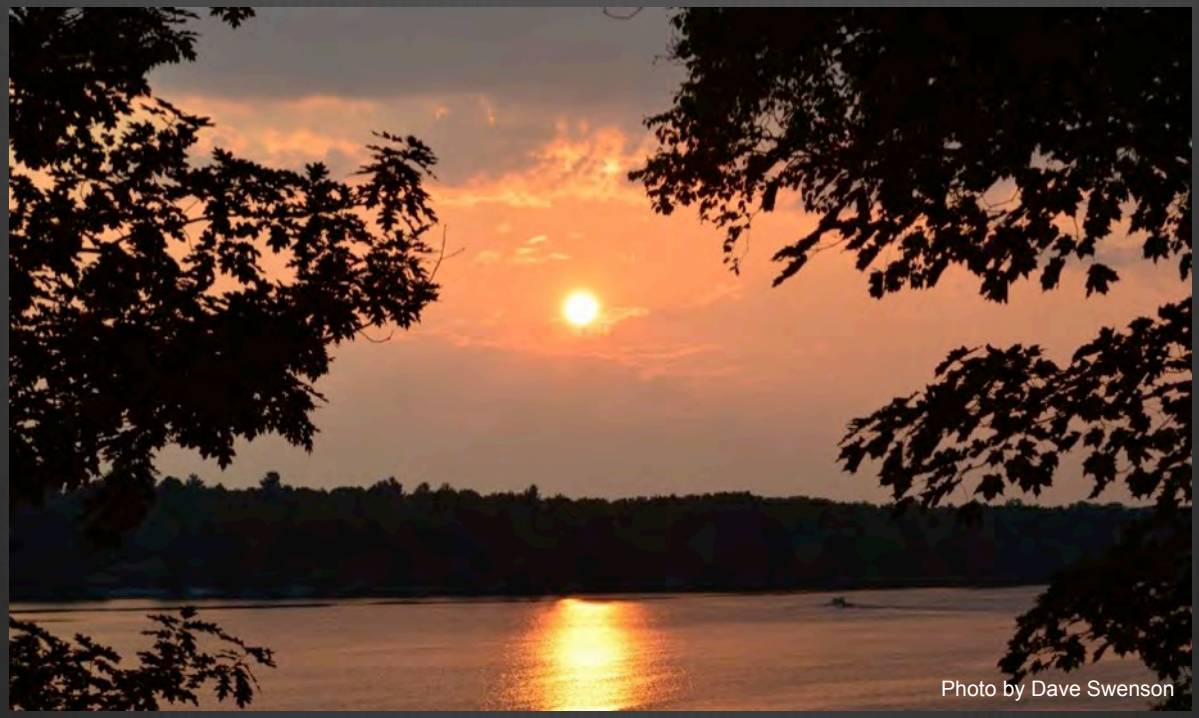
Here Comes the Sun

Duluth Energy Design Conference 26 February 2014



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"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** continuing education requirements."

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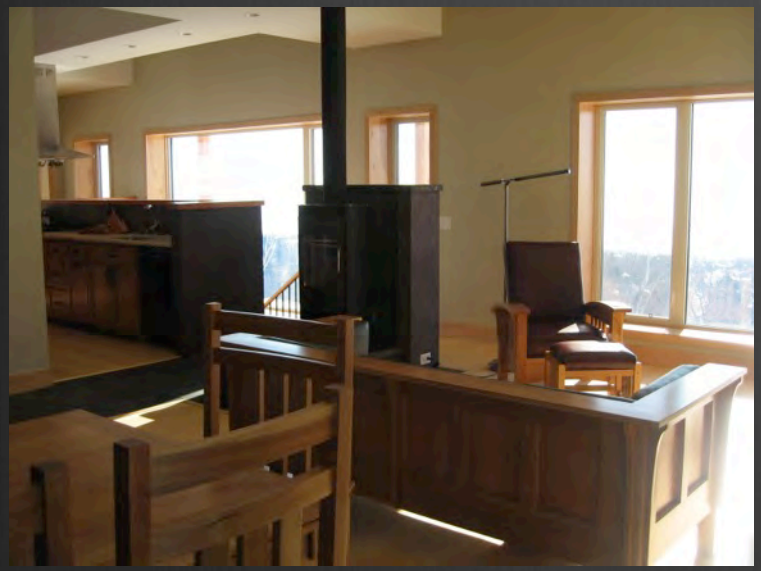
Learning Objectives

1. How the sun affects a building, especially in a cold climate.
2. The sun as a component of “house as a system” thinking: impacting and interacting with building form, enclosure and mechanical systems.
3. Basic passive solar design principles.
4. Applying passive solar design to create a solar-optimized building: site planning, building planning, space planning.
5. Thinking about how to “let the sun shine in” even when a site or building program doesn’t appear optimal for solar-oriented design.
6. The benefits of solar-optimized construction.

Winter in Duluth

Winter in Duluth

February 24, 2014



February 20, 2008

Winter in Duluth

The SUN
is a renewable energy resource.

How the sun affects a building

- Daylight
- Views
- Ventilation
- Glare
- Heat Gain
- Heat Loss

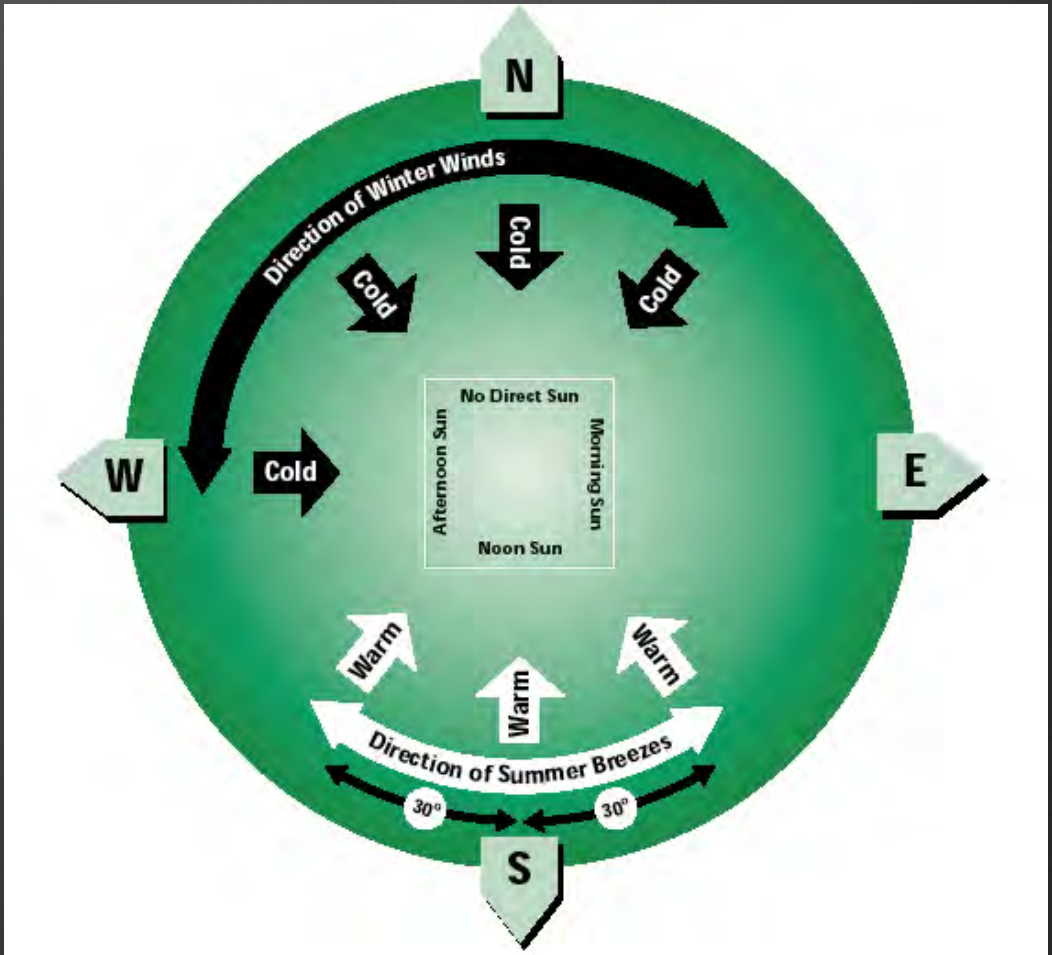


Image from ENERinfo

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

Understanding the sun

- 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.

