

Solar Energy for Domestic Hot Water:

Case studies in Sisimiut 1999-2005

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Contents

- 3 solar systems in Sisimiut
- Sun at high altitudes
- On-line datalogging
- Results & Experiences



www.arcticsolar.com

http://www.byg.dtu.dk/subwebs/greenland/engelsk/index_eng.htm

SISIMIUT

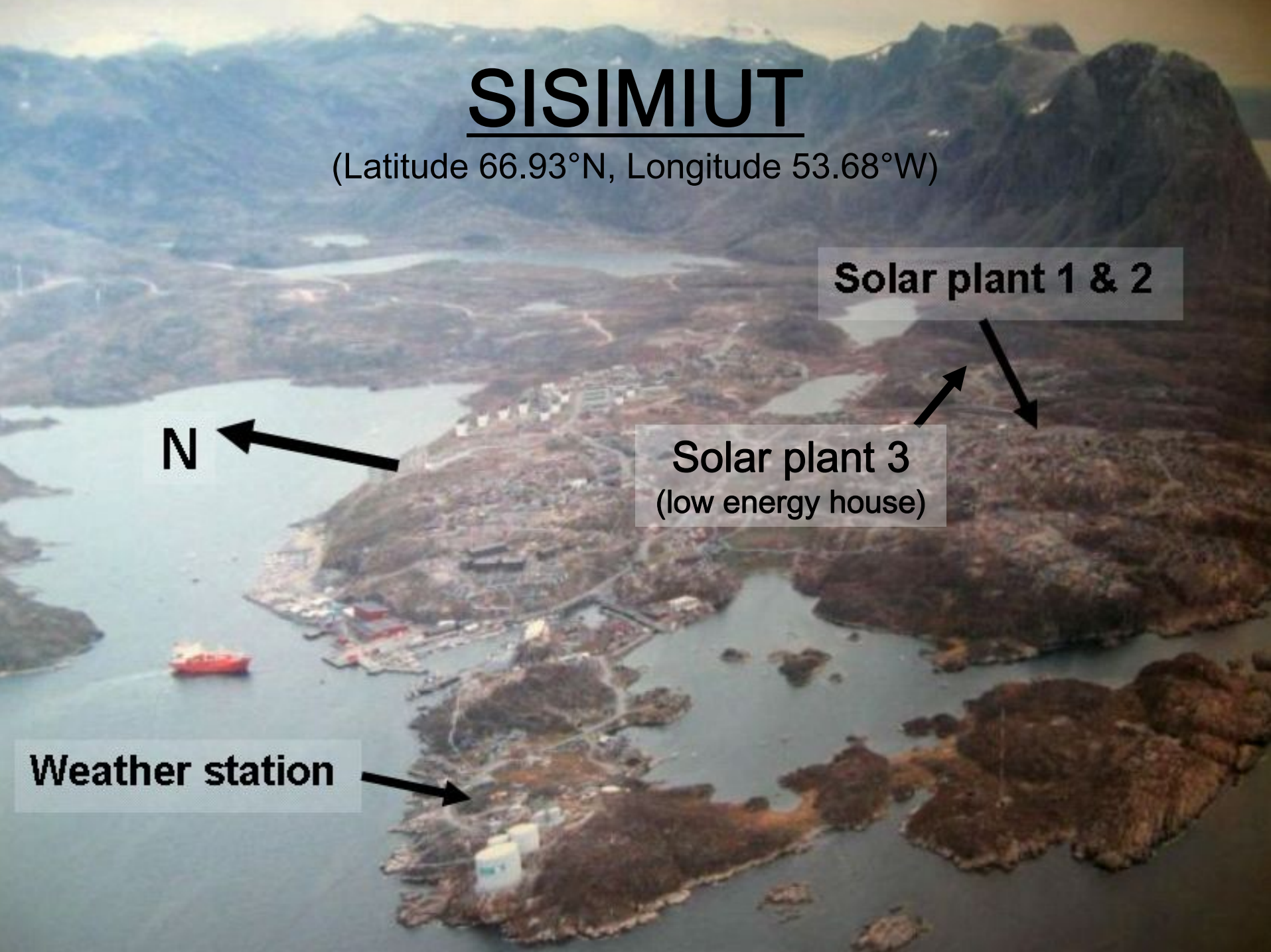
(Latitude 66.93°N, Longitude 53.68°W)

Solar plant 1 & 2

Solar plant 3
(low energy house)

N

Weather station



Solar Plant 1

- Solar panels
 - size: 12 m²
 - type: Flat plate
 - orientation: South-East
 - tilt: 15° from horizontal
- Solar tank
 - size: 260 liters
 - type: Mantel
 - component: preheating
- Building: Dormitory



Solar Plant 2

- Solar panels
 - size: 22 m²
 - type: Flat plate
 - orientation: South-East
 - tilt: 70° from horizontal
- Solar tank
 - size: 1000 liters
 - type: Mantel
 - component: preheating
- Building: Canteen + clothes washing

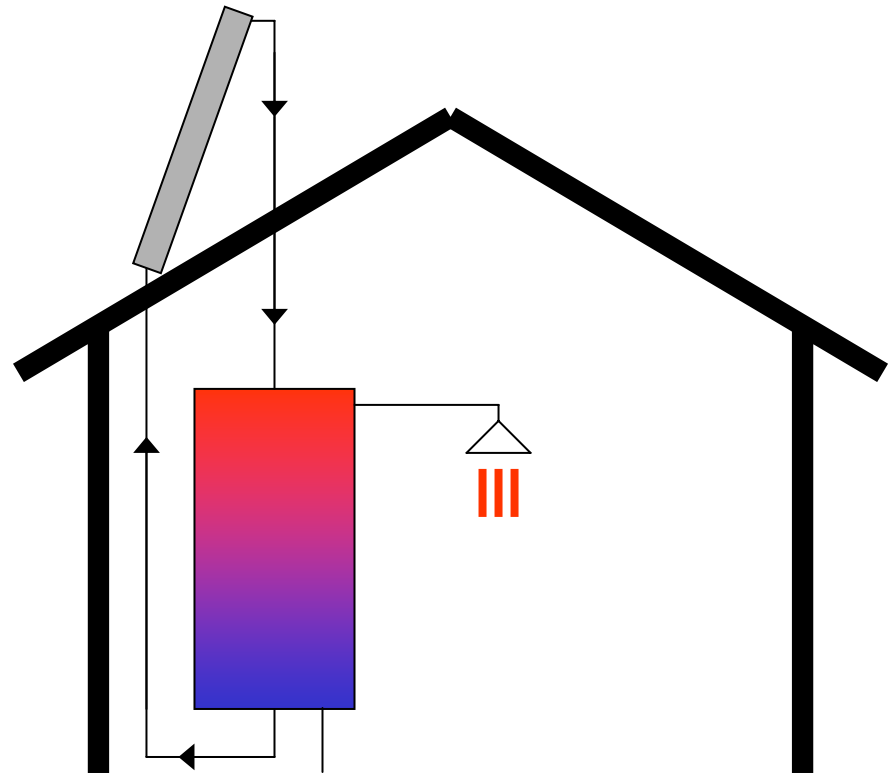
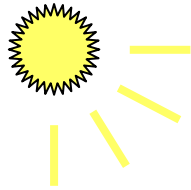


