FINAL REPORT

Measuring the Climate Impact of Residential Buildings: GreenPoint Rated Climate Calculator Version 2

Principal Investigator: Daniel M. Kammen *†

Prepared by:

Christopher M. Jones *†
Wes Sullens‡
Amy Dryden^
Joe Kantenbacher†

September 2012

Prepared for the California Air Resources Board and the California Environmental Protection Agency under contract #09-344 to the University of California, Berkeley

† Renewable and Appropriate Energy Laboratory, University of California, Berkeley
‡ Alameda County Waste Management Authority DBA StopWaste.Org, Alameda County, California
^ Build It Green, Oakland, California
* Corresponding authors: Jones (cmjones@berkeley.edu, 510-643-5048); Kammen (kammen@berkeley.edu, 510-642-1139)

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Acknowledgements

The authors and the California Air Resources Board would like to thank the many stakeholders who provided their time and expertise to review this document.

The Report was submitted in fulfillment of ARB contract number 09-344, Measuring the Climate Impact of Residential Buildings: GreenPoint Rated Climate Calculator Version 2, by researchers at the University of California Berkeley and StopWaste.Org, in partnership with Build It Green. The work was completed as of September, 2012.

List of Reviewers & Attendees of Stakeholder Groups

Energy Sector Stakeholders	*Meeting Date April 26, 2011*
	California Energy Commission
	California Energy Commission
	California Energy Commission
	California Energy Commission
	KEMA Services, Inc.
	Sacramento Municipal Utility District
	Gilleran Energy Management
	Gabel Associates
	Doug Beaman Associates
	Affiliated International Management, LLC
	Zone 7 Water Agency
	Bay-Friendly Coalition
	Practica Consulting
	Koeller & Company/California Urban Water Conservation Council
	California Public Utilities Commission
	GEI Consultants, Inc.
	CalRecycle
	Oregon Department of Environmental Quality
	ICLEI-Local Governments for Sustainability
	The Catholic University of America
	StopWaste.Org
	California Air Resources Board
	Lawrence Berkeley National Laboratory
	California Energy Commission
	Practica Consulting
	Oregon Department of Environmental Quality
	ICLEI-Local Governments for Sustainability
	Koeller & Company/California Urban Water Conservation Council
	KEMA Services, Inc.

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Abstract

This study seeks to update and expand the quantification of greenhouse gas emissions and other co-benefits associated with building green homes in California. The research herein aligns with the GreenPoint Rated Climate Calculator that is administered by Build It Green, a California non-profit organization. Version 1 of the Climate Calculator, first created in 2009, is the most comprehensive single-building quantification tool for green homes in the country. The Climate Calculator relies on independently verified green building standards set forth in GreenPoint Rated, which exceed minimum code provisions for California.

The goals of this research were to review and update Version 1 of the Climate Calculator based on new research; to test and compare results from Version 1 and Version 2 of the Calculator on actual homes; to expand the quantification metrics beyond the original scope where feasible; and provide a free online version of the Climate Calculator to the public. As a result of this work, Version 2 of the Climate Calculator now includes several important peer-reviewed strategies that more accurately measure the benefits of building and renovating green homes. A public version of the Calculator that is informed by this research is forthcoming.

1. Executive Summary

Background
California's Global Warming Solutions Act (AB 32) requires statewide reduction in greenhouse gas emissions to 1990 levels by 2020. The AB 32 Climate Change Scoping Plan adopted green building as a strategy to reduce GHG emissions, but states that further research is needed to quantify GHG reductions. The results of this study are expected to quantify GHG emission reductions of a green home compared to a conventional home regardless of occupant behavior. This information will be useful in quantifying GHG emission reductions to meet the 2020 climate goals of AB 32 and longer-term 2050 climate goals.

The residential sector accounts for 14% of California's greenhouse gas emissions as measured by the California Greenhouse Gas Emission Inventory (CARB, 2011). Green building labeling programs are currently being used by home builders and building owners to reduce energy consumption, increase the value of properties and to reduce the impacts of buildings on environmental quality. Decisions made during the design, construction and deconstruction of homes play an important role in how homes are operated by occupants and the associated greenhouse gas emissions, water consumption and other environmental impacts of homes throughout their lifetime. The GreenPoint Rated Climate Calculator is the first tool to quantify the total avoided greenhouse gas emissions from building green homes, regardless of the ownership or occupancy. It accomplishes this by basing calculations on the assets of homes (e.g., bedrooms, number of appliances, fixtures, etc), rather than occupant behavior. The measures included in the Climate Calculator are drawn from the GreenPoint Rated Program, which is administered by Build It Green and is the residential green building standard that is most commonly adopted by local governments in California.

Methods
This study updates and expands the quantification of greenhouse gas emissions and other co-benefits associated with building green homes in California. The first version of the GreenPoint Rated Climate Calculator (GPR Calculator) quantified the impacts of a core set of residential green building practices related to heating, cooling, water heating, lighting, major appliances, waste generation, indoor and outdoor water consumption, and on-site power generation for new and existing homes. The current project improves this tool by 1) aligning the calculation methodologies with the California Energy Commission's (CEC) Home Energy Rating System for existing homes (HERS Whole House Ratings), 2) improving quantification methodologies in the existing tool, and 3) expanding the functionality of the calculator to include measures that were excluded during the first phase of GPR Calculator development, including time dependent emissions (estimated on an hourly basis, similar to "time-dependent valuation"), energy and non-energy benefits of water efficiency improvements, and embodied energy in construction materials. The calculator has been further improved through feedback from GreenPoint Rated program partners, validation of the existing methodologies via field testing on previously completed GreenPoint Rated projects, and input from a panel of expert stakeholders.

The research was conducted in six phases, covering a single topic in each phase: 1) alignment with HERS Whole House Ratings, 2) energy, 3) water, 4) materials, 5) field testing, and 6) stakeholder feedback. The research consisted of two primary tasks. The first task was to review the existing measures in the tool and validate that the calculations are based on the most updated sources and methods. Second, the research team identified a number of suggested improvements to existing measures, including updated sources and calculation methods, which are outlined in this report.

Results

The research uncovered a number of results that will help improve calculation of building measures to improve the GPR Climate Calculator, as well as other similar tools and research efforts. Some of the most interesting and relevant results are a new methodology for calculating emissions from electricity consumed at different hours of the year, a more accurate estimate of number of building occupants that affects water results in this tool, a new method for embedded energy and greenhouse gas emissions from water consumed in 10 different hydrological regions in the state, a new way to quantify construction waste recycling using ARB emissions factors, and inclusion of embodied emissions in home construction. In some cases the estimated baseline emissions, and therefore, possible emission reduction opportunities, dramatically increase under Version 2 (e.g., inclusion of embodied emissions from building materials), and in other cases, emissions and associated reduction potential dramatically decrease (e.g., embodied emissions of water in Southern California). Taken together, these improvements extend research methods for quantifying green home construction and send policy signals to building developers and planners that emphasizes lower-carbon building methods.

Conclusion

The study provides a number of improvements to how GHG emissions are calculated in the GreenPoint Rated Climate Calculator and improves upon existing methods to measure the climate impacts of residential buildings. This research is expected to impact the way emissions are quantified for green buildings in California and beyond. For example, the main software used for energy compliance in California (EnergyPro) now incorporates an option to use the time-dependent emissions methodology derived in this project. Further, the methodology for construction and demolition waste emissions estimates that were developed in this research are now part of the Action Planning module in the California SEEC (Statewide Energy Efficiency Collaborative) online Climate and Energy Management Suite, developed by ICLEI-U.S. The new ten-region embedded energy in water model may also have broad applicability outside of GreenPoint Rated.

The current project was limited in scope to providing a basic "tune up" and developing some additional methodologies to improve the GreenPoint Rated Climate Calculator. Further research using more comprehensive methods, such as survey data and econometrics, would be needed to more accurately evaluate the greenhouse gas and overall environmental performance of buildings based on their assets (e.g., number of rooms, vintage). Significant coordination and research is also urgently needed to align existing methods in codes, tools, programs and policies with each other and, importantly, with GHG reduction targets for state. The stakeholder engagement process and research methods used in this study may serve to further this coordination.

2. Introduction

California's Global Warming Solutions Act (AB 32) requires statewide reduction in greenhouse gas emissions to 1990 levels by 2020. The residential sector accounts for 14% of California's greenhouse gas emissions according to the California Greenhouse Gas Emission Inventory (ARB, 2011). California's strict building codes, Title 24, have been highly effective at reducing residential energy use; however, much of the future savings can be expected to be offset by population growth (Budhraja, et al., 2003) and continued reliance on relatively old housing stock, 70% of which was built before 1983 (Consol, 2008).

Green labeling programs such as LEED, Energy Star and the GreenPoint Rated system encourage building developers and home owners to design buildings that exceed Title 24 building codes, providing additional energy savings benefits to consumers, and increasing the value of homes, while providing important greenhouse gas reductions and air quality improvements. The GreenPoint Rated labeling program is unique in that it provides a quantitative score based on the expected environmental performance of buildings throughout their life cycle. In addition, the GreenPoint Rated system incorporates a third party verified emissions and resource benefits calculator, called the GPR Climate Calculator, into the rating system. The Climate Calculator is an output from the GreenPoint Rated verification process and is used to calculate a score based on the building's impact compared to a standard, conventional building. The GreenPoint Rated Climate Calculator includes quantification of heating, cooling, water heating, lighting, major appliances, waste generation, indoor and outdoor water consumption, and on-site power generation for new and existing homes. GPR is available for single-family and multi-family homes, as well as for new construction and existing buildings.

A number of other home energy calculators are also available, including the Home Energy Scoring Tool, Recurve, RESNet, Green Compass, TREAT, EPA Portfolio Manager and the Whole-House Energy Rating System (HERS). Of these tools, the most relevant to GPR are the Home Energy Scoring Tool and HERS Whole-House Home Energy Ratings.

The Home Energy Scoring Tool is a home asset calculator, designed to calculate the annual energy consumption of a home in the contiguous United States. The calculator requires data about the home's envelope (air tightness, roof and wall characteristics, window area, etc.), assets (heating and cooling system, water heater), and "demographic characteristics" (age, number of bedrooms, conditioned floor area). These inputs are used to calculate the annual energy consumed by the home's assets. A Home Energy Score is a number from 1 (most inefficient) to 10 (most efficient), which is based on the home's calculated energy consumption and its location in one of over 200 climate zones. As an example, a calculated energy consumption of 290 Mbtus/yr would earn a home in New York a score of 5, but a home in Kentucky a score of 3.

The Home Energy Rating System (HERS) as defined by the California Energy Commission is a California-specific calculator. In August 2009, the California Energy

Commission approved regulations for the adoption of Whole-House Home Energy Ratings of existing homes under the Home Energy Rating System (HERS). Unlike its predecessor, the latest version of HERS (often termed as HERS II) includes energy efficiency ratings for new and existing homes and evaluation of cost-effectiveness of home improvements for heating, cooling, water heating, lighting, appliances, and onsite power generation. The HERS Whole-House Ratings methodology also estimates greenhouse gas (GHG) emissions, but is limited to measures that relate directly to operational energy consumption. The HERS Index is a number ranging from 0 to 250+. The Index value is calculated by taking the ratio of the calculated annual energy consumption, subtracting any energy produced by on-site PV, and dividing the difference by the calculated annual energy consumption of a reference house. The reference house is 2,500 ft2 for houses 2,500 ft2 or larger, and the same size as the rated home for smaller than 2,500 ft2. The reference house is built to the design specification described in the 2008 Residential Alternative Calculation Manual (ACM) Approval Method (CEC, 2008 (2)).

GreenPoint Rated is for California homes, and evaluates a house based not just on energy consumption, but on water use, resource conservation, indoor air quality, and community. Homes earn points for energy efficiency through the inclusion of certain features. For example, the insulation of hot water pipes or installation of an ENERGY STAR refrigerator will each earn the home 1 point. To be GreenPoint Rated, a home must earn a minimum of 50 points overall with a minimum performance in each of the following categories: Energy, Indoor Air Quality, Water Conservation, and Resource Conservation.

Version 1 of the GreenPoint Rated Climate Calculator, developed by a team led by Stopwaste.org, quantified the greenhouse gas benefits of building a GPR home for energy consumption, renewable energy, construction waste and recycling, vehicle miles traveled (VMT) and indoor water and outdoor water. A 2009 report by Stopwaste.org and Buid It Green describing this tool in detail is attached as Appendix E to this report. The original tool has provided greenhouse gas climate scores to thousands of GPR homes in California; however, the research report identified a number of areas that required further research.

The current research seeks to update and expand upon the methodologies developed in the first study (with the exception of evaluating VMT, which is not included in current study). Specifically, the goals of this project are to: 1) align the calculation methodologies with the California Energy Commission's (CEC) Whole House Ratings System (HERS), 2) improve quantification methodologies in the existing tool, 3) expand the functionality of the calculator to include measures that were excluded during the first phase of GPR Calculator development, including time dependent emissions, energy and non-energy benefits of water efficiency improvements, and embodied energy in construction materials, and 4) conduct field testing to identify and reduce barriers to adoption of the new methods by raters and evaluate the impact of the new calculations for sample homes.

3. Methods and Materials

The primary tasks for the contract were to 1) review and validate existing calculations in the GPR calculator, 2) improve GPR by adding new measures that were not previously included, 3) obtain feedback from experts through stakeholder engagements meetings and peer review, 4) test the updated tool with raters in the field, and 5) provide a free and publicly available version of the Calculator.

3.1. Validation and improvement of existing measures

The U.C. Berkeley research team undertook desk research to review all existing calculations in the GPR tool. The assumptions in each calculation were compared with recent research studies and approaches used in other tools. Frequently, the team found different methods in the literature and other tools for calculating energy, resource and greenhouse gas savings from particular measures; however, comparative studies of these different methods were not available. GPR seeks to employ best practices in calculation of GHG savings. The research team considered aligning with existing tools, particularly HERS -Whole House Ratings System, updating existing methods to be in line with current research findings, or developing new methods that better reflect real world operation of homes and corresponding GHG emissions. In many cases, these decisions are subjective, based on the judgment of the research team. For this reason, the project also included stakeholder engagement to review these decisions.

An attempt was also made to validate some of the assumptions and methodologies in GPR with results from real world data. The Residential Energy Consumption Survey (EIA, 2009) was used to validate home energy consumption as well as the estimate of home occupancy in GPR, which is assumed to be a function of number of bedrooms (a critical assumption for many of the water consuming fixtures calculations).

3.2. Inclusion of additional measures

The research report for Version 1 of the GPR Climate Calculator (Build it Green, 2009) identified a number of measures that the original research team was not able to include but that seemed good candidates for inclusion in future versions of the tool. In order to prioritize which of these measures would be included in Version 2, the research team applied the following criteria to each measure:

- **Expected greenhouse gas reduction benefits of the action:**
  Measures that have a high correlation to GHG reductions and for which data are already collected by Raters during the GreenPoint Rated process were prioritized. Measures with lower impacts and/or different or costlier verification procedures than are already in place in the GreenPoint Rated process were reviewed and further ranked in terms of importance. Only those with relatively low verification costs and high impact were included in the Climate Calculator.

- **Feasibility of collecting 3rd party verified data on specific buildings to calculate impacts:**
  Measures that can be verified by Raters in the field and are not too onerous or time consuming were prioritized. Direct feedback from GreenPoint Raters was used to evaluate measures according to this criterion.

- **Technical data available to quantify impacts of particular green building practices:**
  A review of literature and research reports was conducted to evaluate the feasibility of estimating GHG reductions associated with GPR measures as part of the Climate Calculator. Those measures whose data can be directly translated over to a Climate Calculator methodology were prioritized, followed by studies or referenced standards for which data could be manipulated to fit the Climate Calculator inputs. Data that are available but not in a readily usable format, were considered less desirable. Lastly, gaps in data will be listed as justification for removing certain measures from the update.

- **Likelihood of high adoption rates, considering cost-benefit analysis:**
  The cost-benefit of including particular measures in the Climate Calculator was incorporated into our ranking of quantifiable measures. If something is very costly with low GHG benefit, then other measures may take priority. An example may be blackwater treatment systems in homes, whereby water savings can be considerable but equivalent GHG reductions may be minimal. Given the high cost of such blackwater treatment systems, and the difficulty in permitting residential systems, this measure was left off of the Climate Calculator update list.

- **Cost-effectiveness of conducting the research considering other research priorities and project timeline:**
  Given the considerations above, priority was given to the largest set of measures with the highest impact that could be done within the scope of this project.

- **Applicability across all of the GreenPoint Rated rating systems: existing single family homes, new single family homes, and new multifamily homes:**
  The GPR Climate Calculator is an adjunct to the GreenPoint Rated program and checklist, and as such, shares many similarities across each of the rating systems. Version 1 of the various Climate Calculators (single family new homes, existing homes, and multifamily new homes) are consistent across approximately 75% of the measures that are quantified for a particular rating system. The applicability across multiple GreenPoint Rated rating system, especially those focusing on existing buildings, was listed as a prioritization metric.

This prioritization for inclusion of GPR methods strikes a balance between information that can be readily collected by evaluators in the field; and engineering models and empirical research that can estimate emissions during the life cycle of homes.

3.3. Stakeholder Engagement Meetings

The research team and ARB convened four stakeholder meetings with experts to review the major findings of the study. Meetings were held on Energy (Spring, 2011), Water (Summer, 2011), Materials (Fall, 2011) and Summary (Winter, 2012). Experts provided input on the key findings of each section and helped choose between competing methods. A list of experts is included in the beginning of this report.

3.4. Rater Engagement

Build It Green conducted outreach to currently active GreenPoint Raters to gather a pool of volunteers to test the tool. Seven Raters were engaged to assist in evaluating the feasibility of gathering data for the Climate Calculator based on the research completed by U.C. Berkeley and to provide feedback on the proposed data points needed from Raters. The Raters attended an orientation to receive training on how to conduct the field test. Each Rater was assigned 2 projects from a total of 14 projects in the sample. There was an assortment of new home and existing home projects as well as varying intensities of green building measures. In order to replicate the conditions in the field, the variety of projects chosen for evaluation represented homes built before and after 1980, production and custom level homes, projects that originally achieved both high and low GreenPoint Rated scores, and homes in northern and southern that characterized differences in domestic water distribution as well as high and low heating and cooling loads.

The Raters utilized projects that were already rated to compare results from Climate Calculator Version 1 to results from Climate Calculator Version 2. If there were gaps or inconsistencies in the data needed for either version of the Climate Calculator, the additional information was collected by the Rater through a site visit or review of existing documentation such as plans. The Raters used a mockup of the data collection form to collect the data necessary to complete the proposed calculations for Version 2.0 of the Climate Calculator, allowing for side-by-side comparison of the homes under the different versions of the tool.

Upon the conclusion of field testing, Build It Green hosted a round-table discussion for the Raters to provide feedback on their experience of using the new tool. The Raters also provided written comments about the barriers and usefulness of improvements to the tool. Their requests and suggestions have been incorporated into the programming and formatting of the Climate Calculator Version 2 to improve the ease of use an accuracy of data collection.

3.5. Public Version of the Tool

As part of the Version 2 update, Build It Green and StopWaste.Org developed a free and public version of the Climate Calculator tool [coming Fall 2012]. The public tool utilizes the methods and measures gathered during the research phase of this grant, though inputs and assumptions had to be simplified in order to be housed on a public platform. The full GreenPoint Rated Climate Calculator requires hundreds of individual data points that are gathered by a GreenPoint Rater who is an expert on green homes. A public tool, however, needs to be available to a wide audience in an online platform, necessitating the streamlining and simplification of inputs and assumptions. Therefore, the public tool is not a substitution for third-party verified results, which only come from projects certified to the GreenPoint Rated label. However, the public version is intended to educate the public about the benefits of green buildings and the types of measures that reduce the impact of buildings on environmental quality.

4. Results

4.1. Alignment with Title 24 (Part 6)

The GreenPoint Rated Climate Calculator is based on metrics originally included in the Build It Green rating program. A main component of the GreenPoint Rated program and the Climate Calculator is the alignment of home energy use estimates related directly to the California's Energy Efficiency Standards for Buildings, also called Title 24, Part 6, of the California Code of Regulations (Title 24). In addition to home energy usage quantification based on Title 24 energy modeling, several methodologies were developed during the first phases of the Climate Calculator for water, waste, indoor air quality, natural resource consumption and community impacts not covered in the Title 24 energy standards. The carbon footprint calculation methodologies in the GreenPoint Rated Climate Calculator were already reasonably consistent with Title 24, Part 6 energy calculation procedures; however, new calculation procedures have been adopted by the state for the new 2010 building energy efficiency codes since 2010. As such, this project modified calculations in the GreenPoint Climate Calculator to be consistent with these changes to Title 24.

4.2. Time-dependent Emissions

Version 1 of the GreenPoint Rated Climate Calculator uses annual emission factors for California utilities as reported to the California Climate Action Registry. An updated version of these emission factors is now available via the Local Government Operations Protocol Version 1.1 (ARB, 2010) as shown in Table 1 in $kgCO_2/kWh$. The calculator applies these emission factors to all electricity consumption, regardless of the time electricity is consumed, thus ignoring differences in emission rates during peak and non-peak hours of the year.

Table 1. Electric Utility CO2 Annual Emission Factors
Source: Local Government Operations Protocol (ARB, 2010)

Electric Utility Name	Emission Factor (kgCO2/kWh)	
	2006	**2007**
California grid-wide average	381	385
Austin Energy (Not CA Utility)	489	507
City of Anaheim Public Utilities	643	700
City of Palo Alto Public Utilities	18	210
Los Angeles Department of Water and Power	562	557
PacifiCorp	793	805
PG&E	207	288
Platte River Power Authority (Not CA Utility)	887	838
Riverside Public Utilities	611	601
Roseville Electric	257	360
Southern California Edison	291	286
San Diego Gas & Electric	354	366
Sacramento Municipal Utility District	252	324
Turlock Irrigation District	310	366

A unique feature of Title 24 energy efficiency and the HERS program is the Time Dependent Valuation (TDV) of energy, which applies an energy cost multiplier to each of the 8760 hours of the year, based on fuel type and California Energy Commission CEC climate zone. TDV is an estimate of the societal cost of energy, including all societal costs to produce and deliver electricity at any given hour of the year. TDV has traditionally been used to account for varying cost of electricity at different hours of the year; however, emissions from electricity generation also vary by time of year since power is purchased from generation facilities with different, and frequently higher, greenhouse gas emissions during peak hours.

The TDV method in Title 24 Part 6 was produced by consultants E3 and HMG (2006). A portion of this cost is the societal cost of greenhouse gas emissions. The E3/HMG report includes an estimate of CO_2 per kWh at each hour of the year. The estimate ranges from 0.365 to 0.819 kgCO_2/kWh, corresponding to the emissions intensity from combined-cycle natural gas (baseload) vs simple-cycle natural gas (peaker plants).

Figure 1 shows the average hourly emissions intensity in TDV for six CEC climate zones along with the (flat) annual emissions factors for the largest CA electric utilities in the year 2006. The annual utility emission factors for SCE, SMUD & PG&E are lower than all hourly TDV emissions factors, while LADWP's annual emission factor of 0.6 kg CO_2/kWh is within the range of time-dependent values.

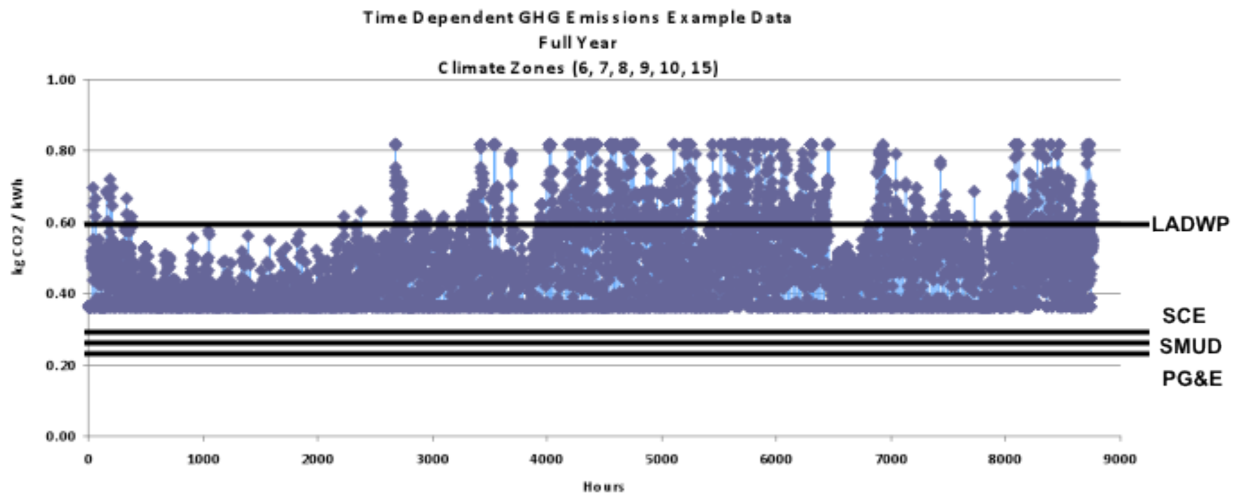

Figure 1: Time dependent CO_2 (hourly) emissions factors and average (flat) CO_2 emissions factors for 4 California electric utilities (kg CO_2 / kWh)

A variety of options were considered to create a reasonably accurate estimate of time-weighted emissions from publically available data. The methods considered were the following:

1. Annual utility emissions factor
   Annual utility emissions factors include all emissions resulting from electricity generated and purchased by a utility divided by all electricity sold by that utility to consumers. These emission factors are available for 13 utilities serving California customers in the Local Government Operations Protocol Version 1 (ARB, 2010). This is the method used in GPR Version 1, and many other tools. The method is straight-forward but does not account for emissions on an hourly basis
2. eGRID non-baseload factor (for each eGRID subregion)
   EPA recommends using their estimate of non-baseload emissions for each eGRID subregion when evaluating mitigation measures. In California, the non-baseload factor is higher than the baseload factor.
3. Annual utility emission factor x eGRID non-baseload / eGRID baseload
   This method would increase the emission factor for each utility in California to account for average marginal emissions, but would not account for emissions on an hourly basis.
4. TDV factor
   Use the hourly TDV value for CO_2/kWh in the E3/HMG report. The assumption is that all kWh reductions displace either natural gas or diesel at given hours of the year, regardless of the utility.
5. Average TDV factor
   Use the average marginal TDV emissions rate (weighted by consumption), 0.49 kg CO_2/kWh, as a flat rate applied across all hours of the year.
6. Adjusted TDV factor specific to each utility (recommended approach)

Use TDV as a weighting factor (hourly emission factor / average emission factor (weighted by consumption) to adjust hourly emissions from each utility.

7. Non-baseload eGRID rate adjusted to a TDV factor
   Use TDV as a weighting factor to adjust the eGRID subregion flat rate.

Based on input from stakeholders, option 6 was the preferred approach. The proposed formula is:

$$emissions\ in\ hour\ \mathrm{h} = kWh_h(utility\ emission\ intensity)\left(\frac{marginal\ TDV_h}{average\ TDV}\right)$$

(equation 1)

Where kWh_h is the electricity consumed in hour h, "utility emission intensity" is the annual emission factor for the electricity provider (i.e., it is the total annual emissions associated with the utility divided by the total annual electricity sold by that utility), "marginal TDV_h" is the emissions intensity (g CO_2/kWh) of the marginal electricity produced in hour h, and "average TDV" is the average of the marginal TDV emission factors for all 8760 hours of a year, weighted by California average consumption of electricity in each hour as provided in the E3/HMG TDV report (E3/HMG, 2008).[1]

Our proposed calculation considers both time-dependent emissions and the utility-specific emission factor. For example, Figure 2 illustrates how this would be applied to homes in the SMUD utility district for the year 2006. Homes that consume more energy during peak hours would have higher emissions than homes that consume less during those hours. On average, homes in the SMUD territory will have higher emissions than PG&E and lower emissions than SCE, since the SMUD annual emissions rate is also between PG&E and SCE rates in the year shown (2006).

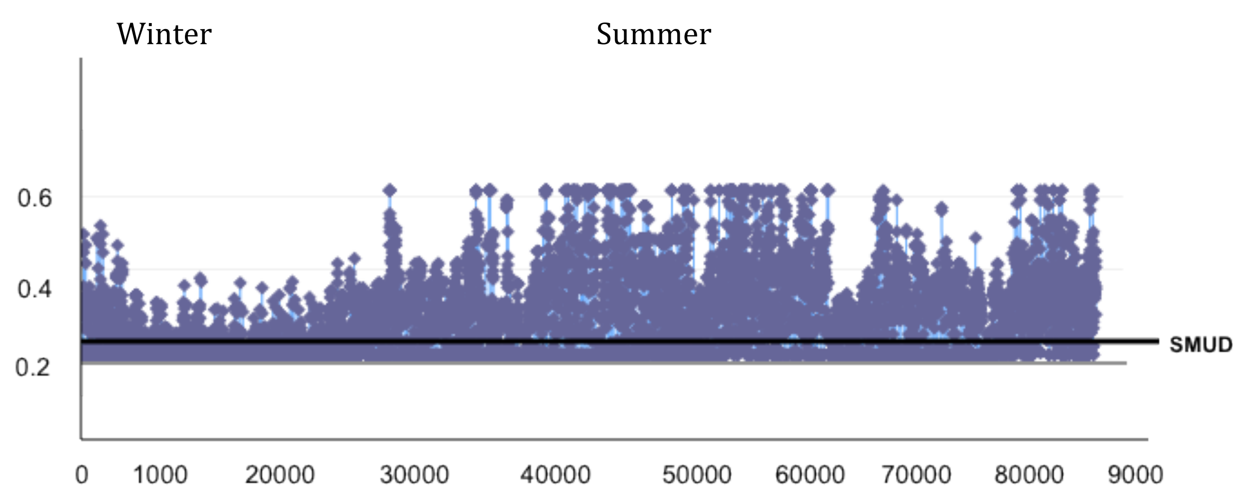

Figure 2: Time-dependent emissions applied to a typical home in the SMUD territory

[1] We used the hourly "Implied Heat Rate" values in the E3/HMG report as a proxy for consumption for the purposes of weighting.

