

Climate change and fossil fuels

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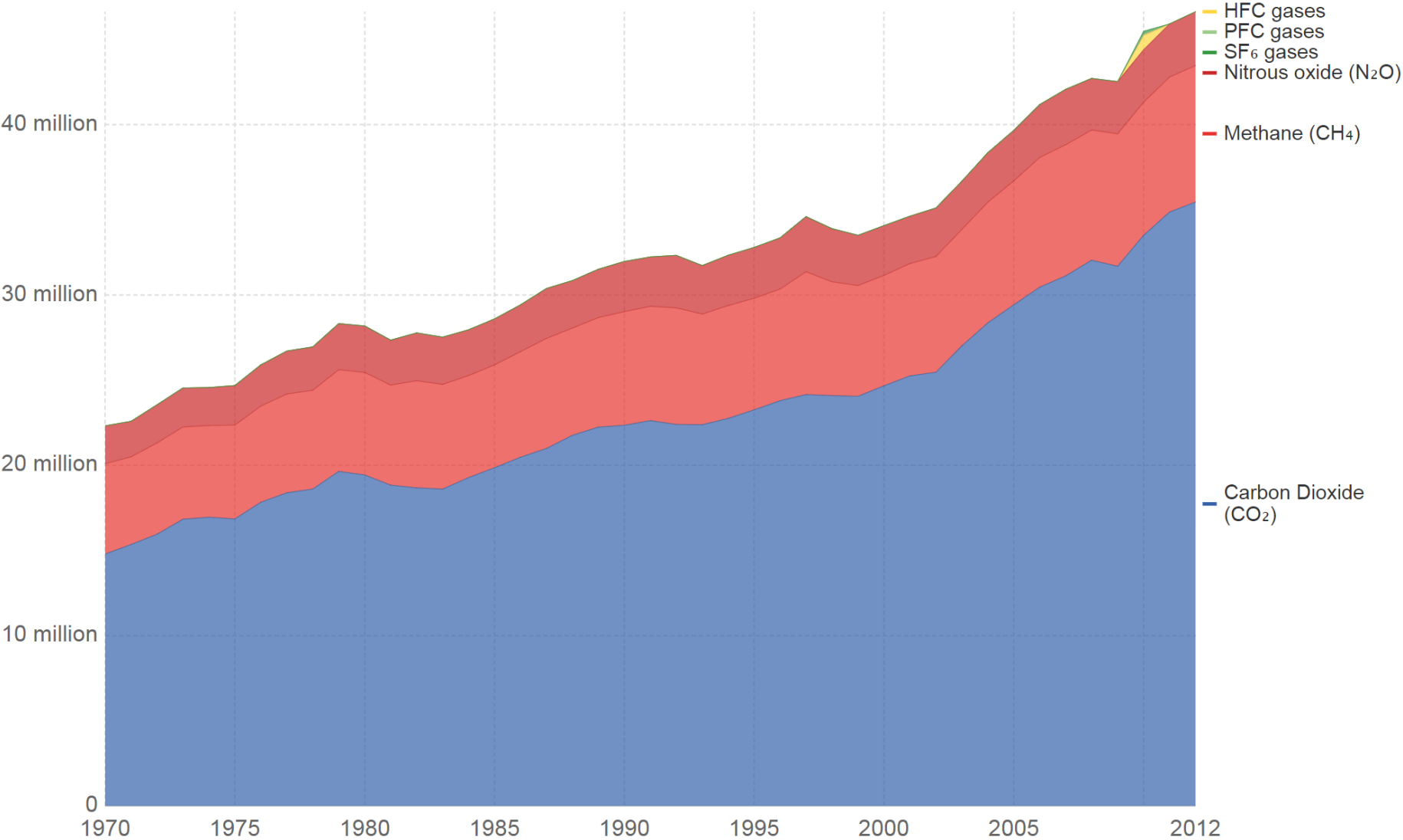
Climate change mechanism

- Temperature of the planet is rising
 - 0,8°C in last 130 years, more than half of that in last 35 years.
- GHG concentration is increasing.
 - CO₂ concentration increased by 40% since pre-industrial time, methane by 150%, nitrous oxide by 20%.
- This increase is caused by human activity.
- There is a relationship between GHG and energy in the atmosphere (greenhouse gas effect).
- Some uncertainty due to the complexity of the issue, positive and negative feedbacks.

Greenhouse gas emissions (CO₂e) by gas, World



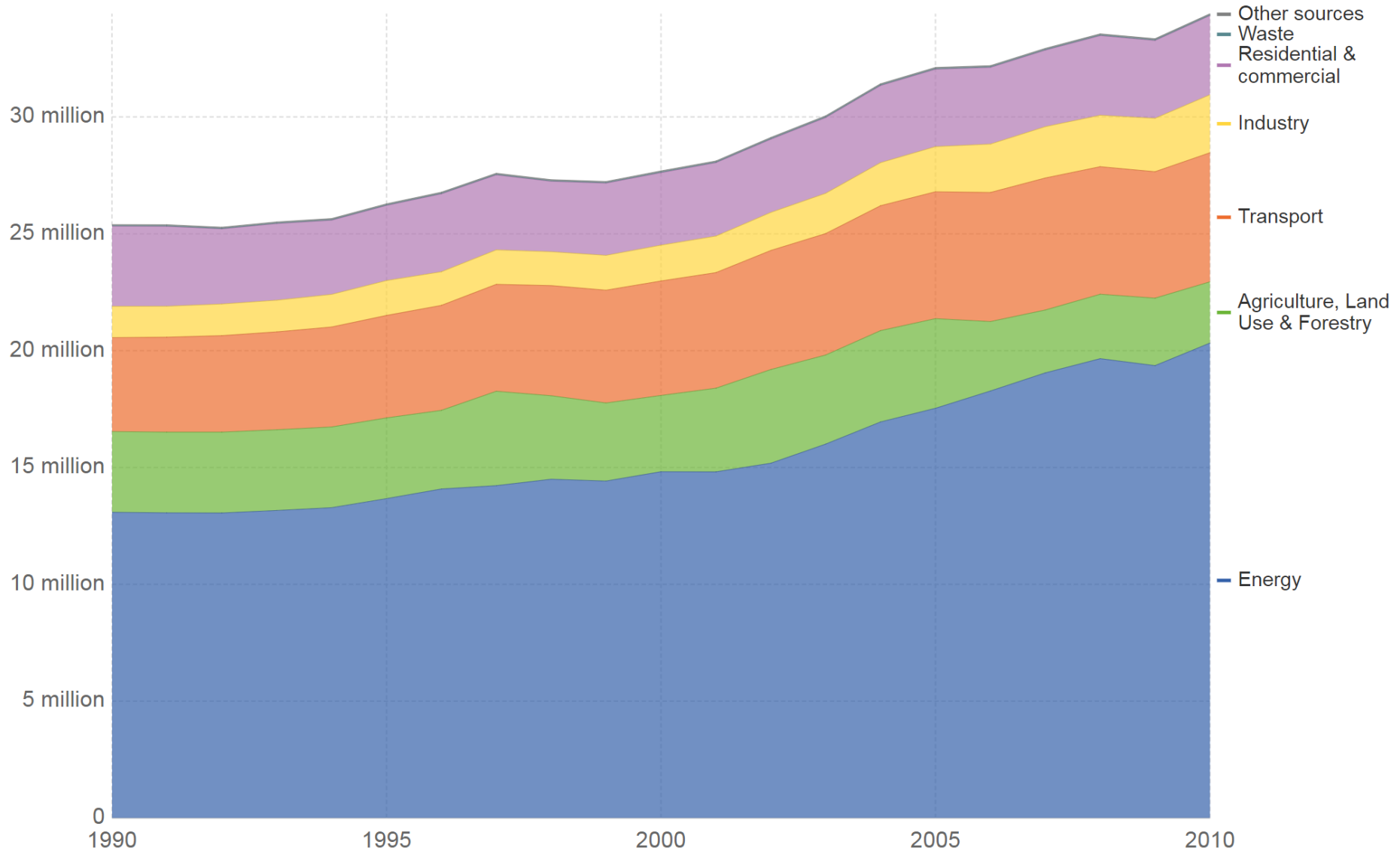
Global greenhouse gas emissions by gas source, measured in thousand tonnes of carbon dioxide equivalents (kt CO₂e). Gases are converted to their CO₂e values based on their global warming potential factors. HFC, PFC and SF₆ are collectively known as 'F-gases'.



