

CO2 Emissions per Capita

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Version 1.1.1, 30 October 2022

DOI:10.5281/zenodo.7264405

all versions DOI:

Abstract

This work analyzes CO₂ emissions per capita (CpC) in the period 1990-2020. The dataset includes 212 countries, 99.8% of the global CO₂ emissions.

The world average CpC was 4.3366 tCO₂/y,cap in 2020, 4.1% above the 1990 level.

CO₂ emissions above the world average CpC in the period 1990-2020 by 81 countries were 39% of the global CO₂ emissions in this period, which increased Global Warming by 0.249°C. The average CpC in 2020 of the 81 countries above the world average CpC was 8.62 tCO₂/y,cap in 2020, 5.6 times more than the countries below the world average.

100 countries reduced CO₂ emissions per capita between 1990 and 2020 by 21% on average, compared to the world average increase of 53%. The reduction of the CpC by the 100 countries decreased Global Warming by 0.21°C.

OECD (1990) countries and Annex I (Kyoto) countries, 41 countries having 22% of the world population, caused 49% of the Global Warming +0.316°C between 1990 and 2020. This group of countries reduced CO₂ emissions by 21% between 1990 and 2020, however, the group's average CpC was still 206% of the world average in 2020, with 8.94 tCO₂/y,cap, compared to 3.38 tCO₂/y,cap of the rest of the world.

10 countries above the world average of CO₂ emissions per capita (2020) with the highest change in cumulative CO₂ emissions between 1990 and 2020, caused 63%

of the Global Warming, $+0.407^{\circ}\text{C}$, in the period. The average CpC of these 10 countries was 195% of the world average, $8.71 \text{ tCO}_2/\text{y,cap}$ in 2020, compared to $2.36 \text{ tCO}_2/\text{y,cap}$ of the rest of the world. The CO2 emission of 5 countries from this group is above the group's average CpC of $8.71 \text{ tCO}_2/\text{y,cap}$, 7% of the global emissions of the world.

Keywords: Climate Change, Global Warming, CO2 emissions, CO2 per capita

Glossary

ΔCO_2	CO2 emissions of the country above the world emissions per capita in the period 1991-2020, tCO_2
Ave	average
BL	baseline
CCO2	global cumulative CO2 emissions according to publication [1] [2], CO2 emissions produced from fossil fuels and cement production only – land use change is not included, tCO_2
CO2	emissions of Carbon Dioxide, CO_2
$\text{CO}_2 \rightarrow \text{GW}$	correlation between cumulative CO2 emissions and Global Warming = $0.000745^{\circ}\text{C}/\text{GtCO}_2$ [3]
CpC	CO2 emissions per capita, $\text{tCO}_2/\text{y,cap}$ (ton CO2 per year, per population of the country)
CpCW	world average CO2 emissions per capita, $\text{tCO}_2/\text{y,cap}$ (ton CO2 per year, per population of the world)
Global Warming	global surface temperature change over land+ocean above 1850-1900 baseline ($^{\circ}\text{C}$)
Group+10P	10 countries above the world average of CO2 emissions per capita (2020) with the highest change in cumulative CO2 emissions between 1990 and 2020

Group1990	OECD members in 1990 or Annex I countries which signed or ratified Kyoto Protocol
Group2022	OECD members in 2022 or Annex I countries which signed or ratified Paris Agreement.
GtCO2	Giga-ton of CO2, 10 ⁹ ton, 10 ⁹ ton, 1,000,000,000 ton of CO2
ktCO2	kilo-ton CO2 = 10 ³ ton, 10 ³ ton, 1,000 ton CO2
MtCO2	Mega-ton CO2 = 10 ⁶ ton, 10 ⁶ ton, 1,000,000 ton CO2
OWID	Our World in Data – Internet site [1] [2]
Pn	Population of the country in year n
Ref	reference
tCO2	ton CO2
tCO2/y,cap	ton CO2 per year, per capita

Formula for Average Annual Change

Formula 1 - Average annual change of parameter X in the period 1990-2020 [%/year]

$$rX = (X2/X1)^{1/(y2-y1)} - 1$$

rX	average annual change of parameter X in the period from y1 to y2, %/year
X1	value of parameter X at the beginning of the period
X2	value of parameter X at the end of the period
y1	beginning of the period = 1990
y2	end of the period = 2020

Correlation between Cumulative CO2 Emissions and Global Warming

The correlation between cumulative CO2 emissions and Global Warming was analyzed in the publication "*Global Warming and Cumulative CO2*" [3].

The correlation is:

Formula 2 - Correlation between Cumulative CO2 Emissions and Global Warming [3] [$^{\circ}\text{C}/\text{GtCO}_2$]

$$\text{CO}_2 \rightarrow \text{GW} = 0.000745^{\circ}\text{C}/\text{GtCO}_2$$

Dataset

Table 1 - CO2 emissions and population dataset [1] [2]

	CO2 emissions			Population
	World	International Transport	Countries	
Source of data	OWID	OWID	OWID	OWID
Reference	[1] [2]	[1] [2]	[1] [2]	[1] [2]
Countries			212	212
From year	1750	1950	varies for each country	
To year	2020	2020	2020	2020
CO2 from fossil fuels	Yes	Yes	Yes	
CO2 from cement production	Yes		Yes	
CO2 from other sources	No		No	
Other GHG	No	No	No	
Land use change	No		No	
Units	tCO2/y	tCO2/y	MtCO2/y	
Resolution	1 tCO2/y	1 tCO2/y	1 ktCO2/y	1 Resident
Cumulative CO2 emissions baseline	1749	1949	1989	

The datasets are from publication [1] [2], CO2 emissions produced from fossil fuels and cement production only – land use change is not included.

Table 2 - Completeness of data for 1990

	CO2 MtCO2/y	Population
World	22,750	5,327,529,078
International transport	558	
World without international transport	22,192	
Dataset 212 countries	22,192	5,318,336,356
Dataset to World	100.0%	99.8%

Table 3 - Completeness of data for 2020

	CO2 MtCO2/y	Population
World	34,807	7,794,798,725
International transport	1,004	
World without international transport	33,803	
Dataset 212 countries	33,790	7,782,877,679
Dataset to world	100.0%	99.8%

Cumulative Global CO2 Emissions

Total global CO2 emissions per year are from 1750 [1] [2]. This is also the first year of calculations of the cumulative CO2 emissions of the world, which means that for this parameter the baseline is 1749.

However, international transport CO2 emissions are from 1950 and the first year of the cumulative CO2 emissions is 1950 [1] [2], which means that for this parameter the baseline is 1949.

The dataset was converted to the 1875 baseline in the publications [6] [7].

Table 4 - Global cumulative CO2 emissions and international transport [6] [7] [tCO2 above 1875 baseline]

		1990	2020
Global cumulative CO2 emissions including international transport	tCO2	792,689,057,443	1,681,608,597,211
International transport cumulative CO2 emissions	tCO2	16,042,804,984	43,700,803,946
Global cumulative CO2 emissions without international transport	tCO2	776,646,252,459	1,637,907,793,265

International transport cumulative CO2 emissions are not related to the specific country, therefore, the comparison between the countries' CO2 emissions and the world is to the global cumulative CO2 emissions without international transport.

World CO2 Emissions per Capita

Chart 1 - World CO2 emissions per capita [1] [2] [tCO2 per year, per capita]

