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 ELECTRICITY SECTOR

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INTERNATIONAL EXPERIENCE OF CARBON PRICING IN THE ELECTRICITY SECTOR

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

Five theme-based reviews of international experience have been aggregated in this ***Carbon Pricing in the Electricity Sector*** report, focusing on analysing the policy interactions between carbon pricing and electricity sector policies. Specifically, the theme-based reviews of international experience are:

1. **Interaction of Electricity tariff policies and CPIs,**
2. **Interaction of support for renewable generation and CPIs,**
3. **Electricity Interaction of Thermal Generators and CPIs,**
4. **Interaction of Hydro Generation and growth in electricity demand and CPIs.**

These reviews of international experience have been prepared according to a common analytical framework, and have a cross-jurisdictional approach, drawing on international experience from multiple jurisdictions of relevance for Brazil. Each review begins by describing the selection of case study jurisdictions, their policy landscape and carbon pricing instruments (CPIs).

The policy interaction analysis focuses on expected interactions between the CPIs and underlying electricity sector policies. Subsequently, the corrections to policies made by governments as a result of expected interactions are presented. Following this, the actual impacts of the introduction of the CPI are presented. These include effects on the functioning of the CPI, impacts on the effectiveness of the underlying policy, and distributional impacts on stakeholders such as households and industries. Finally, the lessons learnt and key implications for Brazil are presented.

In addition, additional research was requested on the topic of "**Mechanisms to alleviate energy price rises due to carbon pricing on low-income households",** which is presented in the appendix.

EXECUTIVE SUMMARY: INTERNATIONAL EXPERIENCE OF CARBON PRICING IN THE ELECTRICITY SECTOR

For each of the five themes, this executive summary presents an overview of the cases studied as well as the lessons learnt from this international experience, before presenting some of the key implications for Brazil.

Theme 1: Interaction of Electricity tariff policies and CPIs

Table 1 – Overview of Theme 1: Interaction of Electricity tariff policies and CPIs provides an overview of the jurisdictions chosen, the CPI adopted, and the interaction studied.

Table 1 – Overview of Theme 1: Interaction of Electricity tariff policies and CPIs

Country	South Africa	New Zealand
CPI	Tax	ETS
Start Year	Under implementation	2008
Current Rate (World Bank, 2017)	8.50 USD/tCO_2e	12.54 USD/tCO_2e
Policy Interaction	Electricity wholesale and retail policy, in a market with a single vertically integrated and regulated utility, ESKOM	Electricity wholesale and retail policy in a competitive electricity market.
Implementation Agency	Department National Treasury, Republic of South Africa	Ministry for the Environment, New Zealand
How Implemented	Tax designed to be revenue neutral by compensating with the reductions in electricity levy Avoid overlap by excluding renewable energy projects of support scheme to be used for carbon tax offsets Revenue recycling to avoid distributional impacts and incentivize mitigation measures	Transitional phase with one-for-two surrender obligation Delay of reductions in free allowance allocation Banking and borrowing of allowances

Country	South Africa	New Zealand
CPI Impacts	Expected: Additional GHG emission reduction Greater demand for renewable energy projects to lower the tax burden No fuel switching or investments in renewable energy expected due to revenue neutral nature of tax	Significant abatement was expected since electricity sector allows fuel switching and pass-through of costs to incentivize rational use of energy. Carbon price was too low to bring about actual changes or abatement
Other Impacts	Overlap might lead to less cost-effective abatement and higher administrative burden	

Source: Own elaboration.

Lessons learnt: Interaction of Electricity tariff policies and CPIs

A CPI in the electricity sector has the potential to reduce GHG emissions by providing three main incentives: short and long-term fuel switching, and for rational use of energy.

International experience suggests that carbon pricing will support fuel switching if the signal is strong enough and merit order dispatch is affected. This depends on the price setting environment or the dispatching environment. Additionally, the installed capacity needs to be flexible to respond to short-term changes and have low carbon capacity available to allow fuel switching.

In New Zealand the existence of competitive wholesale markets and the landscape of installed capacity seems to suggest a carbon price could influence the merit order dispatch and cause fuel switching from coal to gas. Although, no evidence has been found to date that the carbon price in New Zealand did influence the dispatch order and stimulated fuel switching to lower carbon sources. In South Africa, very limited or no fuel switching was expected when the carbon tax is introduced due to the inflexible generation capacity, e.g. mostly coal. Additionally, it is unclear whether ESKOM as the central dispatcher would consider including carbon price in the dispatch criterion, and how this would affect the merit order.

International experience also demonstrates strong price signals are required to affect the competitiveness of generators in favour of low carbon alternatives. In New Zealand's liberal market, a carbon price could potentially make the outlook for renewable generators more attractive than for thermal developers. However, no increased investments in renewables were observed in New Zealand after the introduction of the CPI. It has been speculated that this lack of increased investments was due to a low carbon price. In South Africa, limited changes in investment in new fossil fuel capacity are anticipated when the CPI is first introduced, since initially there will be no price signal, only an informational signal to investors. This is expected to change in successive phases, favouring investments in renewables in the long-term.

The introduction of a carbon price can cause more rational use of energy when costs can be passed on to consumers. In New Zealand, it was expected the carbon price would create incentives for rational use of electricity due to the possibility for companies to pass through additional costs to consumers. However, this was not in line with the electricity tariff policy objective in New Zealand, as they contradict the policy objective to avoid big fluctuations or increases in the electricity price. While in the short-term the carbon tax will have a neutral effect on electricity prices in South Africa, it may increase prices in the long-term and thereby incentivise rational use of energy.

Finally, by compensating other electricity tariff policies, a carbon tax can function as an effective revenue recycling tool thereby also minimizing adverse socio-economic impacts. The primary role of a carbon tax in the short-term in South Africa will be to function as a tool for revenue raising. This revenue can be recycled for support for renewable energy and energy efficiency schemes. The CPI is therefore expected to be in line with the objectives of the electricity pricing policy in South Africa to keep electricity prices low in the short-term.

Implications for Brazil: Interaction of Electricity tariff policies and CPIs

Key conditions for effectiveness of carbon pricing in the electricity sector may be absent in Brazil. The introduction of a carbon price will cause fuel switching if the signal is strong enough, merit order dispatch is affected, and the installed generation capacity of the country is flexible enough to absorb short-term changes by influencing dispatch decisions.

However, switching from fossil fuel to hydro generation in the short term might be challenging in Brazil due to recent drought conditions. Hydro capacity has been low in the past few years, and all the available thermal capacity in Brazil is running. It is unclear whether any spare capacity is available to allow for a short-term switch from coal to gas. Regarding dispatch, as this is controlled by a central body in Brazil, *Operador Nacional do Sistema Elétrico* (ONS), individual generators currently have no control over this process. Therefore, any possible fuel switching from high to low carbon sources can only be brought about by including this as a criterion in decision-making for dispatch by ONS. In the long-term a carbon price could influence prices and thereby influence ONS decision-making process for dispatch.

Carbon pricing may have an impact on the competitiveness thermal generation favouring renewables in government auctions where they compete directly. Brazil's centralised auctions in the regulated market guarantee power producers a route to market. The rules of the auctions vary from auction to auction. Some of them are technology specific (e.g. only solar compete) or for broader categories (e.g. renewables) and in others are opened to more types of generators, in which case thermal and renewables do compete. In the latter case, introducing a carbon price may have an impact on the competitiveness of thermal generators favouring lower carbon generation. The situation may be different in the free market if power producers of different technologies compete more directly.

However, the Brazilian Electricity sector experts who are counterparts for this study indicated that Brazil may be considering an electricity market reform. This could include a move from technology-specific to attribute-specific auctions for the regulated market. Attributes include characteristics of the generation, including for example ramp up time or GHG emissions per unit of electricity produced. If a carbon price were imposed in this scenario, lower carbon generation with similar attributes may have a competitive advantage.

If the carbon price can be passed down to consumers, this may provide an incentive for more rational use of energy resulting in GHG reductions. Brazil has a tariff realism policy in place that incentivises consumers to ration and use their electricity more efficiently. This policy was designed to deal with periods of drought where electricity supply from hydropower is low. The policy functions by giving a signal to consumers when a drought is expected to reduce their consumption. Electricity prices in these times of drought are then higher to reflect the shortage in supply. The objective of a carbon price to incentivise more rational use of energy is in line with the objective of the tariff realism policy. It may be possible to pass through the carbon price to final consumers.

However, electricity price rises would be unpopular in the current climate in Brazil where prices are already high due to high thermal load factors. Moreover, rises in prices could also contradict policies in Brazil that are aimed at keeping tariffs low and to protect lower income households. In the design of a possible carbon price in Brazil it will therefore be important to understand how disproportional impacts on low-income consumers can be avoided. Additionally, more research is needed to understand the level at which a carbon price will incentivise rational use of energy and reduce GHG emissions, without having any negative impacts.

By compensating other electricity tariff policies, a carbon tax can function as an effective revenue recycling tool thereby also minimizing adverse socio-economic impacts. The South Africa case study shows that a carbon tax can be designed in such a way that it does not have an impact on electricity prices but does solely act as a revenue collection tool. This could create an earmarked pot of money for renewable energy support and energy efficiency measures. This might be a possible option for Brazil if it does not want to affect electricity prices to avoid impact on vulnerable groups or have other adverse socio-economic impacts. Simultaneously with the carbon tax, South Africa does signal to utilities to prepare for future costs and see how they could bring about efficiencies. This would potentially prepare the country for the next phase to pass through costs and increase carbon/electricity prices: However, there is also a possibility to have full pass through of costs as shown by New Zealand, which will allow for more efficient use of electricity.

Theme 2: Interaction of support for renewable generation and CPIs

Table 2 provides an overview of the jurisdictions chosen, the CPI adopted, and the interaction studied.

Table 2 – Overview of Theme 2: Interaction of support for renewable generation and CPIs

Country	Netherlands	South Africa
CPI	ETS	Tax
Start Year	2005	Under implementation
Current Rate (World Bank, 2017)	6.49 USD/tCO_2e	8.50 USD/tCO_2e
Policy Interaction	EU ETS overlaps with renewable energy support scheme called stimulation renewable energy (SDE+).	Overlapping with renewable energy support scheme
Implementation Agency	The European Commission – Directorate General Clima	Department National Treasury, Republic of South Africa
How Implemented	Reset the ETS cap for each phase based on expected renewable energy generation from domestic policies Excluding traded sectors that have obligations beyond ETS obligations Design of market stability reserve that can release and absorb permits	Tax designed to be revenue neutral by compensating with the reductions in electricity levy Avoid overlap by excluding renewable energy projects of support scheme to be used for carbon tax offsets Revenue recycling to avoid distributional impacts and incentivize mitigation measures
CPI Impacts	No significant impacts have been recorded The overlap may cause additional administrative costs and less cost-effective abatement	Additional GHG emission reduction Greater demand for renewable energy projects to lower the tax burden No fuel switching or investments in renewable energy expected due to revenue neutral nature of tax
Other Impacts	Weakened price signal of the CPI	Overlap might lead to less cost-effective abatement and higher administrative burden

Source: Own elaboration.

Lessons learnt: Interaction of support for renewable generation and CPIs

Renewable energy schemes overlap with CPIs, but the support schemes also have additional objectives. The case studies of the Netherlands and South Africa show that renewable energy schemes overlap with CPIs by providing the same incentive. The overlap between a policy and a CPI can increase the cost of reducing emissions and have other unwanted impacts on the effectiveness of the instruments and distributional impacts. The case studies also illustrate that renewable energy schemes are generally set out to achieve other policy objectives than CPIs and therefore add additional value next to CPIs focused more widely on GHG emissions objectives. However, interactions between the policies can affect their cost-effectiveness, impact industrial competitiveness and have wider distributional impacts on households.

The interaction of CPIs and renewable policies need to be continually reviewed to ensure that all policies are still achieving their objectives in a cost-effective way. The case study from the Netherlands discusses interactions between the EU ETS and the Dutch stimulation for renewable energy policy (SDE+). It is important to include emission reduction expectations from renewable energy support schemes into the design of the carbon pricing mechanism and to keep this regularly updated. Moreover, other corrective measures to avoid negative overlap between policies include a mechanism to account for uncertain changes to control the amount of carbon allowances and a high transparency and disclosure of objectives and mechanisms of the policies.

In South Africa, where policy priorities of the carbon tax and renewable support policies are different, corrective measures have been taken to minimise overlaps and negative distributional impacts. The South African case study discusses the overlap between a carbon tax and renewable energy support schemes in the form of auctions (REIPPP). This case study highlights the importance of corrective measures by the government to ensure that incentives for renewable energy are additional. It also shows how revenue recycling and exemption of certain industries can counter-act negative distributional and competitiveness impacts. Even though the carbon tax in South Africa still needs to be implemented, the design of the tax taking into account a detailed description of renewable energy support schemes can ensure all policies achieve their objectives.

Additional costs from the overlap of policies may disproportionally impact low-income consumers. The interactions between RES policies and CPIs include negative impacts such as increased administrative costs and higher costs overall for decarbonization, due to the overlap in the objectives of the policies. These additional costs may potentially be passed through to end consumers. As lower-income energy consumers usually pay a higher proportion of their income on energy, price rises for electricity might impact them disproportionally.

Overall renewable energy support schemes have many benefits additional to a CPI and can exist in parallel. Therefore, CPIs should be designed in such a way that they are not negatively impacted by renewable support policies, but instead incorporate emission reduction outcomes of these policies to avoid overlap.

Implications for Brazil: Interaction of support for renewable generation and CPIs

A carbon price on its own may not lead to strong enough incentives to stimulate increased generation capacity from renewable energy. Given the need to expand generation capacity in Brazil, additional incentives for increased investment into renewables are therefore important for the Brazilian context, including the renewable energy schemes that are designed to stimulate these increased investments and make them more favourable than thermal generation options. The case studies illustrate that renewable energy schemes are generally set out to achieve other policy objectives than CPIs and therefore add value next to market-based mechanisms to reduce GHG emissions. It will thus be important in Brazil to have strong policies in place to incentivise investments in renewables. One such an option may be to organise more central auctions that are specifically targeted at renewable energy generators.

In addition, CPIs need to be continually adjusted to harmonise policy objectives. The international case studies describe the importance of including emission reduction expectations from renewable energy support schemes into the design of the carbon pricing mechanism and to keep this regularly updated. Moreover, other corrective measures to avoid negative overlap between policies include a mechanism to account for uncertain changes to control the amount of carbon allowances and a high transparency and disclosure of objectives and mechanisms of the policies. Therefore, if a carbon price is introduced in Brazil, careful design of the instrument and its incentives is crucial to avoid overlap and increased (administrative) costs. It will be especially important to account for any additional renewable energy generation that is brought about via other policies and to account for this when setting emission reduction targets of the CPI.

