Gróf Gyula

Napkollektorok Energetikai értékelése

Energy assessment of the solar collectors

Energetikai értékelés
Energy Assessment

- Mit értünk ez alatt? What does it mean?

=

Technikai + Gazdasági

Technical + Economical

Szempontrendszer

Point of view

$\Rightarrow$ Optimum

Kihez szól? Who is the listener?

- Felhasználók (nem szakmai közönség)
- Users (non specialists)
- Szakmai közönség (specialists):

  Tervezők (Designers)

  Installációs szakemberek

  Fejlesztők (Developers)

  . . .

Technikai szempontok:
(Technical aspects)

- Funkcionális megfelelőség (functions)
- Termodinamikai megfelelőség (thermodynamics)
- Élettartam (life cycle)
- Környezeti hatások (environmental impacts)
- …

Szabványosított minősítési eljárások!
(standards)

SOLAR
SRCC
RATING & CERTIFICATION CORPORATION
TM

SRCC STANDARD 100-08

TEST METHODS AND MINIMUM STANDARDS FOR CERTIFYING SOLAR COLLECTORS

February 2008

INTERNATIONAL STANDARD

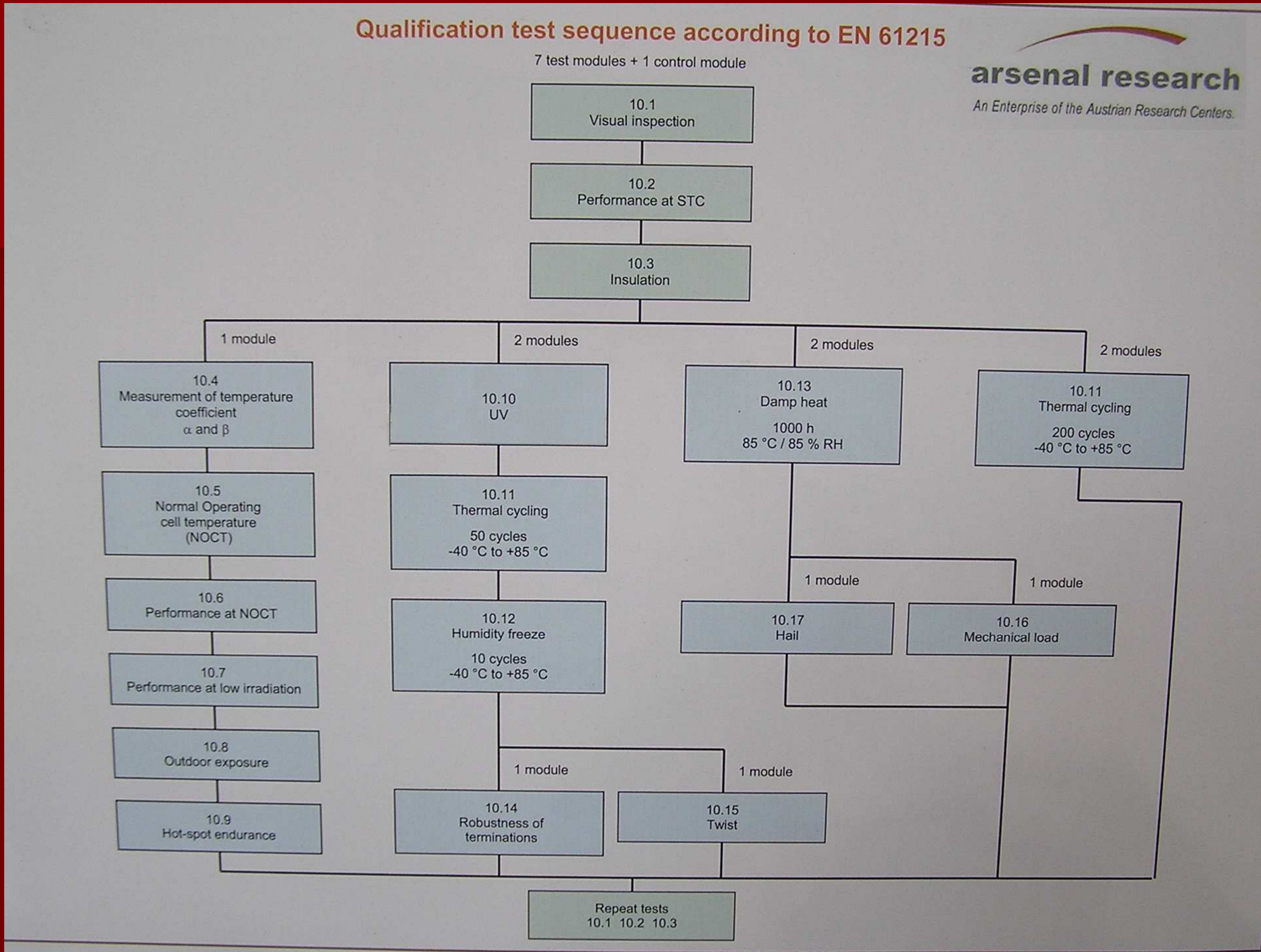
IEC 61215

Second edition
2005-04

Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval

IEC

Reference number
IEC 61215:2005(E)

