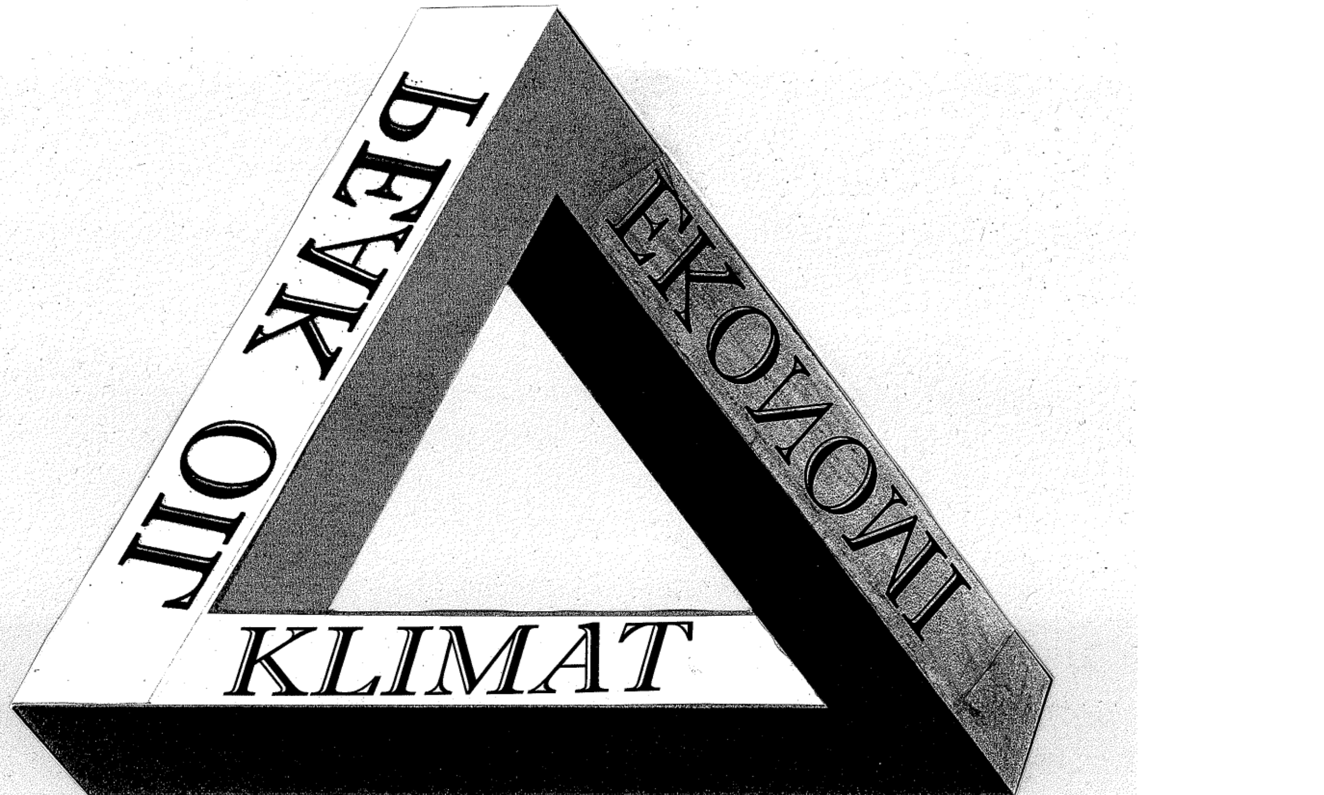
Energiomställningen och klimatet

SU, 18 sept 2013

Claes Trygger

Energigruppen i

Klimataktion Stockholm



.... en trasslig härva

Inledande introspektion:

Övning #1:
Hur många kWh finns i en liter bensin (eller diesel)?

Övning #2:
Hur många kWh finns i vårt dagliga bröd?

SVAR:

Övning #1:

Bensin:	c:a 9 kWh
Diesel:	c:a 10 kWh
Olja:	c:a 10 kWh

Övning #2:

Normalt kaloriintag ligger mellan 2.000 och drygt 3.000 kcal/dygn. 1 kcal = 4.184 J = 4.184 Ws, varav man raskt finner 2,35 – 3,5 kWh

Hur många kilowattimmar ...

gör ***du*** av med varje dag på

- boende
- resor
- föda
- grunkor, grejor och prylar
- underhållning och slikt

?

True fact (the best kind of fact):
En slav kan leverera i storleksordningen 1 kWh per dag.
Ty:

Sustained output of human being: 100 W for 10 hours

Total energy output: 10*100 Wh = 1 kWh

Cf oil: One deciliter contains 1 kWh; costs ~50 öre

Skojig (och hälsofrämjande!) laboration

- Tanka din bil (eller annat fossil-eldat fordon) med en liter soppa.
- Kör tills tanken är tom.
- Rulla hem fordonet med muskelkraft.
- Nu har du förtjänat en stor öl!

Övning #3:

Hur många slavar behöver **DU** för att ersätta din förbrukning av icke förnybar energi?

Energislavar:

Sveriges befolkning utgjordes vid årsskiftet 2012/2013 till 9.555.893 invånare
Sveriges totala slutliga energianvändning under 2010 var 411 TWh (1 TWh = 1.000.000.000 kWh)
411 miljarder kWh/9,6 miljoner människor = 42.800 kWh per person och år
Alternativt:
42.800 kWh/365 dagar = 117 kWh per person och dag (även pensionärer och spädbarn är personer)
Till detta kommer utrikes flyg och sjötransporter samt importvaror – allt som allt minst 150 kWh
Således: ***omkring 150 slavar per person!***

Kul laboration #2 (koka din egen olja):

Tag 4 000 ton döda växter och djur.

Sjud stilla i 150 000 000 år =>

1 fat olja (159 liter) ~ 700 kronor,

med en energi motsvarande 5 slavar, som

arbetar 12 timmar om dygnet - året runt.

Where do we stand today?

Present **energy** consumption: **132.000 TWh**

In terms of **power** consumption: **15 TW**

Present global **population**: **7+ billion**

Average energy consumption: 20 MWh p.p. p.a.

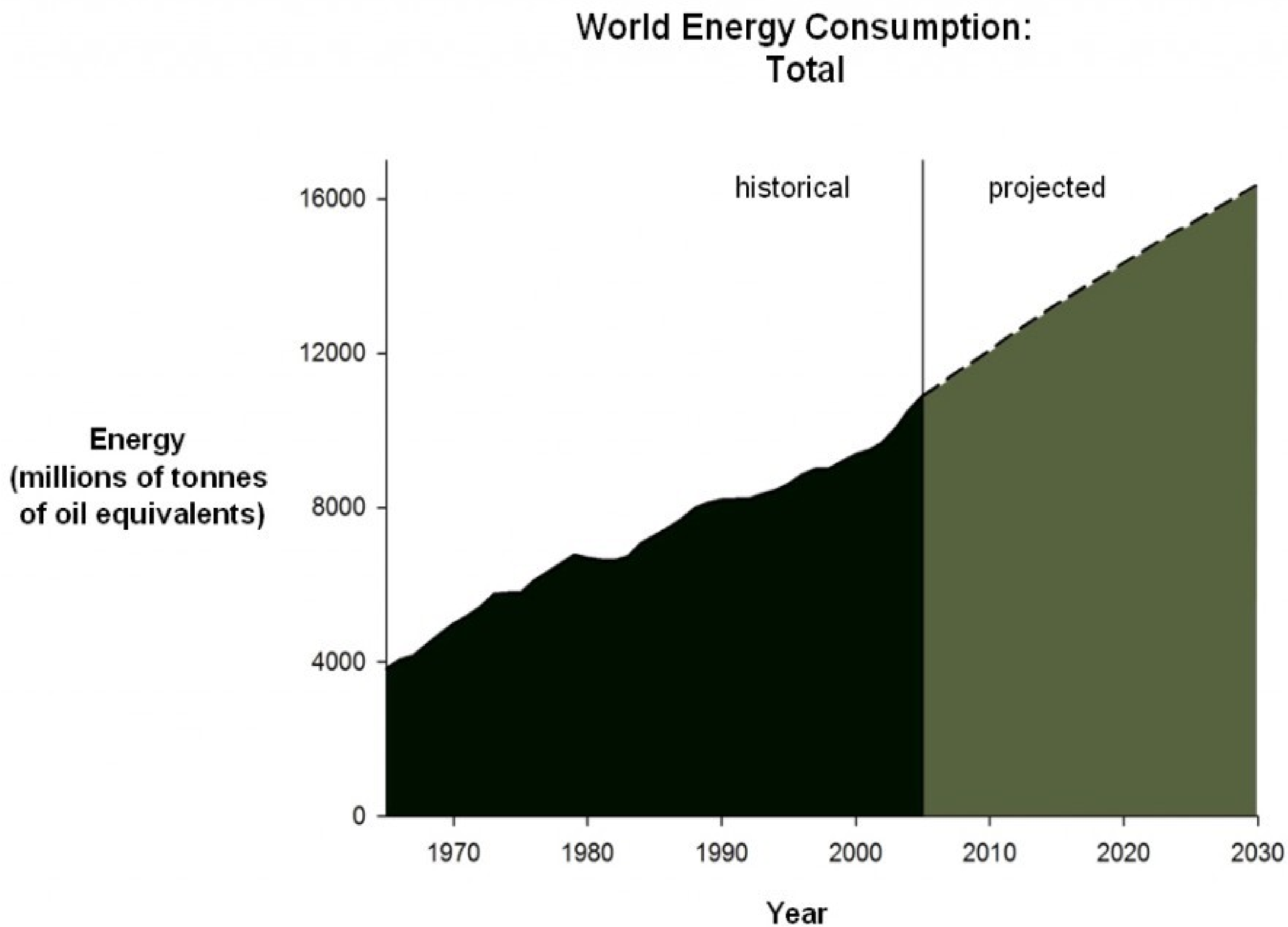
Or, equivalently: **54 kWh p.p. per day**

Average power consumption: **2.3 kW per person**

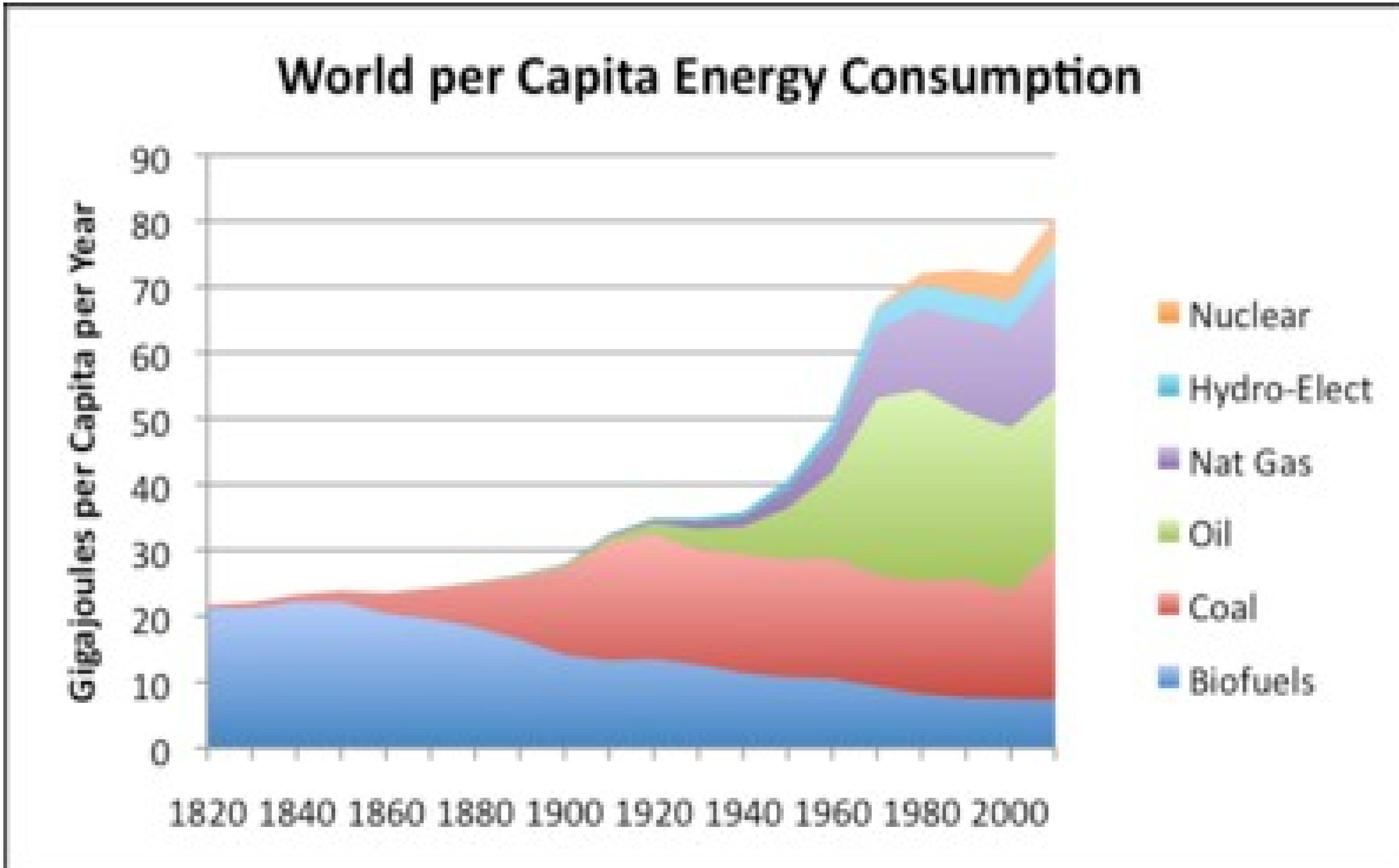
Uneven distribution of consumption:

US:	~12 kW (**290 kWh**/day)
Industrialized countries:	~6.5 kW (**155 kWh**/day)
Developing countries:	~1.2 kW (**30 kWh**/day)

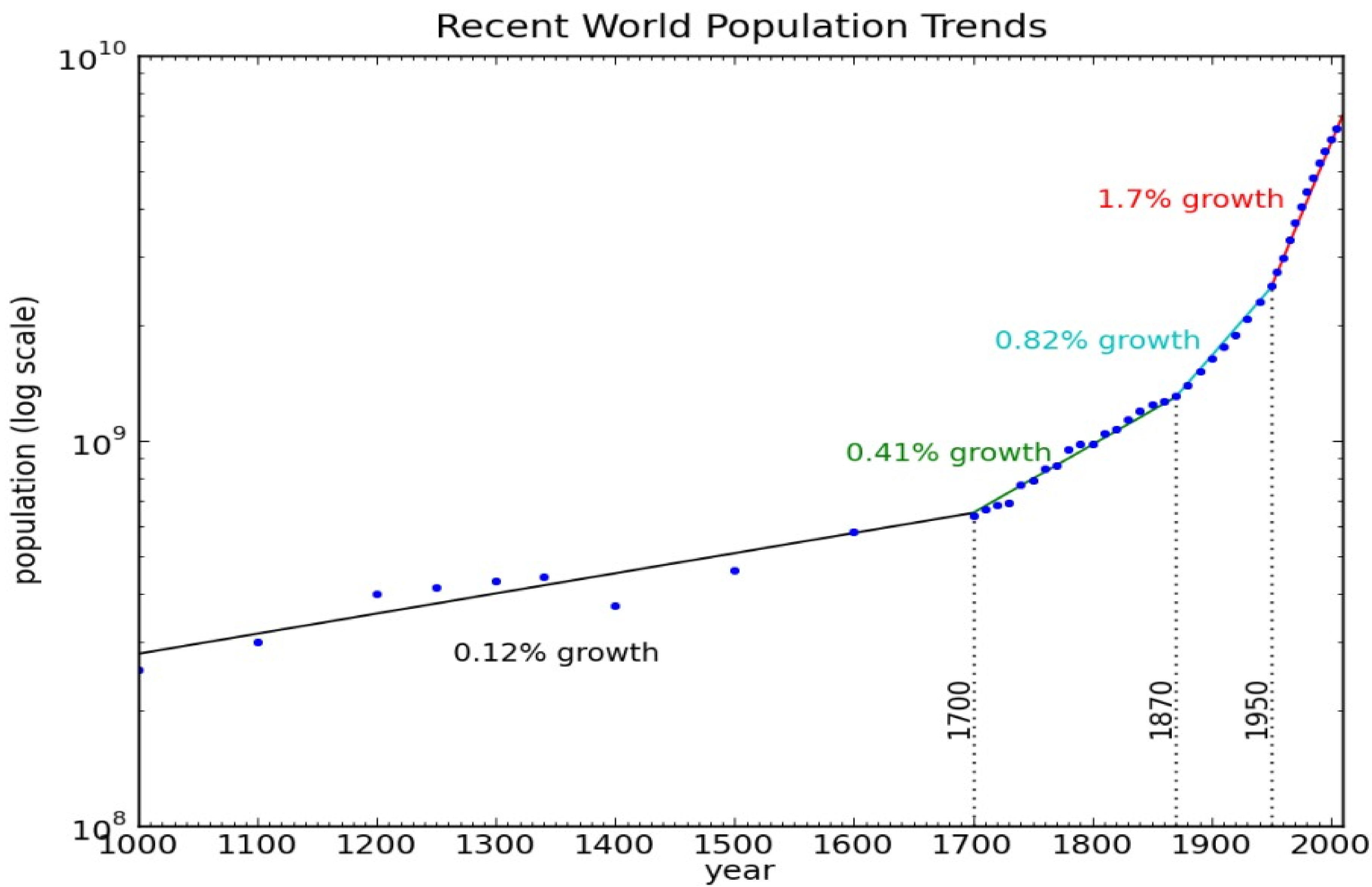
How did we get here – and where are we going next?



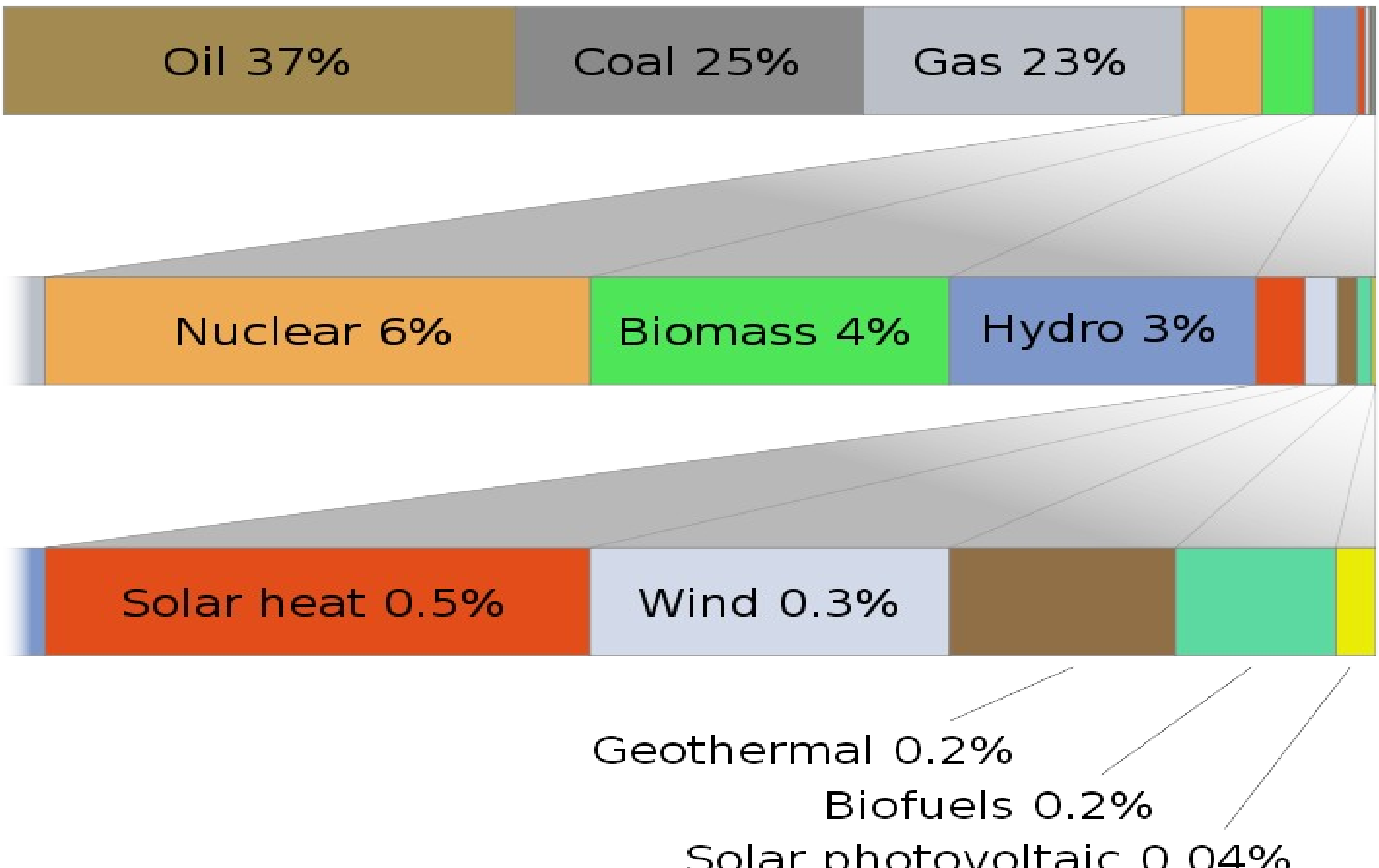
Another point of view



Humanpopulationens tillväxt (OBS: lin-log-skala):



Where does the energy come from?



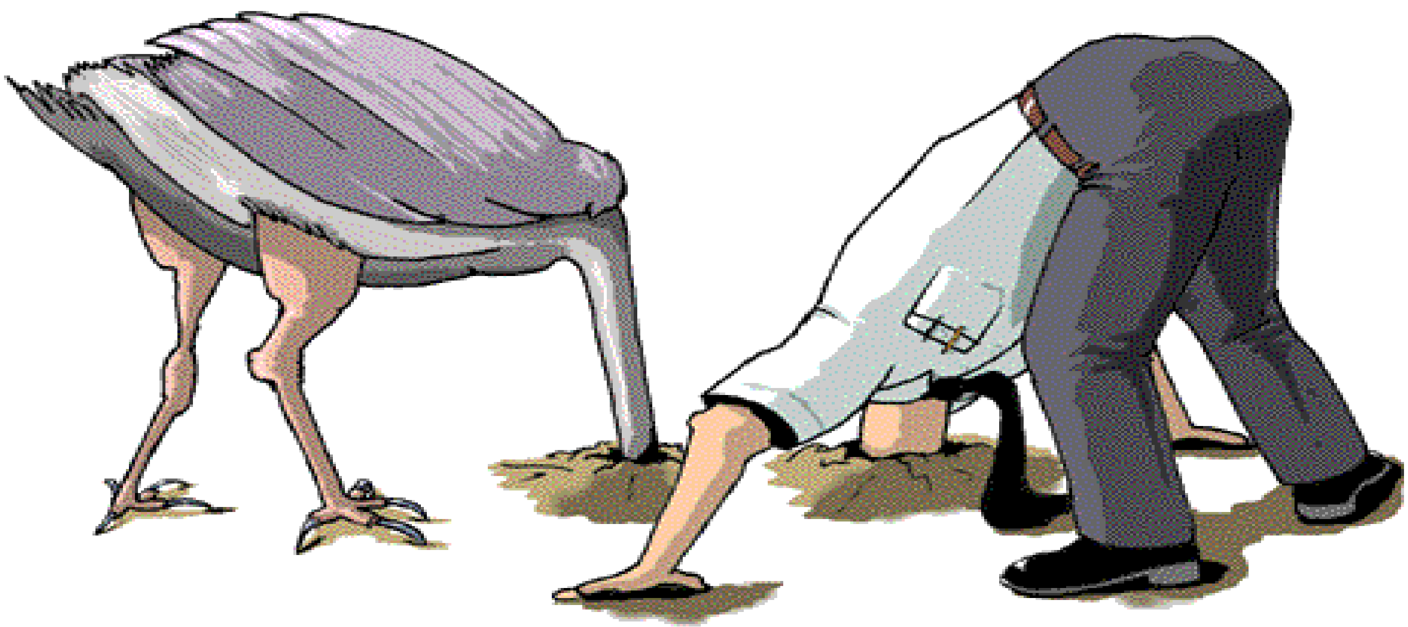
85+ per cent fossil fuels!!

Good Grief! We sure have a problem!

