Climate change and fossil fuels

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International (UN) regime to fight climate change

- Intergovernmental Panel on Climate Change – 1988. (Last report 10/2018)
- Rio Summit on Earth – 1992 (UN conference on environment and development).
  - UNFCCC (UN Framework convention on Climate Change) - consensus vs. 180 parties.
  - Existence of a generally accepted consensus on the climate change as well as the contribution of human activities to this change.
  - Common but differentiated responsibility.
- Kyoto Protocol – approved in 1997, in force 2005.
- Paris Agreement (COP21), 2015. Nationally determined contributions, new every five years.

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Greenhouse gas emissions (CO_2e) by gas, World

Global greenhouse gas emissions by gas source, measured in thousand tonnes of carbon dioxide equivalents (kt CO_2e). Gases are converted to their CO_2e values based on their global warming potential factors. HFC, PFC and SF_6 are collectively known as 'F-gases'.

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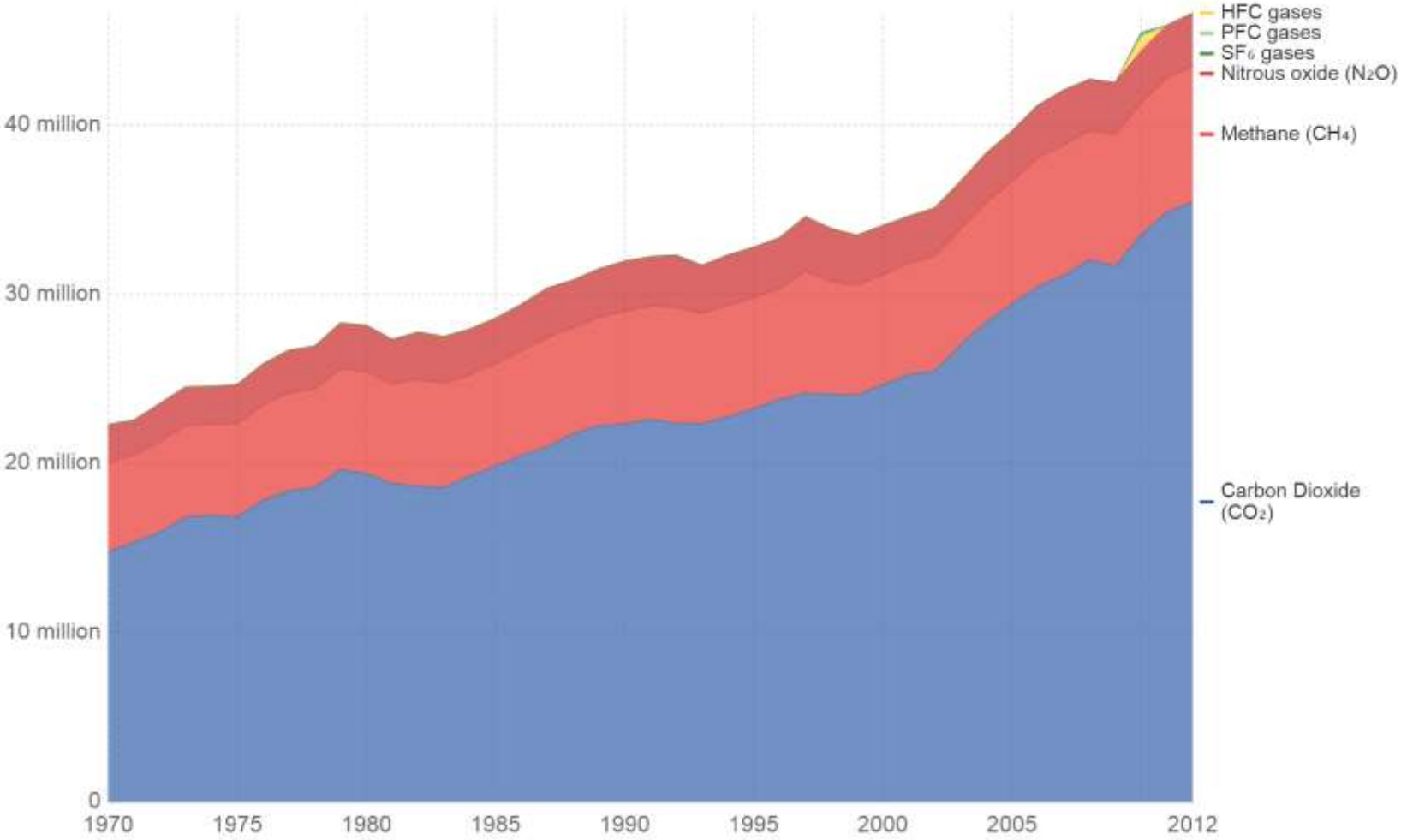

Source: World Bank – World Development Indicators (WDI)

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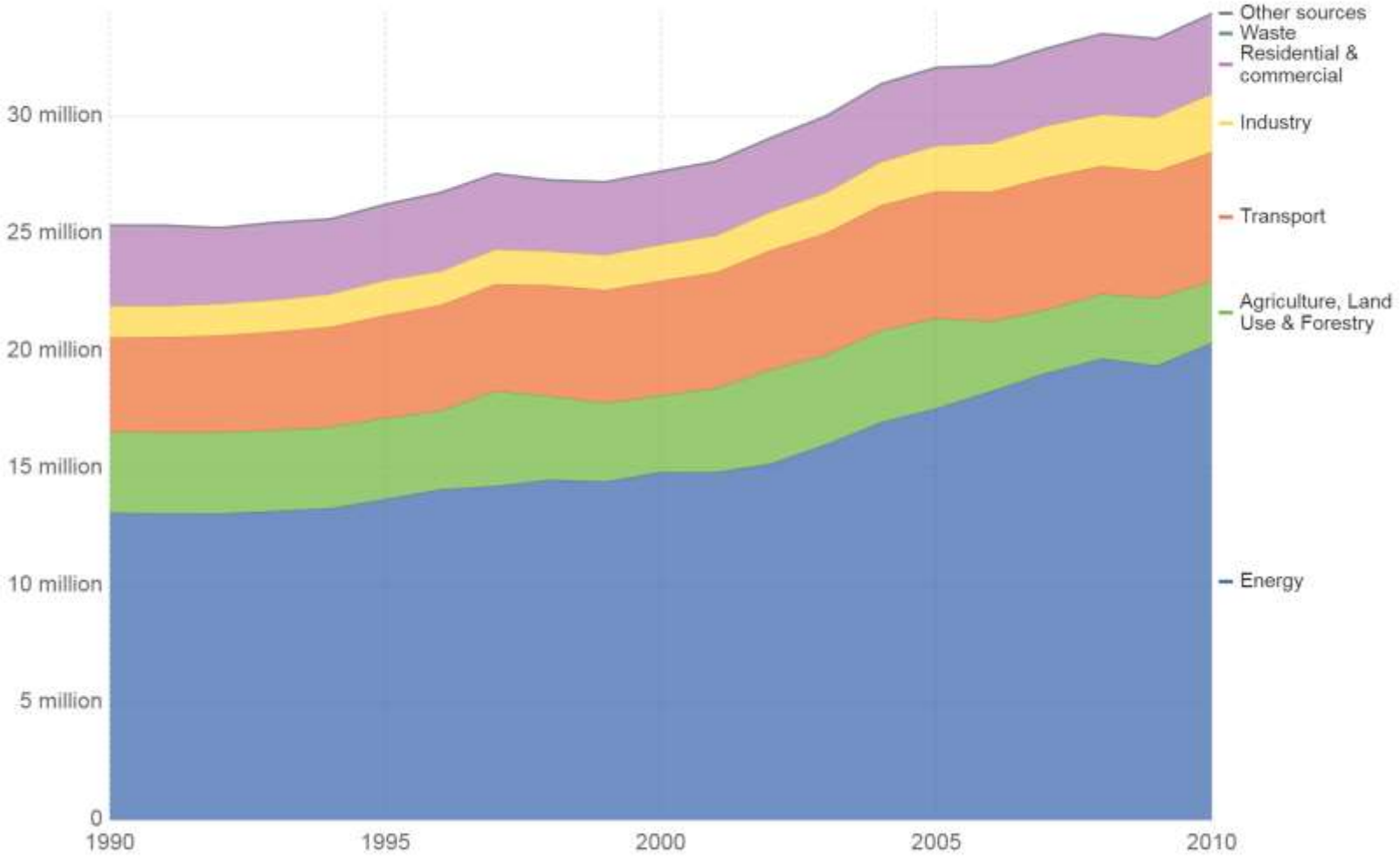
Global carbon dioxide emissions by sector (Gg CO_2)

