Perspektivy budoucnosti lidstva

Tomáš Miléř, PdF MU

Fyzika, filosofie a myšlení, 2014

Moduly jako prostředek inovace v integraci výuky moderní fyziky a chemie, CZ.1.07/2.2.00/28.0182

esf evropský sociální fond v ČR

EVROPSKÁ UNIE

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

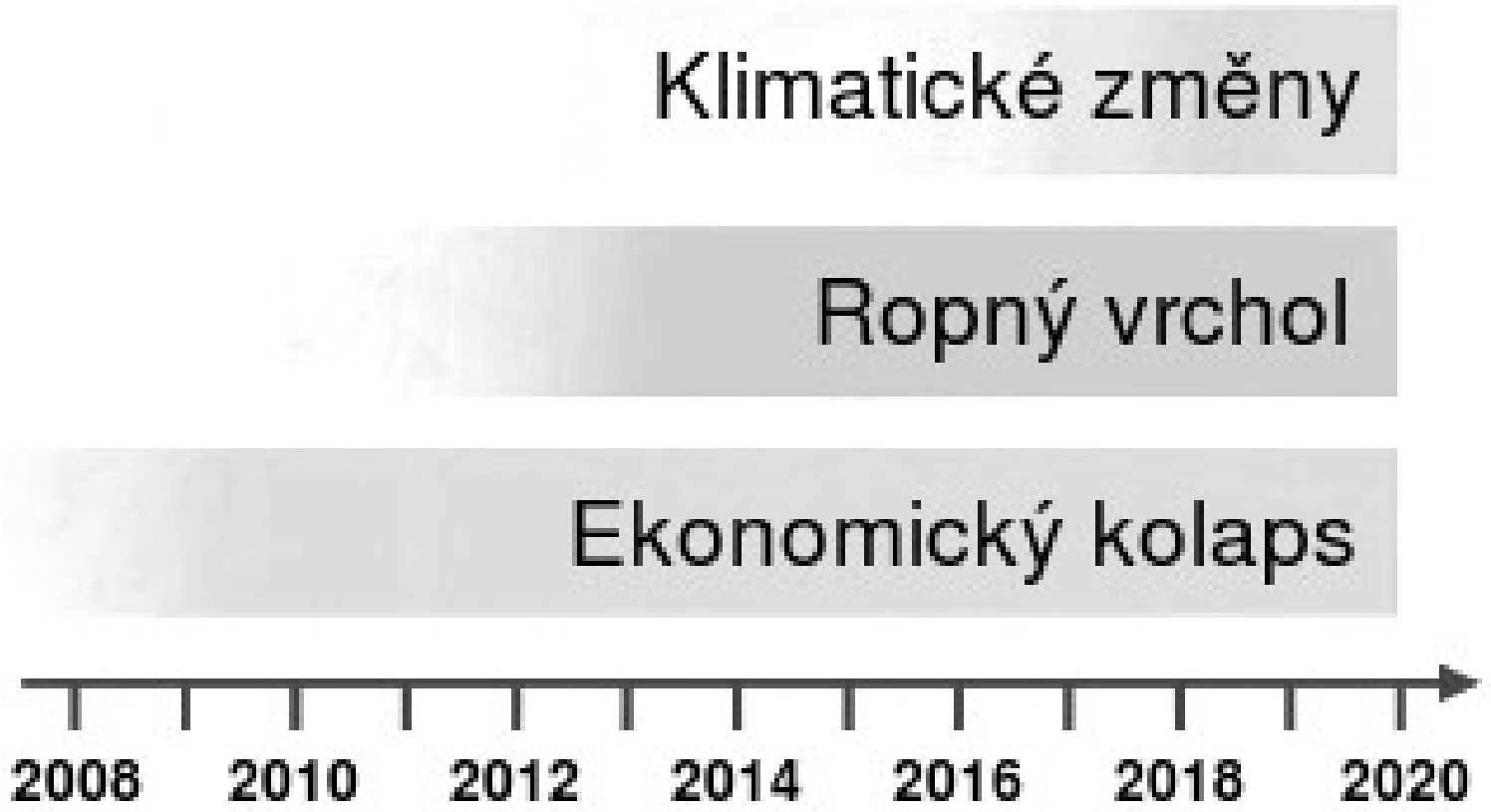
OP Vzdělávání pro konkurenceschopnost

UNIVERSITAS MASARYKIANA BRUNENSIS

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

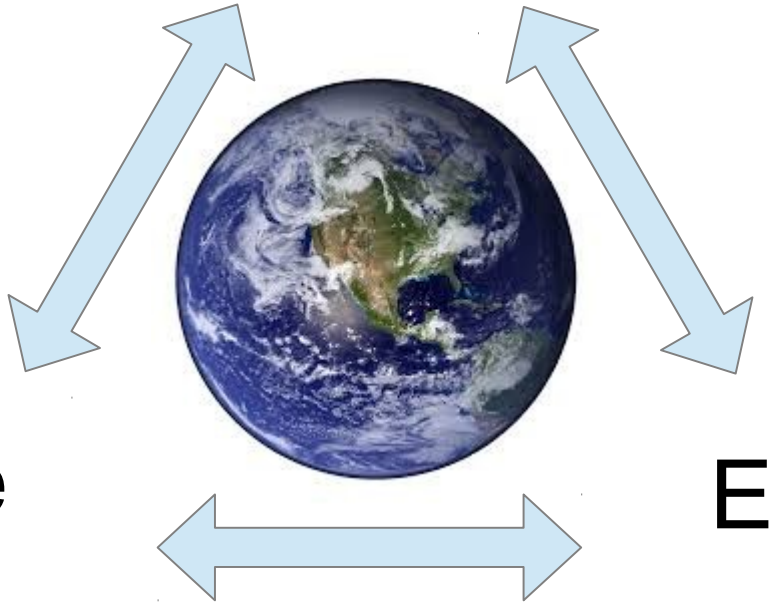
Problem vs. predicament

Aktuální globální problémy



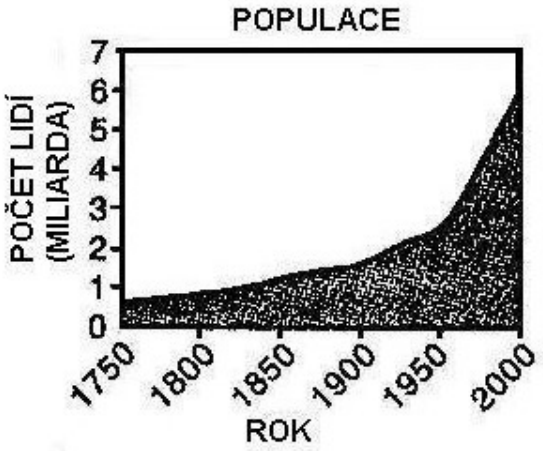
Svět je komplexní, nelineární, adaptivní systém

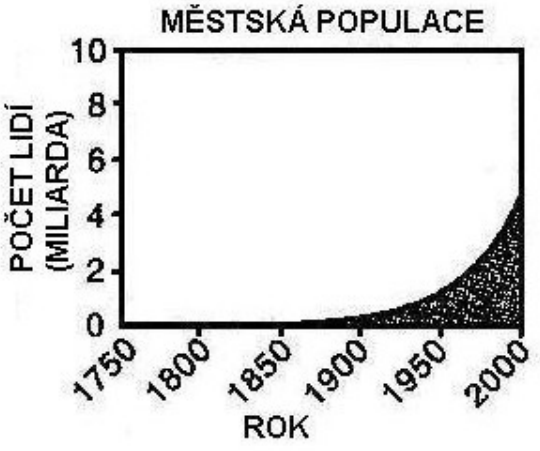
Environment

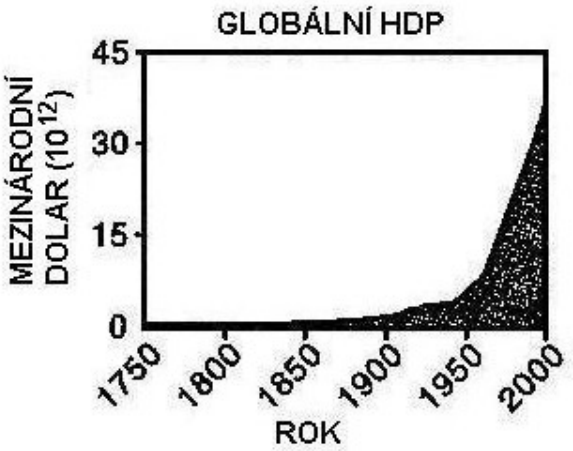


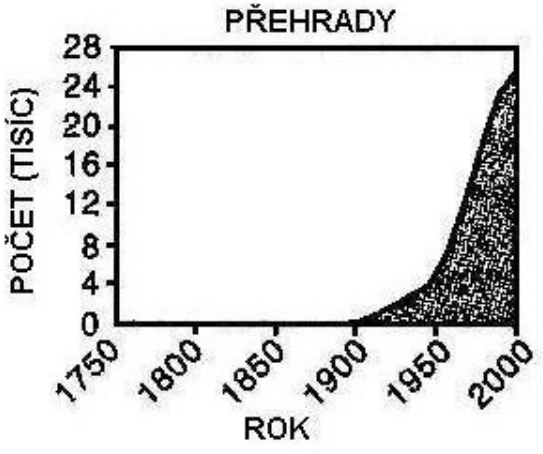
Energie

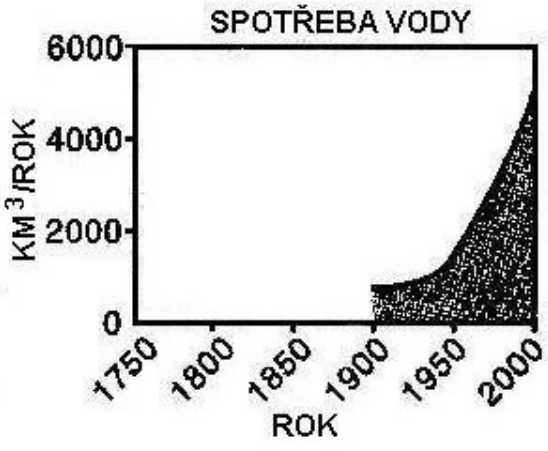
Ekonomika

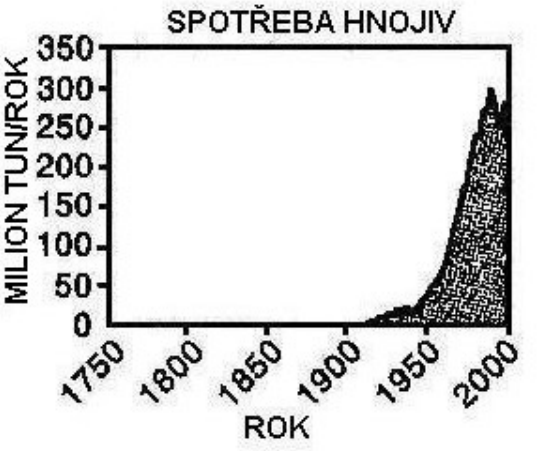

POPULACE
POČET LIDÍ (MILIARDA)
0
1
2
3
4
5
6
7
1750
1800
1850
1900
1950
2000
ROK

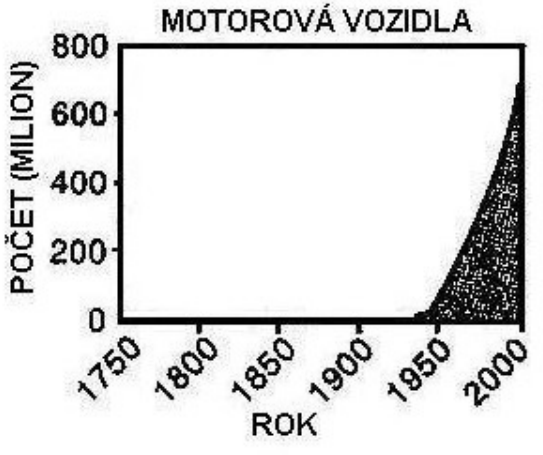

MĚSTSKÁ POPULACE
POČET LIDÍ (MILIARDA)
0
2
4
6
8
10
1750
1800
1850
1900
1950
2000
ROK

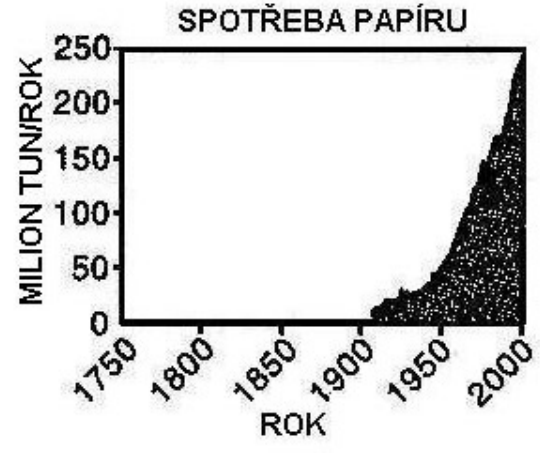

GLOBÁLNÍ HDP
MEZINÁRODNÍ DOLAR (10^{12})
0
15
30
45
1750
1800
1850
1900
1950
2000
ROK

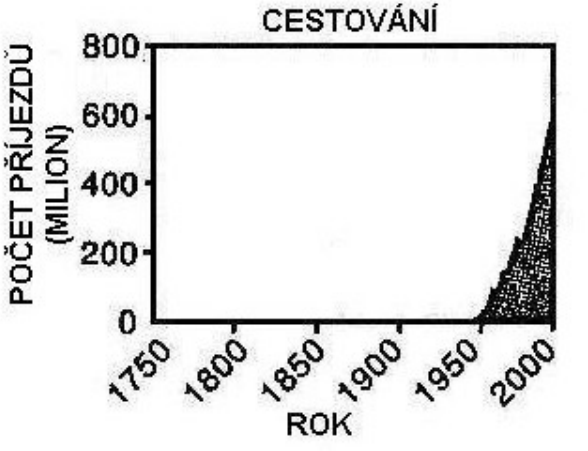

PŘEHRADY
POČET (TISÍC)
0
4
8
12
16
20
24
28
1750
1800
1850
1900
1950
2000
ROK

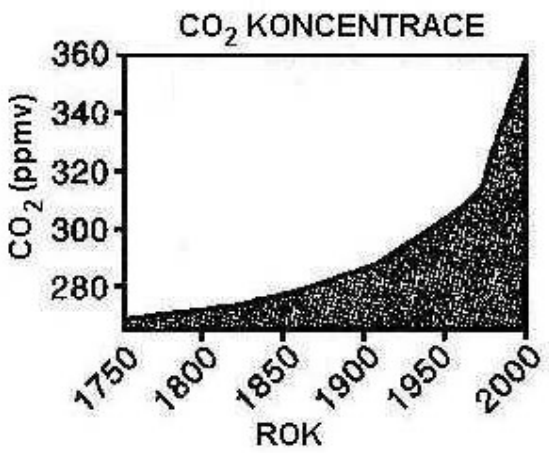

SPOTŘEBA VODY
KM^3/ROK
0
2000
4000
6000
1750
1800
1850
1900
1950
2000
ROK

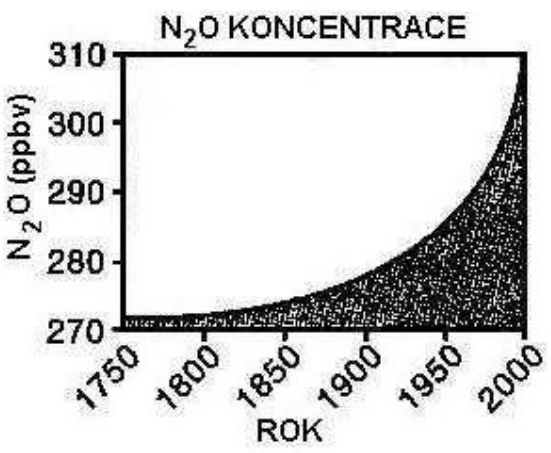

SPOTŘEBA HNOJIV
MILION TUN/ROK
0
50
100
150
200
250
300
350
1750
1800
1850
1900
1950
2000
ROK

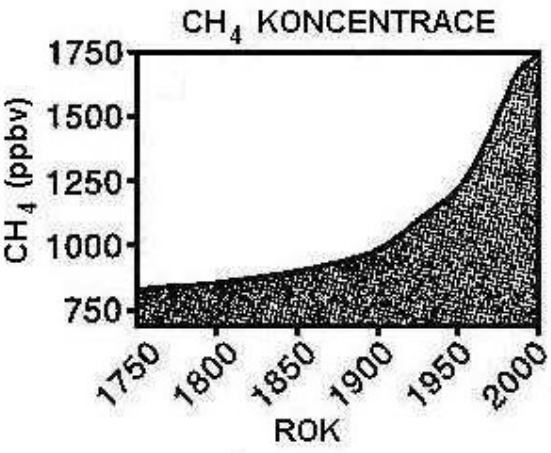

MOTOROVÁ VOZIDLA
POČET (MILION)
0
200
400
600
800
1750
1800
1850
1900
1950
2000
ROK

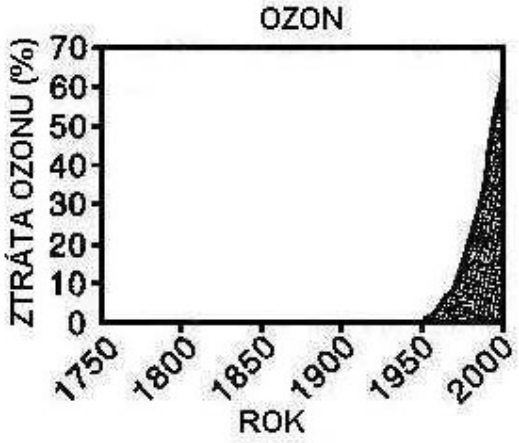

SPOTŘEBA PAPÍRU
MILION TUN/ROK
0
50
100
150
200
250
1750
1800
1850
1900
1950
2000
ROK

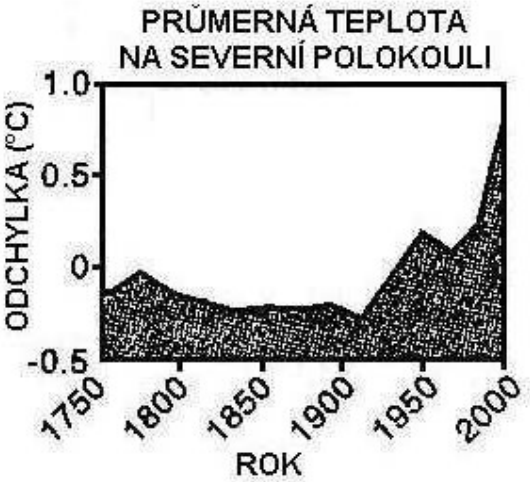

CESTOVÁNÍ
POČET PŘÍJEZDŮ (MILION)
0
200
400
600
800
1750
1800
1850
1900
1950
2000
ROK

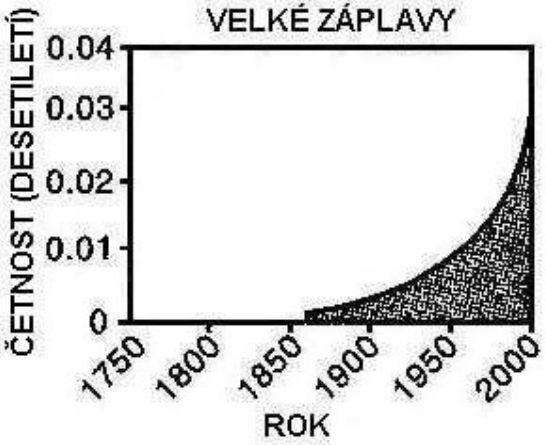

CO_2 KONCENTRACE
CO_2 (ppmv)
360
340
320
300
280
1750
1800
1850
1900
1950
2000
ROK

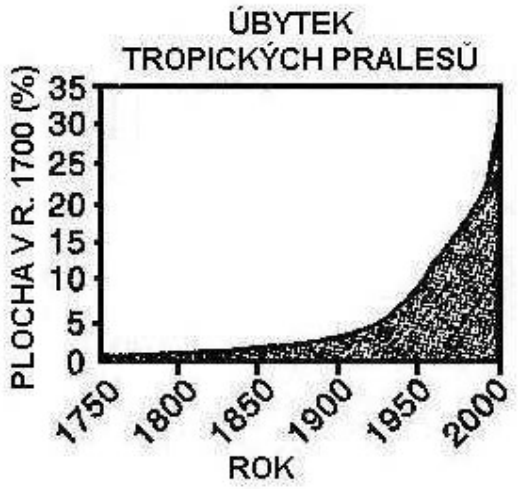

N_2O KONCENTRACE
N_2O (ppbv)
310
300
290
280
270
1750
1800
1850
1900
1950
2000
ROK

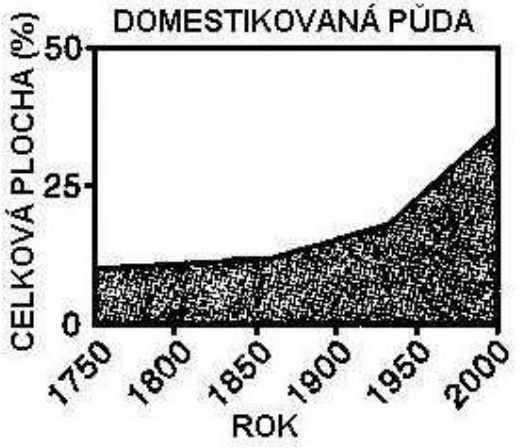

CH_4 KONCENTRACE
CH_4 (ppbv)
1750
1500
1250
1000
750
1750
1800
1850
1900
1950
2000
ROK

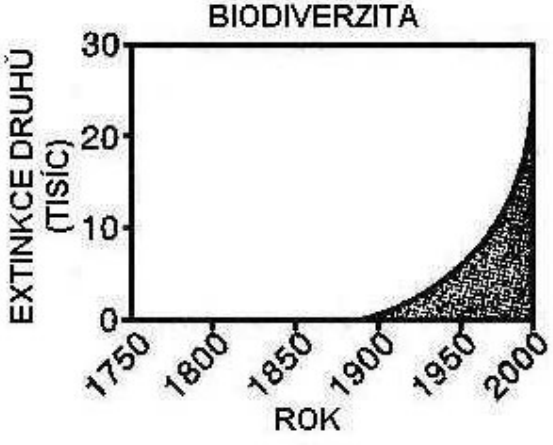

OZON
ZTRÁTA OZONU (%)
70
60
50
40
30
20
10
0
1750
1800
1850
1900
1950
2000
ROK


PRŮMERNÁ TEPLOTA
NA SEVERNÍ POLOKOULI
ODCHYLKA (°C)
1.0
0.5
0
-0.5
1750
1800
1850
1900
1950
2000
ROK


VELKÉ ZÁPLAVY
ČETNOST (DESETILETÍ)
0.04
0.03
0.02
0.01
0
1750
1800
1850
1900
1950
2000
ROK


ÚBYTEK
TROPICKÝCH PRALESŮ
PLOCHA V R. 1700 (%)
35
30
25
20
15
10
5
0
1750
1800
1850
1900
1950
2000
ROK


DOMESTIKOVANÁ PŮDA
CELKOVÁ PLOCHA (%)
50
25
0
1750
1800
1850
1900
1950
2000
ROK


BIODIVERZITA
EXTINKCE DRUHŮ
(TISÍC)
30
20
10
0
1750
1800
1850
1900
1950
2000
ROK

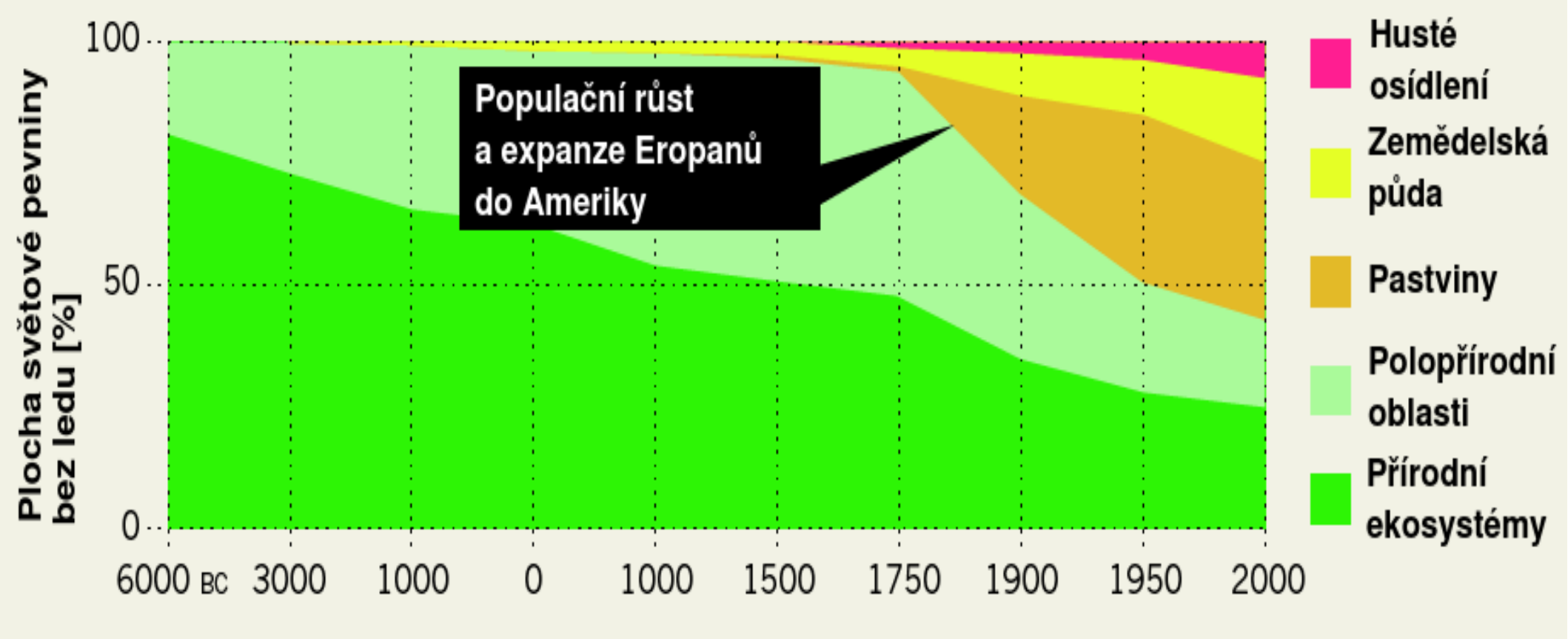
Antropocén

- … současná geologická epocha
- Paul J. Crutzen

- Podle Crutzena lze za počátek antropocénu považovat období, kdy James Watt zdokonalil parní stroj (patent 1769).

