



Fakultet kemijskog inženjerstva i tehnologije  
Sveučilište u Zagrebu

Kolegij:

# Obnovljivi izvori energije

Prof. dr. sc. Ante Jukić

Zavod za tehnologiju nafte i petrokemiju / Savska cesta 16 / tel. 01-4597-128 / [ajukic@fkit.hr](mailto:ajukic@fkit.hr)



## UVODNO PREDAVANJE

# Što je naša energetska budućnost ?



# 10 glavnih svjetskih problema u sljedećih 50 godina:

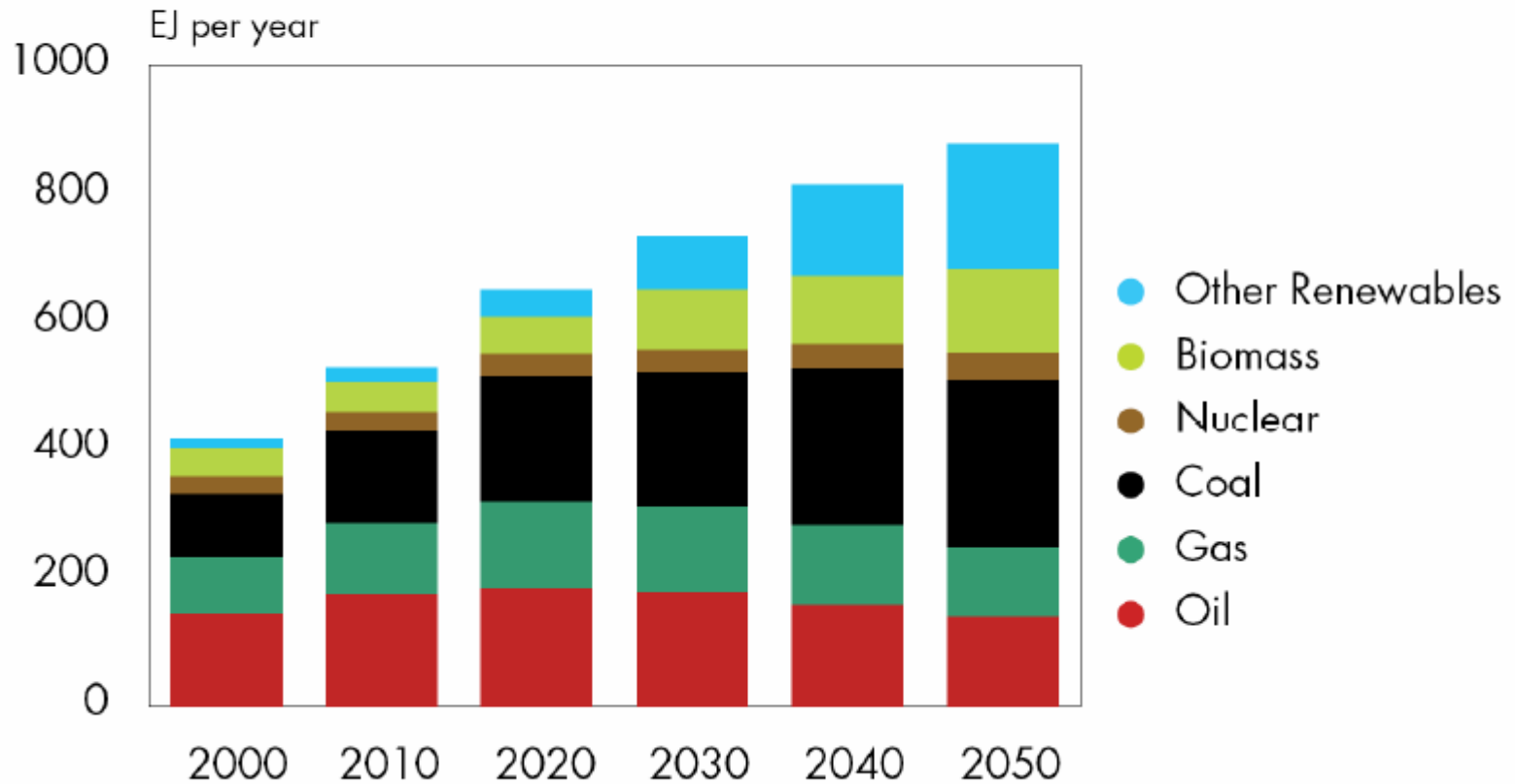


1. ENERGIJA
2. VODA
3. HRANA
4. OKOLIŠ
5. SIROMAŠTVO
6. TERORIZAM & RAT
7. BOLEST
8. OBRAZOVANJE
9. DEMOKRACIJA
10. STANOVNIŠTVO



