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ENERGY-EFFICIENT COMMUNITY DEVELOPMENT IN CALIFORNIA: CHULA VISTA

PIER FINAL PROJECT REPORT

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Preface

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts focus on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Energy-Efficient Community Development in California: Chula Vista is the final report for the Chula Vista Research Project, contract number 500-06-004, conducted by the National Energy Center for Sustainable Communities at San Diego State University (through the San Diego State University Research Foundation). The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

Table of Contents

APPENDICES

ATTACHMENTS

List of Figures

List of Tables

Abstract

This research project provided findings on how community leaders and builders can integrate land use, transportation, and urban design features and certain building energy technologies to produce energy-efficient development projects in California. Researchers modeled these technologies and design features for two development sites in Chula Vista, California, and assessed their impact on the environment and the existing electric and natural gas utility infrastructure. Additionally, researchers examined market and institutional barriers that prevent municipalities and the development industry from adopting these types of communities.

The research findings suggested integrated use of these technologies and features can reduce aggregate energy consumption and carbon dioxide emissions of a large-scale development project by as much as 45 percent and 33 percent, respectively, when compared to a Title 24 compliant project. However, the researchers concluded a fundamental market transformation is necessary to achieve these gains, and state agencies and utilities must take leadership roles in facilitating the transformation. Additional research could improve modeling tools, further evaluate the carbon reduction potential of various technologies and design features, and resolve economic and policy barriers impeding this form of development in California.

Keywords: Low-carbon communities, energy-efficiency, community-scale development, advanced energy technologies, land use, urban design, transportation, density, mixed-use development, urban heat island effect, stormwater runoff, carbon sequestration, 4D analysis, building energy modeling, Chula Vista, distributed generation, district energy, public policy, development industry, green buildings, sustainable urban design

Executive Summary

Introduction

Within the next 20 to 25 years, the United States will design, construct, or renovate more than half of all structures in the country. This construction and renovation equates to approximately 213 billion square feet of space, half of it in homes that have yet to be constructed. 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.

Purpose

This project determined how to integrate new building design and infrastructure strategies and technologies with energy-efficient land use patterns and urban design features to lower energy consumption and energy-related air emissions in proposed California communities as they are being developed.

Project Objectives

The project investigated–through research of new information– the technical, market, and policy barriers to more sustainable communities in California. The six supporting objectives were:

1. Estimate the relative efficiency and emissions reduction performance of individual energy efficiency, demand response, renewable energy, and distributed generation technologies in typical development projects.
2. Determine the extent that applying these technologies reduces peak demand and results in better utilization of existing use infrastructure.
3. Determine market-feasible combinations of energy technology and design options that can increase building energy efficiency by more than 25 percent above the 2005 Title 24 Building Energy Efficiency Standards.
4. Estimate which community design features can improve energy technology performance or reduce energy consumption of a site. These design features include, mixed-use/moderate density, transit-oriented development; stormwater runoff and carbon sequestration measures; urban heat island reduction measures; and passive solar building orientation.
5. Determine the maximum incremental cost that the California building industry and consumers will accept for energy-efficient residential, commercial, industrial, and institutional structures.
6. Determine which financial and business models, public policies, and incentives will accelerate deployment of these technologies in California building developments.

Project Approach and Results

Results of the building and site modeling suggest strategic integration of these technologies and design features can reduce aggregate energy consumption of large-scale development projects up to 43 percent, peak demand by 45 percent, and carbon dioxide emissions by 33 percent as compared to a Title 24 compliant project. The modeling that was conducted to determine the optimal combination of market-feasible technologies indicates these technologies are building specific. The specific combinations for 40 building types and space uses common to urban and residential development projects in California are contained in Appendix A, *A Building and Site Design Technical Reference Guide for Energy-Efficient Community Development in California*.

Results of cost analyses indicate that the average maximum incremental cost the California building industry will accept for energy-efficient structures is between $1.59 and $7.41 per square foot of construction. Given the range calculated for the enhancements modeled in this research project ($2.00 to $15.00 per square foot), the researchers concluded that in today's market significant economic incentives will be necessary to encourage adoption of beyond-code energy efficiency measures.

Results of the financial, business, and policy analysis show that communities need new public and private sector management models to address barriers that currently impede adopting these technologies and site features by the building industry. These barriers include:

- Misalignment between Energy-Efficient Community Development investment costs and benefits.
- Need for direct and indirect financial support for the building industry.
- Insufficient municipal capacity, incentives, and procedures to encourage Energy-Efficient Community Development projects.
- Consumers' reluctance to pay premiums for energy-efficient properties.
- Investment risks that inhibit capital project financing.

The researchers concluded that a fundamental market transformation will be necessary to achieve these gains, and state agencies and utilities must take leadership roles in facilitating the transformation.

Conclusions

Two essential changes necessary for this transformation are as follows:

- All entities in the real estate development transaction chain–lenders, investors, developers, builders, design professionals, appraisers, and brokers–recognize the value of energy-efficient building technologies and community design.
- Developers are able to capture capital investments in energy-efficient features through prices that are acceptable to consumers.

This report includes a discussion of state and local government and utility-funded interventions required for these changes.

Recommendations

This research is a first step toward better understanding the potential of energy-efficient community development to assist the state in meeting its energy efficiency and emissions reductions goals. The report recommends a more sophisticated examination of this potential in the coming years. Recommending:

- Comprehensive assessment of energy-efficiency and emissions-reduction potential of all available land use, infrastructure, transportation, and urban design features and a more thorough examination of their impact on the performance of building and infrastructure energy technologies.
- Comprehensive, state-wide examination of the same potential for district energy systems in California.
- Translation of this research into a set of improved modeling tools, methods, and site development guidelines to assist local communities and private development industry in advancing energy-efficient projects.
- Comprehensive review of relevant state, regional, and local public policies to ascertain where policy innovations would facilitate this development throughout California.

Benefits to California

This project is expected to produce benefits for California's electricity and natural gas ratepayers by assuring public and private development practitioners to improve community-scale energy efficiency, affordability, and reliability. These contributions will also significantly decrease both local and global environmental impacts associated with end-use energy and resource consumption.

This report provides specific quantification of energy and emission reduction gains achievable by sophisticated, smart growth development projects modeled in this research. New proposed research would move beyond this work and chart a feasible pathway to more substantial gains, potentially reducing aggregate energy consumption of large-scale, mixed-use development sites by as much as 50 percent and carbon dioxide emissions by 50 percent or more.

1.0 Introduction

1.1. Background and Overview

Opportunity Statement - Within the next 20-25 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 space, half of it in new homes that 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 existing research addresses how to optimize the efficiency of these technologies in relation to one another or in aggregate to achieve community-scale energy efficiency. Further, little or no research has sought to determine how to maximize performance of energy efficiency, demand response, renewable energy, and distributed energy technologies and strategies through energy-efficient community planning, design, and development.

Given the scarcity of engineering research in this area, there has been little effort in social science research to identify legislative, regulatory, and market barriers and solutions associated with energy-efficient community development. Research of this nature is essential to engage the private sector in investment, design, and construction of energy-efficient residential, commercial, industrial, institutional, and mixed-use development projects in California.

Historically California has been a leading state in promoting energy efficiency and resource conservation. It has now become the lead state in the 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), and Executive Order S-3-05 all contain strategies and goals that will continue to move the state forward in each of these areas of sustainable energy management. 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 and the development industry in pursuit of this objective.

Research Goal - The goal of this research project was to increase energy efficiency and improve air quality in California by determining which actions and technologies in the California loading order[2] can be combined with enabling community design options.

1 *Toward a New Metropolis: The Opportunity to Rebuild American*, Arthur C. Nelson, Virginia Polytechnic Institute and State University, prepared for the Brookings Institution Metropolitan Policy Program, December 2004.

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:

I. Optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand.

1.2. Project Objectives

The primary objective of the project was to resolve, through research and development of new knowledge, outstanding technical, market, and policy barriers to creation of more sustainable communities in California.

Supporting research objectives were as follows:

1. Estimate relative energy efficiency and emissions reduction performance of individual energy efficiency (EE), demand response (DR), renewable energy (RE), and distributed generation (DG) technologies (advanced energy technologies) in all types of development projects.
2. Determine the extent to which the application of these technologies will reduce peak demand and result in better utilization of existing utility infrastructure.
3. Determine market-feasible combinations of energy technology and design options that will increase building energy efficiency by more than 25% above existing 2005 Title 24 standards.
4. Estimate the degree to which enabling community design options (i.e., mixed-use/ moderate density/transit-oriented development; stormwater runoff and carbon sequestration measures; urban heat island reduction measures; and passive solar building orientation) can improve energy technology performance in development projects.
5. Determine maximum incremental cost the California building industry and consumers will accept for energy-efficient residential, commercial, industrial, and institutional structures.
6. Determine which financial and business models, public policies, and incentives would lead to accelerated deployment of EE, DR, RE, and DG technologies in development projects in California.

II. Meet generation needs first by renewable energy resources and distributed generation.
III. Support additional clean fossil fuel central-station generation.

2.0 Project Methods

2.1. Summary

This chapter describes in detail the methods, tasks, and assumptions employed to address the project research objectives. The research team included energy technology and urban design modelers, construction process engineers, municipal planners, building officials, real estate market analysts, and developers.

The team selected two planned development sites in the City of Chula Vista (Site A and Site B) to explore potential economic and environmental costs and benefits of alternative energy technology and community design options in large-scale projects. To examine alternative community design options, researchers then generated a hypothetical site (Site X) from the attributes of these two sites.

The team conducted detailed building engineering modeling on the two primary sites to compare energy efficiency and emissions reduction performance of the technology alternatives to the performance expected from a set of conventional building features for the sites. Next, the team examined the modeling results to determine the impact of these alternatives on building construction and to identify additional costs associated with alterations. The electric and gas utility also examined the modeling results to determine the extent to which these alternatives could reduce peak demand and result in better utilization of existing utility infrastructure. Similarly, the team used planning and design modeling to quantify the comparative performance benefits of a set of alternative development options for the sites.

With regard to the social science research objectives, the team held a series of workshops with real estate development experts, public officials, and utility representatives to identify solutions to barriers preventing use of energy-efficient development alternatives in California. It also conducted online surveys of the development and capital market industries to examine the market's sensitivity to costs associated with this form of development and to deepen the researchers' understanding of associated investment risks. Additional telephone interviews with developers and building industry leaders enabled the research team to ask follow-up questions on workshop and survey results and to solicit input from the industry on what it needs most to undertake this form of development.

Figure 1 provides a schematic depiction of the specific research focus areas and the approximate sequence of the analysis.

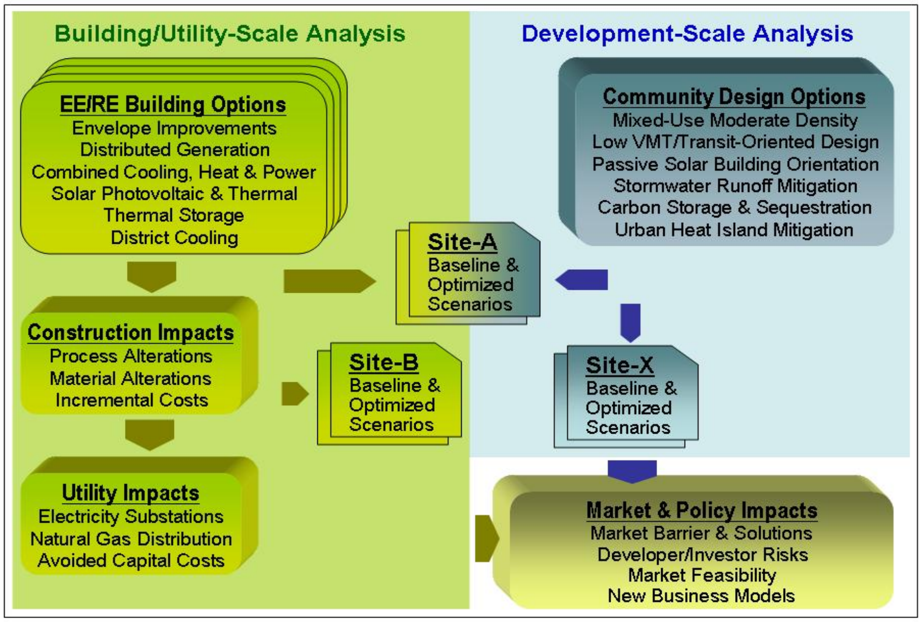

Figure 1. Schematic of the Research Focus and Sequence

Source: National Energy Center for Sustainable Communities

2.2. Case Study Sites

The two planned community development projects selected as case studies for this research are located on a 6,000-acre parcel of land known as the Otay Ranch in Chula Vista, California. The projects on this greenfield parcel will accommodate 27,389 residents in 10,306 dwelling units upon completion in 2015. The sites are representative of development types common to California communities. Figure 2 is an aerial photograph of the development sites (circled).

Figure 2. Otay Ranch Development Site

Source: National Energy Center for Sustainable Communities

This report refers to the first site as Site A; it consists of a 290-acre mixed-use commercial development. The site will contain 180 commercial, residential, and mixed-use residential/commercial structures with various configurations of six space-use types: restaurant, retail, hotel, office, library, and residential buildings. Site A will consist of 6,600,719 square feet (s.f.) of new development with residential buildings representing approximately 41% of the total (2,711,980 s.f.).

The second site is Site B; it consists of a 418-acre mixed-use residential and commercial development. The site will contain 866 residential and mixed-use residential/commercial structures with 4,270 living units for 6,776,027 s.f. of living space and 357 retail store/commercial units for 296,259 s.f. of commercial space.

A hypothetical Site X is designated as a 418-acre mixed-use development quite similar to Site B but incorporating several building prototypes from Site A as well. Site X allowed the research team to examine energy and emissions performance of the full suite of community design options that they were not able to model in either of the actual development sites.[3]

2.3. Modeling Tools

The research used six building and district energy technology and urban design modeling tools:

1. Building Energy Analyzer[tm] (BEA)–a proprietary product of the Gas Technology Institute (GTI). Researchers used BEA to model energy, economic, and environmental parameters for 15 types of commercial, institutional and commercial/residential mixed-use structures.

2. Energy-10[tm]–a proprietary product of the Sustainable Building Industry Council (SBIC). Researchers used Energy-10[tm] to model five types of single and multi-family residential buildings.

3. City Green[tm]–a proprietary product of the American Forests organization. Researchers used City Green to model alternative landscape design elements and to support evaluation of the urban heat island effect.

4. Mitigation Impact Screening Tool (MIST)–a product of the U.S. Environmental Protection Agency. MIST enables users to assess the impact of increasing urban albedo (reflectance) and/or urban vegetation in reducing the urban heat island effect.

5. CommunityViz[tm]–a proprietary product of the Orton Family Foundation. Researchers used CommunityViz to model potable water and wastewater treatment infrastructure; urban runoff; alternative land-use configurations; and transportation infrastructure, patterns and strategies. CommunityViz enables users to co-register and synthesize data inputs from other software tools and to produce 360-degree visualizations and real-time impact simulations. Stakeholders used this in meetings where they evaluated alternative design options.

3 A list of Site A and X limitations is included in Appendix P.

Modeling of transportation infrastructure, patterns, and strategies for energy consumption and emission impacts entailed estimating average daily vehicle-miles traveled (VMT) using both quantitative factors such as housing density and road patterns and qualitative factors such as the probability residents would choose alternative modes of transportation. Based on the estimated VMT, researchers calculated potential savings in energy consumption and air emissions using generally accepted averages.[4]

6. TERMIS–a proprietary product of 7-Technologies. Termis is a hydraulic modeling tool used for design and analysis of district energy systems.

2.4. Building Energy Technology Modeling

The building energy technology-modeling task entailed analyzing and selecting an optimal mix of energy-efficient building materials and advanced energy technologies for building prototypes planned for Site A and Site B. Maximum energy savings and a realistic, acceptable payback on investment were the criteria used to make these selections.[5]

The research team initiated determination of assumptions and prototypes by compiling a building design, construction, and equipment modeling assumptions manual for each site (Attachments I and II). The team used the manuals to guide the modeling work.

The manuals provide details on building envelope geometry, construction materials, and HVAC equipment specifications for prototypical structures similar to those planned for each site. They also provide details on the specific modeling approaches. They itemize the 2005 Title 24 mandatory and prescriptive features for the modeled buildings and all evaluated alternative energy-efficient (EE) building materials and equipment, and they provide installed costs for these materials and equipment.

In addition, the manuals provide economic assumptions necessary to calculate EE measure paybacks such as local utility rate structures and PV system and other applicable rebates. Developers of each site and appropriate municipal officials reviewed and pre-approved the manuals to ensure the building modeling used a realistic set of real world assumptions.

Site A was the first of the two sites analyzed. As noted above, the site will contain 180 commercial, residential, and mixed-use residential/commercial structures with various configurations of six space-use types. Considered together, there will be 6,600,719 s.f. in Site A, with residential applications representing approximately 41% of the total or 2,711,980 s.f.

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4 The spatial modeling inputs, variables, and outputs in CommunityViz are listed in Appendix O.

5 Acceptable payback here means a simple payback time less than the useful life of the material, equipment, or feature being analyzed.

The researchers modeled 15 prototypical buildings for the site. Descriptions of the prototypes are contained in the Site A modeling assumptions manual (Attachment I) and are listed in Table 1 below. Figure 3 provides the location for the prototypes on the developer's site utilization plan.

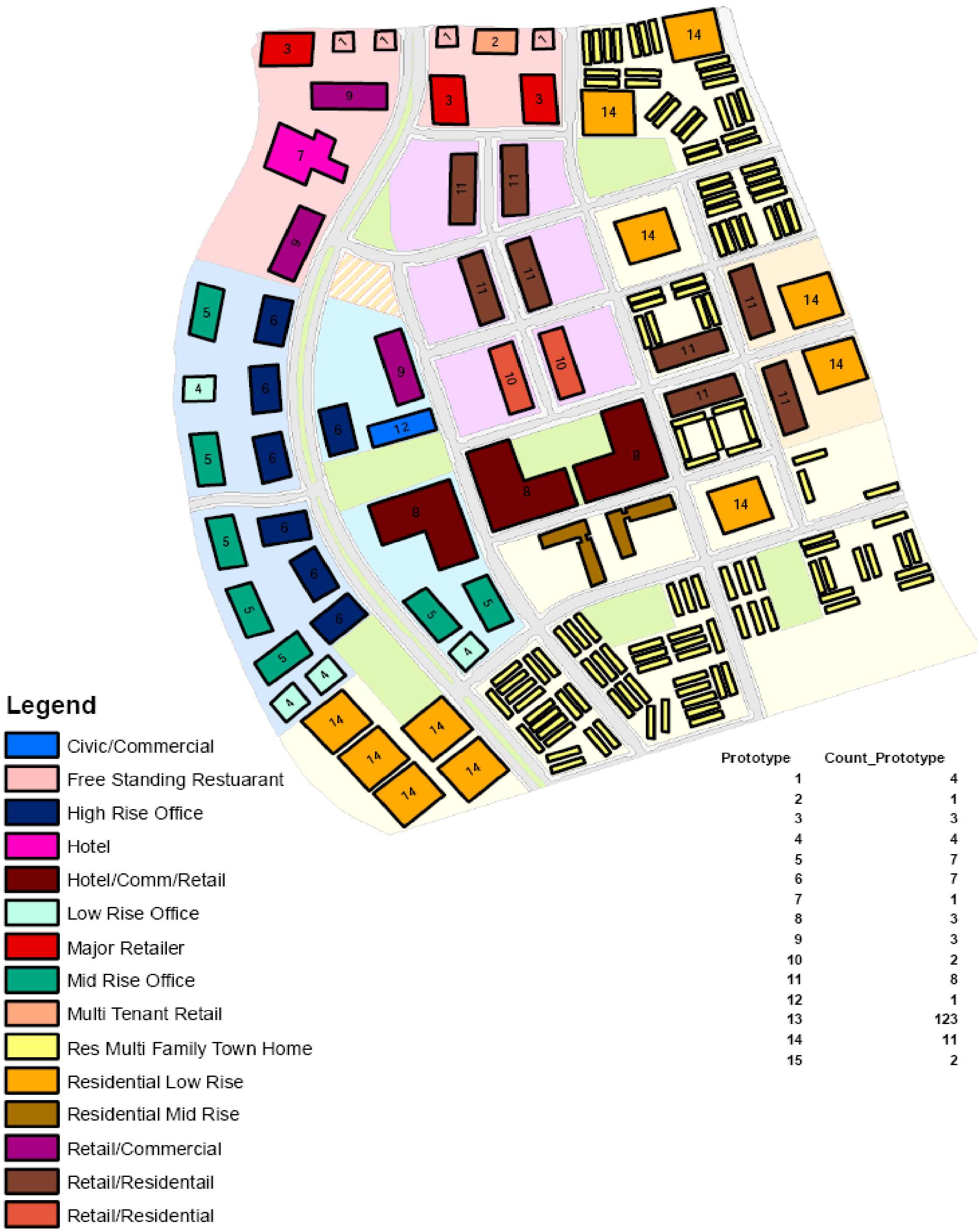
Table 1. Site A Prototypical Buildings

1	Freestanding Full Service Restaurant	FSR
2	Multi-Tenant Retail Shop	MTR
3	Major Retailer Store	MRS
4	Office Building Low-Rise	LRO
5	Office Building Mid-Rise	MRO
6	Office Building High-Rise	HRO
7	Large Hotel	LGH
8	Small Hotel	SMH
9	Retail/Commercial Mixed Use	RCM
10	Retail/Residential Mixed Use Mid-Rise	RRM
11	Retail/Residential Mixed Use Low-Rise	RRL
12	Civic/Commercial Mixed Use	CCM
13	Residential Multi-Family Townhome	RTH
14	Residential Low-Rise	RLR
15	Residential Mid-Rise	RMR

Source: National Energy Center for Sustainable Communities

In contrast to the predominantly commercial character of Site A, Site B will be a predominantly residential and mixed-use residential/commercial development. The site will contain 866 buildings featuring 4,270 residential units with 6,776,027 s.f. of living space and 357 retail store/commercial units representing 296,259 s.f. of commercial space. The researchers selected five distinct building prototypes to represent these structures in the modeling. Table 2 describes these prototypes. The Site B modeling assumptions manual (Attachment II) provides the building geometry, floor plans, materials, equipment, and other relevant details. Figure 4 provides the location for the prototypes according to the developer's site utilization plan.

The research team used the BEA and Energy-10 modeling tools described above to analyze variable energy, economic, and environmental impacts of both development sites. Researchers compared the results to conventional and alternative approaches to building design and construction.



Prototype	Count_Prototype
1	4
2	1
3	3
4	4
5	7
6	7
7	1
8	3
9	3
10	2
11	8
12	1
13	123
14	11
15	2

Figure 3. Site A Utilization Plan and Prototypical Building Placement
Source: National Energy Center for Sustainable Communities

Table 2. Site B: Prototypical Buildings

Building Name	Luminara	Chambray	Artisan	Artisan	Studio Walk	Studio Walk	Studio Walk	Gateway	Gateway	Gateway	Gateway	Gateway
Space Usage	Residential	Residential	Residential	Retail	Residential	Retail	Retail	Residential	Retail	Retail	Retail	Retail
Building Prototype #	**01**	**02**	**03**	**03**	**04**	**04**	**04**	**05**	**05**	**05**	**05**	**05**
Model	RES	RES	RES	RSCSM	RES	RSCSM	RSISM	RES	RSCSM	RSISM	RSCLG	RSILG
Residential Units	1	2	5	0	10	0	0	84	0	0	0	0
Model Qty per Building	1	1	1	2	1	1	4	1	2	5	1	3
Model Length	42	49	72	19	172	19	19	198	39	39	44	44
Model Width	30	31	50	27	50	27	27	153	26	26	58	29
Stories	2	2	2.5	1	2	1	1	4	1	1	1	1
Floor-to-floor Ht.	11	11	11	14	11	14	14	11	14	14	14	14
Total sqft	2,540	2,982	9,091	510	17,215	510	510	121,309	1,003	1,003	2,528	1,242
Bedrooms	4	3	3	-	4	-	-	206	-	-	-	-
People per Unit	6	5	5	-	6	-	-	-	-	-	-	-
People Per Building	6	10	25	13	60	13	13	332	26	26	67	33
Sqft per Person	423	298	364	38	287	38	38	365	38	38	38	38
Roof Sqft	1,778	2,087	3,636	510	8,608	510	510	30,327	1,003	1,003	2,528	1,242
Roof Available %	0%	0%	45%	0%	45%	0%	0%	45%	0%	0%	0%	0%
Window %	18%	12%	7%	16%	11%	16%	10%	8%	10%	10%	16%	10%
Door % (3.5'x8')	3%	1%	6%	0%	4%	0%	0%	4%	0%	0%	0%	0%
Adiabatic Wall %	0%	0%	8%	50%	0%	50%	79%	0%	50%	70%	50%	70%
Average Orientation deg	212	178	201	201	206	206	206	171	171	171	171	171
Building Count	**265**	**99**	**47**	**47**	**80**	**80**	**80**	**33**	**33**	**33**	**33**	**33**

Source: National Energy Center for Sustainable Communities

Figure 4. Site B: Utilization Plan and Prototypical Building Placement

Source: National Energy Center for Sustainable Communities

Alternative EE measures included the following:

- Energy-efficient glazing
- Alternative framing and improved envelope insulation (roof, floors, walls, and doors)
- Energy-efficient lighting
- High efficiency space cooling equipment
- High efficiency heating, domestic hot water equipment
- *EnergyStar* appliances
- Thermal storage
- Solar thermal heating
- On-site power generation using solar photovoltaic (PV) systems
- On-site power generation with heat recovery using internal combustion (IC) engines and a microturbine system

The modeling entailed detailed analysis of building envelope energy loses and internal energy loads for occupants and all fixtures and equipment, including space conditioning and ventilation systems. Specifically, the modeling included 8,760 hour-by-hour consumption of five types of building energy uses including electricity, natural gas, space cooling, space heating, and domestic water heating.

The research team analyzed four alternative development scenarios for each of the sites, as described below.

***Builder Proposed Baseline* (BPB) *Scenario*:** Defined as one in which construction materials, lighting, and operating equipment for each structure are designed to meet the California 2005 Title 24 energy efficiency standards or to exceed it if specified as such in building plans provided by the developers. Detailed descriptions of the developer's proposed plan for each prototypical structure are contained in Attachments I and II, the modeling assumptions and results for Sites A and B, in the Modeling Scenario tables under the column heading "Proposed Baseline" (pages 134 to 184 for Site A, and pages 64 to 93 for Site B).

***EE Package* (EE) *Scenario*:** Defined as one in which advanced energy efficiency measures are employed in all structures to achieve increased energy efficiency, economic savings, and air emission reductions. These measures include alternative grades of wall and roof insulation, windows, doors, lighting, HVAC equipment including thermal storage, appliances, and implementation of solar thermal technology. Detailed descriptions of the EE measures modeled for each prototypical structure are contained in Attachments I and II, in the Modeling Scenario tables under the column headings Alternative 1 to 3 (pages 134 to 184 for Site A, and pages 64 to 93 for Site B), and in the sections titled Thermal Storage and Solar Thermal (page 187 for Site A, and pages 95 and 96 for Site B).

EE Package with DG **(EE-DG[6])** ***Scenario:*** Defined as one in which advanced energy efficiency measures are employed using fossil fuel-based (natural gas) onsite power generation units with heat recovery technology on all suitable structures. The modeling assumptions manuals sections of Attachments I and II titled "Internal Combustion Engines in CHP Configuration" and "On-site Combined Heat and Power" (page 186 for Site A, and page 95 for Site B), describe details of the Combined Heat and Power (CHP) systems.

EE Package with PV **(EE-PV)** ***Scenario*****:** Defined as one in which advanced energy efficiency measures are employed with solar photovoltaic technology on all suitable structures. The sections of Attachments I and II titled "On-Site Power Generation–Photovoltaics" (page 185 for Site A, and page 94 for Site B) describe details of the solar photovoltaic systems. Once researchers modeled these four scenarios for the two development sites, the team analyzed the findings to determine energy efficiency, economic savings, and emissions reduction potential of the alternative development approaches. Additionally, the team generated individual structure and aggregate development-wide load duration curves for each site. Staff from San Diego Gas and Electric (SDG&E) then evaluated these data to determine the extent to which the alternative scenarios reduced peak demand and resulted in a better utilization of existing utility infrastructure.

2.5. Utility Impact Analysis

The objective of the utility impact analysis was to determine the extent to which application of the modeled building technologies in typical development projects would reduce peak demand and result in better utilization of existing utility infrastructure.

Once the researchers calculated building energy loads for each building prototype, the results were aggregated for the Site A and Site B developments and then provided to the electric and gas utility distribution planning departments at SDG&E for analysis.

In the case of the electric utility impact analysis, utility planners estimated aggregate distribution system demand associated with each of the modeled technology enhancement

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6 It should be noted that the economics component (simple payback and ROI analysis) of the EE-DG option analysis presented in this report may have at this point in time more hypothetical than practical value. At the time the CVRP study analysis began (spring of 2007) the DG analysis was based on applicable 2007 California Self-Generation Initiative Program (SGIP) guidelines which provided a rebate of $600/kW for IC-engine based CHP systems and a $800/kW for microturbine-based CHP systems. Preliminary calculations showed a very long payback of 17 years for the Site A microturbines DG option and consequently microturbines were not considered as a valid technology for larger commercial buildings, even as they qualified from the emissions point of view. On the other hand, the paybacks for IC engine-based DG system were acceptable (7.5 years). Considering that the units were to be run in a CHP configuration with heat recovery, the analysis included SGIP-permitted heat recovery credit that qualified IC installations from the emissions point of view. However, the 2008 SGIP eliminated all DG rebates except the wind and fuel cell applications. That makes the Site A DG analysis more a "what if" case than a practical deployment target, as the payback is not acceptable without the rebates. Nonetheless, the analysis was included in this report to illustrate the potential energy efficiency and environmental gains from targeted CHP deployment.

scenarios and assessed the associated electrical facilities necessary to meet those demands (i.e., circuits, substations, transformer banks, and related facilities).

For the natural gas utility impact analysis, utility planners estimated design day pressures for piping and regulator facilities needed to meet gas demand of the builder proposed baseline and the EE and EE-DG scenarios modeled for each development site.

Utility planners set natural gas distribution system design points for an extreme 24-degree heating day or the worst-case heating day scenario the system must have capacity to serve. Thus planners conventionally design natural gas distribution systems with much greater capacity than a development site would demand in a typical year or in some cases a typical decade. Additionally, planners design distribution systems with additional capacity for future load additions within existing developments (e.g., the addition of a cogeneration unit at a commercial site or swimming pools in residential complexes) and, unless a planned site is landlocked, for adjacent sites that may be developed in the future.

Given these factors, the team designed the impact analysis to estimate the degree to which the modeled builder proposed baseline (BPB) and EE-DG scenario loads would affect the capital infrastructure requirements and costs for each development site. The analysis considered this impact under both a conventional approach to distribution pipe planning and an optimized approach, one specifically designed to meet only the loads modeled. To determine the piping, pressure, and regulator requirements needed to meet these loads, utility planners used Advantica's SynerGEE gas modeling software and site utilization plans to generate alternative distribution systems for analysis. The planners designed and analyzed five distribution systems, including the following:

1. A conventionally designed distribution system for the development area <u>without</u> the the Site A and Site B natural gas loads (Appendix A).
2. A conventionally designed distribution system for the area <u>with</u> the builder proposed baseline (BPB) scenario loads for sites A and B (Appendix B).
3. An optimized distribution system serving the BPB scenario loads (Appendix C).
4. An optimized distribution system serving the EE-DG scenario loads (Appendix D).
5. An optimized distribution system serving the EE-DG scenario loads with the addition of a new regulator station (Appendix E).

Appendices E through I contain the schematic plans for each of these systems.

The key cost assumptions used in this analysis include the following:

- Gas service line and metering costs would be the same for all scenarios. All customers who use gas need gas services and meters. The only exception would occur with the metering required for the EE-DG scenario, but even those locations would require standard meter sets and services. Therefore, they would not result in significant additional gas system costs.

- All gas pipe was assumed to be polyethylene and installed in a joint trench with other utilities in a greenfield all-dirt environment with no existing pavement.
- Installed greenfield gas pipe cost estimates were based on the following unit costs:

Pipe Size	Cost $/ft
2-Inch	$38.60
3-Inch	$44.10
4-Inch	$55.13
6-Inch	$65.15

Note: These are order-of-magnitude values and are not adequate for detailed cost estimating. SDG&E's smallest gas main is a 2-inch polyethylene pipe. Gas mains then step up in size to a 3, 4, and 6-inch pipe with capacity doubling with each incremental increase in size.

2.6. Technology Construction Impacts and Economic Evaluation

Technology Construction Impacts

Although the modeling method described above did consider the installed cost of the alternative EE measures and technologies in its economic evaluation, additional analysis was necessary to evaluate the impact of their installation on overall construction processes and operations and to estimate the cost of that impact.

Researchers measured potential impact in this case through imputed cost impacts associated with the energy efficiency technologies. Cost impacts could be positive or negative. The team generated estimates of the costs to install individual technologies (and by summation, packages) as part of the energy analysis to estimate simple payback as described under building modeling above. However, increases to these costs could also accrue due to potential disruptive impacts on and alterations in the construction process. To enable the reader a better understanding of the implications of such alterations, the following paragraphs provide background and description of the varied dynamics considered.

Because construction processes are linked chains of specialized operations conducted by separate companies, modifications can have unintended and disruptive consequences for the larger process. Therefore, researchers used process analysis tools to model potential impacts of required process changes and to map potential cost impacts over and above the direct cost of the installation work. Utility incentive programs also affect costs by offsetting the first cost or otherwise affecting cash flows more than by the amount indicated by the energy efficiency gains themselves. Therefore, the economic feasibility assessment included consideration of utility incentive programs as well.

The analysis team assessed the overall construction process and perturbations that would be introduced by substitution or insertion of different materials into the building, thereby requiring alternate construction operations. The construction process, particularly with the complexity of the building prototypes modeled in this project, consists of a complex, fragmented supply chain of owners, contractors, subcontractors, and suppliers. The industry is composed of temporary, contract-driven relationships between participants in a given project. Furthermore, a range of external influences affect a given construction project.

This complexity in project organization and function induces the development of relatively entrenched practices and production approaches that are referred to as the culture of the construction industry. These include the relationship between designers and contractors, the contracting and contractor selection procedures, and the development of a subcontractor-driven approach to the construction process. Builders deploy production assets primarily in the form of subcontracted labor, with dividing lines between subcontractors largely (and traditionally) along distinctions between trades. Thus, subcontracts are based primarily on the particular type of materials being installed and the classes of work being conducted rather than on some other consideration such as space within the structure.

A number of factors affect the selection of general contractor, subcontractors, and suppliers for a given project. These primarily are cost, availability, and reputation. A typical building project might include 80 different companies including designers, the general contractor, subcontractors, and suppliers. Given the number of companies in any given region, especially in the subcontractor community, the odds do not support repeated work by exactly the same team on multiple projects. Consequently, the production system constantly must adjust to a new set of "handoffs," or transitions from one subcontractor's work to the next. For example, once the building's framing is completed, the plumbing subcontractor can begin installing pipes through the appropriate frame members. Thus, the work of the framing subcontractor is "handed off" to the plumbing subcontractor. The handoff is both physical in terms of the framing holding up the pipes and temporal in that the frame is built first.

Handoffs like this are repeated dozens of times over the course of a project. The work of the following subcontractor usually depends on the work done by the preceding subcontractor, either for structural support (such as the relationship between drywall and framing), collision potential (such as between plumbing and mechanical systems), or tolerance and finish condition (such as between drywall and electrical service trim). Because these dependencies exist and the sets of subcontractors involved differ from one project to the next, there is strong pressure for relatively established traditions to develop, at least in a given geographic area, governing the sequence of operations and the characteristics of the work at time of handoff.

In this research project, proposed modifications to the final building conditions tinkered with these established processes. The product completed according to the proposed energy-efficient alternate designs is different from the normal product. As a result, there exists potential for problems to arise during construction that disrupt established practices for handoffs by changing the nature of the product, the condition of the product at the time of handoff, or the number and sequence of handoffs that take place.

In general, such disruptions can be expensive to accommodate in the production process and can introduce expenses beyond the difference in cost associated with additional materials. The research team therefore analyzed the costs to determine the cost implications of the new process versus standard construction practices. The construction process cost analysis consisted of the following generic steps:

1. Evaluate the process implications of the various building component alternates described in Attachment I, the Site A modeling assumptions, as compared to the base case, and characterize these implications by their impact on the processes.
2. Select alternates from the characterization that potentially have implications for process disruption.
3. Develop a process map of the base case for those cases and the alternate(s) of interest.
4. Identify potential cost implications of disruptions noted using the process maps.

<u>Economic Evaluation</u>

For all packages and technologies determined to be feasible, researchers assessed potential cost savings arising from available incentive programs that might enhance market adoption. This assessment utilized the building modeling data described above as input. In the building modeling, the team completed a detailed analysis of the energy performance of a wide range of energy efficiency upgrades and distributed generation equipment including both photovoltaic and internal combustion engines for the prototype structures at Site A.

Researchers did not consider the internal combustion engine option in this analysis because, as noted above, the associated incentive for this option had been eliminated.

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. The team estimated cost effectiveness using the simple payback period [Equation (1)]:

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

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 electricity cost savings from a 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

Technologies were deemed to be 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 (EE option). The team also developed a corresponding cost differential over the builder baseline for the EE option. For cases where photovoltaics were cost effective and practical, the team also determined a cost for the same system including photovoltaics, referred to as the EE-PV option. Because the California Solar Initiative is so fundamental to the economics of photovoltaics, the payback period for photovoltaic systems already includes government incentives.

To assess the impact of incentives on the payback period, the team estimated SDG&E incentives under the Sustainable Communities Program. Equation (2) calculates the payback with these incentives.

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

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

The research team estimated the incentives available from SDG&E's 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 incenting construction practices that significantly exceed Title 24 requirements. Builders can earn incentives by demonstrating they have incorporated energy efficiency alternatives well above Title 24 requirements in a building. 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 a structure [Equations (3) through **Error! Reference source not found.**(5)] [(SDG&E 2008)].

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

where I_{elec} = electric incentive ($)

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

AS_{kWh} = annualized electrical savings in kWh

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

Where I_{gas} = gas incentive ($)

AS_{therms} = annualized gas savings in therms

(5) $$I_U = I_{elec} + I_{gas}$$

SDG&E offers an additional 20% incentive 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.

Equation (2) applies these incentives for each prototype. Two examples below show calculations to illustrate the process.

Example–Commercial Building Calculation

The modelers' analysis for Urban Site, Prototype 4 (low-rise office structure) derived the data contained in Table 3a below. These data are summarized in Attachment 1, Tables 27 and 28, Site A: Modeling Results.

Table 3a. 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

Source: National Energy Center for Sustainable Communities

The calculation for the optimum EE package proceeds as follows:

Estimated energy improvement over the builder baseline is

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

The builder baseline is the set of construction practices proposed by the developer and the building community as standard practice in the region. This set of practices is above the requirements of Title 24. Previous modeling by the research team found the builder baseline would exceed Title 24 requirements by 8-13%. Detailed energy modeling would be required to determine the right number. To estimate the incentive effect, one needs only an unbiased estimate of the result compared to Title 24. Therefore, the analysis used a moderate assumption of 10% better than Title 24. Accordingly, $Perf_{T24} \approx 14.1\% + 10\% = 24.1\%$. Using this value, the incentives are calculated as follows:

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

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

Substituting the necessary values in Equation (2),

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

For the optimum EE package, this means the incentive package reduces the payback period by approximately 1.2 years, from 9.7 years to 8.5 years. Attachment I (page 190) and Attachment II (page 99) show equipment life expectancies.

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

Estimated energy improvement over the builder baseline is

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

Using previous assumptions, $Perf_{T24}$ ≈ 49.8% + 10% = 59.8%. The incentives can be calculated as before; however, the maximum energy savings of 25% controls the maximum value of the incentive in each case.

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

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

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

In this case, operations and maintenance (O&M) costs and value of utility net metering credits generated affect the payback. As explained below Equation (1), the annual O&M expense is estimated using 0.12% of the (pre-CSI incentive) first cost of the system, or OM_{EE} = (0.12%)(740,608) = \$889/yr. The modeling effort provided the electricity cost savings from net metering. For this prototype R_{EE} = \$2826/yr. Equation (2) estimates the payback period.

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

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

SDG&E offers an additional 20% incentive for use of sustainable practices (including LEED certification or equivalent). This additional incentive reduces the payback period another 0.3 years for both packages.

Example–Residential Building Calculation

The modeler's analysis for Residential Site: Prototype 3 (artisan residential) derived the data contained in Table 3b below. Attachment II, Tables 18 and 19, summarize these data.

Table 3b. 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

Source: National Energy Center for Sustainable Communities

The calculation for the optimum EE package proceeds as follows:

Estimated energy improvement over builder baseline is

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

The builder baseline is the set of construction practices proposed by the developer and the building community as standard practice in the region. This set of practices is to be above the requirements of Title 24. Previous modeling found the builder baseline would exceed the Title 24 requirements by an amount from eight to 13%. Detailed energy modeling would be required to determine the right number. Estimation of the incentive effect requires only an unbiased comparison of the result to Title 24. Therefore, the analysis used a moderate assumption of 10% better than Title 24. Accordingly, $Perf_{T24} \approx 11.2\% + 10\% = 21.2\%$. The incentives are calculated using this value.

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

$$= \left[0.10 + \frac{(21.2 - 10)}{100}\right](41,274 - 38,948)$$

$$= (0.212)(2,326) = \$493$$

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

$$= \left[0.34 + \frac{4.4(21.2 - 10)}{100}\right](1260 - 1040)$$

$$= (0.83)(220) = \$183$$

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

Substituting the necessary values in Equation(2),

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

For the optimum EE package, this means the incentive package reduces 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 is

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

Using the same assumption as before, PerfT24 ≈ 29.6% + 10% = 39.6%. The incentives are calculated using this value. However, the maximum value of the incentive in each case is controlled by the maximum energy savings of 25%.

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

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

In this case, operations and maintenance costs and the value of utility net metering credits generated affect the payback. For example, for prototype 3, operation, maintenance, and electricity cost savings from net metering 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 reduces the payback period by approximately 0.8 years, from 16.2 years to 15.4 years.

SDG&E offers an additional 20% incentive for each case for use of sustainable practices in the projects (including LEED certification or equivalent). This additional incentive reduces the payback period another 0.2 years for both packages.

Chapter 3 provides results for all building prototypes at both sites.

Once researchers completed these analyses, assessment of market feasibility for construction could proceed. Based on the process analysis, activities found to have disruptive influences on the process could result in additional costs. Researchers then could calculate cash flow improvements arising from utility-based incentives, along with their potential impact on simple payback. The results section in Chapter 3 presents the lowest payback periods for the most feasible alternatives based on these analyses.

2.7. District Cooling System Evaluation

In addition to modeling the energy, economic, and environmental performance of alternative EE measures and technologies, the research team also examined the efficacy of a district energy system for Site A. Co-funding provided by the International District Energy Association (IDEA) made possible this expanded study. In the study, researchers evaluated incorporation of a district cooling system to determine if it could achieve further energy efficiency and environmental benefits while remaining cost competitive with stand-alone cooling at individual buildings. To perform this evaluation, researchers used the individual and aggregate 8,760 hourly building energy data generated for both the BPB and the EE-PV development scenarios. Each of these scenarios produced different peak loads and annual cooling consumption.

The research team evaluated district cooling under each scenario with and without Thermal Energy Storage (TES). To calculate electricity energy charges, researchers analyzed hourly annual peak loads for sizing of the district cooling plant and infrastructure, monthly peak loads for calculation of electricity demand charges, and cooling consumption for each of the SDG&E utility rate periods (on-peak, semi-peak, and off-peak).

For the district cooling configurations with TES technology, researchers developed daily load profiles for different times of the year and utilized analysis of these profiles to size the TES tank for optimal peak shaving. Researchers used the analysis to estimate annual plant cooling production (ton-hours) at each of the SDG&E utility rate periods with the optimal use of the TES facility. For both scenarios, researchers developed capital costs for the district cooling plant with and without TES, for the chilled water system, and for Energy Transfer Stations (ETS) at individual buildings.

To size the distribution piping for capital cost estimation, researchers prepared a hydraulic model of the distribution network using TERMIS, a hydraulic modeled software package specifically designed for analysis of district energy systems. They calculated district cooling plant peak and average electricity consumption for the three utility rate periods. They did this by acquiring detailed manufacturer performance data for chiller selections for both baseline and optimum plant configurations and by binning wet bulb temperature data for San Diego.

Researchers then used monthly peak electricity demand, electrical consumption by utility rate period, and the SDG&E rate tariff to calculate electricity costs. They calculated water consumption for each alternative using a water balance tool and determined water costs using applicable local water utility rates.

Researchers calculated annual operating costs for capital recovery, electricity, water, and water treatment chemicals, maintenance, and operating labor. They then compared total annual operating costs for the district cooling alternatives to total annual operating costs for the stand-alone alternatives. Stand-alone alternatives have cooling production at individual buildings.

2.8. Assumptions for Technical and Economic Modeling

2.8.1. Building Scenarios

The economic feasibility of district cooling hinges on load density and is most feasible when serving high-density areas. Large buildings that are close together make the best candidates for district cooling. The cost of distribution pipe mains is lower when buildings are close together, and the cost of chilled water service lines and energy transfer stations are lower on a unit cost per ton basis for larger buildings. Conversely, small buildings or buildings requiring a long extension of piping to reach can be prohibitively expensive to serve with a district cooling system.

Researchers performed an initial evaluation of the stock of buildings proposed for Site A development and decided to eliminate building Type 13 (townhomes) and Type 14 (low-rise residential) from the detailed district cooling economic analysis. They based this decision on the small cooling loads and the location of these buildings on the fringes of the development. Therefore, researchers' analysis assumed building Types 13 and 14 remained stand-alone buildings with cooling production equipment at each individual building (split system heat pumps).

Table 4 lists the quantity of each building prototype in the proposed Site A development and peak cooling loads for each building type for the two development scenarios. This table also lists peak cooling load totals for all the buildings in the development except Types 13 and 14 that use stand-alone systems. Note that this set of buildings is only 25% of the total buildings in the development, but accounts for 90% of peak load.

Appendix F contains detailed information for each of the building prototypes for the BPB and the EE-PV option. This information includes building prototype cooling system (stand-alone cooling) production; building square footage; annual cooling consumption; annual space cooling related electric consumption, including heat rejection; and average unit electric cost for buildings.

Table 4. Site A: Development Buildings and Cooling Loads

Building Prototype ID	Building Prototype Description	# of Bldgs	Builder Baseline Scenario Peak Cooling Load (tons)	EE-PV Configuration Scenario Peak Cooling Load (tons)
1	Free Standing Restaurant	4	127	120
2	Multi Tenant Retail	1	74	44
3	Major Retailer	3	278	254
4	Low Rise Office	4	297	236
5	Mid Rise Office	7	1,600	1,348
6	High Rise Office	7	3,650	3,143
7	Hotel	1	199	197
8	Hotel/Comm./Retail	3	1,117	969
9	Retail/Commercial	3	788	630
10	Retail/Residential	2	314	265
11	Retail/Residential	8	1,006	808
12	Civic/Commercial	1	322	271
13	Res Multi Family Town Home	123	734	610
14	Residential Low Rise	11	357	323
15	Residential Mid Rise	2	143	123
TOTAL - "All Buildings."		180	11,006	9,341
TOTAL - "All Buildings less Types 13 & 14"		46	9,916	8,408

Source: National Energy Center for Sustainable Communities

2.8.2. Plant Configurations

Researchers developed four conceptual plant configurations they compared to stand-alone cooling production at individual buildings. These configurations are as follows:

- District Cooling without TES for Builder Proposed Baseline (BPB) scenario.
- District Cooling with TES for BPB scenario.
- District Cooling without TES for EE-PV scenario.
- District Cooling with TES for EE-PV.

For the BPB scenarios, the district cooling plant is assumed to be configured with chillers in a parallel arrangement (not in series) and chillers not equipped with variable frequency drives (VFDs). Researchers considered this the baseline configuration.

In modeling the EE-PV scenario, researchers assumed the district cooling plant would be configured with chillers in a series-counter flow arrangement and equipped with variable frequency drives (VFDs).

Arranging chillers in a series-counter flow configuration reduces chiller lift, thereby increasing efficiency of the chiller pair. Figure 5 illustrates this reduction in lift. Installing VFDs on chillers provides substantially higher efficiencies at lower than design condenser water temperatures

(ECWT). Installing VFDs on chillers, therefore, is highly beneficial to district cooling plants with evaporative cooling towers and significant seasonal and daily variability in wet bulb temperatures. For plant configurations with TES, researchers' analysis assumed the type of TES would be an unpressurized, stratified chilled water storage tank. A stratified chilled water storage tank is one where supply and return water reside in the same tank separated only by a thermocline. Chilled water storage has substantially lower capital costs than other methods of TES, such as ice storage.

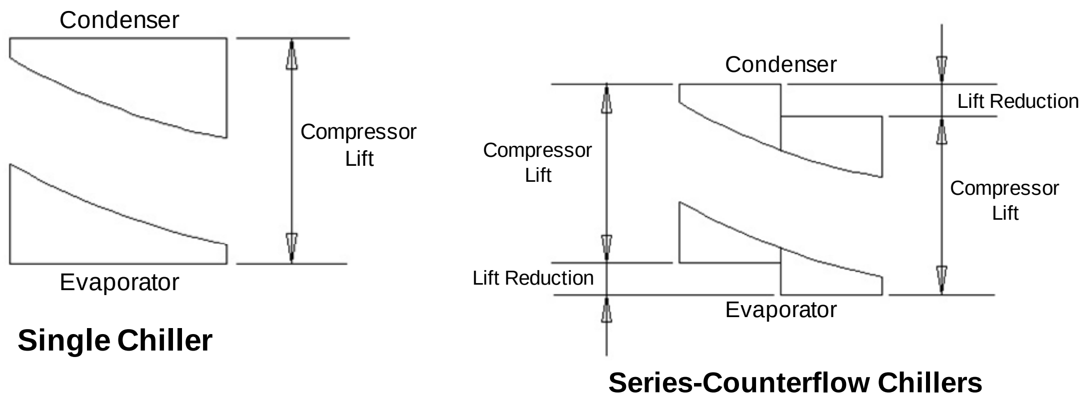

Figure 5. Series-Counter Flow Lift Reduction

Source: National Energy Center for Sustainable Communities

The installed cost of chilled water TES capacity is typically less than the installed cost of chiller capacity. If engineers install a very tall chilled water storage tank, the tank can also maintain static pressure in the system and protect it from surge, or the water-hammer effect. Chilled water storage has the additional advantage of not needing to be located in close proximity to the chiller plant, which can improve system hydraulics and reduce distribution pipe size. For this evaluation, researchers assumed the chilled water TES tank would be located adjacent to the plant. They did not account for potential distribution piping capital cost savings associated with a more hydraulically beneficial location for the tank.

The downside to chilled water TES is that the tank is very large relative to other TES technologies, such as ice storage, and could be difficult to site due to zoning or architectural limitations. Another potential downside to stratified chilled water TES is that the supply temperature cannot be lower than approximately 40°F or the balance of the thermocline will be disrupted.

2.8.3. Annual Cooling Production

Researchers assumed annual cooling production (ton-hrs) for the stand-alone alternatives with cooling production at individual buildings equal to the aggregate building cooling consumption provided for the BPB and EE-PV optimum scenarios. These numbers (Appendix F) are as follows:

- BPB = 14,814,215 ton-hrs.
- EE-PV = 12,305,738 ton-hrs.

For the district cooling alternatives, researchers assumed total annual plant cooling production to be the aggregate cooling consumption above plus 0.5% additional for distribution thermal losses.

To calculate electricity costs for the district cooling alternatives, researchers identified the quantity of cooling production (ton-hrs) generated in each of the six electric utility rate periods as defined in SDG&E Schedule AL-TOU. For the district cooling scenarios without TES, they extracted total cooling consumption for each of the rate periods directly from the 8760 hourly data for the aggregate building cooling consumption. They increased the totals to account for thermal losses.

District cooling scenarios with TES required more in-depth analysis to determine the quantity of cooling production (ton-hrs) generated in each of the six SDG&E utility rate periods since TES peak shaving shifts production from peak times to off-peak times.

For the TES alternatives, researchers developed daily load profiles for different times of the year. They analyzed these profiles to size the TES tank for optimal peak shaving and to estimate annual plant cooling production at each of the utility rate periods. Figure 6 depicts the peak day profile for the BPB scenario generated from the 8,760 hourly data. The dashed line indicates the average load for the peak day. Researchers sized plant compressors for this TES plant alternative to produce the tons below the dashed line (52% of diversified peak) and sized TES to produce the tons above the dashed line (48% of diversified peak).

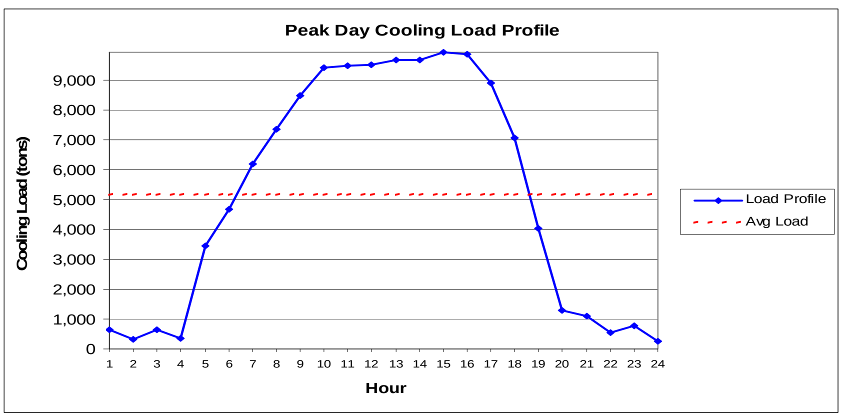

Figure 6. Peak Day Load Profile for BPB scenario

Source: National Energy Center for Sustainable Communities

Appendix G contains several example load profiles for the BPB scenario for different times of the year. These profiles illustrate aggregate system peak load before application of the diversity factor for the district cooling alternatives. Appendix G also includes TES charge and discharge tables researchers constructed to determine the amount of compression required during on-peak, semi-peak, and off-peak utility rate periods throughout the year. Note, for example, that on the May 1 cooling day plant compression (chillers on) can be confined to the off-peak period, which dramatically reduces plant electricity cost. Another significant benefit to shifting compression to off-peak time periods, in many regions, is that the electricity produced during these time periods is often cleaner and more efficient; whether benefit is realized for Chula Vista will depend on the power production mix for the region.

Appendix H contains load profiles and TES analysis for the EE-PV/optimum scenario. Table 5 lists the plant annual cooling production by utility rate period that researchers developed for each of the district cooling alternatives using 8,760 hourly data and TES analysis.

Table 5. Plant Annual Cooling Production by Utility Rate Period

Utility Rate Period	BPB Scenario		EE-PV Scenario	
	District Cooling Without TES (ton-hrs)	District Cooling With TES (ton-hrs)	District Cooling Without TES (ton-hrs)	District Cooling With TES (ton-hrs)
Summer On-Peak	4,165,532	1,071,891	3,454,835	904,894
Summer Semi-Peak	2,650,251	2,781,059	2,296,368	2,314,849
Summer Off-Peak	2,216,744	5,179,577	1,877,736	4,409,197
Winter On-peak	615,551	0	477,385	0
Winter Semi-Peak	4,141,244	142,212	3,406,085	118,444
Winter Off-Peak	1,099,024	5,713,607	854,907	4,619,933
Total, Plant Annual Cooling Production	14,888,346	14,888,346	12,367,316	12,367,316

Source: National Energy Center for Sustainable Communities

2.8.4. Stand-alone Building Production Equipment Sizing and Capital Cost Assumptions

The capacity of production equipment installed in individual buildings will be higher than the calculated production requirements for the buildings for the following reasons:

- Units must be sized to meet cooling requirements of individual zones within buildings for individual split system heat pumps and unitary packaged air-conditioners, and therefore do not take advantage of diversity at the building level.
- Engineers typically design building central chiller plants with production equipment redundancy to limit lack of cooling availability if a piece of equipment is out of service. However, building chiller plants have fewer chillers than district plants.
- HVAC designers typically oversize production equipment relative to actual capacity requirements to avoid the risk of under-sizing equipment.

To determine individual building production equipment installed capacity for capital cost estimation purposes, researchers applied the following factors to individual building peak cooling loads to account for over-sizing, redundancy, and diversity considerations: central chiller plant = 1.4, heat pumps / unitary packaged = 1.6. In the researchers' experience, these factors are quite low. If they used higher factors for installed individual building production equipment, the economics for district cooling alternatives would be more favorable.

The capital cost assumption for stand-alone building chiller plants for the BPB scenario was $2,090/ton. This total installed cost includes chillers, cooling towers, all piping and mechanical equipment, electrical equipment, controls and instrumentation, the structure, engineering, and project management. The capital cost assumption for split system heat pumps was $1,000/ton. This is total installed cost and based on approximately 60% of installed heat pump cost apportioned to cooling. In addition, researchers credited buildings with heat pumps with $500/ton against capital costs to account for the higher cost of a hydronic HVAC system compatible with district cooling service. Table 6 below presents capacity and installed capital cost of plant cooling production equipment for all alternatives.

2.8.5. District Cooling Plant Sizing and Capital Cost Assumptions

For district cooling systems, total production capacity required for peak system load is typically less than the total of peak loads for individual buildings in the system. This is primarily due to differences in building usage type (e.g., office vs. residential), but may also be influenced by differences in solar loading and occupancy. For analysis of district cooling configurations, researchers assumed a system diversity factor of 0.94 which, based on the researchers' experience, is appropriate for the mix of building types included in the district cooling system.

Researchers based capital cost estimates for the chilled water plant on inclusion of one fully redundant chiller and associated plant auxiliaries. In many cases, district cooling systems have been able to operate at acceptable levels of reliability without the need for a redundant production unit because of the operating flexibility achieved by serving a large number of buildings. Therefore, inclusion of a redundant chiller in the economic analysis is a conservative assumption with respect to feasibility of district cooling for Site A.

Table 6 presents a breakdown of quantity of chillers and capacity of chillers and thermal storage researchers assumed for each of the district cooling alternatives and used as the basis for plant capital cost development.

Table 6. Plant Capacity and Capital Cost

	BPB Scenario			EE-PV Scenario		
	District Cooling Without TES	District Cooling With TESS	Stand-alone (Cooling Production Individual Buildings)	District Cooling Without TES	District Cooling With TES	Stand-alone (Cooling Production Individual Buildings
Undiversified peak cooling demand (tons)	9,916	9,916	9,916	8,408	8,408	8,408
Load diversity factor	0.94	0.94	1.00	0.94	0.94	1.00
Diversified peak cooling demand (tons)	9,321	9,321	9,916	7,904	7,904	8,408
Thermal storage peak capacity (tons)	-	4,487		-	3,710	
Chiller firm capacity (tons)	9,321	4,834		7,904	4,194	
Number of chillers for firm capacity	6	4		6	4	
Chiller size (tons)	1,554	1,208		1,317	1,048	
Installed chiller capacity for N+1 (tons)	10,875	6,042		9,221	5,242	
Installed plant/equip capacity (tons)	10,875	10,530	14,341	9,221	8,952	12,139
Installed plant/equip cost ($)	$ 19,435,000	$ 18,290,000	$ 24,828,000	$ 17,354,000	$ 16,220,000	$ 23,088,000
Installed plant/equip cost ($/ton)	$ 1,787	$ 1,737	$ 1,731	$ 1,882	$ 1,812	$ 1,902

Source: National Energy Center for Sustainable Communities

2.8.6. Land Cost Assumptions

Researchers estimated land requirements for each of the four district cooling plant alternatives. They calculated land cost estimates based on $22/s.f., the average land cost on the east side of the City of Chula Vista where Site A is located. For this preliminary economic evaluation, they incorporated land costs into overall capital cost for the district cooling alternatives. This overstated annual operating costs for the district cooling scenarios by a small amount. While there is cost associated with the space occupied by individual building central plants for the stand-alone analyses, researchers did not include land costs for the stand-alone alternatives due to difficulty of quantifying and valuing this space.

