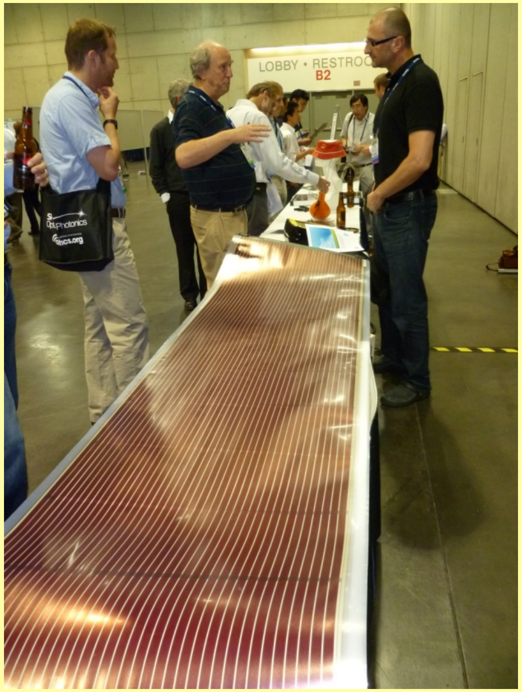
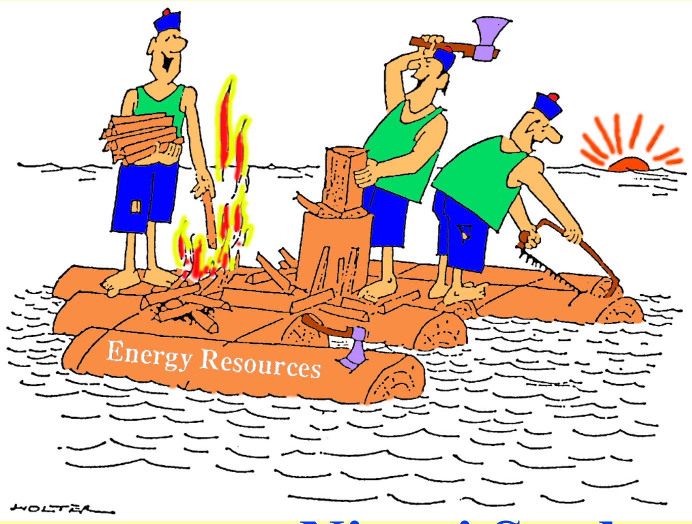
HAPPY BIRTHDAY TO ICTP FOR 50 YEARS !!!

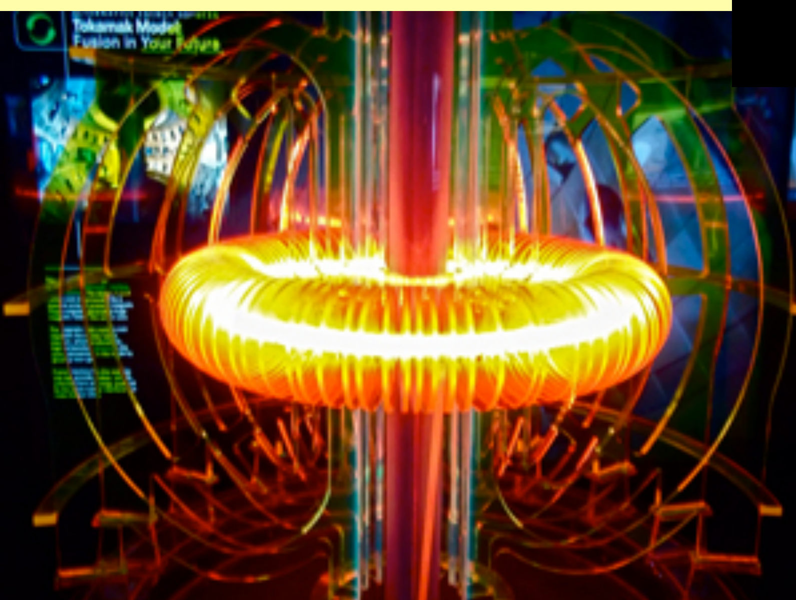
Solar Energy for World Peace





Niyazi Serdar SARICIFTCI
Linz Institute for Organic Solar Cells (LIOS)
Johannes Kepler University of Linz, Austria
www.lios.at

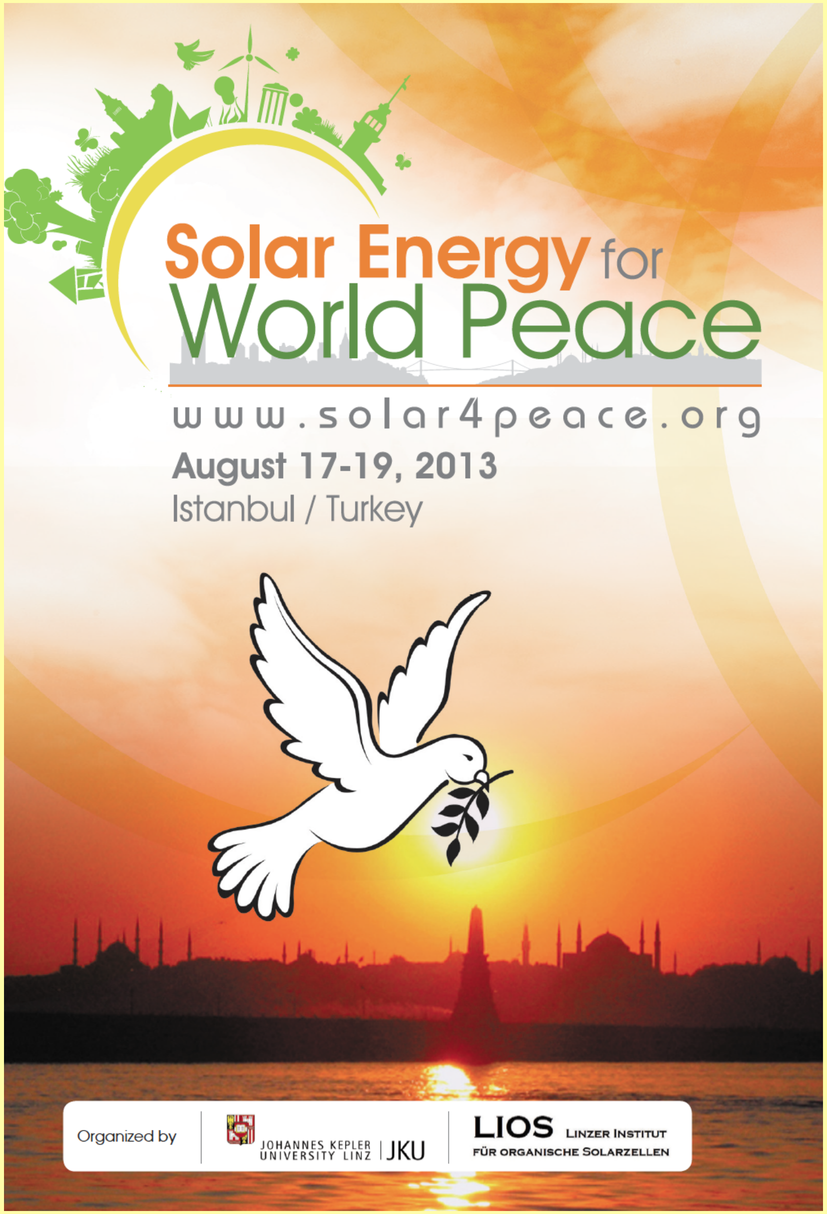
My TOKAMAK Works



IN A SAFE DISTANCE OF

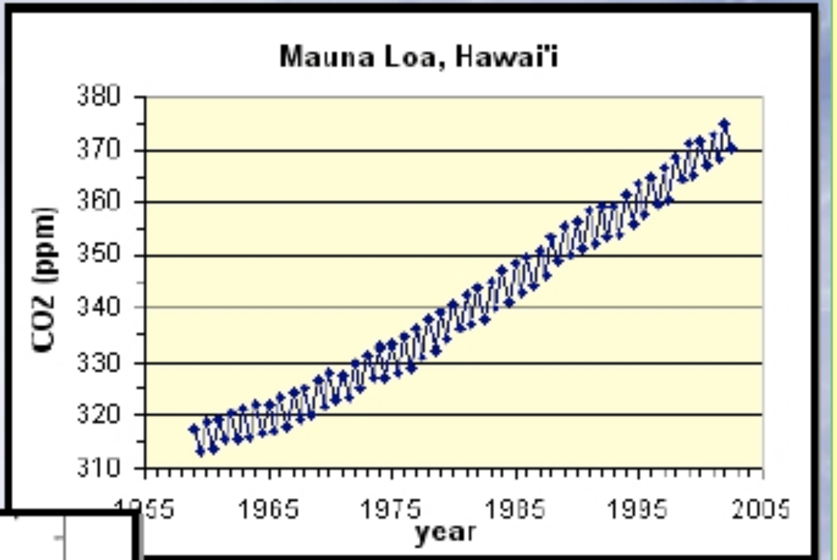
150 MILLION KM

Sign our petition at www.solar4peace.org



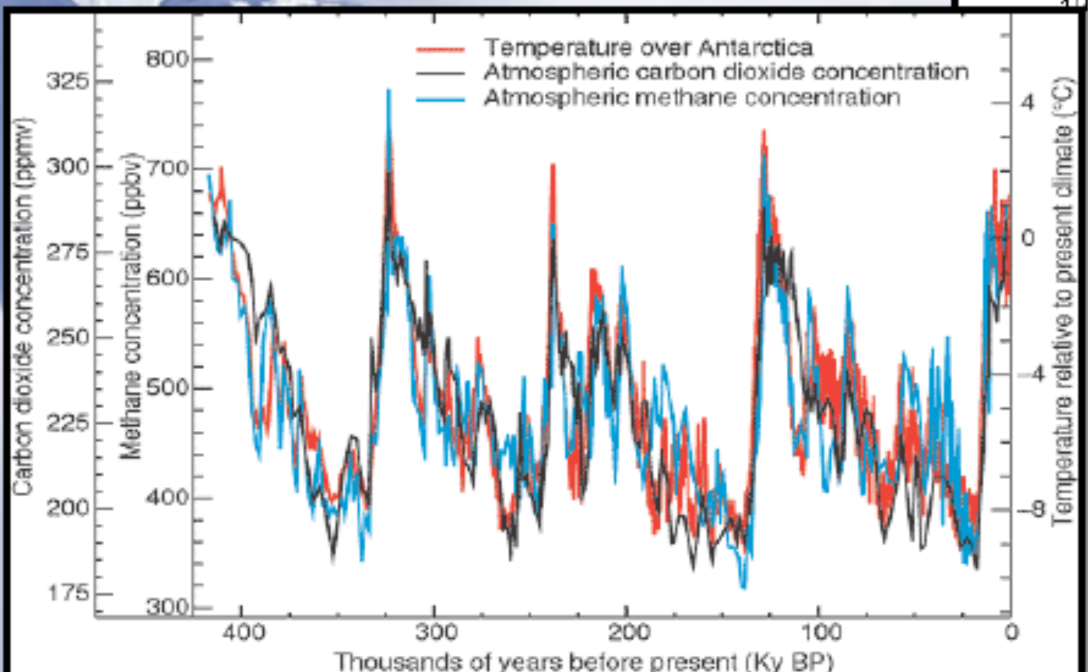
Our planet will be warmer

CO_2 Konzentrationen



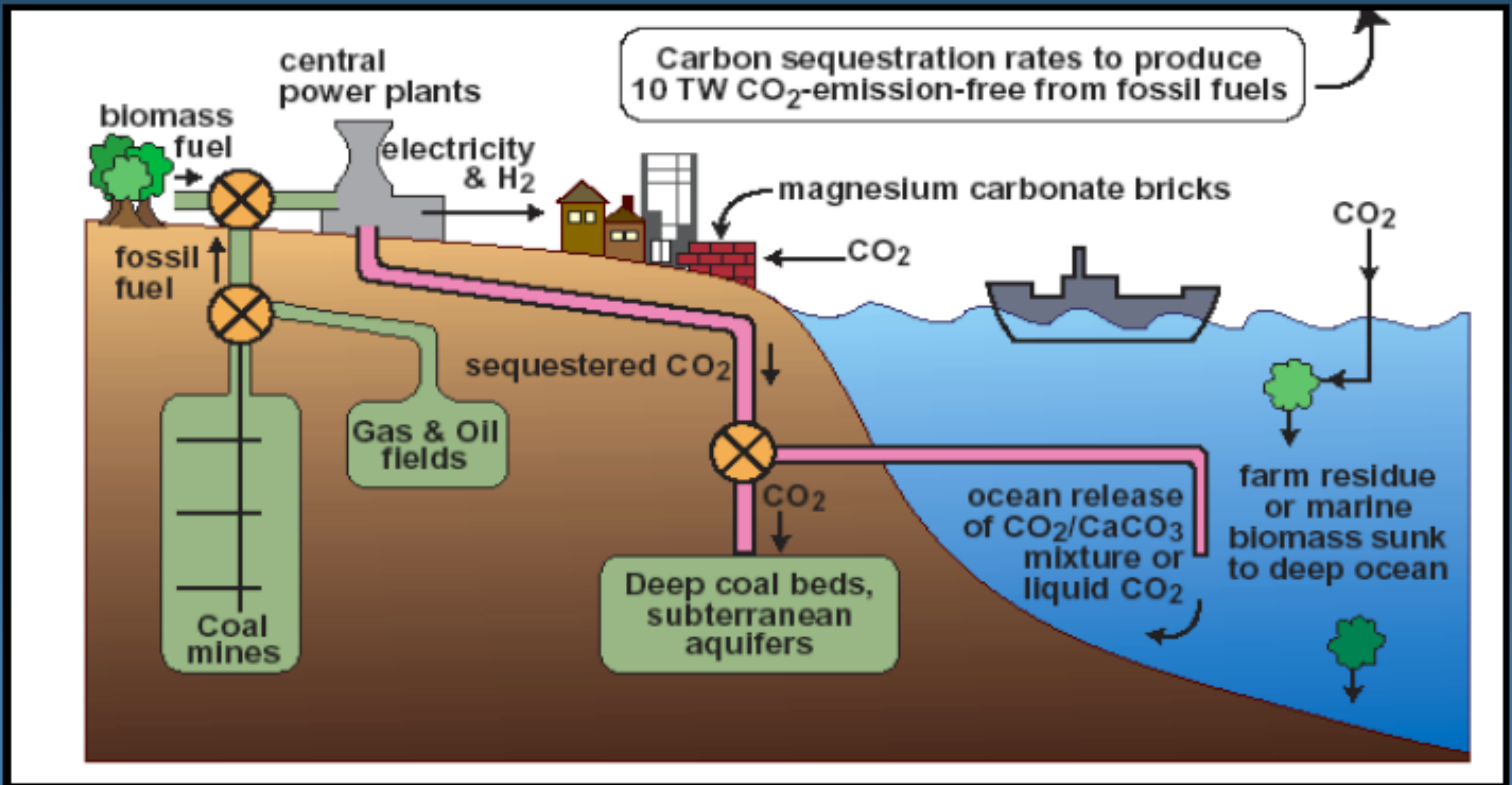
Keeling Atmospheric Data Set

Daten aus Vostok-Eisbohrungen

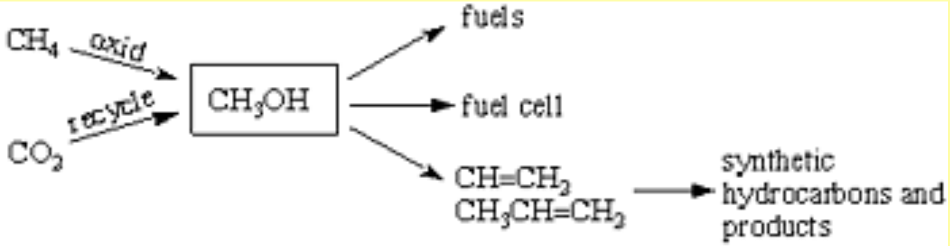


Can we get rid of CO2?

