SOLAR ENERGY FOR EVERYONE

Light : "Let there be light"

Different thoughtmodels
for the phenomenon :

The POOL-BALL theory (Newton)
The VIBRATION theory (Huygens)
The ELECTRIC EEL theory (Planck, Einstein)
The CONSCIOUSNESS theory (Hills, Eastern Philosophies)

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Energy : The stuff that makes things change

The PRINCIPLE OF ENERGY : The sum of all changes is constant

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Heat : Different thoughtmodels
for the phenomenon :

The FLUID theory : Heat is a kind of FLUID
The ENERGY theory : Heat is a kind of ENERGY

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Optics : The art of changing the direction of light by :

Bending it (Refraction) → Lenses
Bouncing it (Reflection) → Mirrors

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Mathematics: **Geometrical Optics:**

2 dimensional mathematical model
pointfocus
conic sections

can be expanded to 3 dimensions in TWO ways:

Rotation: spherical optics

Translation: cylindrical optics

Physics: The understanding of your relationship to reality leads to the knowledge of how to manipulate it e.g.

Practics: How to gather your own energy:

The Pointcollector: a source of power

The Linecollector: a source of heat

How and "how much" they work and how you can build them

Astronomy: Geocentric worldviews

Hipparchus
Ptolemy

Heliocentric worldviews

Aristarkus
Kopernicus
Galilei

Solar Navigation: How to keep your collector aimed at the sun

1. all day (the daily cycle)
2. all year (the yearly cycle)

Storage: How to store the collected heat

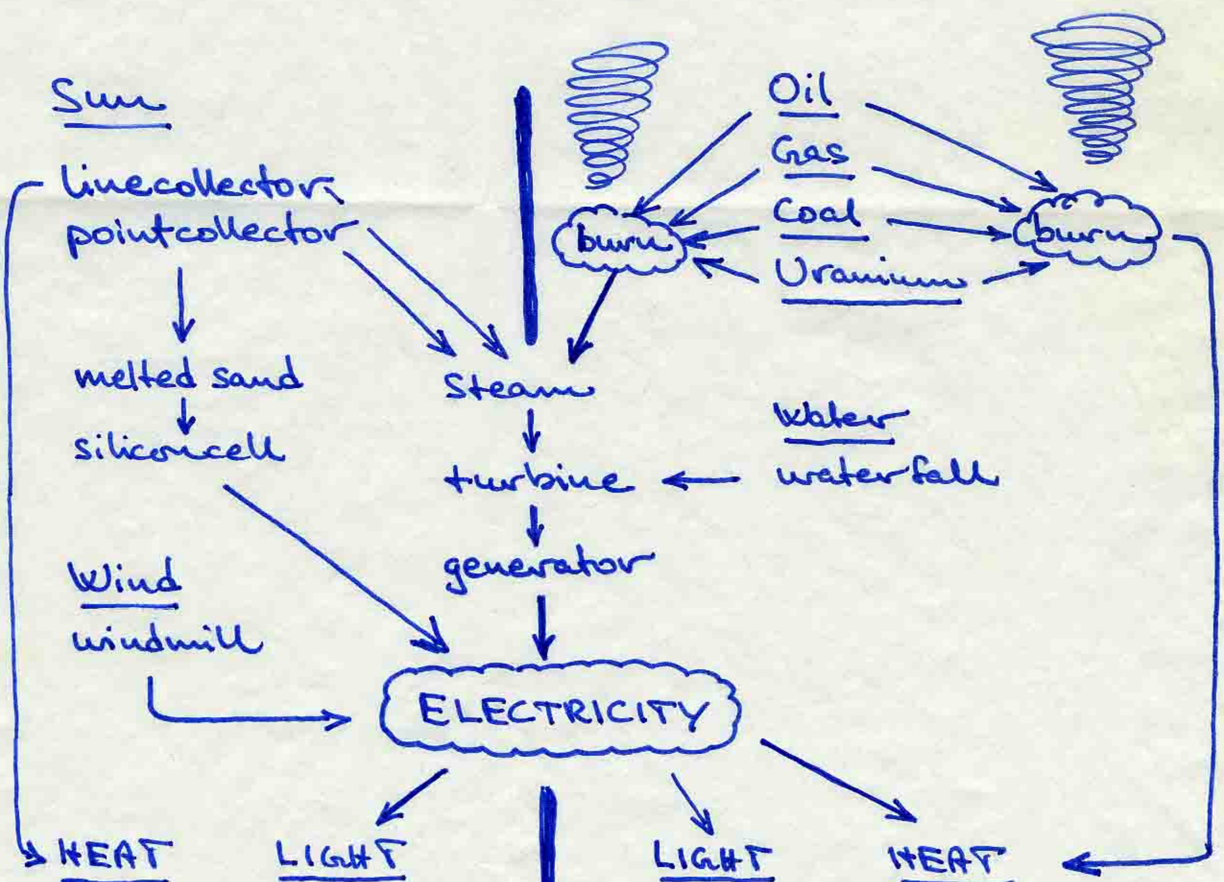
Storage capacity proportional to specific heat and volume

