FORMULATION OF SECTORAL STUDIES

(ELECTRICITY, FUEL, INDUSTRY AND AGRICULTURE)

AND PROPOSITION OF DESIGN OPTIONS

FOR CARBON PRICING INSTRUMENTS

COMPONENT 1 OF THE PMR IMPLEMENTATION PHASE

INTERNATIONAL EXPERIENCE OF CARBON PRICING IN THE INDUSTRIAL SECTOR

The consortium

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INTERNATIONAL EXPERIENCE OF CARBON PRICING IN THE INDUSTRIAL SECTOR

This report presents **International Experience regarding Carbon Pricing and the Industrial Sector** prepared by Ricardo Energy & Environment and Vivid Economics for the Ministry of Finance under Brazil's PMR Programme.

The international experience has been aggregated in this report, focusing on analysing the policy interactions between carbon pricing and industry sector policies for the following two themes:

1. Experience of Carbon Pricing Instruments in Industrial Sectors in Selected Jurisdictions Regarding Carbon Leakage and Competitiveness Impacts
2. Industrial Energy Efficiency Policy Instruments

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THEME 1: EXPERIENCE OF CARBON PRICING INSTRUMENTS IN INDUSTRIAL SECTORS IN SELECTED JURISDICTIONS REGARDING CARBON LEAKAGE AND COMPETITIVENESS IMPACTS

EXECUTIVE SUMMARY

Table 1 provides an overview of the jurisdictions chosen, the CPI adopted, the interaction studied, key impacts of these policies and high-level lessons learnt.

Table 1 - Summary table for carbon leakage and competitiveness industry theme

Main jurisdictions	EU	California	Australia
CPI	ETS	ETS	Tax
Start year	2005	2012	2012
Average carbon price	US$5.91/t$CO_2$e [2016 average]	US$12.78/t$CO_2$e [2016 average[1]]	US22.91/tCO_2e [2014]
Implementation agency	European Commission	California Air Resources Board (CARB)	Clean Energy Regulator (CER)
Implementation modality	Regional collaboration and increasing stakeholder engagement.	Transparent legislative process	Legislative process, carbon tax set to transition into an ETS
CPI impacts	Both absolute emissions and emission intensity reductions	Economy-wide absolute emissions reductions but increase in industrial absolute emissions. Emission intensity of industry likely reduced	Likely emission intensity reductions

[1] Up to October 2016

Main jurisdictions	EU	California	Australia
Other impacts	Protected industry against carbon leakage. Windfall profits gained by certain sectors. Electricity prices increased.	Effective border tax on electricity imports introduced to protect against resource shuffling. Electricity and fuel prices increased.	Transport fuels excise taxes increased and fuel-tax credits decreased.
Lessons	Early and continuous stakeholder engagement from the early stages of CPI design increases the likelihood of successful policy implementation by generating widespread buy-in The introduction of a CPI provides an opportunity to rationalize existing (energy) taxes. Effective CPI introductions align existing taxes with carbon pricing to reduce and/or avoid countervailing incentives CPIs increase direct and indirect costs that lead to negative competitiveness impacts and risk of carbon leakage Several mechanisms exist to reduce carbon leakage risk. These mechanisms can evolve over time to be more complex and reduce their disadvantages Revenue recycling can reduce competitiveness and carbon leakage impacts using several methods (Limited) evidence suggests that CPIs have reduced the emissions intensity of industry		

Source: Vivid Economics.

Lessons learnt: stakeholder consultations

Early and frequent stakeholder engagement and incorporation of feedback are key to generating buy-in which can be leveraged to achieve deeper emission reductions over time. Stakeholder input during the design of a CPI can enhance buy-in and address issues early on. Stakeholder engagement has occurred internationally through mechanisms such as written submissions and thematic workshops. Widespread buy-in can be leveraged to achieve deeper emission reductions over time which imply increasing mitigation costs. The repeal of Australia's CPM may reflect the downside of not achieving significant buy-in, while ongoing consultations with stakeholders facilitated the successful increasing stringency of the EU ETS and Californian ETS.

Lessons learnt: tax reform as part of implementing CPIs

The introduction of CPIs represents an opportunity to reform tax systems to improve overall efficiency. Tax reform could improve the efficiency of the tax system and ensure that taxes are focussed on specific externalities, and there is evidence that it can produce a double dividend of improved environmental outcomes and a reduced overall tax burden. Without such reform, double taxation on emissions may arise. Energy policies counteracting the CPI may also be removed over time, such as fossil fuel subsidies or fuel-tax credits. Tax reform can also mitigate negative distributional impacts on low-income households. A variety of jurisdictions successfully reduced distortionary taxes such as income taxes or social contributions to this end. The UK and Germany, for example, reduced the employee social contribution requirements for firms in response to introducing new environmental taxes to relieve competitiveness impacts on firms. There are examples of similar cost-relieving reforms in other income taxes for both firms and households in British Columbia, and for households in Sweden, Australia and Chile. Comparable distortionary tax reductions are already offered in Brazil, such as the reforestation rebate on income taxes. A carbon tax provides greater opportunity to reform the tax system as its implementation requires amending the tax code, whereas the introduction of an ETS can be done separately from the tax system.

Lessons learnt: competitiveness and carbon leakage impacts

CPIs create direct and indirect costs that cause competitiveness impacts and could lead to carbon leakage. Direct costs are costs incurred by the firm's own emissions, either through purchasing ETS allowances (or the opportunity cost of not selling free allowances) or through paying carbon tax liabilities. Indirect cost are costs associated with the in electricity (and heat) prices due to the inclusion of electricity production in the ETS or carbon tax or associated with the price of other inputs due to their sectors' inclusion. Table 2 shows that costs vary by industry and direct costs almost always outweigh indirect costs in the EU. Cement and iron and steel producers in the EU have significantly higher estimated costs compared to the glass, chemicals, and paper industries. Indirect costs are often in the single-digit percentages in the EU.

Table 2 - The estimated direct and indirect compliance costs for select producers in the EU ETS over 2015-2019 are frequently in the single-digit percentages

Industry	Direct cost / GVA (%)	Indirect cost / GVA (%)
Glass producers	5 to 8	2 to 4
Chemical producers	3 to 8	2 to 4
Iron and steel producers	17	5
Paper producers	4	6 to 7
Cement producers	42	5

Note: Direct cost assumptions: Direct costs are adjusted using an auctioning factor to determine how many allowances a sector will need to purchase at auction if it is not on the carbon leakage list. This factor is currently based on a sector' actual data from previous years (European Commission, 2014c). Only estimates from subsectors meeting the carbon leakage threshold criteria are provided. Ranges provided were industry presented reflect more than one subsector with different cost estimates.

Indirect cost assumptions: An average emission intensity factor is assumed across industries based total fuel mix used for electricity production (EUROPEAN COMMISSION, 2014a).

Assumption in both cost calculations: An assumed allowance price of €30//tCO_2 (EUROPEAN COMMISSION, 2014a).

Source: (EUROPEAN COMMISSION, 2014f).

Competitiveness impacts and carbon leakage can occur when carbon prices, and therefore costs, diverge between jurisdictions Competitiveness impacts occur when firms in jurisdictions with higher carbon prices may lose market share to firms in jurisdictions without or with lower carbon prices. Carbon leakage occurs when firms move production to jurisdictions without, or with lower, carbon prices. This reduces domestic employment and may cause higher global emissions.

Jurisdictions all use similar methods to determine which sectors are at risk of carbon leakage. All the jurisdictions analysed used criteria based on metrics of emission intensity and/or trade intensity to determine sectors at risk of carbon leakage. It is becoming apparent, however, that it is the combination of these two measures which is most important for leakage risk identification. In the EU ETS, chemicals, iron and steel, and cement producers were among the industries determined to be at risk of carbon leakage.

International evidence of industry competitiveness impacts and carbon leakage shows little to no actual impacts. Available evidence shows little carbon leakage or competitiveness impacts in jurisdictions that have introduced CPIs. Several reviews of the impacts of the EU ETS on industrial competitiveness across multiple sectors finds evidence of no significant impacts on firms' employment, turnover, or profitability. Firms in California may be particularly vulnerable to carbon leakage risk due to its ETS being sub-national, but there is only anecdotal evidence of this. The Australian CPM did not have a significant impact on the competitiveness of the industrial sector, as evidenced by rising operating profits from 2013 onwards. There are three possible explanations for the evidence of little carbon leakage impact: measurement inaccuracy may be such that real leakage has not been found, carbon prices may have been too low, or it might be evidence that support mechanisms for industry have successfully mitigated the risk of leakage (PMR, 2015).

Support to industries at risk of carbon leakage can be given through free allowance allocation, for an ETS, through absolute tax rebates or tax rate reductions, for a carbon tax, or general tax reform or border carbon adjustments (BCAs) for either type of CPI. If the CPI is an ETS, support could be given through free allowance allocation. However, the method used to freely allocate allowances should be carefully considered in terms of managing the potential trade-offs between abatement incentives and windfall profits, as shown in Table 3. Overall international experience suggests that free allocation using efficiency benchmarks and current production data is most effective at providing sectoral support while maintaining abatement incentives and guarding against the accrual of windfall profits. If the CPI is a carbon tax, support can be given through tax reductions or exemptions. Several jurisdictions provide graduated support based on categories of carbon leakage risk. Both ETSs and carbon taxes can also support industry through reforming other taxes or introducing BCAs which impose carbon costs on imports.

Table 3 - Allowance allocation methodologies differ by their advantages and disadvantages and the jurisdictions which have used them

Method	Description	Advantages	Disadvantages
Grandfathering (e.g. EU ETS Phase 1 and 2)	Free allocation based on firms' historical emissions	Demand-side abatement incentives preserved. Simple method with data available	Long-term reliance reduces abatement incentive. Weak leakage protection. Windfall profits likely. No recognition of past efforts.
Fixed sector benchmarking (e.g. EU ETS Phase 3)	Free allocated based on past production and benchmark of emissions intensity	Rewards early action and incentivizes longer term efficiency improvements	Sector benchmark calculations are data-intense and complicated. Windfall profits possible
Output based allocation (e.g. California ETS)	Free allocated based on current production and emissions-intensity benchmarks	Incentivizes emissions intensity improvements. Strong leakage prevention. Windfall profits minimised	Benchmark calculation and current production data difficulties

Source: Adapted from (PMR, 2015, 2016).

The carbon price differential between a country and its trading partners could also influence the initial level of support required by industry. As the experience of the Nordic countries shows, carbon leakage may be more likely when there is a significant difference between the domestic carbon price and that of a country's trading partners. However, as countries around the world increasingly look towards carbon pricing, carbon cost differentials between countries will lessen.

The free allocation support given to firms can evolve over time into more complex, efficient, and environmentally sound mechanisms. Grandfathering is the simplest form of free allowance allocation in terms of methodology and data requirements and may represent a reasonable starting point for support. The EU ETS used grandfathering in Phases 1 and 2 and transitioned towards fixed benchmarking in Phase 3 to increase the instrument's stringency.

Carbon revenue recycling can be used to achieve multiple objectives, including reducing negative competitiveness impact on industry. Table 4 shows the five main uses for which jurisdictions have recycled carbon revenues, along with each of their opportunities and challenges. Industry competitiveness can be supported both directly and indirectly in several of these uses.

Table 4 - Jurisdictions have considered five uses for CPI tax revenues, with unique opportunities and challenges

Revenue use	Opportunity	Challenges
1. Reduce other taxes (e.g. Sweden)	May improve tax system efficiency and promote economic activity	May imply preferential treatment of some groups

Revenue use	Opportunity	Challenges
2. Direct to households (e.g. British Colombia)	Addresses household equity concerns and enhances public support	May miss productivity improvement opportunities
3. Transitional support to industry (e.g. UK)	Supports economic growth and generates industry support	May counter the CPI's intention and entail assessment of 'winner' industries
4. Support general government spending (e.g. Mexico)	Increases resource availability and fiscal flexibility	Returns on spending difficult to evaluate or verify
5. Fund mitigation/adaptation investments (e.g. NER 300)	Aligns to the same goal as the carbon price and may directly correct for market failures	May create market distortions; entail assessment of 'winner' industries or risk inefficiency

Source: Adapted from (CPLC, 2016).

Recycling carbon revenues using strict-earmarking rules may be sub-optimal in the long term. There are two central methods to recycle the revenues of a carbon pricing instrument: recycling back into the general budget or strictly earmarked for specific purposes. Strict earmarking, however, is likely not the best solution, due to the uncertain and dynamic nature of economic development. Several jurisdictions use different approaches:

– soft-earmarking: revenue allocated towards particular ends without specific formula; and
– hybrid earmarking: a portion of revenue recycled towards specific purposes and a portion recycled back into the general government budget

Lessons learnt: emissions impacts

Analysing the ex-post impact of CPIs on industrial emissions is challenging due to the identification problem and studies use different estimation methodologies. A number of factors influence industry emissions and emissions intensity including fuel prices, new technologies, and other climate and energy policies. This results in an identification problem in attributing the cause of emission reductions to the CPI. Ideal analysis would require a perfect counterfactual situation to determine emissions levels without the CPI. Studies use different methodologies to estimate the impact of CPIs on industry emissions, which address the identification problem to varying degrees. Trend analysis observes a jurisdiction's industrial emissions over the period of a CPI's implementation and this may conflate the impact of the CPI with the impact of another exogenous factor. Macroeconomic analyses compare actualised industry emission to projected business as usual (BAU) scenarios to find the impact of the CPI. Econometric studies are more robust and address the counterfactual problem by directly estimating the relationship between a CPI and industrial emissions by taking into account many different variables.

Although available data is limited, there is some evidence to suggest that CPIs have reduced industry emissions intensity. There is some evidence to suggest that CPIs have succeeded in reducing industrial emissions in recent years. EU absolute emissions fell by 327 $MtCO_2e$ or 38.1% over

1990-2012 in manufacturing industries and construction IPCC sectors ((EEA, 2014). Australia's Treasury and DIICCSRTE modelling (2013) project that emissions in Australia would have been 17 $MtCO_2e$ (2.8%) higher in the absence of the carbon pricing mechanism in 2012-2013 (CCA, 2014). While much of these reductions are the result of other factors, such as the financial crisis, there is some evidence that the EU ETS reduced industry's emissions intensity. Macroeconomic analysis suggests the EU ETS reduced the emissions intensity of industry by 0.9% over 2008 and 2009 compared to a BAU scenario using the average emissions intensity of the last two years of Phase 1 ((EGENHOFER *et al.*, 2011).

Implications for Brazil: experience of CPIs in industrial sectors

Industry support can prevent CPIs resulting carbon leakage while retaining the incentives for industry to reduce its emissions intensity. There is evidence that very little to no carbon leakage has occurred as a result of CPIs being introduced in jurisdictions across the world. This could be the result of carbon prices being too low, measurement inaccuracy or rather that support mechanisms delivered to industry have been successful. However, evidence from the international experience shows that CPIs have reduced the emissions intensity of industry in the EU, which suggests that CPIs do have an impact that is being measured and thus the lack of carbon leakage is likely due to successful support mechanisms.

Mechanisms to support industry can be implemented simultaneously to a CPI and may possibly remove distortions, but should always include stakeholder input, evolve over time. Countries around the world identify sectors at risk of carbon leakage using a combination of emissions-intensity and trade-intensity indicators. Support can be provided through free allowances if the CPI is an ETS or tax rebates or rate reductions if the CPI is a carbon tax. General tax reform or the application of border carbon adjustments (BCAs) can also support industry whether the CPI is an ETS or a carbon tax. This kind of reform may also remove distortions by removing countervailing energy policies and removing any double taxations, while carbon revenues can be recycled to support households and other negatively affected entities. The implementation of industry support must incorporate early stakeholder feedback and be amenable to frequent review. It is essential that support given to industry evolves over time to become more targeted and performance-based, such that the emission reduction objective of the CPI is not undermined and abatement incentives remain strong.

However, the insights from the international experience of CPIs and industrial sectors must be considered against the backdrop of local context. The emissions from Brazil's industrial sector are not as significant as most other countries' industrial sectors. For example, Brazil's industrial sector's emissions are significantly less important than their AFOLU emissions compared to other countries as shown in Figure 1. 2013 emissions from industrial processes in the same year comprised only 4% of Brazil's total GHG emissions, compared to the average for other BRICs countries of 7% (WORLD RESOURCES INSTITUTE, 2014). The industry sector has also been under significant international pressure and faces declining competitiveness. In 2013/14 Brazil ranked 56 out of 143 countries in the World Economic Forum's Global Competitiveness Index, in 2017/18 Brazil ranks 80 out of 137 countries

(IMF, 2017; SCHWAB, 2013). Brazil's macroeconomic environment indicator ranks particularly poorly in 2017/18 at 124 out of 137, while the top three problematic elements revealed in an ease of doing business survey were tax rates, restrictive labour regulations, and corruption (IMF, 2017).

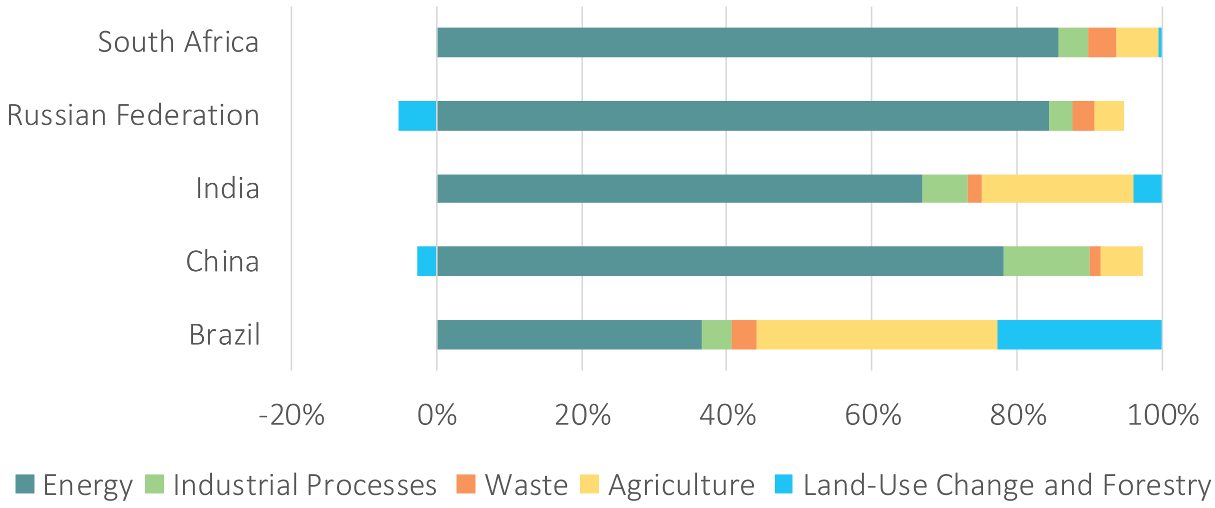

Figure 1 - In 2013, Brazil's AFOLU sector comprised 56% of total GHG emissions, while the average for other BRICS countries in the same year is 8%

Source: (WORLD RESOURCES INSTITUTE, 2014).

1 INTRODUCTION

This theme covers the interactions between carbon pricing and industrial sectors. The key questions are:

1. How have industry stakeholders been involved and what changes have been made to the carbon pricing instrument (CPI)?
2. What changes to the existing tax system for industry have been made when CPIs were implemented?
3. How has the competitiveness of different industries been affected by CPI? Has carbon leakage been significant?
4. What has been done to remedy the impact on competitiveness and carbon leakage?
5. How has the revenue of CPIs been used to help reduce negative impacts on competitiveness and carbon leakage?
6. What has been the impact on industrial sector emissions from CPIs?

The results can provide important lessons for designing a CPI in Brazil. The development of these lessons will be undertaken jointly with the Brazilian team during their design recommendations for Brazil.

The theme is laid out as follows:

- Section 2 provides background on the international case study jurisdictions, the design of their CPIs, and the reason for their selection
- Section 3 summarizes the process of stakeholder consultation and how this has influenced changes in CPIs to answer key question 1
- Section 4 covers key question 2 on whether and how the tax system has been reformed because of the implementation of CPIs
- Section 5 provides answers for key questions 3, 4 and 5 on what competitiveness and carbon leakage impacts have occurred and how they have been remedied and what role revenue recycling has played
- Section 6 covers the last key question and provides an overview of the impact of CPIs on industrial emissions

2 DESIGN OF CARBON PRICING INSTRUMENT

The case study jurisdictions have been selected based on four criteria:

- **availability of information:** the availability of information and ex-ante and ex-post evaluations of the impacts on competitiveness and carbon leakage impacts;
- **stakeholder involvement:** jurisdictions that have had stakeholder involvement to generate buy-in for carbon pricing.
- **lessons from revisions:** jurisdictions that revised their carbon pricing instruments in response to stakeholder concerns and competitiveness impacts, as well as to deal with unintended consequences; and
- **applicability to Brazil:** jurisdictions with similar industrial structures to Brazil

The selected (main) jurisdictions are:

- **California**, with an emissions trading system (ETS);
- **The EU**, with an ETS, and with a focus on the countries covered in the electricity and fuels case studies ; and
- **Australia**, with a (former) fixed price ETS.[2]

Where available, the report incorporates relevant information from the following (supplemental) jurisdictions:

- Mexico, with a tax;
- South Africa, with a tax;
- Chile, with a tax; and
- China, with regional ETSs.

This section provides details on the background and overall design of the CPI in the jurisdictions. Further detail on the stakeholder consultations, tax reform, competitiveness and carbon leakage impact and mitigation measures, as well as emission impacts are provided in subsequent sections.

2.1 EU ETS

The EU ETS is part of a wider EU-level energy policy suite developed to achieve emission reduction targets. The EU 2030 climate and energy framework sets three targets for 2030:

1. cut GHG emissions by 40% compared with 1990 levels;

[2] The Australian Carbon Pricing Mechanism can be described as a fixed price ETS because entities were obliged to surrender tradeable emissions allowances for every tonne of GHG they produced, but the price of the emissions allowances was fixed each year (CER, 2015a).

2. increase the share of renewable energy consumption to 27% of final energy consumption; and

3. improve energy efficiency by 20% (EUROPEAN COMMISSION, 2017a).

The EU ETS is currently in its third phase and covers almost half of the emissions of its 31 Member States. It currently covers 28[3] EU Member States and 3[4] European Economic Area-European Free Trade Association (EEA-EFTA) states. In its third phase (2014-2020), the ETS covers 11,000 energy-intensive installations in industry, electricity generation and intra EU airline flights, accounting for 45% of all GHG emissions in covered countries (EUROPEAN COMMISSION, 2017c). The emissions cap for 2016 was approximately 1.93 GtCO_2e (ICAP, 2017b).

The EU ETS began in 2005 and the coverage of sectors and gases in the EU ETS has grown since its first phase, as shown in Table 5. Phase 1 (2005-07) included power generation and energy-intensive industries and only one GHG: CO_2. Phase 2 (2008-12) added N_2O, generated from nitric acid production, as an additional GHG covered. Phase 3 (2013-2020) expanded the sectoral and GHG coverage further. Certain smaller facilities can opt-out of the ETS if they are subject to regulation which achieves equivalent emissions reductions as would the ETS. Smaller facilities include those with emissions less than 25 ktCO_2e per year and/or combustion plants with thermal rated input below 35 MW, and hospitals (EUROPEAN COMMISSION, 2015d).

Table 5 - The EU ETS expanded which sectors and GHGs is covered throughout its phases

Phase	Sectors covered	GHGs covered
Phase 1 (2005-2007)	Power generation Energy-intensive industries	CO_2
Phase 2 (2008-2012)	Power generators Energy-intensive industries Nitric, adipic, and glyoxylic acids production	CO_2 N_2O from nitric, adipic, and glyoxylic acids production
Phase 3 (2013-2020)	Power generators Energy-intensive industries Nitric, adipic, and glyoxylic acids production Commercial aviation within EU ETS countries	CO_2 from power generation, energy-intensive industries and commercial aviation N_2O from nitric, adipic, and glyoxylic acids production Perfluorocarbons (PFCs) from aluminium production

Source: (EUROPEAN COMMISSION, 2017c).

[3] Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.

[4] Iceland, Liechtenstein and Norway.

The EU ETS was set up as a mechanism to comply with Kyoto Protocol emissions reduction targets. A green paper, published in 2000, put forward initial design ideas of an ETS which could help achieve the level of abatement required under the Kyoto Protocol in a cost-effective manner. This was followed by significant stakeholder discussions with feedback from many governmental and non-governmental organisations that helped to refine the proposal (EUROPEAN COMMISSION, 2000). The result was the formulation of the EU ETS Directive in 2003 which laid out the mechanics of the system and paved the way for the launching of the EU ETS in 2005 (EUROPEAN COMMISSION, 2003, 2017b).

A key feature of an ETS is that the carbon price - EU allowance (EUA) price - is market determined. The weighted average monthly EUA price has moved significantly, from a high of around €27.37/tCO_2e (US$42.56/t$CO_2$e[5]) in June 2008 to €4.42/tCO_2e (US$4.66/t$CO_2$e[6]) in December 2016, as shown in Figure 2 (QUANDL, 2017). This price volatility, while a sign that the cap can be achieved at relatively low-cost recently, creates additional uncertainty for regulated entities and the (currently) low prices reduce the incentive to reduce emissions further.

Figure 2 - Weighted average monthly EUA prices fell over time and stabilised around 5 €/tCO2e

Source: (QUANDL, 2017).

The collapse of the EUA price after 2008, driven by the global financial crisis and resulting drop in industrial output and emissions, prompted a response by the EU to maintain the mitigation incentive. The low EUA price was to be increased by a short- and a long-term solution:

[5] Using Average monthly exchange rate between Dollar and EUR for June 2008 from (OFX, 2017)

[6] Using Average monthly exchange rate between Dollar and EUR for December 2016 from (OFX, 2017)

- The short-term solution was to 'back-load' issuance of EUAs. 900 million EUAs due to be issued 2014-2017 were instead back-loaded to 2019-2020 (EUROPEAN COMMISSION, 2014e, c). This tightening of the EUA supply is hoped to drive up EUA prices.
- The proposed long-term solution is a 'market stability reserve' starting in 2019. This reserve will be a rule-based mechanism that automatically alters auction volumes when allowance surplus[7] thresholds are breached, described in Table 6 (EUROPEAN COMMISSION, 2015d). This will control the supply of allowances to help reduce price volatility. The back-loaded 900 million allowances will be reintroduced into the market stability reserve rather than directly into the market so as to avoid any structural imbalances (EUROPEAN COMMISSION, 2015c).

Table 6 - The rules for the market stability reserve entail lower auction volumes if the allowance surplus increases above a threshold level

Allowance Surplus	Change in auction volume	Other conditions
Greater than 833 million allowances	Reduced by 12%	-
Less than 400 million	Increased by up to 100 million allowances	-
400 million < allowance surplus < 833 million	Increased by up to 100 million allowances	If for more than six consecutive months prices of allowances are three times higher than the average price during the preceding two years

Source: Adapted from (EUROPEAN COMMISSION, 2015d).

