

Table 157. R/RMUMRB - Retail Internal Small Shop (RISS) Alternatives

Measure	Baseline	Alternative 1	Alternative 2	Alternative 3	EE Package
Appliances	Not Applicable	None	None	None	No Alternative
CHP	Not Applicable	None	None	None	No Alternative
Roof Material	Not Applicable	None	None	None	No Alternative
Water Heating	EF=0.594	EF=0.823	None	None	Alternative 1
Windows	U=0.57, SHGC=0.61	U=0.26, SHGC=0.37	U=0.22, SHGC=0.22	None	No Alternative
Space Heating	Heat Pump (See Space Cooling)	None	None	None	No Alternative
Space Cooling	HSPF 8.1, EER 11.07, COP 3.28	HSPF 8.6, EER 12.19, COP 3.52	HSPF 8.8, EER 12.70, COP 3.74	HSPF 9.2, EER 12.88, COP 3.66	No Alternative
Lighting	1.5 watts/sqft	None	None	None	No Alternative
Photovoltaics	Not Applicable	None	None	None	No Alternative
Roof Insulation	Not Applicable	None	None	None	No Alternative
Solar Thermal	Not Applicable	None	None	None	No Alternative
Thermal Storage	Not Applicable	None	None	None	No Alternative
Wall Insulation	R11 batt	R19 batt	R21 batt	R21 batt + R5 rigid	No Alternative

Table 158. R/RMUMRB-RISS Alternatives Impact on Utility Costs and Paybacks

Prototype #5 Gateway Retail Internal Small Shop					
Alternative	Elec Utility \$	Gas Utility \$	Total Utility \$	Alt Cost \$	Payback yrs
Baseline	\$2,890	\$1,625	\$4,515	\$0	NA
Baseline + EE Package	\$2,890	\$1,575	\$4,465	\$371	7.4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	\$2,890	\$1,575	\$4,465	\$371	7.4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	\$2,899	\$1,625	\$4,524	\$148	never
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	\$2,884	\$1,625	\$4,509	\$443	73.8
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	\$2,878	\$1,625	\$4,503	\$320	26.7
Baseline + High Efficiency Cooling, HSPF 8.8, EER 12.70, COP 3.74	\$2,874	\$1,625	\$4,499	\$640	40.0
Baseline + High Efficiency Cooling, HSPF 9.2, EER 12.88, COP 3.66	\$2,874	\$1,625	\$4,499	\$1,599	100.0
Baseline + Envelope Insulation - Walls, R19 batt	\$2,892	\$1,625	\$4,517	\$70	never
Baseline + Envelope Insulation - Walls, R21 batt	\$2,894	\$1,625	\$4,519	\$130	never
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	\$2,897	\$1,625	\$4,522	\$821	never

Table 159. R/RMUMRB-RISS Alternatives Impact on Energy Consumption

Prototype #5 Gateway Retail Internal Small Shop					
Alternative	Elec kWh	Elec MMBtu	Gas MMBtu	Total MMBtu	MMBtu Saved
Baseline	14,931	51	13	64	0
Baseline + EE Package	14,931	51	9	60	4
Baseline + High Efficiency Domestic Hot Water, EF=0.823	14,931	51	9	60	4
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	15,024	51	13	64	0
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	14,881	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	14,845	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 8.8 ,EER 12.70, COP 3.74	14,821	51	13	64	0
Baseline + High Efficiency Cooling, HSPF 9.2 ,EER 12.88, COP 3.66	14,810	51	13	64	0
Baseline + Envelope Insulation - Walls, R19 batt	14,955	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt	14,969	51	13	64	0
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	14,998	51	13	64	0

Table 160. R/RMUMRB-RISS Alternatives Impact on TDVI

Prototype #5 Gateway Retail Internal Small Shop					
Alternative	Space Sqft	Elec TDVI	Gas TDVI	Total TDVI	TDVI Saved
Baseline	1,003	286	14	300	0
Baseline + EE Package	1,003	286	10	297	3
Baseline + High Efficiency Domestic Hot Water, EF=0.823	1,003	286	10	297	3
Baseline + High Efficiency Glazing, U=0.26, SHGC=0.37	1,003	288	14	302	-2
Baseline + High Efficiency Glazing, U=0.22, SHGC=0.22	1,003	285	14	299	1
Baseline + High Efficiency Cooling, HSPF 8.6, EER 12.19, COP 3.52	1,003	284	14	299	1
Baseline + High Efficiency Cooling, HSPF 8.8 ,EER 12.70, COP 3.74	1,003	284	14	298	2
Baseline + High Efficiency Cooling, HSPF 9.2 ,EER 12.88, COP 3.66	1,003	284	14	298	2
Baseline + Envelope Insulation - Walls, R19 batt	1,003	287	14	301	-1
Baseline + Envelope Insulation - Walls, R21 batt	1,003	287	14	301	-1
Baseline + Envelope Insulation - Walls, R21 batt + R5 rigid	1,003	287	14	302	-2

4.0 Assessment of Utility Incentive Impacts on Market Feasibility

Appendix A contains a description of the methods and equations used for evaluating the impact of utility-based incentives on the payback period for energy efficiency packages. Using the methods outlined there, researchers produced simple paybacks incorporating the incentives.

These are summarized in Tables 161 and 162 for both sets of building prototypes presented in the preceding two chapters. Blank fields indicate a particular package was not considered cost effective and/or practical for addition of photovoltaics, even with incentives. Results with an asterisk (*) indicate the relevant package and prototype achieve an estimated increase in building energy efficiency of 25% or more above the existing 2005 Title 24 standard.

Table 161. Urban-Site: SDG&E Incentive Impacts by Prototype

Prototype	Optimum EE Package			Combined Optimum EE-PV Package		
	Payback Without Incentive (Years)	Payback Counting SDG&E Incentive		Payback Without Incentive (Years)	Payback Counting SDG&E Incentive	
		High Estimate (Years)	Low Estimate (Years)		High Estimate (Years)	Low Estimate (Years)
1 (FSR)	5.5	4.6	4.8	19.0*	16.8*	17.2*
2 (MTR-c)	12.5	11.6	11.7	20.0*	17.9*	18.3*
2 (MTR-i)	11.3	9.7	10.0	19.8*	17.8*	18.1*
3 (MRS)	4.1	2.7	2.9	21.9*	19.8*	20.1*
4 (LRO)	9.7	8.2	8.5	17.2*	15.3*	15.6*
5 (MRO)	3.4*	1.8*	2.1*	11.7*	10.0*	10.3*
6 (HRO)	3.6	2.1	2.3	6.1*	4.4*	4.7*
7 (LGH-hs)	2.9	1.4	1.7	11.0*	9.1*	9.4*
7 (LGH-r)	5.4	4.4	4.6	19.1	17.0	17.3
8 (SMH-hs)	3.8	2.3	2.6	16.2*	14.1*	14.5*
8 (SMH-os)	8.3	6.8	7.1	16.8*	14.9*	15.2*
8 (SMH-r)	6.4	5.5	5.6	19.2*	17.1*	17.4*
8 (SMH-ex)	7.4*	5.8*	6.1*	--	--	--
8 (SMH-in)	7.9*	6.3*	6.5*	--	--	--
9 (RCM-os)	3.6	2.1	2.3	10.8*	9.1*	9.3*
9 (RCM-c)	9.4	8.0	8.3	--	--	--
9 (RCM-in)	8.0	6.5	6.8	--	--	--
10 (RRM-res)	6.9	6.0	6.1	11.1*	9.9*	10.1*
10 (RRM-c)	8.6	7.2	7.4	--	--	--
10 (RRM-in)	7.9	6.3	6.5	--	--	--
11 (RRL-res)	10.7	9.8	9.9	11.8*	10.7*	10.9*
11 (RRL-c)	8.9	7.4	7.7	--	--	--
11 (RRL-in)	9.7	8.2	8.5	--	--	--
12 (CCM-lib)	3.0*	1.4*	1.6*	--	--	--
12 (CCM-os)	3.5*	2.0*	2.2*	10.2*	8.5*	8.8*
13 (RTH)	15.6	12.4	13.0	11.6*	11.3*	11.4*
14 (RLR)	9.0	7.2	7.5	12.0*	11.8*	11.8*
15 (RMR)	6.0	4.5	4.7	10.6*	10.1*	10.2*

The prototype numbers, codes and the values reported in Table-161 “Payback Without Incentive” column for both packages correspond to the values contained in the preceding chapters. The high and low estimates refer to the estimate of the incentive amount. The higher the

estimate, the lower the payback, which explains why the column labeled “High Estimate” for each package exhibits a lower payback period. The difference between the high and low estimate is the 20% incentive for sustainable practices.

Table 162. Residential-Site: SDG&E Incentive Impacts by Prototype

Prototype	Optimum Alternatives Package			Combined Optimum EE-PV Package		
	Payback Without Incentive (Years)	Payback Counting SDG&E Incentive		Payback Without Incentive (Years)	Payback Counting SDG&E Incentive	
		High Estimate (Years)	Low Estimate (Years)		High Estimate (Years)	Low Estimate (Years)
1 LR-RES	12.5	11.4	11.6	--	--	--
2 CR-RES	10.1	8.9	9.1	--	--	--
3 AR-RES	9.4	8.4	8.6	16.2	15.2	15.4
3 AR-RSCSM	11.5	10.2	10.4	--	--	--
4 SW-RES	9.1	8.1	8.3	16.7	15.8	16.0
4 SW-RSCSM	12.7	11.2	11.5	--	--	--
4 SW-RSISM	14.8	14.0	14.1	--	--	--
5 GR-RES	9.4	8.5	8.6	11.1	10.0	10.2
5 GR-RSCSM	7.6	6.1	6.4	--	--	--
5 GR-RSISM	5.8	4.1	4.4	--	--	--
5 GR-RSCLG	7.4	6.8	6.9	--	--	--
5 GR-RSILG	7.4	6.8	6.9	--	--	--

Once again, the high and low estimates in Table 162 refer to the estimate of the incentive amount. Again, the difference between the high and low estimate is the 20% incentive for sustainable practices.

In addition to the incentive payable to owners, SDG&E also provides incentives to designers to help defray the cost of the additional design work associated with

including EE upgrades in a building. Researchers did not explicitly include these incentives to develop the payback periods in Tables 161 and 162 because the design costs are estimated separately in the upgrade costs. These incentives are presented in Tables 163 and 164. Note: There were no designer incentives available for Prototypes 13-15.

**Table 163. Urban-Site: SDG&E Designer Incentive:
Prototype and Package**

Prototype	Optimum EE Package	Optimum EE - PV Package
1 (FSR)	\$1,086	\$6,455
2 (MTR-c)	\$63	\$1,270
2 (MTR-i)	\$209	\$1,315
3 (MRS)	\$4,816	\$32,470
4 (LRO)	\$3,896	\$16,053
5 (MRO)	\$17,515	\$35,832
6 (HRO)	\$33,828	\$42,616
7 (LGH-hs)	\$10,718	\$21,489
7 (LGH-r)	\$1,026	\$6,348
8 (SMH-hs)	\$7,441	\$23,296
8 (SMH-os)	\$2,205	\$9,152
8 (SMH-r)	\$1,100	\$6,532
8 (SMH-ex)	\$563	--
8 (SMH-in)	\$510	--
9 (RCM-os)	\$12,141	\$22,399
9 (RCM-c)	\$230	--
9 (RCM-in)	\$214	--
10 (RRM-res)	\$4,335	\$16,916
10 (RRM-c)	\$247	--
10 (RRM-in)	\$224	--
11 (RRL-res)	\$1,269	\$14,794
11 (RRL-c)	\$255	--
11 (RRL-in)	\$219	--
12 (CCM-lib)	\$6,737	--
12 (CCM-os)	\$19,524	\$34,517

**Table 164. Residential-Site: SDG&E Designer Incentive:
Prototype and Package**

Prototype	Optimum Alternatives Package	Optimum EE - PV Package
1 (LR-RES)	80	--
2 (CR-RES)	100	--
3 (AR-RES)	226	1,456
3 (AR-RSCSM)	83	--
4 (SW-RES)	550	2,989
4 (SW-RSCSM)	78	--
4 (SW-RSISM)	22	--
5 (GR-RES)	3,093	22,099
5 (GR-RSCSM)	217	--
5 (GR-RSISM)	93	--
5 (GR-RSCLG)	8	--
5 (GR-RSILG)	8	--

5.0 Alternatives for Community Site Development

This chapter describes the energy-efficient/low-carbon design alternatives modeled in the Chula Vista Research Project (CVRP). These alternatives include:

- Mixed-use / moderate-density development
- District energy systems
- Urban runoff mitigation measures
- Carbon sequestration measures
- Urban heat island reduction measures
- Passive solar building orientation.

