Passive Solar Heating Project Analysis

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Clean Energy Project Analysis Course

Passive Solar Heating on Residence, France

Photo Credit: Pamm McFadden (NREL Pix)

Natural Resources Canada Ressources naturelles Canada

Canada

Objectives

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- Review basics of Passive Solar Heating (PSH) systems
- Illustrate key considerations for PSH project analysis
- Introduce RETScreen® PSH Project Model

What does PSH provide?

- 20 to 50% of space heating requirements

...but also...

- Improved comfort
- Better daylight
- Can reduce cooling costs
- Reduced window condensation
- Can permit smaller heating/cooling plant

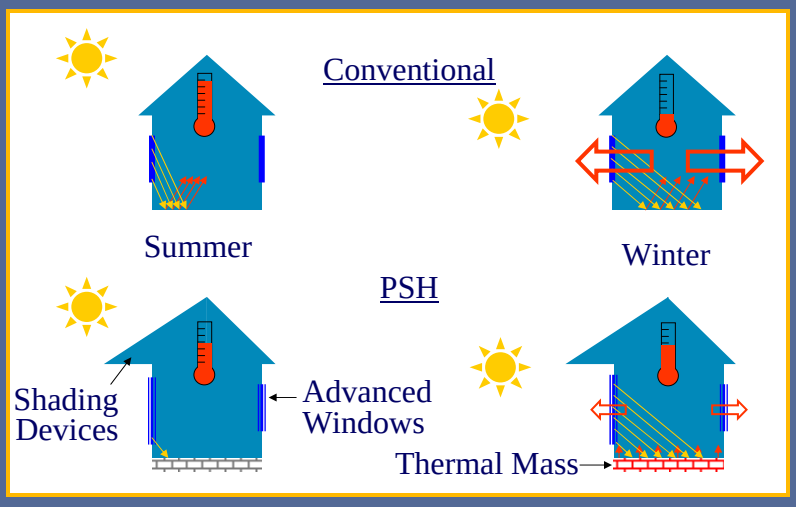
Passive Solar Heating Designed on Residential Building, Germany

Photo Credit: Fraunhofer ISE (from Siemens Research and Innovation Website)

The NREL Building in Golden, Colorado

Photo Credit: Warren Gretz (NREL Pix)

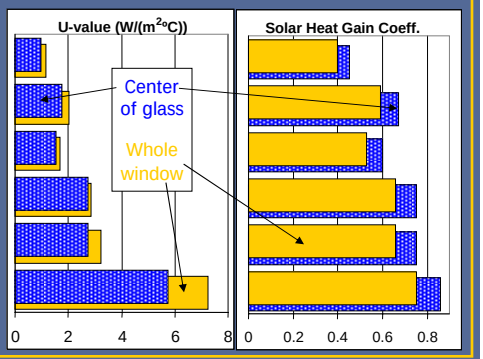
Principles of Operation of PSH



Advanced Window Technologies

- Double and triple glazed
- Low emissivity
- Inert gas fill
- Insulative spacers
- Insulated frames, thermal break

Panes	e	Fill	Spacer	Frame
3	0.1	Inert	Insul.	Wood
3	0.8	Air	Alumin.	Wood
2	0.1	Inert	Insul.	Wood
2	0.8	Air	Alumin.	Wood
2	0.8	Air	Alumin.	Aluminum
1	0.8	-	-	Aluminum



Shading and Thermal Mass

- Shading prevents overheating in summer
  - Overhangs on equator-facing exposure for when sun is high
  - Deciduous trees, nearby buildings and structures
  - Screens, shutters, awnings, recessed windows, blinds, etc.

- Thermal mass stores heat, minimizing temperature swings
  - If equator-facing window area exceeds 8 to 10% of heated floor area, traditional light-weight construction house will overheat
  - Use double gyproc walls, ceilings, ceramic floors, brick fireplace, etc.
- Active systems can be used to distribute heat through building

Solar Resource vs. Requirement for Space Heating

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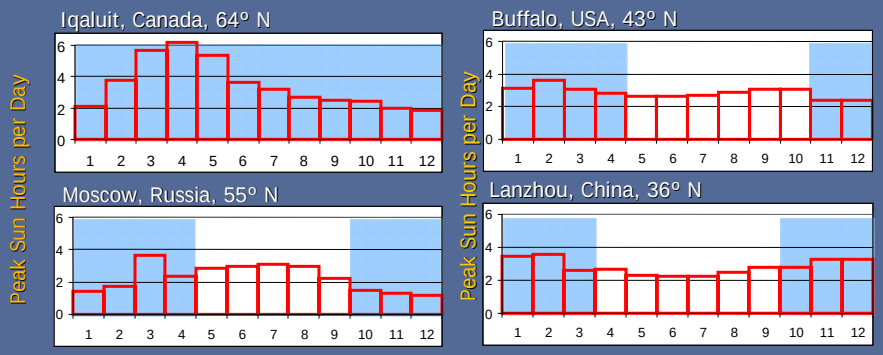