Integrated Solar Design

can provide half of the required space heating 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.

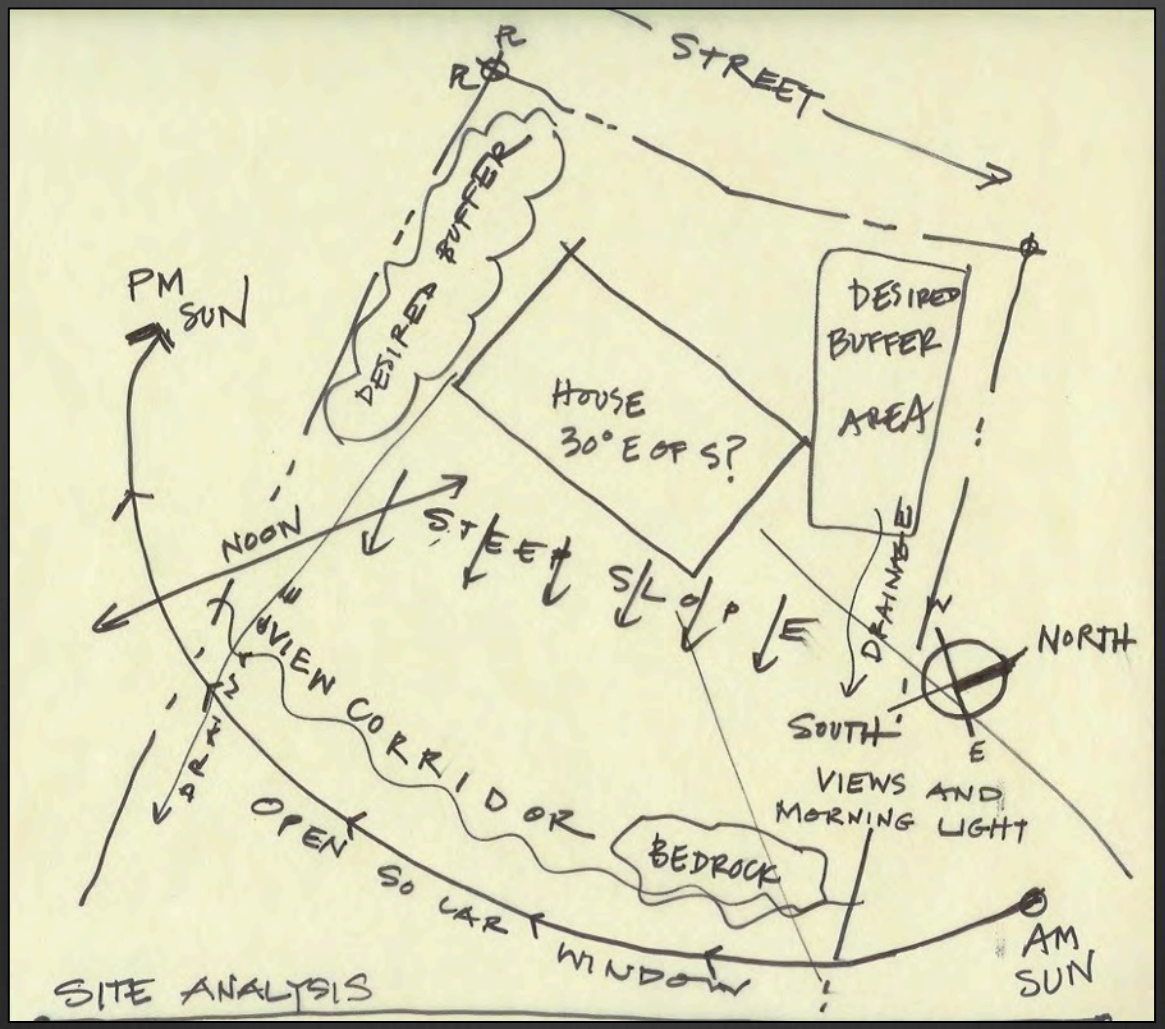
House as a (solar) system

Define your goals to determine the best methods and tools.

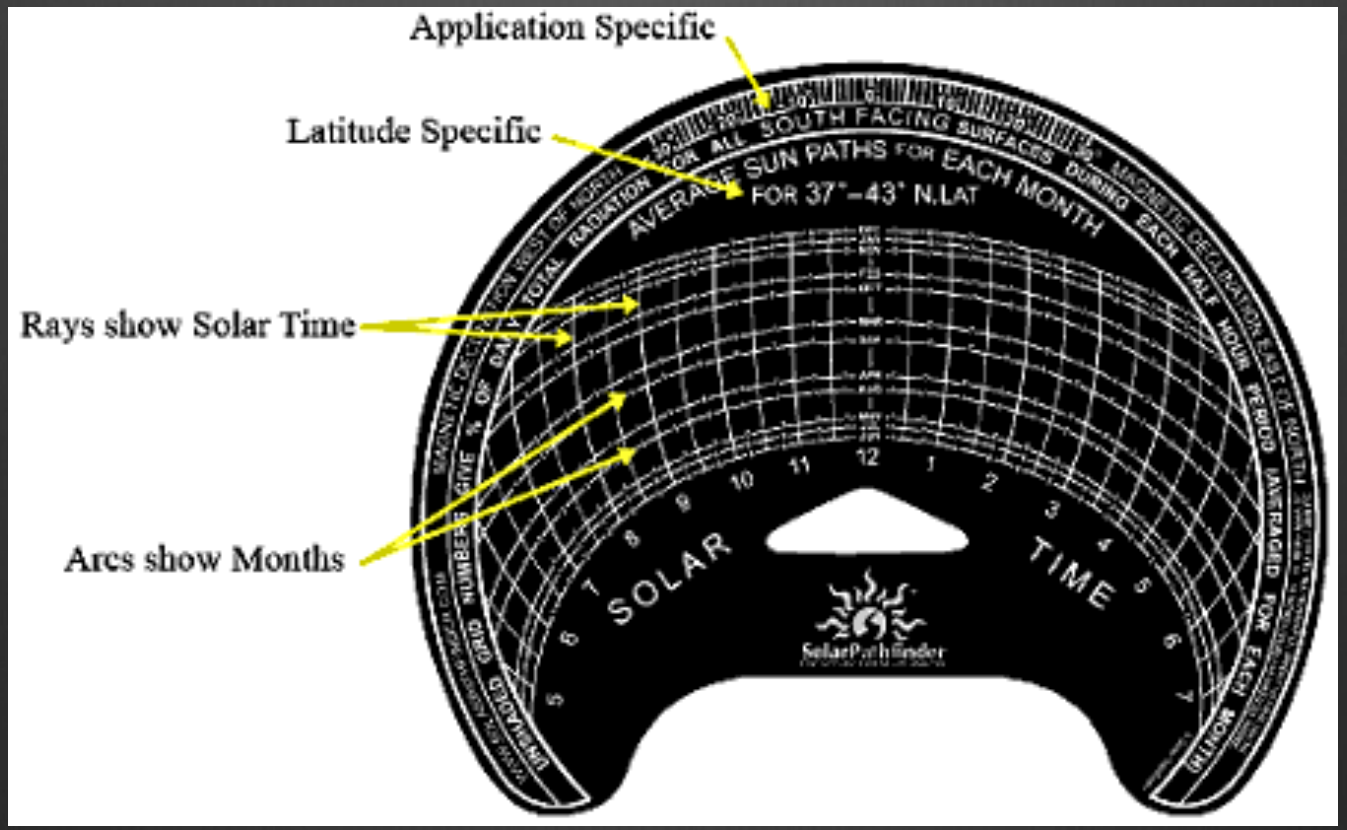
The SUN's energy can be used in almost every project you undertake.

