Nuclear Regulatory Commission
Exhibit # - NRC000069-00-BD01
Docket # - 05200012| 05200013
Identified: 08/18/2011

Admitted: 08/18/2011 Withdrawn:
Rejected: Stricken:

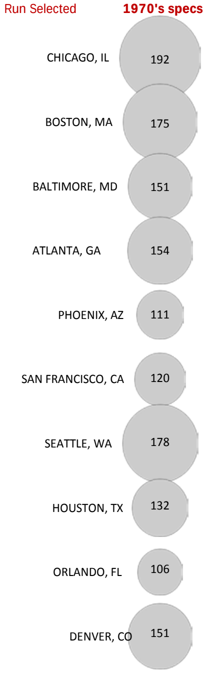
NRC000069
08/17/2011

Vintage Home Analysis | Interactive Dashboard

Annual Site Consumption (MMBTU/yr)

By City (for each run)

Run Selected 1970's specs



By Run (Energy Efficiency Package)

Select City: Houston

		1970's specs	% Δ	IECC 2009	% Δ	A	% Δ	A+B	% Δ	A+B +C	% Δ	A+B+C+D	% Δ	A+B+C+D+E	% Δ
1	Total	132	-	74	44%	90	32%	59	55%	57	57%	51	62%	41	69%
2	Heating	48	-	26	46%	29	39%	19	60%	17	64%	15	69%	15	69%
3	Cooling	40	-	13	67%	26	35%	11	73%	11	73%	7	83%	7	83%
4	WaterHeating	18	-	15	15%	17	3%	11	35%	11	35%	11	35%	2	91%
5	Appliances	17	-	13	26%	12	30%	12	30%	12	30%	12	30%	12	30%
6	Lighting	6	-	4	30%	3	61%	3	61%	3	61%	3	61%	3	61%
7	MELs	3	-	3	0%	3	0%	3	0%	3	0%	3	0%	3	0%

% Δ Indicates Savings % Over Baseline 1970's Home

Help

For a video of the dashboard tutorial, go to: CARB-SWA website

Printing Instructions

Run Legend

Hover for Details

A:Typ. Weatherization Upgrades

B: Better HVAC

C: Thermal Envelope Upgrades

D: Best Available HVAC

E: Renewables (PV&SHW)

Specifications

Scroll to See Specs

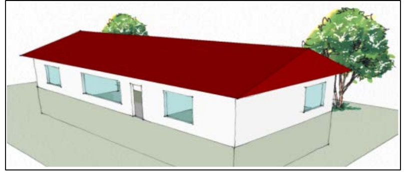
	Baseline 1970s Home	IECC 2009	1970's specs
Above-Grade Wall Assembly	2x4 wood framing at 16" O.C w/ R-11 cellulose or fiberglass	R-13	2x4 wood framing at 16" O.C w/ R-11 cellulose or fiberglass
Finished Below-Grade Wall Assembly	-	R-0	-

Highlights

Selected City	**Houston**
Climate Zone	2 Moist
Primary Fuel	Electricity
Window to Wall Ratio	North -0.11; South -0.19; East -0.11; West -0.03

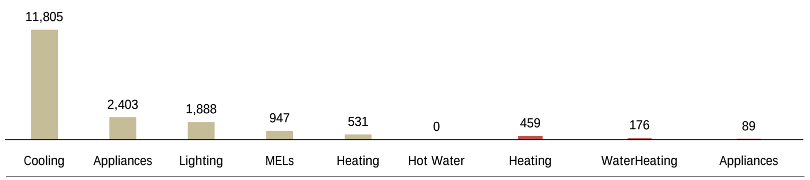
The House
1600 Sft.ranch style home oriented North (front face)with 3 bedrooms.

For a detailed description
Click here

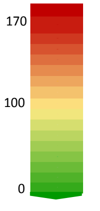


Fuel Summary

Electric End Use (kWh/yr) Gas End Use (Therms/yr)