This chapter provides the energy efficiency performance of each alternative compared to conventional options. Where possible, it also includes basic planning considerations for their use on large-scale development projects. The specific energy efficiency and emissions reduction performance of these alternatives will naturally vary from site to site, driven by specific energy end-uses, building types and orientations, site composition, and climate. Relevant findings from the Chula Vista Research Project (CVRP) are cited below to provide a general sense of their relative performance.

5.1. Mixed-Use / Moderate Density

5.1.1. Description

Mixed-use development is characterized by the co-location of residential uses with commercial-office, commercial-retail, and often public/institutional uses. Residents of a mixed-use community development

typically have access to a variety of employment, shopping, recreational, and entertainment amenities all within a quarter-mile walking distance from their homes. Mixed-use developments often include a range and mix of housing options including single-family detached houses, attached townhouses, and multifamily condominium complexes, often with commercial retail and office space at ground-level or the second floor.

Moderate-density development is characterized by approximately 11 dwelling units per acre (dua), whereas conventional lower-density development in Southern California is typically three to four dwelling units per acre. Moderate-density developments encourage the use of public transportation and typically place the highest density housing options closest to transit corridors, station facilities, and transit stops. Moderate-density developments include a variety of structures that generally do not exceed 10 stories in height.

5.1.2. Energy Efficiency Performance

Mixed-use/moderate-density developments have been shown to be more energy and resource efficient than lower density developments. This is because they create spatial conditions that facilitate economical use of advanced energy-efficient technologies and district energy systems; they reduce vehicular petroleum consumption and emissions; and they dramatically increase both land use efficiency and household energy savings.

Use of Advanced Energy Technologies

The CVRP researchers modeled the central power plant electricity consumption of a

mixed-use/moderate-density (11 dua) development served by combined cooling, heat and power (CCHP) technologies. They compared that consumption to an equivalent amount of commercial space in a lower-density (3 dua) development served by conventional conditioning equipment. Results showed a 68% reduction in central power plant electricity in the mixed-use/moderate-density development. This decrease translated into significant reductions in central power plant emissions. However, use of CCHP also increased local emissions when the technology was driven by a fossil fueled (natural gas) prime mover such as an internal combustion reciprocating engine. By contrast, renewably-based CCHP systems offered the benefit of significantly reduced central power plant energy consumption and emissions and lower (or even negligible) local emissions, depending on the source of energy used.

Researchers conducted a similar analysis to examine economic feasibility of a district energy/cooling system to serve an equivalent cooling load in a moderate-density development and a low-density development. Modeling results indicated costs associated with a district cooling system designed to serve the moderate-density development were 181% lower than the costs of a system designed to serve the same load in a conventional low-density development. Additionally, research findings indicated the additional cost of a system to serve a low-density development would render such a system economically unfeasible. The next section of this chapter provides an overview of district energy technologies, additional information on their energy efficiency compared to conventional space conditioning

technologies, and a set of planning and design guidelines.

Vehicular Petroleum Consumption and Emissions

CVRP researchers modeled the vehicle-miles-traveled (VMT), petroleum consumption, and vehicular emissions for a moderate-density / low-density comparison. They found the moderate-density development reduced VMT by 12-15% which significantly reduced petroleum consumption and vehicular emissions by approximately the same amounts.

Land Use Efficiency and Household Energy Savings

Using the same density figures described above (11 and 3 dua), CVRP researchers compared land use consumption and per-household energy savings for the same size population. Modeling results indicated a moderate-density development could reduce land consumption by up to 80%, and its diversity in housing could produce as much as 50% per household energy savings. These savings were produced as a result of smaller housing units, and shared walls and heating, air conditioning and ventilation systems between units.

5.1.3. Planning Considerations

To optimize energy efficiency and emission reduction potential of mixed-use/moderate-density development alternatives, it was necessary to conduct detailed energy modeling of the constituent buildings. Researchers also modeled site design features that impact energy consumption, in particular, features affecting ambient air temperatures (discussed further below). They imported this data into a geographic information system (GIS) platform to enable planners to examine energy and emission

impacts of alternative development designs. There are a number of tools now available that can achieve this level of analysis. In the case of CVRP, researchers used the following six building and district energy technology and urban design modeling tools:

- Building Energy Analyzer™ (BEA)- a proprietary product of the Gas Technology Institute (GTI)
- Energy-10™ - a proprietary product of the Sustainable Building Industry Council (SBIC)
- City Green™ - a proprietary product of the American Forests organization
- Mitigation Impact Screening Tool (MIST) – a product of the U.S. Environmental Protection Agency
- CommunityViz™ - a proprietary product of the Orton Family Foundation
- TERMIS - a proprietary product of 7-Technologies

Researchers used BEA to model energy, economic, and environmental parameters for 15 types of commercial, institutional, and commercial-residential mixed-use structures. They used Energy-10™ to model five types of single and multi-family residential buildings. They used City Green to model alternative landscape design elements and to support evaluation of the urban heat island effect. They used MIST to assess the impact of increasing urban albedo (reflectance) and/or urban vegetation in the urban heat island effect.

Modeling of potable water and wastewater treatment infrastructure, urban runoff, alternative land-use configurations,

transportation infrastructure and patterns used CommunityViz. Researchers also used CommunityViz to co-register and synthesize data inputs from the other software tools and to produce 360-degree visualizations and real-time impact simulations.

Modeling of transportation infrastructure, patterns, and strategies for energy consumption and emission impacts entailed estimating average daily vehicle-miles traveled (VMT). The analysis used both quantitative factors, such as housing density and road patterns, and qualitative factors, such as the probability residents will choose alternative modes of transportation. Based on estimated VMT, researchers calculated potential savings in energy consumption and air emissions using generally accepted averages.

TERMIS is a hydraulic modeling tool used for the design and analysis of district energy systems.

There are now several tools on the market to combine archived energy consumption and emissions data for common building types in California with transportation data and a land use GIS design tool. The best known tool is I-PLACE3S, developed with funding from the U.S. Department of Energy and the California Energy Commission. This tool is useful for conducting high-level analysis where only general estimates of building energy consumption and emissions are sufficient. For more accurate estimates, it is necessary to build customized databases derived from the geometry and building features planned for a development site.

Once a site's total energy (electricity and natural gas) demand is known, a simple

calculation determines air emissions. The relevant conversion factors used in this calculation are as follows:

- **CO₂**: 700.4 lbs/MWh of electric energy produced and 117.6 lbs/MMBtu of gas energy used at the building level
- **SO_x**: 0.128 lbs/MWh of electric energy produced and 0.00059 lbs/MMBtu of gas energy used at the building level
- **NO_x**: 0.352 lbs/MWh of electric energy produced and 0.092 lbs/MMBtu of gas energy used at the building level

5.2. District Energy Systems

5.2.1. Description

District energy systems contribute to community sustainability and security by maximizing the efficient use of a variety of fuels to co-generate and deliver electricity and thermal energy locally. Because district energy thermal networks aggregate and link the heating and cooling requirements of dozens or hundreds of buildings, they create a greater scale of thermal energy use. Greater scale facilitates flexible fuel solutions at a central plant and allows for thermal storage applications that would not be feasible on an individual building basis. In addition to fossil fuels, district energy systems can utilize a combination of locally available renewable resources such as municipal solid waste, community wood waste, landfill gas, wastewater facility methane, biomass, geothermal, lake or ocean water, and solar energy. District energy systems also improve local economies by increasing energy reliability,

stabilizing energy costs, attracting new businesses, increasing property values, and re-circulating energy dollars in the local economy.

District energy systems produce electricity, hot water, steam and/or chilled water at a central plant and then distribute the energy through underground wires and pipes to adjacent buildings. Lights, appliances, equipment and machinery use the electricity. Space heating and cooling and a variety of commercial/industrial processes use the hot and chilled water and steam

From a sustainability standpoint, the essential advantage of a district energy system over a conventional, remote central power plant is a far more efficient use of the input fuel relative to end-uses. Typically, only one-third of the fuel energy input to a conventional fossil-fuel power plant is delivered to the end-use consumer as electricity. The vast majority of the energy generated is discharged in the form of heat to adjacent rivers, lakes, and the atmosphere, resulting in significant thermal pollution. When this energy is discharged to the environment, consumers purchase more electricity and natural gas to meet needs that could have been satisfied by recovering and using the wasted thermal energy.

By contrast, local district energy systems capture most of the heat energy generated in electricity production and use it to produce steam and hot and chilled water. This process is known as co-generation and is made possible by combined heat and power (CHP) technologies such as gas fired reciprocating engines, gas turbines, heat exchangers, and absorption chillers (Figures 21, 22, and 23).