**2050: 8-10 milijardi ljudi  
(30 % porast !!!)**

# Primary energy demand by source



Source: Shell energy scenarios to 2050, 2007

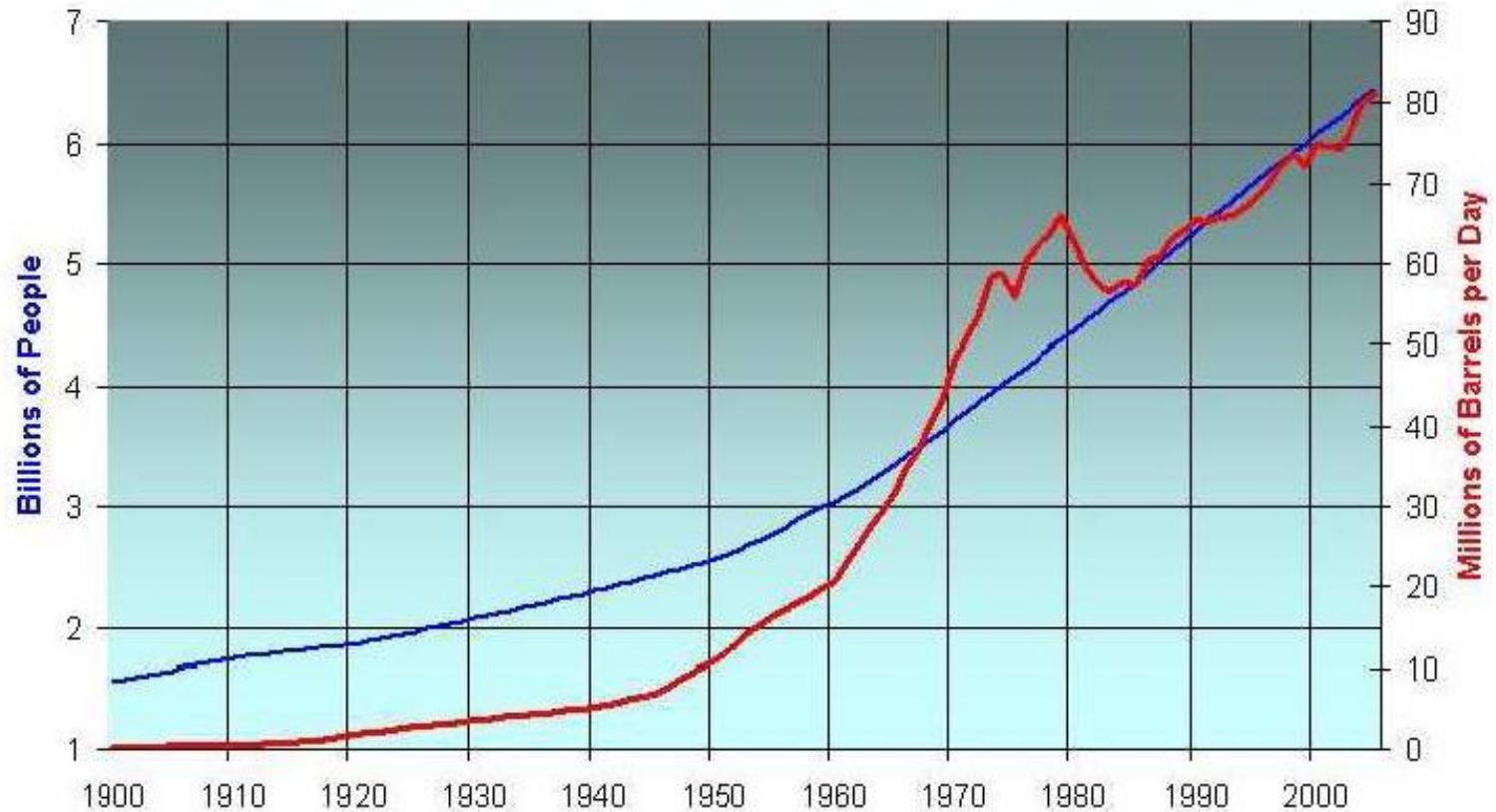
**E (eksa) =  $10^{18}$**



U svijetu se svakodnevno koristi oko  $13,5 \times 10^9$  L nafte i približno  $8,5 \times 10^9$  m<sup>3</sup> prirodnog plina.

Svjetska se potrošnja povećava; predviđa se da će do 2030. godine, ukupna svjetska potražnja za energijom porasti za približno 50%.

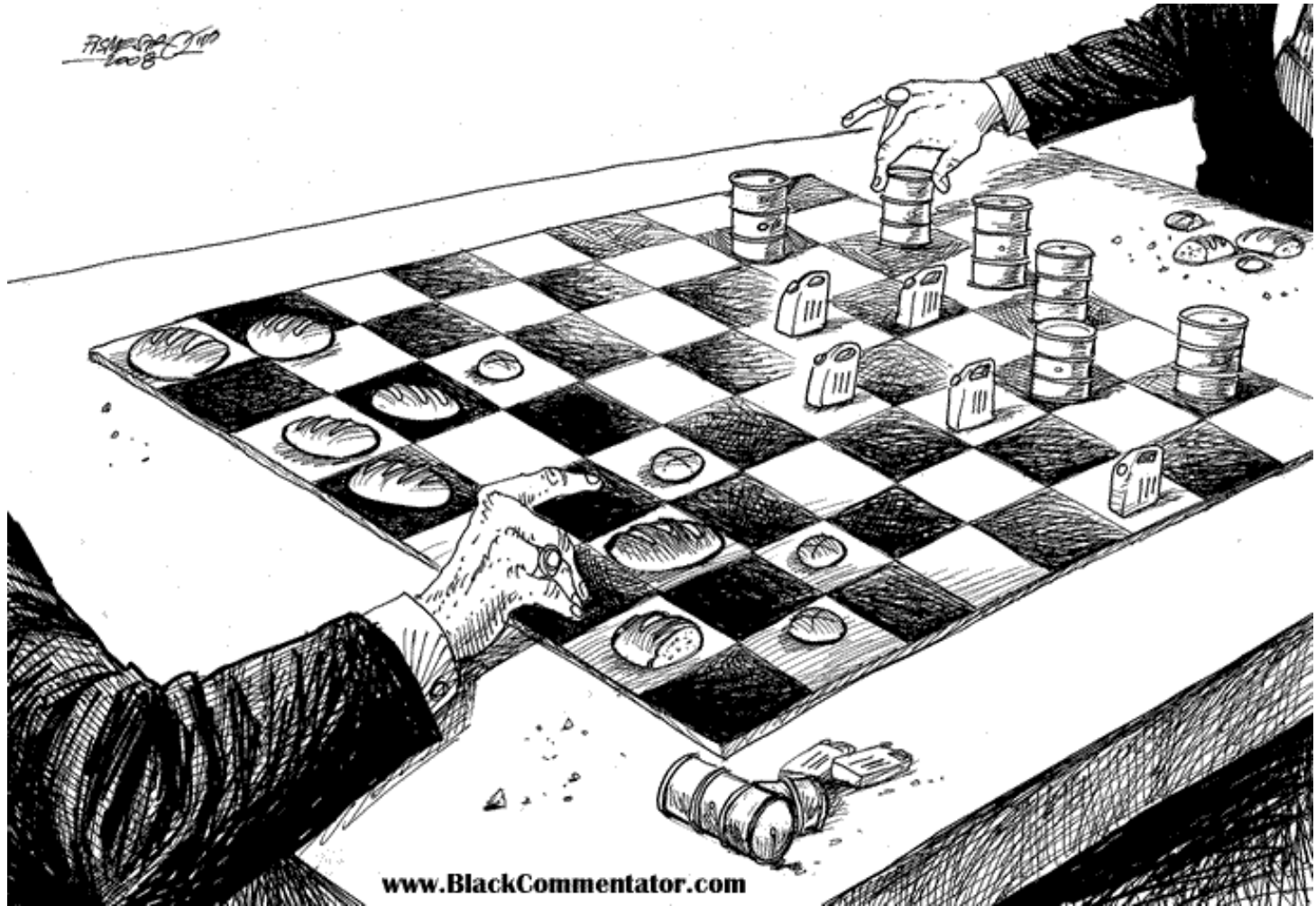
# Svjetsko stanovništvo i proizvodnja nafte, 1900-2005



