Carbon Footprint of Single-Family Residential New Construction

Prepared for

California Building Industry Association

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Executive Summary

In September of 2006, California Governor Arnold Schwarzenegger signed the California Global Warming Solutions Act (AB 32) into law which sets California Greenhouse Gas (GHG) emission standards for the next 50 years. The California Air Resources Board (CARB) is required to develop regulations and market mechanisms that will ultimately reduce California's greenhouse gas emissions. By 2020, AB 32 requires the State's emissions of GHGs to be at the same level as they were in 1990. By 2050, AB 32 and Executive Order S-3-05 require emission levels to be reduced 80% below the levels in 1990.

These standards are for all California sectors – road transportation, residential, industrial processes, commercial, and livestock/agriculture – and each sector has a responsibility to help reduce their emissions. In order for the new residential sector to comply with AB 32, the carbon emissions of today's new homes must be compared to new homes constructed in 1990. ConSol, at the request of the California Building Industry Association (CBIA), was asked to perform this analysis.

To estimate residential new construction's emissions, ConSol collected data from a number of different sources including California Air Resources Board (CARB), California Energy Commission (CEC), Building America, California Lighting Technology Center, Environmental Protection Agency (EPA), California Climate Action Registry, and various studies. First, the average size of a 1990 and a 2006 home was established. ConSol then determined the energy use of a typical single-family home built in 1990 and in 2006 in various climate zones. In each case, ConSol calculated energy use from the following areas: water heating, space cooling and heating; appliances; lighting; and plug load. Heating and water heating were converted from kBTU to kWh to maintain consistency between units. After determining total energy usage in 1990 and 2006, conversions were used to establish GHG emission rates in metric tons per year.

According to CARB and the CEC, the top three California GHG emitters by sector are transportation, industrial and residential with 40.4%, 25.4% and 14.2% of total emissions, respectively, when electrical emissions are added to the appropriate industry sector. California's residential GHG emissions include emissions from residential consumption and emissions resulting from the electricity generated for residential use.

There are approximately 13,270,000 housing units in California. 113,000 new residential units were completed in 2007. Typically, new housing only adds about 1% to the total residential housing stock each year. The emissions from residential new construction make up 0.12% (approximately one-tenth of one percent) of annual GHG emissions for California.

Based on ConSol's findings, which were reviewed by the CEC, whole-house energy use in new homes built in 2006 decreased by 25% compared to homes built in 1990, despite the fact that the average square footage increased from 2,160 to 2,488 during that time. . This energy reduction is attributed to the stringent California energy code in conjunction with increasingly stringent national appliance standards. The per capita electricity sales of California compared to the rest of the U.S. supports this. With the advent of the California energy code in 1978, the state has

maintained a level per capita electrify use which is presently 50% less than the national per capita electricity use.

The carbon emissions from a new home built to 1990's code was 10.9 metric tons of CO_2e per house per year. The carbon emissions from a new home built to 2006's code was 8.2 metric tons of CO_2e per house per year. Thus, new residential construction under the 2005 Title 24 energy code has already exceeded the 2020 goal by 25%.

To meet the 2050 goal, options to reduce levels of GHG emissions were explored. Homes built to the New Solar Homes Partnership Tier II level (35% over 2005 Title 24) with a 2.4 kW photovoltaic system reduce the emissions from a 2005 Title 24 code compliant new home from 8.2 to 4.4 metric tons of CO_2e per year.

New residential construction accounts for only 0.12% of California's building energy usage each year. To reduce GHG emissions in the entire residential marketplace, we must also look at retrofit. The existing building sector is so large that it is critical to investigate the opportunities for it as well as new construction.

Introduction

The year 2007 saw an increased consensus, not only among the scientific community, but of the nation as a whole, concerning the role of greenhouse gasses in altering the global climate and contributing to global warming. In September 2006, California Governor Arnold Schwarzenegger signed the California Global Warming Solutions Act (AB 32) into law which sets California GHG emission standards for the next 50 years. The California Air Resources Board (CARB) is required to develop regulations and market mechanisms that will ultimately reduce California's greenhouse gas emissions.

Assembly Bill 32 and Executive Order S-3-05 Milestones

Year	Milestone
2012	GHG Rules and Market Mechanisms Take Effect
2020	State Emissions = 1990 Level
2050	State Emissions = 80% Below 1990 Level

These standards are for all California sectors[1], which means each sector – road transportation, residential, industrial processes, commercial, and livestock/agriculture - has a responsibility to help reduce their emissions.

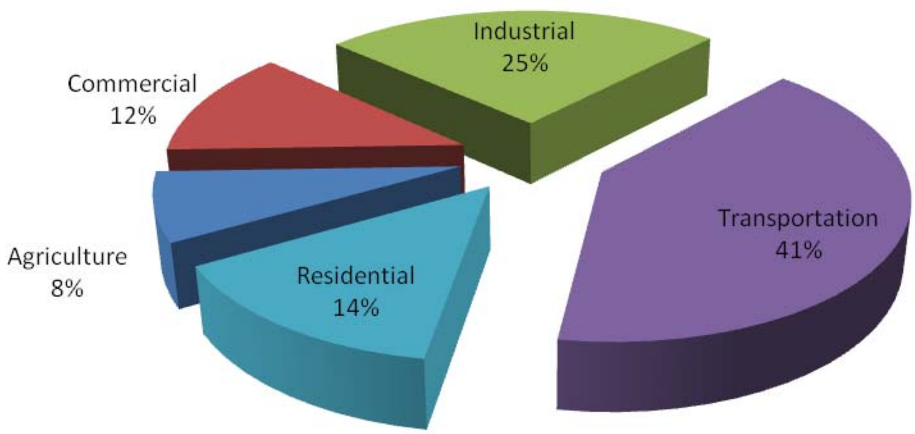

Figure 1 – 2004 California's Greenhouse Gas inventory by sector – Appendix Table 1

California's Residential GHG emissions make up 14% of the state's total emissions. This includes gas emissions from residential consumption and emissions resulting from the electricity generated for residential use.[2]

[1] Rogers, Jamesine, et al. "Staff Report – California 1990 Greenhouse Gas Emissions Level and 2020 Emissions Limit." California Air Resources Board. November 16, 2007.
[2] Electrical emissions incorporated via QFER, California Energy Commission, September 2006 http://www.energy.ca.gov/electricity/consumption_by_sector.html

CBIA asked ConSol to determine the greenhouse gas emissions from single-family residential new construction in 1990 and currently.