Global carbon dioxide (CO_2) emissions, measured in gigagrams of CO_2 per year.



Source: UN Food and Agricultural Organization (FAO)

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Methane emissions by sector (Gg CO_2e)

Breakdown of total global methane (CH_4) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO_2e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.

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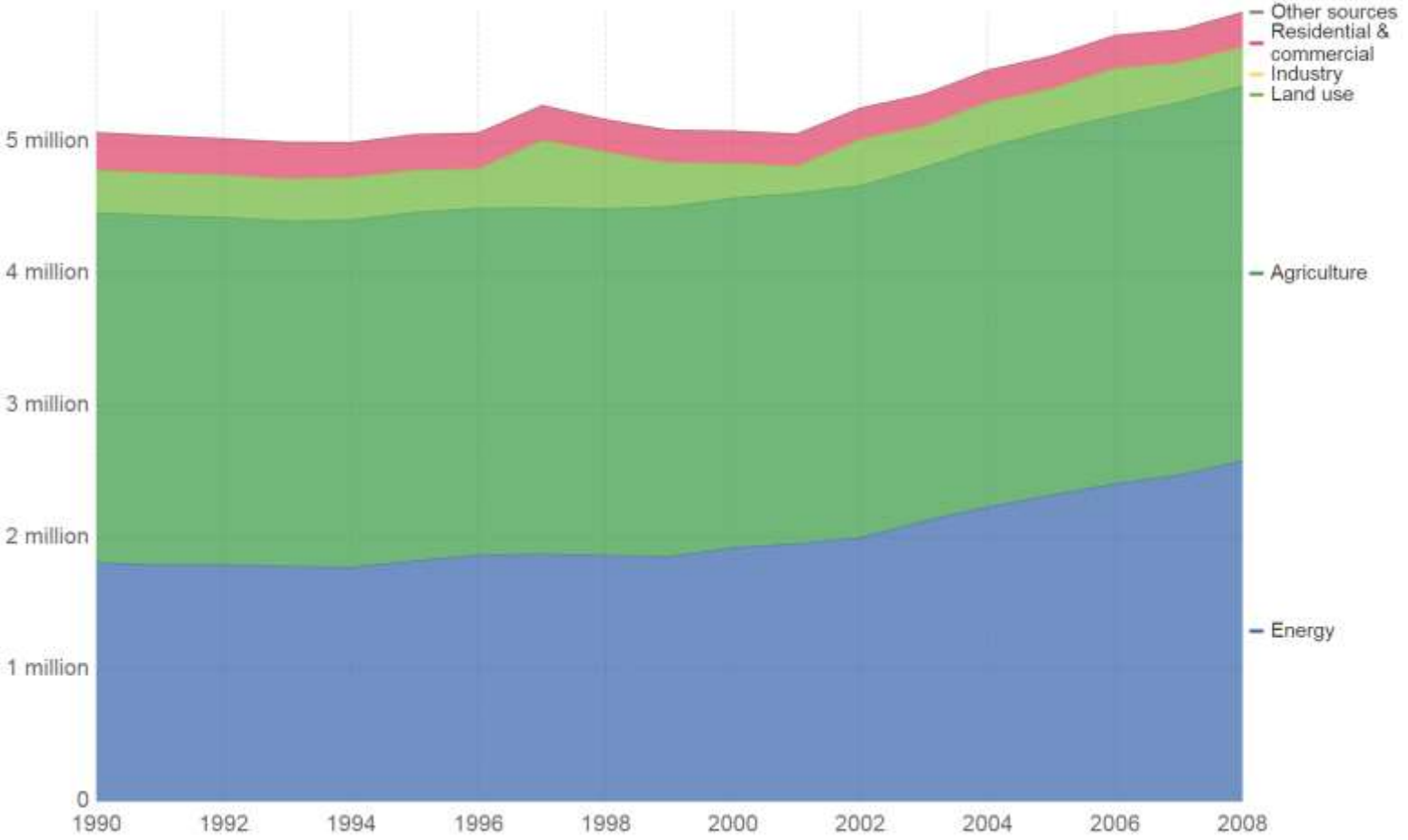

Source: UN Food and Agricultural Organization (FAO)

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Nitrous oxide emissions by sector (Gg CO_2e), World

Breakdown of total global nitrous oxide (N_2O) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO_2e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.

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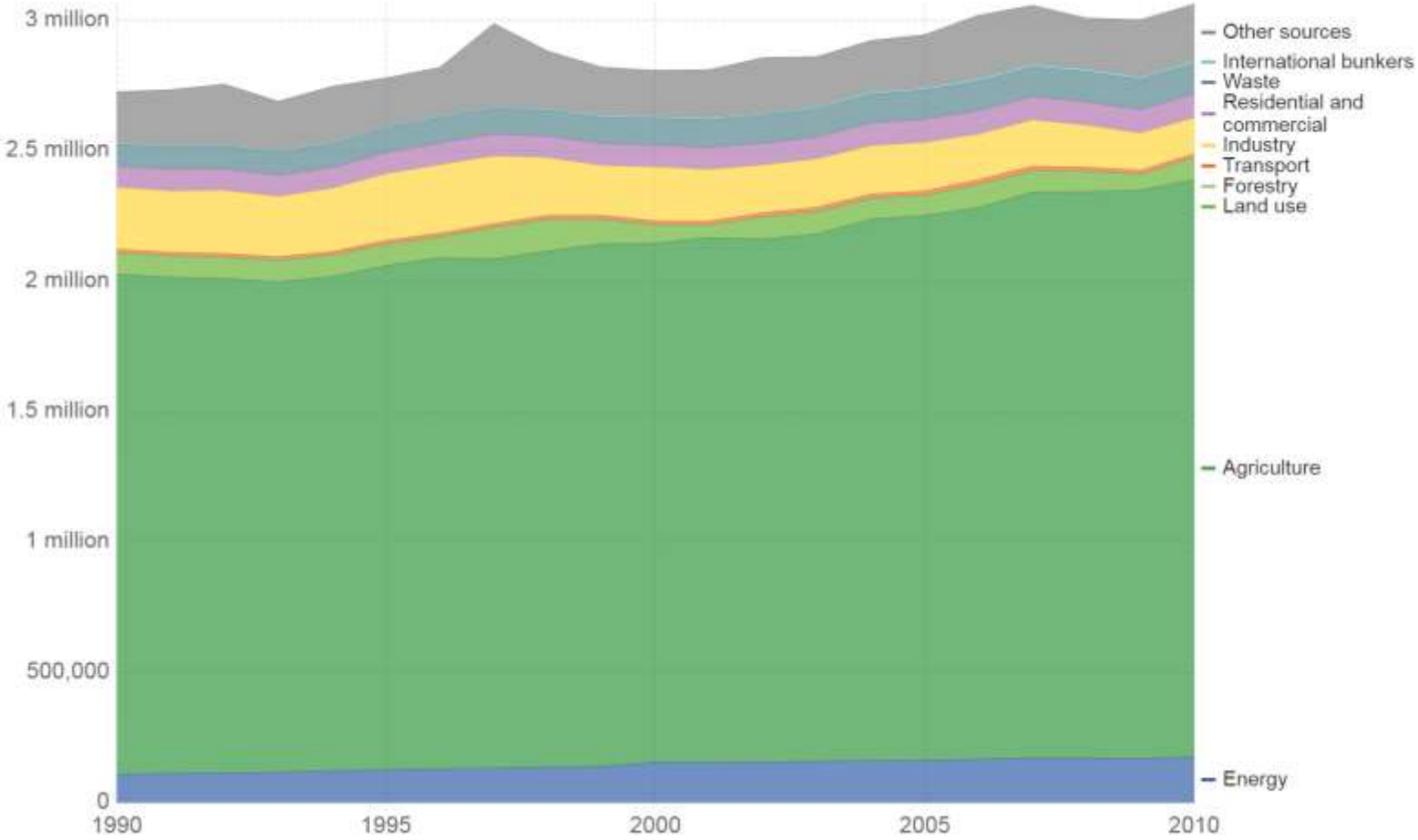

