"I remember when there was no damn environment."

Architecture and Efficiency

26 April 2010

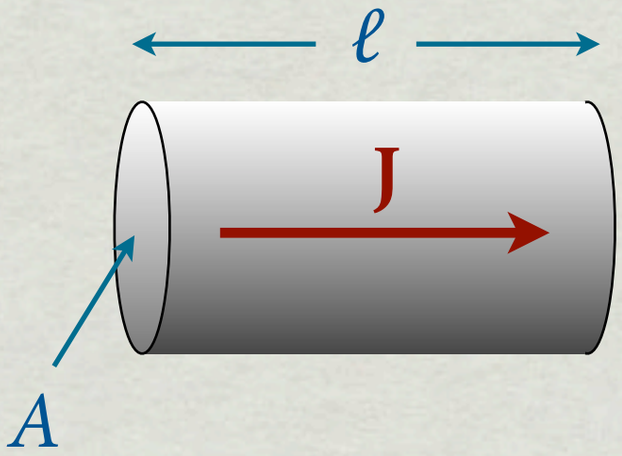
Overview

- R-values
- Building materials
- Approaches to green buildings
- LEED
- Roofing
- Passive solar

Insulation

$$\mathbf{J}_e = -\sigma \nabla V$$

$$R = \frac{\ell}{\sigma A}$$



$$\mathbf{J}_h = -\kappa \nabla T$$

$$R = \frac{\ell}{\kappa A}$$

UNITS

R-Values in $\frac{\text{ft}^2\ ^\circ\text{F h}}{\text{BTU}}$

CONVERT TO SI

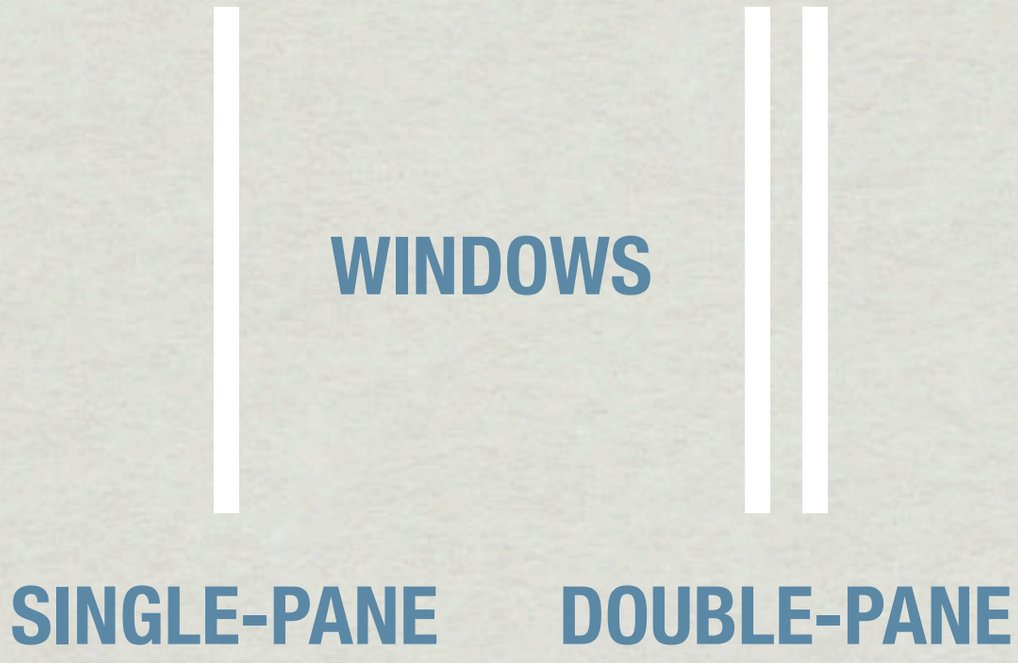
$$\frac{\text{ft}^2\ ^\circ\text{F h}}{\text{BTU}} = 0.176 \frac{\text{m}^2\ \text{K}}{\text{W}}$$

R-VALUES ADD LIKE SERIES RESISTORS

Example

R-values per inch

- Glass = 7.2
- Wood = 1.3
- Wallboard = 1.0
- Brick = 0.11
- Fiberglass batts = 3.16
- Air = 1.4



Issues

- Center-of-cavity
- Clear-wall
- Whole-wall
- Airtightness
- Moisture tolerance
- Sound insulation

DOE Quietly Increases Recommended Insulation

HTTP://WWW.MOTHEREARTHNEWS.COM/ENERGY-MATTERS/US-DEPARTMENT-ENERGY-QUIETLY-RAISES-INSULATION-STANDARDS.ASPX

U.S. Department of Energy Recommended* Total R-Values for New Wood-Framed Houses

Zone	Gas	Heat Pump	Fuel Oil	Electric Furnace	Attic	Cathedral Ceiling	Wall: Cavity	Wall: Insulation Sheathing	Floor
1	✓	✓	✓	✓	R30 to R49	R22 to R38	R13 to R15	None	R13
2	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R13
2				✓	R30 to R60	R22 to R38	R13 to R15	None	R19 - R25
3	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R25
3				✓	R30 to R60	R22 to R38	R13 to R15	R2.5 to R5	R25
4	✓	✓	✓		R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 - R30
4				✓	R38 to R60	R30 to R38	R13 to R15	R5 to R6	R25 - R30
5	✓	✓	✓		R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 - R30
5				✓	R38 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
6	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
7	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
8	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30

