From Sand and Sun to Electricity and Hydrogen

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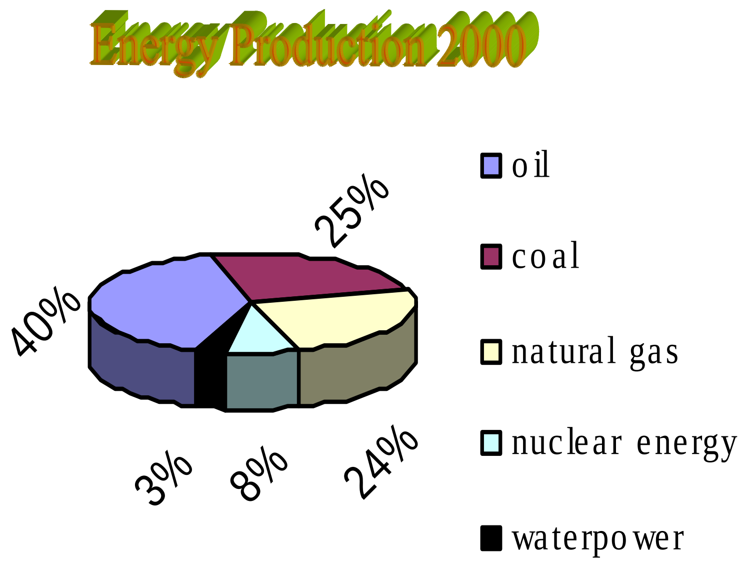
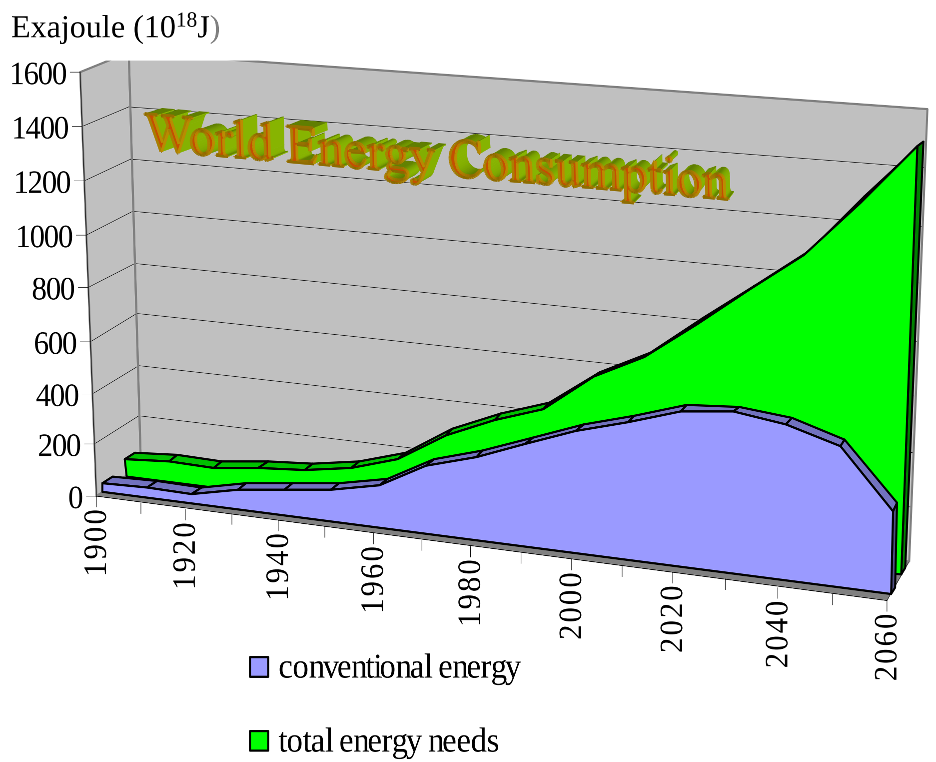
citysolar
power plants

The Problem ...

G. Schröder, R. Prodi, E. Stoiber; HYFORUM 2000:

*The most urgent challenges facing the just beginning new century are focussing on the fields of health, food and **energy***





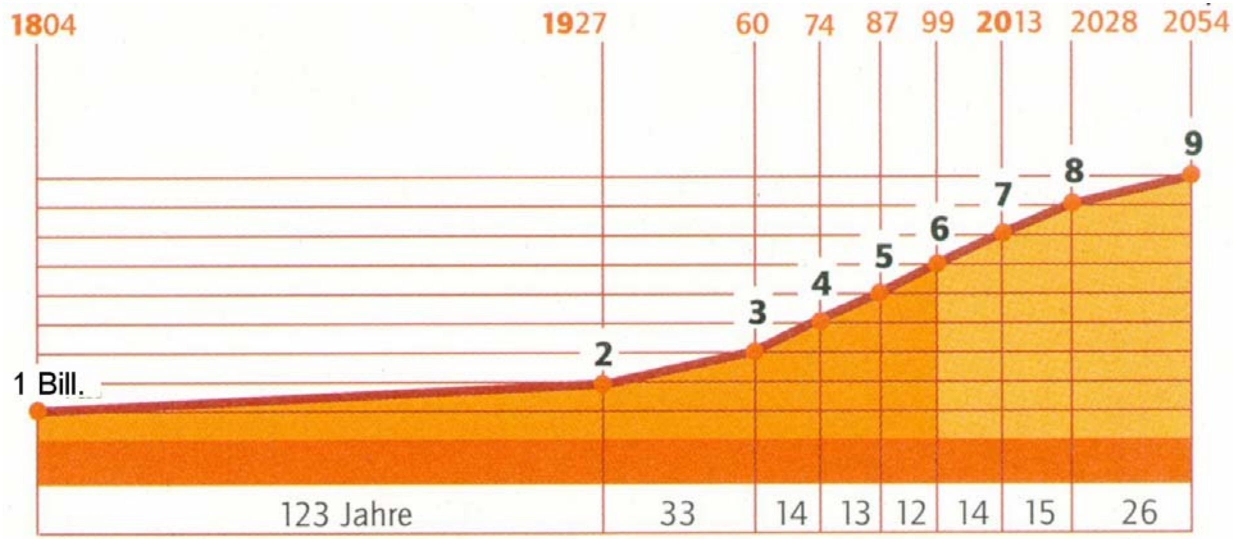
... in Numbers and Statements

- Within one day, mankind burns more carbon, oil and natural gas than being formed within a thousand years in history of earth. In forty years the need of energy will be twice as much (Greenpeace)