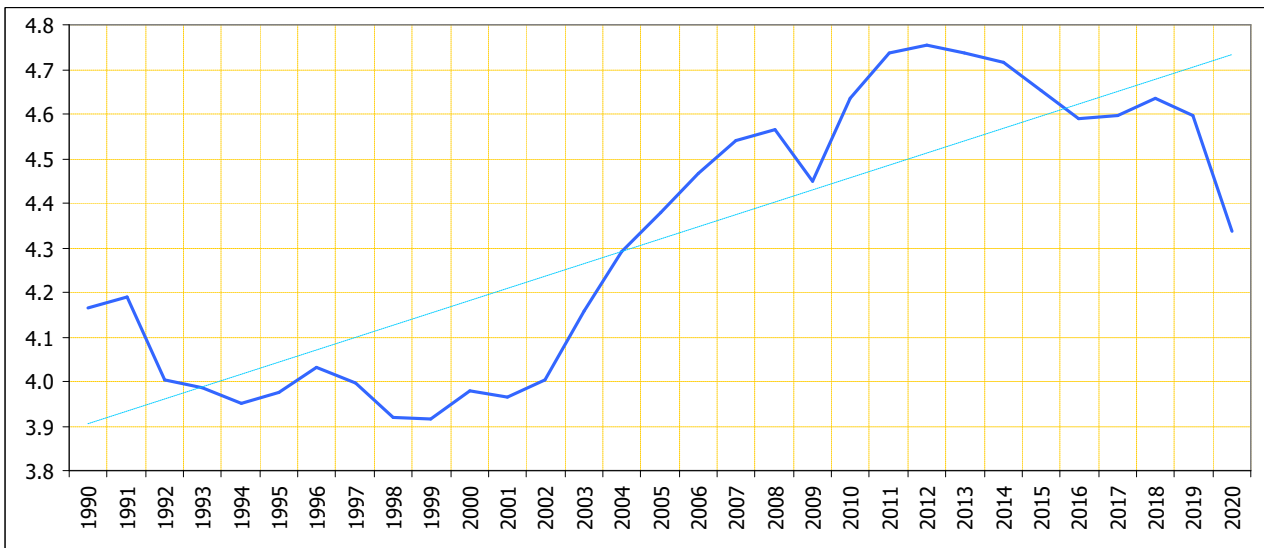
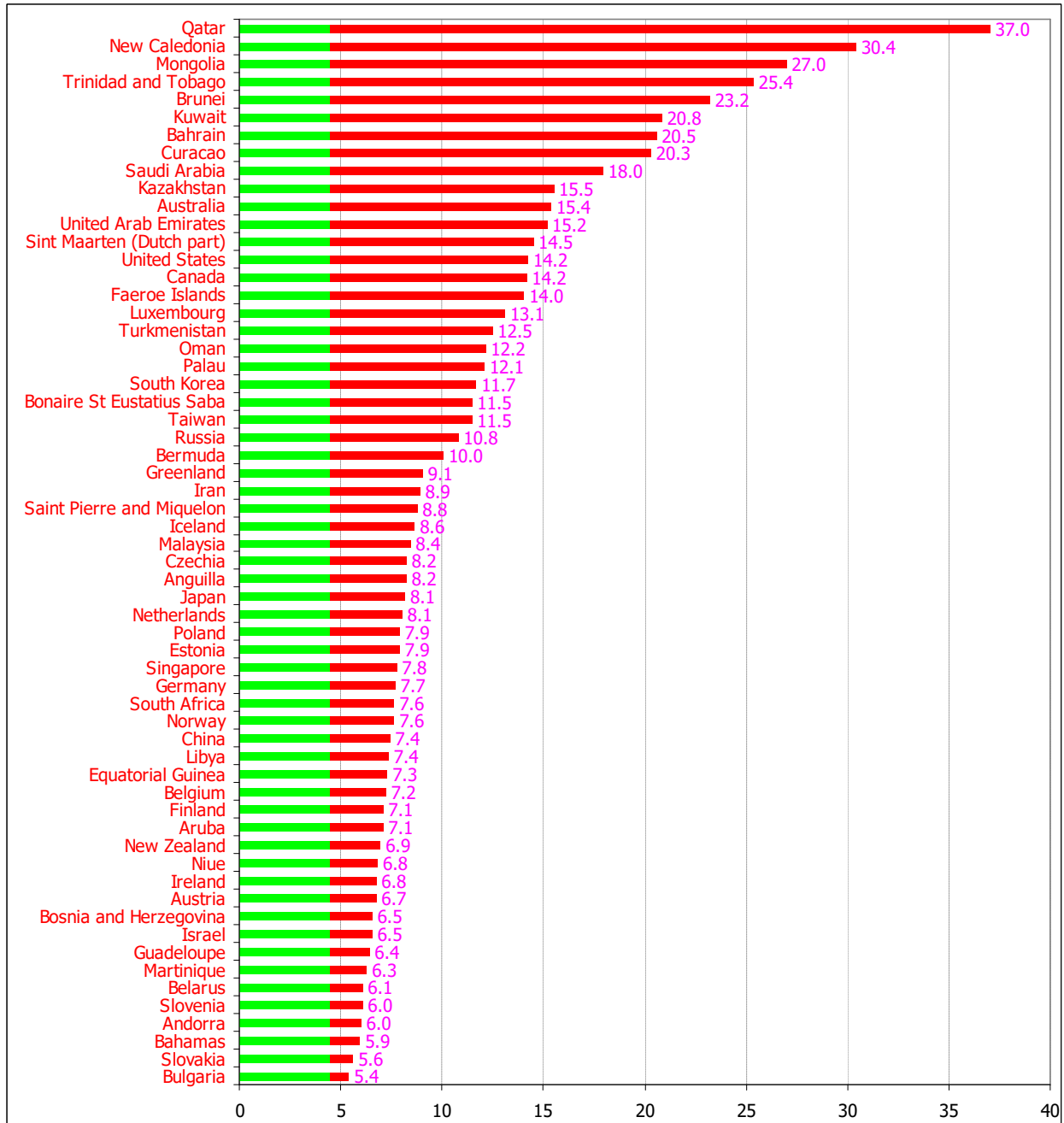


Table 5 - World averages [1] [2]

		1990	2020
CO2 emissions	MtCO2/y	22,192	33,803
1990-2020 change	%/year		+1.41%
Population		5,327,529,078	7,794,798,725
1990-2020 change	%/year		+1.28%
CO2 per Capita	tCO2/y,cap	4.1655	4.3366
1990-2020 change	per period		4.1%
average annual change	%/year		+0.13%

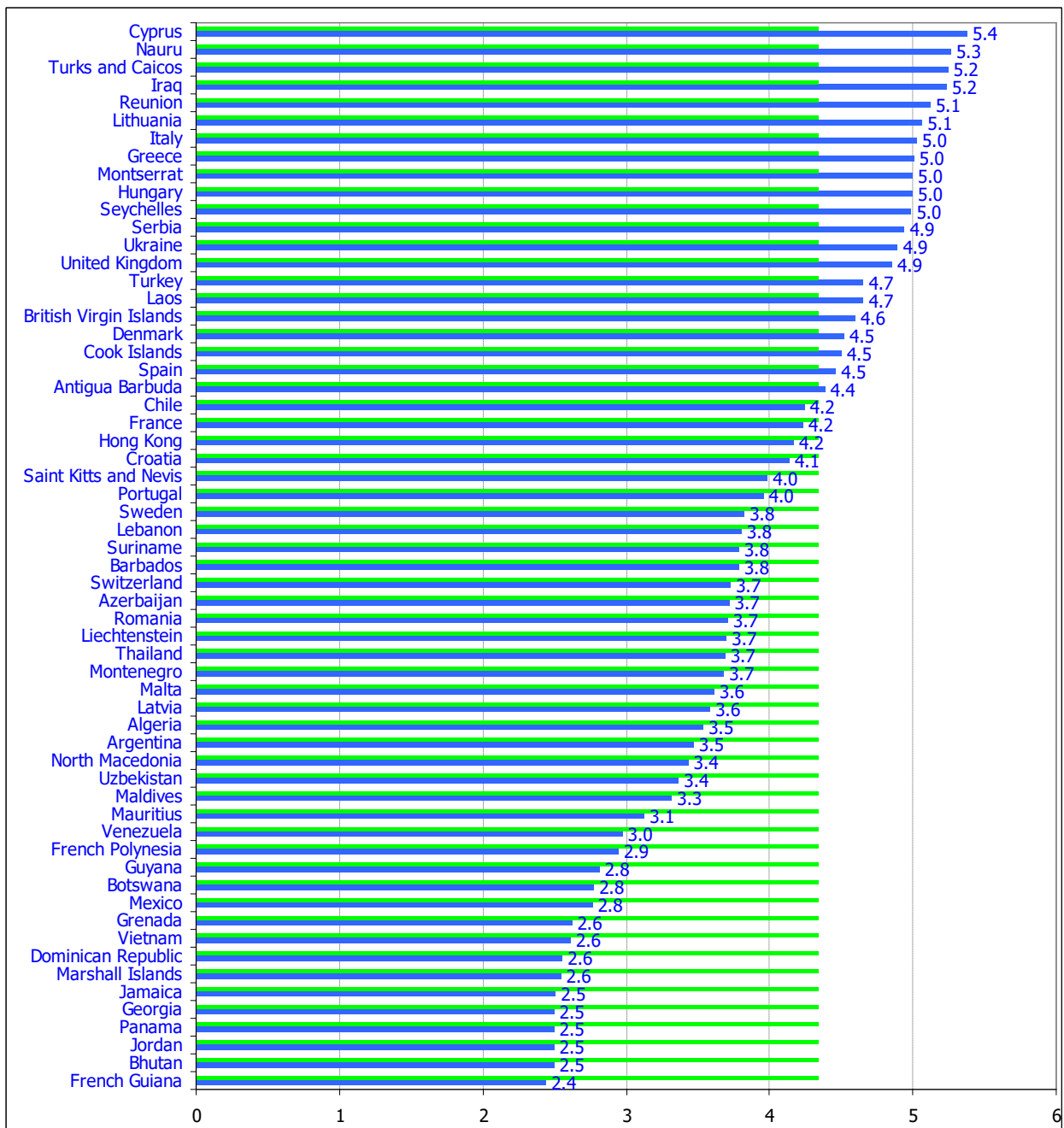
CO2 Emissions per Capita in 2020

Chart 2 - 60 countries with the highest CO2 emission per capita in 2020 [part 1/4]
[tCO2 per capita]



