Discussion Paper
Research Project on Renewable Energy Economics,
Graduate School of Economics, Kyoto University

INCLUDING TRANSPORT FUELS IN EMISSIONS TRADING SCHEMES:

LESSONS FROM CALIFORNIA FOR GERMANY'S NEW FUELS ETS

28th April 2021

Sven Rudolph[a], Takeshi Kawakatsu[b], Achim Lerch[c], Elena Aydos[d] and Seiji Ikkatai[e]

[a]Associate Professor, Hakubi Center / GSGES, Kyoto University, Japan.
[b]Professor, Faculty of Public Policy, Kyoto Prefectural University, Japan.
[c]Professor, FOM University of Applied Sciences for Economics and Management.
[d]Senior Lecturer, University of Newcastle Law School, Australia.
[e]Professor, Graduate School of Environmental Sciences, Musashino University, Tokyo, Japan.
Contact: rudolph@econ.kyoto-u.ac.jp.

INCLUDING TRANSPORT FUELS IN EMISSIONS TRADING SCHEMES:

Lessons from California for Germany's New Fuels ETS

Sven Rudolph[a], Takeshi Kawakatsu[b], Achim Lerch[c], Elena Aydos[d] and Seiji Ikkatai[e]

[a]Associate Professor, Hakubi Center / GSGES, Kyoto University, Japan.
[b]Professor, Faculty of Public Policy, Kyoto Prefectural University, Japan.
[c]Professor, FOM University of Applied Sciences for Economics and Management.
[d]Senior Lecturer, University of Newcastle Law School, Australia.
[e]Professor, Graduate School of Environmental Sciences, Musashino University, Tokyo, Japan.
Contact: rudolph@econ.kyoto-u.ac.jp.

Abstract:

Emissions from the transport sectors remain to be the Achille's Heel of climate policy. In spite of emissions reductions in industry and power generation in climate pioneer jurisdictions such as California and Germany, transport sector emissions have not been significantly reduced. So how can this Achilles Heel of modern climate policy be cured? Theory and practice of treating transport sector carbon dioxide (CO2) emissions have mainly focused on regulatory (e.g. low carbon fuel standards), subsidy (e.g. tax credits for electric vehicles), of tax approach (e.g. carbon taxes). However, California has been using an emission trading scheme (ETS) for the transport sector since 2015, and Germany is going to implement its own Fuels ETS (F-ETS) next year. Against this background, we briefly recollect the advantages of cap-and-trade, before describing the design of both the Californian and the German approach to including transport sector emissions in ETS. We then comparatively evaluate the designs based on a set of ambitious sustainability criteria developed by Rudolph et al. (2012) and analyze the (expected) results. We mainly conclude that ETS can be used for sustainably limiting transport sector emissions, but the respective design has to reflect the specifics of the sector. We also show that, while already being an ambitious approach, Germany's new program could greatly benefit from three major program revisions.

Keywords: Climate Policy, Emissions Trading, Transport, Sustainability, California, Germany

1. Introduction

Transport sector emissions remain the Achilles Heel of climate policy. The 2018 special report of the Intergovernmental Panel on Climate Change (IPCC) reminds that "[p]athways limiting global warming to 1.5°C … require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems" (IPCC, 2018). This is particularly true for the transport sector. Despite of greenhouse gas (GHG) emission reductions in industrial and electrical stationary sources in some countries, transport sector emissions have remained difficult to arrest and are jeopardizing successes in other sectors (EEA,2020). Hence, there is an urgent need to more effectively control transport sector emissions.

In addition to regulatory instruments such as low carbon fuel standards e.g. for electrical vehicles, or planning such as public transportation infrastructure development, market-based instruments can play an important role in reducing transport sector emissions (Marta et al, 2019). While much of the literature and policy has focused on taxation and subsidies, cap-and-trade has emerged as an alternative in several pioneering jurisdictions: New Zealand has been covering domestic transport in its multi-sector Emissions Trading Scheme since 2010, California has covered transport emissions in its multi-sector cap-and-trade program since 2015. Germany phases in a national heating and transport fuels cap-and-trade program from 2021, and the Regional Greenhouse Gas Initiative (RGGI) is just about to finalize its Memorandum of Understanding (MOU) for the Transportation & Climate Initiative (TCI), a regional transport sector cap-and-trade scheme in the Northeastern USA[1]. Due to the comparable total amount of transport sector emissions, this paper focuses on California and Germany.

In general, cap-and-trade, also known as emissions trading or carbon markets, offers a number of advantages. Cap-and-trade

- differentiates and prioritizes scale, distribution, and allocation decisions in an economy beyond quantitative economic growth (Daly, 2019);
- is capable of achieving pre-set emission targets at minimum cost to society (Endres, 2011);
- can be made truly sustainable (Rudolph et al, 2012);
- has been spreading across the globe and governance levels (ICAP, 2019);

[1] https://www.transportationandclimate.org/.

- is considered permissible under the Paris Agreement Article 6 (UN, 2015).

In consequence, sustainable transport sector cap-and-trade could become a core policy for parties to effectively, efficiently, and fairly contribute to achieving the Paris Agreement target, while avoiding presumably socially unfair, environmentally ineffective, high-cost interventions in the mobility market (Lerch, 2020).

2. The California Cap-and-Trade Program (CalCaT)

2.1 GHG Trends and Climate Policy Programs

The State of California is the biggest US state economy with 1990 total GHG of 433 million tons (the second highest in the US) and 2017 per capita emissions of 10.7 tons (the second lowest in the US) (CARB, 2019a). Just as Germany, California has been a climate policy leader particularly in North America at least since Governor Arnold Schwarzenegger initiated climate policy legislation in the early 2000s. As a consequence, GHG emissions fell by 14% between their 2004 peak and 2017. The initial GHG target of stabilizing emissions at the 1990 level by 2020 was achieved early in 2016, while more ambitious future reduction targets aim at -40% by 2030 and net carbon neutrality by 2050.