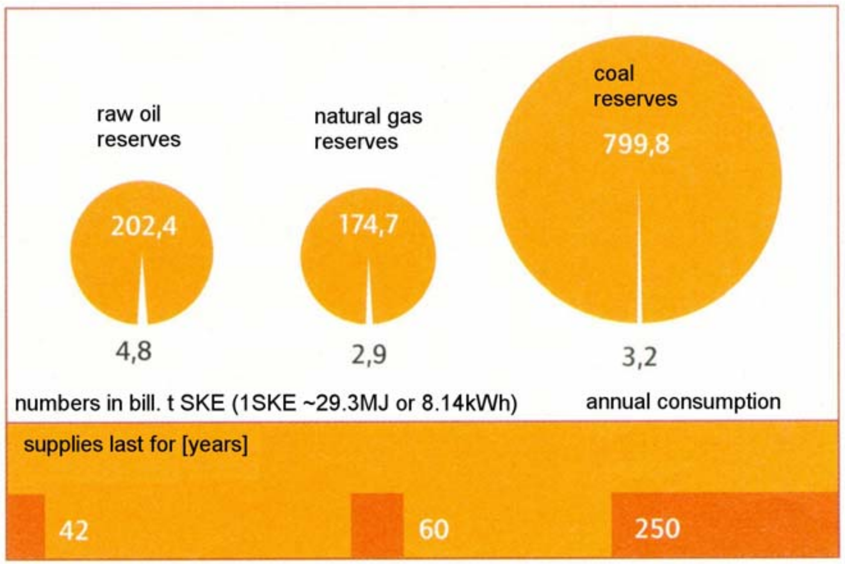
- Step by step the earth runs out of oil (Fritz Varenholt, Shell AG)

- The problem with the green house gas (CO_2) (HYFORUM 2000)

World population in billions [prognosis]