Source: UN Food and Agricultural Organization (FAO)

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Mitigation tools

- **Price based instruments** (carbon pricing) - taxes on CO2; taxes on inputs or outputs of procesess (fuel); subsidies for emission reducting activities; emission trading systems (cap and trade systems), feed in tariffs, green certificates…
- **Comand and control regulations** – technology standards (biofuel blend mandate, minimum energy performance standards); performance standards (fleet average CO2 vehicle efficiency); prohibition or mandating of central products or practices (bulbs, vacuum cleaners); certification, reporting requirements; land use planing…
- **Information and voluntary approaches** – rating programmes, public information campaigns, education, awards.

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Carbon pricing

- To decrease demand we need to raise its cost. Trying to find the balance of the costs and benefits of carbon production, not to reducing it entirely. To internalize the externalities.
- Instruments that reach throughout the economy, influencing all production and consumption decisions.
- 1)figuring out how much carbon we want to put into the environment. 2) Then a cost must be applied:
  - applying tax on it (Pigouvian tax)
  - cap-and-trading
- Both these systems raise some revenue that could be used to offset the negative macroeconomic impacts of energy price rises.

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Carbon taxes

- Norway – CO2 tax introduced in 1991. Oil and gas sectors and usage. Sectors covered by EU ETS exempted, with exeption of the offshore oil and gas sector.
- Japan – introduced in 2012 to raise revenue for energy efficiency and RES programmes, not as a direct price incentive.
- Switzerland – CO2 levy intended as an incentive for energy efficiency and for shifting toward cleaner heating and proces fuels (not to raise revenue). In place since 2008.
- British Columbia (Canada) – introduced in 2008. Revenue neutral, compensated by income and corporate tax cuts. Consumption fuels dropped by 5-15%, while in the rest of Canada increased by about 3%.

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Cap and trade systems

- A government assigns to itself the right to put emissions into the environment.
- It defines what it believes to be the socially optimal quantity of emissions.
- The govevernment generates a number of permits equal to the amount of allowable emissions.
- These permits are allocated to emitters to trade with them – market is created.

= economically efficient, provides incentives for efectivity of the system. To develop technology that would allow one to reduce emissions at a cost lower than that of buying a permit, that spurs innovation and technological development.

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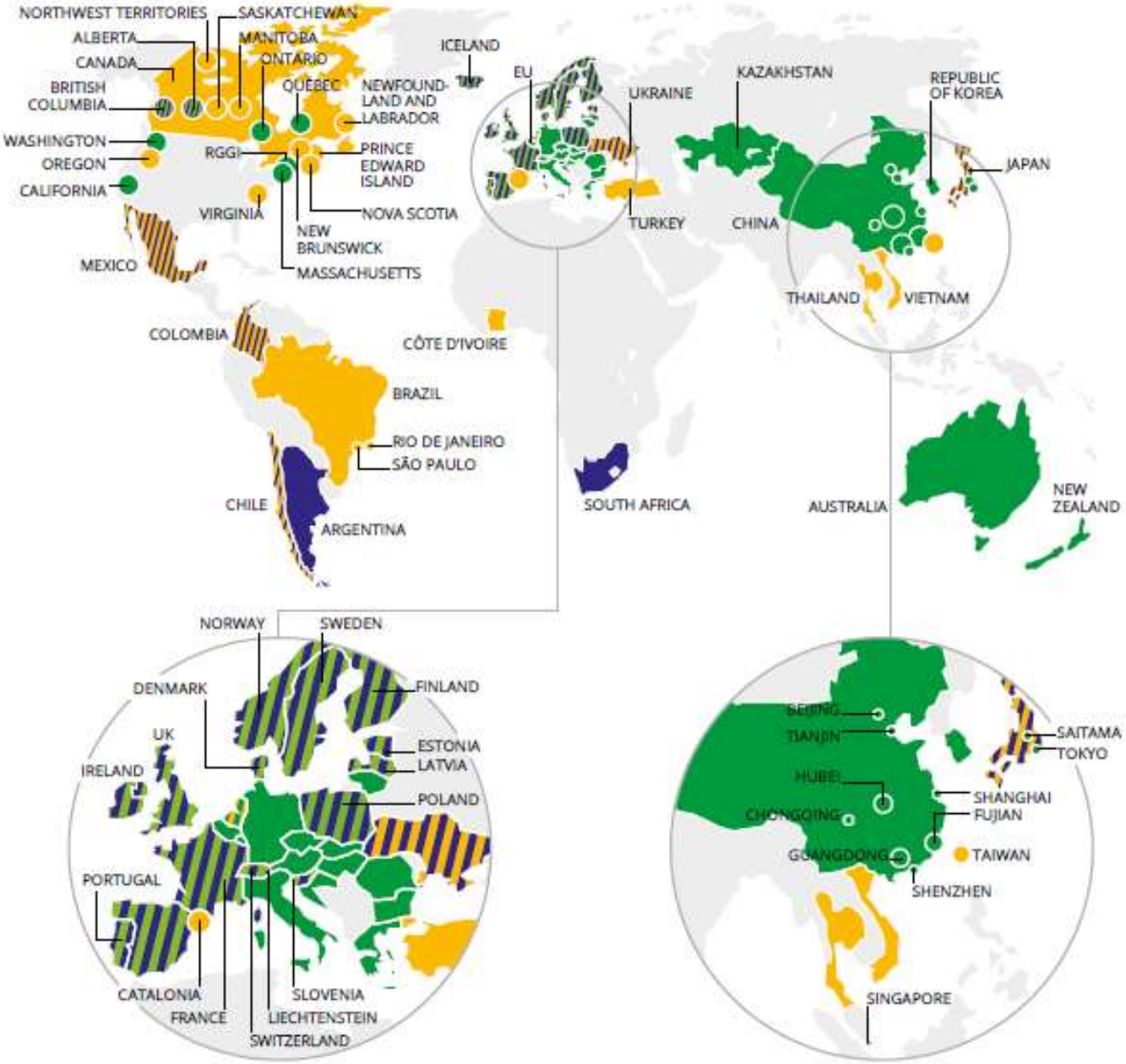

Tally of carbon pricing initiatives implemented or scheduled for implementation

- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- Carbon tax implemented or scheduled, ETS under consideration
- ETS implemented or scheduled, carbon tax under consideration

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Carbon tax vs. cap and trade system

- Carbon tax:
  - Simpler to understand, easier to built, more transparent.
  - Keeps pushing for reducing the emissions despite technology development.
  - Is to be implemented more quickly.
  - Greater price predictability.
- Cap and trade system
  - Avoids negative connotation of ´tax´.
  - Some companies are effective in lobbying for exemptions.
  - Known reduction of emissions, unknown price.