Source: World Bank - World Development Indicators (WDI)

Global carbon dioxide emissions by sector (Gg CO₂)

Global carbon dioxide (CO₂) emissions, measured in gigagrams of CO₂ per year.

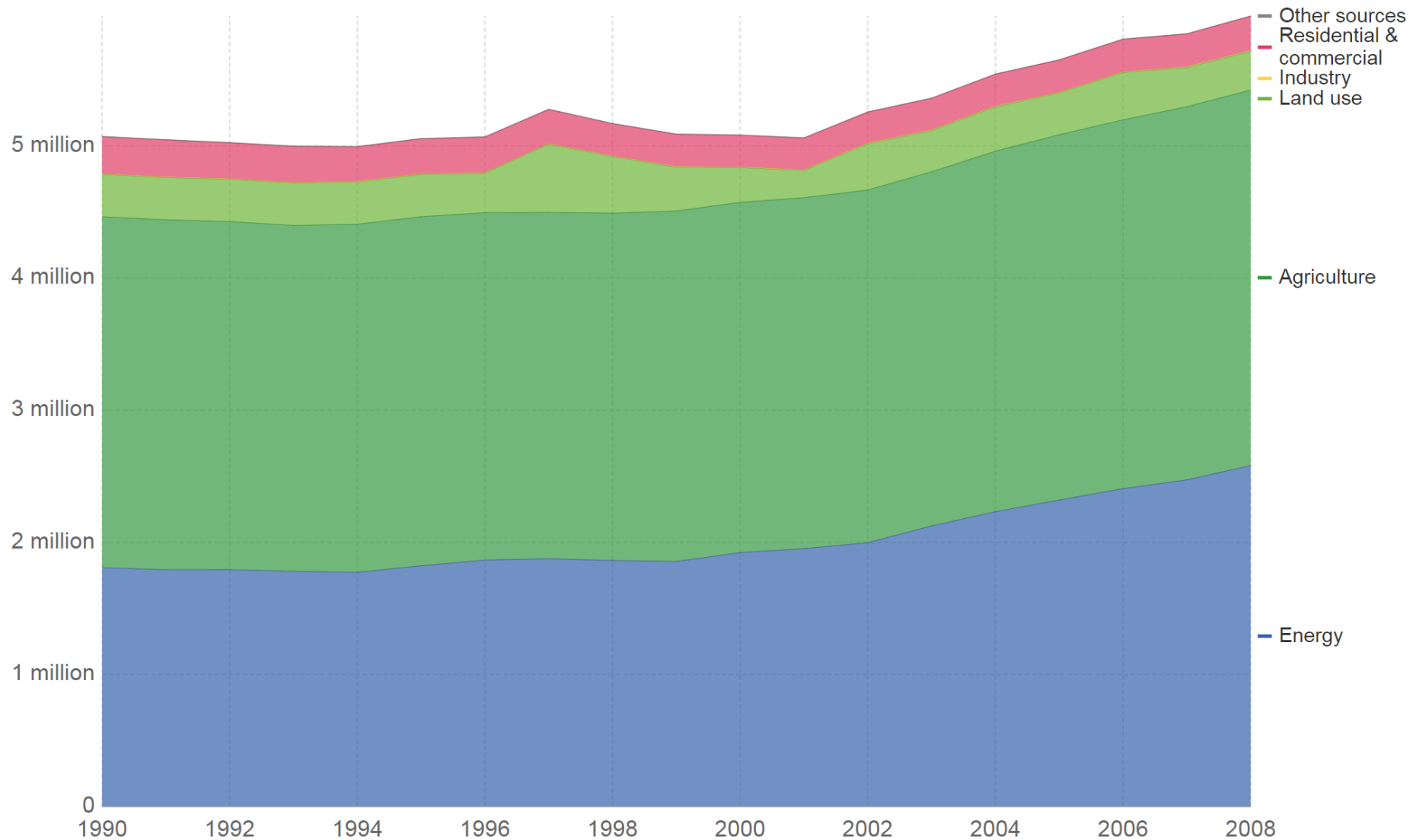


Source: UN Food and Agricultural Organization (FAO)

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Methane emissions by sector (Gg CO₂e)

Breakdown of total global methane (CH₄) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO₂e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.



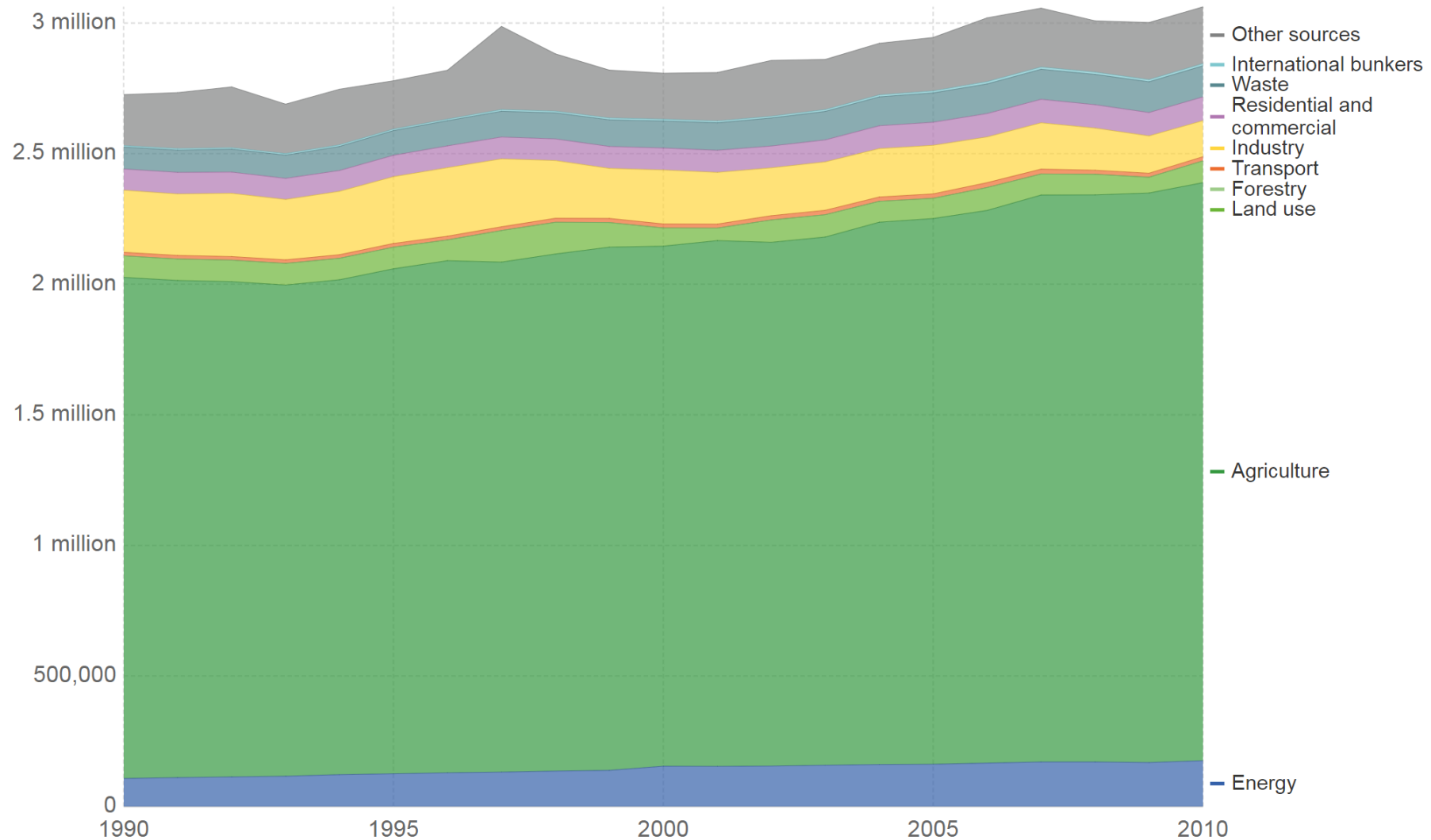
Source: UN Food and Agricultural Organization (FAO)

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Nitrous oxide emissions by sector (Gg CO₂e), World



Breakdown of total global nitrous oxide (N₂O) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO₂e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.