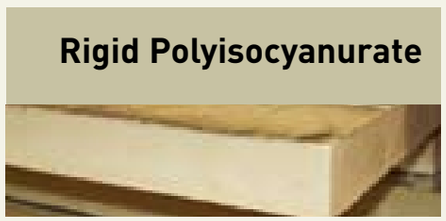
HTTPS://WWW1.EERE.ENERGY.GOV/CONSUMER/TIPS/PRINTABLE_VERSIONS/INSULATION.HTML

Insulation Chart

INSULATION	R-VALUE	WHAT IT LOOKS LIKE	COMMOM APPLICATIONS
Fiberglass Batts 	2X4 = R-11 2X6 = R-19* 2X10 = R-30 2.9-3.8/inch	Pink or yellow blankets. Can be unfaced, paper or plastic faced, or encapsulated for ease of installation.	Install in open wall, floor or ceiling cavities. Must be carefully installed avoiding gaps, voids or compression.
Cotton-Fiber Batts 	2X4 = R-13 2X6 = R-19* or R-21 2x10 = R-30 3.0-3.7/inch	Light blue to dark blue fluffy cotton, made from blue jean manufacturing cut-offs.	Non-toxic. Non-irritating during installation. Can be used in place of other batt insulation products. A newer product not typically found in older homes.
Rockwool Batts 	2X4 = R-13 2X6 = R-22 2x10 = R-33 2.8-3.7/inch	Dark gray or black batts with paper facing.	Often used in the 1950-1960's, but uncommon today.
Fiberglass Loose Fill 	2.2-2.7/inch (varies based on density)	Pink, yellow or white fluffy material that comes compressed in bags.	Good choice for blowing into attics. Important that contractor set blower correctly to establish correct thickness and density.
Cellulose Loose Fill 	3.0-3.7/inch	Gray finely chopped up newspaper with fire retardant added - usually borate salts which inhibits mold and fungus.	Excellent choice for blowing into attic or closed wall cavities. Be sure to seal any air gaps first so dust does not blow into home.
Vermiculite Loose Fill 	2.4/inch	Looks like kitty litter or very small mica flakes. May contain asbestos.	No longer used today.

*These R-Values are applicable to homes built before 2003. Current code requires higher insulation levels.

HTTP://WWW.SEATTLE.GOV/DPD/STATIC/DIYWEB_LATESTRELEASED_DPDP016083.PDF

Extruded Polystyrene (ExPS or XPS) Rigid Foam	5.0/inch	Blue or pink rigid board.	Waterproof. Excellent for exterior sealing or insulating basement walls. Can be applied directly to concrete. Must be protected from sunlight.
Expanded Polystyrene (EPS) Rigid Foam 	3.6-4.4/inch	Usually white - also know as 'bead board'	Low cost but not as sturdy or moisture resistant as ExPS. Must be protected from sunlight.
Rigid Polyisocyanurate 	6.0-6.5/inch	Foam boards with foil facing. 4x8, 4x9 and 4x10 foot sheets.	Thermax or R-max are common trade names. Best R-value overall. Best choice for maximum insulation in a thin area such as rafters in a cathedral ceiling.
Low Density Spray Foam 	3.8/inch	Yellowish, white foam that goes on wet and dries quickly. Expands as it is applied.	Excellent for sealing irregular gaps. Includes "Icynene" and soy based foams.
High Density Spray Foam 	6.5/inch	Yellowish, white foam that goes on wet and dries quickly. Expands as it is applied.	Excellent for sealing irregular gaps. Includes "Corbond" and urethane.

HTTP://WWW.SEATTLE.GOV/DPD/STATIC/DIYWEB_LATESTRELEASED_DPDP016083.PDF

TIPS FOR LOWERING ENERGY USE

A. Energy Measures that Save a Lot and Have Little or No Cost

- Keep your home at or below 68°F.
- Lower heating thermostat 10°F at night and when home is unoccupied.
- Close fireplace damper when fireplace is not in use.
- Replace furnace air filters regularly.
- Lower water heater thermostats to 120°F.
- Insulate hot water pipes and install heat trap fittings at flex connections. Insulate the first five feet of cold line.
- Install low flow efficient showerheads and faucet aerators.
- Install gaskets behind electric outlets and switch plates on exterior walls.
- Seal air leaks to attic and crawl space with spray foam.
- Caulk and weatherstrip windows, doors, cracks and holes.
- Dust baseboard and wall heaters.

B. Energy Measures with an Estimated One to Two-Year Payback

- Install programmable thermostats.
- Have a blower door test conducted to assist with air sealing.
- Install do-it-yourself plastic storm windows.
- Repair fireplace damper seal.
- Install compact fluorescent lights in all fixtures.
- Install dimmer switches, photocells, timers and motion detectors.
- Install do-it-yourself insulated panel or cover to seal fireplace when not in use.
- Tune up heating and cooling equipment.
- Insulate and air seal rim joist area in basement.