CO_2-Einlagerung



RECYCLING CO2



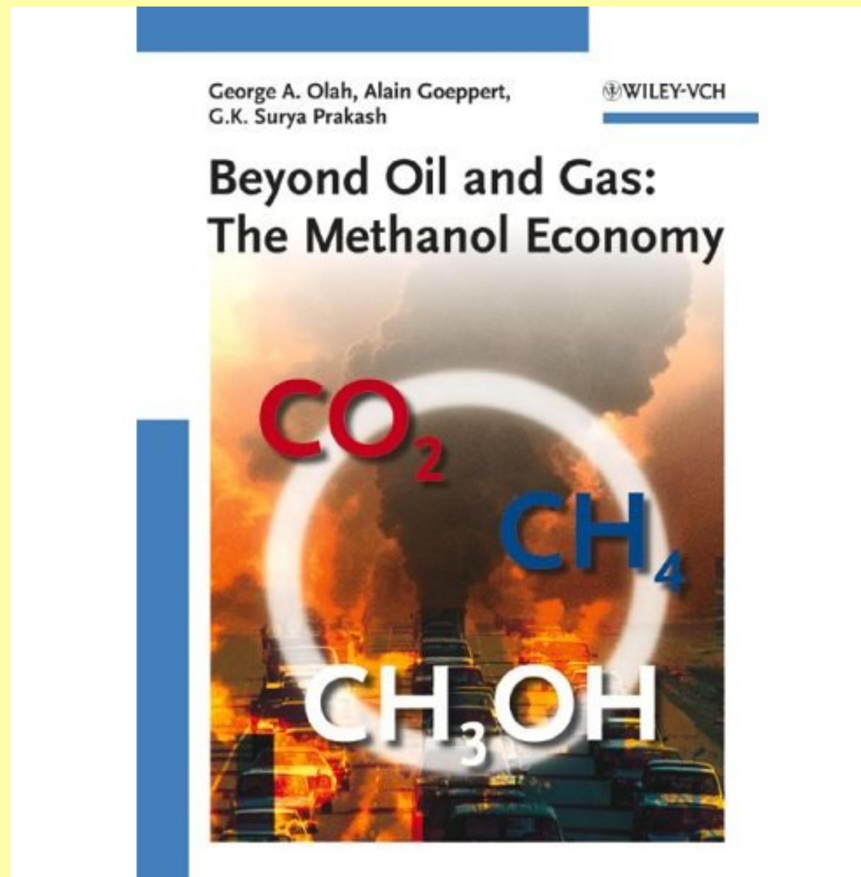
Methanol as carrier and storage of energy

a.) Methanol can be mixed to gasoline

b.) Methanol is used in fuel cells

c.) Methanol is starting chemical for
Many other derivatives

George Olah, Nobel Prize 1994
Univ. of Southern California, USA



Solarenergie-Potential

- Theoretisch: 1.2×10^5 TW einfallende Solarenergie

  (1.76×10^5 TW erreichen die Erde, 0.30 mittlere Albedo)

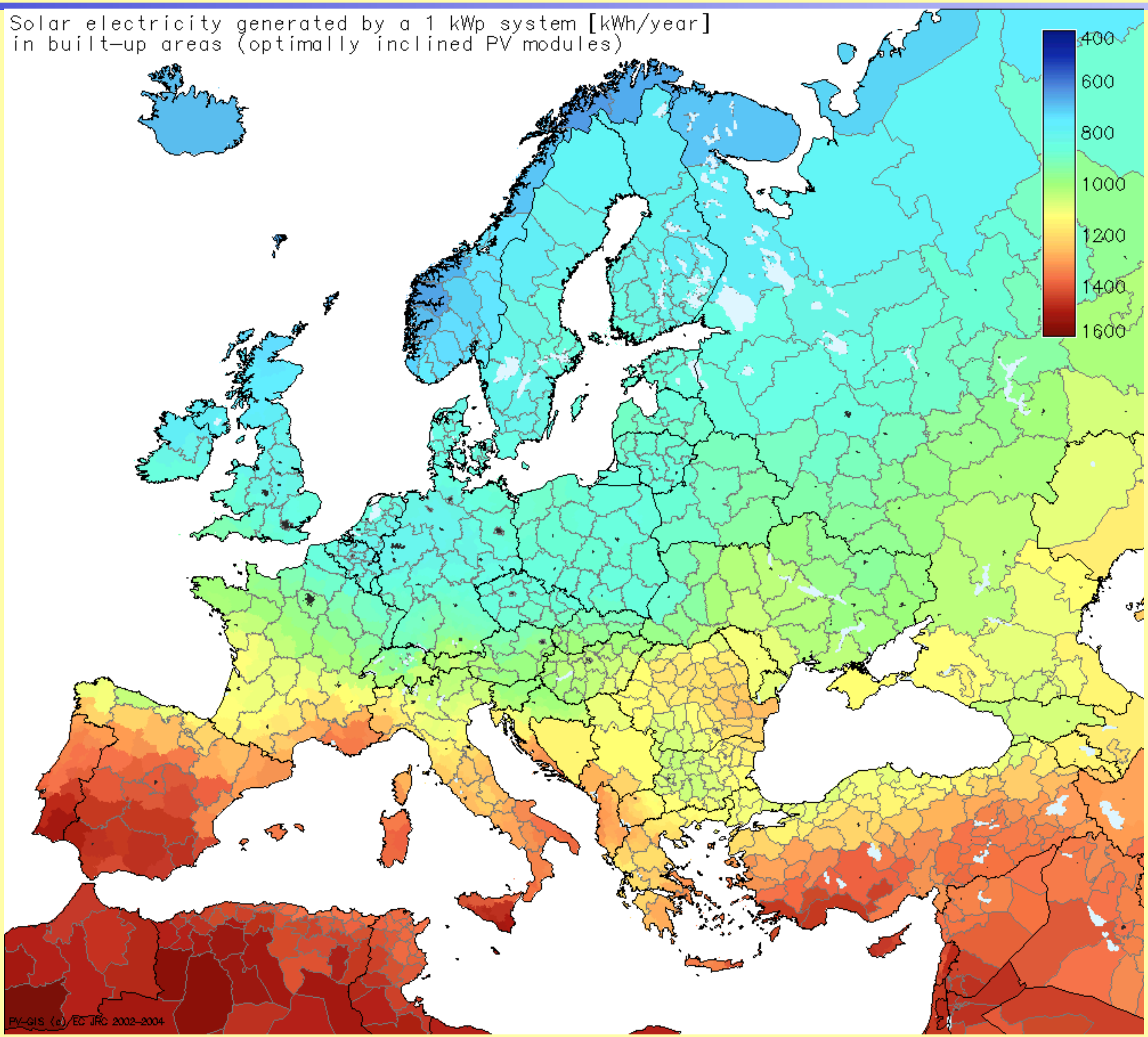
  - Einstrahlung in 1 h entspricht Jahresbedarf von 14 TW

- Praktisch: ≈ 600 TW Solarenergie-Potential

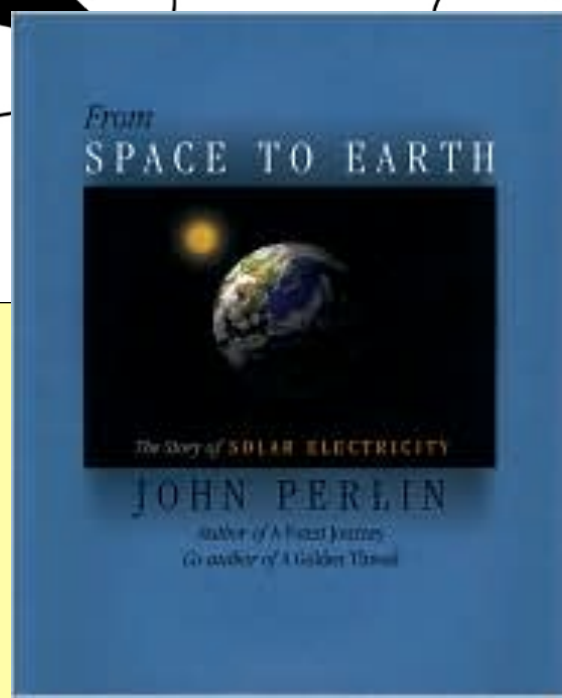
  (50 TW - 1500 TW abhängig von genutzter Fläche etc.; WEA 2000)

  Küstennahes Solarstrom-Potential von ≈ 60 TW (bei 10% Solarzellen-Wirkungsgrad)

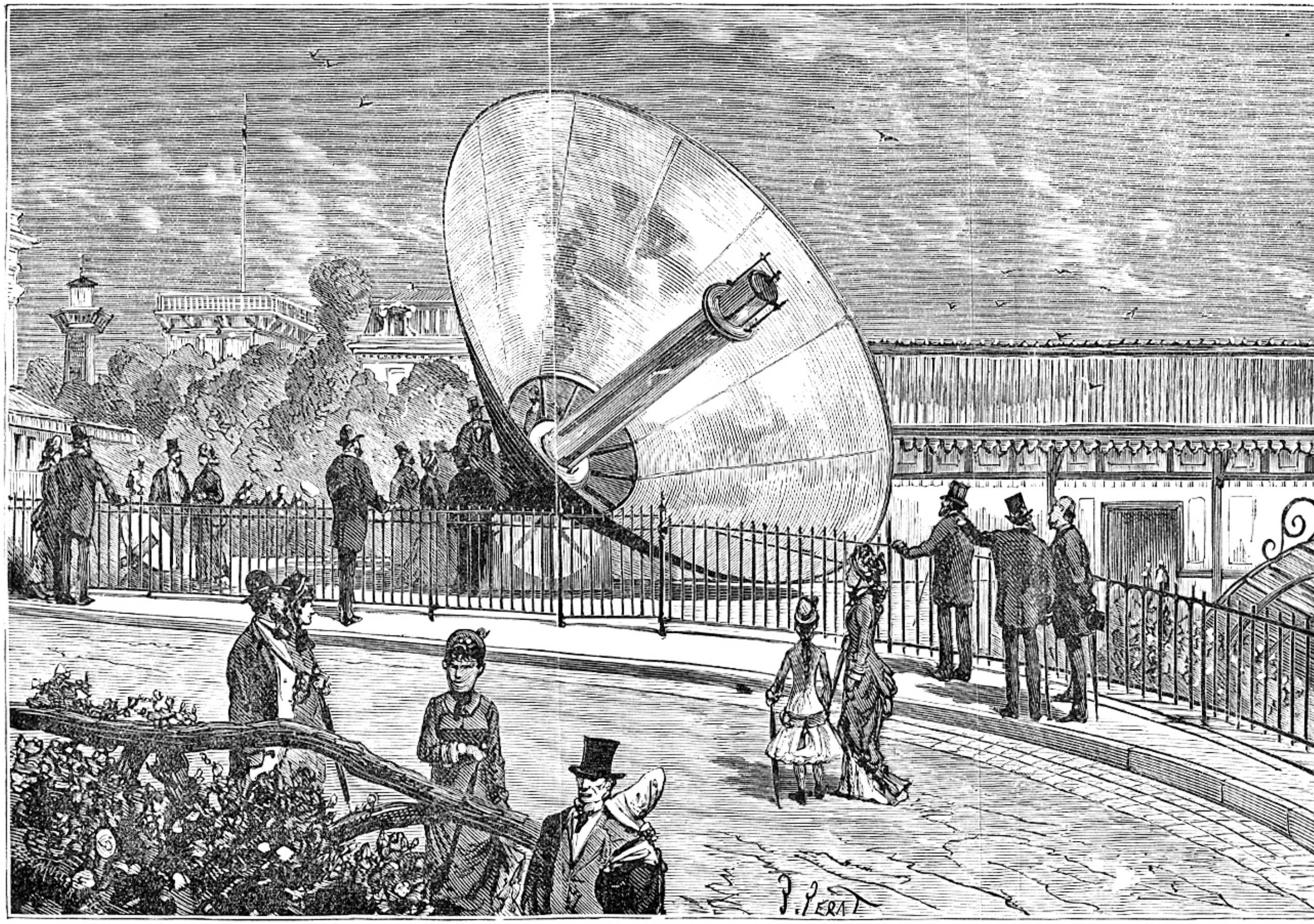
Solar Energy Distribution in Europe



History of Solar Energy by John Perlin



EXPOSITION UNIVERSELLE DE 1878.

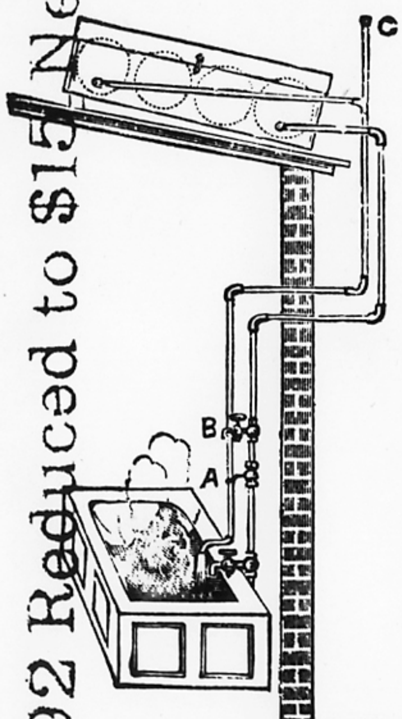


Vue générale de mon grand appareil exposé au Trocadéro, en 1878, (Annexe de l'Exposition Algérienne).

Climax Solar-Water Heater

UTILIZING ONE OF NATURE'S GENEROUS FORCES

THE SUN'S HEAT { Stored up in Hot Water for Baths, Domestic and other Purposes.



GIVES HOT WATER at all HOURS
OF THE DAY AND NIGHT.

NO DELAY.

FLOWS INSTANTLY.

NO CARE. NO WORRY.

ALWAYS CHARGED.
ALWAYS READY.

THE WATER AT TIMES
ALMOST BOILS.

Price, No. 1, $25.00

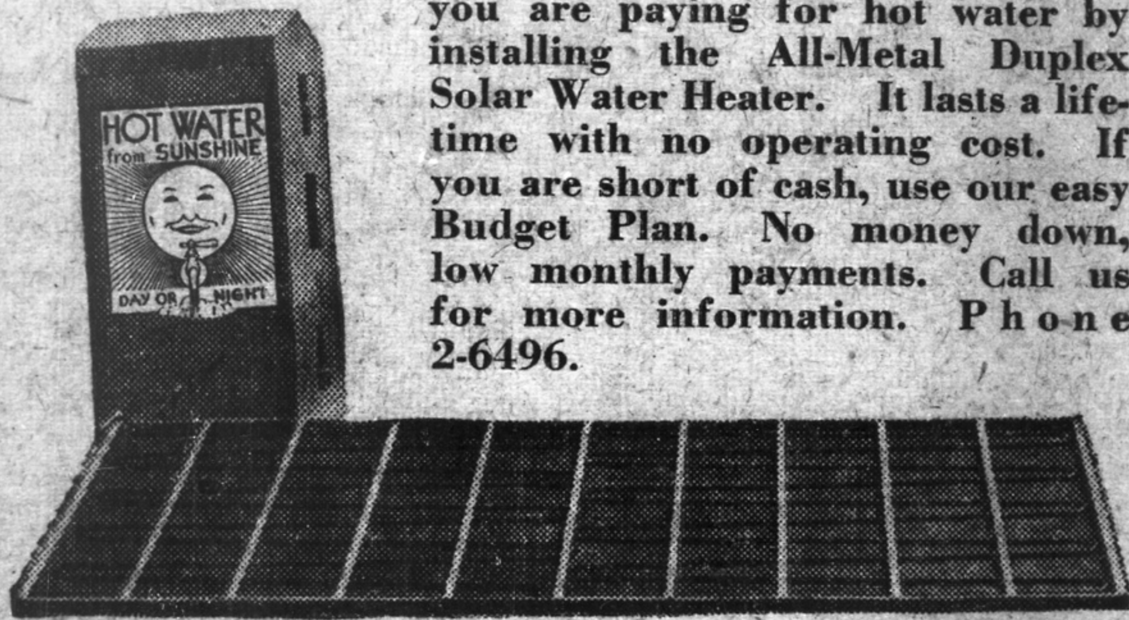
This Size will Supply sufficient
for 3 to 8 Baths.

