



On the physical basis of economy

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&

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Outline of this talk

- Why physicists should pay attention to economy?
- Four pillars of present economic theory (and why they are deeply wrong)
 - Free market
 - Commodification
 - Infinite substitutability
 - Endless growth
- Why (classical) economists should pay attention to Physics?
- Conclusions: A call to scientists

Why physicists should pay attention to economy

- Because economic analysis and the design of economical goals are based on statistics of physical quantities (but the Laws of Physics are not taken into account!)
- Because recurrently the diagnosis is mathematically odd and derived from it the adopted measures are definitely a failure
- Because the continuity of our work depends on the good course of the economy.
- Because we can help improving the situation using our standard tools and methods

Four pillars of classical Economy

Free market:

“The best system to regulate all economic relations is free market”

A free market is:

- Efficient
- All agents have equal access to market
- All agents have equal access to information

Free markets cannot exist in a free state; a free state leads to a natural market (oligopolistic)

The exigency of bringing freedom to the market is in fact a strongly ideological statement, nothing to do with *free market*.

Commodification

“All human interactions can be brought to the market”

Commodification means that anything which is meaningful for humans can have (*has*) a price tag.

Conversely, anything which cannot be assigned a price is *inexistent* in practical terms.

Even human relations, of any kind, can be commoditized.

Money is the measure of everything. We can then talk about human capital (labour) and natural capital (land).

Commodification is in fact a strongly ideological assumption

Infinite substitutability

“At any time that the market runs short of any good, it will find an equivalent substitute in short order”

Infinite substitutability assumes that the market, via price signals, create the adequate incentives for substitutes to appear.

According to this hypothesis, innovation is just a question of money; breakthru innovations just require more money.

Time is not a constraining variable; no matter the complexity of substitution, substitutes orderly appear when required.

Infinite substitutability is worse than an ideological assumption: it is a kind of magic or religion.

Endless growth

“Growth is good and is equivalent to wealth. Growth can continue forever unabated ”

As growth is equated to wealth, all the efforts in standard economic thought are put in maximizing growth.

All statistical indicators of the economic activity of a region, starting by GDP, must grow in a healthy economy

The goal for enterprises at any level is to grow, just to grow.

From all assumptions, growth is in fact the most controversial one, but also for that reason it is rarely seriously debated

Endless growth is more than a strongly ideological assumption: it is the very fabric of capitalism, and so it is unquestionable.

What's wrong with free market?

Market inefficiencies

- Markets cannot efficiently provide public goods (free access to everyone: free riding)
- Adverse selection (no possible marketization on high-risk or low profit activities)
- Natural monopolies (access barriers)
- Tragedy of commons
- Tendency to create oligopolies

Abusive externalization

If the only driver of market is own profit, producer has all the incentives to externalize any charge.



EXTERNALITIES!

Air pollution



Water pollution



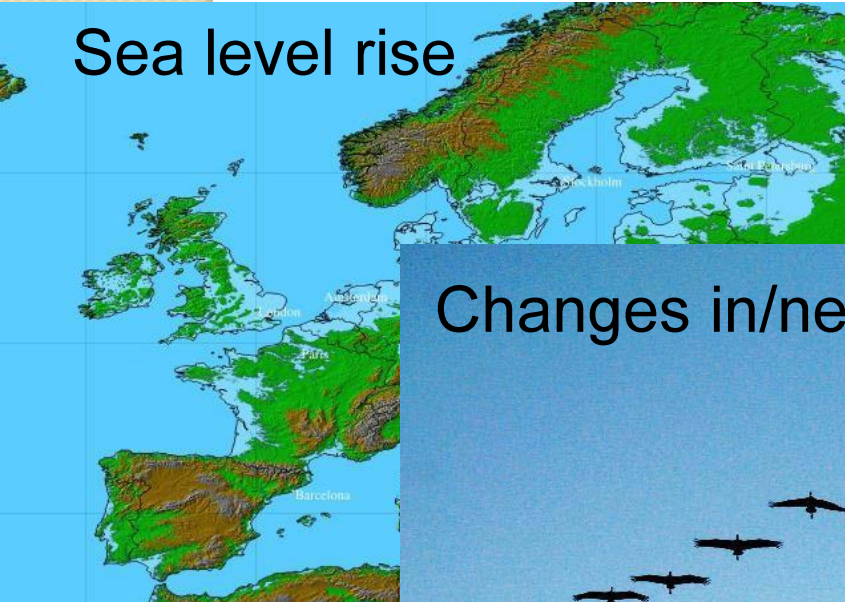
Massive dumping



... and Climate Change!

CLIMATE CHANGE!