2.2 CALIFORNIA ETS

California established its ETS in 2012 and it currently covers emissions from the power and industry sectors as well as emissions from natural gas and transportation fuels. Initially, it covered only entities in the industry and power sectors, which accounted for 48% of the state's emissions. Industrial facilities were included if they emitted more than 25 $ktCO_2e$ per year, which covered producers of electricity, cement, glass, iron and steel, lime, hydrogen, nitric acid, pulp and paper, petroleum, and oil and natural gas (CARB, 2011a). Since a revision in 2015, it expanded to cover retail sales of mineral transport fuels (such as gasoline, diesel, and natural gas), which in 2014 accounted for 37% of the state's emissions (ARB, 2017). Together, the ETS currently covers 85% of emissions. The state of

[7] The allowance surplus is the total number of allowances in circulation, which is determined each year as the total allowances issued minus the allowances surrendered for compliance, taking into account international credits used for compliance and allowances already in the reserve (EUROPEAN COMMISSION, 2015d). The total number of allowances in circulation in a given year is defined by the (EUROPEAN COMMISSION, 2015b) as 'the cumulative number of allowances issued in the period since 1 January 2008, including the number issued pursuant to Article 13(2) of Directive 2003/87/EC in that period and entitlements to use international credits exercised by installations under the EU ETS in respect of emissions up to 31 December of that given year, minus the cumulative tonnes of verified emissions from installations under the EU ETS between 1 January 2008 and 31 December of that same given year, any allowances cancelled in accordance with Article 12(4) of Directive 2003/87/EC and the number of allowances in the reserve' (p. 3).

California has a target of reducing emissions to 80% below 1990 levels in 2050, and the Californian ETS's overall emissions cap in 2015 was 394.5 $MtCO_2e$, which corresponds to 8.5% below 1990 levels (CARB, 2011a, 2017a; SCHMALENSEE; STAVINS, 2015). Since 2014, the ETS has been formally linked to Quebec's ETS (WCI, 2016). The average allowance price in 2016 was approximately US$13/$tCO_2e$.

The design and implementation of the California ETS took five years and followed a transparent legislative process. Recognising that California had become a significant emitter of GHGs in the United States, the state introduced the *Global Warming Solutions Act (Assembly Bill 32)* in 2006 which allowed for the development of market mechanisms to achieve a goal of reducing emissions to 1990 levels by 2020. Assembly Bill 32 mandated that the California Air Resources Board (CARB) develop a Climate Change Scoping Plan to outline how these emissions reductions would be achieved. The 2008 version of this Scoping Plan included a cap-and-trade program. The CARB submitted the rules for a cap-and-trade program in 2011 and the ETS was signed into law in the same year (IETA, 2018). The process of introducing the ETS has faced legal challenges from a variety of stakeholders, based on the validity of the tax and its perceived reach across state borders, which is beyond the CARB's jurisdiction. However, so far the courts have consistently found in favour of the program (SILVERSTEIN, 2017).

The California ETS includes a (hard) price floor and a (soft) price ceiling to guarantee that the scheme maintains mitigation incentives while ensuring compliance costs are kept reasonable. In 2013, a price floor for allowance auctions was set at US$10.71/$tCO_2e$, rising annually by 5% plus inflation each year, and sits at US$13.57/$tCO_2e$ in 2017 (ARB, 2013, 2016). A soft price ceiling works through the release of three equally sized allowance portions when the auction price exceeds threshold prices. These allowance portions come from a cost containment reserve that is funded by the diversion of an increasing share of annual allowances over time[8] (IETA, 2018). In 2017, the three threshold price points are US$40/$tCO_2e$, US$45/tCO_2e, and US$50/$tCO_2e$ and, like the price floor, rise by 5% plus inflation each year (C2ES, 2014; CARB, 2011a). The price of allowances as well as the floor and ceiling prices are shown in Figure 3. To date the global financial crisis and its impact on industrial output and emissions has meant that the price floor has been binding in several auctions, whereas none of the ceiling prices have yet been reached.

[8] During the first compliance period (2013-2014), 1% of allowances are diverted to the cost containment reserve, while during the second (2015-2017) and third (2018-2020) compliance periods this share rises to 4% and 7%, respectively.

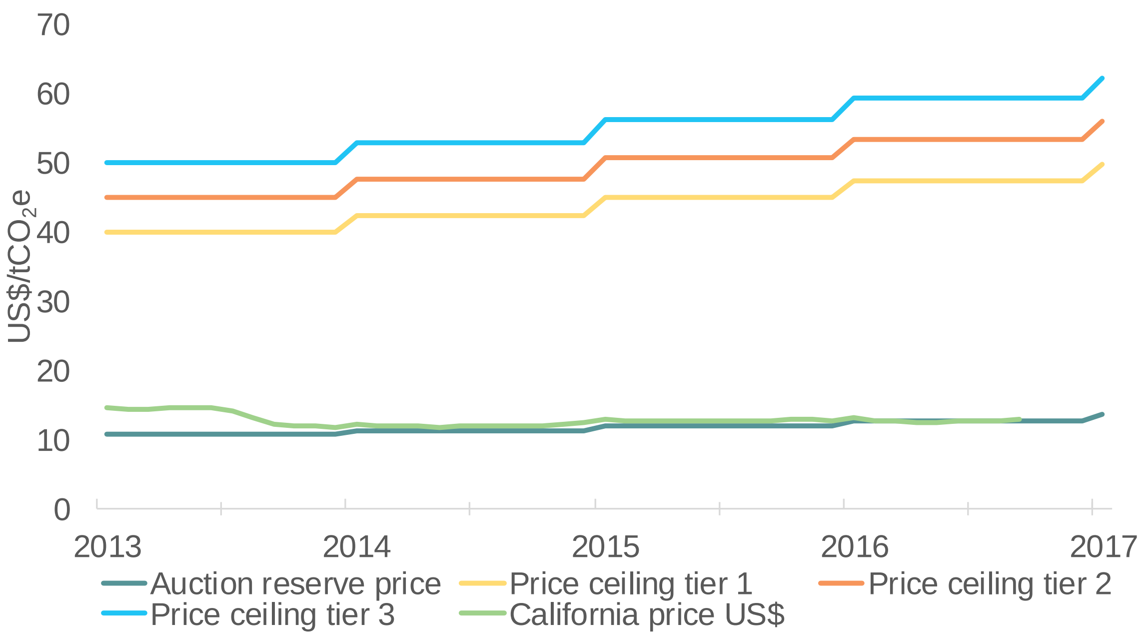

Figure 3 - Average monthly California allowance prices have hovered around the price floor almost since the beginning of the ETS.

Source: Adapted from CARB Annual Auction Price Reserve Notices (2014-2016) and (CPI, 2017).

The California ETS, like the EU ETS, is part of a wider array of state and federal energy policies. The Clean Energy and Pollution Act (Senate Bill 350) stipulates the goals of doubling energy efficiency savings and requiring 50% of all retail electricity to be from renewables in California by 2030 (CEC, 2016). The Californian Low Carbon Fuel Standard (LCFS) mandates emission intensity reductions in transportation by placing a carbon price on fuel emissions which exceed a benchmark. The LCFS will interact with the ETS, as discussed in Fuels Theme: Carbon Pricing and Biofuel Policies. It is likely that these policies will overlap with the ETS in the same way that similar policies in the EU overlapped with the EU ETS.

2.3 AUSTRALIA CARBON PRICING MECHANISM (CPM) AND DIRECT ACTION PLAN

Australia operated a fixed price ETS between 2012 and 2014. The Clean Energy Act introduced the Carbon Pricing Mechanism (CPM), which placed a fixed price of AUD$23/t$CO_2$e (US$17.04/tCO_2e[9]) on emissions with the view to become an ETS with a market determined price after three years (IETA, 2016). Australian firms purchased tradeable emissions allowances to cover their emissions, making the CPM similar to an ETS; however, the fixed price characteristic of the CPM meant it aligns more closely to a carbon tax. The CPM covered over 60% of Australia's GHG emissions including emissions from electricity generation from power stations, other stationary energy generation, landfill waste, industry, and transport. The only sources of emissions not covered by the CPM were decommissioned underground mines; legacy industrial processes; legacy landfill waste; land use; on-road and light

[9] Using Average Annual Exchange rate between Dollar and Australian Dollar for 2016 from (OFX, 2017).

transport; and agriculture, forestry and fishing (BANERJEE, 2012; CER, 2015b). Facilities included under the CPM were those emitting more than 25 ktCO_2e per year or landfill facilities emitting more than 10 ktCO_2e per year (AUSTRALIAN GOVERNMENT, 2011b; C2ES, 2011).

The Carbon Pricing Mechanism was introduced in the 2011 Clean Energy Act. The Act gave legal basis to measures that would help Australia meet its obligations under the Kyoto Protocol and achieve its targeted reduction of emissions to 80% below 2000 levels by 2050. The Australian Clean Energy Regulator was established in order to administer the CPM (AUSTRALIAN GOVERNMENT, 2011b). The 2007 National Greenhouse and Energy Reporting (NGER) Act mandated the reporting of GHG emissions and energy consumption from 2009 onwards, thereby supporting the implementation of the carbon pricing instrument (AUSTRALIAN GOVERNMENT, 2017c; C2ES, 2011).

The CPM price was designed to be fixed for the first three years and then transition to an ETS with a flexible price. The prices for the first three years of the CPM were predetermined and set at AU$ 23.00/tCO_2e (2012); AU$24.15/t$CO_2$e (2013); and AU$ 25.40/tCO_2e (2014). From 2015 onwards, the regulations intended that the CPM become an ETS with a flexible price and a price ceiling for the first three years of AU$20/t$CO_2$e above the expected carbon price in international markets, rising by 5% annually (BANERJEE, 2012). This flexible price period was to also contain a price floor, set at AU$15/t$CO_2$e and rising by 4% per year (C2ES, 2011).

The CPM was part of a suit of energy policies directed at mitigating climate change. The 2011 Carbon Farming Initiative (CFI) allowed farmers and land managers to earn carbon credits from voluntary emission reduction projects. These credits could be sold to organisations looking to offset their emissions (AUSTRALIAN GOVERNMENT, 2011a).The 2001 Renewable Energy Target (RET) scheme initially aimed to generate 4 100 GWhs of renewable electricity and, in 2009, increased this target to 41,000 GWhs of renewable electricity by 2020 (CER, 2016a). The RET functions both at the large-scale, by providing financial incentives for the expansion of renewable energy power stations, and at the small-scale, by incentivising households and small businesses to implement renewable energy solutions, and instituted certificate trading (AUSTRALIAN GOVERNMENT, 2017d). All of these polices overlapped with the CPM's intention of reducing emissions.

The CPM was repealed in 2014 and replaced by the Direct Action Plan, which implemented a baseline-and-credit scheme. A new government took power in Australia and repealed the Clean Energy Act, replacing it with the Direct Action Plan, which they claimed would reduce emissions more cost effectively than a carbon tax (AUSTRALIAN GOVERNMENT, 2013).The repeal of the Act left the Clean Energy Regulator intact to administer the new plan and continue the mandatory reporting of GHGs under the NGER Act (IETA, 2016). The new plan uses a Safeguard Mechanism to provide baseline emission caps to facilities emitting greater than 100 ktCO_2e per year in eight sectors including mining, oil and gas extraction, manufacturing (including metals and cement), transport, and waste (IETA, 2016). The baselines act as flexible annual emission caps and if a facility produces emissions greater than its baseline then it needs to purchase offsetting credits. Flexibility in compliance is provided through multi-year compliance monitoring, such that breaching the baseline in a single year will not invoke the requirement for offsets as long as multi-year average emissions levels are below the baseline (CER, 2016c). Simultaneously, the Emissions Reduction Fund (ERF) was introduced, which credits and purchases emissions reductions from voluntary projects in the agriculture, building, electricity, forestry, industry, transport, and waste sectors with particular emphasis on agriculture (IETA, 2016).The credits are then sold on to facilities looking to offset their emissions. Together, the Safeguard Mechanism and the ERF make up the baseline and credit scheme of the Direct Action Plan.

The carbon price under the Direct Action Plan is determined competitively by the average auction price revealed in ERF credit purchases. The Clean Energy Regulator undertakes reverse auctions when purchasing credits from emission reduction projects from the ERF. This aims to achieve lowest-cost abatement, which is supported by the use of an undisclosed benchmark price that acts as a price ceiling for what the government will pay for emission reductions (IETA, 2016). The volume-weighted average auction price from the first three ERF auctions (April 2015; November 2015; April 2016) declined steadily from US$13.95/t$CO_2$e to AU$12.25/tCO_2e to AU$10.23/t$CO_2$e (IETA, 2016). However, the two subsequent auctions have seen the volume-weighted average auction price stabilise and begin to rise. The November 2016 auction resulted in an average auction price of AU$10.69/t$CO_2$e, while the April 2017 auction resulted in an average price of AU$11.82/t$CO_2$e (CER, 2016b, 2017).

The Direct Action Plan exists in largely the same wider energy policy context as did the CPM, except with the inclusion of the National Energy Productivity Plan (NEPP) and the reform of the RET. The 2015 NEPP aims to improve Australia's energy efficiency by 40% by 2030 (AUSTRALIAN GOVERNMENT, 2017b). Considering the ERF purchases emissions reductions from projects, the increased impetus to increase energy efficiency and thus reduce emissions could lead to increased competition for credits and drive down the carbon price. The RET scheme was reformed in 2015 to lower targets to 33,000 GWhs of renewable electricity in 2020 (CER, 2016a). The RET targets renewable energy deployment, whereas the ERF focuses on emission reduction projects in land-based forestry, agriculture, and landfill and waste sectors (IETA, 2016). The potential for overlap between these two policies is therefore minimal.

2.4 SUPPLEMENTARY JURISDICTIONS (MEXICO, SOUTH AFRICA AND CHINA)

Mexico, South Africa, and China's carbon pricing instruments regimes cover different GHGs and different sectors.

- Implemented in 2014, Mexico's carbon tax is applied at the point of sale/import of the ten most common fossil fuels[10] - natural gas being taxed at a zero rate - and therefore covers potentially all sectors that use fossil fuels (MCCOY, 2015; MUÑOZ, 2016). The design of

[10] Natural gas, propane, butane, gas (regular and premium), jet fuel, turbosine and other kerosene, diesel, fuel oil (heavy and regular 15), oil coke, mineral carbon (SEMARNAT, 2014).

the tax means that there are no explicit inclusion thresholds, as seen in the ETS in the EU and California, because all fossil fuel sales are taxed (ICAP, 2016). The tax covers approximately 40% of Mexico's total GHG emissions (IETA, 2014).

- The South African carbon tax is currently being designed. It proposes to cover combustion and process emissions from all sectors except waste, agriculture and forestry due to measurement difficulties. The tax covers six GHG emissions: CO_2; CH_4; N_2O; PFCs; HFCs; and SF_6. The carbon tax will apply to facilities undertaking activities that fall under a predefined list of GHG emitting activities and with a thermal capacity greater than 10MW (GOVERNMENT OF SOUTH AFRICA, 2015).
- China implemented subnational pilot ETSs from 2013 onwards that are planned to lead to a national ETS starting in 2017. Seven pilot ETSs (five at a city-level and two at a provincial-level) will provide insight for the introduction of a national ETS.
- China is currently implementing its national ETS which will help achieve China's goal of reducing the carbon intensity of GDP by 40 to 45% in 2020 relative to 2005 levels (IETA, 2015). It covers CO_2 emissions from the following sectors: petrochemicals, chemicals, building materials, iron and steel, non-ferrous metals, paper making, power (including power generation and grid) and aviation. The phase 1 (2017-2019) cap is estimated to be between 3 and 5 $GtCO_2e$ per year. Only firms that consumed more than 10 kilotons of standard coal equivalent (ktce) per year, in any of the years between 2013 to 2015, will be included in the ETS (ICAP, 2017a; SWARTZ, 2016).

The carbon pricing instruments in the supplementary jurisdictions are introduced through iterative processes and sometimes together with packages of reforms.

- Mexico's carbon tax was part of a package of fiscal and energy reforms in 2013. The tax is collected by the revenue collection agency, Servicio de Administración Tributaria (SAT). The initial tax proposal was accepted by the congress after it was amended to not tax natural gas and lower the tax rates on the remaining fuels (MUÑOZ, 2016). The reduction of the carbon tax rate was the result of significant congressional debate which reduced the revenue generating ability of the fiscal reforms as a whole, possibly in response to negative media attention depicting the reforms as a revenue generating scheme (MCCOY, 2015). The fiscal and energy reform further included significant changes in the energy industry to increase private competition and introduce independent regulatory bodies (IEA, 2016). The state monopoly on electricity generation and fossil fuel extraction ended in 2013, and new electricity and petroleum laws and regulations passed in 2014 (IRENA, 2015). The carbon tax was also accompanied by the simultaneous reform of energy product price controls (MUÑOZ PIÑA, 2015).
- South Africa's carbon tax is being introduced as part of South Africa's response to climate change. This introduction has followed a nine-year iterative and consultative process, having published six documents for public discussion and engagement (NATIONAL

TREASURY, 2016b). The carbon tax is planned to be accompanied by the reform of several of the country's other energy taxes

- China used regional and city pilot ETSs to provide experience and information for the design and implementation of the national ETS. The pilot ETSs were selected from regions and cities with diverse economic development, sectoral composition as well as emission profiles such that the impact of carbon pricing on different regions of the country will be better understood when implementing the National ETS (THE CLIMATE GROUP, 2013).

The carbon taxes in Mexico and South Africa (in the future) are set at relatively low rates.

- Mexico's carbon tax is set at different rates for different fossil fuels, depending on their carbon content compared to natural gas (IEA, 2016). The initial average tax rate was proposed at US\$5.70/tCO_2e, but political considerations reduced the finally accepted average tax rate to US\$3.50/tCO_2e with a cap on the tax rate of 3% of the sales price of the fuel (PMR, 2017b). The carbon tax rates for different fuels went up by an average of 4% in 2014-2015, but the Ministry of Finance has the discretion to set the tax rates each year as evidenced by the tax rate being set at a maximum of US\$2.50/tCO_2e in July 2016 (MUÑOZ, 2016; PMR, 2017b).
- The headline carbon tax rate in South Africa is US\$8.16/tCO_2e[11]. However, offsets and exemptions available mean that the effective tax rate is closer to US\$0.41-3.26/tCO_2e (WORLD BANK, 2016). The overall tax rate is to increase each year by 2% plus inflation until reaching US\$9.86/tCO_2e[12] in 2019 (PMR, 2017b).

The carbon price in the national Chinese ETS is likely to be market-determined, potentially with some government intervention.

- Although no price controls have been explicitly mentioned to date, several pilot ETSs (Beijing, Guangdong, Hubei, Shenzhen) contained allowance reserves for the purpose of adjusting prices, and Shanghai had an explicit price floor (IETA, 2015).
- The regional ETSs exhibited carbon prices determined significantly by non-market forces such as regional governments or local companies with large allowance market power. As a result, the carbon prices in the different regions in 2014 varied widely from US\$3.3/tCO_2e to US\$8.8/tCO_2e (DUAN; WU; KADILAR, 2015). However, the importance of non-market forces driving carbon prices may be reduced on the national scale, when local governments and large local companies become relatively less important.

The carbon pricing instruments in Mexico, South Africa, and China fit into the wider energy policy landscape in different ways.

[11] Using Average Annual Exchange rate between Dollar and ZAR for 2016 from (OFX, 2017).

[12] Using Average Annual Exchange rate between Dollar and ZAR for 2016 from (OFX, 2017).

- Mexico has targets of creating 24.3 GW of renewable energy capacity by 2018, an active strategy of rural electrification through providing households with 250W of solar home systems, and an auction procurement programme for 2,215 million litres of local bioethanol under 10 year contracts (IRENA, 2015).
- South Africa has a range of energy policies looking to reduce emissions, some of which will complement and others which will overlap the carbon tax. Complementary to the fixed-price carbon tax, the country has implemented a number of other regulations to open the grid for the connection of independent renewable power providers (DEPARTMENT OF ENERGY, 2015). Overlapping policies are the 17.8 GW of renewable capacity target for 2030 and the multi-year carbon budgets that companies will need to meet. These will be voluntary until 2020, but thereafter may become compulsory and include an enforcement mechanism (TROLLIP; BOULLE, 2017).
- China's energy policy is expected to influence the future carbon price level in the ETS. The 13th Five-Year Plan for Energy Development has a range of energy consumption and production targets for 2020 including a total energy consumption cap of 5 Gtce, a cap of 58% of coal use in primary energy consumption, a goal of at least 15% of non-fossil fuel energy consumption, and individual targets for specific energy generation technologies. China has also described goals of reducing the energy and emissions intensity of their economy by 15 and 18% respectively in 2020, relative to 2015 levels (TIANJIE, 2017).

3 STAKEHOLDER CONSULTATIONS

The theoretical process of stakeholder consultations is laid out in the ETS and Carbon Tax handbooks (PMR). The (PMR, 2016) handbook on designing ETSs includes stakeholder engagement as one of its 10 key steps in designing an ETS. It stresses that transparent, honest and meaningful stakeholder engagement helps improve the long-term viability of the instrument and increase persistent public support. In practice, countries have had a varying degree of stakeholder involvement. The (PMR, 2017a) carbon tax handbook for policy makers emphasises the importance of stakeholder engagement early on during the design phase to identify concerns and align objectives.

In the EU, the introduction of the EU ETS was facilitated by continuous and broad stakeholder engagement. The EU published a Green Paper in anticipation of the first Phase of the EU ETS, to elicit reaction regarding the design elements of the instrument from a wide range of stakeholders, including government and non-government organisations. This helped to identify potential issues and challenges from multiple perspectives (EUROPEAN COMMISSION, 2000). For example, the UK carried out stakeholder engagements in preparation for Phase 2 of the EU ETS. Separate consultations were held for within government and for the public. Consultation with the public was held between April and September 2005 and focussed on high-level methods of allowance allocation (as discussed in Section 0). The results of the stakeholder engagement were published as a report that explained the government's policy decisions (UK GOVERNMENT, 2007). For the preparation of Phase 3 and Phase 4, there is evidence of more EU-wide stakeholder consultation. A stakeholder review of the EU ETS began in 2008, which resulted in the publishing of several directives and amendments to legislation, most importantly the 'revised EU ETS Directive' which informed the design of Phase 3 (FALLMANN *et al.*, 2015). In preparation for Phase 4 of the EU ETS, a wide range of stakeholders have been consulted using online platforms, workshops, written consultations, and questionnaires. The topics were technical elements including carbon leakage protection, allocation methods, fund design, regulatory fees, and issues more specific to certain stakeholders, such as waste gas transfers in the steel sector and high labour costs in the ceramic sector leading to inflated GVA and resulting in low carbon leakage classifications (EUROPEAN COMMISSION, 2015a).

Extensive stakeholder engagement supported the design and implementation, and continues to support the functioning of, the Californian ETS. The CARB held consistent public meetings, from 2009 onwards, in preparation of the ETS, with multiple stakeholders covering a range of topics regarding the ETS (CARB, 2017b). Continued stakeholder engagement once the ETS began resulted in legislative amendments in 2015 to allay concerns of allowance supply shortages in the event of the sale of the entire allowance price containment reserve (see 1.2.2 for details on the allowance price containment reserve) (IETA, 2018). For the upcoming third compliance period (2018-2020), stakeholder engagement is addressing concerns relating to allowance allocation, provisions for the electricity sector[13], compliance, use of offsets, auction administration, monitoring provisions, product benchmarks, and

[13] Especially regarding out of state electricity imports which may be leading to carbon leakage, as discussed in Section 5.3.

carbon leakage risks (CARB, 2016c). The regional linking of the California ETS to the Quebec ETS in 2014 through the Western Climate Initiative (WCI) also required local stakeholder engagement as public comment on the proposed ETS rule amendments was legally necessary (VAICIULIS, 2013). Stakeholder consultation has generally occurred through frequent open public meetings, webinars, and workshops. The outputs from these engagements, including comments received and resolutions made, are widely documented and publicly available which increases the transparency of the process (CARB, 2017b).

In Australia, the CPM was developed with support from industry stakeholder engagement. Two roundtables were set up to elicit the technical opinions of industry, NGOs, environment groups and labour unions. The industry roundtable comprised two working groups on transitional assistance and the energy sector; similarly, the NGO roundtable comprised two working groups on household assistance and the land sector (AUSTRALIAN GOVERNMENT, 2011d). The main emissions reduction mechanism of the Direct Action Plan, the Emission Reduction Fund (ERF), was also developed with the input of business and wider community stakeholders throughout the process (AUSTRALIAN GOVERNMENT, 2017a). The first major public consultation was the ERF Green Paper which invited input into the design of the ERF and created technical working groups to identify promising emission reduction opportunities and policy interactions (AUSTRALIAN GOVERNMENT, 2013).

Stakeholder engagement has also been important in the design of South Africa's carbon tax. (NATIONAL TREASURY, 2010) published policy papers, such as the Carbon Tax Discussion paper and the Carbon Tax Policy Paper and draft legislation and regulations, have allowed for written public input into the design of the tax (PMR, 2017a). The draft regulations for the carbon tax were published mid-2016 to elicit public comments, of which 65 were received and are being considered (GOVERNMENT OF SOUTH AFRICA, 2015; NATIONAL TREASURY, 2016a; WORLD BANK, 2016).

3.1 KEY POINTS FOR STAKEHOLDER ENGAGEMENT

Early and frequent stakeholder engagement and incorporation of feedback are key to generating buy-in which can be leveraged to achieve deeper emission reductions over time. Stakeholder input during the design of a CPI can enhance buy-in and address issues early on. Stakeholder engagement has occurred internationally through mechanisms such as written submissions and thematic workshops. Widespread buy-in can be leveraged to achieve deeper emission reductions over time which imply increasing mitigation costs. The repeal of Australia's CPM may reflect the downside of not achieving significant buy-in, while ongoing consultations with stakeholders facilitated the successful increasing stringency of the EU ETS and Californian ETS.

4 TAX REFORM AS PART OF IMPLEMENTING CARBON PRICING INSTRUMENTS

The introduction of a CPI provides the opportunity to reform the existing tax system to improve overall efficiency. Carbon pricing is likely to interact with the tax system and may necessitate tax reforms to enhance the efficiency and the effectiveness of the tax system as a whole. This section lays out examples of the interaction of carbon price instruments and tax systems, and what reforms have been implemented in response. The discussion is separated into the reform of energy taxes (Section 4.1, covering taxes on energy consumption and production) and the reform of other taxes (Section 4.2, such as direct and indirect taxes on households and firms), with available evidence presented from main and supplementary jurisdictions. Section 4.3 provides an overview of the general uses and methodologies for recycling carbon pricing revenues and Section 4.4 presents empirical evidence of the impact of tax reforms.

Tax reform has only occurred on a national scale in all jurisdictions. There has been no evidence of a country which implemented national carbon pricing while reforming taxes for only certain geographies. This would create heterogeneous incentives within a country which could have unintended consequences.

4.1 REFORM OF ENERGY TAXES

Sweden reformed its energy taxation system when it introduced a carbon tax. Sweden introduced a carbon tax on fossil fuels in 1991. As part of its introduction, it reduced pre-existing energy tax rates (on petrol, diesel, and fossil fuels for heating) by 50% (ÅKERFELDT; HAMMAR, 2015).

Sweden's energy taxation system was gradually reformed after joining the EU ETS to increase transparency and efficiency of climate and energy taxes. In 2009, Sweden adopted reform measures to their energy taxation system which would be implemented over six years. The carbon tax on industries covered by the EU ETS was abolished in 2011 as the tax was allegedly causing carbon leakage to other EU Member States (HAMMAR; ÅKERFELDT; STERNER, 2013). However, at the same time, Sweden also introduced a 30% energy tax on industries covered by the EU ETS (IEA, 2013a). These reforms shifted the focus of the tax to energy consumption rather than CO_2 emissions (which was being covered by the EU ETS). Unless energy consumption taxes specifically target another negative externality apart from emissions, this system could entail a type of double taxation on the same externality which reduces the efficiency and fairness of the overall system. This follows the basic tenant that environmental taxes should be transparent and targeted as directly as possible to the source of an externality to allow flexibility in abatement (OECD, 2011).

Norway provided carbon tax exemptions for sectors involved in the EU ETS. Norway implemented an ETS in 2005 which was linked to the EU ETS at the beginning of Phase 2 and fully harmonised by Phase 3 (IETA, 2018). The Norwegian carbon tax, which began in 1991, exempted sectors covered by the EU ETS[14] to avoid the same carbon emissions being taxed twice (PMR, 2017b). Exemptions from Norway's carbon tax also include other sectors that are emissions-intensive and exposed to international competition (NORWEGIAN MINISTRY OF THE ENVIRONMENT, 2009).

