Pädagogische Hochschule Wien

ENERGY - ENVIRONMENT

H.FIBI/I.HANTSCHK

Intensiv Program EFEU LLP/AT-230/22/08

ΓΔ Εκπαίδευση και πολιτισμός

GD Bildung und Kultur

OStR. Mag.rer.nat. Hans Fibi & Prof. Ingrid Hantschk
University of Education Vienna
Grenzackerstraße 18
1100 Vienna
Austria
Phone: +436643833955
e-mail: Hans210347@a1.net or johann.fibi@phwien.ac.at

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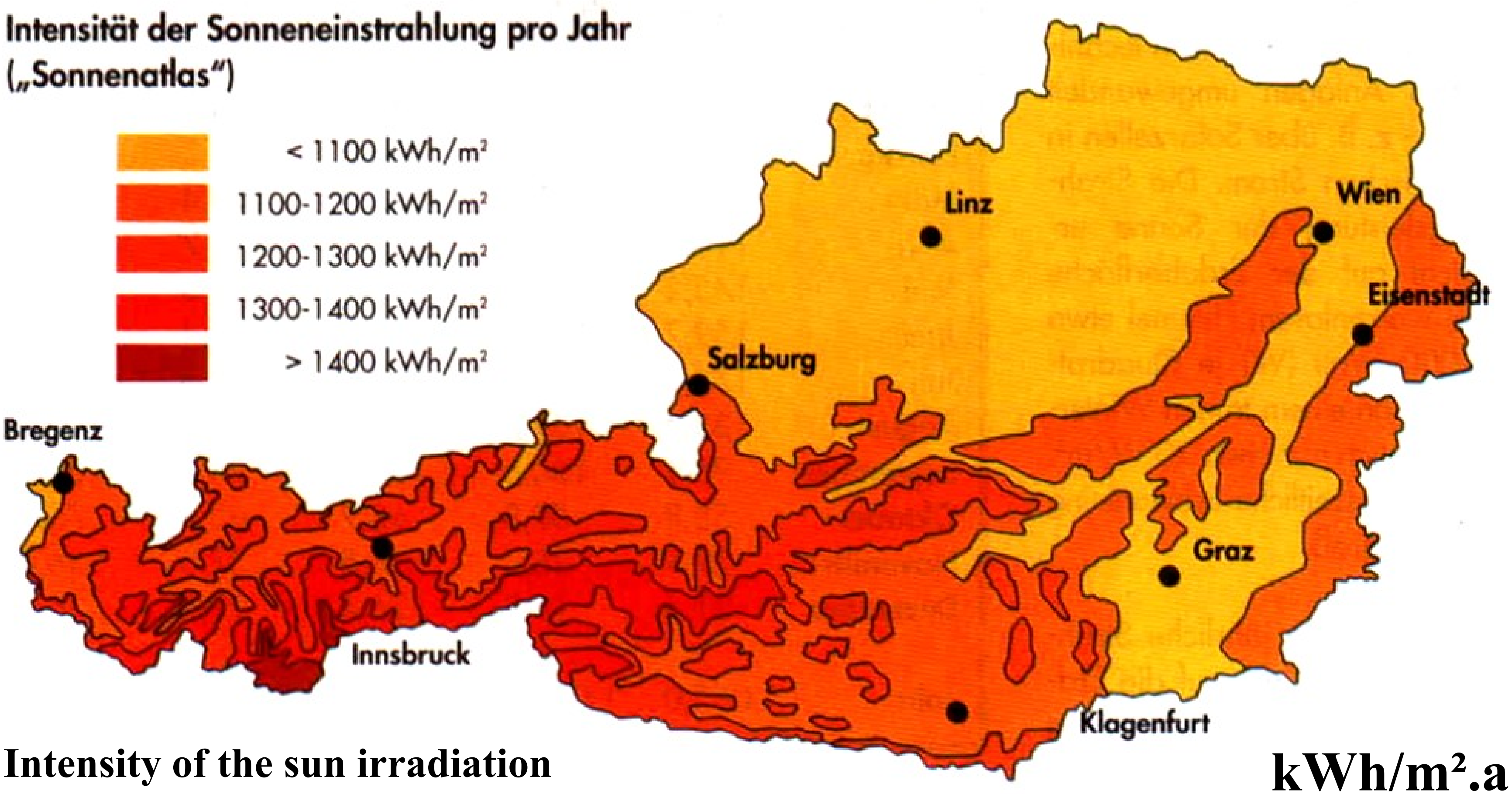
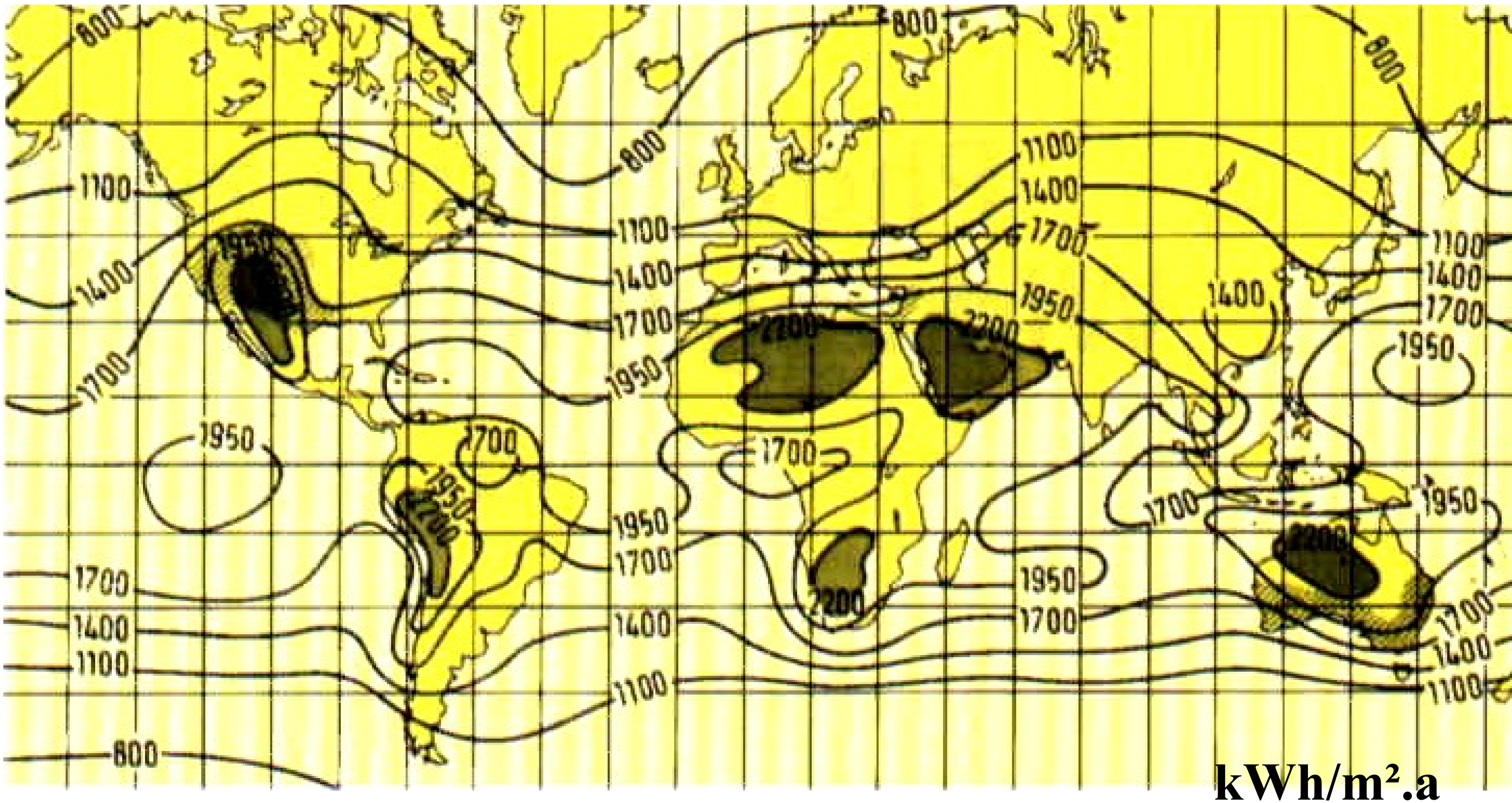
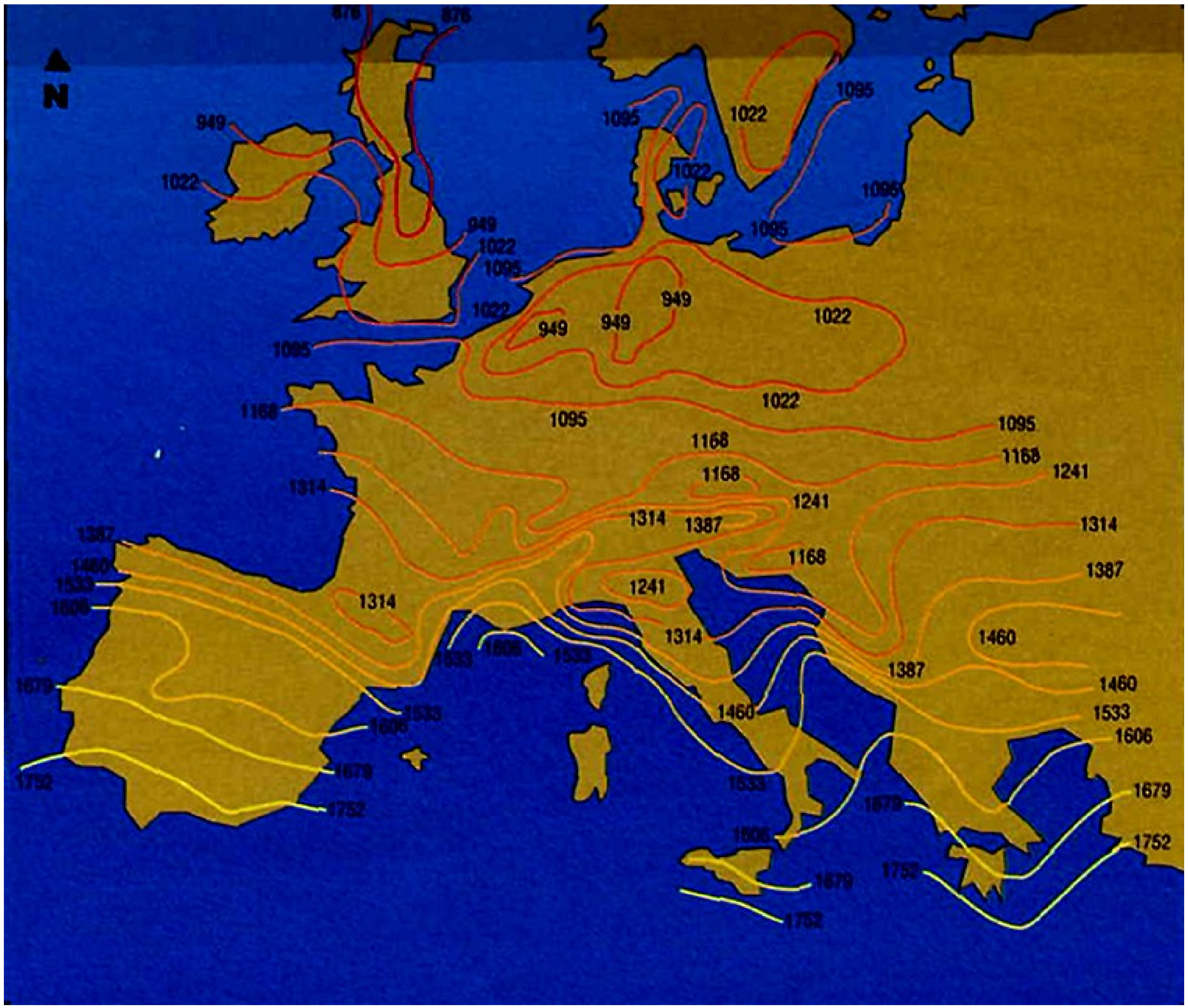


Intensity of the sun irradiation in Austria (yearly)

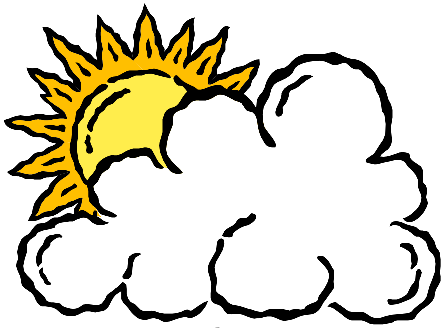
kWh/m².a


800
1100
1400
1700
1950
2200
kWh/m².a



North UK:
876 kWh/m².a
South Spain, Portugal:
1752 kWh/m².a
Compare to Sahara:
2200 kWh/m².a

Estimate – what do you need ?



Energy from the Sun
1 MWh/a.m^2

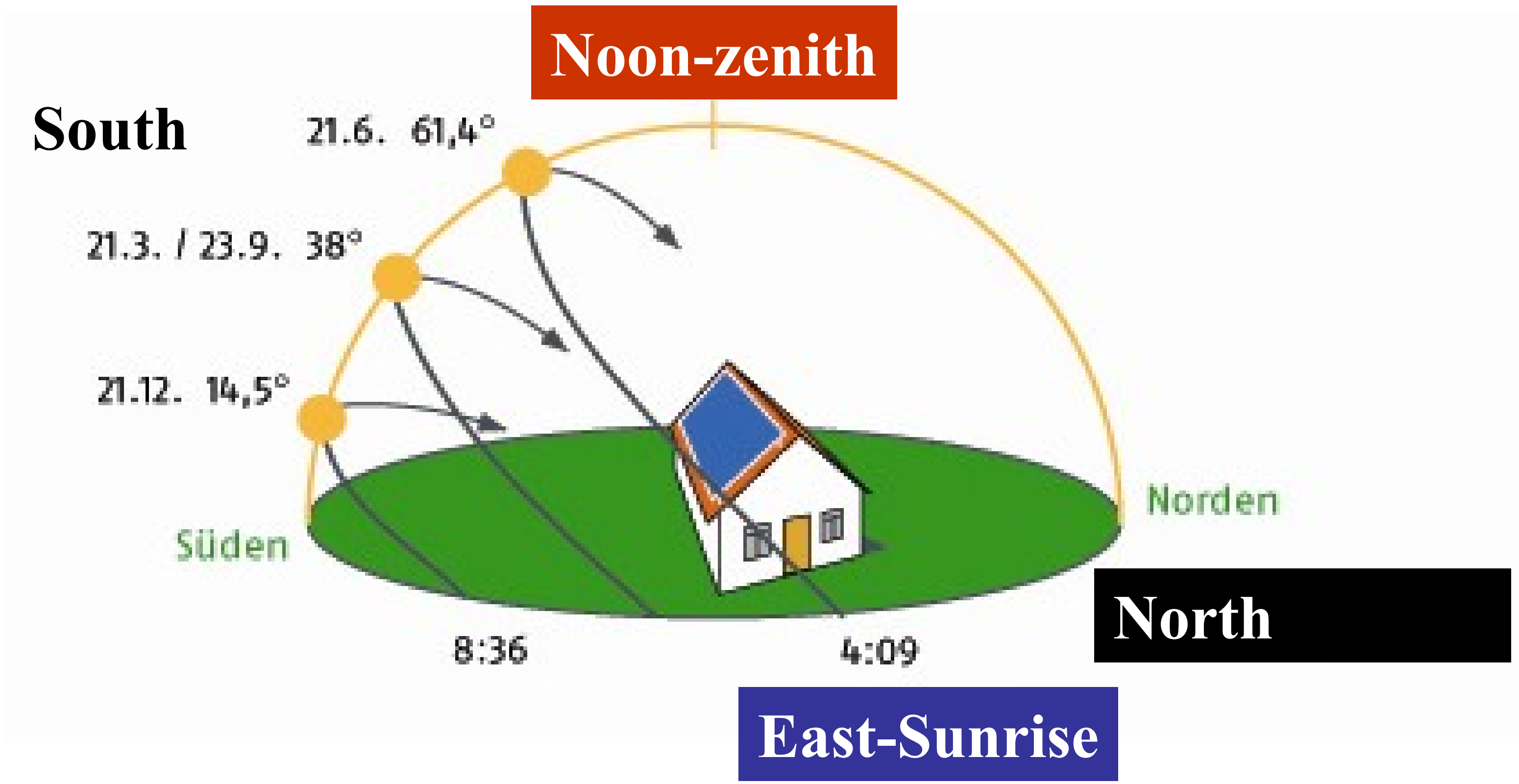
Solar Cell: η = 0,1 / Transfer η = 0,7 / Total η = 0,07

Energetic Output: 70 kWh/m².a
2,7 kWh/m².d

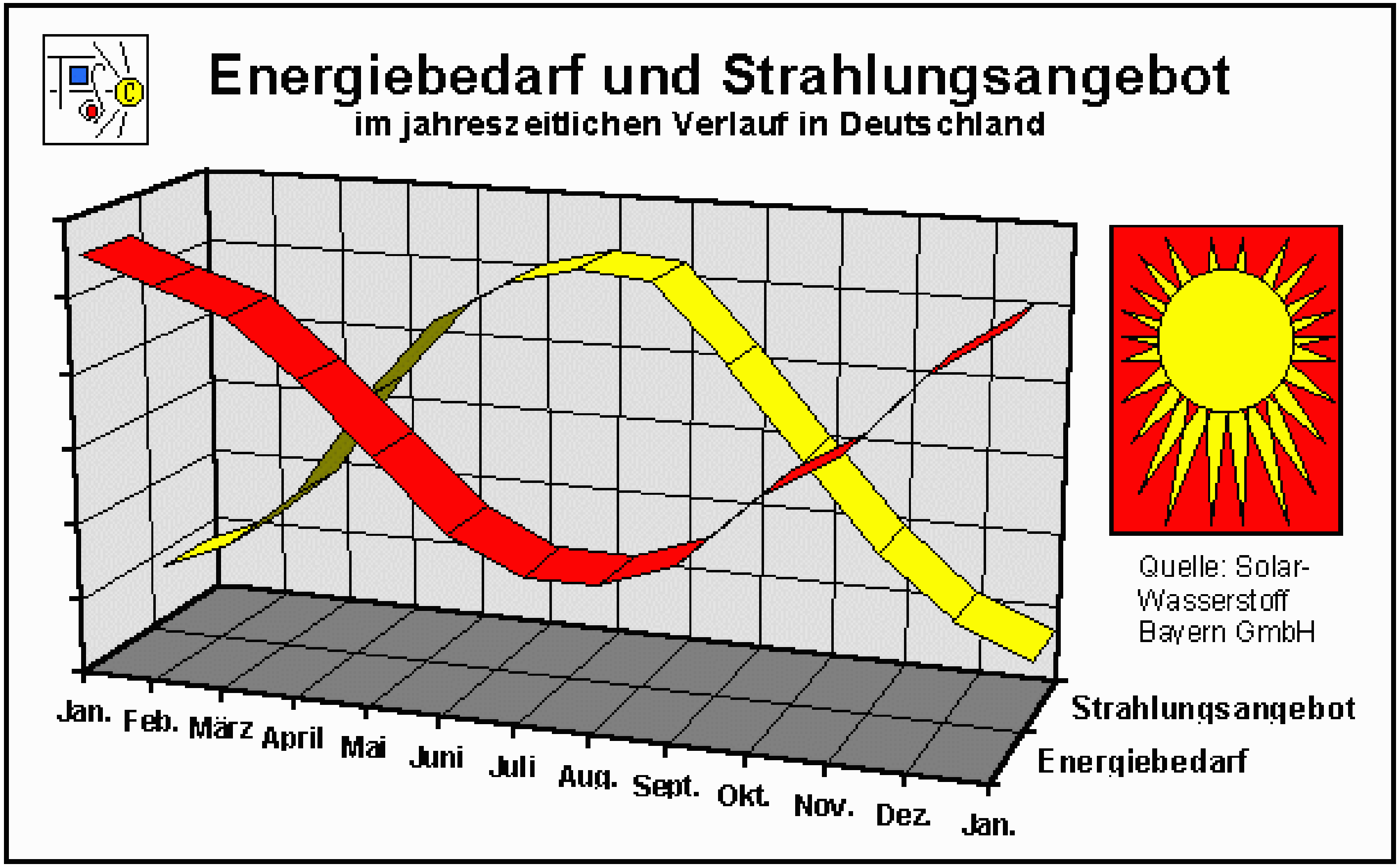
Summer up to 10 kWh/m².d

Winter: 150 Wh/m².d

Solar Cells on the Roof

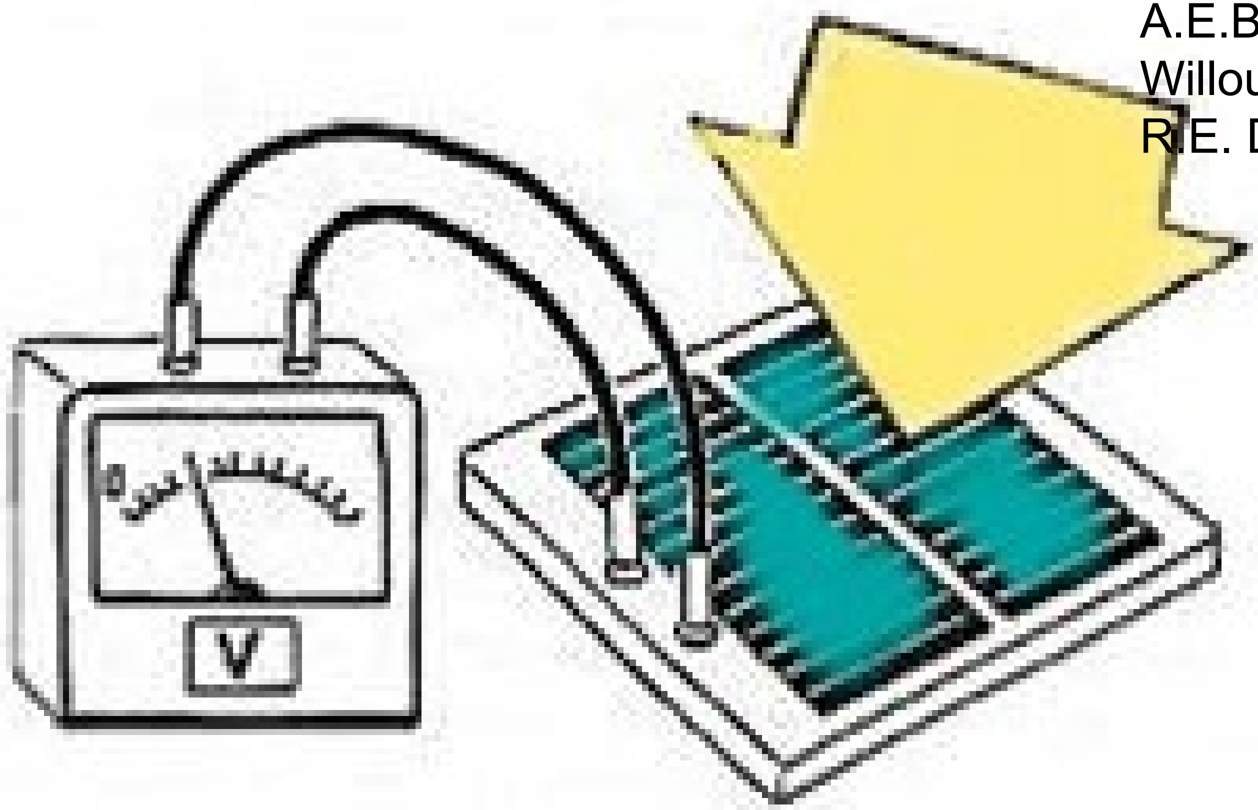


Energy Demand versus Offer of Irradiation



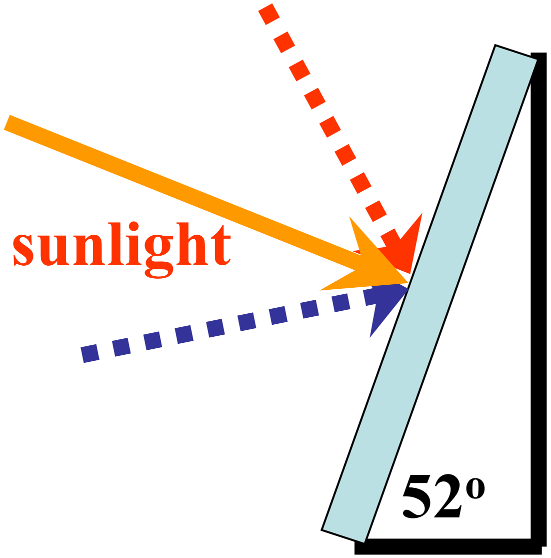
Offer
Demand

Photovoltaics – nothing new



Photovoltaischer Effekt
Photovoltaic Effect
A.E.Becquerel 1839
Willoughby Smith 1873
R.E. Day/W.G.Adams 1875

Estimate – what do you need ?



two maxima of power spring and autumn

because of shadowing: area increases by factor 6,5

For ensuring a safe power supply: use the factor 3 times !