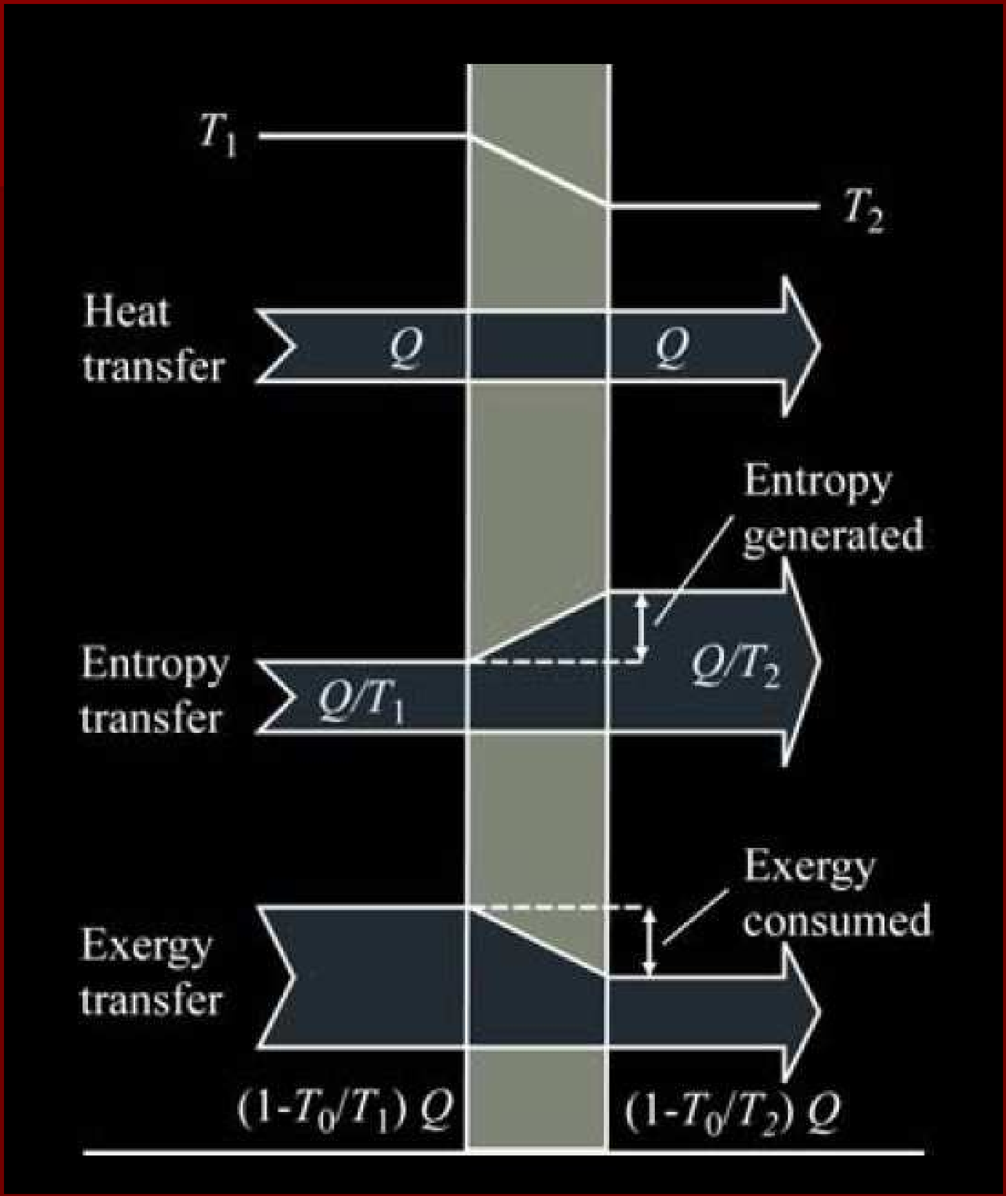

Qualification test sequence according to EN 61215
7 test modules + 1 control module
arsenal research
An Enterprise of the Austrian Research Centers.
10.1
Visual inspection
10.2
Performance at STC
10.3
Insulation
1 module
2 modules
2 modules
2 modules
10.4
Measurement of temperature coefficient
α and β
10.5
Normal Operating cell temperature (NOCT)
10.6
Performance at NOCT
10.7
Performance at low irradiation
10.8
Outdoor exposure
10.9
Hot-spot endurance
10.10
UV
10.11
Thermal cycling
50 cycles
-40 °C to +85 °C
10.12
Humidity freeze
10 cycles
-40 °C to +85 °C
1 module
1 module
10.14
Robustness of terminations
10.15
Twist
10.13
Damp heat
1000 h
85 °C / 85 % RH
1 module
1 module
10.17
Hail
10.16
Mechanical load
10.11
Thermal cycling
200 cycles
-40 °C to +85 °C
Repeat tests
10.1 10.2 10.3

Kollektor értékelés termodinamikai lehetőségei:

- Hőmérséklet szemlélet
- Energia szemlélet
- Entrópia szemlélet
- Exergia szemlélet

Cél: meghatározni az energia átalakítás
hatékonyságát
veszteségeket (mennyiség, minőség)
utalni a gazdaságosságra

Characterization of the heat transport:



Temperature method

- optimal temperature for getting power from a heat source -

$f(T_f, T_h)$ characteristic function of heat source

$g(T_h, T_o)$ function of use of energy

$$\frac{\partial \left[f(T_f T_h) \cdot g(T_h, T_o) \right]}{\partial T_h} = 0 \rightarrow T_{h\max}$$

$$P_{\max} = f(T_f T_{h\max}) \cdot g(T_{h\max}, T_o)$$

Problem: knowledge of the characteristic function

Case of radiation

$$f\left(T, T_h\right) = C \cdot \left[T_f^4 - T_h^4\right] \qquad g(T_h, T_O) = 1 - \frac{T_O}{T_h}$$

$$T_{h\max} = \sqrt[5]{\frac{T_O}{4}\left[T_f^4 + 3 \cdot T_{h\max}^4\right]}$$

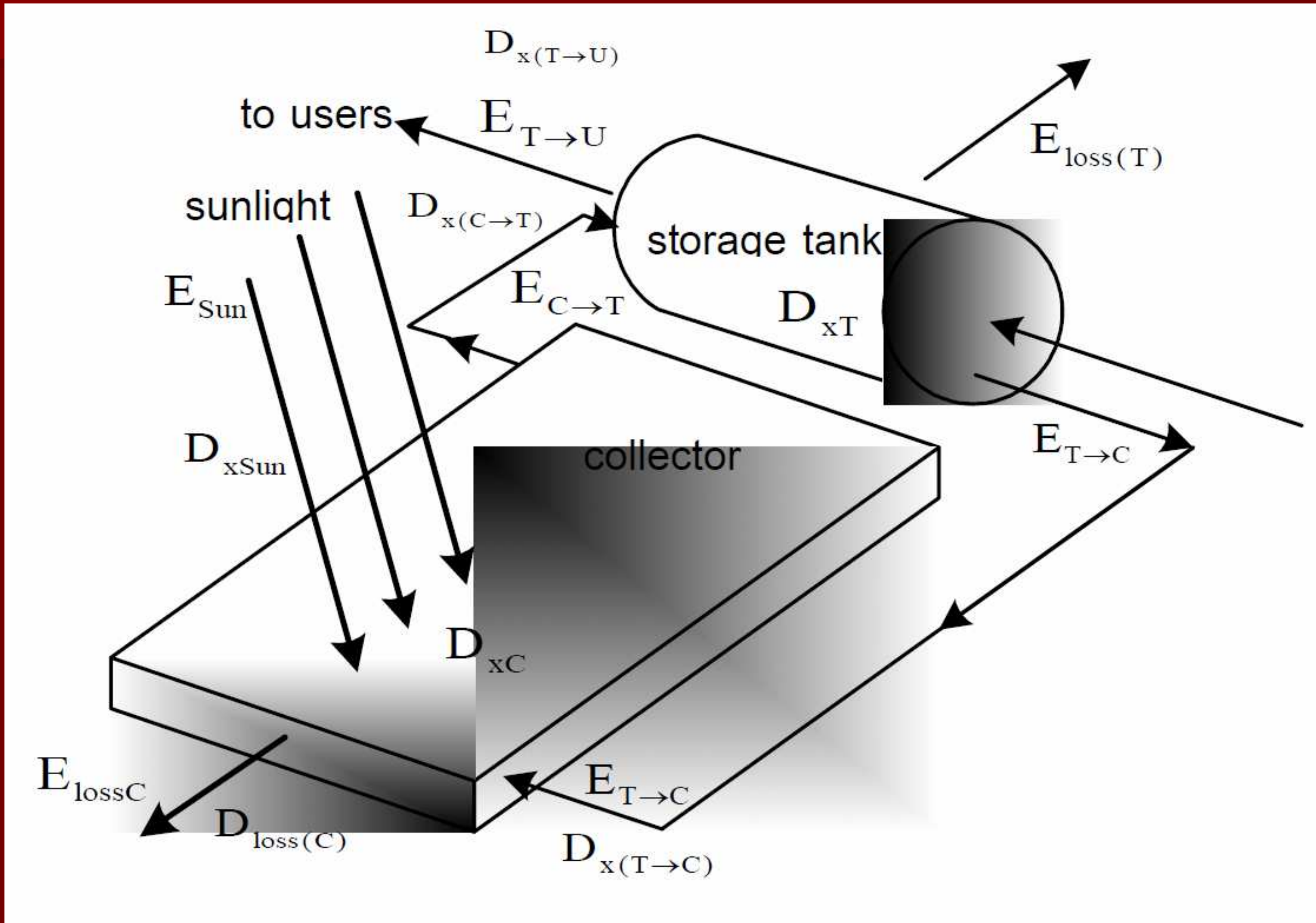
Case of convection or conduction:

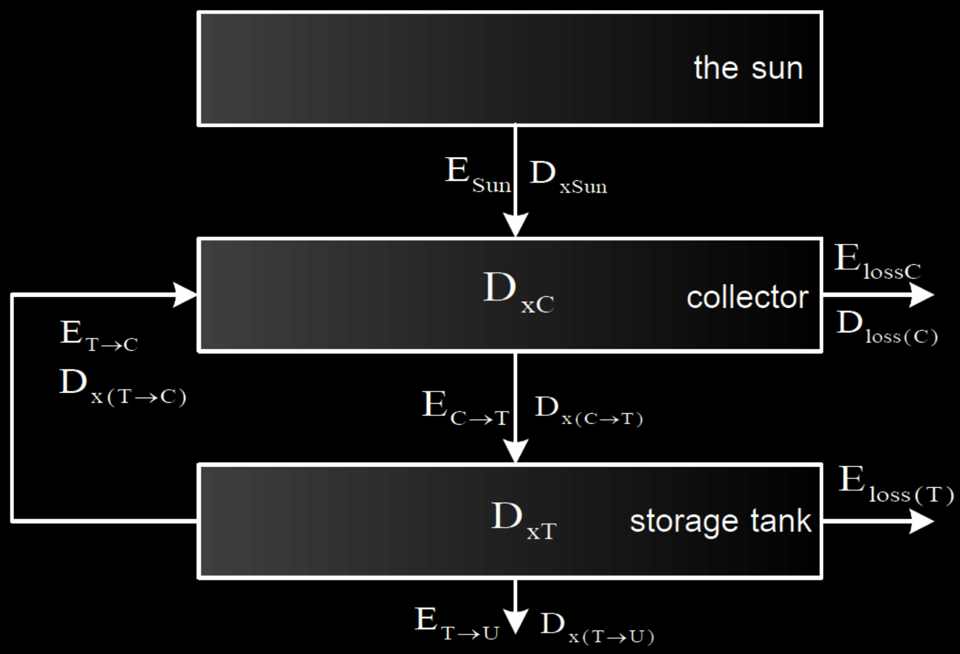
$$f\left(T, T_h\right) = C \cdot \left[T_f - T_h\right] \qquad g(T_h, T_O) = 1 - \frac{T_O}{T_h}$$

$$T_{h\max} = \sqrt{\left[T_f \cdot T_O\right]}$$

Energy method - Energia szemlélet

- application of the energy conservation -





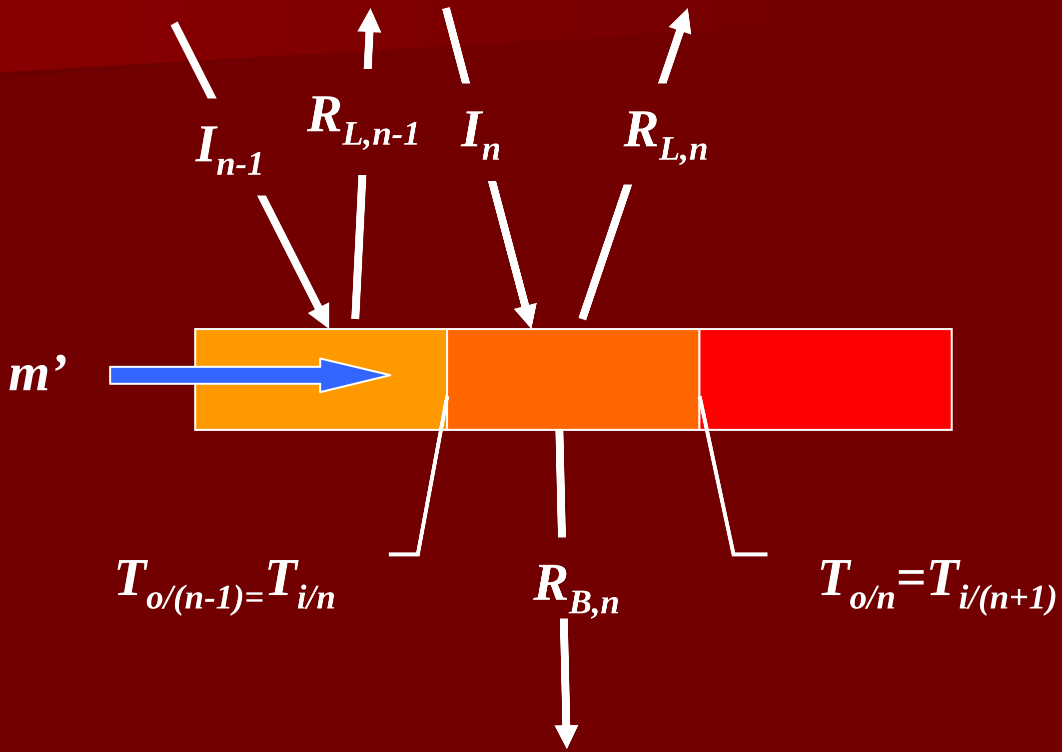
Energy balance equations in this model are :

at collector : $E_{Sun} + E_{T\rightarrow C} = E_{lossC} + E_{C\rightarrow T}$

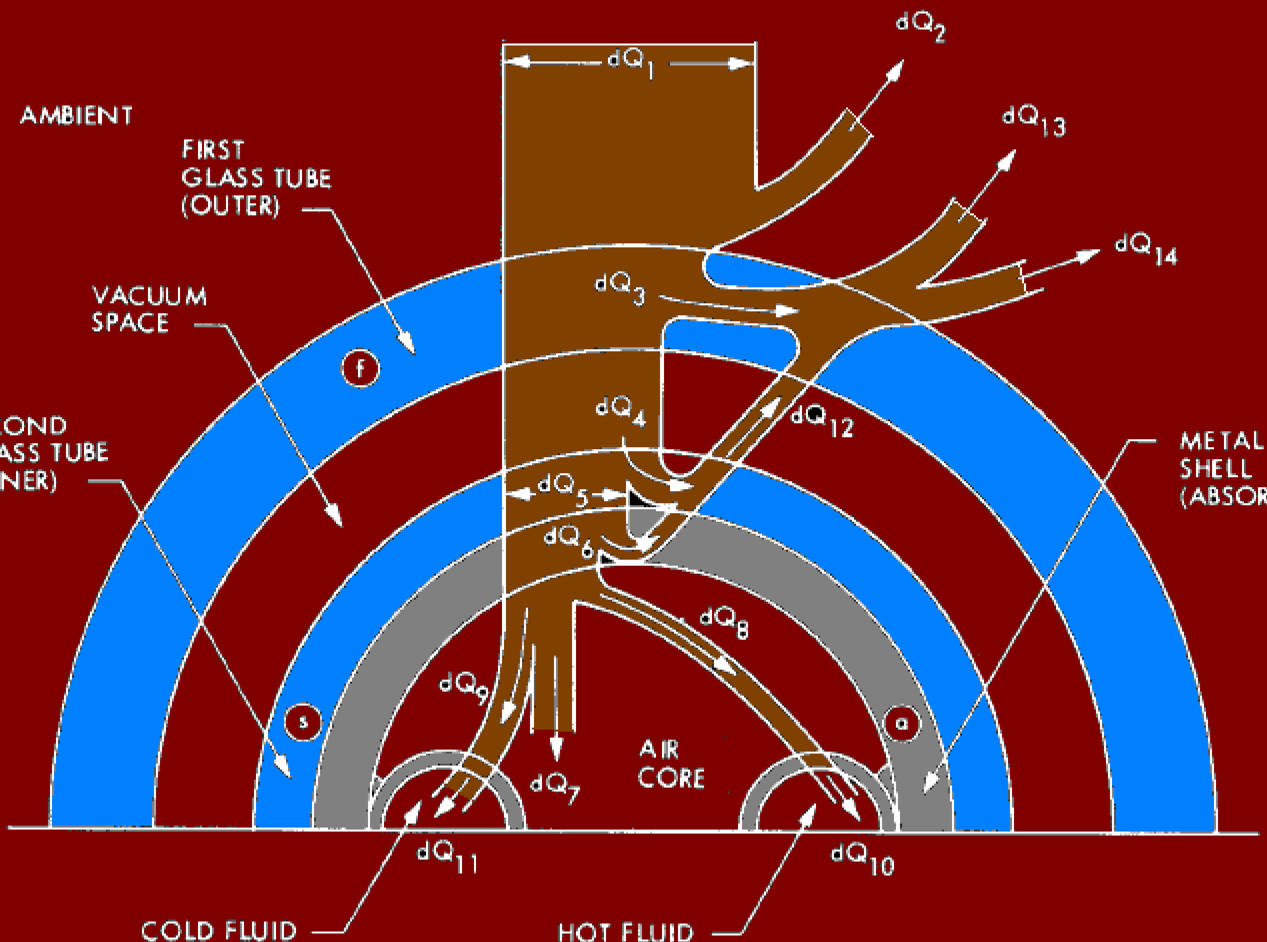
where E_{Sun} is power from sun (input power)(W) , $E_{T\rightarrow C}$ is power from storage tank to collector associated with water recycle(W) , E_{lossC} is power losses due to imperfectly thermal insulation in collector (W) , $E_{C\rightarrow T}$ is power from collector to storage tank(W)

at storage tank : $E_{C\rightarrow T} = E_{loss(T)} + E_{T\rightarrow U} + E_{T\rightarrow C}$

