Choosing Insulation:
So many options, so little time, and so much need for information

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ENERGY DESIGN
conference & expo

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code /1 hour energy** continuing education requirements."

Learning Objectives - You will be able to:

- ***Identify*** characteristics needed for cavity insulation
- ***Identify*** characteristics needed for rigid exterior insulation
- ***Choose*** between interior and exterior foundation insulation
- ***Choose*** between venting or not venting roof insulation systems
- ***Design*** and specify insulated assemblies that have drying potential
- ***Incorporate*** key environmental performance characteristics of insulation
- ***Use*** one of the best information resources on insulation

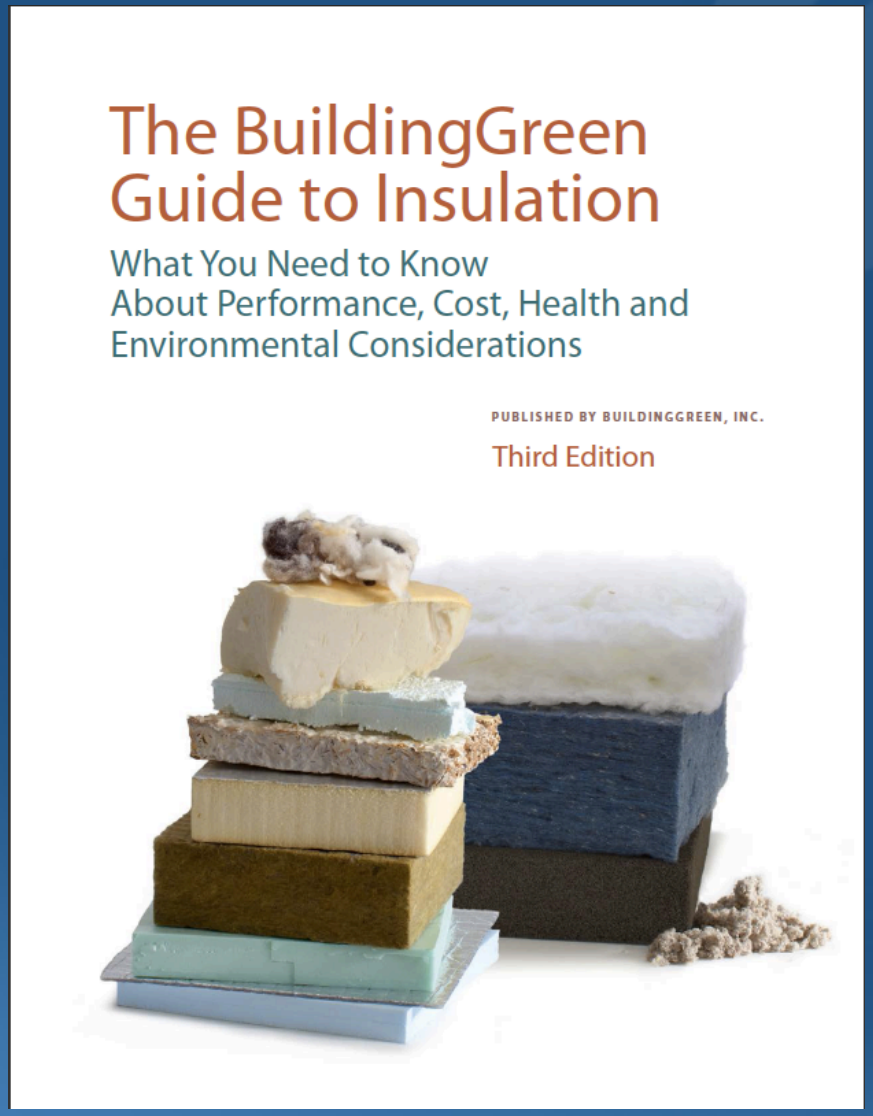
Placing Insulation in Context

Building Assembly Priorities for All Climates

- *Bulk water management*
- *Air tightness*
- *Designated directional drying potential*
- *Insulation*

Managing both energy and moisture is not just a good idea; it's THE LAW…

The Reference



Why we like insulation

- Primary role of insulation
  - Energy
  - Thermal comfort
- R-value and U-factor
- Function of three modes of heat transfer:
  - Conduction
  - Convection
  - Radiation