CLARENCE M. KEMP, BALTIMORE, MD.

Price Of No.1 Heater for
1892 Reduced to $15 Net

¾ MILLION DOLLARS SAVED

It may not seem possible, but it is a fact, 15,000 satisfied owners of the ALL-METAL DUPLEX SOLAR WATER HEATER actually saved ¾ Million Dollars the past year in hot water bills. You too, can save all the money you are paying for hot water by installing the All-Metal Duplex Solar Water Heater. It lasts a lifetime with no operating cost. If you are short of cash, use our easy Budget Plan. No money down, low monthly payments. Call us for more information. Phone 2-6496.



SOLAR WATER HEATER CO.

325 N. W. 25TH STREET   PHONE 2-6496   MIAMI, FLA.

EAST COAST BRANCHES:

FT. LAUDERDALE, FT. PIERCE, ORLANDO, VERO BEACH, PALM BEACH

SOLAR POWER LIQUID AIR

MECHANICAL POWER, HEAT, LIGHT, ELECTRICITY, REFRIGERATION AND FERTILIZERS

FROM SUN HEAT AND AIR

YOU ARE INVITED TO ATTEND AN

EXHIBITION RUN

OF THE

FIRST PRACTICAL SOLAR ENGINE

AT 3400 DISSTON STREET

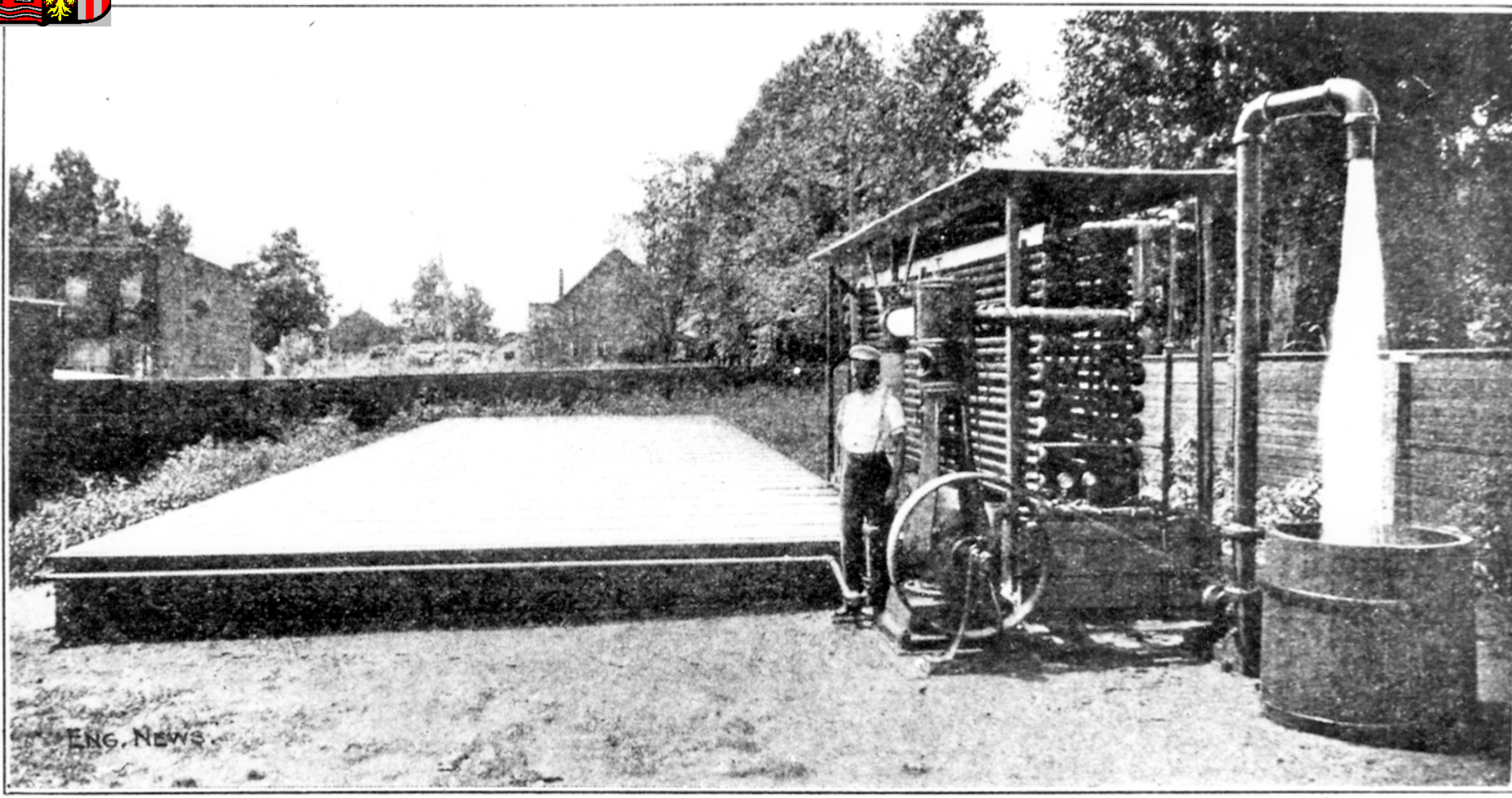
TACONY, PHILADELPHIA, PA.

ANY CLEAR AFTERNOON BETWEEN TWELVE AND THREE P. M. DURING THE NEXT TWO WEEKS

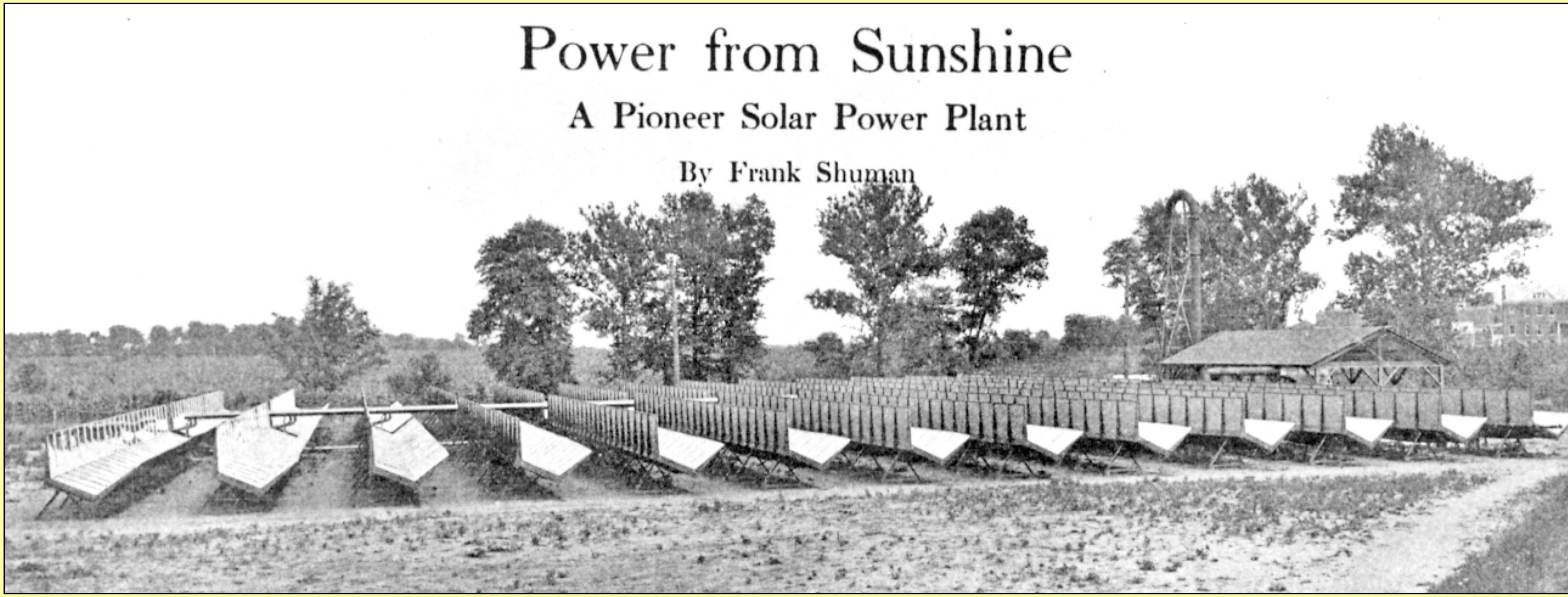
PLEASE ACKNOWLEDGE RECEIPT AND SAY WHEN YOU WILL COME

FRANK SHUMAN

TACONY, PHILADELPHIA, AUG. 20TH, 1907



A STEAM ENGINE OPERATED BY THE SUN'S HEAT AT FACTORY, PHILADELPHIA, AUGUST, 1907.
Frank Shuman, Inventor.


Power from Sunshine

A Pioneer Solar Power Plant

By Frank Shuman

Solar Stirling Engines

McDonnell Douglas/Southern of California
California Edison 25 kW dish/Stirling system.
The 944 square foot concentrator consists of 82 spherically curved glass mirrors each 3 foot by 4 foot.
The United Stirling 4-95 Mark II engine
(4 cylinders of 95 cc displacement) uses hydrogen as the working pressure at a maximum gas pressure of 2900psi..
This engine delivered 25kW output at 1000W/m2 insolation.

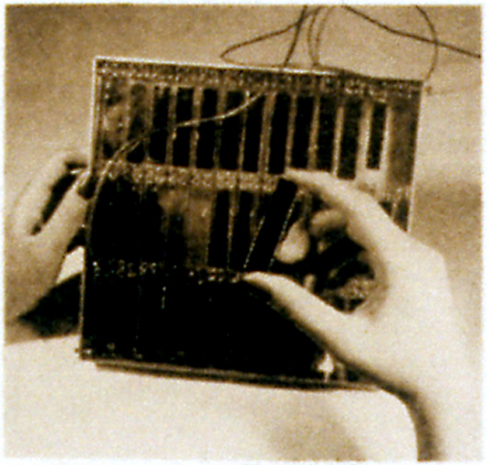
THE SUN'S ENERGY: FUEL UNLIMITED

THREE INVENTORS exhibited last week a small metal box slatted with black, glassy strips. Raw materials for the strips come from sand and borax. But the strips—silicon thinly seeded with boron—turn sunlight into electricity, may provide more power than all the world's coal, oil, uranium. The inventors:

Calvin S. Fuller, 52, chemist.
Daryl M. Chapin, 47, engineer.
Gerald L. Pearson, 49, physicist.

The three men worked as a team at Bell Telephone Laboratories, where all went from college a quarter century ago. Mr. Fuller found how to make the strips, Mr. Pearson put in electronics knowledge, Mr. Chapin put the pieces together.

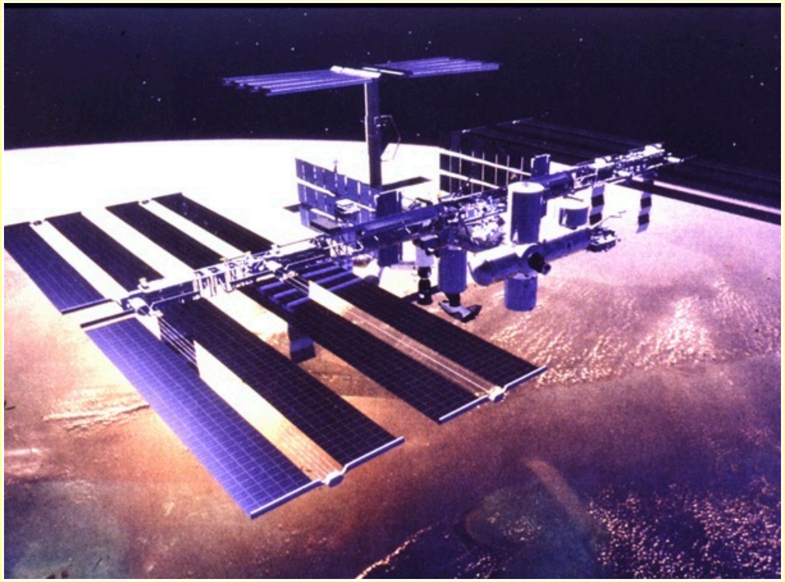
Secret of the Bell solar battery is electronic activity much like that in a photographer's light meter, but much more powerful. The sun's energy causes rapid movements of electrons in the silicon strips. The movements create voltage, become direct-current electricity that can be kept in storage batteries.



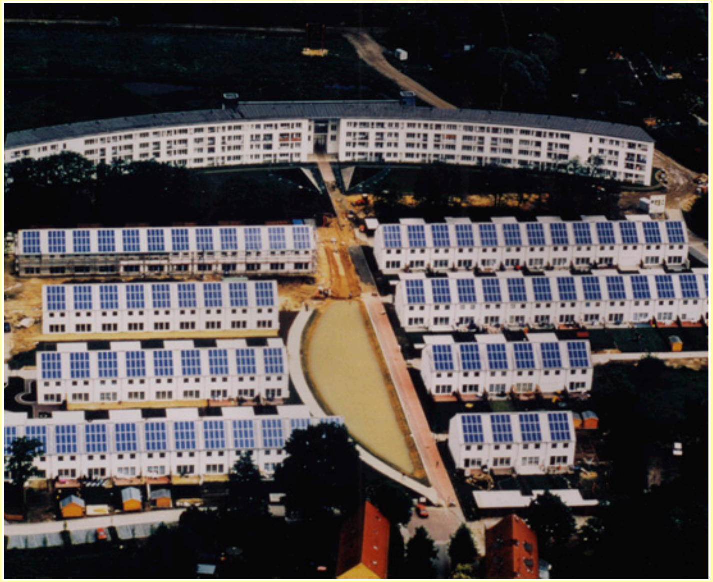
Photos: Bell Laboratories

A pocket-size sun battery will send radio signals several miles. The Bell company foresees first uses as power for mobile radio telephones and to charge batteries for rural telephone systems. The Defense Department is highly interested. Engineers are dreaming of silicon-strip powerhouses. The future: limitless.