The main software used for energy compliance in California (EnergyPro) now incorporates the methodology we derived in this project so that all their software modules include an hourly emission factor output profile. We utilized EnergyPro to examine the impact of time-dependent emission factors on calculated household carbon footprints from electricity consumption. The hourly electricity consumption by four house models in six different California urban areas was calculated using EnergyPro, and the emissions associated with that electricity consumption was calculated using two different methodologies: (1) based on the TDV methodology described above and (2) based on using an annual average utility-specific emissions factor. A comparison of calculated carbon footprints based on the annual average versus the time-dependent values indicated that, generally, using the TDV methodology resulted in increased calculated carbon footprints. The exceptions to this occurred when the modeled house had electric space heating (as opposed to gas), and for houses in the LADWP utility service area.

4.3. Energy Consuming Appliances

The Climate Calculator uses data from Energy Star (ES) to determine baseline appliance energy and water use, as well as Energy Star performance thresholds. The data points for Energy Star complying models can be overridden by Raters if known, but the default Energy Star kWh, therms and gallons/cycle values can be used if values are not known or entered by Raters. For each appliance, the Energy Star calculators make assumptions about the number of times each appliance is used each year and about the amount of energy consumed by each use. The project team analyzed the 2008 Residential Energy Consumption Survey data to evaluate the assumptions in the Energy Star calculators. It was found that the Energy Star usage estimates are not entirely consistent with the best available consumer behavior data (e.g., ES overestimates the average number of loads of laundry a household washes each year), but there are no inconsistencies between ES and GPR.

HERS and GPR both include many of the same major appliances (clothes washers and dryers, dishwashers, and refrigerators), while the HERS calculator features one additional appliance (ovens). As with appliances, in HERS energy use for lighting is calculated based on the house's conditioned floor area (CFA), while in GPR, lighting energy use is asset-based (that is, calculated by counting light bulbs and making assumptions about for how long each bulb is in use).

Regression modeling was used to examine correlations between occupancy and appliance use, using multiple combinations of household asset variables in the Residential Energy Consumption Survey. While there was found to be a fairly good statistical correlation between occupancy and appliance use (esp. for dishwasher and clothes washers), there were not found any regression models that could accurately predict appliance energy consumption based on asset variables (such as the number of bedrooms, number of bathrooms, etc.). Given the lack of statistical power, it was decided to continue to use Energy Star calculators to calculate energy consumption and savings.

The Energy Star website still uses the same savings calculators from 2009 that were referenced in Version 1 of the GPR Climate Calculator. The only exception was for dishwashers, where Energy Star is in the process of updating their criteria. The new criteria will separate standard-size models ($<$295 kWh/year) from compact-sized models ($<$222 kWh/year). In comparison, the 2009 criteria list all compliant dishwashers at $<$294 kWh. Because of the nearly identical values for compliant standard sized models, it was determined that no change was necessary at this time.

Figure 3 and Figure 3-2 show a comparison of the estimated kWh and therms of natural gas used by sample homes in Version 1 and Version 2. Since no changes have been made to the calculations, energy consumption is identical in both versions.

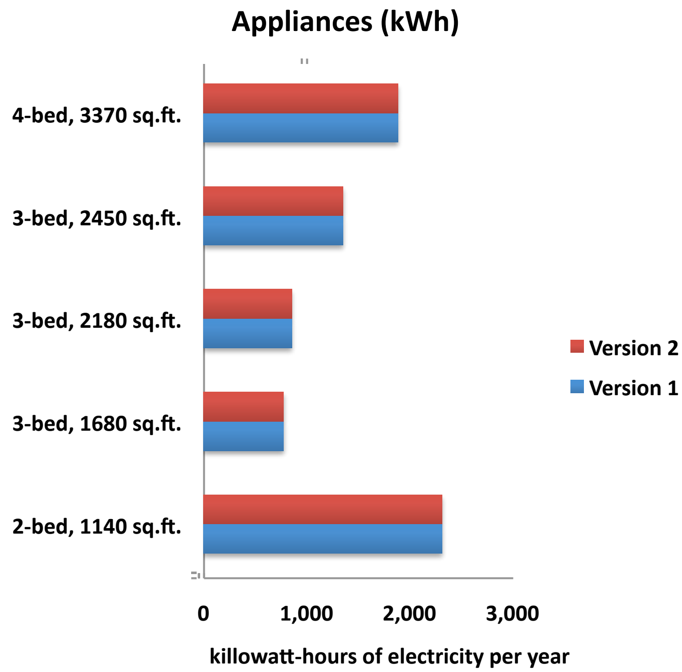

Figure 3: Appliance electricity consumption for GPR versions 1 and 2 in 5 sample homes

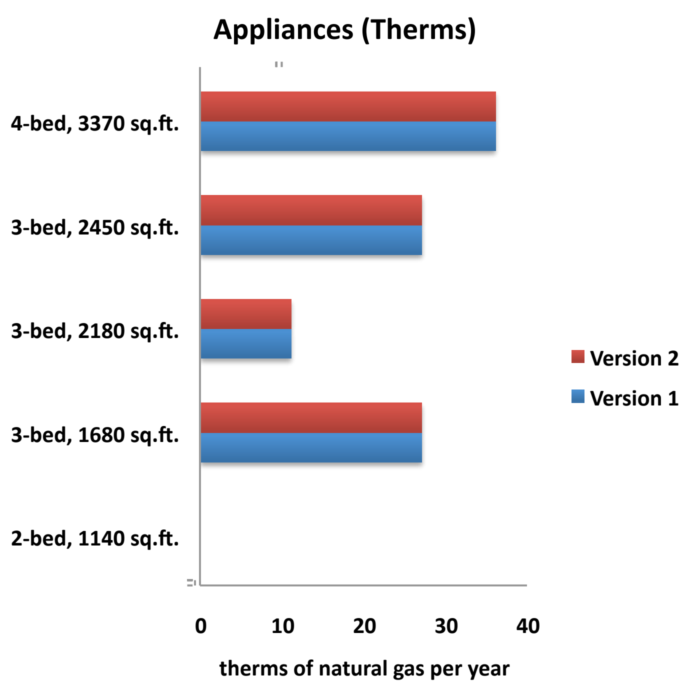

Figure 3-2: Appliance natural gas consumption for GPR versions 1 and 2 in 5 sample homes.

4.4. Home Size Efficiency

Currently, GPR recognizes that smaller homes tend to use less energy than do larger homes with identical characteristics (other than square footage). The calculator uses a factor of 0.7 to estimate anticipated energy savings derived from building a house smaller than the Title 24 reference size. The rationale for a 0.7 adjustment factor is that energy use in homes does correlate linearly to the size of the home. Therefore, during the Climate Calculator Version 1 planning, it was determined that 0.7 was a best guess at estimating energy use in homes which were built smaller than the reference “average” home size.

For Version 2, 2005 RECS data was used in an attempt to validate the current 0.7 factor, but the size of the relevant data subset of the validation process was insufficient to support or discredit the use of 0.7 factor. During the Energy Stakeholder event, participants discussed the 0.7 factor and concluded that the adjustment factor was satisfactory given the lack of data to justify any correction to a more statistically significant number. Participants agreed that some adjustment factor was necessary, and 0.7 seemed reasonable for most homes. Further research is needed to improve this assumption.

4.5. Interactive Prescriptive Energy Efficiency Effects: GreenPoint Rated Elements

For new homes, energy measures that are required in the California Building Energy Code (Title 24 part 6) are not included in GreenPoint Rated energy savings estimates since they do not exceed minimum code requirements. The building measures taken to achieve energy performance beyond code are detailed as part of the whole building energy modeling in GreenPoint Rated, and thus are not quantified individually. Energy savings from good design and high performance building technologies are included as part of the modeled home’s performance.

For existing homes, there are two types of GreenPoint Rated categories: whole house and partial house (called “Elements”).

Whole House: The project must meet the minimum requirements of the Green Point Rated checklist, which includes energy efficiency performance modeling.

Elements: For partial retrofits (or any other project not requiring Title 24 energy performance modeling), the checklist identifies specific measures a project may claim prescriptively.
Savings for energy-related measures are calculated based on the improved performance over a typical home of the same size and vintage. The Elements program uses four vintage categories: 1) pre-1980 (i.e., pre-Title 24); 2) 1980-2001; 3) 2002-2005; and 4) 2006-present. The four vintages correspond with significant changes in building energy

efficiency practices coinciding with major Title 24 updates. Historic information, like SEER of air conditioning or insulation levels in the walls, can be estimated based on vintage and energy savings over the assumed basecase.

For the Elements rating, rather than expecting a home to have a full energy model conducted, GreenPoint Rated allows a prescriptive list of energy upgrades commonly found on remodel projects. These strategies have clear energy savings, but without a comprehensive energy model, estimates of savings must be made. Measures like attic insulation, duct sealing, high efficiency HVAC, and high efficiency hot water systems all save energy differently in different homes and climate zones. Further complicating issues are the interactive effects of when homeowners upgrade several prescriptive measures at one time. The various implemented measures have assumed savings, but those savings should not simply be added on top of each other if there are interactive effects. For example, if a homeowner upgrades a water heater and also installs attic insulation, then those two prescriptive measures do not have overlap and therefore the savings of each can be assumed to be achieved (i.e., added together). Yet, if that same remodel also included and upgraded furnace, the impact on energy use will now have two upgrades that affect space heating: attic insulation and furnace efficiency. Therefore, attenuation factors need to be developed in order to account for interactive effects on prescriptive energy upgrades where overlaps of savings exist.

To accomplish this in the Climate Calculator Version 1, the team based prescriptive savings data on the best available studies at the time (CEC, 2008 and KEMA, 2006). To account for interactive effects, the team derived a formula whereby measures that have overlapping energy savings result in the multiplication of efficiencies (not additive). Further, there is a maximum savings factor for kWh and therms, which cannot be exceeded via the prescriptive measures, no matter how many measures are installed. This maximum represents what our stakeholders felt was a feasible upper limit of energy savings due to upgrades for the various building vintages, and average around 40% reduction at the maximum. Should a homeowner seek greater energy savings, it is likely they would take the whole building path, thereby relying on a more accurate whole house energy model.

For Version 2, the Energy stakeholder group was presented the prescriptive interactive effects methodology and rationale for discussion. It was agreed by the group that although not perfect or necessarily accurate on a specific home, the approach to apply interactive effects and maximum savings for prescriptive upgrades was satisfactory. Therefore, the decision was made to keep the same approach for Version 2 regarding prescriptive energy savings estimates. When the new energy code comes into effect in 2014, the Calculator will be revised to reflect new data sets and baselines as appropriate. The interactive effects table is included as Appendix C.

4.6. Shade Trees

Trees sequester carbon when growing and also cool surrounding air, resulting in reduced air conditioner use in hot climates. In order to estimate savings, the Climate Calculator

Version 1 development included a literature search for shade tree effects on cooling reduction in homes in various climate zones. The two studies referenced at the time showed savings from 8-12% for mature shade trees located on single family home lots [page 150 from Energy-Efficient Landscapes by McPherson, Rowntree and Wagar (1995) and a Chapter from Urban Forest Landscapes, Integrating Multidisciplinary Perspectives (Edited by Gordon A. Bradley)]. For Version 1, a factor of 8% savings is estimated in order to be on the conservative end of the savings range. Specifically the GPR guidelines state that this factor will be applied under the following conditions:

> Trees that will shade an average of 50% of the east, west and south sides of the home and its windows and at least 50% of sidewalks, patios, driveways within 50 feet of house (based on shadow at noon on June 21 and 15 years' growth). A shade study should be completed to calculate coverage at 10am, noon and 3pm. The arithmetic mean of these three values will be used as the effective shaded area.

The 8% factor is applied on top of energy model-predicted energy use during summertime and is influenced by climate zones. Therefore, a house built in the central valley will experience the greatest potential energy savings from shade trees, whereas a coastal home will see very low, or no, savings due to shade trees.

For Version 2, the team looked for new resources and found some very detailed shade tree studies, such as the National Tree Benefits Calculator (Arbor Day Foundation, 2012), from the Arbor Day Foundation, which provides detailed results for specific trees in many climate zones. Another robust calculator is the Center for Urban Forest Research's Tree Carbon Calculator (USDA, 2012). These tools provide the best available information on tree carbon sequestration, the amount of carbon stored over the life of trees, and shade tree energy saving information. However, the amount of inputs necessary in order to determine the energy saved or carbon sequestered from shade trees in the Climate Calculator proved to be too difficult. The time and effort necessary to gather the extra data points for full shade tree analysis was too costly for the GreenPoint Rater process. Therefore, the existing methodology was deemed suitable by our stakeholders for continuation into Version 2. Given the rather strict requirements to receive this credit, few homes qualify (including none of the 14 homes tested during field testing of this project).

4.7. Advanced refrigerants and refrigerant leakage

Gases used in refrigeration escape at a rate of 2% a year, or 1 lb per year for a typical home application (U.S. Green Business Council, 2005). Each refrigerant has an associated global warming potential (GWP) related to this amount and interval that can be compared to the same mass of CO_2 (with a GWP of 1).
For the purposes of GreenPoint Rated, the Climate Calculator uses the refrigerant leakage assumption above to base savings from selecting environmentally preferable refrigerants.

In Version 1, the list of refrigerants was quite short and included R-22 (baseline), ammonia, HFC-134a, HFC-407c, and HFC 410a.

For Version 2, the assumption of leakage and default refrigerants and baseline (R-22) remain the same. However, many new refrigerants are now added to the Climate Calculator per updated EPA lists and can be selected in order to quantify benefits from advanced refrigerants. The final list of emission factors is provided in Appendix A.

4.8. Indoor Water

The water module of the GreenPoint Rated Climate Calculator estimates the total annual water consumption by a household by summing the expected water consumption indoors and outdoors, and then subtracting the amount of water captured by grey- and rainwater systems. GHG emissions are estimated for the energy used to extract, convey and transport water.

GPR engages in a bottom-up accounting of indoor water consumption, summing the individual daily or annual water draw of six components: dishwashers, clothes washers, showers, toilets, bathroom sinks, and kitchen sinks. In GPR, indoor water consumption is measured by estimating the flow through four fixtures (showerheads, kitchen faucets, bathroom faucets, and toilets) and two appliances (clothes washers and dishwashers). This section discusses how GPR models water consumption by these features, and identifies areas for improvement for Version 2 of the calculator.

Occupancy

A few of the water consuming features of homes depend on the number of occupants in the house. In GPR, assumed appliance energy demand is based on ENERGY STAR calculations, which have fixed values based on assumed usage rates, with some features of homes having variable use depending on number of occupants (i.e., dishwashers, clothes washers, kitchen faucets, bathroom faucets, showers and toilets).

The GPR Calculator Version 1 uses the industry standard formula to calculate occupancy:

Occupancy = 1 + number of bedrooms

This formula assumes that every bedroom in homes will contain occupants and the first bedroom will contain two adults.

Using the Residential Energy Consumption Survey (RECS), we developed a simple regression model between occupancy and number of bedrooms as an alternative to the current GPR method. The regression model represents the correlation between occupancy and number of bedrooms based on real world results in thousands of California homes recorded in the detailed RECS survey. Using the RECS, a simple regression between occupancy and number of bedrooms yields the following formula:

Occupancy = 0.41 * number of bedrooms + 1.8
(equation 2)

At the water stakeholder meeting, the experts agreed with the research team that this represents a more realistic view of expected occupancy in homes over the previous formula. Figure 3 compares the results for total building water consumption for a typical four bedroom home under the different occupancy formulas. The revised formula results in reduced consumption for all homes larger than one bedroom. A typical four bedroom home consumes 20,000 fewer gallons of water than under the previous estimate.

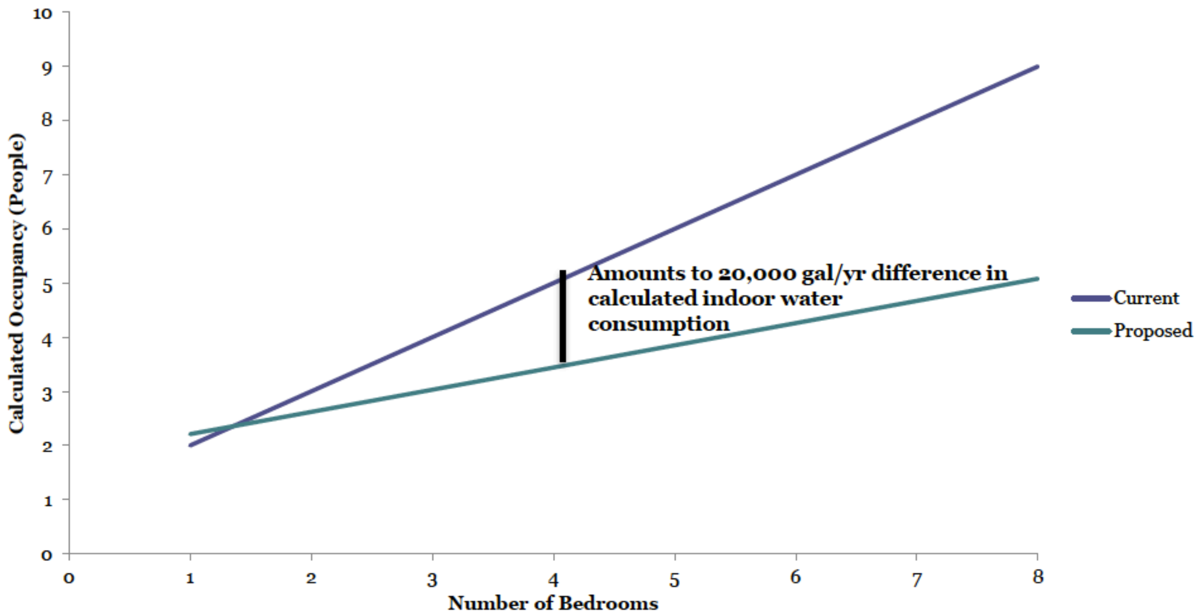

Figure 4: Gallons of water consumed by homes under current formula and proposed formula

The stakeholders agreed that the previous formula overestimates the number of occupants and consequently also overestimates the amount of savings from energy and water saving measures that are calculated on a percentage basis. As a result of these discussions, it was decided to use the revised formula to calculate building occupants in GPR.

Fixtures

Below is the formula with which total daily indoor water consumption by a fixture is calculated in GPR Version 1:

Usage = Fixture Assets x Fixture Usage Frequency x Usage Duration x Water Flow Rate

$$\left[\frac{gal}{house \cdot day}\right] = \left[\frac{\#\ fixtures}{house}\right]\left[\frac{\#\ usage\ events}{\#\ fixtures \cdot day}\right]\left[\frac{minutes\ usage}{usage\ event}\right]\left[\frac{gal\ used}{minute}\right]$$

(equation 3)

Total indoor water consumption is found by summing the calculated usage of individual fixtures.

Fixture Assets refers to the number of toilets, showerheads, etc., in the house. The Rater records the number of planned/existing fixtures of each type. This is straightforward and should be subject to little in the way of error.

Fixture Usage Rates describes the number of times each fixture is used. Total usage is the product of the number of people in the home (occupancy) and the number of times each person is assumed to use a fixture.

Occupancy in Version 1 of the calculator was assumed to be equal to the number of bedrooms in the home plus one. The new formula is **equation 2**. Below is a chart of the assumptions regarding number of times an individual will use a given fixture each day. These assumptions are based on the 2008 California Green Building Standards Code.

Table 2: Water fixtures in GPR

Fixture	Uses Per Person Per Day
Toilet	3.75
Kitchen Faucet	1
Bathroom Faucet	3
Shower	1

In terms of occupant behavior, it is assumed that each fixture is used according to the schedule in the above chart. That is, each person will use each showerhead 1 time per day. Embedded in this assumption is the assumption that there is no preferential usage (e.g., an individual will use a standard toilet the same number of times as a high-efficiency toilet rather than preferentially use one or the other).

Usage Duration

Each fixture is assumed to be in operation for a certain amount of time during each usage. Those durations are presented in the following chart:

Table 3: Usage duration of water fixtures in GPR

Fixture	Usage Duration
Toilet	1 flush
Kitchen Faucet	4 min.
Bathroom Faucet	0.25 min.
Shower	8 min.

There has so far not been found a good resource to confirm or contradict these usage duration numbers, for either an individual fixture or the set of fixtures.

Water Flow Rate

Each fixture is assumed to have a certain flow rate. These rates are presented in the following chart:

Table 4: Water flow rate for fixtures in GPR[2]

Fixture	Flow Rate
Std. Toilet	1.6 gpf
HE Toilet	1.28 gpf
Composting Toilet	0 gpf
Std. Kitchen Faucet	2.2 gpm
HE Kitchen Faucet	1.8 gpm
Std. Bathroom Faucet	2.2 gpm
HE Bathroom Faucet	1.5 gpm
Std. Showerhead	2.5 gpm
HE Showerhead	2.0 gpm

Appliances
Two appliances (clothes washers and dishwashers) are placed within the "Plugload" module of the GPR calculator, but all the same contribute to the calculated annual household water consumption value. Unlike the four fixtures discussed above, GPR does not calculate the water consumption of these appliances based on a bottom-up, occupancy-based equation, but rather utilizes the water-consumption assumptions of the relevant ENERGY STAR appliance calculator. (See the Energy chapter for a more information on ENERGY STAR calculators.) The reasonableness of these assumptions, coupled with the respectability of their source, argues in favor of retaining this method and these values for Version 2 of the calculator.

As noted above, the four fixtures and two appliances featured in GPR cover a majority of the indoor water demand of an average household. However, according to a report by the consulting firm ConSol, there is an additional source of water demand that deserve consideration: leaks. Presumably, new construction will not suffer substantially from leaks, and so this category need not be included in a new-home GPR.

Recommended Changes to the Indoor Water Component of Version 2

We have identified three changes to make in the indoor water module for Version 2 of the calculator:

Recommendation 1: Revise the fixture water use formula to align with the 2010 California Green Building Standards Code. Under the previous formula, which was based on the 2008 California Green Building Standards Code, the daily water use for fixture type f = Quantity_f x Flow rate_f x Duration_f x Daily uses_f x Occupancy

[2] These rates are consistent with the U.S. national standards (EPAct and the ASME standard) and the high efficiency toilets, bathroom lavatory faucets and showerheads are also consistent with the EPA WaterSense Program.

Where, Quantity is the number of fixtures in the house, Flow rate, Duration, and Daily uses are behavioral assumptions from the 2008 California Green Building Standards Code, and Occupancy is forecast based on the number of bedrooms in the house.

The implication of this fixture usage formula is that each person in the house will use each fixture according to the behavioral assumptions of the 2008 Standards. (For example, if there are two showerheads, each person in the house will take two eight-minute showers each day. With three showerheads, each person would take three showers each day.) Unlike the other behavioral assumptions from the 2008 Standards, multiplying the individual water usage rates by the number of fixtures does not see to conform with lived experience, and it is recommended that the GPR remove the $Quantity_f$ factor from its indoor water use calculation.

The new formula would be as follows:

Usage = Fixture Usage Frequency x Usage Duration x Water Flow Rate

$$\left[\frac{gal}{day}\right] = \left[\frac{\#\ usage\ events}{\#\ fixtures \cdot day}\right]\left[\frac{minutes\ usage}{usage\ event}\right]\left[\frac{gal\ used}{minute}\right]$$

(equation 4)

Recommendation 2: Use an average efficiency value for calculating the water use by indoor fixtures.

Removing the $Quantity_f$ factor will require that GPR make certain assumptions about which fixtures home occupants will use in those cases where there exist fixtures of different efficiency levels (e.g., a house contains two toilets: 1 high-efficiency, 1.28 gpf and 1 standard, 1.6 gpf). It is recommended that the calculator base its daily water consumption formula on the average efficiency of fixtures in the house, implying that each fixture has an equal probability of being selected for each water-use event.

Recommendation 3: Allow Raters to designate rain- and greywater as being for outdoor use.

Currently, capture and use of rain- and greywater is credited in the indoor water section of the calculator. Though greywater can be used to fill toilet tanks, it is more commonly used outdoors for landscaping and agriculture. While from a water consumption perspective, it doesn't matter where the greywater is used, there are implications for embedded energy calculations.

For use of rain- or greywater indoors, it is recommended that there be a cap set within the calculator that limits the credit that a household can achieve for use of non-potable water. Because toilets are the only indoor use of non-potable water, it is recommended that the annual indoor use credit cap be equal to the calculated annual water use by household toilet fixtures.

Figure 5 shows results for indoor water use for appliances only (not including faucets). Since no changes were recommended the results are identical in both versions of the tool.

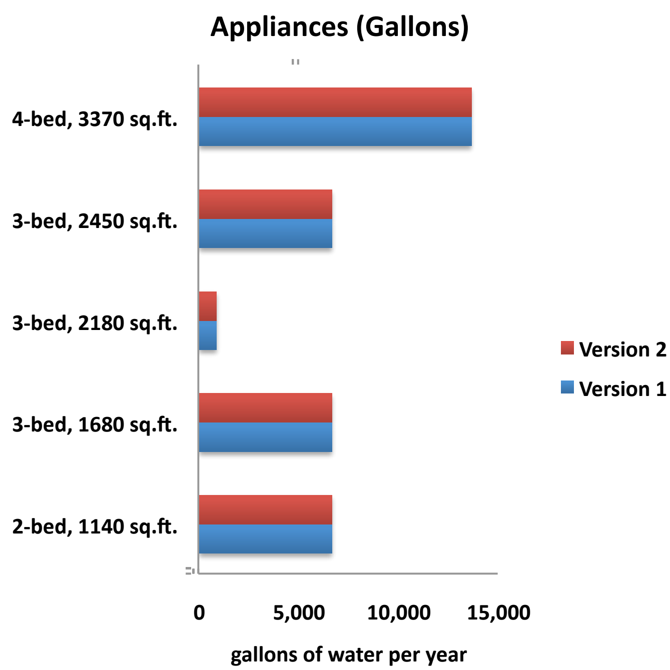

Figure 5: Appliance water consumption (in gallons) for GPR versions 1 and 2 in 5 sample homes

Figure 6 shows total annual water consumption for all purposes (faucets, showers, toilets, dishwashers and clothes washers). As expected, total household water consumption is reduced significantly in most cases due to our revised estimate of occupancy in the home (equation 2) and the elimination of the Quantity_f factor of fixtures from the flow rate formula (equation 4).

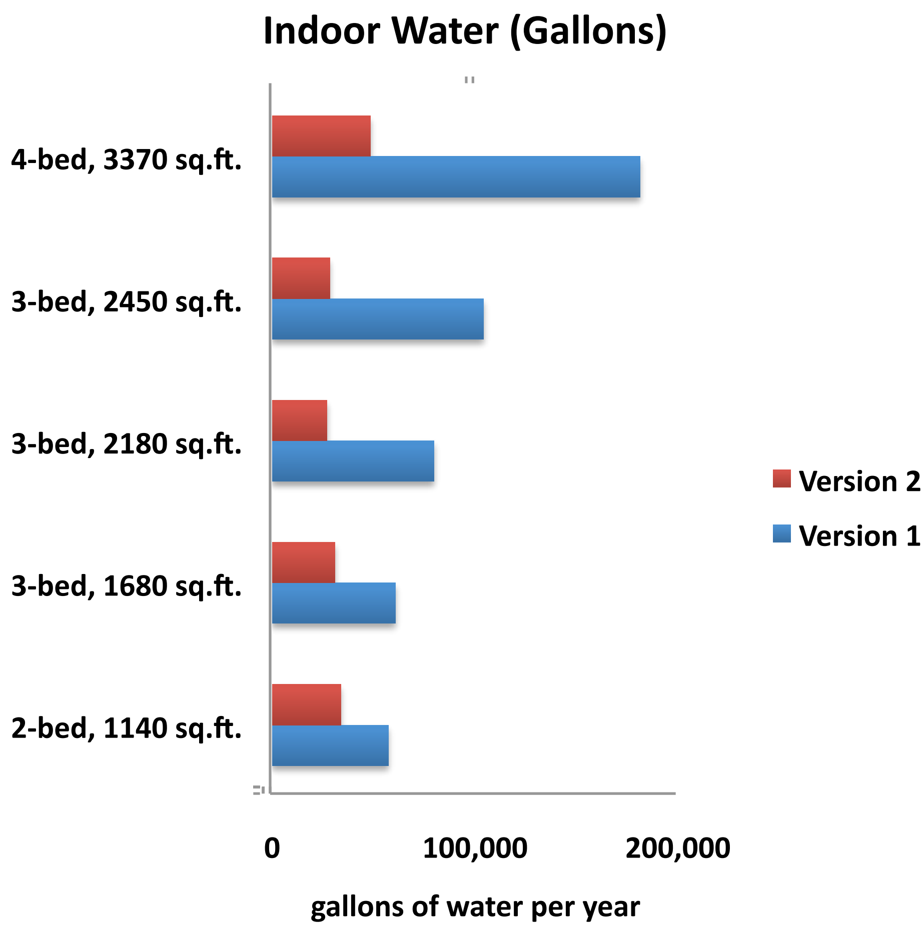

Figure 6: indoor water consumption (in gallons) for GPR versions 1 and 2 in 5 sample homes

4.9. Outdoor Water

In GPR, outdoor water consumption is measured by estimating irrigation needs of the household landscape. This section discusses how GPR models landscape water consumption.