Solar Plant 3

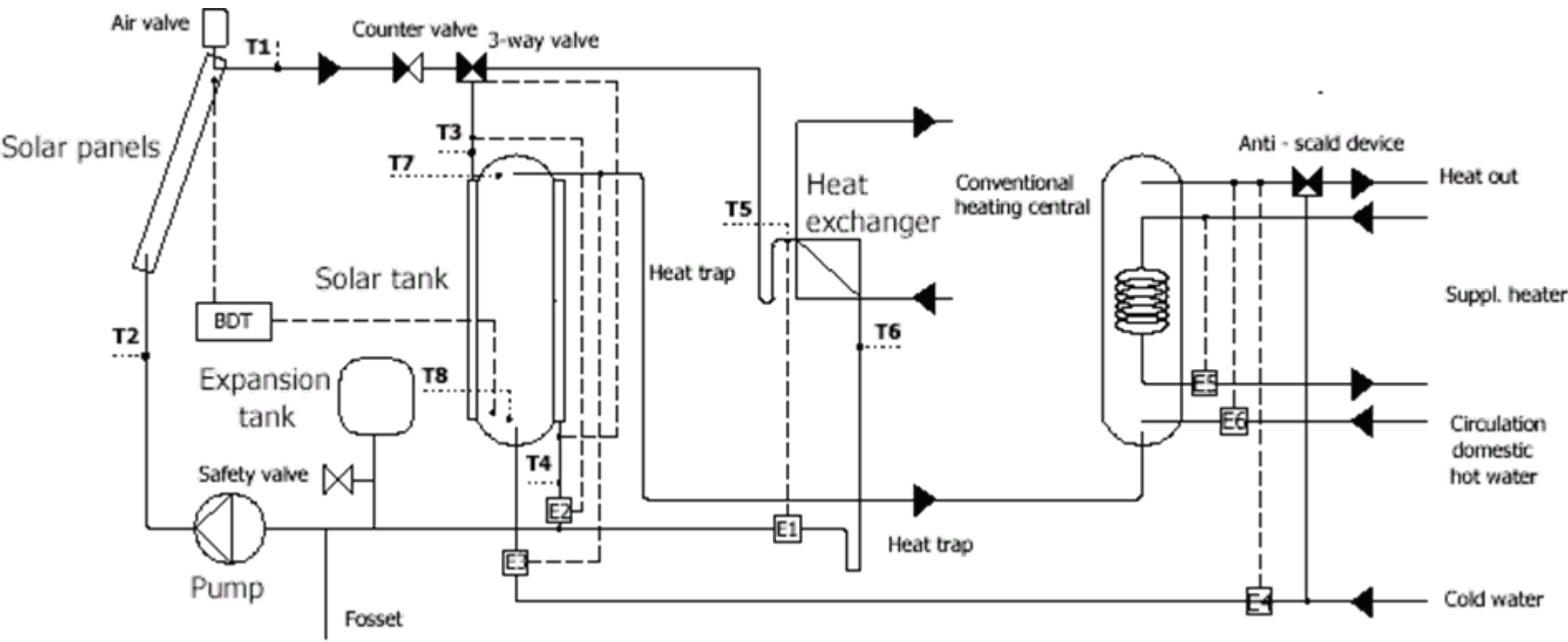
- Solar panels
 - size: 8 m²
 - type: Flat plate
 - orientation: South-East
 - tilt: 70° from horizontal (?)
- Solar tank
 - size: 300 liters (?)
 - type: Mantel
 - component: Hot water tank
- Building: 1 family house + exhibition



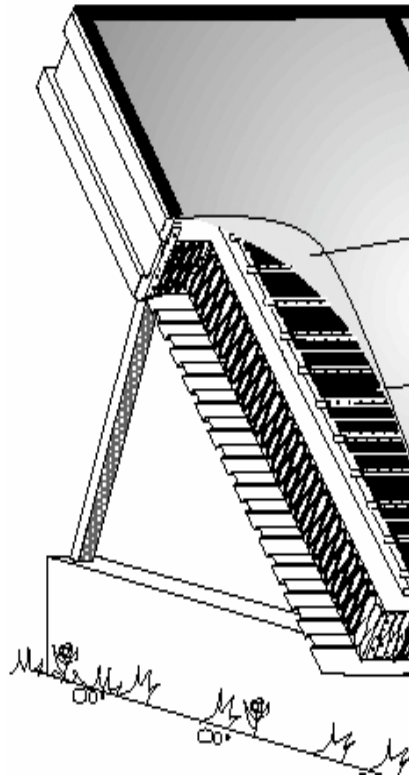
Solar Domestic Hot Water System (1)



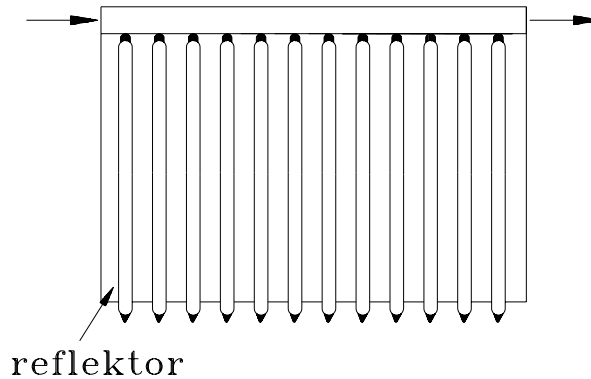
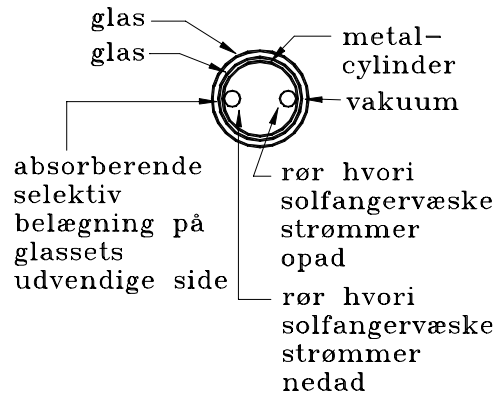
Solar Domestic Hot Water System (2)