Energy policies that affect emissions

- Energy taxes and subsidies
  - Non-climate objectives (funding of infrastructure, revenue rasing), can shift the average and relative prices of fuels, therefore act as a significant carbon price. (and vice versa).
- Energy efficiency
  - The primary motivation for energy efficiency policies is cost savings to consumers and society, improved energy security. Emissions savings a positive by-product.
  - Performance standards, information and labelling, energy provider obligations in lightning, equipment and buildings.
- Development and deployment of low-carbon supply
  - Technology support policies – research development to demonstration projects to support for deployment

Renewable Energy Investment

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

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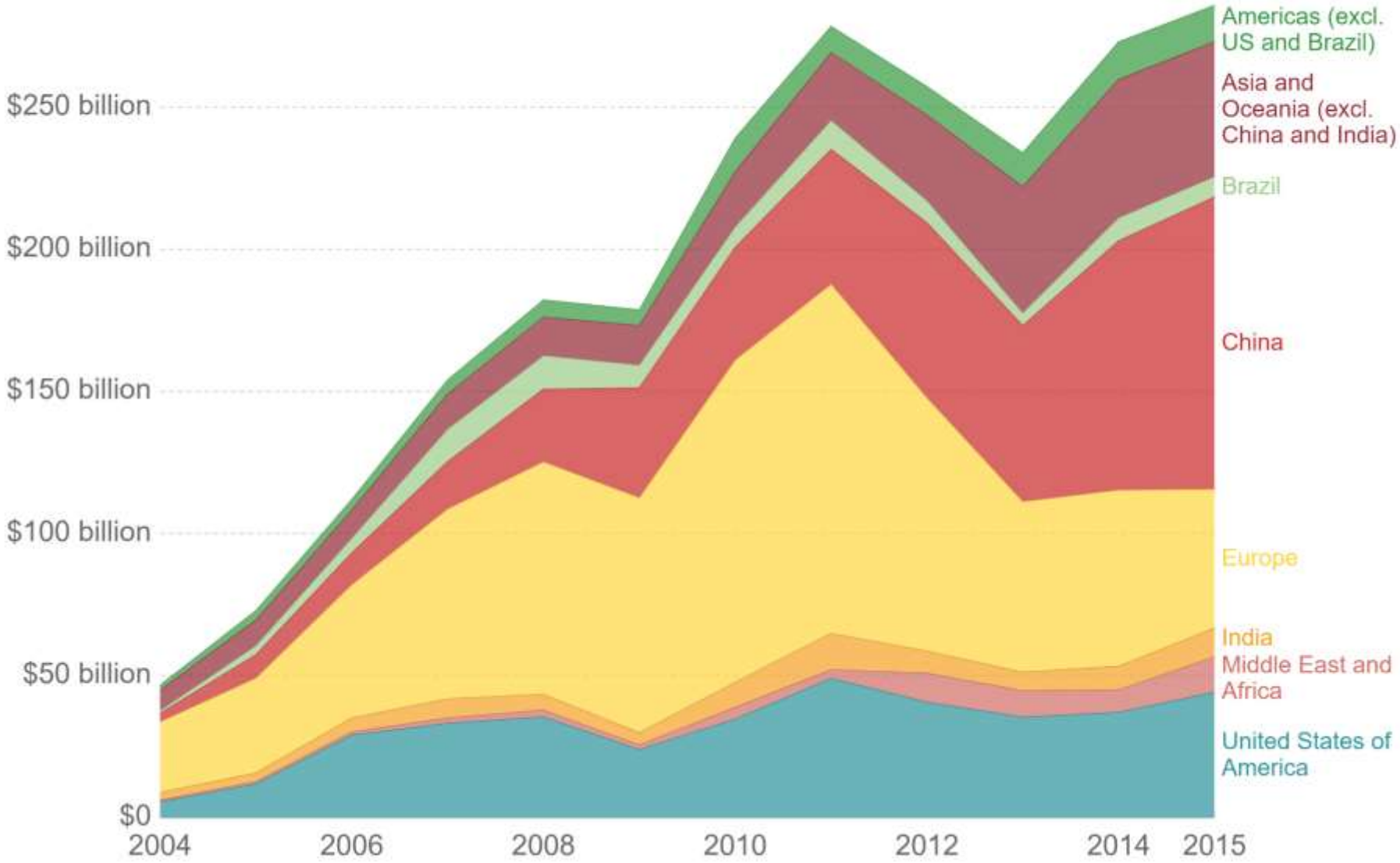
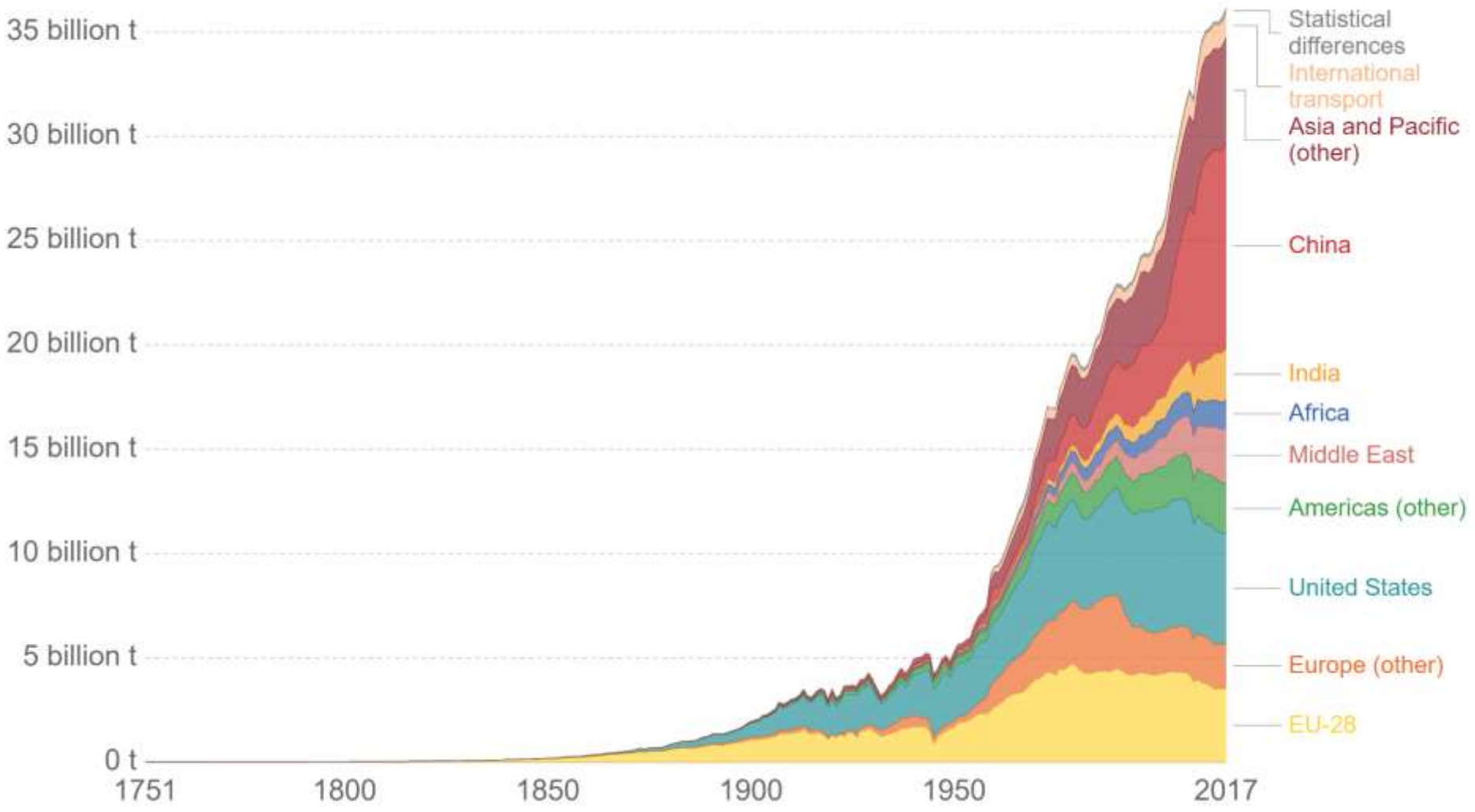