2.8.7. Chilled Water Distribution System Assumptions and Capital Costs

Based on the customer base assumption for the analysis (all buildings less Types 13 and 14), researchers developed a preliminary chilled water distribution system routing for the district cooling network to develop capital cost estimates. They developed a hydraulic model for this distribution routing using TERMIS. Figure 7 is the nodal map from the model, showing the assumed distribution pipe routing. Table 7 below presents the pipe sizes and associated trench feet of piping that were determined via hydraulic modeling and used as the basis for capital cost estimation for the BPB scenario.

Building numbers on the piping map in Figure 7 comport with the building prototype identification numbers. The plant is assumed to be located on the west side of Site A; there may be an opportunity to locate the plant within a parking ramp for office buildings. Appendix I contains a larger copy of this pipe routing map and Appendix J contains a summary of distribution piping system capital costs.

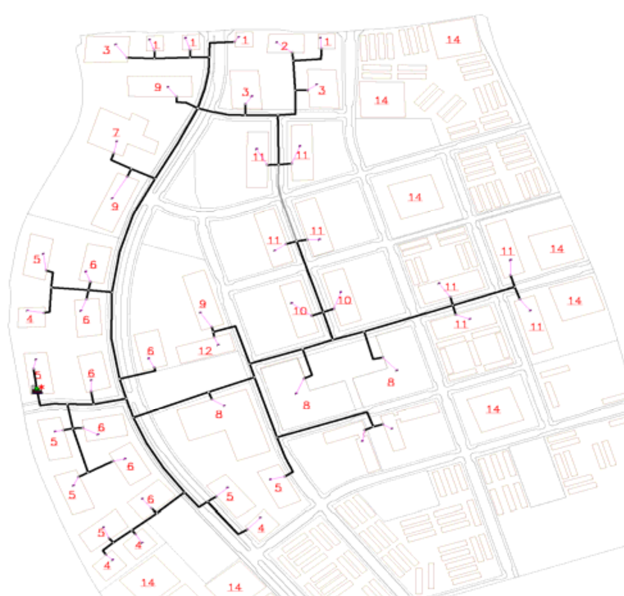

Figure 7. Chilled Water Distribution Piping System

For capital cost estimates, researchers assumed the distribution system would be constructed of pre-insulated, welded steel piping. Not requiring insulation on some or all of the distribution piping would reduce capital cost. Whether insulation is economically justified or technically required depends on a variety of factors such as climate, bury depth, supply water temperature maintenance requirements, and system phasing. Researchers did not undertake a technical evaluation of insulation requirements, so capital cost assumptions for distribution piping may be conservative with respect to the feasibility of district cooling for Site A.

Table 7. Distribution System Pipe Sizes and Trench Feet

Nominal Pipe Size	Trench Feet of Piping
3	485
4	1,806
5	3,589
6	1,679
8	2,356
10	2,244
12	495
14	733
16	629
20	296
24	227
Total	14,540

Source: National Energy Center for Sustainable Communities

2.8.8. Building Energy Transfer Station (ETS) Assumptions and Capital Costs

Energy Transfer Station (ETS) is a term used for the facility installed at a customer building where cooling is transferred from the district cooling system to the building's internal HVAC systems. An ETS installation typically consists of the following components:

- Plate and frame heat exchangers transferring heat to the building's hydronic space heating system.
- A control valve or valves to regulate hot water flow through the heat exchangers.
- An energy meter to measure customer hot water demand and consumption.
- Piping, strainer(s), and isolation valves.
- Pressure and temperature gauges and/or transmitters.
- Controls integrated with overall system for larger ETS.

Table 8 presents estimated energy transfer station capital costs for each of the prototype buildings in both of the development scenarios.

Table 8. ETS Capital Costs

Building Prototype ID #	Building Prototype Description	# Bldgs	Builder Baseline ETS Capital Costs	EE-PV Configuration ETS Capital Costs
1	Free Standing Restaurant	4	$79,200	$74,800
2	Multi Tenant Retail	1	$35,600	$25,500
3	Major Retailer	3	$123,800	$116,900
4	Low Rise Office	4	$142,600	$125,200
5	Mid Rise Office	7	$607,800	$512,300
6	High Rise Office	7	$1,186,300	$1,037,300
7	Hotel	1	$75,400	$75,000
8	Hotel/Comm./Retail	3	$374,100	$329,500
9	Retail/Commercial	3	$275,900	$239,200
10	Retail/Residential	2	$127,300	$112,500
11	Retail/Residential	8	$432,600	$359,700
12	Civic/Commercial	1	$109,600	$94,700
15	Residential Mid Rise	2	$71,700	$65,300
TOTAL - "All bldgs less Types 13 & 14"		46	$3,642,000	$3,168,000

Source: National Energy Center for Sustainable Communities

2.8.9. Building Energy Transfer Station (ETS) Assumptions and Capital Costs

Table 9 summarizes capital cost estimates used in the economic analysis for this evaluation.

Table 9. ETS Capital Cost Summary

Capital Cost Item	Builder Baseline Scenario			EE-PV Configuration Scenario		
	District Cooling Without Thermal Storage	District Cooling With Thermal Storage	Stand-alone (Cooling Production at Individual Buildings)	District Cooling Without Thermal Storage	District Cooling With Thermal Storage	Stand-alone (Cooling Production at Individual Buildings)
DC plant / Building production equip.	$ 19,435,000	$ 18,290,000	$ 24,828,000	$ 17,354,000	$ 16,220,000	$ 23,088,000
Distribution piping system	$ 9,751,000	$ 9,751,000	$ -	$ 9,263,000	$ 9,263,000	$ -
Energy transfer stations (ETS)	$ 3,642,000	$ 3,642,000	$ -	$ 3,168,000	$ 3,168,000	$ -
Land purchase cost	$ 467,000	$ 515,000	$ -	$ 396,000	$ 437,000	$ -
Total	$ 33,295,000	$ 32,198,000	$ 24,828,000	$ 30,181,000	$ 29,088,000	$ 23,088,000

Source: National Energy Center for Sustainable Communities

Operating & Maintenance Costs

Electricity Cost: Stand-alone Alternative—Researchers calculated electricity costs for the stand-alone alternatives for each building prototype using annual space cooling related electric consumption including heat rejection (kWh) and the average unit electric cost for the building

($/kWh). Since they calculated electricity costs for the stand-alone alternatives using average unit cost for the overall building, building cooling production costs used in the analysis could potentially be overstated or understated to the extent average unit electricity cost for cooling production differs from average electricity unit cost for the balance of the building.

Electricity Cost: District Cooling Alternatives—Researchers obtained detailed manufacturer performance data for chiller selections specific to the City of Chula Vista's climate conditions for calculation of electricity costs for the district cooling alternatives. They based chiller selections on the following key criteria: 80°F design entering condenser water temperature (ECWT) and 40°F supply and 56°F return water temperature. They selected ECWT of 80°F based on an ASHRAE 0.4% design wet bulb temperature of 73°F and a 7°F cooling tower approach at design conditions.

The research team obtained chiller performance data for district cooling plant configurations under both development scenarios, for peak conditions, and for a full range of part load and reduced ECWT conditions. Appendix K lists performance data for the chiller selections utilized for the analysis and demonstrates the dramatic improvement in efficiencies achieved with chillers in series-counter flow arrangement and driven with VFDs.

Utilizing this chiller performance data, researchers made estimates for both configurations under both development scenarios of peak plant kW/ton for each month of the year and average plant kW/ton for each of the six utility rate periods. The research team estimated plant kW/ton by considering each of the following factors:

- Chiller EWTC based on peak and average wet bulb temperatures extracted from binned temperature data for San Diego.
- Percent loading on individual chillers.
- Percent loading for overall plant (for estimating plant auxiliaries).

Researchers used these kW/ton estimates in conjunction with the following items to calculate annual electricity costs for each district cooling alternative:

- Utility electrical tariff.
- Plant monthly peak demand figures (tons).
- Plant cooling production figures (ton-hrs) for each utility rate period.

The rate tariff used for electricity cost calculations was SDG&E's Schedule AL-TOU. Researchers selected secondary service since the cost difference between primary and secondary service was very small, and chiller selections were for low voltage units due to availability of low cost, unit mounted VFDs. Appendix L lists rate tariff figures used in the analysis, including EECC and DWR-BC charges. To the researchers' understanding, there was a new demand and energy charge rate structure for the EECC commodity charge issued in May 2008. Per discussions with SDG&E personnel prior to issuance of the new rate, its structure should be beneficial to large customers such as district energy plants. Researchers did not incorporate this new rate structure into the economic analysis for this evaluation.

Researchers extracted plant monthly peak demand figures used for electricity cost calculations from aggregate 8760 data. They developed plant cooling energy production figures as discussed above and presented earlier in Table 5. The evaluation results of the next chapter contains the electricity use and costs researchers calculated using this methodology.

Other O&M Costs–Table 10 below presents operating and maintenance costs for all items except electricity.

Table 10. Operating Cost Assumptions (except electricity)

Operating cost assumption	Builder Baseline Scenario		EE-PV Config. Scenario	
	District Cooling	Stand-alone	District Cooling	Stand-alone
Water, monthly meter fee (US$/month)	$ 342	$ 342	$ 342	$ 342
Water, consumption rate (US$/HCF)	$ 2.614	$ 2.614	$ 2.614	$ 2.614
Water consumption (HCF per 1000 ton-hours)	2.67	2.76	2.62	2.72
Water treatment chemicals cost (US$/HCF)	$ 1.70	$ 1.70	$ 1.70	$ 1.70
Production equip. maintenance (% of capital)	1.50%	2.20%	1.50%	2.26%
Distrib. & ETS equip. maintenance (% of capital)	0.80%	N/A	0.80%	N/A
Operating labor (Full-Time-Equivalents)	6	9	6	9
Labor costs ($/FTE)	$ 65,000	$ 65,000	$ 65,000	$ 65,000

Source: National Energy Center for Sustainable Communities

Researchers calculated water consumption for each alternative based on chiller efficiency, using a cooling tower water balance tool. They determined water costs using San Diego Water Authority commercial rates.

Researchers estimated annual maintenance costs as a percentage of capital cost. The production equipment maintenance costs in Table 10 for the stand-alone alternatives are based on 2.0% for individual building chiller plants and 4.0% for heat pumps.

Researchers' used their experience for a system of this size to determine operating labor full-time-equivalent (FTE) positions for the district cooling alternatives. FTEs for stand-alone alternatives assumed approximately 1/3 of an FTE for each of the 26 buildings with chilled plants and no operating labor for the 20 buildings with individual split system heat pumps or unitary packaged AC.

Cost of Capital Assumptions—Table 11 presents cost of capital assumptions for the economic analysis. Researchers assigned a longer term to district cooling alternatives since these are longer-lived assets and investors in district cooling utilities generally have a longer term view than developers and builders.

Table 11. Cost of Capital Assumptions

Assumption Item	District Cooling	Stand-alone
Debt as % of total financing	70%	70%
Equity as % of total financing	30%	30%
Debt interest rate	5%	5%
Equity return on investment	15%	15%
Weighted average cost of capital	8%	8%
Term (years)	20	15
Capital recovery factor	0.102	0.117

Source: National Energy Center for Sustainable Communities

Technical Considerations Regarding Assumptions

The assumptions for district cooling plant efficiency in this analysis presume the system is operated efficiently in a manner that maximizes the investment. One key requirement for efficient operation of a district cooling plant is that the district cooling developer works with designers of the buildings. Such cooperation ensures the plant is designed and operated to provide desired return water temperature back to the district cooling plant so the plant does not suffer from low delta T syndrome. The high-efficiency building HVAC systems planned for Site A include key features required to ensure high return water temperature (such as variable volume systems with 2-way valves at coils). Nonetheless, early confirmation of the compatibility of building HVAC designs with the district cooling system is important.

2.9. Community Design Option Modeling

At the time this research project was proposed to the Energy Commission (April 2006), the researchers intended to model energy and emissions performance of developer-proposed land use, urban design, infrastructure, and transportation elements for Site A and Site B and to compare the results to an enhanced set alternatives for each site.

However, by the time research was initiated (April 2007), Site A had advanced to a stage in the development planning process where most of these spatial elements had become fixed, thereby precluding modeling of alternatives. Fortunately, many of these fixed elements incorporated the best of the Smart Growth design principles,[7] so the research team elected to estimate the degree the developer proposed plan for Site A exceeded the efficiency and emissions performance expected of a conventional plan for the site. Under this approach, the developer's plan for Site A became the optimized scenario, and the conventional plan became the baseline scenario.

The situation was the same for Site B. However, given the need to model the full array of alternative community design options, including transportation elements, researchers elected to work with the Site B developer to formulate a hypothetical site. The hypothetical site, labeled

7 Smart Growth best practices can be found at: http://www.smartgrowth.org/about/principles/default.asp?res=1280

Site X, was similar to Site B and incorporated building prototypes used in both Site A and Site B. Consistent with the modeling approach for Site A, researchers formulated a conventional baseline scenario to serve as the basis for comparison to the alternatives modeled in Site X. Figures 8 and 9 depict the two site utilization plans.

To model energy and emissions impacts of alternative community design options, researchers assembled and integrated a suite of land use planning, urban design, and impact analysis tools. The objective of the modeling scenarios was to determine which options enabled use of advanced energy-efficient technologies and which would significantly reduce energy consumption, emissions, vehicle-miles traveled (VMT), stormwater runoff, and the urban heat island (UHI) effect.

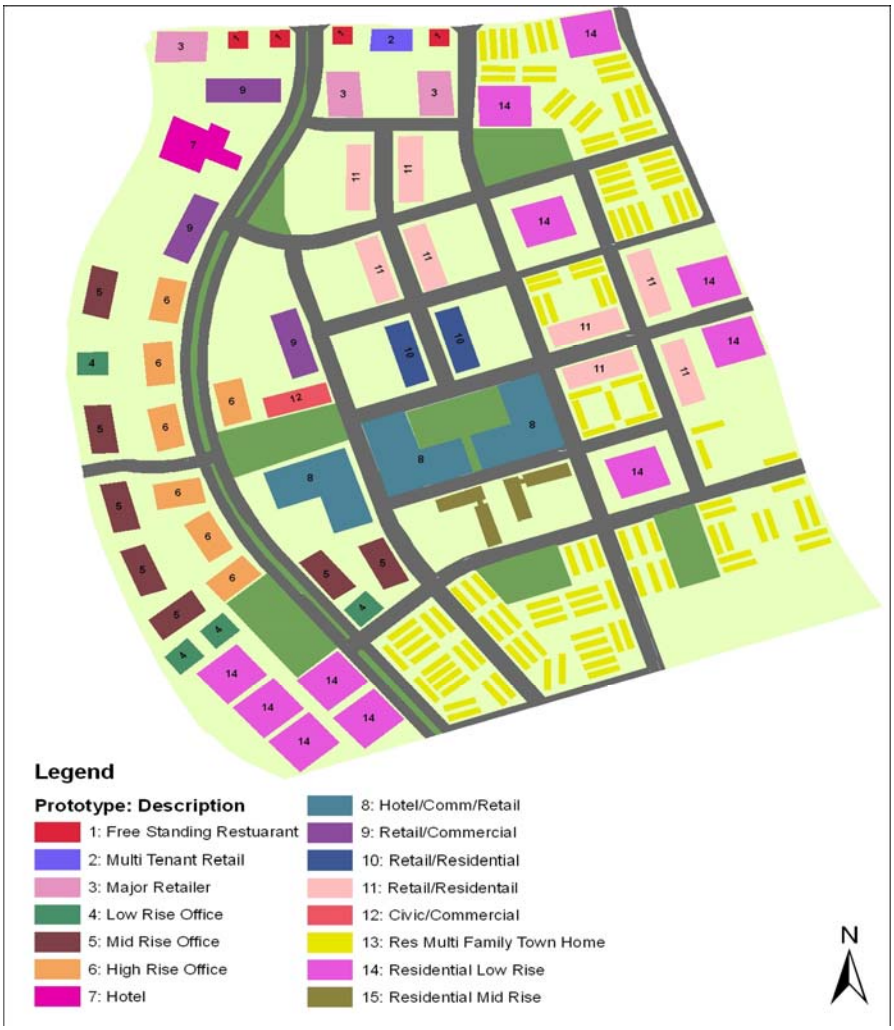

Figure 8. Site A: Utilization Plan

Source: National Energy Center for Sustainable Communities

The databases imported into the community-scale modeling included the following:

- BEA and Energy10™ building energy and emission profiles for prototypical buildings from Sites A and B.
- Potable water, wastewater, and infrastructure data from the city, developer, and utilities.
- Grading and stormwater management data from the developer.
- Transit study data from the regional transportation planning agency (SANDAG).

Figure 9. Site X: Site Utilization Plan

Source: National Energy Center for Sustainable Communities

As stated in the methods summary, the tools used for community-scale modeling included:

- CITYgreen™– used to assess the impact of alternative green infrastructure elements.
- Mitigation Impact Screening Tool (MIST)– used to assess the impact of increasing urban albedo (reflectance) and/or urban vegetation to reduce the urban heat island effect.
- CommunityViz™– used to model alternative land-use configurations; alternative transportation infrastructure, patterns, and strategies; potable water and wastewater treatment infrastructure; and urban runoff. Researchers also used CommunityViz™ to co-register and synthesize data inputs from the other software tools and to produce 360° visualizations and real-time impact simulations for stakeholder meetings.

Appendices P and Q contain lists of inputs, outputs, and other details for the modeling of Sites A and X, respectively.

2.9.1. Community Design Options

The research team examined energy efficiency and related emissions performance of five alternative community design options, as follows:

- Mixed-Use, Moderate-Density Development
- Urban Runoff Mitigation Measures
- Carbon Sequestration Measures
- Urban Heat Island Mitigation Measures
- Passive Solar Building Orientation

As stated earlier, researchers modeled two scenarios for each site. The first was the baseline scenario that entailed a conventional approach to site development without the aid of alternative community design options. The second was the optimized scenario in which four of the five design options were applied to the development sites. The fifth option, passive solar building orientation, was a limited examination and applied only to Site X. The section below provides a description of the methods used to model each of the design options.

Mixed-Use, Moderate-Density Development

Mixed-use, moderate-density development is the co-location of residential uses with commercial-office, commercial-retail, and often public-institutional uses. Residents of a mixed-use community 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 homes, attached townhomes, and multifamily condominium complexes, often with commercial retail and office space at ground level or the second floor.

Moderate density for this project is defined as 11.2 dwelling units per acre. Conventional development in the City of Chula Vista is typically 3.3 dwelling units per acre. Moderate-density development encourages use of public transportation and typically places 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.

In addition to offering a variety of housing options and easy pedestrian access to amenities and rapid transit, moderate-density developments are believed by community planners to be more energy and resource efficient than lower density developments. To examine this further, researchers sought to quantify the benefits of moderate-density development relative to the performance of advanced energy-efficient technologies and district energy systems at Site A. Researchers also sought to quantify the benefits of moderate-density development vs. low-density development relative to petroleum consumption and vehicular air emissions and to land use efficiency for sites A and X. The methods and assumptions for each examination follow.

CCHP Technologies– Multi-story commercial office and retail buildings found in moderate to high-density developments are ideal candidates for use of advanced energy-efficient technology known as combined cooling, heating, and power (CCHP) technologies, referenced earlier in this report. These technologies use energy more efficiently by capturing waste heat produced in power generation for use in space conditioning (cooling or heating) and for the generation of domestic hot water. In Chula Vista's climate, recaptured heat is best converted and utilized to meet commercial building cooling demands. Heating and domestic hot water loads are generally insufficient to warrant use of the recaptured heat for those purposes.

To quantify CCHP energy efficiency and emissions performance in a moderate-density site and to compare it to the performance of a conventional approach to energizing and conditioning commercial buildings in a lower density site, researchers conducted a two-part analysis.

Part one of the analysis entailed modeling energy and emissions performance of CCHP systems at Site A in a set of commercial buildings with sufficient thermal loads to make their use economical–the optimized scenario. Researchers selected building prototype 6 (P6) as the test building for analysis since its size and associated cooling loads were substantial enough to warrant a central chiller based cooling system. This configuration entailed substitution of some of the buildings' electric chillers with absorption chillers that can be driven by heat recovered from onsite distributed generation (DG) systems. In this case, the prime mover in the system was an internal combustion (IC) reciprocating engine.

In the moderate-density, optimized scenario for Site A, researchers sited seven P6 prototype buildings with a mix of residential, retail, and other commercial buildings. The P6 prototype was a nine-story office building with approximately 225,000 square feet floor area. The seven P6 buildings represented 1.5 million square feet of commercial space and, when clustered together, promoted adjacent residential, commercial, retail, and transit development as well.

Part two of the analysis focused on the low-density development scenario for Site A (the baseline scenario) and the performance of a set of commercial buildings equivalent in square footage to the seven P6 buildings. However, it utilized conventional space-conditioning systems and no onsite power generation. The commercial building prototype common to lower density developments is prototype 4, a two-story office building of approximately 30,000 square feet. Figure 10 below provides a visual comparison of the two building prototypes used in the analysis.

To determine the number of P4 buildings required to match the equivalent amount of space contained in seven P6 buildings, researchers calculated the total square footage of the P6 structures in the optimized scenario for Site A and divided that number by the square footage of one P4 building. Given this simple calculation, approximately 53 P4 buildings equaled the space of seven P6 buildings. Table 12 below provides the basis for this calculation.

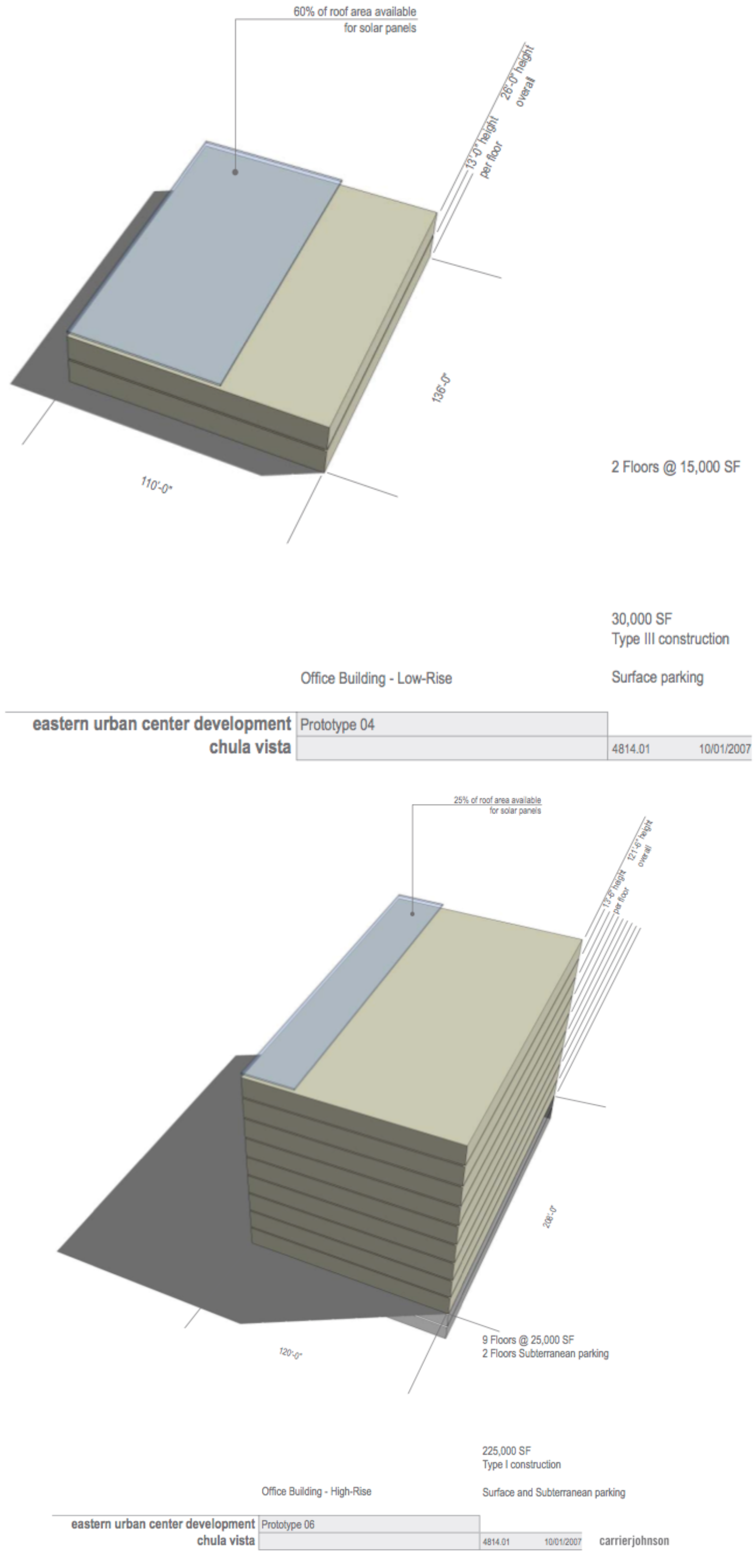

Figure 10. Comparison of Building Prototypes 4 (top) and 6 (bottom)

Source: National Energy Center for Sustainable Communities

Table 12. Site A: Building Space Conversion Calculation

Individual P6 High Rise Office Square Footage		224,640
Total P6 Buildings in Plan	×	7
Total P6 Square Footage		1,572,480
Individual P4 Low Rise Office Square Footage	÷	29,920
Individual P4 / Total P6 Square Footage (rounded)		53

Source: National Energy Center for Sustainable Communities

The next chapter presents the aggregated energy and emissions performance results for the two sites under these different scenarios. They are based on the building energy consumption figures and the emissions factors below.

The calculated annual energy consumption of a P6 building equipped with CCHP technology was 684,148 kWh of electric energy and 21,807 MMBtu of natural gas. The calculated annual energy consumption of a P4 building without CCHP technology was 285,304 kWh of electric energy and 215 MMBtu of natural gas energy. Researchers generated aggregate figures by multiplying the annual energy consumption for each prototype by the number of those prototypes for the two scenarios. To calculate emissions for energy generated or consumed, researchers used the conversion factors contained in the U.S. EPA *2006 Emissions & Generation Resources Integrated Database* (eGRID2006). The factors used are as follows:

- **CO_2**: 700.4 lbs/MWh of electricity produced and 117.6 lbs/MMBtu of gas energy used at the building level.
- **SO_x**: 0.128 lbs/MWh of electricity produced and 0.00059 lbs/MMBtu of gas energy used at the building level.
- **NO_x**: 0.352 lbs/MWh of electricity produced and 0.092 lbs/MMBtu of gas energy used at the building level.

<u>District Energy Systems</u>– As noted earlier in this chapter, researchers conducted an extensive technical and economic feasibility analysis of the use of a district cooling system vs. stand-alone building technologies to serve Site A. In addition, researchers were interested in examining the role development density plays in economic feasibility of a district cooling system. To pursue this interest, researchers conducted a comparative economic analysis of two district cooling configurations: one designed to serve the optimized, moderate-density scenario and the other to serve the baseline, low-density scenario for Site A.

Key factors that determine the economic feasibility of a district energy system include the aggregate load density of the buildings served by the system and the capital costs for distribution piping and the energy transfer stations (ETS) located at each building served. To determine the aggregate cooling load density for the optimized Site A scenario, researchers aggregated the hourly load profiles for each of the served building prototypes referenced in the district cooling evaluation described earlier. This included all prototypes except for P13, P14, and P15.

To determine piping and ETS capital costs for a similar district cooling system for the baseline/low-density scenario, researchers generated a piping distribution plan to serve approximately the same amount of square feet of building space as the optimized scenario but in lower density structures across the baseline site. To equal the aggregate cooling load of the optimized scenario and approximately the same amount of space required more than twice as many lower density buildings. Table 13 contains the building distribution list for the baseline and optimized scenarios used in this analysis.

Table 13. Site A: Building Distribution List for the District Energy Density Analysis

		Baseline		**Optimized**	
Bldg. ID	Description	# in Plan	Total Commercial Space (sq ft)	# in Plan	Total Commercial Space (sq ft)
1	Free Standing Restaurant	17	125,800	4	29,600
2	Multi-tenant Retail	15	300,000	2	40,000
3	Major Retailer (Big Box)	13	422,500	3	97,500
4	Low Rise Office	53	1,590,000	4	120,000
5	Mid Rise Office	8	800,000	7	700,000
6	High Rise Office	0	-	7	1,575,000
7	Large Hotel	0	-	1	171,000
8	Small Hotel	4	608,000	3	456,000
9	Retail/Office Mixed Use	0	-	3	315,000
10	Retail/Residential Mixed Use Mid Rise	0	-	2	66,000
11	Retail/Residential Mixed Use Low Rise	0	-	8	256,000
12	Civic/Office Building	0	-	1	22,200
Total		110	3,846,300	45	3,848,300

Source: National Energy Center for Sustainable Communities

To calculate the distribution piping costs for the low-density scenario, researchers first calculated total trench feet of pipe per square mile for the optimized scenario derived from the earlier district cooling evaluation. They then multiplied this number by the total area of the low-density scenario. For the moderate-density scenario, researchers assumed an average piping cost of $650 per trench foot (assuming a pair of cooling pipes), which includes construction management and engineering costs and a 10% contingency cost.

In the low-density scenario, it is likely the average pipe size for additional piping would be somewhat less than the average pipe size for the moderate-density scenario. However, this would be offset by the necessity of larger pipe mains to maintain the same distribution pressure. Given this offset, $650 per trench foot for additional piping provided a reasonable estimation of the piping capital cost required in the low-density scenario. Total distribution piping cost for this scenario was then determined by multiplying this unit cost by the total length of piping required by the distribution plan.

Researchers calculated the additional ETS costs as a percent increase over the moderate-density scenario based on the average cooling load for each of the buildings served in the low-density scenario. As expected, ETS costs increased since there are more buildings connected to the system. However, this is somewhat balanced by smaller loads for each building. Researchers ignored pumping costs because they assumed a maximum pressure for the distribution system, within a 150 psi pressure class limitation. A lower density scenario would not require more pumping power in this case, although the piping sizes may be marginally bigger. Because all piping assumed in the moderate-density scenario was pre-insulated (a conservative estimate in Chula Vista's climate zone), researchers did not deem incremental heat gain losses significant relative to the increased capital costs required. The following chapter presents the results of this analysis.

<u>Petroleum Consumption and Vehicular Air Emissions</u>– To quantify the benefits of moderate versus low-density development relative to petroleum consumption and vehicular air emissions, researchers examined design features that influence vehicle-miles-traveled (VMT).

Mixed-use, moderate-density development is considered to result in lower VMT than lower density developments because of co-location of residences, employment and retail centers, entertainment amenities, and street and sidewalk patterns that promote better pedestrian access. By contrast, low-density development results in higher resident VMT due to more curvilinear streets and cul-de-sacs, intentional separation of uses, and incomplete sidewalks.

Researchers used the 4D method to compare the relative vehicle miles traveled (VMT) savings due to design features such as population and employment densities, diversity of housing and jobs, accessibility to regional destinations, and design of streets and sidewalks. Using the 4D approach, researchers estimated VMT associated with integrated building, land use, and transportation development options for Site A and Site X and calculated energy, emissions, and cost savings using generally accepted averages.

The 4D method enabled researchers to estimate changes in vehicle trips (VT) and VMT resulting from these community design factors. The researchers calculated VT and VMT changes from empirically derived elasticities indicating the degree of overall VT and VMT change as a result of a unit change in each factor. For example, every 1% increase in the diversity factor results in a 0.032% decrease in VMT. Therefore, its elasticity is said to be -0.032. The U.S. Environmental Protection Agency (EPA) commissioned the studies to derive these elasticity measures in support of its development of the Smart Growth Index tool. The EPA collaborated with Criterion Planners the tool, and Hubbard and Walters at Fehr & Peers further refined it through their work in the Sacramento region and in connection with Blueprint Sacramento.[8] Several California locations, including San Louis Obispo, Contra Costa County, Humboldt County, and the San Joaquin Valley, have used 4D elasticities.[9] Table 14 provides the elasticities the researchers used for this project.

Table 14. 4D Elasticities

Factors	Vehicle Trips	Vehicle-Miles Traveled
Density	-0.043	-0.035
Diversity	-0.051	-0.032
Design	-0.031	-0.039
Destinations	-0.036	-0.204

Source: US EPA 2002

The four factors are measured in the following way:

- Density = Percent change in population and employment density calculated as [(population + employment) per square mile].
- Diversity = Percent change in jobs and population calculated as {1 – [absolute value (b * population – employment)/ (b * population + employment)]} where
  b = regional employment / regional population.
- Design = Percent change in the Design Index calculated as [0.0195 * street network density + 1.18 * sidewalk completeness + 3.63 * route directness] where:

8 Hess et al 1999; Cervero and Kockelman, 1997; Hubbard and Walters 2006.

9 Loudon et al 2007.

0.0195 = coefficient applied to street network density, expressing the relative weight of this variable compared to the other design index variables.

street network density = length of street in miles/area of neighborhood in square miles.

1.18 = coefficient applied to sidewalk completeness, expressing the relative weighting of this variable compare to the other design index variables.

sidewalk completeness = length of sidewalk / length of public street frontage.

3.63 = coefficient applied to route directness, expressing the relative weighting of this variable compared to the other design index variables.

route directness = average airline distance to center / average road distance to center.

- Destinations = Percent change in Gravity Model denominator for study Transportation Analysis Zones (TAZs) *i*: Sum [Attractions(*j*)*Travel Impedance (*i*,*j*)] for all regional TAZs.

Each factor is then multiplied by the related elasticity to arrive at a percent change in Home Bound (HB) VMT attributable to that factor. The addition of the four percent changes results in the total percent change in HB VMT for the modeled scenario.

The research team derived the variable assumptions required for this analysis from the following sources:

1. Study Area Size
    a. Derived from the total area of the site plans.
2. Persons per household
    a. Baseline: derived from latest census for the City of Chula Vista.
    b. Optimized: based on conversations with developers (higher density areas tend to have fewer persons per household).
3. Density
    a. Baseline: 3.3 dwelling units/acre based on a typical suburban gross density.
    b. Optimized: derived from site plan and building dwelling unit assumptions.
4. Dwelling Units
    a. Baseline: density × study area size.
    b. Optimized: derived from the number of buildings and units per building indicated in the site plans.
5. Population
    a. Persons per household × Dwelling Units.

6. Employment
    a. Baseline: based on conversations with Chula Vista planning staff.
    b. Optimized: total commercial area / 823 sqft per employee.[10]
7. Regional Employment
    a. From SANDAG's 2030 Long Range Forecast (2008).
8. Regional Population
    a. From SANDAG's 2030 Long Range Forecast (2008).
9. Transit Percentage
    a. From SANDAG's mobility tables (2007).
10. Sidewalk Completeness
    a. Baseline: Assumption based on conversations with Chula Vista planners.
    b. Optimized: Derived from site plans.
11. Street Network Density
    a. Total street length / study area size in sq miles.
12. Pedestrian Route Directness
    a. Derived through spatial analysis measuring the straight line distance and network distance to the center of the site (the ratio of these two measures represents the route directness).
13. Average Auto Trip
    a. From SANDAG (Data Warehouse: Transportation 2000).
14. Average Transit Trip
    a. Baseline: Based on conversations with SANDAG staff.
    b. Optimized: Based on conversations with SANDAG staff. (a separate SANDAG transit study was not conducted for this research project).

Tables 15 and 16 contain the variable assumptions for Site A and Site X. Table 17 provides vehicular petroleum and emissions assumptions used in the analysis.[11]

<u>Land Use Efficiency</u>–To examine the impact of moderate-density development on land use efficiency, researchers conducted a simple land consumption analysis on Sites A and X. In this analysis, researchers took the number of dwelling units from the optimized scenarios for each site and divided them by the gross density figure of 3.3 units per acre (considered low-density development by the City of Chula Vista in its General Plan Update). The product of that calculation was the number of acres required to accommodate those dwelling units for each site at the reduced density. Researchers used gross density this analysis as it accounts for roads, parks, non-residential units, and other infrastructure. Researchers calculated land acquisition costs for the lower density comparison assuming an average land cost of $22 per square foot. The next chapter presents the results of this analysis.

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10 Average amount of commercial floor area that equates to one job based on Commercial Buildings. (EIA 1999)

11 Values derived from *Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks*, Office of Transportation and Air Quality, USEPA, 2005.

Table 15. Site A: 4D Analysis Parameter Assumptions

Parameter	Baseline	Optimized
Size – Acres	215	215
Persons Per Household	2.56[12]	2.06[13]
Population	1814	4946
Dwelling Units	550	2401
Employment	451	4723
Regional Employment	1,573,740	1,573,740
Regional Population	3,245,280	3,245,280
Transit Percentage	6%	6%
Sidewalk Completeness	75%	100%
Pedestrian Route Directness	0.60	0.71
Average Auto Trip	28 min	28 min
Average Transit Trip	40 min	35 min
Street Network Density	15 length / sq mi	15.3 length / sq mi

Source: National Energy Center for Sustainable Communities

Table 16. Site X: 4D Analysis Parameter Assumptions

Parameter	Baseline	Optimized
Size – Acres	310	310
Persons Per Household	2.56	2.06
Population	2618	9342
Dwelling Units	1023	4535
Employment	651	4888
Regional Employment	1,573,740	1,573,740
Regional Population	3,245,280	3,245,280
Transit Percentage	6%	6%
Sidewalk Completeness	75%	100%
Pedestrian Route Directness	0.60	0.76
Average Auto Trip	28 min	28 min
Average Transit Trip	40 min	20 min
Street Network Density	15 length / sq mi	16.5 length / sq mi

Source: National Energy Center for Sustainable Communities

12 Based on 2000 Census mean for Chula Vista.

13 Assumed persons per household based on developer assumption that includes a diversity of residents that draws down averages seen in single-family communities.

Table 17. Vehicular Petroleum and Emissions Assumptions

Pollutant/Fuel	Emissions and Fuel Consumption rate (per mile driven)
Hydrocarbons	1.36 grams (g)
Carbon monoxide	12.4 g
Nitrogen oxides	0.95 g
Particulate matter (PM_{10})	0.0052 g
Particulate matter ($PM_{2.5}$)	0.0049 g
Carbon dioxide (CO_2)	369 g
Gasoline consumption	.0417 gallons (gal)

Source: National Energy Center for Sustainable Communities

Urban Runoff Mitigation and Carbon Sequestration Measures

Urban runoff mitigation is the process of diverting stormwater flows from collection, retention, detention, and storm sewer processing facilities. Communities pursue these measures to reduce costs associated with construction of these facilities and, in the case of processing facilities, to reduce energy consumption and energy-related air emissions. Although there are a number of measures for diverting stormwater, the measures considered in this project were the use of increased tree plantings and open space. Increased tree plantings also provide another benefit to communities through carbon sequestration and pollutant removal.

To quantify stormwater diversion performance and cost savings and energy consumption and carbon reduction benefits of these measures, researchers compared two scenarios for Sites A and X. 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 and an equivalent dollar value can be calculated for costs associated with construction of facilities to handle the diverted stormwater. The primary indicator for carbon sequestration is the number of tons of CO_2 stored in the biomass of planted trees. This section describes the tools, methods, and modeling assumptions used by researchers to analyze the impact of urban runoff and carbon sequestration measures applied to both sites.

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. Researchers derived land cover assumptions from site plan data provided by the developers and datasets derived from a variety of sources, including aerial photography, satellite imagery, and GIS vegetation layers. Researchers classified the datasets into land cover features such as tree canopies, open spaces, impervious surfaces, and water surfaces. They then configured this information into feasible landscape plans to conduct the CITYgreen™ analysis.

The research team calculated stormwater runoff, concentrations, and peak flow through use of the Urban Hydrology for Small Watersheds model, also known as the Technical Release 55 (TR-55) model. This model is commonly used by civil engineers for 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 the 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 researchers 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. A Curve Number is a parameter used in hydrology for predicting runoff potential and varies by land cover type and soil type.[14] The number ranges from 30 to 100 with lower numbers indicating lower runoff potential. The calculation of diverted stormwater is estimated by taking a site-wide Curve Number, weighted by percentage of each land cover type, under different scenarios and comparing it to a baseline (for example, a site with canopy versus a site with no canopy). The difference in the Curve Number between two scenarios then drives the calculation of the stormwater volume diverted using the TR-55 methodology. The equations for calculating the stormwater savings are provided below.[15]

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 = (total study area acres × 0.6) × 209

Lag Time:
$L = ((F×0.8) × ((S + 1.0) × 0.7) / (1900 × ((slope) × 0.5)))$

Time of Concentration:
$T_c = 1.67 × L$

Unit Peak Discharge:
$\log(q_u) = C_0 + C_1 × \log(T_c) + C_2[\log(Tc)] × 2$

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14 Curve numbers for land use and soil types are contained in Appendix Q.

15 Derived from the CITYgreen User Manual, 2002, References and Appendices, p. 87.

Peak Flow:

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):

$V_s = V_r \times (C0 + (C1(q_o/q_i)) + (C2 \times ((q_o/qi)^2)) + (C3 \times (qo/qi)^3)) \times$ study area acres × 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[16]

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

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 tree canopies for the two development sites.

The CITYgreen™ tool incorporates the USDA's Urban Forest Effects Model (UFORE) to calculate tree canopy potential to remove five criteria pollutants from the atmosphere. In addition to calculating the annual pollutant levels reduced by tree canopies, the model also calculates the associated dollars saved on negative externalities from these pollutants 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

16 See table of coefficients by rainfall type in Appendix R.

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):

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

Annual flux values are summed by estimating 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, including San Diego, 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 land cover maps for each development site and to calculate their annual carbon sequestration. While storage and sequestration varies by tree species and maturity, 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 18 provides the averages used by researchers for this analysis.

Table 18. Carbon Storage and Sequestration Canopy Assumptions

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

Source: National Energy Center for Sustainable Communities

Tables 19 and 20 provide additional assumptions used in stormwater runoff, carbon sequestration, and air quality analysis of both development sites.

Table 19. Site A: Land Cover Assumptions

	Baseline		Optimized	
Land Cover Type	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 and grass cover > 75%	10.9	5.30%	10.9	5.30%
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	206.1[17]	100.00%	206.1	100.00%

Source: National Energy Center for Sustainable Communities

Additional Site A 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)[18]
Raintype = I[19]

Electricity Multiplier for Stormwater Processing: 652 kWh per acre-foot of water[20]

Air Quality Assumptions (for San Diego region):

Weight of Pollutant Removed Per Square Meter of Canopy[21]

Ozone 7.6 grams
Particulate Matter 5.6 grams

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17 Number excludes a portion of unplanned land that is within the original site, explaining the difference between the total area in this analysis and the 4D and land area analysis

18 Used to determine the curve numbers associated with each land cover type. These values are contained in Appendix S.

19 Used to determine coefficient values for the TR-55 calculations. Appendix R contains the table of Rain Types and associated coefficient values.

20 Multiplier derived from Hoffman, Alan R. 2004. *The Connection: Water and Energy Security.*

21 From air quality data associated with San Diego and packaged with CITYgreen

Nitrogen Dioxide	2.8 grams
Sulfur Dioxide	0.8 grams
Carbon Monoxide	0.7 grams
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 Canopy[22]

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 Canopy[23]

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

Table 20. Site X: Land Cover Assumptions

	Baseline		Optimized	
Land Cover Type	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[24]	100.00%	337	100.00%

22 Based on average for typical trees used in urban forestry (McPherson, Nowak, Rowntree 1994, 2001). Please see Attachment IV, *Tree Guidelines for Coastal Southern California Communities*., p. 14.
23 *Ibid.*

Source: National Energy Center for Sustainable Communities

Additional Site X Assumptions:

Stormwater Runoff Assumptions:

P	=	1.75 inches
A_m	=	0.53 sq mi
F_p	=	1.0
Soil Type	=	D (very impervious, based on the site's location)
Raintype	=	I (based on the site's location)

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

Air Quality Assumptions (for San Diego region):

Weight of Pollutant Removed Per Square Meter of Canopy

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

Dollar Value of Pollutant 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 Canopy

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 Canopy

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

24 Number includes streets on the perimeter of the site.

Urban Heat Island Mitigation Measures

According to the U.S. EPA, "*heat island* describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with one 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. "[25]

The UHI effect can be mitigated by using lower-albedo (less reflective) materials on urban surfaces as well as through trees plantings. To quantify the impact of these measures on energy consumption for Sites A and X, researchers modeled two scenarios for each: one that included use of these measures and the other that did not include them. They then calculated site-wide albedo for both scenarios. Using MIST, researchers calculated the average temperature reduction and percent reduction in energy for residential, office, and retail buildings. They applied this information to the energy usage assumptions calculated for each prototype. This tool and the modeling approach are detailed below.

The EPA developed the Mitigation Impact Screening Tool (MIST) to analyze alternative urban heat island mitigation measures for development sites. MIST provides qualitative assessments of likely impacts of heat island effect mitigation measures averaged at the city-scale.[26] Measures investigated include highly reflective construction and paving materials and urban vegetative cover. Researchers 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 combined these meteorological impacts with energy and tropospheric ozone air quality models to estimate the impact specified mitigation measure(s) may have on the development sites. The MIST results are intended only as a first-order estimate urban planners can use to assess the viability of heat island mitigation strategies for their communities. Attachment III contains a more detailed description of the atmospheric modeling, domain definitions, and control simulation components of MIST.

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

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

26 MIST atmospheric modeling definitions and control simulations are contained in Attachment III, p. 6 to 9.

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 the different types of surface cover since the analyses were based on conceptual site plans that had no or little indication of parking, pathways, courtyards, and other fine details. After removing roads, sidewalks, roofs, and parks specifically represented in the plan, there remained a large percentage of unclassified land cover in each site.

Researchers could not reasonably assume all of the remaining land cover would be of one type. However, absent specific plans for these areas, estimating a large range of land cover types would not contribute significantly to the analysis. Instead, they made a general assumption that unclassified land would be divided into two categories: pavement and open space. Since they applied these assumptions to both sites, the relative differences still revealed impacts associated with the 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 team assumed total pavement area coverage of 41%. This assumption was derived from analysis of the Sacramento metropolitan region characterizing the urban fabric.[27] In that report, researchers found 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 more closely resemble this area than outlying residential, office, or industrial areas. Therefore, researchers believe this was a reasonable estimate, acknowledging 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. The percent coverage of these areas was calculated and then subtracted from the target coverage of 41%. The remaining percentage represented the relative share of unclassified land that was classified as paved. The remaining percentage of 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 governs 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. The optimized scenario featured higher albedo materials for key land cover types, specifically roofs and streets.

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

- Streets: Asphalt (Albedo .04)

27 See Rose, Akbari, Taha. 2003, p. 2.

- 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

Site A: consists of five main land cover types: street, sidewalk, roof, park, and unclassified cover as indicated in Table 21 below. Researchers applied the albedos described above to the same area for the baseline and the optimized scenarios and then weighted according to the percent coverage. Tables 21 and 22 indicate how the unclassified area albedo was derived 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 21. Site A: Albedo Assumptions Based on Surface Type

			Surface Albedo		Weighted Albedo		
Land Cover	% Cover	Area (sq feet)	Baseline	Optimized	Baseline	Optimized	Delta
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

Source: National Energy Center for Sustainable Communities

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)[28]: 862
- Annual heating degree days (65F Base): 1,321

Table 22. Site A: Reflectance Assumptions for "Unclassified" Land Cover

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

Source: National Energy Center for Sustainable Communities

Researchers then used these assumptions and the relative albedo differences as input for MIST analysis of the site that 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 that are provided in the results section of this report.

Site X: Urban Heat Island Effect Analysis Assumptions

Researchers also divided Site X into five land cover categories and calculated weighted albedo values for the site. Tables 23 and 24 provide these values.

Table 23. Site X: Albedo Assumptions Based on Surface Type

			Surface Albedo		Weighted Albedo		
Land Cover	% Cover	Area (sqft)	Baseline	Optimized	Baseline	Optimized	Delta
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

Source: National Energy Center for Sustainable Communities

28 Cooling Degree Days (CDD) is 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 occur per year.

Table 24. Site X: Reflectance Assumptions for "Unclassified" Land cover

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

Source: National Energy Center for Sustainable Communities

The relative difference in albedo became one of the variables entered into the MIST analysis as in Site A, along with the following assumptions:

- Population: 9,342
- Latitude: 32.6
- Annual mean temperature: 63.7
- Annual cooling degree days (65F Base)[29]: 862
- Annual heating degree days (65F Base): 1,321

Again the team applied MIST outputs to the building energy consumption data to arrive at the approximate aggregate energy and emission reductions detailed in the results chapter of this report.

Passive Solar Building Orientation

The spatial modeling team also sought to quantify the impact passive solar building orientation could have on energy consumption in a development project. However, it should be noted this analysis was of a limited nature since National Renewable Energy Laboratory (NREL) is currently conducting an exhaustive study of the subject for the Energy Commission.

Passive solar building orientation entails the placement of a building on a site with the explicit intention of optimizing solar access and shading to reduce energy use and cost for space heating and cooling. By facing the long side of a structure south and the short sides 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. A true passive solar-designed building also includes thermal mass storage (thick walls and/or floors that absorb heat during the day and release it at

29 The same CDD and HDD assumptions are made for Site X as were made earlier for Site A

night) and often appropriate tree shading decrease heat gain in summer. The single-family homes 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. These higher density buildings would see asymmetric benefits because some of the units would be unable to take full advantage of orientation. In addition, glazing on these prototype buildings tended to be evenly distributed. Although it is possible to incorporate certain features of passive solar design into these buildings to take better advantage of natural light, researchers did not explicitly model these design features.

To quantify the energy reduction potential of passive building orientation in Site X, the researchers modeled a single-family home (Prototype 1 in Site B). This prototype had an attached garage in the front and was shorter on the entry side. Thus, when the building faced north, the long side of the structure faced east and west where most of the glazing was located. To reveal the impacts of orientation, researchers plotted annual gas and electric usage against orientation in thirty-degree intervals starting from north (0 degrees). The next section provides the results of this analysis.

2.9.2. Community Design Option Market Feasibility

Lack of cost information associated with the modeled options hampered the research team's determination of market feasibility of the community design. As a surrogate for direct cost analysis, the team examined the projected energy cost savings associated with the use of urban heat island mitigation measures on the two development sites and the cost of those measures. Researchers used the energy and emissions savings from the building energy modeling work and the MIST calculations for the first half of this analysis. They used the incremental costs for whitetopping of streets, improved roof coatings, and additional tree plantings for the second half of the analysis. These costs included the following:

- Whitetopping: $4.00 /sq yd./in. of thickness[30]
- White roof coating: $0.20 /s. f.[31]
- Tree: $445.00 per tree (including labor)[32]

2.10. Market and Public Policy Analysis

The research team conducted a market and policy analysis with the following objectives:

30 US EPA 2005 *Cool Pavement Report*

31 PG&E *Cool Roof Design*

32 Costs derived from discussions with planning department personnel at the City of Chula Vista. The number of trees were estimated by dividing the total canopy area by the average tree canopy size, 1116 s.f., estimated by Rosenzweig and Solecki, 2006

- To determine the maximum incremental cost the California building industry and consumers would accept for energy-efficient residential, commercial, industrial, and institutional structures.
- To determine which financial and business models and associated public policies and incentives would lead to accelerated deployment of EE, DR, RE, and DG technologies in typical development projects in California.

Researchers employed several research methods to pursue these objectives, including: literature review of related industry, government, and utility research and policy initiatives; workshops with community development stakeholders; surveys and interviews with practitioners and leaders of the real estate development and finance industries. The sections below provide a brief description of these methods.

<u>Literature Review</u>– Researchers conducted a review of recently published studies on incremental costs of energy-efficient buildings and barriers underlying reluctance of developers to invest in them. They also reviewed recent government and utility policy documents to ensure their evaluation of alternative financial, business, and policy incentives was set within a relevant institutional context. During this review researchers paid particular attention to documents recently published by National Association of Industrial and Office Properties (NAIOP), National Science and Technology Council Committee on Technology, California Energy Commission, California Air Resources Board, California Public Utilities Commission, and California Investor-Owned Utilities. The most relevant publications reviewed are listed at the end of this report.

<u>Stakeholder Workshops</u>– Researchers conducted three stakeholder workshops to advance the second market and policy research objective listed above. Participants at the workshops included, but were not limited to, representatives of (1) the real estate development transaction chain, including investors, lenders, developers and builders, design professionals, brokers, and appraisers; (2) environmental organizations and community advocacy groups; and (3) local and state government agencies.

The first workshop defined the market and policy analysis task and solicited input from the Chula Vista Research Project Advisory Committee[33] and from key members of the San Diego-area development industry and academic institutions. This input enabled researchers to refine the definition of several key project terms used in the subsequent survey and interview sub-tasks, including the term e*nergy-efficient community development*.[34] Input received during the first workshop also resulted in generation of five subordinate questions researchers were

33 The Chula Vista Research Project Advisory Committee list is contained in Appendix N.

34 Defined as development of residential, commercial, and mixed-use structures and community infrastructure that integrate renewable and advanced energy-efficient technologies and performance enhancing urban design to reduce energy consumption and greenhouse gas emissions.

advised to consider in addressing the two research objectives for this task. These questions became the focus of the second workshop:[35]

1. What are the most significant policy, regulatory and market barriers to investment in energy-efficient community development projects in California?
2. What are the perceived and real additional costs associated with design and construction of energy-efficient community development projects? What potential public policies, incentives, and other financial assistance could reduce these costs?
3. What are the perceived financial barriers and risks that prevent capital market entities from investing in energy-efficient buildings and community development projects?
4. What is the current market demand and acceptance level for energy-efficient development projects? What is necessary to increase that demand and acceptance?
5. What are the perceived benefits for developing energy-efficient homes, buildings, and communities? What are effective means to increase those identified benefits?

During the second workshop, 55 representatives from the aforementioned organizations divided into five discussion tables to explore each of the research questions developed in the first workshop. Each table completed a discussion summary worksheet and presented it to all participants during a concluding plenary discussion.

The third workshop prioritized the lists of barriers and solutions.[36] The highest ranked barriers became the focus of strategic problem-solving break-out sessions. These sessions produced a preliminary strategy to address each barrier through collaborative action among government, industry, utility, academic, and advocacy organizations. Participants then presented and discussed the strategies in a concluding plenary session.

<u>Capital Market Survey</u>– Researchers conducted an online capital market survey to determine perceived risks and barriers associated with investment in energy-efficient buildings and community development projects. The target group for the survey was real estate finance/investment/development industries (i.e., lenders, equity investors, and developers). Researchers used the survey instrument Survey Monkey.[37] In addition to the research questions, the research team requested additional information from respondents to enable it to stratify and analyze responses by market segment. A set of 120 respondents completed the surveys that researchers collected over a 15-day period from June 15, 2008, to June 30, 2008.

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35 As the team members planned the second workshop (January 2008), they decided that subordinate question number three would be better addressed in the planned survey work than in the workshop. Therefore, the team replaced it with another question on distribution channels. See the final list of questions and more details in Appendix T.

36 The group prioritized the lists using a keypad voting system that enabled individual participants to vote anonymously and showed simultaneous tabulation and presentation of the aggregate scores for all participants.

37 Surveymonkey.com

Development Industry Survey– Researchers conducted an additional survey of development, building, and allied industries to advance the first market and policy analysis objective: to determine the maximum incremental cost their industries and consumers would accept for energy-efficient residential, commercial, and industrial structures. Once gain, researchers sent email invitations to participate to local members of the National Association of Industrial and Office Properties (NAIOP) and to members of the California Building Industry Association (CBIA).

The survey solicited participant responses to the incremental costs calculated for the three energy-efficient building technology options modeled earlier in the research (i.e., EE, EE-PV, and EE-DG options). These costs were expressed as increments to per square foot building construction costs. The surveys utilized attitudinal questions and a Likert Scale to measure the degree to which respondents agreed or disagreed with the market feasibility of the incremental costs modeled for each option. The survey also solicited estimates from respondents on the maximum incremental costs they believed the current marketplace and consumers would sustain for buildings featuring these options. The research team also requested information to enable it to stratify and analyze responses by market segment. A set of 22 respondents completed the surveys on surveymonkey.com over a 19-day period between August 22, 2008, and September 10, 2008.

Telephone Interviews– Leaders of CBIA, representatives from member companies, and several leading green homebuilders participated in follow-up telephone interviews to discuss findings from the stakeholder workshops and both surveys. The interviews examined incremental cost and risk factors associated with green building and development and solicited public policies and incentives to support energy-efficient community development in California.

3.0 Project Results

This chapter provides the results of the analytical methods employed to address each of the six research objectives in the project. These objectives are repeated below for reader convenience. The following sections discuss each objective independently.

1. Estimate relative energy efficiency and emissions reduction performance of individual energy efficiency (EE), demand response (DR), renewable energy (RE), and distributed generation (DG) technologies (advanced energy technologies) in typical development projects (residential, commercial, industrial, institutional).
2. Determine the extent to which application of these technologies in typical development projects would reduce peak demand and result in better utilization of existing utility infrastructure.
3. Determine market-feasible combinations of energy technology and design options that would increase building energy efficiency by more than 25% above 2005 Title 24 standards.
4. Estimate the degree to which enabling community design options (i.e., mixed-use/ moderate density/transit-oriented development, stormwater runoff and carbon sequestration measures, urban heat island reduction measures, and passive solar building orientation) can improve energy technology performance in typical development projects.
5. Determine maximum incremental cost the California building industry and consumers will accept for energy-efficient residential, commercial, industrial, and institutional structures.
6. Determine which financial and business models and associated public policies and incentives would lead to accelerated deployment of EE, DR, RE, and DG technologies in typical development projects throughout the State of California.

3.1 Building Energy Technology Performance

This section addresses the following research objective:

- Estimate relative energy efficiency and emissions reduction performance of individual energy efficiency (EE), demand response (DR), renewable energy (RE), and distributed generation (DG) technologies (advanced energy technologies) in typical development projects (residential, commercial, industrial, institutional).

Since Site A and Site B are distinct from one another relative to their site utilization plans, mix of building types, and demand loads, the results of the energy technology performance modeling are presented below under separate sub-sections beginning with Site A.

3.1.1. Site A: Gas and Electric Utility Use Impacts

Figure 11 below presents the results of the four modeled development options relative to their impact on site-wide annual energy (gas and electric) consumption. Again, the four options entailed development of Site A utilizing:

- Standard building materials and equipment - the builder's proposed baseline.
- Buildings enhanced with energy efficiency features - the EE package.
- Buildings enhanced with the EE package and solar photovoltaic panels - the EE package w/PV.
- Buildings enhanced with the EE package and distributed generation technologies -the EE package w/DG.

Analysis of the results indicates implementation of all applicable and economically feasible EE options on all suitable buildings could lower Site A annual energy consumption from the builder proposed baseline of 359,000 MMBtu to 313,000 MMBtu or by 12.8%. Implementation of the EE-PV option on all suitable buildings could further reduce electric grid and natural gas utility consumption to 255,000 MMBtu or by 27.8% compared to the builder's baseline option. Deployment of the EE-DG option on all suitable buildings would not be as effective in reducing Site A consumption of grid-provided electric energy as the EE-PV option. It could lower consumption to 168,000 MMBtu from the 217,000 MMBtu expected from use of the EE option alone. However, natural gas consumption would increase significantly, reaching 237,000 MMBtu as compared to 95,000 MMBtu for the EE option. The increase results in the highest natural gas consumption of any of the modeled development scenarios.

Figure 11 shows consumed electric and natural gas energy expressed as Btu or the heat content of equivalent utilities. Although often used, strict Btu analysis does not reflect other important factors associated with the value of energy consumed by a community at different times of the day and year. Therefore, the results of Site A energy efficiency analysis are also presented using the Title 24 prescribed Time Dependant Valuation (TDV[38]) approach. To enhance the accuracy of the modeling, the researchers included appliances and other internal loads in their analysis not accounted for by a standard Title 24 TDV approach. This enhanced modeling method is termed the Time Dependant Valuation Inclusive approach (TDVI[39]).