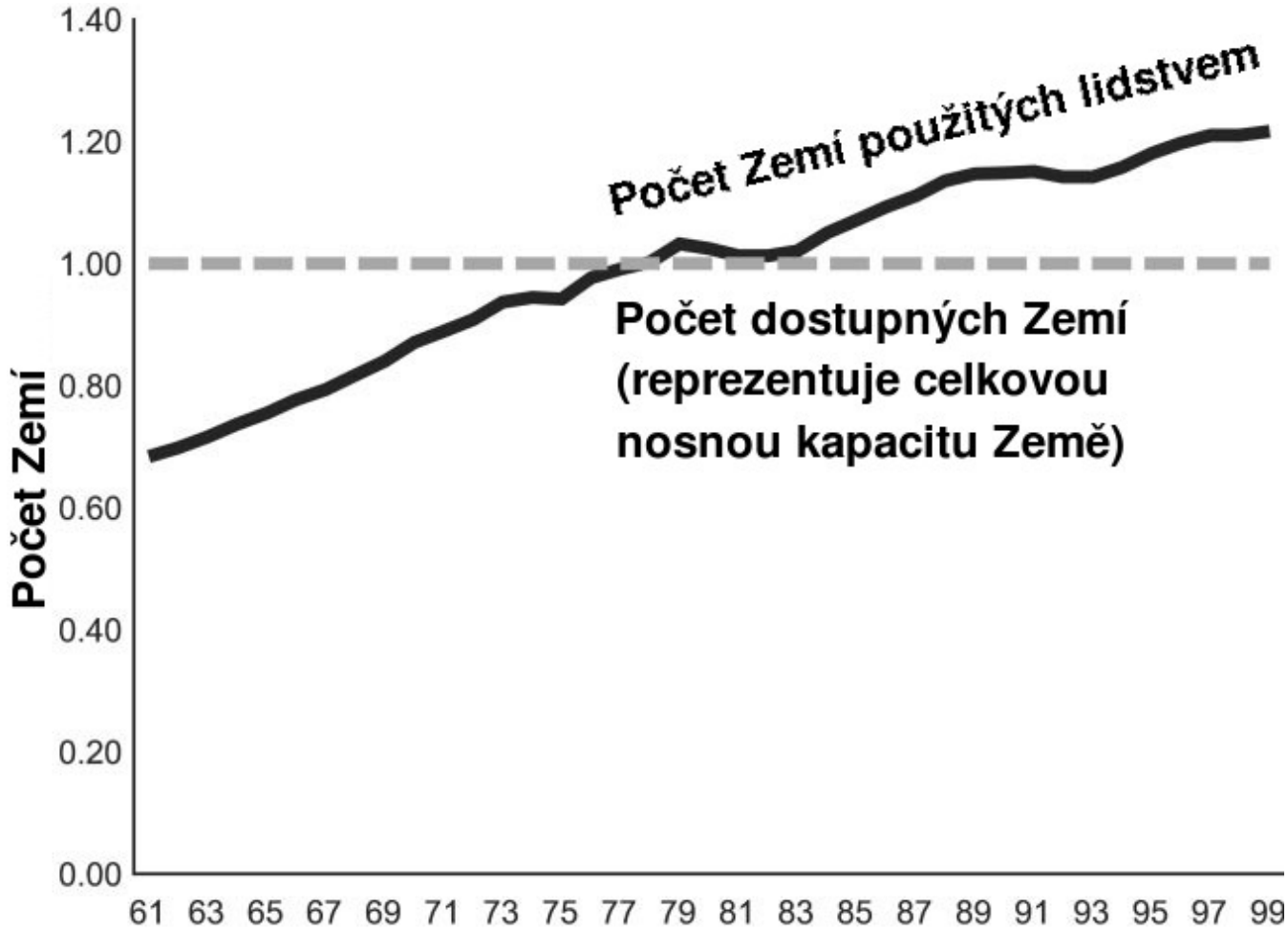
http://academics.eckerd.edu/instructor/carlsopr/Papers/Anthropocene.pdf
http://blisty.cz/art/51845.html
http://www.vesmir.cz/clanek/bedrich-moldan-priroda-a-civilizace-zivotni-prostredi-a-rozvoj-lidske-civilizace

Transformace biosféry

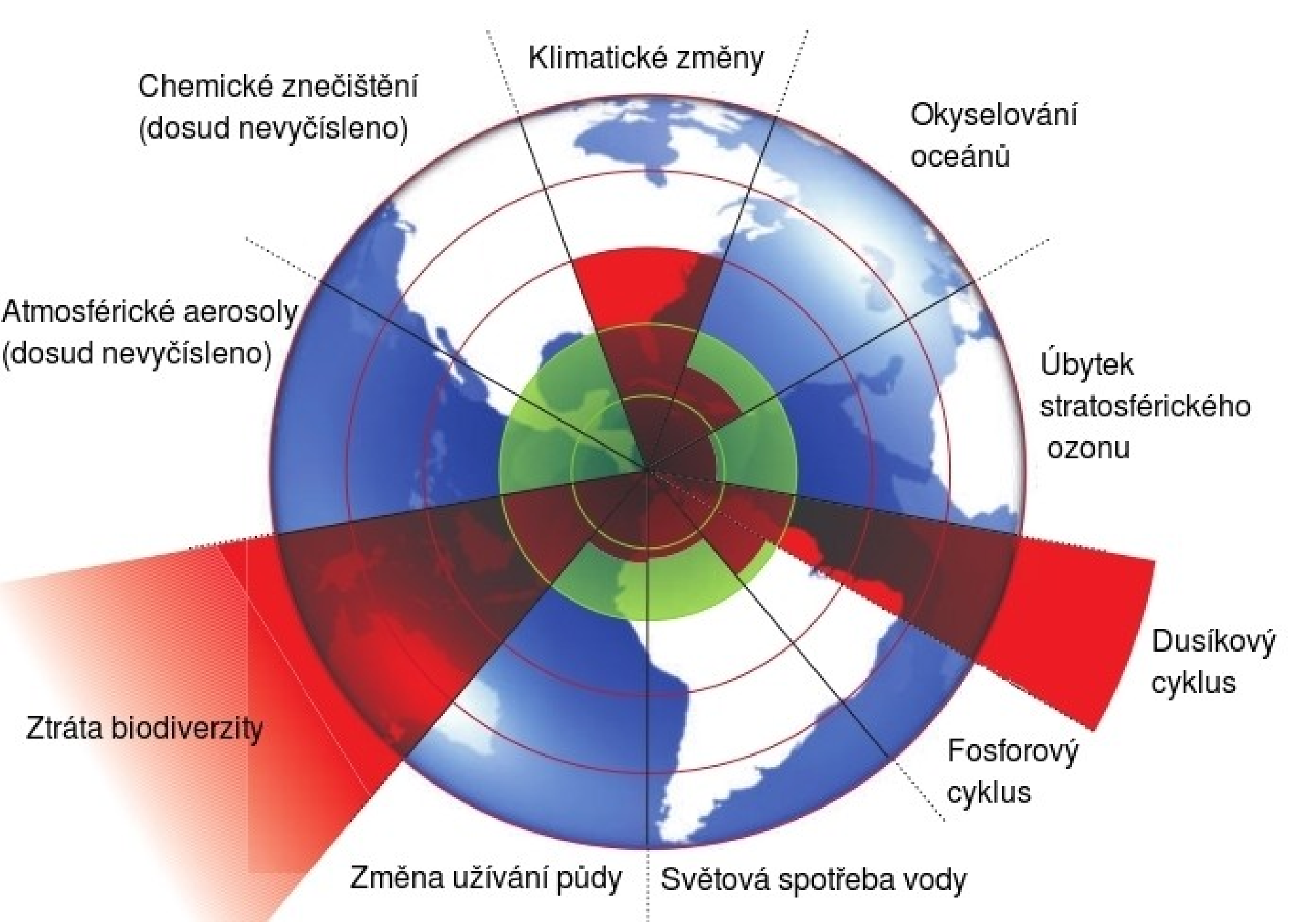


JONES, Nicola, 2011. *Human influence comes of age*. Nature

Nosná kapacita Země ve stavu přestřelení (overshoot)



Wackernagel, M. 2002. *Tracking the ecological overshoot of the human economy.* PNAS, http://www.pnas.org/content/99/14/9266.full.pdf



Rockström, J. et all., 2009, *A safe operating space for humanity*, NATURE

Modelování environmentálních dopadů lidské činnosti

Kayova rovnice (modelování emisí uhlíku)

$$M = C$$

M – emise uhlíku
C – vytěžený uhlík

Kayova rovnice (modelování emisí uhlíku)

$$M = \frac{C}{E}\ E$$

M – emise uhlíku
C/E – energetické zdroje
E – spotřeba primární energie

Kayova rovnice (modelování emisí uhlíku)

$$M = \frac{C}{E} \; \frac{E}{HDP} \; HDP$$

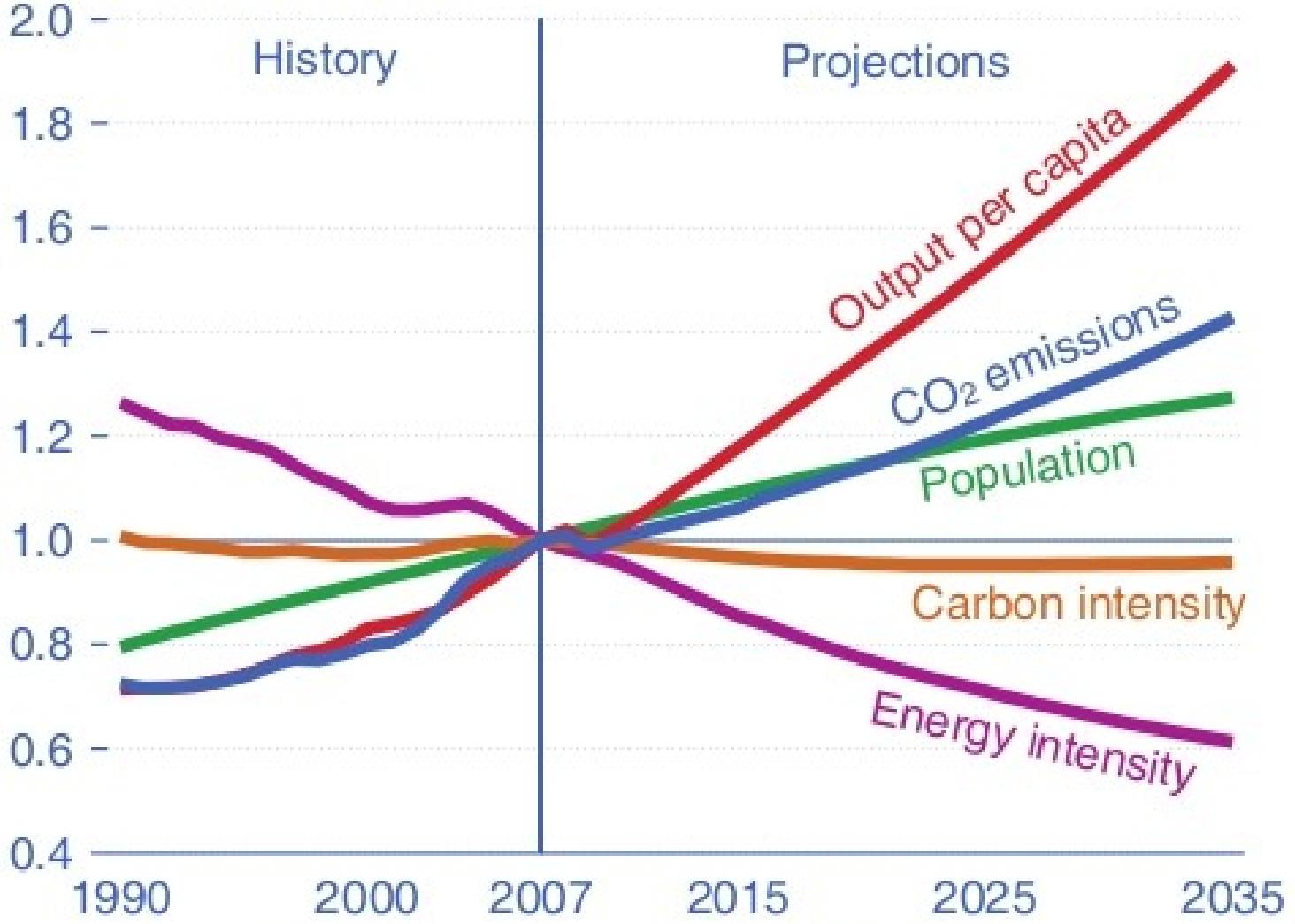
M – emise uhlíku
C/E – energetické zdroje
E/HDP – energetická náročnost HDP
HDP – hrubý domácí produkt

Kayova rovnice (modelování emisí uhlíku)

$$M = \frac{C}{E}\ \frac{E}{HDP}\ \frac{HDP}{N}\ N$$

M – emise uhlíku
C/E – energetické zdroje
E/HDP – energetická náročnost HDP
HDP/N – HDP na občana
N – světová populace

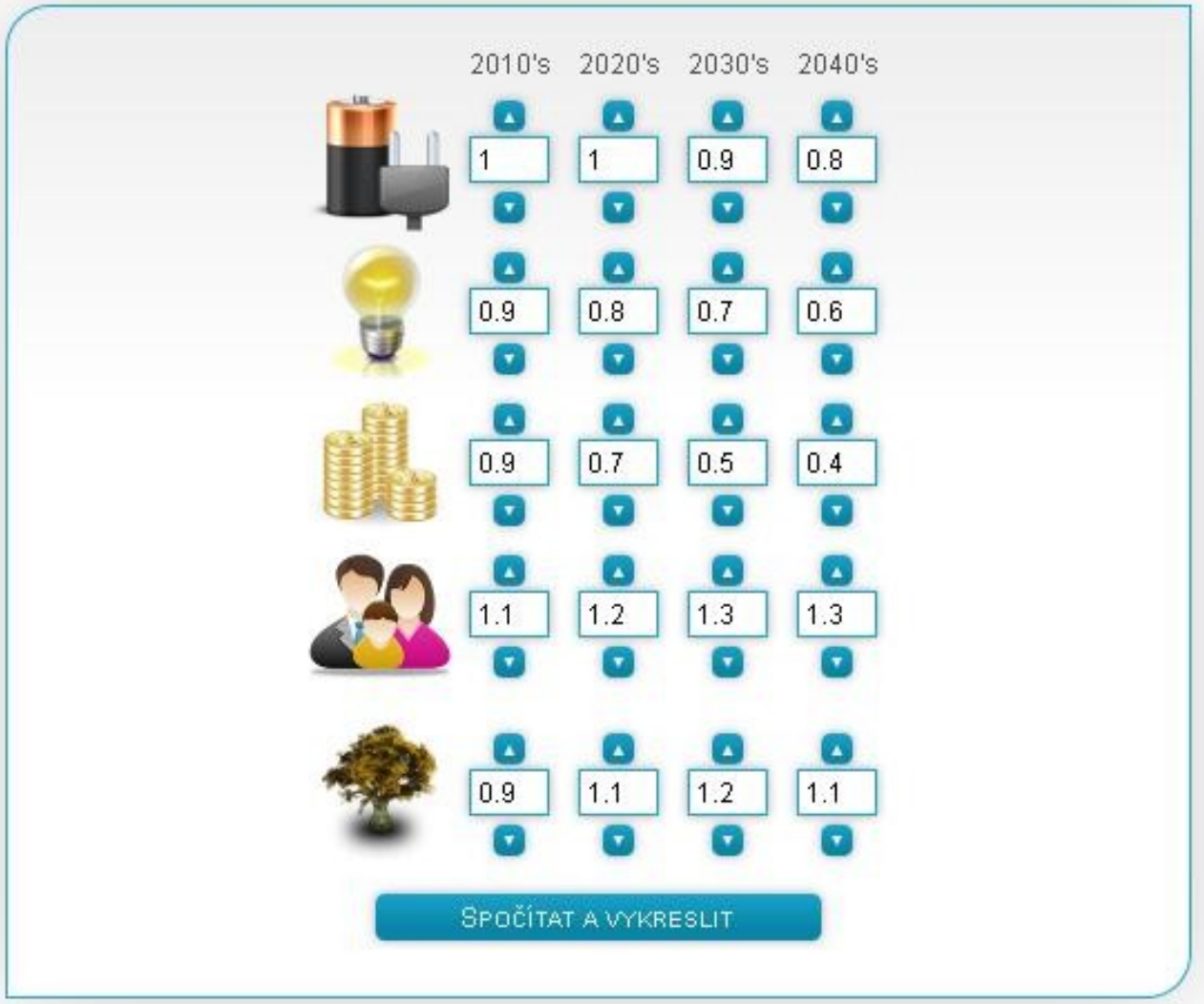
Figure 11. Impacts of four Kaya factors on world carbon dioxide emissions, 1990-2035 (index: 2007 = 1.0)



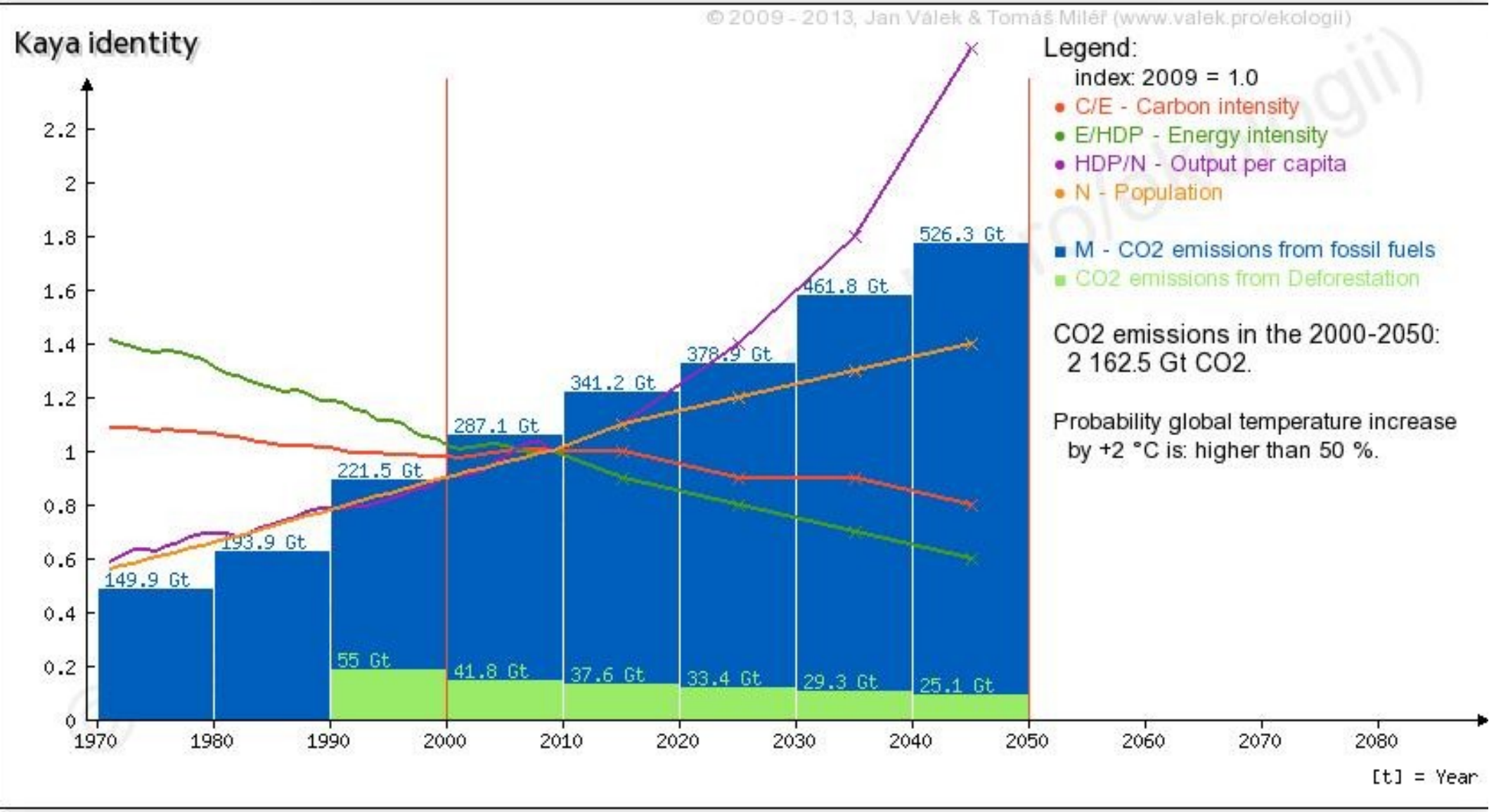
U.S. Energy Information Administration
International Energy Outlook 2010

Kaya identity

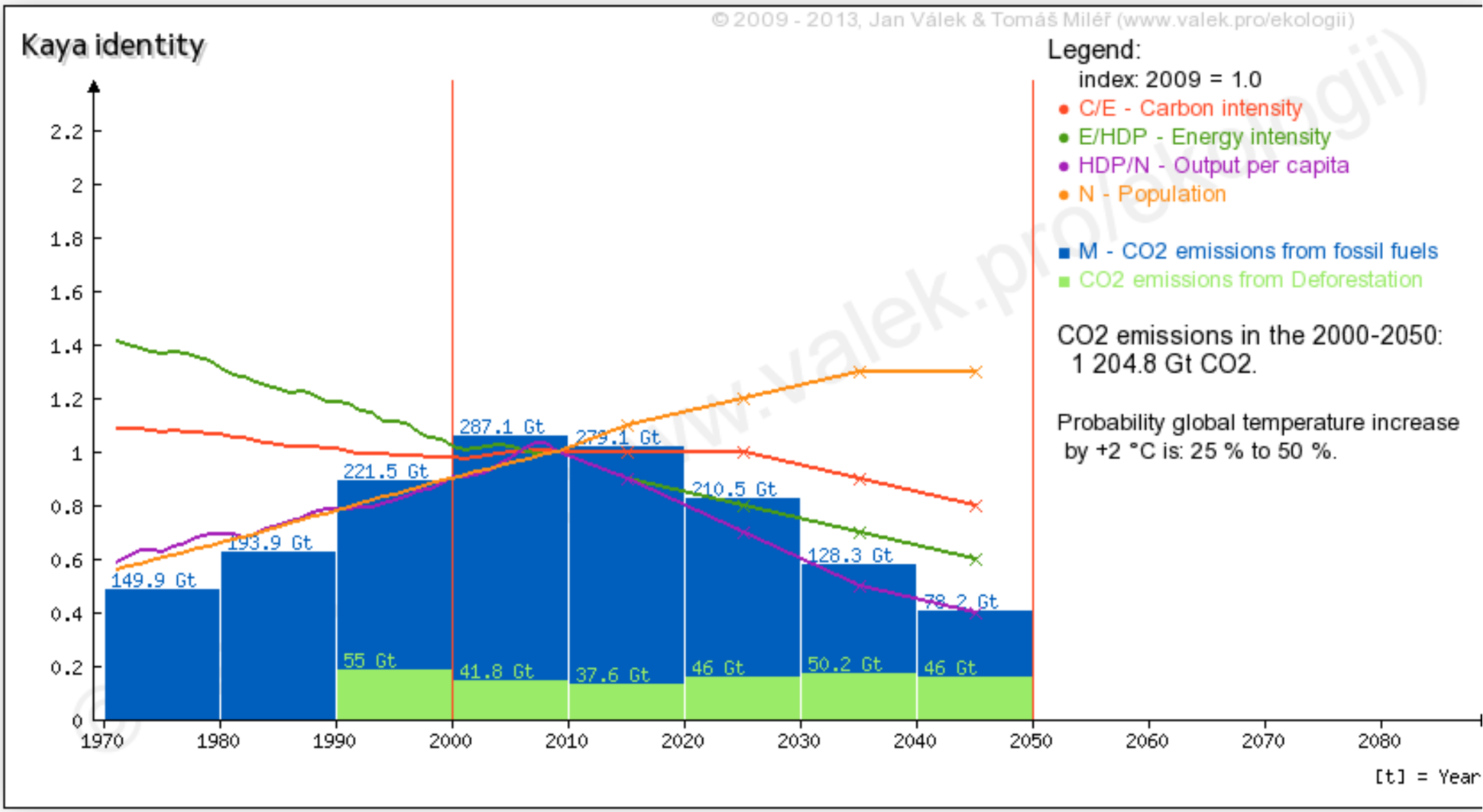
$$M = \frac{C}{E} \cdot \frac{E}{HDP} \cdot \frac{HDP}{N} \cdot N$$



www.valek.pro/ekologii/kaya



www.valek.pro/ekologii/kaya



www.valek.pro/ekologii/kaya

Zátěž životního prostředí (I-PAT) Ehrlichova rovnice

$$I = P \cdot A \cdot T$$

I – Impact
P – Population
A – Affluance
T – Technology

Ehrlich, P. R., Holdren, J. P., 1971, *Impact of population growth*, SCIENCE

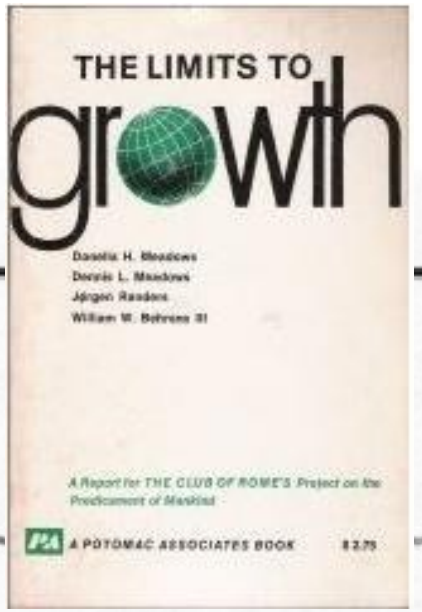
Zátěž životního prostředí (I-PAT)

$$I = \frac{P \cdot A}{S}$$

I – Impact
P – Population
A – Affluance
S – Sustainable Technology

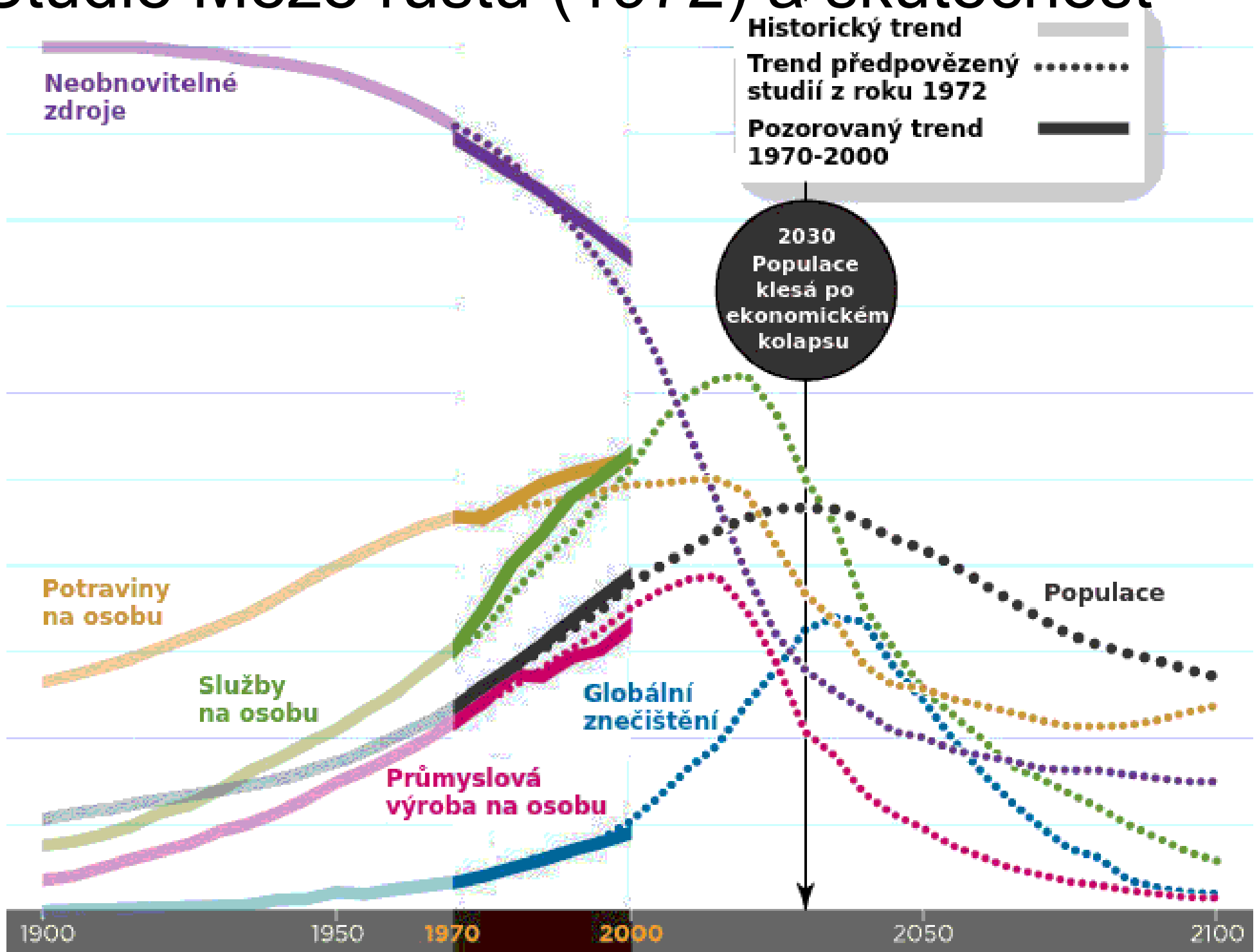
Sachs, J., 2008, *The common wealth*, Penguin Group