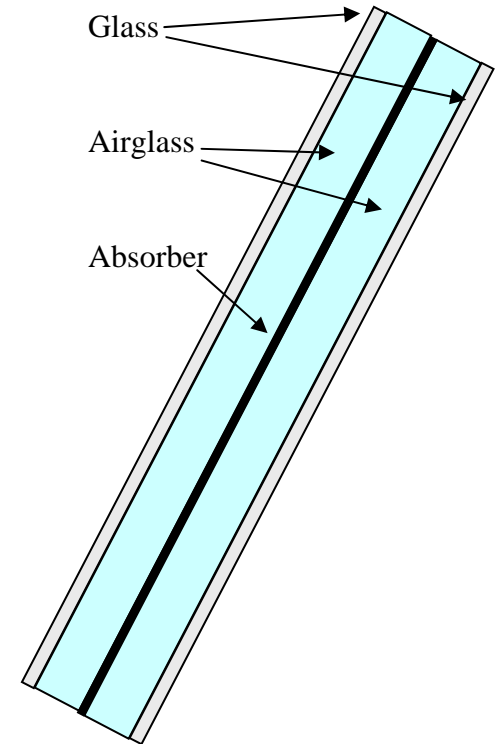
Solar Collector Types



FLAT PLATE

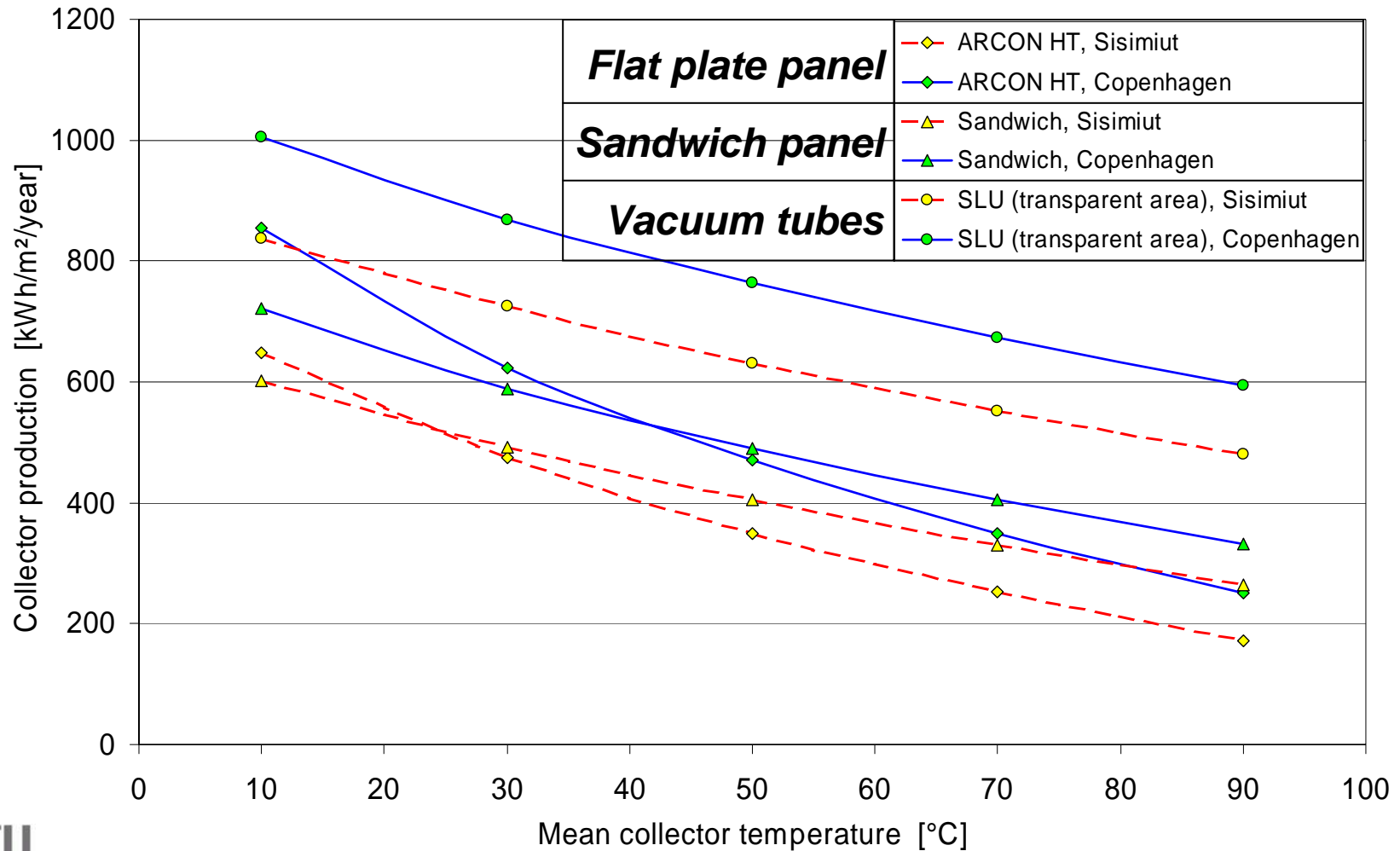


VACUUM TUBE



SANDWICH

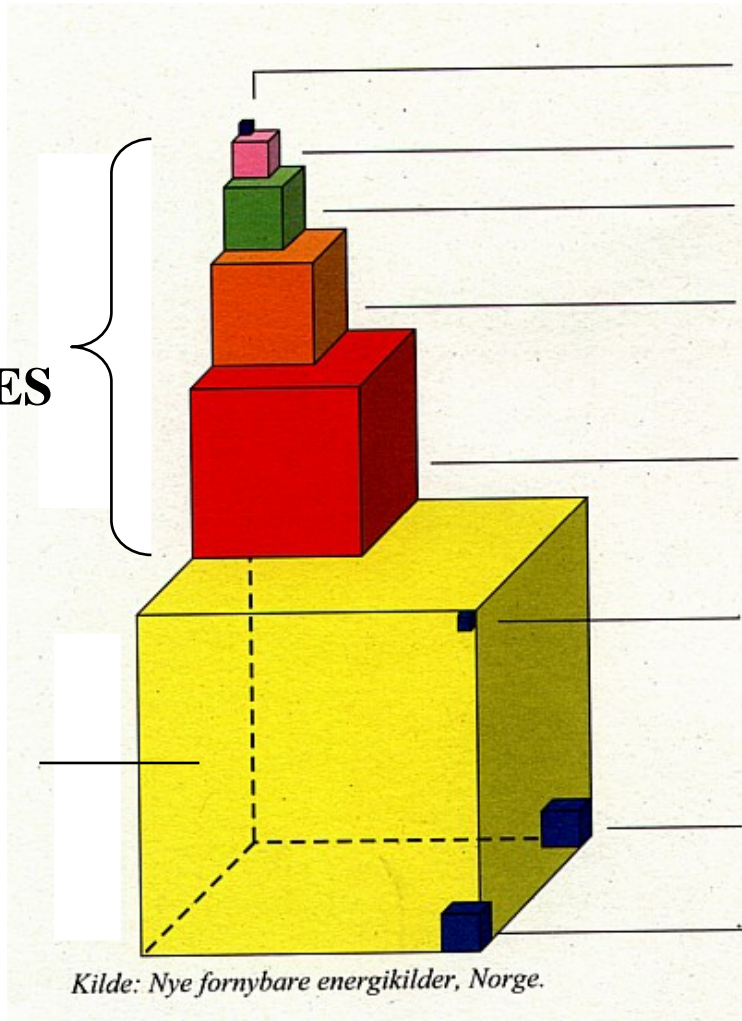
Heat Production Curves



