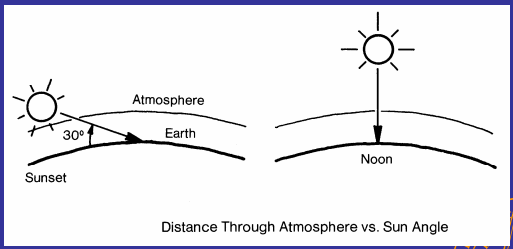
F5: Solar angles and climatic pre-conditions

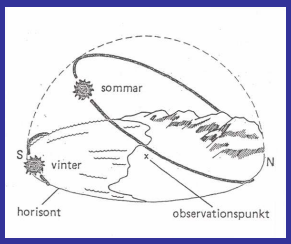
Architectural design regarding the outdoor climate

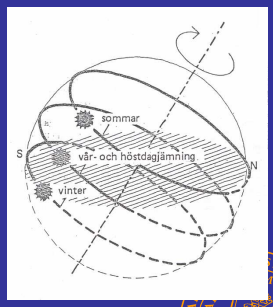
Why do we have so little sun during the winter?



Distance Through Atmosphere vs. Sun Angle

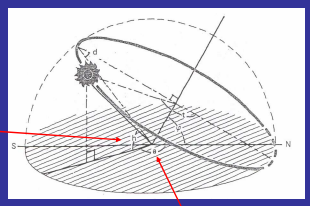
Solar paths

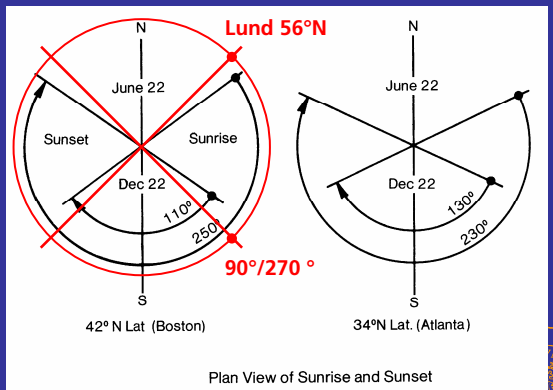




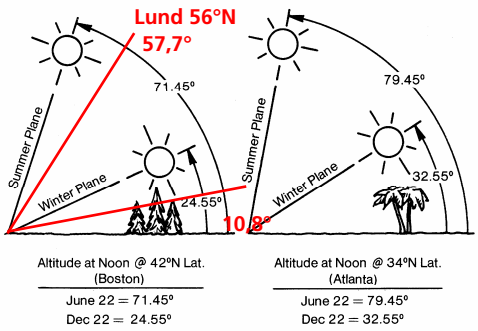
Solar angles

Solar height *h*, Azimuth (bearing) *a*





Plan View of Sunrise and Sunset



Daily Path of the Sun Viewed Looking East

Paris: 48°N, Madrid: 41°N, Shanghai 31°N, Waterloo 43°N,

Calculation of solar height and azimuth

$$\sin h = \sin d \cdot \sin \varphi - \cos d \cdot \cos \varphi \cdot \cos t$$

$$\sin a = (\cos d - \sin t) \div \cos h$$

h = solar height
a = azimuth
t = time angle
d = declination
φ = latitude for the site
(All angles in the same unit, either degrees or radians)

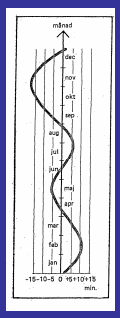
Rule of thumb

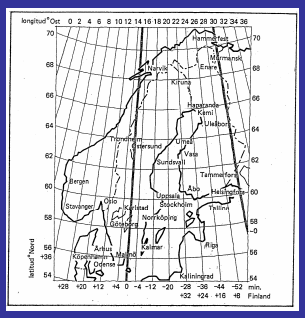
- Solar height at noon (12) = 90° – latitude of site ± declination*

* The declination = the angle of the earth axis in relation to the solar path, -23° at winter solstice, 0° at the equinoxes and +23° at summer solstice.