Sea level rise

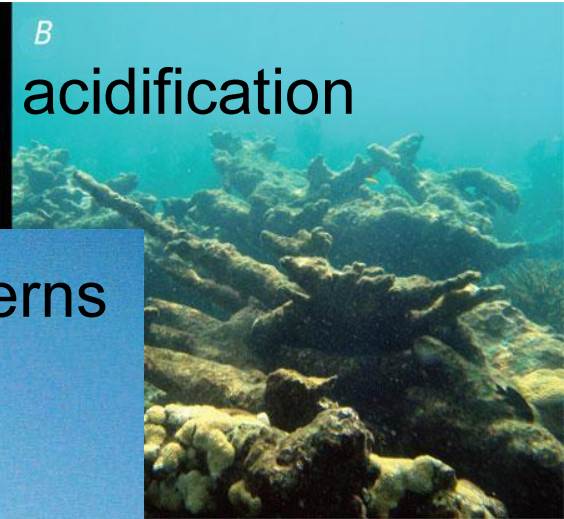


A

Ocean

B

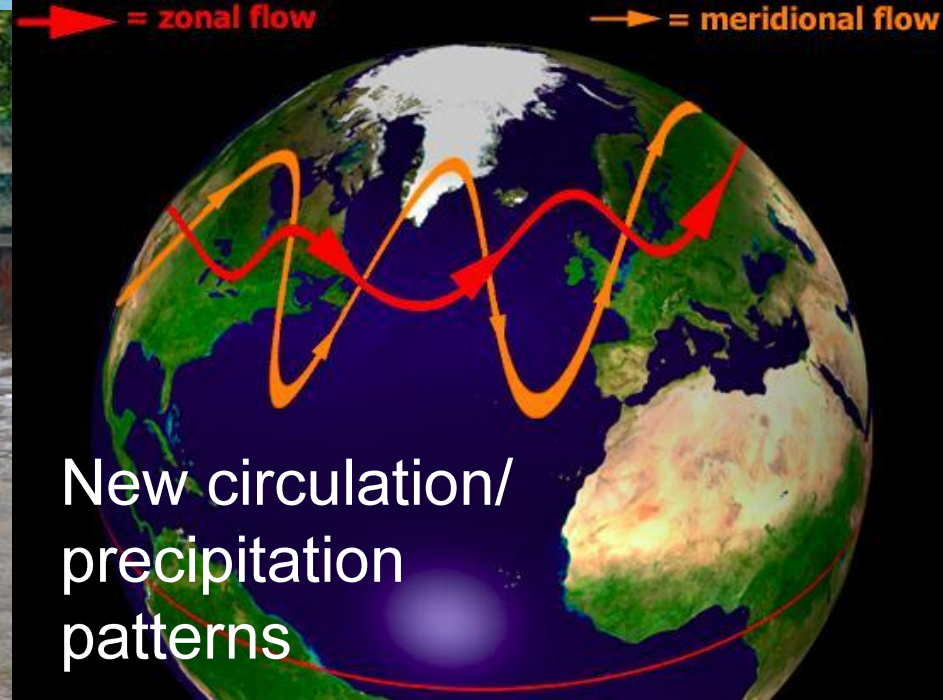
acidification



Changes in/new migration patterns



Weather extremes

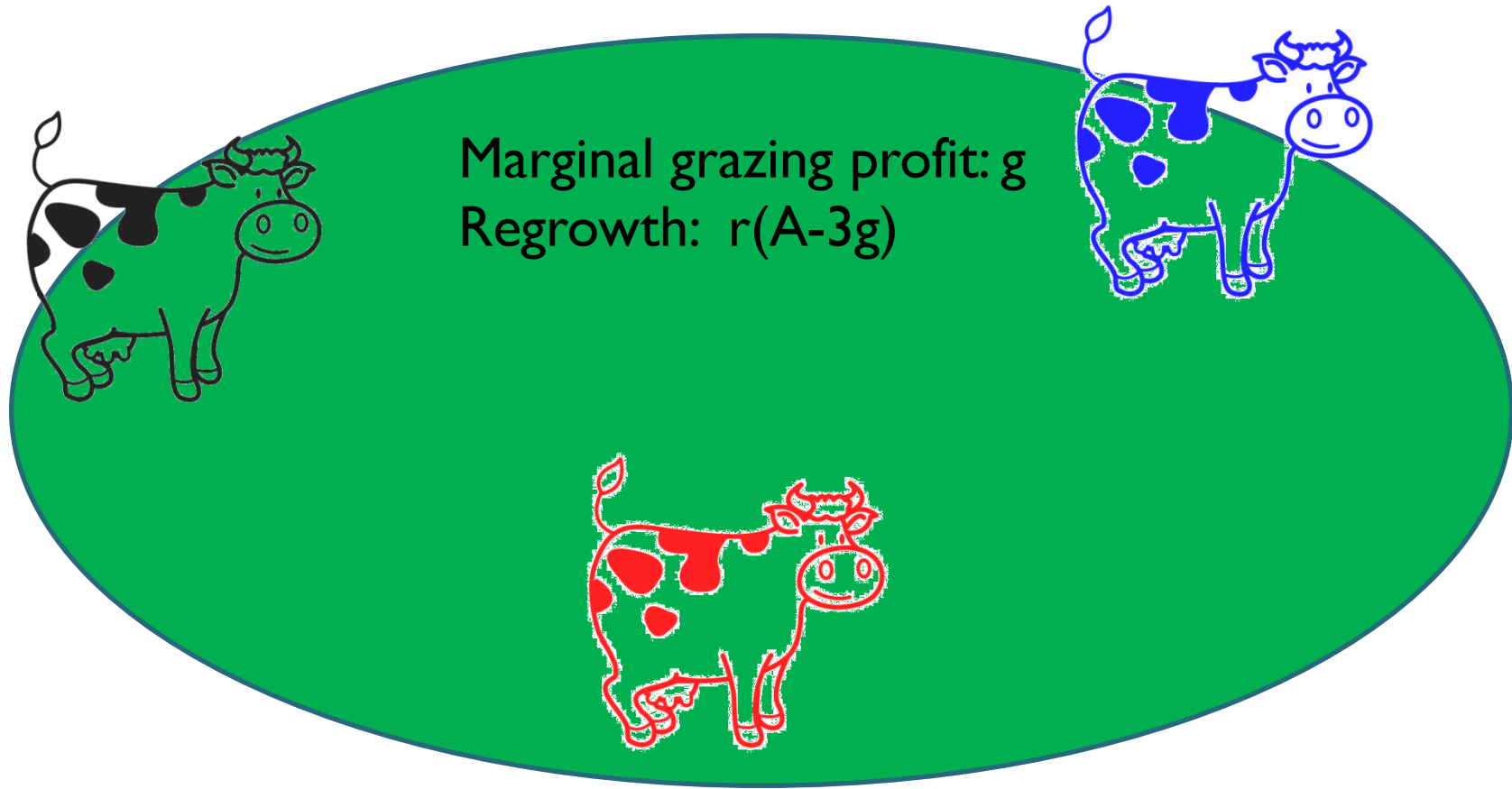


New circulation/
precipitation
patterns

Anoter market inefficiency: The tragedy of commons

On a purely rational basis, common goods are exploited until its entire destruction

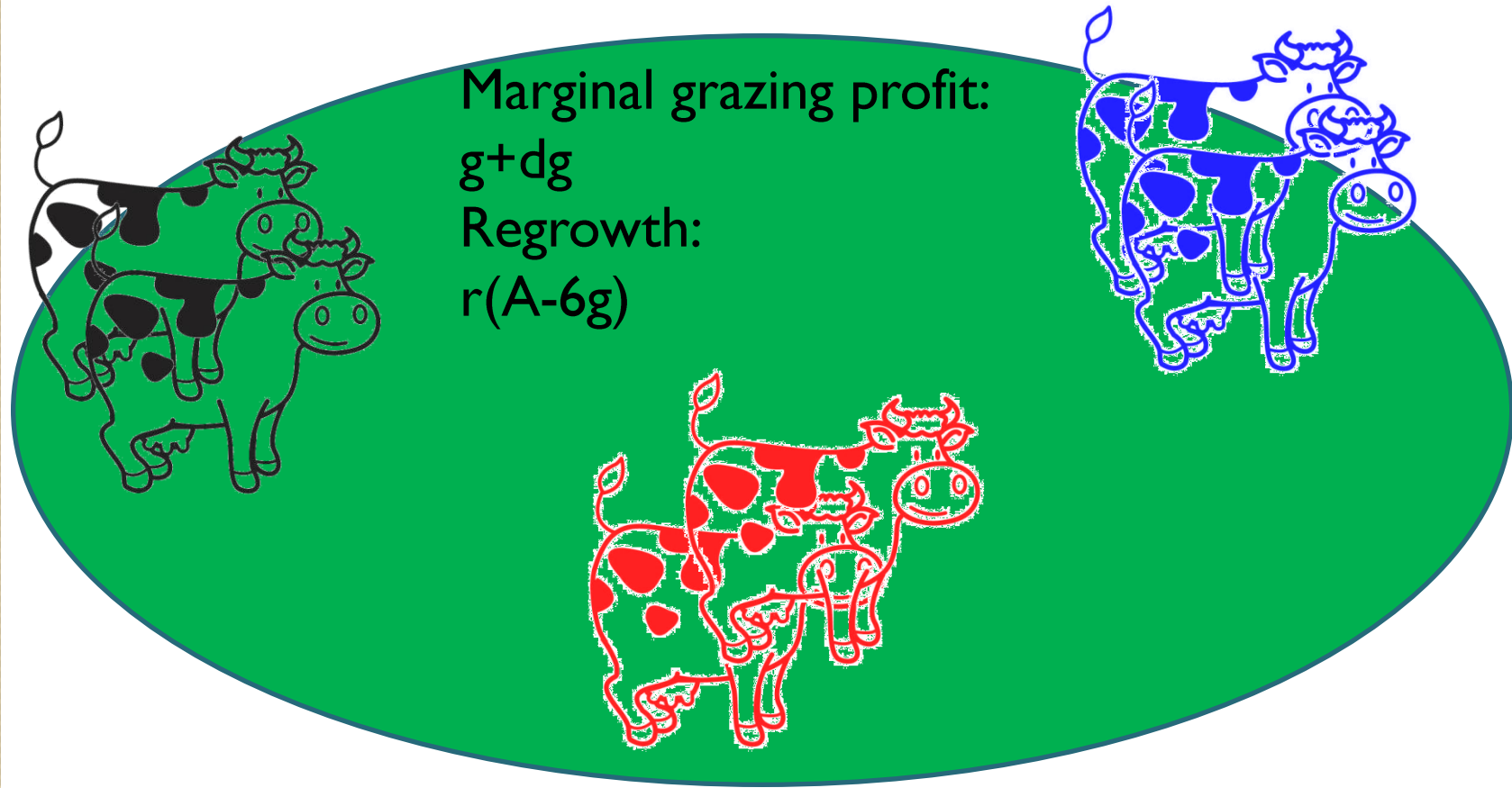
Traditional sharing of commons



Anoter market inefficiency: The tragedy of commons

On a purely rational basis, common goods are exploited until its entire destruction