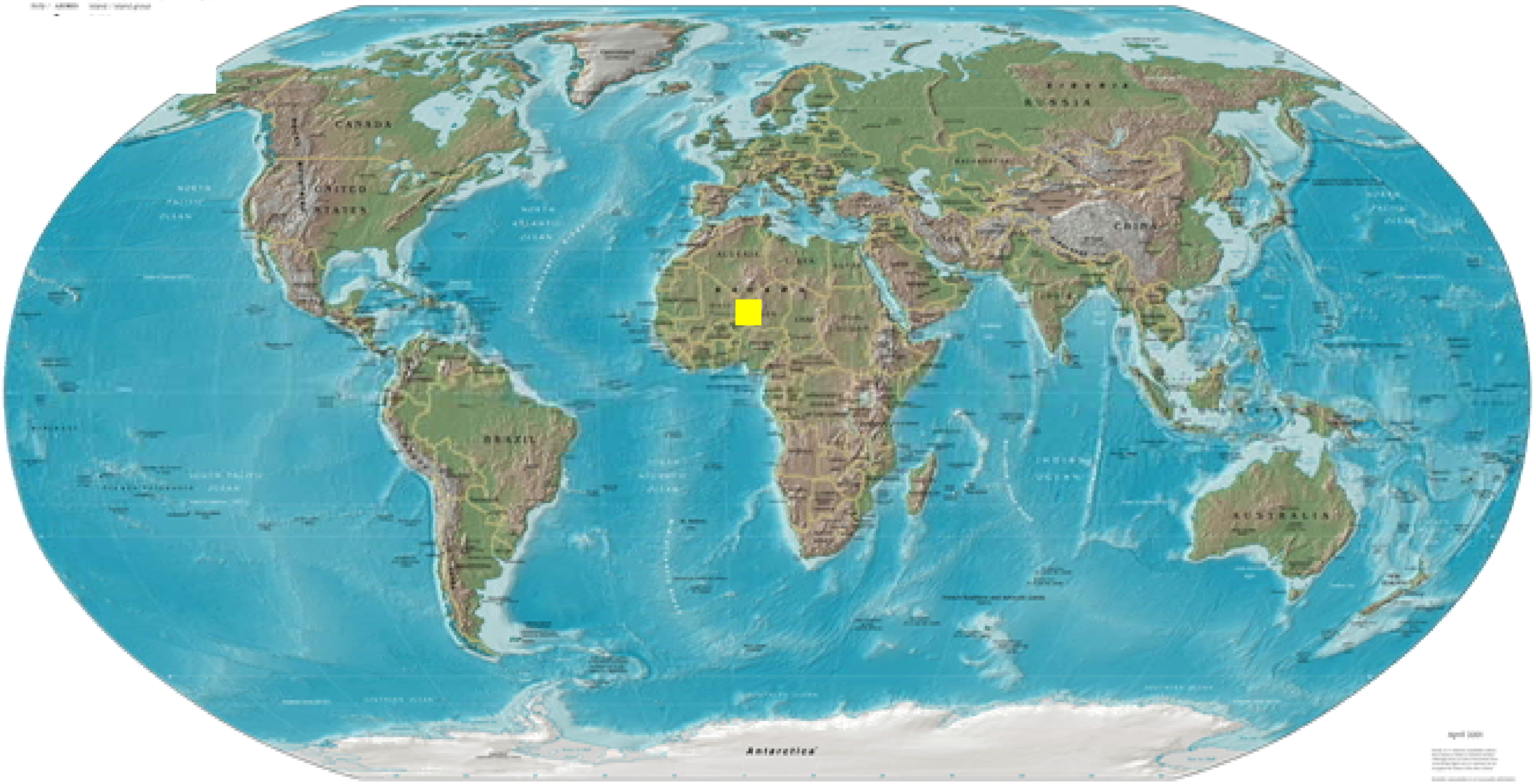


Resources in carbon based energy



Proposed Solution

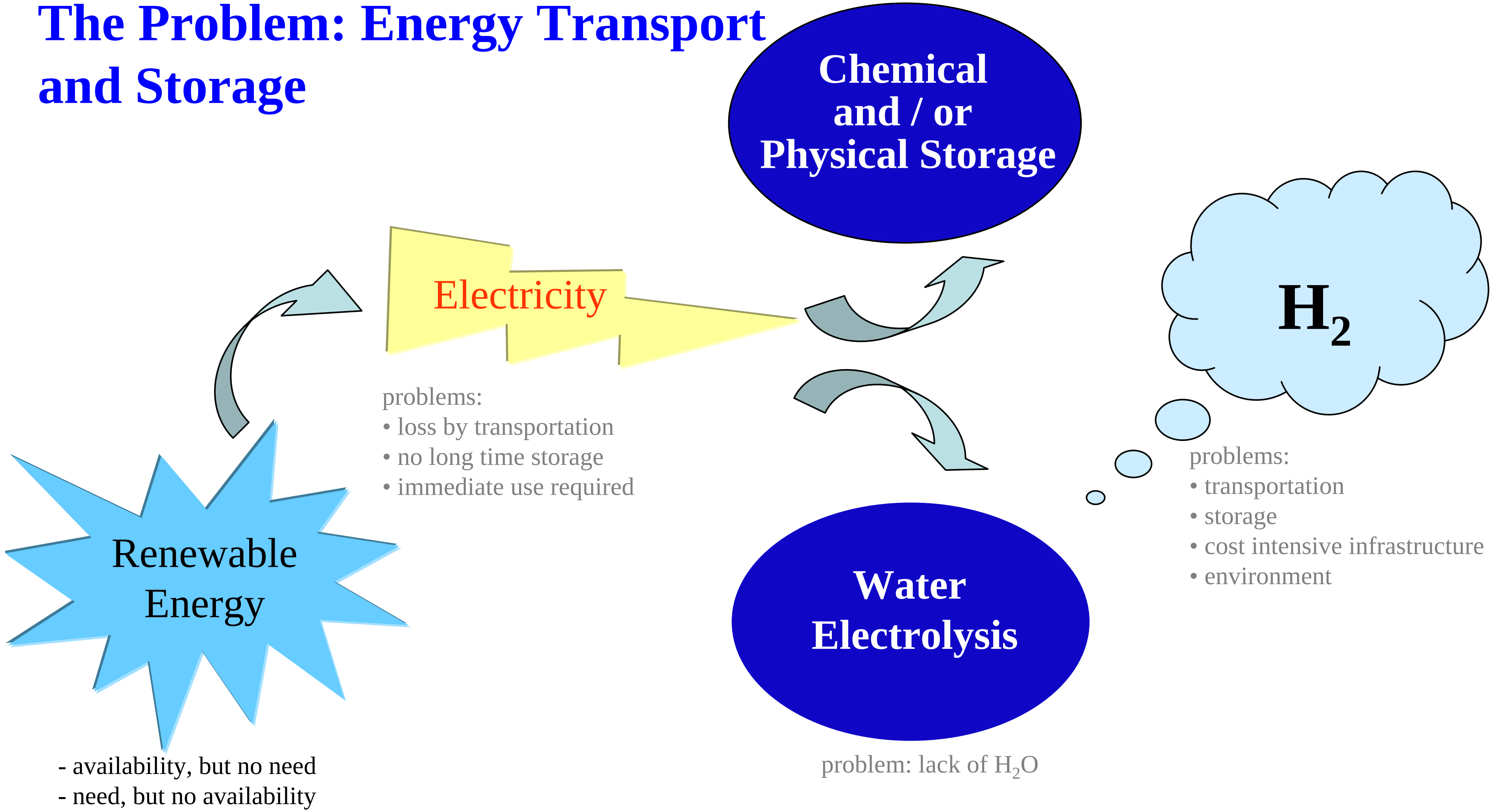
Question: **How many space is required to supply mankind with sufficient solar energy ?**



Surprising Answer: **An area of 700 km x 700 km in e.g. the Sahara desert is sufficient to supply the complete energy annually consumed by mankind worldwide**

Efficiency of the solar system 10 %

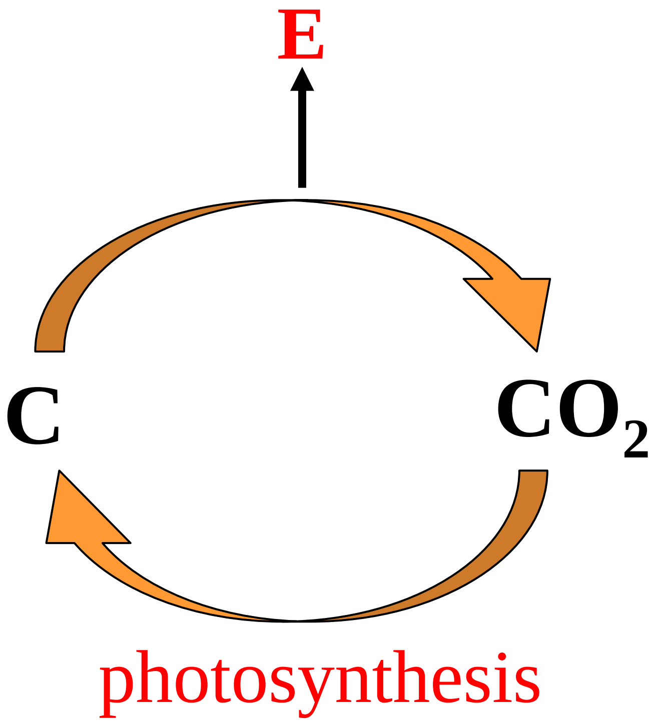
The Problem: Energy Transport and Storage

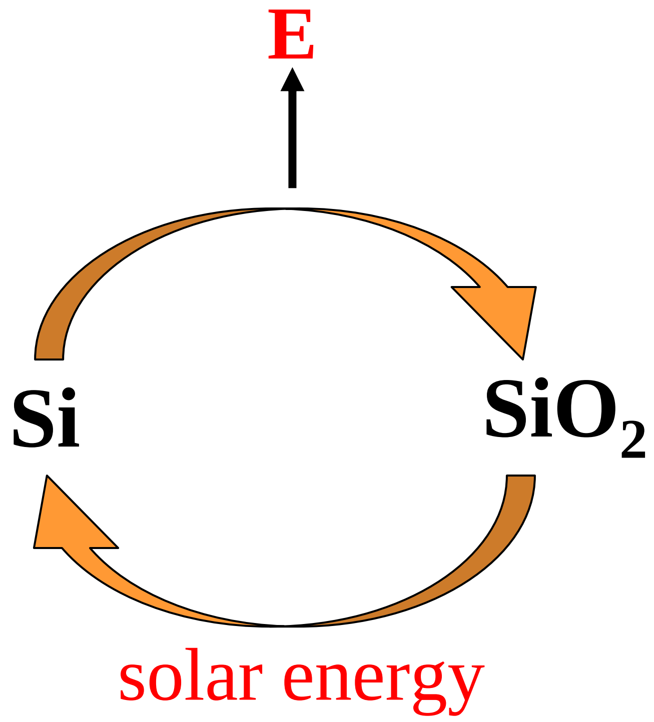


Statement of the Energy Departement, Washington DC, *July 2002*: … we are looking for „revolutionary" new energy production schemes, being convinced that „incremental" progress and all of the conventional approaches to fuel cells, photovoltaics, fossil fuels etc., aren´t going to be sufficient for the future. Simply, our need is a secondary energy carrier, which is transportable without hazards.