Source: UN Food and Agricultural Organization (FAO)

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Possible Effects of Climate Change

Eventual Temperature Rise Relative to Pre-Industrial Temperatures

Type of Impact	1°C	2°C	3°C	4°C	5°C
Freshwater Supplies	Small glaciers in the Andes disappear, threatening water supplies for 50 million people	Potential water supply decrease of 20–30% in some regions (Southern Africa and Mediterranean)	Serious droughts in southern Europe every 10 years. 1–4 billion more people suffer water shortages	Potential water supply decrease of 30–50% in southern Africa and Mediterranean	Large glaciers in Himalayas possibly disappear, affecting ¼ of China’s population
Food and Agriculture	Modest increase in yields in temperature regions	Declines in crop yields in tropical regions (5–10% in Africa)	150–550 million more people at risk of hunger. Yields likely to peak at higher latitudes	Yields decline by 15–35% in Africa. Some entire regions out of agricultural production	Increase in ocean acidity possibly reduces fish stocks
Human Health	At least 300,000 die each year from climate–related diseases. Reduction in winter mortality in high latitudes	40–60 million more exposed to malaria in Africa	1–3 million more potentially die annually from malnutrition	Up to 80 million more people exposed to malaria in Africa	Further disease increase and substantial burdens on health care services
Coastal Areas	Increased damage from coastal flooding	Up to 10 million more people exposed to coastal flooding	Up to 170 million more people exposed to coastal flooding	Up to 300 million more people exposed to coastal flooding	Sea-level rise threatens major cities such as New York, Tokyo, and London
Ecosystems	At least 10% of land species facing extinction. Increased wildfire risk	15–40% of species potentially face extinction	20–50% of species potentially face extinction Possible onset of collapse of Amazon forest	Loss of half of Arctic tundra Widespread loss of coral reefs	Significant extinctions across the globe

Climate change as a public policy problem

Is uniquely global

- Environmental problems usually regional (Beijing's smog, waste from EU's industry).
- Climate change - impacts may be regional, but phenomenon is global.
- The global nature of climate change also complicates any sensible climate policy. It is tough to get voters to enact pollution limits on themselves, when those limits benefit them and only them, but it is tougher to get voters to enact pollution limits on themselves if the costs are felt domestically, but the benefits are global = a planetary free riding problem.
- Impact of climate change is not evenly distributed among regions and countries. Different vulnerability.

Climate change as a public policy problem

Is uniquely long-term

- The past decade was the warmest in human history. The one before was the second-warmest. The one before was the third-warmest.
- Changes are evident. Arctic sea ice has lost half of its mass, three-quarters of this volume in only the past thirty years.
- But the worst consequences of climate change are still remote, often caged in global, long-term averages. The worst effects are still far off – but avoiding these predictions would entail acting now.

Climate change as a public policy problem

Is uniquely irreversible

- Stopping emitting carbon now we still would have decades of warming and centuries of sea-level rise locked in. Full melting of large West Antarctic ice sheets may be unstoppable.
- Over 2/3 of the excess CO₂ in the atmosphere that wasn't there when humans started burning fossil fuels will still be present a hundred years from now. Over 1/3 will be there in 1000 years.

Climate change as a public policy problem

Is uniquely uncertain.

- Last time concentration of carbon dioxide were as high as they are today, at 400 ppm, at Pliocene (3 million years ago). Average temperatures back then were around 1-2,5°C warmer than today, sea levels were up to 20 meters higher, and camels lived in Canada.
- We wouldn't expect any of these dramatic changes today. The greenhouse effect needs decades to centuries to come into full force, ice sheets need decades to centuries to melt, global sea levels take decades to centuries to adjust accordingly. CO₂ concentrations may have been at 400 ppm 3 million years ago, whereas rising sea levels lagged decades or centuries behind.

Climate change as a public policy problem

It is uniquely expensive

- Around current climates massive investments and industrial infrastructures is build, that makes temperature increases costly.
- The current models estimates that warming of 1°C will cost 0,5% of global GDP, 2°C around 1% GDP, 4°C around 4% GDP.
- We could think about damages as a percentage of output in any given year. At a 3 percent annual growth rate, global economic output will increase almost twenty-fold in a hundred years
- Or lets assume that damages affect output growth rates faster than output levels. Climate change clearly affects labor productivity, esp. in already hot countries. Then the cumulative effects of damages could be much worse over time.

Important Events in International Climate Change Negotiations

Year, Location	Outcome
1992, Rio de Janeiro	UN Framework Convention on Climate Change (UNFCCC). Countries agree to reduce emissions with “common but differentiated responsibilities.”
1995, Berlin	The first annual Conference of the Parties to the framework, known as a COP. U.S. agrees to exempt developing countries from binding obligations.
1997, Kyoto	At the third Conference of the Parties (COP-3) the Kyoto Protocol is approved, mandating developed countries to cut greenhouse gas emissions relative to baseline emissions by 2008-2012 period.
2001, Bonn	(COP-6) reaches agreement on terms for compliance and financing. Bush administration rejects the Kyoto Protocol; U.S. is only an observer at the talks.
2009, Copenhagen	COP-15 fails to produce a binding post-Kyoto agreement, but declares the importance of limiting warming to under 2°C. Developed countries pledge \$100 billion in climate aid to developing countries.
2011, Durban	(COP-17) participating countries agreed to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015, to take effect by 2020.
2015, Paris	COP-21 195 nations sign the Paris Agreement, providing for worldwide voluntary actions (INDC's) by individual countries.

International regime to fight climate change

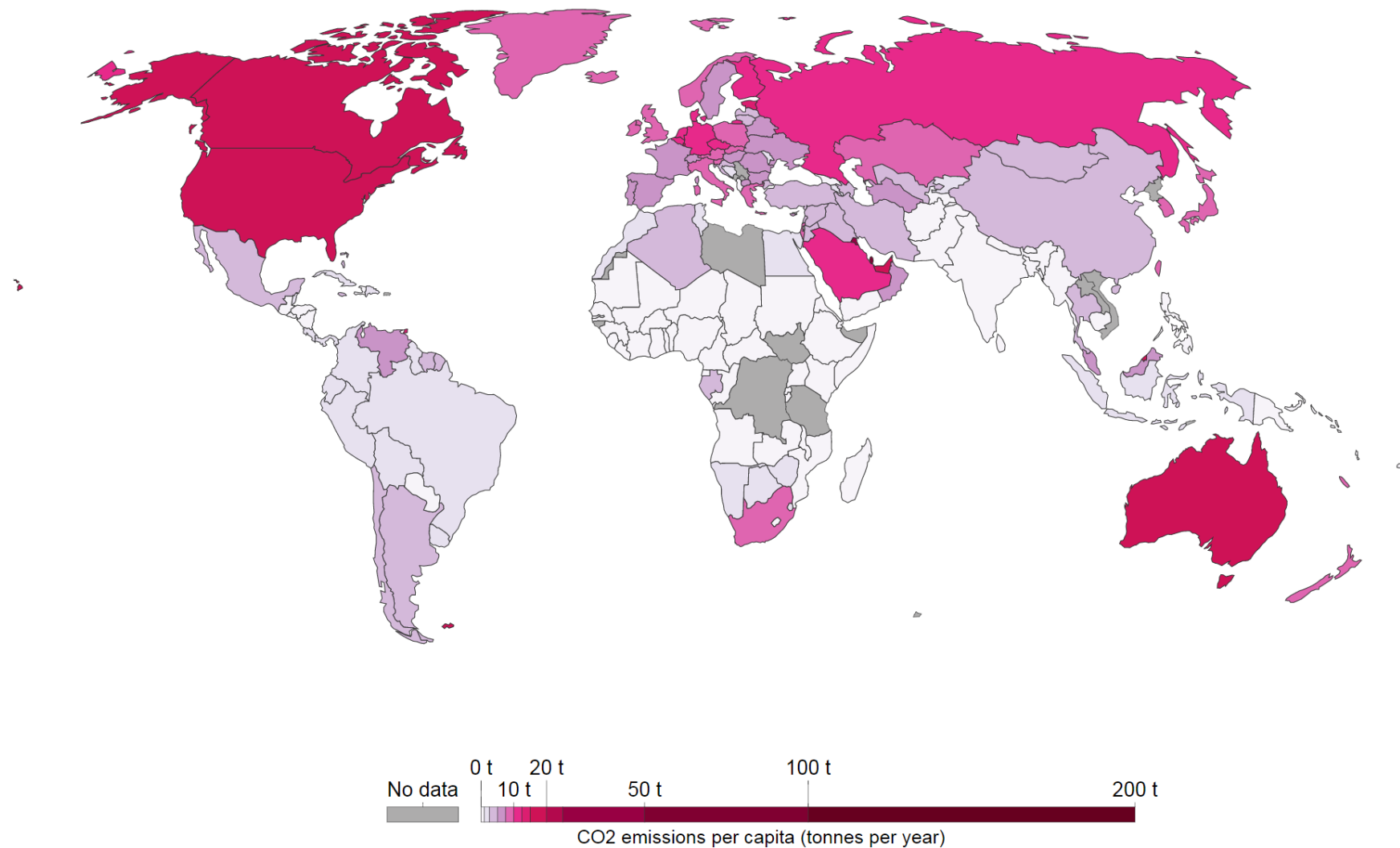
- Intergovernmental Panel on Climate Change – 1988.
 - Rio Summit on Earth – 1992 (UN conference on environment and development) → UNFCCC.
 - Kyoto Protocol.
 - 1997, in force 2005.
- = Existence of a generally accepted consensus on the climate change as well as the contribution of human activities to this change.