C. Energy Measures with an Estimated Two to Five-Year Payback

- Insulate walls in a heated basement, and the rim joist of an un-heated basement or crawl space.
- Install attic insulation to achieve a minimum R-38.
- Install underfloor insulation to achieve a minimum R-30.
- Install fireplace modifications such as glass doors, flue top damper and outside combustion air.
- Install do-it-yourself insulated window shades or shutters.
- Install wall insulation in un-insulated exterior walls.
- Install do-it-yourself solar warm air panel or hot water preheat.

D. Energy Measures with an Estimated Payback of More Than Five Years

- Install commercial storm windows.
- Replace existing single-pane windows with new double, or even triple-pane, windows.
- Replace older furnace or boiler with a 90%+ condensing unit.
- Install a fireplace insert into an existing fireplace.
- Install an energy efficient hot water tank or tankless hot water heater.
- Replace conventional oil furnace burner with a new flame retention burner.
- Install active solar hot water system.

Drain Water Heat Recovery

If your family takes a lot of showers, these simple devices are a good investment. A simple copper tube wrapped heat exchanger fits on your vertical main drain line, where it picks up wasted heat and feeds it back to the water heater. www.power-pipe.us

Ventilation HRV/ERV

These fan systems quietly bring in plenty of fresh air that is pre-warmed by outgoing stale air. Most units are from 60% to 90% efficient at recovering heat. A central ventilation system is an especially good option for a tightly sealed home and allows you to add filtration and control the sources of fresh air to improve the air quality in your home.

Laundry Spinner

A wastebasket sized gadget that can spin wet clothes at 3200 rpm, quickly taking out nearly half of the water. Reduces dryer run time up to 50% and adds convenience. www.laundry-alternative.com/drying.htm

Solar Hot Water

Solar is back as a hot item again and is cost-effective in Seattle. Some Seattle residents are getting 50-70% of their hot water needs met through solar hot water heating. Since hot water can be 15% of our home energy (and greenhouse emissions), that's a big warm contribution to reducing climate change! www1.eere.energy.gov

Solar Electric

Washington's new PV (photovoltaic) generation incentive makes solar PV more affordable. If you're not able to install PV right away, make your home 'solar ready' as a first step, especially if opening walls. www.northwestsolarcenter.org/Resource/publication

Monday, April 26, 2010

RMI

- 4000 ft^2
- Superinsulated
- Solar heated
- Complete air exchange in 10 hrs
- Heavy-gas filled, IR-reflecting windows
- Reglazing in 2005–9 uses xenon fill; has R-values of 12.5
- Walls are stone / foam / stone (R = 40)
- Ceiling R = 80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David Saeta, IDS

- Tipping point in commercial construction happened about 18 months ago
- LEED something (certified, silver, gold, platinum)
- Converting existing structures:
  - Lighting
  - HVAC, variable-speed drives
  - Environmentally friendly cleaning solvents
- Title 24 — California leading the pack

Green Home Guide

- Make sure your walls and attic are well insulated
- Upgrade or replace windows
- Plant shade trees and shrubs around your house
- Replace an older furnace with a high-efficiency system
- Improve the efficiency of your hot water system
  - Turn down temperature to 120°F, insulate lines
- Replace incandescent lightbulbs with compact fluorescents
- Unplug old refrigerators

HTTP://GREENHOMEGUIDE.COM/KNOW-HOW/ARTICLE/9-WAYS-TO-MAKE-YOUR-HOME-MORE-ENERGY-EFFICIENT

LEED Certification

- Leadership in Energy and Environmental Design
- Started in 1993 by Robert K. Watson of NRDC
- Outlines procedures for assessing “greenness” of a building

LEED for Homes (2008)

- Good practice (0 pts)
- Better practice (1 pt)
- Best practice (2 pts)

Certified	45–59
Silver	60–74
Gold	75–89
Platinum	90–136
Total Pts	136

HTTP://WWW.USGBC.ORG/DISPLAYPAGE.ASPX?CMSPAGEID=147

Minimum Point Requirements

Credit Category	Prerequisites	Minimum point requirements	Maximum points available
Innovation & Design Process (ID)	3	0	11
Location & Linkages (LL)	0	0	10
Sustainable Sites (SS)	2	5	22
Water Efficiency (WE)	0	3	15
Energy & Atmosphere (EA)	2	0	38
Materials & Resources (MR)	3	2	16
Indoor Environmental Quality (EQ)	7	6	21
Awareness & Education (AE)	1	0	3
Total	**18**	**16**	**136**

Exhibit 4: Threshold Adjustment (point range: -10 to +10)

Maximum home size (ft2) by number of bedrooms					Adjustment to award thresholds*
≤ 1 Bedroom	2 Bedrooms	3 Bedrooms	4 Bedrooms	5 Bedrooms	
610	950	1290	1770	1940	-10
640	990	1340	1840	2010	-9
660	1030	1400	1910	2090	-8
680	1070	1450	1990	2180	-7
710	1110	1500	2060	2260	-6
740	1160	1570	2140	2350	-5
770	1200	1630	2230	2440	-4
800	1250	1690	2320	2540	-3
830	1300	1760	2400	2640	-2
860	1350	1830	2500	2740	-1
900	**1400**	**1900**	**2600**	**2850**	**0 (“neutral”)**
940	1450	1970	2700	2960	+1
970	1510	2050	2810	3080	+2
1010	1570	2130	2920	3200	+3
1050	1630	2220	3030	3320	+4
1090	1700	2300	3150	3460	+5
1130	1760	2390	3280	3590	+6
1180	1830	2490	3400	3730	+7
1220	1910	2590	3540	3880	+8
1270	1980	2690	3680	4030	+-9
1320	2060	2790	3820	4190	+10
For larger homes, or homes with more bedrooms, see below.					