HERS © Index



Scale not shown if HERS Index is > 180
HERS Index 182

Emissions

Note on Calculation

CO_2 Equivalent cars

CO_2 16.2 tons/yr

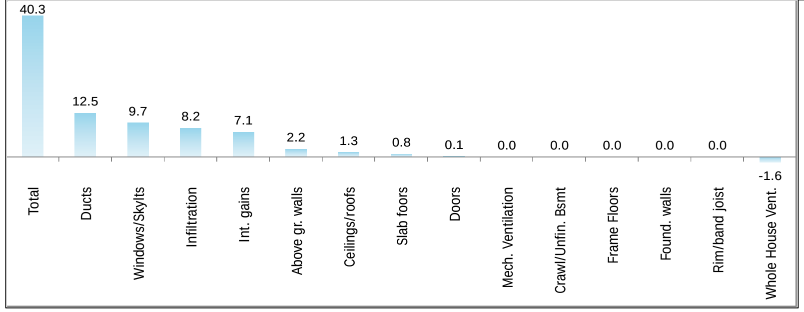
SO_2 52.9 lbs/yr

NO_X 28.3 lbs/yr

Component Consumption Summary

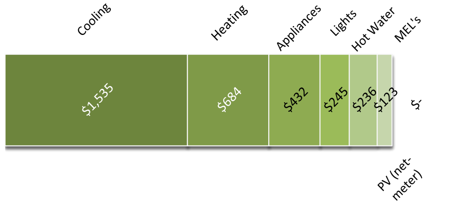
Select Graph: Cooling Consumption

Cooling in MMBTU/yr



Cost Analysis ($/yr)

Total Annual Cost	$ 3,255	Annu. Elec.	###### ######
Average Monthly Cost	$ 271	Annu. Gas	#### ########



$/kWh*	$	0.13
$/Therm*	$	1.34

*Rates are State Averages with a fixed rate of $8/month

Net Metered Excess Sell-Back Rate $/kWh $ 0.12

Credits

U.S. Department of Energy

Consortium for Advanced Residential Buildings

Steven Winter Associates Building Systems Consultants

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Retrofitting America: A 1970s Home Energy Efficiency Analysis

As we approach the end of 2010, economic instability has led to increased focus on existing homes across the building industry. Weatherization efforts, renovations, and gut rehabs are being carried out to decrease utility bills, improve occupant comfort, and increase home resale values. This shift of attention to existing homes calls for a deeper understanding of the built conditions of vintage homes and the impact of energy efficiency improvement strategies.

Under Building America, the CARB[1] team has taken an initiative to identify the energy benefits of various retrofit energy efficiency measures for a typical 1970's ranch home in **ten cities** across **four climate zones** in the United States. A tool was developed that enables users to compare a **typical 1970s ranch home** against an **IECC 2009 code-compliant home** of the same configuration and against the **70s base case *plus* retrofits**. Using modeling software (REM/Rate v12.85), CARB evaluated the **cumulative** impact of a set packages of improvement strategies. A description and images of the model home can be found in the *Project Assumptions* section below. See the *Energy Efficiency Packages* section for further details on the improvement strategies utilized for this analysis.

In an ongoing effort to present large amounts of data in a visual, easy to read format, CARB has designed an interactive dashboard. This dashboard presents an overview, while also enabling the user to filter the data based on selections and drill-down to examine the underlying data. For the city selected, this dashboard displays **ten sections of information**:

1.) Annual Site Consumption (MMBTU/yr or 1,000,000 BTU/yr) by Energy Efficiency Package (referred to as 'run')
2.) Comparison of Annual Site Consumption (MMBTU/yr) for all 10 cities based on the Run selected
3.) Specifications – Detailed information used to develop the comparative models
4.) Annual Fuel summary: Electric loads (kWh/year) and Natural Gas loads (Therms/year)
5.) HERS index (Home Energy Rating Score[2])
6.) Component Breakdown (4 options to select: Cooling or Heating Consumption or Cooling or Heating Loads)
7.) Cost Analysis: Total Annual Cost, Average Monthly Cost, Annual Electrical Cost, and Annual Gas Cost
8.) Emissions report – The CO_2 equivalent in number of cars, based on savings for selected run
9.) Highlights – Provides details on the Climate Zone, Fuel Types, and Window to Wall Ratio
10.) Help

Project Assumptions

Modeling was based on a typical ranch home that is 1,600 square feet and has 3 bedrooms and 2 bathrooms. For Climate Zones (CZ) 4 and 5, an unconditioned basement was assumed. A vented crawl space was assumed in CZ 3, and a slab was assumed in CZ 2. The window to wall ratio for each orientation are identified in the "Highlights" section of the dashboard.