Statement of J. Hambrecht, Chief Executive of BASF, *The Economist*, *Nov. 4th, 2006*: "Our fantasy is that in the future solar energy will be stored and put to work chemically, much as it is in plants through photosynthesis".

A New Energy Cycle: Possible solution for future solar energetics and chemistry





Abundance C: 0,02 %

Organo-C: $2 \cdot 10^{-7}$ % (!)

26,3 % Si 56,4 % SiO_2

C_nH_{2n+2}

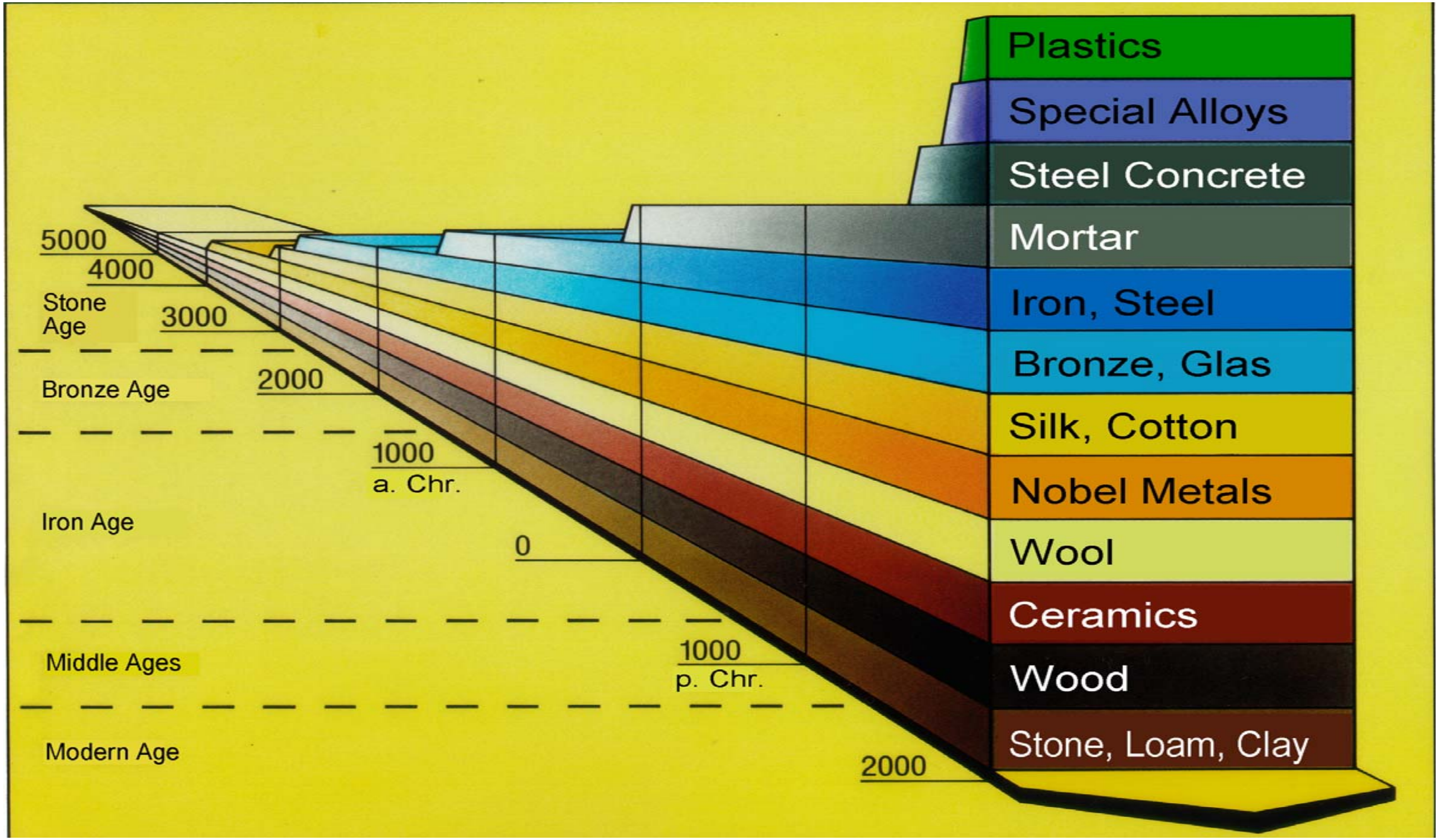
Si_nH_{2n+2}

	C	Si*
Energy content [kJ/g]**	32,8	32,6
Energy density [kJ/mL)**	74,2	75,9

** obtained from heat of formation of the oxides

Abundance of SiO_2 in Nature

Building Blocks for the Cultural Development of Mankind

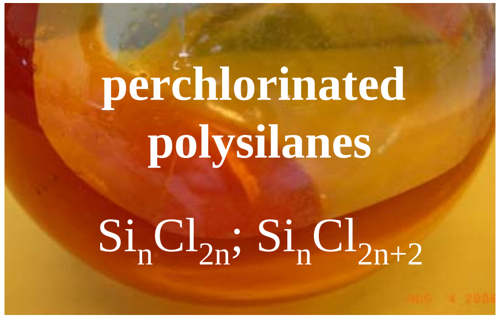


From Sand to Photovoltaics and “Printable Electronics“

$SiCl_4$

HCl

Plasma-Process



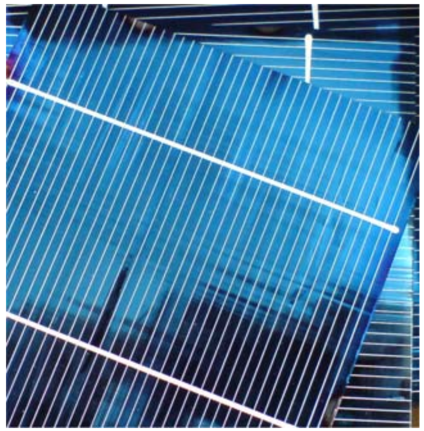
$SiCl_4$

Pyrolysis

~ 350 °C

PV-Silicon

PV-Thin Films / Printable Electronics



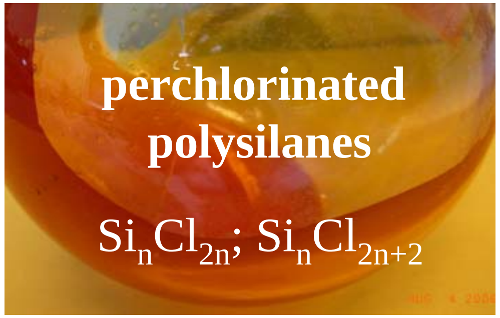
From Sand to Photovoltaics and “Synthetic Silicon Oil“