Targets and policies have been enacted mainly by the 2006 California Global Warming Solutions Act, Assembly Bill 32 (AB32), and the follow-up 2016 Senate Bill 32 (SB32) and outlined in detail in three Scoping Plans of 2008, 2014, and 2017 (CARB, 2006; 2008; 2014; 2017a; 2017b). Policies included the Renewable Portfolio Standard (RPS), the Emissions Performance Standard (EPS), and the Low Carbon Fuel Standard (LCFS) as well as the California Cap-and-Trade Program (CalCaT), worldwide the first cap-and-trade program to include transportation fuels.

Still, transport sector GHG emissions increased from 150 million tons in 1990 to 170 million tons in 2017. Given the share of transport sector GHG emissions (41% in 2017) and the longtime increasing trend, already from 2015, California has included the transport sector in CalCaT, which had started with smaller scope back in 2013. A model rule for a multi-sector cap-and-trade scheme had been developed and published in 2008/10 under the umbrella of the Western Climate Initiative (WCI), a joint project of several western US states, Canadian provinces, and even Mexican states, for reducing GHG emissions by a linked cap-and-trade program[2]. The Scoping Plans, supporting regulation, and the 2017 AB398 (CARB, 2017c) laid out the details for transport coverage under CalCaT[3].

2.2 CalCaT Design

CalCaT covers all six Kyoto GHG (CO_2, CH_4, N_2O, SF_6, HFCs, PFCs) plus NF_3 and other

[2] For details on the model design see WCI (2010).
[3] For general design overviews see ICAP (2020) and CARB (2015a).

fluorinated gases. In order to also achieve broad sector coverage, California chose a two-step, combined downstream-upstream approach. CalCaT has thus been covering large industrial facilities and electrical utilities (including imports) downstream at the facility level since 2013, and liquid and gaseous fossil fuels (i.e. diesel, petroleum, natural gas, liquefied natural gas) for use in smaller facilities, buildings, and the transport sector upstream at the supplier level since 2015. Hence, different from the new sector-specific German Fuels Emissions Trading Scheme, California chose a multi-sector design without specific sector caps. Participation is mandatory for all entities falling under the inclusion threshold of annual GHG emissions of at least 25,000 t CO_2e. As a result, California now covers approximately 500 entities and caps 80% of its GHG emissions.

CalCaT started with a relatively generous cap, but has recently significantly stepped up ambitions. Reduction targets have been 4% from the 2012 business-as-usual scenario between 2013 and 2014, 15% from 2015 levels by 2020, and 49% from 2015 levels by 2030. In more detail, in 2013, the absolute volume cap was set at just below 163 million metric tons of CO_2e, which was 2% below the business-as-usual scenario for 2012, and was then again reduced by 2% in 2014. In 2015, due to broadened coverage, the cap increased to almost 395 million tons and then declined by 12 million tons or somewhat more than 3% per year between 2016 and 2020. In 2020, the cap thus reached a little over 334 million tons. From 2021, the cap decreases by about 13.4 million tons annually at an average cap decline factor of 5% to reach 200 million tons by 2030.

California Carbon Allowances (CCA), each worth one metric ton of CO_2e emission in a given year, are initially allocated in a mix of free allocation and auctioning. Overall, 65% of all allowances allocated in 2019 were available through auction, while the remaining 35% were allocated free of charge. Both natural gas and electrical utilities receive allowances on behalf of ratepayers. Hence, the allowance value has to benefit ratepayers and achieve emission reductions. For electrical utilities, individual allocations are based on long-term procurement plans, while natural gas supplier allocations are based on 2011 sales. Investor-owned utilities (IOU), roughly two thirds of all utilities, must consign all allocated allowances to auction, and auction proceeds are then redistributed to ratepayers. Public-owned utilities (POU) and electrical cooperatives (COOP) may directly redistribute the allowance value, without consigning allowances to auctions.

While other sectors receive allowances either for free (industry) or on behalf of ratepayers (electrical and gas utilities), transport fuel distributors do not receive free allocations. Instead, they have to purchase all allowances required for program compliance either via public auctions or on the secondary market.

Auctions were held separately in California in the first compliance period, but since the 2014 link with Quebec, the two jurisdictions have held joint auctions. Auctions happen quarterly in February, May, August, and November, and follow the “single round, sealed bid, uniform price”-format. Unsold allowances are transferred to the reserve. In addition to public auctions, allowances can also be acquired on the secondary market, e.g. the Intercontinental Exchange. Both the primary and the secondary market are open to all covered facilities and interested parties.

CalCaT applies a sophisticated set of rules for redistributing allowance value. Statute requires that

1. the allowance value from allocations to electrical and natural gas utilities must benefit ratepayers and achieve emission reductions;
2. revenues originating from allowance auctions and Allowance Price Containment Reserve (APCR, see below) sales
    a. have to be partly (25% of all revenues until 2016, 35% since then) used in programs that benefit and/or are located in disadvantaged communities or low-income communities or households;
    b. must be invested in programs that generate environmental benefits;
    c. are partly appropriated for specific projects such as high-speed rail, affordable housing, sustainable communities, transit operations, or fire prevention.

Proceeds are first transferred to the Greenhouse Gas Reduction Fund (GGRF) and then, based on above mentioned general rules, redirected to individual projects through investment plans outlined by the Public Utilities Commission (PUC). In addition, IOU pay out the California Climate Credit (CCC) to their customers on an equal credit per household basis[4]. The CCC is determined by the proceeds generated from IOU allowances consigned to auction minus funding for clean energy and energy efficiency programs, for assistance to industry and small business customers, for decarbonization pilot projects, and for administrative and outreach costs. While the exact US$ value of the credit depends on the individual utility, between 2014 and 2019, on average, each eligible household received a 30 US$ Residential Electric California Climate Credit and a 25$ Residential Natural Gas California Climate Credit via rebates on their respective energy bills independent of the actual energy consumption. The allowance value initially allocated to POU is redistributed upon POU's own decision, but still the above-mentioned first basic rules applies and investments have to be reported to the PUC annually.

In order to increase flexibility beyond trading, CalCaT allows banking and offset use, while prohibiting borrowing. Banking is allowed even across compliance periods and only restricted by a generous holding limit for each individual entity. Offsets can be used under quantitative and qualitative restrictions. Until 2020, a quantitative limit of 8% of individual entities' compliance obligations applied. From 2021 to 2025 this limit will be set at 4% and will remain at 6% thereafter. Also, from 2021 onwards, not more than half of the quantitative limit may come from offsets that do not provide Direct Environmental Benefits (DEB) to California. Performance standards define DEB eligibility by offset activity category. Offset project

[4] For details on the CCC, see CARB (2020).

categories eligible under CalCaT are CO_2 sequestration in forest projects and urban forestry, CH_4 reduction in livestock projects, mining projects, and rice cultivation, as well as Ozone Depleting Substances reduction projects. While all projects basically have to originate from the USA, CalCaT also accepts offset credits from linked jurisdictions, currently only Quebec, which particularly adds the project category of landfill site gas capture. All offset projects have to acquire independent third-party verification and have to comply with specific CARB-approved offset protocols. Particularly, for all project categories, emission reductions have to be real, additional, quantifiable, permanent, verifiable, and enforceable.

For price control, CalCaT has been using an Auction Reserve Price and a Cost Containment Reserve and adds a "hard price ceiling"[5] in 2021. Acting as a price floor, an Auction Reserve Price was initially set at 10 US$ in 2013 and has increased since by 5% over inflation. In 2020, the Auction Reserve price stood at 16.68 US$. For cost containment, until 2020, the Allowance Price Containment Reserve (APCR) acted as a "soft price ceiling". It offered allowances on a regular basis in three equal price tiers. Triggers were initially set for 2013 at 40, 45 and 50 US$/ and have increased by 5% over inflation since then. In 2020, the price triggers were 62.29 US$, 70.09 US$, and 77.86 US$. The allowances came from different Compliance Period budgets: 1% from budget years 2013-2014, 4% from budget years 2015-2017, and 7% from budget years 2018-2020. In addition, APCR allowances were only available for entities registered in California[6].

From 2021, the cost containment provisions change in two ways: First, there will be two cost containment points at 41.40 US$ and 53.20 US$, which, when hit, trigger allowance sales from the APCR. The post-2020 APCR receives remaining allowances from the pre-2020 ACPR and from the 2021-2030 budget. Second, there will be a "hard price ceiling" at 65 US$, which, when hit, allows covered entities to buy the all allowances necessary for compliance at this fixed price. CARB will first use APCR allowances to satisfy demand, but when exhausted, additional allowances will be sold, and sale revenues will be used to purchase quality offset credits of the same amount.

2.3 Design Evaluation and Program Results

With respect to program evaluation, isolating effects of CalCaT on the transport sector is a most challenging task due other influential factors such as competing policies, economic cycles, and technological advancements, and has so far not been taken on rigorously and comprehensively (LAO, 2020). Still, the following insights can be gained from several years of CalCaT operation.

[5] While a "soft price ceiling" mitigates price surges, it does not guarantee an upper limit of the price, a "hard price ceiling", in turn, does.
[6] The linked Quebec Cap-and-Trade Scheme, however, has its own cost containment measure, which has a similar design to the one used in California.

2.3.1 Design Evaluation

An evaluation of CalCaT's treatment of transport fuels against sustainability criteria for GHG cap-and-trade design developed by Rudolph et al. (2012) shows that the Californian program complies with the vast majority of sustainability criteria. CalCaT's particular strengths are its broad coverage, full auctioning for the transport sector, and revenue recycling that specifically targets low-income households. However, while CalCaT applies a decreasing absolute volume cap, the emission limit is not in line with the emission reduction necessities of keeping global warming well below 2°C. Particular weaknesses are the collar and the rather generous offset rules.

2.3.2 Environmental Effects

Entities covered under CalCaT's cap have significantly contributed to overall GHG emission reductions in California and to achieving the state's climate goal four years ahead of time. In 2017, California's GHG emissions summed up to 427 million tons, already six million tons below the 2020 target (CARB, 2019a). However, sector data reveals that huge differences in emission trends exist amongst sectors under the cap. While the energy sectors experienced dramatic emissions reductions of almost 35% between 2012 and 2017, the industrial sector only reduced its emissions by approx. 2%, and the transport sector, after an interim low, has even increased its emissions by more than 5% recently.

Still, the independent effect of CalCaT on covered sector emissions remains unclear (LAO, 2019). While CARB estimated CalCaT to contribute 236 million tons or 38% to cumulative emission reductions between 2021 and 2030, making it the single most effective measure (CARB, 2017b), LAO (2019) argues that so far CalCaT's non-binding cap has not played an important role in setting incentives to reduce emissions. This view was supported by Granados and Spash, (2019) simple regression. The authors also argued that California's is only following a nation-wide trend of decreasing emissions and that 19% of emission reduction in California between 2000 and 2015 could be explained by changes in general economic conditions. However, in a more sophisticated ex post analysis based on decomposition analysis, Mastrandrea, Inman and Cullenward (2020) found a modest effect of the price signal on actual emission reductions. While they also confirmed that reduced economic activity in the wake of the 2008 financial crisis were the major contributor to early emission reductions, in 2014 the impact of policies on emissions surpassed the GDP effect. However, no study has so far identified the independent effect of the fuel price signal originating from the economy-wide cap on emissions from the transport sector.

Without doubt, though, CalCaT has forced covered entities into compliance with program obligations and guaranteed total emissions to stay below the cap. CARB's official Compliance Reports for Compliance Periods I and II (2013-2014, 2015-2017) showed almost 100% compliance with the state obligation to surrender allowances equal to emissions not only for transport sector entities but for covered facilities as a whole (CARB, 2018).

Still, several analysts warn that even under continuing 100% compliance, CalCaT's banking rule in combination with over-achievement before 2020 could put California's 2030 target at serious risk (Cullenward, Inman and Mastrandrea, 2019). They, using banking metrics, calculated the private[7] bank to be up to 227 million allowances, which is almost as much as the cumulative mitigation contribution of CalCaT to the 2030 target.[8] It has to be kept in mind, though, that this fact does not undermine the environmental effectiveness of CalCaT, because respective emission reductions had simply been done in earlier compliance periods leading to overcompliance at the time.

While price ceilings usually also raise concerns about environmental integrity, because they can lead to additional allowance allocations inflating the cap, CalCaT's allowance prices have remained far off the respective trigger prices. With respect to the hard price ceiling to become effective in 2021, CARB's advisory group emphasizes that 65 US$ is well in the range of recent Social Cost of Carbon (SCC) estimates and limits price volatility, while also conceding that a higher ceiling could incentivize beneficial high-cost mitigation projects as carbon capture and sequestration (CSS) (IEMAC, 2018).

Additional major concerns about CalCaT's environmental integrity have been raised with respect to emissions leakage from resource shuffling in the electricity sector[9] and forest offsets [10]. However, given the focus of this paper on a comparative analysis of transport fuels treatment in the German F-ETS and Cal CaT, a detailed analysis of these aspects is out of the scope of this paper.

In sum, while the independent effect of CalCaT on transport fuel emissions remains an open question, CalCaT has probably set an extra incentive to reduce emissions and has at least served as a "backstop" to ensure cumulative emissions to stay below the pre-determined total emissions cap.

2.3.3 Economic Impacts

Transport fuel pricing is part of California's multi-sector CalCaT and CalCaT itself is again embedded in a suite of instruments outlined in AB32 and SB32 as well as the accompanying (updated) Scoping Plans. So far, the independent economic effect of transport fuel carbon pricing has not been studied. For the complete set of policies, however, ex ante general-equilibrium model studies by CARB have estimated the GDP effect compared to the business-as-usual scenario to be between +0.3% and –0.2% in 2020 and –0.2 and –0.6% in 2030, while external studies estimated 2020 GDP effects to range from +1.1 to –2.2% (CARB, 2014).

[7] CARB holds extra allowances in the Government Reserve and Holding accounts.

[8] The holding limit for banked allowances does not prevent this, because the current calculation rule allows the entirety of covered entities to hold a up to 50 times the allowances currently banked. For details see Inman (2020).

[9] See e.g. Bushnell et al (2014) and Cullenward (2014).

[10] See e.g. Ruseva et al (2017) and, Gan and McCarl. (2007).

In 2017, based on the methodologies developed by the US Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), CARB calculated the economic damages avoided by the implementation of the updated Scoping Plan and the respective GHG emissions reductions to add up to 1.9 to 11.2 billion US$ for the year 2030, depending on the respective discount rate used (2.5-5%) (CARB, 2017b). According to the study, CalCaT alone saves between 0.6 and 6.6 billion US$, the largest share of any individual measure. In contrast, direct program costs in 2030 range from 1.7 to 5.2 billion US$ depending on CalCaT's 2030 allowance price.

Ex post studies on the independent economic impact of CalCaT are still rare. One particularly noteworthy macroeconomic input-output modelling exercises, however, focused on the Inland Empire, which has particular relevance for transport emissions (NEXT10, 2019). The Inland Empire, a transportation hub, center of the logistics and warehouse industry, and a "bedroom community" for Los Angeles is particularly fragile with respect to trapping air co-pollution, accommodating some of the lowest income households in California, and having a particularly big share of emissions from the transport sector. While between 2010 and 2016 the region realized total net benefits (including ripple effects) of 14.2 billion US$ in economic activity and 73,000 jobs from the Scoping Plan's major policies, only 25.7 million US$ of net benefits in economic activity and 154 jobs could be attributed to CalCaT. Including the disbursements of all 2010-2016 GGRF funds will raise the numbers to 150 million US$ net benefits in economic activity and 1,000 jobs. For the period 2017 to 2030, total cap-and-trade compliance costs are expected to be 3.24 billion US$, while appropriated GGRF funds sum up to 2.9 to 7 billion US$, again most probably making the region a net beneficiary.

With respect to the allowance price, three major observations can be made[11]. First, there has been a general trend towards a price increase from the early levels of around 12 US $ to just below 18 US$ in 2020. Second, the market price has closely followed the floor prices in CARB auctions. Third, at several occasions the secondary market price fell below the floor price. This mainly impacts state revenues (see below).

In sum, while the independent impact of transport fuel coverage under CalCaT remains unknown, California's climate program in general and CalCaT in particular only negligibly affect the state GDP, but generate significant net benefits to the state and its citizens. However, due to the lack of scarcity the CO_2e price remains low.

2.3.4 Social Impacts

CARB's initial 2008 study on economic effects of the Scoping Plan estimated a positive impact on households across income brackets (CARB, 2008). In 2020, while middle-and high-

[11] For details on quarterly auction results see the respective notices in https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/auction-information (retrieved: September 8, 2020) and for the general price development California Carbon Dashboard – Carbon Price. In: http://calcarbondash.org/ (retrieved: June 18, 2020).

income households would realize 500US$ net savings, low-income households' net-savings would be 400US$. In addition, the implementation of the Scoping Plan was estimated to create 40,000 jobs for middle-income and 50,000 for low-income workers. The same report also indicated that the implementation of the Scoping Plan would result in a range of public health benefits. The economic value of air-quality improvements was calculated to mount up to 4.4 billion US$ in 2020 and the reduction of smog-forming NO_X and Particular Matter (PM) 2.5. would reduce premature deaths by 780.

CARB's 2017 calculation of 2030 economic impacts updated household net savings to a range of 115-280 US$ depending on CalCaT's allowance price (CARB, 2017b). The report also re-calculated the economic value of avoided negative health impacts to be up to 1.8. billion US$ in 2030 and the number of avoided premature deaths to be up 3,300.

The 2020 California Climate Investments (CCI) report emphasized the positive effects of California's auction revenue spending via the GGRF (CCI, 2020). By the end of 2019, a total of 12.5 billion US$ had been raised, 5.3 billion US$ of which had been invested. These investments funded more than 428,000 projects in 68 major programs ranging from land preservation and tree planting to household energy efficiency measures and community air quality protection to workforce development and fire prevention. About half of the funds have particularly benefited low-emission transportation projects, and 57% of investments benefited low-income communities and households. CIC admitted, that the average GHG abatement cost of the investments has been 119 US$, but emphasized the co-benefits such as employment opportunities and improved air quality. In 2019, e.g., CCI funded projects supported approx. 10,500 jobs and reduced GHG emissions by almost 45 million tons of CO_2e as well as smog-forming NO_X emissions by 20,000 tons.

One major caveat, however, is that, as Bushnell (2017, 2020) pointed out, auction proceeds are far more volatile than allowances prices (Bushnell, 2020). Due to the specific design of CalCaT, in cases where the secondary market price for allowances drops below the auction floor price, the resulting reduction of allowances in circulation does not impact free initial allocations but only state auction sales. As a major consequence, CARB sales of allowances dropped to zero on several occasions in the past, e.g. in May and August 2016, generating zero revenues for the GGRF. Bushnell (2020) calls this "The High Cost of Low Carbon Prices".

3. Germany's New Fuels Emissions Trading Scheme

3.1 GHG Trends and Climate Policy Programs

Germany is the seventh biggest emitter of GHG in the world with 1990 emissions of 1,253 tons and 2017 per capita CO_2 emissions of around 9.5 tons, but has long been considered a global climate policy leader[12]. The fourth biggest economy in the world has constantly reduced its GHG emissions and easily achieved its Kyoto Protocol commitment (–21% by 2008-2012 from 1990 levels) ahead of time. Germany signed and ratified the Paris Agreement and committed to GHG emission reduction of 40% by 2020, 55% by 2030, and net carbon neutrality by 2050, the former of which, however, was only achieved due to the emissions drop caused by the COVID-19 economic crisis (Creutzig et al, 2020). The EU Effort Sharing Regulation, which breaks down the non-EU ETS share of the EU Nationally Determined Contribution (NDC) to the Paris Agreement to the member states level, obliges Germany to reduce its non-EU ETS GHG emissions by 38% from 2005 levels by 2030 (EU, 2018). The most recent "Federal Climate Change Act" (BMU, 2019a) was adopted on November 18, 2019 and is supposed to guarantee compliance with this share. The Act also defines annual absolute volume emission budgets for all economic sectors for the years 2020 to 2030. According to the Act, transport sector emissions have to be reduced by 42% from 1990 levels by 2030, i.e. 95 million tons in 2030.

In order to achieve its targets, as set by several climate protection programs embedded in the European Union climate strategy, Germany has implemented a policy mix that includes both market-based instruments such as the EU ETS, subsidy-based schemes such as the Feed-in Tariff (FIT), and regulatory approaches such as the recent coal phase-out[13]. The FIT as well as the EU ETS have been largely successful and GHG emissions in all sectors but one have decreased.

Transport sector emissions, however, stood at 165 million tons in 2019, which is exactly the same level as 1990, and are thus comparable to the Californian level, while the trend has been slightly more positive. Transport emissions in Germany account for 19% of total GHG emissions in Germany, which is less than half the share in California. Partly as a reaction to this deficit, Germany proposed the national Fuels Emissions Trading Scheme (F-ETS) for the transport and household sectors in its "Climate Protection Program 2030" of September 20, 2019, and legislated details in the respective "National Fuels Emissions Trading Law" (BMU, 2019b; 2020b).

3.2 Design of the German F-ETS

In order to achieve the transport sector targets, the German F-ETS covers CO_2 emissions from fossil fuel combustion (particularly light heating oil, liquefied petroleum gas, natural gas, coal, petroleum and diesel) in transport and building heating[14]. Different from California, Germany thus chose a sector-specific design with a sectoral cap. Instead of final fuel consumers, the compliance responsibility rests with the producers and distributors of fossil fuel upstream.

[12] For detailed information see BMU (2020a).
[13] In addition to that, Germany decided to phase out nuclear energy by 2022 as the second major part of the German "Energiewende", the Energy Transformation (a better translation actually being Energy Turnaround).
[14] For details on the design see UBA/DEHSt (2020).

The German F-ETS is thus capable of covering almost 100% of respective sector emissions.

With respect to cap, initial allocation, and price management, the F-ETS unfolds in two phases: a fixed price phase from 2021 and a flexible market price phase starting from 2026. In both phases, the cap is basically determined by the share of Germany's total GHG emissions outside of the EU ETS that are covered by the national F-ETS in the reference period 2016-2018. This share will then be applied to the respective total number of emissions rights allocated to Germany by the 2018 EU Effort Sharing Regulation (EU, 2018), i.e. a 38% reduction by 2030 from 2005 levels to be achieved by a linear reduction path.

However, as in some cases entities are covered by both the EU ETS and the national F-ETS, a respective extra amount of allowances is provided in the F-ETS to cover double compliance obligations. In addition, due to the initial fixed-price phase, annual emissions can exceed the cap from 2021 to 2025. As a compensation, the German government has to guarantee additional emission reductions in other sectors or purchase allowances from other EU Member States.

In Phase I, allowances are allocated based on an annual fixed price, which increases from 25 Euro in 2021 to 55 Euro in 2025, thus resembling a carbon tax. From 2026 onwards, allowances will be fully allocated by auctioning.

With respect to flexibility options, the German F-ETS allows banking only from Phase II and prohibits borrowing. So far, offsets have not been considered. For price management in Phase II, the German F-ETS applies a price collar with a price floor at 55 Euro and a price ceiling at 65 Euro.

Revenues from this CO_2 pricing approach will be partially redistributed to citizens, mainly by lowering the renewable energy feed-in tariff apportionment and, by increasing the commuter tax relief. While the concrete money values of these redistribution measures largely depend on the actual revenues, internal calculations by the German Ministry of Finance estimate a reduction of the renewable energy apportionment (2020: 6.756 Eurocent/kWh) by 2.08 Cent per kilowatt hour in 2021, 1.73 in 2022, 1.84 in 2023, 2.71 in 2024, and 3.42 in 2025. Following internal calculations of the German Ministry of Finance, this would mean annual electricity cost savings of 50 to 100 Euro for an average household. The commuter tax relief (2020: 30 Eurocent from the 21st kilometer driven) is supposed to increase to 35 Eurocent in 2021-2023 and further to 38 Eurocent in 2024-2027. From 2027 the relief will go back to 30 Eurocent.

3.3 Comparative Design Evaluation and Outcome Estimates

An evaluation of the German F-ETS against sustainability criteria for GHG ETS design developed by Rudolph et al. (2012) shows that Phase II complies significantly better than Phase I. First, Phase I lacks an absolute volume cap on transport sector emissions, which will only be effective from 2026. Second, while initial price levels are significant and the 55 Euro price floor in Phase II is even in line with the SC-CO_2, the 65 Euro price ceiling applied from 2026 onwards is far too low. The German Emissions Trading Authority (DEHSt) calculated the price effect of the new F-ETS on gasoline and diesel to be only between 6 (2021) and 13 (2030) Eurocent per liter for gasoline and 7 (2021) to 15 (2030) Eurocent per liter diesel. Third, the subsidization of household electricity and transport via the auction revenue spending scheme partially thwarts the CO_2 price signal and is not in line with the concept of equal emission rights.

Compared to CalCaT's treatment of transport fuels, Germany's F-ETS excels in several ways, while also lagging behind in other aspects. First, with respect to coverage, Germany uses a sector-specific cap-and-trade scheme, which, at least in the cap-phase, will guarantee emission reductions in the transport sector; however, this comes at the cost of efficiency losses compared to an economy-wide scheme such as CaCaT. Second, just as in the case of CalCaT Germany, there is no free-of-charge allocation to the transport sector. Germany, however, starts with a rather high fixed price, before moving to full auctioning only from 2026. Third, Germany is not accepting any offsets, so emission reductions will occur in the transport sector itself, albeit at the cost of higher overall abatement costs. And last, the German price floor is several times higher than the one in California and will thus guarantee a stronger price incentive to reduce emissions.

In contrast, the price ceiling in Germany is not noticeably higher than in CalCaT. Moreover, CalCaT does much better in directing auction revenues to the protection of low-income households, while Germany's redistribution scheme is rather undifferentiated with respect to household income.

In October 2019, the German Institute for Economic Research (DIW) estimated the effects of an earlier proposal for the F-ETS with lower prices and lower levels of redistribution (Bach et al, 2019). The study concluded that, first, total emissions reduction would have added up to 1.5 Million in 2021 and 28.5 Million tons in 2030, given the price ceiling would have determined the price from 2026 onward. In the transport sector, the F-ETS would have led to emission reductions of 17.1 Million tons by 2030, which would have been only 30% of the current emissions reduction gap of 61 million tons. Second, annual government revenues would have increased by 12.2 billion Euro. And third, the F-ETS would not fully eliminate the regressivity of the CO_2-pricing approach. In 2026 the total average burden on household income would have been 0.7%, but the effect on low-income households would have accounted for more than 1%, while the effect on higher income households would have only been 0.4%.

The February 2020 update of the DIW estimate, now based on the current design (Bach et al, 2020), shows that, first, the new design with higher prices and redistribution will lead to emission reduction in 2021 more than twice as high (3.4 million tons) as in the earlier proposal, but in 2030 reductions will even be less (25 million tons) than in the initial proposal. One major reason for this is that the effective price ceiling of 65 Euro is only 5 Euro higher than in the original proposal, and at the same time the reduction of the feed-in tariff apportionment is five times as high as in the initial. In the transport sector, GHG emissions will be lowered by 18.5 million tons in 2030, which is still only about one third of the emission reduction gap. The major reason for this limited effect of the increased CO_2 price on fuel is the simultaneous increase of the commuter tax relief. Second, the updated DIW study shows that the December compromise reduces the regressivity of the F-ETS significantly, while not completely eliminating it. In 2026 the total average burden on household income will be reduced to 0.43%, the effect on low-income households to 0.5%, and the effect on higher income households to below 0.3%.

In comparison with CalCaT, due to the separated market and a higher price the German F-ETS to a greater extent guarantees emission reduction in the transport sector itself, while California's economy-wide scheme cannot guarantee any emission reduction in specific sectors. Even so, the low price ceiling compared to the expected real scarcity price of the pre-set caps is expected to dilute the cap and shift reduction obligations to other sectors. With respect to social impacts, the German F-ETS, different from CalCaT, will not be able to fully compensate households for extra costs. Even after revenue re-distribution, the German F-ETS will still be creating an extra burden to households across income brackets, while CalCaT in fact generates extra benefits for households. In addition, the German F-ETS burdens low-income households more than high income households. In comparison, early estimates on CalCaT showed greater benefits for high-income households compared to low-income, but recent ex post studies on Climate Investments emphasize the significantly higher share of revenue use in low-income communities, which suggests greater effects on lower income brackets than initially estimated.

4. Discussion and Conclusions

Transport emissions have been the Achilles Heel of ambitious climate policy even in countries and regions that have excelled in GHG emission reductions in other sectors. While most of the literature on carbon pricing in the transport sector having focused on a tax approach, some of the previously expected problems with transport sector cap-and-trade have recently been solved, e.g. with respect to the objection concerning the high number of emitters. Hence, cap-and-trade has become a reasonable market-based alternative to fuel carbon taxation. This article has analyzed two prominent transport sector cap-and-trade schemes with respect to their design and (expected) performance: the California Cap-and-Trade Program (CalCaT) and the German Fuels Emissions Trading Scheme (F-ETS).

California implemented an early big-size multi-sector GHG cap-and-trade program to also cover transport emissions from 2015. In its five years history of operation, Cal CaT has produced ambivalent results. On the positive side, California showed that multi-sector GHG cap-and-trade is possible and that transport sector emissions can be included upstream, even if other sectors (industry, electrical utilities) are covered downstream. Also, California demonstrated that full auctioning for the transport sector from the beginning is doable and even politically feasible, given revenues are fully redistributed with special consideration for low-income households. On the downside, however, the resulting allowance price, even when supported by non-market measures, has not triggered emission reductions in the transport sector. Obvious reasons from an economics perspective are high marginal abatement costs and/or an inelastic demand, particularly if compared to other sectors. While cost efficiency still calls for an economy-wide cap-and-trade scheme, other than economic reasons might call for specific transport sector caps. If so, the Californian experiences suggest the following two alternatives:

1) an economy-wide market with full auctioning, a high-enough price floor to trigger specific transport sector emission reduction, and full revenue recycling particularly benefitting low-income households

2) a separate market for transport sector emissions with a scarcity cap that generates a high-enough price to incentivize transport sector emissions reductions, full auctioning, and revenue earmarking to particularly benefit low-income households

Against the backdrop of these experiences, the German F-ETS which covers transport and heating fuels and is supposed to start in 2021, features some promising design elements. It starts with a relatively high price per ton of CO_2 emission, later implements a rather ambitious cap based on the specific transport sector target and a price floor in line with the Social Cost of Carbon Dioxide (SC-CO_2) (≥ 60 US$ in 2030), and redistributes some of the revenues from full auctioning of allowances with the intention of limiting the regressivity of the pricing approach.

However, experience in California, ex ante impact analysis of the German F-ETS, and ambitious sustainability design criteria for greenhouse gas cap-and-trade teach that in order to sustainably reduce transport emissions to the pre-set sector limit, Germany's F-ETS would greatly benefit from

- replacing the price escalator by an absolute volume cap in line with the sector target trajectory from the beginning;

- removing the price ceiling and steadily raising the price floor to a level in line with estimated Paris target achievement costs (≥ 100 US$ in 2030); and

- earmarking all revenues to an equal per capita climate dividend.

In any case, if designed sustainably and adjusted to the specifics of the transport sector, cap-and-trade could become a potent element of the medication to heel the transport sector Achilles Heel and prevent climate pioneers to be fatally wounded by transport sector emissions. Germany's Fuel ETS, despite of all shortcomings in detail, is a first important step towards curing this historic weakness.

Funding:

This article is one of a research projects on "Regional Carbon Pricing in North America" funded by The Japan Society for the Promotion of Sciences Grants-in-Aid for Scientific Research (KAKENHI No. KK20160009).

Declaration of Interests:

Not conflict of interests.

References

Bach, S., Isaak, N., Kemfert, C., and Wägner, N. (2019). Lenkung, Aufkommen, Verteilung: Wirkungen von CO_2-Bepreisung und Rückvergütung des *Klimapakets*, Berlin: DIW.

Bach, S., Isaak, N., Kampfmann, L., Kemfert, C., and Wägner, N. (2020). Nachbesserung beim Klimapaket richtig, aber immer noch unzureichend – CO_2-Preise stärker erhöhen und Klimaprämie einführen. Lenkung, Aufkommen, Verteilung: Wirkungen von CO_2-Bepreisung und Rückvergütung des *Klimapakets*, Berlin: DIW.

BMU (2019a). *Gesetz zur Einführung eines Bundes-Klimaschutzgesetzes und zur Änderung weiterer Vorschriften*. Berlin: BMU.

BMU (2019b). *Klimaschutzprogramm 2030 der Bundesregierung zur Umsetzung des Klimaschutzplans 2050*. Berlin: BMU.

BMU (2020a), *Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2020 National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2018*, Berlin: BMU

BMU (2020b). *Gesetz über einen nationalen Zertifikatehandel für Brennstoffemissionen* (Brennstoffemissionshandelsgesetz – BEHG), Berlin: BMU.

Bushnell, JB (2020). *The High Cost of Low Carbon Prices*. In: https://energyathaas.wordpress.com/2020/06/15/the-high-cost-of-low-carbon-prices/ (retrieved June 15).

Bushnell, JB., Chen, Y and Zaragoza-Watkins, M (2014). "Downstream Regulation of CO2 Emissions in California's Electricity Sector." *Energy Policy,* 64, 313–323.

CARB (2006). *Assembly Bill 32 – California Global Warming Solutions Act,* Sacramento: CARB.

CARB (2008). *Climate Change Scoping Plan – A Framework for Change,* Sacramento: CARB.

CARB (2014). First Update to the Climate Change Scoping Plan – Building on the Framework. Sacramento: CARB.

CARB (2015a). *Overview of ARB Emissions Trading Program,* Sacramento: CARB.

CARB (2017a). *Senate Bill 32 – California Global Warming Solutions Act: Emissions Limit,* Sacramento: CARB;

CARB (2017b). *California's 2017 Climate Change Scoping Plan – The strategy for achieving California's 2030 Greenhouse Gas Target,* Sacramento: CARB.

CARB (2017c). *Assembly Bill 398 – California Global Warming Solutions Act: Market-based Compliance Mechanisms,* Sacramento: CARB

CARB (2018). *2015-2017 Full Compliance Period Compliance Obligation Summary,* Sacramento: CARB.

CARB (2019a). *California Greenhouse Gas Emissions for 2000 to 2017 – Trends of Emissions and Other Indicators,* Sacramento: CARB.

CARB (2020). *California Climate Credit,* In: https://www.cpuc.ca.gov/climatecredit/ (retrieved June 26).

CCI (2020). *Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds,* Sacramento: CCI.

Creutzig, F., Lohrey, S., Emele, L., Le Quéré, C and Jones, M (2020). *COVIS-19 und CO2-Emissionen in Deutschland – Eine Analzse basierende auf den Schätzungen des Global Carbon projects,* Berlin. Mercator Research Institute on Global Commons and Climate Change.

Cullenward, D., Inman, M and Mastrandrea, MD (2019). "Tracking Banking in the Western Climate Initiative Cap-and-Trade Program." *Environmental Research Letters,* 14(12), 124037, 1-11.

Cullenward, D (2014). "Leakage in California's Carbon Market," *The Electricity Journal*, 27(9), 36-48.

Daly, HE (2019) "Top 10 Policies for a Steady-State Economy", at https://steadystate.org/top-10-policies-for-a-steady-state-economy/ (retrieved Apr. 18).

EEA (2020). *Transport – Increasing oil consumption and greenhouse gas emissions hamper EU progress towards environment and climate objectives*, (Brussels: EEA)

Endres, A (2011). *Environmental Economics* (Cambridge: Cambridge University Press).

EU (2018). *Regulation on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement,* Strasbourg: EU Parliament and Council

Ezcurra, MV et al. (eds) (2019), *Environmental Fiscal Challenges for Cities and Transport – Critical Issues in Environmental Taxation Vol XXI*, Part III (Cheltenham/Northampton: Edward Elgar).

Gan, J., and McCarl, BA. (2007). "Measuring Transnational Leakage of Forest Conservation." *Ecological Economics,* 64(2), 423-432.

Granados, JT and Spash, CL., (2019). "Policies to Reduce CO2 Emissions – Fallacies and Evidence from the United States and California." *Environmental Science and Policy*, 94, 262-266.

ICAP (2019). *Emissions Trading Worldwide – Status Report 2019* (Berlin: ICAP).

ICAP (2020). *Emissions Trading Worldwide – Status Report 2020* (Berlin: ICAP).

IEMAC (2018). *2018 Annual Report of the Independent Emission Market Advisory Committee,* Sacramento: IEMAC, Ch. 7.

Inman, M (2020). *Holding Limits Don't Constrain Banking in California's Cap-and-Trade Program.* In: http://www.nearzero.org/wp/2018/12/13/holding-limits-dont-constrain-banking-in-californias-cap-and-trade-program/ (retrieved June 11).

IPCC (2018). *Global Warming of 1.5°C* (Geneva: IPCC).

LAO (2019). *Assessing California's Climate Policies,* Sacramento: LAO.

LAO (2020). *Assessing California's Climate Policies – Electricity Generation,* Sacramento: LAO.

Lerch, A (2020). Klimapolitik für den Verkehrssektor – Echter Emissionshandel statt heiteres Preise-Raten, *ÖkologischesWirtschaften* 35, p. 10.

Mastrandrea, MD., Inman, M and Cullenward, D (2020). "Assessing California's Progress Toward its 2020 Greenhouse Gas Emissions Limit." *Energy Policy,* 138, 111219.

NEXT 10 (2019). *The Net Economic Impacts of California's Major Climate Programs in the Inland Empire – Analysis of 2010-2016 and Beyond*, Berkley: NEXT 10.

Rudolph, S et al (2012). "Towards Sustainable Carbon Markets: Requirements for Effective, Efficient, and Fair Emissions Trading Schemes," in Larry Kreiser et al. (eds): *Carbon Pricing, Growth and the Environment* – Critical Issues in Environmental Taxation Vol. XI (Cheltenham/Northampton: Edward Elgar), 167-183.

Ruseva, T., Marland, E., Szymanski, C., Hoyle, J., Marland, G and Kowalczyk, T (2017). "Additionality and permanence standards in California's Forest Offset Protocol – A review of project and program level implications." *Journal of Environmental Management,* 198, 277-288.

UBA/DEHSt (2020). *Nationales Emissionshandelssystem – Hintergrundpapier,* Berlin: DEHSt.

UN (2015), *Paris Agreement*, New York: UN.

WCI (2010). *Design for the WCI Regional Program*, Sacramento: WCI.