Climate Change Technical Report

Sonoma Mountain Village

Prepared for:
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Rohnert Park, California

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Acronyms

AB	Assembly Bill
AB 32	California Global Warming Solutions Act of 2006
ACM	Alternative Compliance Method
AF	acre feet
ANPR	Advanced Notice of Proposed Rulemaking
ARB	California Air Resources Board
B20	biodiesel (20%)
BAAQMD	Bay Area Air Quality Management District
BARBD	Building America Research Benchmark Definition
BATS	Bay Area Travel Survey
BAU	Business as Usual
bhp	brake horsepower
C	carbon
CAFE	corporate average fuel economy
CAPCOA	California Air Pollution Control Officers Association
CBECS	Commercial Buildings Energy Consumption Survey
CCAR	California Climate Action Registry
CCR/CCF	California Code of Regulations
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CF_4	tetrafluoromethane
CFC	chlorinated fluorocarbons
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	CO_2 equivalents
DHW	domestic hot water
DOT	Department of Transportation
E85	85% ethanol blend
EF	emission factor
EIA	United States Energy Information Administration
EIR	Environmental Impact Report
EISA	Energy Independence and Security Act of 2007
EMFAC	emissions estimation software programs
ENVIRON	ENVIRON International Corporation
FCV	fuel cell vehicle
FFV	flexible fuel vehicle
GDP	gross domestic product
GGE	gasoline gallon equivalent
GHG	greenhouse gas
GRP	General Reporting Protocol
GSHP	ground source heat pump
GVW	gross vehicle weight
GWP	global warming potential
HBO	home-based other (trip)
HBW	home-based work (trip)
HFC	hydrofluorocarbons
HR 2764	The Consolidated Appropriations Act of 2008
HVAC	heating, ventilating, and air conditioning
IPCC	Intergovernmental Panel on Climate Change
kW	kilowatt

kWh	kilowatt-hour
kW-hr/yr	kilowatt-hours/year
lbs	pounds
LCA	Life Cycle Assessment
LCFS	Low Carbon Fuel Standard
LDA	light-duty auto
LDT	light-duty truck
LEED	Leadership in Energy and Environmental Design
MA	Massachusetts
MEL	miscellaneous energy load
MN	Minnesota
mpg	miles per gallon
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
MW	megawatts
NHB	non-home-based (trip)
N_2O	nitrous oxide
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
O_2	oxygen
OPR	Office of Planning and Research
PFC	perfluorocarbon
PG&E	Pacific Gas and Electric
PHEV	plug-in hybrid electric vehicle
ppb	parts per billion
ppm	parts per million
PV	photovoltaic
RFS	Renewable Fuel Standard
RPS	California's Renewables Portfolio Standard
RTP	Regional Transit Plan
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCWA	Sonoma County Water Agency
SF_6	sulfur hexafluoride
SMV	Sonoma Mountain Village
sqft	square feet
TDV	Time Dependent Valuation
tonnes	Metric tonnes; 1,000 kilograms
UNEP	United Nations Environment Programme
URBEMIS	Urban Emissions Model
US	United States
USEPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
WARM	WAste Reduction Model
WCI	Western Regional Climate Action Initiative
WMO	World Meteorological Organization

Executive Summary

Sonoma Mountain Village (SMV) is a proposed mixed use community to be built in Rohnert Park, Sonoma County. SMV will result in approximately 1,892 new residences at full build out and will include 790,307 square feet (sq. ft.) of commercial (i.e., office and retail uses) and 35,000 sq. ft. of municipal space. In comparison to a Business as Usual (BAU) scenario in which none of the sustainable features of the development are incorporated, SMV's annual emissions represent an improvement of 66%, if Pavley Standards for vehicular emissions are incorporated as expected.

Codding Enterprises' primary goal for SMV is to create a model for development's contribution toward reaching California's 2050 targets for greenhouse gas (GHG) emissions, which is to reduce statewide GHG emissions to 80% below 1990 levels. SMV is planned to have sustainable design to reach those goals with key features including:

- **Energy:** Meeting all heating, cooling, water heating, lighting, and other electricity needs through the use of on-site renewable power (photovoltaics, solar water heaters, and renewably-powered heat pumps)
- **Energy:** Improving upon 2005 Title 24 standards by at least 30% for residential buildings, 10% for retrofitted commercial buildings, and 20% for new commercial buildings (See the Project Description for information on performance relative to the new 2008 standards)
- **Vehicle Emissions:** Reducing vehicle miles traveled (VMT) through the compact, mixed-use, transit-oriented design of the development; a bicycle network; and convenient sidewalks and paths. SMV will also have an on-site "travel coordinator" to assist residents in identifying transportation alternatives to driving.
- **Construction:** Reusing waste concrete and asphalt to reduce truck hauling emissions and material life-cycle emissions
- **Water:** Reducing municipal water use and sewage generation through use of reclaimed water and greywater for central irrigation, and water efficiency standards (e.g., toilets, urinals, showerheads, dishwashers, clothes washers). Codding has determined that SMV can be developed without any additional municipal drinking water allocation.[1]
- **Waste:** Reducing overall waste generation in conjunction with a 70% rate of reclaiming, recycling, or composting in order to meet a target of 2% of typical waste generation sent to landfill.

This climate change technical report reflects SMV's sustainable features in this GHG inventory.

[1] Codding Enterprises. 2007. Sonoma Mountain Village: Water Plan. October 10.

This development will result in both one-time and annual direct and indirect emissions of GHGs. The term, “direct emissions of GHGs” refers to GHGs that are emitted directly as a result of the project and includes land use change and construction emissions. Indirect emissions are those emissions that the project entitlement will enable, but that are not controlled by the project proponent. This report discusses the scientific and regulatory developments surrounding global climate change and provides an inventory surveying the emissions that would result from approving SMV.

There is a general scientific consensus that most current global warming is the result of human activity on the planet. This man-made, or anthropogenic, warming is primarily caused by increased emissions of GHGs that keep the earth’s surface warm. This is called “the greenhouse effect” and contributes to global climate change.

Lawmakers at the national, state and local levels have introduced legislation and regulations aimed at better tracking and controlling GHGs. On the national level, there are some incentives for businesses and individuals to take voluntary steps to limit GHG emissions. However, no federal legislation capping GHG emissions or requiring reporting has been passed. Over two years ago, California enacted the California Global Warming Solutions Act of 2006 (Assembly Bill 32 or AB 32), which established mandatory reductions in state-wide GHG emissions by 2020. The California Legislature passed Senate Bill 97 (SB 97), which addresses GHG analysis under the California Environmental Quality Act (CEQA). SB 97 requires that the Office of Planning and Research (OPR) develop guidelines for the mitigation of GHG emissions and their effects for adoption by January 1, 2010 by the California Air Resources Board (ARB). More recently, the Legislature passed Senate Bill 375 (SB 375), which is intended to limit GHG emissions from cars and light trucks by improving the efficiency of regional land development patterns. No binding rules or regulations have been developed that address climate change analysis under CEQA. However, as discussed further below, on October 24, 2008, ARB released a preliminary draft proposal on developing CEQA thresholds of significance for GHG emissions; a December 9, 2008, meeting followed with additional details, but CEQA thresholds for developments have not been advanced since that time. The Bay Area Air Quality Management District (BAAQMD) is also developing CEQA thresholds of significance, but they are currently in the preliminary stages of that work.

Residents and the employees and patrons of commercial and municipal buildings and services use electricity, heating, and are transported by motor vehicles. These activities directly or indirectly emit GHGs. The most significant GHG emissions resulting from such residential and commercial developments are emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHG emissions are typically measured in terms of tonnes of CO_2 equivalents (CO_2e), calculated as the product of the mass emitted of a given GHG and its specific global warming potential (GWP).

The emissions inventory presented in this report is consistent with the methodologies established by the California Climate Action Registry (CCAR), where possible. The SMV emissions inventory considers six categories of GHG emissions: emissions due to vegetation changes, construction activities, residential and commercial building energy use, mobile sources, area sources, and municipal sources. Residential and non-residential buildings are negligible since SMV will obtain energy from renewable sources. Area sources are negligible since no fireplaces or gas powered lawn maintenance equipment will be allowed. The emissions resulting from embodied energy in renewable energy sources are also considered in this GHG emission inventory. The emissions from construction and land use (vegetation) change are one-time emissions events. The other emissions occur annually throughout the life of the project.

A variety of methods are employed to develop a complete GHG emissions inventory. In addition to well-established emission factors for certain activities and emission estimates based on similar activities in other representative communities; several emissions estimation software programs are used. These include EMFAC, OFFROAD, Urban Emissions Model (URBEMIS), WAste Reduction Model (WARM), Building America Research Benchmark Definition (BARBD), and Micropas.

Emissions from the various aspects of SMV are presented in Table ES-1. Both the one-time emissions and emissions that are expected to occur each year after build-out of the SMV development are presented. There are 11,833 tonnes of CO_2e one-time emissions. The annual emissions from the use of the development amount to 11,866 tonnes CO_2e/year. Of the annual emissions, about 95% result from vehicular emissions associated with residential activities. There are no GHG emissions from the energy use associated with residential and non-residential buildings, as SMV is committed to meeting 100% of its residential and non-residential building energy needs with renewable sources of energy. If the one-time emissions (construction and land use change) are annualized assuming a 40-year development life (which is likely low), then the one-time emissions account for approximately 296 tonnes per year, or 2.4% of the annual emissions. Taking these annualized one-time emissions into account, the annual emissions are 12,162 tonnes CO_2e/year.

To place the emissions from SMV into context, the estimated 66% reduction in GHG emissions exceeds AB 32's goal of achieving emissions reductions of 28.3% below BAU. The improvement over BAU is also equivalent to a reduction of 53% below the development's share of 1990 GHG emissions. This approaches California's 2050 goal of achieving 80% reduction from 1990 levels.

This inventory was prepared as a worst-case analysis. For example, it assumes that all emissions from SMV are "new," in the sense that, absent the development of SMV, these emissions would not occur. Given the global nature of GHG emissions, "new" global GHG emissions are those caused by economic growth and population growth (births); local development projects accommodate such growth.

As an example of why these are worst-case emissions, these emissions are estimated assuming that the transportation system does not change in the future. This assumption is clearly an over-simplification, as the measures incorporated into the California Global Warming Solutions Act of 2006 (AB 32) mandate change in this area and would reduce future GHG emissions from the development. Accordingly, an assessment of the impacts of currently implemented rules on GHG emissions from vehicle travel is included.

Table ES-1
Summary of Greenhouse Gas Emissions for Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

Source	GHG Emissions		Percentage of Annual CO_2e Emissions (%)
Vegetation	tonnes CO_2e total	-1,991	NA
Construction (Non-Building)		7,282	NA
Construction (Buildings)		6,542	NA
Total (one time emissions)		**11,833**	NA
Residential	tonnes CO_2e / year	0	0%
Non-Residential		0	0%
Mobile		11,270	95%
Municipal		596	5%
Area		0	0%
Total (annual emissions)		**11,866**	**NA**
Annualized Total	**tonnes CO_2e / year**	**12,162**	**NA**

1 Introduction

Sonoma Mountain Village (SMV) is a proposed mixed use community to be built in Rohnert Park, Sonoma County. SMV will result in approximately 1,892 new residences at full build out and will include 790,307 square feet (sq. ft.) of commercial (i.e., office, services and retail uses) and 35,000 sq. ft. of municipal space. Codding Enterprises' primary goal for SMV is to create a model for residential and commercial development that can aim towards California's 2050 targets for greenhouse gas (GHG) emissions, which is to reduce statewide GHG emissions to 80% below 1990 levels. SMV is planned to have sustainable features to reach those goals with key features including:

- **Energy:** Meeting all heating, cooling, water heating, lighting, and other electricity needs through the use of on-site renewable power (photovoltaics, solar water heaters, and renewably-powered heat pumps)
- **Energy:** Improving upon 2005 Title 24 standards by at least 30% for residential buildings, 10% for retrofitted commercial buildings, and 20% for new commercial buildings. (See the Project Description for information on performance relative to the new 2008 standards)
- **Vehicle Emissions:** Reducing vehicle miles traveled (VMT) through the compact, mixed-use, transit-oriented design of the development; a bicycle network; and convenient sidewalks and paths. SMV will also have an on-site "travel coordinator" to assist residents in identifying transportation alternatives to driving.
- **Construction:** Reusing waste concrete and asphalt to reduce truck hauling emissions and material life-cycle emissions
- **Water:** Reducing municipal water use and sewage generation through use of reclaimed water and greywater for central irrigation, and water efficiency standards (e.g., toilets, urinals, showerheads, dishwashers, clothes washers). Codding has determined that SMV can be developed without any additional municipal drinking water allocation.[2]
- **Waste:** Reducing overall waste generation in conjunction with a 70% rate of reclaiming, recycling, or composting in order to meet a target of 2% of typical waste generation sent to landfill.

This climate change technical report reflects SMV's sustainable features in this GHG inventory to the extent that quantification is possible.

The SMV development will result in one-time and annual (direct and indirect) emissions of GHGs. Direct emissions of GHGs refers to GHGs that are emitted directly as a result of the

[2] Codding Enterprises. 2007. Sonoma Mountain Village: Water Plan. October 10.

project and include land use change and construction emissions. Indirect emissions are those emissions that the project entitlement will enable, but that are not controlled by the project proponent. This report discusses the scientific and regulatory developments surrounding global climate change and provides an estimate of an emissions inventory that would result from entitling SMV. This report also places the emissions inventory from SMV into context.

Residents, employees, and patrons of commercial and municipal buildings use electricity, heat their homes and water (typically with natural gas), and are transported in motor vehicles, all of which directly or indirectly emit GHGs. The principal greenhouse gases resulting from such developments are emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). CO_2 is considered the most important GHG, due primarily to the large emissions produced by fossil fuel combustion, especially for the generation of electricity and powering of motor vehicles. CH_4 and N_2O are also emitted by fossil fuel combustion, though their emissions are much less significant than CO_2. CH_4 is also emitted from the transmission, storage, and incomplete combustion of natural gas.

The effect that each of these gases can have on global warming is a combination of the mass of their emissions and their global warming potential (GWP). GWP indicates, on a pound for pound basis, how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. CH_4 and N_2O are substantially more potent GHGs than CO_2, with GWPs of 21 and 310, respectively.[3] In emissions inventories, GHG emissions are typically reported in terms of pounds (lbs) or tonnes[4] of CO_2 equivalents (CO_2e). CO_2e are calculated as the product of the mass emitted of a given GHG and its specific GWP. While CH_4 and N_2O have much higher GWPs than CO_2, CO_2 is emitted in such vastly higher quantities that it accounts for the majority of GHG emissions in CO_2e, both from residential developments and human activity in general.

The SMV project is located within the jurisdiction of the Bay Area Air Quality Management District (BAAQMD). However, as BAAQMD guidelines for the preparation of GHG inventories have not yet been developed, this inventory has been developed consistent with the methodologies established by the California Climate Action Registry (CCAR) where possible. When guidance from the CCAR is lacking, methodologies established by the Intergovernmental Panel on Climate Change (IPCC)[5] and best available science are used. Legislation and rules regarding climate change, as well as scientific understanding of the extent to which different activities emit GHGs, continue to evolve; as such, the inventory in this report is a reflection of the guidance and knowledge currently available.

[3] GWP values from IPCC's Second Assessment Report (SAR, 1996) are still used by international convention and are used in this protocol, even though more recent (and slightly different) GWP values were developed in the IPCC's Third Assessment Report (TAR, 2001)

[4] In this report, "tonnes" will be used to refer to metric tonnes (1,000 kilograms). "Tons" will be used to refer to short tons (2,000 pounds).

[5] The WMO and the UNEP established the IPCC in 1988; it is open to all members of the United Nations and WMO.

At the entitlement stage of a development, while the number of homes, the approximate size of commercial areas and the locations of both are known, the exact designs of the homes, businesses and facilities are not. Even so, the types of buildings and the types of facilities at the future SMV site can be used for developing an estimate of the project's anticipated GHG emissions. Energy used in a building depends in part on the built environment; however, actual future emissions from the site will depend heavily upon the future homeowners' and business owners' habits. Because the actual future occupants and their habits are not yet known, average current behavior is assumed. That assumption is likely to be a "worst-case" assumption. Given the current regulatory environment and the media focus on global climate change, it is likely that the actual future occupants will be more sensitive to the GHG emissions caused by their activities and, therefore, their activities will result in lower GHG emissions than average current behavior shows.

1.1 Emissions Inventory

The SMV emissions inventory considers the following categories of GHG emissions:

- emissions due to land use (vegetation) changes,
- emissions from construction activities,
- residential building operations emissions,
- non-residential building operations emissions,
- mobile source operations emissions,
- municipal operations emissions,
- emissions savings from on-site renewable energy.

In addition, estimates of “life-cycle” GHG emissions from building materials and renewable energy systems are presented. Life-cycle emissions include all of the emissions caused by the existence of a product or project, for example, GHG emissions from the processes used to manufacture and transport materials used in the buildings and infrastructure. This estimate is to be used for comparison purposes only and is not included in the final inventory as these emissions would be accounted for under California Global Warming Solutions Act of 2006 (AB 32) in other industry sectors. In addition, life-cycle analyses inherently involve many uncertainties. For example, in a life-cycle analysis for building materials, somewhat arbitrary boundaries must be drawn to define the processes considered in the life-cycle analysis.[6] Although life-cycle emission estimates can provide a broader view of a project’s emissions, life-cycle analyses often double count emissions that might be attributable to other sectors in a comprehensive analysis. The applicability of information to a specific geographic location, climatic zone and building type can influence the life-cycle GHG emissions. Further uncertainty

[6] For instance, in the case of building materials, the boundary could include the energy to make the materials, the energy used to make the machine that made the materials, and the energy used to make the machine that made the machine that made the materials.

of life-cycle analyses come from some basic choices, such as the useful life of a building or road which can substantially change the outcome of the life-cycle analysis.

The inventory does not consider GHG emissions from sources outside of SMV that may indirectly service SMV residents (e.g., a landfill) that would be covered by other GHG emissions inventories or whether the emissions from SMV are "new" in the sense that, absent the development of SMV, these emissions may not occur. However, emissions from water use and construction worker commuting are included.

The timeframe over which GHGs are emitted varies from category to category, which is taken into consideration in the emissions inventory. For most of the categories, GHGs will be emitted every year that the development is inhabited. For these categories (residential buildings, non-residential buildings, mobile sources, municipal services, area sources, and renewable energy), the inventory includes estimates of annual GHG emissions from ongoing development operations. GHG emissions from two of the categories, construction and changes in vegetation, are one-time events that will not be part of the development's ongoing activity. These one-time emissions can be divided by the estimated lifetime of the project to allow direct comparison of these two emissions classes. The inventory presents estimates of these one-time emissions, converts them to annualized estimates, and integrates them into an annual inventory.

It is worth noting that the GHG emissions estimates assume there are no reductions in GHG-generating activities over time. This is clearly unlikely, and presents a conservative analysis, given the expected reductions in GHG emissions from most activities that will take place over the years due to future regulations, greater public awareness and the likely increasing costs of energy. For example, the emissions estimated for mobile sources assumes that there will not be an improvement in fuel economy or decarbonization of the energy supply; this is not realistic, given the mandates of AB 32, and other regulatory developments, as discussed later in this report. The effect of these rules is evaluated in a semi-quantitative manner in Section 6.0 of this report.

A variety of methods are employed to develop a complete GHG emissions inventory. In addition to well established emission factors for certain activities and emission estimates based on similar activities in other representative communities; several emissions estimation software programs are used. These include EMFAC, OFFROAD, Urban Emissions Model (URBEMIS), WAste Reduction Model (WARM), Building America Research Benchmark Definition (BARBD), and Micropas. Later sections of the report describe these models and other estimation methods. The major emissions sources that exist in residential developments are described later in this report.

1.2 Comparison of GHG Emissions

Because, to date, the BAAQMD and ARB have not established significance thresholds for GHG emissions under the California Environmental Quality Act (CEQA), the proposed GHG emissions from SMV are compared to other inventories to gain perspective on the impact these emissions may have[7]. To evaluate SMV's GHG emissions, the SMV inventory is compared with the Business as Usual (BAU) scenario. The SMV inventory is also compared with emissions reductions thresholds associated with regulations being developed by the California Air Resources Board (ARB) pursuant to AB 32 to determine if the development is likely to be consistent with rules propagated for California to meet its 2020 emissions reduction goal. In addition to absolute emissions, emissions per capita are compared with the current average per capita emissions of California residents. Finally, to understand the large-scale significance of SMV's GHG emissions, the inventory is compared to state, national and global inventories.

1.3 Report Description

This report contains seven sections. Following this introduction, Sections 2 and 3 detail the state of climate change science and the regulatory setting. Section 4 presents the results of the SMV GHG Inventory. Section 5 compares these results to various benchmarks to gain perspective on what impact the SMV development will have on overall GHG emissions. Section 6 analyzes the impact of regulatory developments on SMV's GHG emissions. Finally, the main findings from the report are summarized in the conclusion which is Section 7.

[7] Both SCAQMD and ARB have recently released proposed significance thresholds, but these have not been finalized at this time.

2 State of Science

This section summarizes the scientific issues surrounding climate change and global warming. It also provides a discussion of the actions and phenomena that contribute to climate change and puts into context global, national, and state emissions of GHGs.

2.1 Global Climate Change

Global warming and *global climate change* are both terms that describe changes in the earth's climate. *Global climate change* is a broad term used to describe any worldwide, long-term change in the earth's climate. This change could be, for example, an increase or decrease in temperatures, the start or end of an ice age, or a shift in precipitation patterns. The term *global warming* is more specific than *global climate change* and refers to a general increase in temperatures across the earth. Though global warming is characterized by rising temperatures, it can cause other climatic changes, such as a shift in the frequency and intensity of rainfall or hurricanes. Global warming does not necessarily imply that all locations will be warmer. Some specific, unique locations may be cooler even though the world, on average, is warmer. All of these changes fit under the umbrella of global climate change.[8]

While global warming can be caused by natural processes, there is a general scientific consensus that most current global warming is the result of human activity on the planet.[9] This man-made, or anthropogenic, warming is primarily caused by increased emissions of "GHGs" that keep the earth's surface warm. This is called "the greenhouse effect." The greenhouse effect and the role GHGs play in it are described below.

2.2 The Greenhouse Effect

Greenhouses allow sunlight to enter and then capture some of the heat generated by the sunlight's impact on the earth's surface. The earth's atmosphere acts like a greenhouse by allowing sunlight in, but trapping some of the heat that reaches the earth's surface. When solar radiation from the sun reaches the earth, much of it penetrates the atmosphere to ultimately reach the earth's surface; this solar radiation is absorbed by the earth's surface and then re-emitted as heat in the form of infrared radiation.[10] Whereas the GHGs in the atmosphere let solar radiation through, the infrared radiation is trapped by greenhouses gases, resulting in the warming of the earth's surface.[11] This phenomenon is referred to as the "greenhouse effect".

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[8] Other definitions of "Greenhouse Effect" and "Global Warming" can be found on Merriam-Webster online: http://www.m-w.com/. A definition for "Climate Change" can be found on dictionary.com which uses Webster's New Millennium™ Dictionary of English, Preview Edition (v 0.9.6).

[9] From the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers." Available online at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

[10] All light, be it visible, ultraviolet, or infrared, carries energy.

[11] Infrared radiation is characterized by longer wavelengths than solar radiation. Greenhouse gases reflect radiation with longer wavelengths. As a result, instead of escaping back into space, greenhouse gases reflect much infrared radiation (i.e., heat) back to Earth.

The earth's greenhouse effect has existed far longer than humans have and has played a key role in the development of life. Concentrations of major GHGs, such as CO_2, CH_4, N_2O, and water vapor have been naturally present for millennia at relatively stable levels in the atmosphere, adequate to keep temperatures on Earth hospitable. Without these GHGs, the earth's temperature would be too cold for life to exist.

As human industrial activity has increased, atmospheric concentrations of certain GHGs have grown dramatically. Figure 2-1 shows the increase in concentrations of CO_2 and CH_4 over time. In the absence of major industrial human activity, natural processes have maintained atmospheric concentrations of GHGs, and, therefore, global temperatures at constant levels over the last several centuries.[12] As the concentrations of GHGs increase due to human activity, more infrared radiation is trapped, and the earth is heated to higher temperatures. This is the process that is described as human-induced global warming.

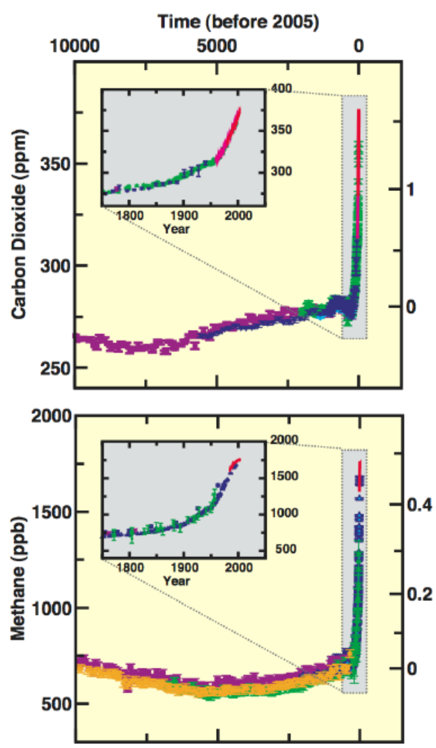

Figure 2-1. Carbon dioxide and methane concentrations have increased dramatically since the industrial revolution.[13]

In 2007, the IPCC began releasing components of its Fourth Assessment Report on climate change. In February 2007, the IPCC provided a comprehensive assessment of climate change

[12] Examples of natural processes include the addition of GHGs to the atmosphere from respiration, fires, and decomposition of organic matter. The removal of greenhouse gases is mainly from plant and algae growth and absorption by the ocean.

[13] Adapted from figure SPM-1 of the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers." Available online at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

science in its Working Group I Report.[14] It states that there is a scientific consensus that the global increases in GHGs since 1750 are mainly due to human activities such as fossil fuel use, land use change (e.g., deforestation), and agriculture. In addition, the report states that it is likely that these changes in greenhouse gas concentrations have contributed to global warming. Confidence levels of claims in this report have increased since 2001 due to the large number of simulations run and the broad range of available climate models.

2.3 Greenhouse Gases and Sources of Their Emissions

The term "GHGs" includes gases that contribute to the natural greenhouse effect, such as CO_2, CH_4, N_2O, and water, as well as gases that are only man-made and that are emitted through the use of modern industrial products, such as HFCs, chlorinated fluorocarbons (CFCs), and sulfurhexafluoride (SF_6). These last three families of gases, while not naturally present in the atmosphere, have properties that also cause them to trap infrared radiation when they are present in the atmosphere, thus making them GHGs. These six gases comprise the major GHGs that are recognized by the Kyoto Accords (water is not included).[15] There are other GHGs that are not recognized by the Kyoto Accords, due either to the smaller role that they play in climate change or the uncertainties surrounding their effects. Atmospheric water vapor is not recognized by the Kyoto Accords because there is not an obvious correlation between water concentrations and specific human activities. Water appears to act in a positive feedback manner; higher temperatures lead to higher water concentrations, which in turn cause more global warming.[16]

The effect each of these gases has on global warming is a combination of the volume of their emissions and their GWP. GWP indicates, on a pound for pound basis, how much a gas will contribute to global warming relative to how much warming would be caused by the same mass of CO_2. CH_4 and N_2O are substantially more potent than CO_2, with GWPs of 21 and 310, respectively. However, these natural GHGs are nowhere near as potent as sulfur hexafluoride (SF_6) and fluoromethane, which have GWPs of up to 23,900 and 6,500 respectively.[17] GHG emissions are typically measured in terms of mass of CO_2e. CO_2e are calculated as the product of the mass of a given GHG and its specific GWP.

The most important greenhouse gas in human-induced global warming is CO_2. While many gases have much higher GWPs than the naturally occurring GHGs, CO_2 is emitted in such vastly higher quantities that it accounts for 85% of the GWP of all GHGs emitted by the United States.[18] Fossil fuel combustion, especially for the generation of electricity and powering of

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14 Available online at: http://www.ipcc.ch/ipccreports/ar4-wg1.htm
15 This Kyoto Protocol sets legally binding targets and timetables for cutting the greenhouse-gas emissions of industrialized countries. The US has not approved the Kyoto treaty.
16 From the IPCC Third Assessment Report: http://www.grida.no/climate/ipcc_tar/wg1/143.htm and http://www.grida.no/climate/ipcc_tar/wg1/268.htm
17 California Climate Action Registry General Reporting Protocol - Reporting Entity-Wide Greenhouse Gas Emissions. SAR values, Appendix C. http://www.climateregistry.org/resources/docs/protocols/grp/GRP_V3_April2008_FINAL.pdf
18 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, U.S. Environmental Protection Agency. Available online at: http://epa.gov/climatechange/emissions/downloads/08_CR.pdf

motor vehicles, has led to substantial increases in CO_2 emissions and thus substantial increases in atmospheric CO_2 concentrations. In 2005, atmospheric CO_2 concentrations were about 379 parts per million (ppm), over 35 percent higher than the pre-industrial concentrations of about 280 ppm.[19] In addition to the sheer increase in the volume of its emissions, CO_2 is a major factor in human-induced global warming because of its lifespan in the atmosphere of 50 to 200 years.

Concentrations of the second most prominent GHG, CH_4, have also increased due to human activities such as rice production, degradation of waste in landfills, cattle farming, and natural gas mining. In 2005, atmospheric levels of CH_4 were more than double pre-industrial levels, up to 1774 parts per billion (ppb) as compared to 715 ppb.[20] CH_4 has a relatively short atmospheric lifespan of only 12 years, but has a higher GWP than CO_2.

Nitrous oxide concentrations have increased from about 270 ppb in pre-industrial times to about 319 ppb by 2005.[21] Most of this increase can be attributed to agricultural practices (such as soil and manure management), as well as fossil-fuel combustion and the production of some acids. Nitrous oxide's 120-year atmospheric lifespan increases its role in global warming.

Besides CO_2, CH_4, and N_2O; there are several gases and categories of gases that were not present in the atmosphere in pre-industrial times but now exist and contribute to warming. These include CFCs, used often as refrigerants, and their more stratospheric-ozone-friendly replacements, HFCs. Fully fluorinated species, such as sulfurhexafluoride (SF_6) and tetrafluoromethane (CF_4), are present in the atmosphere in relatively small concentrations, but have extremely long life spans of 50,000 and 3,200 years each, making them potent GHGs.

2.4 Current and Projected Climatic Impacts of Global Warming

A strong indication that global warming is currently taking place is the fact that the top seven warmest years since the 1890s occurred after 1997. Furthermore, a warming of about 0.2°C per decade is projected by currently accepted models.

There is a scientific consensus that global climate change will increase the frequency of heat extremes, heat waves, and heavy precipitation events. Other likely direct effects include an increase in the areas affected by drought and by floods, an increase in tropical cyclone activity, a rise in sea level, and recession of polar ice caps. The impacts of global warming have already been demonstrated by substantial ice loss in the Arctic.[22] Figure 2-2 shows the rise of global temperatures, the global rise of sea level, and the loss of snow cover from 1850 to the present.

[19] Page 2 of the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers."
[20] Page 4 of the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers."
[21] Page 4 of the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers."
[22] Statistics from IPCC Working Group I and II Reports.

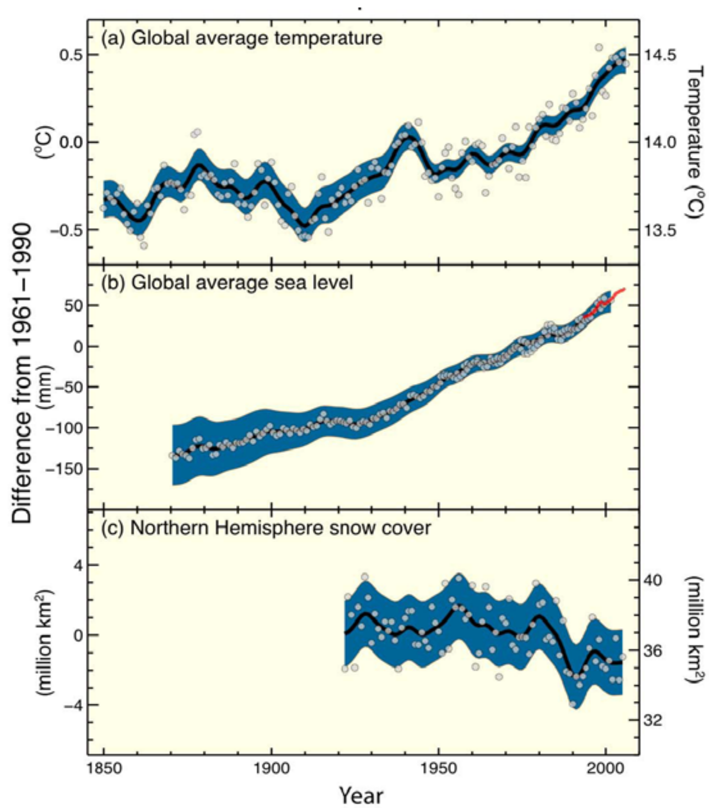

Figure 2-2. Global warming trends and associated sea level rise and snow cover decrease.[23]

2.5 Socioeconomic Impacts of Global Warming

Global temperature increases may have significant negative impacts on ecosystems, natural resources, and human health. Ecosystem structure and biodiversity will be compromised by temperature increases and associated climatic and hydrological disturbances.[24] The availability and quality of potable water resources may be compromised by increased salinisation of ground water due to sea-level rises, decreased supply in semi-arid and arid locations, and poorer water quality arising from increased water temperatures and more frequent floods and droughts.[25] These impacts on freshwater systems, in addition to the effects of increased drought and flood frequencies, can reduce crop productivity and food supply.

In addition to compromising food and water resources, there are other means through which climatic changes associated with global warming can affect human health and welfare. Warmer temperatures can cause more ground-level ozone, a pollutant that causes eye irritation and respiratory problems. Ranges of infectious diseases will likely increase, and some areas will

[23] Figure SPM-3 of the IPCC "Climate Change 2007: The Physical Science Basis, Summary for Policymakers."
[24] From the IPCC Working Group II Report.
[25] From the IPCC Technical Paper VI: "Climate Change and Water". Available online at: http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf

face greater incidences of illness and mortality associated with increased flooding and drought events.

In its April 2007 Working Group II Report, the IPCC provided an assessment of the "current scientific understanding of impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability".[26] Here, the IPCC states that although some people will gain and some will lose because of global climate change, the overall change will be one of social and economic losses. California in particular is an area that could be negatively impacted by global warming. Global warming could alter the seasonal pattern of snow accumulation and snowmelt, which serve as primary sources for California's drinking water and irrigation water supplies. The scientific community projects extensions in the periods of high forest fire risk. Climatic changes would also affect agriculture, a major California industry, which could result in economic losses. For example, the heat wave in July 2006 is estimated to have cost the California dairy industry in excess of one billion dollars.[27]

2.6 Global, National, and California-wide GHG Emissions Inventories

Worldwide emissions of GHGs in 2004 were 26.8 billion tonnes of CO_2e.[28] In 2004, the United States (US) emitted about 7 billion tonnes of CO_2e or about 24 tonnes of CO_2e per year per person.[29] Over 80% of the GHG emissions in the United States are comprised of CO_2 emissions from energy related fossil fuel combustion. In 2004, California emitted 0.492 billion tonnes of CO_2e, or about 7% of the US emissions. If California were a country, it would be the 16^{th} largest emitter of GHGs in the world.[30] This large number is due primarily to the sheer size of California. Compared to other states, California has one of the lowest per capita GHG emission rates in the country. This is due to California's higher energy efficiency standards, its temperate climate, and the fact that it relies on substantial out-of-state energy generation.

In 2004, 81% of greenhouse gas emissions (in CO_2e) from California were comprised of CO_2 emissions from fossil fuel combustion, with 4% comprised of CO_2 from process emissions. CH_4 and N_2O accounted for 5.7% and 6.8% of total CO_2e respectively, and high GWP gases[31] accounted for 2.9% of the CO_2e emissions. Transportation is by far the largest end-use category of GHG emissions. Transportation includes that used for industry (i.e., shipping) as well as residential use.

[26] Available online at: http://www.ipcc-wg2.org/index.html
[27] Office of the Governor.
[28] Sum of Annex I and Annex II countries without counting Land-Use, Land-Use Change and Forestry (LULUCF) http://unfccc.int/ghg_emissions_data/predefined_queries/items/3814.php For countries that 2004 data was unavailable, the most recent year was used.
[29] 2006 Inventory of U.S. Greenhouse Gas Emissions and Sinks. Available online at: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLP4/$File/06ES.pdf
[30] Anywhere between the 12^{th} and 16^{th} depending upon methodology. Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004. California Energy Commission.
[31] Such as HFCs and PFCs.

2.7 Potential for Reduction of GHG Emissions

In May 2007, the IPCC produced its Working Group III Report on the "scientific, technological, environmental, economic and social aspects" of reducing GHG emissions to alleviate climate change.[32] The report concluded that, even with current policies for sustainable development and mitigation of climate change, global GHG emissions will continue to grow over the next several decades.

[32] Available online at: http://www.ipcc.ch/ipccreports/ar4-wg3.htm

3 Regulatory Setting

Climate change has only recently been widely recognized as a threat to the global climate, economy and population. As a result, the climate change regulatory setting – federal, state and local – is complex and evolving. This section identifies key legislation, executive orders, and seminal court cases related to climate change germane to the Sonoma Mountain Village development project GHG emissions.

3.1 Federal Action on Greenhouse Gas Emissions

3.1.1 Federal Action on Greenhouse Gas Emissions

In 2002, President George W. Bush set a national policy goal of reducing the GHG emission intensity (tons of GHG emissions per million dollars of gross domestic product) of the U.S. economy by 18% by 2012. No binding reductions were associated with the goal. Rather, the USEPA administers a variety of voluntary programs and partnerships with GHG emitters in which the USEPA partners with industries producing and utilizing synthetic GHGs to reduce emissions of these particularly potent GHGs. In early 2009, the Obama administration announced its intent to implement a cap-and-trade system to reduce GHG emissions 80% by 2050[33]; however, no cap-and-trade legislation has been passed at this time.

3.1.2 April 2007 Supreme Court Ruling

In *Massachusetts et al. vs. Environmental Protection Agency et al.* (April 2, 2007) the U.S. Supreme Court ruled that the Clean Air Act authorizes the USEPA to regulate CO_2 emissions from new motor vehicles. The Court did not mandate that the USEPA enact regulations to reduce GHG emissions, but found that the only instances where the USEPA could avoid taking action were if it found that GHGs do not contribute to climate change or if it offered a "reasonable explanation" for not determining that GHGs contribute to climate change. On July 11, 2008, EPA released an Advanced Notice of Proposed Rulemaking (ANPR) inviting comments on options and questions regarding regulation of GHGs under the Clean Air Act. The ANPR announced a 120-day public comment period that concluded on November 28, 2008.

3.1.3 Corporate Average Fuel Efficiency Standards

In response to the U.S. Supreme Court ruling, the Bush Administration issued an executive order on May 14, 2007, directing the USEPA and Departments of Transportation (DOT) and Energy (DOE) to establish regulations that reduce GHG emissions from motor vehicles, non-road vehicles, and non-road engines by 2008. On December 19, 2007, the Energy Independence and Security Act of 2007 (EISA) (discussed below) was signed into law, which requires an increased Corporate Average Fuel Economy (CAFE) standard of 35 miles per gallon for the combined fleet of cars and light trucks by model year 2020. EISA requires establishment of interim standards (from 2011 to 2020) that will be the "maximum feasible average fuel economy" for each fleet. On October 10, 2008, the National Highway Traffic

[33] http://www.whitehouse.gov/agenda/energy_and_environment/

Safety Administration (NHTSA) released a final environmental impact statement analyzing proposed interim standards for model years 2011 to 2015 passenger cars and light trucks. The standards for model year 2011, signed into law on March 23, 2009, are expected to raise the industry-wide combined average to 27.3 miles per gallon.

3.1.4 Energy Independence and Security Act of 2007

In addition to setting increased CAFE standards for motor vehicles, the EISA includes other provisions:

- Renewable Fuel Standard (RFS) (Section 202);
- Appliance and Lighting Efficiency Standards (Section 301–325);
- Building Energy Efficiency (Sections 411–441).

Additional provisions of the EISA address energy savings in government and public institutions, promoting research for alternative energy, additional research in carbon capture, international energy programs, and the creation of “green jobs.”

3.1.5 Reporting Requirements

Congress passed “The Consolidated Appropriations Act of 2008” (HR 2764) in December 2007, which includes provisions requiring the establishment of mandatory GHG reporting requirements. The measure directed USEPA to publish draft rules by September 2008, and final rules by June 2009 mandating reporting “for all sectors of the economy.” On March 10, 2009, USEPA proposed a comprehensive, mandatory national system for reporting GHG emissions. The rule will apply only to those GHG emissions produced by major sources in the U.S., specifically those with emissions equal to or above 25,000 tonnes CO_2e / year. Sources covered by the rule will include cement production, iron and steel production, electricity generation, and other energy intensive sectors. Virtually all sectors covered will be required to submit the first annual report to the USEPA in 2011 for emissions generated in calendar year 2010. The proposed rule was published in the Federal Register on April 10, 2009. The proposed rule is available for public comment until June 9, 2009.[34]

3.2 Regional Agreements

3.2.1 Western Regional Climate Action Initiative (WCI)

The WCI is a partnership among seven states, including California, and four Canadian provinces that are implementing a regional, economy-wide cap-and-trade system to reduce global warming pollution. The WCI will cap the region's electricity, industrial, and transportation sectors with the goal of reducing the heat-trapping emissions that cause global warming 15% below 2005 levels by 2020. California is working closely with the other states and provinces to design a regional GHG reduction program that includes a cap-and-trade approach. As

[34] More information is available at: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html

mentioned in the AB 32 Scoping Plan, the ARB plans to develop a cap-and-trade program that will link California and the other member states and provinces.

3.3 California Legislation

California has enacted a variety of legislation that relates to climate change, much of which sets aggressive goals for GHG reductions within the state. However, none of this legislation provides definitive direction regarding the treatment of climate change in environmental review documents. As discussed below, the Office of Planning and Research (OPR) has been directed to develop guidelines for the mitigation of GHG emissions and their effects; ARB must adopt regulations by January 1, 2010. OPR recently released a guidance document, discussed below, for treatment of GHG under CEQA, but this document is purely advisory and serves as guidance only. On January 8, 2009, OPR released Preliminary Draft CEQA Guideline Amendments for Greenhouse Gas Emissions. These amendments propose specific obligations of public agencies to address GHG emissions as part of the CEQA requirements to determine a project's effects on the environment. In addition, on October 24, 2008, ARB released a draft preliminary staff proposal entitled "Recommended Approaches for Setting Interim Significance Thresholds for Greenhouse Gases under the California Environmental Quality Act" (Draft ARB Thresholds). More detail was provided in another document released on December 9th, 2008. The Draft ARB Thresholds provide a framework for developing CEQA significance thresholds for industrial, commercial and residential projects. But, as of the release date of this document, many details remain unresolved and the ARB Thresholds document is still in draft form.