Source: International Renewable Energy Agency, 2017

Annual total CO_2 emissions, by world region



Source: Carbon Dioxide Information Analysis Center (CDIAC); Global Carbon Project (GCP)
Note: "Statistical differences" notes the discrepancy between estimated global emissions and the sum of all national and international transport emissions.
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Climate change as a uniquely global public policy problem

- Environmental problems usually regional (Beijing´s smog, Romania´s industrial waste).
- 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 uniquely long-term public policy problem

- 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-quaters 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 uniquely irreversible public policy problem

- 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.

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Climate change as uniquely uncertain public policy problem

- 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 uniquely expensive public policy problem

- Around current climates masive 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 hudred 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.

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Primary energy consumption by world region

Global energy consumption by region, measured in terawatt-hours (TWh). Note that this data includes only commercially-traded fuels (coal, oil, gas), nuclear and modern renewables used in electricity production. As such, it does not include traditional biomass sources.

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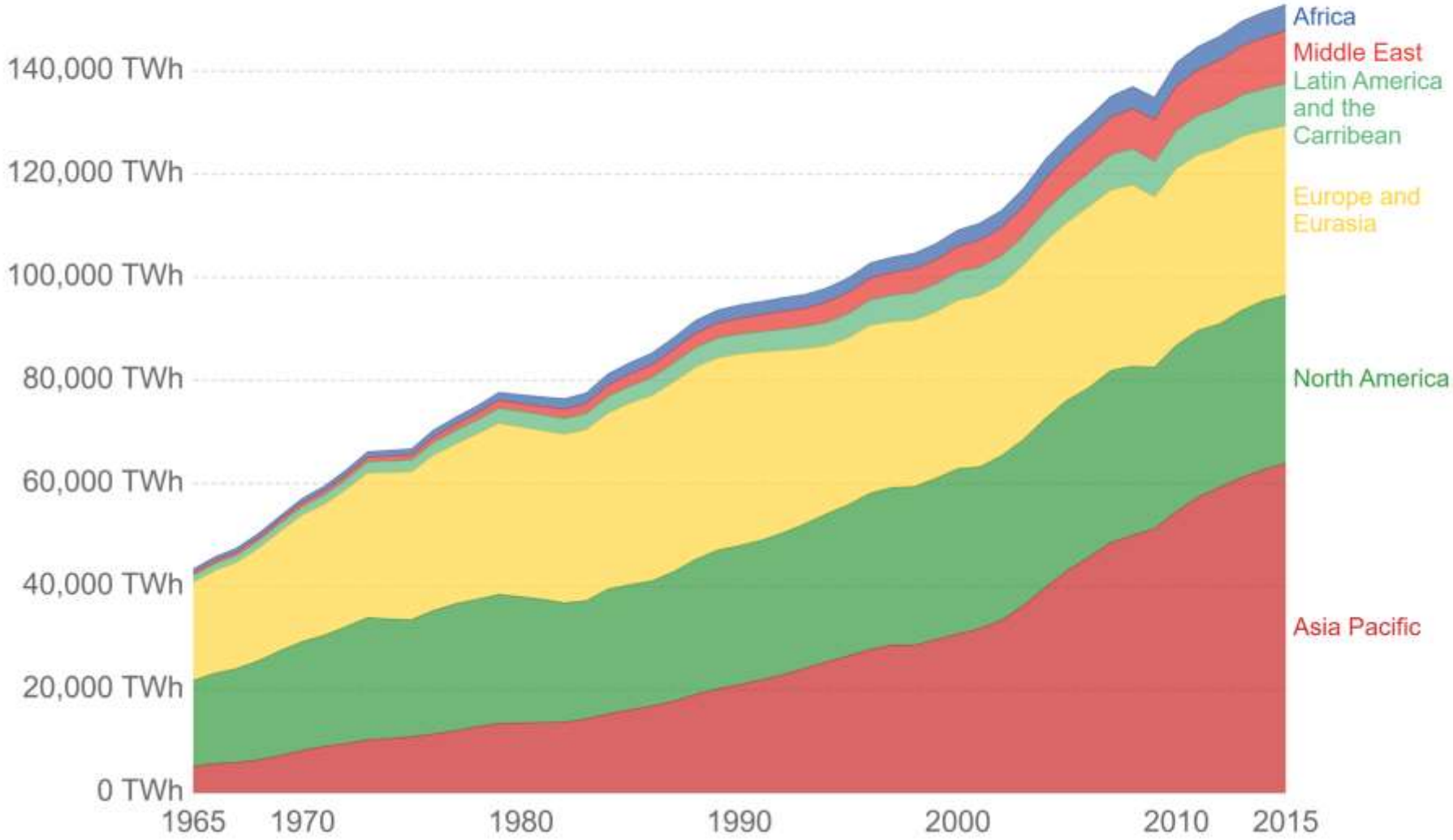

Source: BP Statistical Review 2016

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)

