The development of global greenhouse gas emissions 2021 in the light of climate policies targets

Hans-Joachim Ziesing

"Energy Transformation and Climate Change Challenges?"

25th REFORM Group Meeting
October 03-07, 2022 – Salzburg Schloss Leopoldskron

Instead of a preface - State of the Climate in 2021

- In 2021, the dominant greenhouse gases released into Earth's atmosphere continued to increase. The annual global average carbon dioxide (CO_2) concentration was 414.7 ± 0.1 ppm, an increase of 2.6 ± 0.1 ppm over 2020, the fifth-highest growth rate since the start of the instrumental record in 1958.
- This brings the concentration of CO_2 to, once again, the highest in the modern record and ice core records dating back 800,000 years.
- The growth rate for methane (CH_4) was the highest on record and the third highest for nitrous oxide (N_2O), contributing to new record high atmospheric concentration levels for both gases.

Source: American Meteorological Society. State of the Climate in 2021. Vol. 103, No. 8, August 2022

Agenda

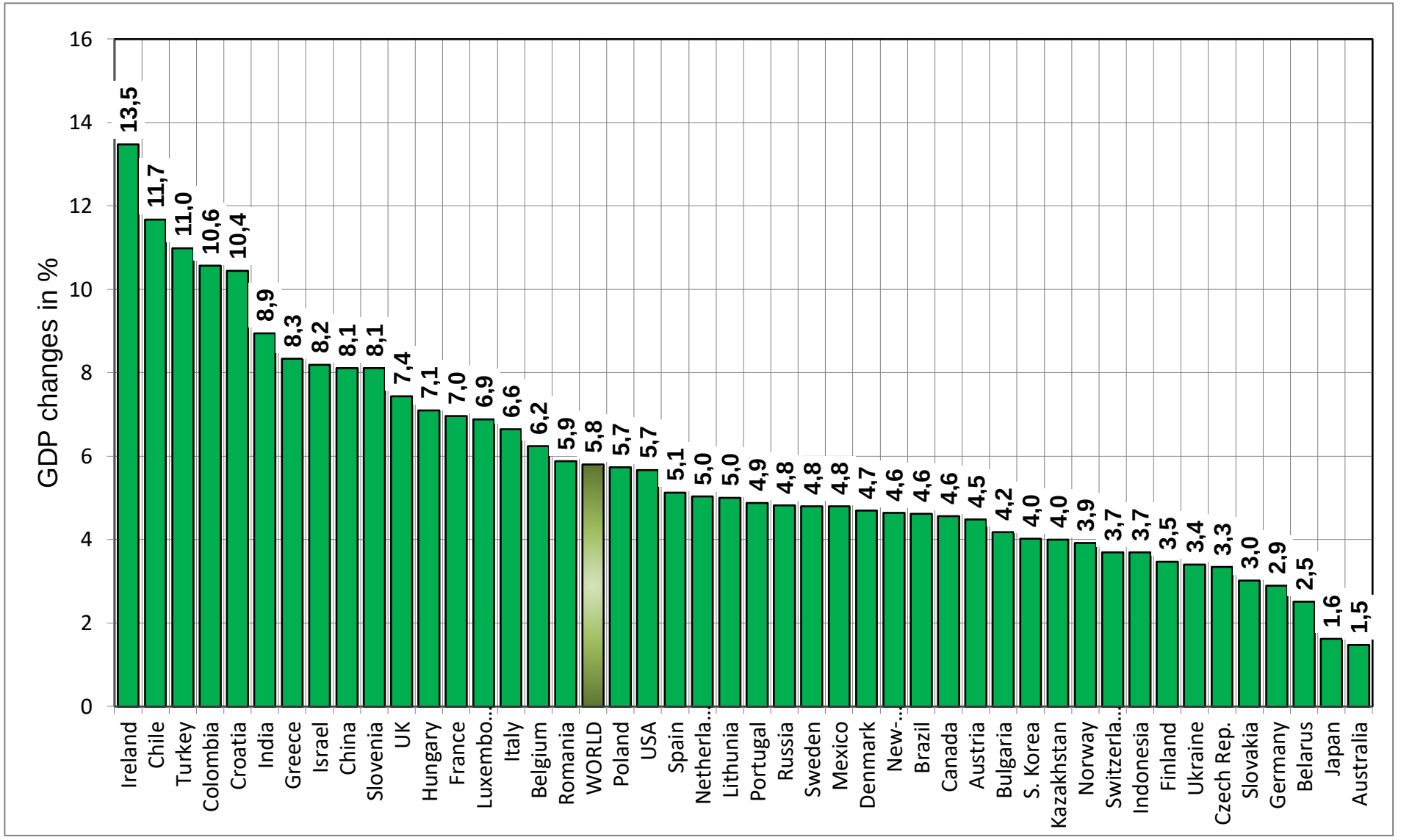
- Current development of global greenhouse gas emissions
  - Data sources and emissions development 1990 to 2021 by country and region
  - Drivers of emissions development
  - Development of energy consumption and energy productivity
- IEA-Scenarios of emissions development until 2050
- Some conclusions

Main data sources for estimating GHG emissions for 2021

- **UNFCCC: National Communications from Parties included in Annex I to the Convention; National Greenhouse Gas Inventory Data from Annex I Parties for 1990 to 2020 (Greenhouse gas emissions/CO_2-emissions)**
- **International Energy Agency (IEA): CO_2 Emissions from Fuel Combustion, 2020 Highlights, Annual historical series (1971-2019)**
- **BP Statistical Review of World Energy 2021, June 2022**
- **The World Bank, World Development Indicators, Database July 2022**
- **Eurostat Database**

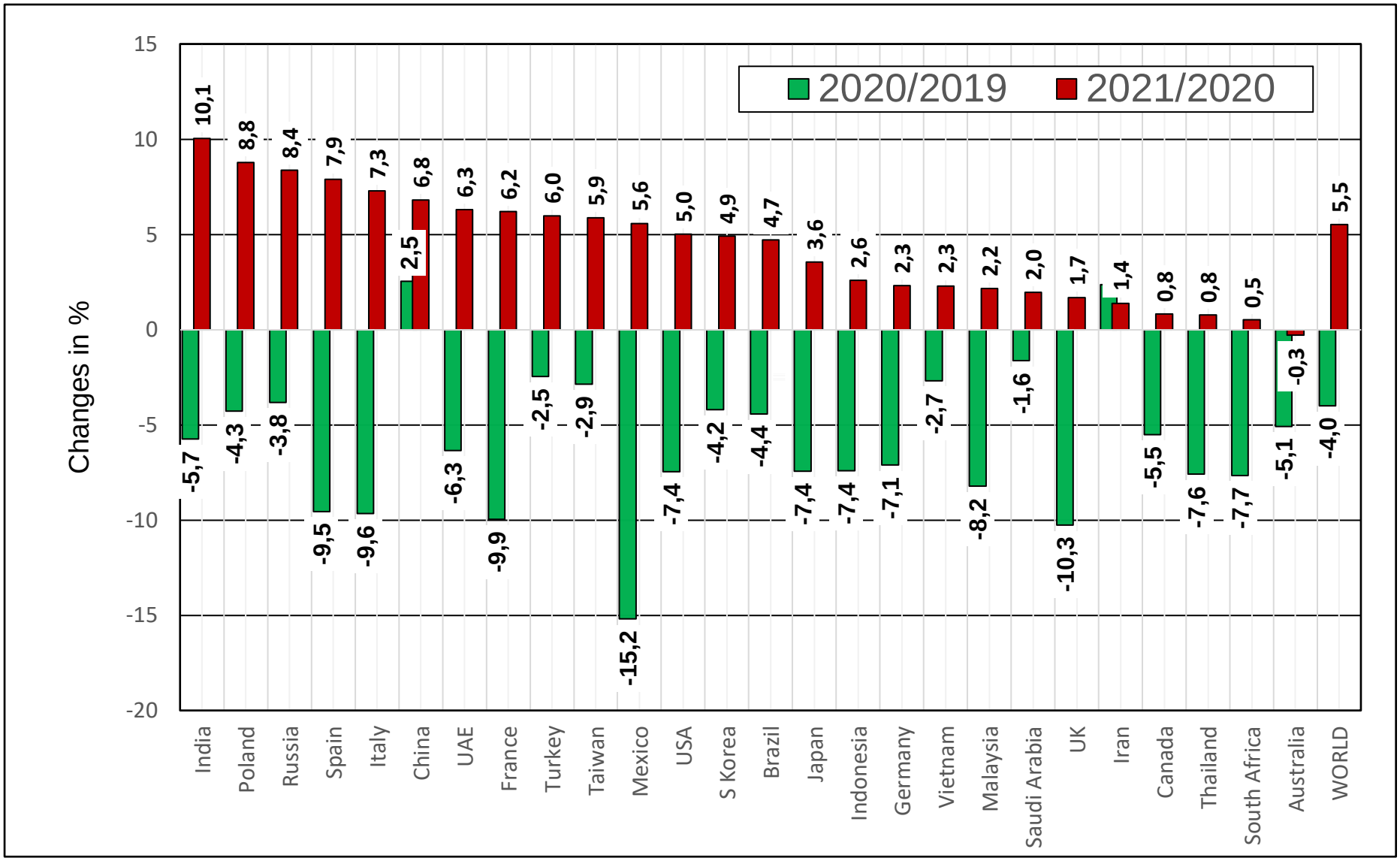
CO_2 emissions up to 2021 in Non-Annex I countries are extrapolated from the 2021 data on energy consumption published in the BP Statistics, June 2022, which are shown by country and energy source.