Kyoto Protocol

- 4 GHG (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) + hydrofluorocarbons and perfluorocarbons.
- Annex I. countries (37 industrialized countries + EU15), Non-annex I. parties.
- Reducing of GHG emissions by 5,2 % for the first commitment period of 2008-2012. (4,2 % after USA left). Base year 1990.
- Reduction of emissions from fossil fuel combustion; reduction emission in other sectors (land-use or direct industrial emissions); flexible mechanisms – Emission trading, CDM, JI.
- Common but differentiated responsibility.

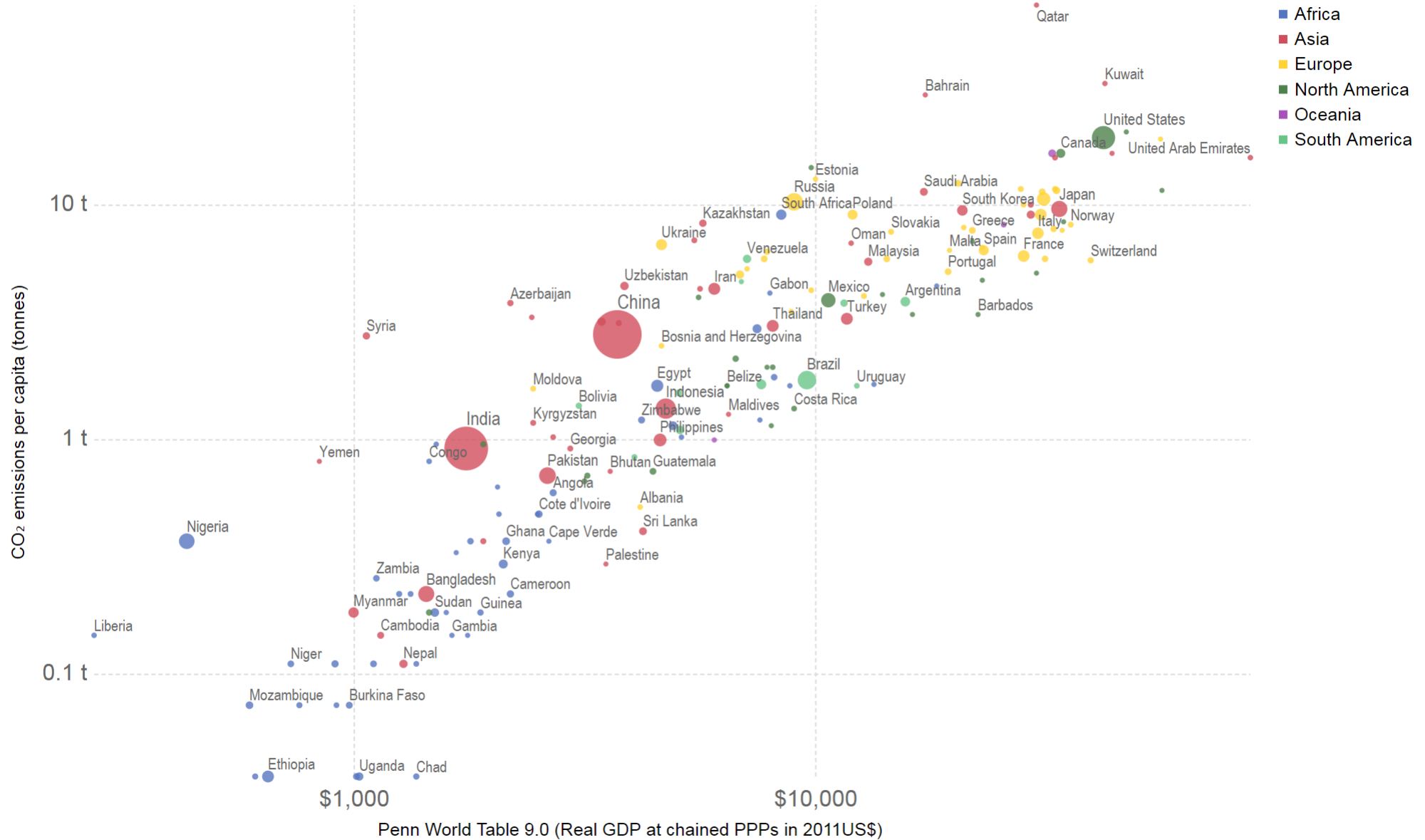
CO₂ emissions per capita, 1997

Average carbon dioxide (CO₂) emissions per capita measured in tonnes per year



CO₂ emissions per capita vs GDP per capita (international-\$), 1997

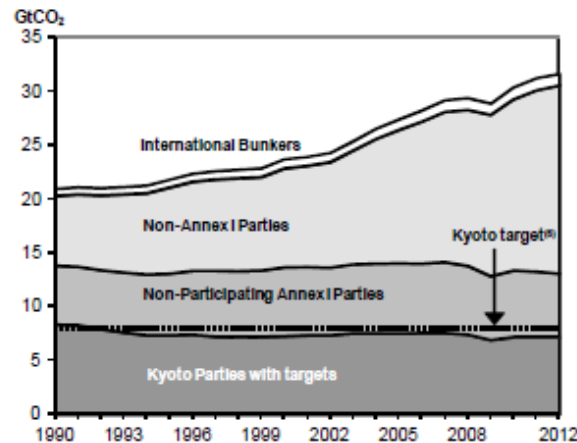
Carbon dioxide (CO₂) emissions per capita (tonnes per year) vs GDP per capita (int.-\$). The size of the bubbles represent population size.