Finally, additional costs from the overlap of policies may disproportionally impact low-income consumers. Both RES and CPI typically pass on costs to consumers, thereby making it likely that interaction between the policies will have distributional impacts. Moreover, overlap between policy objectives, such as double incentives for generators to take up renewables, can cause higher administrative costs that can possibly be passed on to consumers. Increased costs to bring about emission reductions, or significant rises in electricity prices may impact low-income consumers disproportionally, as they spend the largest proportion of their income on electricity.

Additionally, the case studies highlight the importance of corrective measures by the government to ensure that incentives for renewable energy are additional. It also shows how revenue recycling and exemption of certain industries can counter-act negative distributional and competitiveness impacts. Even though the carbon tax in South Africa still needs to be implemented, the design of the tax that considers a detailed description of renewable energy support schemes can ensure all policies achieve their objectives.

These findings are relevant to consider for Brazil, where policy is aimed at keeping prices low and minimising distributional impacts. It will be important for Brazil to consider possible distributional impacts of policy interactions when designing a CPI and including mechanisms in the design of the CPI that can avoid any negative impacts. Lessons can also be learned from South Africa on the use of the carbon tax as a revenue recycling tool to mitigate any possible distributional impacts of the CPI.

Theme 3: Interaction of CPIs and thermal generators

Table 3 provides an overview of the jurisdictions chosen, the CPI adopted, and the interaction studied.

Table 3 – Overview of Theme 3: Interaction of CPIs and thermal generators

Country	UK, Poland, Spain, and Germany	Australia
CPI	EU ETS	Carbon Pricing Mechanism (CPM), a fixed-price ETS
Start Year	2005	2012
Current Rate	US\$5.91/tCO_2e [2016 average]	US\$22.91/tCO_2e [2014]
Policy Interaction	Support mechanisms for thermal power generation and electricity dispatch orders	Transitional support to thermal generators and households and competitive electricity dispatch order.
Implementation Agency	The European Commission – Directorate General Clima	Australian Government Clean Energy Regulator (CER)
How Implemented	Reset the ETS cap for each phase based on expected renewable energy generation from domestic policies Excluding traded sectors that have obligations beyond ETS obligations Design of market stability reserve that can release and absorb permits	Legislative process, carbon tax set to transition into an ETS
CPI Impacts	Support to thermal generation countervails CPI-induced abatement Competitive dispatch can facilitate fuel-switching	Transitional support facilitated the move to carbon pricing for households and thermal generators, before the CPM repealed in 2014 Competitive dispatch can complement a CPI.
Other Impacts	Interacts with electricity price management and may have distributional consequences	Support to households helped mitigate the regressive impact of electricity price increases

Source: Own elaboration.

Lessons learnt: Interaction of CPIs and thermal generators

Support for thermal generation capacity growth implies a trade-off between electricity price management and abatement. Liberalising prices to allow cost pass-through or providing thermal generators free allowances in the CPI both achieve emissions intensity reductions, but do not reduce the price impact on consumers. Whereas keeping CPI prices low in general reduces the price impact on consumers but does not contribute significantly to reducing the emissions intensity of electricity generation. The interaction between CPIs and (thermal) generation capacity growth thus faces a trade-off against three policy objectives: Incentivising investment into new thermal generation, which generates emissions, to cover rising demand; reducing emission intensity; reducing the price impact on consumers (and distributional impacts between generators).

Direct financial support to fossil fuel generation is evident in many countries implementing CPIs, but this countervails the CPI and is generally being phased out. This support is provided for reasons such as providing transitional support, managing electricity prices, and increasing access to electricity. In particular, fossil fuel thermal generation has been supported in Poland through a scheme called the stranded costs compensations (SCC), Spain supports fossil fuel electricity generation through funding coal stockpiles, and Australia supported thermal generation through payments for plant closures and the provision of free carbon units. However, this form of support countervails the CPI and in most countries the focus has been on gradually phasing out fossil fuel support over a period in order to avoid costly disruption to the market.

Well-designed capacity markets can increase electricity security and have minimal overlap with a CPI. Capacity markets, such as in the UK and Spain, can enhance security of electricity supply in the presence of large amounts of intermittent renewable generation. Lessons learnt in terms of design can also improve the functioning of capacity market and limit the overlap with a CPI. These improvements include implementing command and control emission intensity regulations as backstops, splitting new capacity markets from markets for existing capacity, and designing the market so that engagement of demand-side reduction options is encouraged.

Distributional impacts on thermal generators are addressed by supporting or exempting the sector, or re-distributing revenue. In many ETS, concerns about the negative impacts of the carbon price has led to regulators providing free allowances to thermal generators. If cost pass-through is allowed, electricity prices increase (due to opportunity cost pricing), and generators gain windfall profits. An alternative approach is to exempt energy sources from the carbon pricing instrument. Mexico exempted natural gas, and Chile exempted biomass thermal generation from their respective carbon taxes, while the UK exempted electricity derived from renewable sources from its Climate Change Levy over 2001-15. Distributional impacts on thermal generators can also be reduced by redistributing carbon revenues. Infra-marginal rents accruing to low carbon generation can be taxed and redistributed to mitigate distributional impacts, or carbon revenues can be recycled back into sectors to encourage certain technologies, such as Alberta’s new technology fund or the EU ETS’s NER 300 programme.

CPIs may cause regional distributional impacts if electricity generation technology varies geographically, but targeted, direct support may reduce these impacts. In the EU, lower-income regions faced higher costs due to reliance on more emissions intense electricity generation technology. The Derogation Policy mitigated these distributional issues by granting the lower income countries extended periods of free allocation for the power sector, in exchange for investment plans to modernise and diversify their energy mix. However, this policy may have countervailed the carbon price and led to higher emissions, especially in Poland where most of the support went into fossil fuel generation. The Modernisation Fund is aimed at an improvement on the Derogation Policy and supports low-income countries during the low-carbon transition through the sale of 310 million allowances. Funding will be based on transparent and competitive bidding with smaller projects measured against objective criteria. This could be particularly relevant for Brazil, where the remote north regions receive electricity mainly from isolated oil thermal generating plants (IAEA, 2016).

Competitive dispatch facilitates fuel-switching, which supports the CPI. Carbon pricing increases the operating costs of carbon-intensive generators such that they may be replaced in the dispatch order by lower carbon electricity generation, reducing the overall emissions intensity of the electricity system. Significant fossil fuel switching in the electricity sectors of the UK and Germany was witnessed in the EU ETS over 2005-13. Similarly, Australia's electricity sector witnessed fuel-switching away from black and brown coal generation, while the market share of hydro generation increased.

The extent of fuel-switching is influenced by the flexibility of the CPI and other exogenous factors. Commodity price volatility, for example, can reverse fuel-switching. In the EU ETS over 2010, coal prices fell relative to gas prices, which induced fuel-switching towards coal, increasing emissions. CPI inflexibility to changing market conditions can exacerbate this, as is the case in ETSs with significant oversupply of allowances.

Implications for Brazil: Interaction of CPIs and thermal generators

Implementing a CPI in Brazil's electricity sector require careful consideration of the ongoing electricity market reform plans to avoid negative distributional impacts. The current electricity pricing could result in a CPI creating uneven cost distribution. In the price-regulated market, households and other small consumers are largely protected from price increases, but thermal generators bear the burden. In the price-unregulated market, large consumers face increased prices while generators bear less of a burden and low-carbon generators (particularly hydro) could reap increased infra-marginal rents if they are not signed on to long term power purchasing agreements.

Additionally, in the presence of geographic variation in generation technology, a CPI would lead to regional cost disparities - which may be mitigated by revenue redistribution. This is particularly relevant for isolated consumers in the north/north-west, whose energy demand is primarily supplied by thermal generators using diesel oil (ONS, 2017). Liberalising prices in the sector could help minimise the distributional impacts on thermal generators in the regulated market but may cause worsen the geographic distributional impacts on consumers served by more emissions-intensive generators.

THEME 4: HYDRO GENERATION AND GROWTH IN ELECTRICITY DEMAND

Table 4 provides an overview of the jurisdictions chosen, the CPI adopted, and the interaction studied.

Table 4 – Overview of Theme 4: Hydro generation and growth in electricity demand

Country	Finland	Norway	Sweden	British Columbia	Quebec
CPI	EU ETS and carbon tax	EU ETS and carbon tax	EU ETS	Carbon tax	ETS
Start Year	2005 and 1990	2005 and 1991	2005	2008	2013
Current Rate (PMR, 2017a)	US\$1.34/tCO_2 [tax]	US\$ 71.84/tCO_2e [2012 average] (Johnston, 2012)	US\$5.91/tCO_2e [2016 average]	US\$ 21.61/tCO_2e	US\$ 14.75/tCO_2e (IETA, 2018)
Policy Interaction	CPI interaction with hydro dominated electricity sector	CPI interaction with hydro dominated electricity sector	CPI interaction with hydro dominated electricity sector	CPI interaction with hydro dominated electricity sector	CPI interaction with hydro dominated electricity sector
Implementation Agency	Ministry of Finance	Ministry of Climate and Environment	The European Commission – Directorate General Clima	Ministry of Finance	Ministry of Sustainable Development, Environment, Wildlife and Parks
How Implemented	First country to implement a carbon tax in 1990. Several tax refund mechanisms incorporated into the energy taxation system.	Implemented a carbon tax in 1991 Started a domestic ETS in 2005, for sectors not under the carbon tax ETS formally linked to the EU ETS in 2009 EU ETS sectors exempt from the tax	Reset the ETS cap for each phase based on expected renewable energy generation from domestic policies Excluding traded sectors that have obligations beyond ETS obligations Design of market stability reserve that can release and absorb permits	Tax made revenue neutral due to business and distributional concerns	Only emissions from electricity and industry covered in first phase Linked to California ETS in 2015

Country	Finland	Norway	Sweden	British Columbia	Quebec
CPI Impacts	Little recorded evidence of emissions reductions in hydro dominated electricity sector	Little recorded evidence of emissions reductions in hydro dominated electricity sector	EU ETS has not had significant impacts on Sweden's electricity sector's emissions intensity	Little recorded evidence of emissions reductions in hydro dominated electricity sector	Little recorded evidence of emissions reductions in hydro dominated electricity sector
Other Impacts	Tax revenues shifted from labour to other taxes to minimise distributional impacts	ETS raised electricity prices and led to increased infra-marginal rents for hydro producers			

Source: Own elaboration.

LESSONS LEARNT: HYDRO GENERATION AND GROWTH IN ELECTRICITY DEMAND

Carbon pricing has had a low impact on reducing emissions in international jurisdictions with electricity sectors which have high shares of hydropower. Carbon pricing instruments in electricity sectors with similar shares of hydropower in electricity generation have had little impact on emission reductions. The emissions intensity of these sectors is generally already low. In particular, the EU ETS has not had significant impacts on Sweden's electricity sector's emissions intensity, possibly due to minimal available short run abatement opportunities (Widerberg & Wräke, 2009).

However, the jurisdictions identified have experienced little, if any, growth in thermal generation demand which is not the case for Brazil. For example, Sweden's annual electricity generation varied little between 380-420 TWh over 2005-15[1] (Swedish Energy Agency, 2015). While Brazil's electricity sector emissions intensity is currently 97 tCO_2e/GWh, less than a fifth of the world average of 580 tCO_2e/GWh, it is also expecting a 40% increase in coal, oil, and natural gas thermal generation capacity growth over 2014-24. This implies that natural gas utilisation, in particular, will decrease from around 73% in 2014, to 38% in 2024. Thermal capacity growth will likely vary depending on the region, for example the remote northern regions generate electricity mainly through isolated oil-fired power plants (IAEA, 2016).

The introduction of a carbon price in the electricity sector can create infra-marginal rents for hydro generators. If the marginal electricity generator burns fossil fuels, then it will face an increase in costs and therefore raise the selling price of electricity. Zero (and low) carbon generators dispatched receive additional infra-marginal rents as the price of their output increases without any change in their

[1] Except for the year 2009 where electricity generation dipped to 354 TWh, which may be attributable to the impact of the financial crisis.

costs. This depends crucially on the marginal generator being able to pass-through costs and raise electricity prices.

Distributional impacts depend on the structure of the electricity market, in particular the dispatch model and price regulation. Competitive electricity dispatch models facilitate distributional impacts on generators. In the UK, Germany, and Australia the merit-order is competitively determined and electricity prices reflect the marginal cost of generation, whereas, in Brazil the dispatch model is centrally coordinated to minimise costs and take into account water scarcity and transmission issues. Electricity prices often vary from the marginal cost of generation. The level of electricity price regulation also influences distributional impacts. Fully liberalised electricity prices allow cost pass-through resulting in higher consumer prices, potential consumer competitiveness issues, and increased infra-marginal rents for hydro generators. Regulated electricity prices only allow a certain ‘regulated’ amount of cost pass-through, which limits the increase in electricity prices, and thereby lowers the profit margins of thermal generators.

Implications for Brazil: Hydro generation and growth in electricity demand

Emissions regulation should focus on future capacity in hydro-dominated electricity markets expecting growth in thermal generation. International experience suggests that CPIs have little effect on emissions reductions in electricity markets dominated by hydro-generation and with little coal-generation. However, significant additional thermal generation capacity will be required in the future to meet rising electricity demand. As such regulating the emissions of future capacity additions, potentially through command and control mechanisms or well-designed capacity markets, may be more effective than carbon pricing given that this can provide greater certainty about fuel choice and can also include local air pollution and other negative impacts of thermal generation.

However, command and control mechanisms may be cost inefficient as they do not consider the cost of compliance. Regulatory approaches in the power sector include mandatory norms, technology or emissions standards and technology bans or moratoriums for new developments. For example, Norway imposes strict authorisation criteria for new generation investments that consider environmental issues, and Scotland, as the UK, has a requirement to install CCS for fossil fuel power stations once it becomes available.

APPENDIX: MECHANISMS TO ALLEVIATE ENERGY PRICE RISES DUE TO CARBON PRICING ON LOW-INCOME HOUSEHOLDS

Table 5 provides an overview of the jurisdictions chosen, the CPI adopted, and the interaction studied.

Table 5 – Overview of Theme 5: Mechanisms to alleviate energy price rises due to carbon pricing on low-income households

Theme	Country/region	CPI	Policy interaction
Mechanisms to alleviate energy price rises for low-income households	Australia Eastern Europe South Africa Chile Mexico	Fixed-price ETS EU ETS Carbon tax Carbon tax Carbon tax	Outline of determination of households eligible for support, mechanisms to support these households, revenue recycling mechanisms and the impacts of these schemes on low-income households.