Estimate – what do you need ?

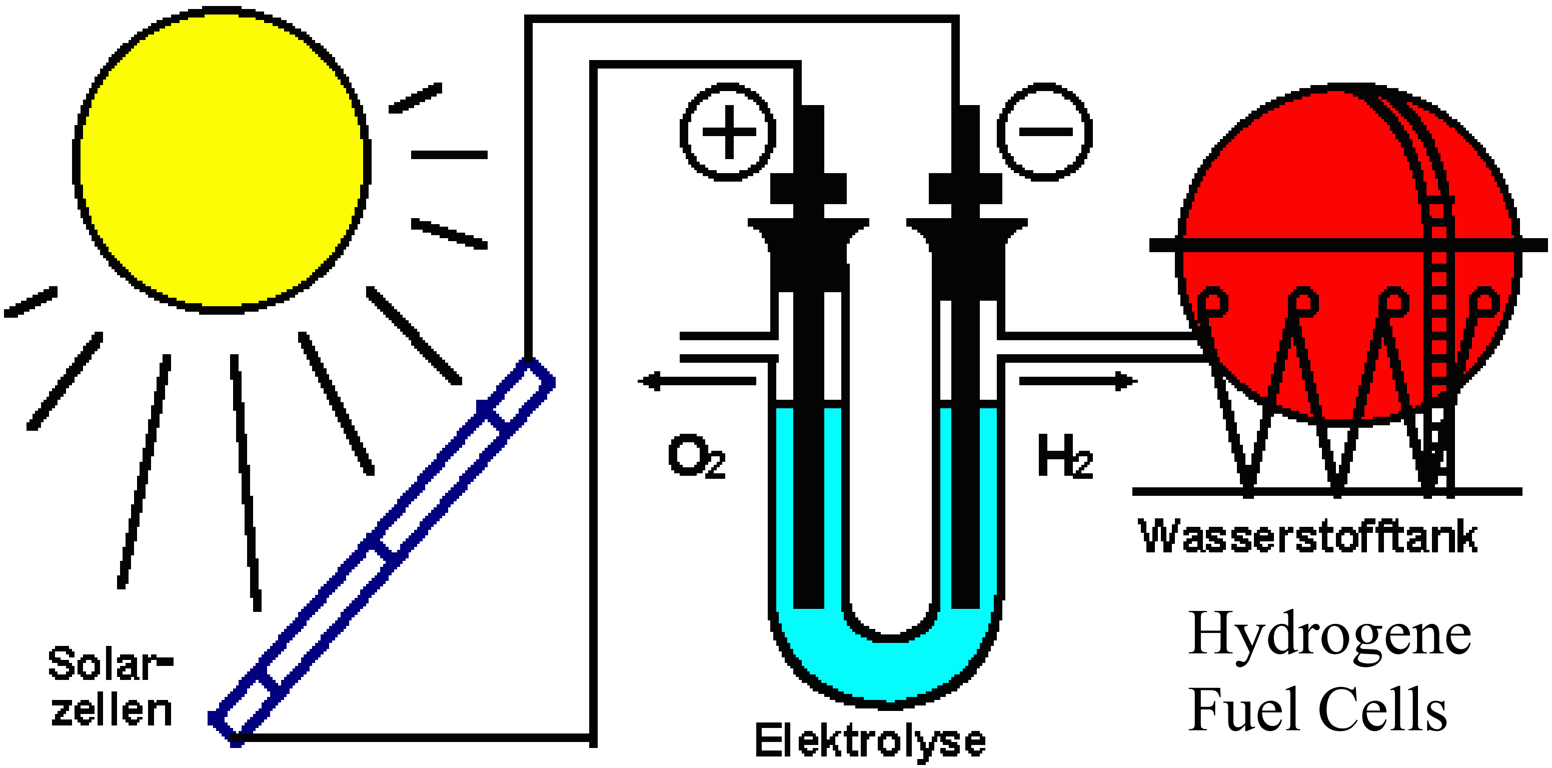
Solar Cells on the Roof

SOLAR CELLS on the ROOF

Optimized Position of the Roof:
Direction to the south
Inclination: 30 °

If the direction shows to South-West with a slope of 50 °:
you need 10 % more exposed area

Storage of Energy



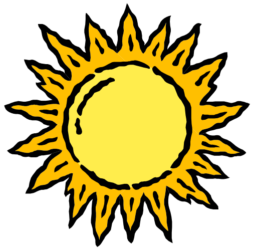
Hydrogene
Fuel Cells

Solar Cells

Electrolysis

Substitution of Mineral Oil by Hydrogene

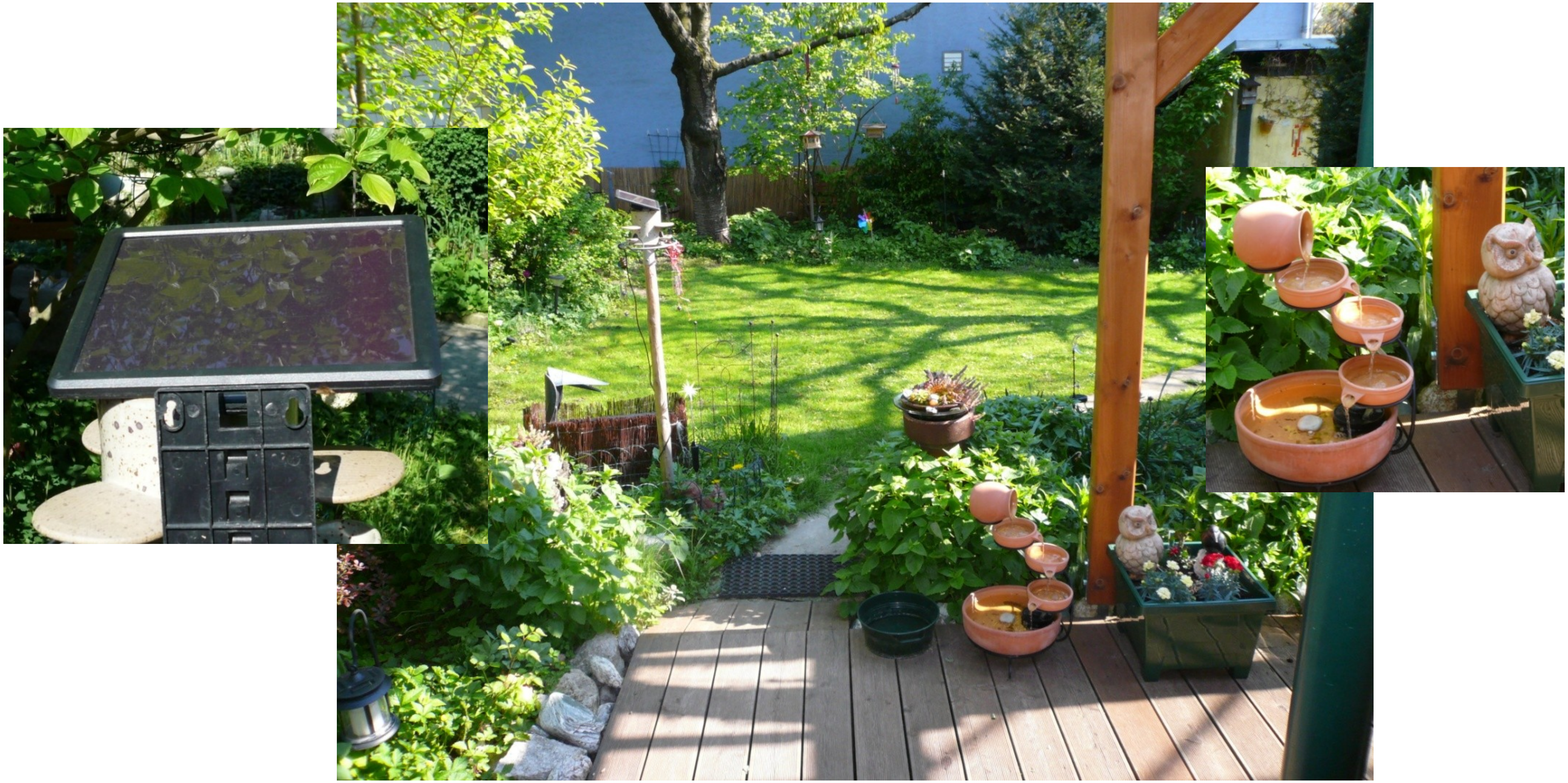
1 kg mineral oil.......12 kWh energetic equivalent
Equivalent for 10 kg mineral oil a day:
120 kWh



Efficiency of electrolysis / hydrogene: 70%
$\eta = 0,7$
12 kWh : 0,7 = 17 kWh „hydrogene equivalent“
for substituting 10 kg mineral oil by hydrogene
you need 170 kWh.

Production per day:
Solar Energy: 2,7 kWh/m².d
By this:
170 kWh/d : 2,7 kWh/m².d = 63 m²
For Safety: 189 m²
Length of a square: 14 m Solar Cells

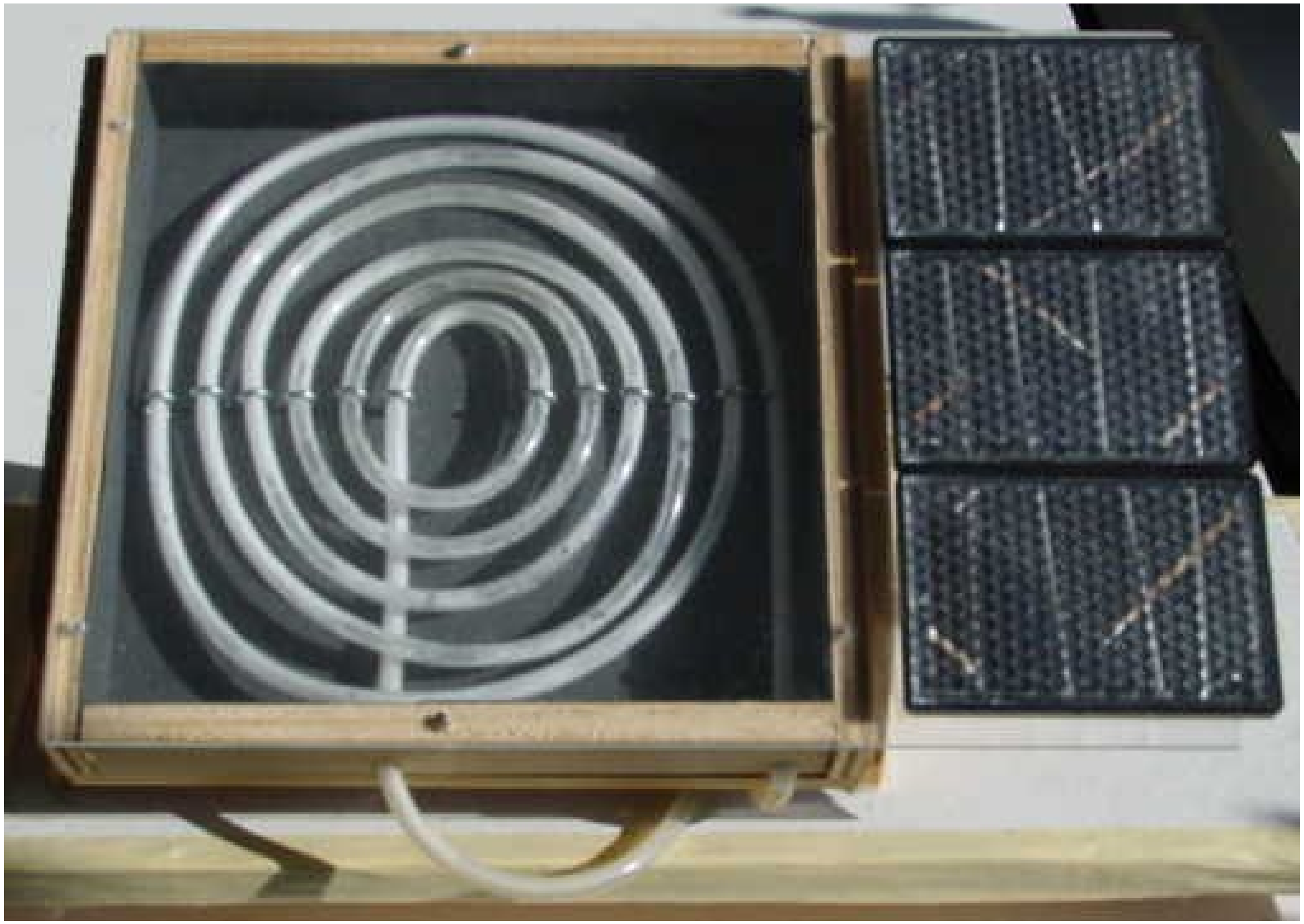
Solar Cell Devices



Solar Cell Devices

Solar Cell Devices

Experiment



Solar Cells run a pump – the pump forces water through the pipe.
The wooden case is covered by a glass plate
➔ Model of a flat panel.

Photovoltaics

Die stromaufwärts Photovoltaik GmbH sorgt für hauseigenen Solarstrom.

Hausfassaden belegt
mit Solarzellen.....

Photovoltaics

Quelle: Kurier 2008-04-20

Lärmschutzwand an der Autobahn

Loser Photovoltaic Power Station

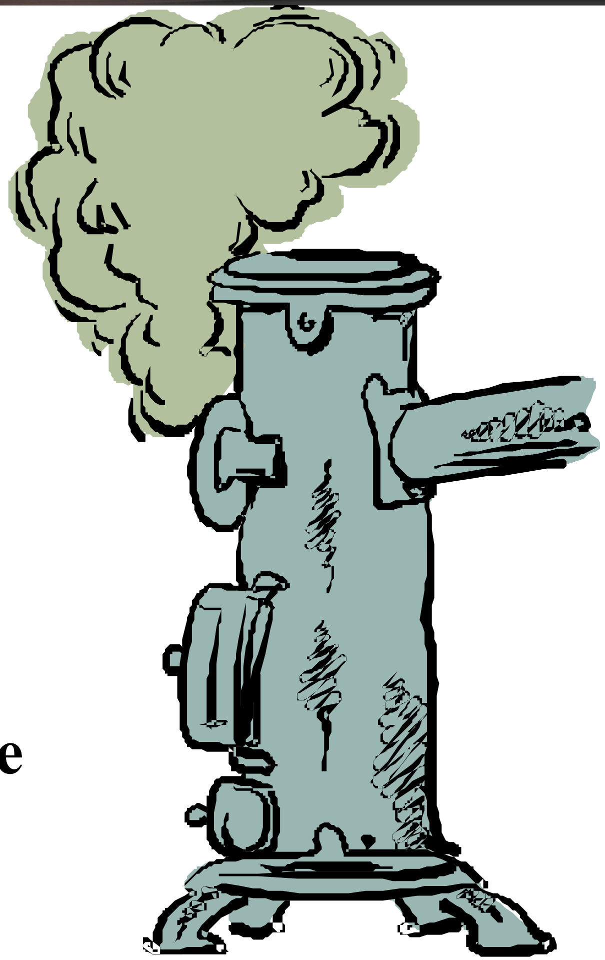
Sun Power Station Loser, 40 kW
Foto: Verbund

Energy in Austria 2006

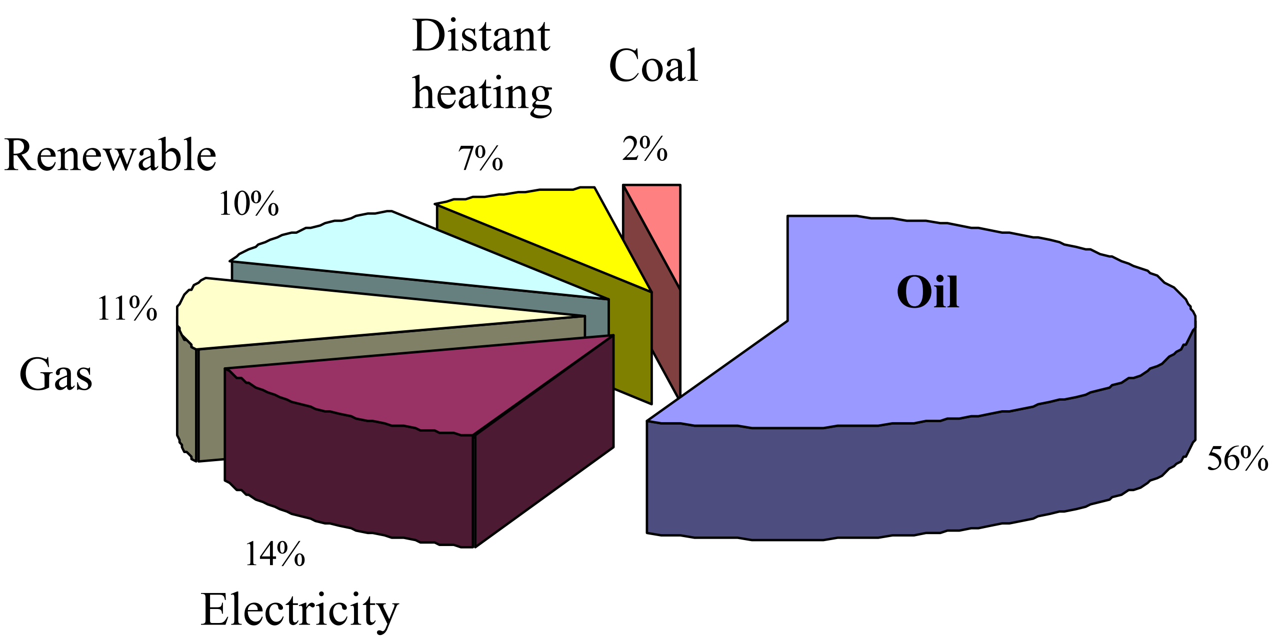
Österreich (Austria) 2006:

Gesamtenergieverbrauch
1 092 767 TJ = 1,092 EJ

- **56% Ölprodukte**
- **14% Strom**
- **11% Gas**
- **10% erneuerbare Formen der Energie**
- **7% Fernwärme**
- **2% Kohle**



Quelle: Statistik Austria



Renewables In Austria:

1. Water
2. Wind
3. Sewage Plants
4. Flat Panels
5. Photovoltaic
6. Biomass
7. Waste (?)
8. Others

www.ipcc.ch
www.ucar.edu/news/features/climatechange/regionalimpacts/jsp

Energy in Austria 2006

Germany

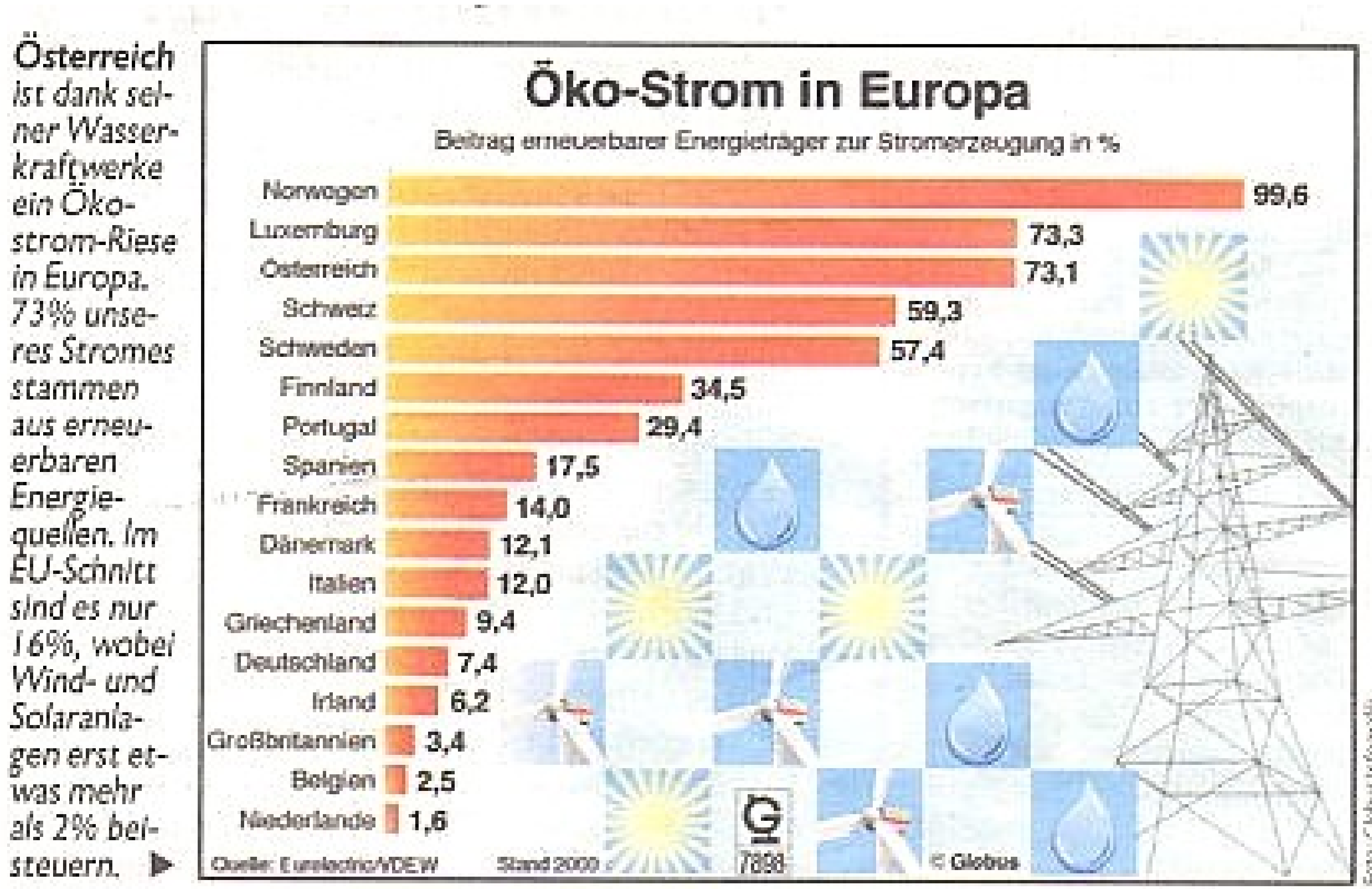
Photovoltaics
Installed in Germany till 2007: 3,8 GW
installation 2004: 0,6 GW
installation 2005: 0,85 GW
installation 2006: 0,85 GW
new installation 2007: 1,1 GW

Flat Panels
Installed in Germany till 2007: 6,4 GW
installation 2004: 0,5 GW
installation 2005: 0,65 GW
installation 2006: 1,05 GW
new installation 2007: 0,65 GW

Ecological Electricity in Europe

Austria: 73% of electricity is born by renewable energy (water !!). EU-average value: 16%

about 2% wind converter and solar applications


Österreich ist dank seiner Wasserkraftwerke ein Öko-strom-Riese in Europa. 73% unseres Stromes stammen aus erneuerbaren Energiequellen. Im EU-Schnitt sind es nur 16%, wobei Wind- und Solaranlagen erst etwas mehr als 2% beisteuern. ▶

PH Wien

One household needs...