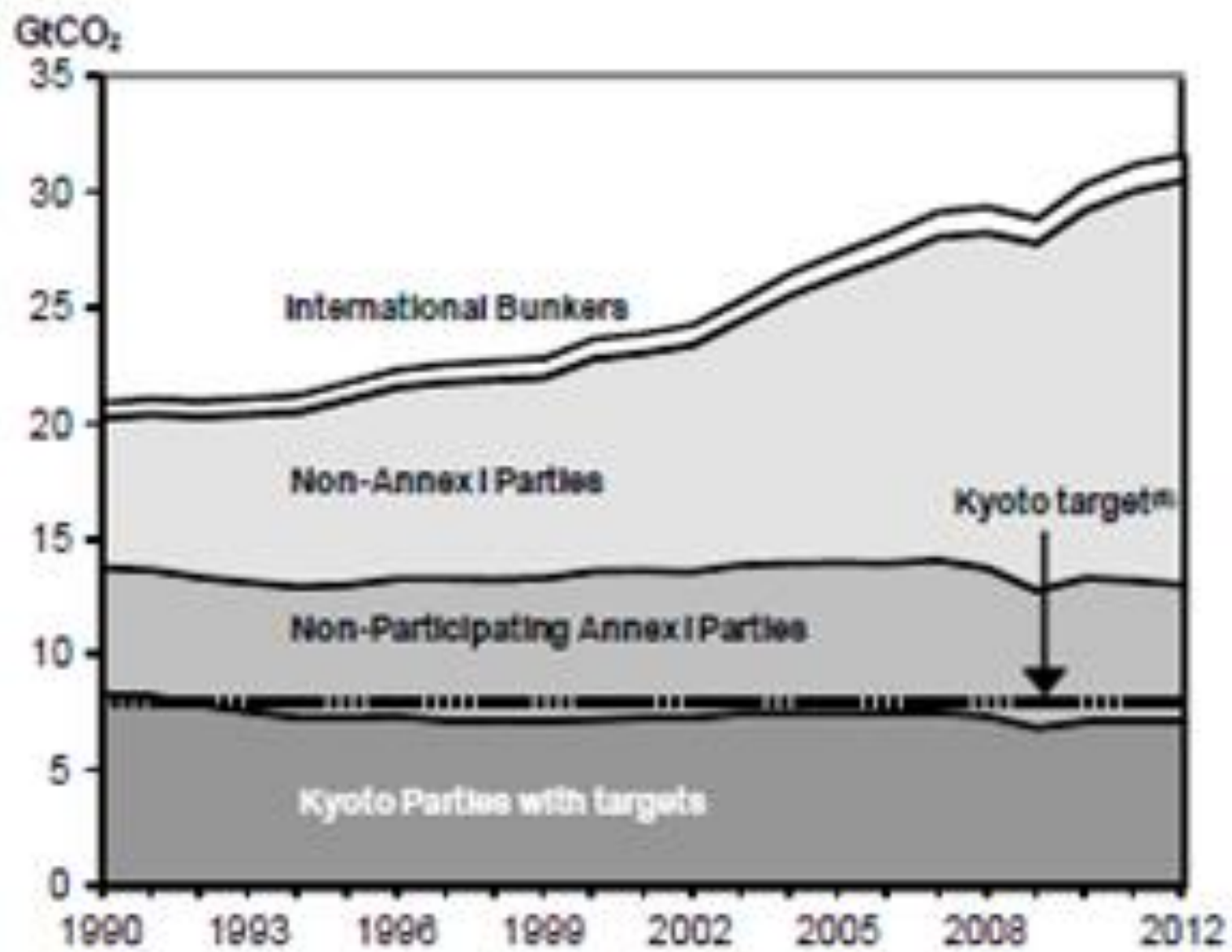
Kyoto Protocol results

- In 2012, CO₂ emissions from fuel combustion across all Parties with KP targets were 14% below 1990 levels.
- Emissions in the EU-15 were 8% below 1990 levels.
- Some industrialised countries have seen significant increases (Australia +48%), New Zealand (+44%), Spain (+30%).
- Despite extensive participation of 192 countries the KP is limited in its potential – U.S. remains outside, developing countries do not have emission targets.
- The KP implies action on less than one-quarter of global CO₂ emissions.
- Through its flexibility mechanisms the KP has made CO₂ a tradable commodity, and has been a driver for the development of national emission trading schemes.

	1990 MtCO ₂	2012 MtCO ₂	% change 90-12	Kyoto Target		1990 MtCO ₂	2012 MtCO ₂	% change 90-12	Kyoto Target
KYOTO PARTIES WITH TARGETS ⁽¹⁾	8,339.6	7,157.0	-14.2%	-4.6% ⁽²⁾	OTHER COUNTRIES	12,014.7	23,497.4	95.6%	
<i>Europe</i>	3,154.5	2,906.4	-7.9%		<i>Non-participating</i>				
Austria	58.4	64.7	14.8%	-13%	<i>Annex I Parties</i>	5,550.9	5,983.9	7.8%	
Belgium	107.9	104.6	-3.1%	-7.5%	Belarus	124.8	71.1	-43.0%	-8%
Denmark	50.6	37.1	-26.7%	-21%	Canada ⁽¹⁾	428.2	533.7	24.6%	-6%
Finland	54.4	49.4	-9.1%	0%	Malta	2.3	2.5	10.4%	none
France ⁽³⁾	352.8	333.9	-5.4%	0%	Turkey	126.9	302.4	138.3%	none
Germany	949.7	755.3	-20.5%	-21%	United States	4,868.7	5,074.1	4.2%	-7%
Greece	70.1	77.5	10.5%	+25%					
Iceland	1.9	1.8	-2.5%	+10%	<i>Other Regions</i>	6,352.7	17,334.0	172.9%	none
Ireland	30.6	35.5	16.3%	+13%	Africa	545.0	1,032.4	89.4%	none
Italy	397.4	374.8	-5.7%	-6.5%	Middle East	549.9	1,647.1	199.5%	none
Luxembourg	10.4	10.2	-1.3%	-28%	N-OECD Eur. & Eurasia ⁽⁴⁾	630.0	528.8	-16.1%	none
Netherlands	155.8	173.8	11.5%	-6%	Latin America ⁽⁴⁾	842.5	1,583.3	87.9%	none
Norway	28.3	36.2	27.9%	+1%	Asia (excl. China) ⁽⁴⁾	1,507.5	4,291.4	184.7%	none
Portugal	39.4	45.9	16.4%	+27%	China	2,277.7	8,250.8	262.2%	none
Spain	205.2	266.6	29.9%	+15%					
Sweden	52.8	40.4	-23.4%	+4%	INTL. MARINE BUNKERS	363.2	602.2	65.8%	
Switzerland	41.6	41.3	-0.8%	-8%	INTL. AVIATION BUNKERS	256.3	477.8	86.4%	
United Kingdom	549.3	457.5	-16.7%	-12.5%					
European Union - 15	3,082.7	2,827.1	-8.3%	-8%	WORLD	20,973.9	31,734.3	51.3%	
<i>Asia Oceania</i>	1,339.5	1,641.7	22.6%						
Australia	260.5	386.3	48.3%	+8%					
Japan	1,056.7	1,223.3	15.8%	-6%					
New Zealand	22.3	32.1	44.0%	0%					
<i>Economies in Transition</i>	3,845.6	2,608.8	-32.2%						
Bulgaria	74.9	44.3	-40.9%	-8%					
Croatia	21.5	17.2	-20.1%	-5%					
Czech Republic	148.8	107.8	-27.6%	-8%					
Estonia	35.8	16.3	-54.3%	-8%					
Hungary	66.4	43.6	-34.4%	-8%					
Latvia	18.6	7.0	-62.4%	-8%					
Lithuania	33.1	13.3	-59.8%	-8%					
Poland	342.1	293.8	-14.1%	-6%					
Romania	167.5	79.0	-52.9%	-8%					
Russian Federation	2,178.8	1,659.0	-23.9%	0%					
Slovak Republic	56.7	31.9	-43.8%	-8%					
Slovenia	13.3	14.6	9.6%	-8%					
Ukraine	687.9	281.1	-59.1%	0%					

