Bren | Valle Verde

Carbon Neutral Planning for a Senior Community

A Group Project submitted in partial satisfaction of the requirements for the degree of

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by

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The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principle of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required for all students in the Master of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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Abstract

Valle Verde, a retirement community in Santa Barbara, California, is a leader in the field of sustainability. Through its Green Initiative the organization has already reduced its impact on the environment; however, management now has a greater goal: to become carbon neutral, by reducing net greenhouse gas (GHG) emissions to zero, by the end of 2020. To help Valle Verde accomplish this milestone, we evaluated the community's current emissions by conducting a GHG inventory for fiscal year 2009–2010, which resulted in 1,494 metric tons of carbon dioxide equivalent ($MTCO_2e$). We projected this result to 2020 and concluded that Valle Verde will need to abate 1,648 $MTCO_2e$ to become carbon neutral by the end of that year. In order to evaluate the organization's strategic options, we also analyzed the effectiveness of its existing green programs, which have already reduced annual emissions by approximately 50%. With a clear understanding of Valle Verde's past actions and estimated future emissions, we then provided a comprehensive strategy that serves as a roadmap for achieving carbon neutrality in 2020. In order to present feasible solutions, we considered Valle Verde's institutional and operational constraints as well as the cost-effectiveness of each particular strategy. Given these parameters, it will be a challenge for Valle Verde to achieve carbon neutrality in 2020 solely by way of technology-based strategies. The organization will have to purchase carbon offsets as well. By employing our suggested recommendations, which include both emissions reduction strategies and carbon offsets, Valle Verde can become carbon neutral in 2020, thereby reducing its impact on the environment, preempting future climate change legislation, and enhancing its brand as the leader in sustainability in the retirement community sector.

Executive Summary

The drastic increase in atmospheric concentrations of greenhouse gases (GHGs) over the last several decades has led to measurable changes in global climate. These changes include an increase in average global temperatures, melting of arctic and glacial ice, sea-level rise, increased precipitation combined with extended droughts, and a higher overall frequency of extreme weather events.[1] It is "extremely unlikely" that these observed changes in climate are the result of natural forcing.[1] On the contrary, they are very likely linked to human activities. Failure to recognize our effect on the natural environment, and to make drastic behavioral adjustments, may lead to catastrophic and irreversible changes to the Earth as we know it.

The issue of climate change is global and therefore extremely complicated. The abundance of economic and geopolitical factors involved creates a wide range of obstacles that must be overcome in order to reach a decisive international agreement. While governments continue to work towards an international climate treaty, individual communities and organizations are forging ahead. They are doing this not only to meet existing state and local standards, or because it can be financially beneficial in the long run, but because they believe it is their duty as members of society.

Valle Verde is a leader in this charge. The retirement community has developed a Green Initiative, which includes programs for solar power generation, green remodeling, energy conservation, native landscaping, water reclamation, solid waste reduction, recycling, and alternative transportation. While the organization has received numerous awards for its programs, management has even grander ambitions. They would like to further reduce waste and consumption of energy, water, and other resources, while creating a healthier living and working environment for the residents and staff. Specifically, Valle Verde would like to reduce its overall carbon footprint with the ultimate goal of becoming carbon neutral by the end of 2020. In this way, it will become a true model of sustainability for other retirement communities and similar organizations.

This Bren Group Project attempts to help Valle Verde achieve its goals. In order to do this, it is imperative to have a clear understanding of the community's impacts on the environment. In recent years, many organizations have conducted GHG inventories for this purpose, and we chose this course of action as well. By translating all GHG emissions into one consistent and commonly used metric, carbon dioxide equivalent (CO_2e), we established a baseline of GHG emissions for Valle Verde's 2009-2010 fiscal year. We then projected this baseline out to

2020, and used it as a basis for evaluating various reduction strategies that, when combined, will lead to carbon neutrality.

Valle Verde faces numerous obstacles in measuring and reducing its GHG emissions, including limited availability of current and historical data; a service-oriented business model in which the desires of its residents are the primary concern; and financial limitations, including those associated with being a non-profit organization.

The Valle Verde Group Project attempts to overcome these obstacles by clearly outlining and following a six-step process:

1. Calculate Valle Verde's current GHG emissions using the Greenhouse Gas Protocol as a framework.
2. Define carbon neutrality within this framework with respect to Valle Verde's management objectives.
3. To the extent possible, evaluate Valle Verde's existing Green Initiative, specifically to inform our approach to selecting reduction strategies.
4. Project Valle Verde's future emissions to 2020 in order to establish a specific baseline from which GHG emissions reductions could be calculated.
5. Analyze various GHG reduction strategies and evaluate their cost-effectiveness and feasibility.
6. Provide a comprehensive recommendation through which Valle Verde can achieve carbon neutrality in 2020.

The goal of the GHG inventory was to establish a baseline from which GHG emissions reductions could be calculated, ultimately resulting in a carbon neutral campus by 2020.

There are various ways to define carbon neutrality, and this dictates how difficult and costly it will be to achieve net-zero emissions. We developed the scope of our definition in accordance with industry norms, and in consultation with Valle Verde management. It includes all direct emissions from stationary and mobile combustion as well as fugitive emissions. It also includes indirect emissions from purchased electricity. Given these parameters, our analysis resulted in GHG emissions of 1,494 $MTCO_2e$ for fiscal year 2009–2010.

In looking at Valle Verde's Green Initiative, we were able to gain a better understanding of the progress made thus far in reducing GHG emissions on the campus. We evaluated the effects of the solar panel system, LED lighting, ENERGY STAR appliances, dual pane windows, electric carts, the campus hybrid car, composting, reclaimed water, reduced fertilizer use, and the recycling program, among other things. Our calculations show that Valle Verde's efforts have already reduced its GHG emissions by 36%–51% compared to estimated levels prior to the implementation of its many green programs. This analysis provided us with much needed insight on the effectiveness of various strategies as well as on the room for improvement in these and other areas.

In order to know how much further Valle Verde will have to go to achieve carbon neutrality by 2020, we projected our GHG inventory results out to that year, resulting in total emissions of 1,648 $MTCO_2e$. We then evaluated numerous reduction strategies in terms of GHG abatement potential, net present value (NPV) over their lifetimes, and cost-effectiveness. By doing this, we were able to compile a comprehensive strategy through which Valle Verde can achieve carbon neutrality by the end of 2020 in the most cost-effective manner. This strategy includes installing additional solar panels, replacing all remaining appliances and boilers with ENERGY STAR appliances, installing more efficient insulation and radiant heat barriers, installing smart meters, and purchasing carbon offsets.

By implementing our recommended strategies Valle Verde can become carbon neutral by the end of 2020. In doing so, the organization will reduce its impact on the environment, preempt future climate change legislation, and enhance its brand as the leader in sustainability among retirement communities.

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Acronym Guide

AAHSA	American Association of Homes and Services for the Aging
AB 811	California Assembly Bill 811
AB 32	California Assembly Bill 32
ABHOW	American Baptist Homes of the West
AF	Acre-feet
AFUE	Annual fuel utilization efficiency
BAU	Business-as-usual
CARB	California Air Resources Board
CEC	Community Environmental Council
CEDA	Comprehensive Environmental Data Archive
CFL	Compact-fluorescent light bulb
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPI	Consumer price index
DOE	U.S. Department of Energy
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EIO-LCA	Economic Input-Output Life-Cycle Assessment
EIS	Energy Information Systems
EMS	Energy Management Systems
EPA	Environmental Protection Agency
GGP	Greenhouse Gas Protocol
GHG	Greenhouse gas
GWP	Global warming potential
HCF	Hundred cubic feet, equal to 748.05 gallons
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
kWh	Kilowatt-hour
LCI	Life-cycle inventory
LED	Light-emitting diode light
LEED	Leadership in Energy and Environmental Design
MMBTU	Million British Thermal Units
$MMTCO_2e$	Million metric tons carbon dioxide equivalent
MPG	Miles per gallon
$MTCO_2e$	Metric tons carbon dioxide equivalent, equal to 1,000 kg CO_2e

MTD	Santa Barbara Metropolitan Transit District
MWh	Mega-watt hour, equal to 1,000 kWh
N_2O	Nitrous oxide
NPV	Net present value
ODS	Ozone-depleting substances
PFCs	Perfluorocarbons
PV	Photovoltaic
SCAG	Southern California Association of Governments
SCE	Southern California Edison
SF_6	Sulfur hexafluoride
UNFCCC	United Nations Framework Convention on Climate Change
USGBC	United States Green Building Council
U.S. LCI	United States Life-Cycle Inventory Database
VMT	Vehicle miles traveled
VOC	Volatile organic compound
WARM	EPA Waste Reduction Model
WRI	World Resources Institute

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1. Project Background

1.1. Significance

1.1.1. Climate Change and its Effects

There is indisputable evidence that the earth's climate is warming, with observed increases in average global air and ocean temperatures, snow and ice melting, and rising sea levels.[2] The Intergovernmental Panel on Climate Change (IPCC) is very confident that human industrial activities have contributed to this warming.[2] Climate change is influenced by the concentration of greenhouse gases (GHGs) and aerosols in the atmosphere, changes in reflectance from the land surface, and variation in incoming solar radiation.[3] GHGs trap solar radiation that is reflected off the Earth's surface, thus warming the planet.[3] Human activities that increase the concentrations of atmospheric GHGs include, but are not limited to, the use of fossil fuels for energy, transportation, and industry; deforestation; and food production.[4]

Global concentrations of GHGs have increased significantly since 1750, when societies began to industrialize.[2] The six major GHGs—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—have increased by 70% in atmospheric concentration from 1970 to 2004.[5] CO_2, the most abundant GHG, has increased by 80% during this time period.[5]

It is important to note that GHGs vary in their ability to warm the Earth.[4] In order to compare the global warming potential (GWP) of these different gases, their amounts are often expressed in a common metric based on carbon dioxide called CO_2 equivalent (CO_2e).[2] For example, methane has a GWP of 21, indicating that it has 21 times the impact on climate change than an equivalent amount of CO_2.

The predicted effects of climate change go far beyond warmer temperatures. Many ecological processes are expected to be impacted, causing alterations of social and economic systems in turn. Furthermore, the effects on ecosystems, which are already being witnessed, are not uniformly distributed. They vary considerably depending on location. In response to this, the California Environmental Protection Agency compiled a report on climate change specific to California for former Governor Schwarzenegger and the California Legislature.[6] The report states that climate change will impact California by:

- Increasing air pollution due to rising temperatures that will foster the frequency, duration, and intensity of wildfires, as well as facilitate air pollution formation;
- Reducing the volume of water stored in snowpack, amplifying the existing strain on water resources; and
- Decreasing agricultural crop yields, resulting in increased costs to farmers and economic losses for one of California's biggest industries.[6]

1.1.2. The State of Climate Change Policy

As the sixth largest economy and the 12th largest emitter of GHGs in the world with a long history of groundbreaking environmental solutions, California is in a unique position to influence the international community.[7] In 2005, Governor Schwarzenegger signed Executive Order S-3-05, establishing an unbinding commitment to reduce California's GHG emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050. The Governor's Executive Order was codified with a binding statewide limit on GHG emissions and a provision for additional enforcement authority when Assembly Bill 32 (AB 32) was signed into law.[8]

AB 32, also known as the Global Warming Solutions Act of 2006, is the most comprehensive program of regulatory and market mechanisms to reduce GHGs in the United States. The emission levels of the six major GHGs mentioned above, the same as those regulated internationally under the Kyoto Protocol, were established at 1990 levels of 427 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) which serves as the emissions limit to be achieved by 2020.[9] Under a "business-as-usual" scenario prepared by the California Air Resources Board (CARB), AB 32 will reduce 2020 GHG emission levels by approximately 40%, or around 173 $MMTCO_2e$. By 2012, the market mechanism and mandatory caps adopted by CARB will become legally enforceable and subsequently ratcheted down to meet the December 31, 2020 deadline of 1990 GHG emission levels. To achieve this goal, California will need to increase its renewable energy supply by at least 33% by 2020, create stricter energy efficiency standards, reduce vehicular emissions, improve alternative transportation, and increase water conservation measures.[8]

Another piece of legislation that was passed, Assembly Bill 811 (AB 811), allows willing property owners to create contractual assessment districts to finance the installation of renewable energy and building energy efficiency improvements.[10] AB 811 gives property owners access to low-interest loans that are paid back through property taxes to complete solar installations or energy retrofits. In addition, the Million Solar Roofs Initiative incites the installation of solar panels for homes and businesses, with a goal of reducing GHG emissions by 3 million tons. [11]

At the local level, the Community Environmental Council (CEC) has undertaken an initiative to shift Santa Barbara County away from dependence on fossil fuels in one generation.[12] In 2004, Fossil Free by '33 became the CEC's singular mission as a response to three fundamental challenges related to fossil fuels: energy independence from politically unstable and largely anti-American regions, the approach of peak oil whereby oil becomes increasingly less cost-effective to extract, and climate change. To accomplish its goal, the CEC has focused its energy plan on the most cost-effective solutions with the most potential for local influence.[12]

1.1.3. The Role of Senior Communities

Businesses and institutions have at least five motivations for adopting measures to reduce their GHG emissions: 1) some energy efficiency measures also save money; 2) failing to act now will impact their business in the longer term; 3) policies will likely require changes or will impose a price on carbon; 4) greening can help market a brand with consumers; and 5) it is the "right thing to do" for future generations. The pervasive issue these organizations face is figuring out what they need to do that makes economic sense. One important sector that is facing this question is the retirement industry.

The retirement industry is growing rapidly. Individuals 85 years or older currently represent the fastest growing age group in the U.S. and the U.S. Census Bureau expects that 20% of Americans will be at retirement age by 2030.[13] There is a growing and urgent need for retirement communities to accommodate this demographic, particularly in California where the population of retirees is expected to double by 2030.[14] Given the growth in this segment of the population, the share of GHG emissions attributed to retirement communities will grow as well. Therefore, in order to mitigate the effects of climate change, this industry will have to play an increasingly important role in our collective effort to reduce GHG emissions.

1.1.4. Valle Verde Retirement Community

In 1958, the First Baptist Church purchased a 65-acre orchard property in the Hidden Valley area of Santa Barbara, California and formed a corporation to build a Christian senior community. Construction began in 1965 and the community was named Valle Verde in commemoration of the active role of the former owner, Verde Rutherford, in its development.

Figure 1-1: Valle Verde street view

In 1970, the organization currently known as American Baptist Homes of the West (ABHOW) began managing Valle Verde. ABHOW operates 18 affordable housing communities and 11 continuing care retirement communities, providing financial and other supportive services as an expression of its Judeo-Christian mission.[15] Valle Verde itself is a nonprofit retirement community and is committed to its Mission Statement: "to enhance the dignity, independence, well-being, and security of older people, through the provision of housing, health care, and supportive services."[16]

During the 1970s and 1980s, ABHOW oversaw the expansion of Valle Verde, which now includes an enlarged Health Center, North and West campus residential apartments, the Quail Lodge Assisted Living facility, a library, and an outdoor pool. Over the next 3 to 5 years, Valle Verde plans to add 40 single-story homes, thereby increasing its resident population from 376 to 434.[17] Management also plans to renovate campus facilities, such as the dining room, fitness center, and chapel and is considering the addition of a staff parking lot as well.[17]

Figure 1-2: Valle Verde campus including future expansion

Valle Verde is extremely sensitive to its impact on the environment and is currently at the forefront of sustainability in the retirement community industry. In 2004, community members, residents, and nonprofit executives developed a Green Initiative to reduce waste generation and water and energy consumption on the campus.[18] This Green Initiative is divided into six different environmental programs: Energy, Green Building, Transportation, Recycling, Food, and Landscaping. While the organization has received numerous awards recognizing its efforts, including awards from the American Association of Homes and Services for the Aging (AAHSA) and the City of Santa Barbara, the community is now pressing towards a loftier goal: to become carbon neutral in 2020.

By achieving carbon neutrality, Valle Verde will be positioned to help California achieve its ambitious emissions reduction goals outlined in AB 32 and to be a local leader in the CEC's Fossil Free by '33 campaign. Valle Verde's achievements will also serve as a case study for other retirement facilities and similar communities, such as college campuses, hotels, hospitals, restaurants, summer camps, and nursing homes, interested in becoming carbon neutral or otherwise reducing their environmental impacts. In particular, Valle Verde will serve as an example of how other retirement communities managed by ABHOW can abate GHG emissions.

1.2. Objectives & Approach

The goal of this Bren Group Project is to provide a roadmap through which Valle Verde can become carbon neutral by the end of 2020. Achieving this goal involves several intermediate objectives. First, we must gain a clear understanding of the organization's current GHG emissions. Then, in order to identify potential ways to reduce those emissions, we must evaluate the effectiveness of the current Green Initiative and investigate other potential reduction strategies that have not yet been implemented at Valle Verde. With a clear picture of the organization's financial and institutional constraints, as well as the cost-effectiveness of each potential strategy, we can develop a scenario under which Valle Verde can become carbon neutral.

In recent years, many companies and organizations have turned to GHG inventories to evaluate their impact on the environment, to identify opportunities to reduce emissions as well as energy and materials costs, and to increase profits through new competitive advantages.[19] Measuring direct emissions from a smokestack may be fairly simple, but calculating indirect emissions, such as employee travel, waste disposal, and those hidden in the supply chain, is much more difficult. While there are many consulting firms and software programs that aid in performing these assessments, the most widely used system is the Greenhouse Gas Protocol.[20]

The Greenhouse Gas Protocol (GGP) was created by the World Resources Institute and the World Business Council for Sustainable Development,[20] and has been used for a decade by governments and corporations to measure, evaluate, and manage GHG emissions.[20] The criteria include three scope areas: Scope 1 involves direct emissions from stationary and/or mobile combustion as well as fugitive emissions; Scope 2 involves indirect emissions from purchased electricity; and, Scope 3, which is reported voluntarily, includes any other emissions, such as waste management, employee travel, and consumer use and disposal of products.[19] This Bren Group Project used the GGP—the industry standard—to conduct Valle Verde's GHG inventory.

The goal of the GHG inventory was to establish a baseline from which GHG emissions reductions could be calculated, ultimately resulting in a carbon neutral campus in 2020. There are various ways to define carbon neutrality, and the scope of this definition dictates how difficult or costly it will be to achieve net-zero emissions. In accordance with industry norms, and in consultation with Valle Verde management, we included only Scopes 1 & 2 emissions when establishing this baseline. There were several reasons for this decision. First, it is difficult to set boundaries on Scope 3 emissions because, when considering the life-cycle approach, these boundaries can stretch outward infinitely. Furthermore, there were significant data limitations with respect to Scope 3 emissions. From a practical perspective, it is challenging to achieve carbon neutrality even from a baseline that includes only Scopes 1 & 2. Including Scope 3 would make it virtually impossible. Thus, our working definition of carbon neutrality is when annual net emissions from Scopes 1 & 2 equal zero by the end of 2020. Despite this narrowed definition, for the purpose of obtaining a more complete and informative picture of Valle Verde's emissions, we conducted a comprehensive inventory as well, which included emissions that fell under all three scopes.

In order to measure the progress that Valle Verde has already made towards carbon neutrality, we evaluated the Green Initiative within the context of GHG emissions. To do this, we looked at the various programs that the organization has implemented, and performed quantitative analyses whenever possible using a common index—CO_2e emissions abated. While there were significant data limitations during this step, understanding its strengths and weaknesses in these terms will allow Valle Verde to focus its attention on the most effective and appropriate strategies going forward.

In order to decide what blend of strategies Valle Verde would have to implement to become carbon neutral at a given time in the future, we needed to know what the annual emissions would be up to that point. We therefore projected the community's emissions levels through 2020 in the absence of additional actions.

Once a clear picture was obtained of Valle Verde's future GHG emissions and of the impact of the Green Initiative, we analyzed various ways to further reduce emissions on the campus. This involved expanding upon the existing strategies as well as proposing new ones. In considering potential strategies, we conducted a feasibility assessment of each, which was based on four factors:

- Given our definition of carbon neutrality, we focused only on measures that would fall under Scopes 1 and 2.
- For existing strategies, we identified the level of campus-wide saturation to assess whether or not there was room for improvement in a given area.
- For all strategies, we evaluated whether or not they would impede on the residents' lifestyle.
- For all strategies, we evaluated their cost-effectiveness.

Finally, with these criteria in mind, we compiled a set of reduction strategies that will most cost-effectively drive Valle Verde to carbon neutrality by the end of 2020.

2. Valle Verde Greenhouse Gas Inventory

2.1. Protocol & Tool Choices

The GGP is an international protocol that governments and business leaders use to manage GHG inventories. It has served as the foundation for nearly every GHG standard and program throughout the world, including the Climate Registry (a prominent North American nonprofit collaboration for reporting and verifying GHG emissions), and the International Standards Organization (ISO), which has modeled the ISO 140564-I standard after the GGP's Corporate Accounting and Reporting Standard.[20] As a result, we determined that using the GGP was the most relevant accounting and reporting mechanism for our project. The World Resources Institute (WRI) offers several reporting standards—Corporate Standard, Project Protocol, and Product and Supply Chain. The most appropriate for Valle Verde is the Corporate Standard, as it covers all aspects of running a business and is most comprehensive for Valle Verde's facilities.

An important factor in conducting a GHG inventory is to incorporate life-cycle cradle-to-gate emissions into the production or consumption of goods or services. Cradle-to-gate emissions are generated during the extraction of materials to create a product or service, as well as during the manufacturing and transportation of the product or service until it reaches the consumer. We utilized Climate Earth's Comprehensive Environmental Data Archive 4.0 (CEDA 4.0), which uses various life-cycle inventory (LCI) databases, such as U.S. LCI and Ecoinvent 2000, to analyze the cradle-to-gate carbon emissions of various goods and services. CEDA calculates GHG emissions for 480 different product and service categories using national economic and environmental data. We used economic value-based allocation for emissions rather than system expansion to avoid issues of product substitution.[21] The user can input the purchaser or producer price of a good or service to obtain the emissions of the associated product.

CEDA's economic input-output life-cycle assessment (EIO-LCA) model and other calculators, like Carnegie Mellon's EIO-LCA, are often preferred to process-based LCAs because process-based LCAs are more time-consuming and expensive. It is often difficult to validate a process-based LCA because companies and manufacturers do not want to release proprietary and confidential information about their goods and services.[22] EIO-LCAs alleviate this problem because national economic producer-to-consumer sector averages are used in place of company-specific data. EIO tables facilitate first order approximations of economy-wide environmental impacts of a product or service.[22] A separate, yet equally important factor in using EIO-LCAs is iterative process used to calculate emissions, finding the largest impact products first and refining the scale when necessary.

An advantage of using the CEDA framework over the Carnegie Mellon framework was the comprehensive nature of the GHG emissions for N_2O, HFCs, PFCs, and SF_6. As a result, failing to include these emissions would underestimate Valle Verde's annual emissions significantly.[23]

2.2. Scope & Emissions Sources

The GGP separates all GHG emissions into three categories or scopes. Scope 1 includes all direct emissions, which are defined as "emissions from sources that are owned or controlled by the reporting entity."[20] These emissions result from on-site combustion in stationary and mobile sources, and also include fugitive process emissions. Fugitive emissions refer specifically to intentional or unintentional releases of GHGs, often related to HFC emissions during the use of refrigeration and air conditioning equipment.[20] Scope 2 includes indirect emissions defined as "emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity."[20] These emissions result from electricity produced at the power plant that is then used to provide power to buildings and electric vehicles. Scope 3 emissions are defined as "other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc."[20] Figure 2-1 below illustrates the emissions sources at Valle Verde and their scope breakdown according to the GGP.

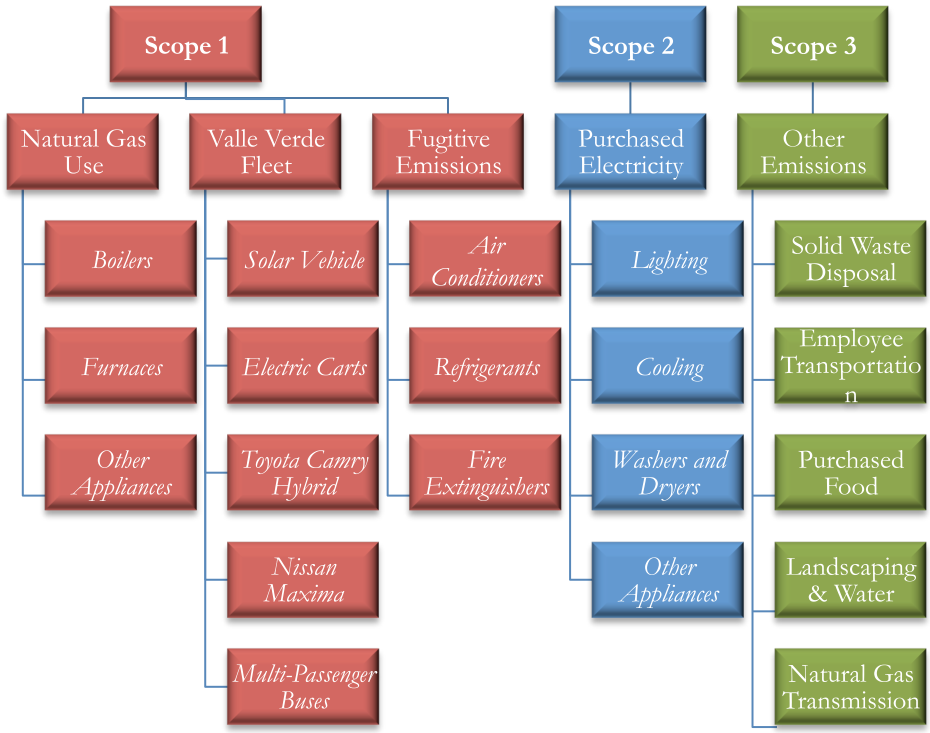

Figure 2-1: Greenhouse Gas Protocol Scopes Applied to Valle Verde

2.3. Methodology and Assumptions

Data, such as kilowatt-hours (kWh) and million British Thermal Units (MMBTU), were collected from a variety of agencies, utilities, and Valle Verde staff for Valle Verde's fiscal year 2009–2010 (October 2009–September 2010) and inputted into an Excel spreadsheet. CEDA 4.0 matrices (LCI, economic, and environmental) were then factored into each data set. Because utilities often have different billing periods (i.e. natural gas for 30 days, electricity for 28 days, etc.) data were pro-rated per day to maintain time consistencies. The data were multiplied by emissions factors (kg CO_2/kWh, kg CH_4/kWh, etc.), then multiplied by a global warming potential for the relevant gas (Table 2-1). The resulting value was a measurement of emissions in a unified unit of measure across all types of GHGs. The formulas used to calculate GHG emissions are described in Appendix I.

The IPCC and other organizations often calculate emissions using a GWP average for 100 years, as various GHGs have different lifetimes. These varying lifetimes impact the atmosphere's ability to retain or release radiation over different time scales (Table 2-1).

Table 2-1: IPCC Atmospheric Lifetimes of Greenhouse Gases and Global Warming Potential[3]

Kyoto GHGs	Atmospheric Lifetime (Years)	Global Warming Potential (GWP100)
Carbon Dioxide (CO_2)	5–200	1
Methane (CH_4)	12	21
Nitrous Oxide (N_2O)	114	310
Hydrofluorocarbons (HFCs)	1–260	140–11,700[24]
Perfluorocarbons (PFCs)	Thousands of years	6,500–9,200[24]
Sulfur Hexafluoride (SF_6)	3,200	23,900

Because CEDA's framework of calculations is based on economic and environmental data from 2002, any data that were provided in 2009–2010 dollars were converted to 2002 dollars using the Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator.[25] CEDA also provides factors to transform purchaser prices (the amount a final consumer pays for a good or service) into producer prices (the amount spent to produce a good or service). This conversion is a necessary step since consumers pay a price that is higher than the actual cost of producing a good or service, which reflects the GHG emissions generated during the production of a good or service.