	Fill in	Result
Demand of electric energy in kWh/a	6000	
1 m² solar cell provides 70 kWh/a	70	
Area to be covered by solar cells in m²		86
This is a square with the sidelength	9,3	m
For safety use the area-factor 3		
This is a square with the sidelength	16,0	m

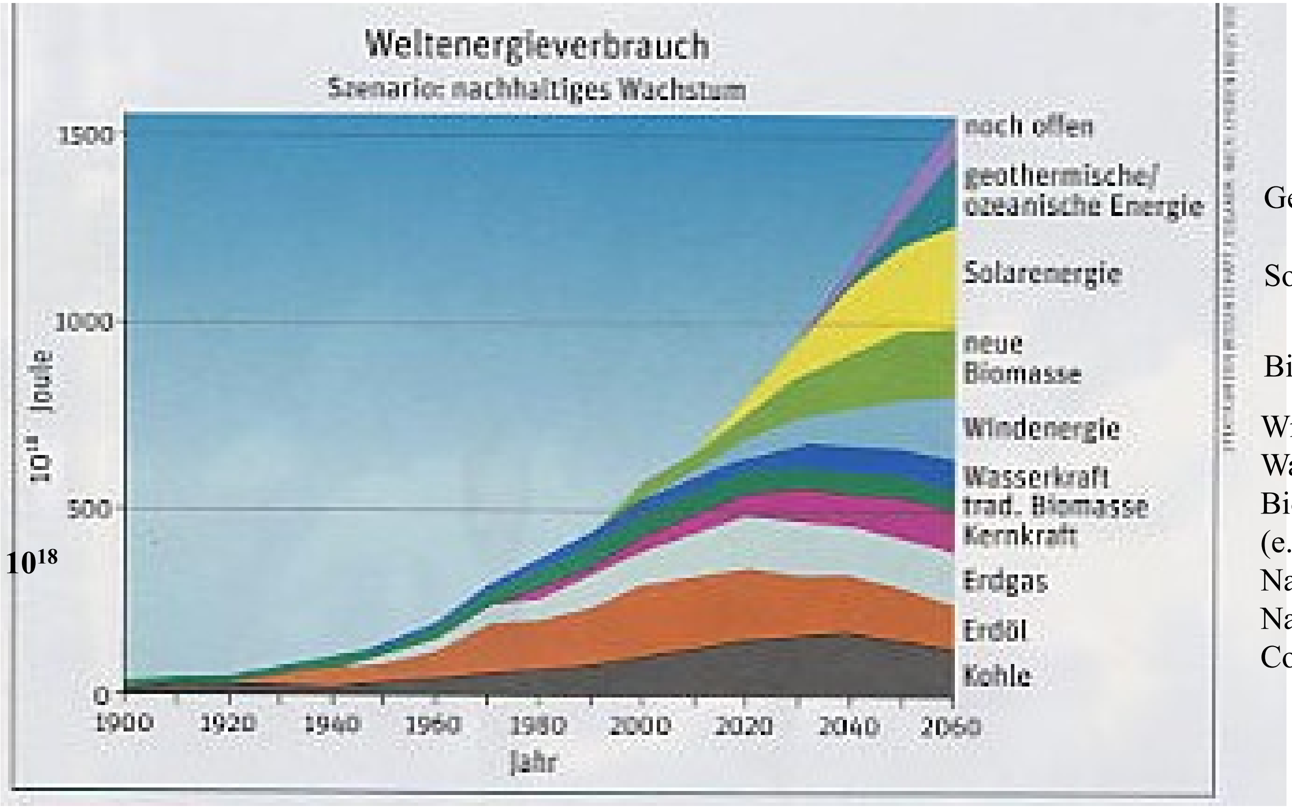
Vienna must be covered by solar cells with a square sidelength of about 50 km.

Idea: Covering roofs by solar cells

Energy worldwide

Vergleich:
Comparison – Energy Consumption
Welt - worldwide: 478,7 EJ
USA: 98 EJ
DE: 14 EJ
AT: 1 EJ

Source:
Spektrum d. Wissenschaft 09/2007

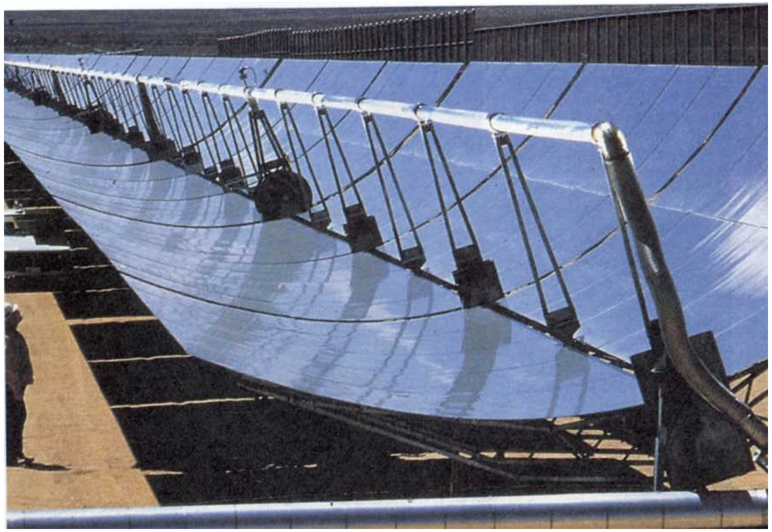


10^{18}

Geothermic/ocean
Solar energy
Biomass (new)
Wind
Water
Biomass old (e.g.wood)
Natural Gas
Natural Oil
Coal

Energy in USA 2008

Verfügbare Fläche im Südwesten (Kalifornien, Wüste): 650.000 km²
Einstrahlung 2500 kWh/m².a entspricht 8 kWh/m²d
Ertrag berechnet 5000 EJ/a
System: Parabolrinnenkraftwerk
Druckluft wird erzeugt (85 bar ~ 85.000 hPa)
In Kavernen (leere Erdgaslager, etc.) gespeichert
Druckluft erhitzen ➔ Drucksteigerung
Betrieb von Hochdruck- und Niederdruckturbine
Hochspannungs-Gleichstrom-Überlandleitungen
HVDC-Leitungen
Zu verbessern: Energieträger Salzschmelze (~ 300 °C)



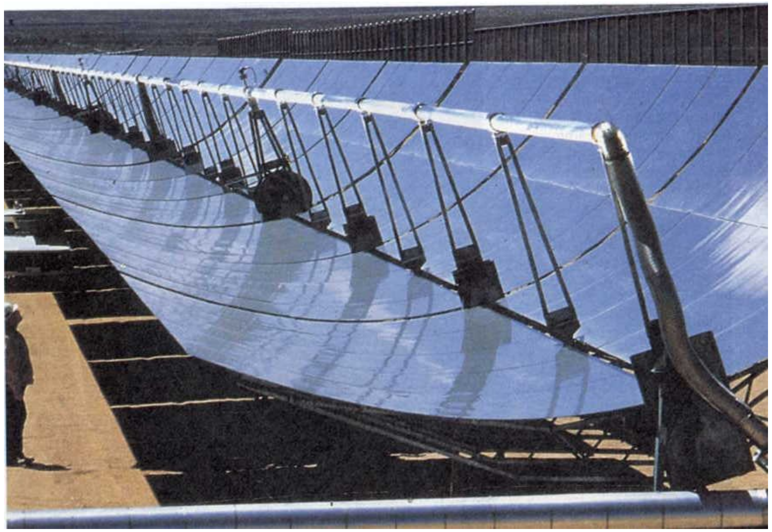
line focus

Vergleich:
Welt: 478,7 EJ
USA: 98 EJ
DE: 14 EJ
AT: 1 EJ

Quelle: Spektrum der Wissenschaft März 2008

Energy in USA 2008

Usable area in California (desert): 650.000 km²
Irradiation2500 kWh/m².a equalling 8 kWh/m²d
Calculated yield 5000 EJ/a
System: Parabolrinnenkraftwerk Cylindric Collector
Generation of Compressed Air (85 bar ~ 85.000 hPa)
Stored in Cavities (former natural gas store), etc.)
Heating of Compressed Air ➔ Rising Pressure
Running of High-Pressure-and Low Pressure Turbines
Power Mains-DCV-Lines
HVDC-LINES
To be improved: energetic carrier salt melt (~ 300 ^{o}C)



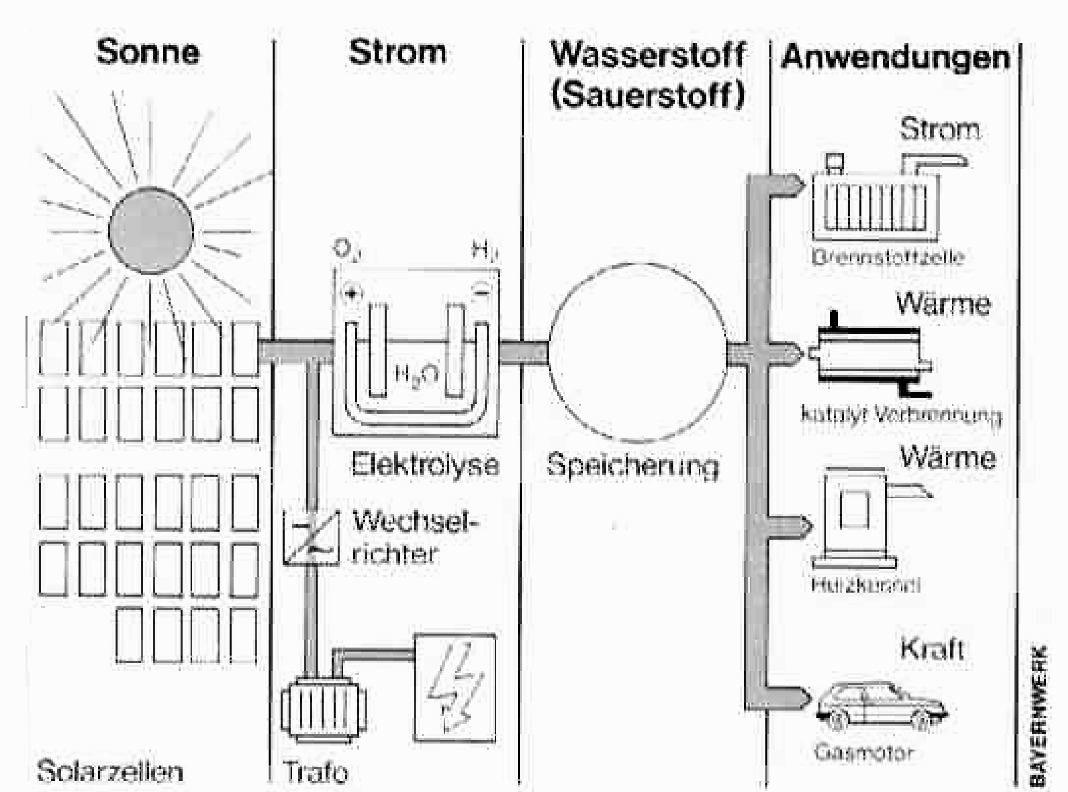
line focus

Compare::
World: 478,7 EJ
USA: 98 EJ
DE: 14 EJ
AT: 1 EJ

Source: Spektrum der Wissenschaft März 2008

Hydrogene Project

Application:
Fuel - Cells: Electricity
Katalytic Combustion: Caloric Energy



This is the Euro-Quebec-Hydro-Hydrogene-Project

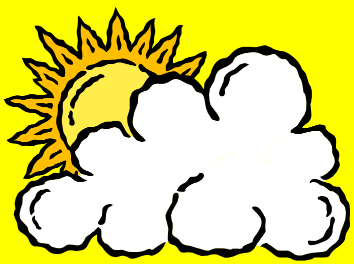
Production of electricty

The photovoltaic produced Electricity may be directly (inverter) transfered to the mains or stored as energetic carrier HYDROGENE, dating from electrolysis of WATER („HYDRO“)

Motor of vehicles run by means of hydrogene

Application and Efficiency

Energy from the Sun
1 MWh/m².a



Solar Cells

Absorption $\eta = 0,12$
Electrolysis $\eta = 0,8$
Total Efficiency $\eta = 0,1$

Hydrogene 100 kWh/m².a

Solar Thermic Power Plant

Absorption $\eta = 0,2$
Electrolysis $\eta = 0,8$
Total Efficiency $\eta = 0,16$

Hydrogene 160 kWh/m2.a

Parabolic Mirror

Absorption $\eta = 0,6$
Thermochemical Processing $\eta = 0,4$
Total Efficiency $\eta = 0,24$

Hydrogene 240 kWh/m².a

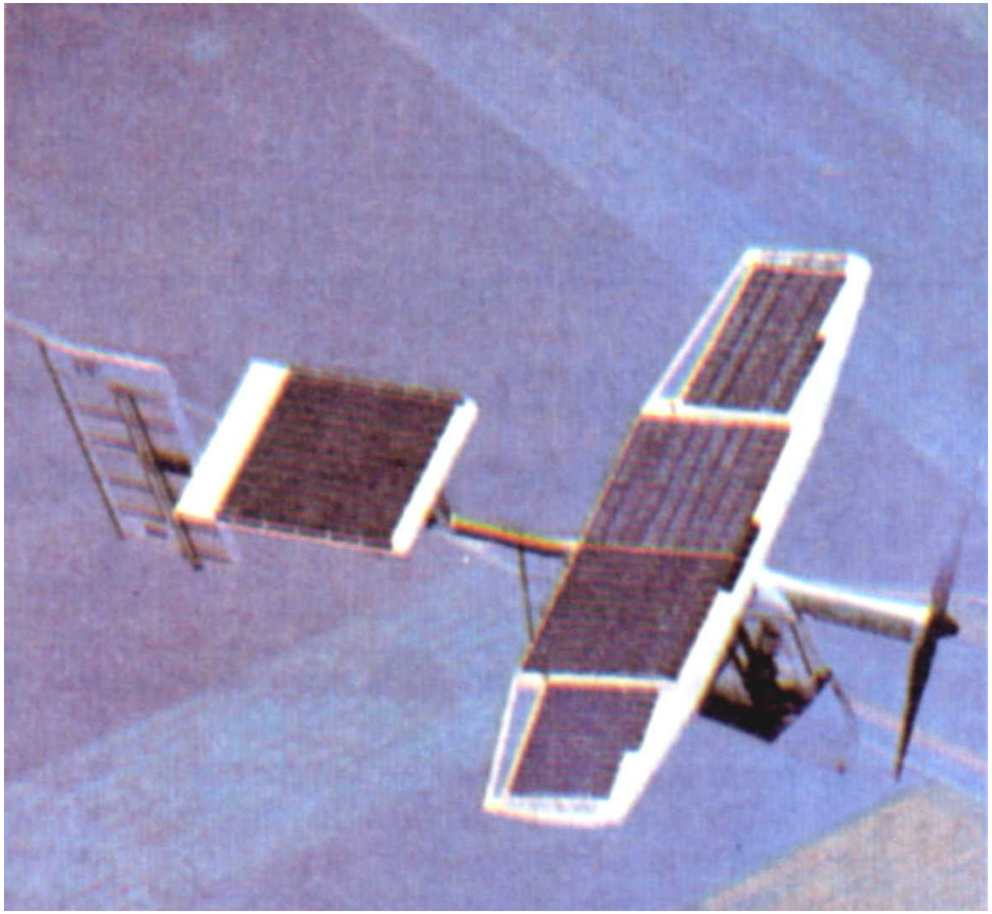
Other Applications

Zeppelin „Ella“

Other Applications

Helios

Other Applications



Challenger
engine 2 x 2,7 kW

Greenhouse Gas

Jahr 2005 verglichen mit der vorindustriellen Zeit

	Antriebe in W/m²
Kohlenstoffdioxid CO_2	1,5
Methan CH_4, FCKW,N_2O	1
Ozon O_3 troposhärisch	0,4
Ozon O_3 stratosphärisch	-0,1
Wasserdampf aus Methan	0,1
Albedo	-0,2
Aerosole (Absorption, Wolken)	-1,3
Sonne	0,2
anthropogen netto	1,6

More or less greenhouse-effect 2005 compared to time before industrial revolution

Vapour from Methane

Reflection, Scattering

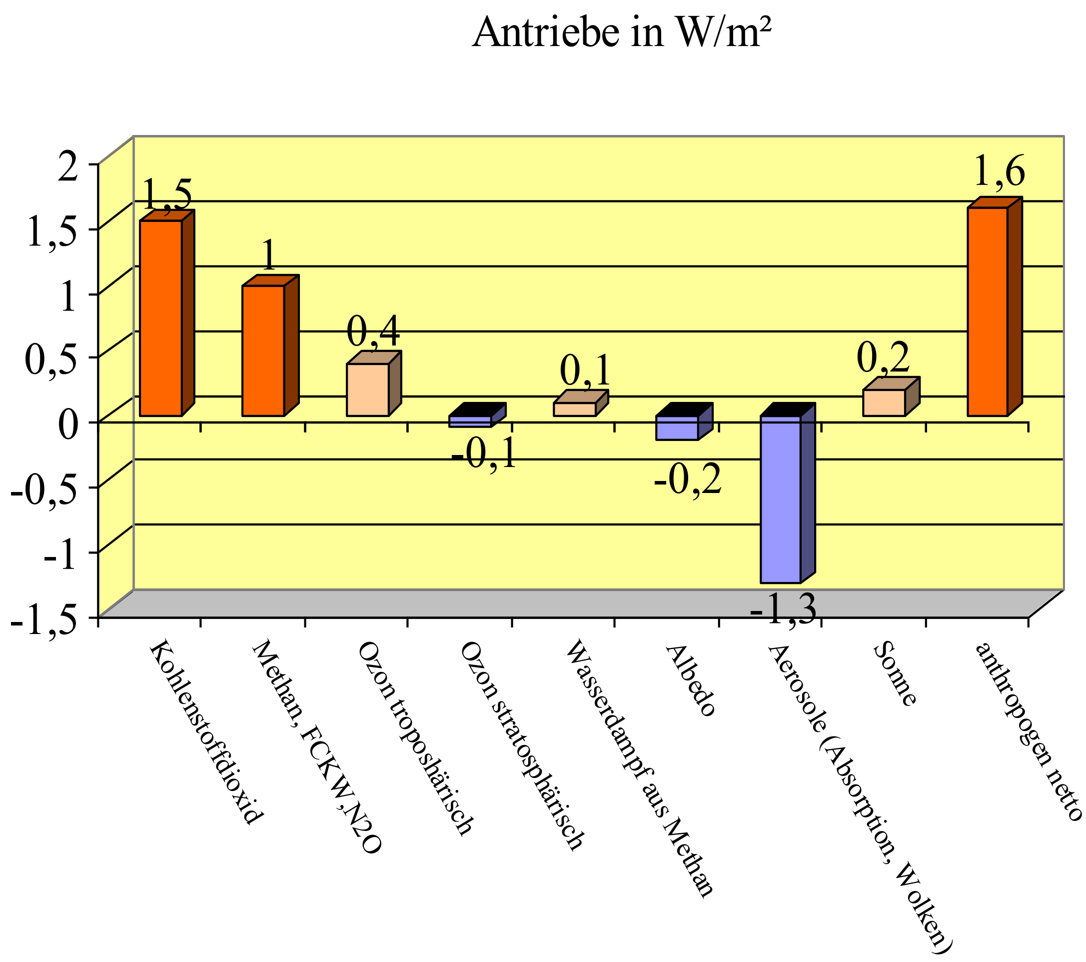
Aerosol (dust), clouds ...absorption

Sun

Anthropogene Effects (total)

Greenhouse Gas

The diagram shows....