Energy balance in „Cell” level:

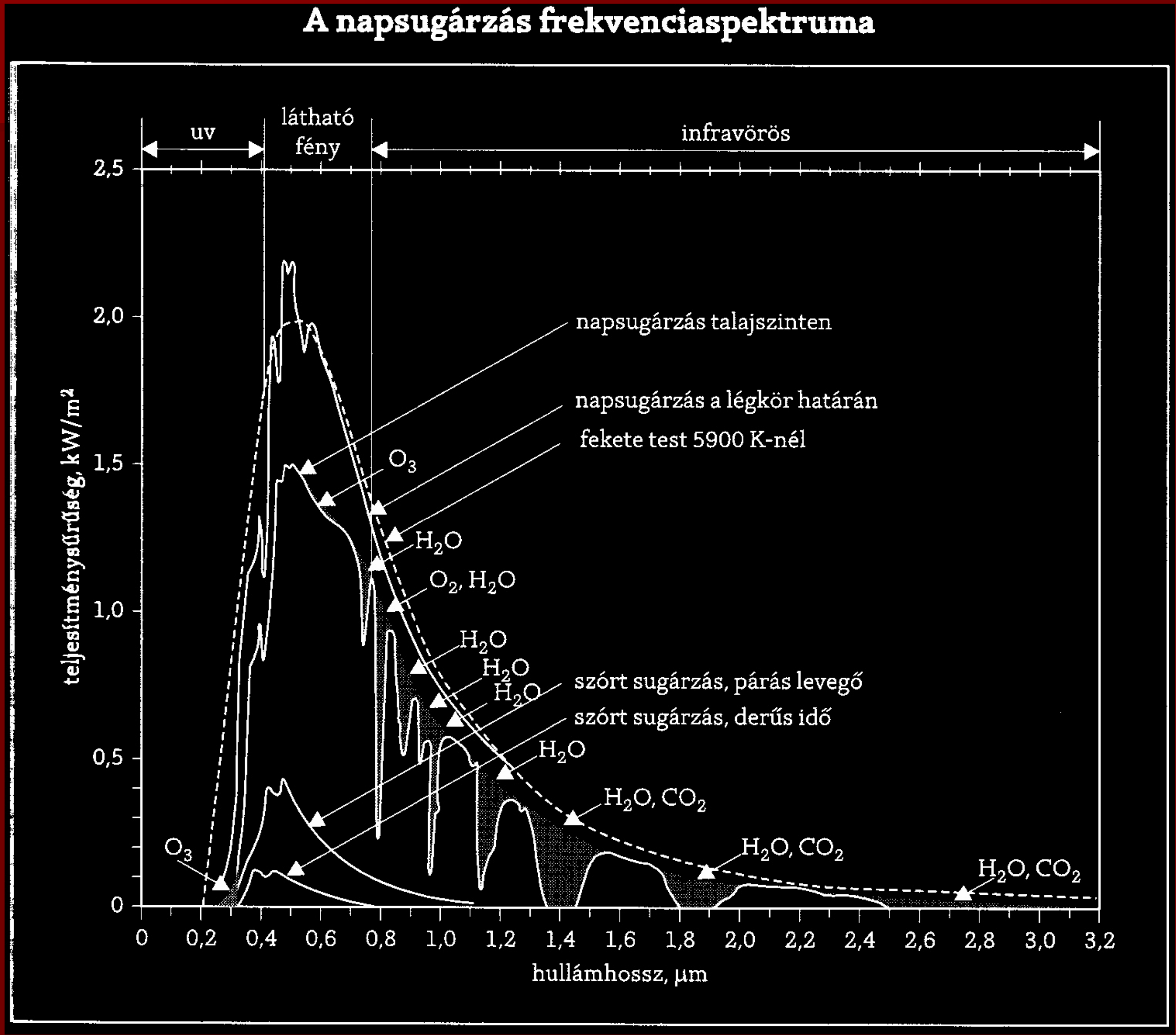


Energy balance:



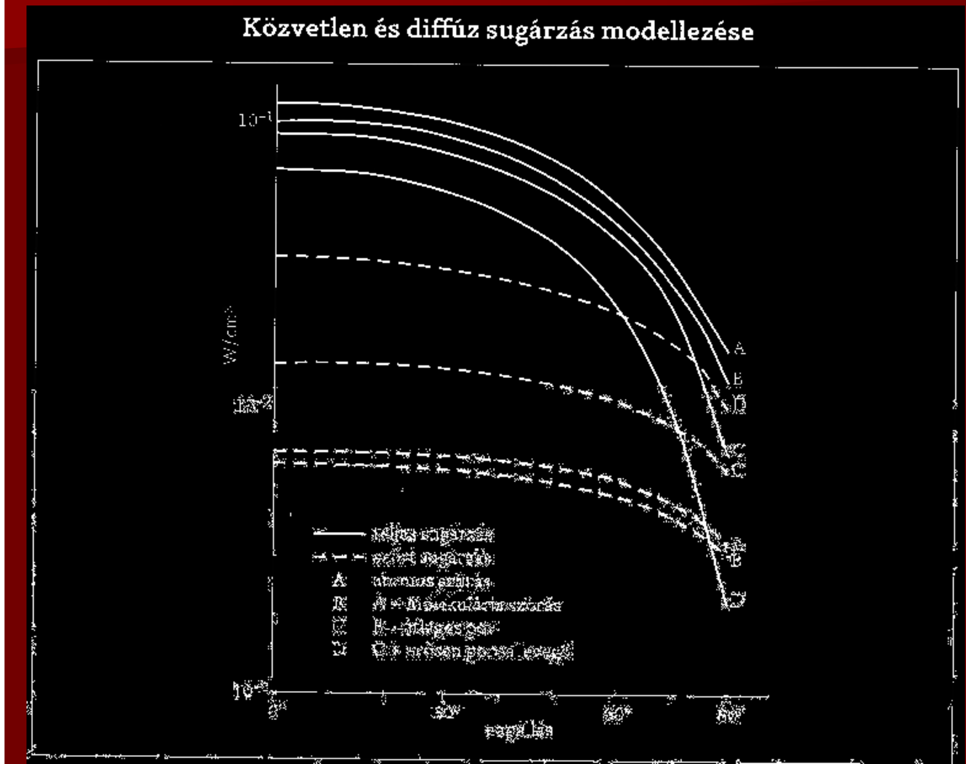
Sankey diagram for a twin tubular collector

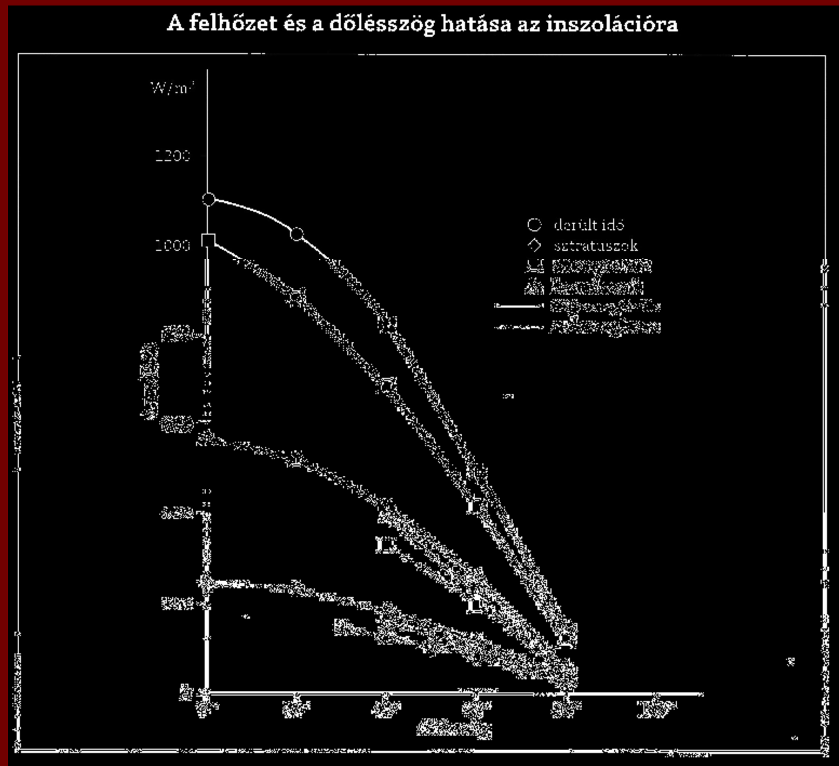
Input data (1):