Changes of real GDP 2021 versus 2020 in selected countries



sources: World Bank; World Development Indicators (July 2022). NOTE: GDP in US-$ in 2015 prices

Changes of primary energy 2021 vs 2020 and 2020 vs 2019 in countries with ≥ 4 Exajoule (around 100 Gtoe)



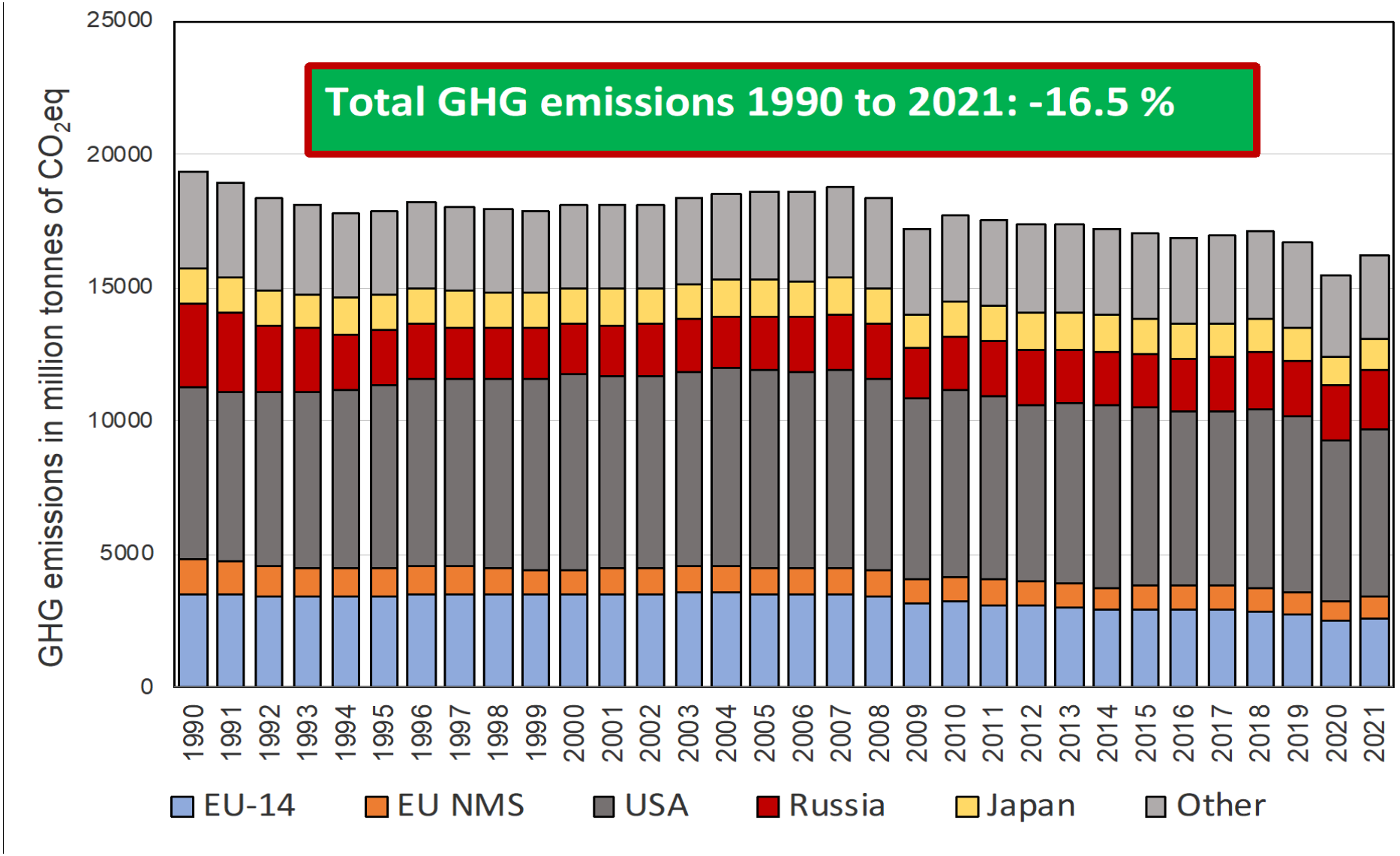
sources: BP Statistical Review of World Energy, June 2022

Greenhouse gas emissions in Annex I parties 1990 – 2021

	1990	2000	2010	2019	2020	2021	2020/19	2021/20	2021/1990
	GHG emissions in Gt CO_2eq						changes in %		
EU 14	3485	3478	3220	2717	2463	2581	-9.4	4.8	-25.9
EU NMS	1333	937	932	865	811	859	-6.2	5.9	-35.5
EU 27	4818	4414	4152	3582	3275	3440	-8.6	5.1	-28.6
UK	797	714	609	448	406	426	-9.5	5.0	-46.6
Japan	1270	1375	1301	1210	1148	1174	-5.1	2.3	-7.5
Australia	426	490	537	546	528	517	-3.4	-2.0	21.5
USA	6453	7328	7007	6572	5981	6276	-9.0	4.9	-2.8
Canada	595	727	710	738	672	679	-8.9	1.0	14.1
Turkey	220	299	399	508	524	560	3.1	7.0	155.1
Russia	3163	1892	2012	2123	2051	2198	-3.4	7.2	-30.5
Ukraine	942	428	407	334	318	314	-4.8	-1.3	-66.7
Belarus	146	83	93	94	90	91	-4.3	1.5	-37.8
New Zealand	3163	1892	2012	2123	2051	2198	-3.4	7.2	-30.5
Total Annex I	**19389**	**18153**	**17722**	**16698**	**15511**	**16195**	-7.1	4.4	-16.5

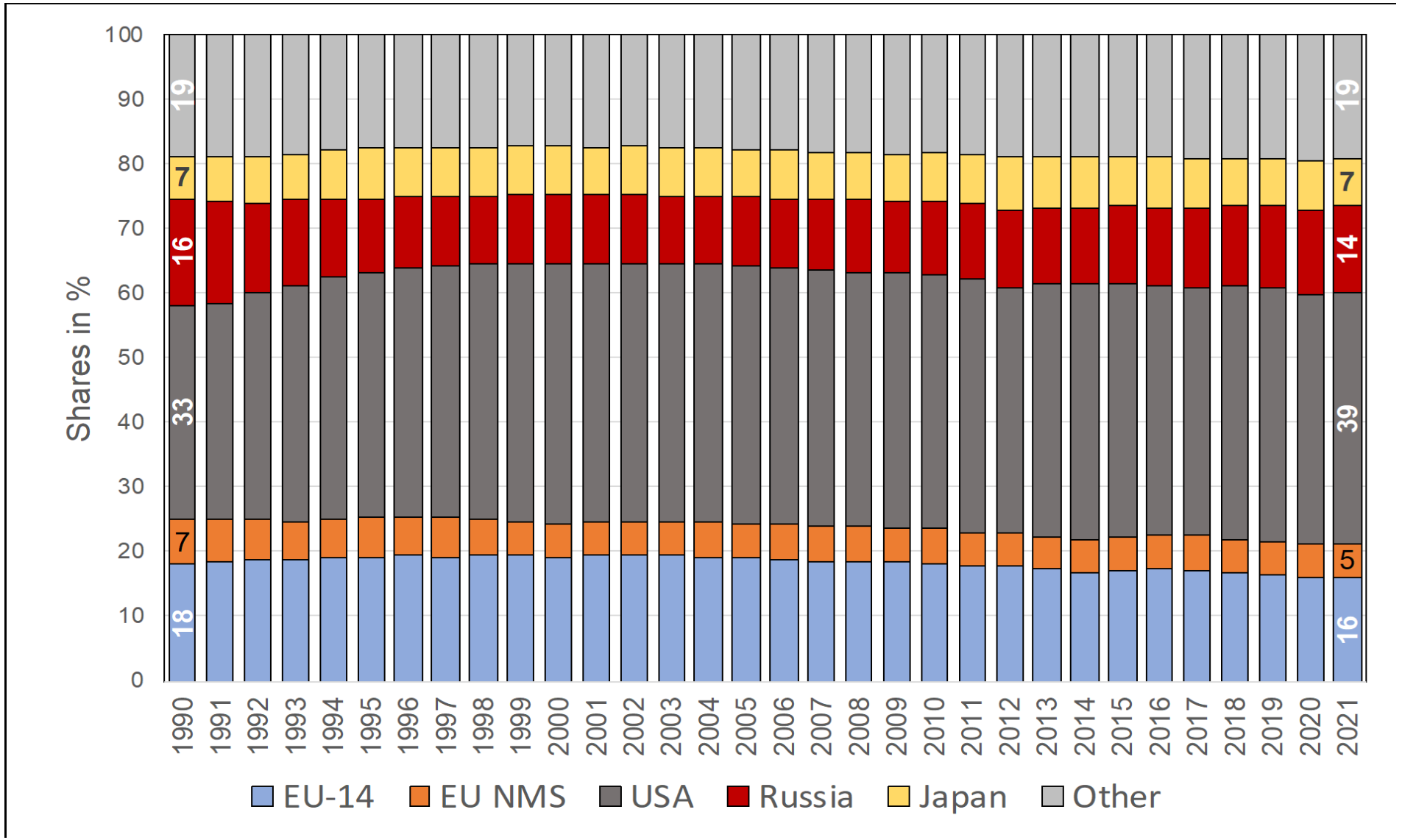
sources: UNFCCC; World Bank; IEA; BP; author‘s calculation.