Energy – from the Sun

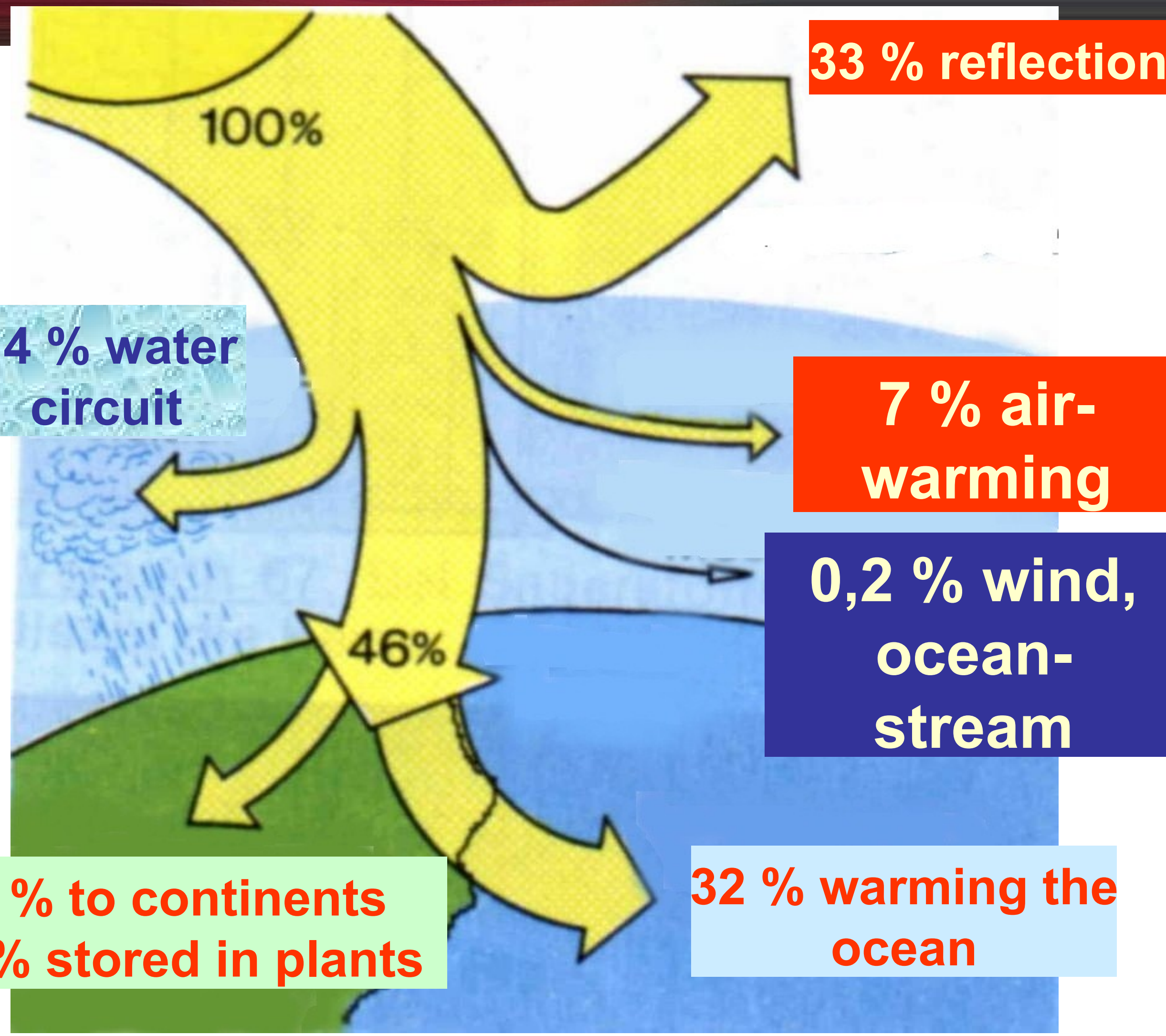
PHWien

nuclear fusion

ENERGY IRRADIATED FROM THE SUN

Sun:
3,85.10^{26} W

Earth-Atmosphere1,75.10^{17} W
1,3 kW/m²

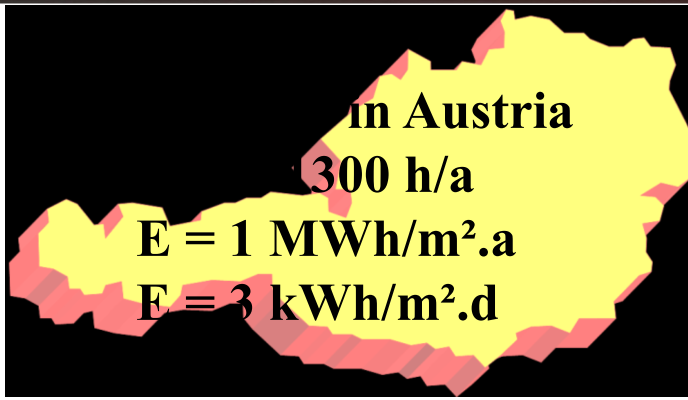


Others

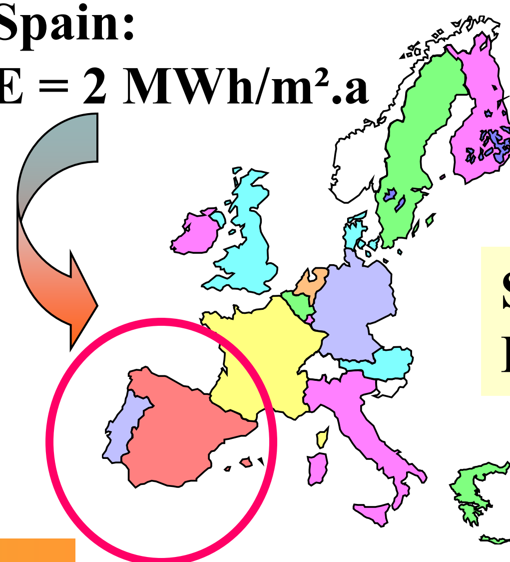
...residual warmth
...warmth dating from nuclear decay of natural occuring radionuclides

tidal energy
gravitational energy

Energy from the Sun



Spain:
E = 2 MWh/m².a



Sahara:
E = 2,6 MWh/m².a

summer: max. 1 kW/m²

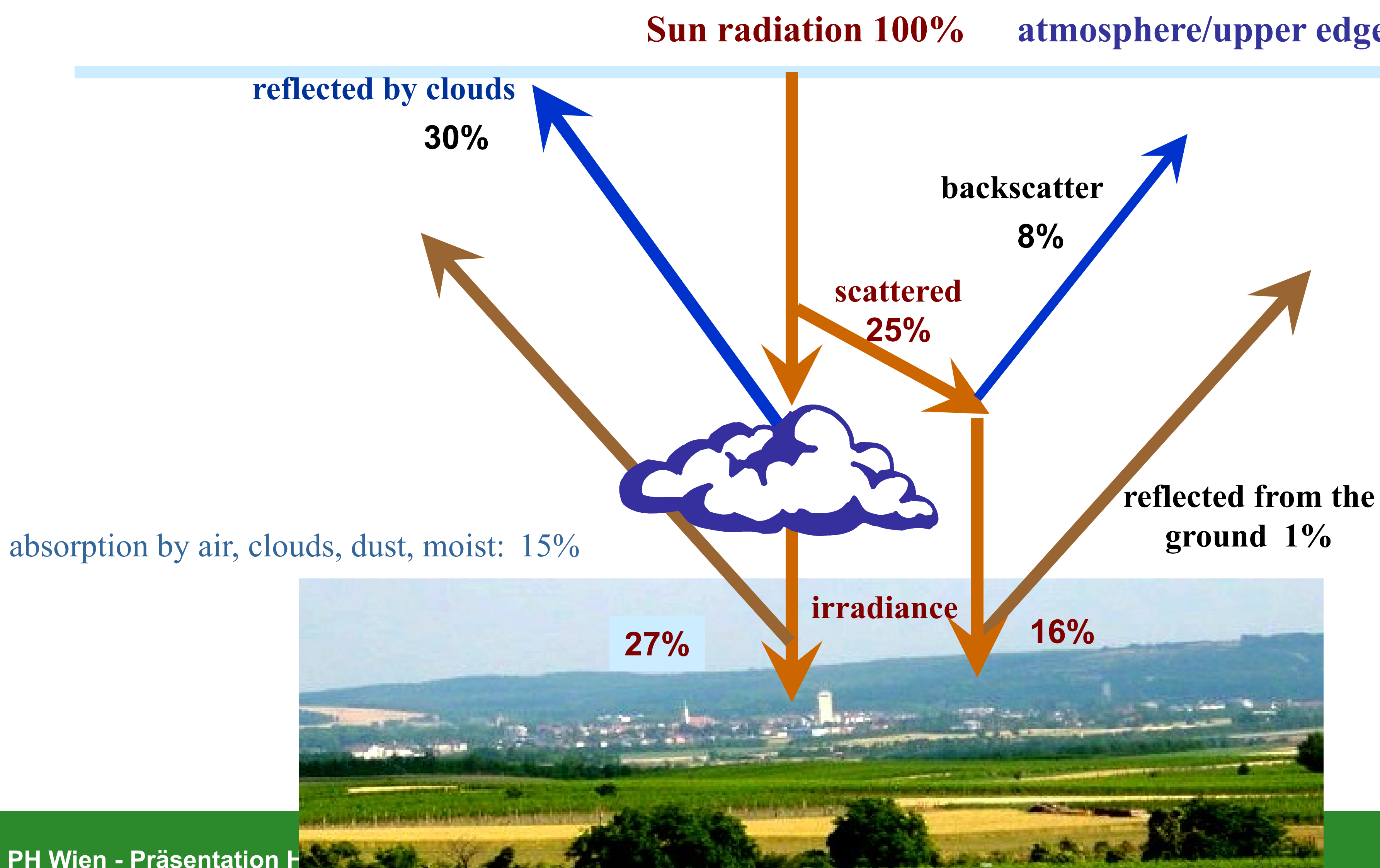
spring, autumn: 0,6 kW/m²

winter: 0,2 kW/m²

Extreme values:
Summer, bright weather:
➔ 1 000W/m²

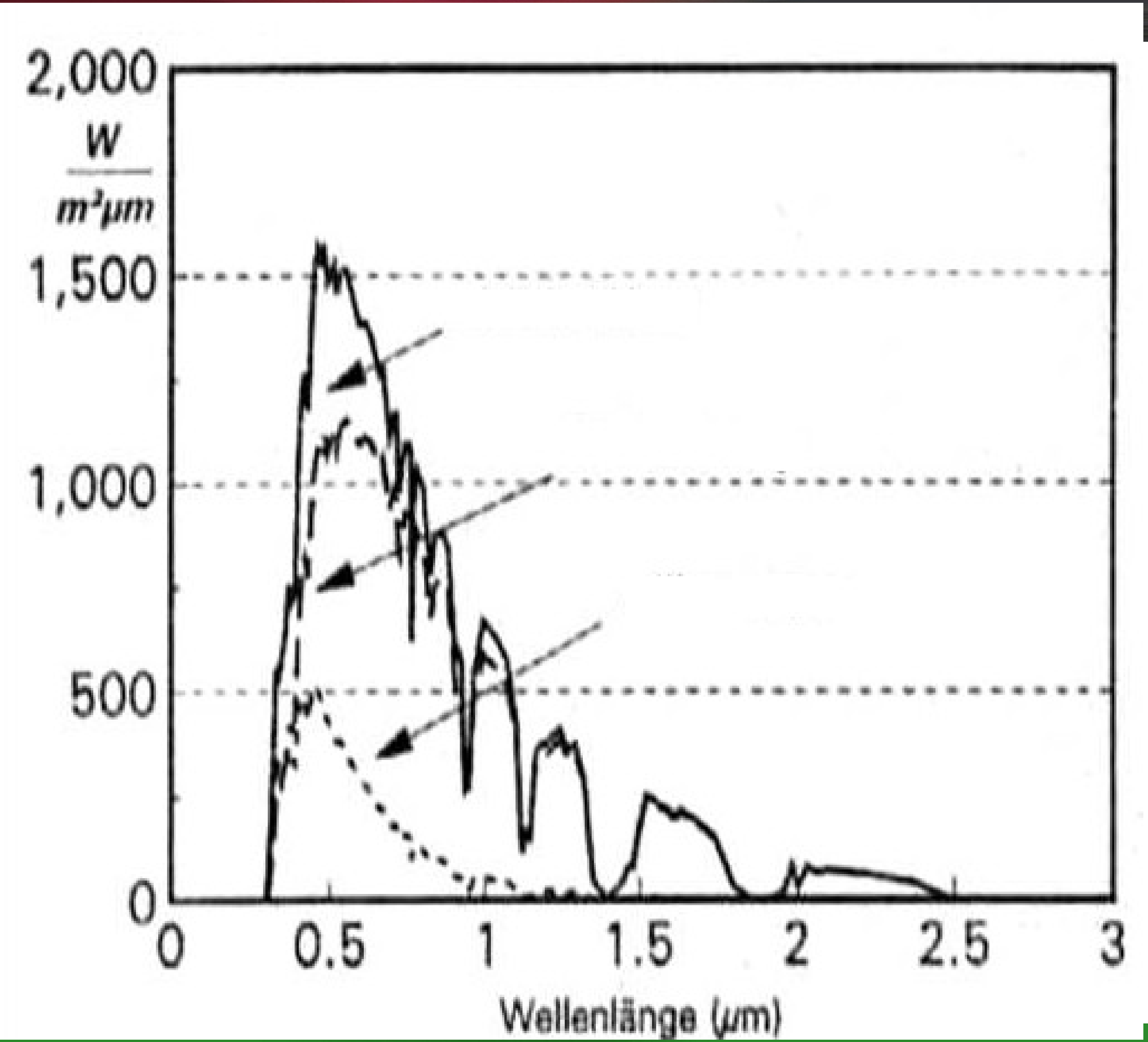
Cloudy Day in Winter:
➔ 20 W/m²

Distribution of Energy

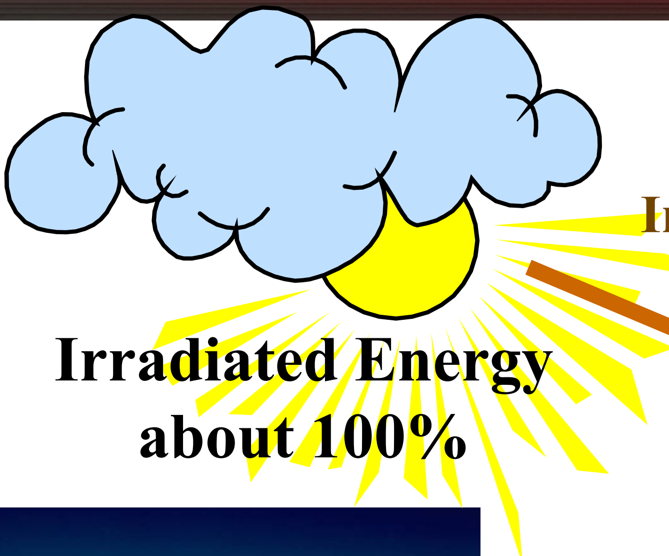


Radiation Spectrum

irradiance

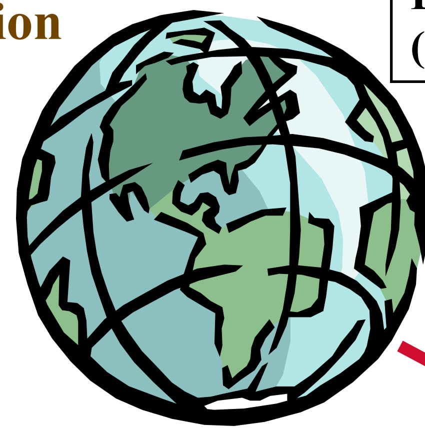


Energetic Balance of the Globe

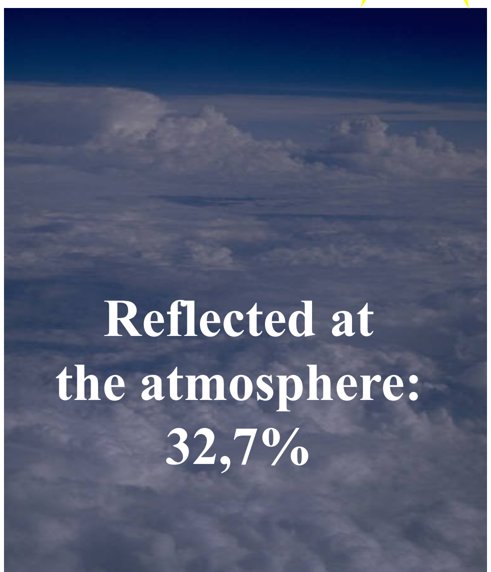


Irradiated Energy about 100%

Direct Irradiation 27%



Warmth of Earth: 0,02 %
Tidal Energy: 0,002 %
Energy production by men (anthropogene): 0,005 %

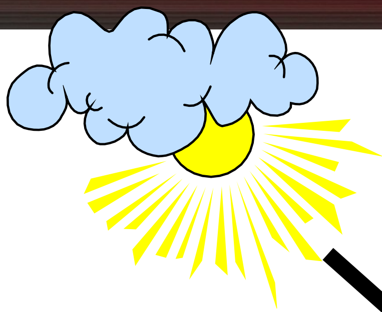


Reflected at the atmosphere: 32,7%

Stream und Photosynthesis: 0,3% (Wind, Sea)

Warmth emission (IR) to space: 67%, from this evaporation: 12,4%

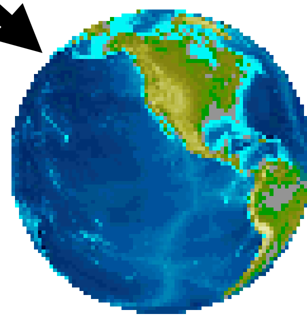
Entropy



Energetic input
- small entropy

Photons

Any living being needs an energetic input with small entropy for loading it up with entropy dating from metabolism – and excreting it.



interactions
generation of circuits
loading with entropy

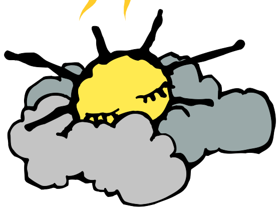
The cold space
is the deposit
for waste entropy

Energetic output
carries much entropy

Density of Radiation s Power

Surface of the globe, medium geografic latitude:
good conditions: 1 000 W/m²
cloudy day: 200 W/m²
winter, diffuse radiation only: 20 W/m²

1000 W/m²



200 W/m²

20 W/m²

Mean Value: about 300 W/m²

~ 1000 W/m²

~ 300 W/m²

Density of Radiation s Power

Seasons of the year, Austria:
summer: max. 900 - 1 000 W/m²
spring, autumn: up to 600 W/m²
winter: up to 250 W/m

1000 W/m²

250 W/m²

600 W/m²

extreme values: (Kesselbachfassung):
30.6.1990: 700 W/m²
13.6.1990: 180 W/m²

Irradiation to the Globe

To the half the terrestrial globe facing the sun is irradiated:

$P = P_0 \,.\, A$ ⟹ aerea perpendicular to the direction of radiation

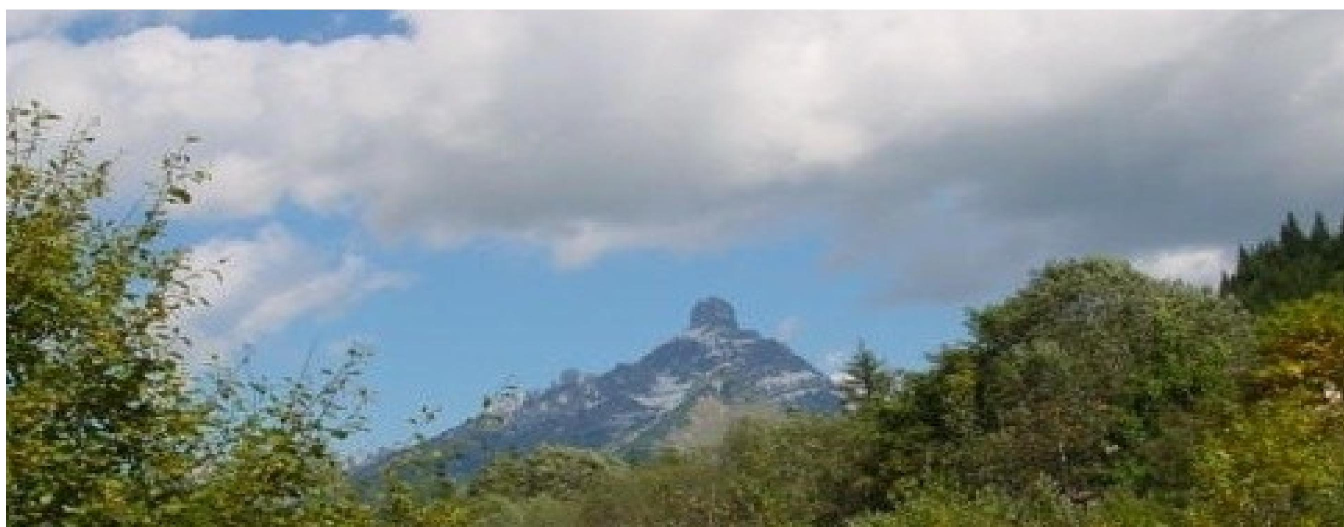
$$\mathbf{P = P_0 \,.\, r^2\pi = 1370\ (W/m^2).(6{,}37.10^6\ m)^2.\pi}$$

$$\mathbf{P = 1{,}75.10^{17}\ W}$$

surface
of the globe
$O = 4r^2.\pi$

Density of Power
mean value:
$$\mathbf{P = 343\ W/m^2}$$

local differences
create the weather !



Radiation Balance

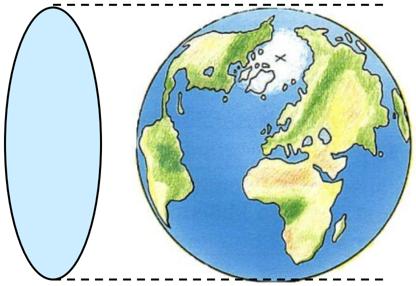
$$(1-\alpha).1370 = 4.\ 5{,}67.10^{-8}\ .\ T^4$$

$\alpha = 0{,}3$
Albedo

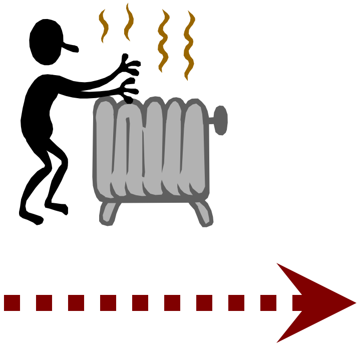
Solar Constant

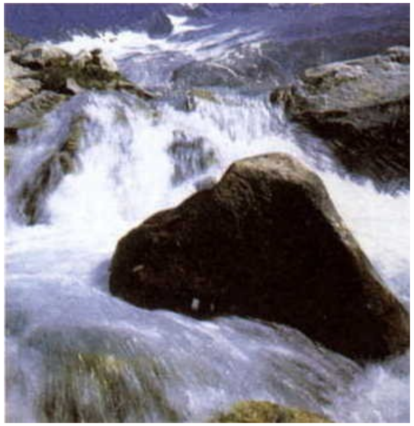
σ in $W/m^2.K^4$

ratio from cross section $r^2\pi$ (irradiance) to globe s surface $4r^2\pi$ (emission)



Result: T = 255 K = - 18 °C
(radiation temperature of the globe)
Reality: T = 288 K = + 15 °C





Greenhouse Effect

Difference from 255 K to 288 K:

Greenhouse-Effect (not a total one).