Below is the formula with which total yearly outdoor water consumption by a fixture is calculated:

Usage = Area x Reference Evapotranspiration x 0.62 x Evapotranspiration Adjustment Factor

$$\left[\frac{gal}{year}\right] = [lawn\ area, ft^2]\left[\frac{inches}{ft^2 \cdot yr}\right]\left[\frac{gal}{inch}\right][\text{unitless}]$$

(equation 5)

Where,

- Area is the landscaped area around the house. The Rater records the planned/existing landscape area for a house. This is straightforward and should be subject to little in the way of error.
- Reference Evapotranspiration is the amount of water a specific species of grass needs in a specific climate. This value is fixed and can be looked up in a table. This is straightforward and should be subject to little in the way of error.
- 0.62 is a conversion factor for the gallons of one square foot-inch (that is, a box with a volume of 144 in3).
- Evapotranspiration Adjustment Factor is the ratio of two factors: the plant factor and the irrigation efficiency. The plant factor is the water requirement of a plant expressed as a percentage of the reference plant (i.e., the reference evapotranspiration). The plant factor for turf grass is about 0.8, while for drought-tolerant shrubs it is closer to 0.3. Irrigation efficiency is the percentage of water that leaves the irrigation system that lands on plants that need watering.

The Calculator includes water savings from well-designed and maintained home-size landscapes that utilize a range of water-efficient elements. The Calculator uses a water budget for outdoor landscapes that is based on the California Department of Water Resource's (2009) Model Water Efficiency Landscape Ordinance (MWELO). Additionally, principles taken from the Bay-Friendly Landscaping Guidelines are included in GreenPoint Rated as a basis for holistic water conservation techniques outdoors.[3] Landscape water conservation starts with creating drought-resistant soils with compost and mulch, selecting low-water using plants, planning for hydrozoned irrigation areas, and installing high efficiency irrigation technologies. These strategies combined together can save large amounts of water.

For Version 2, an analysis of the current outdoor water use in landscapes was undertaken. The Calculator actually features two ways in which outdoor water use is calculated: a formula for savings that is based on the GreenPoint Rated measures selected and cross-referenced to a study on typical outdoor water use in California. A second approach is to develop a water budget per the state Model Water Efficient Landscape Ordinance (MWELO) calculations. For GreenPoint Rated, either method can be used so long as only one method is chosen.

There are three direct means by which one can achieve outdoor water consumption reductions: 1) landscaping with less thirsty plants, 2) using a higher-efficiency irrigation system, and 3) using a smart or weather-based irrigation control system. These three measures are seen as independently effective. That is, there are no interaction effects among the measures. This appears to be a fair first-order assumption. Other indirect water conservation measures, such as adding mulch, limiting overspray via good design, and

[3] Information about the Bay-Friendly Landscaping program can be found at www.bayfriendly.org. For more details on the landscaping guidelines used in the Calculator, see Appendix B.

building healthy soil with compost instead of synthetic fertilizers are also effective at limiting water use. GreenPoint Rated draws on the Bay-Friendly Landscaping program to include a number of these strategies in the checklist.

For the Version 2 review, stakeholders were asked questions about the rationale for the V1 prescriptive checklist assumptions and calculations, as well as the more detailed MWELO water budget methodology. It was determined that no significant changes were needed because the current methodology accomplished the goals that the Climate Calculator had for home landscape areas. First, for smaller front yards typical of production built housing—where landscaped areas are typically less than 1,500 square feet—there exists a need to quantify water savings without developing a full water budget. Second, for sites that do contain large landscape areas, the water budget is essentially required per MWELO, and it was determined that GreenPoint Rated should be equivalent to the state MWELO requirements. Therefore, based on a detailed review and stakeholder input, only very minor edits to the outdoor water calculations were made; mostly to account for the new hydrological water region dataset and a change in water irrigation efficiency assumptions due to MWELO updates.

One of the minor changes includes a greater granularity of detail surrounding the use of rainwater and greywater in homes. In Version 1 of the Climate Calculator, rainwater was only assumed to be +/- 300 gallons of capacity. Further, it was assumed that rainwater would only be used outdoors (and thus only displace outdoor water use). Greywater was assumed to only displace indoor water, and was considered only applicable for indoor permitted greywater systems. For Version 2, both rainwater and greywater have been updated. The total system capacity, as determined by an expert of record for permitted systems or determined by tank size capacity for unpermitted systems, can now be entered in the Calculator. Further, the use of rain-or greywater systems can now be quantified to offset water use indoors or outdoors.

Further recommendations include: 1) allowing Raters to designate which zone (indoor vs outdoor) captured water will displace, and 2) establishing a cap on the amount of captured water that can be used indoors. In most cases, toilets are the only indoor fixture suited for application of grey- or rainwater, and as such, homes should not get credit for more indoor use than is calculated to be used by toilets over the course of a year.

Figure 7 shows results for outdoor water use for 5 sample homes. Since no changes were recommended the results are identical in both versions of the tool.

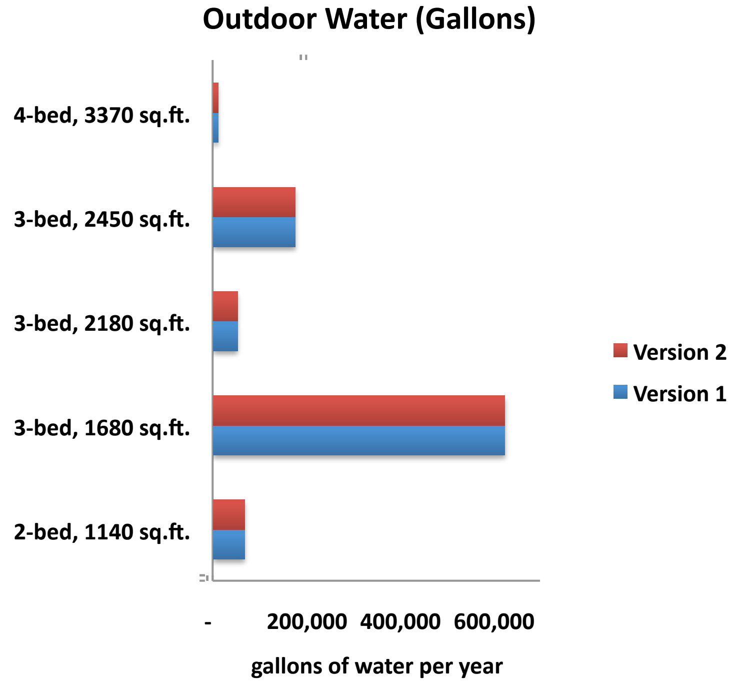

Figure 7: Total outdoor water consumption (in gallons) for GPR versions 1 and 2 in 5 sample homes

The following section describes updates to the hydrological regions of the Climate Calculator and the associated greenhouse gas emissions from water consumption.

4.10. Embedded Energy and Emissions of Water

To calculate energy use and greenhouse gas emissions associated with water use, the current version of GPR utilizes values from a California Energy Commission report (CEC, 2005). That 2005 report presents embedded energy values in a 2x2 matrix defined by geographic zone (Northern versus Southern California) and consumption location (indoor versus outdoor). The total embedded energy of water is the sum of four components: supply and conveyance, treatment, distribution, and wastewater treatment. The difference in embedded energy of water between Northern and Southern California is due to a higher supply and conveyance factor for water used in Southern California. The difference in embedded energy between indoor and outdoor water is attributed to the energy requirements of treating wastewater generated by indoor water use.

In 2006, a second CEC report (CEC, 2006) refined and updated the calculations of the 2005 report. The barest step for tuning up the GPR calculator would be to replace the current values in GPR with those given in the 2006 report. As the 2006 report retains the 2x2 structure of the original, 2005 report, this should pose a minimal challenge.

The data in Study 1 of the 2010 CPUC report "Embedded Energy in Water Studies" provides the means for calculating the embedded energy of water use in California with a higher granularity that of the North/South division of the current GPR methodology. The report divides California into 10 hydrologic regions, and data provided about these regions allow for the calculation of the average amount of energy expended per unit of water consumed.[4]

Calculating the greenhouse gas emissions associated with embedded energy is a more complicated matter. The CPUC report distinguishes two types of energy use associated with water consumption: electricity that is used to produce and transport water within a hydrologic region ("physical energy") and electricity that is used in other regions to bring water to a given region ("embedded energy"). As insufficient information is provided concerning extra-regional sources of water (i.e., where a region's embedded energy is spent), it is not possible to assign specific emissions factors to the embedded energy of each region.[5] A state-wide emission factor may provide a fair first-order approximation of embedded emissions.

Recommended Changes to the Embedded Energy in Water Component of Version 2

Based on the state of data in the field, it is recommended that Version 2 of the calculator adopt a "hybrid" model that incorporates information from the 2006 CEC report and the 2010 CPUC Study 1 report. This model would use the treatment, distribution, and wastewater treatment categories existing in the current GPR calculator version and update the values for those categories based on the 2006 data. For the supply and conveyance segment, it is proposed that the current model be modified to fit the ten-region, hydrologic map developed in Study 1 of the 2010 report, "Embedded Energy in Water Studies."

[4] The data allow for an average across sectors (industrial, agricultural, etc.), not for the residential sector, specifically.
[5] Study 2 of the 2010 CPUC report discusses energy use at the level of water agencies. This level of granularity provides the opportunity to develop a model of even greater detail. However, there is insufficient uniformity in the data provided by individual water agencies to allow for a consistent model based on Study 2 to be built.

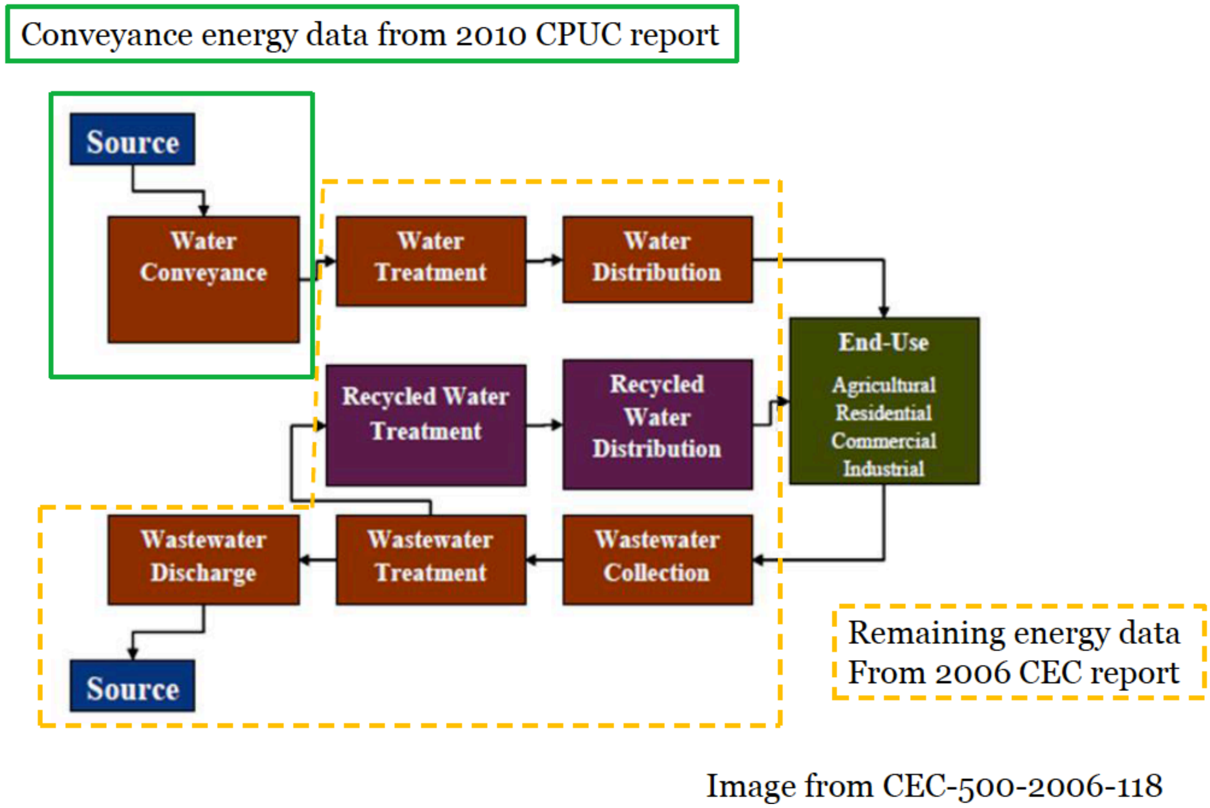

Figure 8: Embedded energy of water model

Using data provided from two recent CEC studies, we derived indoor and outdoor energy intensity (kWh/MG) and carbon intensity (g CO2e/kWh) for each of the 10 hydrological regions in California (Table 4).

Table 5: Indoor and Outdoor Energy Intensity and Carbon Intensity of old 2-region and new 10-region water models

Region	Indoor Energy Intensity (kWh/MG)	Outdoor Energy Intensity (kWh/MG)	Carbon Intensity (g CO_2e/kWh)
Current (North)	3950	1450	variable
Current (South)	12700	10200	variable
North Coast	3670	1760	303
San Francisco	4260	2340	303
Central Coast	5810	3900	356
South Coast	7150	5240	387
Sacramento River	3580	1670	303
San Joaquin River	4410	2500	268
Tulare Lake	6020	4110	268
North Lahontan	3290	1380	207
South Lahontan	8340	6430	345
Colorado River	4860	2950	309

Applying these factors to standard home tends to decrease emissions in the two Southern hydrological zones and increase emissions in all other zones (Figure 9). This follows since the previous estimate from the South underestimated the amount of water pumped from local aquifers, thus decreasing the energy and carbon intensity of extracted water.

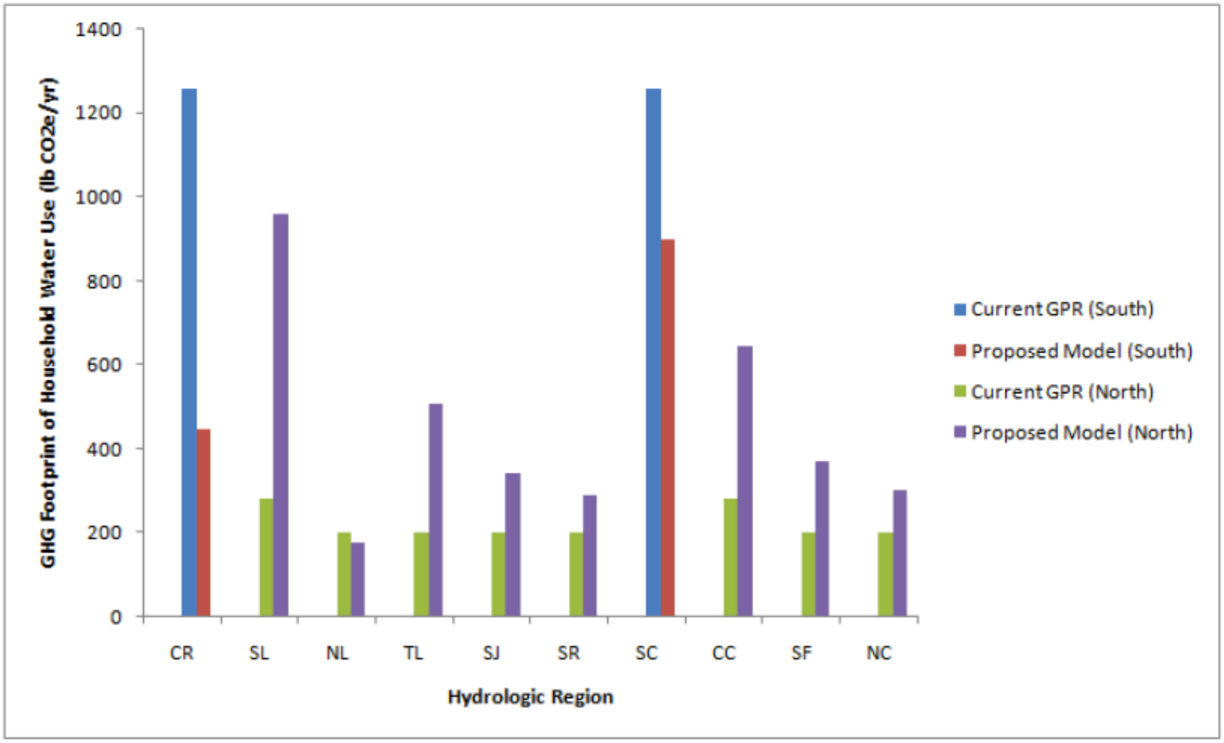

Figure 9: Comparison of embedded CO2 between the old 2-region model and the new 10-region model in Northern and Southern hydrological zones

4.11. Materials

Construction and demolition are major contributors to the total life cycle greenhouse gas impact of homes, accounting for upwards of 100 metric tons of CO_2e over the life cycle of homes (Oregon DEQ, 2011). The GPR Climate Calculator Version 1.0 report included a list of measures related to building materials that were not included in the original study. The current research team was tasked to evaluate the potential of quantifying greenhouse gas emissions from each measure.

Each measure was evaluated based on the total expected GHG impact, the availability of reliable data, the ease of quantification, the presence of co-benefits, and the ability of GreenPoint Raters to collect sufficient data in the field to support the calculations. A summary of results and justification for inclusion or exclusion in Version 1 of the Calculator is included in Appendix D. Ultimately, the research team was able to calculate GHG reduction benefits for the following measures related to the use of building materials in homes:

- Reduced home size (considering the full embodied emissions of construction materials)
- Extended life of roofing materials
- Wood flooring vs. carpet
- Construction & demolition waste recycling

Reduced home size

According to a recent in-depth study conducted for the Oregon Department of Environmental Quality (DEQ, 2010), emissions associated with the manufacturing of new and replacement building materials, materials transport and construction account for over 100 metric tons of CO_2e over a 70 year expected lifetime for an average 2,262 square foot home. To put this in perspective, typical California homes emit about 4.5 metric tons of CO_2e per year from electricity and natural gas consumed in homes (Jones and Kammen, 2011), or ~300 tCO2 over 70 years. Despite the magnitude of embodied emissions, they are typically overlooked in home rating systems.

The Oregon DEQ study modeled the full life cycle GHG impacts of four different home types: extra small: 1149 sq.ft., small: 1633 sq.ft., medium: 2262 sq.ft, and large: 3424 sq.ft. The climate impacts for materials production, transport and construction for these home sizes are plotted in Figure 10. A best fit regression line for these data is a second order polynomial function:

Climate Impact = 0.0097X^2 – 10.012x + 80256
(equation 6)

Where Climate Impact is the total greenhouse gas emissions (kg CO_2e) resulting from the manufacturing of new and replacement materials over a 70 year expected lifetime of homes, and x is the floor area in square feet of the home. Applying this formula, a 1,000 square foot home requires 80.0 metric tons CO_2 for materials, while a 2,000 sq.ft. home requires 99.0 metric tons, for a savings of 19 tCO_2 over its lifetime.

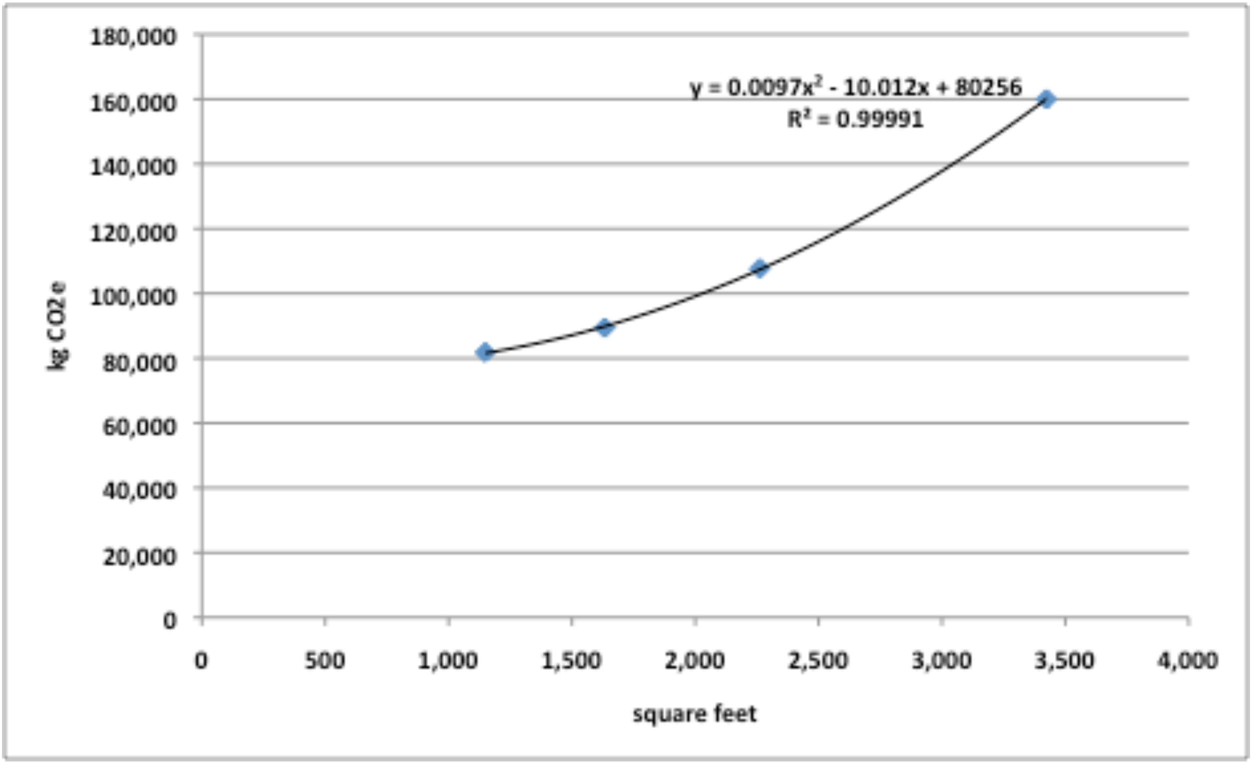

Figure 10: **Lifetime GHG emissions from manufacturing new and replacement materials, materials transport and construction for different size model homes. Source: Oregon DEQ, 2010**

Extended life of asphalt shingle roofing materials

Extended life roofing materials require fewer emissions from materials manufacturing and construction. According to the Oregon DEQ study, manufacturing 40-yr asphalt shingle roofing material produces 2.4 kg CO_2/sq.ft. A 20-yr asphalt roofing material is 1.6 kg CO_2/sq.ft, but two roofs are needed over 40 years. Therefore, using 40-yr roofing materials vs. 20-yr materials saves

1.6 kg CO_2 per sq.ft. x 2 - 2.4 kg CO_2 per sq.ft. = 0.8 kg CO_2 per sq.ft.
(equation 7)

For example, installing a 40-yr roof on a 2,000 square foot home saves (0.8 x 2,000) 1,600 kg CO_2.

Figure 11 shows GHG savings for 10 out of a sample of 14 GPR homes that have extended life roofing materials. Savings range from 0.7 to 1.7 metric tons CO_2.

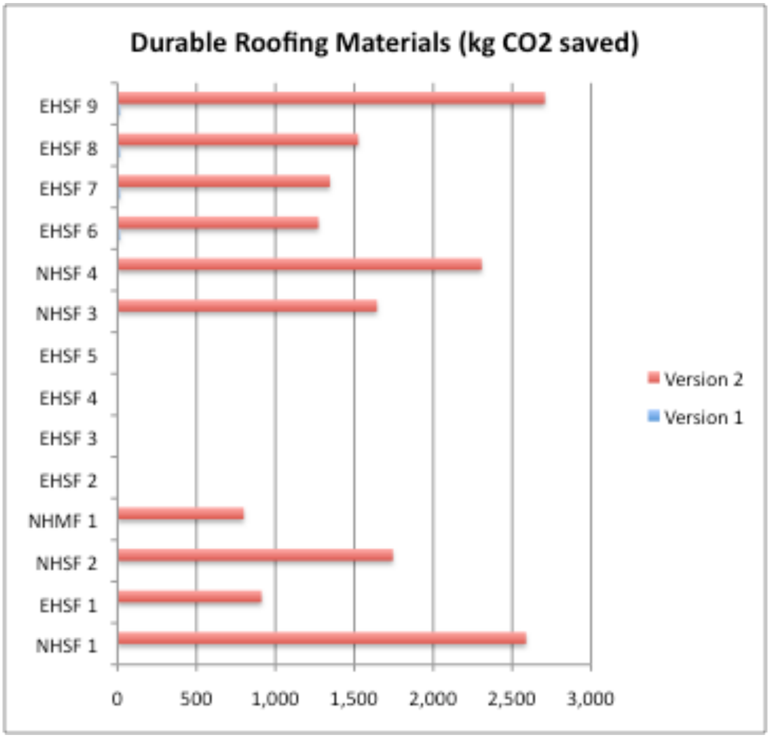

Figure 11: GHG savings in sample GPR home with and without durable roofing materials

Wood flooring vs. carpet

Carpet has the highest impact of all materials, contributing over 20 metric tons CO_2 over the lifetime of homes. Wood flooring, on the other hand, is roughly carbon neutral over its lifetime, with the CO_2 emissions from manufacturing offset by emissions from forest re-growth and energy recovery (depending on disposal technology employed). Additionally, hardwood floors can be expected to last roughly the life of homes, while carpet generally needs to be replaced every ten years. According to the Oregon DEQ study, carpet contributes 1.2 kg CO_2 per square feet for each 10 years (when carpets are replaced) and wood flooring contributes 0.2 kg CO_2/sq.ft. Assuming the carpet is replaced 6 times over the lifetime of the home and hardwood floors are never replaced, the difference in emissions is 1.2(6) – 0.2 = 7 kg CO_2 per sq.ft. To be conservative and to account for area rugs, we divide this number by 2 for a savings of 3.5 kg CO_2 per square foot of hard woodflooring.

(1.2 kg CO_2 per sq.ft. x 6 – 0.2 kg CO_2 per sq.ft.) / 2 = 3.5 kg CO_2 per sq.ft. **(equation 8)**

For example, a home with 1,000 square feet of hardwood flooring would result in 3.5 * 10000 / 2 = 1,750 kg CO_2 saved.

Figure 12 shows GHG savings from 8 out of 14 sample GPR homes that have hardwood flooring. Savings range from ~2 to 10 metric tons CO_2.

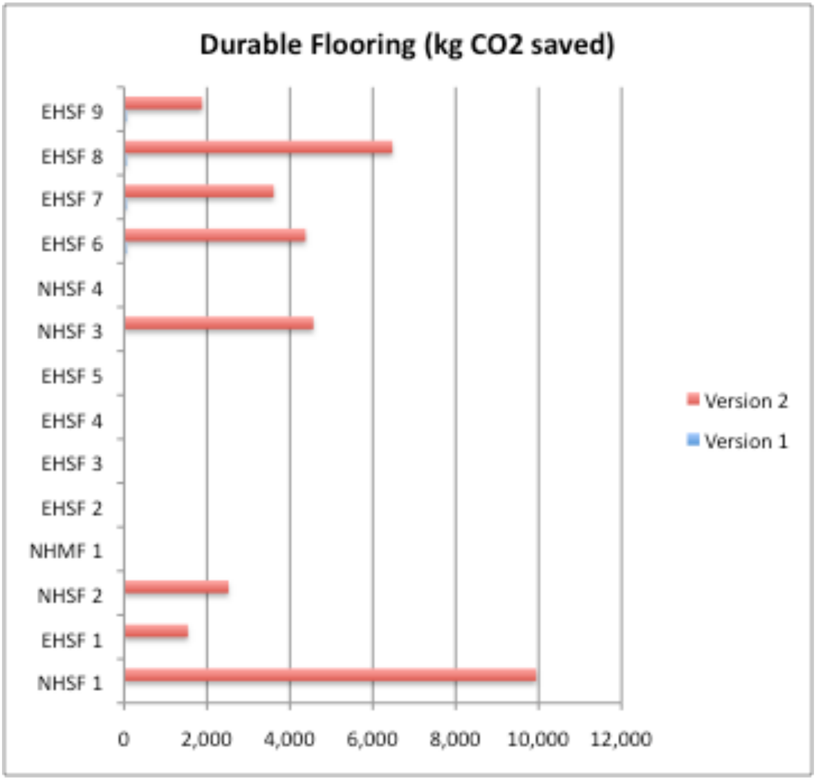

Figure 12: GHG savings in sample GPR home with and without durable flooring

The authors of the Oregon DEQ study do note important sources of uncertainty, which affect our use of this study. These include the fact that values for embodied emissions in materials come from a limited and mixed set of databases (BEES for asphalt shingles, USLCI for wood, EcoInvent for most other materials). It is unclear the range of total possible emissions for each product. One of the authors noted in an email communication that “The carpet production impact data was a compromise between numerous sources. There were sources that had lower GHG intensities and those that had much larger impacts.” This author also noted that the authors of the study did not intend the study to be used to compare different materials (e.g., carpet vs. hard wood flooring), but generally agreed that the methods seemed reasonable.

The time scale of savings is also an important consideration and potential source of uncertainty. We assume a lifetime of 70 years, similar to the Oregon study. A large fraction of emissions are from replacement materials. A home with a shorter lifespan would require fewer replacements, and thus fewer emissions. The time horizon is also important for our assumptions about the length of roofing materials and flooring. In the case of roofing materials, we calculate savings over the course of 40 years, the expected lifetime of the upgraded roofing materials. In the case of hard wood floors, we assume they will last the entire life of the home and that carpeting will remain as a type of flooring during the entire life of the home. This negates the possibility that some future owner will decided to add a different type of flooring at some point in the future.

To check our use of the Oregon Study as a scoping tool, we explored and collected a significant number of bottom-up, specific, comparative examples of some of "best practices" of material use. We also examined the Athena Institute's Impact Estimator for Buildings (Athena Institute, 2012) and the National Institute for Standards and Technology's Building for Environmental and Economic Sustainability (BEES 4.0) (NIST, 2012) tools but concluded that they were too complex for our purposes. The Oregon study estimates appear to be within the range of other studies and acceptable for our purposes.

