GREENHOUSE GAS EMISSIONS CALCULATIONS

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MEMORANDUM

To: Stephanie Strelow

From: Don Ballanti

Date: September 24, 2009

Subject: Santa Cruz SOI Greenhouse Gas Analysis

Background

Gases that trap heat in the atmosphere are referred to as greenhouse gases (GHGs) because they capture heat radiated from the sun as it is reflected back into the atmosphere, much like a greenhouse does. The accumulation of GHGs has been implicated as a driving force for global climate change. Definitions of climate change vary between and across regulatory authorities and the scientific community, but in general can be described as the changing of the earth's climate caused by natural fluctuations and anthropogenic activities which alter the composition of the global atmosphere.

California State law defines greenhouse gases as:

Carbon Dioxide (CO_2)
Methane (CH_4)
Nitrous Oxide (N_2O)
Hydrofluorocarbons
Perfluorocarbons
Sulfur Hexafluoride

The overall approach to the GHG calculation is based upon the technical advisory of the

Governor's Office of Planning and Research (OPR) embodied in the document *CEQA and Climate Change: Addressing Climate Change Through California Environmental Quality Act (CEQA) Review*. According to the Governor's Office of Planning and Research, the most common GHG that results from human activity is carbon dioxide, followed by methane and nitrous oxide. The last 3 of the six identified GHGs are primarily emitted by industrial facilities. For this analysis, only carbon dioxide, methane and nitrous oxide emissions will be considered. These primary greenhouse gases are described below.

Carbon dioxide (CO_2)

Carbon dioxide is primarily generated by fossil fuel combustion in stationary and mobile sources. Due to the emergence of industrial facilities and mobile sources in the past 250 years, the concentration of carbon dioxide in the atmosphere has increased 35 percent. Carbon dioxide is the most widely emitted GHG and is the reference gas (Global Warming Potential of 1) for determining GWPs for other GHGs.

Methane (CH_4)

Methane is emitted from biogenic sources, incomplete combustion in forest fires, landfills, manure management, and leaks in natural gas pipelines. In the United States, the top three sources of methane are landfills, natural gas systems, and enteric fermentation. Methane is the primary component of natural gas, which is used for space and water heating, steam production, and power generation. The GWP of methane is 21.

Nitrous Oxide (N_20)

Nitrous oxide is produced by both natural and human-related sources. Primary human-related sources include agricultural soil management, animal manure management, sewage treatment, mobile and stationary combustion of fossil fuel, adipic acid production, and nitric acid production. The GWP of nitrous oxide is 310.

Greenhouse Gas Effects

There is international scientific consensus that human-caused increases in GHGs have and will continue to contribute to global warming, although there is uncertainty concerning the magnitude and rate of the warming. Potential global warming impacts in California may include, but are not limited to, loss in snow pack, sea level rise, more extreme heat days per year, more high ozone days, more large forest fires, and more

drought years.[1] Secondary effects are likely to include a global rise in sea level, impacts to agriculture, changes in disease vectors, and changes in habitat and biodiversity.

Statewide Greenhouse Gas Programs

In 2005, in recognition of California's vulnerability to the effects of climate change, Governor Schwarzenegger established Executive Order S-3-05, which sets forth a series of target dates by which statewide emission of greenhouse gases (GHG) would be progressively reduced, as follows: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels.[2]

In 2006, California passed the California Global Warming Solutions Act of 2006 (AB 32), which requires the California Air Resources Board (CARB) to design and implement emission limits, regulations, and other measures, such that feasible and cost-effective statewide GHG emissions are reduced to 1990 levels by 2020 (representing a 25 percent reduction in emissions).

AB 32 establishes a timetable for the CARB to adopt emission limits, rules, and regulations designed to achieve the intent of the Act. CARB staff is preparing a scoping plan to meet the 2020 greenhouse gas reduction limits outlined in AB 32. In order to meet these goals, California must reduce their greenhouse gases by 30 percent below projected 2020 levels, or about 10 percent from today's levels.