conduction loss proportional to thermal conductivity and surface area

storage time $\sim \frac{1}{\text{conduction loss}}$

The big HEATHOLE in the ground

Electricity: Different ways of making it:



Localized system

The energy is generated at the place where it is used

NO POWERLINES
NO OILTANKERS
NO STRIPMINES
ECOLOGIC

Centralized system

Global transportation of energy and material is necessary

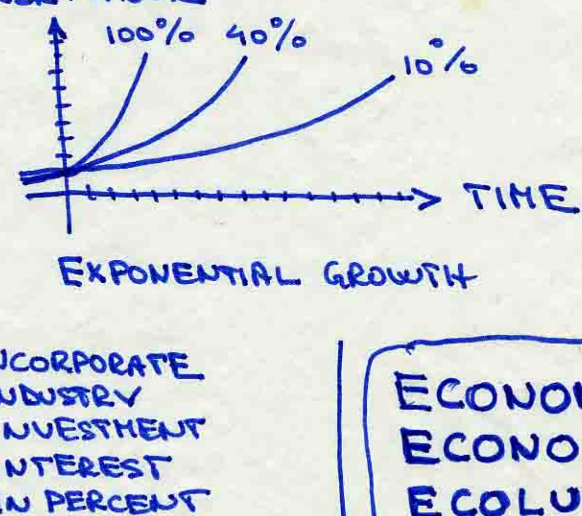
POWERLINES
OILTANKERS
STRIPMINES
ECONOMIC

"The Energy Problem": The choice between two different relationships to reality :

ECOLOGIC	ECONOMIC
DIRECT RELATIONSHIP	INDIRECT RELATIONSHIP
Man as a creator of his environment	Man as a consumer of his environment
FOOD CLOTHES SHELTER TRANSPORTATION	FOOD CLOTHES SHELTER TRANSPORTATION
Creative energy is measured in	Consumptive energy is measured in
SKILLS FAVOURS (FRIENDSHIPS) INFORMATION (SHARING) JOY	MONEY PRODUCTS PATENTS (SECRETS) PROFIT

Money : PRODUCE
PRODUBBLE WITH CONSTANT SPEED
PROFIT
PROFESSION
PROGRESS
PROPAGANDA
PROMOTION
PRODUCTIVITY
PROPERTY
PROSPERITY
PRODIGALITY
PROFANITY
PROFLIGACY
PROMISCUITY
PROSTITUTION
PROLIFERATE
PROBLEMS

CAPITAL
CANCER
CATASTROPHE



EXPONENTIAL GROWTH

INCORPORATE
INDUSTRY
INVESTMENT
INTEREST
IN PERCENT
INCREASE
INFLATION

Nomenclature

A = collector area, m^2

φ = declination of the sun (degrees)

