Dealing with Climate Change
Mitigation or/and Adaptation

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Outline

- Description of status quo
  - Greenhouse gases: not just the CO_2
  - Patterns and trends of production
    - Europe (EU) and its share
    - Wider effects of EU policies?
- Possible policies
  - Mitigation of climate change
  - Adaptation to the change
- Low carbon economy
  - Options
  - Costs
- Conclusion

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Greenhouse Gases

- While the CO_2 seems to be the biggest problem, it is not the only greenhouse gas
  - There are naturally occurring greenhouse gases: water vapour, ozone (0_3)
- Gases produced by human activity
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
  - Hydrofluorocarbons (HFCs)
  - Perfluorinated compounds:
    - Sulphur hexafluoride (SF_6)
    - Nitrogen triflouride (NF_3)
    - Perfluorocarbons (PFCs)
  - Fluorinated ethers (HFEs)
  - Perfluoropolyethers (e.g., PFPEs)
  - Chlorofluorocarbon (CFCs)
  - Hydrochlorofluorocarbon (HCFCs)

Source: Greenhouse Gas Protocol, National Geographic

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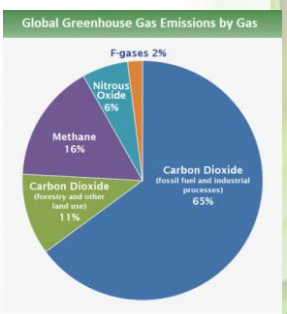
Global Data: 2010



Source: IPCC (2014); Exit based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

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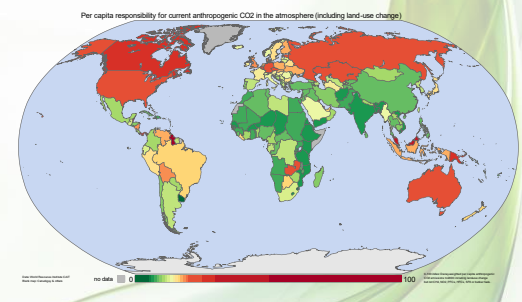
Responsibility for the Anthropogenic CO_2



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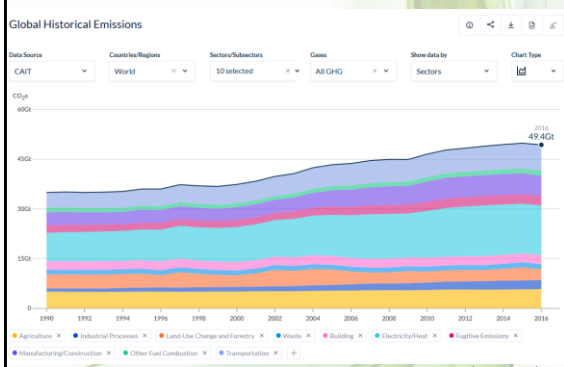

Source: Climatewatch
Link to data on moodle

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Problems with the Data & Comparisons

- Availability of data for various types of activities
- The role of value chains: allocation of the emissions (and of the responsibility)
- Example:
  - The often mentioned case of ships and bunker fuels

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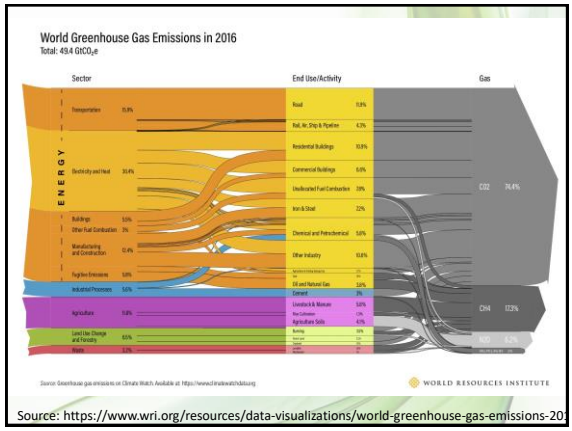

Source: https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-201

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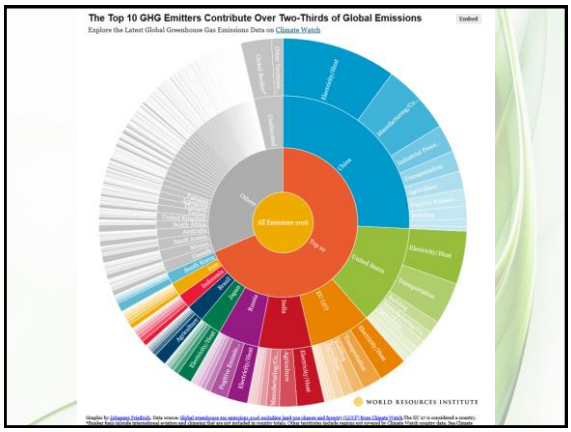