Site Planning: bring your compass!

Site Planning – basic analysis



A technical solar site analysis



www.solarpathfinder.com

Solar Pathfinder can provide precise evaluation of solar opportunity.

The solar pathfinder

The sun will not shine on this site until approximately 9:30am during the month of December. It will be shaded again in the afternoon from about 2:15pm to 3:45pm.

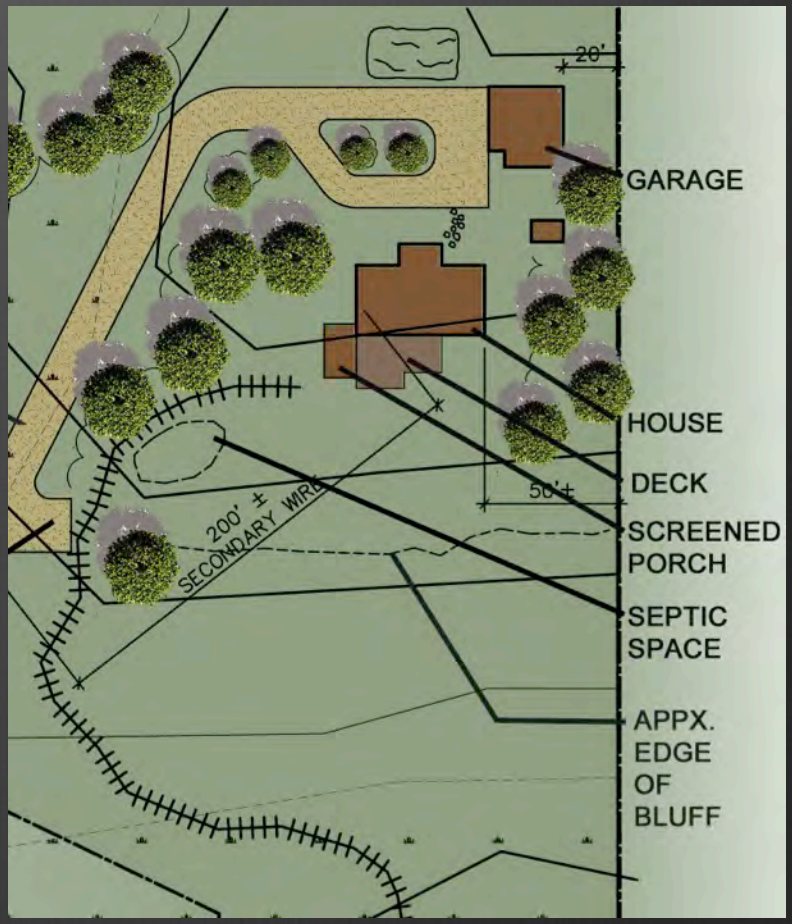
In February, the sun will shine on the site from 9:15am throughout the rest of the day.

www.solarpathfinder.com

On your building site, when will the south face of building be in shade?

Solar Site Design

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



Building Planning for Passive Solar

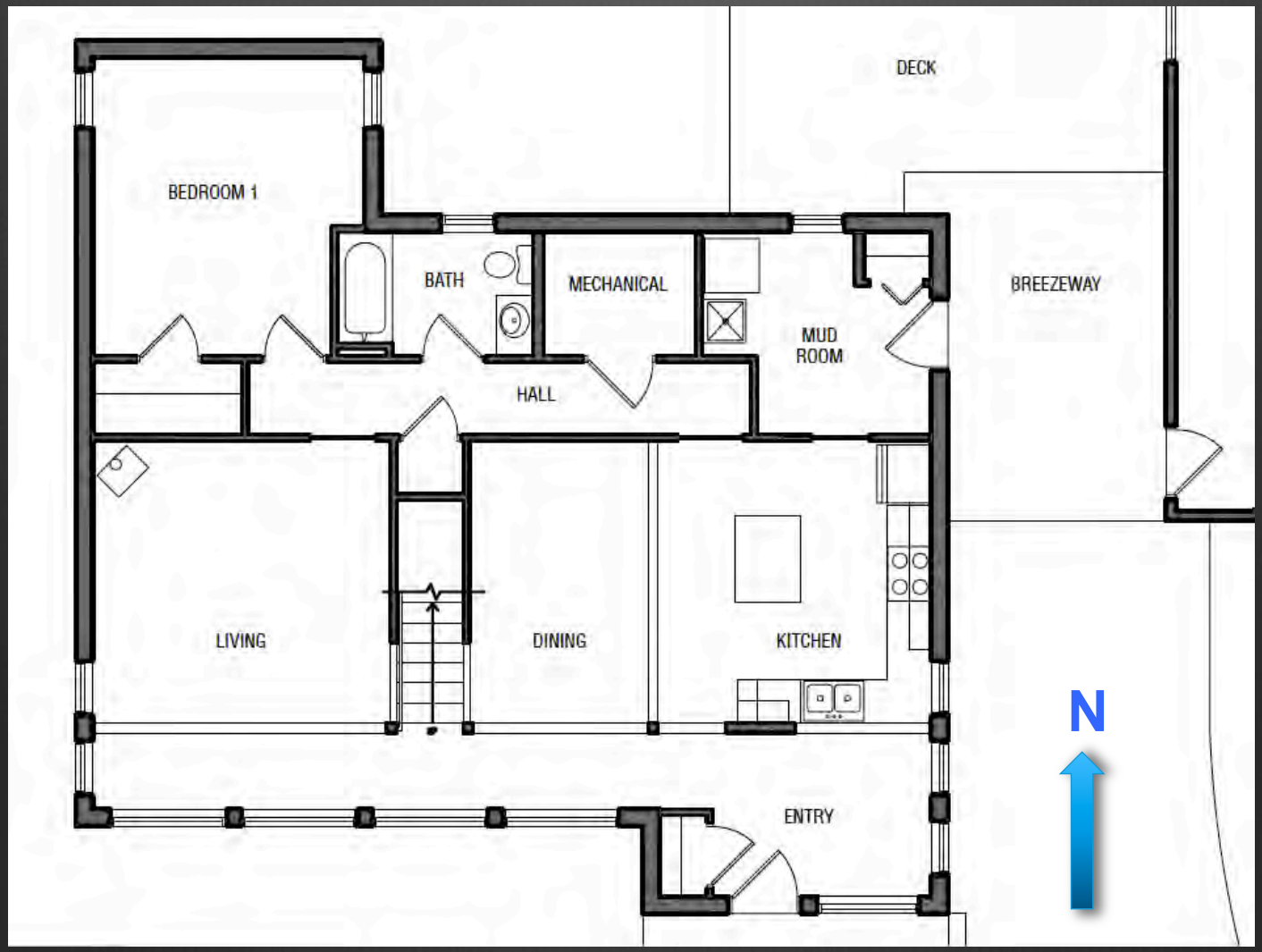
1. South-facing building facade, within 30 degrees of south
2. Longer axis of building running east-west
3. Open plan as much as possible – especially on south side
4. Window shading to let in winter sun, keep out summer sun
5. Cross ventilation to reduce cooling load
6. Early planning to minimize unwanted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