Under the Australian CPM, emissions from the transport sector were targeted through changes in fuel taxes and credits. In particular, transport fuels excise taxes increased and fuel-tax credits decreased (C2ES, 2011). The fuel-tax credit was reduced by the same amount as the carbon price for fuel used in private vehicles; and fuel used for light vehicles for business purposes (AUSTRALIAN GOVERNMENT, 2011c). This taxation amendment effectively widened the scope of the CPM to the transport sector. The reduction of the fuel tax credit was repealed in 2014 with the CPM (AUSTRALIAN GOVERNMENT, 2014).

The EU proposed to amend their energy taxation system in 2011 to reflect the ambitions of climate policies; however, negotiations were unsuccessful and the proposal was withdrawn in 2015. The main proposed change was to include a minimum carbon tax rate into the EU energy tax system for sectors outside the ETS to harmonise the way Member States implement carbon taxes. Minimum energy taxes were also proposed based on a fuel's energy to reward energy efficiency (EUROPEAN COMMISSION, 2011b). Introducing common-EU carbon and energy tax standards aimed to improve the efficiency of the ETS by aligning emissions- and energy-reduction incentives across Europe. However, negotiations on the proposed amendments failed. The principle of equal national taxation on all energy products was particularly problematic for some Member States and key challenges to the proposal were never resolved and thus the proposal was withdrawn in March 2015 (EUROPEAN COMMISSION, 2015e).

The Mexican carbon tax was introduced as part of a general energy market reform. The carbon tax was accompanied by the introduction of a per litre fixed excise tax for diesel and the removal of fossil fuel consumption support measures through the gradual liberalising of fuel prices (MUÑOZ PIÑA, 2015). Wider energy market reforms were also implemented, such as the abolition of state monopolies in the electricity and petroleum sectors, which increased the effectiveness of the carbon tax by making the sector more responsive to price changes (PMR, 2017a).

The intended introduction of the South African carbon tax will also be accompanied by changes to the energy taxation system. Tax rebates for energy efficiency savings from businesses and income generated from the sale of certified emissions reductions from CDM projects will be introduced. Additional reforms include the reduction of the electricity levy and tax rebates for renewable energy. The carbon tax aims to be revenue-neutral for the first five years, by recycling all revenues into these reforms, which aim to complement the carbon tax by incentivising firms to reduce their indirect emissions resulting from electricity use (GOVERNMENT OF SOUTH AFRICA, 2015; NATIONAL TREASURY, 2013).

[14]Except for offshore petroleum and aviation.

It may be necessary to remove countervailing energy pricing policies and liberalize the energy sector, to effectively implement a carbon price. The impact of fossil fuel subsidies countervails the intention of the carbon tax by directly counteracting the price signal. As discussed in the Electricity Theme: Hydropower and Growth in Thermal Generation, these subsidies may need to carefully be removed over time while taking into account potentially negative distributional impacts. Furthermore, (FAN *et al.*, 2014) discuss the implementation of carbon pricing in China and conclude that electricity market reform, in terms of increasing competition and allowing market-based pricing, may be a pre-requisite to the successful introduction of a carbon pricing instrument. Price controls in the electricity sector hinder abatement, by reducing the incentive to save electricity on the demand side, and reduce the overall efficiency of the pricing mechanism (DUAN; WU; KADILAR, 2015; YAXIONG, 2014).

4.2 REFORM OF OTHER TAXES

The British Columbia carbon tax was implemented with several other tax system reforms, for both firms and households, aiming to achieve revenue neutrality and increase stakeholder buy-in. The British Columbian carbon tax introduced personal and corporate tax reforms and direct transfers, funded by carbon tax revenue (PMR, 2017b). The personal tax reforms and direct transfers targeted low income households by reducing the tax rate by 5% for the two lowest income groups, providing direct transfers through the Low Income Climate Action Tax Credit, and delivering a number of homeowner, senior citizen and other social direct transfers (BRITISH COLUMBIA MINISTRY OF FINANCE, 2013). General corporate tax reforms included a gradually reduced tax rate from 12% (in 2007) to 11% (in 2008), to 10.5% (in 2010), to 10% (in 2011). Small business tax rates were also reduced gradually from 4.5% to 2.5% and the income-tax threshold for small businesses was increased by 25%. A number of direct transfers to industry were also implemented through tax credits (BRITISH COLUMBIA MINISTRY OF FINANCE, 2013). In 2013, the total carbon tax revenue was CA$ 1.120 billion while personal and corporate tax reductions and transfers totalled CA$ 546 million and CA$834 million respectively. The carbon tax and associated reforms therefore entailed a net reduction in the fiscal budget of CA$260 million in 2013 (BRITISH COLUMBIA MINISTRY OF FINANCE, 2013). This tax reform was intended to produce a double dividend by incentivising emission reductions while reducing the overall tax burden on the economy and pricing pollutants in place of productive goods (such as labour) (CPLC, 2017).

Germany reformed environmental taxes between 1999 and 2003 to shift revenue collection away from social security contributions (SCCs) towards resource consumption taxes. Two new laws incrementally increased taxes on the consumption of heating oils, road fuels, and introduced an electricity consumption tax. The government used the additional tax revenues to reduce employers' and employees' SSCs (AGNOLUCCI, 2011). The tax reform was 90% revenue-neutral and aimed to stimulate employment and promote efficient energy use and renewable energy adoption. Initially, certain sectors and technologies acquired derogations from the new energy taxes, but these began to phase out in 2003. The Industry and agriculture sectors received reduced tax rates, while the manufacturing sector could apply for a tax cap. Efficient technologies, public transport, and self-produced renewable electricity gained various tax exemptions, and a reduced tax rate applies to natural gas until 2020 (KNIGGE; GÖRLACH, 2005).

The UK's Climate Change Levy (CCL) was introduced in 2001 with reforms to the corporate tax regime, also with the intention of realising a double-dividend. The CCL is an energy tax on the consumption of electricity, gas, solid fuels or liquefied petroleum gas (LPG). A 0.3 percentage point reduction in the social contributions (National Insurance) requirement for firms complemented the introduction of the CCL. The social contribution reductions intended to offset the CCL costs for firms and make the CCL revenue-neutral. However, the rebate given to firms each year over the period 2001-2006 was more than the revenue gained from the CCL, making the reform in fact revenue negative (NATIONAL AUDIT OFFICE, 2007). In recognition of concerns that firms with large workforces benefitted more from the social contribution reductions than energy-intensive firms, the government included Climate Change Agreements (CCAs) for certain industrial processes. The CCAs initially provided energy intensive industries with an 80% lump-sum discount on the levy if they developed plans indicating measures and targets to reduce emissions or energy use (NATIONAL AUDIT OFFICE, 2007). The current tax discount rates range from 65 to 90%, depending on the source of energy (HMRC, 2017). The reforms to the social contribution requirements and the CCA discounts may have resulted in a double dividend as they maintained the emission reduction incentive while reducing the overall cost of the tax system.

The introduction of carbon taxes was also accompanied by personal tax reform in Sweden and Australia. Sweden introduced higher income tax thresholds and more tax credits, to support low- and middle-income households in the face of gradually increasing carbon and energy costs. Over 2007-2012, increased tax revenue from environmental taxes totalled EUR 0.5 billion while reduced fiscal revenue from personal tax reform totalled EUR 8.6 billion (HAMMAR; ÅKERFELDT; STERNER, 2013).The Australian CPM also introduced personal tax reforms to ensure that the carbon tax was revenue neutral. Reforms included increased tax-free thresholds for income tax, income tax cuts, and an increase in direct transfers to pensioners and families (WITHANA *et al.*, 2013). Comparable distortionary tax reductions are already offered in Brazil, such as the reforestation rebate on income taxes.

The Chilean carbon tax was implemented among a suit of policy reforms which helped build support for the measure. The Chilean carbon tax was approved by parliament in 2014 as part of a package of policy reforms: tax (increased corporate taxes and the imposition of vehicle emission taxes) and other (e.g. education and health system), with the start of the tax expected in 2018 (BAVBEK, 2016; PMR, 2015; YEO, 2014). The Chilean government expects to collect significantly more revenue[15] from their broader tax reforms compared to the carbon tax alone and has stipulated that the revenue from reforms will go towards funding health and education initiatives (PMR, 2017a). The relatively small

[15] Of the order of US$8.3 billion versus US$160 million (PMR, 2017a).

incidence of the carbon tax combined with revenue recycling into developmental goals aims to build stakeholder support.

4.3 EMPIRICAL EVIDENCE OF TAX REFORM IMPACT

In most jurisdictions, there is little evidence yet on the impact of tax reforms implemented simultaneously with carbon pricing, however, the experience of British Columbia suggests that reform has supported the progressivity of the carbon price. A computable general equilibrium (CGE) model impact assessment of the British Columbia carbon tax finds that the accompanying tax reforms make it a progressive instrument even before revenue recycling efforts are taken into consideration. This is partly dependent on the income effect (tax reductions) outweighing the spending-side effect (increased prices) due to British Columbia's high reliance on hydropower-generated electricity and relatively similar household spending on fossil fuels across income groups (BECK *et al.*, 2015). Both opinion polls and the support received by the governing political party speak to the success of the British Columbian carbon tax, and this success is often attributed to the accompanying tax reforms (KOMANOFF; GORDON, 2015).

The energy tax reform accompanying the 1991 carbon tax in Sweden limited the impact of the carbon tax on industry and may have supported the realisation of a double dividend. As a result of the energy tax reform, the total taxation faced by industry reduced following the introduction of the carbon tax. This is often identified as one of the main reasons for the lack of observed impact on Swedish industry directly after the carbon tax of 1991 (JOHANSSON, 2000). Over 1990-2013, Sweden experienced GDP growth of 61% and emissions reductions of 23%.

Evidence suggests that the introduction of energy taxes in the UK and Germany combined with the reform of other distortionary taxes produced emissions reductions without harming industry competitiveness. An empirical analysis of the UK's CCL and accompanying social contribution tax reform compares regulated firms to unregulated firms and concludes that the CCL caused emissions abatement without affecting the competitiveness of the UK manufacturing industry over 2001 to 2004 (MARTIN; DE PREUX; WAGNER, 2014). Tax reform in Germany lead to total SSC relief of around €16.1 billion for employees and employers and achieved both emission reductions and employment increases. One analysis suggests that the German tax reform led to an increase in employment of 250,000 people and a 2.4% reduction in CO_2 in 2003, compared to a reference scenario without the reform (KNIGGE; GÖRLACH, 2005). In addition, Germany also introduced additional income tax reductions and child allowance increases in 2003 which offset any regressive distributional effects of the energy taxes (BACH *et al.*, 2002). A combined analysis of the impact of both Germany's imposition of higher energy taxes and the UK's introduction of the CCL, and the associated tax reforms that accompanied their introduction, suggests that reform led to short term energy consumption reductions and finds relatively insignificant (and sometimes positive) employment impacts (AGNOLUCCI, 2011).

Simulations of tax reforms and cross country studies following other environmental regulations provide evidence that cutting existing taxes using revenue-generating regulation improves efficiency. Simulations of potential emissions regulations show that regulations which raise revenue to cut other tax rates can lead to lower aggregate social costs and greater overall efficiency compared to regulations which do not (GOULDER; PARRY; BURTRAW, 1996; REPETTO *et al.*, 1992; SHACKLETON *et al.*, 1993). This efficiency gain may be even larger if one considers the impact of distortionary taxes on the relative prices of consumption goods (PARRY; BENTO, 2000). An overview of 56 ex ante impact simulations of environmental tax reforms in Europe finds that double dividends are often achievable. Environmental tax reforms are generally effective at reducing carbon emissions and can result in modest positive employment impacts[16] which are amplified when tax reforms target SCC reductions for low-income workers (BOSQUET, 2000). A review of ex post evaluations of environmental tax reform in Europe states that the overall consensus is that tax reform does result in a weak double dividend, although its impact on output, employment, competitiveness and carbon leakage is generally small (SPECK *et al.*, 2011).

4.4 KEY POINTS FOR TAX REFORM

The introduction of CPIs represents an opportunity to reform tax systems to improve overall efficiency. Tax reform could improve the efficiency of the tax system and ensure that taxes are focussed on specific externalities, and there is evidence that it can produce a double dividend of improved environmental outcomes and a reduced overall tax burden. Without such reform, double taxation on emissions may arise. Energy policies counteracting the CPI may also be removed over time, such as fossil fuel subsidies or fuel-tax credits. Tax reform can also mitigate negative distributional impacts on low-income households. A variety of jurisdictions successfully reduced distortionary taxes such as income taxes or social contributions to this end. The UK and Germany, for example, reduced the employee social contribution requirements for firms in response to introducing new environmental taxes to relieve competitiveness impacts on firms. There are examples of similar cost-relieving reforms in other income taxes both firms and households in British Columbia, and for households in Sweden, Australia and Chile. Comparable distortionary tax reductions are already offered in Brazil, such as the reforestation rebate on income taxes. A carbon tax provides greater opportunity to reform the tax system as its implementation requires amending the tax code, whereas the introduction of an ETS can be done separately from the tax system.

[16] Achievable is wage-price spirals can be avoided and the labour market is sufficiently flexible (BOSQUET, 2000).

5 COMPETITIVENESS AND CARBON LEAKAGE IMPACTS

Competitiveness and risk of carbon leakage occurs when carbon prices, and therefore costs, diverge between jurisdictions. Firms in jurisdictions with higher carbon prices may lose market share to firms in jurisdictions without or with lower carbon prices; this may also incentivizes firms to move production to jurisdictions without, or with lower, carbon prices, leading to carbon leakage. (EUROPEAN COMMISSION, 2015d). A sector's vulnerability to carbon leakage is typically determined by two indicators: emissions-intensity and trade intensity. The greater the emissions-intensity of a sector, the greater the cost differential between sectors in different jurisdictions will be, and hence the incentive to relocate production. The trade intensity of a sector provides an indication of how much the sector can pass on carbon costs to its consumers without losing market share (PMR, 2015). The more important international trade is to a sector's profits, the more any increases in local costs disadvantage the local sector.

The (global) emissions reduction objective of the carbon price might be adversely impacted by carbon leakage. Carbon leakage results in illusory emission reductions because emissions reductions in the jurisdiction covered by the (higher) carbon price are counteracted by emission increases in the jurisdiction with no (or lower) carbon price, where production relocated. This increases the economic cost of later reaching global climate stability. Carbon leakage may also cause negative economic and political consequences where reduced local production may lead to job losses and stranded assets (PMR, 2015, 2016).

5.1 SECTOR CLASSIFICATION

In the EU ETS, California, and Australia, regulators have determined which sectors are at risk of carbon leakage using metrics which aim to capture the two central issues:

- Emissions intensity
- Trade intensity

California classifies sectors into three categories of carbon leakage risk using different threshold criteria combinations of emissions intensity and trade intensity. Table 7 set out the thresholds for classifying high, medium, and low (and very low for emissions intensity) sectoral emissions intensity and trade intensity. Table 8 shows which combinations of categories of emissions and trade intensities determine which sectors are high, medium or low carbon leakage risk.

Table 7 - In the California ETS sectors are classified into four categories of emission intensity and trade intensity

Classification	Emission intensity ($MtCO_2e$/GVA)	Trade intensity (%)
High	≥ 5,000	Trade intensity >19

Classification	Emission intensity ($MtCO_2e/GVA$)	Trade intensity (%)
Medium	1,000 to 4,999	10 ≤ Trade intensity ≤ 19
Low	100 to 999	Trade intensity < 10
Very low*	< 100	N/A

Note: * only for emissions intensity

Trade intensity is defined as the sum of imports and exports divided by the sum of shipments and imports.

Source: (CARB, 2012).

Table 8 - In the California ETS sectors are classified into three carbon leakage risk categories based on the combination of their emission intensity and trade intensity categories

Carbon leakage risk	Emission intensity	Trade intensity
High	High	High Medium Low
	Medium	High
Medium	Medium	Medium Low
	Low	High Medium
Low	Low	Low
	Very Low	High Medium Low

Source: Adapted from(CARB, 2012).

Carbon leakage risk in the EU ETS is determined by measures of compliance cost increases and trade intensity - both in combination and in isolation. Table 9 shows the three quantitative methods through which a sector could be determined to be exposed to carbon leakage risk. They consider the costs imposed by the ETS and/or the trade intensity (defined as the sum of imports and exports divided by the total value of turnover plus imports). The compliance costs imposed by the ETS is a proxy for the emission-intensity of firm, but crucially factors in the gross-value added (GVA) to ensure that the ETS represents a significant cost. The trade intensity measure estimate the importance of trade (imports and exports) as a proportion of the domestic market (EUROPEAN COMMISSION, 2014d).

In the EU ETS, a qualitative assessment can also be used to classify as at risk of carbon leakage if it does not quite meet the quantitative thresholds. If a sector is on the borderline of being considered at risk by the quantitative measures, or data is missing, a qualitative assessment[17] can be undertaken to determine carbon leakage risk. This qualitative assessment analyses the extent to which an installation can reduce its emissions or electricity consumption, projections of market characteristics, or uses profit margins as an indicator of long-run investment decisions (EUROPEAN COMMISSION, 2014d).

Table 9 - In Phase 3 of the EU ETS there are three quantitative methods for determining carbon leakage risk based on costs of compliance and/or trade intensity

Carbon leakage criteria method	Compliance cost criteria		Trade intensity criteria
Quantitative method 1	Direct and indirect compliance costs ≥ 5% of the sector's GVA	AND	Trade intensity > 10%
Quantitative method 2	Direct and indirect compliance costs ≥ 30% of the sector's GVA		
Quantitative method 3			Trade intensity > 30%

Source: Adapted from (EUROPEAN COMMISSION, 2014d)(CARB, 2012).

However, from Phase 4 onwards, only the combination of emissions intensity and trade intensity will be used as criteria. In Phase 3 of the EU ETS, the industrial sectors considered to be at risk of carbon leakage covered more than 97% of industrial ETS emissions (EUROPEAN COMMISSION, 2015a), meaning that virtually all industry sectors received carbon leakage support. As a result, several new potential methods of classifying sectors at risk carbon leakage have been proposed for Phase 4. In all of these proposed methods, the use of compliance cost is replaced by a direct measure of emissions-intensity and, most importantly, a sector is to be determined at risk of leakage only by looking at the combination of a sector's emission intensity[18] and trade intensity. Most of the newly proposed methods also include an element of differentiated support based on medium/high/very high carbon leakage risk thresholds (EUROPEAN COMMISSION, 2015a).

The classification of carbon leakage risk in the carbon tax regime of Australia used a similar measure of emissions intensity calculation as the Californian ETS, but a different calculation of trade intensity compared to both the Californian ETS and the EU ETS. Australia's CPM determined sectors to be at risk of carbon leakage if they are both emissions intensive and trade exposed (EITE). Emissions intensity is defined as GHG emissions per dollar of GVA in sectors and has two categories:

- high (2,000 tCO_2e/AU$ million in revenue; or 6,000 tCO_2e/AU$ million in GVA); or

[17] The qualitative assessment is based on three criteria. "First criterion: indirect CO2 costs of at least 2.5% of GVA. Second criterion: Assuming a sector or subsector has a trade intensity of at least 25%, sufficient evidence that the sector or subsector is unlikely to be able to pass on the indirect CO2 costs. Third criterion: Fuel and electricity substitutability established by the 2010 Benchmarking Decision at least in respect of part of the sector concerned." (EUROPEAN COMMISSION, 2015c).

[18] Emissions intensity is defined as emissions divided by GVA

- medium (1,000 tCO_2e/AU$ million in revenue; or 3,000 tCO_2e/AU$ million in GVA).

Trade intensity is calculated differently compared to both the Californian ETS and the EU ETS. The Australian CPM measure of trade intensity is the value of trade as a proportion of local production rather than the value of trade as a proportion of the total local market. A sector was considered trade-intensive if the sum of imports and exports was greater than 10% of domestic production in any single year over 2004-2008. Trade exposure could also be determined qualitatively if evidence showed that cost pass through is constrained due to international competition (MARCU *et al.*, 2013).

In the Chinese regional pilot ETS programmes the criteria used to determine sectors at risk of carbon leakage is unclear (SWARTZ, 2016)**.** The criteria used to determine carbon leakage risk for most of the regional ETSs are not available, but, in Shenzhen, large-scale manufacturing firms are allocated allowances directly through one-on-one negotiations with the government (ENVIRONONOMIST, 2015; YE *et al.*, 2016). No descriptions of the criteria that will be used to determine carbon leakage risk in the proposed Chinese national ETS have yet been published.

The South African draft carbon tax bill defines emissions-intense and trade-intense sectors separately. Transitional assistance is proposed to be given to all sectors at a basic rate, while additional assistance is provided for trade exposed and emissions intense sectors. Trade exposed sectors are defined as those in which exports are 40% greater than domestic sales, while the calculation of the emissions intensity benchmark, against which firms will be measured, is still to be determined based on input from industry associations and companies (GOVERNMENT OF SOUTH AFRICA, 2015). The proposal stipulates that support will be given separately to trade exposed sectors and emissions-intensive sectors with no combined criteria requirement. However, the carbon tax bill is still in draft phase and may change based on stakeholder consultation.

Mexico's carbon tax is unlikely to result in carbon leakage; however, support is provided by allowing entities to comply with their tax obligations using local offsets. The main focus of the tax is the transport sector, with only 4% of industry emissions covered by the tax (OECD, 2014). Entities under the tax are able to comply with their tax obligations by using offsets from local Mexican CDM projects which can ease the burden on entities potentially at risk of carbon leakage (PMR, 2017b). With this reduced risk of carbon leakage, Mexico does not identify EITE sectors nor provide specific support to mitigate carbon leakage.

5.2 COMPETITIVENESS SUPPORT AND CARBON LEAKAGE PREVENTION

The competitiveness support and carbon leakage prevention differ for ETSs and carbon taxes.

5.2.1 ETS

In an ETS, sectors at risk of carbon leakage may be supported by two mechanisms: providing cost-neutrality through reforming other local taxes or providing firms with free emissions allowances to alleviate cost increases. Reforming local taxes was discussed in Section 4. This subsection focuses on the use of free allowance allocation. This has been the most common form of support within ETSs.

The impact of supporting sectors through free allowance allocation is influenced by the allocation method utilised. Free allowance allocation creates trade-offs, as the reduction of carbon leakage risk may also reduce the price signal and the incentive to reduce emissions (PMR, 2016). The impact of free allowance allocation depends on the level of support provided, which is significantly influenced by the methodology used to allocate allowances in general. Table 10 describes the four methods of allowance allocation.

Table 10 - Allowance allocation methodologies differ by their advantages and disadvantages and the jurisdictions which have used them

Allocation method	Description	Advantages	Disadvantages	Example Countries
Auctioning	Selling allowances via a market mechanism (periodic auctions) ensures efficient functioning of the trading market and maintains incentives for abatement by providing a price signal. This method creates revenue.	Raises revenue and requires less political input. Auctions also facilitate price discovery; does not distort incentives; and reward early action.	No direct support for carbon leakage sectors and may bias against smaller firms.	Remaining emissions not freely allocated in both EU ETS Phase 3 and California ETS
Grandfathering	Freely allocating allowances to firms based on their historical emissions – either directly or past production or fuel use multiplied by an emissions factor. Allocation is independent of current production.	A simple methodology to support sectors with easily available data. Demand-side abatement incentives maintained	Long-term reliance reduces abatement incentive. Theoretically weak prevention of leakage, as firms' incentives not affected. Windfall profits may occur and early action is penalized.	EU ETS Phase 1 and 2
Fixed sector benchmarking	Allowances allocated to firms are based on their past production multiplied by a product or sector level benchmark of emissions intensity (either average or indexed to a subset of efficient firms). The overall amount of free allowances is only infrequently updated.	Rewards early action and incentivizes longer term efficiency improvements. Demand-side abatement incentives maintained.	Sector benchmark calculations are data-intense and complicated. Windfall profits and reduced production still possible.	EU ETS Phase 3

Allocation method	Description	Advantages	Disadvantages	Example Countries
Output based allocation	Emissions-intensity benchmarks (either sector-level or a firm’s historical emissions intensity) are used to determine allocation in conjunction with the most current production data. The use of current production data entails greater sensitivity in terms of allocation decisions.	Incentivizes emissions intensity improvements while maintaining output. Risk of windfall profits minimised. Strong, targeted leakage prevention.	Benchmark calculation and current production data difficulties. Less demand--side- abatement incentivized as user prices less affected. Adherence to overall ETS cap not certain.	California ETS

Source: Adapted from (PMR, 2015, 2016).

Jurisdictions have used different approaches:

- The California ETS uses an output-based allocation metric which provides industry assistance to sectors at risk of carbon leakage through allocating a proportion of their emission allowances for free, depending on their level of leakage risk. This support is achieved through the industry assistance factor (AF) which is used in the free allowance allocation formula and varies according to carbon leakage risk classification and compliance period, as shown in Table 11. The Californian method utilises current production levels rather than historical production, making allocation more flexible and efficient. The efficiency benchmark may be product-based or energy-based (if a firm's activity or product is not as simple). The current product-based efficiency benchmark is set at 90% of the sector's average emissions intensity in order to incentivise efficiency improvements (CARB, 2011b). Therefore, while the first phase of the California ETS gives all carbon leakage risk categorised sectors 100% free allocation, individual firms will receive fewer than 100% of the allowances needed to cover all their emissions if they are more emissions-intense than their respective sectoral benchmark. This methodology maintains the incentive to reduce emissions intensity while maintaining production levels, which reduces negative competitiveness impacts and targets firms at risk of carbon leakage more directly (PMR, 2015).
- Phase 3 of the EU ETS uses fixed sector benchmarking such that sectors which pass the binary carbon leakage risk test are given 100% of their benchmarked allowances for free. The sectoral efficiency benchmark is calculated as the average emissions intensity of the 10% most emissions-efficient firms in each sector over the period 2003-2007 (EUROPEAN COMMISSION, 2011a). This method incentivises emissions intensity improvements for low efficiency firms as they receive fewer free allowances if they are below the benchmark (PMR, 2015). While a firm considered at risk of carbon leakage will still receive 100% of their allocated allowances for free in Phase 3; the amount of allowances allocated to the firm might not cover their total emissions if their emissions-intensity is above the benchmark, which would necessitate the purchase of additional allowances to cover the emissions gap. This Phase entailed a shift away from grandfathering allocation as a result of the EU's aim to increase the instrument's stringency over phases by replacing free allocation with more auctioning. The allocation amendments also stipulated that at least 20% of firms' allowances must be purchased in 2013, with this percentage rising to 70 and then 100 in 2020 and 2027 respectively (IETA, 2011). The criteria for determining sectors at risk of carbon leakage will change in Phase 4, as discussed above, but free allocation will still be the support mechanism to these sectors with 6.3 million free allowances available for industry over 2021 to 2030 (EUROPEAN COMMISSION, 2015a). Free allocation to these sectors will also become more targeted by using updated industry benchmarks, aligning allocation more closely with recent production data, improving the flexibility of the new entrants reserve, and compensating indirect costs to electricity intensive industries (EUROPEAN COMMISSION, 2015a, e). Extensive stakeholder engagement ensured buy-

in to the change in allocation method and the previously discussed change in carbon leakage classification criteria.