Λ = geographical latitude (— " —)

Θ = sunrise hour angle (— " —) (true solar time)

m_h = relative optical air mass

m = optical air mass

p = atmospheric pressure (millibars) ($1\ mb = 10^3\ dyne/cm^2$)

G = total insolation on a surface perpendicular to the sunrays (W/m^2)

F_λ = spectral correction factor for silicon solar cells

ϕ = angle with x-axis of normal to horizontal surface element

K = time angle from solar noon

ξ_S = angle of south facing flat collector with horizontal surface

Π = angle with X-axis of normal to tilted collector surface

λ = angle between actual latitude and optimum latitude for given declination and collector angle ξ

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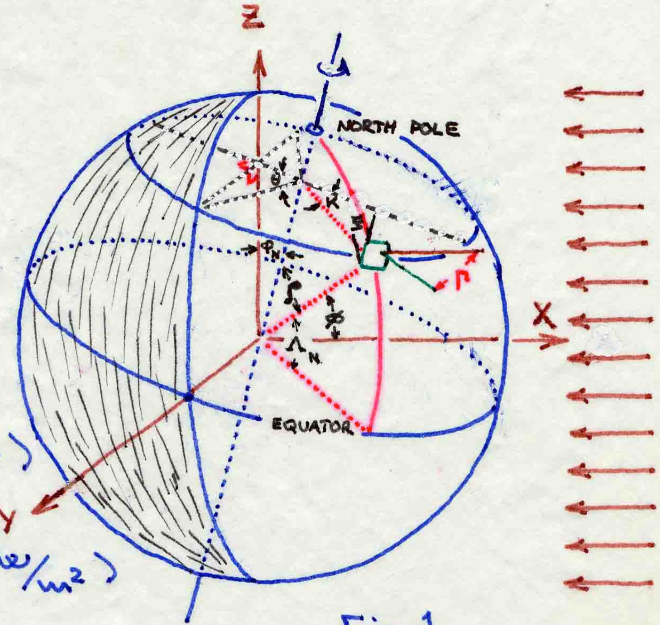

Fig. 1

P = power (watts)

I = current output (amperes)

V = voltage output (volts)

Q = charge (ampere-hours)

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SUBSCRIPTS

N = north

S = south

Opt = Optimum

Max = Maximum

EQUATIONS

$$\varrho = \frac{\pi}{2} - \Lambda_N = \frac{\pi}{2} + \Lambda_S \quad (1)$$

$$m = 10^{-3}\, p\, m_h \quad (2)$$

$$\Lambda_{N_{opt}} = \varphi_N + \xi_S \quad (3)$$

$$\Lambda_{S_{opt}} = \varphi_S + \xi_N \quad (3)$$

$$\Lambda_{opt} - \Lambda = \lambda \quad (4)$$

$$\cos\phi = \cos\varrho \sin\varphi + \sin\varrho \cos\varphi \cos K \quad (5)$$

$$\cos\phi_{max} = \cos\varrho \sin\varphi + \sin\varrho \cos\varphi \quad (6)$$

$$\cos\Theta = \tan\varphi / \tan\varrho \quad (7)$$

$$\cos\Pi = \cos(\varrho+\xi)\sin\varphi + \sin(\varrho+\xi)\cos\varphi\cos K \quad (8)$$

$$\cos\Pi_{max} = \cos(\varrho+\xi)\sin\varphi + \sin(\varrho+\xi)\cos\varphi \quad (9)$$

The power input on a horizontal collector of area A is given at any moment by the equation

$$P_{in} = AG \cos \phi \qquad (10)$$

and for a collector facing south and making an angle of ξ with the horizontal by the equation

$$P_{in} = AG \cos \Gamma \qquad (11)$$

Equations (5) and (8) give us ϕ and Γ as functions of S, φ and K. Equation (1) gives the relation between S and the latitude and figure 2 gives the solar declination φ for each month throughout the year

n.s

Both $\cos \phi$ and $\cos \Gamma$ will reach their maximum at solar noon (i.e. for K = 0)