World Energy Resources

**ENERGY
RESERVES**

**ANNUAL
SOLAR
ENERGY**



World's annual energy consumption

Gas reserves

Oil reserves

Uranium reserves

Coal reserves

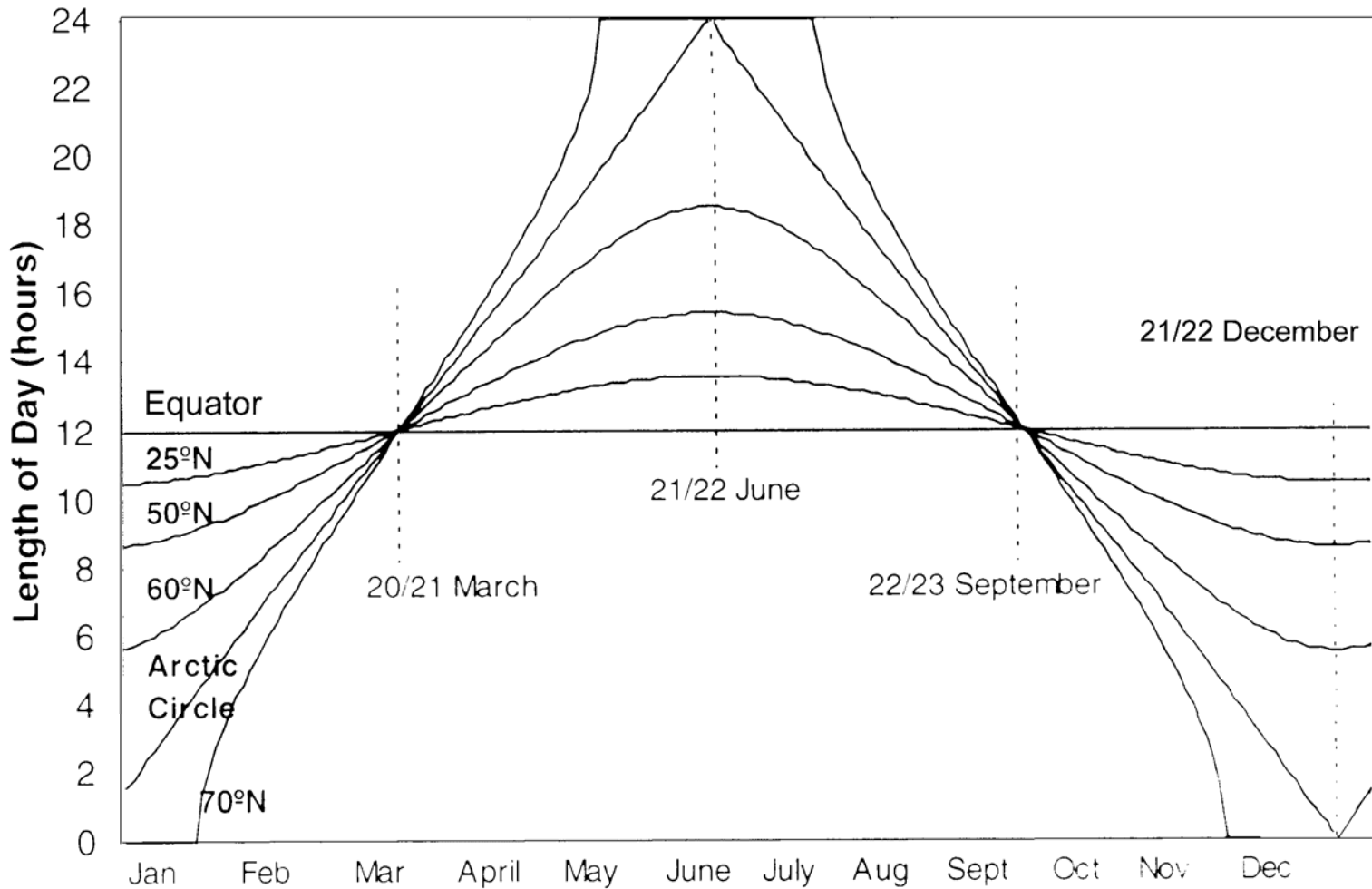
Hydro (usable)