Note: As an example, an Adjustment of -5 means that the threshold for a “Certified” LEED home is 40 points (rather than the 45 points for an averaged sized home). Similarly, Silver would require a minimum of 55 points rather than 60 points; Gold would require a minimum of 70; and Platinum would require a minimum of 85 points.

Exhibit 5: Threshold Adjustment Equation

Threshold adjustment = 18 * log (actual home size / neutral home size) / log (2)

Neutral home size, as used in Exhibit 4, is determined according to the following table:

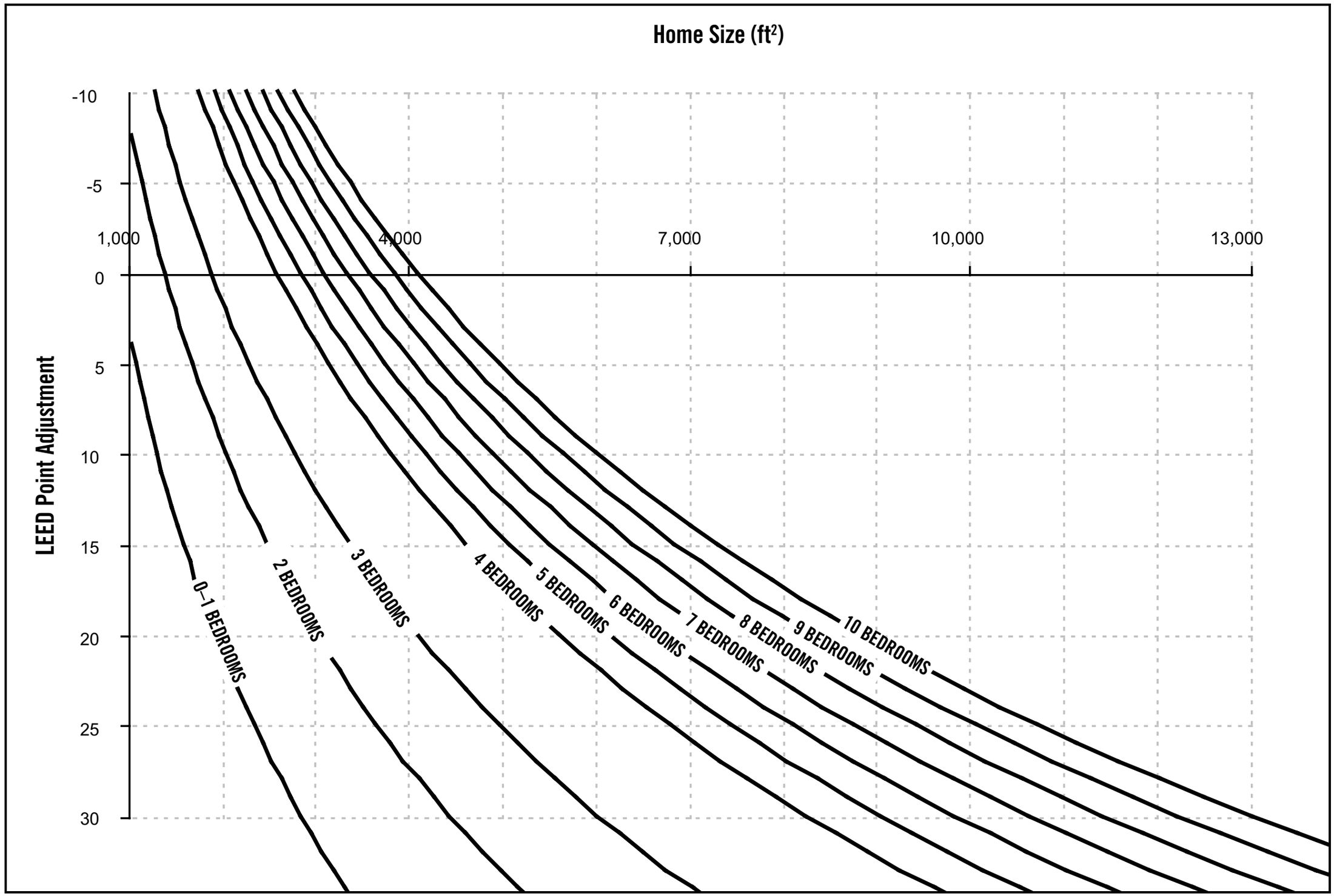
Bedrooms	**≤1**	**2**	**3**	**4**	**5**	**6 or more**
Neutral home size (ft^2)	900	1,400	1,900	2,600	2,850	250 ft^2 more for each additional bedroom

Note: For homes with more than 5 bedrooms, "neutral home size" is defined as follows: 2850 + [250 (number of bedrooms) – 5)]*

- A 100% increase in home size yields an increase in annual energy usage of 15% to 50%

- A 100% increase in home size yields an increase in materials usage of 40% to 90%

Exhibit 6: Threshold Adjustment Curves (point range: -10 and above)



Building Orientation (ID 1 pt)

- Glazing area on the north- and south-facing walls is at least 50% greater than the sum of the east- and west-facing walls.
- East-west axis is within 15° of due east-west.
- Roof has at least 450 ft^2 of south-facing area oriented appropriately for solar applications.
- At least 90% of the glazing on the south-facing wall is completely shaded at noon on 6/21 and unshaded at noon on 12/21.