No local, state, or regional agency has promulgated binding regulations for the treatment of GHG analysis or mitigation in CEQA documents. The discussion below provides a brief overview of the ARB and OPR documents and of the primary legislation that relates to climate change which may affect the emissions associated with the proposed project.

3.3.1 Assembly Bill 32 (Statewide GHG Reductions)

The California Global Warming Solutions Act of 2006, widely known as AB 32, requires ARB to develop and enforce regulations for the reporting and verification of statewide greenhouse gas emissions. ARB is directed to set a greenhouse gas emission limit, based on 1990 levels, to be achieved by 2020. The bill sets a timeline for adopting a scoping plan for achieving greenhouse gas reductions in a technologically and economically feasible manner.

The heart of the bill is the requirement that statewide GHG emissions must be reduced to 1990 levels by 2020. California needs to reduce GHG emissions by approximately 28.3% below business-as-usual predictions of year 2020 GHG emissions to achieve this goal. The bill requires ARB to adopt rules and regulations in an open public process to achieve the maximum technologically feasible and cost-effective GHG reductions. Key AB 32 milestones are as follows:

- June 30, 2007—Identification of discrete early action greenhouse gas emissions reduction measures. On June 21, 2007, ARB satisfied this requirement by approving three early action measures. These were later supplemented by adding six other discrete early action measures.

- January 1, 2008—Identification of the 1990 baseline GHG emissions level and approval of a statewide limit equivalent to that level. Adoption of reporting and verification requirements concerning GHG emissions; the regulation was finalized in December 2008. On December 6, 2007, ARB approved a statewide limit on GHG emissions levels for the year 2020 consistent with the determined 1990 baseline.
- January 1, 2009—Adoption of a scoping plan for achieving GHG emission reductions. ARB adopted the Proposed Scoping Plan at its December 11, 2008 meeting. The Proposed Scoping Plan outlines a suite of measures that the ARB intends to implement to reach its 2020 and 2050 goals. These measures include the cap-and-trade program, energy efficiency, vehicle GHG standards, water efficiency programs, and other GHG-reducing strategies.
- January 1, 2010—Adoption and enforcement of regulations to implement the “discrete” early actions.
- January 1, 2011—Adoption of GHG emissions limits and reduction measures by regulation.
- January 1, 2012—GHG emissions limits and reduction measures adopted in 2011 become enforceable.

3.3.2 Executive Order S-3-05 (Statewide GHG Targets)

California Executive Order S-03-05 (June 1, 2005) mandates a reduction of GHG emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050. Although the 2020 target is the core of AB 32, and has effectively been incorporated into AB 32, the 2050 target remains the goal of the Executive Order.

3.3.3 Low Carbon Fuel Standard (LCFS)

Executive Order S-01-07 (January 18, 2007) requires a 10% or greater reduction in the average fuel carbon intensity for transportation fuels in California regulated by ARB. ARB identified the LCFS as a Discrete Early Action item under AB 32, and the draft regulation was released on October 10, 2008.

3.3.4 Senate Bill 1368 (GHG Emissions Standard for Baseload Generation)

Senate Bill (SB) 1368 prohibits any retail seller of electricity in California from entering into a long-term financial commitment for baseload generation if the GHG emissions are higher than those from a combined-cycle natural gas power plant. This performance standard applies to electricity generated out-of-state as well as in-state, and to publicly owned as well as investor-owned electric utilities.

3.3.5 Assembly Bill 1493 (Mobile Source Reductions)

AB 1493 requires ARB to adopt regulations by January 1, 2005, to reduce GHG emissions from noncommercial passenger vehicles and light-duty trucks of model year 2009 and thereafter.

The bill requires the California Climate Action Registry to develop and adopt protocols for the reporting and certification of greenhouse gas emissions reductions from mobile sources for use by ARB in granting emission reduction credits. The bill authorizes ARB to grant emission reduction credits for reductions of greenhouse gas emissions prior to the date of enforcement of regulations, using model year 2000 as the baseline for reduction.

In 2004, ARB applied to the USEPA for a waiver under the federal Clean Air Act to authorize implementation of these regulations. The waiver request was formally denied by the USEPA in December 2007 after California filed suit to prompt federal action. In January 2008 the State Attorney General filed a new lawsuit against the USEPA for denying California's request for a waiver to regulate and limit GHG emissions from these automobiles. In January 2009, President Barack Obama issued a directive to the USEPA to reconsider California's request for a waiver. Written comments will be accepted by USEPA until April 6, 2009. While the decision is not yet overturned, the USEPA is expected to approve the waiver to implement AB 1493.

3.3.6 Senate Bills 1078 and 107 (Renewables Portfolio Standard)

Established in 2002 under Senate Bill 1078 and accelerated in 2006 under Senate Bill 107, California's Renewables Portfolio Standard (RPS) requires retail suppliers of electric services to increase procurement from eligible renewable energy resources by at least 1% of their retail sales annually, until they reach 20% by 2010.

3.3.7 Executive Order S-14-08 (Renewables Portfolio Standard)

California Executive Order S-14-08 (November 11, 2008) mandates retail suppliers of electric services to increase procurement from eligible renewable energy resources to 33% by 2020. This is a further increase in RPS over Senate Bills 1078 and 107.

3.3.8 Senate Bill 375 (Land Use Planning)

SB 375 provides for a new planning process to coordinate land use planning and regional transportation plans and funding priorities in order to help California meet the GHG reduction goals established in AB 32. SB 375 requires regional transportation plans, developed by Metropolitan Planning Organizations (MPOs), including the Metropolitan Transportation Commission (MTC) relevant to the project area, to incorporate a "sustainable communities strategy" in their regional transportation plans that will achieve GHG emission reduction targets set by ARB. SB 375 also includes provisions for streamlined CEQA review for some infill projects such as transit oriented development. SB 375 will be implemented over the next several years.

SB 375 is similar to the Regional Blueprint Planning Program, established by the California Department of Transit, which provides discretionary grants to fund regional transportation and land use plans voluntarily developed by MPOs working in cooperation with Council of Governments. The Metropolitan Transportation Commission (MTC) is currently developing its 2009 Regional Transit Plan (RTP) with AB 32 goals in mind, and its 2013 RTP will be its first plan subject to SB 375.

3.3.9 Energy Conservation Standards

Energy Conservation Standards for new residential and non-residential buildings were adopted by California Energy Resources Conservation and Development Commission in June 1977 and most recently revised in 2008 (Title 24, Part 6 of the California Code of Regulations [CCF]).[35] Title 24 requires the design of building shells and building components to conserve energy. The standards are updated periodically to allow for consideration and possible incorporation of new energy efficiency technologies and methods. The 2006 Appliance Efficiency Regulations (Title 20, CCR Sections 1601 through 1608), dated December 2006, were adopted by the California Energy Commission on October 11, 2006, and approved by the California Office of Administrative Law on December 14, 2006. The regulations include standards for both federally-regulated appliances and non-federally regulated appliances. While these regulations are now often seen as "business as usual," they do exceed the standards imposed by any other state and reduce GHG emissions by reducing energy demand.

On July 17, 2008, the California Building Standards Commission adopted the nation's first green building standards. The California Green Building Standards Code (proposed Part 11, Title 24) was adopted as part of the California Building Standards Code (Title 24, California Code of Regulations). Part 11 establishes voluntary standards, that will become mandatory in the 2010 edition of the Code, on planning and design for sustainable site development, energy efficiency (in excess of the California Energy Code requirements), water conservation, material conservation, and internal air contaminants.

3.3.10 Senate Bill 97 (CEQA Guidelines)

SB 97 requires that OPR prepare guidelines to submit to the California Resources Agency regarding feasible mitigation of GHG emissions or the effects of greenhouse gas emissions as required by CEQA. The Resources Agency is required to certify and adopt these revisions to the State CEQA Guidelines by January 1, 2010. The Guidelines will apply retroactively to any incomplete environmental impact report, negative declaration, mitigated negative declaration, or other related document. On January 8, 2009, OPR released Preliminary Draft CEQA Guideline Amendments for Greenhouse Gas Emissions. As currently proposed, these amendments state that the lead agency should consider the following when assessing the significance of impacts from GHG emissions on the environment:

- Extent the project helps or hinders the goals of AB32.
- Extent project may increase consumption of fuel and energy resources.
- Extent project impacts or emissions exceed any threshold of significance.

No specific methodologies for performing an assessment are indicated, but rather it is left to the lead agency to determine the appropriate methodologies in context of a particular project.

[35] Although new building energy efficiency standards were adopted in April 2008, these standards do not go into effect until 2009. Thus, the 2005 standards that went into effect on October 1, 2005 remain the current Title 24 standards.

The proposed amendments state that lead agencies should consider all feasible means of mitigating greenhouse gas emissions that substantially reduce energy consumption or GHG emissions. These potential mitigation measures may include carbon sequestration. If off-site or carbon offset mitigation measures are proposed they must be part of reasonable plan of mitigation that the agency itself is committed to implementing. No threshold of significance or any specific mitigation measures are indicated.

3.3.11 Office of Planning and Research Advisory on CEQA and Climate Change

In June 2008, the OPR published a Technical advisory entitled *CEQA and Climate Change: Addressing Climate Change Through CEQA* (OPR Advisory). This guidance, which is purely advisory, proposes a three-step analysis of GHG emissions:

1. *Mandatory Quantification of GHG Project Emissions.* The environmental impact analysis must include quantitative estimates of a project's GHG emissions from different types of air emission sources. These estimates should include both construction-phase emissions, as well as completed operational emissions, using one of a variety of available modeling tools.
2. *Continued Uncertainty Regarding "Significance" of Project-Specific GHG Emissions.* Each EIR document should assess the significance of the project's impacts on climate change. The OPR Advisory recognizes uncertainty regarding what GHG impacts should be determined to be significant and encourages agencies to rely on the evolving guidance being developed in this area. According to the OPR Advisory, the environmental analysis should describe a "baseline" of existing (pre-project) environmental conditions, and then add project GHG emissions on to this baseline to evaluate whether impacts are significant.
3. *Mitigation Measures.* According to the OPR Advisory, "all feasible" mitigation measures or project alternatives should be adopted if an impact is significant, defining feasibility in relation to scientific, technical, and economic factors. If mitigation measures cannot sufficiently reduce project impacts, the agency should adopt whatever measures are feasible and include a fact-based statement of overriding considerations explaining why additional mitigation is not feasible. OPR also identifies a menu of GHG emissions mitigation measures, ranging from balanced "mixed use" master-planned project designs to construction equipment and material selection criteria and practices.

In addition to this three-step process, the OPR Advisory contains more general policy-level guidance. It encourages agencies to develop standard GHG emissions reduction and mitigation measures. The OPR Advisory directs ARB to recommend a method for setting the GHG emissions threshold of significance, including both qualitative and quantitative options.

3.3.12 ARB Preliminary Draft Proposal: Recommended Approaches for Setting Interim Significance Thresholds for Greenhouse Gases Under the California Environmental Quality Act (Draft ARB Thresholds)

In October 2008, ARB released a draft proposal for identifying CEQA thresholds of significance for industrial, commercial and residential developments. These were updated in December

2008, by the release of draft preliminary guidelines on performance standards. The Draft ARB Thresholds propose a framework for developing thresholds of significance that rely upon the incorporation of a variety of performance measures to reduce GHG emissions associated with a project, as well as a numerical threshold of significance above which a project must include detailed GHG analysis in an EIR and incorporate all feasible mitigation measures. Although ARB proposed a 7,000 tons-per-year threshold for industrial projects, a numerical threshold for commercial and residential projects was not proposed. In addition, the Draft ARB Thresholds incorporate SB 375 by providing that commercial and residential projects that comply with a previously approved plan, which, essentially, satisfies SB 375 and for which a certified final CEQA document has been prepared, is presumed to have a less than significant impact related to climate change. There have been no updates in the ARB thresholds since December, and their future development is unclear.

3.4 Local Air Quality Management District (BAAQMD) Policies

BAAQMD has no specific GHG emissions reduction goals or policies. The BAAQMD is currently updating its CEQA guidelines for significance thresholds, and may be including thresholds for GHG emissions in its update.

3.5 Sonoma County Policies

In October, 2008, Sonoma County released a Community Climate Action Plan which sets a target for reducing GHG emissions 25% below 1990 levels by 2015. The County expects to achieve the bulk of the emission reductions in three broad categories: energy efficiency, renewable energy production, and transportation, which are expected to reduce emissions below business as usual projects by 4%, 15%, and 17%, respectively.

3.6 City of Rohnert Park Policies

The City of Rohnert Park, within which the SMV development will be built, has a Green Building Ordinance which requires individual buildings to comply with the LEED Rating System for commercial buildings and the GreenPoint Rated System for residential buildings.[36,37] The LEED Rating system and GreenPoint Rated program emphasize resource conservation, indoor air quality, water conservation, community, and energy efficiency.

[36] The U.S. Green Building Council operates the LEED Rating Systems. More information is available at: http://www.usgbc.org/

[37] More information on GreenPoint Rated for new and existing homes is available at: http://www.builditgreen.org/greenpoint-rated

4 Greenhouse Gas Inventory

This section describes the methods that ENVIRON International Corporation (ENVIRON) used to estimate GHG emissions from SMV after development and full build out. It includes some aspects that are fully within the control of Codding Enterprises, such as grading and the placement of utilities; some aspects that are in control of the individuals building the houses and commercial buildings, such as construction emissions; and some aspects for which control over emissions is shared by the developers and the residents, such as emissions from traffic by the development's future residents and employees in the commercial areas. In addition, an estimate of "life-cycle" GHG emissions (i.e., GHG emissions from the processes used to manufacture and transport materials used in the buildings and infrastructure as well as renewable energy systems) is presented. This estimate is to be used for comparison purposes only and is not included in the final inventory as these emissions would be attributable to other industry sectors under AB 32. The inventory does not consider GHG emissions from most sources outside of SMV that may indirectly service the residents that would be covered by other GHG emissions inventories or whether the emissions from the development are "new" in the sense that, absent the development, the emissions may not occur. However, emissions from water use and construction worker commuting are included. Each aspect of the GHG inventory is described in this section. Actual GHG emissions at full build-out at SMV are expected to be substantially lower due to regulatory developments; therefore, the GHG emissions reported in this section are a conservative estimate.

4.1 Evaluation of "New" Emissions

Given the global nature of GHG impacts, it is difficult to determine which emissions from a given project are "new" on a global scale. As described in this section, there are methods of estimating emissions from certain aspects of projects, such as that from the additional vehicle travel associated with the project. However, it is not clear how to determine what proportion of those emissions are truly additional, or new, in the global sense, or what proportion of those emissions would have occurred globally without the project.

Analyses for evaluating the airborne criteria pollutant impacts of new projects for inclusion in environmental documents have already, in a sense, addressed the issue of what is "new". However, the impacts of GHG emissions differ from those of criteria pollutants in that they are a function of global concentrations rather than local concentrations and, therefore, specific locations of where emissions occur is less important than for criteria pollutants. The calculation of "project" criteria pollutants (oxides of nitrogen, sulfur oxides, carbon monoxide, volatile organic compounds, lead, and particulate matter) in air quality emissions inventories for use in EIRs has a long history. The South Coast Air Quality Management District (SCAQMD) first published a comprehensive manual on the analysis of air quality impacts in 1993, and the Bay Area Air Quality Management District (BAAQMD) followed in 1999. Other smaller districts have prepared detailed guidance documents that describe the methods that should be used to calculate emissions inventories for EIRs from projects, including residential and commercial projects.

The goal of estimating emissions of criteria pollutants from projects is to understand whether there are significant new emissions in California's air basins, which have a limited ability to absorb additional criteria pollutant emissions without adverse air quality impacts. A review of how air quality analyses typically address the issue of whether emissions are "new" is instructive as to how to address the emissions of GHGs. However, unlike with criteria pollutants, the impacts of GHG emissions are a function of their global concentrations, rather than local concentrations. Thus, the question of whether or not a project's GHG impacts are significant, both on a project basis and on a cumulative basis, must be asked based on global, rather than basin-wide, considerations.

When evaluating the air quality impacts for a new project, such as a residential development, the vehicular emissions associated with the residents as they work and shop within the basin are counted as new emissions in traditional air quality analyses, even if those new residents would have moved from another house in the same air basin. The typical rationale for this approach is that the new residential development represents growth in the basin. As a result, all emissions associated with its residents' vehicle travel should be counted as new emissions, even if this might lead to some over-counting of criteria pollutant emissions from the project.

World rankings of nations' GHG emissions generally depend on which gases are accounted for, and whether land use changes are considered. Without considering land use changes, in recent years, the US has been the top GHG-emitting country in the world. When all of the developed countries are grouped together, they contribute approximately 52% of world-wide GHG emissions.[38]

To understand the global scale impact of GHGs, it is useful to understand that the increase of new GHG emissions globally is caused by economic and population growth. Emission growth rates are the highest among developing countries. While GHG emissions in developed countries were unchanged over the 1990-2002 period, emissions increased by 47% in developing countries during that same time period. Emissions in China grew about 50% during that time period -- preliminary estimates show that China's GHG emissions increased 35% in 2003 and 2004 alone. This increase in developing country GHG emissions is due to the increasing demand for higher standards of living as a result of GDP growth, requiring more vehicles and greater electricity demand. Also, developing countries often lack the technology or capital to utilize energy efficient products or to construct cleaner burning power plants. GHG emissions in China are growing slightly faster than primary energy use as the fuel mix increasingly favors coal, a high-carbon fuel. China accounts for 39% of the projected increase between 2004 and 2030, and will overtake the United States as the world's biggest emitter before 2010.[39]

38 Baumert, K.A., T. Herzog, J. Pershing. 2005. Navigating the Numbers: Greenhouse Gas Data and International Climate Policy. (http://www.wri.org/climate/pubs_description.cfm?pid=4093)

39 http://www.iea.org/textbase/weo/fact_sheets/fs_GlobalEnergyTrends.pdf (accessed June 12, 2007) *World Energy Outlook 2006: Fact Sheet- Global Energy Trends The World's Energy Future: Where Are We Headed?*

In the developed world, GHG increases are directly tied to population growth. Therefore, it makes sense to consider operational emissions (including vehicular emissions) from new residences as growth, as residences are rarely removed from the housing supply once constructed. There are exceptions, such as when one housing development replaces another, and, in those cases, the replacement residential development need not be considered growth.

However, it is not clear that non-residential (i.e. office space, retail space, and industrial buildings) development should be considered new growth for vehicular travel purposes. To the extent that non-residential development serves existing residential development, its vehicular travel may not be new. For instance, if the new non-residential area serves an area with a high residential/ non-residential balance, then this new non-residential growth will reduce shopping and work trip lengths and will reduce GHG emissions associated with mobile sources. If, however, the new non-residential area results in longer trips for its workers and shoppers than they would have previously made, then it adds GHGs emissions. Non-residential development that could potentially increase VMT would be facilities that draw trips from far away that otherwise would not be made. A theme park, for example, may be viewed as such a development.

In this report, it is assumed that the new non-residential area serves an area with a high residential/non-residential balance. Therefore, this new non-residential growth likely will reduce shopping and work trip lengths from existing residences, and can reduce GHG emissions associated with mobile sources.

The approach described above is different than that for criteria emissions. For criteria pollutants, if new emissions move into the basin, although there is a reduction in criteria emissions elsewhere, these emissions are new to the basin and therefore counted. For GHGs, if the emissions simply moved from one basin to another, the emissions would not be new on a global scale. To evaluate the sustainability of new non-residential developments, one must ask if the shoppers' and workers' travel distances to the new non-residential development are longer or shorter than the distances those same individuals currently travel to their non-residential areas.

To the extent that new non-residential development serves new residential development, much of the non-residential vehicle travel would already be counted in the evaluation of the new residential development. Although the vehicle trips would be already counted elsewhere, the operational emissions from heating and cooling the non-residential areas would be considered to be new, as there are new non-residential buildings that goes along with growth in residential areas.

Accordingly, GHG emissions from VMT serving non-residential areas will only be counted if the non-residential areas contribute to greater VMT as a result of their locations. If the non-residential development lowers VMT, then it will be considered to have a zero or negative GHG contribution as a result of the fact that it has generated shorter operational vehicle trip lengths than would have otherwise occurred. It should be noted that as SMV is a mixed use community, this issue does not directly affect SMV VMT calculations; all VMT from SMV residents are calculated regardless of destinations internal or external to the development or purpose of trip.

4.2 Units of measurement: Tonnes of CO_2 and CO_2e

The term "GHGs" includes gases that contribute to the natural greenhouse effect, such as CO_2, CH_4, N_2O, and water, as well as gases that are only man-made and that are emitted through the use of modern industrial products, such as hydrofluorocarbons (HFCs) and CFCs. The most important greenhouse gas in human-induced global warming is CO_2. While many gases have much higher GWPs than CO_2, CO_2 is emitted in such vastly higher quantities that it accounts for 85% of the GWP of all GHGs emitted by the United States.[40]

The effect each of these gases has on global warming is a combination of the volume of their emissions and their GWP. GWP indicates, on a pound for pound basis, how much a gas will contribute to global warming relative to how much warming would be caused by the same mass of CO_2. CH_4 and N_2O are substantially more potent than CO_2, with GWPs of 21 and 310, respectively. GHG emissions are typically measured in terms of mass of CO_2e. CO_2e are calculated as the product of the mass of a given GHG and its specific GWP.

In many sections of this report, including the final summary sections, emissions are presented in units of CO_2e either because the GWPs of CH_4 and N_2O were accounted for explicitly, or the CH_4 and N_2O are assumed to contribute a negligible amount of GWP when compared to the CO_2 emissions from that particular emissions category.

In this report, "tonnes" will be used to refer to metric tonnes (1,000 kilograms). "Tons" will be used to refer to short tons (2,000 lbs).

Additionally, exact totals presented in all tables and report sections may not equal the sum of components due to independent rounding of numbers.

4.3 Resources

To estimate GHG emissions from SMV, ENVIRON directly or indirectly relied primarily on five different types of resources: emissions estimation guidance from government-sponsored organizations, government-commissioned studies of energy use patterns, energy surveys by other consulting firms, emissions estimation software, and building energy modeling software. These sources are described below.

4.3.1 Emissions Estimation Guidance

This inventory was developed using guidance from two government-sponsored organizations to assist in the estimation of GHG emissions. The first is the CCAR, which was established by the California Legislature to assist willing parties in estimating and recording their GHG emissions to

[40] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004, U.S. Environmental Protection Agency. Available online at: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBSC3/$File/06_Complete_Report.pdf

use as a baseline for meeting future emissions reduction requirements. Publications by the CCAR include not only recommendations on how to compile a GHG emissions inventory, but also relevant data on energy use and emissions that are utilized in this protocol. The second organization is the IPCC, which was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The IPCC's main role is to assess information on climate change which is synthesized in IPCC reports, including methodology reports. These reports also include relevant emission factors and specific scientific data that can be used to estimate GHG activities from various activities.

4.3.2 Emissions and Energy Use Studies

For estimating emissions based on electrical and natural gas energy use, literature information on patterns of energy use must often be employed. Studies commissioned by the United States Energy Information Administration (EIA) and the CEC provide data on energy use patterns associated with municipal activities, natural resource distribution, and other activities that will take place in SMV. These data were used to estimate energy use patterns which were applied to the specific characteristics of SMV to estimate GHG emissions. In addition to EIA and CEC studies, studies performed by individual municipalities or scientific organizations are also used in this report.

4.3.3 Emissions Estimation Software

The ARB, the SCAQMD, and other public and private organizations have developed several software programs to facilitate the calculation of emissions from construction, motor vehicles, and urban developments by streamlining emissions estimation from these sources. This inventory was developed using several models to estimate GHG emissions from the SMV development. These are the OFFROAD2007 model, the EMFAC model, the URBEMIS model, the Building America Research Benchmark Definition model, the Micropas model, and the WARM model. The features of each of these models are described below.

> OFFROAD – OFFROAD2007 is the most recent version of a model developed by the ARB to estimate the activity and emissions of off-road mobile emissions sources, such as construction equipment. OFFROAD contains a database of default values for horsepower, load factor, and hours per day of operation and can calculate emission factors based on the type of equipment and year of use.
>
> EMFAC – EMFAC, also developed by ARB, compiles real fleet data on the county-level for the state of California, including vehicle model year distributions, vehicle class (e.g., light-duty auto (LDA), medium-duty truck, heavy-heavy-duty truck) distributions, and emission rate information to generate fleet-average emission factors for most criteria pollutants and CO_2. EMFAC2007 is the newest version of the program. Emission factors from EMFAC depend on the vehicle class, vehicle technology, speed, year of operation, average ambient air temperature, and relative humidity.
>
> URBEMIS – The URBEMIS software was created by SCAQMD, although it is used by other air districts as well. It estimates emissions associated with different aspects of

urban development. The Operational Data module in URBEMIS calculates emissions from mobile sources operating during the use of a development based on emission factors from EMFAC and traffic use information specific to a development. Mobile source emissions during the construction phase are calculated separately in the construction module of URBEMIS. URBEMIS provides county, air district / air basin, or state wide averages for number of daily trips per housing unit and per student at an elementary school in the absence of more specific information from traffic engineers. URBEMIS also provides air district-specific default values for vehicle fleet characteristics (vehicle class distribution and technology categories) and travel conditions (average trip length, trip speed, and relative frequency of each type of trip). URBEMIS (Version 9.2.4), uses EMFAC2007 emission factors and calculates CO_2 emissions using District-specific default parameters for various inputs including vehicle fleet characteristics and travel conditions.

In addition to mobile source emissions, URBEMIS can also calculate emissions associated with the construction phase of a development and emissions from area sources, such as fireplaces, once the development is operational. The URBEMIS construction module enables separate emissions calculations from each of the three typical stages of any construction project: demolition, site grading, and building construction. Based on the timing of construction and size of the development, URBEMIS defaults can be used to estimate emissions. Alternatively, the user can override these defaults by entering specific information about the construction project, such as what types and numbers of equipment are going to be used. In terms of area sources, URBEMIS is equipped to estimate GHG emissions from three types of GHG-emitting area sources based either on program defaults or more specific project information inputted by the user. These uses are natural gas fuel combustion, hearth fuel combustion, and landscaping equipment.

Building America Research Benchmark Definition– Building America Research Benchmark Definition (BARBD) was developed by NREL in consultation with home developers and builders within the Building America Program. This benchmark tool was developed to provide a means for tracking progress toward residential energy savings. The model includes a series of user profiles, intended to represent the behavior of a typical set of occupants. This benchmark is frequently updated with the most recent benchmark model released December 20, 2007. This information was used to determine the energy use for appliances and plug in energy use in homes.

Micropas – Micropas 7.3[41] is a building energy efficiency modeling package approved by the California Energy Commission as a 2005 Title 24 residential ACM. The Micropas software calculates the energy use per square foot per year and the Time Dependent

[41] Micropas version 7.3 is available for purchase at: http://www.micropas.com/

Valuation (TDV) of the energy use per square foot per year to determine Title 24 compliance. Micropas is typically used for residential buildings.

WARM – WAste Reduction Model (WARM) was developed by the USEPA to track GHG emission reductions from various waste management options. [42,43] It calculates the GHG emissions associated with a baseline waste management strategy, as well as those associated with an alternative strategy that may include source reduction, recycling, composting, combusting or landfilling. WARM then calculates the GHG savings associated with the alternative strategy (as compared with the baseline strategy). ENVIRON has used WARM to compare SMV's waste management strategy to a business-as-usual (BAU) strategy in the following chapter.

4.4 Indirect GHG Emissions from Electricity Use

As noted above, indirect GHG emissions are created as a result of electricity use. When electricity is used in a building, the electricity generation typically takes place offsite at the power plant; electricity use in a building generally causes emissions in an indirect manner. SMV has committed to using renewable energy to power its buildings. Some off-site systems associated with SMV's GHG emissions inventory (i.e. water and wastewater conveyance and treatment) that require electricity will be supplied power by Pacific Gas & Electric (PG&E). Accordingly, these indirect GHG emissions from electricity usage not associated with renewable energy are calculated using the PG&E carbon-intensity factor of 636 lb CO_2e per MW-hr.[44] This emission factor takes into account the current mix of energy sources used to generate electricity for PG&E and the relative carbon intensities of these sources.[45]

4.5 Vegetation Change

This section presents the calculation of the positive and negative GHG emissions associated with vegetation removal and re-vegetation at the SMV development. The majority of land at the development is already either fully developed (northern parcel – light industrial) or graded and drained (southern parcel). Thus, vegetation change is expected to be small upon full build-out of the development. The permanent removal of existing vegetation can contribute to net GHG increases by reducing existing carbon sequestration capacity.[46] Areas that are temporarily

[42] WARM is available for free at: http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html.

[43] WARM is based on the methodology presented in USEPA's *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, available at: http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf.

[44] California Climate Action Registry (CCAR) Database. Pacific Gas and Electric Company PUP Report. 2007.

[45] When calculating indirect emissions due to electricity usage, it is important to consider that indirect emissions from using a given amount of electricity will vary with the fuel-mix used to produce electricity. For example, CO_2 emissions per kW-hr from a coal-fired power plant are significantly higher than CO_2 emissions per kW-hr from a natural gas-fired power plant. Therefore, to most accurately estimate GHG emissions from the SMV development, the carbon intensity of the specific mix of energy sources PG&E uses to generate electricity was used to calculate emissions since PG&E is the most likely source of electricity for SMV.

[46] In this section, it is assumed that all mature land-types (at least 20 years old) are at steady-state. See The World Resource Institute (WRI) "Land Use, Land-Use Change, and Forestry Guidance for GHG Project Accounting" protocol available online at: http://www.ghgprotocol.org/DocRoot/97hb6BCSAAG2bImO7c9d/LULUCF%20Final.pdf

disturbed but re-vegetated with the same vegetation type are assumed to have no net impact. Following completion of the SMV project, many privately owned areas will become re-vegetated with trees, shrubs and other vegetation. These areas could potentially sequester more CO_2 from the atmosphere than was sequestered pre-development. The difference between the total before-development sequestered CO_2 and the after-development sequestered CO_2 is the one-time CO_2 released from clearing the vegetation less the CO_2 sequestered by new plantings.[47] The overall CO_2 emissions due to vegetation change will result from two processes: 1) the change in the amount of CO_2 sequestered by vegetation, which would lead to a one-time GHG release, and 2) the amount that can be expected to be sequestered by new plantings. Both issues are discussed in this section.

In this section of this report, the units CO_2 and CO_2e are used interchangeably. CH_4 and N_2O are assumed to contribute a negligible amount of GWP when compared to the CO_2 emissions from vegetation change.

4.5.1 Quantifying the One-Time Release by Changes in Carbon Sequestration Capacity

The one-time release of GHGs due to permanent changes in carbon sequestration capacity was calculated using the following four steps:[48]

1. Identify and quantify the change in area of various land types due to the development (i.e. alluvial scrub, non-native grassland, agricultural, etc.). – These area changes include not only the area of land that will be converted to houses, but also areas disrupted by the construction of utility corridors, water tank sites, and associated borrow and grading areas. Areas temporarily disturbed that will eventually recover to become vegetated will not be counted as vegetation removed as there is no net change in vegetation or land use.[49]
2. Estimate the biomass associated with each land type. – For the purposes of this report, ENVIRON has listed the land types that are present at the SMV development site and characterized them using the available general vegetation types found in the IPCC publication Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines).[50] This characterization is shown in Table 4-1. The general IPCC vegetation types are as follows:
    - Forest Land;
    - Grass Land;
    - Wetland;
    - Cropland and

[47] In this section we assume that mature ecosystems do not have a net influx or outflux of carbon.
[48] This section follows the IPCC guidelines, but has been adapted for ease of use for the SMV development.
[49] This assumption facilitates the calculation as a yearly growth rate and CO_2 removal rate does not have to be calculated. As long as the disturbed land will indeed return to its original state, this assumption is valid for time periods over 20 years.
[50] Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

- Settlements.

California vegetation is heavily dominated by scrub and chaparral vegetation which may not be accurately characterized by default forest or grass land properties. Consequently, ecological zones and biomass based subdivisions identified in the IPCC Guidelines were used to sub-categorize the vegetation as tree or scrub dominated. The biomass values for each vegetation type are based on these categories which relate the SMV vegetation to the IPCC vegetation types. Forest land, grass land and crop land categories and subcategories were used to determine the CO_2 emissions resulting from land use impacts at SMV.

3. Calculate CO_2 emissions from the net change of vegetation. – When vegetation is removed, it may undergo biodegradation,[51] or it may be combusted. Either pathway results in the carbon (C) present in the plants being combined with oxygen (O_2) to form CO_2. To estimate the mass of carbon present in the biomass, biomass weight is multiplied by the mass carbon fraction, 0.47. [52] The mass of carbon is multiplied by 3.67[53] to calculate the final mass of CO_2, assuming all of this carbon is converted into CO_2. The results of this calculation are shown in Table 4-2 for each type of vegetation.
4. Calculate CO_2e emissions from green waste piles. – Codding Enterprises will vegetate some SMV area currently covered by green waste composting piles. Biogenic emissions from green waste composting are mainly composed of aerobic/anaerobic degradation products. Non-biogenic emissions from green waste composting are mainly emissions resulting from vehicle use to transport the waste. Green waste piles are also responsible for carbon sequestration through carbon storage and the conversion of some of the waste to humus. Removal of green waste composting piles will result in net CO_2e emissions, because of the loss of ability to sequester CO_2. Biogenic emissions of CO_2, being a part of the natural cycle, are not included in the inventory as a conservative measure. However, anaerobic emissions of CH_4, as they are a result of man-made activities, are included in the inventory. As non-biogenic emissions constitute a negligible portion of the emissions, they are also not included in the inventory as a conservative measure. The results of these calculations are shown in Tables 4-3 and 4-4.
5. Calculate the overall change in sequestered CO_2. – For all types of land that change from one type of land to another,[54] initial and final values of sequestered CO_2 are calculated using the equation below.

Overall Change in Sequestered CO_2 [tonne CO_2]

[51] Cleared vegetation may also be deposited in a landfill or compost area, where some anaerobic degradation which will generate CH_4 may take place. However, for the purposes of this section, we are assuming that only aerobic biodegradation will take place which will result in CO_2 emissions only.
[52] The fraction of the biomass weight that is carbon. Here, a carbon fraction of 0.47 is used for all vegetation types from IPCC (2006), default forestland and agricultural land ratio. CCAR assumes a similar value of 0.5 in its Forest Selector Protocol.
[53] The ratio of the molecular mass of CO_2 to the molecular mass of carbon is 44/12 or 3.67.
[54] For example from forestland to grassland, or from cropland to permanently developed.

$$= \sum_i (SeqCO_2)_i \times (area)_i - \sum_j (SeqCO_2)_j \times (area)_j - (SeqCO_2)_{gw} \times (Mass)_{gw}$$

Where:

$SeqCO_2$	=	mass of sequestered CO_2 per unit area [tonne CO_2/acre]
area	=	area of land for specific land use type [acre]
i	=	index for final land use type
j	=	index for initial land use type
$SeqCO_{2gw}$	=	mass of sequestered CO_2 per tonne of green waste [tonne CO_2/tonne green waste]
$Mass_{gw}$	=	mass of green waste [tonne green waste]

Table 4-1 shows the effective change in the amount of sequestered CO_2 due to the change in land use of the developed area for each land type. By developing on previously graded land, SMV does not release CO_2 due to land use changes as would happen if the development was built at a vegetated location. The total equivalent CO_2 emissions attributable to the net change of vegetation, shown in Table 4-1, are approximately 48 tonnes. The total CO_2e emissions from green waste piles attributable to man-made activity (i.e., CH_4 emissions only), shown in Table 4-4, are approximately 4 tonnes. The total CO_2 sequestered (one-time) by green waste piles, shown in Table 4-4, are approximately 158 tonnes.

4.5.2 Calculating CO_2 Sequestration by Trees

Planting individual trees on residential property and elsewhere in SMV will sequester CO_2. Changing vegetation as described above results in a one-time carbon-stock change. Planting trees is also considered to result in a one-time carbon-stock change. Table 4-5 presents default annual CO_2 sequestration rates on a per tree basis, based on values provided by the IPCC. An average of 0.035 tonne CO_2 per year per tree can be assumed for trees planted, if the tree type is not known.

Urban trees are only net carbon sinks when they are actively growing. The IPCC assumes an active growing period of 20 years. Thereafter, the accumulation of carbon in biomass slows with age, and will be completely offset by losses from clipping, pruning, and occasional death. Actual active growing periods are subject to, among other things, species, climate regime, and planting density. In this report, the IPCC default value of 20 years will be assumed. Note that trees may also be replaced at the end of the 20-year cycle, which would result in additional years of carbon sequestration. However, this would be offset by the potential net release of carbon from the removal of the replaced tree.

Approximately 2,739 net new trees will be planted in SMV community.[55] Planting these trees in the community will sequester approximately 2,194 tonnes CO_2. This was calculated by using the following sequestration rates for various tree species:

- Soft maple: 0.043 tonne CO_2 per year per tree
- Hardwood maple: 0.052 tonne CO_2 per year per tree
- Mixed hardwood: 0.037 tonne CO_2 per year per tree
- All other species (average tree): 0.035 tonne CO_2 per year per tree

ENVIRON assumed a growth period of 20 years.

This sequestration brings the net CO_2 emissions from vegetation to: 203 tonnes (land use changes) – 2,194 tonnes (2,739 net new trees in the community) = 1,991 tonnes (or a net decrease in the amount of CO_2 released. The net CO_2 emissions from vegetation changes are presented in Table 4-6.

4.6 Construction Activities

This section describes the estimation of GHG emissions from construction activities at SMV. Based on the SMV Project Description[56], construction will occur over six phases, 1A, 1B, 1C, 1D, 2, and 3, over 12 to 20 years. There are six major construction sub-phases for each phase of this urban development: demolition, grading, underground construction, sub-grade and rock, building construction and paving. GHG emissions from these construction sub-phases are largely attributable to fuel use from construction equipment, worker commuting, and vendor trips. SMV has committed to using B-20 biodiesel for all construction equipment[57]. B-20 biodiesel is a mixture of 20% biodiesel and 80% diesel. GHG emissions resulting from use of biodiesel are counted as biogenic emissions based on CCAR's GRP[58], hence the GHG emissions resulting from the biodiesel component in B20 biodiesel are not included in the inventory. Biodiesel would account for 20% of total fuel used in construction equipment operations.

CO_2 emissions associated with different aspects of urban development can be estimated using a combination of software programs. The OFFROAD2007[59] and the EMFAC2007[60] models are used to generate emission factor data for construction equipment and motor vehicles,

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[55] Site-specific planting data obtained from Sonoma Mountain Village Project Description. 2008.
[56] Sonoma Mountain Village Project Description, 2008.
[57] Sonoma Mountain Village One Planet Communities Sustainability Action Plan Version 1.3. 2008.
[58] California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009).
[59] California Air Resources Board Mobile Source Emissions Inventory Program. December 2006. http://www.arb.ca.gov/msei/offroad/offroad.htm
[60] Emission Factors (EMFAC2007) model (Version 2.3). November 2006. California Air Resources Board. http://www.arb.ca.gov/msei/onroad/latest_version.htm

respectively. These values serve as inputs for the URBEMIS[61] model, which estimates emissions from several different aspects of urban development including from construction sources based on emission factors and information specific to the development.

Because biodiesel construction equipment generates little to no CH_4 and N_2O, these chemicals are assumed to contribute a negligible amount of GWP when compared to the CO_2 emissions from construction equipment. Accordingly, these chemicals are not considered when estimating CO_2e from biodiesel-fueled equipment. For worker and vendor commuting, CH_4 and N_2O are explicitly calculated when estimating CO_2e.

4.6.1 Estimating GHG Emissions from Construction Equipment

This section describes how emissions from off-road equipment used during demolition, grading, underground construction, sub-grade and rock, building construction and paving are calculated. It was assumed that negligible GHG emissions are produced by architectural painting equipment. It is important to note that GHG calculations are intended to estimate long-term emissions, while air quality emission calculations are intended to estimate worst-case daily scenarios. As such, the methodology presented in this section of the report will be different than the approach listed in the corresponding air quality section.

ENVIRON calculated construction equipment emissions primarily using project specific data provided by Codding. Where data was not available, ENVIRON used URBEMIS default methods and assumptions. Quantities and types of equipment and duration for all construction phases, with the exception of equipment counts for the commercial building phase, were provided by Codding. [62,63]

For commercial building construction equipment, ENVIRON used URBEMIS defaults and methods to estimate equipment quantities and equipment-hours. Following URBEMIS defaults, ENVIRON assumed that each piece of equipment will operate for 8 hours a day during the non-building construction phases (*i.e.*, demolition, grading, underground construction, sub-grade and rock and paving sub-phases.) An equipment-hour is defined as one hour of a piece of equipment being used. Table 4-7 contains specifications for each type of construction equipment (horsepower, load factor, and GHG emission factor) provided by OFFROAD2007 and describes the detailed GHG calculations.

SMV has committed to using B20 biodiesel in an effort to reduce GHG emissions associated with construction. Per guidance from the CCAR General Reporting Protocol, emissions from the diesel and biodiesel portions are calculated separately. Only emissions from the diesel

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[61] Urban Emissions Model (URBEMIS) (Version 8.7 – 2002 / Version 9.2.4 – 2008). Jones & Stokes Associates. Prepared for: South Coast Air Quality Management District. http://www.urbemis.com

[62] The list of equipment used during some construction sub-phases was provided by Kirstie Moore of Codding Enterprises in a pdf file. Received *2009.02.25 Construction Schedule.pdf* on February 25th 2009.

[63] Email from Kirstie Moore of Codding Enterprises received on March 24th 2009.

portion are included in the final GHG emissions inventory since biodiesel is considered to be biogenic. CO_2 emissions for each type of construction equipment were calculated as follows:

*Equipment Emissions$_{biodiesel}$ [grams] = Total equipment-hours * equipment horsepower * load factor*[64] * *0.2 * Emission factor$_{biodiesel}$ [g/bhp-hr]*

*Equipment Emissions$_{diesel}$ [grams] = Total equipment-hours * equipment horsepower * load factor*[65] * *0.8 * Emission factor$_{diesel}$ [g/bhp-hr]*

where:

*Emission factor$_{biodiesel}$ [g/bhp-hr] = Emission Factor$_{diesel}$ [g/bhp-hr] * Emission Factor$_{biodiesel}$*[66] *[kg CO_2/gallon] / Emission Factor$_{diesel}$*[66]*[kg CO_2/gallon]*

Where:

Equipment emissions$_{biodiesel}$	=	CO_2 emissions from use of biodiesel to fuel the equipment [grams CO_2]
Equipment emissions$_{diesel}$	=	CO_2 emissions from use of diesel to fuel the equipment [grams CO_2]
Total equipment-hours	=	Total hours of operation of the equipment over the course of the project [hours]
Equipment horsepower	=	Rated average horsepower of the equipment [bhp]
Load factor	=	Fraction of time the equipment is in use during a typical work day
Emission factor$_{biodiesel}$	=	Biodiesel emission factor on a per brake horsepower-hr basis [g CO_2/bhp-hr]
Emission factor$_{diesel}$	=	Diesel emission factor on a per brake horsepower-hr basis [g CO_2/bhp-hr]
Emission factor$_{biodiesel}$	=	Biodiesel emission factor on a per gallon fuel basis [kg CO_2/gallon fuel]
Emission factor$_{diesel}$	=	Diesel emission factor on a per gallon fuel basis [kg CO_2/gallon fuel]

[64] Load factor is the percentage of the maximum horsepower rating at which the equipment normally operates.
[65] Load factor is the percentage of the maximum horsepower rating at which the equipment normally operates.