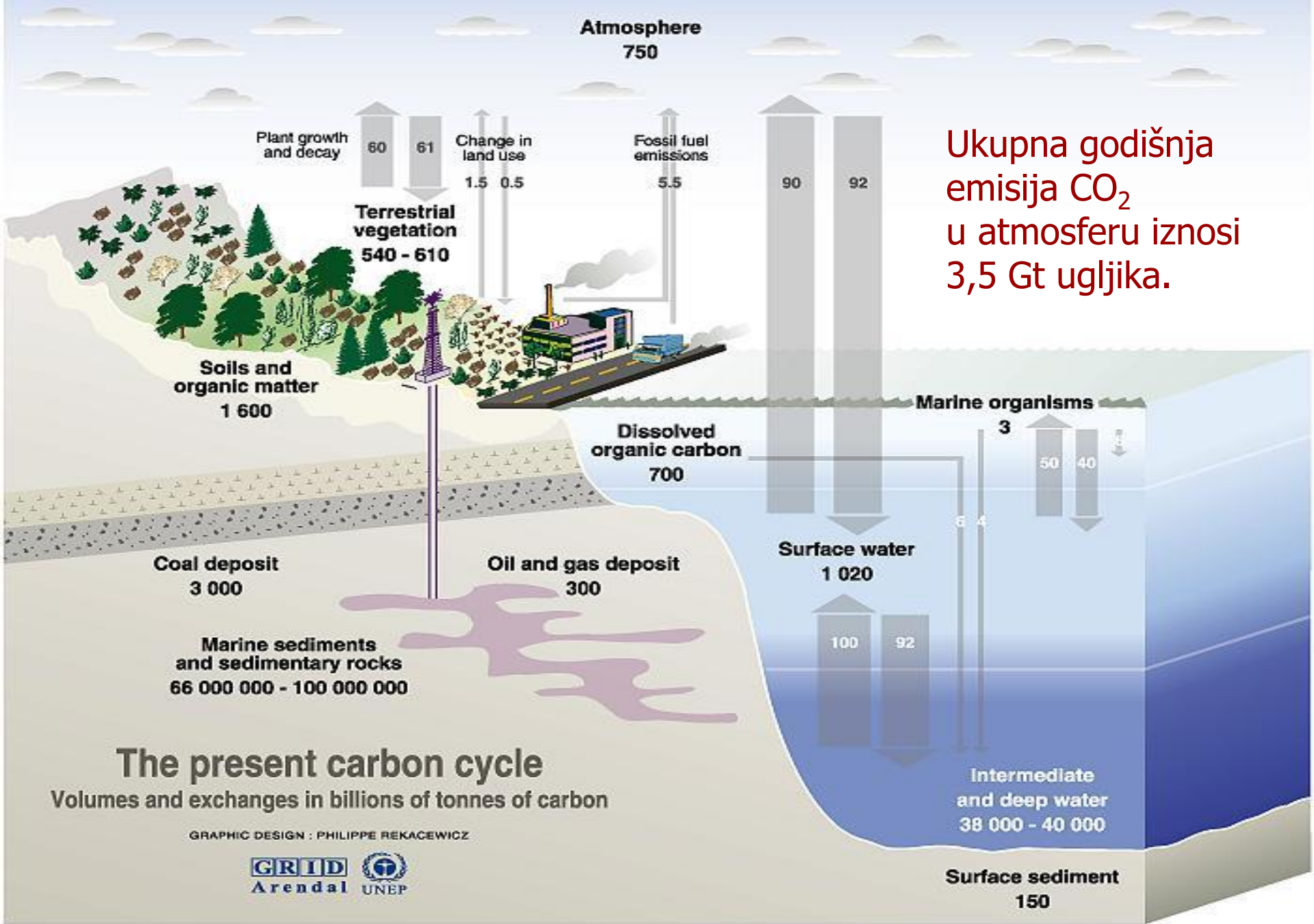
## Cijena sirove nafte u US\$ od svibnja 2008.



FISHMAGAZINE  
2008



[www.BlackCommentator.com](http://www.BlackCommentator.com)



Ukupna godišnja emisija CO<sub>2</sub> u atmosferu iznosi 3,5 Gt ugljika.

### The present carbon cycle

Volumes and exchanges in billions of tonnes of carbon

GRAPHIC DESIGN : PHILIPPE REKACEWICZ



Sources: Center for climatic research, Institute for environmental studies, university of Wisconsin at Madison; Okanagan university college in Canada, Department of geography; World Watch, November-December 1998; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

# Global warming: Causes and effects

Earth's temperature has risen about 1 degree Fahrenheit in the last century. The past 50 years of warming has been attributed to human activity.

Burning fuels such as coal, natural gas and oil produces greenhouse gases in excessive amounts.

Greenhouse gases are emissions that rise into the atmosphere and trap the sun's energy, keeping heat from escaping.

The United States was responsible for 20 percent of the global greenhouse gases emitted in 1997.

Most of the world's emissions are attributed to the United States' large-scale use of fuels in vehicles and factories.

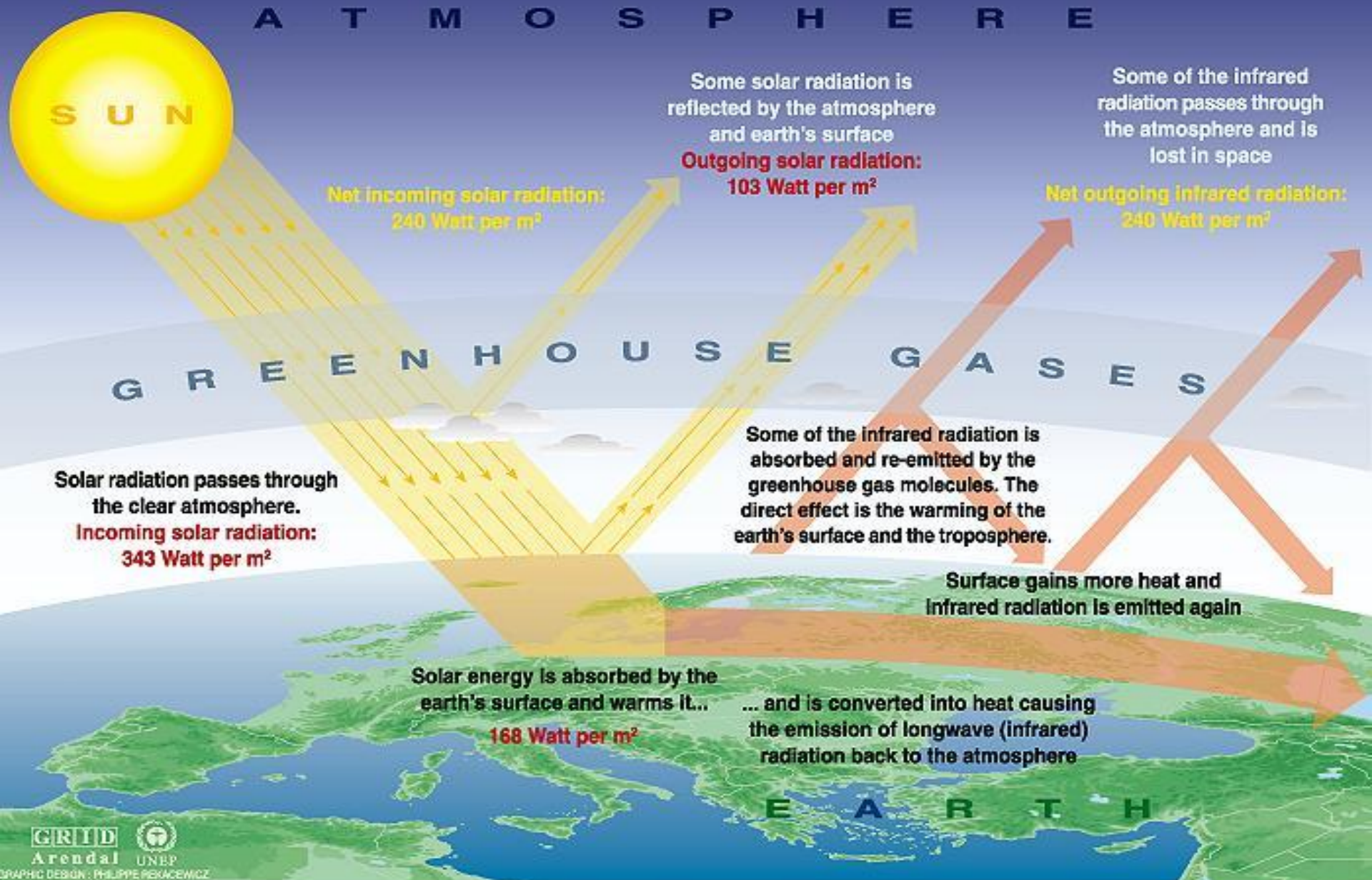
During the past 100 years global sea levels have risen 4 to 8 inches.

Some predictions for local changes include increasingly hot summers and intense thunderstorms.



Damaging storms, droughts and related weather phenomena cause an increase in economic and health problems. Warmer weather provides breeding grounds for insects such as malaria-carrying mosquitoes.