2.3.1. Scope 1 Emission Sources

Natural Gas Use

Valle Verde burns natural gas on its facility for heating, cooking, and maintenance. Southern California Gas provided data in dollars only, as the utility did not maintain consumption records for all of Valle Verde's accounts (for each apartment). Using the Energy Information Administration's (EIA) records of California price of natural gas delivered to residential customers, average monthly prices were divided by Valle Verde's total expenses on natural gas to estimate average monthly therm consumption from on-site combustion for the FY09–10.[26] To calculate natural gas Scope 1 emissions, we used the EIA's emissions factors for CO_2, CH_4, and N_2O,[27] which are the emissions released from natural gas combustion, and factored in GWPs.

Fugitive Emissions

Fugitive emissions are also part of the required reporting framework in the GGP. Valle Verde uses outside contractors to service the on-campus coolants and refrigerants that might result in fugitive emissions so, unfortunately, records regarding these emissions were not available to us. To alleviate this data gap, we used a proxy of California estimated Ozone Depleting Substance (ODS) substitutes per capita for Valle Verde, as Valle Verde's per capita emissions would reflect all of the same sources—air conditioning (for their main buildings), refrigeration (in each apartment and in the kitchen), fire safety equipment, and fuel-driven on-site vehicles with air conditioning and coolants.

California's per capita ODS substitutes from the 2000–2008 CA GHG inventories were regressed to extrapolate to 2010 data.[28] The 2010 predicted value of ODS substitutes was then multiplied by the number of residents on-site at Valle Verde to find total fugitive emissions for Valle Verde.

Valle Verde Fleet

Valle Verde maintained unleaded fuel expenditures for August 2009–July 2010, but only recorded costs and not total gallons purchased. Information on fuel prices was obtained through Michael Drummond, Administration Assistant of Campus Activities. Total gallons consumed were estimated by dividing total expenditures by the average weekly CA price of gasoline for each month using EIA retail gasoline historical prices—4,166 gallons (traveling approximately 55,000 miles).[29] These data were converted to CO_2e using fuel emissions coefficients from the EIA and GWPs.[27]

2.3.2. Scope 2 Emission Sources

Electricity

The campus generates some electricity on-site through solar photovoltaics (PV) panels, but the majority of electricity is purchased from Southern California Edison (SCE). According to the GGP, Valle Verde is still responsible for emissions that are produced off-site at a power plant. Therefore, using SCE's records of Valle Verde's electricity consumption and Environmental Protection Agency's (EPA) eGRID (Emissions & Generation Resource Integrated Database) 2005 GHG Annual Output Emission Rates for California (subregion: WECC California), consumption in kWh was multiplied by emissions factors and GWP for CO_2, CH_4, and N_2O.[30] In this case total kWh consumption was available for the facility, but all 68 electricity meters were aggregated into one account so we were unable to identify hot spots in electricity consumption on the campus.

2.3.3. Scope 3 Emission Sources

Employee Transportation

Data for employee transportation were obtained through Valle Verde's management. Alexa Steadman, Executive Administrative Assistant, administered a 2010 survey for Valle Verde's purposes to evaluate employee transportation methods. Questions included:

1. What is your zip code?
2. How many miles do you live from Valle Verde?
3. What is your primary mode of transportation?
4. Year, make, and model of your vehicle?
5. Do you carpool?
6. If so, how many passengers travel with you?
7. How many days per week do you commute to Valle Verde?

We analyzed the results of Valle Verde's employee transit survey. All respondents with incomplete information for questions 4 and 7 were removed, reducing original response of 113 employees to only 62. All carpool information was ignored, and we only considered primary mode of transportation. We assumed that the number of miles that respondents live from Valle Verde is the same distance as a one-way commute to Valle Verde. We multiplied number of miles commuted, by 2 to account for round-trip travel, and multiplied this product by the number of days commuting to work per week, times 50 work weeks in a year. By dividing the amount of miles by the lowest combined new MPG (miles per gallon) rate for each vehicle listed, we obtained the total number of gallons used per driver per year.[31] Walking, biking, and riding the bus were assigned an MPG rating of zero. We took the average gallons of gasoline consumed commuting from the 62 respondents, which was then multiplied by the total number of employees (220) to get the total number of gallons of gasoline used by employees per year. This value—98,243 gallons—was converted in kilograms of CO_2 using the same emissions factors as on-site transportation.

To calculate the nitrous oxide and methane emissions that result from employee transportation, it was necessary to make assumptions about the number of miles commuted and the vehicles driven by Valle Verde employees since the emissions coefficients for these two GHGs are in kilograms per mile traveled based on year and vehicle type (passenger vehicle or light duty truck). We used the average number of miles commuted by the 62 respondents and multiplied it by the total number of employees at Valle Verde to estimate the total number of miles commuted annually. The average vehicle driven by Valle Verde employees is a 2001 passenger vehicle. We used the EIA emission coefficients associated with this type of vehicle and the GWPs for N_20 and CH_4 to calculate kilograms CO_2e. Complete data related to Valle Verde's employee transportation is provided in Appendix II.

Food

Paul Childers, the interim Director of Dining Services, supplied us with 2 weeks of Valle Verde's food purchasing manifests from various vendors. Valle Verde does not maintain food data for extended periods of time. The supplied data was extrapolated over Valle Verde's fiscal year. It was assumed that the data is an accurate representation of the retirement community's food purchases. During Thanksgiving and Christmas Valle Verde may purchase more food to accommodate residents' holiday visitors. However, it was determined by both Valle Verde's Executive Director and interim Director of Dining Services that Valle Verde's food procurement remains fairly consistent for the rest of the year.

Different food and cooking items were assigned to CEDA categories that best described them. When these items did not fit into one of CEDA's specific categories they were assigned to the category "all other food manufacturing." Products such as bread, baked goods, and meats that may be delivered to Valle Verde frozen were placed into more specific categories, such as "bread and bakery product manufacturing" rather than CEDA's broad "frozen food manufacturing" category. We were not able to confirm with Valle Verde if these types of food are delivered frozen. The only two food items assumed to be delivered frozen were "veggie patties" and "chili rellenos." Two items ("Milk Café Lait" and "Laura's Petite Four Asst.") were difficult to classify, but with internet research and information on the food supplier we made a best guess. A complete list of food products and their associated CEDA categories can be found in Appendix III.

Natural Gas Transmission

As described above, natural gas data was obtained from Southern California Gas Company in dollars per month. These billed amounts were converted into 2002 dollars and then producer prices. Finally, these producer prices were entered into the CEDA tool, providing use with GHG emission estimates for the energy needed to transmit natural gas to Valle Verde.

Waste

Allied Waste supplied a complete billing history for Valle Verde from December 2009 to September 2010. Valle Verde's monthly waste bills are fairly constant, since they pay a flat monthly rate. However, monthly bills change as Valle Verde adds and/or removes recycling, composting, and trash containers. We assumed that the monthly bills for October 2009 and November 2009 were equal to December 2009 bill in order to complete Valle Verde's GHG inventory for fiscal year 2009–2010. These monthly bills were added together and entered into CEDA to calculate the annual Scope 3 emissions for waste disposal.

Water

Water data for all of Valle Verde's water meters were obtained through the City of Santa Barbara, measured in HCF (hundred cubic feet) and dollars per month. Expenses were converted to 2002 dollars and producer prices, and then entered into CEDA to predict emissions resulting from the electricity needed to transport water. Because CEDA 4.0 does not distinguish between reclaimed and potable water, both sets of meters were aggregated to find the total Scope 3 emissions for water.

2.3.4. Sources of Uncertainty

Limitations in available data, differing billing periods, and the use of state and national average emission coefficients are significant sources of uncertainty which impact the results of our GHG inventories. Data limitations made it necessary to find alternative ways to obtain the necessary data to estimate GHG emissions. Additionally, the lack of availability of data over the entire fiscal year made it necessary to assume that the given data were an accurate portrayal of Valle Verde's typical expenses. Furthermore, utilities have different billing periods, requiring average daily utility use and costs to be used instead of data specific to our inventory's time frame. All of our emission coefficients, except those for electricity, are national averages. Electricity's emissions coefficients are regional averages. All of these coefficients do not take into account Santa Barbara's and Valle Verde's utility profile, which may impact emission factors for various emission sources.

Given the complexity and challenging nature of collecting all necessary and pertinent data, the accuracy of the inventory was only as robust as the available data. In many cases, utilities billed once every few months rather than the typical once per month. As a means of developing complete data sets, average daily costs was inferred for those months using number of days in the billing cycle and total consumption for those days. In some cases, like natural gas, consumption data was received as expenses rather than therms, and average California natural gas prices were therefore used to predict consumption. It is possible that natural gas consumption values are not entirely accurate due to the varying costs of natural gas by utility.

Some data were not available in totality because Valle Verde does not collect and/or maintain formal records of some emission sources, such as resident transportation, waste disposal services, and food procurement. Employee and on-site transportation data faced similar limitations that required certain assumptions to estimate emissions. In the case of food, complete data was obtained for only two weeks, and it was difficult to determine how many food items were delivered to Valle Verde.

Allied Waste was unable to provide a complete set of bills for Valle Verde's 2009–2010 fiscal year, and it was impossible to obtain waste data broken down into tons of specific materials, such as various recyclables, municipal solid waste (trash), and composting. Although CEDA 4.0 does not differentiate between these materials, there are specific GHG coefficients assigned to various wastes that depend on their method of disposal. With data on the amounts of different materials discarded it would have been possible to use these coefficients to more accurately estimate GHG emissions.

CEDA has some inherent limitations in estimating a facility's emissions. First, CEDA draws upon national, sector-based databases, with product costs and emissions valued at the national level. This may distort Valle Verde's emissions because some products that Valle Verde purchases may be from local vendors and sources (which in turn may reduce the emissions associated with the transport of the product to Santa Barbara). Second, CEDA's categories are sector-based, which limits emissions such as from potable and reclaimed water from being represented separately and at a finer scale.[22]. Third, CEDA does not take into account the costs of living in Santa Barbara, further affecting emissions calculations. For example, entering cost data for ten apples in Santa Barbara may actually be equivalent to a different quantity of apples in another region of the country—so allocating emissions per apple may be incorrect. Valle Verde's emissions may be over or under estimated based on the product or service given CEDA's aggregated framework.

Additionally, CEDA suggests that there is a scalar ratio between the economic output per dollar spent and emissions. That is to say, CEDA calculates the amount of output of emissions in kg CO_2e per dollar spent. If one spends $10 on some product or service, the emissions are multiplied by that scalar of 10. This suggests that there is a linear relationship between emissions and economic output, which in fact may not be the case (as marginal costs vary with the production of some number of units).

A sensitivity and uncertainty analysis was conducted to examine how our various assumptions and inputs would impact the results of our GHG inventories. Lacking information on the potential range of true values, we increased or decreased each assumption or input by 10% and evaluated the effect on the two inventories. For example, we assumed that Valle Verde was charged California's monthly average price for a therm of natural gas to calculate monthly therm consumption. To explore how sensitive our inventories were to this assumption we increased monthly gas prices by 10% and calculated the new GHG emissions for natural gas. We then replaced the previous value for the natural gas emissions with this new value and found the new GHG emissions totals for both the comprehensive and carbon neutral inventories. We used the following formula to calculate the percent change in our inventories.

$$\left(\frac{new\ inventory\ total - old\ inventory\ total}{old\ inventory\ total}\right) \times 100\%$$

We then repeated this process with natural gas prices decreased by 10%. For certain assumptions, such as year of vehicle and type of vehicle (i.e. light duty truck), it was not possible or logical to decrease/increase the assumption by 10%. In these cases we explored the impact of driving passenger vehicles and heavy-duty trucks and then altering the year a car was made by a single EPA tier.

2.4. Carbon Neutrality Defined

Carbon neutrality can take on many definitions, but in general it is defined as the balance between the amount of carbon being emitted and sequestered or offset.[32] For the purposes of this project, though, we had to define specifically what would be included in the framework of carbon neutrality to give Valle Verde some indication of the success of its reduction strategies. Most reporting standards suggest only considering Scopes 1 and 2 emissions, as quantifying Scope 3 emissions can be significantly challenging for the following reasons:

1. **There is no limit to determining what emissions should and should not be included**. If Scope 3 emissions are to focus on all cradle-to-gate emissions of all products, we might have to include emissions from an

entity three or four or even five levels upstream in the supply chain, where many degrees of separation would add complexity.

2. **Quantification of emissions becomes guesswork.** When dealing with several degrees of separation from the main Scope 3 emissions (like water, waste, etc.), it becomes more difficult to estimate emissions.
3. **Reducing Scope 3 emissions may impact resident behavior**. Valle Verde management insists that strategies for reducing emissions do not require changes in resident behavior.
4. **Becomes impossible to attain carbon neutrality**. Including all three scopes in defining carbon neutrality makes it virtually impossible to achieve.

Based on these four concerns, and with the guidance of the Executive Director of Valle Verde, we chose to define carbon neutrality as the point at which net GHG emissions from Scopes 1 and 2 only equal zero. This provides Valle Verde with a more feasible goal of becoming carbon neutral by the end of 2020. Once the organization achieves this milestone, it is assumed that the community will remain carbon neutral in perpetuity.

Although our definition of carbon neutrality includes emissions from Scopes 1 and 2 only, we also conducted a more complete assessment of Valle Verde's GHG emissions. This additional assessment, which we call the Comprehensive Inventory, includes emissions from Scope 3 in addition to those from Scopes 1 and 2. The purpose of this Comprehensive Inventory was to provide Valle Verde with a more representative picture of its total emissions. Furthermore, this information will be valuable if the organization attempts to reduce emissions beyond Scopes 1 and 2 in the future.

2.5. Results

Valle Verde generated a total of 1,494 metric tons of carbon dioxide equvalent (MTCO_2e) from Scope 1 and 2 sources during FY09–10. This amount of GHG emissions is equivalent to the those generated annually by 286 passenger vehicles.[33] A large portion of Valle Verde's Scope 1 and 2 emissions resulted from on-site combustion of natural gas and off-site emission from electricity generation (Table 2-2 and Figure 2-2). Due to lack of submetered data from Southern California Gas Company and Southern California Edision, it is difficult to attribute the use of natural gas and electricity to specific sources within the campus.

Fugitive emissions are also a significant portion of Valle Verde's Scopes 1 and 2 emissions (11%) (Table 2-2 and Figure 2-2). However, this number may be overestimated as it is based on California's fugitive emissions estimate for 2010 and may include more than residential and commercial emissions.

We expected Valle Verde's fleet transportation to be a small source of emissions (Table 2-2 and Figure 2-2) because little transportation occurs by company operated vehicles. Also, the fleet transportation does not account for resident and employee transportation, which are likely to be more substantial contributors of emissions.

Table 2-2: Valle Verde's Scopes 1 & 2 GHG Emissions Inventory, FY 09–10

Scope	Total Annual Emissions (kg CO_2e)	Total Annual Emissions ($MTCO_2e$)	Percent of Total
Scope 1 (Natural Gas Use)	692,000	692	46%
Scope 1 (Fugitive Emissions)	158,000	158	11%
Scope 1 (Valle Verde Fleet)	37,000	37	2%
Scope 2 (Electricity)	607,000	607	41%
TOTAL	**1,494,000**	**1,494**	**100%**

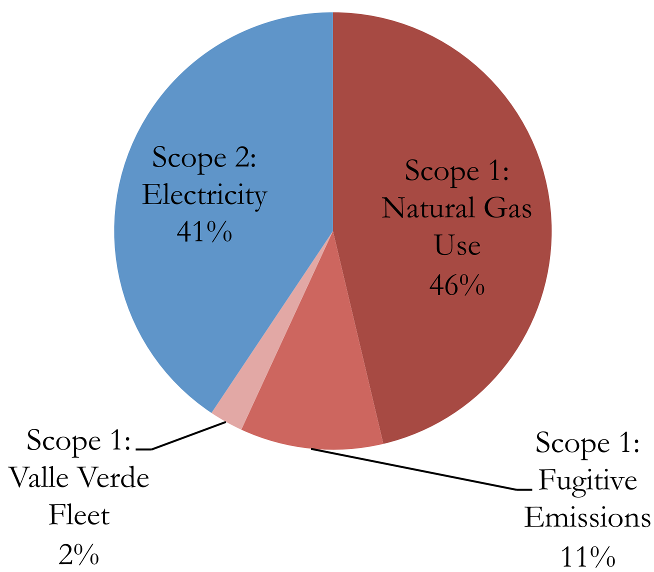

Figure 2-2: Valle Verde's Scopes 1 & 2 GHG Inventory, FY 09–10

To have a better understanding of the magnitude and scale of Valle Verde's emissions we compared Valle Verde's per capita emissions to California's per capita emissions (Figure 2-3). Valle Verde generated approximately half the per capita emissions of California over the course of one year. It is important to acknowledge that Valle Verde's emissions are based on the inventory that was conducted for FY 09–10, while California's inventory is from 2008—the most recent inventory available. Nonetheless, the comparison provides Valle Verde with some indication of where its emissions stand in the context of another population.

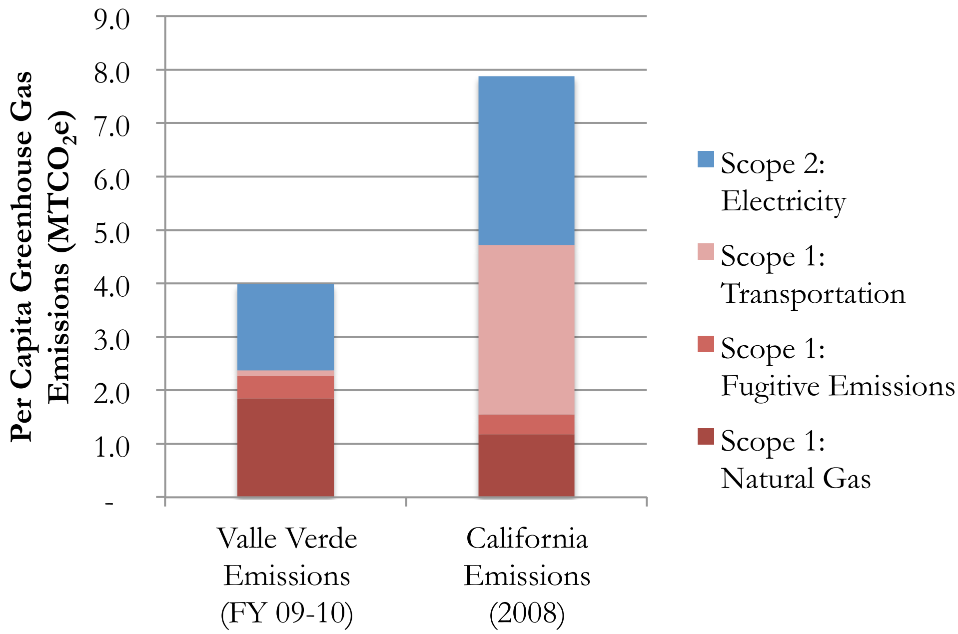

Figure 2-3: Valle Verde and California Scopes 1 & 2 Emissions Per Capita

Valle Verde is below California's per capita emissions generation for Scopes 1 and 2 emissions, which is all that is relevant for our study of carbon neutrality. There are two categories that warrant increased attention: natural gas use and transportation. Valle Verde has a higher consumption of natural gas per capita than California, which may be attributed to residents' needs to keep apartments warmer than average Californians. According to the U.S. Department of Health and Human Services, the elderly are at risk of hypothermia when indoor thermostats run lower than 65ºF,[34] and average temperatures in Santa Barbara hover around 61ºF.[35] As a result, it is likely that residents turn up the thermostats in individual apartments to maintain an appropriate temperature setting. Also, residents may ask that thermostat temperatures in common spaces be set higher to maintain consistent comfort as well. In addition to heating apartments, Valle Verde uses natural gas to heat water in all apartments and facilities on campus. With 214 apartments and additional use for hot water in the main kitchens, laundries, gymnasium, and other facilities, it is likely that Valle Verde has high natural gas use for heating water.

Valle Verde also has significantly lower emissions associated with transportation when compared to California. Valle Verde's fleet is a small contributor to overall emissions, since the company only owns a few vehicles, while the Scope 1 transportation emissions for California includes the millions of vehicles operated within the State's boundaries (note that California's transportation emissions are from passenger and light-duty truck vehicles—those most comparable to the Valle Verde fleet).

It is also important to understand how much Valle Verde's emissions fall under Scopes 1 and 2 in the context of its total emissions. Valle Verde's comprehensive inventory emissions totaled 4,361 $MTCO_2e$ during FY09–10 (Table 2-3), the same amount generated annually by 834 passenger vehicles.[33] Figure 2-4 demonstrates how Scopes 1 and 2 compare to Scope 3 emissions.

Table 2-3: Valle Verde's Comprehensive GHG Emissions Inventory, FY 09–10

Scope	Total Annual Emissions (kg CO_2e)	Total Annual Emissions ($MTCO_2e$)	Percent of Total
Scope 1 (Natural Gas Use)	692,000	692	16%
Scope 1 (Fugitive Emissions)	158,000	158	4%
Scope 1 (Valle Verde Fleet)	37,000	37	1%
Scope 2 (Electricity)	607,000	607	14%
Scope 3 (Employee Transportation)	880,000	880	20%
Scope 3 (Food)	1,330,000	1,330	31%
Scope 3 (Natural Gas Transmission)	365,000	365	8%
Scope 3 (Waste)	124,000	124	3%
Scope 3 (Water)	168,000	168	4%
TOTAL	**4,361,000**	**4,361**	**100%**

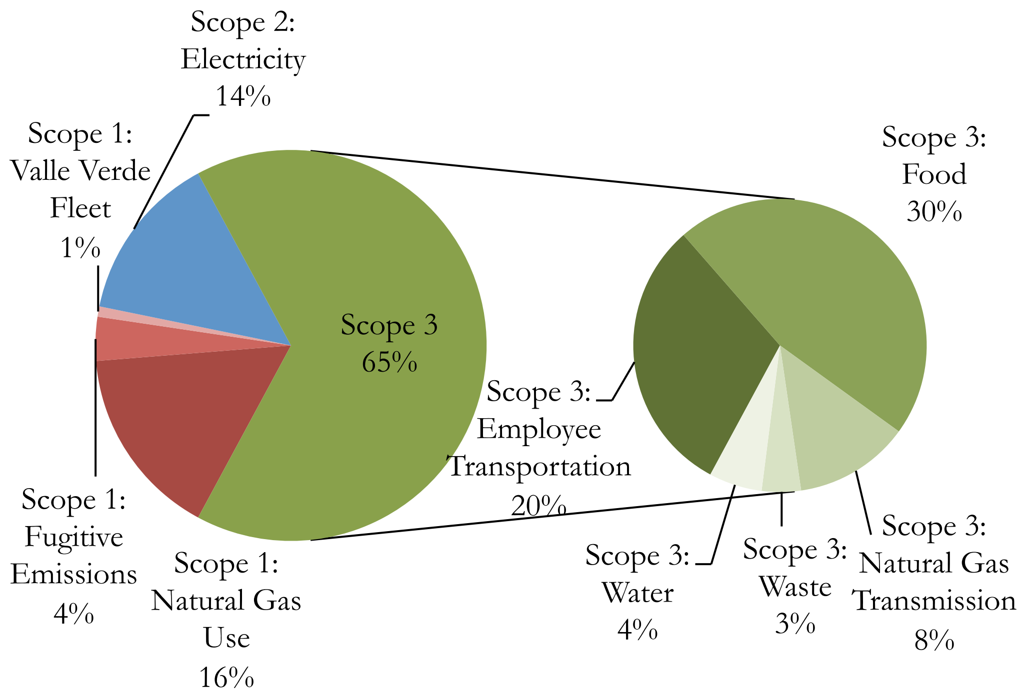

Figure 2-4: Valle Verde's Comprehensive GHG Emissions Inventory, FY 09–10

It is clear that Valle Verde's Scope 3 emissions are significantly larger than Scopes 1 and 2 combined (Figure 2-4). It is likely that much of Valle Verde's emissions are from food purchasing, but it is also possible that CEDA approximations of food purchasing emissions are overestimated due to the complexity of food-miles traveled, farming/growing practices, local food prices, and insufficient data for an entire year. Therefore, Scope 3 may not be an entirely reliable estimate of campus emissions. Furthermore, reducing Scope 3 emissions might constrain resident preferences—types of food consumed, resident miles driven, etc.—and are not within Valle Verde management's realm of emissions reduction strategies. Scope 3 emissions are therefore not included in our inventory used to achieve carbon neutrality. Still, the comprehensive inventory provides a bigger picture of Valle Verde's emissions and informs management of the significant sources of emissions on campus.

2.6. Sensitivity and Uncertainty Analysis

The Scopes 1 and 2 Inventory was the most sensitive to the price of natural gas, amount of electricity used, and per capita fugitive emissions (Table 2-4). The Comprehensive Inventory was the most sensitive to the price of natural gas, amount of gallons of gasoline consumed by employees traveling to work, and food costs (Table 2-5).

Table 2-4: Scopes 1 & 2 Inventory Sensitivity Analysis

Emission Source	Scope	Assumption/ Input Changed	Amount Changed	Impact on Scopes 1 & 2 Inventory
Natural Gas	1	monthly price of gas	-10.00%	5.14%
			10.00%	-4.21%
Fugitive Emissions	1	per capita emissions for VV	-10.00%	-1.06%
			10.00%	1.06%
Electricity	2	monthly kWh consumed	-10.00%	-4.06%
			10.00%	4.06%

Table 2-5: Comprehensive Inventory Sensitivity Analysis

Emission Source	Scope	Assumption/ Input Changed	Amount Changed	Impact on Comprehensive Inventory
Natural Gas	1	monthly price of gas	-10.00%	1.76%
			10.00%	-1.44%
Employee Transit	3	annual gallons consumed	-10.00%	-2.01%
			10.00%	2.01%
Food	3	annual expenditure on all food categories	-10.00%	-3.05%
			10.00%	3.05%

The sensitivity and uncertainty analysis identifies the inputs and assumptions that, if inaccurate, would cause the most variation in our GHG inventories' results. It is recommended that these data be refined in order to improve the accuracy of future inventories. A complete table of our sensitivity and uncertainty can be found in Appendix IV.

In addition to highlighting data that should be better refined for future inventories, the sensitivity and uncertainty analysis also identified a reasonable range of emissions. After altering assumptions and inputs as described above, we created worst- and best-case scenarios. To approximate the best-case scenario, we summed up the difference between the emission source values calculated in our original inventories, and the assumption and input changes that if true would have caused our inventory to be smaller. We did the same procedure for assumptions and inputs that would have increased the emissions of our inventory if they were true to estimate the worst-case scenario. Given our assumptions and uncertainties it is possible that Scopes 1 and 2 emissions range from 1,351–1,653 $MTCO_2e$ (Figure 2-5), whereas our best estimate of Valle Verde's GHG emissions for FY09–10 from Scopes 1 and 2 sources is 1,494 $MTCO_2e$.