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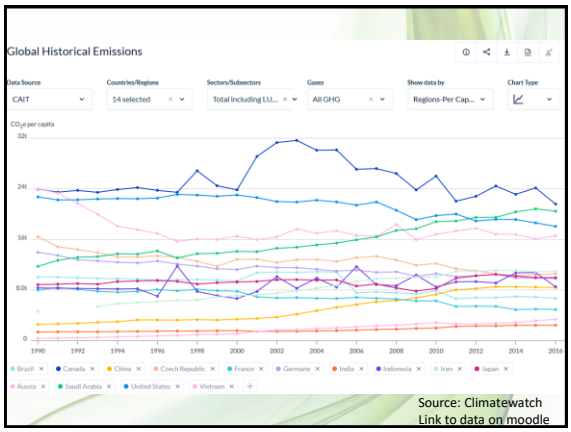

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Official EU Data

- Overview:
  - https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics#Trends_in_greenhouse_gas_emissions
- Greenhouse gas emission statistics:
  - https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics&redirect=no

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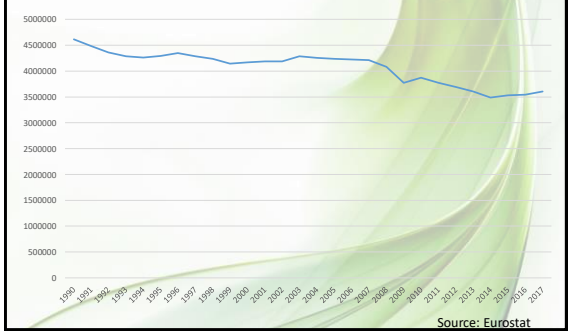
EU 27: Greenhouse Gas Emissions

CO_2 + CO_2 equivalents of N_20, CH_4, HFC, PFC, SF6, NF3 in thousands of tonnes, all sectors and indirect CO_2



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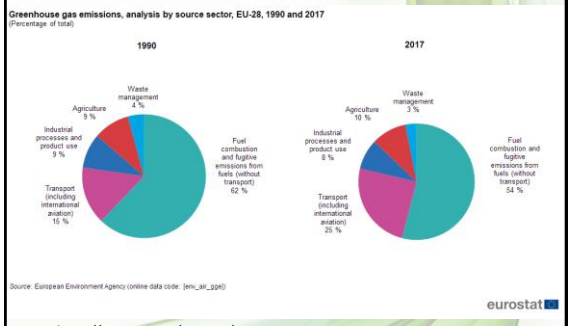
Greenhouse gas emissions, 1990 & 2017



https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics#Trends_in_greenhouse_gas_emissions

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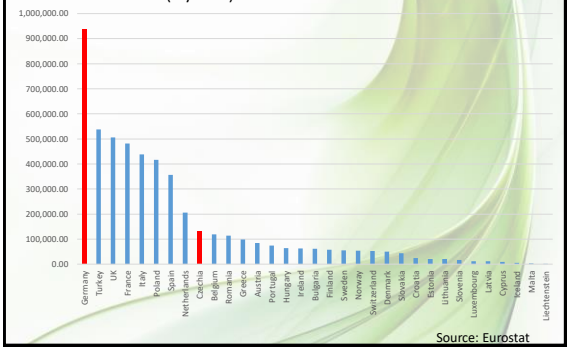
Contribution by Country, 2017

EU28 + Iceland (Kyoto) + selected other countries



Source: Eurostat

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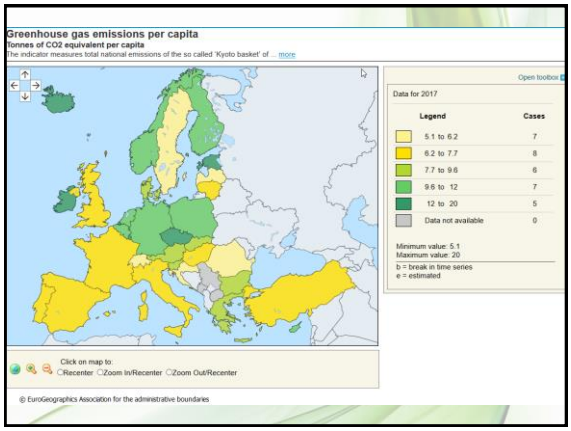