Globe emits infrared (**thermalization**):

Max. at T = 255 K would be 11 μm,

Max. at T = 288 K is 10 μm.

Greenhouse-Gases:

they absorb and reemit in the IR:

vapour max. 0,9-2,0 μm,

inefficient between 3-5 and 7-11 μm)

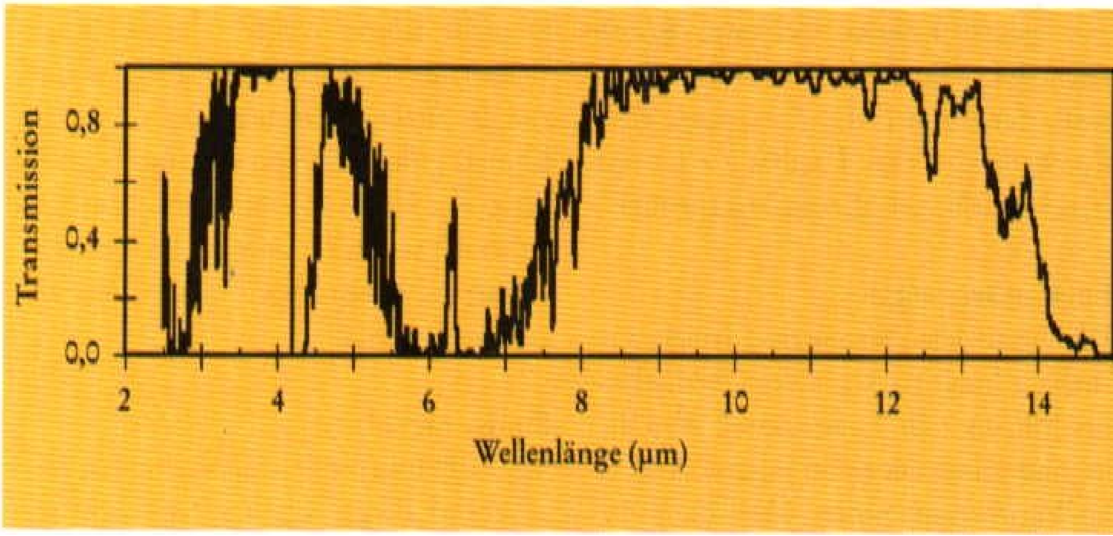
CO_2 only in the Infrared (4,2 μm)

O_3 at $\lambda < 0,3$ μm

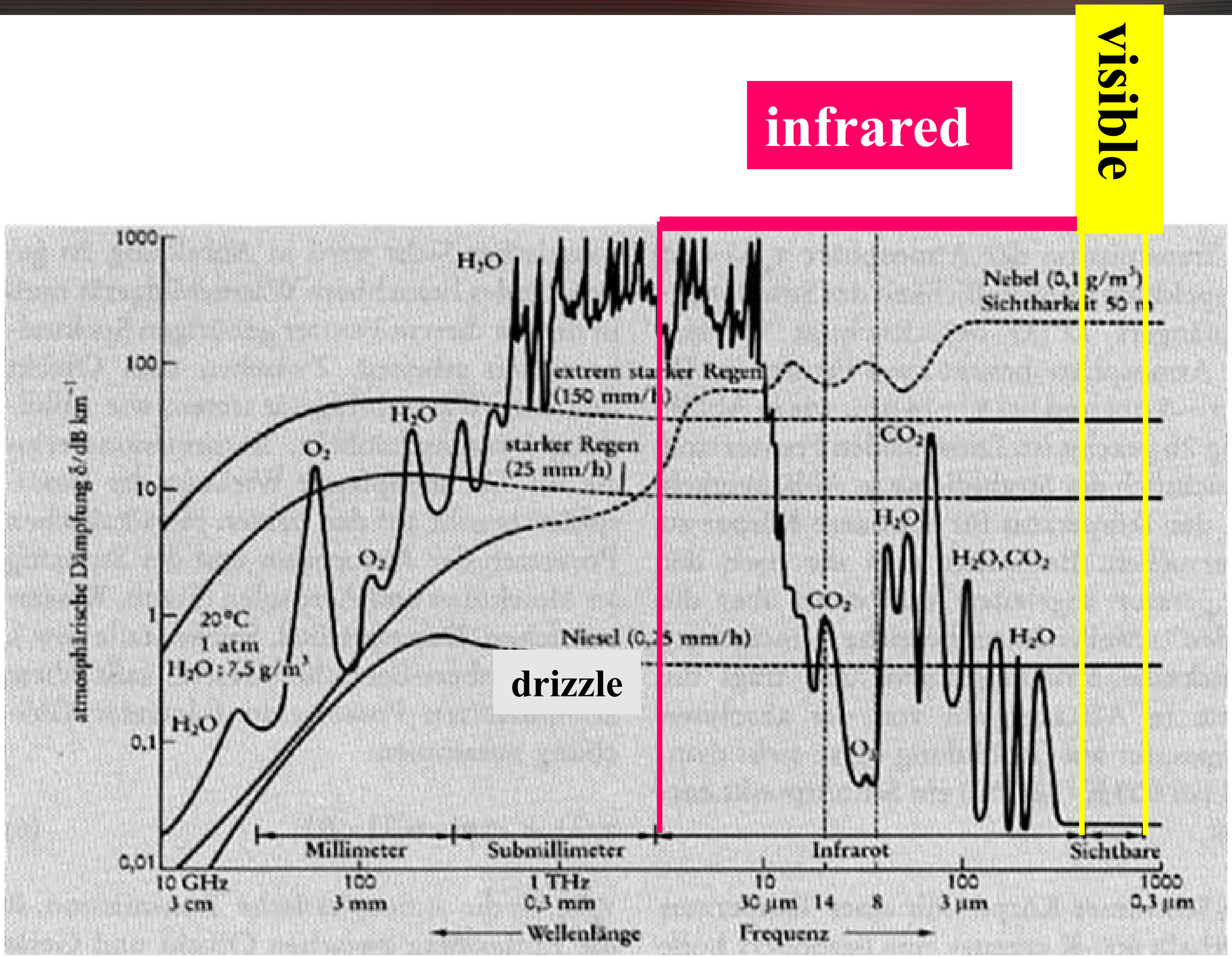
CH_4 within windows of H_2O

CO

NO_x



Atmospheric Absorptance



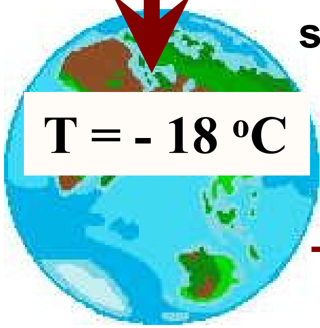
Specific Absorption of the atmosphere:

H_2O: 2,7/3,2/6,3 µm

CO_2: 2,7/4,3/15 µm

Other Applications

1370 W/m²



T = - 18 °C

Irradiance: visible light up to shortwaved IR (3 µm)

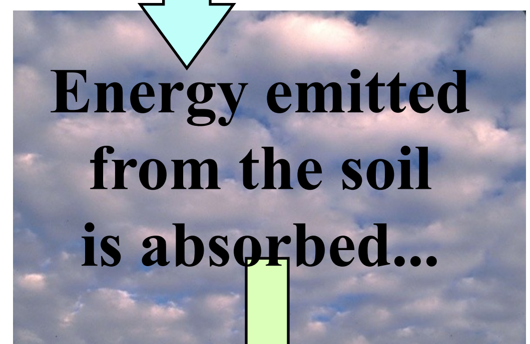
mean 300 W/m²

emission in the IR (about 10 µm)

T = 288 K = + 15 °C

rising of temperature of about dT = 33 K

Very cold nights - without clouds or fog.
In winter clouding during the night protects from severe frost.
Of what clouds do consist ?
What is ment by greenhouse-effect?

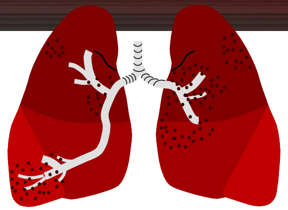


...and partially reemitted.

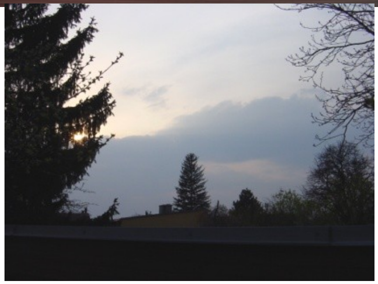
The natural greenhouse-effect is essential !

Too much is a bad thing !

Natural Greenhouse Gases



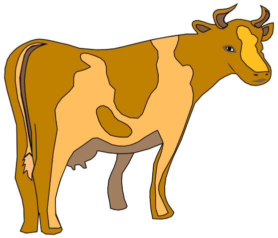
Carbon Dioxide
Respiration, Decomposition
21,8 %



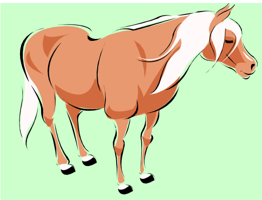
Vapour 62,4%

Ozone 7,3 %

N_2O
Bacteria
4,3%



Carbon Dioxide: volcano
Ammonia: animals - excrement



Methane
Cultivation of Rice, Cattle
2,4%

Anthropogene Greenhouse Gases

Methane
Cattle, Rice,
Natural Gas,
Waste Gas
19%

Carbon-Dioxide
Fossil Fuels
50%

Ozone
indirectly by
KFZ, Industry
8 %

FCKW
Propellent, Foam,
Coolants
17%

Ammonia: Cattle, Sewage Works

NO_x-Gases: KFZ

N_2O
Fertilizer, Wood-Clearing
Combustion of Biomass

Model Natural Greenhouse Effect

$(e + t) . 342\ W/m^2 = \sigma . T^4 + k . 342\ W/m^2$

$\sigma = 5{,}67.10^{-8}\ W/m^2.K^4$

1,3 kW/m² irradiated to $r^2.\pi$ is distributed over the whole world $4r^2.\pi$; result: 342 W/m² surface of the globe

k = 0,32
Coefficient of Convection

e = 0,51 (related to 342 W/m²)
Coefficient of Irradiation

t = 0,95
Reemission-Coefficient (IR)

(nach Bartsch, Joachim, 1. Phys.Inst. RWTH Aachen)

Radiant temperature of the earth
T = 287 K = 14,81 °C

$$1{,}46 . 342\ W/m^2 = \sigma . T^4 + 0{,}32.342\ W/m^2$$

Climatically Relevant Trace Gases

CO_2:
combustion (fossil fuels)
woodland s clearing by fire,
erosion, respiration.
deminished by photosynthesis,
and by absorption of ocean
share: 280 ➔ 350 ppm

CH_4:
rice-cultivation (Sumpfgas),
cattle, waste gas, natural gas.
deminished by photochemical
oxidation - troposphere
share: 0,7➔1,65 ppm

Vapour: 10 - 20 000 ppm

Climatically Relevant Trace Gases

FCKW:
propellents, coolants, floatings, solvents
deminished by photochemical processes in the stratosphere
share: 0 ➔0,3 ppm (3 ppb?)

O_3:
stratosphere: 8-10 ppm (?)
troposphere: <0.001 - 0,03 ppm
KFZ-waste gas, fossil fuels; indirect from NOx, CO, CxHy
deminished by oxidation

N_2O:
nitrogen-fertilizer, bacteria, biomass -combustion(?)
deminished by photochemical processes ➔ 0,3 ppm

CO: ➔ 200 ppb

NO_x, SO_2:
combustion, biomass, ore smelting
➔ 50 ppb

NH_3 → 0,1 ppb
cattle, sewage works.

Efficiency of the Greenhouse Gases

Greenhouse-Gas/ Effect per molecule compared to CO_2	
CO_2	1
CH_4	21
N_2O	206
CF_2Cl_2	15800
CF_3Br	16000
$HCFCl_2$	9940

(nach W.Chandler, J. Reilly, Dahlem-Konferenz 1990)

Amounts emitted per year:	
CO_2	6-7 Gt C/a
O_3 (ground)	1 Gt
FCKW	1,1 Mt
N_2O	4-7 Mt N/a
CH_4	140-370 Mt C/a
NO_x	25-50 Mt
SO_2	120-200 Mt

natural gas	1,4 t CO_2/t SKE
crude oil	2,5 CO_2/t SKE
coal	2,68 CO_2/t SKE
lignite	3,25 CO_2/t SKE

Factors of emission (spezific CO_2-Emissions in kg(C)/GJ:

coke:	30,5
coal	23,9
gasoline	22,3
biomass	21,1 (?)
oil	18,8
Methanol	16,4
natural gas	13,5

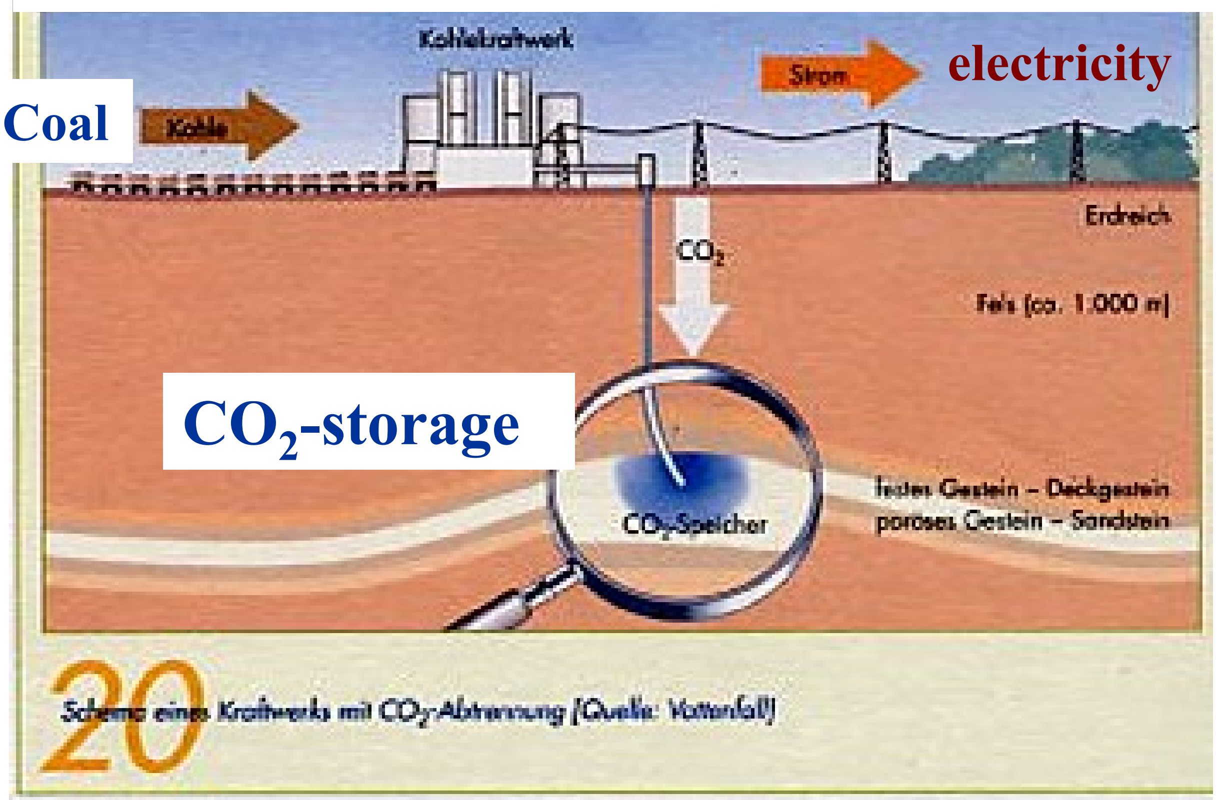
No CO_2

Pilotanlage für ein CO_2-freies Kraftwerk

Caloric power plant free of CO_2 – it is separated from the flue gas and stored in sandstone layers.

Pilot in Brandenburg, DE

Caloric power plant



soil

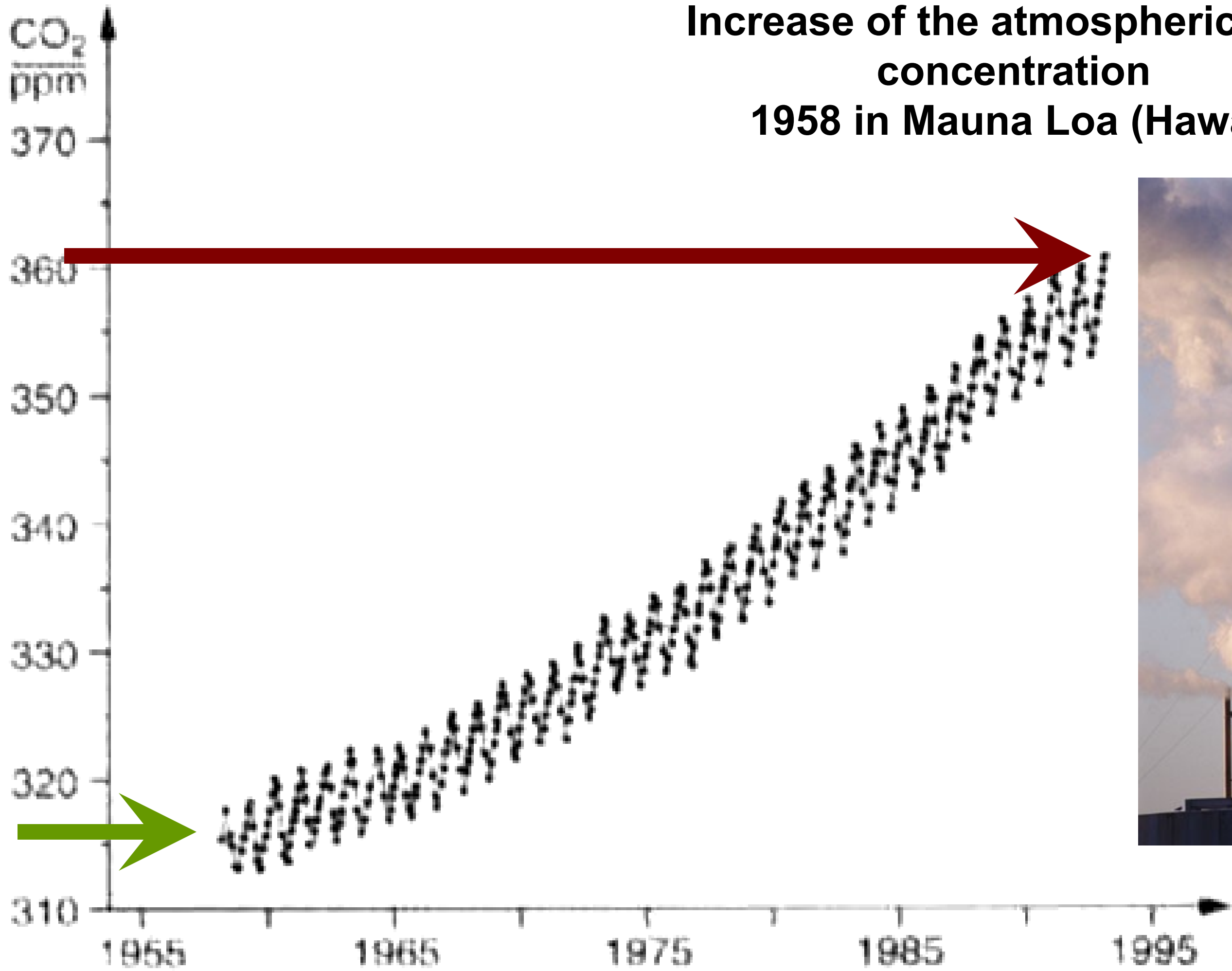
rock (~ 1000 m)

solid rock

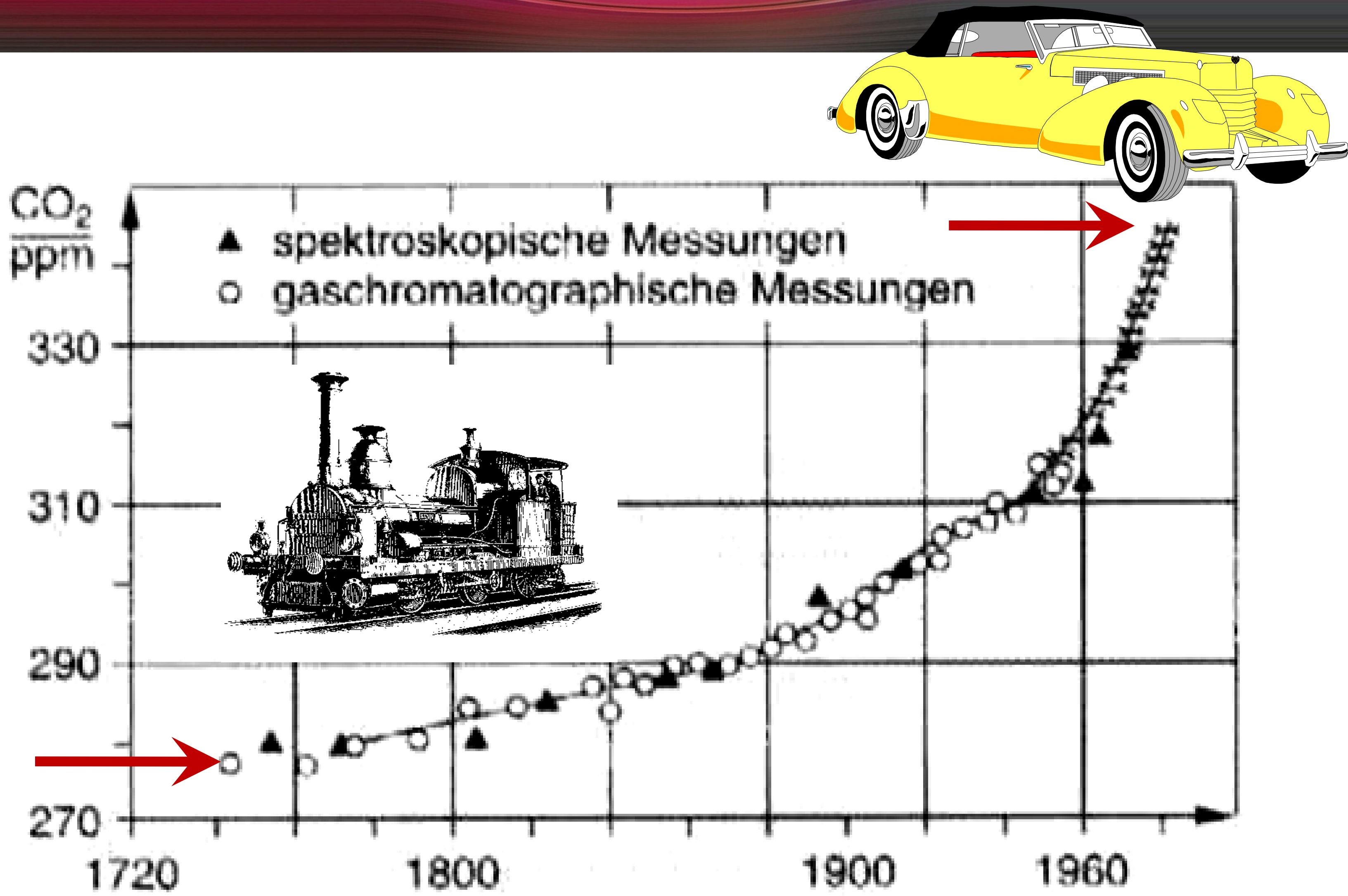
porous rock (sandstone)

