Roof Savings Calculator

www.roofcalc.com

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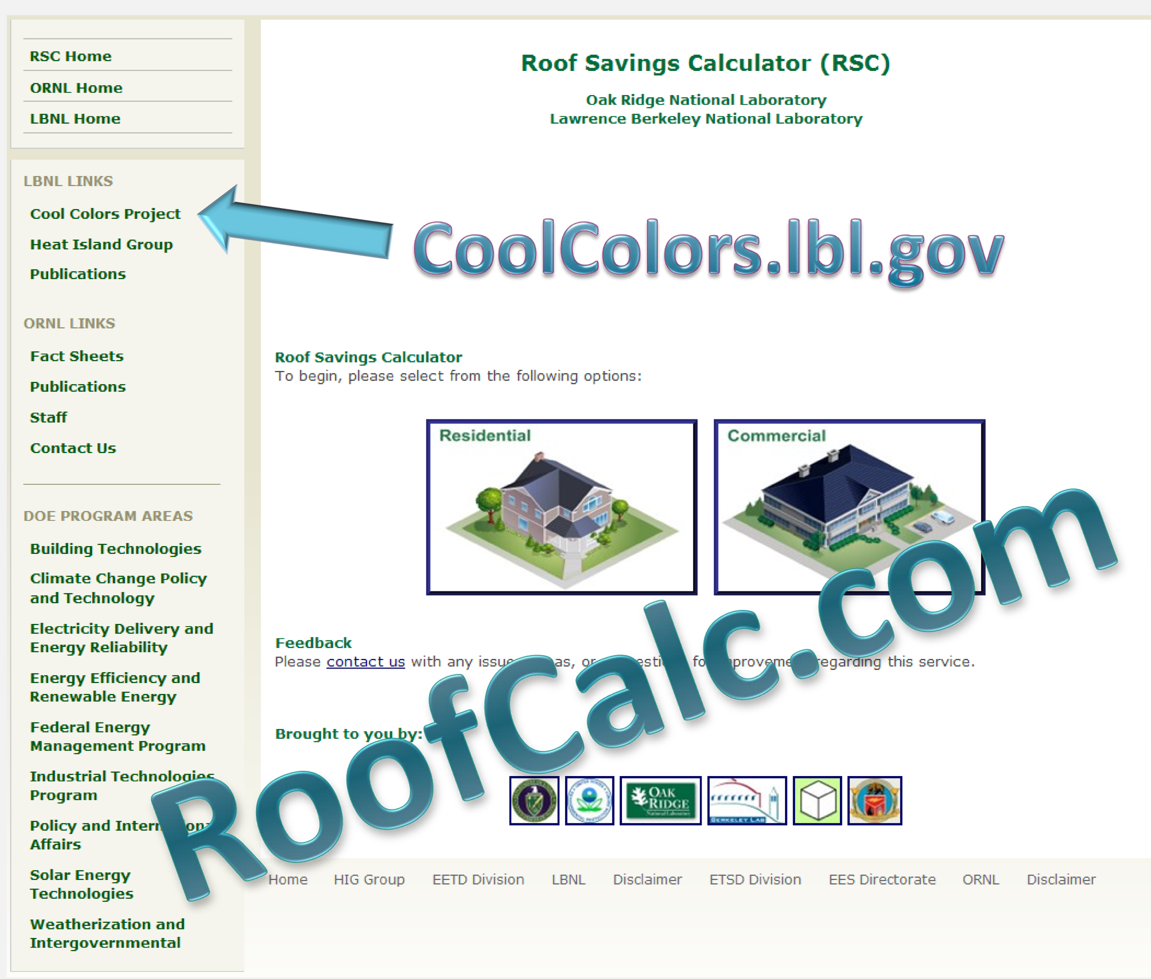
Abstract

The Roof Savings Calculator was developed as an industry-consensus roof savings calculator for commercial and residential buildings using whole-building energy simulations. It is built upon the *DOE-2.1E* engine for fast energy simulation and integrates *AtticSim* for advanced modeling of modern attic and cool roofing technologies. An annual simulation of hour-by-hour performance is calculated for the building properties provided based on weather data for the selected location. Annual energy savings reported are based upon heating and cooling loads.