Construction & Demolition Waste Recycling

As part of the Version 2 update, the construction & demolition waste recycling estimation module of the GPR Climate Calculator was updated in order to better reflect current practice, match current regulatory requirements for construction waste diversion, include new data sets, and to promote consistency across California in how waste recycling is estimated. The major changes are described below.

New Baseline: The baseline diversion percentage for newly constructed homes was changed from 0% recycling to 50% based on the California Green Building Standards Code (known as CALGreen) mandatory minimum code provisions that went into effect January 1, 2011. CALGreen now requires that all new construction achieve a 50% diversion threshold. Therefore, even though compliance with this provision is not necessarily consistently enforced across all jurisdictions in California, the decision was made to raise the baseline to reflect the new regulatory minimums. Savings are then estimated only for those savings that take place above regulatory minimum 50%. As such, $MTCO_2E$ savings from C&D recycling are reduced substantially compared to estimated savings from Version 1 of the Climate Calculator for new homes.

Figure 13 shows results from a sample new home rated under Version 1 and 2. The two baseline diversion rates are vastly different (0% for V1, 50% for V2). The actual diversion rate of the home was 74%, meaning that for Version 1 the actual diversion percentage was 74%, but for Version 2 the incremental diversion rate above code standard is only 24%. This updated baseline diversion rate results in substantially less amounts of incremental waste diversion (and the associated emissions equivalent) for new homes constructed in California after 2011. Note that for existing homes rated under the GreenPoint Rating system the diversion rate basecase is the same for Version 1 and 2 (0%). This equanimity will be true until the building code is changed, likely on January 1, 2014, to require 50% waste diversion for all residential projects including existing building additions and alterations.

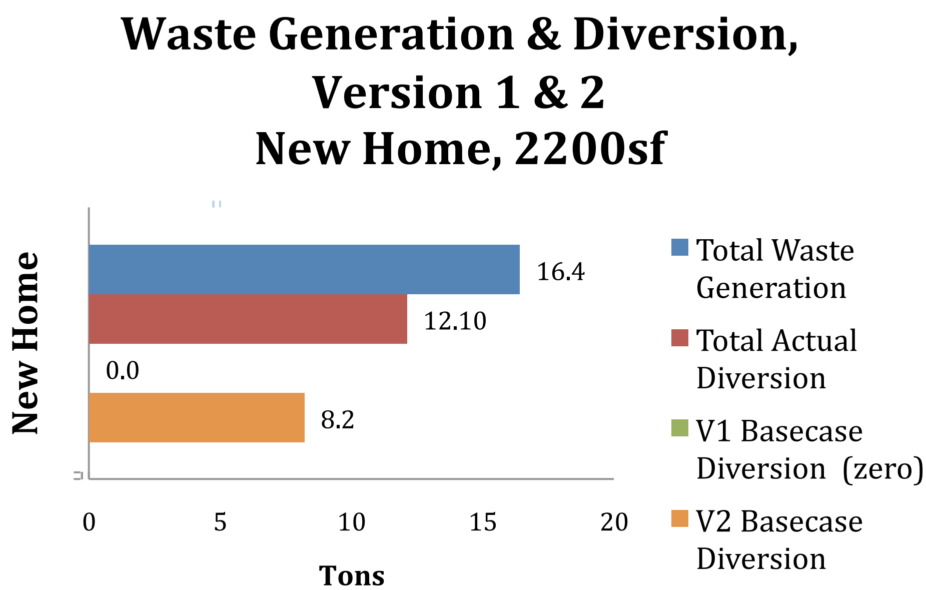

Figure 13: Waste Generation & Diversion, Version 1 & 2. New Home, 2200 sq.ft.

New Emissions Factors: WARM: Since Version 1 was developed in 2009, the EPA's Waste Reduction Model (WARM) has been updated with revised emissions factors as well as new building material categories. Version 1 of the Calculator was utilizing emissions factors from WARM v9, but WARM version 12 is now available. As such, the newest emissions factors for both landfilling waste as well as lifecycle benefits (diversion due to recycling, composting and waste prevention/reuse) are utilized for the Climate Calculator V2 update. Building materials that are eligible for quantification in GreenPoint Rated are also expanded to include fiberboard, carpet, asphalt concrete, and asphalt shingles (in addition to the previously available cardboard, concrete, dimensional lumber, yard waste, and mixed metals).

New Emissions Factors: CARB: Since Version 1 of the Climate Calculator, CARB has developed Recycling Emissions Reduction Factors (RERF) and Composting Emissions Reduction Factors (CERF)[6] as part of the mandatory recycling regulatory process in conjunction with CalRecycle. Although not as complete of a set of emissions factors as WARM (in terms of number of building materials included), the CARB emissions factors represent a more California-specific set of embedded research results and assumptions. Therefore, it was determined to replace appropriate WARM emissions factors with the CARB RERF and CERF values where applicable.

Since the CARB RERF/CERF factors only apply to the lifecycle emissions impacts from waste recycling and composting, the landfill emissions factors must be

[6] Found online at www.calrecycle.ca.gov/Actions/PublicNoticeDetail.aspx?id=248&aiid=248

presented separately. In Version 1 of the Climate Calculator we were able to bundle both types of emissions contained in the WARM model due to the consistent dataset (lifecycle + landfill were both calculated using the same logic and data assumption). However, with Version 2 there is a need to separately present the results for landfilling (based on WARM, a national tool) and lifecycle emissions (now based on California-specific data that also includes expanded quantification of upstream lifecycle impacts). This separation maintains the same distinction of types of waste-related emissions found in protocols and emissions inventory schemes and Climate Action Plans.

WARM version 12 includes carbon sequestration credit for organic materials deposited into landfills. As such, dimensional lumber, yard waste, cardboard, and other organic materials that are landfilled include a portion of negative emissions due to sequestering carbon in landfills (in addition to positive emissions from as methane production at landfills). These sequestration credits in WARM temper the effects of alternative waste reduction scenarios (recycling, composting or combustion), sometime substantially or even surpassing the benefits from recycling. While the sequestration issue was present in WARM v9, it is now even more apparent when we compare WARM landfill numbers to CARB recycling/composting emissions factors. In some cases (such as dimensional lumber), the sequestration credit given by landfilling in WARM is greater than the emissions benefit from recovering wood for biofuel in California. Therefore, in our Calculator we choose to zero-out those parts of WARM where landfill sequestration credit is given. This concept and rationale are explored in depth in Appendix B: Recommended Materials Management Emission Factors & Presentation of Results for the GreenPoint Rated Climate Calculator, a memo produced by ICLEI for StopWaste.Org in 2011.

An example of the combination of WARM and CARB RERFs/CERFs is shown in the following table that was adapted from the ICLEI memo found in Appendix B. See column "C" for examples on how the WARM and CARB emissions factors are combined in this new approach.

Table 6: Sample Emissions Factors as Applied to a GreenPoint Rated Home's Typical Waste Profile

Percent of C&D Waste, Alameda County. From Waste Characterization Study, M. Southworth		Landfill Emissions $MTCO_2e$/Ton			**C. Life-Cycle Emissions $MTCO_2e$/Ton**	
		No LFG	LFG and Flaring[d]	LFG with Generation	**ARB**	**WARM**
Corrugated Containers	6%	2.27	0.03	-0.01	**-5.00**	
Yard Trimmings [a]	21%	0.79	0.34	0.29	**-0.42**	
Lumber [b]	42%	1.17	0.12	-0.02	**-0.21**	
Drywall (methane from paper backing) [c]	13%	0.18	0.18	0.18		**0.03**
Mixed Metals	3%					**-5.40**
Concrete	15%					**-0.01**
Asphalt						**-0.08**
Asphalt Shingles						**-0.09**

[a] Life-cycle factor represents composting as the management strategy
[b] Life-cycle factor represents combustion as the management strategy
[c] The WARM recycling pathway for drywall includes agricultural gypsum as the primary outcome of diversion; relatively little recycled drywall displaces production from virgin material.
[d] This set of factors is utilized in the calculation for the prototypical house

This new methodology of pairing WARM and CARB emission factors is being referenced by ICLEI in the new Action Planning module in the California SEEC (Statewide Energy Efficiency Collaborative) online Climate and Energy Management Suite.[7] Importantly, the SEEC tools (and the Climate Calculator V2) portray results from landfilling emissions based on WARM, and lifecycle impacts based on CARB/WARM combination. SEED and GPR CC V2 keep the reporting of these two emissions sources separate, which is a change from Version 1 where total WARM numbers (landfill + lifecycle) were added together. This new separation is more in line with actual emission accounting schemes (scopes), plus eliminates the apples-to-oranges comparison between WARM and CARB emissions estimates for landfills and lifecycle impacts. The approach developed during this Climate Calculator V2

[7] http://californiaseec.org/tools-guidance/seec-climate-and-energy-management-suite-1

scope of work is being leveraged by other agencies and organizations in order to create a consistent way of estimating emission reductions due to construction waste recycling in California.

Impacts in Homes

The landfill impacts of several homes are shown below. The emissions from landfilling between WARM 2009 and WARM 2012 change by a relatively small amount because the WARM values themselves changed very little. The variation between homes seen in Figure 14 is a result of the different constitution of materials generated and disposed of in each home. For example, home number 2 had a large amount of concrete in the waste stream, which has a relatively low emissions impact in landfills. Home 14 also had much more waste generation, resulting in higher emissions. Homes 7 and 11 had similar amounts of waste, but contain significant amounts of lumber in the waste stream (which have been zeroed out due to the sequestration issue mentioned above) and therefore overall landfill emissions are quite low.

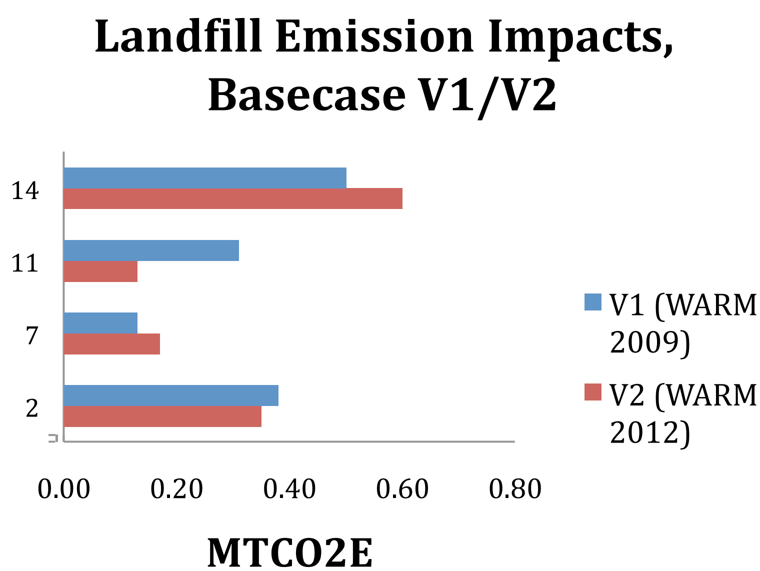

Figure 14: Landfill Emission Impacts in Basecases 1 and 2

Results comparing the lifecycle emissions impacts of V1 and V2 are shown in Figure 15. Note that the difference are again shown by the make-up of materials in the diverted waste stream; some materials have low recycling/composting emissions reductions while others have relatively high negative emissions.

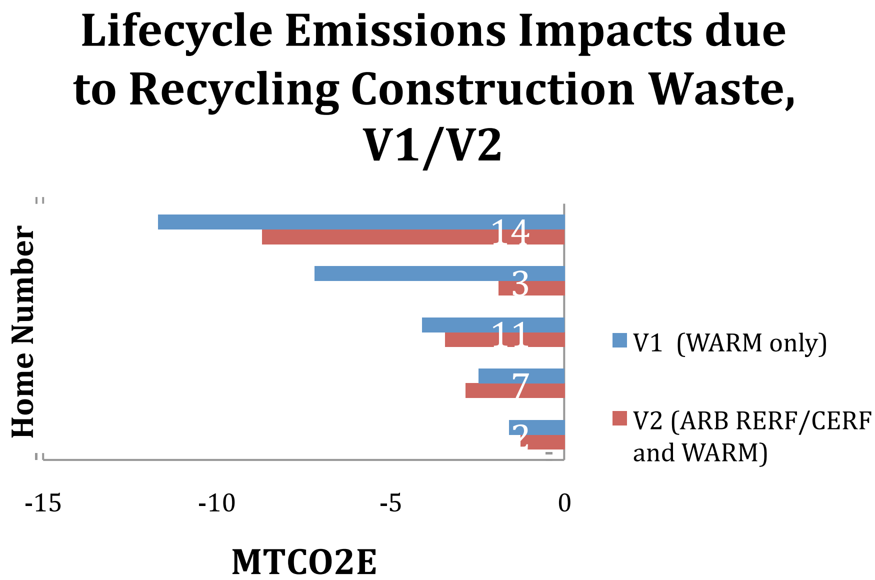

Figure 15: Lifecycle Emissions Impacts due to Recycling Construction Waste, Versions 1 & 2

4.13. Feedback from Raters

In addition to quantitative feedback (Figures 3, 3-2, 5, 6, 7, 11, 12 & 13), GreenPoint Raters provided qualitative feedback on the success and barriers of obtaining the required data points as well as the time required to gather data. Seven GreenPoint Raters were asked to use the new version of the calculator and provide qualitative feedback on their experience collecting data and using the new calculations. Build It Green convened a roundtable forum for the Raters to share their experiences in using both Version 1 and Version 2 of the tool.

The GreenPoint Raters offered a number of suggestions to revise the data inputs for ease of use and reduced calculations for the Raters as well as availability of data. Their feedback is summarized in the following sections: energy, Water, Materials and General use of the tool.

Energy
Raters reported confusion over inconsistencies in the language used in the Project Application Form instructions, and the reports from energy modeling software. They also needed clarification on how to do energy valuation for the Existing Home Elements projects. To address these issues, Build It Green will amend the language of the instructions and create a full guide on where information can be found, including examples of project descriptions and files.

Most of the discussion was focused on the difficulty in obtaining energy modeling reports or exports from the software from energy consultants required for the revised TDV evaluation of emissions associated with energy efficiency.

> "The proposed energy evaluation which required the Rater to obtain a copy of the energy file from the energy consultant was a barrier to obtaining the data as well as confusing to explain the process of creating the file itself."

This comment led the project team to re-evaluate the process of obtaining the data and ultimately the quantification was built into the modeling software itself. Therefore the Rater does not need to complete any calculations and can request a specific report that includes the specific data needed for the GPR Calculator.

Water

In refining the evaluation of embodied energy, the hydrological zone for each project would be required to calculate the embodied energy of water. Raters were asked to look up a map, identify the hydrologic zone and manually select it. Initially Raters reported difficulties using the hydrologic zone map because the map granularity was too coarse and the county and hydrologic zone boundaries didn't match, with some counties covering more than one hydrologic zone.

As a result, the team was able to obtain a list of the hydrologic zones based on zipcode, so the additional information required to better quantify the impacts of water conservation does not require additional inputs from the Rater.

They also experienced confusion over the documentation of greywater and rainwater catchment systems as only estimates are available due to the fact that these systems are not metered. To remedy these issues, Build It Green will specify in the instructions that the greywater and rainwater reporting should be based on system design rather than actual usage.

Materials

By adding the embodied energy of materials in particular carpet, the initial inputs required by the Rater were cumbersome to obtain.

> "*Think of recording flooring for a 200 unit project, that can add a lot of time.*"

As a result the team evaluated the critical data points and reduced the required inputs while still achieving the goal of quantifying embodied energy associated with carpet and hardwood flooring.

Waste diversion was another section where Raters were required to provide a number of data points. As waste diversion can be difficult to track, it was suggested to clarify the inputs of recycled and diverted waste, total generated waste and garbage. Additionally, where possible the inputs should be based on the typical information received in the industry and conversions or additional calculations should be built into the Climate Calculator.

> "*Provide volume to weight calculations for each area of checklist that asks for weight or better yet Build conversion table into form*"

General Use of the Tool

As the data fields and inputs are expanded this increases the time and effort required to complete the rating. In order to reduce time and effort to complete the rating and increase the possibility of gathering all data for the climate calculator, the climate calculator should have defaults where possible, have calculations built into the Calculator, and use data the Rater is already collecting.

> "Reduce the amount of inputs required by the Rater by using automatic look up tables integrated into the Climate Calculator. It will save us time as well as reduce the request for information from the builder. Reduce the calculations the Rater needs to complete outside the form. Integrate calculations into the Climate Calculator itself."
>
> "Clarify units for items such as greywater and rainwater and waste."

Based on the feedback the project team evaluated the feasibility of utilizing the proposed calculations and data points and identified next steps as necessary. These recommendations will allow Build It Green to revise the tool for optimal implementation by Raters to be able to quantify climate benefits of the GPR projects.

4.14. Total Emissions

The total energy footprint emissions of a subset of GreenPoint Rated homes investigated for this study are presented below. The set of buildings reviewed for Version 1 and 2 are few, therefore are not expected to represent averages across a larger pool of homes. However, the homes in Figure 16 represent several different types of homes and provide useful insight into how the Climate Calculator recognizes the new data and assumptions from Version 2 as compared to Version 1. Further research is recommended to greater understand anticipated results from a wider array of building types, vintages, and design strategies (such as Passive Haus, zero net energy, or LEED compliant).

The 1140sf, 2-bedroom home in Figure 16 represents an above code green home with good energy performance above energy code minimums. The home is small so is able to capture some benefits from embodied energy savings in the new materials methodology which do not show up in these charts. Interestingly, although the basecase was reduced from V1 to V2, the total footprint for the green home remained virtually the same because the V1 assumptions for energy (flat consumption) closely matched the more accurate time-dependent emissions rate, based on heating/cooling demand and utility area.

The second home in the figure (1680 sf 3 bedroom) shows emissions estimates going up with Version 2. This increase is due to the energy time-dependent emissions factors based on where the home is located and the needs for cooling in the summer, the effects of which are enhanced in Version 2 (and may explain the substantially large net increase over Version 1).

The third example provides an interesting look at how zero energy homes are modeled under the Climate Calculator. This home was constructed to far exceed energy code and includes solar electric and hot water systems. Because of the somewhat erratic behavior of the chart (with extremely divergent positive and negative emissions numbers for baseline and actual cases), it is likely that further research into more accurately modeling zero energy homes using the metrics provided in GreenPoint Rated is necessary (i.e. energy modeling software is not an accurate way to model homes that greatly exceed minimum energy code requirements AND have renewable energy generation).

Home number 4 (3 bedroom, 2450 sf) represents an emissions profile that was anticipated at the start of the study to be the most common type of outcome for V2 updates. That is, the baseline and actual footprint emissions numbers decrease in-step from V1 to V2 due to the stricter basecase and more accurate estimations for emissions based on energy consumption.

The fifth home (4 bedroom, 3370sf) shows that the footprint for Version 2 has gone up substantially from Version 1. Again, this is likely due to the home's location and heating/cooling demand.

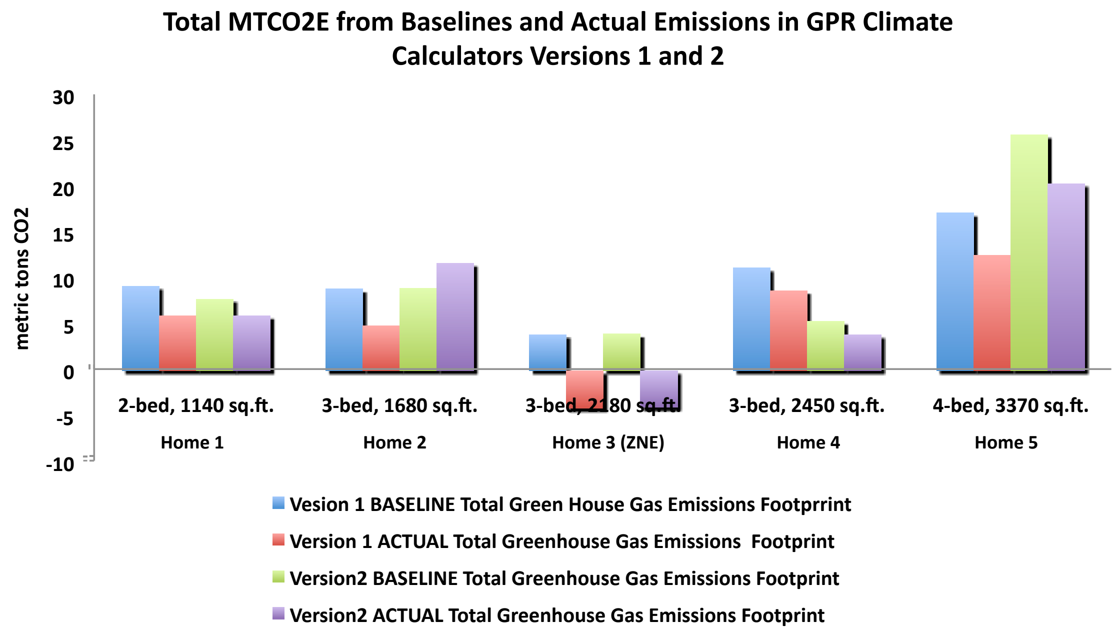

Figure 16: Total metric tons CO2e from baseline and actual cases of GreenPoint Rated Climate Calculators Versions 1 & 2

5. Discussion

The purpose of this study was to validate and update the GreenPoint Rated Climate Calculator with best available greenhouse gas calculation methodologies and to expand the capacity of the tool to provide valuable estimates of greenhouse gas impacts of home construction and renovation projects in the state of California.

Time Dependent Emissions
The inclusion of time dependent emissions provides a more accurate assessment of a home's climate impact by accounting for electricity consumption at peak and non-peak hours. The methodology developed for GPR Version 2 scales hourly emissions estimates from GPR compliant software for each California electric utility by emissions estimates from peak and off-peak power used in Title 24 part 6 time dependent valuation data.

With this new methodology that takes into consideration emissions at hours of peak demand, homes in high cooling areas will have both higher emissions and larger potential emission reduction opportunities, on average, than homes in areas with low cooling demand.

It is important to note that the TDV underlying data was not intended for this purpose. The Title 24 part 6 TDV calculation assumes alternating between natural gas and diesel backup generation at different hours of the year. The model does not consider that other backup systems would be used (e.g., stored hydro). Also, the estimates were for two utilities only (PG&E and SCE) and are now several years out of date. Our approach is to use these as scaling factors. On the aggregate, over the course of a year, the model does yield higher emissions during summer cooling hours, as would be expected.

Energy Consuming Appliances
This study suggested no major changes to the methods used to calculate energy consumption for household appliances. The current method uses U.S. EPA Energy Star calculators to estimate energy consumption (electricity and natural gas) for a range of household appliances. While we found Energy Star calculators to be not entirely consistent with average usage rates for certain appliances (e.g., clothes washers), we were not able to develop regressions models or other methods that could accurately predict energy consumption based on the assets of homes (e.g., number of bedrooms, bathrooms, etc.).

Home Size Efficiency
This study used regression analysis to attempt to develop a model of estimated energy usage for homes of different sizes; however, the size of the relevant data subset of the validation process was insufficient to support or discredit the use of the current methodology.

Interactive Prescriptive Energy Efficiency Effects
The current methodology for evaluating interaction effects between different prescriptive measures in GPR is to use a table of presumed interaction effects. A more accurate way

to account for interaction effects would be for Raters to use the whole home energy model; however this is too burdensome for the GreenPoint Rated Elements program which only considers the addition of certain features to homes and does not require a full home energy audit. The stakeholders agreed that the current table seemed a reasonable first approximation to limit the benefits of adding multiple prescriptive measures together that seek to limit emissions from a single source (such as adding attic insulation and a more efficient heater).

Shade Trees

The current study proposes no changes to the current estimate for energy savings from shade trees. While the energy savings from reduced cooling load can be considerable for trees that shade large portions of homes accurately modeling this benefit was beyond the scope of the current study.

Advanced Refrigerants and Leakage

This study substantially updated GHG estimates from refrigerants and refrigerant leakage. See Appendix A for the full list of refrigerants now considered in GPR Version 2.

Indoor Water

Estimates of indoor water usage were changed considerably in the current tool. First, the occupancy formula for the new tool assumes fewer people occupy homes with more than one bedroom. The previous GPR calculator considerably overestimated building occupancy for typical homes, assuming two people occupied one bedroom in each home and one person also occupied each additional room. The new estimate is based on average household occupancy per room using the Residential Energy Consumption Survey (RECS) data for California. This more realistic estimate reduces total household water consumption considerably for larger homes (a decrease of over 30% for 4-bedroom homes) and slightly increases water consumption for single-bedroom homes (an increase of 7%). Second, the formula for calculating water consumption was changed to ignore the number of fixtures in home; the assumption is, for example, that having more showers in the home does not result in more people taking showers. Third, the new tool assumes fixtures with different efficiency ratings are used, on average, the same amount of times by household members. And fourth, the tool allows for a more accurate end use of rainwater and greywater systems. The net effect of these changes is reduced water consumption estimates for most homes (a reduction of between about 30% and 70% for both baseline and rated homes).

Outdoor Water

No major changes were recommended for outdoor water. The stakeholders agreed that GPR should be consistent with Model Water Efficient Landscape Ordinance (MWELO). GPR Version 2 does include minor adjustments for rainwater and greywater, allowing Raters to determine the end use of these water collection systems.

Embedded Energy and Emissions of Water

This study provides a substantial update to the embodied emissions of water. The previous study assumed a simple two-region water model (Southern California and the rest of the state). The new model uses data from updated CPUC report "Embedded Energy in Water Studies" to estimate embodied energy from 10 hydrological zones in California. This more accurate assessment considers average rates of water extraction and water imports for each region. While this new 10-zone model is an improvement over the previous 2 zone model, it hides differences within regions. For example, the model assumes average emissions from imported water (conveyed over an average distance) even if a city gets all of its water from local sources. The new model generally results in lower emissions for Southern California regions (where all water was assumed to be imported over a mountain pass) and an increase in Northern California locations.

Materials

The Oregon DEQ study, used as the basis for embodied emissions in materials, represents an important step forward in quantifying emissions from the full lifecycle of buildings. Using data from this study, we were able to estimate emission reductions from 1) reduced homes size, 2) durable roofing materials, and 3) durable flooring. Taken together, these measures provide reductions of upwards 30 metric tons CO_2 for more than one of the sample homes modeled by Raters for this study. By comparison, the average home has annual emissions from electricity and natural gas combined of 4 to 5 metric tons CO_2.

Recycling of construction and demolition materials provides another substantial source of emission reductions; however, GPR Version 2 reduces the impact of C&D recycling overall due to new California standards that require C&D recycling of 50% of materials or more. An important finding and contribution of this study is the new combined emission factors for C&D waste materials using a combination of emission factors from the California Air Resources Board (CARB) and the EPA WARM model.

Field Testing

The old and new versions of the GreenPoint Rated Climate Calculator were compared in the field by several GeenPoint Raters for a total of 14 homes. The Raters provided qualitative input on the ease or difficulty of gathering the additional data points and using the new tool. Build It Green used this information to generate quantitative results to compare the two tools (see figures in main report for each section). This process was useful to identify and reduce potential sources of confusion and resulting user error while at the same time validating the ability of Raters to successfully deploy the tool in the field.

6. Summary and Conclusions

The GreenPoint Rated Climate Calculator is widely regarded as a credible rating of the greenhouse gas footprint of California residential building construction and renovations. The rigor and comprehensiveness of the tool help make GPR the most popular green building rating program in the State of California. This study extends the capacity of this tool to provide useful information to developers, building owners and municipal governments. This study also contains a number of results, which contribute to understanding of emissions associated with residential buildings.

Some of the most interesting and relevant findings are:

1. **Validation of most of GPR's existing methods**
   Most of the existing methods in Version 1 of GreenPoint Rated Climate Calculator were found to be based on best available evidence by the research team and these findings were extensively peer-reviewed by multiple expert stakeholders.

2. **A more accurate estimate of the number of building occupants**
   Existing standards for green building (e.g., 2010 California Green Building Standards Code) appear to overestimate occupancy of buildings based on an over-simplified assumption of two occupants in the first bedroom and one occupant for each additional bedroom. This assumption leads to overestimates of water consumption of homes. The current research project uses a simple linear regression formula to estimate occupancy based on actual California homes (in the RECS survey), providing a more accurate assessment of building occupancy, and related water consumption.

3. **A new methodology for calculating "time-dependent emissions" from electricity**
   This study presents a new model for estimating emissions based on hourly use of electricity, as modeled in Title 24 – compliant software. This new approach modifies the emission factor of each California utility on an hourly basis, accounting for expected peak and non-peak emissions. The result is higher emissions and emission reduction opportunities for homes in high cooling zones.

4. **A new method for embedded energy and greenhouse gas emissions from water consumed in 10 different hydrological regions in the state**
   The previous GPR calculator (and other tools, such as the CoolCalifornia calculators), account for embedded energy and associated GHG emissions of water consumption based on an older 2-region model of California. This report develops a 10-region model based on new research by the California Public Utilities Commission of embedded energy in water, and an estimate of related GHG emissions for each region. The result of this change, dramatically increases the carbon intensity of water consumed in northern hydrological zones and

dramatically decreases the carbon-intensity of water consumed in the two southern hydrological zones, compared to the previous estimate.

5. **Inclusion of embodied emissions in home construction**
   Few studies or carbon calculators consider GHG emissions embedded in home construction materials. Using data from a recent study sponsored the Oregon Department of Environmental Quality; this study estimates emissions of building materials and provides one-time reduction in GHG emissions for homes that are smaller than the base case (due to fewer materials used), and for durable wood flooring and asphalt shingles.

6. **A new way to quantify construction waste recycling using a combination of EPA and CARB emissions factors**
   This study updates emissions used to estimate waste and recycling emissions from construction materials using a combination of California-specific data provided by the California Air Resources Board and the U.S. EPA WARM Model. This new methodology has broad applicability for other tools, codes and programs in the state and has already been incorporated in the Statewide Energy Efficiency Collaborative (SEEC) online carbon management tool developed by ICLEI – Local Governments for Sustainability.