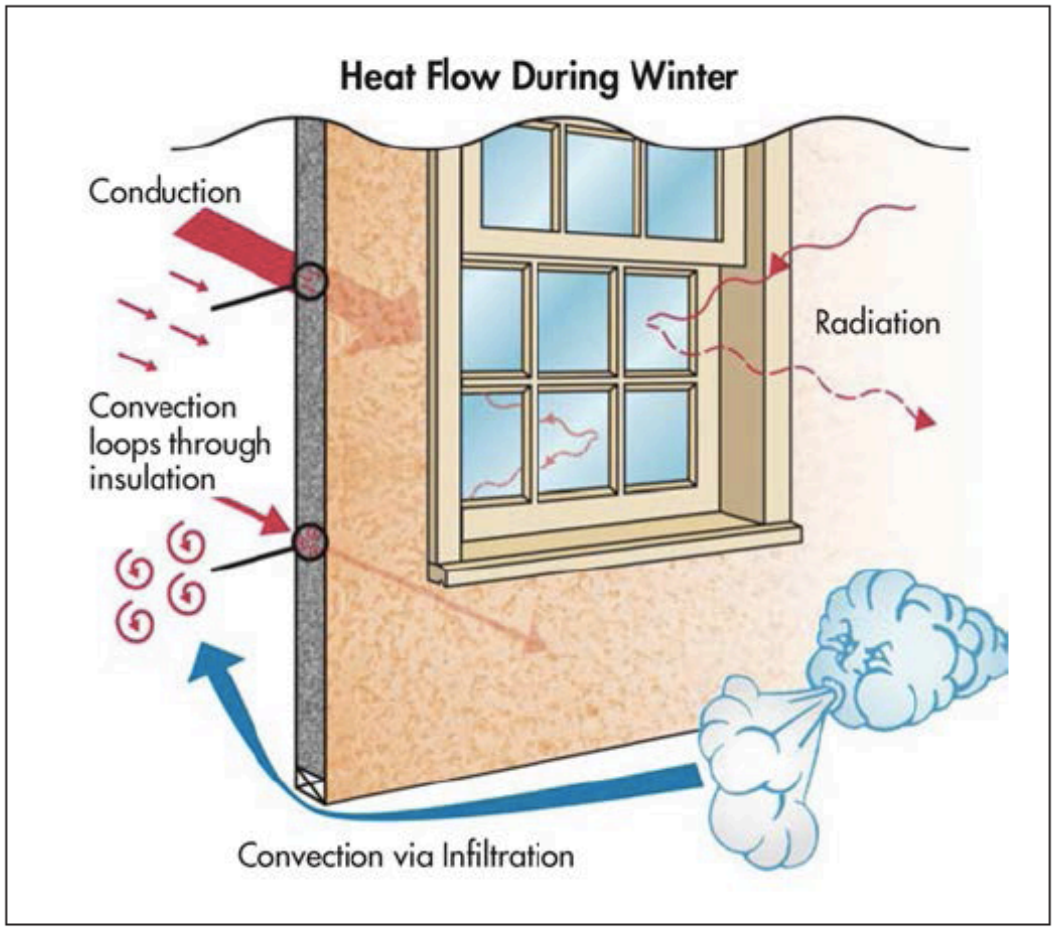


Illustration: Peter Harris

The BuildingGreen Guide to Insulation Third Edition, 2017

Insulation: How much is enough?

RECOMMENDATIONS BY DOE CLIMATE ZONES FOR NORTH AMERICA												
Assembly Area	Hot (Zones 1–2)			Moderate (Zones 3–4)			Cold (Zones 5–6)			Coldest (Zones 7–8)	
	IECC		BG	IECC		BG	IECC		BG	IECC	BG
BUILDING ENVELOPE R-VALUES											
Slab	0		0	0	10	10	10		15	10	25
Basement wall	0		10	5/13	10/13	20	15/19		30	15/19	40
Floor above vented crawl space	13		15	19		25	30		40	38	50
Above-grade walls (wood-framed)	13		15	20 or 13+5		25	20 or 13+5	20+5 or 13+10	40	20+5 or 13+10	50
Ceiling – Flat	30	38	50	38	49	40	49		60	49	70
Ceiling – Cathedral			40				50			60	
FENESTRATION											
Window U-factor – E, W, N	NR	0.40	0.35	0.35		0.25	0.32		0.2	0.32	0.15
Windows U-factor – South				0.35			0.25				
Window SHGC – E, W, N	0.25		<0.2	0.25	0.40	<0.33	NR		NR	NR	NR
Window SHGC – South	<0.3		>0.3		<0.4	>0.3	>0.5		>0.4		>0.4
Exterior door (unit U-factor)	NA		0.3	NA		0.3	NA		0.25	NA	0.2
AIRTIGHTNESS											
Airtightness (ACH50)	NA		2	NA		2	NA		1.5	NA	1