Face the building south (within 30 deg)

Space Planning:
optimize the sun for light and heat

- Morning-use spaces east/ southeast
- Daytime-use spaces south
- Evening-use spaces west
- Utility spaces north
- Heat-generating spaces north
- Open living spaces to help heat flow

Solar-optimized space plan



Solar-optimized space plan

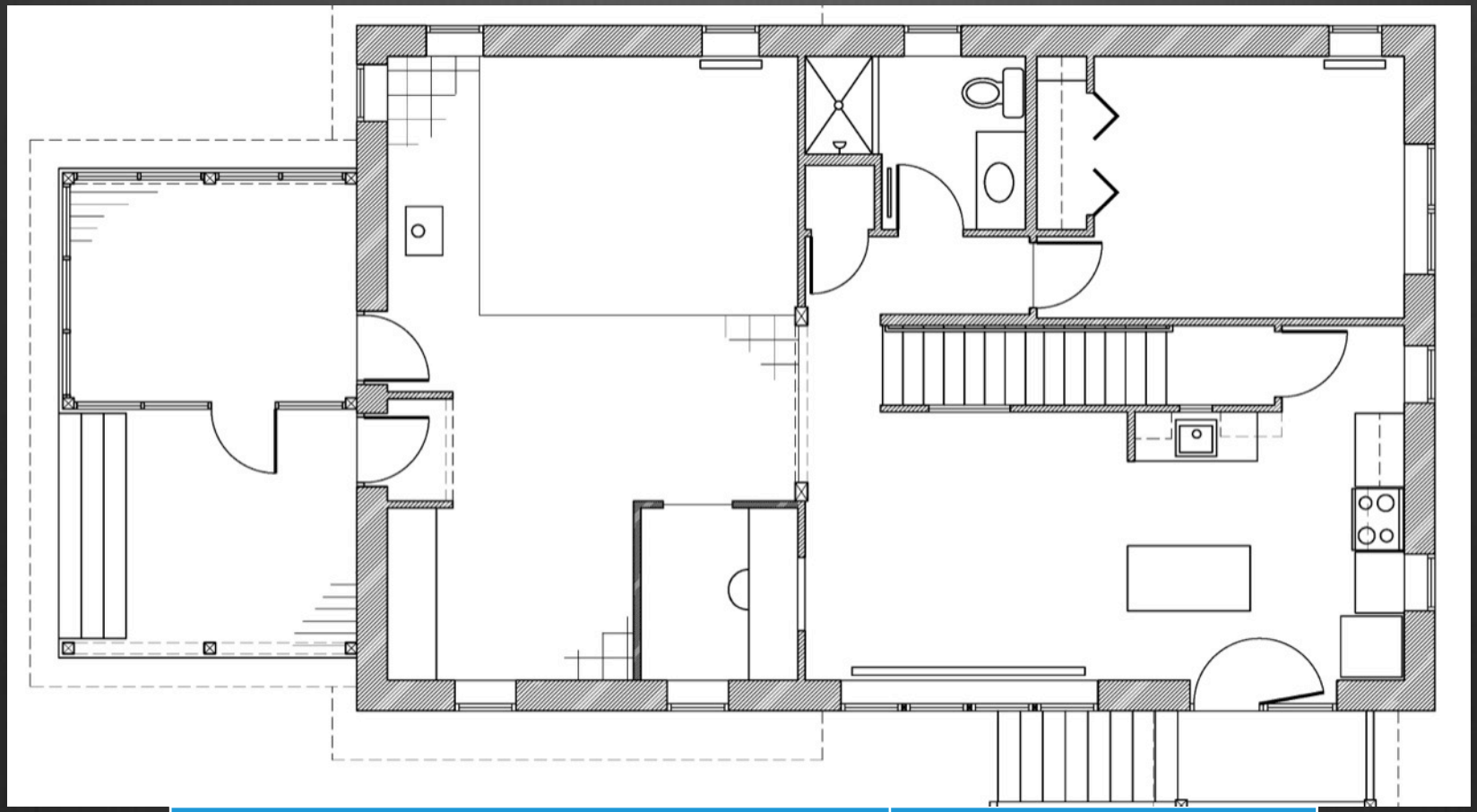
Open living/dining with large windows
Kitchen on the east, and open to south-facing entry

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 causes glare and overheating, so reduce windows on the west side and reduce SHGC of west-facing glass.
   - Trees on the west side can help shade the building
3. Plan space and windows for cross-ventilation
4. Minimize windows to the north whenever possible.
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.