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38 Time-Dependent Valuation (TDV) is the method for valuing energy in the performance approach contained in the 2005 Building Energy Efficiency Standards, aka Title 24, 2005. Under TDV the value of electricity differs depending on 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. For more information visit:
http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/index.html

39 Time Dependent Valuation Inclusive (TDVI) energy consumption accounts for all building energy uses including energy consumed by appliances, plug loads and lights. Use of TDVI in calculating building energy efficiency differs from the use of TDV calculations conducted for Title 24 building compliance certification where the energy used for cooling, heating and domestic hot water is used as indicator of residential building energy efficiency. The Title 24 commercial building TDV method does, however, account for lights and receptacles load. Use of TDVI in the modeling enabled the researchers to gain a better understanding of the impacts of various EE measures on overall building energy consumption than was possible using Title 24 certification software such as Energy PRO 4.3 or Micropas7

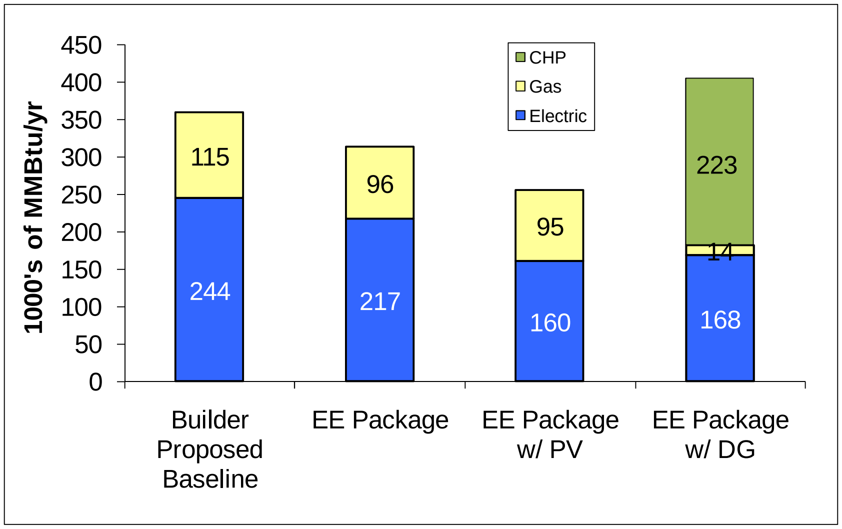


Figure 11. Total Annual Energy Consumption (all buildings)
Source: National Energy Center for Sustainable Communities

Figure 12 indicates implementation of the EE option could lower Site A TDVI energy consumption from the builder proposed baseline of 217 kBtu/sf-year to 190 kBtu/sf-year or by 12.1%. Implementation of the EE-PV option could further reduce TDVI energy consumption to 52 kBtu/sf-year, for a total reduction of 31.3% compared with the builder proposed baseline. Similar to the results shown in Figure 11, deployment of the EE-DG option would not be as effective in reducing Site A TDVI energy consumption as the EE-PV option. However, in contrast to Figure 11 where energy is expressed in Btu and EE-DG shows the highest use (at TDVI energy consumption of 170 kBtu/sf-year), the EE-DG option is 33.8% better than the builder proposed baseline TDVI energy consumption. This illustrates DG technology, while increasing consumption of low TDVI-valued fuel like natural gas, can significantly decrease consumption of high TDVI-valued electricity from the grid.

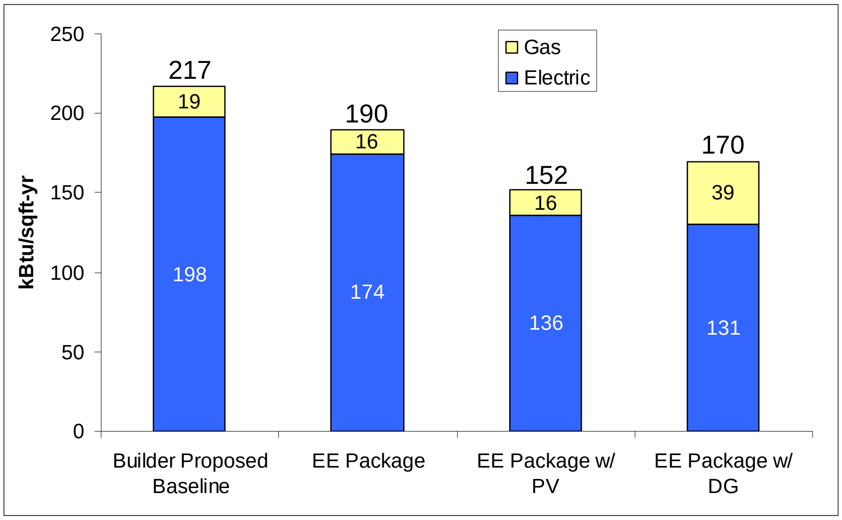


Figure 12. TDVI Energy Consumption (all buildings)

Source: National Energy Center for Sustainable Communities

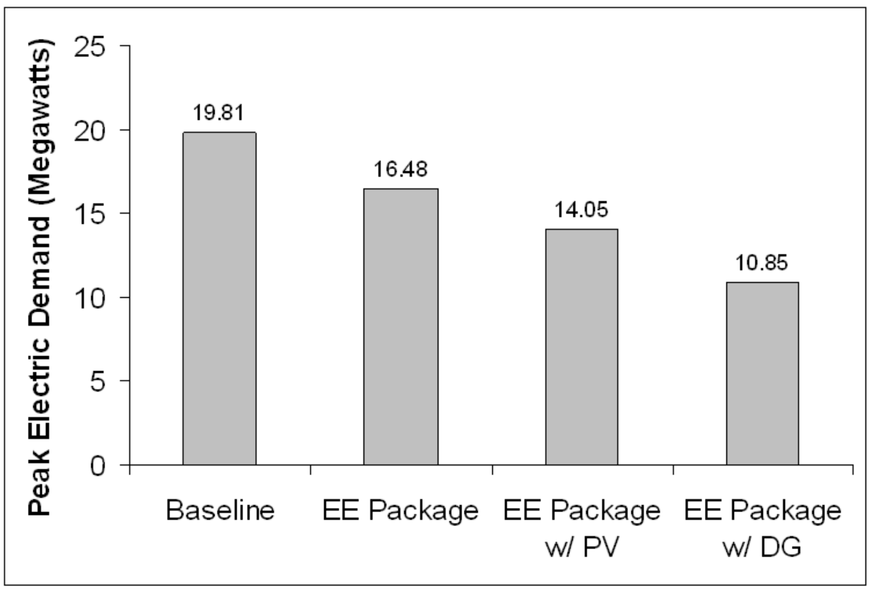


Figure 13. Peak Electric Demand (all buildings contributions)

Source: National Energy Center for Sustainable Communities

Table 25. Specific Cost of Electric Peak Demand Reduction

	Peak MW	Total Cost	$/kW for Reduced Peak Demand
Baseline	19.809	-	-
EE Package	16.478	$10,068,880	$3,023
EE Package w/ PV	14.045	$55,372,374	$9,607
EE Package w/ DG	10.851	$15,795,566	$1,763

Source: National Energy Center for Sustainable Communities

Peak demand reduction is an essential objective of community-scale energy efficiency and integrated energy technology and urban design. Figure 13 presents the impact of the four modeled development options on peak demand, and Table 25 lists their implementation costs. Implementation of the EE option would result in lowering Site A electric peak demand from the builder proposed baseline of 19.81 MW to 16.48 MW or by 16.8%. At $3,023/kW this is also the second least expensive of the three analyzed options.

Implementation of the EE-PV option could further reduce electric peak demand to 14.05 MW or by a total of 29.1% compared with the builder proposed baseline. At $9,607/kW, this is the most expensive of the three options. Implementation of the EE-DG option could reduce Site A electric peak demand to 10.85 MW, which is better than the EE-PV option and 45.2% less compared to the builder proposed baseline. The cost of implementing EE-DG option is $1,763/kW.[40]

3.1.2. Site A: Environmental Impacts

Figures 14 through 16 present the cumulative annual air emissions associated with Site A annual electricity and natural gas consumption under the four development options. Researchers based the calculations on the conversion factors contained on page 190 of Attachment I and assumed end-use delivery efficiency of 92% for electricity and 98.4% for natural gas.

Figure 14 indicates implementation of the EE option could lower Site A annual CO_2 emissions from the builder proposed baseline of 30,924 metric tons/year to 27,174 metric tons/ year or by 12.1%. Implementation of the EE-PV option could further reduce CO_2 emissions to 21,403 metric tons/ year or by 30.8%. Deployment of the EE-DG option would be less effective in reducing Site A CO_2 emissions than the EE-PV option. However, at 28,865 metric tons/year, it is still 6.7% lower than the builder proposed baseline CO_2 emissions.

40 Based on incentives of $600/kW of installed DG. See footnote 6 for additional explanation.

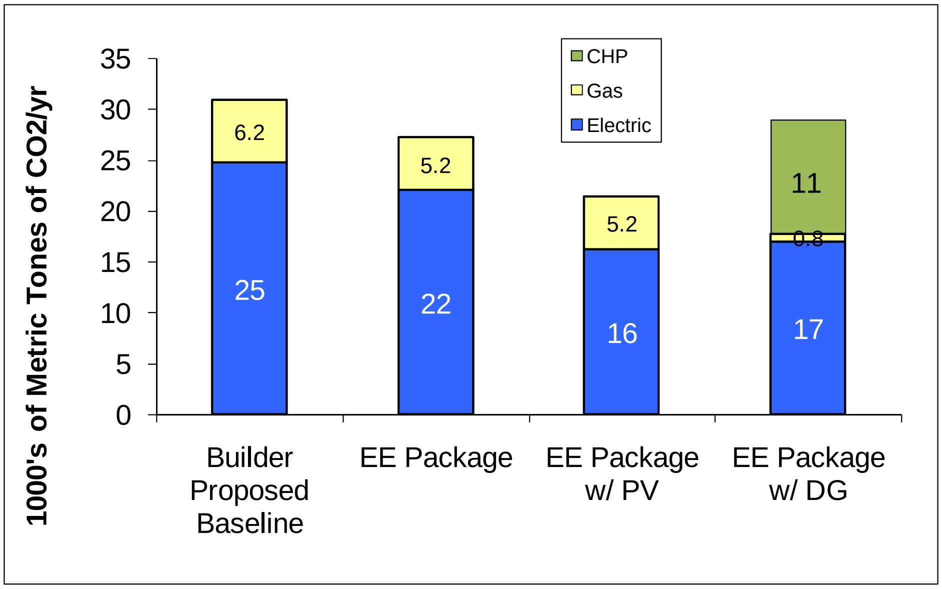
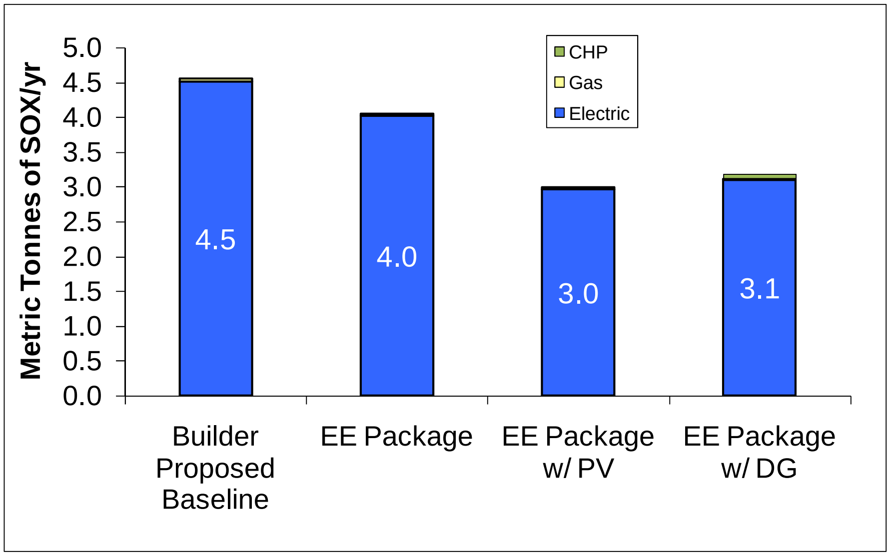


Figure 14. Total Annual CO_2 Emissions (all buildings contributions)
Source: National Energy Center for Sustainable Communities

Figures 15 and 16 show SO_x and NO_x emissions impacts. Use of the EE option could lower Site A annual SO_x emissions to 4.05 metric tons/year from the builder proposed baseline of 4.55 metric tons/year or by 11%. NO_x emissions would be 14.79 metric tons/ year with EE option implemented vs. 16.93 metric tons/year for the builder proposed baseline, a reduction of 12.6%.



Note: Gas and CHP contributions to SO_x emissions are too small to illustrate on this chart given the scale.

Figure 15. Total Annual SO_x Emissions (all buildings contributions)
Source: National Energy Center for Sustainable Communities

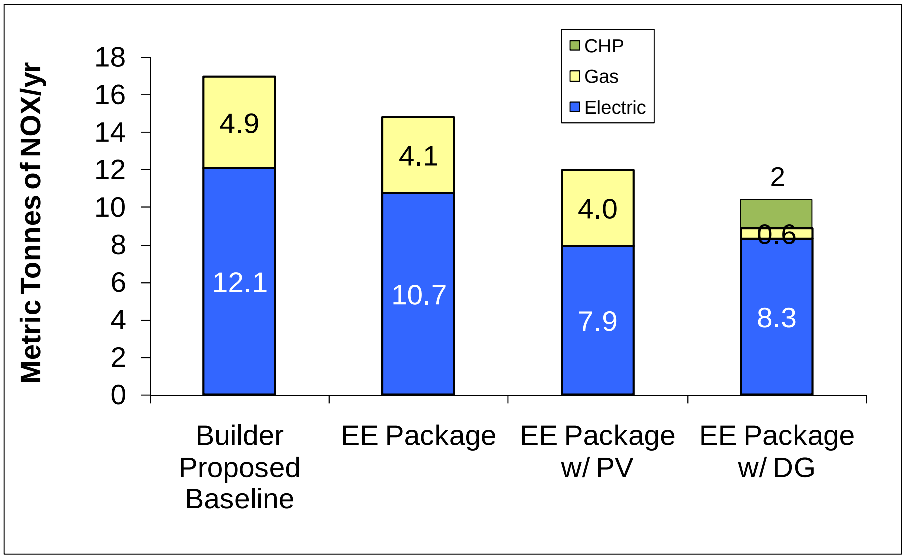


Figure 16. Total Annual NO_x Emissions (all building contributions)

Source: National Energy Center for Sustainable Communities

Implementation of the EE-PV option could further reduce SO_x emissions to 2.99 metric tons/ year or by 34.2% and NO_x emissions to 12 metric tons/ year or by 29.3% as compared to the builder proposed baseline. Implementation of the EE-DG option could reduce Site A SO_x emissions to 3.17 metric tons/ year or by 30.3% and NO_x emissions to 10.40 metric tons/ year or by 38.5% as compared to the baseline.

3.1.3. Site A: TDVI Impacts by Building Prototype

The charts and tables presented below provide a better understanding of which building prototypes are the most energy intensive and the degree to which they contribute to Site A annual energy consumption. The charts shown in Figures 17 to 20 provide TDVI energy density for each of the 15 building prototypes modeled in the research as well as total annual TDVI–based energy consumption for all the buildings of the same type (shown as a chart insert).

Table 26 indicates the relative contribution each building prototype makes toward total TDVI energy consumption for Site A. The results are expressed as a utility-specific percentage (electric and gas) as well as a utility-specific percentage per total site TDVI. In the builder proposed baseline configuration, the freestanding full service restaurant (FSR) prototype has the highest TDVI consumption or 1,126 kBtu/sf-year (Figure 17). However all FSR buildings contribute only 2.4% to Site A total TDVI energy consumption (Table 26).

As shown in Figures 17 to 20 and in Table 24, high-rise office (HRO) buildings contribute the most to Site A total TDVI energy consumption. Therefore, they should be considered the prime target for uniform implementation of selected energy efficiency measures.

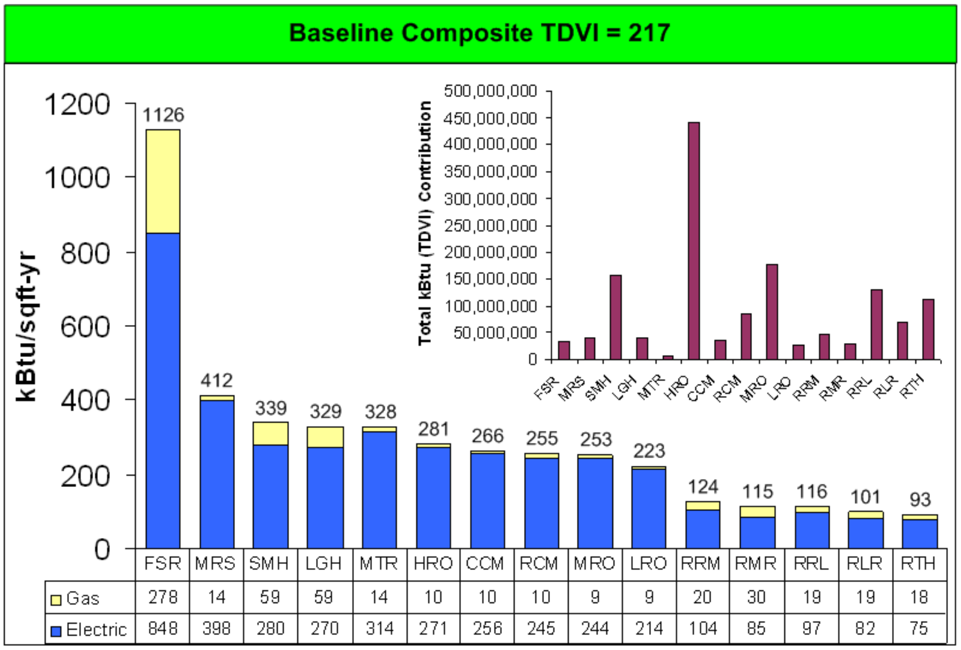


Figure 17. Site A: Builder Baseline - TDVI per Building Type

Source: National Energy Center for Sustainable Communities

Table 26. Site A: TDVI per Building Type (composite for prototype end-use areas)

	Baseline	Elec. TDVI as % of Total Elec. TDVI	Gas TDVI as % of Total Gas TDVI	Elec. TDVI as % of Total Site TDVI	Gas TDVI as % of Total Site TDVI
1	Freestanding Full Service Restaurant	1.9%	6.6%	1.8%	0.6%
2	Multi-Tenant Retail Shop	0.5%	0.2%	0.4%	0.0%
3	Major Retailer	3.0%	1.1%	2.7%	0.1%
4	Office Building Low-Rise	2.0%	0.9%	1.8%	0.1%
5	Office Building Mid-Rise	13.1%	5.1%	11.9%	0.4%
6	Office Building High-Rise	32.6%	12.7%	29.8%	1.1%
7	Hotel - Large	2.5%	5.8%	2.3%	0.5%
8	Hotel - Small	10.3%	16.7%	9.4%	1.4%
9	Retail/Commercial Mixed Use	6.3%	2.8%	5.8%	0.2%
10	Retail/Residential Mixed Use Mid-Rise	3.3%	4.1%	3.0%	0.4%
11	Retail/Residential Mixed Use Low-Rise	9.1%	8.5%	8.3%	0.7%
12	Civic/Commercial Mixed Use	2.6%	1.0%	2.4%	0.1%
13	Residential Multi-Family Townhome	6.9%	17.5%	6.3%	1.5%
14	Residential Low-Rise	4.3%	10.6%	3.9%	0.9%
15	Residential Mid-Rise	1.7%	6.3%	1.5%	0.5%

Source: National Energy Center for Sustainable Communities

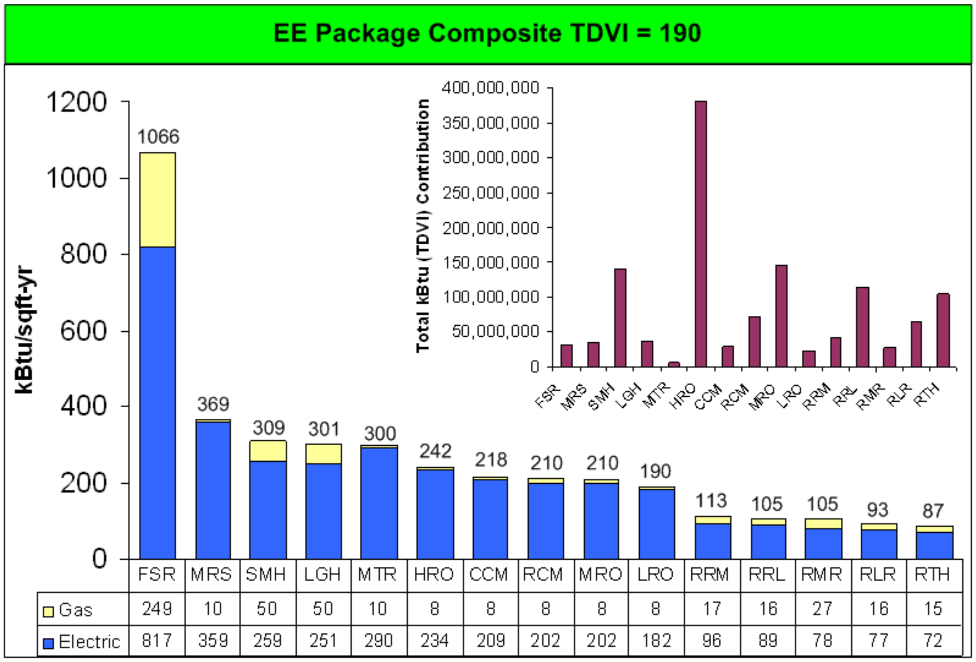


Figure 18. Site A: EE Packages Only Option - TDVI per Building Type
Source: National Energy Center for Sustainable Communities

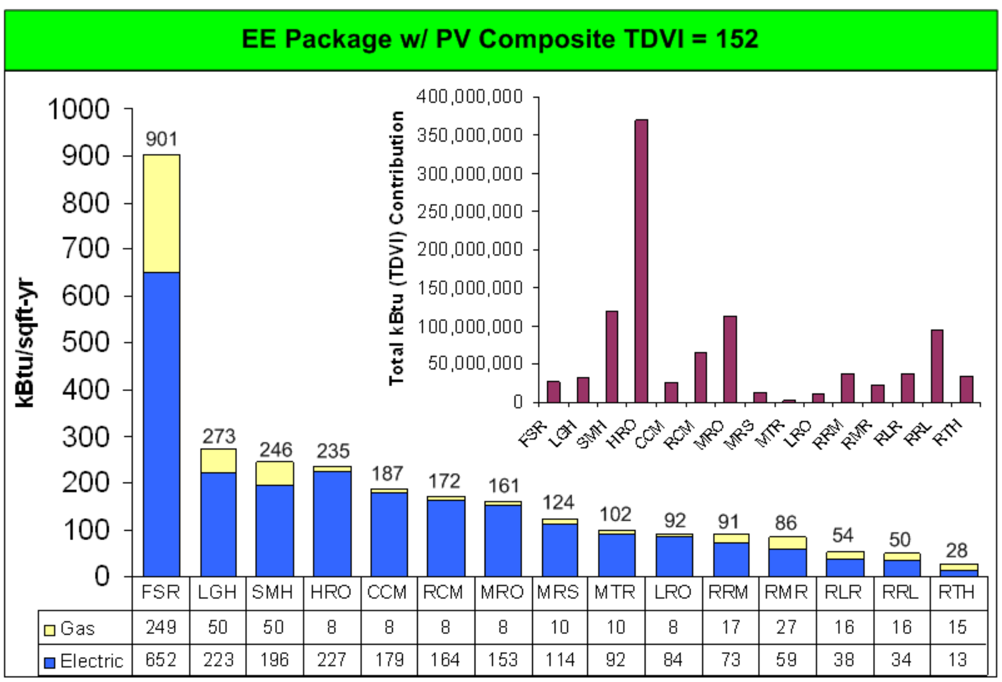
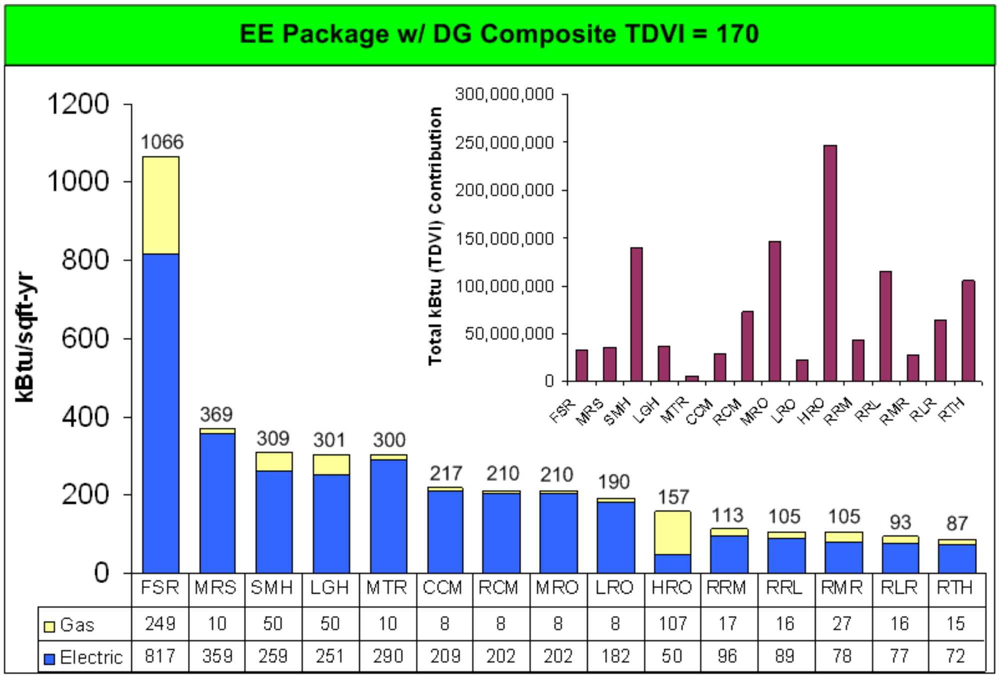


Figure 19. Site A: EE Package with PV Option - TDVI per Building Type
Source: National Energy Center for Sustainable Communities



	FSR	MRS	SMH	LGH	MTR	CCM	RCM	MRO	LRO	HRO	RRM	RRL	RMR	RLR	RTH
Gas	249	10	50	50	10	8	8	8	8	107	17	16	27	16	15
Electric	817	359	259	251	290	209	202	202	182	50	96	89	78	77	72

Figure 20. Site A: EE Package with DG Option - TDVI per Building Type

Source: National Energy Center for Sustainable Communities

3.1.4. Site A: TDVI Impacts by Space-Use Type

Figures 21 to 24 illustrate which of the six space use types is the most energy intensive and the degree to which they contribute to Site A total annual energy consumption. The charts provide TDVI energy density for various floor plans as well as total annual TDVI – based energy consumption for all the space uses of the same type (shown as a chart insert).

As in the previous table, Table 27 indicates the relative contribution each space use makes toward total TDVI energy consumption for Site A. Results are expressed as a utility-specific percentage (electric and gas) as well as a utility-specific percentage per total site TDVI.

As seen in Figure 21 (the builder proposed baseline), restaurants have the highest TDVI of 1,122 kBtu/sf-year. However, the total square footage of office space exceeds any of the five remaining uses and contributes more than 51% of the total Site A TDVI energy consumption (Table 27). Therefore, office space should be considered the prime target for energy efficiency interventions.

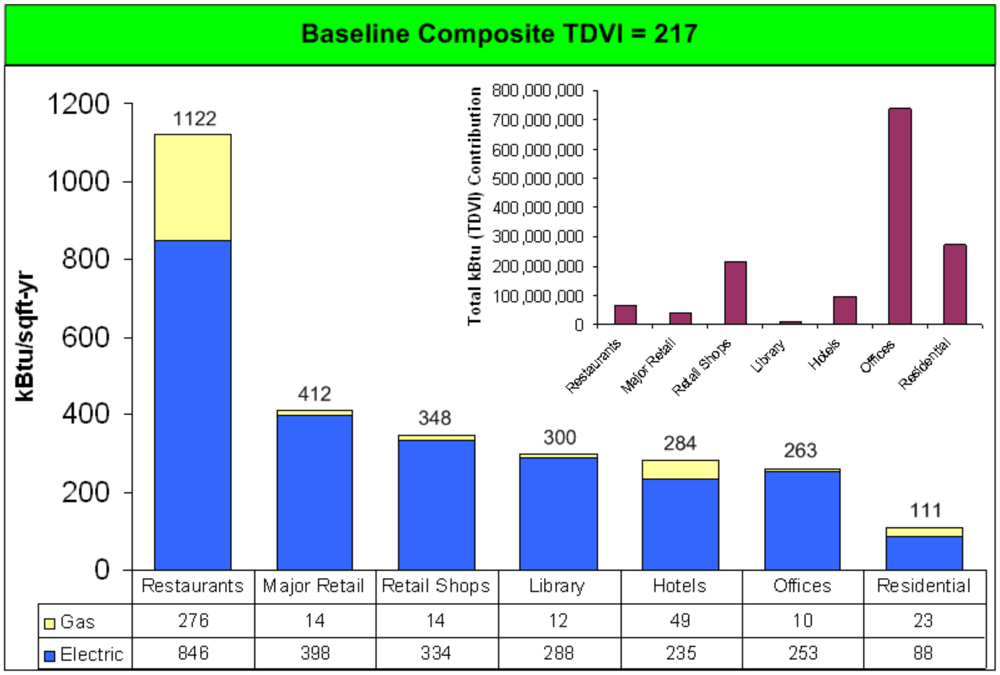


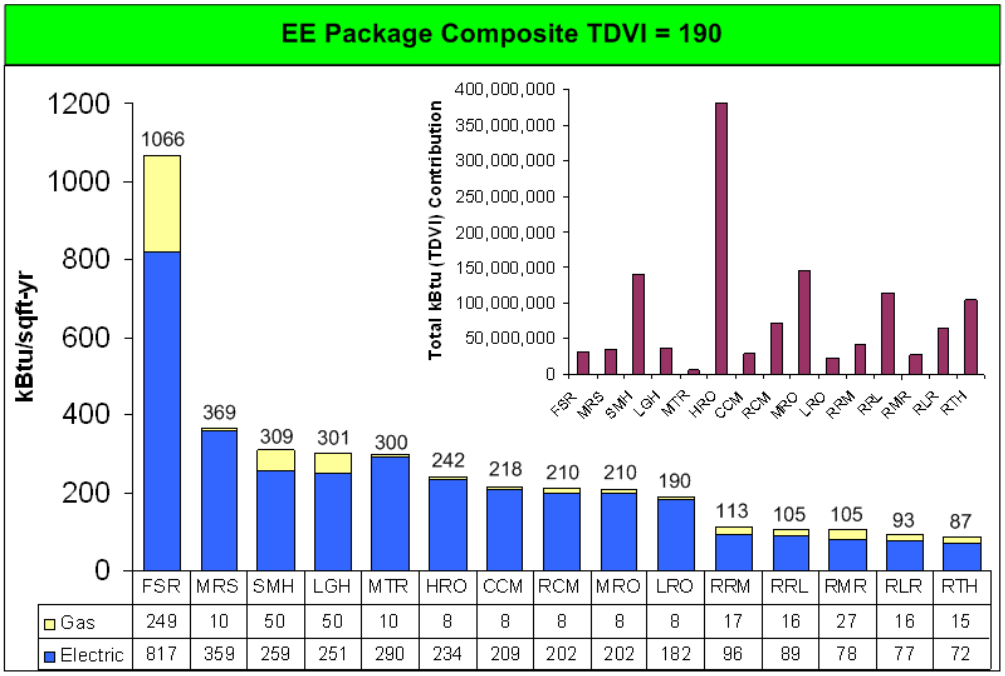
Figure 21. Site A: EE Builder Baseline - TDVI per Space-Use Type

Source: National Energy Center for Sustainable Communities

Table 27. Site A: TDVI per End-Use Area (composite for all buildings types)

Baseline	Elec. TDVI as % of Total Elec. TDVI	Gas TDVI as % of Total Gas TDVI	Elec. TDVI as % of Total Site TDVI	Gas TDVI as % of Total Site TDVI
Restaurants	3.8%	13.2%	3.5%	1.1%
Retail Shops	15.7%	7.0%	14.3%	0.6%
Major Retail	3.0%	1.1%	2.7%	0.1%
Offices	54.3%	21.5%	49.6%	1.9%
Hotels	6.0%	13.8%	5.5%	1.2%
Library	0.6%	0.3%	0.5%	0.0%
Residential	16.7%	43.2%	15.2%	3.7%

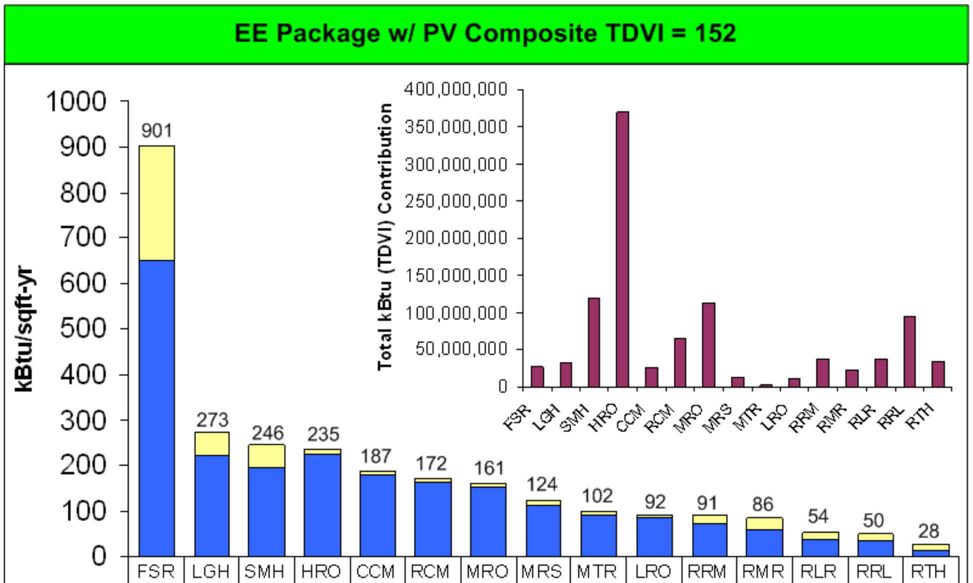
Source: National Energy Center for Sustainable Communities



	FSR	MRS	SMH	LGH	MTR	HRO	CCM	RCM	MRO	LRO	RRM	RRL	RMR	RLR	RTH
Gas	249	10	50	50	10	8	8	8	8	8	17	16	27	16	15
Electric	817	359	259	251	290	234	209	202	202	182	96	89	78	77	72

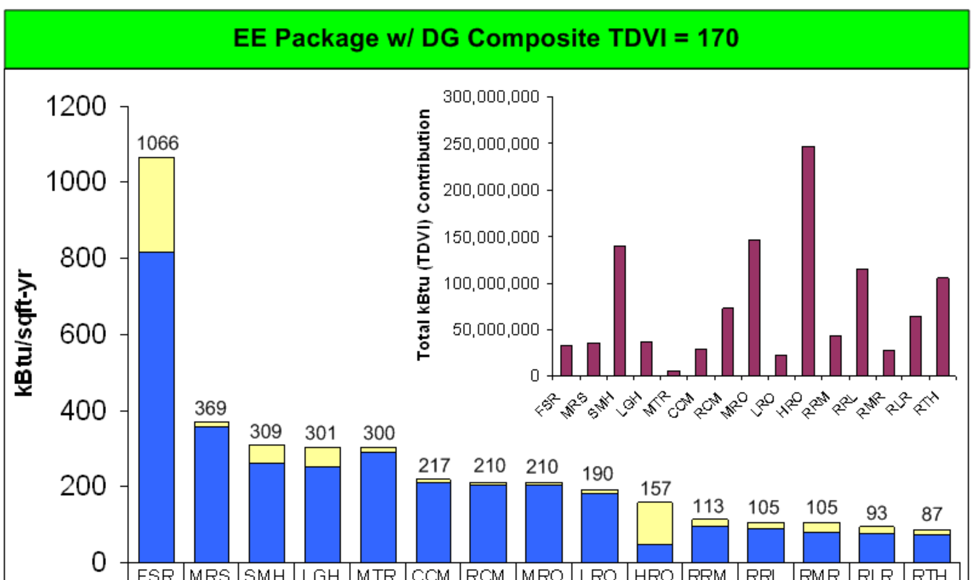
Figure 22. Site A: EE Package Option - TDVI per Space-Use Type

Source: National Energy Center for Sustainable Communities



	FSR	LGH	SMH	HRO	CCM	RCM	MRO	MRS	MTR	LRO	RRM	RMR	RLR	RRL	RTH
Gas	249	50	50	8	8	8	8	10	10	8	17	27	16	16	15
Electric	652	223	196	227	179	164	153	114	92	84	73	59	38	34	13

Figure 23. Site A: EE Package with PV Option - TDVI per Space-Use Type
Source: National Energy Center for Sustainable Communities



	FSR	MRS	SMH	LGH	MTR	CCM	RCM	MRO	LRO	HRO	RRM	RRL	RMR	RLR	RTH
Gas	249	10	50	50	10	8	8	8	8	107	17	16	27	16	15
Electric	817	359	259	251	290	209	202	202	182	50	96	89	78	77	72

Figure 24. Site A: EE Package with DG Option - TDVI per Space-Use Type
Source: National Energy Center for Sustainable Communities

3.1.5. Site A: Composite Results - Economics and Summary Tables

Tables 28 through 31 provide comparison of the three modeled options and the builder proposed baseline development option relative to energy consumption, emissions, and economics. Table 28 indicates that implementation of the recommended economically feasible EE options could lower Site A annual utility costs by $1,704,589 or 11.3%. Simple payback on the investment necessary to implement the EE options in Site A would be 5.9 years with a return-on-investment (ROI) of 16.9%.

Table 28. Impacts of EE Package vs. Builder Baseline

Parameter	Baseline	EE Package	% Savings
TDVI (kBtu/sqft-yr)	217	190	12.3%
Electricity (kWh/yr)	71,575,322	63,706,917	11.0%
Electric Demand (Max MW)	19.809	16.478	16.8%
Gas (MMBtu/yr)	114,606	95,542	16.6%
Total Energy (MMBtu/yr)	358,821	312,910	12.8%
Emissions - CO2 (tonnes/yr)	30,924	27,174	12.1%
Emissions - SOx (tonnes/yr)	4.55	4.05	11.0%
Emissions - NOx (tonnes/yr)	16.93	14.79	12.6%
Energy Cost ($/yr)	$15,110,206	$13,405,617	11.3%
Simple Payback (years)	n/a	5.9	n/a
ROI (%)	n/a	16.9	n/a

Source: National Energy Center for Sustainable Communities

Table 29 indicates that enhancement of the EE option with PV could reduce Site A electric and natural gas annual utility costs by $4,879,683 or by 32.3% compared to the builder proposed baseline. Simple payback of the EE-PV option would be 12.4 years with a ROI of 8.1%.[41]

Table 29. Impacts of EE Package + PV vs. Builder Baseline

Parameter	Baseline	EE Package w/ PV	% Savings
TDVI (kBtu/sqft-yr)	217	152	30.0%
Electricity (kWh/yr)	71,575,322	47,003,474	34.3%
Electric Demand (Max kW)	19.809	14.045	29.1%
Gas (MMBtu/yr)	114,606	95,462	16.7%
Total Energy (MMBtu/yr)	358,821	255,838	28.7%
Emissions - CO2 (tonnes/yr)	30,924	21,403	30.8%
Emissions - SOx (tonnes/yr)	4.55	2.99	34.2%
Emissions - NOx (tonnes/yr)	16.93	12	29.3%
Energy Cost ($/yr)	$15,110,206	$10,230,523	32.3%
Simple Payback (years)	n/a	12.4	n/a
ROI (%)	n/a	8.1	n/a

Source: National Energy Center for Sustainable Communities

41 Assumes excess electricity generated by PV qualifies for net metering based utility credits. PV installation incentive of $2550/kW is applied.

Table 30 suggests that implementation of the EE-DG option could reduce Site A combined electric and natural gas annual utility costs by $2,412,065 or by 16% as compared to the builder proposed baseline option. Simple payback of the EE-DG option would be 7 years with a ROI of 14.3%.

Table 30. Impacts of EE Package + DG vs. Builder Baseline

Parameter	Baseline	EE Package w/ DG	% Savings
TDVI (kBtu/sqft-yr)	217	170	21.7%
Electricity (kWh/yr)	71,575,322	49,239,156	31.2%
Electric Demand (Max kW)	19.809	10.851	45.2%
Gas (MMBtu/yr)	114,606	236,634	-106.5%
Total Energy (MMBtu/yr)	358,821	404,638	-12.8%
Emissions - CO2 (tonnes/yr)	30,924	28,865	6.7%
Emissions - SOx (tonnes/yr)	4.55	3.17	30.3%
Emissions - NOx (tonnes/yr)	16.93	10.40	38.5%
Energy Cost ($/yr)	$15,110,206	$12,698,141	16.0%
Simple Payback (years)	n/a	7.0	n/a
ROI (%)	n/a	14.3	n/a

Source: National Energy Center for Sustainable Communities

However, as previously noted, economic calculations of the DG option were based on 2007 California Self Generation Incentive Program (SGIP) guidelines that provided a rebate of $600/kW for internal combustion (IC) engine-based CHP systems and a rebate of $800/kW for microturbine-based CHP systems. Subsequently, 2008 SGIP eliminated all DG rebates except for wind and fuel cell applications. That makes Site A DG analysis presented in this report more a "what if" analytical case than a valid energy efficiency option, since DG technology becomes economically unfeasible without rebates. The economics could potentially become more favorable over time in the advent of lower equipment costs and restored incentives.

Table 31 illustrates details of the Site A PV system[42] economics. The evaluated PV installations would total ~1,140 kW (dc) of installed capacity. The installation would reduce Site A annual electric utility cost by $3,073,567, including $336,520 in electricity exported back to the grid.

The simple payback for PV option alone (with no other EE measures included) would be 14.8 years with an ROI of 6.83%.

42 See Attachment I to review technical details/modeling assumption for PV based on-site power, p. 185.

Table 31. Details of PV* Economic Calculation

Standalone PV Economics		
Excess PV generated electricity exported to the utility grid	Exported Electricity (kWh/yr)	2,949,340
	Net Metering Credits ($/yr)	$336,520
	Net Value of PV Generated Electricty ($/yr)	$3,073,567
Economics of PV system (net value) includes value of net metering utility credits and direct savings from displacing grid supplied electricity	Raw PV installed cost	$73,309,641
	Incentive @ $2.55/watt	$29,136,469
	PV cost after Subsidy	$44,173,172
	PV O&M ($/yr)	$87,972
	Simple Payback	14.8
	ROI	6.8%

Notes: Approx. 1,140 kW (dc) of PV systems installed. Roof area available for PV varies from 25% to 60% depending on building prototype. PVinstalled costs as shown include metering and a switchgear.
Source: National Energy Center for Sustainable Communities

3.1.6. Site B: Energy - Gas and Electric Utility Use Impacts

Figure 25 below presents results of the four modeled development options for the 866 buildings in Site B relative to their impact on site-wide annual energy (gas and electric) consumption.

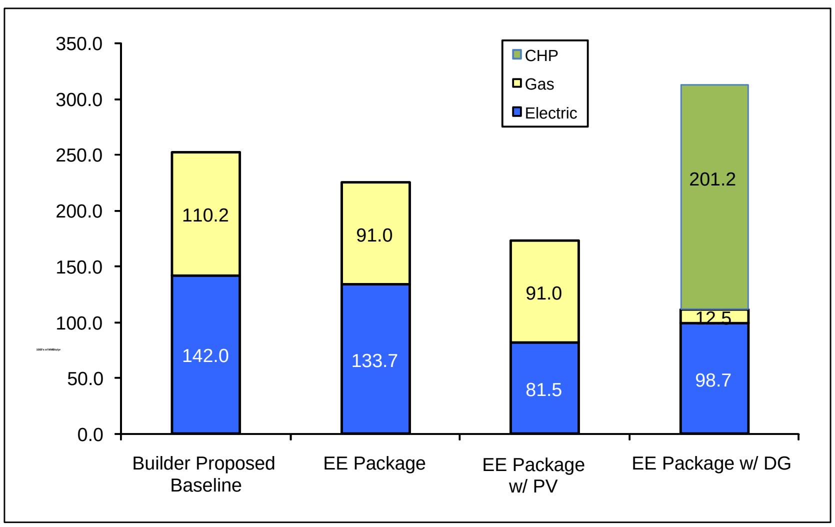


Figure 25. Total Annual Energy Consumption (all buildings)
Source: National Energy Center for Sustainable Communities

Analysis of the results indicates implementation of all applicable and economically feasible EE options could lower Site B annual energy consumption from the builder proposed baseline (BPB) of 252,200 MMBtu to 224,700 MMBtu or 10.9%. Implementation of the EE-PV option could further reduce electric grid and natural gas utility consumption to 172,500 MMBtu or 32.6% compared to the BPB option. Implementation of the EE-DG option would not be as effective as the EE-PV option in reducing Site B consumption of grid-provided electric energy. However, it could lower consumption to 98,700 MMBtu from the 133,799 MMBtu expected from use of the EE option alone. On the other hand, natural gas consumption would increase significantly, reaching 237,000 MMBtu as compared to 95,000 MMBtu for the EE option. The increase results in the highest natural gas consumption of any of the modeled scenarios.

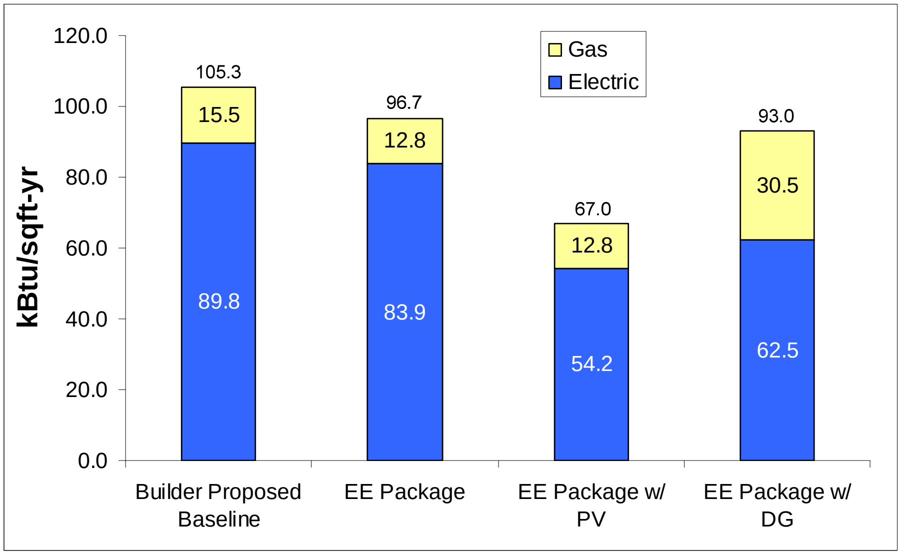


Figure 26. TDVI Energy Consumption (all buildings)
Source: National Energy Center for Sustainable Communities

Figure 26 indicates that implementation of the EE option could lower Site B TDVI energy consumption from the BPB option of 105.3 kBtu/sf-year to 96.7 kBtu/sf-year ,or a reduction of 8.2%. Implementation of the EE-PV option could further reduce TDVI to 67 kBtu/sf-year or by 36.4% compared with the BPB option. Implementation of EE-DG would not be as effective in reducing Site B TDVI energy consumption as EE-PV. However, while it increases consumption of low TDVI-valued fuel like natural gas, DG can significantly decrease the use of high TDVI-valued grid electricity.

Figure 27 and Table 32 present the performance and relative costs associated with the modeled development options. They indicate that implementation of the EE option would result in lowering Site B electric peak demand from the BPB option of 11.27 MW to 10.31 MW or 8.8%. Table 32 indicates this is the least expensive option ($8,265/kW) among those modeled. Implementation of EE-PV could further reduce electric peak demand to 9.44 MW or 16.2% compared to the BPB option. At $8,265/kW, this is the most expensive of the three analyzed options. Implementation of EE-DG could reduce Site B electric peak demand to 9.8 MW, slightly less than EE-PV but still 13% less than the BPB option. The cost of implementing the EE-DG option would be $10,771/kW. [43]

43 Based on incentives of $800/kW of installed DG. See footnote 6 of this report for an additional explanation.

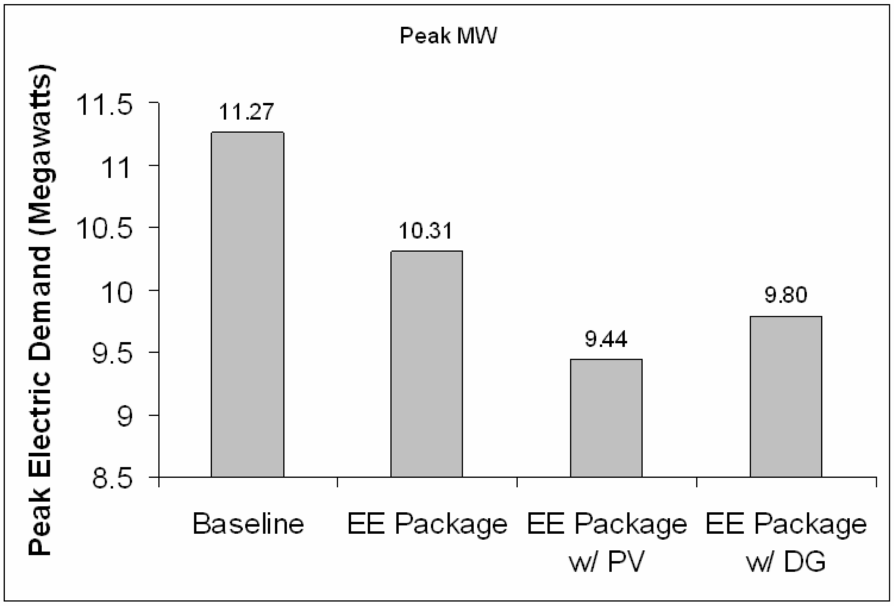


Figure 27. Peak Electric Demand (all buildings contributions)
Source: National Energy Center for Sustainable Communities

Table 32. Specific Cost of Electric Peak Demand Reduction

	Peak MW	Total Cost	$/kW for Reduced Peak Demand
Baseline	11.268	-	-
EE Package	10.308	$7,934,659	$8,265
EE Package w/ PV	9.442	$49,615,206	$27,172
EE Package w/ DG	9.797	$15,843,991	$10,771

Source: National Energy Center for Sustainable Communities

3.1.7. Site B: Environmental Impacts

Figures 28 to 30 present the annual air emission impacts associated with consumption of electricity and natural gas for each of the modeled options in Site B. The calculations assume end-use delivery efficiency of 92% for electricity and 98.4% for natural gas.

Figure 28 indicates that the EE option could lower Site B annual CO_2 emissions from the BPB option of 20,335 metric tons/ year to 18,459 metric tons/ year or 9.2%. Implementation of the EE-PV option could further reduce CO_2 emissions to 13,179 metric tons/ year or 35.2%. Implementation of EE-PG would not be effective in reducing Site B CO_2 emissions. At 21,393 metric tons/year, it would be 5.2% higher than the BPB emissions.

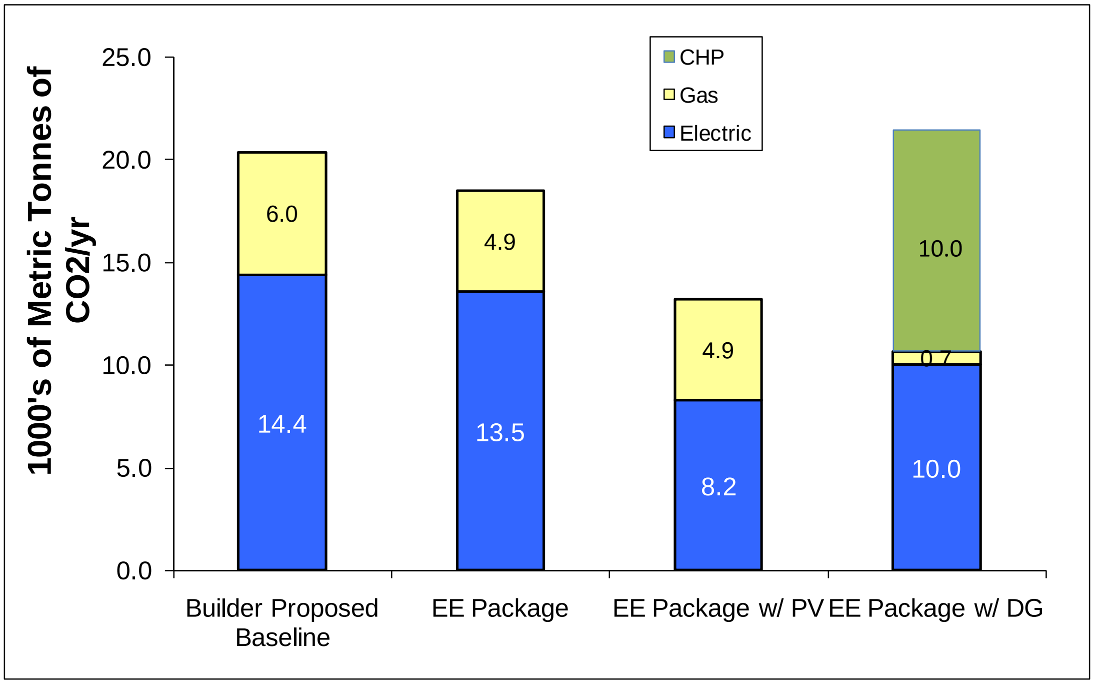
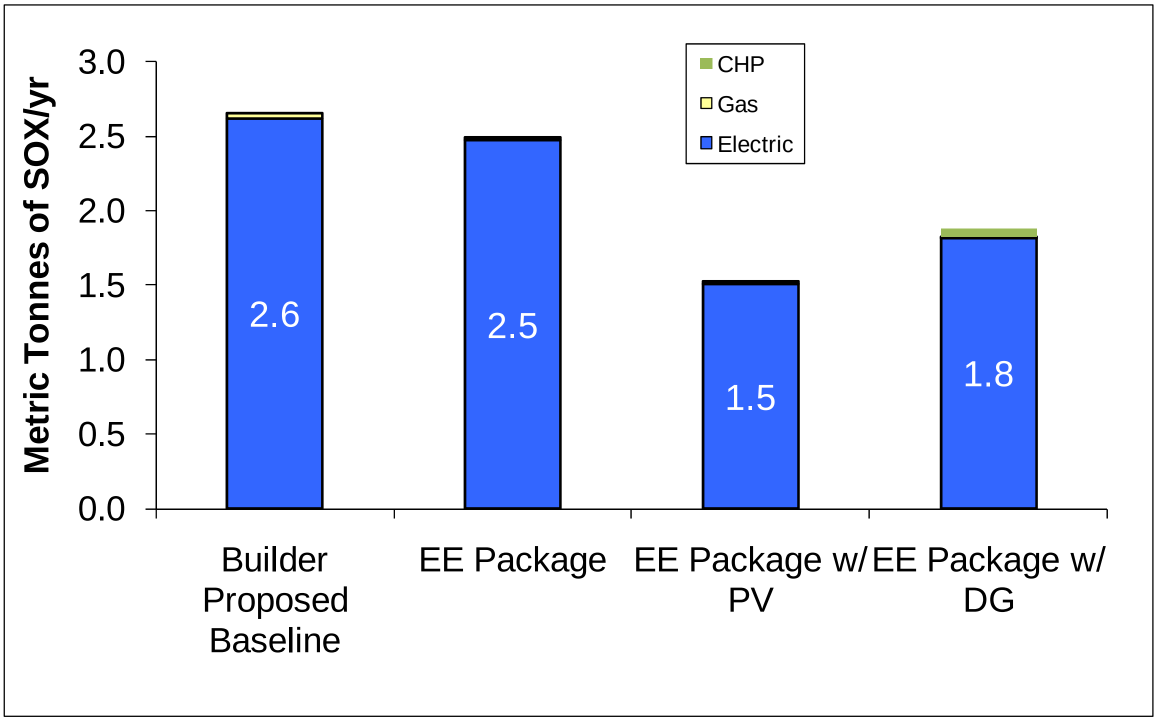


Figure 28. Total Annual CO_2 Emissions (all buildings contributions)
Source: National Energy Center for Sustainable Communities

Figures 29 and 30 show SO_x and NO_x emissions impacts. The EE option could lower Site A annual SO_x emissions to 2.5 metric tons/year from the baseline of 2.66 metric tons/ year or 6.0%. NO_x emissions would be 10.46 metric tons/year with the EE option vs. 11.69 metric tons/year for the baseline, a reduction of 10.5%.

Implementation of the EE-PV option could further reduce SO_x emissions to 1.53 metric tons/ year or 42.3%, and NO_x emissions to 7.88 metric tons/year or 32.5% as compared to the BPB baseline. Implementation of the EE-DG option could reduce Site B SO_x emissions to 1.88 metric tons/year or 29.1%. NO_x emissions at 5.97 metric tons/year could be 48.9% lower than the BPB baseline.



Note: Natural gas and CHP contributions to SOx emissions are too small to show on this chart

Figure 29. Total Annual SO_x Emissions (all buildings contributions)

Source: National Energy Center for Sustainable Communities

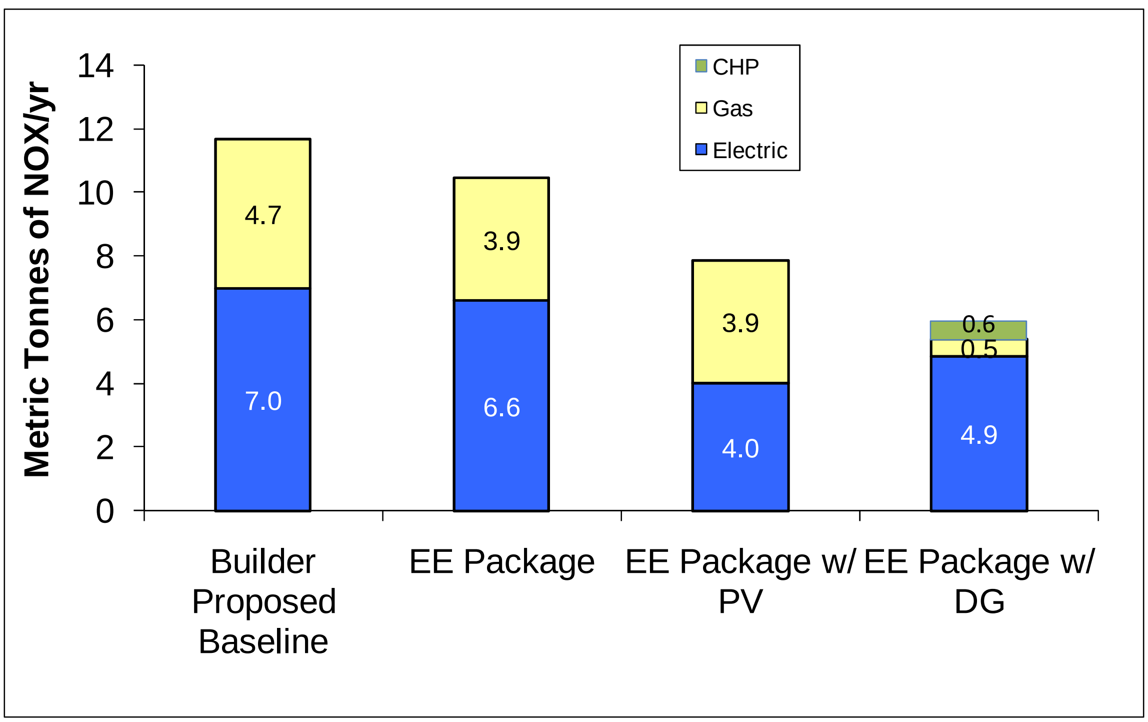


Figure 30. Total Annual NO_x Emissions (all buildings contributions)

Source: National Energy Center for Sustainable Communities

3.1.8. Site B: TDVI Impacts by Building Prototype

The charts and tables presented here illustrate which building prototypes are the most energy intensive and the degree to which they contribute to Site B annual energy consumption. The charts shown in Figures 31 to 34 provide the TDVI energy density for each of the five modeled building prototypes as well as total annual TDVI-based energy consumption for all buildings of the same type. Table 33 indicates the relative contribution each building prototype makes toward total TDVI energy consumption for Site B. Results are expressed as a utility-specific percentage (electric and gas) as well as a utility-specific percentage per total site TDVI.