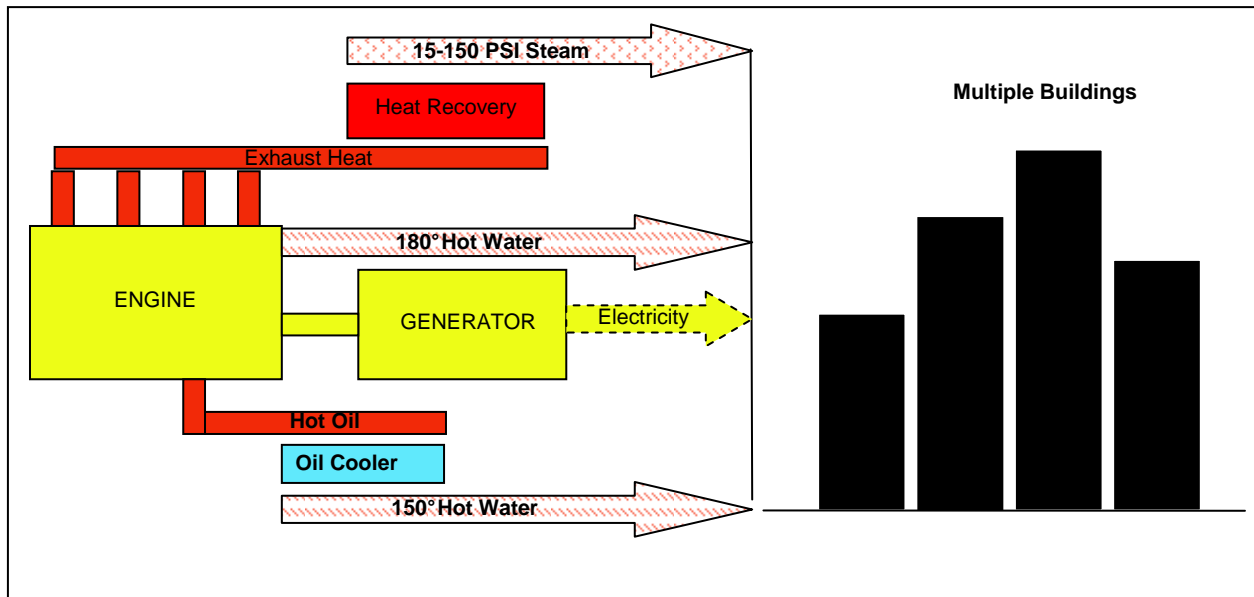


Figure 21. Reciprocating Engine with Heat Recovery from Exhaust and Coolants

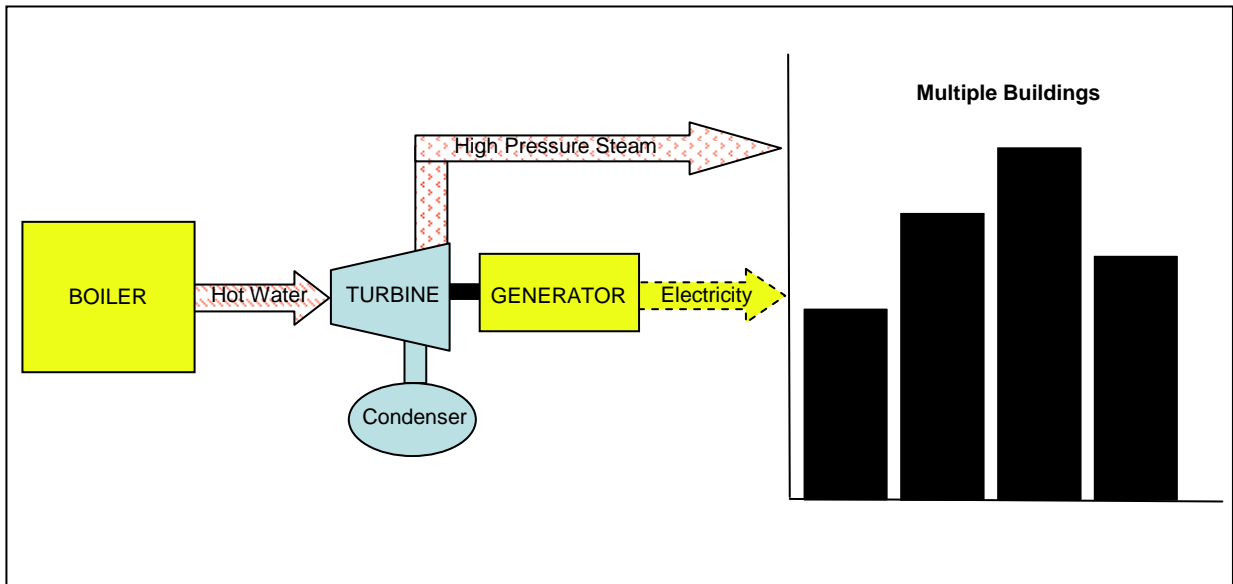


Figure 22. Variable Extraction Steam Turbine with Heat Recovery

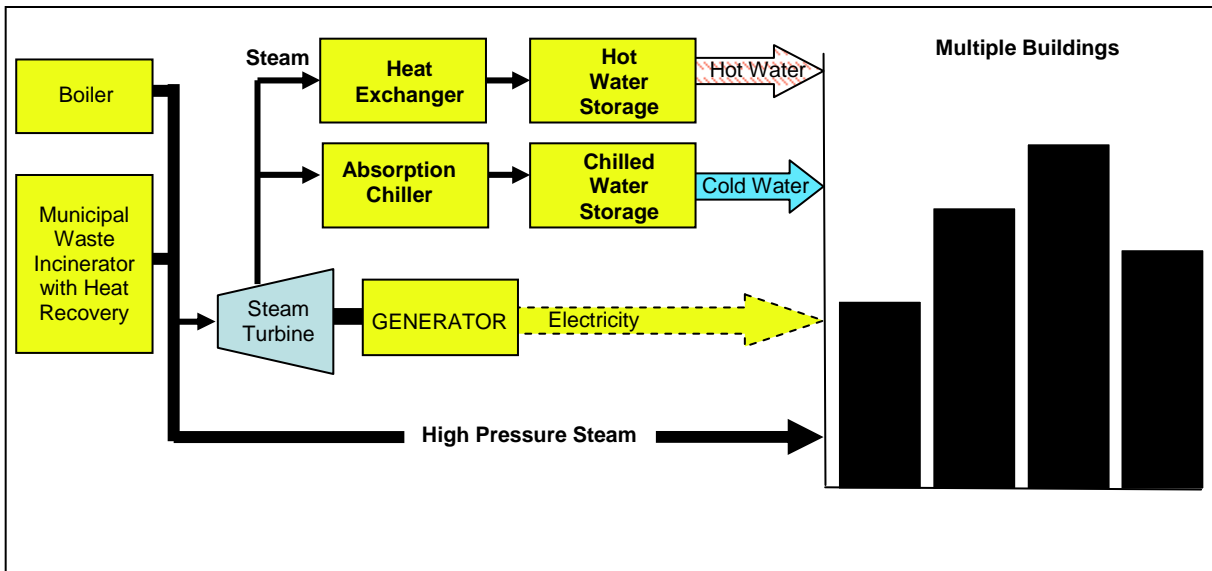


Figure 23. Community Energy Systems Delivering Multiple Services

5.2.2. Energy Efficiency Performance

CVRP researchers determined a district energy system featuring thermal energy storage (TES) technologies could reduce electricity consumption of the modeled site by over 3 million kWh and provide substantial reduction in emission of pollutants and greenhouse gasses. Furthermore, the ability to peak shave with the TES alternative significantly reduced peak power requirements, thereby reducing the electrical infrastructure required to meet peak cooling loads.

5.2.3. Planning Considerations

There are four classifications of district heating and cooling (DHC) systems differentiated by the characteristics of the areas they are designed to serve. These include:

- Densely populated urban areas.
- High-density building clusters.
- Industrial or research campuses.

- Low-density residential areas.

As a rule of thumb, there are three requirements that must be met for a DHC system to operate economically:

- 1 There must be a high load density - determined by the thermal load per unit of building floor space, number of stories, and total number of buildings in the area to be served. The capital investment in a DHC system designed for a greenfield site must be at least partially recovered through a contribution margin of energy sales to end-users that are located within close proximity to one another. In an existing urban site, there must be a significant vertical density of customer buildings to be served to warrant the considerable cost per trench foot of constructing the underground network of piping for a DHC system.

- 2 There must be a large annual load factor - the ratio between the actual amounts of energy consumed annually to the amount of energy that would be consumed if the peak thermal load were to be imposed continuously for a full year. Thermal energy requirements must be significant enough throughout the year that the capital cost recovery of a DHC plant and piping network is not allocated to a limited period of off-peak demand.
- 3 There must be a rapid rate of consumer connections to the system. This requirement is particularly important since 50-75% of total district energy system investment is the cost of installing transmission and distribution network piping. The sequence and location of “anchor users” relative to the main central plant and distribution trunk are also important factors.

DHC systems are cost-effective in *large*, densely populated urban areas where there are a variety of building types, end-uses, and nearby sources of thermal energy such as power plants, industrial sites, and municipal solid waste disposal facilities. DHC systems serving larger urban areas typically require a phased construction period of 20-30 years, miles of distribution piping, and several thousand megawatts of electrical capacity. These systems can cost in the hundreds of millions of dollars and typically involve extensive and complex institutional arrangements to plan, finance, build, and operate. Moreover, in an urban setting, district energy systems compete openly with on-site alternatives like boilers, chillers, and electric heat. The risks of

constructing a DHC system can be significant as there are no assurances that customers will connect to and use the system's services.

DHC systems serving *smaller*, high-density clusters such as suburban shopping malls, healthcare and hospitals complexes, university campuses, and mixed-use complexes, can be designed and installed in 3-10 years. These systems have much smaller distribution networks and need only several hundred megawatts of generating capacity. Typical costs for these smaller systems can range from a few million to tens of millions of dollars and typically involve institutional arrangements involving only a few decision makers in the development process. In institutional settings where the central plant is owned by the same entity as the end-user buildings, market risk for return on capital is reduced.

Process steam and hot water demands are the drivers of the economics of DHC systems designed to serve industrial complexes. These systems are often similar in size and complexity to systems serving high-density clusters. Low-density residential areas are not cost effective applications for district heating and cooling in the United States, given the high capital costs and low rates of utilization per trench foot of distribution piping investment. Residential application of district heating has proven to be cost effective in Europe and Scandinavia where residential densities are typically higher. These systems are designed for residential blocks with a generating capacity of 1-3 megawatts and deliver low-temperature hot water to their consumers. In many northern European cities, district heating is the predominant source of comfort and may exceed 85%

market share of residential space. Given the success of these European models, planners are now considering residential district energy systems for several new, large-scale residential development projects in California and across the nation.

It is important to note there is not a universal standard for the configuration of a district energy system. The availability of alternative energy sources, potential for cogeneration, peak hourly loads, energy pricing, annual energy consumption patterns, and market potential will vary by region and by the specific site.

Underground soil and congestion conditions, soil types, urban density, and building HVAC systems can effect technical design considerations. Ambient weather trends and the ratio of customer space uses such as commercial office, residential, retail and mixed use, event and arena space and high-volume users like hospitals, research, and data centers all impact system design parameters.

There are, however, a set of standard factors, minimum requirements, and ranges to consider when investigating the economic and technical feasibility of a district energy system utilizing cogeneration or municipal waste incineration. These include the following:

- Ambient Air Temperatures - There must be a minimum of 4,000 heating degree days in a year to make DHC system economically feasible for space heating. A degree day unit (referred to as a degree day) is a measurement of indoor heating requirements affected by outside temperatures. The number of degree day units for any given day is calculated by subtracting the mean

outside temperature from 65°F, and the total degree-days for any longer period is the sum of the degree days of the individual days in that period. Degree day tables and maps are available from the National Climatic Data Center at the U.S. Department of Commerce. For district cooling systems, customers typically should consume more than 1,000 equivalent full load hours. In other words, a 200 ton peak demand building should consume 200,000 ton hours over the course of a year.

- Area Energy Demand - Each unit of land area to be served by a district heating system must have a high hourly and annual thermal energy demand.
- Location of Thermal Plant - The energy production plant must be located close to the area to be served to reduce capital costs and thermal losses in transmission.
- Transmission Distances - Three to five miles is the maximum distance between a production plant and the end of the distribution network for an economical steam line. Fifteen miles is the maximum distance for a hot water line when thermal energy is derived from an electrical power plant. Three miles is the maximum distance for a hot water line when thermal energy is derived from a municipal solid waste incinerator.
- Land Use Zoning Threshold - All zones in which 50% or more of the land is designated for single-family detached housing, single-family attached housing, town houses, open space, or other low energy

intensity uses are generally not considered viable for district energy systems.

- Cooling Load Concentration - For central cooling plants to be practical, cooling load concentrations must be 150 to 250 tons per 100 lineal feet of distribution piping runs.
- Piping System Cost - If the cost of the piping system is less than one-third of the total chilled water system cost, a central chilled water system becomes cost-effective.
- Substantial Anchor Load – In the phased construction of a new district energy system, an anchor tenant or initial user should contract for at least 20% of the initial plant capacity investment. The capital risk is further mitigated with a higher percentage pre-subscribed to the service. The location of the anchor load should be proximate to the future market density and not an isolated node on a network.
- Plant Footprint - In urban settings, the high cost of real estate significantly impacts the economic feasibility of a DHC system as central plant space requirements can be considerable. Many cities have integrated district heating and cooling plants into the frame of urban parking garages to increase the yield of the real estate parcel and to provide incremental income for a reasonable companion use.
- Condenser Water Sources – Many DHC systems utilize contiguous

ivers, lakes, and bays for condenser water and/or winter cooling cycles.

This minimizes air rights for locating cooling towers and provides a low-cost source of winter cooling to data centers and high-rise building cores.

- Age of Buildings and Life Cycle – The opportunity to avoid capital costs of replacement heating and cooling equipment is the most important factor in a building owner’s decision to connect to a DHC system. In planning a DHC system for an existing urban site, planners must consider the age, type, and life cycle stage for the individual buildings within the proposed service area. Sites predominantly occupied by newer buildings with existing in-building boiler and chiller equipment will not prove to be economical for a DHC system, as owners of these buildings will not be inclined to connect to the system.
- Utility Rates – Planners must understand the natural gas and electric utility rates in effect at a proposed development site to determine the economic feasibility of a DHC system. In many urban areas where time-of-day rates, load factor ratchet penalties, and high-peak electric demands exist, district cooling systems with thermal or ice storage are economically attractive. A thorough analysis of the existing rate structures must be one of the first tasks engaged by planners examining the potential feasibility of a DHC system.

Table 165. Minimum Standards, Requirements and Ranges for a DHC System

Minimum/Maximum Standards	District Heating System	District Cooling System	District Steam System
Heating Degree Days	Min: 4,000	NA	Min: 4,000
Cooling Load Hours	NA	Min. 1,000 equivalent full load hours	NA
Energy Transmission Distances	Max: 15 miles when the source is a power plant Max: 5 miles when the source is a waste incinerator	Max: 5 miles when the source is a power plant Max: 5 miles when the source is a waste incinerator	Max: 7 miles when the source is a power plant Max: 5 miles when the source is a waste incinerator
High-Energy Intensity Land Uses	Min: 33% or greater	Min: 50% or greater	Min: 50% or greater
Piping System Costs	Max: 33% of total system cost	Max: 40% of total system cost	Max: 40% of total system cost
Pre-subscribed Anchor Load	Min: 25% of plant capacity	Min: 20% of plant capacity	Min: 25% of plant capacity
Building Area in SF	Min:2,000,000	Min:2,500,000	Min: 5,000,000
Combined FAR* & Acreage	Min:3-7	Min: 3-10	Min:3-7

*FAR – The Floor Area Ratio (FAR) is a measure of development intensity. FAR is the ratio of the amount of floor area of a building to the amount of area of its site. For instance, a one-story building that covers an entire lot has an FAR of 1. Similarly, a one-story building that covers 1/2 of a lot has an FAR of 0.5. A four story building that covers ½ of a lot has an FAR of 2.0.

5.3. Urban Runoff Mitigation and Carbon Sequestration Measures

5.3.1. Description

Urban runoff mitigation is the process of diverting stormwater flows from collection, retention, detention and/or storm sewer processing facilities. Communities interested in reducing costs associated with construction of these facilities pursue these measures. For processing facilities, an additional goal is to reduce energy

consumption and energy-related air emissions associated with their operation. Although there are a number of different measures for diverting stormwater, the measures considered in the CVRP were use of increased tree plantings and open space. Increased tree plantings provide another benefit to communities through carbon sequestration and pollutant removal, assisting them in meeting their carbon and pollutant reduction goals.