Or, actually, (at least) *three* problems:

- Anthropogenic Global Weirding, AGW
- Resource depletion
- A population biology problem

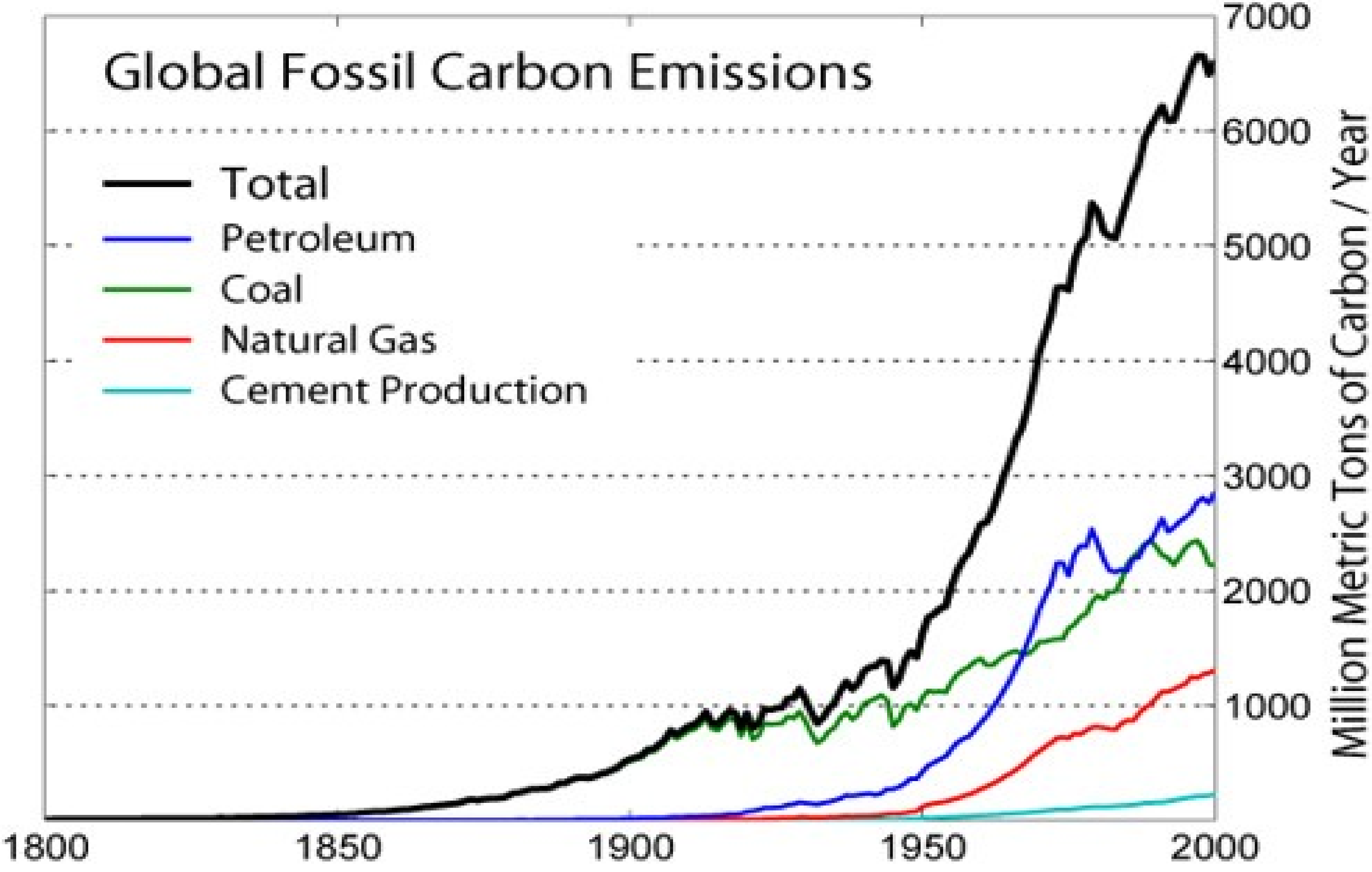
Foten i en rävsax och huvudet i sanden -

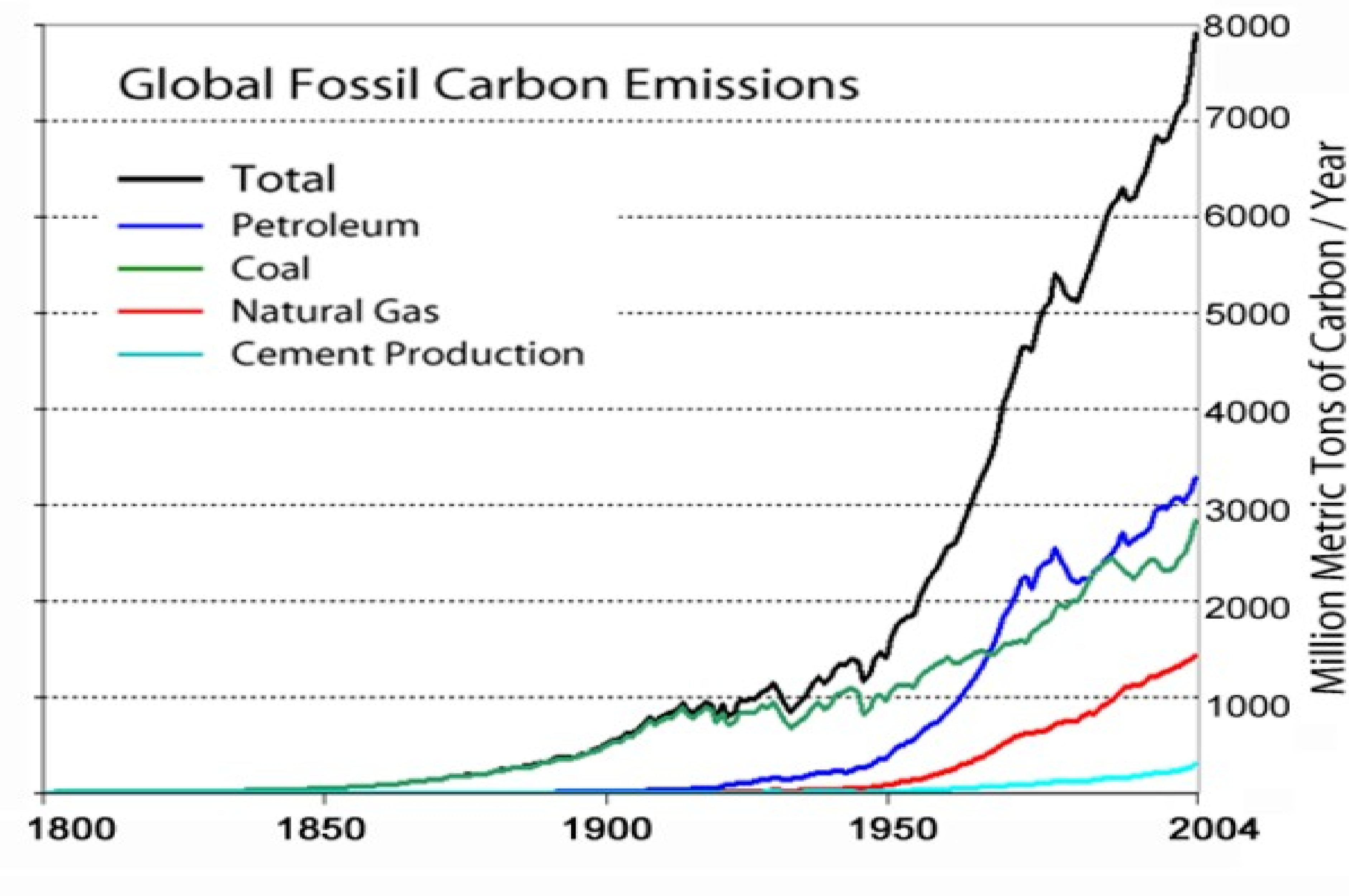


– en synnerligen obekväm, ohållbar (och oestetisk) position

Vi inleder med (den globala) rävsaxen:

1.Fossil fuels generate carbon emissions

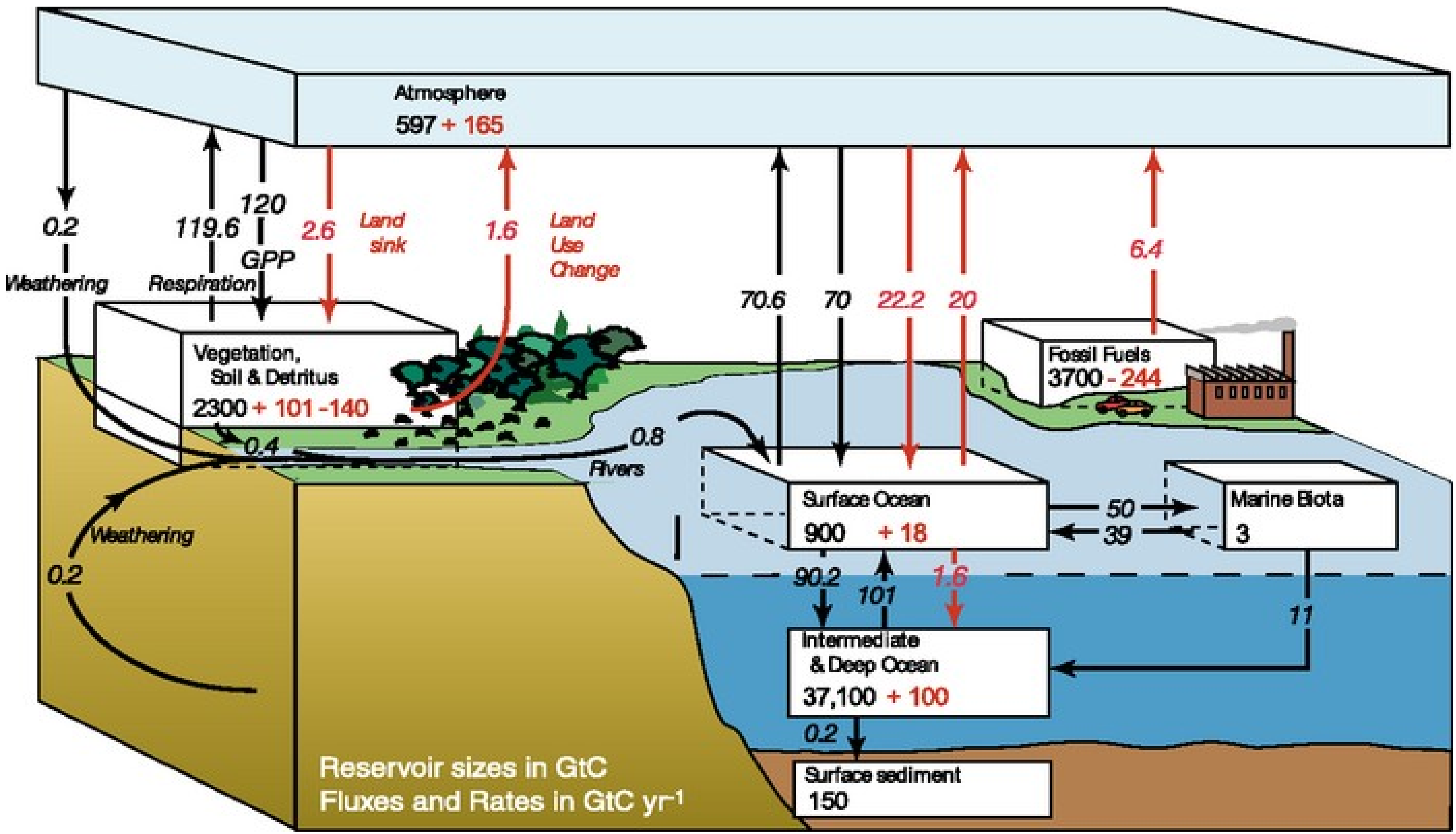


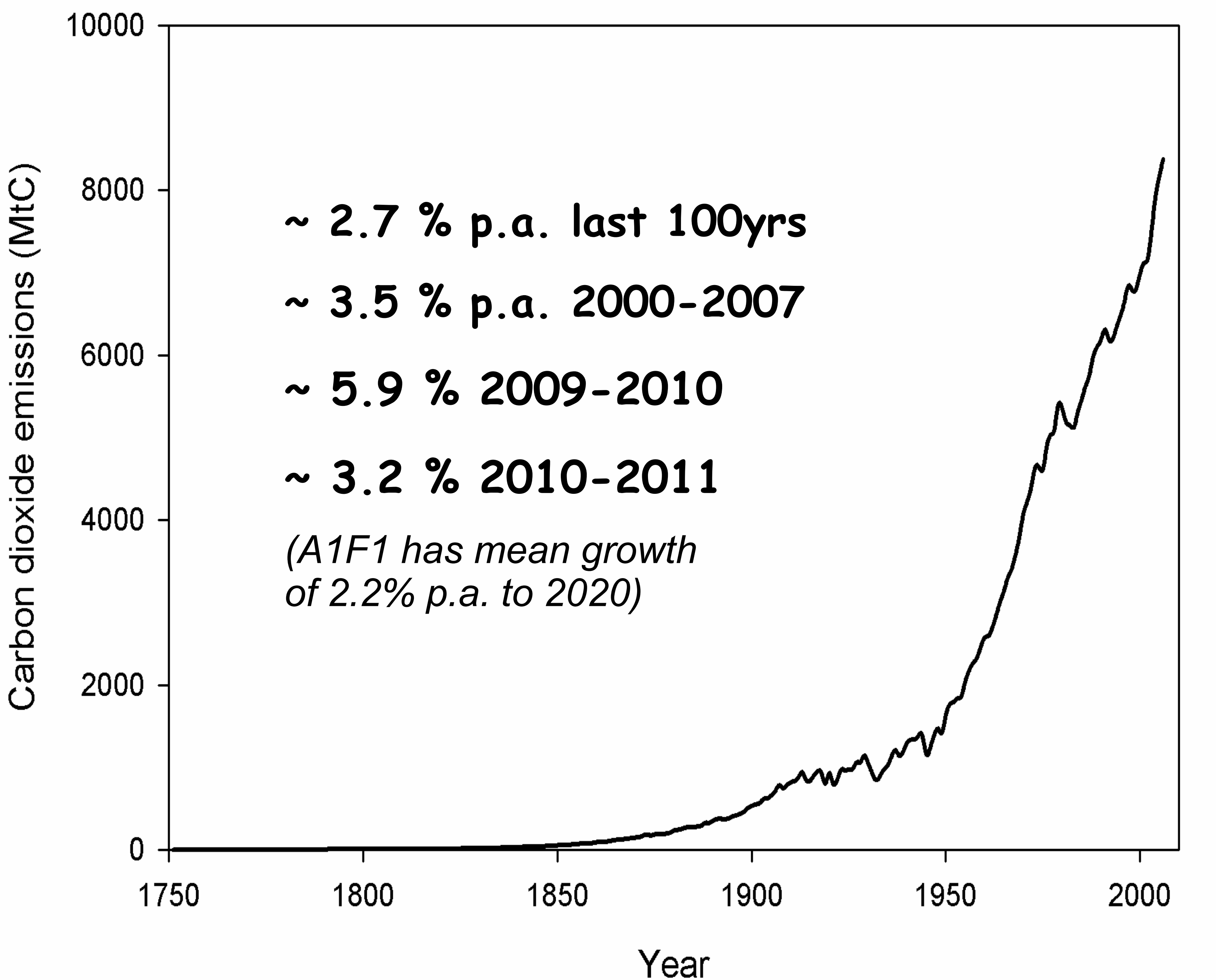

Global Fossil Carbon Emissions
Total
Petroleum
Coal
Natural Gas
Cement Production
8000
7000
6000
5000
4000
3000
2000
1000
Million Metric Tons of Carbon / Year
1800
1850
1900
1950
2004

Andra koldioxidkällor

Ytterligare bidrag kommer från avskogningen i tropikerna: avverkning av 13 miljoner hektar skog (30 procent av Sveriges yta!) varje år – mellan en halv och en fotbollsplan i sekunden - bidrar med 6.5 miljarder ton koldioxid årligen.

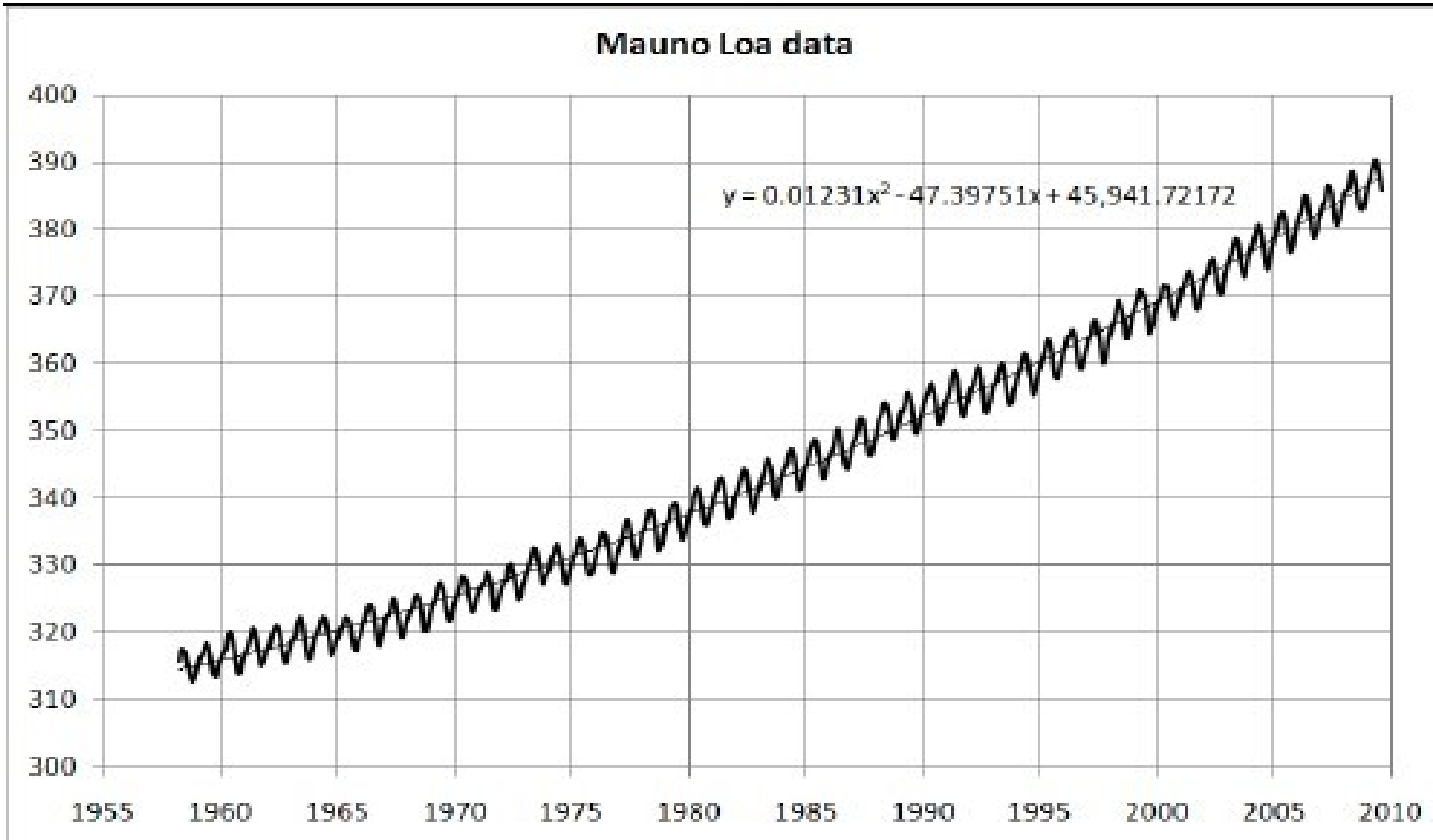
Kolets vägar genom världen:

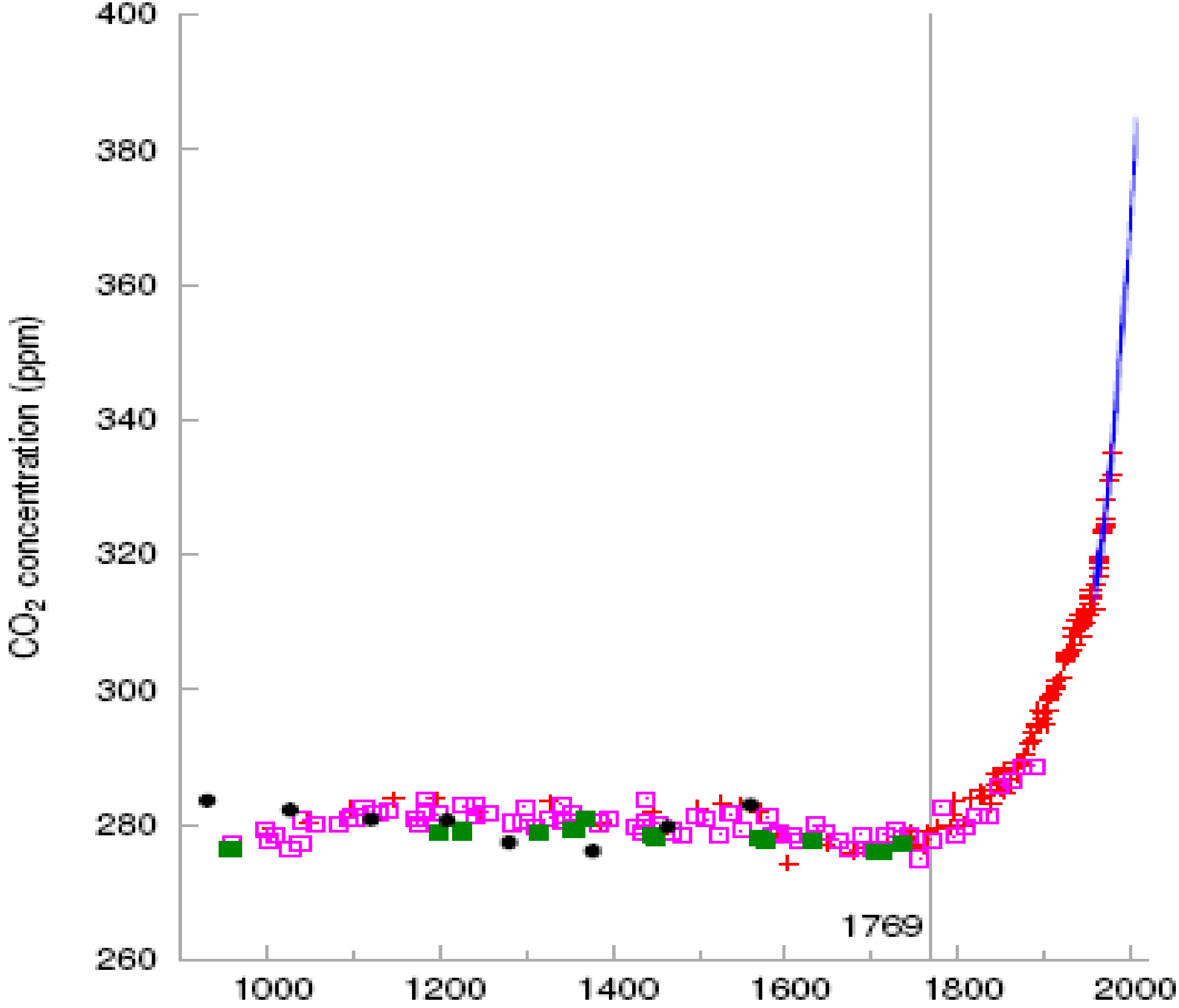




10000
8000
6000
4000
2000
0
Carbon dioxide emissions (MtC)
1750
1800
1850
1900
1950
2000
Year
~ 2.7 % p.a. last 100yrs
~ 3.5 % p.a. 2000-2007
~ 5.9 % 2009-2010
~ 3.2 % 2010-2011
(A1F1 has mean growth
of 2.2% p.a. to 2020)

The Keeling curve (Mauna Loa, Hawaii)



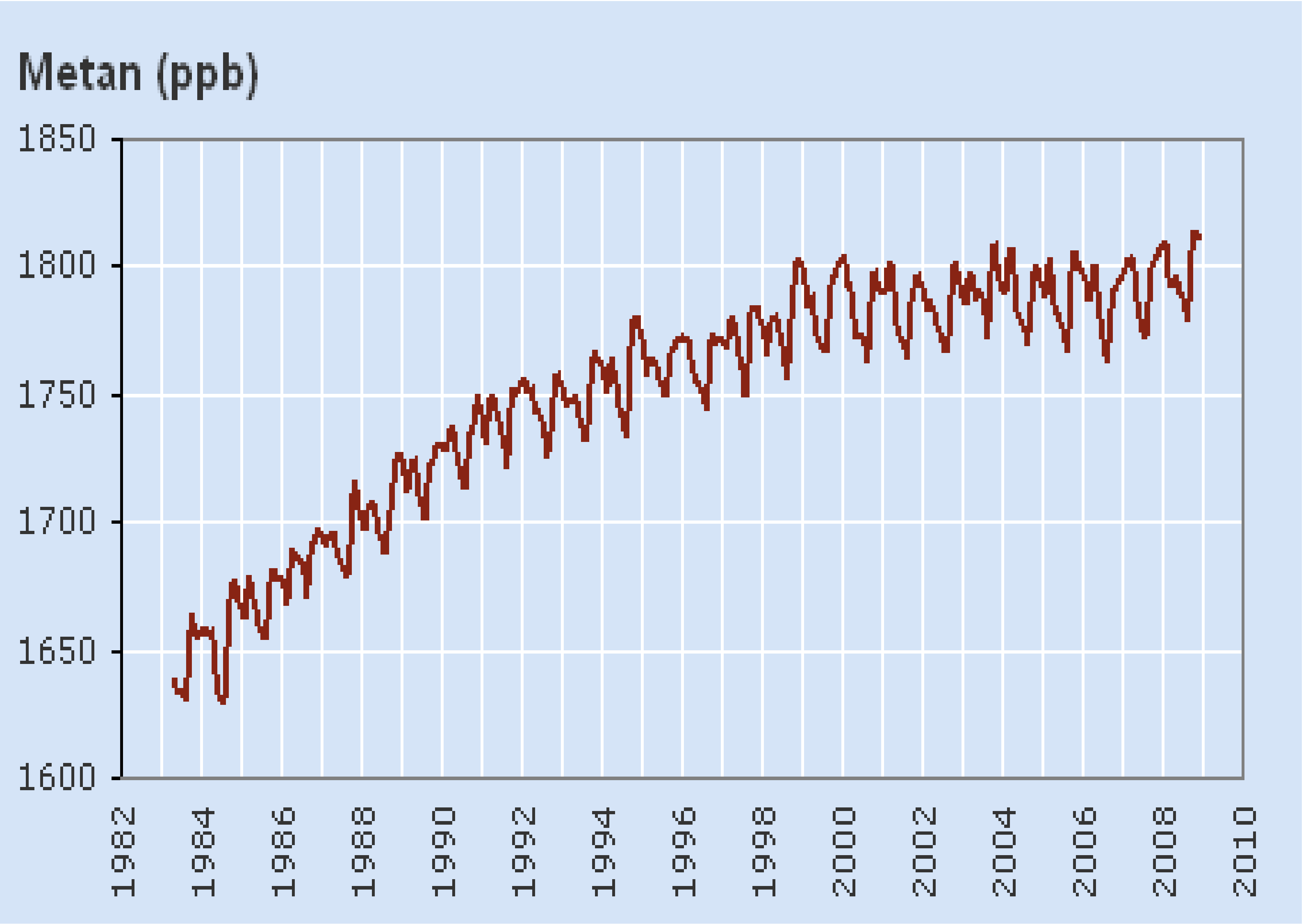


CO_2 concentration (ppm)
400
380
360
340
320
300
280
260
1769
1000
1200
1400
1600
1800
2000