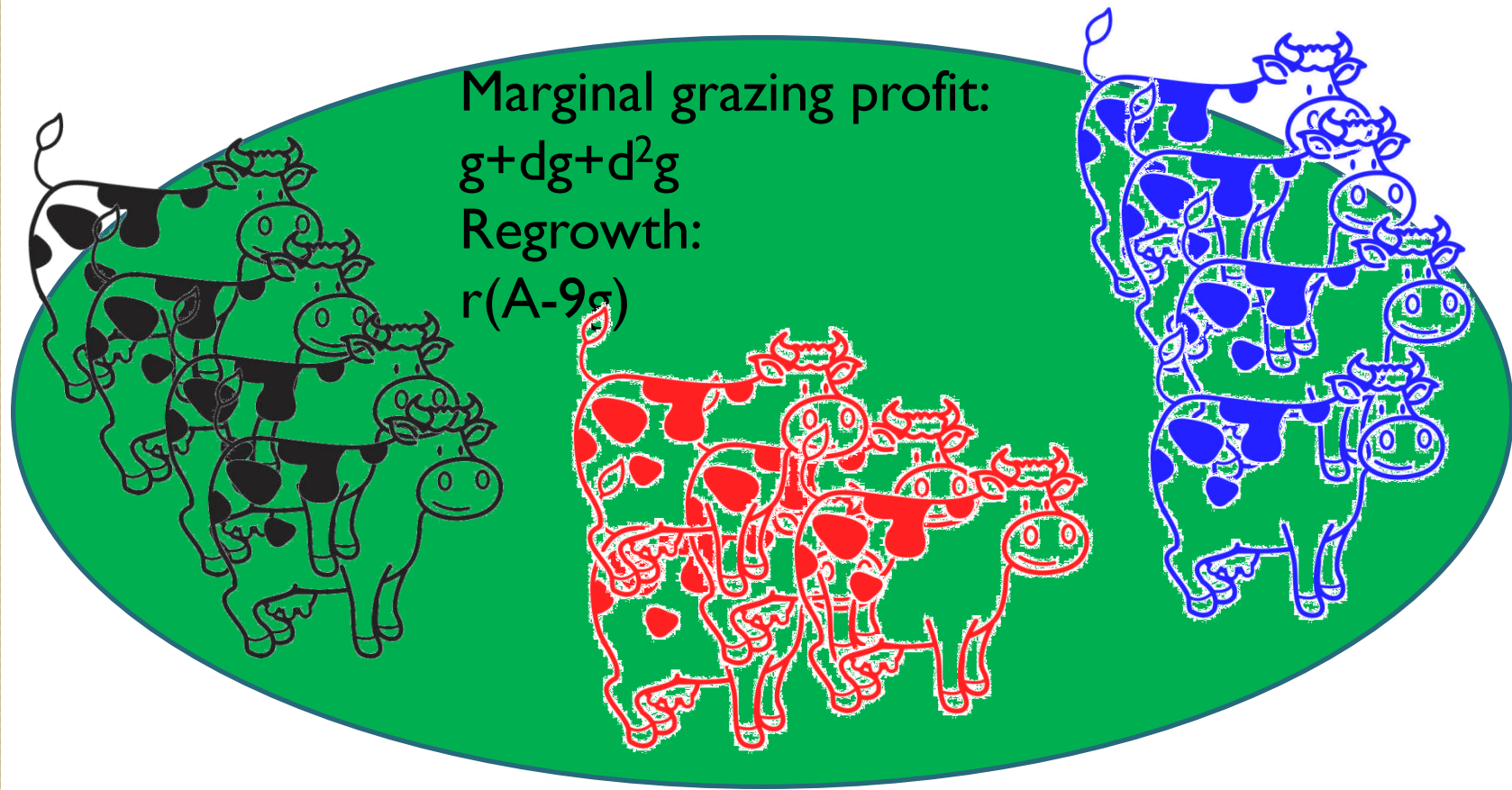
Competence starts....



Anoter market inefficiency: The tragedy of commons

On a purely rational basis, common goods are exploited until its entire destruction

Competence accelerates....

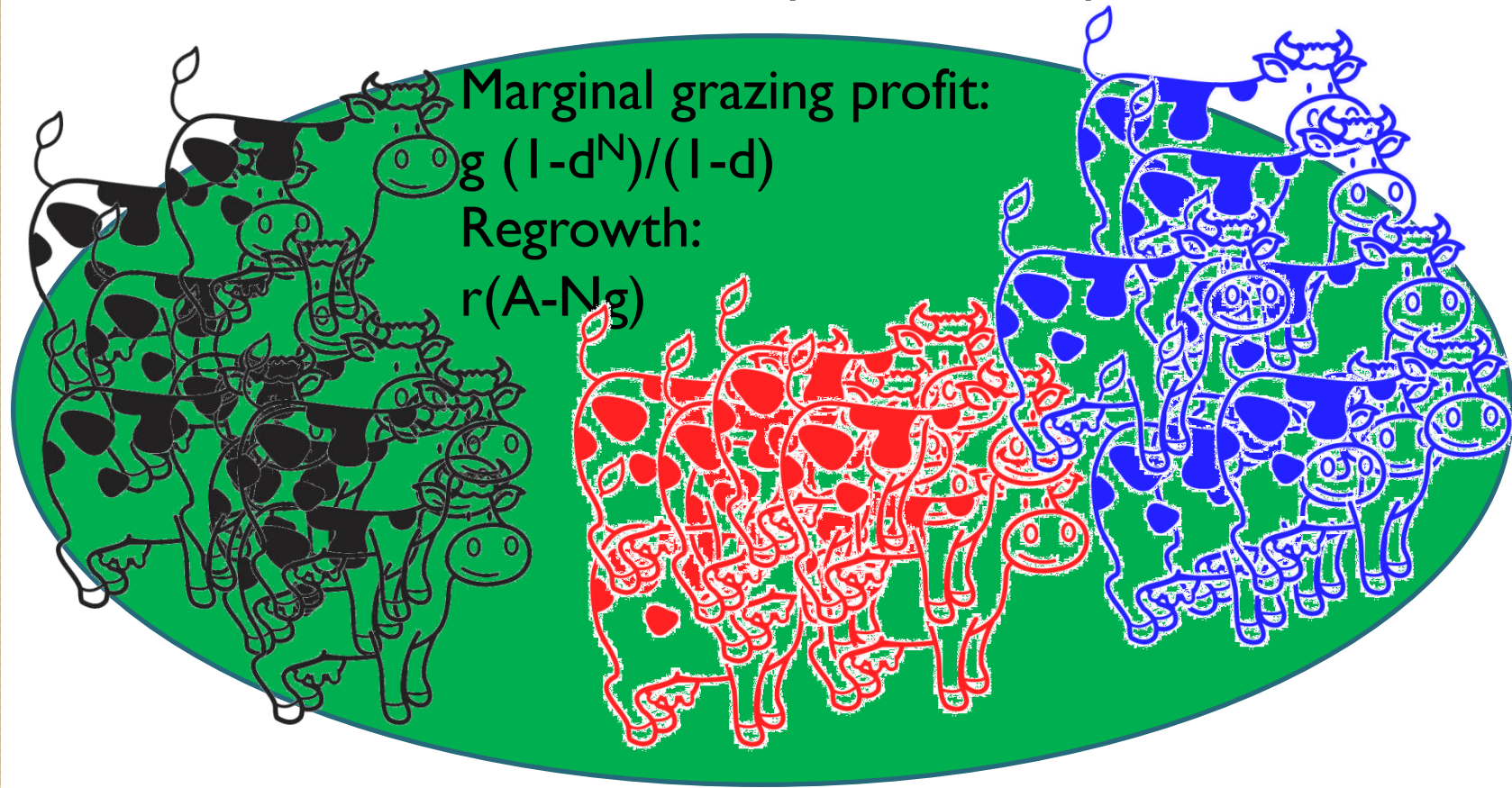


Anoter market inefficiency: The tragedy of commons

On a purely rational basis, common goods are exploited until its entire destruction

Eventually....

When $r(A - Ng) < Ng$ the pasture collapses



Unequal access to the market and to information

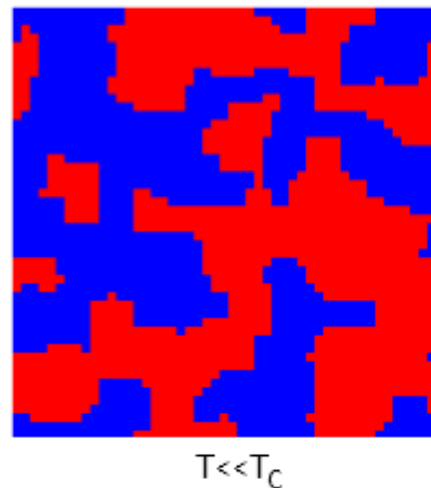
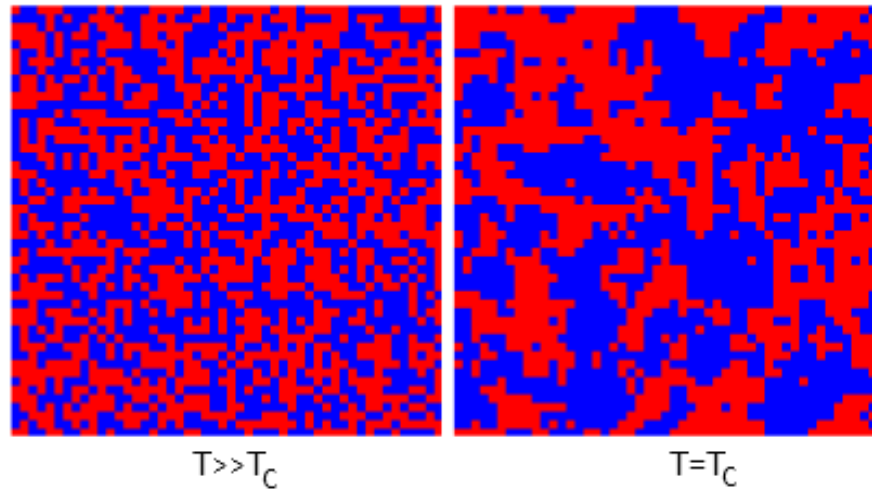
Real-world markets are unequal.

- Purchasers are not provided full information on what they buy: illusion of choice
- There is no real competence: concentration (oligopoly)



The example of spin glasses

Without further constraint, markets tend to coalesce in an oligopolistic state (regulations $\sim$ temperature)



What's wrong with commodification?

Not all human interactions are profit-oriented

Classical examples are family, friends, NGOs, church, schools, health...

Commodification has put a price tag on some classical non-profit-oriented activities (schools, health).