Source: Own elaboration.

Lessons learnt: Mechanisms to alleviate energy price rises due to carbon pricing on low-income households

CPIs can increase electricity prices significantly and thereby impact end-use consumers. As low-income households spend the largest proportion of their income on electricity typically, CPIs can potentially impact them disproportionally. The analysis of 5 case studies shows there are some general mechanisms that are effective in alleviating energy price rises caused by CPIs for low-income households.

If a CPI raises electricity prices, households face distributional impacts and can be supported through direct transfers without diluting the carbon price signal. The regressive impacts of electricity price increases necessitate support be given to certain groups. However, supporting mechanisms should be designed to be coherent with carbon pricing mechanism. Revenue recycling, such as direct transfers to households, can provide support while maintaining the carbon price signal. Australia, for example, provided assistance to low-income households through direct cash transfers and tax cuts, financed largely by the CPM itself, which were designed such that the emission reduction incentive of the carbon price signal was retained. Similarly, Phase 3 EU ETS no longer provided free allowances to the power sector and indirectly alleviated distributional impacts. While not reducing electricity prices, the increase in government revenue from auctions could be used to support low-income households

It is important to have a smart design of selecting households that are eligible for support to mitigate impacts of CPIs on energy prices. This is important to make the policy cost-effective. South Africa demonstrates that a self-selection method whereby households with a low ampere connection to the grid get guaranteed a free proportion of electricity works well. However, the mechanism should also include a revenue raising component to be able to afford this scheme, e.g. cross-subsidization.

Energy price rises can also bring about more rational use of energy and thereby GHG emission reductions. It will therefore be important to find a right balance between no significant price rises that impact low-income households disproportionally, but enough incentives for rational use of electricity. The case studies also demonstrate that revenue recycling is an effective mechanism to prevent negative impacts of a CPI on low-income households and could perhaps be used to find this balance.

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1 INTRODUCTION - SELECTION OF CASE STUDY JURISDICTIONS

This chapter will start with a brief overview of the characteristics of the Brazilian electricity sector that have been used to select case studies for each chapter.

1.1 BRAZILIAN ELECTRICITY SECTOR

1.1.1 ELECTRICITY LANDSCAPE

The electricity sector is dominated by hydropower and accounts for only a small share of the country's overall GHG emissions. Hydropower accounts for 64.5% of total power supply capacity and 65.8% of total electricity generation in 2016 (EPE, 2016; MME, 2017). The remainder of electricity comes from thermoelectric generation and an increasing share of renewables such as wind (Corrêa Da Silva, De Marchi Neto, & Silva Seifert, 2016; Instituto Acende Brasil, 2015). The electricity sector only accounts for 3.5% of total GHG emissions (and 12.6% of CO_2 emissions (EPE/MME)) and has an emissions intensity of 97 tCO_2e/GWh, less than a fifth of the world average of 580 tCO_2e/GWh.

Strong electricity demand growth will require new generation capacity. Installed capacity will increase by 78.6GW to reach 212.5GW in 2024 - 41 GW of which was already contracted for by 2014 – which will be accompanied by an additional 70,000 km of transmission lines and 163 giga volt amperes in substations to the National Interconnected System (SIN).[2] The total investment in electricity generation and transmission between 2014 and 2024 is estimated to be US$101.3 billion and US$40.8 billion, respectively (SPE/MME 2014).

Expected increases in energy demand until 2024 imply a near 40% increase in Brazil's required thermal generation capacity. While hydropower is the dominant form of electricity generation in the country, its expansion is becoming increasingly constrained by geographic remoteness, environmental and social sensitivities and concerns over water supply certainty. This means that expected future increases in electricity demand will likely become increasingly reliant on other sources of electricity generation (IEA, 2013). Brazil is expecting a 40% increase in coal, oil, and natural gas thermal generation capacity growth over 2014-24, as shown in Figure 1. However, natural gas capacity is expected to increase by 75% while simultaneously reduce its electricity generation by 6%, implying that utilisation will decrease from around 73% in 2014 to 38% in 2024.

[2] Of the total capacity increase, 73.5 GW are in the National Interconnected System (SIN). The remainder fall on captive consumers (6.8 GW) whereas there is a fall in isolated systems by 1.7 GW.

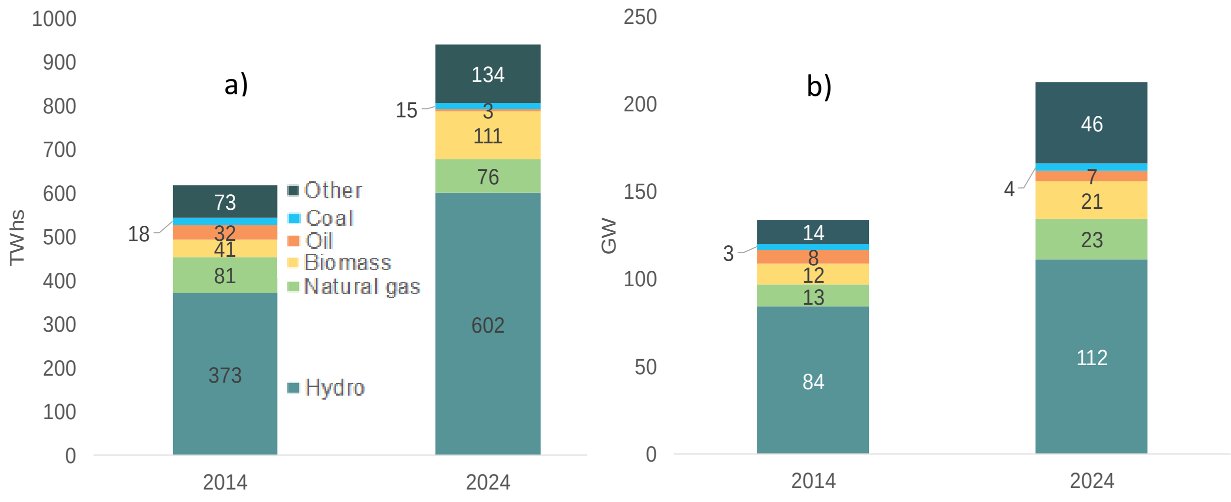

Figure 1 - Over 2012-24, coal, oil and gas see a 28% reduction in electricity generation (a), but a 40% increase in capacity (b)Note: The category 'Other' includes imports, nuclear, wind, solar, and industrial gas

Source: Office of Strategic Energy Studies (2015).

Brazil has a diversified hydropower system with storage that allows for the integration of intermittent renewables, but it also has regional discrepancies between supply and demand creating transmission challenges. Brazil's hydropower is derived from a variety of hydro-basins which are connected and co-ordinated in SIN. This diverse portfolio provides significant flexibility that will be important for allowing the integration of more intermittent renewables. However, large parts of Brazil's hydroelectric potential are a long way from electricity consumption centres and requires significant transmission. Consequently, localised generation, mainly thermal and renewables, is often preferred to some extent.

Policymakers are therefore focused on increasing access in remote areas and maintaining affordability. The Brazilian medium-term plan for the energy sector (*Plano Decenal de Expansão de Energia, PDE*) includes the objectives of ensuring energy security, maintaining energy affordability, increasing access to energy and meeting emission reduction targets (Luomi, 2014). While 99% of Brazilians have access to electricity, providing electricity to the balance of almost one million people in remote northern sections of the country is a policy imperative, but it is also recognised as challenging (IEA, 2013; World Bank, 2012).

Given that the supply of these remote regions is principally provided by oil thermal generators, the geographic and distributional impacts of carbon pricing will be especially important. Households in remote northern states tend to have the highest rates of poverty in Brazil and electricity tariff structures already subsidise electricity usage in these areas (Soares et al, 2016). Electricity is supplied mainly via small thermal generation plants, which typically rely on oil (IAEA, 2016).

The government exerts a large influence along the electricity sector value chain. The federally owned company Eletrobras holds 40% of generation capacity in Brazil with other state companies (CESP (8%), Cemig (7%), Copel (5%)) holding an additional 20%. The remaining 40% is owned by the private sector. This generated electricity is passed on to the transmission grid, which is owned by

Eletrobras (69%) and by other state companies (31%), thereby making transmission almost exclusively under government control.

However, recent reform has taken place in the electricity sector. The electricity sector in Brazil has been formally unbundled since 1995, stipulating that distribution companies are not allowed to carry out generation or transmission activities, nor sell electricity to large-scale consumers. Generation companies in turn need to be disconnected from distribution companies. Reforms have aimed to increase private participation, including through a more liberalised approach to electricity dispatch and the splitting of the electricity sector into two markets to allow private investment into new generation (EIA, 2015).

1.1.2 KEY POLICIES AND INSTRUMENTS

There are a number of existing policy instruments in the thermal electricity generation sector in Brazil which are likely to interact with carbon pricing instruments. The discussion below focuses on the key policies which have been identified as the most significant in terms of their interaction with the carbon price signal and in the context of the key issues of relevance to Brazil.

First, direct supports for thermal generators across Brazil incorporate subsidies through fixed input prices and tax exemptions. There are two main policies:

1. While oil prices were formally deregulated in 2002, up until recently the government effectively intervened using the pricing decisions of the state-owned enterprise, Petrobras, to limit price variation and control inflation (Coady et al., 2013). While current low international prices imply low or zero subsidies, higher international oil prices in the future may lead to higher implicit or explicit subsidies;
2. Coal and natural gas used in electricity generation have been explicitly exempted from fuel taxes (PIS & COFINS). The implied subsidy provided by the exemptions for coal and natural gas purchased for thermal electricity generation amounted to US$47 million in 2014[3] (OECD, 2016).

Second, to improve energy access in remote areas and affordability for low income households, the sector is supported using two funds.

- The $4.2 billion Energy Development Account (CDE) has a variety of objectives including: to support low-income households; to support diesel- and coal-fired power plants; to encourage the expansion of natural gas in Brazil; to maintain the competitiveness of alternative energy sources; and to support electrification of rural areas. The CDE is funded by various levies on electricity distributors who sell electricity to consumers (Filho, 2012), and;
- Primarily funded out of the CDE, the US$1.5 billion Fuel Consumption Fund (CCC) (OECD, 2017) supports diesel-powered thermal generators in remote northern regions of Brazil so that

[3] Using exchange rate from: https://fred.stlouisfed.org/series/AEXBZUS

households in these areas benefit from geographically equalised tariffs. The Fund provides thermal generators in these areas resources equal to the difference between the high cost of generating electricity in the region and the national average cost of generation (OECD, 2014a).

Eletrobras originally administered both the CDE and the CCC, however, as of January 2017 these funds are administered by the Brazilian electric energy trading chamber (*Câmara de Comercialização de Energia Elétrica* – CCEE) (US SEC, 2016).

Third, the country's electricity market structure has been reformed to increase private generation capacity. In 2004, a new model for the electricity sector was implemented which established two electricity markets, supported by a reserve market:

- The regulated market (*Ambiente de Contratação Regulada* -ACR), electricity supply contracts to deliver electricity five-years and three-years ahead are purchased by distribution companies through auctions for existing plant electricity or future capacity. Contract lengths range from 15 years, for thermal generation, to 30 years for hydro generation. Regulated market public auctions also impose price ceilings on electricity supply bids (Dutra & Menezes, 2015)
- The free market (*Ambiente de Contratação Livre* - ACL)., which allows non-regulated consumers[4] to purchase electricity at freely negotiated prices and terms.
- Reserve auctions are also held to provide reserve capacity to ensure energy security.

Electricity dispatch is organised centrally according to cost minimisation principles but takes into account water scarcity issues. The non-profit Operator of the National Electricity System (ONS) centrally determines the short-term generation dispatch order by estimating national electricity demand while considering hydrological conditions and transmission issues (US SEC, 2016). Dispatch does not take into account competitively determined contracts but instead co-ordinates the hydro-based electricity mix complemented by thermal power plants to ensure reliable electricity supply (Filho, 2012)[5]. The differences between the amount of electricity physically generated and consumed and the amount of electricity established to be produced or consumed in the competitively-determined contracts is accounted for and settled each month, with any differences paid to generators (Corrêa Da Silva et al, 2016). Thus the Brazilian short term market is a mechanism to settle differences between agents' contracted electricity production or receipt and what commitments are actualised, rather than an actual market whereby generators make the decisions themselves about whether to produce electricity (Calabria, 2014).

[4] Unregulated consumers are large consumers (≥ 3 MW) or a consortium of consumers (≥ 0.5 MW), who have the option to buy energy in any environment, but must notify the distributor 5 years if they want to return to the regulated market, or special consumers (0.5-3 MW) who can buy renewable energy directly from producers in the free market (Enel, 2017).

[5] http://documents.worldbank.org/curated/en/114141468265789259/pdf/638750PUB0Exto00Box0361531B0PUBLIC0.pdf

1.1.3 Electricity tariffs in Regulated and Free Markets

There are two markets in Brazil in which electricity is traded: the regulated market (*Ambiente de Contratação Regulada* -ACR) and the free market (*Ambiente de Contratação Livre* - ACL).

In the regulated market, representing 75% of electricity sales, distribution companies sell the energy directly to consumers. The rates in this market are set by the regulatory agency ANEEL (Brazilian Electricity Regulatory Agency). ANEEL is an independent agency operating at the national level, which implements policy decided by the Ministry of Mines and Energy (MME). ANEEL is responsible for managing concessions for electricity generation, transmission and distribution activities, and the determination of transmission and distribution prices (Calabria, 2014; Gallo & Lopes Lobianco, 2015; Instituto Acende Brasil, 2015).

The electricity tariff in the **regulated market** is set based on costs of energy generation, transmission and distribution and 14 different taxes and levies.

The other 25% of electricity is sold to large-scale consumers (over 3MW) in the free market. There are about 150 energy trading companies active in the free market. In the free market, rates are negotiated between consumers and generators or traders. High tariffs in the regulated market are increasingly driving large consumers into the free market (Costa, 2017). However, smaller consumers are unable to access the lower prices associated with the free market.

1.1.4 Key objectives of the Brazilian electricity tariff policy

The cost of electricity in the regulated market is dependent on the needs to expand the grid and generation capacity, to allow access to electricity for low-income and remote communities, and to account for the increasing demand for electricity of an emerging economy (Instituto Acende Brasil, 2015).

Some of the key policy objectives are highlighted:

Modicidade tarifária – Since the early 2000s, a key objective has been to minimise electricity tariffs faced by consumers as a priority. The key instruments for achieving this include centralised auctions, intended to introduce competition.