Studie Meze růstu, 1972

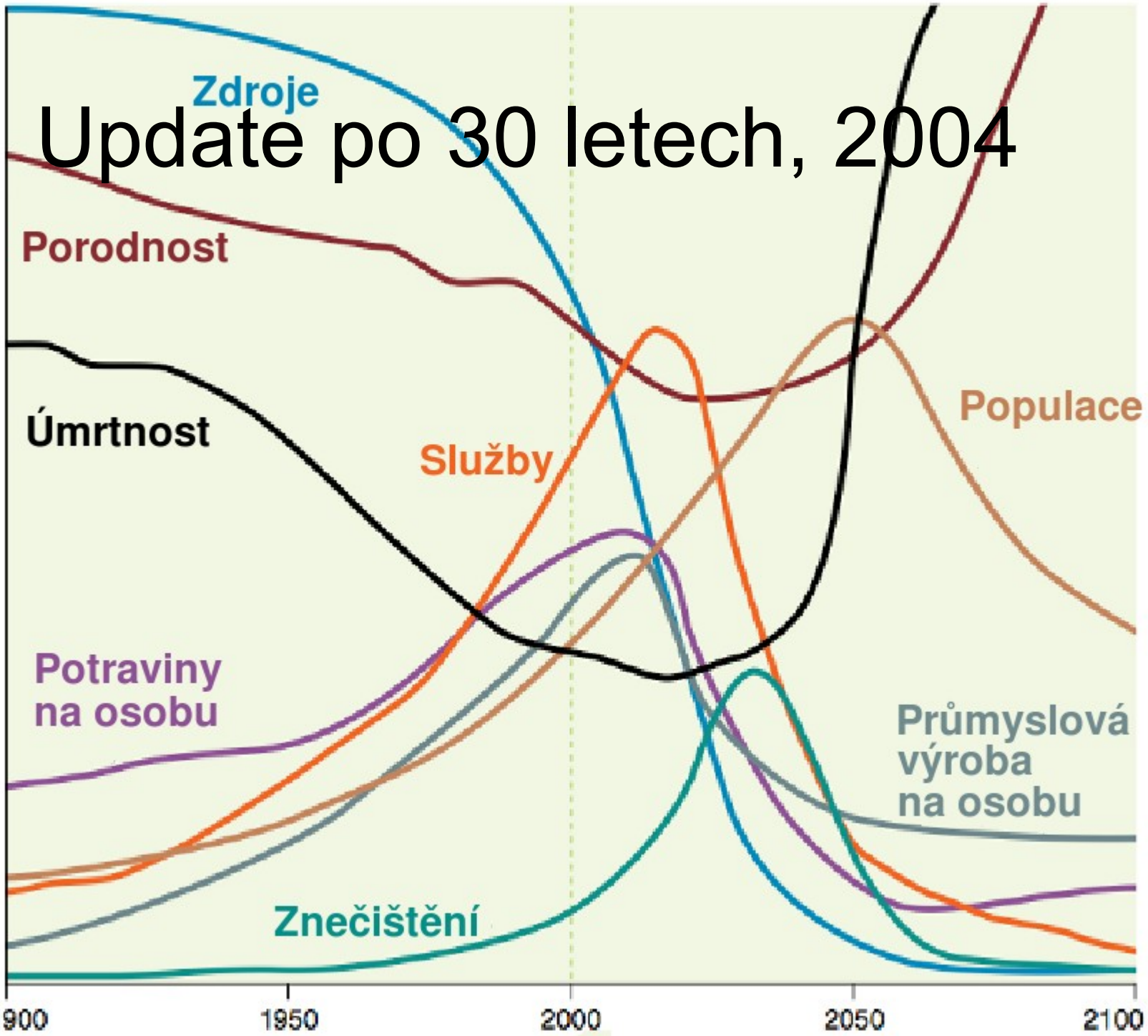


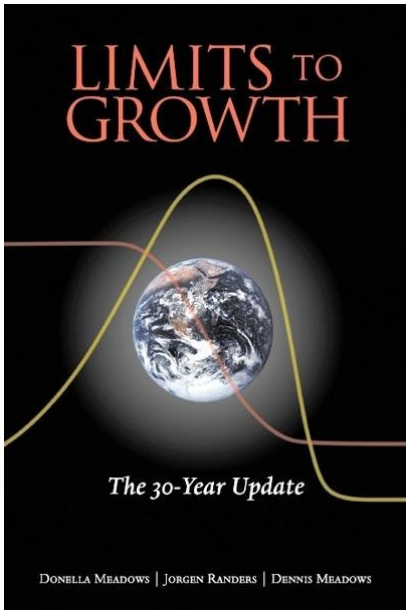
http://cs.wikipedia.org/wiki/Meze_r%C5%AFstu#Meze_r.C5.AFstu_a_World3

Studie Meze růstu (1972) a skutečnost



Update po 30 letech, 2004





http://www.esf.edu/efb/hall/2009-05Hall0327.pdf
http://gaiachange.blogspot.com/2011/09/integrated-global-change-model-part-1.html

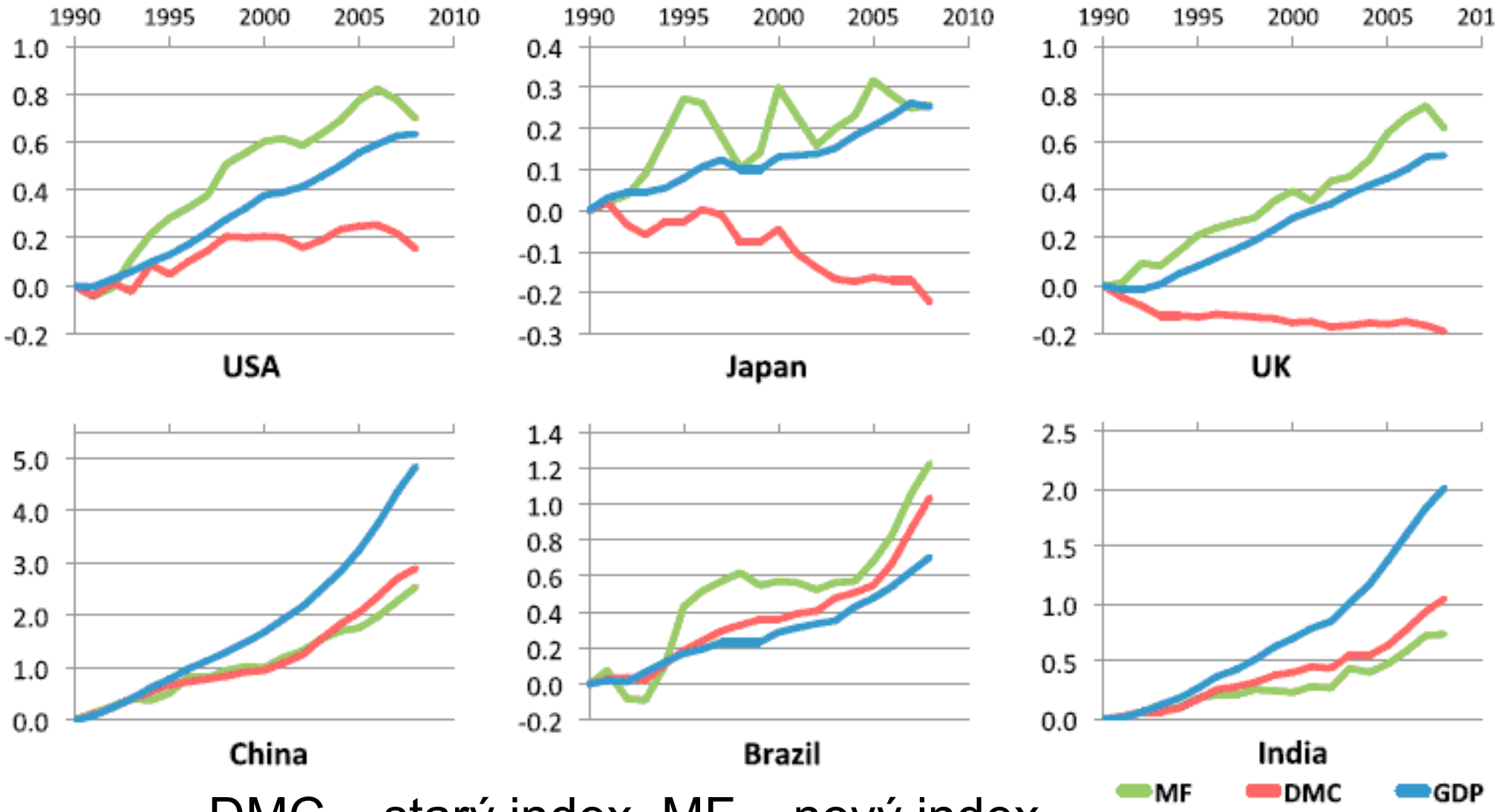
„Nejzávažnější ekologické problémy současnosti mají svého společného jmenovatele. Je jím ekonomický růst praktikovaný v prostředí, jehož zdroje jsou omezené.“

Jan Keller
Až na dno blahobytu, 1995

„Roste ekologická účinnost technologií ve všech odvětvích a oborech, postupně se **rozdvojují křivky ekonomického výkonu a zátěže prostředí.** Až dosud ve většině případů klesá zátěž pouze **relativně**, to zamená, že s ekonomickým růstem stoupá, byť pomaleji než růst samotný. Konečný cíl, **absolutní** pokles zátěže i při rostoucím výkonu, je však obecně přijímán a v některých případech ho již bylo dosaženo.“

Bedřich Moldan
(Ne)udržitelný rozvoj, 2003

Problém je i v metodice výpočtu indexu zátěže životního prostředí

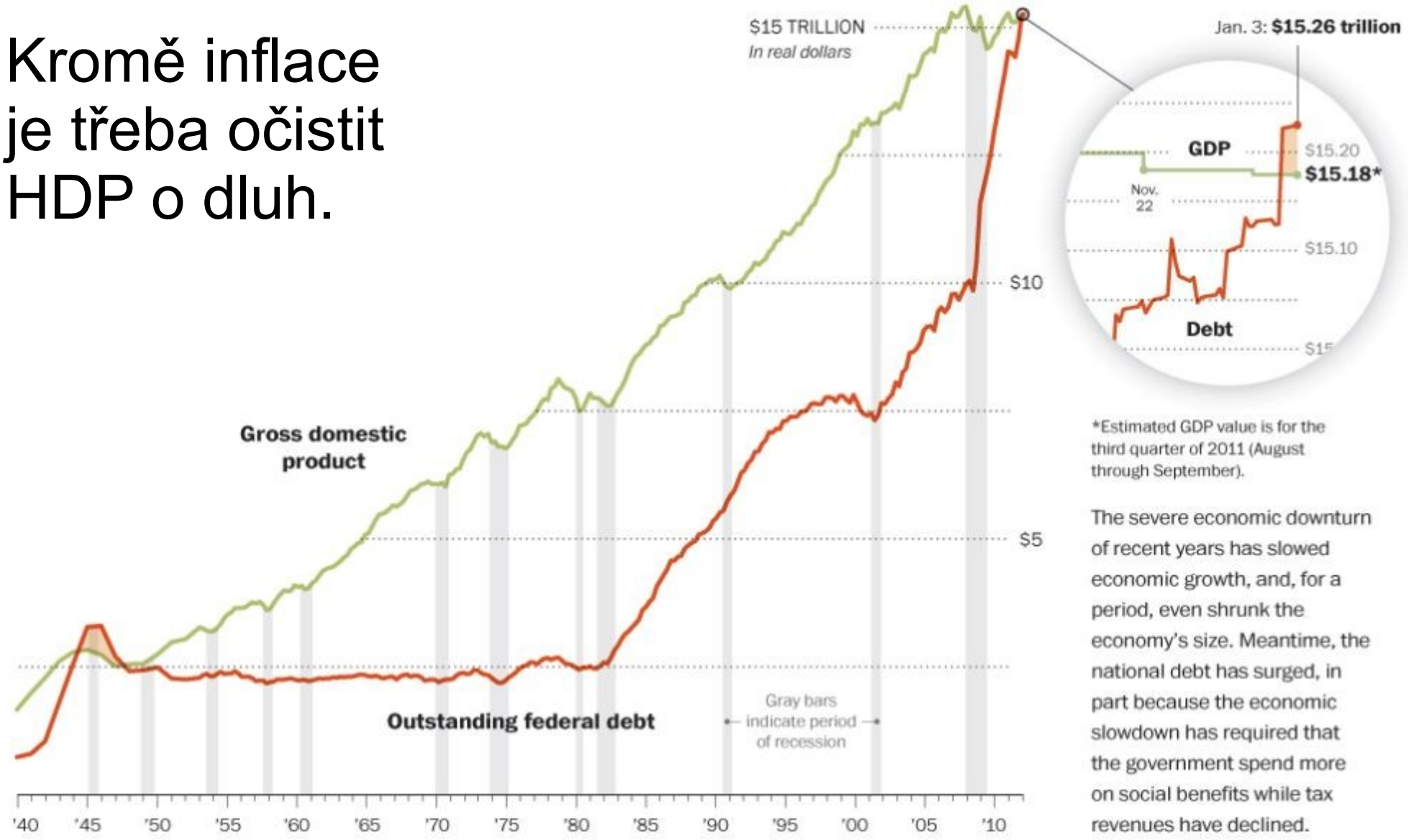


DMC – starý index, MF – nový index

WIEDMANN, T. et. al, 2013. *The material footprint of nations*. PNAS

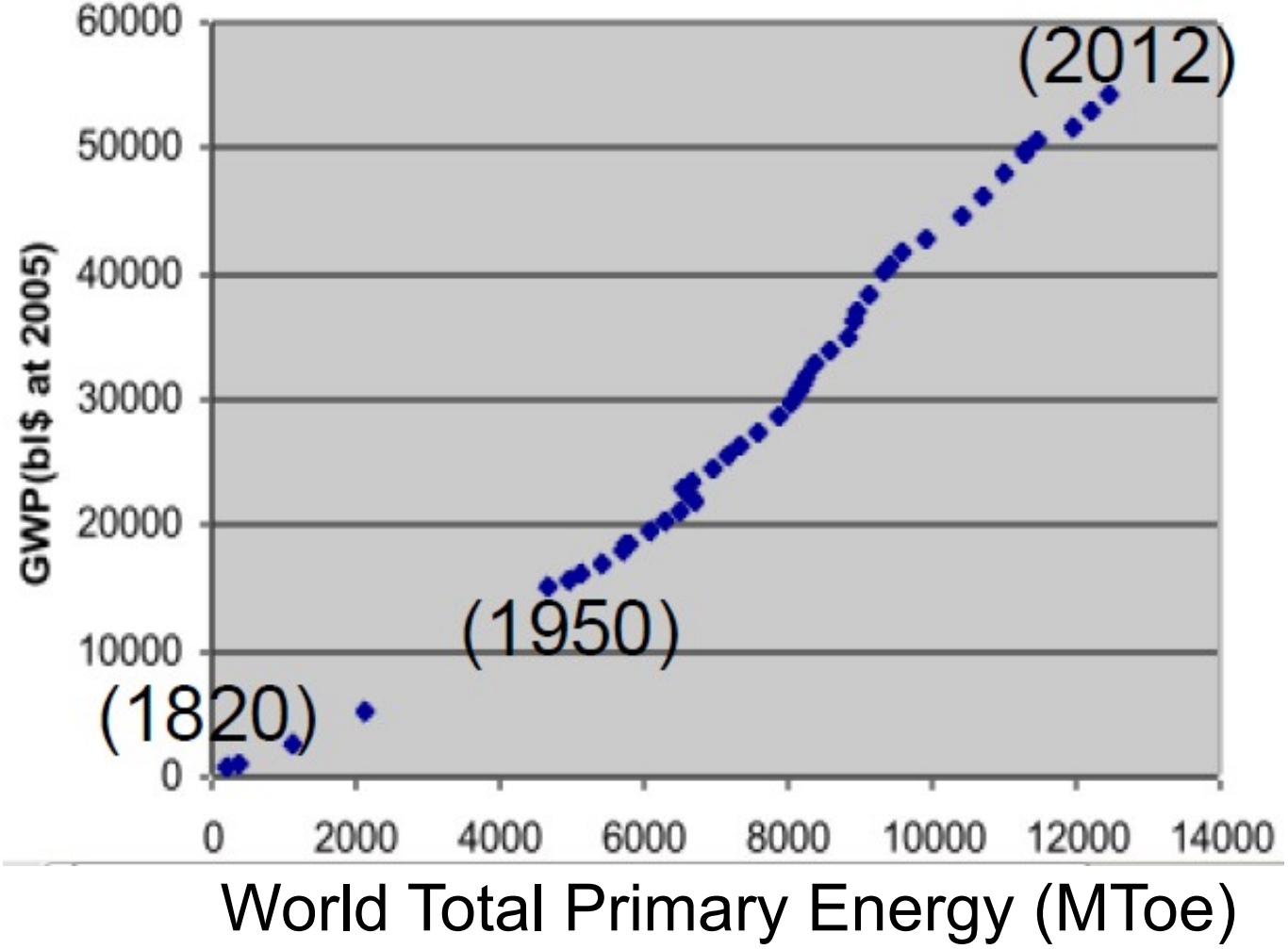
Problém je v metodice výpočtu HDP

Kromě inflace je třeba očistit HDP o dluh.



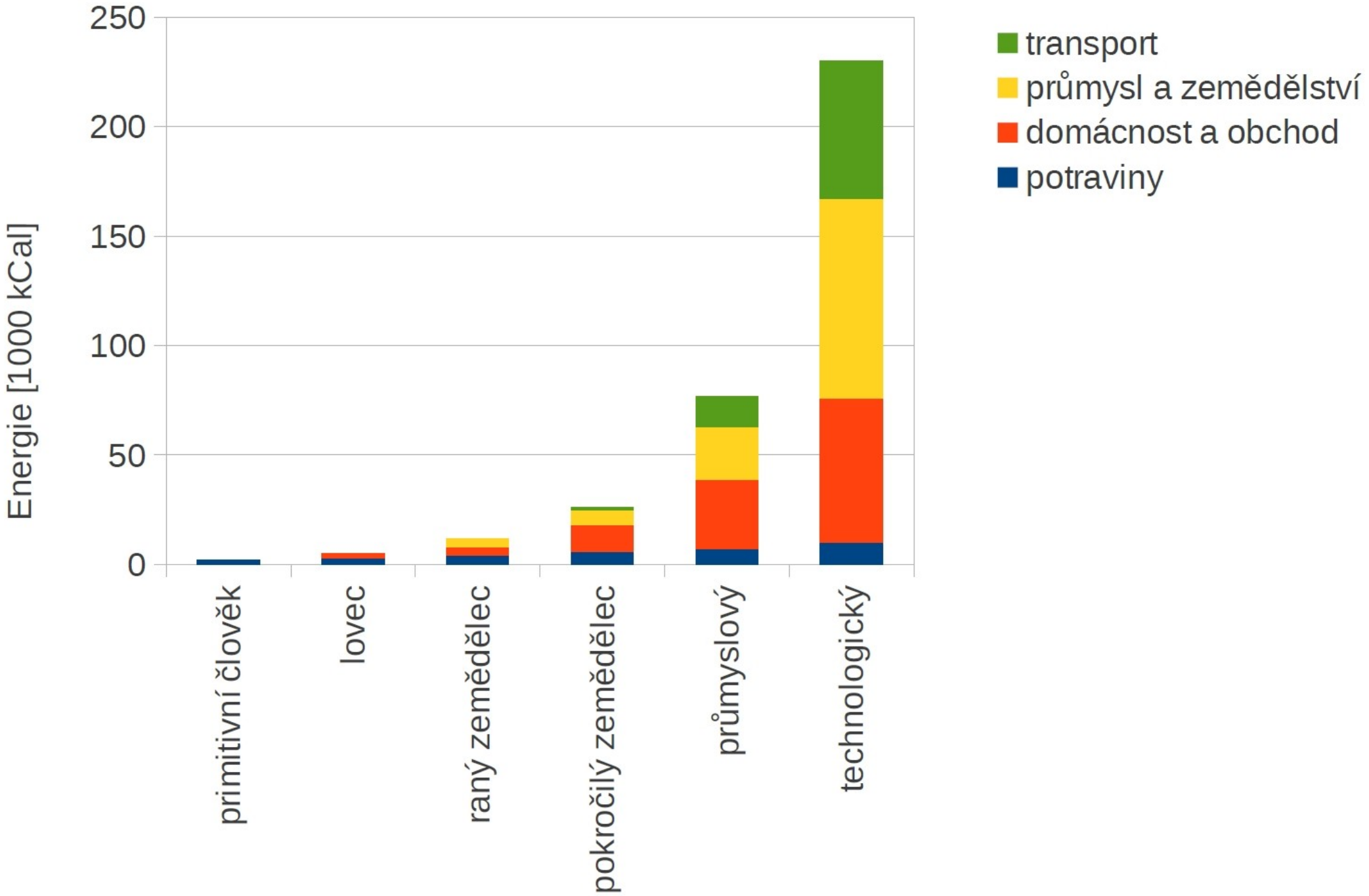
http://www.intellectualtakeout.org/library/chart-graph/2012-debt-gdp

K ekonomickému růstu je třeba energie...



Energie

Spotřeba energie na osobu a den



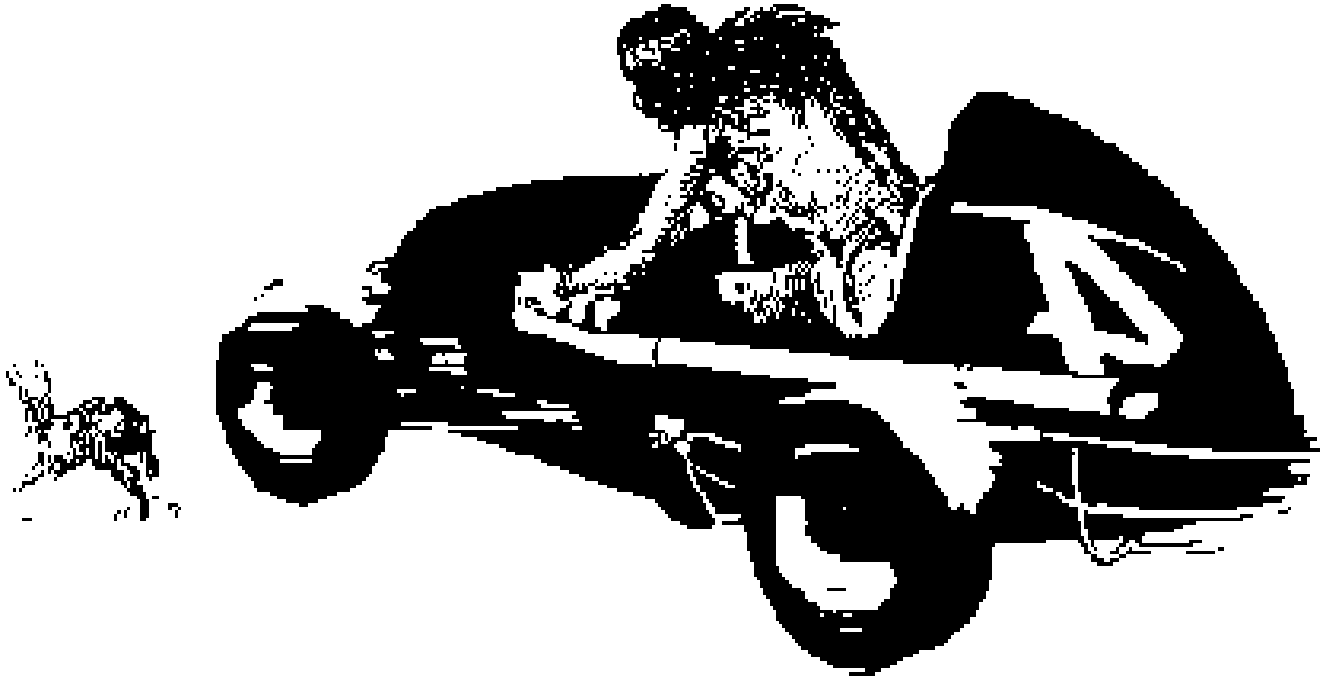
Low Hanging Fruit

Energetická návratnost

Energetická návratnost

http://www.holon.se/folke/kurs/logexp/rabbit.shtml

Energetická návratnost



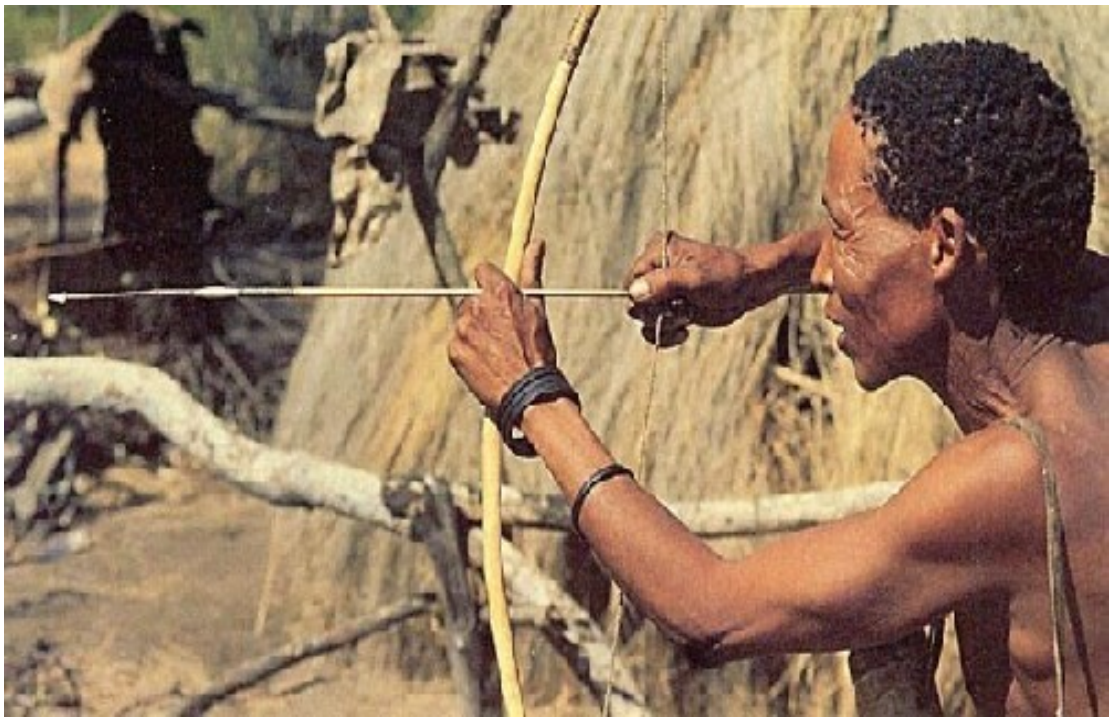
http://www.holon.se/folke/kurs/logexp/rabbit.shtml

Energetická návratnost

Harvesting with Horses, 1916. In the early part of the 20th century, horse power was provided by real horses to pull machinery. This grain harvesting crew was working in eastern Oregon.
http://archives.library.oregonstate.edu/files/archives/rg/rg158inv8_14.html

Energetická návratnost

Rozvinuté země 1:10



Pro Křováky asi 10:1

HALL, Ch., et al. 2009. *What is the Minimum EROI that a Sustainable Society Must Have?* Energies

Energetická návratnost

Energy Returned on Energy Invested

EROI = energie získaná / energie vložená

$$EROI = \frac{E_{GROSS}}{E_{INV}}$$

Energetická návratnost

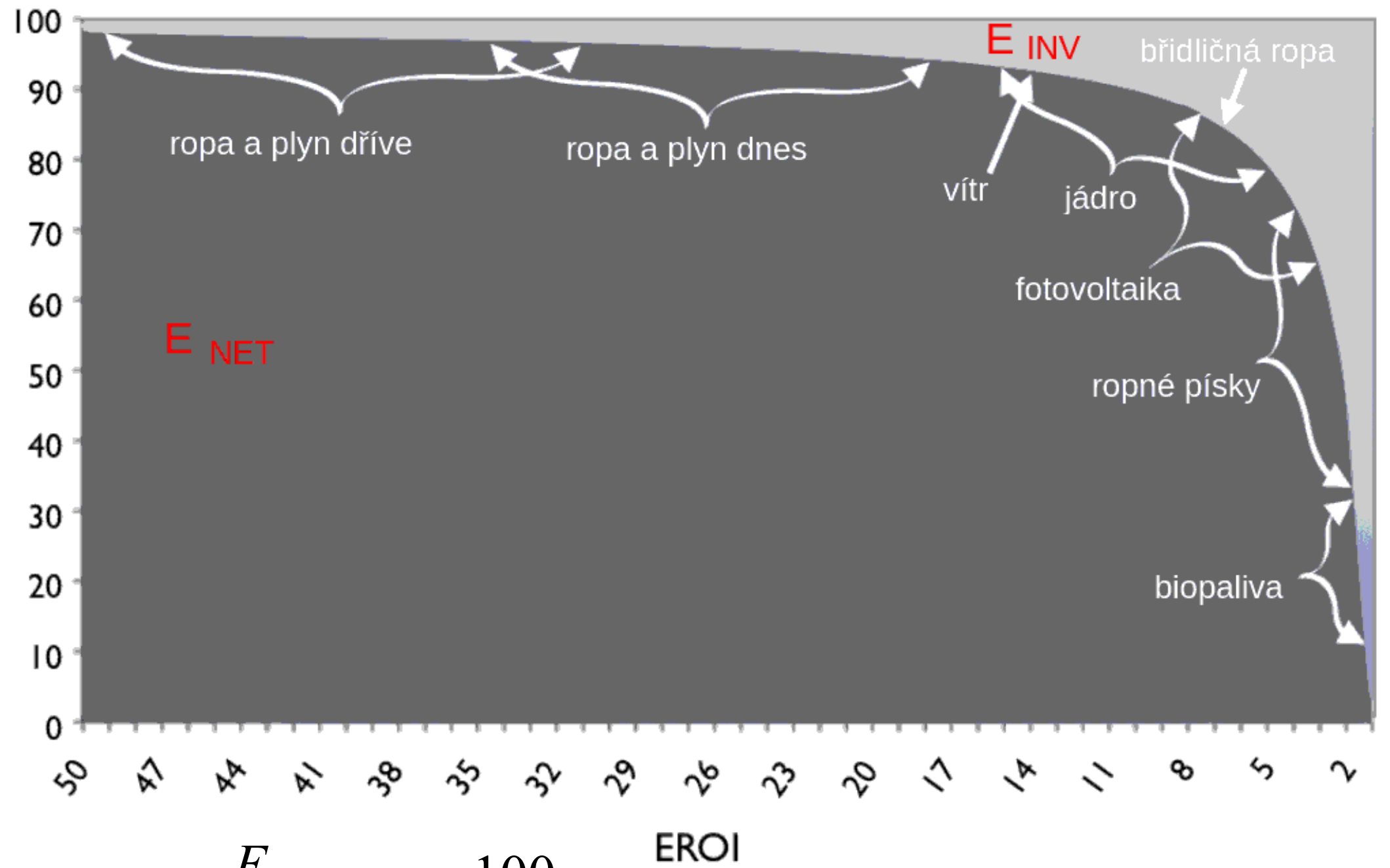
Energy Returned on Energy Invested

EROI = energie získaná / energie vložená

$$EROI = \frac{E_{GROSS}}{E_{INV}}$$

Skutečnou hodnotu pro společnost má *čistá energie* E_{NET}, která zbude po odečtení energetických výdajů na získání energie a její koncentrování.

$$E_{NET} = E_{GROSS} - E_{INV} \qquad E_{NET} = E_{GROSS}\left(1 - \frac{1}{EROI}\right)$$

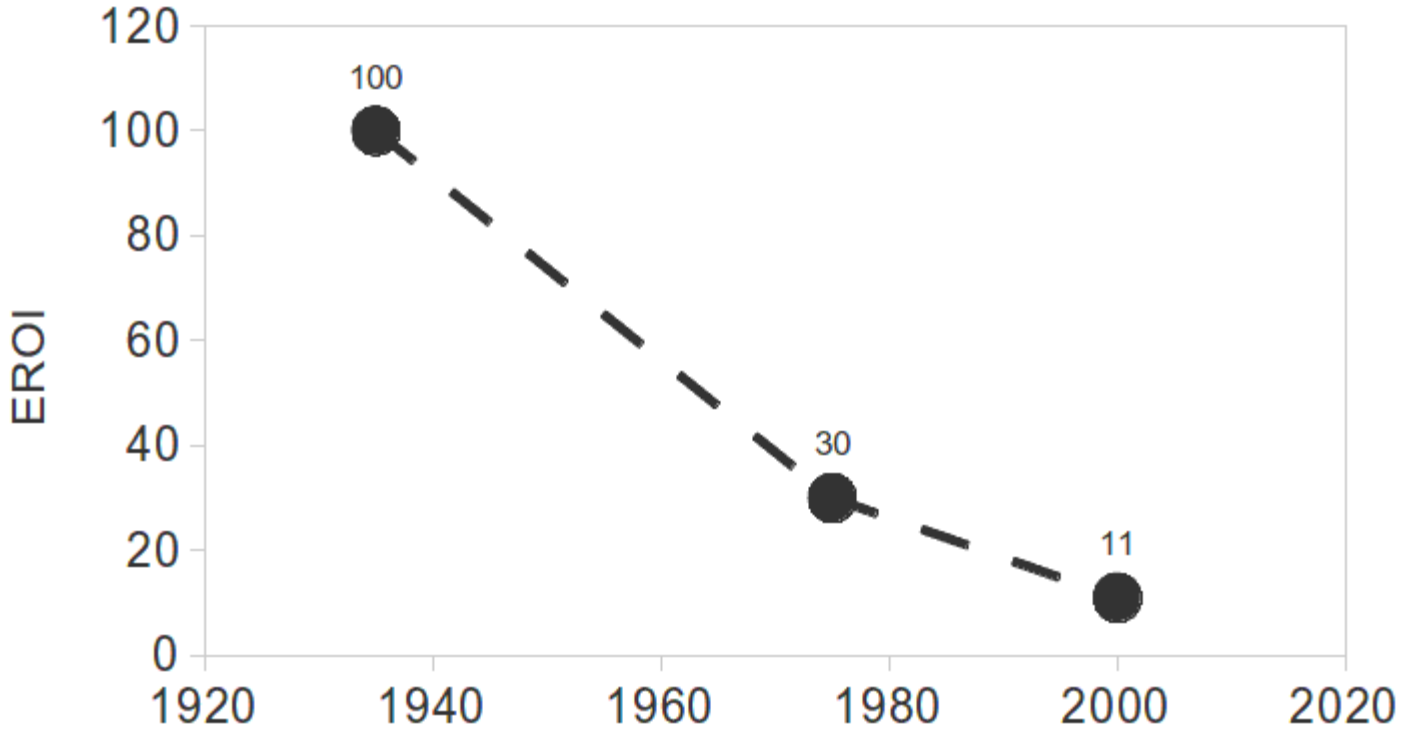


$$EROI = \frac{E_{GROSS}}{E_{INV}} = \frac{100}{E_{INV}}$$

Pro $EROI \leq 1$ je $E_{NET} \leq 0$.

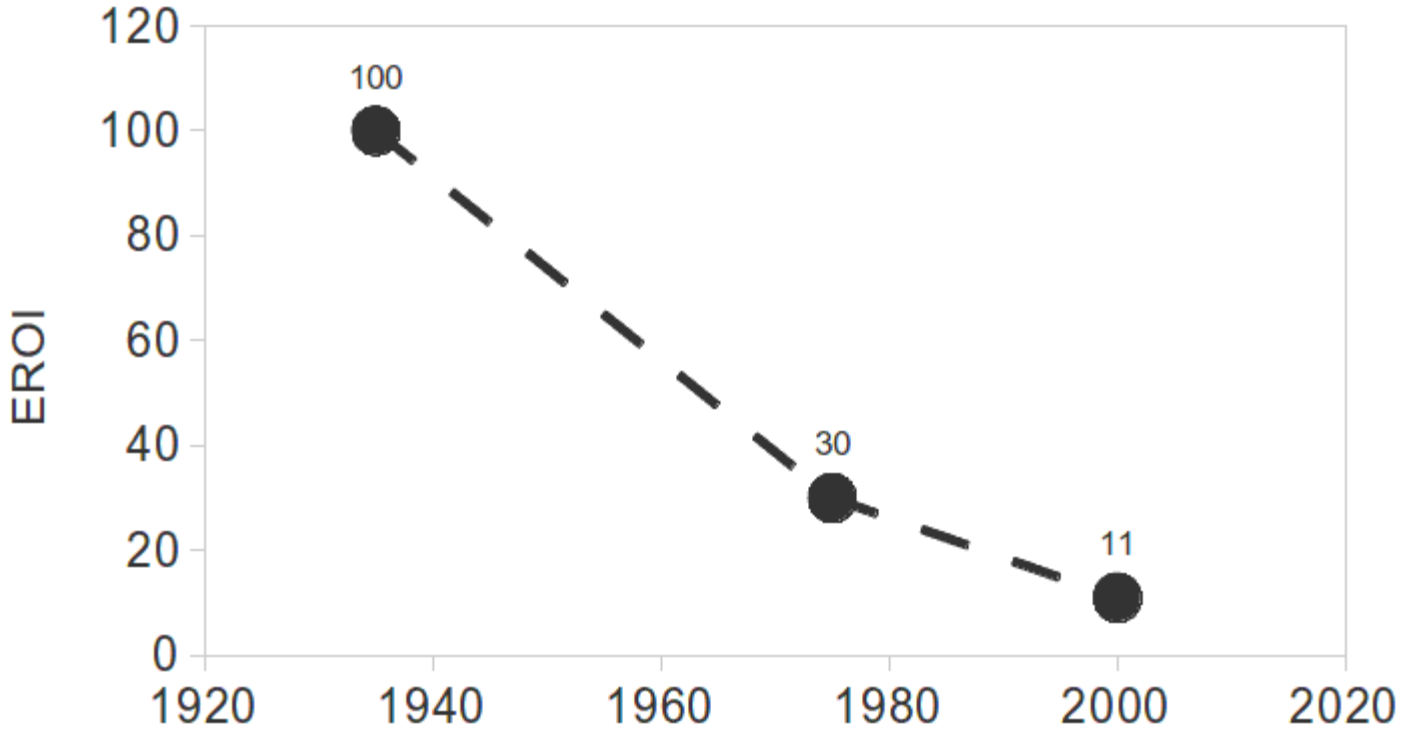
http://www.roboticscaucus.org/ENERGYPOLICYCMTEMTGS/Nov2012AGENDA/documents/DFID_Report1_2012_11_04-2.pdf

Pokles energetické návratnosti těžby ropy v USA



CLEVELAND, C. 2005. *Net energy from the extraction of oil and gas in the United States*. Energy
GAGNON, N. et al. 2009. *A Preliminary Investigation of Energy Return on Energy Investment for Global Oil and Gas Production*. Energies

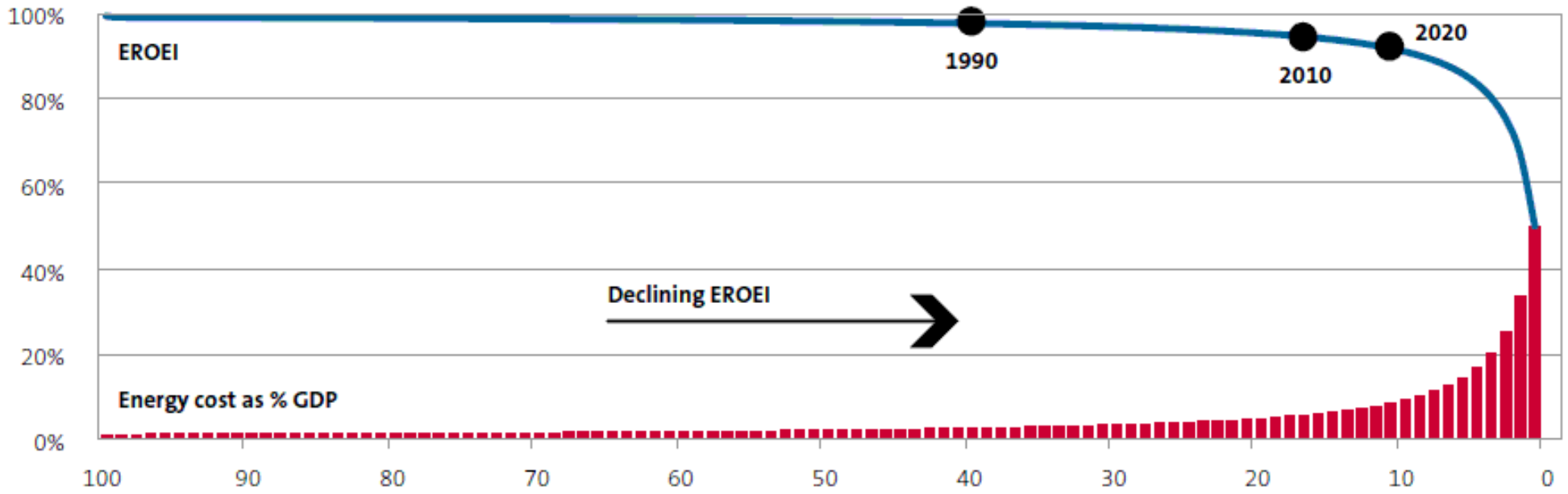
Pokles energetické návratnosti těžby ropy v USA



Průměrná hodnota EROI pro celý svět klesla asi na 18:1 v roce 2006!

CLEVELAND, C. 2005. *Net energy from the extraction of oil and gas in the United States*. Energy
GAGNON, N. et al. 2009. *A Preliminary Investigation of Energy Return on Energy Investment for Global Oil and Gas Production*. Energies

Fig. 1.5: Nearing the energy returns cliff-edge*



* Source: Tullett Prebon analysis

http://ftalphaville.ft.com/files/2013/01/Perfect-Storm-LR.pdf

Fig. 5.14: High EROEI

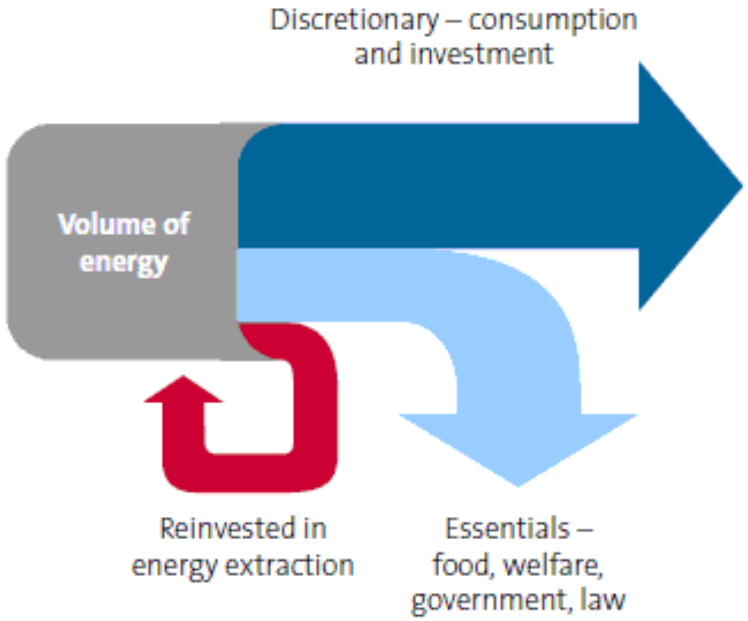
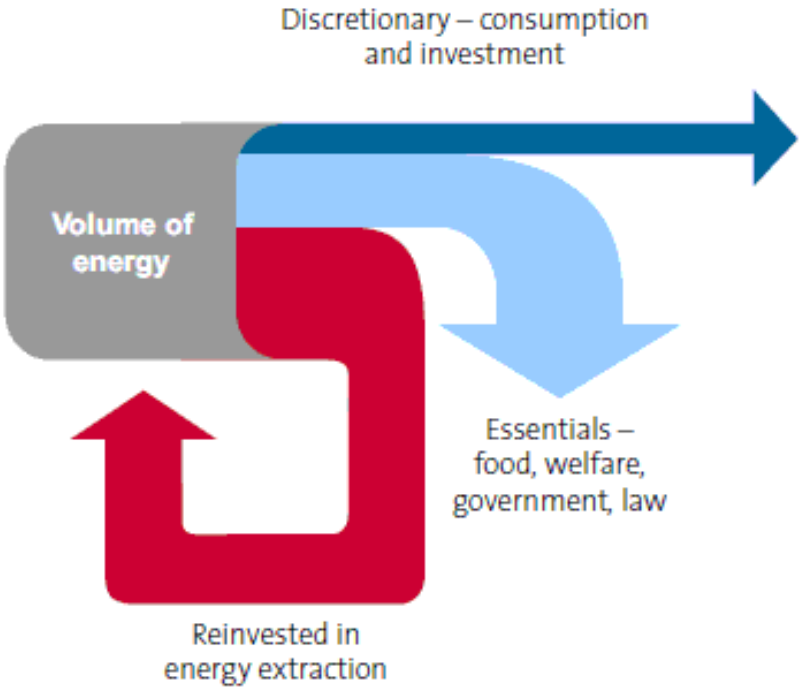


Fig. 5.15: Low EROEI



* Source: Tullett Prebon estimates, see text

http://ftalphaville.ft.com/files/2013/01/Perfect-Storm-LR.pdf

Maslowova hierarchie potřeb

Minimální energetická návratnost

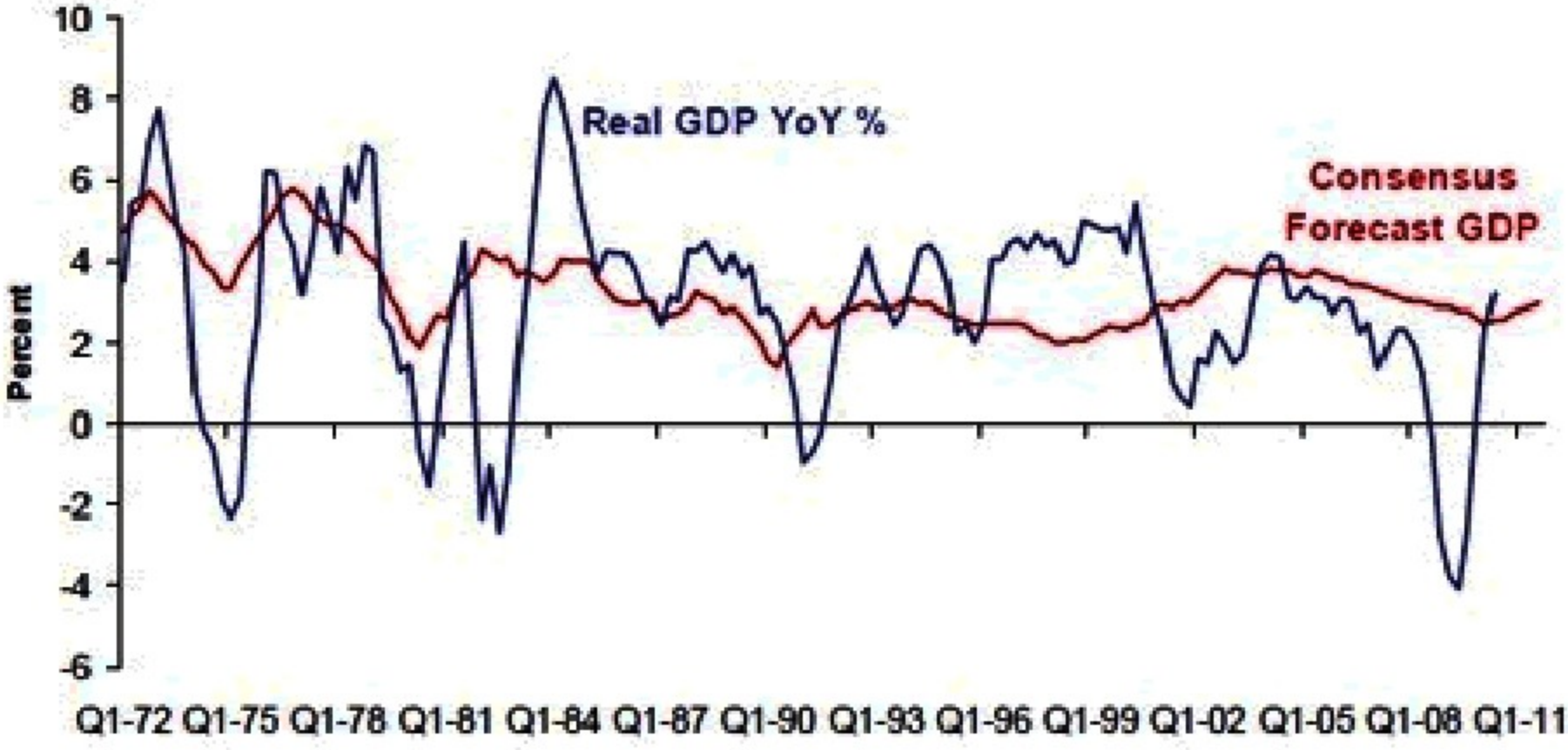
Funkce společnosti	Minimální EROI
Umění aj.	14:1
Zdravotnictví	12:1
Vzdělávání	9:1 až 10:1
Podpora rodiny a pracujících	7:1 až 8:1
Produkce potravin	5:1
Transport	3:1
Rafinace ropy	1,2:1
Těžba ropy	1,1

LAMBERT, J. G., et al. 2014. *Energy, EROI and quality of life.* Energy Policy
HALL, Ch. 2011. *Introduction to Special Issue on New Studies in EROI*. Sustainability
HALL, Ch., et al. 2009. *What is the Minimum EROI that a Sustainable Society Must Have?* Energies

Ropa a ekonomika

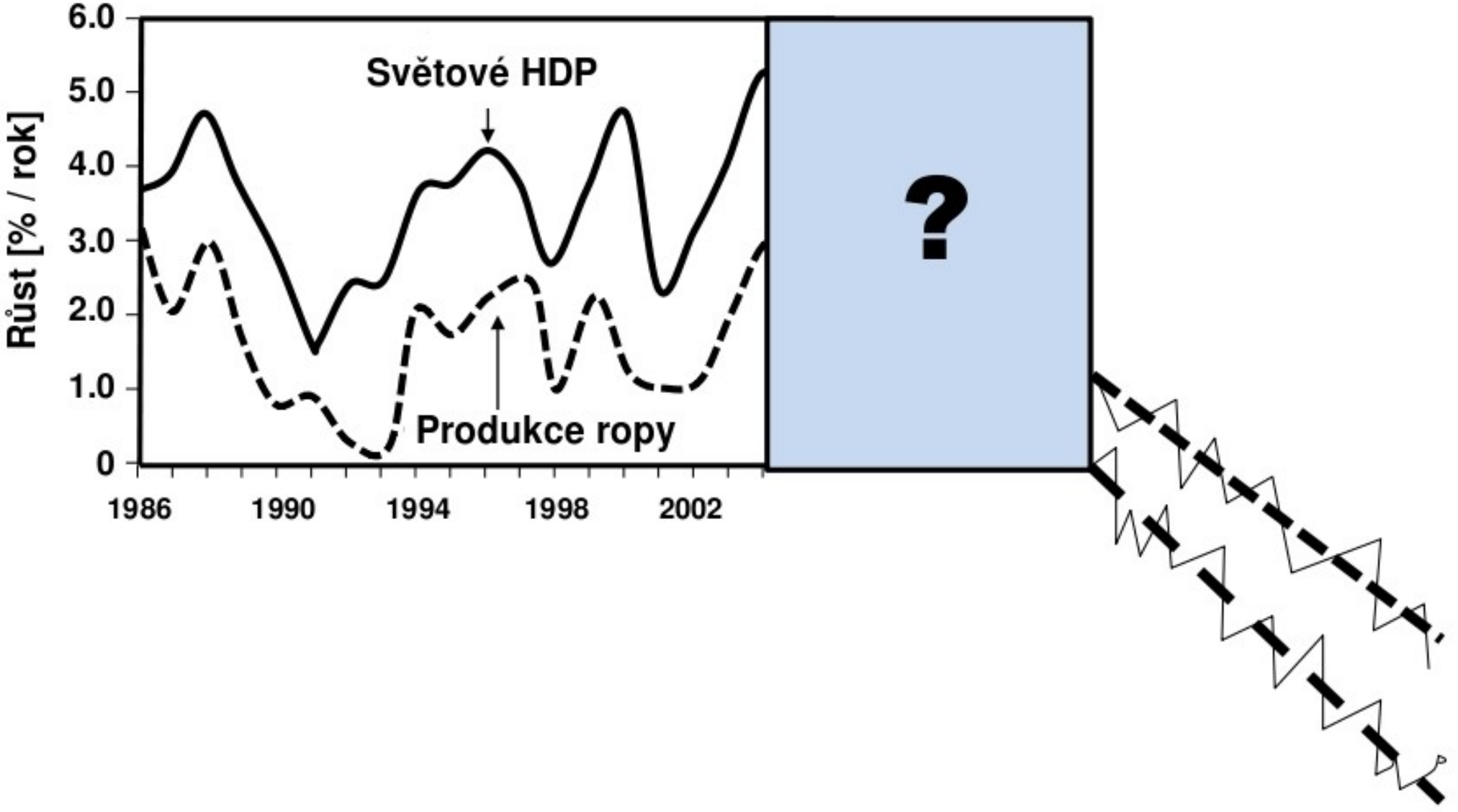
Můžeme věřit ekonomům?

Srovnání předpovědí ekonomů s realitou
Růst světového HDP (%) 1972–2011



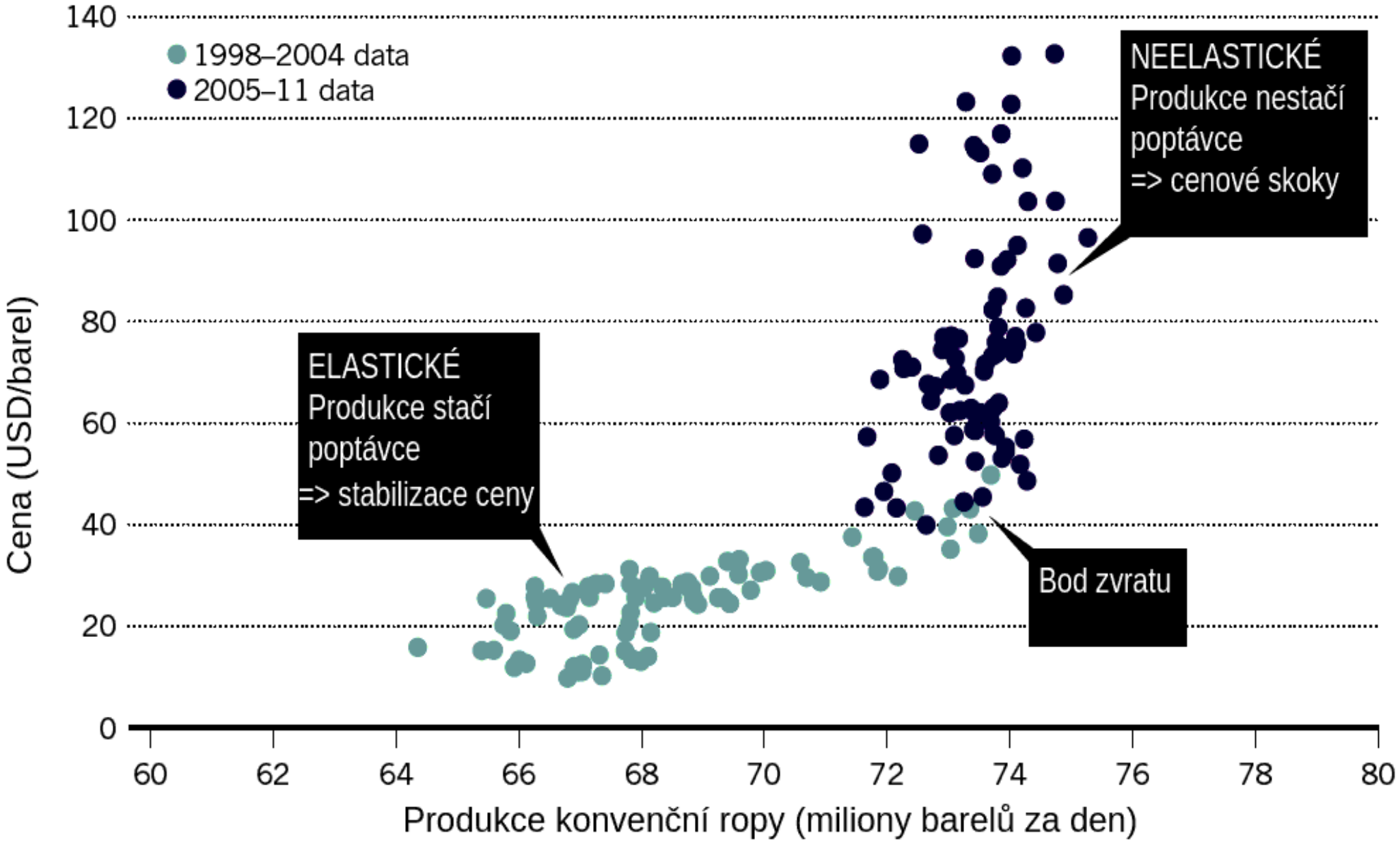
Source: Federal Reserve Bank of Philadelphia *Actual data through Jun 2010; projection through Sep 2011*

Korelace růstu světového HDP a produkce ropy



FÁZOVÁ ZMĚNA

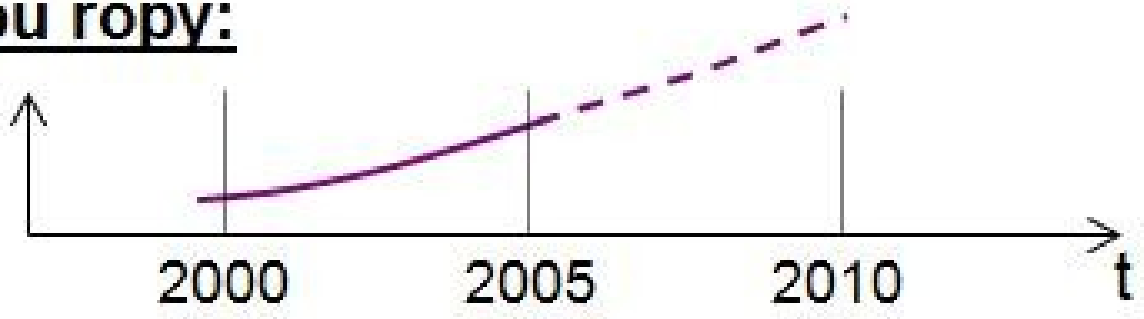
Náhlá změna v ekonomice ropy je patrná v grafu produkce vs. ceny



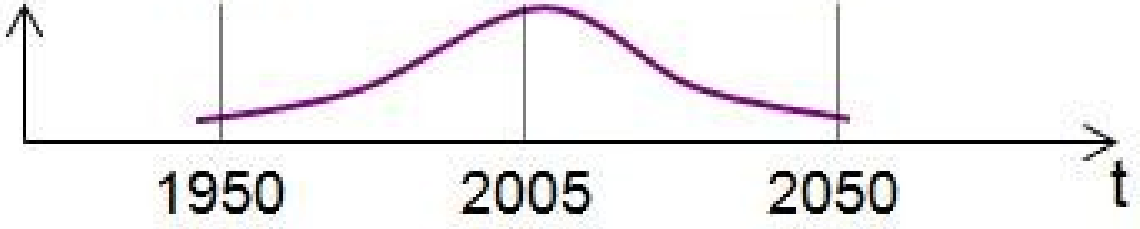
Murray, J., King, D. 2012, *Oil's tipping point has passed*, NATURE

Úhel pohledu na těžbu ropy:

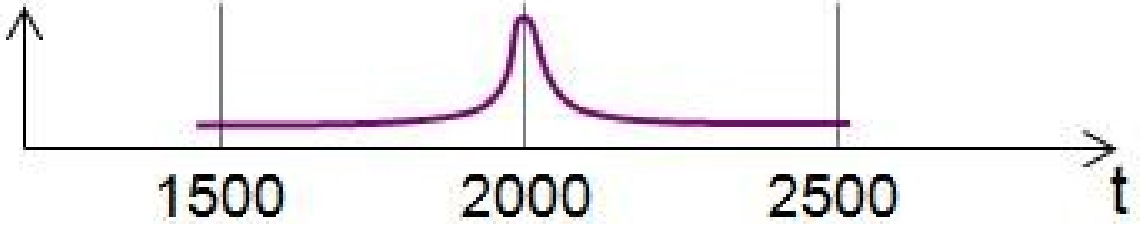
A) očima ekonoma



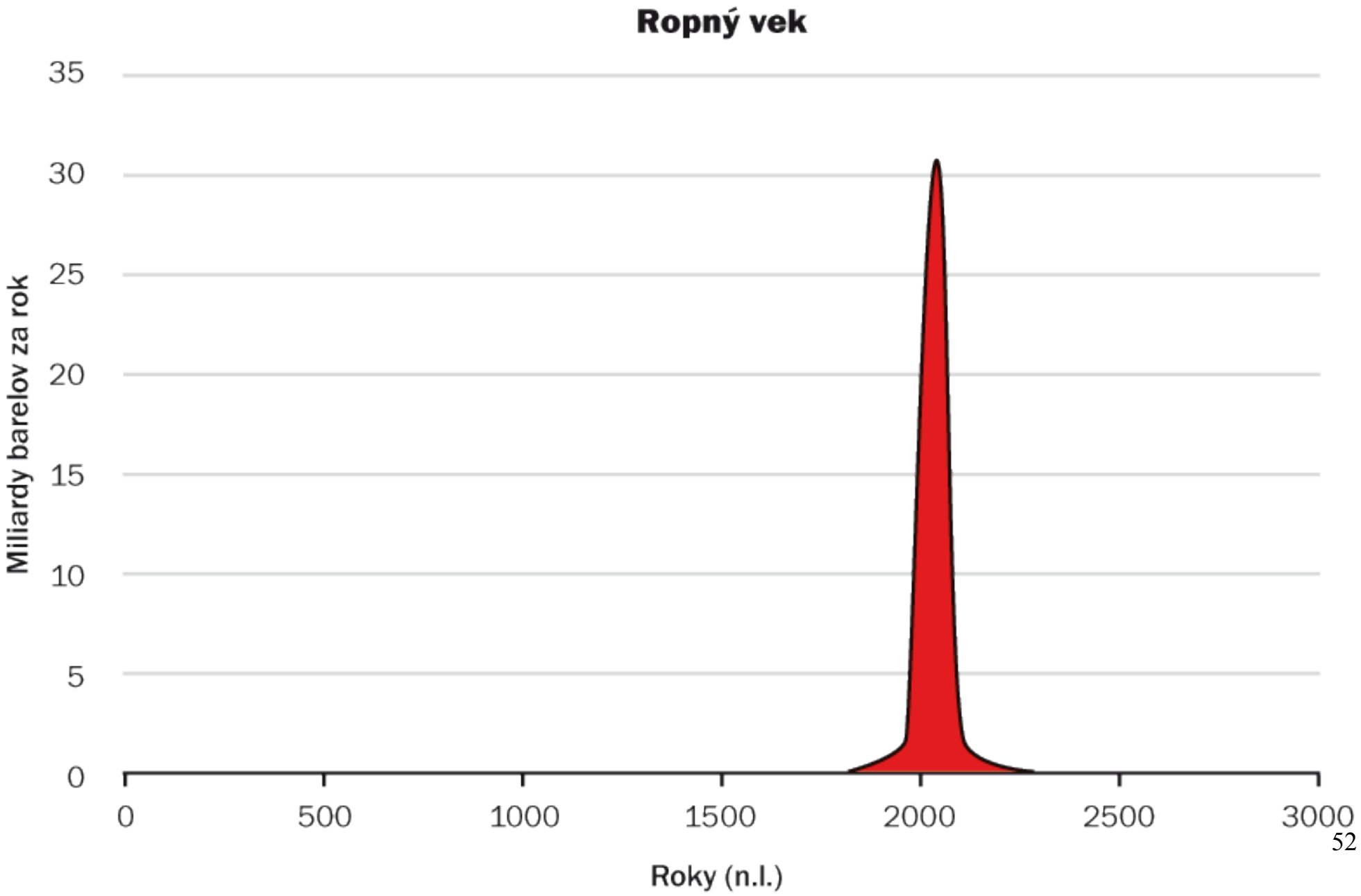
B) očima geologa
(Hubert, 1955)



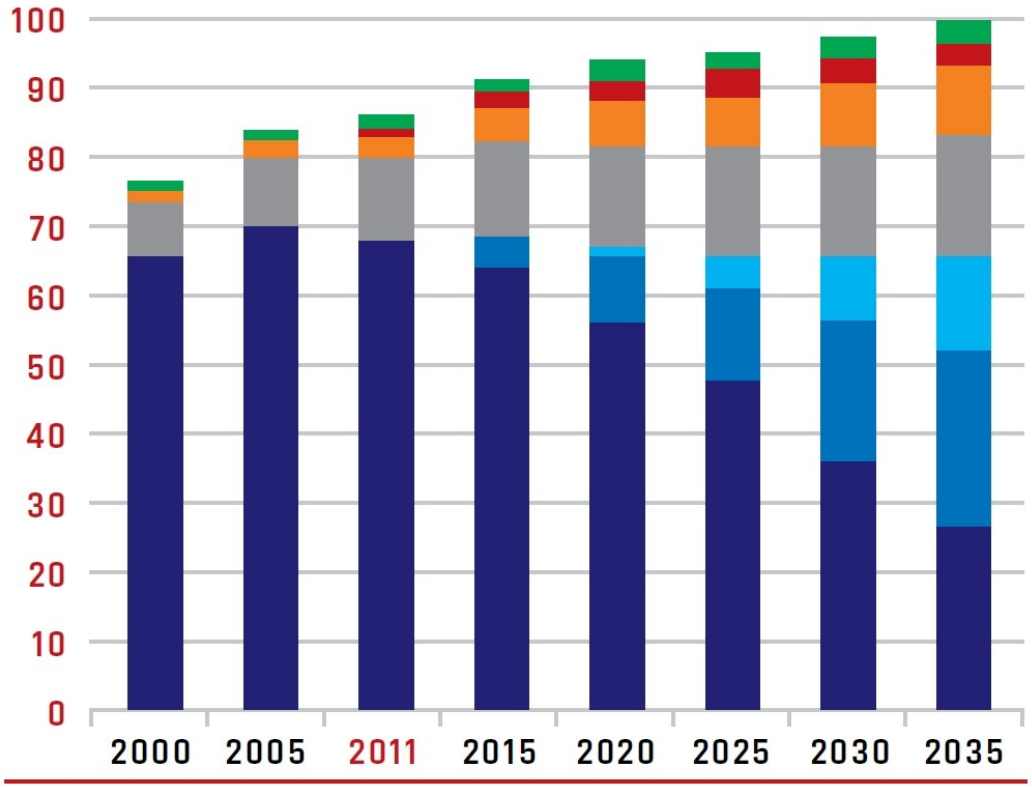
C) očima historika



Éra ropy z historické perspektivy



Scénář produkce ropy podle IEA
(WEO 2012)



PRODUKCE A CENA ROPY – VÝHLED

milliony barelů za den

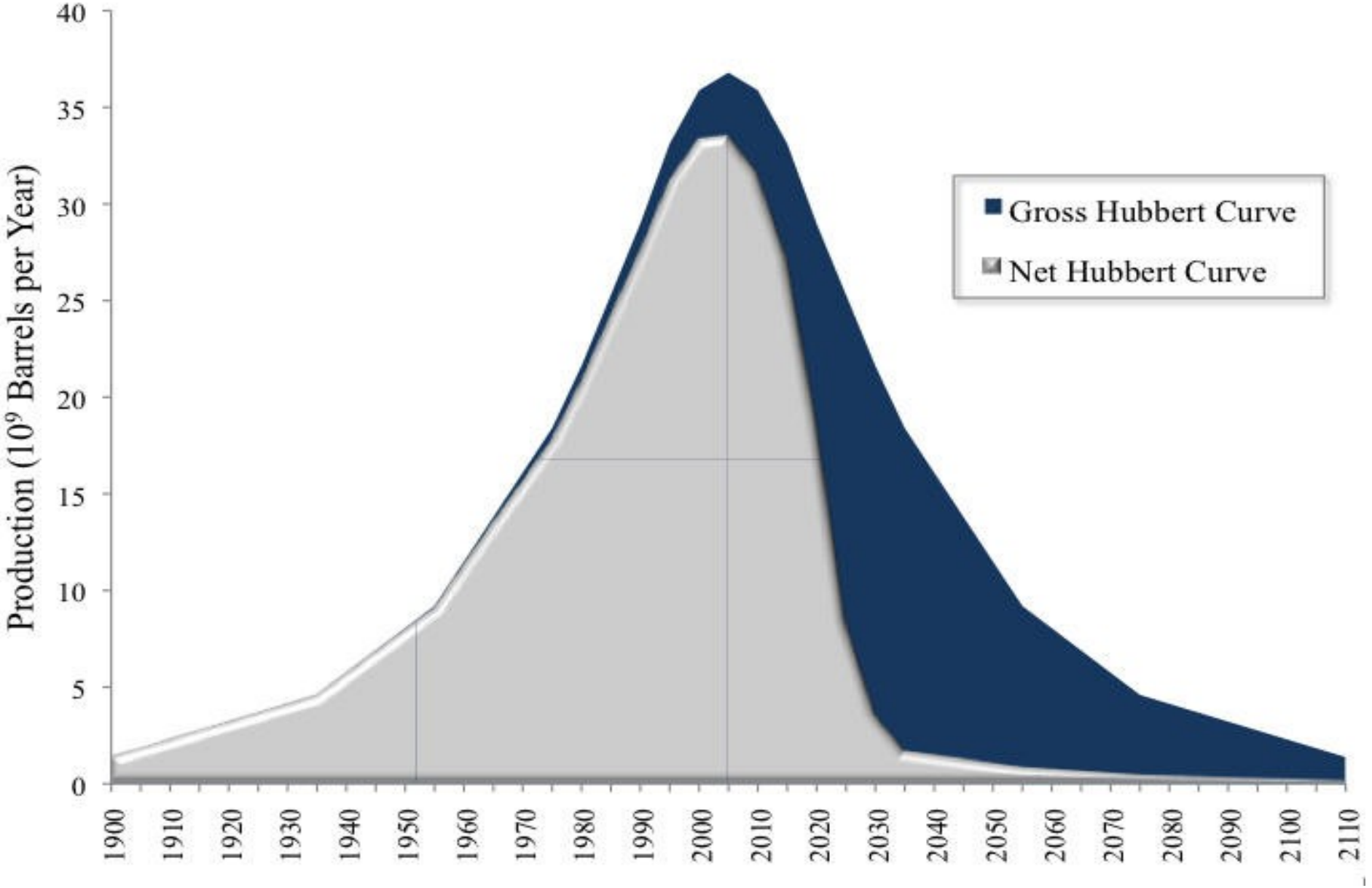
- nárůst objemu při zpracování surové ropy
- lehká ropa z nízkopropustných vrstev
- další druhy nekonvenční ropy
- kondenzáty zemního plynu a dalších uhlovodíků

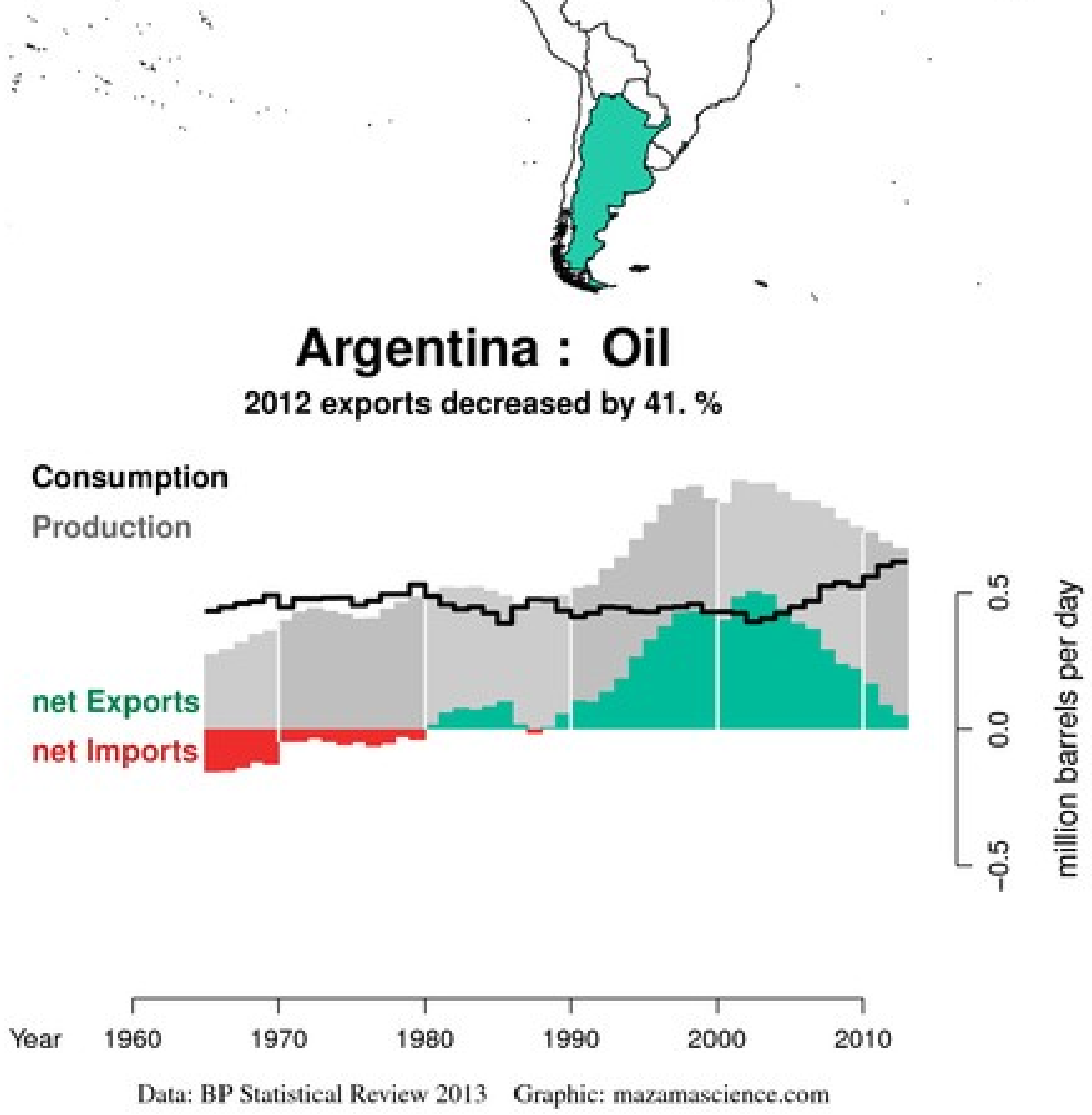
Klasická ropa:

- dosud neobjevená ložiska
- objevená ložiska, na kterých dosud nebyla zahájena těžba
- ložiska využívaná v současnosti

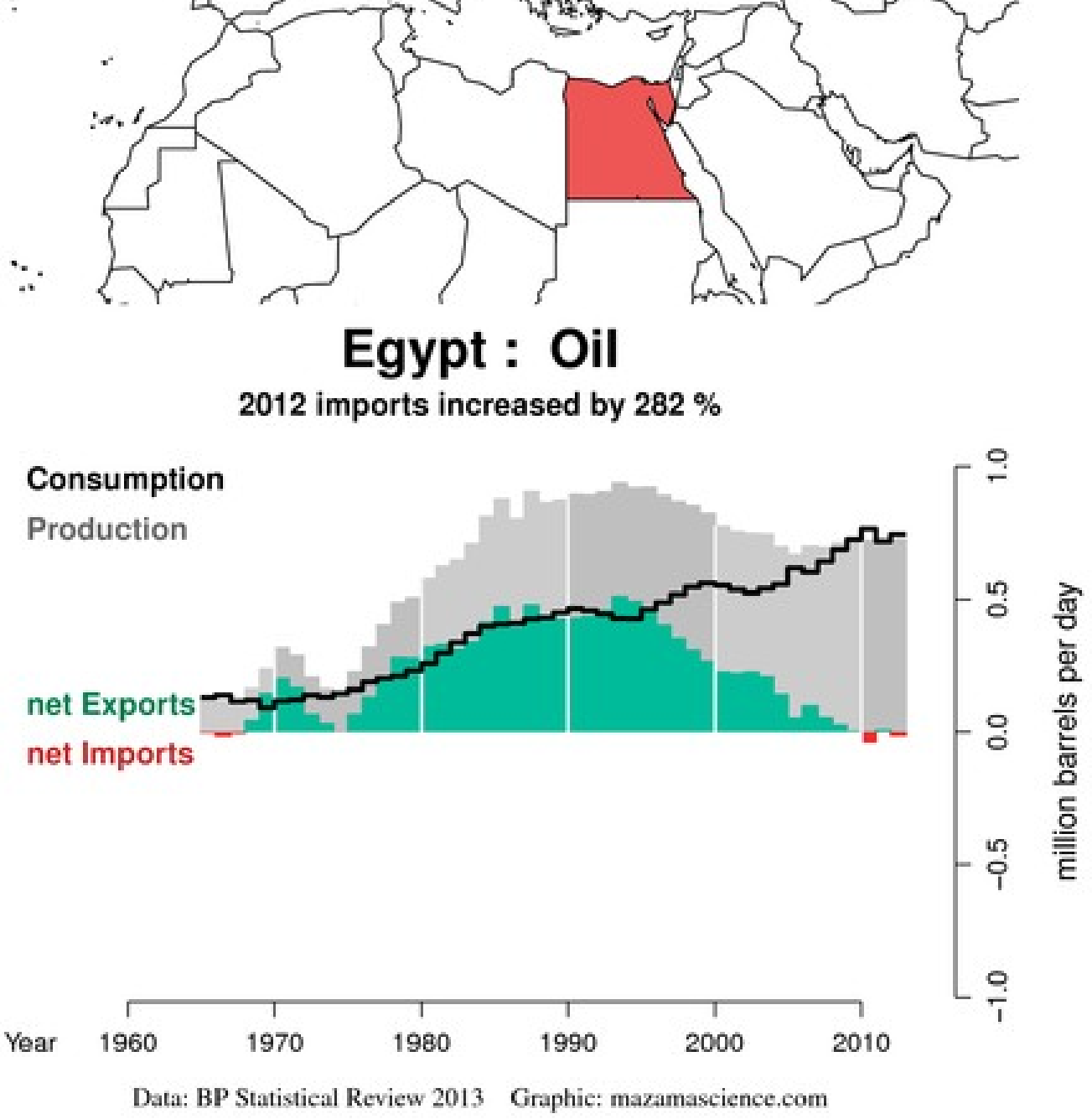
ZDROJ: IEA

Kerr, Richard A., 2012, *An Oil Gusher in the Offing, but Will It Be, Enough?*, SCIENCE