The green range is the world average in 2020 = 4.3366 tCO2/y,cap

Chart 3 - CO2 emission per capita in 2020 [part 2/4] [tCO2 per capita]



The green range is the world average in 2020 = 4.3366 tCO2/y/cap

Chart 4 - CO2 emission per capita in 2020 [part 3/4] [tCO2 per capita]

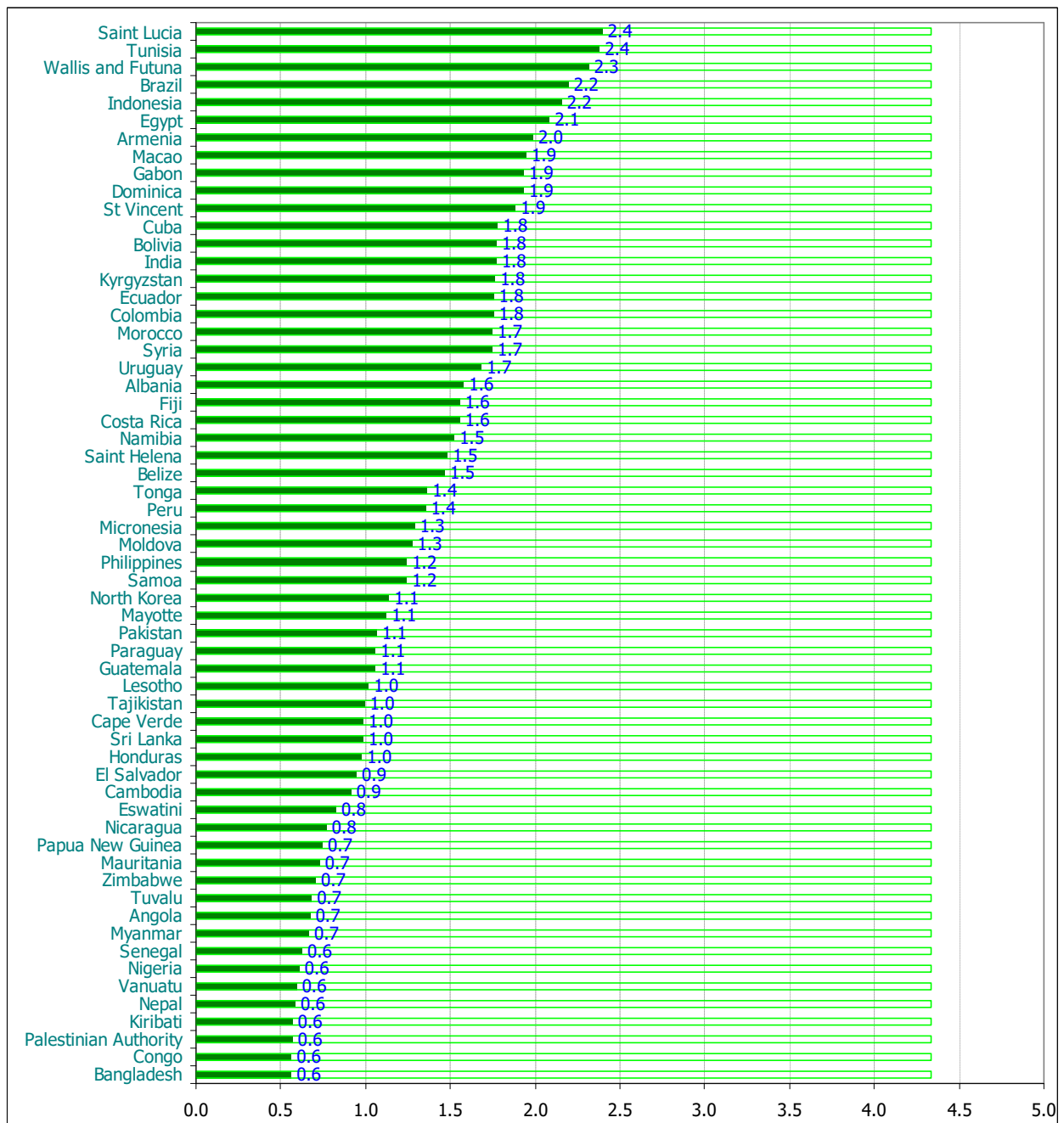


Chart 5 - CO2 emission per capita in 2020 [part 4/4] [tCO2 per capita]

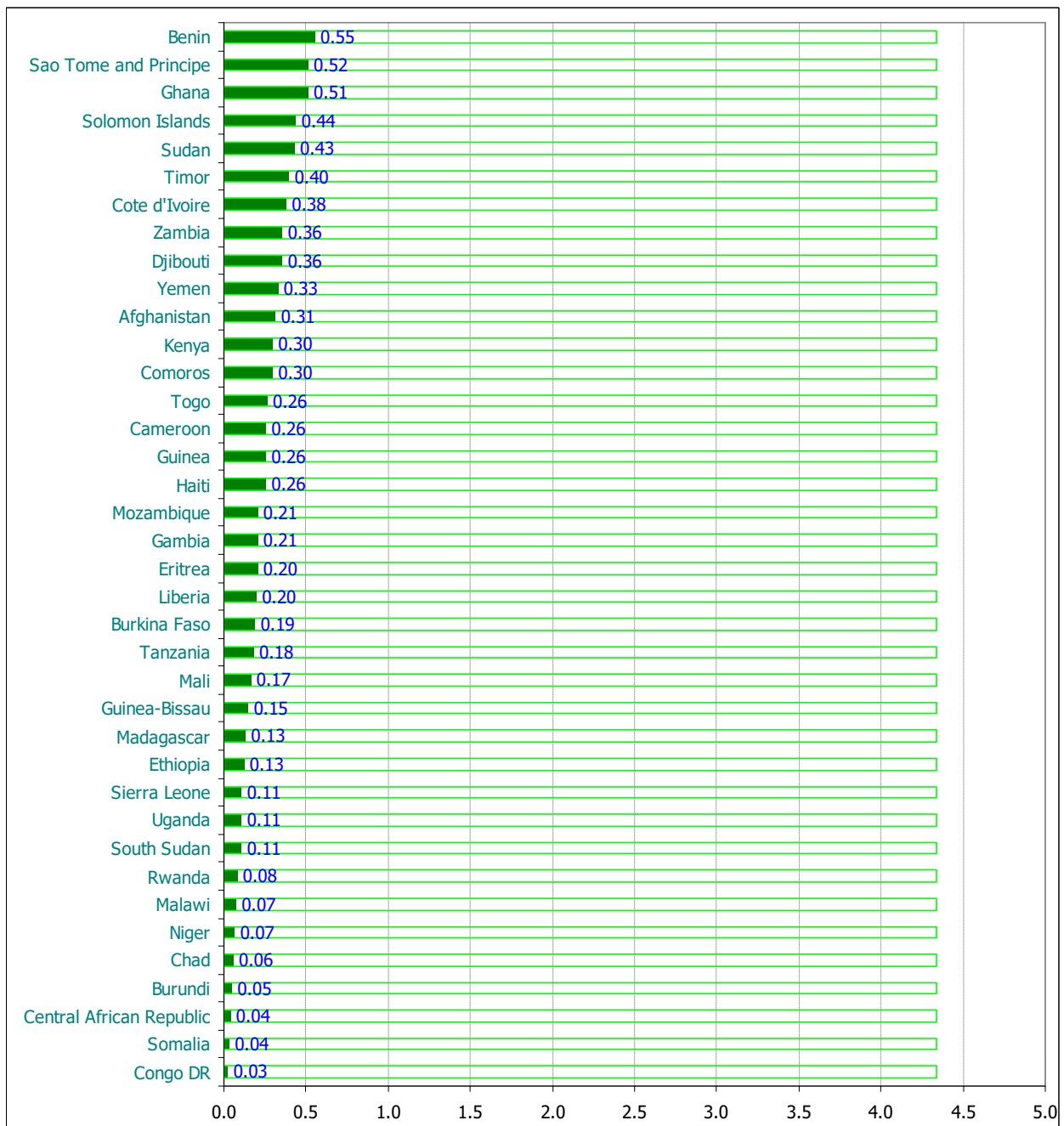


Table 6 - Countries above and below the world average CO2 emissions per capita (CpCW) in 2020