Bandeira tarifaria – By means of “traffic light” tariffs, conceived to encourage rational consumption of electricity, consumers are made aware of whether the marginal costs of generation in the following month, and therefore the electricity prices, are expected to be low (green) or high (red). This was instituted in 2015 following a dry spell in which hydro output was low, and consumers had to be encouraged to ration.

Tariff realism: In 2014 Brazil began to focus on “tariff realism“, which aims at the alignment of the end consumer tariffs with the electricity production cost. Electricity tariffs began to increase in the beginning of 2015, in order to address the 2014 deficit by an average tariff increase of 50%.

Equidade tarifária – The tariff equity policy objective aims not to impact one particular income group disproportionately.

1.1.5 CENTRALIZED AUCTIONS FOR CONTRACTING NEW POWER PROJECTS

Centralised auctions are held in order to contract new power projects for the regulated market in Brazil. These auctions are organized by the National Electricity Regulator (ANEEL) under the guidance of the Ministry of Mines and Energy. This mechanism targets both renewable and thermal technologies, although there are separate auctions for each technology type. This allows the government to select the technologies which will participate in an auction process. The centralized auctions for renewables serve as the main policy instrument in Brazil to promote renewable energy generation, since growth in the sector is a national priority (International Renewable Energy Agency, 2015).

The main objective of this policy is to generate capacity to bridge the gap between supply and demand, as Brazil's demand has grown 4.3% annually. It also aims to ensure adequate supply in the country based on load forecasts, optimal management of hydropower reserves by distribution companies and efficiency in the procurement process by reducing information gaps between the government and industry. When an electricity generator wins the auction, it will sign a contract with a power distribution utility and will be awarded a guaranteed offtake for 20 years.

2 INTERACTION OF ELECTRICITY TARIFF POLICIES AND CPIS

This chapter comprises an analysis of the interaction between CPIs and electricity tariff policies. It will describe two case study jurisdictions and interactions of their electricity tariff policies with CPIs.

2.1 CARBON PRICING AND ELECTRICITY POLICY INTERACTIONS

This section will provide the introductory theory behind the key interactions studied in this report, namely how carbon pricing instruments interact with electricity tariff policy.

2.1.1 ELECTRICITY TARIFF POLICIES

There are several characteristics of electricity sector which determine electricity tariffs, both physical and related to the policy or regulatory environment. This study focuses on the policy and regulation which determines wholesale and retail electricity prices.

Regarding the policy which determines wholesale electricity prices, we will focus on the regulatory environment for wholesale price setting. In most markets, the electricity price is determined by the marginal cost of generation in a merit order, and dispatch is also determined by this merit order. The merit order may be determined by wholesale spot markets, or in the case of Brazil's regulated market, it is determined by the system operator's dispatching decision. However, prices may also be negotiated through direct bilateral contracts between producer and consumer (e.g. free market in Brazil). This price in turn is affected by the physical characteristics of a country's installed capacity (technology types, capacity, and other attributes), and the level of competition between generators.

Regarding the policy which determined retail prices, the regulatory approach in a country will determine the extent to which generation, transmission, distribution, environmental and other costs are passed through to final consumers, and how they are shared out amongst different consumer groups, e.g. through taxes and levies. In addition, taxes and levies with a variety of different objectives including social and environmental objectives (e.g. support to RES generation) may also be applied.

Carbon pricing instruments interact with these key determinants of electricity tariff policy in the following three ways:

In the short-term CPIs seek to encourage fuel switching in electricity generation. CPIs make high carbon thermal generation more expensive than lower carbon substitutes, allowing for instance for the possibility of switching from coal to gas generation. Whether this happens depends on whether carbon pricing can affect the dispatch merit order. As seen above, this will depend on how the dispatch merit order is comprised (spot market, command and control decision by central dispatcher). In addition, the physical switching capacity must also be available within the market (e.g. availability of gas capacity). The extent to which fuel switching happens also depends on the level of competition within the electricity market and on the price differential of the sources considering a possible carbon price.

In the medium to long term, CPIs seek to make fossil fuel based generation less competitive. As renewable sources become more competitive, this can lead to fuel switching in the longer-term. Regarding regulation, this is partly determined by the regulatory routes to market for new power projects (whether fossil based and renewable generation compete directly, or, centralised technology specific auctions are held). In addition, as a commercial investment decision, this typically depends on the returns that power producers expect from the project, which is based on the volume, price and investment outlook that can be influenced by a carbon price or renewable energy targets.

The carbon price signal passed onto electricity prices can encourage a rational use of electricity through energy efficiency incentives. This depends on the degree to which the carbon price causes the electricity price to rise and if the carbon price is passed through to final consumers. Where the point of obligation is on the generators of electricity, the extent to which the cost is passed through to consumers is referred to as the pass-through rate (PTR). The level of PTR heavily depends on the regulation in place that determine whether electricity generators are allowed to pass costs through to consumers. These regulations are usually negotiated and agreed with regulators in advance. Secondly, the PTR is dictated by the price elasticity of demand and can be expected to be higher in less elastic markets. Elasticity depends on market factors such as the availability of information on prices, barriers to switching suppliers, and sensitivity of consumers. Low-income households and energy intensive industries are typically more price sensitive.

2.2 Selection of case study jurisdictions

New Zealand has been selected as a case study for several reasons. Like Brazil, New Zealand's electricity market is considered as not fully regulated and not fully liberalised (Electricity Authority in New Zealand, 2012). New Zealand also has a significant amount of generation capacity coming from hydro-energy and has recently introduced a carbon pricing mechanism.

South Africa was selected as a case study because it is an emerging economy, with similar challenges to Brazil. These comprise access to electricity for low-income and remote communities and the electricity tariff policy objective to keep electricity prices low, while demand is growing rapidly (BusinessTech, 2015).

Experiences with the implementation of the New Zealand Emissions Trading Scheme (NZ ETS) and the South African carbon tax are presented in this chapter.

2.3 New Zealand

This chapter will present the case study from New Zealand and will demonstrate the impacts of interactions between electricity tariff policies and a CPI.

2.3.1 Electricity Pricing Policy Landscape

This section will follow the approach mentioned above to outline which characteristics in the New Zealand electricity market are important to consider when looking at the impact of a carbon price to reduce GHG emissions. **These include determinants for fuel switching, long-term investment in renewable energy generation and PTR of costs.**

2.3.1.1 Determinants for fuel switching

New Zealand's generation capacity consists of 54% hydropower, 20% gas, 10% geothermal, 7% wind and 6% coal. Electricity in New Zealand is traded in a wholesale market, which is regulated by the electricity industry participation code. Electricity generators can submit bids via a wholesale information and trading system. In this system, electricity generators report how much they will generate for the next half hour and for what price. Transpower then selects the lowest price deal for each time period. The prices for electricity that is selected fluctuate heavily, depending on seasonal demand and weather conditions that change the availability of hydropower.

2.3.1.2 Determinants for long-term investment in new generation capacity

The previous New Zealand Government tried to satisfy both the objective of increasing competition and the objective of increasing renewable energy generation of electricity to 90% by 2025 (Renewable Energy World, 2007).

New Zealand has a liberalised market where independent power producers (IPPs) can participate. IPPs are free to make their own investment decisions for the construction of new capacity. These decisions typically depend on the returns that the IPPs expect from the project, which is based on the volume, price and investment outlook that can be influenced by a carbon price or renewable energy targets.

While a previous New Zealand government introduced a ban on the construction of new thermal generation plants in 2000, this was repealed in 2010. Since 2011 the New Zealand government has taken several measures to remove barriers for investments in renewable energy. These include new legislation that requires the consideration of the benefits of the generation to be included in the resource consenting process (Ministry of Economic Development, 2011).

2.3.1.3 Determinants for PTR of costs

The utilities and policy landscape in New Zealand illustrates that the electricity price that consumers pay reflects energy costs, line charges, metering costs, retail and operating costs. Companies are free to pass on any costs to consumers. This includes the costs associated with environmental policies.

The key objectives of New Zealand's electricity tariff policy include: competitive wholesale markets, support to renewable generation, avoidance of electricity prices fluctuations and protection of vulnerable income groups.

One of the main policies regulating the market is the Electricity Industry Reform Act, which was amended in the Electricity Amendment Act of 2001 (Electricity Authority in New Zealand, 2012; Ministry of Business Innovation and Employment, 2016). The main objective of this regulation is to promote competition in the electricity market for the long-term benefit of consumers in New Zealand. The Act allows the Government to provide incentives for firms to increase competition.

Electricity market participants in New Zealand pass their emissions costs on to consumers. The actual pass-through of social or environmental levies depend on several factors, including:

- contracts between firms;
- the specific type of energy consumed;
- the choices of the energy producer for passing costs onto households and consumers;
- whether a firm receives an allocation for emissions-intensive trade-exposed (EITE) activities.

92% of generation capacity is owned by five companies in New Zealand. The electricity is sold to consumers by retail companies. This supply market is dominated by the same five companies that dominate the generation market.

2.3.2 Emissions Trading Scheme - New Zealand

The ETS in New Zealand is the government's main policy response to climate change. It is designed to support New Zealand to meet its international obligations to reduce GHG emissions.

The scheme requires all sectors of the economy to report on their emissions, and to purchase and surrender emission allowances to cover those GHG emissions. This price on GHG emissions is intended to create a financial incentive for investments in technologies or practices that reduce emissions. Just over half of the country's GHG emissions are now covered by the ETS and are obliged to obtain New Zealand Units (NZUs), which are carbon allowances (Richter & Chambers, 2014).

Electricity sector companies in New Zealand do not receive free allocation of emission units and they are expected to pass on all the costs of buying NZUs to their customers.

2.3.3 Expected interactions of the CPI with the underlying policy landscape

This section will consider what the expected impacts were on the efficacy of the ETS when introduced into the existing electricity tariff policy landscape. The main interactions that will be studied include the effects the introduction of the CPI has on GHG emission reductions through fuel switching, rational use of energy and investment in renewable energy considering the alignment with New Zealand's electricity policy objectives.

2.3.3.1 FUEL SWITCHING

Dispatch decisions in New Zealand are made in a spot market on the basis of marginal costs. This method of central dispatch decision-making in combination with the flexible installed generation capacity of New Zealand makes fuel switching possible when a carbon price is introduced.

Additionally, New Zealand generates 7% of its electricity from coal and 20% from gas. This seems to suggest that a fuel switch from coal to gas would be possible, as gas is an energy source that can rapidly be switched on and off depending on the prices in the spot market and dispatch decisions. Gas in general emits much lower amounts of GHGs to the atmosphere than the burning of coal for electricity generation. A fuel switch from coal to gas could therefore reduce GHG emissions in the short-term.

Overall, the introduction of the ETS in New Zealand was expected to cause significant fuel switching to lower-carbon generation sources due to available capacity and competitive dispatch enabled through the competitive spot market.

2.3.3.2 LONG-TERM INVESTMENT IN RENEWABLE ENERGY GENERATION

In the longer term, the expectation was that the ETS would incentivise increased investments in renewable energy as the carbon price would make New Zealand's electricity from thermal generation less competitive. Investment decisions for new capacity in New Zealand is mostly based on the expected return on investment and additional regulation that can support renewable generation, as explained in the previous chapter. Both the presence of a carbon price and legislation that supports renewable energy generation, suggests that renewable energy would offer a more favourable investment outlook compared to thermal generators in New Zealand.

2.3.3.3 PTR OF COSTS TO INCENTIVIZE RATIONAL USE OF ENERGY

Lastly, the government expected the carbon price to impact electricity prices and thereby incentivise rational use of electricity by consumers. Wholesale electricity prices were expected to increase by 5%, i.e. 1 cent/ kWh under a carbon price of 15 New Zealand Dollars (NZD) and 10% (or 2 cents/ kWh) under a scenario of a carbon price of 25 NZD. With the planned introduction of the ETS the expectation would be that retail consumer prices for electricity would increase by 4-5% during the first phase of the ETS (Richter & Chambers, 2014).

The CPI in New Zealand is expected to be in line with New Zealand's electricity tariff policies that aim to have a high level of competition in the electricity sector. However, as prices are expected to increase under a CPI it does counteract the policy objective to keep electricity prices low in New Zealand and protect vulnerable groups. As described above, electricity prices are expected to increase significantly under the ETS.

In conclusion, the following outcomes were expected following the introduction of a CPI:

- The existence of competitive wholesale markets in New Zealand would allow the carbon price to influence the merit order dispatch and cause fuel switching from coal to gas. This is in line with current electricity market policies that promote competitiveness.
- Increased investments in renewable energy due to New Zealand's liberal market where a CPI would make the investment outlook for renewable generators more attractive for developers. Also in line with competitiveness policies.
- Lastly, incentives for rational use of electricity due to the possibility for companies to pass through additional costs to consumers. However, this is not in line with the electricity tariff policy objective, as they contradict the policy objective to avoid big fluctuations or increases in the electricity price.

2.3.4 CHANGES MADE BY THE GOVERNMENT TO COMPENSATE FOR THE INTERACTION AND HARMONIZE POLICY INSTRUMENTS

2.3.4.1 HOW WAS THE CPI CHANGED BASED ON THE EXPECTED INTERACTION?

Since the introduction of the ETS in 2008 the government of New Zealand has made several adjustments to the ETS to minimize the effects of the carbon price on the competitiveness of trade exposed industries and households. These changes include:

A transitional phase called the one-for-two surrender obligation was created, to moderate the initial impacts of the CPI during the economic downturn. This initial phase was extended through formal reviews in 2009 and 2011. In this phase, measures were put in place to allow non-forestry participants to surrender one emission unit for every two tonnes of GHG emissions. In addition, participants were provided with the option to buy NZUs from the government for a fixed price of 25 NZD. This was meant to limit the potential costs faced by emitters, as the effective carbon price they pay is half the unit price.

Delay of the introduction of reductions in the level of free allocation of NZUs indefinitely, to protect the competitiveness of businesses in emissions intensive and trade exposed (EITE) industries. The free allocation of allowances to industry is a common measure taken by governments implementing an ETS. In New Zealand, the free allocation is output-based. However, it will be phased out by 1% of the starting level per year starting when a full unit obligation is in place. Allowances are also allocated to the forestry and industrial sectors. These amendments in 2012 allowed the Government to auction NZUs under a cap, but this has not been implemented as of July 2016 (Environmental Defense Fund, Motu Economic and Public Policy Research, & IETA, 2016).

