Energy

Turnaround or continuity?

By Michel de Rougemont
Version 2022, July 15, 2023

As the years go by, new statistical data replaces the previous ones.

BP has stopped issuing them, and this task was passed on to the Energy Institute.

Worldwide primary energy consumption continues to rise at an average annual rate of of 1.0 %, mainly driven by non-OECD countries, which are also consuming more fossil fuels.

Less conventional analyses are needed to understand the complexity of this issue.

In this brief review, the contribution of energy to growth will be examined, as well as the share of fossil fuels in the current energy mix. This highlights the huge magnitude of the challenge posed by the goal of decarbonisation.

To go beyond these facts alone, broad outlines of an energy strategy are proposed.

Data source for this presentation: 2023 Statistical Review of World Energy
https://www.energyinst.org/statistical-review/resources-and-data-downloads
and World Bank's WDI DataBank,

The fossil fuel conundrum

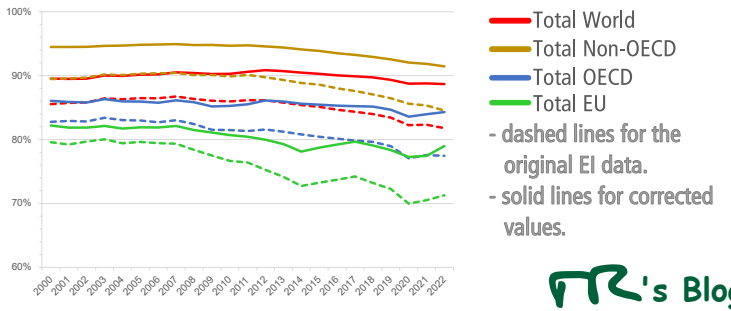
- The Statistical Review of World Energy is THE public source of energy data.
  Others are partial or subject to a costly paywall.
  Popular sites such as ourworldindata.org make extensive use of EI data.
- Energy production does not take place in the same place as energy consumption.
  Consequently, comparisons between countries must be based on consumption data.
- The conundrum: EI assumes that non-fossil fuel sources consume an "input equivalent" corresponding to the efficiency of thermal power stations. For example, a solar panel producing 1 megajoule will be assigned an "input equivalent" of 2.63 MJ, based on an assumed "thermal" efficiency of 38%. This fictitious efficiency varies over the years.
- Nuclear power plants use a thermal process to capture the fission energy from uranium, their primary energy source. An average conversion efficiency of 33% can be applied rather than this fictitious efficiency.
- In their main forms - hydro, solar thermal or photovoltaic panels, and wind turbines - the said renewables have no primary source to be accounted for.
  Their low conversion efficiency into electricity or useful heat is certainly significant, but only a part of what is passing by is harvested, without drawing on a limited resource.
  The concept of an "input equivalent" based on thermal energy should therefore not be used.
- It follows that BP's interpretation of primary energy consumption, now endorsed by EI, is misleading. It increases the relative weight of so-called renewable energies, and therefore dilutes that of fossil fuels.
- This systematic bias is wrong.
  It makes fossil fuels seem more benign, as does the task of eliminating them. However, it does not alter the enormity of the decarbonisation challenge.
- **Corrected figures will be used in this review:**

In 2022:

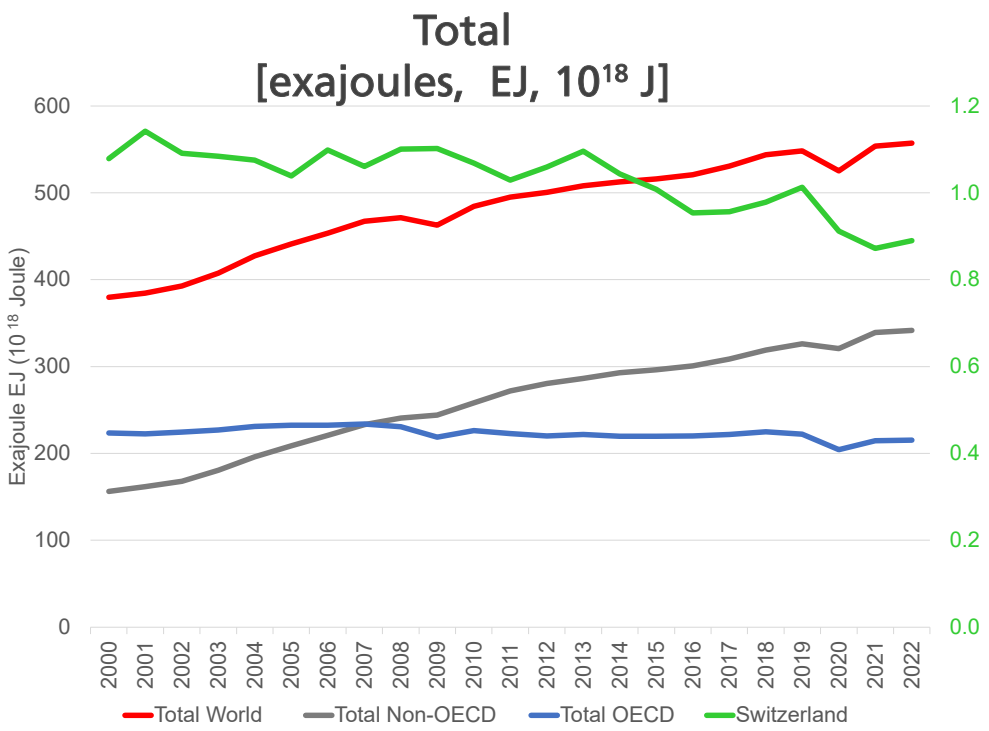
Primary energy consumption worldwide [EJ]:	**557**	**and not**	**604**
Primary energy consumption per capita [GJ/cap]:	**69.9**	**and not**	**75.7**
Share of fossil fuels [% of total energy]:	**88.7 %**	**and not**	**81.8 %**