First press release, 1954



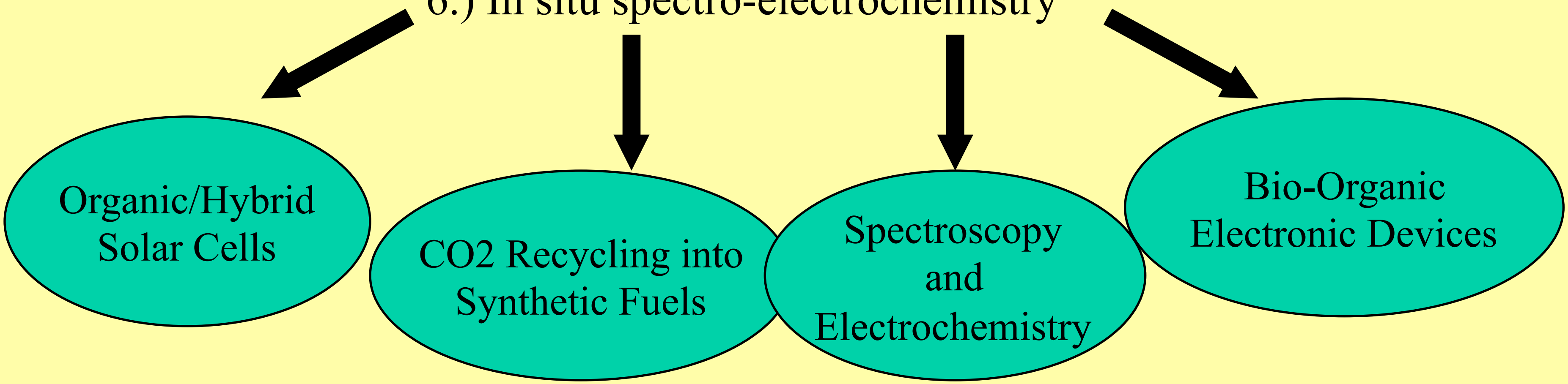





Linz Institute for Organic Solar Cells

Physics of Organic Semiconductors:

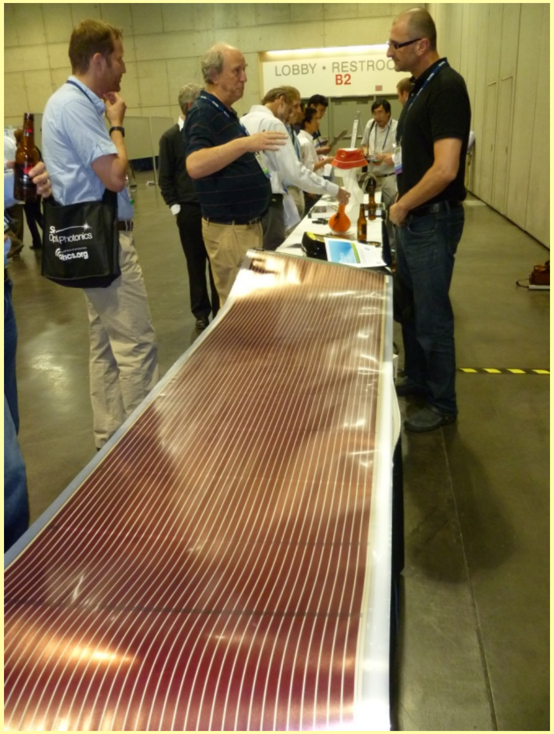
1.) Photoexcited spectroscopy
2.) Photoconductivity
3.) Thin film characterization
4.) Nanoscale engineering
5.) Nanoscale microscopy (AFM, STM...)
6.) In situ spectro-electrochemistry

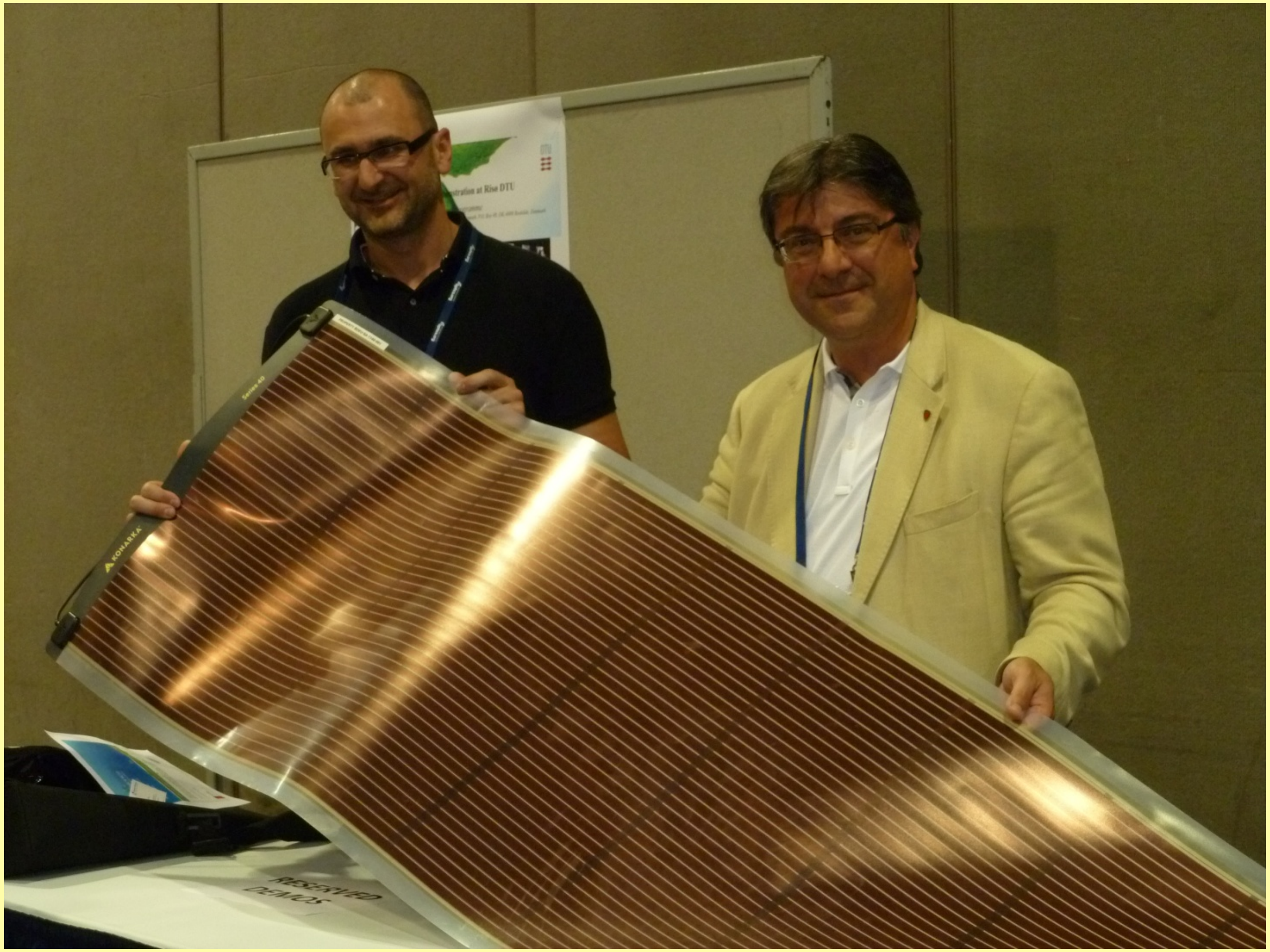


„Incubator“ for small high tech spin-off companies

Semiconducting Polymer “Inks”

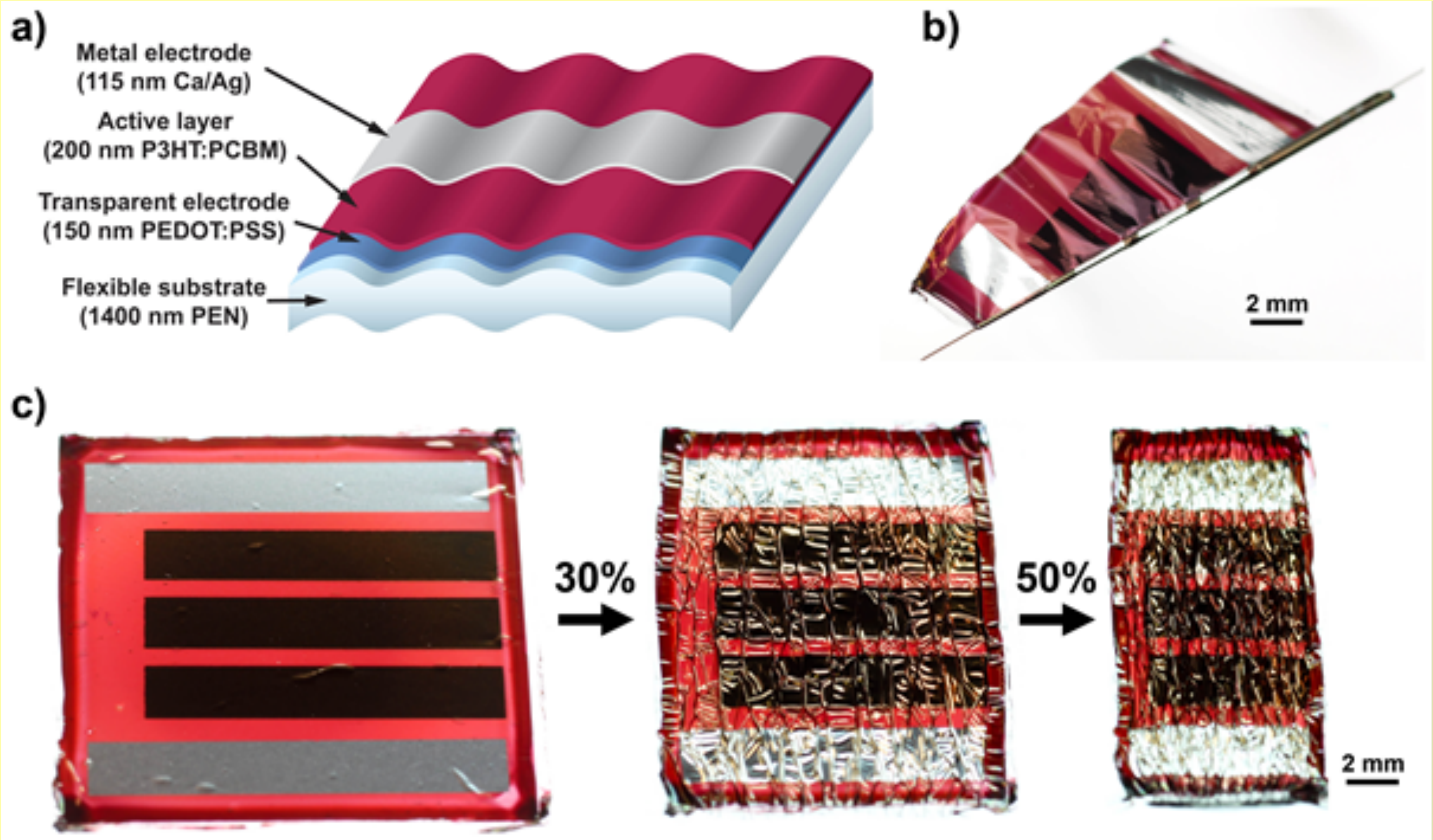
Roll to roll produced solar cells





Konarka Inc.

Ultrathin, shrinkable, strechable organic solar cells



Martin Kaltenbrunner, Matthew White *et al*. *Nature Comm*. **DOI: 10.1038/ncomms1772 April, 2012** nature COMMUNICATIONS

OPEN

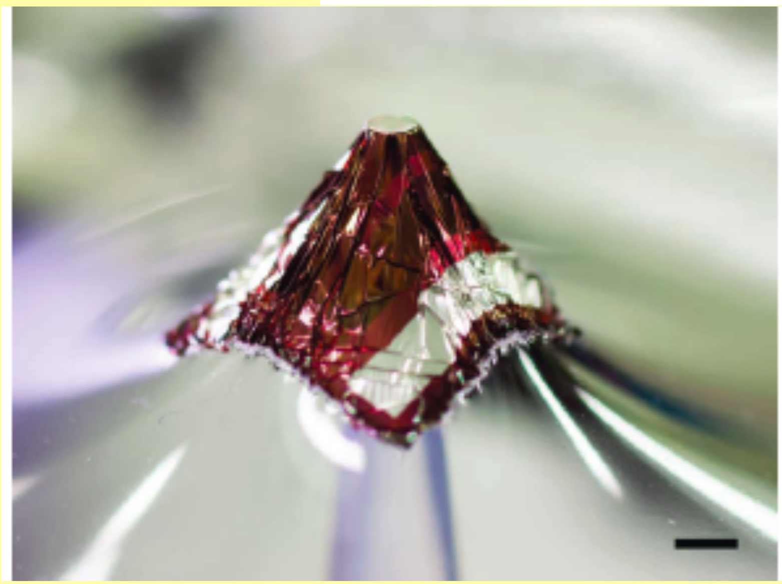
ARTICLE

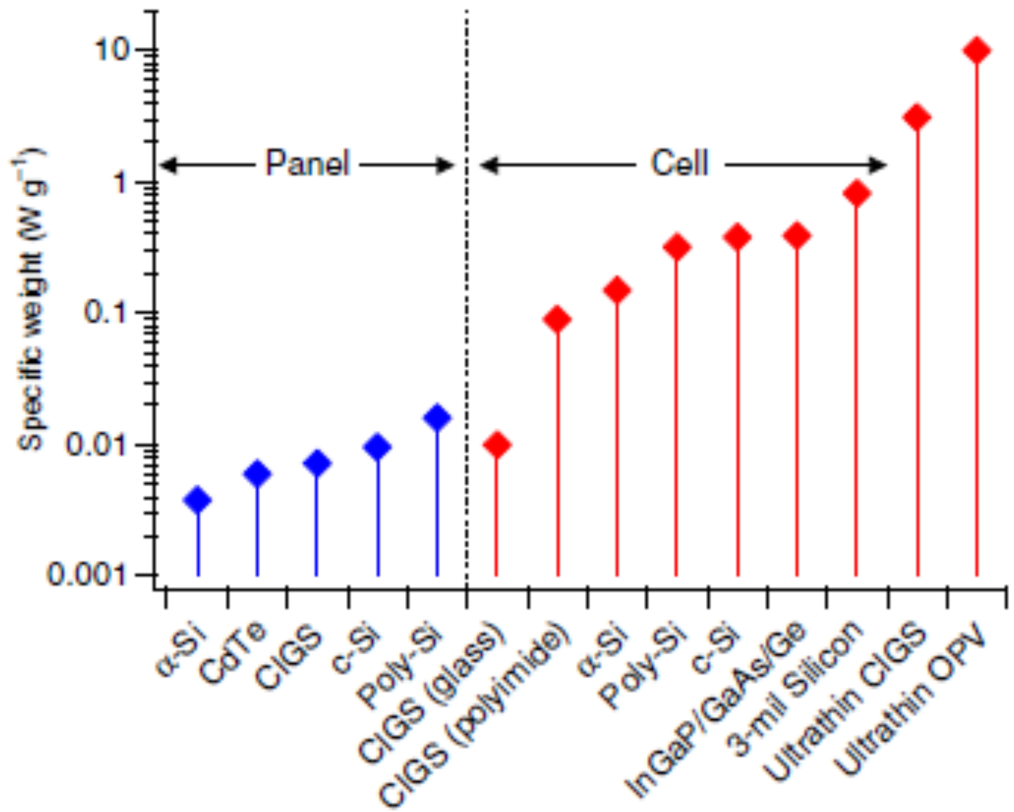
Received 17 Nov 2011 | Accepted 2 Mar 2012 | Published 3 Apr 2012

DOI: 10.1038/ncomms1772

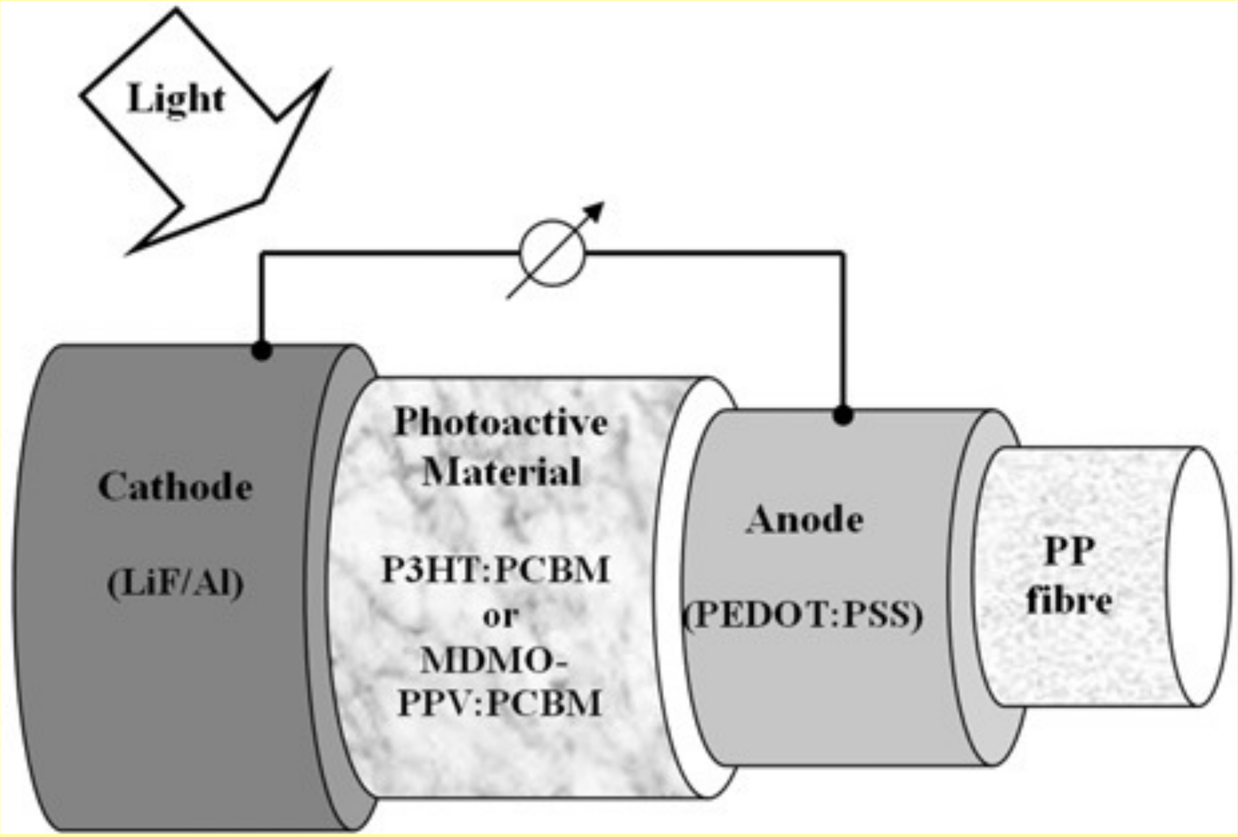
Ultrathin and lightweight organic solar cells with high flexibility