To quantify stormwater diversion performance and cost savings and the

energy consumption and carbon reduction benefits of these measures, researchers compared two scenarios for the two modeled development sites.

The baseline scenario entailed minimal tree coverage on each site, while the optimized scenario introduced an additional 10% of tree coverage. The primary indicator for urban runoff mitigation is stormwater diversion for a two-year, 24-hour peak rain event. The volume diverted during such an event is measured in cubic feet. Researchers calculated an equivalent dollar value for costs associated with construction of facilities to handle the diverted stormwater. The primary indicator for carbon sequestration is the number of tons of CO₂ stored in the biomass of planted trees.

5.3.2. Energy Efficiency and Emissions Performance

The CVRP modeling results indicated only a modest increase in a tree canopy and a decrease in impervious surfaces could produce significant construction cost savings for developers, as well as energy and carbon emissions savings. For the two modeled development sites, a modest 10% increase in tree canopy resulted in a 48% increase in stormwater diversion for the first site and a 64% increase in stormwater diversion for the second site. This diversion translated into a savings of approximately \$122,300 for the developer of the first site by not having to construct stormwater retention and detention pond systems. For the second site, the developer could save as much as \$387,440 in construction costs associated with these systems.

Communities with these systems do not enjoy direct energy savings since their sanitary sewer facilities do not process stormwater flows. However, they derive

other benefits from additional tree plantings. Trees provide enhanced air filtration and carbon sequestration, and they lower levels of non-point source surface water pollutants, especially in urban areas. For those California communities that do have combined stormwater and sanitary sewer systems, increases in stormwater diversion do translate into energy and carbon emissions savings. For the first development site, a 10% increase in the tree canopy translated into an annual savings of 915.27 kWh over what would be expected from conventional plantings at development sites. This denotes reduction of 614 lbs. of carbon emissions annually. For the second site, a 10% increase in the tree canopy translated into an annual savings of 2,899.57 kWh over conventional plantings at development sites. This denotes reduction of 2031 lbs. of carbon emissions annually.

Modeling revealed a baseline 2.4% tree canopy would store 213 tons of CO₂ in existing trees and would sequester an additional 1.66 tons per year at the first more urban site⁶. A 10% increase in canopy cover would result in storage of 1,099 tons of CO₂ and sequestration of 8.56 tons annually. Table 166 contains tailpipe pollutant removal data for the baseline and optimized development scenarios for the site.

6. Storage refers to the amount of carbon stored in the biomass of trees on planting. Sequestration refers to the additional amount of carbon stored every year the trees grow.

Table 166. Site A: Tailpipe Emissions Removed by Trees Annually

	Baseline		Optimized	
	Pounds Removed	Value	Pounds Removed	Value
Carbon Monoxide	31	\$ 13	159	\$ 68
Ozone	335	\$ 380	1,731	\$ 1,959
Nitrogen Dioxide:	124	\$ 1,031	638	\$ 5,318
Particulate Matter	247	\$ 507	1,276	\$ 2,616
Sulfur Dioxide	35	\$ 27	182	\$ 137
Total	772	\$ 1,958	3986	\$ 10,098

At the second more residential site, modeling revealed a baseline 5% tree canopy stores 725 tons of CO₂ in existing trees and sequesters an additional 5.64 tons per year. Increasing the canopy cover to 15% stores 2,174 tons of CO₂ and sequesters

an additional 16.93 tons per year. Table 167 contains tailpipe pollutant removal data for the baseline and optimized development scenarios for this site.

Table 167. Site B: Tailpipe Emissions Removed by Trees Annually

	Baseline		Optimized	
	Pounds Removed	Value	Pounds Removed	Value
Carbon Monoxide	105	\$ 45	315	\$ 135
Ozone	1,141	\$ 1,292	3,424	\$ 3,876
Nitrogen Dioxide	421	\$ 3,507	1,262	\$ 10,520
Particulate Matter	841	\$ 1,725	2,523	\$ 5,175
Sulfur Dioxide	120	\$ 90	360	\$ 270
Total	2,628	\$ 6,659	7884	\$ 19,976

5.3.3. Planning Considerations

To enable development practitioners to conduct their own analysis of this stormwater runoff and carbon sequestration mitigation alternative, the text below describes the basic methodology used by the CVRP team to generate the results presented here.

CVRP researchers used CITYgreen™ to analyze the ecological and economic benefits of tree canopies and other green/open space features for the baseline and optimized scenarios for each development site. CITYgreen™, built on the ESRI ArcGIS platform, allows users to derive assumptions from spatial datasets. The primary input to CITYgreen™ is a classified land cover dataset for each development scenario. Site plan data provided by the developers and datasets derived from a variety of sources including aerial photography, satellite imagery, and GIS vegetation layers affected the land cover assumptions. The datasets were classified into land cover features such as tree canopies, open spaces, impervious surfaces, and water surfaces. Researchers then configured this information into feasible landscape plans to conduct CITYgreen™ analysis.

Stormwater runoff mitigation analysis

The research team calculated stormwater runoff, concentrations, and peak flow through use of the Urban Hydrology for Small Watersheds model, also known as Technical Release 55 (TR-55). Civil engineers commonly use this model in the design of stormwater management facilities. It was developed by the Natural Resource Conservation Service, a bureau of the U.S. Department of Agriculture. CITYgreen™

uses TR-55 modeling results to calculate the volume of runoff from land cover based on the two-year, 24-hour rain event. This calculation allows planners to examine the impact of tree planting on urban runoff and to estimate savings attributed to diverted stormwater.

CITYgreen™ produces this calculation by first assigning a Curve Number to each classified land cover type. Curve Number is a parameter used in hydrology for predicting runoff potential and varies by land cover and soil type.⁷ The number ranges from 30 to 100; lower numbers indicate lower runoff potential. Users estimate diverted stormwater by taking site-wide Curve Numbers, weighted by percentage of each land cover type, under different scenarios and comparing them to a baseline (for example, a site with a canopy versus a site with no canopy). The difference in Curve Numbers from two scenarios drives the calculation of stormwater volume diverted using the TR-55 methodology.⁸

Carbon Sequestration Analysis

Using the same land cover assumptions generated for the stormwater analysis, researchers used the CITYgreen™ tool to calculate air pollution removal and carbon storage and sequestration potential of the tree canopies for the two development sites.

The CITYgreen™ tool incorporates the USDA Urban Forest Effects Model (UFORE) to calculate tree canopy potential to remove five criteria pollutants from the atmosphere.

7. Curve numbers for land use and soil types is contained in Appendix B.

8. The equations for calculating the stormwater savings are provided in Appendix C.

In addition to calculating annual pollutant levels reduced through the use of tree canopies, the model also calculates the associated dollars saved on negative externalities, such as increases in asthma and other respiratory ailments and decreases in tourism. CITYgreen™ estimates the amount of pollution in a given area based on data from the nearest city, in this case San Diego. The pollution removal rate or flux (F) is calculated by multiplying the deposition velocity (V_d) by the concentration of the pollutant (C):

$$F \text{ (g/cm}^2\text{/sec)} = V_d \text{ (cm/sec)} \times C \text{ (g/cm}^3\text{)}$$

Annual flux values are summed by estimating the total pollutant flux by hour over a surface in periods where pollutants are known to exist. These numbers are pre-calculated in CITYgreen™ for 55 modeled regions and are expressed as the weight of

pollutant removed per square meter of canopy.

Researchers also used the UFORE model to calculate the amount of carbon stored in the trees represented on the land cover maps for each development site and to calculate their annual carbon sequestration. While storage and sequestration varies by tree species and maturity, the researchers assumed a weighted average of trees appropriate for urban plantings. Based on assumptions of average carbon storage and sequestration for trees used in a typical urban forestry program, CITYgreen™ calculates a carbon storage and sequestration weight per square meter of canopy. Table 168 below provides the averages used by the researchers for this analysis.

Table 168. Carbon Storage and Sequestration Canopy Assumptions

	Weight per Square Meter
Carbon Storage	96.46 g
Carbon Sequestration	0.75 g

Tables 169 and 170 below provide additional assumptions used in the stormwater runoff, carbon sequestration, and air quality analysis of both development sites.

Table 169. Site A: Land Cover Assumptions

Land Cover Type	Baseline		Optimized	
	Acres	Percent	Acres	Percent
Impervious Surfaces: Buildings/structures all other buildings	57.2	27.80%	57.1	27.70%
Impervious Surfaces: Paved - drain to sewer	36.2	17.60%	36.3	17.60%
Meadow: (Continuous grass, generally mowed, not grazed)	1.4	0.70%	1.4	0.70%
Open Space: Grass/scattered trees	10.9	5.30%	10.9	5.30%

and grass cover > 75%				
Trees: Grass/turf understory ground cover > 75%	3.4	1.70%	24.1	11.70%
Trees: Impervious understory	1.5	0.70%	1.4	0.70%
Urban: Commercial/business	95.5	46.30%	74.8	36.30%
Total	206.19	100.00%	206.1	100.00%

Table 170. Site B: Land Cover Assumptions

Land Cover Type	Baseline		Optimized	
	Acres	Percent	Acres	Percent
Impervious Surfaces: Buildings/structures all other buildings	78.2	23.20%	78.2	23.20%
Impervious Surfaces: Paved - drain to sewer	82.2	24.40%	82.2	24.40%
Open Space - Grass/Scattered Trees: Grass cover > 75%	19.2	5.70%	19.2	5.70%
Trees: Grass/turf understory ground cover > 75%	16.8	5.00%	50.5	15.00%
Urban: Commercial/business	140.5	41.70%	106.8	31.70%
Total	337.10	100.00%	337	100.00%

Additional Site Modeling Assumptions

Stormwater Runoff Assumptions (for the TR-55 calculations, see previous subsection):

- P = 1.75 inches
- A_m = .32 sq mi
- F_p = 1.0
- Soil Type = D (very impervious)¹¹
- Raintype = I¹²

Electricity Multiplier for Stormwater Processing: 652 kWh per acre-foot of water¹³

Air Quality Assumptions (for San Diego region):

-
- 9. Number excludes a portion of unplanned land that is within the original site.
 - 10. Number includes streets on the perimeter of the site.
 - 11. Used to determine the curve numbers associated with each land cover type. These values are contained in Appendix B.
 - 12. Used to determine coefficient values for the TR-55 calculations. Appendix D contains the table of Rain Types and associated coefficient values.
 - 13. Multiplier derived from Hoffman, Alan R. 2004. *The Connection: Water and Energy Security*.

Weight of Pollutant Removed Per Square Meter of Canopy¹⁴

Ozone	7.6 grams
Particulate Matter	5.6 grams
Nitrogen Dioxide	2.8 grams
Sulfur Dioxide	0.8 grams
<u>Carbon Monoxide</u>	<u>0.7 grams</u>
Total	17.4 grams

Dollar Value of Pollutants Removed Per Square Meter of Canopy

Ozone	0.006767
Particulate Matter	0.004518
Nitrogen Dioxide	0.006767
Sulfur Dioxide	0.001653
Carbon Monoxide	0.000940

Weight of Stored Carbon per Square Meter of Canopy¹⁵

Young Trees	72.31 grams
Mature Trees	99.15 grams
Even Mix	120.89 grams
Unknown Age	96.46 grams

Annual Rate of Carbon Sequestration per Square Meter of Canopy¹⁶

Young Trees	1.62 grams
Mature Trees	0.17 grams
Even Mix	0.34 grams
Unknown Age	0.75 grams

14. From air quality data associated with San Diego and packaged with CITYgreen.

15. Based on average for typical trees used in urban forestry. (McPherson, Nowak, Rowntree 1994, 201)
Please also see Tree Guidelines for Coastal Southern California Communities. McPherson, Scott, Simpson, Xiao, and Peper. 2000.
http://www.fs.fed.us/psw/programs/cufr/products/2/cufr_48.pdf

16. *ibid.*

The principal cost associated with urban runoff mitigation and carbon sequestration measures is the cost of tree plantings. At the time of the completion of this guide, the average cost of planting a tree, including labor and materials, was approximately \$445 in most Southern California communities. For an excellent source of information on individual tree species and their carbon reduction potential please see:

Tree Guidelines for Coastal Southern California Communities. 2000.
McPherson, Gregory, Klaus I. Scott, James R. Simpson, Qingfu Xiao, and Paula J. Peper.
www.fs.fed.us/psw/programs/cufr/products/2/cufr_48.pdf

5.4. Urban Heat Island Effect Mitigation Measures

5.4.1. Description

According to the U.S. EPA, “the term heat island describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C). Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality”.¹⁷

Use of lower-albedo (less reflective) materials on urban surfaces, as well as through tree plantings, can mitigate the UHI effect. To quantify the impact of these

measures on energy consumption for the two development sites, researchers modeled two scenarios for each, one included use of these measures and the other did not. They then determined site-wide albedo for both scenarios. Next, they calculated average temperature reduction and percent reduction in energy for residential, office, and retail buildings using MIST. Researchers applied these results to the energy usage assumptions calculated for each prototype.