In the builder proposed baseline configuration, the Gateway mixed-use residential /commercial building prototype has the highest TDVI, 98.9 kBtu/sf-year (Figure 31). All Gateway buildings contribute more than 62% of Site B TDVI (Table 33). Since the Gateway buildings contribute most to Site B TDVI energy consumption, this prototype would be considered the prime target for deployment of energy efficiency measures.

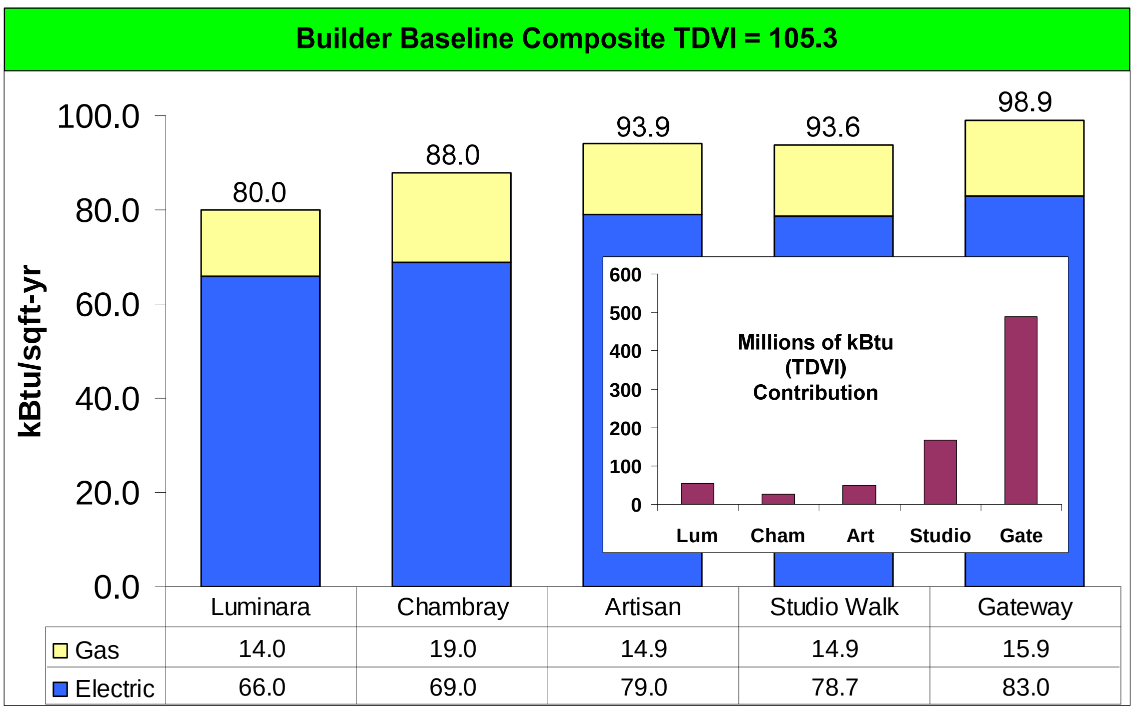


Figure 31. Site B: Builder Baseline - TDVI per Building Type
Source: National Energy Center for Sustainable Communities

Table 33. TDVI per Building Type (composite for prototype all end-use areas)

	Baseline	Elec. TDVI as % of Total Elec. TDVI	Gas TDVI as % of Total Gas TDVI	Elec. TDVI as % of Total Site TDVI	Gas TDVI as % of Total Site TDVI
1	Luminara	6.6%	8.1%	5.7%	1.2%
2	Chambray	3.0%	4.8%	2.6%	0.7%
3	Artisan	6.3%	6.1%	5.4%	0.9%
4	Studio Walk	21.6%	20.3%	18.4%	3.0%
5	Gateway	62.5%	60.6%	53.3%	8.9%

Source: National Energy Center for Sustainable Communities

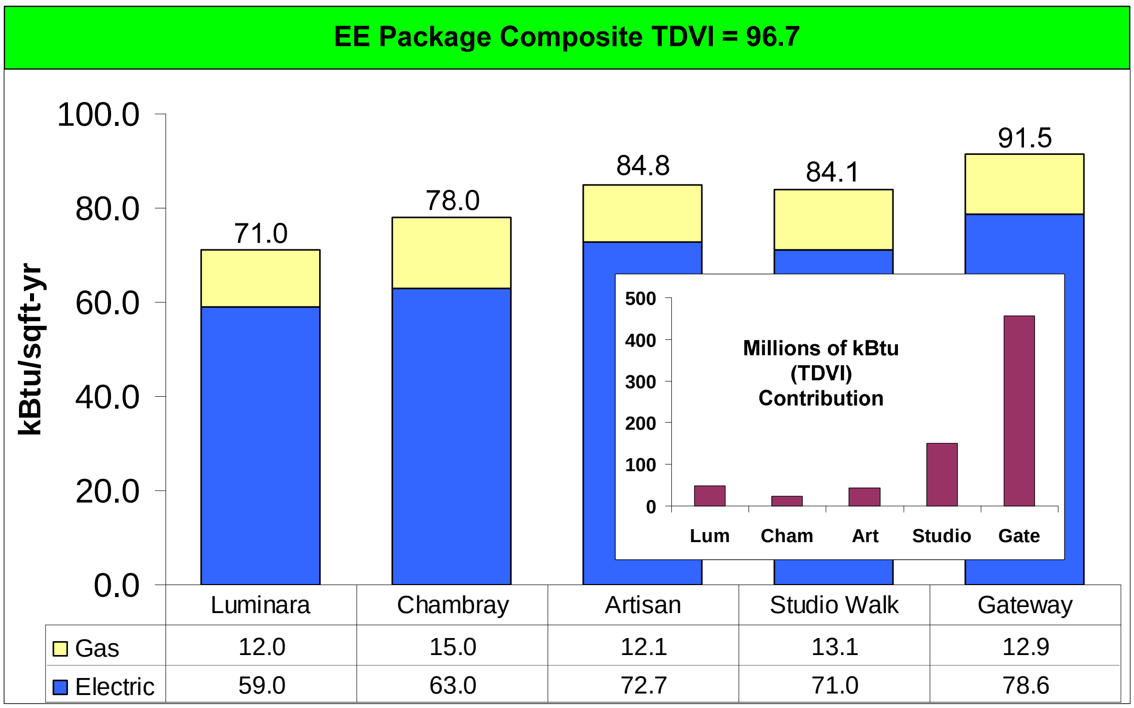


Figure 32. Site B: EE Packages Only Option - TDVI per Building Type

Source: National Energy Center for Sustainable Communities

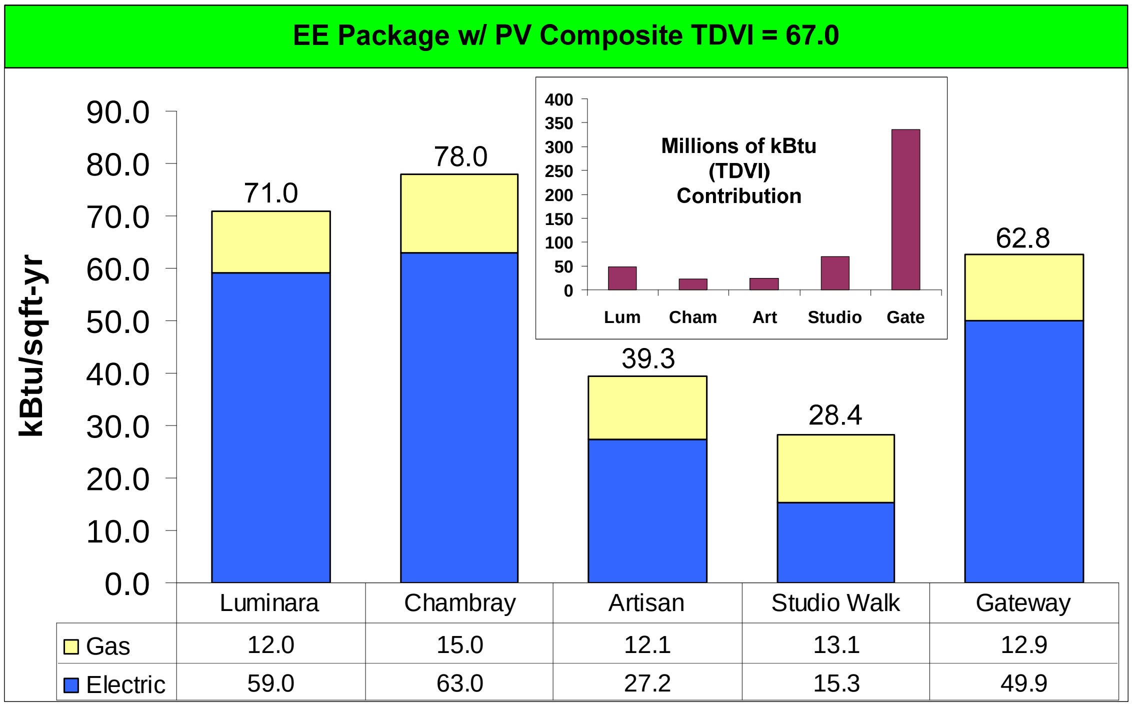


Figure 33. Site B: EE Package with PV Option - TDVI per Building Type
Source: National Energy Center for Sustainable Communities

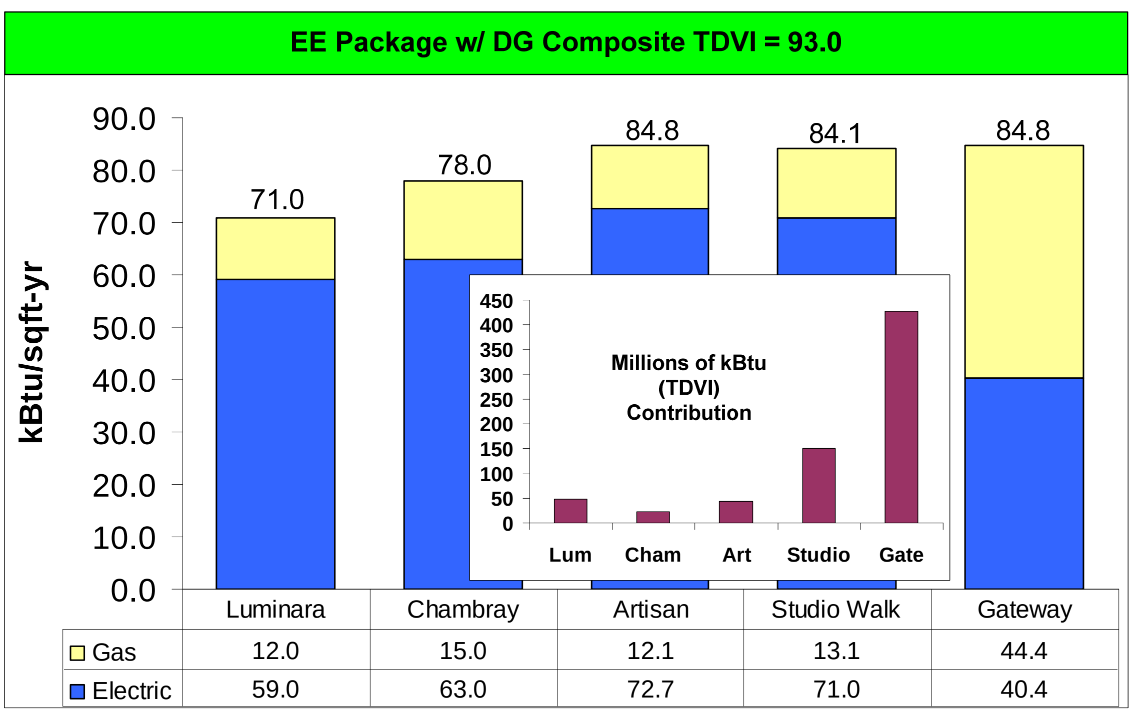


Figure 34. Site B: EE Package with DG Option - TDVI per Building Type
Source: National Energy Center for Sustainable Communities

3.1.9. Site B: TDVI Impacts by Space-Use Type

Figures 35 to 38 illustrate two space use types, residential and retail, as to energy intensity and the degree to which each contributes to Site B total annual energy consumption. The figures show TDVI energy density for residential and retail spaces as well as total annual TDVI- based energy consumption for all buildings of the same type. Table 34 indicates the relative contribution of each space use type toward total TDVI energy consumption for Site B. Table 34 expresses results as a utility-specific percentage (electric and gas) as well as a utility-specific percentage per total site TDVI.

As illustrated in Figure 35, retail spaces have very high TDVI energy consumption, 300.1 kBtu/sf-year, compared to 87.8 kBtu/sf-year for residential spaces. However, because Site B would consist of 4,270 residential units with a total of 6,776,027 s.f. of living space and only 357 retail store/commercial units representing a total of 296,259 s.f. of space, residential spaces contribute more than 74% of Site B TDVI (Table 34). Figures 36 to 38 portray the same profile.

Therefore, despite their lower specific TDVI energy consumption, residential spaces contribute most to Site B TDVI energy consumption and might be considered a prime target for deployment of selected energy efficiency measures.

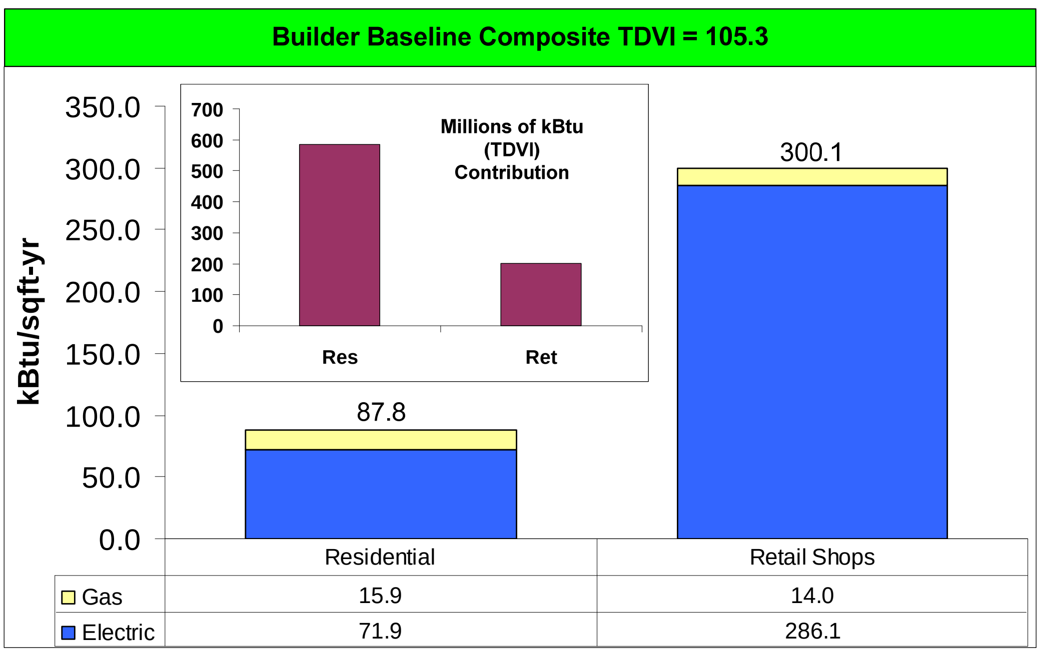


Figure 35. Site B: EE Builder Baseline - TDVI per Space-Use Type

Source: National Energy Center for Sustainable Communities

Table 34. Site B: TDVI per End-Use Area (composite for all buildings types)

Baseline	Elec. TDVI as % of Total Elec. TDVI	Gas TDVI as % of Total Gas TDVI	Elec. TDVI as % of Total Site TDVI	Gas TDVI as % of Total Site TDVI
Residential	71.6%	8.1%	61.0%	13.5%
Retail Shops	28.4%	4.8%	24.2%	1.2%

Source: National Energy Center for Sustainable Communities

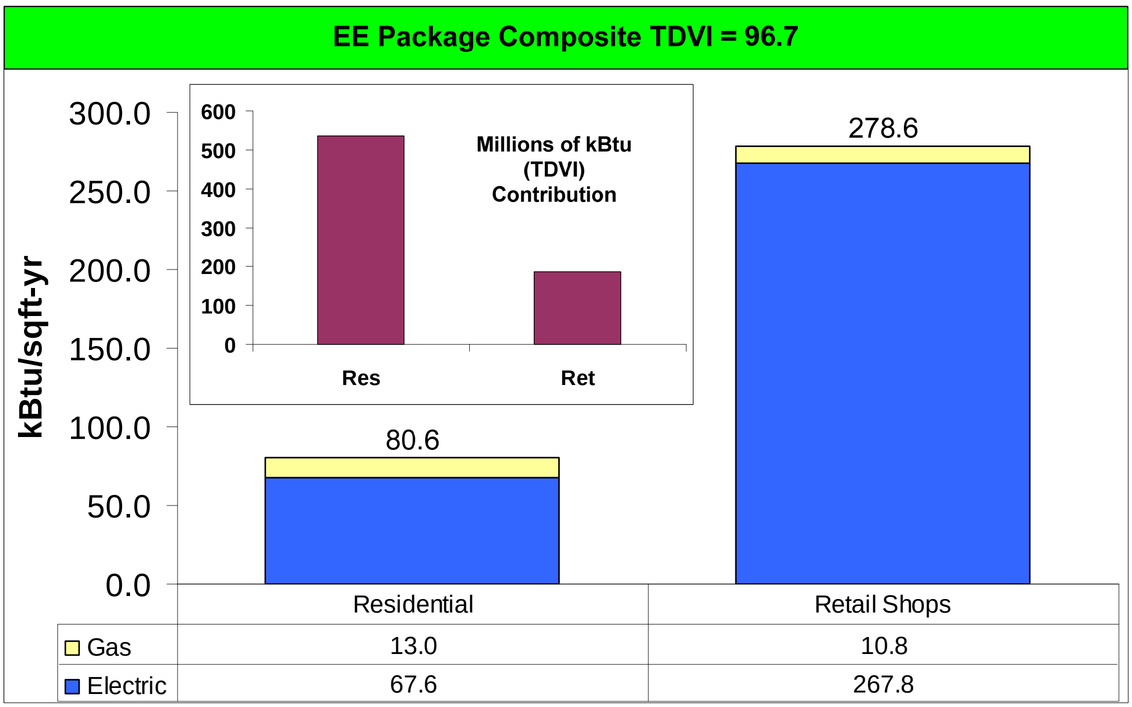


Figure 36. Site B: EE Package Option - TDVI per Space-Use Type

Source: National Energy Center for Sustainable Communities

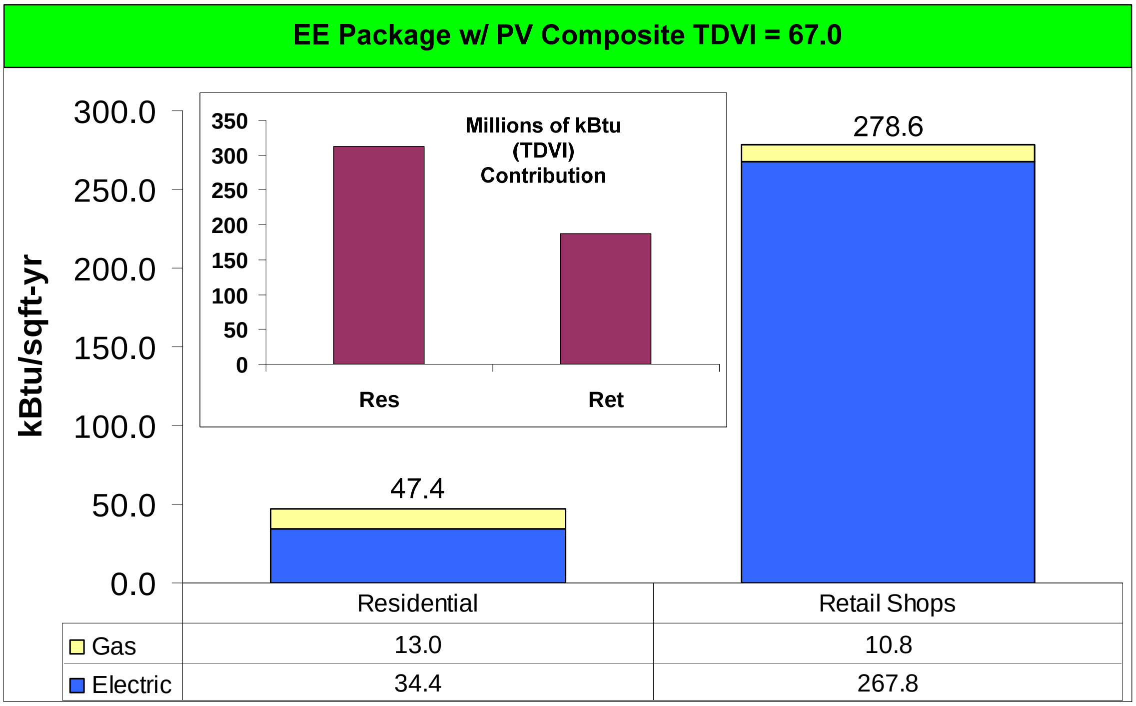


Figure 37. Site B: EE Package with PV Option - TDVI per Space-Use Type
Source: National Energy Center for Sustainable Communities

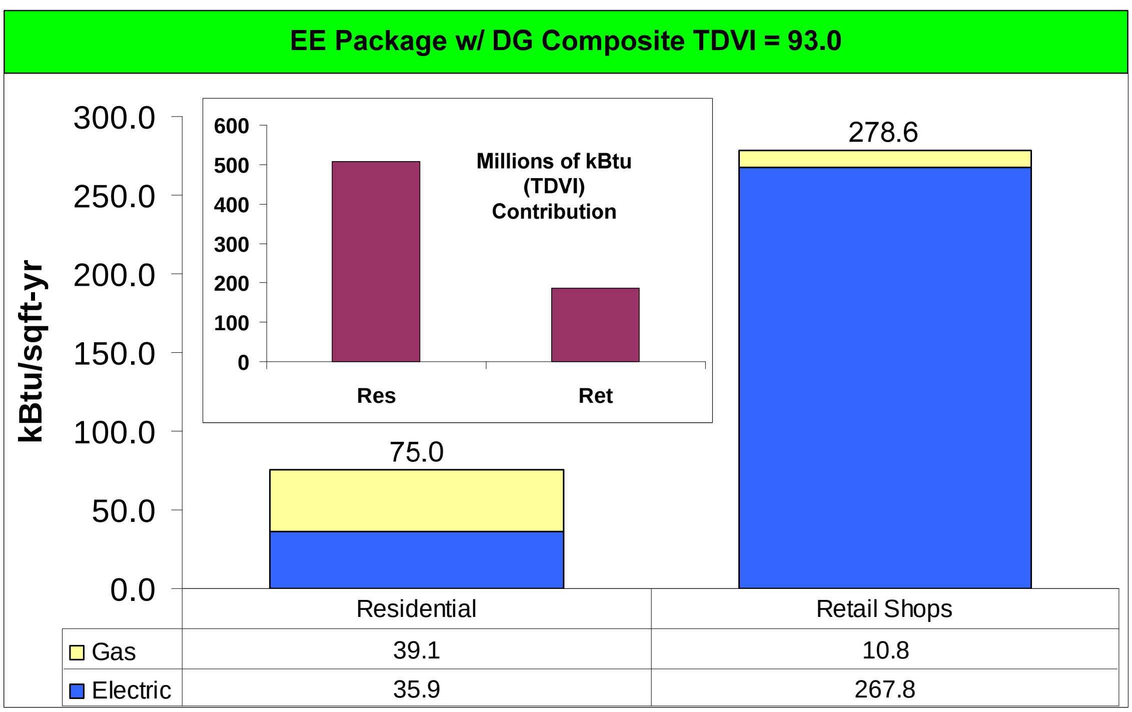


Figure 38. Site B: EE Package with DG Option - TDVI per Space-Use Type
Source: National Energy Center for Sustainable Communities

3.1.10. Site B: Composite Results - Economics and Summary Tables

Tables 35 through 38 compare energy consumption, emissions, and economics of the three modeled options and the builder proposed baseline option. Previous sections of this report discussed the first nine parameters in each table. Therefore, only the economic parameters will be discussed here.

Table 35 indicates implementation of the recommended economically feasible EE options could lower Site B annual utility costs by $812,155 or by 6.8%. Simple payback on the investment necessary to implement EE options would be 9.8 years with a ROI of 10.2%. Supplementing the EE option with PV (Table 36) could reduce Site B electric and natural gas annual utility costs by $3,346,177 or by 27.9% compared to the BPB option. Simple payback of the EE-PV option would be 14.8 years with a ROI of 6.7%.[44]

Table 35. Impacts of EE Package vs. Builder Baseline

Parameter	Baseline	EE Package	% Savings
TDVI (kBtu/sqft-yr)	105.29	96.71	8.2%
Electricity (kWh/yr)	41,603,751	39,182,298	5.8%
Electric Demand (Max MW)	11.27	10.31	8.5%
Gas (MMBtu/yr)	110,164	90,968	17.4%
Total Energy (MMBtu/yr)	252,116	224,658	10.9%
Emissions - CO2 (tonnes/yr)	20,335.17	18,458.70	9.2%
Emissions - SOx (tonnes/yr)	2.66	2.50	6.0%
Emissions - NOx (tonnes/yr)	11.69	10.46	10.5%
Energy Cost ($/yr)	$11,983,344	$11,171,189	6.8%
Simple Payback (years)	n/a	9.8	n/a
ROI (%)	n/a	10.2	n/a

Source: National Energy Center for Sustainable Communities

44 Assumes excess electricity generated by PV qualifies for net metering based utility credits. PV installation incentive of $2550/kW is applied.

Table 36. Impacts of EE Package + PV vs. Builder Baseline

Parameter	Baseline	EE Package w/ PV	% Savings
TDVI (kBtu/sqft-yr)	105.29	66.99	36.4%
Electricity (kWh/yr)	41,603,751	23,889,289	42.6%
Electric Demand (Max MW)	11.27	9.44	16.2%
Gas (MMBtu/yr)	110,164	90,968	17.4%
Total Energy (MMBtu/yr)	252,116	180,010	28.6%
Emissions - CO2 (tonnes/yr)	20,335.17	13,178.60	35.2%
Emissions - SOx (tonnes/yr)	2.66	1.53	42.3%
Emissions - NOx (tonnes/yr)	11.69	7.88	32.5%
Energy Cost ($/yr)	$11,983,344	$8,637,167	27.9%
Simple Payback (years)	n/a	14.8	n/a
ROI (%)	n/a	6.7	n/a

Source: National Energy Center for Sustainable Communities

Table 37 indicates implementation of the EE-DG option could reduce Site B combined electric and natural gas annual utility costs by $2,378,368 or by 19.8% as compared to the BPB option. Simple payback of the EE-DG option would be 6.7 years with a ROI of 14.9%. However, as previously noted, economic calculations of the DG option were based on 2007 CA SGIP guidelines that provided a rebate of $800/kW for microturbine-based systems with heat recovery. The 2008 SGIP eliminated all DG rebates except for wind and fuel cell applications. This again makes Site B DG analysis more a "what if" analytical case than a valid energy efficiency option, since DG technology becomes economically unfeasible without the rebates. However, over time the economics could become more favorable with the advent of lower equipment cost and the return of incentives.

Table 38 illustrates the economics of Site B PV system deployment.[45] The evaluated PV installations would total ~10,760 kW (dc) of installed capacity. This would require that approximately 45% of available roof areas for all prototype buildings 3, 4, and 5 be used for PV systems. Simple payback for the PV option alone (no other EE measures included) would be 13.8 years with a ROI of 7.3%.

45 See page Appendix=B of this report to review technical details / modeling assumption for PV based on-site power

Table 37. Impacts of EE Package + DG vs. Builder Baseline

Parameter	Baseline	EE Package w/ DG	% Savings
TDVI (kBtu/sqft-yr)	105.29	92.95	11.7%
Electricity (kWh/yr)	41,603,751	28,920,574	30.5%
Electric Demand (Max MW)	11.27	9.80	13.1%
Gas (MMBtu/yr)	110,164	213,695	-94.0%
Total Energy (MMBtu/yr)	252,116	312,372	-23.9%
Emissions - CO2 (tonnes/yr)	20,335.17	21,393.10	-5.2%
Emissions - SOx (tonnes/yr)	2.66	1.88	29.1%
Emissions - NOx (tonnes/yr)	11.69	5.97	48.9%
Energy Cost ($/yr)	$11,983,344	$9,604,976	19.8%
Simple Payback (years)	n/a	6.7	n/a
ROI (%)	n/a	14.9	n/a

Source: National Energy Center for Sustainable Communities

Table 38. Details of PV* Economic Calculation

Standalone PV Economics		
Excess PV generated electricity exported to the utility grid	Exported Electricity (kWh/yr)	4,979,410
	Net Metering Credits ($/yr)	$568,151
	Net Value of PV Generated Electricty ($/yr)	$3,102,173
Economics of PV system (net value) includes value of net metering utility credits and direct savings from displacing grid supplied electricity	PV Raw installed cost	$69,071,395
	Incentive @ $2.55/watt	$27,452,004
	PV cost after Subsidy	$41,619,391
	PV O&M ($/yr)	$82,886
	Simple Payback	13.8
	ROI	7.3%

* Total of ~10,760 kW (dc) of PV systems installed on 45% of the roof areas of prototypes 3 to 5.

Source: National Energy Center for Sustainable Communities

3.2. Utility Impacts

This section of the results addresses the following research objective:

- Determine the extent to which application of these technologies in typical development projects would reduce peak demand and result in better utilization of existing utility infrastructure.

As in the preceding discussion, this section presents results of electric and natural gas utility impacts for each modeled option for the two development sites.

3.2.1. Site A: Electric Utility Impacts

Distribution planners at San Diego Gas & Electric Company conducted utility impact analysis after reviewing all the load profiles generated by researchers for each of the modeled development options for Site A.

Results of the analysis indicate estimated demand load for the site as planned by the builder (BPB development option) would be 19.8 MW. Implementation of the EE development option (energy-efficient lighting, insulation, windows, roof materials, and HVAC systems) would permanently reduce distribution system demand load by 3.3MW or 17.4%.

Implementation of the EE-PV option in Site A would reduce demand during sunny periods from approximately 9am to 6pm. The estimated reduction would be approximately 2.4 MW or a 12% reduction from the 19.8 MW load demand for the site. However, PV produces energy intermittently, and high residential circuit loads have peak demand during the weekday between 6pm and 9pm. Therefore, the PV option would not affect residential peak demand.

Implementation of the DG development option would produce a 5.63 MW or 28% reduction in Site A load demand. However, the DG systems would have to be available 100% of the time with N-1[46] redundancy designed into the system to eliminate additional electric distribution planning to serve the required capacity for the site.

Estimated demand of close to 20 MW would require three distribution circuits and associated electric facilities. Three circuits would provide capacity and reliability if an N-1 condition such as loss of one circuit occurs.

The estimated impact of the EE development option would still require three circuits to provide both capacity and reliability if an N-1 condition occurred. However, average circuit loading would decrease from 6.6MW to 5.5 MW. Additionally, substation loading would decrease by 3.3 MW or 11%. All substation electric facilities would remain unchanged.

The estimated impact of the EE-PV development option would also still require three circuits to provide both capacity and reliability in the event of an N-1 condition. Planned circuit loading would be the same as with the EE option in the event solar energy was not available. However, during periods of PV operation, loading would decrease to 4.7 MW. Substation transformer bank loading would decrease by 5.76 MW or 19.2%. All substation electric facilities would remain unchanged.

The estimated impact of the EE-DG development option, assuming 100% availability with an N-1 worse case scenario redundancy designed into the system, would reduce required circuitry from three to two and reduce associated electrical facilities as well. The average load on the two

46 An N+1 redundancy is a system configuration in which multiple components (N) have at least one independent backup component to ensure system functionality continues in the event of a system failure. To be at a level of N+1, the overall system integrity should not be impacted by the failure of any one component, and should continue to function at acceptable performance levels after the loss of any component.

circuits would be 5.4 MW each. Two circuits and associated electrical facilities would provide sufficient capacity and reliability if an N-1 condition resulted. Under the same assumptions, the substation transformer bank loading would decrease by 8.96 MW or 30%. One less circuit would be installed at the substation. However, all other substation electrical facilities would remain unchanged.

3.2.2. Site A: Gas Utility Impacts

Similar to the electric utility impact analysis, SDG&E natural gas distribution planners reviewed all load profiles generated by the researchers to determine distribution piping, pressures, and regulators necessary to serve Site A.

The analysis required design of alternative piping systems under the different development options. These are contained in Appendices C through G. The first design (Appendix A) shows the existing natural gas utility infrastructure at the development site. The second design (Appendix B) shows a conventional or "baseline" piping layout (described in Chapter 2) to meet SDG&E-estimated demand for Site A buildings. The third design (Appendix C) shows an optimized piping layout designed to meet the loads of the researchers' modeled EE development option. The fourth and fifth designs (Appendices D and G) show the optimized piping layout designed to meet the modeled EE-DG loads. Since the EE-PV development option does not affect natural gas usage at the site, researchers did not do a gas distribution layout nor conduct analysis.

Tables 39 through 41 provide the cost of providing gas mains to serve SDG&E-estimated demand scenarios and researchers' EE and EE-DG development options for Site A. Appendices B, E, and G contain the necessary piping pressures for the combined sites A and B.

Table 39. Site A: Pipe Sizing and Costs – SDG&E Conventional Plan

Site A: SDG&E-Estimated Baseline Loads w/ Conventional Plan & Pipe Sizing		
Pipe Size	Pipe Footage	Cost $
2-Inch	5148	$200,769
3-Inch	9336	$420,137
4-Inch	8392	$469,927
6-Inch	3811	$255,340
Total	26687	$1,346,172

=Source: National Energy Center for Sustainable Communities

Table 40. Site A: Pipe Sizing and Costs – Optimized Plan for the EE Option

Site A: EE Option Loads with an Optimized Plan & Pipe Sizing		
Pipe Size	Pipe Footage	Cost $

2-Inch	22876	$892,157
3-Inch	551	$24,809
4-Inch	3260	$182,545
6-Inch	0	$0
Total	26687	$1,099,512

Source: National Energy Center for Sustainable Communities

Table 41. Site A: Additional EE-DG Costs Requirements

Additional Cost Requirement to Accommodate Distributed Generation Loads	
Distribution Regulator Station	$250,000

Source: National Energy Center for Sustainable Communities

Analysis of the tables and appended plans suggests a significantly lower natural gas demand for the EE development option. Piping system costs are also lower since there are fewer large pipe sizes, although the total piping length remains the same as for SDG&E-estimated loads. However, the addition of DG to the EE option results in an additional capital requirement of $3, 340 over the SDG&E conventional distribution plan capital requirement.

3.2.3. Site B: Electric Utility Impacts

Results of the analysis indicate estimated demand load for the site as planned by the builder (BPB development option) is 11.27 MW. Implementation of the EE development option would reduce demand load to 10.31 MW. Both of these loads would require two circuits. Utility planners believe the approximately one MW reduction produced by the EE development option over the baseline option could influence future circuit needs if developers planned similar high efficiency measures for adjacent areas. However, given the modest scale of the estimated load reductions for the modeled development options at Site B and concerns for system capacity and reliability, the utility would not alter its distribution plans for the site.

Most utility substations currently provide 120 MVA (megavolt amperes - one million volt amperes) of capacity through four transformer banks at approximately 30 MVA each. This capacity equates to a maximum of 16 circuits per substation averaging 7.5MW per circuit or 375 amps at 12 kV. Ties between circuits allow alternative feeds in the event of an outage. Circuits have reserve capacity for these contingencies. Due to heavier loading in denser areas such as the Site B development, the utility would typically reduce the number of circuits from the substation to 12 -14 circuits to provide flexibility to serve areas from other circuits when an outage occurs.

As in the Site A example, the utility would not include PV or DC technology for planning purposes, citing inability to rely on PV or DG for peak situations. These resources may be included in future planning if more redundancy, physical assurance, and confirmed impact on peak are present.

3.2.4. Site B: Gas Utility Impacts

As in the electric utility impact analysis, SDG&E natural gas distribution planners reviewed all load profiles generated by the researchers to determine the necessary distribution piping, pressures, and regulators necessary to serve the Site B development.

Tables 42 through 44 provide overall results related to the cost of providing gas mains to serve the SDG&E-estimated demand scenario and researchers' EE and EE-DG development options for Site B. Appendices B, E, and G contain the necessary piping pressures for the combined Sites A and B.

Table 42. Site B: Pipe Sizing and Costs – SDG&E Conventional Plan

Site B: SDG&E-Estimated Baseline Loads w/ Conventional Plan & Pipe Sizing		
Pipe Size	Pipe Footage	Cost $
2-Inch	12027	$469,058
3-Inch	1115	$50,172
4-Inch	843	$47,199
6-Inch	1465	$98,146
Total	15450	$664,575

Source: National Energy Center for Sustainable Communities

Table 43. Site B: Pipe Sizing and Costs – Optimized Plan for the EE Option

Site B: EE Option Loads with an Optimized Plan & Pipe Sizing		
Pipe Size	Pipe Footage	Cost $
2-Inch	13142	$512,541
3-Inch	2308	$103,846
4-Inch	0	$0
6-Inch	0	$0
Total	15450	$616,387

Source: National Energy Center for Sustainable Communities

Table 44. Site B: Additional EE-DG Costs Requirements

Additional Cost Requirement to Accommodate Distributed Generation Loads	
Distribution Regulator Station	$250,000

Source: National Energy Center for Sustainable Communities

Analysis of the tables and the appended plans suggests a less significant but still lower natural gas demand for the EE development option. Piping system costs, given the reduction in number of larger pipe sizes, would also be lower, although the total piping length remains the same. However, addition of DG to the EE option results in an additional capital requirement of $201,812 over the SDG&E conventional distribution plan capital requirement.

3.3. Technology Construction Impacts and Market Feasibility

This section addresses the following research objective:

- Determine market-feasible combinations of energy technology and design options that will increase building energy efficiency by more than 25% above 2005 Title 24 Building Energy Efficiency Standards.

More specifically, this section provides results of analyses conducted on construction and market feasibility of the modeled energy technology options. The following section covers market feasibility of the community design options.

As explained in Chapter 2, this assessment included an analysis of construction process impacts of technologies as well as assessment of potential cost offsets and reductions in payback period from utility company incentives. Results of these analyses are presented independently, followed by a discussion of overall market feasibility.

3.3.1. Construction Process Feasibility Assessment

This assessment consisted of four steps as outlined in Chapter 2. This section presents the results of each step.

Evaluation and characterization of process implications

Attachment I, Site A modeling assumptions,) presents a number of alternates for a variety of building systems, including the external walls, roofing, fenestrations, mechanical systems, appliances, and generating systems. Researchers studied specific changes implied by each alternate to determine the process implications. They characterized these implications as one or more of the following types (Table 45), based on an initial assessment of the alternates:

- <u>Product substitution</u>–The alternate requires a product used in the base case be replaced with a different product. Implications of this kind of alternate are minimal, subject to assumptions of similar product availability and lead time. These assumptions appear to be appropriate for the cases included in this research. An example of product substitution is the replacement of a standard air conditioning unit with a higher SEER unit. The same building trades are involved in the same order, but the specific unit that will be set on the anchor bolts is different. There may be lead-time implications, but the sourcing process can address this issue. Alternates considered for this project do not include items with dramatically different supply chain conditions than the normal product, so lead-time concerns are not expected.

Table 45. Summary of Construction Impacts of Alternative Building Elements

Building Component	Alternative Type	Process Impacts	Comments
External Walls	Alt 1 & 2: Material substitution	Minimal	Captured by material and/or labor delta
	Alt 3: Additional step (rigid insulation), multiple trades	Interface/ tolerance trade interaction	Interview and modeling required
Roofing (Prototype 6)	Alt 1 & 2: Add'l step (rigid insulation) TBD trade	Trade interaction	Interview and modeling required
	Alt 3: Additional step (rigid insulation), multiple trades, add'l step (elastomeric) same trade	Trade interaction, minimal for elastomeric	Similar to above plus material and labor delta
Roofing (all others)	Alt 1 & 2: Material substitution	Minimal	Captured by material and/or labor delta
	Alt 3 (where present): add'l step (elastomeric) same trade	Minimal	Captured by material and/or labor delta
Windows	Product substitution	Minimal	Captured by material and/or labor delta
HVAC	Product substitution	Minimal	Captured by material and/or labor delta
Space Heating	Product substitution	Minimal	Captured by material and/or labor delta
Appliances	Product substitution	Minimal	Captured by material and/or labor delta
Lighting	Product substitution or arrangement	Minimal	Captured by material and/or labor delta
On-site power generation	Additional system, new trade involved	Minimal to the building package system	Captured by material and/or labor delta

Source: National Energy Center for Sustainable Communities

- Additional step, same trade–A trade-based subcontractor within the overall production system must conduct an additional activity, but does not add a handoff to an additional trade. This is a minor disruption and just means a given subcontractor will have control of a given area of the project for a longer time. This impact can be estimated effectively.

- Additional step, multiple trades– Some trade-based subcontractors have additional steps, and new handoffs exist within the production system. This is a more serious disruption and requires additional analysis.

From Table 45, the majority of building component alternates contemplated for the development scenarios are substitutions of one material or equipment for another. The process implications of such a change are minimal. Thus, expected cost differentials for the alternate are the difference in cost for the item being replaced over the base case item plus any difference in labor or equipment requirements to install the alternate item. This research did not study lead time or material availability differences which might have overall process implications. The specific replacements contemplated by the set of alternates proposed in this work are not expected to have significant lead time or availability implications.

Selection of potentially disruptive alternates

Exceptions to the general rule of little potential for process disruption are the external wall alternates, including rigid insulation and roofing systems for Prototype 6. Researchers studied the alternatives to evaluate potential cost implications of the resulting process disruptions.

3.3.2. Process Mapping and Estimation of Cost Impacts

The most important tool in process analysis is the development of process maps. Process analysis uses maps in a number of ways, including assisting in visualizing the process, communicating the process, and providing material for quantitative analysis of the process or simulation. The visualization component is particularly cogent here to compare process maps for two different building alternates to determine the changed handoffs or additional steps.

The information needed for creation of process maps includes the steps in the process, the entities that conduct those steps, and the process logic. In this context, process logic refers to an understanding of the steps that must be completed for a given step to begin. Literature sources and one or a combination of three basic methods (Damelio 1996) can provide information for creation of process maps: (1) self-generation by the individual creating the process map; (2) interviews with knowledgeable participants in the process contractors, subcontractors, suppliers, etc.; and (3) observation of the process. Although literature, self-generation, and observation provided some information for building alternate construction process mapping, one-on-one interviews were the major sources of information needed for process maps in this research.

The general process consisted of developing an initial map from self-generation and literature review. Researchers used this map to start the conversation in interviews conducted with project managers and estimators at commercial construction companies. They used a short description of the process map concept first and led to a discussion of the particular map being studied. Researchers asked the interviewee to consider the process map and to indicate areas where the map did not match their understanding of the process. The interview resulted in an improved map, which the researcher brought back for clarification and validation a few days later. Observations of the process in action at building sites provided a final opportunity to incorporate additional changes.

Process maps are graphical depictions of the steps that make up a process. However, the nature of the steps composing the process can be variable. Thus, representative symbols that visually designate activities, buffers, transportation, communication, decisions, and other operations are used in process maps to determine inefficiencies. Descriptions added to these symbols provide further information on the type of activity or inspection. Arrows connect each symbol in sequence in the process map. For the level of analysis needed for this study, researchers used simplified symbolization consisting of circles to represent the beginning and end-point of a particular process, rectangles to represent activities conducted during the process, and arrows to outline the process logic. Process logic also involves placing activities into a rough temporal order from left to right.

The type of process map used in the building alternate process mapping effort is a cross-functional map. Cross-functional process maps depict how activities within a given process cut across several functions or entities (Damelio 1996). This type of map shows the sequence of steps of the process, as well as the functions or entities responsible for these steps. The functions or entities can be from within one company–such as different departments of the same company–or, as in the case of processes in the building industry, from several companies–such as the general contractor, trade contractors, inspectors, etc. This type of identification of responsible parties in construction processes is a very useful mechanism that helps identify complexities involved in the process, particularly identification of handoffs.

In cross-functional process maps, each department or entity is assigned one row or swimlane. This row depicts all responsibilities of that department or entity. In this case, the rows or swimlanes provide a means to relate the activities of a given trade contractor. The process logic can be represented by location of activities from left to right and between arrows, and handoffs are clearly identified when arrows cross boundaries between lanes. Figure 39 presents the process map for the base case external wall process. The same map would be appropriate for Alternate 3 (rigid exterior insulation) where the exterior veneer is plaster. Figure 40 presents this scenario.

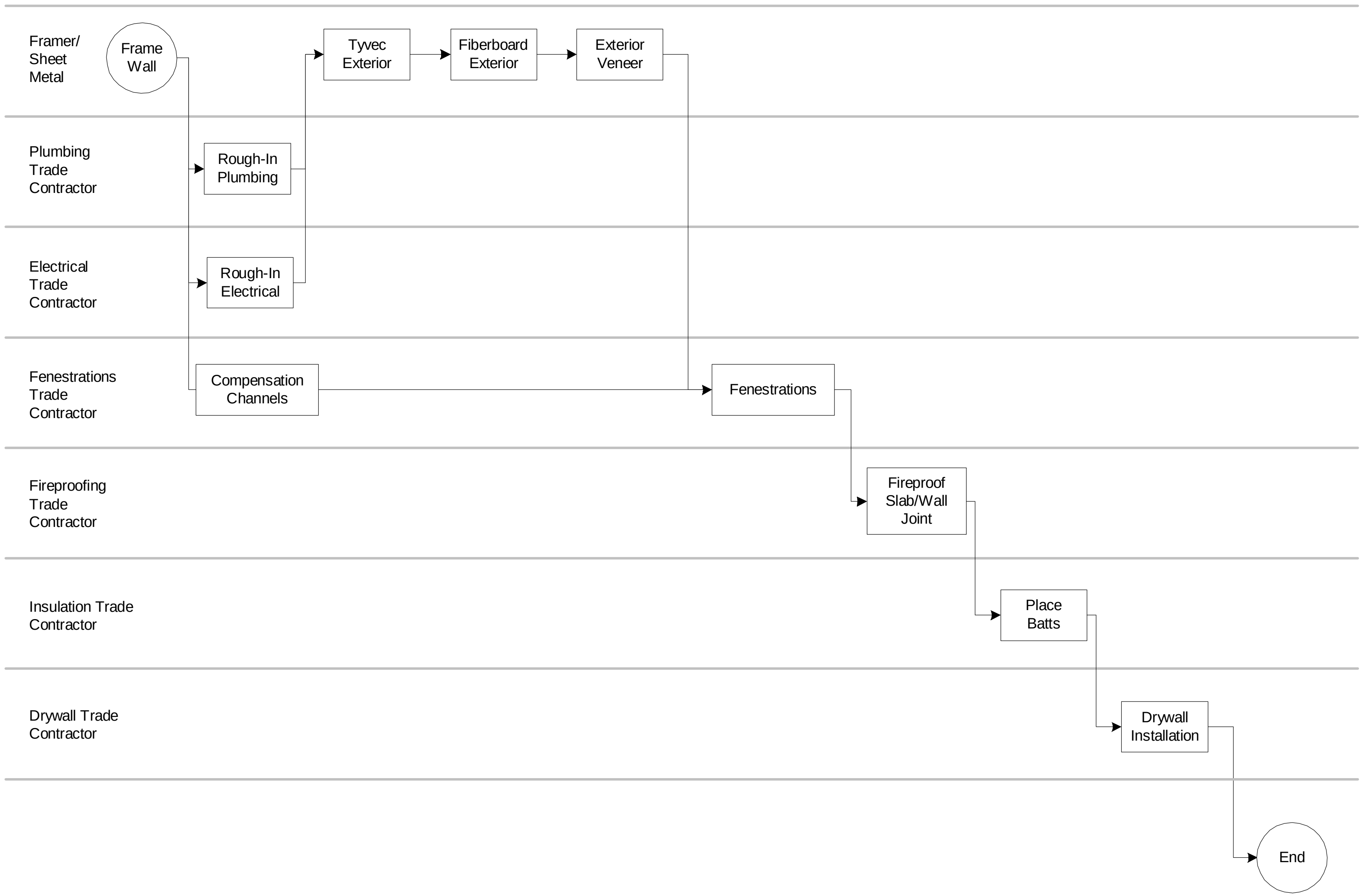


Figure 39. Base Case External Wall Process Map

Source: National Energy Center for Sustainable Communities

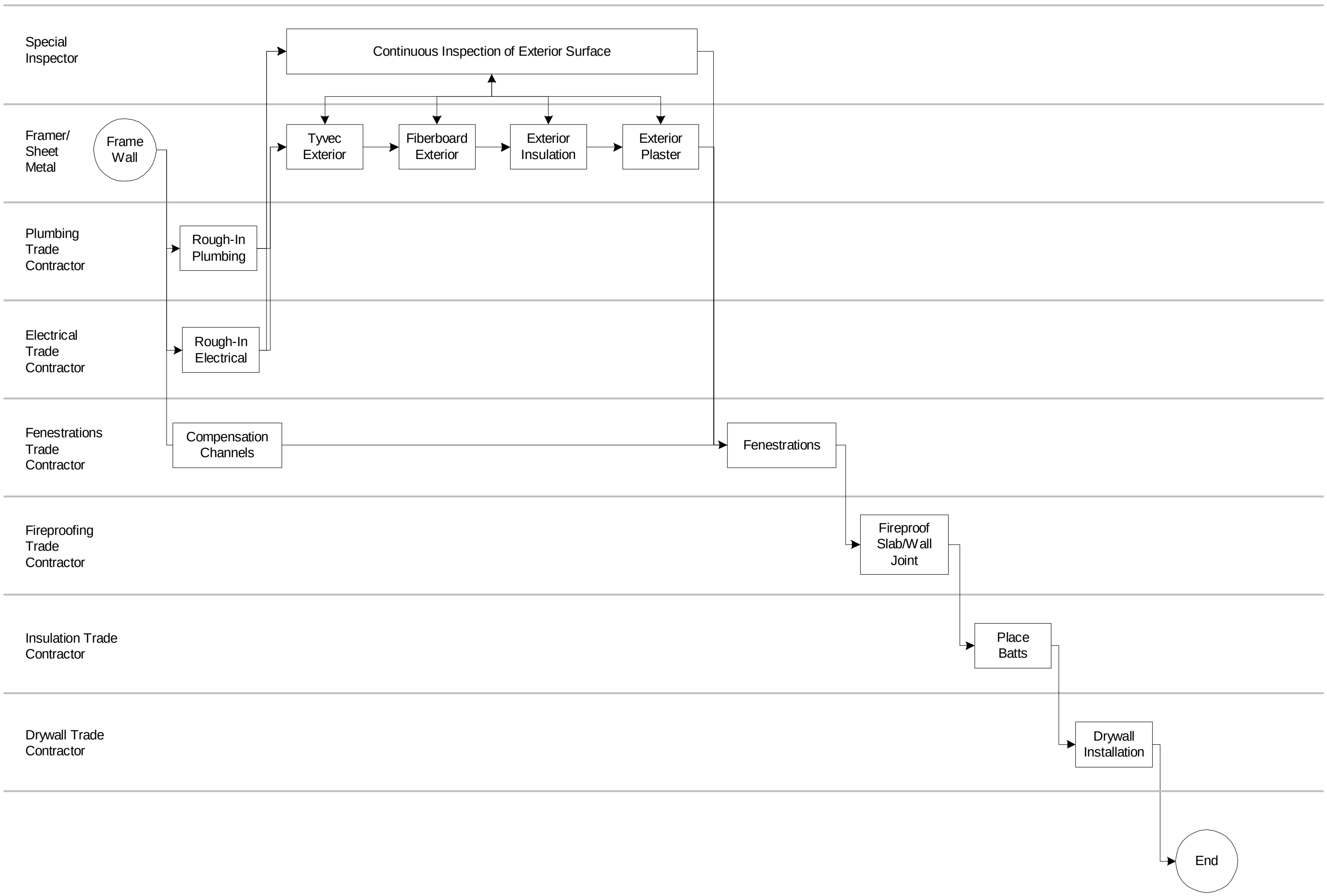


Figure 40. Process Map: Rigid Exterior Insulation - Plaster Veneer

Source: National Energy Center for Sustainable Communities

Figure 40 shows a typical construction approach for commercial structures in which the wall is framed, rough-ins are completed, and the exterior veneer is installed. The exterior veneer is usually the responsibility of the framing/sheet metal trade contractor, who is generally assigned the entire exterior wall system. That contractor installs window glass (fenestration) around the exterior veneer and creates a proper seal for weatherproofing, and then the process continues with fireproofing, insulation, and drywall on the interior surface.

Several of the proposed alternates to the exterior wall system create little or no disruption to this process. Alternates 1 and 2 involve thicker insulation in the wall. The change to thicker insulation batts (depending on thickness) would necessitate different framing materials and different insulating materials but no change in trade or schedule. The disruptions would be minimal - the cost differential of the materials and labor . If rigid insulation is used but the exterior veneer is not plaster, the builder would assign the framer/sheet metal contractor one more activity to install this product. No new inspections or handoffs would be created.

If the exterior veneer is plaster, the system would look very different. Because there is a history of problems with exterior insulation finish system (EIFS) performance, any application of plaster over rigid insulation comes under additional scrutiny. Past EIFS application problems include water penetration, mold, and degradation of the underlying sheathing.[47] A number of substantial construction defect liability judgments and settlements have occurred. Thus, although the product specified in Alternate Three is not technically an EIFS, it shares the broad strokes of EIFS surfaces and creates pressure to view them as such. Contractors in the San Diego region adopt special inspection requirements for such systems because of liability concerns.

The addition of the special inspector results in a new swimlane at the top of Figure 40 that is not present in Figure 39. This represents the addition of a full-time quality control inspector during the exterior sheathing operation with the commensurate cost. Researchers estimated the cost for the plaster prototypes based on the total square footage of external wall and a reasonable crewing strategy, divided by the exterior square footage, to achieve a unit cost impact. The average result for the appropriate prototypes was $0.30 per square foot.

In addition, the exterior rigid insulation products must be sanded and prepped to a smooth surface before plaster can be applied. This process produces a substantial quantity of dust, which is difficult to capture and is generally objectionable to the public and to stormwater quality control agencies. To prevent release of this dust, it is common to shroud the scaffolding at an additional cost. Researchers developed a simplified estimate of this cost by adding five feet to the exterior plan dimensions of the prototypes and calculating the resulting area of scaffold coverage needed. They then divided the result by the actual exterior wall area to

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47 *Building Envelope Design Guide - Exterior Insulation and Finish System (EIFS*), Gary L. Zwayer, Wiss, Janney, Elstner Associates, Inc. June 2009. Can be found on the National Institute of Building Science website at http://www.wbdg.org/design/env_wall_eifs.php.

achieve a unit cost impact. The average result for the appropriate prototypes was $0.15/square foot.

Aside from the inspections, no new handoffs are associated with the alternate because the trade contractor already working the job adds the insulation. Thus, the cost differential for this alternate over the base case consists of the labor and material cost difference for the exterior insulation plus the additional impacts of the inspection and shrouding costs. No stochastic analyses such as discrete event simulation experiments are needed because no new handoffs are involved. The estimated additional costs for materials and labor for the exterior insulation itself and the thicker bats based on the *2007 R.S. Means Building Cost Data Guide* are $0.83/square foot and $0.13/square foot, respectively, for a total cost impact of $1.41/square foot.

Researchers initiated a similar effort for the roofing process, based on potential disruption for roofing alternates in prototype 6 (Table 45). They determined the alternate created a potential for process disruption because the rigid insulation in the middle of the roof membrane system would be installed by a different trade contractor and thus would represent a new handoff. However, interviews revealed such systems are commonly installed by roofing contractors who have liability for water-tightness of the entire system. Thus material and labor cost differentials are the only cost impacts.

There are concerns for potential damage to the insulation while it is exposed before the membrane covers it, but these are usually handled by scheduling and coordination with roof penetrations and have no significant cost differences. Rigid insulation sometimes necessitates additional labor to accommodate changes to the roof drainage, but labor cost differential captures this impact. Thus, the interview process revealed cost impacts are confined to those represented by material and labor deltas without need to adjust process maps.

3.3.3. Assessment of Utility Incentive Impacts on Market Feasibility

Chapter 2 presented 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. Tables 46a and 46b summarize these for both sites. Blank fields indicate researchers did not consider a particular package cost effective and/or practical for addition of photovoltaics, even with incentives. The results with an asterisk (*) indicate the relevant package and prototype achieve an estimated increase in building energy efficiency of 25% or more above the 2005 Title 24 standard.

The prototype numbers, codes, and values reported in Table 46a "Payback Without Incentive" column for both packages correspond to the values contained in Attachment I. 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.

The prototype numbers, codes, and values reported in Table 46b "Payback Without Incentive" column for both packages correspond to the values contained in Attachment II. Once again, 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. Again, the difference between the high and low estimate is the 20% incentive for sustainable practices.

Table 46a. Site A: SDG&E Incentive Impacts by Prototype

	Optimum EE Package			Combined Optimum EE-PV Package		
	Payback Without Incentive	Payback Counting SDG&E Incentive		Payback Without Incentive	Payback Counting SDG&E Incentive	
Prototype	(Years)	High Estimate (Years)	Low Estimate (Years)	(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*

Source: National Energy Center for Sustainable Communities

Table 46b. Site B: SDG&E Incentive Impacts by Prototype

Prototype	Optimum Alternatives Package: Payback Without Incentive (Years)	Optimum Alternatives Package: Payback Counting SDG&E Incentive High Estimate (Years)	Optimum Alternatives Package: Payback Counting SDG&E Incentive Low Estimate (Years)	Combined Optimum EE-PV Package: Payback Without Incentive (Years)	Combined Optimum EE-PV Package: Payback Counting SDG&E Incentive High Estimate (Years)	Combined Optimum EE-PV Package: Payback Counting SDG&E Incentive 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	--	--	--

Source: National Energy Center for Sustainable Communities

In addition to the incentive payable to owners, SDG&E also provides incentives to designers to help defray the cost of additional design work associated with including EE upgrades. Researchers did not explicitly include these incentives to develop the payback periods in Table 46a and 46b. They estimated design costs separately in the upgrade costs. Tables 46a and 46b present these incentives. Designer incentives are not available for Prototypes 13-15.

Table 47a. Site A: SDG&E Designer Incentive: Estimates by 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

Source: National Energy Center for Sustainable Communities

Table 47b. Site B: SDG&E Designer Incentive: Estimates by 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	--

Source: National Energy Center for Sustainable Communities

3.4. Site A: District Cooling System Evaluation

3.4.1. Annual Electricity Consumption and Cost

As stated in the methods chapter, researchers conducted a special study in this project to examine economic feasibility of a district cooling system in place of conventional stand-alone air conditioning systems to serve Site A. Table 48 below presents results of the study. Appendix M provides more detailed breakdowns of electricity cost calculations.

Results of the analysis and content of the table indicate annual electricity costs are significantly lower for the district cooling alternatives than for the stand-alone alternatives. The district cooling alternatives with thermal energy storage (TES) further reduce electricity costs due to their ability to shift cooling production from high-cost peak times to lower cost semi-peak and off-peak times.

The factors contributing to the district energy system's cost effectiveness relative to the stand-alone alternative are the following:

- The large chillers used in the district system are highly efficient.