- Months with average temperature less than or equal to 10°C are shaded

Example of PSH Costs & Savings

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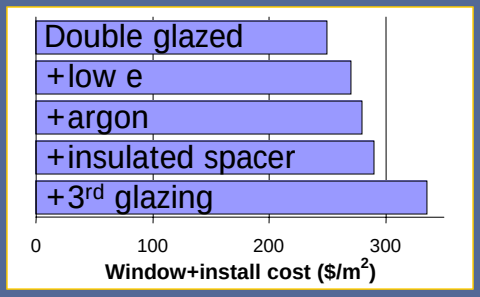
Canadian Single Family Dwelling



- Additional window costs
  - 5 to 35%
  - $400 to $2,000 per house

- Savings of 20 to 50% of space heating costs

Gas	$0.25/m³	$150 to $380 per year
Oil	$0.35/l	$210 to $520 per year
Electricity	$0.06/kWh	$270 to $680 per year

Passive Solar Heating Project Considerations

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- New construction most cost-effective
  - Freedom to orient windows to face equator and avoid west
  - Heating system size and perimeter heating can be reduced

- Retrofit cost-effective if windows being replaced anyways
- Most cost-effective where heating load high compared to cooling load
  - Low rise residential in moderate to cold climates are best
  - Commercial and industrial buildings have high internal gains
- Consider windows in conjunction with rest of envelope

Examples: Canada and USA

Low Energy Buildings

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- Passive solar techniques incorporated into conventional-looking buildings
- Financial considerations not always paramount: comfort, sound abatement, appreciation of quality, and environment

Good Shading and Advanced Windows, USA

Photo Credit: Hickory Corporation (NREL Pix)

Waterloo Green Home, Ontario, Canada

Photo Credit: Waterloo Green Home

Examples: Germany and Lesotho

Self-sufficient Solar Houses

- More glazing, more thermal mass, and control of air distribution
- All space heating needs can be met by solar energy
- Advanced window technologies permit more flexible window placement, heat gains from diffuse radiation

Solar Rondavel, Thaba-Tseka, Lesotho

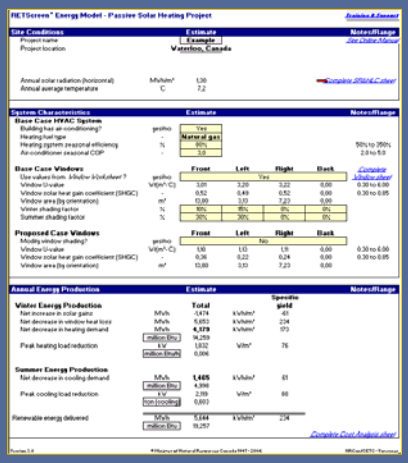
Photo Credit: Vadim Belotserkovsky

Freiburg, Solar Home

Photo Credit: Fraunhofer ISE
(from Siemens Research and Innovation Website)

RETScreen® Passive Solar Heating Project Model

- World-wide analysis of energy production (or savings), life-cycle costs and greenhouse gas emissions reductions
  - Low-rise residential and small commercial buildings
  - In a heating dominated climate
  - Window gains and losses
  - Average effects of shading
- Only 12 points of data for RETScreen® vs. 8,760 for hourly simulation models
- Currently not covered:
  - Non-vertical windows
  - Instantaneous effects of shading
  - User-specified building thermal mass


RETScreen® Energy Model - Passive Solar Heating Project

Site Conditions — Estimate — Notes/Range
Project name: Example
Project location: Waterloo, Canada
Annual solar radiation (horizontal) — MWh/m² — 1,30
Annual average temperature — C — 7,2

System Characteristics — Estimate — Notes/Range
Base Case HVAC System
Building has air-conditioning? — yes/no — Yes
Heating fuel type — - — Name of gas
Heating system seasonal efficiency — % — 90%
Air-conditioner seasonal COP — - — 3,0

Base Case Windows — Front — Left — Right — Back
Use values from 'Window' worksheet? — yes/no — Yes
Window U-value — W/(m²·°C) — 3,00 — 3,20 — 3,22 — 0,00
Window solar heat gain coefficient (SHGC) — - — 0,52 — 0,49 — 0,52 — 0,00
Window area (by orientation) — m² — 10,80 — 3,03 — 7,23 — 0,00
Winter shading factor — % — 90% — 85% — 0% — 0%
Summer shading factor — % — 30% — 30% — 0% — 0%