Martin Kaltenbrunner[1,2,3], Matthew S. White[4], Eric D. Głowacki[4], Tsuyoshi Sekitani[2,3], Takao Someya[2,3], Niyazi Serdar Sariciftci[4] & Siegfried Bauer[1]





Textile integrated organic solar cells fibers



Ayse Bedeloglu *et al*, Textile Research Journal (2009)

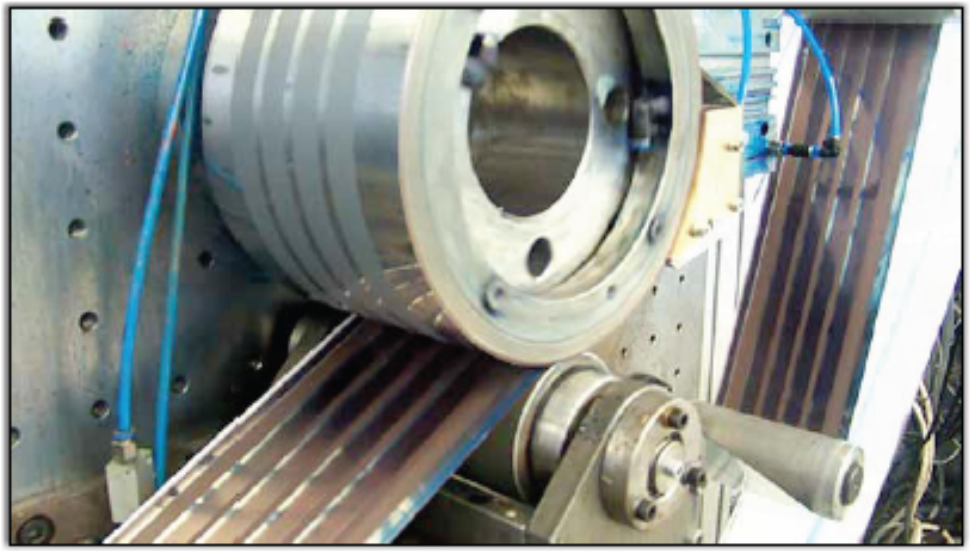
Solar cell integrated textiles

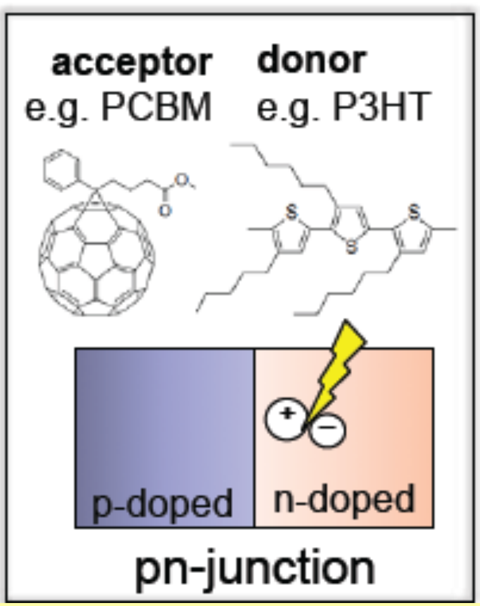
A commercial solar jacket and bag

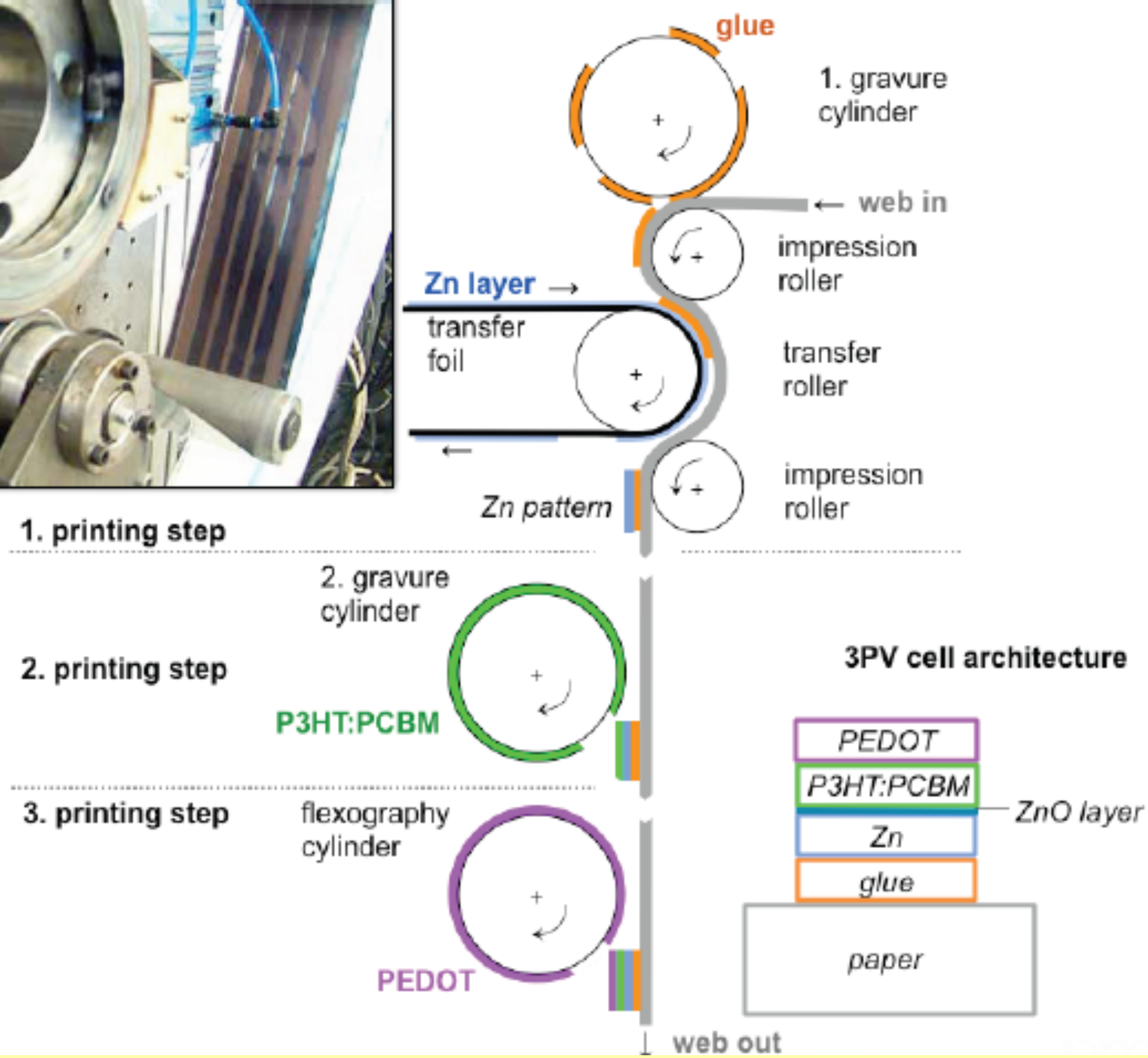
www.scottevest.com www.neubers.de

Paper solar cells, Arved Hübler et al.

technology approach: 3PV printed paper photovoltaics







Sariciftci Heeger Patents at UCSB

US005331183A

United States Patent [19]

Sariciftci et al.

[11] **Patent Number: 5,331,183**

[45] **Date of Patent: Jul. 19, 1994**

[54] **CONJUGATED POLYMER - ACCEPTOR HETEROJUNCTIONS; DIODES, PHOTODIODES, AND PHOTOVOLTAIC CELLS**

[75] Inventors: **N. S. Sariciftci; Alan J. Heeger**, both of Santa Barbara, Calif.

[73] Assignee: **The Regents of the University of California**, Oakland, Calif.

[21] Appl. No.: **930,161**

[22] Filed: **Aug. 17, 1992**

[51] **Int. Cl.**[5] **H01L 29/28**

[52] **U.S. Cl.** **257/40**; 257/184; 257/461; 136/263

[58] **Field of Search** 257/40, 184, 461; 365/215; 136/263

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,171,373 12/1992 Hebard et al. 257/40

OTHER PUBLICATIONS

Kamat, P. "Photoinduced Charge Transfer Between Fullerenes and Semiconductor ZnO Colloids" J. Am. Chem. Soc., 1991, 113, pp. 9705–9707.

Wang, Y. "Photoconductivity of Fullurene-Doped Polymers" Nature, Apr. 16, 1992, pp. 585–587.

Arbogast, J. W., et al., "Photophysical Properties of C_{60}" J. Phys. Chem., Jan. 10, 1991, pp. 11–12.

Sze, M. S., *Physics of Semiconductor Laser Devices*, (1981) Wiley-Interscience, New York, Chapter 13, "Photodetectors" pp. 743–789.

Sze, M. S., *Physics of Semiconductor Laser Devices*, (1981) Wiley-Interscience, New York, Chapter 14, "Solar Cells" pp. 790–838.

Primary Examiner—Sara W. Crane

Attorney, Agent, or Firm—Morrison & Foerster

[57] **ABSTRACT**

This invention relates generally to the fabrication of heterojunction diodes from semiconducting (conjugated) polymers and acceptors such as, for example, fullerenes, particularly Buckminsterfullerenes, C_{60}, and more particularly to the use of such heterojunction structures as photodiodes and as photovoltaic cells.

15 Claims, 3 Drawing Sheets

Sariciftci Heeger Patents at UCSB

We claim as our Invention:

1. A heterojunction device comprising
a. a layer of a conjugated polymer which serves as a donor, and adjacent thereto, a
b. layer of an acceptor material comprising an acceptor selected from the group consisting of the group of fullerenes, substituted fullerenes, fullerene derivatives, polymers comprising fullerenes or substituted fullerenes or of organic or polymeric acceptors having electronegativity in the range to enable a photoinitiated charge separation process defined

3. A heterojunction device comprising
a. a conjugated polymer which serves as a donor, and adjacent thereto,
b. an acceptor material comprising an acceptor selected from the group consisting of fullerenes or fullerene derivatives, polymers comprising fullerenes or fullerene derivatives, organic and or polymeric acceptors having electronegativity in the range to enable a photoinitiated charge separation

where
donor (D) and acceptor (A) units are either covalently bound (intramolecular), or spatially close but not covalently bonded (intermolecular);
"1,3" denotes singlet or triplet excited states, respectively,
and where a heterojunction between the conjugated polymer and acceptor material is formed in situ by controlled segregation during solidification from a solution containing both the donor and the acceptor moieties.

Definition →

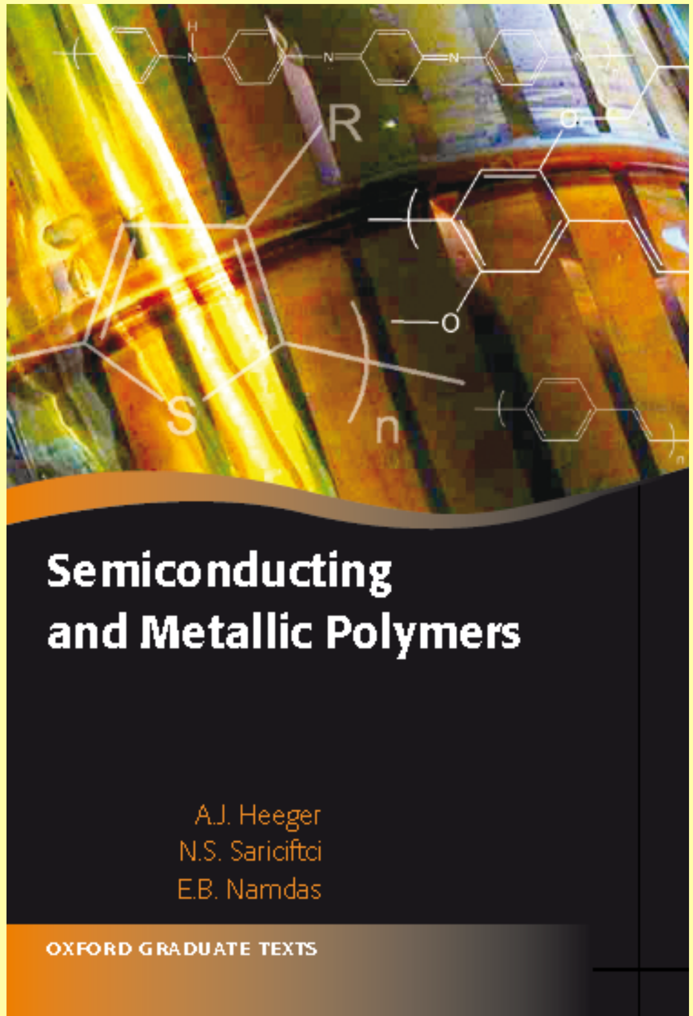
Birth of Bulk Heterojunction, 1992

Semiconducting and Metallic Polymers

---for they combine the electronic properties of metals and semiconductors

and

the processablity, synthesis advantages and flexibility of polymers..