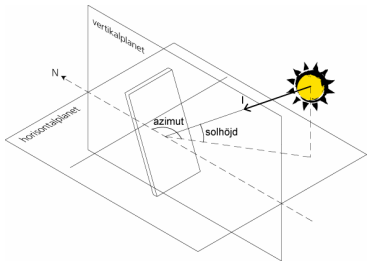
True solar time

The sun is always highest in the sky at 12.00 true solar time!

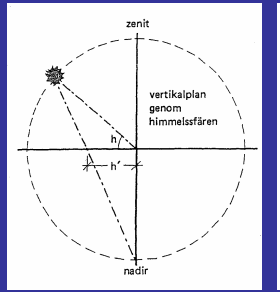


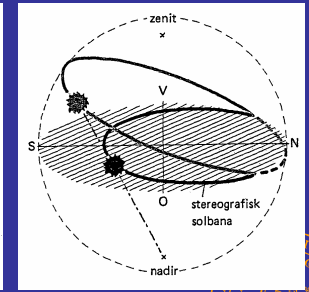


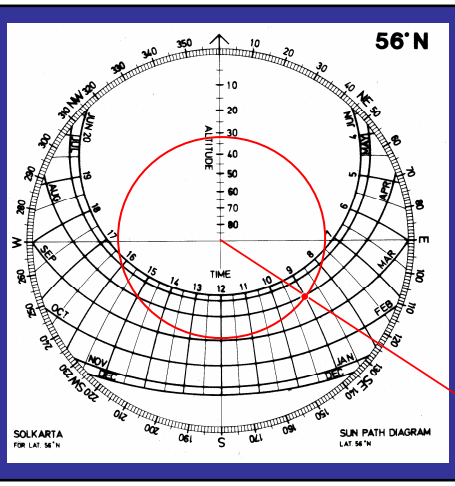
Solar height and azimuth



Stereographic projection



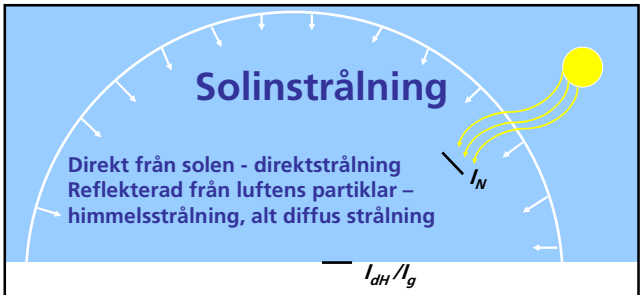




Question:
Solar height and azimuth on April 15 at 9 o'clock?

Answer:
h = 33°
a = 124°

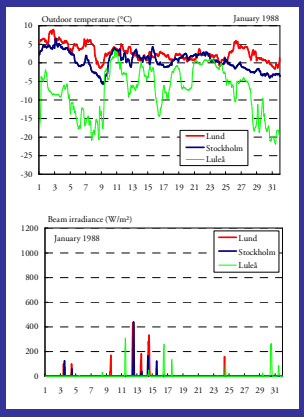
Solinstrålning



Direkt från solen - direktstrålning
Reflekterad från luftens partiklar – himmelsstrålning, alt diffus strålning

- Direkt solstrålning mot normalen, I_N
- Diffus solstrålning, I_{dH}
- Global solstrålning (direkt + diffus) mot horisontalen, I_g
- Markreflekterad strålning