Figure 1: View of the house with an unconditioned basement (CZ 4 and 5)

[1] The Consortium for Advanced Residential Buildings (CARB) is led by Steven Winter Associates, Inc. and is part of the Building America Program. Building America is an industry-driven research program, sponsored by the U.S. Department of Energy, designed to accelerate the development and adoption of advanced building energy technologies in new and existing homes. www.carb-swa.com

[2] The HERS Index is a scoring system established by the Residential Energy Services Network (RESNET) in which a home built to the specifications of the HERS Reference Home (based on the 2006 International Energy Conservation Code) scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. The lower a home's HERS Index, the more energy efficient it is in comparison to the HERS Reference Home.

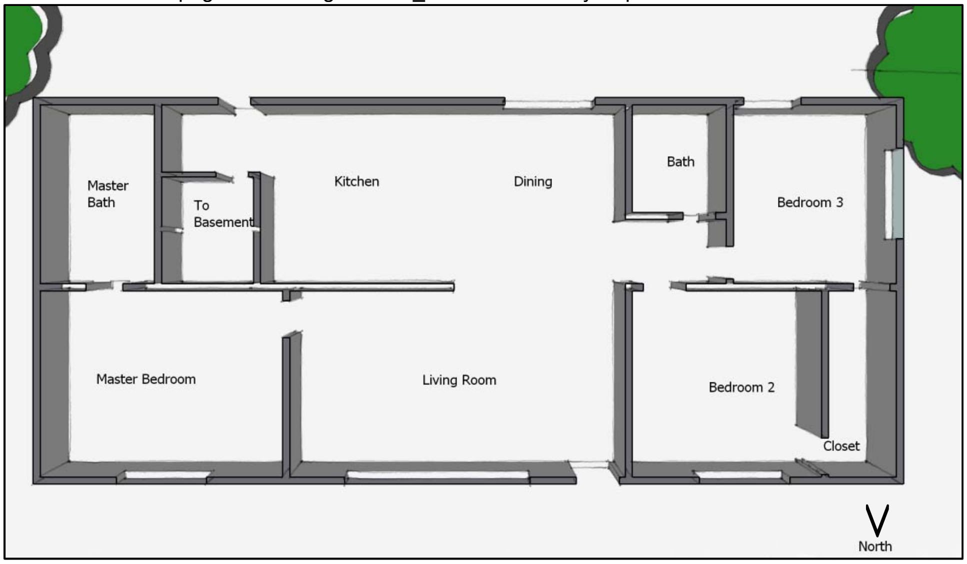

Figure 2: Plan of a typical 1970's ranch home

Cumulative Approach

When viewing the dashboard, the "Annual Site Consumption" section at the top includes a summary table labeled "By Run (Energy Efficiency Package)". This table presents a summary of the seven individual runs conducted for the model. The results of each run are presented as a set of two columns in the table. For each run, the first column displays the consumption and the second shows the percentage of energy savings when compared to the base case model.

To begin, the dashboard tool allows the user to select a city in which the typical home, described previously, was modeled. Assumptions specific to that location, including construction and foundation types, were incorporated into the model for that city. The first set of columns in the "By Run" table are labeled "1970s specs" and this represents the base case model for the location. The second set of columns to the right, labeled "IECC 2009", display data for the same house if it were constructed to meet IECC 2009 performance requirements. This provides a snapshot of the percentage of savings that can be gained if the home were updated to comply with IECC 2009.

There are five additional runs listed to the right of the code compliance run. These are labeled: A, A+B, A+B+C, A+B+C+D, and A+B+C+D+E. These runs are based on a cumulative modeling approach. As shown in the "Run Legend" on the right-hand side of the screen, there are five defined packages of improvements (A, B, C, D, and E). The model was run first with the improvements of package A alone, presented as run A. Next, the improvements in package B were applied in addition to package A and are presented in run A+B. Each subsequent package of improvements was applied cumulatively and the results are shown.

Under the description of each run, users will see a circle-shaped toggle button. When a user clicks this button, the selected run is highlighted and the data presented in the tables and graphics on the dashboard is updated for the run. To compare detailed information for the individual runs, a user can toggle between the runs and explore the information specific to that run. It should be noted that, for all runs, the percentage of savings is compared to the base line model.