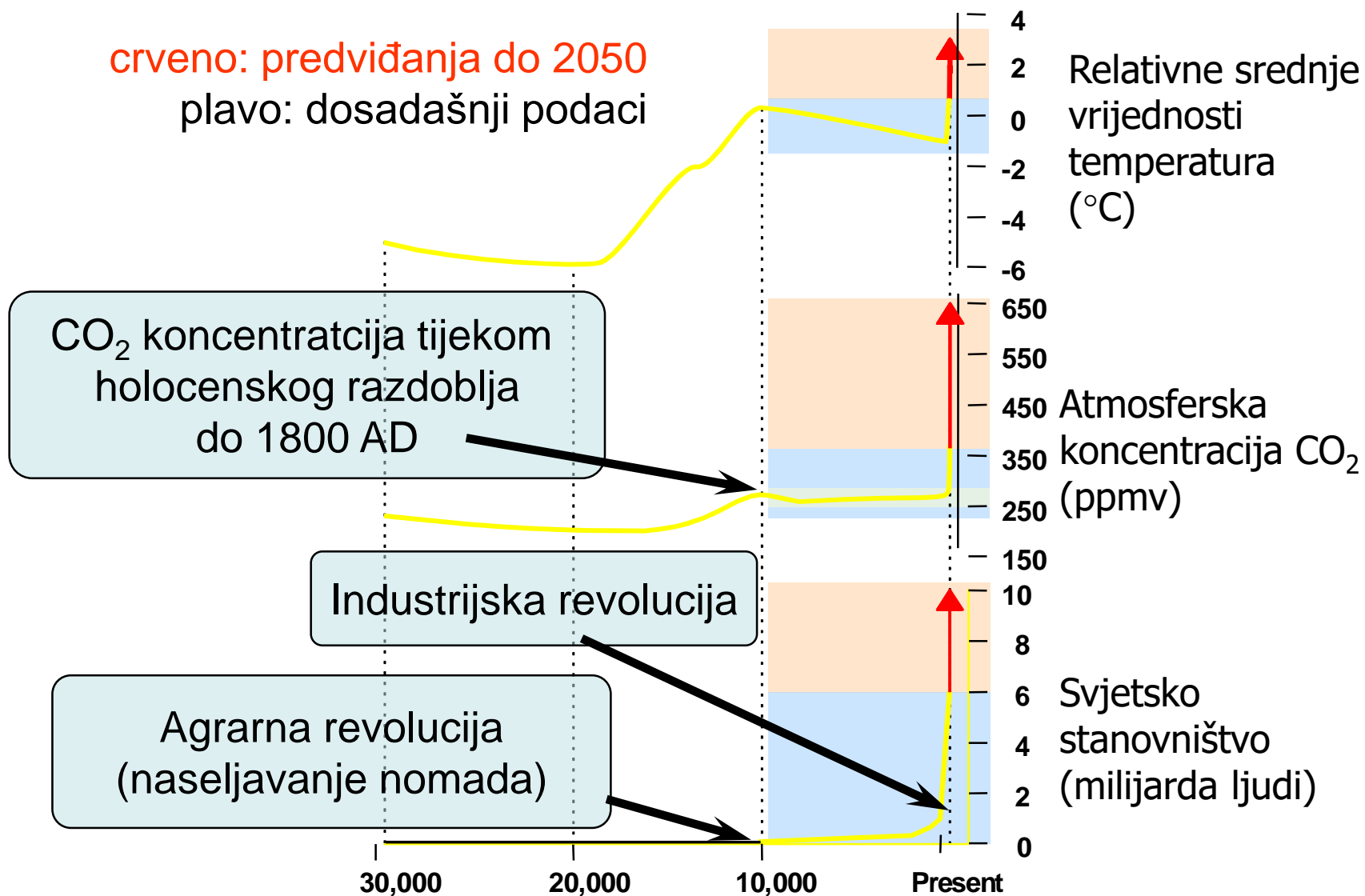
# The Greenhouse effect



GRID Arendal UNEP  
GRAPHIC DESIGN: PHILIPPE PEKACEWICZ

Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

# Promjene temperature, koncentracije CO<sub>2</sub> i svjetskog stanovništva



# Globalno zatopljavanje: kontroverzna tema

- Prvo razmatranje od strane političara: “Kyoto” protokol ?
- Da li je svijet u opasnosti od nadolaska novog ledenog doba ?
- Da li je svijet u ozbiljnoj opasnosti zbog podizanja razine mora ?
- Da li su nedavno ispoljeni ekstremni vremenski uvjeti uzrokovani globalnim zatopljavanjem ?
- Nestaju li snjegovi Kilimandžara zbog globalnog zatopljavanja ?
- Da li će globalno zatopljavanje dovesti do širenja malarije?
- Nije li Američki ured za obranu (U.S. Department of Defense) proglasio globalno zatopljavanje prijetnjom nacionalnoj sigurnosti ?
- Nisu li najnoviji klimatski modeli pokazali da će globalno zatopljavanje biti mnogo gore nego što se prvotno mislilo ?
- Nisu li se nacionalne akademije svih vodećih industrijaliziranih zemalja složile da je globalno zatopljavanje vrlo ozbiljna prijetnja ?
- Ne utapaju li se polarni medvjedi zbog otapanja leda?
- Da li postoji razmimoilaženje među znanstvenicima oko globalnog zatopljavanja ?
- Bez osporavanja: svijet se zagrijava, a čovjek je barem djelomično za to odgovoran. Neprekidna je znanstvena rasprava o pokazateljima koji se koriste u računalnim modelima kojima se predviđaju klimatski uvjeti u budućnosti. Ne možemo biti sigurni da li će doći do značajnijeg zagrijavanja svijeta, ne znamo koliko opasno, ako uopće, će biti čak i zagrijavanje u značajnoj mjeri.