Production (10^9 Barrels per Year)
40
35
30
25
20
15
10
5
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
Gross Hubbert Curve
Net Hubbert Curve



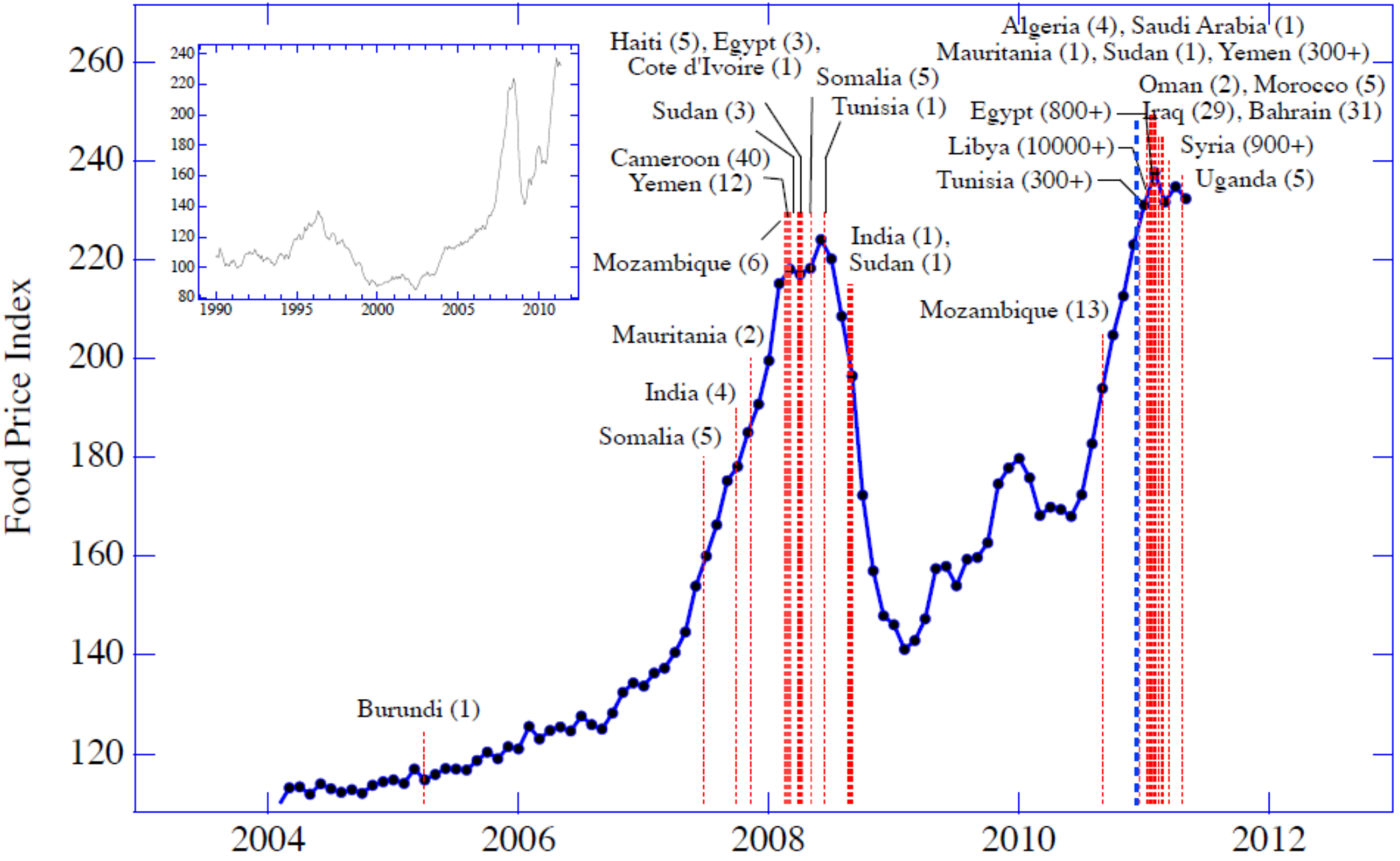
2002 – státní bankrot
2013 – inflace 25 %



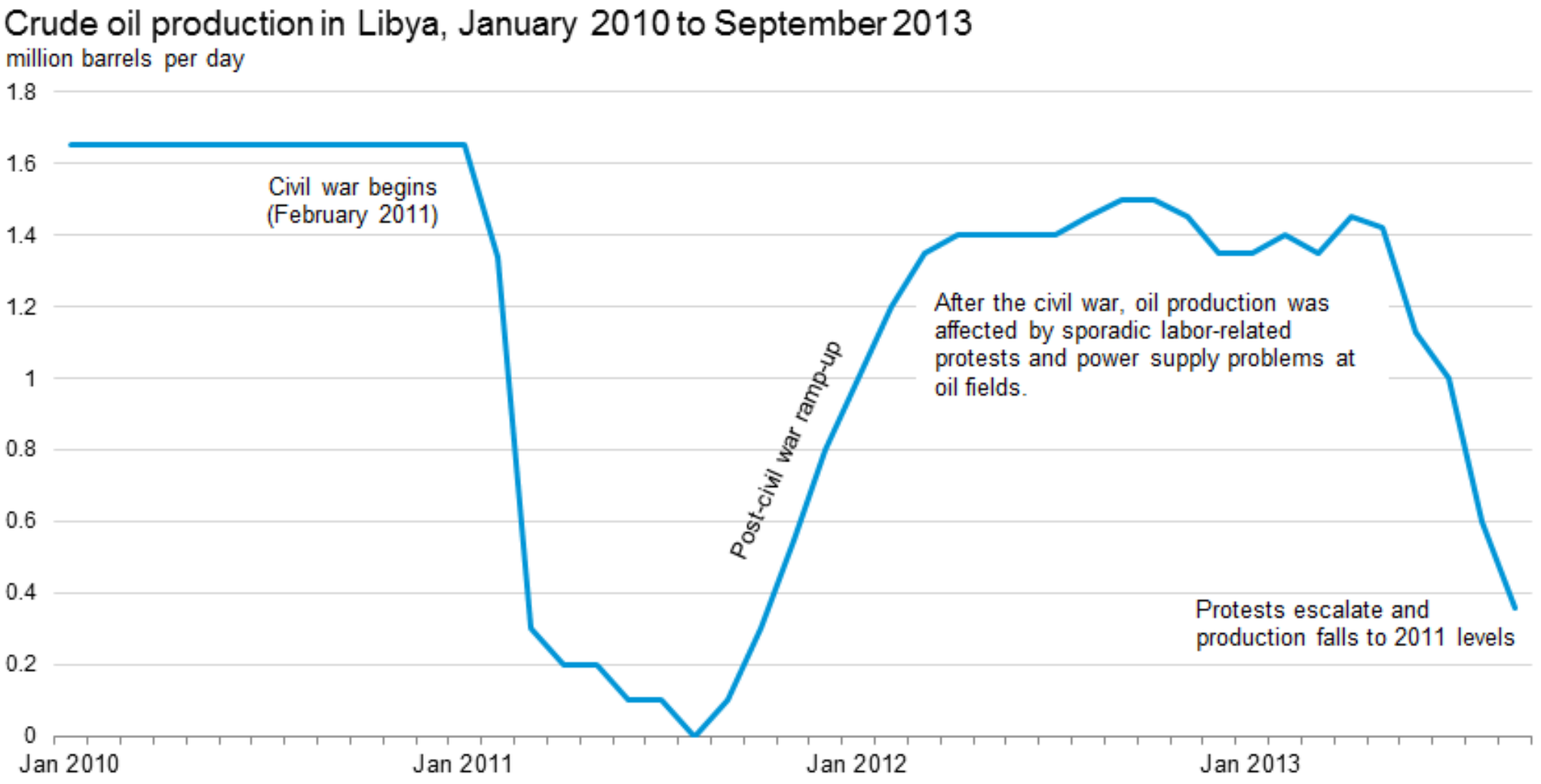
2010 – dovoz ropy, ruské sucho

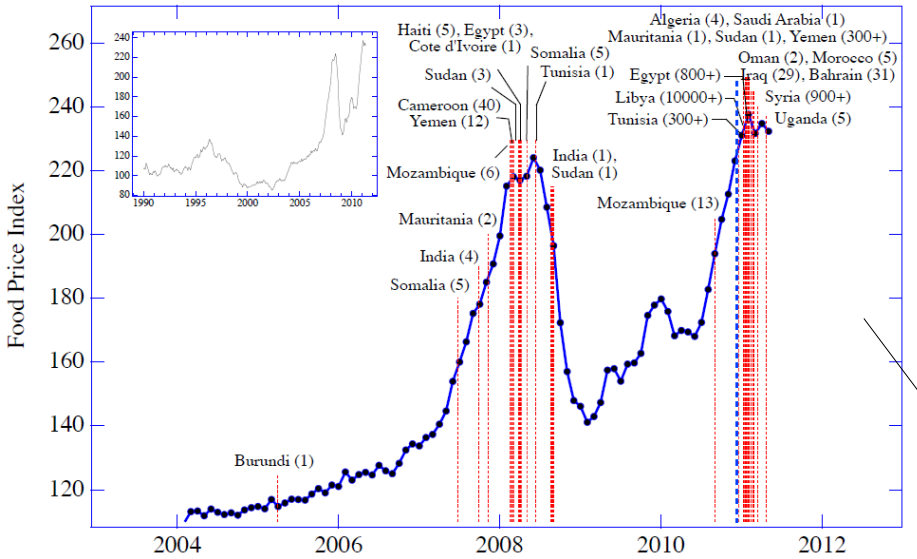
2011 – „Arabské jaro“

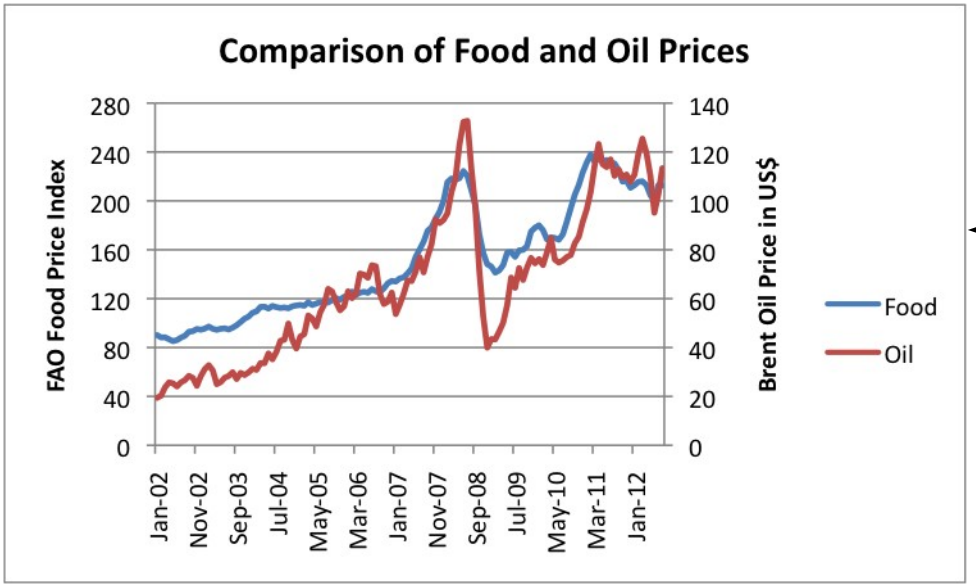
Cena potravin a nepokoje ve světě

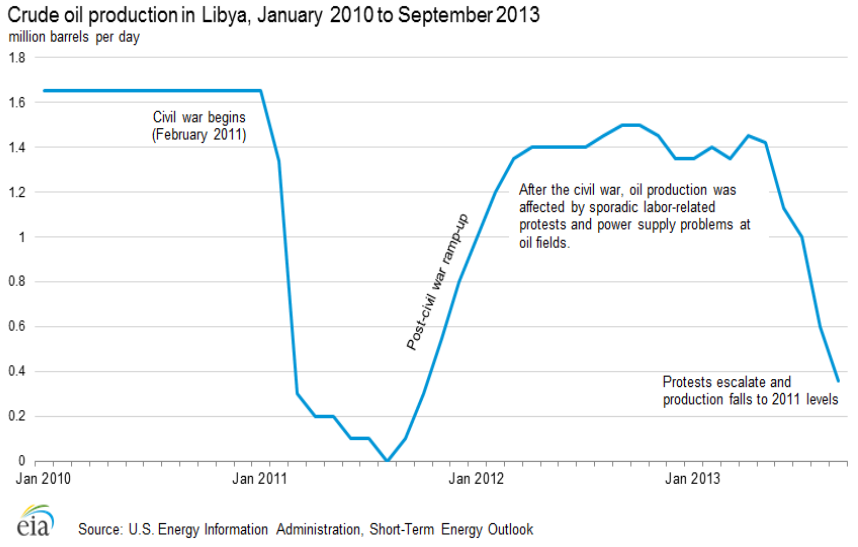


Produkce ropy vs. nepokoje v Lybii

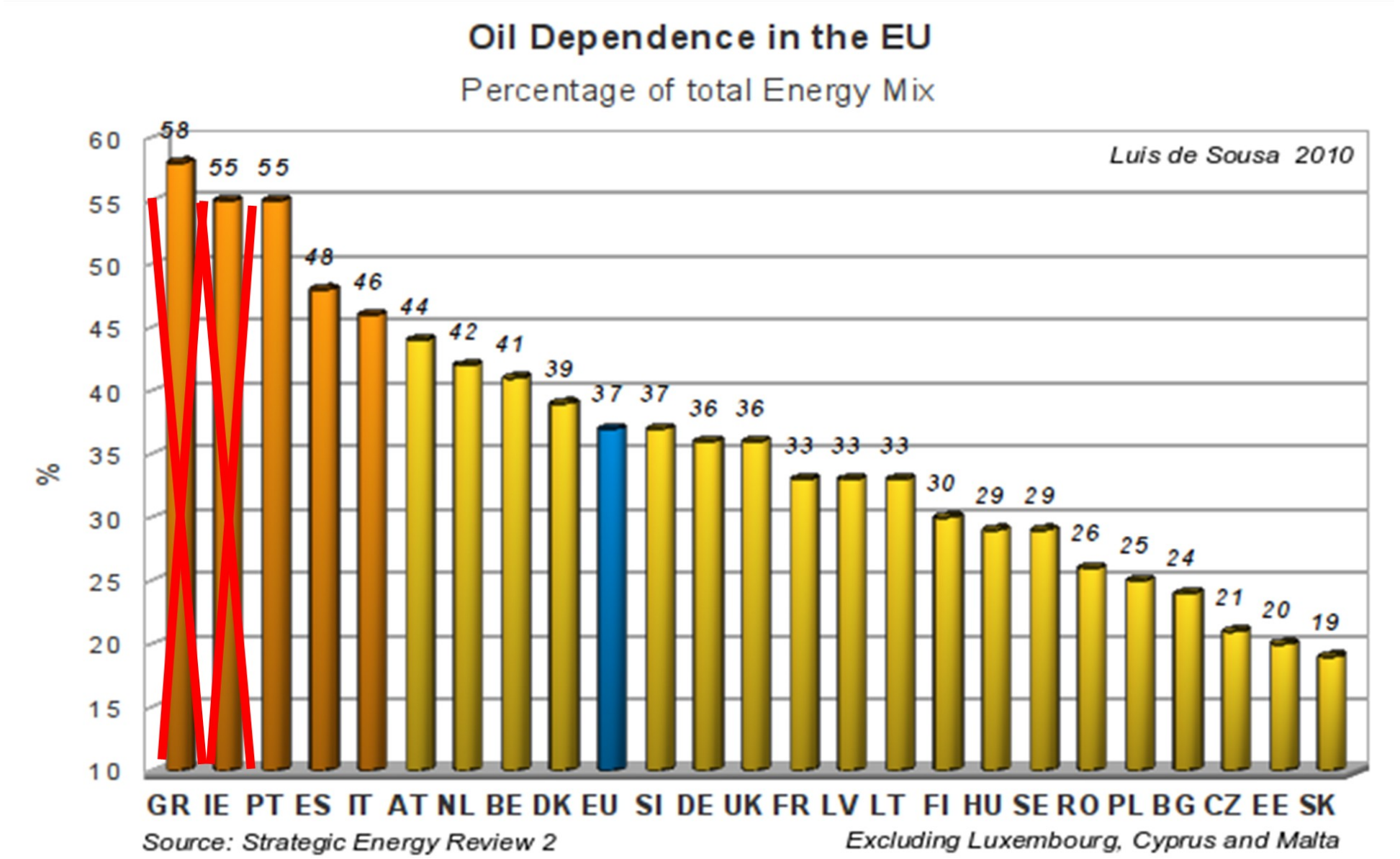



Food Price Index
260
240
220
200
180
160
140
120
2004
2006
2008
2010
2012
Haiti (5), Egypt (3), Cote d'Ivoire (1)
Somalia (5)
Sudan (3)
Tunisia (1)
Cameroon (40)
Yemen (12)
Mozambique (6)
India (1), Sudan (1)
Mauritania (2)
India (4)
Somalia (5)
Burundi (1)
Algeria (4), Saudi Arabia (1)
Mauritania (1), Sudan (1), Yemen (300+)
Oman (2), Morocco (5)
Egypt (800+)
Iraq (29), Bahrain (31)
Libya (10000+)
Syria (900+)
Tunisia (300+)
Uganda (5)
Mozambique (13)


Comparison of Food and Oil Prices
FAO Food Price Index
Brent Oil Price in US$
280
240
200
160
120
80
40
0
140
120
100
80
60
40
20
0
Jan-02
Nov-02
Sep-03
Jul-04
May-05
Mar-06
Jan-07
Nov-07
Sep-08
Jul-09
May-10
Mar-11
Jan-12
Food
Oil

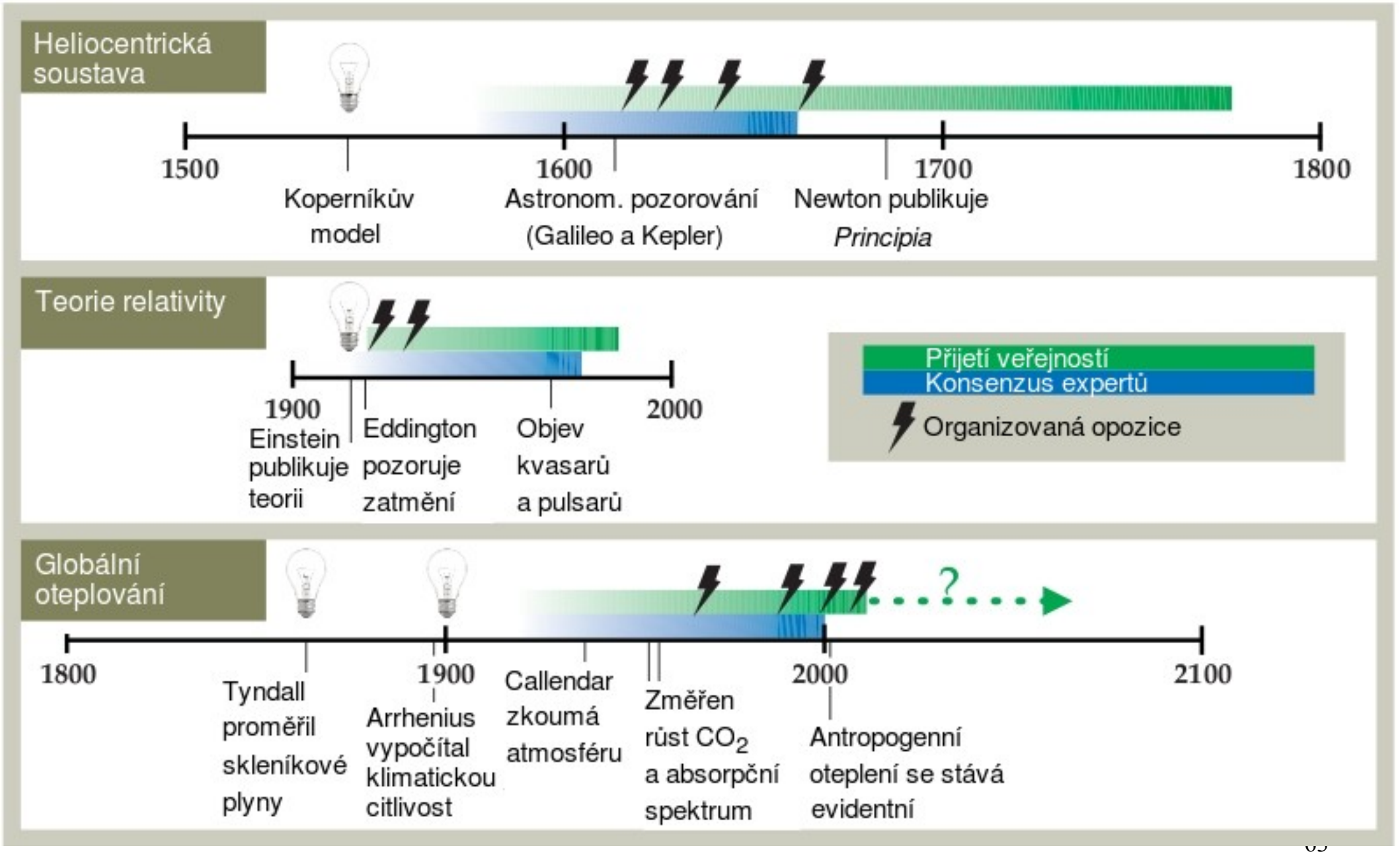

Crude oil production in Libya, January 2010 to September 2013
million barrels per day
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Civil war begins (February 2011)
Post-civil war ramp-up
After the civil war, oil production was affected by sporadic labor-related protests and power supply problems at oil fields.
Protests escalate and production falls to 2011 levels
Jan 2010
Jan 2011
Jan 2012
Jan 2013
eia
Source: U.S. Energy Information Administration, Short-Term Energy Outlook

Ropa a PIGS: Země s vysokým podílem ropy v energetickém mixu odcházejí první



Globální změna klimatu

Přijetí teorií odborníky a veřejností



Sherwood, *Science controversies past and present*, Physics today 2011
http://physicstoday.org/resource/1/phtoad/v64/i10/p39_s1?bypassSSO=1