The researchers used MIST to analyze the impact of cool-roof coatings, cool pavement, and increased tree canopies to mitigate the urban heat island.

5.4.2. Energy Efficiency Performance

The modeled application of urban heat island mitigation measures produced 5-14% in kWh energy savings for residential and commercial structures in both development sites. In the predominantly urban development site, modeling indicated a 10% increase in vegetation and a 0.09 increase in albedo (reflectance of surfaces) resulted in a temperature decrease ranging from 1.3°F to 2.8°F. This albedo change represented the overall weighted average change for the entire site. These temperature reductions translated to a 13% savings in residential kWh, a 5% savings in commercial-office kWh, and a 5% savings in commercial-retail kWh. The model results, however, showed a small increase in gas consumption due to increased heating demand for residential, retail, and office units. Converting MMBtu to equivalent kWh showed a net energy savings of 3,835,803 kWh community-wide, as well as a 3,029,248 lb savings in CO₂ emissions, a 635 lbs saving in SO_x emissions, and a 1,344 lb savings in NO_x emissions.

17. U.S.EPA Heat Island Home Page at:
<http://www.epa.gov/heatisland/index.htm>

Modeling results for the predominantly residential development site indicated a 10% increase in vegetation and a 0.11 increase in albedo resulted in a temperature decrease ranging from 1.1°F to 2.4°F. The MIST parametric model predicted an average savings of 14% in residential kWh, a 6% savings in commercial-office kWh, and a 6% savings in commercial/retail kWh. The model results also showed a small increase in gas consumption due to increased heating demand for residential, retail, and office units. Converting MMbtu to equivalent kWh resulted in a net energy savings of 9,283,511 kWh community-wide, as well as a 7,248,920 lb savings in CO₂ emissions, a 1,503 lb saving in SO_x emissions, and a 3,245 lb saving in NO_x emissions.

5.4.3. Planning Considerations

To enable development practitioners to conduct their own analysis of urban heat island mitigation alternatives for proposed projects, the text below describes the basic methodology used by the CVRP team to generate the results presented here. At the center of the analysis is the use of the Mitigation Impact Screening Tool (MIST).

The U.S. EPA developed the MIST tool to analyze alternative urban heat island mitigation measures for development sites. MIST provides qualitative assessments of likely impacts of heat island effect mitigation measures at a city scale. Researchers investigated mitigation measures such as highly reflective construction and paving materials and urban vegetative cover. They also used MIST to investigate average temperature reduction and to estimate the resulting impacts on ozone and energy consumption.

Once the research team examined a range of albedo, vegetation, and combined albedo-vegetation scenarios for each site, they used MIST to extrapolate the results from a set of detailed meteorological model simulations for the San Diego region. They then combined these meteorological impacts with energy and tropospheric ozone air quality models to estimate the impact the specified mitigation measures may have on the development sites. It should be noted that the MIST results are intended only as a first-order estimate urban planners can use to assess the viability of heat island mitigation strategies.

To establish the baseline for both development sites, researchers applied a reflectance assumption to urban surfaces (roads, sidewalks, parks, roofs, etc.). The baseline represented the minimum requirements for roof albedo in California and typical developer paving choices for roads. The specific values are referenced later in this section.

Researchers then created an optimized scenario for each site that included use of mitigation measures including cool roof coatings and road pavement. Because MIST uses a site-wide albedo differential as an input, the team developed a weighted measure of site-wide albedo for different types of surfaces. There were some challenges in estimating different types of surface cover since these analyses were based on conceptual site plans that had little or no indication of parking, pathways, courtyards, and other details. After removing roads, sidewalks, roofs, and parks represented in the plan, there remained a large percentage of unclassified land cover in each site.

Researchers could not reasonably assume all the remaining land cover would be of one type. However, estimating a large range of land cover types would not contribute significantly to the analysis. Instead, researchers made a general assumption that unclassified land would be divided into two categories: pavement and open space. Since they applied these assumptions equally to both sites, the relative differences still revealed impacts associated with use of urban heat island effect mitigation measures.

To arrive at a reasonable mix of pavement and open space within the unclassified areas of each site, the research team assumed total pavement area coverage of 41%. They derived this assumption from an analysis of the Sacramento metropolitan region characterizing the urban fabric.¹⁸ In that report, researchers found approximately 41% of areas characterized as downtown/city center were comprised of pavement.

While the CVRP study areas are not as dense as a typical city center, they are more closely related to these areas than outlying residential, office, or industrial areas. Therefore, researchers believed this was a reasonable estimate for the study areas, acknowledging that pavement cover varies widely from community to community. It is likely the percentage of pavement would be lower in less dense areas, but these areas amount to little more than one-third of the total CVRP study area.

In each site there was a specified amount of paved area classified as streets and sidewalks. Researchers calculated the

percent coverage of these areas and then subtracted from the target coverage of 41%. The remaining percentage represented the relative share of unclassified land that the researchers classified as paved. The remaining percentage of the unclassified land was classified as open space and assumed to be covered by grass and vegetation. Using these assumptions, researchers calculated a weighted albedo for the unclassified land and used this in calculating the site's total weighted albedo.

The type of material covering each land type drove the albedo assumptions. The goal of this analysis was to illustrate how a change of materials can reflect more sunlight and lower overall ambient air temperature in a development site. The optimized scenario featured higher albedo materials for key land cover types, specifically roofs and streets.

18. See Rose, Akbari, Taha. 2003.

The baseline scenario for both sites assumed the use of the following materials:

- Streets Asphalt (Albedo .04)
- Sidewalk Gray Portland cement concrete (Albedo .45)
- Roof Minimum required cool roof (Albedo .7)
- Park and Open Space Grass and vegetation (Albedo .23)
- Parking Lots Asphalt (Albedo .04)

The optimized scenario for both sites assumed the following materials:

- Streets Asphalt with 6 inch whitetopping (Albedo .45)
- Sidewalk Gray Portland cement concrete (Albedo .45)
- Roof Double coat of cool roof coating (Albedo .85)
- Park and Open Space Grass and vegetation (Albedo .23)
- Parking Lots Asphalt (Albedo .04)

Site A: Urban Heat Island Effect Analysis Assumptions

Table 171 below shows Site A divided into five main land cover types: street, sidewalk, roof, park, and unclassified. Researchers applied the albedos described above to the same area for the baseline and for the optimized scenarios and then weighted them according to the percent coverage.

Tables 172 and 173 below indicate how they derived the unclassified area albedo according to the approach described above. The resulting difference (delta) of 0.09 was the relative increase in albedo between the baseline and optimized scenarios. MIST used this number to arrive at the relative energy savings attributable to the increase in albedo and vegetation.

Table 171. Site A: Albedo Assumptions Based on Surface Type

Land Cover	% Cover	Area (sq feet)	Surface Albedo		Weighted Albedo		Delta
			Baseline	Optimized	Baseline	Optimized	
Street	10.93%	981,533	0.04	0.45	< .01	0.05	0.05
Sidewalk	7.35%	659,715	0.45	0.45	0.03	0.03	0
Roof	27.18%	2,440,558	0.7	0.85	0.19	0.23	0.04
Park	6.98%	627,038	0.23	0.23	0.02	0.02	0
Unclassified	47.56%	4,270,294	0.19	0.19	0.1	0.1	0.02
Total	100.00%	8,979,139			0.34	0.43	0.09

The researchers generated a set of variable assumptions for the site to be used in the MIST calculations. These included the following:

- Population 4,946
- Latitude 32.6
- Annual mean temperature 63.7
- Annual cooling degree days (65F Base)¹⁹ 862
- Annual heating degree days (65F Base) 1,321

Table 172. Site-A: Reflectance Assumptions for “Unclassified” Land cover

Site-A:	Parameter	%
	% Target Pavement Cover	41%
	% Pavement in Plan	18%
Unclassified	% Parking	23%
Split	% Open Space	77%
Weighted	Parking	0.01
Albedo	Open Space	0.18
	Total Weighted Albedo	0.19

19. Cooling Degree Days (CDD) are a measure of how many degrees above the base (65F) are experienced in a year. Subtracting 65 from the average temperature in a given day results in the number of CDDs. Summing all of these over the year produces the annual CDD number used here. Similarly, Heating Degree Days are a measure of how many degrees below the base are occur per year.

Researcher then used these assumptions and the relative albedo differences as input for the MIST analysis of the site. This produced a range and mean reduction in ambient air temperature and a related reduction in energy requirements for buildings in three general categories: residential, office, and retail. The team applied these percent reductions to the building modeling data for the baseline

energy profile. The result was an aggregate energy reduction and related cost reductions.

Site B: Urban Heat Island Effect Analysis Assumptions

Researchers also divided Site B into five land cover categories and calculated weighted albedo values for the site. Tables 173 and 174 provide these values.

Table 173. Site-B: Albedo Assumptions Based on Surface Type

Land Cover	% Cover	Area (sqft)	Surface Albedo		Weighted Albedo		Delta
			Baseline	Optimized	Baseline	Optimized	
Street	17.91%	2,589,600	0.04	0.45	0.01	0.08	0.07
Sidewalk	6.12%	885,381	0.45	0.45	0.03	0.03	0
Roof	23.57%	3,408,049	0.7	0.85	0.16	0.2	0.04
Park	5.05%	730,516	0.23	0.23	0.01	0.01	0
Unclassified	47.35%	6,848,348	0.2	0.2	0.1	0.1	0
Total	100.00%	14,461,897			0.3	0.41	0.11

Table 174. Site B: Reflectance Assumptions for “Unclassified” Land cover

Site B	Parameter	%
	% Target Pavement Cover	41%
	% Pavement in Plan	24%
Unclassified	% Parking	17%
Split	% Open Space	83%
Weighted	Parking	0.01
Albedo	Open Space	0.19
	Total Weighted Albedo	0.2

The relative difference in albedo became one of the variables entered into the MIST analysis as in Site A. Researchers applied the following assumptions:

- Population 9,342
- Latitude 32.6
- Annual mean temperature 63.7

- Annual cooling degree days (65F Base)²⁰ 862
- Annual heating degree days (65F Base) 1,321

Again the team applied MIST outputs to the building energy consumption data to arrive at approximate aggregate energy and emission reductions detailed above.

20. The same CDD and HDD assumptions are made for Site B as were made earlier for Site A.

5.5. Passive Solar Building Orientation

5.5.1. Description

Passive solar building orientation entails the placement of a building on a site with the explicit intention of maximizing the sun and shade for heating and cooling to reduce energy use and cost. By facing the long side of a structure to the south and the short sides to the east and west and including overhangs or awnings over windows, the structure will capture solar heat in the winter and block solar gain in the summer. This can also be accomplished by minimizing the windows on the east and west sides of the structure and by increasing window cover on the south side. A true passive solar-designed building will also make use of a thermal storage mass (thick dark walls that can absorb heat during the day and release it at night) and shading by trees to decrease heat in the summer. The single-family homes modeled in this limited study were not modeled with all of these features.

A building that is oriented toward the sun with more glazing on the south side (up to about 10% of floor area) is considered *solar tempered*. The single family homes modeled in this study fit within this category. Researchers modeled only one single family home for this analysis since other residential buildings were multi-family buildings. These higher density buildings would see asymmetric benefits. Some of the units would be unable to take full advantage of orientation because they would be shaded by adjacent mid-rise or high-rise buildings. Glazing on these prototype buildings tended to be evenly distributed. Although it is possible to incorporate some features of passive solar

design into these buildings to take better advantage of natural light, researchers did not model these features.

5.5.2. Energy Efficiency Performance

Results of the limited analysis conducted under CVRP on passive solar building orientation led researchers to conclude that building orientation alone, without the aid of additional passive solar building design features, would produce improvements in energy efficiency and cost savings, although modest. Reductions in natural gas and electric consumption ranged between 2% and 3%.

5.5.3. Planning Consideration

Researchers found that east-west building orientation, where the greatest length of a structure is facing south, resulted in energy usage savings of 2.8% annually for electricity and 2.2% annually for natural gas. These are modest savings, but resulted merely from changing the direction of the building without any additional design or mechanical features. Researchers produced this finding by modeling a single-family detached home prototype from the building energy analysis work and examining the impact on energy efficiency associated with thirty-degree incremental changes in building orientation. Prototype 1 described in Chapter 3 was used for this analysis. Figures 24 and 25 below illustrate the electricity (kWh) and natural gas (MMbtu) consumption for the structure plotted against orientation where 0 is north and 180 is south.