The contributions of CH_4 and N_2O to overall GHG emissions are likely small (< 1% of total CO_2e) from diesel construction equipment,[66] and were therefore not included in this calculation. CO_2e emissions from biodiesel use in construction equipment are not included in the inventory as biodiesel emissions are considered biogenic.

The total one-time, non-biogenic GHG emissions from all construction equipment is 6,542 tonnes CO_2e. The total one-time biogenic GHG emissions from all construction equipment is 1,524 tonnes CO_2e. As mentioned above, biogenic emissions are not included in this inventory. The total amount of GHG emissions from demolition equipment is 92 tonnes CO_2e. The total amount of GHG emissions from grading equipment is 292 tonnes CO_2e. The total amount of GHG emissions from underground construction equipment is 1,227 tonnes CO_2e. The total amount of GHG emissions from subgrade and rock equipment is 72 tonnes CO_2e. The total amount of GHG emissions from building construction equipment is a one-time emission of approximately 4,827 tonnes CO_2e. The total amount of GHG emissions from paving equipment is a one-time emission of approximately 32 tonnes CO_2e.

4.6.2 GHG Emissions from Worker Commuting

Emissions from worker commuting are associated with workers involved in the demolition, site grading, building construction, subgrade and rock, and paving sub-phases. Emissions related to trips made by vendors were calculated separately (see Section 4.6.3). GHGs are emitted from worker vehicles in two ways: running emissions, produced by driving the vehicle, and startup emissions, produced by turning the vehicle on. The majority of worker commute emissions are running emissions. Table 4-8 details emission calculations for worker commutes.

Running emissions were calculated using the same general method for the demolition, grading, underground construction, subgrade and rock, building construction and paving sub-phases. Total running emissions from worker commuting during each sub-phase were calculated by estimating the total Vehicle Miles Traveled (VMT) by construction workers, and then multiplying this value by the representative GHG emission factors for the vehicles they are expected to drive. The total VMT by construction workers for a given phase is calculated as follows:

VMT = Number of worker trips x average one-way commute length x 2 commutes/day

For the demolition, grading, underground construction, subgrade and rock, and paving sub-phases, the number of worker trips is equal to 125% of the number of pieces of equipment

[66] California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009). ENVIRON estimates these emissions to be less than 1% of total GHG contributions for diesel fueled equipment.

used. The duration of the sub-phases was obtained from Codding Enterprises.[67] The length of the average one-way commute (13 miles) was provided by Codding Enterprises.[68]

For the building construction phase, the number of worker trips for residential and non-residential building construction was provided by Codding Enterprises.[69]

After total VMT for SMV is calculated, GHG emissions for this development can be calculated from the following equation:

CO_2 emissions = VMT * [0.5 * EF_{LDA} + 0.25 * (EF_{LDT1} + EF_{LDT2})]

Where:

VMT = vehicle miles traveled
EF_{LDA} = emission factor of light duty autos
EF_{LDT1} = emission factor of light duty trucks: up to 6000 GVW (gross vehicle weight)
EF_{LDT2} = emission factor of light duty trucks: up to 8500 GVW

The CO_2 calculation involves the following assumptions:

a. URBEMIS defaults assume that half of the workers commute with light duty trucks (LDTs) and half commute in light duty autos (LDAs).[70]

b. Half of the LDTs were assumed to be type 1 and the other half type 2.

c. The emission factor depends upon the speed of the vehicle. The URBEMIS default value of 30 miles per hour was used.

d. EMFAC emission factors from the year 2009 were used for EF_{LDA}, EF_{LDT1}, and EF_{LDT2}.

Startup emissions are CO_2 emissions associated with the additional energy that it takes to start a cold vehicle and heat the engine. For construction workers during all phases, the startup emissions were calculated using the following equation:

CO_2 emissions from mobile start-up = Worker Trips * [0.5 * $EF_{LDA\text{-}startup}$ + 0.25 * ($EF_{LDT1\text{-}startup}$ + $EF_{LDT2\text{-}startup}$)]

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[67] The list of equipment used during some construction sub-phases was provided by Kirstie Moore of Codding Enterprises in a pdf file. Received 2009.02.25 Construction Schedule.pdf on February 25th 2009.
[68] Email from Kirstie Moore of Codding Enterprises received on March 24th 2009.
[69] Email from Kirstie Moore of Codding Enterprises received on March 24th 2009.
[70] Page A-9 of the URBEMIS user manual.

Where:

Worker Trips = Number of worker one-way trips

$EF_{LDA\text{-}startup}$ = Emission factor for start-up of light duty autos

$EF_{LDT1\text{-}startup}$ = Emission factor for start-up of light duty trucks: up to 6000 GVW

$EF_{LDT2\text{-}startup}$ = Emission factor for start-up of light duty trucks: up to 8500 GVW

The CO_2 calculation from vehicle start-up involves the following assumptions:

a. The number of round trips were equal to the number of worker days,

b. The breakdown in vehicles was 50% light duty autos and 50% light duty trucks,

c. Two engine startups per day with a 12-hour wait before each startup.[71]

The USEPA recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their GWPs.[72] To incorporate these additional GHGs into the calculations, the total GHG footprint was calculated by dividing the CO_2 emissions by 0.95.

Table 4-8 summarizes the emission calculations for worker commutes. The total amount of GHG emissions from worker commuting during all phases is a one-time emission of 6,769 tonnes.

4.6.3 GHG Emissions from Vendor Trips

GHGs emitted from vendor vehicles trips are based on running, startup and idling emissions. Idling emissions were estimated only at residential sites. The number of daily vendor trips for residential building construction was based on estimates provided by Codding Enterprises, and the number of daily vendor trips for non-residential construction was based on the size and type of buildings specified and URBEMIS defaults, which are based on two general land use categories: commercial/retail/school/recreation, and office/industrial. The total round trips are the sum of the following:

2.4 * residential units (based on information from Codding Enterprises)[73]

[71] The emission factor grows with the length of time the engine is off before each ignition.
[72] USEPA. 2005. *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle.* Office of Transportation and Air Quality. February.
[73] Email from Kirstie Moore of Codding Enterprises received on March 24th 2009

0.05 * (commercial/retail/school/recreation sqft)/1000

0.38 * (office/industrial sqft)/1000

The total number of daily round trips is multiplied by the number of work days, one-way trip length (8.9 miles, URBEMIS default) and a factor of 2 to account for roundtrips to give the VMT. After total VMT for SMV is calculated, CO_2 emissions from mobile running for this development can be calculated from the following equation:

CO_2 emissions from mobile running = VMT * $EF_{HHD\text{-}running}$

Where:

VMT = vehicle miles traveled (based on 8.9 miles one-way trip distance)
$EF_{HHD\text{-}running}$ = running emission factor of heavy heavy-duty trucks

The CO_2 calculation involves the following assumptions:

a. URBEMIS defaults assume that vendor trips use heavy heavy-duty trucks (HHDs).[74]

b. The running emission factor depends upon the speed of the vehicle. The URBEMIS default value of 30 miles per hour was used.

c. EMFAC emission factors from the year 2009 were used for $EF_{HHD\text{-}running}$.

Startup emissions are CO_2 emitted from starting a vehicle. Startup emissions for vendor trips were calculated using the following assumptions:

a. The breakdown in vehicles was all heavy heavy-duty trucks,

b. Two engine startups per day with a 12-hour wait before each startup.[75]

Using these assumptions, CO_2 emissions from vehicle start-ups can be calculated using the following equation:

CO_2 emissions from mobile start-up = Vendor Trips * $EF_{HHD\text{-}start\text{-}up}$

Where:

Vendor Trips = Vendor trips estimated based on methodology described above

$EF_{HHD\text{-}start\text{-}up}$ = emission factor for start-up of heavy heavy-duty trucks

[74] Page A-12 of the URBEMIS user manual.
[75] The emission factor grows with the length of time the engine is off before each ignition.

Idling emissions are CO_2 emitted during idling. Idling emissions for vendor trips at residential sites were estimated based on data provided by Codding Enterprises, which results in the following assumption:[76]

a. 31.2 idle-hours per residential unit,

With this assumption, the CO_2 emissions from vendor idling can be calculated with the following equation:

CO_2 emissions from mobile idling = Idle hours * $EF_{HHD\text{-}idling}$

Where:

Idle hours = Idling time estimated based on methodology described above

$EF_{HHD\text{-}idling}$ = emission factor for idling of heavy heavy-duty trucks

The contributions of CH_4 and N_2O to overall GHG emissions are likely small (< 1% of total CO_2e) from diesel vehicles,[77] and were therefore not included in this calculation. .The total amount of GHG emissions from vendor trips during building construction is a one-time emission of 513 tonnes of CO_2e as shown in Table 4-9.

4.6.4 Demolition Hauling

Demolition hauling involves removing material from the site during demolition phases. Codding has committed to stockpiling waste concrete and asphalt at the SMV development site so that demolition hauling emissions are eliminated.[57] This is reflected in the truck count used to estimate emissions.

Table 4-10 shows total one-time GHG emissions for construction, including off-road equipment, worker commuting, and vendor trips to be 13,824 tonnes CO_2e for the SMV development.

4.6.5 Uncertainties in Construction GHG Emissions Calculations

ENVIRON was provided with the phase length and number of each type of construction equipment during construction of buildings, with the exception of the quantities of non-residential building construction equipment, which were estimated using URBEMIS.[78] The number of worker and vendor trips for residential building construction was provided by Codding Enterprises and the number of worker and vendor trips for non-residential construction was

[76] Email from Kirstie Moore of Codding Enterprises received on March 24th 2009

[77] California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009). ENVIRON estimates these emissions to be less than 1% of total GHG contributions for diesel fueled equipment.

[78] The list of equipment used during some construction sub-phases was provided by Kirstie Moore of Codding Enterprises in a pdf file. Received *2009.02.25 Construction Schedule.pdf* on February 25th 2009.

estimated using URBEMIS default values and settings. As such, the values using URBEMIS defaults are somewhat uncertain.

4.7 GHG Emissions Associated with Residential Buildings

Residential buildings include single-family homes of various sizes, attached homes, apartments, and condominiums. Codding Enterprises is committed to providing 100% renewable energy to residential buildings at SMV through the use of photovoltaics, ground-source heat pumps, and solar hot water heaters. Additionally, natural gas will not be allowed for residential cooking. As such, there will be no recurring GHG emissions associated with residential buildings. In support of reducing impacts on the environment, Codding Enterprises has committed to building the residential buildings 30% more energy efficient than 2005 Title 24 Part 6 building standards require. This reduces the amount of renewable energy systems required for SMV.

4.8 GHG Emissions Associated with Non-Residential Buildings

Non-residential buildings include all structures except residences that may exist in a development such as government, municipal, commercial, retail, and office space. Codding Enterprises is committed to providing 100% renewable energy to non-residential buildings at SMV. As such, there will be no recurring GHG emissions associated with non-residential buildings. In support of reducing impacts on the environment, Codding Enterprises has committed to building new non-residential buildings 20% more energy efficient than 2005 Title 24 Part 6 building standards require. In addition, Codding Enterprises has committed to eventually renovating existing non-residential buildings to be 10% more energy efficient than 2005 Title 24 Part 6 building standards require. This reduces the amount of renewable energy systems required for SMV.

4.9 Mobile Sources

ENVIRON estimated GHG emissions based upon all miles traveled by SMV residents regardless of internal or external destinations or purpose of trip. Mobile source emissions from new residences are considered to be growth, as residences are rarely removed from the housing supply once constructed. There are exceptions, such as when one housing development replaces another, and, in those cases, the replacement residential development need not be considered growth.

However, it is not clear that commercial development should be considered new growth for vehicular travel purposes. To the extent that commercial development serves existing residential development its vehicular travel may not be new. For instance, if the new commercial area serves an area with a high residential/commercial balance, then this new commercial growth will reduce shopping and work trip lengths and will reduce GHG emissions associated with mobile sources. If, however, the new commercial area results in longer trips for its workers and residents than they would have previously made, then it adds GHG emissions. Commercial development that could potentially increase VMT would be facilities that draw trips from far away that otherwise would not be made. A theme park, for example, may be viewed as such a development.

In this report, it is assumed that new non-residential (i.e. office space, retail space, and industrial buildings) area serves an area with a high residential/ non-residential balance. Therefore, this new non-residential growth will not, independent of the new residential areas, result in new shopping and work trips. Accordingly, new non-residential space in the SMV development area will not contribute to mobile GHG emissions. However, the emissions from heating and cooling the non-residential areas would be considered to be new, as that would reflect growth in non-residential areas that goes along with growth in residential areas.

Accordingly, GHG emissions from VMT serving non-residential areas will only be counted if the non-residential areas contribute to greater VMT as a result of their locations. It should be noted that as SMV is a mixed use community, this issue does not directly affect SMV VMT calculations; all VMT from SMV residents is calculated regardless of internal or external destinations or purpose of trip.

The CCAR GRP[79] recommends estimating GHG emissions from mobile sources at an individual vehicle level, assuming knowledge of the fuel consumption rate for each vehicle as well as the miles traveled per car. Since these parameters are not known for a future development, the CCAR guidance is too specific to use as recommended.

For mobile sources, CH_4 and N_2O are explicitly calculated, multiplied by their respective GWP, and added to the CO_2 emissions, to result in total CO_2e emissions from mobile sources.

4.9.1 Basic Methodology

The methodology and data used to estimate and separate “new” trips and VMT for a development is evolving and difficult to calculate. This section explains the general approaches used to estimate VMT and GHG emissions made by the residents of SMV. Underlying data for the calculations were taken from three different sources: 1) the City of Rohnert Park’s traffic study, 2) URBEMIS files used in the SMV EIR’s air quality section, and 3) a supplementary traffic analysis provided by Fehr and Peers.[80] A primary approach, which uses the City’s traffic study, and two alternate approaches were used to assess these three sources of information. While all three approaches are discussed here, only the primary approach is reported in the GHG inventory.

Traditional traffic models focus upon designing roads and planning a development such that traffic delays will be avoided during peak travel hours. Traditional traffic analyses also provide the total number of daily vehicles on a road which can then be used to calculate toxic or criteria emissions that may have localized health effects. The steps that must be taken to use the information in a traditional traffic model to describe VMT made by SMV residents are described in this section.

[79] California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009).

[80] The results of the city traffic study and the Fehr and Peers traffic analysis were obtained from John Gard on 3/02/2009. The URBEMIS files were obtained from PBS&J.

The first step is to disaggregate the traffic information that is contained in the traffic study into trips made by SMV residents and trips made by non-SMV residents. The second step is to determine the length of trips made by SMV residents. SMV is a balanced community that is situated within the city of Rohnert Park; most trips that leave the site will have to travel only moderate distances. As such, the more trips that are 'captured' within the community because it is designed to have a good mix of residences, shopping, and work, the lower the VMT. As traditional traffic analysis predicts only weekday driving patterns, the third step is to account for differences in weekend and weekday driving patterns. The fourth step is to take all of these parameters into account and calculate the final VMT from SMV residents. The final step is to use the VMT to calculate GHG emissions.

The basic methodology is to first determine the number of trips and trip lengths by trip type made by residents of SMV. This is where there are differences in data sources used as explained in detail later. The trip calculation may incorporate an assumption of the split in trip types (from home to work (HBW), home to other trips such as shopping and school (HBO), and trips made by residents not starting or ending at home (NHB)). For all trip types, directionality is unimportant. For example, an HBW trip is a trip directly from home to work with no stops in-between, or directly from work to home. An HBO trip is a trip directly from home to shopping or from shopping to home. NHB trips are trips between work and other types of destinations, such as a trip to the bank during one's lunch hour.

Since most traffic studies are conducted for weekday conditions, ENVIRON typically calculates weekend traffic by applying differences between the weekend and the weekday traffic based upon a report by Sonoma Technologies.[81] Weekend traffic is assumed to be 74-79% of the weekly capacity, depending on travel distances.[82]

Once trip rates and trip lengths are estimated, the VMT is determined by multiplying the trip rates by the trip length

VMT = Number of Trips * Trip Length

The CO_2 emissions from mobile sources were calculated with the trip rates, trip lengths and emission factors for running and starting emissions from EMFAC2007 as follows:

CO_2 emissions = VMT * $EF_{running}$

Where:

[81] Sonoma Technology, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

[82] A conservative adjustment for weekend travel was assumed for all the trips since information was not available to distinguish between trips on major highways and trips on small streets. The Sonoma Technology report gives a range of values, but does not present a weighted value, thus a conservative percent reduction in the number of trips was selected.

VMT = vehicle miles traveled
$EF_{running}$ = emission factor for running emissions

The running CO_2 calculation involves the following assumptions:

- The emission factor depends upon the speed of the vehicle. Here, it was assumed that internal trips were 35 miles per hour, and external trips were 60 miles per hour. For non-home-based trips, which occur both internally and externally, the emission factor for an external trip speed of 60 miles per hour was used as a conservative estimate.
- EMFAC emission factors from the year 2030 were used for $EF_{running}$ based on Sonoma County fleet mix.

Startup emissions are CO_2 emitted from starting a vehicle. Startup emissions were calculated as follows:

CO_2 emissions = trips * $EF_{startup}$

Where:

trips = trips made by vehicles
$EF_{running}$ = emission factor for running emissions

Startup emissions were calculated using the following assumptions:

- The number of starts is equal to the number of trips made annually.
- The breakdown in vehicles was EMFAC fleet mix for Sonoma County in 2030.
- The emission factor for startup was calculated based on a conservative assumption of long waits between starts.

Nitrous oxide, CH_4, and HFCs[83] are also emitted from mobile sources. The USEPA recommends assuming that CH_4, N_2O, and HFCs account for 5% of mobile source GHG emissions, taking into account their GWPs.[84] Therefore, CO_2 emissions were divided by 0.95 to account for non-CO_2 GHGs.

4.9.2 Approaches to Traffic Modeling

The following sections discuss in details the use of the three data sources to determine trip rates and VMT for SMV residents. It will present a discussion of the differences and limitations of the different approaches. None of the approaches described below incorporate the effects of

[83] HFCs can be emitted from air conditioning systems.
[84] USEPA. 2005. *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle.* Office of Transportation and Air Quality. February. (http://www.epa.gov/otaq/climate/420f05004.pdf)

a traffic concierge or some of the other innovative aspects of the development, such as the public transportation enhancement of the Project. Accordingly, all three methods may result in an overestimate of emissions from traffic at the Project.

4.9.2.1 Primary Approach

The primary approach used in the GHG emission inventory for SMV utilizes information from the City of Rohnert Park's traffic study prepared by AECOM/DMJM. The City's traffic study was performed to examine impacts from three different projects in Rohnert Park, which also included the Northeast Area Specific Plan and Southeast Specific Plan in addition to SMV. During a review of this traffic study by Fehr and Peers, they noted a difference of opinion in the trip generation rate assumed in the traffic study; as a result, ENVIRON used both the original values and the values proposed by Fehr and Peers to estimate GHG emissions.[85]

This study has two issues in applying it to SMV residential mobile source emissions estimation. First, the analysis only takes into account trips external to SMV and Rohnert Park. This does not capture the shorter length trips that remain within SMV and Rohnert Park and thus the approach may underestimate GHG emissions from mobile sources. Secondly, the analysis also does not account for non-home based trips – trips made by residents of SMV that do not originate nor terminate at a home. The Fehr and Peers analysis, performed to supply information necessary to this study and discussed later as the Alternate Approach 2, shows that these non-home based trips accounts for roughly 23% of total VMT generated by SMV residents Data are not available from the AECOM/DMJM study to account for these differences. Finally, the analysis does not take into account changes in trip rates on the weekends. ENVIRON adjusted the number of daily trips to account for the differences between weekend and weekday traffic based on a report by Sonoma Technologies; weekend capacity is assumed to be 79% of weekday capacity for all travel. ENVIRON used emission factors for vehicles based on EMFAC files for the year 2030 (which represents full build-out) for light duty autos, trucks, motorcycles, and motorhomes for Sonoma County.

Total CO_2e emissions from mobile sources for the primary approach are 11,270 tonnes CO_2e/year.

4.9.2.2 Alternate Approach 1

For the first alternate approach, URBEMIS files generated for the air quality section of SMV's EIR were used to estimate GHG emissions from mobile sources. As discussed above, the trips generated by the residents of SMV represent growth. However, new non-residential areas do not necessarily represent growth since people would already be taking these trips. As a result, only trips generated from the residential land uses were used to determine the GHG emissions

[85] Fehr and Peers determined that the AECOM trip generation estimate is too low because the fitted curve equation, which was used to estimate trips associated with the 1,370 condominium units, is based on a number of units (183) much smaller than the proposed number of units at SMV. Using the fitted curve approach gives 4.3 daily trips per unit. Fehr and Peers felt it was more appropriate to use the average rate, or 5.8 trips per unit.

from SMV. Tables 4-12 and 4-13 show the trips and VMT, respectively, made by SMV residents, as found by applying this assumption to the trip rate and length information in the URBEMIS file for operational activities at full build-out (2030). URBEMIS has the ability to incorporate several options to account for project design features into the base trip rates it estimates. The URBEMIS options selected include pass-by and diverted trips, and adjustment for housing density. The total number of trips based on the trip rate in the URBEMIS file is similar to the number of trips in the primary approach; however, this trip rate includes the internal trips that were missing from the primary approach. The default URBEMIS trip length for Sonoma County was used for each trip type. URBEMIS uses primary trip lengths for home based trips. For those residential non-home-based trips, URBEMIS uses a reduced trip length of 0.1 miles for pass-by trips (trips located next door to each other) and 25% of the primary trip length for diverted trips (trips that deviate from primary trip).

As with the primary approach, the daily trips were adjusted to account for weekend/weekday travel differences, and total CO_2e emissions were estimated using the same EMFAC files for 2030. The first alternate approach gives mobile source GHG emissions of 8,203 tonnes CO_2e per year. The total GHG emissions for the first alternate approach are summarized in Table 4-13.

4.9.2.3 Alternate Approach 2

The second alternate approach used the traffic analysis prepared by Fehr and Peers, which focuses on SMV. The traffic analysis by Fehr and Peers drew assumptions from a variety of sources including the Bay Area Travel Survey (BATS), census data, National Cooperative Highway Research Program (NCHRP) Report 365, and output from the SCTA traffic model.

The trips and VMT calculated include all trips and VMT generated by SMV residents. The trip rate is meant to capture both internal trips and non-home-based trips unlike the primary method. This results in a larger number of trips made by SMV than either the primary approach or alternate approach 1 which drives the increased GHG emission for this approach. The trip calculation incorporates an assumption of the split in trip types (from home to work (HBW) 22%, home to other trips such as shopping and school (HBO) 57%, and trips made by residents not starting or ending at home (NHB) 21%.[86] The external/internal ratio for each trip type is important because external trips tend to be longer than internal trips. The overall internalization percentage, 20%, presented by Fehr and Peers is used in this climate change analysis.

Since the Fehr and Peers traffic study was conducted for weekday conditions, ENVIRON calculated weekend traffic by applying differences between the weekend and the weekday

[86] Based on findings in the Bay Area Travel Survey, 2000, for Sonoma County.

traffic based upon a report by Sonoma Technologies.[87] Weekend traffic was assumed to be 74-79% of the weekly capacity, depending on travel distances.[88]

According to the methodology above, each SMV dwelling unit generates 19,329 VMT per year. The total VMT in this alternate approach for SMV residents is 36,571,367 as shown in Table 4-14. This VMT was multiplied by the appropriate emission factors in the next section to calculate GHG emissions from mobile sources at SMV. Table 4-14 shows the CO_2 emissions from vehicles associated with residents of SMV as calculated according to the methodology described above, which is estimated to be 14,952 tonnes CO_2e per year.

4.9.2.4 GHG Emission Reductions due to Mode Shift and Compact Design

It is likely that a portion of the SMV residents would take public transportation when travelling out of SMV. Codding Enterprises has committed to enhancements of the public transportation in the region, including a connection to the approved commuter rail station on East Cotati Avenue and a shuttle between SMV, Sonoma State University, and the new rail station. Further, as part of its compact design, jobs, restaurants, and services will be located within close proximity to housing, enhancing opportunities for walking and bicycling.

Studies have shown that compact developments generally have significantly lower VMT than conventional developments. VMT is in general tied to the density of a development's residences. According to an extensive literature review, Ewing[89] concludes that, "doubling urban densities results in a 25-30% reduction in VMT, or a slightly smaller reduction when the effects of other variables are controlled." Holtzclaw[90] makes a similar deduction and concludes that household density is, "the major explanatory variable for variations in vehicle miles travelled". Note that no urban areas with populations lower than 2.0 million people were included in the Holtzclaw study. Growing Cooler[91] reports that households within developments with twice the density (including the density of uses, accessible destinations and interconnected streets) drive about 33% less than households in low-density sprawl. It reports that in a comprehensive study the "most walkable" neighborhoods had 26% fewer VMT than the "most sprawling neighborhoods". Finally, it concludes that compact development, which again includes a broader definition than just high density, has the potential to reduce VMT per capita by 20-40% relative to sprawl. The general trend points to lower VMT in areas with higher

[87] Sonoma Technology, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

[88] A conservative adjustment for weekend travel was assumed for all the trips since information was not available to distinguish between trips on major highways and trips on small streets. The Sonoma Technology report gives a range of values, but does not present a weighted value, thus a conservative percent reduction in the number of trips was selected.

[89] Ewing, Reid. 1997. Is Los Angeles-Style Sprawl Desirable? *Journal of the American Planning Association,* Vol. 63. No. 1, Winter 1997, pp. 107-126.

[90] Holtzclaw, John. 1994. Using Residential Patterns and Transit to Decrease Auto Dependence and Costs. June 1994.

[91] Ewing et al. 2007. Growing Cooler: The Evidence on Urban Development and Climate Change. October 2007.

densities of households. However, it is important to keep in mind that these conclusions are based on data that are imperfect and that VMT depends on other design features whose effects may not be properly controlled. The URBEMIS model attempts to include density's impact on reduction in VMT, but it is not clear that this effect is correctly accounted for.

It is our understanding that while the Fehr and Peers study (Alternate 2) takes into account reductions in vehicle trips due to transit trips and walking, it cannot take into account all the VMT reductions resulting from the compact design of the development. Current traffic models today do not have this capability. It is possible that SMV may be too small to reflect any notable reductions in VMT so it is uncertain how the compact design would affect VMT. Thus, these trip reductions are difficult to quantify and have not been explicitly accounted for in this analysis.

SMV plans to utilize a travel coordinator that will provide useful information regarding transportation alternatives such as bus schedules, car pools, access to bike and pedestrian pathways. There is little information available to assess the impact this will have on trip reductions for SMV residents. Travel coordinators typically are sponsored by employers and include financial incentives. There are some available studies on travel coordinator programs that do draw from a mixed employee and residential use. The first is Stanford University's travel demand management program[92]. In 2002, the University increased its effort to reduce drive alone trips to campus. In a five-year period, the university claims a 20% decrease in employee drive alone rates, a decrease in commuter parking permit sales, and an increased use of the university shuttle system. It is important to note that the majority of trip reductions were attributable to increased use of Caltrain rail service which increased from 4% to 17.7% of the transportation mode. The North Natomas Transit Management Association located near Sacramento is one of the only residential orientated programs for which some information was available. This community has set a trip reduction goal of 35%. A key feature to this program is the light rail system. Detailed data quantifying the current progress is not available, but it has been described as making strides toward this goal. Taking these two programs into consideration along with the fact that SMV will provide transportation to the nearby rail, it is reasonable to anticipate reductions in trips and therefore VMT for SMV beyond what is quantified in the inventory. However, this has not been quantified in this document.

The different trip rates and trip lengths estimated drive the differences in VMT and GHG emissions between the different approaches. Table 4-15 summarizes the different trip rates, trip lengths, annual VMT, and CO_2e emissions from the three methods discussed. As mentioned above, we would expect that these VMT and GHG values to represent a conservative range since they do not consider the effects of having a compact development and a travel coordinator which are difficult to quantify.

[92] Brodie Hamilton. 2008. The Transportation Demand management Experience at Stanford University. TDM Review. Issue 2.

The main limitation of the primary approach (City's study) is that it does not take into account internal trips and non-home-based trips. Alternate approach 1 (URBEMIS) employs average trip lengths that are significantly lower than the City's study and thus results in lower VMT and GHG emissions. Alternate approach 2 (Fehr and Peers) employs similar average trip lengths as in alternate approach 1, but has higher trip generation rates thus resulting in higher VMT and GHG emissions. After discussions of methodologies, Codding Enterprises requested that the primary approach be used in the GHG inventory.

As mentioned in Section 3.3.5, the waiver needed from USEPA to implement AB 1493 (Pavley Standards) is expected to be granted in the foreseeable future. It is therefore appropriate to apply this regulation to the calculations for SMV's GHG emission inventory for the mobile sector. As further discussed in Section 6.3, ARB has done a study on the CO_2 emission factors as a result of Pavley Standards. Using the ARB report, ENVIRON scaled down EMFAC's 2030 emission factor by the percent reduction expected in 2020 mobile GHG emissions due to the Pavley Standards. The scaling factor from ARB report applies to all light-duty vehicles on the road in 2020; as such, this scaling factor does not account for likely increasingly stringent standards in 2030. Table 4-16 shows that vehicles associated with the SMV development with the Pavley Standards will emit 9,049 tonnes CO_2e per year.

4.9.3 Uncertainty Analysis

In an effort to evaluate the assumptions described in the section it should be noted that the VMT and GHG emissions will change based on further reductions that are likely due to the benefits of the community design to encourage mode shifts. In addition, changes in estimated fleet distribution and emission factors will likely improve based on current and anticipated regulations. Despite the fact that each of the three methodologies result in different predictions for estimating the number of trips and trip lengths, they uniformly indicate that VMT will be lessened due to SMV's traffic-reduction measures. All three are shown in order to illustrate this uncertainty, and as noted above, do not account for some aspects of the development that are expected to reduce VMT, such as the transit coordinator and the public transportation improvements.

4.10 Municipal Sources

This section explains estimates for emissions stemming from municipal sources such as drinking water and wastewater supply and treatment, lighting in public areas, and municipal vehicles.

4.10.1 Water and wastewater supply and treatment systems

In general, the majority of municipal sector GHG emissions are related to the energy used to convey, treat and distribute water and wastewater. Thus, these emissions are generally indirect emissions from the production of electricity to power these systems. Additional emissions from wastewater treatment include CH_4 and N_2O, which are emitted directly from the wastewater.

The amount of electricity required to treat and supply water depends on the volume of water involved. According to Codding Enterprises, the development would generate a total water demand of 381.7 acre-feet (AF) per year. Of this, 274 AF will be potable water supplied by Sonoma County Water Agency (SCWA)[93], and 107 AF will be non-potable municipal reclaimed water, harvested rainwater, or on-site graywater. Three processes are necessary to supply potable water to residential and commercial users: (1) supply and conveyance of the water from the source; (2) treatment of the water to potable standards; and (3) distribution of the water to individual users. After use, the wastewater is treated and reused as reclaimed water. Any reclaimed water produced is generally redistributed to users via pumping. SCWA has committed to providing all the energy required for pumping, treatment of water, and associated building energy from renewable sources by 2015.[94]

As the energy use for different aspects of water treatment (e.g., source water pumping and conveyance, water treatment, wastewater treatment, distribution to users) will be obtained from renewable sources, there are no CO_2e emissions associated with these processes as shown in Table 4-17. Details on the emissions generated by specific aspects of water treatment and supply systems are provided in the following sections.

4.10.2 Potable Water Source Supply and Conveyance

Water is typically supplied to surrounding communities from various reservoirs on the Russian river system and reclaimed water. To supply the annual demand for 274 acre-feet (AF) of potable water SMV will draw upon water from the Russian river system, and also supplement the surface water with ground water.[95,96] The energy needed to supply and convey SMV's water will be used to pump this water from the sources and distribute it throughout the development. The energy requirements will be met by renewable sources[97], hence there are no GHG emissions from potable water supply and conveyance (see Table 4-17).

4.10.3 Potable Water Treatment and Distribution

Since SCWA has committed to providing all the energy required for pumping and treatment of water from renewable sources by 2015, there will be no GHG emissions from potable water treatment and distribution.[98]

4.10.4 Wastewater Treatment

Emissions associated with wastewater treatment include indirect emissions necessary to power the treatment process and direct emissions from degradation of organic material in the wastewater. As the energy required to power the treatment processes will be obtained from renewable sources therefore indirect emissions in SMV do not account for any CO_2e emissions.

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[93] Sonoma County Water Agency expects that the water for SMV will be sourced from the Russian river system.

[94] See http://www.scwa.ca.gov/environment/sustainability/

[95] Sonoma Mountain Village Water Supplies are based on SCWA expected sources for the area. The SCWA obtains most of its water from the Russian river system.

[96] CEC 2005. California's Water-Energy Relationship. Final Staff Report. CEC-700-2005-011-SF.

[97] See http://www.scwa.ca.gov/environment/sustainability/

[98] See http://www.scwa.ca.gov/environment/sustainability/

Wastewater treatment direct emissions in SMV are estimated to account for 374 tonnes of CO_2e emissions per year.

Direct emissions from wastewater treatment include emissions of CH_4 and N_2O. A per capita emission factor for these GHG emissions was developed based on a 2005 US GHG inventory for domestic wastewater treatment (25 teragrams CO_2e/year or 25 million tonnes CO_2e/year)[99] and the 2005 US population (approximately 296,410,404). Direct emissions from wastewater treatment were calculated using the emission factor developed from this data (0.084 tonnes CO_2e per capita per year) and the projected population at SMV (4,438 residents[100]) as shown in Table 4-17. To the extent that wastewater treatment collects methane, either to reduce GHG emissions, or to produce energy, this value may be reduced.

4.10.5 Non-Potable Recycled Water Distribution

Codding Enterprises estimates that non-potable water needs will be equal to 107 AF per year, which will be provided from reclaimed water. Once treated at the wastewater treatment plant, this water must be re-pumped through the development to the end users. Estimates of the amount of energy needed to redistribute and, if necessary, treat reclaimed water is 978 kW-hr per AF if the energy is provided by a non-renewable source.[101] As this energy requirement will be met by renewable sources, water redistribution emissions were calculated to be 0 tonnes of CO_2e as shown in Table 4-17.

In total, all water and wastewater supply, treatment and distribution for SMV is expected to produce 374 metric tonnes of CO_2e annually, assuming that SWCA successfully implements its carbon free water plan.

4.10.6 Public Lighting

Lighting sources contribute to GHG emissions indirectly, via the production of the electricity that powers these lights. Lighting sources considered in this source category include streetlights, traffic signals, area lighting for parks and lots, and lighting in public buildings. SMV is committed to providing renewable energy systems to power the public lighting, as such there are no GHG emissions associated with this source category.

4.10.7 Municipal Vehicles

GHG emissions from municipal vehicles are due to direct emissions from the burning of fossil fuels. Municipal vehicles considered in this source category include vehicles such as police cars, fire trucks, and garbage trucks. The emission factor for municipal vehicles is shown in Table 4-17. Data from reports by Medford, MA; Duluth, MN; Northampton, MA; and Santa Rosa, California[102] show that the CO_2 emissions from municipal vehicles would be approximately[103]

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[99] USEPA. 2007. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005. #430-R-07-002. April. http://epa.gov/climatechange/emissions/downloads06/07Waste.pdf
[100] Provided to ENVIRON by Codding Enterprises.
[101] CEC 2005. California's Water-Energy Relationship. Final Staff Report. CEC-700-2005-011-SF.
[102] City of Medford. 2001. Climate Action Plan. October. http://www.massclimateaction.org/pdf/MedfordPlan2001.pdf

0.05 tonnes per capita per year. Using these studies and the expected SMV population of 4,438, emissions from municipal vehicles in SMV were calculated. Municipal vehicle emissions in SMV are estimated to account for 222 tonnes CO_2e per year.

In total, all municipal sources including water, wastewater, public lighting and municipal vehicles for SMV is expected to produce 596 tonnes of CO_2e annually.

4.11 Area Sources

Area sources emissions stem from hearths (including gas fireplaces, wood-burning fireplaces, and wood-burning stoves) and small mobile fuel combustion sources such as lawnmowers. Fuel combustion associated with these sources produce direct GHG emissions. In SMV, there will be a strict ban on natural gas-fired fireplaces; wood-burning stoves and fireplaces; and gasoline-powered lawn mowers, chain saws, and dust blowers for residential use. In addition, natural gas will not be used to provide heating. The emissions associated with electricity use to power lawn maintenance equipment will be negligible and come from renewable power systems. Therefore, there will be no area sources and no associated emissions.

4.12 Emissions Sources Not Quantified in Inventory

Several emissions sources were not quantified in this inventory, due to their estimated relatively small[104] contribution to GHG emissions. These sources include emissions from refrigeration leaks which are described in more detail below[105].

4.12.1 Refrigeration Leaks

Emissions associated with leaks of high global warming potential gases such as from refrigeration leaks were not quantified. At the entitlement stage of development, the degree of uncertainty in the potential facilities with sources that may have refrigeration leaks make a meaningful quantification of GHG emissions difficult. In addition, since refrigeration systems will be new, they are likely efficient and should be designed to reduce the amount of leaks of high global warming potential gases. As a result of this uncertainty, ENVIRON did not quantify these emissions at this time.

City of Northampton. 2006. Greenhouse Gas Emissions Inventory. Cities for Climate Protection Campaign. June. http://www.northamptonma.gov/uploads/listWidget/3208/NorthamptonInventoryClimateProtection.pdf
City of Santa Rosa. Cities for Climate Protection: Santa Rosa. http://ci.santa-rosa.ca.us/City_Hall/City_Manager/CCPFinalReport.pdf
Skoog., C. 2001. Greenhouse Gas Inventory and Forecast Report. City of Duluth Facilities Management and The International Council for Local Environmental Initiatives. October.http://www.ci.duluth.mn.us/city/information/ccp/GHGEmissions.pdf
[103] In an effort to be conservative, the largest per capita number from these four reports was used.
[104] Typically less than 1% of the overall inventory based upon previous studies.
[105] Black carbon was also not considered. Major sources of black carbon emissions are not present at SMV.

4.13 Project Design Features that Reduce GHG Emissions

The SMV development incorporates many design features to reduce GHG emissions. This section describes the design features that were incorporated into this analysis either directly or indirectly. This section also lists those features that were not quantified in this analysis, but would likely yield further GHG emissions reductions.

4.13.1 Project Design Features whose Emissions Reductions were Incorporated into the Analysis

4.13.1.1 Reductions in emissions from mobile sources

- The circulation system has been designed to encourage residents to make multiple stops per trip by allowing alternate routes and eliminating dead end streets.
- The jobs-housing balance at SMV will help reduce trip lengths in vehicles.

4.13.1.2 Water conservation

- SMV will not require any additional municipal drinking water
- SMV will require less than half of the water per person in a traditional new community.
- Rainwater catchment and reclaimed water will be used for central irrigation.
- Super-efficient fixtures such as toilets, urinals, and irrigation systems, will be used.
- Turf areas will be strictly limited.
- A small graywater collection system will be used for subsurface irrigation.

4.13.1.3 Energy Efficiency and Renewable Sources of Energy

- SMV's electrical, space heating, and hot water demands will all be met by on-site renewable sources of energy.
- SMV will decrease the amount of renewable energy required by implementing energy efficient measures.
- New residential buildings will be 30% more efficient than 2005 Title-24 Building Standards.
- Existing buildings will be retrofit over time to be 10% more efficient than 2005 Title-24 Building Standards
- New commercial buildings will be 20% more efficient than 2005 Title-24 Building Standards.
- Design guidelines to eliminate the need for compressor based cooling.

4.13.1.4 Area Sources

- Wood-burning stoves and fireplaces; natural gas heating and fireplaces; and gas-powered landscaping equipment are all prohibited.

4.13.1.5 Water Conservation

- The Sonoma County Water Agency, which will provide SMV's water service, has committed to provided 100% of its energy with renewable power sources by 2015.

4.13.2 Project Design Features whose Emissions Reductions were not Incorporated into the Analysis but would yield further GHG emissions savings

While these project design features have not been quantified as part of this GHG emissions inventory, they are part of the project and will likely result in further GHG emission reductions.

4.13.2.1 Reductions in emissions from mobile sources

- A travel coordinator will provide useful personalized information regarding transportation alternatives such as bus schedules, car pools, and access to bicycle and pedestrian pathways.
- A walkable site with a bicycle network and public transit will help reduce its mobile emissions.
- A car share program will encourage carpooling.
- The Village square will be located within a five-minute walk of all SMV residences and a short bike ride or drive from surrounding existing neighborhoods.
- Every residence will be near a park.
- The use of biofuels and social marketing will help reduce mobile emissions.

4.13.2.2 Green Waste Management

- An aggressive waste management plan is designed to achieve a 70% diversion rate, including recycling, composting, and reclaiming waste.
- The waste management plan is designed to cut volume sent to landfill by 98% when waste reduction is taken into account.

4.14 Summary of Emissions from SMV

Emissions from the various aspects of SMV are presented in Table 4-18. One-time vegetation emissions are estimated to be -1,991 tonnes CO_2. One-time construction emissions are estimated to be 13,824 tonnes CO_2e. Emissions from residential and non-residential buildings are estimated to be 0 tonnes CO_2e per year, or 0% of the annual project emissions, as SMV is committed to meeting 100% of its building energy demand with renewable sources of energy. Emissions from mobile sources are estimated to be 11,270 tonnes CO_2e per year, or 95% of the annual project emissions. Emissions from municipal sources (water distribution, public lighting, and municipal vehicles) are estimated to be 596 tonnes CO_2e per year, or 5% of the annual project emissions. Emissions from area sources (lawn maintenance) are estimated to be 0 tonnes CO_2e per year, or 0% of the annual project emissions, due to proposed rules at SMV.

Also noted in Table 4-18 is whether the emissions are attributable to a one-time action or are anticipated to occur on an annual basis, during each year after the full build-out of the development. The only one-time emissions are associated with construction and land use change emissions. There are 11,833 tonnes of CO_2e one-time emissions. The annual emissions from the use of the development amount to 11,866 tonnes. If the one-time emissions are annualized assuming a 40-year development life (which is likely low) then the one-time emissions account for approximately 296 tonnes, or 2.4% of the annual emissions. Taking these one-time emissions into account, the annual emissions are 12,162 tonnes per year.