GreenPoint Raters have tested the GreenPoint Rated Climate Calculator Version 2 in the field and have validated the ability to successfully collect data and administer the new tool in the field. In total GPR Raters evaluated 14 homes. Overall, the new changes to GPR Version 2 will have mixed results for different homes; in some cases increasing emissions, and in other cases, decreasing emissions. Importantly, these differences reflect more accurate assessment of emissions and emission reductions than Version 1 and also over other tools and rating programs that use outdated methods.

7. Recommendations

The GreenPoint Rated Climate Calculator is already an industry standard tool for calculating the greenhouse gas emissions from residential home construction and renovation. The current study validates and expands upon this tool by refining and adding new features, which are currently offered in no other building rating system or home carbon calculator. It is hoped that the results of this study can help inform the development of other similar tools and programs in the future.

A number of improvements are still needed to expand the capacity of GreenPoint Rated Climate Calculator and to keep the tool in line with new standards and data sources that are expected to emerge in coming years. It is also important to continually identify research areas to improve greenhouse gas estimates for homes. For example, econometric analysis could be a useful tool to provide improved estimates of energy and water consumption based on the assets of homes. This information would help clarify the extent to which asset-based tools and programs can be used to predict real world occupant behavior. Additional field testing of the GPR Climate Calculator using a much larger sample of homes would be useful to evaluate the impact of the rating system on GHG reductions in the state and help inform needs for Version 3 of the GPR Climate Calculator.

The stakeholder engagement process highlighted the need for further coordination among a wide range of actors engaged green buildings research, tool development, policy and programs throughout California. Such a process would be instrumental in improving building codes to be in line with best available research and practice in the field. An expanded GreenPoint Rated study would improve the State's confidence that green building policies and programs will help meet California's 2020 and 2050 climate goals.

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Glossary of Abbreviations and Acronyms

AB 32	Assembly Bill 32, California State
Btu	British thermal unit(s)
CARB	California Air Resources Board
CFC	chlorofluorocarbon
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
g	gram(s)
GHG	greenhouse gas
GWP	Global Warming Potential
HVAC	heating, ventilating, and air conditioning
IPCC	Intergovernmental Panel on Climate Change
J	joule
kg	kilogram(s)
kWh	kilowatt-hour(s)
lb(s)	pound(s)
MMBtu	one million British thermal units
mpg	miles per gallon
MSW	municipal solid waste

Rater	GreenPoint Rater
t	metric ton(s)
sf	square feet
MWh	megawatt-hour(s)
N_2O	nitrous oxide
NOx	oxides of nitrogen
T-24	California Building Energy Efficiency Standards (Title 24, part 6)
TDV	time dependent valuation
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Appendix A: Total List of Advanced Refrigerants, Climate Calculator Version 2

Advanced Refrigerant	Ozone Depleting Potential (ODP)	Global Warming Potential (GWP)	Common Building Applications
CFC-12	**1**	**10,720**	**Baseline refrigerant**
Ammonia	0	0	Natural refrigerant type, replace R-22/142b, new construction. [LEED 2009, EPA] http://www.sznorinco.com/chemicals/dy/proe23.html
Carbon dioxide	0	1	Natural refrigerant type [LEED 2009]
Desiccant Cooling	0	0	Replace R-22/142b, new construct [EPA]
HFC-134A	0	1320	Replace CFC-12 or HCFC-22 replacement [LEED 2009, EPA]
HFC-23	0	12240	Ultra low temp refrigerant [LEED 2009]
HFC-245fa	0	1020	Insulation agent, centrifugal chillers [LEED 2009]
R-407C	0	1700	Replace HCFC-22 replacement [LEED 2009]
R-410A	0	1890	Air conditioning [LEED 2009, EPA]
ISCEON 59, NU-22, R-417A	0	2350	Replace R-22/142b, new construct/retrofit [EPA]
KDDA, R-438A	0	2270	Replace R-22/142b, new construct/retrofit [EPA]
Propane	0	3	Natural refrigerant type [LEED 2009]
R-125/134a/600a	0	1990	Replace R-22/142b, new construct/retrofit [EPA]
R-404A	0	3900	Replace R-22/HCFC blends, no construct/retrofit, low-temp refrigeration [LEED 2009]
R-407A	0	2110	Replace R-22/142b, new construct/retrofit [EPA]
R-407F			Replace R-22/HCFC blends, new construct/retrofit
R-410B	0	2230	Replace R-22/142b, new construct/retrofit [EPA]
R-421A	0	2630	Replace R-22/142b, new construct

			[EPA]
R-422B	0	2530	Replace R-22/142b, new construct/retrofit [EPA]
R-422C	0	3390	Replace R-22/142b, new construct/retrofit [EPA]
R-422D	0	2730	Replace R-22/142b, new construct/retrofit [EPA]
R-424A	0	2440	Replace R-22/142b, new construct/retrofit [EPA]
R-427A	0	2140	Replace R-22/142b, new construct/retrofit [EPA]
R-434A	0	3250	Replace R-22/142b, retrofit [EPA]
R-437A	0	1810	Replace R-22/142b, new construct/retrofit [EPA]
R-507, R-507A	0	3900	Replace R-22/HCFC blends, no construct/retrofit, low-temp refrigeration [LEED 2009]
RS-44	0	2420	Replace R-22/142b, new construct/retrofit [EPA]
THR-03	0	831	Replace R-22, new construction (window units only) [EPA] http://www.cfs.co.uk/sustainability2003/ecological/conversions.htm

Appendix B: ICLEI Memo on Construction Waste Recycling Emissions Factors

Recommended Materials Management Emission Factors & Presentation of Results for the GreenPoint Rated Climate Calculator

November 15, 2011

Mike Steinhoff, Senior Program Officer
Kara Reeve, Project Manager

Prepared for:
Wes Sullens, Program Manager
StopWaste.Org of Alameda County

ICLEI–Local Governments for Sustainability USA

ICLEI USA Headquarters
180 Canal Street, Suite 401
Boston, MA 02114
USA

Phone: (617) 960-3420
Fax: (617) 248-3974
E-mail: iclei-usa@iclei.org
Website: www.icleiusa.org

U.S. Regional Offices
Midwest – Chicago
Southeast – Atlanta
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Freiburg, Germany

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The mission of ICLEI USA is to build, serve, and drive a movement of local governments to advance deep reductions in greenhouse gas emissions and achieve tangible improvements in local sustainability.

Executive Summary

Build It Green's GreenPoint Rated Climate Calculator is a tool used by developers and independent raters for assessing the climate and other environmental benefits achieved by producing high performance and resource efficient homes. Recent new developments in emissions factors and accounting methods for materials management present the opportunity to improve the function of the calculator in this area. This memo provides guidance towards the further development of materials management related calculations in the tool, with the goals of:

- Providing greater accuracy in the outputs
- Harmonizing the tool with other calculators and emissions factors from the California Air Resources Board
- Allowing the outputs of the Climate Calculator to better support municipal scale adoption of green building initiatives in climate action plans and other greenhouse gas mitigation programs
- Identifying directions for future improvements as supporting data becomes available

Emissions reductions from materials management comes from two different categories. One is from reducing direct contribution of landfill methane from organic materials in the waste stream. The second is from changes to emissions generating processes in material supply chains or changes in biological carbon stocks that result from recycling and composting activities, respectively. New emissions factors for both categories will allow for more refined estimates and ICLEI recommends the following.

- For direct landfill emissions, ICLEI recommends the use of disaggregated landfill methane generation factors found in the material type documentation of the EPA's WARM v 11 tool.
- For indirect emissions impacts, ICLEI recommends the use of the Recycling Emissions Reduction Factors (RERF) and Composting Emissions Reduction Factors (CERF) produced by the California Air Resources Board (ARB), which better represent outcomes of materials management practices specific to the State of California than the national-scale factors found in the WARM tool, for those material types where RERF or CERF value from ARB exists. Specifically for corrugated cardboard, dimensional lumber, and yard trimmings.

In addition to improving the existing calculation types, there are opportunities to include additional materials management calculations to the Climate Calculator as more data becomes available. With regard to construction practices, it is possible to add source reduction strategies achieved from advanced framing techniques to account for the climate benefits of reducing material inputs to a building project. Because the Climate Calculator is aimed at new construction activities, the opportunity to include material re-use as a strategy seems limited, as the availability of materials and their usability would be dependent on project specific factors. This addition faces significant challenges. Currently only EPA WARM provides reduction factors for source reduction. Applying WARM factors for source reduction and ARB factors lumber diversion would lead to the use of inconsistent methodologies for forest carbon and lumber between the two calculations. This challenge would need to be addressed in order to maintain quality standards in the Climate Calculator; however the contribution of source reduction is significant and can potentially provide larger reductions than other materials management options.

Another additional benefit calculation could be included from the addition of dedicated spaces in a home for making participation in household materials management activities more convenient. Adding the ongoing impacts that such features would would allow the Climate Calculator to capture the full climate benefits of GreenPoint Rated homes. However more investigation is needed to determine the marginal impact of recycling and composting program participation from those features.

Lastly the presentation of the results from each individual calculation is key to enabling the results of the Climate Calculator to be applied beyond the rating of an individual development project. Landfill emissions benefits and those derived from other aspects of materials production, distribution and end use, or life-cycle benefits, are fundamentally different in terms of where the reductions take place and how they change or don't change the local emissions that a municipality may be trying to address through a green building strategy based on GreenPoint Rated. Clear separation of the results of both types of calculations will help policy makers more clearly understand how materials management and those aspects of green buildings reduce the emissions both locally and globally.

Introduction

In reviewing *Build It Green's GreenPoint Rated Climate Calculator* (Climate Calculator) for single-family and multifamily homes, several opportunities for improved calculations and overall treatment of emissions reductions associated with construction and demolition waste management have been determined. The aim of these enhancements will be to 1) improve the accuracy of calculations to tailor them to the California context, instead of relying on national average values for all calculations, and 2) to adjust the presentation of results to disaggregate landfill methane from other life cycle (upstream and downstream) emissions impacts of recycling, composting, and other materials management options. Disaggregating the various impacts of these actions will allow local governments to better utilize results from GreenPoint Rated in their community-scale climate action plans and progress reports and give decision makers more clarity of the role of materials management plays in managing local greenhouse gas emissions.

Improvements to the Climate Calculators are driven mainly by recent improvements to the reference data and emissions factors which form the basis of the calculations in the tool. These improvements include recent work by the California Air Resources Board (ARB) to produce recycling emissions reduction factors to support implementation of the State's AB32 Scoping Plan. To date, the Climate Calculators have relied on emissions factors taken from the USEPA Waste Reduction Model (WARM), but the use of WARM has faced challenges due to the way that only summary factors that represent a range of processes were presented in the tool. Therefore, the structure of WARM has made it difficult for users primarily interested in local impacts to disaggregate climate impacts of various waste management strategies. Fortunately, in November 2010, WARM version 11 was released with a number of significant changes to the model. In addition to a wider range of material types covered, a number of new model documentation resources were released that now enable interested parties to better understand the individual components of the final factors as applied in WARM.

Direct Landfill Emission Factors

In the past, many direct landfill emission factors represent the net emissions between methane emissions from anaerobic decay of organic material multiplied by the global warming potential of methane, minus the carbon in the portion of each material which does not break down. Factors presented in this way essentially credit that remaining carbon as being "sequestered" in the landfill. It should be noted that previous versions of the Climate Calculator, as well as tools from other organizations, do not recognize landfill sequestration as an emissions "credit" that would subtracted from a greenhouse gas inventory baseline or a materials management strategy. ICLEI-USA recommends reporting of gross emissions, and the upcoming Community-scale GHG Emissions Accounting and Reporting Protocol (expected release Summer 2012) will not subtract any sequestration credits to lower an inventory baseline.

However, it should also be noted that the way in which factors were taken from the WARM tool directly for use in the GreenPoint Rated Climate Calculator, an implicit credit for sequestration was included due to the way that WARM presents aggregate factors for all the processes. For example the (-0.34 $MTCO_2e$/Ton) factor for landfilling yard trimmings in GreenPoint Rated was included in the tool but not actually used, due to the fact that it was a net negative number that represented more carbon sequestration than emissions generated for each ton of yard trimmings landfilled. Whereas the value of 0.33 $MTCO_2e$/Ton for landfilled corrugated containers was used in GreenPoint Rated also includes sequestration, however the sequestration component is simply outweighed in that case by the methane component, resulting in net emissions avoided when material is diverted from the landfill. The actual amount of methane reduced by diverting corrugated containers is higher than the value of 0.33 $MTCO_2e$/Ton would indicate.

With the latest release of WARM (v 11), documentation materials were released that more fully describe the derivation of each of the factors that are applied in the tool. This enhancement now enables users to disaggregate the factors applied in WARM, and by utilizing the reference material, the outcomes of waste management strategies according to which emissions generating process is affected by an action and is now a reference source for total landfill methane generation can be determined, without any sequestration credits embedded in the figures. Table 1 below depicts ultimate landfill methane generation values for organic material contained in the Climate Calculator as reported in the associated documentation for each material type from the EPA WARM documentation website.

Table 1. Gross GHG emissions from landfill methane generation (excluding transportation, sequestration, etc.) (MTCO2e/Ton) for Organic Materials.

Waste Type	No LFG Collection	LFG Collection and Flaring	LFG Collection with Generation
Corrugated Containers	2.27	0.03	-0.01
Yard Trimmings	0.79	0.34	0.29
Lumber	1.17	0.12	-0.02
Drywall (methane from paper backing)[a]	0.18		

a. Drywall assumed by WARM to be disposed of in a C&D landfill without LFG collection

Three sets of values are available from the WARM (v 11) documentation for the different landfill gas management techniques that may be employed at the receiving landfill. Those landfills with no landfill gas collection present the highest benefit for material diversion. If the landfill gas is being collected and destroyed at the receiving landfill, the benefit of diverting material is somewhat diminished. If a receiving landfill is collecting the gas and putting it to beneficial use in the creation of electricity, than reducing it can result in an emissions penalty by removing a source of biogenic derived electricity, which would be replaced by fossil fueled grid electricity, increasing emissions.

For the GreenPoint Rated Climate Calculator, it is likely that either the values for landfill gas (LFG) collection and flaring or LFG collection with generation are most appropriate for use in the tool, given landfill regulation in the State of California. Further research is likely necessary to determine to what extent receiving landfills in the area are producing electricity and whether it is appropriate to consider that as an outcome of material diversion.

As an exercise to determine the potential impact some of the changes made to the WARM v 11 could have on the Climate Calculator, landfill emissions values were extracted from WARM v 11 under a variety of different settings and compared to those in Version 1 of the Climate Calculator. Table 2 depicts landfill emissions factors from Green Point Rated Climate Calculator and WARM v11. Because no differences were found between the Climate Calculator and WARM v9.01 (they were the same), those factors are omitted here. ARB did not evaluate landfills in its analysis.

Table 2.

WARM Breakdown: Direct Landfill Emissions (MTCO2e/Ton) of Organic C&D Materials								
	Green Point Rated Climate Calc.	WARM v11						
		National Avg LFG Collection	Dry K, Typical	Average K, Typical Operation	Wet K, Typical	Dry K, Aggressive	Average K, Aggressive	Wet K, Aggressive
Corrugated Containers	0.33	0.08	-0.58	-0.54	-0.45	-0.60	-0.57	-0.50
Yard Trimmings	-0.34	-0.11	-0.38	-0.24	-0.12	-0.43	-0.33	-0.26

WARM v11 gives the user an opportunity to evaluate a number of different landfill conditions for moisture regime and the degree to which landfill gas collection is applied at the disposal site. In all of the cases where these variables were altered, landfill sequestration outweighed methane generation, which would credit landfill disposal as a climate positive option if these values were used. When applying the settings to use "National Average LFG Collection" rates, a positive value of 0.08 MTCO2e/Ton did result for corrugated containers, which would give diversion of that material a climate positive result (for reference, the emissions factor range for recycling of corrugated containers is (-3.1) – (-5.0). This setting would be the equivalent of the settings applied in WARM v9.01 and is thus a point of comparison with the 0.33 MTCO2e/Ton value previously used. Using WARM v11 in this case would reduce the benefit of diverting corrugated containers from landfills by 0.25 MTCO2e/Ton.

This analysis is instructive on the capabilities of the latest version of the WARM tool, however it was found to have little applicability to the next version of the GreenPoint Rated Climate Calculator due to the fact that factors reported in the tool itself have other processes including landfill sequestration embedded in them. The WARM documentation was referenced in order to obtain the direct landfill emissions factors without modification by sequestration values. Those values are presented later in Table 7 of this document. One limitation of taking the values from the WARM documentation is that they do not include the additional detail on the influence of landfill conditions in shown above in Table 2. Those modifications only appear in the WARM tool.

Recycling Emission Reduction Factors

Recycling Emission Reduction Factors (RERF)s describe changes to emissions outcomes that result in (future) upstream production processes as a result of providing recycled feedstock materials to be used in place of virgin materials that would require more energy to extract and process. There are a number of different sources of RERF values, all with slight differences as a result of different assumptions and data used to calculate the values. Table 3 summarizes values from several sources for comparison. Sources included here are the current GreenPoint Rated calculator, two recent versions of the WARM model, California Air Resources Board, and the Canadian Greenhouse Gas Calculator for Waste Management (GGCWM).

Table 3. Comparison of Recycling Emissions Reduction Factors (MTCO2e/Ton Reduced)

	GPR Climate Calc.	WARM V 9.01	WARM v 11	ARB	GGCWM
Aluminum Cans	-13.67	-13.67	-13.61	-12.90	-8.75
Steel Cans	-1.80	-1.80	-1.80	-1.50	-1.07
Copper Wire	-4.97	-4.97	-4.97		
Glass	-0.28	-0.28	-0.28	-0.20	-0.09
HDPE	-1.40	-1.40	-1.38	-0.80	-2.06
LDPE	-1.71	-1.71	-1.67		
PET	-1.55	-1.55	-1.52	-1.40	-3.29
Corrugated Containers	**-3.11**	**-3.11**	**-3.10**	**-5.00**	**-2.96**
Magazines/third-class mail	-3.07	-3.07	-3.07	-0.30	-2.90
Newspaper	-2.80	-2.80	-2.80	-3.40	-2.49
Office Paper	-2.85	-2.85	-2.85	-4.30	-2.90
Phonebooks	-2.66	-2.66	-2.65	-2.70	-2.97
Textbooks	-3.11	-3.11	-3.11		
Dimensional Lumber	-2.46	-2.46	-2.46		
Medium-density Fiberboard	-2.47	-2.47	-2.47		
Mixed Paper (general)	-3.54	-3.54	-3.51		
Mixed Paper (primarily residential)	-3.54	-3.54	-3.51		
Mixed Paper (primarily from offices)	-3.42	-3.42	-3.60		
Mixed Metals	**-5.26**	**-5.26**	**-5.40**		
Mixed Plastics	-1.52	-1.52	-1.50	-1.20	-1.63
Mixed Recyclables	-2.88	-2.88	-2.87		
Carpet	-7.23	-7.23	-7.22		
Personal Computers	-2.27	-2.27	-2.26		
Concrete	**-0.01**	**-0.01**	**-0.01**		
Fly Ash	-0.87	-0.87	-0.87		
Tires	-1.84	-1.84	-0.39		
Asphalt Concrete			**-0.08**		
Asphalt Shingles			**-0.09**		
Drywall			**0.03**		

The largest observed difference in factors occurs in the corrugated containers category between previous versions of WARM and the new ARB methods. ARB attributes this difference to both the manufacturing stage and forest carbon sequestration portions of their calculations. WARM attributes no manufacturing stage emissions to cardboard, whereas the ARB method attributes an emissions benefit of 1.3 MTCO2e/ton for this component of the RERF. Considerable additional increases in GHG reductions would be observed with the adoption of the ARB value for corrugated containers.

In the mixed metals category, WARM v11 increases the benefit slightly from (-5.26) to (-5.40). ARB did not produce a value for mixed metals. Both versions of WARM state a definition for mixed metals as 29% aluminum and 71% steel. As an experiment, a mixed metals ARB value was calculated here by applying those percentages to the individual metals and summing them together. For ARB this resulted in a value of (-4.81) MTCO2e/ton of mixed metals. This is considerably less than that currently used in GreenPoint Rated. For comparison, the same method was applied to the WARM individual metals to see if the mixed metals value matched. In neither case did it match, yielding (-5.24) and (-5.22) for versions 9 and 11 respectively. Not only did the values not match, the benefit of version 11 is smaller relative to version 9. This contrasts with the published values for mixed metals, where the WARM v11 shows considerably increased benefit when compared to version 9. Whatever the cause, it is clear that WARM attributes different processes to the materials in the mixed metals category than they do for cans, which may be appropriate for the form of the metals found in C&D waste streams. The experimental value for ARB is of little use in this case. It would be desirable for ARB to produce a RERF for mixed metals consistent with their other methods if they are to be the sole source of RERF values used in the Climate Calculator, but until that time, using the WARM factor of -5.4 MTCO2e/ton for mixed metals should be sufficient. .

Lastly, the RERF values for concrete did not change between WARM v9.01 and V11, neither ARB or GGCWM published a value for concrete.

In Summary, ICLEI recommends using the more California relevant factors from ARB. In this case the change only affects the corrugated containers material type since ARB did not produce factors for any of the other waste types that are relevant to the GreenPoint Rated calculators. Table 4 summarizes the recommended factors to be applied in the next version of Climate Calculator for recycling.

Table 4 Recommended RERF factors for application in the GreenPoint Rated Climate Calculator

Material Type	Value $MTCO_2e$/Ton	Source
Corrugated Containers	-5.00	ARB
Drywall	0.03	WARM
Mixed Metals	-5.40	WARM
Concrete	-0.01	WARM
Asphalt	-0.08	WARM
Asphalt Shingles	-0.09	WARM

Composting Emission Reduction Factors

Emissions reductions that occur as a result of composting represent the net result of increased emissions caused by both equipment use and biological processes required to compost organic matter and decreases in emissions that result from compost utilization. In all sources reviewed, the indirect reductions in emissions from compost utilization outweigh emissions released by producing and transporting it. Table 5 depicts these findings.

Table 5.

Composting Emissions Reduction Factor			
	GreenPoint Rated Climate Calculator	WARM, All Versions and Settings	ARB
Yard Trimmings	-0.2	-0.2	-0.42

Of note here is that both versions of WARM have the same factor as the Climate Calculator. The methods underlying the ARB factors are based on a single pathway that is one of many outcomes that could result from composting green waste. However, that particular pathway is based on likely outcomes that would occur in California (such as the weather conditions where the composting takes place and the way in which the final compost product is utilized), and are probably more realistic for GreenPoint Rated users than those represented by the WARM model, which is based on outcomes that would be applicable nationwide. One potential limitation of the ARB factor is that it is not specific to the feedstock that was used to produce the compost, but rather uses a blended average. GreenPoint Rated is solely focused on landscaping waste which has considerably different characteristics from other types of compostable waste types, such as food debris. ARB should be consulted to determine if there are plans to refine this factor for specific feedstock types.

Despite the limitation noted, the ARB factor of (-0.42) $MTCO_2e$ reduced per ton of yard trimmings composted is recommended for use in the next version of the GreenPoint Rated calculator.

Combustion Emissions Factors

Because the pathway for diverted lumber is chipping and combustion for biomass utilization, the GreenPoint Rated Climate Calculator applies only the combustion factor for dimensional lumber. Table 6 below compares the values for these outcomes. Note that the value for ARB is officially listed as a recycling emissions reduction factor in the draft report, and the process modeled to develop the factor is combustion for energy generation. The values for ARB are likely lower in this case because the biomass energy created is offsetting cleaner California grid energy than what would be achieved by offsetting the national average energy generation.

Table 6.

Combustion Emissions Reduction Factor				
	GreenPoint Rated Climate Calculator	WARM v 9.1	WARM v. 11	ARB
Dimensional Lumber	-0.79	-0.79	-0.61	-0.21

ICLEI recommends using the ARB factor of (-0.21) $MTCO_2e$ reduced per ton of dimensional lumber diverted since the ARB factor better represents emissions reductions potential in California.

Emissions Factor Summary:

Table 7 below depicts a summary of all the factors above as they should be applied in the GreenPoint Rated Climate Calculator. One thing that is noteworthy here is the separation of landfill emissions from upstream, or lifecycle, emissions in the final result. This separation should remain as these factors are applied in the GreenPoint Rated Climate Calculator. For more on that discussion, see the Presentation of Results section of this report.

Table 7. All Factors as proposed applied in GPR Calculator.

Percent of C&D Waste, Alameda County From Waste Characterization Study, M. Southworth		Landfill Emissions $MTCO_2e$/Ton			Life-Cycle Emissions $MTCO_2e$/Ton	
		No LFG	LFG and Flaring[d]	LFG with Generation	ARB	WARM
Corrugated Containers	6%	2.27	0.03	-0.01	-5.00	
Yard Trimmings [a]	21%	0.79	0.34	0.29	-0.42	
Lumber [b]	42%	1.17	0.12	-0.02	-0.21	
Drywall (methane from paper backing) [c]	13%	0.18	0.18	0.18		0.03
Mixed Metals	3%					-5.40
Concrete	15%					-0.01
Asphalt						-0.08
Asphalt Shingles						-0.09

a. Life-cycle factor represents composting as the management strategy
b. Life-cycle factor represents combustion as the management strategy
c. The WARM recycling pathway for drywall includes agricultural gypsum as the primary outcome of diversion, relatively little recycled drywall displaces production from virgin material.
d. This set of factors utilized in the calculation for the prototypical house

Note that the selection of the "LFG and Flaring" set of landfill gas factors were selected to complete the sample calculation for a prototypical house. It should be verified that this is the correct baseline conditions at landfills that are currently receiving C&D debris. One option for the GreenPoint Rated Climate Calculator would be to have the ability to optionally select the base case landfill conditions and apply different sets as appropriate for whether or not gas collection is occurring and whether energy is being produced from that gas.

Table 8 displays the results of calculations performed with these factors on a prototypical 2,000 ft^2 single family home, which generates 8.5 lbs of C&D waste per square foot during construction. Results below included the basecase of 50% diversion as mandated by the California Building Standards code, as well as GreenPoint Rated uses rates of 80 and 100% diversion. Table 8 also contains a the savings at 80 and 100% diversion as compared to the California minimum 50% diversion rate.

Table 8: Calculated Reductions from factors applied to a prototypical household (MTCO2e)

	Base Case 50% Diversion		GPR 80% Diversion		GPR 100% Diversion	
	Landfill Emissions Avoided	Life-Cycle Emissions Avoided	Landfill Emissions Avoided	Life-Cycle Emissions Avoided	Landfill Emissions Avoided	Life-Cycle Emissions Avoided
Corrugated Containers	0.01	1.28	0.01	2.04	0.01	2.55
Yard Trimmings	0.30	0.37	0.49	0.60	0.61	0.75
Lumber	0.21	0.37	0.34	0.60	0.43	0.75
Drywall (methane from paper backing	0.10	-0.02	0.16	-0.03	0.20	-0.03
Mixed Metals		0.69		1.10		1.38
Concrete		0.01		0.01		0.01
Asphalt		0.00		0.00		0.00
Asphalt Shingles		0.00		0.00		0.00
Total	0.62	2.70	1.00	4.32	1.25	5.41
Savings Compared to Base Case			**0.37**	**1.62**	**0.62**	**2.70**

Source Reduction:

Source Reduction is a strategy of avoiding consumption of materials all together by either substituting existing materials through re-use, or by minimizing the amount of material needed to complete the project. One significant change in WARM v11 is the inclusion of RERFs for new construction and demolition material types. These include asphalt, roofing shingles, and drywall. WARM v11 also includes "Source Reduction" emission reduction factors for fiberglass insulation, vinyl flooring, and wood flooring. Source reduction calculations could be considered for inclusion in future versions of the tool to greater promote source reduction as a waste management option. One of the biggest challenges to including source reduction in the calculator is a lack of reliable references that characterize the amount and composition of the material types that can be effectively source reduced. A preliminary investigation into the potential for including source reduction calculations was done to assess the feasibility of this option, and the results of that effort are found later in this section.

A review of C&D waste source reduction data found that the vast majority of C&D source reduction information is related to deconstruction and material reuse strategies, which are not applied widely in the new construction market, but could be added as a way to encourage the integration of salvaged materials into new construction projects. Further, in the GreenPoint Rated Existing Home rating system, there are significant opportunities for deconstruction and the integration of salvaged materials. Future updates to GreenPoint Rated should include these aspects. Additionally, for new homes, the two activities that would fit within a future version of the Climate Calculator tool are pallet recycling and advanced framing.

Since the current Climate Calculator tool accounts for all dimensional lumber recycling as combustion, pallet recycling would likely be treated similarly, and by default may already be adequately covered by the tool.

For advanced framing applications, the goal is to minimize the amount of material needed to build a structure, thereby reducing demand. Currently the GPR tool does include points given for advanced framing and other efficient use strategies but does not quantify the benefit of those strategies. This is due in part to the difficulty in calculating a total volume of material that is reduced based on the housing size. Table 9 below demonstrates a potential pathway for making that calculation. The citations used are the result of an initial search for adequate references and further investigation is needed to ensure their applicability to the tool. However they are useful here to illustrate the potential of including this feature in future versions of the GreenPoint Rated calculator.