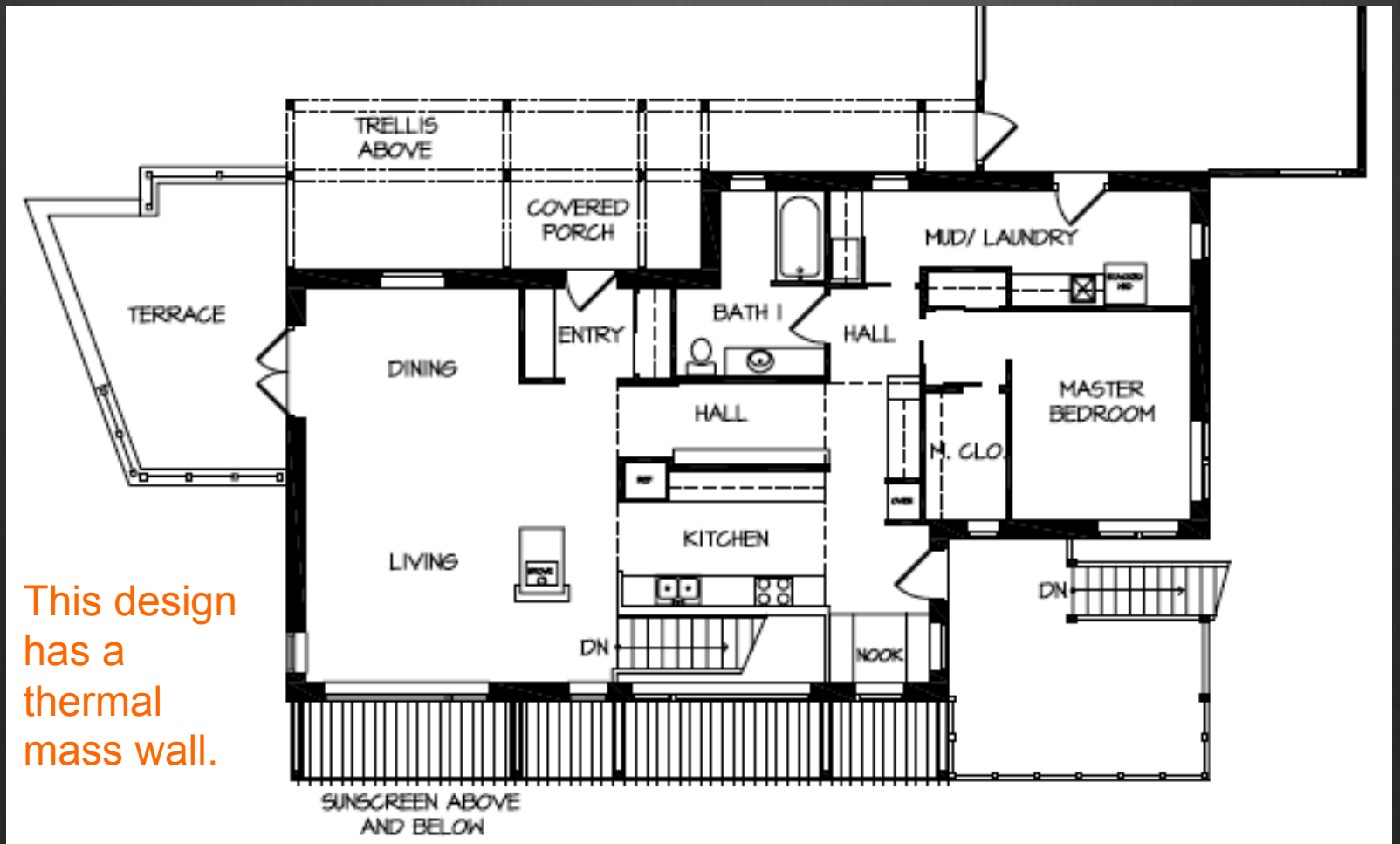


Floor Area	1050 ft2
South Window Area	83 ft2
% south window to floor area	8%

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

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

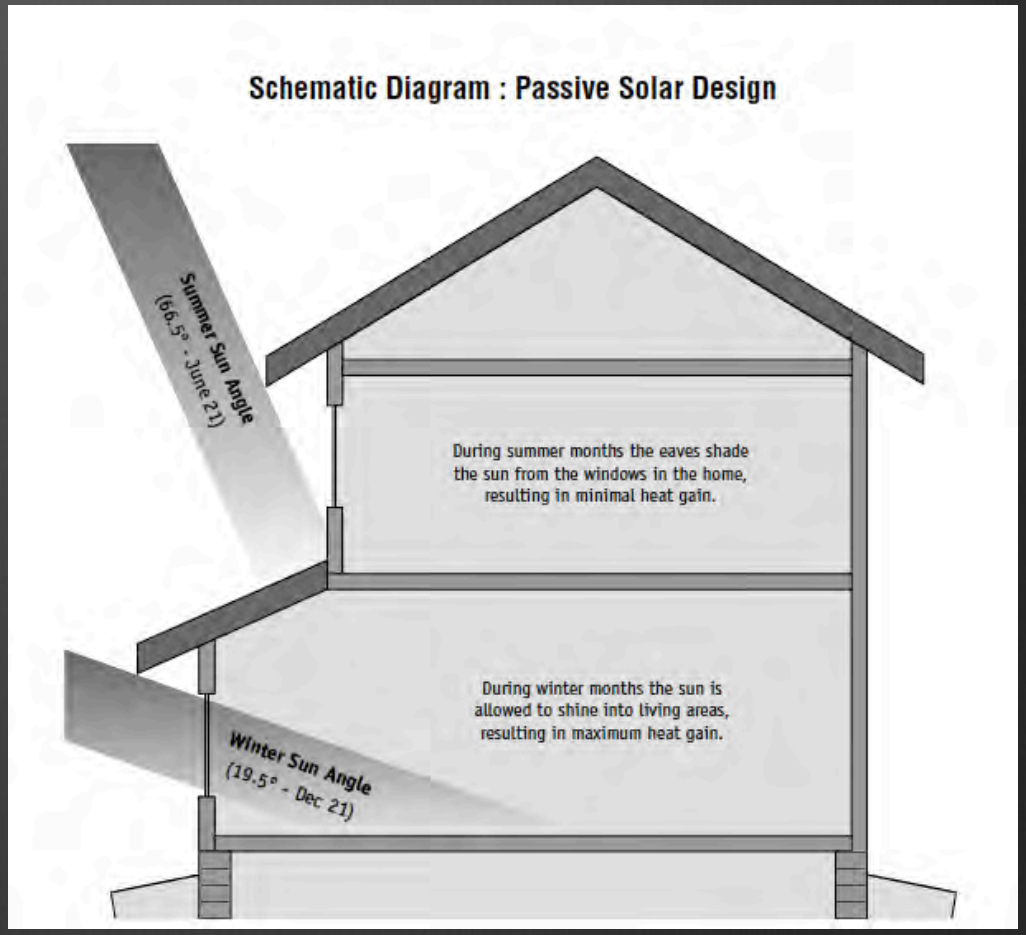


Image created by Jacob LeBeau/www.ecohomeduluth.com

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

Exterior trellises and solar thermal collectors

Solar-designed overhangs

Know your solar altitude

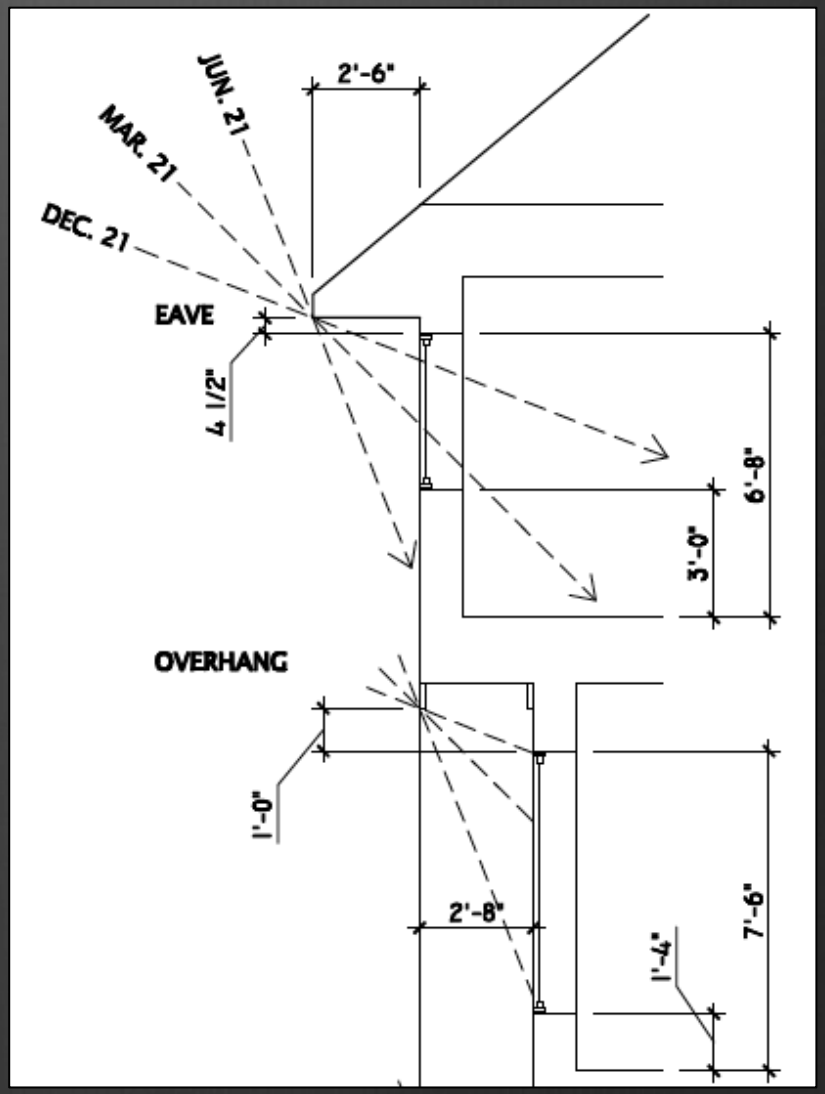
Solar altitude in Duluth:

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

Managing the sun's entry into the home

Summer sun is blocked by the roof overhang

Winter sun enters, passing under the exterior trellis

Same view, different day

FEB

JUNE

More than a beautiful view

Windows and Energy Balance

- Windows gain heat through the glazing, on all but the north side.
- All windows lose heat through the glazing, the edge spacer, and the frame.
- An insulated frame is good.
- A thermal edge spacer is important.
- To select the glazing – look for a balance of high solar heat gain with low glazing transmission losses.