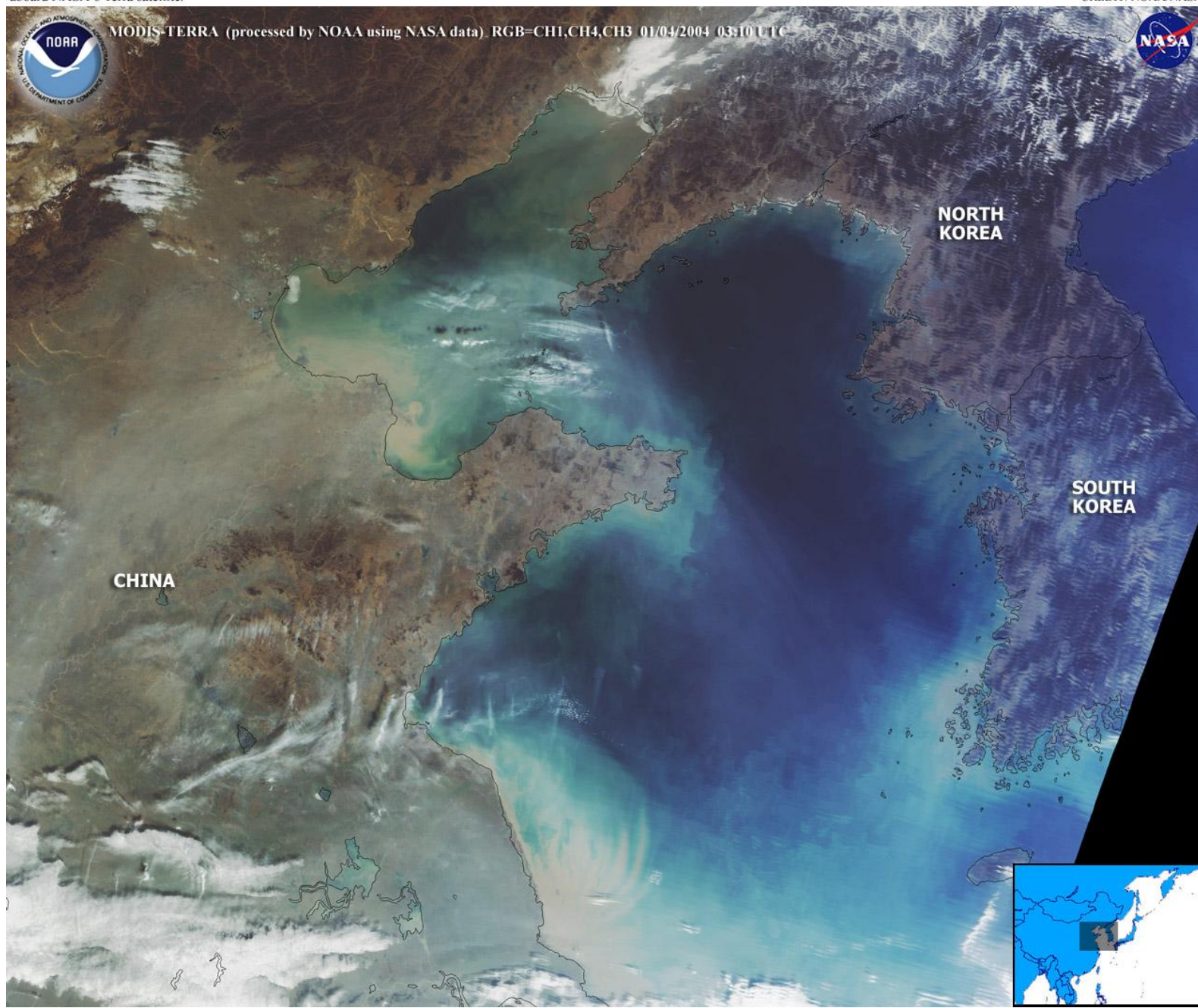
# Zagađivanje

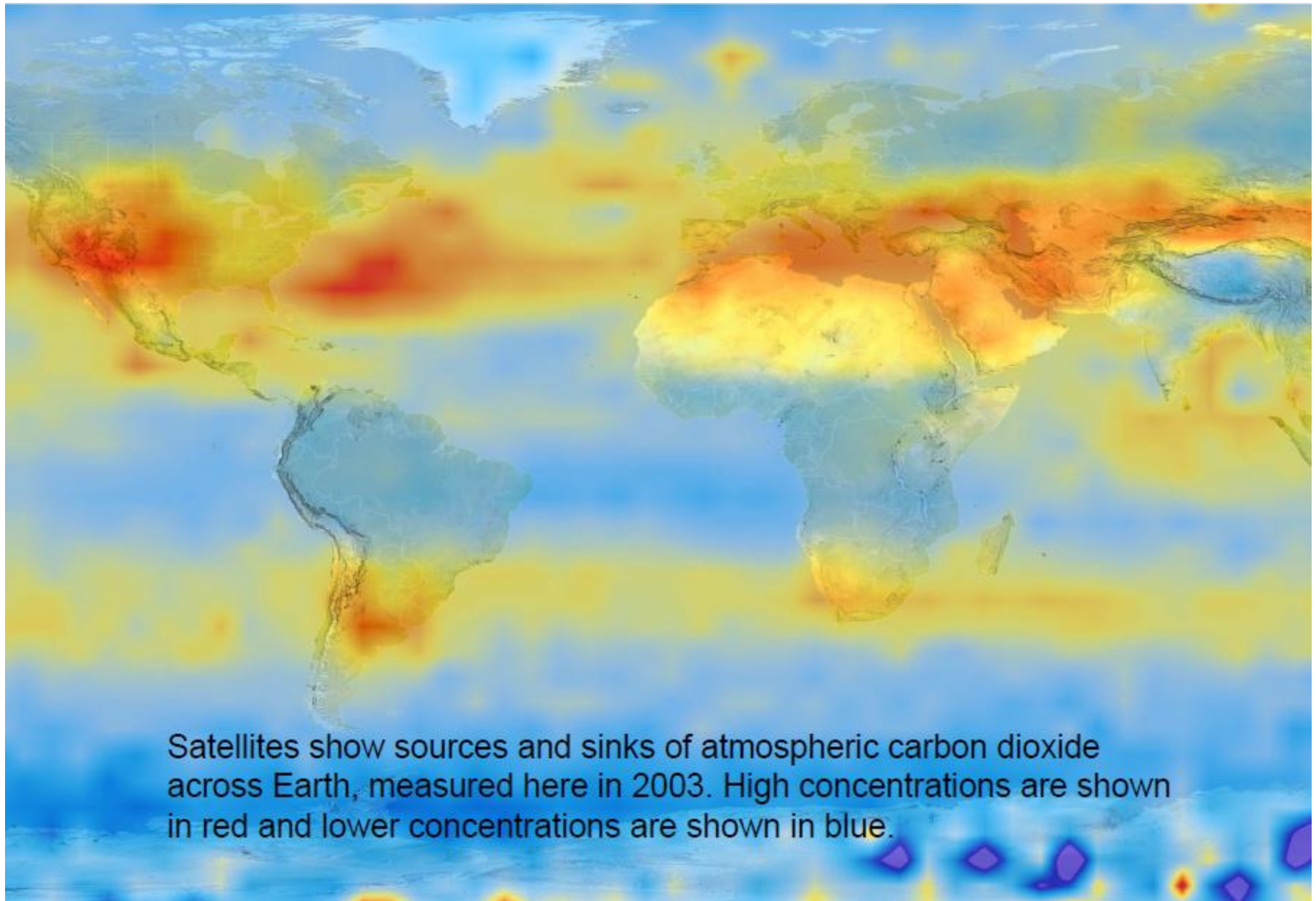
- Zagađivanje predstavlja ogroman problem diljem svijeta, nepovoljno i štetno utječući na živote milijuna ljudi, te uzrokujući brojne bolesti i smrtne slučajeve.
- Glavni uzročnici: sječa šuma, zagađivanje rijeka, zagađivanje okoliša, kontinuirana industrijalizacija i urbanizacija te zagađivanje tla. Zagađivala koja kontaminiraju zrak u naseljima - fino suspendirane čestice (PM) (1-10), SO<sub>2</sub>, i ozon predstavljaju najčešće i najakutnije opasnosti.
- Najnovije studije o utjecajima kroničnog izlaganja utjecajima zagađivala iz zraka izlučile su čestice kao zagađivala najodgovornija za skraćivanje životnog vijeka usljed izlaganja utjecaju nezdravog zraka. Ova zagađivala uzrokuju poteškoće vezane za poremećaje disanja ili druge zdravstvene poremećaje. Zagađivanje voda čini ih neprikladnim za piće i druge primjene. Također, to je glavni uzrok većine bolesti nastalih putem vode.
- Potencijal i izgledi za nenamjernu ili namjernu kontaminaciju okoliša, hrane i poljoprivrednih proizvoda porasli su nedavno zbog općeg rata protiv terorizma i predstavljaju jedan od rastućih izazova. Prema tome, brzo otkrivanje zagađivala u okolišu koristeći najsuvremenije tehnologije od iznimnog je značenja. Zagađivanje okoliša u nekim zemljama u razvoju doseglo je zabrinjavajuću razinu, te stoga praćenje razine zagađivala u realnom vremenu osjetilima povezanima u mreže, te postaje za promatranje, nužno kako bi se dobio pravi uvid.
- Potrebno kvalitativno i kvantitativno interaktivno praćenje zagađivanja.