Greenhouse gas emissions in Annex I parties 1990 – 2021

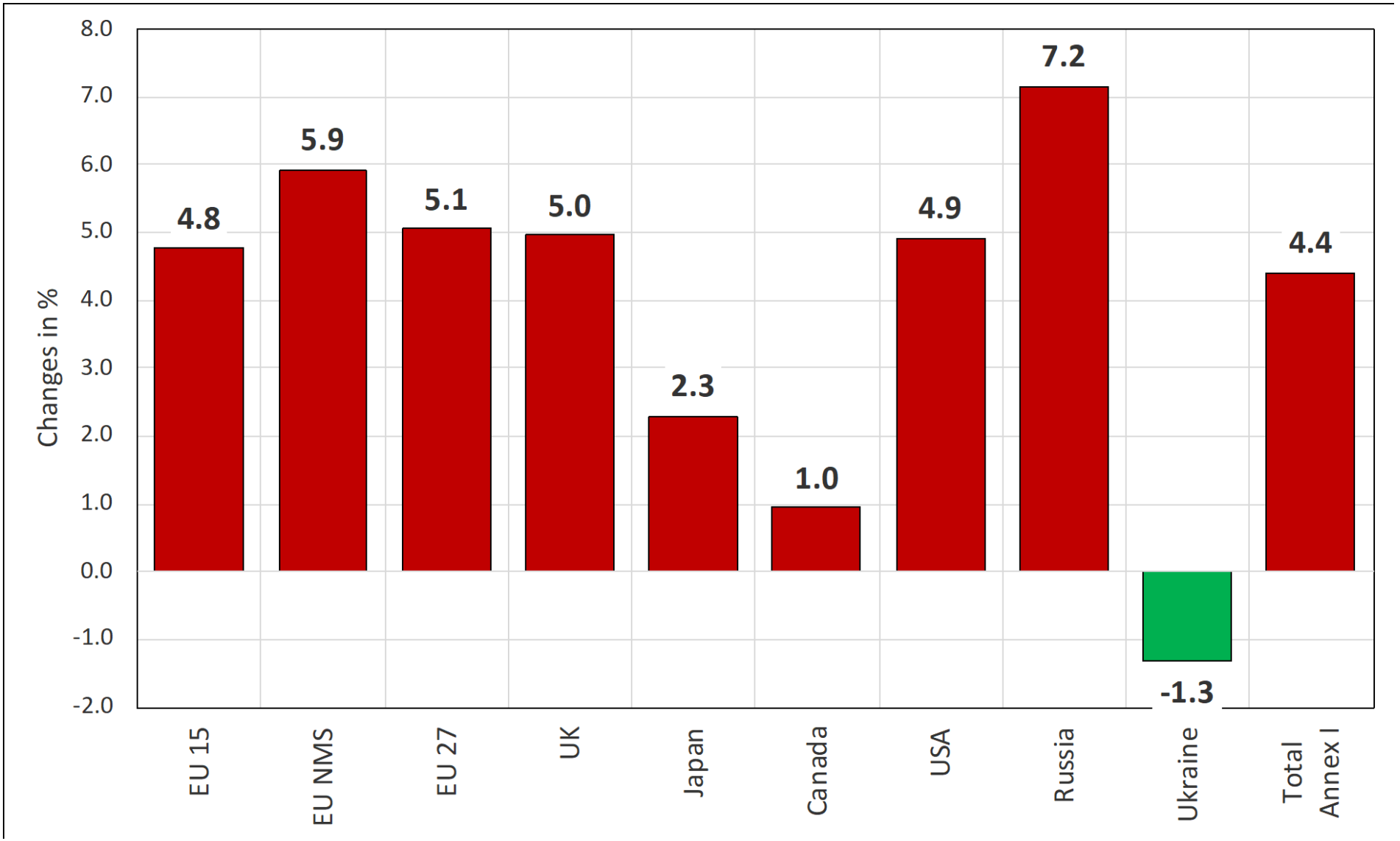


sources: UNFCCC; World Bank; OECD; IEA; BP; author‘s calculation.

Regional shares of GHG emissions in Annex I parties 1990 – 2021

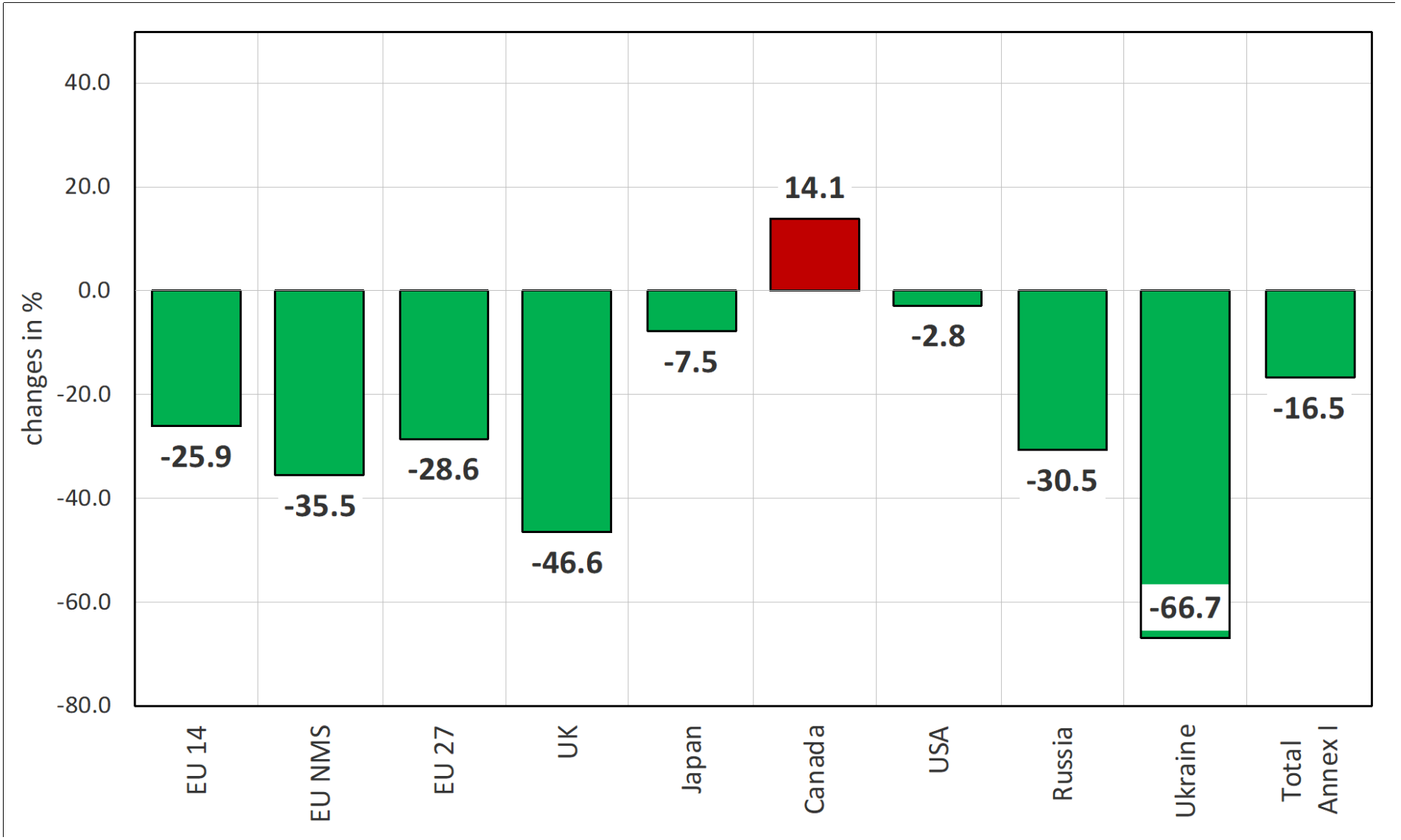


GHG emissions in Annex I parties: 2020 - 2021



sources: UNFCCC; IEA; BP; author‘s calculation.

GHG emissions in Annex I parties: 1990 - 2021



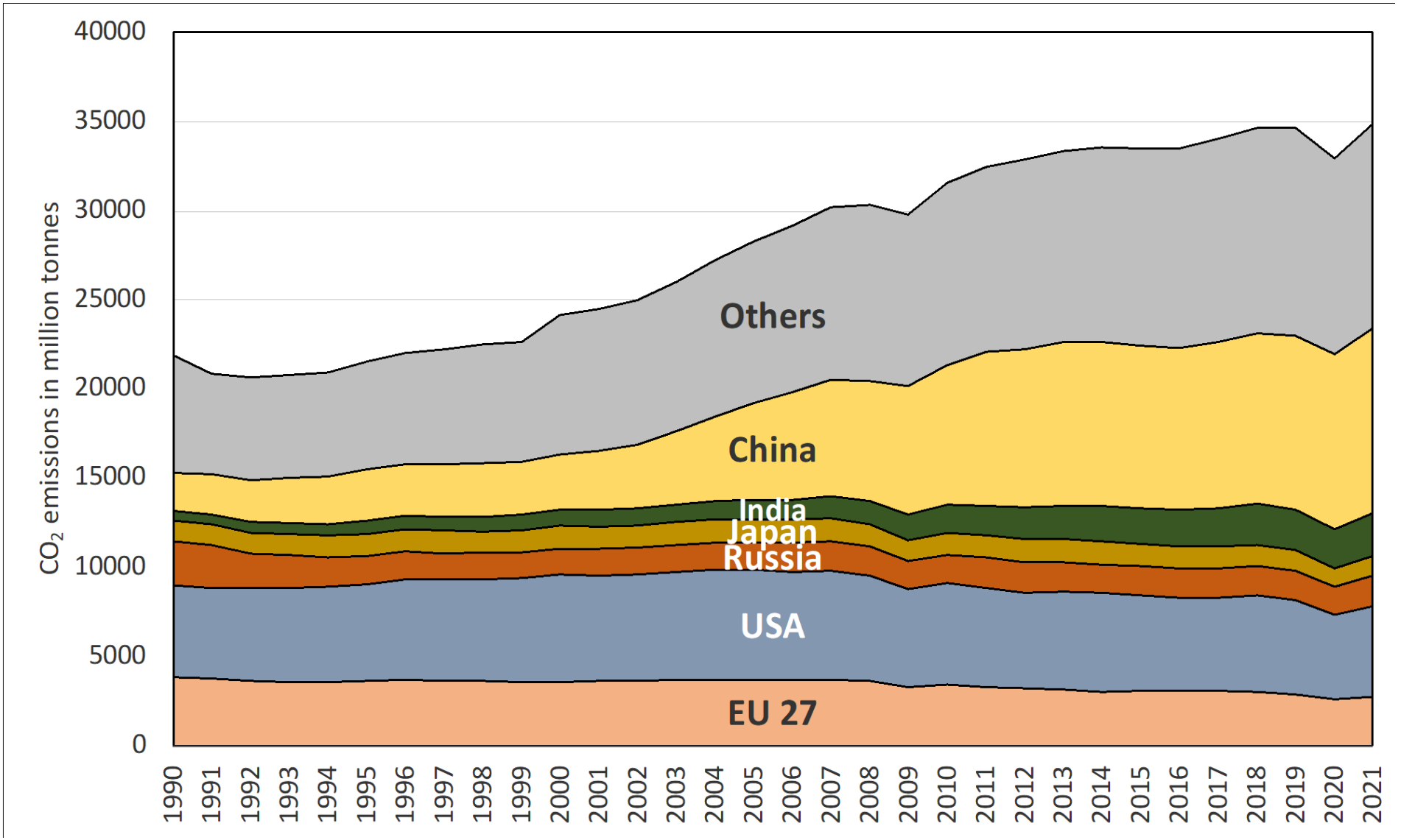
sources: UNFCCC; IEA; BP; author‘s calculation.