- There are a large number of chillers in the district cooling plant, so individual chillers can be more fully loaded at part system loads and therefore are more efficient.
- A series-counter flow chiller arrangement (as described in the methods chapter) is practical due to the number of chillers.
- The district energy alternative allows use of cost reducing technologies such as thermal storage.
- Hourly monitoring for all hours in a day every day helps ensure the plant runs at optimal efficiency.

Table 48. Annual Electricity Consumption and Cost

Utility Rate Period	Builder Proposed Baseline			EE-PV Configuration		
	District Cooling Without TES	District Cooling With TES	Stand-alone (Cooling Production at Individual Buildings)	District Cooling Without TES	District Cooling With TES	Stand-alone (Cooling Production at Individual Buildings)
Summer On-Peak (kWh)	2,665,941	686,010	2,942,222	1,900,159	497,692	1,985,120
Summer Semi-Peak (kWh)	1,590,150	1,668,635	2,176,560	1,148,184	1,157,425	1,515,377
Summer Off-Peak (kWh)	1,285,711	3,004,155	2,033,139	844,981	1,984,139	1,366,911
Winter On-peak (kWh)	338,553	-	704,150	190,954	-	476,573
Winter Semi-Peak (kWh)	2,277,684	78,217	3,572,066	1,362,434	47,378	2,395,329
Winter Off-Peak (kWh)	604,463	3,142,484	1,262,323	341,963	1,847,973	844,801
Total annual electricity use	8,762,503	8,579,501	12,690,461	5,788,675	5,534,605	8,584,112
Total annual electricity cost	$ 1,755,500	$ 1,235,200	$ 2,203,900	$ 1,273,100	$ 857,300	$ 1,529,900

Source: National Energy Center for Sustainable Communities

In addition to cost savings, reduced electricity consumption of the district cooling alternatives would reduce pollution and greenhouse gas emissions generated by central power plants serving Site A. The district cooling with TES alternatives reduce energy consumption by 4.11 million kWh as compared to builder baseline stand-alone alternatives. The reduction for the EE-PV scenario is 3.05 million kWh. Utilization of TES is particularly helpful in reducing environmental emissions since it shifts chilled water production to off-peak times when cleaner and more efficient base-load production facilities rather than peaking facilities produce electricity.

3.4.2. Site A: Annual Operating Cost Analysis Results

Table 49 below summarizes results of annual operating cost analysis, comparing the economics of a district cooling system for Site A with the economics of stand-alone cooling production at individual buildings.

Table 49. Annual Operating Cost Analysis Results

Annual Operating Cost Item	Builder Baseline Scenario			EE-PV Configuration Scenario		
	District Cooling Without TES	District Cooling With TES	Stand-alone (Cooling Production at Individual Buildings)	District Cooling Without TES	District Cooling With TES	Stand-alone (Cooling Production at Individual Buildings)
Capital recovery	$ 3,391,200	$ 3,279,500	$ 2,900,700	$ 3,074,000	$ 2,962,700	$ 2,697,400
Electricity	$ 1,755,500	$ 1,235,200	$ 2,203,900	$ 1,273,100	$ 857,300	$ 1,529,900
Water	$ 108,000	$ 108,000	$ 87,100	$ 88,800	$ 88,800	$ 73,900
Water treatment chemicals	$ 67,600	$ 67,600	$ 54,000	$ 55,100	$ 55,100	$ 45,400
Maintenance	$ 398,700	$ 381,500	$ 547,000	$ 359,800	$ 342,700	$ 521,400
Operating labor	$ 390,000	$ 390,000	$ 585,000	$ 390,000	$ 390,000	$ 585,000
Total annual operating costs	$ 6,111,000	$ 5,461,800	$ 6,377,700	$ 5,240,800	$ 4,696,600	$ 5,453,000
Cost diff. from "Stand-alone"	-4.2%	-14.4%		-3.9%	-13.9%	

Source: National Energy Center for Sustainable Communities

Results of the economic analysis indicate the district cooling alternatives without TES have a moderate annual operating cost advantage over stand-alone cooling production. Once TES is introduced to the district cooling configuration, the economic advantage of district cooling alternatives over stand-alone alternatives is more significant due to substantially reduced electricity costs and a minor reduction in plant capital costs.

3.4.3. Site A: Items Not Evaluated that Could Impact Results

A number of items researchers did not evaluate within the scope of this preliminary analysis could affect the results of economic comparison of district cooling versus stand-alone cooling production. The following paragraphs discuss some of these.

Researchers assumed the thermal storage tank would be sited near the district cooling plant for the scenario with chilled water thermal storage. If it is possible to site the storage tank in a more hydraulically beneficial location such as on the opposite side of the development, overall distribution piping sizes could be reduced. This could result in a net lifecycle cost benefit for the thermal storage scenarios.

Another potential scheme for the thermal storage scenarios not analyzed within the scope of this analysis is a design that provides lower supply water temperature at peak times (e.g., 36°F versus 40°F). This may provide lifecycle cost savings to the project by utilizing a low temperature fluid in lieu of plain water thermal storage, which allows the benefits of stratified thermal energy storage with chilled water supply temperatures lower than 39.4°F. Although this scheme requires somewhat higher energy consumption at peak times and additional equipment and piping within the chilled water plant, it would reduce the size requirements for both the thermal storage tank and the distribution piping system, offering significant capital cost savings.

If the siting of a chilled water thermal storage tank were not possible due to land constraints or architectural issues, it would be possible to utilize ice storage in lieu of chilled water thermal storage. This solution would have higher plant capital costs and operating costs than chilled water storage, but the space requirements for the thermal storage tank would be dramatically reduced. It is unlikely ice storage would reduce lifecycle costs versus chilled water storage, but this option could provide significant cost savings over a district cooling plant without thermal storage due to the favorable utility rate structure.

As discussed in the methods chapter, distribution capital cost could be reduced if insulation is not required for some or all of the distribution piping. This would improve the economics of the district cooling alternatives for Site A.

The new EECC commodity charge rate structure should be beneficial to large customers like district cooling plants, as discussed in the previous chapter. This could improve the economics of the district cooling alternatives for Site A.

3.5. Community Design Option Performance

This section of the results addresses the following research objective:

- Estimate the degree to which enabling community design options can improve energy technology performance in typical development projects.

In addition to this objective, researchers designed the analysis to estimate the degree to which these community design options can reduce overall energy consumption and emissions in large-scale development projects.

The design options considered by the researchers included mixed-use/moderate-density development, stormwater runoff and carbon sequestration measures, urban heat island reduction measures, and passive solar building orientation. The findings presented below are the result of applying the methods described in the previous section to Site A and Site X. For both sites, researchers made comparisons between an optimized scenario featuring these advanced design options and a baseline scenario without these options. In the case of the district energy system and passive solar design options, the analysis focused on Site A and Site X, respectively.

3.5.1. Mixed-Use, Moderate-Density Development

As stated in the methods section, researchers examined the relationship between mixed-use, moderate-density development and the performance of CCHP and district cooling technologies. They studied the affect this design option has on community energy consumption and emissions reduction relative to transportation and land use efficiency. The research findings support the hypothesis that mixed-use, moderate-density development does enable the economical use of distributed generation (CCHP technologies and district cooling technologies) and results in both a significant reduction of central power plant energy consumption and central emissions. The findings indicate this design option also significantly reduced land consumption, vehicle miles traveled (VMT) and associated petroleum consumption, and emissions in both case study sites. The sections below present these results and supporting evidence for each.

Result #1: Mixed-use, moderate-density development enabled the economical use of distributed generation-CCHP technologies in Site A and resulted in a significant reduction of central power plant energy consumption and emissions. However, local emissions increased significantly.

Modeling results (Tables 50 and 51) indicated use of distributed generation-combined cooling, heat, and power (CCHP) technologies in Site A (the optimized scenario) would decrease the amount of electricity needed from the utility grid by 68%(10.3 million kWh annually (approximately 35,263 MMBtu). The associated utility grid emissions from central power plants (CO_2, SO_x, and NO_x) would all decrease by 68%. However, these power plant emission reductions would be offset by increases in local emissions associated with the use of CCHP. Specifically, CO_2 would increase by 79%, and NO_x would increase by 152% compared to the emissions expected from central power plants meeting the same load requirements. Use of natural gas-fueled CCHP would result in a 64% *reduction* in central power plant SO_x emissions.

By contrast, renewably-based CCHP systems could offer the benefit of reduced central power and local emissions, depending on the source of energy used. However, present economic and performance barriers, particularly concerning the intermittency of solar energy, need to be resolved before renewably-based CCHP systems can cost-effectively deliver these benefits. Similarly, advances in emissions controls for fossil fuel based systems, coupled with the return of utility incentives, could deliver similar benefits.

Table 50. Site A: Annual Site-Wide Energy Use

	Energy Source	Baseline Scenario Central Plant Elec.	Optimized Scenario CCHP	
	Total Bldgs in Site	53	7	
Site-wide Grid Energy Usage	Electric (kWh	15,126,305	4,793,650	(10,332,655)
	Gas (MMBtu)	11,395	152,649	141,254

Source: National Energy Center for Sustainable Communities

Table 51. Site A: Annual Site-Wide Emissions (electric- and gas-related)

	Baseline Emissions by Source			Optimized CCHP Scenario Emissions by Source				
	Electric	Gas	Total	Electric	Gas	Total	Difference	% Change
CO_2 (lbs)	10,590,843	1,340,052	11,930,895	3,354,241	17,951,522	21,305,763	9,374,868	79%
SO_x (lbs)	1,936	7	1,942	613	90	703	(1,239)	-64%
NO_x (lbs)	5,171	1,048	6,220	1,638	14,044	15,682	9,462	152%

Source: National Energy Center for Sustainable Communities

Result #2: Mixed-use, moderate-density development enabled the economical use of advanced district cooling technologies in Site A and resulted in a significant reduction of central power plant-generated energy consumption and emissions.

Modeling results indicate the costs associated with a district cooling system designed to serve a moderate-density, mixed-use development are 181% lower than the costs of a system designed to serve the same load in a conventional low-density development. Additionally, research findings indicate the cost of a system to serve a low-density development would render such a system economically unfeasible.

The primary factor responsible for the elevated costs in segregated-use, low-density development is the requirement for a larger number of trench-feet of pipe to distribute district cooling and increased costs related to energy transfer station (ETS) connections at individual subscriber buildings. As Table 52 illustrates, the low-density (baseline) development scenario is approximately 3.35 times larger than the moderate-density scenario for Site A.

Table 52. Site A: Baseline and Optimized Density and Land Area Comparison

Site-A Parameters	Baseline	Optimized
Dwelling Units	2401	2401
Gross Density	3.3	11.17
Land Area (acres)	728	215
Land Area (sq miles)	1.14	0.34

Source: National Energy Center for Sustainable Communities

To model the cost impacts of a district system in a low-density development scenario for Site A, researchers used the same factors for calculating the trench-feet of pipe requirements used for the moderate-density development scenario, which was 42,765 trench-feet/square mile. The total trench-feet of piping necessary to serve the low-density development would be approximately 48,751 linear feet. Matching the same amount of commercial space served in the moderate-density/optimized scenario at lower densities in the baseline scenario resulted in 110 commercial buildings, 65 more than served in the optimized scenario. Each additional building represents additional ETS costs to connect subscriber buildings to the system.

Assuming a cost of $650 per trench foot of pipe and a length of 48,751 feet, the cost of laying pipe would be $31,688,647 in the baseline scenario. In the optimized scenario, the cost would be $9,451,000 (Table 53). With the addition of ETS costs, capital costs for a district cooling system to serve the low-density baseline development would be $35.5 million, while the costs for the optimized moderate-density development would be $12.6 million. Total capital cost of conventional stand-alone cooling technologies at individual buildings in the low-density development would be $21,343,000. These costs would be $23,088,000 in the moderate-density development. Given the substantial additional capital investment necessary to build a district system in the low-density development and the extremely long pay-back on that investment relative to energy cost savings, a project of this nature would not be built.

Table 53. Site A: Capital Cost Comparisons for District Energy

Capital Costs Comparisons

	Baseline	Optimized	Difference
Piping Costs	$ 31,688,647	$ 9,451,000	$ (22,237,647)
ETS Costs	$ 3,822,000	$ 3,168,000	$ (654,000)
Total Cap Costs	$ 35,510,647	$ 12,619,000	$ (22,891,647)

Source: National Energy Center for Sustainable Communities

Result #3: Mixed-use, moderate-density development significantly reduced vehicle miles traveled (VMT) in both Site A and Site X and resulted in a 12.5% and 15% reduction of petroleum consumption and automobile-related emissions, respectively. Specific findings for each site follow.

Site A

Based on 4D analysis of factors affecting travel behavior, the optimized scenario reduced vehicle miles traveled per person by 1,182 miles annually. This is a 12.5% reduction in the baseline VMT. U.S. Department of Transportation Federal Highway Administration statistics (from its 2003 table of licensed drivers-ratio of drivers to population) suggest that 63% of the resident population in Chula Vista are drivers. This translates into a total annual reduction in VMT for

Site A of 3,683,000 miles, a distance sufficient to circle the earth at the equator more than 460 times. The annual reduction of 1,182 VMT per person is equivalent to approximately 153,458 fewer gallons of petroleum per year. This reduction in VMT would lead to reductions of 12.5% in all auto-related emissions. Table 54 summarizes total emissions for the optimized and baseline scenarios.

Table 54. Site A: Total Annual Emissions by Scenario

Emissions (lbs)	Baseline	Optimized	Difference
CO	1,295,035	1,133,625	(161,411)
CO_2	24,014,123	21,021,049	(2,993,074)
Hydrocarbons	88,552	77,515	(11,037)
NO_x	81,191	71,071	(10,119)
PM10	340	297	(42)
PM2.5	321	281	(40)

Source: National Energy Center for Sustainable Communities

Site X

Application of this set of community design options in Site X would result in an annual reduction in VMT per person of 1,424 miles, a 15% decrease from the baseline. Total annual reduction for this site would be over 8,370,000 miles, a distance sufficient to circle the earth at the equator more than 1,050 times. This would reduce petroleum consumption by approximately 360,600 gallons every year.[48] Table 55 summarizes related tailpipe emissions reductions.

Table 55. Site X: Total Annual Emissions by Scenario

Emissions (lbs)	Baseline	Optimized	Delta
CO	1,525,631	1,297,012	(228,619)
CO_2	45,357,788	38,560,829	(6,796,960)
Hydrocarbons	167,257	142,193	(25,064)
NOx	116,875	99,361	(17,514)
PM10	641	545	(96)
PM2.5	605	515	(91)

Source: National Energy Center for Sustainable Communities

48 Based on the EPA and DOT average fleet fuel economy of 24 mpg (2005).

Result #4: Moderate-density development significantly reduced land consumption and dramatically reduced annual household energy consumption for the modeled sites.

Results indicate moderate-density development would reduce land consumption by up to 70% in the case of Site A and nearly 78% in the case of Site X. Diversity in housing in a moderate-density development resulted in a per household energy savings of nearly 50% for Site A and 20% for Site X. These savings would result from smaller housing units and shared walls, heating, air conditioning, and ventilation systems. The sections below provide site-specific details.

Site A

The optimized and baseline development scenarios showed significant differences in per household energy use. The optimized scenario had 2,401 residential dwelling units. Assuming the same number of units at a density of 3.3 dwelling units per acre, the baseline scenario required approximately 728 acres of land. This was more than three times the land requirement of the optimized scenario, assuming a moderate gross density of 11.17 dwelling units per acre. Table 56 provides the data underlying this comparison, and Figure 41 expresses the comparison graphically.

Table 56. Site X: Land Use Comparison

	Baseline	Optimized
Dwelling Units	2401	2401
Gross Density	3.3	11.17
Land Area (acres)	728	215
Land Area (sq miles)	1.14	0.34

Source: National Energy Center for Sustainable Communities

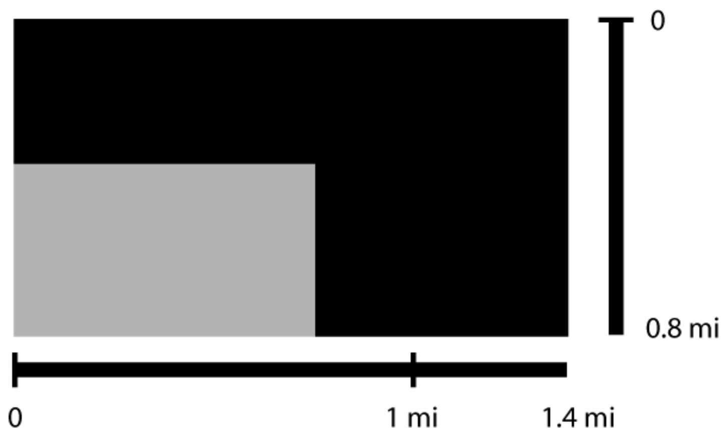

Figure 41. Site A: Comparison of Land Consumption
Source: National Energy Center for Sustainable Communities

Under these land use patterns, the optimized scenario uses approximately 5,493 kWh per household annually, while the baseline alternative uses approximately 11,049 kWh per household based on average residential energy usage.

Site X

The optimized scenario had 4,535 residential dwelling units. Assuming 3.3 dwelling units per gross acre, the baseline residential scenario would require 1,374 acres to accommodate the same number of units. In this case the adjusted baseline consumed 4.4 times more land than the optimized scenario.

As in the Site A analysis, the optimized scenario performed better on a per household basis. The optimized scenario used about 8,816 kWh per household annually, while the baseline used 11,049 kWh per household.[49] Table 57 and Figure 42 provide additional details and a graphic expression of the comparison.

Table 57. Site X: Land Area Comparison

	Baseline	Optimized
Dwelling Units	4535	4535
Gross Density	3.3	14.6
Land Area (acres)	1374	310
Land Area (sq miles)	2.14	0.49

Source: National Energy Center for Sustainable Communities

49 The prototype single-family homes used in this analysis are the same as those used in the Site A analysis.

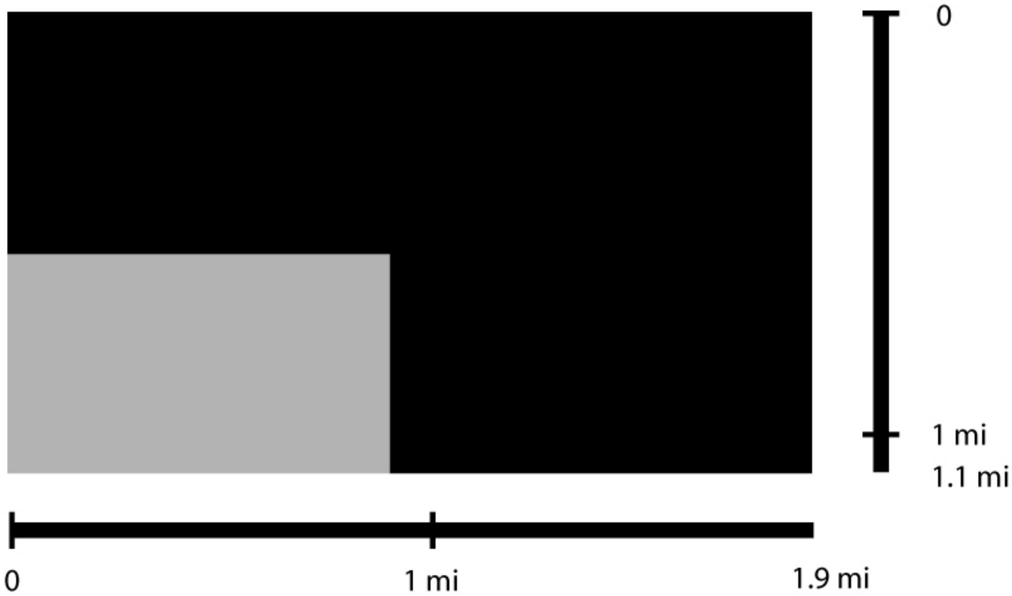

Figure 42. Site X: Comparison of Land Consumption
Source: National Energy Center for Sustainable Communities

Based on an assumption of $22/sf provided by the City of Chula Vista, the low-density scenario land costs would be nearly $698 million, while the moderate-density scenario land costs would be $206 million. Both scenarios maintain the same number of dwelling units, but the moderate-density scenario would save a developer $492 million in land acquisition costs. Table 58 summarizes these costs.

Table 58. Site A: Comparative Land Acquisition Costs

	Land Area (acres)	Associated Costs
Baseline	728	$ 697,656,960
Optimized	215	$ 206,038,800
Savings	513	$ 491,618,160

Source: National Energy Center for Sustainable Communities

3.5.2. Urban Runoff Mitigation and Carbon Sequestration Measures

Researchers examined two relationships: the relationship between urban runoff mitigation measures and energy consumption and emissions, and the relationship between carbon mitigation measures and air quality. Urban runoff mitigation and carbon storage and sequestration measures in this analysis focused primarily on the impact of tree plantings. Because researchers sought to determine the incremental benefits of trees on a site, the site plan was the same for both scenarios in Site A and Site X. This deviates from other analyses in the research project where the two scenarios fall into different densities and different spatial layouts. This controls for other factors that would differ between a higher density and a lower density site such as topography, building layout, and pavement cover. By holding the site layout constant, the research team was able to make conclusions related directly to the impact of planting trees. The findings below include energy and emissions savings due to tree plantings for runoff mitigation and carbon sequestration.

Result #5: Trees provide a number of benefits, including stormwater management, air filtration, and carbon sequestration. Modest increases in tree canopies and decreases in impervious surfaces produced energy savings, stormwater facility construction costs savings, and emissions reductions for both development sites.

Modeling indicated that a 10% increase in tree canopy resulted in a 48% increase in stormwater diversion for Site A and a 64% increase in stormwater diversion for Site X. Diverting stormwater runoff helps keep pollutants out of the water supply, especially in urban areas. However, it does not translate directly into energy savings for communities where stormwater is not combined with sanitary sewer systems and therefore not processed through a wastewater treatment plant. This is the case in Chula Vista, where gravity systems and retention or detention ponds handle stormwater. To illustrate the value of diverted stormwater from combined stormwater and sanitary sewer systems, researchers conducted energy savings calculations for Site A and Site X as if they used a combined sewer system similar to the systems serving Sacramento and San Francisco.

Site A

Modeling revealed that a tree canopy placed over approximately 2.4% of the development site (5 acres) would produce a diversion of 65,319 cubic feet (cu ft) of water from stormwater management facilities annually. This 2.4% represented the modest tree cover in the baseline. An additional 10% of tree cover modeled in the optimized scenario, an additional 20 acres, resulted in an incremental diversion of 61,149 cu ft. Taken together, a 12.4% tree canopy contributed to a total diversion of 126,468 cu ft of water when compared to the same site with no trees.

Reduction in the severity of peak events and overall volume of stormwater runoff due to increased tree cover could save a developer significant construction costs by reducing the number of retention and detention ponds needed for a site. With regard to Site A, the addition of a 10% canopy could save the developer approximately $122,300 in costs associated with the construction of these stormwater pond systems.

Table 59 presents the annual energy and energy-related emissions savings resulting from additional tree coverage on the site if it were served by a combined storm and sanitary sewer system. Although the savings are modest, they would become more significant with additional tree coverage and the introduction of other stormwater management measures such as deployment of a variety of impervious surfaces across the site. Because the baseline assumed a certain amount of tree cover, the baseline in the following table reflects diverted stormwater over a “plant nothing” scenario. The optimized scenario then represents the incremental savings over the baseline and the "Total" column reveals the overall savings of the optimized scenario over a "plant nothing" scenario. This is also true for Table 60.

Table 59. Site A: Annual Stormwater Treatment Energy and Emissions Savings

	Baseline	Optimized	Total
Total Water Diverted (cu ft)	65,319	61,149	126,468
Treatment Energy (kWh/cu ft)[50]	0.0150	0.0150	0.0150
Total Energy (kWh) Savings	977.69	915.27	1892.96
CO2 (lbs) Offset	684.97	641.24	1326.20
SOx (lbs) Offset	0.125	0.117	0.242
NOx (lbs) Offset	0.334	0.313	0.647

Source: National Energy Center for Sustainable Communities

Site X

Modeling revealed that a tree canopy placed over approximately 5% of the development site (16.8 acres) would divert 106,806 cu ft of water from stormwater management facilities annually. This was the amount of coverage modeled in the baseline scenario. Increasing this baseline by 10% in the optimized scenario (an additional 33.7 acres) would divert an additional 193,720 cu ft of water.

In total, a 15% tree cover representing 50.5 acres would divert a total of 300,525 cu ft. The diversion of 193,720 cu ft of water in the optimized scenario is equivalent to a $387,440 construction cost savings for the developer resulting from avoided construction of retention and detention pond systems. Table 60 contains energy and energy-related emissions savings associated with the use of this measure on a similarly sized site served by a combined storm and sanitary sewer system.

50 Based on an average of 652 kWh/acre-foot (Hoffman 2004)

Table 60. Site X: Annual Stormwater Treatment Energy and Emissions Savings

	Baseline	Optimized	Total
Total Water Diverted (cu ft)	106,806	193,720	300,525
Treatment Energy (kWh/cu ft)	0.0150	0.0150	0.0150
Total Energy (kWh) Savings	1598.66	2899.57	4498.22
CO2 Offset	1120.02	2031.44	3151.45
Sox Offset	0.205	0.371	0.576
NOx Offset	0.547	0.992	1.538

Source: National Energy Center for Sustainable Communities

Result #6: Modest increases in tree canopy led to significant storage and sequestration of carbon and other pollutants in both Site A and Site X.

Site A

Modeling revealed a baseline 2.4% tree canopy would store 213 tons of CO_2 in existing trees and would sequester an additional 1.66 tons per year.[51] Additional pollution removal has an estimated value of $1,958 annually, based on California's estimates of external costs related to individual pollutants (health care costs, loss of tourism, etc.) as aggregated by CITYgreen™ (American Forests 2004). A 10% increase in canopy cover would result in storage of 1,099 tons of CO_2 and sequestration of 8.56 tons annually. Researchers estimated total savings from pollution reductions to be $10,098 annually. Table 61 contains tailpipe pollutant removal data for the baseline and optimized development scenarios for the site.

51 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 61. 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

Source: National Energy Center for Sustainable Communities

Site X

Modeling revealed a baseline 5% tree canopy stored 725 tons of CO_2 in existing trees and sequestered an additional 5.64 tons per year. Researchers estimated the value of removing other air pollutants at $6,659, based on California's estimates of externalities related to individual pollutants. Increasing the canopy cover to 15% stored 2,174 tons of CO_2 and sequestered an additional 16.93 tons per year. Researchers estimated avoided indirect costs from pollutant removal at $19,976. Table 62 contains tailpipe pollutant removal data for the baseline and optimized development scenarios for the site.

Table 62. Site X: 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

Source: National Energy Center for Sustainable Communities

The principal cost associated with this urban runoff mitigation and carbon sequestration measure is the cost of tree plantings. According to officials at the City of Chula Vista, the average cost of planting a tree, including labor and materials, is $445. Given this unit cost, Tables 63 and 64 provide details on planting costs for the optimized scenarios at Site A and Site X, respectively.

Table 63. Site A: Tree Planting Costs

Canopy Area (sf)		897,772
Individual Tree Canopy (sf)		1116
Total Trees		804
Unit Cost	$	445.00
Total Cost	$	357,982

Source: National Energy Center for Sustainable Communities

Table 64. Site X: Tree Planting Costs

Canopy Area (sf)		1,467,972
Individual Tree Canopy (sf)		1116
Total Trees		1,315
Unit Cost	$	445.00
Total Cost	$	585,347

Source: National Energy Center for Sustainable Communities

3.5.3. Urban Heat Island Effect Mitigation Measures

Researchers used MIST to analyze the impact of specific urban heat island (UHI) mitigation measures. These included cool-roof coatings, cool pavement, and increasing tree canopy. The following discussion presents results of this analysis for both sites.

Result #7: Modeled application of urban heat island mitigation measures produced 5-14% kWh energy savings for residential and commercial structures in both development sites

Site A

Modeling results 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, as mentioned in the methods chapter. These modeled 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 space heating demand for residential, retail, and office units during cold weather.

Converting MMbtu to equivalent kWh reveals a net energy savings of 3,835,803 kWh community-wide, as well as a 3,029,248 lbs savings in CO_2 emissions, a 635 lbs savings in SO_x emissions, and a 1,344 lbs savings in NO_x emissions. Table 65 provides additional detail.

Table 65. Site A: Electric and Gas Energy and Emissions Savings

			Electricity-Related Emissions Savings			Gas-Related Emissions Savings		
	Electricity Savings (kWh)	Gas Savings (MMbtu)	CO2 (lbs)	SOx (lbs)	NOx (lbs)	CO2 (lbs)	SOx (lbs)	NOx (lbs)
Residen..	7,018,338	(5,000)	4,915,643.77	898.35	2,400.27	(588,045.10)	(2.95)	(460.04)
Office	2,555,640	(844)	1,789,969.92	327.12	874.03	(99,301.13)	(0.50)	(77.68)
Retail	2,206,760	(2,678)	1,545,615.02	282.47	754.71	(314,962.49)	(1.58)	(246.40)
Total		(8,523)	8,251,228.71	1,507.93	4,029.01	(1,002,308.72	(5.03)	(784.12)

Source: National Energy Center for Sustainable Communities

Site X

Modeling indicated a 10% increase in vegetation and a 0.11 increase in albedo resulted in a temperature decrease ranging from 1.1 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, however, showed a small increase in gas consumption due to increased space heating demand for residential, retail, and office units. Converting MMbtu to equivalent kWh reveals a net energy savings of 9,283,511 kWh community-wide, as well as a 7,248,920 lbs savings in CO_2 emissions, a 1,503 lbs savings in SO_x emissions, and a 3,245 lbs savings in NO_x emissions. Table 66 provides additional detail.

Table 66. Site X: Electric and Gas Energy and Emissions Savings

			Electricity-Related Emissions Savings			Gas-Related Emissions Savings		
	Electricity Savings (kWh)	Gas Savings (MMbtu)	CO_2 (lbs)	SO_x (lbs)	NO_x (lbs)	CO_2 (lbs)	SO_x (lbs)	NO_x (lbs)
Residen.	2,351,869	(1,989)	1,647,248.89	301.04	804.34	(233,877.65)	(1.17)	(182.97)
Office	1,840,499	(717)	1,289,085.67	235.58	629.45	(84,353.68)	(0.42)	(65.99)
Retail	789,308	(1,205)	552,831.30	101.03	269.94	(141,686.45)	(0.71)	(110.84)
Total	4,981,676	(3,911)	3,489,165.86	637.65	1,703.73	(459,917.78)	(2.31)	(359.80)

Source: National Energy Center for Sustainable Communities

It is important to note the MIST tool is primarily a qualitative tool for comparing relative impacts among UHI scenarios. In this regard, these numbers are best used in concert with other analyses to set goals for reducing UHI. In addition, this analysis is based on general assumptions about land cover that are not explicitly included in the conceptual land use plans provided to the research team. The following chapter presents recommendations regarding these limitations.

The three UHI interventions modeled for each site included white topping of asphalt, a double coat of white paint on all roofs, and additional tree planting. Tables 67 and 68 contain the incremental costs associated with each intervention for each site.

Table 67. Site A: UHI Intervention Costs

White topping costs		
Area (SY)		109,059
Thickness (in)		6
Incremental Unit Cost ($/SY/in)[52]	$	4.00
Total Incremental Cost	*$*	*2,617,421*
Roof coating costs		
Area (sf)		2,440,558
Coats		2
Incremental Unit Cost ($/sf)[53]	$	0.20
Total Incremental Cost	$	976,223
Tree planting costs		
Canopy Area (sf)		897,772
Individual Tree Canopy (sf)[54]		1116
Total Trees		804
Unit Cost[55]	$	445.00
Total Cost	*$*	*357,982*
Total Intervention Investment	$	3,951,626

Source: National Energy Center for Sustainable Communities

52 US EPA 2005 *Cool Pavement Report*, p. 25.

53 PG&E *Cool Roof Design*, p. 13.

54 Rosenzweig and Solecki 2006, Appendix A, p. 93.

55 In consultation with City of Chula Vista staff.

Table 68. Site X: Urban Heat Island Intervention Costs

White topping costs		
Area (SY)		287,733
Thickness (in)		6
Incremental Unit Cost ($/SY/in)[56]	$	4.00
Total Incremental Cost	$	6,905,602
Roof coating costs		
Area (sf)		3,408,049
Coats		2
Incremental Unit Cost ($/sf)[57]	$	0.20
Total Incremental Cost	$	1,363,220
Tree planting costs		
Canopy Area (sf)		1,467,972
Individual Tree Canopy (sf)[58]		1116
Total Trees		1,315
Unit Cost[59]	$	445.00
Total Cost	$	585,347
Total Intervention Investment	$	8,854,169

Source: National Energy Center for Sustainable Communities

Using the results of MIST modeling, researchers calculated energy consumption reduction associated with application of UHI mitigation measures for each site. As noted above, although electric energy consumption decreased, natural gas consumption increased marginally to

56 US EPA 2005 *Cool Pavement Report*, p. 25.

57 PG&E Cool Roof Design, p.13.

58 Rosenzweig and Solecki 2006, p. 93. See Also, Attachment IV, *Tree Guidelines for Coastal California Communities*, for coverage by tree species, p. 57.

59 In consultation with City of Chula Vista staff.

account for additional nighttime or cold weather space heating due to the slight decrease in the ambient air temperature. With this slight increase factored into the analysis, overall annual energy cost savings associated with this set of interventions for Site A was $903,443. Table 69 below contains the numbers used in this calculation.

Table 69. Site A: Annual Energy Savings Due to Urban Heat Island Interventions

	Electricity Savings (kWh)	Cost Savings for Electric	Gas Savings (MMbtu)	Cost Savings for Gas	Net Savings
Residential	2,351,869	$ 503,097	(1988.76)	$ (23,705)	$ 479,391.27
Office	1,840,499	$ 315,881	(717.29)	$ (8,550)	$ 307,331.16
Retail	789,308	$ 131,073	(1204.82)	$ (14,361)	$ 116,711.99
Total	4,981,676	$ 950,052	(3910.87)	$ (46,617)	$ 903,434.42

Source: National Energy Center for Sustainable Communities

Total incremental investment in UHI intervention for Site A over the baseline scenario was $3,951,626. A simple payback calculation showed just 4.4 years. It is important to note simple payback does not account for full life cycle costs of the investments such as maintenance. Additionally, these numbers do not reflect the full savings from potential public health benefits.

Researchers conducted the same analysis on Site X. It showed a similarly reasonable payback period of 3.9 years, with costs totaling $8,854,169 and annual savings totaling $2,254,377. Table 70 below contains the numbers used in the savings calculation.

Table 70. Site X: Annual Energy Savings Due to UHI Interventions

	Electricity Savings (kWh)	Cost Savings for Electric	Gas Savings (Mbtu)	Cost Savings for Gas	Net Savings
Residential	7,018,338	$ 1,536,902	(5000)	$ (59,605)	$ 1,477,297
Office	2,555,640	$ 440,969	(844)	$ (10,065)	$ 430,904
Retail	2,206,760	$ 378,101	(2678)	$ (31,925)	$ 346,176
Total	11,780,738	$ 2,355,972	(8523)	$ (101,595)	$ 2,254,377

Source: National Energy Center for Sustainable Communities

3.5.4. Passive Solar Building Orientation

As stated in the methods section, researchers examined the relationship between passive solar building orientation and energy savings. This analysis was tertiary, but the researchers did determine this design option could produce modest energy savings. Savings result just from orientation and the relationship between glazing and a primary southern exposure. With additional design elements, single-family homes could see even more savings using non-mechanical means.

Result #8: East-west building orientation resulted in modest energy savings from passive solar gains for a prototypical single-family home modeled at Site X.

Researchers found east-west building orientation, where the greatest length of a structure is facing south, resulted in energy usage savings of about 2.8% annually for electricity and 2.2% annually for natural gas. These are modest savings, but they result merely from changing the direction of the building without any additional design or mechanical features.

Researchers selected a single-family prototype from the building energy analysis work and modeled energy efficiency impacts associated with incremental changes in building orientation at Site X. Prototype 1 for Site X was modeled in thirty-degree increments.

Figures 43 and 44 below illustrate the electricity (kWh) and natural gas (MMbtu) consumption for the structure plotted against orientation where zero 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. For electricity, the percent difference in energy use was 2.8% with a cost savings of just 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 as mentioned in the methods chapter. Readers are encouraged to investigate the National Renewable Energy Laboratory's (NREL) report on the subject of optimal solar building and subdivision orientation and planning, available from NREL or the California Energy Commission sometime in late 2009 or 2010.

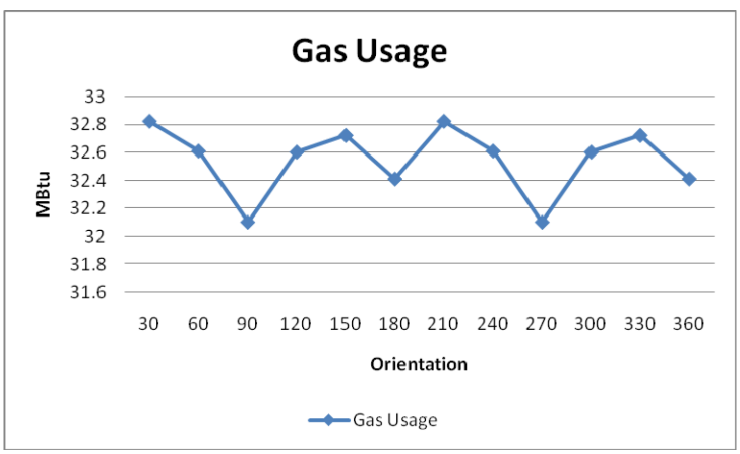

Figure 43. Site X: Gas Usage for Prototype-1 Plotted Against Orientation

Source: National Energy Center for Sustainable Communities

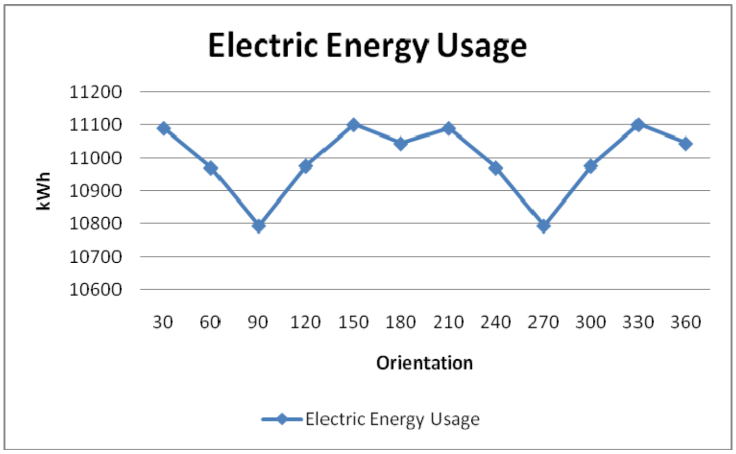

Figure 44. Site X: Electricity Usage for Prototype-1 Plotted Against Orientation

Source: National Energy Center for Sustainable Communities

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 and infrastructure. Because these costs are by definition site-specific, this report does not provide such estimates.

3.6. Incremental Costs and Needed Models, Policies, and Incentives

This section of the results addresses the following two research objectives:

- Determine maximum incremental cost the California building industry and consumers will accept for energy-efficient residential, commercial, industrial, and institutional structures.
- Determine which financial and business models and associated public policies and incentives will lead to accelerated deployment of EE, DR, RE, and DG technologies in typical development projects throughout California.

3.6.1. Maximum Acceptable Incremental Costs

Researchers determined the maximum incremental cost the California building industry and their consumers will accept for energy-efficient structures varies by technology enhancement and by developer. However, researchers determined most development industry practitioners believe the incremental costs of the modeled energy-efficient/technology enhancement packages are too high, and presently there is insufficient market demand for energy-efficient structures[60] in California. Discussion of the maximum acceptable incremental costs is presented below.

60 Defined as structures featuring one of the three technology enhancements modeled in the research project.

Researchers reached these determinations by conducting an online survey of San Diego area members of NAIOP and CBIA, and through a series of follow-up telephone interviews. Additionally, researchers reviewed related industry research on the cost of designing and constructing energy-efficient buildings.

Twenty-two (22) development industry practitioners responded to the survey during late August and early September of 2008. Developers represented 41% of the respondents, followed by property managers (18%) and design professionals (18%). Other participants included real estate brokers, investors, and government employees. Figure 45 graphically depicts the distribution of survey respondents by occupational subgroup.

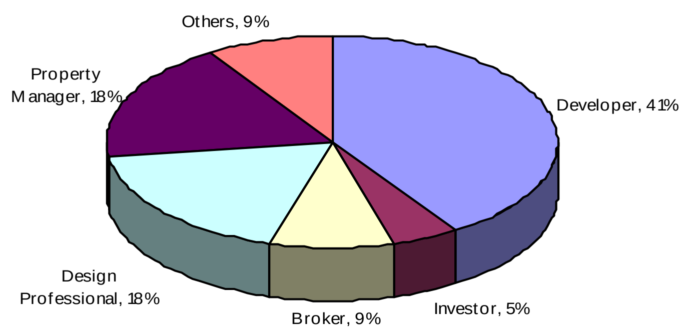

Figure 45. Distribution of Survey Respondents by Occupational Subgroup

Source: National Energy Center for Sustainable Communities

This survey defined energy-efficient buildings as those exceeding 2005 Title 24 building energy efficiency standards by 20-43%. Researchers structured the survey to solicit industry responses to specific incremental costs associated with each of the energy-efficient enhancement packages modeled for 40 different commercial and residential building prototypes. These enhancements included:

- Envelope and Equipment Enhancements (EE): higher efficiency grades of wall and roof insulation, windows, doors, lighting, heating-ventilation-air conditioning equipment, thermal storage technology, and energy-efficient appliances.
- Distributed Generation Enhancement (DG): installation of onsite power utilizing advanced natural gas-fueled electric power generators with heat recovery for heating and/or absorption cooling.
- Solar Photovoltaic Enhancement (PV): installation of photovoltaic panels on rooftops.

Researchers examined combinations of these enhancements for each building type. They then determined economically feasible packages of enhancements based on a simple payback threshold: energy cost savings of the package exceeded the useful life of package components. The various combinations of EE and EE-DG packages described above have an average simple payback of approximately 7 years, and the EE-PV package has a payback of approximately 14 years. All payback calculations were based on available California rebates and incentives.

Researchers calculated costs of installing the packages for each building type and then expressed them as an additional cost increment per square foot of construction (incremental cost). Incremental costs for these enhancements are as follows:

- EE package = $2/square foot (with a range of $1 to $5/square foot depending on building type).
- EE-DG package = $4/square foot (with a range of $3 to $5/square foot, assuming incentives).
- EE-PV package = $15/square foot (with a range of $5 to $30/square foot).

The first question sought to determine whether in today's marketplace developers found the incremental construction costs calculated for the three building enhancements acceptable. Thirty percent either agreed (15%) or strongly agreed (15%) the incremental costs were acceptable, while 35% either disagreed (25%) or strongly disagreed (10%). One third of the respondents were neutral on the question.

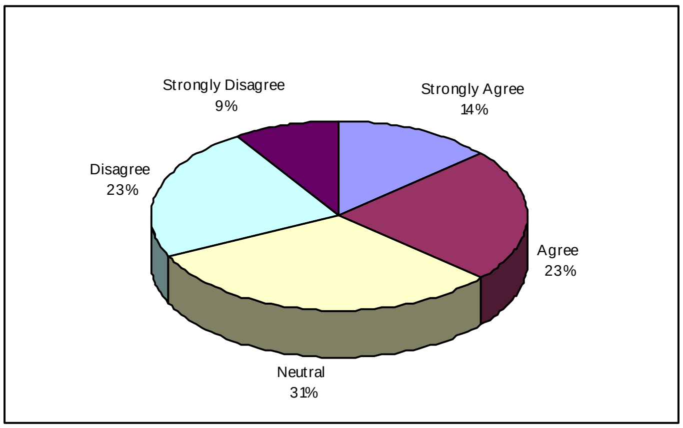

Figure 46. Acceptability of Incremental Costs

Source: National Energy Center for Sustainable Communities

The next three questions sought to determine what maximum incremental costs the development industry would find acceptable for each of the three enhancement packages. In the case of the EE package, about 18% believed maximum acceptable cost per square foot (s.f.) would be $3.00, 4.5% believed the cost would be $2.50 per s.f., and about 23% believed the maximum acceptable cost would be $2 per s.f. The balance of respondents (54.4%) believed the maximum acceptable cost would be $1.50 per s.f. or less. The statistical average acceptable incremental square foot cost was $1.84.

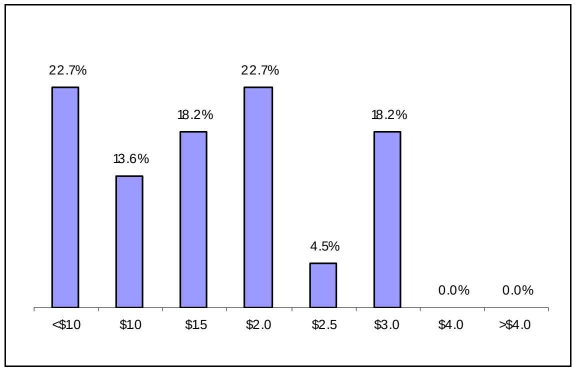

Figure 47. Maximum Incremental Costs for EE Technology Enhancements

Source: National Energy Center for Sustainable Communities

With regard to the EE-DG package, 31.8% of respondents found $4 to $5 per s.f. to be the maximum incremental cost that would be acceptable. The balance of respondents was evenly divided in its opinion the maximum acceptable costs lay between $3.50 and less than $2.00 per s.f. The average per square foot acceptable incremental cost was $2.81.

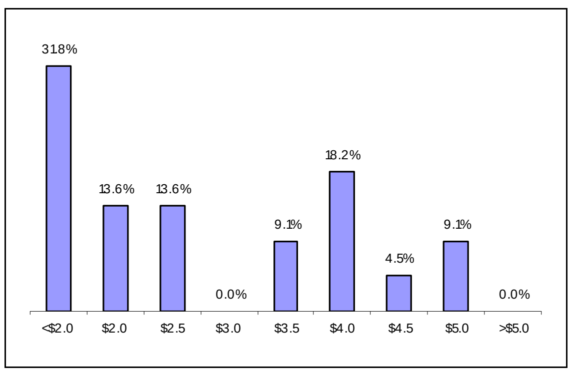

Figure 48. Maximum Incremental Costs for EE-DG Technology Enhancements

Source: National Energy Center for Sustainable Communities

In the case of the EE-PV package, approximately 19% of respondents believed the maximum acceptable incremental cost was between $15 and $20 per s.f. of construction. Approximately 38% believed the maximum acceptable cost was $10 per s.f. and the balance of respondents believed maximum acceptable incremental costs were under $10 per s.f. The average cost across this range was $8.28.

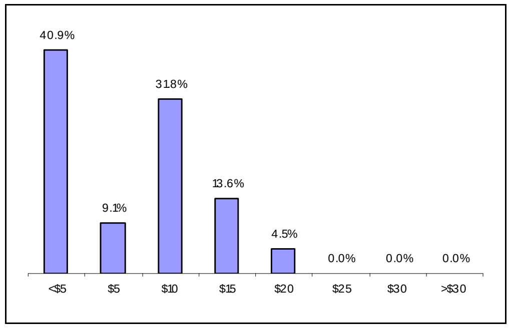

Figure 49. Maximum Incremental Costs for EE-PV Technology Enhancements

Source: National Energy Center for Sustainable Communities

In summary, respondents' average maximum acceptable incremental costs were $1.59, $2.64, and $7.41 per square foot for the three types of packages (i.e., EE, EE-DG, and EE-PV). For the EE technology option, almost half (45.4%) of respondents did find the modeled $2.00 incremental cost to be acceptable and some (18.2%) would be willing to pay as much as $3.00 s.f. for that enhancement. However, in the case of both the EE-DG and EE-PV technology enhancements, the majority of respondents found $4.00 and $15.00 incremental costs, respectively, to be too high.

To examine difference in acceptability among occupational groups, researchers evaluated the responses for each major subgroup: developers, property managers, design professionals, and others. Figure 50 below compares their responses for acceptability of incremental costs for all three enhancements (Question #1). It indicates both developers and property managers are more pessimistic about market acceptance of technology enhancement packages, while design professionals are much more optimistic.

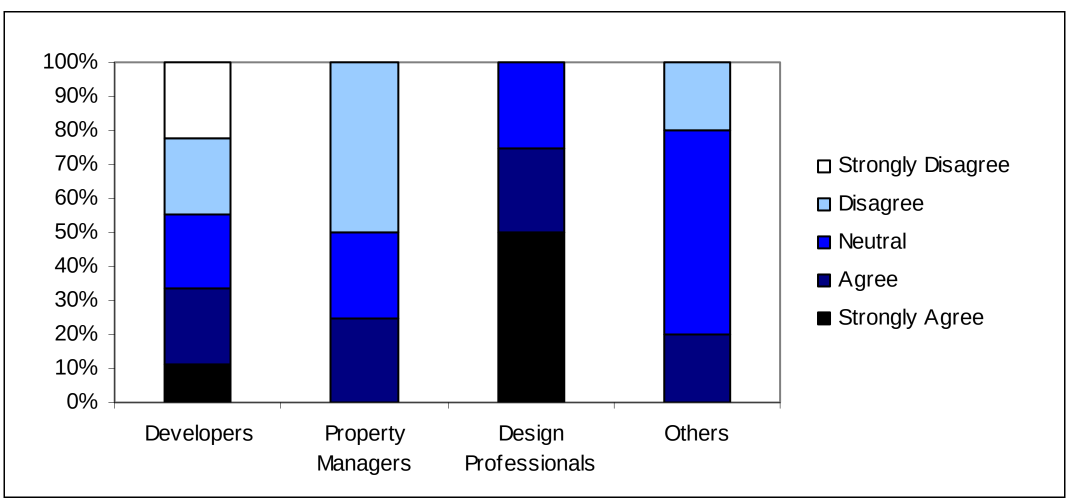

Figure 50. Acceptability of Incremental Costs for the Modeled Technology Enhancements

Source: National Energy Center for Sustainable Communities

Subgroups also had very different opinions with regard to maximum incremental cost per square foot of construction they would accept for each package. Table 71 and Figure 51 summarize and compare the responses of the four subgroups. The pattern is similar across all subgroups. Design professionals were willing to pay more for energy-efficient technology enhancements. In contrast, the maximum prices real estate professionals, particularly developers, were willing to pay was much lower.

Table 71. Acceptable Incremental Costs for Technology Packages by Subgroup

Technology Enhancements & Costs / sq.ft.	Overall	Developers	Property Managers	Design Professionals	Others
EE ($2.00)	1.59	1.43	1.45	2.00	1.66
EE & DG ($4.00)	2.64	1.83	2.25	3.63	2.50
EE & PV ($15.00)	7.41	5.22	6.75	11.75	8.40

Source: National Energy Center for Sustainable Communities

Figures 51-53 graphically portray these results.

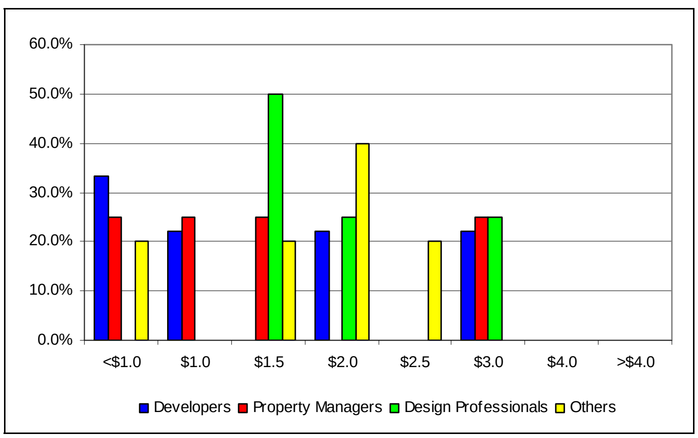

Figure 51. Acceptable Incremental Costs: EE Technologies by Subgroup
Source: National Energy Center for Sustainable Communities

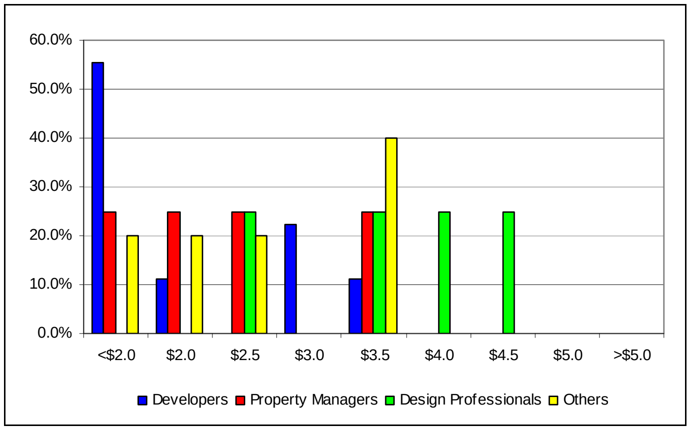

Figure 52. Acceptable Incremental Costs: EE-DG Technology by Subgroup
Source: National Energy Center for Sustainable Communities

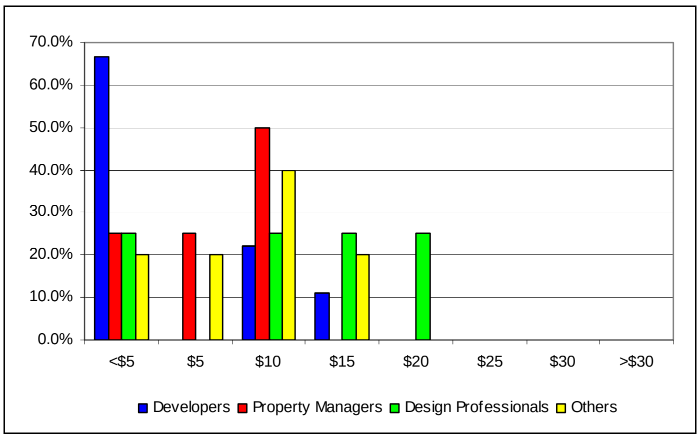

Figure 53. Acceptable Incremental Costs: EE-PV Technology by Subgroup
Source: National Energy Center for Sustainable Communities

To broaden the analysis to community-scale development projects, researchers conducted follow-up interviews with select representatives from CBIA-member companies. They designed interviews to solicit the perceived factors influencing the incremental cost of community-scale energy-efficient development projects and to assess the current market demand for this form of development.

Researchers asked interviewed representatives to rank order the most significant factors they believed influence additional cost of designing and building a project utilizing advanced renewable and energy-efficient technologies. The collective responses revealed a remarkable degree of uniformity among developers about the top-five factors affecting cost. In rank order they are:

1. Lengthened development cycles due to novelty of these types of projects and lack of knowledge among municipal planning officials responsible for approving them.
2. Corresponding increases in planning, design, and engineering expenses.

3. Increased material and equipment costs.
4. Increased installation and inspection costs.
5. Interconnection charges for distributed generation technologies, and difficulty negotiating interconnection agreements with utilities.

There are very few projects to evaluate with regard to estimated incremental costs of an energy-efficient community development project. However, researchers were able to identify one large-scale sustainable community project in southern California where the developer was willing to share cost information under condition of remaining anonymous. The 8,200 acre planned community for 120,000 residents will feature energy and resource efficient features such as:

- A community solar PV electric system.
- Sustainable site development features:
  - Smart growth features.
  - Mixed-use development.
  - Passive solar building orientations.
  - Stormwater runoff mitigation and treatment.
  - Enhanced trail systems to promote pedestrian mobility.
- Building envelope and equipment enhancements:
  - Radiant barriers.
  - Night breeze cooling system.
  - Ultra efficient HVAC systems.
  - Indoor air quality features.
  - Compact fluorescent lighting.
  - *ENERGY STAR* appliances and windows.
  - Water-efficient appliances and fixtures.
- Construction Site Impact Mitigation:
  - Construction waste reduction program.
  - Wood conservation program.

The developer estimated the incremental cost of adding these features to the overall project to be in the range of 20-35%, depending on available incentives.

Repeating a concern heard in each of the earlier workshop discussions, most of the interview respondents indicated they did not believe a sufficient market demand currently existed to warrant additional cost and risks of large-scale, energy-efficient community development. Causal factors related to this insufficient demand mirror the barriers identified in workshop discussions. The paragraphs below discuss these barriers.

While two-thirds of survey respondents did not find the incremental costs of the modeled building technology enhancements acceptable, there is collateral evidence some developers are willing to assume additional cost and inherent risks if there is a perception of achieving a competitive advantage.

A recent study entitled *The Economics of Green* examined incremental construction costs associated with design and construction of buildings built to meet standards of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification. The study suggests some developers are willing to pay between 3.7% and 10.3% more for buildings that carry the LEED-certification and perceive additional investment capable of producing a competitive market advantage. An examination of 1,788 LEED-certified buildings and the costs of more resource-efficient materials, operating equipment, and design features in five commercial markets determined these findings. Table 72 illustrates average cost increases associated with receiving LEED designation based on the designation and the jurisdiction.[61]

Table 72. Incremental Costs for LEED-Certified Buildings by Markets

Markets	Platinum	Gold	Silver
San Francisco	7.8 %	2.7 %	1.0 %
Merced	10.3 %	5.3 %	3.7 %
Denver	7.6 %	2.8 %	1.2 %
Boston	8.8 %	4.2 %	2.6 %
Houston	9.1 %	6.3 %	1.7 %

Source: National Energy Center for Sustainable Communities

3.6.2. Financial and Business Models and Public Policies and Incentives

Researchers determined the financial and business models, public policies, and incentives that will accelerate deployment of energy-efficient technologies in projects across California will be those that resolve economic, informational, and procedural barriers. These models, policies, and incentives should address the following:

1. Need for direct and indirect financial support for developers and builders.
2. Misalignment of investment costs and benefits, the Split Incentive Dilemma.
3. Lack of knowledge among municipal officials inhibiting approval of EECD projects.
4. Lack of uniform municipal procedures and related incentives for EECD projects.
5. Lack of municipal investments in enabling green infrastructure.
6. Lack of consumer willingness to pay for the value of energy-efficient features.
7. Investment risks that inhibit capital market entities from financing EECD projects.

61 The table *is* contained in *The Economics of Green* by Norm Miller (USD Burnham Moores Center for Real Estate), Jay Spivey, and Andy Florance (with CoStar), 2008. Reprinted with permission.

These seven barriers, in order of importance, emerged as the top barriers generated by stakeholders attending workshops, by capital market and development industry surveys, and by follow-up interviews with industry practitioners and leaders.[62] The following subsection describes these seven barriers and presents stakeholder input with regard to needed financial and business models and public policy incentives.

Addressing the Need for Direct and Indirect Financial Support for Developers and Builders

Stakeholders identified the unmet need for financial support as the single greatest barrier to the adoption of energy-efficient building technologies and EECD projects in California. Although this barrier emerged among others during workshops, it became the top item during October 2008 after an extensive set of telephone and in-person interviews with senior officials of CBIA and executives of some large production homebuilding companies. The President and CEO, the Chairman, the CFO/Secretary, other current and past CBIA officers and statewide opinion leaders provided interviews. Researchers also spoke with senior executives at Lennar Homes, Pardee Homes, and Brookfield Homes, three of the most aggressive and sustainability-minded builders in the country in 2008.