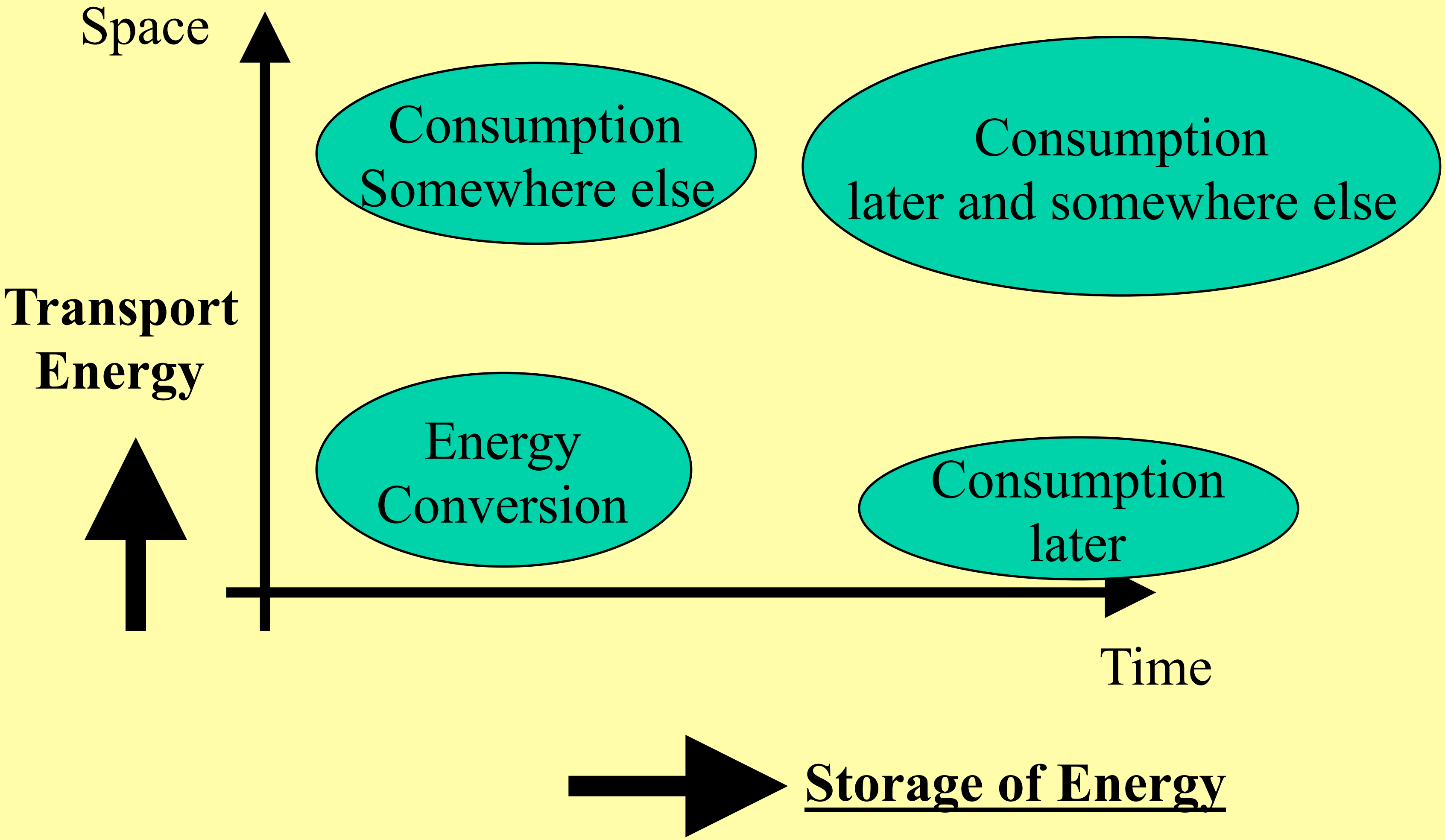


What is the next challenge in

Organic Solar Energy Conversion?

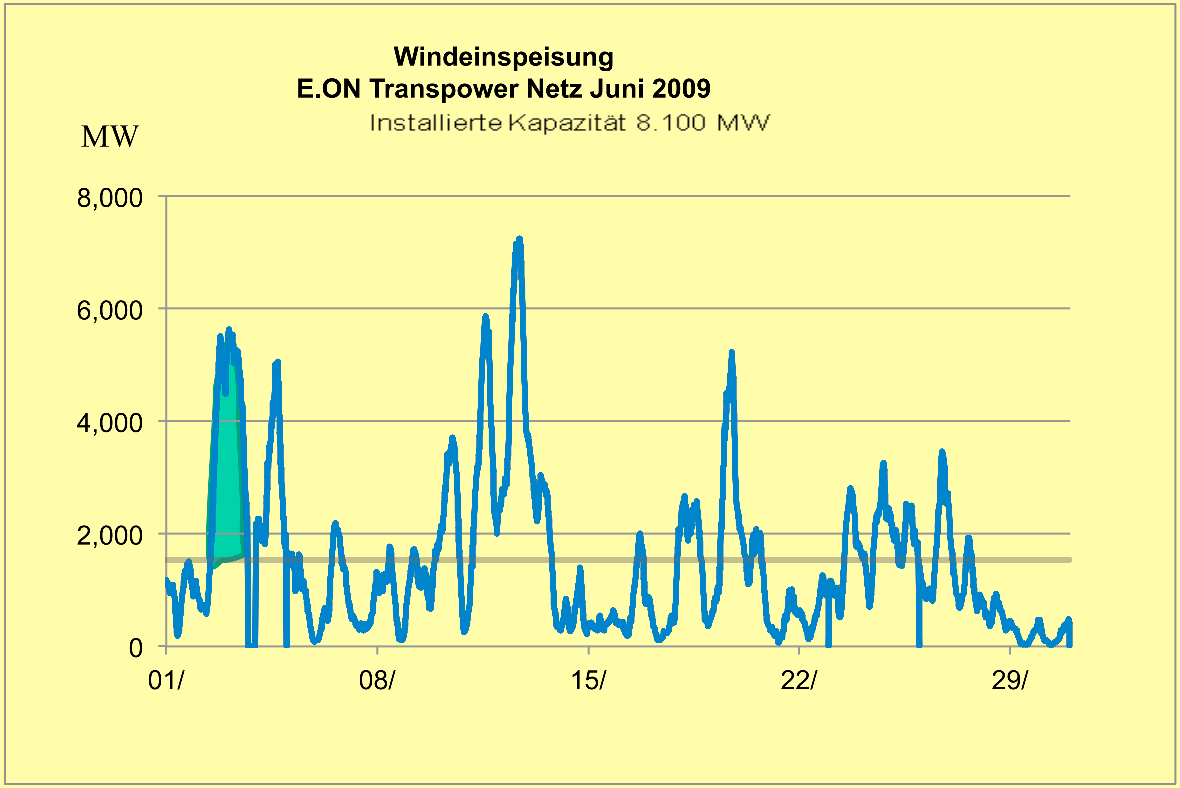
Solar energy into chemical energy

Storage-Transport Problem



Transportable fuel created by solar energy conversion !!!

These 2



Breites nicht regelbares Schwankungspektrum stellt unlösbare Anforderung an Netzbetrieb

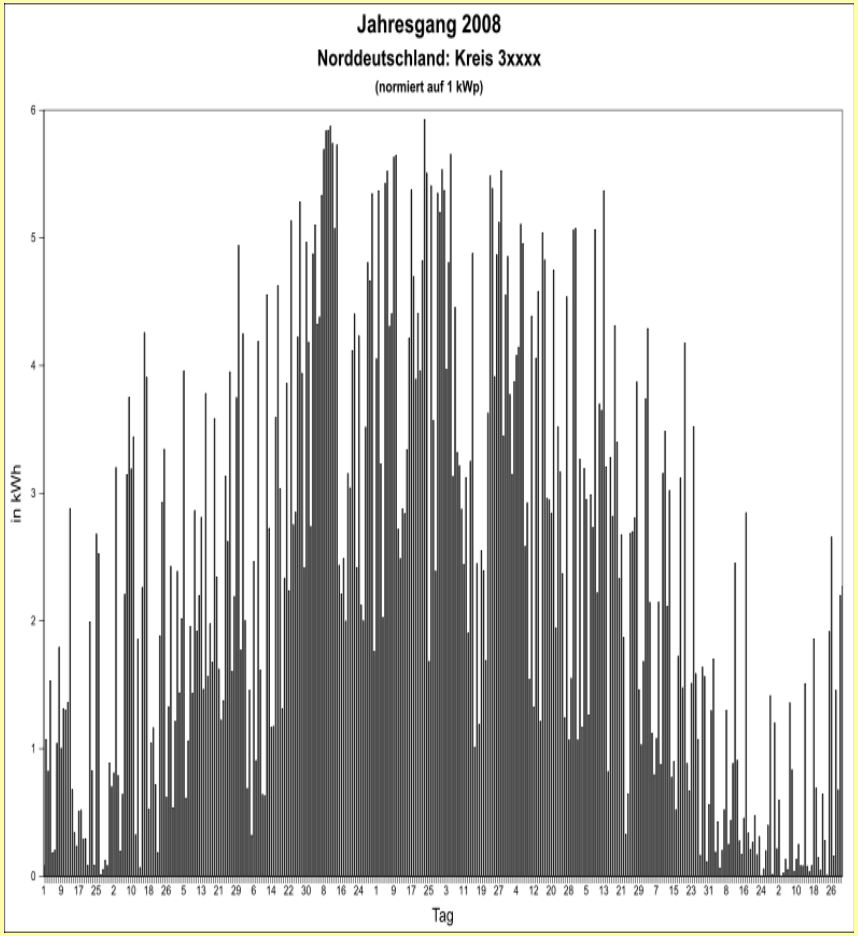
Strombeitrag kann daher nur kleinen Teil des Bedarfs decken

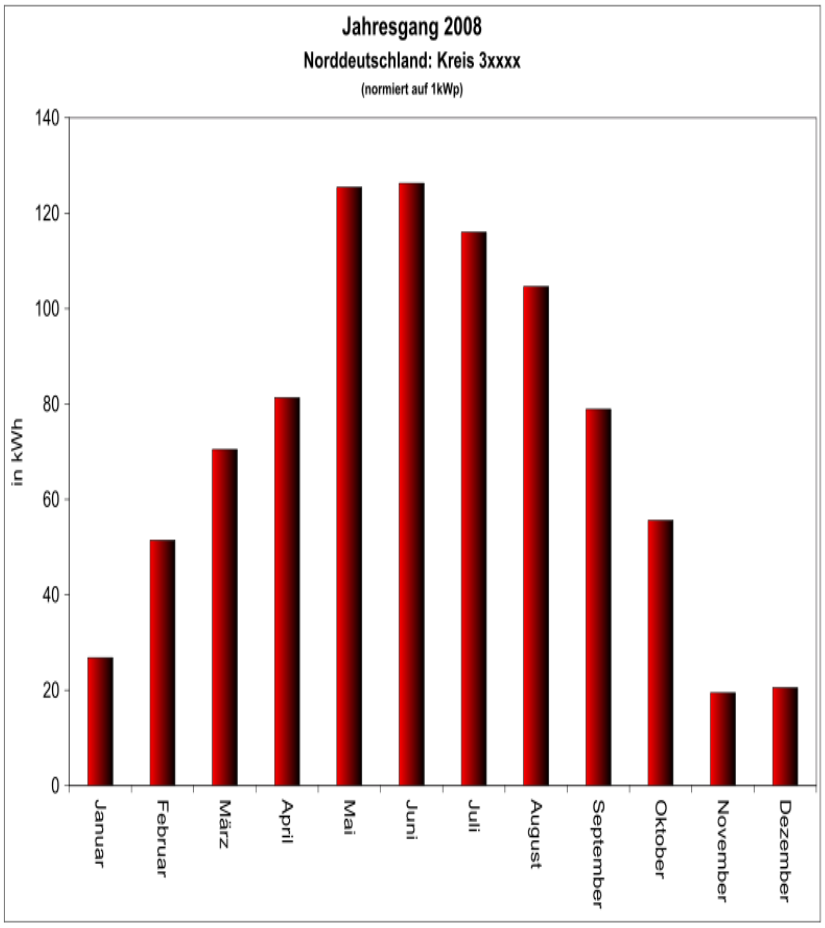
Schwankung zwischen 0% und 100%
Wind Deutschland: Durchschnitt 18%

PV Deutschland: Durchschnitt 10%

Kaltfront 3.6.09:
~ 4 GW x 20 h = 80 Millionen kWh

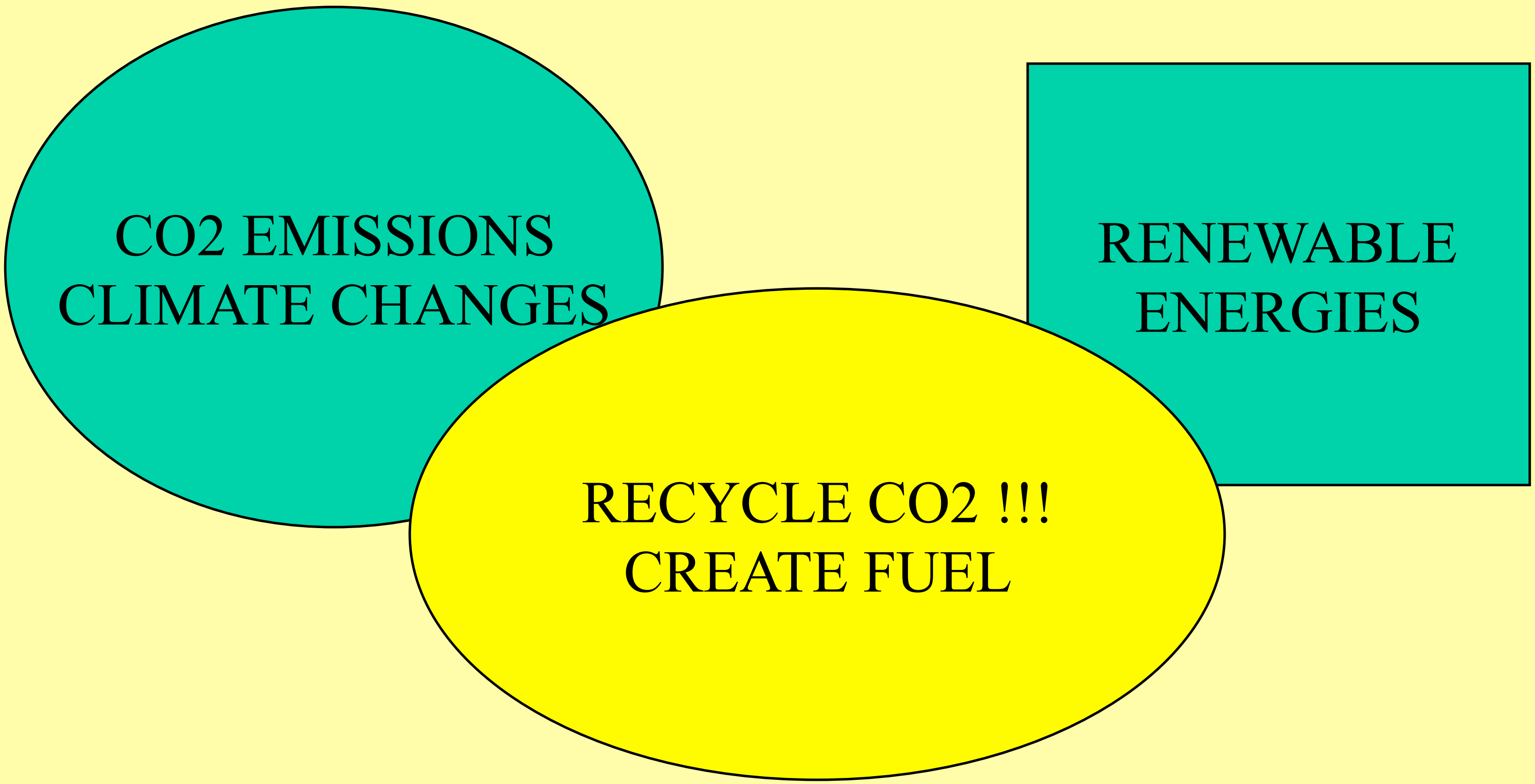
Seasonal Fluctuations In Photovoltaics:





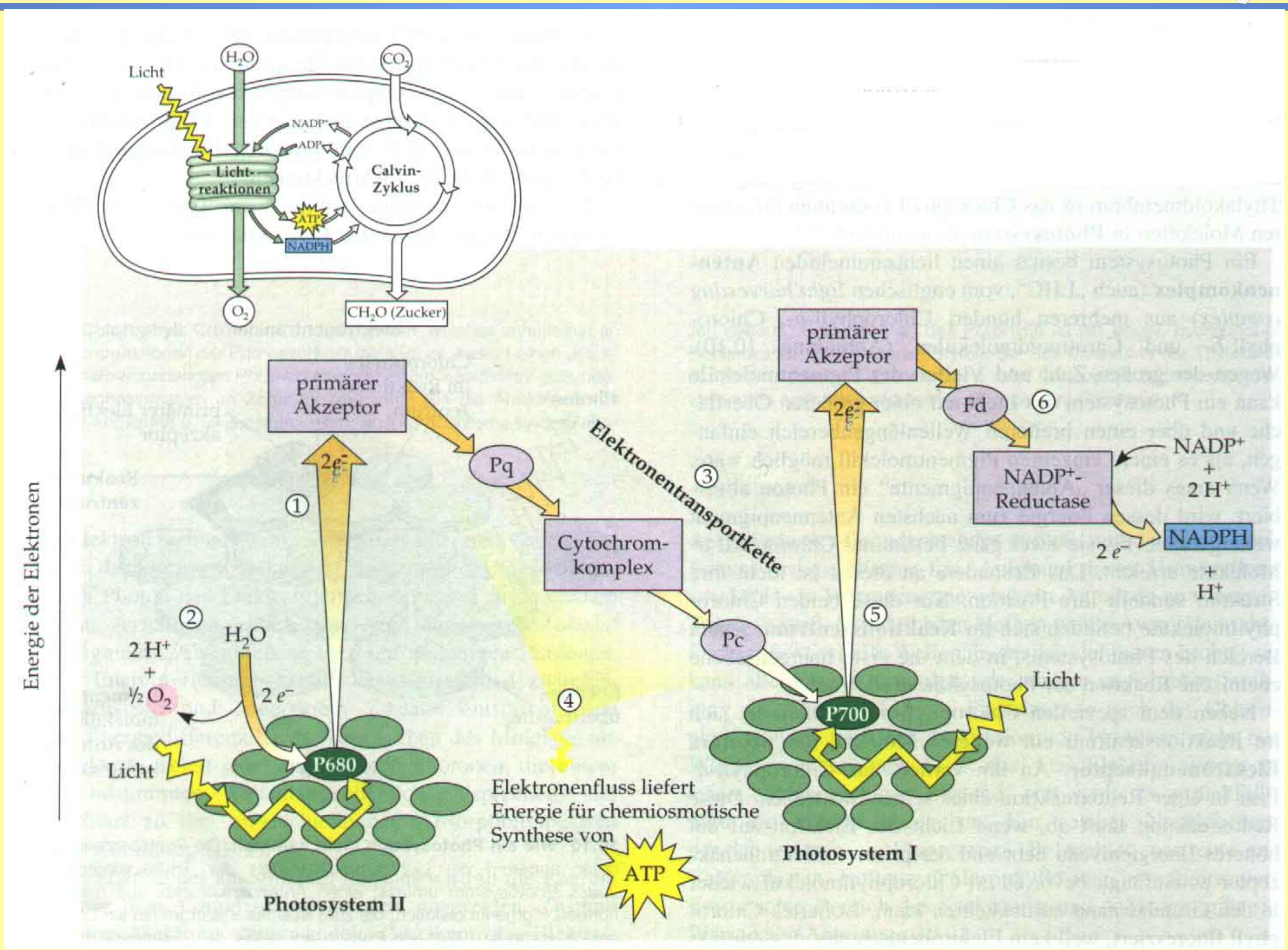
Interfacing two R&D worlds

INTERFACE BETWEEN CO2 REDUCTION AND RENEWABLE ENERGY CREATION



Future recycling of CO2 as important mission of renewable energies

Natural Photosynthesis



Recycling of CO_2

Over 90 % of emitted CO_2 is generated by energy products.

To convert back CO_2 to fuels hydrogen or energy is required.

One promising field in this direction is the **photochemical, electrochemical or biochemical reduction of carbon dioxide**

IS IT POSSIBLE TO RECYCLE CO_2?
The answer is yes!

$$CO_2 + 2e^- + 2H^+ \rightarrow HCOOH \quad (1)$$

$$HCOOH + 2e^- + 2H^+ \rightarrow CH_2O + H_2O \quad (2)$$

$$CH_2O + 2e^- + 2H^+ \rightarrow CH_3OH \quad (3)$$

$$CH_3OH + 2e^- + 2H^+ \rightarrow CH_4 + H_2O \quad (4)$$

Steps in methanol oxidation/production.

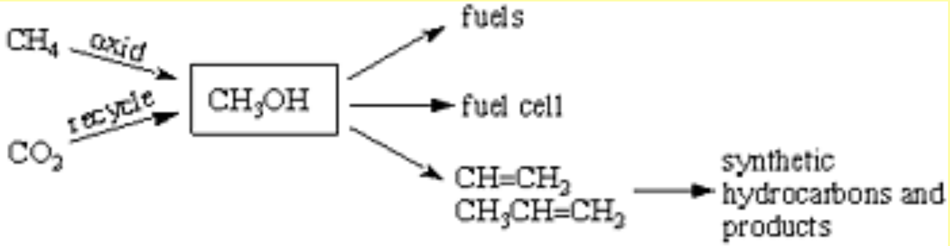
Overall: 6e- process

CH3OH + H2O → CO2 + 6H+ + 6e-

Biocatalysis

Photocatalysis

Electrocatalysis



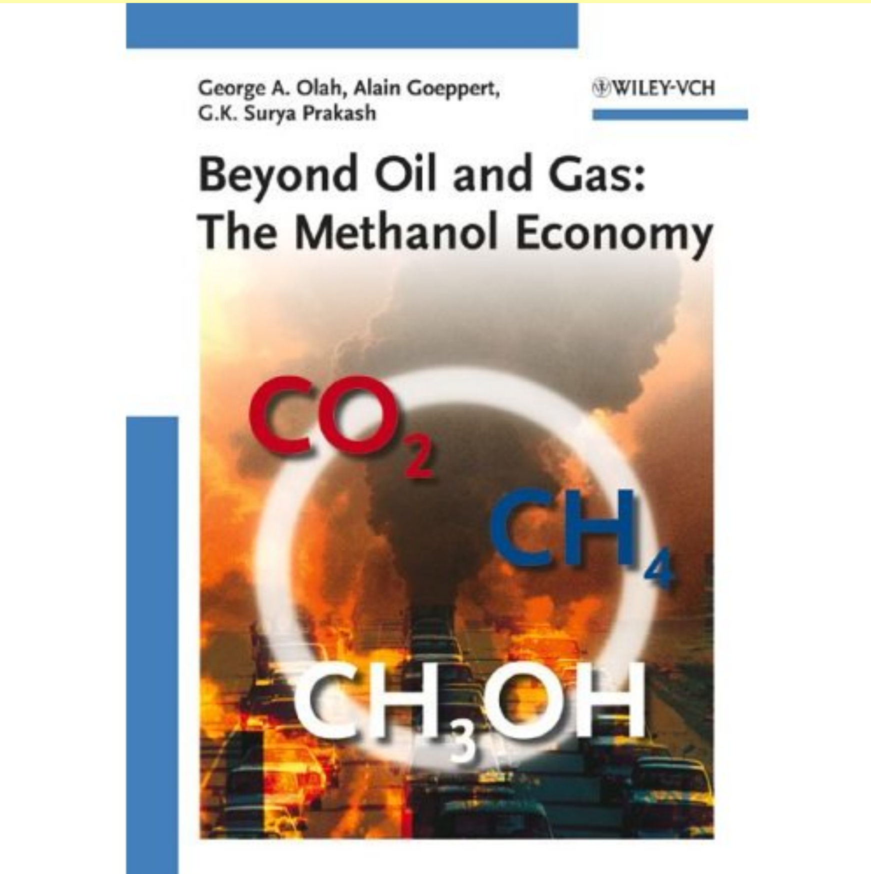
Methanol as carrier and storage of energy