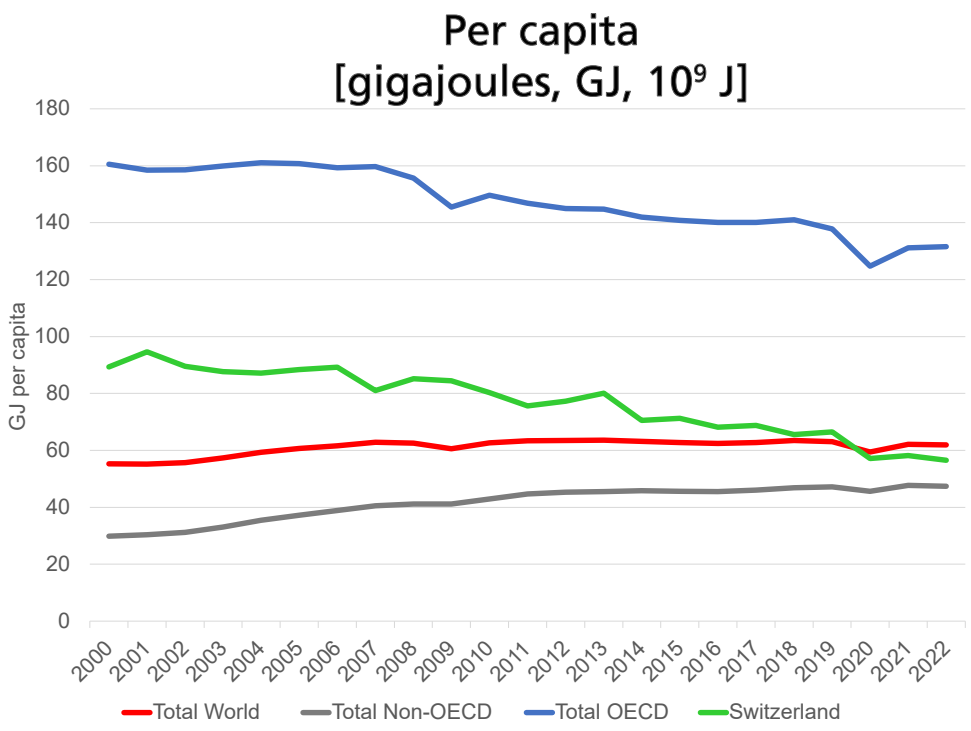
Fossil fuels in 2022

	Original	Corrected	Trend 5 yr %/a	Years to zero
Total World	81.8%	88.7%	-0.27	331
Total Non-OECD	84.5%	91.5%	-0.39	237
Total OECD	77.4%	84.3%	-0.22	386
China	81.6%	89.7%	-0.62	144
US	81.1%	85.8%	-0.10	904
Total EU	71.3%	79.0%	-0.17	458
India	88.5%	94.1%	-0.28	334
Russian Federation	86.3%	88.4%	-0.27	328
Japan	84.9%	91.1%	-0.74	123
South Korea	83.2%	83.0%	-0.75	111
Canada	63.9%	77.0%	0.08	
Saudi Arabia	99.9%	100.0%	-0.01	19 579
Germany	76.2%	87.0%	0.10	
Brazil	50.3%	73.2%	-1.20	61
Indonesia	89.8%	97.1%	-0.23	417
Mexico	89.9%	94.7%	-0.26	365
France	53.7%	54.8%	1.09	
United Kingdom	74.8%	83.5%	-0.20	419
Turkiye	81.2%	91.4%	-0.62	147
Italy	83.4%	92.8%	-0.06	1 483
Australia	85.5%	93.6%	-0.76	123
Spain	69.8%	78.2%	-0.83	95
South Africa	94.2%	96.0%	-0.01	11 572
Egypt	94.3%	97.6%	-0.16	600
Argentina	85.3%	92.5%	-0.34	274
Switzerland	47.1%	55.5%	-1.80	31



Primary energy consumption





EI data corrected by the author for primary energies

While the 'West', particularly the European Union, is no longer increasing its energy consumption, the 'rest of the world' is trying to catch up.

However, this virtue of the West stems from an economy that is increasingly based on services, while labour-intensive and energy-intensive production has been transferred to emerging and developing countries, with no discernible reversal yet.

The industrialisation and development of the countries of the "rest of the world" brings with it new responsibilities in terms of environmental protection, which their economic growth will have to meet.

However, a 'Westerner' still consumes 3 times more energy than a person outside the OECD.

Note on Covid-19: it was a bad idea to celebrate 2020 as a first year of sobriety. 2021 and 2022 have shown that energy demand has not weakened.

In any case, whether it's a historical anomaly, a pandemic, a war, or meteorological variations, such disruptions should never be taken as a long-term trend.

General figures for 2022

2022	Primary Energy [EJ]					Per capita		Population		GDP	
	Original EJ	% of World	Corrected	% of World	Trend %/a	MWh/cap	Trend %/a	Millions	Trend %/a	Billions USD*	Trend %/a
Total World	604.04	100.00%	557.09	100.00%	0.97	69.9	0.00	7 974.9	0.97	89 746	2.34
Total Non-OECD	369.62	61.19%	341.70	61.34%	2.04	51.8	0.95	6 595.4	1.08	36 244	3.53
Total OECD	234.42	38.81%	215.39	38.66%	-0.60	156.1	-1.03	1 379.5	0.43	53 502	1.57
China	159.39	26.39%	145.11	26.05%	3.42	101.8	3.19	1 425.9	0.22	16 325	5.25
USA	95.91	15.88%	90.56	16.26%	0.36	267.7	-0.15	338.3	0.51	20 953	2.06
Total EU	58.18	9.63%	52.51	9.43%	-2.18	117.4	-2.34	447.3	0.16	15 213	1.37
India	36.44	6.03%	34.24	6.15%	2.97	24.2	2.04	1 417.2	0.91	2 955	3.97
Russian Federation	28.89	4.78%	28.21	5.06%	-0.29	195.0	-0.19	144.7	-0.10	1 472	1.13
Japan	17.84	2.95%	16.62	2.98%	-1.69	134.1	-1.27	124.0	-0.43	4 509	-0.20
South Korea	12.71	2.10%	12.74	2.29%	0.30	245.9	0.18	51.8	0.12	1 737	2.22
Canada	14.14	2.34%	11.73	2.10%	-0.64	304.9	-1.64	38.5	1.02	1 748	1.54
Saudi Arabia	11.50	1.90%	11.49	2.06%	0.06	315.6	-1.18	36.4	1.26	767	2.29
Germany	12.30	2.04%	10.77	1.93%	-3.32	129.2	-3.49	83.4	0.18	3 618	0.53
Brazil	13.41	2.22%	9.21	1.65%	0.45	42.8	-0.20	215.3	0.64	1 901	1.49
Indonesia	9.77	1.62%	9.04	1.62%	5.97	32.8	5.11	275.5	0.82	1 122	3.39
Mexico	8.73	1.44%	8.28	1.49%	0.75	65.0	-0.00	127.5	0.75	1 244	0.26
France	8.39	1.39%	8.22	1.48%	-3.77	127.3	-3.92	64.6	0.15	2 644	0.94
United Kingdom	7.31	1.21%	6.55	1.18%	-2.94	97.0	-3.36	67.5	0.43	3 163	0.59
Turkiye	7.01	1.16%	6.23	1.12%	1.01	73.0	0.23	85.3	0.78	1 194	4.46
Italy	6.14	1.02%	5.52	0.99%	-1.52	93.5	-1.20	59.0	-0.32	1 937	0.47
Australia	5.98	0.99%	5.47	0.98%	-0.24	208.8	-1.48	26.2	1.26	1 579	2.16
Spain	5.76	0.95%	5.14	0.92%	-0.75	108.1	-1.16	47.6	0.41	1 306	0.58
South Africa	4.82	0.80%	4.73	0.85%	-2.12	78.9	-3.20	59.9	1.12	360	0.42
Egypt	3.98	0.66%	3.85	0.69%	0.52	34.7	-1.21	111.0	1.75	454	4.85
Argentina	3.60	0.60%	3.33	0.60%	0.04	73.1	-0.61	45.5	0.65	598	-0.03
Switzerland	1.05	0.17%	0.89	0.16%	-1.42	101.8	-2.08	8.7	0.67	776	1.56

