Current and future energy needs

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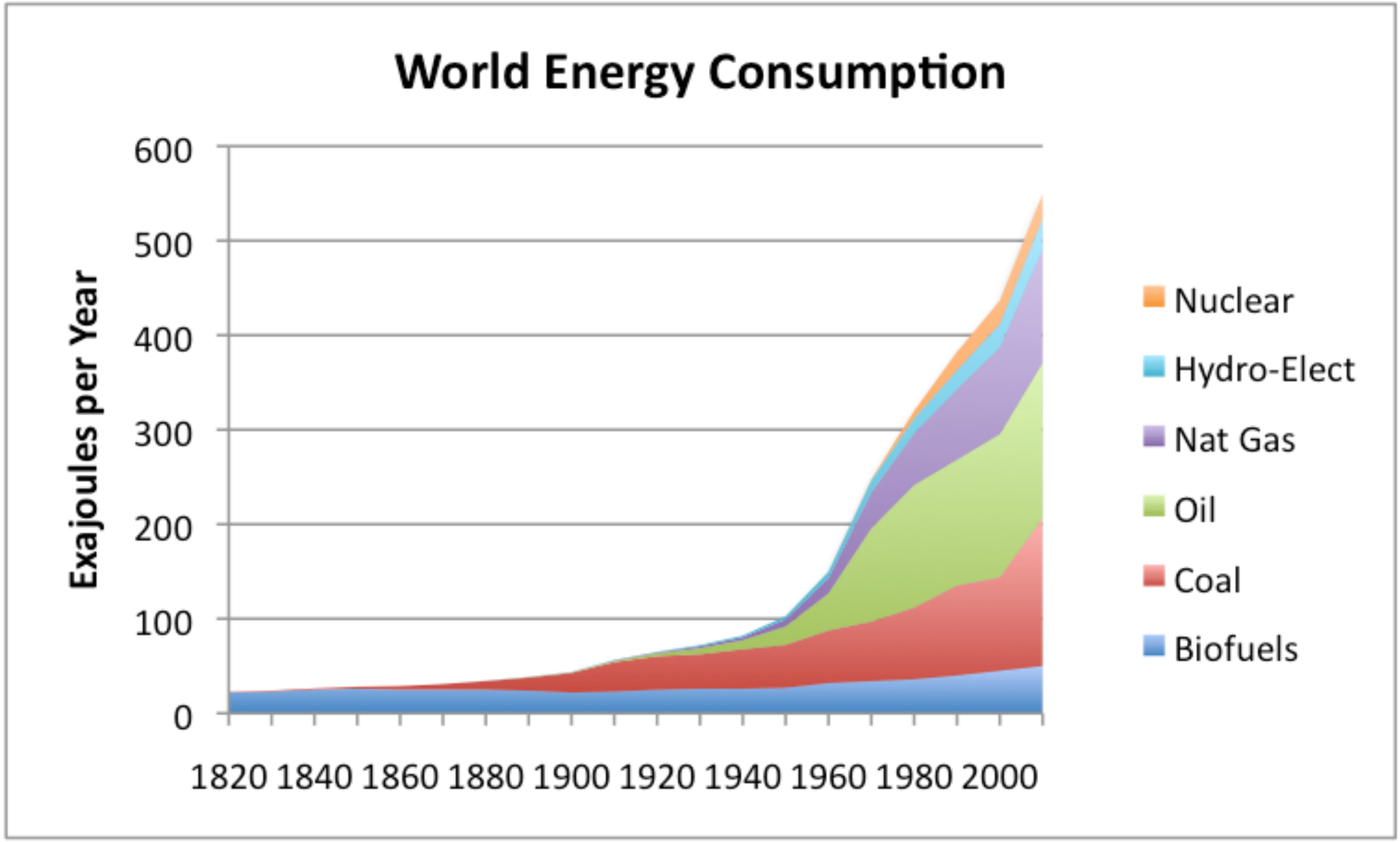
Medact