Table 9. Potential factors for a dimensional lumber source reduction calculation

Board Feet Consumed per ft^2 of construction [a]	Volume of a board foot of finished lumber (ft^3)[b]	Density of finished lumber (lbs/ft^3)[c]	Consumption Savings Potential [d]	Source Reduction Emission Factor ($MTCO_2e$/Ton)[e]
6.09	.0833	31	0.25	2.02

a. Calculated from DOE Buildings Energy Databook, Table 2.5.7, http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/2.5.7.pdf
b. http://www.unc.edu/~rowlett/units/dictB.html
c. Mid-range value for Yellow Pine http://www.engineeringtoolbox.com/wood-density-d_40.html
d. http://twoplusfour.com/resources/pdf_downloads/green_documents/advanced_framing.pdf
e. WARM Documentation, Introduction to Wood Products, Exhibit 5. http://www.epa.gov/climatechange/wycd/waste/downloads/wood-products-chapter10-28-10.pdf

With draft factors in place, we can examine the potential impact of these factors as if they were applied in the GreenPoint Rated Climate Calculator. Table 10 below demonstrates the result of the total amount of source reduced lumber and avoided life-cycle emissions that would result from the factors above being applied to a 2,000 ft^2 single family home. The potential emissions reduction of this single addition is significant. In and of itself, it shows that there are more potential emissions avoidance from this single action than from all waste management activities. Again the key variable that needs further investigation is the potential savings that can occur by utilizing advanced framing techniques.

Table 10. Result of source reduction calculation on a 2,000 ft^2 single family house

Total Avoided Wood Consumption (tons)	Total Life-Cycle Emissions Reduced ($MTCO_2e$)
3.93	7.95

Including a source reduction calculation in GreenPoint Rated as described above does present several other challenges. This first of these is what the impact on waste generation rates this activity has. One could assume that the rate of waste generation stays the same and the overall amount of wood waste generated would be proportional to the smaller amount brought on site for a project. In practice it is likely that builders skilled in advanced framing techniques are more likely to be more resource efficient than average, resulting in a smaller percentage of waste from the initial amount of wood brought on site. Therefore, some adjustment is likely necessary, but there is little information publically available on these differences. Additional field research should inform any decision around adjustments to the waste generation rates.

Another more serious difficulty in applying these numbers would be in the way that it would cause a mixing of two different emissions factor sources which model the same pathways for forest products differently. Source reduction factors for wood waste would be reliant on the forest sequestration model from EPA WARM, which is based on sequestration at the forest stand level. Recycling factors applied to corrugated containers would be reliant on the "theoretical tree" model of sequestration developed by ARB. This would result in potential internal conflicts with how the GreenPoint Rated Climate Calculator accounts for forest carbon sequestration. Further study into both models is recommended before deciding to include source reduction in the GreenPoint Rated calculator.

Onsite Waste Management Support

One additional calculator that could potentially be included in future versions of the GreenPoint Rated calculators pertains to the inclusion of home composting amenities as part of a project to encourage participation in that activity. Reviews of existing literature on the subject have not revealed a direct connection between availability of facilities and increased participation in composting. Often citied alongside of the availability of facilities are a host of socio-economic and demographic factors that play a role in the determination of participation rates[8],[9].

[8] Hage, Soderholm, and Berglund. Norms and Economic Motivation in Household Recycling: Empirical Evidence from Sweden. *Resources, Conservation, and Recycling.* 2009. vol. 53 pp 155-165.
[9] Edgerton, McKenchnie, Dunleavy. Behavioral Determinants of Household Participation in a Home Composting Scheme. *Environment and Behavior.* 2009. vol. 41:151.

The results of these studies produce factors which could be used to program a calculator to predict outcomes, however utilizing such detailed models would also require that either the user enter values to represent the socio-economic and demographic characteristics of the likely tenants, or that information would have to be assumed in the calculator's construction and hard coded. Neither of these two options appear to fit with the methods used in other aspects of the Climate Calculator and are not recommended.

An option that might be more straightforward in its application and automatically attuned to local socio-economic factors and likely participation rates would be to apply observed participation rates in similar local programs. The challenge with this approach is to determine what the marginal impact of adding dedicated facilities would have on participation in the program. For example, the observed 25% participation rates[10] for the current curbside organics collection in Alameda County could be considered to be the baseline condition. If it were possible to demonstrate that homes with dedicated recycling and composting fixtures that made those activities easier had higher participation rates, the difference could be attributed to the facilities and counted as a benefit in the calculator. It is possible that those homes with dedicated and convenient fixtures would have very high participation rates relative to the average for the county, and the potential reductions associated with this measure could be significant. More importantly, they would be ongoing benefits, similar to energy saving calculations in the tool, rather than the one-time benefit derived from materials management in the construction phase. More study is encouraged to determine the marginal participation rates that are associated with this type of measure before it is included in the tool.

One additional consideration that would need to be made for this addition to the tool would be a differentiation in the factors used for measures that support home-based backyard composting from those meant to facilitate participation in a municipal or county collection program. The CERF figures provided by the Air Resources Board account for the net emissions that would be reduced after accounting for the small amounts of methane that can be generated by large scale composting operations and from the fuel consumed to process the material. For a small backyard composter operated by hand, those added emissions from heating compost piles in commercial operations are avoided and the emissions benefit of those systems would be higher. Additionally the end use of the final product would likely be different for home produced compost and the emissions benefits of compost use may be significantly different in that case.

[10] Source Separated Residential Composting in the U.S. *Biocycle.* December 2007. Vol. 48, No. 12. http://www.jgpress.com/archives/_free/001526.html

Presentation of Results

There are two measures that ensure that the emissions reductions reported by a calculator are accurate and being put to beneficial use. The first consideration is whether the calculations are methodologically complete and consistent. Secondly, is whether the results are presented in such a way as to be clearly interpreted by the user in the right context. An example of where the latter has not been done is with the EPA WARM tool. Because of the way factors are aggregated in that tool and the way that the final results are presented, the user is not able to understand and account for the individual processes at work. Because WARM has been the best available tool to manage greenhouse gases from waste for a number of years, many users have based reduction estimates for the waste management aspects of their action plans from WARM outputs. This causes a conflict where a user of a tool or consumer of subsequently produced reports can get the impression that waste related emissions reductions will help them achieve their emissions reduction goals. The only way to establish whether or not a goal has been achieved is to perform a re-inventory of emissions at the goal's target date. Out-of-boundary reductions will not show up on that re-inventory if traditional methods are utilized. Increasingly, local governments are accounting for out-of-boundary emissions impacts that result from consumption and activity within their jurisdiction. In those cases, it would be appropriate for reductions to be counted, however differentiation between the two is still a key importance because the management strategies for the different categories can vary.

Another reason why it is good practice to separate direct landfill emissions from out-of-boundary impacts is that the factors for out-of-boundary emissions are inherently uncertain, regardless of their source. They rely on assumptions on what happens to a diverted waste product after it leaves the possession of the party that did the initial diversion, which complicates any ability to audit the actual final destination of the materials diverted. There are likely to be many possible outcomes that differ from the fate of the materials as described in the methodologies from either ARB or EPA. Thus their applicability for determining specific outcomes may be limited. In its guidance document "Quantifying Greenhouse Gas Mitigation Measures", the California Air Pollution Control Officers Association (CAPCOA) has articulated some standards to which greenhouse gas reduction calculation methods should strive to achieve. Particularly relevant here are standards on Accuracy and Reliability, and Verification.

CAPCOA defines Accuracy as:

> "…the closeness of the agreement between the result of a measurement or calculation, and the true value, or a generally accepted reference value. When a method is accurate, it will, for a particular case, produce a quantification of emissions that is as close to the actual emissions as can practicably be done with information that is reasonably available."

This definition provides a few caveats that EPA or ARB methods could fall back on. Those methods are certainly in line with the final phrase of that definition, since data to determine the fate of recyclables is generally not reasonably available. When assessing Reliability however, these methods will likely fall short. CAPCOA defines Reliability as:

> "A reliable method will yield accurate results across a range of different cases, not only in one particular case."

This poses a problem in that the methods used to define a RERF or other life-cycle factor are defined by one particular average case. It is unlikely that any waste stream would follow that pathway with any certainty.

A final challenge noted in the CAPCOA guidance that is true of all end-of-useful-life emissions calculations is that of Verification. Because of the number of parties involved and the number of possible pathways a particular waste stream can take after leaving the site of initiation diversion, verification would be nearly impossible.

Recognizing these facts, practitioners in greenhouse gas management can begin to articulate clear guidance on how to properly account for in boundary and out of boundary impacts on materials management practices. The lack of guidance to date is evident in the variety of ways that different communities have accounted for the two in the climate action plans.

Presentation of Results in Climate Action Plans

To illustrate the different approaches that have been taken, several climate action plans from Bay Area communities were reviewed to see how each accounted for and planned reductions around waste management. Table 11 summarizes those findings.

Table 11. Summary of waste emissions inventory and reduction treatments

Community Name	Baseline Inventory Waste Emissions (Year; MTCO2e)	Forecast Year Waste Emissions (Year; MTCO2e)	Inventory Calculation Basis	Planned Waste Emissions Reduction (Year; MTCO2e)	Reduction Calculation Basis	Notes
Emeryville	2004; 5,801	2020; 9,640	WARM	2020; 16,766	WARM	Emissions reductions anticipated are greater than inventoried waste emissions.
Hayward	2005; 52,438	Not broken out in report	WARM	2020; 21,851 2050; 68,798	Not Clearly Stated	Text states planned reductions only from landfill methane
Oakland	2005: Landfill – 126,361	Not broken out in report	WARM, EIO-LCA	2020; 113,055	Not Clearly Stated	Text notes life-cycle impacts but reductions estimates only indicate values from direct landfill emissions

	2005; Upstream - 3,065,110					
San Francisco	Not Quantified	NA	NA	302,000	Not Clearly Stated	Text clearly indicates life-cycle reductions accounted for
Berkeley	Not Quantified	NA	NA	2020; 68,000	WARM	Notes the difference between in boundary and out of boundary

In reviewing the different action plans, it is clear that most practitioners recognize the difference between in boundary and out of boundary emissions reductions and that the resources they have relied on to date conflate the two. Some communities such as Berkeley and San Francisco cite the lack of clear guidance in this area and therefore did not attempt to include waste emissions in their inventory, however their use of WARM to calculate reductions indicate that those reductions also include out-of-boundary impacts.

The cities of Hayward and Emeryville take somewhat different approaches to the issue. Both recognize that their inventory takes into account only direct landfill emissions, however Emeryville does count out-of-boundary reductions towards their goal, whereas Hayward explicitly only includes landfill emissions reductions towards their goal.

The City of Oakland maintains in and out-of-boundary emissions separately and recognizes the difference in the two in the text of the report. However that clarity breaks down somewhat during the discussion of reduction calculations.

What is clear, is that each community is putting their best effort forth in properly accounting for waste related emissions impacts, but lack the means to do so thoroughly and document which emissions are being accounted for and the sources of those accounting methods. In part, this is because all of the abovementioned CAPs utilized an earlier version of WARM (v.9 or earlier) and therefore lacked the ability to dissect emissions factors in any meaningful way. The inclusion of waste-related lifecycle emissions impacts in CAPs is a relatively new phenomenon that seeks to recognize the full climate benefits of recycling and materials management in community's greenhouse gas mitigation efforts. However because most of those reductions occur outside the accounting domain of a city, the emissions that are being reduced were likely not part of that community's GHG inventory. As more cities elect to perform consumption-based GHG inventories that account for the emissions created in the production and distribution of materials consumed in their community, it would be appropriate to apply life-cycle reductions to that portion of their emissions profile.

Improving these calculations will require two elements to come together. First, the upcoming ICLEI Community-Scale GHG Accounting and Reporting Protocol will define consistent preferred and alternate methods that each municipality following the Protocol will use to calculate direct landfill emissions. The Protocol will also provide additional reporting approaches for those municipalities that choose to also account for and report on life cycle emissions associated with different waste management strategies as well as emissions associated with the consumption of material goods. Those methods will aim to increase transparency and detail as to what portion of emissions come from various processes and stages in a material's life cycle, and whether or not they occur within or outside a community's geopolitical boundary.

Performing the calculations of waste impacts will also require more detailed inventory data, including some knowledge of the ultimate destination of the waste that is generated by the community. The finer the scale of local data available, the more policy relevant actions can be included in the GreenPoint Rated Climate Calculators. For example, none of the action plans reviewed for this study mentions the waste characterization used to calculate emissions from different material types in their inventory, and those jurisdictions likely used default waste characterizations from either CalRecycle or national defaults from US EPA. However it is known that within Alameda County, the fraction of food waste is significantly higher than those characterizations would indicate. For example the EPA Figures indicate food waste as accounting for 12.7% of MSW generation[11], whereas a local study in Alameda County puts this figure at 18.7%[12], a difference that would lead to sizeable errors when scaled to the waste generated by an entire jurisdiction. The reason for the difference is possibly due in part to the success of diversion programs for other material types in Alameda County, and to active marketing campaigns aimed at food scrap recycling in Alameda.

Knowing more specific generation rates for food waste from homes would allow local decision makers to better understand the potential for emissions reductions from organics diversions and incorporate specific waste diversion measures into their climate action plans accordingly. The information to estimate the reductions associated with actions before a policy is enacted could be supplied from within the Climate Calculator or associated documentation. Another potential application of the tool would be in using it to aggregate and report on the benefits created by GreenPoint Rated developments at the municipal scale. The ability to quickly summarize the impact of preferred development methods using the GreenPoint Rated framework would raise profile of the rating system to policy makers and likely lead to greater adoption of the rating system as a specific action to help reduce the environmental and climate impacts of their community. Maintaining a clear separation between landfill and life cycle impacts will also help to prevent possible misconceptions about how waste related emissions management options affect local sources of GHG emissions.

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[11] USEPA. November 2009. Municipal Solid Waste Generation, Recycling, and Disposal in the United States, Detailed Tables and Figures for 2008. Table 1. Materials Generated in the Municipal Waste Stream. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2008data.pdf

[12] Stopwaste.org. June 2009. 2008 Alameda County Waste Characterization Study. Table 3-1, 2008 Countywide Waste Composition and Disposal. http://www.stopwaste.org/docs/acwcs-2008r.pdf

The GreenPoint Rated Climate Calculator has the opportunity to be among the first new resources to begin to empower local decision makers with a detailed understanding of the emissions impacts of materials management. Though this tool is focused on C&D waste primarily, this action will set a precedent which other waste management tools will likely follow.

Final Recommendations

Updates to the Green Point Rated Climate Calculators

In summation, ICLEI recommends the following changes be made to the Climate Calculators:

1. Create two pathways of emissions reductions for material diversions and maintain that separation through the final summary outputs of the tool.
    a. One pathway for direct reductions in landfill emissions
    b. One pathway for out-of-boundary or life-cycle impacts
    c. Impacts are never summed within the tool and guidance should be included to instruct the user when it is and is not appropriate to do so.
    d. Results should be presented in the finest level of detail reasonably attainable to maximize the users understanding of the size and location of emissions reductions, so as to provide more insight for decision makers to prioritize reduction strategies.

2. Using best available local data, a calculator worksheet that models the impact of the inclusion of household organics diversion should be included in a future release of the tool.
    a. Calculations should clearly delineate direct landfill emissions impacts and life-cycle impacts that occur outside of the local jurisdiction.

3. For direct landfill emissions apply WARM factors for landfill emissions as illustrated in Table 7.
    a. Determine whether LFG and Flaring or LFG and electricity generation are the most suitable factors to apply
    b. Optionally, provide the user the ability to select which factor set based on local knowledge of receiving landfills.

4. Where available, apply factors developed by ARB
    a. Recycling factor for corrugated containers
    b. Composting factor for yard trimmings
    c. Combustion factor for dimensional lumber

5. For recycling of material types not covered by ARB, apply WARM factors as illustrated in Table 7.

Directions for Further Research

In addition to changes to the calculator, this effort has revealed several areas for additional research that will further the development of future versions of the GreenPoint Rated Climate Calculators.

It has been demonstrated that the emissions reduction potential for source reduction as a materials management strategy is quite large; however several key questions need to be answered in order to develop a reliable calculator to quantify those impacts. Among those questions are:

1. How do resource efficient building techniques reduce consumption of all material types used on a job site?
2. What are the impacts on waste creation and thus default waste generation rates that determine outcomes for recycling practices also accounted for in the tool?
    a. Generation rates should be reduced as appropriate to avoid double counting.
3. What are the implications of mixing sources of emission factors that both represent the same process differently, as in the case of forest carbon sequestration between the WARM and ARB methods?
    a. Are there other sources that can give a complete and consistent set of factors that represent all the materials management options available?

Including a calculator to model the impact of including onsite composting and recycling facilities within a residential or multifamily home would be a good way to incorporate ongoing waste management benefits of GreenPoint Rated projects. The construction of such a calculator would more likely be informed by local experiences with outcomes of programs in the Bay Area, rather than from a complicated statistical model based on attitudes towards recycling and socio-economic factors. The latter would not only be cumbersome to implement in the tool, it would also require considerable additional effort on the user's behalf to enter all the necessary information. A more reasonable approach may be to base a calculation on local empirical evidence on how similar programs have worked in similar situations. For example, programs that have provided composting bins to residents at reduced cost can provide adequate insight into the likelihood of individuals utilizing those facilities if they were provided. An example study was done for a program by the Oregon Department of Environmental Quality[13]. However, the results of that study are not recommended for use in a future version of the Climate Calculator, due to the many differences between the location and scale of that study and areas where GreenPoint Rated is likely to be applied. There

[13] Oregon Department of Environmental Quality. June, 2004. Survey of Home Compost Bin Recipients – La Grande, Oregon. http://www.deq.state.or.us/lq/sw/compost/lagrandesurvey.htm

is an additional challenge with making this calculation that relates to the perspective of a development project and determining the marginal impact of this action on collection program participation rates. More research into this topic is recommended in order to include such calculations in the tool.

Appendix C: GPR Elements Prescriptive Energy Interactive Effects Matrix

GreenPoint RATED

EXISTING HOMES: ELEMENTS PRESCRIPTIVE ENERGY PATH

Summary of Interactive Effects 1% = low (or no) interactive effect 5% = medium to high interactive effect

	Attic insulation up to or exceed current code	Crawl space insulation to code	Wall insulation to code	High efficiency furnace - 90% AFUE minimum	High efficiency water heater - .62 EF	Radiant barrier	Window upgrades must be to dual pane	Ducts leakage < 15%	Duct insulation to code	14 SEER, 11.5 EER A/C unit	Programmable thermostat	Blower door test	Comments and Notes
Attic insulation up to or exceed current code		1%	1%	5%		1%	1%	1%	1%	5%		1%	Insulation interactive with heating and cooling, and radiant barrier, but not other insulation. Interactive with duct leakage, because less insulation means heating/cooling runs more and then reducing duct losses can save more energy.
Crawl space insulation to code	1%		1%	5%			1%	1%	1%	5%		1%	Crawl space insulation interactive with heating only (not cooling).
Wall insulation to code	1%	1%		5%				1%	1%	5%		1%	Same as crawl space insulation, but savings are interactive with A/C, too.
High efficiency furnace - 90% AFUE minimum	5%	5%	5%			1%	5%	5%	5%			5%	
High efficiency water heater - .62 EF													Water heater is not interactive with any other measure
Radiant barrier	1%			1%						1%			Radiant barrier reflects heat away from roof. Radiant barrier saves more energy if there is no attic insulation. No impact on heating load.
Window upgrades must be to dual pane	1%	1%		5%						5%		1%	Perhaps very minor interactivity with duct leakage, but assumed to be quite small.
Ducts leakage < 15%	1%	1%	1%	5%					1%	5%		1%	
Duct insulation to code	1%	1%	1%	5%				1%		5%			Duct insulation means you can run the heating and cooling less.
14 SEER, 11.5 EER Air conditioning unit	5%	5%	5%			1%	5%	5%	5%			5%	
Programmable thermostat													P-stats basically interactive with everything. Not running the A/C means insulation saves less, and saves on the heating and cooling units as well. Note, p-stats energy saving potential questionable.
Blower door test	1%	1%	1%	5%				1%		5%			Blower door test is basically to find leaks and then assumes that you seal them. Therefore, similar to duct leakage measure.

Appendix D: Building materials measures: justification for inclusion or exclusion in GPR Version 2.0

Measures	Source	GHG Impact	Co-Benefits	Easily Quanitfiable/ Generalizable	Reason for Inclusion or Exclusion	Current GPR Method	Proposed GPR Method
ENTIRE HOUSE							
Reduce Size (sq ft) of Home	Oregon Study, Jones and Kammen (2011)	Large	Large	Yes/Yes	Size (sq ft) is of Key Importance to GHG Footprint, materials reduction and other co-benefits	Credit for homes under 2000 sq ft for reduced materials	Carbon footprint of home to include GHGs from materials based on 70 year lifetime, 70 metric tons CO2 per 2262 sq.ft. home = 30 kgCO2e/sq.ft or 0.44 kgCO2e/sq.ft. per year. Under this linear method a 1000 sq.ft. home would get 35 tCO2e credit upfront, or 35/70 tCO2e per year
Recycling materials at construction and demolition stages	Stopwaste study	Small one time benefit	Small one time benefit	Yes/Yes	Stopwaste has collected good data on buildilng materials and appropriate emission factors for each material	The tonnage of each type of material recycled x EPA WARM model. Average savings = 5.7 metric tons for 100% diversion rate for typical home	Updated methodology based on Air Resources GHG emission factors from recycled materials, typical building materials. Benefit only accrues above 50% diversion rate, which is now state code. Average savings = 2 metric tons for 100% diversion rate for typical home
Support reuse of existing, processed materials (recycled content)	Stopwaste study; Oregon study	Small one time benefit	Small one time benefit	No/Yes	Too many materials in home with different life spans to effectively evaluate for GPR; however, the Orgeon study provides data that could be used on a case-by-case basis	None	None
Multi-family units	Oregon Study	Large	Large	No/No	Most of the benefits are included in Title 24. Materials benefits are small and may be offset by additional support structures, e.g., steel outside staircase	None	None
Construction Material Efficiencies (brick, concrete alternatives, earthen, straw, glas, metals, bamboo, wood, plywood, vinyl, rock, plastics, stucco, spray insulation (and beyond), thatch/grass, foam etc.)	Literature review; DOE Buildling Energy Data Book	Minor	Minor	No/No	Too few comparative quanitative studies, too dependent on local area resources and total design	None	None
Roofing							
40-year asphalt shingles instead of 20-year shingles	Oregon Study	Small	Small	Yes/Yes	Easy to quantify. 40-yr roofing material is 4.8 kgCO2/sq.ft; 20-yr roofing material is 3.2 kgCO2/sq.ft, but two roofs are needed over 40 years. 4.8 - 3.2(2) = 1.6. transport and end of life assumed identical	None	Savings of 1.6 kgCO2e per sq.ft. over 40 year lifespan, or 400 gCO2/sq.ft per year
Use Reflective Roofing	California Energy Code, DOE Buildling Energy Data Book	Power in #s	Minor	No/No	Already accounted for in energy code. Studies on % benefits conflicted, minor savings associated with insulation vs. painted	None	None
Create Green Roofs	DOE Buildling Energy Data Book	Minor	Significant	No/No	Studies on % benefits varied, minor savings associated with insulation, cost often prohibites adoption	None	None
Construction Material Efficiencies (PVC, Metal, Asphault, Shakes, Slate, Ceramic, Concrete, Membrane, Vinyl)	Literature review	Minor	Minor	No/No	Too few comparative quanitative studies, too dependent on local area resources and total design	None	None

Measures	Source	GHG Impact	Co-Benefits	Easily Quanitfiable/ Generalizable	Reason for Inclusion or Exclusion	Current GPR Method	Proposed GPR Method
Flooring	***Durability is of***						
Wood floors instead of carpet	Oregon Study	Moderate impact	Energy can be recovered at end of life	Yes/Yes	Calculation is easy. Carpet has highest impact of all materials both during production and at end of life.	None	2 kgCO2/sq.ft of wood floor for each 10 yrs (when carpets replaced), or 14 kgCO2/sq.ft for 70 home lifetime = 0.2 kgCO2/sq.ft per year. To be conservative and to account for area rugs, divide numbers above by 2
Construction Material Efficiencies (local quarying, non-toxic cleaning, support salvage, no VOC etc. Stone vs. tile vs. linoleum)	Literature review; DOE Buildling Energy Data Book	Minor	Minor	No/No	Too few comparative quanitative studies, too dependent on local area resources and total design	None	None
Siding	***Durability is of***						
Durable siding	Oregon Study	Not significant	Not significant	Yes/Yes	Benefits too small to quantify	None	None
Construction Material Efficiencies (Wood, Vinyl, Composite, Fiber)	Literature review; DOE Buildling Energy Data Book	Minor	Minor	No/No	Too few comparative quanitative studies, too dependent on local area resources and total design	None	None
Framing							
OVE (Ladder blocking — uses less wood; provides more room for insulation; increase insulation by minimizing studs; switch	Help Forums, Best Practice Lists, Other..., NAHB, Toolbase.org	Power in #s	Minor	Yes	Minimal materials benefits. Energy benefits should be included in Title 24	None	None
Neighborhood Scale							
Subdivision layout, orientation	Literature review	Significant	Significant	No/No	Too many best practices could be encompassed in this idea. Although the developer could support some of them them (ex. ensurance that no cars were needed to reach all basic needs) they do not necessarily have control over all of the regulations, depending on the area.	None	None
Landscape Materials	Literature review; DOE Buildling Energy Data Book	No	Yes	No/No	Too many best practices could be encompassed in this idea. Support local landscape, natural materials, mulch for bee gardens, local composting etc.	None	None
Other	***These are landscape/con***						
Design with landscape	Literature review	Significant	Significant	No/No	Too many best practices could be encompassed in this idea. Although the developer could support some of them them.	None	None
Redevelopment of Existing Building	Literaure review; California Energy Code	Power in #s	Minor	No/No	Too case specific, too many variations of required changes. Whole building LCAs very varied.	None	None

Appendix E: GreenPoint Rated Climate Calculator Report for Version 1 (March 2009)

The GreenPoint Rated Climate Calculator

March 2009 Update

GreenPoint RATED
A PROGRAM OF BUILD IT GREEN

Build It GREEN
Smart Solutions from the Ground Up

GREEN BUILDING
in Alameda County

Contents

Executive Summary

A number of lifestyle-based carbon calculators have been developed to estimate an individual's or household's carbon footprint, but until now, no tool existed to measure the total avoided greenhouse gas emissions from building green homes.[14]

The new **GreenPoint Rated Climate Calculator**, developed by a team led by Green Building in Alameda County, provides this information in a way that's systematic, credible and backed by third-party verification.

The Climate Calculator is likely to be an influential tool for helping California's residential building industry reduce its carbon footprint. The Calculator is an adjunct to the GreenPoint Rated program, which provides a consumer label for green homes.

When a house or multifamily building undergoes the GreenPoint Rating process, the Climate Calculator will generate data on greenhouse gas (GHG) emissions avoided, measured in carbon dioxide equivalents, or CO_2e. Other savings are also calculated, including non-CO_2 savings like gallons of water, tons of waste, kilowatt-hours of electricity, and therms of natural gas.

Notable findings

- **Buildings in denser, transit-oriented communities provide the greatest emissions reductions.**

- **In the building's design, the most important CO_2e reduction strategies are building energy efficiency, reduced home size, photovoltaic systems, energy-efficient appliances (including non-HCFC refrigerants), construction waste recycling, and water savings from efficient landscapes and plumbing fixtures.**

- **Construction and demolition waste recycling produces immediate and significant one-time CO_2e savings for the building and community.**

- **Green retrofits or remodeling reduces net CO_2e emissions, while constructing new housing (whether green or conventional) increases net CO_2e emissions. Given that 70% of homes in the state were built before 1980,[15] the opportunity for true emissions reduction is greatest in the existing home sector.**

[14] See Appendix F for an abbreviated list of carbon calculators.

[15] California Energy Commission household forecast for California Energy Demand 2008–2018, November 2007, report number CEC-200-2007-015-SF2.

Introducing the GreenPoint Rated Climate Calculator

Green buildings incorporate a suite of environmentally preferable practices during siting, design and construction. Consequently, most green buildings are thought to have lower carbon footprints than traditionally built or remodeled buildings; but how much lower? Which green building strategies are most effective for reducing greenhouse gas (GHG) emissions? While the operational energy-related emissions savings from the building industry are well understood, how do the indirect- and non-energy benefits of green buildings compare? How will the growing inventory of green homes contribute to the state's ambitious GHG reduction goals?

The GreenPoint Rated Climate Calculator helps answer these questions. When a remodeled or newly built residence undergoes the GreenPoint Rating process, a third-party Rater will use the Calculator to generate data on GHG emissions avoided and other savings.[16] The Climate Calculator produces four sets of data:

- CO_2e data derived from the building's green design features, including:
    - building energy efficiency,
    - reduced home size,
    - photovoltaic systems,
    - energy-efficient appliances,
    - advanced refrigerants,
    - water-efficient plumbing fixtures, and
    - water-efficient landscapes;
- CO_2e data related to the recycling of construction and demolition waste;
- CO_2e data related to the project's location, which quantifies the potential reduction in miles driven by residents who live in more compact, transit-oriented, mixed-use developments; and
- Non-CO_2 savings, including gallons of water, tons of waste, kilowatt-hours of electricity, and therms of natural gas.

All these results are incorporated into a GreenPoint Rated consumer label for each home (see page 13 for a preview illustration).

[16] See the Build It Green website at www.builditgreen.org for more information on the GreenPoint Rated program and the Green Building Guidelines for New Homes, Multifamily buildings, and Existing Homes.

Background & Methodology

The green building measures included in the Calculator are drawn from the *Green Building Guidelines* and GreenPoint Rated checklists published by Build It Green for single-family new construction, multifamily new construction and single-family existing homes.

The underlying standards and methodologies built into the Climate Calculator were developed with help from:

- climate change experts,
- State of California agency staff, and
- energy and green building leaders.[17]

The project team encountered some challenges as they sought to develop a Calculator based on accurate, verifiable data and assumptions. Foremost was the need to make the Calculator truly representative of the numerous co-benefits that green buildings provide, some of which have impacts on GHGs while others do not. Also, to be credible the Calculator had to reference valid standards, research reports, and assumptions.