It is important to note that these emissions are estimated assuming that the transportation system do not change in the future. This assumption is clearly incorrect, as AB 32 and other legislative and regulatory mandates will result in GHG emission reductions in both areas. Table 4-19 shows the overall GHG emission inventory if the reduction in GHG emissions from vehicles is considered since it is foreseeable that the waiver needed to implement AB 1493 (Pavley Standards) will be granted. Incorporating the Pavley Standards results in 94% of the GHG emission inventory attributable to vehicular emissions associated with residents from SMV. The annual emissions from the use of the development would amount to 9,646 tonnes of CO_2e. Taking one-time emissions into account, the annual emissions would be 9,941 tonnes per year.

As noted in Section 3 of this report, AB 32 requires that GHG emissions from California be reduced to 1990 levels by 2020. This represents a reduction of approximately 28.3% from projected 2020 growth. The goals of AB 32 are likely to be reached by increasing renewable or non-carbon producing electricity production, and changing the transportation system to rely on a set of low carbon fuels. As most of the carbon footprint of SMV results from transportation, these carbon emissions are likely overestimated as a result of the implementation measures of AB 32. Section 5 puts SMV emissions in context and includes an analysis of a Business as Usual (BAU) scenario compared to SMV.

Furthermore, Governor Schwarzenegger's Executive Order S-3-05 set a target to reduce GHG emissions by 2050 to levels 80% less than the 1990 levels. It is likely that future measures will be implemented to reach this goal that similarly may result in reductions of GHG emissions for sources in SMV beyond those stated in this report.

4.15 Life Cycle Emissions of Building Materials

An estimate of "life-cycle" GHG emissions (i.e., GHG emissions from the processes used to manufacture and transport materials used in the buildings and infrastructure) is presented in this section and attached as Appendix C. This estimate is to be used for comparison purposes only and is not included in the final inventory as these emissions would be attributable to other industry sectors under AB 32. For instance, the concrete industry is required by law to report emissions and undergo certain early action emission reduction measures under AB 32. Furthermore, for a life-cycle analysis for building materials, somewhat arbitrary boundaries must be drawn to define the processes considered in the life-cycle analysis.[106] Recognizing the uncertainties associated with a life-cycle analysis, the California Air Pollution Control Officers Association (CAPCOA) released a white paper which states: "The full life-cycle of GHG emissions from construction activities is not accounted for in the modeling tools available, and the information needed to characterize GHG emissions from manufacture, transport, and end-of-life of construction materials would be speculative at the CEQA analysis level.[107]"

The calculations and results discussed here and presented more fully in Appendix C are estimates and should be used only for a general comparison to the overall GHG emissions estimated in this report. Life Cycle Assessment (LCA) emissions vary based on input assumptions and assessment boundaries (e.g., how far back to trace the origin of a material). Assumptions made in this report are generally conservative. However, due to the open-ended nature of LCAs, the analysis is highly uncertain.

Appendix C is an ENVIRON report that evaluates the life cycle GHG emissions associated with the building materials for this project. The life cycle GHG emissions include the embodied energy from the materials manufacture and the energy used to transport those materials to the site. The report then compares the life cycle GHG emissions to the overall annual operational emissions. The materials analyzed in the report include materials for 1) residential and non-residential buildings, and 2) site infrastructure. This report calculates the overall life cycle emissions from construction materials to be approximately 655 – 4,550 tonnes CO_2 / year. This represents 5.5– 38% of the annualized GHG emissions from the SMV area.

The report estimated the life cycle GHG emissions for buildings by conducting an analysis of available literature on LCAs for buildings. According to these studies, approximately 75 - 97% of GHG emissions from buildings are associated with energy usage during the operational phase; the other 3 – 25% of the GHG emissions is due to material manufacture and transport. To estimate these fractions, it was assumed that energy used in the buildings is generated using a traditional mix of fossil fuels in the United States. Using the GHG emissions from the operation of buildings, 3 – 25% of building emissions corresponds to approximately 3.4 – 36% of the project emissions. These overall fractions are higher than they would have been for a traditional project due to the low overall energy use of this project.

The report in Appendix C calculated the life cycle GHG emissions for certain components of infrastructure (roads, storm drains, utilities, gas, electricity, and cable). This analysis considered the manufacture and transport of concrete and asphalt only, as ENVIRON assumed that other construction materials such as steel would be present in much smaller quantities. Because the manufacture of concrete has a higher CO_2 emission factor and most construction estimates

[106] For instance, in the case of building materials, the boundary could include the energy to make the materials, the energy used to make the machine that made the materials, and the energy used to make the machine that made the machine that made the materials.

[107] CAPCOA. 2008. CEQA & Climate Change: Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act. Available online at: http://www.capcoa.org/ceqa/?docID=ceqa&PHPSESSID=df1348d6f7eff0fc2a8263d19f6d10dd

higher quantities of concrete than asphalt, the majority of the emissions for infrastructure result from the manufacture of concrete. Because the asphalt and concrete are locally sourced, the transportation emissions are relatively small. If a 40-year lifespan of the infrastructure is assumed, the total annualized emissions from embodied energy in infrastructure materials are approximately 2.2% of the project emissions. Again, these emissions are lower than they would have been for a traditional project due to the low overall energy use of this project.

The overall life cycle emissions, annualized by 40 years, are 655 – 4,550 tonnes CO_2 / year, or 5.5 – 38% of the annualized GHG emissions from the SMV project. The bulk of these emissions (3.4 – 36%) are from general life cycle analysis studies and do not reflect specific information from SMV for the building materials used in this Project. There are aspects of the project that will tend to drive the life cycle emissions towards the lower end of the range, including the planned reuse of some existing building space and infrastructure materials, such as concrete and asphalt, and the emphasis on the use of local construction materials.

Again, note that the calculations and results presented in this life cycle report are estimates and should be used only for a general comparison to the overall GHG emissions estimated in the main report. LCA emissions vary based on input assumptions and assessment boundaries (e.g., how far back to trace the origin of a material). Assumptions made in this report are generally conservative. However, due to the open-ended nature of LCAs, and the fact that literature evaluation, not site specific studies, were used to analyze the embodied energy, the analysis should be considered to yield highly uncertain results. Additionally, these estimates likely double count emissions from other industry sectors.

4.16 Life Cycle Emissions of Renewable Energy Systems

An estimate of the life cycle emissions of renewable energy systems is summarized here. The life cycle GHG emissions include the embodied energy from the materials manufacture and the energy used to transport those materials to the site, and operate the system. The life cycle GHG emissions at SMV will then be compared to the GHG emissions resulting from non-renewable energy technologies. The materials analyzed in this report include materials for 1) photovoltaics (PVs), including polycrystalline silicon PVs and amorphous silicon PVs, and 2) ground source heat pumps. While domestic solar water heaters supplemented by air source heat pumps will also be used in approximately half of the residential dwelling units at SMV, and all remaining units will have air source heat pumps, ENVIRON assumed that the associated life cycle GHG emissions are counted in the building materials LCA presented in Appendix C. This assumption follows the fact that traditional water heating technologies are generally included with the building materials and are not separately quantified. As described below, we estimate the overall life cycle emissions from renewable energy systems to be 589 tonnes CO_2 per year, or 5.0% of the annual GHG emissions from the SMV project.

ENVIRON estimated the life cycle GHG emissions for various PV technologies. At SMV, approximately 90% of the PV systems will be polycrystalline silicon, while the remaining 10% will be amorphous silicon technology. The estimated LCA GHG emission factors for polycrystalline silicon PVs and amorphous silicon PVs are 37 and 38 grams of CO_2 per kilowatt-hour, respectively.[108,109] Using an estimated annual electricity generation in residential dwelling units at SMV provided by Codding Enterprises, shown in Table 4-20, along with an estimated lifetime of 20 years, ENVIRON estimated the life cycle GHG emissions from PVs to be 6,280 tonnes CO_2, or 314 tonnes CO_2 per year. This result is shown in Table 4-21. These emissions represent roughly 2.6% of the annual GHG emissions from the operation of Sonoma Mountain Village residential buildings using non-renewable sources of energy.

ENVIRON also estimated the life cycle GHG emissions for the 800 residential ground source heat pumps (GHSPs) to be installed at SMV. The estimated LCA GHG emission factor for GSHPs is 1.05 x 10^{-4} tonnes CO_2e per kilowatt-hour (thermal) of heat provided over its lifetime.[110] ENVIRON estimated that the amount of thermal energy that a GSHP provides over its lifetime at SMV is equal to the amount of thermal energy that would be met using more traditional means. ENVIRON estimated this quantity using Micropas software, which is described in detail in Section 5.4.2. As shown in Table 4-22, the estimated life cycle emissions of the ground source heat pumps is 5,506 tonnes CO_2e, or approximately 275 tonnes CO_2e per year over their 20 year lifetime. These emissions represent approximately 2.3% of the annual GHG emissions at SMV.

Table 4-23 presents the summary of life cycle GHG emissions from renewable technologies at SMV. The total one-time emissions are 11,786 tonnes CO_2, or, assuming a 20-year lifetime, 589 tonnes CO_2 per year. This annual emission rate is equivalent to approximately 5.0% of the annual operational emissions at SMV. In comparison, emissions associated with energy use in a typical mixed use development will range from 30% to 70% of the total GHG emissions, depending largely on the amount of traffic associated with the development. Accordingly, the emissions associated with energy use in buildings (which is the bulk of electricity use at SMV) is very small compared to a typical mixed use development. To illustrate, in PG&E territory, within which SMV is located, the average GHG emissions due to residential energy use is approximately 4.4 tonnes CO_2e per household per year.[111] Compare this to the 589 tonnes CO_2 per year associated with the embodied energy of renewable energy technologies at SMV, which is about 0.3 tonnes CO_2 per year per household.[112] Therefore, the annualized GHG emissions associated with residential energy use per household at SMV are roughly 7% of those associated with a typical household in PG&E territory.

[108] Fthenakis, V. and Alsema, E. Photovoltaics Energy Payback Times, Greenhouse Gas Emissions and External Costs: 2004-early 2005 Status. Prog. Photovoltaic.: Res. Appl. 2006; 14:275-280. Available at: http://www.clca.columbia.edu/papers/Photovoltaic_Energy_Payback_Times.pdf

[109] Dones, R. et al. Greenhouse Gas Total Emissions from Current and Future Electricity and Heat Supply Systems. Available at: http://gabe.web.psi.ch/pdfs/lca/GHGT4_Interlaken_1998.pdf

[110] World Energy Council. Comparison of Energy Systems Using Life Cycle Assessment. July 2004. Available at: http://www.worldenergy.org/documents/lca2.pdf

[111] ENVIRON calculated this value using estimates of residential electricity and natural gas use per household in PG&E territory, as well as the number of households in PG&E territory, as reported in the California Energy Commission's *California Energy Demand 2008-2018: Staff Revised Forecast* (October, 2007). ENVIRON used the PG&E electricity and natural gas emission factors of 0.636 lb CO_2e/kWh and 117 lb CO_2e/MBTU from Sections 5.4.3 and 5.4.4 of this report. CEC report available at: http://www.energy.ca.gov/2007publications/CEC-200-2007-015/CEC-200-2007-015-SF.PDF

[112] This calculation assumes that there are 1,892 households in SMV.

Again, note that the calculations and results presented in this life cycle report are estimates and should be used only for a general comparison to the overall GHG emissions estimated in the main report.

5 Inventory in Context

5.1 SMV Greenhouse Gas inventory in Context

The lead agency has not published interim significance thresholds for GHG emissions applicable to industrial projects at this time. In lieu of specific thresholds or standards, this section is intended to place the GHG emissions from the proposed residential development in context with respect to intensity, consistency with AB 32 goals, and magnitude. For the intensity comparison, we compare the built environment emissions with that from a BAU comparison of standard energy use for buildings in California in the same climate zone. In addition, we compare anticipated mobile emissions to Sonoma County and emissions savings from water usage in the development. For comparison with AB 32 goals, we compare the GHG emissions with the levels likely to be mandated under AB 32. Finally, the emissions from the project at build-out are compared to California and global GHG emissions in order to put the project emissions in a global context.

5.2 Characterization of Emissions

In 2004, 81% of greenhouse gas emissions (in CO_2e) from California were comprised of CO_2 emissions from fossil fuel combustion, with 4% comprised of CO_2 from process emissions. CH_4 and N_2O accounted for 5.6% and 6.8% of total CO_2e respectively, and high GWP gases[113] accounted for 2.9% of the CO_2e emissions. Transportation is by far the largest end-use category of GHGs. Transportation includes that used for industry (i.e., shipping) as well as residential use.

5.3 Comparison with AB 32-mandated Emissions Limits

As noted earlier, AB 32 requires that statewide GHG emission in 2020 be equal to 1990 levels. California-wide GHG emissions in 1990 were 0.427 billion tonnes.[114] It is projected that emissions in 2020 under a business as usual scenario accounting for growth will be 0.596 billion tonnes[115]. This would require a 28.3% decrease in emissions by 2020 to achieve AB 32 goals. The population in California is projected to be 42,210,000 in 2020. In order to achieve AB 32-mandated goals, the per capita emissions would have to be 10.1 tonnes CO_2e (see Table 5-1 for calculation details). SMV has estimated emissions of 12,162 tonnes per year, or 2.7 tonnes per capita per year.[116] The California per capita CO_2 emissions includes industries such as heavy industry, refining, and transportation of materials while the SMV per capita CO_2 emissions do not include these emissions. AB 32 will be reducing emissions in a variety of different ways, including increasing energy efficiency and introducing more renewable energy sources. It is difficult to compare the Project per capita emissions to the AB 32 goals as it is not clear what fraction of the reduction will be achieved in which sectors, and what portion will be achieved

[113] Such as HFCs and PFCs.
[114] http://www.arb.ca.gov/cc/inventory/1990level/1990level.htm. California Air Resources Board.
[115] http://www.arb.ca.gov/cc/inventory/data/forecast.htm#summary_forescast
[116] Based upon 4,438 residents.

from energy efficiency and what fraction will be achieved by renewable resources. This is discussed more fully below.

5.4 Business as Usual Comparison

In order to put the GHG emission inventory into context and justify an improvement heading towards meeting the reduction goals set for 2020, it is necessary to compare the GHG emission inventory expected for SMV to the GHG emissions that would occur from a community that would be built today without the project design features and energy reduction commitments made by Codding Enterprises. This baseline comparison is referred to as Business as Usual (BAU). This represents the GHG emission inventory if things were continued to be built according to current standards. The major categories of the GHG emission inventory are considered separately. These include residential and non-residential buildings, mobile sources, municipal lighting, and water sources. The remaining categories include municipal vehicles and area sources. These categories represent a small fraction of the total inventory and do not have appropriate emission factors to quantify the reductions that are likely to occur at SMV compared to BAU.

5.4.1 Vegetation

Tables 5-2 through 5-5 follow the same methodology presented in Section 4.5 of this report. The BAU vegetation emissions were calculated assuming non-settlement areas in the SMV development remain in their existing condition. Additionally, no net trees would be planted. The BAU vegetation results in a one-time net sequestration of 450 tonnes CO_2e. SMV represents a 342% increase in vegetation CO_2e sequestration from BAU.

5.4.2 Construction

Tables 5-6 through 5-9 follow the same methodology presented in Section 4.6 of this report. The BAU construction emissions were calculated by assuming that all the construction equipment operates on conventional diesel fuel. SMV is committed to using biodiesel (B20) for the construction equipment. The BAU emissions from worker and vendor commuting were estimated using the same assumptions outlined in Section 4.6. The BAU construction emissions were estimated to be 15,459 tonnes CO_2e. Therefore, SMV represents an 11% decrease in construction-related CO_2e emissions from BAU.

5.4.3 Residential Buildings

Residential buildings at SMV include detached single-family homes, detached cottages and second dwelling units, attached single family rowhouses and townhouses, and attached multifamily apartments and condominiums. This section describes the methods used to estimate the GHG emissions associated with activities in those types of residential buildings. For this BAU analysis, it was assumed that each of these homes was minimally Title 24 compliant. The GHG emissions from these homes were then compared to the GHG emissions from homes at SMV, which is expected to be negligible due to the incorporation of renewable energy at SMV.

The amount of energy—and, therefore, the amount of associated GHG emissions emitted per dwelling unit— will vary with the type of residential building. Accordingly, information on the type of residential buildings that are planned for SMV is required to estimate GHG emissions. Codding Enterprises provided data summarizing the main residential building categories for SMV. The major types of residential buildings are:

- Detached single-family homes (large lot and conventional);
- Detached cottages and second dwelling units; and
- Attached single-family rowhouses and townhouses
- Attached multifamily apartments and condominiums

GHGs are emitted as a result of activities in residential buildings when electricity and natural gas are used as energy sources. Combustion of any type of fuel emits CO_2 and other GHGs directly into the atmosphere; when this occurs in a residential building, it is a direct emission source[117] associated with that building. GHGs are also emitted during the generation of electricity from fossil fuels. When electricity is used in a residential building, the electricity generation typically takes place offsite at the power plant; electricity use in a residential building generally causes emissions in an indirect manner.

While fuel combustion generates CH_4 and N_2O, the emissions of these GHGs typically comprise less than 1% of CO_2e emissions from electricity generation and natural gas consumption.[118] Fuel oil, kerosene, liquefied petroleum gas, and wood can also be used as fuels, but will likely contribute only in small amounts as combustion sources within residential buildings. Thus, although emission factors for electricity generation and natural gas combustion were obtained for CO_2, it is assumed that these emission factors are representative of CO_2e emissions.

Energy use in residential buildings is divided into (1) energy consumed by the built environment, and (2) energy consumed by uses that are independent of the construction of the building, such as plug-in appliances. In California, Title 24 governs energy consumed by the built environment, including the HVAC system, water heating, and some fixed lighting. Non-building or 'plug-in' energy use can be further subdivided by specific end-uses (refrigeration, cooking, lighting, etc.). Energy use for each was calculated separately, as described in the following sections. The resulting energy use quantities were then converted to GHG emissions by multiplying by the appropriate emission factors, incorporating information on local electricity production.[119]

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[117] California Climate Action Registry (CCAR) General Reporting Protocol (GRP), Version 3.1 (January 2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

[118] Ibid. Tables C1 and C2. The methane and nitrous oxide emission factors are negligible compared to the total CO_2 emission factor for electricity generation in California.

[119] The Pacific Gas and Electric specific emission factor for electricity deliveries is 635.67 lbs CO_2/MWh. From the California Climate Action Registry Database: Pacific Gas and Electric Company 2007 PUP Report. 2009. Although this emission factor accounts for only CO_2, the emissions associated with N_2O and CH_4 contribute to less than 1% of the electricity generation CO_2e emissions. Available at:

5.4.3.1 Estimate of Residential Energy Use Intensity

ENVIRON developed CO_2e intensity values (i.e., CO_2e emissions per Dwelling Unit per year) for the residential building types found in SMV using Micropas 7.3 energy modeling analysis and estimation methods presented in the Department of Energy technical report entitled, 'Building America Research Benchmark Definition'.[120] Six building types representative of the planned residences at SMV were modeled in Micropas: a large lot single-family dwelling, a conventional single-family dwelling, a detached cottage or second dwelling unit, a building with attached single-family small rowhouses, a building with attached townhouses and large rowhouses, and a multi-family building with attached smaller units (apartments, condominiums, and lofts)[121]. ENVIRON modeled these buildings in the same climate zone as SMV. The methods that were used and the assumptions that were made in estimating energy use are described below.

5.4.3.2 Energy Use in the Built Environment

To determine Title 24 compliance, Micropas software was used to calculate the total energy use as well as the total daily valuation (TDV) of energy use in the built-environment (on a per square foot per year basis). TDV energy use is a parameter that reflects the burden that a building imposes on an electricity supply system. In general, there is a larger electricity demand and, hence, higher stress on the supply system during the day (peak times) than at night (off peak). To account for this variation, the calculation of TDV assigns different weights for energy used at different times. For example, a building that uses a given amount of electricity during the peak mid-day period will have a higher TDV value than a building using an equivalent amount of electricity during off-peak hours. Title 24 compliance is based on TDV and not on annual energy use.

Title 24 determines compliance by comparing the energy use of a modeled (or 'proposed') home to a minimally Title 24 compliant 'standard home' of equal dimensions. Title 24 focuses on building energy efficiency per square foot; it places no limits upon the size of the house or the actual energy used per dwelling unit. When a proposed home is modeled using Micropas, a standard home based upon the specifications of the wall area, window area, and square footage of the proposed home is also modeled. The standard Title 24 compliant home for each house type was used to estimate energy use.

Table 5-10 presents the general specifications for each dwelling unit modeled. Appendix A provides the Micropas input files where details of the modeled houses can be found.

The Micropas analysis provides annual electricity use for the HVAC system and annual natural gas usage for both the heating and domestic hot water (DHW) systems per building. Although

https://www.climateregistry.org/CARROT/public/Reports.aspx

120 Robert Hendron. "Building America Research Benchmark Definition, Updated December 20, 2007". National Renewable Energy Laboratory Technical Report. NREL/TP-550-42662. January 2008. Available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/42662.pdf

121 Due to the methods needed to calculate total energy use in this section, the breakdown of building types has been simplified into six representative residential unit sizes.

built-in lighting is covered under Title 24[122], it is not taken into account when determining TDV per square foot; as such, task lighting energy use is not calculated during an alternative compliance method (ACM) run such as Micropas. These energy use values were divided by the number of dwelling units per building to calculate annual energy use of each dwelling unit. HVAC electricity use and natural gas use values from the Micropas runs are presented in Table 5-12. Built-in lighting covered by Title 24 was calculated using values from BARBD for hard-wired lighting. The specifications for built-in lighting for Title 24 are less prescriptive than the building envelope and do not have a specific energy use budget or comparison to a standard compliant unit. The regulations require some of the lighting to use high efficiency fixtures (a high ratio of light intensity to wattage) or to control the lighting with specific types of switches/sensors. Title 24 requires that at least 50% of the wattage used in a kitchen must be from high efficiency fixtures.

Title 24 compliant electricity use on a per dwelling unit basis is 3,430 kWh per year for cottages and second dwelling units, 4,257 kWh per year for attached multifamily units, 4,072 kWh per year for attached small rowhouses, 4,781 kWh per year for attached townhomes and large rowhouses, 5,315 kWh per year for conventional single-family homes, and 6,686 kWh per year for large size single-family homes. Natural gas use in Title 24 compliant residences on a per dwelling unit basis is 45 MBtu per year for cottages and second dwelling units, 37 MBtu per year for attached multifamily units, 40 MBtu per year for attached small rowhouses, 49 MBtu per year for attached townhomes and large rowhouses, 70 MBtu per year for conventional single-family homes, and 91 MBtu per year for large size single-family homes.

5.4.3.3 Building America Research Benchmark Definition – Major Appliances

Micropas does not calculate energy use from major household appliances such as refrigerator, clothes washer and dryer, dishwasher, and cooking range. These are typical appliances provided with a new residential unit that the developer and building have some control over. The energy use for these major appliances was estimated using guidance from the Department of Energy's Building America Research Benchmark Definition (BARBD). This technical manual presents empirical equations for electricity usage derived using data from the 2001 Residential Energy Consumption Survey. The electricity usage of the major appliances were estimated using equations based on the number of bedrooms per dwelling unit except refrigerators was set to one value for all residence types, because it was assumed not to be influenced by the floor area or number of bedrooms of the dwelling unit. For dryers and cooking ranges, which can be either gas or electric, it is assumed that 50% of the houses will use electric and 50% would have used natural gas appliances. Therefore, values provided represent 50% of natural gas usage for natural gas models, and 50% electricity usage for both electric and natural gas (if applicable) models.

Table 5-11 summarizes the estimated major appliance energy use for the six residential types. The annual electricity use of major appliances is 1,391 kWh per year for cottages and second

[122] All built in lighting must comply with a set of prescribed measures.

dwelling units, 1,697 kWh per year for attached multifamily units, 1,560 kWh per year for attached small rowhouses, 1,738 kWh per year for attached townhomes and large rowhouses, 1,849 kWh per year for conventional single-family homes, and 1,954 kWh per year for large size single-family homes. In addition the annual natural gas use of major appliances is 3.3 MBtu per year for cottages and second dwelling units, 4.7 MBtu per year for attached multifamily units, 4.1 MBtu per year for attached small rowhouses, 4.9 MBtu per year for attached townhomes and large rowhouses,5.4 MBtu per year for conventional single-family homes, and 5.9 MBtu per year for large size single-family homes.

5.4.3.4 Building America Research Benchmark Definition - Plug-in Energy Use

Additional energy use from loads such as lighting, office equipment, plug-in cooking equipment, and electronics are also part of the anticipated energy use for a residential development. Similar to the major appliances above, energy use values for plug-in appliances, lighting and miscellaneous energy loads (MELs) were estimated using guidance from the Department of Energy's Building America Research Benchmark Definition (BARBD)[123] Plug-in lighting energy use was determined by the finished floor area, whereas the electricity usage for miscellaneous energy loads (e.g. home entertainment devices, computers, and small kitchen appliances) were determined by equations involving the number of bedrooms, finished floor area, and a California-specific load multiplication factor.

Table 5-12 summarizes the estimated plug-in energy use for the six residence types. The annual electricity use for plug-in appliances, lighting, and miscellaneous energy loads (on a per dwelling unit per year basis) is 532 kWh for cottages and second dwelling units, 767 kWh for attached multifamily units, 702 kWh for attached small rowhouses, 858 kWh for attached townhomes and large rowhouses, ,939 kWh for conventional single-family homes, and 1,155 kWh for large size single-family homes. Table 5-12 summarizes the combined energy use including the Title 24 systems, major appliances, and plug ins.

5.4.3.5 Estimation of Annual Greenhouse Gas Emissions from Residential Buildings

Energy use data from Tables 5-12 were multiplied by the emission factors presented in Table 5-13 to generate CO_2e intensity values (i.e., CO_2e emissions per dwelling unit) for each building type, which are shown in Table 5-14.

Table 5-15 shows the yearly CO_2e emissions from BAU residential buildings by incorporating the aforementioned emission factors from Table 5-14 and the number of dwelling units for each building type for Title 24 systems. Total CO_2e emissions would be 5,226 tonnes per year without improvements over Title 24 and without renewable energy. Specifically, the cottages and second dwelling units (222 dwelling units) would emit 587 tonnes per year, the attached multifamily units (951 dwelling units) would emit 2,142 tonnes per year, the attached small

[123] US Energy Information Administration (EIA). Public Use Microdata. http://www.eia.doe.gov/emeu/recs/contents.html.

rowhouses (169 dwelling units) would emit 413 tonnes per year, the attached townhouses and large rowhouses (250 dwelling units) would emit 749 tonnes per year, the conventional single-family homes (235 dwelling units) would emit 972 tonnes per year, and the large size single-family homes (65 dwelling units) would emit 362 tonnes per year

Table 5-15 shows the yearly CO_2e emissions from BAU residential buildings by incorporating the aforementioned emission factors from Table 5-14 and the number of dwelling units for each building type for Title 24 systems and major appliances. Total CO_2e emissions would be 6,609 tonnes per year without improvements over Title 24 and without renewable energy. Specifically, the cottages and second dwelling units (222 dwelling units) would emit 715 tonnes per year, the attached multifamily units (951 dwelling units) would emit 2,845 tonnes per year, the attached small rowhouses (169 dwelling units) would emit 526 tonnes per year, the attached townhouses and large rowhouses (250 dwelling units) would emit 939 tonnes per year, the conventional single-family homes (235 dwelling units) would emit 1,165 tonnes per year, and the large size single-family homes (65 dwelling units) would emit 419 tonnes per year

Table 5-15 shows the yearly CO_2e emissions from BAU residential buildings by incorporating the aforementioned emission factors from Table 5-14 and the number of dwelling units for each building type for Title 24 systems and all plug-in energy. Total CO_2e emissions would be 7,034 tonnes per year without improvements over Title 24 and without renewable energy. Specifically, the cottages and second dwelling units (222 dwelling units) would emit 749 tonnes per year, the attached multifamily units (951 dwelling units) would emit 3,055 tonnes per year, the attached small rowhouses (169 dwelling units) would emit 560 tonnes per year, the attached townhouses and large rowhouses (250 dwelling units) would emit 1,001 tonnes per year, the conventional single-family homes (235 dwelling units) would emit 1,229 tonnes per year, and the large size single-family homes (65 dwelling units) would emit 440 tonnes per year

5.4.3.6 Uncertainties in Residential Building GHG Calculations

Several factors lead to uncertainties in the above analysis. These are described below.

- Although all BAU buildings are assumed to be Title 24 compliant, Title 24 does not specify building dimensions (e.g. size, height, or orientation). Title 24 also provides significant flexibility for window types, window amounts, insulation choice, and other parameters. This uncertainty is not expected to either overestimate or underestimate emissions. Title 24 grants enough flexibility that if a designer puts in more windows than is 'allowed' under the prescriptive measures, the energy efficiency losses can be offset by improving the window quality, or installing a more efficient HVAC system. Although the designs of each BAU residence are not exactly known, each home will be Title 24 compliant, and thereby all design features of the home that make it less energy efficient will be offset by design features that make it more energy efficient.
- Energy use will vary considerably depending upon the design of the home. The residential units to be built in SMV will vary considerably in size, layout, and overall design. The parameters used here are intended to represent average homes in each category.

- Built environment energy use will vary considerably depending upon the home owners' habits regarding energy use. For instance, homeowners determine the set point of thermostats, the duration of showers, and the usage of air conditioning, among other things. Codding Enterprises will have little, if any, influence over these choices made by the homeowner. Current median behavior attributes were assumed for this report.
- Plug-in energy use will also vary considerably depending upon the appliances, lights, and other plug-ins installed by the homeowner. Codding Enterprises will have little, if any, influence over these choices made by the homeowner. As above, the current median behavior attributes are represented here.

5.4.4 Non-Residential Buildings

Non-residential buildings include all structures except residences that may exist in a development such as government, municipal, commercial, retail, and office space. This section describes the methods used to estimate the GHGs associated with activities in BAU non-residential building types similar to those that would exist at SMV. Similar to the residential building BAU analysis, a non-residential BAU building is assumed to be a minimally Title 24 compliance building.

The amount of energy used, and the associated GHG emissions emitted per square foot of available space vary with the type of non-residential building. For example, food stores are far more energy intensive than warehouses, which have little climate-conditioned space. Codding Enterprises provided data[124] summarizing the general non-residential building categories planned for SMV and the area of floor space planned for each building type. The same mix of non-residential building types and square footage is assumed for the BAU buildings. For new developments, the exact types of buildings are typically unknown. As such, not all building categories that may actually exist in SMV are represented below. However, all of the non-residential building area is accounted for, and the tables provided in this section present the differences in energy intensities from building type to building type. The types of non-residential buildings as provided to ENVIRON are:

a. Mixed-use Office
b. Grocery store
d. Retail
    I. Retail stores
    II. Strip shopping mall
e. Restaurants
    I. Restaurant/cafeteria
    II. Fast food
f. School
    I. Preschool/daycare

[124] The SMV Project Description and supplemental information provided by Codding Enterprises were used to estimate total square footage of buildings and the types of building present.

g. Enclosed mall
h. Hotel
i. Public assembly
  I. Movie theater
  II. Civic space
j. Recreation
  I. Gym

Similar to the case for residential buildings, GHGs are emitted as a result of activities in non-residential buildings for which electricity and natural gas are used as energy sources. Combustion of any type of fuel emits CO_2 and other GHGs directly into the atmosphere; when this occurs in a non-residential building this is a direct emission source[125] associated with that building. GHGs are also emitted during the generation of electricity from fossil fuels. When electricity is used in a non-residential building, the electricity generation typically takes place offsite at the power plant; electricity use in a non-residential building generally causes emissions in an indirect manner.

While fuel combustion generates CH_4 and N_2O, the emissions of these GHGs typically comprise less than 1% of CO_2e emissions from electricity generation and natural gas consumption.[126] Fuel oil, kerosene, liquefied petroleum gas, and wood can also be used as fuels, but generally contribute only in small amounts as combustion sources within non-residential buildings. Although emission factors for electricity generation and natural gas combustion were obtained for CO_2, it is assumed that these emission factors are representative of CO_2e emissions.

Similar to energy use in residential buildings, energy use in non-residential buildings is divided into energy consumed by the built environment and energy consumed by uses that are independent of the construction of the building such as plug-in appliances. In California, Title 24 governs energy consumed by the built environment, mechanical systems, and some fixed lighting. Non-building energy use, or “plug-in” energy use can be further subdivided by specific end-use (refrigeration, cooking, office equipment, etc.). The following two steps were performed to quantify the energy use due to non-residential buildings:

1. Calculate energy use from systems covered by Title 24[127] (HVAC system, water heating system, and the lighting system).
2. Calculate energy use from office equipment, plug-in lighting, and other sources not covered by Title 24.

[125] California Climate Action Registry (CCAR) General Reporting Protocol (GRP), Version 3.1 (January 2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf
[126] Ibid., Tables C1 and C2. The methane and nitrous oxide emission factors are negligible compared to the total CO_2 emission factor for electricity generation in California.
[127] Title 24, Part 6, of the California Code of Regulations: California's Energy Efficiency Standards for Residential and Nonresidential Buildings. http://www.energy.ca.gov/title24/

The resulting energy use quantities were then converted to GHG emissions by multiplying by the appropriate emission factors obtained by incorporating information on local electricity production.[128] The total GHG emissions for non-residential BAU buildings similar to those at SMV is estimated to be 5,846 tonnes CO_2e per year. The following sections describe the methodologies employed to estimate GHG emissions.

5.4.4.1 Estimate of Non-residential Energy Use Intensity

ENVIRON developed CO_2e intensity values (CO_2e emissions per sqft per year) for building types found in SMV using data from the 2003 Commercial Buildings Energy Consumption Survey (CBECS).[129] The methods that were used to estimate this for BAU non-residential buildings similar to those as SMV are described below.

5.4.4.2 EIA Database

The overall electricity use for the building types was calculated based on data provided by the EIA.[130] The building types and subcategories are shown in Table 5-16. Building categories provided by Codding Enterprises differ slightly from the two levels of default building categories in the EIA database. Table 5-16 also provides the mapping used to relate SMV building types to EIA building types.

Each building type has a characteristic electricity and natural gas use per square foot of building space. Energy use was based upon buildings in EIA climate zone 4 (includes California climate zone 2). Electricity use per square foot (electricity intensity) for each building sample was first calculated. The electricity intensities were then averaged taking into account the weighting factor for each building in the survey. Similarly, the natural gas use per square foot (natural gas intensity) for each building sample was first calculated and subsequently averaged taking into account the weighting factor for each building in the survey.

Table 5-17 lists the typical breakdown of electricity use among several end uses for electricity in various non-residential building types. Table 5-18 lists the typical percentage breakdown of end uses for natural gas in various non-residential building types. The end use data provide an estimate of the percent of the total energy use comprised by Title 24-regulated (built environment) and plug-in electricity in each building type. The Title 24-regulated electricity use (cooling, space heating, water heating, lighting, ventilation) and the non-built electricity use (office equipment, refrigeration, cooking,) are presented in Table 5-19. The Title 24-regulated natural gas use and the non-built natural gas use (primarily from cooking) are also presented in Table 5-19.

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[128] The Pacific Gas and Electric specific emission factor for electricity deliveries is 635.67 lbs CO_2/MWh. From the California Climate Action Registry Database. Pacific Gas and Electric Company 2007 PUP Report. 2009. Although this emission factor accounts for only CO_2, the emissions associated with N_2O and CH_4 contribute to less than 1% of the electricity generation CO_2e emissions.

[129] US Energy Information Administration (EIA). Public Use Microdata 2003. Available at http://www.eia.doe.gov/emeu/cbecs/contents.html

[130] Table 3a and 3b of: http://www.eia.doe.gov/emeu/cbecs/enduse_consumption/pba.html

The electricity and natural gas use per square foot for each building type are converted to GHG emissions as shown in the next section.

5.4.4.3 Estimation of Annual Greenhouse Gas Emissions from Non-Residential Buildings

Energy use data from Table 5-19 were multiplied by the emission factors presented in Table 5-20 to generate CO_2e intensity values (CO_2e emissions per sqft building area). The results are shown in Table 5-21. The CO_2e intensity values presented in Table 5-21 represent the non-residential BAU building types similar to those found in SMV described earlier. The annual CO_2e emissions for different building types range from 3.09 tonnes per 1,000 sqft for a public assembly (social/meeting) building to 40.1 tonnes per 1,000 sqft for a fast food restaurant.

Table 5-22 shows the yearly CO_2e emissions from non-residential BAU buildings similar to those as SMV by incorporating the emission factors developed as discussed above and the square footage of each of the main building categories. The overall CO_2e emissions associated with non-residential energy use is estimated to be 5,846 tonnes CO_2e per year.

5.4.4.4 Uncertainties in Non-residential Building GHG Calculations

Several factors lead to uncertainties in the above analysis. These are described below.

- The EIA energy use data for electricity and natural gas end-uses (Table 5-17 and Table 5-18) uses values from all climate zones and buildings built in all years. Data for new buildings broken down by climate zone is not yet available from the EIA. It is not clear that plug-in energy use would change substantially with climate zone, however, the percent of energy represented by plug-in uses will vary with climate zone. To the extent that more energy is used in the built environment in less temperate zones, this may serve to underestimate the plug-in energy use slightly.
- For new developments, the exact types of buildings are typically unknown. As such, not all building categories that may actually exist in SMV are represented in this analysis. For example, the Project Description mentions a data center, but does not provide details of the data center size. To the extent that information was available, all of the commercial building area is accounted for and the best available assessment of the building type composition of SMV was used. The tables provided in this section present the differences in energy intensities from building type to building type.
- ENVIRON used a baseline energy use value for non-residential buildings based upon survey data of current building stock. Although the correct comparison for BAU is with the Title 24 standards that were in effect in 2008, a direct comparison with these standards is not available. Current building stock is likely less efficient than the requirements for new buildings under Title 24, however, this was assumed to be the baseline values in this analysis since a better comparison of a standard Title 24 compliant building was not available.

5.4.5 Transportation

Consistent with one of the options in the OPR Guidance, this section discusses a comparison of project emissions with the goals of AB 32. In the developing world, GHG increases are directly tied to population growth. Therefore, it makes sense to consider operational emissions (including vehicular emissions) from new residences as growth, as residences are rarely removed from the housing supply once constructed. There are exceptions, such as when one housing development replaces another, and, in those cases, the replacement residential development need not be considered growth.

However, it is not clear that commercial development should be considered new growth for vehicular travel purposes. To the extent that commercial development serves existing residential development its vehicular travel may not be new. For instance, if the new commercial area serves an area with a high residential/commercial balance, then this new commercial growth will reduce shopping and work trip lengths and will reduce GHG emissions associated with mobile sources. If, however, the new commercial area results in longer trips for its workers and residents than they would have previously made, then it adds GHGs emissions. Commercial development that could potentially increase VMT would be facilities that draw trips from far away that otherwise would not be made. A theme park, for example, may be viewed as such a development.

In this report, it is assumed that new commercial area serves an area with a high residential/commercial balance. Therefore, this new commercial growth will reduce shopping and work trip lengths and will reduce GHG emissions associated with mobile sources. Accordingly, we assume that all commercial space in SMV will not contribute to mobile GHG emissions. To the extent that this development serves new residences, its traffic emissions are accounted for in the residential vehicle emissions.

Vehicle emissions will be reduced in the future regardless of the development location, as the implementation of AB 32 will require improvements in vehicle mileage, increased use of public transit, and the incorporation of low-carbon fuels into the transportation fuel supply[131].

Table 5-23 compares the annual VMT at SMV to the annual VMT by light duty autos and trucks in Sonoma County. Both are normalized by the number of dwelling units in order to compare the VMT per dwelling unit. [132] Sonoma County, considered here as the BAU scenario, has a total VMT of 3,932,211,000 miles per year. Table 5-23 shows that this is 20,337 miles per dwelling unit as compared with 14,713 miles per dwelling unit at SMV. However, the SMV traffic estimation method includes only residential vehicles. The Sonoma County estimate includes commercial vehicles and pass-through traffic. In addition, the SMV estimates were developed

[131] The Low Carbon Fuel Standard (LCFS) mandated under Governor Schwarzenegger's Executive Order S-01-07 and currently being developed by the California Air Resources Board (ARB) requires a reduction in carbon intensity of California's transportation fuels by at least 10% by 2020.

[132] Sonoma County VMT found in the 2005 California Motor Vehicle Stock, Travel, and Fuel Forecast, 2005; total value multiplied by fraction of all California vehicles that are light duty autos and trucks. Sonoma County population is from the 2006 US Census.

with different methodologies and different underlying assumptions than were the Sonoma County estimates. Therefore, they should be used only for an approximate comparison. Using this rough comparison, SMV represents a 28% reduction in VMT and approximately a 25% reduction in CO_2e compared to BAU.

In addition, a 1995 study prepared for ARB determined that annual VMT per dwelling units under “smart growth” principles should be 22,000 to 25,000 miles for sub urban level 3 areas[133]. The annual VMT per dwelling unit for SMV is 14,713 miles. Thus, SMV will generate fewer VMT on a per dwelling unit basis than the ARB report suggests for a "smart growth" development.

5.4.6 Water and Wastewater

The BAU comparison for water and wastewater treatment and distribution was based on a community that would use approximately 545 acre-feet of water annually with 439 acre-feet of potable water and 107 acre-feet of recycled water and generate 387 acre-feet of wastewater. The SMV Water Plan estimates that 42% reduction in residential water demand and 30% reduction in commercial water demand will result by implementing various water saving measures in the SMV development. The BAU numbers are based on not implementing project design features and not creating additional recycled water for use in the region. Table 5-24 shows the calculations for the BAU scenario. Since the Carbon Free Water Plan was not a part of AB 32’s Scoping Plan, the BAU scenario assumes that all the energy required for various operations such as portable water supply and conveyance, treatment and distribution, non-potable water treatment and distribution and wastewater treatment is supplied by PG&E. The energy requirements for various operations such as portable water supply and conveyance, treatment and distribution, non-potable water treatment and distribution and wastewater treatment were obtained from CEC’s report[134]. The energy intensity of the operations was combined with PG&E’s carbon-intensity factor to obtain the CO_2e emissions as shown in Table 5-24. The BAU scenario results in emissions of 618 metric tonnes of CO_2. The SMV development is 39% better than BAU.

5.4.7 Public Lighting and Municipal Vehicles

Table 5-24 shows the CO_2e emissions for public lighting for the BAU scenario as 190 tonnes CO_2e per year. The emissions were estimated assuming that the energy required for public lighting for the development is supplied by PG&E. The emissions for the BAU scenario from municipal vehicles are unchanged from what has been estimated for the SMV development. This brings the total CO_2e emissions from public lighting and municipal vehicles in the BAU scenario to 412 tonnes, which shows that SMV is 46% better than BAU.

[133] JHK & Associates, Inc. 1995. Transportation-Related Land Use Strategies to Minimize Motor Vehicle Emissions: An Indirect Source Research Study. June.