World-wide CO_2 emissions 1990 – 2021 by regions

Region	1990	2000	2010	2019	2020	2021	2021/2020	2021/1990
	million tonnes of CO_2						changes in %	
WORLD	21,894	24,168	31,584	34,699	32,927	34,877	5.9	59.3
Annex I	15,073	14,521	14,220	13,128	12,044	12,734	5.7	-15.5
Non-Annex I	6,821	9,647	17,364	21,571	20,882	22,143	6.0	224.6
including China	2,122	3,140	7,873	9,754	9,831	10,365	5.4	388.4
EIT	4,355	2,521	2,690	2,621	2,488	2,672	7.4	-38.6
OECD	12,069	13,514	13,288	12,308	11,163	11,744	5.2	-2.7
EU 27	3,845	3,583	3,421	2,898	2,608	2,784	6.7	-27.6
EU 14	2,810	2,853	2,683	2,227	1,984	2,110	6.3	-24.9
EU NMS	1,035	730	737	671	624	674	8.0	-34.9

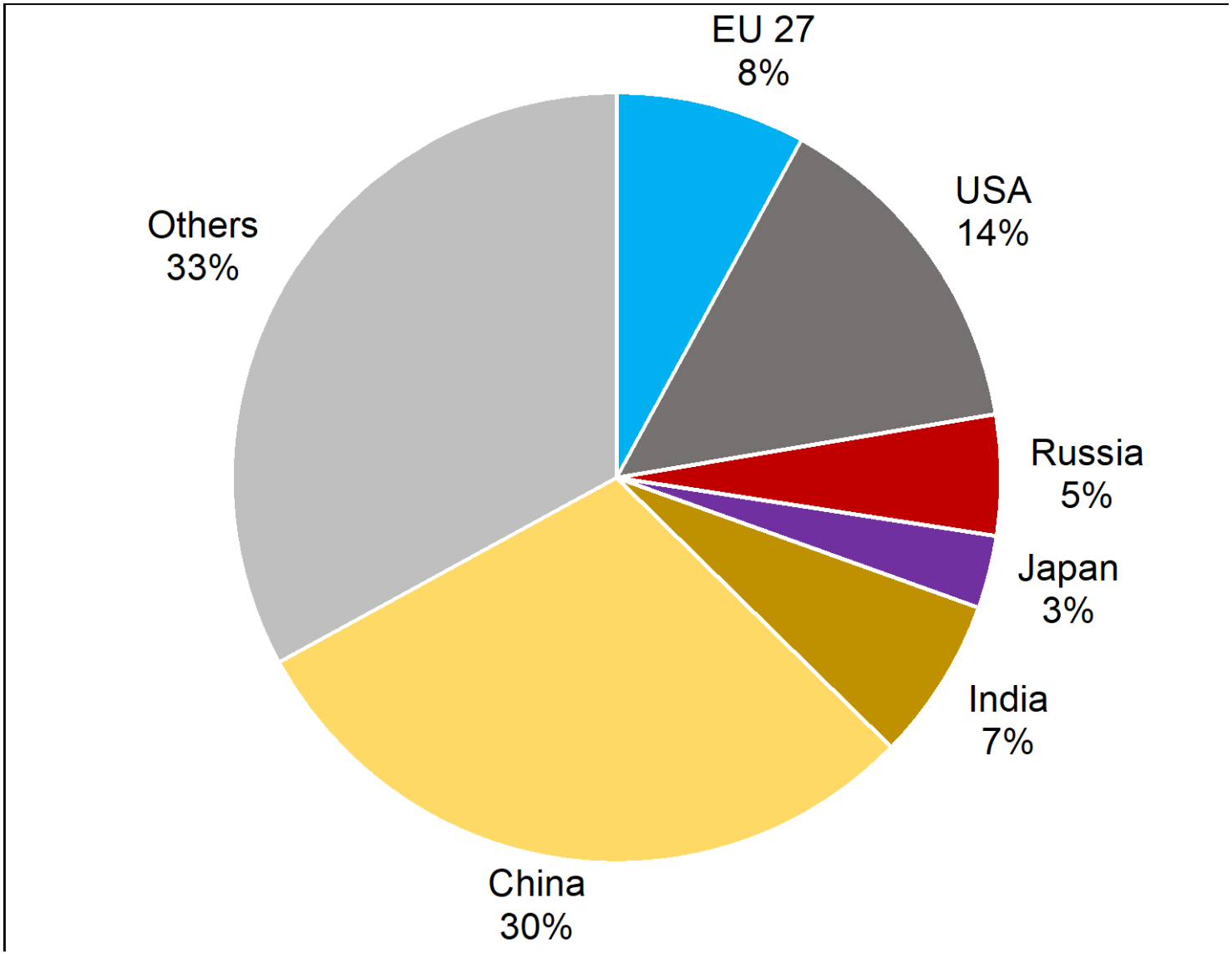
sources: UNFCCC; IEA; BP; author‘s calculation.

World-wide CO_2 emissions by countries 1990 - 2021



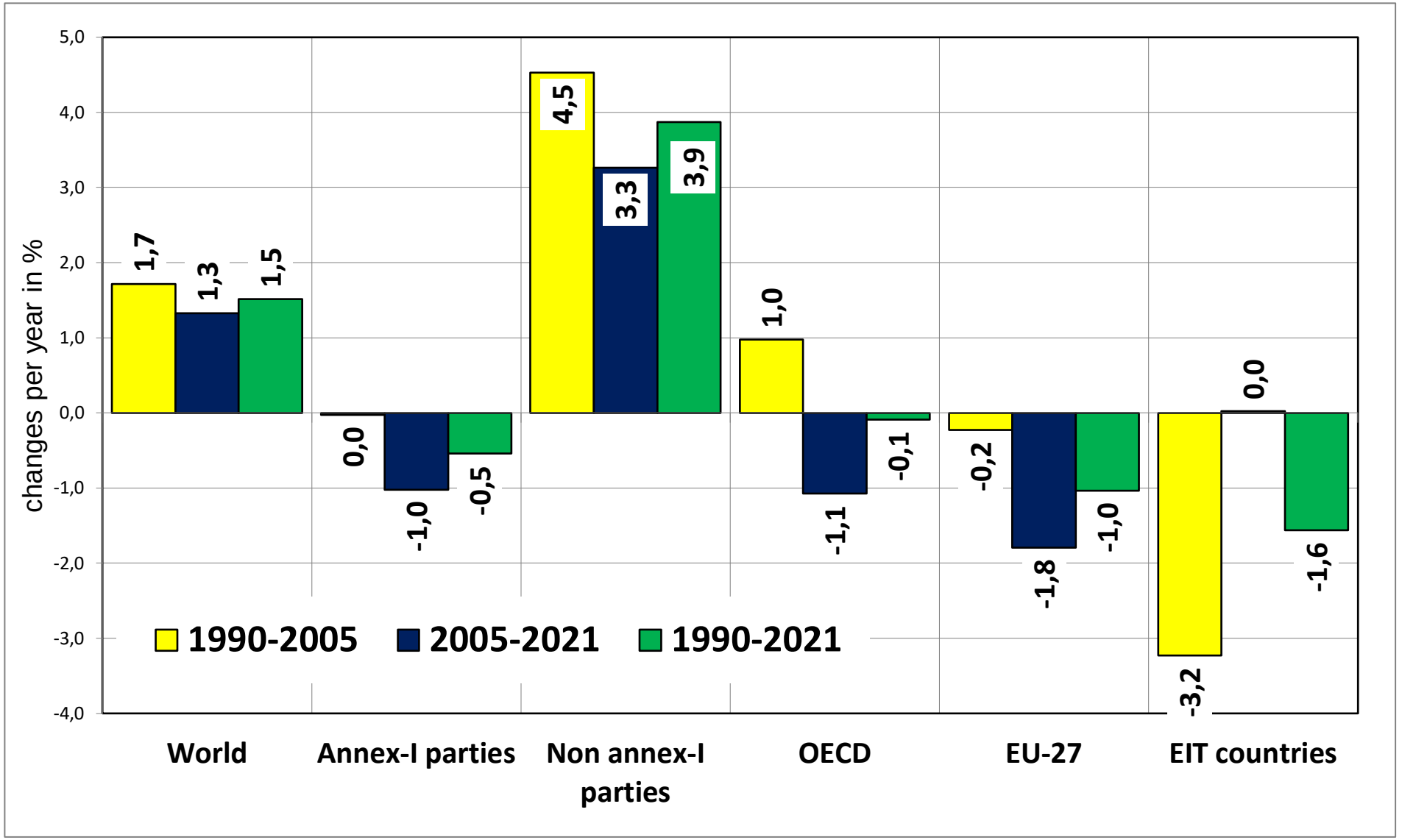
sources: UNFCCC; IEA; BP; author‘s calculation.

Share of countries and country groups in global CO_2 emissions 2021



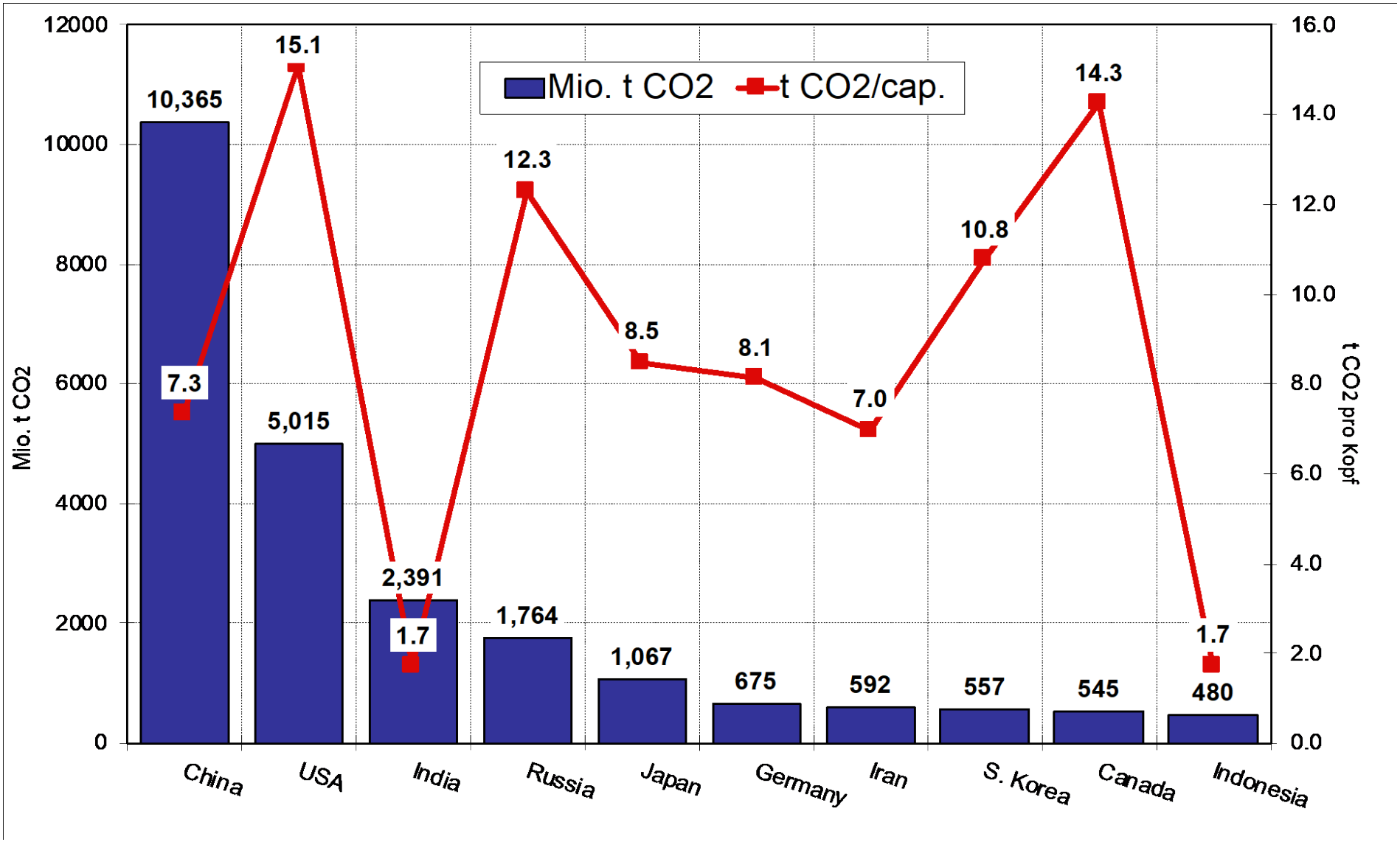
sources: UNFCCC; OECD; IEA, BP; author‘s calculations