Location

Level	Community resources within 1/4 mile	Community resources within 1/2 mile	Transit rides within 1/2 mile per weekday
Basic (1 point)	4	7	30
Extensive (2 points)	7	11	60
Outstanding (3 points)	11	14	125

Table 2: Types of Basic Community Resources

- ❑ Arts and entertainment center
- ❑ Bank
- ❑ Community or civic center
- ❑ Convenience store
- ❑ Daycare center
- ❑ Fire station
- ❑ Fitness center or gym
- ❑ Laundry or dry cleaner
- ❑ Library
- ❑ Medical or dental office
- ❑ Pharmacy
- ❑ Police station
- ❑ Post office
- ❑ Place of worship
- ❑ Restaurant
- ❑ School
- ❑ Supermarket
- ❑ Other neighborhood-serving retail
- ❑ Other office building or major employment center

Note: Up to two of each type of community resource may be counted. For example, two restaurants within ¼ mile may be counted as two community resources; four restaurants also count as two.

Landscaping

Table 3: Limited Conventional Turf

Percentage of designed landscape softscape area that is conventional turf	Points
41–60%	1
21–40%	2
20% or less	3

Table 5. Reduction in Water Demand

Reduction in estimated irrigation water usage	SS 2.5 points	WE 2.3 points	Total points
20–24%	2	0	2
25–29%	3	0	3
30–34%	4	0	4
35–39%	5	0	5
40–44%	6	0	6
45–49%	6	1	7
50–54%	6	2	8
55–59%	6	3	9
60% or more	6	4	10

Roofing

Solar Reflectance Index

- Standard black (reflectance 0.05, emittance 0.90) is 0
- Standard white (reflectance 0.80, emittance 0.90) is 100
- The standard black has a temperature rise of 90°F (50°C) in full sun, and the standard white has a temperature rise of 14.6°F (8.1°C)