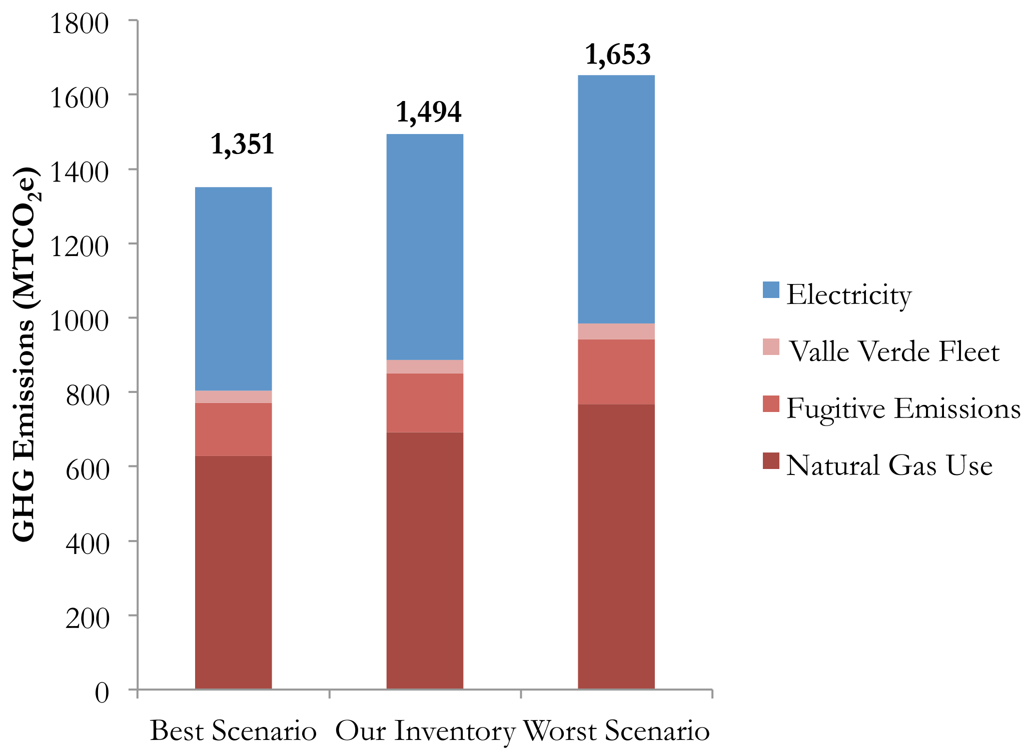

Figure 2-5: Scopes 1 & 2 Uncertainty Analysis

Incorporating our assumptions and uncertainities into the Comprehensive Inventory (includes Scope 3) provided us with a plausible range for emisions of 3,929–4,814 $MTCO_2e$ (Figure 2-6), relative to the best approximation for all of Valle Verde's GHG emissions is 4,361 $MTCO_2e$.

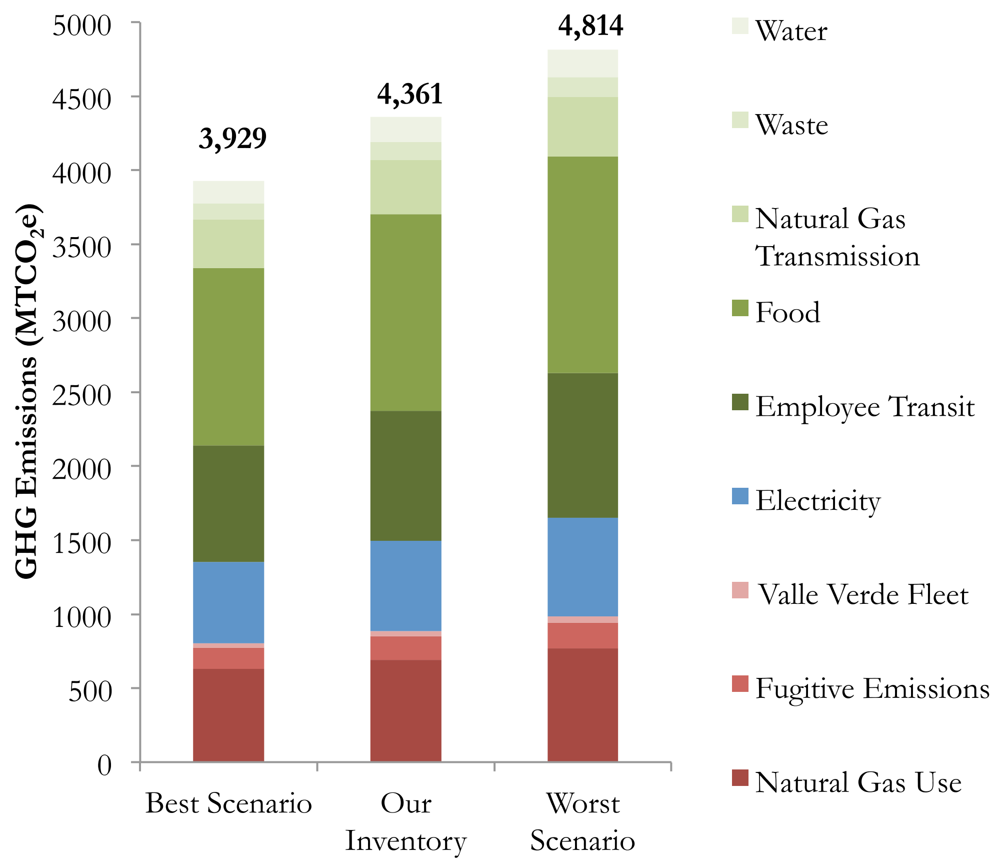

Figure 2-6: Scopes 1–3 Uncertainty Analysis

3. Valle Verde's Green Initiative

3.1. General Description

Over the last six years Valle Verde has implemented a campus-wide Green Initiative to improve the environment by reducing consumption, waste, and dependence on fossil fuels. As it has expanded over the years, the Green Initiative has reduced operating costs and improved the quality of life of both residents and staff members on campus. Originally started by community members, Valle Verde residents and non-profit executives, the Green Initiative has received numerous awards, including:

- California Waste Reduction Award: 2007, 2008, and 2009
- City of Santa Barbara Solar Energy System Recognition Award and Certificate: 2007 and 2009
- AAHSA Leading-Edge Care and Services Award: 2008
- Central Coast Magazine Green Award Nominee: 2008
- Santa Barbara Green Award: 2007

The Valle Verde Green Initiative is built around six specific operational areas that typically have large and direct impacts on the environment: Energy, Green Building, Transportation, Food, Recycling, and Landscaping. Each of these programs is comprised of various strategies that help reduce consumption and increase efficiency. In this chapter we estimate the GHG emissions reductions already achieved by Valle Verde's Green Initiative programs and identify the remaining capacity for these programs to be expanded or improved to further decrease GHG emissions in the future. In order to make these estimates we applied the same methodology used to create our GHG inventories and relied on many assumptions and used several formulas, which are described in greater detail in Appendix V. We acknowledge that these programs have other important environmental benefits (e.g., water conservation) beyond climate change, but we do not attempt to quantify or describe these benefits here.

3.1.1. Energy

Valle Verde has employed several methods to reduce its energy consumption while improving the company's bottom line, including the use of energy efficient light bulbs, Energy Star appliances, and solar power generation. Currently, 64% of the light bulbs on campus are light-emitting diodes (LEDs), and the remaining 36% are a combination of compact fluorescents (CFLs) and incandescent bulbs to be replaced in the coming years. Valle Verde uses Energy Star appliances and has replaced some of their old boilers with newer, 95% efficient models. The organization has installed solar panels on covered walkways, and a solar water heating system for the swimming pool. They have also installed flash and solar hot water heaters in the residence units to reduce natural gas consumption for heating purposes. In sum, these renovations yielded an estimated utility cost savings of $210,620 for the campus in 2009.[17]

Solar Panels

PVs generate electricity directly from the sun and can be used to reduce electricity consumption from the grid. There are several different kinds of PV cells, including crystalline silicon and thin film cells, each offering a different level of conversion efficiency. Currently, 90% of the demand for PV cells is for the more efficient crystalline silicon cells.[36] Their average efficiency is approximately 15–16%, but cells with efficiencies as high as 22–23% are currently available.

Valle Verde has installed solar panels incrementally throughout the campus since 2006. They began with 52 Mitsubishi panels rated at 170 watts, and then added 104 Sharp panels with similar wattage. In 2009, they added another 102 SunPower panels, each rated at 230 watts. The campus currently has 258 panels, which are collectively able to generate a maximum of 49,884 watts.

In order to evaluate the impact of the solar panels, we used the avoided burden approach. Essentially, the amount of energy generated by the panels would otherwise have to be generated at the power plant; therefore, using the panels prevents the generation of that much conventional, carbon-intensive energy. Following this logic, we had to estimate the actual energy generated by solar panels on an annual basis, and to do this we made several assumptions. Based on generally accepted principles, we assumed that over the course of a full year a typical solar PV system produces energy for 5 hours per day in Southern California.[37] This accounts for seasonal variations as well as shading losses. We reduced the number of panels by 20% because the geometric layout of the available space will most likely limit the potential to arrange the system in the most optimal way. We also assumed that the energy production of the panels is 95% of the manufacturer's rating, and that 10% of this energy is lost due to wiring and transmission inefficiencies. Finally, inverter efficiency is typically 90%. Total efficiency therefore amounts to: 95% x 90% x 90% = 76.95%.[37]

Given this, the maximum power generated by the entire solar PV system is 38,386 watts. Taking into account the number of hours of production per day, the PV system yields 190 kWh per day. This results in a total of **70,000 kWh per year**.

We then used the EPA's eGrid sub-region WECC California to calculate the total emissions that would result from the production of 70,000 kWh, or 70 mega-watt hours (MWH), of electricity at a power plant[30] (Table 3-1).

Table 3-1: Annual Savings due to Solar Panel Energy

Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
70	23	1.5%	0.5%

Efficient Lighting

Average households dedicate roughly 10% of their energy budgets to lighting, and new technologies can reduce energy consumption for lighting needs by 50–75%.[38] Designing for natural light can substantially reduce the need for artificial lighting during daytime hours. Using high-efficiency light bulbs, such as CFLs, last 6 to 12 times longer than incandescent bulbs.[38] Beyond CFLs, new innovations in solid-state lighting are making the widespread adoption of LEDs more realistic in the near term.[39] LEDs provide greater brightness and color quality, a longer life of up to 25,000 hours, and they do not draw power when in the off state.[40] CFLs and LEDs also generate less heat, which provides the indirect benefit of reducing cooling demand. Outdoor lighting also consumes a large portion of electricity, and should be designed to both require less energy and reduce light pollution.

Over the last several years, Valle Verde maintenance staff have installed CFL and LED lighting in many of Valle Verde's apartments. As of September 2010, approximately 80% of all apartments have been remodeled using LED/CFL lighting. Of this 80%, LEDs are used in 80% of the remodeled apartments, while CFLs are using in the remaining 20%. At the same time, maintenance began switching fluorescents from T-12 to more efficient T-8 bulbs. The resulting savings of electricity (and therefore emissions) is very significant, indicating that the switch from incandescent and T-12 to LED, CFL, and T-8 lighting was effective at enhancing energy efficiency.

Given that the rate of installation for light bulbs is unknown, we have estimated the savings that Valle Verde has had for 1 year (comparing 2006 equipment to 2010 equipment). Based on savings calculations, Valle Verde has likely saved between **338–507 MWh** of electricity per year for the entire facility, amounting to **112–167 MTCO$_2$e** in GHG emissions saved (Table 3-2).

It is not surprising that Valle Verde has generated significant energy and emissions savings due to lighting efficiencies. Incandescent light bulbs are particularly inefficient; the amount of lumens per watt of energy expended is fairly low (10–17 lumens per watt). In addition, though not emissions related, incandescent bulbs have short average operating lives, meaning that bulbs must be changed every 750–2,500 hours.[41] On the other hand, CFL and LED bulbs are more energy efficient (50–70 lumens per watt and 27–92 lumens per watt, respectively), and have considerably longer lifetimes (10,000–50,000 hours)—not to mention that CFLs and LEDs use significantly less watts.[42] As a result, Valle Verde saves a substantial amount of electricity.

Table 3-2: Annual Savings due to CFL and LED Lighting

Electricity Savings (MWh)	GHG Emissions Savings (MTCO$_2$e)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
338–507	112–167	7.5–11.2%	2.6–3.8%

ENERGY STAR Appliances

ENERGY STAR is a joint program of EPA and Department of Energy (DOE) that allows Americans to save money and reduce energy consumption through the use of energy efficient household items.[43] In 2009, the program helped reduce domestic GHG emissions equal to those from thirty million cars, and saved over $17 billion in utility charges.[43] ENERGY STAR products include many appliances, electronics, heating and cooling systems, and light fixtures and bulbs. The use of any combination of products that display the ENERGY STAR label can dramatically reduce energy consumption, and the U.S. government recently announced that it is increasing energy efficiency standards under the ENERGY STAR program. Furthermore, utility companies offer rebates for the purchase of ENERGY STAR-approved products[44] as well as for old appliances that are retired.

Like efficient lighting, ENERGY STAR products can help reduce electricity consumption. With the help of Valle Verde maintenance staff, we accumulated an inventory of most major appliances—refrigerators, dishwashers, washer/dryers, stovetops, and microwaves—that would be installed in apartments currently being remodeled. Using model numbers, we were able to determine how many appliances are ENERGY STAR labeled, and of those that are, how much electricity those appliances have saved compared to an equivalent non-ENERGY STAR model. The three main appliances that we evaluated were refrigerators, dishwashers, and washer/dryers (as microwaves and stovetops are not labeled as ENERGY STAR products). We did not assess the main laundry and kitchen facilities due to incomplete model information.

Of all purchased appliances, none of the refrigerators or washer/dryers (and only one of two dishwashers) is considered ENERGY STAR. As a result, the only appliance that could be evaluated for savings was the one style of dishwasher being purchased that is ENERGY STAR qualified. Assuming all apartments have the new dishwasher installed and using DOE estimated energy use for that dishwasher, Valle Verde annually saves approximately **7 MWh** of electricity and **2 $MTCO_2e$** of GHG emissions.

The savings estimated for the use of the new ENERGY STAR dishwasher model is primarily based on the assumption that Valle Verde replaced the non-ENERGY STAR dishwashers in all 202 apartments with the ENERGY STAR dishwasher. This is unlikely given that appliances are changed out every ten years during a remodel (and in some cases even less frequently based on the occupant).

Valle Verde also purchases commercial ENERGY STAR products for the main facility's kitchen. Based on the provided brand and equipment types, we made the assumption that (using EPA ENERGY STAR product guides) certain pieces of equipment such as the fryer, two refrigerators, and a freezer were in fact ENERGY STAR qualified. Though data limitations prevent us from calculating a more reasonable estimation of GHG savings, we used the EPA's Savings Calculator for ENERGY STAR Qualified Commercial Kitchen Equipment. The calculator was developed to estimate energy consumption of commercial kitchen equipment and savings achieved with ENERGY STAR appliances.[45] Within the calculator several assumptions were made, such as power source (natural gas vs. electric), size of the equipment, and lifetime of equipment.

Using the EPA calculator, it is estimated that commercial ENERGY STAR appliances lower Valle Verde's energy use by **1 MWh and 65 MMBTU** annually, while reducing GHG emissions by **4 $MTCO_2e$** per year (Table 3-3).

Table 3-3: Annual Savings from ENERGY STAR Commercial Appliances

Current ENERGY STAR Equipment	Electricity Savings (MWh)	Natural Gas Savings (MMBTU)	GHG Emissions Savings ($MTCO_2e$)
Deep fryer	-	50	3
Refrigerators	1	-	0.4
Griddle	-	15	0.8
TOTAL	**1**	**65**	**4**

As observed, Valle Verde's procurement of ENERGY STAR appliances for both the residential living spaces and commercial spaces has feasibly reduced Valle Verde's energy consumption by **8 MWh and 65 MMBTU**, while decreasing GHG emissions by **6 $MTCO_2e$** (Table 3-4).

Table 3-4: Annual Savings due to all ENERGY STAR Appliances

Current ENERGY STAR Equip-ment	Electricity Savings (MWh)	Natural Gas Savings (MMBTU)	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Compre-hensive Inventory
Residential	7	-	2	0.1%	0.0%
Commer-cial	1	65	4	0.3%	0.1%
TOTAL	**8**	**65**	**6**	**0.4%**	**0.1%**

Replacing Old Campus Boilers

Today, furnaces and boilers can be as highly energy efficient as 95–100%.[38] When compared to older models with efficiencies between 68–72%, upgrading to new heating systems can decrease energy consumption substantially.[38] Retrofitting old furnaces and boilers is also an option, but the costs of such upgrades should be compared to the cost of purchasing a new, high efficiency furnace or boiler.[38]

Valle Verde installed its original boilers in 1965. These boilers were 45% efficient. In its quest to increase efficiency, the organization has replaced 26 of those 29 boilers with new Munchkin boilers, which are 95% efficient. These boilers qualify under the ENERGY STAR program, which requires boilers to have annual fuel utilization efficiency (AFUE) ratings of 85% or greater.[46] Given the lack of data regarding the old boilers, it is difficult to draw comparisons; however, we were able to do a basic analysis using the ENERGY STAR Savings Calculator.[46]

The ENERGY STAR Savings Calculator for boilers provides a means to compare boilers with different energy efficiencies. In order to use it, we needed to include several factors, including the area serviced by each boiler, the type of fuel, geographic location, and the time period in which the campus was built.

Since we did not have exact figures for the total area of all buildings, resident and other, we assumed that the area of all resident units (200,772 ft^2) accounted for 80% of the total area, with the Health Center, Quail Lodge, and administrative buildings accounting for the other 20%. We then split the total area of all buildings on campus, which was 250,965 ft^2, equally among the 29 boilers. This resulted in service area of 8,654 ft^2 per boiler.

We input this information into the calculator, along with natural gas as the type of fuel, Santa Barbara, California as the location, and 1960–1969 as the time period in which the campus was built. The calculator then provided us with the annual energy consumption by the old, 45% efficient boilers and the new, 95% efficient boilers. From this we were able to derive energy consumption before and after the upgrades (Table 3-5).

Table 3-5: Breakdown of Boilers and Annual Energy Use

Boiler Type	Natural Gas Use (MMBTU)	Quantity Before Upgrade	Quantity After Upgrade	Natural Gas Use Before Upgrade (MMBTU)	Natural Gas Use After Upgrade (MMBTU)
Old (45%)	240	29	3	6,971	721
New (95%)	82	0	26	0.00	2,143
TOTAL	**-**	**-**	**29**	**6,971**	**2,864**

Using the before and after figures for energy consumption, we calculated annual energy and GHG emissions savings of **4,107 MMBTU and 218 $MTCO_2e$** (Table 3-6).

Table 3-6: Annual Savings due to Boiler Upgrades

Natural Gas Savings (MMBTU)	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
4,107	218	14.6%	5%

Hot Water Systems

Water heating can account for 14–25% of energy consumed in a home.[38] Water heating systems are chosen based on fuel type, size, efficiency, and cost. In terms of energy use, solar water heaters and demand (tankless) water heaters are the most efficient. Swimming pool heating systems are extremely energy intensive, and installing a high-efficiency solar pool heater can make a significant difference.[38] Simple solutions such as using a pool cover, managing water temperature, and installing a more efficient pump can also be employed.

According to the DOE, water heaters have significant heat losses when not properly insulated (at least R-24), so it is recommended to install water heater blankets on water heaters.[47] Insulating water heater tanks can decrease heat loss 25–40% in some cases (assuming that the currently installed water heater is not already insulated properly).[47] Water heater blankets are typically inexpensive and easy to install, but require professional installation.

Since the inception of the Green Initiative, Valle Verde maintenance has installed solar water collectors and tankless water heaters in 40% of its apartments. Based on the equipment installed in those apartments, the solar water collector system does not require any outside energy to pump or heat water; the water that is heated in the solar collector is stored in a 40-gallon tank. The tankless water heater then draws from the preheated water to instantly heat water to the appropriate water temperature setting and sends it directly to the user.

To estimate Valle Verde's natural gas savings from solar-tankless water heating systems we made several assumptions and used information specific to Santa Barbara regarding the amount of solar energy the City receives. We used an efficiency rating of 0.6 for a natural gas water heater, which accounts for the inefficiency of the water heater's insulation and the amount of thermal energy dissipated. We then estimated the amount of natural gas consumed daily to heat water for one person's use. This amount was multiplied by the number of residents at Valle Verde. From this we were able to estimate the quantity of GHG emissions that resulted from heating water for Valle Verde residents annually. We then approximated the amount of energy from natural gas needed to heat this same amount of water using solar-tankless water heaters.

From these values, we calculated the emissions saved through the installation and use of the solar-tankless system. Using the solar collector and tankless water heater system, approximately **809 MMBTU** have been saved per year, while emissions savings ranged from **43–44 MTCO$_2$e** annually (Table 3-7).

Table 3-7: Annual Savings due to Solar-Tankless Water Heating

Quantity of Water Use Per Capita (Gallons)	Natural Savings (MMBTU)	Emissions Savings (MTCO$_2$e)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
20	809	43	2.9%	1.0%
35	810	44	2.9%	1.0%

Based on all the assumptions necessary to make these calculations, it is possible (and likely) that the amount of energy and emissions varies.

Solar Pool Heating System

Valle Verde has a 5,760 ft^3 swimming pool. Heating a swimming pool requires a very large amount of energy. In an attempt to minimize its energy consumption for pool heating purposes, the organization has installed a solar pool heating system. The system consists of 12 3 x 10 black plastic panels through which the water is pumped and heated by solar energy before being returned to the pool. The facility also uses a 300,000 BTU Laars backup heater, which is powered by natural gas and is 93% efficient.

As in the solar panel evaluation, we quantified the effect of the solar pool heater by using the avoided burden method. The amount of energy generated by the solar pool heater would otherwise have to be produced by combustion of natural gas in the backup heater; therefore, using the pool heater prevents this natural gas use and the associated emissions.

In order to quantify the energy generated by the solar collectors, we considered several factors. Using monthly averages obtained from the NASA Langley Research Center Atmospheric Science Data Center,[48] we derived annual insolation in Santa Barbara, which amounted to **1,814 kWh per square meter**. Given that the total area of the solar collectors is 33.45 m^2, we were able to calculate total energy absorbed by the collectors, which was **60,683 kWh**.

According to DOE, the typical solar factor–a measure of efficiency–of flat panel solar collectors is between 0.50 and 0.75.[49] Being that we did not have a specific solar factor for Valle Verde's solar pool heating system, we assumed it has a solar factor of 0.65. In other words, 65% of the total energy absorbed by the system is transferred to the water. This amounts to **39,444 kWh**.

In order to quantify the GHG emissions resulting from the generation of 39,440 kWh by the backup heater, we converted this figure to **136 MMBTUs**. We then adjusted for the backup heater's efficiency of 93%, and arrived at **145 MMBTU** as the total necessary energy required from the backup heater. We found that Valle Verde's solar pool heating system reduces GHG emissions by 8 $MTCO_2e$ annually (Table 3-8).

Table 3-8: Annual Savings due to Solar Pool Heating

Natural Gas Savings (MMBTU)	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
145	8	0.5%	0.2%

Water Heater Blankets

Valle Verde has installed water heater blankets on approximately 10% of gas water heaters to help reduce heat loss inefficiencies. This amounts to 13 of 128 apartments, while approximately 40% of all apartments have solar collectors and tankless heaters that do not require blankets for insulation.

Like calculations for solar water heaters, many assumptions were made. Using the energy needed to heat up a typical 40-gallon water heater that would satisfy the amount of water a person typically uses in one day (20–35 gallons).[50] These calculations were based on how much water a person typically uses a day, the heat capacity of water, and the typical efficiency of a gas water heater. Emissions were then calculated per capita and finally for Valle Verde's entire facility.

Next, we estimated the increased efficiency of the water heater when adding a blanket around it and looked at two scenarios—an increase of 25% and of 45%.[47]

Originally we assumed that the efficiency of the water heater was due strictly to heat loss, which allows us to attribute all increased efficiency from the blankets to recovered heat loss. The resulting energy factors were then added in to the calculations to estimate the energy required (per capita) to heat water in a normal gas water heater and in a gas water heater wrapped in a blanket (Table 3-9).

Table 3-9: Annual Savings due to Installation of Water Heater Blankets on 13 Heaters

Increased Efficiency with Blanket	Amt of Water Use Per Capita (Gallons)	Natural Gas Savings (MMBTU)	Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Compre-hensive Inventory
25%	20	205	11	0.7%	0.3%
	35	359	19	1.3%	0.4%
40%	20	318	17	1.1%	0.4%
	35	557	30	2.0%	0.7%

Radiant Heat Barriers

Radiant heat barriers help reduce cooling costs through reducing summer heat gain in attics. These barriers consist of highly reflective materials that reflect and re-emit (rather than absorb) radiant heat.[51] Some brands of radiant heat barriers suggest that cooling costs can be reduced up to 17% in hot, sunny climates,[52] while others suggest a more moderate 5–10% reduction in cooling costs.[51] Valle Verde has installed 12 RadiantGUARD aluminum barriers, 2 Hy-Tech ceramic paint barriers, and 3 solid-foam/aluminum backing barriers. Due to data limitations and lack of product specificity, we did not calculate GHG emissions saved as a result of these products. We predict that, given the minimal level of campus saturation and the reduced A/C use needed on campus, the savings are not as significant as other Green Initiative strategies.

3.1.2. Green Building

According to Architecture 2030, commercial and residential buildings account for nearly half of the carbon emissions of the entire U.S.[53] In response, green building strategies have started playing an important role in the reduction of anthropogenic GHG emissions. Green buildings are designed to use less energy and water, and to reduce life-cycle impacts of materials used.[53] Leadership in Energy and Environmental Design (LEED) certification through the U.S. Green Building

Council (USGBC) is the premier certification system in the United States. However, some businesses and organizations might find the process of certification through the USGBC to be strenuous and time consuming; instead, those businesses are using materials and techniques that are often applied when designing a green building.

Valle Verde has adopted the latter strategy for its 65-acre campus, consistently investing in green building improvements when resident turnover occurs. During this time, resident units are retrofitted with advanced energy efficiency technologies, such as low-flow showerheads and toilets, dual pane windows, solar-powered attic vents, water heater blankets, hot water pipe insulation, and radiant heat barriers in attics. Solar tubes and skylights are also installed in each unit to increase natural lighting, minimizing the need for artificial lighting. Other green building strategies, such as zero or low volatile organic compound (VOC) paints, finishes and glues, and recycled carpets, do not directly affect GHG emissions, but they address other environmental concerns, such as indoor air quality.

Dual Paned Windows

Multi-paned windows can significantly reduce the heating and cooling of a structure. Specifically, double pane and triple glazed windows can insulate up to twice as much as single pane windows.[54] According to the CEC, installing double pane windows could have a potential cost savings of $1.6 million in Santa Barbara County for residential buildings.[55]

Valle Verde has replaced 50% of the windows on its campus with dual pane, low-e (low emissivity) windows by Milgard. As mentioned previously, energy efficient windows such as these can have a significant effect on heating and cooling requirements. Their reflective coating can prevent heat from entering in the summer, and the dual panes prevent leakage and allow for better retention of indoor temperature.

Given the lack of information regarding Valle Verde's window model numbers and specifications, we made several assumptions in order to quantify their overall effect. Based on information provided by the organization, we knew that the average U-factor of their dual pane windows was 0.50 and the average solar heat gain coefficient was 0.29. We then looked at Energy Star windows to draw a comparison.

Energy Star windows typically save between 7%–15% of energy consumption,[56] and they must have a U-factor lower than 0.36 and a SHGC less than 0.31 in the

South-Central Zone.[57] Given that Valle Verde's window specifications are slightly less optimal, we concluded that their windows are slightly less efficient than the average Energy Star window. Therefore, Valle Verde's windows fall in the lower end of the Energy Star range, saving 10% of energy consumption.

In 2010, Valle Verde consumed **13,001 MMBTU** of natural gas and **1,840 MWh** of electricity. Since only half of the windows on campus had been replaced, we must consider that energy savings amounted to 5% instead of 10%. This means energy consumption would have been **13,685 MMBTU** and **1,937 MWh**. The resulting annual savings of **684 MMBTU** and **97 MWh** are equivalent to reducing GHG emissions by 68 $MTCO_2e$ (Table 3-10).

Table 3-10: Annual Savings due to Dual-Paned Windows

Natural Gas Savings (MMBTU)	Electricity Savings (MWh)	GHG Emissions Saved ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
684	97	68	4.6%	1.6%

Solar Tubes

In addition to the implementation of CFL/LED lighting, maintenance crews also installed solar tubes in all 214 apartments since 2006. Solar tubes, also known as tubular daylighting devices, collect sunlight from rooftops and transmit the light through diffusers to illuminate indoor spaces.[57] Their refractive light properties allow for maximized luminosity for a given space, thereby reducing the necessity of turning on lights.