Fotosynthesis

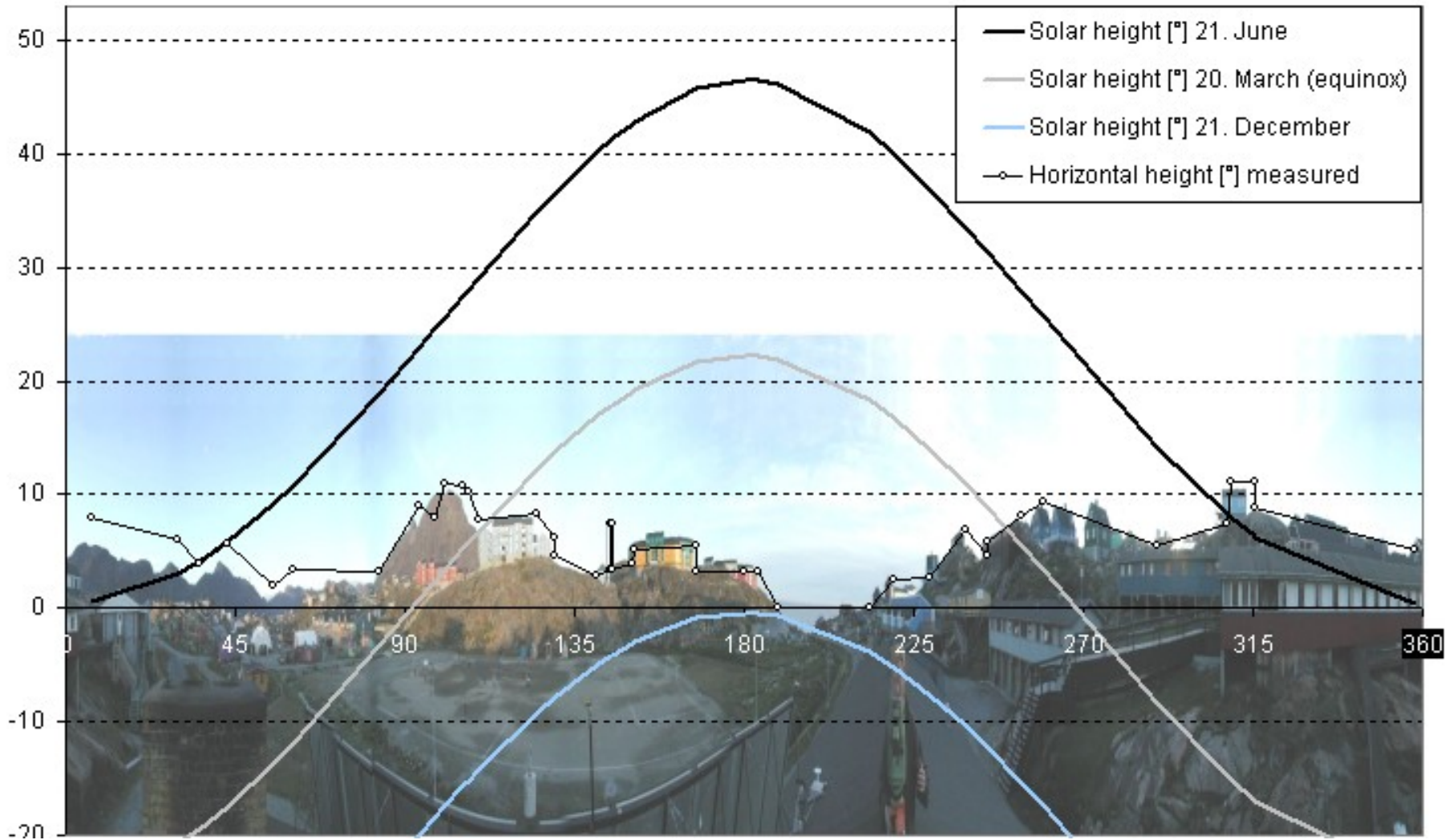
Wind energy

Kilde: Nye fornybare energikilder, Norge.

Daylight hours

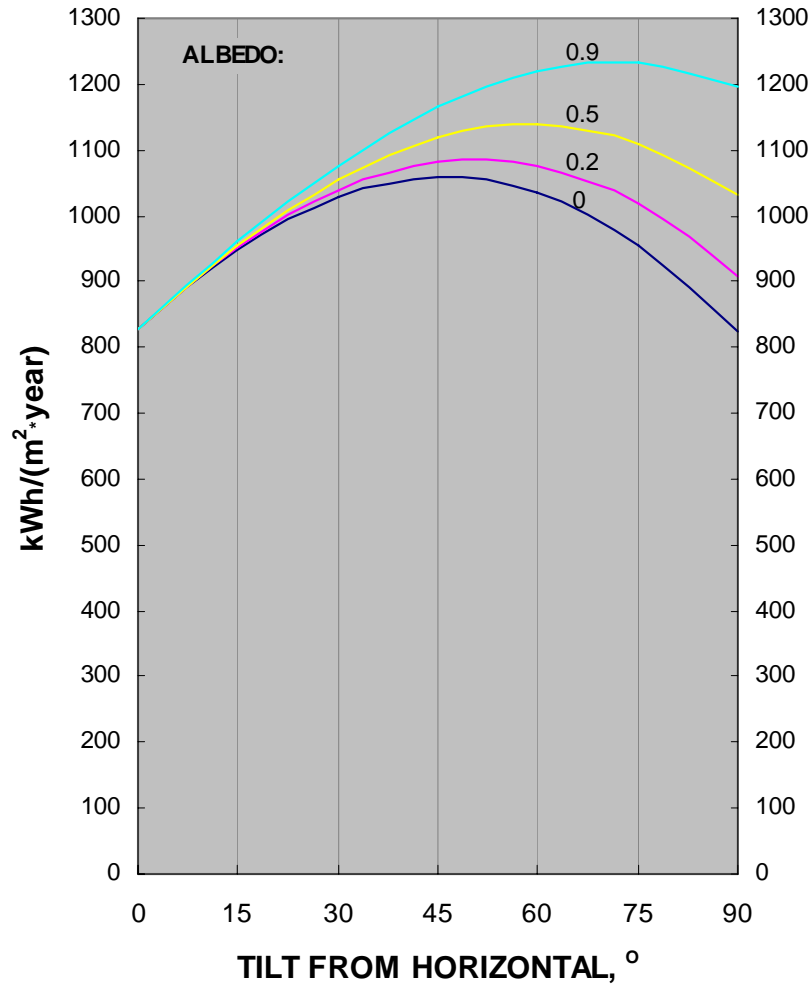


Annual Solar Path in Sisimiut



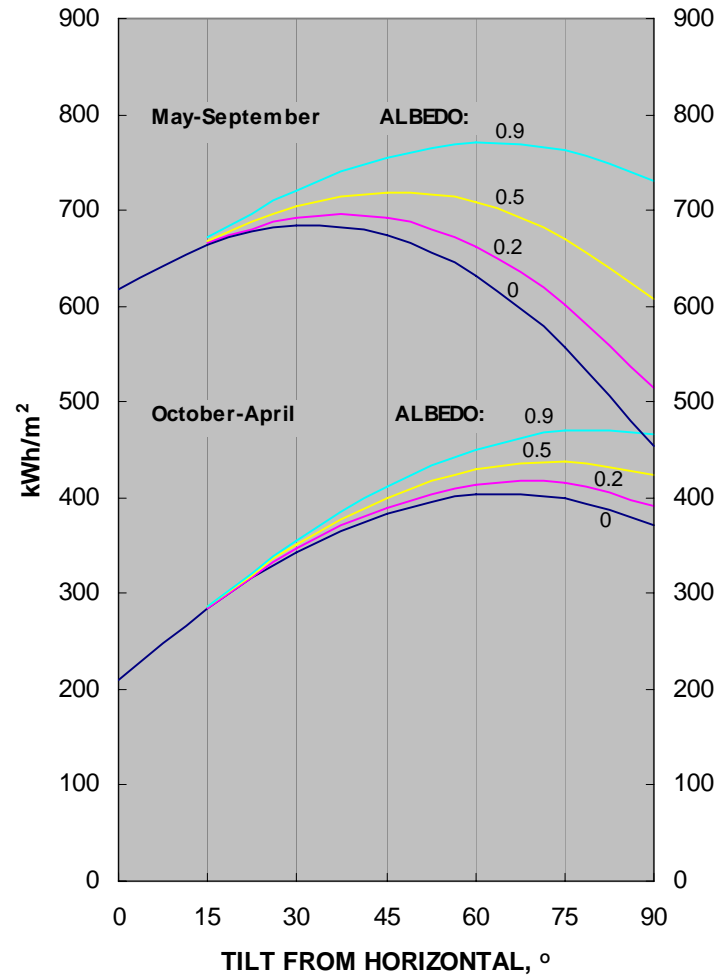
Orientation and Radiation (1)