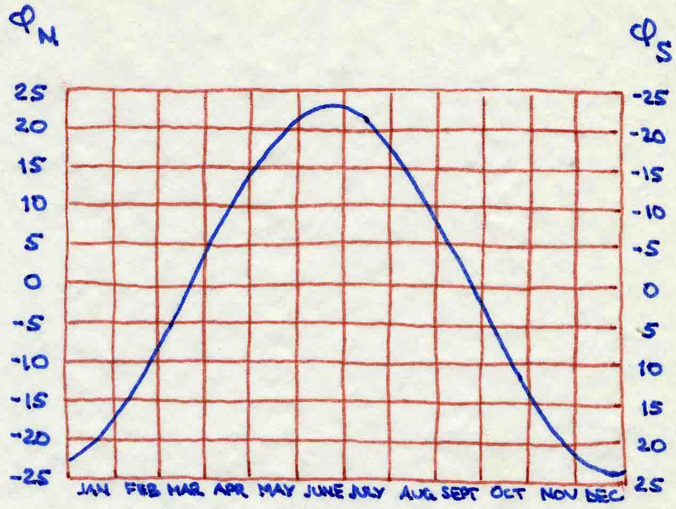

Fig. 2 : Solar declination as a function of date for Northern and Southern Hemisphere

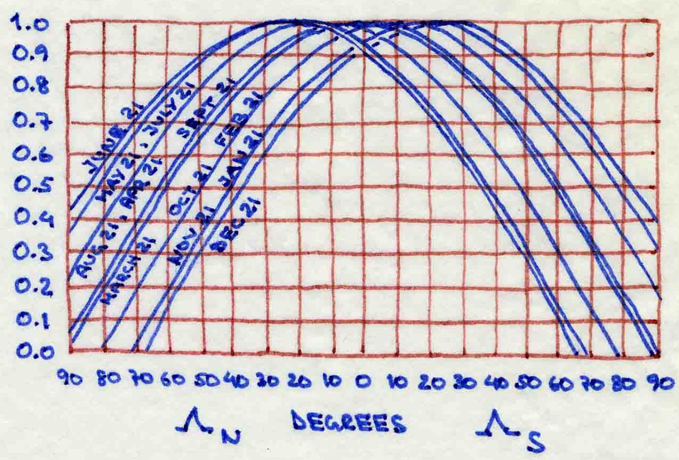

Fig. 3 : $\cos \phi_{max}$ as a function of latitude for Northern and Southern Hemisph. with the 21st of each month as parameter

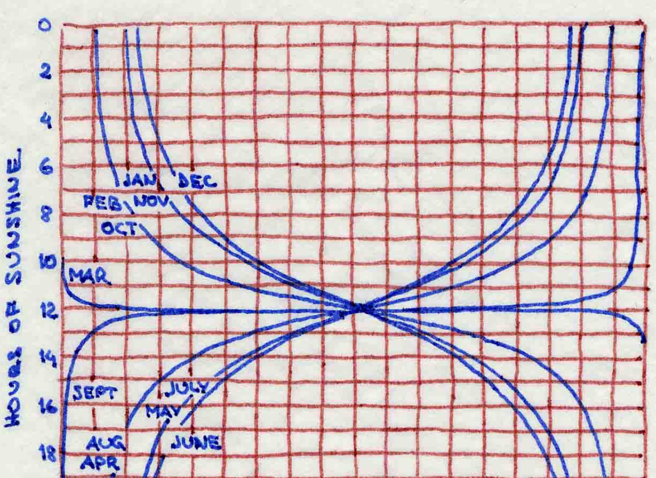

Fig. 4 : Hours of sunshine per day for clear days as a function of latitude with the 21st of each month as parameter

From Fig. 3 and Fig. 4
you can make a fast determination
of the relative magnitude
of the insolation
on a horizontal surface
at any part of the globe