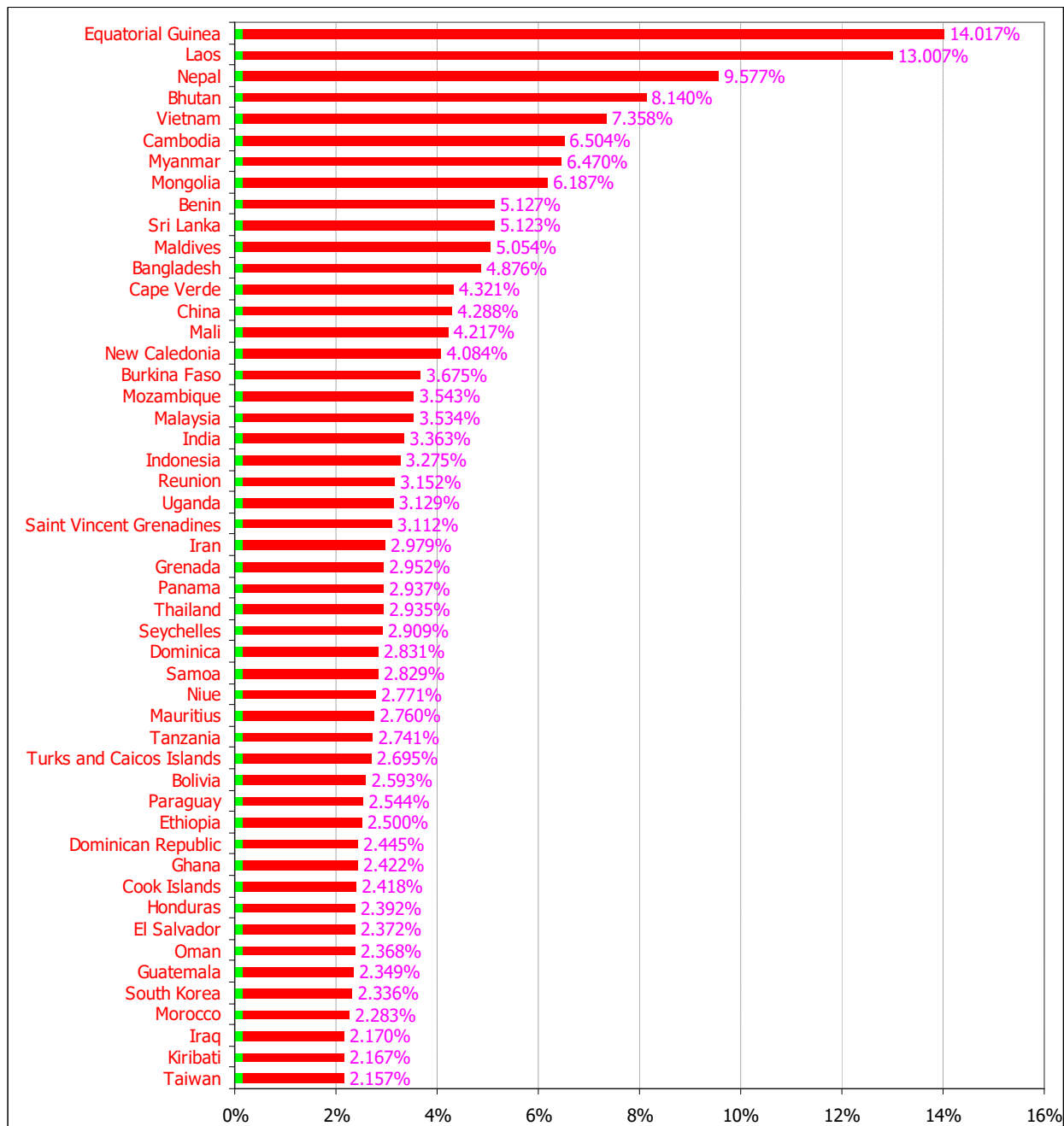
	Countries	Population	CO2/y 2020 MtCO2/y	CpC 2020 tCO2/y,cap
Countries > World	81	3,080,893,558	26,545	8.62
Countries < World	131	4,702,082,049	7,245	1.54

Change in CO2 Average Annual Emissions per Capita from 1990 to 2020

The average annual change in the world CO2 emissions per capita in the period 1990-2020 was calculated using Formula 1.

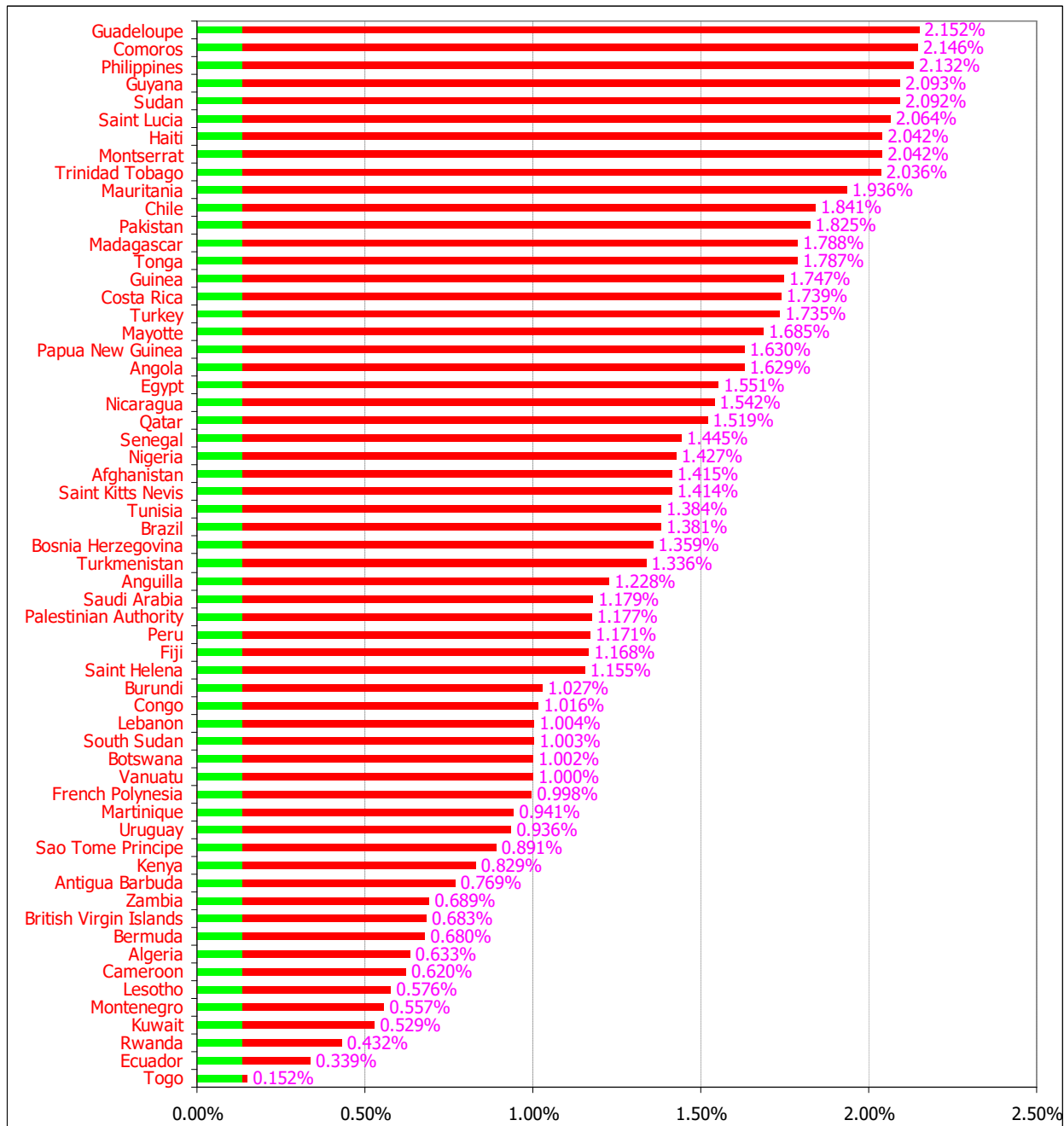
The average change is 0.134% per year.