Other are seriously disrupted by commodification (friends, NGOs)

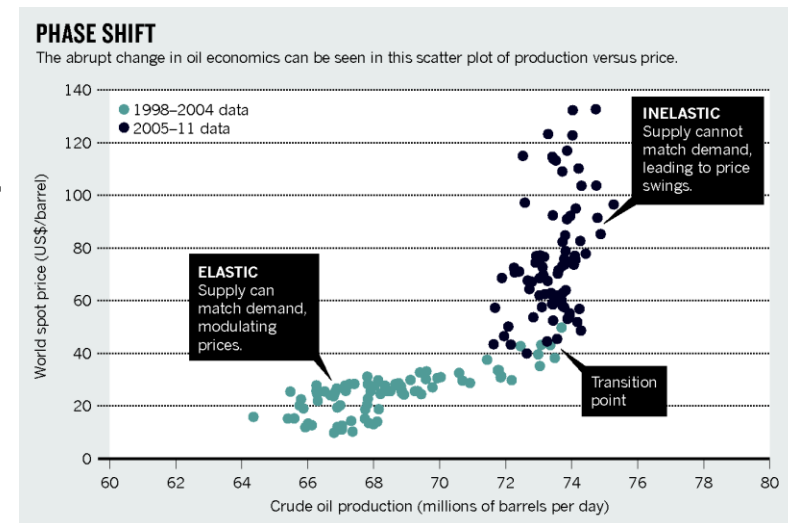
Only a few are left aside as for their value for providing core values (family, church), that are however commoditized

Market overrates fluxes in front of stocks (no scarcity signal)

Hotelling's rule states that as a commodity approaches the scarcity point in an efficient market, price undergoes a phase transition.

However, some unsubstitutable commodities have become scarce without ever signaling it before the price shock.

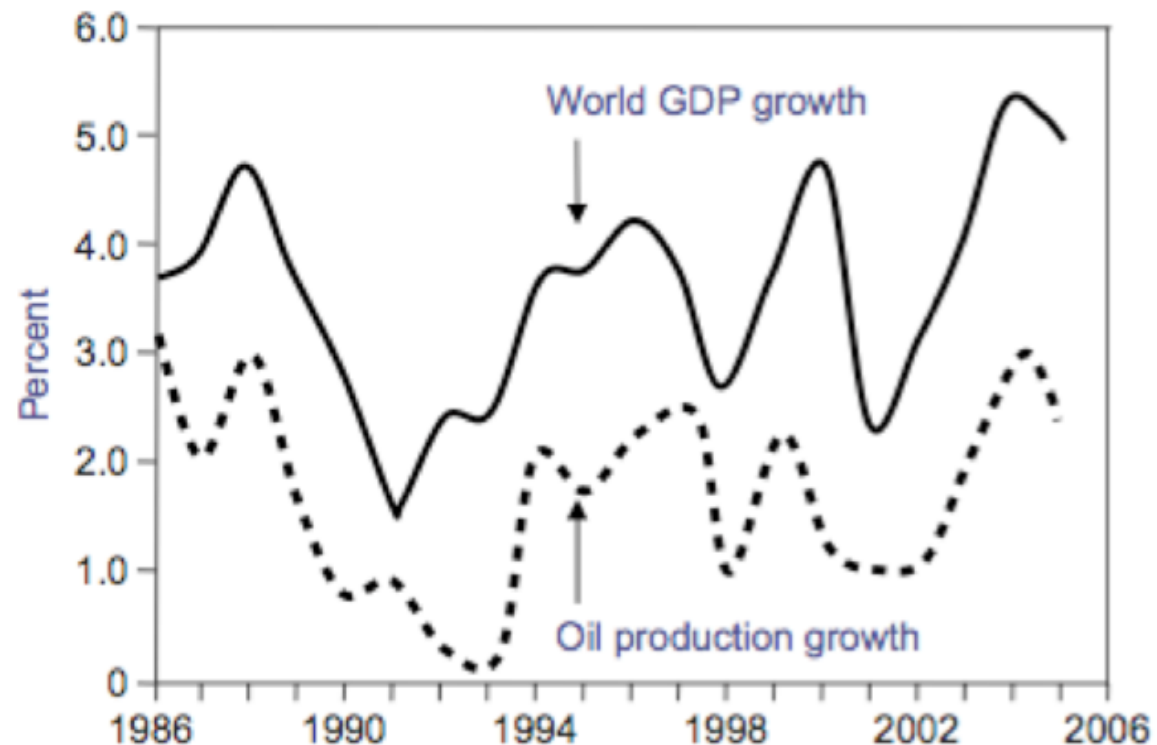
The problem is that market is short-terministic: today benefit is overrated in front of future scarcity.



(Murray & King, *Nature* 48, 433-435 (2012))

Energy is not yet another commodity

History shows a close tie between world economic growth and oil growth



Source: Robert L Hirsch. Mitigation of maximum world oil production: Shortage scenarios. Energy Policy 2008

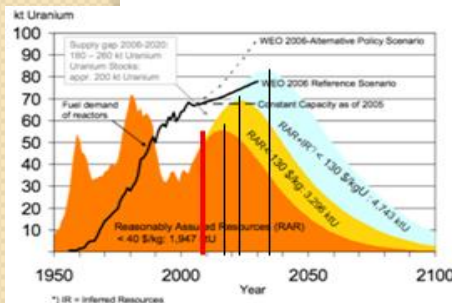
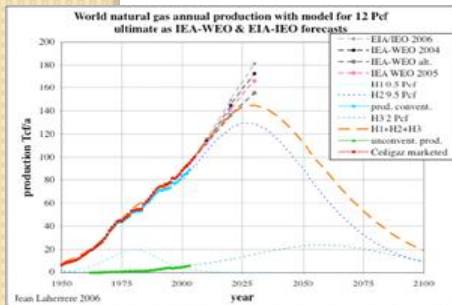
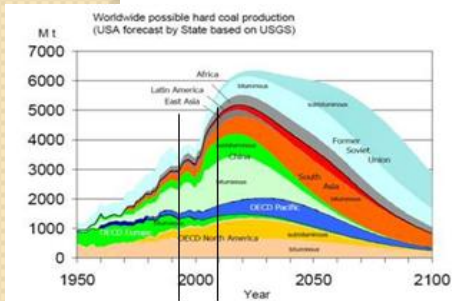
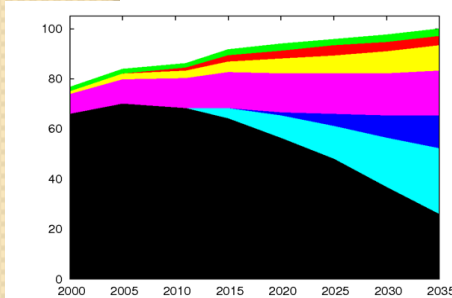
Status of all non-renewable energy sources (BP 2012)

Peak Oil: 2005 (crude)
2015 (total)
33,1% PE

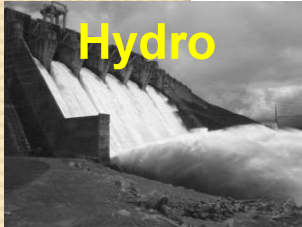
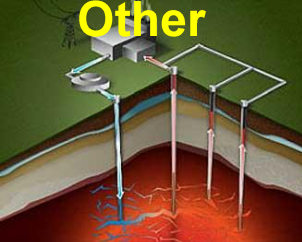
Peak Coal: 2020-2040
30,3% PE

Peak Gas: around 2020
23,7% PE

Peak uranium: before 2020
4,9% PE



Renewable sources are the future! (?)