Sources of Greenhouse Gas Emissions

Anthropogenic GHG emissions worldwide as of 2005 totaled approximately 30,800 CO_2 equivalent million metric tons (MMT CO_2e).[3] The United States was the top producer of greenhouse gas emissions as of 2005. The primary greenhouse gas emitted by human activities in the United States was CO_2, representing approximately 84 percent of total greenhouse gas emissions. Carbon dioxide from fossil fuel combustion, the largest source of US greenhouse gas emissions, accounted for approximately 80 percent of US

[1] California Air Resources Board (ARB). 2006. Climate Change website. (http://www.arb.ca.gov/cc/120106workshop/intropres12106.pdf).

[2] California Air Resources Board (CARB), *Climate Change Draft Scoping Plan: A Framework for Change,* October 2008.

[3] The CO_2 equivalent emissions are commonly expressed as "million metric tons of carbon dioxide equivalent ($MMTCO_2E$)". The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated Global Warming Potential (GWP).

GHG emissions.[4]

The primary contributors to GHG emissions in California are transportation, electric power production from both in state and out-of-state sources, industry, agriculture and forestry, and other sources, which include commercial and residential activities. These primary contributors to California's GHG emissions and their relative contributions are presented in Table 1.

Greenhouse Gas Emission Estimate Methodology

OPR's technical advisory states that "the most common GHG that results from human activity is carbon dioxide, followed by methane and nitrous oxide." The calculation presented below discusses existing and future operational emissions in terms of CO_2e emissions from vehicular traffic, area sources, and energy consumption.

Construction Emissions

The URBEMIS-2007 program (Version 9.2.4) was used to calculate construction emissions of carbon dioxide. The project would result in the construction of 3,175,000 gsf of new building on 73 acres over a roughly 10 year period. Since no specific building information is available, the calculation of annual emissions was based on assumed construction of 10% of the forecast square footage on 10% of the projected area to be disturbed, or 317,500 of new building on 7.3 acres each year.

Since no specific building information is available, the analysis used URBEMIS-2007 default estimates for the phasing of construction activities, equipment usage and construction travel. The URBEMIS-2007 output is attached.

Emissions of methane and nitrous oxide were estimated separately based on the URBEMIS-2007 estimates of carbon dioxide from diesel construction vehicles and equipment. Published methane and nitrous oxide emission factors were utilized to estimate project emissions of these gases based on the estimated carbon dioxide emissions.[5] Because these gases are more powerful global warming gases the emissions were multiplied by a correction factor to estimate "carbon dioxide equivalents". Methane was assumed to have a Global Warming Potential of 21 times that of CO_2, while nitrous was assumed to have a Global Warming Potential of 310 times that of CO_2. A spreadsheet is attached that shows the adjustment of the

[4] US Environmental Protection Agency, *Inventory of US Greenhouse Gas Emissions and Sinks 1990-2006,* 2008.

[5] Bay Area Air Quality Management District, *Source Inventory of Bay Area Greenhouse Gas Emissions*, December 2008.

construction emissions to account for methane and nitrous oxide emissions, with the result reported as CO_2e.

Direct Emissions

Estimates of carbon dioxide generated by project traffic and area sources were made using URBEMIS-2007. URBEMIS-2007 is a program used statewide that estimates the emissions that result from development projects. Land use projects can include residential uses such as single-family dwelling units, apartments and condominiums, and nonresidential uses such as shopping centers, office buildings, and industrial facilities. URBEMIS-2007 contains default values for much of the information needed to calculate emissions. However, project-specific, user-supplied information can also be used when it is available.

Inputs to the URBEMIS-2007 program include trip generation rates, vehicle mix, average trip length by trip type and average speed. Trip rates were calculated so that new traffic would be 3,900 daily trips, which is the allowable increase in traffic per the UCSC 2005 LRDP Settlement Agreement. Average trip lengths and speeds for Santa Cruz County were used. The analysis was carried out assuming a 2020 vehicle mix.

Area source emissions of carbon dioxide were also quantified by the URBEMIS-2007 program. The URBEMIS program identifies 5 categories of area source emissions, but only the following result in emissions of carbon dioxide and would be present within the project:

Natural Gas Combustion
Landscaping Emissions

Natural gas emissions result from the combustion of natural gas for cooking, space heating and water heating. Estimates are based on square footage of new construction.