HTTP://EETD.LBL.GOV/COOLROOF/REF_01.HTM

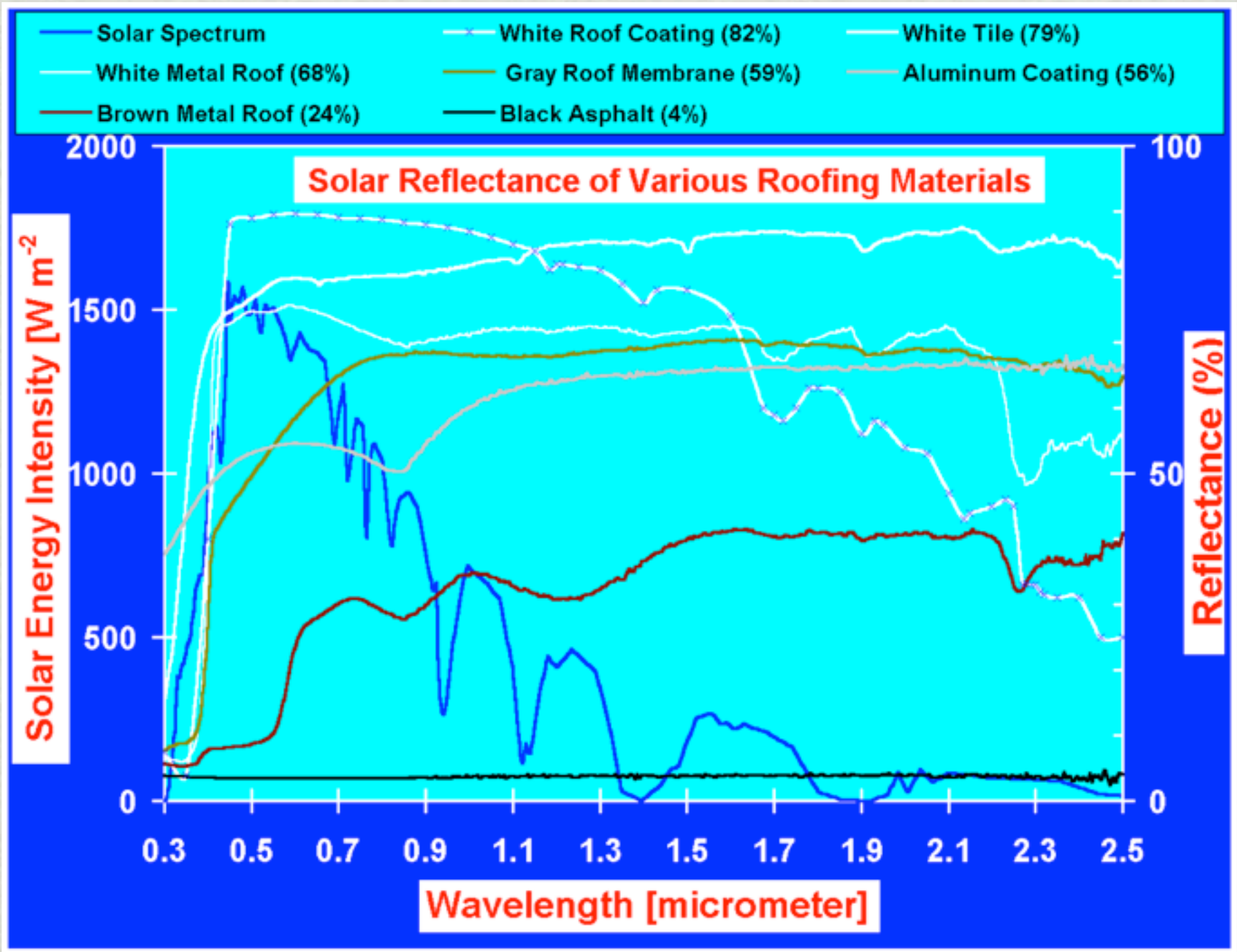
Roofing Materials

Roofing System	SRI	Reflectivity	Emittance
White EPDM (synthetic rubber)	84	69%	87%
Kynar Coated Metal, White	82	67%	85%
New, Bare Galvanized Steel	46	61%	4%
Light Gravel on BUR (built up roof)	37	34%	90%
White Granular Surface Bitumen	28	26%	92%
Dark Gravel on BUR	9	12%	90%
Black EPDM	-1	6%	86%

SRC: LBL & FLORIDA SOLAR ENERGY CENTER

HTTP://WWW.DURO-LAST.COM/COOLZONE/SOLARREFLECTANCE.ASP

Roofing Reflectivity



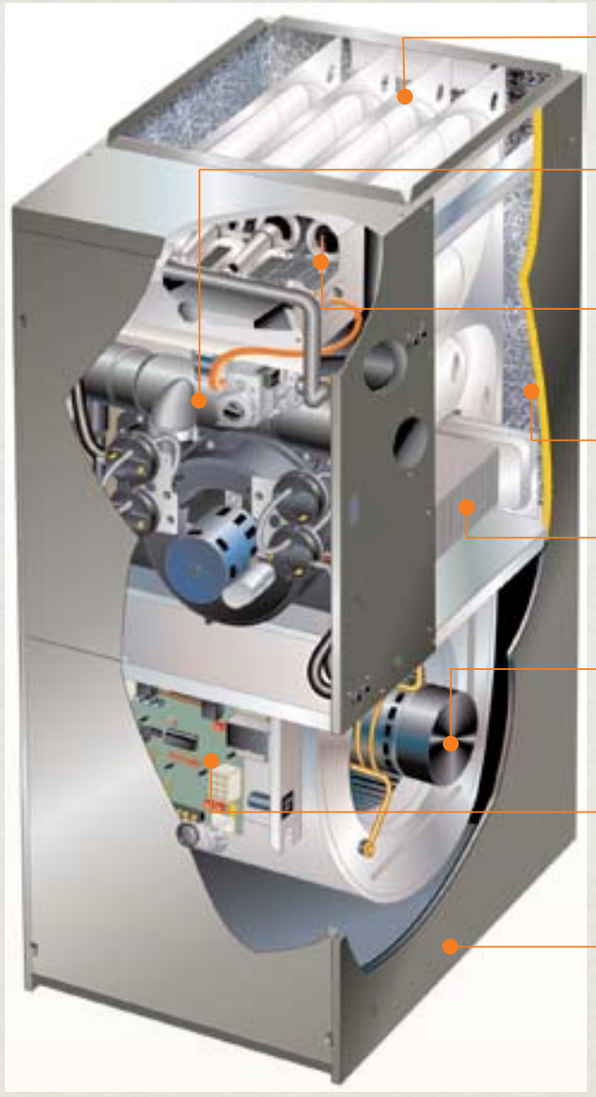
HTTP://EETD.LBL.GOV/COOLROOF/INTRO.HTM

Properties of Roofing Materials

Product	Solar Reflectance	Infrared Emittance	Temperature Rise (°F)	Solar Reflectance Index
red clay tile	0.33	0.9	58	36
red concrete tile	0.18	0.91	71	17
unpainted cement tile	0.25	0.9	65	25
white concrete tile	0.73	0.9	21	90
concrete tile, light beige coating	0.63	0.9	3	76
concrete tile, light brown coating	0.42	0.9	50	48
concrete tile, mauve	0.41	0.9	51	46
concrete tile, pink & gray coating	0.53	0.9	40	63
concrete tile, off-white coating	0.74	0.9	20	92
fiber cement, earth brown color	0.26	0.9	64	27
fiber cement, pewter gray color	0.25	0.9	65	25

LBL AND FSEC

Condensing Furnace



Duralok Plus® Heat Exchanger – Made of patented ArmorTuf™ steel to ensure high reliability and efficiency.

Two-Stage Gas Valve – Works with the variable speed motor to match furnace output to household heating needs.