Chart 6 - CO2 emissions per capita in the period 1990-2020 [#1/4]: 60 countries with the biggest average annual change [%/year]



The green range is the world average change in 1990-2020 = 0.134%/y

Chart 7 - Average annual change in CO2 emissions per capita in the period 1990-2020 [#2/4] [%/year]



The green range is the world average change in 1990-2020 = 0.134%/y

Chart 8 - Average annual change in CO2 emissions per capita in the period 1990-2020 [#3/4] [%/year]

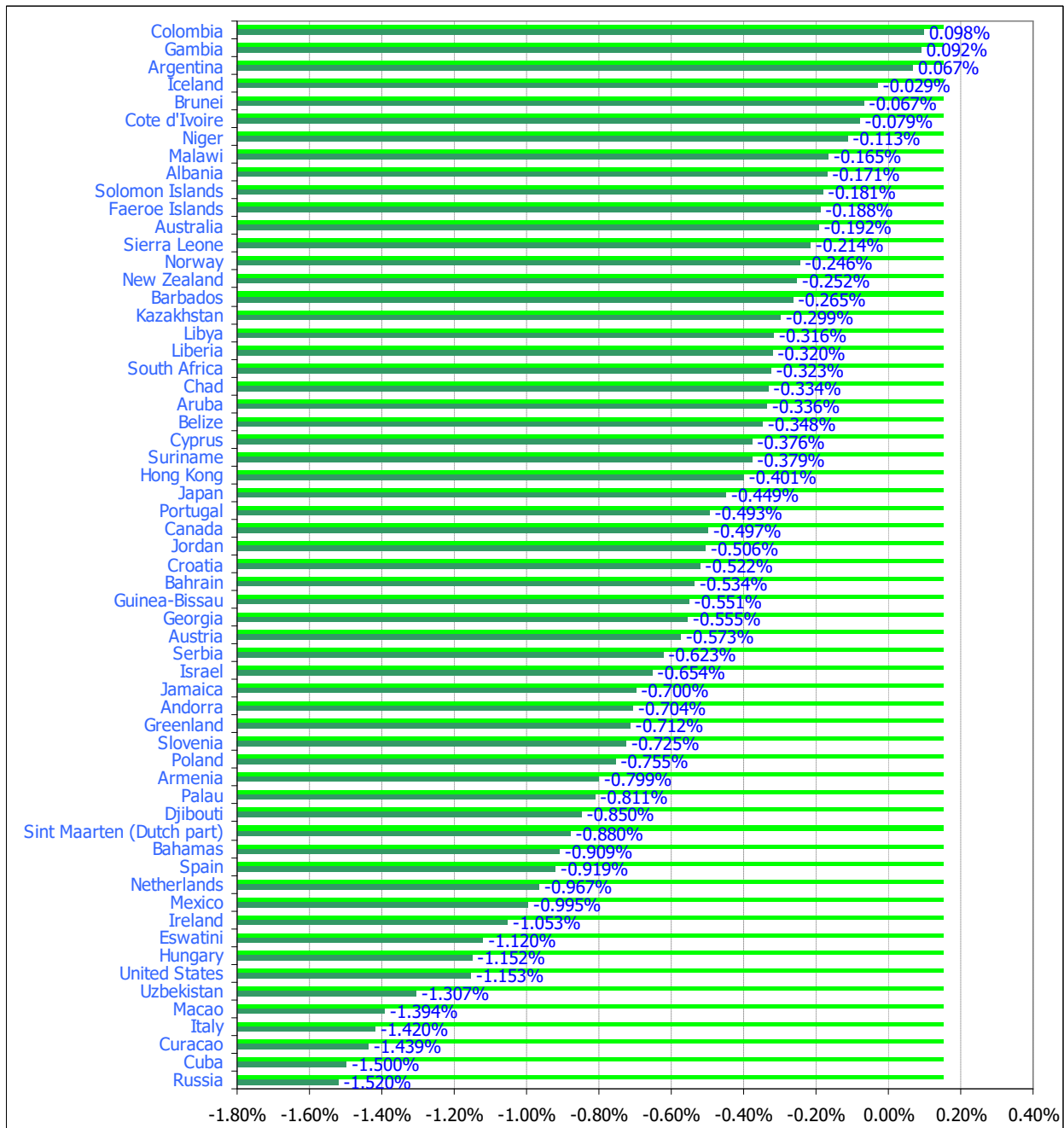


Chart 9 - Average annual change in CO2 emissions per capita in the period 1990-2020 [#4/4] [%/year]

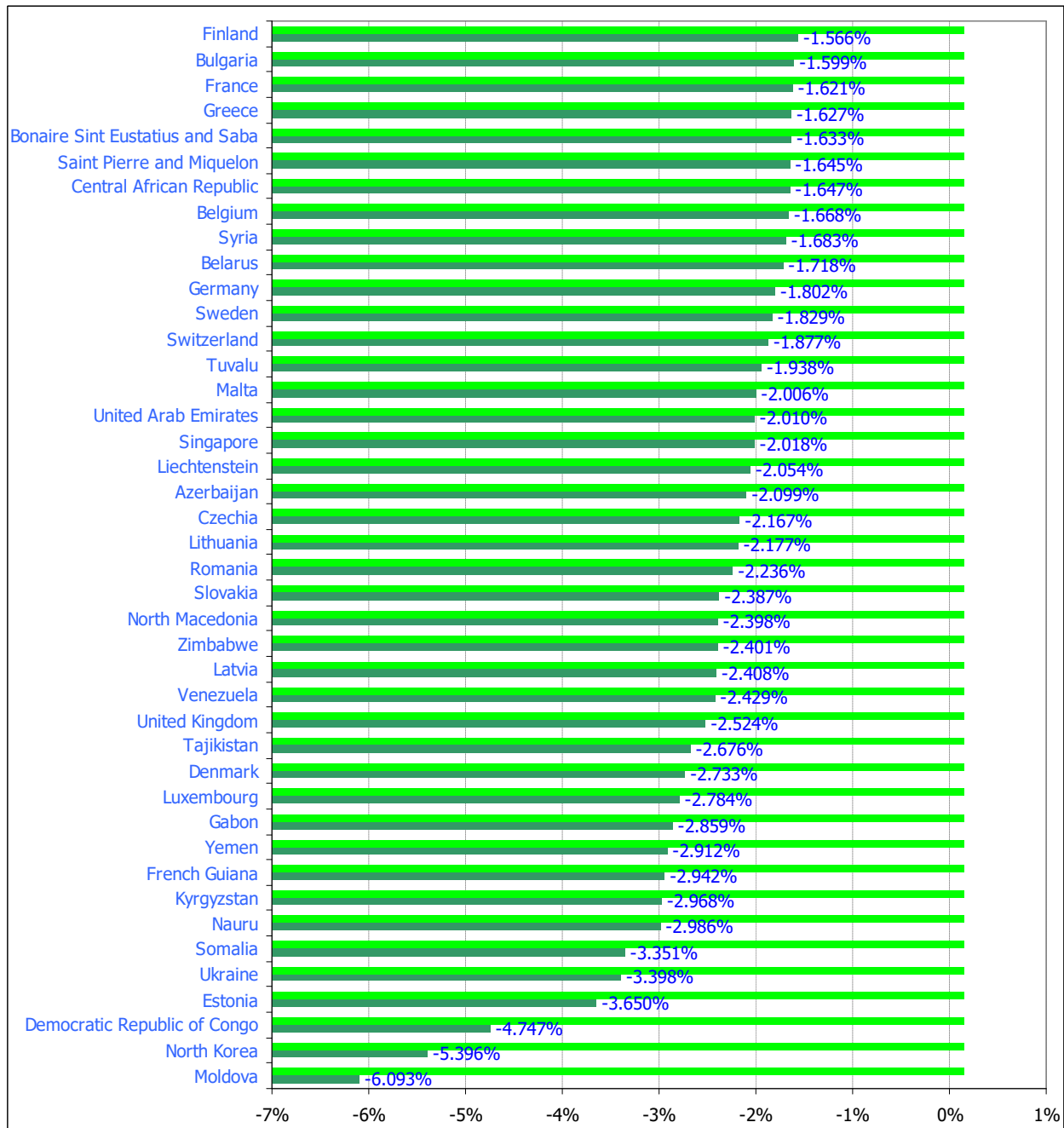


Table 7 - Countries above and below the world average annual change in CpC

	Countries	Population	CO2/y 2020 MtCO2/y	CpC 2020 tCO2/y,cap
Countries > World	110	5,739,286,709	20,000	3.48
Countries < World	102	2,043,590,970	13,790	6.75

Global Warming from CO2 Emissions above World CpC in the Period 1990-2020

Formula 3 - CO2 emissions above the world emissions per capita in the period 1991-2020 [tCO2]

$$\Delta CO_2 = \sum_{n=1991}^{2020} (CO_{2n} - CpCW_n \times P_n)$$

ΔCO_2	CO2 emissions of the country above the world emissions per capita, in the period 1991-2020, tCO2
CO_{2n}	Actual CO2 emissions of the country in year n, tCO2/y
$CpCW_n$	World average of the CO2 emissions per capita in year n, tCO2/y,cap
P_n	Population of the country in year n