Plotting CO_2

Increase of the atmospheric CO_2-concentration 1958 in Mauna Loa (Hawai)



Plotting CO_2

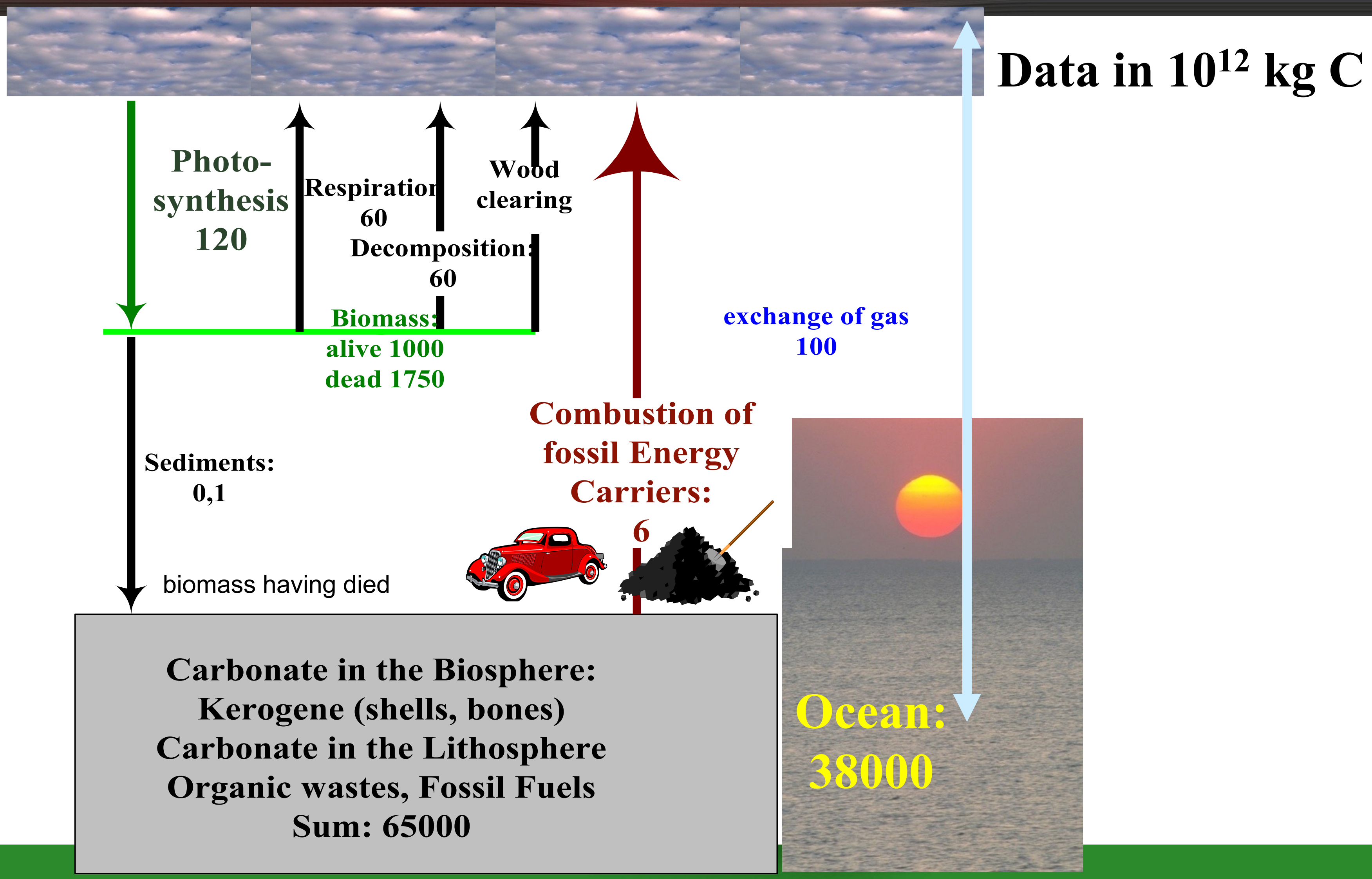


Stored Carbon

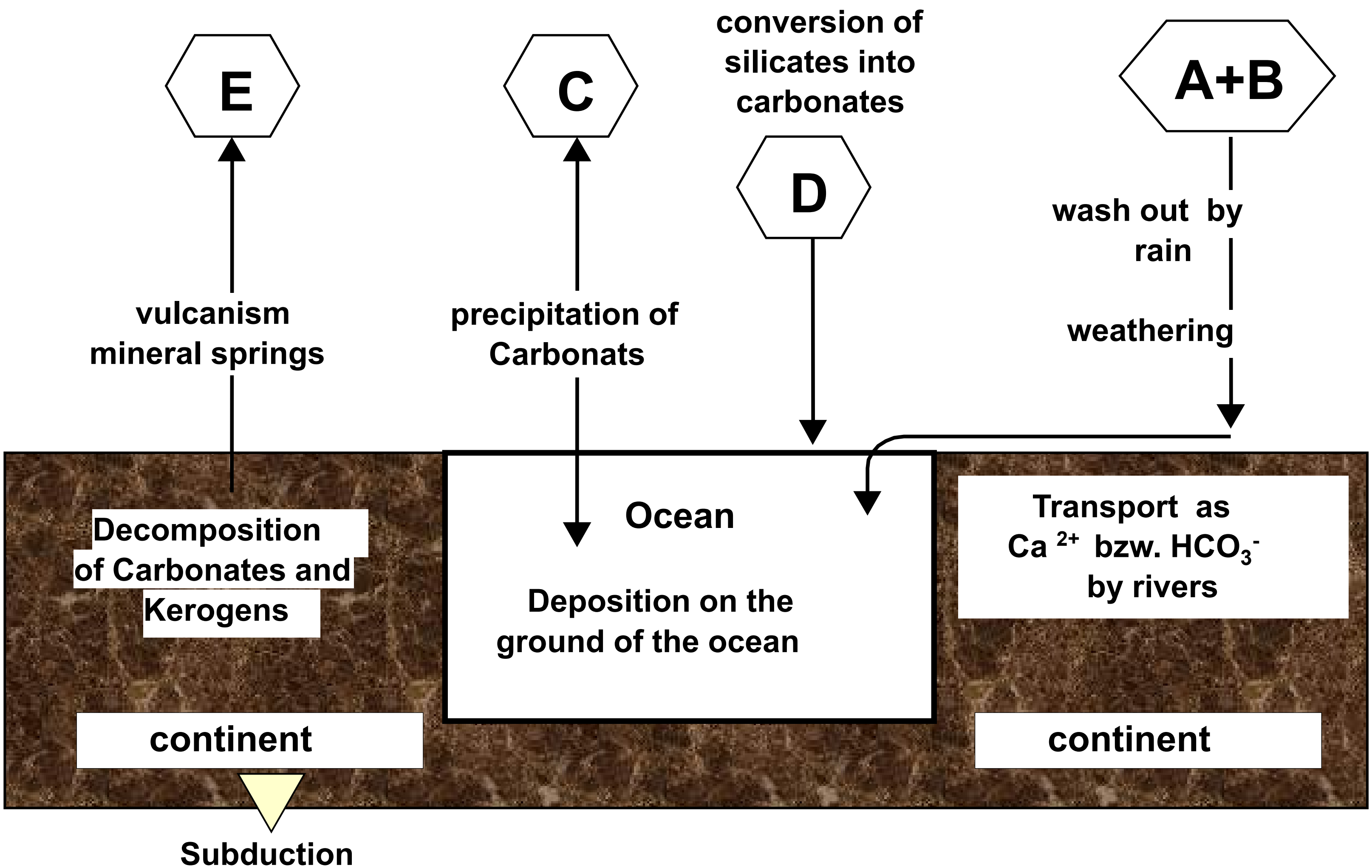
Kind	Gt / C	In relation to living Biomass
Biomass	560	1
Atmosphere	755	1,3
Soil	1720 (3000)	3,1 (5,4)
Fossil fuels	3000-10000	6-18
Ocean	38500	69
from this Surficial Water	700	1,3
Organic Sediments (Kerogen)	15000	26800
Carbonat in Sediments	60000	62500

The geochemical circulations rules the concentration of CO_2 in the atmosphere within long-scaled processes !

Carbon s Circulation



Geochemical Circulation of Carbon



Geochemical Circulation of Carbon

A. Weathering:

$CO_2 + H_2O + CaCO_3 \rightarrow Ca^{2+} + 2HCO_3^-$

B. Weathering of Silicate Rocks:

$2CO_2 + H_2O + CaSiO_3 \rightarrow Ca^{2+} + 2HCO_3^- + SiO_2$

C. Precipitation of Carbonate in the Ocean:

$2HCO_3^- + Ca^{2+} \rightarrow CaCO_3 + CO_2 + H_2O$

D. Weathering of Silicates + Precipitation of Carbonate:

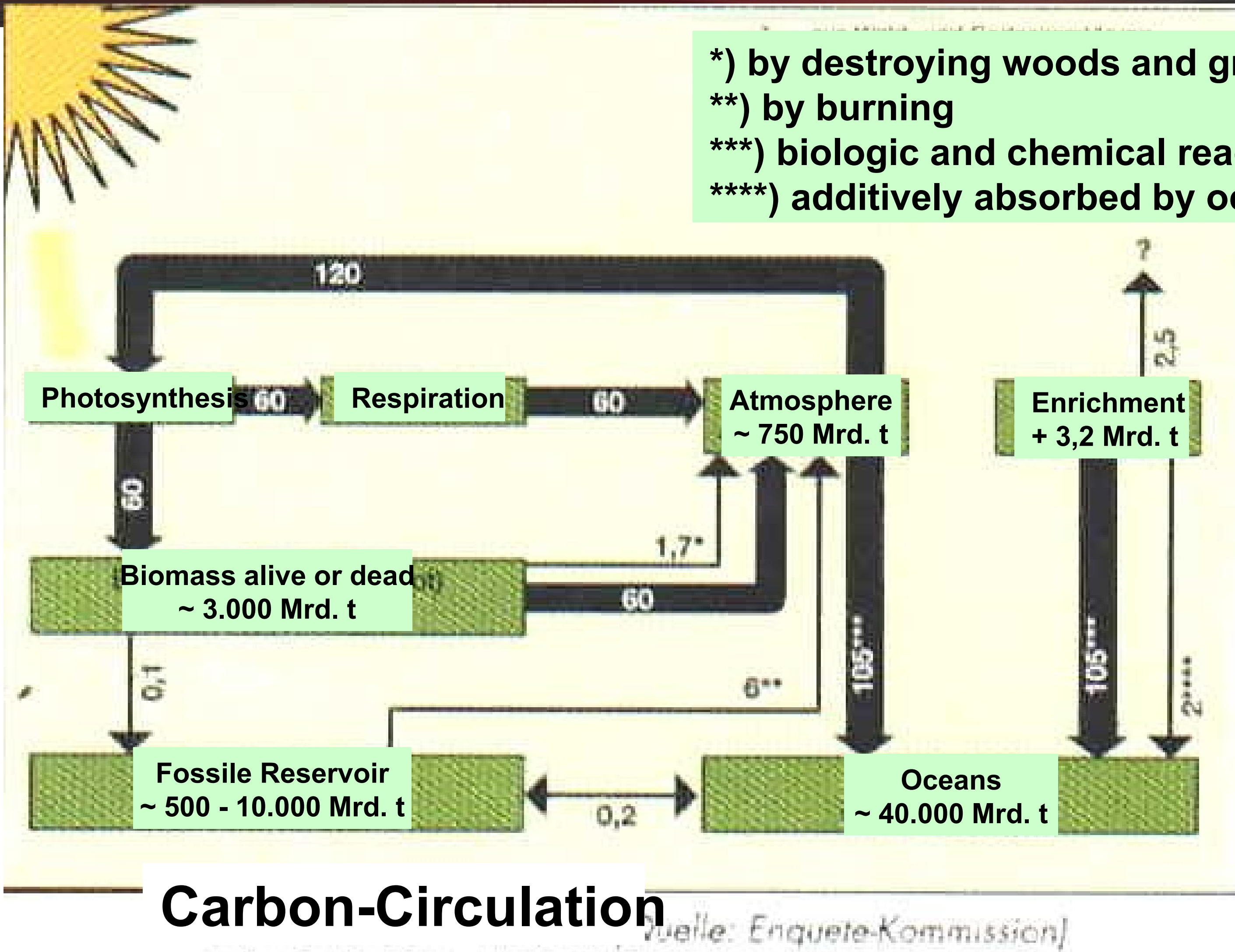
$CO_2 + CaSiO_3 \rightarrow CaCO_3 + SiO_2$

E. Metamorph resp. Magmatic Decomposition of Carbonates:

$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$

Circulation

*) by destroying woods and ground
**) by burning
***) biologic and chemical reaction
****) additively absorbed by ocean



Carbon-Circulation

Enrichment of CO_2 in the Ocean:

Solution of the gas in water

metabolism of greenblue algae

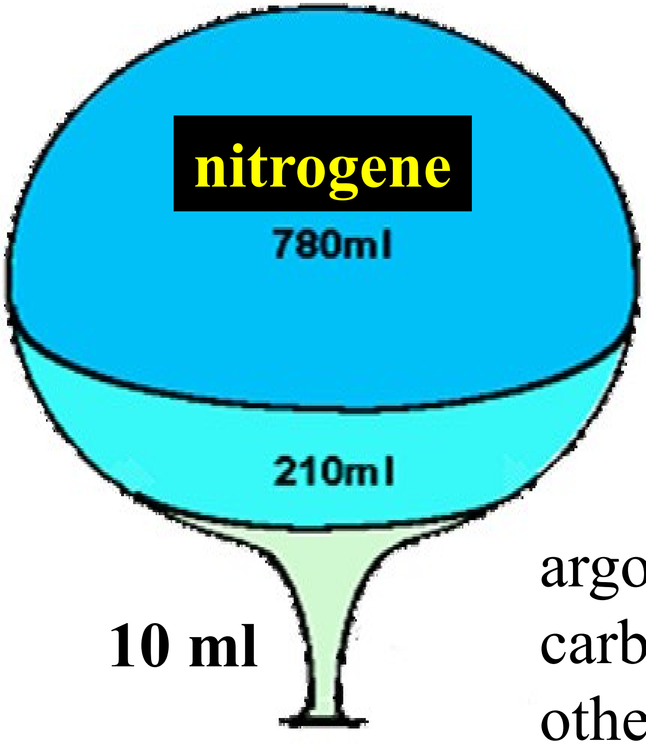
Atmosphere

- **Temperature on surface:** 288 K = + 15 °C
- **Pressure on surface:** p = 1013 hPa
- **Mass of atmosphere:** m = $5{,}3.10^{18}$ kg
  from this:
- mass of **CO_2**: m = $1{,}6.10^{15}$ kg (0,03 Vol.%)
- mass of **N_2**: m = $4{,}1.10^{18}$ kg (78,09 Vol.%)
- mass of **O_2**: m = $1{,}1.10^{18}$ kg (20,95 Vol%)
- **Trace Gases:** maximal share: Ar at 0,93 Vol.%
  Bound C: sediments containing carbonate ($CaCO_3$, $MgCO_3$), living and fossile organic material (plants, petrol, crude oil, coal, peat, lignite).

- **After release of the carbon:**
  Ground pressure 40 000 hPa (40 bar)
  CO_2: 96%
  N_2: 3,2%
  O_2: 0,8%

Planet Venus

composition of air in the 20th century



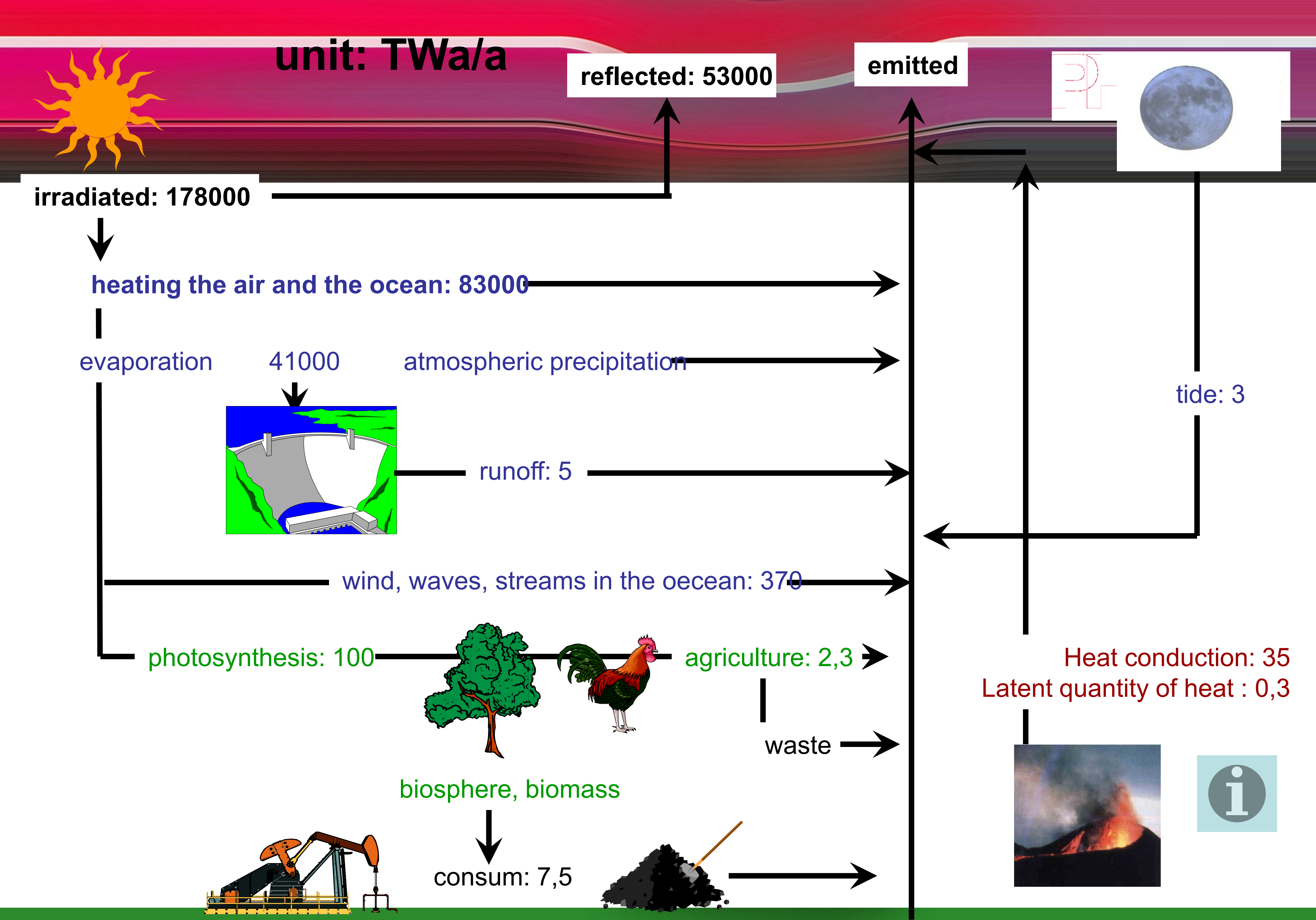
Instead of a balloon – use a bottle

oxygene

10 ml

argon ~ 9,3 ml
carbondioxide ~ 0,36 ml
other gases ~ 0,34 ml

Volume of the balloon: 1 000 ml representing the atmosphere


unit: TWa/a
reflected: 53000
emitted
irradiated: 178000
heating the air and the ocean: 83000
evaporation
41000
atmospheric precipitation
tide: 3
runoff: 5
wind, waves, streams in the oecean: 370
photosynthesis: 100
agriculture: 2,3
Heat conduction: 35
Latent quantity of heat : 0,3
waste
biosphere, biomass
consum: 7,5

Photosynthesis and Enthropy

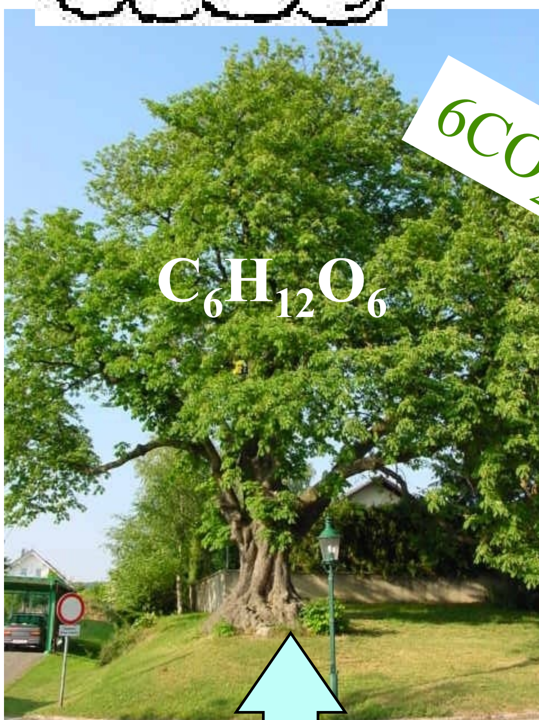
$6\ CO_2$

Energy

$6\ O_2$

H_2O_V

energy balance: absorption of hf



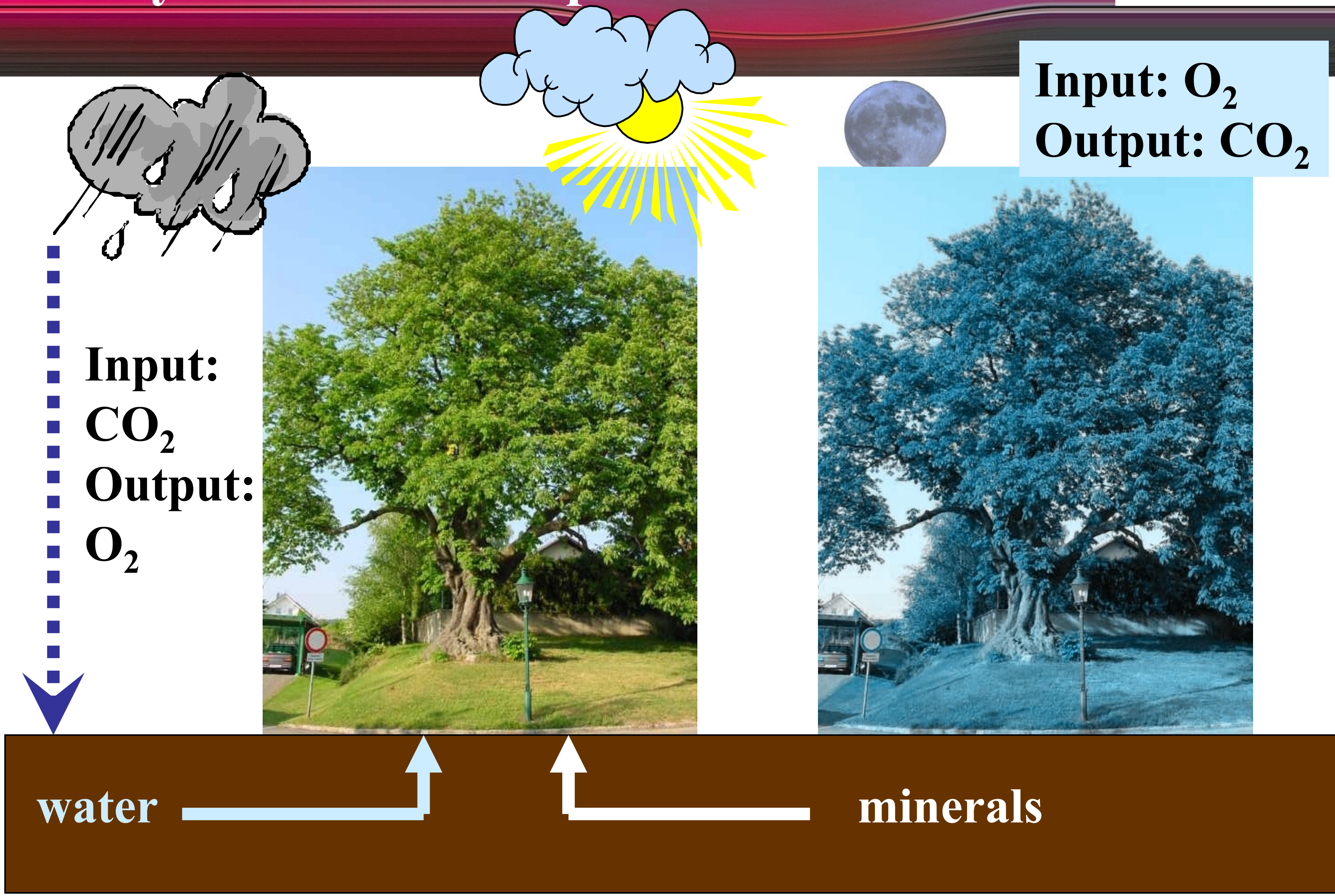
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

more water is used – it is evaporated ??

