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Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world

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HIGHLIGHTS

- We analyze public revenue generated from global carbon tax and cap-and-trade systems.
- 70% of cap-and-trade revenues ($4.60 billion) are earmarked for “green spending”.
- 72% of carbon tax revenues ($15.6 billion) are refunded or used in general funds.
- Revenues per capita vary widely and are a useful qualitative explanatory variable.

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ABSTRACT

We investigate the current use of public revenues which are generated through both carbon taxes and cap-and-trade systems. More than $28.3 billion in government “carbon revenues” are currently collected each year in 40 countries and another 16 states or provinces around the world. Of those revenues, 27% ($7.8 billion) are used to subsidize “green” spending in energy efficiency or renewable energy; 26% ($7.4 billion) go toward state general funds; and 36% ($10.1 billion) are returned to corporate or individual taxpayers through paired tax cuts or direct rebates. Cap-and-trade systems ($6.57 billion in total public revenue) earmark a larger share of revenues for “green” spending (70%), while carbon tax systems ($21.7 billion) more commonly refund revenues or otherwise direct them towards government general funds (72% of revenues). Drawing from an empirical dataset, we also identify various trends in systems' use of “carbon revenues” in terms of the total revenues collected annually per capita in each jurisdiction and offer commensurate qualitative observations on carbon policy design choices.

1. Introduction

For economists, political scientists, and policy analysts who wish to put a price on carbon, the question of optimal carbon pricing mechanisms has long been hotly debated. Some economists have argued for a direct carbon tax (Metcalf and Weisbach, 2009; Nordhaus, 2007) and others have advocated cap-and-trade (Keohane, 2009; Stavins, 2007), while a third group has argued that the two policies are functionally equivalent (i.e. that a given cap-and-trade system can be designed to essentially mimic a carbon tax, and vice versa; Aldy et al., 2010; de Mooij et al., 2012). Policy design elements have been explored in depth conceptually or through modeling exercises.

Carbon pricing is widely implemented across the globe today. Furthermore, jurisdictions enacting carbon prices have often done so for varied political and policy reasons which are not limited to carbon pricing's academic purpose of increasing the marginal cost of greenhouse gas emissions to avoid anthropogenic climate change (Harrison, 2013; Schatzki and Stavins, 2013). The emergence of a global carbon pricing dataset leads to new opportunities for comparative empirical analysis of policy dynamics and design choices as they exist in the real world in order to better inform conceptual understanding of these policies (Tables 1 and 2).

In particular, given growing interest in the United States in the potential for carbon pricing revenue-neutrality to improve the political prospects of broad-based climate policy in that country (Parry et al., 2015; Shultz and Becker, 2013; Taylor, 2015), we have chosen to investigate the use of public revenues which are generated through both carbon taxes and cap-and-trade systems. Our examination of carbon-pricing revenues in all of the major worldwide jurisdictions in which it is practiced suggests that the

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usage of such revenues helps to illuminate the framing of the policy.[1]

Reviewing government literature, we estimate that more than $28.3 billion in government "carbon revenues" are currently collected each year in 40 countries and another 16 states or provinces around the world. Of those revenues, 27% ($7.8 billion) are used to subsidize "green" spending in energy efficiency or renewable energy,[2] while 26% ($7.4 billion) go toward state general funds. Notably, 36% ($10.1 billion) of today's carbon revenues–the largest share overall–are returned to corporate or individual taxpayers through paired tax cuts or direct rebates.

Our observations of carbon pricing in the real world suggest that while the form of a carbon pricing system may be theoretically interchangeable in terms of incentivizing emission reductions, system form does seem to matter in terms of how revenues are used. Namely, cap-and-trade systems earmark a larger share of global revenues for additional "green" spending, while carbon tax systems more commonly refund revenues or otherwise direct them towards government general funds.

2. Methodology

We estimated 2013 revenue collections and expenditures from each global carbon pricing system operating at the state/provincial level or above using government documents and secondary literature, as described in the individual country descriptions contained in Appendices A and B. Expenditures were categorized into three themes[3]:

(1) *Green spending*, which includes any form of government spending on or subsidy toward (primarily) energy efficiency and renewable energy research, development, and deployment, as well as other efforts intended to reduce greenhouse gas emissions related to agriculture and forestry, landfill management, alternative vehicles, and mass transit or transit-oriented development, as well as measures to adapt to climate change. This category does not include all "green spending" undertaken by a government with a carbon pricing system, only that additional spending tied to carbon revenues.

(2) *General funds*, where governments describe carbon revenues as independent of any other public spending obligations, expressly contributing to general funds, or where the use of carbon revenues is not otherwise specified and does not appear to be linked to particular spending programs.

(3) *Revenue recycling*, where carbon revenues are directly returned to some broad portion of the population through individual or business tax rate cuts, tax eliminations, or rebates in order to offset, in aggregate, the negative macroeconomic impacts of higher energy costs under a carbon price. To meet the definition, revenue recycling should be carried out independent of an individual's, corporation's, or sector's cost of emitting carbon dioxide. We therefore do not include free allocation of emission permits (for cap-and-trade systems) as a form of revenue recycling, nor do we count the use of revenues for targeted industry assistance (for trade-exposed or energy-intensive firms).[4]

We then compare each carbon pricing system's revenue uses to other system attributes, with a focus on system "revenue per capita" as a differentiating comparator. Revenue per capita is a useful simplified indicator to understand the fiscal impact of a carbon-pricing system in the aggregate; the incidence of policy costs may actually be more narrow depending on system design, but revenue per capita gives a sense for the policy's overall burden. It is also relatively direct compared to more commonly-used carbon policy indicators such as price per ton of emissions, total emission coverage, or reduction targets. The actual effects of any of those measures are not consistent across implementation environments, as they are filtered through numerous other economic and design variables before being felt.[5]

3. Results

3.1. Carbon cap-and-trade revenues

Carbon cap-and-trade systems raised about $6.57 billion globally in government revenues in 2013 through the sale of emission permits created by public entities.[6] State-run carbon permit auction and sales revenues alone therefore make cap and trade systems a significant policy tool for revenue generation—23% of overall global carbon revenues, and growing (despite the poor salience of these revenues[7] among the general populace). Of carbon cap and trade revenues, 70% are currently spent on "green" subsidies such as support for energy efficiency or renewables, while only 9% are directly returned to taxpayers or individual consumers.

Unlike carbon taxes, which have a longer global track record owing to their continued use in Scandinavian countries since the early 1990s, carbon cap-and-trade systems have only been producing measurable revenues for the last six or seven years. In some cases, such as the

[1] Policy discussions of global policies to price the emission of greenhouse gases such as carbon dioxide, whether through direct taxes or indirect cap-and-trade mechanisms, often focus on the desired *effect* of the new price–reduced emissions by marginally increasing the cost of carbon-intensive energy consumption–rather than the potentially substantial government *revenues* generated alongside. This stands in contrast to Barthold's (1994) observation that environmental excise taxes (such as gas taxes or chemical fees) were historically used primarily as revenue devices rather than incentives to change behavior. In this way, carbon taxes are perhaps more similar to dual-purpose "fiscal-behavioral" sin taxes on alcohol and tobacco products (with the "sin" in this case being carbon emissions).

[2] This represented about 6.4% of 2013 global public subsidies toward renewable energy ($121 billion, according to the International Energy Agency). Measurements of government spending on energy efficiency are both less precise and subject to broad definitional variation; they can conservatively said to be on the order of renewable subsidies, which would put carbon revenue spending at about 3% of the combined global total government "green spending" (IEA, 2013, 2014a, 2014b).

[3] Total spending may not add up to 100% as not all spending is necessarily captured by these three categories and on account of yearly discrepancies in carbon revenue inflows versus expenditures (or, otherwise, formal fund designations). Currencies are converted to nominal U. S. dollars at then-market exchange rates.

[4] The reason is that both free allocation and industry assistance are tied to specific emitter characteristics and more akin, respectively, to selectively lowering the original carbon price (where the government never sees the revenues) or buying off political opposition to the carbon pricing policy (Markussen and Svendsen, 2005). It is arguable that such interventions could in fact be regarded as a form of arms-length "spending" by governments for which it would be politically untenable to actually first take possession of these lost revenues; the implications of such arrangements are left to further study.

[5] Far more precise economic effects of carbon pricing policies are generally estimated through complex economy-specific modeling exercises. See for example, computable general equilibrium (CGE)-based efforts by Meng et al. (2013) for the Australian carbon tax, and comments therein regarding public skepticism of similarly advanced modeling undertaken by the Australian Treasury.

[6] This figure is for direct cash receipts does not include the implicit value of carbon permits granted by the state to emitters through grandfathering or other free allocation; it also does not include the value of emission permits generated through offsets or other peer-to-peer trading.

[7] For example, a recent survey of California residents found that 87% of respondents had heard "nothing" or just "a little" about the state's cap-and-trade program, which began generating government revenues later that year, and that 65% had "very little" or "no" confidence in the state's government to use that money wisely (Baldassare et al., 2012).

Table 1
Global cap-and-trade system revenues.

Cap and trade systems	Annual revenue (millions)	Per capita revenues	Share of GDP	Green spending	General funds	Revenue recycling
European Union Emissions Trading System, Phase III	$4640	$9	0.03%	80%	20%	0%
California AB 32 Cap and Trade System	$1034	$27	0.05%	45%	4%	55%
Regional Greenhouse Gas Initiative (United States)	$447	$8	0.01%	49%	32%	12%
Chinese Provincial Emission Trading Scheme Pilots	$250	$2	0.02%	10%	90%	0%
Quebec Cap and Trade System for Emission Allowances	$100	$13	0.03%	100%	0%	0%
Alberta Greenhouse Gas Reduction Program	$92	$22	0.03%	90%	10%	0%
Switzerland Emission Trading System	$9	$1	0.00%	0%	100%	0%
Combined globally:	*$6572*	*$8*	*0.02%*	*70%*	*21%*	*9%*

Most revenue figures are for 2013 or FY 2013/14. Exceptions due to data availability are: Switzerland ETS (2014). Data sources for each system are cited in the text and include author estimates where necessary. Shares may not add up to 100% as categories are not comprehensive and annual revenue budgeting may not match annual revenue inflows.

European Union's Emission Trading System, revenue production through the auction of emission permits was only added on years after the initial pricing and trading system was in place. In other cases, such as the Regional Greenhouse Gas Initiative in the United States, revenue production was integral from the beginning.[8] In either case, it is notable that more auctioning means more government revenues–potentially introducing government bias (Ciocirlan and Yandle, 2003)—the use of which can either be designed into the policy from the beginning or left to the political process.[9] One potential upside of explicitly considering cap-and-trade revenues from the outset when designing such systems is the ability for governments to engage the public regarding beneficial insights from the economic literature around tax shifting, the potential for double dividends, or revenue distribution–which may not otherwise enter the political dialogue in the same way that they would for a carbon tax.

3.2. Carbon tax system revenues

Direct levies applied downstream to the emission of carbon dioxide and other greenhouse gases or upstream to the sale of carbon-intensive fuels raised about $21.7 billion in government revenues globally in 2013, about three times that from cap and trade systems. As they are generally labeled as straightforward "taxes," "fees," or "levies" in name or public discourse, with exogenously-defined pricing, the costs imposed and revenues generated by these instruments may be particularly publicly salient.[10] This appears to relate to how the revenues are spent. For example, whereas the most popular use of cap-and-trade revenues is on "green" spending, this is actually the least popular use of carbon tax revenues, representing just 15% of spending. Carbon tax revenues are more often returned to taxpayers through other tax cuts and rebates (44%) or are clearly tagged as being used to supplement government general funds (28%). As depicted in the charts that appear later, both the per capita revenues and carbon revenue shares of GDP tend to be much higher for carbon taxes than for cap-and-trade systems: 0.13% of GDP for taxes as opposed to just 0.02% for cap and trade systems.[11]

There are two principal insights gained from this: first, system design makes a difference in how revenue is spent, and secondly system design is tied to how much is spent. Cap and trade may be preferred by jurisdictions with less public support for pricing (Baldwin, 2008; Harrison, 2012), and relatively small amounts of revenue have been raised. Carbon taxes, however, have raised more revenue, but generally do so in a more transparent way.

Though carbon taxes have a longer implementation history than carbon cap-and-trade systems, they appeared to fall from global favor in the mid to late 2000s as attention focused on the potential flexibility in distributional allocation of permits–and therefore political feasibility in implemenation–of carbon cap-and-trade systems.[12] The return of carbon taxes since the late 2000s, however, has often been explicitly justified as much by the ability of the significant revenues they create to offset existing labor taxes (British Columbia) or help reduce recession-hit government deficits (Ireland, Iceland) as by their ability to mitigate carbon dioxide emissions. Other jurisdictions have shown renewed interest in carbon taxes due to their perceived simplicity and stability relative to cap and trade systems (e.g., the United Kingdom's Carbon Price Floor, which functionally acts as a tax, was created to back up volatile EU cap and trade permit prices).

It is worth noting, however, that evidence from the field does not universally support the argument for carbon tax simplicity: whereas some systems, such as British Columbia's, have been

[8] The original RGGI Memorandum of Understanding (2005) and Model Rule (2006) both included language not only on auction revenues, but also on the general allocation of these revenues, for example, specifying that 25% of would be used for "consumer benefit or strategic purpose," as decided by each state and further outlining areas included therein.

[9] See, for example, the lack of provision for revenues produced through California's Global Warming Solutions Act of 2006, as recently described by the California Legislative Analysts Office (2016). The (ultimately failed) United States federal American Clean Energy and Security Act of 2009 h.R. 2454 ("Waxman-Markey Bill") also lacked provisions for revenue in its original draft, though Capitol Hill negotiations subsequently filled that gap (see section 321, "Disposition of allowances" in the final passed revision) as the bill's authors aimed to gather broader support (New York Times, 2009). Meanwhile, President Obama's contemporaneous cap-and-trade proposal did in fact describe planned permit auctioning levels and the revenue use, including directing two-thirds towards tax breaks (Office of Management and Budget, 2009).

[10] Chetty, Looney, and Kroft (2009) helped apply the concept of consumer salience (or, from Taylor and Thompson, 1982, "vividness") to the impact of taxes on purchasing decisions. For carbon taxes specifically, Rivers and Schaufele (2014) argue that the British Columbia carbon tax's impact on gasoline prices has been more salient than an equivalent change in market prices, reflected in a seven-fold larger than expected response in consumer demand in that province, supporting earlier work on excise tax salience by Li et al. (2014). Similarly, O'Gorman and Jotzo (2014) speculate that high elasticity of demand observed for electricity in Australia in the two years following that system's introduction was because of the long lead times and number of news media mentions of the carbon tax over its roll-out.

(footnote continued)

[11] Removing Australia's (now canceled) data point reduces the figure for carbon taxes to 0.09%.

[12] Sector-specific tradable exemptions could theoretically be used to make a carbon tax just as flexible as a cap-and-trade system. In practice, however, this does not seem to have been implemented in any of the systems investigated here, while the trade of permits that have been freely allocated under cap-and-trade systems is common.

Table 2
Global carbon tax system revenues.

Carbon tax systems	**Annual revenue (millions)**	**Per capita revenues**	**Share of GDP**	**Green spending**	**General funds**	**Revenue recycling**
Australia carbon pricing mechanism (canceled)	$8790	$391	0.60%	15%	1%	53%
Sweden carbon dioxide tax	$3680	$381	0.67%	0%	50%	50%
Norway carbon dioxide tax	$1580	$307	0.31%	30%	40%	30%
United Kingdom carbon price floor	$1530	$24	0.05%	0%	85%	0%
British Columbia carbon tax shift	$1100	$239	0.49%	0%	0%	102%
Denmark carbon dioxide tax act	$1000	$177	0.29%	8%	47%	45%
Switzerland carbon dioxide levy	$875	$107	0.13%	33%	0%	67%
Mexico special tax on production and services	$870	$7	0.06%	0%	100%	0%
Finland carbon dioxide tax	$800	$146	0.29%	0%	50%	50%
Ireland natural gas carbon tax, mineral oil tax, and solid fuel carbon tax	$510	$111	0.03%	13%	88%	0%
Japan tax for climate change mitigation	$490	$4	0.01%	100%	0%	0%
France domestic consumption tax on energy products (carbon dioxide)	$452	$7	0.02%	100%	0%	0%
Iceland carbon tax on carbon of fossil origin	$30	$92	0.22%	0%	100%	0%
Combined globally:	*$21,707*	*$49*	*0.13%*	*15%*	*28%*	*44%*

Most revenue figures are for 2013 or FY 2013/14. Exceptions due to data availability are: Denmark (2010), Mexico (2014), France (2014 partial year), Ireland (2012), and Japan (2012). Data sources for each system are cited in the text and include author estimates where necessary. Shares may not add up to 100% as categories are not comprehensive and annual revenue budgeting may not match annual revenue inflows.

carried out in a straightforward way and with high public salience, others, such as the Scandinavian systems, have been subject to so many fuel- and user-specific adjustments to the “carbon price” over time as to be uncertain what the final effect of the policy is. In these cases, there is a confusion of seemingly interchangeable fuel duties, carbon prices, and other value-added taxes such that the actual carbon price–and its revenue stream–is subject to political manipulation and seems to exist on paper only. It is unclear if this phenomenon is an artifact of first-generation northern European carbon tax shifts or if it will affect newer version carbon taxes elsewhere as well.