Corrected for primary energy 'input-equivalent' from EI methodology

Trend: annual average growth rate over last 5 years

* at constant 2015 US$

The countries and regions listed here account for 78 % of the World consumption.

General figures for 2022 (2)

2022

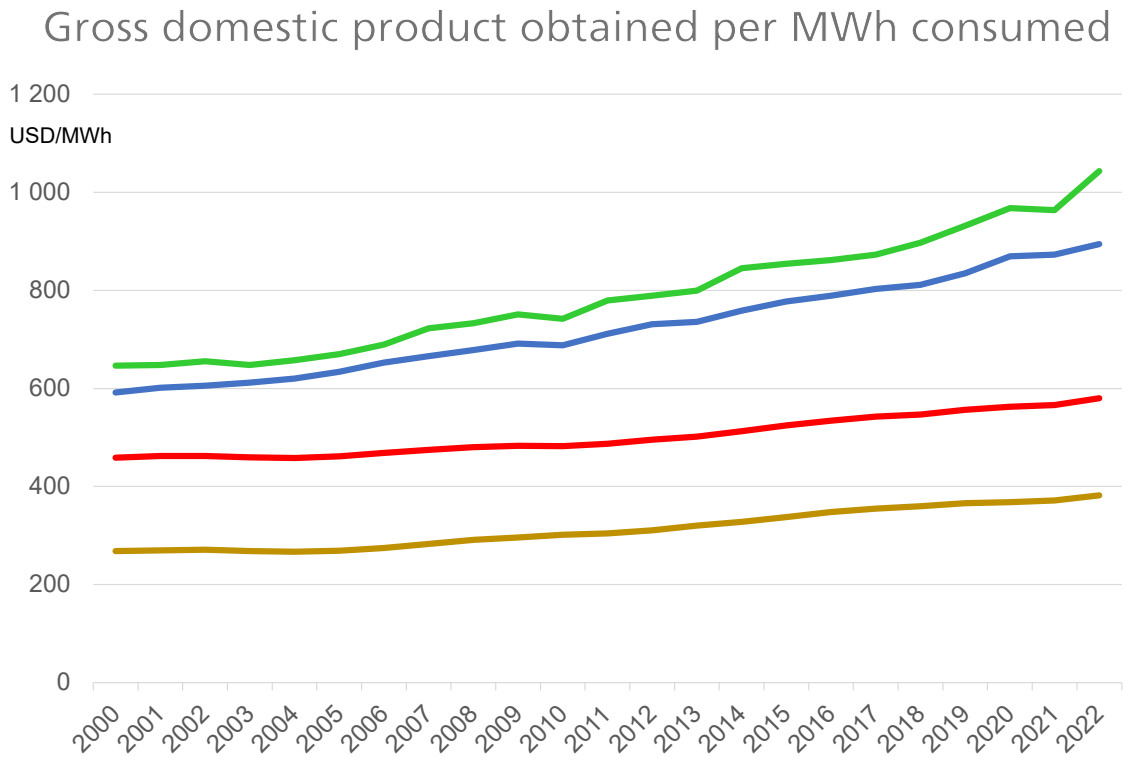
Primary Energies by Nature [EJ]

	All primaries	Fossil fuels	% of total	Nuclear	% of total	Hydro	% of total	Renewables	% of total
Total World	557.09	494.05	88.7%	29.80	5.3%	16.58	3.0%	16.65	3.0%
Total Non-OECD	341.70	312.50	91.5%	9.90	2.9%	11.19	3.3%	8.11	2.4%
Total OECD	215.39	181.55	84.3%	19.90	9.2%	5.39	2.5%	8.54	4.0%
China	145.11	130.10	89.7%	4.65	3.2%	4.98	3.4%	5.38	3.7%
US	90.56	77.74	85.8%	9.03	10.0%	0.99	1.1%	2.80	3.1%
Total EU	52.51	41.47	79.0%	6.77	12.9%	1.06	2.0%	3.21	6.1%
India	34.24	32.24	94.1%	0.51	1.5%	0.67	2.0%	0.82	2.4%
Russian Federation	28.21	24.94	88.4%	2.49	8.8%	0.76	2.7%	0.03	0.1%
Japan	16.62	15.14	91.1%	0.58	3.5%	0.29	1.7%	0.62	3.7%
South Korea	12.74	10.57	83.0%	1.96	15.4%	0.01	0.1%	0.20	1.5%
Canada	11.73	9.03	77.0%	0.96	8.2%	1.52	13.0%	0.21	1.8%
Saudi Arabia	11.49	11.49	100.0%	-	-	-	-	0.00	0.0%
Germany	10.77	9.37	87.0%	0.39	3.6%	0.07	0.6%	0.95	8.8%
Brazil	9.21	6.74	73.2%	0.16	1.8%	1.63	17.7%	0.67	7.3%
Indonesia	9.04	8.78	97.1%	-	-	0.10	1.2%	0.16	1.8%
Mexico	8.28	7.85	94.7%	0.12	1.5%	0.14	1.6%	0.18	2.1%
France	8.22	4.51	54.8%	3.28	39.9%	0.17	2.1%	0.27	3.3%
United Kingdom	6.55	5.47	83.5%	0.53	8.1%	0.02	0.3%	0.53	8.0%
Turkiye	6.23	5.69	91.4%	-	-	0.26	4.1%	0.28	4.5%
Italy	5.52	5.12	92.8%	-	-	0.11	2.0%	0.29	5.3%
Australia	5.47	5.12	93.6%	-	-	0.07	1.2%	0.28	5.2%
Spain	5.14	4.02	78.2%	0.65	12.7%	0.07	1.4%	0.40	7.8%
South Africa	4.73	4.54	96.0%	0.11	2.4%	0.01	0.3%	0.06	1.3%
Egypt	3.85	3.75	97.6%	-	-	0.05	1.4%	0.04	1.0%
Argentina	3.33	3.07	92.5%	0.08	2.5%	0.09	2.7%	0.08	2.3%
Switzerland	0.89	0.49	55.5%	0.26	28.9%	0.11	12.7%	0.03	2.9%