Selecting Windows

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

Proper window glazing selection

SHGC=solar heat gain coefficient

U-value=rate of heat loss

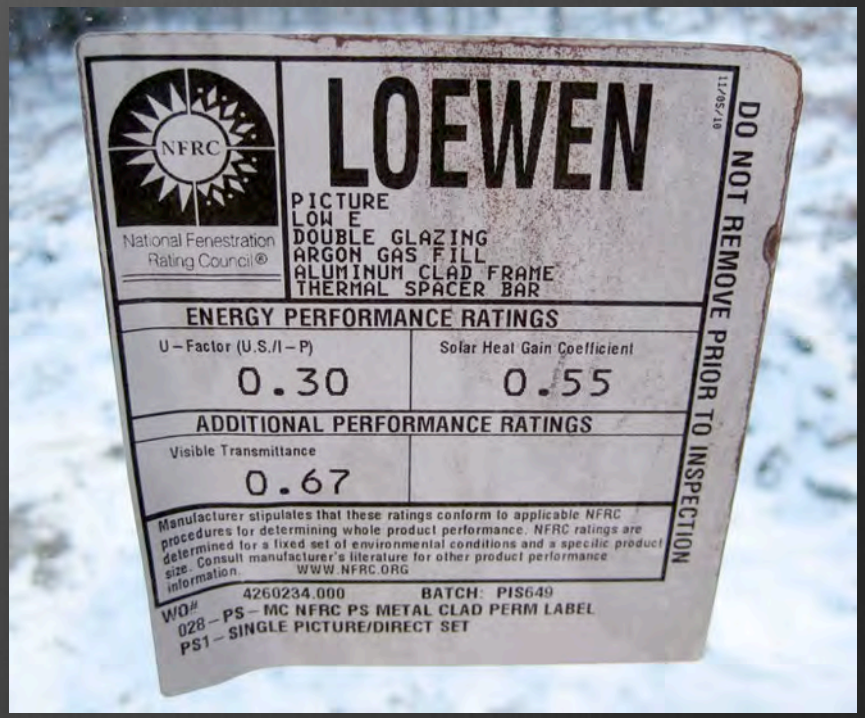
- High SHGC > 0.4
- Low U-value < 0.3
- Usually, in our climate, triple pane glazing
- Low SHGC on west facing glass, usually

Understand the NFRC label

And look to manufacturer's information about center of glass (C.O.G.) for SHGC

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 a better tool for selecting solar performance.