There are approximately 13,270,000 residential units in California. In 2007, 112,000 new residential units were constructed. Making the assumption that all residential units emit the same amount of GHG, the emissions from residential new construction make up 0.12% of annual GHG emissions for California in 2007.

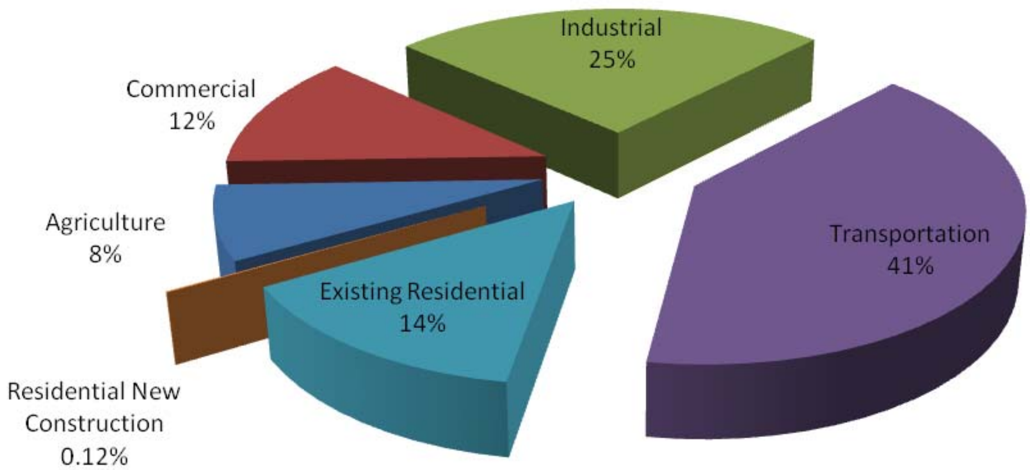

Figure 2 – Annual new single-family residential housing emissions compared to California industry – Appendix Table 2

Methodology and Impacts

To estimate residential new construction's emissions, the average size of a 1990 and a 2006 home was established. ConSol then determined the energy use of a typical single-family home built in 1990 and in 2006. In each case, ConSol calculated energy use from the following areas: water heating, space cooling and heating; appliances; lighting; and plug load. After determining total energy usage in 1990 and 2006, conversions were used to establish GHG emission rates in metric tons per year.

Once results are generated, a pathway to reduce carbon emissions and achieve AB 32 compliance can be determined for new residential construction.

House Sizes

In order to create models for a house in 1990 and in 2006, an accurate estimate of the size of a home was needed. House size was determined using 1990 through 2006 Western Region United States Census Bureau data.[3] This data historically reports single-family new construction home sizes by year and region. These sizes are not state specific; however, they are similar to average sizes seen in ConSol's compliance department over the past two decades. The average sized home was approximately 2,160 ft^2 and 2,488 ft^2 for 1990 and 2006, respectively, a 15% increase in house size. The Western Region includes California, Oregon and Washington. To determine house size in today's depressed housing market, ConSol internally surveyed over 80 master plans due for submittal in 2008. Average housing size was 2,320 ft^2. Similar to the economic slowdown of the early 1990s, average house size is beginning to decrease.

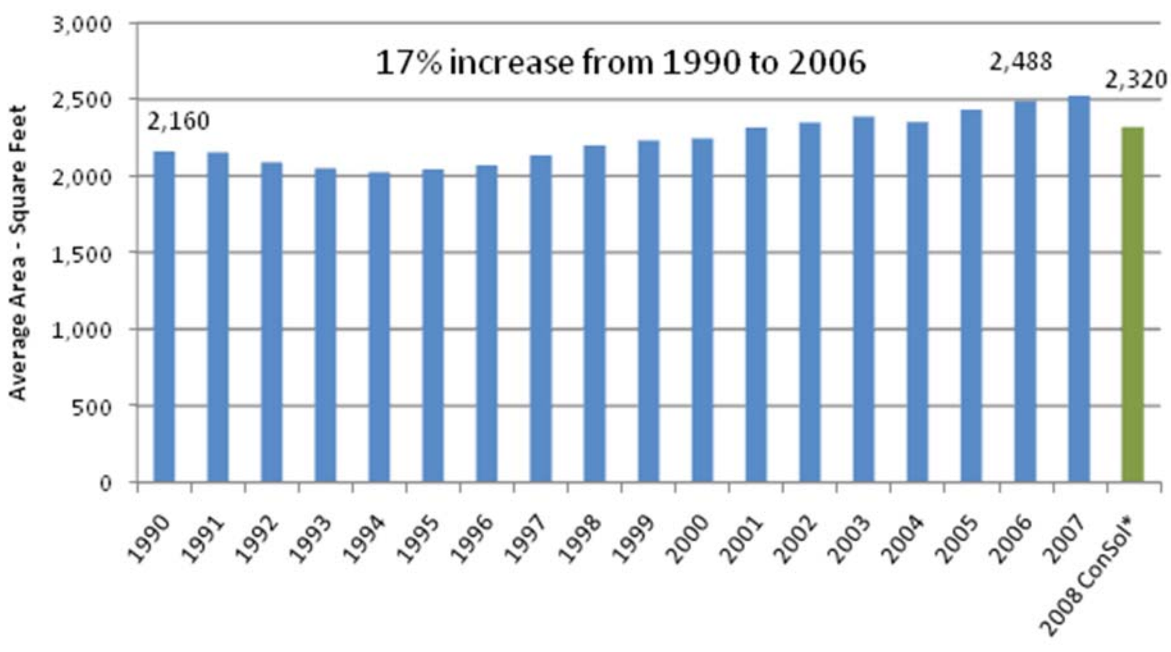

Figure 3 – Average house size in Western States between 1990 and 2006 – Appendix Table 3
2008 ConSol* shows results of internal survey

[3] U.S. Census Bureau. "New Privately Owned Housing Units Completed in the West, by Intent and Design". 7 August 2007 http://www.census.gov/const/compsweintenta.pdf

Water Heating, Space Cooling and Heating

In determining the amount of greenhouse gasses contributed by the water heater and mechanical equipment between 1990 and 2006, it was assumed that all water heaters and the heating components of the mechanical equipment were natural gas burning appliances. This was a simplification assumption due to this studies initial scope of work and the fact the vast majority of California single-family new construction water and space heaters operate on some type of combustible fuel.[4]

To calculate the envelope load, energy compliance software, Micropas version 7.3[5] certified by the California Energy Commission (CEC), was used to estimate energy use in various climate zones for each year there was a Title 24 code update.