A napsugárzás frekvenciaspektruma
uv
látható fény
infravörös
napsugárzás talajszinten
napsugárzás a légkör határán
fekete test 5900 K-nél
O_3
H_2O
O_2, H_2O
H_2O
H_2O
H_2O
szórt sugárzás, párás levegő
szórt sugárzás, derűs idő
H_2O
H_2O, CO_2
H_2O, CO_2
H_2O, CO_2
O_3
teljesítménysűrűség, kW/m²
0
0,5
1,0
1,5
2,0
2,5
0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8
2,0
2,2
2,4
2,6
2,8
3,0
3,2
hullámhossz, μm

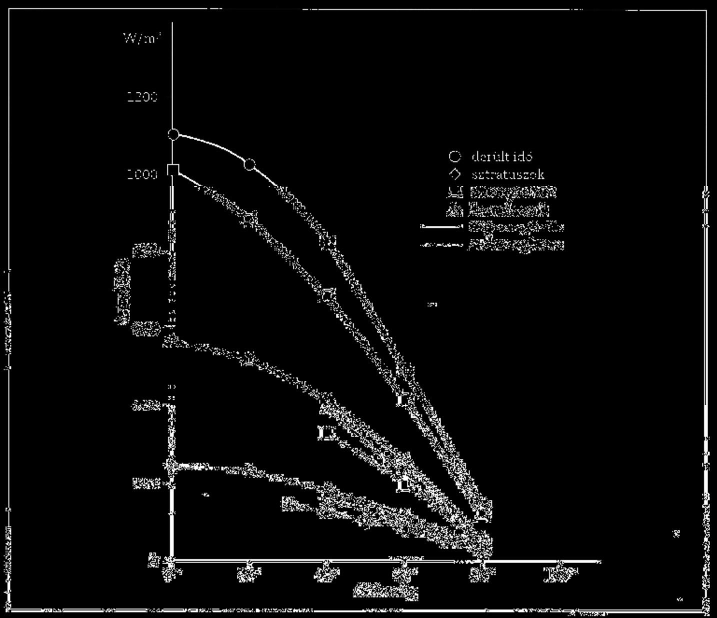
Input data (2):


Közvetlen és diffúz sugárzás modellezése
A
B
C
D

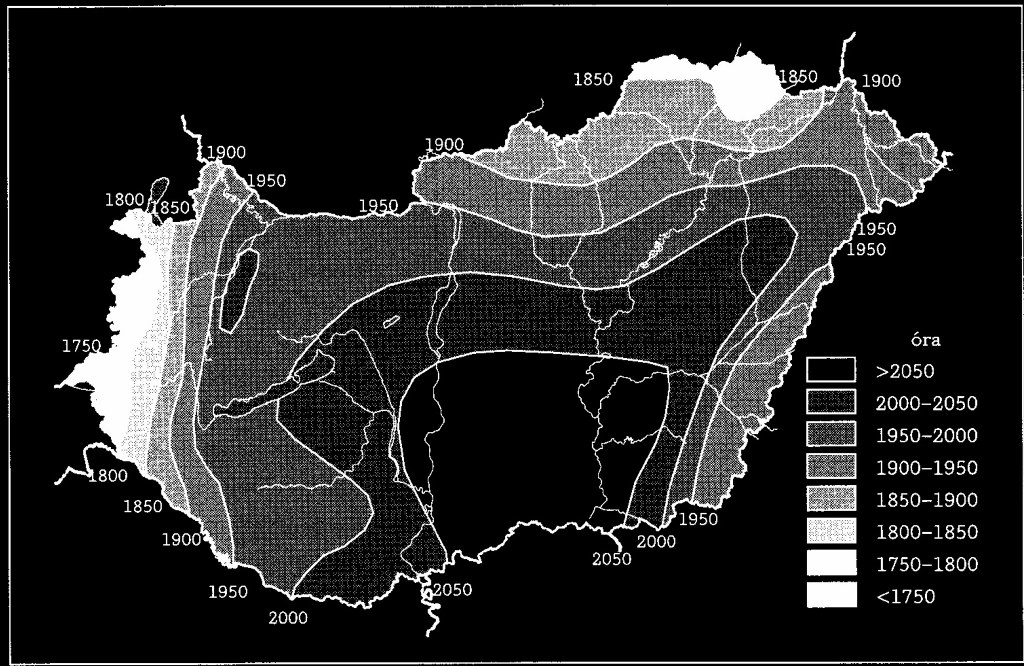

A felhőzet és a dőlésszög hatása az inszolációra
W/m²
1200
1000
derült idő
sztratuszok

Input data(3):

A felhőzet és a dőlésszög hatása az inszolációra



A napsütéstartam évi összegének területi megoszlása Magyarországon

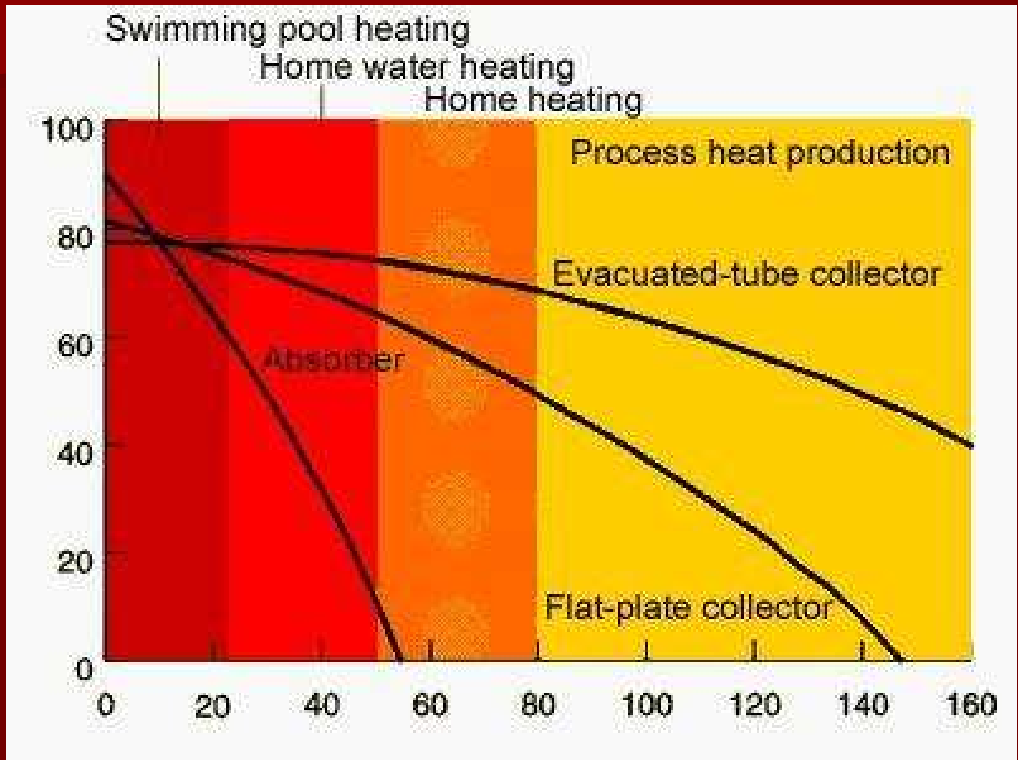


6. táblázat

Napos órák havi és évi átlaga

		Hónapok												Éves átlag
		I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	
napos órák időtartama	Budapest	55	84	137	182	230	248	274	255	197	156	67	48	1933
	Pécs	68	91	146	187	237	259	293	268	206	165	82	59	2061
energia, MJ/m^2	Budapest	111	177	330	438	598	630	650	570	421	270	121	88	4406
	Pécs	120	187	340	476	615	640	660	580	410	270	132	94	4524