Roof Savings Calculator on the Web



Inputs:
Building Details
HVAC efficiency
and utility prices
Roof and Attic Information
(base vs. comparison)

Outputs:
Reports energy
and cost savings

Simulation Results

You save $117/year!

Energy Savings

Total	Cooling	Heating
$117	$96	$21
	933 kWh	0 kWh 3 MBtus

Monthly Savings

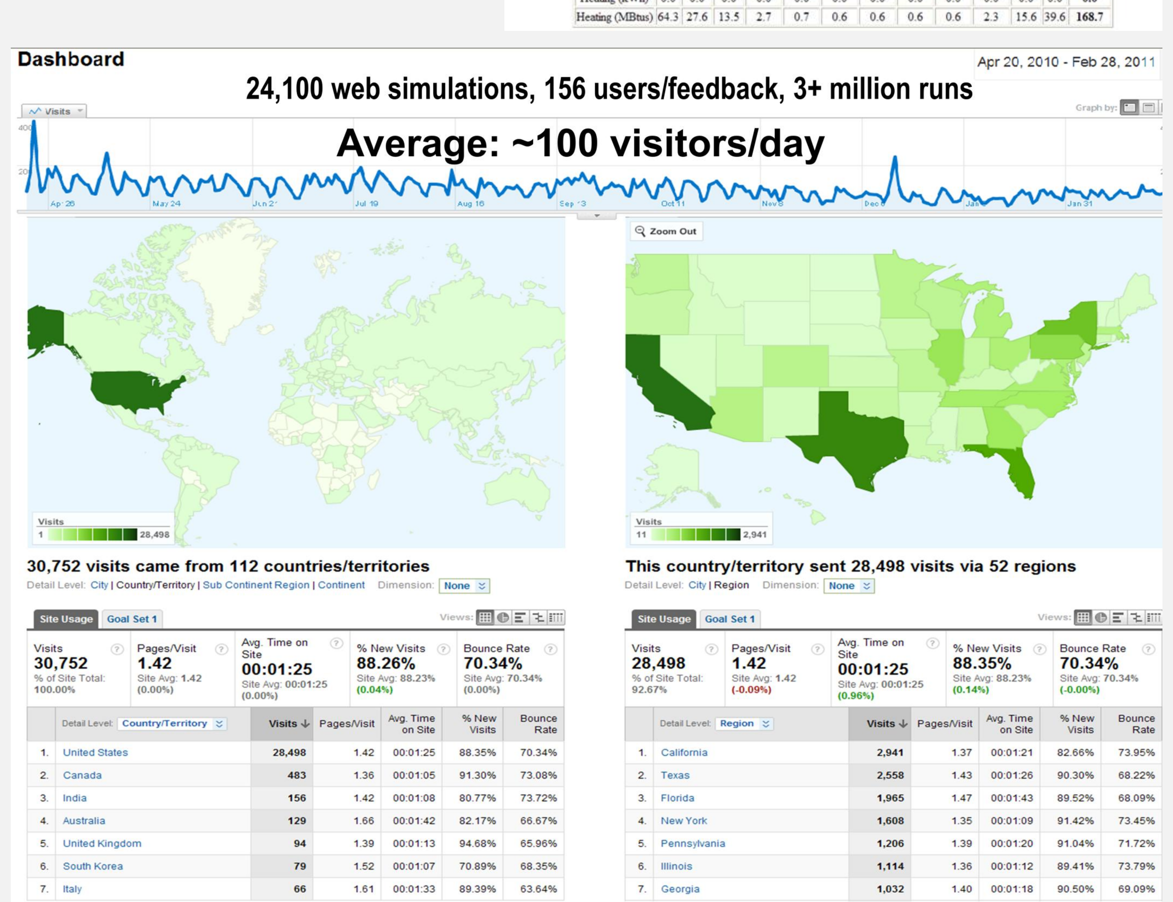
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Cooling Savings (kWh)	-4.9	-19.1	-2.6	48.1	123.4	208.6	210.4	181.9	143.7	51.3	-5.1	-2.9	**932.7**
Heating Savings (kWh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Heating Savings (MBtus)	1.9	0.4	-0.4	-0.3	-0.0	0.0	0.0	-0.0	-0.0	-0.4	0.1	1.3	**2.5**