To complete energy use and envelope load calculations, building data for each energy code cycle (1978, 1984, 1988, 1992, 1998, 2001 and 2005) was determined. The values for the water heater efficiency, mechanical equipment efficiencies, wall, roof, foundation insulation values, and window U-values and solar heat gain coefficients were taken from the 2005 Residential Compliance Manual Vintage Table.[6] The resulting data were energy budgets for space heating, space cooling and water heating in thousands of British Thermal Units (kBTU) per square foot conditioned floor space per year.

The impact of Title-24 in residential new construction on water heating, space cooling, and space heating has been significant. Since the beginning of energy codes in 1978, Title 24 energy consumption of new homes decreased 53% in 2005. Energy consumption has also decreased 30% between 1990 and the 2005 building code.

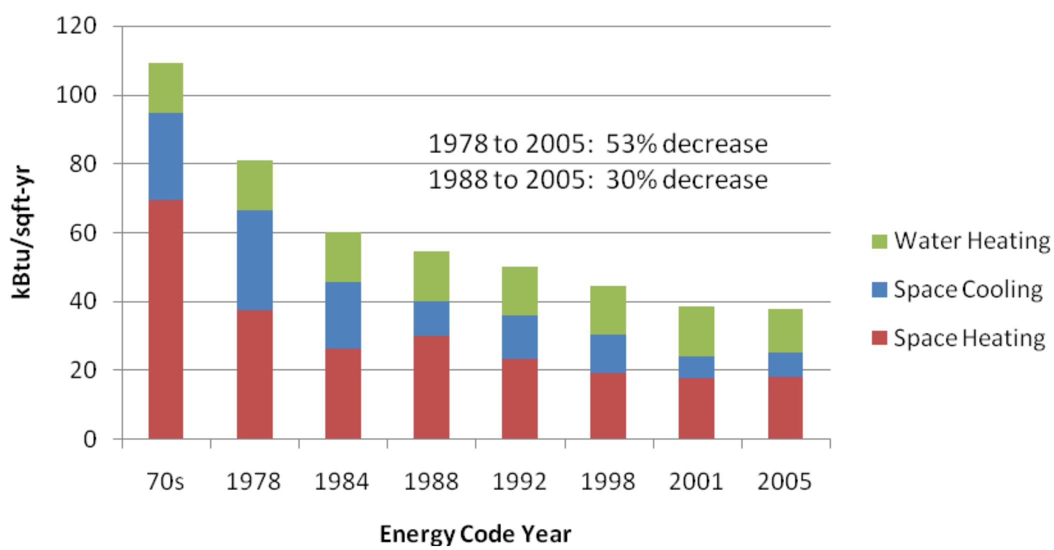

Figure 4 – Impact of Title 24 on residential water heating, space cooling, and space heating from 1970 – 2005 – Appendix Table 4

[4] California Statewide Residential Appliance Saturation Study (KEMA-XENERGY, June 2004)
[5] Enercomp, Inc. 2007. Micropas Version 7.3. Auburn, CA.
[6] http://www.energy.ca.gov/title24/2005standards/residential_manual.html

Appliances

Typical appliances were determined by the 2006 Building America's Benchmark Definition[7,8]. The Building America Benchmark is the U.S. Department of Energy's best predictor of energy use in residential buildings. The following appliances were included: refrigerator, clothes washer, electric clothes dryer, dishwasher, cook top, oven and a microwave. All appliances were assumed to be electric. This assumption was made for simplification purposes and is supported by statistics taken from the Department of Energy's Energy Information Administration.[9]

The energy used from appliances in 1990 was determined through data based on the Energy Data Sourcebook for the U.S. Residential Sector,[10] a study done by the Lawrence Berkeley National Laboratory to support residential forecasting models. The study features statistical data gathered throughout the 1990s. The Energy Data Sourcebook established the 1990 base case and the data used were reported as unit energy consumption (UEC). Energy used from appliances in 2006 was based upon the Building America's Benchmark Annual Appliance and Equipment Load[11] formulas.

The U.S. Census data shows that 2006 average home sizes to be approximately 2,488 ft^2, which would typically be configured with four bedrooms. Therefore, in our formulas, the variable for the number of bedrooms (N_{br}) is four. The following equations were used:

Refrigerator	669
Clothes Washer	$52.5+17.5 \times N_{br}$
Clothes Dryer (electric)	$418+139 \times N_{br}$
Dishwasher	$103+34.3 \times N_{br}$
Cook top and oven (electric):	$302+101 \times N_{br}$
Microwave	135.1

Figure 5 - Equations used to determine electricity consumed (kWh/year)

7 2006 Building America's Benchmark Definition "The Benchmark is generally consistent with mid-1990s standard practice, as reflected in the Home Energy Rating System (HERS) Technical Guidelines (RESNET 2002), with additional definitions that allow the analyst to evaluate all residential end-uses, an extension of the traditional HERS rating approach that focuses on space conditioning and hot water. Unlike the reference homes used for HERS, Energy Star, and most energy codes, the Benchmark represents typical construction at a fixed point in time so it can be used as the basis for Building America's multi-year energy savings goals without the complication of chasing a "moving target"."