	Maximum equivalent power	Dependence on materials	Energy return on Energy Investment
 Hydro	5 TW	Concrete, steel, copper	30
 Wind	1 TW	Concrete, steel, copper (all) neodymium, dysprosium (best)	20
 PV	4.5 TW	Silicon, aluminium, copper (all) tellurium (best)	2.5
 CSP	Unknown	Steel, concrete, copper, aluminium, salts	20
 Other	Few Gw	Steel, concrete, copper, aluminium	10-30

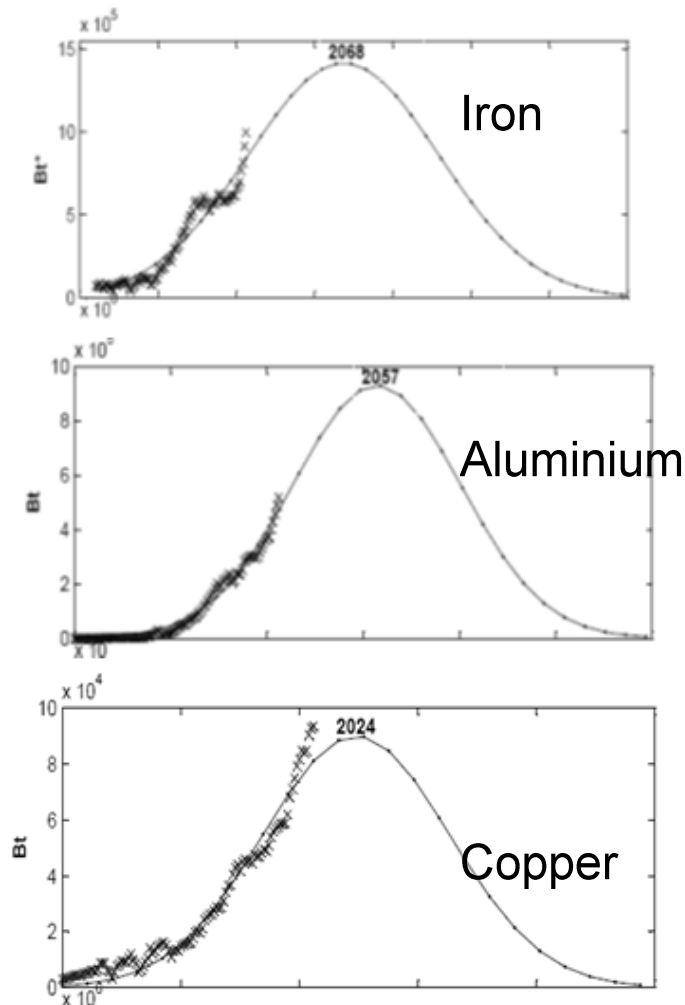
Money is just a token, not actual value (ideological bias on the theory of money)



... money is the language rather than the substance of the real economy. Ultimately, the economy is – and always has been – a surplus energy equation, governed by the laws of thermodynamics, not those of the market.

What's wrong with infinite substitutability?

Resources are necessarily in finite supply



As for non-renewable energy sources, materials have production limits

Source:

Alicia Valero, Antonio Valero.
Physical geonomics: Combining the exergy and Hubbert peak analysis for predicting mineral resources depletion.

***Resources, conservation and recycling* 5(12), 1074- 1083 (2010)**

Possible substitutes for a resource are necessarily in a finite (and not too big) number

Possible combinations of periodic table of elements seem huge

Periodic Table of Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18								
1 H Hydrogen 1.00794	2 He Helium 4.002602																								
3 Li Lithium 6.941	4 Be Beryllium 9.012182																								
5 Na Sodium 22.98976928	6 Mg Magnesium 24.304																								
7 K Potassium 39.0983	8 Ca Calcium 40.078	9 Sc Scandium 44.955912	10 Ti Titanium 47.867	11 V Vanadium 50.9415	12 Cr Chromium 51.9961	13 Mn Manganese 54.938044	14 Fe Iron 55.845	15 Co Cobalt 58.933195	16 Ni Nickel 58.6934	17 Cu Copper 63.546	18 Zn Zinc 65.38	19 Ga Gallium 69.723	20 Ge Germanium 72.630	21 As Arsenic 74.9216	22 Se Selenium 78.96	23 Br Bromine 79.904	24 Kr Krypton 83.798								
25 Rb Rubidium 85.4678	26 Sr Strontium 87.62	27 Y Yttrium 88.90584	28 Zr Zirconium 91.224	29 Nb Niobium 92.90638	30 Mo Molybdenum 95.94	31 Tc Technetium 98.90625	32 Ru Ruthenium 101.07	33 Rh Rhodium 102.90550	34 Pd Palladium 106.36	35 Ag Silver 107.8682	36 Cd Cadmium 112.411	37 In Indium 114.818	38 Sn Tin 118.710	39 Sb Antimony 121.757	40 Te Tellurium 127.6	41 I Iodine 126.90547	42 Xe Xenon 131.29								
43 Cs Cesium 132.90545196	44 Ba Barium 137.327	45 La Lanthanum 138.9047	46 Ce Cerium 140.116	47 Pr Praseodymium 140.90766	48 Nd Neodymium 144.242	49 Pm Promethium 144.9127	50 Sm Samarium 150.36	51 Eu Europium 151.964	52 Gd Gadolinium 157.25	53 Tb Terbium 158.92534	54 Dy Dysprosium 162.50039	55 Ho Holmium 164.930329	56 Er Erbium 167.259	57 Tm Thulium 168.93048	58 Yb Ytterbium 173.054	59 Lu Lutetium 174.967	60 Uuo Ununhexium 289								
61 Fr Francium 223	62 Ra Radium 226	63 Ac Actinium 227	64 Th Thorium 232	65 Pa Protactinium 231	66 U Uranium 238	67 Np Neptunium 237	68 Pu Plutonium 244	69 Am Americium 243	70 Cm Curium 247	71 Bk Berkelium 247	72 Cf Californium 251	73 Es Einsteinium 252	74 Fm Fermium 257	75 Md Mendelevium 258	76 No Nobelium 259	77 Lr Lawrencium 262	78 Uus Ununseptium 286								
79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222	87 Fr Francium 223	88 Ra Radium 226	89 Ac Actinium 227	90 Th Thorium 232	91 Pa Protactinium 231	92 U Uranium 238	93 Np Neptunium 237	94 Pu Plutonium 244	95 Am Americium 243	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 262	
107 La Lanthanum 138.9047	108 Ce Cerium 140.116	109 Pr Praseodymium 140.90766	110 Nd Neodymium 144.242	111 Pm Promethium 144.9127	112 Sm Samarium 150.36	113 Eu Europium 151.964	114 Gd Gadolinium 157.25	115 Tb Terbium 158.92534	116 Dy Dysprosium 162.50039	117 Ho Holmium 164.930329	118 Er Erbium 167.259	119 Tm Thulium 168.93048	120 Yb Ytterbium 173.054	121 Lu Lutetium 174.967	122 Uuo Ununhexium 289	123 Uuh Ununheptium 288	124 Uuq Ununquadium 289	125 Uuh Ununheptium 288	126 Uub Ununbium 286	127 Uut Ununtrium 288	128 Uuq Ununquadium 289	129 Uuh Ununheptium 288	130 Uub Ununbium 286	131 Uut Ununtrium 288	132 Uuq Ununquadium 289
133 Uup Ununpentium 288	134 Uuh Ununheptium 288	135 Uus Ununseptium 286	136 Uuo Ununhexium 289	137 Uut Ununtrium 288	138 Uuq Ununquadium 289	139 Uuh Ununheptium 288	140 Uub Ununbium 286	141 Uut Ununtrium 288	142 Uuq Ununquadium 289	143 Uuh Ununheptium 288	144 Uub Ununbium 286	145 Uut Ununtrium 288	146 Uuq Ununquadium 289	147 Uuh Ununheptium 288	148 Uub Ununbium 286	149 Uut Ununtrium 288	150 Uuq Ununquadium 289								

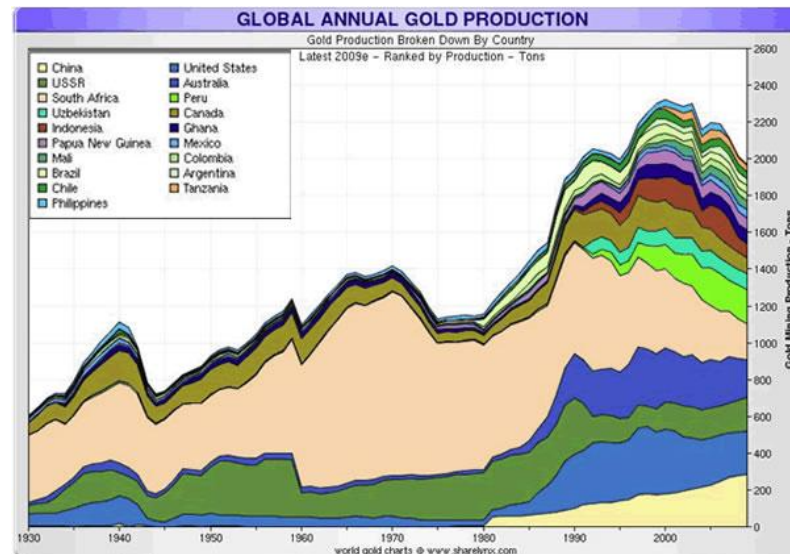
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However, only compounds appearing in significant concentrations can be economically (i.e. energetically) be exploited.