a.) Methanol can be mixed to gasoline

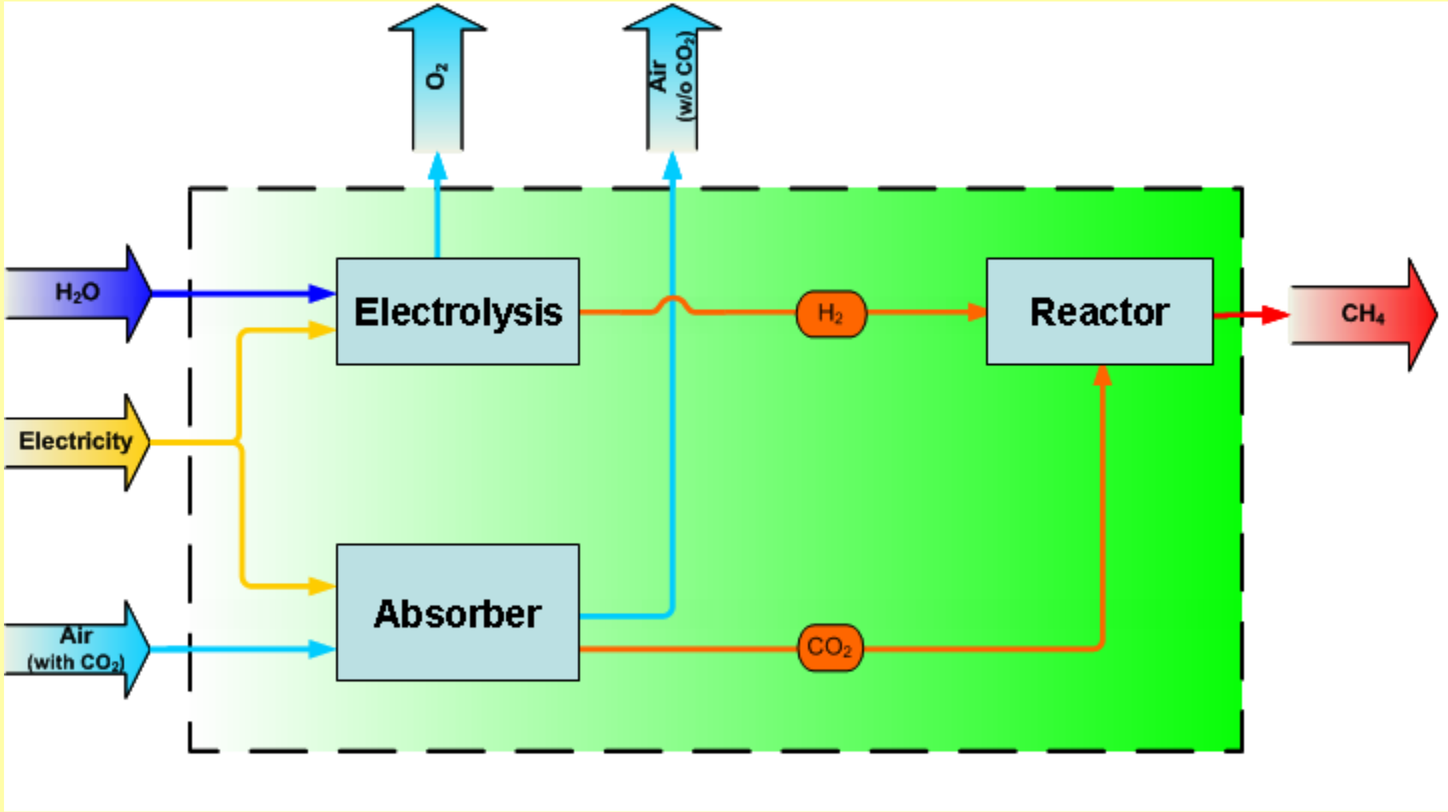
b.) Methanol is used in fuel cells

c.) Methanol is starting chemical for
Many other derivatives

George Olah, Nobel Prize 1994
Univ. of Southern California, USA

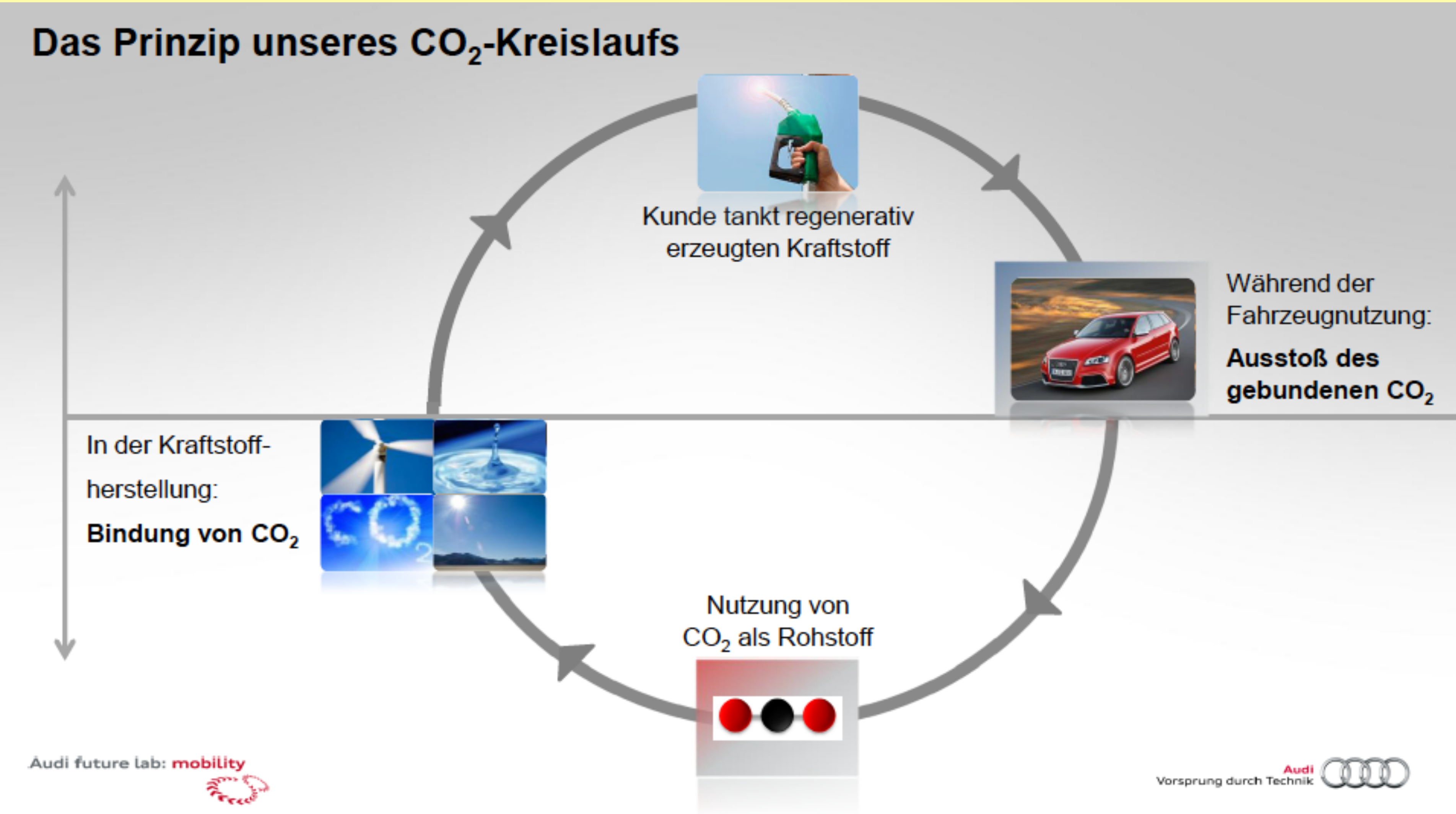


Indirect CO_2 Reduction – A Known Technology

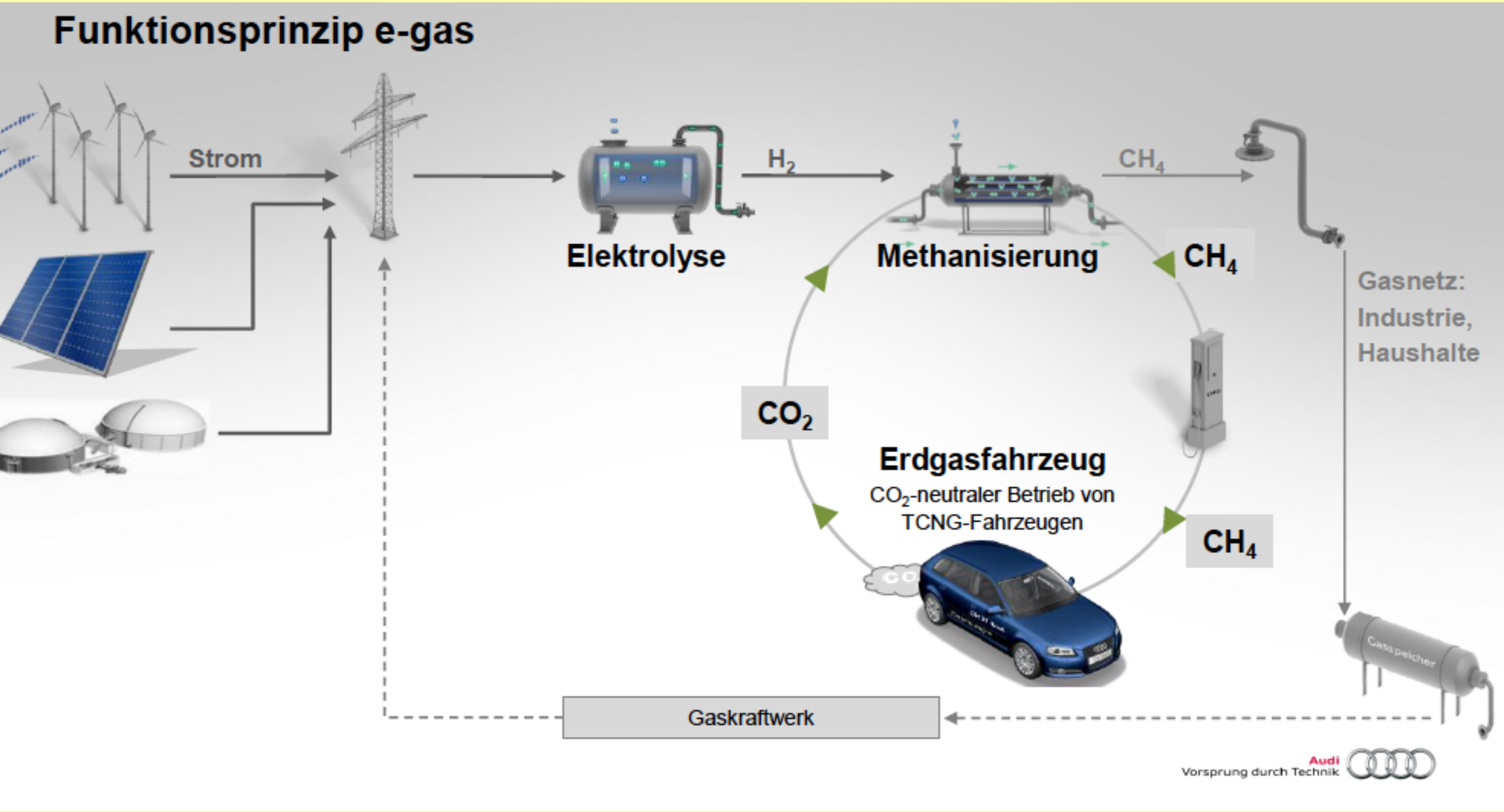


http://www.etogas.com/

Designed and fabricated in ZSW Stuttgart, Germany



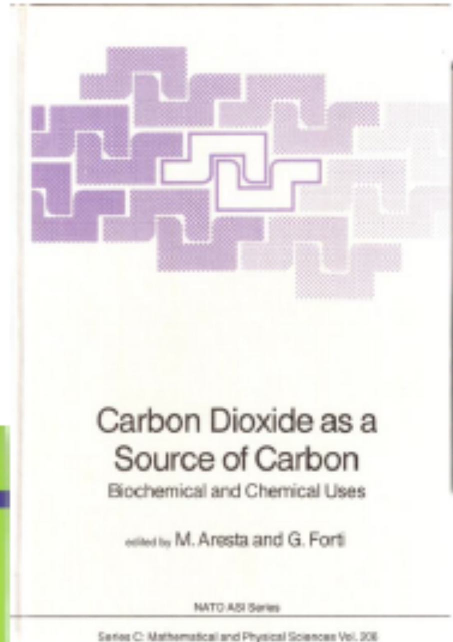
Courtesy of Dr. Pengg, Audi Corp.



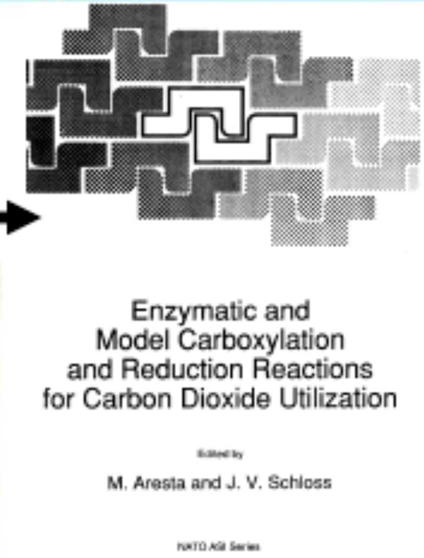
Courtesy of Dr. Pengg, Audi Corp.

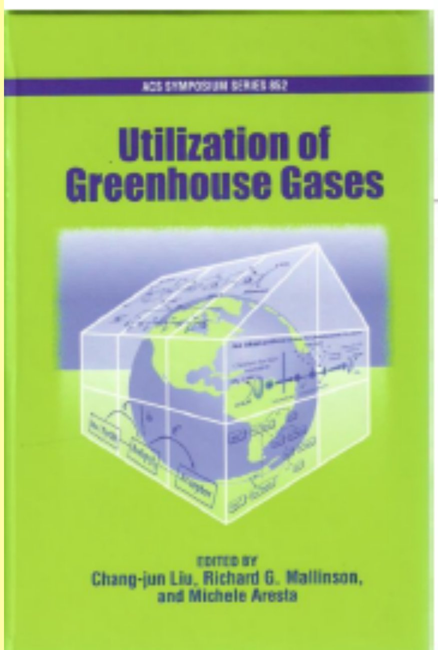
From the basket of published Books…..

1986 →



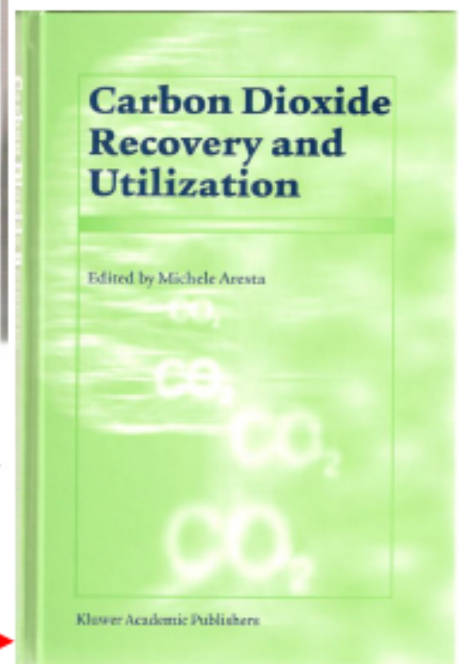
1989 →



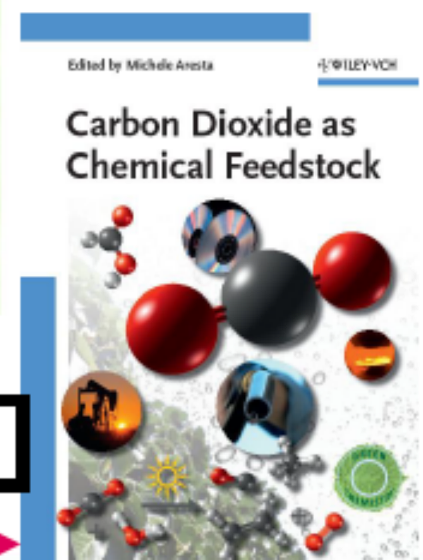


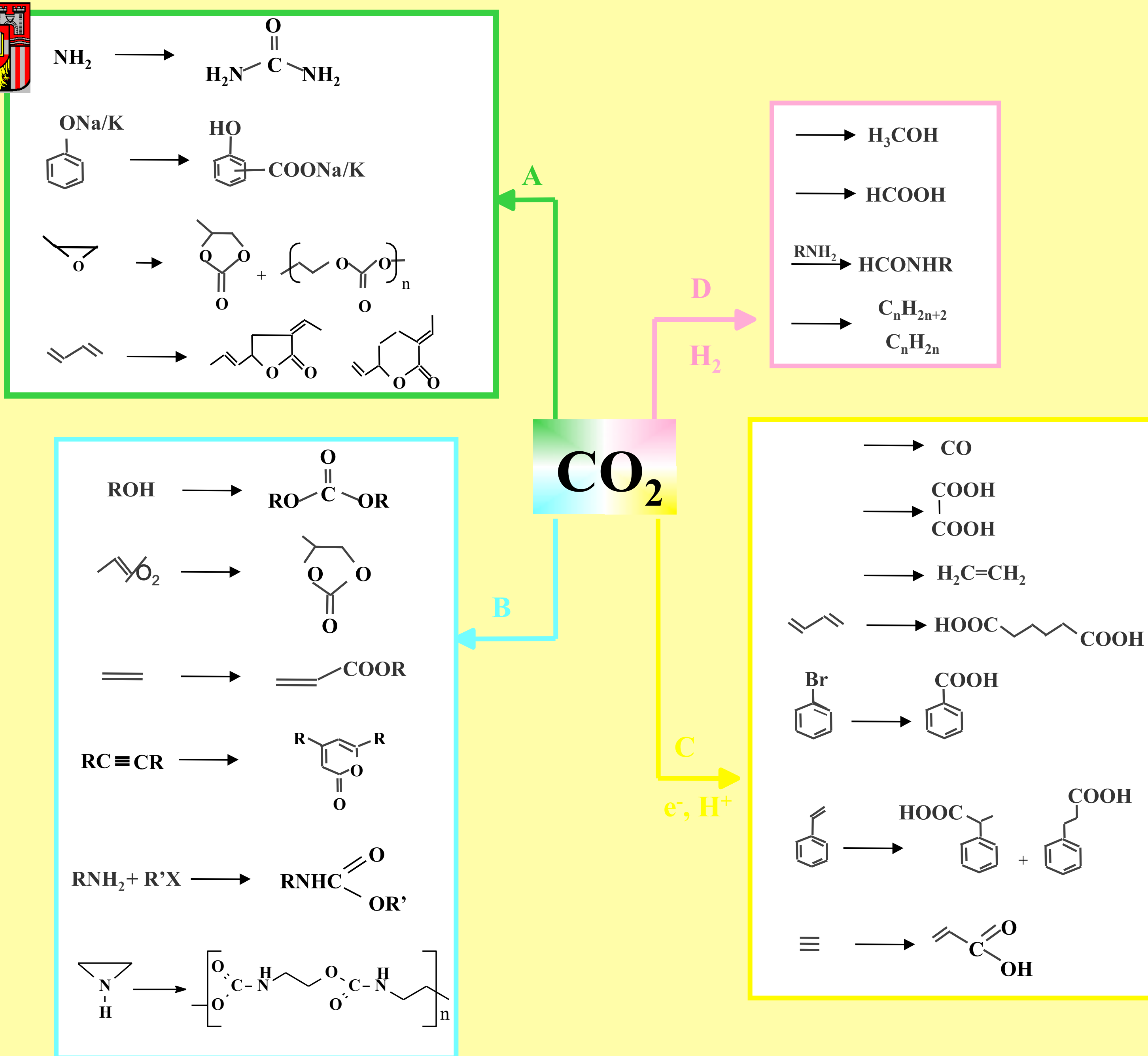
2003 ←

2003 →



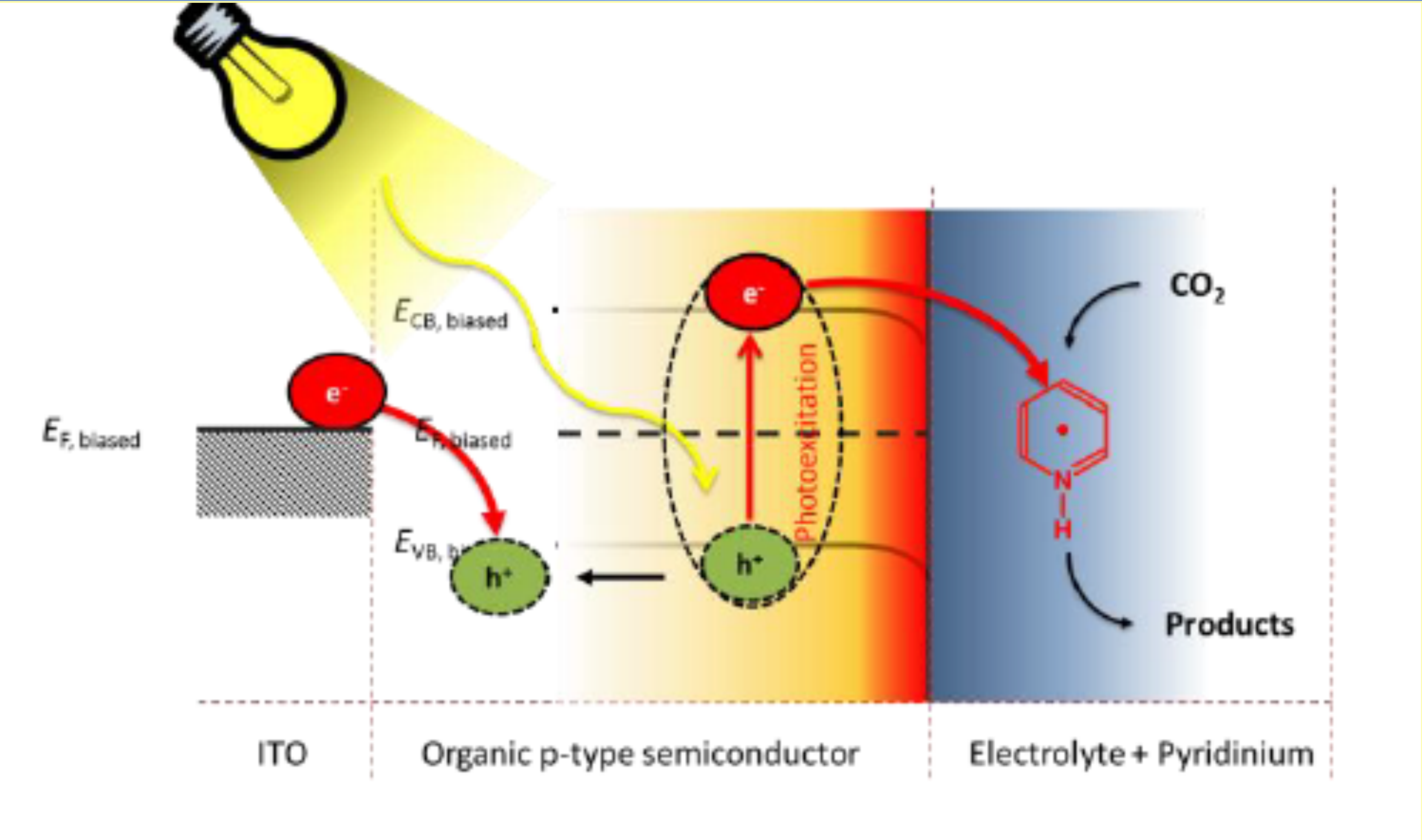
2009





Courtesy of Michele Aresta, Univ. of Bari, Italy

Poly 3-hexylthiophene (P3HT) as Photocathode



For CO_2 reduction to Methanol

Engelbert Portenkirchner et.al 2013

Future is…

Convergence of multiple crisis conditions:

1.) Energy crisis (oil running out)
2.) Climate crisis (CO_2 and global warming)
3.) Demographic crisis (10 Billion population)
4.) Economic crisis (see your daily newspapers)

Will converge to a difficult future around 2050

WE NEED A GLOBAL SOLAR MARSHALL PLAN

THANK YOU FOR YOUR ATTENTION