8 Hendron, Robert. "Building America Research Benchmark Definition, Updated December 15, 2006." January 2007. NREL/TP-550-40968. <http://www.eere.energy.gov/buildings/building_america/pdfs/40968.pdf>
Microwave: p. 21
All other appliances: p. 20
*Assumption: 4 bedrooms per house

9 http://www.eia.doe.gov/emeu/reps/appli/us_table.html

10 Wenzel, Tom P., Koomey, Jonathan G., Rosenquist, Gregory J., Sanchez, Marla, Hanford, James W. "Energy Data Sourcebook for the U.S. Residential Sector." September 1997. LBL-40297 http://enduse.lbl.gov/Info/LBNL-40297.pdf
Refrigerator: p. 71; Dishwasher: p. 85; Clothes washer: p. 93; Clothes dryer: p. 100; Microwave: p. 111; Electric cooktop and oven: p. 111; Miscellaneous End Use: p. 127-129

11 Building America's Benchmark Annual Appliance and Equipment Load
http://www.eere.energy.gov/buildings/building_america/

A 38% reduction in total kWh use per year was found when comparing the energy use in appliances between 1990 and the 2006. An average of 3506 kWh per year was used in 1990 house compared to 2177 kWh per year that was used in the 2006 house.

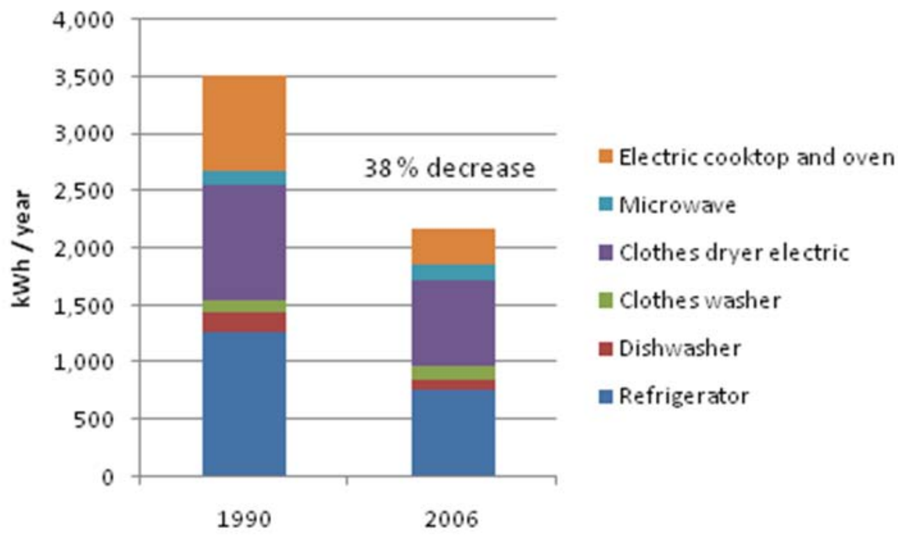

Figure 6 – Appliance energy usage comparison between 1990 and 2006 – Appendix Table 5

Lighting

The layout of homes in the size range of 2,160 ft^2 and 2,488 ft^2 would typically include four bedrooms and two and a half baths with a standard living room, dining room, kitchen, laundry, and hallways. Using this configuration, numbers and types of bulbs were assigned to each area as suggested by the California Lighting and Technology Center (CLTC) Design Guide.[12] Five additional plug-in lamps and five exterior lights were also assumed.

For the 1990 model, all lights were designated as either 60 Watt or 75 Watt incandescent bulbs with the exception of the kitchen where 23 Watt fluorescent bulbs were assumed. The number of bulbs in each room was multiplied by the respective bulb wattage to obtain total wattage output. To calculate the energy usage of the lights per day, the wattage was multiplied by the number of hours each bulb was being used. When considering the hours of operation, it was assumed that the usage habits of Californians has not changed dramatically between 1990 and 2006. The hours of operation for a prototypical home was used from the lighting section of the Building America Benchmark.[13] When the energy usage per day was calculated, it was then converted into kWh/year.

[12] California Lighting Technology Center (CLTC). "Residential Lighting Design Guide: Best practices and lighting designs to help builders comply with California's 2005 Title 24 energy code" (01 August 2005). 10 August 2007 http://cltc.ucdavis.edu/images/news/Title24/lighting-design-guide-version-2.pdf

[13] Building America Benchmark Light Methods http://www.eere.energy.gov/buildings/building_america/

The Building America Benchmark Lighting Method was used to calculate lighting impact in 2006. The following calculations were used to determine the energy usage from lighting per year:

1	Interior Hard Lighting	L1 = 0.8 x (FFA x 0.8+455) kWh/yr
2	Garage Lighting	L2 = 100 kWh/yr
3	Exterior Lighting	L3 = 250 kWh/yr
4	Prototype Hard-wired Lighting	L1, 2 or 3 x (1.12*F1+0.279*FF)

FFA = Finished Floor Area

F1 = fraction of hard-wired lamps in the prototype that are incandescent

FF = fraction of hard-wired lamps in the prototype that are fluorescent

Figure 7 - 2006 Lighting Calculations

The fractions of incandescent and fluorescent hard-wired lamps for 1990 were used from the Energy Data Sourcebook for the U.S. Residential Sector[14], which assumed 88% incandescent lamps and 12% fluorescent lamps were used. In the 2006 model, since most hardwired incandescent lamps under 2005 Title 24 are required to be controlled by occupancy or motion sensors, and therefore consuming power similarly to a fluorescent equivalent, the percentage of fluorescent lamps were estimated at 100%. When calculating the total usage per year, Equation 4 is multiplied by Equations 1, 2 and 3. The sum of these three equations is total annual energy usage. To remain consistent, the same amounts of incandescent plug-in lamps were added to these models as it was done to the prior models. Plug load lighting estimates are for non-hardwired lighting; lamps, torchieres, etc. This plug load is separate from the miscellaneous plug load estimated in the next section. Each model was assumed to have the equivalent of five 60 watt incandescent bulbs.

The 2005 Title-24 Standards significantly increased efficiency in residential lighting by requiring most hard-wired lighting to be occupancy controlled. The increased saturation of fluorescent lights and occupancy sensors in newer homes helped decrease the total lighting energy usage by 62%.