World-wide CO_2 emissions by regions 1990 - 2021



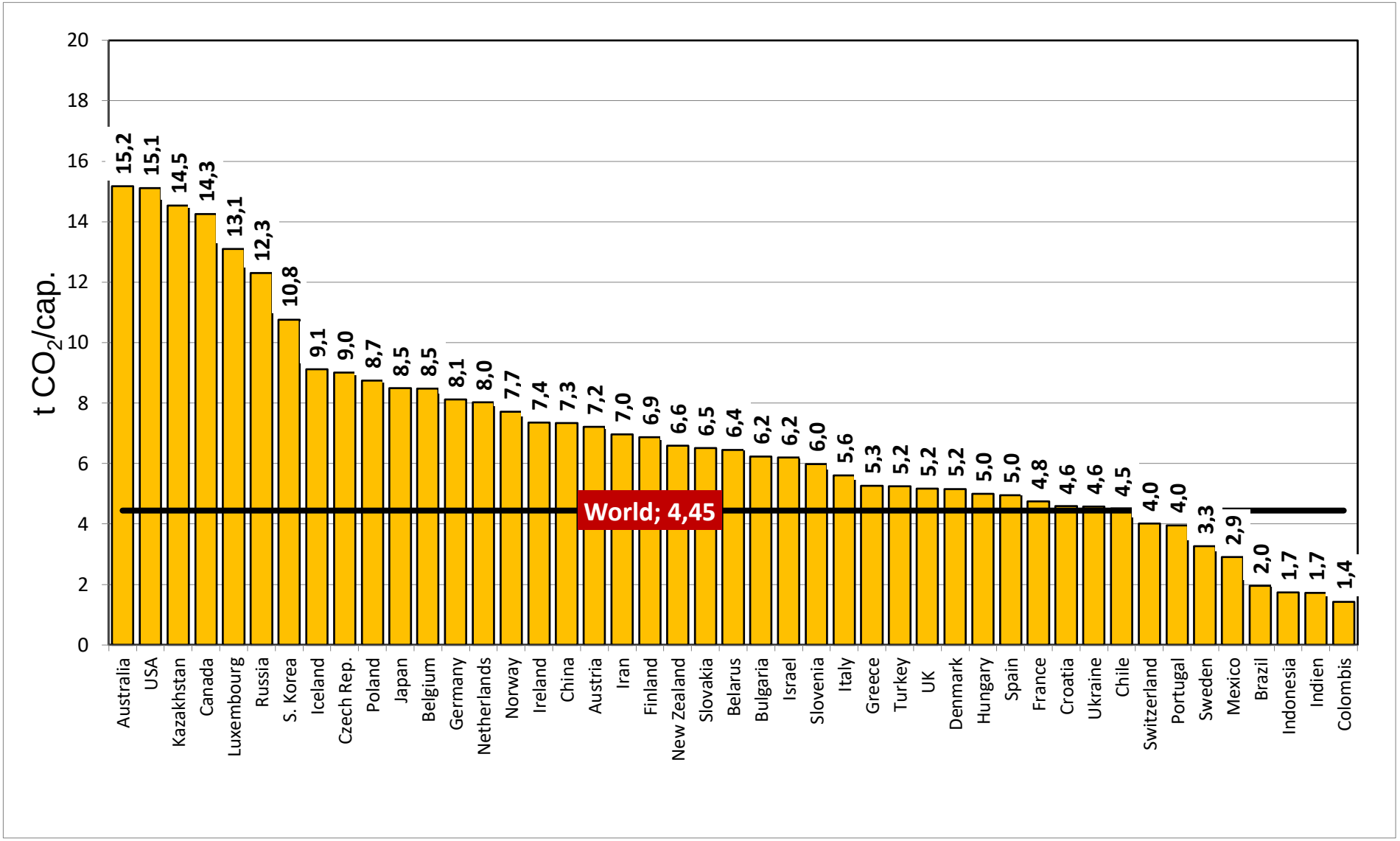
sources: UNFCCC; IEA; BP; author‘s calculation.

The ten major CO_2 emitters world-wide 2021



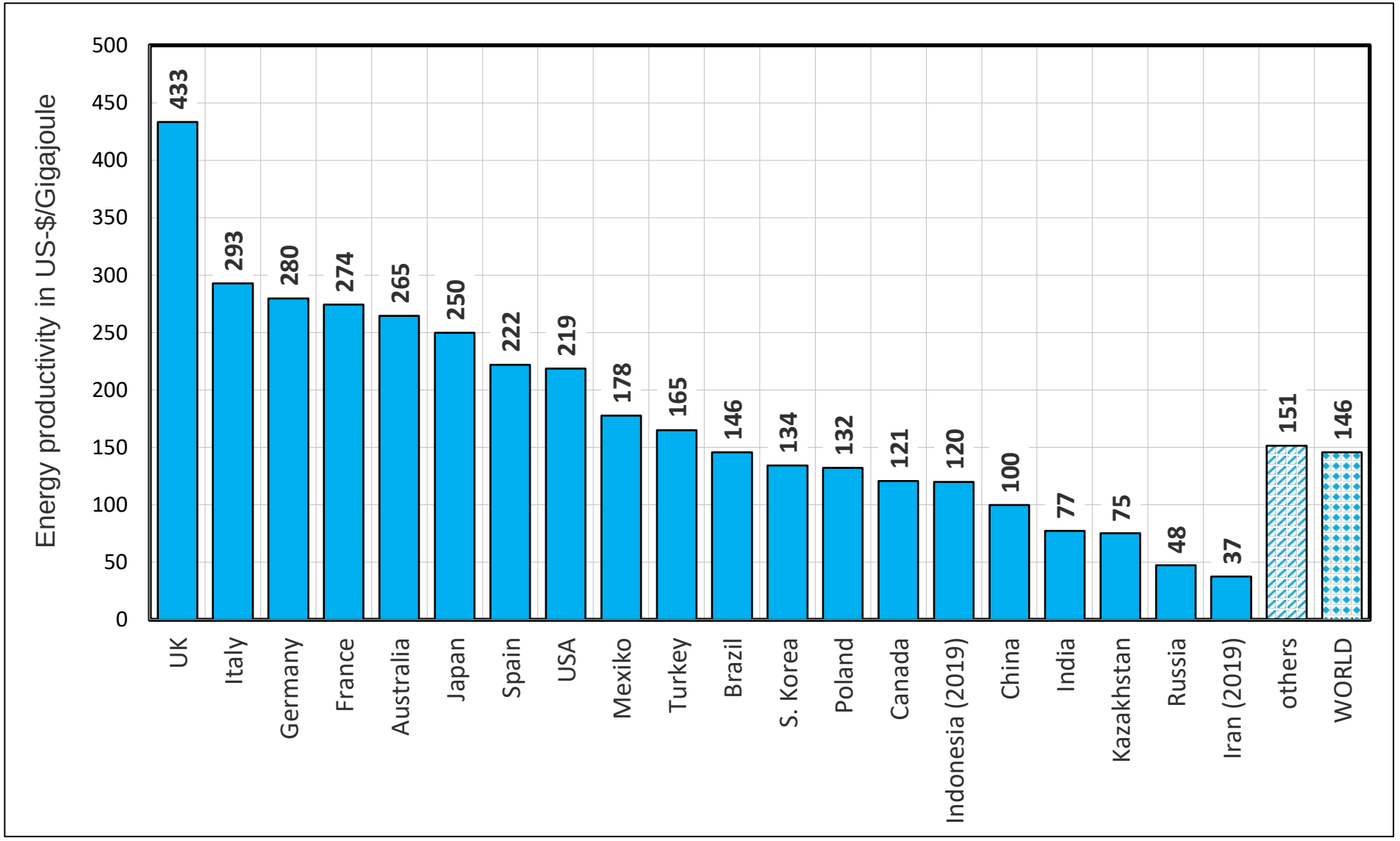
sources: UNFCCC; World Bank; OECD; IEA; Eurostat; author‘s calculation.