YEARLY SOLAR RADIATION ON SOUTH
FACING SURFACE IN SISIMIUT



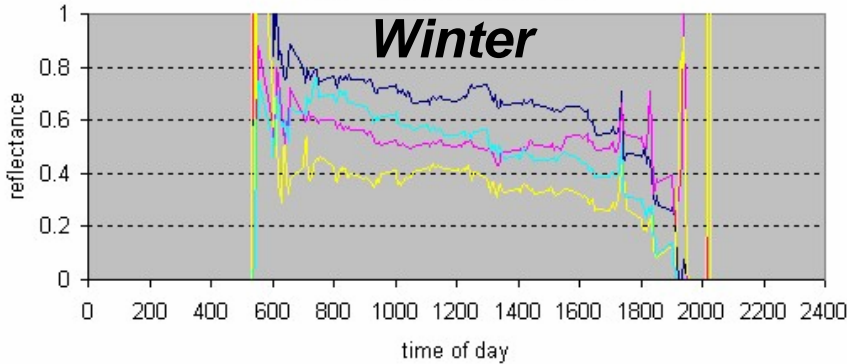
Orientation and Radiation (2)

SOLAR RADIATION ON SOUTH
FACING SURFACE IN SISIMIUT



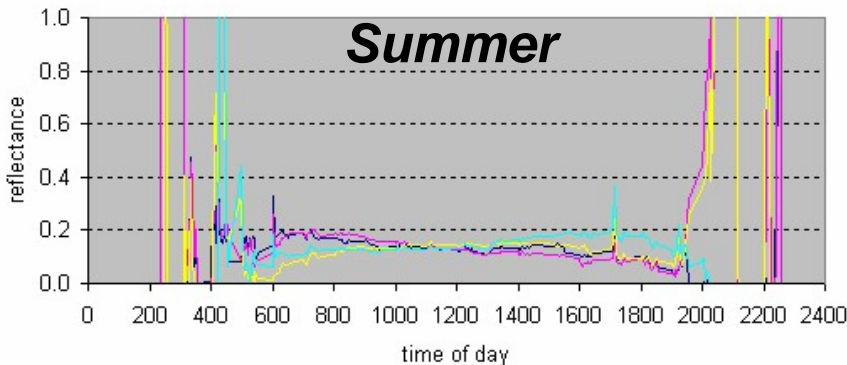
Measured Ground Reflectance

SNOW: Day 100, year 2004
(Telexøen, Sisimiut, Greenland)



- ground reflectance South
- ground reflectance West
- ground reflectance North
- ground reflectance East

NO SNOW: Day 210, year 2003
(Telexøen, Sisimiut, Greenland)



- ground reflectance South
- ground reflectance West
- ground reflectance North
- ground reflectance East



-Pyranometers (Sisimiut):

Horizontal

Vertical South

Vertical North

Vertical East

Vertical West

Ground Reflectance South

Ground Reflectance North

Ground Reflectance East

Ground Reflectance West

Radiation for Different Orientations

kWh/(M²*YEAR)

ORIENTATION TILT FROM HORIZONTAL	North west	West	South west	South	South east	East	North east	North
0°				830 1020				
15°	740 920	840 1000	930 1090	950 1120	910 1090	810 1000	720 920	690 880
30°	670 800	860 970	1010 1120	1050 1180	970 1120	800 970	630 800	580 740
45°	620 700	860 920	1060 1110	1120 1180	1020 1110	800 920	580 700	490 590
60°	600 610	850 860	1070 1060	1140 1140	1020 1060	790 860	560 620	470 480
75°	590 540	830 770	1050 970	1110 1040	1000 960	770 770	540 540	470 410
90°	570 460	780 660	980 840	1030 880	930 830	720 660	530 460	460 350