Proposed Case Windows — Front — Left — Right — Back
Modify window shading? — yes/no — No
Window U-value — W/(m²·°C) — 1,50 — 1,53 — 1,9 — 0,00
Window solar heat gain coefficient (SHGC) — - — 0,36 — 0,22 — 0,24 — 0,00
Window area (by orientation) — m² — 10,80 — 3,03 — 7,23 — 0,00

Annual Energy Production — Estimate — Notes/Range
Winter Energy Production — Total — Specific yield
Net increase in solar gains — MWh — -1,474 — kWh/m² — -61
Net decrease in window heat loss — MWh — 6,853 — kWh/m² — 224
Net decrease in heating demand — MWh — 4,379 — kWh/m² — 173
— million Btu — 14,253
Peak heating load reduction — kW — 1,812 — W/m² — 76
— million Btu/h — 0,006

Summer Energy Production
Net decrease in cooling demand — MWh — 1,405 — kWh/m² — 61
— million Btu — 4,896
Peak cooling load reduction — kW — 2,199 — W/m² — 88
— non-cooling — 0,003
Renewable energy delivered — MWh — 5,644 — kWh/m² — 234
— million Btu — 19,257

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PSH Energy Calculation

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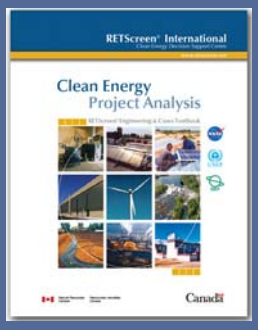
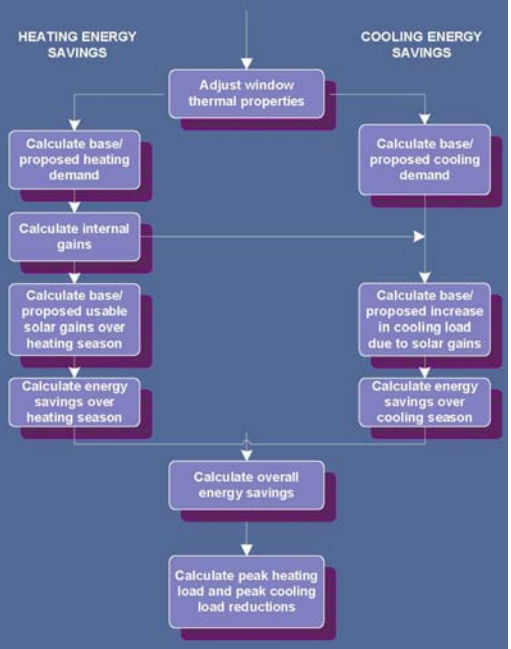


See e-Textbook

Clean Energy Project Analysis:
RETScreen® Engineering and Cases

Passive Solar Heating Project Analysis Chapter



Example Validation of the RETScreen® PSH Project Model

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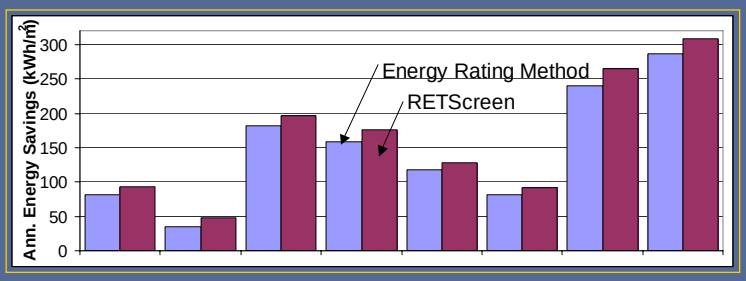
- RETScreen® compared with HOT2-XP for a 200 m² typical wood frame home
  - Double glazed windows upgraded to double glazed low-e with argon
  - RETScreen® to within 18% of HOT2-XP
- RETScreen also compared to Energy Rating Method
  - Annual energy savings for 8 higher performance windows compared to base case double glazed windows



Conclusions

- PSH involves building orientation, energy efficient windows, shading, and thermal mass to reduce space heating costs
- Minimal additional investment in windows can greatly improve performance of building envelope with long term financial benefits
- RETScreen® calculates:
  - Effect of window orientation, size, and technology on solar gains
  - Effect of window technology on heat losses
  - Effect of shading on cooling load
- RETScreen® is an annual analysis with monthly resource calculation that can achieve accuracy comparable to hourly simulation models
- RETScreen® can provide significant preliminary feasibility study cost savings

Questions?

Passive Solar Heating Project Analysis Module
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For further information please visit the RETScreen Website at
www.retscreen.net