[134] California Energy Commission. 2006. Refining Estimates of Water-Related Energy Use in California. PIER Final Project Report. Prepared by Navigant Consulting, Inc. CEC-500-2006-118. December.

Overall for the municipal category comprising of emissions from water and wastewater treatment, public lighting and municipal vehicles from SMV is 42% better than BAU.

5.4.8 Waste Management

Waste management can include recycling, composting, landfilling and waste combustion. In California, there are no municipal waste combustors, so waste combustion is not considered here. Waste management emissions are impacted by four general categories: energy consumption required to make[135], transport, use, and dispose of an item; other manufacturing emissions not related to energy-use[136]; direct methane emissions from landfills; and carbon sequestration within landfills or when composting, which removes GHGs from the atmosphere. The emissions are influenced by the mass of waste generated; the fractions of waste that are recycled, landfilled, or composted; the landfill gas collection system, if there is one; and the transport distances.[137]

Codding Enterprises' waste management goal is to reclaim, recycle, compost, or avoid generating (as measured against a local baseline) at least 70% of waste by weight generated by residents and commercial operations within SMV. In order to estimate the GHG emissions that SMV will avoid as a result of this goal, SMV's waste management strategy is compared with a baseline strategy that encompasses local practices. USEPA's WAste Reduction Model (WARM)[138] is then used to estimate the GHG emissions avoided at SMV compared to BAU.

Table 5-25 provides the estimated total waste generated in Sonoma County. Population and commercial building area are used to scale this quantity for SMV's baseline case. SMV's projected percent improvements over this baseline case are shown in Table 5-26 for several areas. ENVIRON assumed that improvements changed linearly between interim goals in order to calculate a weighted 40-year average percent improvement for each area.

The weight of generated waste is broken down by material in Table 5-27 for both the baseline, using the percent by weight of various materials in a Sonoma County Waste Characterization Study, and the SMV projected case, using the percent improvements shown in Table 5-26. In Table 5-28, the amount of this generated waste which is recycled or composted is estimated. As discussed above, ENVIRON assumes that none of the waste is combusted.

[135] Reuse or recycling avoids the need for a product to be made from virgin materials. Since we are interested in the difference in life cycle CO_2 emissions between a typical scenario and at SMV, the model would account for this GHG savings.

[136] This would account for direct process emissions. For example, the CO_2 released when limestone is converted to lime in steel manufacturing.

[137] USPA, 2002. Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, 2nd Edition. EPA 530-R-02-006. http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf

[138] http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

In Table 5-29, the breakdown of waste generated (or reduced, in the alternative scenario), recycled, composted, or landfilled is given for both the baseline and alternative scenarios. ENVIRON assumes that all waste not reduced, recycled, or composted is sent to landfill.

Table 5-30 gives the estimated GHG impacts of each waste management strategy. A negative value indicates an emission reduction. The total avoided GHG emissions due to SMV's alternative waste management scenario, as compared to BAU, is 9,981 tonnes CO_2e per year. This comparison of emissions associated with waste are provided for discussion purposes only and are not included in the overall BAU comparison for SMV because waste emissions are not accounted for in SMV's GHG inventory. Nevertheless, it provides useful insight into the change in overall GHG emissions associated with SMV's waste management practices.

5.5 BAU Summary

Table 5-31 summarizes the comparisons between SMV and the BAU scenarios discussed in this section. When all emissions, including those where a BAU analysis was not able to be performed are considered, SMV shows a 58% improvement over BAU. Furthermore, this is 42% below the development's share of 1990 GHG emission levels. Further discussions on how these emissions will be reduced based on current and future regulations not considered under the BAU scenario are discussed in Section 6. These regulations are likely to allow SMV to achieve its share in meeting AB 32 goals and approach the further emission reduction goals of Executive Order S-03-05. Table 5-32 summarizes the comparisons between SMV assuming Pavley Standards for the traffic and the BAU scenarios discussed in this section. When all emissions, including those where a BAU analysis was not able to be performed are considered, SMV with Pavley Standards for traffic shows a 66% improvement over BAU and 53% below the development's share of 1990 GHG emission levels.

5.6 Comparison with State, Global, and Worldwide GHG Emissions

The emissions from the project at build-out are compared to California and global GHG emissions to put the emissions from the project in context. The project's annual emissions are approximately 11,866 metric tonnes CO_2e per year, and 11,833 tonnes of one-time emissions. If the one-time emissions are annualized by a development lifetime of 40 years (296 tonnes CO_2e per year), the overall yearly emissions are approximately 12,162 tonnes CO_2e per year. This is equivalent to approximately 2.7 tonnes per capita per year.[139]

Worldwide emissions of GHGs in 2004 were 26.8 billion tonnes of CO_2e per year.[140] In 2004, the US emitted about 7 billion tonnes of CO_2e.[141] Over 80% of the GHG emissions in the US are comprised of CO_2 emissions from energy related fossil fuel combustion. In 2004, California emitted 0.480 billion tonnes of CO_2e, or about 7% of the US emissions. 12,162 tonnes of CO_2e

[139] Assuming a SMV population of 4,438.
[140] Sum of Annex I and Annex II countries without counting Land-Use, Land-Use Change and Forestry (LULUCF) http://unfccc.int/ghg_emissions_data/predefined_queries/items/3814.php For countries that 2004 data was unavailable, the most recent year was used.
[141] 2006 Inventory of U.S. Greenhouse Gas Emissions and Sinks. Available online at: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLP4/$File/06ES.pdf

per year from SMV would be approximately 0.000045% of the world wide emissions, 0.00017% of the United State's emissions, or 0.0025% of California's annual GHG emissions.

6 Impact of Regulatory Developments on SMV's GHG Inventory

As discussed in Section 3.0 there are a number of regulatory developments on both the federal and state level that will impact GHG emissions at SMV. For example, the Low Carbon Fuel Standard (LCFS), the Pavley Standards, and the Energy Independence and Security Act of 2007 all reduce CO_2e vehicle emissions. While a detailed quantitative analysis of each rule and regulation is beyond the scope of this report, it is possible to provide a semi-quantitative evaluation of the impact of the passed and planned rules and regulations on SMV's GHG inventory. In this section, ENVIRON presents an evaluation of the planned standards for renewable power requirements, LCFS, vehicle efficiency, and vehicle tailpipe emissions. These regulatory developments will assist in meeting AB32 goals and continue toward the 2050 goal of an 80% reduction from 1990 levels.

Executive order S-03-05 mandates that California emit 80% less GHGs in 2050 than it emitted in 1990. As of 2004, California was emitting 12% more GHG emissions than in 1990. For California to emit 80% less than it emitted in 1990, the emissions would be only 18% of the 2004 emissions. Accounting for a population growth from 35,840,000 people in 2004 to approximately 55,000,000 people in 2050, the emissions per capita would have to be only 12% of what they were in 2004. This means 88% reductions in per capita GHG emissions from today's emissions intensities must be realized in order to achieve California's 2050 GHG goals. Clearly, energy efficiency and reduced vehicle miles traveled will play important roles in achieving this aggressive goal, but the decarbonization of fuel will also be necessary.

The extent to which GHG emissions from traffic at SMV will change in the future depends on the quantity (e.g. number of vehicles, average daily mileage) and quality (i.e. carbon content) of fuel that will be available and required to meet both regulatory standards and residents' needs. As discussed above, renewable power requirements, the low carbon fuel standard, and vehicle emissions standards will all decrease GHG emissions per unit of energy delivered or per vehicle mile traveled. In this section we discuss the impact that future regulated fuel decarbonization may have on vehicular emissions at SMV.

The California Energy Commission (CEC) published "State Alternative Fuels Plan"[142] in which it noted the existence of "challenging but plausible ways to meet 2050 [transportation] goals." The main finding from this analysis is that reducing today's average per capita driving miles by about 5 percent (or back to 1990 levels), in addition to the decarbonization strategies listed below, would achieve S-03-05 goals of 80% below 1990 levels. The approach described below is directly[143] from the CEC report:

[142] State Alternative Fuels Plan. December 2007 CEC-600-2007-011-CMF. Available online at: http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF
[143] Ibid. Page 67 and 68.

An 80 percent reduction in GHG emissions associated with personal transportation can be achieved even though population grows to 55 million, an increase of 50 percent. The following set of measures could be combined to produce this result:

1. Lowering the energy needed for personal transportation by tripling the energy efficiency of on-road vehicles in 2050 with:
    a. Conventional gas, diesel, and flexible fuel vehicles (FFVs) averaging more than 40 miles per gallon (mpg).
    b. Hybrid gas, diesel, and FFVs averaging almost 60 mpg.
    c. All electric and plug-in hybrid electric vehicles (PHEVs) averaging well over 100 mpg (on a greenhouse gas equivalents (GGE) basis) on the electricity cycle.
    d. Fuel cell vehicles (FCVs) averaging over 80 mpg (on a GGE basis).
2. Moderating growth in per capita driving, reducing today's average per capita driving miles by about 5 percent or back to 1990 levels.
3. Changing the energy sources for transportation fuels from the current 96 percent petroleum-based to approximately:
    a. 30 percent from gasoline and diesel from traditional petroleum sources or lower GHG emission fossil fuels such as natural gas.
    b. 30 percent from transportation biofuels.
    c. 40 percent from a mix of electricity and hydrogen.
4. Producing transportation biofuels, electricity, and hydrogen from renewable or very low carbon-emitting technologies that result in, on average, at least 80 percent lower life cycle GHG emissions than conventional fuels.
5. Encouraging more efficient land uses and greater use of mass transit, public transportation, and other means of moving goods and people.

The measures described above are the types of measures that will yield required reductions. Although these types of measures are expected to occur and are consistent with the SMV development plan, SMV is not claiming any credit for these measures.

6.1 Renewable Power Requirements

A major component of California's Renewable Energy Program is the Renewables Portfolio Standard (RPS) established under Senate Bills 1078 (Sher) and 107 (Simitian). Under the RPS, certain retail sellers of electricity are required to increase the amount of renewable energy each year by at least 1% until 20% by December 31, 2010. Executive Order S-14-08 sets an even higher goal of 33% by 2020. Renewable sources of electricity include wind, small hydropower, solar, geothermal, biomass, and biogas. The increase in renewable sources for electricity production will decrease indirect GHG emissions from SMV because electricity production from renewable sources is generally considered "carbon neutral."[144] Because SMV has committed to meeting its energy needs with 100% renewable power, the RPS will not affect SMV emissions directly.

6.2 Low Carbon Fuel Standard (LCFS)

As mentioned previously, the LCFS requires a reduction in carbon intensity of transportation fuels by at least 10% by 2020. The LCFS encompasses the life cycle emissions for fuels (i.e., "well-to-wheel"). Thus, not only does it include the vehicle tailpipe emissions from the use of the fuel, it also includes all the energy used to produce, process, and transport the fuel. By design, the implementation of the LCFS would decrease the overall GHG emissions for California. However, its impact on vehicle tailpipe emissions is not obvious, as the reductions would be distributed throughout the fuel's lifetime, including fuel production. As the SMV GHG inventory only considers the vehicle tailpipe emissions, and not the life cycle emissions for transportation, it is difficult to quantitatively assess the impacts of the LCFS on the inventory. The LCFS will directly affect the emission factor and the fuel economy since alternate fuels will have various energy/carbon content. Fuels identified as possible alternatives to conventional gasoline and diesel include biodiesel, ethanol E85, and compressed natural gas (CNG). According to a study by TIAX, LLC, well-to-wheel GHG emissions for E85 derived from Midwest corn feedstock and CNG from North America would be expected to be roughly 22% and 30% lower relative to reformulated gasoline.[145]

Table 6-1 presents a few scenarios to illustrate the impact of LCFS on tailpipe emissions at SMV. The baseline scenario represents the current vehicle miles traveled at SMV. Total annual vehicle miles travelled (VMT) is 27,837,762 miles per year as found in the primary approach in Section 4.9; for this scenario we will assume a fleet distribution of 95% gasoline vehicles and 5% diesel vehicles and a fleet average emission factor. The GHG inventory for vehicle tailpipe emissions in this scenario is approximately 13,253 metric tonnes CO_2 per year.[146] The GHG emissions depend on the emission factors for each fuel (kg CO_2/gallon of fuel), average fuel economy (miles per gallon), and the VMT.[147]

[144] There is some debate on the carbon neutrality of using biomass and biogas for electricity production. While some may argue that the carbon released as CO_2 from biomass or biogas combustion originated from the atmosphere and thus does not contribute any net additional carbon to the atmosphere, others argue that the combustion still releases CO_2 into the atmosphere and thus cannot be ignored. For sake of the semi-quantitative analysis presented here, we assume that electricity production from renewable sources is carbon neutral. However, this should not be interpreted as a policy judgment for either argument.

[145] California Energy Commission (CEC) and California Air Resources Board (ARB). 2007. State Alternative Fuels Plan. Commission Report. CEC-600-2007-011-CMF. December.

[146] This figure only includes CO_2 and not CO_2e and does not include start-up emissions for purposes of comparison to this analysis.

[147] The emissions estimated in Table 6-1 here are derived differently compared to emissions calculated from the EMFAC model runs for the SMV inventory; the estimated emissions for the baseline scenario are roughly within 10% of the vehicle emissions developed using EMFAC. This difference is likely due to improvements in vehicle technology estimated for 2011. However, for purposes of this semi-quantitative analysis, this should be acceptable since the emissions presented in this table are only for comparative purposes and are not meant to represent actual emissions at SMV.

Scenario A represents a replacement of conventional California diesel with biodiesel. While the emission factor for biodiesel is lower (9.46 kg CO_2/gal) compared to conventional California diesel (10.15 kg CO_2/gal), the average fuel economy of vehicles running on California diesel is higher (7.9 mpg) than for vehicles running on biodiesel (7.1 mpg).[148,149] The result is that the overall tailpipe vehicle emissions at SMV would increase slightly if California diesel were replaced by biodiesel. This is a case where the overall life cycle analysis GHG emissions for biodiesel are lower than that for conventional California diesel, but the actual tailpipe emissions would be slightly higher.

Scenario B represents a replacement of conventional California gasoline with an 85% ethanol blend (E85). Compared to conventional California gasoline, E85 has a lower emission factor on a per gallon basis (6.10 kg CO_2/gal)[150] but also a lower fuel economy (15.2 mpg)[151] due to the lower energy content of E85. The resulting tailpipe emissions at SMV in this scenario would be roughly 6.6% lower than the baseline scenario. In this case the decreased fuel economy for E85 vehicles was more than offset by the lower emission factor, resulting in lower tailpipe emissions.

Scenario C represents a replacement of conventional California gasoline with compressed natural gas (CNG). Compared to conventional California gasoline, CNG has a lower emission factor on a per equivalent gallon basis (5.31 kg CO_2/equivalent gallon).[152] The current commercially available car running on CNG has a higher fuel economy (28 mpg)[153] than that for the average gasoline vehicle. The resulting tailpipe emissions at SMV in this scenario would be over 48% lower than the baseline scenario. In this case, the increased fuel economy for CNG and the lower emission factor both contribute to the lower tailpipe emissions.

These scenarios illustrate that the alternative fuels available in the future can have different effects on vehicle tailpipe emissions which is accounted for in the SMV GHG inventory. The degree of impact on the SMV's GHG inventory can be slight to moderate depending on the fuel mix available. The semi-quantitative analysis presented here is only speculative. This analysis does not account for improvements in vehicle technology (i.e., emission factors and fuel economy are constant) or changes in VMT for SMV's population. In reality, vehicle technologies

[148] Emission factors for fuels were from the California Climate Action Registry General Reporting Protocol, Version 3.1 (January2009).

[149] Average fuel economy data for biodiesel from the Department of Energy website: http://www.fueleconomy.gov/feg/biodiesel.shtml

Average fuel economy data for diesel-fueled vehicles obtained from fuel usage and VMT projections for 2008 from the California Department of Transportation report "California Motor Vehicle Stock, Travel, and Fuel Forecast" available at: http://www.dot.ca.gov/hq/tsip/smb/documents/mvstaff/mvstaff05.pdf

[150] Emission factors for fuels were from the California Climate Action Registry General Reporting Protocol, Version 3.1 (January2009).

[151] Average fuel economy data for E85 from the Department of Energy website: http://www.fueleconomy.gov/feg/ethanol.shtml

[152] Emission factors for fuels were from the California Climate Action Registry General Reporting Protocol, Version 3.1 (January2009).

[153] Fuel economy for a 2008 Honda Civic fueled by CNG available at: http://www.fueleconomy.gov/feg/byfueltype.htm

are likely to improve and VMT will increase as SMV's population increases. Nevertheless, the LCFS, by definition, should result in lower overall GHG emissions in California. However, these emission reductions are not reflected in SMV's GHG inventory.

6.3 Vehicle Emissions Standards/Improved Fuel Economy

The two regulatory measures considered in this section are the vehicle GHG emission standards enacted under AB 1493 (Pavley) (Table 6-2) and the increased fuel economy standards under the Energy Independence and Security Act of 2007 (EISA) (Table 6-3). As discussed in Section 3.3, the Pavley standards require GHG emission reductions from vehicles equivalent to approximately 30% by 2016. The EISA requires that manufacturers achieve a Corporate Average Fuel Economy (CAFE) of 35 mpg by 2020. Thus, a direct comparison between the Pavley standards and the EISA standards is not possible because the Pavley standards regulate GHG emissions in terms of grams of CO_2e per mile driven while the EISA regulates fuel economy in terms of miles per gallon of fuel consumed. However, ARB released a study comparing the GHG emissions benefit of the California and the federal standards.[154] The analysis presented here is based on the ARB study. Due to limited data availability concerning projected standards, ENVIRON performed the following analysis using mobile emissions corresponding to the year 2020, although the inventory presented in Chapter 4 includes mobile emissions for the year 2030, or full build-out.

The current average GHG emissions rate on a per mile basis for the SMV development is 432 grams CO_2e per vehicle mile traveled (g CO_2e/mile) (Table 6-4). This is approximately 15% higher than the assumed fleet-average standard for 2010 vehicles (375 g CO_2e).[155] One must consider that the vehicle fleet at SMV will consist of vehicles of various model years, which is the reason why the average GHG emissions rate is much higher than the assumed standard for 2010 model year vehicles. As a rough approximation, one can assume that at full build-out in 2030, the vehicle fleet at the SMV development will also have an average GHG emissions rate that is 15% higher (i.e., more GHG emissions will occur) than the standard in place.

Table 6-5 shows the estimated GHG emissions rate on a per mile basis for the SMV development under the Pavley standards and under the EISA standards in 2020.[156] The GHG emissions rate would decrease from 432 g CO_2e/mile to 234 g CO_2e/mile under the Pavley standards, a reduction of approximately 46%. Under the EISA, the GHG emissions rate would decrease to 293 g CO_2e/mile, a reduction of approximately 32%. The GHG emissions rate on a per mile basis at SMV in 2020 will depend on the actual vehicle fleet mix present at that time.

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[154] California Air Resources Board (ARB). 2008. Comparison of Greenhouse Gas Reductions For the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations.

[155] The assumed fleet-average standard here assumes only current pre-EISA CAFÉ standards in effect. The mobile source emissions from EMFAC for SMV in 2020 do not assume any reductions in GHG emissions from regulatory activities. Therefore, for this approximation, we compared the 2020 emissions provided by EMFAC to the CAFÉ standards in 2010.

[156] The Pavley standard only regulates emissions up to the year 2016. However, the ARB assumes that additional GHG emission reductions will be required up to 2020.

However, this analysis shows that both the Pavley standard and the federal standard will have a significant impact on the vehicle tailpipe emissions.

7 Conclusion

Codding is committed to having SMV make the business case for sustainable development. By including key sustainable features such as providing all energy needs through renewable energy sources, reducing building energy needs, designing SMV with compact design principles, and providing alternatives to driving, SMV is expected to have substantially lower GHG emissions than the average California development. ENVIRON attempted to reflect these sustainable features in this emissions inventory. This emissions inventory was prepared consistent with the methodologies established by the CCAR where possible. The SMV emissions inventory considers seven categories of GHG emissions: emissions due to vegetation changes, emissions from construction activities, residential emissions, commercial building emissions, mobile source emissions, municipal emissions, and area source emissions. The emissions from construction and land use change would be one-time emissions events, while the other emissions would occur annually, throughout the life of the project. A semi-quantitative assessment of the impact of rules to reduce GHG intensity in electricity production and vehicle use was also included.

A variety of methods were employed to develop the GHG emissions inventory. In addition to well established emission factors for certain activities and emission estimates based on similar activities in other representative communities, several different estimation software were used. These included EMFAC, OFFROAD, BARBD, URBEMIS, and WARM. For energy use in buildings, Micropas energy modeling software was used.

Emissions from the various components of the SMV development are presented in Table 4-18. This table identifies the one-time emissions that would be attributable to project entitlement, and the annual emissions expected to occur each year after the full build out of the development. There are approximately 11,833 tonnes of CO_2e one-time emissions. The annual emissions from the use of the development amount to approximately 11,866 tonnes. Of this amount, 95% result from vehicular emissions associated with residential and commercial activities, and 0% result from the energy use associated with residential and non-residential buildings, as SMV is committed to meeting 100% of its residential and non-residential building energy demand with renewable sources of energy. If the one-time emissions are annualized assuming a 40-year development life (which is likely low), then the one-time emissions account for approximately 2.4% of the overall emissions. As discussed below, these figures reflect conservative assumptions that likely overstate the GHG emissions that would result from this project.

It is anticipated that the waiver from USEPA necessary to implement Pavley Standards will likely be granted. The annual emissions from the use of the development using Pavley Standards for traffic amount to 9,941 tonnes. Of this amount, 94% result from vehicular emissions associated with residential and commercial activities, and 0% result from the energy use associated with residential and non-residential buildings, as SMV is committed to meeting 100% of its residential and non-residential building energy demand with renewable sources of energy.

Compared to California's 2020 BAU per capita emissions, 14.1 tonnes CO_2e per capita, a 28.3% decrease in emissions by 2020 is required to achieve AB 32 goals. In order to achieve

AB 32 mandated goals, the per capita emissions would have to be 10.1 tonnes CO_2e. SMV has estimated emissions of 12,162 tonnes per year, or 2.7 tonnes per capita per year.[157] This estimate does not include emissions from heavy industry, refining, or commercial transportation.

As a result of the various design elements incorporated into the SMV project, the development exceeds AB 32's goal of 28.3% below BAU in several areas. For example, as designed, buildings in SMV are expected to emit no greenhouse gases from the use of electricity and natural gas due to SMV's goal to meet 100% of its residential and non-residential energy demand from renewable sources. Vehicular emissions from SMV residents are roughly 25% fewer per dwelling unit than BAU. Additionally, SMV's municipal sources are 42% better BAU which does not include water efficiency measures and energy efficient street lighting. The emission savings combined for SMV represent a 58% reduction from a BAU situation without taking into consideration changes in emission factors, occupant energy use reductions, and categories that do not permit a BAU comparison for at this time. It should be noted that each estimate was developed using a different methodology; any conclusions based upon a comparison of these numbers should note the difference in methodologies. This is a 58% overall reduction from BAU and is 42% below the development's share of 1990 GHG emissions. When Pavley Standards are applied to the traffic emission inventory, the emission savings combined for SMV represent a 66% reduction from a BAU situation and are 53% below the development's share of 1990 GHG emissions. It is yet unclear as to how to compare construction, vegetation change, municipal, and area emissions to AB 32 mandated goals.

The GHG emission inventory for SMV was based on several conservative assumptions. In addition, anticipated state and federal regulatory developments are expected to result in lower GHG emissions from SMV than are represented in this analysis. For example, both the Pavley vehicle emissions standards and the increased CAFE standards under the Energy Independence and Security Act of 2007 (EISA) will result in a moderate decrease in SMV's GHG inventory as tailpipe emissions would be roughly 26 - 40% lower.

Thus, while the SMV project already exceeds AB 32's 2020 targets and is approaching California's 2050 targets, upon implementation of existing and anticipated legislative and regulatory mandates, actual emissions associated with the project will likely be considerably lower.

[157] Assuming a population of 4,438 residents in SMV.

Tables

Table 4-1
CO_2 Sequestration Change due to Land Use Change
Sonoma Mountain Villlage
Rohnert Park, California

Vegetation Type[1]	**IPCC Designation**[2]	**IPCC Sub qualification**	**Tons Dry Matter Carbon/Acre**[3] (tonne/acre)	**Sequestered CO_2 / Acre**[4] (tonne/acre)	**Total Impacted Area**[5] (acres)	**CO_2 Sequestration Capacity of Removed Vegetation** (tonne)
Developed	Settlements		0.0	0.0	-1	0
Grass- and Herb-Dominated Vegetation Type	Grassland		1.2	4.3	10	45
Grassland	Grassland		1.2	4.3	-7.0	-30
Native Perennial Grassland/California Annual Grassland	Grassland		1.2	4.3	-6.0	-26
Riparian and Bottomland Vegetation Type	Forest Land	Scrub	3.9	14.3	4	60
GRAND TOTAL	-		-	-	**0**	**48**

Notes:
1. Land types shown here represent vegetation that will be potentially removed upon development.
2. Land types are mapped to generalized IPCC Land Designations (IPCC 2006).
3. Dry matter carbon per acre was determined from information contained in Table 4-2.
4. It is conservatively assumed that all carbon is eventually converted into CO_2. Multiply the mass of carbon by 3.67 to calculate the final mass of CO_2 (the molecular mass of CO_2 / the molecular mass of carbon is 44/12 or 3.67).
5. Data provided by Codding Enterprises. A positive number indicates the amount of land removed and a negative number indicates that this land type is added.

Abbreviations:
CO_2 - carbon dioxide
IPCC - Intergovernmental Panel on Climate Change

Sources:
Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

Table 4-2
Carbon per Acre for IPCC Land Types
Sonoma Mountain Villlage
Rohnert Park, California

IPCC Designation	Sub qualification	Above Ground Biomass[1] [tonne d.m./acre]	Ratio of Above Ground / Below Ground Biomass[2]	Total Biomass [tonne d.m./Hectare]	Total Biomass[3] [tonne d.m./acre]	Tons Dry Matter Carbon/Acre[4] [tonne/acre]
Forest Land[5]	Scrub	5.7	2.17	-	8.3	3.9
Grassland[6]		-	-	6.1	2.5	1.2
Settlements		-	-		0.0	0.0

Notes:

1. Numbers listed are used in conjunction with above ground/below ground ratios to calculate total biomass per acre. Values from source converted to tonne/acre.
2. This value is used to calculate total biomass when data for the total biomass is not available for a particular land type.
3. Total biomass is either 1.) Listed directly in the IPCC protocol, or 2.) Calculated from above ground biomass and the Above Ground / Below Ground biomass ratios as follows: Total = Above + (Above / Ratio). Values from source converted to tonne/acre as necessary.
4. Total biomass is multiplied by carbon fraction in plant material (0.47) to calculate carbon content. From IPCC (2006), default value for Forest Land (Table 4.3 of IPCC). Here, it is assumed that agricultural vegetation has the same carbon fraction as other vegetation types.
5. The value for the ratio of above ground/below ground biomass for various scrub types corresponds to the IPCC value for temperate mountain/continental systems (other broadleaf above-ground biomass <75 tonnes/hectare)(Table 4.4 of IPCC, p. 4.49). This value is likely to be conservative since scrub is a type of shrub which is likely to have a smaller ratio than for trees. The value for above ground biomass applied to various scrub types is based on a value of 1,417 g biomass/m^2 (or 5.7 tonne biomass/acre) for coastal sage scrub (Gray and Schlesinger). It is assumed that all scrub types will have similar values.
6. Total biomass for grassland corrsponds to IPCC value for grassland in warm temperate-dry climates (Table 6.4 of IPCC).

Abbreviations:

d.m. - dry mass
IPCC - Intergovernmental Panel on Climate Change

Sources:

Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm
Biomass, production , and litterfall in the coastal sage scrub of Southern California. Gray, John T. and Schlesinger, William H. American Journal of Botany. Volume 68, No.1 (January 1981).

Table 4-3
Green Waste Emission Factor
Sonoma Mountain Villlage
Rohnert Park, California

Type of Waste to Compost	Carbon Storage of Waste[1]	Carbon Storage due to Humus Formation[2]	Total CO_2 Emissions Savings due to Carbon Storage
	(tonnes CO_2e/ tonne waste)	(tonnes CO_2e/ tonne waste)	(tonnes CO_2e/ tonne waste)
Green Waste Only	0.20	0.19	0.39

Notes:
1. Using the average value. Values range from 0.02 to 0.08 MTCE per wet ton organics immediately after application of compost and 24 years post application. USEPA 2006.
2. USEPA 2006.

Abbreviations:
CO_2e - carbon dioxide equivalents
GHG - greenhouse gases
MTCE - metric tonnes of carbon dioxide equivalents
USEPA - United States Environmental Protection Agency

Sources:
Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. (USEPA 2006) Available at: http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf

Table 4-4
CO_2e Sequestration by Existing Green Waste Piles
Sonoma Mountain Villlage
Rohnert Park, California

Activity	Density [1]	Height of Greenwaste Piles[2]	Area of Greenwaste Piles[3]	Direct Emissions				Sequestration	
				Emission Factors as CO_2e (Biogenic)[4]		Emissions as CO_2e (Biogenic)[5]		CO2 Sequestration Capacity of Removed Greenwaste Piles (per tonne)[6]	CO_2 Sequestration Capacity of Removed Greenwaste Piles[6]
				CO_2	CH_4	CO_2	CH_4		
	(kg/m^3)	(m)	(m^2)	(lb CO_2e/tonne waste)	(lb CO_2e/tonne waste)	(tonnes CO_2e)	(tonnes CO_2e)	(tonnes CO_2e/ tonne waste)	(tonnes CO_2e)
Composting	502.5	1.5	1578	661	20	121	4	0.39	158

Notes:
1. Density obtained from CIWMB 2007.
2. Height of pile obtained from optimal pile structure requirements found in SCAQMD's Technology Assessment for Proposed Rule 1133, page 1-7.
3. Codding indicated that 0.39 acres of existing greenwaste piles will be removed, to be replaced by irrigated grass, trees, shrubs, and groundcovers.
4. Biogenic emissions include the direct emissions from green waste degradation.
5. ENVIRON assumed that the entire area is filled with greenwaste piles that are conical in shape with a base diameter of 5 feet, following SCAQMD's optimal pile structure guidance for Rule 1133.
6. Carbon sequestration capacity of removed greenwaste piles.

Abbreviations:
CH_4 - methane
CIWMB - California Integrated Waste Management Board
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalents
GHG - greenhouse gases
kg - kilogram
lb - pound
m - meter
SCAQMD - South Coast Air Quality Management District

Sources:
Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Composting Facility in San Joaquin Valley (California Intergrated Waste Management Board). October 21 2007. (CIWMB 2007) Available at: http://www.ciwmb.ca.gov/Publications/Organics/44207009.pdf
SCAQMD, 2002. Technology Assessment for Proposed Rule 1133. Available at: http://www.aqmd.gov/rules/doc/r1133/r1133_techassessment.pdf

Table 4-5
CO_2 Sequestration Capacity of New Vegetation Plantings
Sonoma Mountain Villlage
Rohnert Park, California

Vegetation Species[1]	IPCC Species Class Designation	Sequestered CO_2 / Unit[1] (tonne/unit/year)	Unit	Total Quantity of New Vegetation	Unit	CO_2 Sequestration Capacity of New Vegetation[2] (tonne)
Soft Maple	Soft Maple	0.043	trees	300	trees	258
Hardwood Maple	Hardwood Maple	0.052	trees	390	trees	406
All Other Types	Miscellaneous	0.035	trees	-341	trees	-239
Mixed Hardwood	Mixed Hardwood	0.037	trees	2,390	trees	1,769
GRAND TOTAL	-	-		**2,739**	**trees**	**2,194**

Notes:

1. Species class-specific sequestration values are provided in Table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4". For species that do not appear in Table 8.2, the species was classifed as "miscellaneous" and the average value of all listed data was used.
2. An active growing period of 20 years was assumed for the new trees planted.

Abbreviations:

CO_2 - carbon dioxide
IPCC - Intergovernmental Panel on Climate Change

Sources:

Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

Table 4-6
Change in CO_2 Sequestration Due to Land Use Changes and New Vegetation Plantings
Sonoma Mountain Villlage
Rohnert Park, California

CO_2 Sequestration Capacity of Removed Vegetation[1]	CO_2 Sequestration Capacity of New Vegetation	Net Change in CO_2 Sequestration Capacity[2]
(tonne)	**(tonne)**	**(tonne)**
-203	2,194	1,991

Notes:

1. This value represents the net CO_2 sequestered from land use changes and removal of green waste piles minus any biogenic emissions due to man-made activities (i.e., CH_4 emissions from anerobic degredation) . Biogenic CO_2 emissions from the removed vegetation are conservatively excluded from this analysis since they would have happened naturally, absent human activity.

2. A positive value represents an increase in sequestration capacity and thus a net reduction in CO_2.

Abbreviations:

CO_2 - carbon dioxide

Table 4-7
GHG Emissions from Construction Equipment
Sonoma Mountain Village
Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Biodiesel)[7]	Emission Factor (Diesel)[7]	CO_2e Emission (B20 Biodiesel)[8,9]	
									CO_2e Emission (Biodiesel Component)	CO_2e Emission (Diesel Component)
							(g/bhp-hr)	(g/bhp-hr)	(tonnes)	
Phase 1A	Demolition	Excavators	1	365	168	0.57	530	568	4	16
		Loaders	1	365	108	0.55	530	568	2	10
		Portable Crusher	1	365	142	0.78	530	568	4	18
		Water Trucks	1	365	189	0.50	530	568	4	16
		Demolition Total							**14**	**60**
	Grading	Graders	1	365	174	0.61	530	568	4	18
		Scrapers	3	365	313	0.72	530	568	26	112
		Water Trucks	1	365	189	0.50	530	568	4	16
		Plate Compactors	1	365	8	0.43	530	568	0	1
		Grading Total							**34**	**146**
	Underground Construction	Excavators	4	1,217	168	0.57	530	568	49	212
		Water Trucks	2	1,217	189	0.50	530	568	24	105
		Loaders	2	1,217	108	0.55	530	568	15	66
		Backhoes	2	1,217	108	0.55	530	568	15	66
		Underground Construction Total							**104**	**448**
	Subgrade and Rock	Graders	1	146	174	0.61	530	568	2	7
		Scrapers	1	146	313	0.72	530	568	3	15
		Tire Roller Scraper	1	146	95	0.56	530	568	1	4
		Subgrade and Rock Total							**6**	**26**
	Building Construction	Excavators	1	2,021	168	0.57	530	568	21	88
		Forklifts	2	2,486	145	0.30	530	568	23	98
		Graders	2	5,727	174	0.61	530	568	129	553
		Tractors/Loaders/Backhoes	1	3,315	108	0.55	530	568	21	90
		Cranes	1	2,486	399	0.43	530	568	45	194
		Generator sets	1	3,315	549	0.74	530	568	143	612
		Welders	3	3,315	45	0.45	530	568	21	92
		Building Construction Total							**402**	**1,726**
	Paving	Pavers	1	122	100	0.62	530	568	1	3
		Steel Drum Roller	2	122	95	0.56	530	568	1	6
		Paving Total							**2**	**9**
		PHASE TOTAL							***563***	***2,415***
Phase 1B	Demolition	Excavators	1	122	168	0.57	530	568	1	5
		Loaders	1	122	108	0.55	530	568	1	3
		Portable Crusher	1	122	142	0.78	530	568	1	6
		Water Trucks	1	122	189	0.50	530	568	1	5
		Demolition Total							**5**	**20**
	Grading	Graders	1	49	174	0.61	530	568	1	2
		Scrapers	3	49	313	0.72	530	568	3	15
		Water Trucks	1	49	189	0.50	530	568	0	2
		Plate Compactors	1	49	8	0.43	530	568	0	0
		Grading Total							**5**	**19**

Table 4-7
GHG Emissions from Construction Equipment
Sonoma Mountain Village
Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Biodiesel)[7]	Emission Factor (Diesel)[7]	CO_2e Emission (B20 Biodiesel)[8,9] — CO_2e Emission (Biodiesel Component)	CO_2e Emission (B20 Biodiesel)[8,9] — CO_2e Emission (Diesel Component)
							(g/bhp-hr)	(g/bhp-hr)	(tonnes)	
Phase 1B	Underground Construction	Excavators	4	511	168	0.57	530	568	21	89
		Water Trucks	2	511	189	0.50	530	568	10	44
		Loaders	2	511	108	0.55	530	568	6	28
		Backhoes	2	511	108	0.55	530	568	6	28
		Underground Construction Total							**44**	**188**
	Subgrade and Rock	Graders	1	73	174	0.61	530	568	1	4
		Scrapers	1	73	313	0.72	530	568	2	7
		Tire Roller Scraper	1	73	95	0.56	530	568	0	2
		Subgrade and Rock Total							**3**	**13**
	Building Construction	Excavators	1	1,044	168	0.57	530	568	11	45
		Forklifts	2	31	145	0.30	530	568	0	1
		Graders	2	5,915	174	0.61	530	568	133	571
		Tractors/Loaders/Backhoes	1	41	108	0.55	530	568	0	1
		Cranes	1	20	399	0.43	530	568	0	2
		Building Construction Total							**145**	**620**
	Paving	Pavers	1	73	100	0.62	530	568	0	2
		Steel Drum Roller	2	73	95	0.56	530	568	1	4
		Paving Total							**1**	**6**
		PHASE TOTAL							***202***	***866***
Phase 1C	Demolition	Excavators	1	24	168	0.57	530	568	0	1
		Loaders	1	24	108	0.55	530	568	0	1
		Portable Crusher	1	24	142	0.78	530	568	0	1
		Water Trucks	1	24	189	0.50	530	568	0	1
		Demolition Total							**1**	**4**
	Grading	Graders	1	219	174	0.61	530	568	2	11
		Scrapers	3	219	313	0.72	530	568	16	67
		Water Trucks	1	219	189	0.50	530	568	2	9
		Plate Compactors	1	219	8	0.43	530	568	0	0
		Grading Total							**20**	**88**
	Underground Construction	Excavators	4	268	168	0.57	530	568	11	47
		Water Trucks	2	268	189	0.50	530	568	5	23
		Loaders	2	268	108	0.55	530	568	3	14
		Backhoes	2	268	108	0.55	530	568	3	14
		Underground Construction Total							**23**	**99**
	Subgrade and Rock	Graders	1	24	174	0.61	530	568	0	1
		Scrapers	1	24	313	0.72	530	568	1	2
		Tire Roller Scraper	1	24	95	0.56	530	568	0	1
		Subgrade and Rock Total							**1**	**4**

Table 4-7
GHG Emissions from Construction Equipment
Sonoma Mountain Village
Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Biodiesel)[7]	Emission Factor (Diesel)[7]	CO_2e Emission (B20 Biodiesel)[8,9] CO_2e Emission (Biodiesel Component)	CO_2e Emission (Diesel Component)
							(g/bhp-hr)	(g/bhp-hr)	(tonnes)	
Phase 1C	Building Construction	Excavators	1	860	168	0.57	530	568	9	37
		Forklifts	2	1,377	145	0.30	530	568	13	54
		Graders	2	4,875	174	0.61	530	568	110	470
		Tractors/Loaders/Backhoes	1	1,836	108	0.55	530	568	12	50
		Cranes	1	1,377	399	0.43	530	568	25	107
		Generator sets	1	1,836	549	0.74	530	568	79	339
		Welders	3	1,836	45	0.45	530	568	12	51
		Building Construction Total							**258**	**1,109**
	Paving	Pavers	1	24	100	0.62	530	568	0	1
		Steel Drum Roller	2	24	95	0.56	530	568	0	1
		Paving Total							**0**	**2**
		PHASE TOTAL							***304***	***1,306***
Phase 1D	Demolition	Excavators	1	49	168	0.57	530	568	0	2
		Loaders	1	49	108	0.55	530	568	0	1
		Portable Crusher	1	49	142	0.78	530	568	1	2
		Water Trucks	1	49	189	0.50	530	568	0	2
		Demolition Total							**2**	**8**
	Underground Construction	Excavators	4	170	168	0.57	530	568	7	30
		Water Trucks	2	170	189	0.50	530	568	3	15
		Loaders	2	170	108	0.55	530	568	2	9
		Backhoes	2	170	108	0.55	530	568	2	9
		Underground Construction Total							**15**	**63**
	Subgrade and Rock	Graders	1	24	174	0.61	530	568	0	1
		Scrapers	1	24	313	0.72	530	568	1	2
		Tire Roller Scraper	1	24	95	0.56	530	568	0	1
		Subgrade and Rock Total							**1**	**4**
	Building Construction	Excavators	1	307	168	0.57	530	568	3	13
		Forklifts	2	664	145	0.30	530	568	6	26
		Graders	2	1,739	174	0.61	530	568	39	168
		Tractors/Loaders/Backhoes	1	885	108	0.55	530	568	6	24
		Cranes	1	664	399	0.43	530	568	12	52
		Generator sets	1	885	549	0.74	530	568	38	164
		Welders	3	885	45	0.45	530	568	6	24
		Building Construction Total							**110**	**471**
	Paving	Pavers	1	49	100	0.62	530	568	0	1
		Steel Drum Roller	2	49	95	0.56	530	568	1	2
		Paving Total							**1**	**4**
		PHASE TOTAL							***128***	***550***
Phase 2	Grading	Graders	1	49	174	0.61	530	568	1	2
		Scrapers	3	49	313	0.72	530	568	3	15
		Water Trucks	1	49	189	0.50	530	568	0	2
		Plate Compactors	1	49	8	0.43	530	568	0	0
		Grading Total							**5**	**19**

Table 4-7
GHG Emissions from Construction Equipment
Sonoma Mountain Village
Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Biodiesel)[7]	Emission Factor (Diesel)[7]	CO_2e Emission (B20 Biodiesel)[8,9]: CO_2e Emission (Biodiesel Component)	CO_2e Emission (B20 Biodiesel)[8,9]: CO_2e Emission (Diesel Component)
							(g/bhp-hr)	(g/bhp-hr)	(tonnes)	(tonnes)
Phase 2	Underground Construction	Excavators	4	779	168	0.57	530	568	32	136
		Water Trucks	2	779	189	0.50	530	568	16	67
		Loaders	2	779	108	0.55	530	568	10	42
		Backhoes	2	779	108	0.55	530	568	10	42
		Underground Construction Total							**67**	**287**
	Subgrade and Rock	Graders	1	73	174	0.61	530	568	1	4
		Scrapers	1	73	313	0.72	530	568	2	7
		Tire Roller Scraper	1	73	95	0.56	530	568	0	2
		Subgrade and Rock Total							**3**	**13**
	Building Construction	Excavators	1	644	168	0.57	530	568	7	28
		Forklifts	2	280	145	0.30	530	568	3	11
		Graders	2	3,648	174	0.61	530	568	82	352
		Tractors/Loaders/Backhoes	1	373	108	0.55	530	568	2	10
		Cranes	1	186	399	0.43	530	568	3	15
		Building Construction Total							**97**	**416**
	Paving	Pavers	1	73	100	0.62	530	568	0	2
		Steel Drum Roller	2	73	95	0.56	530	568	1	4
		Paving Total							**1**	**6**
		PHASE TOTAL							***172***	***740***
Phase 3	Grading	Graders	1	49	174	0.61	530	568	1	2
		Scrapers	3	49	313	0.72	530	568	3	15
		Water Trucks	1	49	189	0.50	530	568	0	2
		Plate Compactors	1	49	8	0.43	530	568	0	0
		Grading Total							**5**	**19**
	Underground Construction	Excavators	4	389	168	0.57	530	568	16	68
		Water Trucks	2	389	189	0.50	530	568	8	33
		Loaders	2	389	108	0.55	530	568	5	21
		Backhoes	2	389	108	0.55	530	568	5	21
		Underground Construction Total							**33**	**143**
	Subgrade and Rock	Graders	1	73	174	0.61	530	568	1	4
		Scrapers	1	73	313	0.72	530	568	2	7
		Tire Roller Scraper	1	73	95	0.56	530	568	0	2
		Subgrade and Rock Total							**3**	**13**
	Building Construction	Excavators	1	815	168	0.57	530	568	8	35
		Forklifts	2	25	145	0.30	530	568	0	1
		Graders	2	4,619	174	0.61	530	568	104	446
		Tractors/Loaders/Backhoes	1	33	108	0.55	530	568	0	1
		Cranes	1	17	399	0.43	530	568	0	1
		Building Construction Total							**113**	**484**

Table 4-7
GHG Emissions from Construction Equipment
Sonoma Mountain Village
Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Biodiesel)[7]	Emission Factor (Diesel)[7]	CO_2e Emission (B20 Biodiesel)[8,9]	
									CO_2e Emission (Biodiesel Component)	CO_2e Emission (Diesel Component)
							(g/bhp-hr)	(g/bhp-hr)	(tonnes)	
Phase 3	Paving	Pavers	1	73	100	0.62	530	568	0	2
		Steel Drum Roller	2	73	95	0.56	530	568	1	4
		Paving Total							**1**	**6**
		PHASE TOTAL							***155***	***666***
	TOTAL								**1,524**	**6,542**

Notes:
1. The construction phases were obtained from Sonoma Mountain Village Project Description provided by Codding Enterprises.
2. The list of equipment to be used during the demolition, grading, underground construction, subgrade and rock and paving sub-phases was provided by Kirstie Moore of Codding Enterprises in a pdf file.
3. The list of equipment used for residential building construction sub-phase was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
4. The list of equipment used for non-residential building construction sub-phase was obtained using URBEMIS.
5. The equipment-hour of individual equipment used in demolition, grading, underground construction, subgrade and rock and paving sub-phases is estimated based on sub-phase and phase duration provide by Codding Enterprises and URBEMIS defaults.
The equipment-hour for residential and non-residential building construction equipment was based on the following methodology:
Duration of building construction sub-phase = Total Phase duration - Duration of demolition phase - Duration of grading sub-phase - Duration of underground construction sub-phase - Duration of subgrade and rock sub-phase - Duration of paving sub-phase
where:
Total Phase duration was obtained from Sonoma Mountain Village Project Description provided by Codding Enterprises
Duration of each sub-phase was obtained from the file provided by Kirstie Moore of Codding Enterprises in a pdf file.
Duration of non-residential building construction sub-phase = Duration of building construction sub-phase * Square footage of all non-residential construction during the sub-phase/ Square footage of all construction during the sub-phase
Duration of residential building construction sub-phase = Duration of building construction sub-phase * Square footage of all residential construction during the sub-phase/ Square footage of all construction during the sub phase
6. The values of Horsepower, Load Factor of each type of equipment are from OFFROAD2007 defaults.
7. Construction equipment are assumed to operate on B20 diesel (20% biodiesel and 80% diesel) based on Sonoma Mountain Village One Planet Communities Sustainability Action Plan.
Emission factor for biodiesel (g/bhp-hr) = Emission Factor for diesel (g/bhp-hr)*Emission factor for biodiesel(kg CO_2/gallon)/Emission Factor for diesel(kg CO_2/gallon)
Emission factor for diesel (g/bhp-hr) was obtained from OFFROAD 2007.
Emission factor for diesel (kg CO_2/gallon) and Emission factor for biodiesel (kg CO_2/gallon) were obtained from California Climate Action Registry General Reporting Protocol.
8. Since B20 Biodiesel is a mixture of 20% biodiesel and 80% diesel, the CO_2 emission was calculated as follows:
CO_2 Emission (Biodiesel) = Equipment Hours x HP x Load Factor x Emission Factor x Unit Conversion Factor x 20%
CO_2 Emission (Diesel) = Equipment Hours x HP x Load Factor x Emission Factor x Unit Conversion Factor x 80%
9. Assume CO_2 = CO_2e because the contribution of CH_4 and N_2O to overall GHG emissions is likely small (< 1% of total CO_2e) from diesel construction equipment.