White-Roof Utility Usage

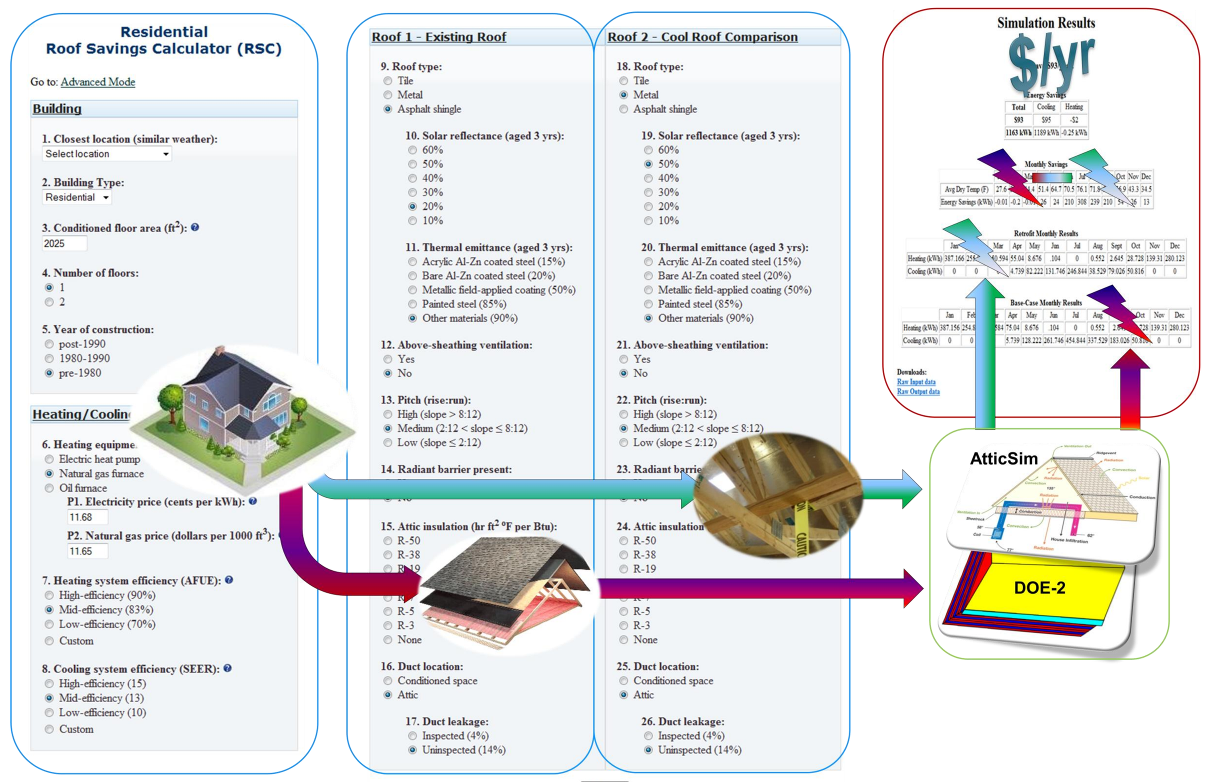
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Cooling (kWh)	25.4	140.5	597.5	1978.1	3969.2	6145.9	7027.0	6442.0	4476.9	1785.4	595.9	4.7	**33188.5**
Heating (kWh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Heating (MBtus)	62.4	27.1	13.9	2.9	0.7	0.6	0.6	0.6	0.6	2.7	15.6	38.3	**166.1**

Base-Case Utility Usage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Cooling (kWh)	20.5	121.4	594.9	2026.2	4092.6	6354.5	7237.4	6623.9	4620.6	1836.7	590.8	1.8	**34121.2**
Heating (kWh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Heating (MBtus)	64.3	27.6	13.5	2.7	0.7	0.6	0.6	0.6	0.6	2.3	15.6	39.6	**168.7**



RoofCalc System Overview



Roofing Parameters

Residential Roof Types

Roofs can be created with many material types involving different durability and thermal properties. This calculator supports the most common residential roof types for the US:

Asphalt Shingles, Metal Roof, Tile Roof

Commercial Roof Types

Roofs can be created with many material types which have varying durability and thermal properties. This calculator supports the most common commercial roof types for the US building stock including:

Built-Up, Metal, Modified Bitumen, Concrete Pavers, Single-Ply Membranes

Above-Sheathing Ventilation

Above-sheathing ventilation (ASV), also known as "roof on a roof", provides an air gap with thermally induced air flow patterns which has been shown to reduce heat flow penetrating the attic by at least 30% compared to a direct-to-deck nailed roof. This calculator models ASV using a 4" air gap.