Banking and borrowing of allowances has been used to reduce the impact on trade exposed industry in various ETS schemes. Cap and trade can lead to price volatility because the inelasticity of the supply of permits is combined with inelastic demand for permits in the short run (e.g. when plant, equipment and technology are fixed). Such volatility makes corporate planning difficult and is unappealing to risk-averse investors. Instability can be mitigated by allowing 'banking and borrowing' of quotas. In New Zealand, there are no quantitative or time-based limits on banking allowances, and borrowing is enabled.

Participants of the ETS can meet their obligations for the prior year using the current year's free allocation. Carrying forward some banked units is necessary and to be expected, mostly because foresters need to manage ETS obligations over long harvest cycles. In the case of New Zealand, it is acknowledged that if too many allowances remain in circulation, they will lower the carbon price and will thereby hinder the effectiveness of the scheme.

It should be noted that any intervention to control or reduce either carbon or electricity prices will impact on the effectiveness of the CPI to reduce emissions. An intervention would decrease the expected impact on fuel switching, increased investment in renewable energy and also cause the electricity prices to increase by a smaller amount, thereby providing a weaker price signal to consumers for rational use of electricity.

For these reasons, New Zealand is now considering the removal of the one-for-two surrender obligation. This removal would increase the incentive to reduce emissions and give businesses greater certainty when making investment decisions. This would be particularly important for long-lived assets, that will be affected by potentially higher costs of emissions in the future.

However, if the NZ ETS moved to a full surrender obligation, demand for units would double and costs to NZ ETS participants would increase. This is expected to result in increased costs to participants with indirect implications for non-participating companies, households and the wider economy. The scale of these impacts depends partly on the carbon price, which is difficult to predict. The government wants to ensure the benefits from moving to a full surrender obligation are balanced with keeping the cost to the economy manageable. They are therefore considering the option to gradually move to a full surrender obligation or to adjust the existing 25 NZD fixed price surrender option. The government also plans to increase free allocation to emissions-intensive and trade-exposed activities to mitigate the impact on vulnerable sectors.

2.3.4.2 *How was the underlying policy changed based on the expected interaction?*

Additionally, there are several measures which can be taken to amend underlying electricity tariff policies in order to account for disproportional impacts on low-income users and energy intensive users. However, the New Zealand government has so far only considered changes in the ETS rather than changes to electricity tariff policies to mitigate the impacts of policy interactions.

2.3.5 Actual impacts of the introduction of the CPI

The actual impacts of the introduction of the CPI in New Zealand on emissions, investment in renewables and the carbon pricing signal were weaker than expected. The decrease in thermal energy production responsible for large amounts of GHG emissions either did not occur or was attributed to factors other than the carbon price signal. The following effects on energy source generation were observed in New Zealand after the introduction of the ETS in 2008 up to 2010:

Coal generation increased from 2007 to 2010 from 4.8 to 5.3 million tonnes. This has been attributed to the easing of the global financial crisis.

Gas generation increased from 8.0% to 10.2% of total consumer energy from 2007 to 2010. This has been attributed to increased production at certain gas fields in New Zealand.

Renewable generation increased from 67% to 74%. However, this has mostly been attributed to the higher levels of water in hydro lakes rather than price incentives from the ETS (Richter & Chambers, 2014).

The above does not provide evidence that fuel switching in short or long term occurred as a result of carbon pricing between 2008-2010. The data also seems to suggest that the current price signal of the ETS in New Zealand is too low to bring about these expected changes, nor provide incentives for the rational use of energy.

From 2011 onwards, no significant changes in generation were observed. Moreover, no accounts have been recorded whereby lower-carbon options were prioritised in the half-hourly wholesale market, i.e. the dispatch of electricity. This seems to suggest that the ETS did not incentivise fuel switching in New Zealand in the way it was expected to (Richter & Chambers, 2014).

It has also been reported that electricity prices in New Zealand did not increase as a consequence of the ETS introduction. Therefore, it can be concluded that the CPI did not incentivise more rational use of energy, as was originally expected.

Figure 2 shows that the carbon price was at a low level from 2012 to 2016. The above described limited effects of the carbon price are mostly due to this low price. Only since the latter part of 2016 has the price been over 15 NZD per tonne, as anticipated by the government initially. Further research thus needs to be carried out to see what the effects of this higher carbon price are on electricity tariffs and GHG emissions in New Zealand.

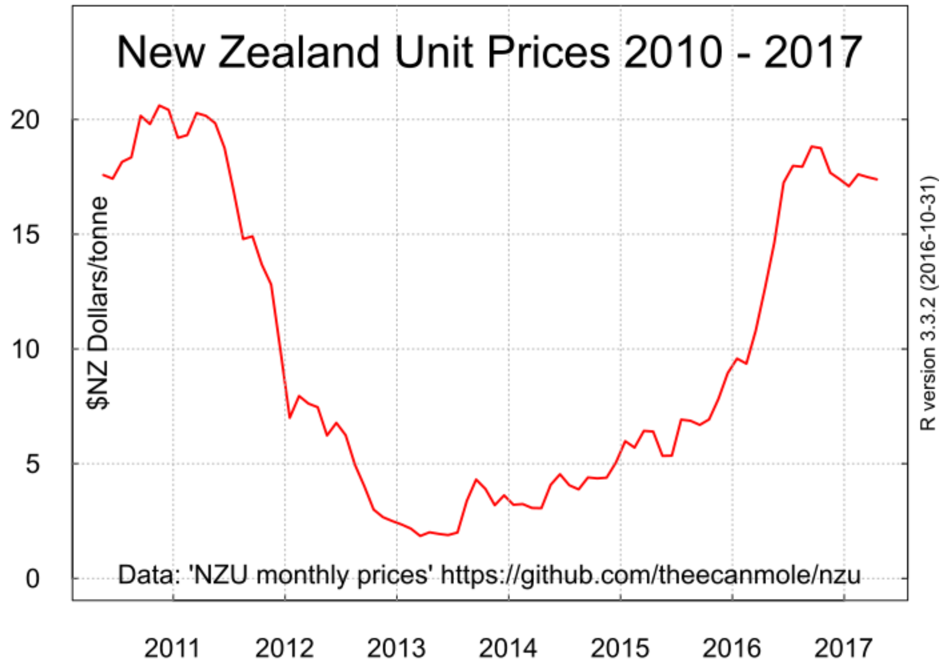

Figure 2 - New Zealand Carbon Price 2010- 2017

Source: Motu Economic and Public Policy Research, 2016.

In conclusion, the carbon price in New Zealand was too weak to bring about the emissions reductions that were expected:

No evidence has been provided for fuel switching due to the introduction of the NZ ETS. The fuel switching to lower carbon generation that did occur was instead attributed to economic drivers such as the recession and weather conditions.

It has been speculated that due to the low carbon price, the investment outlook for fossil or renewable generation has not been significantly impacted.

Finally, electricity prices in New Zealand did not rise after the introduction of the CPI, thereby not providing a price signal to promote more rational use of energy in New Zealand.

2.4 South Africa

This chapter will present the case study from South Africa and will demonstrate the impacts of interactions between electricity tariff policies and a CPI.

2.4.1 Electricity Pricing Policy Landscape

This section will follow the approach presented above to outline which characteristics in the South African electricity market are important to consider when looking at the impact of a carbon price to reduce GHG emissions. These include determinants for fuel switching, long-term investment in renewable energy generation and PTR of costs.

2.4.1.1 Determinants for fuel switching

The electricity market in South Africa operates under a near monopoly where ESKOM, a state-owned company, owns 96% of the generation capacity. ESKOM has an 'internal pool' whereby IPPs can bid a price and a volume of electricity to be produced for each hour of the day ahead. ESKOM then decides the merit order based on the lowest prices bid until all demand is met. In the current system, ESKOM is the dominant entity in South Africa for generation and transmission of electricity. IPPs are allowed but only play a minor role in the current system. IPPs can sell their electricity directly to the customer or to ESKOM.

South Africa generates 92% of its electricity from coal and 7% from nuclear sources. The private sector and municipalities own the other 4%. ESKOM also operates the transmission grid and is responsible for 58% of the distribution of electricity. Municipal and other distributors are responsible for the other 42% of distribution of electricity (Fisher & Downes, 2010).

2.4.1.2 Determinants for long-term investment in new generation capacity

In South Africa, investment in new capacity is determined by market liberalisation policies and the REIPPP scheme. The market liberalisation policies allow IPPs to participate in long-term investment for renewables. The REIPPP scheme provides guarantees to make investments in renewables more attractive.

The electricity market in South Africa has recently been liberalised. Previously, long term investments in new capacity were dominantly made by ESKOM. As ESKOM owns most of the transmission network in South Africa as well, ESKOM also decided whether a new power project can be connected to the grid.

Currently, IPPs can participate in the market and make investment decisions to build new generation capacity. These investment decisions of IPPs typically depend on the returns that are expected from the project. This is based on the volume, price and investment outlook of the project and these determinants can be influenced by a carbon price or renewable energy targets. For example, South Africa has a mechanism in place to stimulate investments into renewables for new capacity generation. This is the Renewable Energy Independent Power Procurement (REIPPP) scheme, whereby the government organises central auctions for renewable energy generators to bid on. The government provides support to these generators by offering guaranteed offtake. This scheme and its interactions with a CPI in South Africa are further explored in section 3.3.

2.4.1.3 Determinants for PTR of costs

The electricity price in South Africa is determined between ESKOM and NERSA, the regulator. ESKOM can apply for a certain amount of revenue required based on a return on the regulated asset base and pass-through of costs. NERSA can then approve or amend this request, after which ESKOM calculates the corresponding electricity tariff based on this set revenue allowance and forecast of sales.

In total, only 16-18% of sales of electricity in South Africa is sold to the residential sector. Industry accounts for the other 82 – 84%.

The electricity prices in South Africa are some of the lowest in the world due to historical subsidies and the government trying to keep prices low (Fisher & Downes, 2010; Republic of South Africa National Treasury, 2011). The aim of the government to keep electricity prices low through restricting the amount of revenue that ESKOM can claim, suggests that not all generation, transmission, distribution and environmental costs imposed by a possible CPI are free to be passed through to consumers in South Africa. The revenues for ESKOM that are allowed by NERSA are decoupled from actual expenses incurred by ESKOM. This seems to suggest that there is no real opportunity for ESKOM to fully or sufficiently pass through generation, transmission and distribution costs to consumers.

2.4.2 Carbon Tax - South Africa

South Africa has been considering the implementation of a carbon tax, to support its commitments to GHG emissions reductions of 34% by 2020 and 42% by 2025.

South Africa is in the process of implementing a carbon tax that will be applicable to the electricity sector. The objective of the carbon tax is to allow a smooth transition to a low-carbon economy by *"correcting the prevailing prices of goods and service that generate excessive levels of anthropogenic GHG emissions"* (Simcock, 2016; South Africa National Treasury, 2013). The choice for a carbon tax over an emission trading scheme is based on three assumptions:

- that the low number of industry players in the energy sector combined with the reduced number of abatement opportunities in South Africa do not provide enough opportunity for sufficient competition. Subsequently, permit prices for an ETS would have limited effectiveness;
- the oligopolistic construction of the energy sector in South Africa is unable to provide efficiency gains under an ETS system; and
- that South Africa does not have the institutional capacity necessary for a transparent, credible and competitive ETS.

The carbon tax is also assumed to have low administrative costs and is planned to be set at 120 ZAR per tCO_2e (about 13.6 USD). The plan is to increase this carbon price by 10% annually until 2019 (the first phase). There will be a tax-free exemption threshold of 60% allowed for all obligated entities (i.e. 60% of emissions are tax free). Emission-intensive, trade-exposed industries are allowed a higher threshold of up to 95%. The threshold has been set with the idea it will effectively impose a tax on 5-40% of emissions and thereby set a price of 6-48 ZAR per CO_2e. This carbon tax includes an allowance for companies to offset 5-10% of their emissions. This offsetting mechanism effectively creates a hybrid CPI between a carbon tax and a trading system (Simcock, 2016).

In the implementation of the carbon tax, the South African government considered distributional impacts including impact on electricity prices and lower-income groups. The government is considering changes in the electricity levy, a levy imposed on thermal generators, with the aim to have no net impact on electricity prices.

The government also considered competitiveness concerns related to disadvantaging trade exposed industrial sectors. To adjust for the competitiveness impacts the South African government is considering a longer period of phasing in of the tax rate for trade-exposed industries, such as mining and machinery and equipment, or a higher exemption rate for these industries (Ward & De Battista, 2016).

2.4.3 Expected Interactions of the CPI with the underlying policy landscape

This section will consider the expected interaction of introducing the carbon tax in South Africa with the existing electricity price mechanisms and policies. The main interactions that will be studied include the effects the introduction of the CPI has on GHG emission reductions through fuel switching, rational use of energy and investment in renewable energy considering the electricity tariff landscape in South Africa and its policy objectives.

2.4.3.1 Fuel Switching

When a carbon tax is introduced in South Africa, the electricity landscape will allow for very limited fuel switching possibilities in the short-term. 92% of generation of electricity is from coal with another 7% from nuclear, thereby limiting the options to switch in the short term from coal to a lower-carbon option, as the market does not have any spare capacity at the moment.

2.4.3.2 Long-term investment in renewable energy generation

The current plan in South Africa is to introduce the carbon price gradually and at the same time phase out the electricity levy. This means there will be no actual increase in investment costs for thermal generators. The carbon price is therefore expected not to give a strong **price** signal in the short-term to discourage fossil fuel investments, in favour of renewables. However, the carbon tax will send a strong **informational** signal to discourage thermal generation investments, as it suggests renewables might be a more competitive generation source in the long-term when the carbon tax will rise. Additionally, as mentioned previously, the REIPPP scheme also incentivises investment into renewables to overcome upfront cost barriers associated with renewable power projects. The REIPPP however also interacts with the carbon tax. This interaction is further explored in section 3.3.

In the long-term, the carbon tax might continue to rise, while this cannot be further compensated by a reduction of a levy. This higher carbon price might incentivise ESKOM to manage its portfolio differently and increase investments in renewable energy, due to different expectations on return on investments of renewable energy projects. Additionally, following further liberalisation of the market in South Africa, increasing numbers of IPPs are expected to develop new projects, as they are attracted by the support of the carbon tax in developing renewable energy (South Africa National Treasury, 2015).

2.4.3.3 PTR OF COSTS TO INCENTIVISE RATIONAL USE OF ENERGY

The introduction of a carbon tax in South Africa was designed in such a way that it would be 'revenue neutral' in its first phase. The carbon tax is planned to be implemented simultaneous with a reduction in the electricity levy, resulting in no net effect on electricity prices (Swart & Deloitte, 2015). In its first phase, the carbon tax was expected to increase electricity prices between 1 and 2 cent per kWh. Therefore, the electricity levy (currently causing 3.5 cent increase per kWh on all non-renewables independent of emissions) will be phased out with the same amount, so that there will be no net effect on electricity prices. Instead, revenue could be earmarked and distributed towards a shift toward a low carbon economy, without impacting economic growth.