- Phases 1 and 2 of the EU ETS predominantly used grandfathering. Grandfathering provides allowances to firms based entirely on their historical emissions. This method of allocation means that the number of allowances allocated to a firm for free is independent of its current behaviour and because they have an opportunity cost, there is an incentive for firms to add the allowance price to their marginal cost of production leading to windfall profits (DEMAILLY; QUIRION, 2006). The allowance supply needed under grandfathering in Phase 1 was overestimated which lead to an oversupply causing the EUA price to fall to zero in 2007. In Phase 2, the total amount of allowances was reduced by 6.5%, however, global economic recession resulted in diminished output and hence demand for allowances which once again reduced the EUA price (EUROPEAN COMMISSION, 2017c). Grandfathering was also widely criticised in the EU for providing firms with greater absolute historical emissions with greater support, thus effectively punishing early abatement (EUROPEAN COMMISSION, 2015d).
- The Australian CPM provides support to sectors at risk of carbon leakage through output based free allowance allocation in the same fashion as an ETS. Covered firms in Australia purchased allowances at a fixed price to cover their tax liability. The Jobs and Competitiveness Program gave support to sectors at risk of carbon leakage via output-based free allocation of emissions allowances based on emissions intensity sector benchmarks. The benchmarks were determined by the average emissions intensity of a sector over two years (2006-07 and 2007-08). Sectors deemed highly and moderately emissions-intense freely received emissions permits to the value of 94.5 and 66%, respectively, of the average emissions intensity sector benchmark. This assistance was to diminish by 1.3% per year (PMR, 2015). These permits could be used for compliance, sold back to the regulator, or traded in the carbon market (PMR, 2017b).
- China has yet to decide how to design its national ETS to deal with carbon leakage, but considering that free allocation was the primary allowance method in all of the regional ETS pilots in China (SWARTZ, 2016), it is possible that this will also be the method of support for EITE sectors in the national ETS. It is not clear how these free allowances might be allocated.

Table 11 - The California ETS provides differentiated support across carbon leakage risk categories and compliance periods

Carbon leakage risk	Industry assistance factor (AF) by compliance period (per cent)		
	2013-2014	2015-2017	2018-2020
High	100	100	100
Medium	100	75	50
Low	100	50	30

Source: Adapted from(CARB, 2012).

The use of efficiency benchmarks – as with fixed sector benchmarking or output based allocation - may create structural imbalances. For some industries, the possibility to improve emissions efficiency is a function of the year a facility was built, the technology used (largely determined by year built); and the technical production process. In the short run, a firm may not be capable of changing the first two elements and may not have complete control over the emissions from the production process. For example, some chemical processes necessitate a floor-proportion of emissions based on thermodynamic limits and so achieving emissions reductions below a certain threshold may be impossible (IEA, 2013b). Incentivising firms to change to more efficient production processes is undoubtedly desirable but exposing firms to uncontrollable factors, such as time and certain chemical processes, may result in negative economic outcomes.

5.2.2 TAX

Carbon taxes also support sectors at risk of carbon leakage either through reforming local taxes or through directly reducing the effective burden of the carbon tax. The mechanism of reforming local taxes to support carbon leakage risk sectors is discussed in Section 4. The main alternative support mechanism is through reducing the carbon tax burden on sectors at risk of leakage, either through exemptions or tax rate reductions or absolute rebates on tax payments (PMR, 2017a).

South Africa's carbon tax will reduce the tax liability for firms based both on their level of trade exposure and on the emissions-intensity of their current production relative to a sector benchmark. All sectors receive a basic 60% tax-free basic allowance, however additional allowances are made for emissions intense and trade intense sectors. Sectors can receive up to 10% additional tax-free allowances (support will potentially be graduated) depending on their level of trade exposure. A further 5% of tax free allowances has been proposed to be available to companies based on a formula which rewards efficient companies compared to an emissions intensity benchmark[19] for the sector (GOVERNMENT OF SOUTH AFRICA, 2015).

5.2.3 EITHER ETS OR TAX

Under either an ETS or a tax, support for sectors at risk of carbon leakage may also be provided through border carbon adjustments (BCAs); however, these imply significant implementation challenges. BCAs impose higher import duties on goods based on their carbon content in order to alleviate the risk of carbon-intensive goods being imported cheaply from regions without a carbon price into regions with a carbon price. However, this mechanism would require administratively complex calculations of the carbon content of imported goods and may face legal challenges by the World Trade Organisation (WTO) (PMR, 2015).

[19] The calculation methodology is still under consideration.

5.3 EMPIRICAL EVIDENCE OF CARBON LEAKAGE AND COMPETITIVENESS IMPACTS

5.3.1 EVIDENCE OF CARBON LEAKAGE

Carbon pricing may, in theory, imply significant compliance costs for industries. These stem from both direct and indirect costs:

- Direct cost: are costs incurred from the purchase of additional allowances to cover a firm's emissions in excess of free allocation (EUROPEAN COMMISSION, 2014d).
- Indirect cost: are the costs associated mainly with the rise in electricity prices ,due to the inclusion of electricity production in the ETS. Indirect costs can be associated also with the inclusion, in the ETS, of any other sector that provides inputs for industries (EUROPEAN COMMISSION, 2014d).

The European Commission estimated the potential annual compliance costs over 2015-2019 for all industries in order to determine which sectors are at risk of carbon leakage. Table 12 presents the estimated annual direct and indirect costs that sectors would face in the ETS without carbon leakage support over 2015 to 2019[20]. Costs vary by industry and direct costs almost always outweigh indirect costs. The EU cement and iron and steel industries have notably higher estimated costs. The annual indirect costs are frequently in the low single-digit percent in the EU (expressed as cost per GVA – a proxy for margins) (EUROPEAN COMMISSION, 2014f).

Table 12 - The estimated direct and indirect compliance costs for select producers in the EU ETS over 2015-2019 are frequently in the single-digit percentages

Industry	Direct cost / GVA (%)	Indirect cost / GVA (%)
Glass producers	5 to 8	2 to 4
Chemical producers	3 to 8	2 to 4
Iron and steel producers	17	5
Paper producers	4	6 to 7
Cement producers	42	5

Note: Direct cost assumptions: Direct costs are adjusted using an auctioning factor to determine how many allowances a sector will need to purchase at auction if it is not on the carbon leakage list. This factor is currently

[20] In the California ETS, (CARB, 2016b) (2016A) uses 2014 emissions and an allowance price equal to the price floor in 2021 to estimate that direct compliance costs for facilities could range from US$25,000 to close to US$900 million. Similarly, in terms of indirect costs, the CARB estimated that that the electricity price paid by industry would increase by US$ 6.35/MWh (approximately 5% of 2015 prices) for every US$10/tCO2e increase in the allowance price. This would also affect fossil fuels for households and industry, where every US$10/tCO2e allowance price increase would result in an increase of approximately 10c$ per gallon of gasoline and diesel, and 5c$ per thermal unit of natural gas (CARB, 2016b; EIA, 2017).

based on a sector' actual data from previous years[21] (EUROPEAN COMMISSION, 2014d). Only estimates from subsectors meeting the carbon leakage threshold criteria are provided. Ranges provided were industry presented reflect more than one subsector with different cost estimates.

Indirect cost assumptions: An average emission intensity factor is assumed across industries based total fuel mix used for electricity production (EUROPEAN COMMISSION, 2014b).

Assumption in both cost calculations: An assumed allowance price of €30/tCO_2 (EUROPEAN COMMISSION, 2014b).

Source: (EUROPEAN COMMISSION, 2014f).

Globally, evidence suggests little to no carbon leakage has occurred in jurisdictions that have introduced carbon pricing instruments. (BOLSCHER *et al.*, 2013) investigated the impact of the first two EU ETS Phases and found no evidence of carbon leakage as defined as the relocation of production due to ETS costs**.** Similarly, a literature review of key empirical studies on carbon leakage between 2007 and 2013, mainly focussed on the EU ETS and often within the cement and iron and steel sectors, finds no strong evidence of the occurrence of carbon leakage. While this might be evidence of the success of support mechanisms, carbon prices may also have just been too low as of yet to stimulate wider-ranging leakage, or measurement inaccuracy may be such that real leakage is not being found (PMR, 2015).

However, the existence of carbon leakage may be more important for smaller states and when there are carbon price differentials between neighbour states. (NÆSS-SCHMIDT, 2011), for example, finds that for every 100 tCO_2 abatement achieved in the sectors most at risk of carbon leakage in the Nordic[22] countries, emissions in other EU countries increase by 102 tCO_2. This is explained by Nordic countries on average having a 33% higher internal carbon price than the EUA price and Nordic industries being more energy efficient and consuming electricity with lower carbon-content than their neighbouring countries.

Firms in California may be particularly vulnerable to carbon leakage risk due its ETS being sub-national and highly trade exposed, but there is little robust evidence of carbon leakage. To help address carbon leakage, the carbon price has been extended to include electricity imports, effectively imposing a subnational border carbon adjustment (BCA) (CARB, 2011a; IETA, 2018). However, leakage may still be occurring due to the complexity of power contract chains. These chains can become so entangled that the source of power becomes unknown, at which point they become 'unspecified' emissions sources which are given default emission rates of natural gas power plants (ROBERTS, 2014). If the actual source of electricity has an emission intensity greater than gas, then this would result in carbon leakage. This emphasises the challenges faced by BCAs as discussed above although it is more likely to be a challenge given the specific circumstances of California which has an interconnected electricity grid with states without a carbon price. Cement producers in the state have also expressed carbon leakage concerns, even with free allowance support, as they already experience higher costs

[21] Whereas in the previous carbon leakage lists this auctioning factor was an assumed uniform 75% (EUROPEAN COMMISSION, 2014d).

[22] Denmark, Finland, Iceland, Norway, Sweden, and Faroe Islands, Greenland, and Åland

than neighbour state competitors, due to stricter environmental rules and higher labour and fuel costs. As such, they have advocated for border-adjustment taxes on incoming carbon-intensive products (ZUCKERMAN *et al.*, 2014).

5.3.2 EVIDENCE OF COMPETITIVENESS IMPACTS

It is unlikely that significant competitiveness impacts have occurred as a result of the EU ETS in the EU to date. Several reviews of the literature on the impacts of the EU ETS on industrial competitiveness across sectors such as pulp and paper, cement, iron and steel, petroleum, and chemicals find evidence of no significant impacts on firms' employment, turnover, or profitability (ARLINGHAUS, 2015; MUÛLS *et al.*, 2016). Similarly, (ABRELL; ZACHMANN; NDOYE, 2011) looked at firm-level effects of the EU ETS and found that regulated firms did not experience any significant impacts on profits, employment, or added value over 2005 – 2008.

There has also been evidence of cost pass-through in the EU's industrial sectors, which may have allowed them to gain windfall profits from free allocation. (SANDER *et al.*, 2010) find that the Iron and Steel sector managed to pass through the full opportunity cost of freely obtained allowances into their sales prices during Phase 1 and 2 of the EU ETS, allowing them to gain windfall profits. Other studies also identify that the cement and steel sectors may have realised between €5 billion and €2 billion, respectively, in windfall profits due to their classification as EITE and their subsequent free allocation support (SANDBAG, 2017). An empirical analysis of cost pass-through in the UK refinery, glass, chemicals and ceramics sectors suggests that most sectors are able to pass on significant proportions of their carbon costs. This analysis found that the glass sector was less capable of cost pass-through and the iron, steel, chemicals, and refineries sectors are sometimes capable of over 100% cost pass-through (OBERNDORFER; ALEXEEVA-TALEBI; LOSCHEL, 2010). An econometric investigation into cost pass-through in the EU ETS also finds that cost pass through is significant in the iron and steel, cement, and refineries sectors, and less so for the glass sector. Market power, bargaining power and exposure to international competition are major determinants of the ability to pass through costs (CE DELFT; OEKO-INSTITUT, 2015).

The Australian CPM did not have a significant impact on the competitiveness of the industrial sector, in part due to the significant amount of support provided by the government. Over the two years while the CPM was in place, the Jobs and Competitiveness Programme issued the iron and steel sector 18 $MtCO_2e$; the cement sector 10 $MtCO_2e$; and the bulk flat glass sector 0.3 $MtCO_2e$ in free emissions allowances to alleviate carbon leakage risk (CER, 2015c, d). The steel sector, in particular, was also supported by a AU$300 million fund to support innovation and investment (Marcu et al., 2013). Furthermore, operating profit in the Australian manufacturing industry consistently fell before rising from 2012 onwards (although employment continued to decline) as shown in Figure 4. This rise in profit may be an indication that the CPM had no negative competitiveness impact within the Australian manufacturing industry.

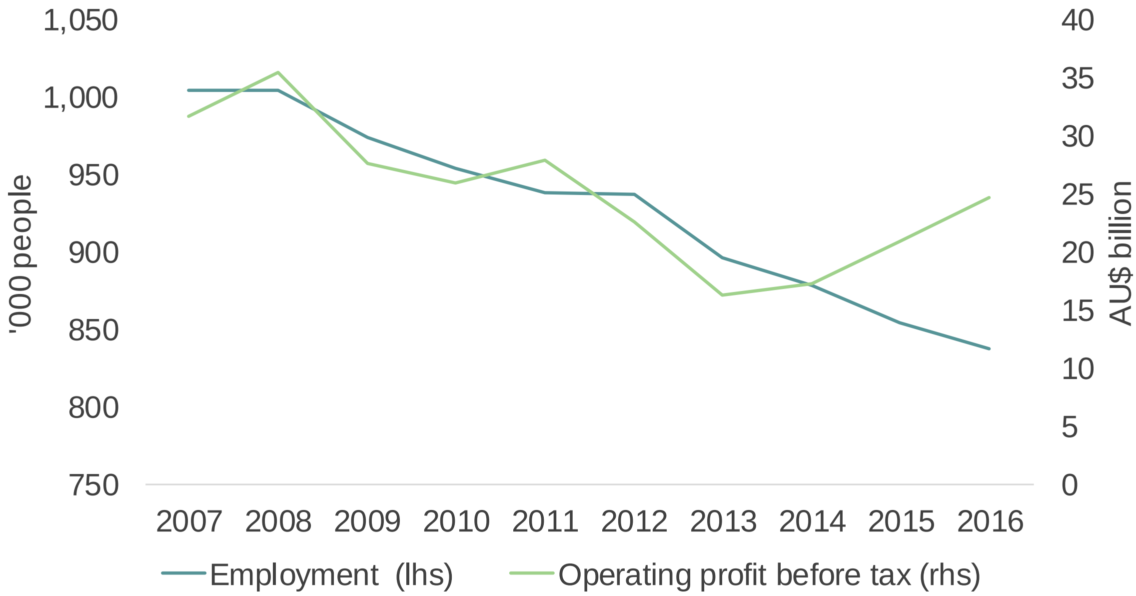

Figure 4 - While employment continues to decline, operating profit has picked up since 2013 in the Australian manufacturing industry

Source: (AUSTRALIAN BUREAU OF STATISTICS, 2017).

5.4 REVENUE RECYCLING

There are two central methods through which to recycle the revenues of a carbon pricing instrument: recycling back into the general budget or earmarked for specific purposes. Treating revenues as part of the general budget could provide government finance ministries with more flexibility and is theoretically macroeconomically efficient; however, using revenue for specific purposes may help generate support for the carbon pricing instrument, increase transparency, and promote investor confidence (BARANZINI; CARATTINI, 2017; COTTRELL *et al.*, 2013).

Globally, more carbon pricing revenues are recycled into specific purposes than into general government budgets. In 2015, total world revenue from all carbon pricing was US$ 26 billion. Of all the revenue collected from carbon pricing instruments 63% has been recycled back into specific purposes[23] and only 26% has gone towards general state funds[24] (CARL; FEDOR, 2016). ETSs generally deliver greater recycled spending on technology, while carbon taxes are associated with higher levels of recycling through refunds or general state funds (CARL; FEDOR, 2016).

Often in jurisdictions, the revenue from carbon pricing is earmarked for specific purposes such as funding new technologies and social programmes.

[23] 27% has gone into spending on energy efficiency and renewable energy and 36% has been recycled back to corporate or individual taxpayers through tax cuts or rebates (CARL; FEDOR, 2016).

[24] These percentages do not sum to 100% because these categories are not comprehensive and annual revenue budgeting may not match annual revenue inflows (CARL; FEDOR, 2016).

Box 1. **Lessons for Brazil**

Brazil's fiscal collection system is complex and comprises different types of taxes which vary in terms of revenue recycling requirements and may differ regionally. Brazil has a system of levies (tributos) which can be categorised into contributions (contribuições), fees (taxas), and general taxes (impostos). The main distinction between the levies is that revenue from contributions is strictly earmarked for specific purposes, fees are paid directly to an entity providing some kind of service, and revenue from general taxes is recycled back into the general government budget. Most contribution levies are so strictly earmarked that the revenue goes directly into ring-fenced funds without ever going through the fiscus. Brazil has three levels of government: federal, state (estado), and local (municipio). Only the federal government may impose levies, but the other levels of government may act as collectors or administrators of tax. The federal government may choose to impose differential levies across states and local government jurisdictions (NOGUEIRA; NOGUEIRA, 2006, 2005). The different levy categories do not distinguish lump-sum from distortionary taxes.

The imposition of a carbon tax will interact with a tax system to affect three main areas:

- the net cost impact;
- the distribution of costs; and
- the effectiveness of revenue recycling.

The net impact on costs depends on the mechanisms used to offset compliance costs, which may produce a double dividend. Total compliance costs can be reduced by reforming other elements of a jurisdiction's tax system upon the implementation of a carbon price, as discussed in Sections 4.1 and 4.2. The net impact on costs depends on the level of tax reform compared to the level and scope of the carbon price. For example, both the UK's introduction of the CCL coupled with corporate tax reform and British Columbia's carbon tax implementation combined with personal and corporate tax reforms, resulted in net lower costs imposed on industry. The introduction of carbon taxes together with the reform of other distortionary taxes can therefore create a double-dividend of addressing a negative externality while reducing total costs.

Variable tax rules across regions may complicate the impact of tax reforms, but distributional impacts can be mitigated through careful reform design. If there is geographic variation in taxation rules, such as different levies across states or local government regions, then the costs of a carbon price will differ by region. At the extreme, this has been evidenced in the Californian ETS which imposed carbon costs in one State but not in others and may have led to competitiveness concerns for firms within California (discussed in Section 0). There are no examples of carbon taxes being implemented at the sub-national level, which implies that a carbon tax in Brazil should be implemented at the federal level. The distribution of costs is also affected by the type of taxes reformed: distortionary or lump-sum. Reforming certain distortionary taxes may benefit firms with certain cost structures. For example, in the UK's implementation of the CCL reforming social contribution requirements may have had the desirable effect of favouring firms with high labour intensities. Reforming taxes by removing countervailing fossil fuel subsidies (as in Mexico), reducing transport fuel tax credits (as in Australia), or providing rebates for energy efficiency and renewable energy (as in South Africa) may better target negative externalities and accentuate the carbon price signal. Tax reforms at the individual level such as increasing tax-free thresholds and reducing the tax rate for lower income households may also help ensure the progressivity of the income tax system by offsetting increases in consumer prices related to the carbon price.

The effectiveness of recycling carbon tax revenues may be optimised by using soft-earmarking. As discussed, strict recycling of carbon revenue may not be the most desirable mechanism to distribute revenues back into the economy and soft-earmarking revenues towards broad aims may be the best approach to ensure transparency while also allowing governments flexibility.

Recycling carbon revenues back into the government budget for general spending theoretically increases the economic efficiency of the system. Revenue from the carbon tax in Mexico is legally required to be deposited back into the general budget (GARCIA, 2017). Similarly, in the UK all revenues from carbon pricing are recycled into the general government budget because earmarking is not permitted (PMR, 2017a). In the EU, the (CPLC, 2016) estimates that 32% of countries incorporate some form of general budget revenue recycling from auctions. This method theoretically allows governments to use revenues for spending on areas unrelated to climate change, based on priorities, which increases the economic efficiency of the system. However, this may also raise public concerns on a lack of transparency and lead to perceptions of a government implementing a tax in order to raise revenues (MARRON; MORRIS, 2016). Brazilian *impostos*[25] are defined by the recycling of tax revenues back into the general government budget, thus the carbon prices of the jurisdictions above align best with this type of Brazilian tax.

Recycled carbon pricing revenues can be used for several purposes, each of which come with opportunities and challenges, as shown in Table 13**.** Only row four in Table 13 illustrates general revenue recycling, with all the other uses entailing some form of earmarking. Industry competitiveness can be supported both directly and indirectly in several of these uses.

Table 13 - Carbon pricing revenues can be recycled either into the general government budget or towards specific purposes

Revenue use	Opportunity	Challenges
Reduce other taxes	May improve tax system efficiency and promote economic activity.	May imply preferential treatment of some groups.
Direct to households	Addresses household equity concerns and enhances public support.	May miss productivity improvement opportunities.
Transitional support to industry	Supports economic growth and generates industry support.	May counter the CPI's intention and entails assessment of 'winner' industries which may encounter vested interests.
Support general government spending	Increases resource availability and fiscal flexibility to provide economic support.	Returns on spending difficult to evaluate.

[25] See Box 1.

Revenue use	Opportunity	Challenges
Fund climate investments	Aligns to the same goal as the carbon price and may directly correct for market failures.	May create market distortions; inefficiencies; entail 'winner' industry selection; and represent over-stepping government. Level of revenues may, by itself, be inadequate for specific investments

Source: Adapted from (CPLC, 2016).

There is room between exact earmarking and general revenue recycling, such that revenue can be 'soft'-earmarked for purposes without exact allocation formula. This provides governments with greater flexibility. Soft-earmarking revenues for tax reform, as discussed in Sections 4.1 and 4.2, have been made in Sweden, British Columbia and Chile. Similarly, South Africa's carbon tax design includes soft commitments to recycle revenue into initiatives such as the installation of solar water heater geysers; provision of free basic electricity for low income households; improved public transport; and road-to-rail freight shifting without committing to exactly how much revenue will be apportioned to each (NATIONAL TREASURY, 2014, 2016a).

California takes a hybrid approach to revenue recycling. The majority of carbon revenues is strictly earmarked towards objectives such that pre-defined portions of revenues generated are recycled into spending on energy efficiency and renewable energy projects in public buildings, supporting disadvantaged communities, as well as low carbon transportation, natural resource conservation programmes, and direct household transfers in the form of electricity bill rebates (LAO, 2014). However, around 4% of the revenues is recycled back into the general government budget to cover general employee and administrative costs (CARL; FEDOR, 2016).

The best use of revenues and best method to recycle them will be determined by the specific context of a jurisdiction, but any rules made should be consistently reviewed. Different jurisdictions will have different needs in terms of transparency requirements, administrative simplicity, accountability, and social investment, and will need to find their own balance between revenue used for specific purposes and for the general budget. Public consultation and clear communication is key to ensure wide-ranging stakeholder buy-in for whichever revenue recycling mechanism is chosen (CPLC, 2016). Strict earmarking, however, is likely not the best solution, as the uncertain and dynamic nature of economic development may cause initially optimal rules to fast become obsolete. Governments should frequently review all revenue recycling decisions to ensure optimality (BOWEN, 2015).

5.5 KEY POINTS FOR COMPETITIVENESS AND CARBON LEAKAGE IMPACTS

The emission intensity and trade intensity of firms determines the severity of the competitiveness impacts resulting from CPIs and are good variables to identify carbon leakage

risk. Emissions intensity is important as firms incur direct costs from their own emissions and incur indirect costs from increased electricity (and heat) prices due to the coverage of electricity production under the CPI. Trade intensity is important as it shows how vulnerable firms are to competition from firms in other jurisdictions. Competitiveness impacts occur when firms from jurisdictions with higher carbon prices lose market share to firms in jurisdictions with lower carbon prices, whereas carbon leakage occurs when firms in higher price jurisdiction move production to lower price jurisdictions. It is becoming apparent that it is the combination of emission intensity and trade intensity that is most important for carbon leakage risk identification.

Jurisdictions with CPIs support sectors at risk of carbon leakage in a few different ways. Industries deemed at risk of carbon leakage have been supported through free allowance allocation in ETSs, through absolute tax rebates or tax rate reductions in carbon taxes, or general tax reform or border carbon adjustments (BCAs) for either type of CPI. The free allocation support given to firms can evolve over time into more complex, efficient, and environmentally sound mechanisms. CPI revenue recycling can be used to achieve multiple objectives, including reducing negative competitiveness impact on industry, however recycling using strict-earmarking rules may be sub-optimal in the long term.

Evidence of little to no competitiveness and carbon leakage impacts may reflect the success of jurisdictions' support. Available evidence shows little carbon leakage or competitiveness impacts in jurisdictions that have introduced CPIs. Several reviews of the impacts of the EU ETS on industrial competitiveness across multiple sectors finds evidence of no significant impacts on firms' employment, turnover, or profitability. The Australian CPM did not have a significant impact on the competitiveness of the industrial sector, as evidenced by rising operating profits from 2013 onwards.

6 EMISSIONS IMPACTS

The impact of CPIs on industrial emissions are challenging to analyse. It is instructive to consider both absolute emissions and emissions intensity but both are affected by a wide range of factors other than the carbon price including fuel prices, the introduction of new technologies and – crucially – other energy and climate policies. This creates an identification problem in determining the causal impact of CPIs. Studies estimate the impact of CPIs on emissions using different methodologies. Trend analysis observes a jurisdiction's industrial emissions over the period of a CPI's implementation and this may conflate the impact of the CPI with the impact of another exogenous factor. Macroeconomic analyses compare actualised industry emission to projected business as usual (BAU) scenarios to find the impact of the CPI. Econometric studies are more robust and address the counterfactual problem by directly estimating the relationship between a CPI and industrial emissions by taking into account many different variables. This section presents an overview of what emission reductions could be targeted and presents the available evidence in the case study jurisdictions.

Industrial sectors can respond to the implementation of a CPI through adopting changes in their production inputs, technologies and processes to reduce their absolute emissions and emissions-intensity. In an approximate cost hierarchy, fuel switching and energy efficiency measures tend to be the least expensive, with changes in technologies and processes being often far costlier – and sometimes too costly to be incentivised by a carbon price at all but very high levels. Figure 5 highlights the three main areas of abatement opportunities for firms. Carbon pricing targets the cost-effective abatement shown in the blue section. The abatement in the red section may be supported by the carbon price, but given that they have negative net costs anyway, unlocking them may require other policies. Abatement opportunities in the green section are too costly for an introductory carbon price without raising concerns over distributional impacts and more targeted policies may be needed.

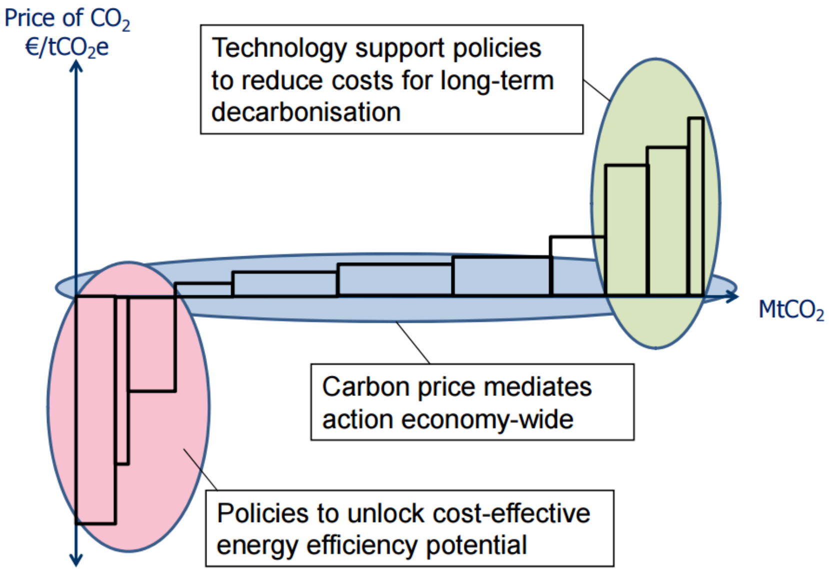

Figure 5 - CPIs incentivise cost-efficient emission reductions – further policies may be required to remove non-price barriers and to unlock higher-cost emission reduction technologies

Note: Additional policies beyond carbon pricing may be needed to remove non-price barriers to cost-effective energy efficiency potential

Source: (HOOD, 2011).