Per capita CO_2 emissions in selected countries 2021



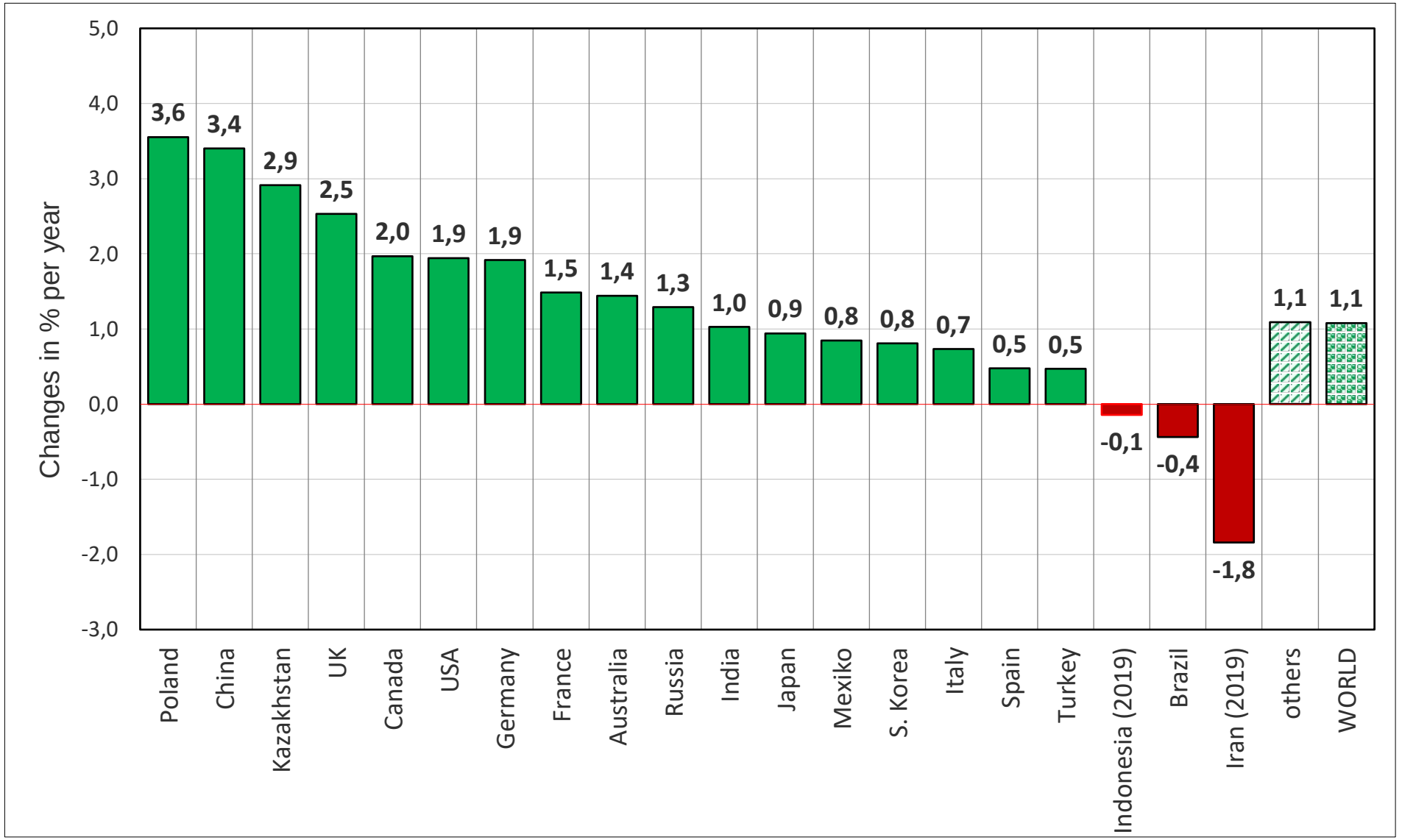
sources: UNFCCC; World Bank; IEA; Eurostat; BP; author‘s calculation.

Energy productivity in the 20 largest emitting countries 2021



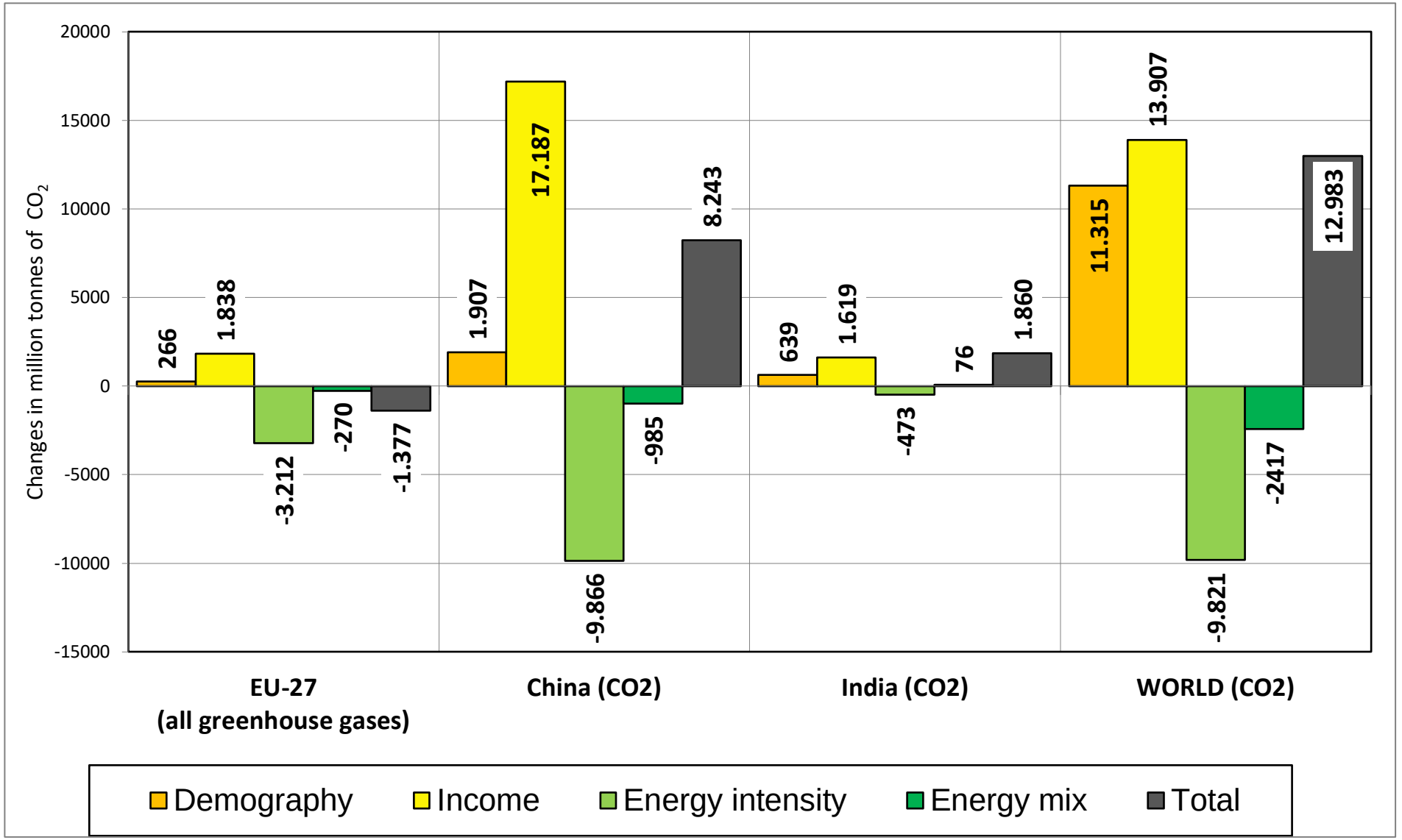
sources: World Bank; IEA; BP; author‘s calculations.

Changes of energy productivity in the 20 largest emitting countries 1990 – 2021



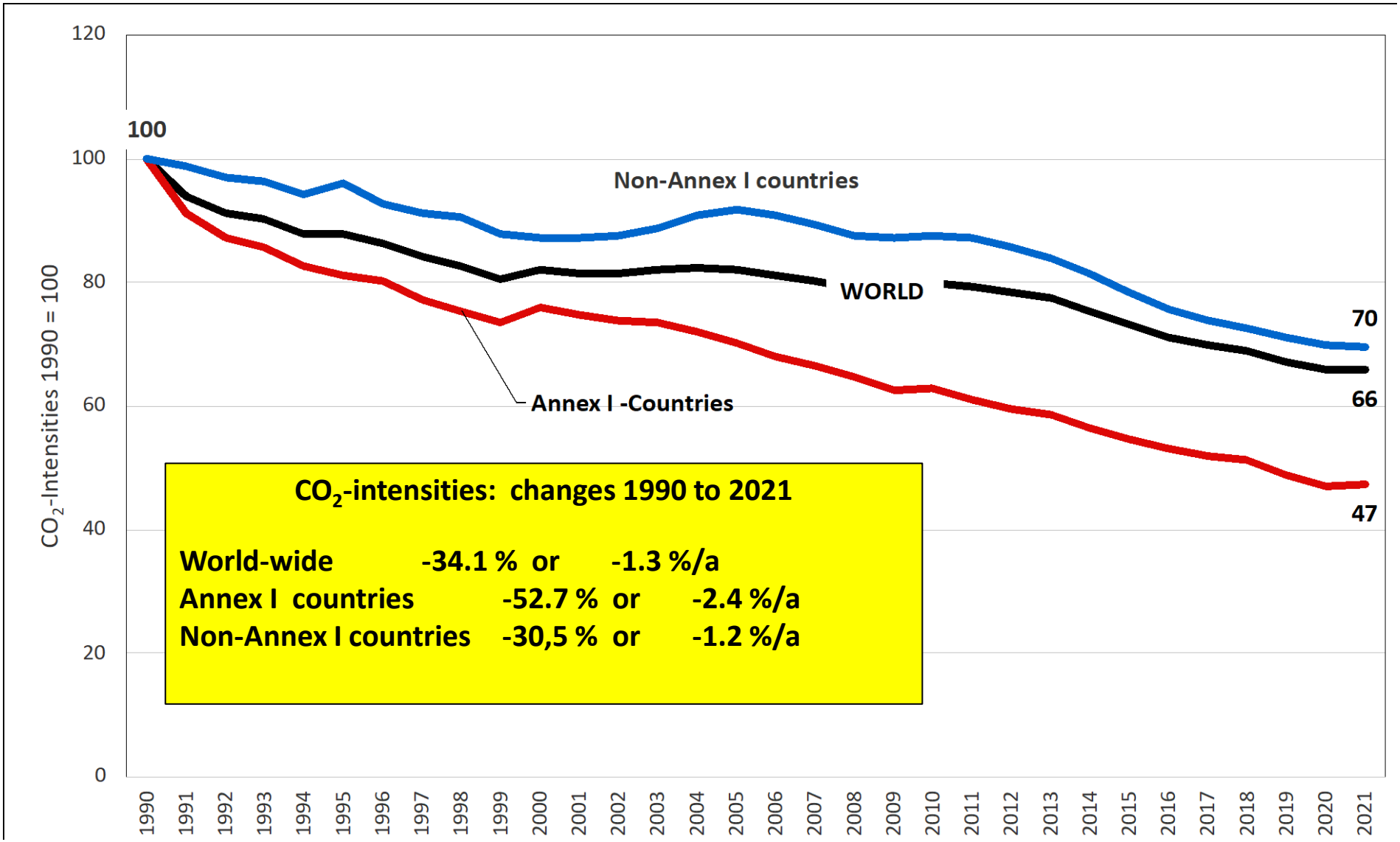
sources: World Bank; BP; author‘s calculation.