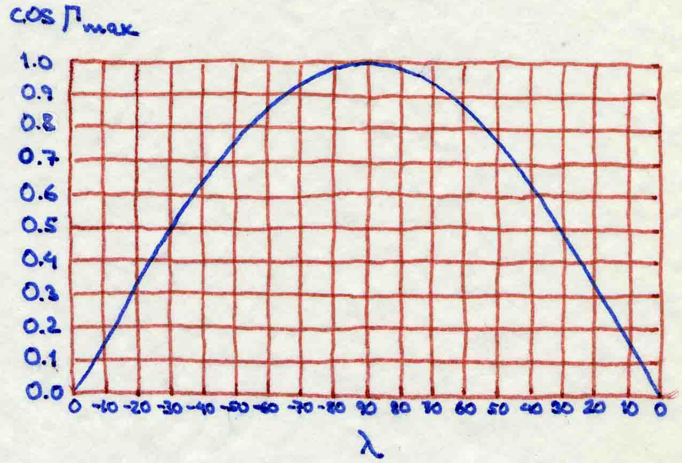

Fig. 5: cos Γ_{max} as a function of λ

cos Γ_{max}
cannot conveniently be represented
in the same way
since this would require
one graph for each angle ξ

Therefore
cos Γ_{max} is shown in fig. 5
as a function of λ
which is defined by eqs. (3) and (4)

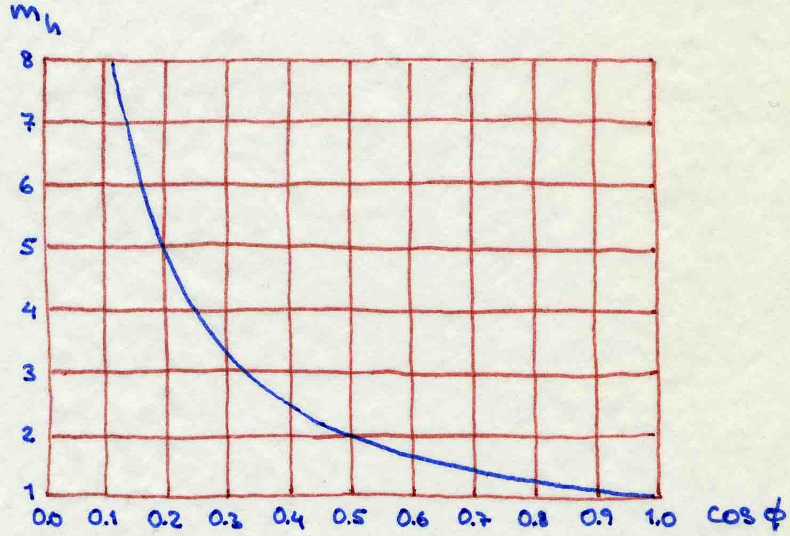

Fig. 6: Relative optical air mass (m_h) versus cos ϕ

The insolation intensity G
is not constant
but varies with the length of path
in the atmosphere
through which the sun rays must pass
i.e. the optical air mass

The relative optical air mass (m_h)
is a function of cos ϕ
which is shown in fig. 6

The optical air mass (m)
is a function of height
above sea level
and thus atmospheric pressure

It can be determined
from the relative optical air mass
using eq. (2)

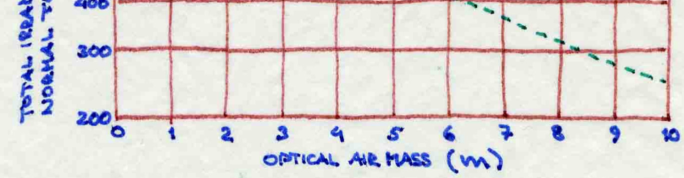

Fig. 7: Total insolation (G)
on a surface perpendicular to the sun's rays
and same insolation corrected for silicon solar cell
relative spectral response
as a function of optical air mass