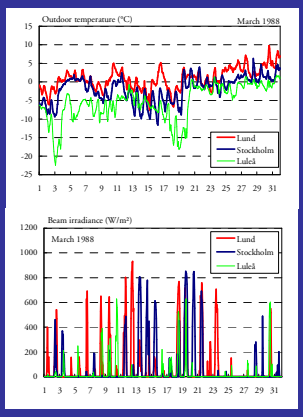
Januari



Utomhustemperatur

Direkt solstrålning

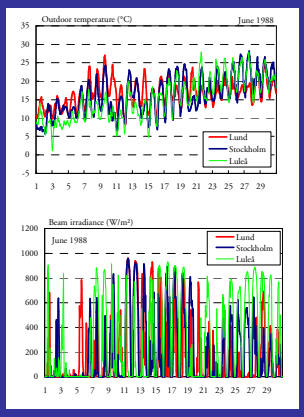
Mars



Utomhustemperatur

Direkt solstrålning

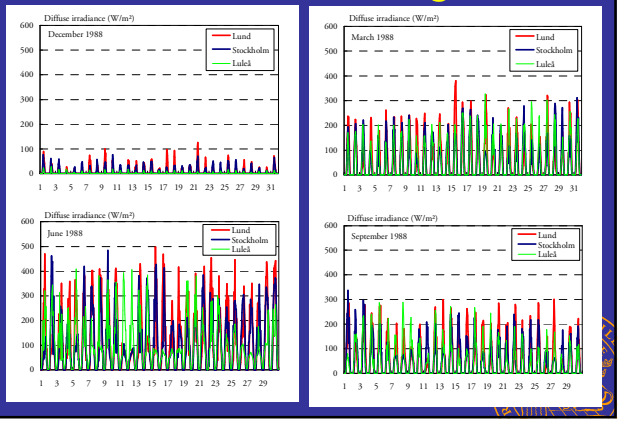
Juni



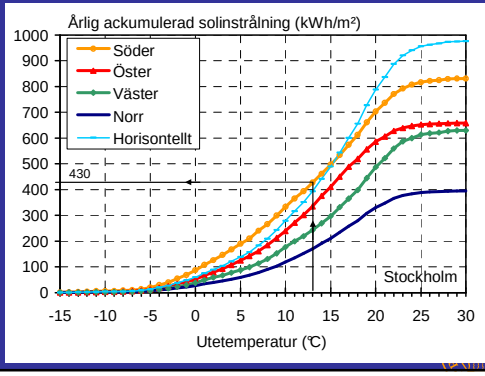
Utomhustemperatur

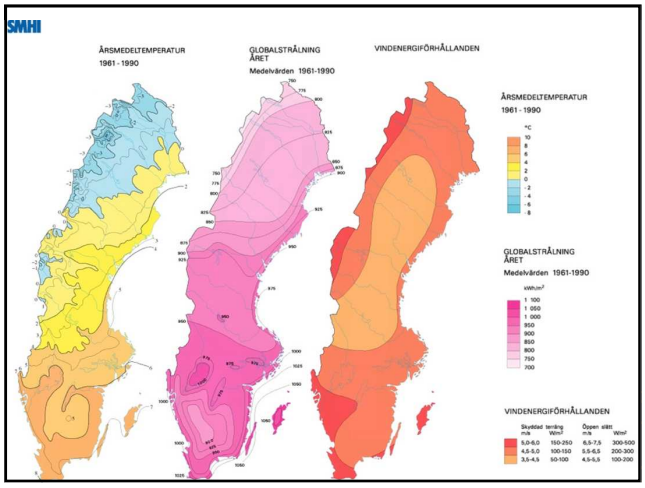
Direkt solstrålning

Diffus solstrålning

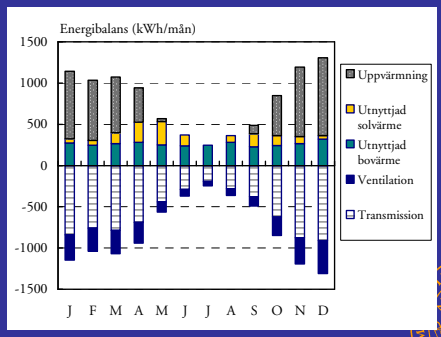


Accumulated solar radiation towards vertical surfaces for var. outdoor temp.