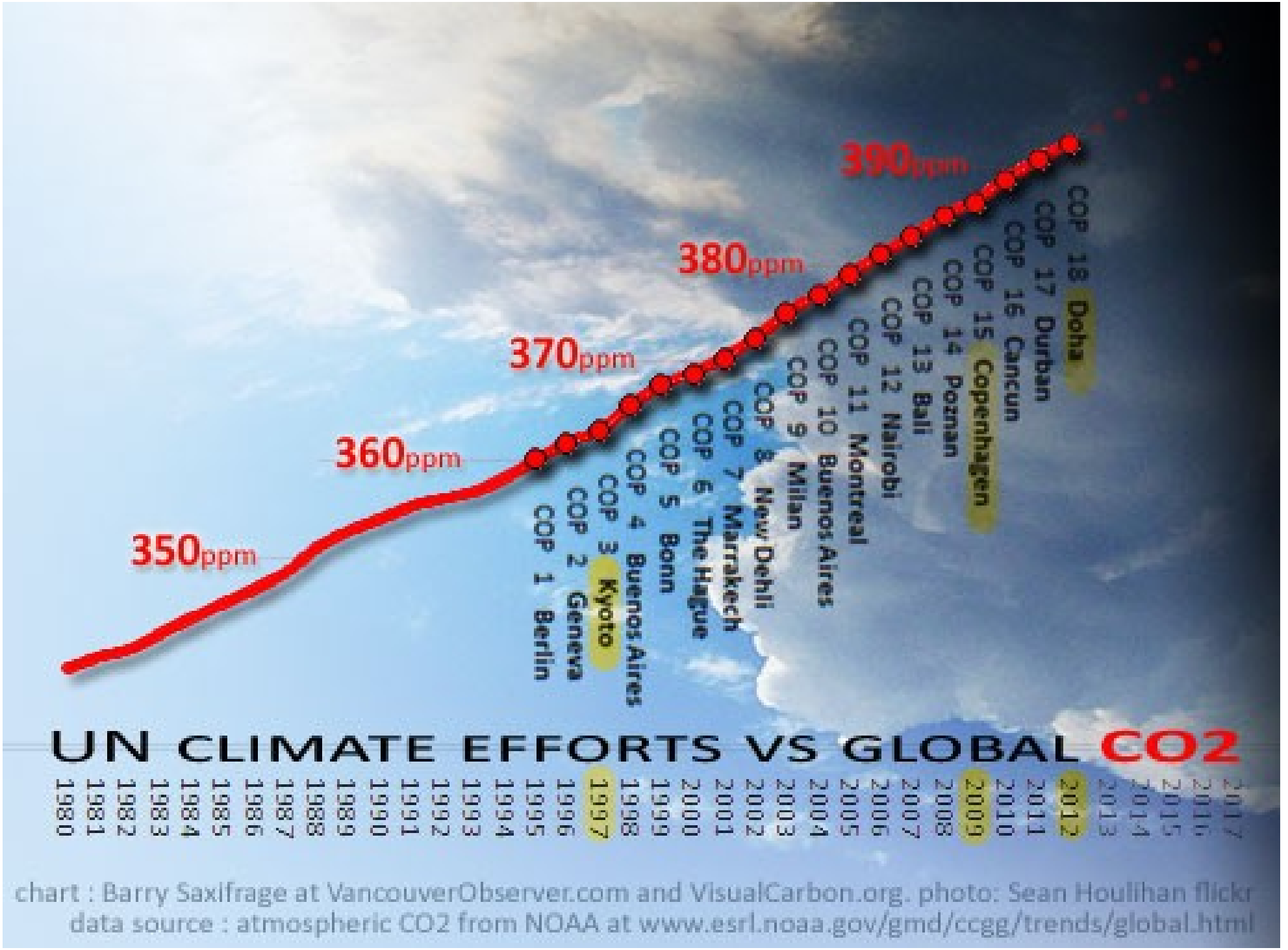
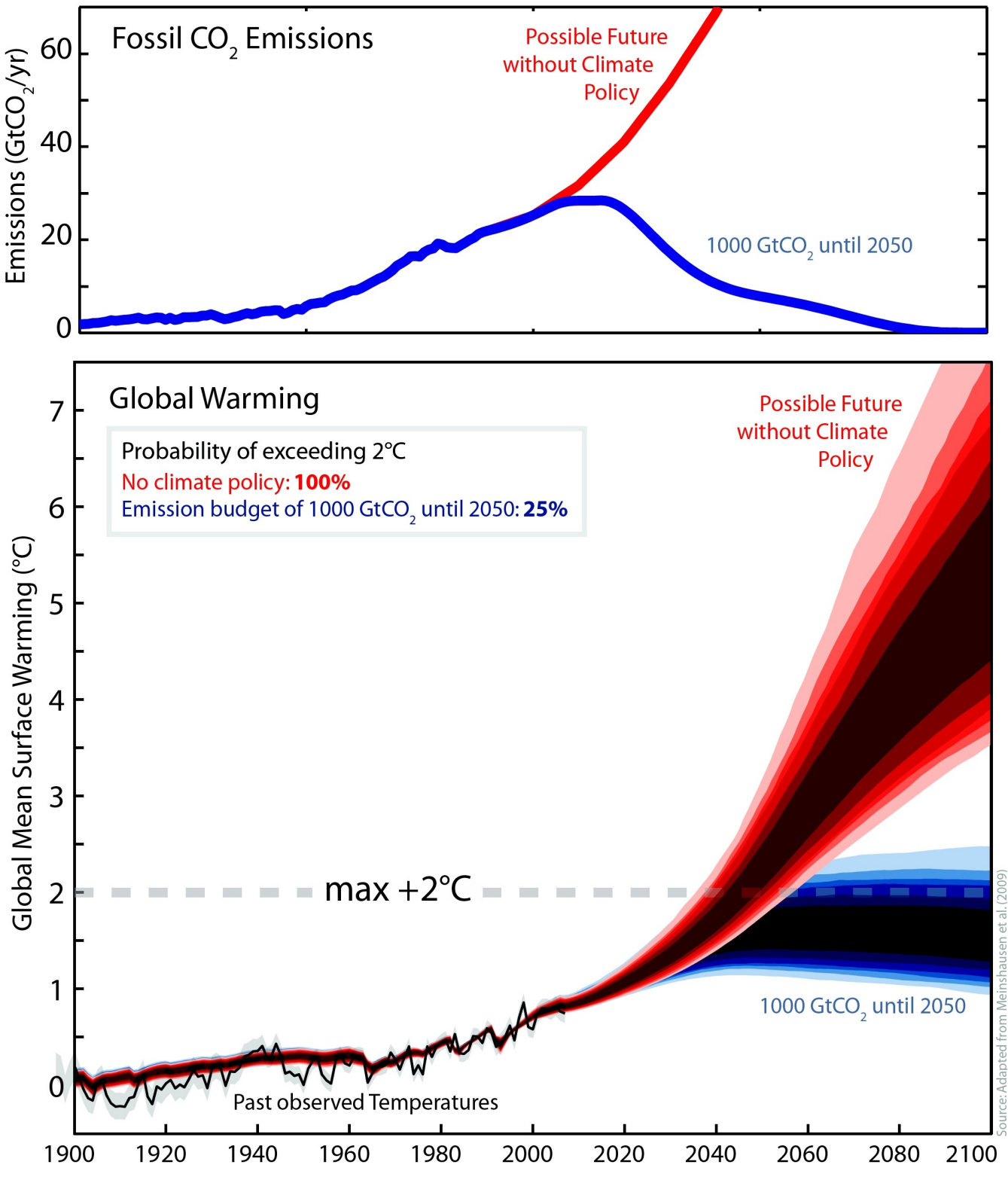


chart : Barry Saxifrage at VancouverObserver.com and VisualCarbon.org. photo: Sean Houlihan flickr
data source : atmospheric CO2 from NOAA at www.esrl.noaa.gov/gmd/ccgg/trends/global.html



Meinshausen M. et al.,
Greenhouse-gas emission targets for limiting global warming to 2 °C,
Nature 2009

Limiting cumulative CO_2 emissions over 2000–50 to 1,000 Gt CO_2 yields a 25% probability of warming exceeding 2°C.

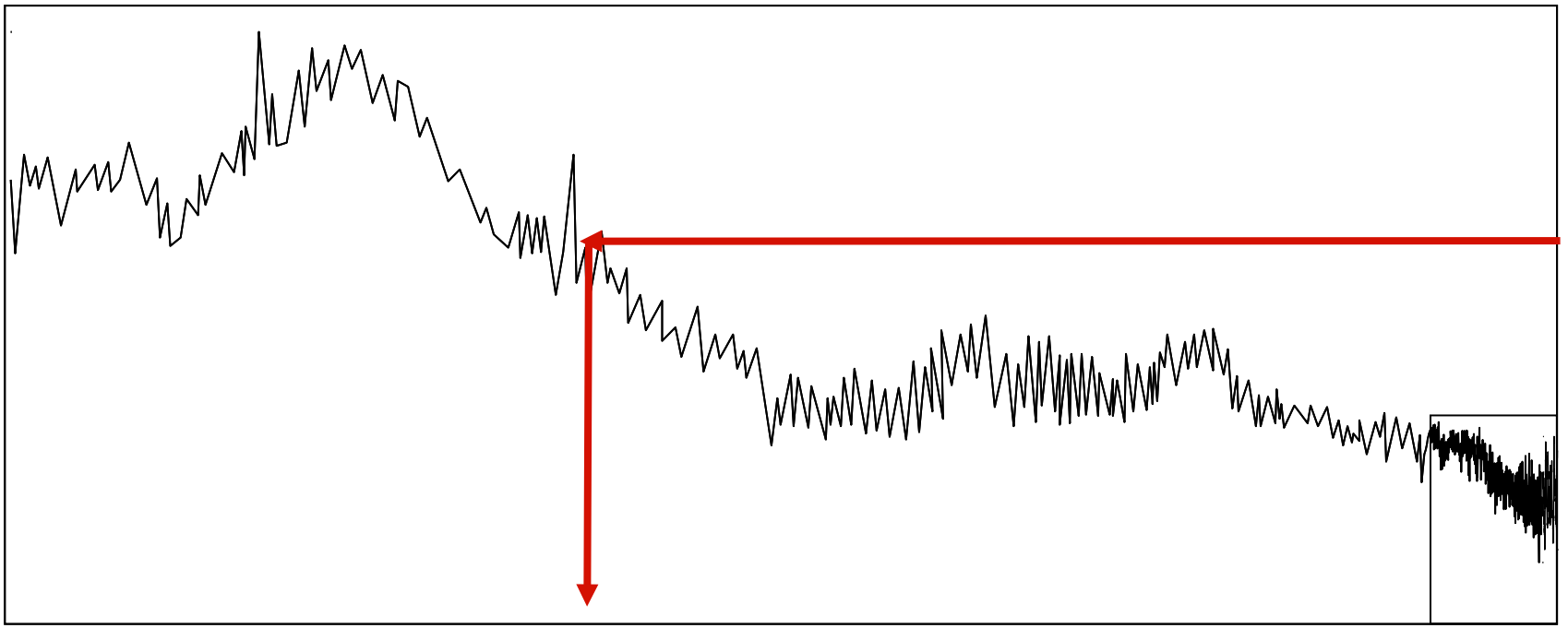
Limit of 1,440 Gt CO_2 yields a 50% probability.

As known 2000–06 CO_2 emissions were 234 Gt CO_2.

Meinshausen M. et al., *Greenhouse-gas emission targets for limiting global warming to 2 °C*, Nature 2009.

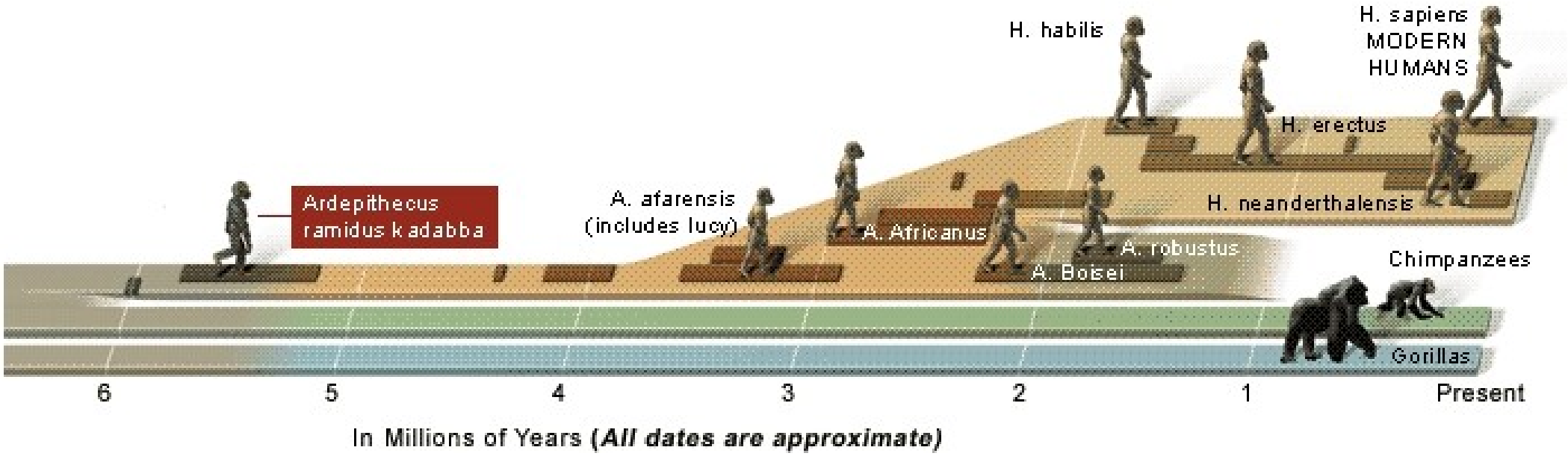
http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8

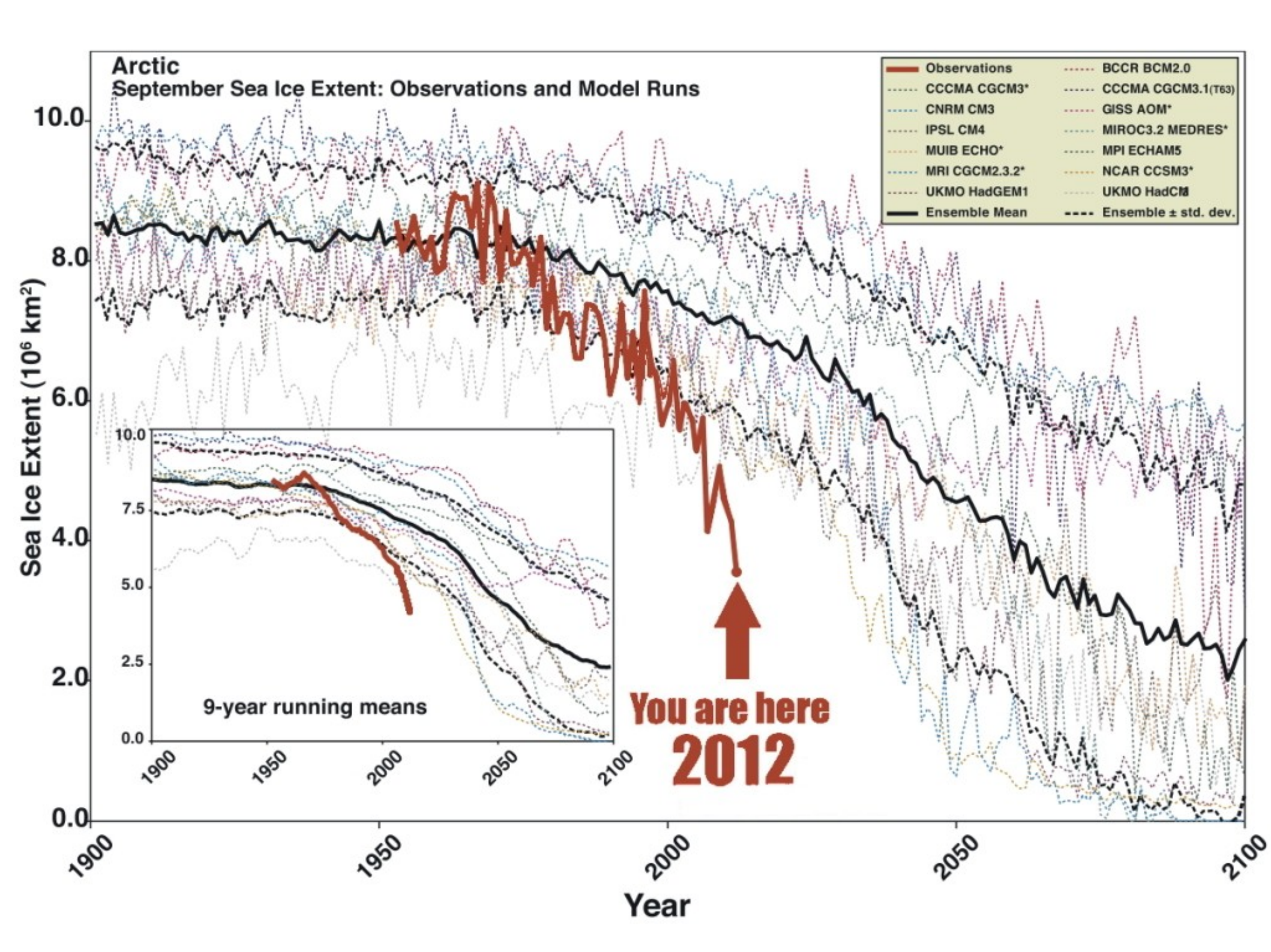
Oteplení o 6°C



40 mil. let

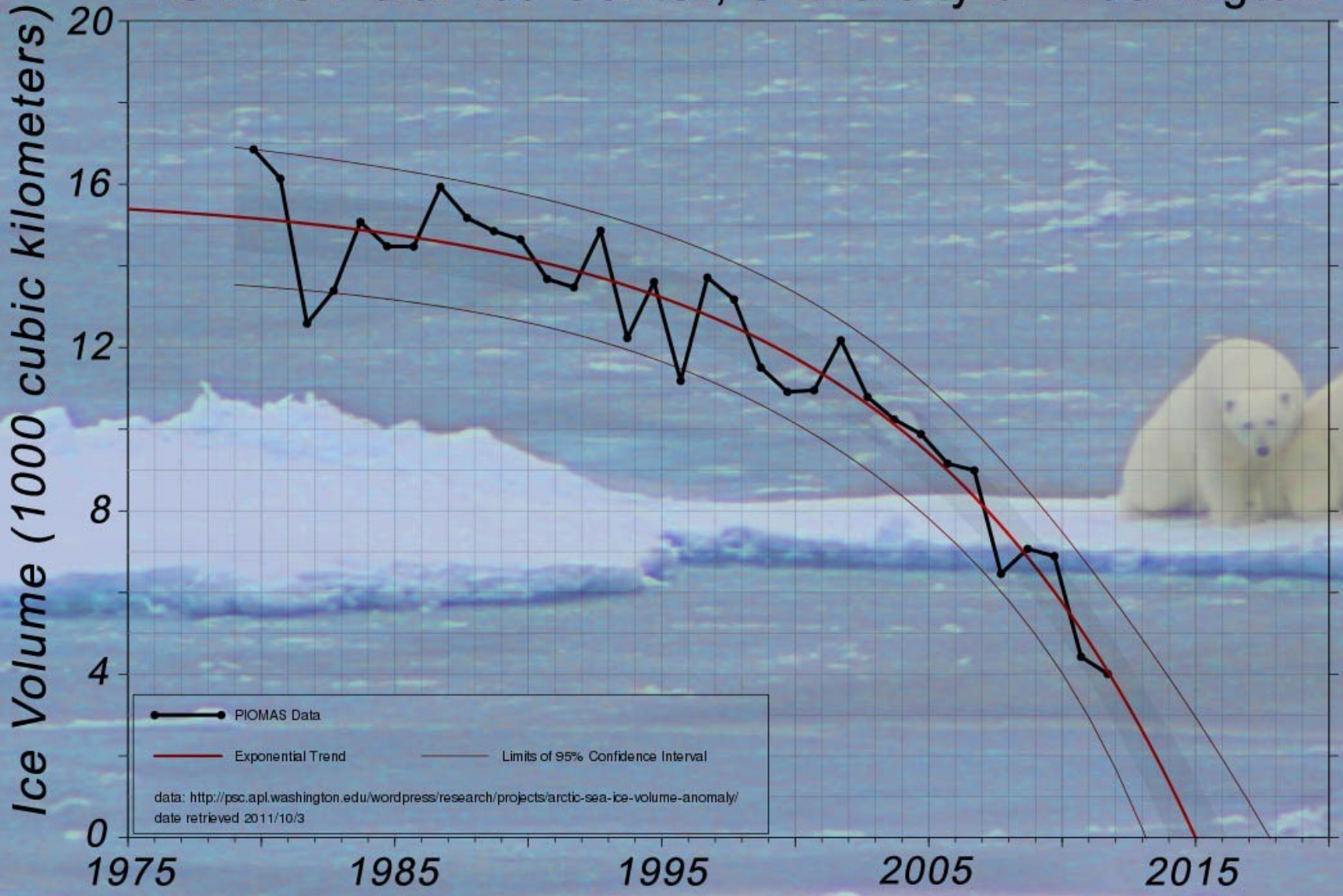
- Rod homo – cca 2 miliony let
- Homo sapines – cca 200 000 let



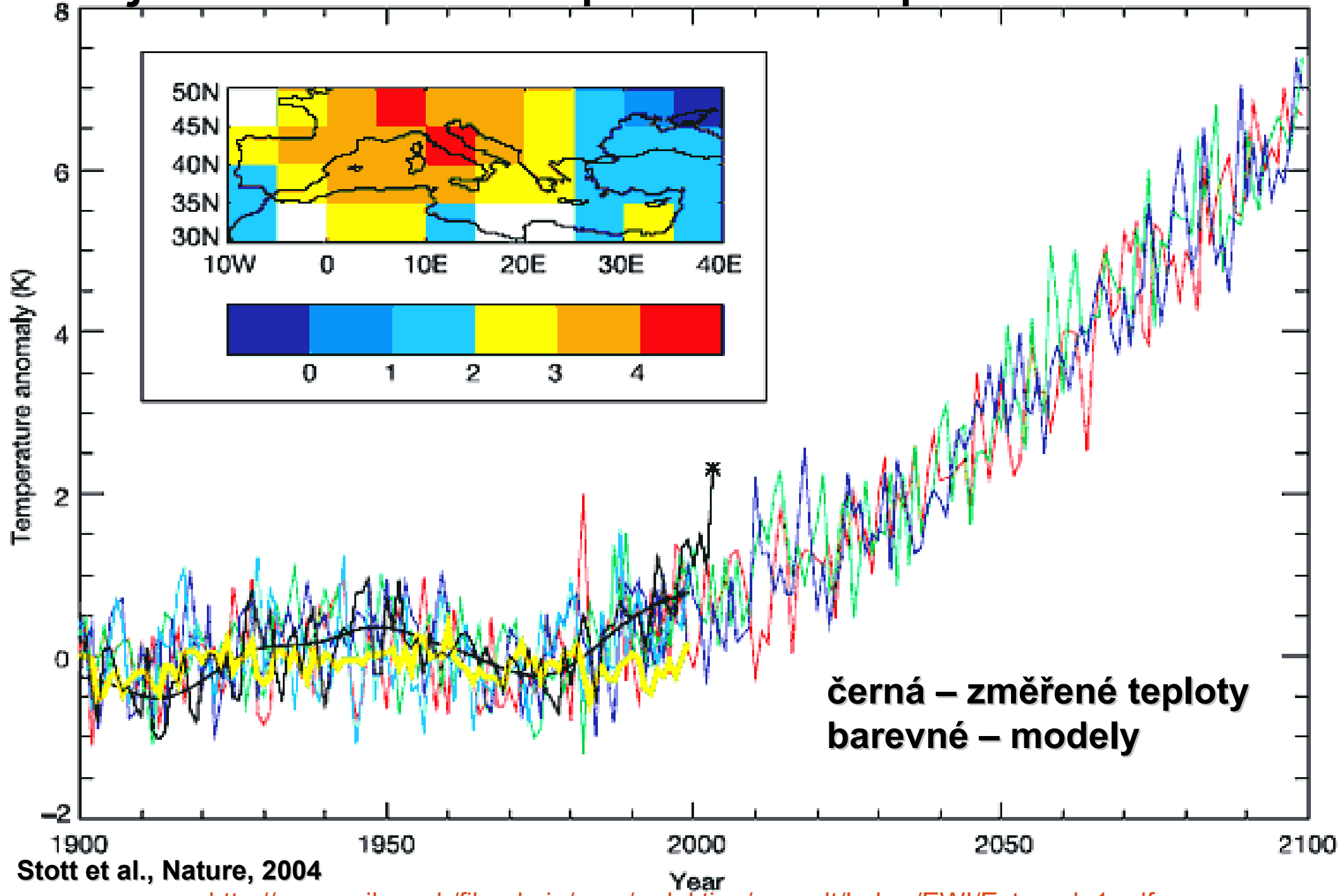

Arctic
September Sea Ice Extent: Observations and Model Runs
Observations
CCCMA CGCM3*
CNRM CM3
IPSL CM4
MUIB ECHO*
MRI CGCM2.3.2*
UKMO HadGEM1
Ensemble Mean
BCCR BCM2.0
CCCMA CGCM3.1(T63)
GISS AOM*
MIROC3.2 MEDRES*
MPI ECHAM5
NCAR CCSM3*
UKMO HadCM
Ensemble ± std. dev.
Sea Ice Extent (10^6 km^2)
Year
9-year running means
You are here
2012

Annual Minimum Arctic Sea Ice Volume

PIOMAS Polar Ice Center, University of Washington



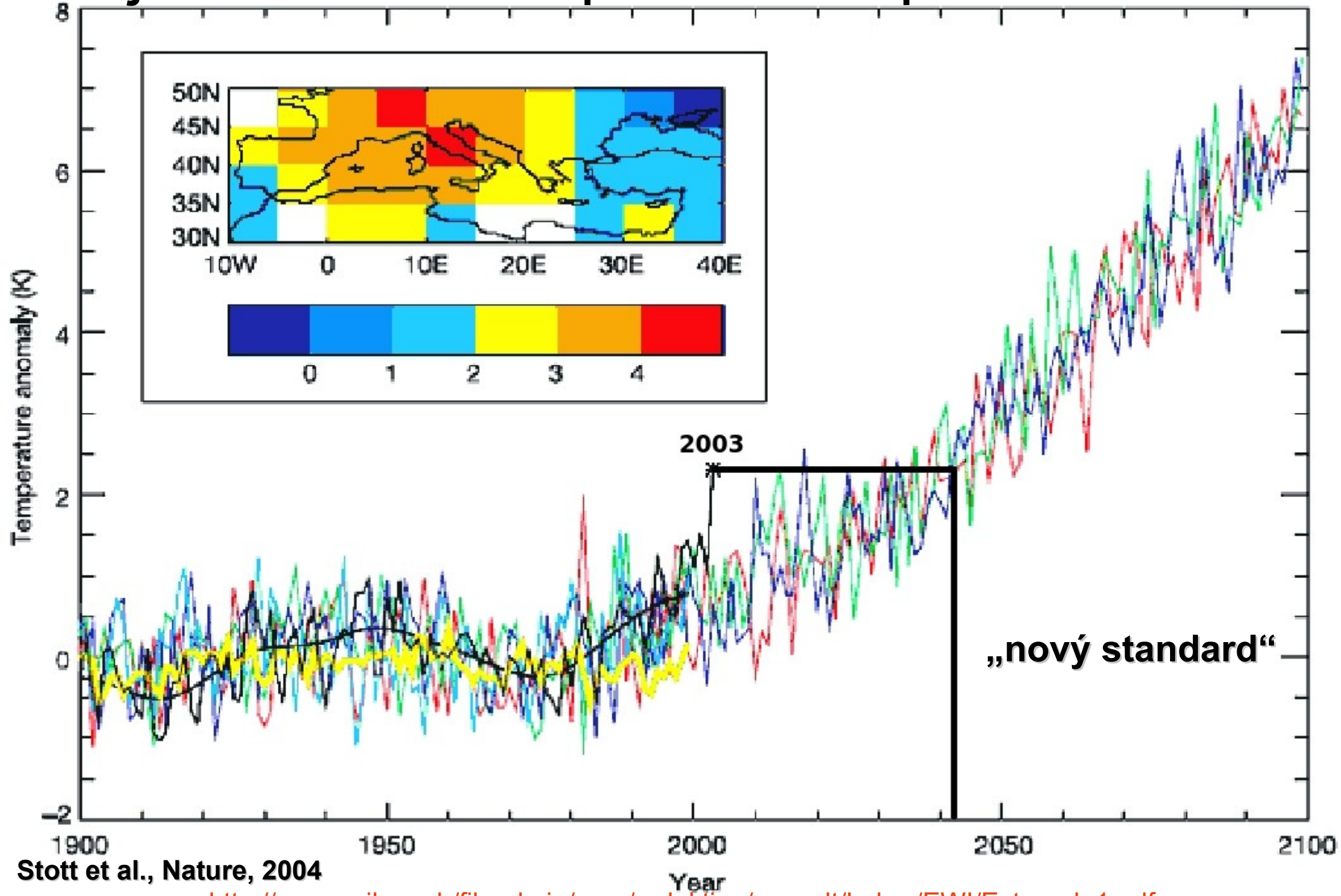
Projekce letních teplot v Evropě ve 21. st.



Stott et al., Nature, 2004

http://wwz.unibas.ch/fileadmin/wwz/redaktion/umwelt/Lehre/EWI/External_1.pdf

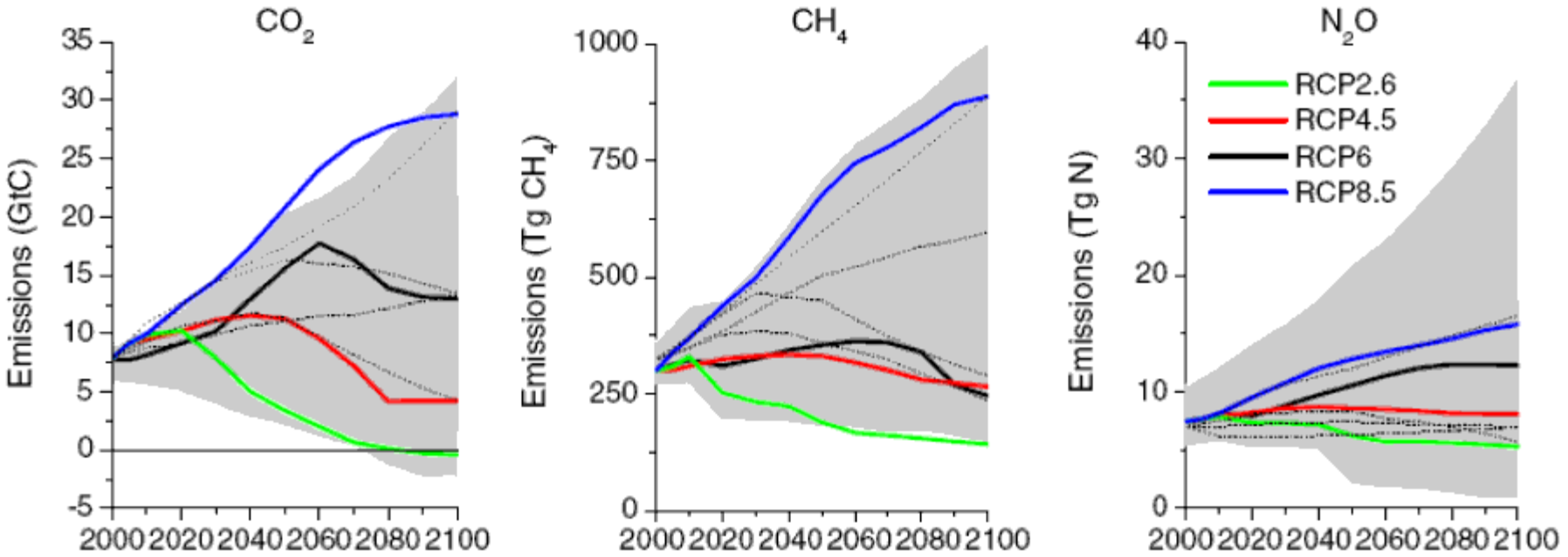
Projekce letních teplot v Evropě ve 21. st.



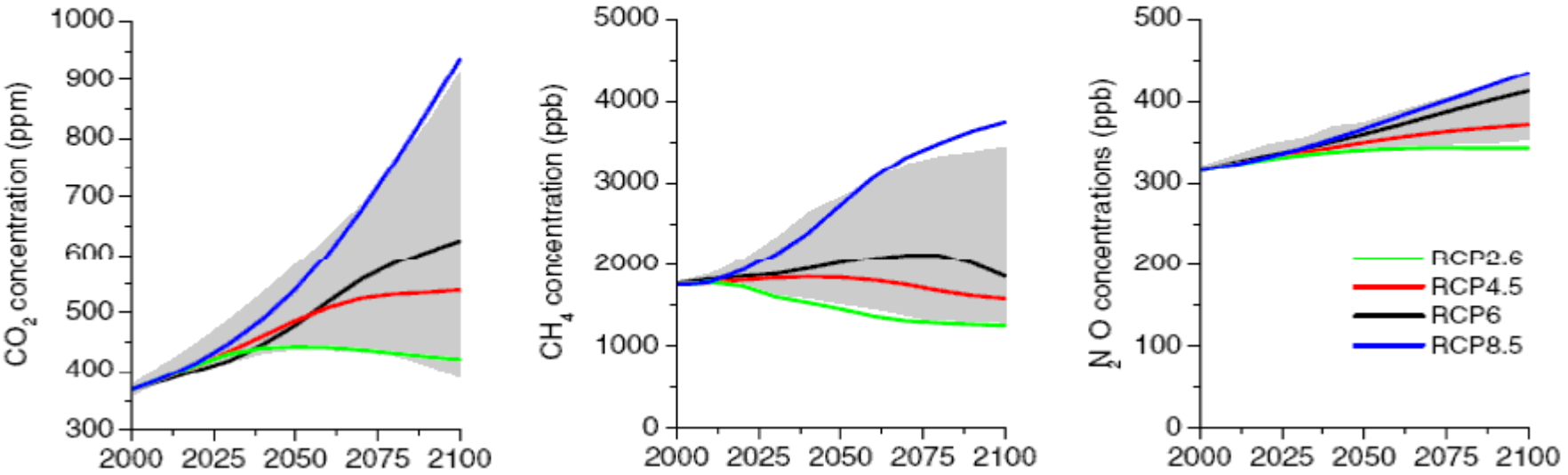
Stott et al., Nature, 2004

http://wwz.unibas.ch/fileadmin/wwz/redaktion/umwelt/Lehre/EWI/External_1.pdf

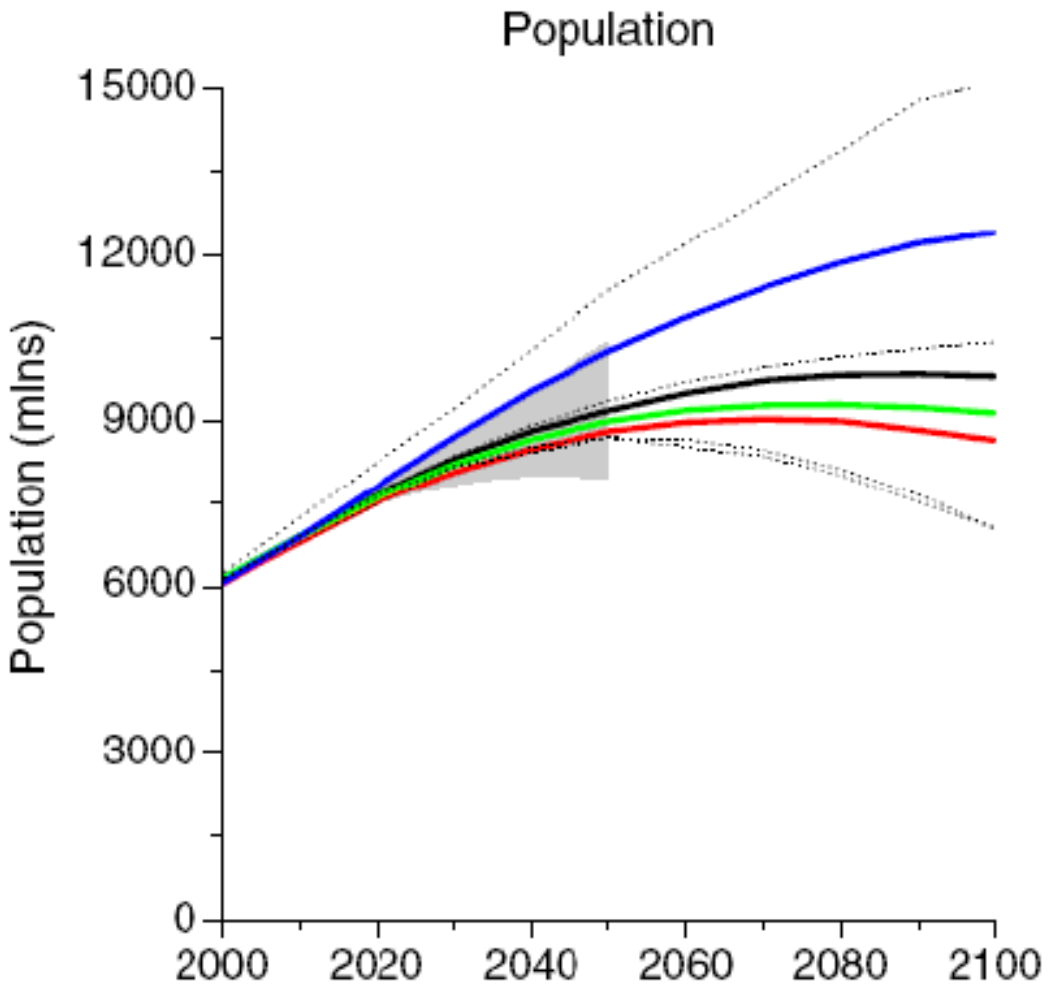
RCP Emission Trajectories IPCC AR5

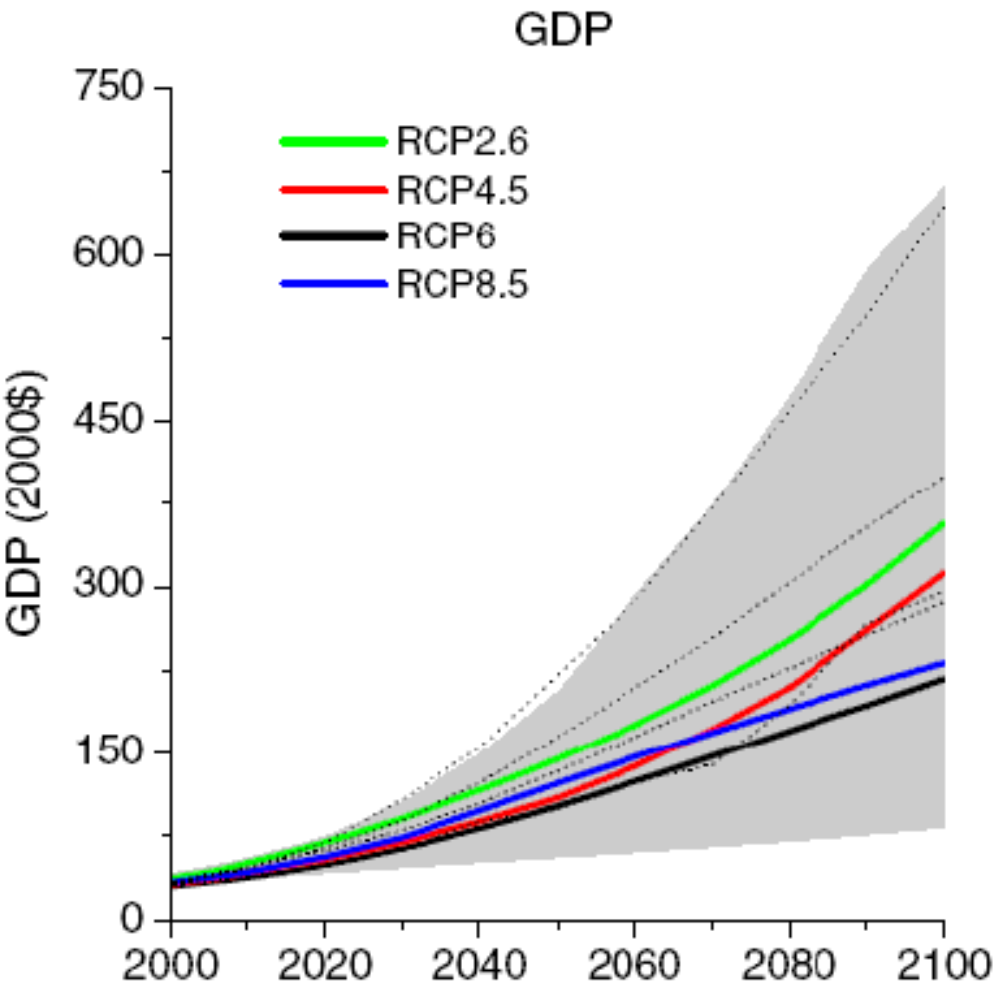


Greenhouse Gas Concentrations



IPCC AR5


Population
Population (mlns)
15000
12000
9000
6000
3000
0
2000
2020
2040
2060
2080
2100


GDP
GDP (2000$)
750
600
450
300
150
0
2000
2020
2040
2060
2080
2100
RCP2.6
RCP4.5
RCP6
RCP8.5

IPCC AR4

"Neutrality" of the SRES Scenarios The SRES scenarios are intended to exclude catastrophic futures. Such catastrophic futures feature prominently in the literature. They typically involve large-scale environmental or economic collapses, and extrapolate current unfavorable conditions and trends in many regions...

...Many of these scenarios suggest that catastrophic developments may draw the world into a state of chaos within one or two decades. In such scenarios GHG emissions might be low because of low or negative economic growth, but it seems unlikely they would receive much attention in the light of more immediate problems. Hence, **this report does not analyze such futures.**

https://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=91

„...This catastrophic and ongoing failure of market economics and the laissez-faire rhetoric accompanying it (unfettered choice, deregulation and so on) could provide an opportunity to think differently about climate change.

...The world is moving on and we need to have the audacity to think differently and conceive of alternative futures.

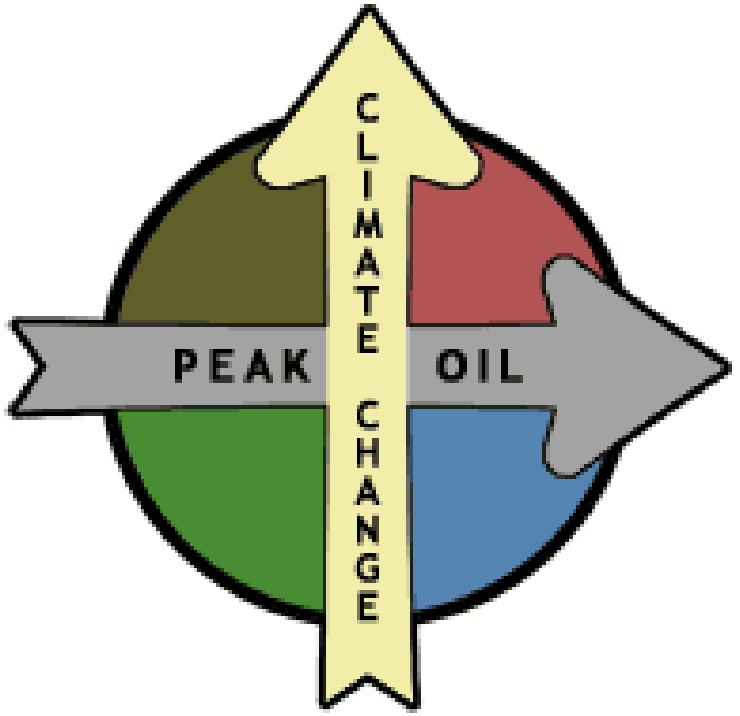
Civil society needs scientists to do science free of the constraints of failed economics...“

Prof. Kevin Anderson, Deputy Director of the Tyndall Centre

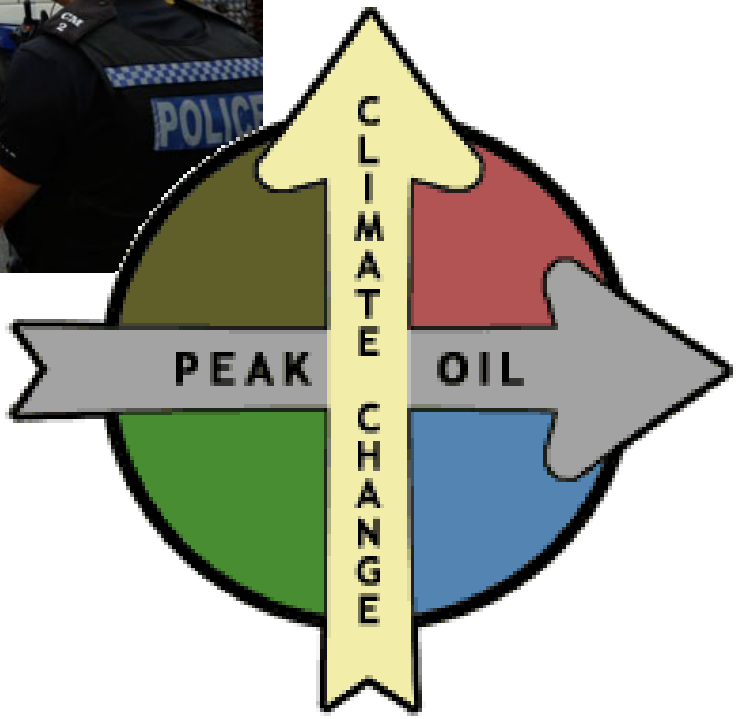
Andreson, K., Bows. A. 2012, A new paradign for climate change, NATURE CLIMATE CHANGE

http://www.ecoshock.info/2012/11/kevin-anderson-what-they-wont-tell-you.html

Perspektivy budoucnosti lidstva



http://www.sei-international.org/video-archive/1827



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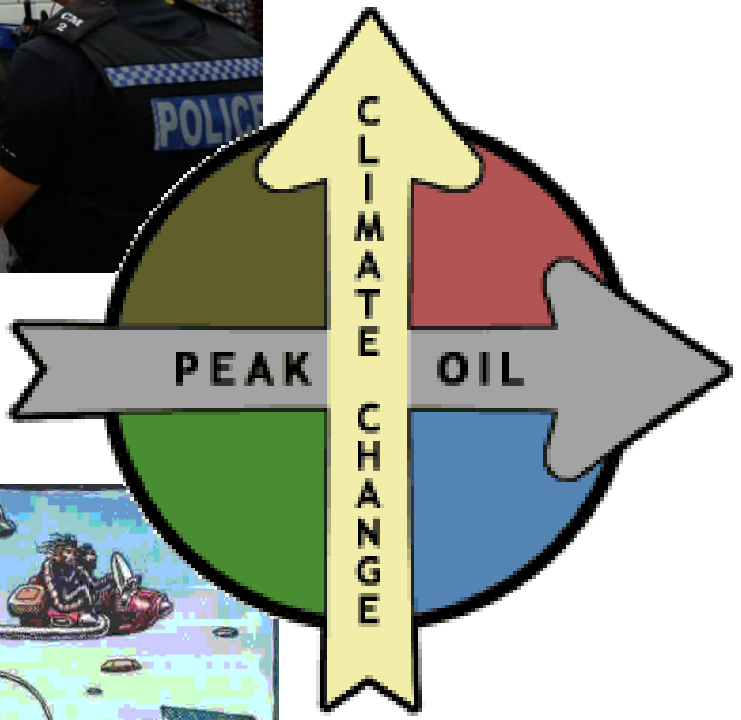

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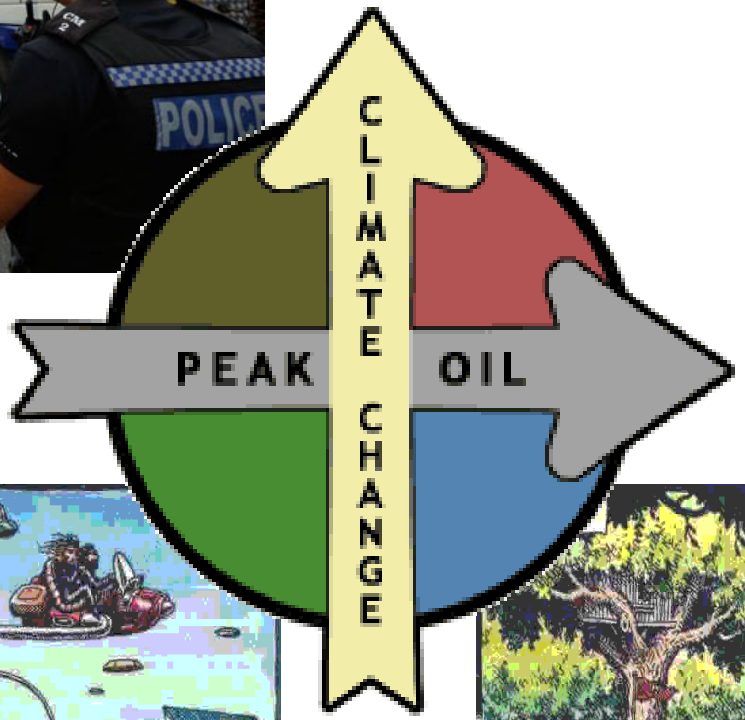

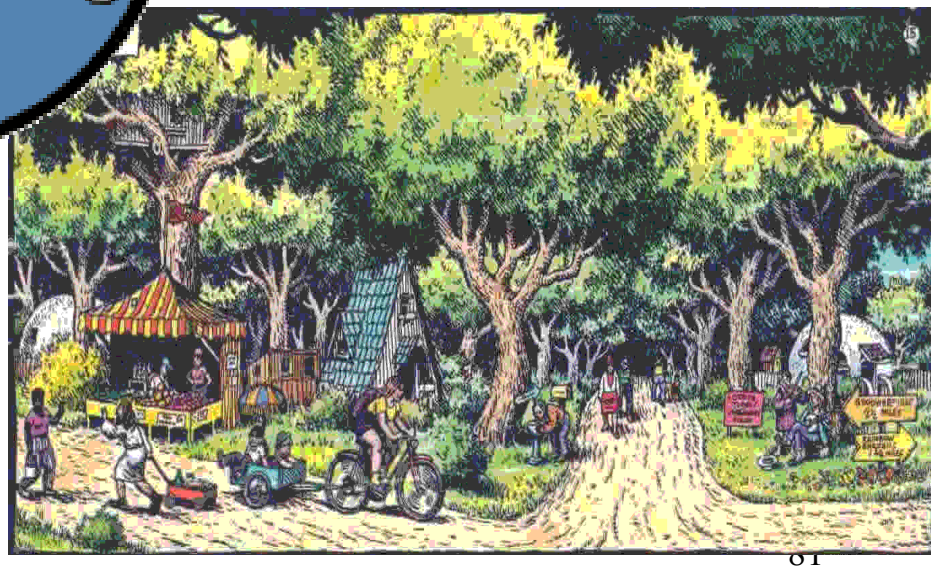

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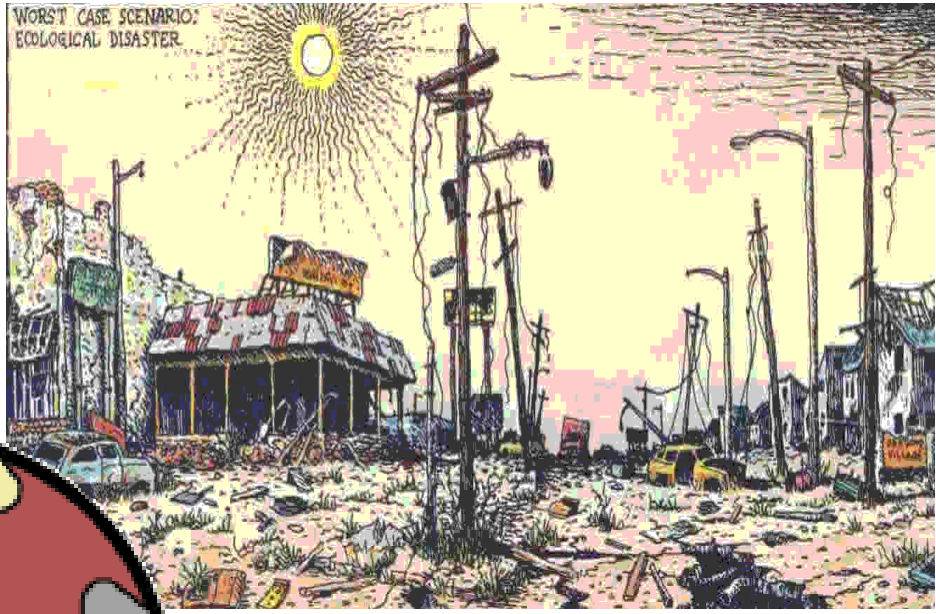

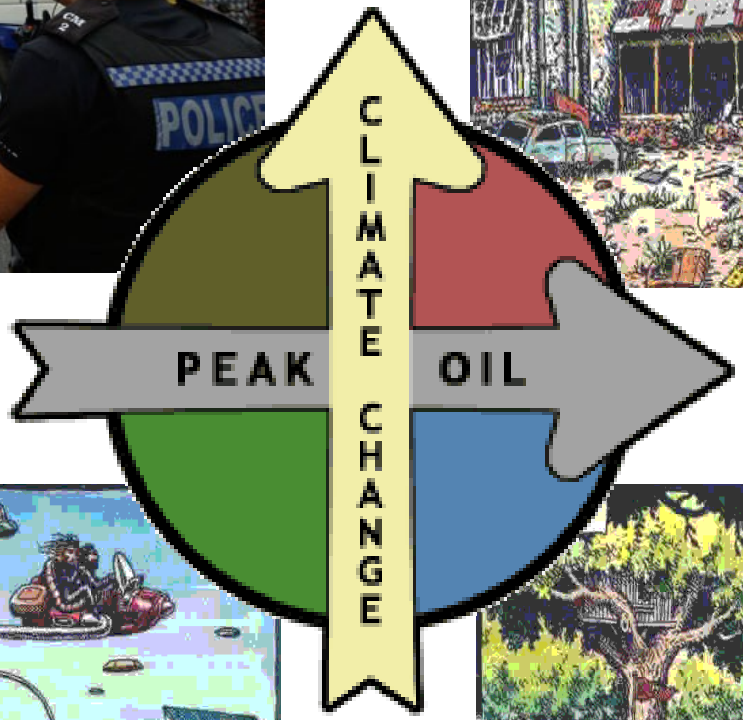

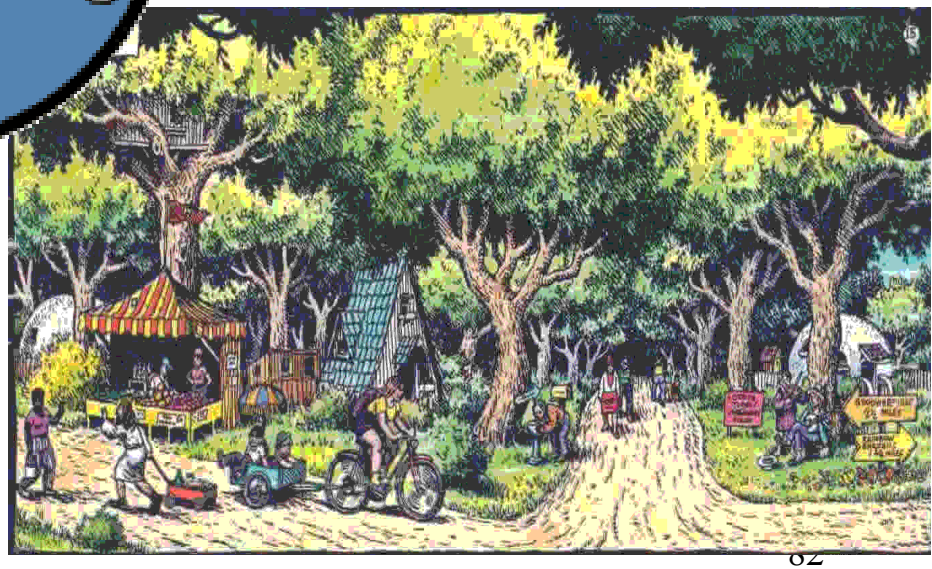

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„Nejvíce pozornosti psychologů přitahují ty problémy životního prostředí, které v lidech vyvolávají nejsilnější emoční odezvu, např. **environmentální katastrofy**, **globální klimatické změny** či **vymírání přírodních druhů**.“

Jan Krajhanzl

Dobře utajené emoce a problémy životního prostředí

“No evidence is powerful enough
to force acceptance of a conclusion
that is emotionally distasteful.”

Žádné důkazy nejsou dost silné,
aby vedly k přijetí závěru,
který je emočně nestravitelný.

Theodosius Dobzhansky

As Sherlock Holmes famously said,
“when you have eliminated the impossible,
whatever remains, however improbable,
must be the truth“.

Sir Arthur Conan Doyle, The Sign of Four, 1890

Děkuji za pozornost!