E.g, Au in sea water 6 ppb, U limit 0.02%, Cu 0.01%

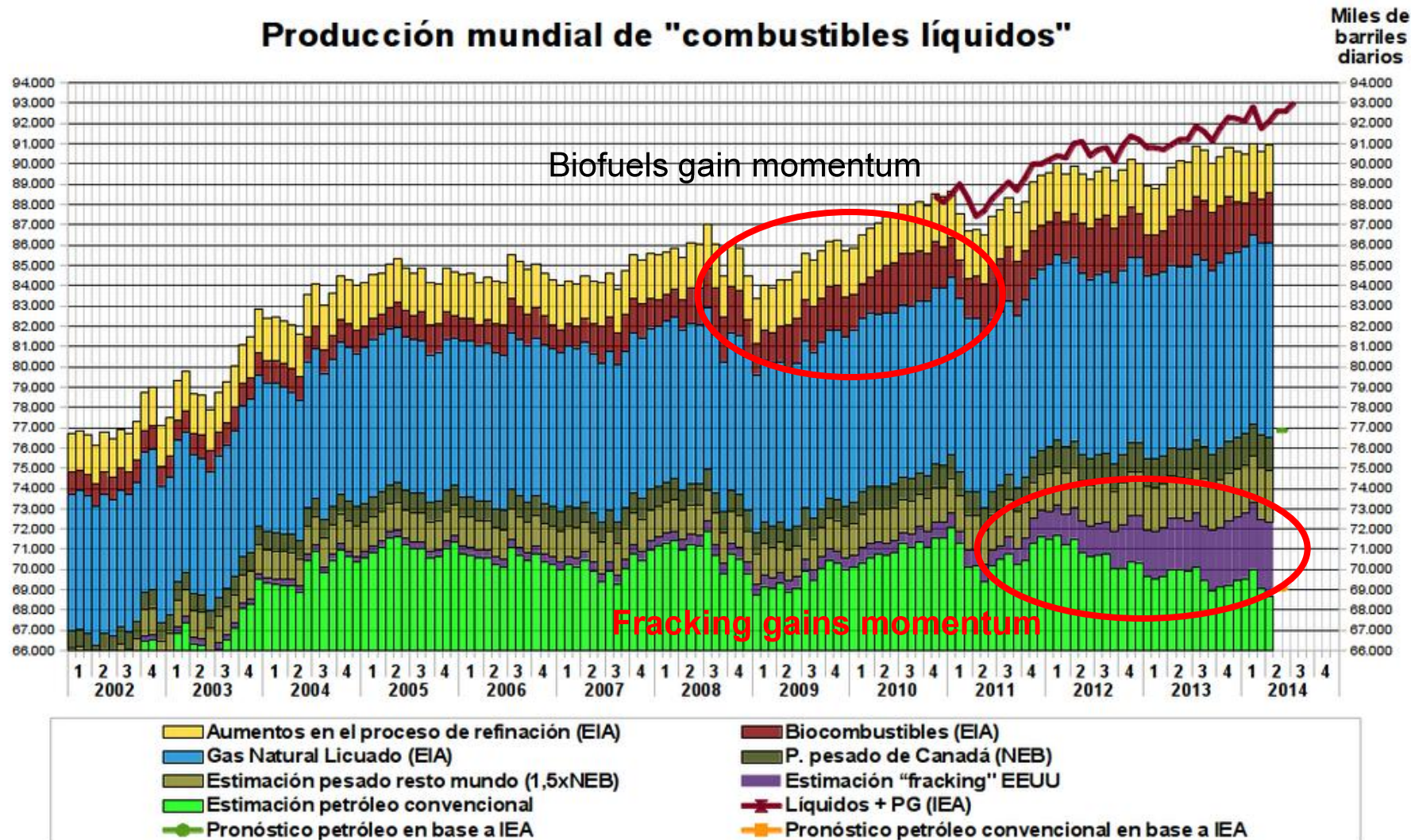
Market signals are an expression of wish, not a certainty of having (economic theory as magic or religion)

- There is no logical reason for which a substitute appears if we happen to need one.
- There is no logical reason for which the market could timely anticipate a substitute when required.
- Past experience shows us that this is not not true in general.



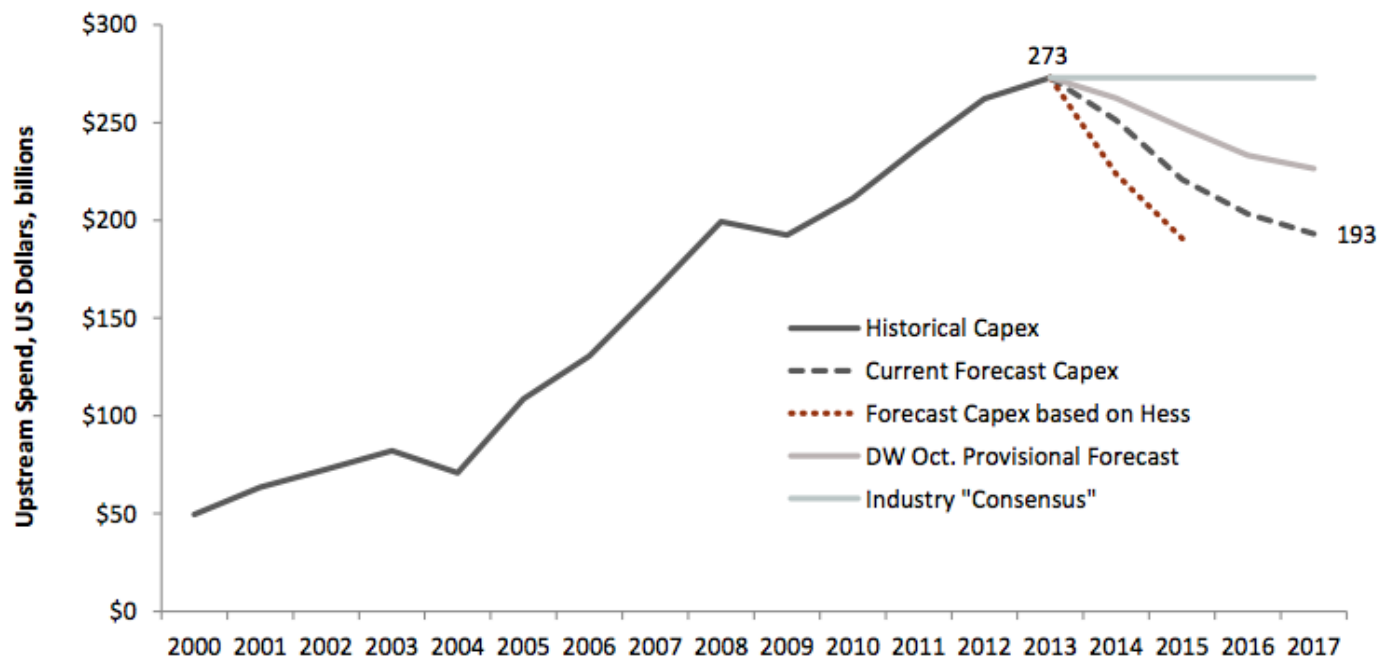
Source: www.sharelynx.com

The example of oil: peak crude oil and oil substitutes since 2005.



March 2014: After losing money for years (especially with unconventional oil) Big Oil have started a hasted divestment.

Listing Oil Majors: Capex

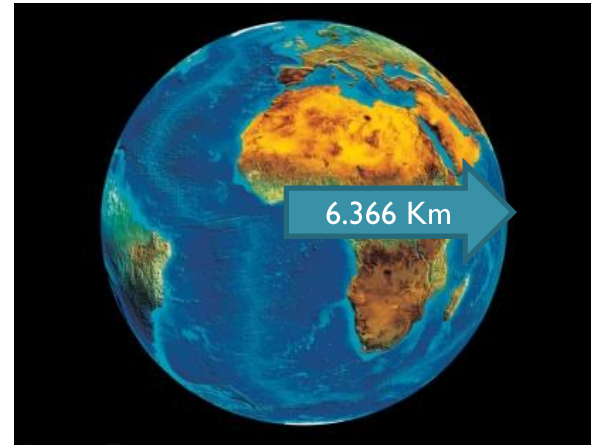


Historical and Forecast Crude Oil Production and Capex (Provisional, subject to Revision)

Combined data for BG, BP, COP, CVX, ENI, OXY, PBR, RDS, STO, TOT, XOM
Source: Bloomberg via Phibro Trading LLC

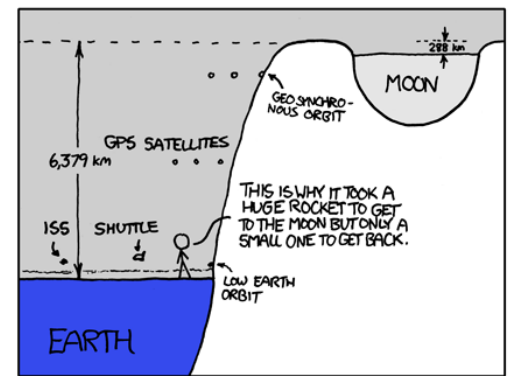
What's wrong with endless growth?

The planet is finite...



... and Outer Space exploration by Humankind is too slow for the required expansion rates.