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EU Measures and Promises

- For 2020, the EU has committed to cutting its emissions to 20 % below 1990 levels.
- This commitment is one of the headline targets of the Europe 2020 growth strategy, known as the Climate and Energy package.
- The headline target for a 20 % GHG emissions reduction by 2020 includes international aviation but excludes LULUCF.
- The core policies that contribute to reaching this target are the **EU Emissions Trading System**, covering major polluters in energy and industry, including aviation, and responsible for roughly 45 % of all emissions, and the **Effort-Sharing Decision**, covering the remaining emissions (agriculture, waste, buildings, etc.), under national binding targets for each EU Member State

Source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics#Trends_in_greenhouse_gas_emissions

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The EU: Alone or Not?

- The EU can:
  - Influence its own manufacturing/transportation/energy sectors
    - Danger: indirect effects (substitution)
  - Perhaps it can inspire other countries to voluntary follow similar policies
  - Can it exert pressure on non-member (and non-associated) countries?
    - Ability of the EU to "project power"?
    - **Effects of the EU market?**
      - Example: GDPR
        - Non-EU companies preferred to adapt to the regulation
        - EU regulation plays the role of a role model for regulatore effort in other countries
      - Possible test: EU-Mercosur agreement

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Mitigation/Decarbonization

Meet the Paris Target!

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Mitigation: Focus on GHG (CO_2) Reduction – Climate Goals

- The attitude is logical: let's preserve the Earth as it is
- Proponents of the approach may not see the situation as hopeless
  - Variation of per capita GHG emissions suggests opportunities for progress
  - Limited success in actual emissions might have been achieved
    - Morgan: positively mentions the success in transportation (car) regulation
- And they fear that the chasing possible alternatives might distract us or cause even greater (unforeseen) problems

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Problems and Additional Threats

- Our progress has been extremely limited
  - We are not meeting the original objectives, we are quickly using up the original estimated "carbon budget"
- We do not even have any guarantee that the original objectives make any sense
- Some nasty surprises may be ahead of us
  - GHG potential of permafrost thawing….
  - Nonlinearities – precipitous effects of warming on climate
- While the alternatives appear cynical and troublesome, actual mitigation might require negative emissions

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- "A small forcing can cause a small [climate] change or a huge one."

  — *National Academy of Sciences, 2002*

- Not only for climate but for many other complex systems, scientists had come to accept that a small, even random, event could trigger sweeping change
  - https://history.aip.org/climate/rapid.htm

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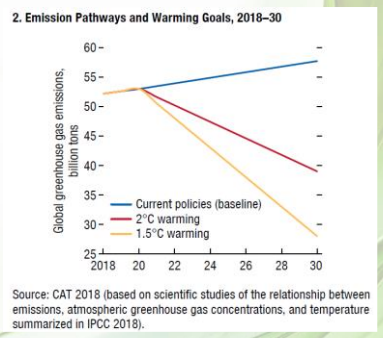
Objectives v. Reality



Source: CAT 2018 (based on scientific studies of the relationship between emissions, atmospheric greenhouse gas concentrations, and temperature summarized in IPCC 2018).

Cited via IMF (2019).

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Zero or Even Negative GHG Emission

- We might be able to change the trends more abruptly if we attempt to actively eliminate e.g. carbon dioxide
  - And store it….
- Similar technologies have been proposed, but
  - Many resemble science fiction
  - Possible scaling problems
  - Many seem to require quite a lot of energy
- Examples:
  - Geoengineering – modifications of atmosphere,
  - Carbon capturing
- Dangers:
  - Fake sense of security (solution is in the pipeline)
  - Law of unforeseen consequences

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Adaptation

Adapt or Perish!

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Why Adaptation?

- Previous successes limited, perhaps largely driven by fluctuations in economic activity
- The targets are arbitrary (Nordhaus)
  - *The world isn't saved should we limit atmospheric concentrations to 450 parts per million, nor lost should concentration surpass that threshold.*

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What are We Adapting To?

- Unusual and more extreme weather patterns
  - Related to that: draughts, but also flash floods in some areas
- Global sea level rise (SLR) – (Groeskamp & Kjellson 2020)
  - It lags behind global-mean temperature rise, but it has risen over 21 cm since 1880 and it is accelerating (Church & White 2011).
  - Global mean SLR will continue beyond 2100 (Church et al. 2013).
- Accelerated pressure on agriculture
- Industry and energy production can be influenced too
  - July 2019: high temperatures and low river flows caused troubles to nuclear reactors in Europe
    - https://www.nrdc.org/experts/christina-chen/nuclear-vs-climate-change-feeling-heat-0
- Possible changes in migration

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How to Adapt?