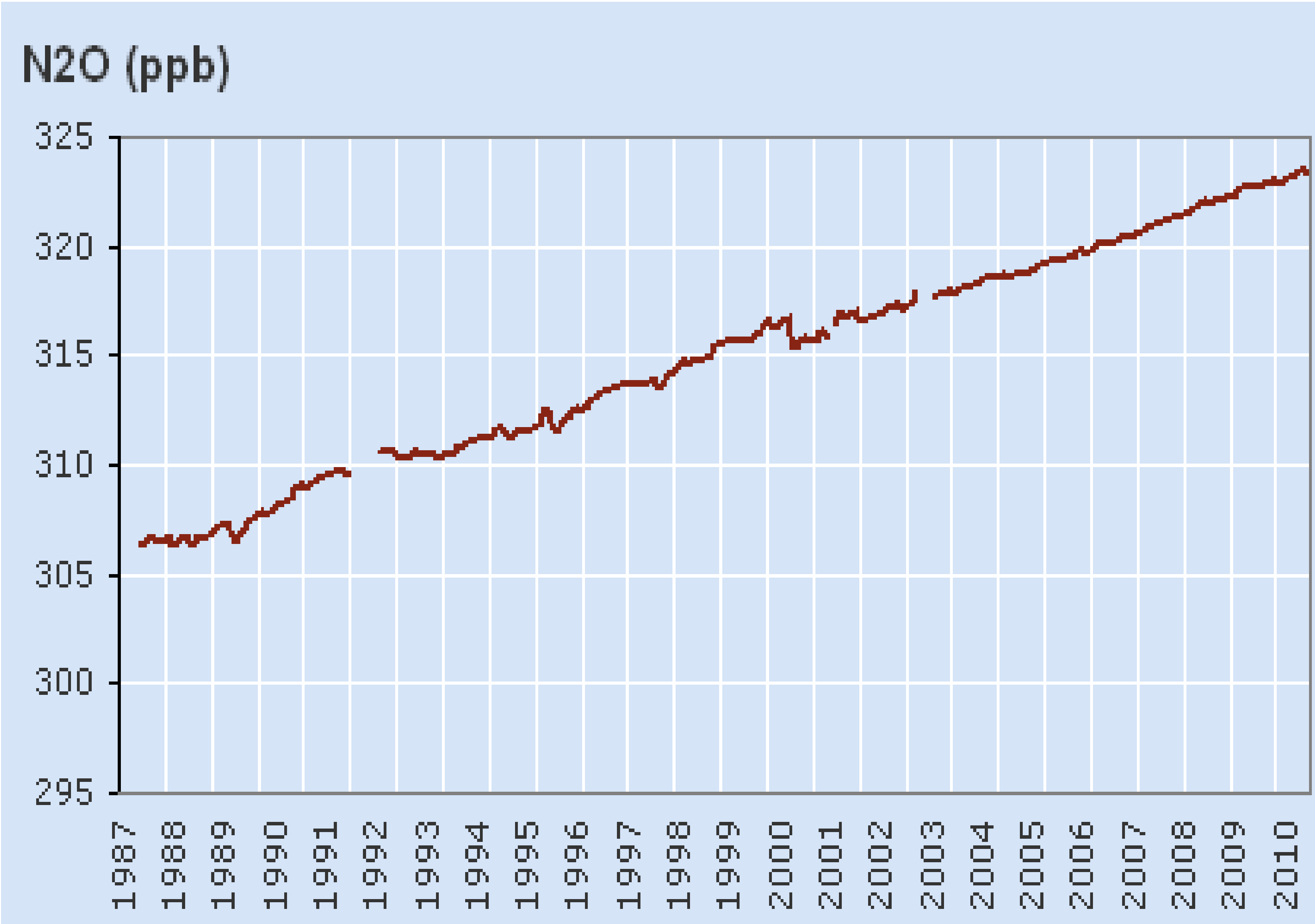

CO2
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
CO2 parts per million
current level
For 650,000 years, atmospheric CO2 has never been above this line ... until now
1950
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
YEARS before today (0 = 1950)

Andra klimatpåverkande gaser

- Metan
- Dikväveoxid (lustgas)
- Fluorkolväten (freoner)
- Ozon (den marknära sorten)
- Sot (njaaa ... ingen gas, detta)
- Aerosoler (inte heller en gas)
- Svavelhexafluorid



Metan (ppb)
1850
1800
1750
1700
1650
1600
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

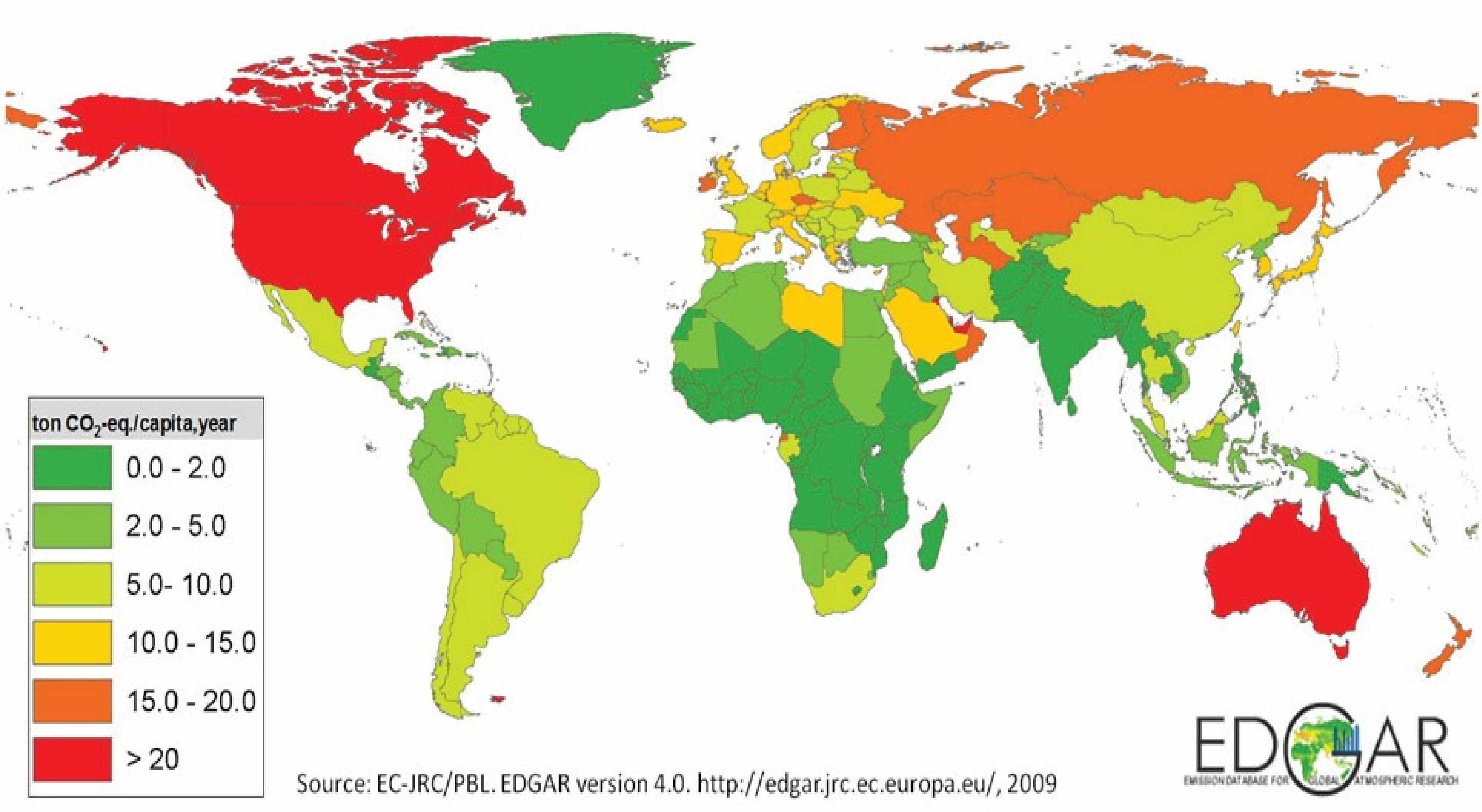

N2O (ppb)
325
320
315
310
305
300
295
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

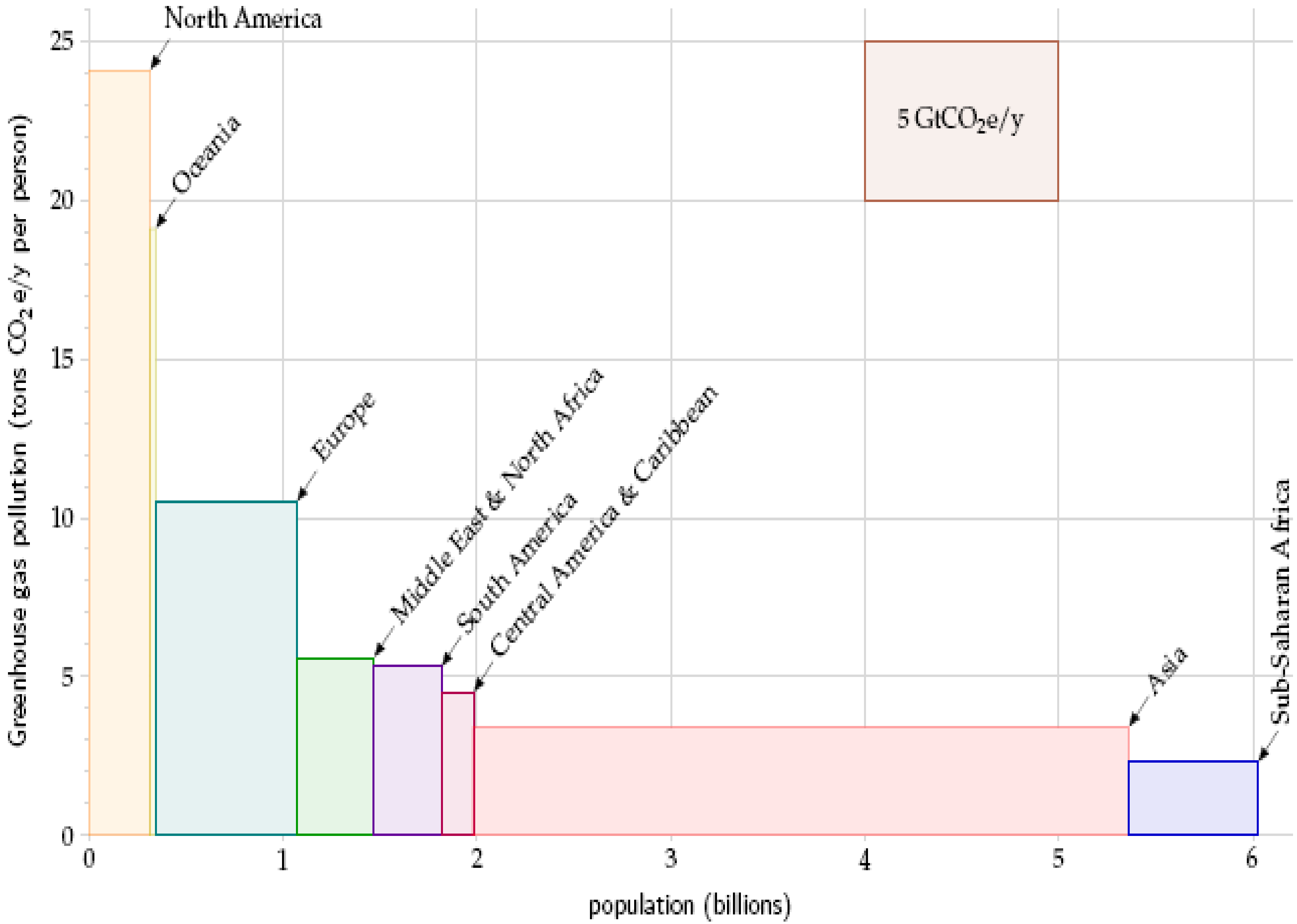
CO_2 , CO_2(e), CO_2(kyoto) ...

CO_2(e): Anger mängd av en växthusgas uttryckt som den mängd koldioxid som (momentant) ger samma klimatpåverkan

60 procent av utsläppen av GHG är CO_2
40 procent är lustgas (dikväveoxid, N_2O), metan (CH_4), fluorkolväten etc.

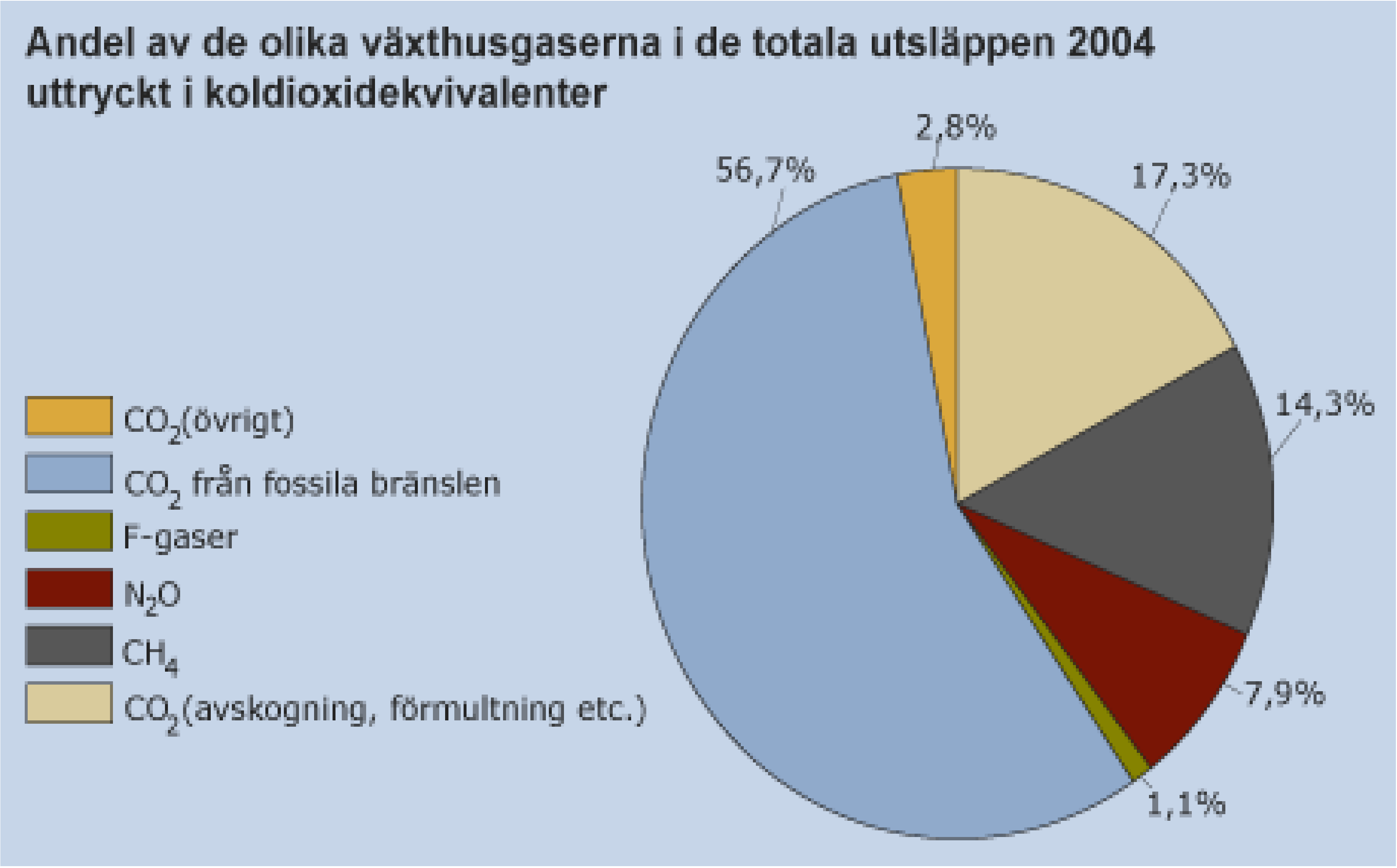
Utsläpp per person 2005



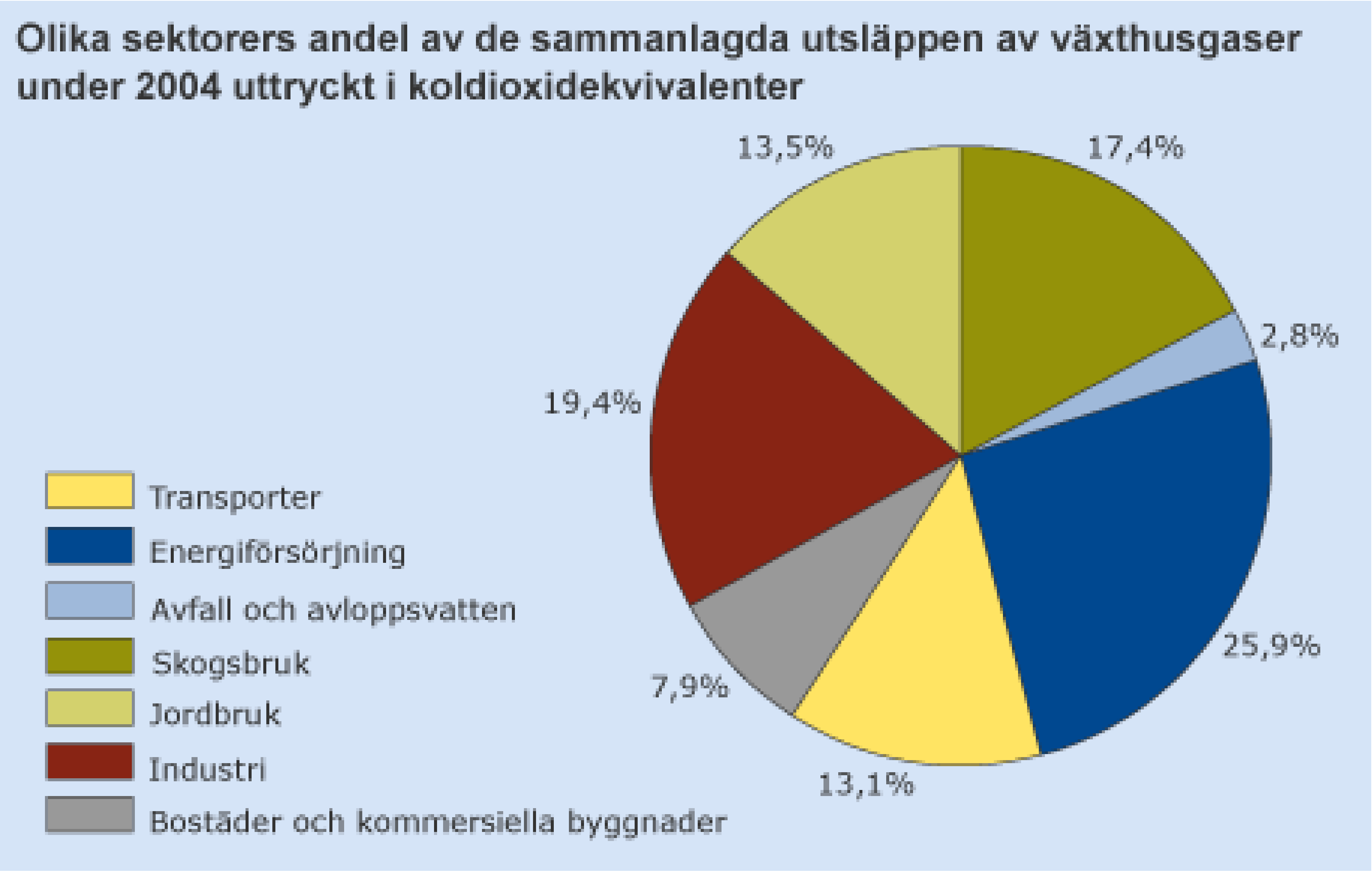


North America
Oceania
Europe
Middle East & North Africa
South America
Central America & Caribbean
Asia
Sub-Saharan Africa
5 $GtCO_2e/y$
Greenhouse gas pollution (tons CO_2e/y per person)
population (billions)
0
5
10
15
20
25
0
1
2
3
4
5
6

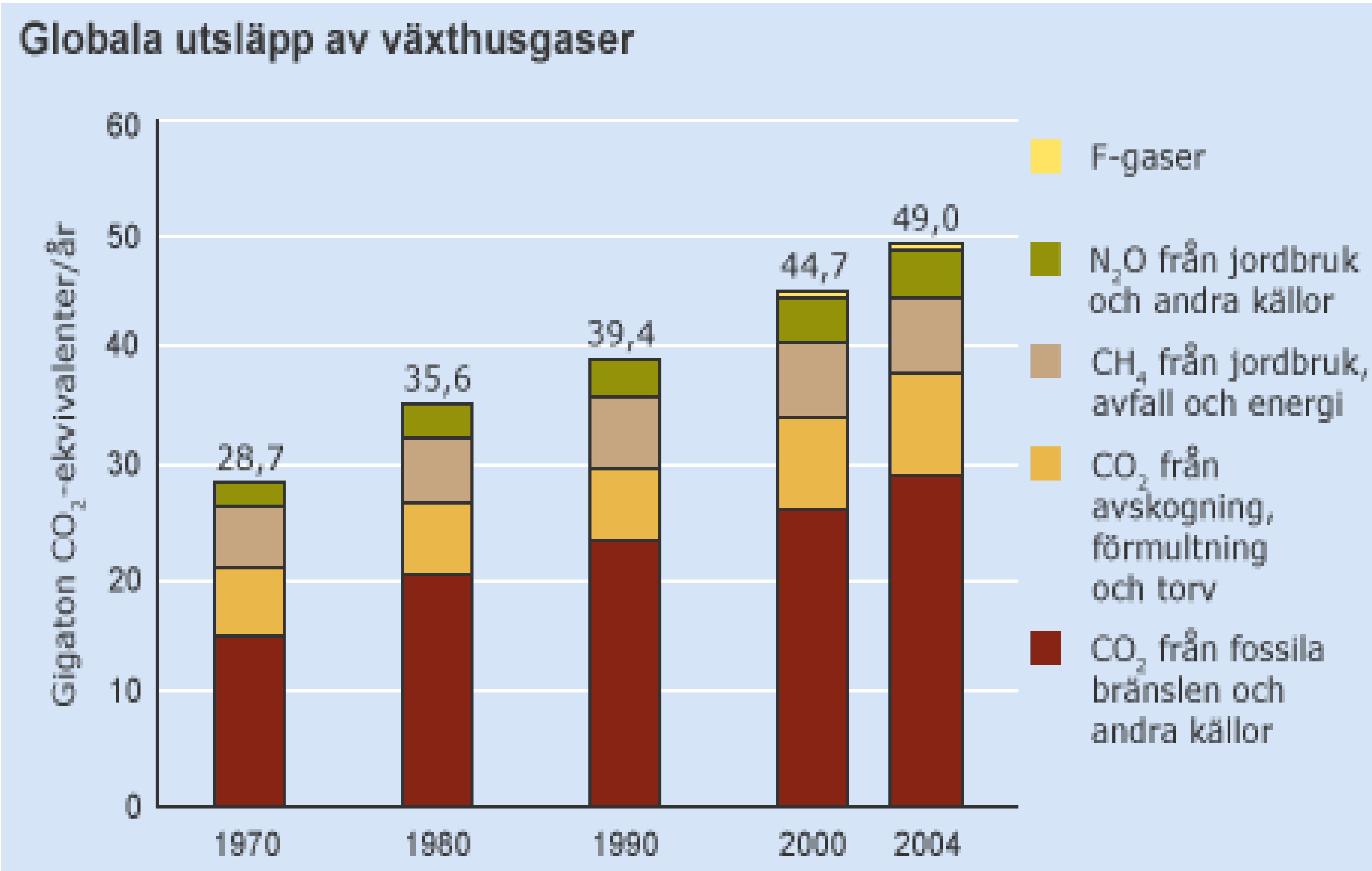
Fördelning på gaser



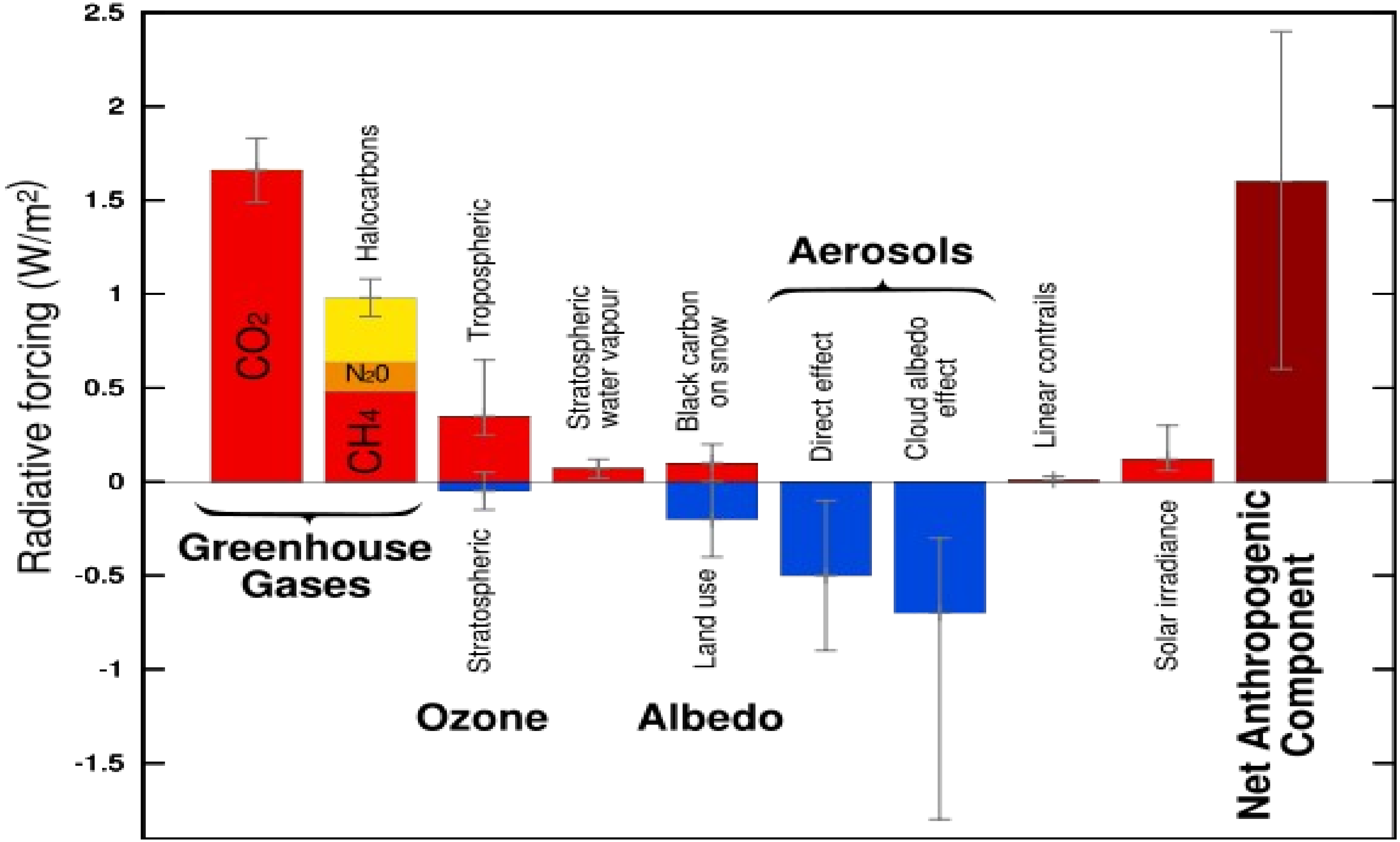
Fördelning på sektorer



Hur kom vi hit???