Components influencing GHG emissions 2021 vs. 1990



sources: UNFCCC; IEA; World Bank; author‘s calculaton.

GHG/CO_2 intensity in Annex I countries/world-wide CO_2 intensity 1990 - 2021



sources: UNFCCC; IEA; World Bank; BP; author‘s calculation.

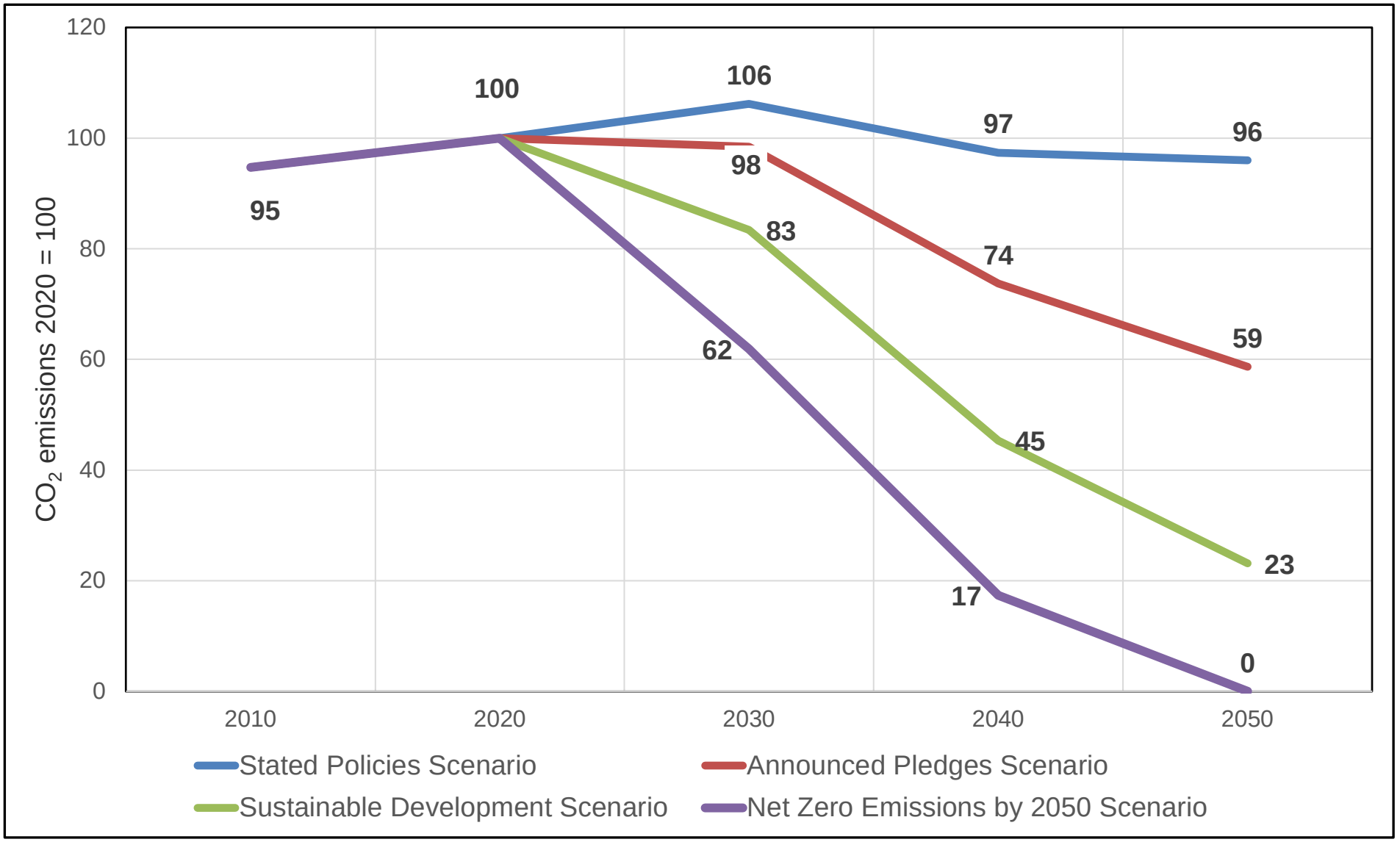
IEA: World Energy Outlook 2021 – Emissions Scenarios up to 2050

In a momentous period for the future of energy and emissions, this *World Energy Outlook* uses several long-term scenarios to illustrate the choices that face the world's decision makers. The main scenarios are:

- **Net Zero Emissions by 2050 Scenario (NZE),** which sets out a narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050.
- **Announced Pledges Scenario (APS)**, which assumes that all climate commitments made by governments around the world, including NDCs and longer term net zero targets, will be met in full and on time.
- **Stated Policies Scenario (STEPS)**, which reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, as well as those that have been announced by governments around the world.
- **Sustainable Development Scenario (SDS)**, which, like the NZE, achieves key energy-related United Nations Sustainable Development Goals related to universal energy access and major improvements in air quality, and reaches global net zero emissions by 2070.

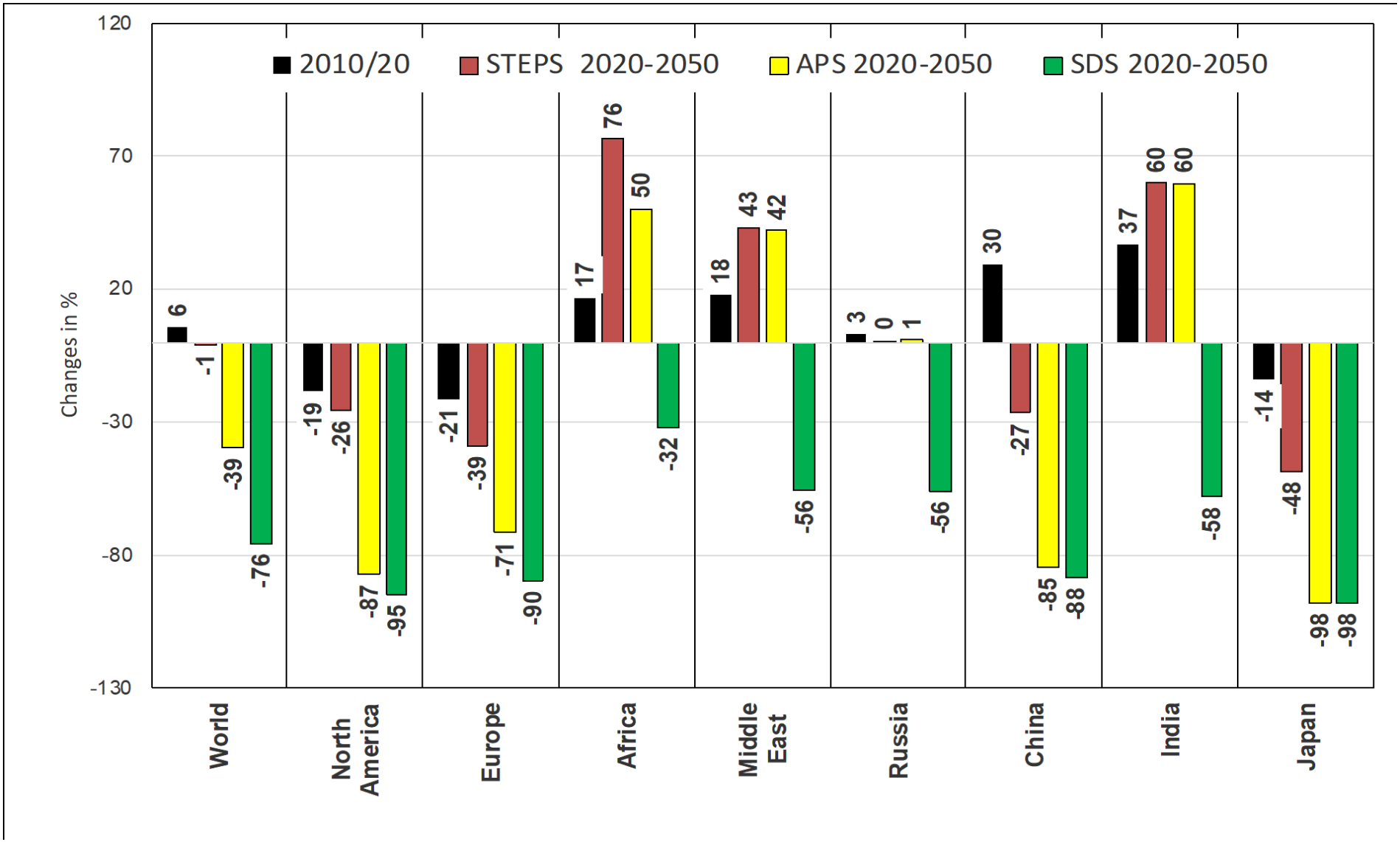
source: IEA, World Energy Outlook 2021.