Much like the light bulbs, it is unknown what the installation rate of solar tubes was over the last 5 years, so we have estimated the savings that Valle Verde has accrued for 1 year (comparing no solar tubes to all apartments with solar tubes). Two different cases were analyzed: amount of electricity and emissions saved if the lighting fixtures in the apartments used incandescent bulbs (on the low end) and if fixtures used LED bulbs (high end savings). If replacing the energy used by incandescent bulbs, Valle Verde has likely saved **351–527 MWh** of electricity per year for the whole facility, and **116–174 $MTCO_2e$** of GHG emissions (Table 3-11). Replacing the energy used by LED bulbs, Valle Verde has likely saved **109–164 MWh** of electricity per year for the whole facility, and **36–54 $MTCO_2e$** of GHG emissions (Table 3-11).

Table 3-11: Annual Savings due to Solar Tube Installation

Replaced Bulbs with Solar Tube	Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
Incandescent bulbs	352–527	116–174	7.8–11.6%	2.7–4.0%
LED bulbs	109–164	36–54	2.4–3.6%	0.8–1.2%

It is expected that the savings from the installation of solar tubes changing from incandescent bulbs be larger than LED bulbs because LED bulbs are more energy efficient. But in both cases, the energy savings is significant. One shortcoming of using this method of savings, though, is that the solar tubes will only be effective if residents change their light behavior. If residents still turn lights on the same amount of time as they did prior to solar tube installation, no perceived savings will occur.

3.1.3. Transportation

In order to reduce transportation's negative impact on GHG emissions, Valle Verde has become an early adopter of many of the energy efficiency technologies recently introduced by the transportation industry. To reduce emissions resulting from the use of the campus sedan, Valle Verde purchased a relatively efficient 2009 Toyota Camry Hybrid sedan. The company has also supplemented its fleet with 12 electric maintenance carts, two resident around-town shuttles, and a solar powered on-campus shuttle. In addition, Valle Verde offers an alternative transportation program for its employees, successfully lobbied for a Metropolitan Transit District (MTD) bus stop on campus, opts for video conferencing when feasible, and promotes itself as a bicycle-friendly community.

Campus Hybrid Car

In the United States, a typical vehicle releases about 6–9 tons of CO_2 directly into the atmosphere each year.[58] Hybrid and plug-in hybrids can reduce per vehicle emissions by 26–75% compared to less fuel-efficient gasoline vehicles.[59] Aware of the significant GHG reductions that hybrid vehicles provide, Valle Verde purchased a 2009 Toyota Camry Hybrid sedan, with a combined average 34 MPG rating. According to Michael Drummond, Administration Assistant of Campus Activities, the Toyota Hybrid is the first car of choice when automobile transportation is needed, replacing the company owned 2003 Nissan Maxima sedan with a combined average 21 MPG rating. The Toyota Hybrid is used for all long distance travel to further fuel conservation, and averages about 200 miles traveled per month.

To calculate the total environmental benefit of driving a hybrid in place of the conventional Nissan Maxima, it is necessary to multiply the hybrid's miles per month by months per year (200 x 12) to get 2,400 miles driven per year. Dividing the annual miles traveled by the average combined MPG ratings for both vehicles and subtracting the difference gives the number of gallons of gasoline avoided by opting for the Toyota hybrid (71 gallons) over the Nissan Maxima (114 gallons), or **44 gallons of gasoline saved**. Therefore, by using the Toyota hybrid Valle Verde reduces its GHG emissions by **0.4 $MTCO_2e$ annually** (Table 3-12).

Table 3-12: Annual Savings due to Hybrid Car

GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
0.4	0.0%	0.0%

Electric Carts for Staff Use

According to the IPCC, a single gallon of gasoline represents 19.4 pounds of CO_2 emissions.[60] As a way of reducing its reliance on gasoline purchases, Valle Verde owns and operates 12 electric carts used by maintenance departments, including gardeners, Wellness Services, Marketing, and Housekeeping. Each of the electric carts has either a 6 or 12 volt battery, and takes between 3–4 hours to recharge. For each, the meter starts at 20 amps and goes down progressively over the 3–4 hour time period. There is no quick charge for the electric carts.

The cumulative GHG emissions calculation of the 12 electric maintenance carts relies on this equation:

$$volts \times amps \times charge\ hours$$

Twelve carts with an average 9-volt battery use a conservative 20 amps each, and need an average of 3.5 hours per day, every day, to recharge. This amounts to **3 MWh of electricity needed annually to run these electric carts.** The estimated total emissions of the 12 electric vehicles are therefore **1 $MTCO_2e$ per year**. The alternative modes of transportation for the maintenance departments are a 2000 Chevrolet Silverado 1500 truck, with a 17 MPG rating, and a 1992 Nissan truck, with a 22 MPG rating. Assuming that each cart averages 5 miles per week over 52 weeks, and the alternative mode of transportation would be one of the fore mentioned pick-up trucks and using an average of their MPG ratings, the **annual savings of using electric carts instead of the campus's pick-up trucks is 16 $MTCO_2e$** (Table 3-13).

Table 3-13: Annual Savings due to Electric Carts

GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
16	1.1%	0.4%

Solar-Electric On-Campus Shuttle

Since 1990, transportation has been responsible for a 47% net increase in total U.S. GHG emissions, and, as of 2008, accounted for approximately 27% of the country's emissions profile.[61] GHG emissions from transportation have also increased at a faster rate than any other sector, and nearly three quarters of its emissions come from road vehicles.[62] As a result, increasing pressure has been placed on the transportation sector to advanced energy-efficient technologies, such as solar powered vehicles, to replace fossil fuel consumption.[63]

In March 2010, Valle Verde purchased an 11-passenger Deluxe Solar Kudo 6113K-11. This solar-electric shuttle is used 7 days a week to transport residents around campus. It operates on a solar panel producing 60 volts, and is backed-up with batteries with a combined 48 volts. According to the manufacturer's website, the Deluxe Solar Kudo can replace up to 12 gallons of gasoline per day in the winter, and 18 gallons of gasoline per day in the summer.[64]

To calculate the reduction in GHG emissions from using the solar powered on-campus shuttle we assumed it was only charged via its solar panel, and never plugged in to an electrical outlet. According to Michael Drummond, Administration Assistant of Campus Activities, the solar-electric shuttle averages 50 miles per week or 2,600 miles per year. By calculating the GHG emissions for this distance when using the Nissan Maxima we were able to estimate the avoided gasoline, **124 gallons per year**, and emissions from using the solar-electric vehicle, **14 $MTCO_2e$ per year** (Table 3-14).

Table 3-14: Annual Savings due to Solar-Powered On-Campus Shuttle

GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
14	0.9%	0.3%

Despite this result, it is extremely difficult to accurately calculate the environmental benefit of this mode of transportation due to counterfactual speculation of potential alternatives. It is possible that many of the activities utilizing the solar vehicle could be taken care of by walking instead. Considering this is a senior community, however, long distances would most likely require a comparable vehicle, such as one of the company owned electric carts or the Nissan Maxima.

Alternative Transportation Program for Employees

Valle Verde's Scope 3 emissions from transportation are the result of employees commuting to-and-from campus, and their emissions are not included in the Scopes 1 & 2 Inventory used to define carbon neutrality. Nonetheless, reducing employee transportation's impact on Scope 3 emissions requires a broad range of strategies, including increasing vehicle energy efficiency, lowering the carbon content of fuels, and reducing vehicle miles of travel (VMT) through the utilization of walking, biking, and public transportation alternatives.[65] Together these initiatives could reduce overall employee transportation GHG emissions by 5–17% by 2030.[66,67]

Although Valle Verde has no means of lowering the carbon content of fuels for its employees, who emit an average **7 $MTCO_2e$ by driving to-and-from work each year**, the organization offers an alternative transportation program for its employees to reduce VMT by encourage carpooling and bus use. Unfortunately, the emissions savings impact of public transportation is highly dependent on efficiency technology, type of fuel, and, most importantly, the number of passengers per vehicle.[67] Although we know MTD's fleet uses a mix of diesel and diesel-electric hybrid buses, calculating the emissions saving of traveling by bus proved too difficult due to data limitations.

However, commuting by bus in the U.S. is estimated to emit only around 12.1 $MMTCO_2e$ each year, or less than 1% of transportation sector GHG emissions.[67] On average, U.S. buses have about 28% of seats occupied, resulting in 33% lower

GHG emissions per passenger mile than single vehicular travel.[68] At full capacity, the GHG emissions savings rise to 82% for a typical diesel bus. Even with only seven passengers on board, a 40-passenger diesel bus is more efficient than an average single-occupancy vehicle.

To increase vehicle energy efficiency for employee travel, Valle Verde offers short-term loans to help staff buy fuel-efficient vehicles. Management is also looking into purchasing a loaner car for off-campus business trips, and is planning to participate in the Traffic Solutions Commuter Challenge, where employee teams compete against other business by making round-trip commutes by bike instead of by car.[69]

Resident Around-Town Shuttles

Valle Verde is not responsible for the off-campus trips of its community residents, and their emissions have not been inventoried for the purpose of this study. However, Valle Verde has implemented four initiatives directed at reducing resident VMT: 1) establishing a Country Store on campus to reduce off-site travel for everyday products; 2) creating a bicycle-friendly community for residents and employees; 3) lobbying for, and obtaining, a MTD bus stop on campus; and 4) providing resident around-town shuttles. This last initiative has effectively transferred emissions that would otherwise be the responsibility of individuals on to Valle Verde Scope 1 emissions.

Both the 13-passenger 2003 Ford E-350 Super Duty shuttle and the 21-passenger 1998 Ford El Dorado operate on regular unleaded gasoline. The average number of passengers for the Ford E-350 Super Duty is 257 per month, or approximately 10 per day, and the number of miles driven per month is 1,526, or 50 miles per day. The total mileage of the Ford E-350 Super Duty is 121,986, and the El Dorado has been driven a total of 104,332 miles. Assuming that both shuttles have a combined MPG rating of 13, **the cumulative annual GHG emissions of the shuttles is 13 MTCO_2e.** Although this reflects a less than 1% net increase in Valle Verde's comprehensive emissions inventory, overall GHG emissions have been reduced by decreasing resident VMT.

3.1.4. Food

Agricultural activities account for 10–12% of all anthropogenic GHG emissions, and Valle Verde has implemented three programs to reduce GHG emissions associated with food purchasing and resident food consumption.[70] The retirement community hosts a weekly farmers market, supporting locally produced agriculture, and tries to buy fruits and vegetables from local food providers when possible. Both of these strategies are attempting to reduce food miles traveled and therefore the associated GHG emissions with food transportation. Lastly, Valle Verde endeavors to reduce food deliveries to only three times a week from each food provider.

It was not possible to specifically quantify the impact that local food purchases and reduced food deliveries have on Valle Verde's GHG emissions given the scope of our project and time constraints. Particularly, it is difficult to gain information from each food provider and to calculate the associated emissions with Valle Verde's specific food purchases and deliveries. In essence, we would be completing an additional GHG inventory for each of Valle Verde's food suppliers.

Reduced Food Deliveries

Although Valle Verde attempts to decrease GHG emissions from food purchases by receiving three food deliveries per week, Valle Verde may receive up to six shipments per week from their produce suppliers in order to satisfy residents' desire for fresh fruits and vegetables. However, it can be assumed that by reducing food order deliveries, Valle Verde is decreasing GHG emissions associated with the community's food purchases. Unfortunately, it was not possible to calculate these potential benefits due to data and time limitations.

Buying Local

Based on the food purchases we reviewed for 2 weeks, approximately 2% of food purchases were from The Berry Man Inc., a local food vendor that aims to provide customers with fruits and vegetables that are locally sourced (within 75 miles of Santa Barbara County). The Berry Man estimates that roughly 60% of its produce comes from local farms.[71] However, buying local food does not necessarily reduce GHG emissions.

With respect to transportation of food products, research on the benefits of purchasing locally grown foods is inconclusive and the GHGs released during food transportation rely on many factors such as "method of transportation, fuel and loading efficiency of vehicles, and consumer travel."[72] The type of food purchased has a far more significant influence on the amount of associated GHGs emitted. For example, approximately 80% of GHG emissions generated from the food industry are the result of livestock production, including the transportation and production of animal feed.[73]

Farming practices also affect food GHG emissions. A literature review funded by the UN's Food and Agriculture Organization found that food produced organically requires 30 to 50% less energy than conventionally grown food.[74] Conventionally produced food requires energy intensive inputs, such as fertilizers, pesticides, and concentrated animal feeds, ultimately increasing the GHG emissions generated from conventional agriculture compared to organic farming.[74] Additionally, organic farming techniques may also increase the ability for crops, biomass, and soil to sequester more carbon than conventional methods.[74] However, the GHG emission difference between organic and conventional foods may be nonexistent or very small when crops are grown in greenhouses.[74] Unfortunately, there is little information on the GHG emissions generated by organically and conventionally produced food during post-harvest activities, such as packaging, transportation, storage, and reaching the end consumer.[74] This lack of information makes it difficult to determine how these different ways of growing crops impacts GHG emissions generated from food production.

Due to the dynamic system in which food is produced, transported, and prepared for consumption it is challenging to draw generalizations about GHG emissions of different foods. Therefore it was not possible for us to estimate the amount of GHG emissions reduced achieved by Valle Verde's decision to purchase local food.

3.1.5. Recycling

GHGs are emitted from solid waste through both transportation and disposal of waste.[75] In the U.S. solid waste is disposed of through incineration or landfill decomposition, whereby waste decomposes and GHGs, such as methane, are released.[76] In 2006, GHG emissions from solid waste disposal in California totaled 6.31 $MMTCO_2e$, approximately 1.3% of the State's net emissions.[77]

In order to minimize the impact of waste generation, Valle Verde engages in various recycling programs that also reduce the amount of GHGs emitted from waste disposal. The organization recycles office paper and supplies, as well as old paints and solvents. Furthermore, recycling locations on campus provide residents with a convenient way to participate in the recycling program. Computers are donated to a local elementary school, electronic devices are recycled, wood waste is chipped into mulch for landscaping, and food scraps from Valle Verde's dining services are composted through the City of Santa Barbara's commercial compost program. In addition, Valle Verde uses electronic work orders for maintenance and remodels, and keeps electronic medical records. A thrift store on campus also gives residents the opportunity to reuse furniture, clothes, linens, and small appliances that may otherwise be disposed.

Recycling and Composting

To increase waste diversion from landfills, Valle Verde has recycling and composting programs. Valle Verde provides recycling carts in the residents' waste disposal areas to facilitate recycling. Additionally, Valle Verde has four recycling dumpsters located around the campus to use for business operations. In May 2010, Valle Verde joined the City of Santa Barbara's commercial composting program. The campus now has a 2 cubic yard dumpster devoted to collecting kitchen scraps from the dining facility.

The conversion factor for waste emissions provided by CEDA does not distinguish between method of waste disposal and type of waste disposed. However, the type of waste, such as paper or food scraps, influences the amount of GHG emissions associated with its disposal. GHG emissions that result from waste also depend on the method of disposal, such as landfilling, composting, and recycling.

Although we were unable to obtain data on the weight of different materials disposed of, which is necessary to calculate their associated GHG emissions (these coefficients are in GHG emissions per ton of waste), we were able to use a 2008 California Waste Characterization Study and information provided by Valle Verde and Allied Waste to approximate the weight of recyclables, trash, and food scraps discarded.[78]

Valle Verde's trash is disposed of at a landfill that generates energy from landfill gas recovery. This method of landfilling actually results in negative GHG emissions, functioning as a GHG sink, since it prevents landfill gas, which is mostly high GWP methane, from being released into the atmosphere. This methane is captured and then burned to produce electricity, releasing carbon dioxide that has a lower GWP. The same amount of carbon dioxide gas that is emitted from generating energy is the roughly same as the amount of methane that would have been released from the landfill without energy generation.

Methane, however, has a higher GWP than CO_2, so when the methane emissions are multiplied by its larger GWP the result is a greater amount of $MTCO_2e$ released without energy generation. Producing energy from landfill gas also decreases the need to generate energy from a non-renewable source, such as fossil fuel fired power plants.[79] Similarly, recycling results in negative GHG emissions since materials are reused in other products, preventing the harvesting and processing of virgin materials to create these products.[80] Composting also results in negative GHG emissions for food scraps since the composting process does not release methane as food decomposition at a landfill does.[81]

To calculate the benefits of Valle Verde's recycling and composting efforts we used two approaches. The first approach used general conversion factors that anticipate the GHG emission reductions achieved by recycling or composting waste instead of landfilling.[80] These factors are based on national averages.[80] The second method relied on inputting values into EPA's Waste Reduction Model (WARM) calculator, which compares previous disposal methods with current disposal methods.[82]

The WARM calculator allows the user to enter specific information about how and where the waste is disposed of. For example, the calculator allows the input of the distance between the generation site of the waste and the location of landfill, materials recovery facility, and composting facility, in addition to if the landfill generates electricity from landfill gas.[83] Thus, the WARM calculator provides a more complete picture of the GHG emissions associated with Valle Verde's waste disposal. The GHG emission reductions results for FY 09–10 of using both the coefficients and WARM are provided below (Table 3-15). Note that the results are displayed in ranges due to the method used to calculate amount (in weight) of discarded materials.

Table 3-15: Annual Savings due to Composting and Recycling

Previous Disposal Method	Current Disposal Method	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
Average American Landfill	Compost	63–89	N/A†	1.4–2.0%
Average American Landfill	Recycling 59% of recyclable materials	314–543	N/A†	7.2–12.5%
Valle Verde Specific Landfill*	Compost	116–164	N/A†	2.7–3.8%
Valle Verde Specific Landfill*	Recycling 59% of recyclable materials	896–1,545	N/A†	20.5–35.4%

*Used WARM calculator that allows the input of burning landfill gas for energy and the distance traveled from Valle Verde to the Tajiguas landfill, materials recovery facility, and composting facility.
†This strategy does not affect Scopes 1 and 2 emissions and therefore this value is not applicable.

Source Reduction

In addition to waste diversion, Valle Verde also engages in several programs to reduce the purchasing of materials, preventing the generation of waste. This approach is called source reduction. Office paper use has been reduced through various initiatives at Valle Verde, such as using electronic work orders and medical records. By using electronic work orders, Valle Verde saves approximately **0.05 $MTCO_2e$ annually** (Table 3-16). Medical records require more paper than work orders, so creating electronic medical records is expected to decrease annual GHG emissions more than electronic work orders. However, due to data limitations it was not possible to calculate these savings.

Valle Verde reduces the disposal of green waste in the landfill by chipping wood scraps from landscaping operations into mulch. WARM was used to calculate the GHG emission changes that result from the source reduction of wood waste. By not sending wood waste to the landfill, Valle Verde is estimate to **increase its GHG emissions by approximately 2 $MTCO_2e$ annually** (Table 3-16).[83] The capture and burning of landfill gas for energy that occurs at the Tajiguas landfill is responsible for this increase. This perverse incentive to generate more waste if the waste is going to a landfill that generates energy from landfill gas exposes one of the difficulties with carbon accounting. However, this GHG emission estimate does not consider the emissions associated with the manufacturing and transportation of the mulch that Valle Verde would purchase in place of the mulch it chips from the property's wood scraps. Due to data limitations we were not able to calculate these cradle-to-gate emissions.

Table 3-16: Annual Savings due to Source Reduction

Source Reduction Method	GHG Emissions Savings ($MTCO_2e$)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
Electronic Work Orders	0.05	N/A†	0.0%
Waste to Mulch	-2*	N/A†	0.0%

*A negative value represents a net increase in emissions
†This strategy does not affect Scopes 1 and 2 emissions and therefore this value is not applicable.

3.1.6. Landscaping

In order to reduce water waste while saving on water utility bills, Valle Verde has re-landscaped much of its campus with drought-tolerant and native plants. Reclaimed water is used to irrigate the campus landscape using a climate-controlled irrigation system, which operates in the early morning hours to reduce evaporation. Wood waste, including leaves and plant clippings, is used as mulch to increase water retention and divert organic material from landfills. Lawn areas have also been reduced, along with the use of fertilizers.

Reduced fertilizers

In 2007, it is estimated that the production and application of nitrogen fertilizers contributed between 750–1,080 $MMTCO_2e$, or 1–2% of global GHG emissions.[84] In California, N_2O emissions from fertilizer accounted for nearly 16 $MMTCO_2e$, or 2.8% of total GHG emissions in 2004.[85] Fertilizer application is widely associated with an assortment of environmental impacts other than climate change, including the loss of fertile topsoil, eutrophication, desertification, soil acidification, and human health problems.

According to Terry Bentley, Director, Environmental Services, fertilizer use has been reduced at Valle Verde by 80% over the last 5 years. When the Landscaping Initiative was first implemented in 2004, Valle Verde was spending around $1,000 per year (**1.8 MTCO$_2$e**) on fertilizers, and presently only spends $300 annually (**0.5 MTCO$_2$e**). This $700 in reduced fertilizer use results in a **GHG savings of 1 MTCO$_2$e** (Table 3-17).

Table 3-17: Annual Savings due to Reduced Fertilizer Application

GHG Emissions (MTCO$_2$e)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
1	N/A†	0.0%

†This strategy does not affect Scopes 1 and 2 emissions and therefore this value is not applicable.

Reclaimed Water for Landscaping

Pumping water is the single largest use of electricity in California, accounting for over 6.5% of statewide electricity use, exceeding 15,000 gigawatt-hours per year.[86] The State Water Project accounts for 2–3% of state's annual electrical energy use, or about 5 billion kWh per year.[87] Water conservation strategies have important energy saving co-benefits, especially in Southern California where water transport is very energy intensive and expensive to move from distant sources.[88]

In terms of irrigation, decentralized grey water and rainwater systems are often more cost-effective and energy efficient than the use of potable water.[89,90] A conservative estimate of energy savings associated with recycled water is about $270 per acre-foot (AF), and is widely considered among the least energy intensive water supply options.[91] During the 2009–2010 fiscal year, Valle Verde consumed a total of 13767.55 HCF, or 31.6 AF, of reclaimed irrigation water. Based on California Sustainability Alliance's estimate of estimate of energy savings associated with recycled water, this would result in **energy savings of $8,530 and GHG emissions savings of 10 MTCO$_2$e** (Table 3-18).

Table 3-18: Annual Savings due to Use of Reclaimed Water

GHG Emissions (MTCO$_2$e)	GHG Emissions Savings as a Percent of Scopes 1 & 2 Inventory	GHG Emissions Savings as a Percent of Comprehensive Inventory
10	N/A†	0.2%

†This strategy does not affect Scopes 1 and 2 emissions and therefore this value is not applicable.

3.2. Summary of Green Initiative Achievements

Through its various programs under the Green Initiative, it is estimated that Valle Verde saves between 929 and 2,474 $MTCO_2e$ of GHG emissions annually, approximately 21–57% of the community's Comprehensive Inventory (Table 3-19. Specific to Valle Verde's Scopes 1 and 2 emissions, the Green Initiative results in GHG emission savings estimated between 542 and 755 $MTCO_2e$, roughly 36–51% of its Scopes 1and 2 Inventory (Table 3-19).

Table 3-19: GHG Emission Savings Estimates due to Valle Verde's Green Initiative

Green Initiative Program	GHG Savings Estimates ($MTCO_2e$)
Solar Panels	23
Efficient Lighting	112–167
ENERGY STAR Appliances	6
Boiler Replacements	218
Solar-Tankless Water Heaters	43–44
Solar Pool Heating	8
Water Heater Blanket	11–30
Dual Paned Windows	68
Solar Tube Installations	36–174
Campus Hybrid Car	0
Electric Carts	16
Solar-Electric On-Campus Shuttle	14
Resident Around-Town Shuttle	-13
Scopes 1 and 2 Total GHG Savings	**542–755**
GHG Savings as a Percent of Scopes 1 & 2 Inventory	**36%–51%**
Composting Kitchen Scraps	63–164
Recycling	314–1,545
Office Paper Source Reduction	0
Green Waste Source Reduction	-2
Reduced Fertilizer Use	1
Reclaimed Water Use	10
Scopes 1–3 Total GHG Savings	**929–2,474**
GHG Savings as a Percent of Comprehensive Inventory	**21%–57%**

We were unable to estimate the emission reduction achieved we some of the programs implemented under the Green Initiative. These excluded programs include:

- Reduced food deliveries
- Purchasing of locally sourced food
- Use of low flow showerheads and toilets
- Installation of radiant heat barriers
- Insulation of hot water pipes
- Use of recycled materials in buildings
- Installation of solar-powered attic vents
- Use of drought-tolerant landscaping
- Use of climate-controlled irrigation
- Reduction in lawn area
- Use of electronic medical records
- Recycling of electronics
- Recycling of office supplies
- On-campus thrift store (for residents to reuse items within the Valle Verde community)
- Recycling of paints and solvents
- Employee alternative transportation
- Video conferencing
- Short term loans for staff to purchase fuel efficient vehicles
- On-campus convenient store
- Having a MTD bus stop on the campus

The GHG emission savings achieved by all the programs that fall under Valle Verde's Green Initiative is expected to be greater than the estimates provided above.

4. Emissions Projections

To provide Valle Verde with reduction strategies to achieve carbon neutrality by the end of 2020, it was necessary to predict the retirement community's future emissions in the absence of new campus emission reduction strategies. In 2012, Valle Verde will begin construction to expand its campus. It is estimated that by 2020 Valle Verde will house 434 residents, about 60 more people than it housed in 2010. It is not reasonable to assume that GHG emissions per resident will remain the same over this 10-year time period for various reasons. First, California has legislation that will reduce the GHG emissions of people living in the State, such as its Renewables Portfolio Standard and Pavley GHG standards for vehicles. Second, the general trend in California over the last decade is that GHG emissions are decreasing slowly per capita over time.[28,92]

4.1. Methodology to Predict Future Emissions

We lack historical GHG emissions for Valle Verde that are necessary to extrapolate a trend to predict future emissions. Therefore we had to look for a method outside of Valle Verde to project the community's future emissions. We examined two studies that contained historical GHG emissions and predicted GHG emissions. A study carried out by CARB provided historical emissions from 2000–2008[28] and 2020 emissions projections for California.[93]

The second study was produced for the Southern California Association of Governments (SCAG) and contained historical emissions for 2000, 2005, and 2008 and projected emissions for 2010, 2020, and 2035.[94] The SCAG study only inventoried and projected emissions for six counties: Los Angeles, Orange, Riverside, Ventura, San Bernardino, and Imperial.

For both studies we explored scenarios that followed the general trend in net emissions per capita and also combinations of emissions from specific sources per capita. For example, we choose emission sources such as electricity use, residential and commercial natural gas consumption, and ODS substitutes as specific sources of emissions that were closely related to Valle Verde's activities. In the source specific scenarios we excluded emissions from industry (when possible), agriculture, and other emissions sources that did not correspond to Valle Verde's operations. For the CARB study we created a scenario, AB 32, based on historical 2000–2008 GHG emissions data and assumed California would achieve the 2020 emission reductions mandated by AB 32.

We developed six potential per capita emission projection scenarios based on net emissions from each study and three sets of specific source emissions (one from the SCAG study and two from the CARB study). Table 4-1 describes the emission sources included in each these six emission projection scenarios.