Abbreviations:
bhp - brake horsepower
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
hr - hour
N_2O - nitrous oxide

Sources:

Air Resources Board (ARB), 2005. OFFROAD Exhaust Emissions Inventory – Fuel Correction Factors (DRAFT). March. (available at: http://www.arb.ca.gov/msei/offroad/techmemo/off-2006-01.pdf)
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Received from Kirstie Moore of Codding Enterprises *2009.02.25 Construction Schedule.pdf.* February 25th 2009.
Sonoma Mountain Village One Planet Communities Sustainability Action Plan Version 1.3. 2008.

Table 4-8
GHG Emissions from Worker Commutes
Sonoma Mountain Village
Rohnert Park, California

Construction Phase	Sub-Phase	Worker One-Way Trips[1]	VMT[2]	EF_{LDA}[3]		EF_{LDT1}[3,4]		EF_{LDT2}[3,4]		CO_2 Emissions[5]		Total CO_2 Emissions	Total CO_2e Emissions[6,7]
				Running	Startup	Running	Startup	Running	Startup	Running	Startup		
			(miles)	(g/mile)	(g/trip)	(g/mile)	(g/trip)	(g/mile)	(g/trip)	(tonne)			
Phase 1A	Demolition	456	2,965	345	211	419	243	424	259	1.1	0.1	1.2	1.3
	Grading	684	4,448	345	211	419	243	424	259	1.7	0.2	1.9	2.0
	Underground Construction	3,802	24,712	345	211	419	243	424	259	9.5	0.9	10	11
	Subgrade and Rock	137	890	345	211	419	243	424	259	0.3	0.03	0.4	0.4
	Building Construction	435,612	2,831,475	345	211	419	243	424	259	1,085	101	1,186	1,248
	Paving	114	741	345	211	419	243	424	259	0.3	0.03	0.3	0.3
	Phase Total												*1,263*
Phase 1B	Demolition	152	988	345	211	419	243	424	259	0.4	0.04	0.4	0.4
	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.25	0.26
	Underground Construction	1,597	10,379	345	211	419	243	424	259	4.0	0.4	4.3	4.6
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	709,286	4,610,361	345	211	419	243	424	259	1,767	164	1,931	2,033
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*2,038*
Phase 1C	Demolition	30	198	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Grading	411	2,669	345	211	419	243	424	259	1.0	0.1	1.1	1.2
	Underground Construction	836	5,437	345	211	419	243	424	259	2.1	0.2	2.3	2.4
	Subgrade and Rock	23	148	345	211	419	243	424	259	0.1	0.01	0.06	0.07
	Building Construction	326,315	2,121,046	345	211	419	243	424	259	813	75	888	935
	Paving	23	148	345	211	419	243	424	259	0.1	0.01	0.06	0.07
	Phase Total												*939*
Phase 1D	Demolition	61	395	345	211	419	243	424	259	0.2	0.01	0.2	0.2
	Underground Construction	532	3,460	345	211	419	243	424	259	1.3	0.1	1.4	1.5
	Subgrade and Rock	23	148	345	211	419	243	424	259	0.1	0.01	0.06	0.07
	Building Construction	86,696	563,525	345	211	419	243	424	259	216	20	236	248
	Paving	46	297	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Phase Total												*250*
Phase 2	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.2	0.3
	Underground Construction	2,433	15,816	345	211	419	243	424	259	6.1	0.6	6.6	7.0
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	217,495	1,413,720	345	211	419	243	424	259	542	50	592	623
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*631*
Phase 3	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.2	0.3
	Underground Construction	1,217	7,908	345	211	419	243	424	259	3.0	0.3	3.3	3.5
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	573,166	3,725,581	345	211	419	243	424	259	1,428	132	1,561	1,643
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*1,647*
	TOTAL												**6,769**

Notes:

1. Worker trips were calculated for Demolition, Grading, Underground Construction, Subgrade and Rock and Paving phases as follows:
   a. Operation hours for each piece of equipment = 8 hr per day
   b. Number of working days for each type of equipment was provided by Kirstie Moore of Codding Enterprises in a pdf file. Recieved *2009.02.25 Construction Schedule.pdf* on February 25th 2009.
   c. Number of workers = 1.25 x Number of pieces of equipment
   d. Worker Trips = Number of working days x Number of workers

   Worker trips during the Building Construction phase was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
2. Vehicle Miles Traveled = Worker Trips x 13 miles per round trip
   Distance traveled by worker per round trips was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
3. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation refers to the URBEMIS 9.2.4 default vehicle speed: 30 MPH.
   The startup emission factor depends on the settling period before driving. The startup emissions were conservatively calculated based on a 12-hour wait before each engine startup.
4. LDT1: up to 6000 GVW; LDT2: up to 8500 GVW
5. GHG Running Emission calculation formula: GHG Emission = VMT x (0.5 x EF_{LDA} + 0.25 x EF_{LDT1} + 0.25 x $EF_{LDT2})_{Running}$
   GHG Startup Emission calculation formula: GHG Emission = Worker Trips x (0.5 x EF_{LDA} + 0.25 x EF_{LDT1} + 0.25 x $EF_{LDT2})_{Startup}$
   URBEMIS 9.2.4 assumes that LDA and LDT have a 50:50 ratio.
6. $CO_2e = CO_2 / 0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their global warming potentials.
7. The emission factor values for 2009, the anticipated start date of the project, were used for all calculations.

Abbreviations:

CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
EF - emission factor
GVW - gross vehicle weight
HFC - hydro fluorocarbons
hr - hour
LDA - light duty auto
LDT - light duty truck
MPH: miles per hour
N_2O - nitrous oxide
URBEMIS - urban emissions model
VMT - vehicle miles traveled

Sources:

Received from Kirstie Moore of Codding Enterprises. *2009.02.25 Construction Schedule.pdf* . February 25th 2009.

Table 4-9
GHG Emissions from Vendor Trips during Building Construction
Sonoma Mountain Village
Rohnert Park, California

Phase	Vendor Round Trips[1]	VMT[2]	Idling Time[3]	EF_{HHD} [4]			CO_2 Emissions[5]			Total CO_2 Emissions	Total CO_2e Emissions[6,7]
				Running	Startup	Idling	Running	Startup	Idling		
		(miles)	(hours)	(g/mile)	(g/trip)	(g/idle-hour)	(tonne)				
Phase 1A	1,733	30,848	20,966	1825	288	6046	56	1	127	184	184
Phase 1B	833	14,825	10,826	1825	288	6046	27	0	65	93	93
Phase 1C	697	12,399	8,923	1825	288	6046	23	0	54	77	77
Phase 1D	294	5,238	3,182	1825	288	6046	10	0	19	29	29
Phase 2	515	9,175	6,677	1825	288	6046	17	0	40	57	57
Phase 3	650	11,579	8,455	1825	288	6046	21	0	51	73	73
Total											**513**

Notes:

1. Vendor trips occur only during the building construction phase. The vendor trips for residential construction were estimated based on information provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009. The vendor trips for non-residential construction was estimated based on URBEMIS default values. The total trips during each phase was the sum of vendor trips for residential and non-residential construction
   i. 2.4 * # residential units (SMV Data).
   ii. 0.05 *(commercial/retail/school/recreation square ft)/1000 (calculated using URBEMIS).
   iii. 0.38 *(office/industrial square ft)/1000 (calculated using URBEMIS).
2. Vehicle Miles Traveled = Vendor Trips x 17.8 miles per roundtrip , based on URBEMIS default.
3. The idling time at residential sites was estimated based on information provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009. It is assumed that no idling occurs at non-residential contruction sites
   i. 31.2 * # residential units (idle-hours/phase)
4. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation refers to the URBEMIS 9.2.4 default vehicle speed: 30 MPH. The startup emission factor depends on the settling period before driving. The startup emissions are conservatively calculated based on a 12 hour wait before each engine startup.
5. URBEMIS 9.2.4 assumes that all vendors drive heavy-heavy-duty trucks.
   CO_2 Running Emission calculation formula: CO_2 Emission = VMT x $EF_{HHD\text{-}Running}$
   CO_2 Startup Emission calculation formula: CO_2 Emission = Vendor Trips x $EF_{HHD\text{-}Startup}$
   CO_2 Idling Emission calculation formula: CO_2 Emission = Idling Time x $EF_{HHD\text{-}Idling}$
6. Assume CO2 = CO2e because the contribution of CH4 and N2O to overall GHG emissions is likely small (< 1% of total CO2e) from diesel vehicles.
7. The emission factor values of 2009, the anticipated start date of the project, are used for all calculations.

Abbreviations:

CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
EF - emission factor
GVW - gross vehicle weight
HFC - hydro fluorocarbons
HHD - heavy-heavy duty
hr - hour
MPH - miles per hour
N_2O - nitrous oxide
SMV - Sonoma Mountain Village
URBEMIS - urban emissions model
VMT - vehicle miles traveled

Table 4-10
Overall Construction GHG Emissions
Sonoma Mountain Village
Rohnert Park, California

Location	Construction						Worker Commute	Vendor Commute	Total GHG Emissions
	Demolition	Grading	Underground Construction	Subgrade and Rock	Building Construction	Paving			
	(tonnes CO_2e)								
Sonoma Mountain Village	92	292	1,227	72	4,827	32	6,769	513	**13,824**

Notes:

1. See previous tables for calculation details. The table includes emissions from construction equipment, worker commuting and vendor commuting during all the sub-phases and phases of construction. Construction equipment operate on B20 biodiesel which is a mix of 20% biodiesel and 80% diesel. Only emissions from the diesel portion of B20 biodiesel are reported in this inventory, emissions from biodiesel portion of B20 biodiesel are excluded as they are assumed to be biogenic emissions (see California Climate Action Registry General Reporting Protocol).

Abbreviations:

CO_2e - carbon dioxide equivalent
GHG - greenhouse gas

Source:

California Climate Action Registry General Reporting Protocol, Version 3.1 (January2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

Table 4-11
GHG Emissions from Transportation, Primary Approach
Sonoma Mountain Village
Rohnert Park, California

Trip Generation Used	Daily One-Way Trips[1]		Annual VMT[3] Unadjusted	Annual VMT[3] Adjusted	Emission Factor [4]		CO_2 Emissions[5]		Total CO_2 Emissions	Total CO_2e Emissions[6]
					Running	Startup	Running	Startup		
	Unadjusted	Weekend/Weekday Adjustment[2]	(miles/year)	(miles/year)	(g/mile)	(g/trip)	(tonne)			
Original[7]	8,019	7,538	29,614,640	27,837,762	374	106	10,415	291	10,706	**11,270**
Revised[7]	9,850	9,259	36,376,630	34,194,032			12,793	358	13,151	**13,843**

Notes:

1. Annual trips provided by Fehr & Peers based on traffic study.
2. Daily trips were adjusted to account for differences between the weekend and the weekday traffic based on a report by Sonoma Technology. The weekend traffic was assumed to be 79% of weekly capacity.
3. Annual VMT provided by Fehr & Peers based on a trip length of 10.12 miles.
4. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation conservatively refers to vehicle speed of 60 miles per hour. The startup emission factor depends on the settling period before driving. The startup emissions were conservatively calculated based on a 12 hour wait before each engine startup.
5. Emission factors for vehicles based on EMFAC files for 2030, based on LDA, LDT1, LDT2, motorcycles, and motorhomes for Sonoma County. Speeds of 60 miles per hour were conservatively used to determine emission factors.
6. $CO_2e = CO_2 / 0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their global warming potentials.
7. Fehr and Peers had a difference in opinion concerning the trip generation rate assumed in the traffic study. ENVIRON used both the original values and the revised values to estimate GHG emissions.

Abbreviations:
CO2 - carbon dioxide
CO2e - carbon dioxide equivalents
EF - emission factor
g - gram
LDA - light duty auto
LDT - light duty truck
VMT - vehicle miles travelled

References
Sonoma Technology, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

Table 4-12
Trip Generation Rates Based on URBEMIS, Alternate Approach 1
Sonoma Mountain Village
Rohnert Park, California

Residential Housing Type	Number of Units[1]	URBEMIS Trip Rate[2]	Unadjusted Daily Trips[3]	Home-Based Work[3]	Home-Based Shop[3]	Home-Based Other[3]
Single Family Housing	300	7.48	2,244	738	404	1102
Apartments / Low Rise	198	4.58	907	298	163	445
Condo / Townhome	1394	3.42	4,767	1569	858	2341
Total Trips			**7,918**	**2,605**	**1,425**	**3,888**

Notes:
1. Number of units and housing type are based on URBEMIS files provided by PBS&J.
2. URBEMIS trip rate takes into account housing density.
3. The trip type distribution is based on URBEMIS:

Trip Type	Trip Type Distribution
Home-Based Work	32.9%
Home-Based Shop	18%
Home-Based Other	49.1%

Table 4-13
Greenhouse Gas Emissions from Vehicles for the Year 2030, Alternative Approach 1
Sonoma Mountain Village
Rohnert Park, California

Residential Housing Type	Trip Type[1]	Daily One-Way Trips[2]		Trip Distance[4]	Daily Adjusted VMT[5] (miles)	Annual Adjusted VMT (miles)	Emission Factor Running (g/mile)[6]	Emission Factor Starts (g/start)[7]	Annual CO_2 Emissions Running (tonne)	Annual CO_2 Emissions Starts (tonne)	Total Annual CO_2 Emissions (tonne)	Total Annual CO_2e Emissions (tonne)[8]
		Unadjusted	Weekend/Weekday Adjustment[3]	(miles)								
Single Family Housing	Home-Based Work	738	694	10.80	6,471	2,362,046			884	27	911	958
	Home-Based Shop	404	380	7.30	2,394	873,951	**374**	**106**	327	15	342	360
	Home-Based Other	1,102	1,036	7.50	6,710	2,449,155			916	40	956	1,007
Subtotal Single Family Housing		**2,244**	**2,109**		**15,576**	**5,685,152**			**2,127**	**81**	**2,209**	**2,325**
Apartments / Low Rise	Home-Based Work	298	280	10.80	2,615	954,544			357	11	368	387
	Home-Based Shop	163	153	7.30	968	353,179	**374**	**106**	132	6	138	145
	Home-Based Other	445	419	7.50	2,712	989,747			370	16	386	407
Subtotal Apartments/Low Rise		**907**	**852**		**6,294**	**2,297,470**			**860**	**33**	**892**	**939**
Condo / Townhome	Home-Based Work	1,569	1,474	10.80	13,749	5,018,274			1,878	57	1,934	2,036
	Home-Based Shop	858	807	7.30	5,087	1,856,749	**374**	**106**	695	31	726	764
	Home-Based Other	2,341	2,200	7.50	14,256	5,203,341			1,947	85	2,032	2,139
Subtotal Condo/Townhome		**4,767**	**4,481**		**33,091**	**12,078,364**			**4,519**	**173**	**4,692**	**4,939**
Totals		**7,918**	**7,443**		**54,962**	**20,060,987**			**7,506**	**287**	**7,793**	**8,203**

Notes:

1. The trip type distribution is based on URBEMIS:

Trip Type	Trip Type Distribution
Home-Based Work	33%
Home-Based Shop	18%
Home-Based Other	49%

2. The daily trips are based on trip rates calculated using URBEMIS.
3. Daily trips were adjusted to account for differences between the weekend and the weekday traffic based on a report by Sonoma Technologies. The weekend traffic was assumed to be 79% of weekly capacity.
4. Trip distances were provided by URBEMIS. The trip lengths are based on URBEMIS defaults for Sonoma County.
5. Daily VMT was adjusted to account for non-home based trips using the following assumptions:

	Percentage of Trips	Trip Length
Hombe based trips	85%	Trip Distance
Diverted	10%	25% of Trip Distance
Pass-by	5%	0.1 miles

6. Emission factors for vehicles based on EMFAC files for 2030, based on LDA, LDT1, LDT2, motorcycles, and motorhomes for Sonoma County. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation conservatively refers to vehicle speed of 60 miles per hour.
7. The startup emission factor depends on the settling period before driving. The startup emissions were conservatively calculated based on a 12 hour wait before each engine startup.
8. $CO_2e=CO_2/0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs are 5% of emissions on a CO_2e basis.

Abbreviations:

CH_4 - Methane
CO_2 - Carbon Dioxide
CO_2e - Carbon Dioxide Equivalent
GHG - Greenhouse Gas
HFC - Hydro fluorocarbon
N_2O - Nitrous oxide
VMT - Vehicle Miles Traveled

Sources:

Sonoma Technologies, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

Table 4-14
Greenhouse Gas Emissions from Vehicles for the Year 2030, Alternate Approach 2
Sonoma Mountain Village
Rohnert Park, California

Trip Type[1]		Daily One-Way Trips[2]		Trip Distance[4]	Daily Adjusted VMT (miles)	Annual Adjusted VMT (miles)	Emission Factor Running (g/mile)[5]	Emission Factor Starts (g/start)[6]	Annual CO_2 Emissions Running (tonne)	Annual CO_2 Emissions Starts (tonne)	Total AnnualCO_2 Emissions (tonne)	Total Annual CO_2e Emissions (tonne)[7]
		Unadjusted	Weekend/Weekday Adjustment[3]	(miles)								
Internal	Home Based Work	323	304	0.25	76	27,709			9	12	21	22
	Home Based Other	2,009	1,888	0.25	472	172,297	**342**	**106**	59	73	132	139
Total Internal Resident Trips		2,332	2,192		548	200,006			68	85	153	161
External	Home Based Work	2,907	2,691	12	32,296	11,788,191			4,410	104	4,514	4,752
	Home Based Other	6,361	5,888	7.5	44,163	16,119,458	**374**	**106**	6,031	227	6,258	6,588
Total External Resident Trips		9,268	8,580		76,459	27,907,649			10,441	331	10,773	11,340
All	Non-Home Based	3,084	2,899	8	23,188	8,463,712	**374**	**106**	3,167	112	3,279	3,451
Total Non-Home-Based Trips		3,084	2,899		23,188	8,463,712			3,167	112	3,279	3,451
Totals		**14,684**	**13,670**		**100,196**	**36,571,367**			**13,676**	**528**	**14,204**	**14,952**

Notes:

1. The trip type distribution is based on Fehr and Peers. The distribution of internal to external trips for each trip type is the following, resulting in a 20% internalization rate.

Trip Type	Internal	External	Trip Type Distribution
Home Based Work	90%	10%	22%
Home Based Other	76%	24%	57%

2. The daily trips are based on information provided by Fehr & Peers.
3. Daily trips were adjusted to account for differences between the weekend and the weekday traffic based on a report by Sonoma Technology. The weekend traffic internal was assumed to be 79% of weekly capacity. The weekend traffic external was assumed to be 74% of weekly capacity.
4. Trip distances were provided by Fehr and Peers . The internal trip lengths are based on output from SCTA traffic model. The external trip lengths are based on output from SCTA traffic model.
5. Emission factors for vehicles based on EMFAC files for 2030, based on LDA, LDT1, LDT2, motorcycles, and motorhomes for Sonoma County. Speeds of 35 miles per hour for internal trips, and 60 miles per hour for external trips were used to determine emission factors.
6. Starting emission factors are based on the weighted average distribution of time between trip starts based on URBEMIS defaults.
7. $CO_2e=CO_2/0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs are 5% of emissions on a CO_2e basis.

Abbreviations:

ADT - Average Daily Trip
CH_4 - Methane
CO_2 - Carbon Dioxide
CO_2e - Carbon Dioxide Equivalent
GHG - Greenhouse Gas
HFC - Hydro fluorocarbon
N_2O - Nitrous oxide
SCTA - Sonoma County Transportation Authority
VMT - Vehicle Miles Traveled

References

Fehr and Peers. VMT Calculations for Sonoma Mountain Village. March 17, 2009.
NCHRP Report 365. 1998. Travel Estimation Techniques for Urban Planning.
Sonoma Technology, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

Table 4-15
Summary of Greenhouse Gas Emission Methods
Sonoma Mountain Village
Rohnert Park, California

			Primary Approach		Alternate Approach 1	Alternate Approach 2
			Original	Revised		
Daily Trip Rates	Unadjusted		8,019	9,850	7,918	14,684
	Adjusted		7,538	9,259	7,443	13,670
Trip length (miles)	Home-Based Work	Internal	10.12	10.12	10.80	0.25
		External				12
	Home-Based Other	Internal			7.50	0.25
		External				7.5
	Home-Based Shop				7.30	8
	Non-Home Based	Pass-by			0.1	
		Diverted			25% of Home-Based	
Total Annual VMT			27,837,762	34,194,032	20,060,987	36,571,367
Average Trip Length (miles)			10.12	10.12	7.38	7.33
Total CO_2e (tonnes)			11,270	13,843	8,203	14,952

Table 4-16
GHG Emissions from Transportation, Primary Approach, including Pavley Standards
Sonoma Mountain Village
Rohnert Park, California

Trip Generation Used	Daily One-Way Trips[1]		Annual VMT[3] Unadjusted	Annual VMT[3] Adjusted	Emission Factor [4]		CO_2 Emissions		Total CO_2 Emissions	Total CO_2e Emissions[5]
	Unadjusted	Weekend/Weekday Adjustment[2]	(miles/year)	(miles/year)	Running (g/mile)	Startup (g/trip)	Running (tonne)	Startup (tonne)	(tonne)	(tonne)
Original[6]	8,019	7,538	29,614,640	27,837,762	298	106	8,306	291	8,597	**9,049**
Revised[6]	9,850	9,259	36,376,630	34,194,032			10,202	358	10,560	**11,116**

Notes:

1. Annual trips provided by Fehr & Peers based on traffic study.
2. Daily trips were adjusted to account for differences between the weekend and the weekday traffic based on a report by Sonoma Technology. The weekend traffic was assumed to be 79% of weekly capacity.
3. Annual VMT provided by Fehr & Peers.
4. The running emission factor for vehicles is based on EMFAC files for 2030, based on LDA, LDT1, and LDT2, scaled down by the GHG emissions reduction expected in 2020 due to the Pavley standard. Scaling factor from ARB report applies to all light-duty vehicles on the road in 2020; note that this scaling factor does not account for likely increasingly stringent standards in 2030.

   The startup emission factor depends on the settling period before driving. The startup emissions were conservatively calculated based on a 12 hour wait before each engine startup.
5. $CO_2e = CO_2 / 0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their global warming potentials.
6. Fehr and Peers had a difference in opinion concerning the trip generation rate assumed in the traffic study. ENVIRON used both the original values and the revised values to estimate GHG emissions.

Abbreviations:

ARB - California Air Resources Board
CAFE - corporate average fuel economy
CO2 - carbon dioxide
CO2e - carbon dioxide equivalents
EF - emission factor
g - gram
LDA - light duty auto
LDT - light duty truck
VMT - vehicle miles travelled

References

ARB, 2008. Comparison of Greenhouse Gas Reductions for the United States and Canada under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations. Table 10.
Sonoma Technology, Inc. 2004. Collection and Analysis of Weekend/Weekday Emissions Activity Data in the South Coast Air Basin. May.

Table 4-17
GHG Emission Factors for Sonoma Mountain Village Municipal Sources
Sonoma Mountain Village
Rohnert Park, California

Source[1]	Energy Requirements	Units	Emission Factor	Units	Source Quantity[10,11]	Units	Total CO_2e Emissions [tonne CO_2e per year]
Lighting							
Public Lighting[2]	--	kW-hr/capita/yr	--	tonne CO_2e/capita/year	4,438	residents (capita)	--
						Public Lighting Total:	**--**
Municipal Vehicles							
Municipal Vehicles[3]	--	--	0.05	tonne CO_2e/capita/year	4,438	residents (capita)	222
						Municipal Vehicles Total:	**222**
Water and Wastewater, Without Carbon Free Water Plan							
Water Supply and Conveyance (Potable)[4]	690	kW-hr/acre-foot	0.20	tonne CO_2e/acre-foot	274	acre-feet/yr	55
Water Treatment (Potable)[5]	36	kW-hr/acre-foot	0.01	tonne CO_2e/acre-foot	274	acre-feet/yr	3
Water Distribution (Potable)[6]	414	kW-hr/acre-foot	0.12	tonne CO_2e/acre-foot	274	acre-feet/yr	33
Wastewater Treatment (Indirect Emissions)[7]	623	kW-hr/acre-foot	0.18	tonne CO_2e/acre-foot	242	acre-feet/yr	43
Wastewater Treatment Plant (Direct Emissions)[8]	--	--	0.084	tonne CO_2e/capita/year	4,438	residents (capita)	374
Recycled Water Distribution (Non-Potable)[9]	978	kW-hr/acre-foot	0.28	tonne CO_2e/acre-foot	107	acre-feet/yr	30
						Water and Wastewater Total, without Carbon Free Water Plan:	**538**
						Municipal Sources Total, without Carbon Free Water Plan:	760
Water and Wastewater, With Carbon Free Water Plan [11]							
Water Supply and Conveyance (Potable)	--	kW-hr/acre-foot	--	tonne CO2e/acre-foot	274	acre-feet/yr	--
Water Treatment (Potable)	--	kW-hr/acre-foot	--	tonne CO2e/acre-foot	274	acre-feet/yr	--
Water Distribution (Potable)	--	kW-hr/acre-foot	--	tonne CO2e/acre-foot	274	acre-feet/yr	--
Wastewater Treatment (Indirect Emissions)	--	kW-hr/acre-foot	--	tonne CO2e/acre-foot	242	acre-feet/yr	--
Wastewater Treatment Plant (Direct Emissions)[8]	--	--	0.084	tonne CO2e/capita/year	4,438	residents (capita)	374
Recycled Water Distribution (Non-Potable)	--	kW-hr/acre-foot	--	tonne CO2e/acre-foot	107	acre-feet/yr	--
						Water and Wastewater Total, with Carbon Free Water Plan:	**374**
						Municipal Sources Total, with Carbon Free Water Plan:	**596**

Notes:

1. Public Lighting includes streetlights, traffic signals, area lighting and lighting municipal buildings. Emissions from the Water and Wastewater category are primarily due to the energy required for supply, treatment and distribution. GHG emissions attributed to electricity use are calculated using the Pacific Gas & Electric carbon-intensity factor.

2. Emission factor for public lighting is based on a study of energy usage and GHG emissions from Duluth, MN (Skoog, 2001) and the electricity generation emission factor from Pacific Gas & Electric.

3. Emission factors for municipal vehicles are based on the most conservative number from studies of GHG emissions for four cities of different sizes: Medford, MA; Duluth, MN; Northampton, MA; and Santa Rosa, CA. Population data provided by the US Census (2000).

4. Emission factor for water supply and conveyance is based on a Navigant Consulting refinement of a CEC study on the estimated energy necessary to supply 1 million gallons of water in Northern California and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

5. Emission factor for water treatment is based on a Navigant Consulting refinement of a CEC study on the energy necessary to treat 1 million gallons of water for supply in Northern California and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

6. Emission factor for water distribution is based on a Navigant Consulting refinement of a CEC study on the energy necessary to distribute 1 million gallons of treated water and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

7. Emission factor for wastewater treatment is based on a Navigant Consulting refinement of a CEC study on the energy necessary to treat 1 million gallons of wastewater for indoor (i.e., potable or other household) use and the electricity generation emission factor from Pacific Gas & Electric. The value energy requirements for advanced treatment with nitrification was used to represent the energy requirements for membrane bioreactor treatment.

8. Emission factor for the wastewater treatment plant accounts for direct methane and nitrous oxide emissions from wastewater. The value used here is based on the 2005 US inventory of GHG emissions for domestic wastewater treatment plants (USEPA) divided by the 2005 US population. (25 Tg CO_2e/year/296,410,404 people = 0.093 ton CO_2e/capita/year)

9. Emission factor for recycled water distribution is based on a Navigant Consulting refinement of a CEC study of the energy necessary to redistrubute 1 million gallons of reclaimed water (i.e., treated wastewater) and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to non-potable water demand.

10. As provided by Ron Bendorff, Planning Director, the City of Rohnert Park estimates a population of 2.62 persons per residential property. Codding proposes residential developments on 1,694 parcels. Source quantities for water and wastewater are based onCodding Enterprises.

11. Sonoma County Water Agency has committed to providing all the energy required for pumping, treatment of water, and associated building energy from renewable sources by 2015.

Abbreviations:

CEC - California Energy Commission
CO_2e - carbon dioxide equivalent
GHG - greenhouse gas
kW-hr - kilowatt hour
MW-hr - megawatt hour
Tg - teragram
USEPA - United States Environmental Protection Agency

Sources:

California Climate Action Registry (CCAR) Database. Pacific Gas & Electric PUP Report. 2007.
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USEPA. 2007. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005. #430-R-07-002. April. http://epa.gov/climatechange/emissions/downloads06/07Waste.pd

Table 4-18
Summary of Greenhouse Gas Emissions for Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

Source	**GHG Emissions**		**Percentage of Annual CO_2e Emissions[7] (%)**
Vegetation[1]	tonnes CO_2e total	-1,991	NA
Construction (Non-Building)[2]		7,282	NA
Construction (Buildings)[2]		6,542	NA
Total (one time emissions)		**11,833**	NA
Residential[3]		0	0%
Non-Residential[4]		0	0%
Mobile[5]		11,270	95%
Municipal[6]		596	5%
Area		0	0%
Total (annual emissions)		**11,866**	NA
Annualized Total[8]	**tonnes CO_2e / year**	**12,162**	**NA**

Notes:

1. Vegetation emissions are one-time emissions resulting from the removal of existing vegetation and planting of new vegetation in Sonoma Mountain Village. The emissions are estimated assuming that all carbon currently sequestered in the biomass of the vegetation is released to the atmosphere upon removal of the vegetation. A total of 0 acres of existing vegetation is considered to be removed for development purposes. Data for emissions calculations are primarily from the Intergovernmental Panel on Climate Change (IPCC) Guildelines for National Greenhouse Gas Inventories.
2. Construction emissions are one-time emissions reported in total metric tonnes during the construction period 2009-2027. Emissions are calculated using URBEMIS default values, EMFAC2007 and with model inputs prepared by Codding Enterprises. Sources of emissions include construction equipment and vehicles associated with worker commuting and vendor trips. The non-building construction emissions are emissions from grading, paving, and coating operations.

3. As SMV will meet 100% of its residential energy needs through renewable sources of energy, operational emissions for single family and apartment dwelling units are expected to be zero.
4. As SMV will meet 100% of its non-residential energy needs through renewable sources of energy, operational emissions for grocery, misc. retail/commercial/office, hotel, public safety, and institutional buildings are expected to be zero.
5. Mobile source emissions were calculated using EMFAC with model inputs prepared by Fehr and Peers and Codding Enterprises. Mobile source emissions account for residential trips. CO2 emissions were scaled to reflect CO2e emissions based on data from the US Environmental Protection Agency (USEPA).
6. Municipal emissions account for emissions due to energy production associated with water supply, public/street lighting, and municipal vehicles. Energy use estimates for water supply are based primarily on Sonoma Mountain Village Water Plan Emissions from street lighting and municipal vehicles were based upon studies of other cities.
7. Percentages only apply to annual CO_2e emissions; annual and one-time CO_2e emissions cannot be directly compared.
8. One-time emissions (vegetation and construction) are "annualized" in this Total row. This is done by dividing by an annualization factor, 40 years, effectively converting the one-time emission into an annual emission rate. One-time emissions are not annualized in their respective rows above.

Abbreviations:
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
EIA - Energy Information Administration
EIR - Environmental Impact Report
EMFAC - Emission Factors Database
GHG - Greenhouse Gas
N_2O - nitrous oxide
TBD - to be determined
URBEMIS - Urban Emissions Model

Table 4-19
Summary of Greenhouse Gas Emissions for Sonoma Mountain Village, including Pavley Standards
Sonoma Mountain Village
Rohnert Park, California

Source	**GHG Emissions**		**Percentage of Annual CO_2e Emissions[7] (%)**
Vegetation[1]	tonnes CO_2e total	-1,991	NA
Construction (Non-Building)[2]		7,282	NA
Construction (Buildings)[2]		6,542	NA
Total (one time emissions)		**11,833**	NA
Residential[3]		0	0%
Non-Residential[4]		0	0%
Mobile[5]		9,049	94%
Municipal[6]		596	6%
Area		0	0%
Total (annual emissions)		**9,646**	NA
Annualized Total[8]	**tonnes CO_2e / year**	**9,941**	**NA**

Notes:

1. Vegetation emissions are one-time emissions resulting from the removal of existing vegetation and planting of new vegetation in Sonoma Mountain Village. The emissions are estimated assuming that all carbon currently sequestered in the biomass of the vegetation is released to the atmosphere upon removal of the vegetation. A total of 0 acres of existing vegetation is considered to be removed for development purposes. Data for emissions calculations are primarily from the Intergovernmental Panel on Climate Change (IPCC) Guildelines for National Greenhouse Gas Inventories.
2. Construction emissions are one-time emissions reported in total metric tonnes during the construction period 2009-2027. Emissions are calculated using URBEMIS default values, EMFAC2007 and with model inputs prepared by Codding Enterprises. Sources of emissions include construction equipment and vehicles associated with worker commuting and vendor trips. The non-building construction emissions are emissions from grading, paving, and coating operations.
3. As SMV will meet 100% of its residential energy needs through renewable sources of energy, operational emissions for single family and apartment dwelling units are expected to be zero.
4. As SMV will meet 100% of its non-residential energy needs through renewable sources of energy, operational emissions for grocery, misc. retail/commercial/office, hotel, public safety, and institutional buildings are expected to be zero.
5. Mobile source emissions were calculated using EMFAC with model inputs prepared by Fehr and Peers and Codding Enterprises. Mobile source emissions account for residential trips. CO2 emissions were scaled to reflect CO2e emissions based on data from the US Environmental Protection Agency (USEPA).
6. Municipal emissions account for emissions due to energy production associated with water supply, public/street lighting, and municipal vehicles. Energy use estimates for water supply are based primarily on Sonoma Mountain Village Water Plan Emissions from street lighting and municipal vehicles were based upon studies of other cities.
7. Percentages only apply to annual CO_2e emissions; annual and one-time CO_2e emissions cannot be directly compared.
8. One-time emissions (vegetation and construction) are "annualized" in this Total row. This is done by dividing by an annualization factor, 40 years, effectively converting the one-time emission into an annual emission rate. One-time emissions are not annualized in their respective rows above.

Abbreviations:
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
EIA - Energy Information Administration
EIR - Environmental Impact Report
EMFAC - Emission Factors Database
GHG - Greenhouse Gas
N_2O - nitrous oxide
TBD - to be determined
URBEMIS - Urban Emissions Model

Table 4-20
Residential Electricity Provided by Photovoltaics
Sonoma Mountain Village
Rohnert Park, California

Building Type	Typical Estimated Annual Electricity Demand[1] (kWh / yr / DU)	Reduction from Typical Energy Usage	Annual Electricity Demand, SMV (kWh / yr / DU)	Number of Units (DU)	Total Annual Electricity Demand, SMV (kWh / yr)
Residential, primary	7,000	50%	3,500	1,694	5,929,000
Residential, secondary	5,000	50%	2,500	198	495,000
Non-residential	N/A				2,040,000
TOTAL					8,464,000

Notes:
1. Estimate provided by Codding Enterprises.

Abbreviations:
DU - dwelling units
kWh - kilowatt-hour
SMV - Sonoma Mountain Village
yr - year

Table 4-21
Life Cycle Greenhouse Gas (GHG) Emissions from Photovoltaics
Sonoma Mountain Village
Rohnert Park, California

Material	Emission Factor	Percent of Systems[1]	Annual Electricity Generation	Lifetime	Lifetime Energy Generation	Life Cycle Emissions of Material
	(g CO_2/kWh)	(%)	(kWh / year)	(years)	(kWh)	(tonnes CO_2)
Polycrystalline silicon PVs	37	90%	7,617,600	20	152,352,000	5,637
Amorphous silicon PVs	38	10%	846,400	20	16,928,000	643
TOTAL						**6,280**

Notes:
1. Breakdown provided by Codding Enterprises.

Abbreviations:
CO_2 - carbon dioxide
g - gram
GHG - greenhouse gas
kWh - kilowatt-hour
PVs - photovoltaics

Sources:
Fthenakis, V. and Alsema, E. Photovoltaics Energy Payback Times, Greenhouse Gas Emissions and External Costs: 2004-early 2005 Status. Prog. Photovoltaic.: Res. Appl. 2006; **14**:275-280. Available at:
http://www.clca.columbia.edu/papers/Photovoltaic_Energy_Payback_Times.pdf
Dones, R. et al. Greenhouse Gas Total Emissions from Current and Future Electricity and Heat Supply Systems. Available at:
http://gabe.web.psi.ch/pdfs/lca/GHGT4_Interlaken_1998.pdf

Table 4-22
Life Cycle Greenhouse Gas (GHG) Emissions from Ground Source Heat Pumps
Sonoma Mountain Village
Rohnert Park, California

Material	Emission Factor	Annual Thermal Energy Generation per Dwelling Unit[1]	Number of Dwelling Units with GSHPs	Lifetime	Lifetime Thermal Energy Generation	Life Cycle Emissions of Material
	(tonnes CO_2e/kWh)	(kWh / year / DU)	(DU)	(years)	(kWh)	(tonnes CO_2e)
Ground Source Heat Pump	1.05E-04	3,277	800	20	52,436,576	5,506
TOTAL						**5,506**

Notes:
1. ENVIRON estimated the annual thermal energy generation of the ground source heat pump on a per dwelling unit basis by calculating the product of the heat input, as found for a business as usual, Title 24-compliant home using Micropas software, and the Annual Fuel Utilization Efficiency (AFUE), 78%, which was then multiplied by 70% since SMV has committed to beating Title 24 standards by 30% in residential buildings. See Section 5.4.2 of this report for more details on Micropas modeling.