The revenue from the carbon tax can be directly recycled and used for socio-economic purposes without affecting the electricity price. The South African government is planning to reinvest revenue from the carbon tax into energy efficiency schemes, rooftop solar PV schemes, use it as credit for premium charged on renewable energy and for additional support for free basic electricity to low income households and public transport (Republic of South Africa National Treasury, 2015). This illustrates that the carbon tax for at least the first five years will mostly function as a revenue collection tool, as revenues are now earmarked for the purpose described. In the existing electricity levy, this was not possible.

The carbon tax in South Africa has been designed to have a neutral effect on electricity prices up to 2019 by phasing out the electricity levy simultaneously. However, it is uncertain what will happen after this. The government may decide to increase the carbon tax amount further, thereby potentially impacting the electricity price, fuel switching and investments in renewable energy more than outlined in the above expected interactions.

In conclusion, the following outcomes were expected following the introduction of a CPI:

Very limited or no fuel switching is expected when the carbon tax is introduced due to the inflexible generation capacity. Additionally, it is unclear whether a carbon price can affect the merit order dispatch as determined by the central dispatcher, ESKOM.

Additionally, limited changes in investment in new fossil fuel capacity is anticipated when the CPI is first introduced, since initially there will be no price signal, only an informational signal to investors. This is expected to change in successive phases, favouring investments in renewables in the long-term.

While in the short-term the carbon tax will have a neutral effect on electricity prices, it may increase prices in the long-term and thereby incentivise rational use of energy.

The primary role of a carbon tax in the short-term will predominantly be to function as a tool for revenue raising. This revenue can be recycled for support for renewable energy and energy

efficiency schemes. The CPI is therefore to be expected to be in line with the objectives of the electricity pricing policy in South Africa to keep electricity prices low in the short-term.

2.4.4 CHANGES MADE BY THE GOVERNMENT TO COMPENSATE FOR THE INTERACTION AND TO HARMONIZE POLICY INSTRUMENTS

2.4.4.1 HOW WAS THE CPI CHANGED BASED ON THE EXPECTED INTERACTION?

As the carbon tax has not been introduced yet in South Africa, no changes have been made by the government to compensate for the interaction and harmonization of policy instruments. However, an important aspect in the design of the carbon tax in South Africa is the revenue recycling function of the carbon tax to mitigate its potential adverse impacts on industry and households. This revenue recycling mechanism will be explained here.

To reduce the impact of the carbon tax on low-income households, it is expected that the carbon tax will predominantly function as a revenue raising tool. Revenue is planned to be invested in such a way that it will protect vulnerable communities from the impact of potential energy price increases, whilst supporting the transition to a low-carbon economy. These measures include (South Africa National Treasury, 2013; Ward & De Battista, 2016):

- A reduction in the existing electricity levy; (responsible for avoiding increases in the electricity prices);
- Additional tax relief for roof top solar PV energy;
- A credit for the premium charged for renewable energy (wind, hydro and solar, as per the Integrated Resource Plan);
- Additional support for free basic electricity to low-income households;
- Funding of energy efficiency incentives;
- Additional spending on public transport.

South Africa’s emphasis on revenue recycling means that the carbon tax is expected to be revenue-neutral for the first five years (South Africa National Treasury, 2013).

The way in which tax is recycled also influences the impact on the economy and distributional impacts. In South Africa, the National Treasury is planning a broad-based revenue recycling scheme, through combining the carbon tax with a reduction in the electricity levy and additional targeted support for certain sectors that are important for the country’s economy. However, research has demonstrated the way in which revenue is recycled will not just affect economic development, but also the GHG emission reductions brought about by the tax. One such research study demonstrates that if revenues were recycled in a more focussed way (e.g. only recycling it for the solar industry) then the carbon reductions delivered would be much higher (46% lower than the baseline in 2035). However, the impact on economic development would also be higher (the change in annual economic growth would be 2.7%

instead of 3.3% under this focussed scenario) (South Africa National Treasury, 2013; Ward & De Battista, 2016).

2.4.4.2 *HOW WAS THE UNDERLYING POLICY CHANGED BASED ON THE EXPECTED INTERACTION?*

Additionally, there are several measures which can be taken to amend underlying electricity tariff policies to account for disproportional impacts on low-income users and energy intensive users. However, no changes to the electricity tariff policies in South Africa were planned when introducing the CPI other than the ones described above (e.g. the reduction of the electricity levy in South Africa).

2.4.5 ACTUAL IMPACTS OF THE INTRODUCTION OF THE CPI

As the carbon tax has not been implemented yet in South Africa, no impacts of the CPI on emissions from the electricity sector have been observed yet.

2.5 LESSONS LEARNT FROM INTERNATIONAL EXPERIENCE

This chapter has described the interaction between electricity tariff policies and CPIs in New Zealand and South Africa. Some tentative conclusions can be drawn on possible implications of introducing a carbon price mechanism in an existing landscape from these case studies:

A CPI in the electricity sector has the potential to reduce GHG emissions by providing three main incentives: short and long-term fuel switching, and for rational use of energy.

International experience suggests that carbon pricing will support fuel switching if the signal is strong enough and merit order dispatch is affected. This depends on the price setting environment or the dispatching environment. Additionally, the installed capacity needs to be flexible to respond to short-term changes and have low carbon capacity available to allow fuel switching.

In New Zealand the existence of competitive wholesale markets and the landscape of installed capacity seems to suggest a carbon price could influence the merit order dispatch and cause fuel switching from coal to gas. Although, no evidence has been found to date that the carbon price in New Zealand did influence the dispatch order and stimulated fuel switching to lower carbon sources. In South Africa, very limited or no fuel switching was expected when the carbon tax is introduced due to the inflexible generation capacity, e.g. mostly coal. Additionally, it is unclear whether ESKOM as the central dispatcher would consider including carbon price in the dispatch criterion, and how this would affect the merit order.

International experience also demonstrates strong price signals are required to affect the competitiveness of generators in favour of low carbon alternatives. In the liberal market of New Zealand, a carbon price could potentially make the outlook for renewable generators more attractive than for thermal developers. However, no increased investments in renewables were observed in New Zealand after the introduction of the CPI. It has been speculated that this lack of increased investments was due to a low carbon price. In South Africa, limited changes in investment in new fossil fuel capacity is anticipated when the CPI is first introduced, since initially there will be no price signal, only an informational signal to investors. This is expected to change in successive phases, favouring investments in renewables in the long-term.

The introduction of a carbon price can cause more rational use of energy when costs can be passed on to consumers. In New Zealand, it was expected the carbon price would create incentives for rational use of electricity due to the possibility for companies to pass through additional costs to consumers. However, this was not in line with the electricity tariff policy objective in New Zealand, as they contradict the policy objective to avoid big fluctuations or increases in the electricity price. While in the short-term the carbon tax will have a neutral effect on electricity prices in South Africa, it may increase prices in the long-term and thereby incentivise rational use of energy.

Finally, by compensating other electricity tariff policies, a carbon tax can function as an effective revenue recycling tool thereby also minimizing adverse socio-economic impacts. The primary role of a carbon tax in the short-term in South Africa will be to function as a tool for revenue raising. This revenue can be recycled for support for renewable energy and energy efficiency schemes. The CPI is therefore to be expected to be in line with the objectives of the electricity pricing policy in South Africa to keep electricity prices low in the short-term.

3 INTERACTION OF SUPPORT FOR RENEWABLE GENERATION AND CPIS

This chapter focuses on the interaction between CPIs and support for renewable energy generation based on international experience.

3.1 INTRODUCTION

3.1.1 SELECTION OF CASE STUDY JURISDICTIONS

For the selection of case study jurisdictions, the following criteria were used:

- The jurisdiction has a CPI in place.
- The jurisdiction has renewable generation support policies in place that are similar to those in Brazil, e.g. **central auctions** (and net metering), preferential financing mechanisms or tax breaks and grid access policies.
- The government of the jurisdiction has considered some interaction between the policies, taken corrective measures or considered an effective way for both policies to achieve their objectives.
- The jurisdiction is either an OECD country or its socio-economic status is comparable to that of Brazil.

Based on the criteria above, the following jurisdictions have been chosen for a case study analysis:

- The Netherlands
- South Africa

3.2 THE NETHERLANDS

The Netherlands is presented in this chapter as a case study to demonstrate the impacts when a renewable energy support scheme interacts with a carbon price.

3.2.1 THE NETHERLANDS: RENEWABLE ENERGY SUPPORT SCHEME

The existing policy environment to support renewable energy in the Netherlands includes the SDE+ regulation (Stimulating Renewable Energy) which was established in 2011 (Legal Sources on Renewable Energy, 2013). The SDE+ is a scheme whereby the government provides guarantees or risk reductions to renewable energy developers. The scheme consists of both a tendering scheme for renewable energy generation and a net-metering scheme for distributed (small-scale) generation.

The main goal of the SDE+ policy is to encourage the generation of renewable energy in the Netherlands. The policy aims to generate as much renewable energy for the lowest costs possible and thereby be in line with the goal of the government to have 16% of all energy consumption from renewable sources by 2023. This is a different goal from the one set by the EU Renewable Energy Directive whereby the Netherlands need to ensure 14% of all energy originating from renewable sources by 2020, including 37% of electricity demand. However, the government does recognize that more renewable energy generation will include generation from more expensive sources, such as off-shore wind.

Through the SDE+ policy, the government provides compensation to renewable energy generators in cases where income per kWh generated is lower than the costs to produce this kWh. The Dutch tendering scheme is designed to target medium to large size companies and institutions that generate renewable electricity (Held, Ragwitz, Gephart, de Visser, & Klessmann, 2014).

The Dutch government creates a budget plan annually that includes the available funding for tendering schemes that will be opened in that year. This budget is created from a levy on energy bills called *opslag duurzame energie* (ODE). The Dutch government aims to open two tendering schemes per year.

The Dutch tendering scheme is categorized as a '*floating premium determination'* mechanism. This means that the premium depends on the level of the electricity price. By receiving a higher premium when renewable energy prices go down, generators will not be exposed to the risk of the electricity market price fluctuation. However, in this scheme the offtake of electricity is not guaranteed. The scheme consists of sequential bidding rounds where the government defines a base amount with predetermined prices and generators can offer a respective volume.

The SDE+ tendering scheme offers to compensate electricity generation companies for the difference in price between the market price and costs for renewable energy generation over a period of 8, 12 or 15 years, depending on the type of technology used. This means that generators will sell their generated electricity for the current market price and receive a bonus for the difference between this price and a predetermined price per kWh, also called the strike price. The tendering schemes do not prescribe the technology by which the renewable energy is generated. The intention of the policy is that with the SDE+ regulation all technologies will compete, so that the most cost-effective renewable energy mix will be constructed.

However, recently some contracted projects have not been delivered. As a result, the government has implemented a strict monitoring mechanism to ensure winning projects are actually developed and deliver the expected energy. This avoids possible costs to the government associated with having to procure electricity elsewhere if these projects do not deliver as expected.

While most of the SDE+ tendering schemes are technology-neutral, there are SDE+ schemes that are exclusively focused on off-shore wind generation. These exclusive schemes for off-shore wind follow the same principles as described above. The aim of these schemes is to incentivise the growth of off-shore wind power capacity to 4500 MW in 2023 (RVO, 2017). Offshore wind is separated because of its high costs and because the government recognises the necessity to grow offshore wind capacity in order to achieve the 2020 targets.

Consumers of electricity are expected to be the main contributors paying for the surcharge of the SDE+ regulation via the energy bill levy ODE. It is expected that the average household contribution for the

SDE+ regulation will rise from 25 EUR annually in 2015 to 120-240 EUR in 2020. Moreover, the more a consumer uses, the less they will pay in relative surcharges. This means lower-income groups are impacted disproportionally, because they consume less electricity on average than higher-income groups, but proportionally pay more via the ODE (Noothout & Winkel, 2016).

3.2.2 Net Metering Policy

The SDE+ regulation also includes a net metering policy, which is aimed at small-scale generators to promote distributed generation by guaranteeing take up of the power they produce. This is a policy whereby small-scale generators of renewable energy can deduct their generation of power from their electricity bill, thereby only paying the difference. In addition, generating consumers will also not pay an energy tax on the electricity that has been deducted from their bills, resulting in a tax break of about 40 million EUR annually (Produceren, 2014).

Considering the distributional effects of the net metering policy, it has been argued, that the burden of this tax break is carried mostly by other consumers without solar panels, often lower-income groups. In response, the policy has recently been changed to allow people to use it to account for small-scale generation from different locations than their home address, to allow people living in smaller apartments without roofs the same opportunity to benefit from these solar schemes. While this allows broader participation in the scheme, this still does not take away the additional burden on electricity prices of other consumers.

3.2.3 CPI in the Netherlands: EU ETS

The European Union Emission Trading Scheme (EU ETS) is the main policy in the EU to reduce GHG emissions. The scheme had the following objectives when introduced:

- Ensure that the most cost-effective abatement options are developed
- Providing flexibility to businesses about investment timing
- Guaranteeing the achievement of environmental objective (e.g. the cap)
- Minimizing intra-EU distortions and enabling linking with other jurisdictions
- Allowing price discovery through market forces

The purpose of the EU ETS was set to "*promote reduction of greenhouse gas emissions in a cost-effective and economically efficient manner*". However, it was also designed to offer an incentive to invest in renewable energy technology and thereby reduce EU's energy dependency on fossil fuel imports and increase energy security. It is expected that by providing a stable policy environment in the longer-term, the EU ETS incentivises more low carbon investments and clean technology development (European Commission, 2015).

Currently the ETS is in its third phase, running from 2013 to 2020. It covers power and heat generators with a total combustion capacity greater than 20MW (thermal), energy-intensive industry sectors such as oil refineries, steel works, metal producers, etc., and commercial aviation (for flights between

European Economic Area countries). Overall, this is estimated to cover around 50% of all GHG emissions within the EU. The scheme is designed with the target of reducing the emissions from the covered sectors by 21% in 2020 compared to 2005.

The emissions cap of the EU ETS has been designed to include 2,084,301,856 allowances for fixed installations in 2013, with each allowance corresponding to 1 tCO_2e. This cap is now decreased each year by a linear factor of 1.74% per year until 2020. The reduction factor is kept constant to provide policy certainty that helps create investor confidence in the return of their investments in emission reductions. The cap is designed in such a way to be in line with the renewable energy directive, including all the member states' renewable energy targets submitted under this directive. This means that the 20% renewable energy generation by 2020 on final consumption is embedded in the 2020 cap (IETA, 2015c). However, to be in line with the target for emissions by 2030, the reduction factor will need to be changed to 2.2% after 2020 (IETA, 2015c; Laing, Sato, Grubb, & Comberti, 2014).