Table 8 - Global Warming from CO2 emissions above the world CpC in the period 1990-2020

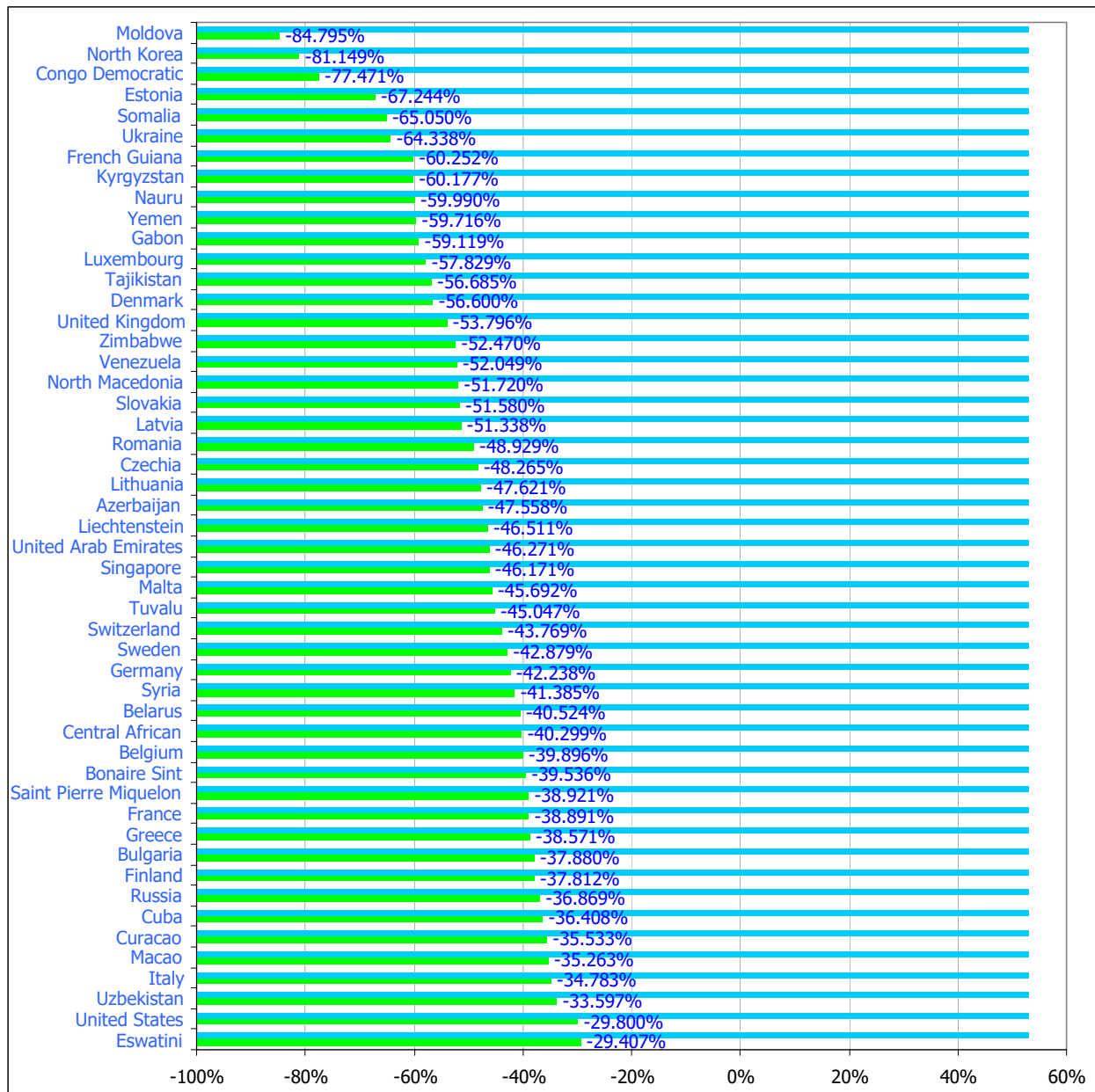
Global cumulative CO2 emissions in the period	861	GtCO2/30y
Countries	87	
CO2 emissions above the world CpC	335	GtCO2/30y
% of global emissions in the period	39%	%/30y
CO2→GW [3]	0.0007454	°C/GtCO2
Global Warming caused by CO2 emissions above the world CpC	0.25	°C

CO2 emissions above the world average in the period 1990-2020 were 335 GtCO2 by 87 countries, 39% of the global CO2 emissions in the same period.

These CO2 emissions above the world average increased Global Warming by 0.25°C, according to the correlation rate 0.000745°C/GtCO2 [3].

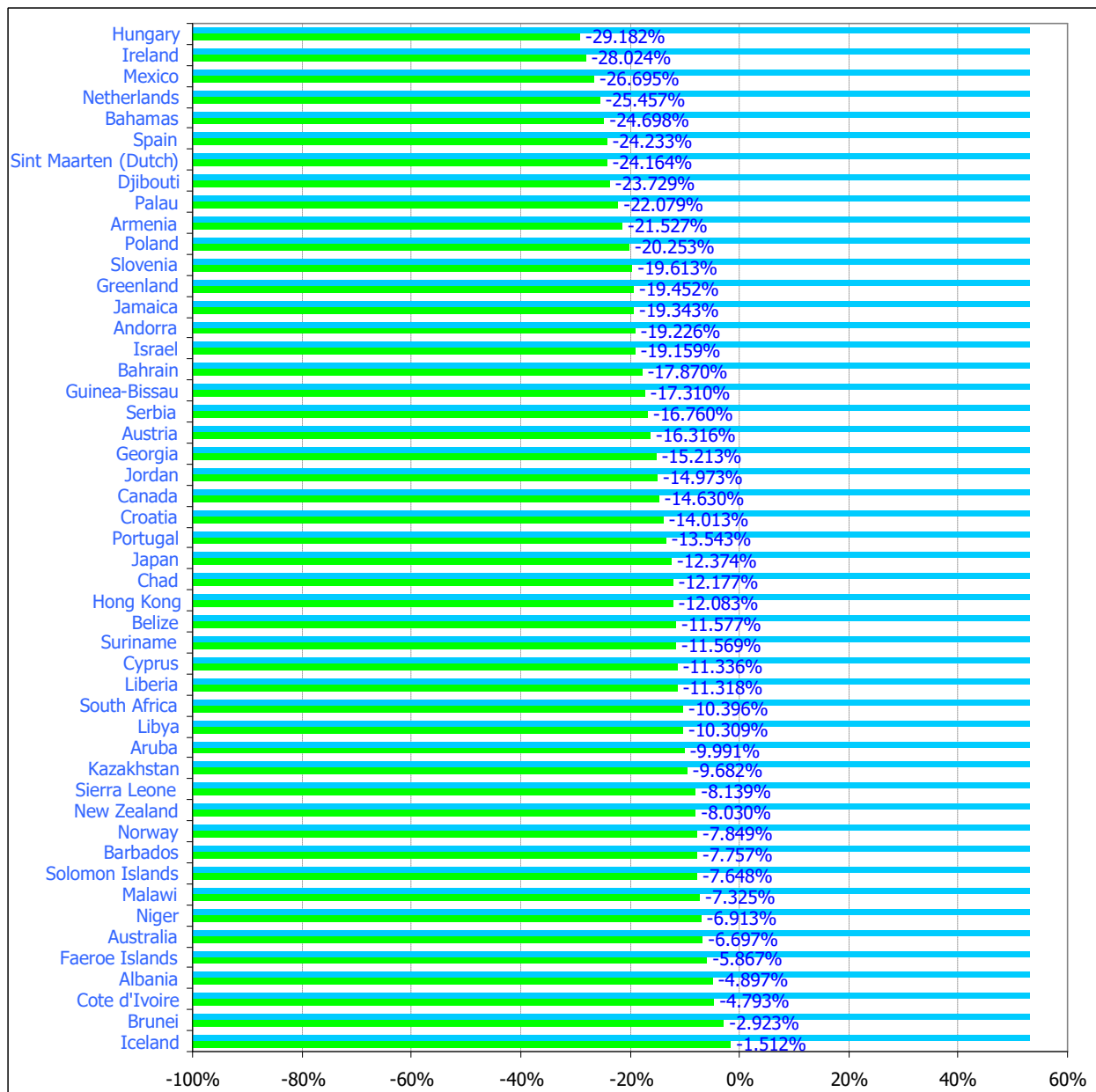
Countries that Reduced CO2 Emissions in the Period 1990-2020

Chart 10 - Countries that reduced CO2 emissions in the period 1990-2020 [#1/2]



The blue range is the change in the world emissions per year between 1990 and 2020 = +53%

Chart 11 - Countries that reduced CO2 emissions in the period 1990-2020 [#2/2]



The blue range is the change in the world emissions per year between 1990 and 2020 = +53%

Table 9 - Countries that reduced CO2 emissions per capita between 1990 and 2020 [1] [2] [Mt CO2/y]

	1990	2020	2020/1990
Number of countries		100	
Group population	1,528,337,151	1,947,512,309	1.27
Group CO2 emissions	MtCO2/y	16,752	13,544
Group CpC	tCO2/cap	10.96	6.95
World CpC	tCO2/cap	4.17	4.34
Mitigation of cumulative CO2 by countries	MtCO2	48,119	
CO2→GW [3]	°C/GtCO2	0.000745443	
Mitigation of Global Warming by countries	°C	0.04	

OECD and Annex I Countries

In this work “Group1990” is a group of countries that were OECD members in 1990 or are Annex I countries that signed or ratified the Kyoto Protocol.