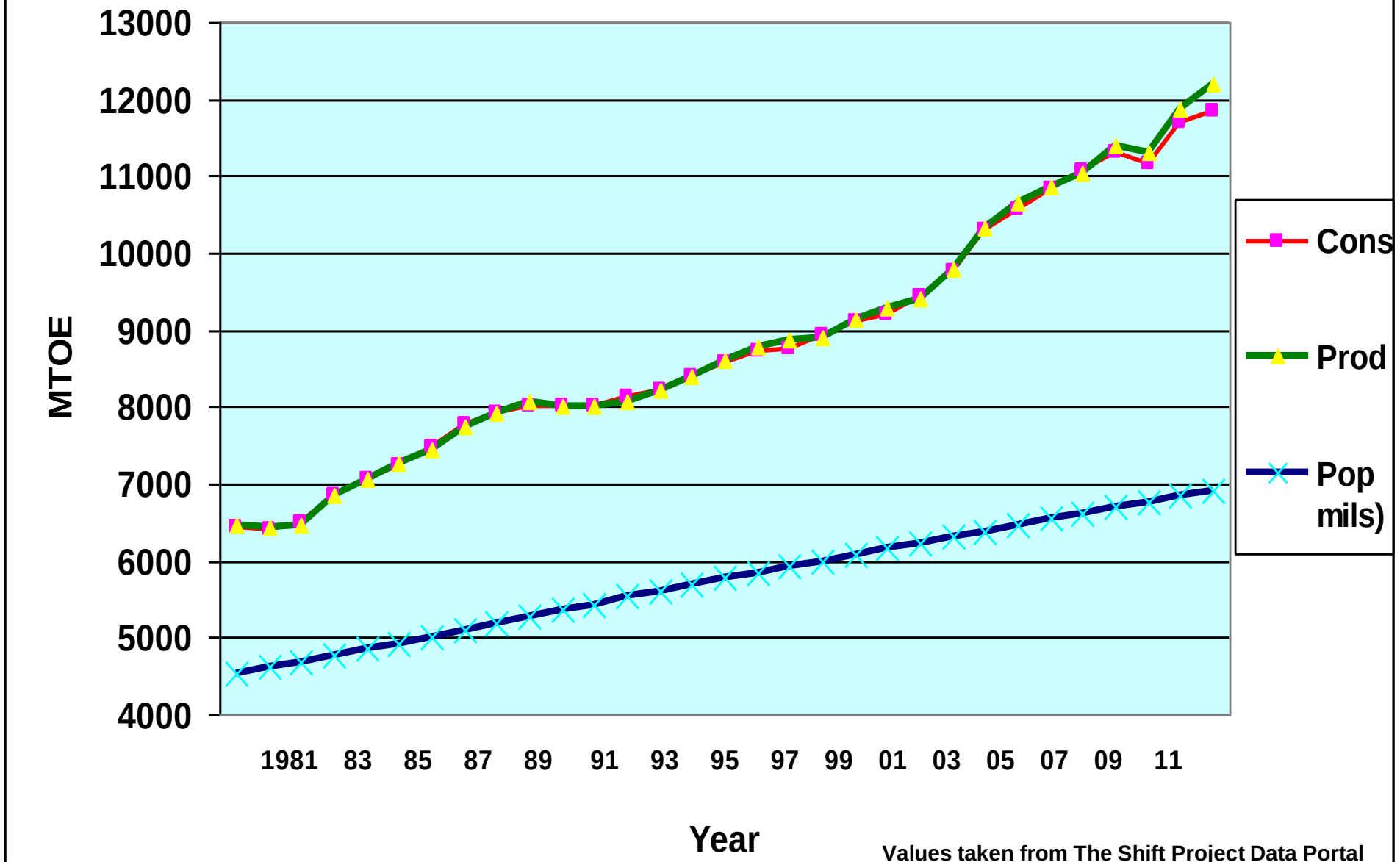
9 December 2016



From 'Financial Sense' 13 March 2012. 500 EJ = 5 x 10^{20} J = 11942.5 MTOE = 138891 TWh

http://www.financialsense.com/contributors/gail-tverberg/world-energy-consumption-since-1820-in-charts

Global population, energy production and consumption 1981 to 2011



Values taken from The Shift Project Data Portal

2012	Total Energy (Mtoe)	Approx for generating electricity	mtoe of used generated electricity (% of col 3)	As nuclear Thermal mtoe	Nuclear electric mtoe	% of col 4
World	12,000	5400	1800* (33)	610	201	11.1
China	2450	1400	400 (29)	24	8.3	2.0
US	2279	1160	350 (30)	200	68	19.5
Russia	739	250	86 (34)	43	14	16.3
India	527	c 300	80 (27)	c 8	2.6	3.3
UK	298	79	27 (34)	17	5.7	20

Making electricity from fossil & nuclear fuels by steam turbines is at best only 33% efficient

* 1800 million tonnes of oil equivalent (mtoe) = 21,000 TWh (Wh^{12})

Spent nuclear fuel (SNF)

Described in 2004 by the US General Accounting Office as

- one of the most hazardous materials known to man

- but posed little danger,
  - in protected containers when transported,
  - and SNF is difficult to disperse.

- But '*widespread harm is possible under certain severe but extremely unlikely conditions involving spent fuel stored in storage pools*'.

- Fukushima arose from such 'extremely unlikely' conditions.

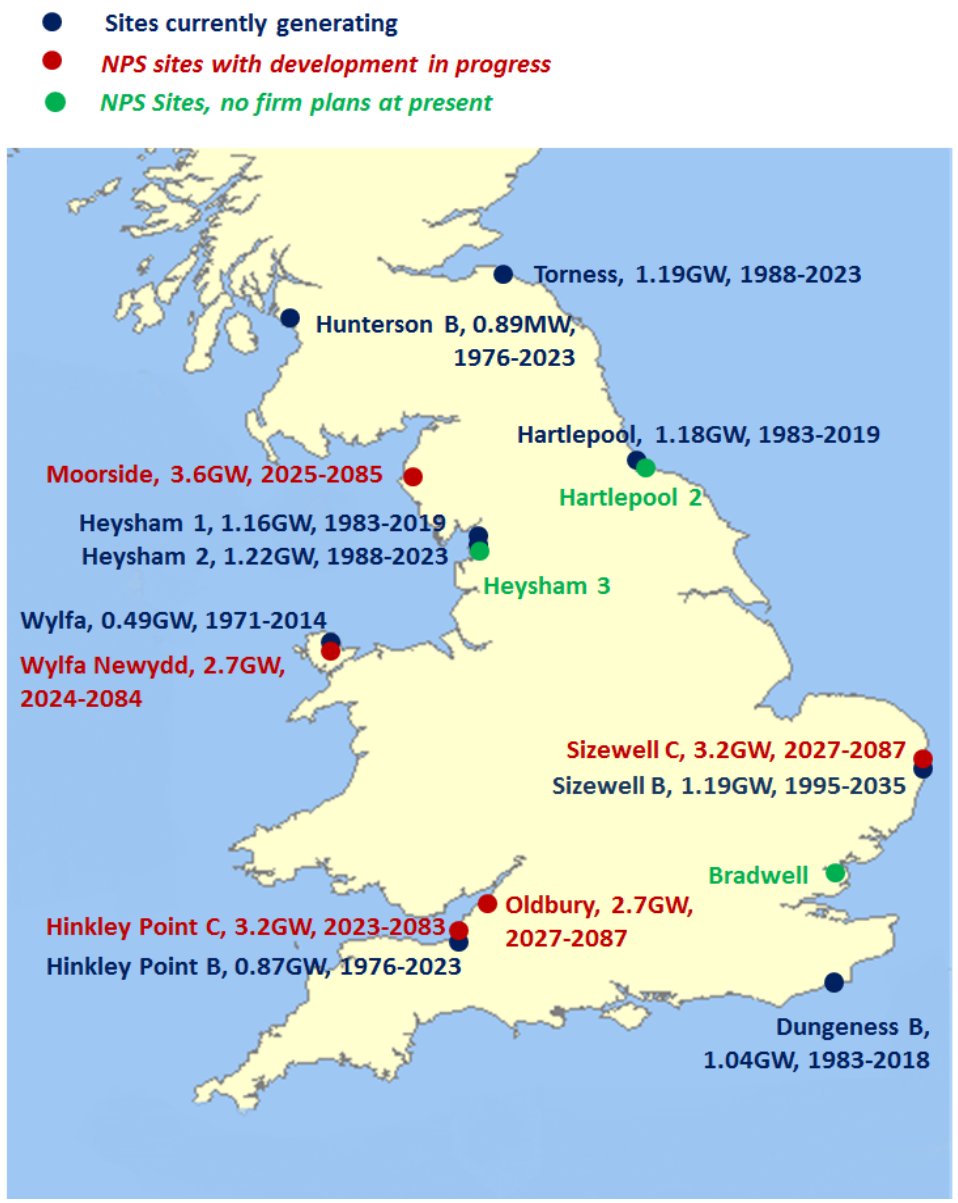
Inventories of UK nuclear waste, by activity (Bq), volume (cubic meters – m3) and mass (tonnes).
From UK Nuclear Decommissioning Authority 2014 * one m^3 of water weighs a tonne.