Table 4-1: Description of the Emissions Sources Included in the Six Projection Scenarios

Six Emission Projection Scenarios and Emission Sources Included in Each Scenario						
	CA-1*	**CA-2*†**	**CA-3**	**SCAG-1*†**	**SCAG-2**	**AB 32**
AB 32 Emission Reduction Goals Are Achieved						✗
Net Emissions *(all sources and sinks)*			✗		✗	✗
Electricity Consumption	✗	✗		✗		
Commercial Natural Gas Use	✗	✗		✗		
Residential Natural Gas Use	✗	✗		✗		
Industrial Natural Gas Use				✗		
ODS Substitutes	✗	✗		✗		
On-Road Gasoline *(passenger vehicles only)*		✗				
On-Road Gasoline *(all types of vehicles)*				✗		

* For the SCAG study residential, industrial and commercial natural gas use were grouped together and for CARB's study residential and commercial natural gas use were grouped together.

† For the SCAG study emissions from gasoline used by on-road vehicles was not broken down by vehicle class, whereas in the CARB study these emissions were separated by passenger vehicles, light-duty trucks, and heavy-duty trucks.

For each of the six scenarios, we used linear regressions to predict the trend in per capita GHG emissions until 2020. We then used the slope of the regressions to construct per capita emission projections for Valle Verde. Once we obtained these predictions we multiplied the per capita emission projections by the total number of anticipated residents in 2020 to estimate Scopes 1 and 2 projected emissions (Figure 4-1). We decided to use the most conservative projection scenario that we developed to predict Valle Verde's 2020 emissions. This scenario, CA-1, only uses California past and projected emissions per capita for electricity consumption, natural gas use from the residential and commercial sectors, and substitutes for ODSs.

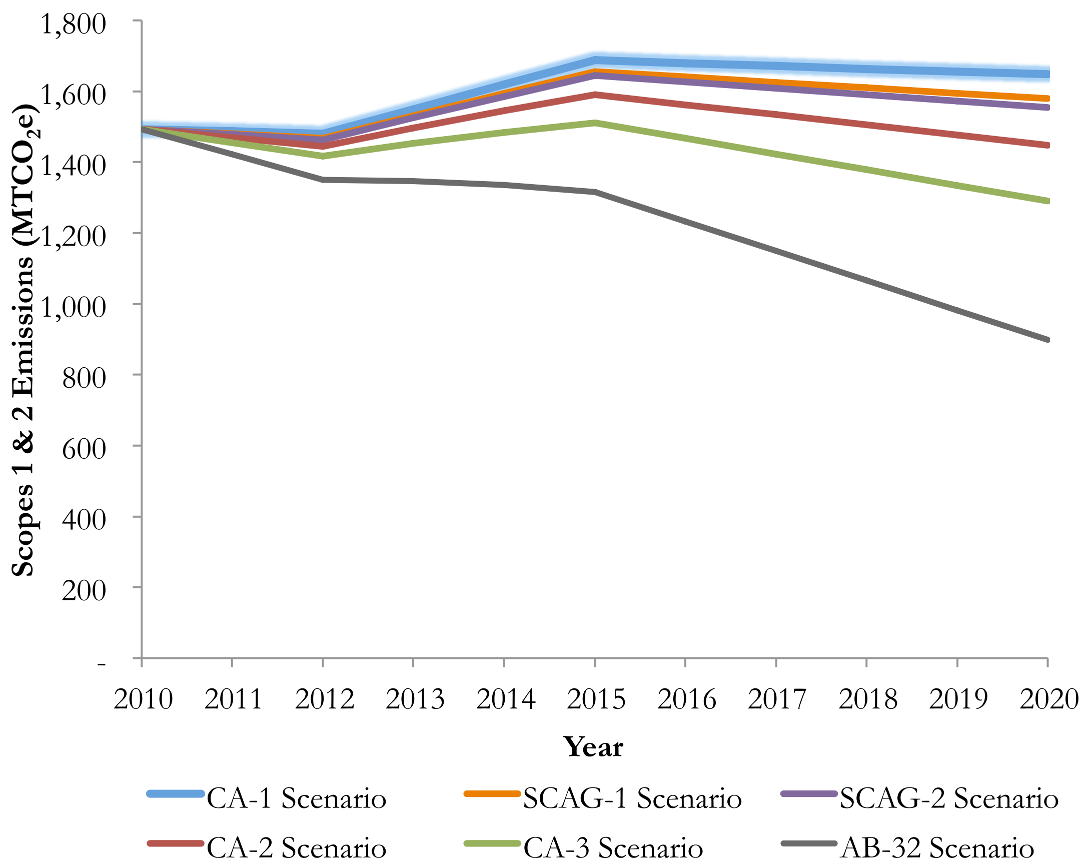

Figure 4-1: Valle Verde's Projected Scopes 1 and 2 Emissions, Five Scenarios

We chose the CA-1 scenario to predict Valle Verde's future emissions for many reasons. The CA-1 scenario predicts the shallowest decline in emissions per capita, providing the most conservative estimate for Valle Verde's 2020 Scopes 1 and 2 emissions. Additionally, this scenario is the best fit to Valle Verde's operations, including emissions from commercial and residential natural gas use, electricity consumption, and substitutes for ODSs. In this scenario, we exclude the transportation emissions generated from gasoline used in passenger vehicles and light duty trucks even though Valle Verde has Scope 1 emissions from motor vehicles. These emissions were omitted because in California they account for a much larger proportion of the State's emissions (roughly 13% of net emissions) than Scope 1 transportation emissions do at Valle Verde, and California's transportation emissions do not approximate the transportation emissions from Valle Verde's fleet.

The AB 32 scenario is the best-case outcome for Valle Verde's 2020 emissions, estimating that the retirement community generates 899 $MTCO_2e$ from Scope 1 and 2 sources. It is important to stress that the AB 32 emissions projection for Valle Verde is very unlikely to occur. For this scenario to occur, California would have to only implement policies that would impact Valle Verde's Scopes 1 and 2 emission sources to achieve the emissions reduction mandated by AB 32. However, it is almost certain that policies executed to achieve AB 32's goal will impact emission sources outside of those sources that contribute to Valle Verde's Scopes 1 and 2 Inventory. For example, policies to reduce emissions from agricultural lands may be used to reach AB 32's emission reduction target, which will not reduce emissions from Valle Verde's Scope 1 and 2 sources.

We did not use projections that resulted from the SCAG study since it failed to incorporate any of the GHG emission mitigation strategies that are being employed by the State to decrease emissions to 1990 levels by 2020. The California study considered the impacts that some of the State's GHG mitigation strategies, such as Executive Order S-21-09 and Pavley 1 GHG Vehicle Standards. EO S-21-09 requires California to obtain 33% of its electricity from renewable sources by 2020[95] and Pavley I GHG Vehicle Standards will decrease GHG emissions from transportation. [96] CARB expects these two standards to reduce the State's GHG emissions by 38 $MMTCO_2e$ in 2020.[97] These anticipated emission reductions will impact Valle Verde's Scopes 1 and 2 emissions in 2020.

The California 2020 projections served as a business-as-usual scenario so that CARB can establish a cap-and-trade market using the difference between these emissions and 1990 levels. The 2020 projection fails to include emission reductions that will be achieved through CARB's AB 32 Scoping Plan, such as energy efficiency and conservation measures,[98] California's cap-and-trade market,[96] and the proposed "refrigerant tracking/reporting/repair deposit program,"[98] all of which will help lower both Valle Verde's and California's Scope 1 and 2 emissions. The exclusion of the impacts of these GHG mitigation programs suggests that our CA-1 scenario is most likely an overestimate of Valle Verde's future emissions.

4.2. Results

Using the CA-1 scenario, Valle Verde's total emissions are predicted to increase from 2012 until 2015 as the campus expands to house more residents. The Scope

1 and 2 emissions will peak in 2015 at 1,687 $MTCO_2e$ and decline to 1,648 $MTCO_2e$ by 2020 (Figure 4-2).

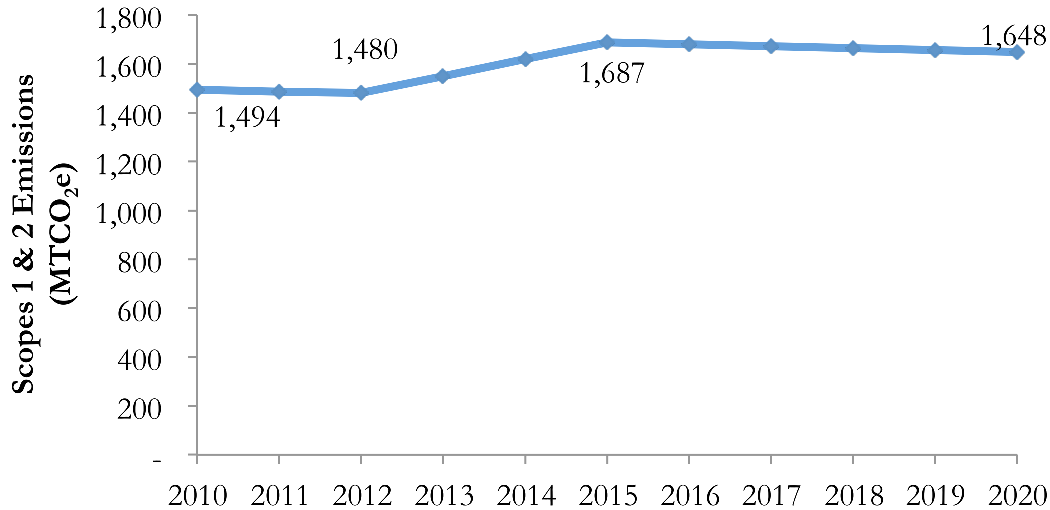

Figure 4-2: Valle Verde's Annual Projected Scopes 1 and 2 Emissions

4.3. Uncertainty Analysis

There are many emission pathways for Valle Verde's 2020 Scopes 1 and 2 inventory, as shown above in Figure 4-1. We use the most conservative estimate for Valle Verde's 2020 Scopes 1 and 2 emissions, 1,648 $MTCO_2e$. However, California's programs aimed at decreasing emissions to 1990 levels by 2020 will impact Valle Verde's future emissions. Therefore our emission estimates reflect an unclear future. To represent this uncertainty we constructed a potential range for these emissions (Figure 4-3). The high-end range is defined by the CA-1 scenario and the bottom range is defined by the AB 32 scenario.

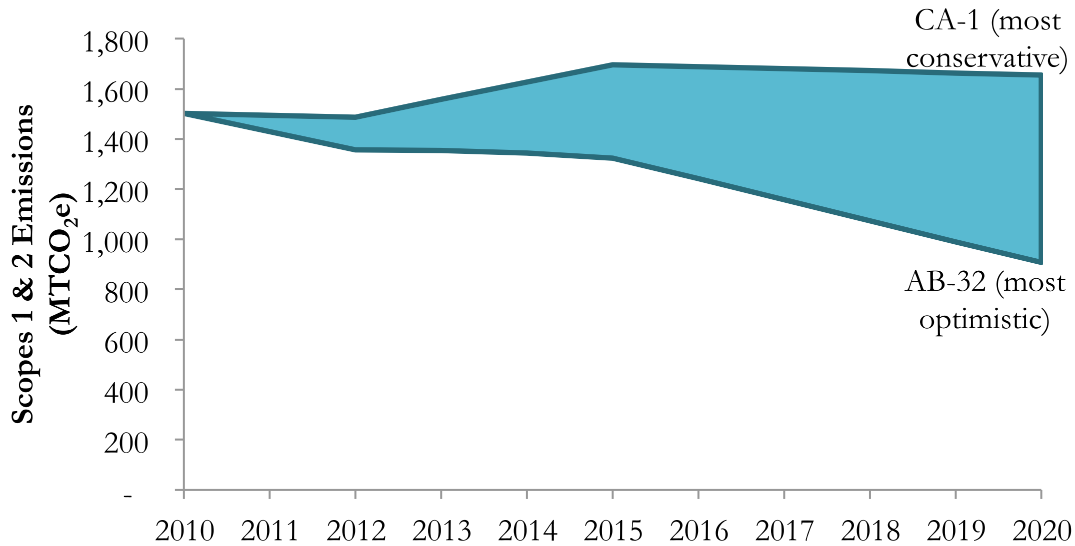

Figure 4-3: Valle Verde Emissions Projection Uncertainty

As described above, there is uncertainty about the amount of GHG emissions that Valle Verde will emit in 2020. The most optimistic projection is the AB 32 scenario, in which California achieves the GHG emission reductions required by current climate change legislation. Under this scenario, Valle Verde would emit approximately 899 $MTCO_2e$ in 2020 from Scopes 1 and 2 sources. The most conservative estimate predicts that Valle Verde's Scopes 1 and 2 emissions in 2020 will be 1,648 $MTCO_2e$. We chose to use the most conservative emission projection. In order for the retirement community to achieve carbon neutrality, we must recommend emission reduction strategies that will decrease Valle Verde's Scopes 1 and 2 emissions by 1,648 $MTCO_2e$ in 2020.

5. Analysis of Reduction Strategies

In order to achieve carbon neutrality, Valle Verde must consider several strategies to reduce their net carbon emissions. A variety of reduction strategies to reduce Scope 1 and 2 emissions were explored based on McKinsey & Company's global GHG abatement curve (Figure 5-1).[99] While the emissions-reduction opportunities and their associated cost and investment needs are presented in a global context, the marginal abatement costs were informative in outlining strategies Valle Verde may pursue at the local level. In addition, our group considered expanding the Green Initiative programs that have a direct effect on reducing Scope 1 and 2 emissions.

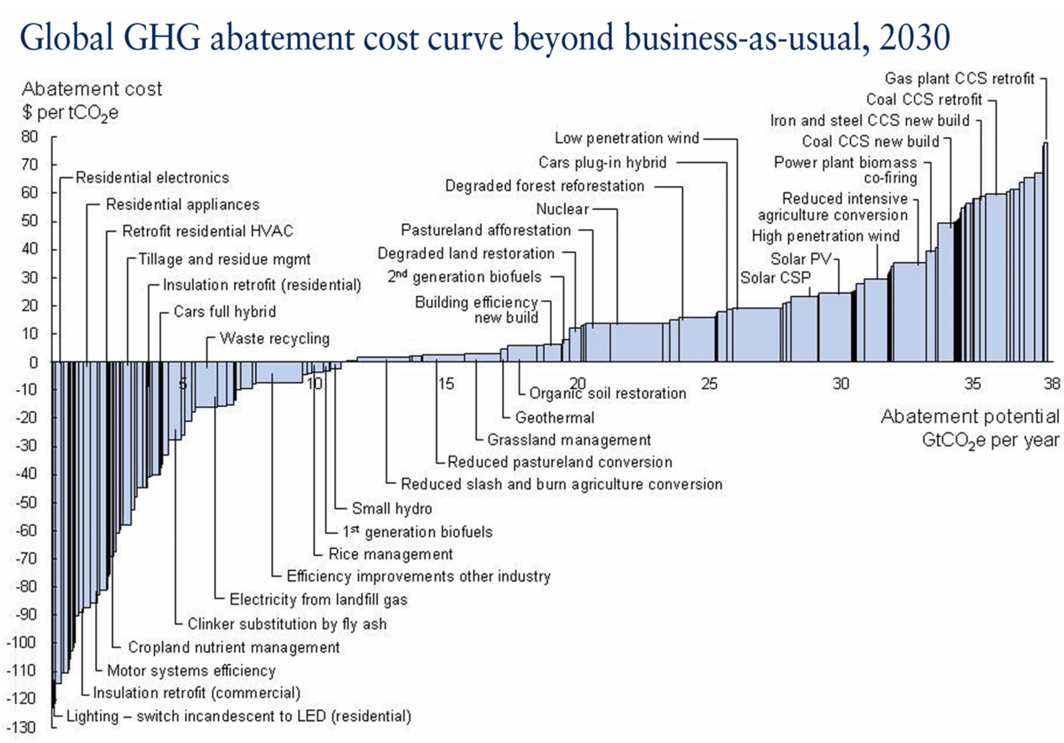

Figure 5-1: McKinsey GHG Abatement Curve[99]

5.1. Criteria for Selecting Strategies

There are numerous strategies that can be implemented to reduce GHG emissions; however, all strategies cannot be uniformly applied to every situation. Whether or not a strategy represents a viable solution depends on a variety of things, including the entity in question; financial, institutional, and physical constraints; the size and scope of the project; and data and time limitations.

Given that Valle Verde had already implemented many green strategies, we considered the potential to expand the community's existing programs as well as proposing new ideas. We researched numerous strategies, and, as we learned more about Valle Verde, we developed an approach to assess the feasibility of each. We based the likelihood of reduction strategies being implemented on the following four factors:

- Given our definition of carbon neutrality, we focused only on measures that would fall under Scopes 1 & 2.
- For existing strategies, we identified the level of campus-wide saturation to assess whether or not there was room for improvement in a given area.
- For all strategies, we evaluated whether or not they would impede on the residents' lifestyle.
- For all strategies, we evaluated their cost-effectiveness.

Keeping these important factors in mind, we conducted detailed analyses of emission reduction strategies that had a strong likelihood of being implemented at Valle Verde. Given Valle Verde stated operational, financial, aesthetic and structural constraints, this project only analyzed reduction strategies that were determined feasible and available for immediate implementation. It is important to note that there are many reduction strategies that do not fit the above criteria, including small scale wind power, geothermal heating systems, fuel cells, and combined heat and power (CHP), among others. While financial, institutional, and operational issues are quite limiting at the present time, these alternative strategies can provide additional emissions reductions in the future.

5.2. Methods for Evaluating Cost-Effectiveness

In order to compare emission reduction strategies in a common metric we developed a framework to evaluate strategies' effectiveness at decreasing Valle Verde's GHG emissions as well as their impact on Valle Verde's finances. This framework relies on calculating the net present value (NPV) and cost-effectiveness, to be defined below, of each strategy. By using these values we are able to convey each strategy's financial implications and contribution to achieving carbon neutrality.

We defined NPV as:

$$NPV_s = Cost_a - Cost_s + \sum_{t=0}^{T} \left(\frac{Payback_s}{(1+r)^t} \right)$$

Where:

- *s* is the emission reduction strategy
- *Cost* is the initial investment cost
- *a* is the business-as-usual (BAU) alternative (in some cases there is no BAU alternative and this term becomes zero)
- *T* is the lifetime of the strategy
- *t* is the year during the lifetime of the strategy after the strategy is implemented
- *Payback* is the annual financial savings that result from implementing the strategy, such as savings on energy bills
- *r* is the discount rate

The following assumptions are made for all strategies:

- The price of electricity is $0.17 per kWh and is constant over time[100]
- The price of natural gas is $11.29 per Million British Thermal Units (MMBTU)[26]
- The discount rate is 7%, the rate suggested by the California Energy Commission for business considering investing in energy efficiency measures[101]
- There are no maintenance costs associated with strategies
- Valle Verde has roughly 10 years to achieve carbon neutrality by the end of 2020

Since Valle Verde has until the end of 2020 to achieve carbon neutrality we assess strategies on a 10-year time frame—approximately the amount of time Valle Verde has to begin implementing strategies after receiving this report. Some strategies, such as installing more energy efficient light bulbs, have a lifetime that is shorter than 10 years. For these strategies, such as LED light bulbs, we approximated the number of times the strategy, light bulbs, would have to be replaced in order to persist for at least 10 years. This approach allows us to calculate the costs and savings of these strategies over a time frame that is a least 10 years long. For strategies that have a lifetime longer than 10 years we assume that Valle Verde would not stop implementing these strategies after achieving carbon neutrality in 2020. Therefore these strategies lifetime extend beyond 10 years.

To include strategies' influence on Valle Verde's annual GHG emissions we created an annual cost-effectiveness equation that incorporated emission reductions with NPV:

$$CE_s = \frac{NPV_s}{GHG_s}$$

Where:

- *CE* is the cost-effectiveness of the strategy
- *s* is the emission reduction strategy
- *NPV* is the net present value of the strategy over its lifetime
- *GHG* is the lifetime amount of GHG emissions saved by the strategy

Using our NPV and cost-effectiveness equations we were able to compare each reduction strategy in order to help provide Valle Verde with possible paths towards carbon neutrality.

5.3. Reduction Strategies

Below we estimate the amount of GHGs that can be abated by expanding current emission reduction strategies and implementing new ones at Valle Verde. In order to calculate these GHG abatement estimates we made several assumptions and used many formulas, which are further detailed in Appendix VI.

5.3.1. Solar Panels

Increasing the production capacity of the solar power system at Valle Verde is a valuable way to reduce energy consumption and the associated GHG emissions. According to Valle Verde management, the community has a significant amount of available space to expand its system. There are three locations on the campus upon which additional solar panels can be installed: the Quail Lodge (10,000 ft^2), the Health Center (9,500 ft^2), and the Main Office (4,500 ft^2). The resulting total available area is 24,000 ft^2.

Valle Verde used SunPower SPR238 solar panels for its most recent installation. Given this, along with the fact that SunPower manufactures the most efficient panels currently available on the market, we assumed that these same panels would be used in any additional installations. Based on panel dimensions, available space, and design losses, which we assumed would be 20%, the total number of watts that may be installed is **341,006 watts**. We then used the same assumptions that we used in the previous solar panel calculation to estimate sun hours and efficiency losses.

Given this, the annual energy generated by the additional solar panels would be **479 MWh per year**. The total GHG emissions that would be avoided annually by installing the solar panels is 158 $MTCO_2e$ (Table 5-1).

Table 5-1: Potential Annual Savings due to Increased Solar Panel Installations

Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)
479	158

Solar panels are generally considered to last for approximately 20 years. Based on this lifespan, and on SunPower's dealer price of **$7.10 per watt installed** of the panels in question, we calculated the NPV and cost-effectiveness of implementing the maximum amount of solar panels.

There are many incentives and rebates at the federal, state, and local level for the installation of solar panels. Unfortunately, given Valle Verde's status as a nonprofit organization, it is not eligible for the majority of them. It is, however, eligible for the California Solar Initiative, which offers Performance-Based Incentives for systems 30 kW and larger, and pays $0.50 per kWh for the first 5 years for government entities and nonprofits.[44] Another option for financing solar power systems is through leasing programs. In this case, an organization can enter into an agreement with a solar leasing program provider or directly with a bank. Under the agreement, the provider or bank will own the solar panels and charge the organization a monthly leasing fee along with reduced electricity fees for the solar power generated.[102] Given the variability of these types of agreements, we did not calculate their associated NPV. Table 5-2 displays the NPV results, with and without incentives from the California Solar Initiative.

Table 5-2: NPV and Cost-Effectiveness of Solar Panels with and without Rebates

Solar Panels	NPV		Cost-Effectiveness ($/$MTCO_2e$)	
	No Rebate	Rebate	No Rebate	Rebate
SunPower SPR238/E19	-$1,000,600	-$18,830	-$320	-$6

5.3.2. LED/CFL Lighting

As discussed in the Green Initiative evaluations, Valle Verde has installed CFL and LED lighting throughout the campus. Given that LEDs are not at full saturation on campus, Valle Verde has the ability to replace the remaining incandescent bulbs with LEDs, and eventually start switching out CFLs for LEDs. The potential emissions savings from changing light bulbs were calculated using the same assumptions and methods as the calculations for evaluating the Green Initiative, though emissions savings were based on replacing all remaining light fixtures with LEDs. The resulting savings can be found in Table 5-3. Note that the range of values was approximated by calculating savings for two different light use durations—10 hours and 15 hours.

Table 5-3: Potential Annual Savings due to Complete LED Replacement

Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)
89–134	29–44

To calculate the cost-effectiveness of installing the remaining LEDs, the annual expenses on electricity were calculated for each type of light bulb (incandescent, CFL, LED) using $0.17 per kWh for the electricity rate (determined to be the most recent price per kWh that Valle Verde paid). We focused on specifically replacing CFL to LED savings, as this would generate a more conservative estimate of savings. We then had to compare the payback per lifetime of the CFL to LED ratio to estimate replacement frequency and annual payback. Based on average market retail pricing, the price per CFL was estimated at $2.53 per bulb, while an equivalent LED was $50. Estimated lifetimes were found to be 15,000 hours per CFL and 25,000 hours per LED. Based on the estimated lifetimes, Valle Verde would need to replace LEDs once from now until 2020. Note that we calculated savings based on 10 hours per day use.

The estimated NPV is negative, at **-$90,720** over the next 10 years to 2020 (Table 5-4). This particular strategy would not break even in terms of cost. Calculated cost-effectiveness would then amount to **-$260 per $MTCO_2e$** (Table 5-4). In this case, Valle Verde would end up spending approximately $17 for every metric ton CO_2e reduction. Part of the reason this value is negative (instead of positive) is that the price of LEDs is significantly higher than CFLs. Once the price drops to $23/LED bulb, the NPV will be positive. In addition, the investment may not appear to be a profitable one because we assumed that we were replacing remaining lights as CFLs, not as incandescents. As a result, the emissions saved would have been much more significant from incandescent to LED.

Table 5-4: NPV and Cost-Effectiveness of Replacing CFLs with LEDs

NPV	Cost-Effectiveness ($/MTCO$_2$e)
-$90,720	-$31

Because Valle Verde has been in the process of replacing lighting and has seen significant savings through LED and CFL use, we anticipate that the facilities management team will continue to push for full installation of LEDs through 2020.

5.3.3. Residential ENERGY STAR

Based on the inventory of current ENERGY STAR appliances, Valle Verde has significant potential to install new ENERGY STAR appliances, replacing older inefficient models. In particular, all 214 apartments could install new refrigerators, dishwashers (because as of July 1, 2011 the current 24" ENERGY STAR models will no longer satisfy the new ENERGY STAR standard[103]), and washer/dryer units. For some appliances Valle Verde installed two different models, for example a Kenmore 46-62042 and Whirlpool ET0WSRXMQ—both small (9–11 c.f.) refrigerators. In these cases we found replacement units for *each* model of appliance, assuming that a similar ENERGY STAR model would replace the corresponding appliance currently used by Valle Verde.

Like in the Green Initiative section, we first calculated energy savings by comparing an ENERGY STAR equivalent appliance to the currently installed equipment. Emissions were then estimated using the same emissions factors. NPV was calculated for the replacement of all appliances using estimated prices for currently installed and new ENERGY STAR appliances. The initial investment cost difference in replacing a unit with an ENERGY STAR one (rather than going with the current model) was included in the NPV calculation, as was the electricity cost savings that result from switching to ENERGY STAR models. Assumed lifetime of each appliance is ten years.

The EPA, DOE, and utility companies currently offer some incentives to help alleviate up-front costs of ENERGY STAR appliances. Therefore NPV and cost-effectiveness were estimated in two ways: first without any rebates, then with currently available rebates. However, ENERGY STAR rebates are subject to expiration (if not renewed in Congress) or amended to different rebate amounts; as a result, NPV and cost-effectiveness may change in the future.

Replace all Refrigerators

Valle Verde will achieve energy savings by replacing all residential refrigerators throughout the campus. There are four types of refrigerators on campus, each with a different amount of savings (Table 5-5).

Table 5-5: Potential Annual Savings due to Residential ENERGY STAR Refrigerator Replacement

Appliance Size (c.f.)	Number of Units for Replacement	Annual Electricity Savings (MWh)	Annual GHG Emissions Savings ($MTCO_2e$)
10.3	64	3	0.9
9.6	64	5	2
15.6	52	5	2
15	34	3	1
TOTAL	**214**	**16**	**6**

Two different scenarios for NPV and cost-effectiveness have been calculated in Table 5-6 below for all residential refrigerator replacement. The scenarios make a distinction in savings with and without ENERGY STAR rebates.

Table 5-6: NPV and Cost-Effectiveness due for Residential ENERGY STAR Refrigerator Replacement

Appliance Size (c.f.)	Number of Units for Replacement	NPV (Lifetime)		Cost Effectiveness (Lifetime)	
		No Rebates	Rebates	No Rebates	Rebates
10.3	64	-$1,990	$1,210	-$230	$140
9.6	64	-$11,330	-$8,130	-$700	-$500
15.6	52	$5,110	$7,660	$300	$450
15	34	$280	$2,030	$30	$210
TOTAL	**214**	**-$7,930**	**$2,770**	**-$600**	**$300**

In aggregate ENERGY STAR refrigerator replacement without rebates does not result in a positive return on investment, while rebates help lower the initial investment costs to result in a positive return in the long turn.