Solar Reflectance

Increased reflectance saves energy by reflecting incoming solar radiation back towards space. Maximum reflectivity is achieved with white roof products. But don't let looks fool you; there are also "cool color" roof products which look dark in the visible spectrum but still reflect most of the heat, giving homeowners the more traditional roof color options as well as the potential energy savings. This calculator models customizable aged reflectance of the outermost roofing product.

Aged (3-year) reflectance is recommended, as studies show most products stabilize their reflectivity within 3 years and are more indicative of lifetime performance. Aged (or weathered) reflectance values can be found on some product labels and the Cool Roof Rating Council (CRRC) lists aged reflectance values for many products. The aged reflectance can be estimated from the initial solar reflectance, based on the California Energy Commission's Worksheet, using the following equation:

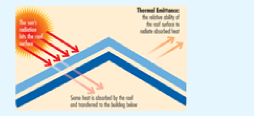
$SR_{3yrs}=0.2+0.7(SR_i-0.2)$

Reflectance, Cool Color Products

Thermal Emittance

Roof products with a low thermal emittance save energy by radiating the absorbed heat toward space. Approximately 90% of materials have an emittance of 90%; low-emittance surfaces such as aluminum foil or a car's sun shade, can have emittances of 5% and emit heat from the reflective side. Solar reflectance and emittance are the two radiative properties used to measure the "coolness" of a roof. This calculator models customizable emittance of the outermost roofing product.

Many organizations, such as the United States Green Building Council (USGBC) and its Leadership in Energy and Environmental Design (LEED) rating system, utilize a combined metric known as the Solar Reflectance Index (SRI).



More info: *LBNL SRI Excel* *ORNL SRI Calculator*

Attic Insulation

Attic insulation protects your home against unwanted heat gain/loss. It is measured by R-value which depends on the material, its thickness, and density with multiple layers added together. Insulation is often one of the most economical ways to make your home more energy efficient. The most common types of insulation are fiberglass batts (usu. pink), cellulose insulation, and spray foam insulation. This calculator supports a custom R-value of attic insulation.

More info: Insulation Calculator Insulation Fact Sheet

Fiberglass Batt, Blown-in, Loose-Fill, Spray Foam

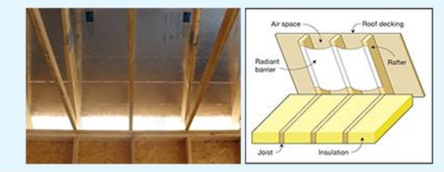
Roof Pitch

The pitch of a roof, also known as angle or inclination, determines how much solar radiation impinges on a building throughout the day. The typical unitless metric is rise-in-run. This calculator supports pitches of 2:12, 4:12, and 8:12 (17, 32, and 59 angular degrees, respectively) for residential buildings; all commercial buildings are modeled as flat roofs with 0.25:12 for rainfall runoff.

Radiant Barrier

Radiant barriers (RB) save energy by reducing the heat radiated into the attic as the roof heats up during the day. RBs consist of a thin layer of highly reflective material, usually aluminum, and must have an emittance less than 0.1 as measured by ASTM C1371. This calculator models a RB in its most effective location, attached to the underside of the rafters with the reflective side facing the attic floor.

More info: RB Calculator RB Fact Sheet



Duct Location

Heating, Ventilation, and Air Conditioning (HVAC) ducts are typically located in non-conditioned spaces, such as the attic, because it is easier and cheaper given the way US buildings are constructed; this is the worst location from an energy perspective. Locating ducts inside a conditioned space, such as between floors or in a conditioned basement, removes the losses from leaky ducts as well as exposure to adverse environmental conditions and can decrease your utility bills significantly. This calculator supports ducts located in a conditioned space or in the attic; simulations in conditioned spaces will run faster as the computationally intensive duct loss model is not invoked.