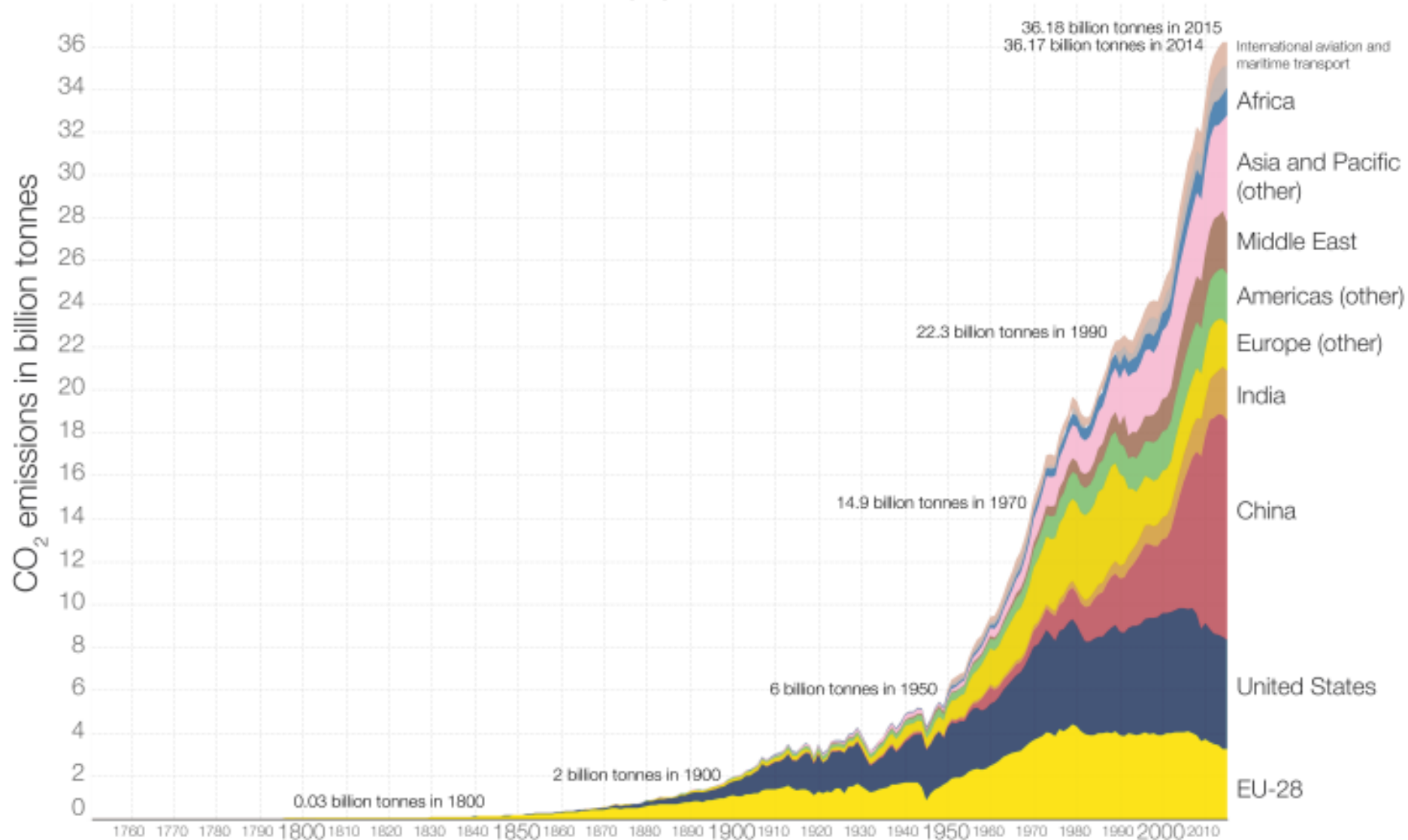


- (1) On 15 December 2011, Canada withdrew from the Kyoto Protocol. This action became effective for Canada on 15 December 2012.
- (2) The actual country targets apply to a basket of six greenhouse gases and allow sinks and international credits to be used for compliance. The overall "Kyoto target" is estimated for this publication by applying the country targets to IEA data for CO₂ emissions from fuel combustion, and is only shown as an indication. The overall target for the combined EU-15 under the Protocol is -8%, but the member countries have agreed on a burden-sharing arrangement as listed.
- (3) Emissions from Monaco are included with France.
- (4) Composition of regions differs from elsewhere in this publication to take into account countries that are not Kyoto Parties.
- (5) The Kyoto target is calculated as percentage of the 1990 CO₂ emissions from fuel combustion only, therefore it does not represent the total target for the six-gas basket. This assumes that the reduction targets are spread equally across all gases.



Global CO₂ emissions by world region, 1751 to 2015

Annual carbon dioxide emissions in billion tonnes (Gt).

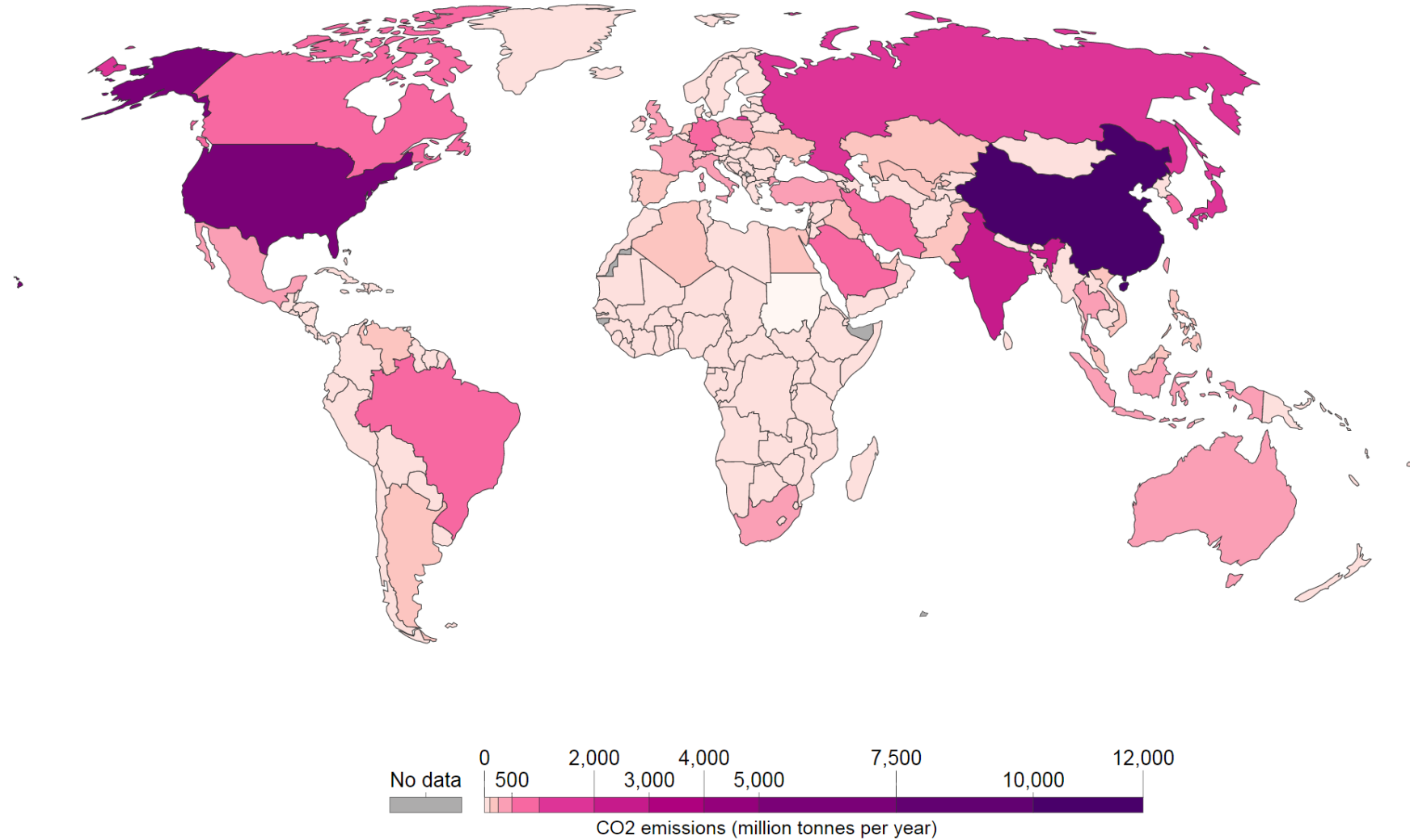


Post-Kyoto system

- Second commitment period of KP for 2013--2020 concluded in 2012 (COP 18 in Doha). Belarus, Canada, Japan, New Zealand, Russia, USA and Ukraine missing. Others reduction commitments covering 13% of global GHG emissions at 2010 levels.
- To limit global temperature increase to less than 2°C above pre-industrial level, countries are negotiating a new climate agreement (partially finalised at COP21 in Paris 2015).
- It builds on the voluntary emission reduction goals for 2020 that were made at COP15 in Copenhagen.
- Developed and developing countries with these aims account for over 80% of global emissions. (goals nevertheless not sufficient to fulfill 2°C limit).