URBEMIS calculates emissions from fuel combustion and evaporation of unburned fuel by landscape maintenance equipment. Equipment in this category includes lawn mowers, rotor tillers, shredders/grinders, blowers, trimmers, chain saws, and hedge trimmers used in residential applications.

The URBEMIS-2007 results for carbon dioxide are attached. The output shows annual emissions of carbon dioxide.

Emissions of methane (CH_4) and nitrous oxide (N_2O) were estimated separately based on the URBEMIS-2007 estimates of carbon dioxide from vehicles and natural gas combustion. CH_4 and N_2O emission factors from Table B in BAAQMD's *Source*

Inventory of Bay Area Greenhouse Gas Emissions were utilized in a spreadsheet to estimate project emissions of these gases.[6] The attached spreadsheet output shows the calculation of CH_4 and N_2O carbon dioxide equivalents and the calculation of total estimated CO_2e emissions for the project from all identified sources.

Indirect Emissions

Indirect emissions are related to secondary emissions of global warming gases emitted away from the site and not directly related to project activities. For example, a portion of the electricity used by the project will be generated by fossil-fueled power plants that generate global warming gases.

Electricity

Global warming gas emissions related to electricity use were estimated using average annual electrical consumption estimates recommended by the California Energy Commission. Emission rates for CO_2, CH_4 and N_2O per megawatt hour were taken from the California Climate Action Registry General Reporting Protocol, Version 3.0. Project electrical usage factor was multiplied by the emission rates per megawatt hour to obtain annual emissions for CO_2, CH_4 and N_2O. These emissions were converted to CO_2 equivalents. The calculation is shown in the attached spreadsheet output.

Water Treatment/Delivery

The treatment and delivery of drinking water is another indirect source of greenhouse gases. It was estimated by using an emission factor created by dividing current estimated greenhouse gas emissions for the Santa Cruz municipal water system of 2119 metric tons per year (CO_2 equivalent) by the system's annual throughput of 39 billion gallons.[7] This per-gallon factor was then doubled to account for the additional energy required to pump water uphill to the project site, then multiplied by the estimated annual project water demand of 100 million gallons. The resulting emission is 108.67 MT CO_2e/year.

Tree and Vegetation Removal

On-site vegetation currently reduces GHG emissions by sequestering carbon dioxide. GHG emissions would therefore increase as on-site vegetation is replaced with

[6] Bay Area Air Quality Management District, *Source Inventory of Bay Area Greenhouse Gas Emissions,* 2008.
[7] City of Santa Cruz, *City of Santa Cruz Greenhouse Gas Emissions Inventory 2005 Municipal and Community Emissions*, 2008.

developed urban surfaces. These emissions are due to the loss of future sequestration by the existing trees. The project would remove an unknown number of trees and other vegetation, which would be partly offset by the planting of new trees.

The EIR for the East Campus Infill Project included a detailed inventory of trees to be removed by that 2-acre development, and an estimate of the net reduction in carbon dioxide sequestration resulting from the removal of trees. It is not possible to identify trees to be removed as part of the Santa Cruz Sphere of Influence Project since development sites and building footprints are not available. The results of the East Campus Infill Project have been utilized to make a conservative estimation of project effects. The East Campus Infill Project site is mostly redwoods, while the north campus development areas are mostly chapparal, mixed evergreen, chapparal/forest transition, with some dwarf redwood forest. Therefore, the GHG emissions per acre for the East Campus Infill Project site would most likely be higher than for the north campus.

Tree removal for the 2-acre East Campus Infill Project was estimated to result in the emission of 1,182.53 MT CO_2e. The construction of the proposed project would require tree removal on about 7.3 acres per year for a period of about 10 years. The resulting annual GHG emission is 4,316.23 MT CO_2e.