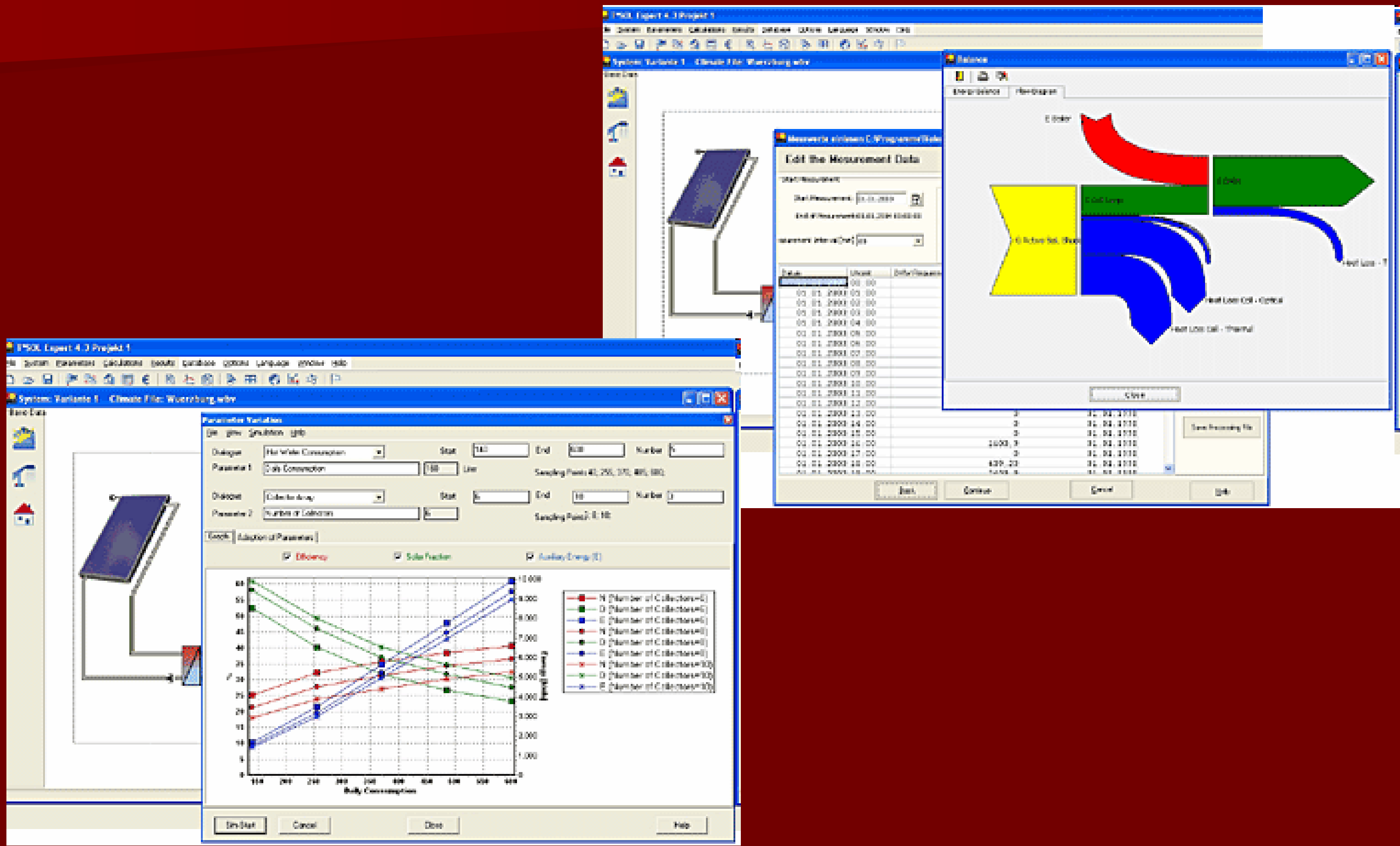
General energy efficiency



$$\eta = \eta_0 - a_1 X - I \cdot a_2 X^2$$

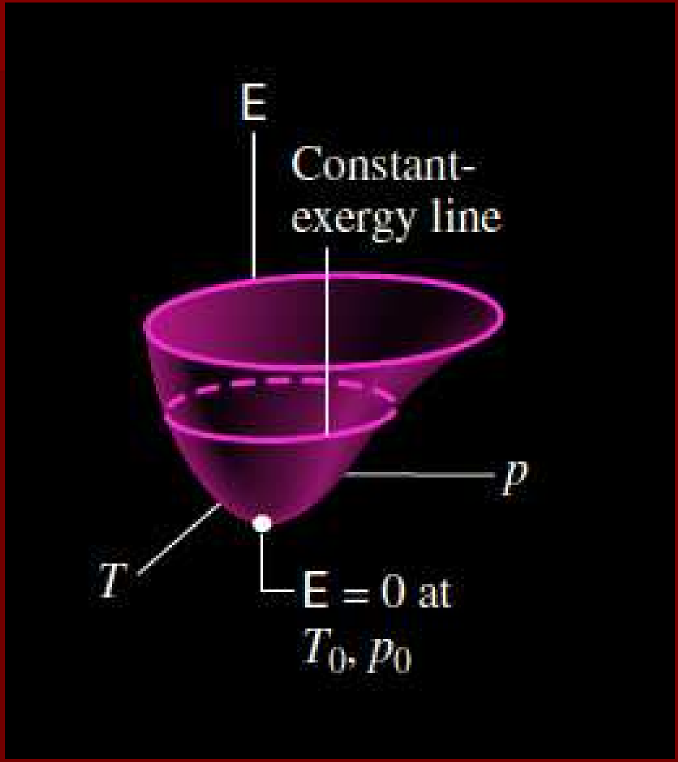
$$\eta_t = \frac{\int_{time} \dot{W}(\tau) \cdot \Delta T(\tau) \cdot d\tau}{\int_{time} A_I \cdot I(\tau) \cdot d\tau}$$

Simulation softwares



Exergy method:

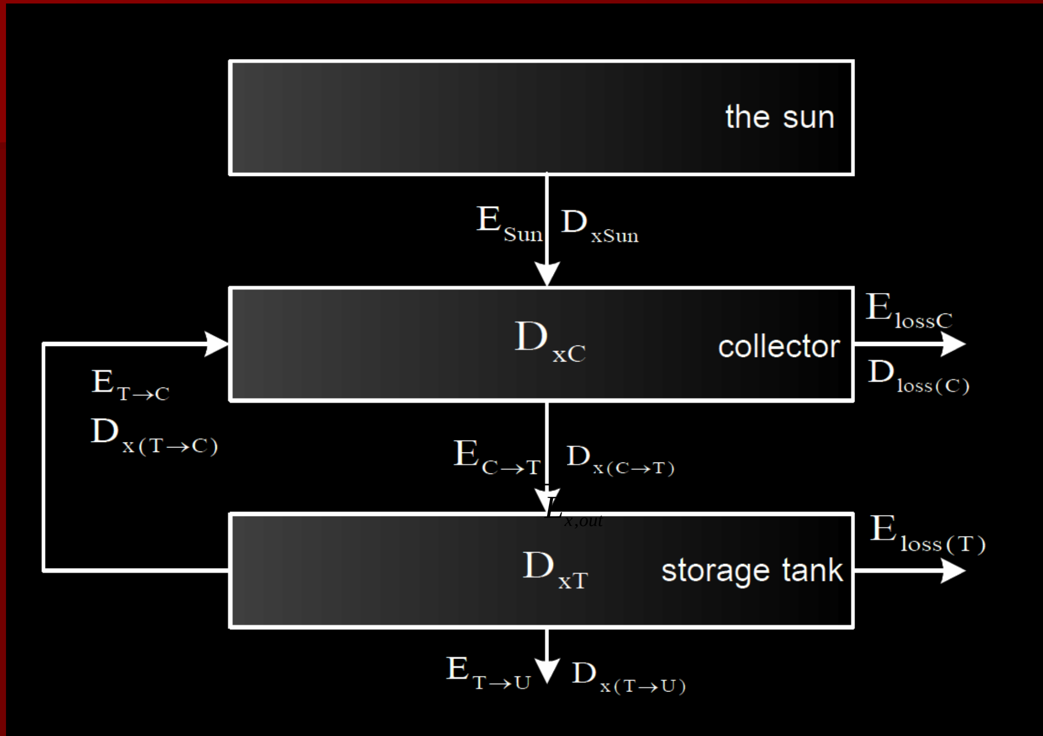
- Calculating the usable part of energy -



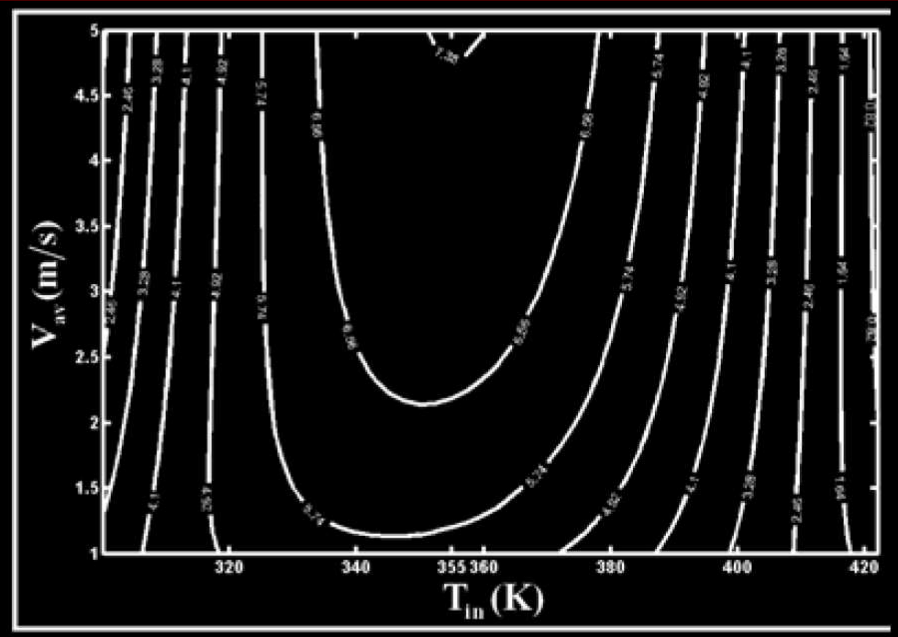
$$e = [(u + V^2/2 + gz) - u_0] + p_0(v - v_0) - T_0(s - s_0)$$

$$\begin{bmatrix} \textit{exergy} \text{ transfer} \\ \text{accompanying heat} \end{bmatrix} = \int_1^2 \left(1 - \frac{T_0}{T_b}\right) \delta Q$$

Exergy flow:



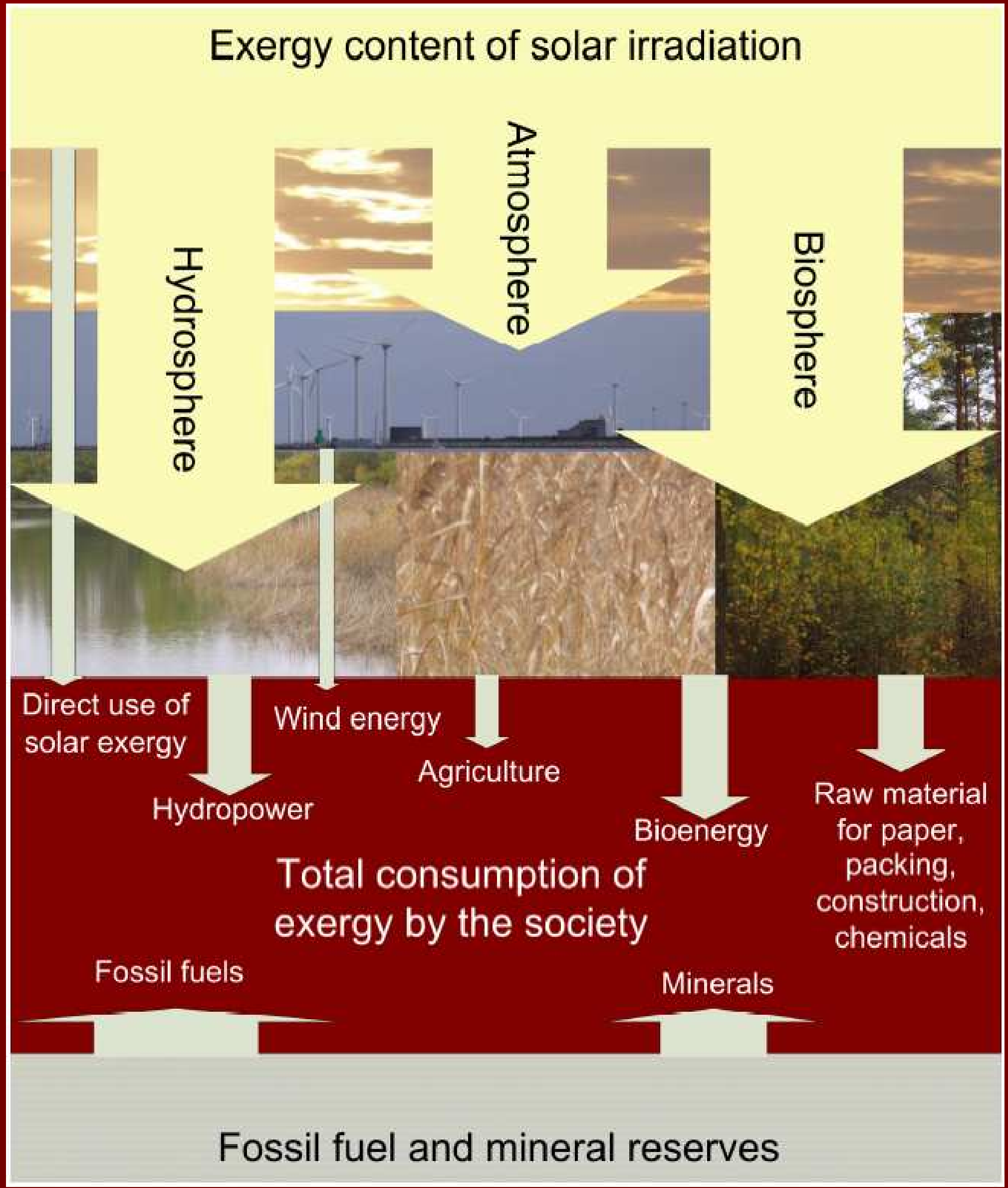
the sun
E Sun
D xSun
D xC
collector
E lossC
D loss(C)
E T→C
D x(T→C)
E C→T
D x(C→T)
D xT
storage tank
E loss(T)
E T→U
D x(T→U)