A dense gray pall of pollution covered much of eastern China on January 4, 2004. The haze has been lingering over this region for more than a month. Some of the aerosol can be seen blowing eastward across the Yellow Sea. This true-color scene was acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite.

CREDIT: NOAA/NASA





Satellites show sources and sinks of atmospheric carbon dioxide across Earth, measured here in 2003. High concentrations are shown in red and lower concentrations are shown in blue.

# New challenges



## Resources

- **Enhanced oil recovery**
  - Deep sea
- **Oil shales and sands**
  - **GTL i CTL**
- **Gas (methane) hydrates**



## Vehicle Technology & Fuels Development

- **Cleaner gasoline & diesel**
  - **New fuels & biofuels**
  - **Engine Efficiency and Reduced Emissions**



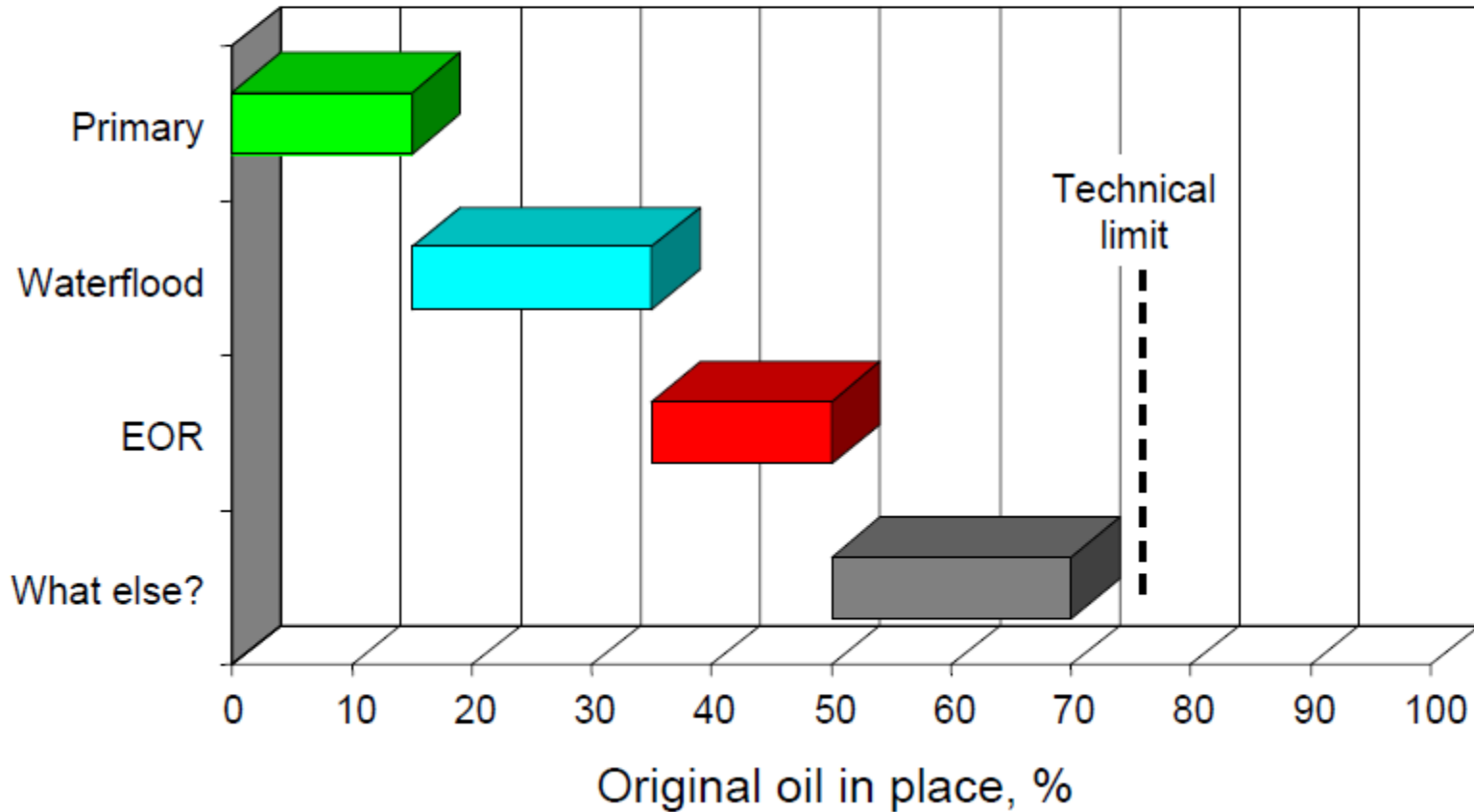
## Renewables

- **Solar**
- **Wind**
- **Biomass**

# New challenges - oil

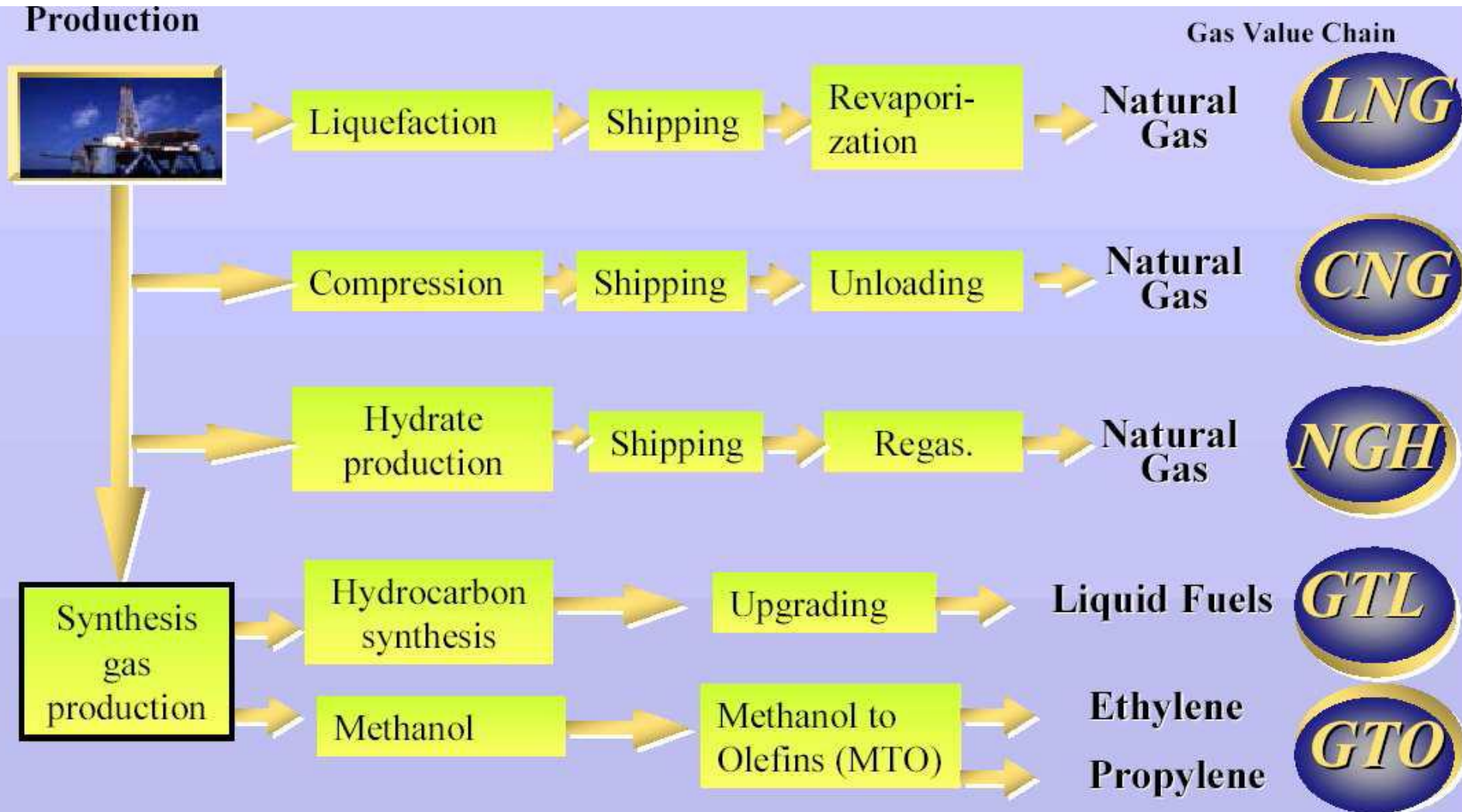
## Maximising recovery – reservoir life cycle