Replace all Dishwashers

Valle Verde will achieve energy savings by replacing all residential dishwashers throughout the campus. Currently Valle Verde apartments house 12-compact dishwashers and 202-standard dishwashers that meet current ENERGY STAR standards. However, as of July 2011, the compact dishwashers will no longer qualify with the new EPA standard. As a result, we suggest that Valle Verde replace the compact dishwashers with dishwashers that will meet the kWh criteria set forth by the EPA—222 kWh per year.[103] Table 5-7 provides a summary of all potential energy savings.

Table 5-7: Potential Annual Savings due to Residential ENERGY STAR Dishwasher Replacement

Appliance Size	Number of Units for Replacement	Electricity Savings (MWh)	Annual GHG Emissions Savings ($MTCO_2e$)
Compact	12	3	0.8
Standard	202	3	1
TOTAL	**214**	**6**	**2**

Table 5-8 indicates the NPV and cost-effectiveness for the replacement of all dishwashers. The summary includes estimated values with and without potential ENERGY STAR rebates. Whether or not Valle Verde receives rebates for replacing all residential dishwashers, the return on investment will still be significantly positive.

Table 5-8: NPV and Cost-Effectiveness for Residential ENERGY STAR Dishwasher Replacement

Appliance Size	Number of Units for Replacement	NPV (Lifetime)		Cost Effectiveness (Lifetime)	
		No Rebates	Rebates	No Rebates	Rebates
Compact	12	$3,370	$3,730	$300	$330
Standard	202	$15,010	$21,070	$1,810	$2,540
TOTAL	**214**	**$18,380**	**$24,800**	**$2,110**	**$2,870**

Replace all Washer/Dryer Units

Valle Verde has the ability to replace all 214 of its washer/dryer stacked units with an ENERGY STAR equivalent model of the same size. Table 5-9 provides an estimate of potential energy savings due to their replacement.

Table 5-9: Potential Annual Savings due to Residential ENERGY STAR Washer/Dryer Replacement

Appliance Size	Number of Units for Replacement	Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)
24"	43	12	4
27"	171	38	13
TOTAL	**214**	**50**	**17**

It is clear that, compared to residential refrigerators and dishwashers, the washer/dryer ENERGY STAR units may provide a greater GHG emissions savings annually. To understand the financial aspect of this set of ENERGY STAR appliances, we must look at the NPV and cost-effectiveness of the strategy with and without rebates (Table 5-10).

Table 5-10: NPV and Cost-Effectiveness for Residential ENERGY STAR Washer/Dryer Replacement

Appliance Size (c.f.)	Number of Units for Replacement	NPV (Lifetime)		Cost Effectiveness (Lifetime)	
		No Rebates	Rebates	No Rebates	Rebates
24"	43	$16,830	$18,340	$420	$450
27"	171	$16,840	$22,820	$130	$180
TOTAL	**214**	**$33,670**	**$41,160**	**$550**	**$630**

As with dishwasher replacement, washer/dryer replacement will be a positive investment whether or not rebates are available for ENERGY STAR products.

5.3.4. Commercial ENERGY STAR

Like residential appliances, Valle Verde has the opportunity to invest in commercial ENERGY STAR units that would help guide the facility toward carbon neutrality. Given the appliance information provided from Valle Verde facilities we assumed that four types of appliances might be viable for ENERGY STAR replacement: 4 holding ovens, 1 steamer, 1 freezer, and 1 refrigerator.

Though data limitations prevent us from calculating a more reasonable estimation of potential GHG savings, we used the EPA's Savings Calculator for ENERGY STAR Qualified Commercial Kitchen Equipment as described in the Green Initiative Evaluations section of the report. Within the calculator several assumptions were made, such as power source (natural gas vs. electric), size of the equipment, and lifetime of equipment. For these calculations, we assume that the steamer is natural gas-powered, while the other appliances are electricity-powered, and that the lifetime of each appliance is 12 years.

We have summarized the potential savings due to the replacement of all four major kitchen appliances with ENERGY STAR equivalent appliances in Table 5-11.

Table 5-11: Potential Annual Savings due to Commercial ENERGY STAR Kitchen Equipment Replacement

Appliance Type	Number of Units for Replacement	Electricity Savings (MWh)	Natural Gas Savings (MMBTU)	GHG Emissions Savings ($MTCO_2e$)
Holding Ovens	4	37	-	13
Steamer	1	-	107	6
Freezer	1	0.9	-	0.3
Refrigerator	1	0.6	-	0.2
TOTAL	**7**	**39**	**107**	**20**

Currently there are few ENERGY STAR rebates for commercial appliances. Many commercial food service rebates expired at the end of 2010, but may be reinstated for 2011. As a result, calculations for NPV and cost-effectiveness were estimated without rebates (Table 5-12).

Table 5-12: NPV and Cost-Effectiveness for Commercial ENERGY STAR Kitchen Equipment Replacement

Appliance Type	Number of Units for Replacement	NPV (Lifetime)	Cost Effectiveness (Lifetime)
Holding Ovens	4	$20,140	$140
Steamer	1	$8,040	$120
Freezer	1	$790	$230
Refrigerator	1	$670	$280
TOTAL	**7**	**$29,640**	**$770**

As with some of the residential ENERGY STAR appliances, commercial ENERGY STAR appliances can also provide a positive return on investment. It is possible that Valle Verde may have a possibility of more GHG emissions savings and positive ROI if other major commercial appliances (such as laundry equipment) can also be replaced with ENERGY STAR equivalent equipment.

5.3.5. Water Heating Systems

Valle Verde has installed solar hot water collectors and tankless water systems in several apartments throughout the campus, with potential to install the collector-tankless system on an additional 60% of the apartments. The potential emissions savings from adding the water system were calculated using the same assumptions and methods as the calculations for evaluating the Green Initiative (Table 5-13). Note that the range of values was approximated by calculating savings for two different quantities of per capita water use: 20 and 35 gallons (Table 5-13).

Table 5-13: Potential Annual Savings due to Hot Water System Replacement

Quantity of Water Use Per Capita (Gallons)	Potential Energy Savings (MMBTU)	Potential Emissions Savings ($MTCO_2e$)
20	1,214	65
35	1,214	66

To calculate the cost-effectiveness of installing the remaining solar collector-tankless water systems, the annual expenses on natural gas were calculated for a regular natural gas water heater and the solar collector-tankless system using $11.29 per MMBTU for the natural gas rate (determined to be the most recent price per MMBTU that Valle Verde paid). Then we compared payback times for each water heating system—a solar collector-tankless system has an estimated lifetime of 17 years, while a natural gas water heater may have a lifetime of 13 years. Therefore a replacement for the natural gas water heater is needed to match the lifetime of the solar collector-tankless system. Estimated price per natural gas water heater was $330, while the solar collector-tankless system was approximately $5,000, using average market retail pricing and lifetimes through Internet research (note that commercial prices may be significantly less). We calculated savings based on a per capita water use of 20 gallons per day.

The estimated NPV is negative, at **-$488,535.05** over the next 10 years to 2020. This particular strategy would not break even in terms of cost. Calculated cost-effectiveness would then amount to **-450 per $MTCO_2e$** over the strategy's lifetime.

Part of the reason this value is negative is due to the price of solar collector-tankless systems, which is significantly higher than a typical natural gas water heater. Furthermore, an average of lifetimes for the solar collectors and tankless water systems was used. In reality, only one part of the system might need replacing after the approximated lifetime. (i.e., if the tankless system has a longer lifetime than the solar hot water collectors, it may be replaced less frequently). In addition, the quoted retail prices here are only estimates and do not include any sort of rebates that might help subsidize commercial-sized purchases.

5.3.6. Efficient Boilers

As discussed in the boiler initiative evaluation, Valle Verde has replaced 26 of its 29 old boilers with 95% efficient boilers. This reduction strategy involves replacing the remaining three boilers with energy efficient boilers. Using the previous results for energy saved by replacing the 26 boilers, we were able to derive the energy saved per boiler replaced. We then multiplied that number by 3 to account for the three remaining boilers and calculated annual GHG emissions savings of 25 $MTCO_2e$ (Table 5-14).

Table 5-14: Potential Annual Savings due to Efficient Boilers

Number of Boilers to Replace	Natural Gas Savings (MMBTU)	Annual GHG Emissions Savings ($MTCO_2e$)
3	474	25

Table 5-15 displays the NPV and cost-effectiveness of replacing the remaining three boilers with 95% efficient boilers. Rebates were not included in this calculation because the Southern California Gas Company provides rebates based on boiler size, and we were not able to obtain information regarding the size of Valle Verde's boilers.

Table 5-15: NPV and Cost-Effectiveness of Efficient Boilers

Number of Boilers to Replace	NPV	Cost-Effectiveness ($/$MTCO_2e$)
3	$40,170	$80

5.3.7. Radiant Heat Barriers

Radiant heat barriers, as addressed in the Green Initiative section, can provide potential energy savings for Valle Verde. For the Green Initiative calculations we assumed that, given the insufficient data to estimate current savings, Valle Verde has not installed radiant heat barriers. To start with potential electricity savings, we had to predict Valle Verde's electricity consumption out to 2020. To estimate how much electricity is used for air conditioning, we used Santa Barbara air conditioning use as a proxy for Valle Verde's use: approximately 17% of electricity is used cooling.[104] Table 5-16 shows 2020 predicted electricity use in total and due to cooling (air conditioning).

Table 5-16: Predicted Electricity Use in 2020

2020 Predicted Electricity Use (MWh)	2020 Predicted Electricity due to A/C (MWh)
2,029	345

Based on Internet research and market information for radiant heat barriers, it is suggested that cooling costs may be reduced up to 17%, while others suggest a more modest 5–10%. For this exercise, we predicted that radiant heat barriers would reduce electricity by 5%; this estimate was chosen because it is conservative in terms of savings, but may adjust for the fact that Valle Verde has installed some radiant heat barriers, which the resulting savings cannot be quantified. Resulting calculations suggest that Valle Verde will be able to reduce electricity consumption by 17 MWh, and save 6 $MTCO_2e$ in emissions (Table 5-17).

Table 5-17: Potential Annual Savings due to Radiant Heat Barriers

Annual Electricity Savings (MWh)	Annual GHG Emissions Savings ($MTCO_2e$)
17	6

To calculate the NPV and cost-effectiveness of this strategy we assumed that radiant heat barriers cost $80 per 1,000 square feet [105] and that radiant heat barriers would be installed to cover all the square feet of buildings on Valle Verde's 2020 campus. In 2020, the retirement community's built environmental will be approximately 317,741 square feet,[106] so this amount of radiant heat barriers will be installed under this emissions reduction strategy. Radiant heat barriers will save Valle Verde money over their 30-year lifetime (Table 5-18).

Table 5-18: NPV and Cost-Effectiveness of Radiant Heat Barriers

Radiant Heat Barriers Installed (ft^2)	NPV	Cost-Effectiveness ($/$MTCO_2e$)
317,741	$10,970	$60

5.3.8. Attic Insulation

Cooling and heating account for between 50–70% of total residential energy use in the United States, and inadequate insulation is the leading cause of residential energy waste.[107] Using different types of insulation can reduce energy costs, and the EPA suggests that homeowners generally save 20% on heating and cooling costs, or up to 10% in total energy costs, through insulation alone.[108] The amount of savings is dependent on the choice of insulation used, and how properly it was installed. Blanket insulation, in the form of batts or rolls, is the most commonly available insulation product, and is typically made of mineral fibers such as fiberglass or rock wool.[109]

Valle Verde currently uses fiberglass batt insulation, which does very little to resist air movement.[110] Compared to alternatives, such as blown-in loose fill, foamed-in-place polyurethane foam, and rigid insulation, batt insulation conforms least to its surroundings, which leads to lower energy efficiency. Spray and rigid insulations provide for more insulating power, but may contain Hydrochlorofluorocarbons (HCFCs), which have an ozone depleting potential and are a GHG.[111] Cellulose insulation has gained momentum in green building insulation for its high recycled content, but requires professional installation, and, when installed improperly, may prevent the installation of drywall or leave gaps.[110] The most preferred type of insulation by zero-energy home and commercial builders, however, is spray polyurethane foam. Spray foam insulation is typically more expensive than batt insulation, but reduces energy loss from air leaks.[112]

Upgraded attic insulation may provide Valle Verde with additional GHG emissions savings as well. We assume Valle Verde does not have the most energy efficient attic insulation in its facilities, which would imply that Valle Verde can install more energy efficient insulation to achieve higher energy savings. To calculate energy savings from additional attic insulation, we first predicted Valle Verde's 2020 natural gas consumption. We next made the assumption that 40% of natural gas consumption results from space heating.[113] Table 5-19 shows the predicted natural gas use due to space heating in 2020 for Valle Verde.

Table 5-19: Predicted Natural Gas Use in 2020

2020 Predicted Natural Gas Use (MMBTU)	2020 Predicted Natural Gas Use due to Heating (MMBTU)
14,341	5,736

It is estimated that heating costs may be reduced by 20–30% through the installation of proper insulation.[114,108] For the purposes of our exercise, we erred on the conservative side of a 20% reduction in heating costs. This value may still overestimate savings because Valle Verde has been upgrading insulation in apartments as they are remodeled. Resulting calculations suggest that Valle Verde will be able to reduce natural gas heating by **1,147 MMBTU** and save approximately **61 MTCO$_2$e** in emissions (Table 5-20).

Table 5-20: Potential Annual Savings due to Insulation Upgrades

Natural Gas Savings (MMBTU)	GHG Emissions Savings (MTCO$_2$e)
1,147	61

In order to calculate the NPV and cost effectiveness of increasing attic insulation, it is assumed that Valle Verde's residential units have existing attic insulation with a thermal resistance rating of R-19. Both the DOE and EPA recommend attic insulation efficiency of R-30 for Santa Barbara, so Valle Verde would need to add R-11 insulation to the existing R-19 insulation in the attics of each residential unit.[115]

According to David Esquer, Salesperson at Masco Contractor Services of California, the cost of installing unfaced fiberglass batt insulation with an R-11rating is $0.39 per square foot. It is further assumed that attic insulation will only be added to existing residential units, and that the 40 additional units of the expansion will satisfy the current EPA standards for R-30 insulation in Santa Barbara residential attics. Assuming batt insulation will be installed throughout Valle Verde's current 259,305 square feet of residential unit ceiling space, Valle Verde can expect to save a significant amount of money over the 30 year lifetime of the strategy.

Table 5-21: NPV and Cost-Effectiveness of Attic Insulation

NPV	Cost-Effectiveness ($/MTCO$_2$e)
$59,600	$30

5.3.9. Dual Pane Windows

Valle Verde has replaced 50% of the windows in its residences with dual pane, Low-E windows by Milgard. This strategy involves replacing the remaining residence windows and all other windows on campus by 2020 with similar energy efficient windows. This calculation takes into account the expansion on the campus, which will take place by then. In order to calculate the effect of this strategy, we used the Valle Verde Community Project EIR to obtain total square footage of all buildings on campus before and after the expansion, which amounted to 259,305 square feet and 317,741 square feet, respectively.[106] Of the former value, 169,743 square feet are attributed to residences, and windows have been replaced in half of this total. We therefore summed the remaining 50%, the area of all other existing campus facilities, and the net additional area that will result from the expansion to obtain **232,870 square** feet—the total area that would require window replacement by 2020.

Using the same assumption as in the Green Initiative chapter, Milgard Low-E windows are expected to save an average of 10% of total energy consumption. Since the total area that will require window replacement by 2020 will be 73% of the total area of the campus, the total energy savings will be 7.3%. Given our consumption projections of 14,341.04 MMBTU of natural gas and 2,029.27 MWh of electricity in 2020, the consequent annual energy savings resulting from this strategy will be **1,047 MMBTU** and **148 MWh**, while GHG emissions will be reduced by 107 $MTCO_2e$ each year (Table 5-22).

Table 5-22: Potential Annual Savings due to Dual Pane Windows

Natural Gas Savings (MMBTU)	Electricity Savings (MWh)	Emissions Savings ($MTCO_2e$)
1,047	148	107

It is generally accepted in the window industry that window area equals 15% of the total square footage of a given building.[116] Therefore, the total window area that will have to be installed at Valle Verde is 34,930 square feet. According to Valle Verde management, replacing windows with Low-E windows costs $30 per square foot. It is expected that Low-E windows cost between $3-$5 more than normal windows.[117] Since new construction will require windows one way or another, we attributed only $4 per square foot to the cost of installing Low-E windows in the new facilities. Given this, and taking into account the Southern California Edison subsidy of $1.35 per square foot, NPV and cost-effectiveness of this strategy are **-$380,850** and **-$180**, respectively (Table 5-23).

Table 5-23: NPV and Cost-Effectiveness of Dual Pane Windows

NPV	Cost-Effectiveness ($/$MTCO_2e$)
-$380,850	-$180

5.3.10. Smart Meters

Smart energy meters measure energy consumption and provide real-time information, enabling energy users to improve the energy efficiency of their building(s),[118] reduce their electricity consumption, and shift energy use away from peak demand times when the price of energy is the highest.[119] However, smart metering has received some criticism. Some studies indicate that energy bills increased after the installation of smart meters.[119] Others argue that changing energy demand will require energy user education in collaboration with smart meters.[119] While there have been some accuracy and security concerns regarding this technology, security guidelines and best practices for smart meter infrastructure are being created.[120]

Currently, SCE is planning to install smart meters in the Santa Barbara community between February and May 2012.[121] To cover the costs of smart metering, SCE is increasing electricity rates by approximately 1.6% from January 2011 to January 2013, the time frame when smart meters are being installed.[121] Since the cost of these smart meters is already incorporated into community's electricity bills and Valle Verde cannot negotiate its electricity rate, it is assumed installing smart meter(s) on the campus does not have an initial investment cost.

Research performed by the Electric Power Research Institute suggests that smart meters can lower annual energy consumption by 4%.[122] Valle Verde may reduce electricity use by **81 MWh** annually, saving an estimated $13,799 and **27 $MTCO_2e$** each year (Table 5-24). Smart meters are anticipated to have lifetime of 32 years,[123] resulting in a NPV of **$146,190** and cost-effectiveness valued at $170 (Table 5-25).

Table 5-24: Potential Annual Savings due to Smart Metering

Electricity Savings (MWh)	GHG Emissions Savings ($MTCO_2e$)
81	27

Table 5-25: NPV and Cost-Effectiveness of Smart Meters

NPV	Cost-Effectiveness ($/$MTCO_2e$)
$146,190	$170

5.4. Summary of Reduction Strategies

There are several different ways Valle Verde can use the above calculations to determine the most appropriate means of achieving their goal of carbon neutrality in 2020. Below are three frameworks we determined were most suitable for Valle Verde's achievement of carbon neutrality, based on overall emissions reductions, long-term financial value, and cost-effectiveness for the lifetime of each strategy explored above.

5.4.1. Strategies by GHG Abatement

If Valle Verde decides to pursue an aggressive mitigation strategy, with the goal of reducing the greatest amount of GHGs possible, it will choose strategies based solely on their ability to reduce GHG emissions over the strategies' lifetime. Without considering the costs associated with each strategy, the following table lists each strategy in descending order of GHGs abated over each strategy's lifetime. By focusing investment on strategies at the top of the table, and working their way down over time, Valle Verde will be able to reduce the greatest amount of total GHGs by the end of 2020 (Table 5-26).

Table 5-26: Strategies by Highest Impact on Annual and Lifetime GHG Abatement

Strategy	Annual GHGs Abated ($MTCO_2e$)	Lifetime GHGs Abated ($MTCO_2e$)
Solar Panels	158	3,160
Dual Pane Windows	107	2,140
Attic Insulation	61	1,831
Solar-Tankless Water Heaters	65	1,097
Smart Meters	27	857
Boilers	25	504
LEDs	29	353
Residential ENERGY STAR Appliances	25	238
Commercial ENERGY STAR Appliances	20	221
Radiant Heat Barriers	6	171
TOTAL	**523**	**10,573**

It is estimated that the cumulative GHG reductions from these strategies will only result in a reduction of 523 $MTCO_2e$ in 2020, with the remaining 1,125 $MTCO_2e$ needing to be compensated by carbon offsets, at a cost of $11,250 when assuming an offset price of $10, in order to achieve carbon neutrality.

5.4.2. Strategies by Net Present Value

If Valle Verde decides to pursue a reduction strategy based solely on the time value of money to determine the long-term financial value of a given strategy, it will consider strategies based on their net present values (NPVs). Disregarding the associated GHGs that will be abated, Table 5-27 lists each strategy in descending order of its associated NPV over the lifetime of the strategy.

Table 5-27: Strategies by Highest NPV over Strategy Lifetime, including Up-Front Cost of Implementation

Strategy	Lifetime of Strategy (Years)	Up-Front Cost	NPV
Smart Meters	32	$0	$146,190
Residential ENERGY STAR Appliances	10	-$42,130	$68,730
Attic Insulation	30	-$101,130	$59,600
Boilers	20	-$16,500	$40,170
Commercial ENERGY STAR Appliances	12	-$25,050	$29,630
Radiant Heat Barriers	30	-$25,420	$10,970
Solar Panels	20	-$1,863,070	-$18,830
LEDs	12	-$158,220	-$90,720
Dual Pane Windows	20	-$772,860	-$380,850
Solar-Tankless Water Heaters	17	-$584,760	-$488,540
TOTAL		**-$3,589,140**	**-$623,650**

If Valle Verde chooses only to pursue strategies with a positive NPV, or profitable investments, their 2020 GHG estimate will be reduced by about 164 $MTCO_2e$. As a result, the remaining 1,484 $MTCO_2e$ will need to be reduced via offsets, costing the retirement community $14,840.

5.4.3. Strategies by Cost-Effectiveness

Coupling the two considerations reviewed above, cost-effectiveness is defined as the NPV of a strategy divided by the amount of GHGs that will be abated over its lifetime. By ranking each strategy by their relative cost-effectiveness Valle Verde is able to determine which strategies can maximize the financial gains of each $MTCO_2e$ abated (Table 5-28).

Table 5-28: Strategies by Cost-Effectiveness

Strategy	Strategy Lifetime (Years)	NPV	Lifetime GHGs Abated ($MTCO_2e$)	Cost-Effectiveness ($\$/MTCO_2e$)
Residential ENERGY STAR Appliances	10	$68,730	250	$270
Smart Meters	32	$146,190	857	$170
Commercial ENERGY STAR Appliances	12	$29,630	240	$120
Boilers	20	$40,170	504	$80
Radiant Heat Barriers	30	$10,970	171	$60
Attic Insulation	30	$59,600	1,831	$30
Solar Panels	20	-$18,830	3,160	-$10
Dual Pane Windows	20	-$380,850	2,140	-$180
LEDs	12	-$90,720	353	-$260
Solar-Tankless Water Heaters	17	-$488,540	1,097	-$450
TOTAL		**-$623,650**	**10,603**	**-$170**

The strategy rankings under this analysis differ from the preceding strategies in several important ways. For example, while replacing the campus boilers with high energy efficiency models is found to be a particularly profitable approach under the NPV strategy, it does relatively little to reduce Valle Verde's GHG emissions, and therefore has a relatively low cost-effectiveness ranking. In addition, solar panels reduce the most GHGs of any of the strategies reviewed. However, under the cost-effectiveness analysis, solar panels rank towards the bottom of the list due to their high upfront cost. Choosing only the strategies with positive cost-effectiveness will result in abating 164 $MTCO_2e$ annually, requiring Valle Verde to purchase 1,484 $MTCO_2e$ of offsets for approximately $14,840.

6. Recommendations for Carbon Neutrality by 2020

After exploring a wide variety of potential emissions reduction strategies, we found that Valle Verde will be able to reduce a portion of its estimated 2020 annual emissions of 1,648 $MTCO_2e$. However, given the community's current institutional and operational constraints, Valle Verde will be unable to achieve carbon neutrality by way of technology-based strategies alone. The purchase of carbon offsets will be required to make up the difference.

6.1. Carbon Offsets

Buying carbon offsets is an alternative to directly reducing emissions from Valle Verde's Scopes 1 and 2 sources. By employing this method Valle Verde would pay for emission reductions achieved elsewhere to offset the remaining emissions it was unable to directly abate. Some examples of offsets include, investing in off-site energy efficient measures, financing reforestation projects, and purchasing renewable energy credits.[124] Valle Verde's electricity provider, Southern California Edison, is expected to offer customers the option to purchase renewable energy credits in the near future.

Although carbon offsets can lead to net emission reductions, some do not effectively reduce GHG emissions.[125] Therefore care must be taken when choosing an offset strategy to purchase. The World Wildlife Fund, in collaboration with the Stockholm Environment Institute and Tricorona (a private firm specializing in carbon offset investments), created a report evaluating different carbon offset standards.[124] This report identified the Gold Standard as "the most stringent quality criteria." It is therefore recommended that, when possible, Valle Verde purchase offsets certified by the Gold Standard. However, in the future other certifiers may determine different standards to verify legitimate offsets, such as the United Nations Framework Convention on Climate Change (UNFCCC).[124]

The price of offsets is dependent on a developing carbon market that has a high degree of uncertainty given the state of climate change legislation at the state, federal, and international level. Offsets currently range in price, selling for as low as $2.75 per $MTCO_2e$ or for as much as $99.00 per $MTCO_2e$.[126] However, as California develops its cap-and-trade program, thereby establishing a market price of carbon, offset prices are likely to increase. In anticipation, CARB is proposing to establish the $10 per $MTCO_2e$ as the minimum price of carbon in 2012, with this price increasing annually.[127] This price of carbon may drive up the costs of offsets well over $10 per $MTCO_2e$ in proceeding years.

While it is likely is that the average price will increase over time as new legislation is implemented, for the purpose of this study carbon offsets are assumed to remain constant at $10 per $MTCO_2e$. Although this low price may seem to lend itself as an economical means of achieving carbon neutrality, over the long run it may be a better financial decision for Valle Verde to invest in an on-site emission reduction strategy even if it has a NPV that is negative. In order to determine when this trade-off is appropriate a cut-off price for offsets needs to be determined. The cut-off price is the price that carbon offsets would have to exceed in order to make an individual reduction strategy a better financial decision (Table 6-1).

Table 6-1: Impacts of Carbon Offset Price on Negative NPV Reduction Strategies

Strategy	Strategy Lifetime (Years)	Annual GHGs abated ($MTCO_2e$)	Strategy NPV (Lifetime, w/Rebates)	Offset NPV (Lifetime, Offset price $10/$MTCO_2e$)	Cut-Off Price of Offset
Solar Panels	20	158	-$18,830	-$17,910	$10
Dual Pane Windows	20	107	-$380,850	-$12,129	$310
LEDs	12	29	-$90,720	-$2,465	$370
Solar-Tankless Water Heaters	17	65	-$488,540	-$6,790	$720

Another important consideration to keep in mind about purchasing offsets is that they must be bought each year and never result in long-term GHG emission reductions for the purchasing party. Although other emissions reduction strategies discussed above may not result in financial savings over the strategies' lifetimes, they do offer some financial benefit by partially compensating their costs. However, carbon offsets will never result in any financial payback. Table 6-2 below depicts how the price of an offset ($/$MTCO_2e$) will impact Valle Verde's short-term and long-term finances. All monetary amounts are the NPV of the costs of purchasing offsets over the designated time period.

Table 6-2: Short-term and Long-term Costs of Offsets

Offset Price ($/MTCO$_2$e)	Net Present Cost for Offsetting 2020 (1 year)	Net Present Cost for Offsetting Through 2030 (11 years)	Net Present Cost for Offsetting Through 2040 (21 years)	Net Present Cost for Offsetting Through 2050 (31 years)
$2.75	$2,750	$22,060	$31,880	$36,870
$10.00	$10,000	$80,240	$115,940	$134,090
$15.00	$15,000	$120,350	$173,910	$201,140
$25.00	$25,000	$200,590	$289,850	$335,230
$50.00	$50,000	$401,180	$579,700	$670,450
$75.00	$75,000	$601,770	$869,550	$1,005,680
$99.00	$99,000	$794,330	$1,147,810	$1,327,500

6.2. Impact of Incentives and Technology Advances

An important assumption incorporated into our analyses of GHG reduction strategies involves the impact of energy efficiency incentives at the federal and state level. These rebates make certain energy efficiency strategies more affordable, given their high upfront costs. The table below provides a list of rebate assumptions.