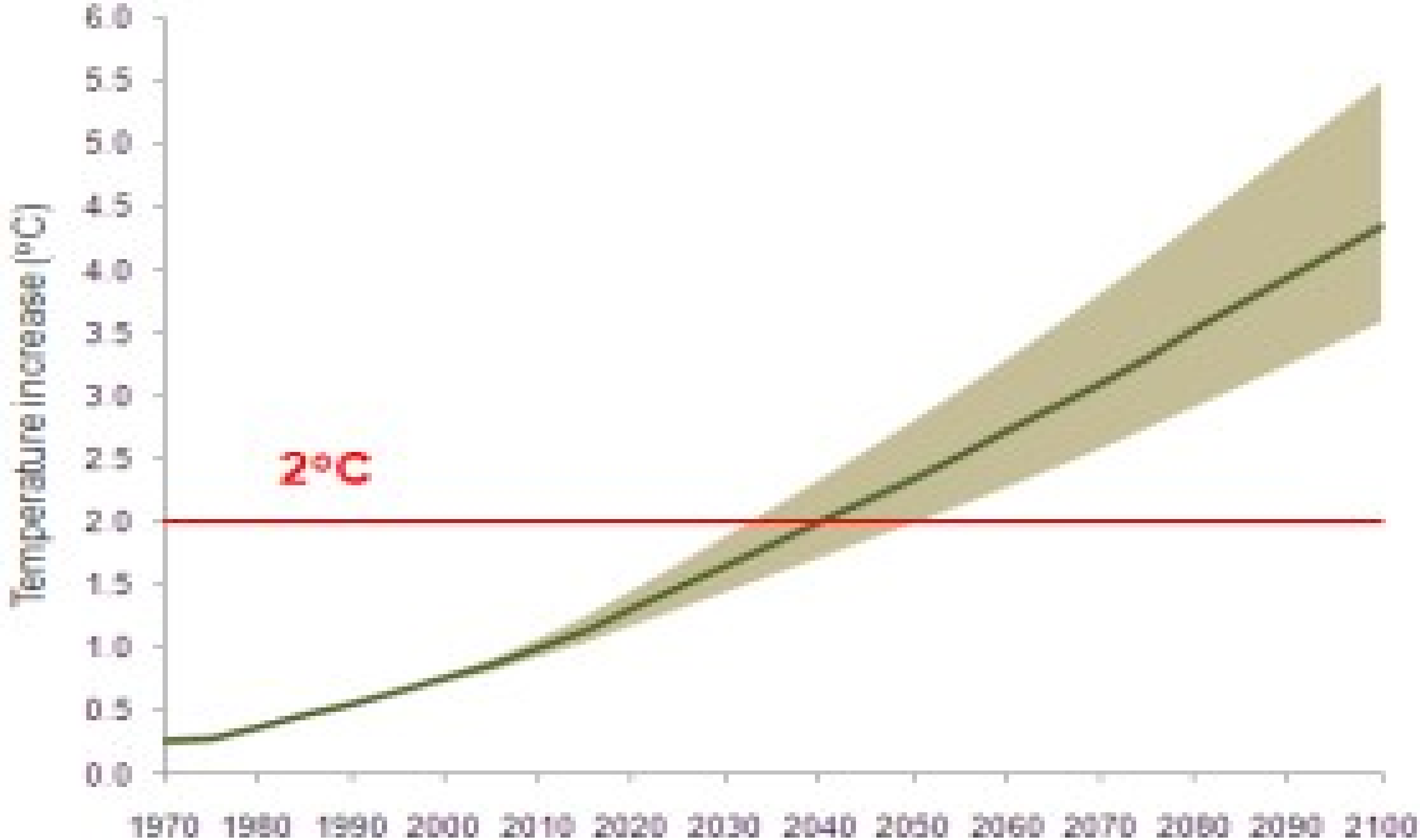


Radiative Forcing Components



Långsiktig temperaturutveckling

(OECD:s generalsekreterare Angel Gurra 24 nov 2011)



Outcome magazine, March 27, 2012

"I think two degrees is out of reach", Yvo de Boer, former executive secretary of the UN's Framework Convention on Climate Change (UNFCCC), said on the sidelines of a conference here on June's Rio+20 summit.

More and more scientists are warning that the objective is slipping away without radical, early cuts in greenhouse-gas emissions. Some consider the goal to be a dangerous political mirage, for Earth is now on track for 3C (5.4 F) of warming or more.

Scientific American, March 26, 2012:

Global Warming Close to Becoming Irreversible

The world is close to reaching tipping points that will make it irreversibly hotter, making this decade critical in efforts to contain global warming, scientists warned on Monday.

The world's temperature looks set to rise by six degrees Celsius by 2100 if greenhouse gas emissions are allowed to rise uncontrollably.

From interview with senior political scientist (2010; källa: Kevin Anderson, Tyndall Centre):

Too much is invested in 2°C for us to say it's not possible –
it would undermine all that's been achieved

It'll give a sense of hopelessness –
we may as well just give in

Are you suggesting we have to lie about our research findings?

Well, perhaps just not be so honest –
more dishonest …"

Borde vi alltså ge upp tvågradersmålet och i stället satsa på, säg, ett fyragradersmål?

Kevin Anderson, bitr föreståndare för Tyndall Centre for Climate Change Research säger

NEJ!

Ty:

For 4°C global mean surface temperature:

5°C - 6°C global *land* mean
& increase °C on the hottest days of:

6°C - 8°C in China
8°C - 10°C in Central Europe
10°C - 12°C in New York

In low latitudes 4°C gives

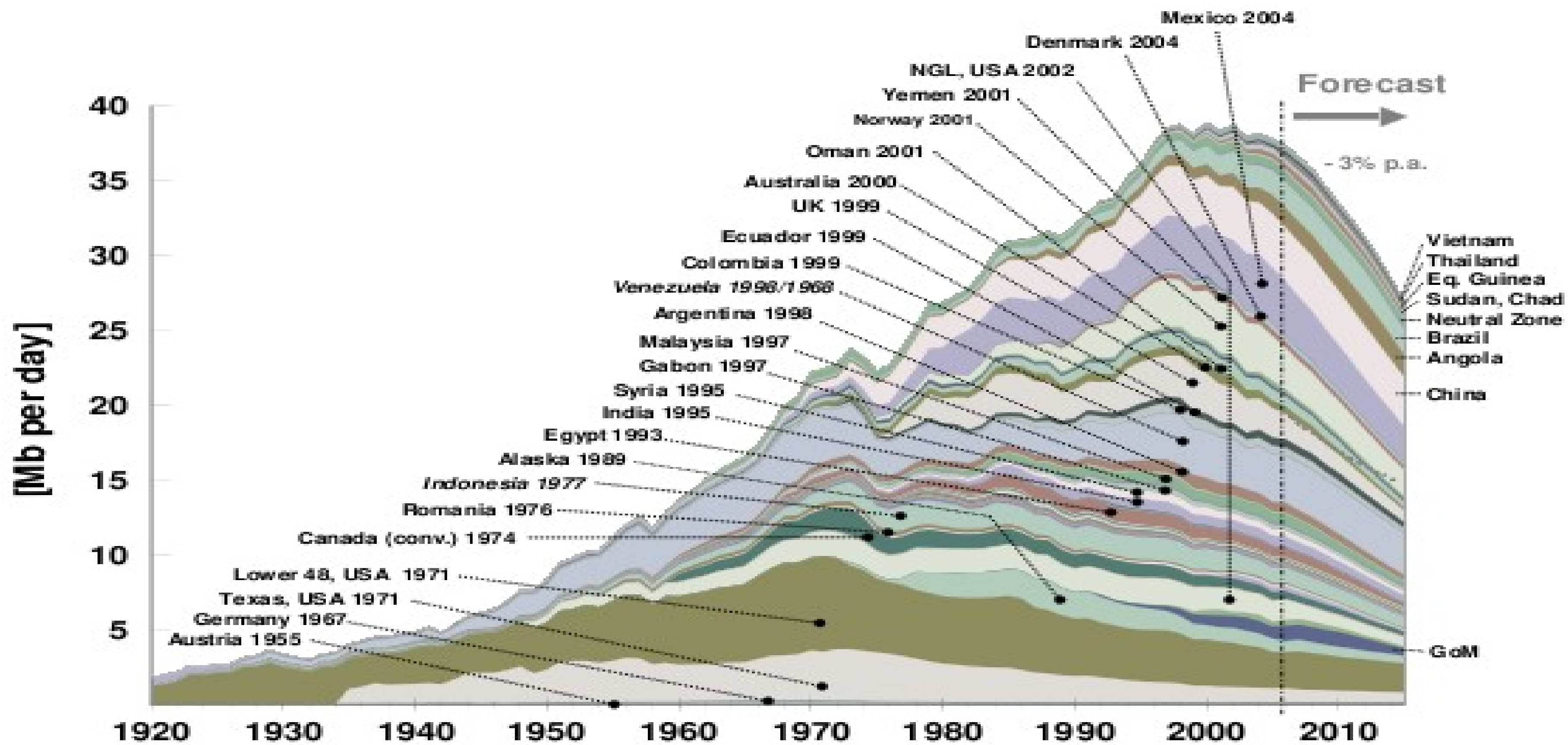
up to 40% reduction in maize & rice

as population heads towards 9 billion by 2050

Stämningsbild från Australien

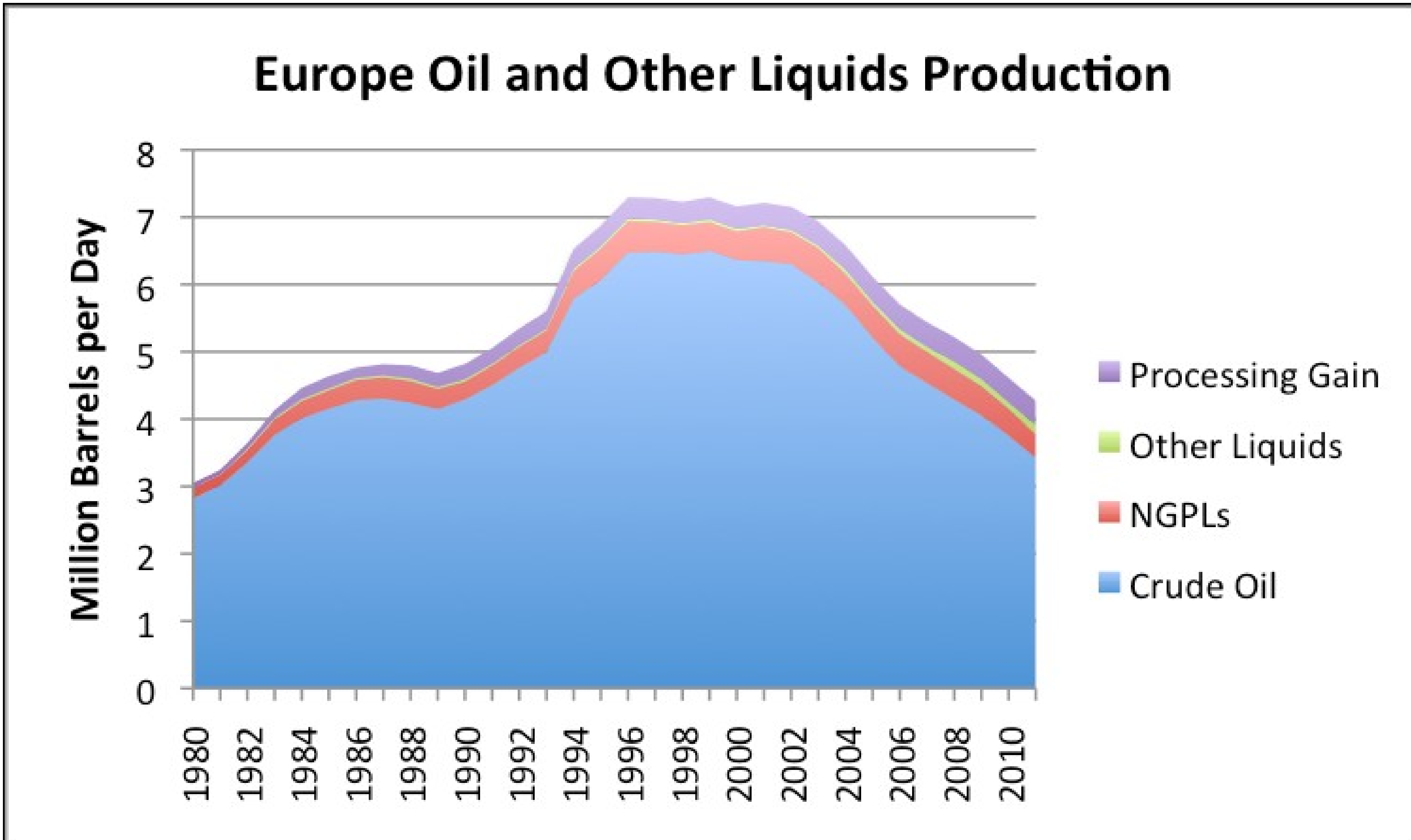
2. Resource depletion

Figure 5: Oil producing countries past peak

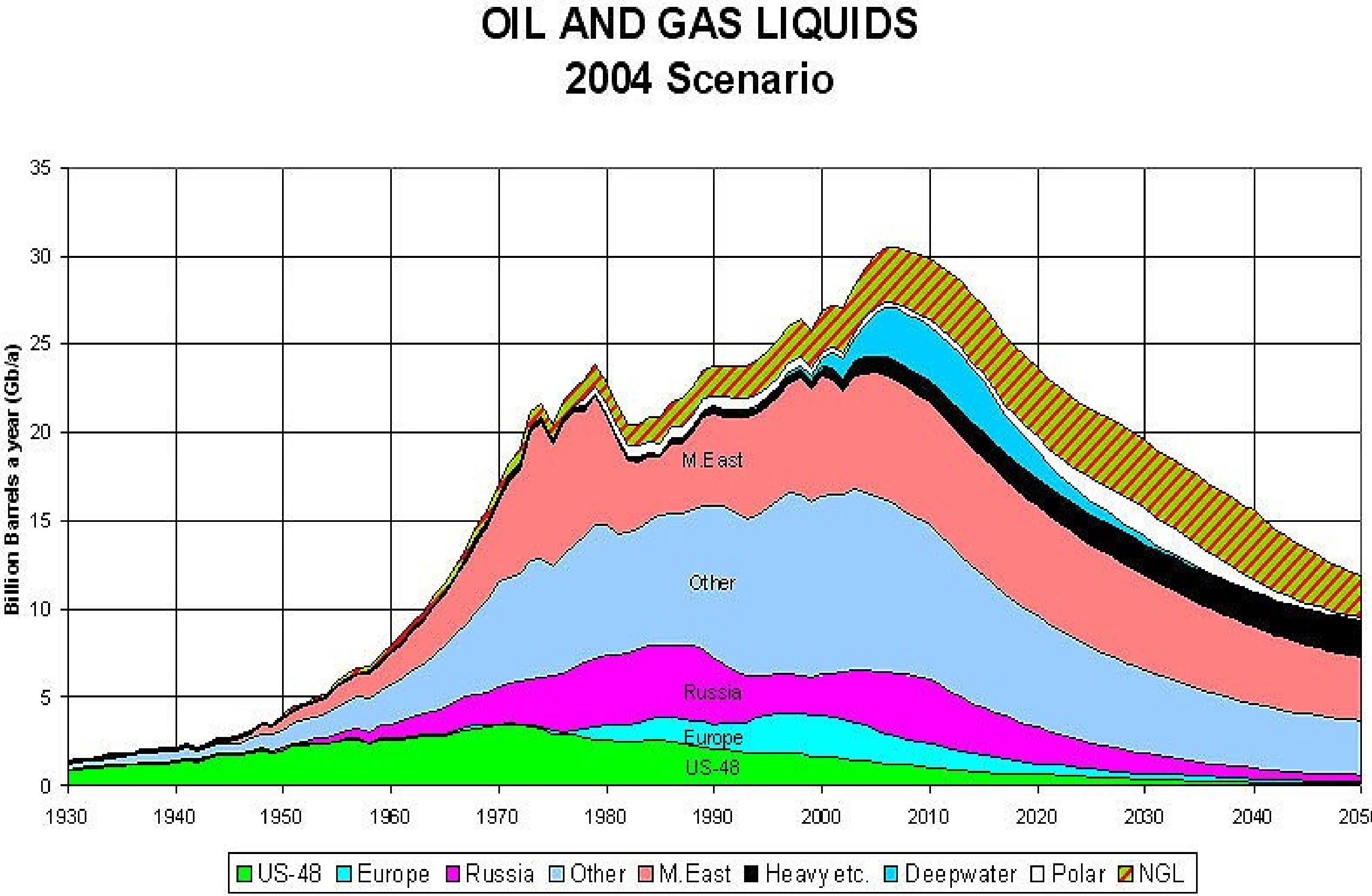


Ludwig-Bölkow-Systemtechnik GmbH, 2007
Source: IHS 2006; PEMEX, petrobras; NPD, DTI, ENS(Dk), NEB, RRC, US-EIA, January 2007
Forecast: LBST estimate, 25 January 2007

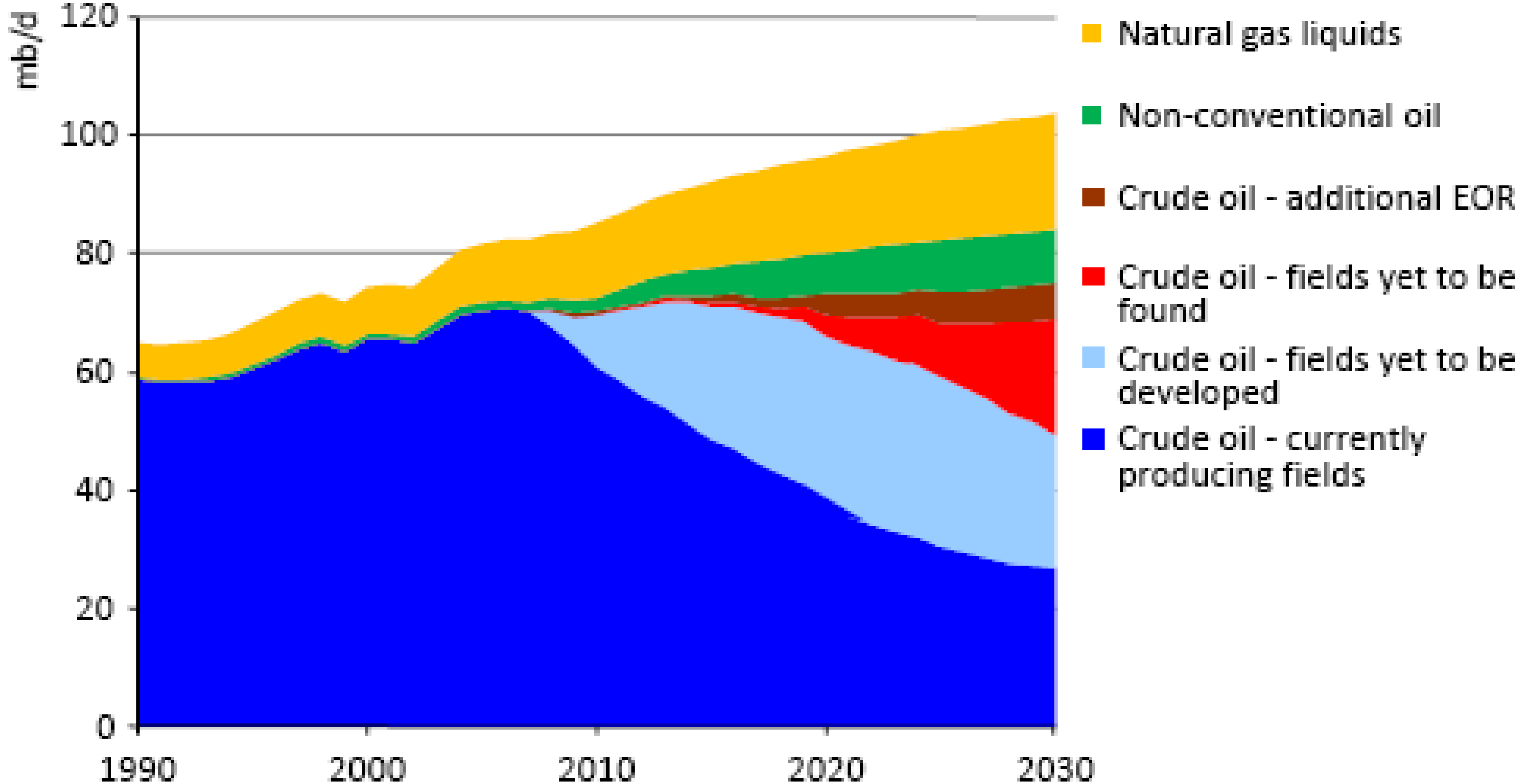
Verkligheten tränger sig på:



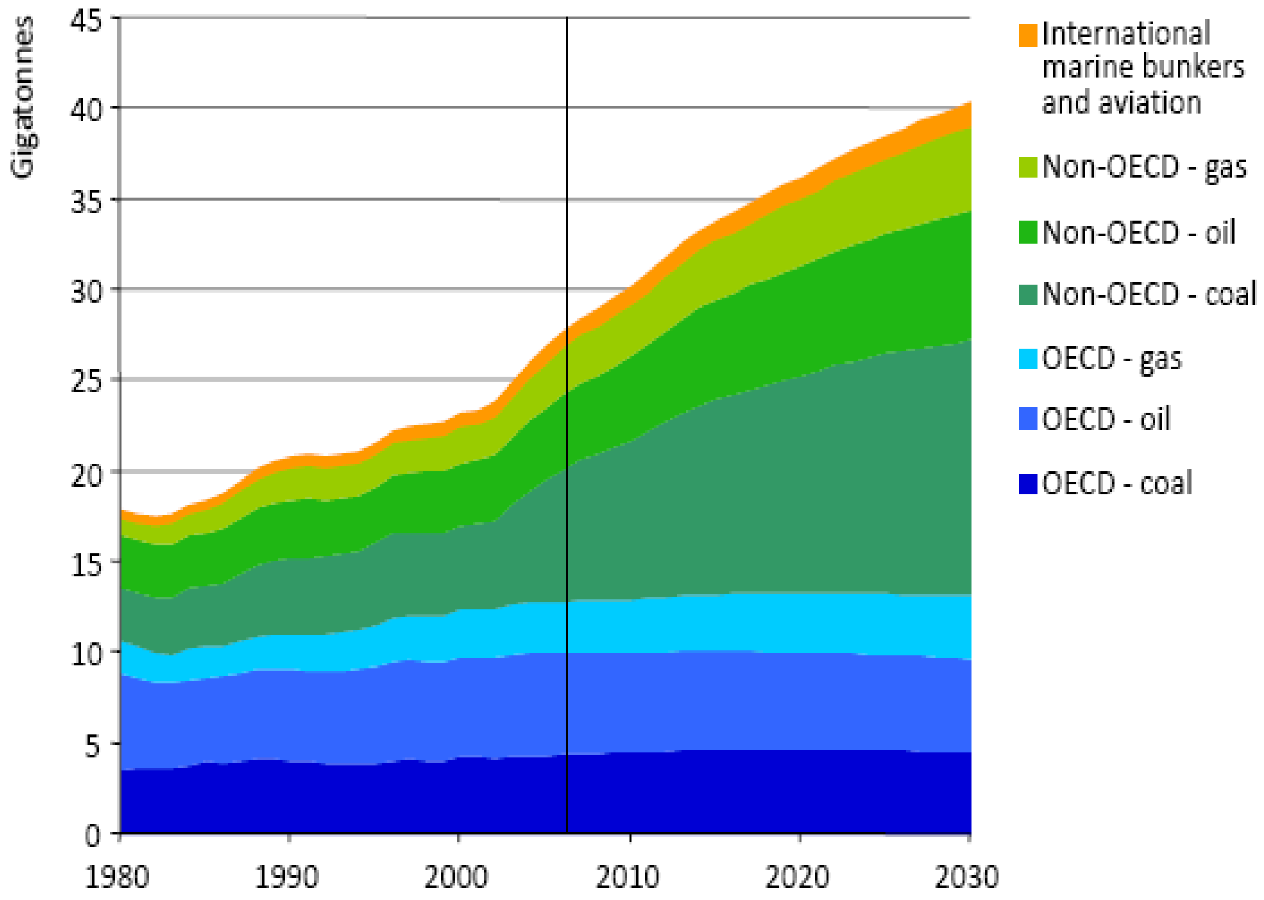
En något föråldrad prognos:



International Energy Agency prediction

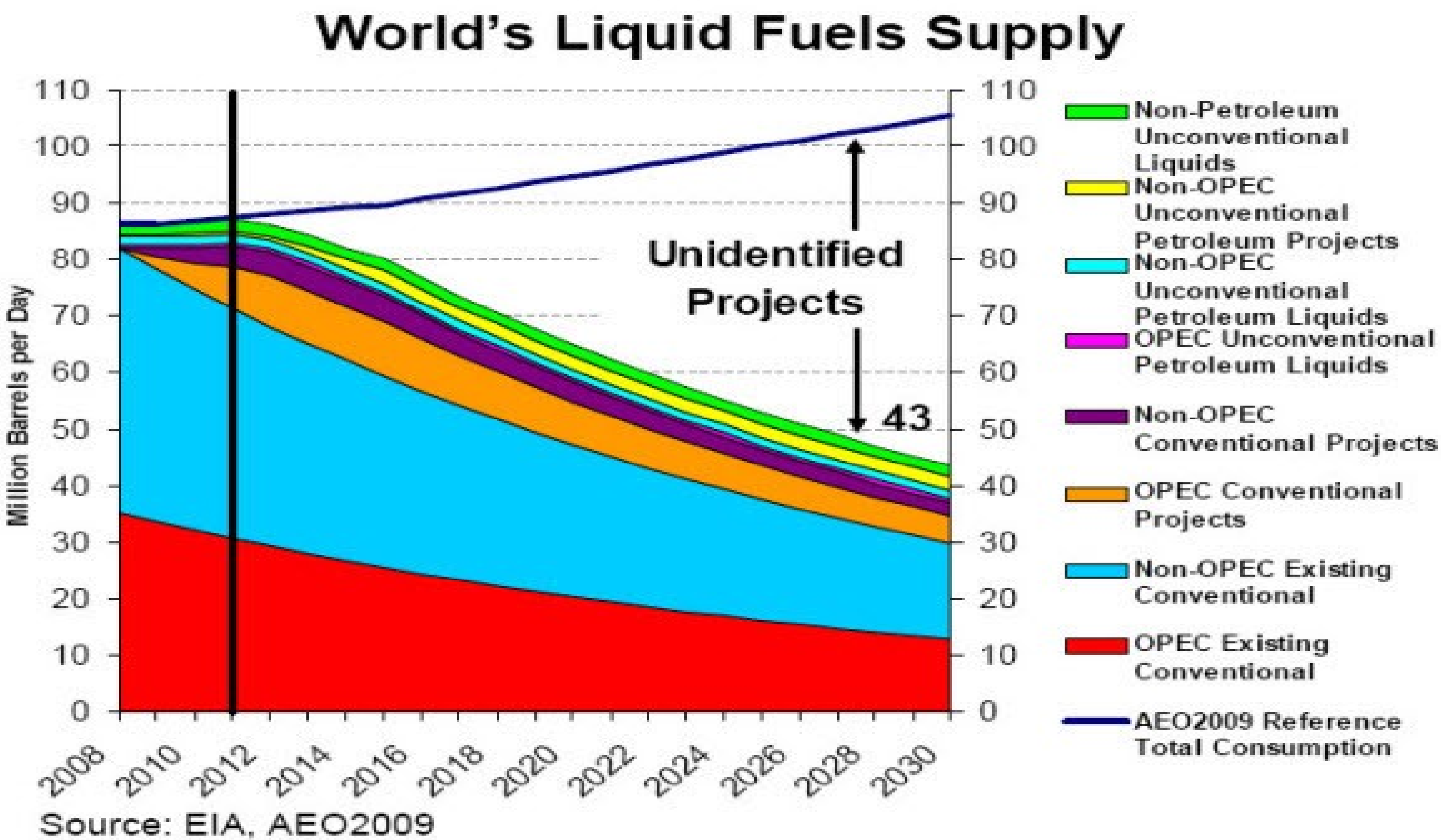


En annan prognos från IEA:



97% of the projected increase in emissions between now & 2030 comes from non-OECD countries – three-quarters from China, India & the Middle East alone

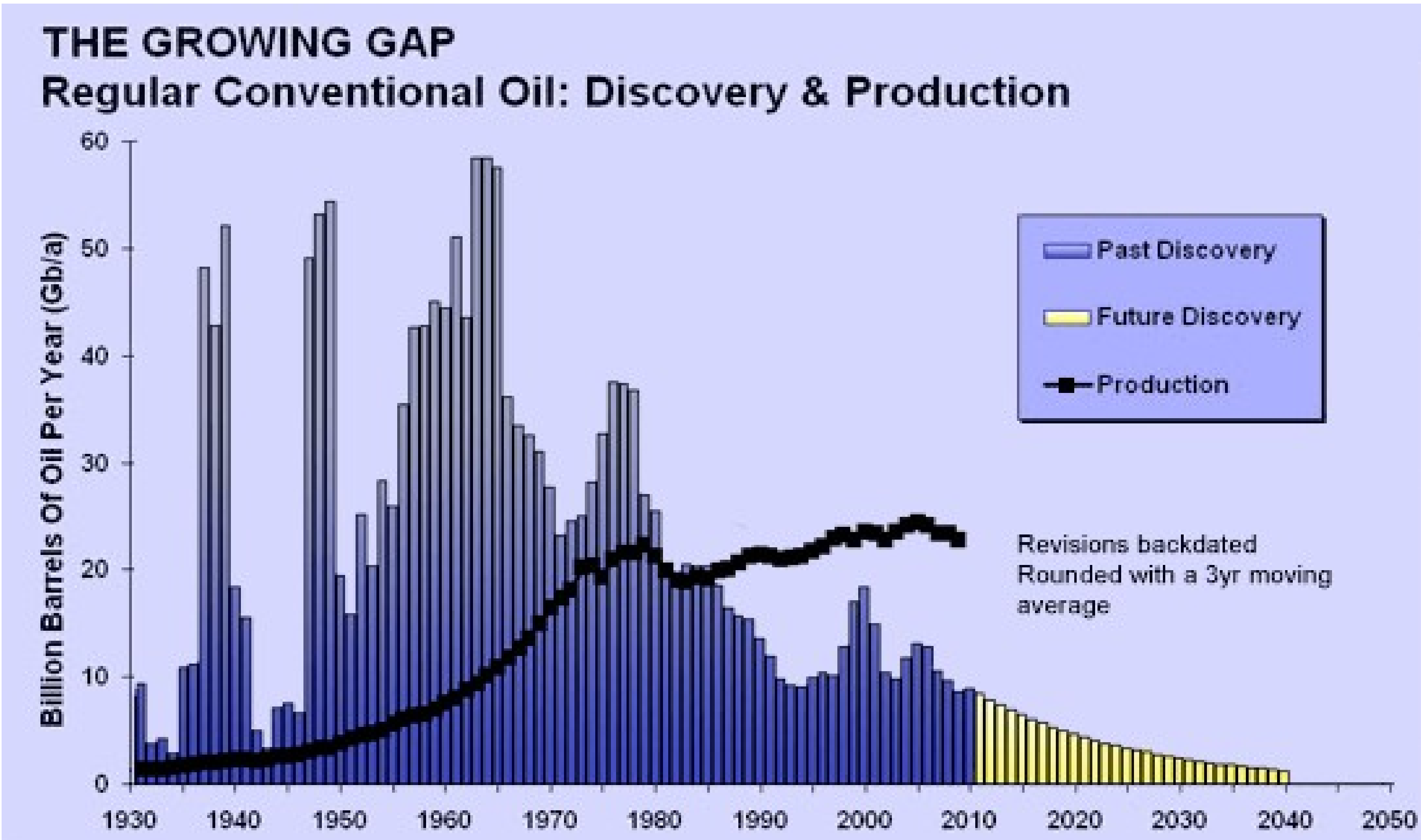
Existerar all denna olja och gas?
Här är EIA:s syn på den saken:



Världen vimlar dock av jokrar:

- Fynd vs utvinning
- Fracking (olja & gas)
- Tjärsand
- Energy Return on Energy Invested, ERoEI

Oljeutvinning och nya fynd:

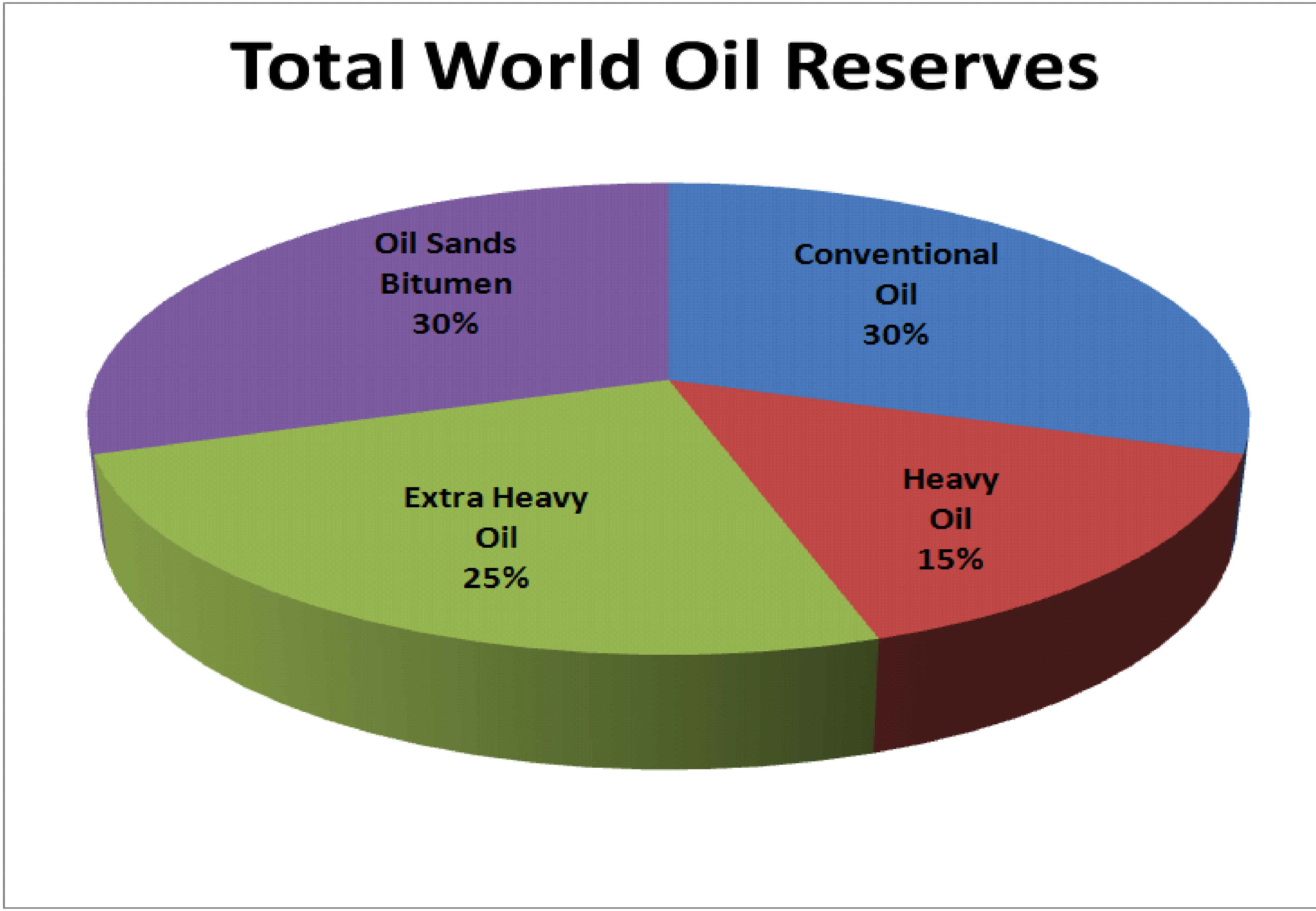


Robert Hirsch, huvudansvarig för rapporten

Peaking of World Oil production (2005)

säger idag följande:

The world has never faced a problem like this. Without massive mitigation more than a decade before the fact, the problem will be pervasive and will not be temporary. Previous energy transitions (wood to coal and coal to oil) were gradual and evolutionary; oil peaking will be abrupt and revolutionary.

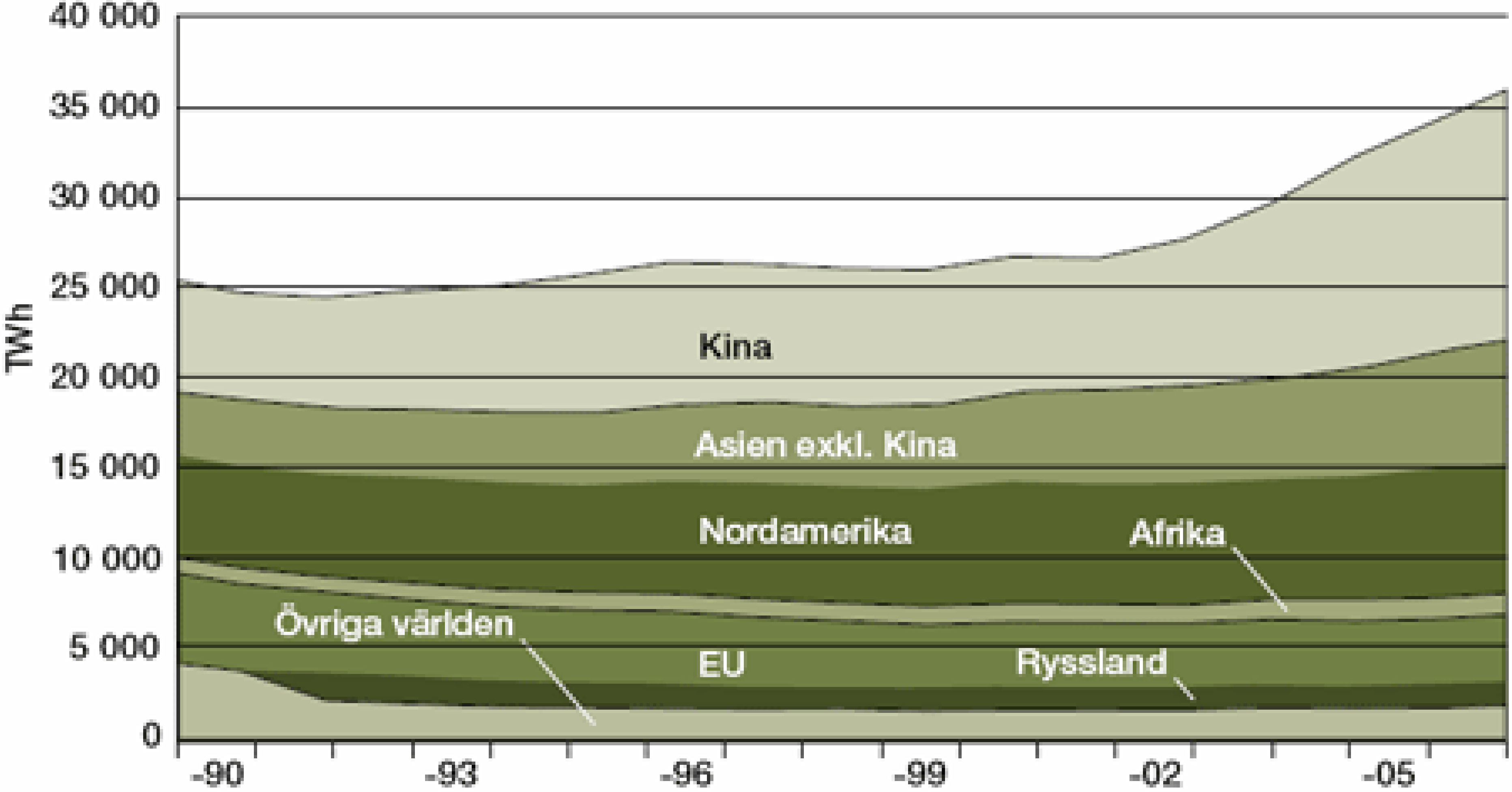

Total World Oil Reserves
Oil Sands Bitumen 30%
Conventional Oil 30%
Heavy Oil 15%
Extra Heavy Oil 25%

Stämningsbild från tjärsandsutvinning i Athabasca (Kanada)

Alberta Tar Sands © Garth Lenz

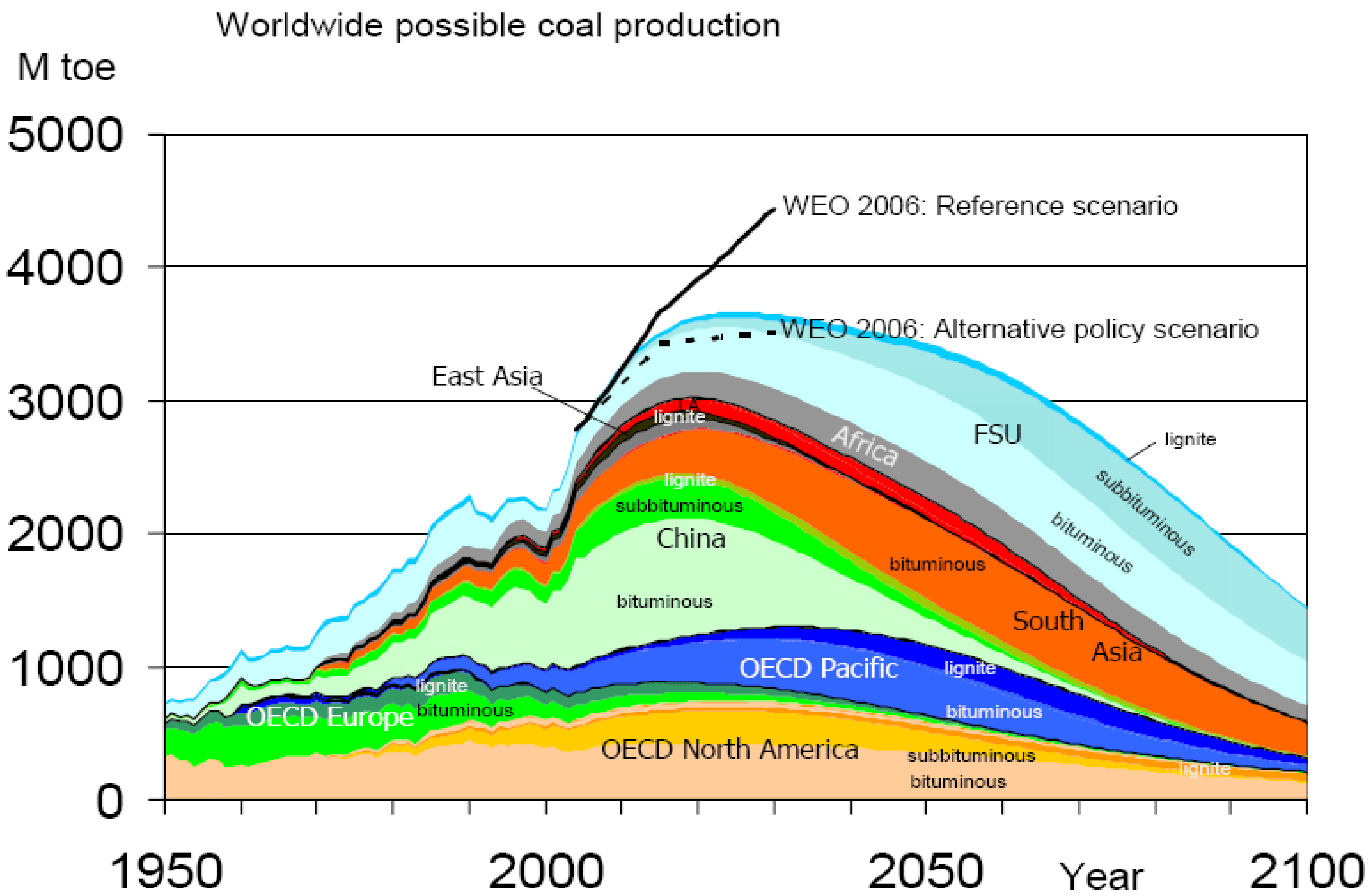
Människan lever emellertid inte av olja allenast ...

Figur 54: Världens kolanvändning 1990–2006



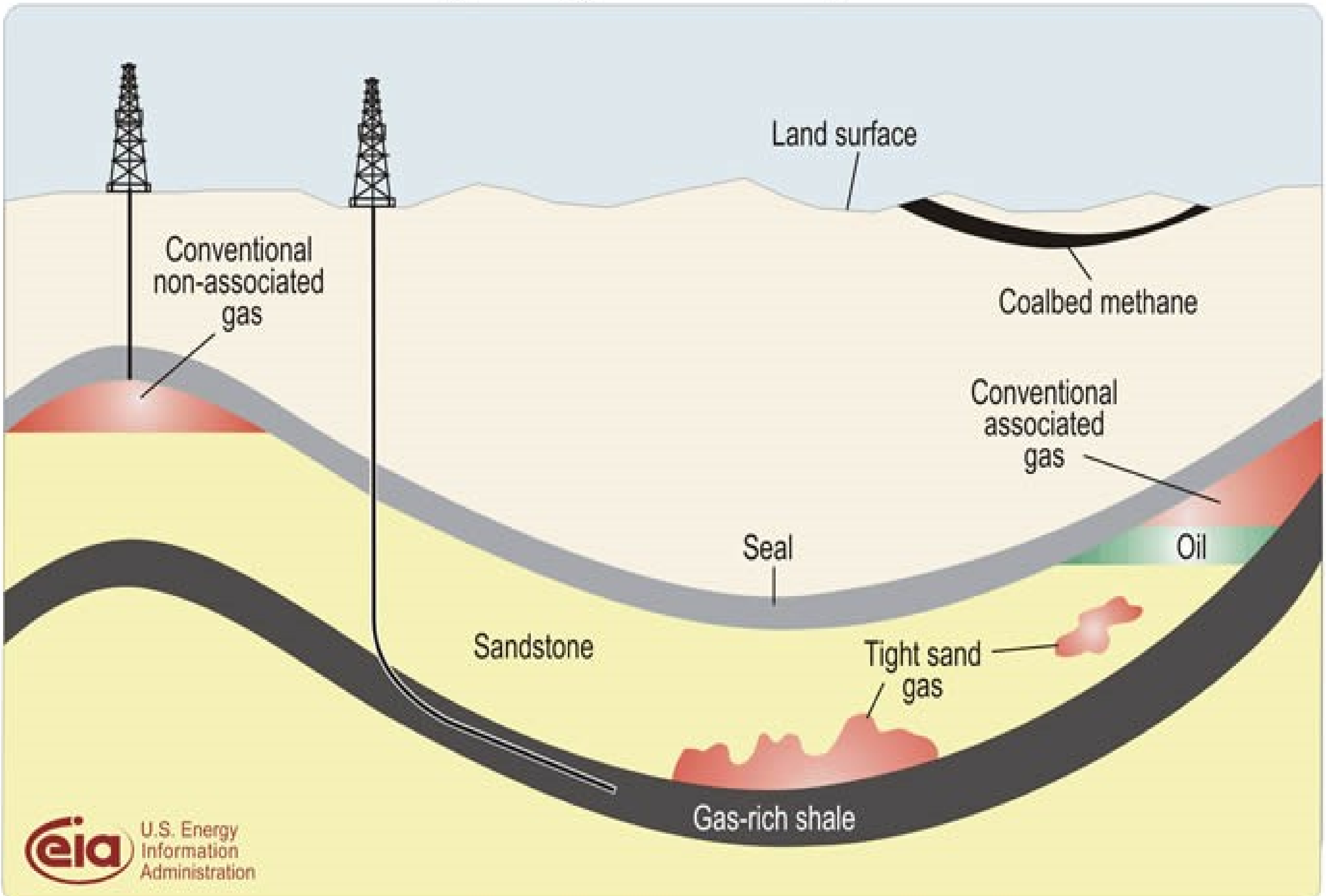
KÄLLA: IEA ENERGY BALANCES OF NON OECD COUNTRIES, 2006. IEA ENERGY BALANCES OF OECD COUNTRIES, 2007. BP STATISTICAL REVIEW OF WORLD ENERGY, 2007

Stämningsbild: kolkraftverk



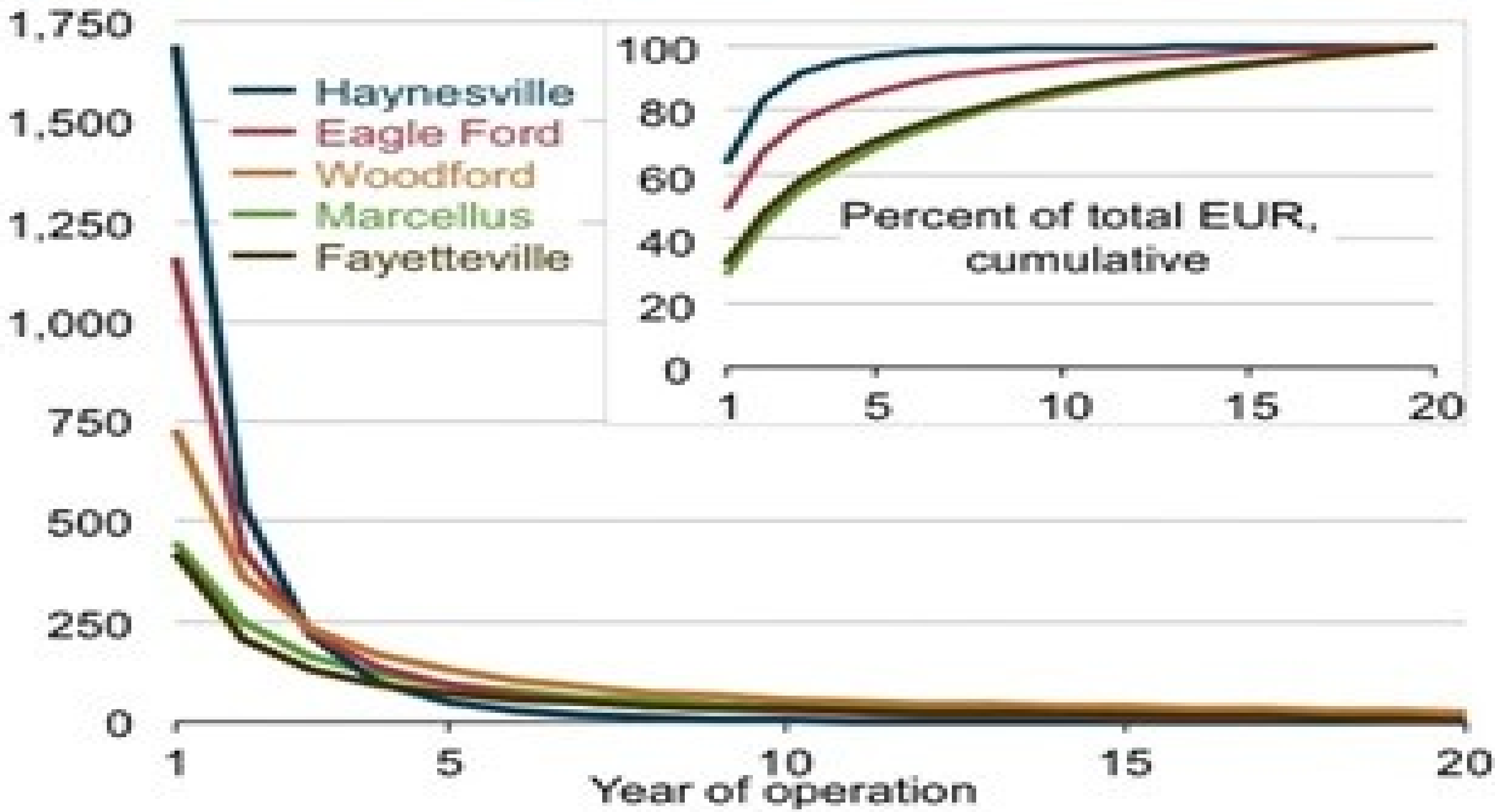
(Source: Energy Watch Group)

Schematic geology of natural gas resources

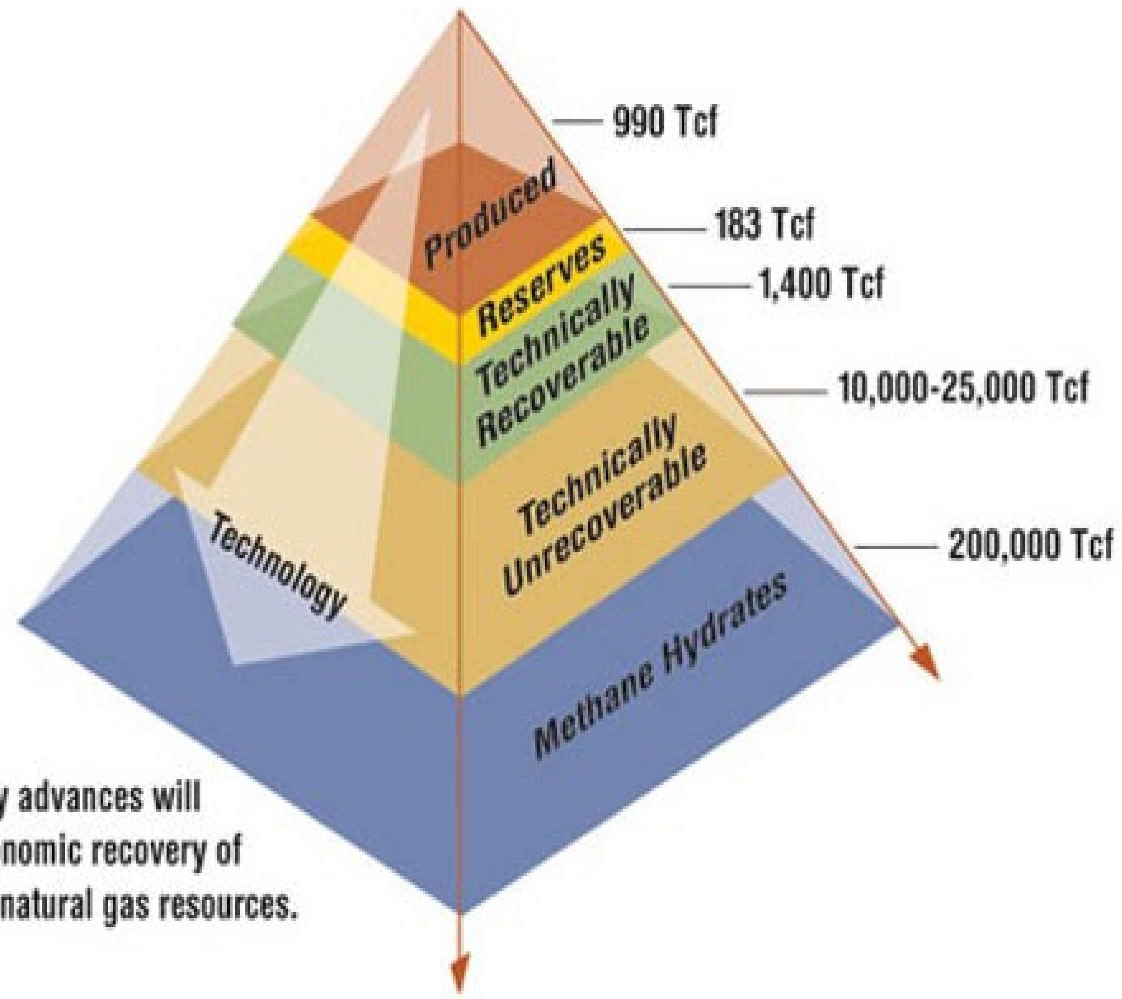


Across a multitude of shale gas plays, fracked wells decline in the range of 40% during the first year of operation:

Figure 54. Average production profiles for shale gas wells in major U.S. shale plays by years of operation (million cubic feet per year)



Profile of Domestic Natural Gas Resources



Technology advances will enable economic recovery of additional natural gas resources.