Ducts in the Attic, Ducts in a Conditioned Space

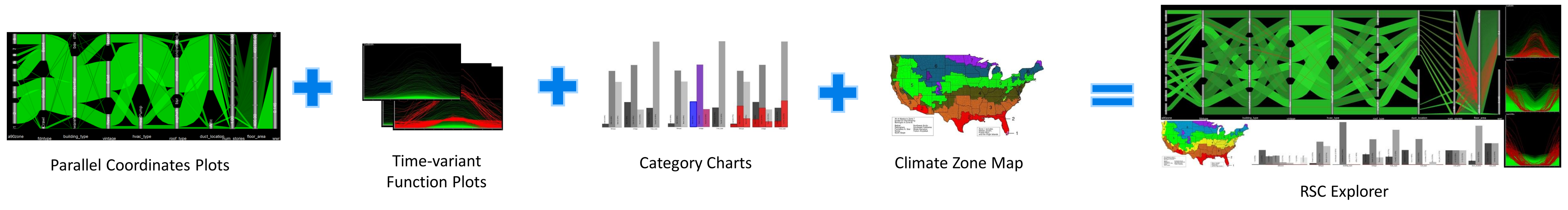
Duct Leakage

Leaky ducts in unconditioned spaces are effectively costing you money to condition the planet, not your house. Commercial buildings have typical leakage rate of 10-20%; likewise, residential buildings typically have duct leakage rates near 14%. The CEC's Title 24 target leakage rate for inspected ducts is 4% and requires no greater than 6%. This calculator supports duct leakage rates of 4% and 14%.

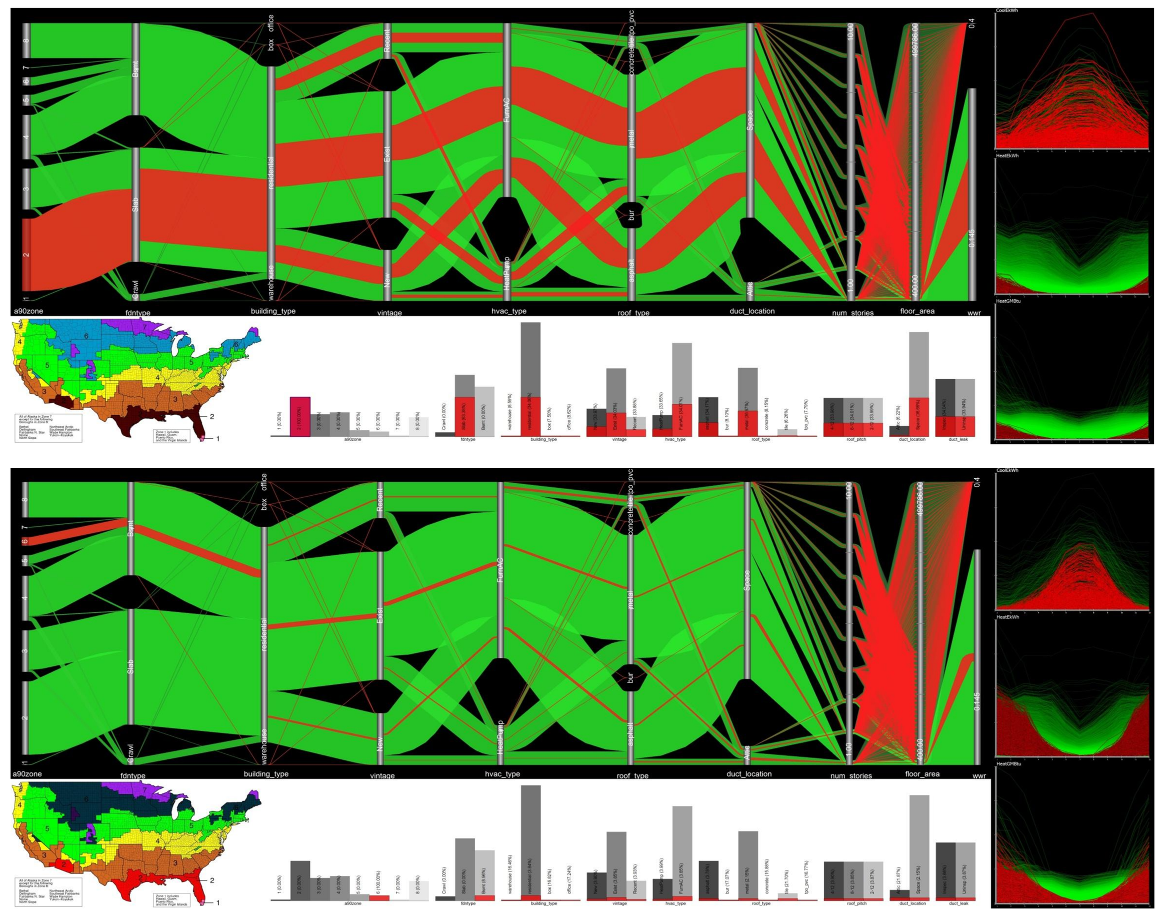
Leaky Connection, Damaged Duct, Sealed Ducts