Table 6-3: Rebate Amounts by Strategy

Strategy	Rebate Amount
Solar Panels	$0.50/kWh for first 5 years
Solar-Tankless	$150/unit replaced or $12.83/therm reduced
Refrigerator - 10.3 c.f.	$50/unit replaced
Refrigerator - 9.6 c.f.	$50/unit replaced
Refrigerator - 15.6 c.f.	$50/unit replaced
Refrigerator - 15 c.f.	$50/unit replaced
Dishwasher - 18"	$30/unit replaced
Dishwasher - 24"	$30/unit replaced
Washer/Dryer - 24"	$35/unit replaced
Washer/Dryer - 27"	$35/unit replaced

In addition, nearly all of the recommended GHG reduction strategies are energy efficient technologies that continue to improve at a geometric rate, and it is likely that many of these strategies will become increasingly cost-effective over time. Unfortunately, the rate at which prices will fall as efficiency improves remains uncertain, and is therefore not incorporated into our study. It is recommended that Valle Verde continue to stay up-to-date on the progress of developing energy efficient technologies they may be able to implement on campus.

6.3. Recommended Carbon Neutrality Package

The strategic package Valle Verde decides to pursue will likely depend on two primary concerns: the amount of GHGs a given strategy will abate and the NPV of investing in that particular strategy. Our group recommends a carbon neutrality package that gives equal weight to these two considerations based on cost-effectiveness, or the NPV of a strategy over the total GHGs abated for the lifetime of each strategy. Table 6-4 and Figure 6-1 list the strategies Valle Verde should undertake in descending order of cost-effectiveness. It excludes all investment strategies that are less cost-effective than buying carbon offsets, and includes the purchase of carbon offsets as a means of addressing the remaining gap between cumulative technological reductions and net zero carbon emissions. In other words, the purchase of carbon offsets as a means of achieving carbon neutrality should be approached as a strategy of last resort.

Table 6-4: Recommended Package of Strategies to achieve Carbon Neutrality

Strategy	Annual GHGs Abated ($MTCO_2e$)	NPV	Lifetime GHGs Abated ($MTCO_2e$)	Cost-Effectiveness ($\$/MTCO_2e$)
Residential ENERGY STAR Appliances	25	$68,730	250	$270
Smart Meters	27	$146,190	857	$170
Commercial ENERGY STAR Appliances	20	$29,630	240	$120
Boilers	25	$40,170	504	$80
Radiant Heat Barriers	6	$10,970	171	$60
Attic Insulation	61	$59,600	1,831	$30
Solar Panels	158	-$18,830	3,160	-$10
Offsets	1,326	-$13,260	1,326	-$10
TOTAL	**1,648**	**$323,200**	**8,338**	**$710**

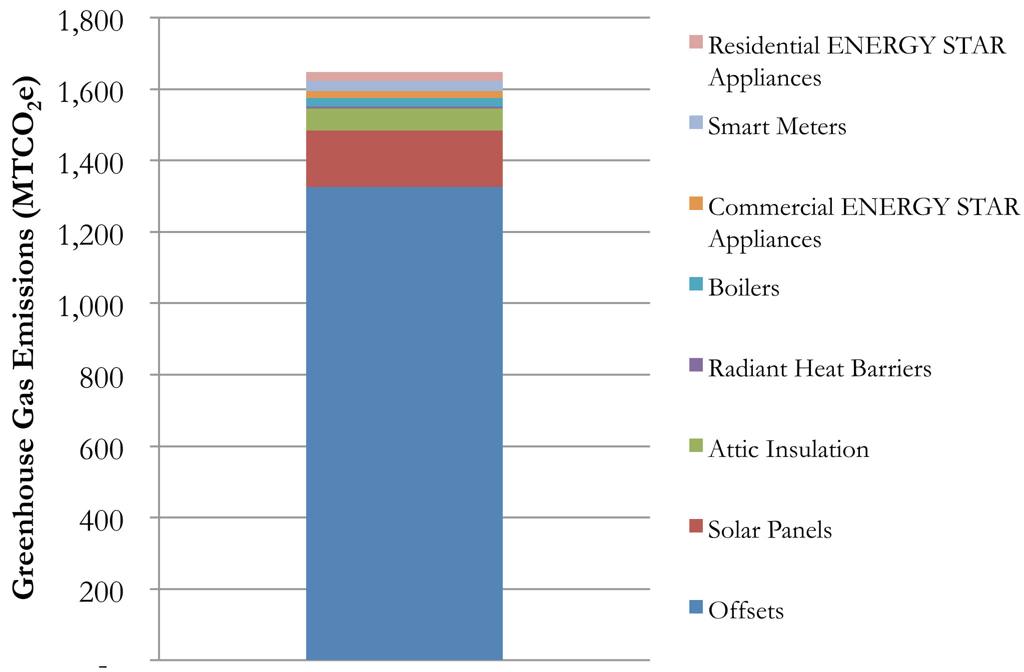

Figure 6-1: Recommended Package of Strategies for Valle Verde to Achieve Carbon Neutrality

Under the recommended carbon neutrality package, Valle Verde will be able to reduce the greatest amount of GHG emissions proportional to each investment's return on investment. By focusing only on cost-effective abatement strategies, with an NPV greater than the cut-off price of carbon offsets, Valle Verde would reduce its annual emissions by approximately 322 $MTCO_2e$ by the end of year 2020.

Smart metering and the installation of ENERGY STAR appliances, such as dishwashers, washers, dryers, refrigerators, and commercial appliances, have the greatest impact on reducing GHG emissions relative to their return on investment, and should therefore take strategic priority within the proposed package. Solar panels should also be installed on campus since their cost of $10 per lifetime GHG abated is equivalent to the purchase of carbon offsets. The recommended package, however, prioritizes solar panels over offsets since they provide significant and ongoing emission reductions, whereas carbon offsets provide no financial payback and would only be effective as a strategy throughout the purchasing year.

Once these technology-based strategies are effectively installed, Valle Verde will need to offset the balance of GHG emissions remaining in order to achieve carbon neutrality. Combined, the efficiency technologies listed in the recommended package leave approximately 1,326 $MTCO_2e$ to be reduced by carbon offsets. Therefore, it is estimated that Valle Verde should prepare to spend approximately $13,260 in carbon offsets alone in order to achieve carbon neutrality by the end of year 2020.

It is important stress that the amount of offsets necessary for carbon neutrality is only a best estimate. The required offset calculation is based on several preceding assumptions listed throughout the report, including the estimation of current Scopes 1 and 2 Inventory, the 2020 GHG projection scenario, and the GHG abatement and NPV associated with each technological strategy. It is further recommended that another Scopes 1 and 2 inventory is undertaken by Valle Verde in 2020 in order to better estimate the necessary amount of carbon offsets to be purchased in order to achieve carbon neutrality within their stated timeframe.

7. Future Directions and Conclusions

We found that Valle Verde emitted 1,494 $MTCO_2e$ during FY09–10 from Scopes 1 and 2 sources. Our Comprehensive Inventory revealed that 65% of Valle Verde's total emissions, including all three Scopes, are released from Scope 3 sources. In addition, Valle Verde has already reduced its annual GHG emissions across all three scopes by 929–2,474 $MTCO_2e$ through the campus' Green Initiative. The success of the Green Initiative may help to explain Valle Verde's lower per capita emissions compared to California's per capita emissions.

We projected Valle Verde's future GHG emissions with consideration to its expanding campus and California's renewable portfolio standard. To achieve carbon neutrality in 2020, it is estimated that Valle Verde will have to reduce its annual GHG emissions by 1,648 $MTCO_2e$. Although Valle Verde can implement technology-based solutions to further reduce annual GHG emissions by 322 $MTCO_2e$, it will be necessary for the community to purchase 1,326 $MTCO_2e$ worth of carbon offsets to become carbon neutral in 2020.

7.1. Recommendations for Future Research

Our examination of Valle Verde's GHG inventories and emission reduction strategies highlights future research opportunities related to GHG accounting and emission abatement strategies. Some of this research is specific to Valle Verde whereas other research can be beneficial to other entities.

To more accurately quantify Valle Verde's GHG emissions, sources that comprised the majority of emissions should be better investigated. Our sensitivity analysis can be used to prioritize data that should be refined, beginning first with the emission sources that impact our inventories' results the most. The necessary data to accurately quantify these emissions should be collected. If possible, the monthly amount of natural gas consumed should be gathered over time to better calculate Scope 1 emissions. Similarly, audits of Valle Verde's waste disposal may reduce uncertainty about emissions generated, or reduced, from composting, recycling, and landfilling.

In addition to improving the quality of data, the use and development of site-specific emissions coefficients would also improve GHG inventory accuracy. For example, Santa Barbara's water supply comes from Lake Cachuma, which is located fairly close to the city. Therefore the emissions associated with the transportation of this water may be less than the national average. Additionally, emission coefficients for different types of water sources, such as reclaimed, irrigation, and tap, may be helpful to better assess Valle Verde's GHG inventory and the impact of the Green Initiative. As previously mentioned, Valle Verde's waste disposal may serve as a carbon sink, it would be intriguing to better quantify the emissions, or sinks, related to this source.

Perhaps, better quantifying Scope 3 emissions would reveal that it is feasible for Valle Verde to achieve carbon neutrality across all three scopes. It would be interesting to explore the economic, operational, environmental, and social feasibility of Valle Verde achieving carbon neutrality for Scopes 1, 2, and 3. Further research on methods to reduce emissions from all sources would be necessary to achieve Scopes 1–3 carbon neutrality.

Better assessment of the impact that Valle Verde's Green Initiative has made on the campus' GHG emissions would be useful to better quantify. Micro-metering and audits for energy, waste, and water may be helpful tools to better understand this impact, as well as the influence the Green Initiative has on utility bills and other environmental issues. Further exploration of the Green Initiative's effects may also provide insight into emission reduction strategies that worked for Valle Verde and highlight potential future strategies to further slash GHG emissions. Additionally, by better calculating the impact of the Green Initiative, Valle Verde will be able to share strategies successful at reducing GHG emissions with other retirement communities.

Different methodologies to evaluate emission reduction strategies would be beneficial to examine. There may be better ways to evaluate the GHG emission reduction achievements and financial impacts of various reduction strategies that were not performed above. Identifying these approaches would be valuable to Valle Verde as well as other organizations and businesses seeking to reduce their GHG emissions. Particularly, it would be beneficial to develop a method to determine the optimal time to implement different reduction strategies.

Finally, developing a standard procedure to inventory GHG emissions of mixed-use facilities, such as Valle Verde, would simplify the process of calculating these emissions, making GHG inventorying accessible to more businesses. This methodology could be accompanied with suggested emissions reduction strategies targeted to specific equipment, businesses, and locations. A tool that catalogues the type and time span of data needed to complete an inventory should be included. Additionally, data substitutes that may be used to calculate GHG emissions in an alternative manner should be offered in the event that the ideal data is not available.

By incorporating this data management tool, small and medium-sized businesses will be able to calculate their carbon footprint with greater ease and accuracy. The majority of GHG inventorying tools are geared towards larger businesses that have the capabilities to track necessary data. We hope that calculating GHG emissions will become simpler for smaller businesses, facilitating the development of GHG management programs at these companies to continue progress towards a carbon neutral and more sustainable society.

7.2. Conclusions

Valle Verde must continuously monitor its progress towards carbon neutrality and the impact that emission reduction strategies have on the community's GHG inventory. Completing annual GHG inventories is essential in assessing Valle Verde's movement towards carbon neutrality. Additionally, the influence that various GHG reduction strategies have on the community's emissions may be different than what we predicted above, which would alter these strategies' cost-effectiveness and the amount of offsets needed to become carbon neutral in 2020.

Examining the long-terms costs of continuously purchasing offsets revealed that they may become less economically viable compared to strategies which reduce GHG emissions of Valle Verde's Scopes 1 and 2. The price of offsets varies and is likely to increase as more companies, governments, and individuals strive to reduce their GHG emissions and turn to offsets as a method to mitigate climate change. It is also important to remember that offsets provide no direct benefit to Valle Verde, such as energy bill savings. Valle Verde must decide if it would rather spend more money upfront on reduction strategies that may not financially pay off or rely on the annual purchasing of carbon offsets from an unpredictable market to achieve carbon neutrality. In confronting these decisions it is important to remember that technology-based strategies are likely to increase in efficiency and decrease in cost over time. Therefore, it is recommended that Valle Verde remains up-to-date on the progress of energy efficient technologies for campus implementation.

It is recommended that Valle Verde create a position within the organization devoted to sustainability, such as a Sustainability Coordinator. The Sustainability Coordinator would complete annual GHG inventories, assess the impact of GHG reduction strategies, evaluate various carbon offset options, and research potential future emission reduction strategies. Other job responsibilities would include assessing the costs and NPV of various GHG reduction strategies as well as researching reduction strategy incentives, such as subsidies, tax breaks, rebates, and loan programs.

By completing annual GHG inventories, the Sustainability Coordinator will be able to better manage and gather data needed to quantify Valle Verde's emissions, reducing the amount of uncertainty from data limitations reflected in our inventory, analysis of the Green Initiative, and reduction strategies. Furthermore, repeated annual GHG inventories will show the general trend of Valle Verde's emissions, helping to better predict future emissions. Improving future emission projections will help identify the necessary emissions reduction measures to achieve carbon neutrality. In addition to having a strong focus on GHG mitigation, the job responsibilities of the Sustainability Coordinator would also encompass other responsibilities close to Valle Verde's Green Initiative.

Valle Verde should also undergo a comprehensive energy audit. Completing an energy audit will identify sources of natural gas and electricity inefficiencies on the campus. Furthermore, the campus could participate in California's Home Energy Rating System (HERS) Program, which would provide home energy ratings of their existing and newly constructed residential units. Once energy inefficiencies are identified and cost-effectiveness options for improvement are recognized, Valle Verde would be able to further reduce energy costs and GHG emissions with improved accuracy. These improvements may be obtained through installing higher energy efficient devices, recommissioning various building components and systems, or applying green building techniques.

Enhanced automation, such as Energy Information Systems (EIS) and Energy Management Systems (EMS), offers several benefits to businesses. These systems monitor energy use to target energy efficiency improvements, lower energy bills, and reduce expenses for operation and maintenance while keeping buildings comfortable for occupants.[128] EIS provide information on building energy; the detail of the information depends on type of EIS technology that is implemented. This information can be as simple as reporting current energy use to as complex as forecasting future energy use and costs from analysis of historical data.[128] Additionally, EIS can be linked to EMS to manage energy use.[128] EMS usually centralizes building(s) energy controls so "a building operator [can] optimize operation of end-use equipment with their facility."[128] In order to improve building energy use, EMS relies on a network of sensors and information communications.[128]Businesses, such as hotels and office buildings, experienced annual energy use reductions ranging from 8% to 50% from using these technologies.[128]

Valle Verde may also benefit from quantifying the campus' carbon sinks. As described above, 66% of Valle Verde's campus is open space and landscaped areas, which includes a 9.8-acre oak woodland preserve.[17] These areas may serve as potential carbon stores, acting as negative emissions for Valle Verde. Furthermore, Valle Verde may want to consider planting native trees in open and landscaped areas to enhance the campus' ability to store carbon. Growing trees naturally sequesters carbon from the atmosphere as they build organic matter. When planted around buildings, trees also reduce the need for air conditioning and heating through the provision of shade and the mitigation of the urban heat island effect.[129] Overall, the U.S. Forest Service estimates the economic benefits associated with tree strategies to be 2 to 6 times more than the upfront and maintenance costs.[129]

In sum, Valle Verde's goal of carbon neutrality by the end of 2020 is a praiseworthy initiative to address its own contribution to global climate change. Widely regarded as an environmental leader within its industry, Valle Verde is effectively raising the bar among its peers by expanding the definition of a sustainable retirement community. Given the rapidly increasing demographic that the senior population represents, Valle Verde's carbon neutrality goal could have a major impact on California's ability to achieve its emissions reduction goals under AB 32. Furthermore, if other retirement communities across the country and the world were to follow Valle Verde's lead, with similar goals of achieving carbon neutrality, the cumulative net reduction in GHG emissions would have a considerable limiting effect on the severity of global climate change.

Appendices

Appendix I: Description of Calculations Made to Transform Data into GHG Emissions

Please note that original data from utilities was pro-rated by day to obtain monthly amounts and that monthly amounts of CO_2e for each emission source were aggregated using the following general formula:

$$\sum_{x=A}^{L} \frac{CO_2e}{month_x} = Annual\ CO_2e$$

Where,
A = October 2009
B = November 2009
C = December 2009
D = January 2010
E = February 2010
F = March 2010
G = April 2010
H = May 2010
I = June 2010
J = July 2010
K = August 2010
L=September 2010

Natural Gas Use
Original Data: Southern California Gas Company

- Dollars spent on natural gas per month ($/month)

Calculations:

$$\frac{\$}{month} \times \frac{therms}{\$} \times \frac{CO_2e}{therm} = \frac{CO_2e}{month} from\ natural\ gas\ use$$

Fugitive Emissions
Original Data: CARB

- Annual emissions from ozone depleting substance substitutes from 2000–2008 (CO_2e)

Calculations:

$$\frac{Annual\ CO_2e}{Annual\ CA\ Population} = Annual\ \frac{CO_2e}{Capita} \text{ for each year (2000–2008)}$$

$$Annual\ \frac{CO_2e}{Capita}\text{ used to create a linear regression to calculate 2010's }\frac{CO_2e}{Capita}$$

$$\text{2010's }\frac{CO_2e}{Capita}\times Valle\ Verde\ Population = Annual\ CO_2e\ from\ fugitive\ emissions$$

Valle Verde Fleet

Data: Michael Drummond

- Dollars spent annually on gas from August 2009–July 2010 ($)

Calculations:

$$\$ \div 12 = \frac{\$}{month}$$

$$\frac{\$}{month}\times\frac{gallons}{\$}=\frac{gallons}{month}$$

$$\frac{gallons}{month}\times\frac{miles}{gallon}=\frac{miles}{month}$$

$$\left(\frac{gallons}{month}\times\frac{CO_2e}{gallons}\right)+\left(\frac{miles}{month}\times\frac{CO_2e}{miles}\right) = \frac{CO_2e}{month}from\ Valle\ Verde\ fleet$$

Electricity

Data: Southern California Edison

- kWh consumed per month (kWh/month)

Calculations:

$$\frac{kWh}{month}\times\frac{CO_2e}{kWh}=\frac{CO_2e}{month}\ from\ electrcity\ use$$

Employee Transportation

Data: Alexa Steadman (in form of survey)

- Survey results analyzed to obtain average annual miles commuted per employee and average annual gallons of gasoline consumed per employee to commute to work

Formula:

Where,

m = average annual miles commuted to Valle Verde per employee

g = average annual gallons of gas used to commute to Valle Verde per employee
M = total annual miles commuted to Valle Verde
G = total annual gallons of gas used to commute to Valle Verde

$$m \times \# \ of \ Valle \ Verde \ employees = M$$

$$g \times \# \ of \ Valle \ Verde \ employees = G$$

$$\left(M \times \frac{CO_2e}{mile}\right) \times \left(G \times \frac{CO_2e}{gallon}\right) = Annual \ CO_2e \ from \ employee \ transportation$$

Food
Data: Paul Childers

- Dollars spent on food per month ($/month)

Formula:

$$\frac{\$}{month} \times \frac{CO_2e}{\$} = \frac{CO_2e}{month} \ from \ waste \ disposal$$

Natural Gas Transmission
Data: Southern California Gas Company

- Dollars spent on natural gas per month ($/month)

Formula:

$$\frac{\$}{month} \times \frac{CO_2e}{\$} = \frac{CO_2e}{month} \ from \ natural \ gas \ transmission$$

Waste
Data: Allied Waste

- Dollars spent on waste service per month ($/month)

Formula:

$$\frac{\$}{month} \times \frac{CO_2e}{\$} = \frac{CO_2e}{month} \ from \ waste \ disposal$$

Water
Data: City of Santa Barbara

- Dollars spent on water per month ($/month)

Formula:

$$\frac{\$}{month} \times \frac{CO_2e}{\$} = \frac{CO_2e}{month} \ from \ water \ consumption$$

Appendix II: Scope 3 Transportation

Valle Verde's Employee Transportation Survey Results:

Respondent #	How many miles do you live from Valle Verde?	Year, make and model of your vehicle?	How many days per week do you commute to Valle Verde?
1	3	1995 Chevy Prism	4
2	4	1995 Acura Integra	
3	6.7	1997 Dodge Pick-up	2.5
4	40	1993 Ford Ranger	5.5
5	48	1999 Chevy Blazer	4
6	15	1995 Toyota Camry	2
7	4	2007 Toyota Corolla	
8	4.5	2003 Buick Rendezvous	5
9	10	2009 Toyota Corolla	5
10	5	1989 Honda Accord	5
11	6	1993 Saturn SC	1
12	10	2001 Ford Expedition	5
13	37.5	2011 GMC Terrain	5.5
14	10	1999 Jeep	
15	10	2007 Honda Civic	
16	45	2006 Chevrolet HHR	4.5
17	5	2006 Nissan Armada	
18	3	2006 Buick LaCrosse	5
19	5	2003 BMW	5
20	5	2005 Saturn Ion	
21	10		
22	5	1996 Toyota Pick-up	3
23	2.75		
24	5	1998 Mercedes	5
25	1	Truck	1.5
26	2.5	2009 Nissan Versa	5
27	7	Ford Expedition	5.5
28	10	2005 Honda	3
29	10	1990 Mitsubishi Mirage	5
30	6.5	Volvo 940	5

Respondent #	How many miles do you live from Valle Verde?	Year, make and model of your vehicle?	How many days per week do you commute to Valle Verde?
31	6.5		5
32	5	1998 Buick	5
33	6	1991 Chevy	5
34	10	1997 Toyota	5
35	3	1994 BMW	6
36	5	2010 Toyota	5
37	42	2000 Toyota Avalon	5
38	6	1999 Ford Explorer	4
39	2	2005 Saturn Ion	
40	35	1999 Dodge Caravan	5
41	5	1995	5
42	5	2002 Mitsubishi Lancer	3
43	7	2000 Honda Odyssey	5
44	5.5	2003 Toyota Camry	5
45	20	Volvo (old)	5
46	40	2008 Toyota Highlander	5
47	56		5
48	5		5
49	56	1986 Toyota Corolla	6
50	2.5	2003 Honda Pilot	5
51	10		4
52	60	2006 Nissan	5
53	3	2000 Buick	5
54	7	1994 Toyota Pick-up	5
55	35	1980 Sierra (van)	2
56	11.36	2003 Jeep Grand Cherokee	5
57	9.45	2008 Honda Civic	5
58	16	2004 Mercury Mountaineer	5.5
59	15	2005 Toyota Camry	3
60	2.5	1998 Honda CRV	4
61	32	2005 Ford Focus	4
62		2006 Jeep Liberty	5
63	40	2006 Honda Accord	5
64	0.25	NA	NA

Respondent #	How many miles do you live from Valle Verde?	Year, make and model of your vehicle?	How many days per week do you commute to Valle Verde?
65	45	2002 Toyota Celica	
66	16	Isuzu Trooper	3
67	60	2010 BMW 528i	5
68	6		5
69	62.5	2008 Sonata	5
70	4	VW Cabrio	5
71	2	Chevy Aveo	2
72	25	2005 Chevy	5.5
73	2	2000 Toyota Tacoma	4
74	51	2006 Toyota Sienna	5.5
75	4	Nissan 2010	6
76	12	1993 Ford Taurus	3
77	12.5	2002 Toyota Tacoma	4
78	2	1995 BMW 325is	5.5
79	9	2009 Saturn Aura	4
80	25	1994 Jeep	5
81	3		6
82	52.5	2003 Nissan Altima	6
83	10	2004 Nissan Sentra	6
84	6	2003 Chevy	5
85	50	2005 Toyota Corolla	5
86	5	2002 Ford	5
87	40	2001 Nissan Frontier	5
88	45	1999 Ford	5
89	7		
90	15	2003 Honda Civic	5
91	10	2001 Mustang	7
92	3	1994 Honda Civic	6
93	3		5
94	2.5	1997 Dodge Dakota	6
95	3	2001 Chevy	5
96	3	2001 Nissan	6
97	8.5	2005 Toyota Prius	3
98	2	2003 Hyundai Accent GL	5

Respondent #	How many miles do you live from Valle Verde?	Year, make and model of your vehicle?	How many days per week do you commute to Valle Verde?
99	56	2001 Honda Civic	5
100	9		5
101	40	2001 Acura	5
102	45	1997 Toyota Camry	5.5
103	3	2000 Ford Taurus	5
104	4	1983 van	5
105	30		5
106	11	2009 Nissan Sentra	5
107	8	2005 GMC Envoy	5
108	35	2004 Ford Freestar	5
109	3	2007 Dodge	4
110	5	2000 Honda CRV	5
111	15	2000 BMW 328ci	5
112	7.5	2007 Mazda	5
113	5	1989 Toyota	5

The MTD's diesel and diesel-electric hybrid fleet can be broken down as follows:

- 40' Flxible (8 buses); 4.03 MPG
- 30' Gillig Hybrid (3 buses); 5.76 MPG
- 30' Gillig diesel (14 buses); 4.81 MPG
- 40' Gillig diesel hybrid (8 buses) 4.7 MPG
- 40' Gillig diesel (15 buses); 4.0 MPG
- 40' Nova diesel (33 buses); 4.46 MPG
- 40' and 45' MCI commuter coaches (5 buses); 4.78 MPG

# of Buses	MPG Rating	Cumulative MPG Rating
8	4.03	32.24
3	5.76	17.28
14	4.81	67.34
8	4.7	37.6
15	4	60
33	4.46	147.18
5	4.78	23.9

Appendix III: Valle Verde Food Items and Suppliers with Assigned CEDA Category

Food Vendor	Food Item Purchased	CEDA Category
Swiss Dairy	AD 2% ECO CS	Fluid milk and butter manufacturing
Swiss Dairy	AD BTRMK HGL	Fluid milk and butter manufacturing
Swiss Dairy	AD SKIM ECO	Fluid milk and butter manufacturing
Swiss Dairy	AD WHL ECO C	Fluid milk and butter manufacturing
Fresh Point	Apple	Fruit farming
Sysco	Apple Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Applesauce	Fruit and vegetable canning, pickling, and drying
The Berry Man, Inc.	Asparagus	Vegetable and melon farming
Sysco	Bacon	Animal (except poultry) slaughtering, rendering, and processing
Fresh Point	Banana	Fruit farming
The Berry Man, Inc.	Banana	Fruit farming
Sysco	Basil Leaves	Fruit and vegetable canning, pickling, and drying
Sysco	BBQ Sauce	Seasoning and dressing manufacturing
Fresh Point	Beans	Vegetable and melon farming
The Berry Man, Inc.	Beans	Vegetable and melon farming
Sysco	Beef	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Beef Brisket	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Beef Patty	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Beef Ravioli	Cookie, cracker, and pasta manufacturing
Sysco	Beef Soup Base	Animal (except poultry) slaughtering, rendering, and processing
Fresh Point	Beet	Vegetable and melon farming
Fresh Point	Bell Pepper	Vegetable and melon farming
Sysco	Biscuit Mix	Bread and bakery product manufacturing