When asked what the most important message their industry could send to California and local government officials relative to energy-efficient development, there was unanimous and clear response: substantial financial support. One senior company executive captured the consensus of all those interviewed when he stated:

> *For the foreseeable future, our emphasis is on least cost construction...We have had the worst numbers since records have been kept. If we invest in clean technologies on a community scale, we will need offsets and incentives to help us make those investments.*

Due to the slowdown in new residential construction, builders are cutting prices and offering never-before-seen bargains on new homes. For example, a Brookfield Vice President told the research team a new 3,200 square foot home in Ontario originally listed for $600,000 in early 2008 recently sold for $419,000. He went on to say Brookfield paid $71,500 in school and city fees on the $419,000 home. "We need help on deferring these development impact fees," said the vice president. CBIA's current president added:

> *We see no near-term relief in sight. Land has a negative value in many areas across the state, and improved lots are selling for far less than their value. Once we get home values stabilized, we can begin working earnestly on more sustainable construction techniques. We want to do it, but it will not happen in the near future without financial incentives.*

From the initiation of the research project in April of 2007 until late summer of 2008, there appeared to be consensus among developer/ builders regarding the type of incentives necessary

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62 Notes from the second stakeholder workshop addressing the five market and policy research questions and the related barriers and solutions are contained in Appendix V.

to stimulate investment in energy-efficient projects. The consensus that emerged from stakeholder workshops was that their industry was most in need of municipal procedural incentives that would accelerate the entitlement process. Expedited plan review was the most valuable incentive developers requested in exchange for agreeing to pursue a green project. With the advancing mortgage crisis, industry leaders interviewed now all believe both direct and indirect financial incentives are what their industry must secure to move forward with this new form of development.

The reason for this shift appears clear: builders will be struggling to sell existing inventory for the next year or two, and they are no longer concerned with faster plan review. Local government planners and building officials now have plenty of time on their hands to review plans. Reinforcing this notion, one CBIA officer stated, "There is no problem getting plans out of any city in California. Everyone is slow."

As the priority of the industry has now shifted to financial rather than procedural incentives, building leaders believe fee deferrals, fee waivers, and other financial incentives are the top benefits that need to be incorporated into future discussions about energy-efficient development projects. They cited the rising cost of development impact fees (DIFs). These fees are averaging close to $100,000 per home, whereas a decade ago they averaged close to $25,000 per home. One officer pointed out the new DIF in Dublin, California, is $156,000 per home.

These leaders also generally agreed high local government fees for multifamily homes were keeping potential builders out of the apartment building business. "High fees are legitimately keeping builders out of the apartment business," said Bob Rivinius, CEO of CBIA. Another builder commented, "The economy is going down and people are struggling, yet commercial fees are going up. It can't be sustained. We need relief."

Industry leaders also suggest giving attention to structuring new state and local government and utility financial incentives for this type of construction. "What is there now is not enough," said one CBIA leader. Developers are trying to bridge the gap between higher construction costs for green construction and costs to meet code. Regardless of the state of the economy, they need incentives to help bridge this gap.

Industry leaders also suggested state and local government agencies and utilities work together to centralize information about available financial incentives and technical assistance and to establish a uniform set of rules for applying for and administering such incentives and assistance.

A senior vice-president of Brookfield Homes provided an example illustrating the need for such an information source and a uniform set of rules. With the assistance of an energy efficiency consultant, he sought to assemble an exhaustive list of available local, state, federal, utility, and research funding sources to approach for what he hoped would be the most energy-efficient, sustainable community in California - the Avenue in Ontario.

This effort identified many potential funding sources, including these:

- U.S. Department of Energy *Building America* funds

- U.S. Environmental Protection Agency *Energy Star* funds
- Southern California Edison (utility) energy efficiency funds
- Inland Empire Utility Agency (IEUA) water efficiency funds
- City of Ontario incentives
- State of California energy efficiency and solar incentives
- Federal tax credits for energy efficiency and solar new residential construction

It took the vice-president and his consultant several weeks to assemble the list and to meet with representatives from each entity identified. In exasperation, he stated, "There has to be a better, more cost-effective way to arrange benefits. This is a terribly time-consuming and expensive process."

The Industry's Top Six Requested Financial Incentives

Researchers asked the interviewed leaders to identify the most important public and private sector incentives they believe will stimulate investment in energy-efficient development projects. They offered six financial incentives. Researchers ranked them relative to the frequency with which leaders referenced them. The paragraphs below discuss the incentives in order of importance.

1. <u>Development Impact Fees Deferral Programs</u> **-** The City Council of Ontario, California, has pioneered a program to permit deferral of payment of Development Impact Fees (DIFs) from the time a building permit is issued to final building inspection. This easy to implement and track incentive is the type of low-cost option many California communities could emulate. A DIF does affect the potential earnings a community would receive during the period of deferral (up to one year). However, the loss of earnings does not affect General Fund revenues, as interest earnings on Development Impact Fees must be segregated from other city revenues and remain in the Development Impact Fee program account. The City of Ontario requires an administrative fee of $5,500 from those participating in the Development Impact Fee Deferral Program to help offset the city's costs for initiating and administering the deferral agreements.

   To qualify for the DIF deferral program, a developer of multiple residential units must enter into an agreement with the city acknowledging the deferred fees until the developer requests a final inspection of the first completed unit. The agreement also provides standard terms to indemnify the city and other provisions that define the specific terms of the DIF deferral. The resolution authorizes the City Manager to execute such agreement without further action by the City Council.

   The Ontario Development Impact Fee Deferral Program was designed and approved for an interim time (initially eight months) and ends December 31, 2008, unless extended by action of the City Council. After the interim period ends, the city will offer no more deferral agreements. Any existing deferral agreements will continue until the fees are due under the agreement. The California Building Industry Association would like to see permanent DIF deferral programs established for industry participants in energy-efficient community development projects across California.

2. Sustainable Buildings Tax Credit – In April 2007, New Mexico enacted SB 463, the Sustainable Buildings Tax Credit. One CBIA Board member suggested California could pass a similar measure. , SB 463 established both a personal and a corporate tax credit for commercial buildings that have been registered and certified by the U.S. Green Building Council at LEED* Silver or higher for new construction (NC), existing buildings (EB), core and shell (CS), or commercial interiors (CI). The amount of the credit varies according to the square footage of the building and the level of certification achieved. Residential buildings certified as sustainable homes can also qualify for the tax credit. Eligible residential buildings include single-family homes and multi-family homes that are certified as either Build Green NM Gold or LEED-H Silver or higher and *Energy Star* certified manufactured homes. The amount of the credit also varies according to the square footage of the building and the level of certification achieved.

   To receive the tax credit, the building owner must obtain a certificate of eligibility from the Energy, Minerals, and Natural Resources Department after the building is completed. The department will only grant certificates until the equivalent of $5,000,000 worth of certificates for commercial buildings and $5,000,000 worth of certificates for residential buildings have been awarded in that calendar year. Further, no more than $1,250,000 of the annual amount for residential buildings can be applied to manufactured housing.

   The taxpayer must then present his/her certificate of eligibility to the Taxation and Revenue Department to receive a document granting the Sustainable Building Tax Credit. If the total amount of a Credit is less than $25,000, the taxpayer can apply the entire amount to his/her income tax in that year. If the credit is more than $25,000, it will be applied in increments of 25% over the next four years. If a taxpayer's tax liability is less than the amount of credit due, the excess credit may be carried forward for up to seven years. A solar thermal system or a photovoltaic system does not qualify for this tax credit if a the taxpayer has already claimed it under New Mexico’s separate Solar Market Development Tax Credit.[63]

3. Higher Density Allowance – Relaxed Park Fee Incentive - Another innovation currently in use in the City of Ontario for an area designated as a green development site is one in which developers are allowed higher densities through the use of the

63 For more information about the tax credit, interested parties can contact Susie Marbury, New Mexico Energy, Minerals and Natural Resources Department, Energy Conservation and Management Division, 1220 S. St. Francis Drive, Santa Fe, NM 87505. Phone: (505) 476-3254.

city's relaxed park fee incentive. In a qualifying development, overall approved density is 4.6 units per gross acre (including parks). However, the City of Ontario collects park fees for only approximately three units per thousand population instead of the allowed five units per thousand population. This frees up some developer money and allows greater net densities since the park acreage granted by the City of Ontario is not included in the units allowed per the gross acre calculation. Essentially, Ontario allows developers a higher density of units (closer to a net of 6.0 units per acre) while requiring less money for park-related fees.

4. Utility and State Financial Incentives for Energy-Efficient Community Design - One building industry leader thought utilities and the State of California were "…missing the boat by not providing design assistance funding to developers up-front in the development process for community-scale projects." He thought utilities should provide such funding through their traditional energy efficiency programs or develop some new programs. In his words, "If the utilities were allowed to give us $5K or $10K…or more…to help us design more sustainable neighborhoods, this would go a long way toward getting us the energy and environmental savings the Governor wants. It takes money to design things right." Some California utilities are evidently considering providing money to builders for LEED design through their energy efficiency program offerings. This may be an effective way to spur more community-scale green construction.

5. Utility Financial Incentives for Green Build Program Participation - There was consensus from building industry experts that there are now two primary green residential builder programs in California: California Green Builder Program (CGBP) and Build It Green (BIG). Some industry leaders suggested that builders who participate in these programs should be provided special financial incentives, especially in the depressed California housing market. The majority of industry experts thought financial incentives for building to these standards should be significantly higher than the $250 to $500 per home offered by utilities for building to *Energy Star* standards. "The data shows that we spend $2K-$3K on energy efficiency upgrades for most of our homes. Utilities need to help us here," commented one CBIA leader.

6. Municipal Bond Funds for Developer Loans - Because of California's current financial crisis, several interviewed building industry experts thought local government bond funds could be important to energy-efficient development projects in the near future. Through this mechanism, the city or county collects funds through a bond and disperses funds to developers involved in sustainable construction techniques and practices. The city of Phoenix, Arizona, currently uses such a bond instrument and offers low-interest loans to developers to assist them with community-scale, sustainability-related development. Said one CBIA leader, "It is about going where the money is...if the state doesn't have it, we need to go the local governments for help."

Addressing the Split Incentive Dilemma – A Misalignment of Investment Cost and Benefits

The so-called "Split Incentive Dilemma" exists when the party investing in energy-efficient building features (materials, technologies, and systems) does not directly benefit from the investment. The dilemma is well known in commercial and residential real estate rental or leasing markets. In these markets, building owners have little incentive to invest in energy-efficient features that produce benefits for tenants who are unwilling to pay premiums to receive them. On the other hand, tenants have little incentive to improve a leased space unless they intend to occupy it for a period sufficient to obtain a return on the investment. To do otherwise would produce a benefit for the building owner or future tenant.

The corollary dilemma for the large-scale community developer is a reluctance to invest in energy-efficient building features when the homeowner benefits from those features over a long period, well beyond the timeframe of the developer's involvement with the project. Further, the development industry sees insufficient market demand for these features at the present time and believes builders are forced to eliminate conventional upgrades such as granite countertops to accommodate energy-efficient features.

To address this barrier, stakeholders attending research workshops took a comprehensive look at the related factors that contribute to it and proposed a strategy that could transform the present real estate market into one in which

- "True Cost" pricing of real estate products (homes, commercial structures, and planned communities) reflects externalities associated with their direct and embedded energy consumption.
- Real estate appraisers, brokers, and buyers are aware of and are willing to pay for "Total Value" of energy-efficient and environmentally compatible real estate commodities.
- Developers integrate energy-efficient and renewable technologies into their projects, are recognized, and are monetarily rewarded for energy and emissions savings they produce.
- Residential, commercial, institutional, and municipal consumers are aware of and responsible for energy and water consumption and air emissions associated with their structures and communities.

Stakeholders believe real estate development and finance industries and state and local agencies must create a series of public-private partnership initiatives to transform the market. However, overall leadership for this effort must sit with the government. Further, stakeholder input suggested the following to address each strategic component listed above:

- To produce True Cost pricing, the industry must understand the externalities related to both the direct and embedded energy consumption and emissions impacts associated with conventional and alternative building. This will entail additional research to advance understanding of potential energy and emissions benefits of alternative land use, infrastructure, transportation, and urban design features at the community scale. Further research can determine the incremental design, development, municipal planning process, and entitlement costs to the developer for including them. True Costs cannot be known without a comprehensive assessment of energy and emissions impacts and costs of both conventional and alternative energy-efficient projects.

- To produce willingness to pay for Total Value of energy-efficient and environmentally compatible real estate commodities, consumers must have some sense of what total value means in relation to their buying decisions. Current consumers receive little information related to the energy efficiency of a new home or commercial structure. Other than efficiency ratings on HVAC and refrigeration equipment, consumers do not have an opportunity to judge overall efficiency, much less the emission impacts of a structure. With the exception of voluntary LEED certification, there is no industry-wide uniform product labeling for energy-efficient structures to aid consumers in making informed decisions. Thus it is impossible to compare one structure to others on the market. Whether through a voluntary industry initiative or mandatory state and local government regulations, uniform adoption of energy-efficiency and emissions performance for all structures and communities must be introduced if consumers are expected to be willing to pay for True Value of an energy-efficient, environmentally compatible real estate commodity.
- To produce a willingness among developers and builders to integrate energy-efficient and renewable technologies into their projects, stakeholders suggested there must be a new model for project accounting and appropriate financial mechanisms to produce a direct return on investment. The new model would be one in which a return on investment equals both an internal and an external rate of return, taking into account all related externalities.

  Financial mechanisms could include incentives, rebates, tax credits, or mortgage arrangements that would result in consumers' willingness to pay premiums for energy-efficient features. This could include third party economic incentives for developers that offset the incremental cost of including these features in their products. In addition to these mechanisms, stakeholders suggested development and construction practitioners need information resources outlining best practices and guidance on use of these technologies in large-sale projects. This might entail development of an industry and municipal online information clearinghouse. They also suggested municipal officials must address outdated and conflicting building ordinances and train personnel to assess energy-efficient development proposals.
- To produce consumer awareness and responsibility for energy and resource consumption, there must be advances in research, development, and demonstration of structure resource monitoring so occupants can observe resource consumption in real-time. This would entail advances in metering devices, building electrical and water monitoring systems, and display technologies that convert resource use into economic and emissions impact information.

Stakeholders suggested such a fundamental transformation of the marketplace would require centralized government leadership and suggested a California Executive Order would be necessary to realize the full strategy. Additionally, they suggested that some portion of the public goods funds be used to plan and execute contributing initiatives and that investor-owned utilities (IOUs) join with the California Public Utilities Commission (CPUC), the Energy Commission, the Department of Finance, and the State Treasurer's Office to further develop this strategy.

In industry interviews, one of the most aggressive green production homebuilders in California independently agreed with workshop participants. He suggested the dilemma will only be resolved when state and local governments and the IOUs offer incentives that transform the marketplace so private lenders and investors are willing to bridge the gap over the long-term. This builder echoed the call for some incentives listed above and added others that he believes state and local government agencies and utilities need to accelerate market transformation. These include the following:

<u>State and Local Government and Utility Incentives</u>

- Incentives for designing, constructing, and performance-verifying energy-efficient community demonstration projects.
- Incentives for passive solar heating and cooling design and construction.
- Incentives for installation of in-home displays to allow consumers to monitor and manage household energy use.

<u>Local Government Incentives</u>

- Code flexibility to allow graywater to be recycled to the toilet. Corresponding wastewater reduction credited back to the builder in the form of a sewer fee reduction.
- Credit to the builder for installation of water-saving fixtures and corresponding reduction in water fees.
- Incentives for builders to recycle graywater for the landscape.
- Incentive for building homes smaller than 2,000 square feet.
- Municipal offers to lock in incentives for four to five years to allow developers to plan energy-efficient communities.

<u>Investor-Owned Utility Incentives</u>

- Higher per kW rebate incentives to help bridge the gap between cost and energy savings.
- Higher incentives for peak kW reduction than for total kW reduction.
- Highest incentives for achieving 20% or more beyond Title 24 energy code. n
- Incentives to builders for use of other non-Title 24 design features that provide energy reduction.
- Increased incentives for solar water heaters to offset their cost.
- Incentive for developers providing Neighborhood Electric Vehicles (NEVs) and plug-in technology for hybrid and electric vehicles in projects.

Addressing Lack of Knowledge among Municipal Officials Inhibiting EECD Projects

One consistent finding from stakeholder workshops was the perception that most municipal government officials and building department personnel are neither familiar with nor capable of evaluating energy-efficient development projects.

Aside from the few cities that have their own energy utility, few municipalities have funding available to develop in-house expertise in the areas of energy supply, transmission, or distribution or to contract out for consulting assistance. The mortgage crisis and the slowing economy have created a precipitous decline in building permits and diminished growth of local property tax revenues, making funding for training of this nature particularly difficult. In addition, stakeholders at the workshops indicated a perception that few external training resources are available to assist municipalities to build in-house capabilities.

To address this barrier and these related factors, stakeholders proposed a strategy that entails development and pilot demonstration of a model municipal program on energy-efficient community development specifically designed for California municipalities. The program would include components that:

- Make the local government "business case" for pursuing EECD.
- Provide case studies of successful and transferrable municipal program elements found elsewhere.
- Provide a set of model EECD site design guidelines and standards, including a set of EECD carbon metrics that enable municipalities to quantify the carbon reduction potential of different design features.
- Provide a model municipal sustainable community development policy that aligns economic and community development priorities with specific energy efficiency and emissions reduction goals.
- Provide guidance on translating development policy into specific codes and standards modifications.
- Provide a list of competent academic or private training consultants capable of crafting and delivering onsite training for municipal personnel.

In addition to these components, stakeholders suggested development of a peer-to-peer network of municipal officials to facilitate transfer of EECD best practices and a clearinghouse of information similar to the one described above.

Stakeholders suggested utilities might be best suited to take the lead and to seek CPUC approval to make the related program elements eligible for funding under their innovation and energy-efficiency portfolio programs. They mentioned organizations such as the Local Government Commission, California universities, and subject matter experts as appropriate partners for utilities to collaborate with to implement this strategy.

Addressing the Lack of Uniform Municipal Procedures and Incentives for EECD Projects

Lack of uniform municipal procedures and related procedural incentives surfaced during workshop discussions and industry interviews as a major impediment for developers considering energy-efficient community projects in California. Most large-scale developers pursue projects in several municipalities across the state, often simultaneously. Consequently, they face the challenge of determining for each project what design features will or will not be permissible and incentivized in each jurisdiction. Meeting this challenge and the challenge of finding financial incentives for an energy-efficient project represents a substantial additional expense to the developer. The aforementioned experience of Brookfield Homes seeking funding for the Avenue project in Ontario, California, provides evidence that the challenge is both frustrating and expensive.

Stakeholder discussions and industry interviews suggest again they need some form of voluntary energy-efficient site development standard and a set of uniform incentives tied to the standard. The U.S. Green Building Council's LEED standard for Neighborhood Development (LEED-ND) is one such voluntary standard currently being pilot-tested nationally and in several California communities. However, several developers specifically stated they desire a new standard specific to California and aligned with the state's climate change goals and objectives.

If such a standard were to be established, development industry participants suggested that the following be considered as key components of a companion incentives program.

- More Flexibility in Zoning Code Requirements - This incentive, now common in many communities across the nation, allows green developers more zoning flexibility. Allowing decreased setbacks and bonuses and relaxed parking requirements and street standards in return for green construction is now generally the rule rather than the exception. CBIA builder interviewees were especially supportive of relaxed parking requirements.
- Cross-Departmental Expedited Plan Review - After years of experience with expedited plan check review in California, builders have learned that unless all municipal departments are involved in expediting plans, they can and will get stuck in departments uninvolved in the faster plan check loop. This will require oversight by a senior city official who will shepherd paperwork through the city process. At least two CBIA officials interviewed pointed out all departments need to be involved in expedited permitting.
- "Gold Star Treatment" - Pioneered by the City of Chula Vista, this easy-to-implement benefit entails ensuring a green builder's plans are affixed with a Gold Star when they are received at the city and then conducting weekly status reviews to ensure the plans are moving expeditiously through the review process. This administrative solution carries a surprising amount of weight with builders when the market is busy.

- Priority Field Inspections - Like the "Gold Star Treatment," this benefit is not as important during a downturn in the economy, since delays are at a minimum due to lack of construction. However, ensuring that green builders get inspections with no delays is a very easy benefit for most communities to provide. It is a low cost benefit and is provided by many jurisdictions now.
- "One-Stop-Shopping," Aggregating Benefits, and Sustainability Coordinators - Some building industry experts interviewed disagreed on the importance of a single point of contact when negotiating and implementing green, energy-efficient construction. Some thought it was very important, while others believed they could negotiate issues directly through the city manager and/or council. In some jurisdictions an experienced building official can offer financial and recognition incentives without council involvement. One industry leader suggested a new area for builder benefits that involves city-hired "sustainability coordinators." He said, "Cities may want to appoint a sustainability coordinator whose job it is to aggregate benefits for green developers like me."

  Sustainability coordinators may be in a position to help spur green, energy-efficient development in the future. Some cities are now hiring sustainability coordinators to help coordinate all green building functions.

- Accelerated Processing of Entitlement and Permit Applications - Despite the fact that this incentive is not as important now as providing direct financial incentives to builders, it remains a very important policy. Shaving time off review processes will always be important to builders, especially after the market picks up again and city staffs once again become stretched thin. Some cities are able to reduce the entitlement turnaround process by as much as 25-50% if a builder's homes perform 50% above minimum energy code. For an energy-efficient community-scale development project, this benefit can be critical, particularly to reverse the generally held perception that green projects take longer to move through the entitlement process.
- Residential Development Allowances in Commercial Zones - Three CBIA officials referenced this increasingly popular policy as important to industry members. It entails allowing a builder to construct residential structures in a commercial area in exchange for the builder's commitment to design and build an energy-efficient community-scale project. This is an easy-to-implement incentive for most cities and counties.
- Tiered Utility "*Energy Star*-Plus" Category – During industry interviews, only one CBIA leader mentioned the *Energy Star* label. He also mentioned the *Energy Star* label is important to some of his colleagues, but said it has become less important for many others over the past year. He believed utilities should consider structuring their financial incentives more toward an "*Energy Star*-Plus" category, where "…we are rewarded with more funding for building well beyond *Energy Star* levels." The researchers believe this two-tiered policy is likely to become commonplace in the future. Many utilities, such as the Public Service Company of New Mexico, already offer a two-tier incentive.

Addressing the Lack of Municipal Investments in Enabling Green Infrastructure

Stakeholders identified municipal investment in enabling green infrastructure as a necessary pre-requisite to engage development industries in designing and building energy and resource-efficient projects. Specifically, they cited need for government leadership that results in partnership initiatives with local utilities that capitalize green infrastructure projects. Such initiatives would enable the industry to take advantage of distributed energy and renewable energy technologies, alternative vehicles and transit, water reclamation systems and stormwater runoff, and urban heat island reduction measures. Stakeholder discussion described factors supporting this barrier include regulatory and utility rules that discourage municipal investment in energy systems, lack of capital for these investments, and lack of constituent awareness and interest in the subject.

To address the barrier and the supporting factors, stakeholders proposed a strategy that entails collaboration between local government advocacy organizations (i.e., Local Government Commission, California League of Cities, etc.), the three major IOUs, the Energy Commission, CARB, and the CPUC to

- Examine and modify existing regulatory and utility rules that impede municipalities and developers from taking advantage of available energy-efficient and renewable-energy technologies and systems. Chief among these are those affecting distributed generation interconnection, sub-metering, standby charges, and inter-lot transfers of energy.
- Provide local governments guidance to form financial mechanisms that can generate the necessary capital for these investments. This could include formation of energy-efficient and renewable technology districts (e.g., Berkeley's solar district) or utility surcharges to create municipal green technology investment funds whose dividends support revolving loan programs.
- Formulate mechanisms to inform and involve consumers in responsible use of energy, water, and material resources, such as the following:
    - Public information elements that educate consumers about the direct and indirect environmental impacts and costs of consumption practices.
    - Clear utility price signals and in-home displays that communicate the cost of their resource consumption in real time.
    - Economic incentives and disincentives such as a utility or local tax rebate at the end of a calendar year for consumer conservation or a carbon tax/surcharge on excessive consumption.

Development industry stakeholders believe government and utility leadership on these initiatives will be necessary to lead to private investment. Other entities to enlist in such an effort should include regional transit planning organizations, infrastructure industry trade organizations, and financing entities.

Addressing the Lack of Consumer Willingness to Pay for the Value of Energy Efficient Features

As stated repeatedly during all stakeholder breakout discussions, most consumers are uninformed about the value of, and are unwilling to pay premiums for, energy-efficient and sustainable design features in their homes, businesses, and communities. At this stage in the evolution of the movement, this is not surprising. However, it is clear action is needed to address this barrier, as it underpins most of the barriers identified in this research.

Stakeholders envision a future where energy-efficiency and responsible resources management are the norm among consumers, rather than the exception, and where enabling technologies are incorporated into the construction of all homes, offices, and institutional buildings.

They believe, if their vision is to become a reality, a series of steps must be taken to lead to a market transformation similar to the one described for the split-incentive barrier:

- Increase market volume for energy-efficient features to the point where their inclusion in new construction represents a negligible incremental cost to builders.
- Ensure at the point-of-sale, all real estate products convey standard industry information about the structure's energy efficiency, emissions impact, and the embedded energy costs of materials.
- Ensure all buildings feature real-time information displays on energy, water, and material consumption; their environmental impact; and economic costs to the consumer.

Considered together, stakeholder input suggests a strategy that entails:

- Additional research to quantify the energy and emissions profiles of different structural building materials and internal operating equipment and systems.
- A public information campaign and a targeted information dissemination effort to ensure these findings reach consumers and industry trade organizations.
- State regulation that mandates minimum building and community development site performance levels for carbon emissions reduction, similar to the Title 24 standard for energy efficiency.
- Economic disincentives and utility price signals similar to those mentioned above in response to the previous barrier (Lack of Municipal Investments in Enabling Green Infrastructure).

Stakeholders believe state and local government agencies must lead this effort, but all other sectors, in particular real estate finance and development, must be active collaborators. In addition, California universities should play a significant role in research and consumer education.

Addressing Investment Risks that Inhibit Capital Market Entities from Financing EECD Projects

To determine investment risks and barriers that inhibit capital market entities from financing energy-efficient development projects, researchers conducted an online survey of those businesses. In early June 2008, they sent 175 email survey invitations to randomly-selected members of the National Association of Industrial and Office Properties (NAIOP) and the Pension Real Estate Association (PREA).

Recipients completed and returned 120 questionnaires between June 15 and June 30, 2008. Respondents represented three occupational subgroups: lenders (34%), equity investors (49%), and developers (17%). The majority of respondents (20%) were located in California, followed by those located in Colorado, Illinois, Texas, New York, and Florida. Over 65% of the participants had been involved with LEED-certified projects or *Energy Star* designated buildings. The high percentage of participants with experience in energy-efficient projects may suggest a sampling bias, i.e., those with experience are more interested in being part of this research and thus more willing to complete the survey.

The survey contained questions related to perceived costs, value, risk, barriers, and participant engagement in energy-efficient building and community development projects. The following text, tables, and figures summarize survey results.

Incremental Costs vs. Value

Researchers designed the first survey question to extend their examination of incremental costs by asking survey participants if they believed an energy-efficient building costs more than an otherwise comparable conventional building. The majority of the respondents (94%) indicated they did believe an energy-efficient building would cost more than a conventional building. Over a third of the sample (38%) estimated the incremental cost to be 1-5% higher, another one third (35%) estimated the cost to be 5-10% higher, and (21%) thought incremental cost would be over 10%. Figure 54 shows these results in a pie chart.

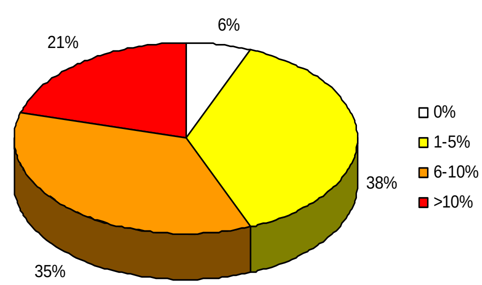

Figure 54. Percentage of Survey Respondents and Their Perceived Percent Incremental Costs of an Energy-Efficient Building over a Conventional Building

Source: National Energy Center for Sustainable Communities

With regard to value, more than 90% of the respondents believed an energy-efficient building has a higher value than a comparable conventional building. An overwhelming majority of respondents considered lower operating costs as the primary factor contributing to higher value. Other contributing factors included higher rent, lower vacancy rate, and lower tenant turnover.

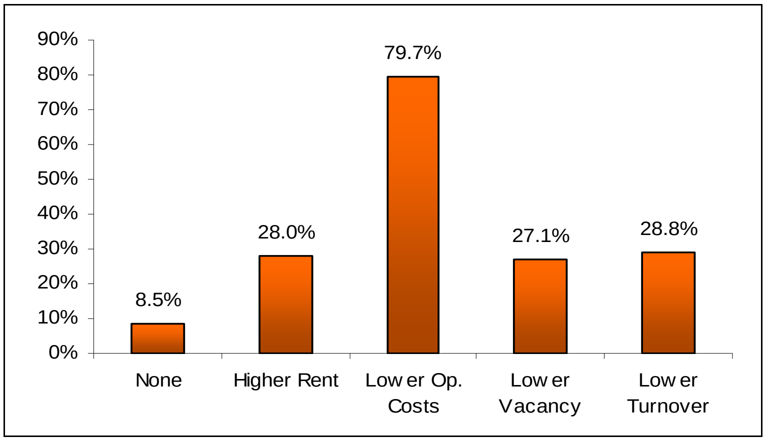

Figure 55. Perceived Factors Associated with Added Value

Source: National Energy Center for Sustainable Communities

Since an energy-efficient building was considered more costly to construct but more valuable to own, respondents were asked if the additional value was sufficient to offset the higher costs. Nearly 60% believed the value was sufficient to offset the cost, while 22% disagreed. About 20% of participants were not sure about the cost-value tradeoff.

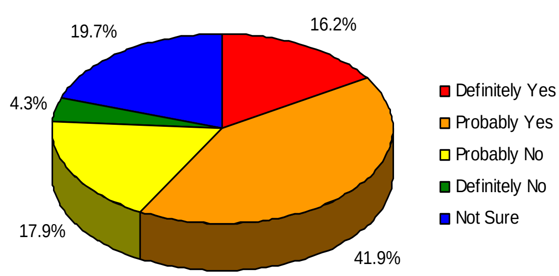

Figure 56. Percent of Survey Respondents Who Perceive that Added Value Is Sufficient to Offset Higher Costs

Source: National Energy Center for Sustainable Communities

Investment Barriers

Drawing from input received during stakeholder workshops, the research team identified five barriers believed to influence finance/investment decision-making relative to energy-efficient building projects. Table 73 and Figure 57 present these barriers and a set of impact factor scores the survey sample assigned to each.

The research indicates the surveyed lenders, investors, and developers believe the most significant barrier is consumers' unawareness of the benefits of energy-efficient buildings or development projects and presumably would be unwilling to pay premiums for them (Barrier 2). The next two barriers were lack of public (state and local government) and private (utility and financial institution) incentives (Barriers 3 and 4). There are no statistically significant differences among survey respondents' ratings of the top three barriers. Respondents ranked the last two barriers, out-dated building codes and scarcity of experienced design teams (Barriers 1 and 5), as significantly less important.

Table 73. Barriers Preventing Investment in Energy-Efficient Development

Barrier	Description	Impact Factor*
Barrier 1	Local building codes are out-dated, so energy-efficient buildings and development projects may violate existing codes	2.21
Barrier 2	Consumers/space users are not aware of the benefits of energy-efficient buildings and development projects	2.67
Barrier 3	State/local governments don't provide sufficient financial incentives	2.65
Barrier 4	Private sector entities such as lenders and utilities don't provide sufficient financial incentives	2.58
Barrier 5	Experienced design teams are difficult to find	2.25

* Each respondent rates the barriers using the following scale: great impact (4), moderate impact (3), little impact (2), no impact (1), and not sure (NA). The impact factor is the weighted average of the ratings, excluding those who were not sure about the impact.

Source: National Energy Center for Sustainable Communities

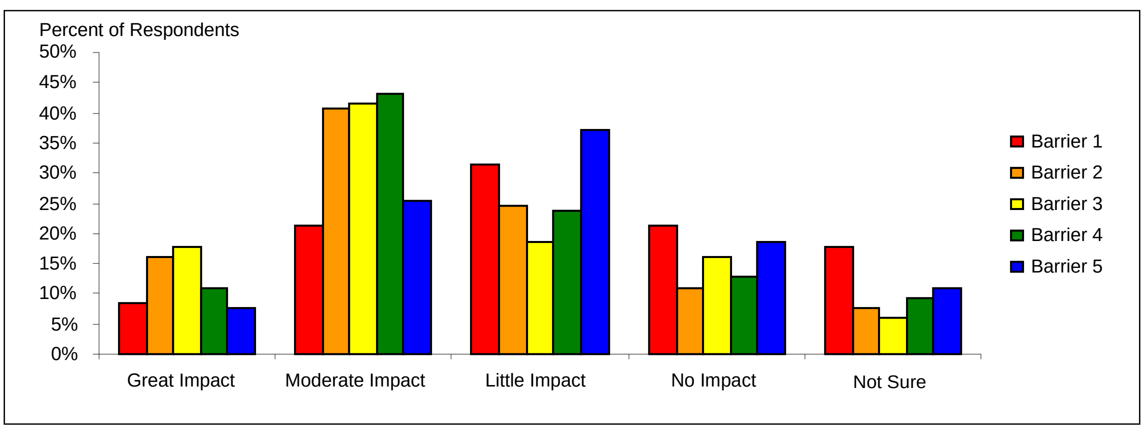

Figure 57. Survey Respondents' Perceived Impact of Barriers

Source: National Energy Center for Sustainable Communities

Investment Risks

Next researchers asked survey respondents to rate the importance of seven risk factors stakeholders had identified as having influence on return on investment. Table 74 and Figure 58 present their responses.

Survey responses indicated the two risks of greatest concern were that tenants would not be willing to pay higher rents to occupy energy-efficient buildings and that the added value of energy-efficient features would not be recognized nor credited by lenders or appraisers. The next two risk factors of greatest concern were that building owners would be unable to capture the added value when they sold their energy-efficient buildings and the possibility of incurring additional fees associated with design, installation, and inspection of energy-efficient features. It is somewhat surprising that survey participants were not very concerned about the possibility the approval and/or entitlement process for an energy-efficient project might take longer than a conventional project.

Table 74. Risks Preventing Investment in Energy-Efficient Development

Risk	Description	Concern Factor*
Risk 1	Tenants might be unwilling to pay higher rent for an energy-efficient building or development project	2.75
Risk 2	The benefits of an energy-efficient building might not be reflected in value (by lenders, appraisers, etc.)	2.62
Risk 3	The owner might be unable to benefit from the higher value when selling the building	2.28
Risk 4	The design process might take longer due to the lack experienced teams	1.93
Risk 5	The approval/entitlement process might take longer	1.63
Risk 6	There might be additional requirements and/or fees involved (design, installation, inspection, etc.)	2.26
Risk 7	As technology continues to change, the building might become functionally obsolete soon	1.97

* Each respondent rates the risks using the following scale: extremely concerned (4), moderately concerned (3), mildly concerned (2), not concerned (1), and not sure (NA). The concern factor is the weighted average of the ratings, excluding those who were not sure about the impact.

Source: National Energy Center for Sustainable Communities

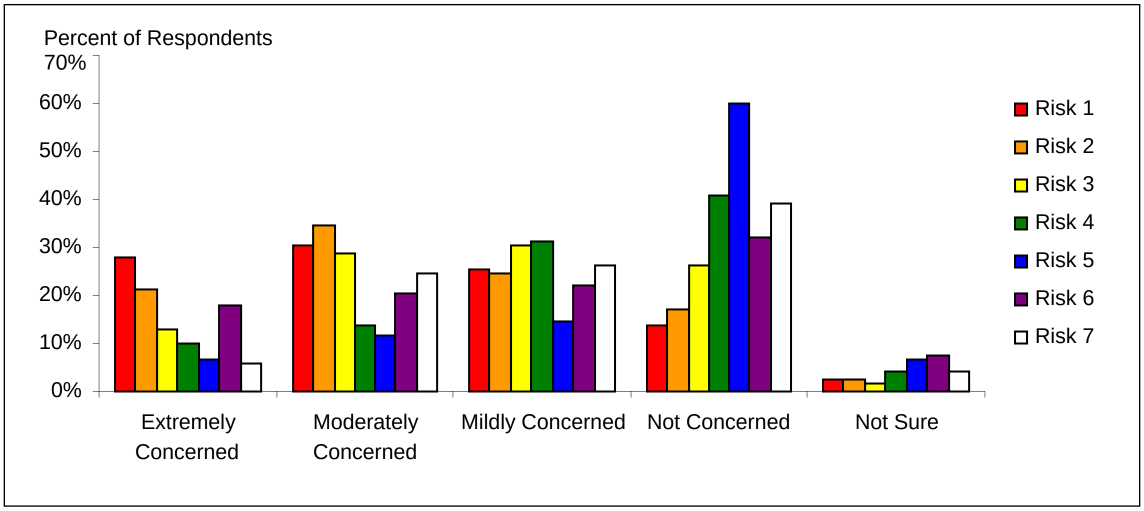

Figure 58. Survey Respondents' Perceived Importance of Risks
Source: National Energy Center for Sustainable Communities

Survey Results by Occupational Subgroup

To examine how real estate capital markets perceive barriers and risks, researchers stratified survey results and analyzed them by occupational subgroup. Subgroups were comprised of lenders, equity investors, and developers. Table 75 presents the average rating of each barrier, as well as its ranking among all barriers (in parentheses), by the entire survey sample and each of the three subgroups. Equity investors consider the lack of consumer awareness of the benefits of energy-efficient buildings as the most significant barrier. Lenders and developers perceive lack of government incentives as the top barrier. The top three barriers also include lack of incentives from the private sector, such as utilities and financial institutions. All three subgroups agree neither outdated local building codes nor the scarcity of experienced design teams are significant barriers.

Table 75. Comparative Impact of Barriers by Occupational Subgroup

Barrier	Entire Sample	Lenders	Equity Investors	Developers
Barrier 1	2.21 (5)	2.31 (4)	2.14 (5)	2.18 (4)
Barrier 2	2.67 (1)	2.68 (2)	2.70 (1)	2.53 (2)
Barrier 3	2.65 (2)	2.71 (1)	2.53 (3)	2.88 (1)
Barrier 4	2.58 (3)	2.58 (3)	2.63 (2)	2.38 (3)
Barrier 5	2.25 (4)	2.31 (4)	2.26 (4)	2.06 (5)

Source: National Energy Center for Sustainable Communities

Table 76 compares the perception of risk factors by occupational subgroups and indicates all three groups are most concerned about the possibility tenants might not be willing to pay higher rent for energy-efficient space. Other important risk factors include the possibility that benefits of an energy-efficient building might not be reflected in appraised property value and there may be additional requirements and/or fees involved. The approval/entitlement process is the least concern by all three groups.

Table 76. Perceived Importance of Risks by Occupational Subgroup

Risk	Entire Sample	Lenders	Equity Investors	Developers
Risk 1	2.75 (1)	2.87 (1)	2.66 (1)	2.72 (1)
Risk 2	2.62 (2)	2.72 (2)	2.63 (2)	2.33 (3)
Risk 3	2.28 (3)	2.18 (4)	2.41 (3)	2.17 (4)
Risk 4	1.93 (6)	1.95 (5)	1.91 (6)	1.94 (5)
Risk 5	1.63 (7)	1.70 (7)	1.54 (7)	1.78 (6)
Risk 6	2.26 (4)	2.29 (3)	2.15 (5)	2.53 (2)
Risk 7	1.97 (5)	1.74 (6)	2.22 (4)	1.78 (6)

Source: National Energy Center for Sustainable Communities

Survey Results by Respondent Experience

Researchers also examined survey results in terms of the respondents' past experience with design and construction of energy-efficient buildings. Sixty-five percent of respondents had financed, developed, or invested in LEED/*Energy Star* buildings. These respondents consider lack of government incentives (Barrier 3) as the most significant barrier to energy-efficient development projects, followed by lack of consumer awareness of the benefits of owning energy-efficient space.

Respondents who had not been involved in LEED or *Energy Star* projects believed lack of consumer awareness had the greatest impact. They ranked lack of incentives offered by private and public sectors second and third. Regardless of their experience, respondents agreed outdated local building codes and scarcity of experienced design teams had much less impact than other barriers. Across all barriers, the value of the impact factors for respondents without experience was significantly higher than the values for respondents with experience. This difference in perception may explain why some firms have not engaged in LEED or *Energy Star* building projects. Table 77 provides the base numbers for these findings.

Table 77. Impact of Barriers by Practitioner Experience

Barrier	Entire Sample	With Experience	Without Experience
Barrier 1	2.21 (5)	2.10 (5)	2.42 (5)
Barrier 2	2.67 (1)	2.51 (2)	2.95 (1)
Barrier 3	2.65 (2)	2.60 (1)	2.74 (3)
Barrier 4	2.58 (3)	2.49 (3)	2.75 (2)
Barrier 5	2.25 (4)	2.14 (4)	2.43 (4)

Source: National Energy Center for Sustainable Communities

Both groups identified the possibilities that tenants may not be willing to pay higher rent for energy-efficient space and third parties may not recognize benefits of an energy-efficient building as the top risk factors. The approval/entitlement process was the least concern. Similar to the impact factor of barriers, respondents without experience exhibited higher concern factors than those who had experience in energy-efficient projects. Table 78 provides the base numbers for these findings.

Table 78. Perceived Importance of Risks by Practitioner Experience

Risk	Entire Sample	With Experience	Without Experience
Risk 1	2.75 (1)	2.53 (1)	3.13 (1)
Risk 2	2.62 (2)	2.36 (2)	3.08 (2)
Risk 3	2.28 (3)	2.12 (3)	2.63 (4)
Risk 4	1.93 (6)	1.77 (6)	2.24 (5)
Risk 5	1.63 (7)	1.40 (7)	2.08 (7)
Risk 6	2.26 (4)	1.99 (4)	2.78 (3)
Risk 7	1.97 (5)	1.88 (5)	2.18 (6)

Source: National Energy Center for Sustainable Communities

Summary

In summary, the capital market survey indicated the following:

- The vast majority of lenders, investors, and developers believe energy-efficient building projects are more expensive to build (5-10% or more), but are also more valuable to own than comparable conventional buildings. The latter perception is due to the assumption of lower owner operating costs. However, a minority also believe there may be lower rates of tenant turnover and higher rents. Most respondents believe these benefits offset additional costs.
- Equity investors believe lack of consumer awareness of the benefits of energy-efficient buildings is the top barrier to investment, followed by lack of private (utility and financial institution) incentives. Lenders and developers believe the top two barriers are lack of public (government) financial incentives and lack of consumer awareness.
- All three occupational subgroups believe the top risk is that tenants will not be willing to pay higher rents for energy-efficient space, followed by concern lenders and appraisers may not recognize the value of this space.

The workshop and industry interviews generated a number of models, policies, and incentives to overcome barriers and risks. These include the following economic incentives and informational mechanisms:

Economic Incentives

- State and local carbon credits for EECD development projects.
- Cash rebates for consumers buying properties in energy-efficient developments.
- Discounted insurance rates for energy-efficient construction.
- Utility and/or municipal subsidies to developers for EECD design consultant costs.
- Collection delay of increased property tax until close of escrow.
- Payment deferral of special assessments until close of escrow.
- Low-interest financing for energy and/or sustainable construction projects.
- Tax credits for homeowners in energy-efficient developments.
- Federal and state income tax reductions for developers and builders of EECD projects.

- Research to generate means of aligning EECD investment costs with long-term benefits.
- Energy-efficient mortgage instruments.

Information Mechanisms

- Demonstration projects for the development industry to document the value of EECD .
- Development industry case studies and examples of successful EECD projects.
- Consumer, lender, and appraisal industry education and training initiatives.
- Best Practices information for public, private, and utility planning practitioners.
- Centralized source of information on EECD (information clearinghouse on incentives).
- Professional training resources for public, private, and utility development practitioners.
- Model design and development guidelines and standards for EECD.

4.0 Conclusions and Recommendations

This chapter describes the conclusions and recommendations for the six research objectives. It draws conclusions directly from the research results for each objective presented in the preceding chapter. This chapter also sets forth a set of additional conclusions that are broader than the individual research objectives. They are presented after the conclusions for the numbered objectives. The subsequent sub-section for each numbered objective presents recommendations, followed by a set of additional recommendations for the Energy Commission's consideration.

4.1 Conclusions

Research Objective #1 - Estimate the relative energy efficiency and emissions reduction performance of individual energy efficiency (EE), demand response (DR), renewable energy (RE), and distributed generation (DG) technologies (advanced energy technologies) in typical development projects (residential, commercial, industrial, institutional).

The researchers have concluded there are no typical development projects. Since they are all site-specific, energy efficiency and emissions reduction performance of individual advanced energy technologies will vary by site. The mix of building types, their end-uses, their proximity to one another, and the climate all determine the appropriate combinations of technologies to reach optimum performance. Further, as was apparent with the analysis of distributed generation, the availability of incentives will affect the economic feasibility of deploying these technologies in development projects.

Having stated this, the researchers concluded significant energy savings and emissions reductions could result for Site A and Site B through use of different energy efficiency and advanced energy technology applications. The discussion below summarizes the specific modeling results that determined this conclusion.

Site A

- Results of the modeling indicated use of the EE package could reduce Site A community annual TDVI-based energy consumption (kBtu/sf-year) by 12.3% below what would be expected if the buildings were built per the builder's specifications. Supplementing the EE option with solar PV-based on-site power generation systems could further reduce the site TDVI to 30.0% below the builder's baseline approach. Substituting solar PV power generation technology with natural gas-fired DG could result in a 21.7% reduction in TDVI energy consumption.
- Use of the EE option could achieve a 16.6% reduction in annual consumption of natural gas (MMBtu/year). Adding PV technology to the EE option would not alter the natural gas consumption at the site. However, using DG technology instead of PV could result

in a significant increase in the consumption of natural gas at the site, by 106.5% as compared to the builder's proposed baseline approach.

- With regard to electric energy consumption (kWh) and peak demand (kW), implementation of the EE option could reduce site annual kWh by 11% and demand by 16.8% below the builder's baseline. Supplementing the EE package with PV technology could result in a cumulative reduction of kWh by 34.3% and kW by 29.1%. Alternatively, using the DG technology with the EE option could reduce annual kWh by 31.2%, which is close to the impact of the PV option. However, DG could be more effective in controlling electric peak demand and could reduce it by 45.2%.
- Energy-related air emissions could also be reduced significantly because of the reduction in energy consumption resulting from the use of the energy-efficient option. Carbon dioxide (CO_2) emissions could be reduced by 12.1%, sulfur dioxide (SO_x) emissions by 11%, and nitrogen oxide (NO_x) emissions by 12.6% as compared to the emissions expected from the builder's baseline. Similar numbers for the EE-PV option showed reductions of 30.8% in CO_2, 34.2% in SO_x, and 29.3% in NO_x. The EE-DG option was not as effective in reducing emissions as the EE – PV option. However, with reductions of 6.7% in CO_2, 30.3% in SO_x, and 38.5% in NO_x , it was still better than the builder's baseline approach.
- Researchers estimated annual utility costs savings associated with use of the energy-efficient option at 11.3% when compared to the builder's baseline approach. They estimated simple payback for the EE package to be 5.9 years with a ROI of 16.9%. The EE-PV option utility cost savings were 32.3% with simple payback of 12.4 years and a ROI of 8.1%. Implementing EE-DG option could result in annual utility cost savings of 16%, a simple payback of 7 years, and a ROI of 14.3%.[64]

Site B

- Results of the modeling indicated use of the EE option could reduce Site B annual TDVI-based energy consumption (kBtu/sf-year) by 8.2% below what could be expected if the buildings were built according to the builder's specifications. Supplementing EE with solar PV-based on-site power generation could further reduce site TDVI to 36.4% below the builder's baseline. Substituting PV power generation technology with microturbine-based DG/CHP generation systems could result in an 11.7% reduction, smaller than the EE-PV option, but still better than the EE option alone.
- Use of the EE option could achieve a 17.4% reduction in annual natural gas consumption (MMBtu/year). Adding PV technology to the EE option could not change natural gas

64 Assumes SGIP rebates of 600/kW. See footnote 6 of this report for additional explanation.

consumption at the site. However, implementing gas-fired microturbine-based DG technology in place of PV could increase Site B natural gas consumption by 94%.

- With regard to electric energy consumption (kWh) and peak demand (kW), implementation of the EE option could reduce site annual kWh by 5.8% and demand by 8.5% below the builder's baseline approach. Supplementing EE option with PV technology could result in a cumulative reduction of kWh by 42.6% and kW by 16.2%. Using DG technology with the EE option could reduce annual kWh by 30.5% and demand by 13.1%.
- Reduction in energy consumption resulting from use of the energy-efficient EE option could significantly reduce energy-related air emissions. Carbon dioxide (CO_2) emissions could be reduced by 9.2%, sulfur dioxide (SO_x) emissions could be reduced by 6.0%, and nitrogen oxide (NO_x) emissions could be reduced by 10.5% as compared to the emissions expected from the builder's baseline approach. Similar numbers for the EE-PV option showed a reduction of 35.2% in CO_2, 42.3% in SO_x, and 32.5% in NO_x. The EE-DG option was not as effective in reducing emissions as the EE-PV option, although it still provided SO_x and NO_x reductions of 29.1% and 48.9%, respectively, over the builder's baseline. However, CO_2 emissions from the EE-DG option was 5.2% higher than the builder's baseline approach. This was because the CO_2 emissions of the DG deployed at Site B entailed a mix of microturbine-based power generation and heat recovery technologies that release more CO_2 than is released during production of an equivalent amount of electricity at a central power plant in California.
- Researchers estimated annual utility cost savings associated with use of the energy-efficient option to be 6.8% when compared to the builder's baseline. They estimated simple payback for the EE option to be 9.8 years with a ROI of 10.2%. The EE-PV option utility costs savings were 27.9%, the simple payback was 14.8 years, and ROI was 6.7%. Implementing the EE-DG option could result in annual utility cost savings of 19.8%, a simple payback of 6.7 years, and a ROI of 14.9%[65].

The energy efficiency measures recommended for implementation in the various Site A and Site B building envelopes include more efficient building materials, higher efficiency HVAC equipment, and selective deployment of DG and PV technologies. However, each building and each space-use type would demand a different combination of these measures to produce optimum energy efficiency and emissions reduction.

Attachment I for Site A and Attachment II for Site B provide descriptions and specific details of recommended combinations for each building prototype. These two appendices provide tables listing recommended measures and showing energy savings and environmental and economic impacts for each of the prototypical buildings. The results provide a wealth of information developers can use when considering appropriate building energy technology packages for

65 Assumes SGIP rebates of 800/kW. See footnote 6 of this report for additional explanation.

their large-scale projects. Of equal utility are the analyses found in the tables that indicate certain energy efficiency measures commonly considered valuable for inclusion in building projects proved to have limited benefit, and the researchers do not recommend their implementation.

Researchers concluded incorporation of a district cooling system to serve Site A compared favorably to stand-alone cooling production at individual buildings. District cooling for the site was most attractive when TES was incorporated into the district cooling system, allowing substantial energy cost reductions due to the time-of-day rate structure of the utility tariff. The optimum configuration district cooling with TES alternative had the lowest annual operating costs of the six alternatives evaluated. This district cooling alternative optimized system efficiency through incorporation of a series-counter flow chiller arrangement, VFDs driving chillers, and chilled water TES.

The reduction in electricity consumption (over three million kWh) for the optimum configuration district cooling plant with the TES alternative could also provide substantial reduction in emission of pollutants and greenhouse gasses. Furthermore, the ability to peak shave with the TES alterative significantly reduced peak power requirements, thereby reducing the amount of electrical infrastructure required to meet peak cooling loads for the development site. The section below discusses other less tangible advantages of district cooling over cooling production at individual buildings.

<u>**Research Objective #2** – Determine the extent to which application of these technologies in typical development projects will reduce peak demand and result in better utilization of existing utility infrastructure</u>.

As stated above, the researchers concluded typical development projects do not exist. Rather, each site is unique to a certain extent. This is particularly true with regard to utility distribution planning. Both electric and gas distribution planners were quite explicit in stating each site required careful examination of individual and aggregate building loads and adjacent near and mid-term development plans to design utility systems to meet both existing and future capacity and to do so with reliability. Although gas distribution planners were able to calculate capital cost impacts of the alternative development scenarios for both Sites A and B, electric distribution planners were reluctant to do so for either site.

Neither the EE nor the EE-PV development options would result in alteration in electric utility plans for either site or for the EE-DG option in Site B. Only the EE-DG development option in Site A was considered a candidate that could reduce the need for one of three circuits and the associated substation facilities. Concern for ensuring system capacity and reliability was the primary reason planners did not deem the other options to have significant utility impact. Insufficient load reduction was not the reason. This was particularly the case with the EE-PV option, given the intermittency of solar energy with variable cloud coverage. In the case of the EE-DG option, both emissions performance and lack of an available utility incentive now make its use both economically unfeasible and undesirable from an environmental standpoint.

Researchers concluded the optimized natural gas loads for Sites A and B would not result in alteration of the utility's infrastructure plans, given the conventional approach to distribution pipe planning and plans to meet the worst case climate conditions for a given area. However, because of increased natural gas loads associated with the EE-DG option, additional pipe pressures and a regulator station would be necessary to meet demand.

Researchers concluded unless sufficient energy system redundancy and non-intermittent sources of renewable energy (or improved solar storage technologies) were included in a site development plan to ensure capacity and reliability, they cannot expect substantial utility savings from reduced utility infrastructure costs. Additionally, researchers concluded that until the emissions performance of fossil-fueled distributed generation technologies are improved and utility incentives are restored, the substantial benefit they provide in peak demand reduction would not be realized in the State.

Research Objective #3 - Determine market-feasible combinations of energy technology and design options that will increase building energy efficiency by more than 25% above existing 2005 Title 24 standards.

Attachments I (page 22) and II (page 24) contain combinations of building envelope measures and technologies exceeding Title 24. Researchers determined that disruptions in the construction process associated with their installation must also be considered in determining market feasibility. For these two specific sites, the construction process implications entail primarily product substitutions. Product substitutions have relatively minor impact on the construction process, primarily involving differential costs for labor and material associated with the substitutions.

One of the roofing alternates would add an additional step to the process. However, this step would be by the same trade contractor. Since this case does not introduce additional handoffs, planners could expect no cost implications beyond the labor, equipment, and material differentials. Of greater concern was one of the exterior wall alternates (stucco over rigid insulation). It exhibited significant potential to disrupt normal processes by the addition of inspection and scaffolding activities. This suggests an analysis of construction process impacts and their associated costs must accompany developer's evaluation of first costs of alternative energy-efficient building.

Researchers concluded that available utility incentives do make a significant contribution to offsetting additional costs associated with the modeled development options. They found these incentive programs reduced the simple payback period for the EE option in the Site A prototypes by approximately 1.3 years, from an average of 7.3 years to an average of 6 years. For the optimal energy efficiency packages augmented with photovoltaic generation, the average simple payback periods decreased by 1.5 years (from 14.5 to 13 years) by available utility incentive programs. For the optimal energy efficiency package, four of the 15 prototypes experienced energy performance at least 25% better than existing 2005 Title 24 standards. When photovoltaic generation was included, all of the prototypes (less one sub-prototype) experienced energy performance at least 25% better than the existing 2005 Title 24 standards.

Research Objective #4 - Estimate the degree to which enabling community design options (i.e., mixed-use/moderate density/transit-oriented development, stormwater runoff and carbon sequestration measures, urban heat island reduction measures, and passive solar building orientation) can improve energy technology performance in typical development projects.

Based on modeling results, researchers concluded that the community design options examined would improve the economics and performance of both CCHP and district energy technologies in large-scale development projects. Additionally, their use and use of other modeled community design options would produce significant reductions in land, energy, and petroleum consumption and energy-related emissions in California communities. The following summary of results discusses these conclusions.

a. *Mixed-use, moderate-density development increases energy and land use efficiency and significantly reduces transportation-related air emissions.*

As expected, compact development does lower per-capita energy use as compared to conventional low-density development typical in most California communities. With residential energy use reduced by more than 25%, compact development contributes significantly to the state's zero net energy goals. These energy savings are the result of the use of multi-family, mixed-use structures that share walls (and envelope efficiencies), highly efficient heating-ventilation-air-and-conditioning systems, and a reduction in transmission line losses, estimated to be approximately 9% of the central power plant electricity delivered (Energy Information Administration).

Efficient use of land is key to growth management for all California's communities. Over the past 20 years, California's population has grown by almost 32%. This population growth is a primary factor in the increase of congestion and related emissions throughout California, and it requires efficient use of land to be manageable. More efficient use of land through mixing uses and increasing density can enable California communities to pursue more effective multi-modal transportation options like highway, rail, bus, bike, and air and offer more efficient technologies like CCHP and district cooling.

Through thoughtful, responsive planning, California communities can increase the number of choices for residents in housing and transportation and build "up" instead of "out" at moderate levels. California communities should pursue context-sensitive density options that would allow a range of development options depending on factors such as transit, proximity to an existing employment or downtown center, and projected population and employment growth.

The average United States citizen uses more energy for transportation than citizens from any other industrialized nation, in part due to greater distances traveled (Gilbert 2002). As of 2006, the percentage of trips to work in a private vehicle in California, excluding carpooling, was not significantly different from nation-wide rates. Seventy-three percent (73%) of California drivers use private vehicles; the national average is 76%. According to a study by Ferrel and Deaken (2001), California led the nation in automobile use after the end of World War II, but the rest of the nation caught up in the early 90s. On average, transportation accounts for about one-third of energy consumption in the United States (Energy Information Administration). This is similar for California. Significant savings in energy and reductions of greenhouse gas (GHG) emissions result from reducing community vehicle-miles-traveled (VMT).

From this research and earlier work on this subject, it is clear that compact, mixed-use development promotes energy and GHG savings by reducing VMT. The mix of employment and housing, a strong network of pedestrian walkways and streets, access to alternative means of mobility, and close proximity to retail stores promote more walking and less driving. This has less to do with a large number of people living in a neighborhood and more to do with the practical efficiency of living close to places where one works, shops, and recreates.

b. *Modest increases in tree canopies and decreases in impervious surfaces produce energy and stormwater facility construction costs savings and emissions reduction in large-scale development projects.*

Researchers concluded that trees increase albedo and provide pervious surfaces that significantly reduce the velocity of stormwater flows, in addition to providing shade. Diversion of stormwater provides significant savings to communities by reducing the size of stormwater management facilities needed to accommodate flows from large-scale developments. In addition, increased tree canopy and decreased impervious surfaces recharge ground water supplies and can reduce need for irrigation of lawns and landscaping. This, in turn, reduces both water and energy use. According to the analysis, total annual energy savings in Site A were 977 kWh in the baseline and 1,893 kWh with a 12.4% canopy. In Site X, annual energy savings were 1,599 kWh for the baseline and 4,498 kWh for the optimized scenario.

c. *Modest increases in tree canopies produce significant storage and sequestration of carbon dioxide and other pollutants in large-scale development projects.*

Although carbon emission reductions proposed by various strategies in this project are significant, planners should not overlook the ability of trees and other vegetation to store and sequester carbon dioxide. The average adult tree sequesters 26 pounds of carbon dioxide a year and produces enough oxygen for a family of four. Additional air quality improvements are significant since trees trap or absorb many pollutants and reduce air temperatures, which reduces the volatility of other pollutants. These associated benefits reduce overall community health care costs and improve quality of life for residents.

d. *Use of urban heat island effect mitigation strategies produce community-wide energy savings.*

The research showed a 10% increase in vegetation and albedo can reduce ambient air temperatures in a typical southern California community development project 1.3°F-2.8°F. The researchers concluded this change results in significant energy savings. A number of recent studies concur with this conclusion and show urban heat intervention measures such as cool white roof coatings can have large impacts on the heat island effect and can reduce cooling energy use substantially.

As an example, a study by Lawrence Berkeley National Laboratory Heat Island Group shows that similar decreases in the warmest climates of California may reduce cooling energy use by as much as 20% (LBNL Heat Island Group 2008). This is especially true in dry, sunny climates such as Chula Vista where solar gain tends to increase temperature dramatically and where the evaporative cooling provided by trees is particularly effective.

Further application of high reflective materials to urban surfaces and additional tree plantings can achieve additional reductions in temperature and energy use for building cooling.

e. *Passive solar building orientation on an east-west axis alone can produce some improvements in energy efficiency.*

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

Research Objective #5–Determine the maximum incremental cost the California building industry and consumers will accept for energy-efficient residential, commercial, industrial, and institutional structures.