- Infrastructure projects
  - Water reservoirs
  - Protection against flooding of selected areas
    - Inspiration: the Netherlands
      - Includes rather spectacular proposals such as the Northern European Enclosure Dam (Groeskamp & Kjellson, 2020)
  - Transportation networks
- Innovations in agriculture (food production)
- Relocation projects (intra- and international)
- Production technologies
  - Design of nuclear power stations
- Restructuring of global value chains

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Why not Both? Is There a Conflict?

- Issue #1: Possible clash of attitudes/philosophies
  - Mitigation – based on the logic of respecting and protecting the status quo
  - Adaptation – might include active steps in the form of modification of the environment
    - Possibly less focus on as fast reduction of CO_2 emissions
    - Changes/damage to the environment will be inevitable

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Is There a Conflict? (3)

- Issue #2: **Moral hazard and resources**
- Both sides emphasize the moral hazard of "the other" strategy
- The strategies might compete for resources

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Practical Path Forward

- A reasonable combination of both measures might exist (Nordhaus):
  - Speed up decarbonization
  - But have the long run in mind
    - Short run v. long run efficiency
      - Cheap solar panels v. efficient ones
      - Cheap gas v. nuclear plants
- Sounds nice – but is it achievable?

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Barriers to Solution

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Barriers to Solution

- Stages – what needs to be achieved:
  - Identification and acceptance
  - Technological barriers
  - Finding consensus at national level
  - Consensus at the EU level
- Political aspects:
  - **Distributional effects** at domestic level
    - Typically made worse by individual-specific uncertainty (Fernandez & Rodrik 1991)
  - **Rent-seeking:** Czech solar power 2008/2009
  - Distributional aspects at international level
  - **Decentralized nature** of global economy
    - Prisoner's dilemma
    - Stag hunt: inhibiting fear
  - Security aspects

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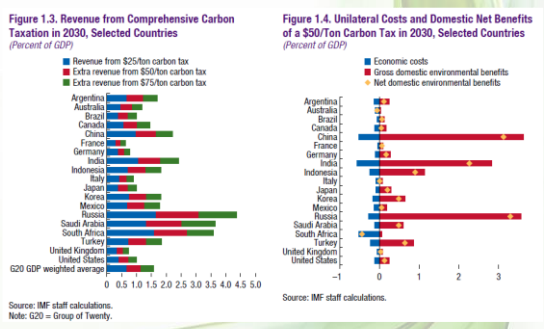

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The Prisoner's Game

Figure 3.2 Prisoners' Dilemma Game (ordinal form)

		Player Beta S1	Player Beta S2
Player Alpha	S1	3, 3	1, 4
Player Alpha	S2	4, 1	**2, 2**

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The Stag Hunt Game

Figure 3.3 Assurance game (Stag Hunt) (ordinal form)

		Player Beta S1	Player Beta S2
Player Alpha	S1	**4, 4**	1, 3
Player Alpha	S2	3, 1	**2, 2**

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Low Carbon Economy

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Our Options for Low Carbon Economy

- In plain terms:
  - Consume and produce less
    - But population is growing…
  - Consume and produce different products and services
  - Produce with the use of different technologies
  - Changes in the design of value chains (transportation): produce somewhere else
  - Use active elimination of greenhouse gases

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Technologies: Actual Options

- What can be included?
  - Clean(er) electric power:
    - Hydro
    - Wind
    - Solar
  - Better technology and regulation
    - Accumulation technologies
      - Problem of wind and solar:
        - Reliability and availability on demand (rather than capacity)
    - Economist (2018):
      - Clean(er) electric power + reliance on electric power (possibly hydrogen-based transportation)
  - Incentives and information
    - Fiscal issues: taxes
    - Correct pricing of climate-related risks
      - Implications for the functioning of financial system

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Fiscal Policies to Mitigate Climate Change

- International coordination required
- Ambitious tax changes/redistributive effort required
- IMF Fiscal Monitor (October 2019)
  - *Limiting global warming to 2°C or less requires policy measures on an ambitious scale, such as an immediate global carbon tax that will rise rapidly to $75 a ton of CO2 in 2030. Under such a scenario, over 10 years electricity prices would rise, on average, by 45 percent cumulatively and gasoline prices by 15 percent, for households, compared with the baseline (no policy action).*

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The average price on global emissions is currently $2 a ton, a tiny fraction of what is needed for the 2°C target