Multivariate Visualization of Large-Scale Parameter Sweeps

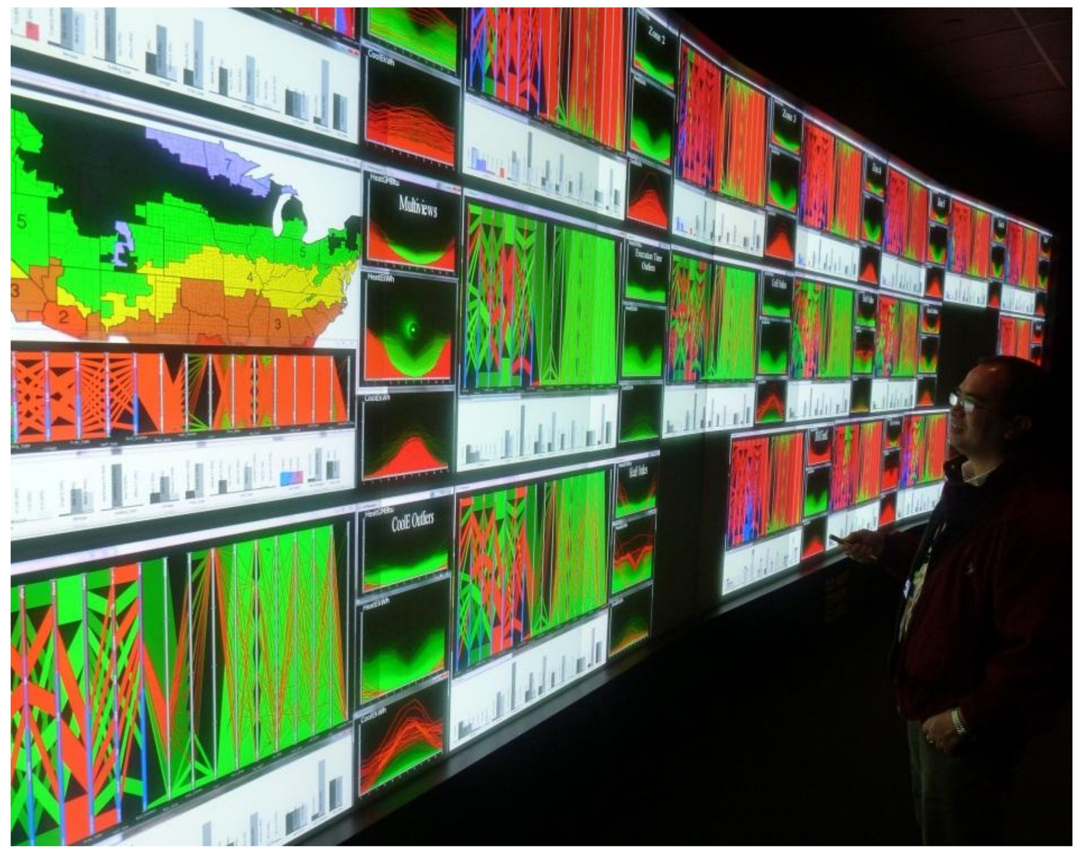
By pulling together data from over 3 million simulation runs, the RSC Explorer visualization tool allows researchers to see their rich data space through several interactive, linked views. Starting from the presented overview (green), the user can make focused selections (red) to see how the simulations related to one another across multiple dimensions.