Abbreviations:
AFUE - annual fuel utilization efficiency
CO_2e - carbon dioxide equivalents
DU - dwelling unit
GSHP - ground source heat pump
GHG - greenhouse gas
kWh - kilowatt-hour
Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Sources:
World Energy Council. Comparison of Energy Systems Using Life Cycle Assessment. July 2004. Available at: http://www.worldenergy.org/documents/lca2.pdf

Table 4-23
Summary of Life Cycle Greenhouse Gas (GHG) Emissions from Renewables
Sonoma Mountain Village
Rohnert Park, California

Emissions Source[1]	Life Cycle Emissions (tonnes CO_2)	Assumed Lifetime of Emissions Source[2] (years)	Total Annualized Emissions (tonnes CO_2 / year)	Total Annual Emissions from Codding (tonnes CO_2 / year)	LCA from Renewables Fraction of Total Emissions (%)
Photovoltaics	6,280	20	314	11,866	2.6%
Ground Source Heat Pumps	5,506		275		2.3%
TOTAL	11,786		589		5.0%

Notes:

1. ENVIRON estimated LCA emissions from two renewable energy sources: photovoltaics and ground source heat pumps. LCA emissions from the 800 domestic solar hot water heaters and all air source heat pumps are assumed to be covered in the LCA analysis of building materials.
2. ENVIRON conservatively assumed a 20-year lifetime for the renewable energy equipment.

Abbreviations:

CO_2 - carbon dioxide
GHG - greenhouse gas
LCA - life cycle assessment

Table 5-1
Sonoma Mountain Village Context Supporting Calculations
Sonoma Mountain Village
Rohnert Park, California

	Tonnes / Year	%
2004 World Emissions	2.68E+10	0.00004%
2004 USA Emissions	7.00E+09	0.0002%
2004 CA Emissions	4.80E+08	0.0025%
Total Project Annual Emissions	1.19E+04	

BAU Projected 2020 CO_2e emissions	5.96E+08	tonnes
CA 1990 CO_2e emissions	4.27E+08	tonnes
Difference	1.69E+08	tonnes
% reduction / increase	28%	%
CA 2020 population	4.22E+07	people
1990 emissions / 2020 population	10.1	tonnes / capita

Sonoma Mountain Village Population	4,438

	Tonnes CO_2 / year	Tonnes / capita / year
Sonoma Mountain Village Mobile Emissions	11,270	2.5
Sonoma Mountain Village Residential Emissions	0	0.0
Sonoma Mountain Village Mobile + Residential	11,270	2.5

Table 5-2
CO_2 Sequestration Due to Land Use Changes and Vegetation Plantings
Sonoma Mountain Village
Rohnert Park, California

Vegetation Type[1]	IPCC Designation[2]	IPCC Sub qualification	Tons Dry Matter Carbon/Acre[3]	Sequestered CO_2 / Acre[4]	Total Impacted Area[5]	CO_2 Sequestration Capacity of Removed Vegetation
			(tonne/acre)	(tonne/acre)	(acres)	(tonne)
Developed	Settlements		0	0.0	1	0
Grassland	Grassland		1.175	4.3	7.0	30
Native Perennial Grassland/California Annual Grassland	Grassland		1.175	4.3	6.0	26
GRAND TOTAL	-		-	-	**14**	**57**

Notes:
1. Land types shown here represent vegetation that will be potentially removed upon development.
2. Land types are mapped to generalized IPCC Land Designations (IPCC 2006).
3. Dry matter carbon per acre was determined from information contained in .
4. It is conservatively assumed that all carbon is eventually converted into CO_2. Multiply the mass of carbon by 3.67 to calculate the final mass of CO_2 (the molecular mass of CO_2 / the molecular mass of carbon is 44/12 or 3.67).
5. Data provided by Codding Enterprises.

Abbreviations:
CO_2 - carbon dioxide
IPCC - Intergovernmental Panel on Climate Change

Sources:
Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

Table 5-3
BAU CO_2e Sequestration by Existing Green Waste Piles
Sonoma Mountain Village
Rohnert Park, California

Facility Type	Density[1]	Height of Greenwaste Piles[2]	Area of Greenwaste Piles[3]	Direct Emissions				Sequestration	
				Emission Factors as CO_2e (Biogenic)[4]		Emissions as CO_2e (Biogenic)[5]		CO2 Sequestration Capacity of Removed Greenwaste Piles (per tonne)[6]	CO_2 Sequestration Capacity of Removed Greenwaste Piles[6]
				CO_2	CH_4	CO_2	CH_4		
	(kg/m^3)	(m)	(m^2)	(lb CO_2e/tonne waste)	(lb CO_2e/tonne waste)	(tonnes CO_2e)	(tonnes CO_2e)	(tonnes CO_2e/ tonne waste)	(tonnes CO_2e)
Composting	502.5	1.5	1578	661	20	121	4	0.39	158

Notes:
1. Density obtained from CIWMB 2007.
2. Height of pile obtained from optimal pile structure requirements found in SCAQMD's Technology Assessment for Proposed Rule 1133, page 1-7.
3. Codding indicated that 0.39 acres of existing greenwaste piles will be removed, to be replaced by irrigated grass, trees, shrubs, and groundcovers.
4. Biogenic emissions include the direct emissions from green waste degradation. See Table 4-3.
5. ENVIRON assumed that the entire area is filled with greenwaste piles that are conical in shape with a base diameter of 5 feet, following SCAQMD's optimal pile structure guidance for Rule 1133.
6. Carbon sequestration capacity of removed greenwaste piles.

Abbreviations:
CH_4 - methane
CIWMB - California Integrated Waste Management Board
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalents
GHG - greenhouse gases
kg - kilogram
lb - pound
m - meter
SCAQMD - South Coast Air Quality Management District

Sources:

A Comparison of Disposal Options for Green Waste: Composting and Use as Alternative Daily Cover for Landfills. ENVIRON International Corporation. August 2008.
Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Composting Facility in San Joaquin Valley (California Intergrated Waste Management Board). October 21 2007. (CIWMB 2007) Available at: http://www.ciwmb.ca.gov/Publications/Organics/44207009.pdf
SCAQMD, 2002. Technology Assessment for Proposed Rule 1133. Available at: http://www.aqmd.gov/rules/doc/r1133/r1133_techassessment.pdf

Table 5-4
CO_2 Sequestration Due to Land Use Changes and New Vegetation Plantings
Sonoma Mountain Village
Rohnert Park, California

Vegetation Species[1]	IPCC Species Class Designation	Sequestered CO_2 / Unit[2]	Unit	Total Quantity of Vegetation[1]	Unit	CO_2 Sequestration Capacity of Vegetation[3]
		(tonne/unit/year)				(tonne)
All Other Types	Miscellaneous	0.035	trees	341	trees	239
GRAND TOTAL	-	-		**341**	**trees**	**239**

Notes:
1. Species class-specific sequestration values are provided in Table 8.2 of "2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4". For species that do not appear in Table 8.2, the species was classifed as "miscellaneous" and the average value of all listed data was used.
2. An active growing period of 20 years was assumed for the trees.

Abbreviations:
CO_2 - carbon dioxide
IPCC - Intergovernmental Panel on Climate Change

Sources:
Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines). Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htı

Table 5-5
CO_2 Sequestration Due to Land Use and Existing Vegetation in Non-Settlement Areas
Sonoma Mountain Village
Rohnert Park, California

Land Use Types	Net CO_2 Sequestration Capacity of Existing Vegetation[1,2] (tonne)
Non-settlement areas - Land Use	57
Existing trees	239
Green waste piles	154
TOTAL	**450**

Notes:

1. Biogenic CO_2 emissions from the green waste piles are conservatively excluded from this analysis.
2. A positive value represents an increase in sequestration capacity and thus a net reduction in CO_2.

Abbreviations:

CO_2 - carbon dioxide

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7] (g/bhp-hr)	CO_2e Emission (Diesel)[8,9] (tonnes)
Phase 1A	Demolition	Excavators	1	365	168	0.57	568	20
		Loaders	1	365	108	0.55	568	12
		Portable Crusher	1	365	142	0.78	568	23
		Water Trucks	1	365	189	0.50	568	20
		Demolition Total						**75**
	Grading	Graders	1	365	174	0.61	568	22
		Scrapers	3	365	313	0.72	568	140
		Water Trucks	1	365	189	0.50	568	20
		Plate Compactors	1	365	8	0.43	568	1
		Grading Total						**183**
	Underground Construction	Excavators	4	1,217	168	0.57	568	265
		Water Trucks	2	1,217	189	0.50	568	131
		Loaders	2	1,217	108	0.55	568	82
		Backhoes	2	1,217	108	0.55	568	82
		Underground Construction Total						**560**
	Subgrade and Rock	Graders	1	146	174	0.61	568	9
		Scrapers	1	146	313	0.72	568	19
		Tire Roller Scraper	1	146	95	0.56	568	4
		Subgrade and Rock Total						**32**
	Building Construction	Excavators	1	2,021	168	0.57	568	110
		Forklifts	2	2,486	145	0.30	568	123
		Graders	2	5,727	174	0.61	568	691
		Tractors/Loaders/Backhoes	1	3,315	108	0.55	568	112
		Cranes	1	2,486	399	0.43	568	242
		Generator sets	1	3,315	549	0.74	568	765
		Welders	3	3,315	45	0.45	568	114
		Building Construction Total						**2,158**
	Paving	Pavers	1	122	100	0.62	568	4
		Steel Drum Roller	2	122	95	0.56	568	7
		Paving Total						**12**
		PHASE TOTAL						***3,019***

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7]	CO_2e Emission (Diesel)[8,9]
							(g/bhp-hr)	(tonnes)
Phase 1B	Demolition	Excavators	1	122	168	0.57	568	7
		Loaders	1	122	108	0.55	568	4
		Portable Crusher	1	122	142	0.78	568	8
		Water Trucks	1	122	189	0.50	568	7
		Demolition Total						**25**
	Grading	Graders	1	49	174	0.61	568	3
		Scrapers	3	49	313	0.72	568	19
		Water Trucks	1	49	189	0.50	568	3
		Plate Compactors	1	49	8	0.43	568	0
		Grading Total						**24**
	Underground Construction	Excavators	4	511	168	0.57	568	111
		Water Trucks	2	511	189	0.50	568	55
		Loaders	2	511	108	0.55	568	34
		Backhoes	2	511	108	0.55	568	34
		Underground Construction Total						**235**
	Subgrade and Rock	Graders	1	73	174	0.61	568	4
		Scrapers	1	73	313	0.72	568	9
		Tire Roller Scraper	1	73	95	0.56	568	2
		Subgrade and Rock Total						**16**
	Building Construction	Excavators	1	1,044	168	0.57	568	57
		Forklifts	2	31	145	0.30	568	2
		Graders	2	5,915	174	0.61	568	714
		Tractors/Loaders/Backhoes	1	41	108	0.55	568	1
		Cranes	1	20	399	0.43	568	2
		Building Construction Total						**775**
	Paving	Pavers	1	73	100	0.62	568	3
		Steel Drum Roller	2	73	95	0.56	568	4
		Paving Total						**7**
		PHASE TOTAL						***1,083***

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7]	CO_2e Emission (Diesel)[8,9]
							(g/bhp-hr)	(tonnes)
Phase 1C	Demolition	Excavators	1	24	168	0.57	568	1
		Loaders	1	24	108	0.55	568	1
		Portable Crusher	1	24	142	0.78	568	2
		Water Trucks	1	24	189	0.50	568	1
		Demolition Total						**5**
	Grading	Graders	1	219	174	0.61	568	13
		Scrapers	3	219	313	0.72	568	84
		Water Trucks	1	219	189	0.50	568	12
		Plate Compactors	1	219	8	0.43	568	0
		Grading Total						**110**
	Underground Construction	Excavators	4	268	168	0.57	568	58
		Water Trucks	2	268	189	0.50	568	29
		Loaders	2	268	108	0.55	568	18
		Backhoes	2	268	108	0.55	568	18
		Underground Construction Total						**123**
	Subgrade and Rock	Graders	1	24	174	0.61	568	1
		Scrapers	1	24	313	0.72	568	3
		Tire Roller Scraper	1	24	95	0.56	568	1
		Subgrade and Rock Total						**5**
	Building Construction	Excavators	1	860	168	0.57	568	47
		Forklifts	2	1,377	145	0.30	568	68
		Graders	2	4,875	174	0.61	568	588
		Tractors/Loaders/Backhoes	1	1,836	108	0.55	568	62
		Cranes	1	1,377	399	0.43	568	134
		Generator sets	1	1,836	549	0.74	568	424
		Welders	3	1,836	45	0.45	568	63
		Building Construction Total						**1,387**
	Paving	Pavers	1	24	100	0.62	568	1
		Steel Drum Roller	2	24	95	0.56	568	1
		Paving Total						**2**
		PHASE TOTAL						***1,632***

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7]	CO_2e Emission (Diesel)[8,9]
							(g/bhp-hr)	(tonnes)
Phase 1D	Demolition	Excavators	1	49	168	0.57	568	3
		Loaders	1	49	108	0.55	568	2
		Portable Crusher	1	49	142	0.78	568	3
		Water Trucks	1	49	189	0.50	568	3
		Demolition Total						**10**
	Underground Construction	Excavators	4	170	168	0.57	568	37
		Water Trucks	2	170	189	0.50	568	18
		Loaders	2	170	108	0.55	568	11
		Backhoes	2	170	108	0.55	568	11
		Underground Construction Total						**78**
	Subgrade and Rock	Graders	1	24	174	0.61	568	1
		Scrapers	1	24	313	0.72	568	3
		Tire Roller Scraper	1	24	95	0.56	568	1
		Subgrade and Rock Total						**5**
	Building Construction	Excavators	1	307	168	0.57	568	17
		Forklifts	2	664	145	0.30	568	33
		Graders	2	1,739	174	0.61	568	210
		Tractors/Loaders/Backhoes	1	885	108	0.55	568	30
		Cranes	1	664	399	0.43	568	65
		Generator sets	1	885	549	0.74	568	204
		Welders	3	885	45	0.45	568	31
		Building Construction Total						**589**
	Paving	Pavers	1	49	100	0.62	568	2
		Steel Drum Roller	2	49	95	0.56	568	3
		Paving Total						**5**
		PHASE TOTAL						***687***
Phase 2	Grading	Graders	1	49	174	0.61	568	3
		Scrapers	3	49	313	0.72	568	19
		Water Trucks	1	49	189	0.50	568	3
		Plate Compactors	1	49	8	0.43	568	0
		Grading Total						**24**

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7]	CO_2e Emission (Diesel)[8,9]
							(g/bhp-hr)	(tonnes)
Phase 2	Underground Construction	Excavators	4	779	168	0.57	568	169
		Water Trucks	2	779	189	0.50	568	84
		Loaders	2	779	108	0.55	568	53
		Backhoes	2	779	108	0.55	568	53
		Underground Construction Total						**358**
	Subgrade and Rock	Graders	1	73	174	0.61	568	4
		Scrapers	1	73	313	0.72	568	9
		Tire Roller Scraper	1	73	95	0.56	568	2
		Subgrade and Rock Total						**16**
	Building Construction	Excavators	1	644	168	0.57	568	35
		Forklifts	2	280	145	0.30	568	14
		Graders	2	3,648	174	0.61	568	440
		Tractors/Loaders/Backhoes	1	373	108	0.55	568	13
		Cranes	1	186	399	0.43	568	18
		Building Construction Total						**520**
	Paving	Pavers	1	73	100	0.62	568	3
		Steel Drum Roller	2	73	95	0.56	568	4
		Paving Total						**7**
		PHASE TOTAL						***925***
Phase 3	Grading	Graders	1	49	174	0.61	568	3
		Scrapers	3	49	313	0.72	568	19
		Water Trucks	1	49	189	0.50	568	3
		Plate Compactors	1	49	8	0.43	568	0
		Grading Total						**24**
	Underground Construction	Excavators	4	389	168	0.57	568	85
		Water Trucks	2	389	189	0.50	568	42
		Loaders	2	389	108	0.55	568	26
		Backhoes	2	389	108	0.55	568	26
		Underground Construction Total						**179**

Table 5-6

BAU GHG Emissions from Construction Equipment

Sonoma Mountain Village

Rohnert Park, California

Construction Phase[1]	Sub-Phase	Equipment[2]	Equipment Number[3,4]	Equipment-Hours[5]	Horsepower[6]	Load Factor[6]	Emission Factor (Diesel)[7]	CO_2e Emission (Diesel)[8,9]
							(g/bhp-hr)	(tonnes)
Phase 3	Subgrade and Rock	Graders	1	73	174	0.61	568	4
		Scrapers	1	73	313	0.72	568	9
		Tire Roller Scraper	1	73	95	0.56	568	2
		Subgrade and Rock Total						**16**
	Building Construction	Excavators	1	815	168	0.57	568	44
		Forklifts	2	25	145	0.30	568	1
		Graders	2	4,619	174	0.61	568	557
		Tractors/Loaders/Backhoes	1	33	108	0.55	568	1
		Cranes	1	17	399	0.43	568	2
		Building Construction Total						**606**
	Paving	Pavers	1	73	100	0.62	568	3
		Steel Drum Roller	2	73	95	0.56	568	4
		Paving Total						**7**
		PHASE TOTAL						***832***
	TOTAL							**8,177**

Notes:

1. The construction phases were obtained from Sonoma Mountain Village Project Description provided by Codding Enterprises.
2. The list of equipment to be used during the demolition, grading, underground construction, subgrade and rock and paving sub-phases was provided by Kirstie Moore of Codding Enterprises in a pdf file. Received *2009.02.25 Construction Schedule.pdf* on February 25th 2009.
3. The list of equipment used for residential building construction sub-phase was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
4. The list of equipment used for non-residential building construction sub-phase was obtained using URBEMIS.
5. The equipment-hour of individual equipment used in demolition, grading, underground construction, subgrade and rock and paving sub-phases is estimated based on sub-phase and phase duration provide by Codding Enterprises and URBEMIS defaults.

   The equipment-hour for residential and non-residential building construction equipment was based on the following methodology:

   Duration of building construction sub-phase = Total Phase duration - Duration of demolition phase - Duration of grading sub-phase - Duration of underground construction sub-phase - Duration of subgrade and rock sub-phase - Duration of paving sub-phase

   where:

   Total Phase duration was obtained from Sonoma Mountain Village Project Description provided by Codding Enterprises

   Duration of each sub-phase was obtained from the file provided by Kirstie Moore of Codding Enterprises in a pdf file. Received 2009.02.25 Construction Schedule.pdf on February 25th 2009.

   Duration of non-residential building construction sub-phase = Duration of building construction sub-phase * Square footage of all non-residential construction during the sub-phase/ Square footage of all construction during the sub-phase

   Duration of residential building construction sub-phase = Duration of building construction sub-phase * Square footage of all residential construction during the sub-phase/ Square footage of all construction during the sub phase
6. The values of Horsepower, Load Factor of each type of equipment are from OFFROAD2007 defaults.

7. For BAU estimates, construction equipment are assumed to operate on diesel. Emission factor for diesel (g/bhp-hr) was obtained from OFFROAD 2007.
8. The CO2 emission was calculated as follows:
   CO2 Emission (Diesel) = Equipment Hours x HP x Load Factor x Emission Factor x Unit Conversion Factor
9. Assume CO2 = CO2e because the contribution of CH4 and N2O to overall GHG emissions is likely small (< 1% of total CO2e) from diesel construction equipment.

Abbreviations:

BAU - business as usual
bhp - break horsepower
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
hr - hour
N_2O - nitrous oxide

Sources:

Air Resources Board (ARB), 2005. OFFROAD Exhaust Emissions Inventory – Fuel Correction Factors (DRAFT). March. (available at: http://www.arb.ca.gov/msei/offroad/techmemo/off-2006-01.pdf)
Air Resources Board (ARB), 2006. Off-Road Emissions Inventory Program (OFFROAD2007). Available at: http://www.arb.ca.gov/msei/offroad/offroad.htm.
California Climate Action Registry General Reporting Protocol, Version 3.1 (January2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf
Received from Kirstie Moore of Codding Enterprises. *2009.02.25 Construction Schedule.pdf* . February 25th 2009.
Sonoma Mountain Village Project Description. October. 2008.

Table 5-7
BAU GHG Emissions from Worker Commutes
Sonoma Mountain Village
Rohnert Park, California

Construction Phase	Sub-Phase	Worker One-Way Trips[1]	VMT[2]	EF_{LDA} [3]		EF_{LDT1} [3,4]		EF_{LDT2} [3,4]		CO_2 Emissions[5]		Total CO_2 Emissions	Total CO_2e Emissions[6,7]
				Running	Startup	Running	Startup	Running	Startup	Running	Startup		
			(miles)	(g/mile)	(g/trip)	(g/mile)	(g/trip)	(g/mile)	(g/trip)	(tonne)			
Phase 1A	Demolition	456	2,965	345	211	419	243	424	259	1.1	0.1	1.2	1.3
	Grading	684	4,448	345	211	419	243	424	259	1.7	0.2	1.9	2.0
	Underground Construction	3,802	24,712	345	211	419	243	424	259	9.5	0.9	10	11
	Subgrade and Rock	137	890	345	211	419	243	424	259	0.3	0.03	0.4	0.4
	Building Construction	435,612	2,831,475	345	211	419	243	424	259	1,085	101	1,186	1,248
	Paving	114	741	345	211	419	243	424	259	0.3	0.03	0.3	0.3
	Phase Total												*1,263*
Phase 1B	Demolition	152	988	345	211	419	243	424	259	0.4	0.04	0.4	0.4
	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.2	0.3
	Underground Construction	1,597	10,379	345	211	419	243	424	259	4.0	0.4	4.3	4.6
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	709,286	4,610,361	345	211	419	243	424	259	1,767	164	1,931	2,033
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*2,038*
Phase 1C	Demolition	30	198	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Grading	411	2,669	345	211	419	243	424	259	1.0	0.1	1.1	1.2
	Underground Construction	836	5,437	345	211	419	243	424	259	2.1	0.2	2.3	2.4
	Subgrade and Rock	23	148	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Building Construction	326,315	2,121,046	345	211	419	243	424	259	813	75	888	935
	Paving	23	148	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Phase Total												*939*
Phase 1D	Demolition	61	395	345	211	419	243	424	259	0.2	0.01	0.2	0.2
	Underground Construction	532	3,460	345	211	419	243	424	259	1.3	0.1	1.4	1.5
	Subgrade and Rock	23	148	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Building Construction	86,696	563,525	345	211	419	243	424	259	216	20	236	248
	Paving	46	297	345	211	419	243	424	259	0.1	0.01	0.1	0.1
	Phase Total												*250*
Phase 2	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.2	0.3
	Underground Construction	2,433	15,816	345	211	419	243	424	259	6.1	0.6	6.6	7.0
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	217,495	1,413,720	345	211	419	243	424	259	542	50	592	623
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*631*
Phase 3	Grading	91	593	345	211	419	243	424	259	0.2	0.02	0.2	0.3
	Underground Construction	1,217	7,908	345	211	419	243	424	259	3.0	0.3	3.3	3.5
	Subgrade and Rock	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Building Construction	573,166	3,725,581	345	211	419	243	424	259	1,428	132	1,561	1,643
	Paving	68	445	345	211	419	243	424	259	0.2	0.02	0.2	0.2
	Phase Total												*1,647*
	TOTAL												**6,769**

Notes:

1. Worker trips were calculated for Demolition, Grading, Underground Construction, Subgrade and Rock and Paving phases as follows:
   a. Operation hours for each piece of equipment = 8 hr per day
   b. Number of working days for each type of equipment was provided by Kirstie Moore of Codding Enterprises in a pdf file. Recieved *2009.02.25 Construction Schedule.pdf* on February 25th 2009.
   c. Number of workers = 1.25 x Number of pieces of equipment
   d. Worker Trips = Number of working days x Number of workers
   Worker trips during the Building Construction phase was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
2. Vehicle Miles Traveled = Worker Trips x 13 miles per round trip
   Distance traveled by worker per round trips was provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009.
3. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation refers to the URBEMIS 9.2.4 default vehicle speed: 30 MPH.
   The startup emission factor depends on the settling period before driving. The startup emissions were conservatively calculated based on a 12-hour wait before each engine startup.
4. LDT1: up to 6000 GVW; LDT2: up to 8500 GVW
5. GHG Running Emission calculation formula: GHG Emission = VMT x $(0.5 \times EF_{LDA} + 0.25 \times EF_{LDT1} + 0.25 \times EF_{LDT2})_{Running}$
   GHG Startup Emission calculation formula: GHG Emission = Worker Trips x $(0.5 \times EF_{LDA} + 0.25 \times EF_{LDT1} + 0.25 \times EF_{LDT2})_{Startup}$
   URBEMIS 9.2.4 assumes that LDA and LDT have a 50:50 ratio.
6. $CO_2e = CO_2 / 0.95$: The United States Environmental Protection Agency (USEPA) recommends assuming that CH_4, N_2O, and HFCs account for 5% of GHG emissions from on-road vehicles, taking into account their global warming potentials.
7. The emission factor values for 2009, the anticipated start date of the project, were used for all calculations.

Abbreviations:

BAU - business as usual
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
EF - emission factor
GVW - gross vehicle weight
HFC - hydro fluorocarbons
hr - hour
LDA - tight duty auto
LDT - light duty truck
MPH: miles per hour
N_2O - nitrous oxide
URBEMIS - urban emissions model
VMT - vehicle miles traveled

Sources:
Received from Kirstie Moore of Codding Enterprises. *2009.02.25 Construction Schedule.pdf* . February 25th 2009.

Table 5-8
BAU GHG Emissions from Vendor Trips during Building Construction
Sonoma Mountain Village
Rohnert Park, California

Phase	Vendor Round Trips[1]	VMT[2]	Idling Time[3]	EF_{HHD}[4]			CO_2 Emissions[5]			Total CO_2 Emissions	Total CO_2e Emissions[6,7]
				Running	Startup	Idling	Running	Startup	Idling		
		(miles)	(hours)	(g/mile)	(g/trip)	(g/idle-hour)	(tonne)				
Phase 1A	1,733	30,848	20,966	1825	288	6046	56	1	127	184	184
Phase 1B	833	14,825	10,826	1825	288	6046	27	0.5	65	93	93
Phase 1C	697	12,399	8,923	1825	288	6046	23	0.4	54	77	77
Phase 1D	294	5,238	3,182	1825	288	6046	10	0.2	19	29	29
Phase 2	515	9,175	6,677	1825	288	6046	17	0.3	40	57	57
Phase 3	650	11,579	8,455	1825	288	6046	21	0.4	51	73	73
Total											**513**

Notes:

1. Vendor trips occur only during the building construction phase. The vendor trips for residential construction were estimated based on information provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009. The vendor trips for non-residential construction was estimated based on URBEMIS default values. The total trips during each phase was the sum of vendor trips for residential and non-residential construction
    i. 2.4 * # residential units (SMV Data).
    ii. 0.05 *(commercial/retail/school/recreation square ft)/1000 (calculated using URBEMIS).
    iii. 0.38 *(office/industrial square ft)/1000 (calculated using URBEMIS).
2. Vehicle Miles Traveled = Vendor Trips x 17.8 miles per roundtrip , based on URBEMIS default.
3. The idling time at residential sites was estimated based on information provided by Kirstie Moore of Codding Enterprises in an email recieved on March 24th 2009. It is assumed that no idling occurs at non-residential contruction sites
    i. 25.2 * # residential units (idle-hours/phase)
4. The running emission factor depends on the speed of the vehicle. The emission factor used in this calculation refers to the URBEMIS 9.2.4 default vehicle speed: 30 MPH. The startup emission factor depends on the settling period before driving. The startup emissions are conservatively calculated based on a 12 hour wait before each engine startup.
5. URBEMIS 9.2.4 assumes that all vendors drive heavy-heavy-duty trucks.
    CO_2 Running Emission calculation formula: CO2 Emission = VMT x $EF_{HHD\text{-}Running}$
    CO_2 Startup Emission calculation formula: CO2 Emission = Vendor Trips x $EF_{HHD\text{-}Startup}$
    CO_2 Idling Emission calculation formula: CO2 Emission = Idling Time x $EF_{HHD\text{-}Idling}$
6. Assume CO2 = CO2e because the contribution of CH4 and N2O to overall GHG emissions is likely small (< 1% of total CO2e) from diesel vehicles.
7. The emission factor values of 2009, the anticipated start date of the project, are used for all calculations.

Abbreviations:

BAU - business as usual
CH_4 - methane
CO_2 - carbon dioxide
CO_2e - carbon dioxide equivalent
g - gram
GHG - greenhouse gas
EF - emission factor
GVW - gross vehicle weight
HFC - hydro fluorocarbons
HHD - heavy-heavy duty
hr - hour
MPH - miles per hour
N_2O - nitrous oxide
SMV - Sonoma Mountain Village
URBEMIS - urban emissions model
VMT - vehicle miles traveled

Table 5-9
BAU Overall Construction GHG Emissions
Sonoma Mountain Village
Rohnert Park, California

Location	Construction						Worker Commute	Vendor Commute	Total GHG Emissions
	Demolition	Grading	Underground Construction	Subgrade and Rock	Building Construction	Paving			
	(tonnes CO_2e)								
Sonoma Mountain Village	115	365	1,534	90	6,034	40	6,769	513	**15,459**

Notes:

1. See previous tables for calculation details. The table includes emissions from construction equipment, worker commuting and vendor commuting during all the sub-phases and phases of construction.

Abbreviations:

BAU - business as usual
CO_2e - carbon dioxide equivalent
GHG - greenhouse gas

Table 5-10
Specifications for Homes Modeled using Micropas
Sonoma Mountain Village
Rohnert Park, California

Specification	Units	Micropas[2]					
		Townhouses and Large Rowhouses (Attached)	Small Rowhouses (Attached)	Cottages and Second Dwelling Units (Detached)	Single Family Conventional (Detached)	Single Family Large Lot (Detached)	Multifamily Apts / Condos (Attached)
Climate Zone		California Climate Zone 2					
Number of Dwelling Units per Building[1]	DU	9	9	1	1	1	6
Dwelling Unit Size[3]	SF	1,600	1,100	900	1,882	2,689	1,000

Notes:

1. Based on information provided by Codding Enterprises.

2. Micropas 7.3 is a building energy efficiency modeling package approved by the California Energy Commission as a 2005 Title 24 residential Alternative Compliance Method (ACM). The Micropas software calculates the site energy use per square foot per year and the Time Dependent Valuation (TDV) of the energy use per square foot per year to determine Title 24 compliance. Micropas version 7.3 is available for purchase at http://www.micropas.com/

3. The Micropas specifications are for the actual home modeled in Micropas whose square footage is closest to the average square footage per dwelling unit of each group of houses. Note that attached housing (multifamily apartments, condominiums, rowhouses, and townhouses) was modeled as large buildings containing multiple units, but the dwelling unit size listed in this table is for an individual unit within the building. The dwelling unit size was calculated as the total square footage of the modeled building divided by the number of units in the modeled building.

Abbreviations:

DU - Dwelling Unit
SF - Square Feet

Table 5-11
Energy Use per Residential Dwelling Unit: Appliances and Plug-ins
Sonoma Mountain Village
Rohnert Park, California

		Dwelling Size[1]		Electricity Delivered (kW-hr/DU/year)[2]									Natural Gas Delivered (MBTU/DU/yr)[2]		
Type	**Type**	**Average Square Footage per DU**	**Bedrooms per DU**	**Refrigerator**	**Clothes Washer**	**Clothes Dryer (Electric)[3]**	**Dishwasher**	**Cooking Range (Electric)[4]**	**Total Major Appliances**	**Plug-in Lighting**	**MELs**	**Total**	**Clothes Dryer (Gas)[6]**	**Gas Cooking Range[5]**	**Total**
Standard Appliances	Townhouses and Large Rowhouses (Attached)	1,583	3.0	669	105	456	206	303	1,738	344	514	2,596	2.6	2.3	4.9
	Small Rowhouses (Attached)	1,100	2.0	669	88	380	172	252	1,560	267	435	2,262	2.2	1.9	4.1
	Cottages and Second Dwelling Units (Detached)	543	1.1	669	71	308	139	204	1,391	178	354	1,923	1.8	1.5	3.3
	Single Family Conventional (Detached)	1,813	3.6	669	116	503	227	334	1,849	381	558	2,788	2.9	2.5	5.4
	Single Family Large Lot (Detached)	2,638	4.2	669	126	548	248	364	1,954	513	642	3,109	3.2	2.7	5.9
	Multifamily Apts / Condos (Attached)	1,231	2.8	669	101	438	198	291	1,697	288	479	2,463	2.5	2.2	4.7

Notes:

1. The homes as specified by Codding Enterprises were grouped into six categories based on the square footage and whether the home is attached or detached. The groups include 1) attached multifamily apartments and condominiums (1,000-1,300 sq ft), 2) attached small rowhouses (1,100 sq ft), 3) attached townhouses and large rowhouses (1,500-1,600 sq ft), 4) detached cottages and second dwelling units (500-900 sq ft), 5) detached single family conventional homes (1,500-2,000 sq ft), and 6) detached single family large lot homes (2,500-3,500 sq ft).
2. Energy use per residential dwelling unit is based on information in BARBD Table 12.
3. Dryers may be either electric or natural-gas fueled. This value represents the average of the electricity requirements for the two dryer types.
4. Cooking ranges can be either gas or electric. This value represents 1/2 the energy required for electric stoves.
5. This value represents 1/2 the natural gas required for natural gas stoves.
6. This value represents 1/2 the natural gas required for natural gas dryers.

Abbreviations:
BARBD - Building America Research Benchmark Definition
DU - dwelling unit
kW-hr - kilowatt-hour
MBTU - million british thermal units
MEL - Miscellaneous electric load

Source:
R. Hendron. Building America Research Benchmark Definition. Technical Report NREL/TP-550-42662. January 2008.

Table 5-12
Energy Use per Residential Dwelling Unit
Sonoma Mountain Village
Rohnert Park, California

	Dwelling Sizes		Electricity Delivered						Natural Gas Delivered			
			Micropas[2]	Micropas[2]	BARBD[3]	BARBD[3]	BARBD[3]		Micropas[2]	Micropas[2]	BARBD[3]	
Title 24 Compliance	Type	Average Square Footage/DU[1]	Heating	Cooling	Hard Wired Lighting	Major Appliances[4,6]	Lighting and Plug-ins[5]	Total	Heating	Domestic Hot Water	Gas Dryers and Oven Ranges[4,6]	Total
			[kW-hr / DU / year]						(MBTU natural gas / DU / year)			
Minimally Title 24 Compliant	Townhouses and Large Rowhouses (Attached)	1,583	88	370	1,727	1,738	858	4,781	22	22	5	49
	Small Rowhouses (Attached)	1,100	66	327	1,418	1,560	702	4,072	17	20	4	40
	Cottages and Second Dwelling Units (Detached)	543	88	358	1,062	1,391	532	3,430	22	19	3	45
	Single Family Conventional (Detached)	1,813	153	500	1,874	1,849	939	5,315	39	25	5	70
	Single Family Large Lot (Detached)	2,638	228	945	2,403	1,954	1,155	6,686	58	27	6	91
	Multifamily Apts / Condos (Attached)	1,231	51	241	1,502	1,697	767	4,257	13	20	5	37

Notes:
1. Information provided by Codding Enterprises.
2. Energy use shown is from a Title 24 compliant house.
3. Estimated using guidance provided by the US Department of Energy (Table 12 of BARBD).
4. Cooking may be performed on an electric range or a natural gas stove. The values shown in these columns are 50% of the energy/heat used for each stove type.
5. "Lighting and Plug-ins" refers to electricity use associated with plug-in lighting, plug-in appliances, and miscellaneous electric loads. This energy use is calculated using guidance from BARBD. Energy use for each dwelling type is based on the number of bedrooms, total finished floor area, and a California-specific plug load multiplier.
6. Dryers and ovens may be electric or gas. The values presented in this table represent 50% of the electricity and/or natural gas use for each equipment type.

Abbreviations:
BARBD - Building America Research Benchmark Definition
DU - dwelling unit
kW-hr - kilowatt-hour

Source:
R. Hendron. Building America Research Benchmark Definition. Technical Report NREL/TP-550-42662. January 2008.

Table 5-13
Emission Factors for Different Energy Sources for Buildings
Sonoma Mountain Village
Rohnert Park, California

Energy Source	Source Units	lb CO_2e /source unit
Electricity[1]	(kW-hr)	0.636
Natural Gas[2]	(MBTU)	117.0

Notes:

1. Emission factor for electricity provided by PG&E, obtained from the California Climate Action Registry Database. Although the California Climate Action Registry Database provides an emission factor for CO_2, it is assumed that the emission factor is representative of CO_2e emissions, since other greenhouse gases associated with electricity generation (such as nitrous oxide and methane) typically comprise less than 1% of CO_2e emissions.
2. Emission factor for natural gas was obtained from California Climate Action Registry (CCAR) Reporting Protocol, Table C.6. Although the CCAR Reporting Protocol provides an emission factor for CO_2, it is assumed that the emission factor is representative of CO_2e emissions, since other greenhouse gases associated with natural gas combustion (such as nitrous oxide and methane) typically comprise less than 1% of CO_2e emissions.

Abbreviations:

CO_2e - carbon dioxide equivalent
kW-hr - kilowatt-hour
lb - pound
MBTU - million british thermal units

Sources:

California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

California Climate Action Registry Database: Pacific Gas and Electric Company 2007 PUP Report. 2009. Available at: https://www.climateregistry.org/CARROT/public/Reports.aspx

Table 5-14
CO_2e Emissions per Dwelling Unit
Sonoma Mountain Village
Rohnert Park, California

Title 24[1] Compliance	Type	DU per Building	Average SF / DU[2]	Title-24 Systems[1]		Title-24 Systems and Major Appliances		Title-24 Systems and All MELs		Title-24 Systems	Title-24 Systems and Major Appliances	Title-24 Systems and All MELs
				CO_2e Electricity[3]	CO_2e Natural Gas[4]	CO_2e Electricity[3]	CO_2e Natural Gas[4]	CO_2e Electricity[3]	CO_2e Natural Gas[4]	CO_2e Total	CO_2e Total	CO_2e Total
				(lbs / DU/year)						(tonnes / DU/year)		
Minimally Title 24 Compliant	Townhouses and Large Rowhouses (Attached)	9	1,583	1,389	5,216	2,494	5,789	3,039	5,789	3.0	3.8	4.0
	Small Rowhouses (Attached)	9	1,100	1,151	4,241	2,142	4,718	2,588	4,718	2.4	3.1	3.3
	Cottages and Second Dwelling Units (Detached)	1	543	958	4,873	1,843	5,260	2,181	5,260	2.6	3.2	3.4
	Single Family Conventional (Detached)	1	1,813	1,606	7,516	2,782	8,148	3,378	8,148	4.1	5.0	5.2
	Single Family Large Lot (Detached)	1	2,638	2,274	10,000	3,516	10,688	4,250	10,688	5.6	6.4	6.8
	Multifamily Apts / Condos (Attached)	9	1,231	1,140	3,825	2,219	4,376	2,706	4,376	2.3	3.0	3.2

Notes:
1. Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code
2. The homes as specified by Codding Enterprises were grouped into six categories based on the square footage and whether the home is attached or detached. The groups include 1) attached multifamily apartments and condominiums (1,000-1,300 sq ft), 2) attached small rowhouses (1,100 sq ft), 3) attached townhouses and large rowhouses (1,500-1,600 sq ft), 4) detached cottages and second dwelling units (500-900 sq ft), 5) detached single family conventional homes (1,500-2,000 sq ft), and 6) detached single family large lot homes (2,500-3,500 sq ft).
3. Converted from kW-hr to lb CO_2e using emission factor from the California Climate Action Registry Database: Pacific Gas and Electric Company 2007 PUP Report. 2009.
4. Converted from MBTU to lb CO_2e using emission factor from California Climate Action Registry General Reporting Protocol (CCAR GRP).

Abbreviations:
CO_2e - carbon dioxide equivalent
DU - Dwelling Unit
kW-hr - kilowatt-hour
lb - pound
SF - Square Feet

Sources:
California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

California Climate Action Registry Database: Pacific Gas and Electric Company 2007 PUP Report. 2009. Available at: https://www.climateregistry.org/CARROT/public/Reports.aspx

Table 5-15
CO_2e Emissions from Electricity and Natural Gas Usage in Residential Dwelling Units
Sonoma Mountain Village
Rohnert Park, California

Title 24[1] Compliance	Housing Type	# Dwelling Units[2]	Title-24 Systems			Title-24 Systems and Major Appliances			Title-24 Systems and All MELs		
			CO_2e Emission Factor (tonne CO_2e / DU / year)	Total CO_{2e} Emissions (tonne CO_2e / year)		CO_2e Emission Factor (tonne CO_2e / DU / year)	Total CO_{2e} Emissions (tonne CO_2e / year)		CO_2e Emission Factor (tonne CO_2e / DU / year)	Total CO_{2e} Emissions (tonne CO_2e / year)	
Minimally Title 24 Compliant	Townhouses and Large Rowhouses (Attached)	250	3.0	749	**5,226**	3.8	939	**6,609**	4.0	1,001	**7,034**
	Small Rowhouses (Attached)	169	2.4	413		3.1	526		3.3	560	
	Cottages and Second Dwelling Units (Detached)	222	2.6	587		3.2	715		3.4	749	
	Single Family Conventional (Detached)	235	4.1	972		5.0	1,165		5.2	1,229	
	Single Family Large Lot (Detached)	65	5.6	362		6.4	419		6.8	440	
	Multifamily Apts / Condos (Attached)	951	2.3	2,142		3.0	2,845		3.2	3,055	

Notes:
1. Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.
2. Information provided by Codding Enterprises.

Abbreviations:
CO_2e - carbon dioxide equivalent
DU - Dwelling Units
MEL - Miscellaneous electric loads

Table 5-16
Categorization of Non-Residential Land Use in Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

General Building Type[1]	Area[1] (SF)	EIA Building Category[2]	% Area[3]	Total EIA Area[4] (SF)
Commercial Office	425,978	Mixed-use office	100%	425,978
Retail - Grocery Store	45,000	Grocery store/food market	100%	45,000
Retail - Medium Box (Single Story)	107,329	Retail store	50%	53,665
Retail - In- Line		Strip shopping mall	50%	53,665
Restaurants - Full Service	39,472	Restaurant/cafeteria	80%	31,578
Restaurants - Quick Service		Fast food	20%	7,894
Daycare	15,000	Preschool/daycare	100%	15,000
Enclosed Promenade	11,528	Enclosed mall	100%	11,528
Hotel	91,000	Hotel	100%	91,000
Movie Theater	25,000	Public assembly (entertainment/culture)	100%	25,000
Civic Space	35,000	Public assembly (social/meeting)	100%	35,000
Gym	30,000	Recreation	100%	30,000
Total Square Footage				825,307

Notes:
1. Building types and areas provided by Codding Enterprises.
2. Building types used in EIA 2003 Commercial Buildings Energy Consumption Survey (CBECS) databases. ENVIRON mapped the Sonoma Mountain Village building types to the EIA categories.
3. The percentage of each Sonoma Mountain Village building type assigned to each EIA category.
4. The product of the area of the Sonoma Mountain Village building type and the percentage of each subcategory. The energy use for each building type is presented in the following tables.