SureLight® Ignitor – Silicon nitride construction ensures long product life and reliable operation.

Special Sound-Absorbing Insulation – Further reduces sound for quiet operation.

Robust Stainless Steel Secondary Heat Exchanger – Allows the furnace to achieve high efficiency levels by capturing additional heat.

Variable Speed Blower Motor – Provides a quiet, consistent flow of air for enhanced comfort, efficiency and humidity control.

SureLight Control Board – Controls furnace operation to ensure high reliability and efficiency.

Durable Steel Cabinet – Made to last with an attractive, high-quality textured paint finish.

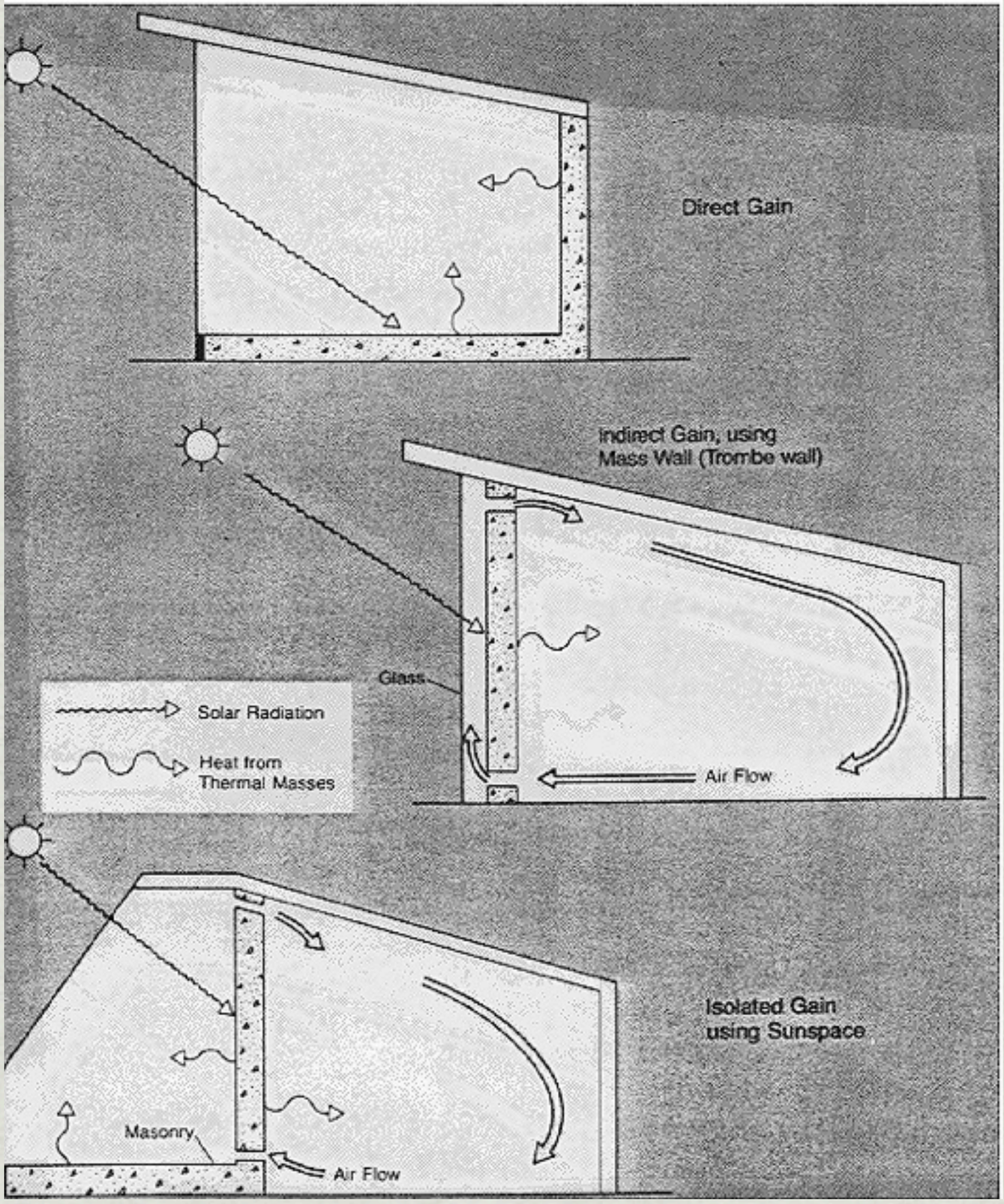
Condensing Gas Furnace Technologies
Enabling condensing furnaces to operate so efficiently are the following technologies:

- **Secondary heat exchanger** – extracts more energy from the fuel than less efficient furnaces equipped with only one heat exchanger. This is achieved by drawing heat from the combustion by-products before they are vented through a special plastic pipe that connects to the floor drain.
- **Modulating gas valve** – regulates the amount of gas that is supplied to the furnace, based on heating demand. Allowing the furnaces to fluctuate between 40% - 100% capacity, energy can be saved during mild weather when demand is low.
- **Variable-speed fan blower** – works in conjunction with the modulating gas valve, changing in speed according to the demand for heat. During mild weather, the fan operates at a low setting to save energy and eliminate uncomfortable blasts of heat and temperature swings, typical of conventional furnaces.
- **ECM (electronically-commutated) motor** – uses 75% less electricity than a standard motor, resulting in lower electricity consumption when the furnace is running.