Although the evidence of the emissions impact of CPIs is scant, particularly for ex-post studies, the following subsections show the impact on absolute emissions and, where available, emissions intensity in the international case study jurisdictions.

6.1 CALIFORNIA ETS

California's whole economy emissions intensity declined by 28% between 2001 and 2014, while GDP has grown 28% in the same period (CARB, 2016a)**.** According to (ALEXANDER EDEN *et al.*, 2016), during the first year of operation of California ETS, emissions decreased by 0.6% while the state's GDP grew over 2%. This trend follows previous years, however, and cannot be attributed directly to the ETS.

While California's total emissions have been declining since 2012, industrial emissions have risen since the start of the ETS until 2014. Companies covered by the ETS reduced their emissions in 2013 by nearly 4%, while companies not covered by the ETS marginally increased their emissions. This suggests that the ETS is leading to firms taking action to reduce their carbon costs (HSIA-KIUNG; MOREHOUSE, 2014). However, California's industrial emissions were around 90 MtCO_2e in 2012 and increased steadily over the next 2 years to reach around 92.5 MtCO_2e in 2014, driven mainly by increased fuel combustion rather than an increase in process emissions (CARB, 2016a).

6.2 EU ETS

The EU has experienced large emission reductions since the introduction of the EU ETS. Analyses of the EU ETS by the European Environmental Agency show significant emissions reductions, especially in the EU15[26]. The first two years of Phase 1 saw cumulative economy-wide reductions of 100-200 $MtCO_2$ (2.4 - 4.7%), while over Phase 2 the economy-wide emission intensity fell by 3.4% on average per year (EGENHOFER *et al.*, 2011; MUÛLS *et al.*, 2016). Studies also show that these reductions did not result from carbon leakage (MUÛLS *et al.*, 2016). EU emissions in 2012 reflected a 19.2% reduction below 1990 levels and, with existing measures in place, is projected to achieve on percent more than its 2020 emission reduction goal of 20% below 1990 levels (EEA, 2014).

Manufacturing emissions in the EU have fallen significantly in recent years. The (EEA, 2014) estimates that the largest sectoral emission reductions over 1990-2012 were from the manufacturing industries and construction IPCC sector, which reduced emissions by 327 $MtCO_2e$ or 38.1%. Emissions from the manufacturing industry in the 28 countries of the EU fell 19% from 2008 to 2014, decreasing from 1,024 $MtCO_2$ in 2008 to 831 $MtCO_2$, as can be seen in Figure 6. While much of these reductions are the result of the financial crisis, there is some evidence that the EU ETS may have contributed: (EGENHOFER *et al.*, 2011) based macroeconomic analysis, found that the EU ETS reduced the emissions intensity of industry by 0.9% over 2008 and 2009 compared to a BAU scenario[27]. The study covered the following sectors: mineral oil refineries; coke ovens; metal ore roasting or sintering; pig iron or steel; cement clinker or lime; glass including glass fibre; ceramic products by firing; and pulp, paper and board.

[26]Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

[27] The BAU scenario is that 2008-2009 are assumed to have the same emission intensity improvements each year as the average over the last two years of Phase 1 of the EU ETS.

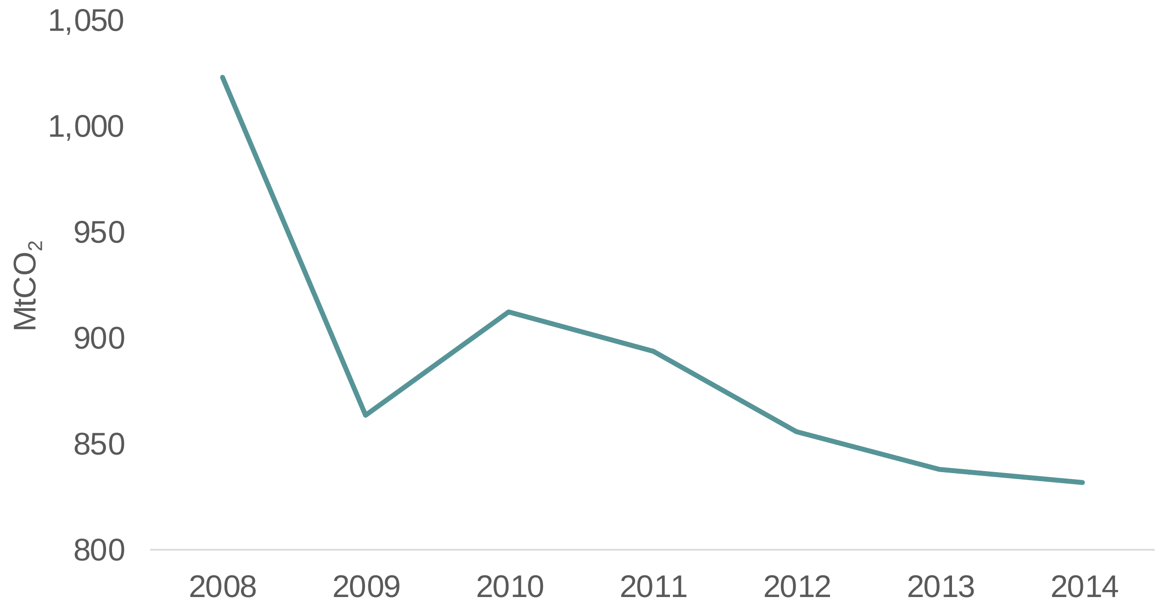

Figure 6 - EU manufacturing emissions continued to decline past the financial crisis

Source: Eurostat (2017).

Structural limitations within the EU ETS, however, may be inhibiting the full potential of abatement opportunities and constant review and reconfiguration is necessary. As discussed above, the number of sectors receiving free allocation may have reduced the abatement impact of Phase 1 and 2 of the ETS, and the support mechanism for future Phases is being amended with this in mind. More importantly, the ETS cap may need to become more flexible to account for variable macroeconomic conditions (such as the financial crisis) otherwise exogenous factors may keep reducing the efficacy of the instrument in terms of incentivising abatement (LAING *et al.*, 2013).

6.3 AUSTRALIA CPM

The emissions of covered sectors fell during the CPM, which can only partly be attributed to the CPM. While total emissions increased by 1.5% between 2012 and 2013, the economy grew at 2.7% over the same period. In terms of attribution to the carbon pricing mechanism, Australia's Treasury and DIICCSRTE modelling (2013) project that emissions in Australia would have been 17 $MtCO_2e$ (2.8%) higher in the absence of the carbon pricing mechanism in 2012-2013 (CCA, 2014). However, Australia's economy has long been on a decarbonisation path, with the economy-wide emission intensity having dropped by 50% between 1990 and 2014. A significant part of this is a structural shift away from emissions intense manufacturing and thus not all of the emissions reductions over 2012 and 2013 can be attributed to the CPM (CCA, 2014).

Under the new Direct Action Plan, emissions from the industrial sector are projected to decline over time. 2015 analysis suggests that, for the metal production and cement production sectors, absolute emissions will decline or stabilise until 2035. However, it is unclear how much of this is due to reduced production under estimated difficult future market conditions rather than regulatory influences (AUSTRALIAN GOVERNMENT, 2015).

6.4 SUPPLEMENTARY JURISDICTIONS

The extent to which the Mexican carbon tax has reduced industrial emissions is unclear to date. **T**he Mexican government stated that the carbon tax has already led to emission reductions of 1.5 $MtCO_2e$ (PMR, 2017b), but no emission reduction data for sectors is available.

6.5 KEY POINTS FOR EMISSION IMPACTS

Analysing the ex-post impact of CPIs on industrial emissions is challenging due to the identification problem and studies use different estimation methodologies. A number of factors influence industry emissions and emissions intensity including fuel prices, new technologies, and other climate and energy policies. This results in an identification problem in attributing the cause of emission reductions to the CPI.

Although available data is limited, there is some evidence to suggest that CPIs have reduced industry emissions intensity. There is some evidence to suggest that CPIs have succeeded in reducing industrial emissions in recent years. EU absolute emissions fell by 327 $MtCO_2e$ or 38.1% over 1990-2012 in manufacturing industries and construction IPCC sectors ((EEA, 2014). Australia's Treasury and DIICCSRTE modelling (2013) project that emissions in Australia would have been 17 $MtCO_2e$ (2.8%) higher without the absence of the carbon pricing mechanism in 2012-2013 (CCA, 2014). While much of these reductions are the result of other factors, such as the financial crisis, there is some evidence that the EU ETS reduced industry's emissions intensity. Macroeconomic analysis suggests the EU ETS reduced the emissions intensity of industry by 0.9% over 2008 and 2009 compared to a BAU scenario using the average emissions intensity of the last two years of Phase 1 ((EGENHOFER *et al.*, 2011).

7 LESSONS FOR BRAZIL

Industry support mechanisms can prevent CPIs resulting carbon leakage while retaining the incentives for industry to reduce its emissions intensity. There is evidence that very little to no carbon leakage has occurred as a result of the introduction of CPIs in jurisdictions across the world. This could be the result of carbon prices being too low, measurement inaccuracy or rather that support mechanisms delivered to industry have been successful. However, evidence from the international experience that shows how CPIs have reduced the emissions intensity of industry in the EU, which suggests that CPIs do have an impact that is being measured and thus the lack of carbon leakage is likely due to successful support mechanisms.

Mechanisms to support industry can be implemented simultaneously to a CPI and may possibly remove distortions, but should always include stakeholder input, evolve over time. Countries around the world identify sectors at risk of carbon leakage using a combination of emissions-intensity and trade-intensity indicators. Support provided can be through free allowances if the CPI is an ETS or tax rebates or rate reductions if the CPI is a carbon tax. General tax reform or the application of border carbon adjustments (BCAs) can also support industry whether the CPI is an ETS or a carbon tax. This kind of reform may also remove distortions by removing countervailing energy policies and removing any double taxations, while carbon revenues can be recycled to support households and other negatively affected entities. The implementation of industry support must incorporate early stakeholder feedback and be amenable to frequent review. It is essential that support given to industry evolves over time to become more targeted and performance-based, such that the emission reduction objective of the CPI is not undermined and abatement incentives remain strong.

However, the insights from the international experience of CPIs and industrial sectors must be considered against the backdrop of local context. The emissions from Brazil's industrial sector are not as significant as most other countries' industrial sectors. For example, Brazil's industrial sector's emissions are significantly less important than their AFOLU emissions compared to other countries as shown in Figure 7. 2013 emissions from industrial processes in the same year comprised only 4% of Brazil's total GHG emissions, compared to the average for other BRICs countries of 7% (WORLD RESOURCES INSTITUTE, 2014). The industry sector has also been under significant international pressure and faces declining competitiveness. Additionally, industrial sectors in Brazil have comparatively small GVA and relatively high trade exposure which accentuates the potential impact of a carbon price on industry competitiveness.

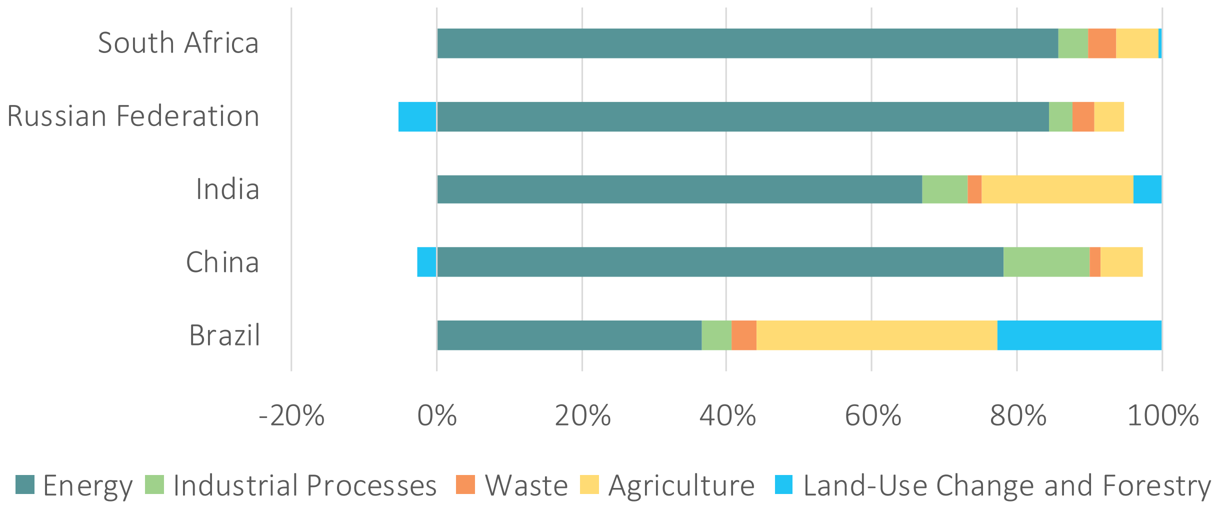

Figure 7 - In 2013, Brazil's AFOLU sector comprised 56% of total GHG emissions, while the average for other BRICS countries in the same year is 8%

Source: (WORLD RESOURCES INSTITUTE, 2014).

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THEME 2: INDUSTRIAL ENERGY EFFICIENCY POLICY INSTRUMENTS

This report presents International Experience regarding Industrial Energy Efficiency Policy Instruments prepared by Ricardo Energy & Environment for the Ministry of Finance under Brazil's PMR Programme.

This study was developed since energy efficiency instruments may be considered as a complement or alternative to carbon pricing instruments in Brazil in the future. This report will focus on **Energy Efficiency Trading Schemes (EETS) and Energy Taxes (ET)**. These instruments create an incentive for energy efficiency, whether by imposing an obligation (EETS) or a price signal (ET), and are often compared to carbon pricing instruments (emission trading systems and carbon taxes). In addition, this study will also provide an overview of complementary instruments, which implemented alongside EETS and ET as a package of policies designed to address key barriers to energy efficiency.

The report begins by providing a conceptual overview and comparison of EETS and ET, followed by case studies of their application. For the EETS, the Indian PAT system is evaluated. For ET, the Swedish Energy Tax is presented.

Sweden also presents an interesting study of overlapping and interacting carbon and energy efficiency instruments. A theoretical overview of the key differences in these instruments, and the advantages and disadvantages of implementing coexisting energy and carbon-based instruments, will be provided.

Finally, an overview will be provided of the complementary EE policy instruments, designed to overcome other barriers to the implementation of EE. As such complementary measures target barriers other than those addressed in EETS/ET, they are often combined with these instruments. Examples of this will be provided.

EXECUTIVE SUMMARY

Tax and trade energy efficiency policy instruments are often compared to carbon pricing instruments (CPIs), whether to be used as an alternative or complement for CPIs. This study focuses on Energy Efficiency Trading Schemes and Energy Taxes, and Table 1 provides an overview of the key design elements.

Overview of the instruments

Energy Efficiency Trading Schemes. In EETS, an energy savings obligation is placed on entities who may either comply by undertaking energy efficiency measures, or surrender energy saving certificates, representing verified savings achieved by other participants in the system. Within the industrial sector energy-intensive consumers are targeted with making savings in their own consumption. A market or trading facility may be created by the regulator to facilitate this trade. Depending on the type of trades carried out and the liquidity of the market there may be a publicly available price for certificates that emerges.

Energy Taxes. In Energy Taxes a regulatory authority establishes a tax on the units of energy consumed (fossil fuels and electricity), which creates an incentive for energy efficiency. The tax liability is usually measured based on verified energy consumed, produced or supplied. While specific Measurement, Reporting and Verification (MRV) systems need to be created, reporting and monitoring can be integrated with existing tax compliance arrangements. It should be noted that in practice, Energy Taxes (ET) are very similar to Carbon Taxes. This is because the emissions covered by carbon taxes are often primarily due to energy consumption. An important difference is the denomination of the tax rate as either energy or carbon.

Table 1 - Overview of the key design elements of EETS and ET

	Energy Efficiency Trading Schemes	Energy Tax
Instrument Type	Obligation and trading scheme	Price Signal via a tax
Point of regulation	Downstream - energy consumer	Upstream - energy supplier is taxed Downstream - energy consumer is taxed
Requirement	Comply by undertaking energy efficiency measures, or buy & surrender energy saving certificates	Pay a tax
Target	Absolute or relative energy efficiency; may be negotiated or benchmark based	Tax rate has implicit energy savings target
Acceptability	Participants are provided more options than just incurring the cost on consumption, through trading allowances. Offsets could be envisaged.	Inflexible. Participants must pay tax on consumption.

	Energy Efficiency Trading Schemes	Energy Tax
Monitoring and verification	Monitoring of energy consumed and output (if relative targets set); downstream verification is more costly	Generally only energy consumed is monitored. Verification / auditing may be done upstream at fuel supplier, less costly
Administrative complexity	Trading and monitoring of installation level outputs increases administrative requirements	Simpler to monitor usually through existing tax system, upstream
Revenue	May be revenue neutral, unless penalties applied	Generates significant revenue for the government, but may be regressive. Revenue recycling may be considered.

While these instruments provide incentives for implementing energy efficiency measures, they should be implemented alongside complementary policies (informational, financial support) to address additional barriers to energy efficiency improvements.

Brazil's energy efficiency instruments. Note that Brazil's current policy mix lacks instruments providing EE incentives. COPPE provided an overview of the current regulatory landscape regarding energy efficiency instruments in Brazil, highlighting PROCEL, CONPET, the utility energy efficiency obligation and BNDES credit lines (detailed in Appendix A.1). PROCEL and CONPET are mainly informational instruments, focused primarily on awareness raising. The latter provide support for financing or implementing energy efficiency measures in industries. At present, no taxes, energy saving targets, trading systems, or minimum efficiency standards, are in place in Brazil.

International Experience with EE instruments

EETS and ET instruments have been implemented worldwide, with mixed results.

India's Perform-Achieve-Trade scheme. Table 2 presents an overview of India's PAT, an EETS.

Table 2 - Overview of India's perform achieve trade scheme

Mechanism	A market-based instrument that follows a baseline and credit model
Timeline	Introduced in 2012 and runs in phases: Phase I (12/13-14/15) and Phase II (16/17-17/18)
Coverage	8 Sectors, 478 facilities
Actors	• Bureau of Energy Efficiency – target setting, compliance • State Designated Agencies (SDAs) – collecting plant data • Energy Auditors – data verification and submission • Power Exchanges - (IEX & PXIL) – market operation

- Electricity Regulatory Commission – regulatory framework

Targets	**Specific Energy Consumption:** measured in absolute terms, "gate to gate" Distributed according to benchmark compared to on current performance Normalised (impact of factors beyond the company's control is neutralised) Phase I target – 4.8%

Effectiveness of PAT. Evidence shows that the targets set for the first cycle of the PAT have not been stringent enough. A significant overachievement of the target indicates a market failing to drive the level of investment to meet the targets, as these would have been probably met under a business as usual scenario. Now that administrators have a better understanding of emissions and abatement potential, tighter targets should be set for the following cycles. Regarding distributional impacts, evidence shows that sectors with high investment costs have achieved less savings than those with lower costs and may require higher incentives for investing in energy efficiency. Long term investments occurred in the first PAT cycle due to a lack of clarity and long-term target setting, which is a barrier for firms to invest in costly and technically challenging energy savings opportunities.

Sweden's energy and carbon tax. Figure 1 provides an overview of the tax.

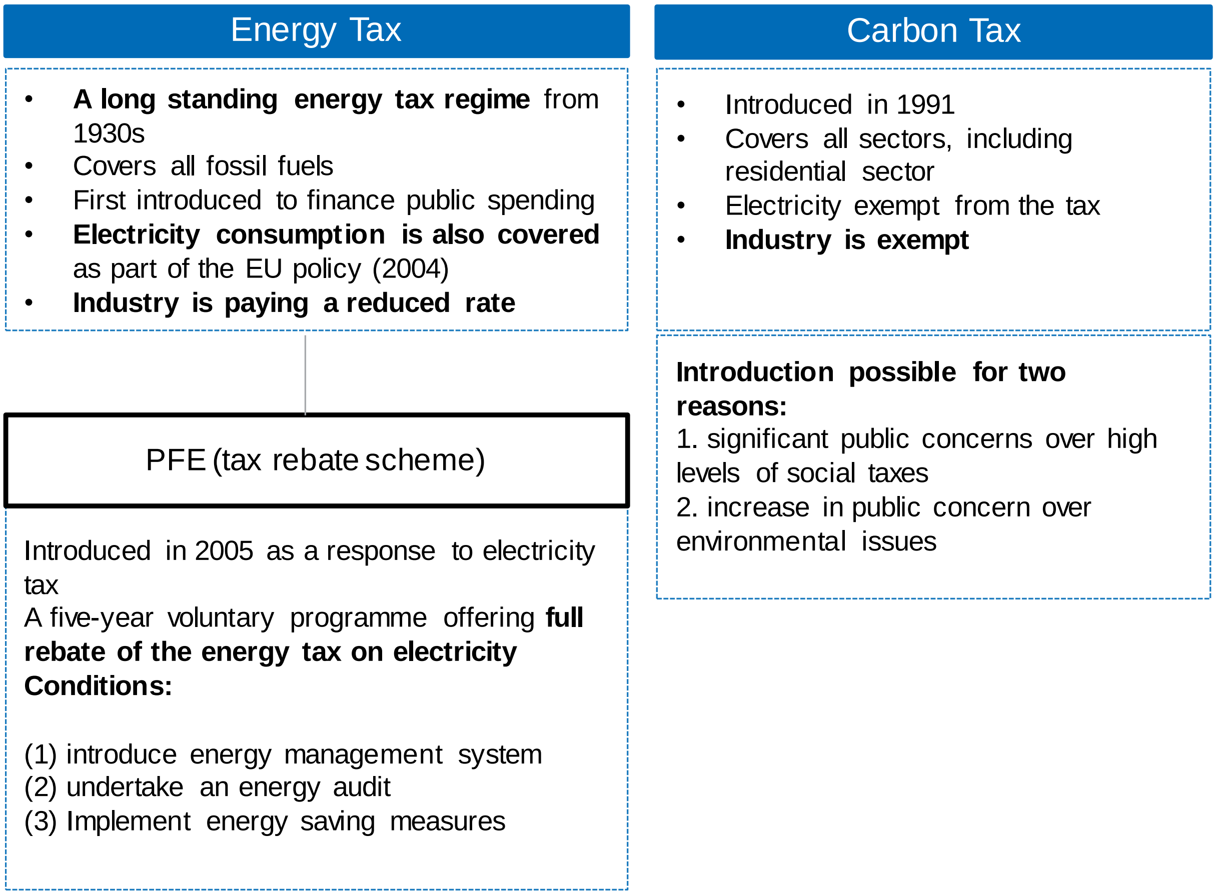


Figure 1 - Overview of Sweden's Energy & Carbon Tax

Effectiveness of the Sweden's tax regime. Results are inconclusive as it is not possible to discriminate the effect of the energy tax, but rather the effect of the whole policy package (i.e. including energy taxes, carbon taxes, EU ETS, etc) is evaluated. Regarding this package, savings were less than expected in 2014 (2.93TWh rather than 11.6TWh) but increased significantly in 2015 to 14.7TWh. In addition, industrial participants which were included in the EU ETS are expected to have higher energy savings (4.5%) between 2014-2020 than those excluded (1.5%).

China's Top 1,000 Energy Consuming Enterprises Programme. This is an example of mandatory target setting. The programme also included mandatory audits. The Top 1,000 Energy Consuming Enterprises programme was launched in 2006. It was designed to save 100 million tonnes of coal equivalent (mtce) over five years (2006 - 2010) in the largest 1,008 enterprises. The 1,000 companies were defined as those consuming a minimum of 180,000 tonnes coal equivalent (tce) per year. They had to set up energy monitoring systems, carry out energy audits to identify opportunities for significantly reducing their energy intensities, prepare energy efficiency plans, and submit all these for analysis. It has been followed by the Top 10,000 under the 12th FYP.

Effectiveness of the Chinese programme. There was a 50% overachievement of the Top 1,000 enterprise programme (at 150 mtce). Estimates from the first years of implementation shows that in

2007 and 2008 enterprises invested over $US 7.5 billion and $US 13.5 billion energy efficiency projects. The programme has been extended under the 12th FYP (2011-2016) with an expanded scope. All companies consuming more than 10,000 tce per year are now included in the scheme, amounting to around 17,000 large enterprises. The scheme was designed to achieve a 16% reduction in energy intensity and an energy saving of 250 mtce, contributing 37% to China's energy savings target. Additional requirement has been placed on participants, including that the Top 10,000 are now mandated to deploy best-available-technology and achieve the world-class energy intensity standard.

Acceptability of EE policy instruments

An interesting consideration for Brazil may be the level of political and stakeholder acceptability of this instrument compared to CPIs.

- Energy efficiency has been recognized by China as the most cost-effective way of enhancing national energy security, improving economic competitiveness and reducing GHGs emissions. China has recognised that, as well as helping to create employment and growth, improving energy efficiency is a cheaper option than energy supply alternatives, whether conventional or renewable.
- Sweden also designed their tax to improve acceptability. When the tax on electricity was introduced in 2004, the regulation gave affected companies the opportunity of being granted tax exemption on their electricity consumption if they take action to improve their energy efficiency. The Swedish government therefore adopted a programme of improving energy efficiency in energy-intensive companies (PFE), with the carrot of reduced taxation.

Co-existing carbon and energy efficiency instruments

Rationale for co-existing energy efficiency and carbon instruments. Since Brazil may consider implementing carbon and energy efficiency instruments at the same time, the rationale and key considerations are presented here. Sweden provides an interesting case study, since at numerous points in the history of the tax policy, industrial fossil fuel combustion activities have been covered by overlapping energy and carbon regulation (carbon tax and EU ETS at certain points), resulting in double regulation.

The objectives of energy and GHG targets can be complementary, since establishing an energy efficiency target can improve GHG intensity of output and indirectly reduce GHG emissions. However, setting a price on carbon through ETS/CT will deliver the cheapest form of abatement, but may not necessarily reduce energy consumption. This is because carbon pricing mechanisms incentivise a wide range of emissions reduction options, including those such as fuel switching that do not affect energy consumption. In Brazil, there may in fact be trade-offs between carbon emissions and energy efficiency. For instance, the use of biomass, although less carbon intensive, can increase energy consumption due to lower conversion efficiencies. Another example is that the use of ethanol in vehicles is less energy efficient than using petrol.

Considerations for co-existing energy efficiency and carbon instruments

Regulating up and downstream together can provide stronger incentives. In the case of electricity production and consumption in Sweden, electricity generation was covered by the EU ETS from 2005, and carbon costs passed through to industrial consumers. The previous year, a tax was introduced on electricity consumption by industrial entities to encourage energy efficiency. Thus, the electricity price was regulated both upstream (carbon price) and at point of consumption (energy tax).

However, there are risks associated with coexisting policies. Firstly, the risk of weakening targets. If the effect of overlapping instruments is not taken into account during target setting, the consequence may be weaker targets. Further, overlapping instruments may distort the carbon price signal. Carbon based instruments aim to incentivise the lowest cost abatement measures through the carbon price signal. However, a coexisting EE policy instrument creates a preferential economic incentive for abatement derived from energy efficiency. This means the combined effect is not to incentivise the cheapest abatement. For example, expensive energy efficiency measures could be implemented instead of cheaper fuel switching options. Finally, double regulation increases administrative and participatory costs.

1 ENERGY EFFICIENCY TRADING SCHEMES AND TAXES

This section will present the basic concepts behind Energy Efficiency Trading Schemes (EETS) and Energy Taxes. Subsequently, case studies of the implementation of these instruments will be presented. It begins by comparing EETS and ET. The Ricardo project team has examined these issues as part of PMR project work it has carried out for Turkey, since the Turkish government is interested in many of the same issues that are important for Brazil. The materials presented here draw on the published reports from that work.