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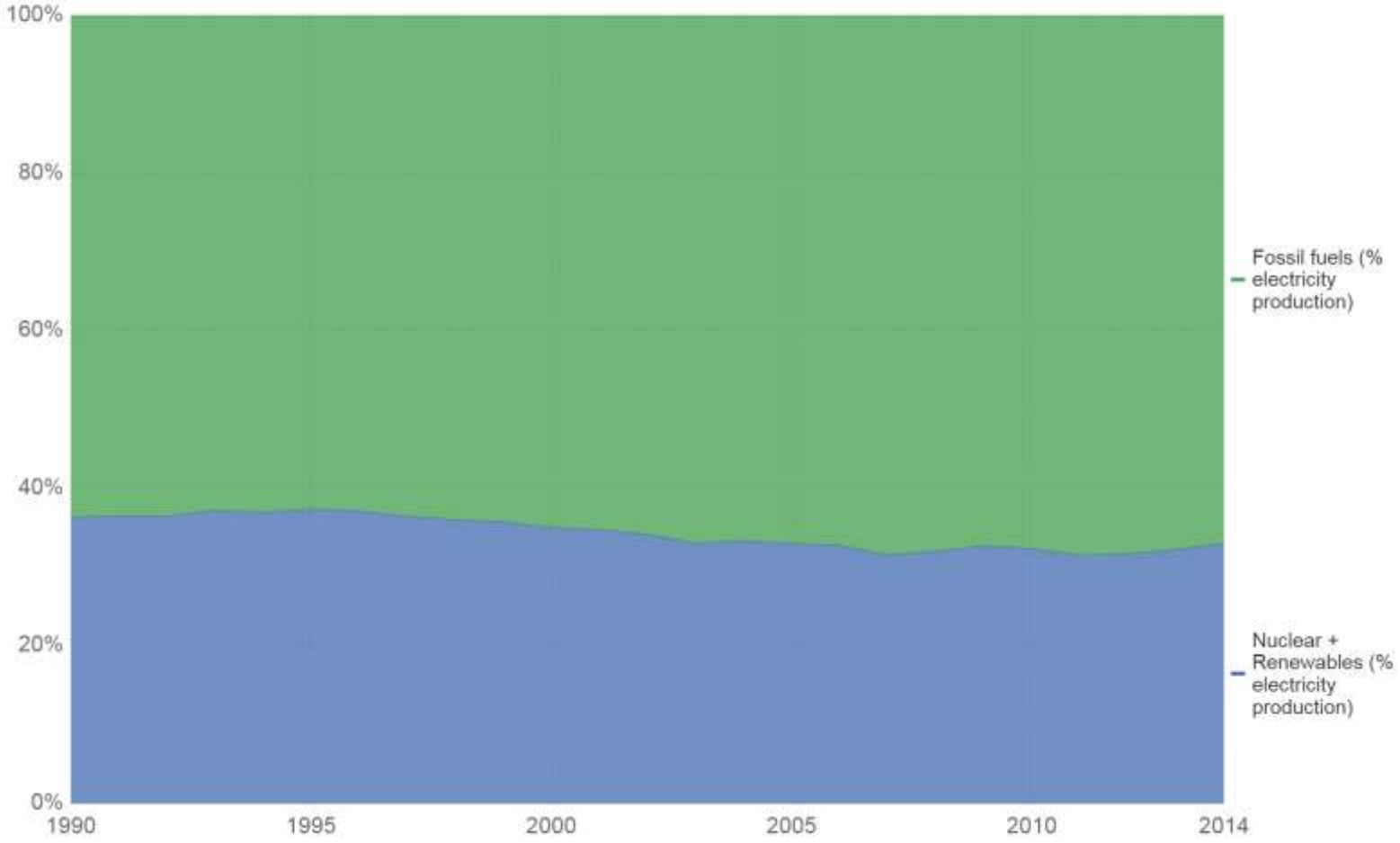

Source: World Bank- World Development Indicators (WDI)

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Energy use vs. GDP per capita, 2015

Annual energy use per capita, measured in kilowatt-hours per person vs. gross domestic product (GDP) per capita, measured as 2011 international-$.

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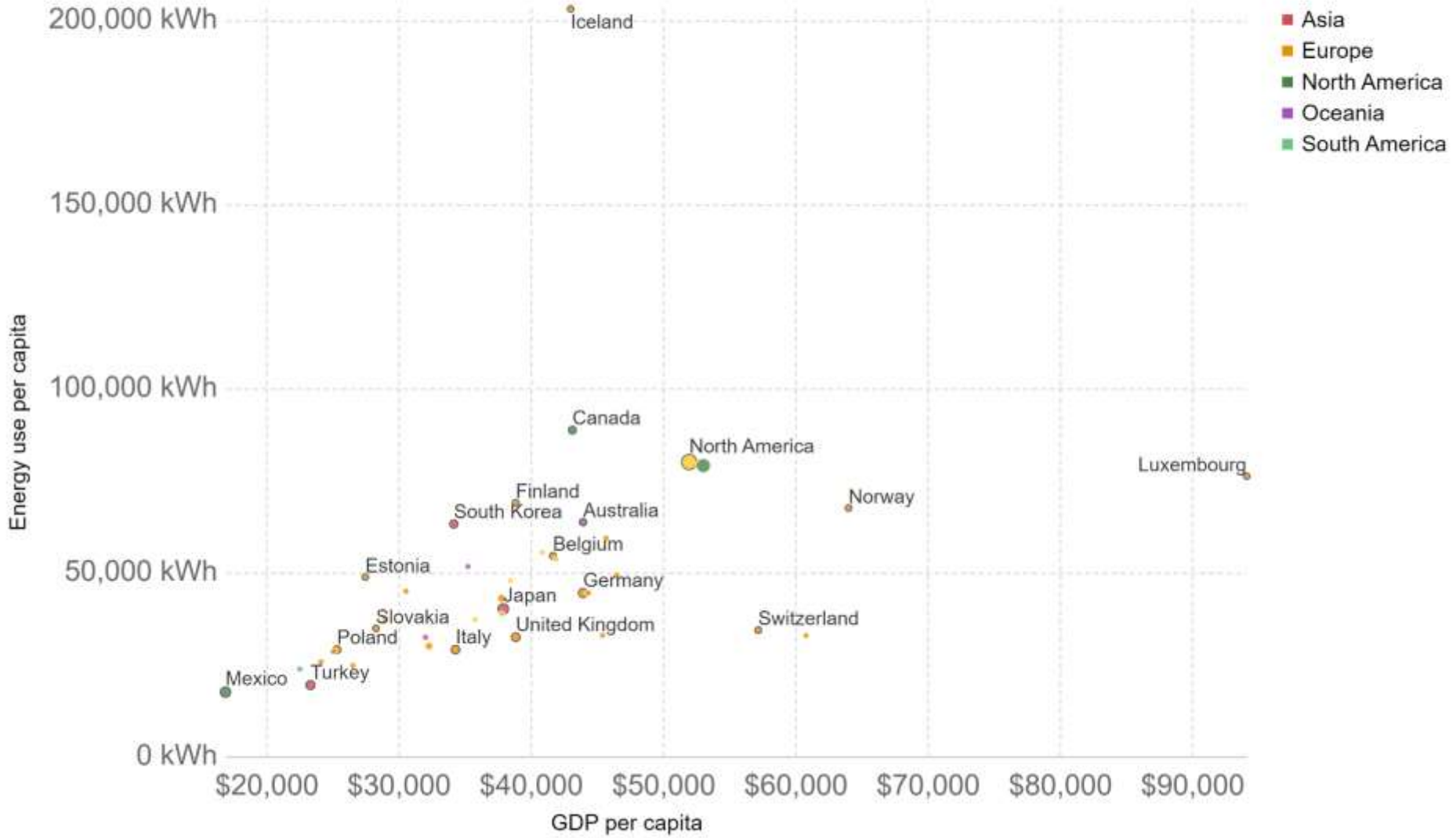
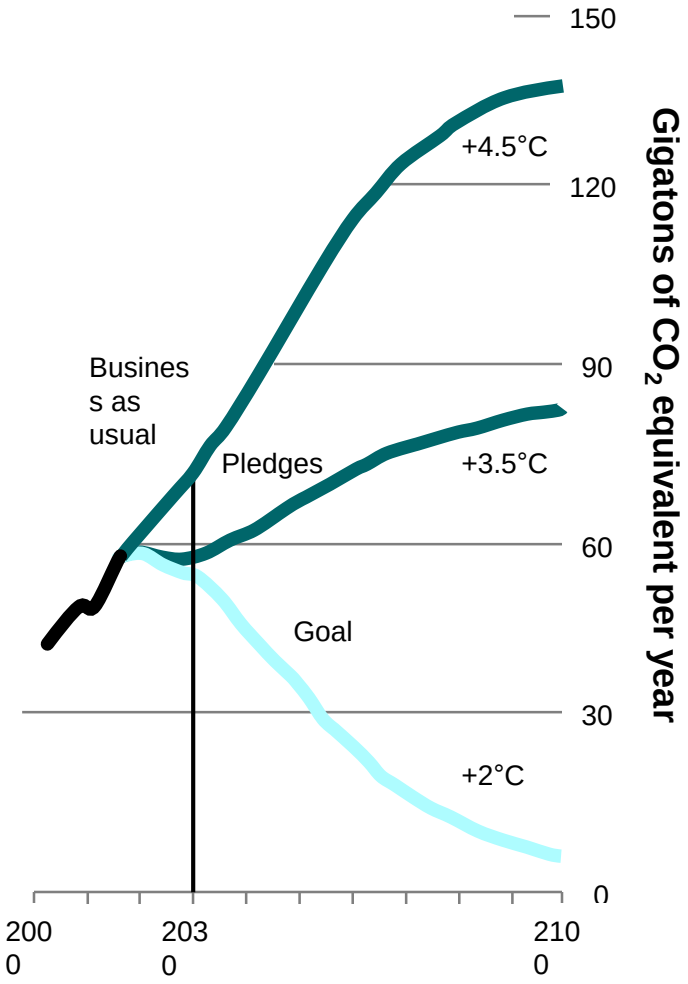