Different modelling studies have shown that electricity firms are most likely to pass on extra costs of the EU ETS to consumers, which is regarded as an unwanted effect of the CPI (Laing et al., 2014). Increases in the price of allowances have been shown to affect electricity prices more than falling prices. However, multiple EU member states have strict regulations to prevent significant price fluctuations of electricity. Passing through costs of the EU ETS to consumers has the benefit of incentivising demand side reduction, while, on the other hand, it can discourage firms to invest in technology and efficiency.

This case study of the Netherlands focuses on how the EU ETS interacts with the SDE+ policy and how the EU ETS is incorporating expected interactions into its design (Daniels & Koelemeijer, 2016; Sijm & van Dril, 2003).

3.2.4 Expected Interactions of the CPI with the existing policy landscape

3.2.4.1 Impact on the effectiveness of the CPI

The renewable energy support schemes overlapped with the aims of the EU ETS by also providing incentives for low carbon generation (World Bank, 2014)**.** The expectation was that the stimulation of renewable energy would cause more emission reductions, thereby significantly reducing the demand for EU emission trading allowances and therefore weakening the emissions price signal set by the EU ETS (IETA, 2015c). The negative impact of such a weakened price signal would cause a spill-over effect of increased emissions in other (non-electricity) sectors. On the other hand, however, it could be argued that a low carbon price demonstrates the positive impact of the renewable support schemes on the effectiveness of the EU ETS.

During the design phase of the EU ETS, the renewable energy generation targets of the Member States were taken into account (20% by 2020) in order to avoid weakening the price signal of the EU ETS. The European Commission has estimated that emission reductions from existing renewable energy support schemes across the EU could amount to over 1 billion tCO_2e. By considering these expected emission reductions, the EU ETS will reflect the marginal abatement costs for achieving any emissions reductions beyond the level considered. Therefore, it was expected that any weakening of the price signal in the EU ETS could be avoided.

The SDE+ regulation was expected to contribute to the considered EU 20% target and not overachieve it (RVO, 2017). Therefore, it was assumed that the SDE+ would not distort the EU ETS and that their policy objectives were aligned.

3.2.4.2 Impact on the effectiveness of the underlying policies

The Dutch government did not seem to expect that the EU ETS system would impact the renewable energy sector or the objectives of the SDE+ regulation. However, as one of the objectives of the EU ETS is to incentivise more investments into renewable energy generation and development, it could be argued that the EU ETS would drive down prices in the tendering scheme of the SDE+.

The net metering policy within the SDE+ regulation is not expected to be impacted by the introduction of the EU ETS (RVO, 2017).

Moreover, the difference in policy priorities between the EU ETS and the additional benefits from SDE+ including local economic development, learning by doing for renewable technologies, creating investor confidence and national energy security, seems to justify the overlap between both policies.

3.2.4.3 Distributional impacts

The overlap of two policies aiming to incentivise renewable energy development could be reflected in rising electricity prices to consumers. This could cause consumers to pay twice for both policies incentivising the same renewable energy generation through 1) electricity generators passing on the cost of compliance with the EU ETS that incentivised them to invest in renewable energy and 2) electricity generators passing on the cost of the SDE+ policy. Moreover, this could be exacerbated by the rising cost of administration of the government having two rather than one scheme that could be also passed on to consumers.

However, as discussed below, in the case of a carbon tax for Brazil, market mechanisms could naturally self-correct for this double payment. For example, the EU ETS might incentivise renewable energy generation and thereby reduce the premium that needs to be paid under the SDE+ scheme. This means energy generators will have a lower cost burden under the SDE+ policy and therefore will need to pass less costs on to end-use consumers. The feedback system thereby indirectly avoids the double payment of costs by consumers.

3.2.5 Changes made by governments to compensate for the interactions and harmonize policy instruments

As the Dutch and the EU governments expected interactions between policy instruments as summarised in the previous chapter, they made efforts to harmonise these to ensure all set objectives would be achieved.

3.2.5.1 HOW WAS THE CPI CHANGED BASED ON THE EXPECTED INTERACTION?

The International Emissions Trading Association (IETA) has drafted several recommendations on how to correct for some interactions that inhibit these policies of achieving their objectives (IETA, 2015c). The first recommendation outlines to avoid overlapping policies as much as possible to not inhibit the market effectiveness of EU ETS. Secondly, many different changes were made to the design of the EU ETS to account for the interactions described above, including:

- Resetting the EU ETS cap at the start of each phase (every few years) to account for the expected emission reductions of renewable energy support schemes in each country. The target of the Netherlands of 20% emission reductions by 2020 through its SDE+ policy has thereby been taken into account.
    - The Renewable Energy directive with its goal of 20% of energy from renewable sources by 2030 is estimated to bring about 2200 $MtCO_2e$ of emission reductions by 2030. It is argued that with the renewable support measures the achievement of GHG targets happens less costs-effectively than if it was only guided by the EU ETS and its carbon price set with possible distributive effects.
- Increased transparency on policies and their effects and careful monitoring of the effects of the renewable energy support schemes effects on emissions.
- Clear governance that sends a clear message that emission reductions need to be realized. For example, binding targets are associated with clear governance.
- Not including traded sectors in the EU ETS that have obligations beyond ETS obligations.
- The design of the market stability reserve: a stabilizing mechanism which can release or take up permits depending on the amount of permits available. If the amount is below 400 million it will release a 100 million extra, if the amount is over 833 million then it will take 100 million permits out. The aim of this mechanism is to stabilize the carbon price and thereby create investor confidence into low-carbon technologies. The EU plans to introduce this mechanism in 2019.

However, it should be noted that all recommendations listed above will add extra administrative costs to the EU ETS. Administrative costs of participating in the EU ETS could range from 1,000 to 20,000 EUR per small-scale installation per year including registration fees for auctions and MRV costs. As there is currently already critique on the high administrative costs for the scheme compared to its effect in sending out a strong carbon pricing signal, especially for companies under 250 employees, this will need to be considered when reviewing these recommendations.

3.2.5.2 *HOW WAS THE UNDERLYING POLICY CHANGED BASED ON THE EXPECTED INTERACTION?*

No data is available that suggests any changes were made to the renewable energy support schemes in the Netherlands to compensate for the (expected) interactions and harmonise policy instruments.

3.2.6 ACTUAL IMPACTS OF THE INTRODUCTION OF THE CPI - EMISSIONS

As outlined above, the 20% renewable energy share target on final consumption in the EU was embedded in the original EU ETS 2020 cap in line with the Renewable Energy Directive. However, despite this consideration there was still about 300 TWh of renewable energy generation in the EU not considered in the ETS cap design between 2008 and 2015. This led to a reduction in EU ETS allowance demand of approximately 210 $MtCO_2e$ (IETA, 2015c).

For example, the Netherlands committed to 14% of all final energy consumption by 2020 to come from renewable energy under the Renewable Energy Directive, which includes 37% of electricity demand in 2020 to be met by electricity generated from renewable energy sources. However, the Dutch tendering policy aims to generate 16% of all energy consumption from renewable sources by 2023. This is a different goal that has not specified the amount of electricity generated from renewable sources and it is linked to a different timeline. The difference between both commitments might cause a weakening of the price signal of the EU ETS, particularly, if the SDE+ results in a more ambitious emission reduction than anticipated in the Renewable Energy Directive.

Overall, it could be argued that renewable energy support systems in different Member States led to less cost-effective emission reductions in the EU than would have been achieved by only having the EU ETS in place. However, the renewable energy support schemes have demonstrated to be effective in driving down prices of renewable energy and have additional policy objectives that are not covered by a CPI.

3.2.7 ACTUAL IMPACTS OF THE INTRODUCTION OF THE CPI – POLICY OBJECTIVES

No significant impacts have been recorded from the introduction of the EU ETS on the effectiveness of the SDE+ regulation in the Netherlands to achieve its objectives.

As described in chapter 3.1.1, it is argued that the SDE+ regulation significantly increased prices for Dutch electricity consumers. There is currently no evidence that the EU ETS has had a role in driving the increase in prices.

3.3 SOUTH AFRICA

This chapter presents a case study from South Africa to describe the impacts of interactions between a renewable energy support scheme and a carbon tax.

3.3.1 Renewable Energy Support Scheme in South Africa

South Africa introduced its first major renewable energy support policy in 2009 in the form of a feed-in-tariff (FIT). However, two years later this FIT was converted into a competitive criteria-based bidding process, called Renewable Energy Independent Power Project Procurement (REIPPP) Program (Grantham Research Institute on Climate Change and the Environment, 2011; Pegels, 2014). This policy asks developers to competitively bid on tariffs for pre-determined renewable energy technologies. These auctions include a fixed capacity allocation for each technology with five bid windows. Each technology is targeted in a separate auction round. Selection criteria for the announcement of winners of the auction are based for 70% on their offered price and 30% on their contribution to economic development in South Africa. Under the REIPPP, the Department of Energy procures electricity from independent power producers. Subsequently, the state-owned company ESKOM buys the electricity through fixed power purchase agreements.

The goal of the policy at the time of implementation in 2011 was to promote the installation of 3,725 MW of renewable energy installed capacity by 2016 (Curran, Metha, Smith, Joubert, & Regan, 2015; Department of Energy and GIZ, 2015; Republic of South Africa National Treasury, 2014; Sa & Nell, 2016; South Africa National Treasury, 2013) and 17,800 MW extra capacity by 2030 (del Rio, 2016). However, a major objective is also to expand generation capacity in South Africa as the capacity at the time (40,000 MW) was not sufficient to keep up with the rapid growth in demand. In addition to incentivising an increase in renewable power generation capacity, REIPPP was expected to support diversification of sources of energy production and their producers, which would assist the introduction of new skills and new investment in the industry as well as enable benchmarking of performance and pricing (KPMG, 2015). It also was expected that REIPPP would reduce transmission losses, as many of the projects under the REIPPP scheme would be located closer to final consumers. Lastly, REIPPP was designed to support local development objectives by creating 400,000 new jobs by 2030 (KPMG, 2015).

3.3.2 CPI in South Africa: Carbon tax

South Africa is in the process of implementing a carbon tax that will be applicable to the electricity sector, as described in chapter 2.4.2. The objective of the carbon tax is to allow a smooth transition to a low-carbon economy by "*correcting the prevailing prices of goods and services that generate excessive levels of anthropogenic GHG emissions*". The choice for a carbon tax over an ETS is based on three assumptions, including

a) that the low number of industry players in the energy sector combined with the reduced number of abatement opportunities in South Africa do not provide enough opportunity for sufficient competition and associated permit prices for an ETS to be effective;

b) the oligopolistic construction of the energy sector in South Africa is unable to provide efficiency gains under an ETS system, and lastly,

c) that South Africa does not have the institutional capacity necessary for a transparent, credible and competitive ETS (South Africa National Treasury, 2013).

The tax is also assumed to have lower administrative costs than an ETS. The carbon tax is planned to be set at 120 ZAR (South African Rand) per tCO_2e (about 13.6 USD). As previously described, the carbon tax includes a gradual phasing to increase the price, tax-free exemptions for certain industries and an offsetting mechanism.

In the implementation of the carbon tax, the South African government considered several distributional impacts. The government is therefore considering changes in the electricity levy to have no net impact on electricity prices. Additionally, the South African government is considering a longer period of phasing in of the tax rate for trade-exposed industries, such as mining and machinery and equipment to adjust for the competitiveness impacts. Another possibility would be to offer trade-exposed industries a higher exemption rate for the carbon tax (South Africa National Treasury, 2013).

This case study will focus on how the new carbon tax and its offset scheme interacts with the REIPPP in South Africa. It will study how both policies can achieve the objectives they intended to realise when they were introduced and how they can be delivered in a most cost-effective way. The distributive and competitiveness impacts of the two policies and their interactions will be the main focus for this case study.

3.3.3 Expected Interactions of the CPI with the existing policy landscape

3.3.3.1 Impact on the effectiveness of the CPI

The South African carbon tax was designed to have minimal overlap with REIPPP. It was however expected that companies might have extra incentives next to REIPPP to invest in renewables, i.e. by avoiding the tax. This similarity in policy objectives that reinforces the effectiveness of each policy seems to suggest harmonisation. However, the overlap in policy objectives might mean that generators and consumers will be paying a higher price for decarbonisation than necessary and be burdened with extra administrative and transaction costs (Sa & Nell, 2016; World Bank, 2017). Implementing and maintaining two rather one scheme for the same policy objectives might not bring about the most cost-effective transition to renewable energy generation in South Africa.

As the carbon tax in South Africa is designed to also include an offsetting scheme, there is an additional, different interaction between the policies at play. The main expected interaction for the offset scheme was that the development of projects under REIPPP would influence the supply for offsets allowed under the carbon tax and thereby weaken the carbon price signal of the offsets included in the carbon tax scheme (Curran et al., 2015). Moreover, the government wanted to ensure that renewable energy developers were not supported twice for the same projects by the government, but instead each policy ensured that additional projects were developed. To avoid both of these expected interactions, REIPPP projects were excluded from the offset scheme in the carbon tax. The offset scheme has now been designed with the intention that supply will never outstrip demand for offsets, thereby enforcing the price signal set by the carbon tax.

As REIPPP projects of ESKOM are not allowed to be counted as offsets, this also avoids the issue that ESKOM would be compensated twice for the same renewable energy development (PMR, 2017a). Particularly, the considered double incentive applies to (1) off-take guarantee under REIPPP and (2) receiving carbon credits via the offsetting scheme of the carbon tax at the same time.

The exclusion of REIPPP for offsets means that renewable energy support as a source of abatement is not available through offsets. Other technologies and methods for emission reductions are therefore encouraged through the offset scheme that may be more expensive than REIPPP projects, as this has already captured some options from the abatement curve available in South Africa. This means that the pricing signal of the offset scheme is actually expected to be strengthened by the exclusion of REIPPP projects. This in turn is expected to be reflected in electricity prices for end-use consumers.

3.3.3.2 *Impact on the effectiveness of the underlying policy*

The REIPPP policy is not expected to be significantly affected by the introduction of the carbon tax in South Africa. However, as one of the objectives of the carbon tax is to incentivise more investments into renewable energy generation and development, it could be argued that the carbon tax drives down prices in the tendering scheme of the REIPPP.