Some words of warning:

Beware of tar ("oil") sands

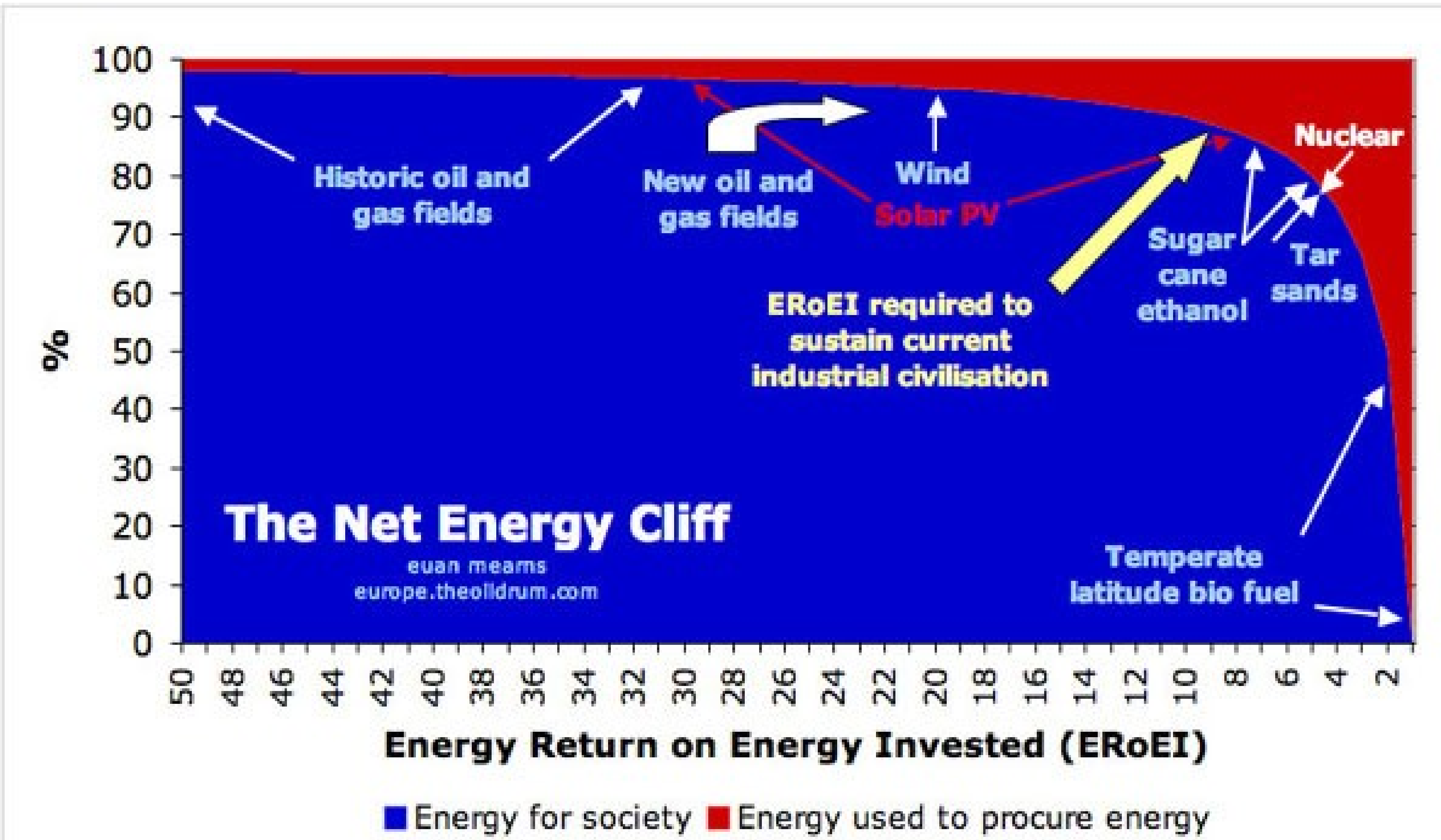
Beware of Arctic oil

Beware of fossil gas

Beware of fracking

Beware of methane hydrates

ERoEI: Allt sämre netto vid energiutvinningen:



Utvecklingen är uppenbart ohållbar.

Även IEA, tidigare synnerligen optimistiskt, har nu insett situationens allvar:

The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable — environmentally, economically, socially. But that can — and must — be altered; *there's still time to change the road we're on.*

What is needed is nothing short of an energy revolution.

[WEO 2008, Executive Summary]

Preventing catastrophic and irreversible damage to the global climate ultimately requires a major decarbonisation of the world energy sources. On current trends, energy-related emissions of carbon-dioxide (CO2) and other greenhouse gases will rise inexorably, pushing up average global temperature by as much as 6°C in the long term. Strong, urgent action is needed to curb these trends.

[World Energy Outlook 2008, Executive Summary]

Ur IEA:s årsrapport WEO 2008:

Världens energisystem befinner sig vid ett vägskäl. Nuvarande globala tendenser då det gäller tillförsel och förbrukning av energi är uppenbart ohållbara – miljömässigt, ekonomiskt, socialt. [.....]

Vad som krävs är inget mindre än en energirevolution. (forts)

För att förhindra en katastrofal och oåterkallelig skada på det globala klimatet fordras en massiv minskning av koldioxidutsläppen från världens energikällor. Om nuvarande utveckling fortsätter, kommer de energirelaterade utsläppen av koldioxid och andra växthusgaser att stiga obönhörligt och på sikt öka den globala medeltemperaturen med så mycket som sex grader.

Tiden rinner ut och det är nu dags att handla.

3. The population biology problem

En tredje aspekt på energi- och resursuttömningsfrågan förbises alltför ofta:

Bakterierna i Petriskålen, karparna i fiskdammen och andra predatorer har något gemensamt med galningar och ekonomer:

"Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.". [**Kenneth Boulding**]

Vad *är* exponentiell tillväxt och *vad gör den* med oss?

$N(t) = N(0)*\exp(p*t)$

Differentialekvation:

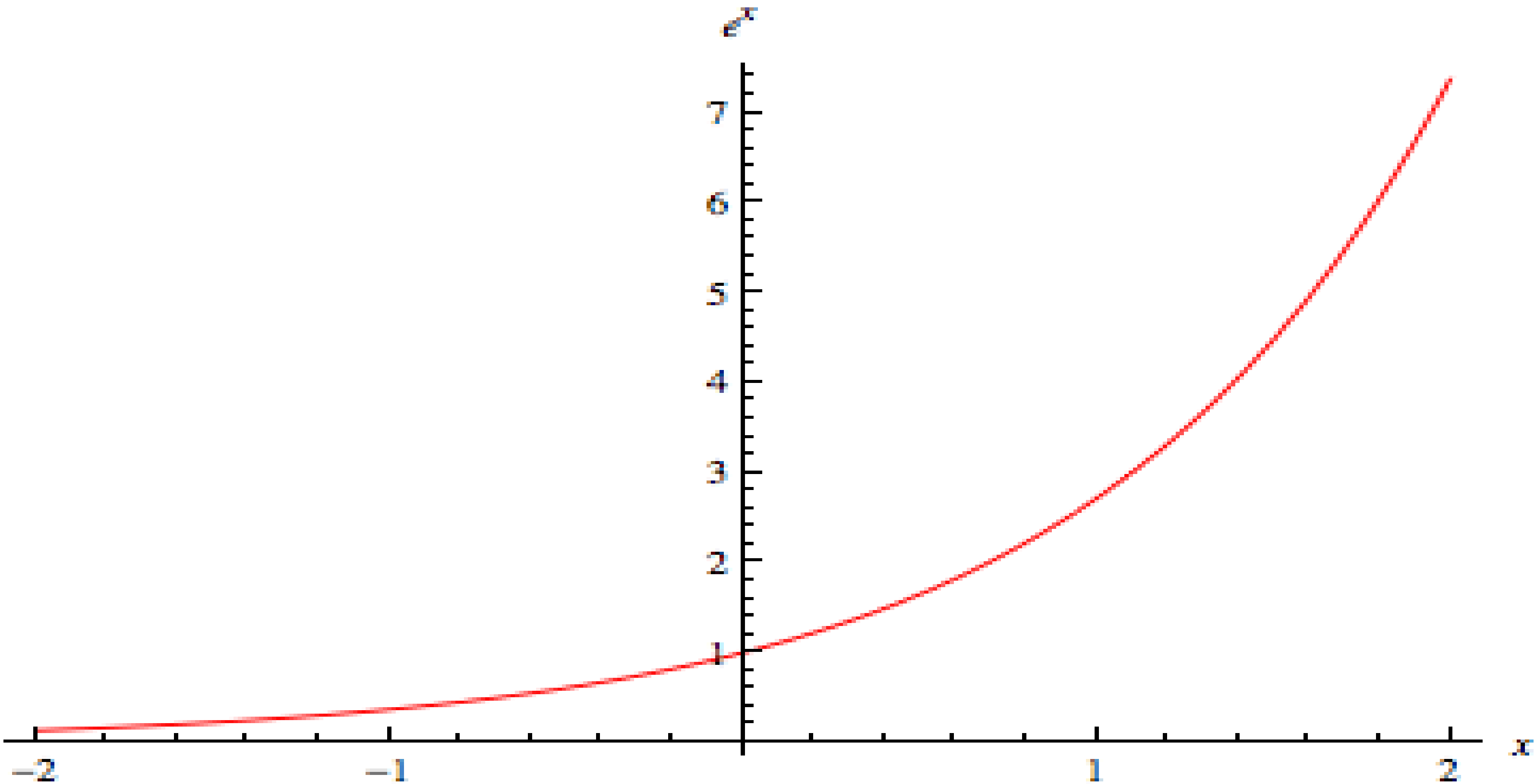
$dN(t)/dt = p*N(t)$ (p är konstant)

Q: Fördubblingstid, d.v.s.

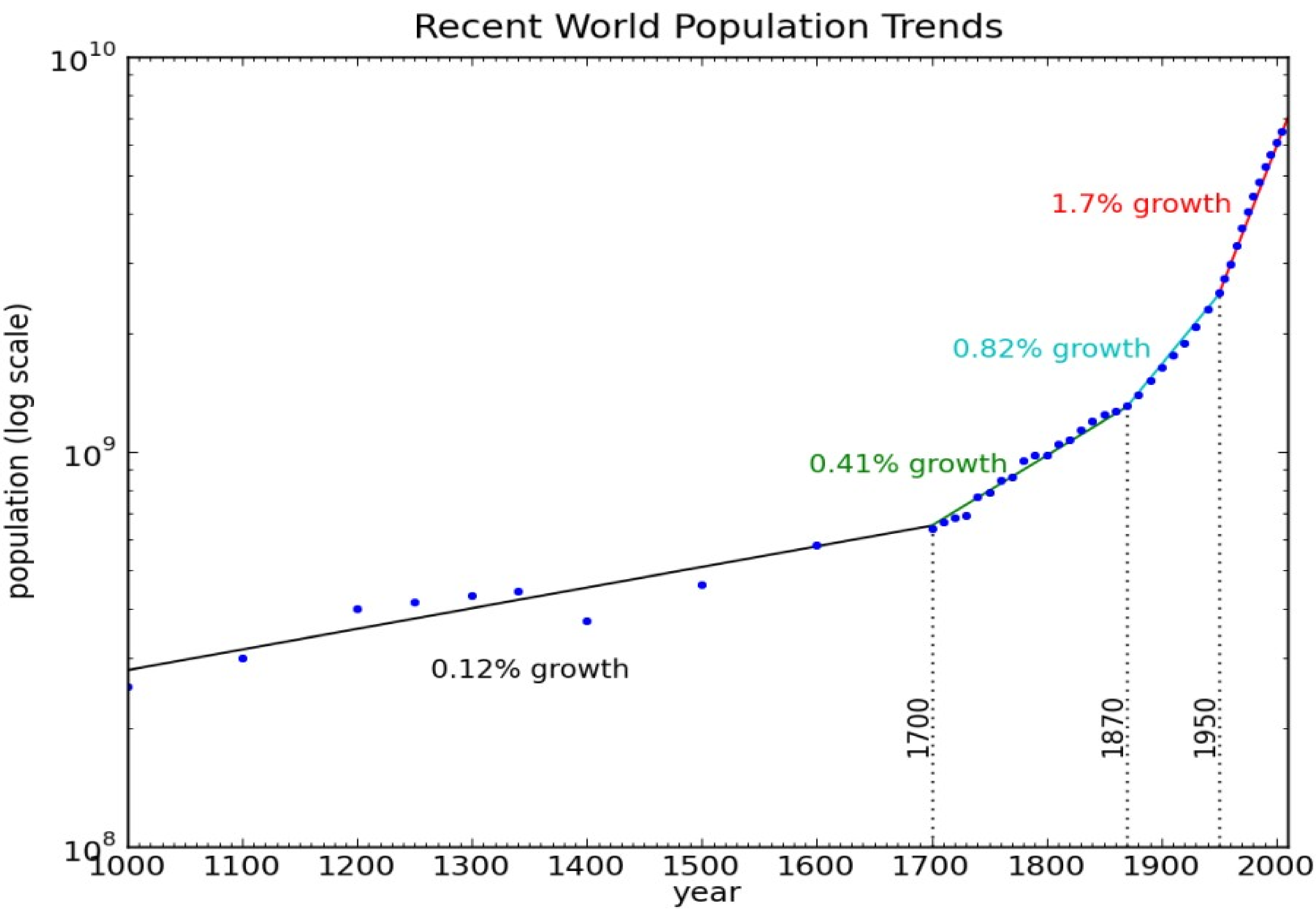
när gäller $N(T) = 2*N(0)$?

A: Då $p*T = \ln(2) = 0,7$

Exempel. Först grafen av exp(t)



Påminnelse:



Recent World Population Trends
population (log scale)
10^{10}
10^9
10^8
year
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
0.12% growth
0.41% growth
0.82% growth
1.7% growth
1700
1870
1950

Övning #1: Koldioxidutsläpp

De årliga utsläppen av fossil koldioxid är idag c:a 30 miljarder ton.

Antag utsläppen ökar med 5,9 procent om året (som de gjorde under perioden 2009 – 2010)

Q: Vilket år kommer utsläppen att uppgå till 60 mdr ton per år?

A: Fördubbling då p*T = 0,7, d.v.s. då
T = 0,7/0,059 = 70/5,9 = 11,86 = 12 år, alltså ***år 2025***

Övning #2: Populationsexempel

Napoleon invaderade år 1800 Egypten (och sköt av näsan på sfinxen. Klantigt, Nappe!)

Detta år hade Egypten en befolkning på 3 miljoner.

Idag, 213 år senare, är befolkningen uppe i 84 miljoner.

Q: Vilken är ökningstakten?

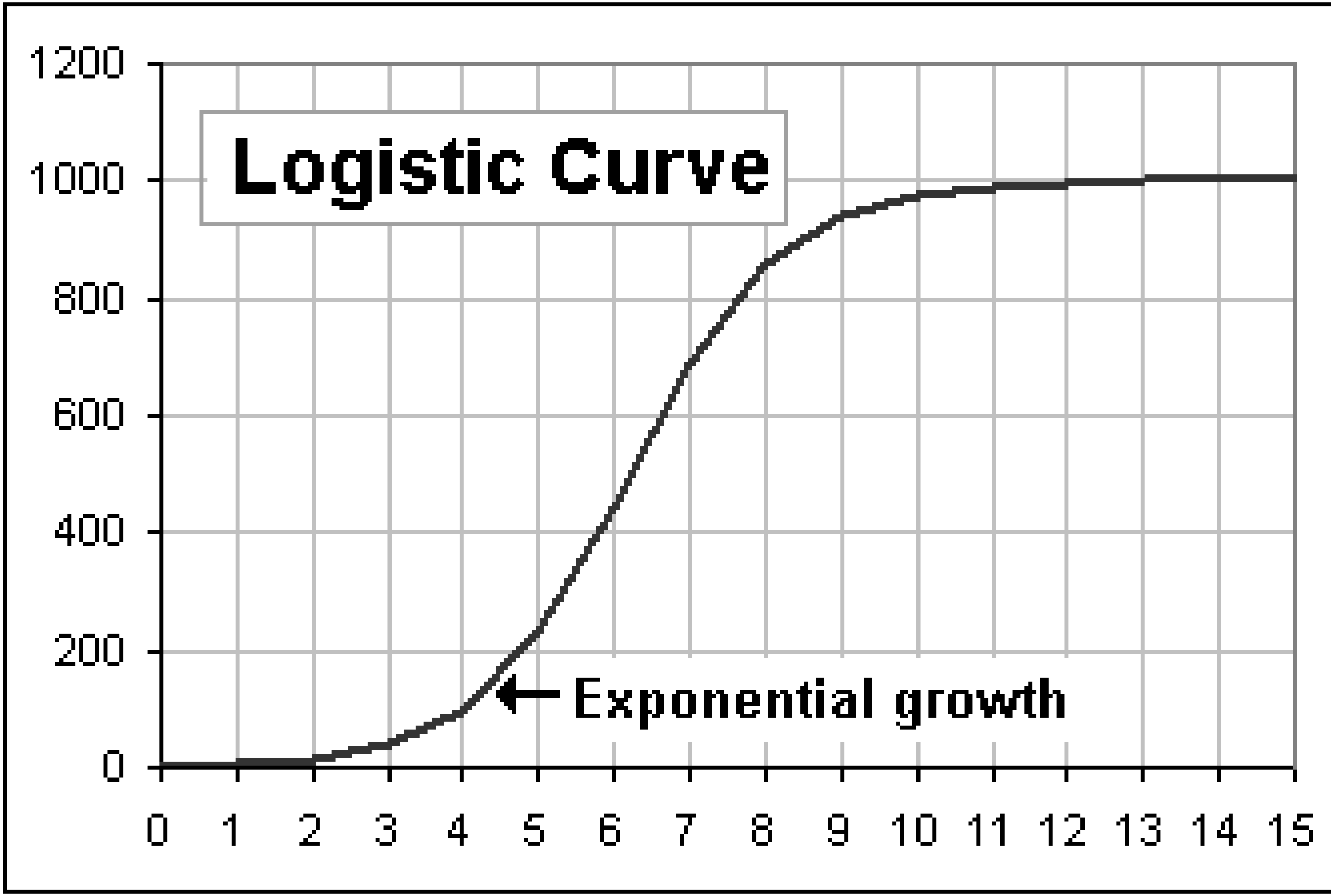
A: 84 = 3*exp(p*213) ger p = ln(28)/213 =
= 3,33/213 = 0,0156, d.v.s. blygsamma
1,56 procent

Men långvarig exponentiell tillväxt i en ändlig värld är en orimlighet. Så vad händer i verkligheten?

En vanlig modell är den s.k. logistiska modellen eller Verhulst-Pearl-modellen: tillväxtintensiteten görs populationsberoende:

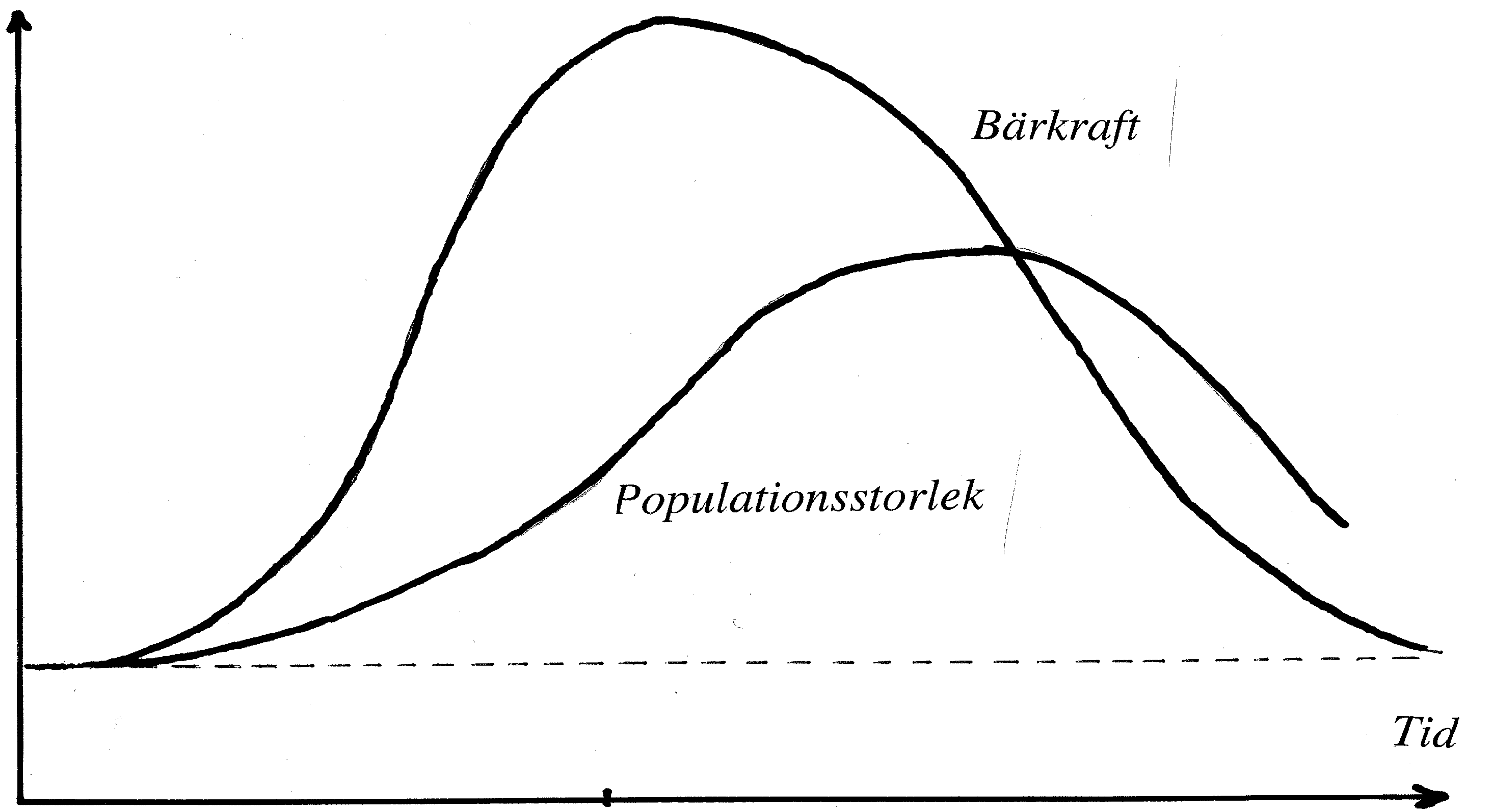
p byts mot p*(1 – N(t)/Nmax), varav

dN(t)/dt = p*(1 - N(t)/Nmax)*N(t)


Logistic Curve
Exponential growth
1200
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Låt oss nu utfodra karparna:

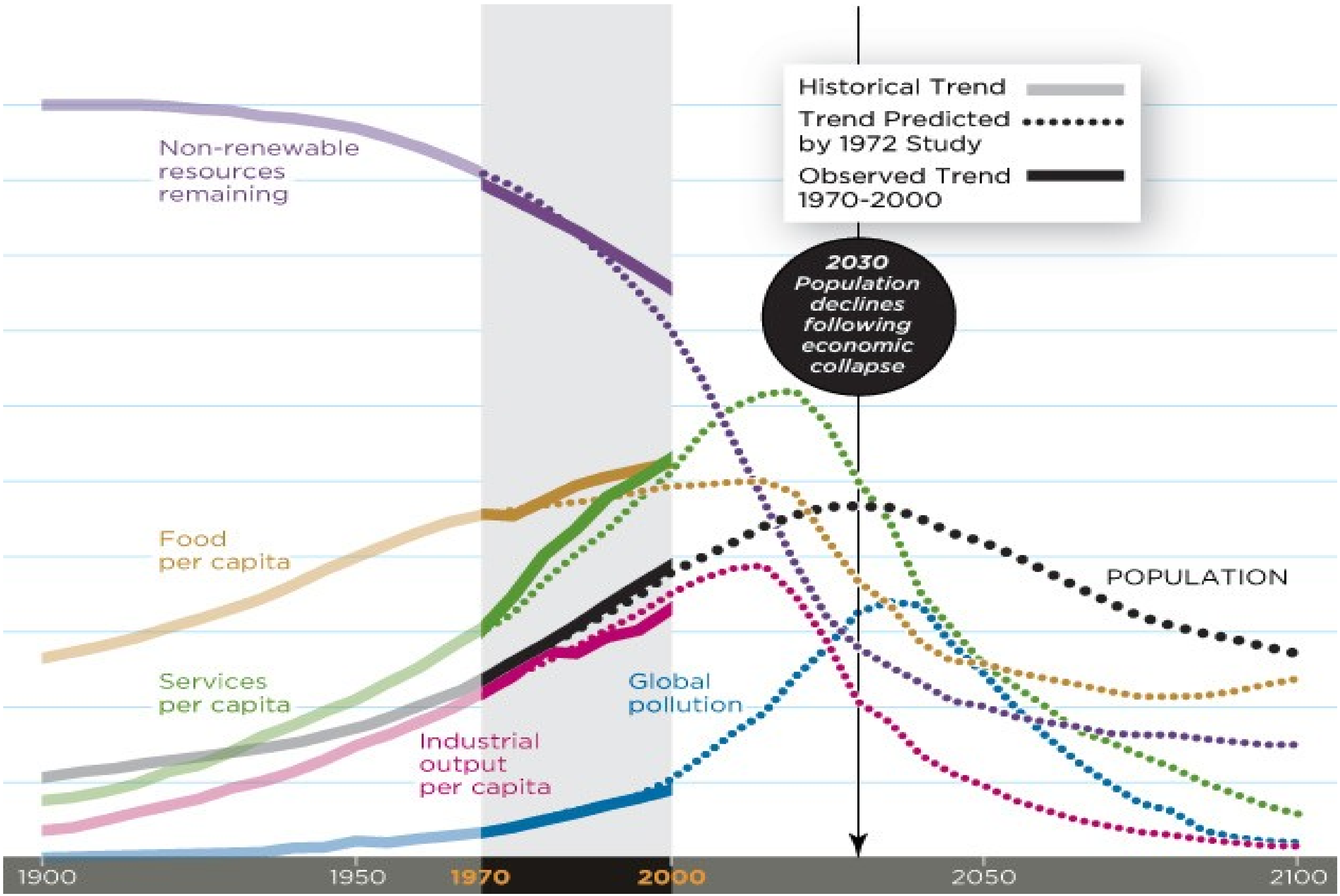
Upp som en sol ...