Source: International Energy Agency (IEA) via The World Bank

COP21 pathways



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Climate Change Adaptation Needs, by sector

Sector	Adaptation strategies
Water	Expand water storage and desalination
	Improve watershed and reservoir management
	Increase water-use and irrigation efficiency and water re-use
	Urban and rural flood management
Agriculture	Adjust planting dates and crop locations
	Develop crop varieties adapted to drought, higher temperatures
	Improved land management to deal with floods/droughts
	Strengthen indigenous/traditional knowledge and practice
Infrastructure	Relocate vulnerable communities
	Build and strengthen seawalls and other barriers
	Create and restore wetlands for flood control
	Dune reinforcement
Human health	Health plans for extreme heat
	Increase tracking, early-warning systems for heat-related diseases
	Address threats to safe drinking water supplies
	Extend basic public health services

Climate Change Adaptation Needs, by sector

Sector	Adaptation strategies
Transport	Relocation or adapt transport infrastructure
	New design standards to cope with climate change
Energy	Strengthen distribution infrastructure
	Address increased demand for cooling
	Increase efficiency, increase use of renewables
Ecosystems	Reduce other ecosystem stresses and human use pressures
	Improve scientific understanding, enhanced monitoring
	Reduce deforestation, increase reforestation
	Increase mangrove, coral reef, and seagrass protection

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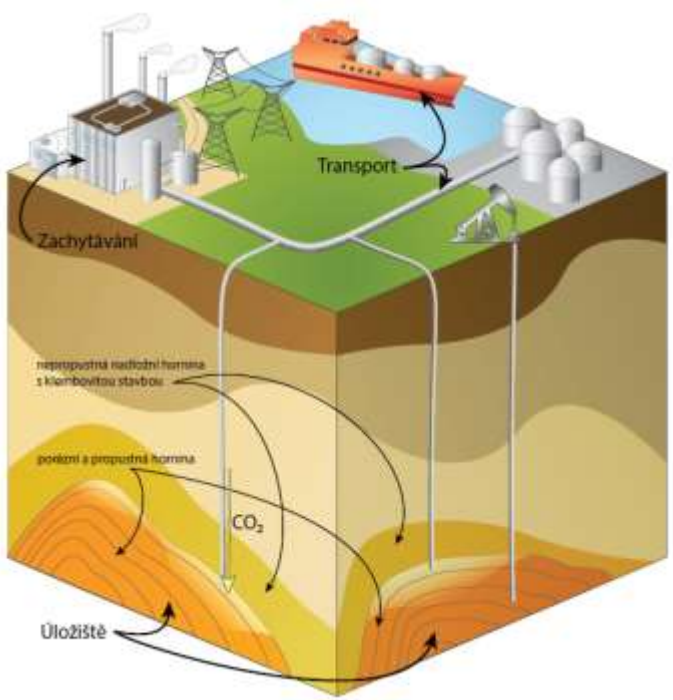
CCS technology

- May address the emissions in both energy and industrial sectors.
  - Capture
  - Transport
  - Storage



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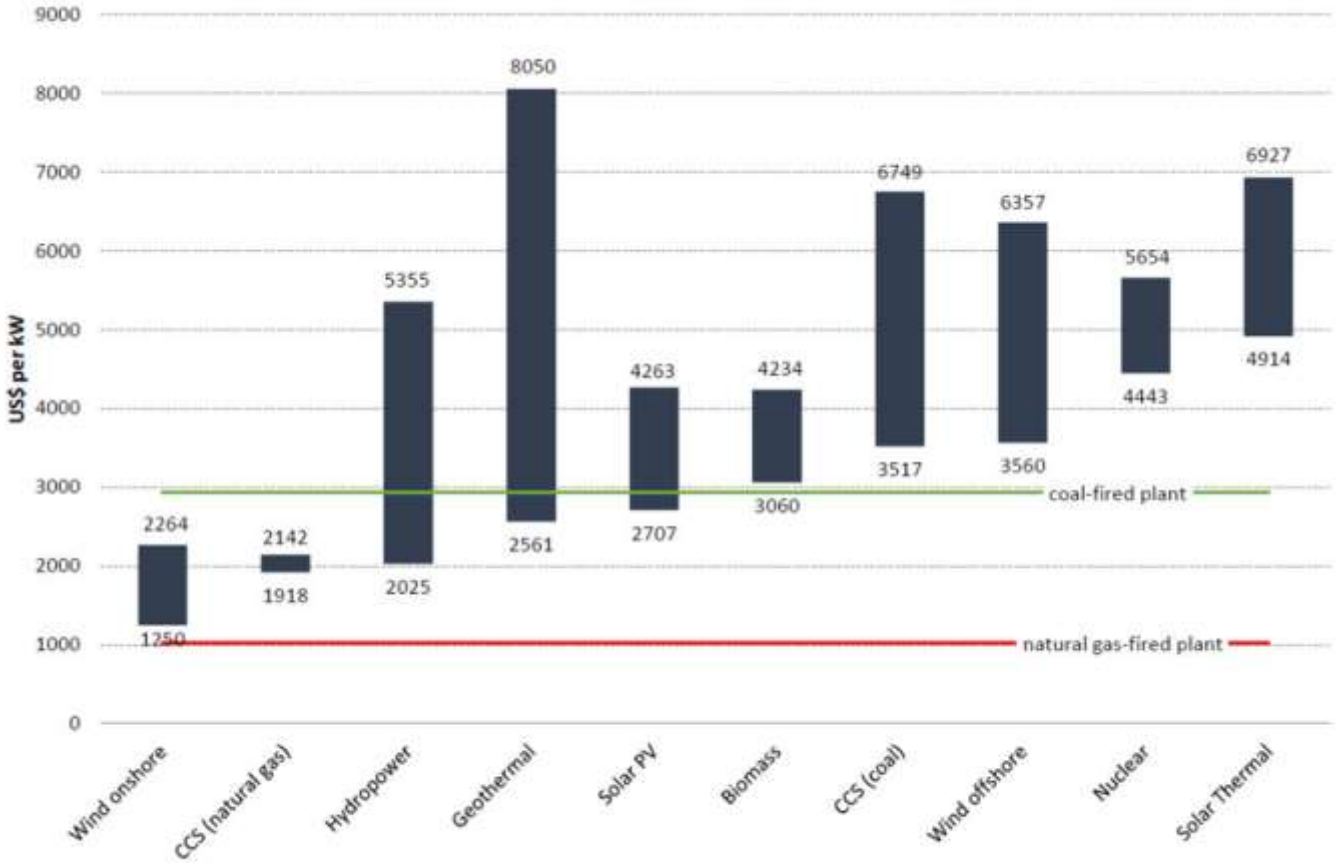
CAPEX of the US power plants (USD2014)