Top 3 values

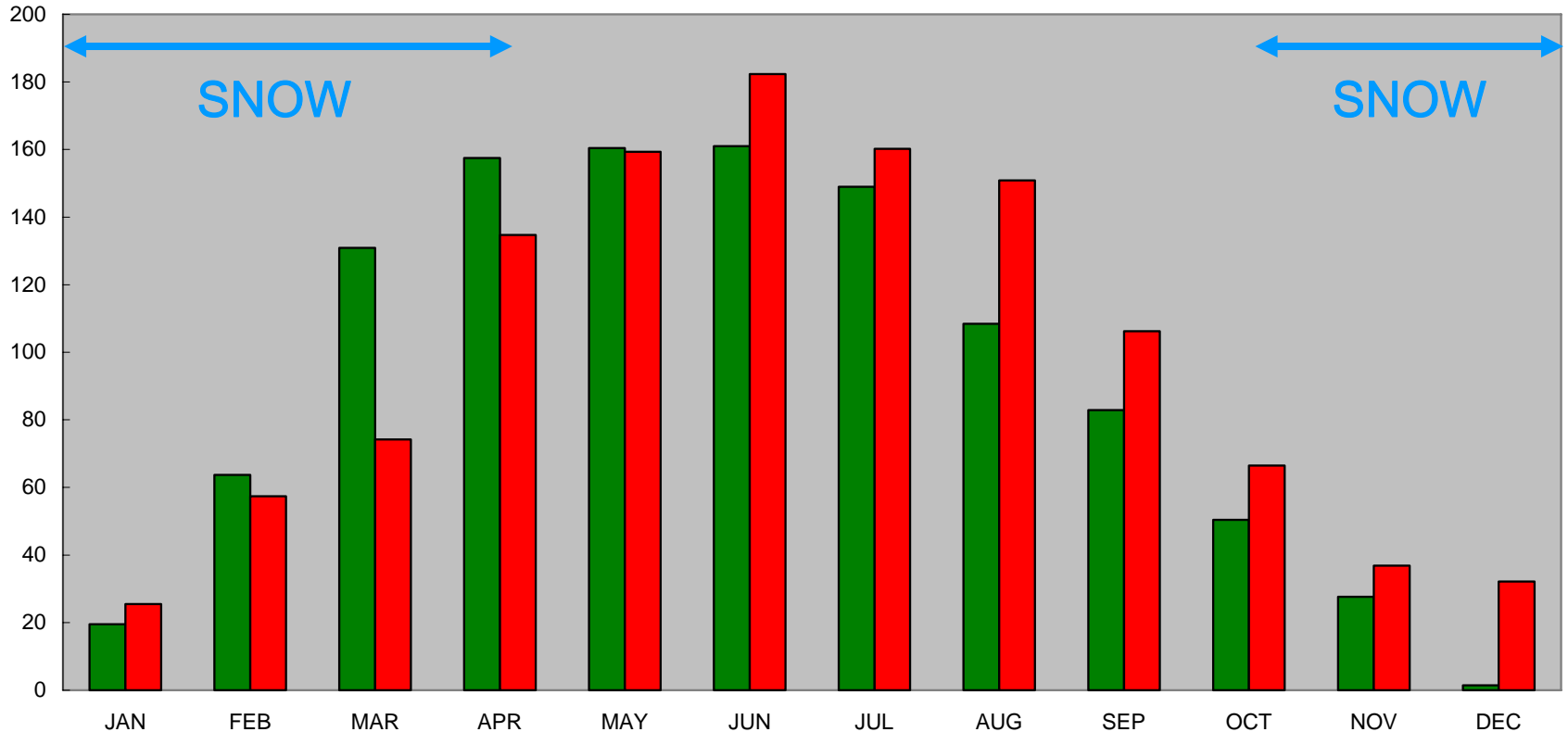


SISIMIUT COPENHAGEN

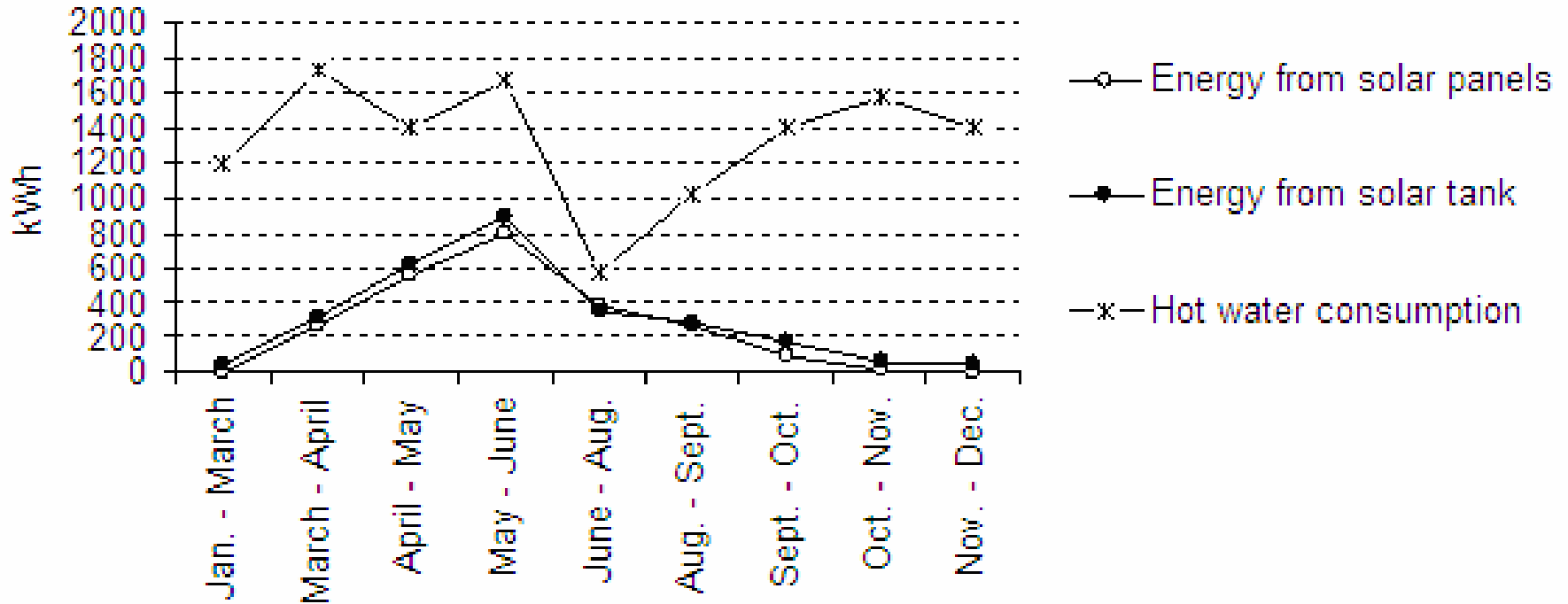
Monthly Insolation: CPH vs. SIS

SOUTHFACING 40° TILTED SURFACE IN COPENHAGEN, ALBEDO: 0.2

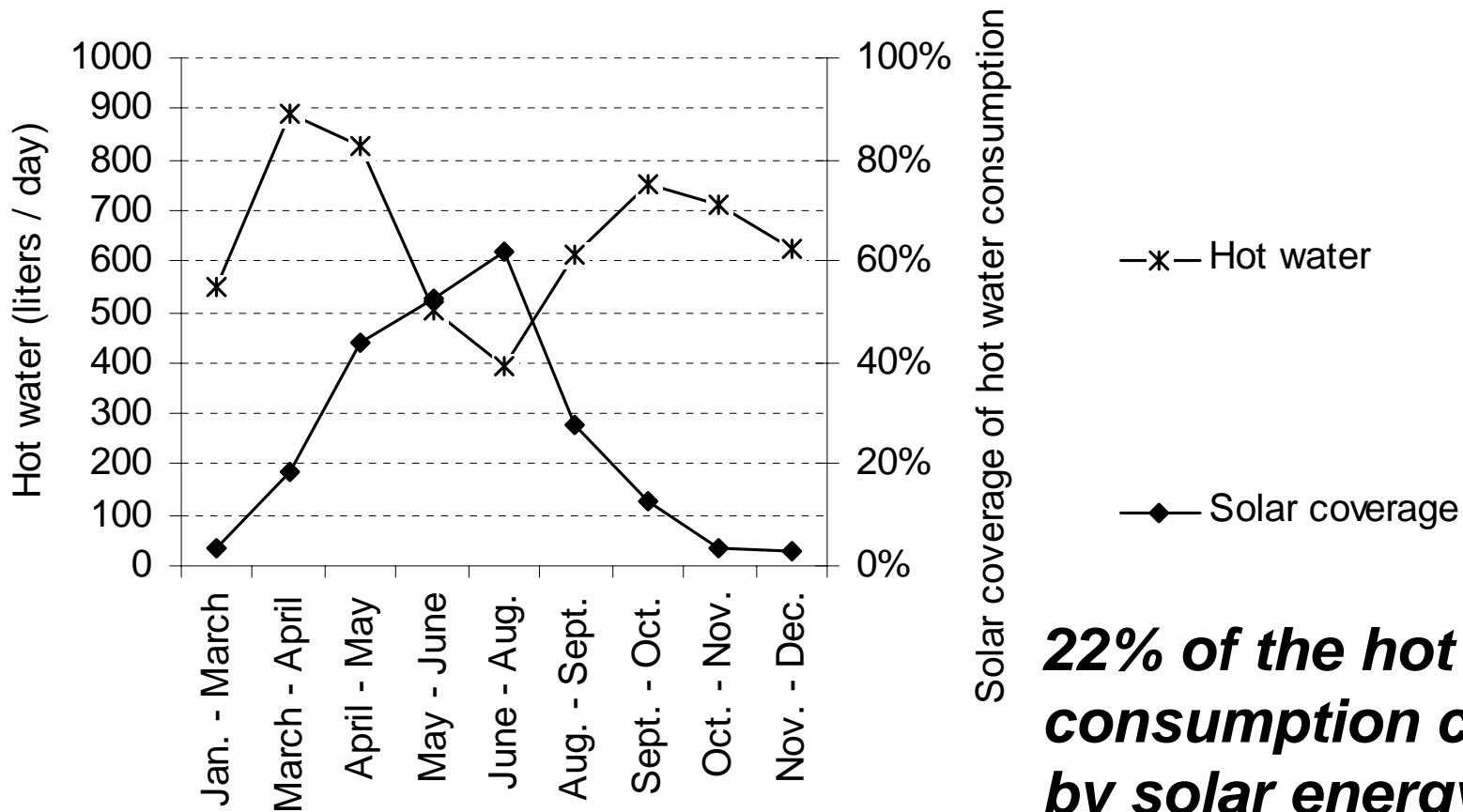
SOUTHFACING 60° TILTED SURFACE IN SISIMIUT, ALBEDO: 0.2 MAY-SEPTEMBER 0.9 OCTOBER-APRIL