Energy Efficiency Trading Schemes. In EETS, an energy savings obligation is placed on obligated entities, who may either comply by undertaking energy efficiency measures, or surrender energy saving certificates, representing verified savings achieved by other participants in the system. Within the industrial sector energy-intensive consumers are targeted with making savings in their own consumption. A market or trading facility may be created by the regulator to facilitate this trade. Depending on the type of trades carried out and the liquidity of the market there may be a publicly available price for certificates that emerges.

Energy Taxes. In Energy Taxes a regulatory authority establishes a tax on the units of energy consumed (fossil fuels and electricity), which creates an incentive for energy efficiency. The tax liability is usually measured based on verified energy consumed, produced or supplied. While specific Measurement, Reporting and Verification (MRV) systems need to be created, reporting and monitoring can be integrated with existing tax compliance arrangements.

It should be noted that in practice, Energy Taxes (ET) are very similar to **Carbon Taxes**. This is because the emissions covered by carbon taxes are often primarily due to energy consumption. An important difference is the denomination of the tax rate as either energy or carbon.

Objectives. EETS and Energy Taxes have multiple objectives. They aim to improve energy efficiency of output in industrial entities to support competitiveness and efficient growth. Further, encouraging a more efficient use of energy supports the achievement of energy security goals. In addition, improving energy efficiency and delivering reductions in combusted fossil fuels can reduce GHG emissions, and support achievement of climate change goals.

Advantages/ disadvantages taxes and trading. Energy taxes and trading systems are both designed to save energy by encouraging the lowest-cost reductions, thus, theoretically they should incentivise the same reductions for a given energy savings price. However, in practice, there is an important difference in the way that the policies are applied. In a tax, policymakers cannot be sure of the energy saving outcome that the policy will deliver and would need to adjust the rate to respond to emerging over or underachievement against the policy objectives. Such adjustments could also affect investor confidence. A trading approach has the advantage that the target can be set in line with the policy objectives and the price signal adjusts to achieve that target, however price variations can also affect investor confidence.

Second, the nature of the incentive for energy efficiency experienced by energy consumers also differs between the options. In a trading system the market price for certificates responds to create an incentive to meet the target. Each participant in the system has a clear understanding of the costs of the certificates under the system, although there is uncertainty in the future price of those certificates. In a tax, the obligated entities could be the direct consumers of energy or the suppliers of energy. The rationale for taking the latter approach is that upstream monitoring of energy can be simpler and it may be easier to apply the tax through a charge on the energy supplied to customers. If the tax is applied in this upstream way, then the price signal for energy efficiency felt by end consumers may not be so transparent or high profile. If it is charged as part of the energy price, then it may not attract the same management awareness as an obligation to acquire and surrender certificates. If the tax is applied as a liability directly for end consumers of energy, then it provides a clear and direct obligation at a stable tax rate.

Third, the options differ in their MRV approaches. An EETS requires that each facility monitors its energy use and productive output. In a point of consumption carbon tax there is also a requirement to monitor energy use, as part of the determination of the tax liability. There would be no requirement to monitor output though. In an upstream carbon tax, the MRV requirements could be much simpler since there are fewer energy suppliers and their accounting for energy supplied will already be well established.

Lastly, the revenue implications of the approaches are different. An EETS may not raise revenue beyond the use of fines or buyout options. It is common (as in the India Perform, Achieve and Trade policy described below) to generate certificates for overachievements by obligated entities against their targets. These certificates are allocated for free. Obligated entities that purchase certificates pay the sellers, not the government authority administering the system. In a tax, revenues are raised in direct relation to the energy consumption of the obligated entities. There may be tax thresholds but overall the tax revenues will be much more significant than for EETS[28]. In both tax and trade instruments, revenues can be recycled to further target emission reductions or alleviate the cost burdens of the policy.

1.1 ENERGY EFFICIENCY TRADING SCHEMES FOR THE INDUSTRIAL SECTOR

This section begins with a conceptual overview of the EETS model. Subsequently, a case study of the implementation of an EETS in India, the PAT system, is presented.

[28] There might be occasions where the tax revenue of the EETS is comparable to the revenue from a tax instrument. For example, if the EETS instrument is designed to have an allocation based on 100% auction, this could lead to similar revenues. Nevertheless, based on the empirical examples, an energy tax tends to achieve higher tax revenues than a trading scheme.

1.1.1 MARKET DESIGN AND COVERAGE

The overall intent of the policy is to achieve a reduction in energy consumption, for instance the consumption of electricity, gas, or other fuels. To achieve this the regulatory authority places an energy savings obligation on participating entities, which are the consumers of energy. These obligated entities may make energy savings themselves or may acquire energy saving certificates that correspond to savings that other parties make over and above their own targets.

The system would cover priority sectors based on factors such as their overall level of energy consumption, opportunities for energy efficiency improvement and the suitability of the industry market structure to a trading mechanism (for instance whether there are large numbers of independent operators that could underpin the functioning of a certificate market).

Participants are usually selected on the basis of a threshold level of energy consumption or some other measure of scale (such as numbers of customers for electricity distributors) or on an activity basis (types of industrial sectors).

1.1.2 TARGETS

Targets would apply over a fixed period, such as a year or series of years. The targets can be expressed as an absolute reduction in overall energy consumption (e.g. tonnes of oil equivalent (toe), or a relative reduction (e.g. energy consumed per unit of industrial activity). The advantage of a relative target is that is better accommodates changes in industrial output, although is a more complex approach as it requires monitoring and target setting that covers industrial output as well as energy consumed.

The targets can be set on a top down basis according to the overall policy objective to save energy or be based on a bottom up assessment of the feasible cost-effective savings that could be made by each obligated entity's facility. A top down approach requires the distribution of targets between obligated entities, so both approaches require a method of facility level allocation/target setting. Two principal approaches for this could be used:

- A standardised method could be applied in which targets are defined according to reference performance metrics, i.e. benchmarks. These benchmarks could relate to the better performing obligated entities in a sector, or some other industry standard. Targets would be distributed in accordance to a participant's performance relative to the benchmark. In this way, poor performers can have more ambitious targets than high performers.
- Targets could be negotiated between government and industry via industry associations. Targets would be at sector level and each sector could decide how to distribute these amongst its participants.

1.1.3 INSTITUTIONS AND COMPLIANCE

There are usually separate public bodies in charge of target setting and administration of the scheme. The target setting would be done by a policy making body, such as the Ministry of Energy. The administration could best be carried out by a regulatory authority, with capacity to develop and oversee the implementation of the policy. The regulatory authority would oversee system compliance and implement enforcement actions, including penalties. It would also apply system charges, such as for registration on to cover annual regulatory costs. Other stakeholders would perform roles in the system, such as:

- Energy auditors would verify the energy efficiency savings, recognised energy auditors are necessary. These are often accredited by the regulatory body.
- Energy service companies can provide services to obligated entities in order to plan and undertake the EE measures required.
- Market operators would operate trading platforms and other market participants engage in the market through the provision of trading services.

1.1.4 MONITORING, REPORTING AND VERIFICATION

Monitoring would be carried out by the obligated entity according to standard laws and guidance that are set out by the policymaking body together with the regulatory authority. The obligated entity would maintain evidence demonstrate the accuracy of its calculated performance to verifiers and the regulatory authority, as needed.

Reporting is usually carried out using a registry, a virtual platform or similar, with an account for each obligated entity, containing information on (for example) energy consumption, energy targets, energy saving certificates allocated or purchased. This is the mechanism by which obligated entities can report in order to comply with the system.

Verification of energy savings against the targets is usually done by third party verifiers such as government accredited energy auditors.

1.2 EETS CASE STUDY: INDIA'S PAT SYSTEM

1.2.1 MARKET DESIGN AND COVERAGE

In 2012 India introduced a new policy to drive improved energy efficiency in some of its major industrial sectors, including the power sector, as part of its National Mission for Enhanced Energy Efficiency (NMEEE). The Perform Achieve and Trade (PAT) initiative is a market-based instrument that follows a baseline and credit model. That is, obligated entities, called Designated Consumers (DCs), have targets for energy efficiency and are credited with energy saving certificates if they perform better than those targets. These certificates (called Energy Saving Certificates (ESCerts) can be traded and those DCs that do not achieve their targets can acquire them to cover any shortfall. The first phase ran from 2012/13 to 2014/15 and the second phase runs from 2016/17 to 2018/19.

In the first phase the scheme covered 478 facilities from 8 energy-intensive sectors: aluminium, chlor-alkali, textile, pulp and paper, iron and steel, fertiliser, cement and thermal power plants. The refinery and railway sectors as well as electricity distribution companies are also included in the second phase.

1.2.2 TARGETS

The targets are expressed on a Specific Energy Consumption basis. The Bureau of Energy Efficiency (BEE) which developed and administers the system, explains that the target reduction for each DC is based on their current levels of energy efficiency, so that energy efficient DCs will have lower target of percentage reduction, as compared to less energy efficient DCs which will have higher targets. While calculating the specific energy consumption, “gate-to-gate” approach is adopted, thereby including all energy consumption against the total production. A robust process of normalization is adopted to neutralize the impact on specific energy consumption due to factors beyond the control of participating DCs (BEE, 2017). The overall energy saving target for the first PAT cycle was 6.7 mtoe, corresponding to a 4.8% reduction in SEC (Environmental Defense Fund *et all*., 2015).

1.2.3 INSTITUTIONS AND COMPLIANCE

- BEE developed the system and identified energy-intensive industries to be covered. It set baselines for energy consumption, assigned specific energy consumption reduction targets and set up a registry for reporting and the trading of ESCerts.
- State Designated Agencies (SDAs) for energy efficiency were involved in collecting plant-specific data.
- Designated auditors are responsible for online data submission, annual audits and verification.
- The two power exchanges IEX and PXIL are the trading platforms for the Energy Saving Certificates. No minimum price is set and banking of ESCerts is allowed during each cycle.
- The Central Electricity Regulatory Commission (CERC) defines the regulatory framework for trading of ESCerts.

1.2.4 MONITORING, REPORTING AND VERIFICATION

Designated Consumers are required to submit a Performance Assessment Document to State Designated Agency with a copy to BEE within three months after the end of the first year of the target cycle. A verification report is then submitted to BEE by an accredited energy auditor.

1.2.5 POLITICAL ACCEPTANCE

The PAT needed a preparation phase of four years that included substantial stakeholder engagement through plant visits and workshops before the scheme was launched[29]. Based on this input the scheme evolved and eventually individual rather than single sectoral targets were introduced. However, some Designated Consumers still lack knowledge about the scheme and the Indian Chamber of Commerce has criticised that the industry needs more information on the mechanisms and systems under the scheme.

1.2.6 EXPECTED IMPACTS

As mentioned above, the main goal of the PAT system was to create a transparent, flexible and robust scheme to achieve energy efficiency measures within specific industrial sectors cost-effectively. The overall energy saving target for the first PAT cycle was 6.68 mtoe distributed across sectors as shown in Table 1 (Ministry of Power, 2017).

Designated consumers within each sector were selected based on an annual energy consumption threshold, so that only larger consumers where included under the PAT scheme. Facilities that were below the annual consumption threshold were not included within the PAT scheme. The threshold used for each sector is listed in Table 1 (e.g. a cement company would be selected as designated consumer only if consumed more than 30,000 toe/year).

Table 1 - PAT – Cycle I target and number of identified designated consumers.

Sectors	Minimum energy threshold (toe/y)	No. of Identified DCs	Expected total energy saving (Million toe)
Power (Thermal)	30,000	144	3.211
Iron & Steel	30,000	67	1.486
Cement	30,000	85	0.815
Aluminium	7,500	10	0.456
Fertilizer	30,000	29	0.478
Paper & Pulp	30,000	31	0.119
Textile	3,000	90	0.066
Chlor- Alkali	12,000	22	0.054
Total		**478**	**6.685**

[29] Turkey PMR: Assessment of Market Based Option, to be published.

1.2.7 ACTUAL IMPACTS

The Indian Ministry of Power published in May 2017 the achievements under the first cycle of the PAT scheme (Ministry of Power, 2017). As shown in Table 2 the scheme has achieved an energy saving of 8.67 mtoe against the targeted energy saving of 6.68 mtoe, i.e. about 30% over-achievement.

Table 2 - PAT – Cycle I number of designated consumers and actual energy savings. The % of under of overachievement compared to the targets is given. (Ministry of Power. 2017)

Sectors	N	Achieved total energy saving for PAT	% under/over
Power (Thermal)	1	3.06	-5%
Iron & Steel	6	2.1	41%
Cement	7	1.44	77%
Aluminium	1	0.73	60%
Fertilizer	2	0.83	74%
Paper & Pulp	2	0.26	118%
Textile	8	0.12	82%
Chlor- Alkali	2	0.13	141%
Total	**4**	**8.67**	**30%**

The results above present a problem when viewed from a theoretical perspective. The market-based approach should drive the level of investment to meet the target, but not more. Such a significant overachievement of the target indicates a market failing. In principle this could be due to a number of reasons. For instance, the savings achieved may have happened anyway under a business as usual scenario. It could be that the market design, with trading happening after the energy monitoring period, was such that there was poor certificate price discovery. It's also possible that risk averse operators chose to make savings to more than cover their own targets, so as not to rely on the market. This last view would correspond to market immaturity not intended by the system designers but could be a natural response to the introduction of the new policy. It is instructive to examine the literature aimed at revealing the underlying causes of the over-supply.

A study to evaluate the impacts of PAT on the cement industry was published in May 2017 (Hena 2017) and the findings seem to disagree with those published by the Ministry of Power. The study found that while the average energy intensity of the designated consumers in the cement industry increased between 2005-2011, the growth rate of energy intensity for the designated consumers in the period of 2007-2011 was 5.1%, compared to 0.4% in 2015-2015. PAT was announced in 2007. These results indicate that PAT is having an effect on designated consumers, by slowing the growth rate of the energy intensity of designated consumers.

Another recent study (Bhandari, 2017) carried out a cost effectiveness analysis of the PAT scheme based on primary and secondary sources of information. The study reports that the targets set under PAT are not strict enough to be additional, with stakeholders stating that the main driver to energy efficiency are the increasing and rising energy prices, rather than the efficiency target set under the scheme. The study also suggests that the fact that the targets are defined only for three years has failed to incentivise long-term investments in energy efficiency as the lack of clarify and consistency is a barrier for investors and firms.

Due to the overachievements met in almost all sectors, the first phase has resulted in an oversupply of certificates and therefore there has been little need for a trading market of certificates. Nevertheless, a similar situation arose after the first phase of the EU ETS (and other carbon trading systems, such as California) where there was an oversupply of allowances due to a significant unexpected drop in emissions, which resulted in over allocation of allowances Once a better understanding on emissions and abatement potential was collected, tighter caps under EU ETS were established.

1.2.8 DISTRIBUTIONAL IMPACTS ON INDUSTRIES

A study by EESL (EESL, 2010) estimated that achieving the target for the first phase is expected to cost the industry $5.4 billion. As shown in Figure 1 all sectors except Thermal and Power Plant have overachieved their targets. The Ministry of Power has published a study (Ministry of Power, 2017) where costs and implemented energy efficient measures are listed for each sector. For example, the aluminium sector has achieved savings of 0.730 Million toe, i.e. 60% higher than the saving target. The report indicates that for achieving these savings the sector has invested around 140 million rupees in various Energy Conservation Measures. Investments costs for the other sectors are not provided.

The effectiveness analysis carried out by Bhandari (Bhandari, 2017) reviewed the expected investments and average actual investments. The study states that the average capital investment has been around 1 – 1.5 million rupees compared to the expected investment of 640 million rupees per designated consumer. The study explains that the low investments reflect the lump sum penalty (1 million rupees) rather than the expected investment.

The study provides a list of investment costs per toe for each of the sectors included under PAT. These investment costs have been plotted (Figure 1) against the ratio of actual savings over actual yearly consumption as published by the Indian Government (Ministry of Power, 2017).

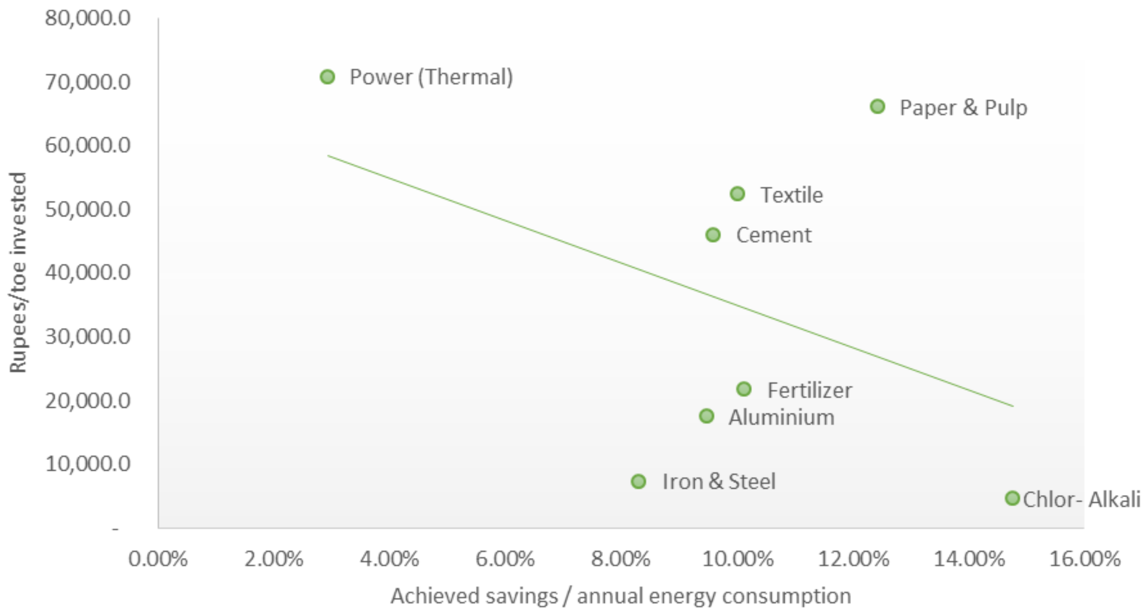


Figure 1 - Investment costs per toe vs the ratio of actual achieved savings over actual annual energy consumption. Ricardo analysis.

Overall, the trend line shows the expected trend, i.e. sectors with high investment costs will achieve less savings and those with lower costs are expected to achieve higher savings. In particular, the graph shows that the power sector, which is the one with the highest investment costs per unit of toe, is also the one achieving lower saving. In contrast, the chlor-alkali sector, which is the one the lowest costs per unit of toe saved, is the one achieving the highest savings. This is in line with expectations, as sectors with technically easier, lower cost abatement opportunities are expected to implement them quickly to avoid penalty costs. Sectors with more technically challenging, expensive opportunities will probably require higher incentives to invest in energy efficiency. With the available information it is unclear why the other sectors have performed as shown in the graph- e.g. why iron and steel, where the cost of energy abetment opportunities is low, have not achieved higher savings.

1.3 ENERGY TAXES FOR THE INDUSTRIAL SECTOR

This section begins with a conceptual overview of the ET. Subsequently, a case study of the implementation of an ET in Sweden is presented.

1.3.1 MARKET DESIGN AND COVERAGE

The policy objective is to provide an incentive to reduce the amount of energy consumed, including via the improvement of energy efficiency. This is achieved by increasing the cost of energy by taxing it, at the point of production, supply or consumption. The tax is expressed as a cost per unit of energy. The tax is mandatory on all obligated entities and can be applied in a range of sectors, including industry.

An energy tax, like any flat tax, can function regressively. This could be minimized or eliminated altogether by various approaches to revenue recycling.

1.3.2 TARGETS

A number of factors will be taken into account when setting the tax rate. The cost of making energy savings will be important, as it enables a link to be made between the price of the tax and the level of energy savings that can be expected as a result. The elasticity of demand will also be important in understanding how the use of energy may decline at higher prices. Other factors include willingness to pay, the wider economic consequences of the tax (for example on industrial competitiveness, jobs, business profits and household costs) as well as the impact on government budgets from the revenue raised.

Tax rebates and thresholds can be applied to reduce cost impacts of the tax, especially during an initial transition phase.

1.3.3 INSTITUTIONS AND COMPLIANCE

As a tax, the rates will normally be decided by the economy or finance ministry, as part of the budget setting processes. The implementation of the tax will be the responsibility of the tax collection authority, either at a national or municipal level, depending on the scope of the tax.

The tax is mandatory and penalties will apply for non-compliance. Obligated entities do not have the flexibility they would under a trading system and must pay the tax rate for all energy liable under the tax design. It’s possible that an offsetting system could be employed, to allow entities to acquire credits instead of paying the tax, up to a certain amount of their liability.

1.3.4 MONITORING, REPORTING AND VERIFICATION

Monitoring can be carried out in one of two principal ways. As mentioned earlier, the tax could be applied upstream, on the energy supply, or at the point of energy consumption. The MRV implications vary in these cases:

- In an upstream system the tax rate applies for eligible energy that is supplied. It may be a liability falling to the energy supplier directly or be a liability for the consumer that is charged and collected by the energy supplier on behalf of the tax authority. In any case the energy tax accounting aligns with the existing mechanism for accounting and charging for energy supply, i.e. the normal metering arrangements. It can therefore be a more modest incremental MRV burden.
- Taxation at the point of consumption is more akin to a facility or organisation level carbon footprint methodology, but with energy being accounted for. It would be necessary for the consuming organisation to calculate its tax liability on an annual basis, from an assessment of

the liable energy that it consumed. This can be more complex than the upstream approach and place an MRV obligation on companies that may not be familiar with carrying out such a process.

Reporting is usually via a registry, a virtual platform or similar, with an account for each obligated entity, containing information on energy use reported, the amount of tax paid, thresholds and offsets used.

Verification of the tax payments would fall under the normal corporate tax governance and audit processes, although specialists in the assessment of energy footprints could verify the accuracy of the calculated energy consumed.

1.4 EE TAX CASE STUDY: SWEDEN ENERGY TAX

Sweden currently taxes both energy use and CO_2 emissions. It has a long-standing energy tax regime, applying to gasoline and diesel since around 1930 and for fossil heating fuels since the 1950s (Åkerfeldt 2015). In 1991 the country also introduced a carbon tax on fossil fuel use, intended to reduce emissions of CO_2 by equalizing the private and social cost of carbon. At the time that the carbon tax was introduced, the energy tax rates were reduced by 50%. More recently, a tax on the electricity consumption was also introduced. In 2004, an energy tax on the electricity used in manufacturing industry, agriculture, forestry and fisheries was introduced at a rate equivalent to the minimum required tax rate as set out in the Energy Taxation Directive. This means that, where manufacturing industry previously paid a zero tax rate on electricity, it must now pay an electricity tax of 0.5 öre/kWh (SEA, 2015).

The policy situation in Sweden provides an interesting example of the role and design of energy and carbon taxes.[30] The main points regarding the design and effectiveness of the tax of the current tax system, and its interactions with the EU ETS, are summarised in the subsequent sections. First, a historical overview of the tax regime in Sweden and how this changed over time, specifically following the introduction of the EU ETS is provided in Figure 2.

[30] The design of these taxes is described in Sweden's plan for implementation of Article 7 of the Energy Efficiency directive (EED) (MEEC, 2013) and its Energy Efficiency Trends and Policies report under the EU's Odyssee MURE II programme (SEA, 2015a). Additional information is provided in Sweden's national Energy Efficiency Action Plan (NEEAP, 2016) and in analysis by the IEA (IEA, 2017).

1930-1950

Energy tax levied on petrol and diesel since 1930 and fossil heating fuels taxed from 1950. Aim: to finance state Public spending.

1970

Aim of tax moved to reduce oil use and increase use of electricity

1990 : the Great Tax Reform

Sweden joined the EU

Environmental element has higher importance

1991

Carbon dioxide introduced. Electricity production is exempt from the tax.

Sulphur tax introduced.

1992

Levy on NOx emissions introduced.

Electricity is subject to the NOx and sulphur tax in certain cases.

1993

Industry exempted from energy tax.

Industry pays only 25% of the carbon tax.

1996

The tax rates for electricity production increased with further increase planned in 1997.

This decision was strongly criticised: impose a severe strain on the competitiveness of manufacturing companies (particularly electricity-intensive industries).

The increases in the tax due to come into effect on 1st July 1997 was replaced by **higher energy taxes on electricity and fossil fuels not used by industry.**

1997

Higher tax rate came into force.

2000

Agriculture, forestry and fisheries are exempt from energy tax and pay only 35% of the carbon dioxide tax

Nuclear power plants now taxed based on gross thermal power output from their reactors (previously taxed on electricity production).

2001: The greener taxation

2002

Carbon tax on fuels raised by 15%

The energy tax on fuels was reduced by an amount corresponding to the increase in the carbon tax.

The tax on electricity was also raised.

The overall level of taxation on manufacturing industry etc. remains unchanged

2003

Introduction of a system of tradable certificates for electricity from renewable sources.

All electricity users, **with the exception of manufacturing processes in energy-intensive industries,** must buy a certain percentage of their electricity from renewable.

2004

Introduction of an energy tax on the electricity used in manufacturing industry, agriculture, forestry and fisheries.

Special rules for energy-intensive industrial activities, reducing the part of the carbon tax.

2005

Manufacturing industry, horticulture, farming, forestry and fisheries pay **no energy tax on fossil fuels, and only 21% of the carbon dioxide tax.**

Program for energy efficiency in energy industry (PFE) was introduced. Full rebate of the energy tax on electricity.

The EU ETS was introduced

2008

Plants covered by EU ETS received a first reduction on carbon tax.

2010

Plants covered by EU ETS received a second reduction on carbon tax. They now pay a tax equivalent to 7 % of the general carbon tax.

2011

All industry (also included in EU ETS) received energy tax. Energy tax of 30% of the general energy tax level.

The manufacturing industries outside of the EU ETS pay 30% of the general carbon tax on fossil fuels.

Industries within the EU ETS exempted from the carbon tax.

2015

The carbon tax for industry outside the EU ETS raised to 60% of the general carbon dioxide tax.

Figure 2 - Overview of the Tax regime in Sweden and how this changed over time, specifically following the introduction of the EU ETS.

1.4.1 MARKET DESIGN AND COVERAGE OF CURRENT TAX SYSTEM

The Swedish tax system is relatively complex. There are different taxes on electricity and fuels, on CO2 and sulphur emissions, and a levy system on NOx emissions.

The tax energy covers all sectors, including housing and services, land-based industries, transport, and industry. In summary, all consumers of energy pay the energy tax and all activities leading to the emission of CO_2 are subject to the carbon tax. The majority of fuels are covered (e.g. petrol, diesel, fuel oil, natural gas, LPG, coal and coke). Electricity for the manufacturing industry, forestry and aquaculture, as well electricity used in municipalities, is also taxed at a rate which varies according to geographical location. The energy tax on electricity is primarily levied on those who generate taxable electric power and those who supply electrical power.

1.4.2 TAX LEVEL

As described in the Odyssee MURE II report, the tax level varies according to whether fuel is used for heating or as motor fuel. There are also variations depending on whether energy is used by households, industry or in the energy conversion sector. Taxes on electricity vary according to geographical location. Table 3 shows a selection of tax rates (SEA, 2015).

Table 3 - Selected energy and carbon dioxide taxes as of 1 January 2015 (SEA, 2015)

Fuel	Energy tax	CO_2 tax
Fuel oil, diesel heating oil, SEK/m^3	850	3,218
Coal, SEK/tonne	646	2,800
Natural gas as vehicle fuel, SEK/1 000 m^3	0	2,049
Natural gas for other purposes, SEK/1 000 m^3	939	2,313
Petrol, environmental class 1, SEK/litre	3.25	2.6
Electricity, general level, SEK/kWh	0.294	0
Electricity, general level, Northern Sweden, SEK/kWh	0.194	0
Electricity, industrial processes, SEK/kWh	0.005	0

The tax rates are reviewed and amended annually taking into consideration any changes in the consumer price index. This maintains the price signal given by the taxes over time.