Annual CO₂ emissions per country, 2014

Annual carbon dioxide (CO₂) emissions are measured in million tonnes



Source: CDIAC

Note: Data converted from carbon to carbon dioxide using conversion factor of 3.67

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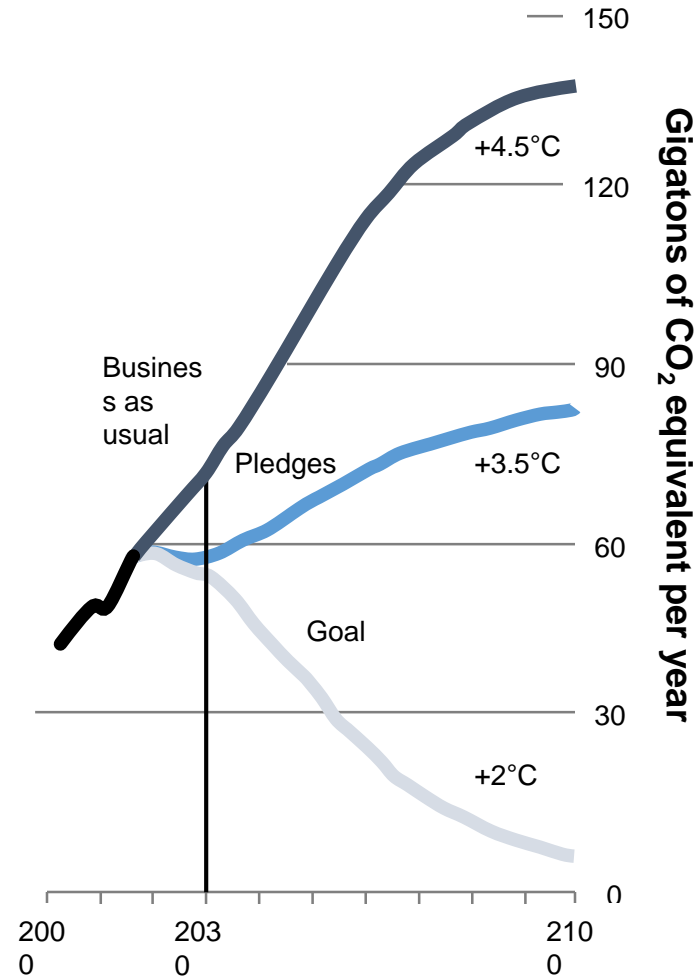
Paris agreement (COP21)

- Legally binding treaty with reduction commitments from 187 countries starting in 2020. It will enter the force once 55 countries covering 55% of global emissions are in. It:
- Reaffirms the goal of limiting global temperature increase below 2 degrees, while urging efforts to limit the increase to 1.5 degrees.
- Establishes binding commitments by all parties to make “nationally determined contributions” (NDCs), and to pursue domestic measures aimed at achieving them.
- Commits all countries to report regularly on their emissions and “progress made in implementing and achieving” their NDCs, and to undergo international review.
- Commits all countries to submit new NDCs every five years, with the clear expectation that they will “represent a progression” beyond previous ones.

Paris agreement (COP21)

- Reaffirms the binding obligations of developed countries under the UNFCCC to support the efforts of developing countries, while for the first time encouraging voluntary contributions by developing countries too.
- Extends the current goal of mobilizing \$100 billion a year in support by 2020 through 2025, with a new, higher goal to be set for the period after 2025.
- Extends a mechanism to address “loss and damage” resulting from climate change, which explicitly will not “involve or provide a basis for any liability or compensation“.
- Requires parties engaging in international emissions trading to avoid “double counting“.
- Calls for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country’s NDC.

COP21 pledges vs. BaU scenario

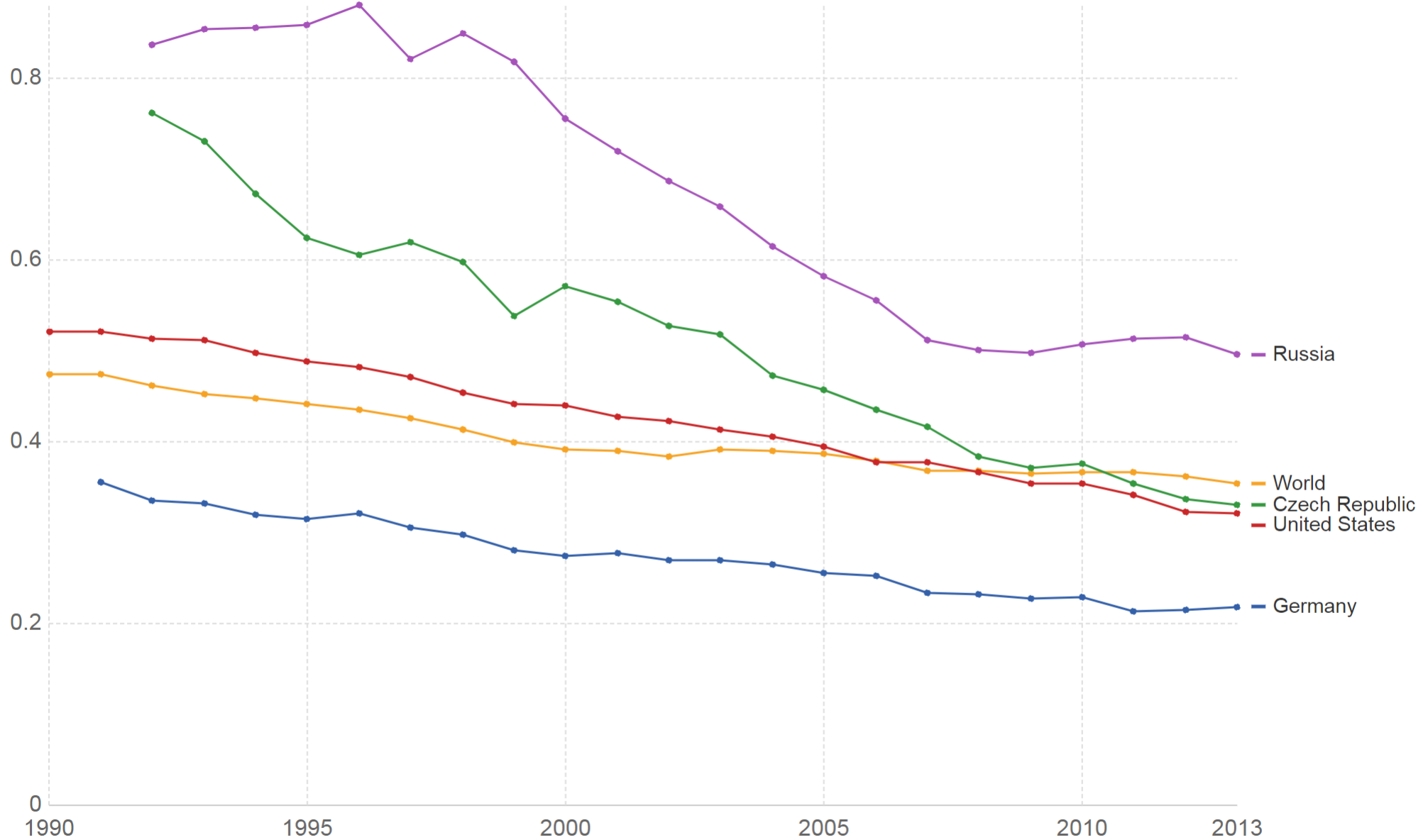


Major cleavages

- Should be a global climate agreement legally binding or not?
- Who it should bind?
- How much aid to provide to help countries adapt to climate change?
- Should compensation be given to developing countries for the damage caused by climate change? (loss and damage).