Although it is true the east-west building orientation 90 and 270 degrees, resulted in the best energy savings, the percent difference from the worst performing

orientation was not substantial. In the case of electricity, the percent difference in energy use was 2.8% with a cost savings of 4.1% annually. For natural gas, the difference was 2.2% in consumption and 1.8% in cost savings annually. However,

similar buildings featuring PV, an east-west orientation, and other passive design features for heating and cooling would result in higher energy savings.

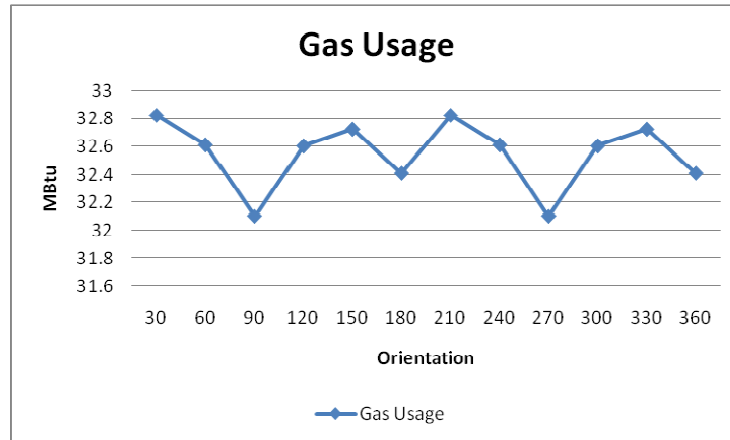


Figure 24. Site B: Gas Usage for Prototype 1 Plotted Against Orientation

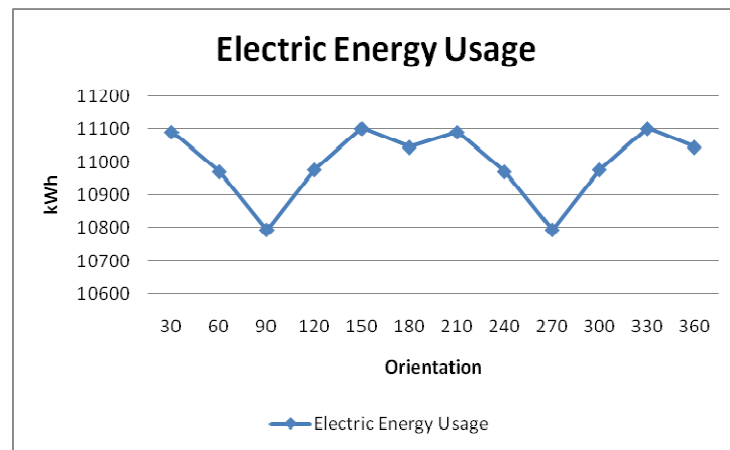


Figure 25. Site B: Electricity Usage for Prototype 1 Plotted Against Orientation

Cost of Passive Solar Building Orientation

The incremental cost of optimizing building orientation can vary dramatically from no additional costs to rotate buildings or an entire site plan to high costs associated with

changes in topography, streets, and infrastructure. Since these costs are by definition site-specific, this guide does not provide an estimate.

Readers are encouraged to investigate the forthcoming National Renewable Energy Laboratory exhaustive research report on the subject of optimal solar building and

subdivision orientation and planning to be published by the California Energy Commission during calendar year 2010.

6.0 Related Resources

6.1. Publications, Papers and Presentations

Although energy-efficient community development is only now emerging as a new field of inquiry among California state research and regulatory organizations, a number of related reference publications, papers, presentations, and websites are now available that contain valuable resources on the subject. A select number of these are presented below.

6.1.1. *Advanced Building and District Energy Technologies*

Building Load Profiles and Optimal CHP Systems. 2002. Czachorski, M., W. Ryan, J. Kelly, presented at ASHRAE Summer Meeting, Honolulu, Hawaii,

Commercial Buildings Energy Consumption Survey. 1999. Energy Information Administration. U.S. Department of Energy

Community - District Energy Systems: Preliminary Planning & Design Standards. 2007. Newman, D., National Energy Center for Sustainable Communities and the International District Energy Association. Available at: http://www.necsc.us/docs/CommunityDistrictEnergy_Systems.pdf

Comparing Economics of Various Methods of Improving Energy Efficiency of Commercial Buildings. Czachorski, M., T. Kingston, J. Wurm. Presented at CLIMA 2007 Congress, June 10-14 2007, Helsinki, Finland.

Economics of CHP Systems. Czachorski, M., Presented at 4th Conference of International Building Performance

Simulation Association - Czech Republic, IBPSA-CZ, Praha, Czech Republic November 7, 2006.

Economics of Commercial Building Cogeneration and Desiccant Technology Combinations. Czachorski, M., J. Wurm. Presented at 14th International Conference VYKUROVANIE Tatranske Matliare, Czech Republic, March 6 - 10, 2006

Economics of Installing Desiccant Dehumidifier in Commercial Buildings Application of Cooling Heating and Power Generation Systems. 2005. Czachorski, M. Presented at ASHRAE Summer Meeting, Denver, Colorado. 2005.

Evaluation of Commercial Markets for Building Cooling Heating and Power Applications in the U.S. Czachorski M., E. Ryan, J. Wurm. Paper presented at Conference Simulace Budov a Techniky Prostedí; II. Národní Konference IBPSA-CZ ; Prague, Czech Republic. 2002.

Evaluating Active Desiccant Systems for Ventilating Commercial Buildings. 2000. L. Harriman, M. Witte, M. Czachorski, D. Kosar, Published in ASHRAE Journal.

Improving the Economy of Ventilation in Commercial Buildings. 2004. Czachorski, M., J. Wurm. VVI Magazine, No. 3, Vol. 13, Published (in Czech) by the Society for Environmental Technology, Novotného Lávkva 5, 11668 Prague 1, Czech Republic.

Large District Energy Systems. Contained in Sustainable Urbanism: Urban Design With Nature. Page 199. 2008. Newman, D., R. Thornton, J. Kelly - authors. D Farr - editor. John Wiley & Sons, Inc. Available at:

<http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471475815.html>

Simulation and Evaluation of Markets for Building Cooling Heating and Power Applications in the U.S. Czachorski M., J. Wurm. Paper presented at Eight International IBPSA Conference – Building Simulation 2003 for Better Design; Eindhoven, Netherlands.

6.1.2. Community Planning, Design and Development Policies

A Renewable Energy Community: Key Elements. 2008. N. Carlisle, J. Elling, and T. Penney, National Renewable Energy Laboratory. A reinvented community to meet untapped customer needs for shelter and transportation with minimal environmental impacts, stable energy costs, and a sense of belonging. Available at: http://www.nrel.gov/applying_technologies/pdfs/42774.pdf

Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies. 2007. Loudon, William et al. Prepared for the State of California Business, Transportation and Housing Agency, and the California Department of Transportation by DKS Associates and the University of California, Irvine

Blueprint for Urban Sustainability: Integrating Sustainable Energy Practices into Metropolitan Planning. Containing the winning entries from the U.S. Competition on Metropolitan Energy Design. 2003. Gas Technology Institute. Available at: http://www.necsc.us/docs/Blueprint_Urban_Sustainability.pdf

Characterizing the Fabric of the Urban Environment: A Case Study of Greater Houston, Texas. 2003. Rose, L.S., H. Akbari, and H. Taha. Lawrence Berkeley National Laboratory Report LBNL-51448

Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. 1994. McPherson, Gregory, David Nowak and Rowan Rowntree. eds. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

City Green: Calculating the Value of Nature: Technical Manual. 2004. Western Climate Initiative - Western Governors' Association. <http://www.westernclimateinitiative.org/AmericanForests>

Commuting in Transit Versus Automobile Neighborhoods. 1997. Cervero, R. and K. Kockelman. Journal of the American Planning Association, Vol. 61, pp. 210-225.

Cool Roof Design Brief. Pacific Gas & Electric. www.pge.com/includes/docs/pdfs/shared/saveenergymoney/rebates/remodeling/coolroof/coolroofdesignbrief.pdf

Costs of Sprawl. 2002. Burchell, R.W., Lowenstein, G., Dolphin, W.R., Galley, C.C., Downs, A., Seskin, S., Still, K.G., and Moore, T. Transit Cooperative Research Program, Transportation Research Board, National Research Council Report. Washington DC: National Academy Press.

Directory of Eco-villages in Europe (Book Review – Reviews the book 'Directory of Eco-villages in Europe'). 1999, Christensen K: Utopian Studies; Vol. 10 Issue 1, p160, 6p.

- Energizing Sustainable Cities: The Power of Planning and Design. 2004. Newman, D. 2004. National Energy Center for Sustainable Communities. A 17-minute DVD, narrated by Bill Kurtis, introduces a vision for sustainable urban energy design as well as a plan and tools for how to get there. Available at: www.necsc.us/store.php
- Energy and Smart Growth. Gilbert, R. 2002.. An Issue Paper.
- Energy, Planning, and Urban Form. 1986. Owens, S. Taylor & Francis publishers.
- Energy-Efficient Development. Contained in Planning and Urban Design Standards. Page 484. 2006. Newman, D. American Planning Association and John Wiley & Sons, Inc. Available at: www.wiley.com/WileyCDA/WileyTitle/productCd-047177751X.html
- Figures for Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks. 2005. US Environmental Protection Agency. Ann Arbor, MI
- Green Building Incentives That Work: A Look at How Local Governments are Incentivizing Green Development. 2007. Yudelson and Associates, the National Association of Industrial and Office Properties. Available at: www.naiop.org/foundation/greenincentives.pdf
- Heat Island Reduction Initiative Cool Pavement Report. 2005. US Environmental Protection Agency. Available at: www.epa.gov/heatisld/resources/pdf/CoolPavementReport_Former%20Guide_complete.pdf
- LEED for Neighborhood Development Rating System – Pilot Version. 2007. U.S. Green Building Council. U.S. Green Building Council.
- Making Travel Models Sensitive to Smart-Growth Characteristics. 2006. Hubbard, D. and Walters, G. at Fehr & Peers. Prepared for the ITE District 6 Conference, Honolulu, HI.
- Mitigating New York City’s Heat Island with Urban Forestry, Living Roofs, and Light Surfaces. 2006. Rosenzweig, Cynthia, and William D. Solecki. www.nyserda.org/Programs/Environment/EMEP/project/6681_25/06-06%20Complete%20report-web.pdf
- Model for Sustainable Urban Design with Expanded Sections on Distributed Energy Resources. 2003. Newman, D., U. McGowan, J. Wrobel. Containing the award-winning U.S. entry to the International Competition for Sustainable Urban Systems Design featuring the Greater San Diego-Tijuana Binational Metropolitan Region. Gas Technology Institute. Available at: www.necsc.us/docs/ORNL_Design_Final.pdf
- Neighborhood Site Design and Pedestrian Travel. 1999. Hess, P.M., et al.. Presentation at the Annual Meeting of the Association of Collegiate Schools of Planning, American Planning Association: Chicago.
- Smart Growth Index Indicator Dictionary. 2002. Criterion. U.S. Environmental Protection Agency, www.epa.gov/smartgrowth/pdf/4_Indicator_Dictionary_026.pdf

Smart Growth Index (SGI) Model. 2002. US Environmental Protection Agency.
www.epa.gov/livablecommunities/topics/sg_index.htm

The Connection: Water and Energy Security. 2004. Hoffman, Alan R. Institute for the Analysis of Global Security.
www.iags.org/n0813043.htm

The Economics of Green. 2008. Miller, Norm. University of San Diego – Burnham Moores Center for Real Estate, San Diego, California

Toward A New Metropolis: The Opportunity to Rebuild America. 2004. Nelson, Arthur C. A Discussion Paper Prepared for the Brookings Institution Metropolitan Policy Program, Virginia Polytechnic Institute and State University

Tree Guidelines for Coastal Southern California Communities. 2000. McPherson, Gregory, Klaus I. Scott, James R. Simpson, Qingfu Xiao, and Paula J. Peper.
www.fs.fed.us/psw/programs/cufr/products/2/cufr_48.pdf

White Roofs Cool the World, Offset CO₂, and Delay Global Warming. 2008. Lawrence Berkeley National Lab, Heat Island Group.
www.energy.ca.gov/2008publications/LBNL-1000-2008-022/LBNL-1000-2008-022.PDF

2030 Regional Growth Forecast Update. 2008. SANDAG.
www.sandag.org/uploads/publicationid/publicationid_1390_8531.pdf

6.1.3. Federal and California State Policies

Energy Independence and Security Act of 2007. U.S. Congress. 2007. Public Law 110–140. Dec. 19, 2007.
frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf

Federal Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings. 2008. National Science and Technology Council/Committee on Technology. NSTC.