HCl

$SiCl_4$

$SiCl_4$

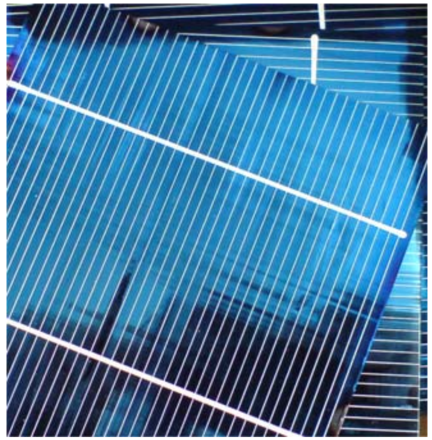
Plasma-Process →



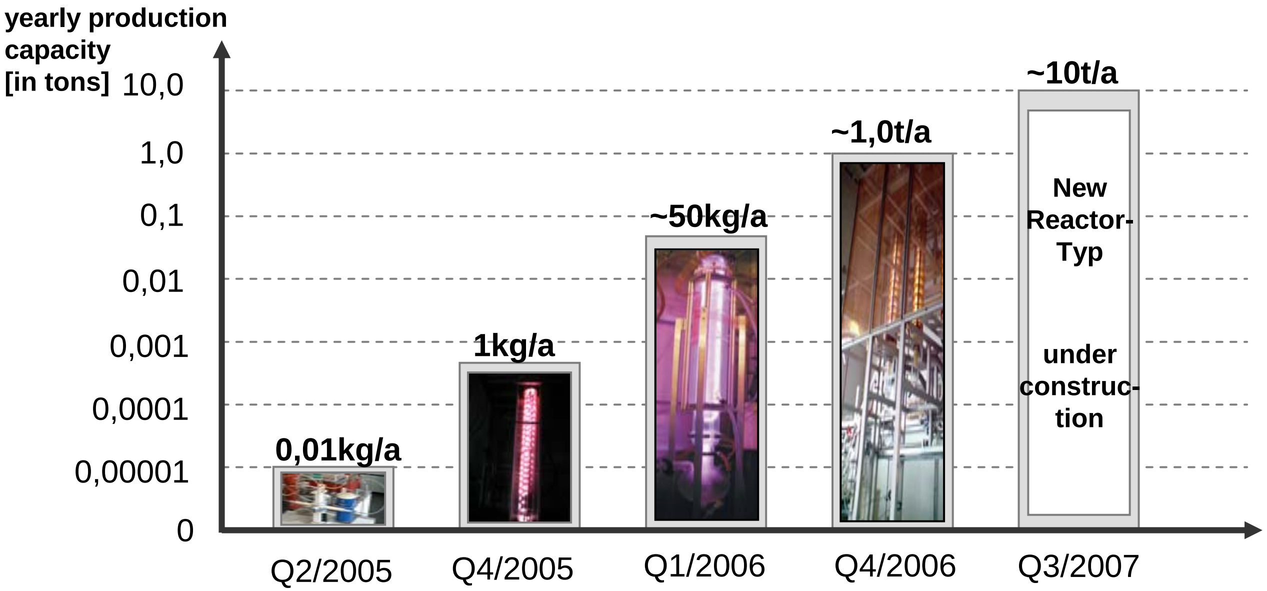
Pyrolysis → ~ 350 °C

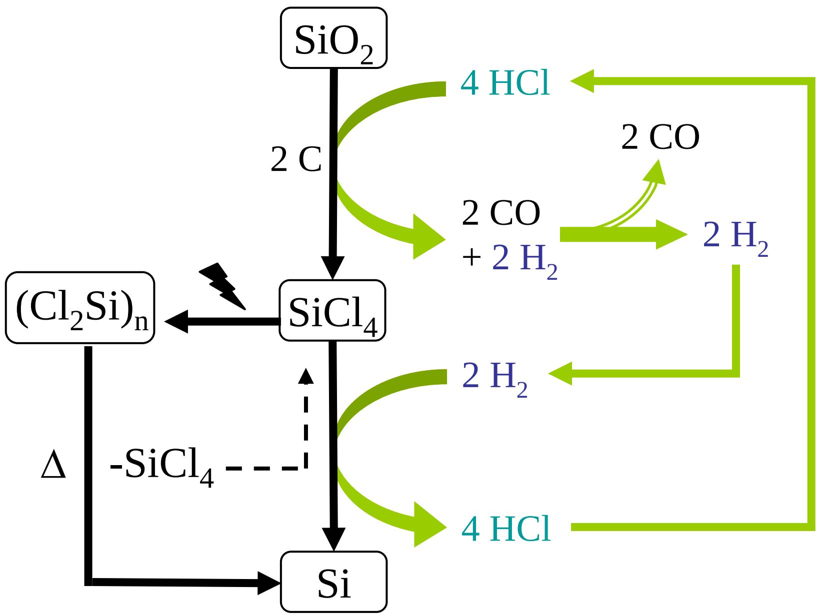
PV-Silicon

solid
H-Polysilanes (HPS)