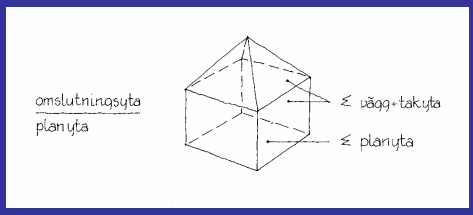


Strategy 1: Minimize losses through the building envelope



Relationship between:

- enclosing area to volume, A_{enc}/V
- enclosing area to floor area, A_{enc}/A_{heat}



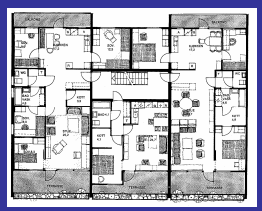
Form

		A_{enc} / V
	A_{enc}= 217m² V = 300 m³	0,72
	A_{enc}= 270 m² V = 300 m³	0,9
	A_{enc}= 350 m² V = 300 m³	1,17

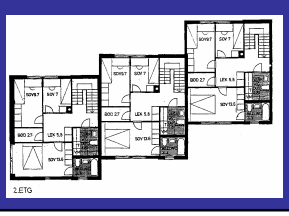
Scale

Side		A_{enc} / V
1	A_{enc}= 6 m² V = 1 m³	6
10	A_{enc}= 600 m² V = 1000 m³	0,6
100	A_{enc}= 60.000 m² V = 1.000.000 m³	0,06

Single-family separate house

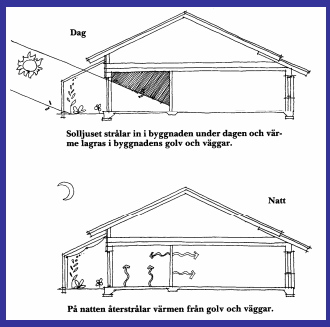


Multi-family dwellings

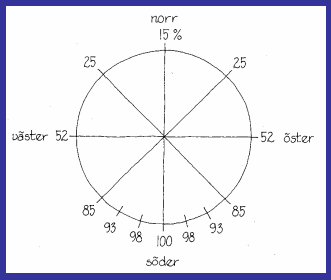


Row houses

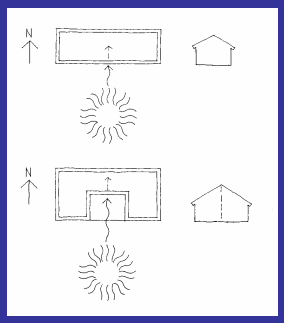
Strategy 2: Solar utilisation



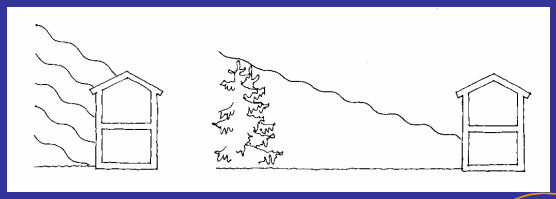
Solar radiation towards vertical surfaces



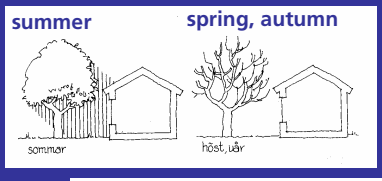
Idea: Long facade or glazed space towards south?