Food Vendor	Food Item Purchased	CEDA Category
The Berry Man, Inc.	Blackberry	Fruit farming
Fresh Point	Blueberry	Fruit farming
Sysco	Blueberry	Fruit farming
The Berry Man, Inc.	Blueberry	Fruit farming
Sysco	Bratwurst	Animal (except poultry) slaughtering, rendering, and processing
Bimbo	Bread	Bread and bakery product manufacturing
Sysco	Bread	Bread and bakery product manufacturing
Sysco	Bread Crumb	Bread and bakery product manufacturing
Sysco	Breadstick	Bread and bakery product manufacturing
Fresh Point	Broccoli	Vegetable and melon farming
Sysco	Brownie	Bread and bakery product manufacturing
Sysco	Brownie Mix	Bread and bakery product manufacturing
Sysco	Butter	Fluid milk and butter manufacturing
Fresh Point	Cabbage	Vegetable and melon farming
Sysco	Cake	Bread and bakery product manufacturing
Sysco	Cake Mix	Bread and bakery product manufacturing
Sysco	Canned Apple	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Baby Corn	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Bean	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Beet	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Peach	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Pear	Fruit and vegetable canning, pickling, and drying

Food Vendor	Food Item Purchased	CEDA Category
Sysco	Canned Soup	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Tomato	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Tuna	Seafood product preparation and packaging
Sysco	Canned Yam	Fruit and vegetable canning, pickling, and drying
Sysco	Canned Yam	Fruit and vegetable canning, pickling, and drying
Sysco	Canola Oil	Soybean and other oilseed processing
Fresh Point	Cantaloupe	Vegetable and melon farming
Sysco	Carmel Sauce	Non-chocolate confectionery manufacturing
Sysco	Cranberry Juice	Fruit and vegetable canning, pickling, and drying
Fresh Point	Carrot	Vegetable and melon farming
Sysco	Catfish	Seafood product preparation and packaging
Fresh Point	Cauliflower	Vegetable and melon farming
Fresh Point	Celery	Vegetable and melon farming
Sysco	Cereal	Breakfast cereal manufacturing
Sysco	Cheese	Cheese manufacturing
Sysco	Cheesecake	Bread and bakery product manufacturing
Sysco	Chicken	Poultry and egg production
Sysco	Chicken Seasoning	Seasoning and dressing manufacturing
Sysco	Chicken Soup Base	Poultry processing
Sysco	Chili Powder	Fruit and vegetable canning, pickling, and drying
Sysco	Chili Relleno	Frozen food manufacturing
Sysco	Cod	Seafood product preparation and packaging
Farmer Bros Co	Coffee	Coffee and tea manufacturing
Sysco	Coffee	Coffee and tea manufacturing
Sysco	Cookie	Cookie, cracker, and pasta manufacturing
Sysco	Cookie Dough	Bread and bakery product

Food Vendor	Food Item Purchased	CEDA Category
		manufacturing
Sysco	Cooking Wine	Wineries
Sysco	Corn	Vegetable and melon farming
Sysco	Corn Tortilla	Tortilla manufacturing
Sysco	Corned Beef	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Cornish Hen	Poultry and egg production
Sysco	Cottage Cheese	Cheese manufacturing
Sysco	Couscous	All other food manufacturing
Sysco	Crab Cake	Seafood product preparation and packaging
Sysco	Cracker	Cookie, cracker, and pasta manufacturing
Sysco	Cranberry Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Cranberry Sauce	Fruit and vegetable canning, pickling, and drying
Sysco	Cream	Fluid milk and butter manufacturing
Sysco	Cream Cheese	Cheese manufacturing
Sysco	Croissant Margarine	Fluid milk and butter manufacturing
Fresh Point	Cucumber	Vegetable and melon farming
Nestle DSD	D/E 3 GAL TUB SOC	Bread and bakery product manufacturing
Sysco	Danish	Bread and bakery product manufacturing
Sysco	Dehydrated Potato	Fruit and vegetable canning, pickling, and drying
Sysco	Diced Beef	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Dried Bean	Fruit and vegetable canning, pickling, and drying
Sysco	Dried Pea	Fruit and vegetable canning, pickling, and drying
Sysco	Éclair	Bread and bakery product manufacturing
Sysco	Egg	Poultry and egg production
Swiss Dairy	FF MILK HGL	Fluid milk and butter manufacturing
Sysco	Flour	Flour milling and malt manufacturing
Sysco	Frozen Yogurt	Ice cream and frozen dessert

Food Vendor	Food Item Purchased	CEDA Category
		manufacturing
Sysco	Fruit Cocktail	Fruit and vegetable canning, pickling, and drying
Fresh Point	Garlic	Vegetable and melon farming
Sysco	Graham Cracker	Cookie, cracker, and pasta manufacturing
Sysco	Granulated Garlic	Seasoning and dressing manufacturing
Fresh Point	Grape	Fruit farming
Sysco	Grape Juice	Fruit and vegetable canning, pickling, and drying
Fresh Point	Grapefruit	Fruit farming
Sysco	Grapefruit	Fruit farming
Sysco	Green Bean	Vegetable and melon farming
Sysco	Ground Beef	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Half & Half Creamer	Fluid milk and butter manufacturing
Sysco	Halibut	Seafood product preparation and packaging
Sysco	Ham	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Hardboiled Egg	All other food manufacturing
Fresh Point	Honeydew	Vegetable and melon farming
Sysco	Horseradish	Fruit and vegetable canning, pickling, and drying
Sysco	Ice Cream	Ice cream and frozen dessert manufacturing
Sysco	Jam	Fruit and vegetable canning, pickling, and drying
Sysco	Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Ketchup	Fruit and vegetable canning, pickling, and drying
Swiss Dairy	KREME QT	Fluid milk and butter manufacturing
Sysco	Lamb	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Lauras Petit Four Asst	Bread and bakery product manufacturing
The Berry Man, Inc.	Leeks	Vegetable and melon farming

Food Vendor	Food Item Purchased	CEDA Category
Fresh Point	Lemon	Fruit farming
Sysco	Lemon Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Lemonade Syrup	Flavoring syrup and concentrate manufacturing
Fresh Point	Lettuce	Vegetable and melon farming
The Berry Man, Inc.	Lettuce	Vegetable and melon farming
Sysco	Lima Bean	Vegetable and melon farming
Sysco	Liquid Coffee	Coffee and tea manufacturing
Sysco	Liquid Egg Whites	All other food manufacturing
Sysco	Lobster	Seafood product preparation and packaging
Swiss Dairy	LOL D EASE 2	Fluid milk and butter manufacturing
Swiss Dairy	LOL YOG LF B	Cheese manufacturing
Sysco	Margarine	Soybean and other oilseed processing
Sysco	Marmalade	Fruit and vegetable canning, pickling, and drying
Sysco	Mayonnaise	Fats and oils refining and blending
Sysco	Meatballs	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Milk 2% Dairy Thick	Dry, condensed, and evaporated dairy product manufacturing
Sysco	Milk Café Lait	Dry, condensed, and evaporated dairy product manufacturing
Sysco	Mint Jelly	Fruit and vegetable canning, pickling, and drying
Sysco	Muffin Mix	Bread and bakery product manufacturing
Fresh Point	Mushroom	Vegetable and melon farming
Sysco	Mustard	Soybean and other oilseed processing
Sysco	Nestle Thickener Food Thicken-up	All other food manufacturing
Sysco	Oatmeal	Breakfast cereal manufacturing
Sysco	Olives	Fruit and vegetable canning, pickling, and drying
Fresh Point	Onion	Vegetable and melon farming
Fresh Point	Orange	Fruit farming
The Berry	Orange	Fruit farming

Food Vendor	Food Item Purchased	CEDA Category
Man, Inc.		
Sysco	Orange Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Pan Vegetable Spray	Soybean and other oilseed processing
Sysco	Pasta	Cookie, cracker, and pasta manufacturing
Sysco	Pastry Dough	Bread and bakery product manufacturing
Sysco	Pea	Vegetable and melon farming
Sysco	Peanut Butter	All other food manufacturing
Sysco	Pepper	Seasoning and dressing manufacturing
Fresh Point	Pepper - Jalapeno	Vegetable and melon farming
Sysco	Pie	Bread and bakery product manufacturing
Fresh Point	Pineapple	Fruit farming
Sysco	Pizza Dough	Bread and bakery product manufacturing
Sysco	Polenta	Wet corn milling
Sysco	Pork Tenderloin	Animal (except poultry) slaughtering, rendering, and processing
Fresh Point	Potato	Vegetable and melon farming
Sysco	Potato	Vegetable and melon farming
The Berry Man, Inc.	Potato	Vegetable and melon farming
Sysco	Potato Chip	Snack food manufacturing
Sysco	Pretzels	Cookie, cracker, and pasta manufacturing
Sysco	Prune	Fruit and vegetable canning, pickling, and drying
Sysco	Prune Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Pudding Mix	Bread and bakery product manufacturing
Sysco	Raisins	Fruit and vegetable canning, pickling, and drying
Fresh Point	Raspberry	Fruit farming
The Berry Man, Inc.	Raspberry	Fruit farming
Sysco	Rice	Grain farming

Food Vendor	Food Item Purchased	CEDA Category
Sysco	Roll Dough	Bread and bakery product manufacturing
Sysco	Rolls	Bread and bakery product manufacturing
Sysco	Salad Dressing	Seasoning and dressing manufacturing
Sysco	Salmon	Seafood product preparation and packaging
Sysco	Salt	Seasoning and dressing manufacturing
Sysco	Sauce Mix	Seasoning and dressing manufacturing
Sysco	Sauerkraut	Fruit and vegetable canning, pickling, and drying
Sysco	Sausage	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Scone Dough	Bread and bakery product manufacturing
Sysco	Sherbet	Ice cream and frozen dessert manufacturing
Sysco	Shrimp	Seafood product preparation and packaging
Sysco	Shrimp Salad	Seafood product preparation and packaging
Sysco	Sour Cream	Cheese manufacturing
Swiss Dairy	SOY SILK PLN	Soybean and other oilseed processing
Sysco	Soybean Oil	Soybean and other oilseed processing
Sysco	Sparkling Apple Cider	Fruit and vegetable canning, pickling, and drying
Fresh Point	Spinach	Vegetable and melon farming
Sysco	Splenda	Nonchocolate confectionery manufacturing
Fresh Point	Squash	Vegetable and melon farming
Sysco	Steak Seasoning	Seasoning and dressing manufacturing
Fresh Point	Strawberry	Fruit farming
The Berry Man, Inc.	Strawberry	Fruit farming
Sysco	Sugar	Sugar cane mills and refining
Sysco	Sugar Packet	Sugar cane mills and refining
Sysco	Sweet & Low	Nonchocolate confectionery manufacturing
Swiss Dairy	SWS WHL PL G	Fluid milk and butter manufacturing

Food Vendor	Food Item Purchased	CEDA Category
Sysco	Syrup	Flavoring syrup and concentrate manufacturing
Sysco	Tea	Coffee and tea manufacturing
Sysco	Tea Liquid	Coffee and tea manufacturing
Sysco	Tea Syrup	Flavoring syrup and concentrate manufacturing
Sysco	Tilapia Filet	Seafood product preparation and packaging
Fresh Point	Tomato	Fruit farming
The Berry Man, Inc.	Tomato	Fruit farming
Sysco	Tomato Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Turkey	Poultry and egg production
Sysco	Veal	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Veal Patty	Animal (except poultry) slaughtering, rendering, and processing
Sysco	Vegetable Juice	Fruit and vegetable canning, pickling, and drying
Sysco	Veggie Patty	Frozen food manufacturing
Sysco	Vinegar	Seasoning and dressing manufacturing
Fresh Point	Watermelon	Vegetable and melon farming
Sysco	Whipped Cream	Cheese manufacturing
Sysco	White Sauce Mix	Seasoning and dressing manufacturing
Fresh Point	Yam	Vegetable and melon farming
Sysco	Yogurt	Cheese manufacturing

Appendix IV: Impacts of Changes to Assumptions and Inputs on GHG Emissions by Emission Source

Emission Source	Scope	Assumption/Input Changed	Amount Changed	GHG Emissions from Source with Change ($MTCO_2e$)
Natural Gas	1	monthly price of gas	-10.00%	768
			10.00%	629
Fugitive Emissions	1	per capita emissions for VV	-10.00%	142
			10.00%	174
Valle Verde Fleet	1	average California monthly price of fuel	-10.00%	41
			10.00%	34
Valle Verde Fleet	1	average MPG of VV fleet	-10.00%	37
			10.00%	37
Valle Verde Fleet	1	Passenger Vehicles	N/A	37
Valle Verde Fleet	1	Heavy Duty Truck	N/A	37
Valle Verde Fleet	1	year of light duty truck	1995–2000	38
			2005 and newer	37
Electricity	2	monthly kWh consumed	-10.00%	546
			10.00%	668
Employee Transit	3	annual gallons consumed	-10.00%	793
			10.00%	968
Employee Transit	3	annual miles traveled	-10.00%	880
			10.00%	881
Employee Transit	3	year of Passenger Vehicle	1995–1999	885
			2004 and newer	878
Employee Transit	3	Light Duty Truck	N/A	881
Employee Transit	3	Heavy Duty Truck	N/A	883
Food	3	annual expenditure on all food categories	-10.00%	1197
			10.00%	1463

Emission Source	Scope	Assumption/Input Changed	Amount Changed	GHG Emissions from Source with Change ($MTCO_2e$)
Natural Gas	3	monthly expenditure on natural gas	-10.00%	328
			10.00%	401
Waste	3	monthly expenditure on waste services	-10.00%	111
			10.00%	136
Water	3	monthly expenditure on water services	-10.00%	151
			10.00%	185

Appendix V: Green Initiative List of Assumptions

LED/CFL Lighting

Data: Terry Bentley

- In 2006, all 218 apartments had only incandescent bulbs and T-12 fluorescent bulbs.
- In 2010, of 214 apartments, 43 used incandescent lighting, 34 used CFL lighting, and 137 used LED lighting.
- Each 1-bedroom apartment has 8 light bulbs and one long fluorescent tube.

Assumptions

- In 2010 all 214 apartments switched to T-8 lighting.
- Incandescent bulb = 75W
- CFL bulb = 18W (75W equivalent)[130]
- LED bulb = 10 W (75W equivalent)[131]
- Even with a change in number of apartments, assume number of light fixtures does not change from 2006 to 2010.
- Assume amount of time lights turned on does not vary between light bulb types.
- Assume Valle Verde has all 1-bedroom apartments; in actuality, Valle Verde has larger apartments (2 bedrooms) but the number may be insignificant.
- Assume yearly lighting to be 10 hours/day for 365 days (average case) and 15 hours/day for 365 (high consumption case).

Solar Tubes

Data: Terry Bentley

- Solar tubes installed = 10-inch diameter solar tube
- As of 2006, no solar tubes were installed.
- As of 2010, every apartment (214) was retrofitted with a solar tube.

Assumptions

- Assume 1 solar tube = 3750 lumens[132]
- 1-75W incandescent bulb at 16W/lumen = 1200 lumens[133]
- 1-10W LED bulb = 615 lumens[131]
- Assume 100% of light is transmitted into living space and illuminates the same region as a light bulb.

ENERGY STAR Appliances

Residential Appliances

Data: Terry Bentley, John Colt

- As of 2010, 202 (estimated) apartments with ENERGY STAR dishwasher (model: Hotpoint HDA2100RWW, 24")
- Lack of sufficient data for all appliances in all apartments

Assumptions

- All apartments have had appliances replaced to the newest models
- Actual number of apartments with ENERGY STAR dishwasher may vary; only a "dozen" of apartments have a different model dishwasher
- No non-ENERGY STAR dishwasher equivalent could be found for the dishwasher being evaluated; instead assumed that the annual average kWh per year used would be higher than the ENERGY STAR qualification level of 324 kWh/year[103]
- Chose 360 kWh/year to be non-ENERGY STAR equivalent dishwasher

Commercial Appliances

Data: Terry Bentley

- 1-Frymaster deep fryer
- 2-Traulsen refrigerators
- 1-Vulcan griddle

Assumptions

- All assumptions are baseline assumptions from the EPA's Commercial Kitchen ENERGY STAR Calculator[45]
- Assume that all four pieces of equipment are ENERGY STAR appliances that fit newest standard
- Frymaster deep fryer
    - Natural gas power supply
    - Lifetime of 12 years, being used 16 hours/day, 365 days/year; 150 pounds of food cooked
- Traulsen refrigerators
    - Solid door (not glass door)
    - Approximate size of 29 cu.ft.; 12-year lifetime that uses 3.3 kWh/day, 365 days/year
- Vulcan griddle
    - Natural gas power supply
    - 3 ft. griddle width that cooks 100 lb food/day; 12-year lifetime used for 12 hours/day, 365 days/year

Hot Water Systems
Data: Terry Bentley

- Water heating system consists of one solar water heater and one tankless water heater
- 40% of apartments have the solar and tankless water heating system (86 apartments)
- Solar Water Collector Storage: SunEarth Copperheart series[134]
- Copperheart series collector has a 40 gallon tank; requires no outside natural gas or electricity
- Copperheart thermal performance ratings from specification sheet
- Tankless Water Heater: Takagi TK-3[135]
- TK-3 Efficiency: 0.84

Assumptions

- U.S. Consumer Product Safety Commission suggests that water should not exceed temperatures above 120ºF when heated.[136]
- Assume the average temperature for cold water is the average temperature for Santa Barbara: 61ºF.[35]
- Assume that the average person uses between 20–35 gallons of water per day; for this study we looked at 20 and 35 gallons daily use per capita.[50]
- Assume that the typical 40-gallon natural gas water heater is 0.5–0.7 efficient. For this study we used an efficiency of 0.6.[137]
- Assume that the amount of energy needed to warm water comes from insolation, which was calculated for Santa Barbara to be 1,814.41 kWh/m^2.[138]
- To facilitate savings calculations, we can assume that distribution of the solar and tankless water systems does not affect calculations, and can therefore calculate the amount of solar panels per person each resident benefits from to account for the 40% saturation of efficient water systems.

Water Heater Blankets
Data: Terry Bentley

- 60% of apartments have regular natural gas water heaters
- Of the 60%, only 10% have water heater blankets—13 apartments have water heaters with blankets

Assumptions

- U.S. Consumer Product Safety Commission suggests that water should not exceed temperatures above 120ºF when heated.[136]
- Assume the average temperature for cold water is the average temperature for Santa Barbara: 61ºF.[35]

- Assume that the average person uses between 20–35 gallons of water per day; for this study we looked at 20 and 35 gallons daily use per capita.[50]
- Assume that the typical 40-gallon natural gas water heater is 0.5–0.7 efficient. For this study we used an efficiency of 0.6.[137]
- Assume that inefficiency of natural gas water heater is due solely to heat loss
- DOE says that water heater blankets can decrease heat loss by 25–45%; if all inefficiency is due to heat loss, natural gas water heater will have increased efficiency of 0.75 (25%) to 0.87 (45%).

Waste Diversion
Data: Terry Bentley

- Recycling containers are 110% full
- Trash containers are 80% full
- Composting container is 90% full

Data: Allied Waste

Waste Disposal Operations at Valle Verde			
Number of Containers	**Size of Containers (cubic yards)**	**Type of Container**	**Frequency of Pick-Up (times picked-up per week)**
1	1.5	Trash	4
1	3	Trash	3
2	4	Recycling	3
1	2	Food scraps	5
22	0.475	Recycling	1
44	0.158	Recycling	1
90	0.158	Trash	2
1	4	Recycling	3

Assumptions

- For some materials, sources provided differing average weight per cubic yard, when this occurred a range of a low weight and high weight per cubic yard was used to account of this variability

Volume to Weight Conversion Ranges of Various Materials Disposed of at Valle Verde		
Material	**Low Weight (pounds per cubic yard)**	**High Weight (pounds per cubic yard)**
Food scraps	1,070[139]	1,513[140]
Compacted trash	500[139]	1,000[139]
Non-compacted trash	150[139]	800[141]
Glass bottles/containers	500 (whole containers)[139]	2,160 (broken glass)[142]
Tin/steel cans	150 (non-flattened steel cans)[139]	850 (tin coated steel cans)[143]
Aluminum cans	50[140]	430[140]
Corrugated cardboard	50 (flattened and loose)[139]	300 (non-compacted)[140]
Paper bags	875 (mixed paper grades)[139]	N/A
Newspaper	360 (loose)[140]	600 (non-compacted)[139]
Office paper	110[140]	380[140]
Magazines and catalogs	875[139]	N/A
Phone books and directories	250[140]	N/A
Other miscellaneous paper	875[139]	N/A
PET (PETE) containers	30[139]	40[140]
HDPE containers	24[139]	67[139]
Miscellaneous plastic containers	50[140]	N/A

- Diversion rate for all California recyclables is equal to the State's average diversion rate, 59%[144]
- Tajiguas Landfill is 23.8 miles from Valle Verde
- The materials recycling facility where Valle Verde's recyclables go is 37.6 miles from the retirement community
- The composting facility is 60.3 miles from Valle Verde

Calculations
t = trash disposed of in trash dumpster
z = food waste disposed of in compost dumpster
r_x = recyclable, where x is defined by a letter ranging between a and m;

Recyclable Material and Formula Notation	
Formula Notation	**Recyclable**
A	Aluminum Cans
B	Corrugated Cardboard
C	Glass bottles and containers
D	HDPE Containers
E	Magazines and Catalogs
F	Miscellaneous Plastic Containers
G	Newspaper
H	Office Paper
I	Other Miscellaneous Paper
J	Paper Bags
K	PETE Containers
L	Phone Books and Directories
M	Tin/Steel Cans

M= pounds of material disposed of by Valle Verde
V = volume of container
W = weight of material in pounds per cubic yard of material
P = percent container is full
N = number of containers with volume V
F = frequency of pick-up of container with volume V
L = percent of recyclable x in recycling bin found using California Waste Characterization Study

The formulas to calculate daily pounds of a material disposed of are as follows
For trash,

$$M_t = V_t \times (W_t) \times \left(\frac{P_t}{100}\right) \times N_t \times \left(\frac{F_t}{7}\right)$$

For food scraps,

$$M_z = V_z \times (W_z) \times \left(\frac{P_z}{100}\right) \times N_z \times \left(\frac{F_z}{7}\right)$$

For recyclables the formula is varied slightly and there is an intermediate step between to calculate the ratio of a recyclable x recycled per total recyclables recycled. This ratio was found using the California Waste Characterization Study conducted by the California Integrated Waste Management Board,[78] which examined the amount of recyclables (in weight) that were improperly disposed of as trash. The California diversion rate during this study was 59%;[144] therefore the amount of recyclables being recycled properly could be determined using the following formula and variables:

T = amount of recyclable in trash in tons,
U= amount of recyclable recycled in tons,
Q= Total amount of recyclable disposed of in tons either in the recycling or trash
R= ratio of U_x recycled out of total recyclables

$$\frac{T_x}{\left(\frac{100\%-59\%}{100}\right)} = Q$$

$$Q_x \times \left(\frac{59\%}{100}\right) = T_x$$

Once the amount of recyclable in tons that was recycled was found it was possible to calculate the ratio of each recyclable that was recycled using the following formula:

$$\frac{U_x}{\sum_a^m U_x} = R_x$$

In order to approximate the ratio of these various recyclables in Valle Verde's recycling dumpsters; we used the same ratio of recyclables found in a California Waste Characterization Study.[78] This study broke down their information for multi-family residences and for commercial business, making it was possible to use this information to more accurately approximate the contents of Valle Verde's recycling containers. Residential units have their own trash area with smaller recycle carts, so data for multi-family complexes was used to estimate recycling contents of these carts. Whereas the larger dumpsters are primarily used by Valle Verde for commercial recycling, so the information on commercial businesses was applied to these recycling dumpsters.

$$M_r = \sum_{x=a}^{m} \left(V_{r_x} \times (R_x) \times (W_{r_x}) \times \left(\frac{L_{r_x}}{100}\right) \left(\frac{P_{r_x}}{100}\right) \times N_{r_x} \times \left(\frac{F_{r_x}}{7}\right) \right)$$

Source Reductions
Data: Terry Bentley, Valle Verde

- One work order is one piece of paper when printed
- Valle Verde has 300 work orders per month

- Valle Verde uses recycled content office paper
- Valle Verde uses 12–32 gallons of mulch per month

Assumptions

- 100 sheets of office paper in one pound of paper[145]
- Source reduction of recycled content office paper results in GHG emission savings of 2.71 $MTCO_2e$ per ton of office paper[80]
- 23.8 miles to Tajiguas landfill from Valle Verde
- Wood chips weight 625 pounds per cubic yard[140]

Calculations Work Orders

$$\frac{300 \times 12}{100} = 36\, pounds\ of\ paper\ used\ annually\ for\ work\ orders$$

$$\frac{36}{2000} \times 2.71 = 0.4878\, MTCO_2e\ saved\ annually$$

Appendix VI: Reduction Strategies Calculations

General Assumptions

- Price of electricity: \$0.17/kWh
- Price of natural gas: \$11.29/MMBTU
- Interest rate: 7.0%

Upgrade to LED Lighting

- CFL lights have lifetime of 15,000 hours; LEDs have lifetime of 25,000 hours
- Price per CFL: \$2.53; price per LED: \$50

The following NPV equation was used:

$$NPV = (C_{CFL} \times R_{CFL} - C_{LED} \times R_{LED}) + \sum_{t=0}^{10} \frac{p(U_{CFL} - U_{LED})}{(1.07)^t}$$

where,
C = Cost of light bulb
R = number of replacements needed until 2020 (R_{CFL} = 5,136 and R_{LED} = 3424)
p = price of electricity, \$0.17/kWh
U = total annual amount of electricity used for each type of light bulb

ENERGY STAR Appliances

- For residential refrigerators, dishwashers, and washer/dryer units, assumed lifetime was approximately 10 years; for commercial kitchen appliances, assumed lifetime was approximately 12 years
- Alternative ENERGY STAR appliances were found on the EPA's ENERGY STAR website[146]
- Prices were inferred through general retail Internet research.

The following NPV equation was used for all ENERGY STAR appliance replacements:

$$NPV = (C_{Current} - C_{ENERGY\ STAR}) + \sum_{t=0}^{10} \frac{p(U_{Current} - U_{ENERGY\ STAR})}{(1.07)^t}$$

where,
C = Cost of appliance
p = price of electricity, \$0.17/kWh
U = total annual amount of electricity used for each type of appliance

Commercial Kitchen ENERGY STAR Appliances
Assumptions

- All assumptions are baseline assumptions from the EPA's Commercial Kitchen ENERGY STAR Calculator[45]
- Assume that all four pieces of equipment are ENERGY STAR appliances that fit newest standard
- Alto-Shaam holding ovens
  - Linear relationship with power per unit volume (assumes full-size, volume of 20 c.f.)
  - Electricity power supply
  - Lifetime of 12 years, being used 15 hours/day, 365 days/year
- Cleveland steamer
  - Natural gas power supply
  - Lifetime of 12 years, being used 12 hours/day, 365 days/year
  - 6 pans per unit, 100 lb. food cooked per day
- Commercial Cooler walk-in freezer
  - Lifetime of 12 years, being used 365 days/year, 13 kWh per day
  - Solid door (not glass)
- National Cooler walk-in refrigerator
  - Lifetime of 12 years, being used 365 days/year, 4.9 kWh per day
  - Solid door (not glass)

Hot Water Systems

- Natural gas water heaters have lifetime of 13 years; the solar hot water collectors and tankless water heaters have an average of 17 year lifetime
- Price per natural gas water heater: $330; price per solar collector/tankless water heater system: $5,000

The following NPV equation was used:

$$NPV = \left(C_{regular} \times R_{regular} - C_{solar} \times R_{solar}\right) + \sum_{t=0}^{10} \frac{p\left(U_{regular} - U_{solar}\right)}{(1.07)^t}$$

where,
C = Cost of water heating system
R = number of replacements needed until 2020 ($R_{regular}$ = 167 and R_{solar} = 128)
p = price of natural gas, $11.29/MMBTU
U = total annual amount of natural gas used for each type of water heating system

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