California Assembly Bill # 32 – Pavley. 2006. California Health and Safety Code, §§ 38500 et seq.
www.climatechange.ca.gov/publications/legislation/ab_32_bill_20060927_chaptered.pdf

California Air Resources Board. 2008. Climate Change Draft Scoping Plan: A Framework for Change - 2008 Discussion Draft. (CARB Scoping Plan). CARB.
www.arb.ca.gov/cc/scopingplan/document/draftscopingplan.pdf

California Energy Commission and California Public Utilities Commission, 2005. Energy Action Plan II, Implementation Roadmap for Energy Policies. CEC and CPUC.
docs.cpuc.ca.gov/word_pdf/REPORT/51604.pdf

California Energy Commission. 2007. Integrated Energy Policy Report (2007 IEPR). CEC-100-2007-008-CMF. CEC.
www.energy.ca.gov/2007_energypolicy/documents/index.html

California Public Utilities Commission. 2007. Decision 98-04-063, Appendix A. CPUC.

California Public Utilities Commission. 2008. California Long Term Energy Efficiency Strategic Plan. CPUC.

California Senate. 2008. Senate Bill 375 – Steinberg.
info.sen.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080902_enrolled.pdf

6.2. Helpful Organizations and Websites

- American Council for an Energy-Efficient Economy
www.aceee.org
- American Planning Association
www.planning.org
- California Center for Sustainable Energy
www.sdreo.org
- California Environmental Protection Agency – Air Resources Board
www.arb.ca.gov/homepage.htm
- California Integrated Waste Management Board Green Building Program
www.ciwmb.ca.gov/GreenBuilding/
- City of Berkeley, Energy and Sustainable Development
www.ci.berkeley.ca.us/SubUnitHome.aspx?id=15404
- City of Chula Vista – Sustainability Center
http://www.chulavistaca.gov/City_Services/Development_Services/Planning_Building/SustainabilityCenter/default.asp
- City of Oakland Environmental Services Division Green Building Resource Center
www.oaklandpw.com/page273.aspx
- City of San Jose, Mayor Reed’s Green Vision for San Jose
www.sanjoseca.gov/mayor/goals/environment/GreenVision/GreenVision.asp
- City of San Francisco Green Building Program
www.sfenvironment.org/our_programs/topics.html?ssi=8&ti=19
- City of Santa Monica, Residential Green Building Program
<http://greenbuildings.santamonica.org/mainpages/whatsnew.htm>
- City of Santa Monica Sustainable City Plan
www01.smgov.net/epd/scp/
- Congress for New Urbanism
www.cnu.org
- County of Marin, Countywide Plan
www.co.marin.ca.us/depts/CD/main/comdev/ADVANCE/cwp/index.cfm

- Danish Board of District Heating (DBDH)
www.dbdh.dk/index.html
- Euroheat and Power Association (Euroheat)
www.euroheat.org
- Global Energy Network for Sustainable Communities
www.globalenergynetwork.org
- International District Energy Association (IDEA)
www.districtenergy.org
- Japan Heat Services Utility Association (JHSUA)
www.jdhc.or.jp/en
- Korea District Heating Corporation (KDHC)
www.kdhc.co.kr/eng
- National Energy Center for Sustainable Communities
www.necsc.us
- Renewable Energy and Energy Efficiency Partnership
www.reeep.org
- Santa Barbara County, Innovating Building Review Committee
www.sbcountyplanning.org/projects/ibrp/index.cfm
- Smart Communities Network – National Center for Appropriate Technologies
www.smartcommunities.ncat.org
- Smart Code Central
www.smartcodecentral.org
- Urban Land Institute
www.uli.org
- U.S. Department of Energy – Office of Energy Efficiency and Renewable Energy
www.eere.energy.gov
- U.S. Department of Housing and Urban Development – Energy Efficient Mortgage Program
www.hud.gov/offices/hsg/sfh/eem/energy-r.cfm
- U.S. Green Building Council – LEED-ND
www.usgbc.org/DisplayPage.aspx?CMSPageID=148
- U.S. Environmental Protection Agency – Smart Growth Website
www.epa.gov/smartgrowth

Glossary

Acronym	Definition
3-D	Three dimensional visual representation of a design
BAU	Business-As-Usual, or a conventional approach to development
BEA	Building Energy Analyzer – proprietary tool of the Gas Technology Institute
Btu	British Thermal Unit
BPB	Builder’s Proposed Baseline
CBIA	California Building Industry Association
CCHP	Combined Cooling Heat and Power technology
CEC	California Energy Commission
CPUC	California Public Utility Commission
CARB	California Air Resources Board
CO₂	Carbon Dioxide
CSI	California Solar Initiative
CVRP	Chula Vista Research Project
DG	Distributed Generation technologies
DR	Demand Response
EE	Energy Efficiency
EE-PB	Energy-Efficiency and Photovoltaic technology option
EE-DG	Energy-Efficiency and Distributed Generation technology option
ET&CD	Energy Technology and Community Design options
ETS	Energy Transfer Stations
GHG	Greenhouse Gas emissions
GTI	Gas Technology Institute
HVAC	Heating, Ventilation and Air Conditioning equipment
IC	Internal Combustion Engine
kWh	Kilowatt hours
LEED	Leadership in Energy and Environmental Design
MIST	Mitigation Impact Screening Tool
NO_x	Nitrogen Oxides
PAC	Project Advisory Committee
RE	Renewable Energy
ROI	Return-On-Investment
TTP	Transit Priority Projects

SANDAG	San Diego Association of Governments
SBIC	Sustainable Building Industry Council
SDG&E	San Diego Gas and Electric
SDSU	San Diego State University
SOx	Sulfur Oxide
SPA	Specific Planning Area Plan
SPV	Solar Photovoltaic
STH	Solar Thermal
T-24	California's Title-24 building energy efficiency standard, 2005
TBD	To-Be-Determined
TDV	Time Dependent Valuation
TDVI	Time Dependent Valuation Inclusive
TES	Thermal Energy Storage
UCC-1	Uniform Commercial Code
UFORE	Urban Forest Effects model
UHI	Urban Heat Island effect
USDOE	US Department of Energy
USEPA	US Environmental Protection Agency
USDA	US Department of Agriculture
VMT	Vehicle Miles Traveled
ZNE	Zero Net Energy

Appendices

- A. Methods for Evaluating Utility Incentives on Payback Period
- B. Curve Numbers for Land Use and Soil Types
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Attachments

- I. Building Energy Modeling Assumptions

Appendix A. Methods for Evaluating Utility Incentives on Payback Period

Researchers used the following methods and equations to determine the impact of available utility incentives on the simple payback period for all modeled energy efficiency features for the urban and residential site building prototypes. The results of these calculations for each prototype package are contained in Chapter 4 of this guide.

Note: Subsequent to completion of modelers' analysis, utility incentive programs eliminated the internal combustion engine option because of persistent emissions control concerns. Therefore, this option is not considered further in this section.

The modelers' analysis included estimation of the cost difference between the builder baseline and the modified case for individual technologies. Furthermore, they considered packages of energy-efficient technologies that could combine cost effectively. They estimated cost effectiveness using the simple payback period. In general, they calculated simple payback using Equation (1).

$$(1) \quad PB = \frac{\Delta C_{EE}}{AS_{EE} - OM_{EE} + R_{EE}}$$

where: PB = simple payback period (years)

ΔC_{EE} = estimated difference in first cost of energy efficiency technology (or package) over the builder baseline (\$)

AS_{EE} = estimated annual savings in energy utility expenditures resulting from the energy-efficient technology (or package) over the builder baseline case (\$/year), calculated as the estimated annual utility cost using the builder baseline technology minus the estimated annual utility cost using the energy efficiency technology (or package)

OM_{EE} = estimated cost of operations and maintenance of the photovoltaic system if part of the energy-efficient package, estimated as 0.12% of the installation cost for photovoltaic systems and zero otherwise

R_{EE} = estimated revenue for electricity over-production from photovoltaic system if part of the energy-efficient package, estimated from the energy simulation with a blended electric rate of \$0.1141/kWh and zero otherwise

Researchers deemed technologies cost effective if the simple payback period was less than the useful life of the technology. The modeling team analyzed energy efficiency upgrades to the envelope, lighting, and mechanical systems, and chose the most cost-effective combination for each prototype in a package referred to as the optimal energy efficiency package or EE opt. They also developed a corresponding cost differential over the builder baseline for EEopt. For cases where photovoltaics were cost effective and practical, they also developed a cost for the same system including photovoltaics, referred to as EEopt+PV. Because the California Solar Initiative is so fundamental to the economics of photovoltaics, the payback period for the photovoltaic systems already includes government incentives.

To assess the impact of incentives on the payback period, researchers estimated SDG&E incentives under the Sustainable Communities Program. They incorporated the incentives into the payback calculation as indicated in Equation (2).

$$(2) \quad PB = \frac{\Delta C_{EE} - I_U}{AS_{EE} - OM_{EE} + R_{EE}}$$

where: I_U = estimated utility incentive to offset the first cost of the system.

Researchers estimated the incentives available from SDG&E Sustainable Communities Program in accordance with the Participant Handbook (SDG&E 2008). SDG&E describes the program as a means to promote green building design practices by encouraging construction practices that significantly exceed Title 24 requirements. Builders can become eligible for incentives by demonstrating they have incorporated energy efficiency alternatives well in advance of Title 24 requirements. Additional incentives are available for satisfying sustainability criteria.

Different incentive structures exist for nonresidential and residential structures. For nonresidential structures, the incentive is calculated for both the electric and gas performance of the structure (Equations (3) through (5) SDG&E 2008).

$$(3) \quad I_{elec} = \left[0.10 + \frac{(Perf_{T24} - 10)}{100} \right] AS_{kWh}$$

where: I_{elec} = electric incentive (\$);

$Perf_{T24}$ = performance of the structure better than Title-24 requirements in percent, maximum of 25; and

AS_{kWh} = annualized electrical savings in kWh.

$$(4) \quad I_{gas} = \left[0.34 + \frac{4.4(Perf_{T24} - 10)}{100} \right] AS_{therms}$$

where: I_{gas} = gas incentive (\$);

AS_{therms} = annualized gas savings in therms.

$$I_U = I_{elec} + I_{gas}$$

An additional 20% is available for projects that also obtain the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) or equivalent certification and perform an on-site renewable energy evaluation. The maximum incentive payable for nonresidential projects is \$150,000.

For residential projects, the incentive is \$165 per dwelling unit, with a \$50,000 maximum per project.

Researchers applied these incentives in Equation (2) for each prototype. Two example calculations are presented below to illustrate the process.

Example – Commercial Building Calculation

The data contained in Table A1. were derived from the from modelers' analysis for Urban Site: Prototype 4 (a low-rise office structure) which is described in Chapter 2.

Table A1. Analytical Results from Building Energy Analysis - Commercial

Variable	Builder Baseline	Optimum EE Package	Optimum EE and PV
Package Cost	n/a	\$90,874	\$532,195
Annual Utility Cost	\$60969	\$51631	\$31,914
Annual Electrical Usage	332,469 kWh	285,304 kWh	140,418 kWh
Annual Gas Usage	249 MMBtu	215 MMBtu	215 MMBtu
Total Annual Energy	1384 MMBtu	1188 MMBtu	694 MMBtu

Payback Period Eqn (1)	n/a	9.7 years	17.2 years
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Calculation for the optimum EE package proceeds as follows:

Estimated energy improvement over the builder baseline was

$$Perf = \frac{\text{Energy Saved}}{\text{Builder Baseline Energy}} \times 100\% = \frac{1384 \text{ MMBtu} - 1188 \text{ MMBtu}}{1384 \text{ MMBtu}} \times 100\% = 14.1\%$$

The builder baseline was the set of construction practices proposed by the developer and the building community as standard practice in the region. This set of practices was recognized to be above the requirements of Title 24. Previous modeling by the research team in the area found that the builder baseline would exceed the Title 24 requirements by 8 to 13%. This estimate of the incentive effect needed only an unbiased estimate of the result compared to Title 24. Therefore, researchers used a moderate assumption that the builder baseline was about 10% better than Title 24. Accordingly, $Perf_{T24} \approx 14.1\% + 10\% = 24.1\%$. Using this value, the incentives can be calculated:

$$\begin{aligned} I_{elec} &= \left[0.10 + \frac{(Perf_{T24} - 10)}{100} \right] AS_{kWh} \\ &= \left[0.10 + \frac{(24.1 - 10)}{100} \right] (332,469 - 285,304) \\ &= (0.241)(47,165) = \$11,362 \\ I_{gas} &= \left[0.34 + \frac{4.4(Perf_{T24} - 10)}{100} \right] AS_{therms} \\ &= \left[0.34 + \frac{4.4(24.1 - 10)}{100} \right] (2490 - 2150) \\ &= (0.96)(340) = \$327 \end{aligned}$$

$$I_U = I_{elec} + I_{gas} = \$11,362 + \$327 = \$11,689$$

Substituting the necessary values in Equation (2),

$$\begin{aligned} PB &= \frac{\Delta C_{EE} - I_U}{AS_{EE} - OM_{EE} + R_{EE}} \\ &= \frac{90,874 - 11,689}{(\$60,969 - \$51,631) - 0 + 0} = 8.5 \text{ years} \end{aligned}$$

For the optimum EE package, the incentive package reduced the payback period by approximately 1.2 years, from 9.7 years to 8.5 years.