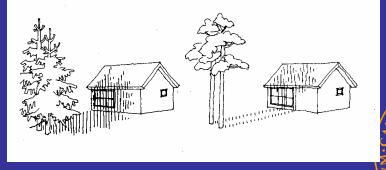


2 storeys increases the facade towards south, less shading

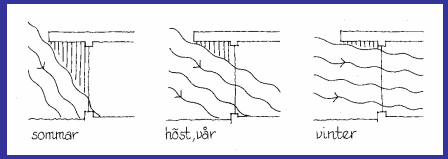


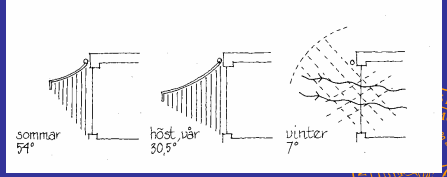
Intelligent solar shading



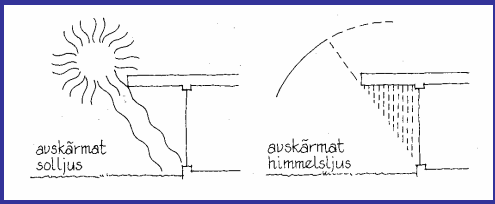


Fixed or movable solar shading?



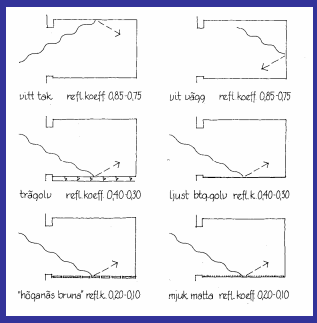


Daylight or solar radiation?



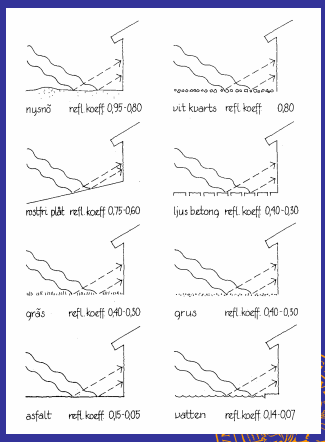
A fixed screen, balcony or similar can make the rooms unpleasantly dark

The reflectance of inner surfaces mainly affects the rooms lightness

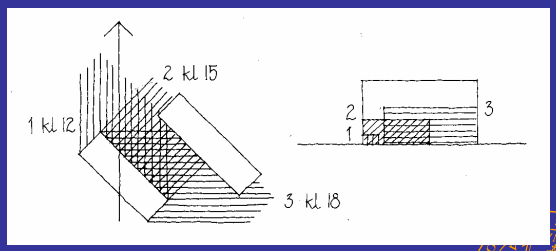


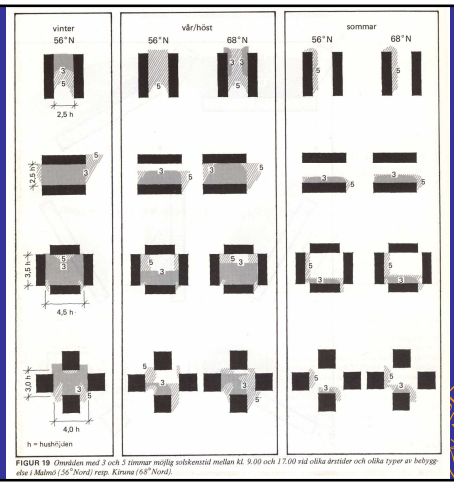
Surface reflectances

The reflectance of the ground



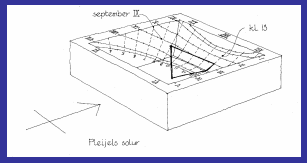
Grouping of houses





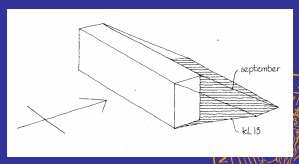
FIGUR 19 *Områden med 3 och 5 timmar möjlig solskenstid mellan kl. 9.00 och 17.00 vid olika årstider och olika typer av bebyggelse i Malmö (56° Nord) resp. Kiruna (68° Nord).*