Lastly, and perhaps most challenging, the Calculator must work for the GreenPoint Raters in the field. A calculator that is too onerous to fill out would drive up the cost of GreenPoint Ratings, while an overly simplified calculator would lack credibility. The GreenPoint Rated Calculator currently meets these objectives, and will continue to be refined as more and better data becomes available and as GreenPoint Raters provide feedback based on their experience with using the Climate Calculator in the field.

For a more detailed discussion of the Calculator's methodology, see Appendix A. Appendix B lists all the measures included in the Calculator at this time. Many *Green Building Guidelines* measures were excluded from the Calculator or deferred to a future version because of the measure's low correlation with climate change or resource benefits (such as light pollution reduction), insufficient data (for example, no third-party study on the energy savings of a gearless elevator compared to a hydraulic elevator), or difficulty devising a way of measuring its impact (for example, environmentally preferable materials). See Appendix D for a list of measures not yet included in the Calculator and Appendix E for a list of measures excluded from the Calculator.

Carbon Footprint and Emissions Avoided

The Calculator is a carbon footprint analysis tool. A footprint seeks to chronicle the *total emissions* for a particular building (or household, individual or organization). The Climate Calculator quantifies the *emissions avoided* when building a green home or using green remodeling practices by comparing the footprint of a

[17] The project team and stakeholders are listed on page 19.

Notable Findings

The findings described here are derived from the project team's extensive research and analysis into the correlations between specific green building strategies and their impacts on GHG emissions and consumption of energy, water and other resources. Findings are based on actual projects that were run-through the Calculator.

- **Buildings in denser, transit-oriented communities provide the greatest emissions reductions.** The research and analysis underpinning the development of the Climate Calculator confirmed what many land use experts have long claimed: that a project's location and layout plays a larger role in its climate change impacts than does the building's design. On average, people living in less sprawling, more transit-oriented communities and cities travel by car much less than people living in lower density communities without good access to public transit or local jobs.

  To assign GHG impacts related to a building's location, the Climate Calculator uses average vehicle miles traveled (VMT) data based not just on a project's density, but also on its proximity to public transit, shopping and other services, and on the neighborhood's accessibility for pedestrians and bicyclists.

- **In the building's design, the most important CO_2e reduction strategies are building energy efficiency, reduced home size, photovoltaic systems, energy-efficient appliances (including non-HCFC refrigerants), construction waste recycling, and water savings from efficient landscapes and plumbing fixtures.**
  - *Building energy efficiency.* The GreenPoint Rated Climate Calculator's baseline assumptions include all the building design strategies required to meet Title 24 Energy Efficiency Standards. The Climate Calculator uses the project's Title 24 energy modeling results to assign a CO_2e reduction value based on avoided emissions from energy savings achieved by exceeding Title 24. This means that the Climate Calculator provides an aggregated CO_2e total for most of the building energy efficiency strategies rather than presenting CO_2e results for individual strategies. Energy measures that are required in the California Building Energy Code (Title 24) are not included in the energy savings analysis since they do not exceed minimum code requirements. For those energy-related measures above code minimums but not accounted for in Title 24 analysis, the Climate Calculator has separately quantified the energy and GHG savings.

Energy Efficiency Strategies for Exceeding Title 24

Exceeding California's Building Energy Efficiency Standards (Title 24) results in reduced greenhouse gas emissions, lower utility costs and increased comfort. Although appropriate strategies will differ depending on the local climate, in general the top strategies include:

- Passive solar design with high thermal mass
- Increased building insulation
- High performance windows
- 14+ SEER air conditioners
- 92%+ AFUE furnaces
- Pipe insulation on all hot water lines
- Home Energy Rating System (HERS) inspections on quality of insulation installation, infiltration leakage and duct efficiency

For information on these and other energy efficiency strategies, refer to the *Green Building Guidelines* for Multifamily, New Homes and Home Remodeling at www.builditgreen.org.

GreenPoint Rated requires time-dependent energy us to be 15% better than energy code, however, the Climate Calculator bases savings on kilowatt-hour per year reductions and are thus independent on the time of day energy is consumed or conserved. Analysis for existing homes was calculated based on the improved performance over a typical home of the same vintage (see Appendix B for more information on measures included in the calculations for existing homes).

- *Home size efficiency*. The size of a house or multifamily housing unit has a large impact on the amount of materials used to construct the home and its energy use once occupied. Larger homes tend to use more heating and cooling energy and produce more construction waste. The Climate Calculator factors in a home's size to show the net energy benefits and reduced waste of building compact spaces.
- *Photovoltaic systems.* If a project has a solar electric system, the Climate Calculator uses the system's estimated kilowatt-hour per year output to assign a CO_2e reduction benefit. The emissions resulting from the project's net electricity use are calculated using the unique power generation mix of the utility that serves that particular location. Solar hot water systems are accounted for in Title 24, so the Climate Calculator uses the Title 24 outputs for calculating the benefits of solar hot water.
- *Appliances.* Energy- and water-efficient appliances are not accounted for in Title 24 but can represent a significant portion of a project's CO_2e footprint.
- *Central laundry.* For multifamily projects, the largest appliance-related savings on larger projects come from having central laundry facilities. When residents use common laundry facilities they tend to wash and dry larger loads less frequently than when laundry appliances are located inside each individual home.
- *Advanced refrigerants.* Using HCFC (R-22) and a leakage rate of 2% per year as the baseline condition, the Calculator estimates the avoided global warming potential (GWP) of using advanced refrigerants, including HFC-134A and HFC-407A, in air conditioners.

Resource Conservation

The GreenPoint Rated Climate Calculator calculates CO_2e savings from construction and demolition (C&D) waste reduction, which can be significant. However, green building provides many other resource conservation benefits that aren't reflected in the Climate Calculator, such as:

- Durable products that require less frequent maintenance and replacement
- Advanced framing techniques, engineered lumber, and Forest Stewardship Council (FSC)-certified framing lumber
- Recycled-content building products, such as decking, ceramic tiles and carpets
- Flooring made from rapidly renewable resources such as cork, linoleum and bamboo

For information on these and other green building strategies, refer to the

70,000 acre-feet per year of stormwater going into stormwater treatment facilities instead of recharging groundwater. The lost stormwater's energy value was 2,250 kWh per acre-foot on average, according to the report.**

*"California's Water-Energy Relationship," California Energy Commission, Nov. 2005, document #CEC-700-2005-011-SF.

**"The Role of Land Use in Meeting California's Energy and Climate Change Goals," California Energy Commission, Aug. 2007, document #CEC-600-2007-008-SF.

- *Water-efficient plumbing fixtures.* The Calculator includes CO_2e reductions for the efficient use of water indoors. Low-flow showerheads, faucets and toilets provide significant water savings in homes. Depending on where the project is located and where the water supply is coming from, the water impacts on GHGs may be quite small compared to the Calculator's other savings areas. However, water efficiency has other benefits, including helping conserve the state's diminishing supplies of potable water.
- *Water-efficient landscapes.* The Calculator includes water savings from well designed and maintained landscapes that utilize a range of water-efficient elements. The Calculator uses a water budget for outdoor landscapes that is based on the California Department of Water Resource's Model Water Efficiency Landscape Ordinance. Additionally, principles taken from the Bay-Friendly Landscaping Guidelines are included in GreenPoint Rated as a basis for holistic water conservation techniques outdoors.[18] Landscape water conservation starts with creating drought-resistant soils with compost and mulch, selecting low-water using plants, planning for hydrozoned irrigation areas, and installing high efficiency irrigation technologies. These strategies combined together can save large amounts of water.

❖ **Construction and demolition waste recycling produces immediate and significant one-time CO_2e savings for the building and community.** Construction and demolition (C&D) waste generation on an individual project occurs only at the time of construction and is not ongoing like energy use. However, recycling high levels of C&D waste can avoid significant CO_2e emissions for the first year on some projects as well as provide ongoing community benefits by reducing emissions from landfills over time.

Waste diversion is a critical consideration given the state's approaching 2020 deadline for reducing GHG emissions.[19] Compared to measures such as energy efficiency that accrue emissions reductions over time, C&D waste recycling provides immediate savings. Further, cities and local governments should consider waste an ongoing source of GHG reductions because construction—and the waste it produces—is an ongoing activity. An estimated 2.6 million new homes will be added to the California housing stock by 2020,[20] and thus the impacts from avoided construction waste are immense. At 5.6 tons of CO_2e saved per home,[21] recycling half the construction waste on new homes has the potential to reduce CO_2e emissions by more than 14.5 million tons by 2020!

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[18] Information about the Bay-Friendly Landscaping program can be found at www.bayfriendly.org. For more details on the landscaping guidelines used in the Calculator, see Appendix B.
[19] Assembly Bill 32, the California Global Warming Solutions Act of 2006, establishes regulatory and market mechanisms for reducing greenhouse gas emissions in California to 1990 levels by 2020.
[20] California Energy Commission household forecast for California Energy Demand 2008–2018.
[21] StopWaste.Org study on emissions reductions from an average size new GreenPoint home.

- **Green retrofits or remodeling reduces net CO_2e emissions, while constructing new homes (whether green or conventional) increases net CO_2e emissions. Given that 70% of homes in the state were built before 1980, the opportunity for true emissions reduction is greatest in the existing home sector.** When comparing Climate Calculator results for various projects, it's important to do an apples-to-apples comparison of similar types of projects. Savings are not directly comparable for new and existing buildings. For new homes, the Calculator is intended to show the avoided emissions of building a green home instead of a traditional home. But building a new home creates emissions that wouldn't have existed otherwise. On the other hand, when an existing home is remodeled using green building practices, the Climate Calculator can be expected to show a net reduction in CO_2e, assuming the home's demand on energy, water and other resources wasn't increased from its previous footprint due to factors such as greatly expanding the home's size.

> ***Indoor Environmental Quality***
> Although the Climate Calculator doesn't specifically address healthy home issues, better indoor environmental quality is one of the most important benefits of building green. Having a healthier home is also one of the main motivations for people to buy green homes, green products and green remodeling services. Best practices for better indoor environmental quality

For each project, the Climate Calculator shows emissions compared to a baseline, conventional building. The Climate Calculator will typically show larger savings for a new home than for a remodeled home because more green building strategies are available to the new home builder. These strategies include orienting the building to take advantage of passive solar design, daylighting and natural ventilation and using super-efficient building techniques such as structural insulated panels (SIPs). But even though more savings per home are available to the new home sector, total emissions actually increase with each new home. When a new home is built that doesn't replace an existing building, there is inevitably a net increase in GHG emissions because the construction has added another building to the state's building stock.
While about 200,000 new homes are built each year, the existing housing stock makes up over 13 million homes and has the greatest potential for net emissions reductions. The GreenPoint Rated Existing Home rating system has been designed to provide an entry point for rating small green remodels and additions, as well as tackling larger renovation projects.[22]

- **More data is needed on GHG impacts from many green building strategies.** Many of the green building measures in the *Green Building Guidelines* were excluded from the Climate Calculator either because they are not applicable (see Appendix E) or because there is currently little or no information about their GHG reduction potential (Appendix D). A consensus-based life-cycle assessment (LCA) tool, for example, is currently not available to estimate the total carbon footprint and embodied energy of

[22] More on the GreenPoint Rated Existing Home program can be found online at www.greenpointrated.org.

specific green building materials.[23] However, those impacts combined with other excluded green building measures could be significant. Climate change and building science researchers are encouraged to help expand knowledge and data in this area.

[23] At this time, the only measures included in the Calculator that account for embodied energy are the C&D waste recycling measures. The Climate Calculator relies on the EPA WAste Reduction Model (WARM), which includes the upstream benefits (manufacturing, extraction, transportation) and downstream energy savings (transportation, methane capture, cogeneration) from recycling.

What these findings mean for…

Policymakers & climate action planners

Green building is a cross-cutting strategy that can augment a city's or local government's Climate Action Plan by reducing emissions in all major policy areas, including transportation, energy and waste. The Climate Calculator is intended to support public-sector policy initiatives in California, such as Assembly Bill 32 and other state and local initiatives for reducing greenhouse gas emissions.

Policymakers have enormous influence over the GHG reduction potential of residential buildings. As noted earlier, compact, transit-friendly communities reduce average vehicle miles traveled. The resulting GHG savings dwarfs the savings arising from a building's design. Planning policies that discourage sprawl and support mixed-use neighborhoods that are walkable, bikable and transit-friendly have the potential to play a major role in reducing a community's carbon footprint.

Policymakers and climate action planners can use results from the Climate Calculator to estimate the GHG emissions reduction potential of homes and multifamily projects in their jurisdiction. The Calculator is also useful for highlighting cross-cutting best practices in a Climate Action Plan or for City planning purposes, such as in adopting green building ordinances or construction and demolition waste recycling policies. A further benefit of the Calculator is that emissions are reported by how direct they are to the project; i.e. "Scopes" as defined by the World Resources Institute. By including the scopes of emissions, it is possible to analyze results from the Climate Calculator for whatever need is desired, whether that be for Climate Action Plans, carbon trading markets, or other uses. [24]

Builders, developers & building designers

The GreenPoint Rated Climate Calculator is not intended as a design tool to help architects or engineers compare the impacts of various design options. Instead, it's intended to allow the builder to demonstrate to the owner or future owners the verified climate benefits of that building. In the future, a stand alone, design version of the tool may be made available for use by project teams.

By providing data for the GreenPoint Rated consumer label, the Climate Calculator will help stimulate market demand for green single-family and multifamily homes as well as green remodeling activities. It also will reward green building professionals by providing them with another tool with which to distinguish their products from competitors who build conventional homes with higher waste, utility bills and GHG emissions.

[24] See Appendix A: Methodology for more on emissions Scopes.

How it works

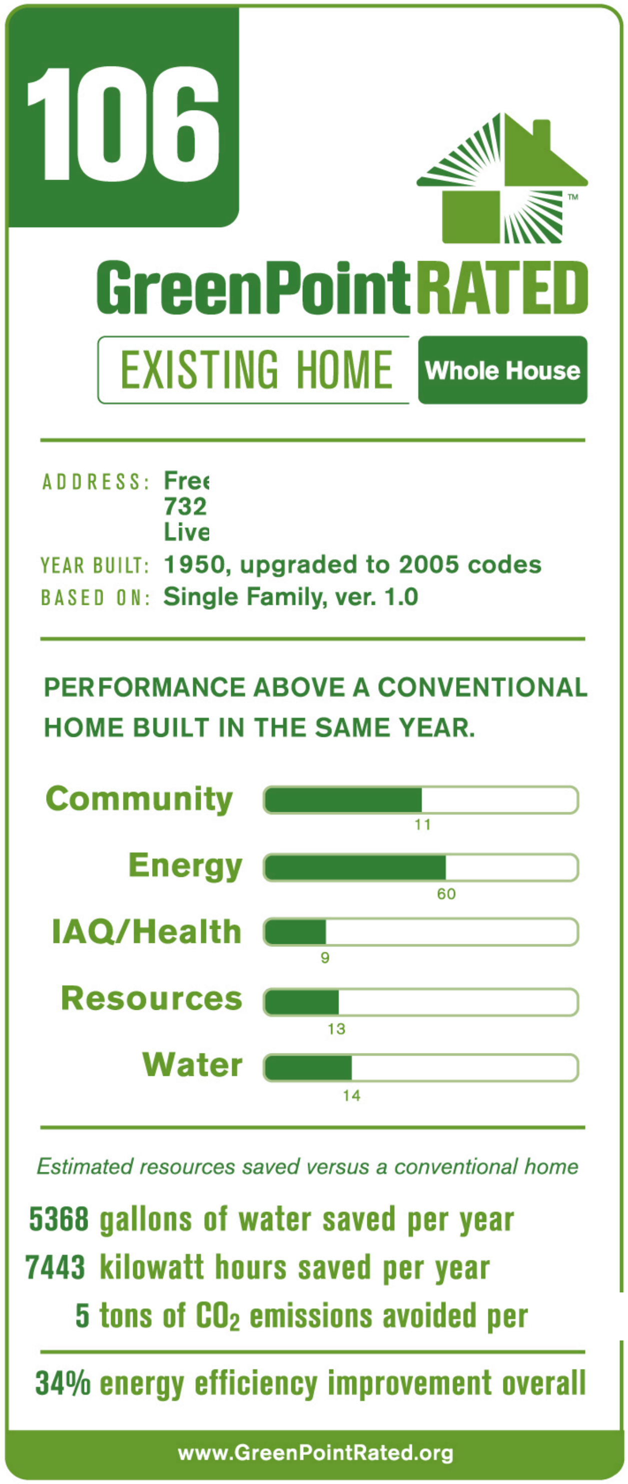
The GreenPoint Rated Climate Calculator is part of the GreenPoint Rating process for single family new homes. The inputs for the Climate Calculator are collected and verified by the GreenPoint Rater through the normal GreenPoint Rating process. The Rater then uploads their verification data and checklist to the forthcoming online Build It Green tracking system. The Build It Green tracking system includes the fully-functioning Climate Calculator along with a revised interface for managing GreenPoint Rated project documentation and verification. Currently the Calculator is housed online within the Tracking System and is not available as a stand-alone tool. Raters upload their GreenPoint Rater verification forms to the Tracking System website and Calculator results are quantified and output in reports available to the Rater and other users of the tracking system.

Next steps

The GreenPoint Rated Climate Calculator is now incorporated into the GreenPoint Rating process for single family new homes. Over the next few months, the Climate Calculator will be built-in to the Rating process for Existing Homes and Multifamily new homes as well. By the end of 2009 all new GreenPoint Rated projects will receive a new version of the consumer label (see preview next page) that includes both the GreenPoint Rated score and the Climate Calculator results.

The Climate Calculator will continue to be refined and updated as more and better data becomes available and as GreenPoint Raters provide feedback based on their experiences with using the Climate Calculator in the field.

Sample GreenPoint Rated Consumer Label with Climate Calculator Savings Results



Project Background

The GreenPoint Rated Climate Calculator was developed with input from many stakeholders, including climate change experts, State of California staff, and energy and green building leaders.

Project team

Project management and funding:	Green Building in Alameda County
GreenPoint Rated coordination:	Build It Green
Technical lead:	KEMA Green Building Services
Technical support:	ICLEI–Local Governments for Sustainability
Stakeholder group:	Representatives from the following agencies: California Energy Commission, California Air Resources Board, California Integrated Waste Management Board, California Department of Public Health, California Urban Water Conservation Council, Center for Clean Products, City of Berkeley, City of Emeryville, City of Rohnert Park, City of San Jose, City of Sacramento, Collaborative for High Performance Schools, CTG Energetics, Environmental Defense, Healthy Buildings Network, Natural Resources Defense Council, San Francisco Department of the Environment, Scientific Certification Systems, SolData, Sustainable Capital, What's Working, US EPA Region 9.

About Green Building in Alameda County

The Green Building in Alameda County program works with building professionals and local governments in Alameda County to increase the supply and capacity for green building, and engages in consumer outreach and policy development to increase the demand for green building. Green Building in Alameda County is a program of StopWaste.Org, which is the Alameda County Waste Management Authority and Source Reduction and Recycling Board operating as one public agency.

For more information:

Green Building in Alameda County
1537 Webster Street, Oakland, CA 94612
510.891.6500 www.buildgreennow.org
Contact: Wes Sullens, Karen Kho

About Build It Green

Build It Green is a non-profit membership organization whose mission is to promote healthy, energy- and resource-efficient building practices in California.

For more information: Build It Green
1434 University Avenue, Berkeley, CA 94702
510.845.0472 www.builditgreen.org
Contact: Tenaya Asan

Appendix E1: Methodology

The Climate Calculator quantifies the climate change benefits of building a specific GreenPoint Rated home. The data inputs for the Climate Calculator are incorporated into the Rater verification process for GreenPoint Rated so that all participating homes will be assigned greenhouse gas and resource reduction benefits. GreenPoint Raters have provided input on the feasibility of obtaining various data in the field. California Climate change experts, State of California agency staff, and energy & green building leaders also consulted on the assumptions behind the calculator.[25]

The green building measures in the Climate Calculator are drawn from the GreenPoint Rated program, which includes single-family new construction, multifamily new construction and single-family existing homes. The measures are broadly grouped into the following seven impact categories for the Climate Calculator with corresponding metrics and methodologies:

1) Energy efficiency and energy reduction measures included in Title 24 performance modeling
2) Energy issues not accounted for in Title 24 performance modeling (prescriptive energy requirements, appliances, renewable energy, refrigerants etc.)
3) Outdoor water use
4) Indoor water use
5) Land use and siting effects on occupant vehicle use
6) Materials and recycling
7) Advanced refrigerants and refrigerant leakage.

The sources of greenhouse gas emissions addressed by the calculator include:

- **Electricity generated by power plants**: For example, 0.49 lbs of CO2e are created for every kilowatt hour (kWh) used in PG&E service territory.[26] Each investor owned utility in California has a corresponding emissions factor of CO2e depending on their mix of power sources.
- **Electricity demand from water use:** On average, the consumption of one million gallons of water in California requires 3950 kWh of electricity for conveyance and treatment.[27] Thus, water savings can be equated to GHG emissions. For the Calculator, the actual location of the project (zip code) will be used to determine the amount of energy embedded in water. See Appendix C: Emissions Factors for list of California utility coefficients used in the Calculator.
- **Heating with natural gas:** In California, 11.6 lbs CO_2e are generated per Therm of natural gas used.[28]
- **Transportation as a function of density**: Emissions from mobile sources are calculated using vehicle miles traveled (VMT), engine data (e.g. engine type and fuel efficiency),

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[25] See the project team and stakeholders on page 19

[26] California Climate Action Registry, http://www.climateregistry.org/CARROT/public/reports.aspx, Clean Air and Climate Protection (CACP), ICLEI and National Association of Clean Air Agencies (NACAA), www.cacpsoftware.org. See Appendix C: Emissions Factors for full citation.

[27] CEC Staff Report: California's Water-Energy Balance (Report CEC-700-2005-11-SF).

[28] California Climate Action Registry General Reporting Protocol, Version 2.2, March 2007.

and GHG emissions per mile traveled. Research has shown that the average number of housing units per residential acre (which excludes other land uses) correlates well with the average vehicle miles traveled (VMT); the higher the density the lower the VMT.[29] As such, it is possible to predict VMT reduction based on change in density at the project level. But density must be done correctly; the Calculator only shows savings if alternative transportation options and pedestrian-friendly design are included as well.

- **Waste materials going to the landfill:** Construction waste typically includes wood, wallboard, corrugated (cardboard), concrete, metal, green waste and other debris. Each has a corresponding GHG emissions factor that is a function of embodied energy in production, transportation, and landfilling.[30] Material waste streams analyzed in the Calculator include wood, cardboard, concrete, green waste, metal, and mixed materials sent to recycling centers (if the average facility recycling rate is known).
- **Leakage of refrigerants**: Gases used in refrigeration escape at a rate of 2% a year, or 1 lb per year for a typical home application.[31] Each refrigerant has an associated global warming potential (GWP) related to this amount and interval that can be compared to the same mass of CO_2 (with a GWP of 1).

Many measures were excluded from the calculator because of either a low correlation with climate change or resource benefits (e.g. light pollution reduction), insufficient data available (e.g. no third party study on the energy savings of a gearless elevator over a hydraulic elevator), or difficulty devising a solid metric by which to measure its impact (e.g. environmentally preferable materials). See Appendix D for a list of measures not yet included in the calculator and Appendix E for a list of measures excluded from the Calculator.

For new homes, energy measures that are required in the 2005 California Building Energy Code (Title 24 part 6) are not included in energy savings estimates since they do not exceed minimum code requirements. The building measures taken to achieve energy performance beyond code are detailed as part of the whole building energy modeling, and thus are not quantified individually. Energy savings from good design and high performance building technologies are included as part of the modeled home's performance.

For existing homes, there are two types of GreenPoint Rated categories: whole house and partial house (called "Elements").

- **Whole House:** The project must meet the minimum requirements of the Green Point Rated checklist, which includes Title 24 performance modeling.
- **Elements:** For partial retrofits (or any other project not requiring Title 24 performance modeling), the checklist identifies specific measures a project may claim prescriptively. Savings for energy-related measures are calculated based on the improved performance over a typical home of the same size and vintage. The Elements program uses four vintage categories: a) pre-1980 (i.e. pre-Title 24); b) 1980-2001; c) 2002-2005; and d) 2006-present. The four vintages correspond with significant changes in building energy efficiency practices coinciding with major Title 24 updates. Historic information, like SEER of air conditioning or insulation levels in the walls, can be estimated based on

[29] Holtzclaw, John, *Smart Growth As Seen From the Air, Convenient Neighborhood, Skip the Car*, June 2000, www.sierraclub.org/sprawl/transportation/holtzclaw-awma.pdf
[30] Waste Reduction Model (WARM) calculator, US EPA, 2008 update, www.epa.gov
[31] LEED NC Reference Guide Version 2.2, US Green Building Council, October 2005

vintage and energy savings over the assumed basecase. These measures are listed in Appendix B.

A note on CO2 emissions types

While the data on emissions generated by the Climate Calculator are informative, not all emissions are equally attributable to the building's design or construction. In particular, some of the emissions data quantified in the Calculator are based on factors outside the control of the building owner or contractor, such as the carbon footprint in each kilo-watt of energy delivered to the site. Because of the different nature of emissions in terms of who owns or creates them, a set of emissions "scopes" are used to classify each type of emission as direct or indirect. See Table A for an overview of the World Resources Institute's definition of emission scopes and how they relate to measures in the GreenPoint Rated Climate Calculator. [32] Each of the measures included in the Climate Calculator are assigned scope 1, 2, or 3.

TABLE A: Emissions Scopes Used in Footprinting

	SCOPE 1	SCOPE 2	SCOPE 3
Definition of Scope	Direct emissions: *Emissions occur on-site and are owned or controlled by the homeowner/builder.*	Indirect emissions from the consumption of purchased electricity: *Emissions occur off-site but are directly attributable to the owner/builder. Scope 2 emissions physically occur at the facility where electricity is generated.*	All other indirect emissions: *Emissions that occur off-site and are a consequence of the activities of the owner/builder, but occur from sources not owned or controlled by the homeowner/builder.*
Measures in the GreenPoint Rated Climate Calculator	Natural gas or propane savings due to energy efficiency, solar water heating, high efficiency appliances.	Electric energy savings due to energy efficiency and/or electricity generated on-site via PVs/wind. Compared against the emissions factor for the utility that serves the site.	Measures with upstream and downstream impacts: waste diversion, recycling, water conservation, embodied energy in materials production, lifecycle analysis.

Footprints

The Climate Calculator defines emissions and resource savings as the difference between a basecase conventional home's profile and the green home. To do this, the Calculator develops two footprints: one based on a conventional home, and the second is the GreenPoint Rated home.

[32] Definitions for Scopes come from the World Resources Institute's *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (rev. ed.),* 2004 (www.ghgprotocol.org).

The basecase conventional home serves as a starting point for comparing the two footprints. The basecase is hypothetically the home that would have been built had it been designed and built to conventional code-compliant standards and practices. The conventional home is developed in the Calculator by estimating average home size, occupancy, energy use, appliance selection, refrigerant type, construction waste profile, development density, and more. Each of the conventional home assumptions have been vetted with leaders in the respective industries and are documented in Appendix B.

The GreenPoint Rated home then becomes the “green” case whereby the green home’s profile is compared against the basecase, conventional home. The difference between the two footprints is the assumed savings. For existing buildings, the methodology is slightly different because the basecase home is based on the vintage of construction, instead of current standard practice, but otherwise the methodology is the same as for new homes.

Appendix E2: Measures Included in the Calculator

The information included in this table was used in the design and creation of the calculator. Measures are organized by categories outlined in Build It Green's Single Family and Multifamily Green Building guidelines. Regional emissions factors used in calculations are summarized in Appendix C.

Measure	Description impact	Data input	Savings	Baseline	Calculation
Community Planning and Design					
Conserve Resources by Increasing Density (10 Units per Acre or Greater)	Increased density is shown to correlate to higher use of transit, and less driving.	Average home density	Calculator developed by ICLEI	Typical density of single family dwellings in sprawl. Adapted from John Holtzclaw study "Smart Growth As Seen From the Air". This calculation includes EMFAC On Road Emission Factors from ARB/BAAQMD.	VMT emissions data are correlated with avg housing units per residential acre and proximity to services/transit. Must include this measure (density) along with the next 3 measures in this table to take credit for VMT savings.
Design for Walking & Bicycling	Pedestrian and bicycle-friendly design correlates with less driving	Same as above	Same as above	Same as above	Included in ICLEI density/VMT calculation above
Pedestrian Access to Community Services within ½ Mile	Mixed-use developments with pedestrian access correlate with less driving	Same as above	Same as above	Same as above	Included in ICLEI density/VMT calculation above
Transit Options	Increased public transit options correlate with less driving	Same as above	Same as above	Same as above	Included in ICLEI density/VMT calculation above
Home Size Efficiency (for new single family homes only)	Smaller homes reduce heating and cooling loads and result in less waste to construct.	house sf	kWh and tons of waste	Assume baseline home size per BIG single family Rater Manual (version 3.4, January 2008, page 65), based on ANSI Z765-2003. Energy: kWh/sf from Title 24 model. Waste: from StopWaste.Org study on average waste generation for new homes.	Energy: Multiply kWh/sf x difference in sf from basecase sf x adjustment factor. Waste: multiply lbs/generated per sf by difference in sq ft from basecase sf.
Site					
Recycle Job Site Construction Waste (Including Green Waste)	Recycling construction waste results in upstream benefits (manufacturing, extraction, transportation) and downstream energy savings (transportation, methane capture, cogeneration) .	lbs waste diverted by material	Crushed concrete, mixed metals, green waste, cardboard & wood tons	No recycling of materials.	Savings based on EPA WAste Reduction Model (WARM) 2008 update.