1.4.3 PROGRAMME FOR ENERGY EFFICIENCY IN INDUSTRY (PFE)

The energy tax on the electricity used in manufacturing industry, agriculture, forestry and fisheries was introduced in 2004, in line with the EU Energy Taxation Directive.

At the same time, however, the Directive gave energy-intensive companies subject to the tax, the opportunity of being granted tax exemption on their electricity consumption if they take action to improve their energy efficiency. The Swedish government therefore adopted a programme of improving energy efficiency in energy-intensive companies (PFE), with the carrot of reduced taxation.

The PFE came into force on 1st January 2005. Companies participating in the five-year voluntary programme can receive a **full rebate of the energy tax on electricity**. In return, they undertake to introduce, within the first two years, an **energy management system** and to perform an **energy audit** in order to determine their potentials for improving the efficiency of their energy use. A condition for participation in the programme is that, over the five-year cycle, companies must apply all the **energy efficiency improvement measures** that have been identified, and which have a payback time of less than three years. Another requirement for participation in the programme is that the company must be an energy-intensive company.

During the spring of 2005, the Swedish Energy Agency approved 131 companies for participation in the programme. Of these 131 companies, most have entered more than one plant in the scheme. In total, they use about 30 TWh/year of electricity in their manufacturing processes, which means that they will now receive a total tax reduction of about SEK 150 million per year. Most of the companies are in the pulp and paper industry (47), the wood products industry (28) or the chemical industry (19). Other participants include companies in the food industry (11), the iron, steel and mining industry (16), the engineering industry and a few other sectors. The scheme was open to admission of more companies up to and including 2009.

1.4.4 INSTITUTIONS, COMPLIANCE AND MONITORING, REPORTING AND VERIFICATION

The Swedish authority that administers and follows up the taxation is the Swedish Tax Agency. In addition, the Swedish Customs is responsible for energy taxation in certain specific cases by virtue of the energy Tax Act.

Monitoring of impacts are based on the average energy prices and tax levels over the saving period. The Swedish Energy Agency is responsible for the yearly review of cumulative energy savings required by the EED. Sweden is required to report its progress toward the target every two years.

1.4.5 POLITICAL ACCEPTANCE

The original energy tax was introduced in the middle of the last century, therefore its views on acceptance are difficult to obtain and would in any case not necessarily be relevant. The position regarding the introduction of the carbon tax in 1991 may be instructive, however. A study highlighted that the introduction of the carbon tax in Sweden, which represented an increase in tax related to energy even when the corresponding energy tax reduction was accounted for, was politically possible for two reasons (Åkerfeldt, 2013). First, there were significant public concerns over high levels of marginal income taxes on capital and labour, and the introduction of the carbon tax was part of a wider major tax reform in which these other taxes were reduced. Second, there was an increase in public and societal concern over environmental issues at the time, and the wider tax reduction created a gap in taxation on production that could be filled by a CO2 tax.

Overall, the carbon tax introduction was part of a green tax shift reform program involving a reallocation of tax revenues of approximately 6% of GDP.

1.4.6 INTERACTIONS BETWEEN THE ENERGY TAX AND EU ETS

As mentioned, Sweden has a long history of overlapping energy and carbon taxes, with the first energy tax introduced in the middle of the last century. The policy has numerous objectives which have changed over the years and has been shown in Figure 2.

Objectives. The original objective of energy taxes was to finance the State's public spending requirements. Since the 1990s, when Sweden became part of the EU the environmental element of energy taxation was given greater importance, as there was a need to bring taxation in line with EU requirements. The aims have evolved into supporting the achievement of Sweden's carbon emissions reduction targets, increasing the proportion of renewable energy, increasing the efficiency of energy use, and finally to reduce the overall use of energy (SEA, 2004). Therefore, the objectives can be said to align closely with those of the EU ETS, which was introduced in 2005.

Overlapping energy and carbon regulation. The changes made by the government over the history of the tax policy reveal a mixed approach to the problem of double regulation, given the overlap between energy and carbon policies. At numerous points in the history of the tax policy, industrial fossil fuel combustion activities have been covered by overlapping energy and carbon regulation (carbon tax and EU ETS at certain points), resulting in double regulation. Industrial electricity consumption has been taxed since 2004. More details are provided in the chronology below.

1991-1993: Industry in Sweden has had **overlapping energy and carbon taxes** between 1991 and 1993, when combusting fossil fuels incurred both an energy and a carbon tax. However, this changed in 1993 with industry receiving special treatment and becoming exempt from the energy tax, and only paid 25% of the carbon tax.

2004: This only changed again in 2004 when, as a result of joining the EU, **taxes on electricity consumption where introduced**. This was introduced alongside the PFE, which could result in rebates on this tax for industries joining the voluntary programme.

2005-2010: In 2005 when the EU ETS was introduced, no further changes were made to the energy tax and the industry continued to be exempted from this tax. The carbon tax on energy intensive industry was reduced to 21%, and this was further reduced 7% in 2010. During this period, both the EU ETS and the carbon tax covered fossil fuel combustion in industrial facilities, leading to **overlapping ETS and Carbon Tax**. The introduction of the EU ETS (2005) at the same time as the industrial electricity consumption tax (from 2004) meant that a **carbon price was imposed on both electricity generation (upstream) and electricity tax on consumption (downstream)**.

2011: This changed again in 2011. The energy tax was imposed on all the industrial sector (including EU ETS industries), but at a discounted rate equivalent to 30% of the general value. At the same time, the carbon tax on EU ETS industries was fully removed. This means that since 2011 both the EU ETS and the energy tax covered fossil fuel combustion in industrial facilities, leading to **overlapping energy tax and ETS**. The tax on industrial electricity consumption remained as before.

1.4.7 ACTUAL IMPACTS

Tax revenues raised. An overview of the taxes paid by the Sweden industry is provided in Figure 3. In addition to the discounted rates other special arrangements for energy intensive industry were in place, for example, in 2011 industry within the EU ETS was exempted from the carbon tax which was charged to the other industries.

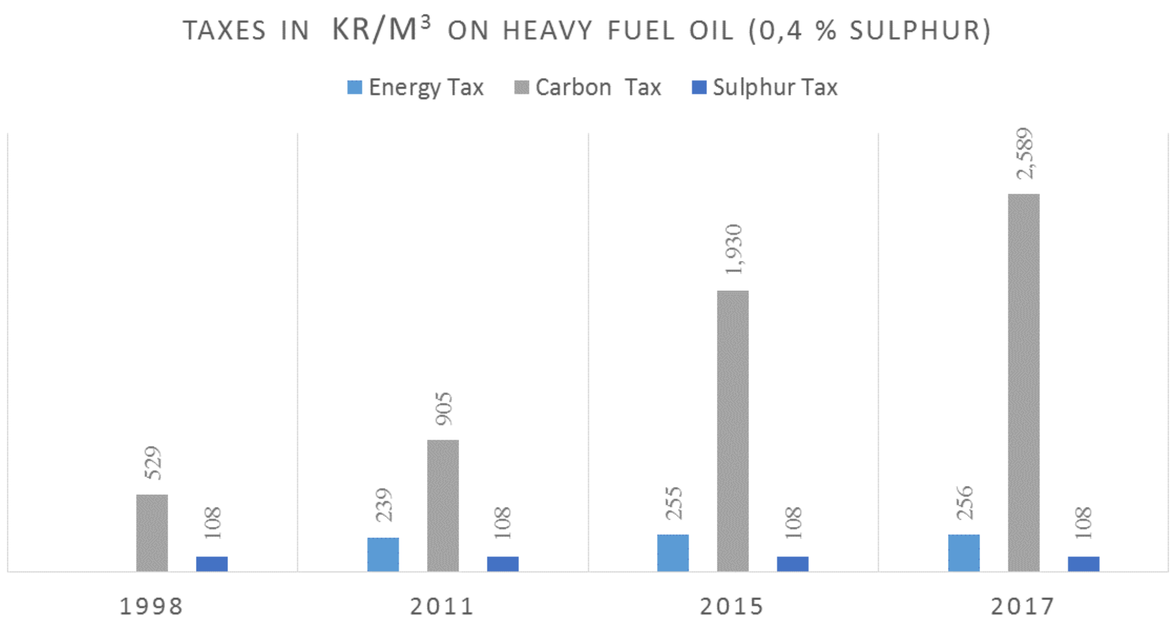


Figure 3 - General energy, carbon and sulphur taxes charged to Industry in Sweden in 1998, 2011, 2015 and 2017 on heavy fuel oil. Effectiveness of the Carbon and Energy Tax.

Sweden has expected that they will achieve a total overall savings of 11.6 TWh in 2014. In reality, however, 2.93 TWh was achieved (MEE, 2016). In 2015 the MS was expected to achieve an annual energy saving of 14.7 TWh and the reported savings are exactly as expected (MEE, 2017).

Sweden has calculated that, in the long-term (2014 -2020) saving within the part of the industrial sector included in EU ETS will amount to approximately 3 TWh, equivalent to a saving of around 4.5%. For the part of the industrial sector not included in EU ETS, the long-term saving amounts to 0.34 TWh, equivalent toe saving of around 1.5% (MEEC, 2013).

Revenue for the government from these taxes has always been an important part of the total revenue, which is also supported by the fact that initially the tax was introduced to raise funds for the public spending. In 2009 revenues from energy taxes raised 8.6 % of State revenue or 2.2 % of GDP (SEA, 2009)

Note, there could be double counting in evaluated energy savings due to similar policy measures achieving the same objective. Double counting is avoided by evaluating the whole policy package (i.e. including energy taxes, carbon taxes, EU ETS, etc) and only counting the energy savings calculated top-down resulting from the energy taxes. The impacts of the taxation measures are assessed for each of the separate sectors, therefore, interactions at the sector level are taken into account. For example, cross-price elasticities are taken into account in the transport sectors, to account for interactions between petrol and diesel consumption.

Effectiveness of Programme for Energy Efficiency in Industry (PFE). The review of the first five years since the scheme was implemented, found that the 100 companies that presented their final reports have saved a total of 1.45 TWh and invested approximately € 70 million in electricity efficiency measures and other measures to improve their energy performance (SEA, 2015b). The program has been discontinued and will end in 2017.

1.4.8 DISTRIBUTIONAL IMPACTS

The 2012 “Energy in Sweden” report (SEA, 2012) notes that the carbon tax rate paid by domestic users is about 20 times higher than that of industry. This is justified in part due to the level of competition the industrial sector faces. If domestic users paid carbon dioxide tax at the same tax rate (Ore/kWh) as industry, fewer emission reduction measures would be incentivised in the domestic sector. If, on the other hand, industry paid the domestic tax rate, it would have a much higher incentive for energy efficiency. However, a carbon dioxide tax can result in industries becoming uncompetitive unless other countries have a similar tax.

Thus, since its first implementation, the Sweden tax regime has sought to protect the competitiveness of industry by implementing a relatively low tax rate and a number of exemptions. Regarding exemptions, for example Industry was exempted from the energy tax since 1993, and only paid a reduced rate (25%) of carbon tax until 2004, when a tax on electricity consumed was introduced. In addition, they are currently exempt from value added tax. Figure 4shows the fuel price and tax rate paid by industry, domestic and transport sector in Sweden in 2001.

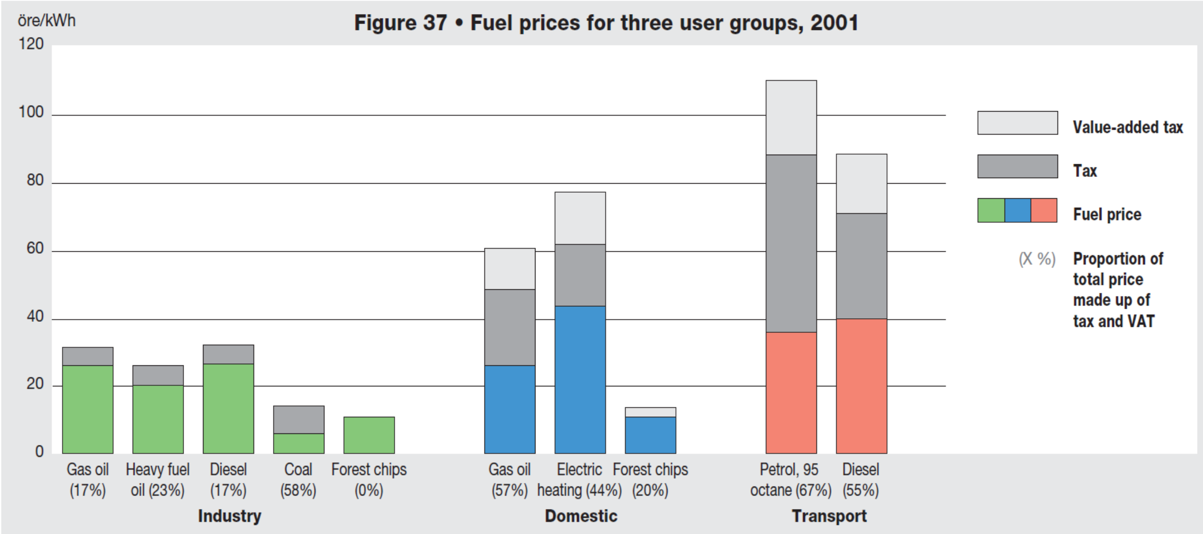


Figure 4 - Fuel prices for the three user groups in Sweden in 2001.

Source: (Energy in Sweden, 2001).

Figure 4 shows that tax levels for domestic consumers in 2001 were quite high. In 2004, the taxes paid by consumers heating their house with gas oil accounted for 62% of the total cost, while only 20% of the cost for those who heated their houses with wood chips consisted of tax and that was value-added tax only. For petrol, tax (including value-added tax) accounted for 68% of the total price.

Figure 5 shows that the discrepancy between industrial and domestic tax rates continued to 2011, despite the increase in the tax rate for industry by this date. Note that Figure 5 shows the rates for industries outside the EU ETS, while those within the EU ETS would have incurred less taxes (light blue).

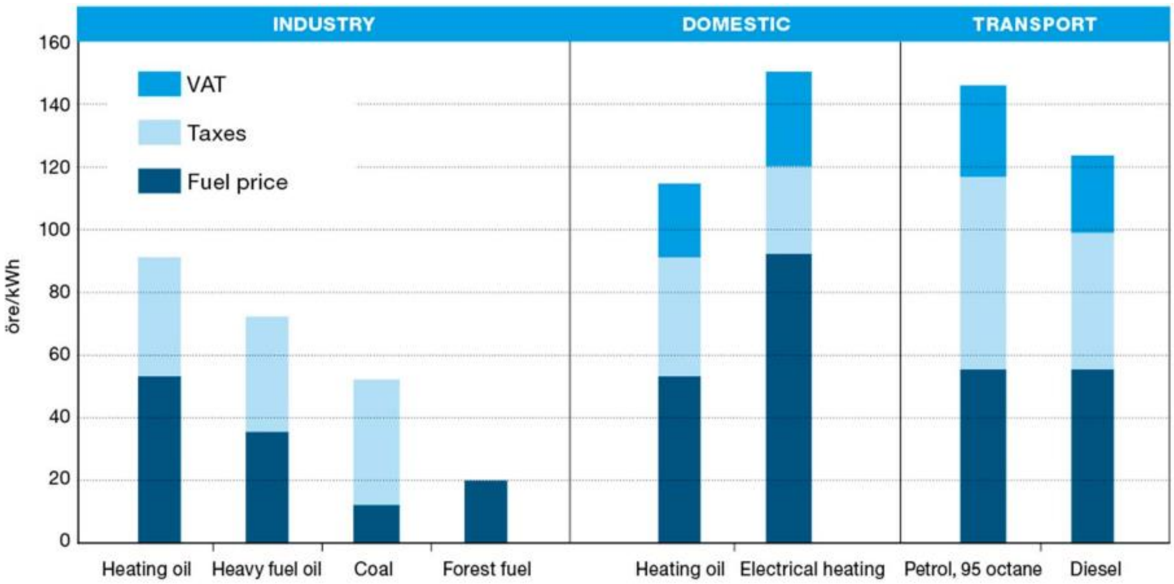


Figure 5 - Fuel prices for the three user groups in Sweden in 2011.

Source: Energy in Sweden, 2011.

2 CO-EXISTING CARBON AND ENERGY INSTRUMENTS

A number of jurisdictions have decided to implement a combination of carbon and energy-based instruments, with the objective of incentivising energy efficiency and GHG reductions. Examples include the UK, which has implemented both the CCL, a tax aimed at encouraging energy efficiency in Industry, as well as the EU ETS. In addition, China considered the implementation of an EETS, however, is in the process of implementing a national ETS, and has in place a comprehensive policy package for encouraging EE. The last of these includes fiscal incentives through electricity tariff policy (which acts similar to an ET, as will be described in Section 4), a programme of setting EE targets with industry through contracts, and support for energy monitoring (1,000 enterprise programme).

Energy and carbon instruments quite often overlap because they apply to the same industrial participants. There may be a strong rationale for doing so however, because they have a similar, but not identical policy objectives (and in some cases conflicting objectives), and the overlap may provide a much stronger incentive for GHG emission reduction and EE. Despite some benefits, there are a number of risks associated.

As this topic has been discussed in great depth in Ricardo's ***Fuel Theme 2: Interaction of Fuel Pricing Policy with Emission Trading Schemes,*** only a high level summary of the key points regarding the objectives, benefits and risks of combining energy and carbon instruments are provided here.

2.1 RATIONALE FOR CO-EXISTING EE AND CARBON INSTRUMENTS

The objectives of energy and GHG targets can be complementary:

- Establishing an energy efficiency target can improve GHG intensity of output and indirectly reduce GHG emissions.
- Establishing an energy savings target can result in GHG reduction.

However, while setting a price on carbon through ETS/CT will deliver the cheapest form of abatement, it may not necessarily reduce energy consumption. This is because carbon pricing mechanisms incentivise a wide range of emissions reduction options, including those such as fuel switching that do not affect energy consumption. In the case of fuel switching, in fact, there may be some trade-offs between carbon emissions and energy efficiency. For instance, the use of biomass, although less carbon intensive, can increase energy consumption due to lower conversion efficiencies. Furthermore, establishing an energy-based target through EETS/ET could miss the opportunity to address non-energy GHG emissions as obliged entities are merely incentivised to reduce energy consumption.

A key benefit of coexisting policies is in achieving multiple objectives. While both instruments can achieve multiple objectives at once, what differentiates them is their primary focus (++). As Table 4 shows, the main objective of a carbon-based instruments is to provide incentives to reduce CO2 emissions, whereas the main objective of the EETS/ET is to provide an incentive for energy efficiency. In addition, as explained there are may be trade-offs between carbon and energy efficiency.

Table 4 – Comparing objectives of carbon and energy instruments

Objectives	Carbon: ETS/CT	Energy efficiency: EETS/ET
Absolute reduction in GHG emissions	++	+
Absolute reduction in energy consumption	May contradict	++
Improving energy efficiency of activities	May contradict	++
Improving carbon intensity of activities	+	+
Stimulating Energy Efficiency markets	+	++
Stimulating Renewable Energy markets	+	
Improving energy security	+	++

2.2 CONSIDERATIONS FOR CO-EXISTING CARBON AND ENERGY INSTRUMENTS

Regulating up and downstream together can provide stronger incentives. An example of coexisting upstream and downstream policies is the situation in Sweden with EU ETS and industrial electricity tax as they affect electricity pricing. The EU ETS provides a carbon price signal for abatement in a wide range of industries, including electricity. This cost is passed through, to some degree, in the electricity price that all consumers pay. The electricity tax also provides an efficiency incentive.

However, there are risks associated with coexisting policies. Firstly, the risk of weakening targets. If the effect of overlapping instruments is not taken into account during target setting, the consequence may be weaker targets. For example, if the effect of carbon measures is not taken into consideration in the baseline when setting EE targets, then this may result in easily achievable targets. Equally, if the effects of EE measures are not taken into consideration when determining the ETS cap, the effect of the reinforcing policy is to reduce emissions, and therefore, weaken the carbon price. The weaker price will have a spill-over impact on the abatement in other sectors. Another way to consider this point concerns policy stringency. If EE and carbon policies were coexisting for the same energy, then the more stringent policy would provide the incentive to meet both policies and the other would be redundant. For example, if a carbon target was so stringent that it required sufficient EE measures to meet the target of an EE policy, then the EE policy would not be required at all.

Overlapping instruments may distort the carbon price signal. Carbon based instruments aim to incentivise the lowest cost abatement measures through the carbon price signal. However, a coexisting EE policy instrument creates a preferential economic incentive for abatement derived from energy efficiency. This means the combined effect is not to incentivise the cheapest abatement. For example, expensive energy efficiency measures could be implemented instead of cheaper fuel switching options.

Finally, double regulation increases administrative and participatory costs. While there may be strong rational to have overlapping policies, the result is increased administrative complexity and regulatory burden for the obligated entities, and consequently, increased costs for the final consumers.

3 OVERCOMING BARRIERS TO EE THROUGH COMPLEMENTARY EE POLICY INSTRUMENTS

As was mentioned in the introduction, EETS and ET provide incentives for implementing energy efficiency measures, either through obligations or through a tax.

However, these instruments do not address additional barriers to energy efficiency improvements, and complementary policy instruments are often required to provide a balanced policy mix. This section presents the key barriers to energy efficiency improvements and complementary policy instruments aimed at overcoming these.

3.1 BARRIERS TO EE AND THE NEED FOR ADEQUATE POLICY MIX

A study by the European Union on EE policy in industry (EU, 2015) highlighted the following key barriers to energy efficiency in Europe:

- Low cost. Low share of energy costs in total costs of the company and therefore low priority for energy efficiency investment.
- Lack of awareness. Information and knowledge deficits both with regard to the existing saving potentials in the company and to existing financial support programmes for investments in energy efficiency (especially relevant in SMEs).
- Impact on output quality. Fear of negative impact of energy efficiency measure on the quality of products and processes.
- Planning uncertainty. Uncertain economic and legal framework and uncertainty in planning.
- Lack of funding and financing. Lack of own capital to undertake the necessary investments and no willingness to use borrowed capital (especially in owner-run companies).
- Transaction costs. High transaction costs of energy efficiency

3.2 POLICY MIX FOR OVERCOMING BARRIERS

Table 5 provides an overview of common EE policy measures and the barriers they address. Note that main objective of EE incentives and obligations are to address the first barrier, of low costs and/or priorities.

Table 5 – EE policy measures and barriers addressed

Policies Instruments	Low cost/priority	Lack of awareness	Impact on output quality	Planning uncertainty	Lack of funding and financing	Transaction costs
Energy efficiency incentives and obligations: EE trading schemes and taxes, ETS and Carbon Tax	✓	✓		✓		
Co-operative Measures e.g. agreements among enterprises on energy efficiency		✓	✓	✓		
Financial e.g. subsidies, grants, loans for energy audits and efficiency investments		✓			✓	✓
Fiscal/Tariffs rebates e.g. tax deduction for energy saving investments in businesses		✓			✓	✓
Information/Education/Training e.g. advice programs for industry, energy management systems	✓x	✓	✓			
Legislative/Informative e.g. mandatory execution of energy audits in large enterprises, building and eco-design standards	✓	✓		✓		

Source: (EC, 2015).

The EU study however also mentions that there are drivers for energy efficiency – such as cost savings, improved productivity and competitiveness. The right policy mix should tackle the barriers above and take advantage of such drivers. Box 1 provides an overview of the EE policy mix in EU, and key principles.

Box 1 - EU Energy Efficiency Policy Mix and principles

Figure 7 provides an overview of the existing EE policy mix in the EU. This shows that most countries have a range of regulatory, fiscal/tariff, and informational measures.

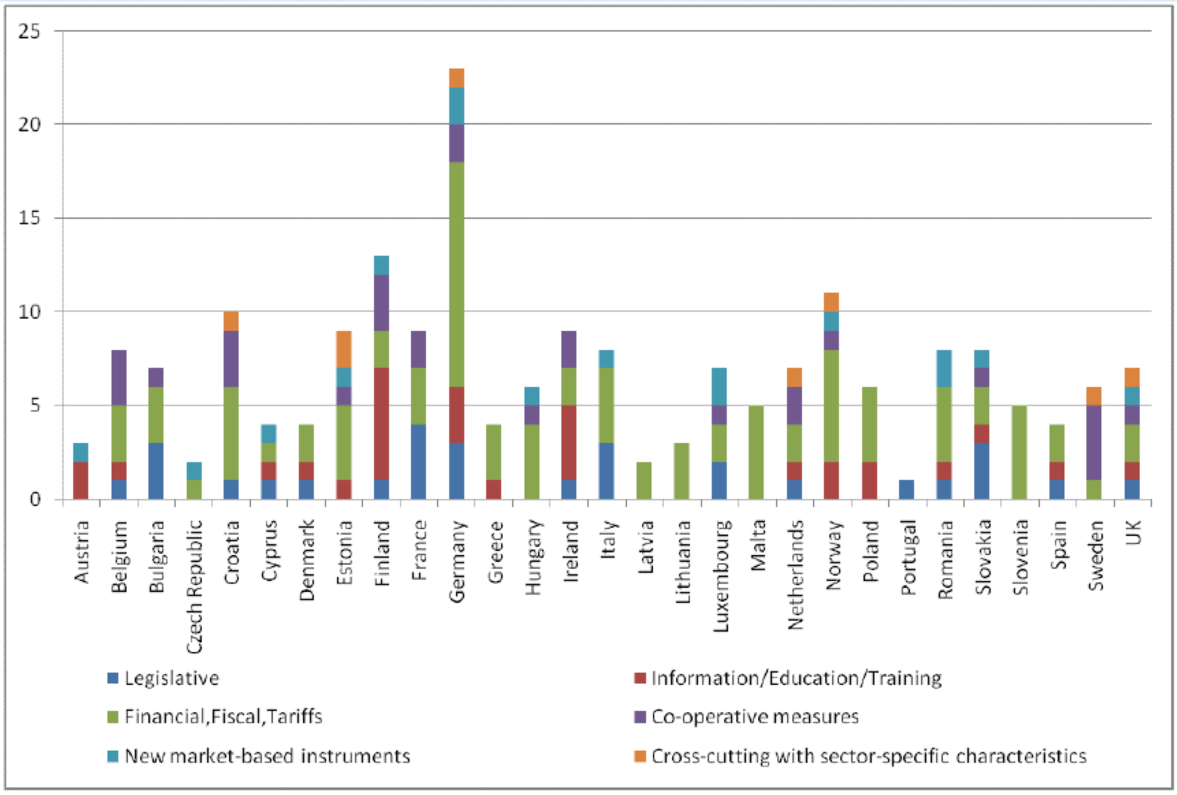


Figure 7 - Existing Energy Efficiency measures by type in EU countries, 2015

The European Commission (EC, 2015) study recommends the following policy mix:

- Regulatory instruments, such as the Ecodesign directive, defining technological baseline and improvements measures in companies
- Fiscal and financial instruments that lower costs, provide funding or financing. These include rebates, on grants and subsidies, or credits lines specifically for EE investments.
- Finally, informational and advisory instruments are extremely important for tackling non-economic barriers. The EU highlights in particular the role of energy management and audit support programmes, which have been a cornerstone also of Chinese Industrial Energy Efficiency policy.

Finally, some countries have new market-based instruments, such as EETS, which are complementary to the measures by providing incentives / obligations for EE.