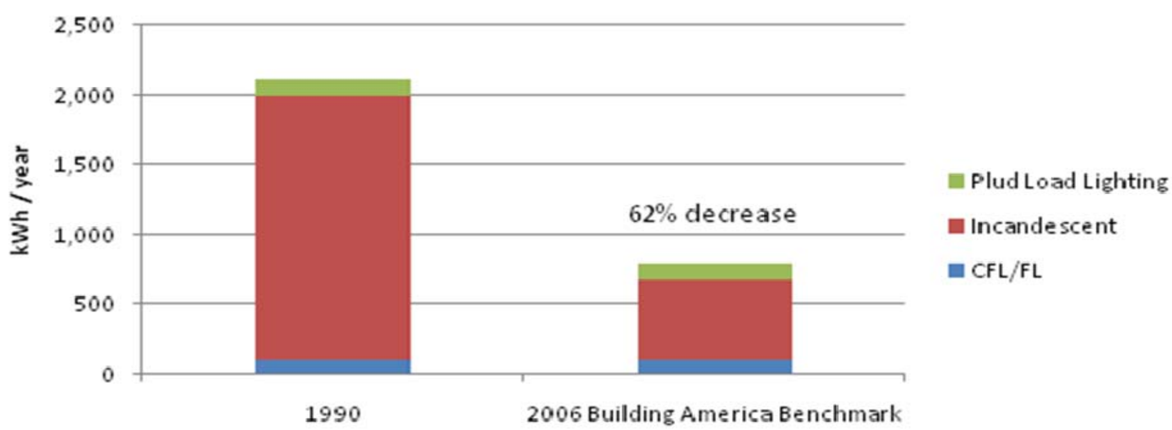

Figure 8 – Lighting load comparison between 1990 and 2006 models – Appendix Table 6

[14] Energy Data Sourcebook for the U.S. Residential Sector (Tom P. Wenzel, September 1997)

Plug Load

Initially, plug load for our 1990 and 2006 models were created via the plug load factor given by the 2006 Building America Benchmark.[15] This factor was solely driven by square footage of the home. After several conversations with the California Energy Commission, these plug loads were modified via data from the 2004 Residential Appliance Saturation Study[16] (RASS) and 1997 Energy Data Sourcebook for the U.S. Residential Sector.[17] The final equations used were:

> **1990**: 12.61 kBtu per conditioned square foot per year
> **2006**: 9.191 kBtu per conditioned square foot per year

In addition to larger homes, increased use of personal computers, multiple television sets, and a variety of other electronics have become commonplace since 1990; plug loads were estimated to increase 294 kWh per year/house from 1990 to 2006.

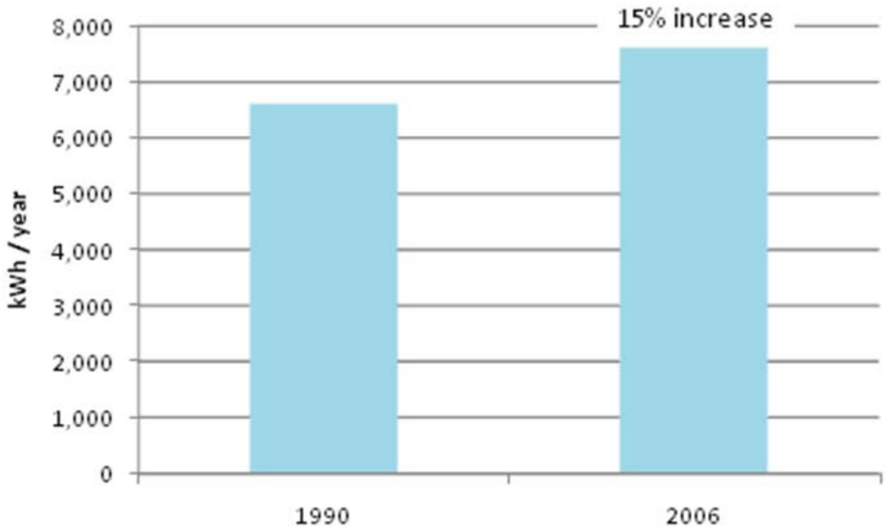

Figure 9 – Plug load - not including plug lighting – comparison between 1990 and 2006 models – Appendix Table 7

[15] Building America Benchmark Plug Load Methods
http://www.eere.energy.gov/buildings/building_america/
[16] California Statewide Residential Appliance Saturation Study (KEMA-XENERGY, June 2004)
[17] Energy Data Sourcebook for the U.S. Residential Sector[17] (Tom P. Wenzel, September 1997)

Whole House Comparison

Total whole house energy use in homes including heating, cooling, water heating, appliances, lighting, and plug load has decreased 25% since 1990.

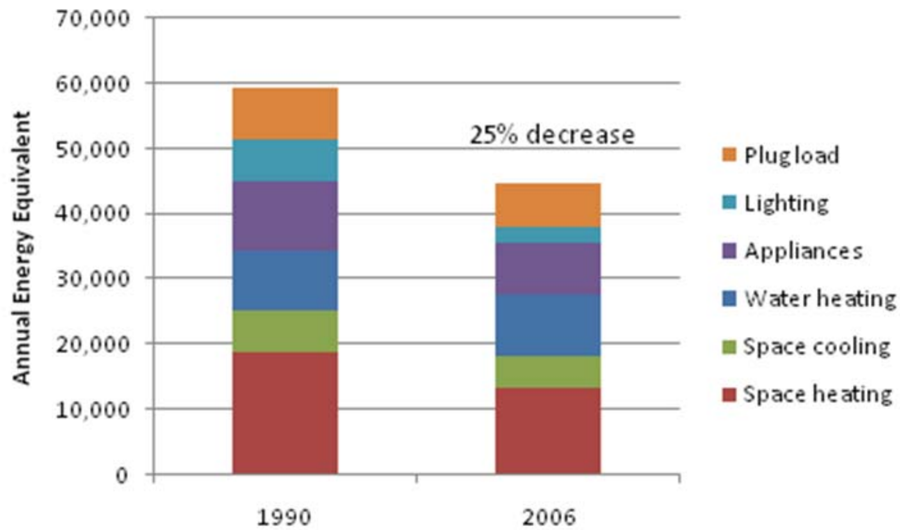

Figure 10 – Whole house energy use comparison between 1990 and 2006 models – Appendix Table 8