The calculation for the combined optimum EE-PV package proceeds as follows:

Estimated energy improvement over the builder baseline was

$$Perf = \frac{\text{Energy Saved}}{\text{Builder Baseline Energy}} \times 100\% = \frac{1384 \text{ MMBtu} - 694 \text{ MMBtu}}{1384 \text{ MMBtu}} \times 100\% = 49.8\%$$

Using the same assumption as before, $Perf_{T24} \approx 49.8\% + 10\% = 59.8\%$. Using this value, the incentives can be calculated as before. However, the maximum value of the incentive in each case was controlled by the maximum energy savings of 25%.

$$I_{elec} = \left[0.10 + \frac{(25-10)}{100} \right] (332,469 - 140,418) \\ = (0.25)(192,051) = \$48,013$$

$$I_{gas} = \left[0.34 + \frac{4.4(25-10)}{100} \right] (2490 - 2150) \\ = (1.00)(340) = \$340$$

$$I_U = I_{elec} + I_{gas} = \$48,013 + \$340 = \$48,353$$

In this case, operations and maintenance costs and revenue from electricity generated by the PV system and sold back to the utility affected the payback. As explained below Equation (1), researchers estimated annual O&M expense using 0.12% of the (pre-CSI incentive) first cost of the system, or $OM_{EE} = (0.12\%)(740,608) = \$889/\text{yr}$. Modeling provided the electrical revenue, for this prototype $R_{EE} = \$2826/\text{yr}$. The revised payback period was then estimated using Equation (2):

$$PB = \frac{\Delta C_{EE} - I_U}{AS_{EE} - OM_{EE} + R_{EE}} \\ = \frac{532,195 - 48,353}{(\$60,969 - \$31,914) - 889 + 2826} = 15.6 \text{ years}$$

For the combined optimum EE-PV package, the incentive package reduced the payback period by approximately 1.6 years, from 17.2 years to 15.6 years.

An additional 20% incentive was also available for each case for adoption of sustainable practices in the projects (including LEED certification or equivalent). This additional incentive reduced the payback period another 0.3 years for both packages.

Example – Residential Building Calculation

The data contained in Table A2. were derived from modelers’ analysis for Residential Site: Prototype 3 (Artisan Residential) which is described in Chapter 2.

Table A2. Analytical Results from Building Energy Analysis – Residential

Variable	Builder Baseline	Optimum EE Package	Optimum EE and PV
Package Cost	n/a	\$8,144	\$89,680
Annual Utility Cost	\$10,268	\$9,400	\$5,974
Annual Electrical Usage	41,274kWh	38,948kWh	24,612kWh
Annual Gas Usage	126MMBtu	104MMBtu	104MMBtu
Total Annual Energy	267MMBtu	237MMBtu	188MMBtu
Payback Period Eqn (1)	n/a	9.4years	16.2years

The calculation for the optimum EE package proceeds as follows:

Estimated energy improvement over builder baseline was

$$Perf = \frac{\text{Energy Saved}}{\text{Builder Baseline Energy}} \times 100\% = \frac{267 \text{ MMBtu} - 237 \text{ MMBtu}}{267 \text{ MMBtu}} \times 100\% = 11.2\%$$

The builder baseline was the set of construction practices proposed by the developer and the building community as standard practice in the region. This set of practices was recognized to be above the requirements of Title 24. Previous modeling in the area found that the builder baseline would exceed the Title 24 requirements by an amount from 8 to 13%. This estimate of the incentive effect needed only an unbiased estimate of the result compared to Title 24. Therefore, researchers used a moderate assumption that the builder baseline was about 10% better than Title 24. Accordingly, $Perf_{T24} \approx 11.2\% + 10\% = 21.2\%$. Using this value, the incentives can be calculated:

$$\begin{aligned} I_{elec} &= \left[0.10 + \frac{(Perf_{T24} - 10)}{100} \right] AS_{kWh} \\ &= \left[0.10 + \frac{(21.2 - 10)}{100} \right] (41,274 - 38,948) \\ &= (0.212)(2,326) = \$493 \end{aligned}$$

$$\begin{aligned}
I_{gas} &= \left[0.34 + \frac{4.4(Perf_{T24} - 10)}{100} \right] AS_{therms} \\
&= \left[0.34 + \frac{4.4(21.2 - 10)}{100} \right] (1260 - 1040) \\
&= (0.83)(220) = \$183
\end{aligned}$$

$$I_U = I_{elec} + I_{gas} = \$493 + \$183 = \$676$$

Substituting the necessary values in Equation (2),

$$\begin{aligned}
PB &= \frac{\Delta C_{EE} - I_U}{AS_{EE} - OM_{EE} + R_{EE}} \\
&= \frac{8144 - 676}{(\$10,268 - \$9400) - 0 + 0} = 8.6 \text{ years}
\end{aligned}$$

For the optimum EE package, the incentive package reduced the payback period by approximately 0.8 years, from 9.4 years to 8.6 years.

The calculation for the combined optimum EE/PV package proceeds as follows:

Estimated energy improvement over builder baseline was

$$Perf = \frac{\text{Energy Saved}}{\text{Builder Baseline Energy}} \times 100\% = \frac{267 \text{ MMBtu} - 188 \text{ MMBtu}}{267 \text{ MMBtu}} \times 100\% = 29.6\%$$

Using the same assumption as before, $Perf_{T24} \approx 29.6\% + 10\% = 39.6\%$. Using this value, researchers calculated the incentives. However, the maximum energy savings of 25% controlled the maximum value of incentive in each case.

$$\begin{aligned}
I_{elec} &= \left[0.10 + \frac{(25 - 10)}{100} \right] (41,274 - 24,612) \\
&= (0.25)(16,662) = \$4,166 \\
I_{gas} &= \left[0.34 + \frac{4.4(25 - 10)}{100} \right] (1,260 - 1,040) \\
&= (1.00)(220) = \$220
\end{aligned}$$

$$I_U = I_{elec} + I_{gas} = \$4,166 + \$220 = \$4,386$$

In this case, the payback was affected by operations and maintenance costs and revenue from electricity generated by the PV system and sold back to the utility. For example, for Prototype 3, operation and maintenance and over-revenue resulted in a positive cash flow of \$1,253 per year.

$$PB = \frac{\Delta C_{EE} - I_U}{AS_{EE} - OM_{EE} + R_{EE}}$$

$$= \frac{89,680 - 4,386}{(\$10,268 - \$5,974) + 1,253} = 15.4 \text{ years}$$

For the combined optimum EE/PV package, this means the incentive package reduced the payback period by approximately 0.8 years, from 16.2 years to 15.4 years.

An additional 20% incentive was also available for each case for adoption of sustainable practices in the projects (including LEED certification or equivalent). This additional incentive reduced the payback period another 0.2 years for both packages.

Appendix B. Curve Numbers for Land Use and Soil Types

Curve Numbers by Land Use and Hydrological Soil Group					
Land Use Description		Hydrological Soil Group			
		A	B	C	D
Cultivated land	Without conservation treatment	72	81	88	91
	With conservation treatment	62	71	78	81
Pasture or range land	Poor condition	68	79	86	89
	Good condition	39	61	74	80
Meadow		30	58	71	78
Wood or forest land	Thin stand, poor cover, no mulch	45	66	77	83
	Good cover	25	55	70	77

Open spaces, lawns, parks, golf courses, cemeteries, etc.	Good condition: grass cover on 75% or more of the area		39	61	74	80
	Fair condition: 50-75% of the area		49	69	79	84
	Commercial and business areas (85% impervious)		89	92	94	95
	Industrial districts (72% impervious)		81	88	91	93
Residential	Average lot size	Average % Impervious				
	1/8 acre or less	65	77	85	90	92
	1/4 acre	38	61	75	83	87
	1/3 acre	30	57	72	81	86
	1/2 acre	25	54	70	80	85
	1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.			98	98	98	98
Streets and roads	Paved with curbs and storm sewers		98	98	98	98
	Gravel		76	85	89	91
	Dirt		72	82	87	89
Open water			0	0	0	0

Appendix C. Stormwater Savings Equations

Derived from the CITYgreen User Manual, 2000, References and Appendices, p. 84

Site Wide Weighted Curve Number (CN):

CN (weighted) = Total product of (CN × Percent land cover area) / total percent area or 100

Potential Maximum Retention After Runoff Begins:

$S = ((1000 / CN) - 10)$

Runoff Equation:

$$Q = [P - .2 ((1000 / CN) - 10)]^2 / P + 0.8 ((1000 / CN) - 10)$$

Flow Length:

$$F = (\text{total study area acres} \times 0.6) \times 209$$

Lag Time:

$$L = ((F \times 0.8) \times ((S + 1.0) \times 0.7) / (1900 \times ((\text{slope}) \times 0.5)))$$

Time of Concentration:

$$T_c = 1.67 \times L$$

Unit Peak Discharge:

$$\log(q_u) = C_0 + C_1 \times \log(T_c) + C_2[\log(T_c)] \times 2$$

Peak Flow:

$$\text{Peak} = (q_u \times A_m \times Q \times F_p)$$

Storage Volume (this is the key indicator of how much stormwater savings result from tree planting):

$$V_s = V_r \times (C_0 + (C_1(q_o/q_i)) + (C_2 \times ((q_o/q_i)^2)) + (C_3 \times (q_o/q_i)^3)) \times \text{study area acres} \times 43560.17 / 12$$

Variable Definitions:

P	=	Average rainfall for a 24 hour period (inches)
A _m	=	Study area acres / 640 to determine square miles
F _p	=	Swamp pond percentage adjustment factor (based on the percentage of open water and swamp that exist on the site)
q _o	=	Existing peak flow condition with trees (cubic feet per second)
q _i	=	Peak flow without trees (cubic feet per second)
C ₀ , C ₁ , C ₂	=	TR-55 coefficients in accordance with rain type ²¹

Output Values:

Peak	=	Peak flow (cubic feet per second)
V _s	=	Storage volume (cubic feet)
V _r	=	Runoff volume (inches)
CN	=	Runoff curve number (weighted)
Q	=	Runoff (inches)
F	=	Flow length (feet)
S	=	Potential maximum retention after runoff begins (inches)
L	=	Lag time (hours)

21. See table of coefficients by rainfall type in Appendix C.

T_c = Time of concentration (hours)
 q_u = Unit peak discharge (cubic feet per second per square mile per inch)

Appendix D. Coefficients by Rainfall Type

Coefficient Values by Raintype				
Rainfall type	$I_a/P^{2.2}$	C_0	C_1	C_2
I	0.1	2.3055	-0.51429	-0.1175
	0.2	2.23537	-0.50387	-0.08929
	0.25	2.18219	-0.48488	-0.06589
	0.3	2.10624	-0.45695	-0.02835
	0.35	2.00303	-0.40769	0.01983
	0.4	1.87733	-0.32274	0.05754

22. $I_a = .2 \times S$

	0.45	1.76312	-0.15644	0.00453
	0.5	1.67889	-0.0693	0
IA	0.1	2.0325	-0.31583	-0.13748
	0.2	1.91978	-0.28215	-0.0702
	0.25	1.83842	-0.25543	-0.02597
	0.3	1.72657	-0.19826	0.02633
	0.5	1.63417	-0.091	0
	II	0.1	2.55323	-0.61512
0.3		2.46532	-0.62257	-0.11657
0.35		2.41896	-0.61594	-0.0882
0.4		2.36409	-0.59857	-0.05621
0.45		2.29238	-0.57005	-0.02281
0.5		2.20282	-0.51599	-0.01259
III	0.1	2.47317	-0.51848	-0.17083
	0.3	2.39628	-0.51202	-0.13245
	0.35	2.35477	-0.49735	-0.11985
	0.4	2.30726	-0.46541	-0.11094
	0.45	2.24876	-0.41314	-0.11508
	0.5	2.17772	-0.36803	-0.09525

Appendix E. Soil Types

Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This hydraulic soil group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.