“Group2022” is a group of countries that were OECD members in 2022 or are Annex I countries that signed or ratified the Paris Agreement.

Group1990 – OECD(1990) + Annex I (Kyoto)Table 10 - Group1990 countries [4] [5]

Countries	OECD(1990)	Annex I (Kyoto)
41	24	39
Australia	✓	✓
Austria	✓	✓
Belarus		✓
Belgium	✓	✓
Bulgaria		✓
Canada	✓	
Croatia		✓
Cyprus		✓
Czechia		✓
Denmark	✓	✓
Estonia		✓
Finland	✓	✓
France	✓	✓
Germany	✓	✓
Greece	✓	✓
Hungary		✓
Iceland	✓	✓
Ireland	✓	✓
Italy	✓	✓
Japan	✓	✓
Latvia		✓
Liechtenstein		✓
Lithuania		✓
Luxembourg	✓	✓
Malta		✓
Netherlands	✓	✓
New Zealand	✓	✓
Norway	✓	✓
Poland		✓
Portugal	✓	✓
Romania		✓
Russia		✓
Slovakia		✓
Slovenia		✓
Spain	✓	✓
Sweden	✓	✓
Switzerland	✓	✓
Turkey	✓	✓
Ukraine		✓
United Kingdom	✓	✓
USA	✓	

Chart 12 - Group 1990 Countries which reduced CO2 emissions between 1990 and 2020 [% tCO2/year]

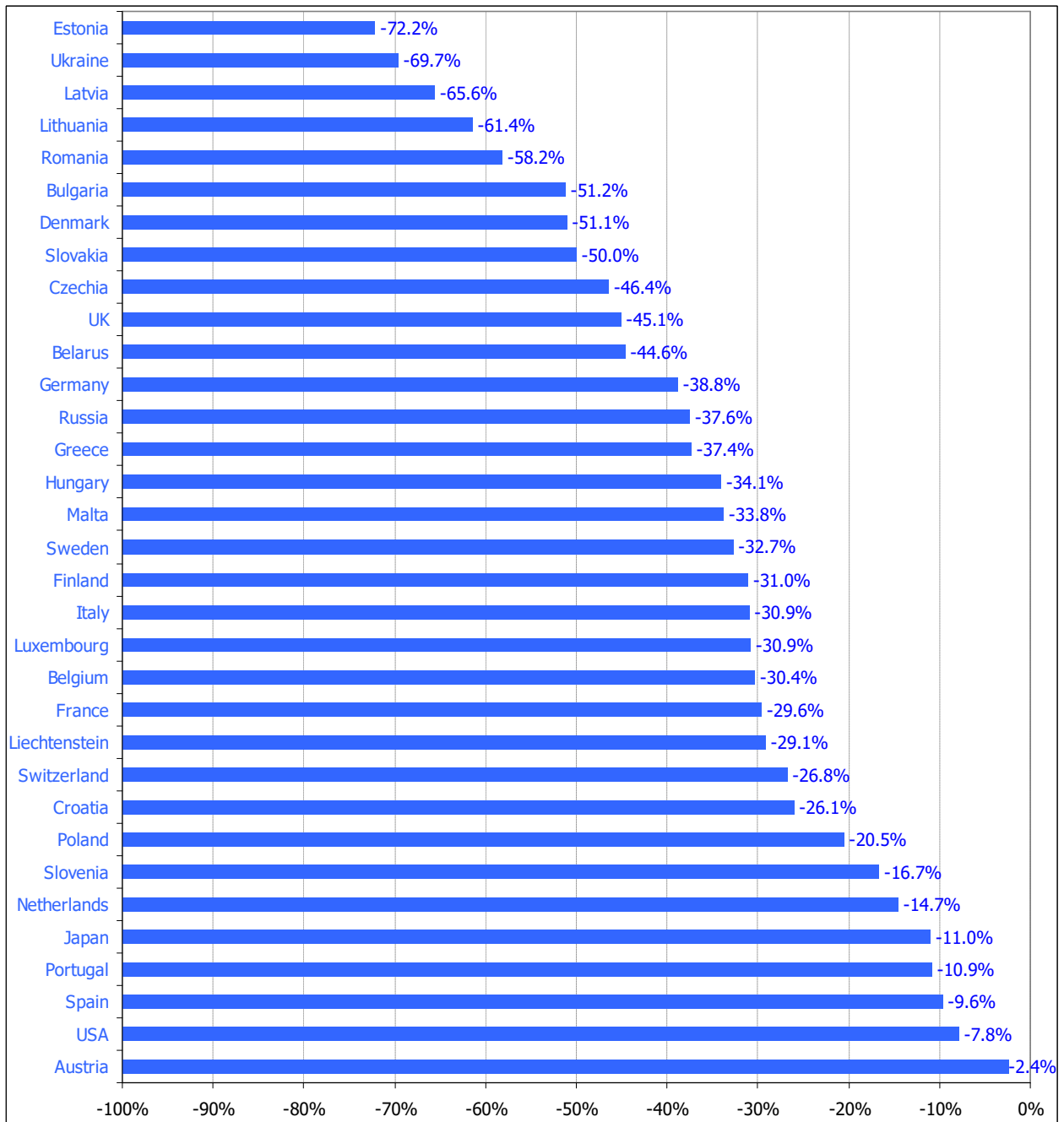
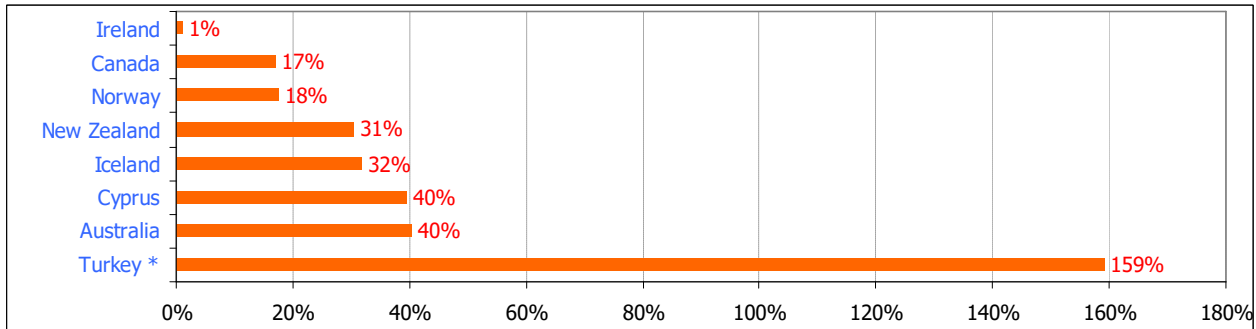


Chart 13 - Group1990 countries which increased CO2 emissions in the period 1990-2020 [% tCO2/year]



* CpC for Turkey was in 1990 the lowest in the Group, 2.8 tCO₂/y,cap, compared to 12.8 tCO₂/y,cap Group average. In 2020 the CpC for Turkey was 4.7 tCO₂/y,cap, still lower than the majority of the Group's members and the Group average 8.9 tCO₂/y,cap.