The per capita electricity sales of California compared to the rest of the U.S. supports the effects of Title 24. With the advent of the California energy code in 1978, the state has maintained a level per capita electricity use while the nation's use increased nearly 50% by 2004.[18]

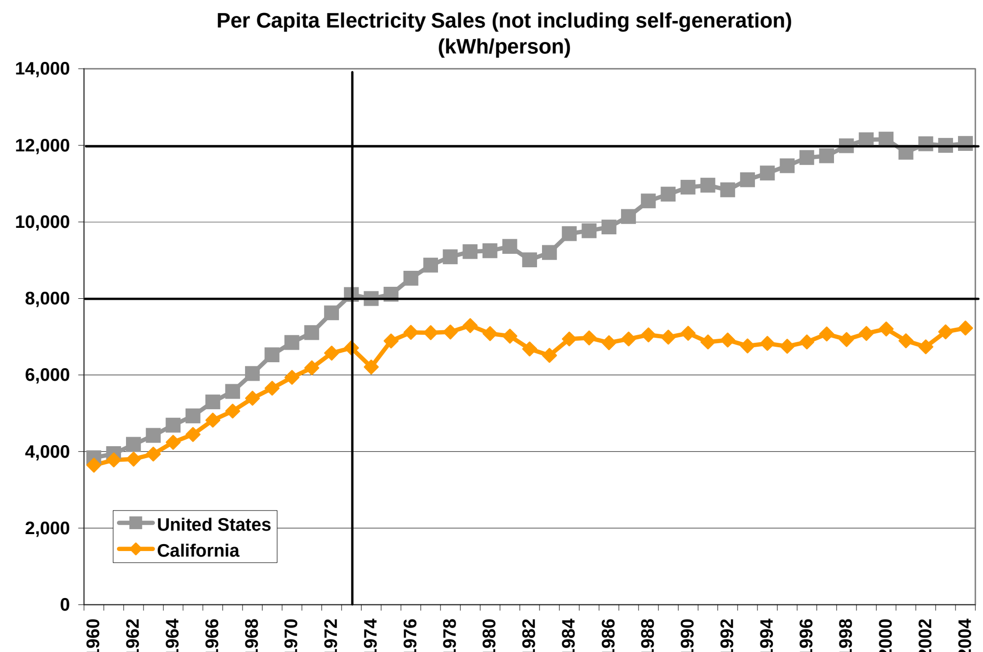

Figure 11 – California versus U.S. average; electricity per capita

[18] Figure taken from Martha Krebs' Clean Air and Climate Change presentation at the first annual Westcarb Conference, November, 2007, http://www.energy.ca.gov/2007publications/CEC-999-2007-038/CEC-999-2007-038.PDF

Energy Conversion to Carbon Emissions

After determining total energy usage in both 1990 and 2006 models, the next step was to determine the amount of greenhouse emissions. The energy modeling software uses thousands of BTUs (kBTU) as the unit of energy savings. kBTUs are then converted to kilowatt hours (kWh) for electricity and Therms for gas. The energy amounts are in California Energy Commission "source" energy, which includes not only the energy used at the site, but all losses encountered delivering the energy to the site, including power generation, transmission, and distribution losses. This is opposed to site energy (e.g., kWh) which is simply the energy consumed by the building itself. The CEC recommended conversion from source to site electric energy is one third.

Using the EPA's Emissions & Generation Resource Integrated Database (eGRID) calculator,[19] kWh savings were converted to Western Region power source specific greenhouse emissions. eGRID represents a comprehensive inventory of environmental attributes of electric power systems. As the EPA's source of air emissions data for the electric power sector, eGRID is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. eGRID contains air emissions data for nitrogen oxides, sulfur dioxide, carbon dioxide, and mercury. Therm savings were calculated via conversion values given by the California Climate Action Registry.[20]

Whole House Carbon Footprint

After determining annual energy use between the 1990 and 2006 housing models, conversions were used to establish GHG emission rates in metric tons per year. Despite data showing that the square footages of homes have increased since 1990, the carbon footprint of homes has decreased 25%, from 10.9 metric tons in 1990 to 8.2 metric tons in 2006. Of the items researched, water heating and plug load energy use increased, which is attributed to increased house size and greater use of electronic devices. Although the water heating energy factor was 0.52 in the 1988 standards and improved to 0.57 in 2006, the increase in house size and the associated increased occupancy were the primary drivers for the increase in water heating energy use.

[19] EPA's Emissions & Generation Resource Integrated Database (eGRID) calculator http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

[20] California Climate Action Registry (CCAR). "California Climate Action Registry General Reporting Protocol: Reporting Entity-Wide Greenhouse Gas Emissions" (March 2007)

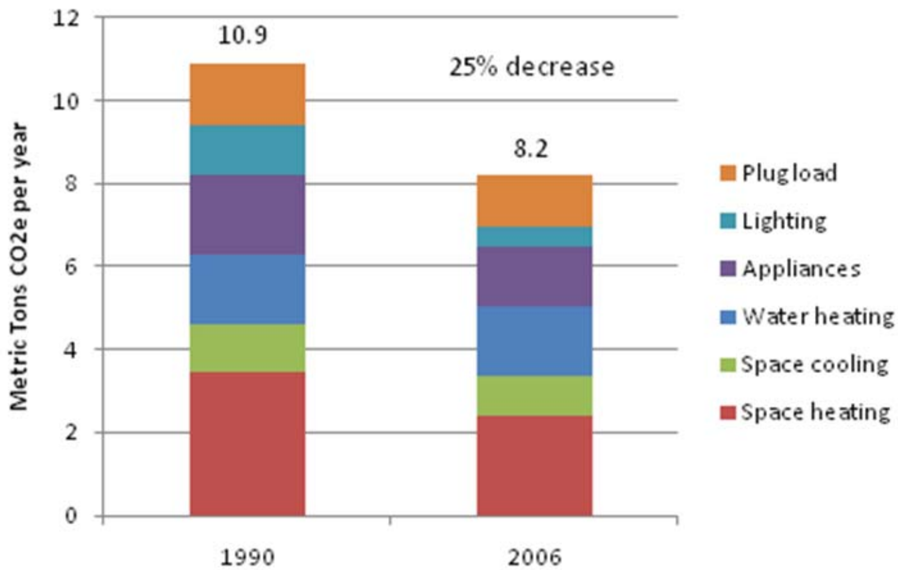

Figure 12 – Annual house carbon footprint comparison for 1990 an 2006 – Appendix Table 9