Adding to this complexity is the increasingly common situation of overlapping carbon tax and carbon cap-and-trade systems, both of which are generating public revenues and which may be directed for separate purposes. In some European cases, including in the United Kingdom and Norway, revenues from the regional cap-and-trade system are more often directed toward green subsidies, whereas a higher share of domestic carbon tax revenues go toward general funds. Goulder and Schein (2013) have argued that carbon pricing instrument choice inherently affects some (but not all) system performance attributes–administrative simplicity as a key differentiating advantage of carbon tax systems, for example, versus cost-effectiveness in achieving a set emission cap target for cap-and-trade. It therefore deserves further investigation whether simultaneously administering both carbon pricing systems within a single economy, as seems to be the practice in eight of the jurisdictions described here, affects real-world realization of such attributes.

3.3. *Time sensitivity of the data*

Carbon pricing and revenue systems change over time, and the data presented here are only recent snapshots–mostly for the year 2013 or FY2013/14.

Some changes are known or can be expected based upon existing law: both the European Union and California cap-and-trade systems are set to rapidly increase their annual revenues in coming years, independent of carbon price (a higher share of auctioned permits in the European case and broader fuel coverage in the California case). The Japanese and French carbon taxes are set to do the same on account of predetermined tax-rate escalation.

Changes can also be unexpected: the Australian carbon tax, which generated the most revenues of any system globally in 2013, was set to transition to a cap-and-trade system but was instead abruptly canceled following a change in government, due in no small part to the tax's unpopularity (Rootes, 2014). Revenues per capita of this tax were among the highest in the world, suggesting that there may be a political ceiling to the amount of carbon tax revenue that can be raised, at least for taxes that do not return a very high percentage of revenues to the taxpayer.[13]

Overall global carbon revenues therefore likely dropped in 2014, but may recover given the organic growth in existing pricing systems or new systems coming on line.[14]

4. Discussion

Carbon taxes generate a range of revenues per capita, but today's cap-and-trade systems generate only moderate revenues per capita. California's AB 32, at $27 per capita (and on an increasing revenue trend), is the highest of the cap-and-trade systems, while nine of thirteen carbon tax systems exceed that level. This observation is supported by economic theory: whereas carbon taxes and cap-and-trade systems both apply a price to all emissions, cap-and-trade systems are often designed to obtain revenue largely from marginal emissions (with baseline emissions at least partially grandfathered through free allocation of emission

[13] Harrison (2010), invoking Kahneman et al. (1991), has argued that carbon taxes may be inherently politically limited in the amount of costs they are able to impose on end consumers, even with revenue recycling, given tendencies towards loss aversion. While Australia's case does not prove our speculation on the existence of a “revenue ceiling,” we nonetheless find the observation useful in the context of some international political commentary following repeal of the tax that “It should serve as a stark warning… climate initiatives will cause American taxpayers to suffer, as Australians had to learn the hard way,” (U.S. Republican ranking member of the Senate Environment Committee James Inhofe, in ClimateWire, 2014), and rhetoric from the Prime Minister stressing the magnitude of the tax's economic impact (“Scrapping the carbon tax will save the average Australian household $550 a year…. The carbon tax was a $9 billion a year hit on the Australian economy.”) during its repeal (Abbot, 2014).

[14] For example, new pricing systems in new jurisdictions have been considered in Korea and South Africa. Looking forward, it is difficult to forecast overall global carbon revenues with accuracy given short-term adjustments in carbon revenue policy parameters–for example, the European Union's recent permit “backloading” auction timing debate–that can significantly affected year-to-year revenues. Year-to-year emissions are relatively stable and predictable as functions of macroeconomic activity and relatively inelastic demands for energy, but the policies to extract revenue from them have shown to be less so.

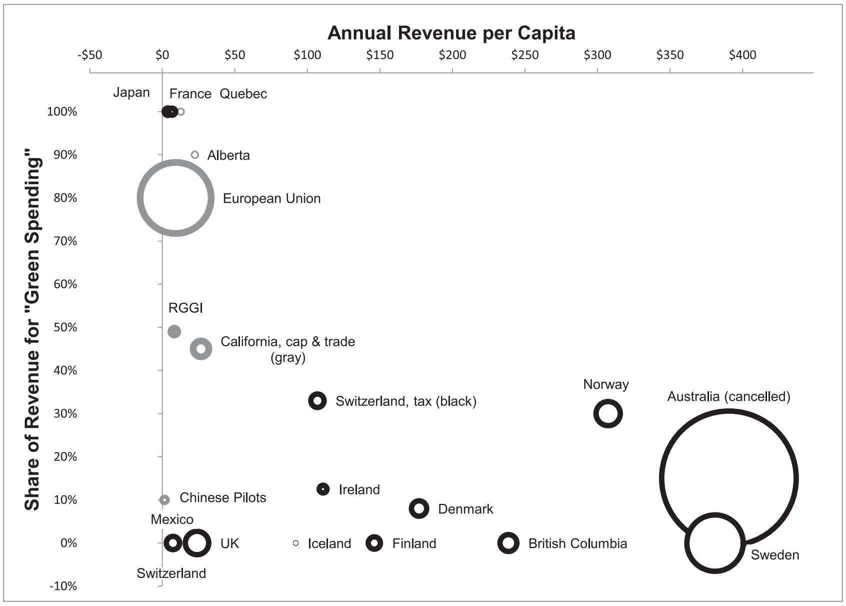

Fig. 1. Global carbon tax and cap-and-trade systems: revenue used for "green spending" vs. revenue per capita. The diameter of each circle on the charts here and below corresponds to the total revenue of each system to give a sense of overall scale—larger circles correspond to larger total system revenues. Cap-and-trade systems are presented in grey; carbon tax systems are presented in black.

permits). Were a cap-and-trade system to implement full auctioning of emission permits, its revenue stream would look more similar to a straight tax (and per capita revenues for any given system would likely increase). Of the cap-and-trade systems described here, only the Regional Greenhouse Gas Initiative in the United States implements near-full auctioning (but at a low floor price). Low cap-and-trade revenues may be a political feasibility feature since something that is not labeled a tax and does not notably dent consumers' wallets may be implemented with less notice (Rabe and Borick, 2012).

While there is broad variability among the per capita burden of the carbon-revenue systems overall, Australia's now-canceled carbon tax stands out as having both the world's largest overall pool of revenues ($8.8 billion) and the largest per capita burden ($391 annually), more even than the Scandinavian countries where carbon taxes have a long history. The Australian per capita revenue level exceeded British Columbia's system by nearly two-thirds, and that system was gradually introduced with a predetermined five-year tax rate ramp-up so as to avoid economic, or political, disruption (See Appendix B for more detail on these two carbon tax systems, both of which were ostensibly set to transition to cap-and-trade systems after an introductory period—neither occurred). This observation may be striking to those who otherwise saw Australia's carbon tax, with its ~$30 per metric ton carbon dioxide price, as being roughly in line with other global carbon pricing systems. In fact, this medium to high per ton price—coupled with the country's high (coal-fired) greenhouse gas emission intensity, an overnight launch, and the fact that simple carbon taxes generate revenues from the full range of priced emissions—meant that Australia's system would result in a larger economic shock than other global carbon-revenue systems, by design. Repealing the tax was thus a major element of the opposition's campaign platform—a similar tack that was tried, but did not work in British Columbia (Jaccard, 2012) where the tax was revenue-neutral and introduced more gradually.

The following figures compare the annual revenues per capita from existing global carbon-pricing systems with the share of their revenues, as used for various purposes, in order to identify and elucidate common trends (Figs. 1–6).

4.1. Green spending

There is a strong split between carbon taxes and cap-and-trade systems on the use of revenues to subsidize energy efficiency, renewable energy, or other climate-change mitigation- and adaptation-related activities. We estimate that 47% of all cap-and-trade revenues are spent on such green subsidies, compared to only 15% of carbon tax revenues. Moreover, among the more substantial global examples, the cap-and-trade system that spends the smallest share of its revenues on green subsidies (California at 45%) exceeds the share from the carbon tax that spends the highest percentage of its revenues on green subsidies (Switzerland at 33%).[15]

Interestingly, there is no system, tax or cap-and-trade, in the upper-right quadrant of this distribution: both high per capita revenues and a high share of revenues spent on green subsidies. This supports the hypothesis that such revenues can only be so narrowly earmarked when the individual impact (and not the absolute scale—see the European Union, for example) is small and relatively unnoticeable.

4.2. Carbon revenues in general funds

The use of carbon revenues to supplement government general funds, without earmarks, has been a relatively unpopular choice for governments enacting carbon revenue systems. Only five of twenty systems direct more than half of their revenues to this purpose. Of those five systems, four are relatively recently enacted carbon taxes with low to mid per capita burdens. Both of the poorer countries with carbon revenue systems are also within this group, as are the two systems explicitly set up during the aftermath of the 2008 global financial crisis to reduce spiraling government deficits (Iceland and Ireland).

The Scandinavian country carbon taxes comprise a special cluster: In practice their revenues are largely directed to general

[15] Exceptions being Japan's small revenue per capita carbon tax, France's nascent carbon tax, and the Chinese provincial or municipal cap-and-trade system pilots.

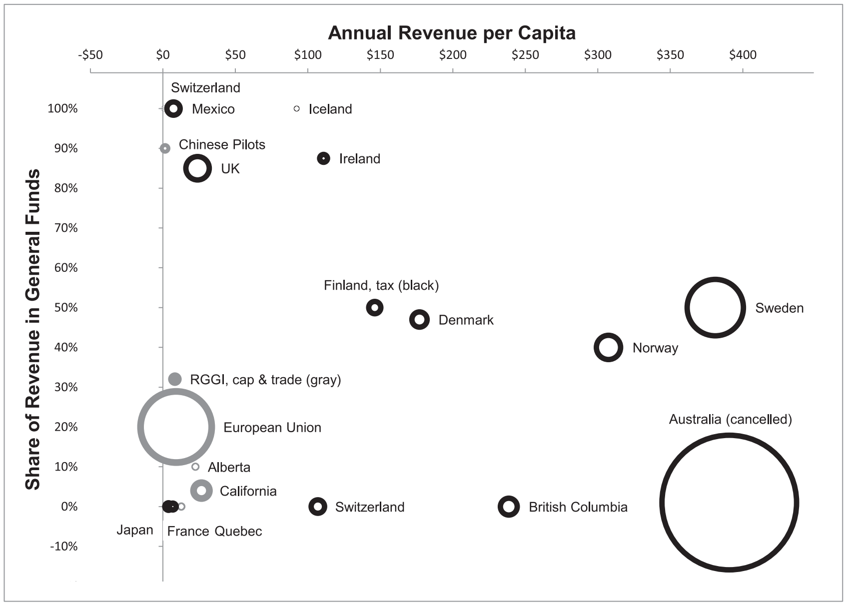

Fig. 2. Global carbon tax and cap-and-trade systems: revenue used for general funds vs. revenue per capita.

funds, but we only account for about half of that here as these environmental taxes (including energy, carbon dioxide, and other pollutants) have been consciously introduced or increased alongside reductions in existing labor taxes, which we regard as a form of partial revenue recycling.

Apart from the Chinese provincial pilots, the Regional Greenhouse Gas Initiative in the United States—another subnational cap and trade system—has the largest share of revenues going toward general funds (32%) of the cap-and-trade systems. Almost all cap-and-trade systems have some share of funding going toward general funds, however, if only to cover public program administration costs ranging between 3% and 6%.

4.3. Revenue recycling

The direct return of carbon-pricing revenues to businesses or individuals through tax breaks or rebates is used by some carbon tax systems but uncommon among cap-and-trade systems.

Only two of seven global cap-and-trade systems (9% of revenues) directly return any revenues. California's AB 32 is an extreme value, returning just over half of its auction revenues, largely though flat rebate checks to households. Even this revenue system, however, is open to interpretation: The "returned" revenues in California's case are never actually possessed by the state but rather its regulated monopoly independent electric power utilities, to whom the permits are consigned (for free) before auction and then returned to household customers largely through a flat rebate on utility bills. The share of California's carbon revenues that are recycled is also set to decline, to about 30% from 2015 onwards, following the expanding sectoral scope of non-revenue-recycled permit auctions (see Appendix A for more detail on the consignment feature). After California, the next highest cap and trade program share to be recycled is the Regional Greenhouse Gas Initiative (at 12%, mostly through electric utility rate relief), the

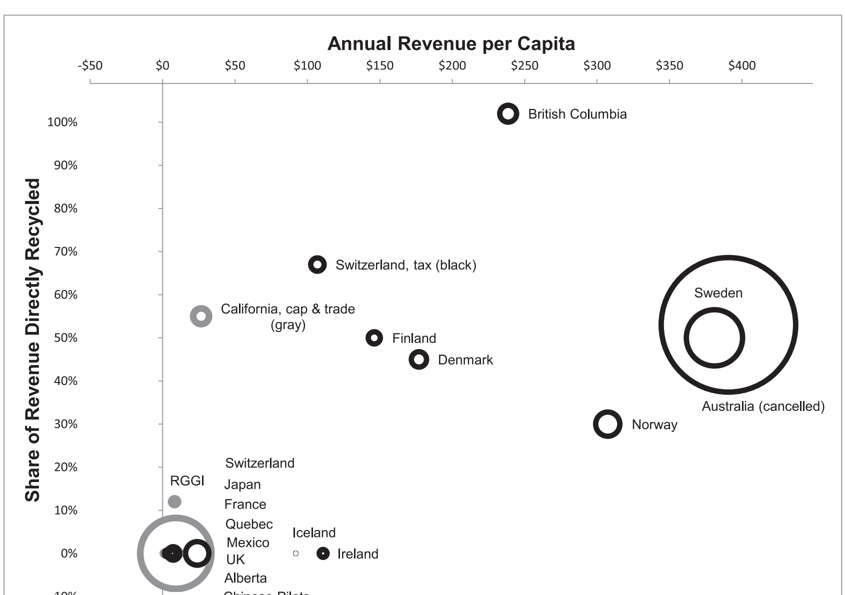

Fig. 3. Global carbon tax and cap-and-trade systems: revenue directly recycled/returned vs. revenue per capita.

United States' other regional carbon revenue system.

Carbon tax revenue recycling is not universal either, with only a slim majority of systems (seven of thirteen, 44% of total revenues) returning revenues. Tax systems that return revenues tend to have larger par capita burdens (greater than ~$100) and include all the Scandinavian systems, reflecting their longstanding and explicit labor-environment tax shift strategy. British Columbia's revenue-neutral carbon tax is an extreme value globally, with *over* 100% of revenues recycled through corporate and individual tax breaks as well as low-income rebate checks. Switzerland's carbon tax is also notable for returning two-thirds of its revenues to residents and businesses through flat checks mailed to all individuals and business payroll tax rebates. Before its cancellation, Australia operated by far the world's largest revenue recycling program, returning over $4 billion annually to households through various individual tax cuts or subgroup targeted rebates (but, unlike British Columbia, Switzerland, and the Scandinavian countries, little to no broad-based recycling to business through tax shifts). No other carbon pricing system recycles more than half of its revenues.

We observe five principal ways that today's carbon revenues are returned to the economy, with many systems using more than one form of recycling. Each form has different distributional and political economy implications and is justified on different grounds:

4.3.1. Corporate tax cuts, either on profits or payroll taxes, granted to businesses (used by seven systems

Australia, Sweden, Norway, British Columbia, Denmark, Switzerland's carbon tax, and Finland). This is the most popular form of recycling, and most carbon revenue systems that do recycle use it. It also tends to be favored by economists as the most efficient way to burnish economic growth when combined with a carbon tax shift (Carbone et al., 2013; Goulder and Hafstead, 2013; McKibben et al., 2012). With energy-consuming businesses otherwise being both heavily impacted by, and politically organized to oppose, carbon-pricing policies (Olson, 1965; Svendsen et al., 2001), it is unsurprising that carbon revenues are used to improve competitiveness by cutting the cost of doing business in other areas. Such carbon "tax shifts" are often described in terms of taxing "bads" (i.e., carbon dioxide pollution) instead of taxing "goods" (i.e., hiring or profit-making). One criticism of this approach from fiscal conservatives is that corporate income taxation that occurs only to raise government revenue–already recognized as being an inefficient form of taxation (Gentry, 2007; Goolsbee, 1998; OECD, 2008)—should in principle be reduced to its lowest possible level independent of any carbon pricing system.[16]

From a distributional perspective, it has also been argued that reducing taxes on businesses creates disproportionate benefit for the wealthier parts of society who are more likely to own stocks or receive corporate dividends (a political issue that surfaced in the case of British Columbia, for example; see Lee and Sanger, 2008). This argument is muted, however, when considering the use of small business- and minimum-wage-targeted or other corporate payroll tax cuts, both of which have the potential to increase employment (Kramarz and Philippon, 2001; Chéron et al., 2008), with broad social and political benefit. One final consideration is the distribution of such tax benefits among not individuals but various business sectors. Whereas six of the seven countries listed above cut tax rates across a broad swath of businesses, Australia cuts only a minor small business tax with limited applicability. Its revenue policy conspicuously did not address the increased cost of doing business felt by general energy-consuming businesses by using revenues to counteract that.

4.3.2. Income-tax cuts granted to individuals (used by five systems: Australia, Sweden, British Columbia, Denmark, and Finland)

The analogue to business tax cuts, broad-based individual tax cuts are the second most common form of revenue recycling and, where used, are often of a similar revenue magnitude to the former. Some systems choose to reduce existing income-tax rates within a bracket and/or increase the tax-free income exemption. Both approaches have low administrative burdens and benefit a broad part of the population that faces marginally increased living costs as a result of carbon pricing and that otherwise carries much of the government revenue burden. From a distributional perspective, income-tax reductions used today tend to be progressive in that rate cuts are focused on lower income tiers. One criticism of this form of recycling, evident in a number of the Scandinavian "labor for carbon" tax shifts, is that it is hard to directly and visibly tie income-tax reductions to carbon-pricing revenues over time and layered on to other changes in the tax code. In the United States, this has been a particular objection of conservative commentators to the basic concept of revenue-neutrality (Murphy, 2012) as it blurs the line between carbon-revenue recycling and the use of carbon revenues for government general funds. British Columbia, and, before its cancellation, Australia, both use this form of recycling but address the salience issue head-on by publishing simple balance tables accounting for how new carbon revenues in each year would offset expected fiscal losses from new income tax cuts (see details in Appendix B).

4.3.3. Broad-based flat rebates granted to individuals or households (used by three systems: California, Australia, and Switzerland)

Carbon stimulus-type "checks in the mail" have been advocated for, drawing from across the political spectrum, as a viscerally appealing way to disburse new carbon revenues in a straightforward and universally visible format (Shultz and Becker, 2013; Hansen, 2015).

The two clearest examples of this today are in California and Switzerland.[17] One argument in favor of flat rebates from a fiscal balance perspective is that revenues used to fund annual "carbon dividends" would be politically difficult to appropriate for other public spending at a later date under a different political environment. (See the example of the Alaska Permanent Fund Dividend in the United States, which has sent checks in the mail to state residents from oil production royalties without interruption for thirty-two years and weathered numerous political attempts at appropriation.) Relevant evidence from the few examples of carbon pricing in the field today does not refute this thesis, but experience remains limited.

From a distributional perspective, one criticism of the flat dividend approach is that it does not compensate different individuals fairly for the costs incurred through carbon pricing. There are many reasons that some classes may be intrinsically more impacted by carbon pricing than others (or, to borrow language normally used to describe firm behavior under carbon pricing, individual marginal abatement costs may vary).[18] For example, short-term switching costs may be particularly high because of starting conditions: including living in less-dense areas with long commutes, older inefficient homes, or more carbon-intensive regional electric power grids. Some individuals may also

[16] See Marron and Toder (2013) for perspectives on corporate tax reform through new carbon taxes in the United States.

[17] British Columbia also used this approach in a one-off case when first introducing its carbon tax policy in order to improve political viability, though it actually used existing surplus revenues from another source in order to do so.

[18] Looking beyond consumer costs, workers in carbon-intensive industries could also be expected to face categorically higher costs from carbon pricing due to job losses.

have less capacity to adjust to a lower-carbon lifestyle: unavailability of public transportation infrastructure, harsher climates, or larger families. Any given level of energy consumption may represent a larger portion of household budgets for those with lower incomes, making new costs incurred by carbon pricing more significant.[19] All these classes would receive the same dividend as those with lower existing carbon footprints, better low-carbon adjustment options, or who otherwise might be shielded from the costs of carbon pricing through subsidized energy pricing regimes.[20] This begs the question that carbon revenue dividends can be thought of as a form of individual compensation to offset specifically incurred carbon-pricing costs–rather they are more a general tool for population-wide macroeconomic stimulus to offset the overall economic drag of pricing emissions.[21] The distributional fairness issue could potentially be addressed by applying tiers to refunds by geography, by income, or by existing baseline energy spending — though these approaches might induce their own set of substantive and political problems, including the potential to mute the carbon price signal for a particular impacted class if not designed correctly. In practice, we are not aware of significant public or political dissatisfaction with existing flat carbon-revenue-recycling systems.

4.3.4. Energy price adjustments (used by three systems: California, the Regional Greenhouse Gas Initiative, and Sweden)

Some systems return carbon revenues by reducing electricity rates, existing fuel taxes, or otherwise granting on-bill rebates tied to volumetric energy consumption. This approach can closely compensate end-users for the increased energy costs faced under a carbon-pricing system, but can be criticized on economic grounds for dampening the effective carbon price signal, which is generally the policy's original intent. For the two United States regional systems that have adopted this approach, it is only used for a small share of overall carbon revenue—about 5–15%—and appears to be more of a stopgap measure justified by regulatory or political expediency in reaction to after-the-fact concerns around policy costs.

California, for example, included a concrete phase-out timeline for its small business electric power on-bill subsidy and justified the rate-reduction approach largely on grounds of minimizing price shock (CPUC, 2013). In the Swedish case (as in the case of the Netherlands and Slovenia, discussed in Appendix B), carbon revenues are not explicitly used to reduce energy prices, but they are used to stand in for existing fuel excise taxes such that in some cases carbon taxes have been raised without actually affecting the final fuel price seen by end users.[22]

[19] Numerous scholars have attempted to model distributional impacts of carbon taxes in, for example, the United States. Considering both geographic and income distributional impacts, Burtraw et al. (2009) observe that carbon footprint variables differ across areas, especially among lower-income households, but that summed tax impacts varied less for upper-income households. Meanwhile, Hassett et al. (2007) argue that distributional incidence of a carbon tax is less varied when considered over an individual's lifetime.

[20] This could lead to petitions for class exemption or overall policy opposition among motivated groups. See, for example, critiques by United States governors of states with coal-intensive electric grids or poor renewable energy resources on compliance with the proposed EPA 111(d) Clean Power Plan (Sean et al. 2014), which aims to limit power sector greenhouse gas emissions.

[21] This is not a problem in Alaska because that program is not a consumption tax.

[22] Here, Sweden appears to be pursuing an accounting concept of taxing energy based upon the marginal externality damages associated with its use (in this case, global carbon emissions) rather than an arbitrary volumetric energy excise tax justified primarily by the government revenue it generates, or which is otherwise intended as a proxy for energy consumption-related pollution (See Oates, 1995, and Hahn, 1989, for early framing discussions of how governments during this period did or did not follow economists' recommendations in setting environmental taxes).

4.3.5. Rebates granted specifically to low-income or other particularly "impacted" households (used by two systems — Australia, British Columbia)

Just two carbon pricing systems globally return some share of revenues directly to poor households or (in the case of British Columbia) to rural households with higher intrinsic or otherwise specially inelastic energy demand (as outlined in Section 4.3.3 above).[23] This use of revenues for poorer consumers in particular (including fixed-income elderly) is generally justified by the argument that they spend a larger share of their income on energy as opposed to other discretionary spending, and so are particularly impacted by the marginal costs of carbon pricing (Dinan, 2012). An extension of this argument is that poor consumers have less ability to afford the higher costs of all goods and services indirectly brought about by pricing carbon throughout the economy. At the same time, however, poorer consumers also tend to spend less money on energy or even other goods and services in an absolute sense than wealthier consumers, so their total carbon-pricing policy costs are less in the aggregate than other income groups. Though there does not appear to be significant political controversy over this form of segregated revenue recycling where it is in use today, another option to address this issue for jurisdictions that grant flat individual rebates would be to instead calibrating the dollar amount of that rebate such that the poorest consumers will be fully or near-fully compensated for increased carbon policy costs through that mechanism alone.

4.4. Non-earmarked versus niche use of revenues

The above chart combines the shares of revenues used in either general funds or recycled into the economy—that is, revenues not earmarked to subsidize the expansion of public spending on some narrow cause. The results are striking: no global system with a burden larger than $22 per capita uses less than half of its revenues in this way. Even that system—Alberta's—applies only to large oil sand producers and so has little effect on the province's general population. The next-highest system is the European Union emission trading system, with an annual burden of just $9 per capita. Globally, systems with larger per capita impact tend to use revenues in non-earmarked ways. Some of the smaller systems, particularly carbon taxes, start that way from the beginning.

This observation should be seen within the existing literature on public support for environmental pricing, given different revenue uses, which is mixed. Thalmann (2004), for example, discerned little different in Swiss voters' fossil energy tax support given different revenue uses. Hsu et al. (2008), showed that the non-niche use of revenues to reduce other existing taxes reduced opposition to gasoline taxes in Canada, supporting earlier survey work by Krupnick et al. (2001) in California. Meanwhile, Sælen and Kallbekken (2011), found that Norwegian voters tended on the whole to view fuel taxes unfavorably but increased their support when revenues are earmarked for green spending, similar to an earlier finding on Dutch transport taxes by Schuitema and Steg (2008) whereby consumers preferred revues be spent on issues with a topical nexus to the sector being taxed.

Given this, an explanatory hypothesis that people and businesses may not support burdensome carbon prices if the revenues are not used in a fiscally conservative way does not contradict the existing literature. That is, as the environmental pricing mechanism increases in strength to affect a higher share of household income, and is observable across many different consumption sectors (as a carbon tax does, but an urban traffic congestion fee

[23] California by law directs a significant share of its "green spending" to low-income households but does not do so through rebates or targeted tax cuts.

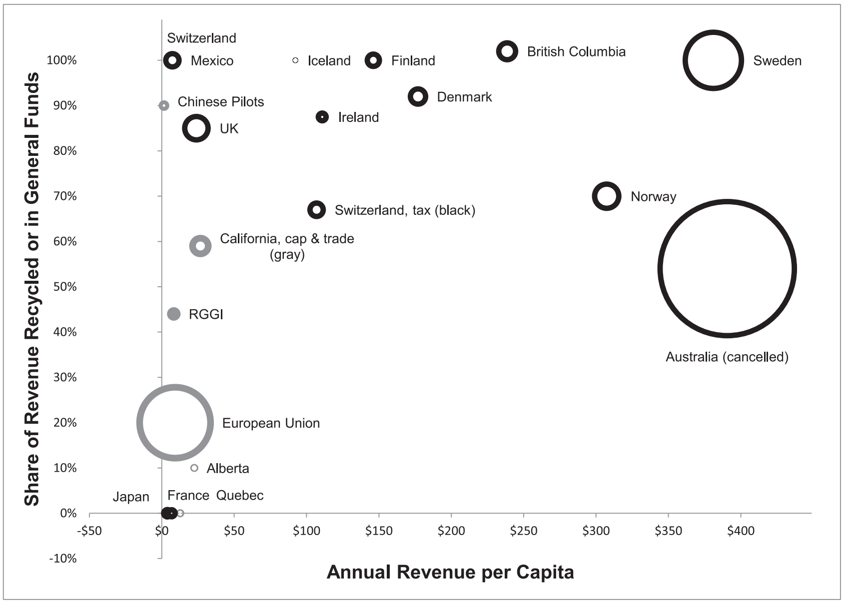

Fig. 4. Global carbon tax and cap-and-trade systems: revenue recycled or used in general funds (combined) vs. revenue per capita.

does not, for example), then it is more likely to be framed in consumers' minds as a broad fiscal instrument rather than a targeted environmental fee, with political viability on account of revenue uses more closely aligned with existing government fiscal priorities.[24] Such attitudes may have played into the demise of the Australian carbon tax, which lies somewhat outside of this trend line with a large $391 per capita burden, but only a modest 54% of revenues used to offset existing taxes or directly rebated to consumers. This meant that a per capita revenue burden of $180 annually—larger than all but three other global carbon-revenue systems in total—was directed toward niche public spending areas, many of them new government expenditures (see Appendix B for details). This level was twice that of second-highest system Norway (per capita niche spending of $92) and over five times that of third-highest system Switzerland ($35). To put this in context, Australia was spending twenty times the European Union cap-and-trade system's annual per capita total carbon revenue burden on niche areas alone.

4.4.1. Carbon-revenue system form and revenue volatility

A general framework in the carbon-pricing literature is that pure carbon taxes offer "price certainty" while pure cap-and-trade systems offer emission "quantity certainty." (Weitzman, 1974; Pizer, 2002)[25] One extension of this argument is that carbon tax price certainty also results in carbon "revenue certainty" to administering governments, given the relative stability of economy-wide emission levels year-to-year. The effect of volatility can be seen in practice: whereas the Provincial Ministry of Finance forecasts year-ahead government revenues from the British Columbia carbon tax within a margin of error less than 5% (allowing them to precisely budget for the use of those revenues), the California government by contrast appropriates much of its own carbon spending after quarterly auctions have already been held and revenues deposited into a separate holding fund. The price volatility inherent in cap-and-trade revenue streams[26] may explain why it is uncommon for them to be relied upon for general fund use or revenue recycling. This suggests that it would be challenging to make a new cap-and-trade system (at a high carbon price) a significant part of a jurisdiction's overall tax system reform.

4.5. Political ideology

This chart shows the generalized political ideology of a jurisdiction's government (majority party and executive) in power at the time of first revenues from each new carbon-pricing system.[27] While the carbon-pricing issue is a highly politically partisan one in the United States, these results suggest that it is less so elsewhere, with several right-leaning jurisdictions having implemented carbon-pricing schemes.[28] The relationship between ideology and carbon system form or revenue use is mixed. Apart from Alberta's oil sands-targeted system, all right-leaning or center governments use carbon taxes rather than cap and trade, while left-leaning governments used both forms. Furthermore, regarding revenue use (again excepting Alberta[29]), all right-leaning or center governments directed at least two-thirds of carbon revenues to be recycled to the public or otherwise used in non-earmarked general funds. Left-leaning governments were mixed in their revenue use.

4.6. Timing of carbon revenue system introduction

The first Scandinavian environment-for-labor tax shift carbon-

[24] This would resonate with a concurrent Kallbekken and Sælen (2011) finding that public support for environmental taxes increased monotonically with pubic trust in the government's use of tax revenues, defined in a questionnaire as "The government makes reasonable use of income [revenue] from taxes and fees."

[25] Recent scholarship has questioned this theoretical framework's (Wara, 2014) applicability to policymaking, pointing out that as a matter of practical politics, cap-and-trade (even if not designed as a hybrid system) has an implicit ceiling price beyond which the cap would be disregarded or modified as politically unviable.

[26] Nordhaus (2007) recounts the volatility observed in global cap-and-trade permit prices; public revenues derived from auction of such permits could be expected to be at least as volatile as the underlying permit prices, unless expressly accounted for through a flexible auctioning mechanism.

[27] National ideological coding is from World Bank's Database of Political Institutions (2012), supplemented by the authors' judgment where data is unavailable. System names marked with an asterisk (*) indicate that a single ruling party held a clear majority of the legislative voting share. In the case of Finland, coded as right leaning, the executive's party affiliation (right) did not match that of the majority legislative party (left, but with only a slight voting share margin over the opposition). Chinese pilots are excluded.

[28] Notably, however, all such systems had modest revenues at outset.

[29] See Appendix A for a discussion of whether Alberta's carbon pricing regime should be considered functionally as a cap-and-trade or a carbon tax system.

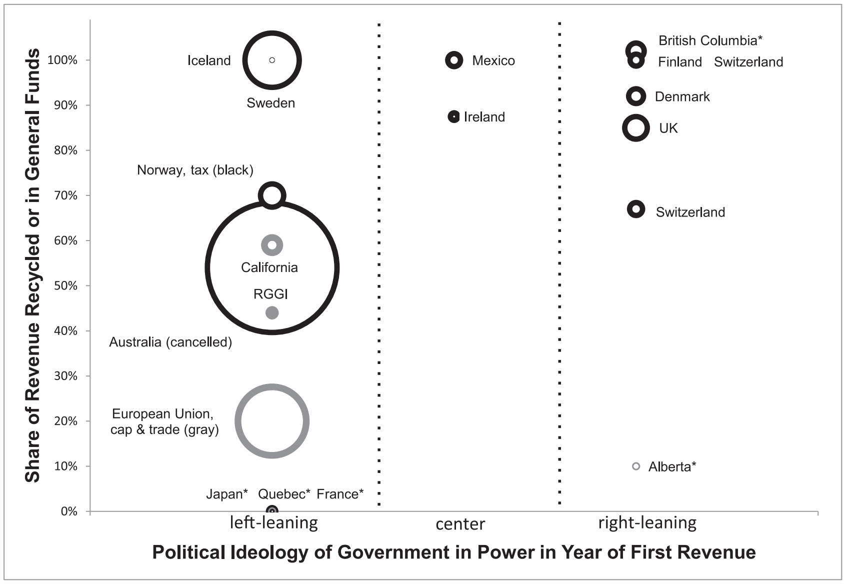

Fig. 5. Global carbon tax and cap-and-trade systems: revenue recycled or used in general funds (combined) vs. political ideology.

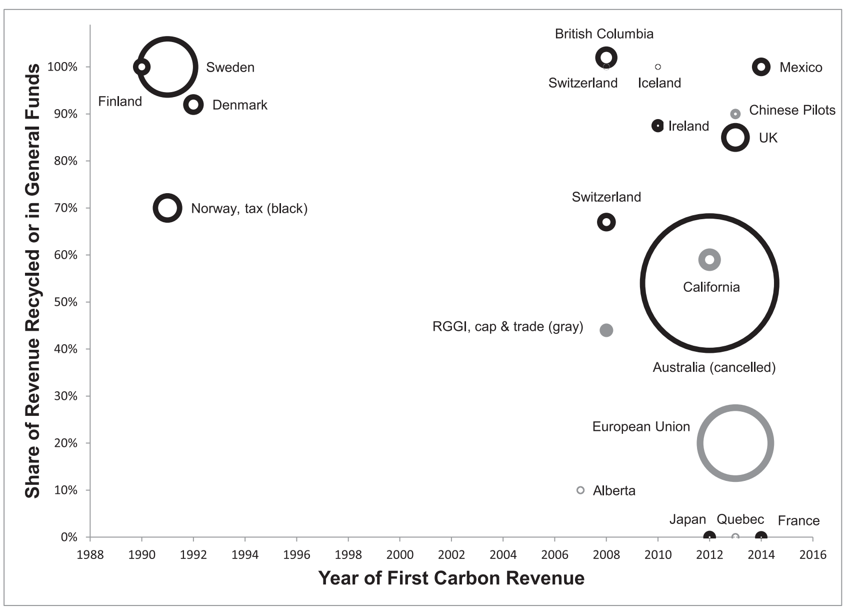

Fig. 6. Global carbon tax and cap-and-trade systems: revenue recycled or used in general funds vs. year of first system revenue.

revenue systems were introduced in the early 1990 s and remained the only revenue-producing global carbon pricing systems for fifteen years.[30] Then, in just the eight years from 2007 to 2014, seventeen carbon-revenue systems (including New Zealand's system, now not revenue producing—see Appendix A) were launched with a variety of per capita revenue burdens, uses of revenue, and forms (including, for the first time, cap-and-trade systems). This most recent cohort of carbon-revenue systems appears to lack any temporal trends in regard to these variables.

In theory, if marginal costs are sufficiently high compared to marginal benefits of emissions, pricing carbon should reduce the level of emissions from business as usual, which, all else equal, should produce carbon-revenue streams that gradually decline over the long term. (This would provide an additional challenge for those hoping to use such revenues as a substantial portion of government funding.[31]) In practice, however, many carbon-revenue systems have actually increased their revenues over time through expanding the scope of their coverage on the economy (e.g., California, Scandinavian countries), increasing the share of

[30] Exempting the Slovenian and Costa Rican so-called "carbon taxes," see Appendix B, and Phase II of the European Union Emission Trading System, in which only a token amount of emission permits were auctioned.

[31] This dynamic has been cited by those opposed to using carbon pricing to offset existing government revenue streams in the United States (Cass, 2015). It is worth noting, however that most proposed United States federal carbon tax schemes, for example, would nonetheless aim to increase revenues through at least the medium term by establishing built-in escalation of the tax rate that exceeded the rate of emission drawdown (Williams and Wichman, 2015). See Chesnaye and Weyant (2006) for a collection projections under the Energy Modeling Forum of global emission trajectories under carbon pricing scenarios.

permits publicly auctioned (European Union), intervening in the market to increase the value of cap-and-trade emission permits (European Union, Regional Greenhouse Gas Initiative), or increasing the rate of a carbon tax (British Columbia, Switzerland, Japan, France, UK, Scandinavian countries—see Appendix A and B descriptions for more details). In cases where revenues have declined, they actually tend to go to rapidly to zero through policy cancellation or operational hiccups (e.g., Australia, New Zealand), though Denmark did undergo a temporary decline in carbon tax revenues due to a lowering of the rate in the early 2000s, since reversed.

5. Conclusion and policy implications

Cap-and-trade systems collect $6.57 billion in government revenues globally, 70% of that designated for "green spending". Carbon taxes collected $21.7 billion, 72% of that for use in general funds or returned to general public. One clear takeaway from our look at carbon revenue systems is that cap-and-trade systems tend to earmark more of their revenues on environmental or other spending. While causation or covariance in this relationship is uncertain, we can hypothesize a few plausible causal pathways and potential implications for jurisdictions such as the United States that might consider enacting such systems.

We do know that in some cases (e.g., Ireland and Iceland), governments that were fiscally stressed started carbon taxes specifically for the general fund revenues they would create. We also know of cases (e.g., British Columbia, Scandinavian countries) in which cutting existing taxes was a major stated upfront goal of establishing a carbon tax. There does not, however, appear to be any clear analogue in which a government launched a cap-and-trade system primarily for the revenues generated or to cut other existing taxes. So, for jurisdictions that already want to recycle or otherwise use carbon revenues for existing fiscal needs, a more straightforward carbon tax seems to be the preferred policy tool.

We also have cases, however, where carbon taxes were the chosen pricing instrument, but upfront revenue intentions were unclear or not a part of the political justification for the overall policy. Results range from using all revenues for general funds (e.g., United Kingdom, Mexico), to recycling a portion of revenues (e.g., Switzerland), to earmarking all revenues on green spending (e.g., Japan, France). So, choosing a carbon tax in absence of a clear revenue policy has not guaranteed a particular outcome.

It is also important to observe that most cap-and-trade systems freely allocate some share of their emission permits. So, at a given per ton carbon dioxide price, cap-and-trade systems are on average generating less public revenue than an equivalent carbon tax would. The higher fiscal stakes of a carbon tax may make the choices around how to use its revenues more politically salient. Of the carbon taxes, the ones with the softest political messaging on revenue use are also the smallest in revenue per capita terms. Of these, Japan and France (and potentially the United Kingdom) are set to grow their revenues quickly as carbon tax rates rise (see Appendix B for details). It remains to be seen if these jurisdictions will revisit carbon-revenue uses or else postpone significant rate increases.

Finally, we can draw from the global experiences outlined above to offer a few observations on a prospective new national or regional carbon-revenue system in the United States, and the potential advantages or novel characteristics it might present compared other emission mitigation policy options or even a "revenue-weak" carbon pricing system. First is simply to recognize that there are a number of other policy options that United States jurisdictions already have at their disposal and use to address greenhouse gas emissions: mandates (e.g. renewables portfolio standards, building codes), technology performance standards (e.g. vehicle fuel economy standards), and subsidies (e.g. production tax credits, net energy metering, financial mechanisms, R&D) for example.[32] But carbon taxes or cap-and-trade systems with auctioning are categorically different in that they are not only emission mitigation instruments but also compromise the relatively few potentially politically palatable new avenues for public-revenue generation (or ways to pay for desired tax cuts elsewhere).[33] Second is that focusing on carbon revenues could improve overall policy lock-in and longevity. The "front end" of a non-revenue-producing carbon-pricing system—or command-and-control environmental policies—could face pressure to be (potentially non-transparently) modified over time so as to adjust headline per-ton pricing rates and exempt or grandfather certain politically influential parties, degrading the overall pricing policy.[34] But if system revenues are tied to visible budgetary ends, then any politically expeditious changes on the front end would have to be grounded in the reality of preserving the back-end revenue stream.[35] Lastly, from a policy efficacy standpoint, it must be acknowledged that though the intended marginal impact of any domestic emission mitigation policy—carbon-pricing or otherwise—would be to slow or avert climate change, that end result itself cannot be relied upon to gauge policy success. Observable geophysical climate dynamics are subject to intertemporal variation, planetary feedbacks, and the emission levels of other countries; even domestic emission trends themselves would be influenced by a number of other economic factors and government regulations apart from carbon-pricing. Absolute, locally-experienced global climate phenomena may not offer sufficient policy support over time. Carbon revenues, on the other hand, are more dependable symbols of a mitigation policy's efficacy: publicly visible, reportable year-to-year, and politically immediate.

New global carbon-revenue streams are launching at a rate of about one every six months. Though total revenues remain relatively modest, they are still at tens of billions of dollars annually and growing. The variation across a multitude of young systems, in both approach and outcome, suggests a lack of strong public or political norms to guide policymakers and constituents through the lawmaking process. Moreover, understanding how these new revenue models relate to conventional income, employment, corporate, or sales taxes is not trivial. Carbon pricing and its revenues are not fully in the realm of tax specialists, not are they the province of energy and climate experts. Through development of this carbon revenue dataset–and its ongoing improvement and maintenance—we hope to have shown that there now exists enough global experience to begin useful comparative analysis among

[32] See Shultz and Bingaman (2014) for a discussion of the variety of greenhouse gas emission mitigation policies commonly in use at the state level, for example.

[33] The possibility of enacting a carbon tax as part of a "grand bargain" comprehensive tax reform package was floated as a "non-traditional revenue source" by Senate Finance Chairman Max Baucus (D) in June 2013 (The Hill, 2013). Two months later, Myron Ebell of the conservative Competitive Enterprise Institute said of a carbon tax, "The danger is that it could be included in a big budget or tax reform deal. Such deals are negotiated in secret…. I think the fact that it is the only thing on the table that would raise a lot of revenue means that it will be a threat for the foreseeable future." Ebell does not support a carbon tax. (Capital Research Center, 2013)

[34] Metcalf and Weisbach (2009) describe mechanisms that a legislature or regulator might employ to guard against ad hoc petitions while preserving some flexibility to update rates given new information, including delegation to expert intermediaries.

[35] In this sense, maximizing the visibility of revenue use could potentially improve overall policy credibility, an important factor in motivating emission mitigation investments (Montgomery and Smith, 2007). Ackerman and Stewart (1985) made a similar observation on the importance of a revenue stream from the market-based pollution controls in giving the regulator an incentive to preserve the enforcement and credibility of the policy.

carbon-revenue systems and offer empirical insights beyond general conceptual models.

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Appendix A. Carbon cap-and-trade system revenues[a]

A.1 European Union Emissions Trading System, Phase III

Active period	2013–2020
Coverage	Coverage varies across twenty-eight member states but generally includes the electric power sector, energy-intensive industrial sectors, and aviation. This totals about 45 percent of economy-wide greenhouse house emissions under a single, European Union-wide emissions cap.
Revenue stream	Total auction revenues for 2013 were $4.64b (EUR 3.63b)[b] at an average permit price of EUR 4.38 (∼$5.60). In 2013, about 40 percent of total emission permits were auctioned, up from only about 4 percent in the second phase of the system, which ended in 2012.[c] In most member states, the electric power sector must now buy all permits at auction, but some countries do get power sector "transition assistance" budgets. Industrial sectors received 80 percent free allocation in 2013, decreasing to 30 percent free allocation in 2020. Aviation receives 85 percent free allocation through 2020. Auctions for the majority of member states are conducted through the common European Energy Exchange (EEX) platform and are returned to individual member states according to their share of total emissions, with ∼12 percent of total revenues held back to redistribute to poorer EU economies. Germany, Poland, and the United Kingdom hold separate auctions and have separate revenue streams. Top revenue streams in 2013 included Germany ($1.01b, EUR 790m), the United Kingdom ($619m, EUR 485m), Italy ($493m, EUR 386m), Spain ($441m, EUR 346m), Poland ($312m, EUR 244m), and France ($279m, EUR 219m). Total expected revenues for third phase through 2020 at the EUR 10.25 (∼$13.09 at nominal y2013 exchange rates) "reference price" would reach about $108b (EUR 85b, though this reference price is about twice the current market price for emission permits and so likely overstates future revenues).
Use of revenues	*Green subsidies:* ∼70–87 percent. - Following debate in the European Parliament environmental committee on use of auction revenues—including potential requirements around non-EU developing country expenditures—use of revenues were ultimately left to individual member states by the European Commission in 2008 with the nonbinding recommendation that at least half of revenues be used for "climate- and energy-related purposes." Under the Monitoring Mechanism Regulation of May 2013, member states were, however, required to begin reporting annual auction revenue spending. According to the European Commission,[d] most countries exceeded the 50 percent "green" spending requirement in 2013 and this area actually represented about $4b (EUR ∼3b), or 87 percent of total spending. In Germany, for example, almost all auction revenue funds flow into a "Special Energy and Climate Fund," which are supplemented by a separate reserve fund and the German government-owned development bank KfW. Most of the expenditures of this fund were directed toward "green" measures, and reported FY2013 spending of about $332m (EUR 260m) on building energy efficiency retrofits, $543m (EUR 425m) on transportation electrification, $230m (EUR 180m) on renewable energy, $166m (EUR 130m) on additional energy efficiency projects, and $140m (EUR 110m) on "climate action programs." Elsewhere in Europe, Spain, France, Romania, Portugal, Lithuania, and others reported spending up to 100 percent of auction revenues on similar domestic "climate and energy related" measures. Spain spent almost all of its funds—$398m (EUR 312m)—specifically on renewable energy, while France dedicated 100 percent of its spending toward nontransport energy efficiency. *Other earmarks:* ∼14–20 percent. - Like a few other European Union states, Germany spent a portion of its auction revenues—$358m (EUR 280m) in 2013, or about a third of its total—on international climate financing. Finland similarly spent about half of its auction revenues on international climate financing and development assistance. International developing country expenditures totaled about 14 percent of total EU revenue expenditures. Meanwhile, there are ongoing debates in other member states around revenue expenditures, with some, including Romania, Czech Republic, and Hungary, proposing spending about half on "green" measures going forward and the other half on other purposes. Greece is generally reported to direct most of its revenues toward renewable energy development, though in 2014 it notified the European Commission of its intention to instead spend a sliding portion of its auction revenues—not to exceed 20 percent—on compensation for energy-intensive industries.[e] *General funds:* ∼8–22 percent. - Austria, Netherlands, Ireland, and Denmark do not earmark auction revenues for specific purposes and so these can be

	considered to go toward general budgets. Poland allocates about half its auction revenues toward general funds. Germany reported spending \$22m (EUR 17 m) on emission trading system management costs. The United Kingdom is also generally regarded as keeping cap-and-trade auction revenues completely un-earmarked, though some observers interpret increased public spending on various green measures as being indirectly funded by this additional revenue stream. *Revenue Recycling:* ~0 percent. - It is unknown if any EU member state reports explicitly returning emission trading system auction revenues to its taxpayers.

[a] This appendix outlines author estimates of revenues from global carbon cap-and-trade systems (in most cases as of 2013), as well as their uses. Please see the World Bank, 2014 annual "State and Trends of Carbon Pricing" report for updated details on other cap-and-trade system design elements. http://documents.worldbank.org/curated/en/2015/09/25053834/state-trends-carbon-pricing-2015

[b] European Commission, "Climate Action: Auctioning," http://ec.europa.eu/clima/policies/ets/cap/auctioning/index_en.htm. This is the European Commission's stated auction revenue, which is similar but not equal to author calculations from EC auction data of EUR 3.204 billion.

[c] Uneven phase I and phase II auctioning did nonetheless produce significant revenues of over EUR 5 billion from 2005 to 2012, mostly concentrated in a few member states, including Germany, where it was fully spent on green activities, and Norway and the United Kingdom, where it was fully transferred to government general funds without earmark. See International Center for Climate Governance, "Recycling the Auction Revenue from Phases I and II of the EU Emissions Trading Scheme," 2013.

[d] European Commission, "Report from the Commission to the European Parliament and the Council Progress Towards Achieving the Kyoto and EU 2020 Objectives," October 2014.

[e] European Commission, "State aid SA.38630 (2014/N)—Greece National scheme for the compensation of indirect EU ETS costs," June 30 2014.

A.2 California AB 32 cap-and-trade system

Active period	November 2012–2020
Coverage	Large emitters (> 25,000 t per year) in industry (including refining) and power generation. Natural gas and motor fuel distributors are included from 2015 onwards. The California cap-and-trade system is estimated by the California Air Resources Board to include 85 percent of economy-wide emissions.
Revenue stream	\$477m in 2013 from permits auctioned by the state to industrial emitters and motor fuel distributors (including future vintage permits) at a price of about \$11.5 per ton carbon dioxide. Of industrial emission permits, ~90 percent were freely allocated at the outset of the program with the remainder auctioned. State revenues for 2014 were \$437m; this figure is expected to approximately triple in 2015 due to the inclusion of motor fuel distributors under the cap-and -trade program. An additional \$557m was raised in 2013 through the state's "consignment" of carbon emission permits to electricity and natural gas utilities. Consigned permit auction revenues for 2014 were \$745m. These groups are granted near-full allocation of historical emission permits for free by the state, but they are required to then immediately auction those permits, separately account for that income, and spend it as determined by state regulatory bodies. Income from the auction of these "consigned" carbon-emission permits can therefore be considered functionally equivalent to government revenue.[f] The California Legislative Analysts' Office estimates that total auction revenues through 2020 will range from \$14–\$70b, depending on future permit prices. Auction results to date have been near the reserve price and so are tracking toward the lower end of that range. For comparison, this revenue level is similar to the state's current capital gains tax receipts.
Use of revenues	*Green subsidies:* ~45 percent. - Though California's AB 32 climate legislation was adopted in 2006 and underwent a series of subsequent regulatory and scoping revisions to establish numerous implementation details, use of revenues from permits directly auctioned by the state was not addressed in legislation until auctions actually began in 2012. The outcome was that the vast majority of direct auction revenues (for emissions from the industrial sector, motor fuel distributors, other large emitters) are earmarked for spending on new climate-change mitigation and adaptation-related programs. Three bills[g] from the state legislature established a "Greenhouse Gas Reduction Fund" to receive auction revenues. The California Department of Finance, with coordination by the California Air Resources Board, distributes these funds, guided by legislative requirements, through annual "Investment Plans" in state-operated "green" projects—state agencies apply for funds for projects that fall within a set of broadly defined areas with a short application. Legislation defines eligible revenue spending to include the following categories: - Low-carbon transportation and infrastructure; - Strategic planning for sustainable infrastructure; - Energy efficiency and clean energy; - Natural resources and solid-waste diversion; and - Other (local and regional government agency programs, funding of nonprofit organizations, and green technology research, development, and deployment). FY2013/14-funded projects included \$30m for low-carbon transportation projects (e.g., tax rebates to state residents for

the purchase electric vehicles) and $30m for a "water-energy efficiency water action plan." Additional disbursements ramped up in FY2014/15, including an additional: $200m for low-carbon transportation subsidies (primarily increasing funding levels for an existing program that gives tax rebates for the purchase of zero-emission cars and vouchers for hybrid and zero-emission trucks and buses as well as funding pre-commercial demonstration project of low carbon freight transportation); $130m in subsidies for transit-oriented low-income housing construction; $75m in low-income home weatherization and rooftop solar subsidies; $50m for public mass transit subsidies aimed at increasing ridership and funding new infrastructure for system connection to the in-development high-speed rail project; $42m for urban forestry as well as other forest management and tree planting programs; $25m for wetland restoration; $25m for waste and recycling programs; $20m for publicly owned building energy efficiency retrofits; and $15 to fund agricultural dairy digesters and biofuel production standards.[h]

California's "green" spending approach has also been justified by appealing to California judicial precedent,[i] which suggests that because the cap-and-trade program's supporting legislation was passed by only a simple a majority in the legislature, auction revenues are in fact "fees" rather than taxes and so must be spent on areas closely related to the goal of the original legislation. In some respects, then, this was decision by default.

Starting in 2015, the share of revenues that accrue to the state (rather than being consigned to electric utilities) will rise from about half to three-quarters of total auction proceeds due to the inclusion of fuel distributors. Because almost all state-auctioned permit revenue expenditures fall within the green spending category, this share is expected to increase commensurately.

Other earmarks: ~25 percent (included within "green spending" category). There are two notable earmarks in California's revenue spending, though both are contained within the overall "green" spending category and so are not calculated separately.

First is construction of the San Francisco-to-Los-Angeles high-speed passenger rail system. The California governor borrowed $500m from the auction revenue fund in 2013 before formal disbursement mechanisms were in place in order to begin funding this project, with an overall estimated budget of $67b dollars. In FY2014/15, high-speed rail construction was actually the first and largest recipient of revenues, at $250m, and 25 percent of all future direct permit auction proceeds are now slated to go toward this program. The full high-speed rail system is not intended to be operational until 2029 (after the cap-and-trade program's current 2020 timeframe), however, and the system's overall greenhouse gas mitigation impacts are uncertain. State agency spending on the rail system therefore technically claims to comply with legislative and judicial requirements to mitigate greenhouse gas emissions by planting trees to offset construction-related emissions.[j]

Second, legislation requires that 25 percent of all Greenhouse Gas Reduction Fund expenditures must be used to benefit the state's "disadvantaged communities," as defined according to geographic area by the California Environmental Protection Agency. This requirement was justified in part by California's original climate legislation declaration that such communities would be disproportionally burdened by climate change, and the potential for such communities to face additional local pollution impacts were large emitters to concentrate operations in such areas under a cap-and-trade system. Agency applications for funds must state how, and estimate what share of, their spending proposals benefit such communities. Most proposals claim to exceed this 25 percent threshold.

General funds: ~4 percent.

- The FY2014/15 state budget requested about $19m from cap-and-trade revenues to fund new staffing positions in various state agencies to manage the expenditure of new green subsidies.[k]

The California Air Resources Board imposes a separate AB 32 "Cost of Implementation Fee" of about $40m annually on major greenhouse gas emitters statewide to cover its own administration costs and those of other implementing agencies. This fee is separate from cap-and-trade auction revenues and it covers a broader set of expenses than just the cap-and-trade system.

Revenue Recycling: ~55 percent.

- As described above, the value of permits consigned by the state government for auction by investor-owned electric power utilities and natural gas distributors is required to be used for the "benefit of their ratepayers, consistent with the goals of AB 32, and may not be used for the benefit of entities or persons other than such ratepayers."[l] The California Public Utilities Commission, which regulates investor-owned utilities, in 2013 required, for example, that 85 percent of electric power utility funds be returned to residential customers, and 10 percent be returned to small-business customers, through separately notated biannual "climate dividend" bill credits. The first dividends, mailed in 2014, totaled about $60 per customer annually; the dividend is the same for each customer, regardless of usage or income level. This relatively unnoticed mechanism has effectively created one of the world's largest carbon-pricing dividends. While revenue recycling represented the majority of California's carbon-revenue spending in FY2013/14, however, its share of total carbon revenue is expected to decline to roughly 30 percent in FY2014/15 and 24 percent in FY2015/16 as the cap-and-trade program's coverage broadens significantly to include natural gas and transport fuel use. In total, direct revenue recycling is expected to be about 35–40 percent—including consignment to both electric and, in part, natural gas utilities—over the program's 2013–2020 implementation period.[m]

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[f] See California Air Resources Board, "Archived Auction Information and Results," January 2015, http://www.arb.ca.gov/cc/capandtrade/auction/auction_archive.htm.

[g] AB 1532 (Pérez), SB 535 (De León), and SB 1018.

[h] California Air Resources Board, "Greenhouse Gas Reduction Fund Programs," September 29, 2014, http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/summaryproceedsappropriations.pdf.

[i] California Supreme Court, 1997, Sinclair Paint vs. State Board of Education.

[j] Letter from Dennis Trujillo, California High Speed Rail Authority, to Cynthia Marvin, California Air Resources Board,, "Greenhouse Gas

Reduction Fund: High Speed Rail Expenditure Record for Fiscal Year 2014–15," August 13 2014.

[k] Mac Taylor for California Legislative Analyst's Office (LAO), "The 2014–15 Budget: Cap-and-Trade Auction Revenue Expenditure Plan," February 2014.

[l] AB 32 Final Rule, Cap and Trade Regulations sections 95870(d), 95890, 95892, and 95893.

[m] California Air Resources Board, "Estimate of State-Auctioned Allowances by Fiscal Year," December 2, 2013; see also California Air Resources Board, "Cap and Trade Regulation, Appendix A, Staff Proposal for Allocating Allowances to the Electric Sector," 7, July 2011.

A.3 Regional greenhouse gas initiative (United States)

Active period	2008–ongoing
Coverage	This regional cap-and-trade program currently covers emissions from electric power generators greater than 25 MW in capacity of nine states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. It is implemented through separate legislation or regulations in each participating state according to a common "Model Rule."
Revenue stream	Auction revenues for 2013 were about \$447m at an average permit clearing price of \$2.92, slightly above the \$2.00 reserve price and following a period of permit surplus during the country's economic recession.[n] Cumulatively, auction proceeds over the period 2008–2014 (including those from New Jersey, which dropped out of the program in 2012) were \$1.94b. Participating states are allocated permit shares under a shared regional cap and use a common platform for quarterly auctions. Almost all allocated emission permits are sold at auction (91 percent of total permits for 2014), and states retain individual discretion on the use of auction revenues, with varying spending patterns.[o] Some states deposit auction revenues into and separately administer a purpose-created fund, while others channel them into existing related spending mechanisms or simply deposit into general funds.
Use of revenues	*Due to data limitations, Regional Greenhouse Gas Initiative (RGGI) revenue allocation is reported here in aggregate over the period 2008–2012 unless otherwise noted.*[p] *Green subsidies:* ~49 percent. - Three of the program's "customer benefit investment" target areas can be classified as green subsidies: energy efficiency (with 46 percent of total revenues) followed by "clean and renewable energy" (4 percent, including financing programs for rooftop solar), and various other greenhouse gas emission mitigation-related expenditures (also 4 percent). Energy efficiency is by far the largest spending category under the Regional Greenhouse Gas Initiative with beneficiaries in both business and residential sectors. Eight of the nine member states spend the majority of their auction revenues on energy-efficiency programs, with Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont each earmarking over 90 percent of total funds for this one category. Examples of subsidized programs include household and business energy audits, low-income home weatherization programs, lighting and appliance retail rebates, job training, and specific building projects. *Other earmarks:* ~0 percent. - There are no known significant unrelated spending earmarks apart from programs specifically targeted at low-income households, small businesses, or public-sector entities that has otherwise already been categorized here as either green spending or revenue recycling. *General funds:* ~13–32 percent. - About 9 percent of auction revenues have been transferred by individual participating states to their own general funds, and a further 4 percent of revenues have been spent on joint and state-level program administration costs. Of collected revenues, 18 percent at the time of accounting had not yet been spent or earmarked by participating states. New Jersey, before withdrawing from the cap-and-trade program in 2012, directed most of its auction revenues toward the state's general fund.[q] *Revenue Recycling:* ~12 percent. - The fourth category of the program's "customer benefit investments" is utility bill "assistance," which can be considered a form of revenue recycling as it directly transfers revenues to a broad set of the population affected by carbon pricing. Implementations vary by state with some programs focused on on-bill subsidies specifically for low-income households or small business whereas others are universal. From 2008–2013, \$122m was spent on this category to 2.3 million customers. Maryland stands out as the only state to return more of its auction revenues through utility rate relief—nearly two-thirds—than it spends on energy efficiency programs.

[n] Potomac Economics for RGGI Inc, "Annual Report On The Market For RGGI CO2 Allowances: 2013," May 2014.

[o] RGGI Inc,, "2014 CO2 Allowance Allocation," December 11, 2014.

[p] Data derived from RGGI Inc, "Regional Investment of RGGI CO2 Allowance Proceeds, 2012," February 2014.

[q] Revenue spending for New Jersey is not included in the overall share estimates presented here.

A.4 Chinese provincial emission trading scheme pilots

Active period	2013–ongoing
Coverage	Three of the seven currently operating Chinese provincial cap-and-trade systems generate government revenues

	through some level of auctioning: Guangdong, Hubei, and Shenzhen (as a separate system within Guangdong Province). Rules vary by province, though many are similar to the California AB 32 cap-and-trade systems coverage of greenhouse gas emitters exceeding 25,000 t annually.
Revenue stream	For Guangdong Province, revenues over the six monthly auctions from December 2013 to May 2014 totaled \$95m (CNY 586m). In a unique approach to permit allocation that is perhaps intended to provide both market signaling and create an effective ceiling price, Guangdong in FY2013/14 required covered entities to purchase at least 3 percent of allocations at government auction (with reserve price of CNY 60, ~\$9.70 per ton carbon dioxide) before being allowed to trade any of their remaining freely allocated permits. In 2015, the required auction share is set to grow to 10 percent. The current Guangdong secondary market permit-trading price is about CNY 21 (~\$3.40) per ton carbon dioxide (as of December 2014), having fallen dramatically since the program's launch. Revenue from the first Hubei Province auction in March 2014 was \$6.5m (CNY 40m). Secondary market trading prices are about CNY 24 (~\$3.90) per ton carbon dioxide-equivalent (as of December 2014) and are basically stable. Shenzhen was set to begin auctioning 3 percent of allocated permits from 2014. Revenue figures are unknown.
Use of revenues	*Green subsidies:* less than ~10 percent. - Hubei reported that 30 percent of auction revenues would by used to fund "corporate carbon reduction," carbon market regulation, and carbon trading administration. While the first of these categories would likely classify as an energy efficiency subsidy, its share of total revenues is unknown. *Other earmarks:* ~0 percent. - Unknown. *General funds:* ~90 percent. - In addition to the administration costs outlined for Hubei revenues, described above, Shenzhen is said to be using auction revenues to "support capacity building."[r] Remaining funds from other jurisdictions are presumably also used to fund administrative costs or else contribute to general government budgets. Revenue Recycling: ~0 percent. - Unknown.

[r] Tang Jin, "Decision Making and Policy Choice in China ETS," Presented at the World Bank Partnership for Market Readiness Conference, Mexico City, May 8, 2014.

A.5 Quebec cap-and-trade system for emission allowances

Active period	January 2013–2020
Coverage	Quebec's current cap-and-trade program is largely harmonized with the California AB 32 cap-and-trade system through a regional partnership known as the Western Climate Initiative. As in California, large emitters exceeding 25,000 t annually are covered, as are fuel distributors from 2015.
Revenue stream	Auction revenues for FY2013/14 totaled \$100m (CAD 106.5m) at an average permit clearing price of CAD 11.21 (~\$10.50, representing current and future vintage sales for the program's first four quarterly auctions).[s] The clearing price in each auction was the minimum reserve price. Though Quebec has held its own auctions from December 2013, it began joint auctions with California in November 2014. With 95 percent hydropower, however, Quebec has not adopted California's "consigned" permit auction approach in the power sector.
Use of revenues	*Green subsidies:* ~100 percent. - Quebec's auction revenues are transferred into an existing provincial "Green Fund" that was established in 2006. Before the introduction of cap-and-trade auction revenues, the Green Fund had annual average expenditures of about \$186m (CAD 200m), so this new funding source represents about half of existing expenditures. Within the fund, cap-and-trade auction revenues are specifically earmarked to finance those (1) greenhouse gas emission mitigation and (2) climate change adaptation measures outlined in the province's "2013–2020 Climate Change Action Plan." The plan has a total budget exceeding \$2.8b (CAD 3b) and broad coverage across thirty different "priorities." The provincial Ministry of Sustainable development, Environment and the Fight against Climate Change administers distribution of auction funds to other provincial ministries and government entities. The administering ministry is required to report annually on the results of the funds it distributes, while recipient ministries must implement "internal procedures" managing the use of funds. Thirteen different government spending programs are currently listed as being at least partially funded by cap-and-trade revenues across the following categories: transport, energy efficiency, "green energy," research and development, and the waste sector. Of these, transport reports the most activity, with programs on freight efficiency, electric vehicles, public transit, and cycling, implemented across four different government entities.[t] *Other earmarks:* ~0 percent. - There are no known unrelated earmarks on Quebec cap-and-trade revenues. *General funds:* ~0 percent. - The use of auction revenues to cover program administration costs is unknown. *Revenue Recycling:* ~0 percent. - There are no known direct revenue recycling programs currently funded under the administering ministry's Green Fund.

[s] Derived from data contained in "Auction of Quebec Greenhouse Gas Emission Units Summary Reports published by the Quebec Ministry of Sustainable development, Environment and the Fight against Climate Change on December 2013, March 2014, May 2014, and August 2014.

[t] Ministère du Développement durable, de l'Environnement, et de la Lutte contre la changement climatique (MDDELCC), "Programmes related to the fight against climate change," January 2015, http://www.mddelcc.gouv.qc.ca/changementsclimatiques/programs.htm.

A.6 Alberta greenhouse gas reduction program

Active period:	2007–ongoing
Coverage	Greenhouse gas emitters exceeding 100,000 t annually — mostly oil sands producers mining product for export—are required to reduce their overall emissions intensity by 12 percent over a 6 year period. Emitters that do not meet this performance target may, among other options (including the trade of emissions performance credits), make compliance payments at a set price to the government.[u]
Revenue stream	Alberta collected about \$92m (CAD 99m) in 2013 from emitters that chose to comply with emission reduction requirements by contributing to the provincial Climate Change and Emissions Management Fund at a set price of CAD 15 (~\$14) per ton carbon dioxide of required emissions reduction. Because covered emitters routinely chose to meet compliance obligations through this set volumetric payment option, the Alberta Greenhouse Gas Reduction Program could also be considered as much a carbon tax (on marginal emissions only) as a cap-and-trade program. The fund has collected CAD 503m (~\$470m at y2013 exchange rates) in total from 2007–2013.
Use of revenues	*Green subsidies:* ~90 percent. - Revenues collected in the Climate Change and Emissions Management Fund are administered by an independent purpose-created entity called the Climate Change and Emissions Management Corporation. This arms-length non-governmental entity distributes funds annually through an "expression of interest" application process to co-invested, nongovernment-funded, climate and environment-related technology research, development, and demonstration projects. Many funding recipients are located within Alberta while some are international. Specific fund focus areas include the development of new technology in both supply- and demand-side energy efficiency, carbon capture and sequestration, and reducing the overall environmental footprint of energy production. Recipient projects are selected competitively through a multistage internal and third-party expert review, with required progress reporting, including project description and accounting on a public website. Under the funding agreement, the Climate Change and Emissions Management Fund receives access to reports and technical data in return for its project investment but not intellectual property rights to the technology. Eighty-eight technology research, development, and demonstration projects have been funded to date. Examples include: research and development undertaken by an Albertan company into "binary fluid injector" thermal refrigeration technologies that could improve industrial energy efficiency; the first pilot project by a small Calgary-based startup demonstrating new direct air carbon dioxide capture technology; research by the University of California Riverside into stable catalysts to convert carbon dioxide and methane into liquid methanol fuel; demonstration by the Canadian Fertilizer Institute of a comprehensive farm fertilizer management program designed to reduce agricultural nitrous oxide emissions; and implementation of commercial-scale manure-to-biogas biorefinery in southern Alberta. To date, the renewable and clean energy project categories have received 68 percent of total funding, many of them in the market demonstration or commercialization stages.[v] Compared to other global carbon-revenue programs, Alberta's approach to using its revenue on "green" issues is notable. It focuses specifically on subsidizing the development of greenhouse gas emission mitigation technologies, it does not fund any new government-run programs or bureaucracy, and it includes robust screening and reporting requirements for recipients that are located both within and outside of the province. *Other earmarks:* ~0 percent. - There are no known unrelated earmarks on Alberta's greenhouse gas reduction program revenues. *General funds:* ~10 percent. - Administration costs for the Climate Change and Emissions Management Corporation are about \$8–9m (CAD 9–10m) per year.[w] *Revenue Recycling:* ~0 percent. - As much of the covered entities' production is exported, Alberta does not implement direct revenue-recycling programs under its Climate Change and Emissions Management Fund.

[u] Province of Alberta, "Climate change and emission mitigation act: Specified gas emitters regulation," Alberta regulation 139/2007, with amendments up to and including Alberta Regulation 225/2014, http://www.qp.alberta.ca/documents/Regs/2007_139.pdf.

[v] Climate Change and Emissions Management Corporation (CCEMC) website, "Portfolio of Funded Projects," http://ccemc.ca/projects/.

[w] CCEMC, "Climate Change and Emissions Management Corporation 2014–2017 Business Plan," April 2014.

A.7 Switzerland emission trading system

Active period	2008–2020
Coverage	The Swiss cap-and-trade system was introduced in 2008 as an opt-in alternative to an existing and more extensive carbon tax (see below) and is focused on large, energy-intensive industrial emitters. It is structured similarly to European Union Emission Trading System.
Revenue stream	- Revenues from the first two permit auctions held in May and November 2014 totaled \$9.1m (CHF 8.3m) at permit clearing prices of CHF 40.25 and CHF 20.00 (~\$44 and \$22), respectively.[x] - The Swiss cap-and-trade system had full free allocation (and so no public revenues) until 2012. Thereafter, it shifted to 20 percent permit auctioning, set to rise gradually to 70 percent auctioning by 2020. Power sector emission permits are fully auctioned, and auctions are held several times each year.
Use of revenues	*Green subsidies:* ~0 percent. - Unknown *Other earmarks:* ~0 percent. - Unknown *General funds:* ~100 percent. - Revenue use from permit auctioning is not explicitly publicly documented and so is assumed to contribute toward general funds. *Revenue Recycling:* ~0 percent. - Unknown

[x] Calculated from data presented on the Federal Office for the Environment (FOEN) English language website, "Emission allowance auction results," http://www.bafu.admin.ch/emissionshandel/05545/12435/index.html?lang=en.

A.8 Other cap-and-trade systems

New Zealand emission trading system

The New Zealand Emission Trading System was phased in across economic sectors from 2008–2013. Permit allocation was a mix of free allocation and government window sales to meet any compliance shortfalls at a set price of NZD 12.5 (~\$15 at y2013 exchange rates) per ton carbon dioxide equivalent. Revenues of about \$2.6m (NZD 3.5m) in total were collected from government sales of ~129,500 t of credits in 2010 and ~147,000 t in 2011. As overall market permit trading prices fell to about NZD 1.25 (~\$1.50) per ton in 2012, reflecting oversupply, no government revenue from sales has been generated since then. It is unclear how revenues collected were spent by the New Zealand government, but are likely to have contributed to administrative costs or other general funds.

Japanese municipal emission trading systems

Various Japanese municipalities, including Tokyo since 2010 and Saitama Prefecture since 2011, have launched cap-and-trade systems focused on large energy users. Permit allocation is largely free and based on both existing emissions levels and the level already-achieved corporate emission reductions. Covered entities may buy offsets to meet compliance, but the level of public revenues, if any, is unknown.

Kazakhstan emission trading system

Kazakhstan has launched a carbon cap-and-trade system, but all permits are currently freely allocated. Auction revenues are anticipated beginning in 2016, but revenue-spending plans are unknown.

Korea emission trading system

The Korean cap-and-trade system launched in January 2015 and focuses on power generators, large industrial emitters exceeding 100,000 t annually, and airlines. All permits are freely allocated through 2018 and so no auction revenues are anticipated before that time.

Appendix B. Carbon tax system revenues[a]

B.1 Australia carbon-pricing mechanism (canceled)

Active period	July 2012–July 2014
Coverage	Large emitters (> 25,000 t per year) in the energy extraction (including fugitive emissions), power generation, industrial, and waste sectors; all natural gas suppliers. Agricultural sector excluded. Domestic aviation, shipping, and rail were included but not household or commercial light vehicle fuel use or off-road fuel use. Estimated to include 60 percent of economy-wide emissions.[b]
Revenue stream	\$8.79b (AUD 9.08b) per year was originally forecast to be raised in FY2013/14 from an AUD \$24.15 (~\$23.40) per metric ton carbon dioxide-equivalent levy.[c] Actual receipts in FY2012/13 were \$6.8b (AUD 6.6b), and revised Australian government budget forecasts for FY2013/14 put expected revenues at \$7.0b (AUD 7.2b).[d]
Use of revenues	*Green subsidies:* ~15 percent. - As planned based upon original projections of FY2013/2014 carbon tax receipts of \$8.79b (AUD 9.08b), new climate, energy use, and environmental initiatives included the creation of a "Clean Energy Finance Corporation" to help fund deployment of renewable and low-carbon power generation, energy efficiency infrastructure, and direct subsidies to the

manufacturers of renewable energy equipment. A "Clean Technology Program" subsidized energy-efficient manufacturing and low-carbon technology deployment for businesses, while a smaller program subsidized household energy efficiency upgrades. A series of land-use measures were also funded, including a biodiversity fund and "Carbon Farming Initiative" carbon sink and offset scheme.
Other earmarks: ~45 percent.
- The Australian carbon tax was notable for how much of the collected tax revenues were earmarked to be spent on "transitional subsidies" for Australia's trade-exposed or otherwise carbon-intensive domestic industries. Major initiatives designed to do this included a "Jobs and Competitiveness Program" to assist industry (largely steel and aluminum producers), a "Coal Sector Jobs Package" focused on mines, and an "Energy Security Fund" to allocate free carbon units and cash payments to coal-fired power generators who publish "Clean Energy Investment Plans" and that was also intended to be used to negotiate the closure (i.e., buyout) of about 2 gigawatts of the most inefficient coal facilities by 2020.
General funds: ~1 percent.
- Establishment of a "Clean Energy Regulator" and other carbon tax administrative costs.
Revenue Recycling: ~53 percent.
- The Australian government termed revenue recycling "household assistance" and was presented as compensating households for the higher costs associated with the carbon tax policy. Such household assistance included: (1) increases in pensions, allowances, and "family payments"; and (2) income-tax cuts for annual incomes less than AUD 80,000 (~$77,400), including raising the tax-free threshold for lower income brackets. According to government estimates, the average household received AUD $10.10 (~$9.80) per week through these measures. It also increased the small business instant asset tax write-off.

[a] This appendix outlines author estimates of revenues from global carbon tax systems (in most cases as of 2013), as well as their uses. Please see the World Bank, 2014 annual "State and Trends of Carbon Pricing" report for updated details on other carbon tax system design elements. http://documents.worldbank.org/curated/en/2015/09/25053834/state-trends-carbon-pricing-2015.

[b] The Australia carbon tax system, from introduction, was originally scheduled to gradually transition into an internationally-linked cap-and-trade program with a relatively narrow price ceiling and floor after three years. This transition, which was described by the government primarily as a cost-limiting measure for industry and opportunity for the Australian agriculture industry to sell offsets abroad, was never implemented. It is also notable that the Australian carbon tax was implemented amid broader national tax reforms. See Jeremy Carl and David Fedor, "Revenue-Neutral Carbon Taxes in the Real World," The Hoover Institution, 2012.

[c] Australia Government, "Clean Future Final Plan," 2011.

[d] Australian Financial Review, "$7.6bn-a-year budget cost to chop carbon tax," February 15 2014.

B.2 Sweden carbon dioxide tax

Active period	1991–ongoing
Coverage	One of the oldest global carbon taxes, Sweden's covers fossil fuels used for heating and transport. Similar to the other long-lived Nordic carbon taxes, Sweden employs exemptions and design modifications for energy-intensive industries designed to reduce leakage. The resulting effective tax rates for industry have generally been around one-third to one-quarter that faced by residential energy consumers.[e]
Revenue stream	~$3.68b (SEK 24b) in 2013, up from about $1.3 billion per year in 1993 following the program's launch, but relatively stable since 2003; the current tax represents 0.7 percent of Swedish GDP from a 2014 general carbon tax rate was SKR 1076 (~$157) per ton carbon dioxide. Sweden's carbon dioxide tax is generally described as a complement to the existing Swedish energy tax.[f]
Use of revenues	*Green subsidies:* ~0 percent. - No known earmarks to subsidize new green spending. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~50 percent. - Revenues from the carbon and energy taxes make up a significant portion of total government receipts and contribute toward the country's general budget. They are considered an integrated part of the tax system and are among the most "revenue generation-focused" of global carbon-pricing systems, even though consumption-behavior change was also acknowledged as a goal of the tax's creation. Administrative costs of Sweden's carbon and energy taxes together are estimated at 0.1 percent of total revenues. Making the taxes administratively simple for both government and taxpayers was an original design priority of the policies.[g] *Revenue Recycling:* ~50 percent. - Sweden enacted personal income-tax reductions in 1991 alongside the introduction of the carbon tax, though the net effect at that time was nevertheless an increase in the overall tax burden. In 2001, employer social security contributions were also reduced, and income-tax-free allowances were extended, alongside further carbon tax reforms and increases. This latter adjustment was described by the government as a "green tax shift."[h] A further labor tax for carbon tax shift occurred over the period 2007–2010, and as before the reductions in labor tax revenues were much larger than new

	gains in carbon tax revenues.[i] There is, however, no direct link established between carbon tax revenue and "funding" these concurrent labor tax cuts, so the above revenue share is only a rough attribution. The Swedish government also notes that its existing energy taxes on vehicle fuels have since 2000 been lowered as the carbon tax rate on vehicle fuels was increased.[j]

[e] Eurostat in 2003 reviewed Nordic carbon and energy taxes, documenting both the substantial variation in effective carbon tax burdens across sectors and the share of environmental tax revenues at that time which could be attributed to the carbon dioxide versus other energy taxes. For example, they estimate that 1999 carbon dioxide taxes accounted for approximately one-fifth to one-quarter total energy tax revenues in each of Sweden, Norway, Finland, and Denmark, with Sweden having the highest share at 0.7 percent carbon tax as a share of GDP (5.1 percent of all government tax revenue) and Finland and Denmark the lowest with 0.4 percent of GDP. (Eurostat, "Energy Taxes in the Nordic Countries: Does the polluter pay?" March 2003.) Speck and Jilkova offer a further accounting of the evolution of Scandinavian carbon and energy taxes through the 1990s and early 2000s. (Stephan Speck and Jirina Jilkova, "Design of Environmental Tax Reforms in Europe," in Carbon-Energy Taxation: Lessons from Europe, edited by Mikael Skou Andersen and Paul Ekins, 2009.)

[f] Statistics Sweden, "Environmentally motivated subsidies and preliminary environmental taxes 2013," May 2014.

[g] Henrik Hammar and Susanne Ackerfeldt, "CO2 Taxation in Sweden," 2011.

[h] Ministry of Environment of Sweden, "Sweden's Fourth National Communication on Climate Change," 2005.

[i] Susanne Akerfeldt for the Ministry of Finance of Sweden, "Swedish energy and CO2 taxes National design within an EU framework" Conference on Environmentally Related Taxes and Fiscal Reform, Rome, December 15 2011

[j] Ministry of Environment of Sweden, "Sweden's Fifth National Communication on Climate Change," 2009.

B.3 Norway carbon dioxide tax

Active period	1991–ongoing
Coverage	Another of the early Nordic country carbon taxes, Norway's carbon tax covers the use of oil, gasoline, and natural gas, with partial exemptions for European Union Emissions Trading System-covered operations. It is estimated to cover 55 percent of the economy's emissions.[k] The level of the tax varies broadly by fuel and sector; one specific element is to target energy-usage patterns by offshore oil producers. In this sense it is not a broad-based general carbon tax despite its incidence being tied to carbon content or emissions.[l] Norway now also separately reports a "carbon dioxide" component of its motor vehicle registration taxes, which is not included here.
Revenue stream	Annual revenues of about ~\$1.58b (NKR 9.3b) in 2013 from the combined general carbon taxes on fuel and on offshore oil production from a 2014 tax rate of NKR 25-419 (~\$4-\$67) per ton carbon dioxide, depending on fuel type and usage.[m] For example, offshore oil producers since 2013 have faced a special "carbon tax" rate of NKR 200 (~\$34) for their platform-based oil- and natural gas-fired power generation operations; the Norwegian government has applied this tax rate to incentivize these producers to instead build electric transmission lines from the mainland grid, which is almost completely hydropower.
Use of revenues	*Green subsidies:* ~30 percent. - When carbon tax rates were raised in 2013, additional revenues were earmarked into expanding the capital base for the government's existing "Green Fund for Climate, Renewable Energy and Energy Efficiency Measures" (actual carbon tax revenue increase from 2012 to 2013 was ~\$454m, mostly from offshore petroleum producers). Annual financial returns on this fund are then spent to subsidize green technology projects by a purpose-created government body named "Enova." Targeted green spending areas include renewables, energy efficiency, and low-carbon research and development. The 2015 Norwegian budget further outlines support for clean technology deployment in the industry sector (so-called "risk reduction measures"), wind power deployment subsidies, passenger rail subsidies, urban transit subsidies, carbon capture and storage (CCS) demonstration projects, and additional funding for existing government funds focused on food security, agriculture, and forestry in developing countries. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~40 percent. - Carbon tax revenues that are not otherwise earmarked for green subsidies or estimated to offset existing tax are assumed to contribute towards government general funds. *Revenue Recycling:* ~30 percent. - In addition to the green subsidies described above, the 2015 budget also described the use of carbon tax revenues to fund reductions in the corporate income tax (the so-called "capital tax"). The above revenue share is only a rough attribution of this tax shift based upon incomplete date.

[k] World Bank Partnership for Market Readiness (PMR), "Putting a price on carbon with a tax," 2014.

[l] See Gert Tinggaard Svendsen, Carsten Daugbjerg, Lene Hjøllund, and Anders Branth Pedersen, "Consumers, Industrialists and the Political Economy of Green Taxation: CO_2 taxation in OECD," Energy Policy, 2001, 29(6):489-497 for a discussion of political dynamics around the numerous adjustments to the carbon energy taxes in Finland following its introduction.

[m] Statistics Norway Statbank, "Environmental economic instruments," January 2015.

B.4 United Kingdom carbon price floor

Active period	2013–2020
Coverage	The tax covers only fossil fuels used for power generation on the island of Great Britain and overlaps with European Union Emission Trading System liability. It was introduced to provide a carbon price floor and market stability in the power sector given the volatility and low level of European cap-and-trade system permit prices. The United Kingdom has since 2001 also applied a separate “Climate Change Levy” to nonresidential final consumption of electricity, natural gas, and solid fuels. Rates are set according to each fuel but do not necessarily correspond to carbon content and have changed over time. We therefore do not consider it a carbon tax. This levy, originally intended to be revenue-neutral, was launched alongside a 0.3 percent reduction in employer national insurance contributions.[n] In fact, the Climate Change Levy was revenue-negative, as its annual revenues of ~$1.29b (~GBP 700 m) over the period 2006–2009 were less than the ~$2.49b (GBP 1.35b) cost of the national insurance contribution reduction from 12.2 percent to 11.9 percent.[o]
Revenue stream	FY2013/14 revenues of ~$1.53b (GBP 975m) from a tax rate of GBP 9.55 (~$15.70) per ton carbon dioxide. The tax rate is set to update annually such that the sum of Carbon Price Floor and the European Union Emission Trading System permit price exceeded a minimum price threshold of GBP 16 ($26.30) per ton carbon dioxide in 2013, rising to GBP 18 (~$29.60) per ton in 2016. The price floor was recently frozen at the GBP 18 per ton level through 2020. The United Kingdom Treasury estimates that revenues will rise to ~$2.34b (GBP 1.42b) in FY2014/15 and ~$3.34b (GBP 2.03b) in FY2015/16, depending on price differentials with the European cap-and-trade system.[p]
Use of revenues	*Green subsidies:* ~0 percent. - Unknown *Other earmarks:* ~15 percent. - Alongside the launch of the carbon tax, the UK government introduced a “compensation for indirect costs of energy and climate change policies for energy-intensive industries” subsidy program of about GBP 100m (~$165m) per year through 2015. The spending program had an initial ceiling of GBP 250m (~$411m); half was earmarked to offset the indirect costs to energy-intensive industries of the carbon price floor's effect on electricity prices, and the other half was intended to offset costs associated with the European Union Emission Trading System. While funding for this pool of money is separate from the revenues generated by the carbon tax itself (it is described as having an ad hoc budget composed of the UK Department of Energy and Climate Change's one-time budgetary “underspend” with the rest coming from the UK Treasury), overall carbon tax revenues appear fungible enough for this to be considered functionally linked spending. *General funds:* ~85 percent. - The use of tax revenues was not explicitly promoted in the launch of the pricing system and subsequent government documents have described revenues as being retained by the UK Treasury as general tax revenue.[q] *Revenue Recycling:* ~0 percent. - Unlike the 0.3-percentage-point reduction in employer national insurance contributions enacted alongside the earlier Climate Change Levy (described above), there are no known offsetting tax-reduction measures explicitly associated with the Carbon Price Floor.

[n] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), “Addressing Competitiveness in introducing ETR: United Kingdom's climate change levy,” 2012.

[o] Jenny Sumner, Lori Bird, and Hillary Smith, “Carbon Taxes: A Review of Experience and Policy Design Considerations,” National Renewable Energy Laboratory (NREL), December 2009.

[p] Elena Ares for the Library of the House of Commons Science and Environment Section, “Carbon Price Floor,” May 2014. See also HM Revenue and Customs, “Climate Change Levy (CCL) & Carbon Price Floor (CPF) Bulletin, January 2015,” February 24, 2015

[q] “All revenue retained by treasury.” Ibid.

B.5 British Columbia carbon tax shift/revenue-neutral carbon tax

Active period	2008–2017
Coverage	Designed to have a broad coverage base, British Columbia's carbon tax covers 70–75 percent of provincial anthropogenic emissions.[r] The tax itself is applied upstream on each fuel, with relatively minor exemptions or rebates granted for international marine and air transportation, non-energy fuel use, biofuels, and some other use cases. It therefore applies in almost every sector across the economy.[s]
Revenue stream	Annual carbon tax revenues were expected to be $1.10b (CAD 1.21b) in FY2013/14 from a CAD 30 (~$28) per ton carbon dioxide-equivalent tax level, fixed since FY2012/13. This represents about 3 percent of the provincial government budget and slightly over 0.5 percent of gross regional product.[t] Revenues from the carbon tax are administered by the British Columbia Ministry of Finance and reported in forward-looking comprehensive budget plans, with annual revisions. Use of revenues was largely established alongside the original formation of the carbon tax. In fact, a major justification for the carbon tax at its outset was to use revenues to reduce the marginal corporate tax rate relative to other Canadian provinces in order to boost economic competitiveness. British Columbia's carbon tax shift program is notable for being net revenue-negative, a fact noted by the provincial

	Ministry of Finance annually since its 2008 launch. In FY2012/13, the overall program was accounted to be revenue-negative to the provincial government by $116m (CAD 120m), and in FY2013/14 was expected to be $18m (CAD 20m) revenue-negative. In the program's initial years, the program stipulated that the minister of finance's personal salary would be docked if more revenues were collected by the tax than were recycled directly back into the economy.[u]
Use of revenues	*Green subsidies:* ~0 percent. - No new environmental, renewable energy, energy efficiency, or other clean technology spending is funded by carbon tax revenues. *Other earmarks:* ~21–42 percent. - The carbon tax shift has near-universal coverage and a straightforward approach to revenue use. Some earmarks, however, have been introduced over the years as particularly impacted groups successfully campaign for relief from the tax. These groups or focus areas do not receive exemption from the tax, nor are they beneficiaries of new program spending, but they do receive targeted tax credits. A few have become significant: FY2013/14 examples include a “children's fitness and arts” tax credit of $7.2m (CAD 8m), a “small business venture capital” tax credit of $2.7m (CAD 3m), and seemingly unrelated business subsector tax credits including an “interactive digital media” business tax credit of $57m (CAD 63m) and provincial film industry tax credits of almost $141m (CAD 156 m). Apparently at least some of these targeted tax expenditures existed under separate budgetary authority before being funded by the carbon tax.[v] Two other types of direct payments or targeted tax cuts have existed in the carbon tax program since its outset but could be considered earmarks. Residents in the rural northern parts of the province, who require additional fuel use to heat their homes in the winter, each year receive a direct stipend of CAD $200 (~$182; for a total annual cost of ~$63m, CAD 69m). Low-income residents also receive targeted tax cuts totaling $176m (CAD $194m) each year. *General funds:* ~0 percent. - No specific funding is known to be identified from the carbon tax revenues for administrative overhead or other supplements to the provincial general fund. *Revenue Recycling:* ~102 percent. More revenues than are actually collected under the tax are recycled under the overall carbon tax shift program to individuals and business through a combination of direct payments, reductions in marginal tax rates, and other targeted tax credits. In total, individuals were set to receive $473m (CAD 522m) in payments and tax benefits for FY2013/14. The most significant broad-based revenue recycling measure in addition to the more narrowly targeted measures described above include a 5-percentage-point reduction in the first two tiers of personal income-tax rate. Businesses, meanwhile, receive their own broad tax-rate cuts, including a small business income-tax-rate cut from 4.5 percent to 2.5 percent, industrial and farm property tax credits, and a cut in the general corporate income-tax rate from 12 percent to 10 percent (this was partially reversed, however, in 2013, when the corporate income-tax rate was raised back to 11 percent). These business tax changes totaled $643m (CAD 710m) in FY2013/14.

[r] Canada National Inventory Report to the United Nations Framework Convention of Climate Change (UNFCCC), 2011.

[s] British Columbia in 2007 made a political commitment towards a North American regional carbon cap-and-trade system by joining the Western Climate Initiative after the Premier visited then-California Governor Arnold Schwarzenegger. Following deliberations with local stakeholders and experts, the Premier subsequently personally championed a provincial carbon tax instead, and details of integration with a potential future cap-and-trade system were left unresolved. UBC’s Kathryn Harrison has published a number of illuminating investigations into the political economy of this and other decisions made in the British Columbia carbon tax system.

[t] British Columbia Ministry of Finance, “Budget and Fiscal Plan 2014/15–2016/17,” February 18, 2014.

[u] Similar to some of the other carbon pricing cases discussed here, British Columbia’s carbon tax was introduced amid a broader comprehensive provincial tax reform package as well as new fuel taxes, which in some cases exceeded the consumer cost impact from the carbon tax. See Jeremy Carl and David Fedor, “Revenue-Neutral Carbon Taxes in the Real World,” The Hoover Institution, 2012

[v] Kathryn Harrison, “The Political Economy of British Columbia’s Carbon Tax,” OECD Working Paper, November 2012.

B.6 Denmark carbon dioxide tax act

Active period	1992–ongoing
Coverage	Denmark's carbon tax covers emissions from the use of oil, natural gas, coal, electricity, and waste incineration. When originally introduced, the Danish carbon tax largely displaced components of an existing energy tax. The carbon tax's coverage was then significantly expanded under the 1996 “Green Tax Package.” Today, the carbon dioxide and energy taxes are administered as complements.
Revenue stream	~$1b (DKK ~5.5b in 2010) per year from a DKK 167 (~$31) per ton carbon dioxide tax rate in 2014.[w] The tax rate is currently set to rise by 1.8 percent annually. Tax rates are not consistent among users: they are lower for energy-intensive industrial users and higher for space heating. Businesses can also significantly reduce their tax burdens by voluntarily entering into energy-efficiency-improvement agreements with the Danish Energy Authority, though the terms of this exemption have changed over time.
Use of revenues	*Green subsidies:* ~5–10 percent. - Of the $256m in additional revenues gained from increasing the carbon dioxide tax in the 1996 Green Tax Package (see

	below; revenue estimates are as of the year 2000), \$59m were directed toward providing business energy efficiency subsidies of up to 30 percent of private investment costs.[x] This was the most significant revenue earmark for green spending established over the course of the Danish carbon tax. *Other earmarks:* ~0 percent. - Energy-intensive industries benefit from significantly reduced carbon tax rates, which is sometimes referred to as a "carbon tax rebate." Only the reduced tax rate is counted here in the above estimate of total tax revenue, and so the reduction is not considered an industry earmark. *General funds:* ~45–50 percent. - Most of the carbon tax revenues contribute toward the government's general budget. Because the tax was developed with the aim of reducing the government's overall reliance on labor taxes, however, we ascribe roughly half of the revenues to each category (see below). The Danish Energy Authority estimated that as 2000, about 1.5 percent of carbon tax revenues were needed for public administration costs, alongside additional private sector administration costs estimated at 1–2 percent of the total carbon tax burden.[y] *Revenue Recycling:* ~45 percent. - Both personal income tax and employer social security contributions have been reduced in stages over carbon tax implementation period. The first stage of the carbon tax (1992–93) came alongside significant reductions in labor taxes and so revenues can be considered to be fully recycled. Expansion in carbon tax revenues from the second stage Green Tax Package reforms (1996) was also largely used to offset new labor tax cuts—\$278 in new revenues were directed toward reductions in the income tax and tax on self-employment as of the year 2000—but some revenues were returned to industry as subsidies (see above). The third-stage reforms (1998), which increased the carbon tax rate, were also returned to the economy.[z] Though reducing these other taxes was stated as an original goal of expanding carbon and energy taxes, carbon tax revenues do not directly fund other labor tax reductions. Labor tax reductions have generally exceeded any new carbon tax revenues generated.[aa]

[w] Danish Energy Agency, "Energy Efficiency Policies and Measures in Denmark," October 2012. Other historical revenue estimates include: \$695m in the year 1999 (Eurostat, "Energy Taxes in the Nordic Countries: Does the polluter pay?," March 2003) and \$905m in 2008 from a rate of about DKR 100 (~\$20) per ton carbon dioxide (Jenny Sumner, Lori Bird, and Hillary Smith, "Carbon Taxes: A Review of Experience and Policy Design Considerations," National Renewable Energy Laboratory (NREL), December 2009).

[x] Danish Energy Authority, "Green Taxes In Trade And Industry—Danish Experiences," 2002

[y] Ibid.

[z] Stefan Speck, "The Design of Carbon and Broad-Based Energy Taxes in European Countries," *Vermont Journal of Environmental Law*, Volume 10, 2008.

[aa] Stefan Speck and Jirina Jilkova, "Design of Environmental Tax Reforms in Europe," Oxford Scholarship Online, February 2010

B.7 Switzerland Carbon Dioxide Levy

Active period	2008–ongoing
Coverage	Switzerland taxes carbon dioxide emissions exceeding a set percentage of a regulated firm's 1990 emission level. Fossil fuels used in heating and power generation are covered, but not those used in the transportation sector. A newer, parallel Swiss cap-and-trade system (see above) allows large industry emitters to opt out of the carbon tax. Switzerland does not participate in the European Union's Emission Trading System.
Revenue stream	~ \$875m in 2014 (CHF 800m) from a tax rate of CHF 60 (~\$56) per ton carbon dioxide emissions. This rate has increased gradually from CHF 12 (~\$11.20) per ton in 2008 to CHF 36 (~\$33.50) per ton over the period 2010–2013, and the Swiss government has held out the possibility of continued future increases based on the country's performance in hitting carbon dioxide emission reduction targets.[ab]
Use of revenues	*Green subsidies:* ~33 percent. - Since the program's outset, Switzerland has earmarked a share of carbon tax revenues to subsidize building-sector energy use reductions, either through energy efficiency or distributed renewable power generation. For the period 2008–2012, a maximum of CHF 200m (~186m) were dedicated to building-sector emission reduction measures. For the period 2013–2020, one-third of total carbon tax revenues (with a cap of CHF 300m, ~\$280m per year) are similarly earmarked—one-third of that for deployment of renewables and two-thirds for building energy efficiency. Only companies that face compliance obligations under the levy scheme are eligible to claim such funding. A further budget of CHF 25m (~\$23.3m) per year is earmarked for a loan guarantee green "Technology Fund." *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~0 percent. - Unknown. *Revenue Recycling:* ~67 percent. - For the period 2013–2020, the remaining two-thirds of carbon tax revenues not spent on building-sector green subsidies are "redistributed to the public and companies"[ac] in the form of household-level lump sum rebates and employer

payroll rebates. In 2014, \$197m (CHF 180m) were returned to businesses through a comprehensive payroll rebate of 0.573 percent, while the general public received a flat carbon tax rebate of \$50.55 (CHF 46.20) per "insured person" (totaling \$414m, CHF 379m), distributed through the country's mandatory basic health insurance system (a mechanism already employed to issue rebates funded by Switzerland's separate "volatile organic compound" tax).[ad]

[ab] The Federal Assembly of the Swiss Confederation, "Federal law on the reduction of CO 2 emissions(CO 2 law): 641.71," December 23, 2011, in German. https://www.admin.ch/opc/de/classified-compilation/20120090/.

[ac] World Bank Partnership for Market Readiness (PMR), "Putting a price on carbon with a tax," December 2014.

[ad] See Swiss Federal Office for the Environment, "Topic: CO2 Levy," in German, http://www.bafu.admin.ch/co2-abgabe.

B.8 Mexico special tax on production and services

Active period	January 2014–ongoing
Coverage	Mexico's carbon tax is intended to cover only the carbon content of fossil fuel use that exceeds the carbon intensity of natural gas. This means that natural gas would face little to no tax burden, but coal or oil use, for example, would be taxed at higher volumetric rates tied to their carbon content. The tax system was introduced alongside a new Mexican global carbon credit trading platform, and large emitters can comply with the "tax" through the purchase of carbon Certified Emissions Reductions credits.
Revenue stream	Third-party estimates of 2014 tax revenues of ~\$870 m (MEX 11.5b) from tax rates ranging from MEX 10 to 50 (~\$0.80 to \$3.80) per ton carbon dioxide (depending on fuel type), and capped at 3 percent of total sale price.[ae]
Use of revenues	*Green subsidies:* ~0 percent. - Mexico has an existing slate of green subsidies to reduce greenhouse gas emissions, but it is unknown if revenues from the new carbon tax will be earmarked for these or additional spending programs. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~100 percent. - Tax revenues are assumed to contribute to government general funds in the absence of known announced earmarks. *Revenue Recycling:* ~0 percent. - No known revenue recycling tied to the carbon tax system. However, the Mexican federal government spends significant sums subsidizing end users of fuels at rates that would appear to exceed the level of carbon tax—for example, \$3.5b annually on gasoline alone.

[ae] Juan Carlos Belausteguigoitia Rius, "Economic analyses to support the environmental fiscal reform," Centro Mario Molina, May 2014.

B.9 Finland carbon dioxide tax

Active period	1990–ongoing
Coverage	One of the oldest global carbon taxes, Finland's carbon tax covers most fossil fuels but does not apply to electricity generation or commercial aviation.[af]
Revenue stream	~\$800m (EUR ~600m) per year from a EUR 35 (~\$45) per ton carbon dioxide tax on the emissions embedded in the carbon content of "heating fuels" and a EUR 60 per ton tax on the carbon content of liquid transport fuels. Carbon tax revenues are estimated as a component of broader energy tax revenues reported by Statistics Finland (totaling EUR ~4b, ~\$5.1b, in 2013).
Use of revenues	*Green subsidies:* ~0 percent. - No known earmarks to subsidize new green spending. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~50 percent. - Finnish carbon tax revenues are transferred directly into government general funds.[ag] *Revenue Recycling:* ~50 percent. - Similar to many other Nordic countries with early carbon taxes, Finland in 1997 reduced personal national and local income taxed and employer social security contributions alongside the carbon tax implementation period, but at levels around five times the new carbon tax revenues. Though these tax reductions were not explicitly tied to the carbon tax,[ah] a representative share of revenues is ascribed here as a tax shift.

[af] As with other the other Scandinavian carbon tax systems, Finland's carbon tax has substantially evolved over time alongside its broad-based energy taxes to meet EU energy tax requirements, to harmonize against the other Nordic energy tax systems, to protect trade-exposed or other favored industries, or to target unrelated energy policy goals. Vehmas (2005), referring to these changes to the carbon tax as "tax departures," argues that the resultant tax structure is essentially a fiscal rather than environmental instrument. Jarmo

Vehmas, "Energy-related taxation as an environmental policy tool—the Finnish experience 1990–2003," Energy Policy, 2005, 33(17):2175-2182.

[ag] Parkkinen in Jenny Sumner, Lori Bird, and Hillary Smith, "Carbon Taxes: A Review of Experience and Policy Design Considerations," NREL, December 2009.

[ah] Ibid.

B.10 Ireland natural gas carbon tax, mineral oil tax, and solid fuel carbon tax

Active period	2010–ongoing
Coverage	Use of natural gas and oil has been covered under the carbon tax since 2010, and solid fuels since 2013, for uses not already covered under the European Union Emissions Trading System.
Revenue stream	~$510m (EUR ~400m) in 2012. The tax rate was set at EUR 20 (~$25.50) per ton carbon dioxide from May 2014, with limited discounts for certain traditional biomass fuels, including peat.
Use of revenues	*Green subsidies:* ~12.5 percent. - Of carbon tax revenues, ~$66m (EUR 50m) are earmarked annually [ai] to fund building and low-income resident energy efficiency measures, including increasing the budgets of the "Warmer Homes" and "Home Energy Savings" energy efficiency retrofit subsidy programs and placing them under a newly formed "National Energy Retrofit Program". *Other earmarks:* ~0 percent. - No other known earmarks (apart from low-income energy efficiency subsidies). *General funds:* ~87.5 percent. - Remaining revenues are used to "support the civil service." The tax was instituted following the 2008 global financial crisis in part to reduce ballooning government deficits without raising income taxes.[aj] There is no explicit legislative link between carbon tax revenues and other specific spending programs. *Revenue Recycling:* ~0 percent. - Direct revenue recycling under the Irish carbon tax is limited. The country does institute an existing "National Fuel Allowance Scheme" weekly cash payment to low- and fixed-income households, whose rate was about EUR 20 (~$25.50) in 2013 and issued for only the colder portion of the year. There is no formal earmarking of carbon tax revenues for this subsidy, whose overall demand is driven largely by employment and macroeconomic conditions, though its continued budgetary support is arguably politically linked to the existence of the carbon tax.[ak] This subsidy totaled ~$280m (EUR 211m) in 2013.[al]

[ai] "EUR 50m of the carbon tax yield will be used to fund measures such as help for households at risk of fuel poverty to make their homes warmer. The local authorities will receive additional funding to retrofit the social housing stock." Ireland Minister for Finance Brian Lenihan, "Financial Statement of the Minister of Finance," December 9, 2009, http://www.budget.gov.ie/Budgets/2010/2010.aspx.

[aj] Elisabeth Rosenthal, "Carbon Taxes Make Ireland Even Greener," *New York Times*, December 27, 2012, http://www.nytimes.com/2012/12/28/science/earth/in-ireland-carbon-taxes-pay-off.html?_r=0.

[ak] Frank Convery, Louise Dunne, and Deirdre Joyce, "Ireland's Carbon Tax and the Fiscal Crisis: Issues in Fiscal Adjustment, Environmental Effectiveness, Competitiveness, Leakage and Equity Implications," *OECD Environmental Working Papers,* October 3, 2013.

[al] Government of Ireland, "Expenditure Report 2013," December 2013, http://www.budget.gov.ie/Budgets/2013/2013.aspx.

B.11 Japan tax for climate change mitigation

Active period	2012–ongoing
Coverage	Covers all fossil fuels with some sectoral exceptions, including agriculture and fishing, domestic aviation, and railways (exemptions are through 2017 only). Designed to be a "broad and thin" tax to avoid overburdening particular sectors of the economy.
Revenue stream	Tax revenues were expected to be $490m (JPY 39.1b) in 2012, rising to ~$3.3b (JPY 262 billion) in 2016 (at y2012 exchange rates). This was from a tax rate of JPY 192 (~$1.80 at y2014 exchange rates) per ton carbon dioxide-equivalent emissions from April 2014, increasing gradually to JPY 289 (~$2.70) by late 2017. The tax is implemented as a supplement to Japan's existing national energy and fuel taxes and represents less than 1 percent of those total revenues.[am] The Japanese government expects the average household burden of the carbon tax to be about JPY 100 (~$0.95) per month.[an]
Use of revenues	*Green subsidies:* ~100 percent. - Revenues are earmarked for spending on the promotion of "innovative domestic low-carbon technology," including lithium ion batteries, energy-efficient equipment use by small and medium-sized businesses, and the promotion of energy efficiency and renewable energy by local governments through "Green New Deal Fund" financing. Many of these measures were outlined in Japan's existing 2012 "4th Basic Environmental Plan."[ao] The Ministry of Finance implements the tax as an add-on to the existing upstream Petroleum and Coal tax, with which revenues are combined and channeled through METI (Ministry of Economy, Trade, and Industry) or the Ministry of

	Environment for spending. Such revenue pooling makes the tracking of carbon tax funds difficult. The Ministry of Environment has begun using these newer carbon tax revenues to subsidize the country's "Joint Crediting Mechanism" in which the government cost-shares 50 percent of a greenhouse gas mitigation infrastructure project's development in return for half of that project's global warming emission credits ($12m was spent on this program in FY2013).[ap] Japan's Ministry of Environment described the express purpose of the carbon tax at its launch as encouraging reductions in domestic greenhouse gas emissions. The use of carbon tax revenues for green subsidies, in addition to elevated prices of fossil fuels from the tax itself and consumer salience of the tax's existence, was one means toward this goal. In 2014, the Japanese *Keidanren* business lobby criticized management of Japanese carbon tax revenues on two grounds. First was a lack of transparency by the government in failing to annually report the actual level of collected carbon tax revenues. Second was a claim that, contrary to announced spending plans, carbon tax revenues were accruing in government general funds or being rolled-over, unspent, year-to-year and not being effectively spent on greenhouse gas mitigating research and development or energy efficiency subsidies.[aq] This criticism was rooted in the unexpected rise in Japanese energy prices—and combined carbon tax Petroleum and Coal Tax revenues—following the shutdown of the country's nuclear power fleet in the wake of the 2011 Great Tohoku Earthquake and Tsunami. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~0 percent. - None specified, though see above *Keidanren* note on actual spending patterns. *Revenue Recycling:* ~0 percent. - Though other tax reforms were enacted in 2012 alongside the creation of the carbon tax, there are no known direct household subsidies or tax swaps explicitly tied to new carbon tax revenues. Some household and commercial green subsidies are delivered in the form of tax credits.

[am] Japan Ministry of Environment Economic Affairs Division, "Japan's Environmental and Automobile Tax System," 2014, http://www.env.go.jp/policy/tax/taxes.pdf.

[an] Japan Ministry of Environment Economic Affairs Division, "地球温暖化対策のための税の導入 [Introduction to the tax on global warming]," 2014, in Japanese, http://www.env.go.jp/policy/tax/about.html.

[ao] Japan Ministry of Environment, "環境基本計画 [Basic Environmental Plan]," April 2012, in Japanese, http://www.env.go.jp/press/files/jp/19833.pdf.

[ap] Takeshi Kuramochi, "GHG Mitigation in Japan: An Overview of the Current Policy Landscape," World Resources Institute, 2014.

[aq] Keidanren, "A Proposal for Near-Term Energy Policy," October 7, 2014, http://www.keidanren.or.jp/en/policy/index07.html.

B.12 France domestic consumption tax on energy products, carbon dioxide component ("contribution climat-énergie – CEE")

Active period	April 2014–ongoing
Coverage	This recently launched French carbon tax covers the carbon content of natural gas, fuel oil, and coal that is not already regulated under the European Union Emission Trading System. From 2015 the tax is set to extend to include transport fuels and heating oil. Industrial entities covered under European Union Emission Trading System, as well as the fishing industry, are exempt.
Revenue stream	Carbon tax revenues for the abbreviated in 2014 inaugural year were expected to be $452m (EUR 340m) from a EUR 7 (~$9.30) per ton carbon dioxide tax rate. Revenues are estimated to climb to ~$3.3b (EUR 2.5b) from a EUR 14.50 (~$19.30) rate in 2015, and $5.3b (EUR 4b) from a EUR 22 (~$29.20) per ton rate in 2016. If enacted, this would make the French tax among the largest carbon-revenue systems globally.
Use of revenues	*Green subsidies:* ~38–100 percent. - One hundred percent of 2014 French carbon tax revenues were set to be spent on the country's "green energy transition plans." The share of green spending is set to decline rapidly over time, however, to 44 percent of 2015 revenues and 38 percent of anticipated 2016 revenues. Meanwhile, an existing French tax break for the production of biofuels was eliminated alongside introduction of the carbon tax. *Other earmarks*: ~0 percent. - No known unrelated earmarks. *General funds:* ~0–62 percent. - As the share of carbon tax revenues earmarked for green subsidies declines over time, the remaining (and growing) revenues will presumably be used to support other government expenditures—no other concrete spending plans are known to have been announced. *Revenue Recycling:* ~0 percent. - Though not included in the original policy plans, a new expenditure program for carbon tax revenue was announced in March 2014, a month before launch, to compensate low-income households for increases in natural gas utility rates due to the inclusion of heating fuels under the carbon tax beginning in 2015. This will increase the share of revenue recycling from the French carbon tax, as enacted.

B.13 Iceland carbon tax on carbon of fossil origin

Active period	2010–ongoing
Coverage	Covers use of diesel, gasoline, fuel oil, and liquid petroleum gas not already covered under the European Union Emissions Trading System. The tax was originally set to expire in 2012 but has now been extended indefinitely.
Revenue stream	Carbon tax revenues for 2013 were estimated to be $30m (IKR 3.6b).[ar] The tax rate in 2014 was set at IKR 1,120 (~$10) per ton carbon dioxide, automatically rising by 3 percent annually.
Use of revenues	*Green subsidies:* ~0 percent. - No known earmarks to subsidize new green spending. *Other earmarks:* ~0 percent. - No known unrelated earmarks. *General funds:* ~100 percent. - The Treasury administers Iceland's carbon-tax revenues for general expenditures. The tax was instituted as a special revenue measure following government deficits realized during the 2008 global financial crisis. *Revenue Recycling:* ~0 percent. - There are no known revenue-recycling measures or tax swaps associated with Iceland's carbon tax.

[ar] Iceland Ministry of Finance and Economic Affairs, "The Fiscal Budget Proposal for 2013," September 2012.

B.14 Other carbon tax systems

Netherlands carbon tax

The Netherlands has had a broad energy and carbon-oriented "Environmental Tax on Fuels" in place since 1992. This was expanded in 1996 with the "Regulatory Energy Tax," which targeted residential and commercial energy users with the express purpose of influencing their consumption behaviors through higher prices. Today, however, the carbon dioxide component of the country's broader energy and environmental taxes appears to be only implicit and, if converted to a rate per ton emissions, is inconsistent across fuels. While Dutch energy tax revenues reached ~$16.5b (EUR ~12.5b) in 2013, the government does not ascribe a share for carbon dioxide.[as] The original 1992 energy and carbon taxes were enacted in order to raise overall government revenues and were not earmarked for other spending. The 1996 supplementary legislation, which raised the carbon tax rate, was explicitly tied to simultaneous reductions in the existing personal income tax, corporate income tax, and employer social security contributions, with tax-free allowances extended.

Slovenia Decree on Tax on Emissions of Carbon Dioxide

Slovenia was the first Eastern European country to introduce a carbon-revenue system when it launched a tax in 1997 at a headline rate of 1,000 Slovene tolar (~$6.26) per ton carbon dioxide. The rate was tripled the following year, resulting in a significant restructuring of the tax to include numerous end-user- and fuel-specific exemptions and discounts to the tax rate. These exemptions, which implemented other adjustments to the value-added tax rate, are so broad and seemingly haphazard as to question whether this tax can be considered a true carbon price as opposed to a fuel excise tax.[at] Revenues for 2004 were reported to be roughly $75 m (1.5 trillion Slovene tolar) with one-third of revenues directed toward green subsidies (energy efficiency and other emission mitigation) with the remaining funds used in general funs without earmark.[au]

Costa Rica Carbon Tax

The Costa Rica government received tax revenues of ~$200 m per year from a levy of 3.5 percent of the market value of individual fossil fuels, covering all fossil fuel use. Though referred to as a "carbon tax," this price-based tax, which has been in place since 1997, does not appear to be tied to the carbon content of fuels and so is in function a more conventional energy sales tax. Thirty-three percent of tax revenues were originally earmarked for use by Costa Rica's State Environmental Services Program, which primarily funds forest conservation programs. After years of consistent underpayment by the central government, however, this share was reduced to 3.5 percent of "carbon tax" revenues in 2001.[av] The government now retains the remaining "carbon tax" funds for general budgetary use.

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