3.3 THE ROLE OF ENERGY MANAGEMENT

Based on the principle that you manage what you measure, policy support for energy auditing and management has been the cornerstone of successful EE policies, as demonstrated in below in all EU countries and in China's ambitious 1,000 enterprise programme.

There has been a strong and growing emphasis on his kind of measure in Europe, with most countries conducting these kinds of instruments. Mandatory industrial energy audits, EE management in industrial enterprises and annual reporting, industrial energy efficiency networks, and intelligent meterings are some of the recent measures highlighted by the EC. Regarding the existing policy mix, the most frequently implemented measures are mandatory energy efficiency certificates for buildings (27% of all audit/management measures, 2015), and there are a significant amount targeted directly at industrial processes/buildings (17%) (EC, 2015).

4 INDUSTRIAL ENERGY EFFICIENCY IN CHINA: A COMPREHENSIVE POLICY MIX

Energy efficiency has received increasing attention by the Chinese Government and a number of regulations, policies and measures have been issued over the past 10 years (Lewis, 2011). The main comprehensive policy framework, covering a number of social and economic aspects and development initiatives, is the Five Year Plan, which, as the name suggests, is re-shaped and modified every five years in order to tackle current and new issues with medium term plans.

The first Plan was developed for the years 1953-1957 and the key tasks highlighted in the Plan were to concentrate efforts on the construction of large and medium-sized industrial projects and to develop agricultural producers' cooperatives to help in the socialist transformation of the agriculture and handicraft industries. More recently the Plans have concentrated on issues such as energy consumption, energy efficiency and emissions. By 2005, the country realised that, without a reduction in energy intensity, it would need to consume three times the level of energy it consumed to sustain its economic growth. This rapid growth presented a serious problem and was not sustainable in the long run. Following the announcement of a target of a 20% reduction in energy intensity stated in 11th FYP, a series of policies, notices, measures, and government reorganizations were put in place to support the realization of the goal.

An overview of the industrial energy efficiency (IEE) policy in China is provided in this section. The policy mix chosen for IEE complements carbon-based measures, the ETS and tackles a number of barriers to incentivise EE:

- Differentiated electricity pricing to encourage EE, and removal of preferential rates for industry. This has an effect similar to EE Taxes. Revenues have been recycled into EE investments.
- The 1000 enterprise programme creates both an obligation for EE and energy savings, through the creation of a contract between the most energy intensive industries and their provincial governments. Importantly, this same programme has a significant emphasis on energy monitoring and management, having provided support for industries to do so.
- China has not yet implement a national EE Trading Scheme, but pilot ETSs have been implemented in a number of Chinese provinces, with the ambition of a national ETS in the coming years.

4.1 ENERGY EFFICIENCY TARGETS

As mentioned above, the centre of China's 11th Five-Year Plan (2006-2010) was a target to decrease the energy consumption per unit of GDP by 20%. China effectively achieved an actual reduction of 19.1%. The closure of inefficient power and industrial facilities helped to the decline in energy intensity during the 11th FYP period. However, China's energy consumption increased from 2,475 million tonnes of coal equivalent (mtce) in 2006 to 3,100 mtce in 2010.

In addition, the government started a national campaign to promote energy efficiency, targeting in particular the largest and least efficient energy consuming enterprises. The Top 1,000 Program targeted approximately 1,000 companies (consuming about one-third of the country's energy) for efficiency improvements (see case study).

The 12th FYP adopted by the Chinese government in March 2011 devoted considerable attention to energy and climate change and established a new set of targets and policies for 2011-2015. Reduction of fossil energy consumption, promotion of low-carbon energy sources, and restructure of the China's economy are at the core of the 12th FYPn. One of the goals was to gradually establish a carbon trading market. Key targets included:

- 16% reduction in energy intensity (energy consumption per unit of GDP);
- Increasing non-fossil energy to 11.4% of total energy use; and
- 17% reduction in carbon intensity (carbon emissions per unit of GDP).

The 12thFYP builds directly on the 11thFYP energy intensity target and its associated programs, setting a new target to reduce energy intensity by an additional 16% by 2015.The scope of the Key Enterprise program was expanded to include 10,000 enterprises consuming more than 5,000 tce. In addition, attention has been given to MRV systems to verify energy savings and to support the development and deployment of new energy efficiency technologies.

Overall, China has achieved an 18.2% reduction in energy intensity during the 12th FYP. The efficiency of industrial and heating boilers and variable frequency drive motors has seen an improvement between 2% to 5% and automated energy management system have been deployed in large industries.

In conclusion, China has achieved improvement in energy intensity of 34% compared to 2005, which have avoided almost 750 mtce of energy consumption. China is intending to build up on these achievements and the 13th FYP (2016 – 2020) set a target for further reduction of energy intensity by 15%.

4.2 OVERVIEW: DRIVING FORCE FOR ENERGY EFFICIENCY IMPROVEMENT IN CHINA

As stated in the Country's INDC, energy efficiency has been recognized by China as the most cost-effective way of enhancing national energy security, improving economic competitiveness and reducing GHGs emissions. China has recognised that, as well as helping to create employment and growth, improving energy efficiency is a cheaper option than energy supply alternatives, whether conventional or renewable.

4.2.1 IMPROVING ECONOMY

Economic arguments for energy efficiency often focus on job creation, enhanced competitiveness and economic development. There are a number of studies that evaluate the relationship between job creation and energy efficiency program. The American Council for Energy Efficiency Economy analysis states that the net increase in jobs from energy efficiency policy implementation, is the result of two major changes; first, an initial expenditure or effort that drives energy bill savings; and second, the subsequent adjustment in spending patterns brought about by that initial expenditure or effort (ACEEE, 2011).

In addition to job creation, improving energy efficiency also contributes to industry and enterprises becoming more competitive in their local and global market, by reduction their cost base. Attention to companies' energy efficiency and emissions is becoming always more important among investors and consumers.

For example, as part of the FYPs China has developed mandatory energy performance target schemes for high energy intensity industry. This scheme, often called Top 1,000 and Top 10,000 aimed to incentivise energy efficiency in industry and required companies to carry out energy audits to identify abatement opportunity. This new legislation has generated a new job demand for auditors, ESCo, engineers and other supporting roles.

4.2.2 ENHANCING NATIONAL ENERGY SECURITY

Energy security has various aspects, access to energy, affordability, adequacy and availability. An enhanced energy security will have a lower supply disruption risk and it is likely to be less dependent on fossil fuel imports. Therefore, improving energy efficiency in the most energy intensive sectors can directly reduce the need of importing fuel. Another aspect of energy security is the physical availability of energy supply systems to cope with demand at peak time. Thus, improving energy efficiency can reduce stress at peak time and delay the need of additional capacity.

National energy security is an important issue for China, both because China is a large oil importer and because, for being a rapidly developing country, it often needs to react to power supply capacity constraints. China has depended on oil imports for more than 50% of its total oil usage since 2009 and estimates suggest that China's oil imports will surpass 80% of its oil usage by 2030 (Yao, 2012). In the past, China has mitigated the oil shortage by relying on coal, which up to 2010 was used to generate 70% of its energy needs, and of which China has massive reserves. Nevertheless, in the last years environmental issues and air pollution have challenged this fuel mix.

4.2.3 ENVIRONMENTAL IMPACTS

The environmental benefits of improving energy efficiency can be delivered at the global and local levels. Local benefits could include improved air quality, with social and economic effects such as reduced health care costs and lower lost working hours due to illness.

As mentioned, due to the large coal consumption over the past 30 years, China has now developed serious environmental problems including thousands of premature deaths as a result of diseases caused by air pollution.

4.3 POLICIES AND INSTRUMENTS

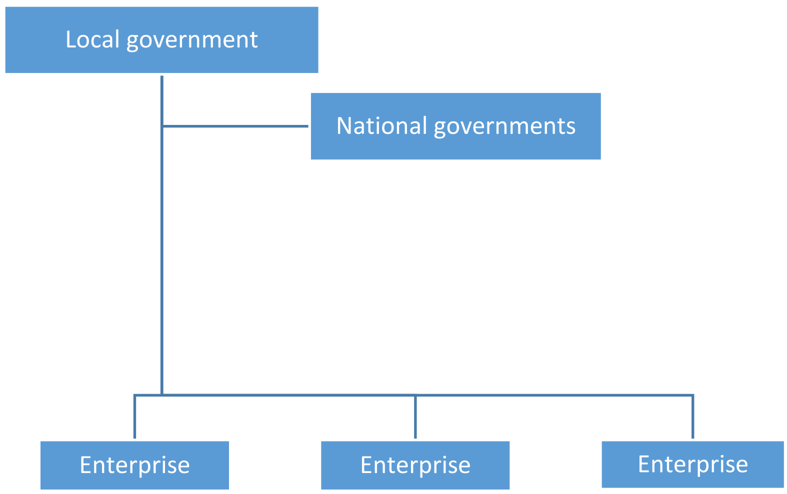
China's Top 1,000 and Top 10,000 Energy Consuming Enterprises programmes

China's Top 1,000 Energy Consuming Enterprises Programme is an example of mandatory target setting. The programme also included mandatory audits. The Top 1,000 Energy Consuming Enterprises programme, which was part of China's 11th FYP was followed by Top 10,000 Energy Consuming Enterprises programme which expanded the scope of the program under the 12th FYP.

China's top 1,000 programme was launched in 2006. It was designed to save 100 million tonnes of coal equivalent (mtce) over five years (2006 - 2010) in the largest 1,008 enterprises. The 1,000 companies were defined as those consuming a minimum of 180,000 tonnes coal equivalent (tce) per year. They had to set up energy monitoring systems, carry out energy audits to identify opportunities for significantly reducing their energy intensities, prepare energy efficiency plans, and submit all these for analysis.

Policy elements	Description
Instrument and jurisdiction	China's Top 1,000 and Top 10,000 Energy Consuming Enterprises programmes
Date implemented	Top 1,000 was implemented under the 11th FYP (2006 – 2010). Top 10,000 was implemented under the 12th FYP (2011 – 2016)
Preceding instruments	N/A

Policy elements	Description
Obligations and target setting	The Chinese government chose an innovative governance/implementation model for this policy. Responsibility for achieving the targets were placed on provincial and local governments which were requested to: • Provide training sessions for Top-1000 enterprises at initiation of program and financial support; • Lead and implement the program, including tracking, supervision, and management of the energy-saving activities of the enterprises; • Oversee the enterprises in their energy management, energy auditing, and energy reporting requirements; • Improve monitoring of enterprises through audits and sampling; • Promote the use of new mechanisms such as target-setting agreements; • Encourage enterprises to meet energy saving targets and attain international advanced levels ahead of schedule At the same time, participants are required to implement energy management through the following activities: • Establish sound energy measuring and statistical system • Submit energy utilization status reports of enterprises regularly (i.e. energy consumption; energy efficiency; cost-effectiveness of energy savings and energy-efficient measures) • Self-conducted energy audits, following the Chinese energy audit standard to identify key issues and potentials, and provide feasible and practical energy-saving measures • Submit energy audit reports to provincial-governments in 6 months for review • Develop energy conservation plans. Under the Top 10,000 programme, increased responsibility was given to local governments which evaluated local enterprises' progress toward their energy-saving target and publicize the results. Targets were set differently in each programme: • During the Top 1,000 programme, targets were set for each enterprise individually by the National Development and Reform Commission (NDRC) and were defined as total energy savings in 2010 against a growth baseline.

Policy elements	Description
	• For the Top 10,000 Program, the energy saving of 250 Mtce was based on the provincial targets submitted to and negotiated with the central government. The target is defined as the total energy savings in 2015 against a growth baseline.
Coverage, obligated entities and eligibility	In the first phase, i.e. Top 1,000, the companies were defined as those consuming a minimum of 180,000 tce. During the second phase, i.e under the 12th FYP, the threshold was lowered to a minimum consumption of 10,000 tonnes of coal equivalent and the coverage was extended to the country's top 10,000 enterprises. The programme actually included more than 15,000 enterprises, 160 large transportation enterprises, and public buildings (each consuming more than 5,000tce per year), giving a total of 17,000 large enterprises.
Institutional set-up	
Mechanics of the instrument	China's Industrial Energy Performance Standards set out the mandatory maximum energy intensity values for existing plants and new builds, taking into account different types of raw materials, fuels, and throughputs. Companies' performances were assessed against these benchmarks using energy monitoring and data collection. Mandatory energy audits were then used to identify opportunities for improvement and their feasibility and implementation plans to be carried out within the next six months of the programme were agreed.

Policy elements	Description
	The rules also allowed companies to aim for more ambitious, voluntary, energy intensity standards.
Additional measures and support	• Companies are supported by provincial and local governments via the provision of energy management training, other assistance and financial support. • Under the Top 10,000 scheme, the provision of financial aid to energy efficiency projects was improved. Financial incentives were provided for energy saving projects on the basis of a fixed payment per tonne coal equivalent saved per year. • No incentives were provided for supporting activities such as conducting energy audits, training or implementing energy management systems. • Capacity-building through structured training programmes was highly supported.
Compliance arrangements	Companies that failed to achieve their minimum targets were issued a "notice of criticism". This notice meant that, any official approval of any capital projects or additional industrial land use requests could have been suspended, and economic sanctions might have been applied. In case of state-owned companies, the "notice of criticism" was raised to the leadership and management team, which often became highly monitored and under pressure from the state agencies. In addition, the onus for achieving targets was also placed to the **provincial and local government**. Provincial and local government departments and officials were measured each year in terms of the collective energy performance improvement of the companies in their jurisdiction. If the targets were not achieved, the relevant government officials also became ineligible for rewards, honorary titles, and/or promotion.
Monitoring, reporting and verification (MRV) requirements	Companies are required to review and submit their energy efficiency plans, energy consumption reports, and the cost-effectiveness of energy efficiency improvements every year.

Policy elements	Description
Interaction with other carbon or energy instruments	The China's Top 1,000 and Top 10,000 Energy Consuming Enterprises programmes were launched as part of the 11th and 12th FYP respectively, and they were only one of the mechanisms of a large policy mix aimed to reduce the energy intensity by set targets. For example, parallel energy pricing and fiscal policy instruments such as the Ten-Key Projects (see section below) were also part of the FYP as additional instruments to overcome barriers. In addition, in the 13th FYP China does not mention the implementation and continuation of the Top 1,000 and Top 10,000 schemes but recognises the new Chinese ETS as the major instrument to achieve energy efficiency targets.
Social and environmental side benefits	The scheme requires companied to perform a mandatory energy audit, this has generated a new job market for energy auditors and ESCos.
Effectiveness	An evaluation of the programme estimated the total energy savings for the Top 1,000 enterprise programme at 150 mtce, i.e. 50 mtce more than originally targeted.
Cost effectiveness	Estimates from the first years of implementation shows that in 2007 enterprises invested over 50 billion RMB ($US 7.5 billion) in technology innovation, implementing over 8000 projects. In 2008 enterprises invested 90 billion RMB ($US 13.5 billion) in energy-saving technical renovations and implemented about 3,000 energy-saving technical renovation projects. Estimated cost for the government are not available.
Political acceptance	It is difficult to establish the issue around political acceptance of the policy in a comprehensive way, and in any case the findings may not translate well to the situation in Brazil.
Lessons learnt	The programme has been extended under the 12th FYP (2011-2016) with and expanded scope[31]. All companies consuming more than 10,000 tce per year are

[31] While the 13th FYP set a further reduction on energy intensity of 15% compared to 2015 value, and a reduction on carbon intensity of 18%, it is unclear whether the Top 10,000 scheme will be maintained or not. Chapter 46 of the 13th FYP claims that carbon emissions will be kept under

Policy elements	Description
	now included in the scheme. Thus, around 17,000 large enterprises are now covered by the scheme. The scheme was designed to achieve a16% reduction in energy intensity and an energy saving of 250 mtce, contributing 37% to China's energy savings target. Additional requirements were added to the Top 10,000 scheme, compared to the Top 1,000, for example additional onus was put on the provincial and local government by requesting them to publish the results. In addition, large companies (over 10,000 tce) were mandated to deploy BAT and achieve the world-class energy intensity standard.
Sources	(IIP, 2015) (Lu, 2014)

4.3.1 ENERGY PRICING AND FISCAL POLICY INSTRUMENTS

As part of the 11th FYP and in addition to the Top 1,000 scheme, the Country developed additional measures and supporting mechanisms to the achievement of the 20% energy savings target.

China energy pricing scenarios is mainly characterised by (Zhou, 2010):

- A highly regulated electricity price
- Unregulated coal prices which have highly increased since 2006
- A high discrepancy between energy prices and actual energy costs. This is mainly due to high price of oil, regulated by the international market and of which China is a large importer, and set electricity prices and oil product prices which do not reflect the cost of the cost of primary source.

The discrepancy between energy prices and actual energy costs have forced the Chinese Government to provide, since 2006, very large subsidies to energy suppliers in order to address the mismatches between relatively low and regulated electricity and oil product prices. Due to this pricing scenario, the generation of energy was enforcing a high cost to the government and therefore, price signals were needed to encourage an improved energy efficiency. These instruments aimed to achieve lower energy

effective control in power, steel, building materials, chemical and other major carbo emitting industries. The FYP state that China will establish a national carbon emissions trading scheme and implement systems for carbon emissions reporting, inspection, verification and quota management.

consumption and therefore a lower production, which eventually meant lower subsidies costs for the government.

In 2004, a policy permitting **different electricity prices** for high consuming industry was introduced. The aim of the policy was to phase out inefficient enterprises as these were asked to pay an increased price for the electricity consumed. In 2006, preferential electricity pricing has been prohibited, while the different electricity price policy based on energy efficiency performance has been extended to include more sectors. In 2007, the policy was adjusted to allow provincial authorities to retain part of the tax revenue, thus incentivising them to apply the policy. On the other hand, some areas did not implement the policy in the same way and offered reduced electricity prices to some high energy consuming industries which went through a sudden and unplanned development.

In recent years China has also used tax revenue to promote energy efficiency, particularly income from corporate income tax, vehicle and fuel taxes and export taxes.

4.3.2 COMPLEMENTARY POLICY INSTRUMENTS - ENERGY EFFICIENCY FINANCING: "TEN-KEY PROJECTS"

In 2007 the Chinese Government allocated 23.5B RMBf ($3.08B) (Zhou, 2010) to improve energy-efficiency and abate pollution. These funding supported the launching of the Ten-Key Projects. The Ten Key Projects have been incorporated into the 11thand the 12thFYP to support the national binding goal of reducing energy intensity (energy consumption per unit of GDP) and carbon intensity (carbon dioxide emissions per unit of GDP) (IEPD, 2017).

The energy-saving target for the Ten Key Projects in the 11th FYP was 240 million tonnes of coal equivalent (Mtce). The programme provided financial incentives for local governments and industry to pursue a wide range of energy-saving projects. The ten project types included the following:

- coal-fired boiler (furnaces) retrofits;
- district cogeneration projects;
- waste heat and waste pressure utilization projects;
- conservation and substitution of oil;
- motor system energy conservation projects;
- energy system optimization projects;
- building energy conservation projects;
- green lighting projects;
- governmental buildings energy conservation projects; and
- energy conservation monitoring and supervision projects.

In addition to the above, the central government also provided financial rewards for energy-savings made by eligible projects under the Ten Key Projects and in eligible industry and enterprises. During the 11th FYP, enterprises were rewarded at a rate between 200-250 RMB for every tce saved per year.

By the end of the 11th FYP (2010), the central government had allocated 8.1 billion RMB to the Ten Key Projects and another 22.4 billion RMB as special funding. In total, more than 5,100 projects were implemented under the "Ten Key Projects" programme. It is estimated that the cumulative energy-savings of the Ten Key Projects was about 340 Mtce during the 11th FYP. Funding for the Ten Key Projects mainly came from the enterprises' own funds, third-party financing, and the central government. Central government funding represented about 5% of the total investment for the Ten Key Projects.

The Ten Key Project programme continued under the 12th FYP and was slightly expanded to include more projects. The energy-saving target for the Ten Key Projects in the 12th FYP is 300 Mtce. The financial rewards for energy-savings have been continued in the 12th FYP as well. The rate of rewards has been increased to 250 - 300 RMB per tce-saved.

5 KEY IMPLICATIONS FOR BRAZIL

Tax and trade energy efficiency policy instruments are often compared to carbon pricing instruments (CPIs), whether to be used as an alternative or complement for CPIs. This study focuses on Energy Efficiency Trading Schemes and Energy Taxes.

While these instruments provide incentives for implementing energy efficiency measures, they should be implemented alongside complementary policies (informational, financial support) to address additional barriers to energy efficiency improvements. Note that Brazil's current policy mix lacks instruments providing EE incentives. COPPE provided an overview of the current regulatory landscape regarding energy efficiency instruments in Brazil, highlighting PROCEL, CONPET, the utility energy efficiency obligation and BNDES credit lines (detailed in Appendix A.1) PROCEL and CONPET are mainly informational instruments, focused primarily on awareness raising (although CONPET does include minimum vehicle emission standards). The latter provide support for financing or implementing energy efficiency measures in industries. At present, no taxes, energy saving targets, trading systems, or minimum efficiency standards, are in place in Brazil.

Effectiveness of EE instruments. EETS and ET instruments have been implemented worldwide, with mixed results.

Regarding the **effectiveness** of the **Indian PAT EETS**, evidence shows that the targets set for the first cycle of the PAT have not been stringent enough. Such a significant overachievement of the target indicates a market failing to drive the level of investment to meet the targets, as these would have been probably met under a business as usual scenario. Now that administrators have a better understanding of emissions and abatement potential, tighter targets should be set for the following cycles. Regarding **distributional impacts,** evidence shows that sectors with high investment costs have achieved less savings than those with lower costs and may require higher incentives for investing in energy efficiency. Long term investments occurred in the first PAT cycle due to a lack of clarity and long-term target setting, which is a barrier for firms to invest in costly and technically challenging energy savings opportunities.

In **Sweden**, results are inconclusive as it is not possible to discriminate the effect of the energy tax, but rather the effect of the whole policy package (i.e. including energy taxes, carbon taxes, EU ETS, etc) is evaluated. Regarding this package, savings were less than expected in 2014 (2.93TWh rather than 11.6TWh) but increased significantly in 2015 to 14.7TWh. In addition, industrial participants which were included in the EU ETS are expected to have higher energy savings (4.5%) between 2014-2020 than those excluded (1.5%).

Finally, in **China**, there was a 50% overachievement of the Top 1,000 enterprise programme (at 150 mtce). Estimates from the first years of implementation shows that in 2007 and 2008 enterprises invested over $US 7.5 billion and $US 13.5 billion energy efficiency projects. The programme has been extended under the 12th FYP (2011-2016) with an expanded scope. All companies consuming more than 10,000 tce per year are now included in the scheme, amounting to around 17,000 large enterprises.

The scheme was designed to achieve a 16% reduction in energy intensity and an energy saving of 250 mtce, contributing 37% to China's energy savings target. Additional requirement has been placed on participants, including that the Top 10,000 are now mandated to deploy best-available-technology and achieve the world-class energy intensity standard.

Acceptability. An interesting consideration for Brazil may be the level of political and stakeholder acceptability of this instrument compared to CPIs.

- Energy efficiency has been recognized by China as the most cost-effective way of enhancing national energy security, improving economic competitiveness and reducing GHGs emissions. China has recognised that, as well as helping to create employment and growth, improving energy efficiency is a cheaper option than energy supply alternatives, whether conventional or renewable.
- Sweden also designed their tax to improve acceptability. When the tax on electricity was introduced in 2004, the regulation gave affected companies the opportunity of being granted tax exemption on their electricity consumption if they take action to improve their energy efficiency. The Swedish government therefore adopted a programme of improving energy efficiency in energy-intensive companies (PFE), with the carrot of reduced taxation.

Co-existing carbon and energy efficiency instruments

Since Brazil may consider implementing carbon and energy efficiency instruments at the same time, the rationale and key considerations are presented here. Sweden provides an interesting case study, since at numerous points in the history of the tax policy, industrial fossil fuel combustion activities have been covered by overlapping energy and carbon regulation (carbon tax and EU ETS at certain points), resulting in double regulation.

Rationale for co-existing energy efficiency and carbon instruments. The objectives of energy and GHG targets can be complementary, since establishing an energy efficiency target can improve GHG intensity of output and indirectly reduce GHG emissions. However, setting a price on carbon through ETS/CT will deliver the cheapest form of abatement, but may not necessarily reduce energy consumption. This is because carbon pricing mechanisms incentivise a wide range of emissions reduction options, including those such as fuel switching that do not affect energy consumption.

In Brazil, there may in fact be trade-offs between carbon emissions and energy efficiency. For instance, the use of biomass, although less carbon intensive, can increase energy consumption due to lower conversion efficiencies. Another example is that the use of ethanol in vehicles is less energy efficient than using petrol.

Considerations for co-existing energy efficiency and carbon instruments

- **Regulating up and downstream together can provide stronger incentives.** In the case of electricity production and consumption in Sweden, electricity generation was covered by the EU

ETS from 2005, and carbon costs passed through to industrial consumers. The previous year, a tax was introduced on electricity consumption by industrial entities to encourage energy efficiency. Thus, the electricity price was regulated both upstream (carbon price) and at point of consumption (energy tax).

- **However, there are risks associated with coexisting policies.**
    - Firstly, the risk of weakening targets. If the effect of overlapping instruments is not taken into account during target setting, the consequence may be weaker targets.
    - Overlapping instruments may distort the carbon price signal. Carbon based instruments aim to incentivise the lowest cost abatement measures through the carbon price signal. However, a coexisting EE policy instrument creates a preferential economic incentive for abatement derived from energy efficiency. This means the combined effect is not to incentivise the cheapest abatement. For example, expensive energy efficiency measures could be implemented instead of cheaper fuel switching options.
    - Finally, double regulation increases administrative and participatory costs

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A. APPENDICES

A. 1 ENERGY EFFICIENCY POLICY INSTRUMENTS IN BRAZIL

COPPE provided an overview of the current regulatory landscape regarding energy efficiency instruments in Brazil. (COPPE/UFRJ, 2017). The key instruments are listed below.

PROCEL. According to the IEA "*the objective of the National Energy Conservation (PROCEL) is to promote the rationalization of production and consumption of electricity, in order to eliminate waste and reduce costs. It helps fund conservation projects involving R&D, demonstrations, educational and training programmes, marketing strategies, direct installation and upgrading inefficient equipment, and demand side management in the electricity sector… This programme has several sub-programmes within it, including programmes targeted at buildings, sanitation, public lighting, municipal energy management, education, and industry, as well as an energy efficiency and consumption label for appliances."(IEA, 2017)*

CONPET. According to the IEA, a "*National Programme for Energy Efficient Use of Petroleum and Natural Gas Derivatives (CONPET). A general programme … conceived to promote the efficient use of these sources of unrenewable energy in transportation, in households, in commerce, in industry and in the agricultural and livestock industries*." *(IEA, 2017).* There are several sub-programmes, focusing on labelling of consumer goods and industrial equipment, awareness raising for the rational use of resources, and in the transport sector, the use of legislation to impose emission limits and reduce pollutants.

Utility energy efficiency obligation. According to the IEA*, "the Brazilian energy regulator ANEEL has imposed obligations on electric power distribution companies to make investments that reduce electric waste, including through undertaking energy efficiency measures. Since 2005, a minimum of 50% of those investments must be allocated to low-income energy efficiency programmes. In 2005-06 and 2006-07, low-income programmes made 63% and 66% of investments respectively, and industry programmes made up 15% and 6% respectively". (IEA, 2017)*

BNDES credit lines. COPPE's report highlights three BNDES credit lines supporting energy efficiency. *BNDES Eficiência Energética*, which finances larger scale industrial energy efficiency projects, *BNDES FINEM* which finances smaller scale energy efficiency projects in the businesses and public sector, and *BNDES FINAME*, support for manufacture and purchase of local content energy efficiency equipment (COPPE/UFRJ, 2017).