Corrected for primary energy 'input-equivalent' from EI methodology

The countries and regions listed here account for 78 % of the World consumption.

Energy and Economy: improving productivity



Over the last 5 years, the world economy has seen average annual growth of:

- 2.3% in GDP,
- 1.0% in primary energy consumption,
- 1.4% in energy productivity.

Energy productivity is defined here as the gross domestic product obtained for each MWh of primary energy consumed.

There are major disparities between countries; trends are multi-factorial (rate of industrialisation, technological performance, nature of activities) and mostly positive.

If the cost of energy (all technologies combined) were to approach these levels, the country in question would consume its entire GDP to produce energy, which is obviously impossible and absurd.

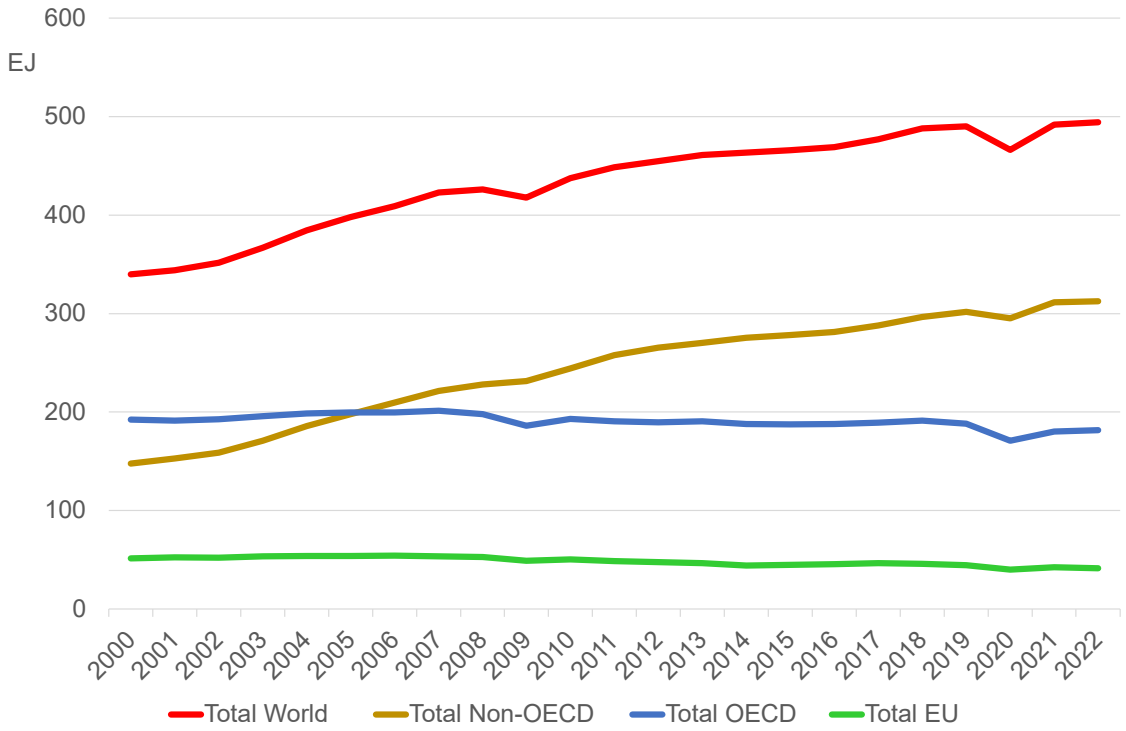
Energy Productivity in 2022

	USD/MWh	Trend 5 yr %
Total World	580	1.35
Total Non-OECD	382	1.46
Total OECD	894	2.19
China	405	1.77
US	833	1.69
Total EU	1043	3.63
India	311	0.97
Russian Federatio	188	1.43
Japan	977	1.52
South Korea	491	1.91
Canada	537	2.19
Saudi Arabia	240	2.23
Germany	1209	3.97
Brazil	743	1.03
Indonesia	447	-2.43
Mexico	541	-0.49
France	1157	4.90
United Kingdom	1739	3.64
Turkiye	690	3.41
Italy	1262	2.02
Australia	1040	2.41
Spain	915	1.34
South Africa	274	2.59
Egypt	425	4.31
Argentina	647	-0.07
Switzerland	3138	3.02

Corrected for primary 'input-equivalent' from EI meth

GDP at constant USD 2015

Fossil fuels consumption



Global consumption of fossil fuels continues to rise (after a false sense of the opposite over the last two years, linked to Covid-19). The downward trend in OECD countries is being impacted by the reverse in the USA.

They account for 88.7% of the world's energy consumption and are only slowly being replaced by other sources, at a rate of -0.27 % each year.

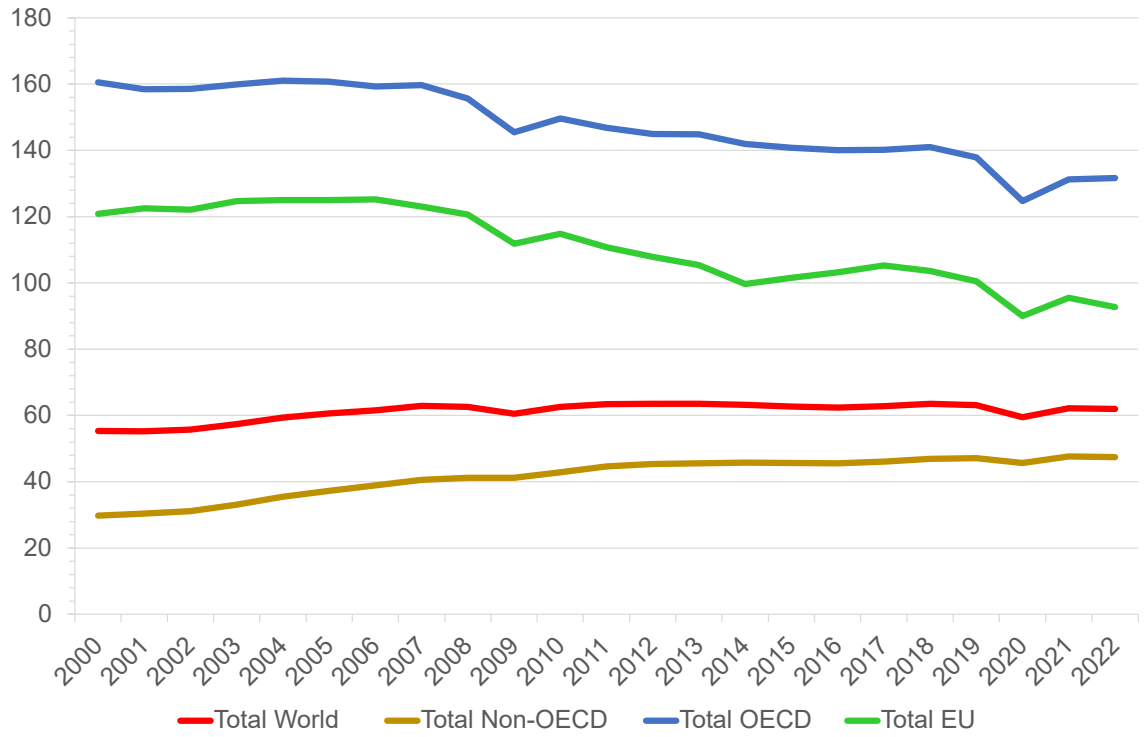
They are therefore essential to ensure that the much heralded energy transition can take place and make significant progress.

Eliminating them prematurely would therefore be counter-productive, and would provoke a severe recession in countries that would dare do so.

Fossil fuels in 2022

	EJ	% of total	Trend 5 yr %
Total World	494.05	100.0%	0.70
Total Non-OECD	312.50	63.3%	1.65
Total OECD	181.55	36.7%	-0.82
China	130.10	26.3%	2.78
US	77.74	15.7%	0.27
Total EU	41.47	8.4%	-2.35
India	32.24	6.5%	2.68
Russian Federation	24.94	5.0%	-0.56
Japan	15.14	3.1%	-2.42
South Korea	10.57	2.1%	-0.45
Canada	9.03	1.8%	-0.56
Saudi Arabia	11.49	2.3%	0.06
Germany	9.37	1.9%	-3.22
Brazil	6.74	1.4%	-0.76
Indonesia	8.78	1.8%	5.72
Mexico	7.85	1.6%	0.48
France	4.51	0.9%	-2.72
United Kingdom	5.47	1.1%	-3.14
Turkiye	5.69	1.2%	0.38
Italy	5.12	1.0%	-1.58
Australia	5.12	1.0%	-1.00
Spain	4.02	0.8%	-1.57
South Africa	4.54	0.9%	-2.12
Egypt	3.75	0.8%	0.36
Argentina	3.07	0.6%	-0.30
Switzerland	0.49	0.1%	-3.20

Fossil fuels per capita



In the "West", each person consumes less fossil fuel (an improvement). The "rest of the world" continues to use more (also an improvement).

The transformation of a modern economy towards more services and less industry partly explains the difference in trends.

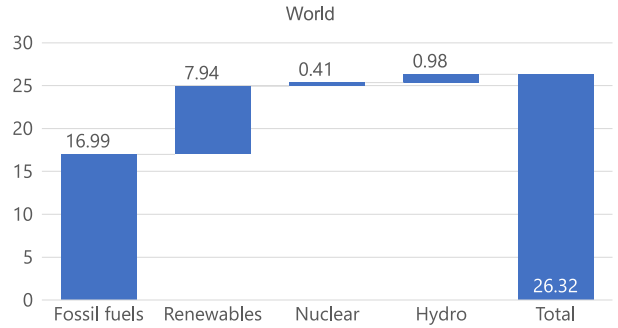
The former consume 2.8x more than the latter.

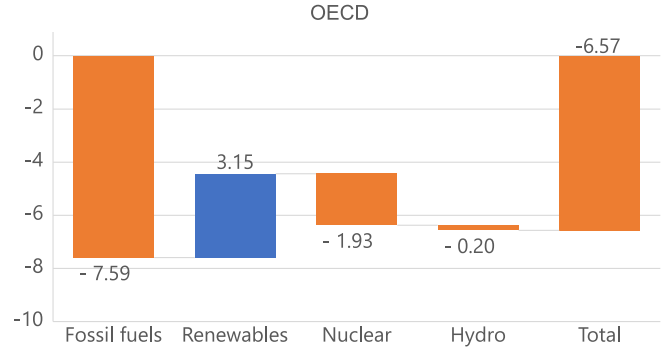
However, the usual argument that "dirty activities are exported to poor countries" is no longer valid; they are also developing at a rapid pace, and not just in industry.

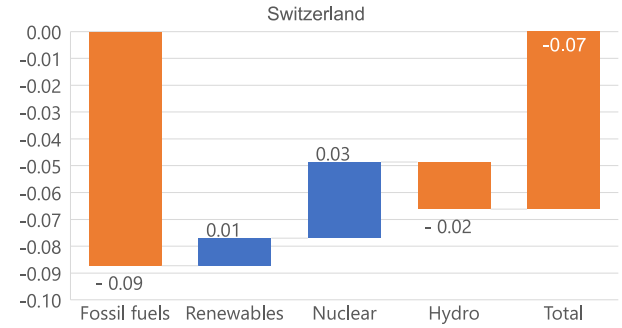
Low per capita consumption depends on the country's energy mix (an advantage for nuclear and hydro power), the general state of development, and technological maturity (productivity).

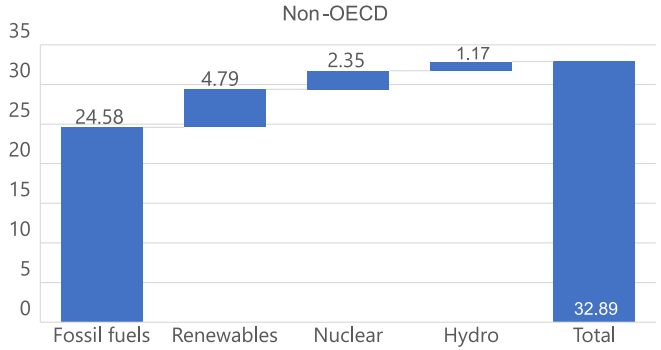
Fossil fuels per capita	MWh/cap	Trend %/a
Total World	62	-0.26
Total Non-OECD	47	0.56
Total OECD	132	-1.24
China	91	2.55
US	230	-0.24
Total EU	93	-2.51
India	23	1.75
Russian Federation	172	-0.46
Japan	122	-2.00
South Korea	204	-0.57
Canada	235	-1.56
Saudi Arabia	316	-1.19
Germany	112	-3.39
Brazil	31	-1.39
Indonesia	32	4.86
Mexico	62	-0.26
France	70	-2.87
United Kingdom	81	-3.56
Turkiye	67	-0.39
Italy	87	-1.26
Australia	195	-2.23
Spain	84	-1.97
South Africa	76	-3.21
Egypt	34	-1.37
Argentina	68	-0.95
Switzerland	57	-3.85

Contributors to increases or reductions









Reading guide

increase

reduction

Global energy consumption has increased by 26.32 EJ over the last five years, at a rate of 1.0% per year.

This growth was achieved by

- 16.99 EJ (65%) in the form of fossil fuels of all kinds (coal, oil, gas),
- 7.94 EJ (30%) in the form of so-called renewable energies,
- 0.41 EJ (2.5%) from nuclear power, and
- 0.98 EJ (3.6%) from hydroelectricity).

In OECD countries, an increase of 6.87 EJ was achieved by reducing fossil fuels (-7.59 EJ) and nuclear power (-1.93 EJ), leaving hydroelectricity virtually unchanged (-0.2 EJ), and only partially replacing it with renewable energies (3.15 EJ).

Please note: the scales of the four diagrams are different.

For their growth, non-OECD countries have to rely 5 to 6 times more on fossil fuels than on so-called renewable energies, because the means to produce the latter are insufficient or too costly.

In most developed countries, the reduction in fossil fuel consumption has been offset mainly by renewables, but also by improvements in productivity.

Hydropower was largely exploited during the 20th century, so its potential for future growth is limited.

The relatively high growth rates of renewable energies are mainly due to their relatively modest size (3.0% in the world, 6.1% in the European Union).

Doubling them within ten years – if that were possible – would not make much of a difference.

Nuclear power has progressed in China, India, Russia, and in Japan thanks to the restarting of plants that were shut down after Fukushima.

However, it has suffered from closures and a long period of overhaul and repair in France.

EI data corrected by the author for primary energies

Performance of so-called "renewables"

Solar Production	2022	Share	Trend 5 yr		CF %
Total World	1322.6	100.0%	24.3%		15.8
Non OECD	664.3	50.2%	31.8%		
OECD	658.3	49.8%	18.8%		
China	427.7	32.3%	29.4%		13.9
European Union	207.2	15.7%	14.2%		
US	206.2	15.6%	21.4%		22.6
Japan	102.4	7.7%	13.6%		15.3
India	95.2	7.2%	34.7%		19.3
Germany	60.8	4.6%	9.4%		11.0
Australia	38.8	2.9%	34.2%		17.8
Spain	33.8	2.6%	18.8%		21.1
Brazil	30.1	2.3%	53.8%	* 4 yr	18.0
Italy	27.5	2.1%	3.0%		13.2
South Korea	27	2.0%	28.5%		15.8
Vietnam	26.4	2.0%	37.9%	* 3 yr	
Total Middle East	23.7	1.8%	82.5%		
France	20.1	1.5%	17.2%		14.2
Mexico	19.3	1.5%	74.3%		25.6
Total Africa	18.2	1.4%	21.1%		
Netherlands	17.7	1.3%	51.7%		10.8
Turkey	15.9	1.2%	40.5%		
Chile	14.5	1.1%	30.0%		30.9
United Kingdom	13.9	1.1%	3.9%		11.2
Switzerland	3.7	0.3%	16.8%		11.1

Photovoltaic and wind Production in 2022, in TWh.

The countries and regions listed account for over 90% of world production.

The trend is the average annual growth over the last 5 years.

The load factor CF is the average utilisation of the rated capacities (100% would mean at full load for the 8760 hours of the year).

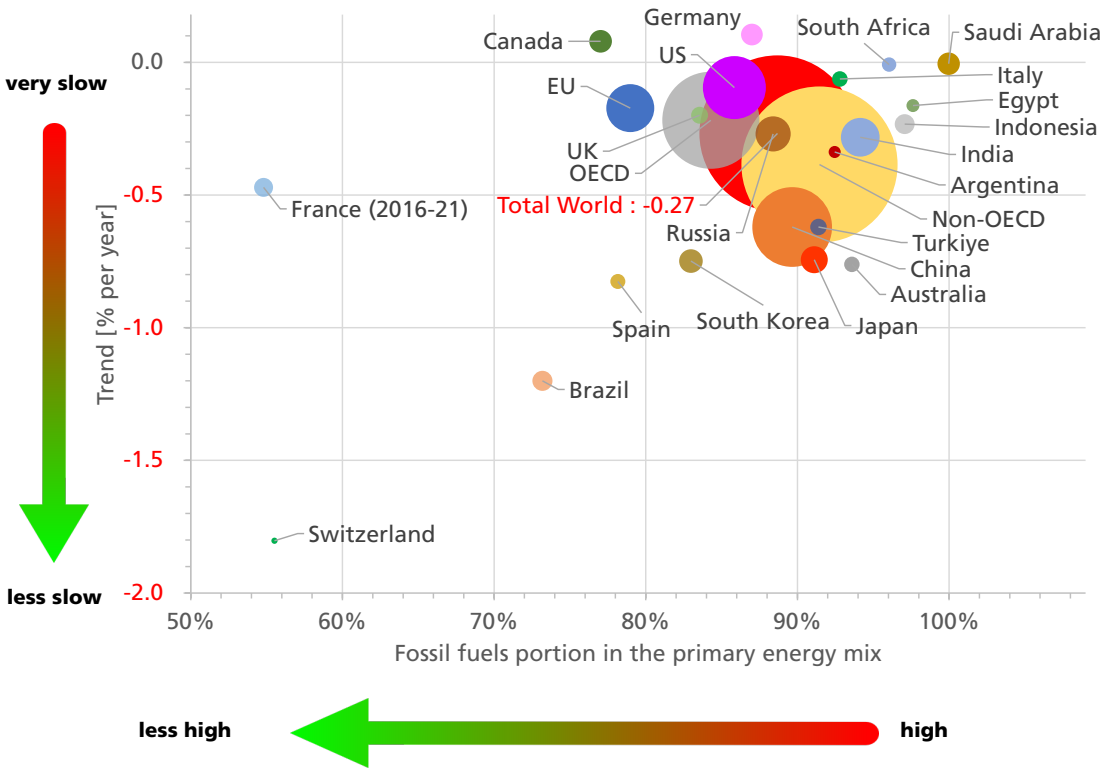
The data is from IRENA, which is of poor quality due to a lack of rigour and gaps in the reports.

Use with caution!

Wind production	2022	Share	Trend 5 yr	CF %
Total World	2104.8	100.0%	13%	27.9
OECD	1093.7	52.0%	9%	
Non OECD	1011.2	48.0%	18%	
China	762.7	36.2%	20%	25.1
US	439.2	20.9%	11%	36.6
European Union	420.5	20.0%	6%	
Germany	125.3	6.0%	3%	22.0
Brazil	81.6	3.9%	14%	41.1
United Kingdom	80.2	3.8%	10%	33.7
India	70.0	3.3%	6%	19.5
Spain	62.7	3.0%	5%	25.0
France	38.0	1.8%	9%	21.8
Canada	37.5	1.8%	4%	28.9
Turkey	35.1	1.7%	14%	
Sweden	32.6	1.5%	13%	27.9
Australia	31.7	1.5%	19%	37.9
Total Africa	23.9	1.1%	12%	
Netherlands	21.2	1.0%	15%	28.3
Italy	20.7	1.0%	3%	20.5
Mexico	20.3	1.0%	14%	32.0
Poland	19.4	0.9%	5%	29.6
Denmark	19.0	0.9%	5%	30.7
Norway	14.8	0.7%	39%	33.2
Argentina	14.2	0.7%	88%	49.1

The lower the level of implementation of a technology, the higher the growth rates.
They tend to weaken in Germany, a sign that the best projects have already been implemented.
The load factor is above all determined by geographical location. For solar energy, medium and high latitudes are unfavourable and require over-investment (more panels) in order to obtain a similar output.

Weaning off fossil fuels



In this diagram, the areas of the bubbles are proportional to the total consumption of primary energy in the given country or group of countries.

The trend is calculated as the average annual rate of decrease in fossil fuel intensity over the period 2017-2022.

The more negative it is, the faster the decarbonisation.

At +1.1% per year, France lies outside the diagram, which is due to the maintenance of its nuclear park and the closure of two reactors.

The COVID-19 pandemic had an effect that has already faded.

EI data corrected by the author for primary energies

The share of fossil fuels in energy consumption is falling almost everywhere, by -0.27 %/a, albeit at different rates.

Compared with this trend 5 years ago (2012-2016, with -0.22 %/a), there has been a slight acceleration from a global perspective, with the following countries worsening their performance: China, USA, Canada, Germany, UK, Italy, South Africa.

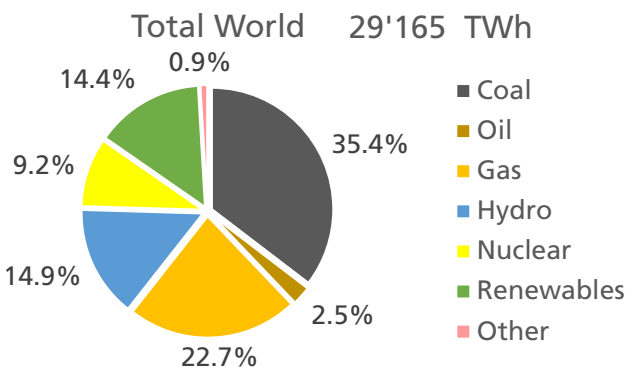
The German case shows where an incoherent energy strategy is leading; the effects of the war in Ukraine cannot be used as an explanation.

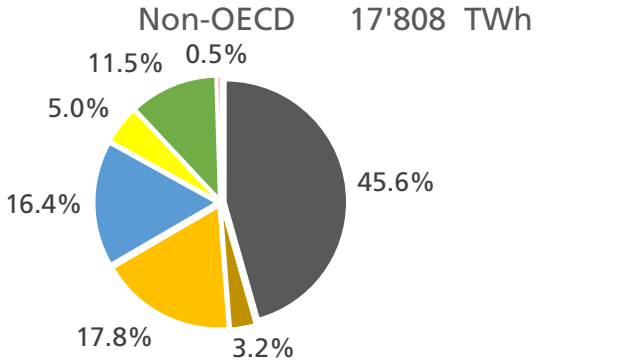
With a global dependence of 88.7%, energy resources in the form of fossil fuels remain essential to ensure growth, even in OECD countries. Their exploration and production are necessary, indeed unavoidable.

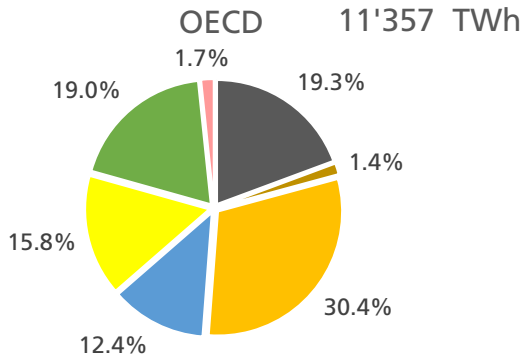
Many countries (France, Norway, Sweden, Switzerland) use virtually no fossil fuels to generate electricity, or little (Canada, Brazil, Spain).

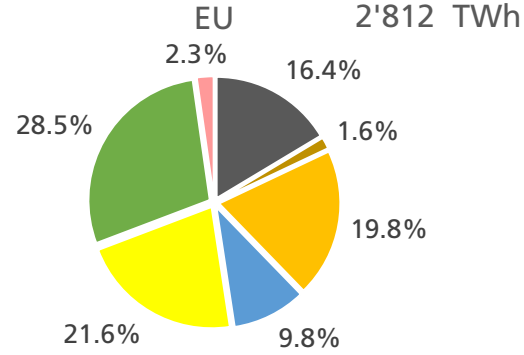
Their decarbonisation strategy must therefore focus on other uses – transport, domestic and industrial heating and cooling.