Environmental considerations – insulation materials

- Tremendous variety of insulation materials
  - Widely different forms, properties, environmental characteristics
- How do we evaluate insulation materials relative to the environment?
- What makes one material better than another?
- Relates to both the material and the application

Spray-applied soy-based polyurethane

Raw materials and recycled content

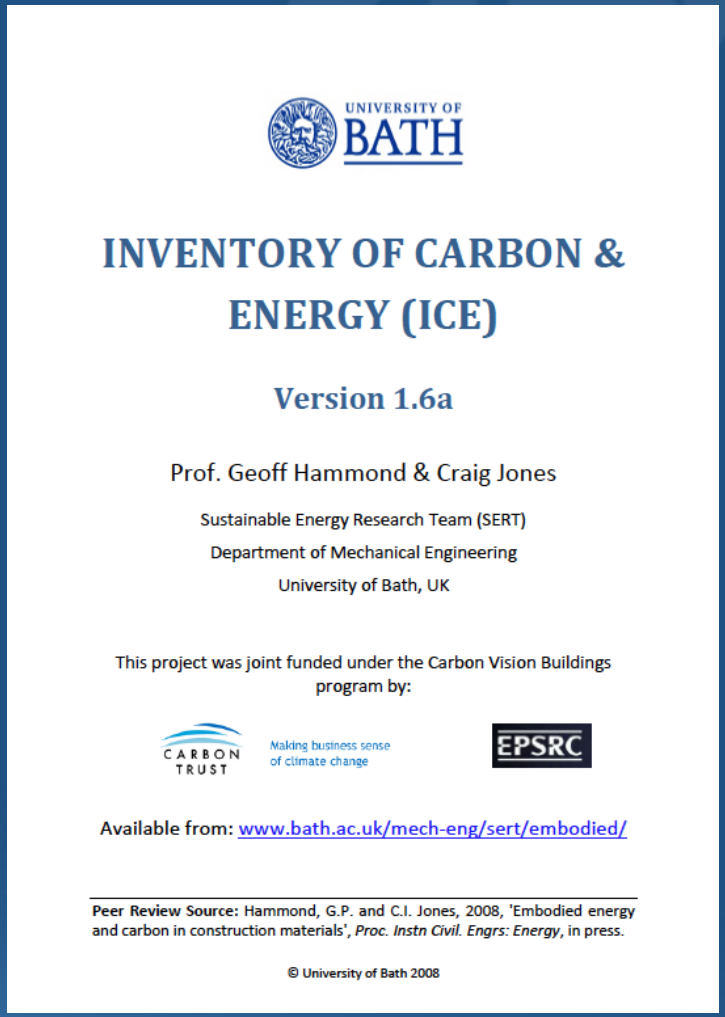
- Where the raw materials come from
- Recycled content is important
- Examples:
  - Cellulose from old newspaper
  - Fiberglass from recycled bottles
  - Cotton insulation from old blue jeans

Bonded Logic cotton insulation factory
Photo: Alex Wilson

Embodied energy and carbon

- Energy to make and transport the stuff
- Huge differences among materials:
  - Cellulose the lowest embodied energy
  - Foam plastics much higher
- ICE Database from the U.K. – free

Inventory of Carbon & Energy, Univ. of Bath, Sustainable Energy Research Team



UNIVERSITY OF BATH

INVENTORY OF CARBON & ENERGY (ICE)

Version 1.6a

Prof. Geoff Hammond & Craig Jones

Sustainable Energy Research Team (SERT)

Department of Mechanical Engineering

University of Bath, UK

This project was joint funded under the Carbon Vision Buildings program by:

CARBON TRUST Making business sense of climate change

EPSRC

Available from: www.bath.ac.uk/mech-eng/sert/embodied/

Peer Review Source: Hammond, G.P. and C.I. Jones, 2008, 'Embodied energy and carbon in construction materials', *Proc. Instn Civil. Engrs: Energy*, in press.

Global Warming Potential (GWP)

- Insulation saves energy—and thus carbon emissions
- But the insulation also has GWP associated with it
- From embodied energy (all mat'ls)
- Blowing agents in extruded polystyrene and most closed-cell spray polyurethane foam far greater GWP

Net-zero-energy house with 4" XPS wrapped around 2x6 walls with cellulose. Photo: Bensonwood

Blowing agents in foam insulation

Type of Insulation	Blowing Agent	Atmospheric Lifetime (yr)	ODP[1]	GWP[2]
Polyisocyanurate				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	Pentane, cyclopentane	–	0	7[3]
Spray Polyurethane				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	HFC-245fa	7.2	0	1,030
3rd Generation	CO_2	–	0	1
4th Generation (2017)	HFO-1233zd	< 0.1	0	7
Extruded Polystyrene (XPS)				
Original	CFC-12	100	1	10,900
2nd Generation	HCFC-142b	17.9	0.065	2,310
3rd Generation	HFC-134a	13.8	0	1,430
4th Generation (TBD)	HFO-1234ze[4]	< 0.1	0	7