Carbon emission intensity of economies

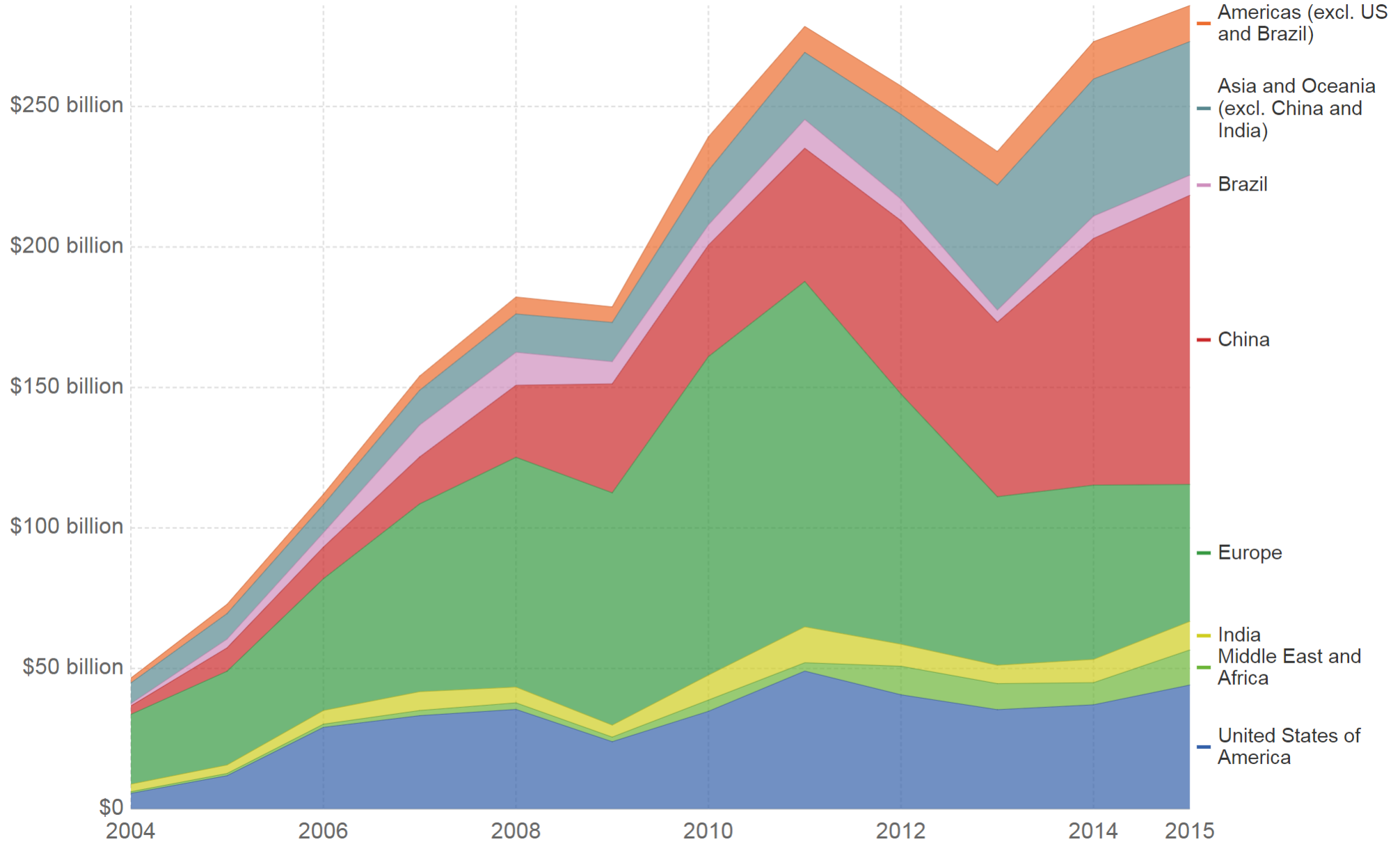
Carbon dioxide (CO₂) intensity of economies measured in kilograms of CO₂ per unit GDP (2011 international- $\text{\$}$)



Source: The World Bank
Note: Gross Domestic Product (GDP) measured in real 2011 int- $\text{\$}$ terms

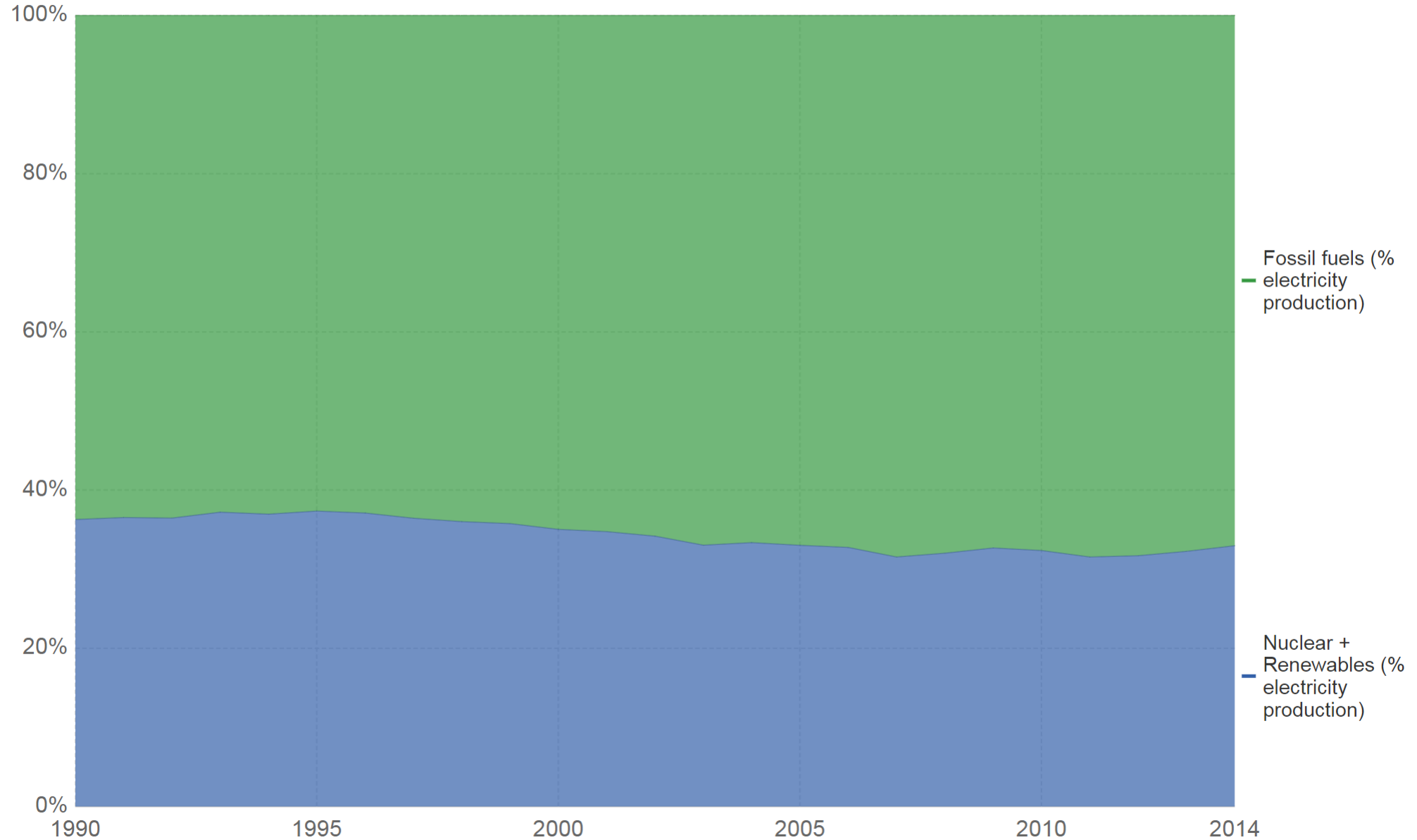
Renewable Energy Investment

Investment in renewable energy technologies per year in billion US dollars by region.



Global electricity production by source

Global electricity production, measured as the percentage contribution from fossil fuels (coal, oil and gas) and low-carbon sources (nuclear, hydropower, biomass, wind, solar, geothermal and marine power)



- More about climate change in MEB415 Environmentální aspekty energetiky/ESS411 Environmental Aspects of Energy.

Sources

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