Measurements (Plant 1)



Measurements (Plant 1)



22% of the hot water consumption covered by solar energy (annual average)

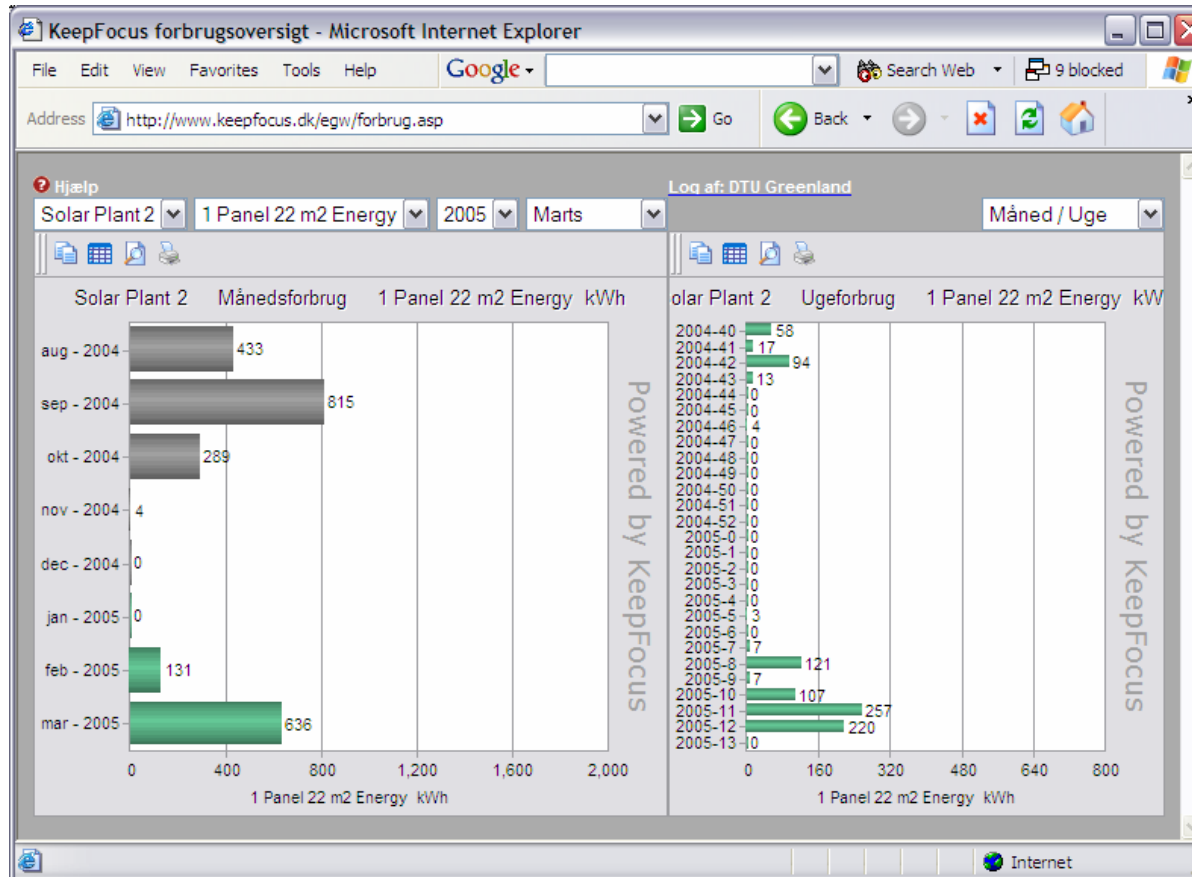
Annual Solar Production (Plant 1, 2 and 3)

Plant	Solar panel area	Hot water consumption	Hot water covered by solar	Solar production
1	12 m ²	600 l/day	22%	3200 kWh
2	22 m ²	~ 1500 l/day	~ 20%	8500 kWh
3	8 m ²	~ 150 l/day	~ 57%	1700 kWh

Calculation example for Solar Plant 3:

- Fuel oil price: 2.68 DDK = 0.45 US dollars
- Annual oil savings: 330 liter
- Annual monetary saving: 884 DDK = 150 US dollars

On-line logging



- short demo if possible –
www.arcticsolar.com

Maintenance and Operation

- Ordinary maintenance required
- Snow often blows off the roof
- Installation of UPS back-up to ensure operation during power-cuts (several times pr. year).
- UPS system also protects sensitive equipment against transients on the electric grid
- On-line logging very useful for easy data collection and monitoring of operation.



Conclusions

Plusses

- High yield pr. m² solar panel
 - bigger space heating demand
 - reflection from snow
- Solar collectors can withstand the harsh climate

Minuses

- Cheap oil
- No subsidies
- No law requirement
- Limited experience



Thank you

www.arcticsolar.com

http://www.byg.dtu.dk/subwebs/greenland/engelsk/index_eng.htm



Maximum Energy Production



= 6 x