Figure 1 from BG Guide to Insulation, 2017

Issue addressed in June, 2010 issue of *Environmental Building News*

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Avoiding the Global Warming Impact of Insulation

Insulation is key to reducing carbon emissions from buildings. But the blowing agents in extruded polystyrene and spray polyurethane foam offset much of that benefit.

by Alex Wilson

TWO COMMON FOAM INSULATION materials are produced with hydrofluorocarbon (HFC) blowing agents that are potent greenhouse gases—extruded polystyrene (XPS) such as Dow Styrofoam of Owens Corning Foamular, and standard closed-cell spray polyurethane foam (SPF). While all insulation materials reduce greenhouse gas emissions (by saving energy), insulating with thick layers of either of these two particular foams results in very long "payback periods" for the global warming potential of the insulation, thwarting even the best attempts to create carbon-neutral buildings. The bottom line is that designers and builders aiming to minimize the global warming impacts of their buildings should choose fiber insulation (cellulose, fiberglass, or mineral wool) or non-HFC foam insulation.

"The more insulation the better" is a common refrain in the green building industry. *EBN* has long advocated very high levels of insulation, particularly in residential and small commercial buildings, which are skin-dominated. At the furthest end of the spectrum is the Passive House movement (see *EBN* Apr. 2010), where it is not uncommon to provide R-50 under a floor slab, R-60 in the walls, and as much as R-100 in the attic. High levels of insulation are seen as a key strategy for achieving net-zero-energy and carbon-neutral performance—the latter meaning that the building will have no net contribution to climate change.

How we achieve high levels of insulation is a very significant issue, however. We rarely pay attention to the fact that insulation materials themselves contribute to greenhouse gas emissions and global warming. This happens in two ways: through the embodied energy of the insulation (the energy use and greenhouse gas emissions that result from manufacturing

(continued on p. 9)

Photo: Bensonwood

Unaware of the recently reported GWP implications of certain foam insulation materials, builder Todd Benson specified four inches of extruded polystyrene over 2x6 studs insulated with dense-pack cellulose in this net-zero-energy home.

In This Issue

Quote of the month:

"Specifying a high-GWP insulation completely defeats the point of using it."

– Scott Shell, FAIA of EHDD Architecture commenting on new information on the global warming potential of insulation materials (page 12)

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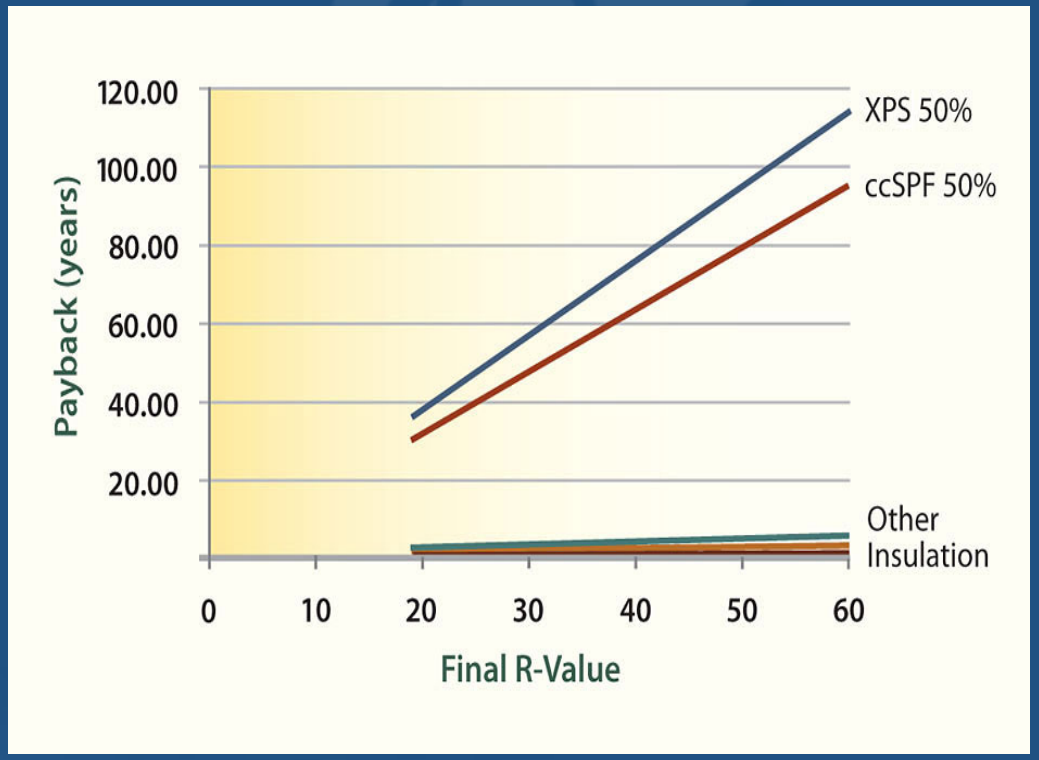
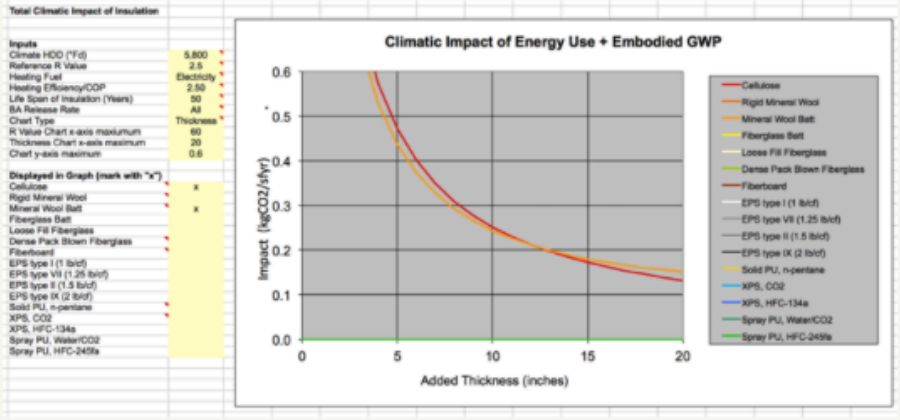


June 2010 groundbreaking article from Environmental Building News

Downloads

Insulation Global Warming Potential Calculator

More insulation is generally better for combating climate change, but not always. Some insulations have high embodied energy, and heating systems and fuels are getting cleaner. Most influential is that some foam insulations have an extremely high embodied GWP due to the blowing agents used. This calculator will help you understand the GWP implications of insulation choices. The Excel file is locked to make it safe from accidental errors. If you want to unlock it, the password is "unlock."



Hazardous chemical constituents - formaldehyde

- Formaldehyde a "known human carcinogen" (12th U.S. Report on Carcinogens - 2011)
- Phenol-formaldehyde was used in most fiberglass & mineral wool insulation
- Formaldehyde binders now gone from all fiberglass batt insulation and some mineral wool batts—Roxul and Thermafiber just announced formaldehyde-free batt insulation in 2017

Photo: Alex Wilson

Hazardous chemical constituents – halogenated flame retardants

- Significant health and environmental concern with brominated and chlorinated flame retardants
- HBCD, used in nearly all polystyrene building insulation listed in the Stockholm Convention on Persistent Organic Pollutants
- TCPP used in most spray polyurethane foam (SPF) and polyisocyanurate foam insulation

XPS on a home in Illinois - photo: Alex Wilson

Safer polyiso insulation – Without halogenated flame retardants

- Polyisocyanurate insulation now available from two manufacturers free from halogenated flame retardants.
- Johns Manville and GAF
- GAF's product is EnergyGuard-NH (for "no halogen")

Halogen-free polyiso - photo: Alex Wilson

Safer polyiso insulation – Without halogenated flame retardants

Halogen-free polyiso - photo: Alex Wilson

Safer polyiso insulation – Without halogenated flame retardants

Halogen-free polyiso - photo: Alex Wilson

Hazardous chemical constituents – Isocyanates

- Spray polyurethane foam (SPF) has two components
  - Polyol
  - Isocyanate
- Isocyanate toxic
- U.S. EPA looking into hazards
- Skin, eye and lung irritation; chemical sensitization

Closed-cell SPF – John Straube photo

Other IAQ Concerns

- Moisture and mold
  - Can be an issue with almost any insulation material
  - Importance of air barriers and vapor retarders
- Fiber shedding
  - Respirable fibers from fiberglass and mineral wool
  - Once believed to be carcinogenic

Installation of Pro Clima variable-permeable vapor retarder in a bathroom over mineral wool batts - photo: Alex Wilson

End-of-Life issues with insulation

- Design for disassembly?
  +/- of "sticky"
- Safe disposal
  - Release of environmental or health hazards
  - Especially blowing agents

Charlotte, NC landfill

Our Guide's Recommendations