Read more at Suite101: Condensing Gas Furnaces: How They Work to Slash Your Energy Bills http://homerenorepair.suite101.com/article.cfm/condensing_gas_furnaces#ixzz0mF06Oiw8

LENNOX

FIGURE 1: Three types of passive design for space heating.



DIRECT GAIN

TROMBE WALL

ISOLATED GAIN USING SUNSPACE

Empire State Building Retrofit

$4.4 MILLION/YR ELECTRICITY SAVINGS

Empire State Building sustainability program

Tony Malkin and the Clinton Climate Initiative established a partnership with Jones Lang LaSalle, Johnson Controls Inc., and Rocky Mountain Institute. The team worked together seamlessly to develop a replicable model for optimizing the performance of an existing building, while reducing greenhouse gas emissions and delivering measurable economic returns.

"The goal with the Empire State Building has been to define intelligent choices which will either save money, spend the same money more efficiently, or spend additional sums for which there is reasonable payback through savings. Addressing these investments correctly will create a competitive advantage for ownership through lower costs and a better work environment for tenants."

- Anthony E. Malkin, Empire State Building

Partner companies
5

Energy-efficiency ideas vetted
60+

Final projects recommended
8

Iterative design process
8 mos.

Annual energy savings
$4.4M

Energy reduction
38%

What?

- Economically viable integrated sustainability program for the Empire State Building including:
- Infrastructure projects
- Design standards
- Tenant energy management
- Property management
- Leasing and marketing initiatives

Why?

- To create a replicable model that will lead to significant reductions in greenhouse gas emissions, and promote sustainable design and operations in existing buildings.

How?

- Rigorous eight-month iterative design process
- Narrowed 60+ ideas to a package of eight recommended projects
- Identified optimal balance of financial and environmental return on investment
- Addresses increased infrastructure needs, utility costs, future planning, and tenant use of energy
- Includes building windows, radiators, automated controls, cooling plant, air quality, tenant space design, and tenant energy use
- Requires the active engagement of an ESCO (JCI), the building owner, and building tenants

How much?

- Incremental cost of $13.2 million
- Saves a maximum of $4.4 million in annual energy costs
- Equivalent to a 38 percent energy reduction

What are the top three things we are hoping to change?

- Dramatically reduce energy use of the Empire State Building, and be able to demonstrate the savings in a transparent and verifiable way
- Improve tenant comfort and reduce tenant energy use via improved design and energy awareness
- Improve the building's marketability
-

What are the top five unique things we are doing?

- "Right steps in the right order" retrofit for whole-systems optimization
- Utilized both industry sustainability ratings, plus created new tools
- Demonstrating that a building retrofit can cost-effectively achieve upwards of 35 percent energy savings
- Innovative commercial model and measurement and verification model
- Designing a model pre-built office suite as a physical example of an integrated sustainability program that bridges base-building and tenant space improvements

What are the top three results we are expecting to see?

- Achieve an energy use reduction of 19 percent in the initial phase, and gradually increase the savings to 38 percent as the longer-term projects are completed
- Create a competitive advantage in the marketplace.
- Cause an increase in the number of multi-tenant building retrofits that seek more dramatic energy use reductions by tackling tenant as well as base-building systems

Developing tools to build on

eQUEST
Baseline model of current energy performance; predicts performance under new measures

Comprehensive carbon footprint tool

Tenant sustainability master planning tool
Engage tenants, provide LEED Platinum pre-built space model and guidelines for energy management

Process of elimination

Identify opportunities

- 60+ energy efficiency ideas were narrowed to 17 implementable projects
- Team estimated theoretical minimum energy use
- Developed eQUEST energy model

Evaluate measures

- Net present value
- Greenhouse gas savings
- Dollar to metric ton of carbon reduced
- Calculated for each measure

Create packages

- Maximize net present value
- Balance net present value and CO_2 savings
- Maximize CO_2 savings for a zero net present value
- Maximize CO_2 savings

Model iteratively

- Iterative energy and financial modeling process to identify final eighht recommendations

EVALUATE current capital projects
Weekly charrettes → Integrated review workshops → Phase presentations and summary findings reports

PERFORM comprehensive energy audit
Weekly charrettes → Integrated review workshops → Phase presentations and summary findings reports

DEVELOP list of potential facility improvement measures
Weekly charrettes → Integrated review workshops → Phase presentations and summary findings reports

BALANCE
- Energy performance optimization
- Carbon footprint reduction
- Maximize energy savings
- Positive net present value

Weekly charrettes → Integrated review workshops → Phase presentations and summary findings reports

FINAL PACKAGE
of implementable facility improvement measures

IMPLEMENTATION PHASE I
- Contracts
- Budget
- Schedule
- Design
- Bid

IMPLEMENTATION PHASE II
- Construction
- On-going measurement and verification through energy performance contract

HTTP://WWW.ESBSUSTAINABILITY.COM/SOCME/CONTENT/FILES/ESBPLACEMATFINAL(2).PDF