Table 11 - Group1990 [OECD(1990) and Annex I (Kyoto)]

		1990	2020	Change	% to 1990
CO2 emissions per year	Mt CO ₂ /y	15,067	11,951	-3,116	-20.7%
average annual change	Mt CO ₂ /y ²			-104	-0.77%
Years to Zero Emissions from 2020	years			115	
Zero Emissions Year				2135	
Cumulative CO2 emissions 1990-2020	Mt CO ₂	0	423,509	423,509	
Population		1,175,432,261	1,336,591,755	161,159,494	13.7%
CO2 per capita	tCO ₂ /y,cap	12.8	8.9		-30.2%
average annual change	%/y				-1.19%

Table 12 - Group1990 and the world between 1990 and 2020

		Group1990	Rest of the world	World
Countries in this work		41	171	212
to world		19%	81%	
Population 1990		1,175,432,261	4,152,096,817	5,327,529,078
to world		22%	78%	
Population 2020		1,336,591,755	6,458,206,970	7,794,798,725
to world		17%	83%	
Population average annual change	%/y	0.43%	1.48%	1.28%
CO2 emissions in 1990	MtCO2/y	15,067	7,125	22,192
to world		68%	32%	
CO2 emissions in 2020	MtCO2/y	11,951	21,852	33,803
to world		35%	65%	
Change in CO2 emissions per year between 1990 and 2020	MtCO2/y	-3,116	+14,727	+11,611
Change in CO2 emissions per year	%/30 years	-21%	+207%	+52%
CO2 average annual change	%/y	-0.77%	+3.81%	+1.41%
Cumulative CO2 emissions 1990-2020	MtCO2	423,509	437,752	861,262
to world		49%	51%	
Global Warming caused by CO2 1990-2020	°C	+0.316	+0.326	+0.642
CO2 per capita 1990	tCO2/y,cap	12.82	1.72	4.17
to world		308%	41%	
CO2 per capita 2020	tCO2/y,cap	8.94	3.38	4.34
to world		206%	78%	
CpC change 1990-2020	%/30 years	-30.2%	+97.2%	+4.1%
CpC average annual change	%/y	-1.19%	+2.29%	+0.13%

Group1990 Years to Zero Emissions per Year

Group1990 decreased the CO2 emissions per year by 3,116 Mt CO2/y from 1990 to 2020, 104 Mt CO2/y² on average. If this 104 Mt CO2/y² annual CO2 mitigation will continue also in the future, Group1990 countries will reach the Zero Emissions target in 2135.

Table 13 - Group1990 years to Zero CO2 Emissions

CO2 emissions in 1990	MtCO2/y	15,067
CO2 emissions in 2020	MtCO2/y	11,951
Change 1990-2020	MtCO2/y	-3,116
average annual change	MtCO2/y ²	-104
Year to Zero Emissions from 2020	years	115
Zero Emissions Year	year	2135

Group2020 – OECD(2020) + Annex I (Paris)Table 14 - Group2022 countries [4] [5]

Countries 48	OECD(2022) 38	Annex I (Paris) 42	in Dataset 47
Australia	07/06/71	✓	✓
Austria	29/09/61	✓	✓
Belarus		✓	✓
Belgium	13/09/61	✓	✓
Bulgaria		✓	✓
Canada	10/04/61	✓	✓
Chile	07/05/10		✓
Colombia	28/04/20		✓
Costa Rica	25/05/21		✓
Croatia		✓	✓
Cyprus		✓	✓
Czechia	21/12/95	✓	✓
Denmark	30/05/61	✓	✓
Estonia	09/12/10	✓	✓
Finland	28/01/69	✓	✓
France	07/08/61	✓	✓
Germany	27/09/61	✓	✓
Greece	27/09/61	✓	✓
Hungary	07/05/96	✓	✓
Iceland	05/06/61	✓	✓
Ireland	17/08/61	✓	✓
Israel	07/09/10		✓
Italy	29/03/62	✓	✓
Japan	28/04/64	✓	✓
Korea	12/12/96		✓
Latvia	01/07/16	✓	✓
Liechtenstein		✓	✓
Lithuania	05/07/18	✓	✓
Luxembourg	07/12/61	✓	✓
Malta		✓	✓
Mexico	18/05/94		✓
Monaco		✓	
Netherlands	13/11/61	✓	✓
New Zealand	29/05/73	✓	✓
Norway	04/07/61	✓	✓
Poland	22/11/96	✓	✓
Portugal	04/08/61	✓	✓
Romania		✓	✓
Russia		✓	✓
Slovakia	14/12/00	✓	✓
Slovenia	21/07/10	✓	✓
Spain	03/08/61	✓	✓
Sweden	28/09/61	✓	✓
Switzerland	28/09/61	✓	✓
Turkey	02/08/61	✓	✓
UK	02/05/61	✓	✓
Ukraine		✓	✓
USA	12/04/61	✓	✓

Table 15 - Group2020 [OECD(2020) and Annex I (Paris)]

		1990	2020	Change	% to 1990
CO2 emissions per year	MtCO ₂ /y	15,763	13,140	-2,623	-16.6%
CO2 emissions average annual change	MtCO ₂ /y ²			-87	-0.60%
Year to Zero Emissions from 2020	years			150	
Zero Emissions Year				2170	
Cumulative CO2 emissions 1990-2020	MtCO ₂ /30y	0	457,416	457,416	
Population		1,356,238,782	1,600,542,439	244,303,657	18.0%
Population average annual change					0.55%
CO2 per capita (CpC)	tCO ₂ /y,cap	11.6	8.2		-29.4%
CpC average annual change	%/y				-1.15%

Highest Change in CO2 Emissions between 1990 and 2020

There are 80 countries above the world average of CO2 emissions per capita (2020). Among them 10 countries were selected with the highest cumulative CO2 emissions between 1990 and 2020, "Group+10P".

Table 16 - Group+10P, 10 countries above the world average of CO2 emissions per capita (2020) with the highest change in cumulative CO2 emissions between 1990 and 2020 [Mt CO2]

Country	CCO2 1990-2020 MtCO ₂ /30y	Global Warming 1990-2020 °C
China	192,560	+0.144
USA	167,527	+0.125
Russia	48,961	+0.036
Japan	36,811	+0.027
Germany	25,844	+0.019
Canada	16,411	+0.012
UK	15,458	+0.012
South Korea	15,216	+0.011
Iran	14,206	+0.011
Italy	12,866	+0.010
Group+10	545,860	+0.407
to World	63%	

Table 17 - Group+10P CO2 emissions per capita [tCO2/y,cap]

Country	MtCO2/y 1990	MtCO2/y 2020	Population 1990	Population 2020	CpC 1990	CpC 2020
China	2,485	10,668	1,176,883,681	1,439,323,774	2.11	7.41
USA	5,113	4,713	252,120,309	331,002,647	20.28	14.24
Russia	2,526	1,577	147,531,562	145,934,460	17.12	10.81
Japan	1,158	1,031	124,505,243	126,476,458	9.30	8.15
Germany	1,052	644	79,053,984	83,783,945	13.31	7.69
Canada	458	536	27,541,323	37,742,157	16.63	14.20
UK	600	330	57,134,377	67,886,004	10.51	4.85
South Korea	250	598	42,918,416	51,269,183	5.84	11.66
Iran	210	745	56,366,212	83,992,953	3.72	8.87
Italy	440	304	57,048,237	60,461,828	7.70	5.02
Group+10P	14,293	21,145	2,021,103,344	2,427,873,409	7.07	8.71

Table 18 - Group+10P and the world between 1990 and 2020

		Group+10P	Rest of the world	World
Countries		10	202	212
to world		5%	95%	
Population 1990		2,021,103,344	3,306,425,734	5,327,529,078
to world		38%	62%	
Population 2020		2,427,873,409	5,366,925,316	7,794,798,725
to world		31%	69%	
change per year		13,559,002	68,683,319	82,242,322
average annual change	%/y	0.61%	1.63%	1.28%
CO2 emissions in 1990	MtCO2/y	14,293	7,899	22,192
to world		64%	36%	
CO2 emissions in 2020	MtCO2/y	21,145	12,658	33,803
to world		63%	37%	
change 1990-2020	MtCO2/y	+6,852	+4,759	+11,611
change 1990-2020	%/30 years	+48%	+60%	+52%
average annual change	%/y	+1.31%	+1.58%	+1.41%
Cumulative CO2 emissions 1990-2020	MtCO2	545,860	315,402	861,262
to world		63%	37%	
Global Warming caused by the group 1990-2020	°C	+0.407	+0.235	+0.642
to world		63%	37%	
CO2 per capita 1990	tCO2/y,cap	7.07	2.39	4.17
to world		170%		
CO2 per capita 2020	tCO2/y,cap	8.71	2.36	4.34
to world		201%	54%	
change 1990-2020	%/30 years	+23.2%	-1.3%	+4.1%
average annual change	%/y	+0.70%	-0.04%	+0.13%

Table 19 - CO2 emissions above Group+10P average CpC in 2020 [MtCO2/y]

Country	Population 2020	CO2/y 2020	Group Ave CpC	Above Group Ave CpC	Above
5		MtCO2/y	MtCO2/y	MtCO2/y	%
USA	331,002,647	4,713	2,883	1,830	39%
Russia	145,934,460	1,577	1,271	306	19%
Canada	37,742,157	536	329	207	39%
South Korea	51,269,183	598	447	151	25%
Iran	83,992,953	745	732	14	2%
Group+10P	649,941,400	8,168	5,660	2,508	31%

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