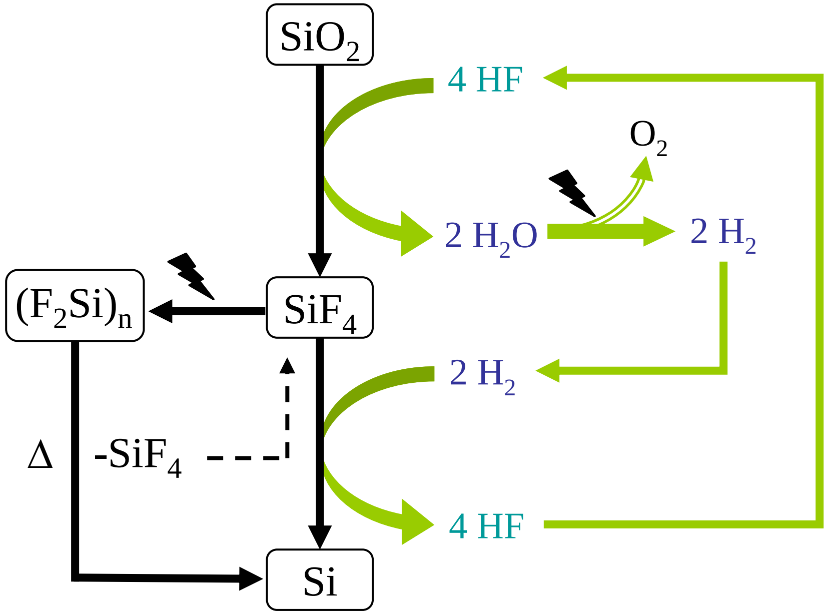
City Solar Pilot Plant



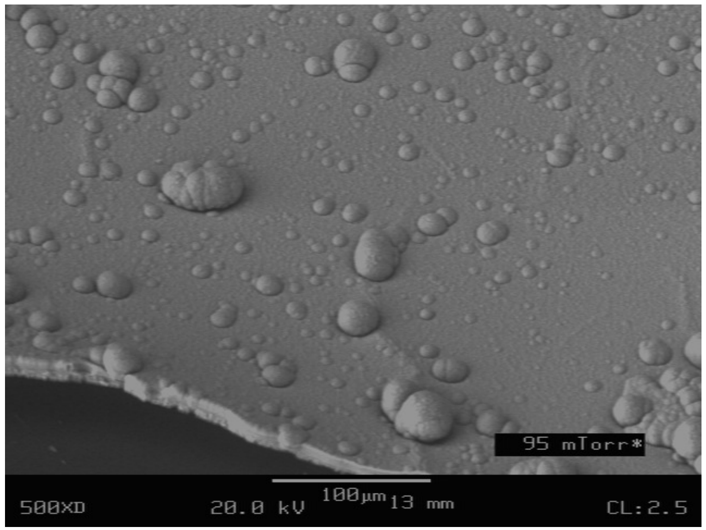


Carbon Free Silicon Production

Laboratory scale device for microwave assisted polysilane and silicon production

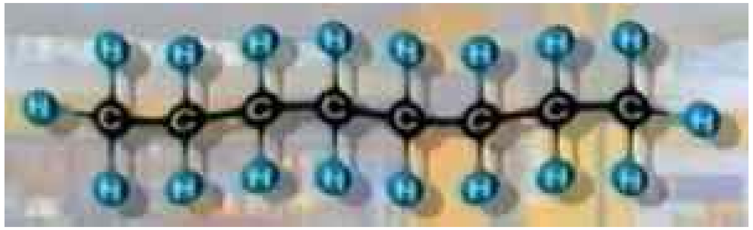


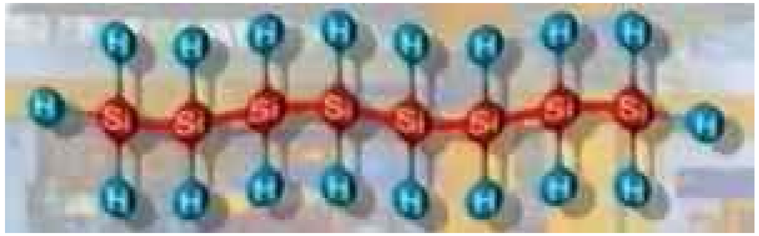
Perfluorinated polysilane, $(F_2Si)_n$



REM picture of silicon from the carbon free fluorine route

CO_2-Free Alternative Fuel


octane


octasilane

Hydrogen Generation from HPS

$$Si_{15}H_{32} + 30\ H_2O \rightarrow 15\ SiO_2 + 46\ H_2$$

452 g 540 g 900 g 92 g ~ 3kWh

92g/452g = 20,35% Hydrogen Content

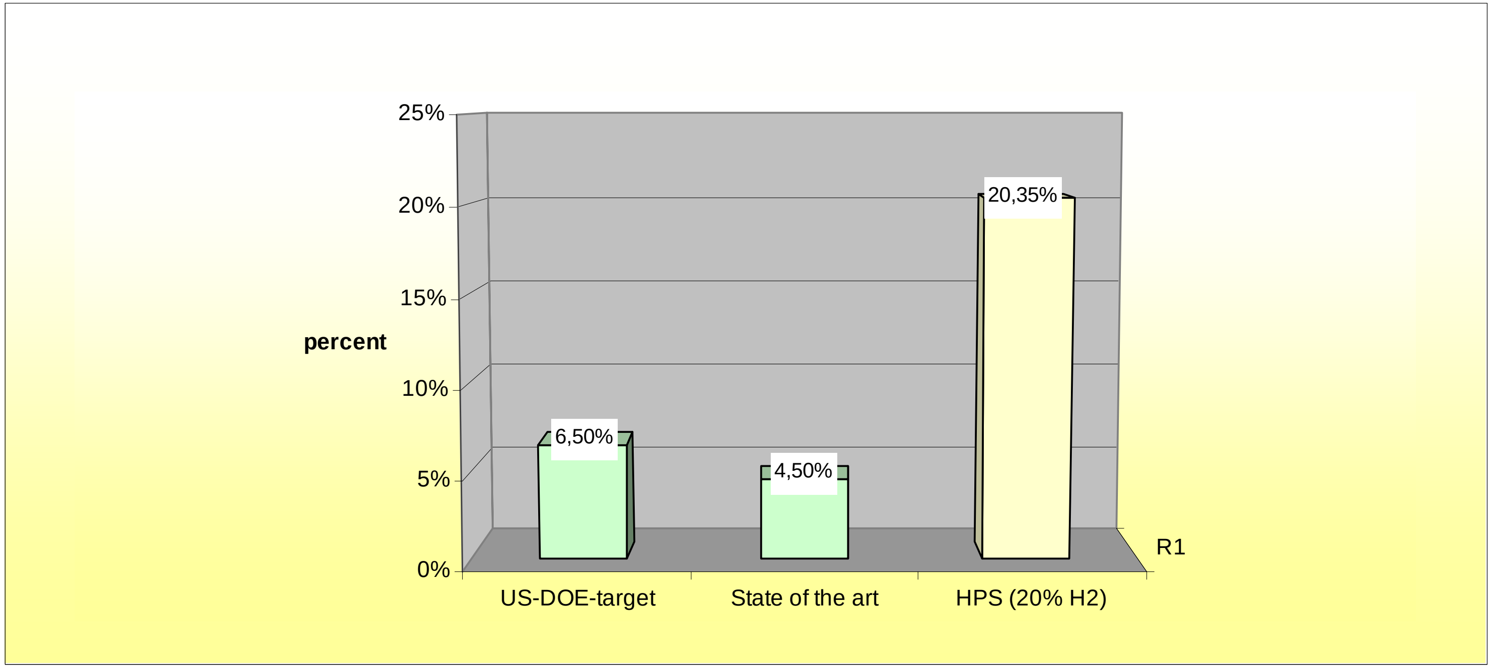
Products from use in PEM fuel cell:

$$46\ H_2 + 23\ O_2 \rightarrow 46\ H_2O$$

92 g 736 g 828 g

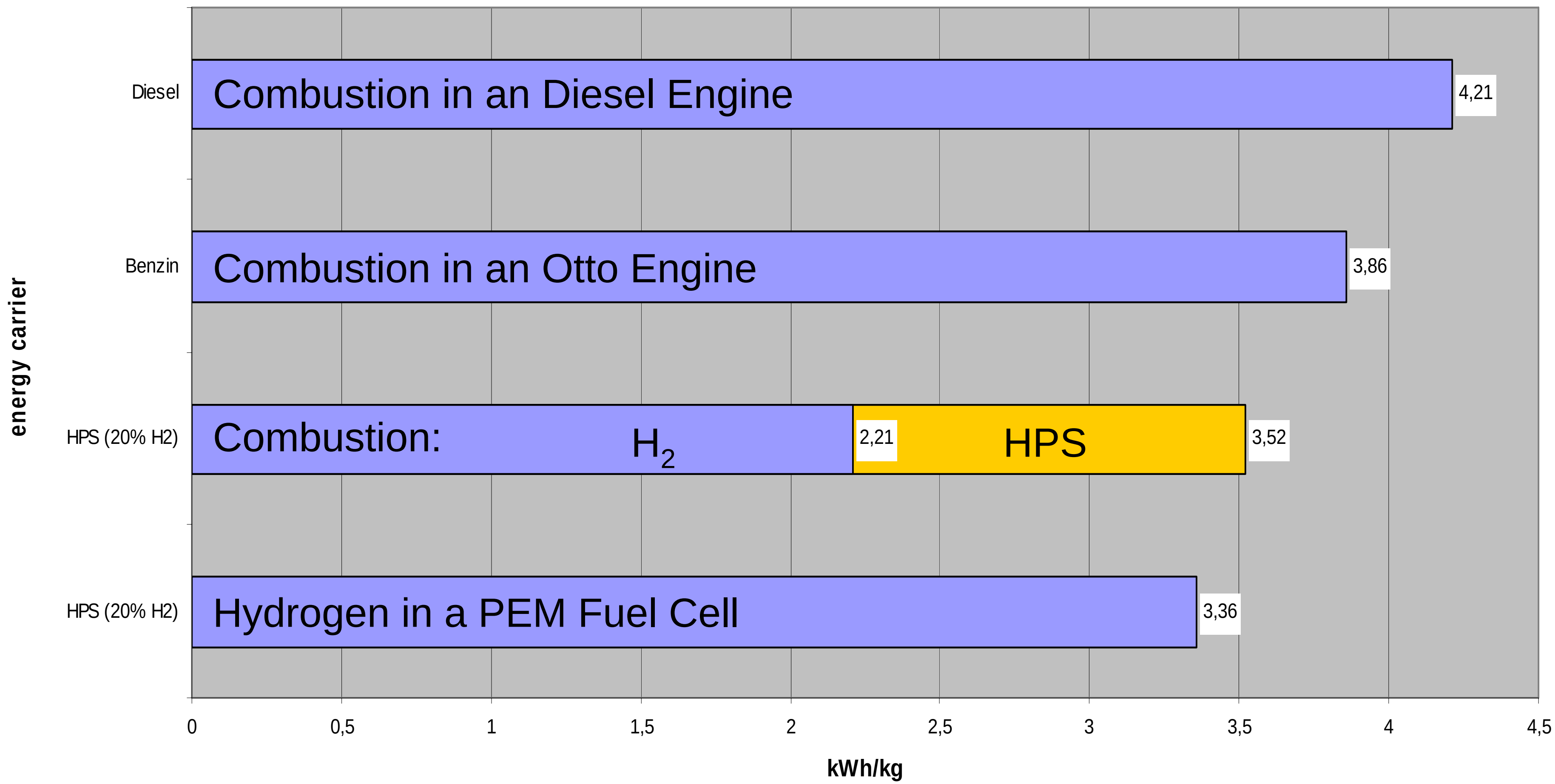
$\Rightarrow$ 900 g SiO_2 + 288 g water are formed