Schematic – recovery factors and “technical limit” vary for each reservoir



Enhanced Oil Recovery (abbreviated EOR) is a generic term for techniques for increasing the amount of crude oil that can be extracted from an oil field. Using EOR, 30-60 %, or more, of the reservoir's original oil can be extracted compared with 20-40% using primary and secondary recovery. Enhanced oil recovery is also called improved oil recovery or tertiary recovery (as opposed to primary and secondary recovery).

# New challenges – natural gas



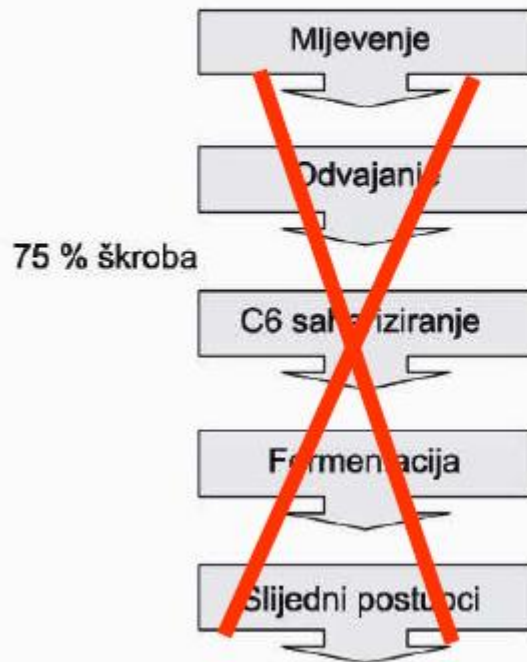
LNG –Liquified Natural Gas; CNG –Compressed Natural Gas; NGH – Natural Gas Hydrates

GTL –Gas To Liquids; MTO – Methanol To Olefins; GTO – Gas To Olefins

# New challenges – biorefinery



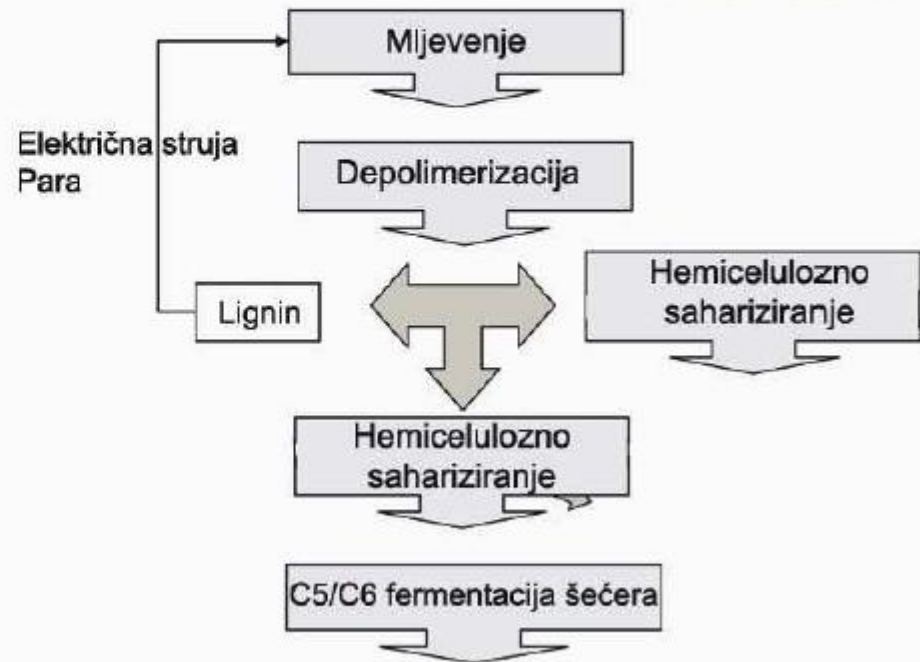
Tok kukuruznog zrnja



Intermedijeri za plastiku: mliječna kiselina, PDO (homopolimeri i kopolimeri p-dioksanona), metanol, etilen glikol itd.