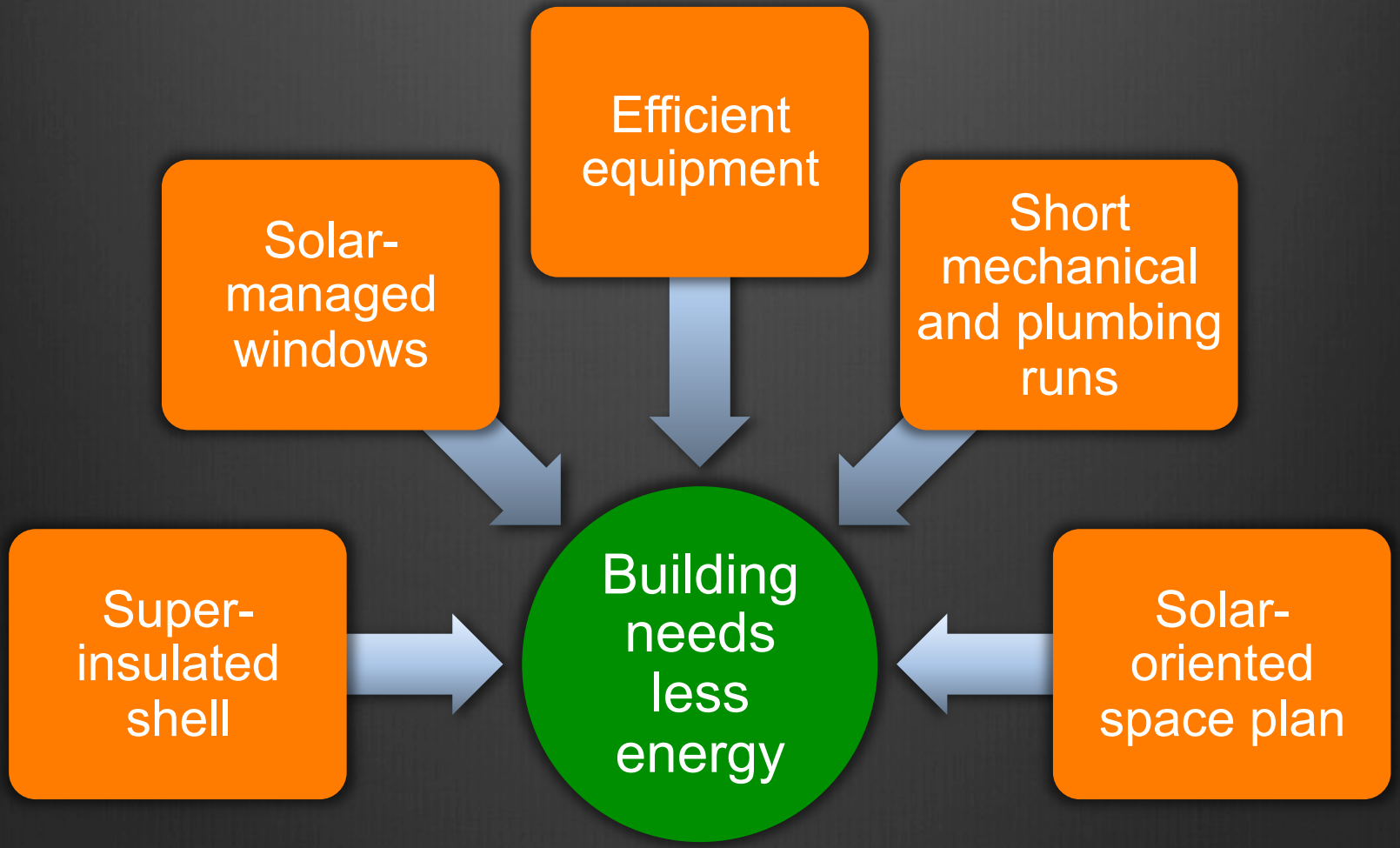


www.buildinggreen.com

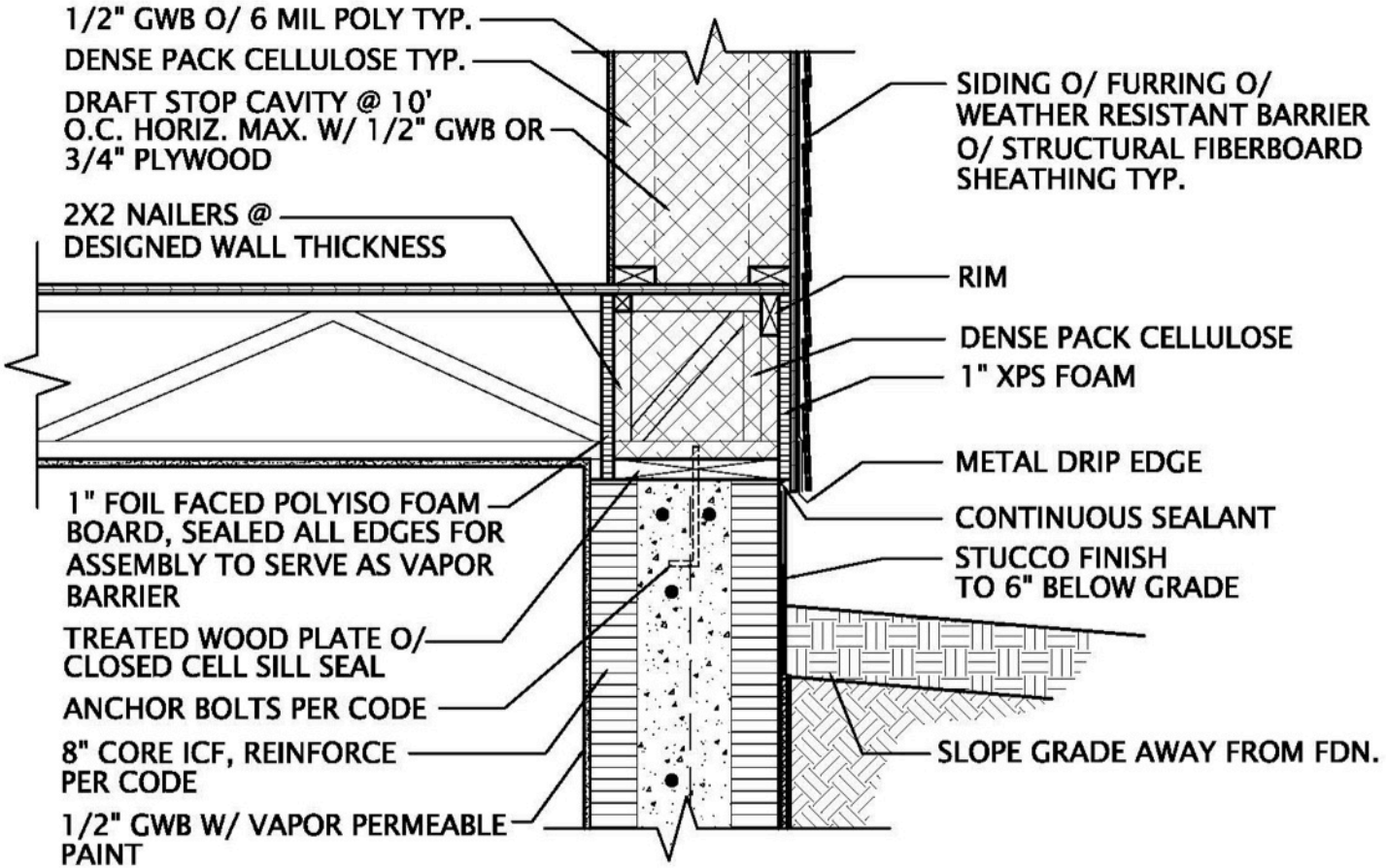
Windows – rules of thumb

1. High solar gain
   - Min 0.5 glazing SHGC or 0.4 whole window SHGC value
2. High thermal performance
   - MAX. overall U-value of 0.24
   - Don't lose more heat from the window than heat gained from the sun
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

Systems Planning (make building energy loads low)