Men det här är ju bara modeller och metaforer – eller hur ...?

Så vad händer egentligen i verkligheten –
vår egen verklighet?

Smithsonian Magazine, April 2012:



Matbrist är inte roligt för någon

The Current Mass Extinction:

Human beings are currently causing the greatest mass extinction of species since the extinction of the dinosaurs 65 million years ago. If present trends continue, *one half of all species of life on earth will be extinct in less than 100 years*, as a result of habitat destruction, pollution, invasive species, and climate change.

http://www.mysterium.com/extinction.html; senaste uppdatering 2 juli 2013

LITET MER DETALJERAT:

Direkta effekter:

Arktis smälter – isbjörnarna dör ut

Glaciärerna försvinner – floderna torkar ut

Havet stiger - översvämningar av låglänta områden

Extremt sommarväder – jmf Europa 2003 m.fl.

Skogsbränderna ökar – Ryssland, Australien, Texas

Orkanerna blir värre? Eller fler? (forts)

Golfströmmen försvagas

Nederbördsmönstret förändras

Arterna kommer ur fas med varandra

Habitatförskjutningar – arter ”trycks över kanten”

Korallreven dör

Skördarna blir sämre, missväxtåren fler

Grönlandsisen smälter (”tipping point” 2.7 C <-->

1.2 C globalt) => havsytan stiger med 6 – 8 meter

Återkopplingar

Arktis istäcke försvinner => jordens albedo minskar => ytterligare uppvärmning

Amazonas kollapsar => tio procent av jordens lungor försvinner och kol frigörs

Marken värms: kolsänka blir kolkälla

Permafrosten tinar => metan frigörs => temperaturen stiger

Metanhydraten tinar => temperaturen stiger

Havens förmåga att lagra koldioxid försämras

Conclusion #1

The present situation is unsustainable.
Business-as-usual will lead to disaster.
A transition is absolutely necessary
- but a transition to what?

Slutsats #1 (om rävsaxen)

Vi har manövrerat in oss i ett hörn:

- Vi är till mer än 85 procent beroende av fossila bränslen
- Våra transporter sker till mer än 95 procent med olja
- Vårt fossilberoende har allvarliga konsekvenser för miljön och klimatet
- Vår drog finns inte i obegränsade mängder – vi börjar skrapa i botten på tunnan

Något måste göras – men vad?

Vi har tre krav/önskemål:

- Fossila koldioxidutsläpp måste bort
- Energin måste bli förnyelsebar
- Kostnaden måste vara överkomlig

Two main alternatives

Nuclear – classical (i.e., uranium) fission, Gen IV fission, fusion (or even LENR?)

Renewables – wind, waves, sun, biomass …

What'll it be?

What about the nuclear option?

- Yesterday: 435 reactors, 370 GWe installed. Nuclear supplies 2 per cent of global energy use.
- Today, after Fukushima: 380 reactors, ~330 GWe
- Tomorrow, if we are to replace all fossil fuels by 2050, we will need approximately 15.000 1 GWe reactors

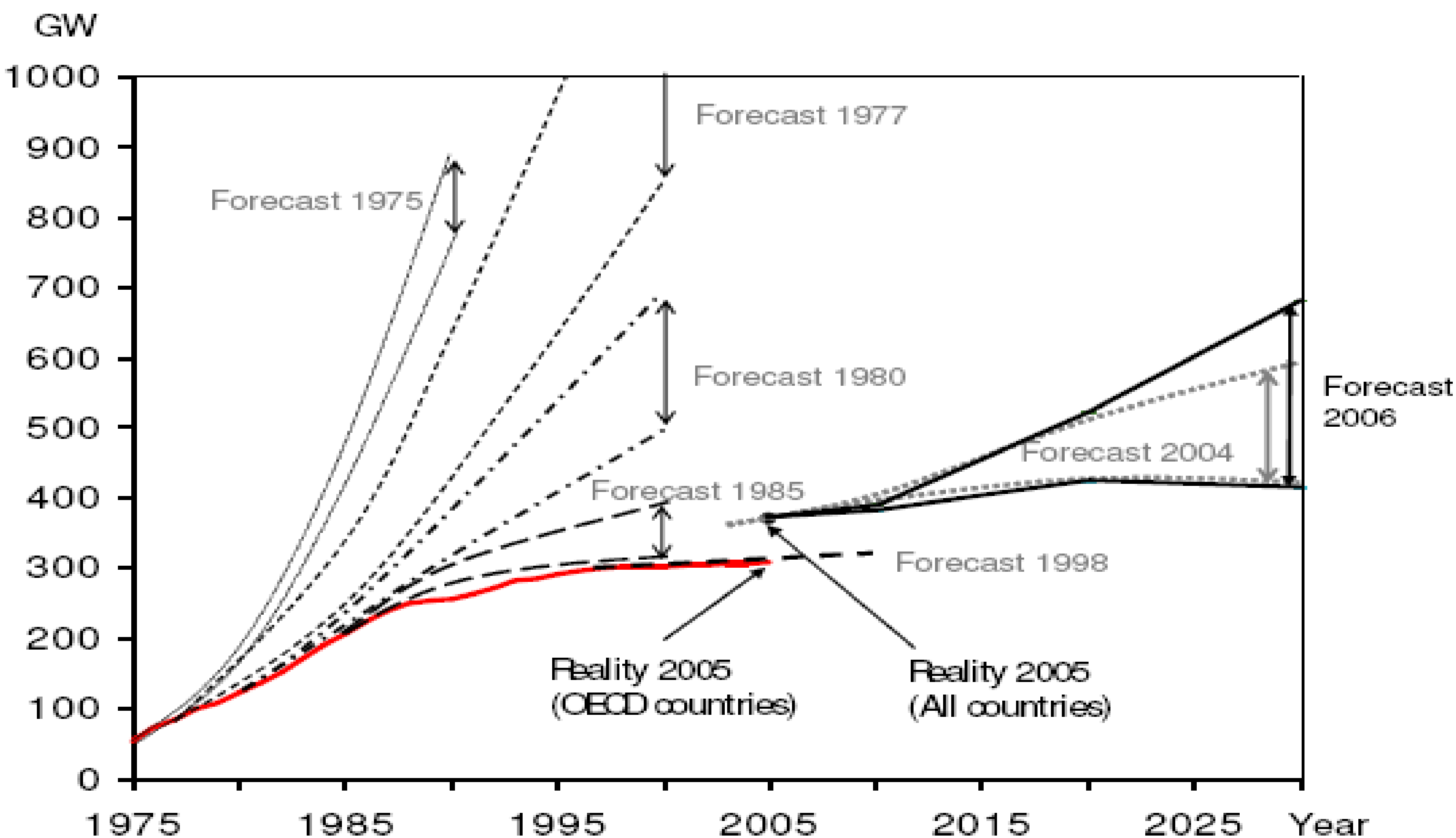
A formidable task!

Must build 1+ new reactor each day for 40 years

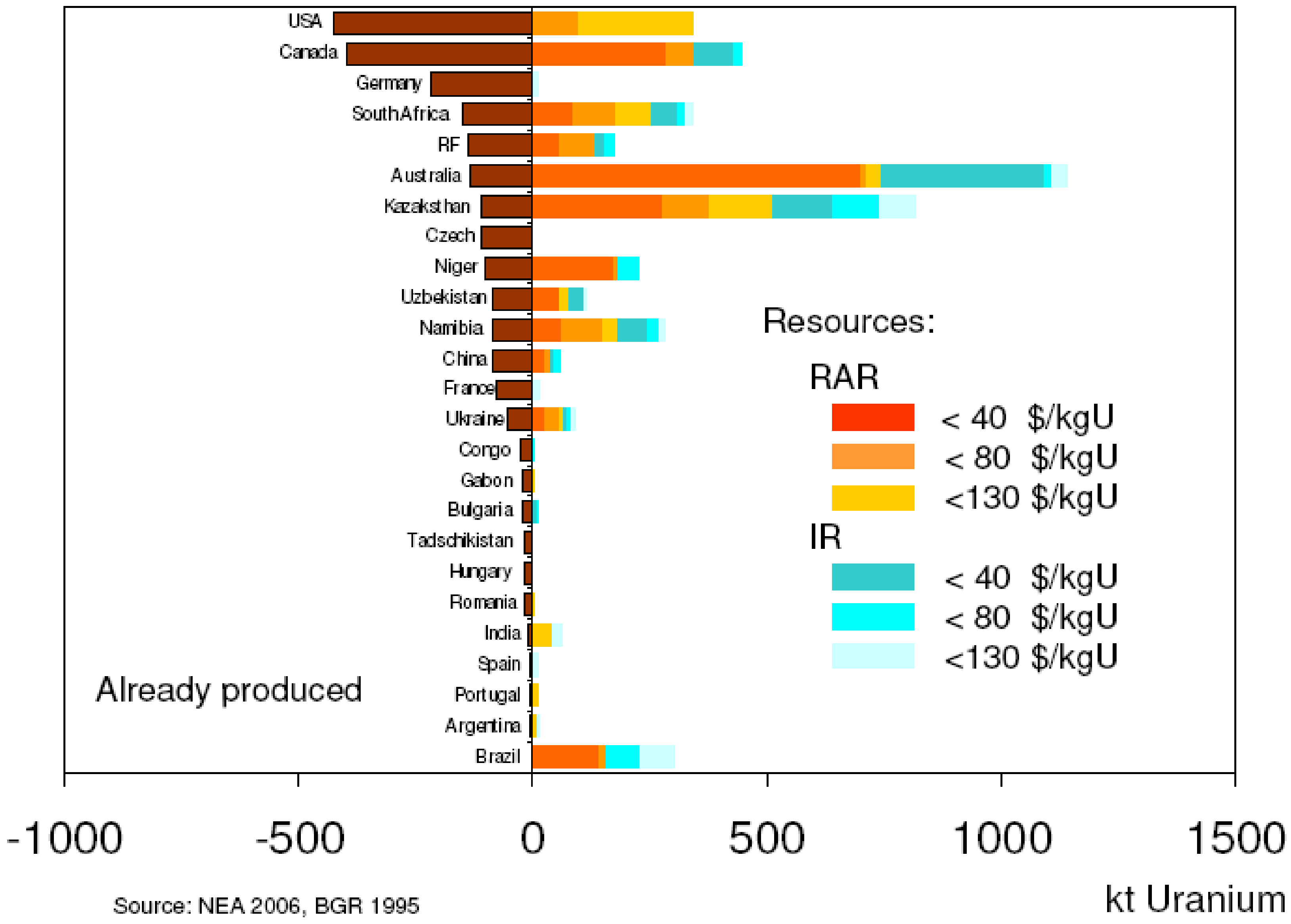
Also, reactors are decommissioned, so

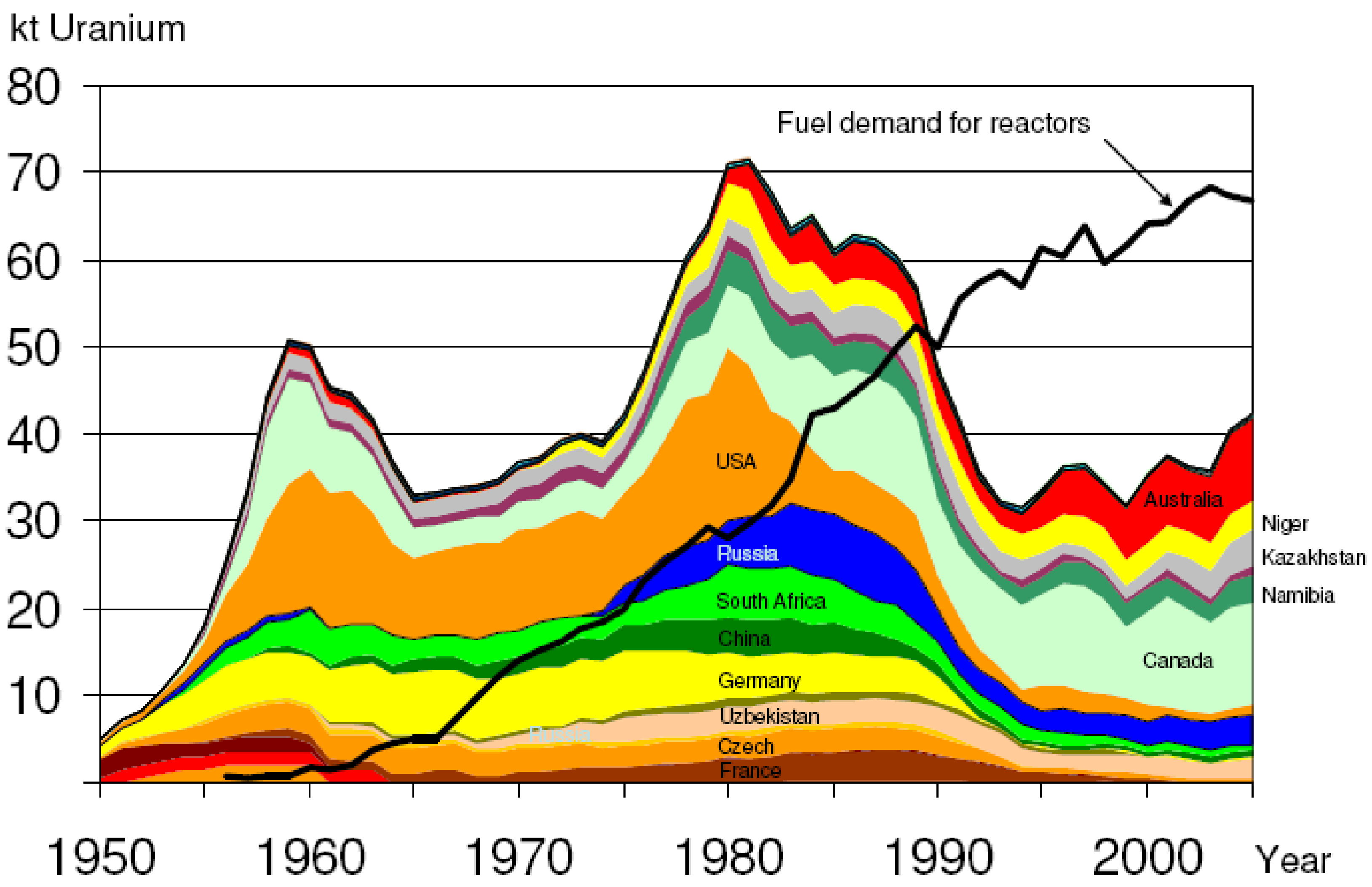
about 300 reactors must replaced every year

The nuclear industry's track record



Data Source: IAEA; Grafics: LBST


USA
Canada
Germany
SouthAfrica
RF
Australia
Kazakhstan
Czech
Niger
Uzbekistan
Namibia
China
France
Ukraine
Congo
Gabon
Bulgaria
Tadschikistan
Hungary
Romania
India
Spain
Portugal
Argentina
Brazil
Already produced
Resources:
RAR
< 40 $/kgU
< 80 $/kgU
<130 $/kgU
IR
< 40 $/kgU
< 80 $/kgU
<130 $/kgU
-1000
-500
0
500
1000
1500
kt Uranium
Source: NEA 2006, BGR 1995


kt Uranium
80
70
60
50
40
30
20
10
Fuel demand for reactors
USA
Russia
South Africa
China
Germany
Uzbekistan
Czech
France
Australia
Niger
Kazakhstan
Namibia
Canada
1950
1960
1970
1980
1990
2000
Year

Stämningsbild: följderna av uranutvinning vid Elliott Lake, Kanada

Stämningsbild: uranutvinning i Rifle, Colorado

New developments may be possible, but **nuclear fission** is no quick fix. Also, present-day nuclear is expensive, dangerous, tied to arms proliferation and lacks an approved method for long term waste storage.

Nuclear fusion is – as has been the case for the last 50 years – at least fifty years into the future.

We can't pin our hopes on the nuclear option.

What does the renewables option comprise?

1. **GEOTHERMAL ENERGY**

2. **RENEWABLE ENERGY**

a. BIOMASS, first generation

- **Wood stuff (branches, treetops), black liquor**
- **Grain, corn, sugar cane**
- **Jatropha**

(to be cont'd)

b. BIOMASS, second generation

- Cellulosic ethanol

c. BIOGAS

d. HYDRO POWER

e. DIRECT SUN

- Hot water panels
- Concentrated solar power, CSP

(more...)

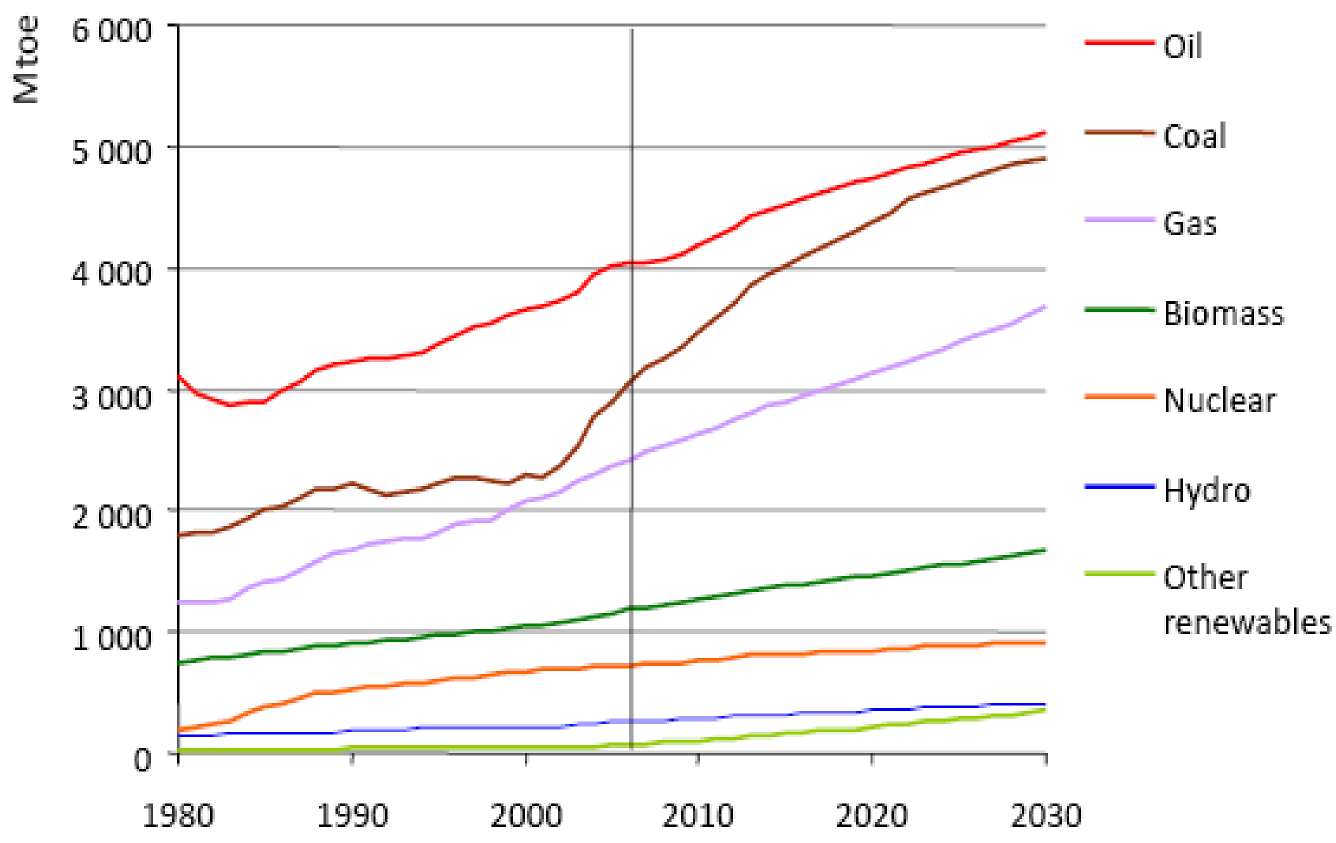
- Photovoltaics

f. INDIRECT SUN & GRAVITATION

- Wind mills
- Wave and tide power

3. HYDROGEN (just an energy *carrier*)

Uppgiften framför oss:



World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

Will a combination of these renewables be sufficient?

Opinions differ – from almost 100 per cent renewables by 2050 (WWF, Greenpeace, Fortum et al) to close to zero (Kunstler, Greer, Heinberg ...), with everything in between.

Let's begin with the broad view ("the systems engineering point of view).

Start with the constraints ("obstacles")

1. The immutable laws of physics:

- Thermodynamics
- Mechanics, eg. Newton's laws
- Electricity (Faraday's & Maxwell's laws ...) etc

First law of thermodynamics

Energy can neither be created nor destroyed.
It can only change forms.

In any process in an isolated system, the total energy remains the same.

Second law of thermodynamics

In a simple manner, the second law states that "energy systems have a tendency to increase their entropy rather than decrease it." This can also be stated as "heat can spontaneously flow from a higher-temperature region to a lower-temperature region, but not the other way around."

Pop version:

TANSTAAFL -

There Ain't No Such Thing As A Free Lunch

2. Facts of Nature

- Geological constraints: existence of resources, ultimately recoverable resources (URR), windy locations, insolation levels, etc
- Biological constraints: plant (in)efficiency
- Agricultural constraints: available arable land, fertilizers, pesticides, herbicides ...

3. Technology/engineering

Improved technology leads to better use of resources, but there are two catches:

- The laws of Nature impose limits

- Jevon's paradox, a.k.a. Rebound effect

4. Economic theory

The enterprises and the market are unable to price non-renewables correctly.

No cost for taking oil, gas, coal etc from their deposits. They are "free".

No costs for emitting CO2 or SO2 or dioxin etc. They are also "free" - i.e., the price is paid by someone else.

Small taxes on CO2 in a few countries

"The tragedy of the commons" (Hardin)

Economics, continued (1)

This distorts the price mechanism, displaces the equilibrium point and leads to socially non-optimal decision making.

Example:
What will it cost to replace an energy slave at 5 - 10 öre/h (everything included) by a human slave?
TRUE FACT: ***Energy is practically free!***

Taxes and subsidies are invoked to correct the situation – a very *ad hoc* remedy.

Economics, continued (2)

Subsidies:

Fossil fuels: USD 700 billion

[Reference: G20 Subsidy Joint Report, 2010]

I.e., coal, oil and gas are artificially made to look cheap.

Governments are shelling out nearly 2 billion US dollars per day to further destabilize the earth's climate.

Renewables: Less than 60 billion US dollars

Moreover, LCC (Life Cycle Cost) considerations are often ignored in favour of short term profit.

Also, the choice of discount rate (how we value the future) can be decisive for our actions.

5. Politics

In the real world, no politician has the guts to do what's really needed – only what *looks good* to the electorate.

Gedankenexperiment: How many politicians will respond favourably to the following propositions:

Impose a country-wide speed limit of 70 km/h

Increase petrol tax by 1 per cent per month ?

6. Sociological constraints

Everybody feels compelled to "*keep up with the Joneses*": Everybody's neighbour is a benchmark for social caste or the accumulation of material goods. Conspicuous consumption is a mighty driver of growth.

A change of attitude is necessary, but will require a concerted effort for many years. The growth paradigm will not surrender without a fight.

But remember: *the Joneses have gone broke* ...

7. Human psychology

Humans resist change.

Dying people avoid the truth.