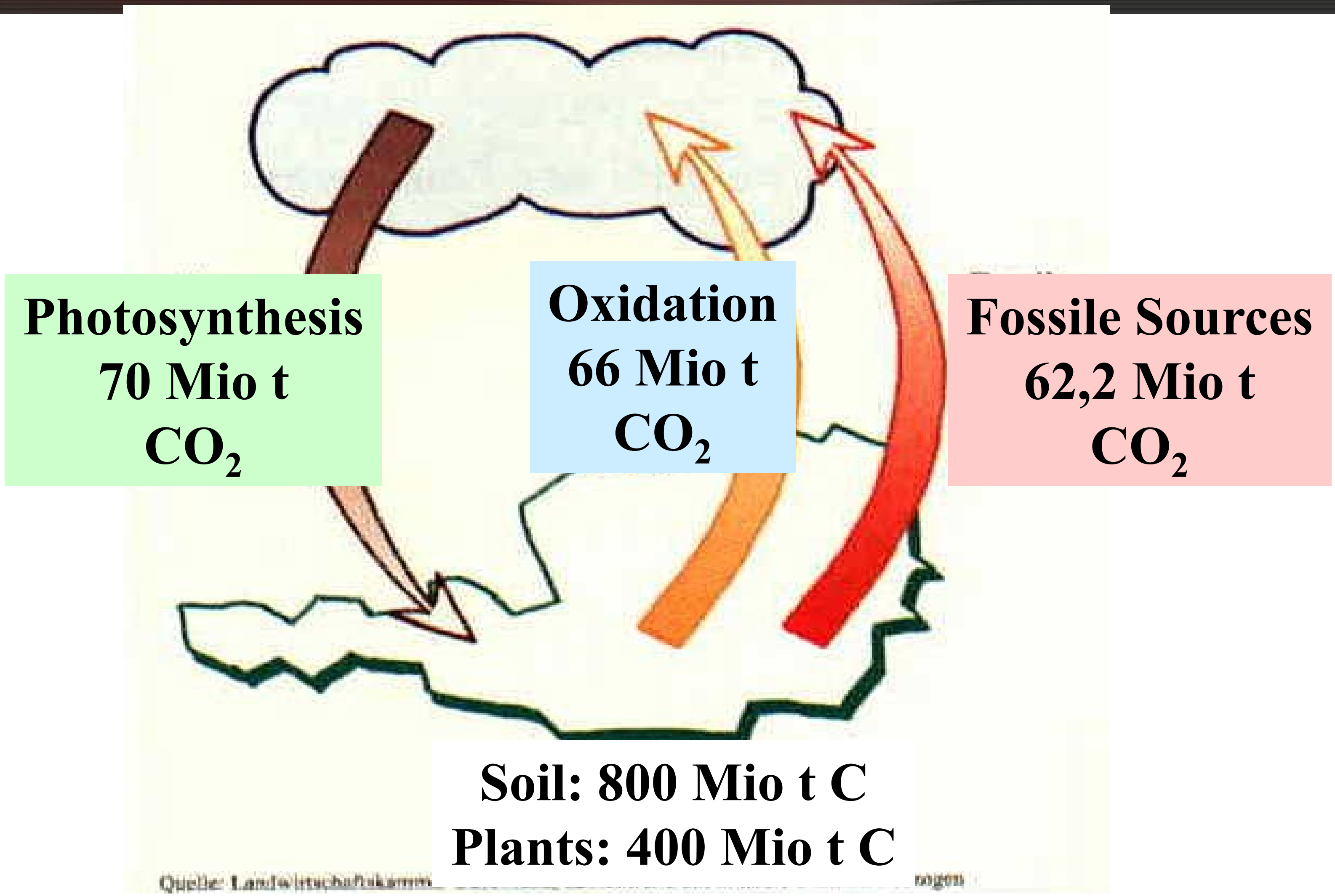
$6\ H_2O$

$S_{out} < S_{in}$:
Because of this dissipation of water ➔ evaporation enables the process enthropically.

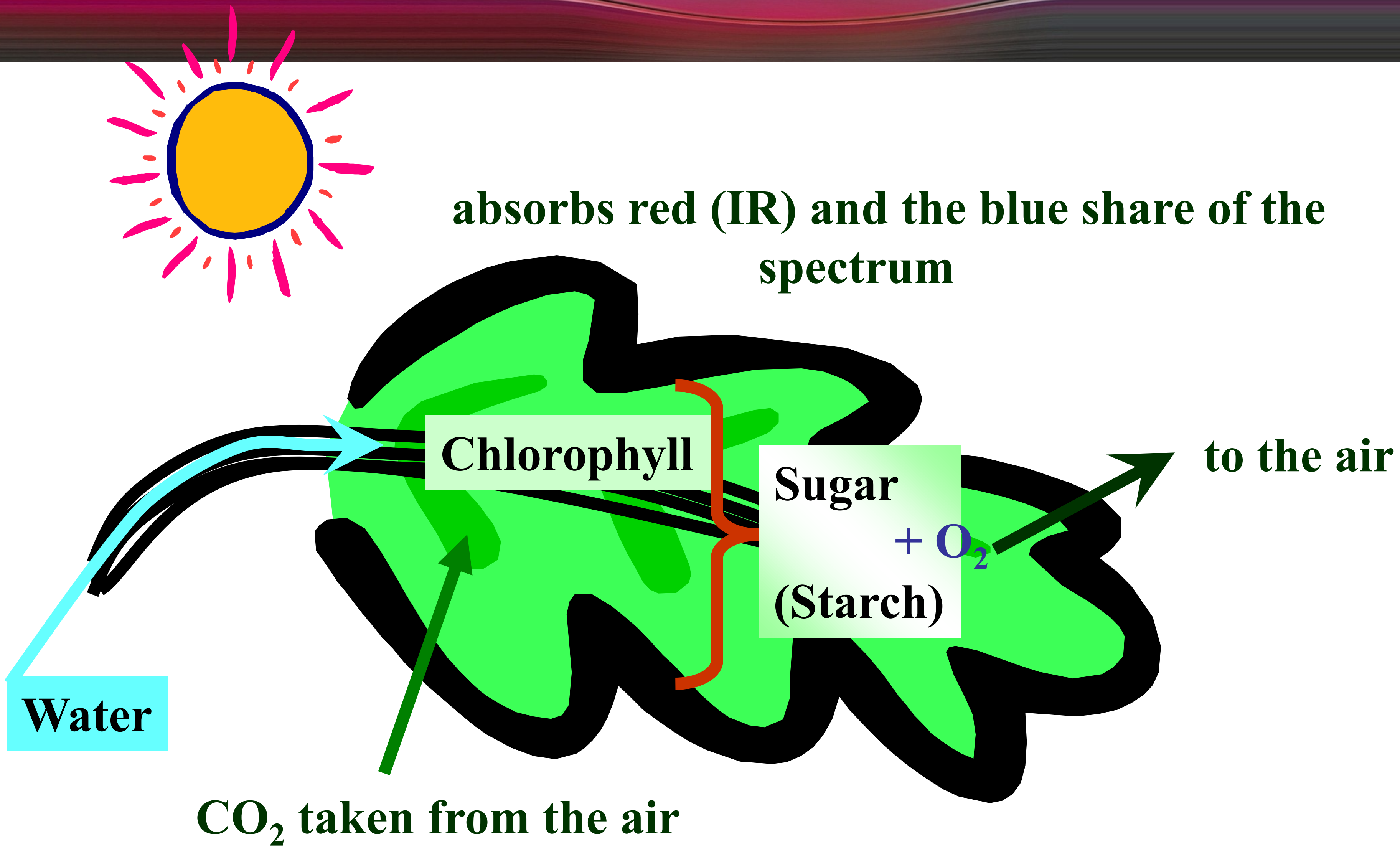
Photosynthesis and Respiration



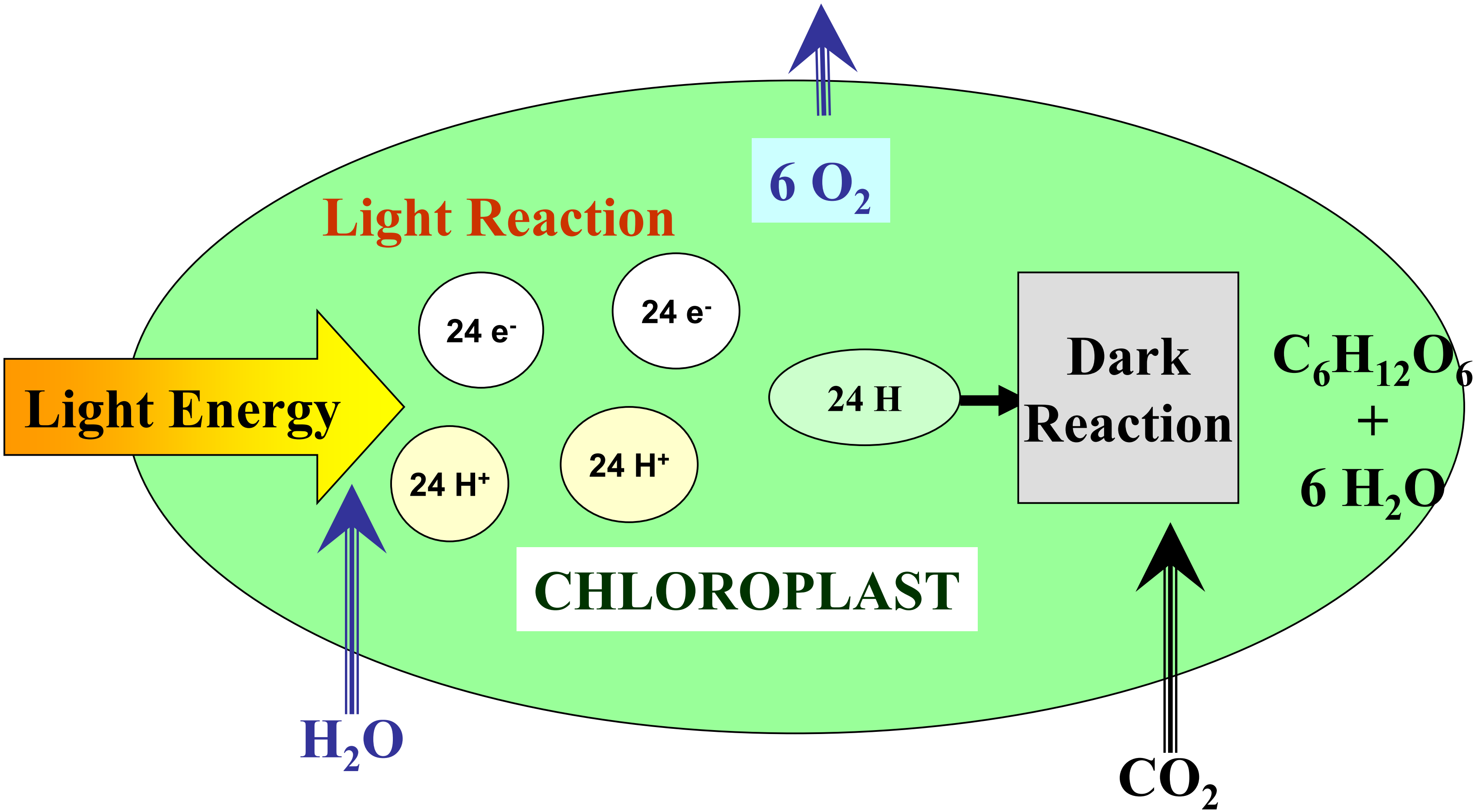
Photosynthesis and Respiration



Photosynthesis



Photosynthesis



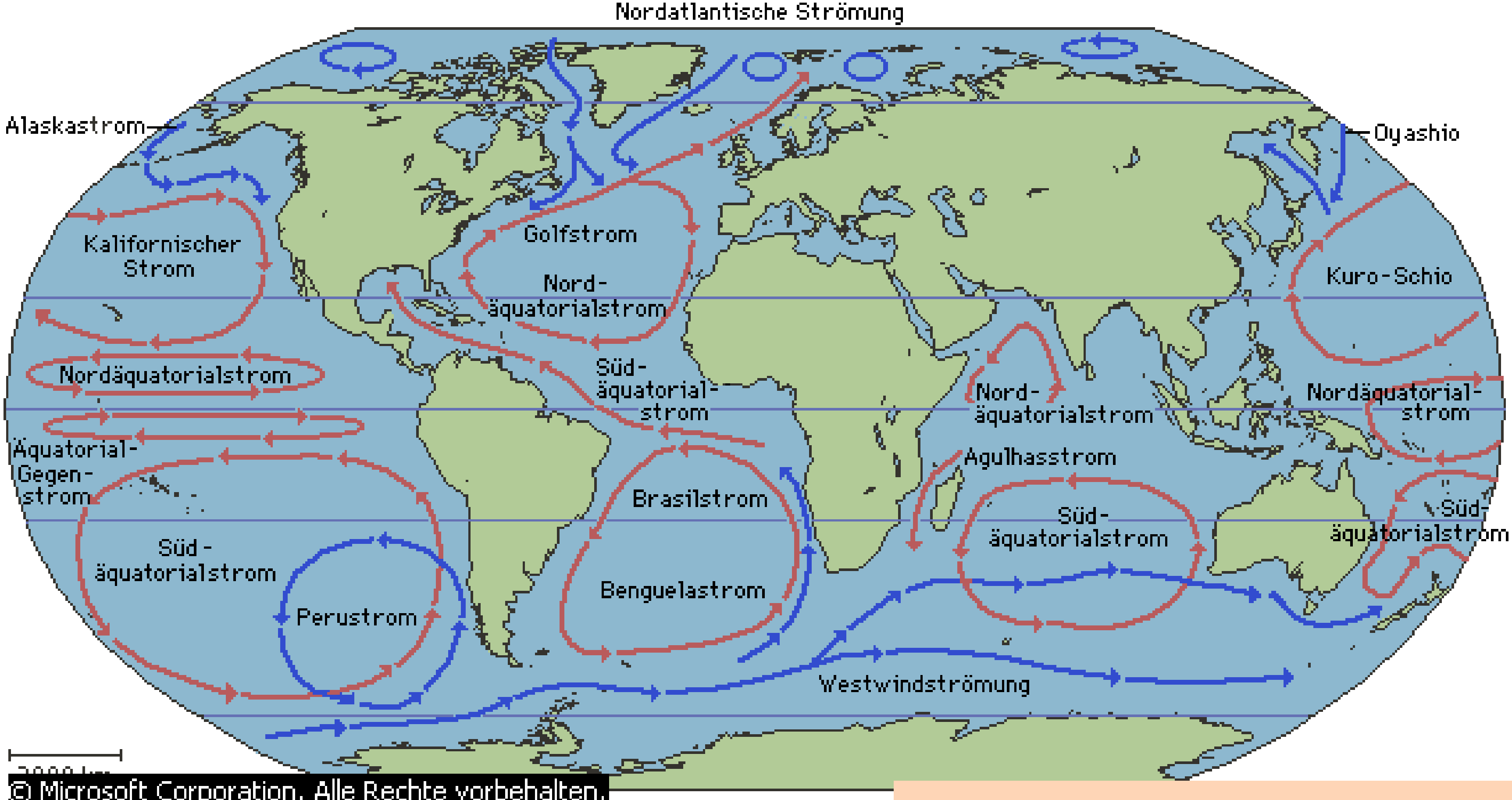
It s only a Tree…..

Utilization of the spectrum: 45%
optimal range: 380-740 nm
max. absorption: blue and red
„Blattgrün“ – green colour of the leaves – UV: signalling colour to insects
η ~ 0,05 (5%) (single leaf - ➔ 25%)
Optimal temperature: 15 – 40 °C

e.g. a beech age 100 years
200.000 leaves
surface of the leaves: 1.200 m²
10^{14} chloroplastes absorb the sunlight
turnover: about 9400 litres
➔ 9,4 m³ CO_2 ➔ O_2 per day.
➔ 3,5.10^6 litres of O_2 per year