Pathway to Increased GHG Reduction

The impact of California's Building Energy Efficiency Standards (Title-24) in residential new construction on water heating, space cooling, and space heating has been remarkable: since the beginning of California energy codes in 1978, envelope energy consumption of new homes has decreased 53%. (Envelope energy consumption is the energy a home uses for space heating, space cooling and water heating.) Since the 1990 AB 32 benchmark, envelope energy has decreased 30%. A 19% reduction in annual energy use by appliances was determined by comparing the energy use in appliances between 1990 and the 2006. The increased saturation of fluorescent lights and occupancy sensors in newer homes has decreased the total energy usage for lighting by 62%. Because of the increased use of personal computers, multiple televisions, and a variety of other electronics that have become commonplace since 1990, a 15% increase in plug loads occurred from 1990 to 2006.

The energy code becomes more stringent with each revision. Incentives, such as federal tax credits and energy efficient rebates, have encouraged builders to build homes with a less and less need for energy consumption. However, with proper incentives residential houses can still be built to further reduce GHG emissions. Installing higher performance energy features will decrease energy use. Adding solar electric panels will lower net energy use even further. Adding new types of incentives such as a state tax credit in addition to federal tax credits and utility incentives will increase cost coverage and drive voluntary efforts to build homes that emit less carbon. These efforts will help lead to the eventual goal to building carbon neutral homes across the state.

Having evaluated the greenhouse emissions in houses built in 1990 and 2006, the next question is where to go from here. While ConSol data shows that houses built in 2006 are already compliant with AB 32's criteria for a house to be at 1990 carbon emissions by 2020, there is still room for a house to decrease its carbon footprint to the 2050 goal. Increasing building features will lower the need for energy use in a house. Photovoltaic (PV) cells can be installed to convert solar energy into electricity a house can use. Tankless water heaters are more efficient than standard water heaters. Higher efficiency air handlers and furnaces will also lower energy use.

Several building programs dramatically increase energy efficient building features, thus decreasing the amount of energy used in a home. An example is the New Solar Homes Partnership's (NSHP) Tier[21] programs. Both Tiers of the NSHP programs require energy features to be at least 15% (Tier II requires 35%) above the 2005 Title 24 code, install Energy Star® appliances, and encourage solar electric panels to be installed in homes. Building to the program qualifies home builders to receive utility incentives up to $2,000 per house to help offset the additional costs. Efforts to enact a state tax credit program, extend federal tax credit deadlines, and increase utility incentives will help ease cost burdens and encourage home builders to build houses that use less energy while increasing market appeal.

[21] http://www.gosolarcalifornia.ca.gov/nshp/

Adding Solar Electricity

Total energy used in a home built to the efficiency requirements of the NSHP Tier II guidelines – 35% over code with a 40% reduction in cooling - drops 19% compared to a home built under current Title 24. It would cost approximately $3,800 to get to this level with the advanced building features required in Tier II.

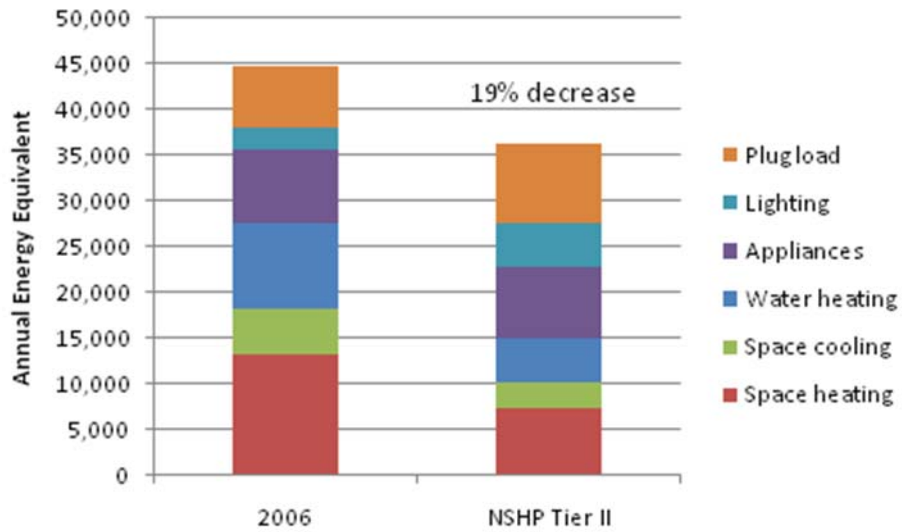

Figure 13 – Total energy use in a home built under current Title 24 code and one under NSHP Tier II guidelines (which is 35% above 2005 Title 24) - Appendix Table 10

From 1990 to 2006, the carbon footprint of new homes has decreased by 25%, but if residential homes were to be constructed following the energy efficiency requirements of the NSHP's Tier II, the carbon footprint would be decreased by an additional 17% compared to 2006's reduction from 1990. And if a Tier II home were to add photovoltaic (PV) cells, a 59% carbon footprint reduction would be realized compared to a home built in 1990.