Table 1.1. Selected Carbon Pricing Arrangements, 2019

Country or Region	Year Introduced	2019 Price ($/Ton CO_2)	Coverage of GHGs, 2018: Million Tons	Coverage of GHGs, 2018: Percent
Carbon Taxes				
Chile	2017	5	47	39
Colombia	2017	5	42	40
Denmark	1992	26	22	40
Finland	1990	65	25	38
France	2014	50	176	37
Ireland	2010	22	31	48
Japan	2012	3	999	68
Mexico	2014	1–3	307	47
Norway	1991	59	40	63
Portugal	2015	14	21	29
South Africa	2019	10	360	10
Sweden	1991	127	26	40
Switzerland	2008	96	18	35
Emissions Trading Systems				
California, United States	2012	16	378	85
China	2020	na	3,232	
European Union	2005	25	2,132	45
Korea	2015	22	453	68
New Zealand	2008	17	40	52
Regional Greenhouse Gas Initiative[1]	2009	5	94	21
Carbon Price Floors				
Canada	2016	15	na	70
United Kingdom	2013	24	136	24

Sources: Stavins 2019; World Bank 2019a; and IMF staff calculations.
Note: CO_2 = carbon dioxide; GHG = greenhouse gas; na = not available.
[1] The Regional Greenhouse Gas Initiative is a market-based program in 10 states in the eastern part of the United States.

Source: IMF (2019)

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Table 1.2. Features of Alternative Mitigation Approaches

Alternative Mitigation Approaches	Potential for Exploiting Mitigation Opportunities	Use of Price/ Market Mechanism	Efficiency across Mitigation Responses Induced by Policy	Energy Price Impacts and Acceptability	Price Predictability	Revenue Generation	Administrative Burden
Carbon Tax	Full, if applied comprehensively (in practice, may contain exemptions)	Yes	People and firms choose most efficient way of reducing emissions	Higher energy prices can be challenging politically	Yes (if trajectory is clearly specified)	Yes (though exemptions may limit revenue base)	Small (if building on existing fuel or royalty tax systems)
Emissions Trading Systems	Full, if applied comprehensively (in practice, often limited to powerful/ large industries)	Yes	People and firms choose most efficient way of reducing emissions	Higher energy prices can be challenging politically	No (unless it includes price floors or similar mechanisms)	Maybe (if allowances are auctioned, but revenue base may be limited)	New capacity needed to monitor CO_2 trading markets
Feebates	Similar to regulations	Yes	People and firms choose most efficient approach within only one activity	Avoiding significant energy price increases may enhance acceptability	Yes (if trajectory is clearly specified)	No (recommended design is revenue neutral)	New capacity needed (for example, to apply fees/ rebates to power generators)
Regulations	Can exploit some key opportunities but not all (for example, reductions in vehicle use)	No	No automatic mechanism	Avoiding significant energy price increases may enhance acceptability	No (implicit prices vary with technology costs, energy prices, and so forth)	No	New capacity needed (for example, to monitor and enforce emission rate standards for power generators)

Source: IMF staff.
Note: CO_2 = carbon dioxide.

Source: IMF (2019)

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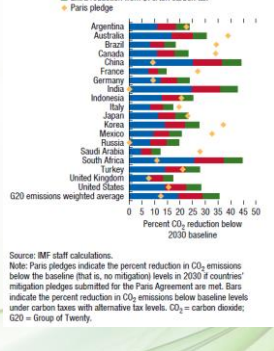
Figure 1.2. Reduction in Fossil Fuel CO_2 from Carbon Taxes in 2030, Selected Countries



Source: IMF staff calculations.
Note: Paris pledges indicate the percent reduction in CO_2 emissions below the baseline (that is, no mitigation) levels in 2030 if countries' mitigation pledges submitted for the Paris Agreement are met. Bars indicate the percent reduction in CO_2 emissions below baseline levels under carbon taxes with alternative tax levels. CO_2 = carbon dioxide; G20 = Group of Twenty.

Source: IMF (2019)

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Conclusion:
What Can be Done Now?

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References

- ClimateWatch data
- Eurostat: Greenhouse gas emissions by source sector (published on Feb 24, 2020)
- Gillingham & Stock (2018) - The Cost of Reducing Greenhouse Gas Emissions. Journal of Economic Perspectives—Volume 32, Number 4—Fall 2018—Pages 53–72
- IMF (2019): IMF Fiscal Monitor (October 2019)
- IMF (2019b): Economics of Climate
- IPCC (2014)
- EPA (2019): Global Greenhouse Gas Emissions Data
  - https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data
- World Resource Institute Interactive Data
  - https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016

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