Electricity in 2022









Total power generated: 29 165 TWh an increase of 2.3%.

Share of total generated with the three fossil fuels:

World	60.6%
Non OECD	66.6%
OECD	51.2%
EU	37.7%

The primary consumption of fossils and fissile raw material depends on the efficiency of each power plant.

Approx. 30% of primary energies in the form of fossil fuels is used to produce electricity. All the electricity produced represents 18.8% of all the primary energy consumed.

To decarbonise electricity production, 17 677 TWh of electricity will have to be generated by other production technologies.

	Coal	Oil	Gas	Total
Power production	10 317	729	6 631	17 677
Thermal efficieny	33%	35%	50%	
Primary required	31 264	2 082	13 263	46 609

Assuming that the efficiencies of today's thermal power generation are those shown in the table above, 46 609 TWh of primary energy will have to be replaced.

In addition, further electrification will be needed to replace other fossil uses (91 000 TWh in 2022) in transport, domestic and industrial heating, and to produce chemicals, steel, cement, and plastics. Making a few savings may reduce this need, but will not be decisive.

Anti-nuclear countries will have to face up to the fact that this technology will be essential to achieve decarbonisation.

In a nutshell

- Global energy consumption continues to rise, by 1.0% per year - GDP by 2.3%.
- 88.7% is consumed in the form of fossil fuels (only 81.8% according to EI, which is incorrect and minimises the problem).
- Roughly speaking, two-thirds of the growth in energy consumption is achieved using fossil fuels.
- This applies especially to non-OECD countries, which have major development needs.
- Decarbonisation is an enormous challenge:
  - The percentage of fossil fuels in the global energy mix is falling by just 0.27% each year. Simplistically and linearly extrapolating this trend, it would take 330 years to reach zero.
  - Size matters!
  - Around 30% of fossil fuels consumed are used to generate electricity. The remainder is used for transport, domestic and industrial heating, and to produce chemicals, cement, steel and plastics.
  - Too much attention is paid to simply changing the way electricity is produced, forgetting that this represents only a third of the energy transition challenge. We will need 2 to 3 times as much electricity capacity to satisfy increased demand.
  - Fossil fuels are still essential for building new facilities dedicated to low-carbon activities.
- This means that premature disinvestment in the exploration and production of fossil fuels would lead to economic, and therefore social, collapse. Germany is showing the way!
- There's no need for meticulous CO_2 accounting, because it suffices to monitor fossil fuel consumption.
  It keeps useless people busy, serves only to blame and shame, and feeds blabla without helping in any way to find solutions.
- A word on Hydrogen:
  This gas is more of a chemical reagent than a secondary energy vector, and premature investments will remain counter-productive because this technology is still too inefficient and the necessary electrical resources are unavailable.
- It would be absurd to simply burn it in combustion engines or fuel cells.
  For its production and for the production of high-energy density liquid synfuels, significant and robust investment in R&D is essential, without any guarantee of results or promise of economic affordability.

Outline of an energy strategy

Preamble

- Each country will adopt its own strategy, hopefully with coherent, realistic and achievable goals.
- All these strategies imply a massive electrification of all human activities, industrial and domestic.
  A formidable undertaking.
- The energy strategy is part of an overall environment and climate strategy, but it needs to be defined in specific and precise terms.
- The energy sector is indispensable. It may only represent 5 to 10% of a country's GDP, but all the other sectors depend on it.
  However, it cannot become a purpose by itself.
- Political arbitrage will be necessary, particularly with regard to the urgency of climate policies aiming at mitigation versus adaptation, considering the relative risks of acting, not acting or acting badly.

Strategic objectives

1. **Security of supply** :
   Meeting society's current and future energy needs at all times and in all places.
2. **Geopolitical independence**
3. **Reducing the use of fossil fuels** to the point where CO_2 emissions remain sufficiently mineralised naturally in the soil and in the depths of the oceans, or captured and then sequestered artificially.
4. Keeping low land occupation to **preserve biodiversity**.
5. Achieve this on the condition of **economic affordability**.

Strategies

1. Permanent supply security
   - Explore and exploit additional fossil resources for as long as necessary.
   - Favour investment in greenhouse gas-free technologies.
   - But do not invest until their supply is truly decarbonised and economically viable (e.g. hydrogen).
2. R&D for new solutions and improved productivity
   - Nuclear, hydrogen, ammonia, formic acid, fertilisers, plastics...
   - Synthetic fuels: high-temperature processes, catalysis, systems.
3. Reducing demand through productivity
   - Improving buildings (insulation, heating and air conditioning).
   - Improve industrial processes.
   - Mass and personalised transport (land, air, sea).
4. Electricity generation
   - Ribbon-shape: run-of-river, nuclear (3rd and 4th generation), geothermal.
   - Fatal harvest from solar and wind power, including storage and grid.
   - Limit it to favourable situations of high load factors, without destabilising the grid.
   - Controllable (storage hydro, detritus, biomass).
5. Change of uses
   - Industries, services and domestic solutions.
   - Allocate time to change a fleet of vehicles or other equipment.
6. Regulations and taxes
   - Set technical standards to be met rather than hoping that taxes and subsidies will encourage investment (illusory and pointless carbon tax).
   - Provide a general economic and social framework, invest in R&D, without *a priori* preferences.

Ask questions, analyse, discuss, consult?

About the author :

Michel de Rougemont, chemical engineer, Dr sc tech, is an independent consultant.

Through his activities in fine chemistry and agriculture, he is confronted, without fearing them, with many challenges related to the safety of people and of the environment.

He has no conflict of interest in relation to the subject of this article.

He has written three essays ;

- « Réarmer la raison. De l'écologie raisonnée à la politique raisonnable » (2017),
- « Entre hystérie et négligence climatique » (2018), et
- « The great delusion of the rescue of the planet by a great reset » (2021, also in French).

See détails here.

Visit these internet sites:

www.mr-int.ch

MR's Blog: blog.mr-int.ch,

A climate oriented one: climate.mr-int.ch,

Another on organic plant protection products: biologicals.mr-int.ch.

Contact :

MR-int
Michel de Rougemont
Enterprise Consulting
Widhagweg 10
4303 Kaiseraugst
Suisse
Mobile +41 79 705 4811
www.mr-int.ch
michel.de.rougemont@mr-int.ch
Skype: micheldr1551

This presentation should not be provided free of charge. It is in deed a work of value that readers may appreciate.

MR's Blog
On & Off the Line