Wastewater Treatment/Solid Waste Disposal

Wastewater treatment and solid waste disposal in landfills are sometimes considered to be indirect sources of GHG emissions that can be linked to new development. The breakdown of organic materials at wastewater treatment facilities and solid waste landfills generates methane, a GHG with a Global Warming Potential (GWP) 21 times that of CO_2, so methane emissions associated with the wastewater and solid waste generated by a project could be calculated.

However, methane is captured at the Santa Cruz city landfill and wastewater treatment plant and used to generate electricity. The City of Santa Cruz *Greenhouse Gas Emissions Inventory* estimates that capture of methane at the city landfill and wastewater treatment plant and its use to generate electricity results in an avoided emission that exceeds actual emissions.[8] This is accomplished by converting methane emissions into CO_2 emissions (with a much lower Global Warming Potential) and by creating electricity that offsets production of GHG emissions at power plants. Since, at least in Santa Cruz, the net effect of wastewater treatment and landfill operations is to

[8] City of Santa Cruz, *City of Santa Cruz Greenhouse Gas Emissions Inventory 2005 Municipal and Community Emissions*, 2008.

result in avoided emissions, the project has not been considered as generating new emissions from these sources.

Results

The project's incremental increase in GHG emissions by component is shown in Table 2. Table 2 shows the maximum GHG emission, which would occur at the year of project completion. Once construction is completed, construction emissions and tree removal sources would be eliminated, and project GHG emissions would then be 17,005.80 MT CO_2e per year.

Table 1: GHG Sources In California, 2004

Source Category	**Annual GHG Emissions (**$MMTCO_2E$)	**Percent of Total**
Agriculture	27.9	5.8
Commercial Uses	12.8	2.6
Electricity Generation	119.8	24.7
Forestry (Excluding sinks)	0.2	0.0
Industrial Uses	96.2	19.9
Residential Uses	29.1	6.0
Transportation	182.4	37.7
Other	16.0	3.3
Totals	484.4	100.0

Source: California Air Resources Board, *California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit,* 2007.

Table 2: Project Greenhouse Gas Emissions, in CO_2 Equivalent

Source	**GHG Emission (Metric Tons/Year)**
Construction	454.74
Transportation	2,870.12
Area Sources	798.74
Electricity	13,228.27
Water Treatment/Delivery	108.67
Tree Removal	4,316.23
Total	21,776.77

Project: Santa Cruz SOI
Spreadsheet to Calculate Greenhouse Gases

CONSTRUCTION EMISSIONS

			CH4 EMISSIONS	N20 EMISSIONS
CONSTRUCTION CO2 EMISSIONS FROM URBEMIS:			TONS/YEAR CO2e	TONS/YEAR CO2e
	497.55	TONS/YEAR	2.49	1.33
CONSTRUCTION C02 EQUIVALENT	**501.36**	TONS/YEAR CO2e		

TRANSPORTATION EMISSIONS

PROJECT INFORMATION:

Residential Units	0.00	Dwelling Units
Office	0.00	
Restaurant	0.00	
Retail	0.00	
Grocery	0.00	
Ref. Warehouse	0.00	
Warehouse	0.00	
Schools	0.00	
Colleges	3,175,000.00	
Hospitals	0.00	
Lodging	0.00	
Misc. cmrcl.	0.00	
	3,175,000.00	Sq. Ft.

TRANSPORTATION EMISSIONS
ANNUAL TRANSPORTATION CO2 EMISSIONS FROM URBEMIS:

	3,152.58	TONS/YEAR	CH4 ANNUAL EMISSIONS	N20 ANNUAL EMISSIONS
			TONS/YEAR CO2e	TONS/YEAR CO2e
	3,164.41	TONS/YEAR CO2e	1.86	9.97

AREA SOURCE EMISSIONS
ANNUAL AREA SOURCE CO2 EMISSIONS FROM URBEMIS:

	876.69	TONS/YEAR	CH4 ANNUAL EMISSIONS	N20 ANNUAL EMISSIONS
			TONS/YEAR CO2e	TONS/YEAR CO2e
	880.64	TONS/YEAR CO2e	0.25	3.70

Sources:
CH4 and N2O emission factors from Table 3 in BAAQMD's "Source Inventory of Bay Area Greenhouse Gas Emissions", December 2008.
CH4 assumed to have a Global Warming Potential of 21 times that of CO2.
N2O assumed to have a Global Warming Potential of 310 times that of CO2.