Energy Efficiency Packages

This section provides a more in-depth explanation of the five categories of energy efficiency packages referenced as letters A through E in the Dashboard's Runs Selector. Again, the baseline model assumes the typical 1970s specifications. The code compliance model is based on the requirements defined in the 2009 International Energy Conservation Code (IECC 2009).

http://carb-swa.com/articles/homepage/RetrofittingAmerica_1970sHomeAnalysis.pdf

A. Typical Weatherization Upgrades:
   1. Air sealing in *accessible* spaces.
      - Reduce building infiltration test results by 1 ACH_{50} through common air sealing methods, such as caulking around windows and baseboard, replacing weather-stripping, and foaming penetrations in exterior assemblies and window rough openings.
   2. Bumping up attic/ceiling insulation
      - Increasing attic insulation to reach a total of R-50.
   3. Replacing windows
      - Upgrading to double pane, low-e windows (U-0.35, SHGC-0.32)
      - Assumes full replacement of frame and sash and complete air sealing
   4. Replacing all lights with CFL lamps and fixtures.
      - Switching from 100% incandescent light bulbs to 100% screw-in compact fluorescent light (CFLs) bulbs (excludes closets and minimally used storage rooms)
   5. Replacing old appliances with Energy Star rated appliances.
      - Replacing an old refrigerator (estimated electrical usage of 1,940 kWh/yr) and dishwasher (estimated energy factor 0.28 EF) with new Energy Star appliances (575 kWh/yr and 0.46 EF, respectively). The dishwasher energy factor (EF) quantifies the number of cycles a dishwasher can run with 1 kWh of electricity.

B. Better Equipment
   1. Replacing the cooling and (or) heating equipment with higher efficiency equipment.
      - Improving cooling performance from 8 SEER to 16 SEER (minimum required to be eligible for current federal tax credit for energy efficient air conditioners). For cold climates that historically didn't have central cooling systems, the baseline comparison is window air conditioner units (EER 8.1).
      - Improving heating performance from 0.76 AFUE (annual fuel utilization efficiency) to 0.93 AFUE (upgrade to a sealed combustion furnace that brings in combustion from the outside to improve safety). For all electric regions, improving from an electric furnace to a heat pump with a 9.0 HSPF (heating seasonal performance factor) efficiency.
   2. Sealing ductwork with appropriate mastic or metal tape.
      - Based on accessibility of ductwork in basements and attic, it assumed that a common leakage rate of 25% leakage to the outside can be reduced to 10% leakage to the outside.
   3. Upgrading the domestic water heater energy factor (EF). Energy Factor is the ratio of useful energy output from the water heater to the total amount of energy delivered to the water heater.
      - For old gas water heaters (0.56 EF), replacing with a tankless gas water heater (0.80 EF). For old electric water heaters (0.86 EF), replacing with a newer tank water heater (0.93 EF).

C. Thermal Envelope Upgrades
   1. Increase in building tightness (reduced infiltration)
      - Reduce building infiltration test results by 4 ACH_{50} (except Orlando with is reduced only by 2 ACH_{50} due to construction type) through more intrusive air sealing methods, such as removing interior drywall to foam rim/band joists, caulking seam between adjoining wood framing members, caulking around all openings in the drywall (electrical boxes, exhaust fans, supply registers, etc.), and sealing any openings between living space and attic (electrical, plumbing, duct chases, flues, etc).
   2. Replacing existing above grade wall and foundation wall insulation with that of higher R-value
      - Adding 2" of exterior rigid insulation in cold climates, 1" in moderate climates, and no additional exterior insulation in hot climates.

- For cold climates with basements, R-10 interior rigid insulation on the foundation walls. Depending on material selected to achieve insulation levels, a thermal barrier may be required to cover the rigid insulation.

D. Best Available HVAC
   1. Reducing duct leakage
      - Ducts brought within the conditioned space. Any ducts in the attic are dropped to the attic floor, encapsulated in closed-cell spray polyurethane foam to the ceiling drywall and buried in the attic insulation.
   2. Replacing existing cooling and(or) heating equipment with the best and the highest rated efficiency equipment
      - Improving equipment efficiencies to a SEER 19, 9.0 HSPF, and 93 AFUE.
   3. Whole-house ventilation provided in accordance with ASHRAE 62.2-2007
      - For hot/humid and mixed/humid climates (CZ 2&3), a balanced heat recovery ventilator (HRV) is provided. For other climates (CZ4 &5), a simple exhaust-only ventilation fan set to run continuously at the desired cfm is provided.