Global CO_2 emissions 2020 – 2050 by type of scenario



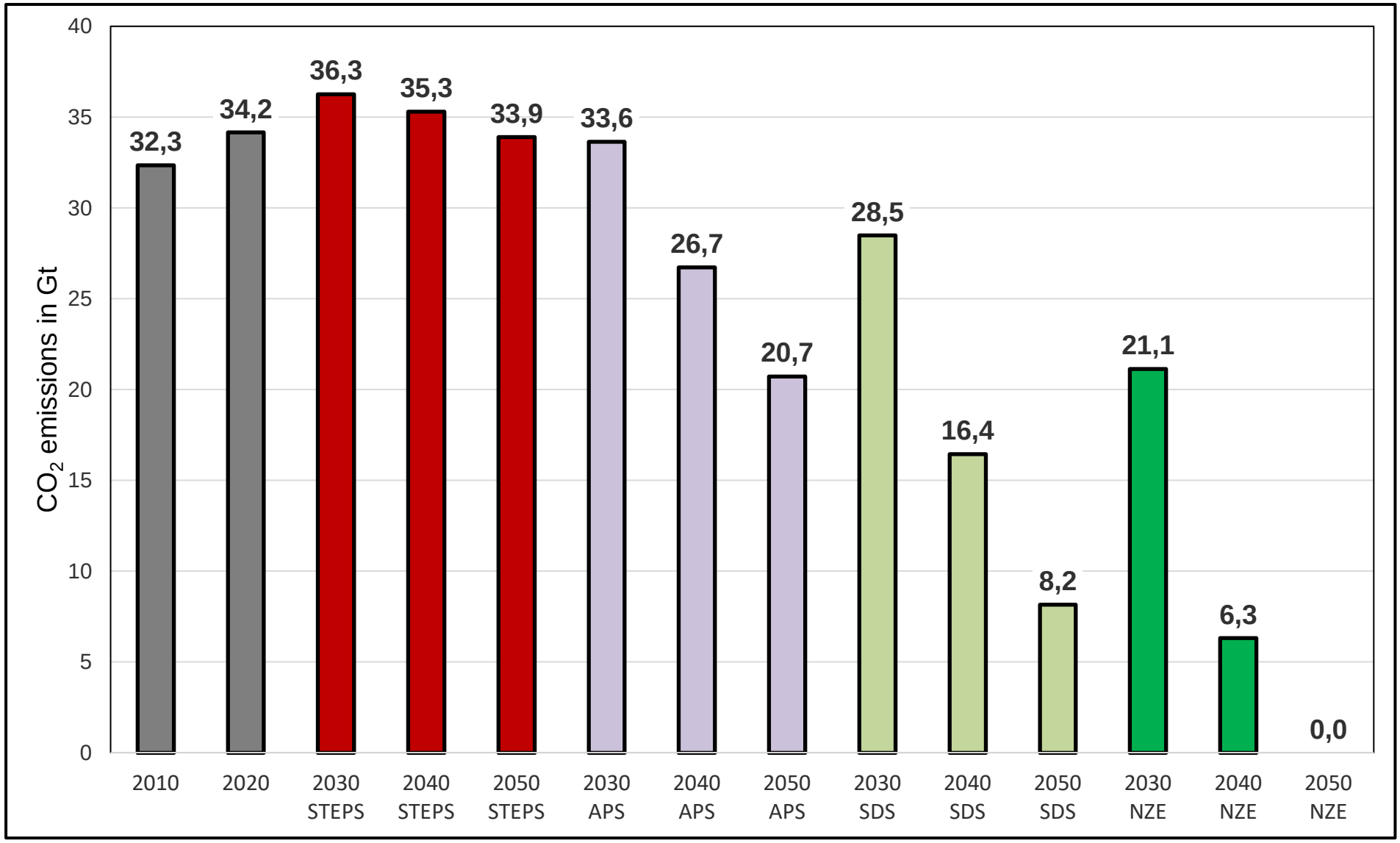
source: Internationale Energy Agency, World Energy Outlook 2021

Changes of total CO_2 emissions worldwide and by region 2010 to 2020 and scenarios 2020 to 2050



sources: IEA, World Energy Outlook 2021. Note: STEPS = Stated Policies; APS = Announced Pledges; SDS = Sustainable Development.

World-wide CO_2-Emissions 2010 – 2020 and scenarios 2030, 2040 and 2050



source: IEA, World Energy Outlook 2021.

Net Zero Emissions by 2050 Scenario

	2020	2030	2040	2050	2050/2020
	in million tones of CO_2				in %
Total CO_2	33903	21147	6316	0	-100
Combustion activities	31582	19254	6030	940	-97
Coal	14110	5915	1299	195	-99
Oil	10264	7426	3329	928	-91
NaturalGas	7138	5960	1929	566	-92
Bioenergy and waste	71	-48	-528	-748	-1154
Industry removals	1	214	914	1186	---
Biofuels production	1	142	385	553	---
Direct air capture	0	71	528	633	---
Electricity and heat sector	13504	5816	-81	-369	-103
Coal	9786	2950	102	69	-99
Oil	628	273	6	6	-99
NaturalGas	3089	2781	268	128	-96
Bioenergy and waste	0	-87	-457	-572	---
Other energy sector	1472	679	-85	-368	-125
Final consumption	18928	14723	7011	1370	-93
Industry	8478	6892	3485	519	-94
Transport	7153	5719	2686	689	-90
Buildings	2860	1809	685	122	-96
Total CO_2 removals	1	317	1457	1936	---
Total CO_2 captured	40	1665	5619	7602	---

source: IEA, World Energy Outlook 2021.

Levels and fuel shares of electricity production in IEA scenarios

	Historical Data		Stated Policy Scenario			Announced Pledges Scenario		
	2010	2020	2030	2040	2050	2030	2040	2050
Total Generation in TWh	**21520**	**26762**	**33575**	**40553**	**46703**	**34362**	**45618**	**54716**
	Generation by fuel shares in %							
Total Generation	100	100	100	100	100	100	100	100
Renewables	**19,7**	**28,4**	**41,9**	**52,3**	**59,7**	**46,3**	**62,2**	**71,2**
Nuclear	12,8	10,1	9,3	8,7	7,9	9,6	8,9	8,1
Hydrogen and ammonia	0,0	0,0	0,0	0,1	0,1	0,3	0,8	0,9
Fossil fuels with CCUS	0,0	0,0	0,1	0,2	0,3	0,4	2,5	3,2
Unabated fossil fuels	67,3	61,4	48,7	38,6	31,9	43,4	25,5	16,5
	Historical Data		**Sustainable Development Scenario**			**Net Zero Emissions**		
	2010	**2020**	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
Total Generation in TWh	**21520**	**26762**	**34424**	**45885**	**57950**	**37316**	**56553**	**71164**
	Generatioin by fuel shares in %							
Total Generation	100,0	100,0	100	100	100	100	100	100
Renewables	**19,7**	**28,4**	**53,1**	**74,9**	**83,6**	**61,1**	**84,0**	**87,6**
Nuclear	12,8	10,1	9,9	9,4	8,1	10,1	8,6	7,7
Hydrogen and ammonia	0,0	0,0	0,3	0,8	1,4	2,3	3,3	2,4
Fossil fuels with CCUS	0,0	0,0	0,9	3,2	3,1	1,2	2,9	1,9
Unabated fossil fuels	67,3	61,4	35,7	11,6	3,7	25,1	1,1	0,4

source: IEA, World Energy Outlook 2021.

Climate impacts of the IEA scenarios

- The outlook based on today's policy settings, the Stated Policies Scenario (STEPS), shows aggregate fossil fuel demand slowing to a plateau in the 2030s and then falling slightly by 2050. The global average temperature rise in this scenario passes the 1.5 degrees Celsius (°C) mark around 2030 and would still be climbing as it reaches 2.6 °C in 2100.
- Announced net zero pledges and enhanced Nationally Determined Contributions, if implemented in full as in the Announced Pledges Scenario (APS), start to bend the curve and means that global energy-related CO_2 emissions fall by 40 % until 2050 and bring the temperature rise in 2100 down to around 2.1 °C.
- A much greater global effort will be essential to reach the relative safety of the Net Zero Emissions by 2050 Scenario (NZE). Announced pledges close less than 20% of the emissions gap in 2030 between the STEPS and the NZE.

source: IEA, World Energy Outlook 2021.

Necessary measures for a climate-compatible pathway

Actions in four key areas over the next decade are essential to keep the door open to a 1.5 °C stabilisation by 2050:

- a **massive push for clean electrification** (mainly solar PV and wind deployment)
- a **renewed focus on realising the full potential of energy efficiency**; together with measures to temper energy service demand through materials efficiency and behavioural change.
- **concerted efforts to prevent leaks from fossil fuel operations**; in particular, the aim must be to cut methane emissions from fossil fuels.
- a **boost to clean energy innovation.** This is a crucial gap to be filled in the 2020s. All the technologies needed to achieve deep emissions cuts to 2030 are available. But almost half of the emissions reductions achieved in the NZE in 2050 come from technologies that today are at the demonstration or prototype stage.

source: IEA, World Energy Outlook 2021.

Necessary measures for a climate-compatible pathway

Getting the world on track for net zero emissions by 2050 requires transition-related investment to accelerate from current levels to around USD 4 trillion annually by 2030.

Transitions are accompanied by marked shifts in energy sector employment, but clean energy jobs expand faster than other sectors fall. The downside risks for jobs are concentrated in the coal sector, where retirements of coal-fired capacity approach 100 gigawatts (GW) per year over the coming decade in the NZE.

If the world gets on track for net zero emissions by 2050, then the cumulative **market opportunity** for manufacturers of **wind turbines, solar panels, lithium-ion batteries, electrolysers and fuel cells** amounts to USD 27 trillion. These five elements alone in 2050 would be larger than today's oil industry and its associated revenues.

source: IEA, World Energy Outlook 2021.

Finally

This WEO-2021 provides **stark warnings** about the pathway that we are on, but also

clear-headed analysis of the actions

that can bring the world onto a path towards a 1.5 °C future – with a

strong affirmation of the benefits that this yields.

source: IEA, World Energy Outlook 2021.

Conclusions – almost the same as all the previous years

- The development of global CO_2 emissions to date is not on the climate protection policy target path.
- The discussion often concentrates on emissions targets. This is necessary and has to be pursued in the future - **but**
- The real emission's development and their business-as-usual-perspectives should not be neglected.
- The gap between the desired targets and the expected real development can only be filled with an appropriate policy and effective measures for more energy efficiency and renewable energies.
- Targets are necessary but not sufficient: It needs policies and measures. That's the proof for an effective climate protection policy and not only the target setting!
- The present figures shows some promising results but the overall turning point is still far far away.

The paper is published in October in:
„Energiewirtschaftliche Tagesfragen“,
10/2022 (in German only)

Thanks for listening

hziesing@t-online.de

Periodic emission budgets with different reduction targets for 2030 and 2050

Targets (2030/2050 versus 1990)	Targets 2030 (Basis 1990 = 4.858 Mt CO_2e)	Actual budget 1990 to 2020	2021 to 2030	2031 to 2050	2021 to 2050	1990 to 2050
	Million t CO_2e	Emission budgets in billion tons CO_2 equivalent				
-40%/-100%	2,915	133.1	31.1	27.7	58.8	191.9
-55%/-100%	2,186	133.1	27.1	20.8	47.9	181.0
-65%/-100%	1,700	133.1	24.4	16.2	40.6	173.7
		Annual average emission reduction in million tons CO_2 equivalent				
-40%/-100%		-50	-44	-146	-112	-81
-55%/-100%		-50	-116	-109	-112	-81
-65%/-100%		-50	-165	-85	-112	-81

sources: UNFCCC; author‘s calculation.