roots: important storage for precipitation

Main Streams in the Ocean



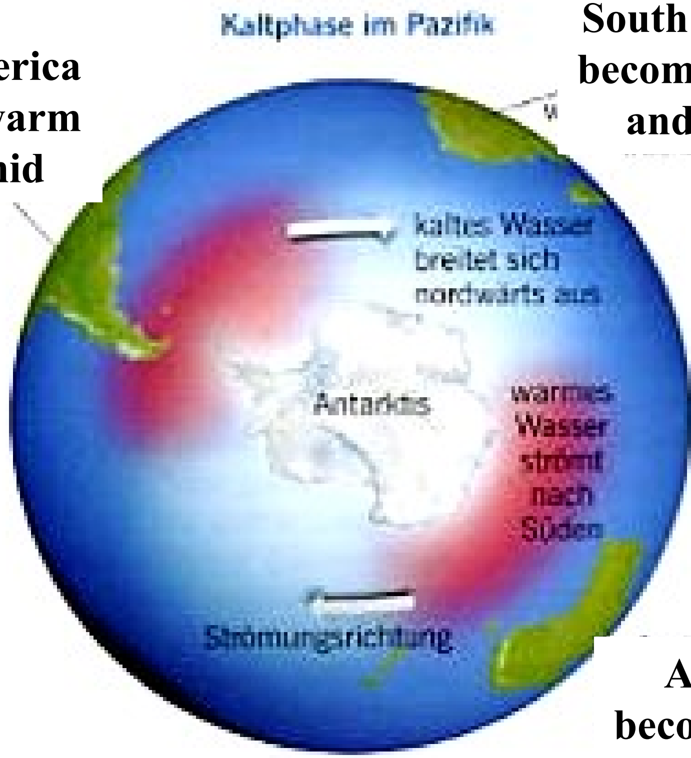
Cold phase in the Pacific

Warm phase in the Pacific

Main streams in the ocean have long-scaled influence to the climate

Circulation round the Antarktis

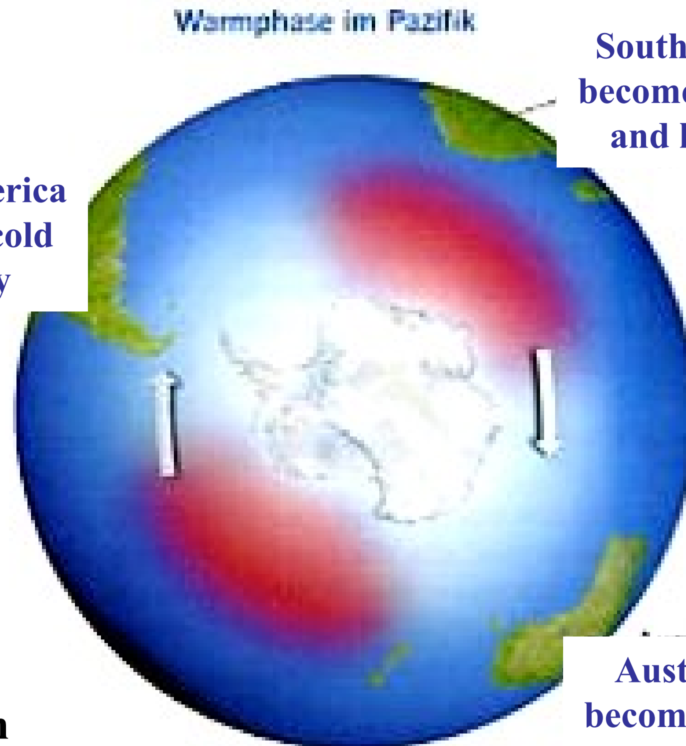
South America becomes warm and humid



South Africa becomes cold and dry

Australia becomes warm and humid

South America becomes cold and dry

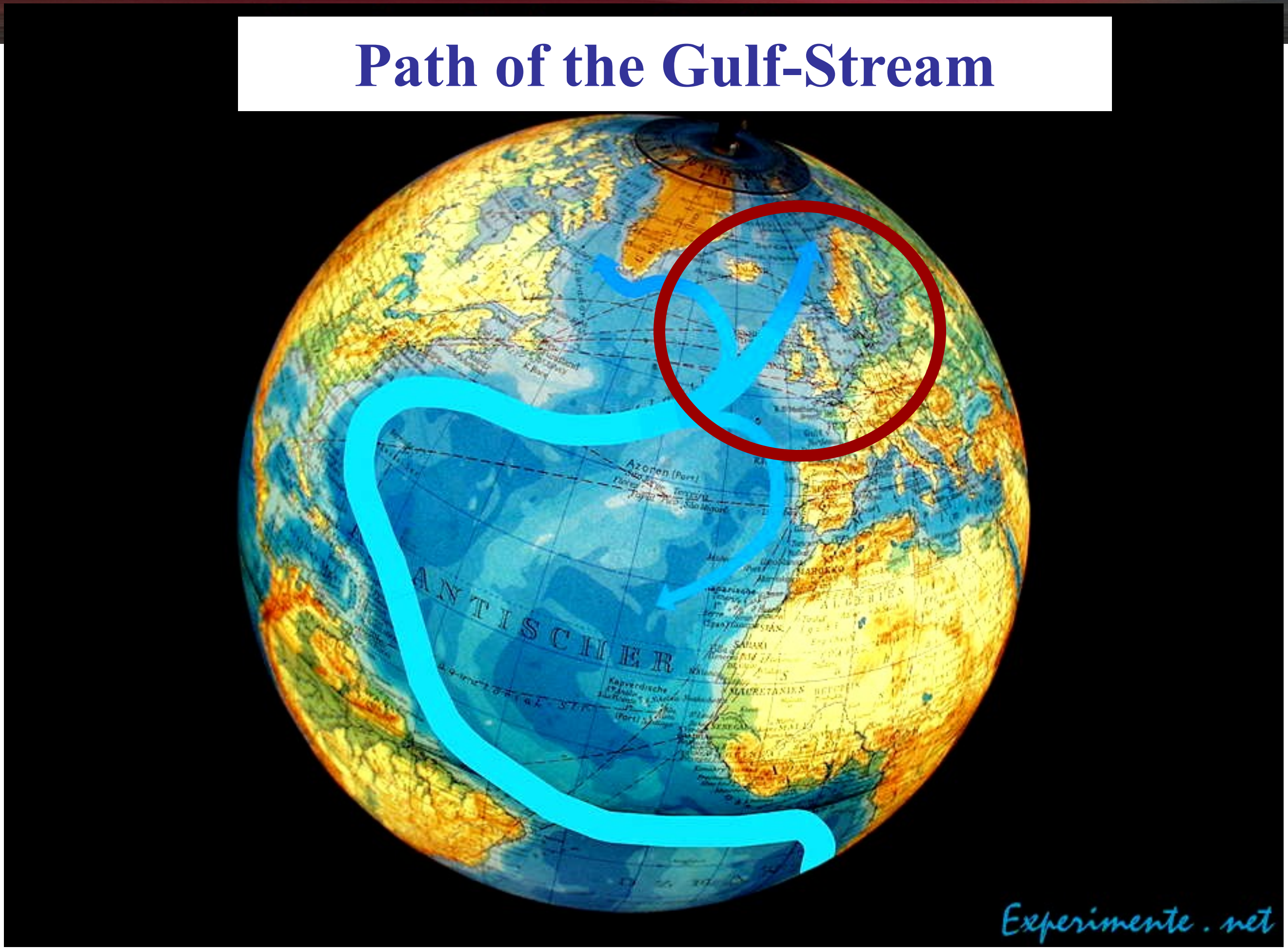


South Africa becomes warm and humid

Australia becomes cold and dry

A climatically relevant circulation

The European Heater



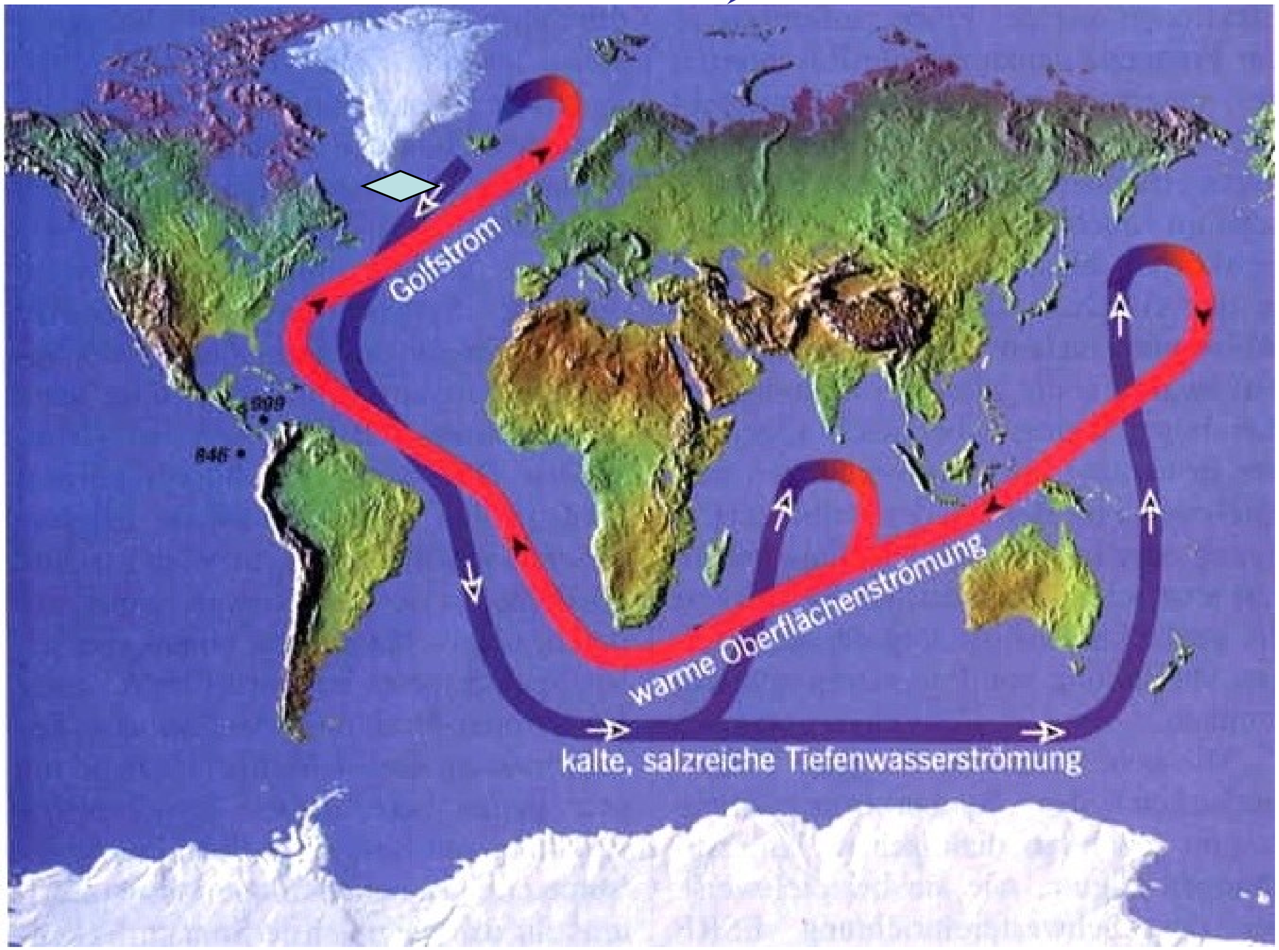
The Gulf-Stream heats Europe.

The Gulf Stream

warm superficial flow

cold deep water flow (high salt s concentration)

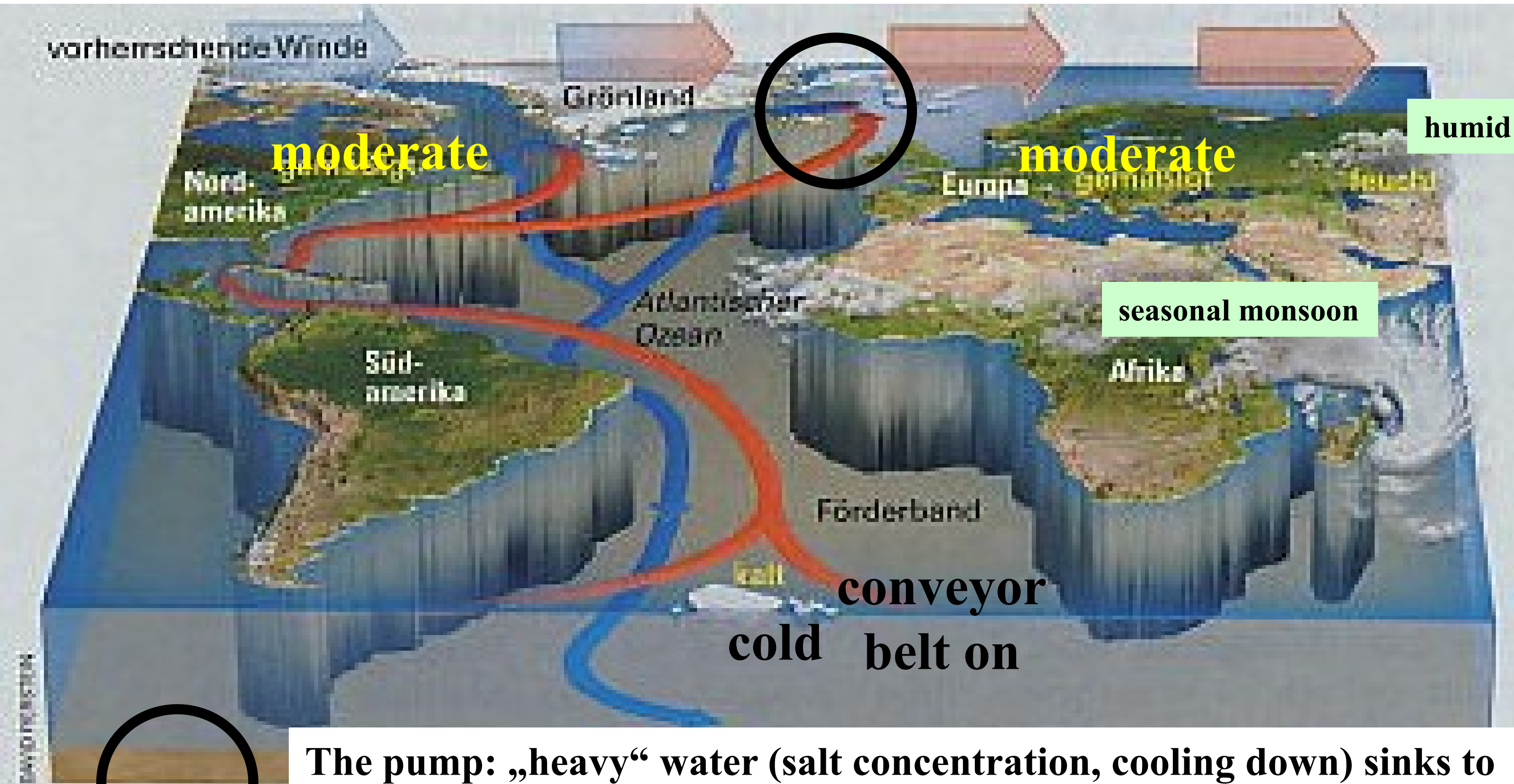
crucial region (pump)



crucial point of the gulf stream: the cold Labrador-stream coming from the north sinks down – this is the pump, because it s exhausting rate sucks the warm superficial water of the gulf stream.

The Gulf Stream

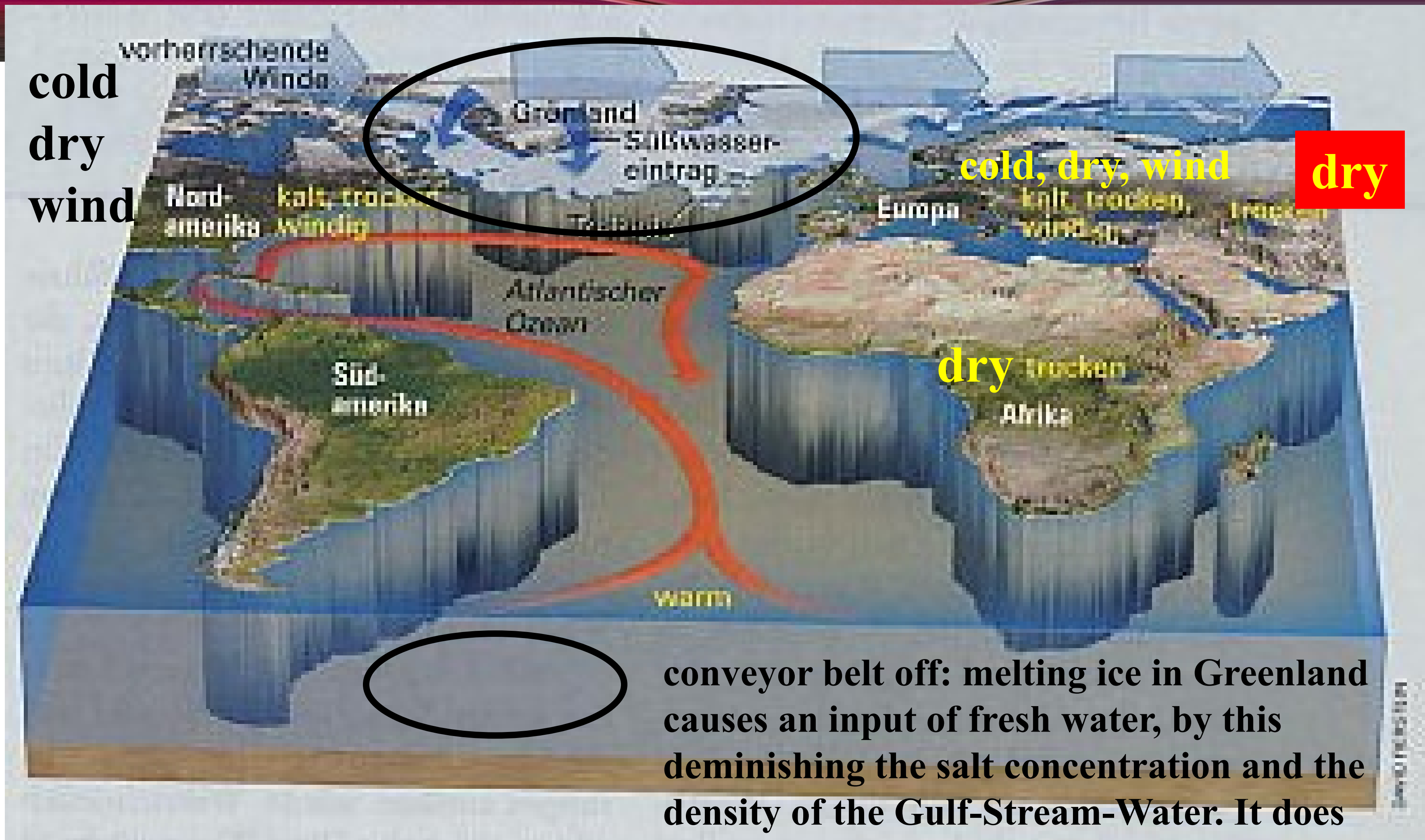
West wind is warmed up by the warm Gulf Stream



The pump: „heavy" water (salt concentration, cooling down) sinks to the bottom of the ozean – deep cold stream „back"

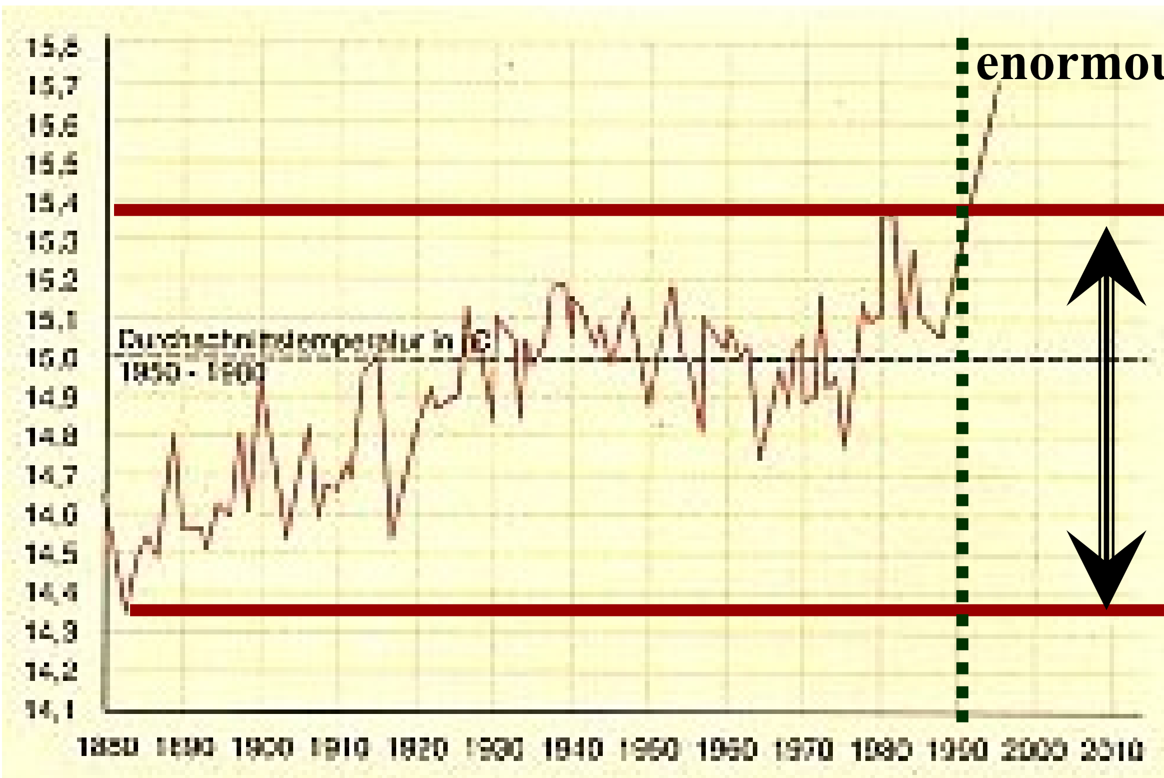
Source: Spektrum March 2005

Without the Gulf Stream



conveyor belt off: melting ice in Greenland causes an input of fresh water, by this deminishing the salt concentration and the density of the Gulf-Stream-Water. It does not sink down, partially it freezes.
The main stream is changed.

The climatic problem: oscillations of the temperature



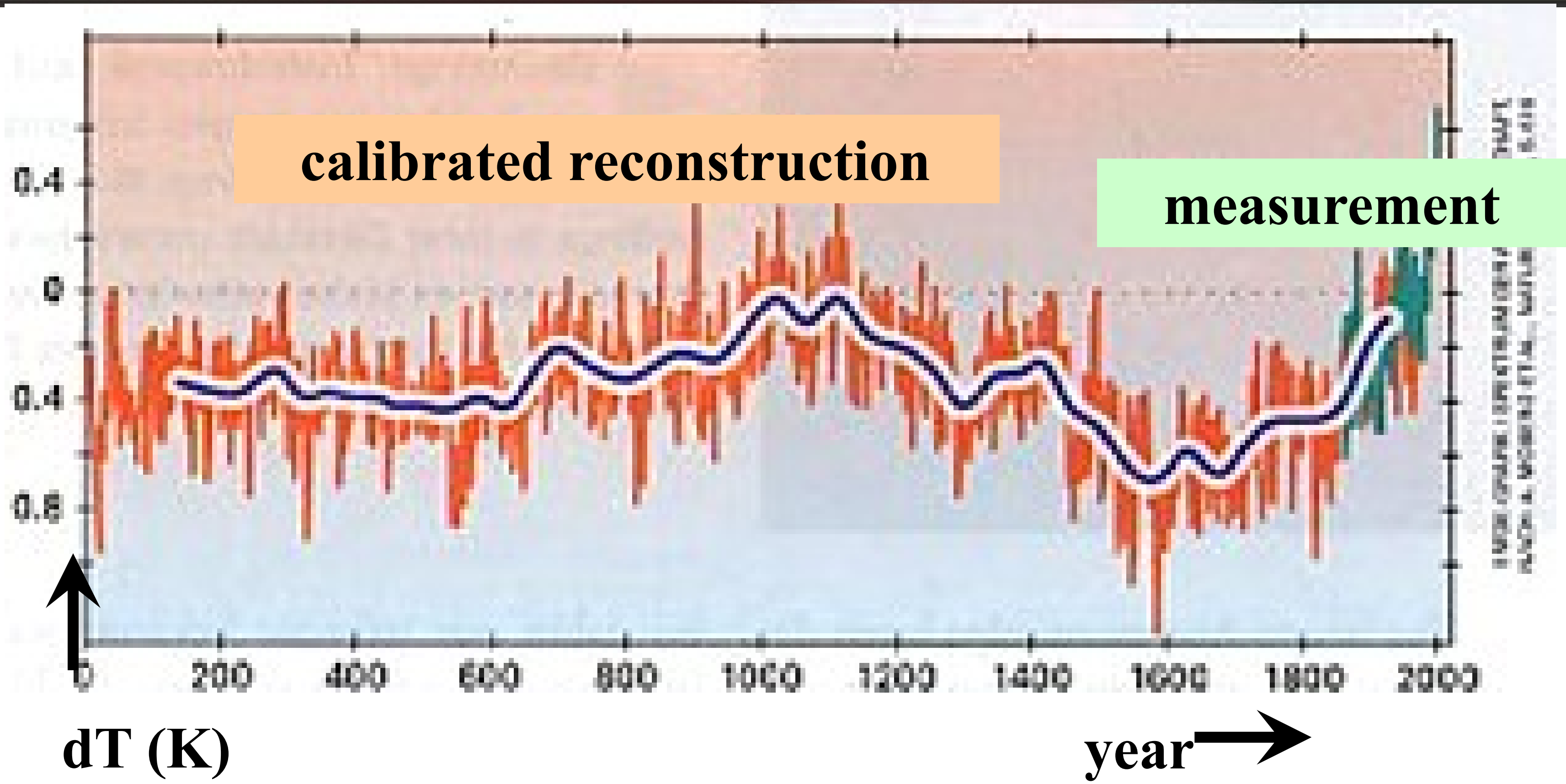
enormously increasing temperature

mean value (1850-1950)

Increase ~ 1 K

Priority:
The climatic problem is the increase of the globe s temperature

The climatic problem: oscillations of the temperature



The last 2000 years: temperature has increased for 1 K

Source: Sven Titz, Historische Temperaturwellen, Spektrum Juni 2005

The climatic problem: oscillations of the temperature