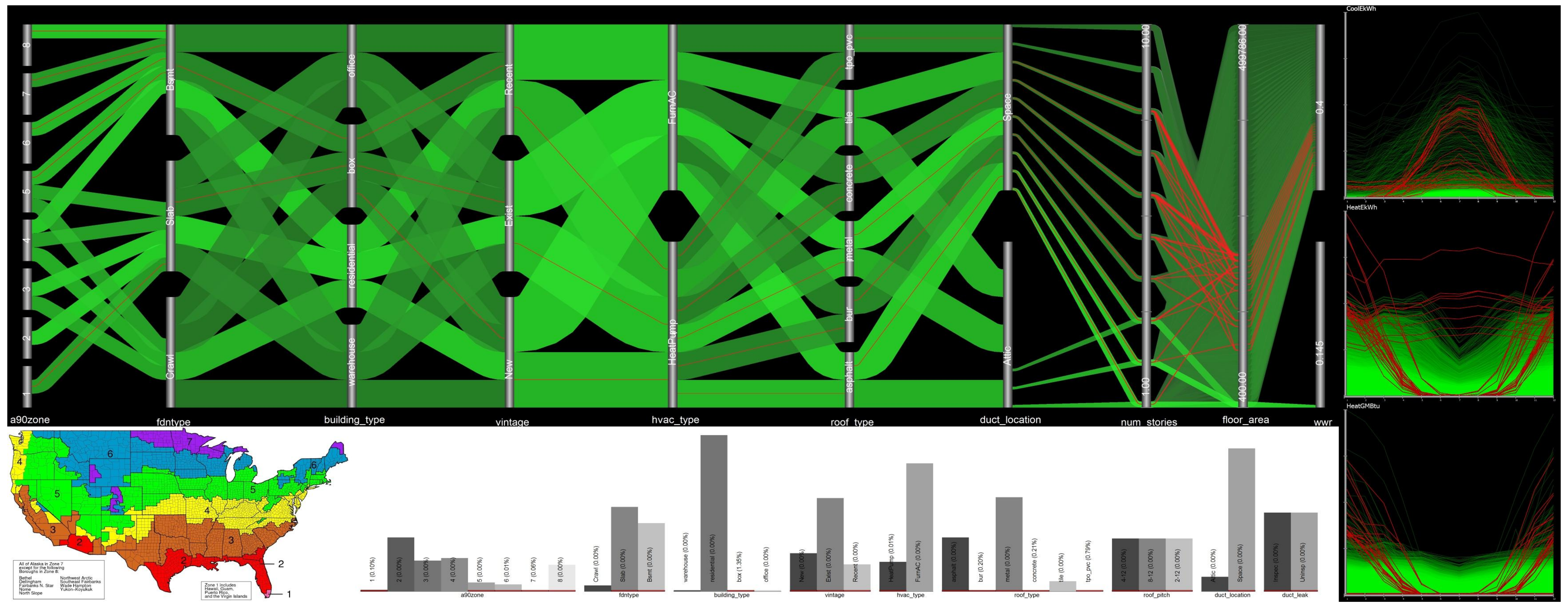
Results



Above, simulation runs from climate zone 2 and 6 have been selected in the top and bottom visualizations, respectively. From here we can verify the distribution of input parameters and identify the energy usage patterns.



Using the EVEREST PowerWall at ORNL, dozens of results were tiled and reviewed by building scientists. They were able to see known relationships in the data, make new hypotheses, and identify potential software bugs.



Several outlier simulations were separated by selecting abnormally high energy usage signatures in the heating time plots. From the parallel coordinates, these focus simulations are shown to have both box building type and heat pump hvac units, which may indicate the reason for the heating problem.

References

New, Joshua R., Miller, W.A., Desjarlais, O., Erdem, E., and Huang, Yu Joe (2011). "Development of a Roof Savings Calculator" in RCI 26th International Convention and Trade Show, Reno, NV, April 2011.

Acknowledgments

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