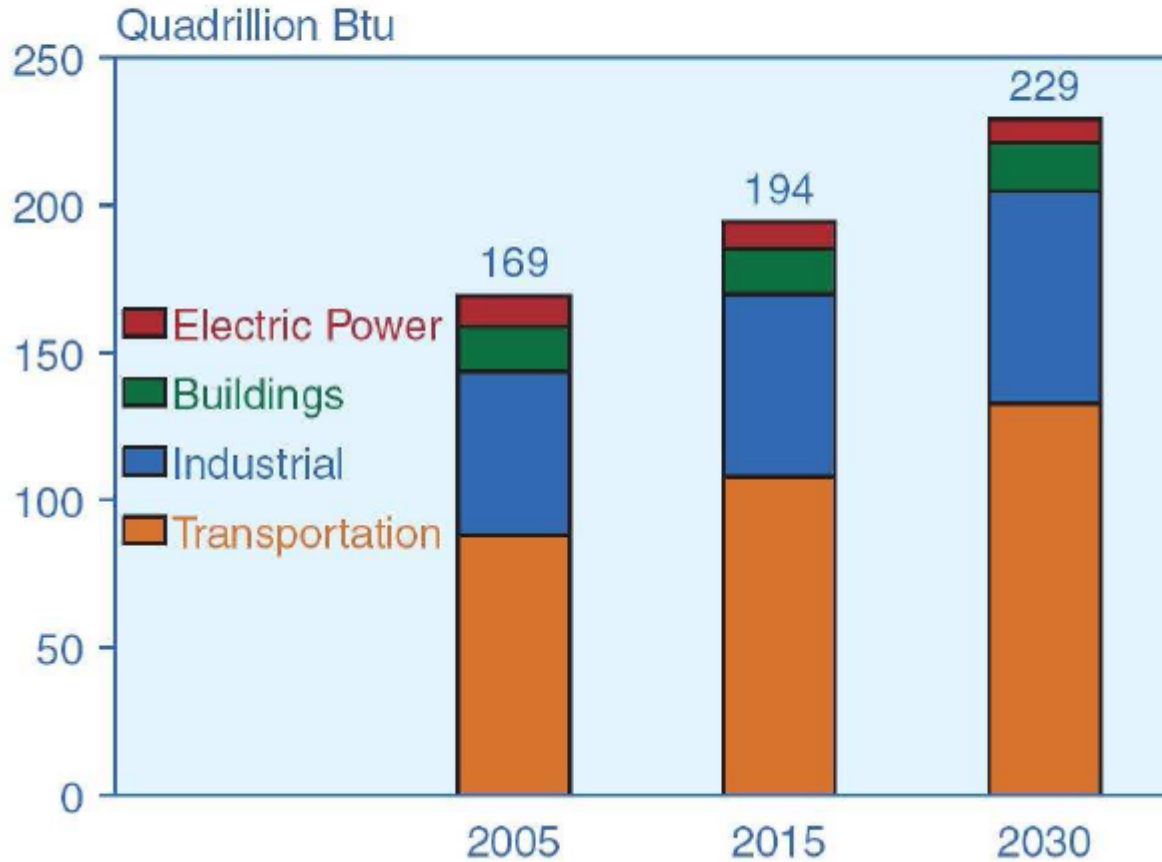


Tok kukuruzne stbljike



# World Liquids Consumption by End-Use Sector 2005-2030

1 BTU = 1 054 – 1 060 J



Source: Eia World Energy Projections Plus (2008)

# New challenges

Improvements in conventional fuel technology

*cost, convenience, existing re-fuelling infrastructure, blend with new components*

improved vehicle efficiency & after-treatment  
cleaner gasoline & diesel

new fuels, e.g. GTL, emulsions & bio-fuels

reduce GHG emissions

future

Gas  
1 : 4  
Underlying de-carbonisation of conventional fuels

Oil  
1 : 2

Coal  
1.5 : 1

Hydrogen  
0 : 1

hydrogen Fuel Cells

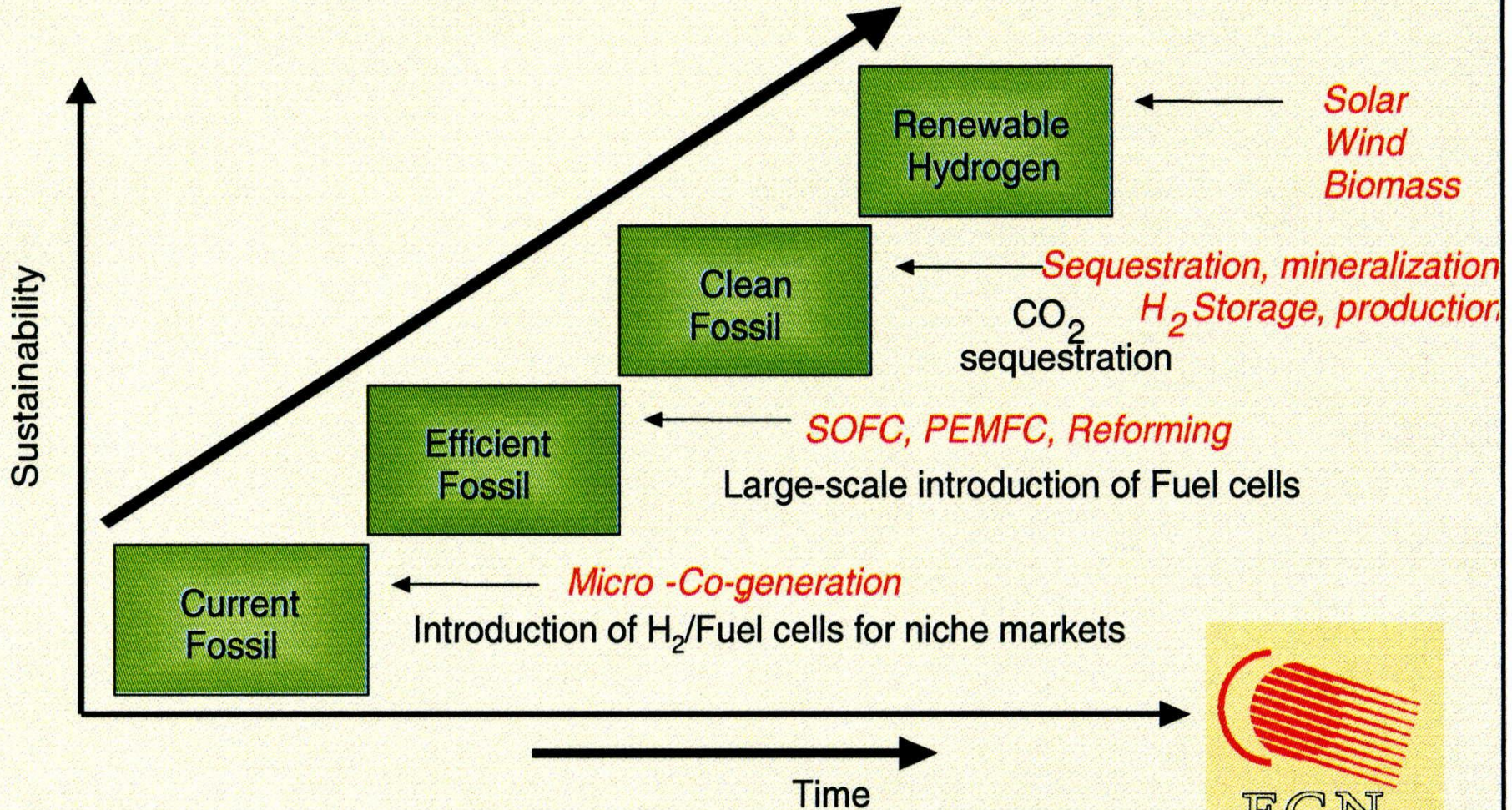
hybrid vehicles

new fuels, e.g. LPG & CNG

Replacements for conventional fuels

today

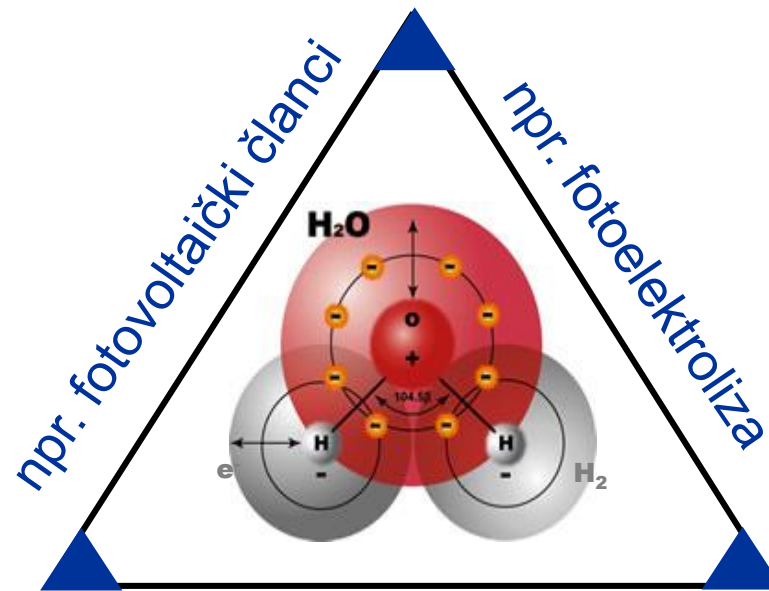
# Transition towards sustainable energy



# Mogući “energijski trokut” budućnosti

izvor

## Sunčevo zračenje



glavni nosilac

gorivni članci / elektroliza

skladištenje & gorivo

## Električna energija

## Vodik