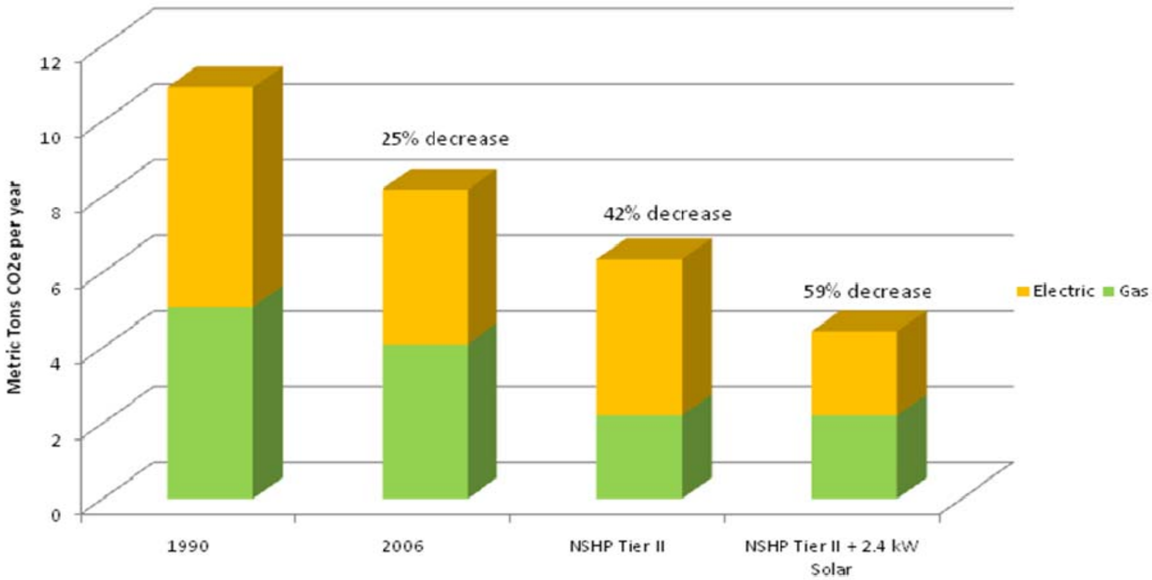

Figure 12 – Carbon footprint of homes built to different energy standards – Appendix Table 11

Homes built to the New Solar Homes Partnership Tier II level (35% over 2005 Title 24) with a 2.4 kW photovoltaic system will reduce the emissions from a 2005 Title 24 code compliant new home from 8.2 to 4.4 metric tons of CO_2e per year at an incremental cost of approximately $25,000 per home.

There are 13,270,000 housing units in California. Approximately 112,000 new residential units were completed in 2007. Typically, new housing makes up only 1% of the total residential housing pool. The emissions from residential new construction make up 0.12% of annual GHG emissions for California. With more than two thirds California's residential buildings built before the California energy code first began in 1978, there are significant opportunities to improve the energy efficiency and reduce greenhouse gases from the existing housing market.

Appendix

Table 1 – CARB 2004 greenhouse gas inventory by industries; electricity emissions

Industry	Industrial Processes	Residential	Commercial	Livestock/ Agriculture	Road Transportati on
Amount of Carbon (MMTCO_2e)	118.7	66.3	57.4	36.5	189.4

Table 2 – New residential housing compared to the industry

Industry	Industrial Processes	New Housing	Residential	Commercial	Livestock/ Agriculture	Road Transportation
Amount of Carbon (MMTCO_2e)	118.7	0.57	65.7	57.4	36.5	189.4

Table 3 – House size in California

	U.S. Census (sq ft)
1990	2,160
1991	2,155
1992	2,090
1993	2,050
1994	2,025
1995	2,045
1996	2,070
1997	2,135
1998	2,200
1999	2,234
2000	2,244
2001	2,317
2002	2,350
2003	2,387
2004	2,352
2005	2,434
2006	2,488
2007	2,523

Table 4 – Impact of Title 24 on water heating, space cooling, and space heating. Average home in Climate Zone 12 by code year.

	70s	1978	1984	1988	1992	1998	2001	2005
Space Heating (kBtu/sf-yr)	69.41	37.52	26.22	30.01	23.39	19.22	17.76	18.23
Space Cooling (kBtu/sf-yr)	25.5	29.1	19.52	10.13	12.51	11.1	6.55	6.95
Water Heating (kBtu/sf-yr)	14.42	14.42	14.42	14.42	14.42	14.42	14.42	12.83

Table 5 – Appliance comparison

Appliance	1990 (kWh/yr)	2006 Building America Benchmark (kWh/yr)
Refrigerator	1,270	669
Dishwasher	179	240
Clothes Washer	103	123
Clothes Dryer (electric)	1,000	974
Microwave	132	135
Electric Cooktop and Oven	822	706

Table 6 – Lighting load comparison

	1990 (kWh/yr)	2006 Building America Benchmark (kWh/yr)
Plug Load	120.5	120.5
Incandescent	1,893	575.3
CFL/FL	100.7	100.7

Table 7 – Plug load comparison (excluding plug lighting)

Year	1990	2006
Energy used (kWh/yr)	1,939	2,233

Table 8 – Whole house energy use comparison in energy equivalents (kWh/year)

	1990	2006
Space Heating	18,997	13,292
Space Cooling	6,412	5,067
Water Heating	9,128	9,355
Appliances	10,518	7,884
Lighting	6,345	2,389
Misc. Plug Load	7,983	6,699

Table 9 – Whole house carbon footprint comparison (metric tons CO_2e/year)

	1990	2006
Space Heating	3.44	2.40
Space Cooling	1.19	0.94
Water Heating	1.65	1.69
Appliances	1.95	1.46
Lighting	01.18	0.44
Misc. Plug Load	1.48	1.24

Table 10 – Whole house energy use comparison (kWh/year)

	2006	NSHP Tier II
Space heating	13,293	7,399
Space cooling	5,068	2,773
Water heating	9,355	4,796
Appliances	7,884	7,830
Lighting	2,389	4,845
Plug load	6,700	8,670

Table 11 – Carbon footprint (metric tons CO_2e/year) of homes built with different standards

	1990	2006	NSHP Tier II	NSHP Tier II + 2.4 kW solar
Electric	5.81	4.09	4.14	2.23
Gas	5.09	4.10	2.21	2.21