ELECTRICITY CONSUMPTION

LAND USE	SQ.FOOTAGE	RATE kwh/sq. ft/year	ANNUAL USAGE (mWH)
College/University	3,175,000.00	10.44	33,147.00
		Total	33,147.00

Rate (lbs./mWH)	Pollutant	TONS/YEAR	TONS/YEAR CO2e
878.71	CO_2	14,563	14,563
0.0067	CH_4	0.1110	2.33
0.0037	N2O	0.0613	19.01
		14,584.6	TONS/YEAR CO2e

Sources:

Electrical use rate from CEC: http://www.consumerenergycenter.org/pv4newbuildings/downloads/II-6A.pdf
Emissions rates for CO2, CH4 and N20 taken from CCAR General Reporting Protocol, Version 3.0, April 2008, Tables C-2 and C-3

SUMMARY OF EMISSIONS

	Tons/Year CO2e	Metric Tons/Year CO2e
Construction	501.36	454.74
Transportation	3,164.41	2,870.12
Area Sources	880.64	798.74
Electrical Usage	14,584.64	13,228.27
Total	19,131.05	17,351.86

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Urbemis 2007 Version 9.2.4

Combined Annual Emissions Reports (Tons/Year)

File Name: C:\Documents and Settings\Don Ballanti\Application Data\Urbemis\Version9a\Projects\santacruzsoioperation.urb924

Project Name: City of Santa Cruz SOI

Project Location: Santa Cruz County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

Summary Report:

AREA SOURCE EMISSION ESTIMATES

	CO2
TOTALS (tons/year, unmitigated)	876.69

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

	CO2
TOTALS (tons/year, unmitigated)	3,152.58

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

	CO2
TOTALS (tons/year, unmitigated)	4,029.27

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Area Source Unmitigated Detail Report:

AREA SOURCE EMISSION ESTIMATES Annual Tons Per Year, Unmitigated

Source	CO2
Natural Gas	876.44
Hearth	
Landscape	0.25
Consumer Products	
Architectural Coatings	
TOTALS (tons/year, unmitigated)	876.69

Area Source Changes to Defaults

Operational Unmitigated Detail Report:

OPERATIONAL EMISSION ESTIMATES Annual Tons Per Year, Unmitigated

Source	CO2
University/college (4 yrs)	3,152.58
TOTALS (tons/year, unmitigated)	3,152.58

Operational Settings:

Does not include correction for passby trips

Does not include double counting adjustment for internal trips

Analysis Year: 2020 Season: Annual

Emfac: Version : Emfac2007 V2.3 Nov 1 2006

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Summary of Land Uses

Land Use Type	Acreage	Trip Rate	Unit Type	No. Units	Total Trips	Total VMT
University/college (4 yrs)		0.87	students	4,500.00	3,915.00	18,674.55
					3,915.00	18,674.55

Vehicle Fleet Mix

Vehicle Type	Percent Type	Non-Catalyst	Catalyst	Diesel
Light Auto	44.9	0.0	99.8	0.2
Light Truck < 3750 lbs	17.8	0.0	97.8	2.2
Light Truck 3751-5750 lbs	20.3	0.0	100.0	0.0
Med Truck 5751-8500 lbs	7.1	0.0	100.0	0.0
Lite-Heavy Truck 8501-10,000 lbs	1.2	0.0	75.0	25.0
Lite-Heavy Truck 10,001-14,000 lbs	0.9	0.0	55.6	44.4
Med-Heavy Truck 14,001-33,000 lbs	1.1	0.0	18.2	81.8
Heavy-Heavy Truck 33,001-60,000 lbs	0.1	0.0	0.0	100.0
Other Bus	0.0	0.0	0.0	0.0
Urban Bus	0.1	0.0	0.0	100.0
Motorcycle	5.1	41.2	58.8	0.0
School Bus	0.1	0.0	0.0	100.0
Motor Home	1.3	0.0	92.3	7.7