The researchers concluded the average maximum incremental price California building industry and consumers will accept for energy-efficient structures is between $1.59 and $7.41 per square foot of construction, depending on the technology enhancement. Since this range is below the range calculated for the cost of enhancements ($2.00 to $15.00 per square foot), researchers concluded significant economic incentives would be necessary to encourage their adoption in today's market. [66]

Almost half of the building industry practitioners (45.4%) contacted in this project believed an incremental price of $2.00 per square foot of construction for energy-efficiency technology was acceptable and some (18.2%) would be willing to pay as much as $3.00 per square foot. However, the balance of the responses from the surveyed industry practitioners brought the average acceptable incremental price to $1.59 per s.f. of construction, leading researchers to conclude additional economic incentives are necessary to offset costs and achieve widespread adoption of this enhancement package.

Building industry practitioners believed the maximum acceptable incremental price for energy-efficiency and distributed generation technology was between $1.83 and $3.63 per square foot of construction (statistical average of $2.64 per s.f.). This average, and even the range, was considerably below the $4.00 per square foot cost calculated for this enhancement (including the benefit of a now retired utility incentive). Given this gap, researchers concluded utility

66 Editor's note: Though this study shows an incremental cost for making buildings more energy-efficient (for the specific measures modeled here), real-world experience is showing that, in some cases, no incremental cost is incurred for increased efficiency. An integrated "whole building" approach for new buildings is critical in reducing up-front design and construction costs.

economic incentives should be reinstated and adjusted upward to enable the building industry to maximize use of the distributed generation technologies modeled in this research.

With regard to the energy-efficiency and photovoltaic technology enhancement, the average acceptable incremental price was $ 7.41 per s.f. of construction. The calculated cost for this enhancement, including all available solar incentives, was more than twice the average acceptable incremental price. This once again led researchers to conclude that additional economic incentives must be offered to achieve significant adoption of this building technology enhancement.

Researchers concluded developers were the most price-sensitive occupational subgroup in the industry and the most conservative in their estimates of what constitutes acceptable incremental costs. By marked contrast, design professionals were the least price-sensitive among all surveyed subgroups. Specifically, survey responses suggested design professionals are more than twice as liberal in their estimation of what constitutes acceptable incremental costs as developers. This finding led researchers to conclude developers need specific economic incentives to accelerate adoption of energy-efficient technologies.

Research Objective #6–Determine which financial and business models and associated public policies and incentives will lead to accelerated deployment of EE, DR, RE, and DG technologies in typical development projects throughout the State of California.

Researchers concluded widespread adoption of these advanced energy technologies and community design features require fundamental transformation of the real estate development marketplace. This transformation will not take place until at least seven principal economic, informational, and procedural barriers to energy-efficient community development are addressed. These barriers are as follows:

1. Inadequate levels of direct and indirect financial support for developers and builders.
2. Misalignment of investment costs and benefits - *Split Incentive Dilemma.*
3. Lack of knowledge among municipal officials inhibiting approval of EECD[67] projects.
4. Lack of uniform municipal procedures and related incentives for EECD projects.
5. Lack of municipal investments in enabling green infrastructure.
6. Lack of consumer willingness to pay for the value of energy efficient features.
7. Investment risks that inhibit capital market entities from financing EECD projects.

In reaching this conclusion, researchers adopted the California Public Utilities Commission's definition of market transformation:

> Long-lasting sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to

67 EECD – Energy Efficient Community Development projects

the point where further publicly-funded intervention is no longer appropriate in that specific market.[68]

Researchers concluded the two essential changes necessary to achieve this transformation are as follows:

- All entities in the real estate development transaction chain (lenders, investors, developers, builders, design professionals, appraisers, and brokers) must recognize the value of energy-efficient building technologies and community design options.
- This recognition should result in market transactions that enable developers to capture capital investments in energy-efficient design features through real estate sale prices that are acceptable to consumers.

Researchers further concluded state and local government and utility-funded intervention will be necessary to produce these changes over five to ten years. Given the results of the research, this intervention should include at least the following seven components:

1. Additional research to further estimate economic and environmental costs and benefits of alternative energy technologies and community design features in large-scale development projects (discussed in detail in the Recommendations sub-section below). This research should advance understanding of the dynamics of community-scale energy consumption and improve the tools and methodologies for assessing different technology and design options. Additionally, this research should entail performance verification to quantify actual energy-efficiency and emission-reduction gains of these options. Case studies can communicate these gains to the development industry.
2. A set of California-specific, mandatory site development standards for energy-efficiency and carbon emissions reduction. These should be performance-based standards to allow developers and builders flexibility in achieving compliance. They should be based on verified performance of alternative technologies and design options determined by the aforementioned research.
3. A uniform set of direct and indirect economic and procedural incentives for developers and builders that recognize and reward, on a graduated scale, performance above minimum compliance. These should include as many of the incentives described in the previous chapter as possible. One centralized database accessible to all development practitioners should contain information about these incentives.
4. Uniform product labeling of all residential, commercial, industrial, institutional structures, and planned communities that communicates estimated energy, water, and resource efficiency of each to consumers at the point-of-sale.
5. An education effort to inform lending, investment, and real estate appraisal and brokerage industries about the value of energy and resource efficient structures and community development projects. A companion initiative should revise real estate

68 See Attachment I to the California Public Utilities Commission Decision 98-04-063.

appraisal practices and generate new financial instruments and mortgage products that reflect that value.

6. Further development of real-time resource (electricity, gas, and water) monitoring technologies that inform consumers about their resource consumption.
7. A workforce training initiative for municipal authorities on the use of tools and methods to evaluate energy-efficient development projects and an awareness-building initiative to communicate the value of these properties to the consumer.

In conclusion, researchers believe it will take this combination of market push and market pull mechanisms to transform the market to the point where public and utility intervention will no longer be necessary to sustain energy-efficient community development in California.

4.2 Additional Conclusions

Researchers concluded that current policy, planning, and regulatory initiatives in California concerning climate change, energy, and the built environment[69] will significantly advance energy-efficient community development in the near future, in particular California's Global Warming Solutions Act of 2006 (Assembly Bill 32, or AB 32). Recent federal initiatives that are advancing research in Zero-Net Energy (ZNE) buildings, communities and smart grids,[70] and linking federal energy technology R&D with the economy, environment, and the effort to rebuild national infrastructure[71] enhance this prospect. These initiatives will bring new resources to this field of research and will provide support to surmount many barriers identified in this project.

While the AB 32 Scoping Plan contemplates formulation of strategies for local governments to use in planning, development, and code compliance to advance energy efficiency,[72] the most immediate state policy initiative that will advance energy-efficient community development is Senate Bill 375. This bill ties AB 32 greenhouse gas emission (GHG) reduction goals for cars and light trucks to the regional transportation planning process and to land use and transportation policy (Steinberg 2008).

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69 These initiatives include the 2007 Integrated Energy Policy Report; California's Global Warming Solutions Act of 2006 (Assembly Bill 32) and the California Air Resources Board AB 32 Draft Scoping Plan; the Energy Action Plan II; SB 375 (green house gas reduction, land use and transportation policy); AB 2021 (statewide energy efficiency goals); the Governors Green Building Executive Order; the California Public Utilities Commission's California Long Term Energy Efficiency Strategic Plan.

70 Federal Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings, National Science and Technology Council – Committee on Technology, Oct 2008 and the Energy Independence and Security Act of 2007.
http://www.bfrl.nist.gov/buildingtechnology/documents/FederalRDAgendaforNetZeroEnergyHighPerformanceGreenBuildings.pdf

71 President-Elect Obama's proposed Economic Stimulus Measure announced November 25, 2008.

72 *Climate Change Proposed Scoping Plan: A Framework for Change*, California Air Resources Board, p. 42

The bill exempts developers of residential or mixed-use projects from the requirement to complete GHG and growth impact assessments on those projects if they include transit elements or are consistent with the metropolitan planning organization's sustainable communities strategy or the alternative planning strategy. Relief from these CEQA requirements represents a significant indirect economic incentive for developers in both time saved in the entitlement process and in consultant fees. The bill also provides streamlining of Transit Priority Projects (TTP), defined as having 50% or more residential use at a minimum density of 20 dwelling units per acre and located with half a mile of a transit stop or corridor. Projects that entail energy-efficient buildings, water conservation measures, and those that meet minimum open space and low income housing requirements may be eligible for a partial or total CEQA exemption under the provision.

Although the incentive relates primarily to the objective of reducing GHG emissions associated with VMT, researchers believe it will help stimulate development industry interest in seeking additional means of reducing the carbon footprint of their projects. This may include use of the building energy technologies and enabling community design options modeled in this research. This interest would be further stimulated should a statewide cap-and-trade program make local governments and private development projects eligible sources of carbon offsets.

The draft AB 32 Scoping Plan does include a recommendation for a statewide cap-and-trade program tied to a western regional program under the Western Climate Initiative.[73] While preliminary CARB recommendations do not contemplate participation of local governments in direct carbon trading, the state will likely develop policies for eligibility of local governments to participate. In conjunction with the cap-and-trade program, a California Carbon Trust would manage the carbon market, playing a similar role to that of the Federal Reserve. Revenues generated by the Trust through the auction of emission allowances or through the assessment of carbon fees would be invested in further GHG reductions, research, development, and demonstration projects.

Two such investments being considered are local government incentives and research, development, and demonstration (RD&D) funding for local government climate change plans. The researchers concluded such incentives and funding could be used to help resolve economic barriers preventing both the development and the capital market industries from adopting energy-efficient community development projects.

The next policy initiative that will have significant influence in moving energy-efficient development forward in the state is the Public Utilities Commission's California Long Term Energy Efficient Strategic Plan. The plan, created in consort with the three major IOU's, also targets market transformation to meet a set of ambitious zero-net-energy goals for residential and commercial building construction by 2020 and 2030 respectively. Together with optimal HVAC performance and consumer access to low-income energy efficiency benefits, these constitute the four goals of the Commission's "Big Bold Energy Efficiency Strategies." The plan contains a set of specific strategies for the four vertical market sectors and seven cross-cutting

73 See: http://www.westernclimateinitiative.org/

areas and provides a set of near-term (2009-2011), mid-term (2012-2015), and long-term (2015-2020) actions designed to implement each strategy.

The most promising aspect of the plan is that it contains many of the resources called for by the stakeholders, developers, and capital market professionals solicited in this research. Specifically needed are customer incentives; codes and standards; education and information; technical assistance; and additional research, development, and demonstration. However, the plan focuses resources almost exclusively on building-scale rather than community-scale energy efficiency. The plan does not consider transportation, water conservation, or energy efficiency performance measurement and verification. During the next planning cycle, the Commission plans to seek alignment between its plan and other long-term water, land use, and greenhouse gas mitigation plans. It will likely consider community-scale energy efficiency to a larger degree at that time. Researchers concluded this plan and the resources it can make available to local governments and the development industry are the best means for advancing community-scale energy efficient development.

With regard to the opportunity to leverage California's leadership and resources in this field of inquiry through other entities, sixteen Federal agencies are currently pursuing related research, development, and demonstration initiatives. Specific topic areas for potential collaboration are contained in the National Science and Technology Council's October 2008 document entitled *Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings*.

Finally, researchers believe a significant opportunity exists for potential collaboration with the U.S. Green Building Council to enhance its evolving LEED standard for Neighborhood Development (LEED-ND) and to develop the California-specific standard proposed in this report.[74] Both the Energy Commission and USGBC would benefit from such collaboration. The Energy Commission would benefit from use of the LEED-ND standard as a foundation for its own standard and from lessons learned in its formulation. The USGBC would benefit from use of Commission-funded research that could be used to revise its LEED-ND standard to reflect the value of alternative energy technologies.

4.3 Recommendations

4.3.1. Research on the Potential of District Cooling in Chula Vista and the State of California

Chula Vista - As discussed in the conclusions chapter, the results of the preliminary study indicated a district cooling system for Site A development was an economically attractive alternative to distributed cooling at individual buildings. Incorporation of district cooling into Site A would bring benefits of convenience, reliability, reduced emissions, and potentially lower electrical infrastructure requirements. Given the results of this evaluation, the recommended next step is a more detailed study that addresses the following:

74 U.S. Green Building Council, *LEED for Neighborhood Development Rating System – Pilot Version*.

1. Siting constraints relative to incorporation of TES and CHP.
2. Economic, energy, and environmental benefits of:
    - Ice storage (if siting of chilled water TES may be problematic).
    - Low temperature supply water.
    - Combined heat and power (CHP).
3. Economic benefits of district cooling implementation for electric infrastructure requirements.
4. Energy, environmental, and economic benefits of district cooling relative to offset grid electricity.
5. Conceptual design for optimal district cooling configurations, including preliminary layout drawings and technical recommendations.
6. Pro-forma financial analysis of optimal district cooling configurations.

State of California - Building on the Chula Vista study, researchers recommend a study to assess potential energy, environmental, and economic benefits of district cooling in California. This statewide study should assess potential for district cooling to reduce energy consumption, greenhouse gas emissions, other pollutants, electric infrastructure requirements, and costs of meeting future energy needs. The study should examine this potential by referencing changes in energy facility capital and fuel costs. It should also consider the market value of GHG reduction. It would assess future capital and fuel cost trajectories for a variety of technologies, including these:

- Low-temperature electric centrifugal water chillers.
- Ice generation and storage.
- Chilled water storage.
- Natural gas-fired combined heat and power (CHP).
- Natural gas-fired chillers with absorption chillers driven with waste heat.
- Solar thermal energy driving absorption chillers.
- Ocean-source and lake-source cooling.

Economic analysis should include a robust life-cycle cost (LCC) approach including capital, operating, and maintenance costs as well as flexibility for variable costs of different fuels and GHG pricing. The analysis should go beyond simple present value economic analysis to weigh long-term risks and uncertainties that affect decisions. GHG pricing should account for possible carbon compliance costs, offset market pricing (voluntary and pre-compliance markets), and projected long-term implications of proposed regulatory frameworks.

Such a study should perform sensitivity analyses to evaluate impacts on total LCC with variations in macro level cost factors: fossil fuel prices and carbon dioxide market value.

4.3.2. Research on Improved Modeling Tools for the Design of Low Carbon Communities

Research is needed to better integrate site planning and urban design tools with building energy analysis tools so public and private planners can more readily assess energy and emissions impacts of alternative development scenarios for community-scale projects.

In the CVRP, researchers created a data-sharing protocol through they co-registered individual building energy consumption files with site planning elements to assess site-wide impacts of alternative development scenarios. Although the effort was successful, it required considerable effort and required modeling individual buildings on a prototype basis. This approach had significant limitations and did not facilitate rapid assessment of alternatives. Any change to building assumptions had to be reloaded into the GIS tool to conduct impact analysis.

The researchers believe integration of existing analysis tools should be much tighter and enable applications to talk to each other dynamically. NREL's Building Energy Optimizer, BEopt, and its Subdivision Energy Analysis Tool, (SEAT), move in this direction and should continue to be supported. These tools will be of great value to the development community.

Further, researchers believe it is in the best interest of California to create a suite of open, accessible, and interoperable tools capable of sharing data easily rather than to focus on development of a single tool for community-scale energy analysis. With open data sharing standards such as eXtensible Markup Language (XML), it has become easier to pass data between applications. Researchers believe a two to three year timeline would be necessary to examine all relevant standards and to develop a set of California guidelines, standards, and tools. Integration of this information would assist municipal planners and private development practitioners in analyzing GHG impacts associated with alternative land use, infrastructure, and building development.

Researchers used 4D analysis to estimate VMT reduction and related GHG in the CVRP. In the absence of specific data, they had to make reasonable assumptions. When using CommunityViz™, the researchers repeatedly adjusted their assumptions and used real and hypothetical data to test the validity of those assumptions. Nonetheless, the process of estimating VMT on a development-scale needs significant improvement.

Design of communities related to transportation can affect obesity, traffic congestion, and global climate change through. There is significant need for tools to help transportation and land use planners understand and demonstrate, to both the public and policy makers, how design alternatives affect global climate change objectives and community livability. The 4D analysis only begins to approximate a number of factors that contribute to walkability, bikability, and transit ridership:

- Public transit—Good public transit is important for walkable neighborhoods.
- Street width and block length—Narrow streets slow traffic. Short blocks provide more routes to the same destination and make it easier to take a direct route.

- Street design—Sidewalks and safe crossings are essential to walkability. Appropriate automobile speeds, trees, and other features also help.
- Pedestrian-friendly community design—Are buildings close to the sidewalk with parking in the back? Are destinations clustered together?
- Freeways and bodies of water—Freeways can divide neighborhoods. While streams, lakes, and other bodies of water can make a walking environment much more enjoyable, they also can make it much more difficult to get to nearby destinations.

This project team recommends a follow-up study with SANDAG and municipalities such as Chula Vista that would help develop more indicators of VMT reductions and tighten assumptions behind 4D analysis. A one to two year project with SANDAG, Chula Vista, and other transportation authorities would allow the team to look closely at design and behavioral impacts on VMT at a site-planning scale. These types of analyses would complement the much larger regional analyses and projections conducted by SANDAG.

4.3.3. Research on Use of Urban Heat Island (UHI) Effect Mitigation Strategies

UHI is a complicated phenomenon affected by multiple variables such as climate, wind patterns, density, impervious cover, and tree canopy. Most UHI modeling tools run through complex micro and meso-climate simulations that have not yet scaled down to desktop applications. The process of predicting UHI in an un-built environment presents many more complications. In place of direct simulation of UHI, the team used the EPA's MIST tool to estimate relative changes in ambient temperature. The MIST tool is based on a parametric model derived from observed data. It is a good general guide, but does not pretend to be highly accurate.

To advance UHI analysis in California, the researchers believe there should be a diagnostic tool that identifies areas in a site plan that will contribute most to UHI. This tool would guide developer and planner decisions on tree plantings, high albedo coatings and pavements, and other interventions to promote cooling. Using expertise at the LBNL, researchers believe a one to two year project would suffice to develop and implement this type of diagnostic and decision support tool. Researchers also believe follow-on research on intervention methods and their relative effects on UHI could develop baselines for more accurate estimates on impacts. All of this is in support of helping planners and developers make better decisions. As part of an increased study on UHI decision support tools, the team recommends a full look at the lifecycle costs of UHI interventions, including the following:

- The full production, maintenance, and replacement costs of concrete cement compared to asphalt.
- A comparative assessment of maintenance and installation costs for cool roof technologies compared to conventional technologies.
- A full assessment of energy savings from trees, accounting for growth, maturation, and death.

- Analysis of the effects of wear on surfaces.

4.3.4. Research on the Impact of EECD on State and Local Development Policies and CEQA

As the market and policy analysis sections of this report have suggested, additional research should address the priority barriers that currently prevent energy-efficient community development in California. Additionally, research should address the translation of solutions to these barriers into viable public policies, guidelines, and development standards at the state, regional, and local levels of government. Attachment III of this report provides the specific areas of focus for the proposed market and public policy research that should be coordinated among academic and independent research organizations.

4.4 Benefits to California

The results of this research project will produce benefits for California's electricity and natural gas ratepayers by enabling public and private development practitioners to contribute toward improvement of community-scale energy efficiency, affordability, and reliability. These contributions will also significantly decrease both local and global environmental impacts associated with end-use energy and resource consumption.

This report has provided specific quantification of energy and emission reduction gains that sophisticated growth-oriented development projects can achieve. Further proposed research would move beyond this work and chart a feasible pathway to more substantial gains, potentially reducing aggregate energy consumption of large-scale, mixed-use, residential, commercial, and institutional development sites (500-2,000+ acre) by as much as 50% and CO_2 emissions by 50% or more.

The advanced energy-efficient technologies and community design options modeled in this research are key tools to assist California as it struggles with energy, environmental, and economic challenges, including the following:

- Rising fuel and electricity prices.
- Inadequate generation, transmission, and distribution capacity to meet increasing electricity demand.
- Reducing greenhouse gas (GHG) emissions.
- Reducing other air pollution associated with meeting energy requirements.

Use of CCHP and district cooling technologies and distribution systems is growing significantly in other parts of the United States and in Europe, Asia, and the Middle East due to significant benefits they provide ratepayers. The benefits to California ratepayers include the ability to reduce peak demand, improve environmental quality, increase building occupant comfort, and provide building owners and mangers increased convenience, flexibility, and reliability at lower costs. The section below describes these benefits further, using district cooling as a specific example.

Reducing Peak Power Demand—The benefits of district cooling with regard to power demand and annual energy use are especially important. District cooling reduces power demand by efficiently producing and delivering ready-to-use cooling to buildings and by shifting power demand to night-time off-peak periods. The economies of scale achieved through district cooling allow use of cost-effective and efficient Thermal Energy Storage (TES). The ability to peak shave with TES can significantly reduce peak power requirements, thereby reducing the electrical generation, transmission, and distribution infrastructure required to meet peak cooling loads.

The ability of district cooling to facilitate TES is especially relevant in view of the California building energy standard, 2005 Title 24. By incorporating consideration of time dependent valuation (TDV) into performance evaluation, Title 24 recognizes the significant energy (and thus environmental) benefits of demand reductions during peak demand periods.

Environmental Benefits—District cooling helps the environment by increasing energy efficiency and reducing environmental emissions including air pollution, the greenhouse gas carbon dioxide (CO_2), and ozone-destroying refrigerants. The emissions footprint of the power grid is highly variable depending on the capacity mix used to meet grid demand in any given hour in the year. This is relevant in view of the ability of district cooling to reduce power demand during peak times. Utilization of thermal storage, in particular, could provide substantial reduction in emissions of pollutants and greenhouse gases by shifting chilled water production to off-peak times when electricity is produced by cleaner and more efficient base-load production facilities compared to traditional peaking facilities.

Comfort—District cooling helps keep people more comfortable because it uses industrial grade equipment to provide a consistent source of cooling. In addition, specialists focus attention on optimal operation and maintenance of cooling systems, providing better temperature and humidity control than typical building cooling equipment. This provides a healthier indoor environment as well as a quieter building with less vibration.

Convenience—District cooling is a far more convenient way to cool a building because cooling is always available in the pipeline, thus avoiding the need to start and stop building cooling units. From the building manager’s standpoint, it is attractive to provide reliable comfort without the worries of managing the equipment, labor, and materials required for operating and maintaining chiller systems. This allows the manager to focus resources on more critical, bottom-line tasks such as attracting and retaining tenants.

Flexibility–The pattern and timing of cooling requirements in a building vary depending on building use and weather. With building chiller systems, meeting air conditioning requirements at night or on weekends is difficult and costly, particularly when the load is small. With district cooling, these needs are met easily and cost-effectively whenever they occur. Each building can use as much or as little cooling as needed, whenever needed, without regard to chiller capacity.

Reliability–The building manager has a critical interest in reliability because he/she wants to keep the occupants happy and wants to avoid dealing with problems relating to maintaining comfort. District cooling is more reliable than the conventional approach because these systems use highly reliable industrial equipment and cost-effectively provide equipment redundancy. With professional operators round-the-clock, district cooling suppliers are specialists with expert operations and preventive maintenance programs. A survey conducted by the International District Energy Association (IDEA) showed district cooling systems have a documented reliability exceeding 99.94%.

Cost Effectiveness—District cooling has fundamental cost advantages. For instance, not all buildings have their peak demand at the same time. In a district cooling system, when cooling loads are combined, more buildings can be reliably served at lower cost. With district cooling, equipment operates at the most efficient levels; building cooling equipment operates for many hours each year at less than optimal levels. District cooling also offers economies of scale to implement more efficient and advanced technologies, such as TES, and to serve reliably many buildings with less labor. For the real estate developer, district cooling systems reduce capital risk because no capital is invested in the building for cooling equipment. Predictable costs also mean reduced operating risks. In a competitive real estate market, buildings that consistently provide superior comfort will attract and keep tenants, thereby maintaining a higher market value.

Most of the other energy technology and community design options modeled in this research project produce many of the same benefits. When considered at the initial stage of site design, developers can determine the optimal mix of these options, and they can integrated them in the planning process to ensure the best prospects for energy efficiency and emissions reductions.

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6.0 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
CO_2	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
NOx	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. SDG&E Gas System Plan w/o Site A and B Loads/Baseline Piping
B. SDG&E Gas System Plan w Site A and B EE-Loads/Baseline Piping
C. SDG&E Gas System Plan w Site A and B EE-Loads/Optimized Piping
D. SDG&E Gas System Plan w Site A and B EE-DG Loads/Optimized Piping
E. SDG&E Gas System Plan w Site A and B Loads/Optimized w/Regulator
F. Site A: Baseline and Optimum Scenarios - Prototype Building Data
G. Site A: Load Profiles and TES Analysis - "Builder Baseline" Scenario
H. Site A: Load Profiles and TES Analysis - "Optimum Configuration" Scenario
I. Site A: Distribution Piping System Layout
J. Distribution Piping System Capital Costs
K. Chiller Selections Performance Data
L. Electric Rate Tariff Information
M. District Cooling Plant Annual Electric Cost Calculations
N. Chula Vista Research Project Advisory Committee
O. Site A: Spatial Modeling Inputs, Variables and Outputs
P. Site X: Spatial Modeling Inputs, Outputs & Assumptions
Q. Curve numbers for land use and soil types
R. Coefficients by Rainfall Type
S. Soil Types
T. Stakeholder Input on Barriers and Solutions

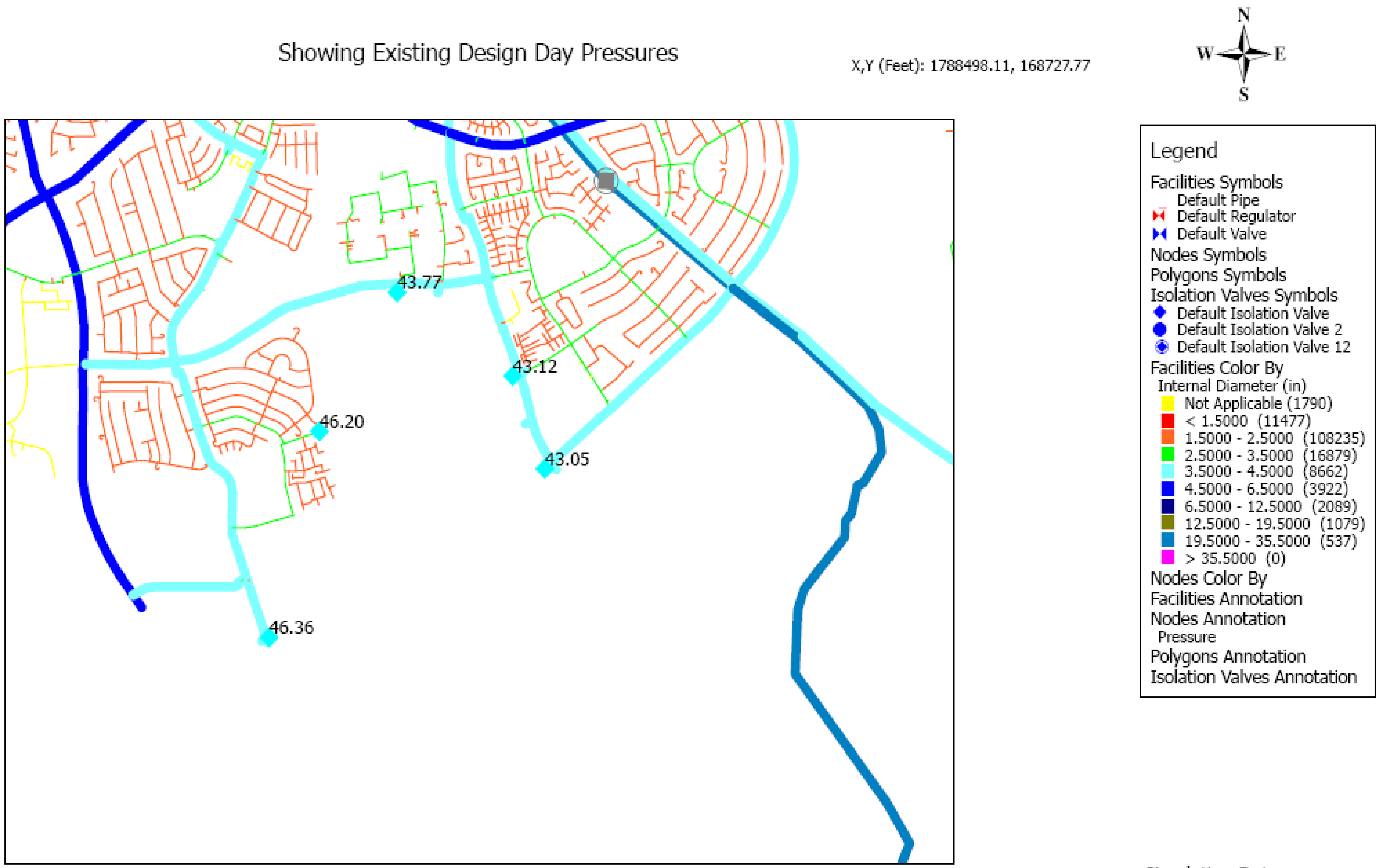
Appendix A

SDG&E Gas System Plan w/o Site A and B Loads / Baseline Piping

Appendix A. SDG&E Gas System Plan w/o Site A and B Loads / Baseline Piping

Showing Existing Design Day Pressures

X,Y (Feet): 1788498.11, 168727.77



Simulation Data:
State: Solved Feasible
Date: 3-3-2005
Time: 0.00

X,Y (Feet): 1772860.85, 157022.11

0 800 1,600 3,200 4,800 6,400 Feet

Scale: 1:27,420

Model Description:
DIGITIZED AS-BUILTS

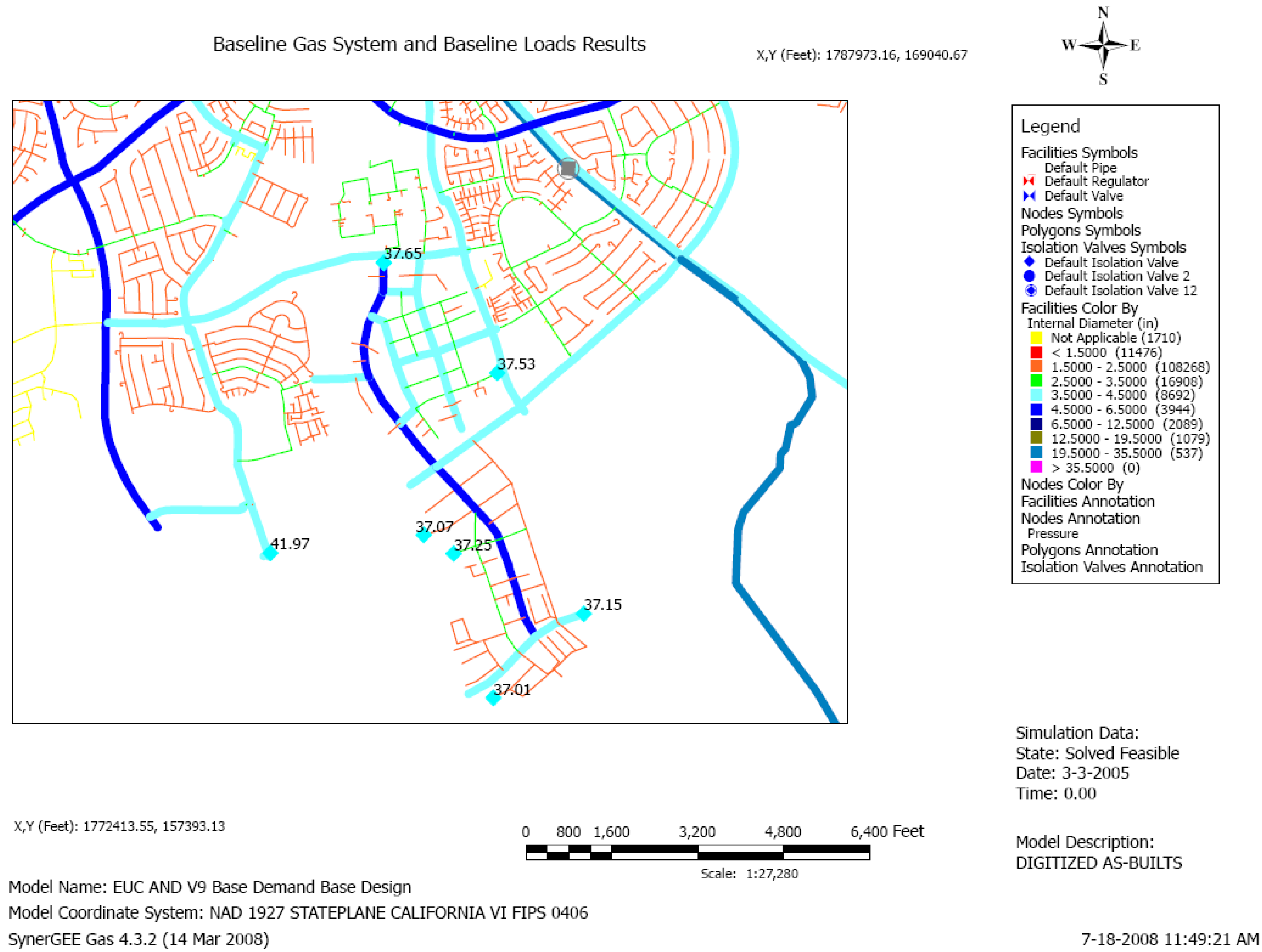
Model Name: SDGE GAS DIST SYS 2008 24HDD
Model Coordinate System: NAD 1927 STATEPLANE CALIFORNIA VI FIPS 0406
SynerGEE Gas 4.3.2 (14 Mar 2008)

7-18-2008 10:43:12 AM

Appendix B

SDG&E Gas System Plan w Site A and B EE-Loads / Baseline Piping

Appendix B. SDG&E Gas System Plan w Site A and B EE-Loads / Baseline Piping

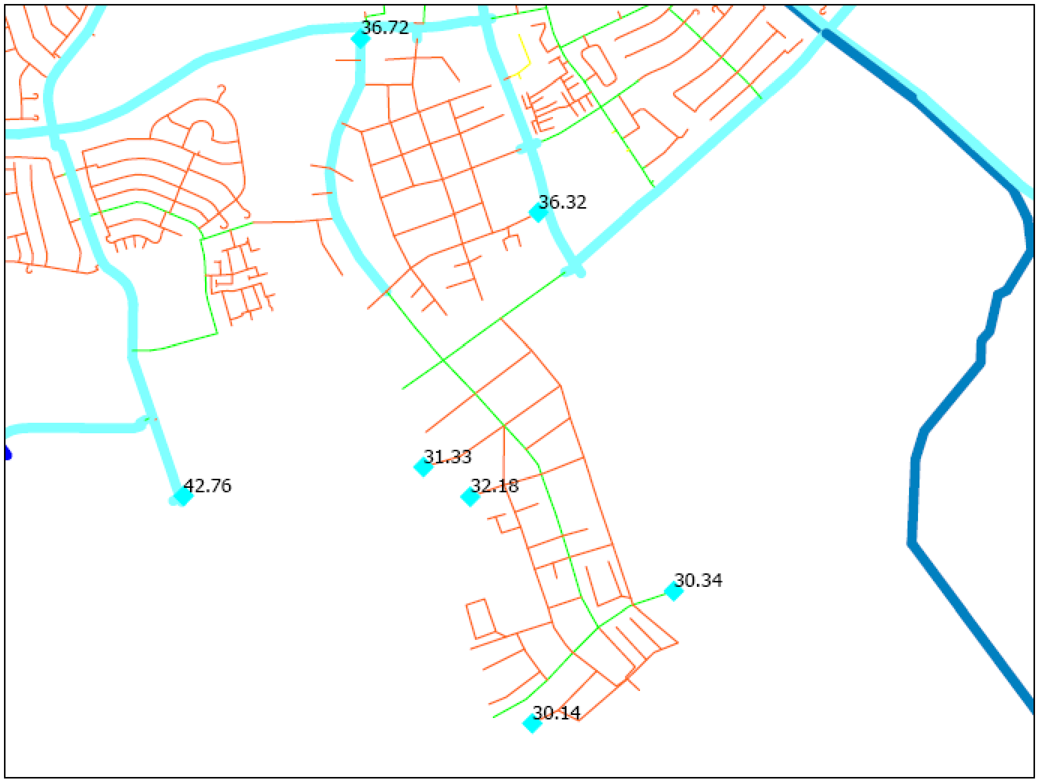


Appendix C

SDG&E Gas System Plan w Site A and B EE-Loads / Optimized Piping

W/ Eastern Urban Center and Village 9 Proposed Additions
Optmized Pipe Sizes Showing Design Day Pressures

X,Y (Feet): 1787345.08, 166408.55



X,Y (Feet): 1775085.41, 157231.27

0 700 1,400 2,800 4,200 5,600 Feet

Scale: 1:21,500

Legend

Facilities Symbols
- Default Pipe
- Default Regulator
- Default Valve

Nodes Symbols

Polygons Symbols

Isolation Valves Symbols
- Default Isolation Valve
- Default Isolation Valve 2
- Default Isolation Valve 12

Facilities Color By
Internal Diameter (in)
- Not Applicable (1710)
- < 1.5000 (11476)
- 1.5000 - 2.5000 (108328)
- 2.5000 - 3.5000 (16895)
- 3.5000 - 4.5000 (8667)
- 4.5000 - 6.5000 (3922)
- 6.5000 - 12.5000 (2089)
- 12.5000 - 19.5000 (1079)
- 19.5000 - 35.5000 (537)
- > 35.5000 (0)

Nodes Color By

Facilities Annotation

Nodes Annotation
Pressure

Polygons Annotation

Isolation Valves Annotation

Simulation Data:
State: Solved Feasible
Date: 3-3-2005
Time: 0.00

Model Description:
DIGITIZED AS-BUILTS

Model Name: EUC AND V9 Base Demand Opt Design
Model Coordinate System: NAD 1927 STATEPLANE CALIFORNIA VI FIPS 0406
SynerGEE Gas 4.3.2 (14 Mar 2008)

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Appendix D

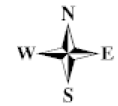
SDG&E Gas System Plan w Site A and B EE-DG Loads / Optimized Piping

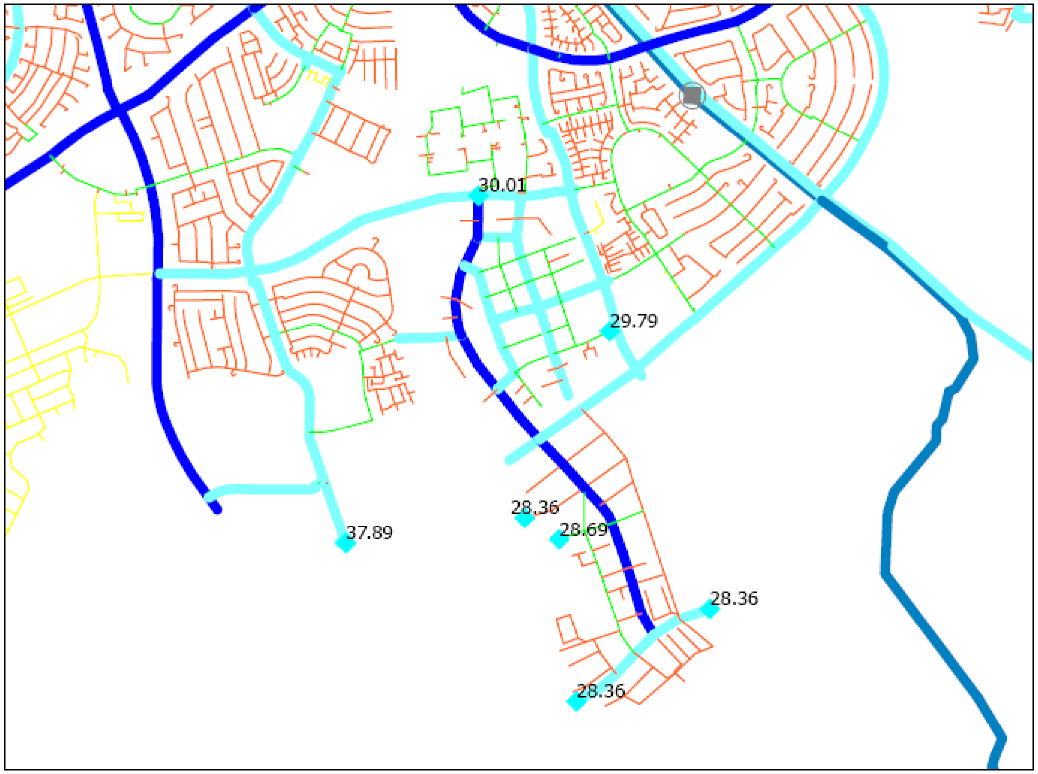
Appendix D. SDG&E Gas System Plan w Site A and B EE-DG Loads / Optimized Piping

W/ Eastern Urban Center and Village 9 Proposed Additions

EE + Distributed Generation Loads with Baseline Gas System

X,Y (Feet): 1788271.78, 169248.63





Legend

Facilities Symbols
- Default Pipe
- Default Regulator
- Default Valve

Nodes Symbols

Polygons Symbols

Isolation Valves Symbols
- Default Isolation Valve
- Default Isolation Valve 2
- Default Isolation Valve 12

Facilities Color By

Internal Diameter (in)
- Not Applicable (1710)
- < 1.5000 (11476)
- 1.5000 - 2.5000 (108268)
- 2.5000 - 3.5000 (16908)
- 3.5000 - 4.5000 (8692)
- 4.5000 - 6.5000 (3944)
- 6.5000 - 12.5000 (2089)
- 12.5000 - 19.5000 (1079)
- 19.5000 - 35.5000 (537)
- > 35.5000 (0)

Nodes Color By

Facilities Annotation

Nodes Annotation

Pressure

Polygons Annotation

Isolation Valves Annotation

Simulation Data:
State: Solved Feasible
Date: 3-3-2005
Time: 0.00

X,Y (Feet): 1771691.36, 156836.93

0 950 1,900 3,800 5,700 7,600 Feet

Scale: 1:29,070

Model Description:
DIGITIZED AS-BUILTS

Model Name: EUC AND V9 DG Demand

Model Coordinate System: NAD 1927 STATEPLANE CALIFORNIA VI FIPS 0406

SynerGEE Gas 4.3.2 (14 Mar 2008)

7-18-2008 3:43:03 PM

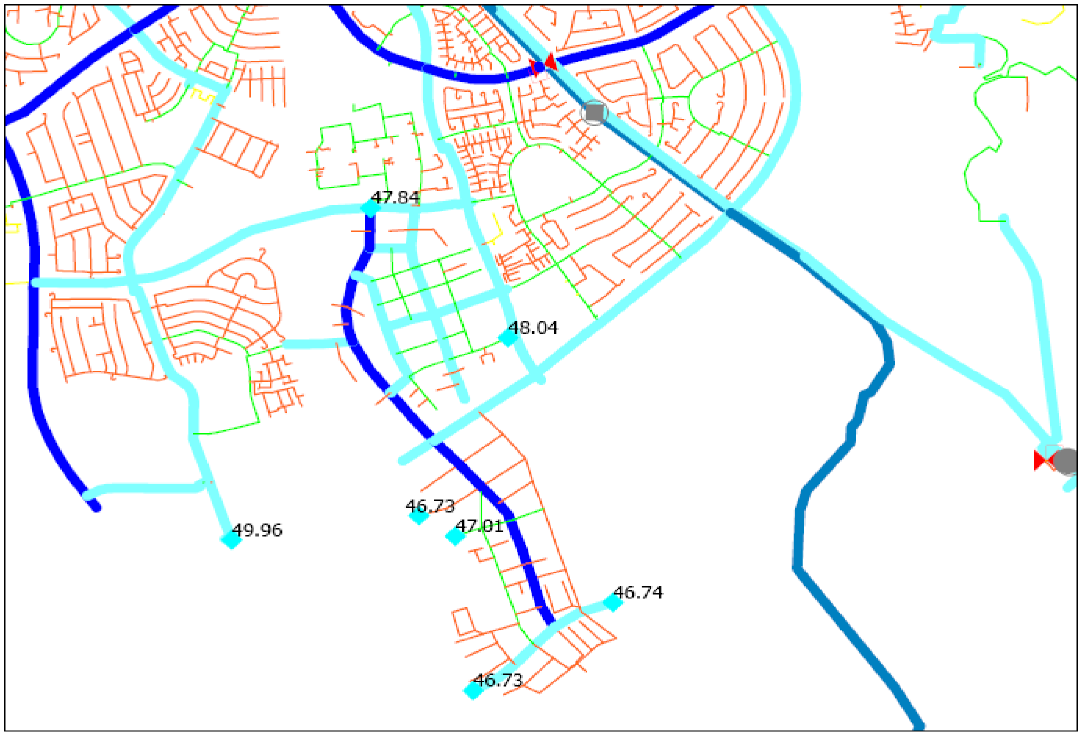
Appendix E

SDG&E Gas System Plan w Site A and B Loads /Optimized w/Regulator

Appendix E. SDG&E Gas System Plan w Site A and B Loads /Optimized w/Regulator

EE + Distributed Generation Loads with Baseline Gas System + New Regulator Station

X,Y (Feet): 1790190.74, 169598.87



Legend
Facilities Symbols
Default Pipe
Default Regulator
Default Valve
Nodes Symbols
Polygons Symbols
Isolation Valves Symbols
Default Isolation Valve
Default Isolation Valve 2
Default Isolation Valve 12
Facilities Color By
Internal Diameter (in)
Not Applicable (1711)
< 1.5000 (11476)
1.5000 - 2.5000 (108268)
2.5000 - 3.5000 (16908)
3.5000 - 4.5000 (8694)
4.5000 - 6.5000 (3945)
6.5000 - 12.5000 (2089)
12.5000 - 19.5000 (1079)
19.5000 - 35.5000 (537)
> 35.5000 (0)
Nodes Color By
Facilities Annotation
Nodes Annotation
Pressure
Polygons Annotation
Isolation Valves Annotation

Simulation Data:
State: Solved Feasible
Date: 3-3-2005
Time: 0.00

X,Y (Feet): 1773705.94, 157258.75

0 800 1,600 3,200 4,800 6,400 Feet

Scale: 1:28,900

Model Description:
DIGITIZED AS-BUILTS

Model Name: EUC AND V9 DG Demand and Reg
Model Coordinate System: NAD 1927 STATEPLANE CALIFORNIA VI FIPS 0406
SynerGEE Gas 4.3.2 (14 Mar 2008)

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Appendix F

Prototype Building Data

Appendix F. Prototype Building Data

Site A: Builder Baseline Scenario - Prototype Building Data

Bldg Proto-type ID	Building Prototype Description	Building Prototype Cooling System (Stand-alone Cooling Production)	# of Bldgs	Square Feet per Building	Total Square Feet	Peak Cooling Load Per Building (tons)	Total Peak Cooling Load (tons)	Cooling Load Density (SF/ton)	Annual Cooling Consump-tion Per Building (ton-hrs)	Total Annual Cooling Consump-tion (ton-hrs)	Total Annual space cooling related electric consumption including heat rejection (kWh)	Average unit electric cost for building ($/kWh)	Est. Total Annual cost of space cooling related electric consumption including heat rejection	Annual space cooling related electric consumption including heat rejection (kWh/ton-hr)
1	Free Standing Restuarant	Unitary Packaged AC	4	7,396	29,584	31.7	127	233.4	39,430	157,718	139,770	$0.147	$20,482	0.89
2	Multi Tenant Retail	Individual Split System Heat Pumps	1	19,656	19,656	74.2	74	265.0	57,862	57,862	70,124	$0.175	$12,255	1.21
3	Major Retailer	Central Chiller, Positive Disp.	3	32,400	97,200	92.8	278	349.3	150,495	451,484	546,678	$0.152	$83,250	1.21
4	Low Rise Office	Individual Split System Heat Pumps	4	29,920	119,680	74.3	297	402.7	87,267	349,067	282,741	$0.174	$49,146	0.81
5	Mid Rise Office	Central Chiller, Positive Disp.	7	99,880	699,160	228.5	1,600	437.1	295,339	2,067,375	2,289,281	$0.175	$400,978	1.11
6	High Rise Office	Central Chiller, Centrifugal	7	224,640	1,572,480	521.5	3,650	430.8	816,947	5,718,626	4,152,479	$0.169	$703,123	0.73
7	Hotel	Central Chiller, Centrifugal	1	121,662	121,662	198.5	199	612.8	331,326	331,326	278,109	$0.139	$38,644	0.84
8	Hotel/Comm/Retail	Central Chiller, Centrifugal	3	152,031	456,092	372.2	1,117	408.5	546,913	1,640,739	1,380,381	$0.153	$210,671	0.84
9	Retail/Commercial	Individual Split System Heat Pumps	3	101,088	303,264	262.8	788	384.7	359,630	1,078,889	1,043,761	$0.176	$183,663	0.97
10	Retail/Residential	Central Chiller, Centrifugal	2	137,035	274,070	157.2	314	871.8	293,947	587,894	473,697	$0.212	$100,459	0.81
11	Retail/Residentail	Individual Split System Heat Pumps	8	77,713	621,701	125.8	1,006	617.9	208,631	1,669,045	1,291,554	$0.195	$252,207	0.77
12	Civic/Commercial	Central Chiller, Positive Disp.	1	133,000	133,000	322.5	322	412.4	412,769	412,769	468,606	$0.176	$82,250	1.14
13	Res Multi Family Town Home	Individual Split System Heat Pumps	123	9,800	1,205,350	6.0	734	1643.1	4,550	559,644	571,040	$0.231	$131,760	1.02
14	Residential Low Rise	Individual Split System Heat Pumps	11	62,498	687,477	32.4	357	1927.3	52,684	579,528	577,207	$0.244	$140,681	1.00
15	Residential Mid Rise	Central Chiller, Centrifugal	2	130,171	260,342	71.7	143	1814.3	145,710	291,420	273,281	$0.244	$66,740	0.94
TOTALS / AVERAGES For "All bldgs"			180		6,600,719		11,006	599.7		15,953,387	13,838,708	$0.179	$2,476,308	0.87
TOTALS / AVERAGES For "All bldgs less Types 13 & 14"			46		4,707,891		9,916	474.8		14,814,215	12,690,461	$0.174	$2,203,867	0.86

Appendix F. Prototype Building Data

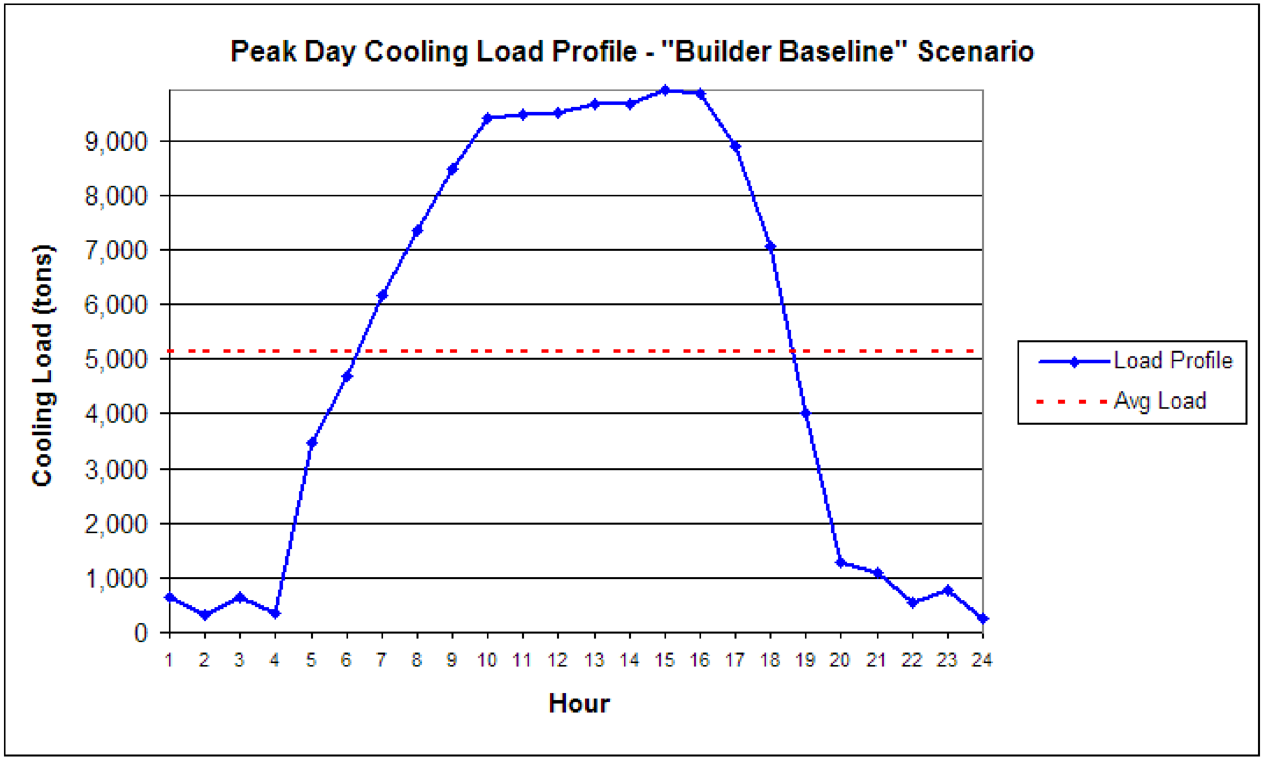
Site A: Optimum (EE-PV) Scenario - Prototype Building Data

Bldg Proto-type ID	Building Prototype Description	Building Prototype Cooling System (Stand-alone Cooling Production)	# of Bldgs	Square Feet per Building	Total Square Feet	Peak Cooling Load Per Building (tons)	Total Peak Cooling Load (tons)	Cooling Load Density (SF/ton)	Annual Cooling Consump-tion Per Building (ton-hrs)	Total Annual Cooling Consump-tion (ton-hrs)	Total Annual space cooling related electric consumption including heat rejection (kWh)	Average unit electric cost for building ($/kWh)	Est. Total Annual cost of space cooling related electric consumption including heat rejection	Annual space cooling related electric consumption including heat rejection (kWh/ton-hr)
1	Free Standing Restuarant	Unitary Packaged AC	4	7,396	29,584	29.9	120	247.2	39,736	158,942	97,408	$0.152	$14,766	0.61
2	Multi Tenant Retail	Individual Split System Heat Pumps	1	19,656	19,656	44.0	44	447.2	53,543	53,543	37,738	$0.265	$9,993	0.70
3	Major Retailer	Central Chiller, Positive Disp.	3	32,400	97,200	84.7	254	382.4	151,275	453,826	386,613	$0.182	$70,524	0.85
4	Low Rise Office	Individual Split System Heat Pumps	4	29,920	119,680	59.0	236	506.7	73,723	294,890	187,710	$0.208	$39,017	0.64
5	Mid Rise Office	Central Chiller, Positive Disp.	7	99,880	699,160	192.6	1,348	518.6	249,684	1,747,789	1,548,435	$0.178	$276,198	0.89
6	High Rise Office	Central Chiller, Centrifugal	7	224,640	1,572,480	449.1	3,143	500.2	699,576	4,897,029	2,904,563	$0.168	$488,673	0.59
7	Hotel	Central Chiller, Centrifugal	1	121,662	121,662	197.3	197	616.7	315,726	315,726	219,049	$0.140	$30,704	0.69
8	Hotel/Comm/Retail	Central Chiller, Centrifugal	3	152,031	456,092	323.0	969	470.7	450,330	1,350,990	937,163	$0.151	$141,112	0.69
9	Retail/Commercial	Individual Split System Heat Pumps	3	101,088	303,264	209.8	630	481.7	272,825	818,475	659,648	$0.177	$116,842	0.81
10	Retail/Residential	Central Chiller, Centrifugal	2	137,035	274,070	132.3	265	1035.6	224,108	448,217	314,441	$0.237	$74,583	0.70
11	Retail/Residentail	Individual Split System Heat Pumps	8	77,713	621,701	101.1	808	769.0	144,679	1,157,434	775,069	$0.210	$162,580	0.67
12	Civic/Commercial	Central Chiller, Positive Disp.	1	133,000	133,000	270.6	271	491.6	340,078	340,078	306,963	$0.176	$53,974	0.90
13	Res Multi Family Town Home	Individual Split System Heat Pumps	123	9,800	1,205,350	5.0	610	1976.6	3,705	455,688	386,037	$0.194	$74,822	0.85
14	Residential Low Rise	Individual Split System Heat Pumps	11	62,498	687,477	29.3	323	2130.5	48,937	538,304	445,682	$0.241	$107,333	0.83
15	Residential Mid Rise	Central Chiller, Centrifugal	2	130,171	260,342	61.6	123	2111.7	134,399	268,799	209,311	$0.243	$50,892	0.78
TOTALS / AVERAGES			180		6,600,719		9,341	706.7		13,299,730	9,415,830	$0.182	$1,712,012	0.71
TOTALS / AVGS FOR "All bldgs less Types 13 & 14"			46		4,707,891		8,408	559.9		12,305,738	8,584,112	$0.178	$1,529,857	0.70

Appendix G

Site A: Load Profiles and TES Analysis - “Builder Baseline” Scenario

Appendix G. Site A: Load Profiles and TES Analysis - “Builder Baseline” Scenario

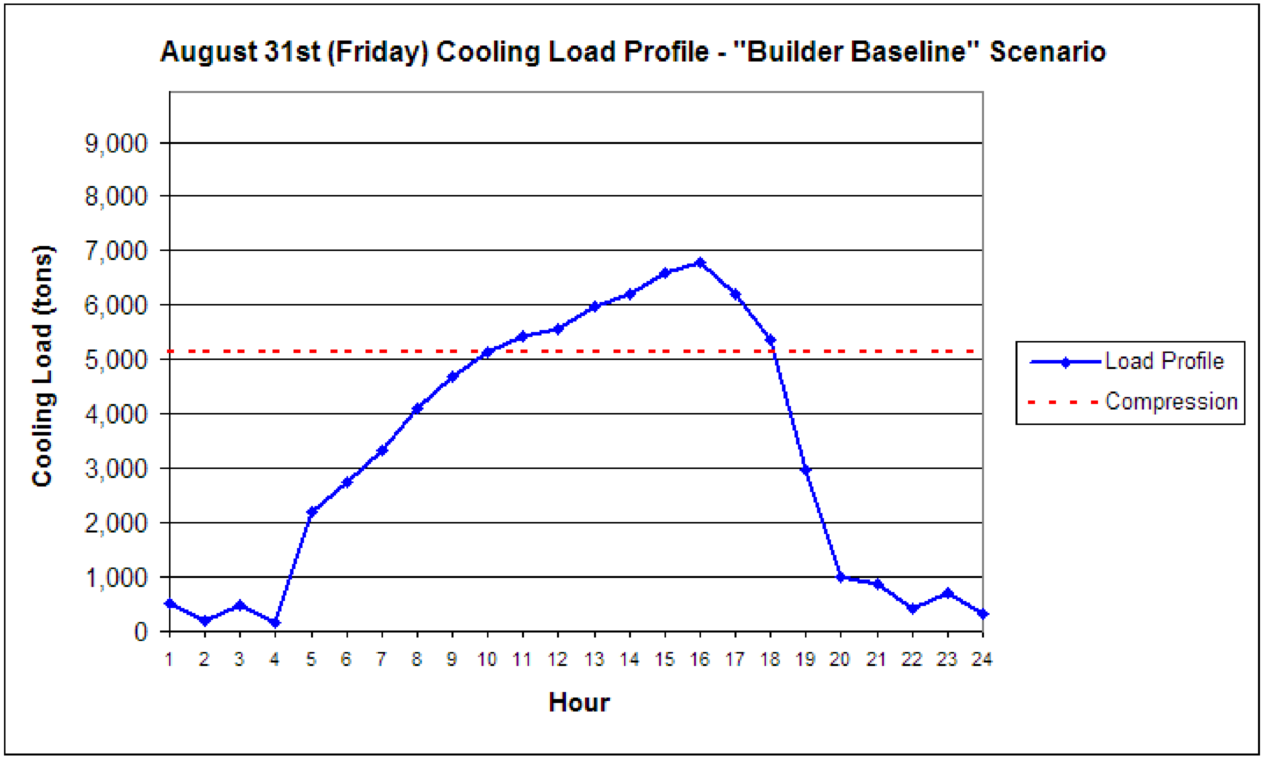


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	4,506		5,146	Off-peak
2	4,829		5,146	Off-peak
3	4,491		5,146	Off-peak
4	4,795		5,146	Off-peak
5	1,690		5,146	Off-peak
6	471		5,146	Off-peak
7		1,026	5,146	Semi-peak
8		2,207	5,146	Semi-peak
9		3,341	5,146	Semi-peak
10		4,247	5,146	Semi-peak
11		4,314	5,146	Semi-peak
12		4,350	5,146	On-peak
13		4,523	5,146	On-peak
14		4,506	5,146	On-peak
15		4,777	5,146	On-peak
16		4,710	5,146	On-peak
17		3,757	5,146	On-peak
18		1,924	5,146	On-peak
19	1,124		5,146	Semi-peak
20	3,873		5,146	Semi-peak
21	4,044		5,146	Semi-peak
22	4,604		5,146	Semi-peak
23	4,372		5,146	Off
24	4,885		5,146	Off