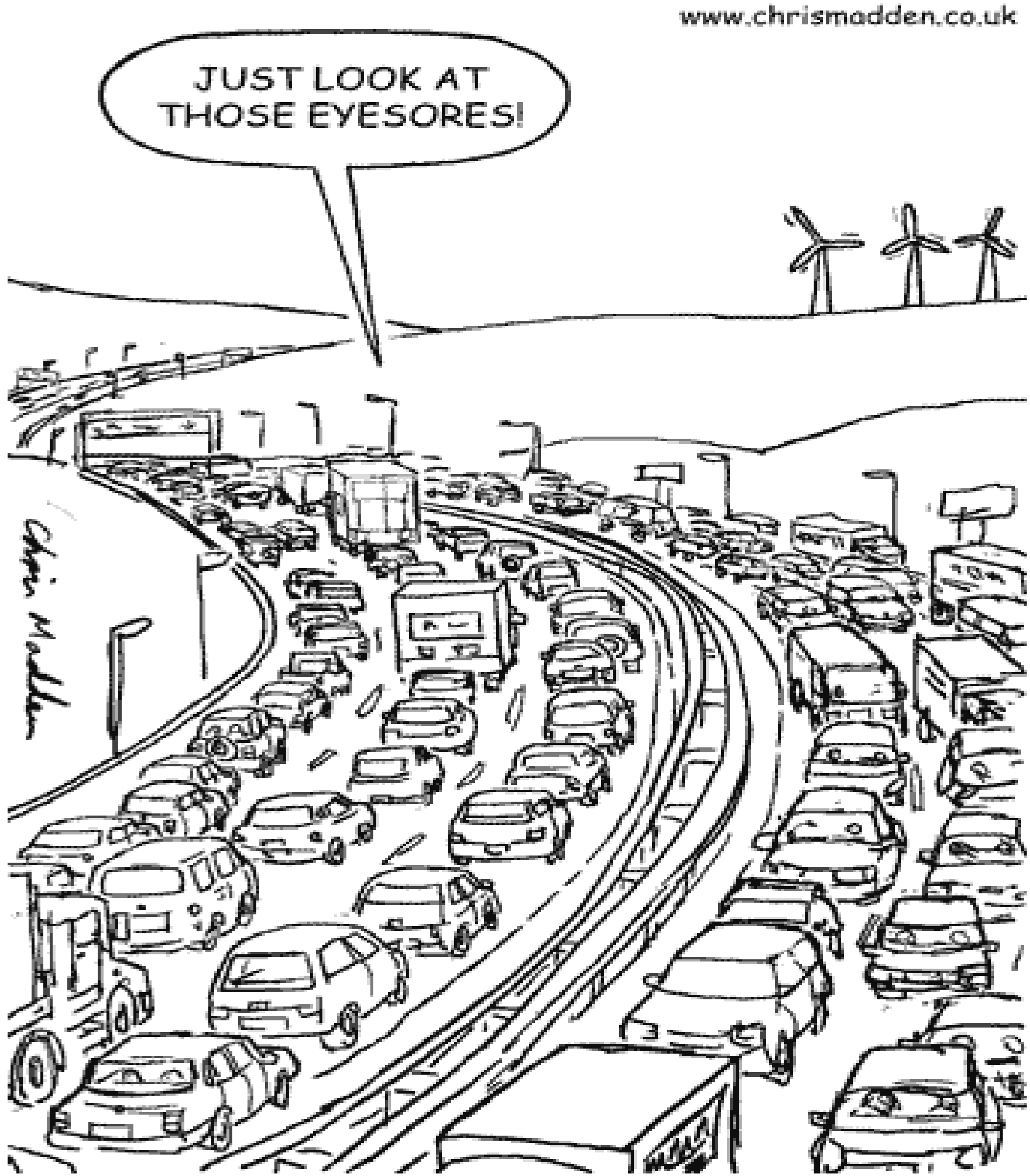
Recall the Elisabeth Kübler-Ross model for death and bereavement counselling, personal change and trauma.

Her five stages of grief model (denial, anger, bargaining, depression, acceptance), are also transferable to personal change and emotional upset resulting from factors other than death and dying.

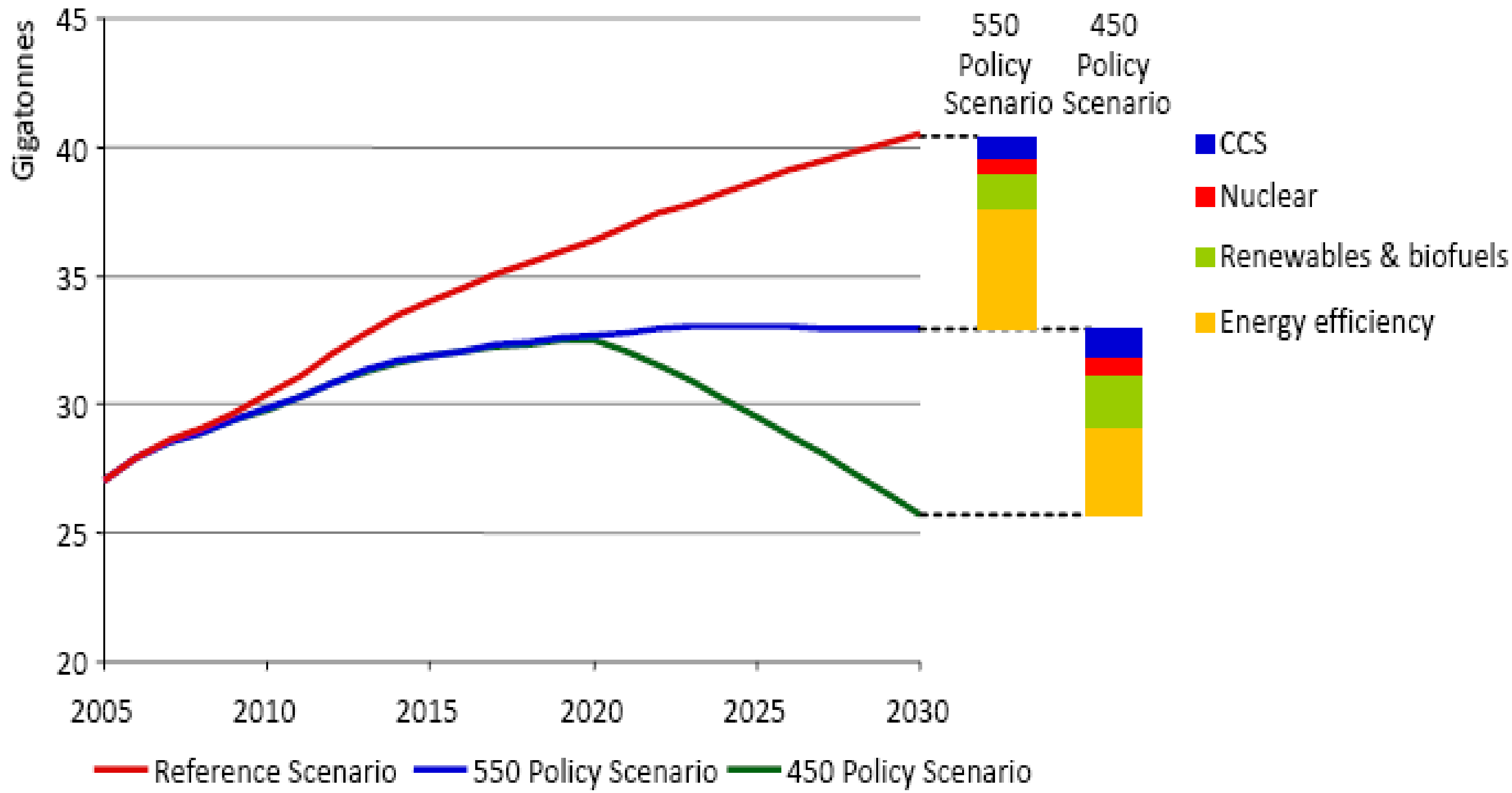
Human psychology, continued

The Kübler-Ross model probably goes a long way towards describing resistance to “power-down”: a more frugal life style, with less travelling, more windmills, more solar, and so on and so forth.

And there is always “the NIMBY effect”: Windmills are sooo ugly ...


www.chrismadden.co.uk
JUST LOOK AT THOSE EYESORES!

Also, time is running out



While technological progress is required to achieve some emissions reductions, increased deployment of existing low-carbon technologies accounts for most of the CO_2 savings

Så upp med huvudet ur sanden!
Vad göra?

We now know what ***must*** be done -

but ***can*** it be done

and ***will*** it be done?

If so - then ***how***?

Some propositions follow:

Mark Z Jacobson and Mark Delucchi:	
A Plan to Power 100 Percent of the Planet with Renewables	**100 %**
Greenpeace:	
***Battle of the Grids* and**	
[r]enewables 24/7. Infrastructure needed to save the climate	**95 – 100 %**
WWF:	
The Energy Report. 100 % renewable energy by 2050	**95 %**
SNF:	
Ett hållbart energisystem	**90 %**
Department of Energy and Climate Change:	
2050 Pathways Analysis	**80 %**
The Swedish government's scientific advisory board:	**70 – 85 %**

A concrete proposition by Mark Z. Jacobson and Mark A. Delucchi:

- 490.000	1	MW tide water turbine
- 5.350	100	MW geothermal plants
- 900	1.300	MW hydro power plants

yield 1.1 TW (9 % of global demand 2030)

- 3.800.000	5	MW wind turbines
- 720.000	0.75	MW wave power plants

yield 5.8 TW (51 % of demand)

- 1.700.000.000	3 kW(!)	photo cells on roofs
- 49.000	300 MW	sun power turbines (i.e., CSP)
- 40.000	300 MW	big photo voltaic plants

yield 4.6 TW (40 %)

Total: 11.5 TW in 2030

The WWF scenario

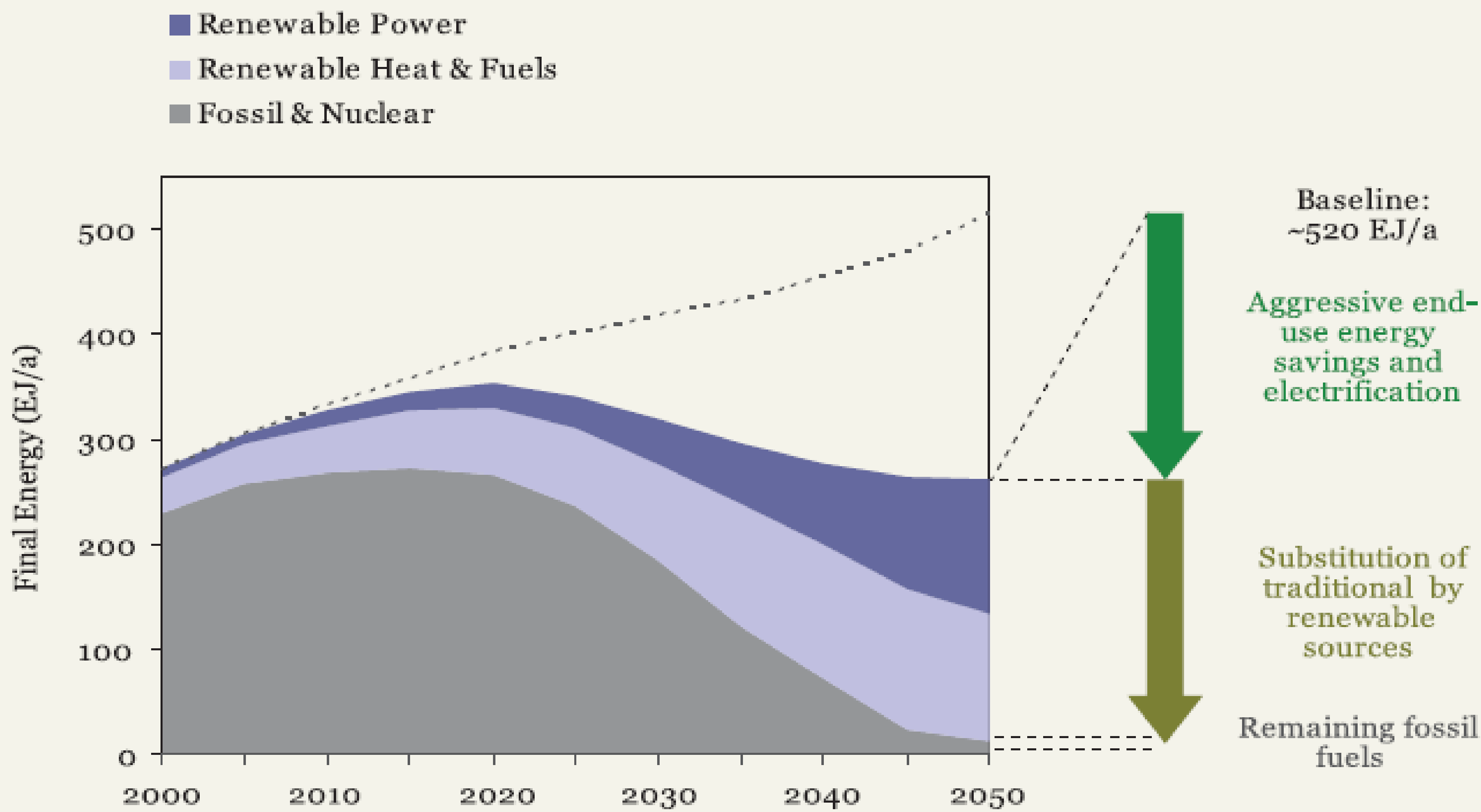


Figure 1
Evolution of energy supply in the Energy Scenario, showing the key developments.
Source: The Ecofys Energy Scenario, December 2010.

J M Greer points to the problem with multiple – possibly even contradictory – goals in the WWF report:

That failure to come to terms with the realities of our predicament is by no means restricted to internet bloggers, to be sure. The World Wildlife Federation, to cite only one example, has just released a lavishly produced study insisting that *the world can replace 95% of its fossil fuel energy from renewables by 2050, with ample room for population increases, ongoing economic growth in the industrial world, and a boom in the nonindustrial world that will supposedly raise it out of poverty.* The arguments in the report will be wearily familiar to anybody who's followed the peak oil debate for any noticeable length of time.

Loads of wishful thinking:

- End subsidies to fossil fuels
- Financial support for renewables
- Ambitious cap-and-trade regimes
- Global climate negotiations must succeed
- People everywhere must become energy efficient
- New financial instruments must be developed
- Investors should switch from fossil to renewables
- Supportive legislation is needed
- More market incentives
- Accept investment payoff 30 years hence

Seriously ...

Invited Editorial in GCB Bioenergy, April 2012

Large-Scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral

Thus, a substantial fraction of WWF:s biomass substitute goes up in smoke ...

Voices from the community of physicists:

David MacKay, professor of physics at Cambridge University and author of the book **Sustainable Energy – Without the Hot Air** (free on the Web)

and

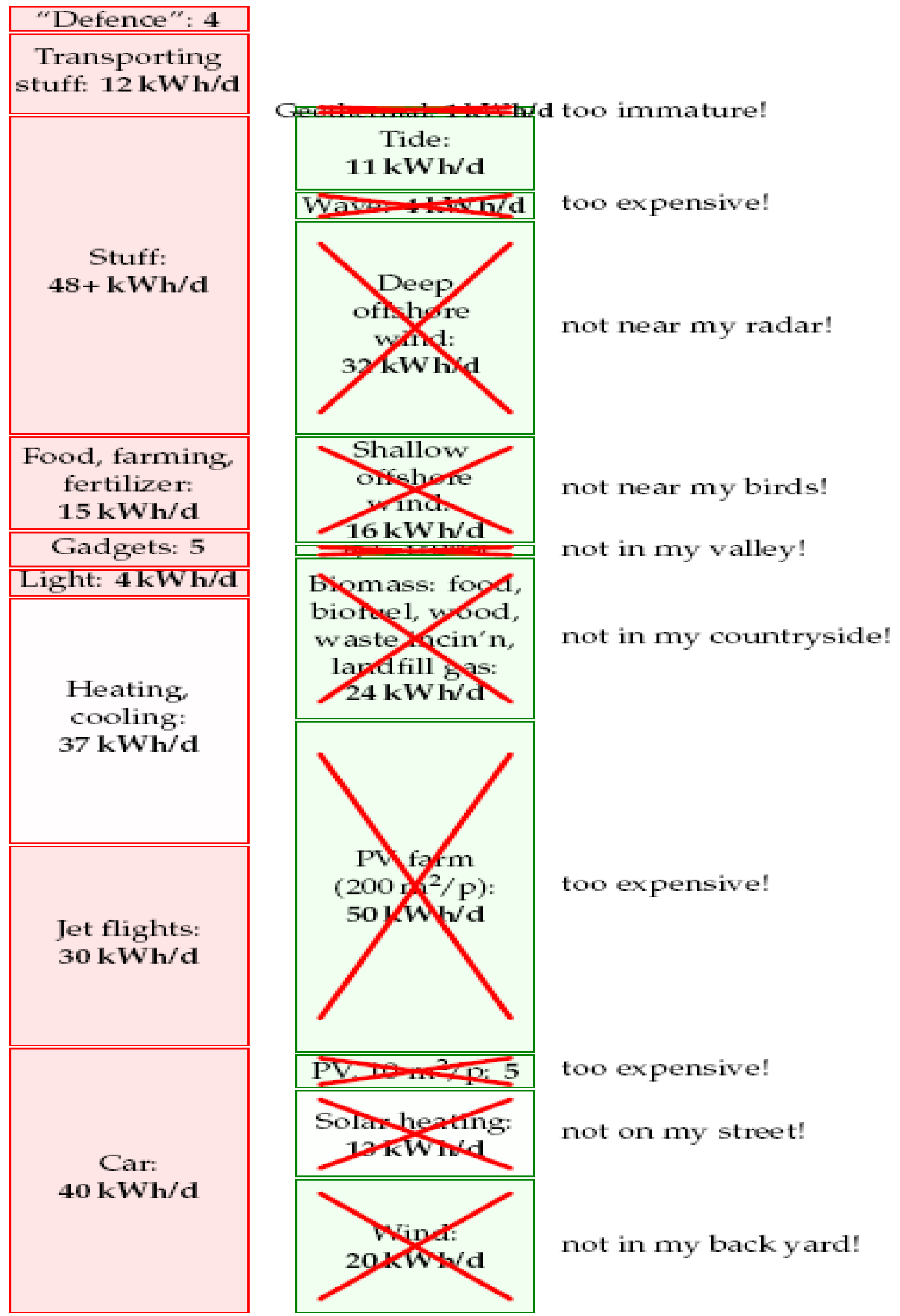
Tom Murphy, associate professor of physics at the University of California San Diego, author of the blog **Do the Math**

Röster från Fysikens Förtrollade Värld

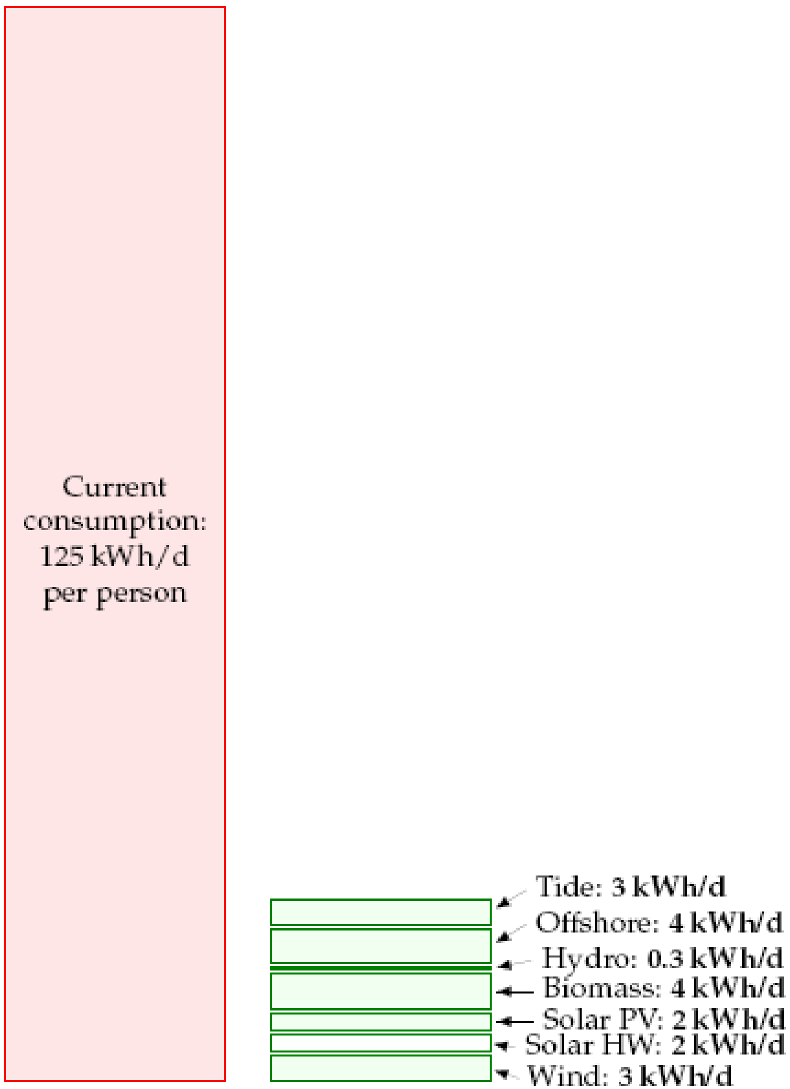
David MacKay, professor of physics at Cambridge University och författare till boken **Sustainable Energy – Without the Hot Air** (gratis på Nätet)

och

Tom Murphy, associate professor of physics at the University of California San Diego och innehavare av bloggen **Do the Math**



"Defence": 4
Transporting stuff: 12 kWh/d
Stuff: 48+ kWh/d
Food, farming, fertilizer: 15 kWh/d
Gadgets: 5
Light: 4 kWh/d
Heating, cooling: 37 kWh/d
Jet flights: 30 kWh/d
Car: 40 kWh/d
too immature!
Tide: 11 kWh/d
Wave: 4 kWh/d
too expensive!
Deep offshore wind: 32 kWh/d
not near my radar!
Shallow offshore wind: 16 kWh/d
not near my birds!
not in my valley!
Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
not in my countryside!
PV farm (200 m²/p): 50 kWh/d
too expensive!
too expensive!
Solar heating: 13 kWh/d
not on my street!
Wind: 20 kWh/d
not in my back yard!



After the public consultation. I fear the maximum Britain would ever get from renewables is in the ballpark of 18 kWh/d per person. (The left-hand consumption number, 125 kWh/d per person, by the way, is the average British consumption, excluding imports, and ignoring solar energy acquired through food production.)

MacKay sums up his findings (ch 18)

1. To make a difference, renewable facilities have to be country-sized, because all renewables are so diffuse.

2. It's not going to be easy to make a plan that adds up, using renewables alone.

When I first approached the subject of energy in our society, I expected to develop a picture in my mind of our grandiose future, full of alternative energy sources like solar, wind, nuclear, biofuels, geothermal, tidal, etc. What I got instead was something like this matrix: full of inadequacies, difficulties, and show-stoppers. **Our success at managing the transition away from fossil fuels while maintaining our current standard of living is far from guaranteed. If such success is our goal, we should realize the scale of the challenge and buckle down now while we still have the resources to develop a costly new infrastructure.** Otherwise we get behind the curve, possibly facing unfamiliar chaos, loss of economic confidence, resource wars, and the unforgiving Energy Trap.

The other controlled option is to deliberately adjust our lives to require fewer resources, preferably abandoning the growth paradigm at the same time.

Can we manage a calm, orderly exit from the building? In either case, the first step is to agree that the building is in trouble. Techno-optimism keeps us from even agreeing on that.

[**Tom Murphy, Do the Math**]

Dennis Meadows, interview 2012:

We began to experiment with a variety of different changes to see what could avert decline. We started with technological changes that increased agricultural productivity, reduced pollution, increased the available supply of natural resources and so forth. What we found was that technological changes alone don't avert the collapse. It requires cultural and social changes as well. You need to stabilize the population, and you need to shift consumption preferences away from material goods to the nonmaterial part—love, freedom, friendship, self-understanding and things like that.

Conclusion #2

We are facing a predicament – not a dilemma:

Our present (Western) lifestyle can not be sustained with renewables – even in the West. Globally, the situation is, of course, even worse.

So:

Renewables are *necessary* but *not sufficient*

Slutsats #2 (ny rävsax!)

Vi har inte att göra med ett (lösbart) problem utan med ett predikament:

Vår nuvarande (västerländska) livsstil kan inte upprätthållas med förnybar energi – inte ens i väst. Globalt är situationen förstås ännu värre.

Så:

En omställning till förnybar energi är nödvändig men inte tillräcklig.

Conclusion #3

Renewables are necessary, but neither renewables alone, nor renewables in conjunction with nuclear, can support our present lifestyle – let alone elevate the rest of the world to our material standard.

Planning for the future must start from this fact.

Slutsats #3

En omställning till förnybar energi är nödvändig, men varken ensam eller i förening med kärnkraft kan den under överskådlig tid låta oss upprätt-hålla dagens livsstil och än mindre kan den höja resten av världen till vår nuvarande materiella standard.

Vår planering för framtiden måste utgå från dessa fakta.

The path into the future ...

... must be characterized by

- conservation
- efficiency
- renewables
- electricity

and

- urbanization

Will we manage?

Vägen in i framtiden ...

... måste därför utmärkas av

- sparsamhet
- effektivisering
- förnybarhet
- elektrifiering

och

- urbanisering

Klarar vi detta?

Och vi små gräsrötter, då ...

... skall vi dra några strån till stacken, eller kan vi lugnt luta oss bakåt och blint lita på FN, EU och den svenska regeringen?

Ånej – så lätt kommer vi inte undan!

For a fairly affluent European:

- Car travel (to work)	50 kWh/d
- Air travel (to Thailand ...)	30 kWh/d
- Home (heating, light)	30 kWh/d
- Food	30 kWh/d
- Stuff	60 kWh/d

which sums to 200 kWh/d

Average Brit: ~125 kWh/d (imports excluded)

(Recall Edman: "Bilen, biffen, bostaden"!)

Börja spara där du står! ...

... med åtta enkla (?) personliga insatser

(förkortad lista från MacKay's SEWTHA):

Turn down your thermostats:	20 kWh/d
Read your meters every week:	4 kWh/d
Stop flying:	35 kWh/d
Drive less and more gently:	20 kWh/d
Don't replace gadgets too early:	4 kWh/d
Change lights to fluorescent or LED	4 kWh/d
Don't buy clutter:	20 kWh/d
Eat vegetarian six days a week:	10 kWh/d

Än värre späkningar:

(Minns: MacKay är från Storbritannien ...)

Eliminate draughts:	5 kWh/d
Double glazing:	10 kWh/d
Improve insulation:	10 kWh/d
Solar hot water panels:	8 kWh/d
Photovoltaic panels:	5 kWh/d
Knock down old building and replace by new:	35 kWh/d
Replace fossil-fuel heating by heat pumps:	10 kWh/d

Det här gick ju galant!

Utan någon egentlig ansträngning eller något nämnvärt lidande lyckades vi spara 200 kWh/dygn!

Att rädda världen kan tydligen gå som en dans – det är bara att bestämma sig.

Lycka till!

To summarize,

Renewables are necessary, but not sufficient

Nukes are no good

Efficiency is of the essence

Material growth must stop

Lifestyle changes will be necessary

And, finally, the good news:

It's not so damn tough, after all!

Just do it!


THE END

Eller … ?

Några avslutande lästips:

Böcker

Tim Flannery: Vädermakarna. Människan och klimatet

John Michael Greer: The Wealth of Nature. Economics as if Survival Mattered

David J C MacKay: Sustainable Energy – Without the hot Air

Donella & Dennis Meadows & Jörgen Randers: Limits to Growth. The 30-Year Update

Bloggar och slikt (ett litet urval):

Cornucopia (Lars Wilderäng)
Livet efter oljan (Daniel Pargman)

The Archdruid Report (John Michael Greer)
Question Everything (George Mobus)

Climate Code Red (D Spratt & P Sutton**)**
Post Carbon Institute (Richard Heinberg m.fl.)

realclimate.org
resilience.org (f.d. energybulletin.net)

and so on and so forth. *Sök, och I skolen finna!*