Measure	Description impact	Data input	Savings	Baseline	Calculation
Landscaping					
Minimize Turf Areas in Landscape Installed by Builder	Electricity used to source, convey and treat water in the state has associated GHG emissions. Following Bay-Friendly Landscaping techniques can significantly reduce water demands from landscapes.[33]	Reference ET, square feet of landscape, and GPR checklist	kWh/gallon of H_2O coefficient adapted from CEC study on Water-Energy relationship	Assume 50% of landscaping consists of regularly watered plants (turf), remaining 50% consists of occasional watering plants. No weather-based controllers.	Must include Hydrozoning, High-Efficiency Irrigation Systems, and must use compost and mulch to get savings. Water budget based on Bay Friendly Landscaping prerequisites and utilizing data from Public Policy Institute of California, and CA WELO.
Implement Hydrozoning: Group Plants by Water Needs	Same as above	Same as above	Same as above	Same as above	Same as above
Install High-Efficiency Irrigation Systems	Same as above	Same as above	Same as above	Same as above	Same as above
Apply 2 inches Compost into the Top 6-12 inches of Soil	Same as above	Same as above	Same as above	Same as above	Same as above
Mulch All Planting Beds to greater of 2" or Local Water Ordinance	Same as above	Same as above	Same as above	Same as above	Same as above
75% of Plants Are California Natives or Mediterranean Species	Same as above	Same as above	Same as above	Same as above	If this measure checked off on checklist, then design case is assumed to have no areas of high water use.
Plant Shade trees	Trees sequester carbon when growing and also cool surrounding air, resulting in reduced air conditioner use in hot climates.	Shade trees or not? Include climate zone	A 25 foot tree reduces annual cooling costs of a typical residence by about 8-12 percent. Assumed 8% cooling savings per home.	No 25' shade trees.	A/C electricity use estimated based on climate zone using RASS study. A/C savings estimates (8-12%) come from Energy-Efficient Landscapes McPherson, Rowntree and Wagar (1995) page 150, and, Urban Forest Landscapes, Integrating Multidisciplinary Perspectives (Edited by Gordon A. Bradley)
Meets California-Friendly Landscape requirements	Reduced water use in landscapes.	Water budget calculation	kWh/gallon of H_2O conserved	Conventional landscaping	kWh/gallon of H_2O conserved
Plumbing					
Install Only High Efficiency Toilets (Dual-Flush or ≤1.3 gpf)	Water is saved by installing toilets that use less water per flush.	# fixtures	gallons per fixture over baseline; apply kWh/gallon of water savings	Assume average flush rate of 1.6 gpf,	CA Building Standards Commission Green Building Code modified with input from CUWCC
Rain Water Collection System	Rain water collection reduces the need for utility water	gallons collected	kWh/gallon of H_2O conserved	No rain water collection	Amount of water collected annually = gallons of water saved

[33] Prerequisite requirements for the Bay-Friendly Landscaping principles are included in the GreenPoint Rated Guidelines. See www.bayfriendly.org for more information on the program.

Measure	Description impact	Data input	Savings	Baseline	Calculation
Composting or waterless toilet	Waterless toilets reduce the need for water.	# fixtures	kWh/gallon of H_2O conserved	conventional toilet of 1.6 gpf	CA Building Standards Commission Green Building Code modified with input from CUWCC
Greywater system operational (includes washing machine at minimum)	Use of greywater reduces the need for utility water supply and for wastewater treatment	gallons collected	kWh/gallon of H_2O conserved	No greywater system	Quantity of greywater = gallons of water saved
Plumbing fixtures with below standard flow rates (faucets <1.5 & showers <2.0 gal/min)	Reduces water use, which saves electricity in pumping water from the reservoirs.	# fixtures	savings (gal) per fixture	Conventional plumbing fixtures based on Federal maximum flow rates (EPAct); kitchen faucets exempt	CA Building Standards Commission Green Building Code modified with input from CUWCC. No hot water savings calculated at this time.
Water savings for waterless urinals	Waterless urinals save water,	# of urinals	savings (gal) per fixture	Federal law requires 1gpf max for urinals. 1 gpf x flushes/yr	CA Building Standards Commission Green Building Code modified with input from CUWCC
Water savings for flow restrictors/ control valves, pre-rinse spray valves	Reduces water and energy use.	# fixtures with flow restrictors installed and flow rates	savings (gal) per fixture	Standard water fixture efficiency	CA Building Standards Commission Green Building Code modified with input from CUWCC. No hot water savings calculated at this time.
Appliances					
Install High Efficiency Air Conditioning with Environmentally Responsible Refrigerants	High efficiency air conditioning lowers energy use (accounted in T24). Some refrigerants have high Global Warming Potential (GWP).	amt of refrigerant /ton of cooling	Compared against GWP of HCFC-22 (also known as R-22)	Standard refrigerant (HCFC-22)	Refrigerant GWPs delta as calculated. 'LEED NC Reference Guide Version 2.2 and EPA website. Assumes 2% leakage per year.
Install Water and Energy Efficient Dishwasher	Water-efficient dishwashers reduce water and energy use	# of dishwash-ers and ENERGY STAR ratings	Use ENERGY STAR calculator for kWh and therm savings.	DOE Standard Dishwasher energy factor and annual water consumption. Differs based on water heater energy source (electric or gas).	Based on ENERGY STAR calculator or actual appliance data.
Install ENERGY STAR Clothes Washing Machine with Water Factor of 6 or Less	Water-efficient clotheswashers reduce water and energy use.	# washing machines and ENERGY STAR ratings	ENERGY STAR clotheswasher calculator for energy (kWh and therm) & water savings	Standard full-size washer water and energy use per year. Differs based on water heater energy source (electric or gas).	Based on ENERGY STAR calculator or actual appliance data.
Install ENERGY STAR Refrigerator	ENERGY STAR refrigerators can reduce electricity bills.	# refriger-ators and ENERGY STAR ratings	kWh savings from ENERGY STAR calculator	DOE standard efficiencies for refrigerator configuration and size	Based on ENERGY STAR calculator or actual appliance data.
Central laundry (multifamily only)	Residents tend to wash larger loads, and less frequently when using a centralized laundry room. This saves on water and energy.	number of units in project	70% water savings, 80% kWh savings, and 81% natural gas savings per year per unit over conventional washers	Central laundry savings use baseline of conventional clothes washers installed in every unit (not ENERGY STAR)	Savings = Conventional clothes washer resource use x (70%, 80%, 81%) = Water savings, kWh savings and natural gas savings.

Measure	Description impact	Data input	Savings	Baseline	Calculation
Heating, Ventilation, and Air Condition (HVAC)					
Don't Install Fireplaces or Install Sealed Gas Fireplaces	Efficient gas fireplaces consume less gas and reduce winter heating costs.	# fixtures	9 therms/yr per fixture	Assume no fireplace	Calculation based on study from the Natural Resources Canada Office of Energy Efficiency www.oee.nrcan.gc.ca/equipment
Building Performance					
Design and Build High Performance Homes - 15% above Title 24 -	High performance homes use less energy	Title 24 report kWh & therms	% above code (Minimum requirement: 15% above code TDV energy budget on CF-1R)	Baseline house that is Title 24 compliant	Title 24 performance model output. Non- TDV kWh and therm usage below baseline code.
Building Diagnostics (Multifamily only)	Commissioning ensures that the building operates according to design intent.	Are diagnostics included or not?	2-20% savings typical. Assume 3% conservative estimate (LBNL study)	Assume no commissioning done - current average energy consumption, or T24 performance model results	3% energy savings relative to performance model for Title 24 home (design case).
Renewable Energy					
Install Photovoltaic (PV) Panels	PV installations displace the need for fossil-fuel based grid electricity	Estimated annual output	kWh offset	Assume no PV panels.	(Annual kWh solar output x tons CO2/utility kWh) = tons of CO2 displaced
Energy Upgrades for Existing Homes (whole house)	Retrofitting existing homes increases energy perfomance	Estimated kWh savings of whole house	% above code or basecase	No actions – modeled average current energy consumption	Calculate using performance software.

Measure	Description impact	Data input	Savings	Baseline	Calculation
Existing Home GPR prescriptive energy measures (Elements - when no T24 modeling required)[34]					
Energy Upgrades, Tier 1					
Attic, crawl space, and wall insulation	A well insulated building has better energy performance.	Climate zone, insulation thickness	Better than basecase	Based on typical house within vintage category	Annual kWh and Btu savings over baseline
High Efficiency Furnace (+90% AFUE)	Higher efficiency furnaces consume less energy	Climate zone, equip specifications	Better than basecase	Based on typical house within vintage category	Rater verification of AFUE
Minimal Duct Leakage < 15% lost	Less leakage = higher efficiency	From test protocol	Better than basecase	Based on typical house within vintage category	Annual kWh and Btu savings over baseline
High Efficiency Air Conditioning Unit (zones 2,4,8-16)	Higher efficiency AC units use less energy to cool the home	Climate zone, equip specifications	Better than basecase	Based on typical house within vintage category	Annual kWh and Btu savings over baseline
Blower Door Test 0.5 ACH or 50% improvement	sealing air leaks can reduce heating and cooling loads	From test protocol	Better than basecase	Based on typical house within vintage category	Rater verification in the field (Based on KEMA study)
Energy Upgrades, Tier 2					
High Efficiency Water Heater	Higher efficiency water heaters consume less energy	Climate zone, equip specifica-tions	Better than basecase	Based on typical house within vintage category	Annual kWh and Btu savings over baseline
Radiant Barrier	Reduces penetration of roof heat into attic	Installed or not	Better than basecase	Based on typical house within vintage category	Rater verification in the field (Based on KEMA study)
Window Upgrades	Improves the loss/gain of heat through windows	Climate zone, equip specifica-tions	Better than basecase	Based on typical house within vintage category	Annual kWh savings over baseline
Duct Insulation	Minimize losses in ducts	Climate zone, insulation R-value	Better than basecase	Based on typical house within vintage category	Annual kWh savings over baseline
Programmable Thermostat	Allows for more control of HVAC use, helpful in reducing energy	Climate zone	Better than basecase	Based on typical house within vintage category	Rater verification in the field (Based on KEMA study)
High Efficiency Air Conditioning Unit (zones 1,3,5,6,7)	Higher efficiency AC units use less energy to cool the home	Climate zone, equip specificat-ions	Better than basecase	Based on typical house within vintage category	Annual kWh and Btu savings over baseline
Water and Energy Efficient Dishwasher Installed	Water-efficient dishwashers reduce water and energy use	# machines and ENERGY STAR ratings	Use ENERGY STAR calculator for kWh savings.	Based on typical house within vintage category	Project use = Gallons/cycle x 0.1 cycles/day x 365 days
ENERGY STAR Refrigerator Installed	ENERGY STAR refrigerators can reduce electricity bills.	# machines & ENERGY STAR ratings	kWh savings from ENERGY STAR calculator	Based on typical house within vintage category	Based on ENERGY STAR calculator
Energy Efficient Lighting (at least 10% of total)	Energy efficient lighting saves energy	Lighting survey	Better than code basecase	Based on typical house within vintage category	kWh savings

[34] Savings are based on the CEC Database for Energy Efficiency Resources (DEER) study, www.energy.ca.gov/deer except where noted as savings estimates from the KEMA Measure Quantification Study of Savings for NCPA/SCPPA, 2006 (referenced herein as "KEMA Study").

Appendix E3: Emissions Factors & Coefficients

EMISSIONS SOURCE	EMISSIONS FACTOR		YEAR	DATA SOURCES
Electricity				
California grid-wide average	878.7	lbs CO_2/MWh	2005	[1]
Austin Energy	1078.0	lbs CO_2/MWh	2005	[2]
City of Anaheim Public Utilities	1416.7	lbs CO_2/MWh	2005	[2]
City of Palo Alto Public Utilities	39.0	lbs CO_2/MWh	2005	[2]
Los Angeles Department of Water and Power	1238.5	lbs CO_2/MWh	2005	[2]
PacificCorp	1747.3	lbs CO_2/MWh	2005	[2]
PG&E	455.8	lbs CO_2/MWh	2005	[2]
Platte River Power Authority	1955.7	lbs CO_2/MWh	2005	[2]
Riverside Public Utilities	1346.2	lbs CO_2/MWh	2005	[2]
Roseville Electric	565.5	lbs CO_2/MWh	2005	[2]
Southern California Edison	641.3	lbs CO_2/MWh	2005	[2]
San Diego Gas & Electric	780.8	lbs CO_2/MWh	2005	[2]
Sacramento Municipal Utility District	555.3	lbs CO_2/MWh	2005	[2]
Turlock Irrigation District	628.5	lbs CO_2/MWh	2005	[2]
Natural Gas				
Natural Gas	11.616	lbs CO_2e/therm	2007	[2]
Propane	0.00567	MTCO2/gallon propane		
Water				
Northern California:				
Indoor water	3,950			
Outdoor water	1,450			
Rainwater system - used indoors	1,450			
Rainwater system - used outdoors	1,450			
Greywater system - used indoors	3,950			
Greywater system - used outdoors	3,950	kWh/million gal.	2005	[3]
Southern California				
Indoor water	12,700			
Outdoor water	10,200			
Rainwater system - used indoors	10,200			
Rainwater system - used outdoors	10,200			
Greywater system - used indoors	12,700			
Greywater system - used outdoors	12,700	kWh/million gal.	205	[3]
Waste				
Concrete	-0.01	MTCO2E per ton recycled	2008	[4]
Wood	-0.79	MTCO2E per ton combusted	2008	[4]
Cardboard	-3.11	MTCO2E per ton recycled	2008	[4]
Mixed metals	-5.26	MTCO2E per ton recycled	2008	[4]
Green waste	-0.20	MTCO2E per ton composted	2008	[4]

EMISSIONS SOURCE	EMISSIONS FACTOR		YEAR	DATA SOURCES
Refrigerants				
Baseline: R-22 refrigerant	1780	lbs CO2/lb of refrigerant	2005	[5]
Ammonia	0	lbs CO2/lb of refrigerant	2007	[6]
HFC-134A refrigerant	1320	lbs CO2/lb of refrigerant	2005	[5]
HFC-407C refrigerant	1700	lbs CO2/lb of refrigerant	2005	[5]
HFC-410A refrigerant	1780	lbs CO2/lb of refrigerant	2005	[5]
Vehicle Miles Traveled				
VMT reduction based on density	Varies	VMTs reduced	2005	[7]

[1] California grid-wide average is from EPA e-RID2006V2_1_year04_aggregation file (Sheet "EGRDSRL04")
[2] Certified CO_2 emission factor for delivered electricity: www.climateregistry.org/tools/members-only/reporting-tips.html
[3] CEC Staff report: California's Water-Energy Balance (Report CEC-700-2005-11-SF)
[4] Savings factors based on EPA WAste Reduction Model (WARM) calculator, www.epa.gov, 2008 update with modifications on assumptions for sequestration by StopWaste.Org and ICLEI.
[5] Based on LEED-NC Reference Guide Version 2.2 (October 2005)
[6] EPA listed refrigerant. http://www.sznorinco.com/chemicals/dy/proe23.html.
[7] EMFAC 2007 data in conjunction with formulas and assumptions for this calculation is adapted from John Holtzclaw's work: “Smart Growth As Seen From the Air, Convenient Neighborhood, Skip the Car.” http://www.sierraclub.org/sprawl/transportation/holtzclaw-awma.pdf

Appendix E4: Measures Not Yet Included in the Calculator

The following list of measures are not included in the Calculator but will likely be included when new research becomes available.

MEASURE	COMMENTS
COMMUNITY DESIGN & PLANNING	
Subdivision Layout & Orientation to Improve Natural Cooling and Passive Solar Attributes	Not adequately addressed in T24 (base = proposed home orientation), but there are too many variables to include this analysis at this time. Perhaps the California Energy Commission or other entity will develop tools for this analysis in the future.
Redevelopment of an existing building	Too many variables and unknowns. Can take credit for source reduction/recycling of construction materials.
SITE	
Reduce Heat-Island Effect - Install light-colored, high albedo materials (solar reflectance index >= 0.3) for at least 50% of site's non-roof impervious surfaces	Not included in T24 modeling. Difficult for GPR raters to verify without significant efforts in documentation. Studies on reducing the urban heat island effect through high albedo materials and correlating those benefits to building sites are not conclusive at this time.
FOUNDATION	
Replace Portland Cement in Concrete with Recycled Flyash or Slag	Concerns over the availability of flyash/slag in the west make this measure questionable for emissions savings due to the amount of transportation energy associated with the use of flyash. Therefore, while we acknowledge flyash as a good practice due to its use of a waste by-product (recycling), and as a less energy intensive material than Portland cement, we are hesitant to claim any benefits in CO_2 emissions due to its use. Flyash is difficult to document for Raters as well. WARM does include a flyash coefficient so in the future this measure may be possible to add.
LANDSCAPING	
Construct Resource-Efficient Landscapes	
No Plant Species Will Require Hedging or Shearing	There are benefits in reduced gasoline use (or in some cases electric) from the avoidance of motorized maintenance equipment to shear hedges and mow lawns. This measure also reduces the amount of green waste produced on site that is either then landfilled or composted. In order to take credit for reduced green waste, we would need average green waste generation rates for hedges, which is not available at this time. This issue will be revisited in next version.
Use 50% Salvaged or Recycled-Content Materials for 50% of Non-Plant Landscape Elements	Difficulty in accurately compiling and understanding life cycle impacts (e.g. raw materials, manufacturing and distribution streams, transportation) make it nearly impossible to accurately estimate CO_2 impacts. Developing baseline emissions estimates for the manufacturing industry would be necessary to truly quantify emissions reductions beyond “standard” practice. Look to tools like Pharos to help with this issue in the future.

MEASURE	COMMENTS
STRUCTURAL FRAME & BUILDING ENVELOPE	
Apply Optimal Value Engineering	Energy savings from this strategy are included in Title 24 as part of the wall framing factor. Documenting a reduction in the quantity of wood was seen as too difficult for Raters to collect economically, so this measure is not included at this time.
Use FSC-Certified Wood	The impact of sustainably harvested forests as opposed to conventional forestry practices on greenhouse gas emissions may be correlated but specific data about it is not currently available. The FSC Board of Directors, with support from FSC staff, is currently debating the role FSC will play in relation to the global climate debate including the possible role of forests in carbon sequestration." April 7th, 2008 at Mongabay.com: news.mongabay.com/2008/0407-hance_fsc_interview.html
Use Recycled-Content Steel Studs for 90% of Interior Wall Framing	May or may not have energy benefit. Recycled steel is better than virgin steel, but probably more intensive than wood framing and may not make up for that in energy savings over life of home. Lifecycle analysis tools are not conclusive at this time. Look to tools like Pharos, Athena Institute, or BuildCarbonNeutral.org in the future.
Green Roofs (25% of roof area minimum)	Has some insulation value, but that benefit can be modeled in Title 24. Stormwater and water savings are dependent on rainfall data, roof design, and other elements which are difficult to quantify. Can include green roofs under the landscape water savings.
Construction materials efficiencies	Difficult to quantify. Even if baseline amount of material could be determined for any specific building or modular building components, transportation/landfilling diversion from this amount would be difficult to calculate.
EXTERIOR FINISH	
Use Recycled-Content (No Virgin Plastic)	Difficulty in accurately compiling and understanding life cycle impacts (e.g. raw materials, manufacturing and distribution streams, transportation) make it nearly impossible to accurately estimate CO2 impacts. Developing baseline emissions estimates for the manufacturing industry would be necessary to truly quantify emissions reductions beyond "standard" practice. Look to tools like Pharos to help with this issue in the future.
INSULATION	
Inspect Quality of Insulation Installation before Applying Drywall	Inspection of insulation installation is critical but difficult to quantify. Title 24 accounts for this in part.
PLUMBING	
Water Submetering	Lack of data related to baseline whole building water usage. One realty company that owns over 75,000 apartment units throughout the country reported average water savings between 20 and 30 percent of total use when submetering was in place. A submetering study in Seattle did not record any savings. Savings are excluded for now because of inconclusive study results.

MEASURE	COMMENTS
HVAC	
Innovative wastewater technology (constructed wetland, sand filter, aerobic system)	Removed from the list because not possible to calculate energy use for a single septic system compared with an innovative wastewater technology. Could possibly assign water-energy benefit based on the CEC study, but savings were deemed too low to justify inclusion at this point. Water savings from reduced sewage are accounted for.
Install drain water heat-recovery system	Not accounted for in Title 24. Savings related to this measure are expected to be quite small, but no peer-reviewed literature was found to quantify expected energy savings.
Install Effective Exhaust Systems in Bathrooms and Kitchens	Specific energy savings data for bathroom fans not available at this time.
Install ENERGY STAR Ceiling Fans & Light Kits in Living Areas & Bedrooms	Ceiling fans can reduce the need for air conditioning. Estimated 151 kWh/yr saved per fan based on ENERGY STAR data. However, baseline data for average fan use was not available at time of development. Revise in next version.
Automatically Controlled Integrated System (including variable speed control)	Integrated systems heat and cool more efficienctly. Night Breeze system is typical of this type of system. Saving data available from Davis Energy Group, but more studies desired before adding to Calculator. Further, some energy benefit may already be accounted for in Title 24. Risk of double-counting.
RENEWABLE ENERGY	
BUILDING PERFORMANCE	
House Obtains ENERGY STAR with Indoor Air Package Certification	Mostly concerned with IAQ, not energy savings. This measure overlaps with many of the above measures and is thus accounted for elsewhere.
Renewable Energy: Extraordinary Passive Solar or other Energy Design (> 50% of load) that is proven to not already be reflected in T-24 modeling	The Rater must establish proof of over and above energy savings not reflected in T24.
FINISHES	
Use Environmentally Preferable Materials for Interior Finish	This measure gives Points for five different kinds of materials. In none of the five cases have we found a credible source for calculating an emissions benefit relative to a baseline scenario. Overall, this is too general and difficult to compare to a baseline scenario at present. Look to tools like Pharos to help with this issue in the future.
Gearless Elevators	No third party study. Without independently verified data on gearless elevators, energy savings cannot be accurately verified.
FLOORING	
Use Environmentally Preferable Flooring	No credible source for calculating an emissions benefit relative to a baseline scenario have been found. Overall, this is too general and difficult to compare to a baseline scenario at present. Look to tools like Pharos to help with this issue in the future.

MEASURE	COMMENTS
APPLIANCES & LIGHTING	
Install Built-In Recycling Center	While recycling and composting at home have benefits, this measure was dropped because it is a behavioral issue. An investigation into the ways to estimate the amount of recycling is being conducted now and this measure will likely be used in the next update of the Calculator.
OTHER	
Materials sourced and manufactured within a 500 mile radius of the home (per LEED for Homes)	Difficulty in accurately compiling and understanding life cycle impacts (e.g. raw materials, manufacturing and distribution streams, transportation) make it nearly impossible to accurately estimate CO2 impacts. Developing baseline emissions estimates for the manufacturing industry would be necessary to truly quantify emissions reductions beyond "standard" practice. Look to tools like Pharos to help with this issue in the future.
Reduced Parking Capacity	Difficult to define a baseline value because jurisdictions vary in their parking requirement. Parking is somewhat accounted for in the density/VMT calculator developed by ICLEI.
Affordability	According to the NPH study "Planning for Residential Parking: A Guide For Housing Developers and Planners" affordable housing requires less parking and therefore less VMT can be expected by residents. However, if reduced parking capacity does in fact drive GHG reductions, then a parking measure should get credit, not affordability. Found online at: www.nonprofithousing.org/actioncenter/toolbox/parking.
E-Meters	Measure not included in calculator due to behavioral aspect of this measure and any associated savings potentially counted in other measures (e.g. installation of energy efficient dishwasher). Also, excluded due to uncertain baseline energy use (i.e. T24 performance estimate not necessarily appropriate). NYSERDA states 10-26% savings on electric consumption from first year. http://www.nyserda.org/publications/SubmeterManual.pdf (PDF page 10)

Appendix E5: Measures Not Applicable to the Calculator

These measures from the Guidelines were considered not applicable to the Calculator.

Reasoning for not including them:
A: Very small or no quantifiable climate change or resource benefit(s) expected
B: Difficult for Raters to acquire data
C: Difficult to define basecase and savings above basecase

MEASURE	Reason for Exclusion		
	A	B	C
COMMUNITY DESIGN AND PLANNING			
Develop Infill Sites			o
Design for Safety & Social Gathering	o		o
Design for Diverse Households	o		o
SITE			
Protect Native Soil and Minimize Disruption of Existing Plants & Trees	o		o
Deconstruct Instead of Demolishing Existing Buildings On Site			o
Install a Foundation Drainage System	o		
Sealed and Moisture Controlled Crawlspace	o		
FOUNDATION			
Use Frost-Protected Shallow Foundation in Cold Areas (C.E.C. Climate Zone 16)	o		
Use Radon Resistant Construction (In At-Risk Locations Only)	o		
LANDSCAPING			
Use Fire-Safe Landscaping Techniques	o		
Reduce Light Pollution by Shielding Fixtures and/or Directing Light Downward		o	o
STRUCTURAL FRAME & BUILDING ENVELOPE			
Use Engineered Lumber		o	o
Design, Build and Maintain Structural Pest and Rot Controls	o		
Reduce Pollution Entering From the Garage	o		
EXTERIOR FINISH			
Install a Rain Screen Wall System	o		o
Use Durable and Non-Combustible Siding Materials			o
Select Durable and Non-Combustible Roofing Materials			o
Window flashing installation techniques specified			o
INSULATION			
Install Insulation that is Low-Emitting (Certified Section 01350)	o		
PLUMBING			
Greywater pre-plumbing (includes washing machine at minimum)	o		
Install drain pans or leak detection devices under plumbed appliances			o

MEASURE	Reason for Exclusion		
	A	B	C
HVAC			
Install Carbon Monoxide Alarm(s)	o		
Humidity control systems (only in humid/marine climate zones 1,3,5,6,7)			o
Install Sealed Combustion Unit	o		
Install High Efficiecny HVAC Filter (MERV 6+)	o		
RENEWABLE ENERGY			
Pre-Plumb for Solar Hot Water Heating	o		
Install Wiring Conduit for Future Photovoltaic Installation & Provide 200 ft^2 of South-Facing Roof	o		
BUILDING PERFORMANCE			
FINISHES			
Design Entryways to Reduce Tracked in Contaminants	o		
Use Low-VOC or Zero-VOC Paint	o		
Use Low VOC, Water-Based Wood Finishes (<250 gpl VOCs)	o		
Use Low-VOC Caulk and Construction Adhesives (<70 gpl VOCs) for All Adhesives	o		
Use Recycled-Content Paint			o
Reduce Formaldehyde in Interior Finish (CA Section 01350)	o		
After Installation of Finishes, Test of Indoor Air Shows Formaldehyde Level <27ppb	o		
Reduce Formaldehyde in Interior Finish (Section 01350)	o		
FLOORING			
Flooring Meets Section 01350 or CRI Green Label Plus Requirements	o		
APPLIANCES & LIGHTING			
OTHER			
Incorporate GreenPoint Rated Checklist in Blueprints	o		
Develop Homeowner Manual of Green Features/Benefits			o
Homebuilder is ISO 14001 certified	o		o
Majority of Homebuilder's management/staff are Certified Green Building Professionals	o		o
Detailed Durability Plan (per LEED for Homes specifications)			o
3rd Verification of Implementation of Durability Plan (per LEED for Homes specifications)			o
Comprehensive Owner's Manual and Homeowner Educational Walkthroughs	o		o

Appendix E6: Other Emissions Calculators

Unlike some calculators, the GreenPoint Rated Climate Calculator isn't a do-it-yourself rating tool that estimates the impacts of individual's behaviors, although it may be complementary to those behavior-based calculators. The GreenPoint Rated score and the Climate Calculator results are independent of the occupants' behavior in most cases. The assumptions used in the Calculator remain valid for that building regardless of ownership or occupancy, unless significant changes are made to the building's structure or systems. For this reason, the Climate Calculator is different from other calculators used for estimating CO_2e attributed to homes.

Methodologies, such as the World Resources Institute methodology, measure impacts on climate change at a macro level, either by assessing the emissions of a business, an entire industry sector, or a local or regional government's jurisdiction. Home carbon footprinting tools, like those that allow users to offset their air travel or purchasing habits, are specific to the behavior of the occupants. The GreenPoint Rated Climate Calculator bridges the gap between those calculators that estimate the carbon footprint of individuals; and the large, industry-wide emissions reporting protocols.

The following is a list of emissions calculators available to help estimate carbon footprints and/or avoided emissions from green building.

US EPA Personal Emissions Calculator
www.epa.gov/climatechange/emissions/ind_calculator.html
For individuals and households, focuses on emissions from household energy use, transportation fuels, and waste disposal. Mostly national averages except for electricity; electricity emissions factors are categorized by geographic subregion. Relies on individual to enter data.

Cool California
www.coolcalifornia.org
Calculates the carbon footprint for home or business energy use, as well as car and air travel, food, and goods and services. Data sources are all based on California metrics.

US EPA Waste Reduction Model (WARM)
www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html
Calculates emissions from landfilling and savings from recycling and composting.

US EPA Recycled Content (ReCon) Tool
www.epa.gov/climatechange/wycd/waste/calculators/ReCon_home.html
Calculates emission savings from using recycled content materials.

Lawrence Berkeley Labs Home Energy Saver
http://hes.lbl.gov
Using inputs from homeowners about their house and energy bills, the program calculates the home's carbon footprint and suggests strategies for efficiency improvements.

ENERGY STAR Portfolio Manager
www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager
Tracks and assesses energy and water consumption across entire portfolio of buildings.

ENERGYguide
www.energyguide.com
Prepares a home energy analysis report designed to help save energy and money.

Home Energy Checkup
www.ase.org/section/homeenergycheckup
A guide to identifying options for reducing energy costs through energy efficiency improvements.

Travel Matters
www.travelmatters.org
Calculates emissions from your travel.