E. Renewables (PV & SHW)
   1. Incorporating solar hot water and photovoltaic systems
      - Solar thermal system (30 square feet of collector area with solar storage tank)
      - Solar electric system (4 kW of photovoltaics facing south and tilted to latitude of site)

Component Breakdown by End-Use

To enable users to use and interpret this data, four options have been provided for the Component Breakdown by End-Use. End-Uses include: Windows/Skylights, Ducts, Slabs Floors, Above-Grade Walls, Infiltration, Ceilings/Roofs, Doors, Mechanical Ventilation, Crawl Spaces/Unfinished Basements, Frame Floors, Foundation Walls, Rim/Band Joists, and Internal Gains. For Cooling, Whole-House Ventilation also appears as an End-Use. This is discussed further in the *Ventilation* section below. Using a pull-down menu, users may choose to view detailed information on either Heating or Cooling End-Use based on either Load or Consumption.

The Consumption data represents the amount of fuel consumed annually by the mechanical equipment. These values account for heating and cooling equipment efficiency. The total Heating and Cooling Consumption values listed in the graphic are equivalent to rows 2 and 3, respectively, of the Annual Site Consumption table for the selected Run. Component consumption data can be used to isolate the savings associated with individual End-Uses and/or adjust the anticipated savings when a component within the prescriptive package of measures is not undertaken.

The Load data represents the annual amount of energy the mechanical equipment must provide to maintain setpoint. The total Heating and Cooling Load values listed in the graphic will not align with the values in the Annual Site Consumption table. Load data can be used to prioritize the major energy consuming features of the home and/or identify opportunities for down-sizing equipment.

Ventilation

As noted above, Whole-House Ventilation appears as an End-Use when viewing the Cooling Component Load and Cooling Component Consumption data. For this analysis, natural ventilation (i.e. operable windows) was assumed for the 1970s base case in all 10 cities. During the Heating Season, the software does not apply an energy penalty associated with ventilation because windows are assumed to be closed. However, during the Cooling Season, use of operable windows for ventilation is assumed to provide an energy benefit to offset mechanical cooling usage.

Mechanical ventilation is introduced into the dashboard analysis as part of Package D, which is described further in the *Energy Efficiency Packages* section. For this analysis, it was assumed that mechanical ventilation would be incorporated as part of a package of upgrades to the mechanical equipment. In practice, CARB recommends evaluating the need for mechanical ventilation in conjunction with measures that address control of envelope leakage.

How Energy Consumption is presented

This Dashboard has been presented in terms of site energy consumption. Site energy refers to the fuel (natural gas, propane, oil, etc.) and electricity consumed within a home as reflected in a homeowner's utility bills. This is the energy that the homeowner uses and is charged for by the utility company. We felt this to be the most beneficial for users of this dashboard in making decisions on the type of energy efficiency measures that they would like to pursue.

The alternative is presenting information in terms of source energy. Source energy accounts for losses that occur in the production, transmission, and delivery of energy to the home. In the case of electricity, the national conversion rate from site to source energy is 3.365. This accounts for generation efficiency (roughly 35% for coal plants) and transmission line losses. Primary energy fuels have varying site to source conversion rates depending on type, but natural gas has a multiplier of 1.092 to account for losses in the storage, transport, and delivery of fuel to the home.

As stated by the US Environmental Protection Agency, "The purpose of the conversion from site energy to source energy is to provide an equitable assessment of building-level energy efficiency. Because billed site energy use includes a combination of primary and secondary forms of energy, a comparison using site energy does not provide an equivalent thermodynamic assessment for buildings with different fuel mixes. In contrast, source energy incorporates all transmission, delivery, and production losses, which accounts for all primary fuel consumption and enables a complete assessment of energy efficiency in a building."[3]

Though source energy allows for a better assessment of home efficiency, site energy is how homeowners, builders, and other anticipated end-users of this tool relate to the financial aspects of energy consumption. Ultimately, utility bills and cost payback influence the decisions to pursue various energy efficiency measures. It should be noted that using site energy for this analysis can be misleading when comparing annual site consumption by region. The following example is provided to help users better assess and interpret this data.

When viewing the *annual site consumption by city (MMBtu/yr)* on the left side of the dashboard, a 1970s vintage home that is an all electric home in Orlando, FL seems to be using 20% less *site energy* than a similar home that is uses both natural gas and electricity in Houston, TX. When viewed in terms of *source energy* (see table below), the Orlando home actually that uses 26% *more* energy.

	energy consumption [MMBtu/yr]	
1970's specs	site	source
Houston, TX	132	281
Orlando, FL	106	356

Links

Dashboard Download link

Dashboard Video Tutorial link

[3] http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf