BUILDING ENERGY 15

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Course Title: A Place in the Sun: Why We (Still) Need Solar-Optimized Design

Course Number: BE1528

Speaker Name/s: Rachel Wagner

Course Date: 4 March 2015

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A Place in the Sun

Why We (Still) Need Solar Optimized Design

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Course Description

As low energy super-insulated structures become more prevalent and the cost of active renewable energy systems drops, is passive solar design still relevant? Does the current technology of building reduce the need for what the sun can provide to a home?

Solar-optimized design is as necessary as ever, perhaps even more so in a world where disruptions to both raw energy supplies and distribution of energy are likely.

An integrated approach to solar design can and should support optimal building performance and occupant comfort. The sun has a place in net-zero or near-net-zero homes, and not just to turn electrons into electricity.

Learning Objectives

1. Recognize how the sun affects a building and its occupants, and that we can choose whether the effects of the sun will be detrimental or useful.

2. See the sun as a component of “house as a system thinking:” affecting and interacting with building form, enclosure, occupant activity and mechanical systems.

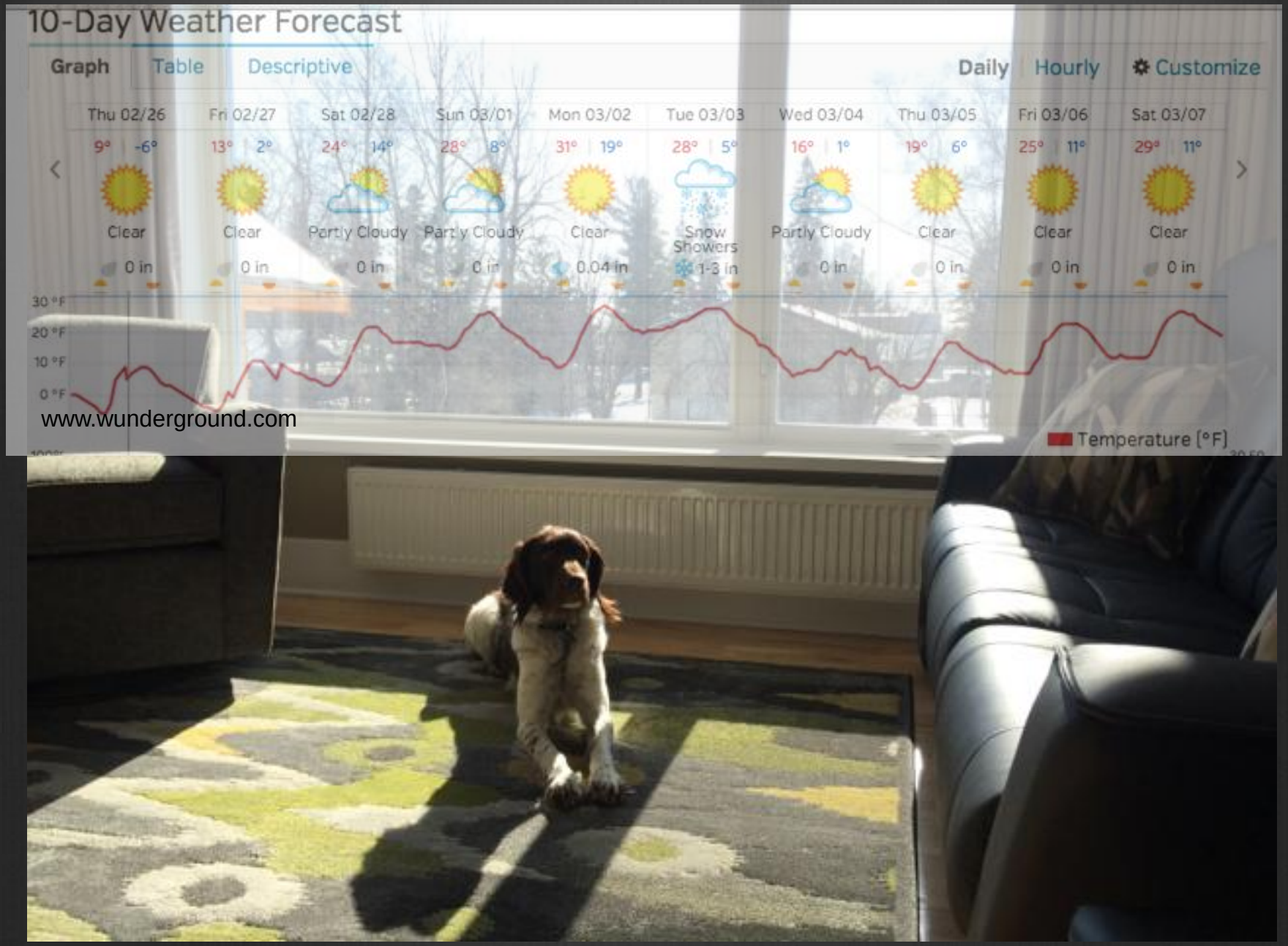
3. Understand basic passive solar design principles and use them to plan space and enclosure to create a solar-optimized building.

4. Begin to think creatively about how to “let the sun shine in” even when a site or building program doesn’t appear optimal for solar-oriented design.

5. Identify integrated solar-optimized design as part of high performance enclosure and systems design.

Image from phrases.org.uk

Has high performance design rendered solar design irrelevant?


10-Day Weather Forecast
Graph
Table
Descriptive
Daily
Hourly
Customize
Thu 02/26
Fri 02/27
Sat 02/28
Sun 03/01
Mon 03/02
Tue 03/03
Wed 03/04
Thu 03/05
Fri 03/06
Sat 03/07
9° -6°
13° 2°
24° 14°
28° 8°
31° 19°
28° 5°
16° 1°
19° 6°
25° 11°
29° 11°
Clear
Clear
Partly Cloudy
Partly Cloudy
Clear
Snow Showers
Partly Cloudy
Clear
Clear
Clear
0 in
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0 in
0 in
0.04 in
1-3 in
0 in
0 in
0 in
0 in
30 °F
20 °F
10 °F
0 °F
www.wunderground.com
Temperature [°F]

The SUN affects our buildings and our experience in our buildings.

Ignore it, and the building (and its occupants) can suffer from the effects of the sun.

Embrace it, and reap the benefits.

Winter in Duluth

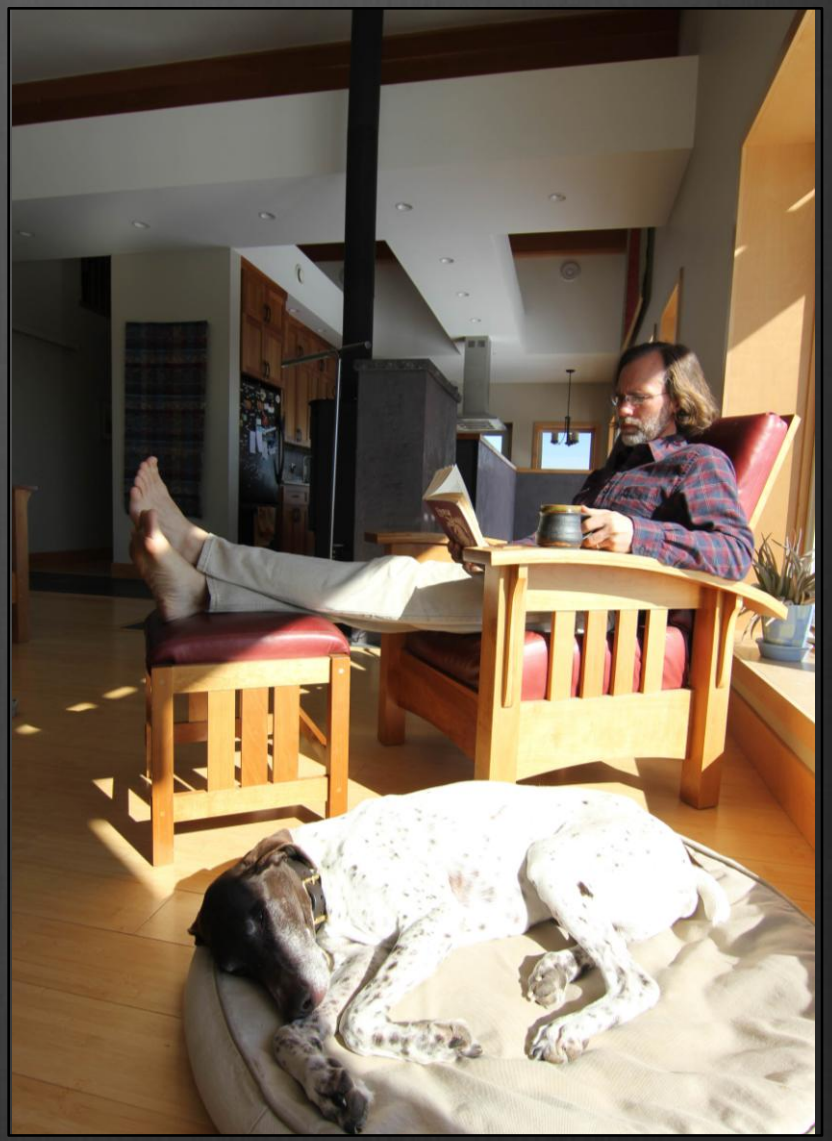
4 December 2013

Also Winter in Duluth

14 February 2015

Winter in Duluth

February 24, 2014



February 20, 2008

How the sun affects a building

- Daylight
- Ventilation
- Glare
- Heat Gain
- Heat Loss
- Moisture

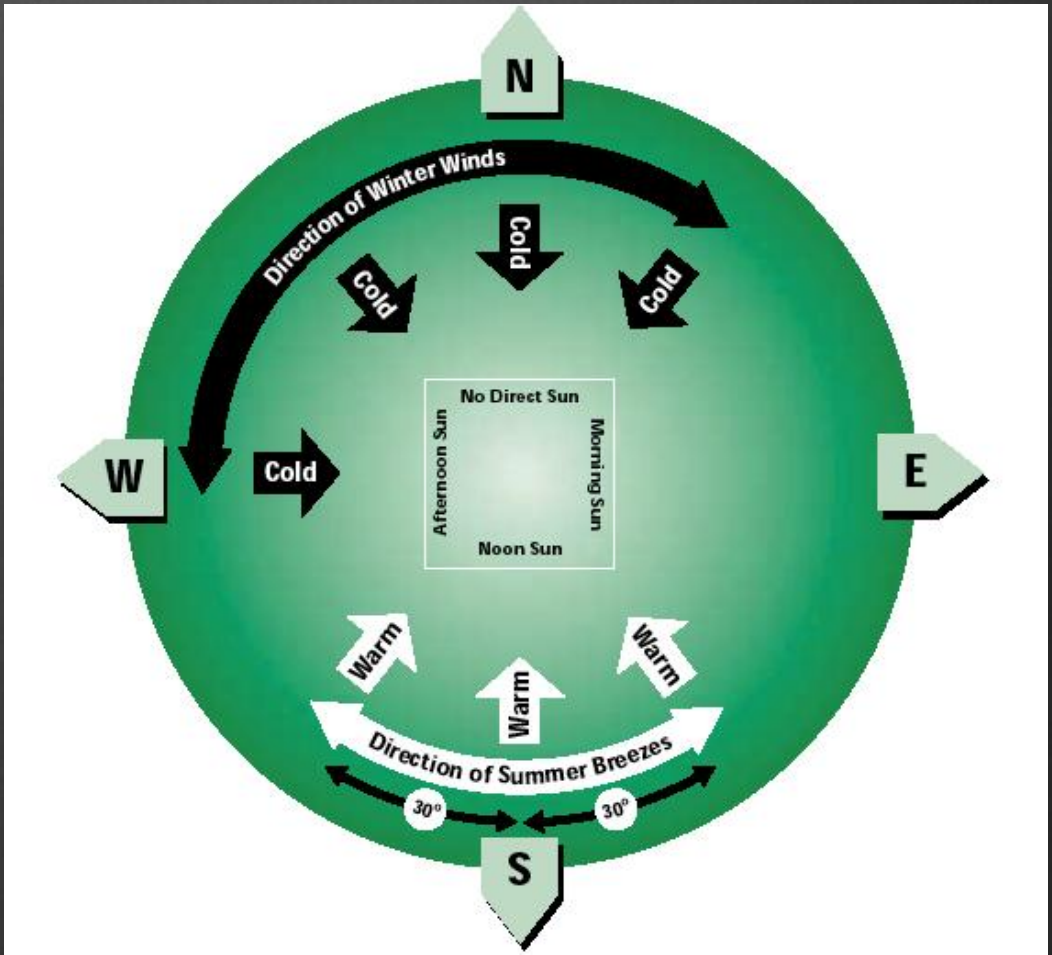


Image from ENERinfo

www.gov.ns.ca/natr/meb/energy.htm

Letting the Sunshine In (or not)

- Little sun on the north
- Morning sun east
- Most sun south
- Afternoon sun west
- High sun angle in summer
- Low sun angle in winter

Know where and when the sun will be in relation to a site and building.

House as a (solar-optimized) system

Integrated Design should include integrating the sun.

Integrated Solar Design

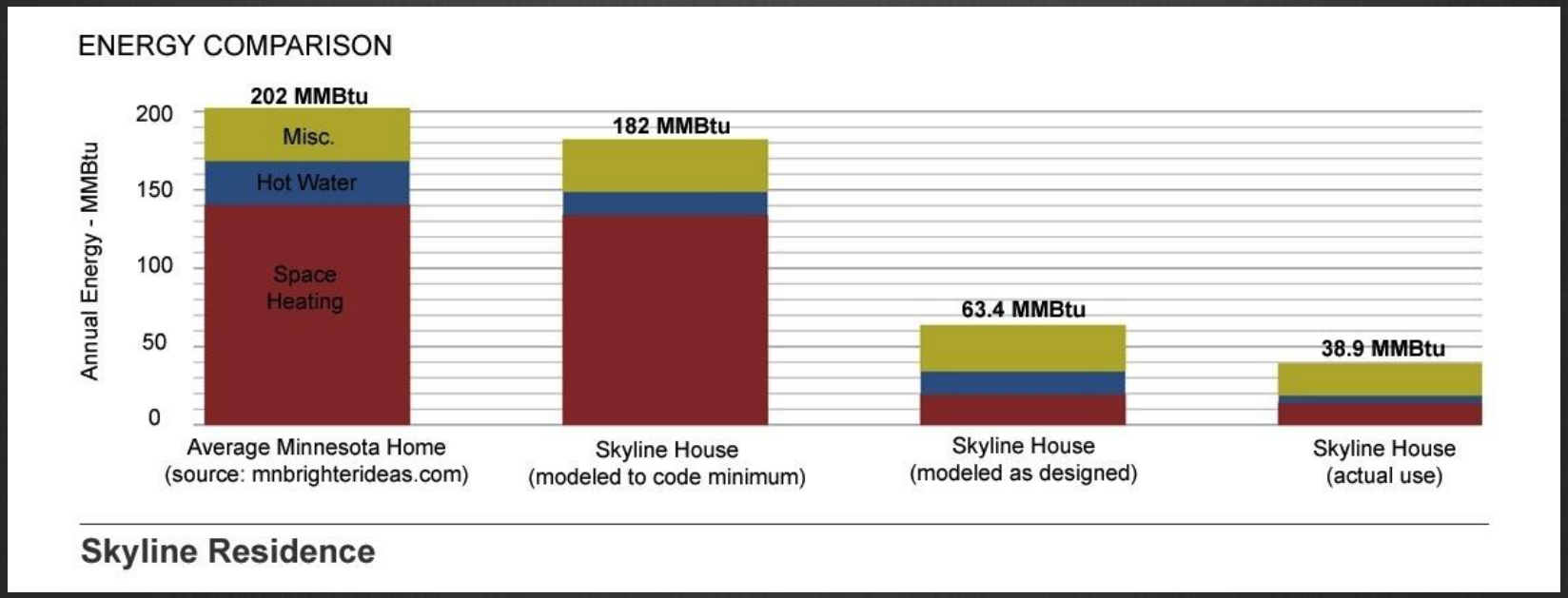
can provide half (or more) of the required annual space heating energy for a home in a cold climate,
can reduce the need for air conditioning, and
can reduce the amount of time the lights need to be on.

Energy modeling – a standard tool

Some kind of energy modeling should be done for high performance, low energy design.

Early energy modeling with REMDesign helps integrate passive solar design with a high performance envelope.

PHPP is one more refined tool for optimized solar design.

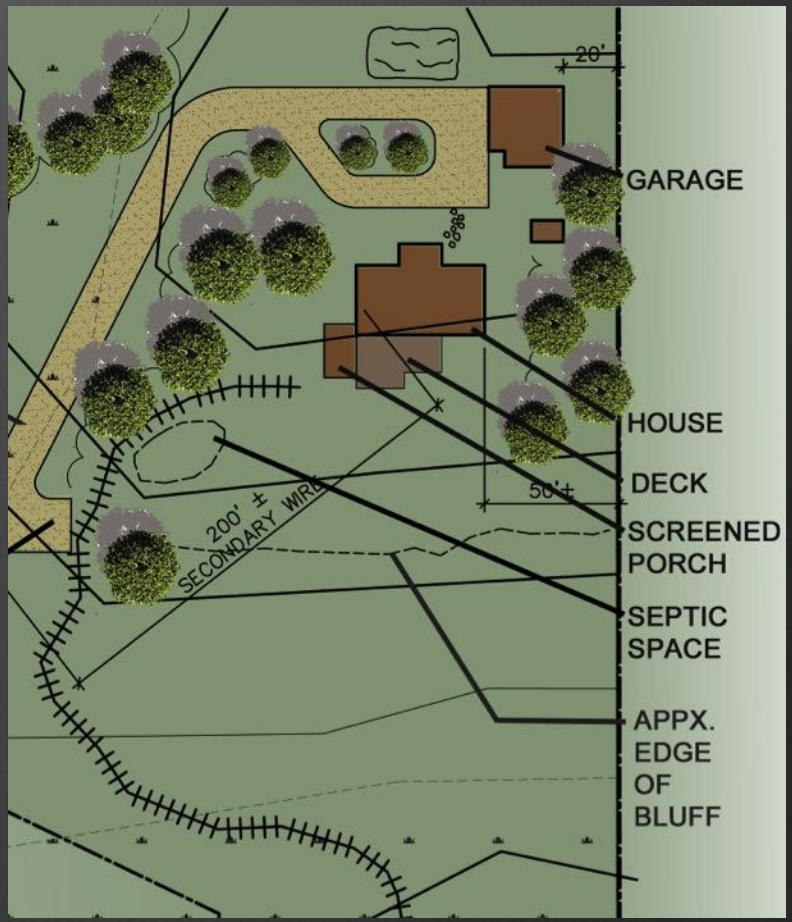


Passive Solar Design Principles

1. Understand the sun's path on your site and when the sun will be able to reach the building.
2. Put most living spaces to the south whenever possible.
3. Create space that allows light and heat to penetrate the occupied areas from south-facing windows.
4. Minimize windows to the north and west.
5. Incorporate structure that will shade summer sun but let in winter sun, on south facing windows.
6. Construct a high-performance, low energy building shell.
7. Select heating and cooling systems that will be responsive to tuning for solar gains.

Solar Site Design

- Minimize shading from the south
- Trees east and west can provide wanted shade in summer, help manage unwanted gains
- Consider the future – trees growing, neighbors building
- Locate other buildings on site sensitively



Face the building south (within 30 deg)

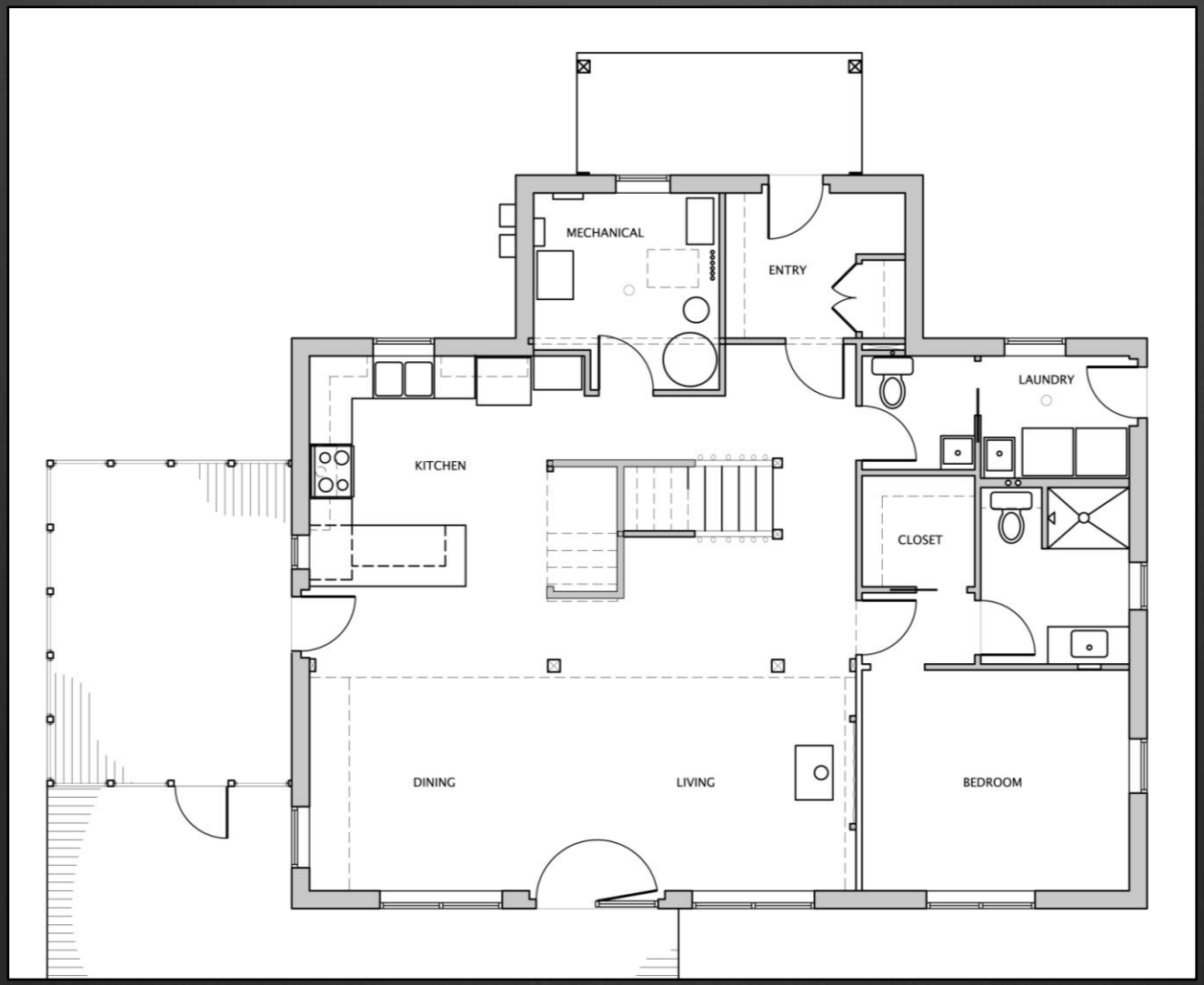
Building Planning for Passive Solar

1. South-facing building facade, within 30 degrees of south
2. Site design and building form to minimize and manage unwanted solar gain
3. Longer axis of building running east-west
4. Open plan as much as possible – especially on south side
5. Window shading to let in winter sun, keep out summer sun
6. Window selection, sizing and placement to deliver desired solar gain
7. Cross ventilation to reduce cooling load
8. Energy efficient building form and enclosure

Space Planning: optimized for light, heat, and ventilation

- Morning-use spaces east/southeast
- Daytime-use spaces south
- Evening-use spaces west
- Utility spaces north
- Heat-generating spaces north
- Open living spaces
- Windows placed for cross-ventilation

Solar-optimized space plan



Solar-optimized space plan

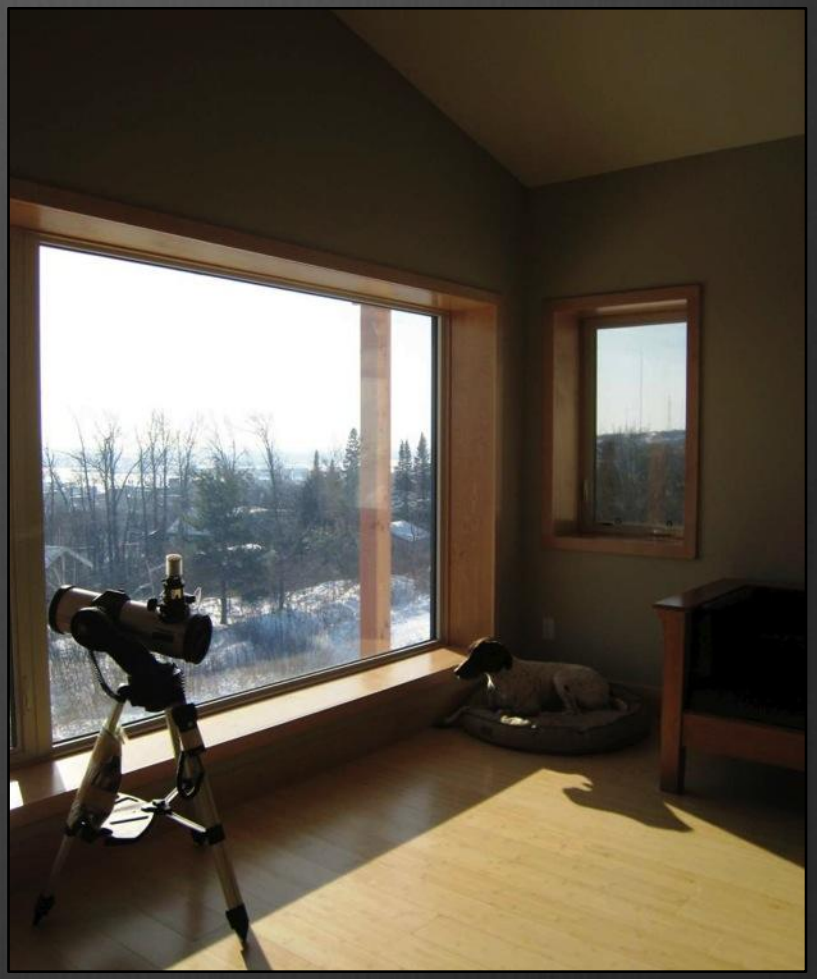
Open living/dining on the south with large windows.
Kitchen on the north, and open to living/dining and entry.

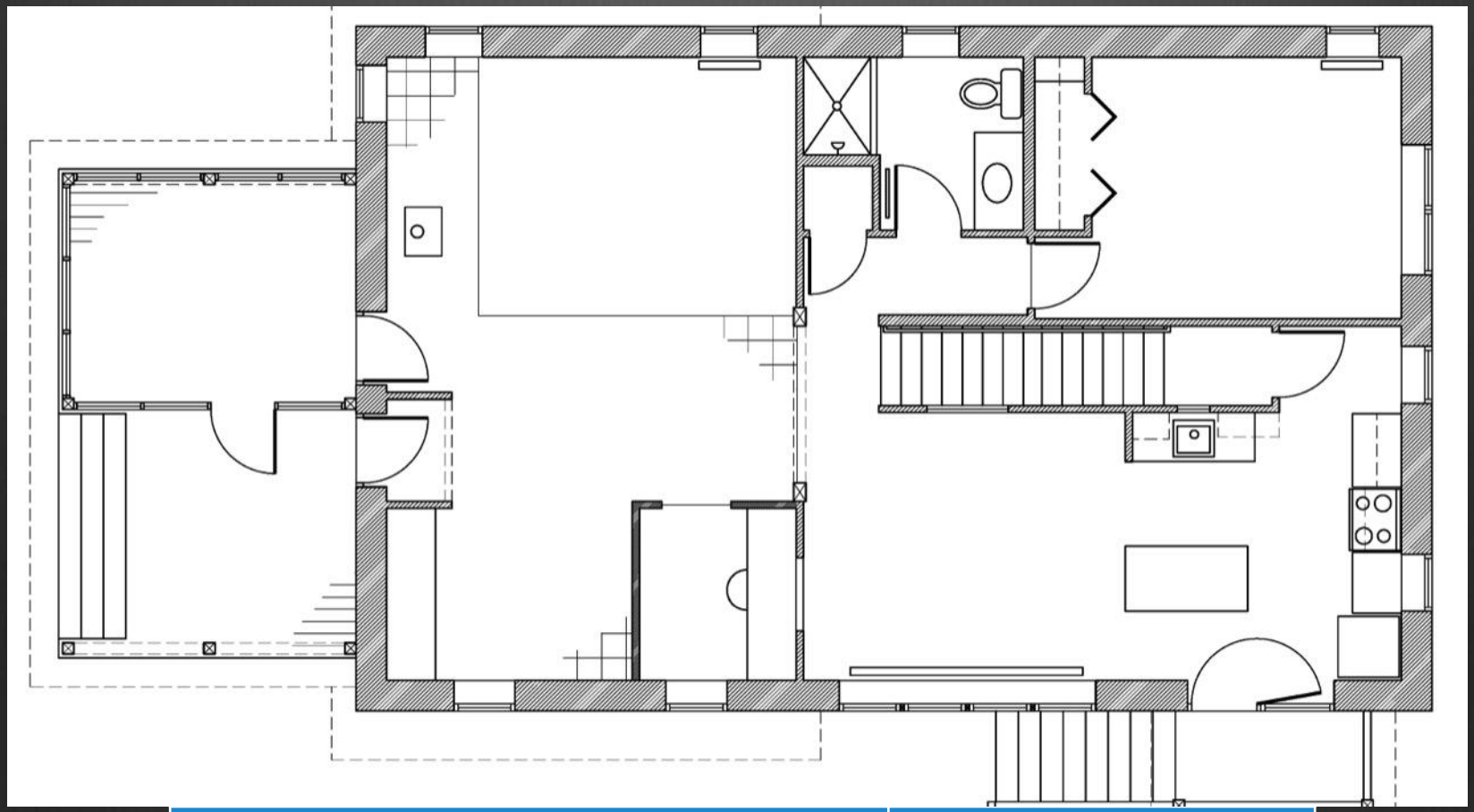
Planning Windows

1. Windows on the south will bring in the most solar gain and be easiest to manage (shade in summer)
2. Too much sun from the west (or east) causes glare and overheating, so reduce windows on the west and east sides and reduce SHGC of west-facing glass.
   - Trees can help shade the windows.
3. Plan space and windows for cross-ventilation
4. Minimize windows to the north.
5. Building energy modeling or calculation tools help refine window sizes, location, and glazing selection.

Area of South-facing Windows

- Calculated south facing glass: 8-12% of floor area (usually)
- If sunlight will strike an area of thermal mass, window area can be larger, but this requires careful design to maintain comfort and energy balance.



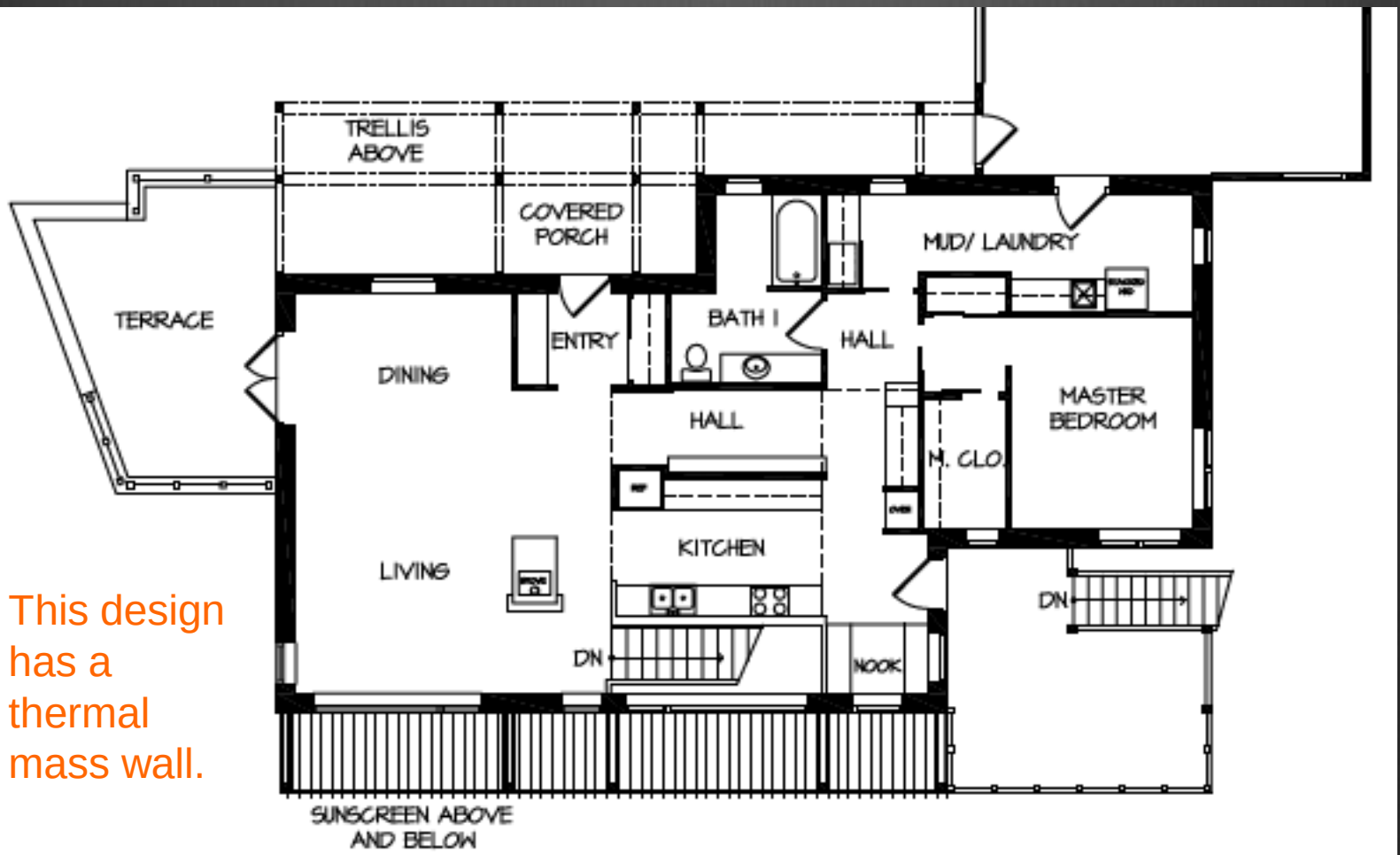


Floor Area	1050 ft2
South Window Area	83 ft2
% south window to floor area	8%

N

N

Floor Area	740 ft2
South Window Area	88 ft2
% south window to floor area	12%



This design has a thermal mass wall.

Floor Area	1330 ft2
South Window Area	185 ft2
% south window to floor area	14%

N

Managing the sun's entry into the home: allow winter sun in, keep summer sun out

Integral roof overhangs

For taller windows (lower sill), overhang may need to be deeper

Solar-designed overhangs

It's not rocket science but it is science.

Properly shade south windows to admit lower altitude of winter sun but block the higher angle of summer sun

- Roof Overhangs
- Trellises
- Sun-shades

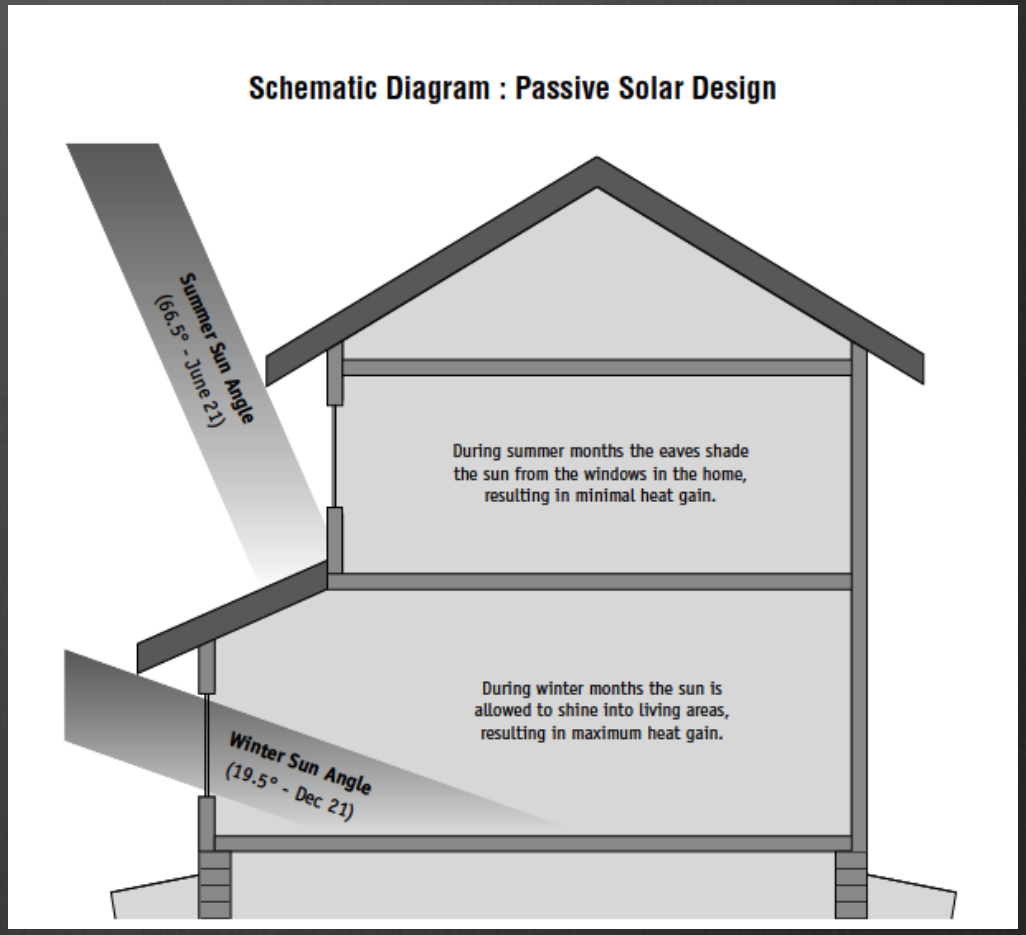


Image created by Jacob LeBeau/www.ecohomeduluth.com

Solar-designed overhangs

Know your solar altitude

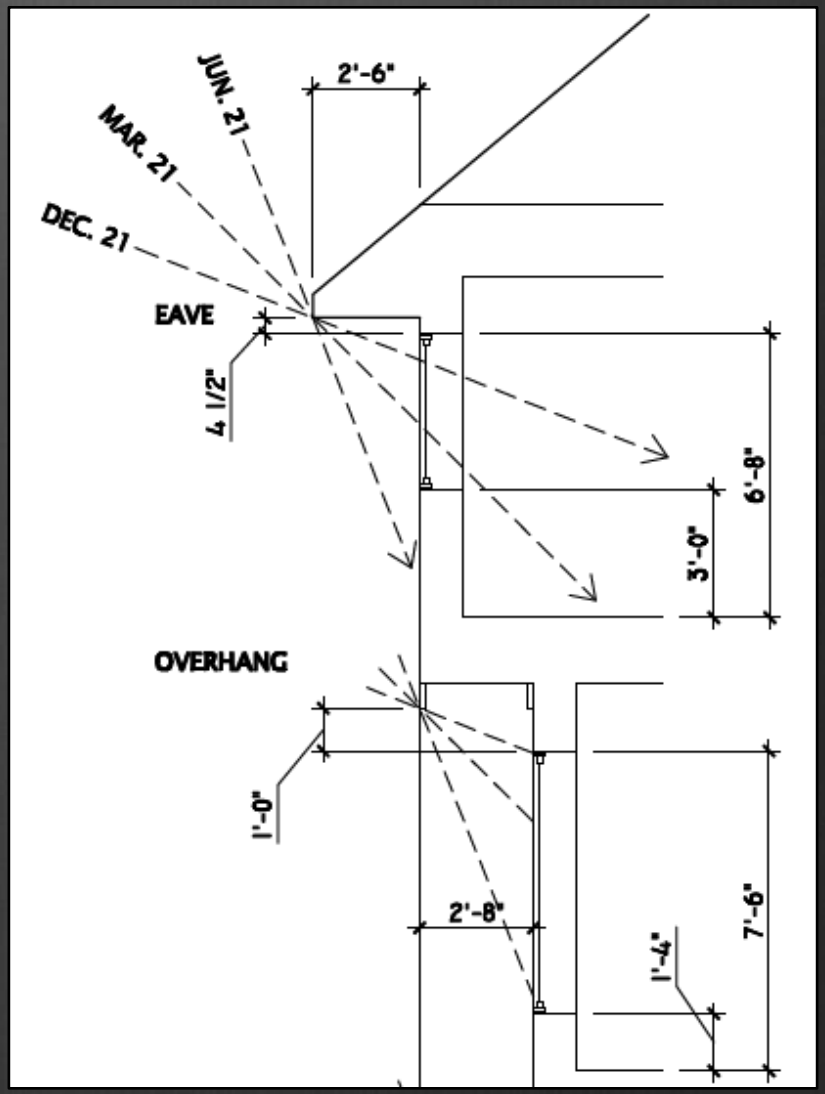
Solar altitude in Duluth:

Dec. 21 = 19.5

Jan. 21 = 23

June 21 = 66.5

www.esrl.noaa.gov/gmd/grad/solcalc/



SketchUp can show accurate shading for any time of year

Free tool: http://www.sketchup.com/download

Same view, different day

FEB

JUNE

Selecting Windows

For passive solar design to work, the heat gained from the south-facing windows should exceed the heat lost through those windows.

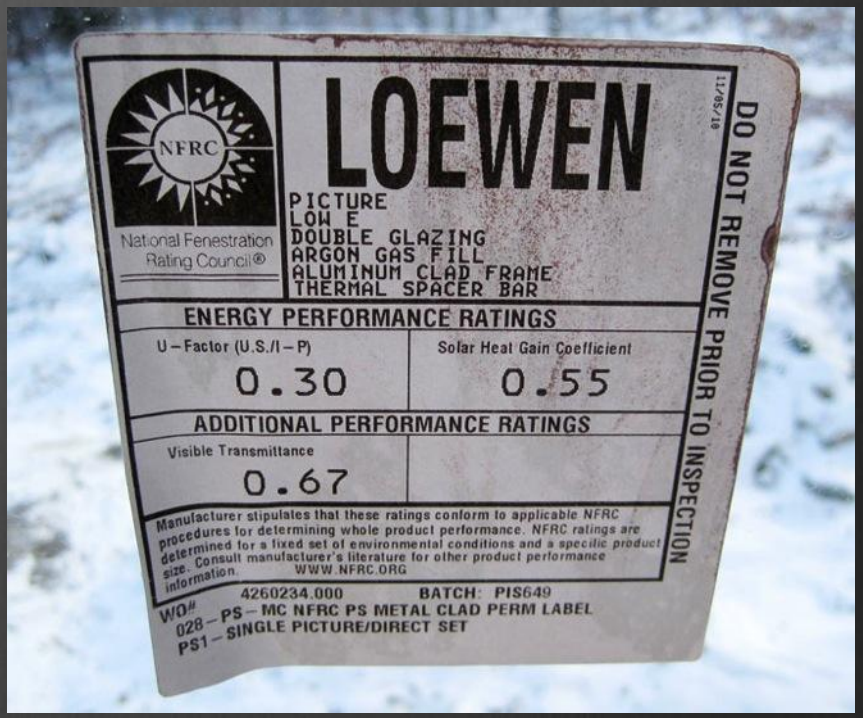
Rules of Thumb for Cold Climate Windows

1. High solar gain on the south
   - Min 0.5 glazing SHGC or 0.4 whole window SHGC value
2. High thermal performance
   - MAX. overall U-value of 0.24
   - Insulated frame + warm edge spacer
3. High visible transmittance
   - It's cold and dark for many months
   - I look for min. glazing VT of .6
4. Condensation resistance
   - Frame with some insulating value
   - Warm edge spacers

Understand the NFRC label

NFRC numbers are “whole window” numbers, so they skew the SHGC and VT because they take the frame into account.

C.O.G. SHGC is the correct tool for selecting solar performance.



www.buildinggreen.com

When solar conditions aren’t optimal

South-facing glass when the view isn't south

- A sunspace – or isolated gain space - can collect, store and distribute solar heat gain.
- Separate from main living spaces
- Larger window to space ratio works because of added thermal mass and interior controls
  - Doors
  - Windows
  - Destratification fan
- A sunspace can be a good addition to an existing home.

The desired views faced west

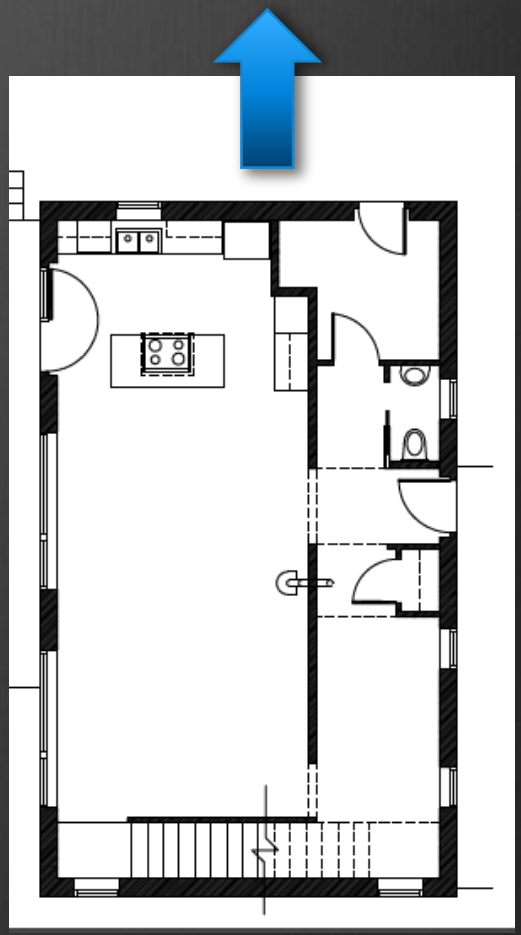
Screened porch blocks unwanted gain

Trees manage unwanted gain

Low-solar gain glazing on west-facing windows

Connection to sunspace

When solar conditions aren’t optimal



Open plan and south stair bring light and warmth into the spaces.

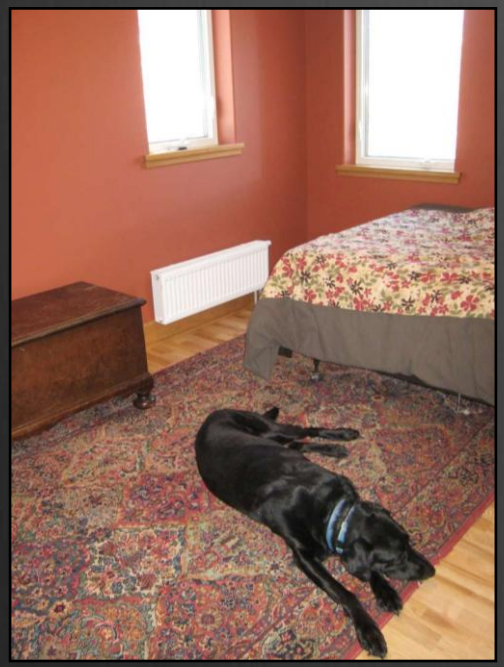
High Performance Solar-Optimized Design

Enclosure + Sun + Systems

If there is no solar gain, even a highly insulated house will gradually cool off. The more insulation, the slower the temperature in the house will drop, but drop it will. With a reasonable amount of passive solar gain and a really well-insulated building envelope, enough heat will enter the house to compensate for most of that heat loss in all but the cloudiest weather.

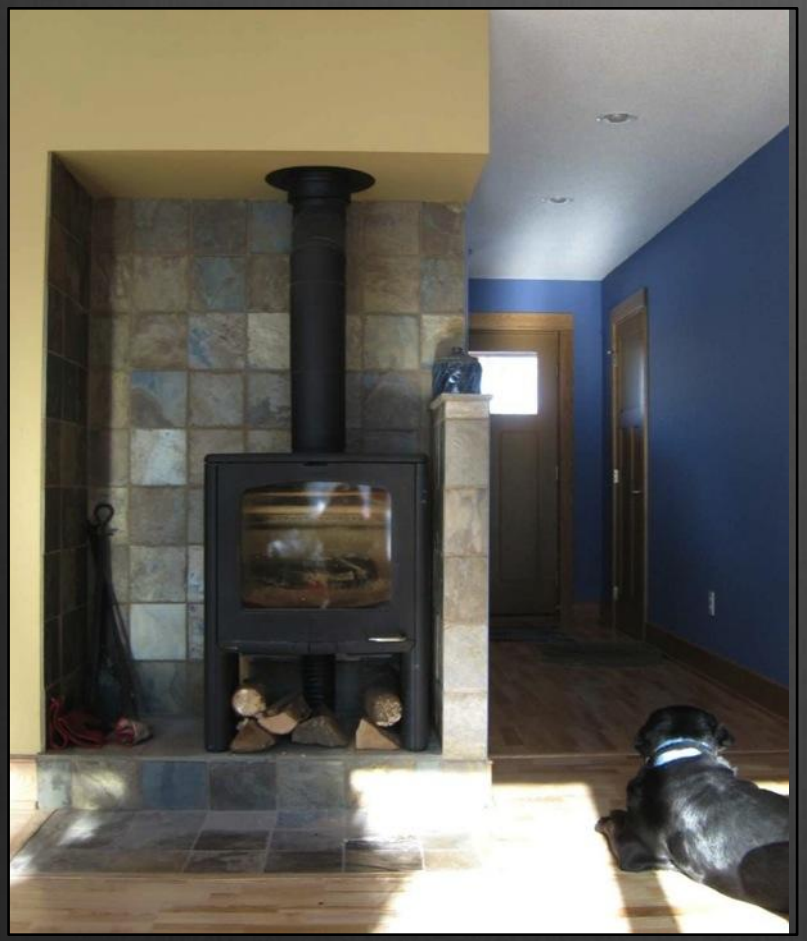
Alex Wilson, Building Green, 2012

Enclosure + Sun + Systems



- Fuel flexibility.
- Integration of renewable and non-renewable energy.
- Responsive design and equipment.

Managed solar gain

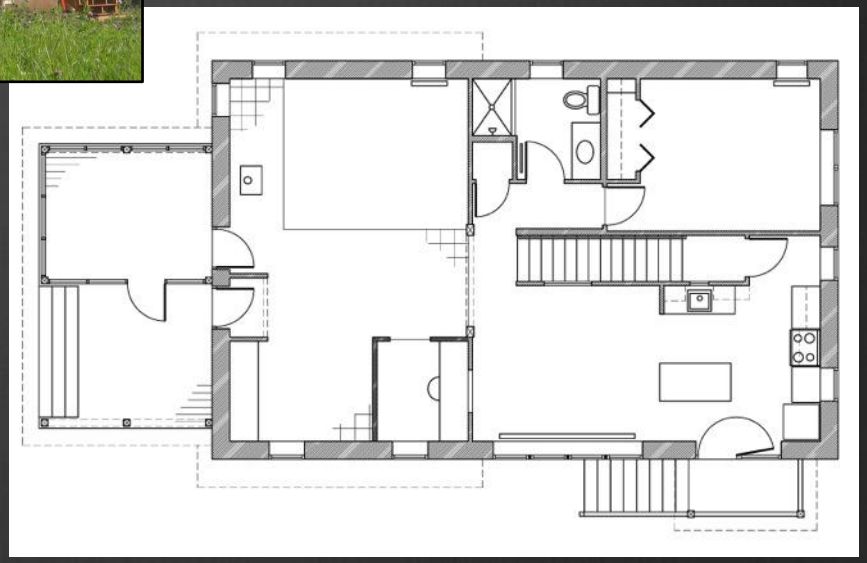


Reduces use of mechanical systems

Offers insurance

FEELS GOOD:
Dog favors the warmth of the sun over the warmth of the fire!

Esko Farmhouse



3150 ft2 (2990 ft2 conditioned)
Modeled Total Energy
64.1 Mmbtu/yr
Modeled Heating Demand
20.5 MMBtu/yr
(6.87 kBtu/ft2/yr)

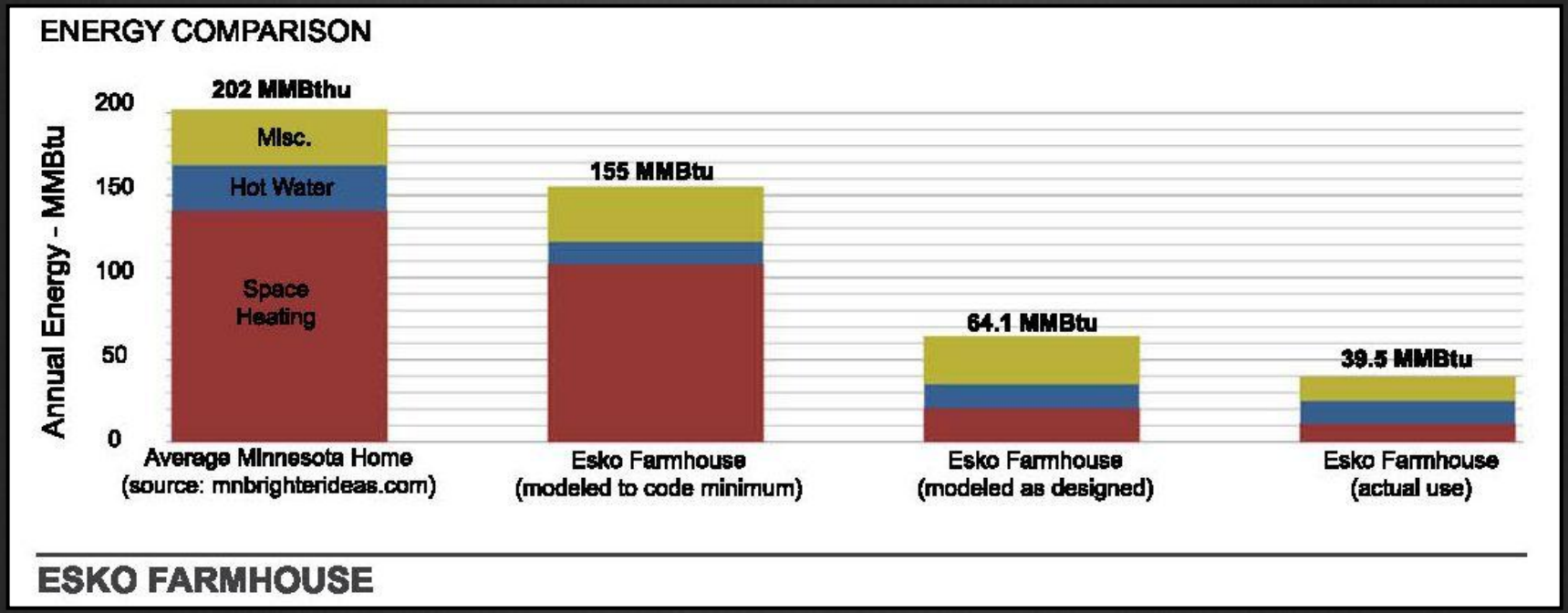
REAL ENERGY USE

Total Energy: 44.3 MMBtu/yr purchased energy (14 kBtu/ft2/yr)

Heating energy used (2009): 8.1 kBtu/ft2/yr

3.5 kBtu/ft2/yr in electric heat and 4.6 kBtu/ft2/yr in wood.

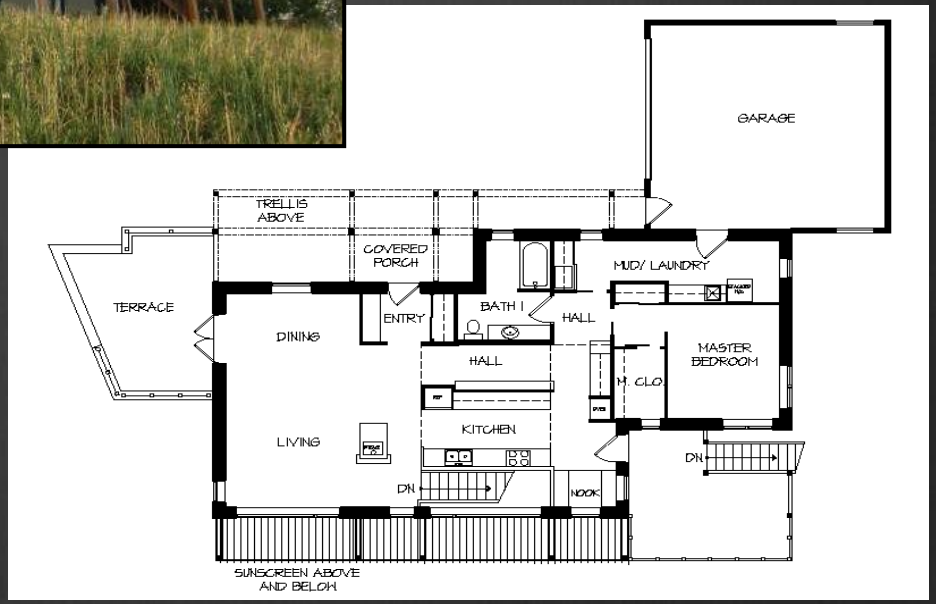
Costs about $300 a year to heat (dual fuel electric rate)



Skyline House

2950 ft2 (2660 ft2 conditioned)

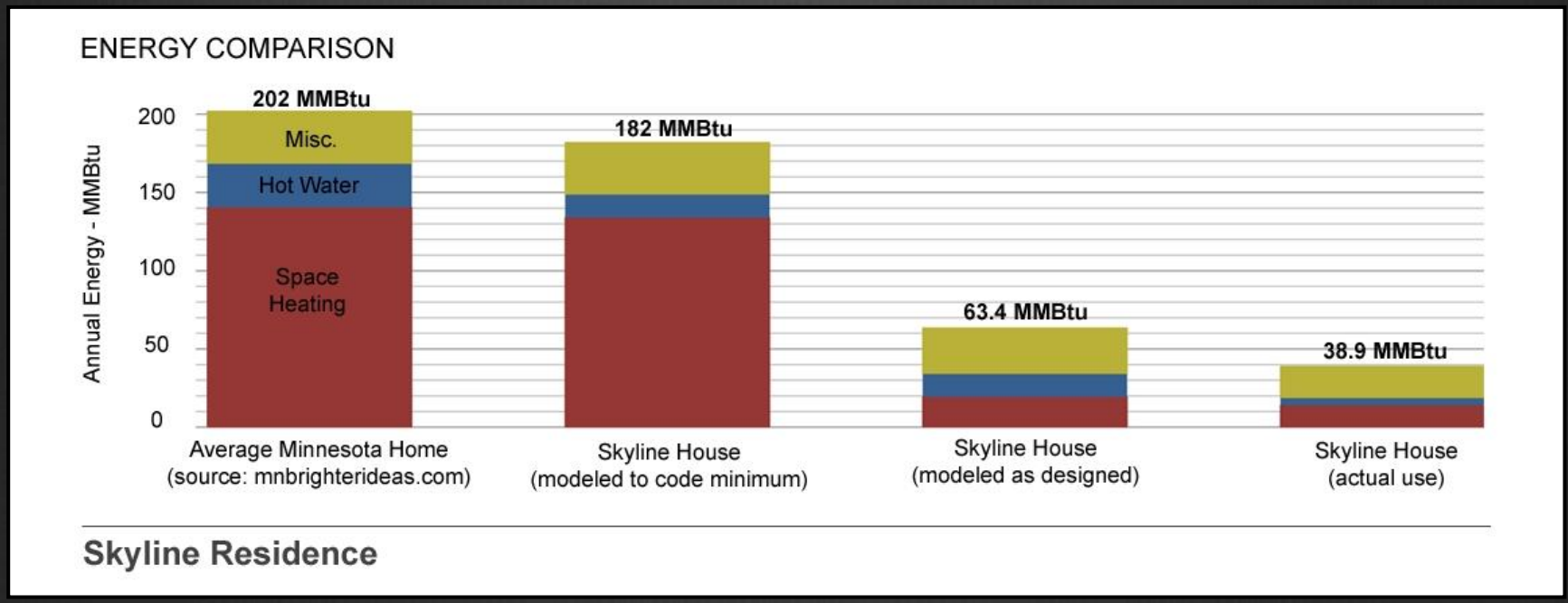
Modeled Heating Demand
19.4 MMBtu/yr
7.3 kBtu/ft2/yr



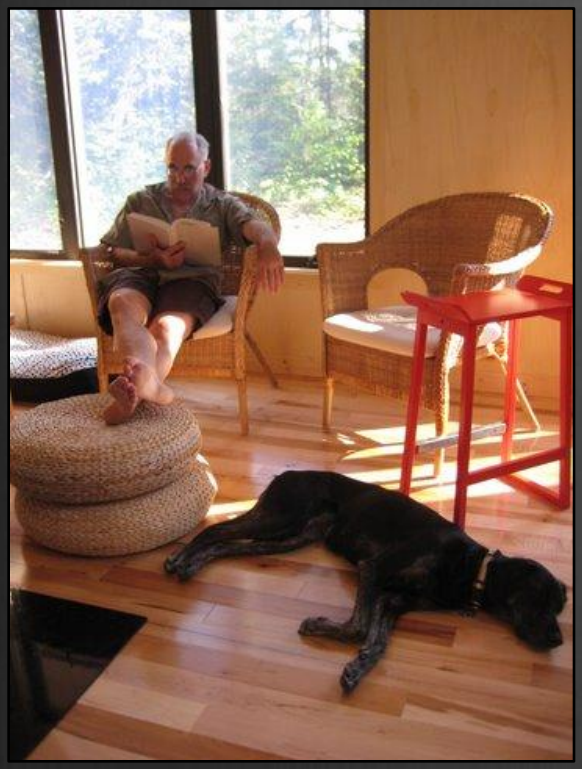
REAL ENERGY USE:

2009 Total energy: 38.9 MMBtu/yr or 13.2 kBtu/ft2

Heating energy purchased:
4.57 kBtu/ft2/year in natural gas



Real Benefits



Comfort and Joy

This concludes The American Institute of Architects Continuing Education Systems Course

Some Helpful Resources

Tap the Sun, published by CMHC (Canada Mortgage and Housing Corporation), hard to find for purchase because it is out of print

Solar Design for Buildings, online published by CMHC:

http://www.cmhc-schl.gc.ca/en/inpr/bude/himu/coedar/upload/OAA_En_aug10.pdf

Concise blogpost about effective passive solar design:

http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/cost-effective-passive-solar-design

Tool for sizing or selecting south-facing windows in a cold climate:

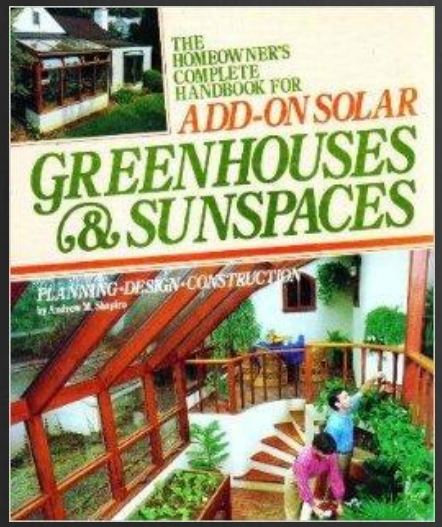
http://www.hsh.k12.nf.ca/technology/cmhc/english/features/sun/index.htm

Some Helpful Technical Tools

REM/Design™

REMDesign energy modeling software
www.archenergy.com/products/remdesign

Passive House PHPP energy modeling software, available from http://www.foursevenfive.com/



The Homeowner's Complete Handbook for Add-on Solar Greenhouses & Sunspaces by Andrew Shapiro

Thank you.

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