Exergy efficiency contour according to average air velocity and fluid inlet

$$\eta_E = 1 - \left\{ \left(1 - \eta_o\right) + \frac{\eta_o T_a \left(1/T_p - 1/T_s\right)}{\left(1 - T_a/T_s\right)} + \frac{U_l (T_p - T_a)\left(1 - T_a/T_p\right)}{I_T\left(1 - T_a/T_s\right)} + \frac{\dot{m} \Delta P T_a}{\rho T_m I_T A_p \left(1 - T_a/T_s\right)} + \frac{\eta_{th} T_a \left(1/T_m - 1/T_p\right)}{\left(1 - T_a/T_s\right)} \right\}$$

„Think about destroying exergy during using energy”



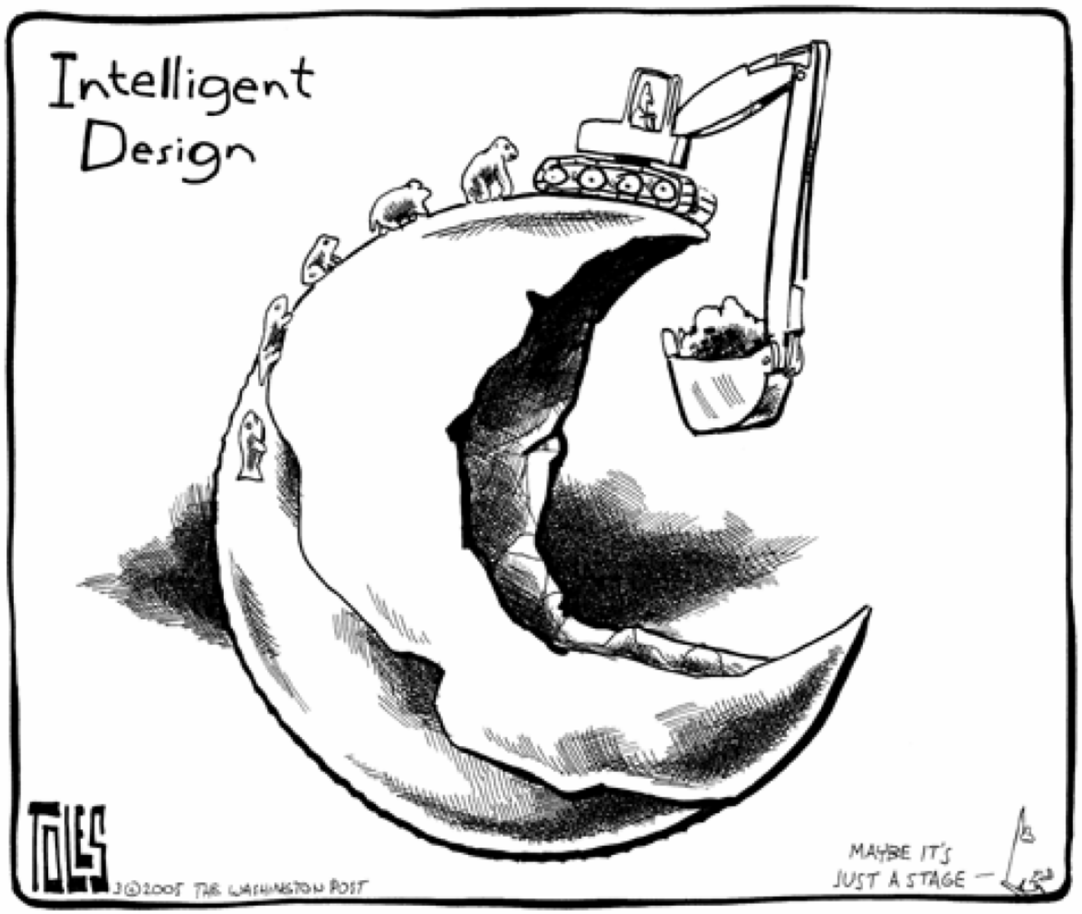
The *performance of a solar heating system* depends on

- ✓ the local climatic conditions
- ✓ the collector area and type

  the overall annual performance of a solar system is technically limited by the amount of energy that can be collected during the winter time. Improvements in collector design can also have a significant effect on the overall system performance.

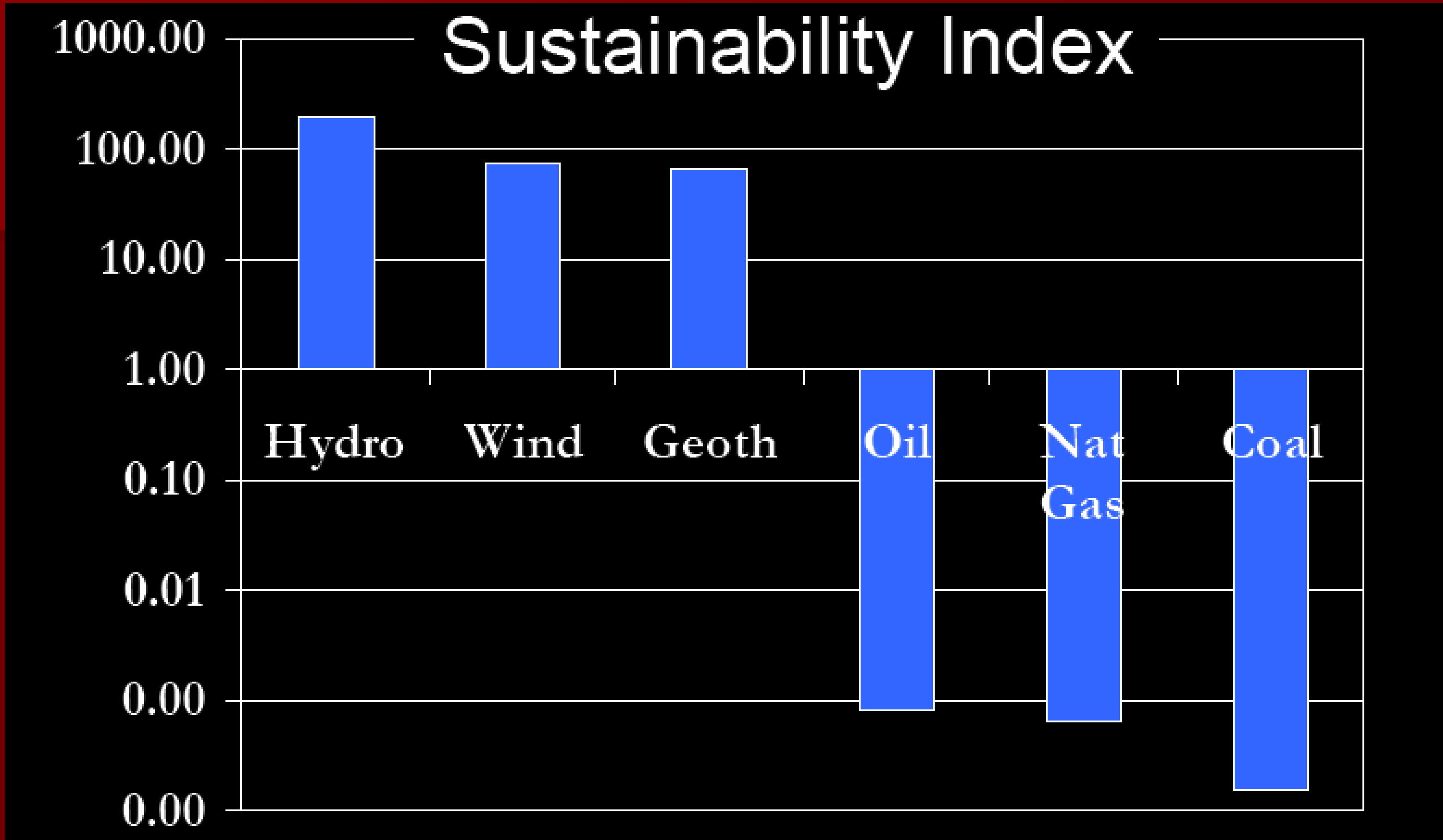
- ✓ the temperature levels

  the *delivery temperature* and the *cold water supply temperature*.



Washington Post, **March 30, 2005**

Thank you for attention!



$$\text{Sustainability Index} = \frac{\text{Return on Exergetic Investment}}{\text{Environmental load}}$$