Fermi's paradox? Hubbert's hurdle

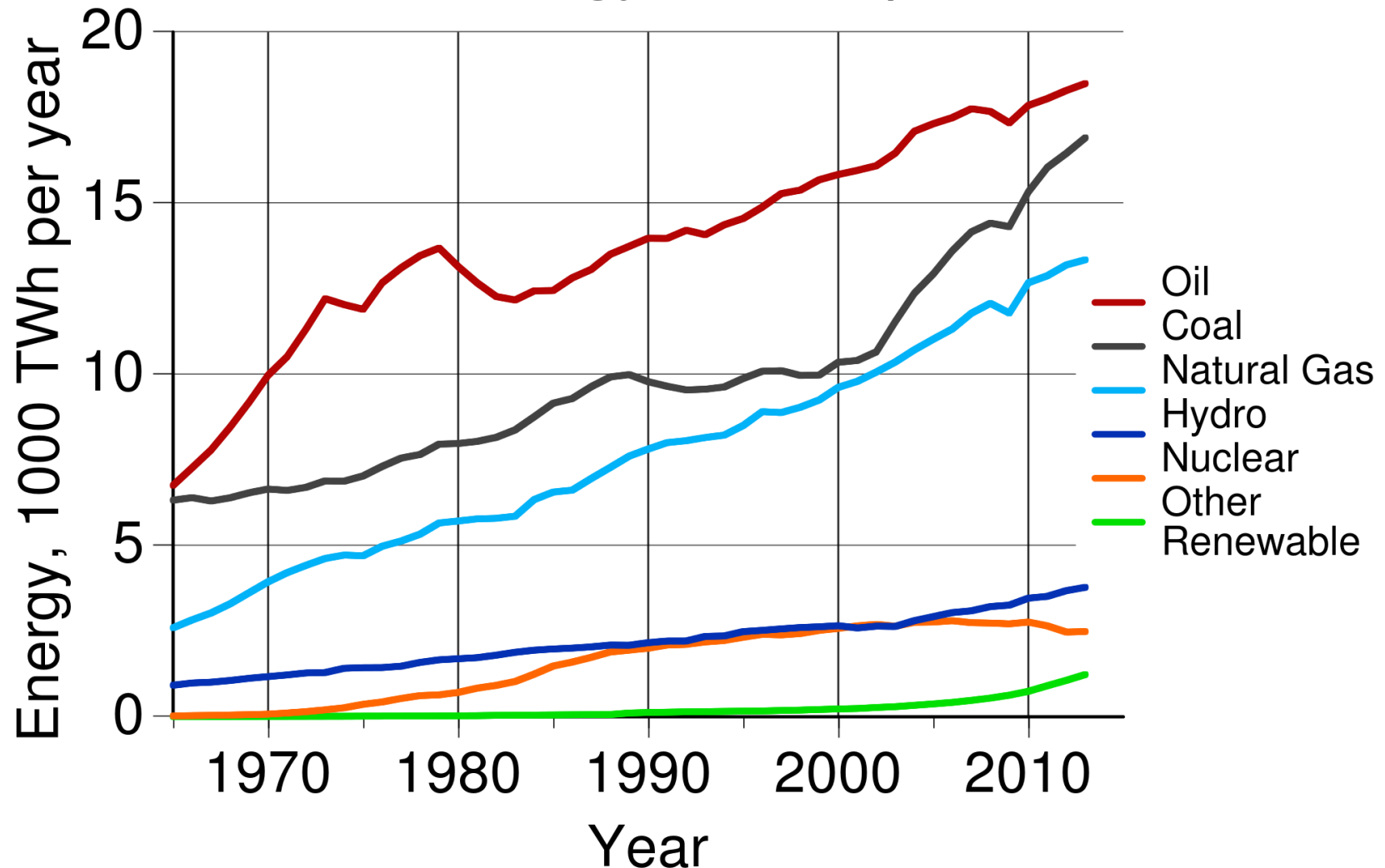


IT TAKES THE SAME AMOUNT OF ENERGY TO LAUNCH SOMETHING ON AN ESCAPE TRAJECTORY AWAY FROM EARTH AS IT WOULD TO LAUNCH IT 6,000 km UPWARD UNDER CONSTANT 9.81 m/s^2 EARTH GRAVITY.

HENCE, EARTH'S WELL IS 6,000 km DEEP.

Despite claims on efficiency and dematerialization, economy has strong, unavoidable material bases.

World energy consumption



Growth of GDP is in fact linked to the needs of capital in a capitalistic system (main ideological bias, hegemonic, unquestionable dogma).

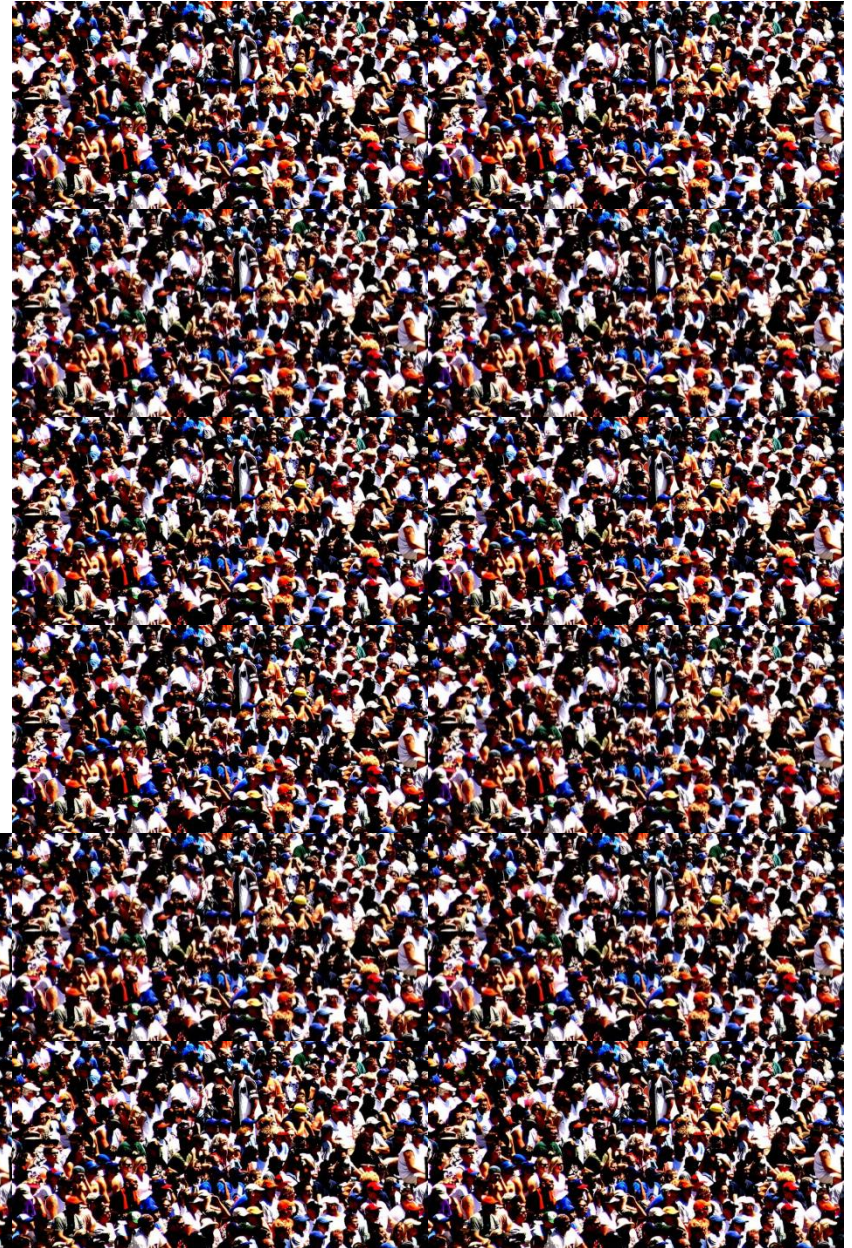
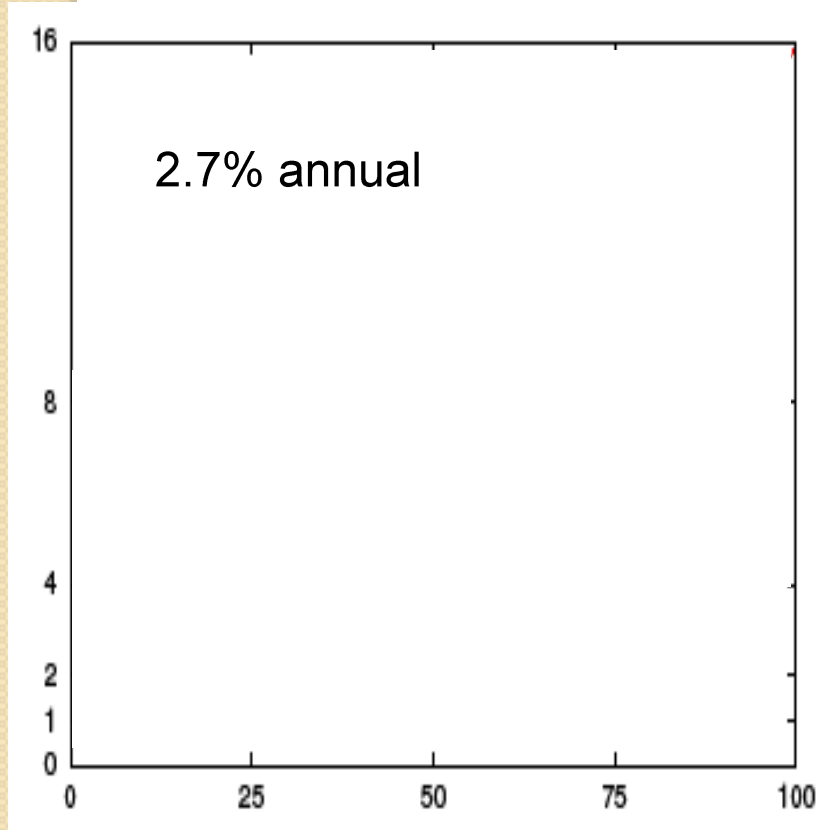
Capital needs regrowth rates above inflation.