Waste characteristics (year of inventory)	HLW	ILW	LLW + VLLW	Total
Activity, Bq (2010)	8×10^{19}	3.9×10^{18}	40×10^{13}	8.4×10^{19}
%	95	5	<0.00001	100
Volume, m^3 (2013)*	1,100	290,000	4,200,000	4,500,000
%	0.02	6.5	93.5	100
Mass, Tonnes (2010)	2,700	300,000	4,700,000	5,000,000
%	0.05	6	94	100

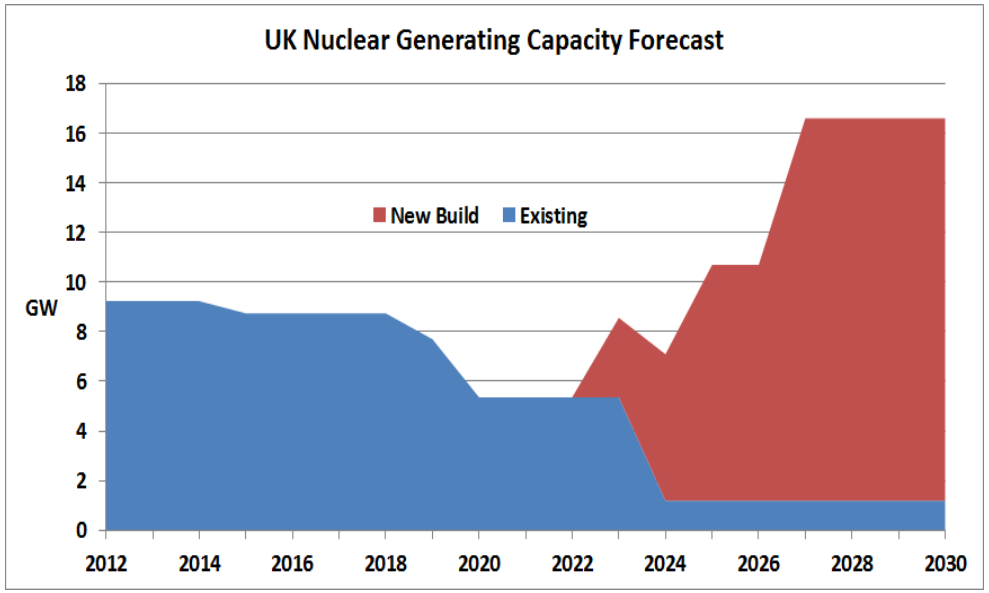
The waste from the world's military and civil nuclear industries combined may be up to 10^{21} Bq. Although radioactivity of fresh SNF decays rapidly during first 20 years, longer-lived residues take millennia to decay

UK nuclear ambitions (BEIS)

Current Nuclear Generation and Planned to 2030



- **Current nuclear capacity in the UK is 9.23GW; will decline as plants approach 'end of life' in mid-2020's.**
- **8 new nuclear designated sites in Nuclear National Policy Statement. Firm site development plans for Hinkley, Sizewell, Wylfa, Oldbury and Moorside.**



	Total Energy (Mtoe)	Approx for generating electricity	Mtoe of all generated electricity	As nuclear thermal	Nuclear electric mtoe	% of col 4
UK 2012	298	79 (27%)	ren 4, nuc 5.6 fossil 17.4 total 27	17	5.6	21
UK 2030 BEIS	200 107 fossil (gas, oil) for transport, industry etc.)	from renewables 15 (5%) from nuc thermal 33 (11%) from fossil 45 (15%) 93 Total	renew 10 nuc 11 fossil (no coal) 15 Tot 36	33	11	31

Energy as a peacemaker

There will be trouble ahead!

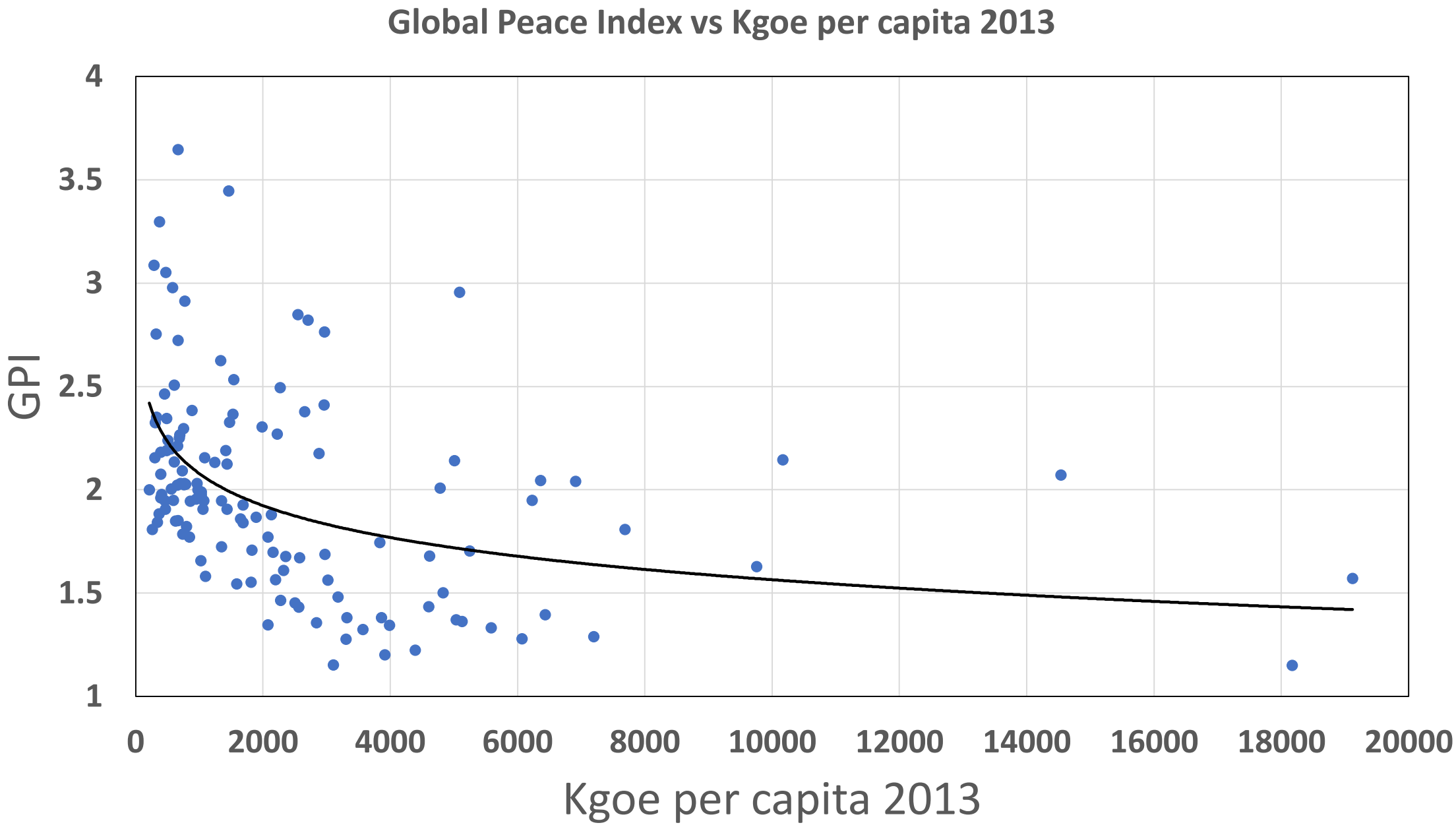
During the 21st century there will be more

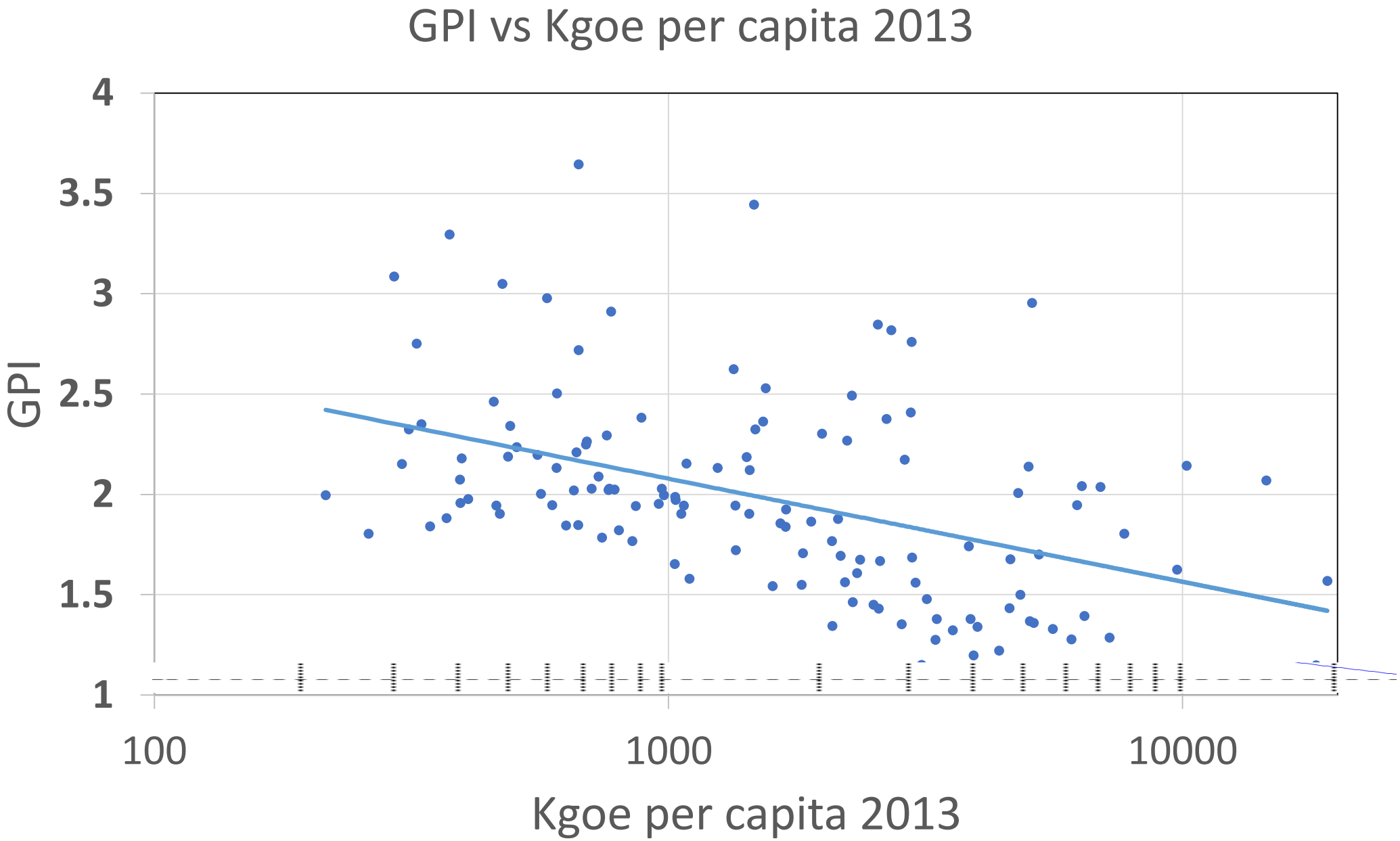
- Anthropogenic climate change
- Population rise
- Scarcity of resources
- Climate-change induced pressure on growing crops
- Widening of the wealth gap
- Awareness by the deprived majority world of the extent of their unequal access to resources

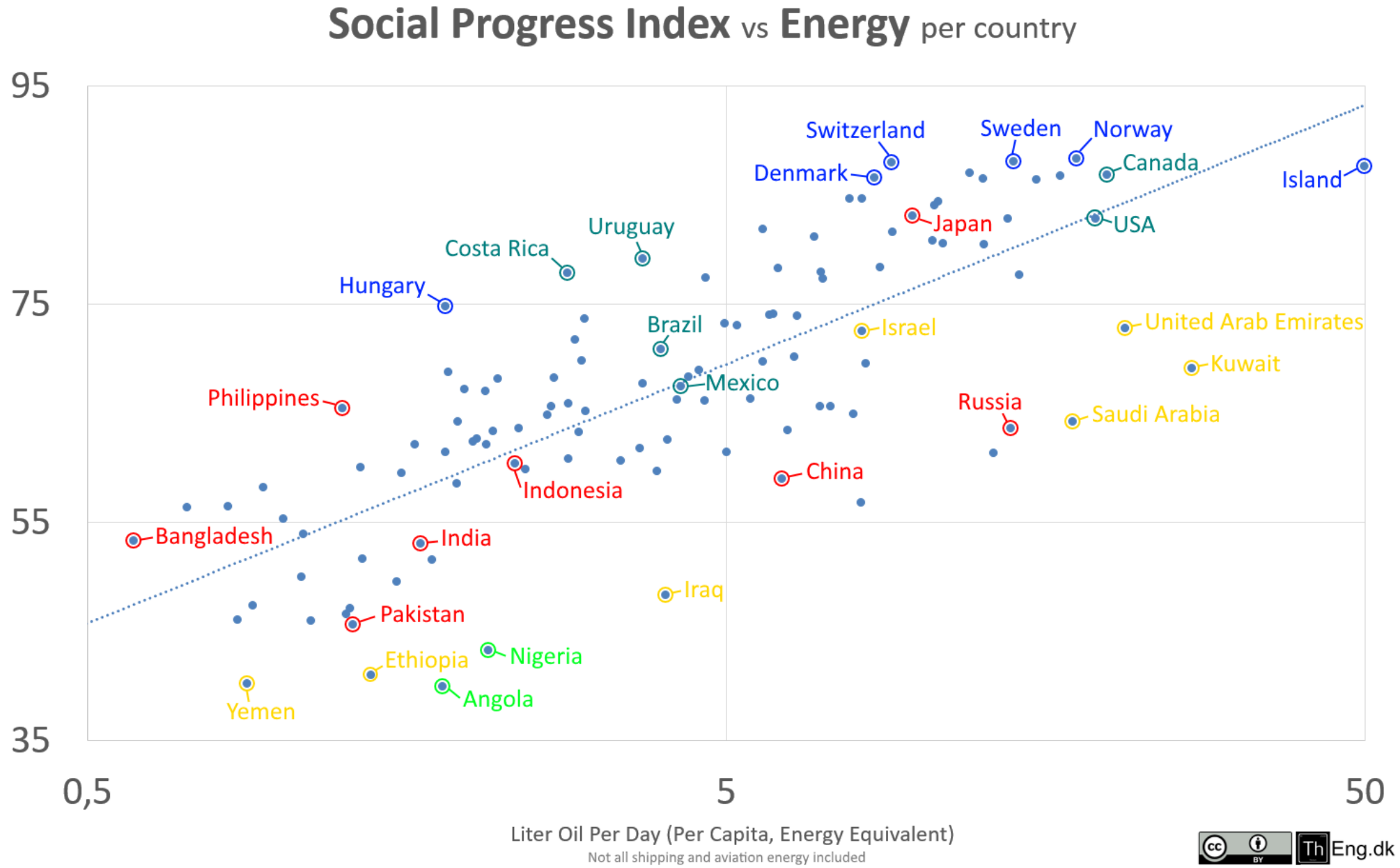
Selected indicators for 2014

Region	Population millions	* mtoe	toe per capita	Electricity consumption mtoe	Electricity consumption toe per capita	Tonnes CO_2 emitted per capita
World	7 249	13 700	1.89	1 888	0.261	4.47
OECD	1 267	5 273	4.16	875	0.690	9.36
Mid East	224	721	3.22	75	0.336	7.72
Non OECD Europe & Eurasia	343	1 124	3.28	134	0.391	7.14
China	1 372	3 066	2.24	464	0.339	6.66
Asia	2 408	1 741	0.72	196	0.081	1.58
Non OECD Americas	480	639	1.33	88	0.183	2.44
Africa	1 156	772	0.67	56.5	0.049	0.96
US	319	2 216	6.94	364	0.967	16.22
UK	65	279	4.44	30.6	0.471	6.31

* mtoe – millions of tonnes of oil equivalent: toe – tonnes of oil equivalent


Global Peace Index vs Kgoe per capita 2013
GPI
4
3.5
3
2.5
2
1.5
1
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Kgoe per capita 2013


GPI vs Kgoe per capita 2013
GPI
4
3.5
3
2.5
2
1.5
1
100
1000
10000
Kgoe per capita 2013



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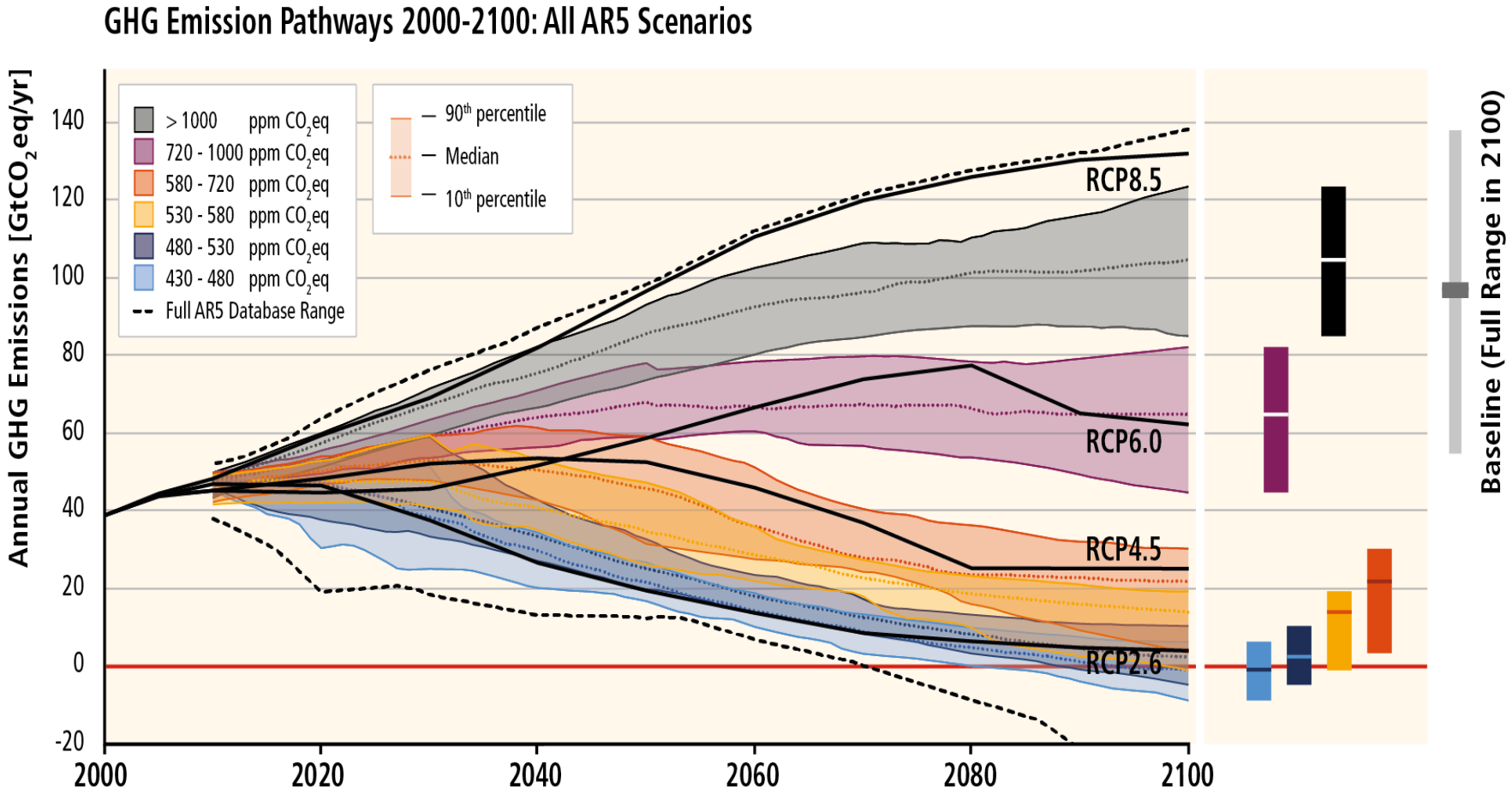
How much energy would a more peaceful world need in the future?



The IPCC's Fifth Assessment Report's (AR5) main scenarios linking anthropogenic GHG emissions with CO_2 eq ppm.

The representation concentration pathways (RCPs) are for the 'worst case' RCP 8.5 (continue much as at present) to the 'best' but most challenging RCP 2.6 – which by 2100 will have reduced the net GHG emissions to zero.

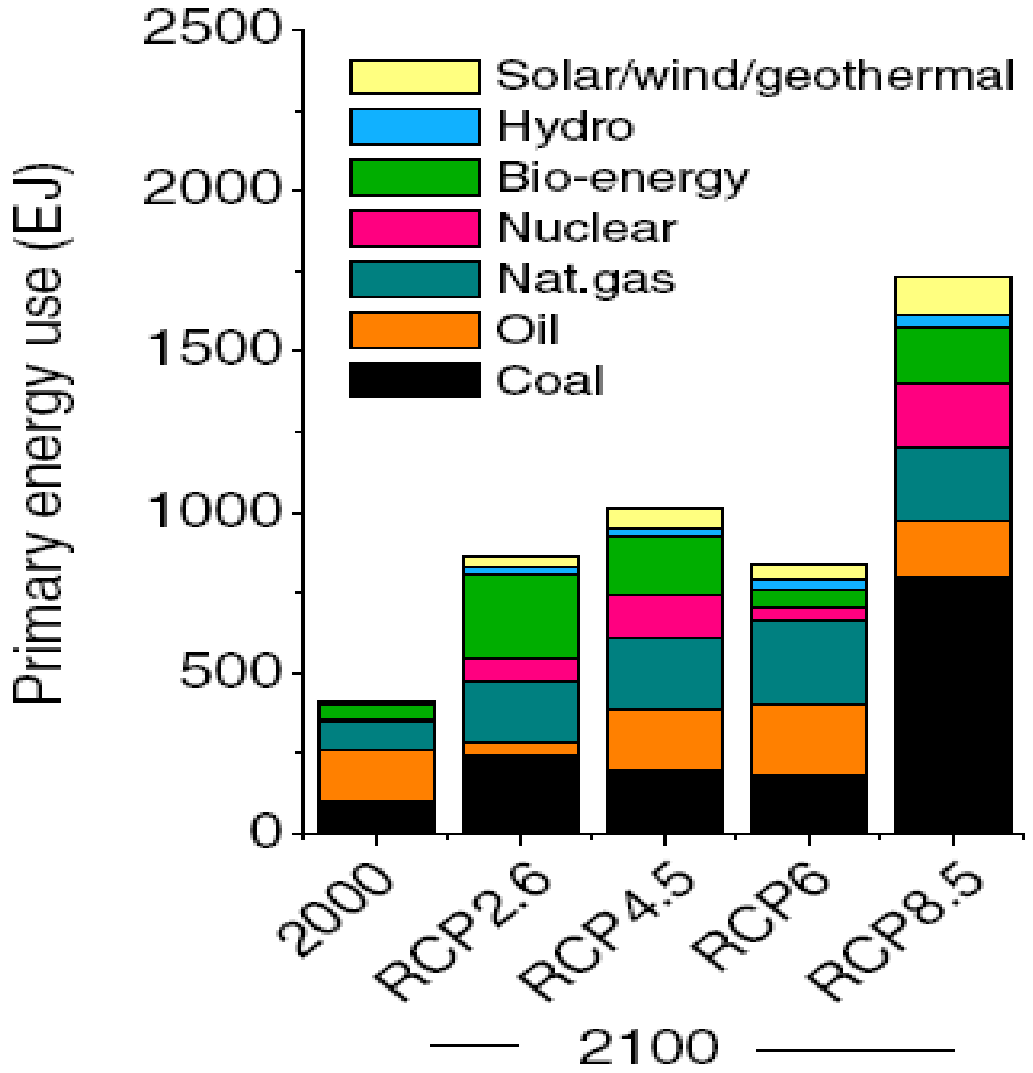
1 Exajoule [EJ] =

23.88459 Mtoe, so

the value 10083 Mtoe

for 2000 = 422 EJ

Exa = 10^{18}



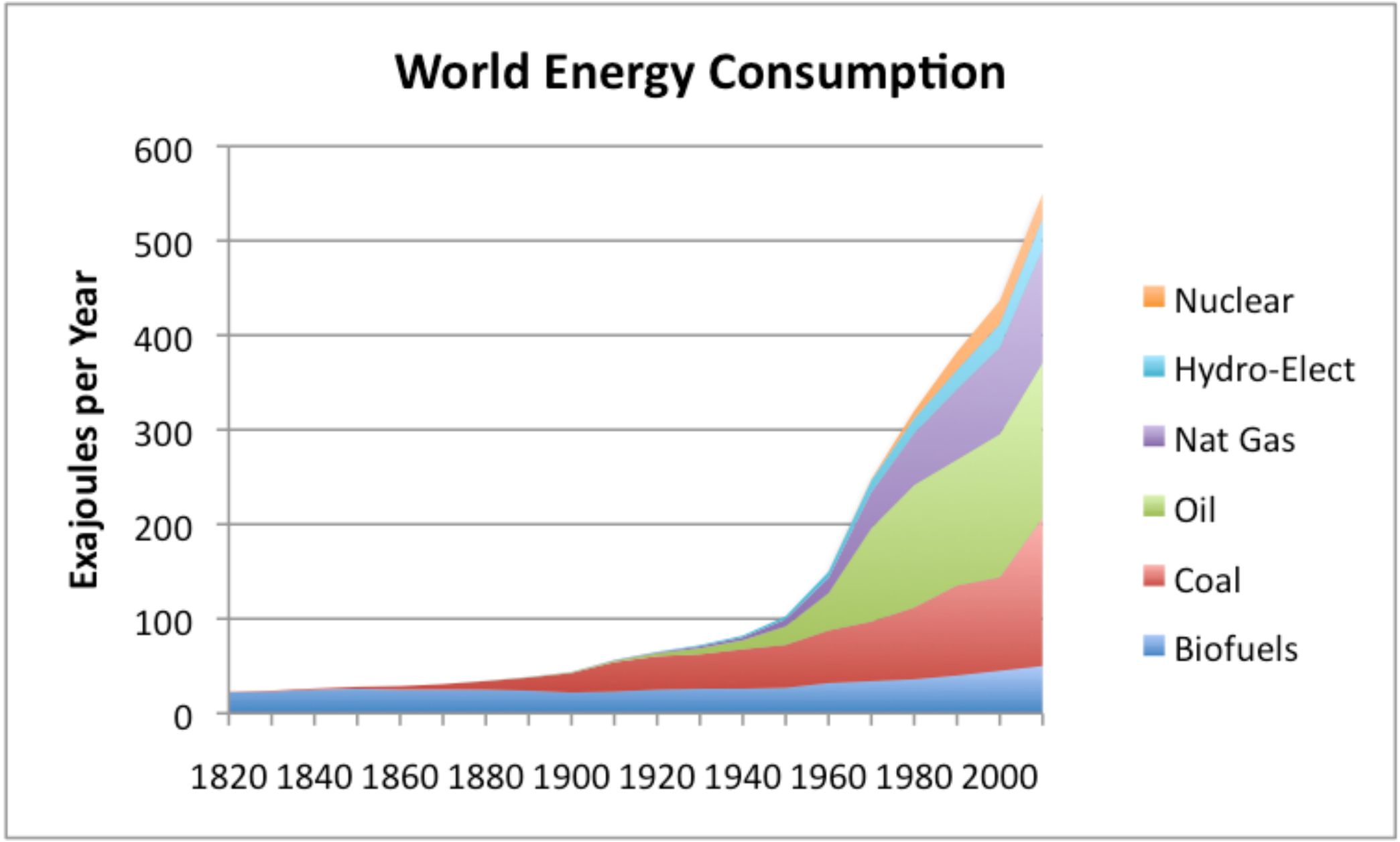
Energy sources at years 2000; and projected at the various RCP in 2100

Figure 14: Energy sources by sector (van Vuuren et.al. 2011) http://www.skepticalscience.com/rcp.php?t=3

One important snag

IPCC RCPs assume a significant amount of carbon capture and storage

World mtoe	Populn millions	mtoe	Fossil fuel	For electricity	Electricity made and used	per cap(toe) mtoe elec	CO_2 conc ppm
2014	7 249	13 390	oil 4 200 gas 2 850 coal 3 900 All fossil 10 950	fossil 3 600 ren 600 nuc 600 total 4 800	fossil 1 200 ren 400 nuc 200 total 1 800	1.85 **0.25**	400
World 2100 IPCC RCP 4.5	11 200	22 800	*fossil* *oil 4300* *gas 5500* *coal 4500* *total 14300, of which 11700 is for generating electricity*	*low carbon* *direct 2 200* *bio 3 600* *nuc therm 2 700* *total 8 500*	*used* *direct 2 200* *bio 1 200* *nuc elec 900* *fossil 3 900* *total 8 200*	2.04 **0.73**	530 (but much more if no CCS)



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Break

World mtoe	Populn millions	mtoe	Fossil fuel	For electricity	Electricity made and used	per cap(toe) mtoe elec	CO_2 conc ppm
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World mtoe	Populn millions	mtoe	Fossil fuel	Low carbon	Electricity made and used	Toe / cap mtoe el	CO_2 conc ppm
2014	7 249	13 700	all fossil 11,100 4 300 oil; 2 900 gas 3 900 coal	3 250 + 650 nuc	1800 (220 nuc)	1.89 **0.26**	390
World 2100 **IPCC RCP 4.5**	11 200	22 800	all fossil 14 300 ***4 300 oil ; 5 500 gas; 4 500 coal***	*all ren 8 500* ***2,200 direct; 3,600 bio*** ***2 700 nuc thermal***	total 8 200 ***3 900 fos: 900 nuc el*** ***1 200 bio; 2 200 direct***	2.04 **0.73**	530 (more if no CCS)
World 2100 **New vision 1**	11 200	22 300	5 000 ***3 000 (gas) for electricity***	17 300 total ***6000 bio; 11300 direct*** ***NO nuclear***	13 700 ***1 000 fossil; 1700 bio;*** ***11 300 direct*** ***NO nuclear***	2.0 **1.22**	?
World 2100 **New vision 2**	11 200	28 300	5 000 ***3 000 (gas) for electricity***	23 300 total ***6 000 bio: 8 300 direct*** ***9 000 nuclear thermal***	13 700 ***1 000 fossil; 1 700 bio*** ***8,300 direct;*** ***3,000 nuclear electric***	2.5 **1.22**	?

However, the International Energy Outlook of the US Energy Information Administration has a very different picture, in which the activities of all Global energy sectors goes up in toto by about 150% across all sectors between 2010 and 2040

Table: World total energy consumption by region and fuel

http://www.eia.gov/outlooks/aeo/data/browser/#/?id=2-IEO2016&sourcekey=0

Power plant electricity generating ‘Capacity’

usually quoted in ‘**GigaWatts**’ (GW or GWe – 10^9 watts),
the amount of power capable of being produced at any one moment.

Supply *over a period of time* is expressed as **TeraWatt hours** (TWh or watt-hours $\times 10^{12}$): convertible to MTOE by a factor of 86,000.

An electricity-generating plant operating at 1 GW throughout the year would generate 8.766 TWh in that year (there are 8766 h in a year),

But no plants work flat out all the time.

Current NPPs do well at 85% capacity.

Fossil fuel plants can be turned ‘down’ or ‘up’ to meet seasonal and diurnal variations; so the annual output from a 1GW capacity gas plant may be 30%

Mtoe

An ‘average’ UK motor car consuming 1 litre of petrol for every 10 miles and travelling 10,000 miles a year consumes a tonne of petrol (toe)

The 1.2 billion cars, busses and lorries on the world’s roads consumed about 10% of the energy demand

THE END