Source: Global CCS Institute analysis

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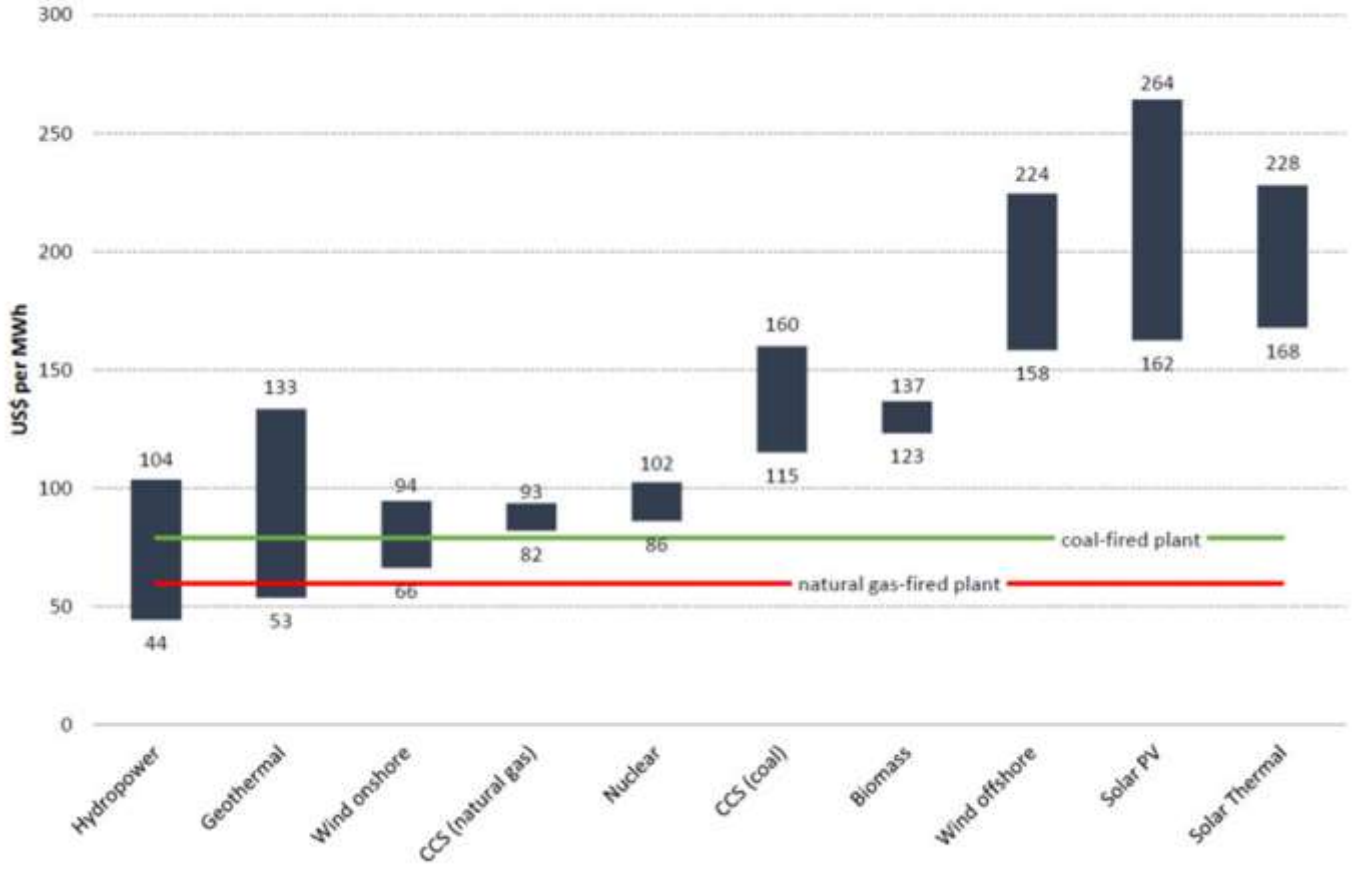
LCOE of the US power plant (USD2014)



Source: Global CCS Institute analysis

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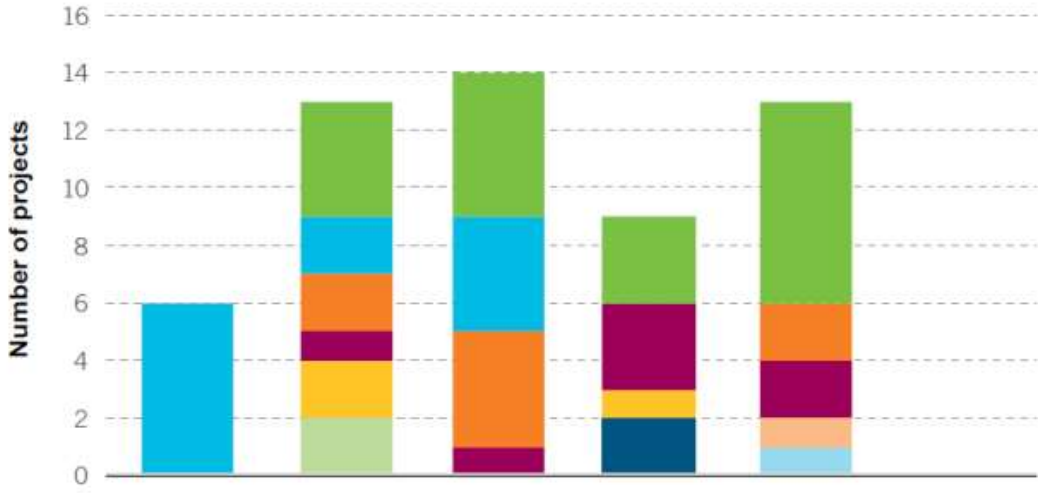
Existing units and units in preparation



	Identify	Evaluate	Define	Execute	Operate	**Total**
United States	0	4	5	3	7	**19**
China	6	2	4	0	0	**12**
Europe	0	2	4	0	2	**8**
Canada	0	1	1	3	2	**7**
Australia	0	2	0	1	0	**3**
Middle East	0	0	0	2	0	**2**
Other Asia	0	2	0	0	0	**2**
South America	0	0	0	0	1	**1**
Africa	0	0	0	0	1	**1**
Total	**6**	**13**	**14**	**9**	**13**	**55**

Sources

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