Fiat currencies are physically debased, and fractional reserve practice allows to create money out of thin air.



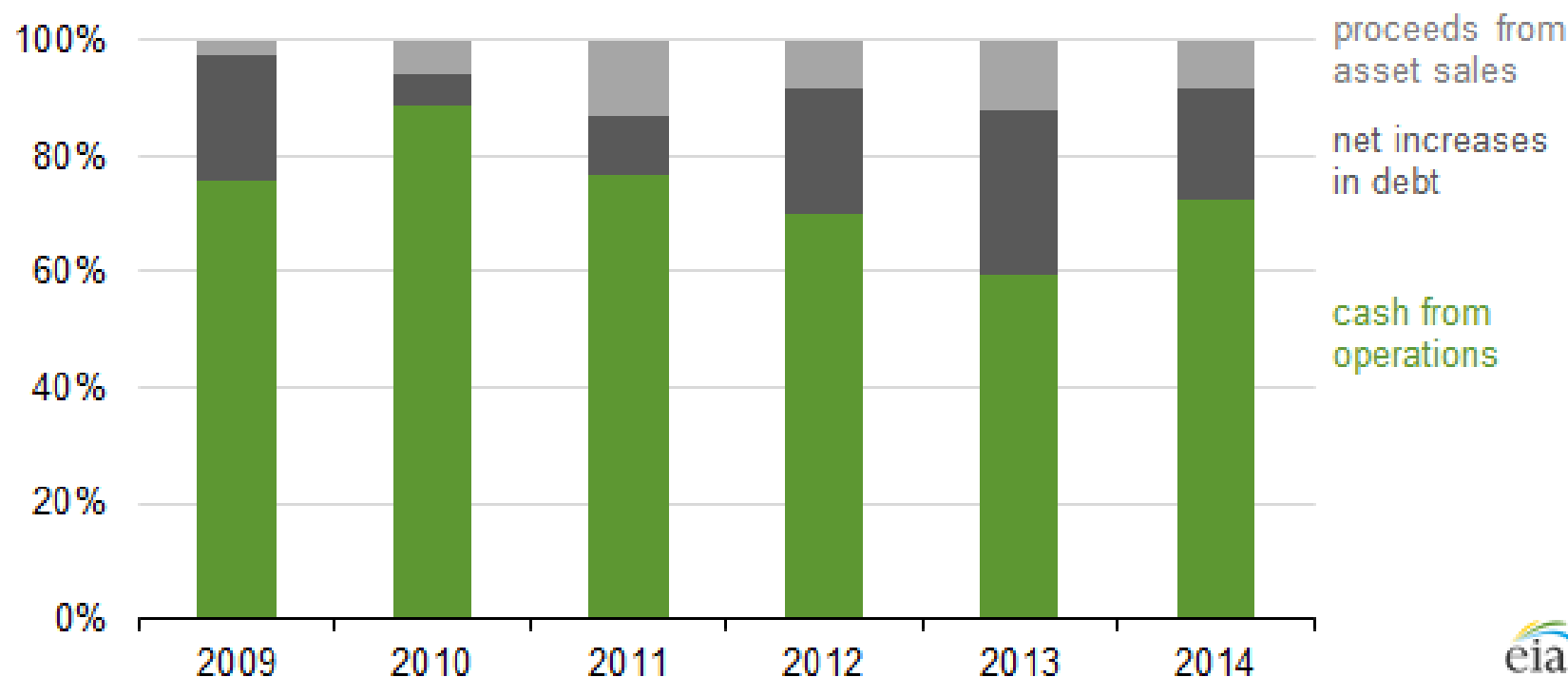
“Dante, in *The Inferno*, put lenders at the bottom of the seventh circle of hell, below mass murderers, heretics, and fallen angels. The only sinners who go further down than lenders were the practitioners of fraud, in the eighth circle, and traitors, in the ninth”. John Michael Greer, *The Archdruid's Report*

Compound interest is to blame!



The hegemony of “growth thinking” implies short-terminism

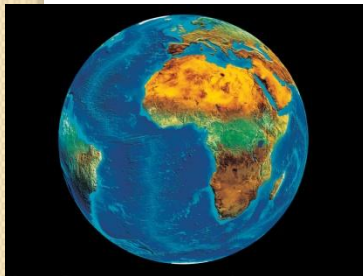
First-quarter sources of cash for major energy companies
compiled from energy companies' quarterly financial reports



The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 14.5°C



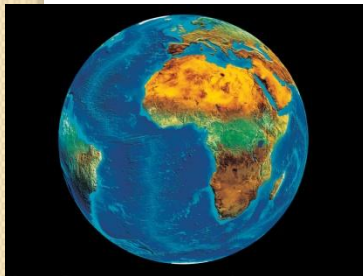
= 0.018 Petawatts (2012)

But assuming a minimum growth rate of 2.3% per annum...

The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 14.5°C



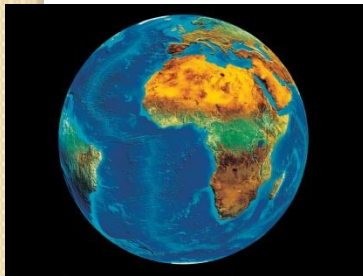
= 0.18 Petawatts (2112)

But assuming a minimum growth rate of 2.3% per annum...

The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 15°C



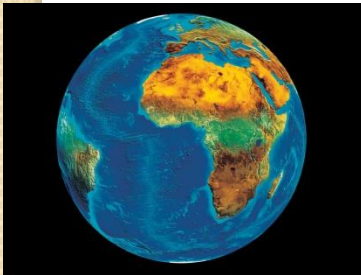
= 18 Petawatts (2212)

But assuming a minimum growth rate of 2.3% per annum...

The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 20°C



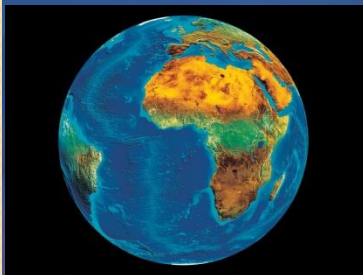
= 180 Petawatts (2312)

But assuming a minimum growth rate of 2.3% per annum...

The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 55°C



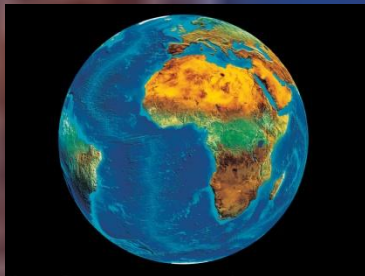
= 1800 Petawatts (2412)

But assuming a minimum growth rate of 2.3% per annum...

The example of energy consumption at exponential rate: centuries to burn the Earth



= 174 Petawatts (equivalent power)



Average Earth temperature = 220°C

= 18 000 Petawatts (2512)

But assuming a minimum growth rate of 2.3% per annum...

Why economists should pay attention to Physics?

- Claims and objectives fixed by economists are plainly absurd when contrasted with the Laws of Physics.
- Economy is a subsystem of Human ecology (circular economy).
- Green landscape mode vs Spaceship Earth mode: the end of growth
- Collapse is indeed a possibility (shall we be the 27th?)
- Modern economic theories, still marginalized, recognise those obvious facts.

Conclusions: a call to scientists!

- Modern economical theory is in open contradiction with the Laws of Physics, with data, and with intuition.
- Nevertheless, Governments all over the world relentlessly apply economic measures which bring us on an absurd spirally of degrading economy.
- Collapse is not only an option: it is our likely destination if we do not change course.
- Scientists can make very strong points while denouncing and revealing the inner inconsistencies of present economical measures.
- It is more than a service to society: it is a duty. Our lives and those of our beloved ones depend on this.