Some economics of climate change: The social cost of carbon

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Overview

- Incentivizing action on climate change
- Putting a price on carbon
- Trends in carbon pricing
- Social cost of carbon
- Carbon tax vs cap-and-trade
- Carbon tax in Greece (case study)
- Conclusions

Incentivizing action on climate change

- Paris Agreement: central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century **well below 2°C above pre-industrial levels** and to pursue efforts to limit the temperature increase even further to 1.5°C
  - This is the first-ever universal, legally binding global climate deal (Dec 2015)
- Meeting the Paris Agreement objective requires the **right policies**.
- That means **creating incentives for change**
  - removing fossil fuel subsidies, introducing carbon pricing, increasing energy efficiency standards and implementing auctions for lowest cost renewable energy

Reducing GHG emissions by putting a price on carbon

- Explicit carbon pricing instruments are:
  - Emissions trading systems (ETSs)
  - Offset mechanisms
  - Carbon taxes
  - Results-based climate finance (RBCF)
- Implicit pricing instruments are:
  - Removal of fossil fuel subsidies (aka "negative carbon pricing")
  - Fuel taxation
  - Support for renewable energy
  - Energy efficiency certificate trading

Latest developments in climate change

- UN IPCC report (August 8, 2019) highlights the importance of land management in combatting climate change
- COP 25 (25th Conference of the Parties) of the UN Framework Convention on Climate Change Conference will take place in Santiago, Chile in December 2019 and is expected to further drive the global climate agenda

Explore the World's Greenhouse Gas Emissions

Find the newest data on global greenhouse gas emissions on **CAIT Climate Data Explorer**

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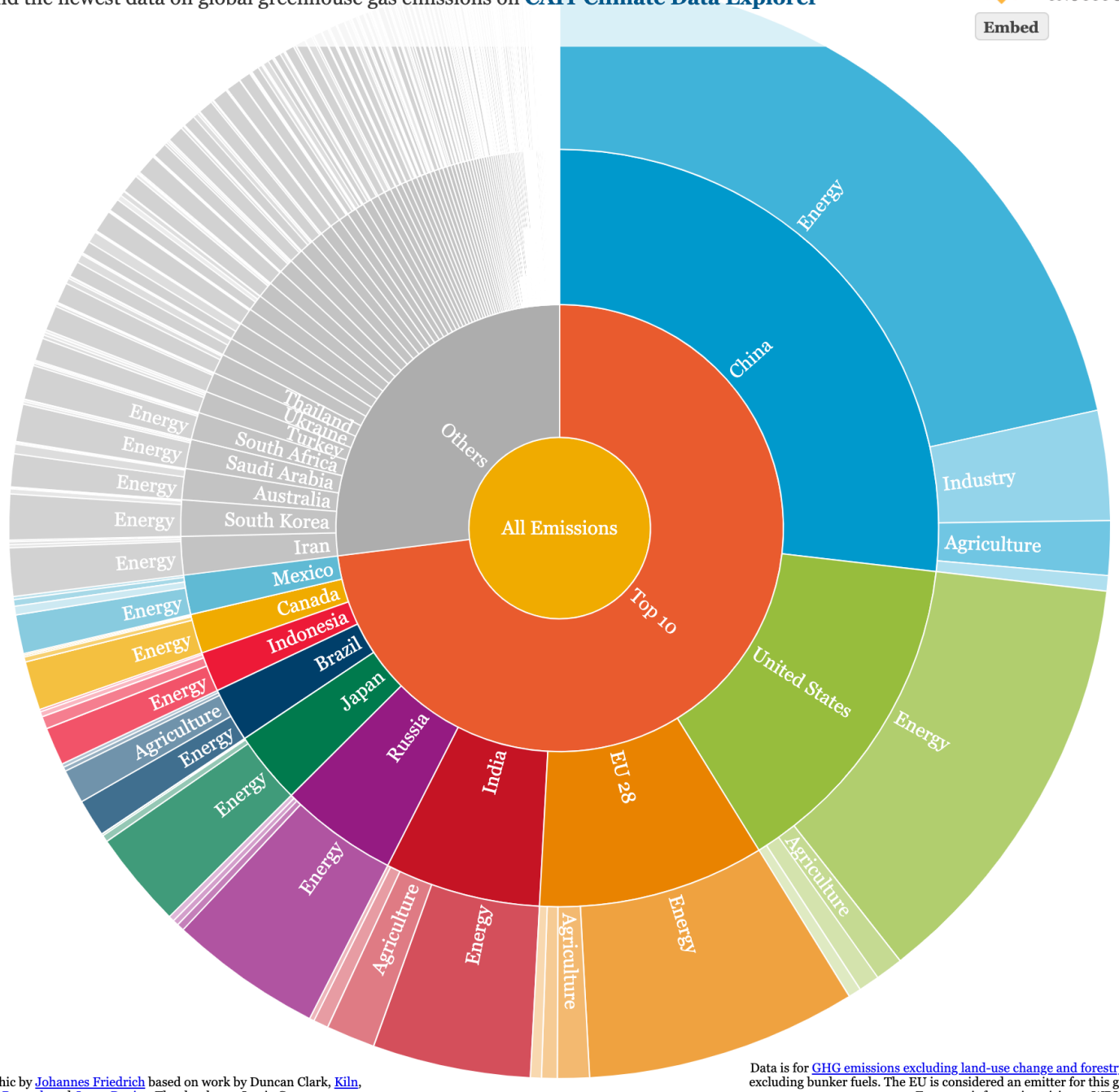
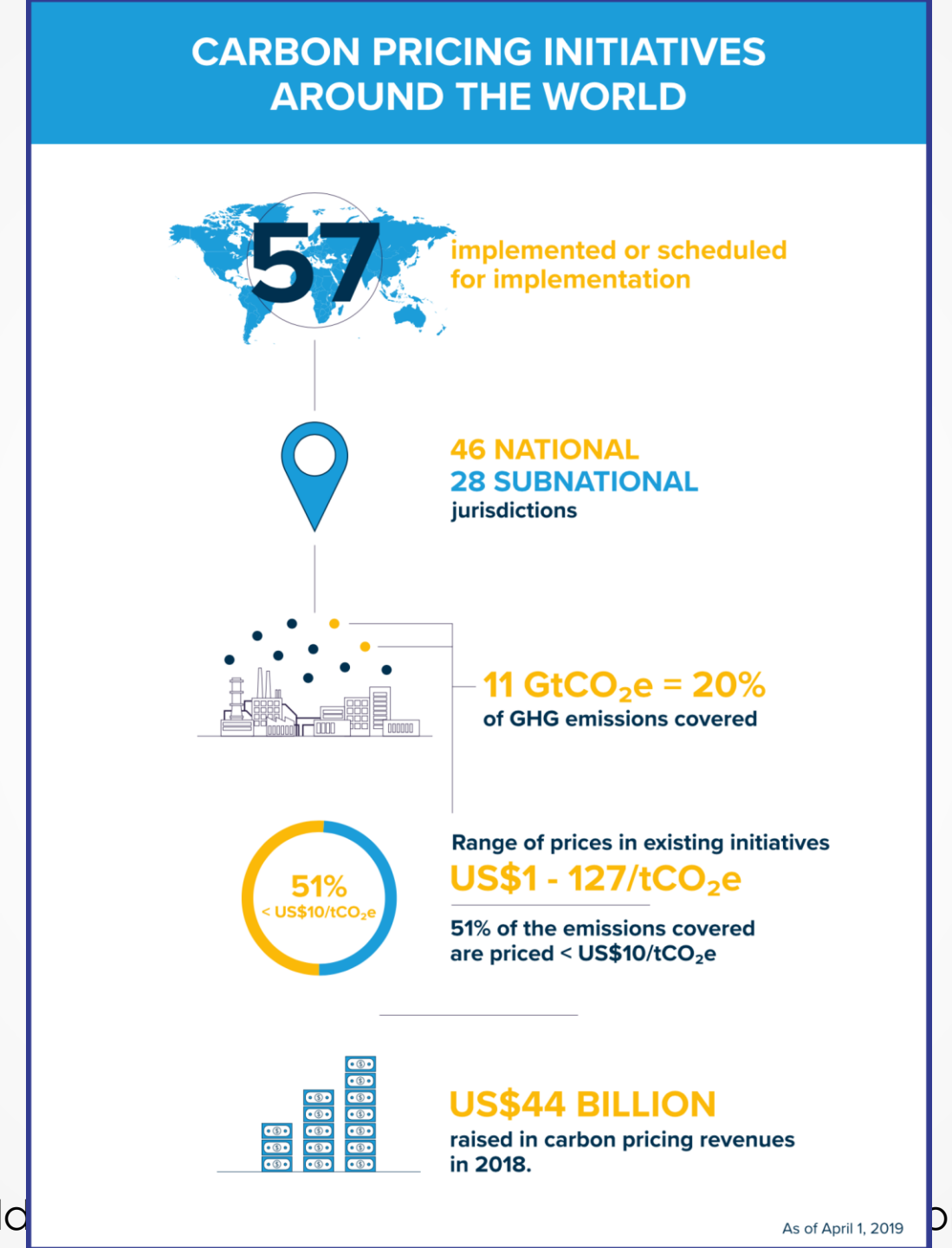