HPS Surpasses DOE Targets Significantly

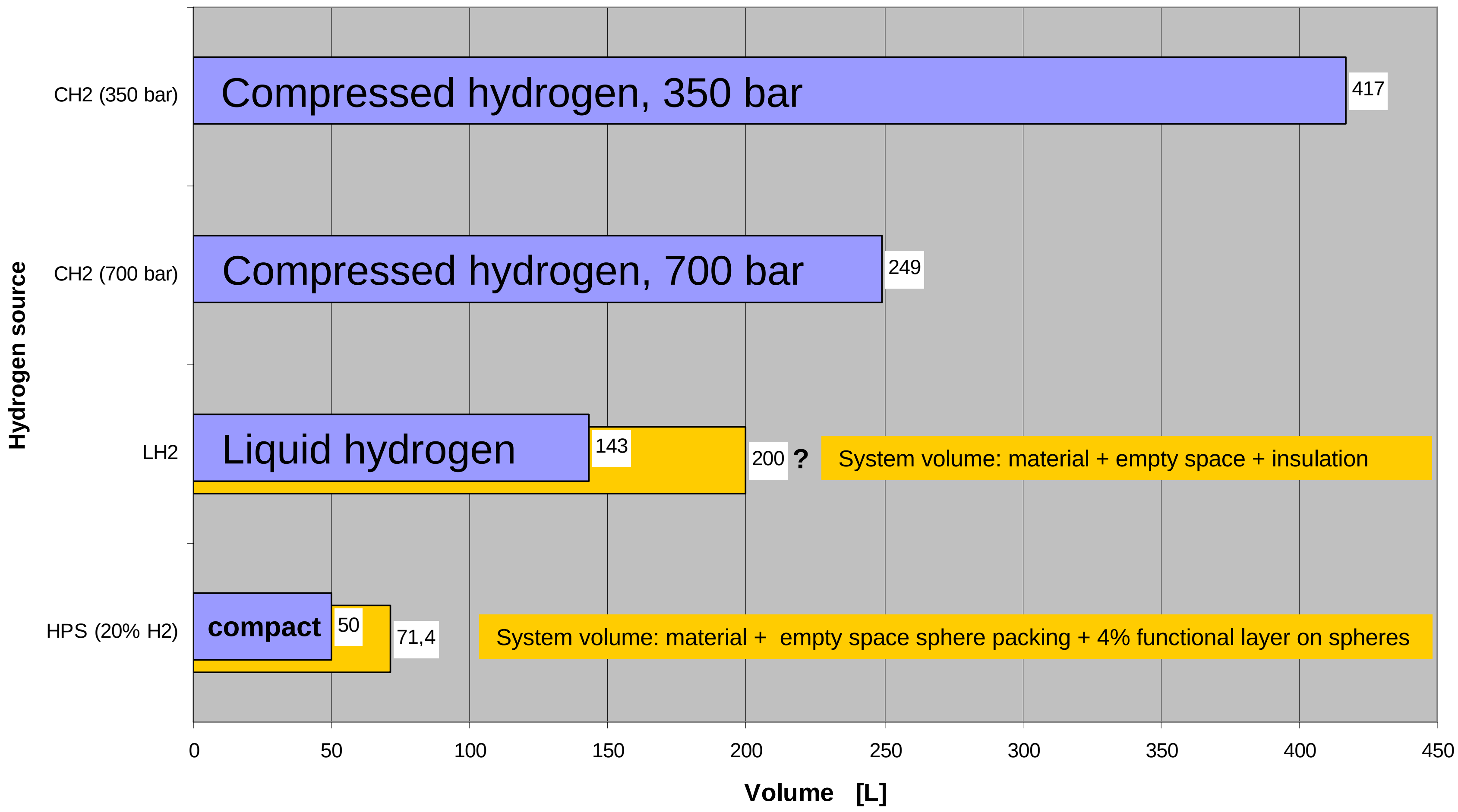


DOE – Targets:	weight of tank	max. 46 kg/100 kWh	✓
	volume of tank	max 48 l/100 kWh	✓
	hydrogen storage capacity	min 6,5 wt. %	✓

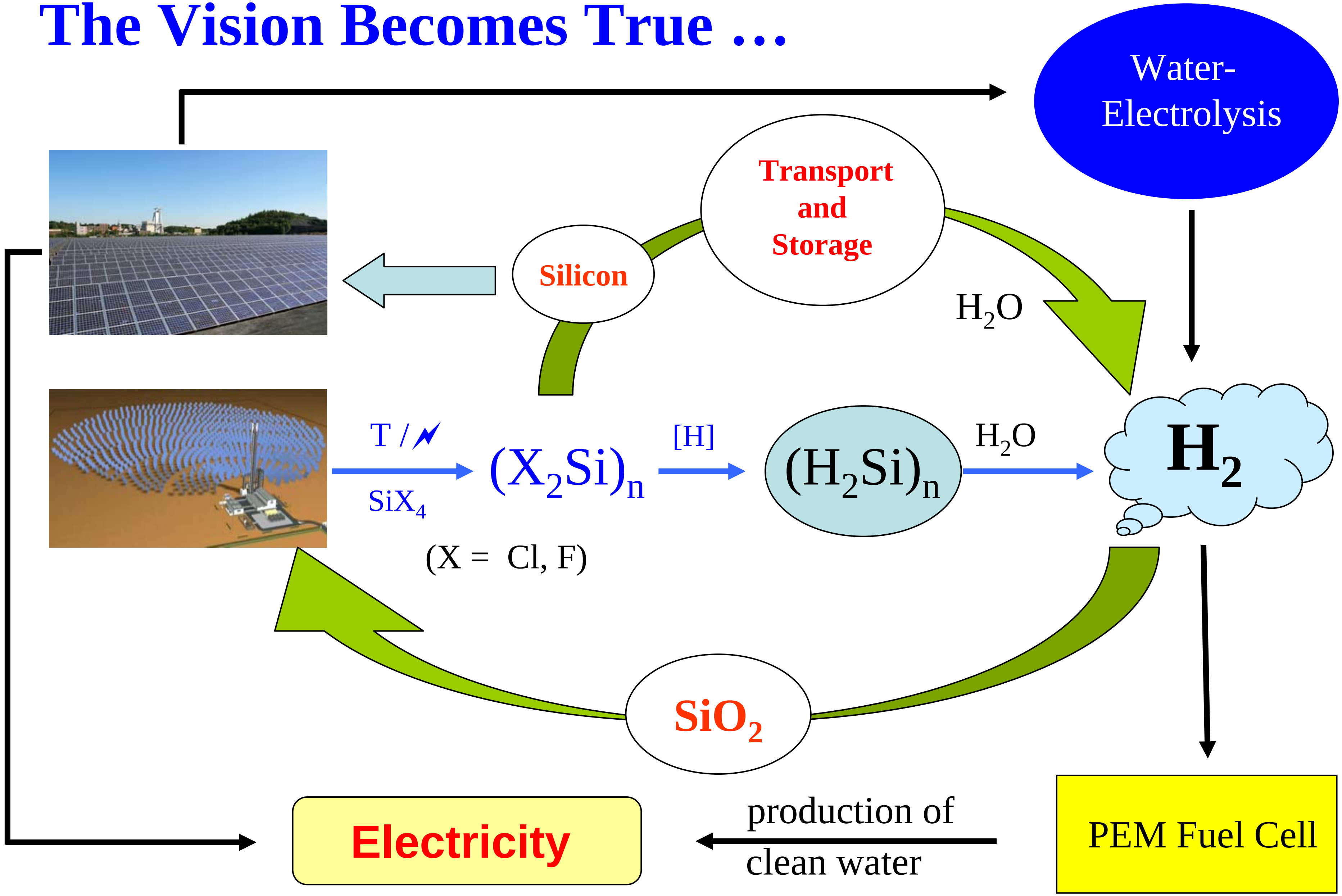
Energy Output per 1 kg of Energy Carrier in Driving Engines



Volume Required for Storage of 10 kg Hydrogen



The Vision Becomes True …



… It's Up to Us to Make it Happen