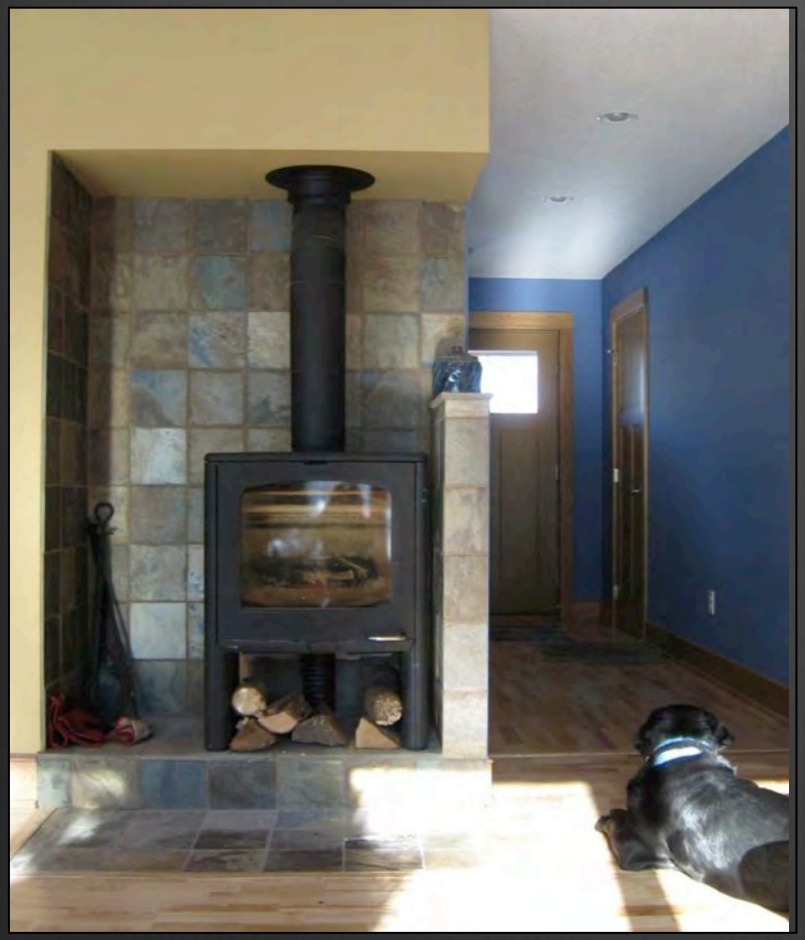


Super insulated building envelope



Double Stud Wall: Floor Truss to ICF Foundation

When space heating loads are low, systems can be small



Passive solar design

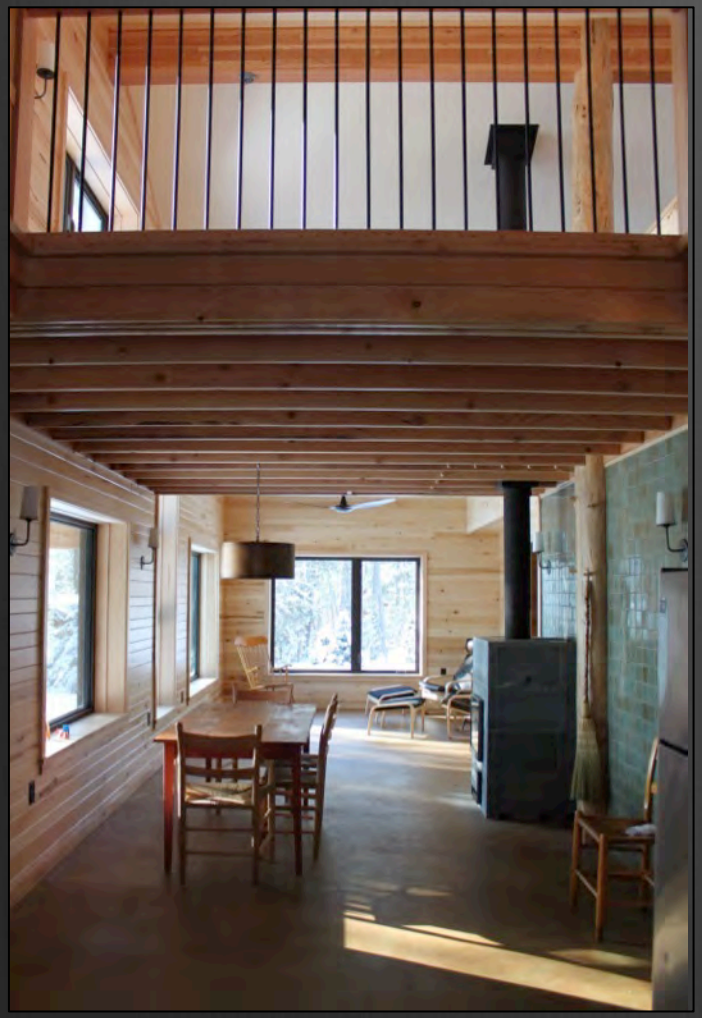
Super-insulated building

Centrally located wood stove

Boiler with low-temp radiators, not many.

Dog favors the warmth of the sun over the warmth of the fire!

Solar-compatible systems



Radiant slab on separate zone

Radiators in bedrooms and bath

No heating system upstairs

Wood stove with thermal mass

Thermal mass floor

Thermal mass wall

Very open plan/volume for heat distribution and dissipation

Integrated Design: sun + systems

Early energy modeling with REMDesign helped integrate initial passive solar design.

Later modeling with PHPP refined and optimized solar design.

In Duluth, a 2700 ft2 house that costs less than $300 a year to heat.

Building Planning for Active Solar

- Roof plane facing south, or other accommodation for equipment
- A steep enough pitch to shed snow and capture sunlight
- No roof vents, dormers, chimneys or other obstructions
- Not shaded by trees, adjacent roofs, or nearby buildings

Building structure that can support solar equipment

- Window overhangs
- Deck railings
- Roofs
- Walls

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
- 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

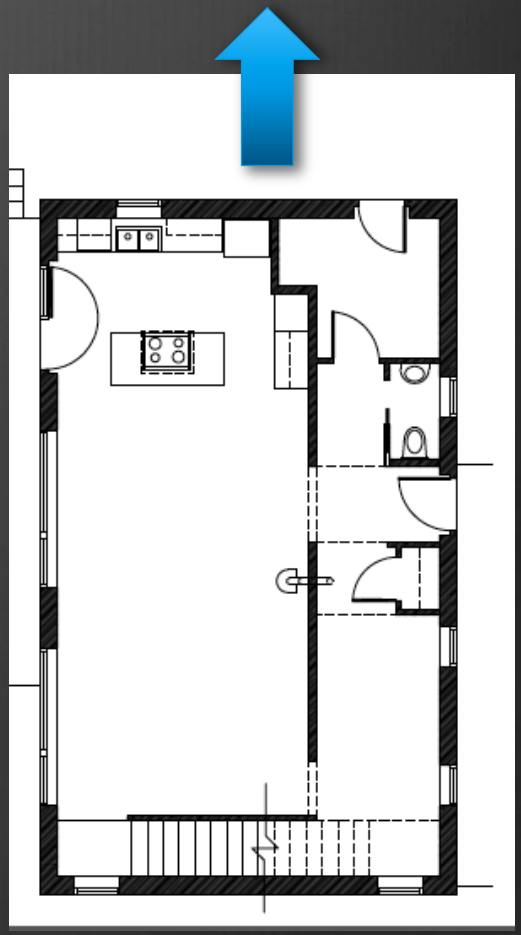
Screened porch blocks unwanted gain

Trees manage unwanted gain

Low-solar gain glazing on west-facing windows

Connection to sunspace

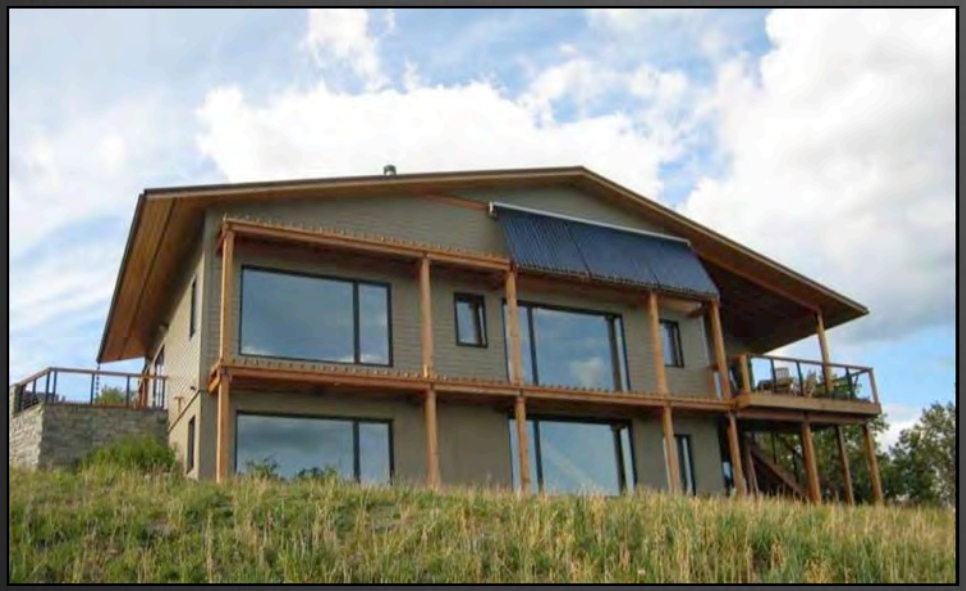
When solar conditions aren’t optimal



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

The Benefits of Solar Design

Skyline House



2660 ft2 living space

2 stories

$195 to heat in 2009

(natural gas)

Passive solar design

Thermal mass wall

Stacked form and services

Integrated solar thermal hot water and heating

Esko House

2690 ft2 living space

2 stories + basement

$303 to heat in 2009

(dual fuel electric)

Passive solar design

Simple building forms

Simple heating systems

Living with passive solar design

Basking in the sunlight = comfort and joy

Solar-Oriented Design Principles

1. Understand the sun's path on your site and when the sun will be able to reach the building.
2. Put living spaces to the south whenever possible.
3. Create space that allows light and heat to penetrate the living area 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 high-performance, low energy building shell.

Some Helpful Resources

www.ecohomeduluth.com

The Passive Solar House by James Kachadorian

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

About those windows:

http://www2.buildinggreen.com/blogs/how-read-those-darn-window-performance-stickers

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

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

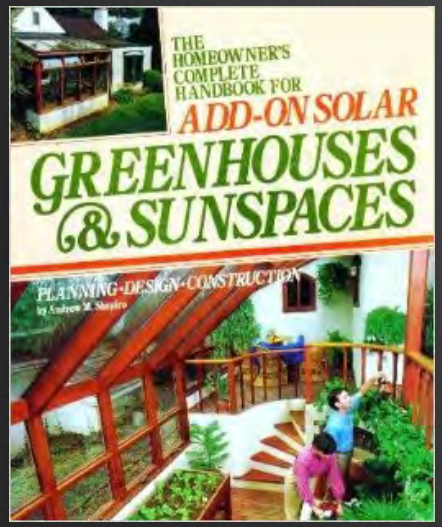
http://efficientwindows.org/new_selection1.php

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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