Thermal Storage Charge/Discharge
43,684 Thermal storage charging, ton-hrs
43,684 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 29%
Ton-hrs at Semi-peak utility rate, % of total 38%
Ton-hrs at Off-peak utility rate, % of total 33%

Appendix G. Site A: Load Profiles and TES Analysis - "Builder Baseline" Scenario / August 31st

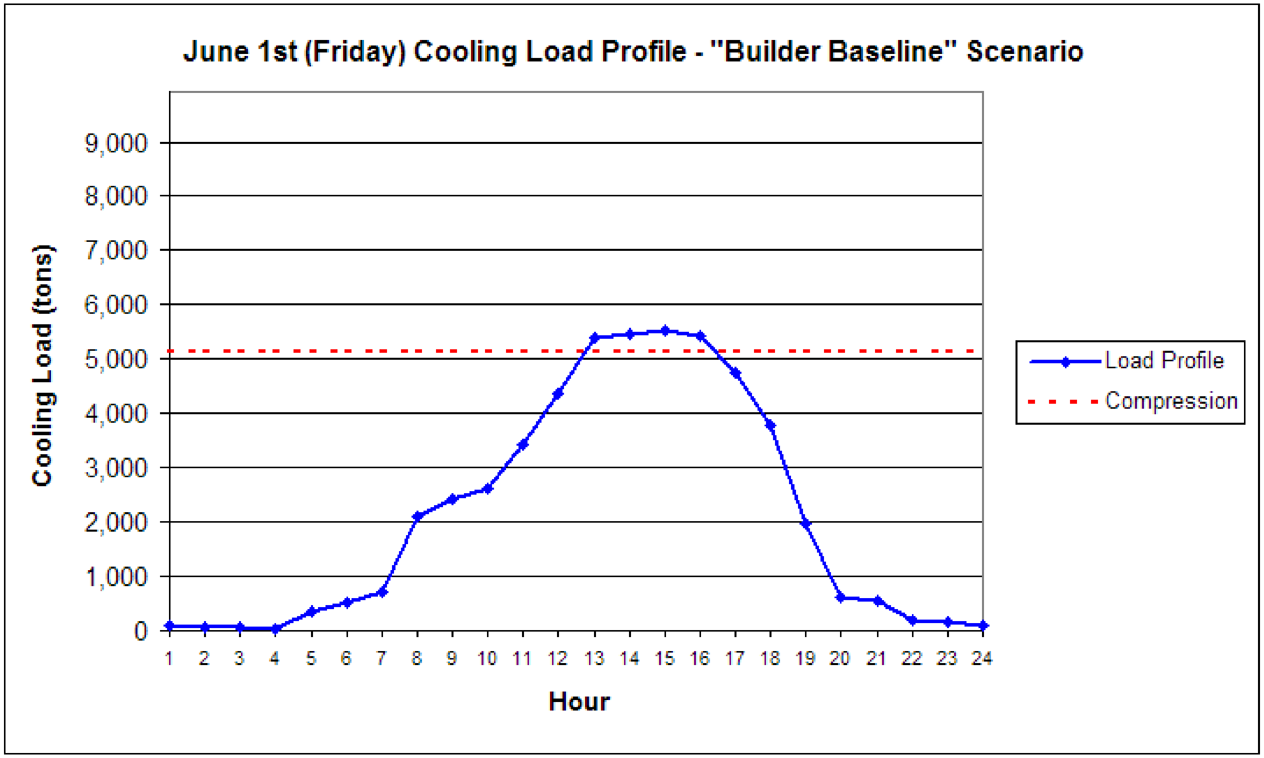


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	4,634		5,146	Off-peak
2	4,952		5,146	
3	4,652		5,146	
4	4,986		5,146	
5	2,946		5,146	
6	2,410		5,146	
7	1,801		5,146	Semi-peak
8	1,041		5,146	
9	467		5,146	
10	14		5,146	
11		294	5,146	
12		5,566	0	On-peak
13		5,964	0	
14		6,205	0	
15		6,582	0	
16		6,782	0	
17		6,217	0	
18		5,352	0	
19		723	2,260	Semi-peak
20	1,200		2,210	
21	2,000		2,861	
22	3,333		3,761	
23	4,421		5,146	Off
24	4,828		5,146	

Thermal Storage Charge/Discharge
43,684 Thermal storage charging, ton-hrs
43,684 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total	0%
Ton-hrs at Semi-peak utility rate, % of total	47%
Ton-hrs at Off-peak utility rate, % of total	53%

Appendix G. Site A: Load Profiles and TES Analysis - "Builder Baseline" Scenario / June 1st

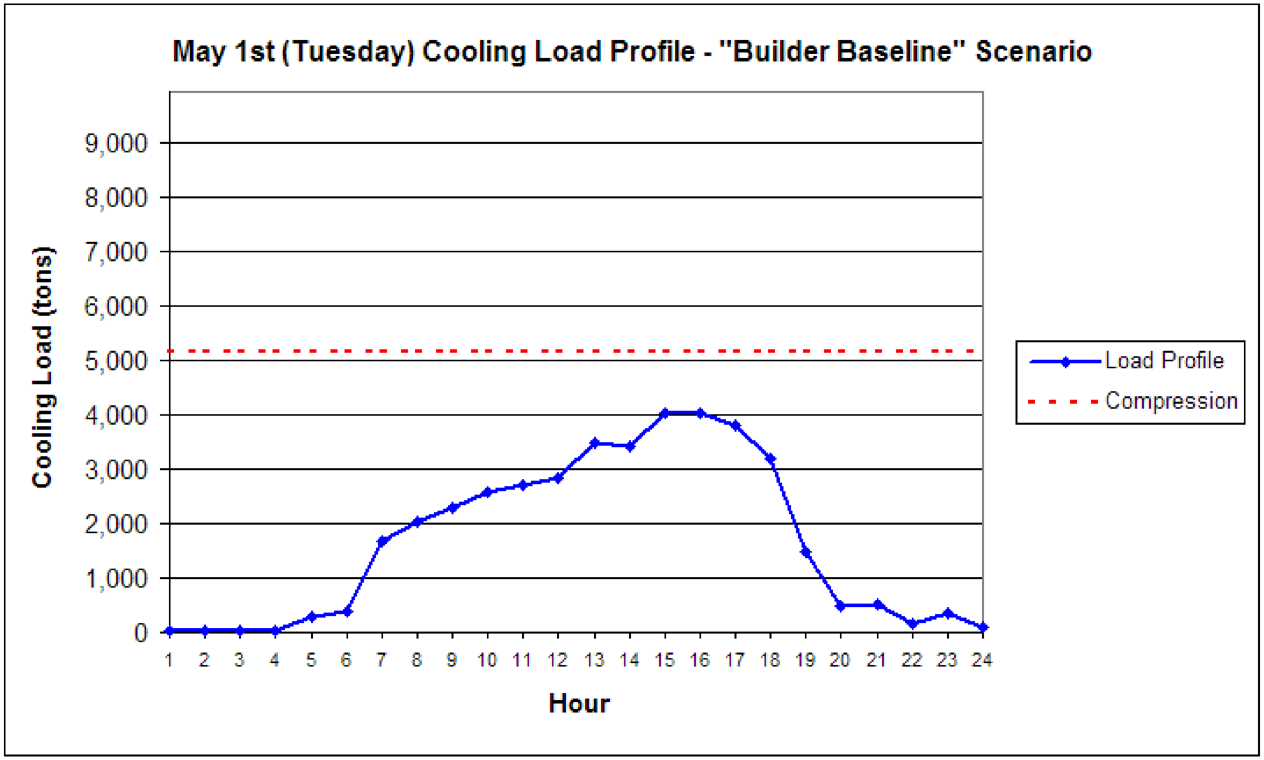


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	5,055		5,146	Off-peak
2	5,066		5,146	
3	5,079		5,146	
4	5,111		5,146	
5	4,778		5,146	
6	4,637		5,146	
7	2,420		3,125	Semi-peak
8			2,087	
9		1,007	1,421	
10		2,622	0	
11		3,418	0	
12		4,351	0	On-peak
13		5,388	0	
14		5,464	0	
15		5,512	0	
16		5,426	0	
17		4,745	0	
18		3,785	0	
19		1,965	0	Semi-peak
20			615	
21	500		1,050	
22	1,000		1,207	
23	4,998		5,146	Off
24	5,040		5,146	

Thermal Storage Charge/Discharge
43,684 Thermal storage charging, ton-hrs
43,684 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 0%
Ton-hrs at Semi-peak utility rate, % of total 19%
Ton-hrs at Off-peak utility rate, % of total 81%

Appendix G. Site A: Load Profiles and TES Analysis - "Builder Baseline" Scenario / May 1st



Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	5,107		5,146	Off-peak
2	5,114		5,146	
3	5,121		5,146	
4	5,123		5,146	
5	4,855		5,146	
6	4,775		5,146	
7		1,669	0	Semi-peak
8		2,029	0	
9		2,273	0	
10		2,562	0	
11		2,691	0	
12		2,833	0	On-peak
13		3,473	0	
14		3,429	0	
15		4,027	0	
16		4,027	0	
17		3,800	0	
18		3,190	0	
19		1,473	0	Semi-peak
20		491	0	
21		522	0	
22		171	0	
23	3,511		3,853	Off
24	5,055		5,146	

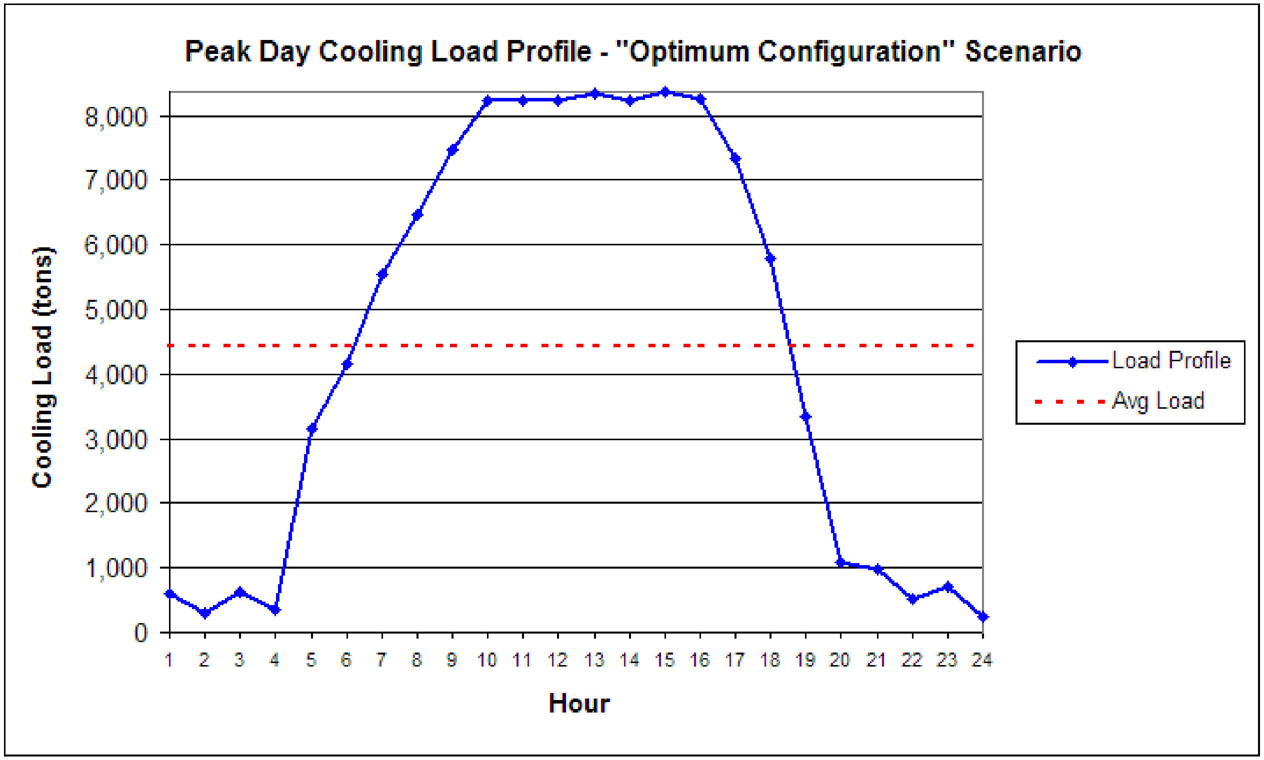
Thermal Storage Charge/Discharge
38,660 Thermal storage charging, ton-hrs
38,660 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 0%
Ton-hrs at Semi-peak utility rate, % of total 0%
Ton-hrs at Off-peak utility rate, % of total 100%

Appendix H

Site A: Load Profiles and TES Analysis for “Optimum Configuration” Scenario

Appendix H. Site A: Load Profiles and TES Analysis for "Optimum Configuration" Scenario

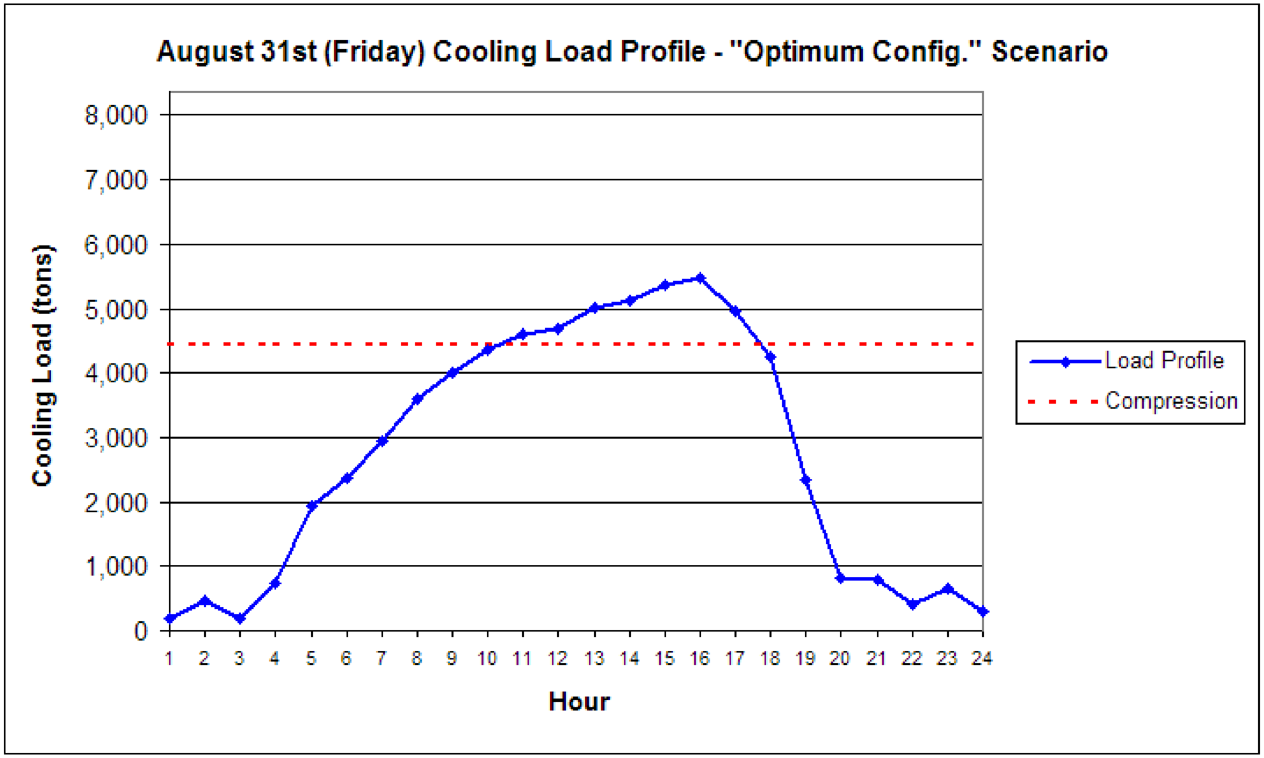


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	3,852		4,440	Off-peak
2	4,132		4,440	Off-peak
3	3,825		4,440	Off-peak
4	4,094		4,440	Off-peak
5	1,285		4,440	Off-peak
6	272		4,440	Off-peak
7		1,112	4,440	Semi-peak
8		2,035	4,440	Semi-peak
9		3,032	4,440	Semi-peak
10		3,782	4,440	Semi-peak
11		3,781	4,440	Semi-peak
12		3,796	4,440	On-peak
13		3,891	4,440	On-peak
14		3,787	4,440	On-peak
15		3,927	4,440	On-peak
16		3,814	4,440	On-peak
17		2,902	4,440	On-peak
18		1,351	4,440	On-peak
19	1,100		4,440	Semi-peak
20	3,341		4,440	Semi-peak
21	3,453		4,440	Semi-peak
22	3,924		4,440	Semi-peak
23	3,736		4,440	Off
24	4,196		4,440	Off

Thermal Storage Charge/Discharge
37,210 Thermal storage charging, ton-hrs
37,210 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 29%
Ton-hrs at Semi-peak utility rate, % of total 38%
Ton-hrs at Off-peak utility rate, % of total 33%

Appendix H. Site A: Load Profiles and TES Analysis for "Optimum Configuration" Scenario / August 31st

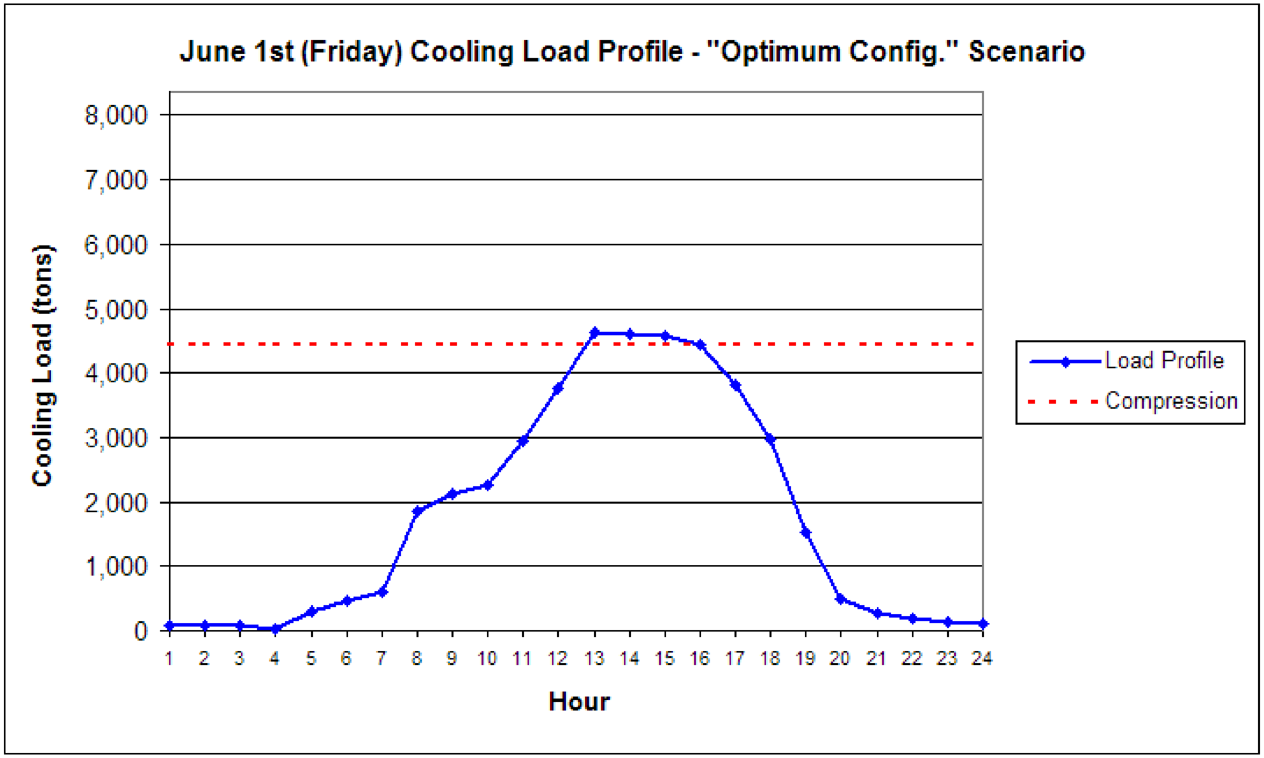


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	4,247		4,440	Off-peak
2	3,977		4,440	Off-peak
3	4,245		4,440	Off-peak
4	3,712		4,440	Off-peak
5	2,492		4,440	Off-peak
6	2,065		4,440	Off-peak
7	1,493		4,440	Semi-peak
8	853		4,440	Semi-peak
9	420		4,440	Semi-peak
10	67		4,440	Semi-peak
11		1,000	3,608	Semi-peak
12		4,690	0	On-peak
13		5,004	0	On-peak
14		5,134	0	On-peak
15		5,373	0	On-peak
16		5,482	0	On-peak
17		4,956	0	On-peak
18		4,240	0	On-peak
19		1,330	1,021	Semi-peak
20	1,200		2,024	Semi-peak
21	2,000		2,779	Semi-peak
22	2,517		2,922	Semi-peak
23	3,786		4,440	Off
24	4,137		4,440	Off

Thermal Storage Charge/Discharge
37,210 Thermal storage charging, ton-hrs
37,210 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 0%
Ton-hrs at Semi-peak utility rate, % of total 46%
Ton-hrs at Off-peak utility rate, % of total 54%

Appendix H. Site A: Load Profiles and TES Analysis for "Optimum Configuration" Scenario / June 1st

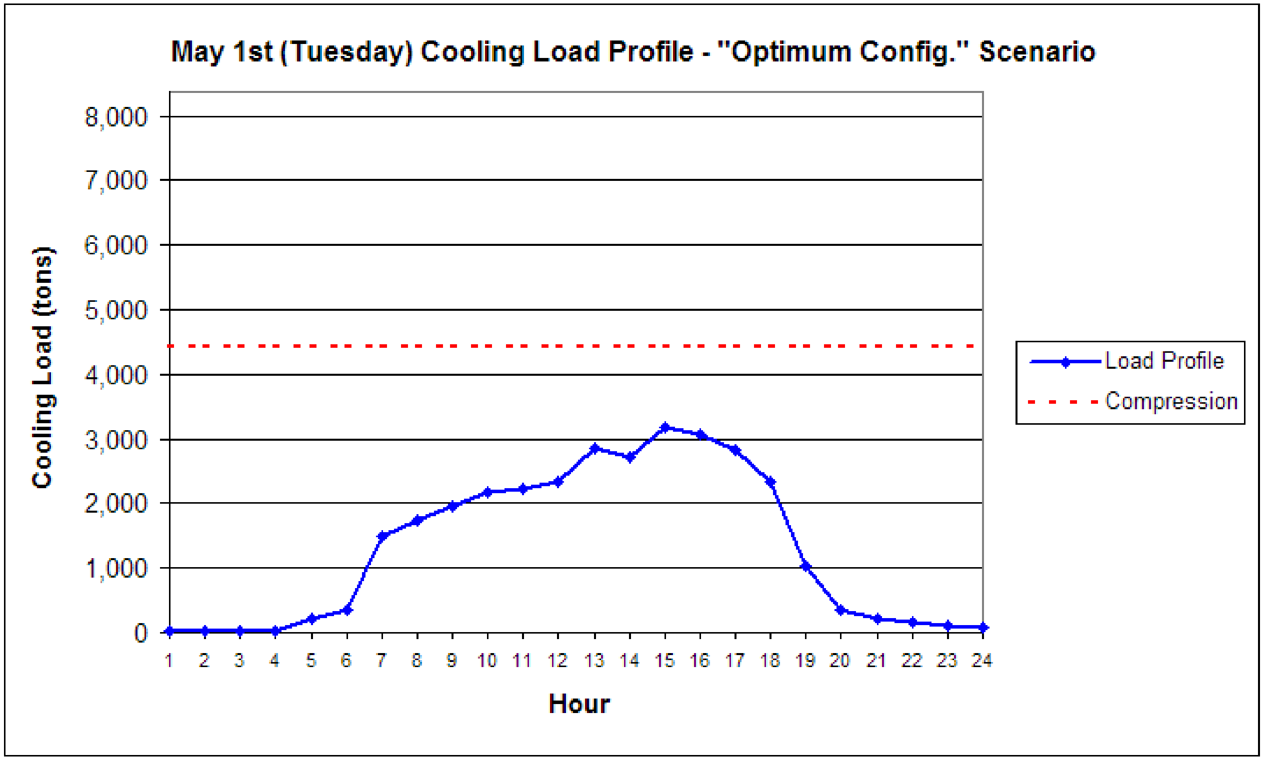


Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	4,352		4,440	Off-peak
2	4,361		4,440	
3	4,366		4,440	
4	4,402		4,440	
5	4,130		4,440	
6	3,974		4,440	
7	1,484		2,079	Semi-peak
8			1,847	
9		1,640	486	
10		2,251	0	
11		2,950	0	
12		3,759	0	On-peak
13		4,634	0	
14		4,619	0	
15		4,579	0	
16		4,449	0	
17		3,808	0	
18		2,984	0	
19		1,537	0	Semi-peak
20			496	
21	500		784	
22	1,000		1,191	
23	4,303		4,440	Off
24	4,340		4,440	

Thermal Storage Charge/Discharge
37,210 Thermal storage charging, ton-hrs
37,210 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 0%
Ton-hrs at Semi-peak utility rate, % of total 16%
Ton-hrs at Off-peak utility rate, % of total 84%

Appendix H. Site A: Load Profiles and TES Analysis for "Optimum Configuration" Scenario / May 1st



Hour	Thermal Storage Charge (ton-hrs)	Thermal Storage Discharge (ton-hrs)	Compression (ton-hrs)	
1	4,403		4,440	Off-peak
2	4,411		4,440	
3	4,418		4,440	
4	4,418		4,440	
5	4,218		4,440	
6	4,080		4,440	
7		1,501	0	Semi-peak
8		1,730	0	
9		1,956	0	
10		2,167	0	
11		2,232	0	
12		2,338	0	On-peak
13		2,861	0	
14		2,723	0	
15		3,175	0	
16		3,078	0	
17		2,824	0	
18		2,347	0	
19		1,043	0	Semi-peak
20		366	0	
21		231	0	
22		156	0	
23	1,780		1,887	Off
24	3,000		3,087	

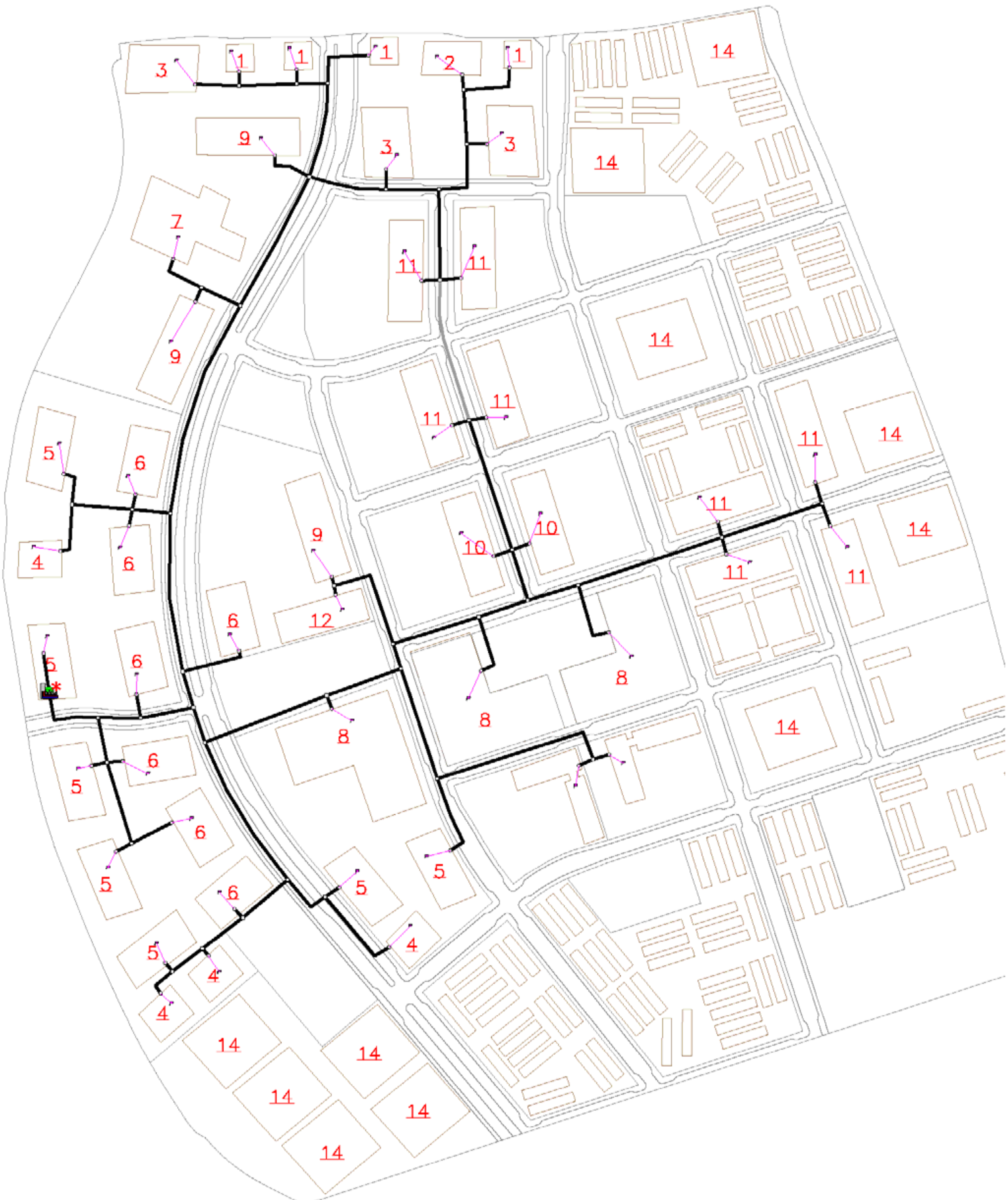
Thermal Storage Charge/Discharge
30,727 Thermal storage charging, ton-hrs
30,727 Thermal storage discharging, ton-hrs

Ton-hrs at On-peak utility rate, % of total 0%
Ton-hrs at Semi-peak utility rate, % of total 0%
Ton-hrs at Off-peak utility rate, % of total 100%

Appendix I

Distribution Piping System Layout (from the hydraulic model)

Appendix I. Distribution Piping System Layout (from the hydraulic model)



Appendix J

Distribution Piping System Capital Costs

Appendix J. Distribution Piping System Capital Costs

Chula Vista EUC Developmemt

Chilled Water Distribution Piping System -

Preliminary Capital Cost Estimate

July 8, 2008

		Cost Est ($)
Construction Costs: 14540 trench ft of pre-insulated chilled water piping (sizes range from 3 in to 24 in)		
Mechanical - Material & Installation	14,540 TF	$3,014,000
Civil - Excavation, Backfill & Reinstatement	14,540 TF	$4,001,000
Contractor Admin., Bonding, Insurance		$351,000
Construction Management & Site Supervision	4.1%	$302,000
Construction Changes	3.0%	$221,000
Construction Costs Subtotal		**$7,889,000**
Owner's Costs:		
Engineering (Design & Construction Support)	9.8%	$773,000
Contingency	10.0%	$789,000
Capital Cost Total		**$9,451,000**

Appendix K

Chiller Selections Performance Data

Appendix K. Chiller Selections Performance Data

		Parallel w/o VFDs (Base)		Parallel with VFDs		Series-CF with VFDs	
% Load	ECWT	KW/TR	% Diff, Base	KW/TR	% Diff, Base	KW/TR	% Diff, Base
100	80	0.541		0.534	-1.3%	0.512	-5.4%
100	75	0.495		0.482	-2.6%	0.459	-7.2%
100	70	0.457		0.429	-6.1%	0.410	-10.3%
100	65	0.424		0.383	-9.7%	0.368	-13.2%
100	60	0.395		0.345	-12.7%	0.326	-17.3%
100	55	0.369		0.301	-18.4%	0.290	-21.5%
90	80	0.531		0.518	-2.6%	0.497	-6.4%
90	75	0.489		0.462	-5.6%	0.441	-9.8%
90	70	0.453		0.409	-9.8%	0.393	-13.2%
90	65	0.420		0.365	-13.1%	0.349	-16.9%
90	60	0.392		0.321	-18.1%	0.306	-21.8%
90	55	0.366		0.280	-23.7%	0.265	-27.6%
80	80	0.531		0.507	-4.4%	0.489	-7.9%
80	75	0.490		0.448	-8.4%	0.431	-12.0%
80	70	0.454		0.395	-13.0%	0.379	-16.4%
80	65	0.423		0.347	-17.9%	0.332	-21.5%
80	60	0.394		0.302	-23.4%	0.288	-26.7%
80	55	0.367		0.260	-29.0%	0.248	-32.3%
70	80	0.538		0.511	-5.1%	0.491	-8.7%
70	75	0.497		0.443	-10.8%	0.426	-14.2%
70	70	0.461		0.384	-16.6%	0.370	-19.7%
70	65	0.429		0.333	-22.4%	0.320	-25.3%
70	60	0.399		0.288	-27.9%	0.276	-30.8%
70	55	0.371		0.245	-34.0%	0.233	-37.3%
60	80	0.552		0.518	-6.0%	0.502	-9.0%
60	75	0.509		0.451	-11.4%	0.433	-14.8%
60	70	0.472		0.386	-18.2%	0.371	-21.4%
60	65	0.439		0.329	-25.0%	0.317	-27.7%
60	60	0.409		0.278	-31.8%	0.269	-34.2%
60	55	0.380		0.231	-39.1%	0.229	-39.7%
50	80	0.573		0.537	-6.3%	0.521	-9.1%
50	75	0.528		0.459	-13.0%	0.446	-15.4%
50	70	0.489		0.399	-18.5%	0.385	-21.2%
50	65	0.455		0.334	-26.6%	0.323	-29.2%
50	60	0.423		0.279	-34.1%	0.268	-36.7%
50	55	0.395		0.235	-40.5%	0.228	-42.2%
40	80	0.581		0.561	-3.3%	0.509	-12.4%
40	75	0.537		0.482	-10.2%	0.451	-16.1%
40	70	0.518		0.413	-20.2%	0.399	-22.9%
40	65	0.482		0.348	-27.8%	0.352	-26.9%
40	60	0.450		0.289	-35.8%	0.308	-31.5%
40	55	0.421		0.244	-42.1%	0.268	-36.4%
30	80	0.622		0.598	-3.8%	0.515	-17.1%
30	75	0.576		0.512	-11.2%	0.446	-22.6%
30	70	0.542		0.452	-16.7%	0.385	-29.0%
30	65	0.512		0.378	-26.1%	0.330	-35.5%
30	60	0.490		0.314	-36.0%	0.282	-42.5%
30	55	0.471		0.267	-43.4%	0.234	-50.2%
20	80	0.723		0.687	-4.9%	0.565	-21.9%
20	75	0.674		0.584	-13.4%	0.481	-28.7%
20	70	0.635		0.506	-20.3%	0.411	-35.3%
20	65	0.603		0.429	-28.9%	0.348	-42.2%
20	60	0.581		0.355	-38.9%	0.289	-50.3%
20	55	0.565		0.313	-44.6%	0.242	-57.1%
15	80	0.832		0.794	-4.6%	0.687	-17.4%
15	75	0.772		0.669	-13.3%	0.584	-24.4%
15	70	0.729		0.575	-21.2%	0.506	-30.6%
15	65	0.695		0.485	-30.2%	0.429	-38.3%
15	60	0.674		0.403	-40.1%	0.368	-45.4%
15	55	0.661		0.343	-48.1%	0.313	-52.6%

Appendix L

Electric Rate Tariff Information

Appendix L. Electric Rate Tariff Information

SDGE Schedule AL-TOU Secondary Rate Tariff Including EECC & DWR-BC Charges

Basic service fee, >500kW ($/Mo)	$ 194.06	
Non-Coincident Demand Charge ($/kW)	$ 10.01	
Summer On-Peak Demand Charge ($/kW)	$ 4.54	(May-Sep)
Winter On-Peak Demand Charge ($/kW)	$ 3.61	(Oct-Apr)

	UDC Total ($/kWh)	EECC Commod. Rate ($/kWh)	DWR-BC Charge ($/kWh)	Total Variable ($/kWh)
Summer On-Peak	0.00590	0.14033	0.00477	0.15100
Summer Semi-Peak	0.00534	0.08283	0.00477	0.09294
Summer Off-Peak	0.00518	0.05807	0.00477	0.06802
Winter On-peak	0.00568	0.14033	0.00477	0.15078
Winter Semi-Peak	0.00534	0.08283	0.00477	0.09294
Winter Off-Peak	0.00518	0.05807	0.00477	0.06802

Time Periods:

All time periods listed are applicable to local time. The definition of time will be based upon the date service is rendered.

	Summer May 1 - Sept 30	Winter All Other
On-Peak	11 a.m. - 6 p.m. Weekdays	5 p.m. - 8 p.m. Weekdays
Semi-Peak	6 a.m. - 11 a.m. Weekdays 6 p.m. - 10 p.m. Weekdays	6 a.m. - 5 p.m. Weekdays 8 p.m. - 10 p.m. Weekdays
Off-Peak	10 p.m. - 6 a.m. Weekdays Plus Weekends & Holidays	10 p.m. - 6 a.m. Weekdays Plus Weekends & Holidays

Appendix M

District Cooling Plant Annual Electric Cost Calculations

APM-2

Appendix M. District Cooling Plant Annual Electric Cost Calculations

District Cooling Plant Electricity Cost Calcs for "Builder Baseline" for "All bldgs less Types 13 & 14" WITHOUT Thermal Storage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Peak Demand (tons)	4,071	4,332	4,520	5,342	5,421	7,354	9,923	8,572	7,990	7,007	5,318	4,506
Monthly Peak kW/ton	0.60	0.60	0.60	0.60	0.60	0.735	0.773	0.773	0.735	0.735	0.60	0.60
Monthly Peak Demand (kW)	2,442	2,599	2,712	3,205	3,253	5,405	7,671	6,626	5,873	5,150	3,191	2,703
Monthly Fixed Charges ($/Mo)	$52,433	$52,433	$52,433	$52,433	$56,000	$78,839	$111,805	$96,602	$85,642	$70,339	$52,433	$52,433

	Period Consump-tion (ton-hrs)	Period Average kW/ton	Period Energy Use (kWh)	Tariff Variable Cost ($/kWh)	Subtotal Variable Cost
Summer On-Peak	4,165,532	0.64	2,665,941	0.15100	$402,557
Summer Semi-Peak	2,650,251	0.60	1,590,150	0.09294	$147,789
Summer Off-Peak	2,216,744	0.58	1,285,711	0.06802	$87,454
Winter On-peak	615,551	0.55	338,553	0.15078	$51,047
Winter Semi-Peak	4,141,244	0.55	2,277,684	0.09294	$211,688
Winter Off-Peak	1,099,024	0.55	604,463	0.06802	$41,116

Total Variable Consumption Charges	$941,650
Total Fixed Demand Charges	$813,821
Total Electricity Cost	**$1,755,472**
Total DC Plant Energy Use (kWh)	8,762,503
Average Electricity Cost per kWh	$0.200
Average kWh/ton-hr	0.589
Average Electricity Cost per ton-hr	$0.118

Appendix M.   District Cooling Plant Annual Electric Cost Calculations

District Cooling Plant Electricity Cost Calcs for "Builder Baseline" for "All bldgs less Types 13 & 14" WITH Thermal Storage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Peak Demand (tons)	4,071	4,332	4,520	5,146	5,146	5,146	5,146	5,146	5,146	5,146	5,146	4,506
Monthly Peak kW/ton	0.60	0.60	0.60	0.60	0.60	0.735	0.773	0.773	0.735	0.735	0.60	0.60
Monthly Peak Demand (kW)	2,442	2,599	2,712	3,088	3,088	3,782	3,978	3,978	3,782	3,782	3,088	2,703
Monthly Fixed Charges ($/Mo)	$33,460	$35,598	$37,134	$42,248	$45,120	$55,228	$58,073	$58,073	$55,228	$51,710	$42,248	$37,014

	Period Consump-tion (ton-hrs)	Period Average kW/ton	Period Energy Use (kWh)	Tariff Variable Cost ($/kWh)	Subtotal Variable Cost
Summer On-Peak	1,071,891	0.64	686,010	0.15100	$103,588
Summer Semi-Peak	2,781,059	0.60	1,668,635	0.09294	$155,083
Summer Off-Peak	5,179,577	0.58	3,004,155	0.06802	$204,343
Winter On-peak	0	0.55	0	0.15078	$0
Winter Semi-Peak	142,212	0.55	78,217	0.09294	$7,269
Winter Off-Peak	5,713,607	0.55	3,142,484	0.06802	$213,752

Total Variable Consumption Charges	$684,034
Total Fixed Demand Charges	$551,132
Total Electricity Cost	**$1,235,167**
Total DC Plant Energy Use (kWh)	8,579,501
Average Electricity Cost per kWh	$0.144
Average kWh/ton-hr	0.576
Average Electricity Cost per ton-hr	$0.083

Appendix M. District Cooling Plant Annual Electric Cost Calculations

District Cooling Plant Electricity Cost Calcs for "Optimum Configuration" for "All bldgs less Types 13 & 14" WITHOUT Thermal Storage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Peak Demand (tons)	3,174	3,365	3,367	4,239	4,243	6,323	8,367	7,185	6,760	5,669	4,272	3,581
Monthly Peak kW/ton	0.51	0.51	0.51	0.51	0.51	0.677	0.731	0.731	0.677	0.677	0.51	0.51
Monthly Peak Demand (kW)	1,619	1,716	1,717	2,162	2,164	4,280	6,116	5,252	4,577	3,838	2,179	1,826
Monthly Fixed Charges ($/Mo)	$41,845	$41,845	$41,845	$41,845	$44,689	$62,474	$89,184	$76,610	$66,785	$52,463	$41,845	$41,845

	Period Consump-tion (ton-hrs)	Period Average kW/ton	Period Energy Use (kWh)	Tariff Variable Cost ($/kWh)	Subtotal Variable Cost
Summer On-Peak	3,454,835	0.55	1,900,159	0.15100	$286,924
Summer Semi-Peak	2,296,368	0.50	1,148,184	0.09294	$106,712
Summer Off-Peak	1,877,736	0.45	844,981	0.06802	$57,476
Winter On-peak	477,385	0.40	190,954	0.15078	$28,792
Winter Semi-Peak	3,406,085	0.40	1,362,434	0.09294	$126,625
Winter Off-Peak	854,907	0.40	341,963	0.06802	$23,260

Total Variable Consumption Charges	$629,789
Total Fixed Demand Charges	$643,274
Total Electricity Cost	**$1,273,063**
Total DC Plant Energy Use (kWh)	5,788,675
Average Electricity Cost per kWh	$0.220
Average kWh/ton-hr	0.468
Average Electricity Cost per ton-hr	$0.103

Appendix M. District Cooling Plant Annual Electric Cost Calculations

District Cooling Plant Cost Electricity Calcs for "Optimum Configuration" for "All bldgs less Types 13 & 14" WITH Thermal Storage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Peak Demand (tons)	3,174	3,365	3,367	4,239	4,243	4,440	4,440	4,440	4,440	4,440	4,272	3,581
Monthly Peak kW/ton	0.51	0.51	0.51	0.51	0.51	0.677	0.731	0.731	0.677	0.677	0.51	0.51
Monthly Peak Demand (kW)	1,619	1,716	1,717	2,162	2,164	3,006	3,245	3,245	3,006	3,006	2,179	1,826
Monthly Fixed Charges ($/Mo)	$22,295	$23,567	$23,582	$29,639	$31,678	$43,925	$47,413	$47,413	$43,925	$41,130	$29,865	$25,069

	Period Consump-tion (ton-hrs)	Period Average kW/ton	Period Energy Use (kWh)	Tariff Variable Cost ($/kWh)	Subtotal Variable Cost
Summer On-Peak	904,894	0.55	497,692	0.15100	$75,151
Summer Semi-Peak	2,314,849	0.50	1,157,425	0.09294	$107,571
Summer Off-Peak	4,409,197	0.45	1,984,139	0.06802	$134,961
Winter On-peak	0	0.40	0	0.15078	$0
Winter Semi-Peak	118,444	0.40	47,378	0.09294	$4,403
Winter Off-Peak	4,619,933	0.40	1,847,973	0.06802	$125,699

Total Variable Consumption Charges	$447,786
Total Fixed Demand Charges	$409,502
Total Electricity Cost	**$857,288**
Total DC Plant Energy Use (kWh)	5,534,605
Average Electricity Cost per kWh	$0.155
Average kWh/ton-hr	0.448
Average Electricity Cost per ton-hr	$0.069

Appendix N

Chula Vista Research Project Advisory Committee

Appendix N. Chula Vista Research Project Advisory Committee

AESC, Inc.	Ronald K. Ishii	Vice President
Brummitt Energy Associates	Beth Brummitt	Principal
California Sierra Club	Carl Zichella	Regional Director
Calif. Building Industry Assn.	Alan Nevin	Chief Economist
Charles Angyal & Associates	Charles Angyal	Principal
City of Chula Vista	Brad Remp	Chief Building Official
Community Fuels	Lisa Mortenson	CEO & Apollo Alliance Member
Efficiency Valuation Organization	Larisa Dobriansky	Board Member
Endurant Energy	John Kelly	Vice President
Local Government Commission	Judy Corbett	Executive Director
National Assn. of Realtors	Lawrence Yun	Dir. Research. & Senior Economist
National Renewable Energy Lab	Nancy Carlisle	Dir. Energy Mngt. & Federal Mkts.
Mortgage Bankers Association	Doug Duncan	Chief Economist
Mortgage Bankers Association	Jamie Woodwell	Senior Staff
Pacific Gas & Electric	Darren Bouton	Mngr. Sustainable Communities
Sempra/ SDG&E	Julie Ricks	Energy Programs Advisor
Schweitzer & Associates	Judi Schweitzer	Principal
Sempra / SDG&E	Chris Yunker	Manager, Emerging Technologies
Southern California Edison	David Jacot	Mngr. Sustainable Communities
U.S. Dept. of Energy	David Berg	Senior Policy Advisor
UC-Davis Inst. Transp. Studies	Susan Handy	Professor & Researcher
UC – San Diego	Paul Linden	Chair, Mech. Engineering

APN-4

Appendix O

CommunityViz Spatial Modeling Inputs, Variables, and Outputs

Appendix O. CommunityViz Spatial Modeling Inputs, Variables, and Outputs

Data Inputs:

- Outputs from the preceding building, infrastructure, and green infrastructure analysis
- SDG&E power distribution plans and emission data for the energy distribution system that will be modeled for this area.

Adjustable Variables:

- Building, infrastructure, and green infrastructure assumptions from previous analysis.
- Transit frequency

Data Outputs:

- Dynamic (automatically updated) impact indicators for energy and resource analysis.
- Transportation Air Emission Reductions
  - Auto PM-10
  - Auto PM-2.5
  - Auto SO_2
  - Auto CO
  - Auto VOC
  - Auto NH_3
  - Auto CO_2
  - Auto CH_4
  - Auto N_2O
  - Petroleum Costs
- Building/Industrial Air Emission Reductions
  - CO
  - Cooling Energy
  - CO_2
  - NO_x
  - SO_x
  - Particulates
- Common Impacts - Population
- Common Impacts - School Children
- Common Impacts - Labor Force
- Common Impacts - Commercial Jobs
- Common Impacts - Vehicle Trips per Day
- Common Impacts - Residential Energy Use
- Common Impacts - Residential Dwelling Units
- Common Impacts - Total Commercial Floor Area
- Common Impacts - Commercial Jobs to Housing Ratio

Appendix P

Limitations Leading to the Creation of Hypothetical Site X

Appendix P. Limitations Leading to the Creation of Hypothetical Site X

Modeling Constraints/Limitations:

The following components were fixed for sites A and B and could not be modified. To create an analysis that the researchers would find useful, they created a hypothetical site X in which they could modify these components:

- Site uses (intensity ranges and land use designations) were restricted
- Grading plan was set
- Alignment of external arterials were fixed
- Design and alignment of internal street system, including block sizes, were fixed
- Bus rapid transit alignment and design were fixed
- Bus stop locations and functions were set
- Regional trail system had been determined by General Development Plan
- Park location sizes/design were set
- Village pathway had been determined by General Development Plan
- Certain access points were required to stay open
- Infrastructure was not to conflict with current design

Appendix Q

Curve Numbers for Land Use and Soil Types

Appendix Q. 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 R

Coefficients by Rainfall Type

Appendix R. Coefficients by Rainfall Type

Coefficient Values by Raintype				
Rainfall type	I_a/P[75]	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
	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	-0.16403
	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

[75] $I_a = .2 \times S$

Appendix S

Soil Types

Appendix S. 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 clay pan or clay layer at or near the surface and shallow soils over nearly impervious material.

Appendix T

Stakeholder Input on Barriers and Solutions

BURNHAM–MOORES
CENTER FOR REAL ESTATE
UNIVERSITY OF SAN DIEGO

Chula Vista Research Project
Real Estate Industry Workshop Questions & Responses

On January 29, 2008, senior representatives from the real estate development, and building industries and the three independently owned utilities assembled at the University of San Diego to provide input on the CVRP research questions previously approved by the Project Advisory Committee. This appendix summarizes that input and provides commentary on the implications for further research. At the end of this appendix, the reader will find a list of the workshop participants.

Key Definition: "Energy-efficient community development" is defined as development of residential, commercial, institutional, and mixed use structures and infrastructure that integrate renewable and advanced energy-efficient technologies, and performance enhancing urban design, to reduce energy consumption and greenhouse gas emissions.

CVRP Research Questions:

1. What are the most significant perceived policy, regulatory and market barriers to investment in energy-efficient community development projects in California?
2. What are the perceived and real additional costs associated with the design and construction of energy-efficient community development projects? What potential public policies, incentives and other financial assistance could reduce these costs?
3. What do you perceive the current market demand and/or acceptance level to be for energy-efficient development projects and what is necessary to increase the demand and acceptance?
4. What are the perceived benefits for developing energy-efficient homes and buildings, and communities? What are the effective means to increase the identified perceived benefits?
5. What are the most important trade organizations and channels (publications, conferences, events) to tap to disseminate the final research findings?

Participant Responses & Commentary:

1. ***What are the most significant perceived policy, regulatory and market barriers to investment in energy-efficient community development projects in California?***

Return on Investment (ROI) - The single most important barrier to energy-efficient community development identified by the participants is the generally held perception that it will not produce a return on the capital investment for the developer/builder. This barrier entails corollary concerns relating to the following issues:

- The uncertainty of the additional/first costs to design an energy-efficient product, to purchase and install the energy-saving equipment and materials and the related construction process, permitting and inspection costs;
- The perception that there is an insufficient demand for such a product among property buyers and tenants. Specifically, the perception that buyers and tenants aren't willing to pay more to own or rent energy-efficient properties;
- The fear that these first costs will further reduce already narrowing profit margins, particularly in the current market, and further narrow the size of the market able to afford the more expensive, energy-efficient product.

A related concern is that the real benefit of an energy-efficient real estate product - energy cost savings over time, doesn't inure to developer/builder that bore the first cost, unless they are able to recover that cost at the point-of-sale or through premium leases.

This input suggests that the researchers need to examine alternative financing mechanisms to both reduce/"buy down" the first costs to the developer/builder and to recover their investment in the remaining costs at the point-of-sale and through lease arrangements over time. A variety of third-party financing mechanisms should be examined.

Needed Market Transformation – One participant suggested the need to transform the present model for energy-efficient real estate products in today's market from one of high margin / premium products sold at a low volume, to a model based on low margin products sold at a high volume. Discussion among participants suggested that a new economy-of-scale will be needed to enable such a model to be viable and that an effort is needed to explore the means of doing so.

Regulatory Constraints & NIMBY Opposition – One participant noted that local governmental regulations and citizen Not-In-My-Back-Yard (NIMBY) opposition often precludes consideration of advanced energy-efficient technologies such as onsite power generation, wind and solar photovoltaic and thermal equipment in large-scale development projects.

Inconsistent Rules & Processes – There is no consistent set of standards for what constitutes a sustainable or energy-efficient development project and currently municipal project planning and building approval processes don't typically recognize the value of this form of development. There needs to be a credible set of bench marks established that both define what an energy-efficient community looks like and a roadmap that will show the development community how to get there in a way that is cost-effective.

Lack of a Compelling Business Case – All discussion groups at the workshop cited the need for compelling examples of developer/builder successes stories or case studies of profitable experiences building and selling energy-efficient development projects in California. In the absence of this, the development community is not likely to pursue this form of development.

During the discussion a number of ideas were offered to address these barriers. These include the following:

a) Creation of a municipal preferred tax treatment districts for developers and buyers of properties in new development/redevelopment districts designed and built to maximize energy, water, and resource efficiency.

b) Development of a carbon emission reduction credit and trading system at the local level to provide a monetary benefit to developers and builders producing low-carbon communities and construction projects.

c) Expedited plan check and approval for developers and builders

d) Utility rate structures that encourage, rather than discourage interconnection of distributed energy technologies into the existing electric utility grid.

2. What are the perceived and real additional costs associated with the design and construction of energy-efficient community development projects? What potential public policies, incentives and other financial assistance could reduce these costs?

The participants identified the following real additional costs:

a) Increases in development cycle times due to the novelty of this type of construction and because neither the public or private development players know how to do this.

b) Increased design and engineering expenses

c) Increased material and equipment costs

d) Increased installation and inspection costs

e) Narrowing of the consumer market! Every $5-10k added to a property's sales price to cover the incremental cost of energy efficient features, the market of potential buyers for that property shrinks.

f) Interconnection charges and difficulty and time to negotiate them with the utilities

g) Potential market rejection of homes that are oversold as "green", particularly if green features are added at the expense (over the loss) of conventional amenities

Potential means of reducing costs offered by participants included the following:

a) An expedited planning process for these energy-efficient development projects

b) Education of all public and private players in the development transaction chain

c) Subsidies for the cost of permitting

d) Municipal development incentives and concessions for energy-efficient developers and builders

e) Re-design/re-writing local building and zoning codes

f) Allow individual building solar PV energy metering

3. ***What do you perceive to the current market demand and/or acceptance level to be for energy-efficient development projects and what is necessary to increase the demand and acceptance?***

There does appear to be growing consumer interest in "green" buildings and communities but real market demand is not there yet. Perceived factors affecting consumer demand include the notion that energy-efficient structures are:

a) more expensive to buy
b) less aesthetically appealing (referencing unappealing PV and solar thermal installations of the past),
c) limited in style and features
d) devoid of other amenities (i.e. granite, premium finishes, etc.)
e) little more efficient than other Title 24,'05 compliant structures on the market

Participants suggested that an increase in market demand will require

a) builder and consumer education
b) measurable benefits demonstrated to prospective buyers
c) increase in the design options
d) increase in financing and lease options that make these properties more affordable
e) some sort of rating system that will allow relative efficiencies of properties to be evaluated by potential buyers
f) ultimately lower costs to the consumer, perhaps by increased incentives
g) making energy-efficiency an optional add-on package for buyers

4. ***What are the perceived benefits for developing energy-efficient homes and buildings, and communities? What are the effective means to increase the identified perceived benefits?***

The general perception of development and building industry participants is "the benefits just aren't there!" The benefits that need to exist to engage the industry in this pursuit are the following:

a) Increased rate of real estate sales and a decreased rental turn-over rate directly associated with buyer/lessee perception of the value of owning/renting an energy efficient building. These are presented as the first of the two key indicators that will signal that a market for energy-efficient development is emerging.
b) Increased developer/builder sales profits and rental premiums directly associated with buyer/lessee perception of the aforementioned value. This is the second of indicator that will signal the emergence of the new market.
c) Broader media recognition of the value of energy-efficient development projects and widespread branding and marketing to build consumer demand.

d) Increased municipal incentives that encourage the industry to pursue these projects, such as lower development and building permitting fees, expedited processing time and other mechanisms that will shorten the development cycle and enable these products to get to market quicker.

e) Evidence that the pursuit of these projects actually increases productivity.

f) Increased government subsidies, tax credits, development concessions, and private capital made available to the development and building industries.

The means of putting these benefits in place follow logically and must include:

a) Consumer education and broad public and private marketing campaigns.

b) Compelling peer-to-peer success stories of energy-efficient projects that have proven to be both marketable and profitable.

c) Detailed case studies that tell the development and building industries how to pursue these projects.

d) Increased public programs and private capital as suggested in f.) above.

e) Increased research and development of energy-efficient building technologies.

5. What are the most important trade organizations and channels (publications, conferences, events) to tap to disseminate the final research findings?

- Urban Land Institute
- California Building Industry Association
- California Investor Owned Utilities
- Building Manufacturers & their Association
- American Planning Association
- California League of Cities
- California Code Officials
- California Fire Marshals Association
- Trade Contractors
- Engineers & General Contractors
- Environmental Organizations
- BOMA / CCDC / ICMA
- Media

Participants at the January 29, 2008
Real Estate Industry Workshop

Company	Participant
Baker Hostetler	Larisa Dobriansky
Benson & Bohl Architects	Richard H. Benson
Bridge Housing Project	Brad Wiblin
Brummitt Energy Associates Inc.	Beth Brummitt
Building Industry Association	Paul Tryon
Building Industry Association	Donna Morafcik
Building Industry Association	Scott Molloy
Burnham-Moores Center for Real Estate	Lou Galuppo
Burnham-Moores Center for Real Estate	Charles Tu
Burnham-Moores Center for Real Estate	Norm Miller
City of Chula Vista	Craig Ruiz
City of Chula Vista	Marisa Lundstedt
City of Chula Vista	Barbara Bamberger
City of Chula Vista	Brad Remp
City of Chula Vista	Andrew McGuire
City of Chula Vista	Denny Stone
Corky McMillin Companies	Nick Lee
Corky McMillin Companies	Rey Ross
Corky McMillin Companies	Bridget McEwen
Corky McMillin Companies	Todd Galarneau
H.G. Fenton	Brian Gates
HomeFed Corporation	Tom Blessent
HomeFed Corporation	Curt Noland
HomeFed Corporation	Hale' Richardson
HUD	Frank Riley
National Energy Center for Sustainable Communities	Doug Newman
Opus West Corporation	Chris Wood
Pacific Gas & Electric	Jenna Olsen
Pacifica Companies	Allison Rolfe
San Diego Housing Federation	Tom Scott
Sempra	Paul Stapleton
Southern California Edison	David Jacot

Attachments

Attachment I. Building Energy Technology Modeling Assumptions and Results for Site A: The Chula Vista Project

This attachment is available in a separate volume, CEC-500-2011-019-AT1.

Attachment II. Building Energy Technology Modeling Assumptions and Results for Site B: The Chula Vista Project

This attachment is available in a separate volume, CEC-500-2011-019-AT2.

Attachment III. The Urban Heat Island Mitigation Impact Screening Tool (MIST)

This attachment is available in a separate volume, CEC-500-2011-019-AT3.

Attachment IV. Tree Guidelines for Coastal Southern California Communities

This attachment is available in a separate volume, CEC-500-2011-019-AT4.