Travel Conditions

	Residential			Commercial		
	Home-Work	Home-Shop	Home-Other	Commute	Non-Work	Customer
Urban Trip Length (miles)	11.8	8.3	7.1	11.8	4.4	4.4

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Travel Conditions

	Residential			Commercial		
	Home-Work	Home-Shop	Home-Other	Commute	Non-Work	Customer
Rural Trip Length (miles)	11.8	8.3	7.1	11.8	4.4	4.4
Trip speeds (mph)	30.0	30.0	30.0	30.0	30.0	30.0
% of Trips - Residential	32.9	18.0	49.1			
% of Trips - Commercial (by land use)						
University/college (4 yrs)				5.0	2.5	92.5

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Urbemis 2007 Version 9.2.4

Combined Annual Emissions Reports (Tons/Year)

File Name:

Project Name: Santa Cruz SOI Construction

Project Location: Santa Cruz County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

Summary Report:

CONSTRUCTION EMISSION ESTIMATES

	CO2
2010 TOTALS (tons/year unmitigated)	497.55

Construction Unmitigated Detail Report:

CONSTRUCTION EMISSION ESTIMATES Annual Tons Per Year, Unmitigated

	CO2

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2010	497.55
Mass Grading 01/01/2010-02/12/2010	36.47
Mass Grading Dust	0.00
Mass Grading Off Road Diesel	34.83
Mass Grading On Road Diesel	0.00
Mass Grading Worker Trips	1.64
Asphalt 02/15/2010-02/28/2010	8.10
Paving Off-Gas	0.00
Paving Off Road Diesel	6.36
Paving On Road Diesel	0.68
Paving Worker Trips	1.06
Building 03/01/2010-12/31/2010	448.79
Building Off Road Diesel	178.33
Building Vendor Trips	34.48
Building Worker Trips	235.98
Coating 12/01/2010-12/31/2010	4.19
Architectural Coating	0.00
Coating Worker Trips	4.19

Phase Assumptions

Phase: Mass Grading 1/1/2010 - 2/12/2010 - Default Fine Site Grading Description

Total Acres Disturbed: 7.3

Maximum Daily Acreage Disturbed: 1.82

Fugitive Dust Level of Detail: Default

20 lbs per acre-day

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On Road Truck Travel (VMT): 0

Off-Road Equipment:

1 Graders (174 hp) operating at a 0.61 load factor for 6 hours per day

1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 6 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day

1 Water Trucks (189 hp) operating at a 0.5 load factor for 8 hours per day

Phase: Paving 2/15/2010 - 2/28/2010 - Default Paving Description

Acres to be Paved: 1.82

Off-Road Equipment:

4 Cement and Mortar Mixers (10 hp) operating at a 0.56 load factor for 6 hours per day

1 Pavers (100 hp) operating at a 0.62 load factor for 7 hours per day

1 Paving Equipment (104 hp) operating at a 0.53 load factor for 8 hours per day

1 Rollers (95 hp) operating at a 0.56 load factor for 7 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day

Phase: Building Construction 3/1/2010 - 12/31/2010 - Default Building Construction Description

Off-Road Equipment:

1 Cranes (399 hp) operating at a 0.43 load factor for 6 hours per day

2 Forklifts (145 hp) operating at a 0.3 load factor for 6 hours per day

1 Generator Sets (49 hp) operating at a 0.74 load factor for 8 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 8 hours per day

3 Welders (45 hp) operating at a 0.45 load factor for 8 hours per day

Phase: Architectural Coating 12/1/2010 - 12/31/2010 - Default Architectural Coating Description

Rule: Residential Interior Coatings begins 1/1/2005 ends 12/31/2040 specifies a VOC of 100

Rule: Residential Exterior Coatings begins 1/1/2005 ends 12/31/2040 specifies a VOC of 250

Rule: Nonresidential Interior Coatings begins 1/1/2005 ends 12/31/2040 specifies a VOC of 250

Rule: Nonresidential Exterior Coatings begins 1/1/2005 ends 12/31/2040 specifies a VOC of 250