Graphic by Johannes Friedrich based on work by Duncan Clark, Kiln, Mike Bostock and Jason Davies. Thanks also to Jamie Cotta.

Data is for GHG emissions excluding land-use change and forestry and excluding bunker fuels. The EU is considered an emitter for this graph. For more information visit our WRI blog.



Source: World

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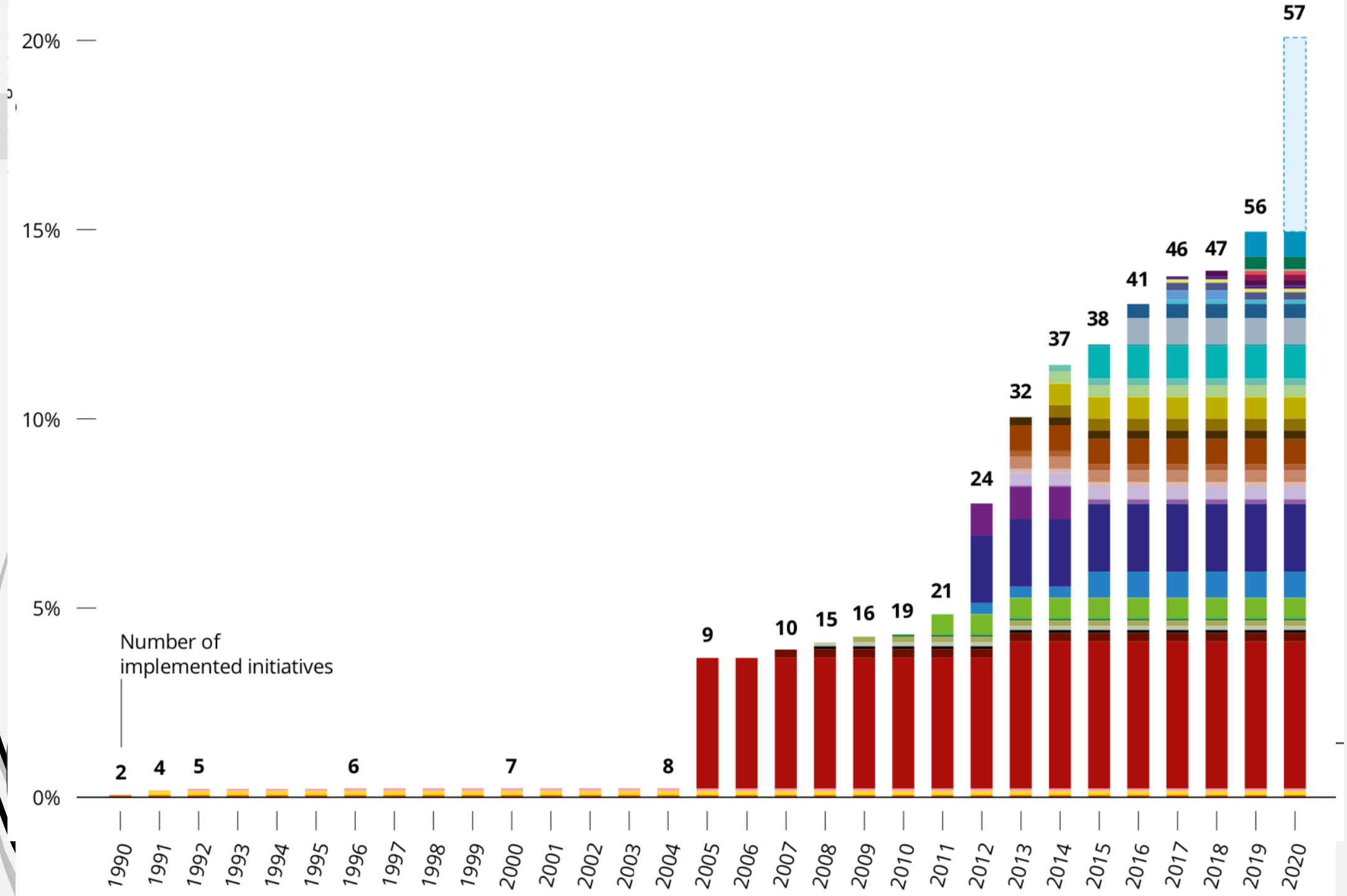
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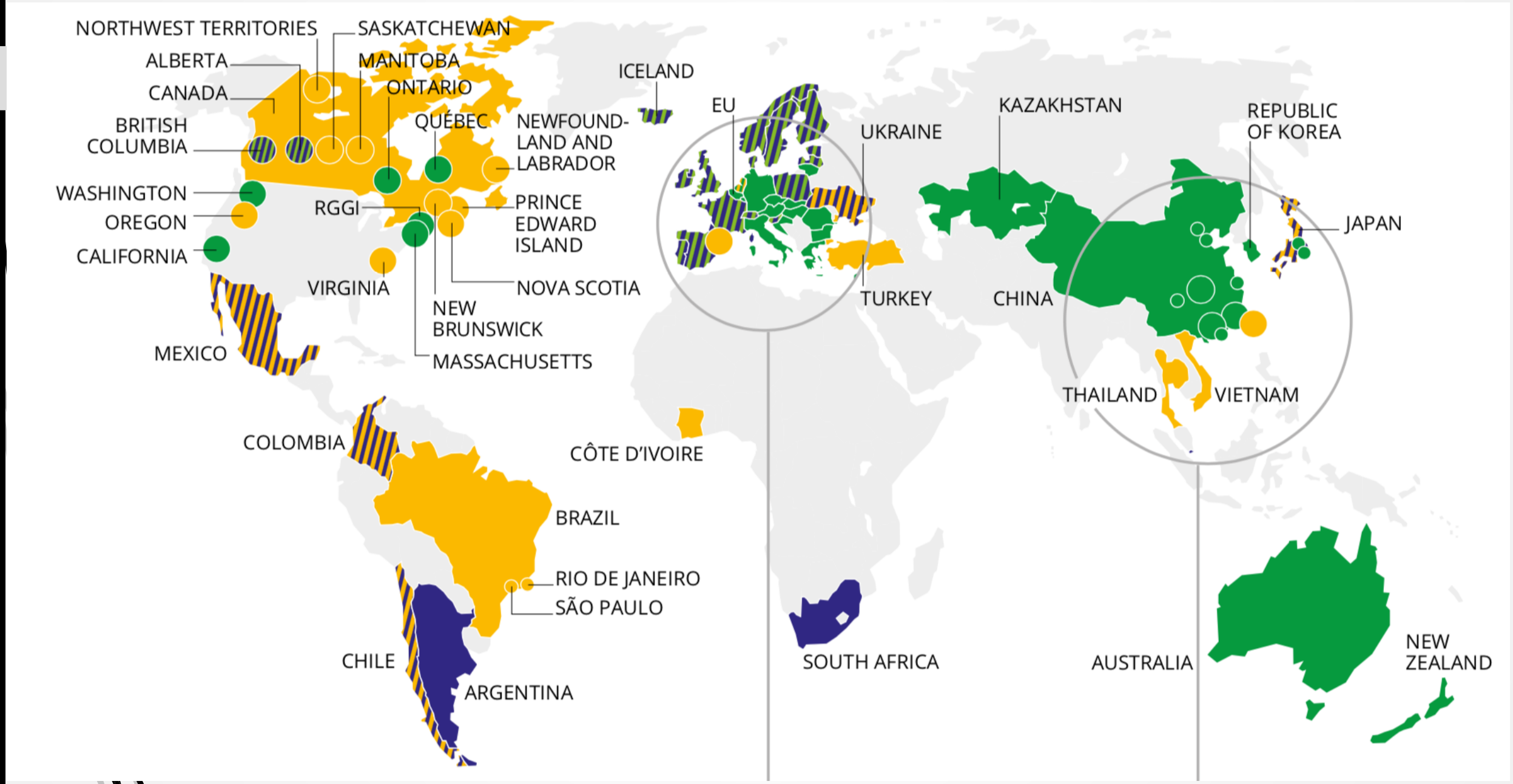
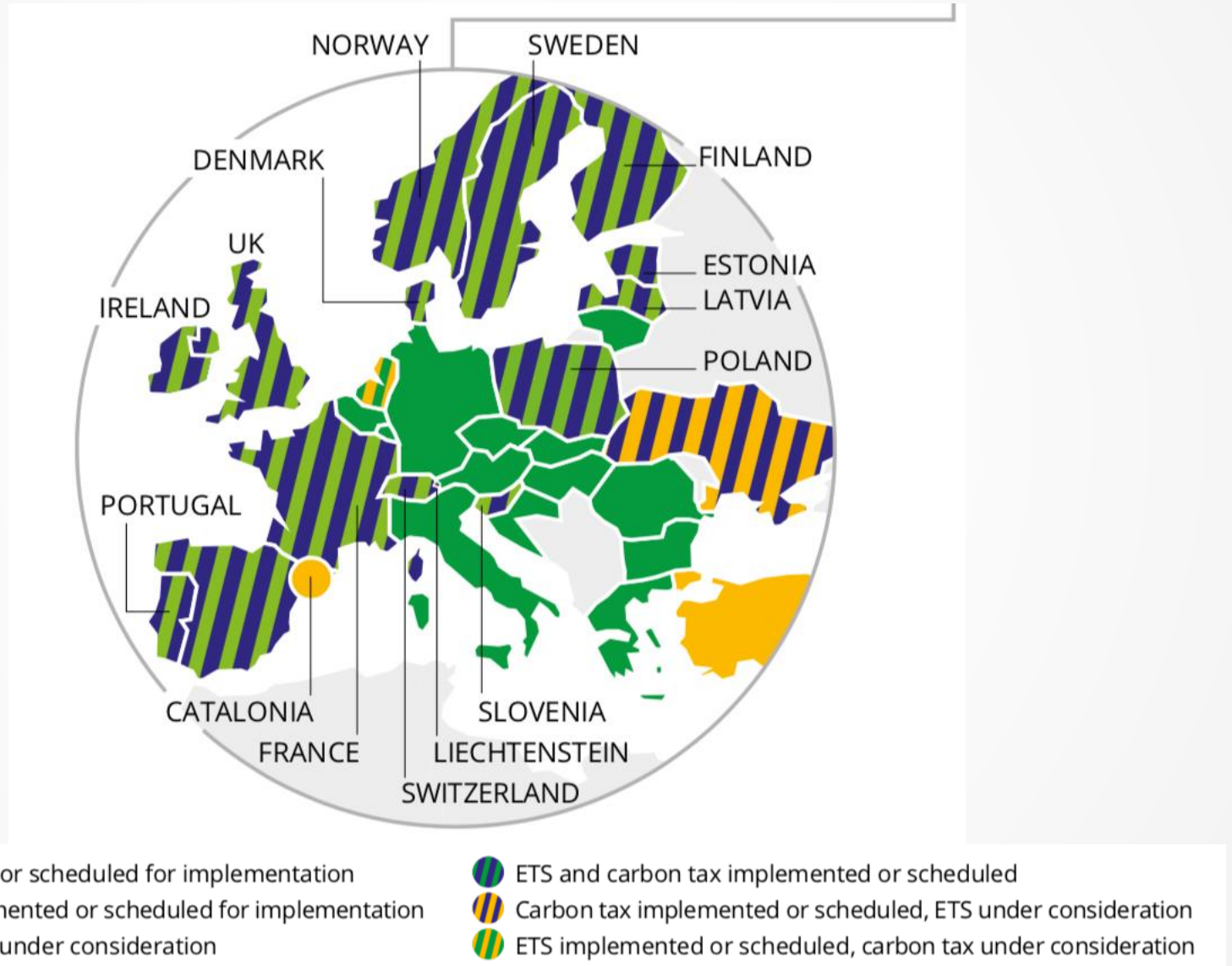
Regional, national and subnational carbon pricing initiatives



Source: World Bank and Ecofys, "State and Trends of Carbon Pricing 2018"

Regional, national and subnational carbon pricing initiatives



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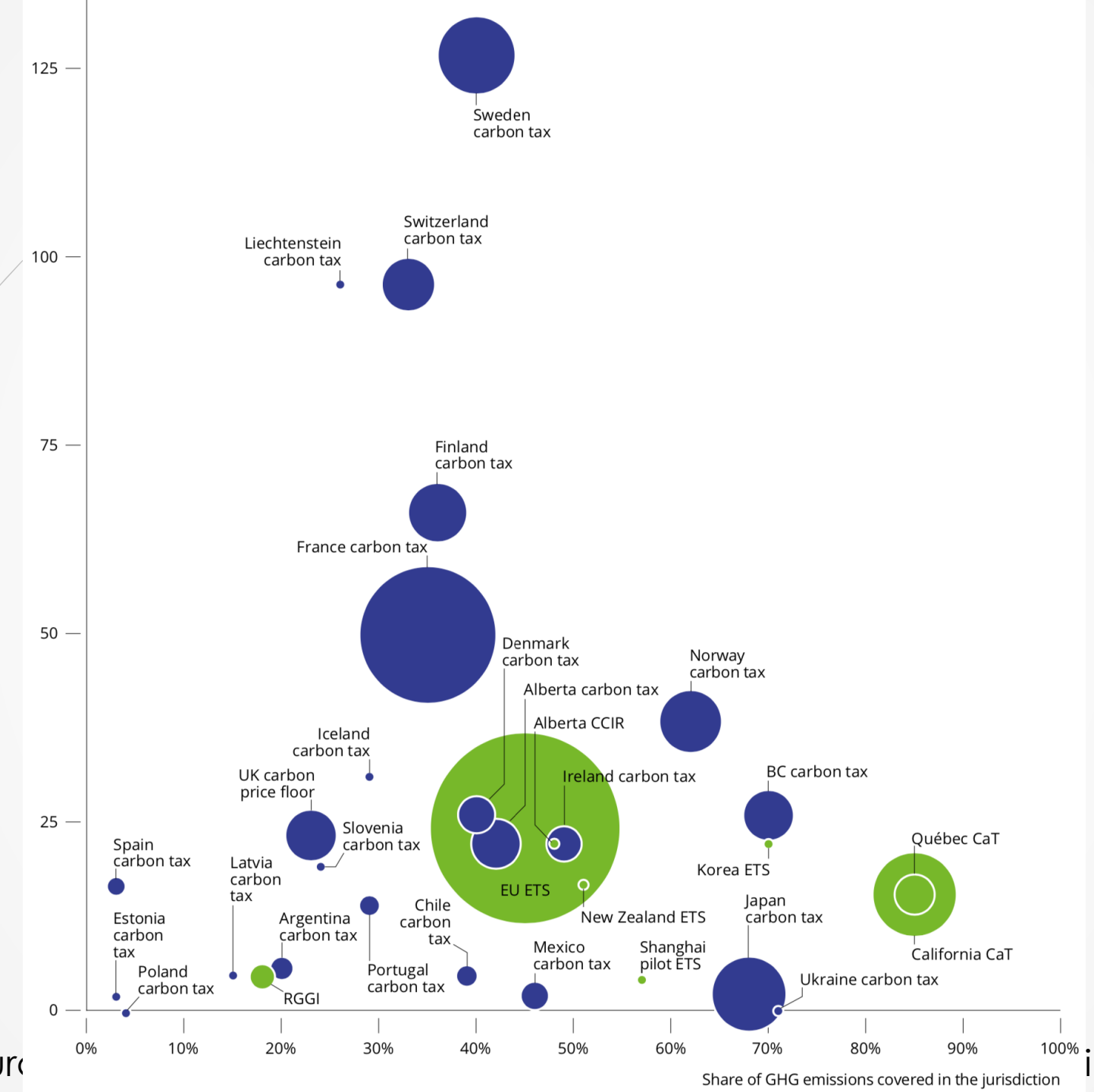


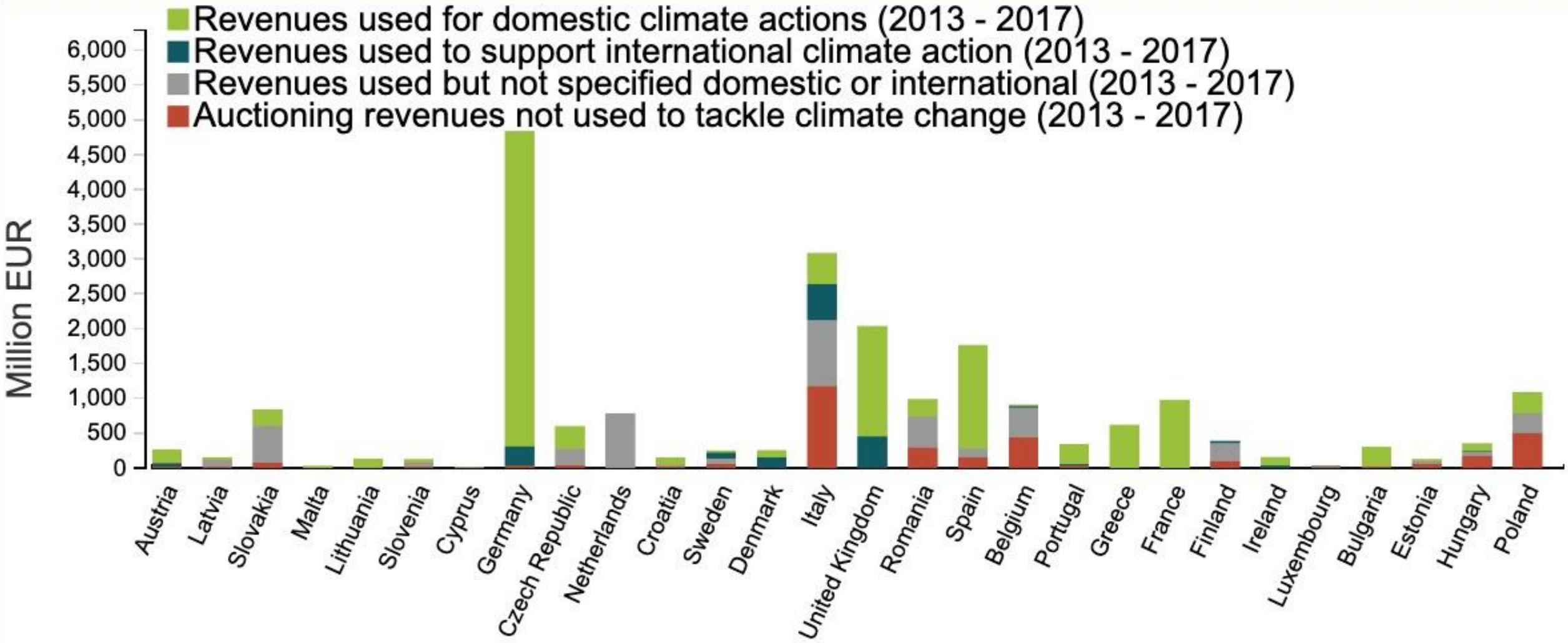
Carbon price, share of emissions covered and carbon pricing revenues of implemented carbon pricing schemes

Highest revenue from:

1. EU ETS
2. France carbon tax
3. Sweden carbon tax
4. California carbon tax

Sour ing 2019"

The ETS revenues scoreboard - who spent how much on what?



created by EU ETS Auctioning Revenues Scoreboard

Carbon tax: how much will you pay vs. how much will you get back?

	2019	2020	2021	2022	
ON	$244	$357	$463	$564	Average cost per household*
	$300	$439	$571	$697	Rebate
	$56	**$82**	**$108**	**$133**	**Difference**
NB	$202	$296	$386	$470	Average cost per household*
	$248	$365	$476	$583	Rebate
	$46	**$69**	**$90**	**$113**	**Difference**
MB	$232	$342	$447	$547	Average cost per household*
	$336	$495	$649	$797	Rebate
	$104	**$153**	**$202**	**$250**	**Difference**
SK	$403	$588	$768	$946	Average cost per household*
	$598	$883	$1,161	$1,419	Rebate
	$195	**$295**	**$393**	**$473**	**Difference**

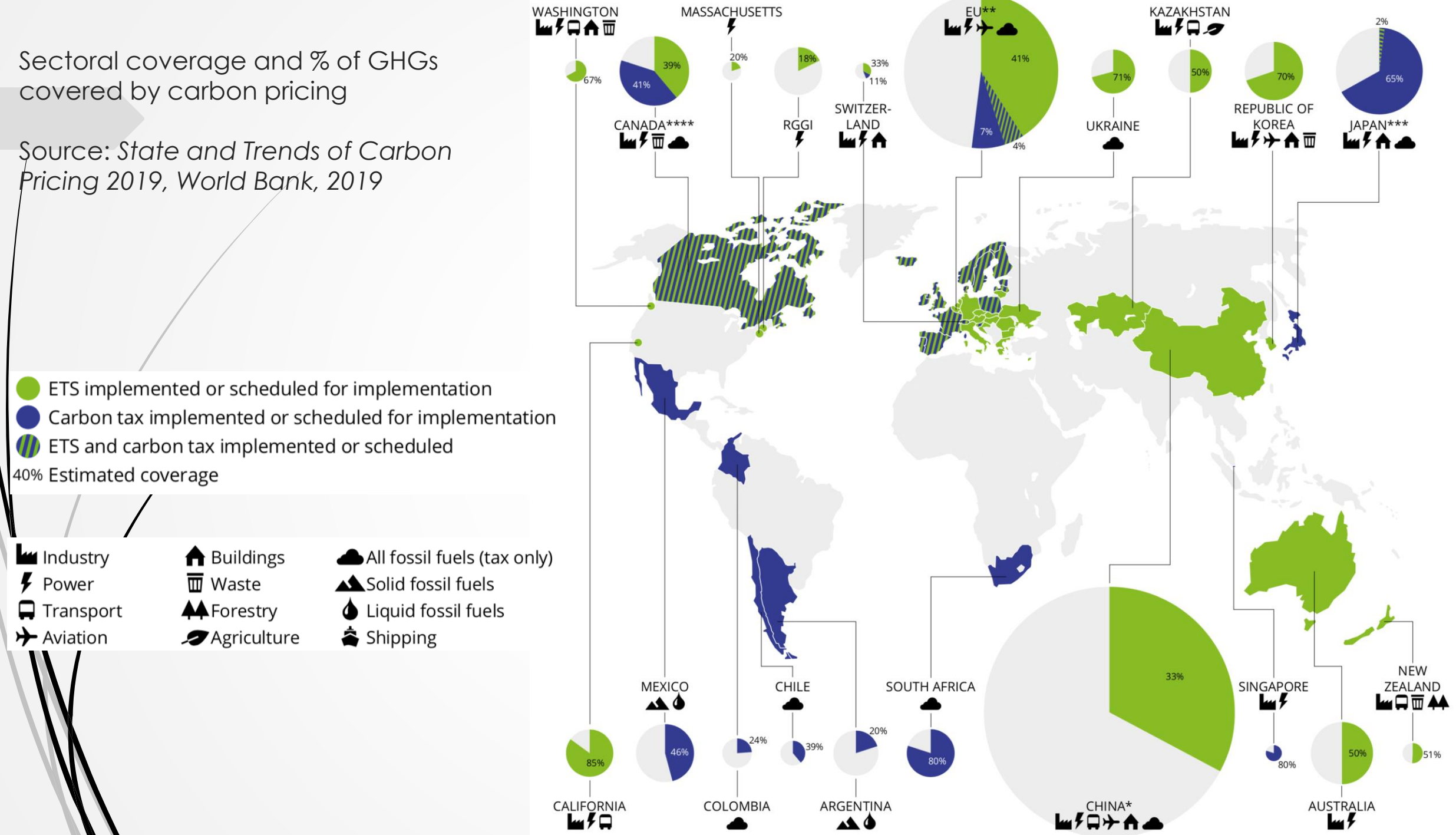
*defined as 2.6 people

CBC NEWS

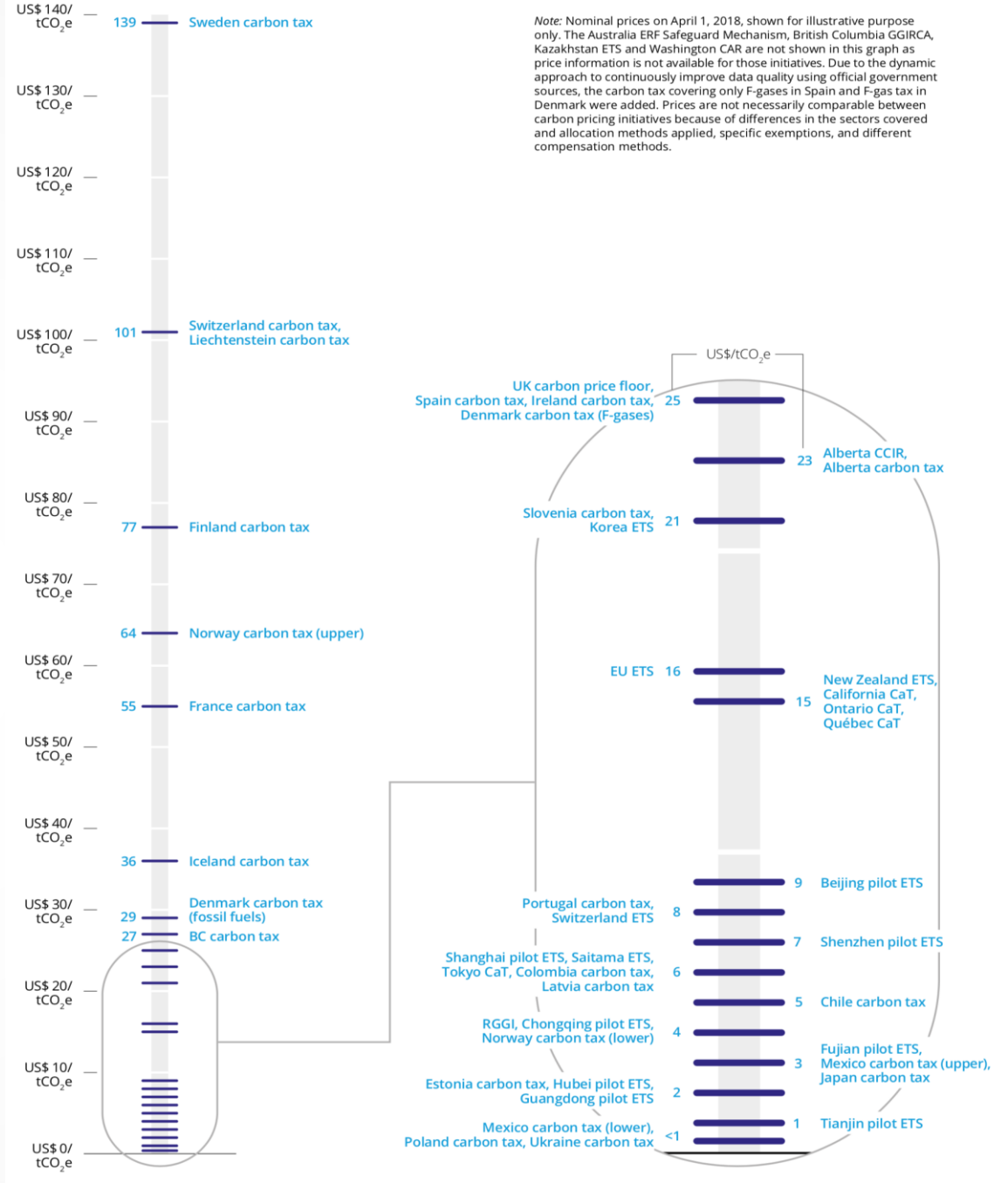
Source: Environment and Climate Change Canada

Sectoral coverage and % of GHGs covered by carbon pricing

Source: *State and Trends of Carbon Pricing 2019, World Bank, 2019*



Prices in implemented carbon pricing schemes



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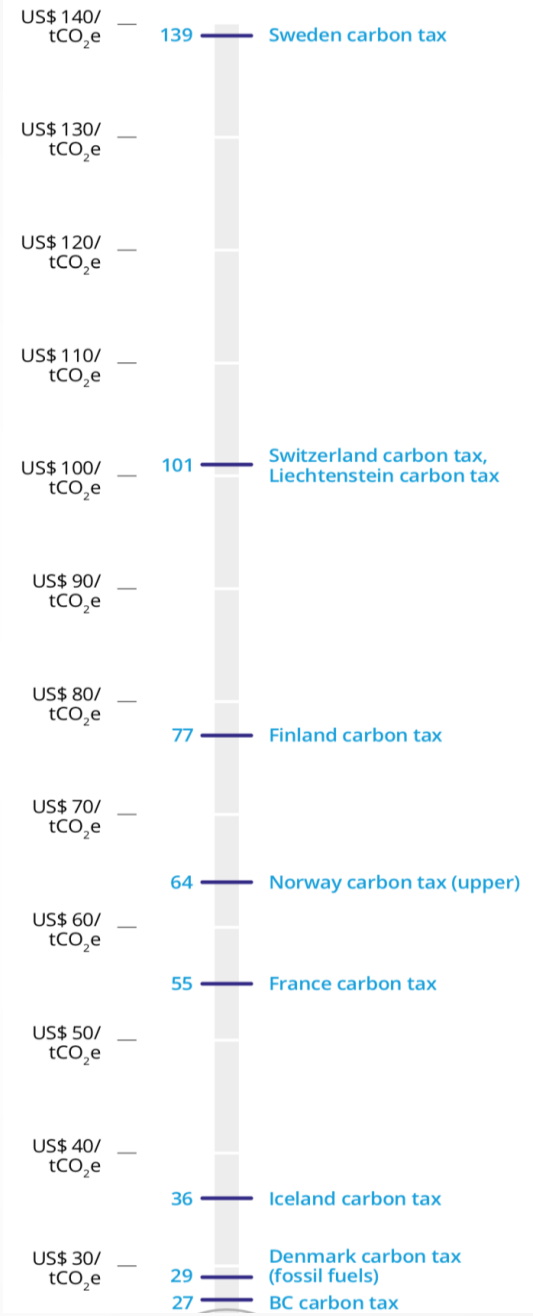

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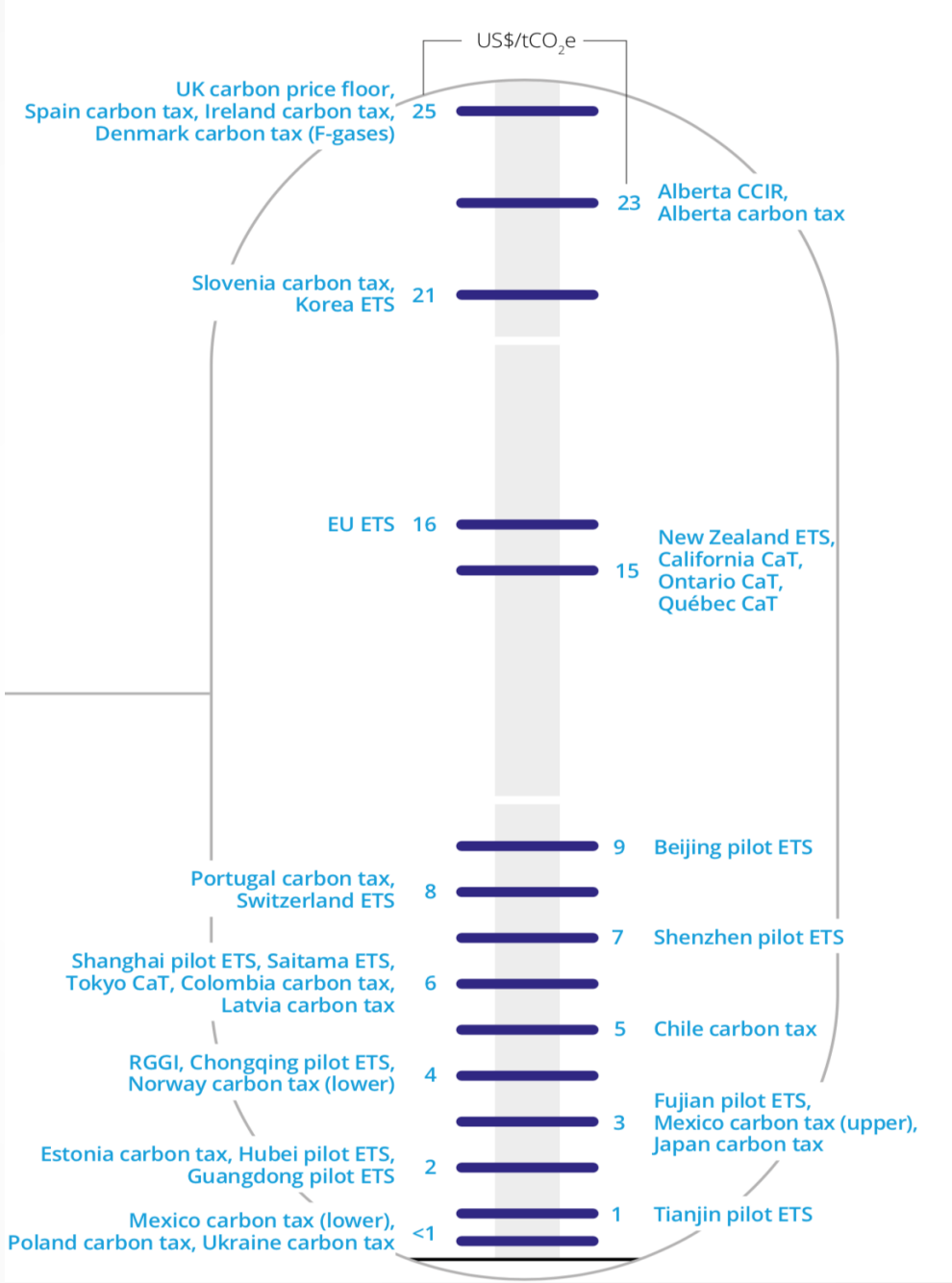


Source: World Bank and Ecofys, "State and Trends of Carbon Pricing 2018"

Climate-related financial disclosure

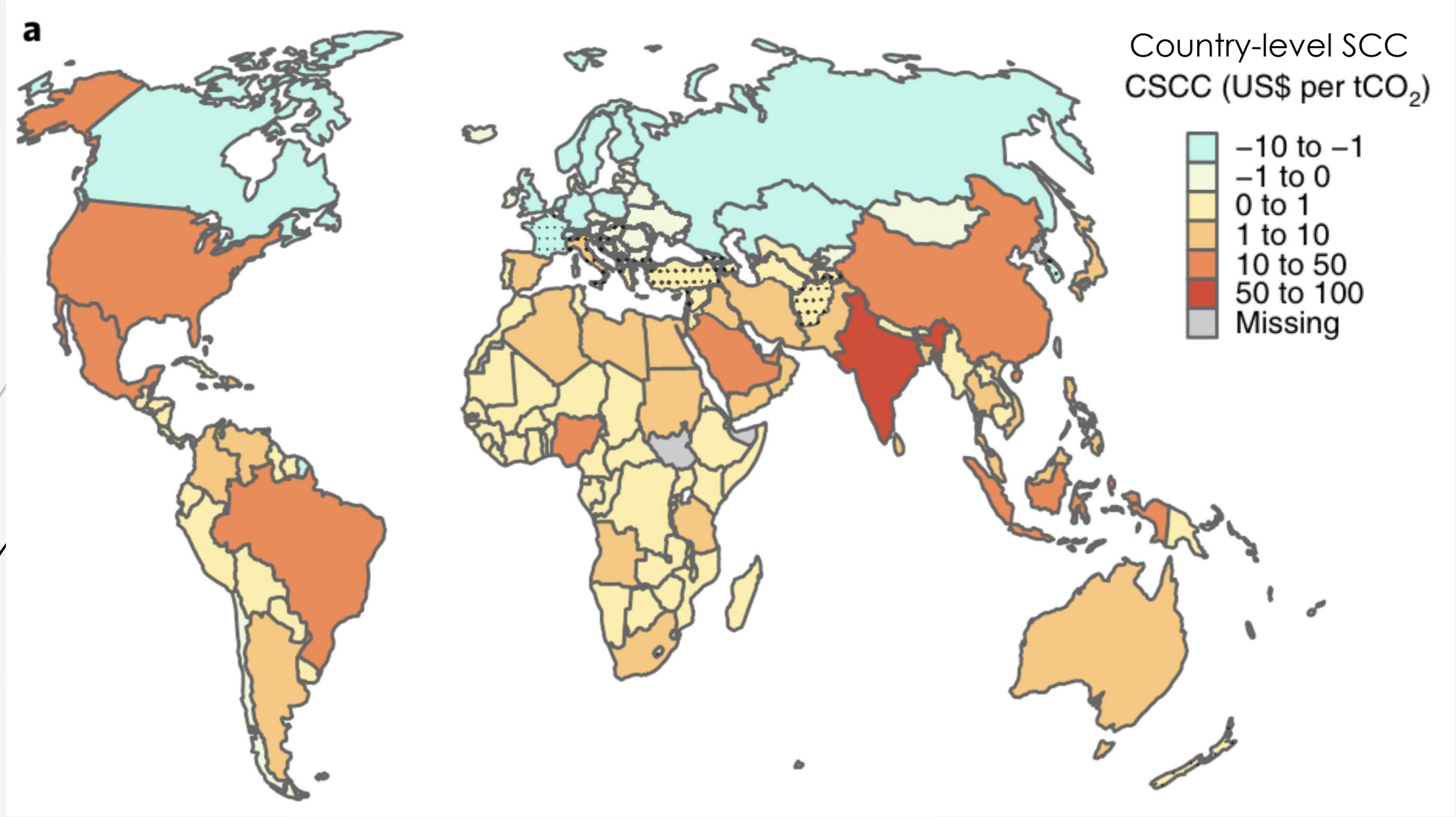
- Organizations and businesses are using international carbon pricing as a tool to:
  - Mitigate climate related financial risks,
  - Discover new low-carbon business opportunities and
  - Prepare for the transition to a low-carbon economy
- Task Force on Climate-related Financial Disclosure (TCFD)
  - Published recommendations (Jun 2017) which aim to improve the reporting and management of climate-related financial risks and opportunities

There is progress, but is it enough?

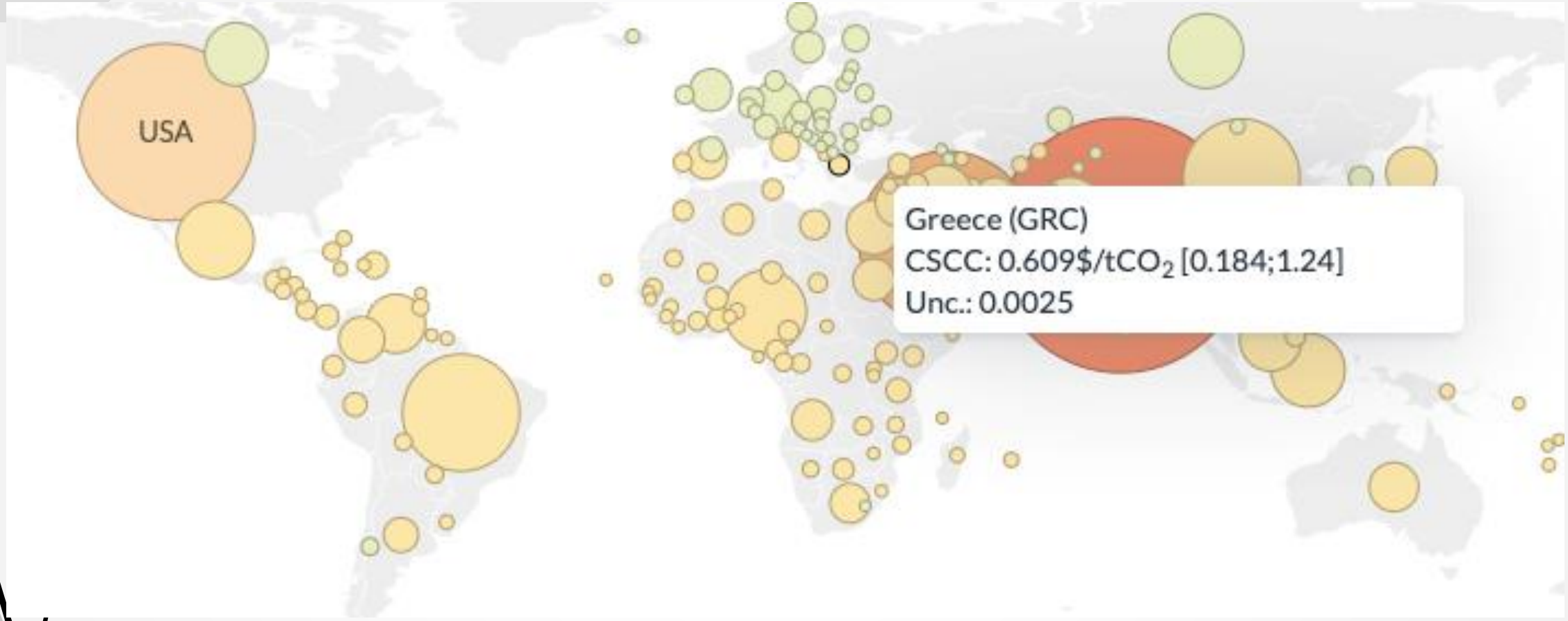
- *"further rises in carbon prices and coverage are needed to stimulate emission reductions in line with the Paris Agreement."* (World Bank and Ecofys, 2018)
- Less than 5% of GHGs are covered under carbon pricing initiatives at a level consistent with achieving the goals of the Paris Agreement (World Bank, 2019)
  - **Target range needed is US$40-80/t$CO_2$e by 2020**

Social cost of carbon (SCC)

- **Is the present value of the marginal cost of the impacts caused by emitting one extra ton of carbon, inclusive of 'non-market' impacts on the environment and human health**
- It is a commonly employed metric of the expected economic damages from GHG emissions
- These estimates are used to inform environmental policy making
- Estimates of the SCC are highly uncertain. Recent estimates of SCC range from \$10 to \$1000 per tCO_2
- They are also highly heterogeneous among regions/countries



Source: Ricke et al. (2018) Country-level social cost of carbon, Nature Climate Change 8, 895-900



Source: https://country-level-scc.github.io/explorer/

Carbon tax vs Cap-and-trade (ETS)

- Both systems aim at reducing GHG emissions
- A carbon tax sets a price directly and provides certainty regarding emission prices
- A cap-and-trade sets a price indirectly through the trade of limited pollution permits
  - A common challenge facing ETSs is market imbalance, which could be due to a mismatch between the cap or emission baseline that was set and expected emissions, the introduction of other policies that affect emissions covered by an ETS, or unforeseen circumstances such as an economic downturn.
- The choice between the two remains ambiguous. In the absence of uncertainty these two systems will achieve the same effect.

EU ETS vs national carbon taxes

- EU ETS is the largest in the world. It trades permits for GHG emitted from large-scale facilities in aviation, industry and power sectors
- EU ETS covers ~45% of the EU's GHG emissions

- Sectors not in the EU ETS: **agriculture**, housing, transport and waste

"The avoidance of taxes is the only intellectual pursuit that still carries any reward"

John Maynard Kaynes

Carbon taxes: Greece case study

- Motivation of study
  - Lack of figures on carbon pricing for Greece
  - Public's acceptance of a carbon tax determines its feasibility
- Related Issues
  - Economic crisis and the public's acceptance of a carbon tax
  - Flat or progressive tax?
- Methodology
  - Estimation of households' willingness-to-pay (WTP) for the implementation of a carbon tax
  - Estimation of income elasticity of WTP

WTP to combat climate change

- 58 WTP estimates in the literature, mostly for USA then Europe (Allo and Loureiro 2014)
- Only two price estimates of climate change adaptation policy exist for Greece.
  - Markantonis and Bithas (2010) surveyed a panel of climate experts
    - Mean WTP € 229,58 (2007). The authors acknowledged that the value was high
  - Nastis and Mattas (2018) WTP for a carbon tax

Income elasticity of WTP for environmental improvement

- Flores and Carson (1997) and Kristrom and Riera (1996) independently developed theory to show that income elasticity of WTP is less than one
- Barbier et al. (2015) was the first to empirically prove it, in a Baltic sea study of eutrophication control, using a small sample
- Nastis and Mattas (2018) empirically prove it using a large sample for WTP related to climate change adaptation

Methodology

- Contingent valuation: Stated preference
- Two surveys, in 2014 and 2015. Nationwide sample size 1393 adults. In-person interviews.
- Surveys were designed to evaluate, among other things, public attitudes and knowledge for a number of climate issues
- WTP question
  - Payment ladder format with variable, odd increments

Contingent valuation

- First used by Davis (1963)
- It has become the most widely used and the most controversial of all environmental valuation methods
- It remains the only method to estimate the total (use and non-use) economic value
- Given the caveats of WTP estimates, this research contributes to the literature by providing benchmark values

Willingness-to-pay

WTP for a discrete change change in the environmental public good Q from an initial level Q^o to a final level Q^1 is written in integral form using the compensated virtual price of Q and p^v as:

$$WTP = \int_{Q^o}^{Q^1} p^v(p, s, U) ds$$

Income elasticity of WTP can be written as:

$$\eta^{WTP} = \frac{\partial WTP}{\partial y} \frac{y}{WTP} = \frac{1}{WTP} \int_{Q^o}^{Q^1} \eta^v(p, s, U)\, p^v(p, s, U) ds$$

where

$$\eta^v = \frac{\partial p^{\frac{v}{y}}(p, Q, e(p, Q, U))}{\partial y} \frac{\partial e(p, Q, U)}{\partial U} \frac{\partial v(p, Q^o, y)}{\partial y} \frac{y}{p^v}$$

and $p^v(p,Q,U)$ is the utility-constant virtual price and $p^{v/y}(p,Q,y)$ is the income-constant price

Climate change perception

- Respondents believe that there is climate change with great certainty:
  - 92% of respondents believe there is climate change
  - 81.5% very or extremely sure that there is climate change

Contingent valuation question

- Respondents' WTP to reduce domestic (Greek) GHG emissions 17% by 2025 (in 10 years)
- 15.4% don't know
- 36.9% are willing to pay euro 0

Table 4 Censored regression model of WTP responses

Variable	*Reduced sample*	*Full sample*
Gender (1 = female)	–0.095 (6.428)	–5.914 (6.574)
Education	1.231 (1.604)	1.503 (1.664)
Age	–0.999 (0.270)	–0.802 (0.281)
Income	0.029 (0.003)	0.028 (0.003)
Household	–2.198 (2.270)	–3.915 (2.307)
Far left	6.852 (15.969)	20.585 (16.836)
Left	10.797 (9.350)	21.735 (9.625)
Centre left	22.406 (10.773)	31.686 (11.090)
Centre	29.405 (9.162)	32.923 (9.305)
Centre right	10.635 (12.331)	16.804 (12.544)
Right	7.554 (15.243)	10.216 (15.410)
Far right	–23.036 (23.446)	–28.611 (23.147)
Global warming ‘no’	–29.897 (29.583)	–26.956 (31.185)
Global warming ‘yes’	76.875 (20.172)	75.957 (20.937)
Constant	–93.058 (34.444)	–116.238 (35.843)
Observations	1146	1354
Sigma	96.292 (2.884)	103.753 (3.163)
R-squared	0.0158	0.0141

Note: Values in parentheses are standard deviations.

Source: Nastis and Mattas (2018)

Estimation of true WTP

- This is the maximum price that individuals are willing to pay for a reduction in GHG emissions
- Assume that respondents' true WTP can be described as a linear function of their sociodemographic attributes:

$$WTP^* = \alpha + \beta' X + \epsilon$$

- where *WTP** is an individuals' true but unobserved WTP, *X* is a vector of their sociodemographic characteristics and *ε* is a normally distributed error term. Using a censored regression model, we can obtain unbiased estimates of a and β, despite not observing *WTP**.

Results

- Annual WTP to reduce GHG emissions by 17% by 2025 is estimated at € 81.47 [95%CI 80.75, 82.19]
- Age: a year of age reduces WTP by € 1
- Income: a € 1000 increase in annual income increases WTP by € 29,55
- Income elasticity of WTP is 0.96

Discussion: Climate change and Behavioral Economics

- Behavioral economics may provide insights into WTP valuations
- Hofstede (2001) developed country-level indexes that measure cultural social norms in comparison to the rest of the world

- Greece has the highest 'uncertainty avoidance index'
- Greece also has a low 'individualism' index, suggesting that people do not act as individuals but feel they are related to society

Table 5 Income elasticity of WTP by income bracket

Income bracket (€)	*Mean WTP*	*Elasticity*	*95% confidence interval*	
378.00	23.04	0.48	0.36	0.61
750.00	25.99	0.85	0.63	1.07
1,250.00	30.82	1.20	0.88	1.51
1,750.00	41.02	1.26	0.93	1.59
2,250.00	46.93	1.41	1.05	1.78
2,750.00	60.82	1.33	0.99	1.68
3,500.00	73.65	1.40	1.04	1.77

Source: Nastis and Mattas (2018)

Conclusions

- Climate change is climbing the political and social agenda
- Further rises in carbon prices and coverage are needed to stimulate emission reductions in line with the Paris Agreement
- Regional effects of climate change differ and so will mitigation and adaptation actions
- Estimates of WTP for a carbon tax in Greece suggest an annual carbon tax of €81 per household
- Higher income elasticity of WTP for the reduction of GHG emissions in higher income brackets suggests that higher income brackets value the environmental improvement more
- A progressive tax could be introduced to increase the social profitability and the likelihood that the climate change policy would pass

Thank you!

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