Abbreviations:
EIA - Energy Information Administration
CBECS - Commercial Buildings Energy Consumption Survey
SF - Square Feet

Sources:
US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: Building Types Definition: http://www.eia.doe.gov/emeu/cbecs/building_types.html

Table 5-17
End-Uses of Electricity for Non-Residential Building Types in Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

Principal Building Activity	Cooling[1]	Lighting[1]	Office Equipment[2]	Refrigeration[2]	Ventilation[1]	Space Heating[1]	Cooking[2]	Water Heating[1]	Other[2]
All Buildings	26%	23%	18%	9%	7%	5%	2%	1%	9%
Education	26%	26%	20%	4%	7%	5%	1%	1%	10%
Food Sales	14%	13%	17%	44%	4%	2%	2%	1%	4%
Food Service	12%	9%	14%	38%	3%	2%	18%	0%	3%
Health Care	35%	22%	17%	3%	8%	3%	1%	0%	9%
Lodging	28%	23%	7%	6%	7%	11%	1%	5%	13%
Mercantile	25%	22%	20%	10%	7%	7%	1%	1%	8%
Retail (Other than Mall)	24%	25%	19%	6%	7%	7%	1%	1%	9%
Enclosed and Strip Mall	25%	20%	20%	13%	7%	6%	2%	1%	7%
Office	29%	22%	26%	1%	7%	6%	1%	1%	8%
Public Assembly	32%	26%	11%	5%	8%	4%	2%	1%	11%
Public Order and Safety	30%	28%	13%	Q	8%	3%	Q	Q	13%
Religious Worship	38%	26%	5%	2%	10%	5%	(*)	(*)	14%
Service	22%	32%	14%	Q	9%	4%	Q	1%	15%
Warehouse and Storage	15%	38%	9%	4%	13%	3%	Q	1%	18%
Other	31%	27%	18%	Q	9%	Q	Q	1%	11%
Vacant	30%	10%	20%	Q	10%	(*)	Q	Q	30%

Notes:
1. Cooling, Lighting, Ventilation, Space Heating, and Water Heating are included in and regulated by California Title 24.
2. Non-built energy uses such as Office Equipment, Refrigeration, Cooking, and Other are not regulated by California Title 24 but still contribute to energy consumption.

Abbreviations:
Q - data withheld, fewer than 20 buildings sampled.
(*) - value rounds to zero in original units.
Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Source:
US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: Calculated from data from Tables 3a and 3b of:
http://www.eia.doe.gov/emeu/cbecs/enduse_consumption/pba.html

Table 5-18
End-Uses of Natural Gas for Non-Residential Building Types in Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

Principal Building Activity	Space Heating[1]	Cooking[2]	Water Heating[1]	Other[2]
All Buildings	73%	14%	10%	3%
Education	81%	8%	4%	6%
Food Sales	71%	13%	13%	Q
Food Service	42%	17%	39%	Q
Health Care	72%	8%	18%	Q
Lodging	53%	30%	9%	4%
Mercantile	76%	10%	9%	6%
Retail (Other than Mall)	78%	11%	Q	9%
Enclosed and Strip Mall	72%	8%	18%	Q
Office	94%	4%	3%	0%
Public Assembly	82%	9%	7%	Q
Public Order and Safety	79%	9%	Q	Q
Religious Worship	85%	8%	5%	Q
Service	73%	25%	Q	Q
Warehouse and Storage	88%	7%	Q	5%
Other	84%	11%	Q	Q
Vacant	95%	5%	Q	Q

Notes:

1. Cooling, Lighting, Ventilation, Space Heating, and Water Heating are included in and regulated by California Title 24.

2. Non-built energy uses such as Office Equipment, Refrigeration, Cooking, and Other are not regulated by California Title 24 but still contribute to energy consumption.

Abbreviations:
Q - data withheld, fewer than 20 buildings sampled.
(*) - value rounds to zero in original units.

Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Source:

US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: Calculated from data from Table 2 of: http://www.eia.doe.gov/emeu/cbecs/enduse_consumption/pba.html

Table 5-19
Energy Use for Non-Residential Building Types in Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

EIA Building Type	EIA[1] Electricity Title 24[2]	Non Title 24[3]	Total[3]	Natural Gas Title 24[4]	Non Title 24[5]	Total[5]
	(kW-hr / SF / year)			(ccf / SF / year)		
Mixed-use office	10.65	5.72	16.37	0.10	0.00	0.10
Grocery store/food market	17.99	35.98	53.97	0.16	0.03	0.19
Retail store	6.30	3.51	9.81	0.07	0.02	0.10
Strip shopping mall	11.94	8.25	20.18	0.23	0.02	0.26
Restaurant/cafeteria	12.12	33.01	45.13	1.41	0.33	1.74
Fast food	28.65	78.04	106.68	1.38	0.32	1.71
Preschool/daycare	6.76	3.71	10.47	0.30	0.05	0.35
Recreation	5.16	2.03	7.19	0.19	0.02	0.21
Public assembly (social/meeting)	5.01	1.97	6.98	0.18	0.02	0.20
Public assembly (entertainment/culture)	28.38	11.19	39.56	0.05	0.01	0.05
Enclosed mall	11.60	8.02	19.62	0.04	0.00	0.04
Hotel	12.84	4.64	17.47	0.20	0.12	0.32

Notes:

1. Data is from the 2003 Commercial Buildings Energy Consumption Survey conducted by the US Energy Information Administration.

2. Includes only Title 24-regulated electricity (cooling, lighting, ventilation, space heating, water heating) but excludes non-built electricity (office equipment, refrigeration, cooking).

3. Electricity use is based upon buildings in the EIA CBECS database from EIA climate zone 4 (includes CA climate zone 2). Electricity use per square foot (electricity intensity) for each building sample was first calculated. The electricity intensities were then averaged taking into account the weighting factor for each building in the survey.

4. Includes only Title 24-regulated natural gas (space heating, water heating) but excludes non-built natural gas (cooking, other).

5. Natural gas use is based upon buildings in the EIA CBECS database from EIA climate zone 4 (includes CA climate zone 2). Natural gas use per square foot (intensity) for each building sample was first calculated. The natrual gas intensities were then averaged taking into account the weighting factor for each building in the survey.

Abbreviations:

EIA - Energy Information Administration
kW-hr - kilowatt-hour
SF - Square Feet
ccf - 100 cubic feet
Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Sources:

US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: http://www.eia.doe.gov/emeu/cbecs/contents.html

Table 5-20
Emission Factors for Different Energy Sources for Buildings
Sonoma Mountain Village
Rohnert Park, California

Energy Source	Units	lb CO_2e /unit
Electricity[1]	(kW-hr)	0.636
Natural Gas[2]	(ccf)	12.0

Notes:

1. Emission factor for electricity provided by PG&E, obtained from the California Climate Action Registry Database. Although the California Climate Action Registry Database provides an emission factor for CO_2, it is assumed that the emission factor is representative of CO_2e emissions, since other greenhouse gases associated with electricity generation (such as nitrous oxide and methane) typically comprise less than 1% of CO_2e emissions.

2. From CCAR General Reporting Protocol (GRP). Emission factors (in kg CO_2/standard cubic feet) is provided in Table C.7. Although the CCAR Reporting Protocol provides an emission factor for CO_2, it is assumed that the emission factor is representative of CO_2e emissions, since other greenhouse gases associated with natural gas combustion (such as nitrous oxide and methane) typically comprise less than 1% of CO_2e emissions.

Abbreviations:
kW-hr - kilowatt-hour
ccf - hundred cubic feet
CO_2e - Carbon dioxide equivalent

Sources:
California Climate Action Registry Database: Pacific Gas and Electric Company 2007 PUP Report. 2008. Available at: https://www.climateregistry.org/CARROT/public/Reports.aspx

California Climate Action Registry General Reporting Protocol, Version 3.1 (January 2009). Available at: http://www.climateregistry.org/resources/docs/protocols/grp/GRP_3.1_January2009.pdf

Table 5-21
CO_2e Emissions from Energy Use in Non-Residential Building Types in Sonoma Mountain Village[1]

Sonoma Mountain Village
Rohnert Park, California

EIA Building Type	Annual Area Emission Factors (tonne CO_2e / SF / year)				
	Title 24 compliant				
	Electricity (Title 24)	Electricity (Total)	Natural Gas (Title 24)	Natural Gas (Total)	Total
Mixed-use office	3.07E-03	4.72E-03	5.45E-04	5.65E-04	5.28E-03
Grocery store/food market	5.19E-03	1.56E-02	8.48E-04	1.01E-03	1.66E-02
Retail store	1.82E-03	2.83E-03	4.09E-04	5.23E-04	3.35E-03
Strip shopping mall	3.44E-03	5.82E-03	1.27E-03	1.40E-03	7.22E-03
Restaurant/cafeteria	3.49E-03	1.30E-02	7.71E-03	9.52E-03	2.25E-02
Fast food	8.26E-03	3.08E-02	7.56E-03	9.33E-03	4.01E-02
Preschool/daycare	1.95E-03	3.02E-03	1.62E-03	1.89E-03	4.91E-03
Recreation	1.49E-03	2.07E-03	1.04E-03	1.16E-03	3.23E-03
Public assembly (social/meeting)	1.44E-03	2.01E-03	9.66E-04	1.08E-03	3.09E-03
Public assembly (entertainment/culture)	8.18E-03	1.14E-02	2.54E-04	2.83E-04	1.17E-02
Enclosed mall	3.35E-03	5.66E-03	1.95E-04	2.15E-04	5.87E-03
Hotel	3.70E-03	5.04E-03	1.07E-03	1.72E-03	6.76E-03

Notes:

1. Data from the 2003 Commercial Buildings Energy Consumption Survey (see Table 5-19) was multipled by electricity and natural gas emission factors (see Table 5-20) to calculate CO_2e emissions intensities.

Abbreviations:

EIA - Energy Information Administration
CO_2e - Carbon dioxide equivalent
SF - square feet
Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Sources:

US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: http://www.eia.doe.gov/emeu/cbecs/contents.html

Table 5-22
Calculation of Greenhouse Gas Intensity for Non-Residential Land Use Categories Present in Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

General Building Type[1]	Area[1] (SF)	EIA Building Category[2]	% Area[3]	Related Area[4] (SF)	Title 24-Compliant: Annual Area Emission Factor[5] ($Tonne\ CO_2e$ / SF / year)	Title 24-Compliant: Annual CO_2e Emissions[6] ($Tonne\ CO_2e$ / year)	
Commercial Office	425,978	Mixed-use office	100%	425,978	5.28E-03	2,251	**5,846**
Retail - Grocery Store	45,000	Grocery store/food market	100%	45,000	1.66E-02	746	
Retail - Medium Box (Single Story)	107,329	Retail store	50%	53,665	3.35E-03	180	
Retail - In- Line		Strip shopping mall	50%	53,665	7.22E-03	387	
Restaurants - Full Service	39,472	Restaurant/cafeteria	80%	31,578	2.25E-02	711	
Restaurants - Quick Service		Fast food	20%	7,894	4.01E-02	316	
Daycare	15,000	Preschool/daycare	100%	15,000	4.91E-03	74	
Enclosed Promenade	11,528	Enclosed mall	100%	11,528	5.87E-03	68	
Hotel	91,000	Hotel	100%	91,000	6.76E-03	615	
Movie Theater	25,000	Public assembly (entertainment/culture)	100%	25,000	1.17E-02	292	
Civic Space	35,000	Public assembly (social/meeting)	100%	35,000	3.09E-03	108	
Gym	30,000	Recreation	100%	30,000	3.23E-03	97	

Notes:
1. Building types and areas provided by Codding Enterprises.

2. Building types used in EIA 2003 Commercial Buildings Energy Consumption Survey (CBECS) databases. ENVIRON mapped Sonoma Mountain Village building type to EIA category.

3. The percentage of each Sonoma Mountain Village building type assigned to each of EIA categories.
4. The product of the area of the Sonoma Mountain Village building type and the percentage of each subcategory.
5. Emissions per sqft per year as calculated in Table 5-21.
6. Emissions for each building type is calculated as emissions per square foot times square footage.

Abbreviations:
CO_2e - Carbon dioxide equivalent
EIA - Energy Information Administration
SF - Square Feet
Title 24 - California Code of Regulations (CCR), Title 24, also known as the California Building Standards Code.

Sources:
US Energy Information Administration. 2003 Commercial Buildings Energy Consumption Survey: http://www.eia.doe.gov/emeu/cbecs/contents.html

Table 5-23
Sonoma Mountain Village Mobile Emissions in Context
Sonoma Mountain Village
Rohnert Park, California

	Annual Vehicle Miles Traveled		Comparison to SMV (% Difference)
	Total Miles[1,2]	Miles per Dwelling Unit[3,4]	
Sonoma Mountain Village	27,837,762	14,713	
Sonoma County	3,932,211,000	20,337	28%

Notes:

1. Sonoma Mountain Village vehicle miles traveled as developed in the primary approach in the mobile sources section.
2. Sonoma County VMT is based on information in the City of Rohnert Park traffic study. The VMT shown is the original value reported in Table 4-11, adjusted to account for differences in weekday/weekend driving. Sonoma County VMT based on information for 2005 in the California Motor Vehicle Stock, Travel, and Fuel Forecast; adjusted to account for only light duty autos and trucks, which comprised 93% of all California vehicles in 2005.
3. Assumes Sonoma Mountain Village number of dwelling units is 1892.
4.VMT per dwelling unit in Sonoma County calculated using the number of households in the county from the U.S. Census for 2005.

Sources:

Caltrans. 2005. California Motor Vehicle Stock, Travel, and Fuel Forecast. California Department of Transportation. December 30, 2005.

U.S. Census Bureau. 2006. Annual Estimates of Housing Units for Counties in California: April 1, 2000 to July 1, 2005 (HU-EST2005-04-06). Population Division, U.S. Census Bureau. August 21, 2006.

Table 5-24
BAU GHG Emission Factors for Sonoma Mountain Village Municipal Sources
Sonoma Mountain Village
Rohnert Park, California

Source[1]	Energy Requirements	Units	Emission Factor	Units	Source Quantity[10]	Units	Total CO_2e Emissions [Tonne CO_2e per year]
Lighting							
Public Lighting[2]	149	kW-hr/capita/yr	0.043	tonne CO_2e/capita/year	4,438	residents (capita)	190
						Public Lighting Total:	**190**
Municipal Vehicles							
Municipal Vehicles[3]	--	--	0.05	tonne CO_2e/capita/year	4,438	residents (capita)	222
						Municipal Vehicles Total:	**222**
Water and Wastewater, Without Carbon Free Water Plan							
Groundwater Supply and Conveyance (Potable)[4]	690	kW-hr/acre-foot	0.20	tonne CO_2e/acre-foot	439	acre-feet/yr	87
Water Treatment (Potable)[5]	36	kW-hr/acre-foot	0.01	tonne CO_2e/acre-foot	439	acre-feet/yr	5
Water Distribution (Potable)[6]	414	kW-hr/acre-foot	0.12	tonne CO_2e/acre-foot	439	acre-feet/yr	52
Wastewater Treatment (Indirect Emissions)[7]	623	kW-hr/acre-foot	0.18	tonne CO_2e/acre-foot	386	acre-feet/yr	69
Wastewater Treatment Plant (Direct Emissions)[8]	--	--	0.084	tonne CO_2e/capita/year	4,438	residents (capita)	374
Recycled Water Distribution (Non-Potable)[9]	978	kW-hr/acre-foot	0.28	tonne CO_2e/acre-foot	107	acre-feet/yr	30
						Water and Wastewater Total, without Carbon Free Water Plan:	**618**
						Municipal Sources Total, without Carbon Free Water Plan:	1,030

Notes:

1. Public Lighting includes streetlights, traffic signals, area lighting and lighting municipal buildings. Emissions from the Water and Wastewater category are primarily due to the energy required for supply, treatment and distribution. GHG emissions attributed to electricity use are calculated using the Pacific Gas & Electric carbon-intensity factor.

2. Emission factor for public lighting is based on a study of energy usage and GHG emissions from Duluth, MN (Skoog, 2001) and the electricity generation emission factor from Pacific Gas & Electric.

3. Emission factors for municipal vehicles are based on the most conservative number from studies of GHG emissions for four cities of different sizes: Medford, MA; Duluth, MN; Northampton, MA; and Santa Rosa, CA. Population data provided by the US Census (2000).

4. Emission factor for water supply and conveyance is based on a Navigant Consulting refinement of a CEC study on the estimated energy necessary to supply 1 million gallons of water in Northern California and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

5. Emission factor for water treatment is based on a Navigant Consulting refinement of a CEC study on the energy necessary to treat 1 million gallons of water for supply in Northern California and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

6. Emission factor for water distribution is based on a Navigant Consulting refinement of a CEC study on the energy necessary to distribute 1 million gallons of treated water and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to potable water demand.

7. Emission factor for wastewater treatment is based on a Navigant Consulting refinement of a CEC study on the energy necessary to treat 1 million gallons of wastewater for indoor (i.e., potable or other household) use and the electricity generation emission factor from Pacific Gas & Electric. The value energy requirements for advanced treatment with nitrification was used to represent the energy requirements for membrane bioreactor treatment.

8. Emission factor for the wastewater treatment plant accounts for direct methane and nitrous oxide emissions from wastewater. The value used here is based on the 2005 US inventory of GHG emissions for domestic wastewater treatment plants (USEPA) divided by the 2005 US population. (25 Tg CO_2e/year/296,410,404 people = 0.093 ton CO_2e/capita/year)

9. Emission factor for recycled water distribution is based on a Navigant Consulting refinement of a CEC study of the energy necessary to redistrubute 1 million gallons of reclaimed water (i.e., treated wastewater) and the electricity generation emission factor from Pacific Gas & Electric. This factor is applied to non-potable water demand.

10. As provided by Ron Bendorff, Planning Director, the City of Rohnert Park estimates a population of 2.62 persons per residential property. Codding proposes residential developments on 1,694 parcels. Source quantities for water and wastewater are based on Codding Enterprises.

Abbreviations:

BAU - business as usual
CEC - California Energy Commission
CO_2e - carbon dioxide equivalent
GHG - greenhouse gas
kW-hr - kilowatt hour
MW-hr - megawatt hour
Tg - teragram
USEPA - United States Environmental Protection Agency

References:

California Climate Action Registry (CCAR) Database. Pacific Gas & Electric PUP Report. 2007.
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Table 5-25
Estimated Waste to Landfill and Diverted Waste
Sonoma Mountain Village
Rohnert Park, California

	Type	Normalization Quantity	Normalization Units	Percent of Waste by Weight (%)	Estimated Total Waste Generated	Estimated Total Waste Generated Units	Estimated Total Waste Generated (tons / yr)
Sonoma County[1]	Residential	469,460	residents	67%	1.66	tons / yr / resident	1,165,936
	Commercial	62,100	1000 sq ft	33%	6.20	tons / yr / 1000 sq ft	
SMV Baseline[2]	Residential	4,438	residents	67%	1.66	tons / yr / resident	11,157
	Commercial	609	1000 sq ft	33%	6.20	tons / yr / 1000 sq ft	

Notes:
1. Sonoma County waste information provided in Sonoma Mountain Village Project Description.
2. To estimate the waste generated at SMV, the waste generation rates for Sonoma County were divided into residential and commercial waste rates using the breakdown provided in the SMV Project Description. The residential waste generation rate was normalized by the number of residents, and the commercial waste generation rate was normalized by 1000 square feet of building area. The normalized waste generation rates were used along with the SMV population and commercial building area to estimate the total waste generated at SMV.

Abbreviations:
SMV - Sonoma Mountain Village

Sources:
Sonoma Mountain Village One Planet Communities Sustainability Action Plan Version 1.3. 2008.
Sonoma Mountain Village Project Description. 2008.

Table 5-26
Projected Improvements over Baseline
Sonoma Mountain Village
Rohnert Park, California

Quantity Relative to Baseline	Projected Percent by Volume[1]			Percent Measured Relative to the Quantity Shown	Projected 40-Year Weighted Average, 2010-2050	
	2010	2015	2025-2050		(Percent by Volume)	(Percent by Weight[2])
Reduction in solid waste generation	14%		39%	Total Waste Stream	34%	34%
Increase in recyling rates	24%		34%	Total Waste Stream	32%	32%
Increase in food waste composting	0%	30%	50%	Food Waste	41%	41%
Increase in greenwaste composting	15%		28%	Greenwaste	26%	26%

Notes:
1. Assume all values increase linearly between dates. Data provided by Codding.
2. Assumes that the projected percent by volume is equal to the percent by weight.

Table 5-27
Weights Generated by Material
Sonoma Mountain Village
Rohnert Park, California

		Weight Generated (tons / yr)	
Material	**Percent by Weight[1]**	**SMV Baseline[2]**	**SMV Projected[3]**
Paper	16.3%	1,817	1,194
Glass	2.6%	288	189
Plastic	7.4%	828	544
Metal	3.9%	437	287
Organics	36.3%	4,050	2,660
Construction & Demolition	27.4%	3,057	2,008
Hazardous & E-Waste	1.4%	152	100
Special Waste	1.7%	186	122
Mixed Residue	3.1%	343	225
TOTAL	100.0%	11,157	7,329

Notes:

1. Percentages as found in Sonoma County Waste Characterization Study, 2007. The percentages are applied to the SMV baseline case.
2. Baseline case is from Table 5-25. The SMV projected weight generated is calculated using the projected 40-year average reduction in solid waste generation from Table 5-26.
3. Calculated using the projected 40-year average reduction in solid waste generation over SMV baseline case from Table 5-26. Assumes that there is no reduction in organics, paper, plastic, or mixed residue.

Source:

Sonoma County Waste Management Agency Waste Characterization Study, 2007.
http://www.recyclenow.org/SonomaCountyWasteCharacterizationStudy2007.pdf

Table 5-28
Estimated Weight Breakdown for Baseline and Projected Scenarios
Sonoma Mountain Village
Rohnert Park, California

		Estimated Weight (tons / yr)					
		SMV Baseline			SMV Projected		
Material	**WARM Category[1]**	**Generated**	**Recycled[2]**	**Composted[2]**	**Generated[3]**	**Recycled[4]**	**Composted[5]**
Paper	Office Paper	1817	1163	0	1194	1009	0
Glass	Glass	288	184	0	189	160	0
Plastic	HDPE	828	530	0	544	460	0
Metal	Mixed Metals	437	279	0	437	369	0
Organics[5]	Food Scraps	2025	0	1296	2025	0	1831
	Yard Trimmings	2025	0	1296	2025	0	1627
Construction & Demolition[6]	Dimensional Lumber	764	489	0	240	203	0
	Concrete	764	489	0	764	646	0
	Mixed Metals	764	489	0	764	646	0
	Glass	764	489	0	240	203	0
Hazardous & E-Waste	Personal Computers	152	97	0	100	84	0
Special Waste	Tires	186	119	0	122	103	0
Mixed Residue	Mixed Recyclables	343	219	0	343	290	0

Notes:

1. ENVIRON assigned the material to the most appropriate material category available in the US EPA software, WAste Reduction Model (WARM), which is used to estimate the greenhouse gas impacts of the green waste management program at SMV.

2. Baseline recycling and composting rates calculated using the 2006 Sonoma County diversion rate of 64%. Assumed this applied to each category individually. In this baseline case, ENVIRON assumed that all of the diverted materials were recycled, except for organics, for which all diverted materials were assumed to be composted.
3. In accordance with the WARM model's underlying assumptions, ENVIRON assumes that there is no reduction in mixed paper, mixed plastics, mixed metals, food scraps, yard trimmings, concrete, or mixed recyclables.
4. Calculated using the increase in the recycling rate from baseline, shown in Table 2.
5. Assumes half of the 'Organics' by weight is food waste and half is greenwaste. The projected 40-year percent increases in food waste and greenwaste composting relative to baseline were used to scale the baseline weight of food waste and the baseline weight of greenwaste, respectively.
6. Construction and demolition debris is assumed to consist in equal parts by weight of dimensional lumber, concrete, metal, and glass.

Abbreviations:

SMV - Sonoma Mountain Village
US EPA - United States Environmental Protection Agency
WARM - WAste Reduction Model
yr - year

Source:

Construction and Demolition Materials, US EPA. 2009. Available at: http://www.epa.gov/epawaste/conserve/rrr/imr/cdm/index.htm

Sonoma County Waste Management Agency Board Approved Diversion Rate, 2006. Countywide, Regionalwide, and Statewide Jurisdiction Diversion Progress Report, California Integrated Waste Management Board. Available at: http://www.ciwmb.ca.gov/LGTools/mars/JurDrSta.asp?VW=In
US EPA WAste Reduction Model (WARM). 2008. Available at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Table 5-29
WAste Reduction Model (WARM) Inputs
Sonoma Mountain Village
Rohnert Park, California

	Estimated Weight (tons / yr)									
	SMV Baseline					SMV Projected				
Material	**Generated**	**Recycled**	**Landfilled[1]**	**Combusted**	**Composted**	**Reduced**	**Recycled**	**Landfilled[1]**	**Combusted**	**Composted**
Office Paper	1817	1163	654	0	0	623	1009	184	0	0
Glass	1052	673	379	0	0	623	363	66	0	0
HDPE	828	530	298	0	0	284	460	84	0	0
Mixed Metals	1201	769	432	0	0	0	1015	185	0	0
Food Scraps	2025	0	729	0	1296	0	0	194	0	1831
Yard Trimmings	2025	0	729	0	1296	0	0	398	0	1627
Dimensional Lumber	764	489	275	0	0	524	203	37	0	0
Concrete	764	489	275	0	0	0	646	118	0	0
Personal Computers	152	97	55	0	0	52	84	15	0	0
Tires	186	119	67	0	0	64	103	19	0	0
Mixed Recyclables	343	219	123	0	0	0	290	53	0	0
Average Diversion Rate, 2010-2050	**64%**					**85%**				

Notes:
1. ENVIRON assumes that all waste not recycled or composted is landfilled.

Abbreviations:
US EPA - United States Environmental Protection Agency
WARM - US EPA's WAste Reduction Model
yr - year

Sources:

US EPA Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. 2006. Available at: http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf
US EPA WAste Reduction Model (WARM). 2008. Available at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Table 5-30
Summary of Greenhouse Gas Emissions from Green Waste Disposal
Sonoma Mountain Village
Rohnert Park, California

GHG Emissions[1,2] (tonnes CO_2e / yr)		Total Change in GHG Emissions[1,2] (tonnes CO_2e / yr)
SMV Baseline	**SMV Projected**	
-11,397	-21,378	-9,981

Notes:

1. Sonoma Central landfill recovers landfill gas for energy generation. As such, ENVIRON assumed that SMV's waste will go to a landfill with a landfill gas control system, with the recovery used for energy. All other WARM model options were set to the default value.

2. A negative value indicates an emission reduction; a positive value indicates an emission increase.

Abbreviations:

CO_2e - carbon dioxide equivalents
GHG - greenhouse gas
SMV - Sonoma Mountain Village
yr - year

Sources:

Landfill Energy Systems. Sonoma Central Landfill Phase 2. Available at: http://www.landfillenergy.com/popups/sonoma_2.htm

US EPA Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks. 2006. Available at: http://epa.gov/climatechange/wycd/waste/downloads/fullreport.pdf

US EPA WAste Reduction Model (WARM). 2008. Available at: http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Table 5-31
GHG Emissions Comparison of BAU to Sonoma Mountain Village
Sonoma Mountain Village
Rohnert Park, California

Source	GHG Emissions (tonnes CO_2e / year)		Percentage Improvement over BAU [1]
	BAU	SMV	(%)
Vegetation[2]	-450	-1,991	342%
Construction[3]	15,459	13,824	11%
Total (One time emissions)	**15,009**	**11,833**	21%
Residential[4]	7,034	0	100%
Non-Residential[5]	5,846	0	100%
Mobile[6]	14,938	11,270	25%
Municipal[7]	1,030	596	42%
Total (Annual emissions)	28,848	11,866	59%
Total Annualized Emissions	**29,223**	**12,162**	**58%**

Notes:
1. The percentage improvement over BAU is an estimate. There are some source categories where appropriate comparisons are available. It is estimated that this value is on the conservative side.
2. Vegetation is based on trees planted and changes to the current vegetation at the site.
3. Construction is based on construction equipment, worker trips, and vendor trips.
4. Residential is based on Title 24, major appliances, and plug in energy use.
5. Non-Residential is based on Title 24 and miscellaneous energy use.
6. Mobile is based on a comparison of Sonoma County travel scaled to the number of dwelling units in SMV. An average of emission factors to account for internal and external speeds was used.
7. Municipal is for water treatment, waste water treatment, street lighting, and municipal vehicles. This is a very conservative estimate since appropriate emission factors to adjust wastewater direct emissions are unavailable.

Acronyms:
BAU - business as usual
SMV - Sonoma Mountain Village

Table 5-32
GHG Emissions Comparison of BAU to Sonoma Mountain Village, including Pavley Standards
Sonoma Mountain Village
Rohnert Park, California

Source	**GHG Emissions (tonnes CO_2e / year)**		**Percentage Improvement over BAU [1] (%)**
	BAU	**SMV**	
Vegetation[2]	-450	-1,991	342%
Construction[3]	15,459	13,824	11%
Total (One time emissions)	**15,009**	**11,833**	21%
Residential[4]	7,034	0	100%
Non-Residential[5]	5,846	0	100%
Mobile[6]	14,938	9,049	39%
Municipal[7]	1,030	596	42%
Total (Annual emissions)	28,848	9,646	67%
Total Annualized Emissions	**29,223**	**9,941**	**66%**

Notes:

1. The percentage improvement over BAU is an estimate. There are some source categories where appropriate comparisons are available. It is estimated that this value is on the conservative side.
2. Vegetation is based on trees planted and changes to the current vegetation at the site.
3. Construction is based on construction equipment, worker trips, and vendor trips.
4. Residential is based on Title 24, major appliances, and plug in energy use.
5. Non-Residential is based on Title 24 and miscellaneous energy use.
6. Mobile is based on a comparison of Sonoma County travel scaled to the number of dwelling units in SMV and adjusted to account for Pavley Standards. An average of emission factors to account for internal and external speeds was used.
7. Municipal is for water treatment, waste water treatment, street lighting, and municipal vehicles. This is a very conservative estimate since appropriate emission factors to adjust wastewater direct emissions are unavailable.

Acronyms:

BAU - business as usual
SMV - Sonoma Mountain Village

Table 6-1
Low Carbon Fuel Standard (LCFS) Effects on Vehicle Tailpipe Emissions[1]
Sonoma Mountain Village
Rohnert Park, California

Baseline Scenario

Fuel	Emission Factor[2]	Fuel Economy[3]		VMT[4]	Emissions[5]
	[kg CO_2/gal]	[mpg]	[g CO_2/mile]	[miles/year]	[metric tonne CO_2/year]
Gasoline	8.81	20.3	434	26,445,874	11,467
Diesel	10.15	7.9	1,283	1,391,888	1,786
					13,253

Scenario A: Replace California Diesel with 100% Biodiesel (B100)[6]

Fuel	Emission Factor	Fuel Economy	Emission Rate	VMT	
	[kg CO_2/gal]	[mpg]	[g CO_2/mile]		[metric tonne CO_2/year]
Gasoline	8.81	20.3	434	26,445,874	11,467
Biodiesel	9.46	7.1	1,329	1,391,888	1,850
					13,317
			Percent Difference from Baseline		0.5%

Scenario B: Replace California Gasoline with 85% Ethanol Blend (E85)[7]

Fuel	Emission Factor	Fuel Economy	Emission Rate	VMT	Emissions
	[kg CO_2/gal]	[mpg]	[g CO_2/mile]	[miles/year]	[metric tonne CO_2/year]
E85	6.10	15.2	400	26,445,874	10,586
Diesel	10.15	7.9	1,283	1,391,888	1,786
					12,372
			Percent Difference from Baseline		-6.6%

Scenario C: Replace California Gasoline with Compressed Natural Gas (CNG)[8]

Fuel	Emission Factor	Fuel Economy	Emission Rate	VMT	Emissions
	[kg CO_2/gal]	[mpg]		[miles/year]	[metric tonne CO_2/year]
CNG	5.31	28.0	190	26,445,874	5,015
Diesel	10.15	7.9	1,283	1,391,888	1,786
					6,801
			Percent Difference from Baseline		-48.7%

Notes:

1. The Low Carbon Fuel Standard (LCFS) mandated under Governor Schwarzenegger's Executive Order S-01-07 and currently being developed by the California Air Resources Board (ARB) requires a reduction in carbon intensity of California's transportation fuels by at least 10% by 2020. At present, the ARB only has a "concept outline" of the LCFS regulation which proposes an Average Fuel Carbon Intensity (AFCI) of 83 g CO_2e/megajoule (MJ) of energy in the fuel for gasoline and 64 g CO_2e/MJ for diesel. However, one must consider that the LCFS considers the life cycle analysis (LCA) emissions for each fuel whereas the emissions presented in this inventory only account for vehicular tailpipe emissions. Thus, the impact on vehicle tailpipe emissions are only speculative.

In this table, ENVIRON presents the various extreme scenarios by which gasoline or diesel is replaced by various alternative fuels which have lower LCA emissions. This analysis assumes that engine technology will not change (i.e., emission factors and fuel economy are constant) and that the vehicle miles travelled (VMT) for the same population will also be similar in 2020. In reality, the fuel-specific emission factors and fuel economy are likely to improve with advanced technologies. However, overall VMT will likely increase for SMV if the population increases. For purposes of this analysis, the emission estimates presented here for future scenarios are attributatble to the same population as in the baseline population.

2. Emission factors for various fuels from the California Climate Action Registry (CCAR) General Reporting Protocol (GRP) (2009). The emission factor for E85 is from the 2007 version of the GRP as E85 was not included in the 2009 version.

3. Average fuel economy for California gasoline and diesel vehicles obtained from forecasts of fuel consumption and vehicle miles travelled for 2008 from the California Department of Transportation (2005).

4. Vehicle miles travelled (VMT) split between gasoline (or replacement) and diesel (or replacement) assumes 95% VMT by gasoline vehicles and 5% VMT by diesel vehicles.

5. These emissions only account for running CO_2 emissions and do not account for starting emissions. The emissions estimated here are derived differently compared to emissions calculated from the EMFAC model runs for the SMV inventory; the estimated emissions for the baseline scenario are roughly within 10% of the vehicle emissions developed using EMFAC. This difference is likely due to improvements in vehicle technology estimated for 2011. However, for purposes of this semi-quantitative analysis, this should be acceptable since the emissions presented in this table are only for comparative purposes and are not meant to represent actual emissions at SMV.

6. Scenario A assumes that California diesel would be replaced entirely by 100% biodiesel (B100). The fuel economy of biodiesel is assumed to be 10% lower than that for California diesel based on US Department of Energy estimates (2008) (http://www.fueleconomy.gov/feg/biodiesel.shtml). Some consider the CO_2 emissions from biological sources to be "carbon neutral". However for purposes of this analysis, the CO_2 from the combustion of biodiesel are accounted for.

7. Scenario B assumes that California gasoline would be replaced entirely by 85% ethanol blend (E85). The fuel economy of E85 is assumed to be 20-30% lower than that for gasoline based on US Department of Energy estimates (2008) (http://www.fueleconomy.gov/feg/ethanol.shtml).

8. Scenario C assumes that California gasoline would be replaced entirely by compressed natural gas (CNG). The fuel economy of CNG is assumed to be 28 mpg based on US Department of Energy estimates (2008) for a 2008 Honda Civic powered on CNG.

Abbreviations:

ARB = California Air Resources Board
B100 = 100% biodiesel
CNG = compressed natural gas
CO_2 = carbon dioxide
E85 = 85% ethanol blend
gal = gallon
LCA = life cycle analysis
LCFS = Low Carbon Fuel Standard
mpg = miles per gallon
SMV = Sonoma Mountain Village
VMT = vehicle miles travelled

Sources:

California Climate Action Registry (CCAR). 2007. General Reporting Protocol, Version 2.2, March. Available at: http://www.climateregistry.org/docs/PROTOCOLS/GRP%20V2-March2007.pdf
California Department of Transportation. 2005. California Motor Vehicle Stock, Travel, and Fuel Forecast. Available at: http://www.dot.ca.gov/hq/tsip/smb/documents/mvstaff/mvstaff05.pdf

Table 6-2
Pavley Vehicle Standards[1]
Sonoma Mountain Village
Rohnert Park, California

Model Year[2, 3]	Greenhouse Gas Emission Standards		
	PC/LDT1[4]	LDT2[5]	Fleet Average[6]
	[g CO_2e/mile]	[g CO_2e/mile]	[g CO_2e/mile]
2002	312	443	354
2009	323	439	360
2010	301	420	338
2011	267	390	304
2012	233	361	271
2013	227	355	265
2014	222	350	260
2015	213	341	251
2016	205	332	243
2017	195	310	229
2018	185	285	215
2019	180	270	207
2020	175	265	203

Notes:
1. The Pavley vehicle standards (Pavley Standards) presented here are pursuant to Assembly Bill 1493 (AB 1493) which requires that the California Air Resources Board (ARB) develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of GHG emissions from motor vehicles. The vehicle GHG emission standards are codified in Title 13 of the California Code of Regulations Section 1961.1(a)(1)(A). Post-2016 and fleet average standards are based on assumptions of fleet mix and further GHG emission reductions from an ARB technical assessment (2008).
2. The Pavley Standards would go into effect starting with model year 2009 vehicles. 2002 emissions are shown as a baseline.
3. The Pavley Standards developed by the ARB mandate emission reductions up to 2016. The standards presented for years 2017 through 2020 represent a commitment by the ARB to further reduce vehicle emissions for the 2020 goals of AB 32.
4. The Passenger Car (PC) and Light-Duty Trucks 1 (LDT1) category covers all passenger cars and light-duty trucks up to 3,750 lbs.
5. The Light-Duty Trucks 2 (LDT2) category covers light-duty trucks between 3,751 - 8,500 lbs and all medium-duty passenger vehicles.
6. The Fleet Average standards are based on an assumed California fleet mix of 70% PC/LDT1 and 30% LDT2.

Abbreviations:
AB = Assembly Bill
ARB = California Air Resources Board
CO_2e = carbon dioxide equivalent
GHG = greenhouse gas
LDT = light duty truck
PC = passenger car

Source:
California Air Resources Board (ARB). 2008. Comparison of Greenhouse Gas Reductions For the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations.

Table 6-3
Fuel Economy and Equivalent CO_2 Emission Rates Based on the EISA[1]
Sonoma Mountain Village
Rohnert Park, California

Model Year[3]	PC		LDT		Fleet Average (California)[2]	
	Fuel Economy [mpg]	CO_2 Emissions [g CO_2e/mile]	Fuel Economy [mpg]	CO_2 Emissions [g CO_2e/mile]	Fuel Economy [mpg]	CO_2 Emissions [g CO_2e/mile]
2007	27.5	338	22.2	423	22.8	390
2008	27.5	338	22.5	417	23.0	386
2009	27.5	338	23.1	406	23.4	379
2010	27.5	338	23.5	399	23.7	375
2011	28.4	326	24.3	385	24.6	362
2012	29.4	315	25.1	371	25.5	349
2013	30.4	304	26.0	358	26.4	337
2014	31.5	293	26.9	346	27.3	325
2015	32.6	282	27.8	331	28.5	312
2016	33.7	270	28.8	318	29.7	299
2017	34.9	259	29.8	305	31.0	287
2018	36.1	249	30.8	292	32.3	275
2019	37.3	240	31.9	281	33.6	265
2020	38.6	230	33.0	270	35.0	254

Notes:

1. The Energy Independence and Security Act of 2007 (EISA or H.R. 6), requires that a Corporate Average Fuel Economy (CAFE) standard of at least 35 miles per gallon (mpg) be achieved by 2020 for passenger and non-passenger automobiles manufactured for sale in the United States (Section 102(b)(2)(A)). Separate increased standards for passenger and non-passenger automobiles may begin in 2011. The data provided here is based on the California Air Resources Board's (ARB's) technical analysis of the Energy Act of 2007 and the Pavley Standards (2008). The increase in fuel economy is based on an assumed linear increase of fuel economy to 2020. It should be noted that the EISA does not place a standard on GHG emissions; the CO_2 emissions shown here are based on the assumed fuel economies for both vehicle classes. Full details on the calculations shown here can be found in the ARB technical analysis (2008).

2. The fleet average fuel economy and CO_2 emissions are based on the mix of vehicles in the California fleet. Full details on the calculations shown here can be found in the ARB technical analysis (2008).

3. Increased fuel economy under the the EISA will not be required until 2011. However, fuel economy and estimated CO_2e emissions are shown only for comparison purposes with the Pavley Standard. The increased fuel economy LDT vehicles for 2009-2010 are based on the rule adopted by the National Highway Traffic Satefy Administration (NHTSA) establishing higher CAFE standards for model year 2008-2011 light trucks.

Abbreviations:

ARB = California Air Resources Board
CAFE = Corporate Average Fuel Economy
CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
EISA = Energy Independence and Security Act of 2007
GHG = greenhouse gas
H.R. = House of Representatives
LDT = light-duty trucks
mpg = miles per gallon
PC = passenger cars

Source:

California Air Resources Board (ARB). 2008. Comparison of Greenhouse Gas Reductions For the United States and Canada Under U.S. CAFE Standards and California Air Resources Board Greenhouse Gas Regulations.

Table 6-4
Average CO_2 Emissions per Vehicle Mile Traveled
Sonoma Mountain Village
Rohnert Park, California

Trip Type	CO_2e Emissions[1] [tonne/year]	VMT[1] [miles/year]	CO_2e Emissions[2] [grams/mile]
All Residents	12,031	27,837,762	432
Total	12,031	27,837,762	
		Weighted Average	432

Notes:

1. Vehicle miles travelled (VMT) for each trip type as found in the primary approach of Section 4.9. CO_2 emissions calculated using 2020 emission factors, generated using EMFAC.
2. CO_2 emissions per mile is calculated by taking the CO_2 emissions and dividing by the VMT for each trip type. The weighted average value is obtained by weighting the CO_2 emissions/mile for each trip type by the VMT.

Abbreviations:

VMT = Vehicle Miles Travelled

Table 6-5
Estimated Fleet-Wide Average GHG Emissions
Sonoma Mountain Village
Rohnert Park, California

	Pavley Standards [g CO_2e/mile]	**EISA [g CO_2e/mile]**
Estimated Fleet-Wide Average CO_2e Emissions in 2020	234	293
Percentage Above Standard for CO_2e Emissions	15%	

Notes:

The estimated fleet-wide average GHG emissions in 2020 take into account that the vehicle fleet in 2020 will be comprised of vehicles spanning many model years. Thus, the expected vehicle emissions in 2020 would be expected to be greater than the actual standard that is implemented for model year 2020 vehicles. The fleet-wide average GHG emissions for SMV (406 g CO_2e/mile) is based on Year 2020 vehicle emissions for California. Compared to the estimated California fleet-wide EISA equivalent in 2010 (363 g CO_2e/mile), the emissions for the SMV development is approximately 12% higher. Thus, in order to estimate the fleet-wide average GHG emissions for 2020, ENVIRON assumed an increase of approximately 12% over the presumed equivalent standards for 2020.

Abbreviations:

CO_2e = carbon dioxide emissions
EISA = Energy Independence and Security Act of 2007
GHG = greenhouse gas