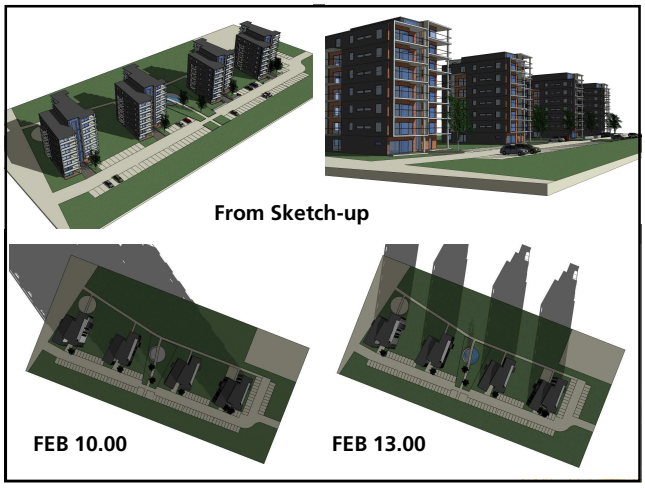
Solar studies in models

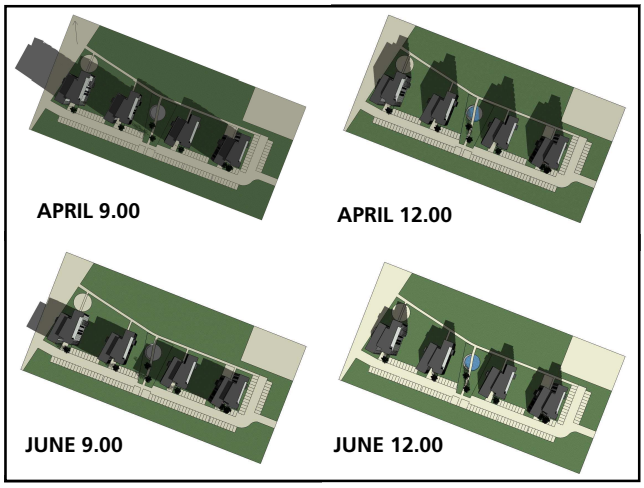


Pleijel's sun dial

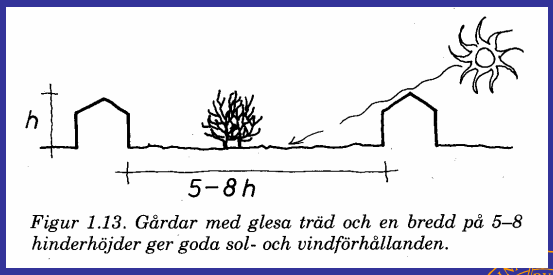
Shadow length







Plan for sun and wind



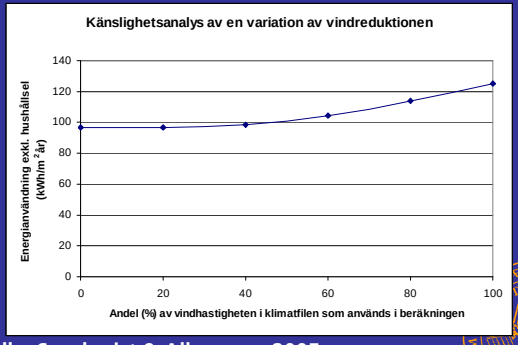
Figur 1.13. Gårdar med glesa träd och en bredd på 5–8 hinderhöjder ger goda sol- och vindförhållanden.

Source: Sol Energi Form

Strategy 3: Build air-tight buildings!

- **Increased cooling → the outer surface resistance is reduced** transmission losses through walls etc increase slightly, largest effect in poorly insulated parts like windows, solar panels, green houses
- **Increased air leakage through cracks and untightnesses**
  increased air-change gives higher ventilation losses

Effect of increased wind speeds at normal infiltration rates



Källa: Sundquist & Allansson, 2005

Summary

- Minimize losses → Build well-insulated buildings
- Minimize losses → Build air-tight buildings
- Utilise "free" energy → Utilise solar energy
- Plan the outdoor environment regarding sun and wind