3.3.3.3 *Distributional impacts*

As described above, REIPPP projects are not eligible to be used as offsets within the carbon tax scheme to avoid weakening the carbon price signal. However, the interaction of policies might cause distributional impacts.

The renewable generator in South Africa might have a double incentive to generate renewable electricity in the future. These include 1) the support provided by the REIPPP and 2) through the carbon tax, which increases the cost of thermal generation relative to the cost of renewables. In the REIPPP, the premium paid by the government to generators for renewables is related to the additional costs of supplying that generation, relative to fossil fuels. If the carbon tax was to be introduced on top of this, lower additional costs of supplying renewable generation would exist relative to fossil fuels. This is because a carbon tax would increase the costs of generating electricity from fossil fuels. Subsequently, this would mean that the government would need to pay less of a premium in the REIPPP scheme to encourage the renewable generation. This interaction between both policies seems to suggest that the market will naturally self-correct to avoid giving a renewable generator a double incentive to generate renewable electricity. By reducing the extra costs, there might also be less risk of high additional costs being passed on to consumers.

However, having two rather than one scheme in place to encourage generators to develop renewable energy could increase administration costs for the government. These additional costs could potentially be passed on to consumers.

3.3.4 Changes made by governments to compensate for the interactions and harmonise policy instruments

As the South African governments expected interactions between policy instruments, they made efforts to harmonise these to ensure all set objectives would be achieved.

3.3.4.1 How was the CPI changed based on the expected interaction?

The South African government anticipated a reduced demand for carbon tax offsets, because of the REIPPP scheme incentivising generators to develop renewables that subsequently could be used as offsets. To compensate for this reduction in demand, the government decided that REIPPP projects could not be used as carbon tax offsets. Through this exclusion the government ensured that the overlap between the CPI and the renewable energy support scheme would be minimal. However, this measure also received critique for not delivering the most cost-efficient method for emission reductions, as was described in section 1 (Du Toit, 2014; Hood, 2013; Simcock, 2016). However, the REIPPP without the carbon tax has so far shown that a renewable auction policy with transparency, profitability and guarantees can attract a significant amount of private sector funding, increase learning in renewable energy deployment and promote social and economic development (Eberhard, Kolker, & Leigland, 2014). It has also demonstrated a fast drop in price per kWh for renewable generation.

The carbon tax in South Africa was intended to be designed in such a way that the revenues of the tax could be recycled and used as a tool to reduce distributional impacts as much as possible. Some of the revenue of the carbon tax is proposed to be used and recycled for the REIPPP programme through soft earmarking and to reduce the electricity levy that would be applicable to these REIPPPP projects as well. In line with this, the government is considering to gradually phase down and restructure the electricity levy. It already started this plan in 2009 when the levy was implemented on the generation of electricity, but renewables and qualifying cogeneration were excluded (Republic of South Africa National Treasury, 2014; Sa & Nell, 2016). This tax exemption can be considered as a first step in developing a carbon tax in South Africa and as an extra incentive for renewable energy generation and investment. By moving a tax on electricity to a tax on carbon the government is also trying to minimise the price rises affecting end consumers. The other goal of the government is to avoid hindering the competitiveness of trade-exposed industries (Janoska, 2014). These sectors are therefore currently exempt from the tax scheme.

3.3.4.2 How was the underlying policy changed based on the expected interaction?

There have not been any changes proposed to the renewable energy support schemes to mitigate the impacts of expected interactions with the CPI or to harmonise policy objectives.

3.3.5 Actual impacts of the introduction of the CPI

3.3.6 Impacts on emissions and carbon price signal

The carbon tax in South Africa has not been implemented yet, so no comments can be made yet on the implications of the interactions between the policies or possible harmonisation of their objectives.

3.3.6.1 Impact on the underlying policies

As the carbon tax has not been implemented yet in South Africa, no comments can be made yet on the impacts on the effectiveness of the REIPPP after the introduction of the CPI.

However, since 2011 more than 6,327 MW from 102 renewable energy projects have been installed as a result of the REIPPP policy in South Africa, with wind contributing to more than half of the capacity. The price decreased significantly through the different rounds of the REIPPP programme with PV solar decreasing by 68% and wind by 42% in 2.5 years since introduction of the policy (Eberhard et al., 2014).

3.3.6.2 Distributional impacts

As the carbon tax has not been implemented yet in South Africa, no comments can be made yet on the distributional impacts of the interactions on households and industries.

Table 6 below summarises the interactions between renewable energy support schemes in the Netherlands and South Africa and the carbon pricing instruments they have in place.

Table 6 - Summary of interactions between renewable energy support schemes in the Netherlands and South Africa and CPIs

Interaction expected at time of introduction	NL: SDE+ and EU ETS	SA: REIPPP and Carbon Tax
Objective of policy	SDE+: “to encourage the production of renewable energy in the Netherlands and thereby solve the market failure that the cost price of renewable energy is higher than the market price”	REIPPP: “to promote the installation of 3,725 MW of capacity of renewable energy by 2016 and17,800MW by 2030” Generate more supply to meet rising demand Stimulate deployment of RE
Objective of carbon pricing	EU ETS: “promote reduction of greenhouse gas emissions in a cost-effective and economically efficient manner”	Carbon Tax: “reduce GHG emissions by changing producer and consumer behaviour; contributing to mitigation and adaptation being taken into account in investment decisions (including on infrastructure); and creating incentives for low-carbon technologies”
Nature of interaction	Overlapping	Overlapping

Interaction expected at time of introduction	NL: SDE+ and EU ETS	SA: REIPPP and Carbon Tax
Effects on Renewable energy support policy objectives	Support the target of 20% share of energy consumption produced from renewable sources	Expected greater demand for renewable energy projects to lower the tax burden. REIPPP projects offsets are excluded to avoid using government resources twice for the same mitigation effort and also excluded from the electricity levy.
Interaction effects on emissions	Within EU same level as dependent on emissions cap design	Additional abatement might be delivered as REIPPP focuses on opportunities that are not delivered with the carbon tax alone.
Interaction effects on emission price signal	Weakened price signal	Carbon tax is set at fixed level, but the adjustments every year can account for the distortions the REIPPP might cause so that the tax level reflects the amount of emission reductions South Africa aims to achieve. Offset eligibility has been designed so that supply never outstrips demand, thereby enforcing the carbon price set by the tax.
Overall	Policy objectives seem better aligned if EU ETS takes into account the expected emission impacts of the existing policy	Easiest abatement options might have been captured by REIPPP already, thereby achieving the carbon tax intended emission reductions would happen not in the most cost-effective way

Source: Own elaboration.

3.4 Lessons learnt from international experience

Renewable energy schemes overlap with CPIs, but the support schemes also have additional objectives. The case studies of the Netherlands and South Africa show that renewable energy schemes overlap with CPIs by providing the same incentive. The overlap between a policy and a CPI can increase the cost of reducing emissions and have other unwanted impacts on the effectiveness of the instruments and distributional impacts. The case studies also illustrate that renewable energy schemes are generally set out to achieve other policy objectives than CPIs and therefore add additional value next to CPIs focused more widely on GHG emissions objectives. However, interactions between the policies can affect their cost-effectiveness, impact industrial competitiveness and have wider distributional impacts on households.

The interaction of CPIs and renewable policies need to be continually reviewed to ensure that all policies are still achieving their objectives in a cost-effective way. The case study from the Netherlands discusses interactions between the EU ETS and the Dutch stimulation for renewable energy policy (SDE+). It is important to include emission reduction expectations from renewable energy support schemes into the design of the carbon pricing mechanism and to keep this regularly updated. Moreover, other corrective measures to avoid negative overlap between policies include a mechanism to account for uncertain changes to control the amount of carbon allowances and a high transparency and disclosure of objectives and mechanisms of the policies.

In South Africa, where policy priorities of the carbon tax and renewable support policies are different, corrective measures have been taken to minimise overlaps and negative distributional impacts. The South African case study discusses the overlap between a carbon tax and renewable energy support schemes in the form of auctions (REIPPP). This case study highlights the importance of corrective measures by the government to ensure that incentives for renewable energy are additional. It also shows how revenue recycling and exemption of certain industries can counter-act negative distributional and competitiveness impacts. Even though the carbon tax in South Africa still needs to be implemented, the design of the tax taking into account a detailed description of renewable energy support schemes can ensure all policies achieve their objectives.

Additional costs from the overlap of policies may disproportionally impact low-income consumers. The interactions between RES policies and CPIs include negative impacts such as increased administrative costs and higher costs overall for decarbonisation, due to the overlap in the objectives of the policies. These additional costs may potentially be passed through to end consumers. As lower-income energy consumers usually pay a higher proportion of their income on energy, price rises for electricity might impact them disproportionally.

Overall renewable energy support schemes have many benefits additional to a CPI and can exist in parallel. Therefore, CPIs should be designed in such a way that they are not negatively impacted by renewable support policies, but instead incorporate emission reduction outcomes of these policies to avoid overlap.

4 INTERACTION OF CPIS AND THERMAL GENERATORS

This theme explores important issues relating to the impact of carbon pricing on fossil fuel generation, and other policies directed towards fossil fuel generators, focusing on three key areas of particular relevance to Brazil. These areas are:

- *Sectoral supports*: the interaction between carbon pricing and support to thermal generating technologies, including both direct financial support such as fossil fuel subsidies and funds, and indirect support such as capacity payments;
- *Distributional issues*: the implication of carbon pricing on geographic and household distributional[6] impacts, as a result of higher electricity prices, and efforts at ameliorating these impacts;
- *Merit order impacts:* the implication of carbon pricing on the dispatch merit orders, and whether this had any adverse impacts.

Carbon pricing will interact with thermal generators' investment decisions and it will be important these interactions are consistent with the government's key energy objectives. Thermal generators, especially those burning fossil fuels, can be expected to be acutely impacted by carbon pricing. Unless corrective measures are adopted, carbon pricing could thus undermine the government's objectives in at least two important ways:

- Energy security could be undermined if carbon pricing reduces returns on capital and thus thermal generation investment across Brazil, and especially the north;
- Access to affordable electricity, especially in remote areas or for low income households dependent on thermal generation supply, could be reduced if carbon pricing leads to electricity price increases.

The theme draws upon insights and lessons from a range of relevant jurisdictions to offer key implications for Brazil as it designs its carbon pricing mechanism. This section firstly provides the Brazilian context by offering a high-level overview of thermal generation sector, its expected growth, and the sector's key policies and instruments of relevance to the above issues. Taking each of the issues in turn, the section then:

- Provides the rationale for case study selection, with more than one jurisdiction provided for each issue in order to ensure lessons remain pertinent to Brazil, a description of the case study context, and a discussion of the implication of carbon pricing in terms of impacts;
- Discusses corrective measures which governments introduced in response to adverse impacts or interactions, how synergies were better realised and discusses other distributional and competitiveness impacts of introducing the carbon pricing instrument, and;

[6] Impacts on emissions-intensive industries are not considered given potential overlap with other themes

- Finally, this section synthesises lessons from each jurisdiction to offer implications for Brazil.

A summary of the section including jurisdictions and policies chosen for case studies is provided in Table 7.

Table 7 - Summary table

Key issue	Brazil instrument(s)	Case study jurisdiction	Case study instrument
Sectoral Support	Fixed fuel prices, tax exemptions, CCC, CDE	Poland	Stranded costs compensation (SCC)
		Spain	Coal stockpile funding; capacity market
		UK	Capacity market
		Australia	Energy Security Fund; Payments for Closure
Distributional Issues	CCC, CDE	EU	Derogation Policy
		Australia	Household assistance package
Merit Order Impacts	Centralised Dispatch	UK	Dispatch mechanism
		Germany	Dispatch mechanism
		Australia	Dispatch mechanism

Source: Own elaboration.

The results are synthesized interactions that provide lessons for designing a carbon price instrument in Brazil. This will be undertaken jointly with the Brazilian team during their design recommendations for Brazil.

4.1 SECTORAL SUPPORT

4.1.1 CASE STUDY JURISDICTIONS AND BACKGROUND

The interaction between carbon pricing and sectoral support measures for thermal generation is considered in the context of Poland, Spain and the UK. These cover countries that both have direct support for thermal generation (Poland and Spain) and countries where the support is provided more implicitly, through capacity markets (Spain, UK).

Poland and Spain have supported thermal generators through direct financial support while capacity payments in Spain and the UK represent an indirect support. The policy rationale for supporting thermal generation in Spain has been the management of electricity prices and to increase access for low-income households, while the policy rationale for stranded costs compensation (SCC) in Poland and capacity payments in the UK and Spain is energy security. All three countries participate in the EU ETS, while the UK has also introduced a carbon price floor, set at £18/tCO_2 until 2020. Although the energy mixes and nature of support for thermal generators are different from those of Brazil, the interactions between the policies and their carbon pricing mechanism offer important lessons.

Fossil fuel thermal generation has been supported in Poland through a scheme called the stranded costs compensations (SCC). The SCC provides compensation to power plants for the cancellation of long-term power purchase agreements (PPAs) which occurred as a result of a European Commission (EC) decision in 2007 that determined the PPAs were unlawful state aid and impeding the liberalisation of the sector (European Commission, 2007b). Given electricity generation in Poland is 90% coal-fired, this essentially represents a fossil fuel subsidy (EEA, 2014; OECD, 2011). The total compensation capable of being provided in Poland is capped at US$4.3 billion[7] and is to be financed by a levy on consumers (European Commission, 2007a). In 2014, the value of the SCC was US$235 million[8] (OECD, 2017).

In Spain, fossil fuel electricity generation has been directly supported by government funding of coal stockpiles and indirectly supported through capacity payments. Until 2014, the government mandated that power plants stockpile enough domestic coal to provide 23 TWh of electricity per year, which would then receive priority dispatch in the electricity merit order. As domestic coal was relatively more expensive, the government would then subsidise the power plant by the difference between the generation cost and the spot electricity sale price, amounting annually to around €400 million in support (General Court of the European Union, 2014). Capacity payments for hydro and thermal power plants entail a fixed rate compensation for the electrical capacity made available to the grid and compensation for new capacity investments, which in 2012 cost €191 million (Coibion & Pickett, 2014; EEA, 2012).

The electricity capacity market in the UK is intended to support energy security, but also may represent an indirect financial support for thermal generators. The capacity market was introduced in the UK to overcome the market failure of missing markets. It is intended to secure electricity supply cost-effectively by incentivising capacity investment while complementing the country's decarbonisation plan (DECC, 2014). It involves capacity payments determined through an auction, whereby generators bid to provide capacity to the grid in times of stress. Similarly, flexible consumers can bid to reduce demand at peak times. Those identified through the capacity mechanism bids receive a lump-sum payment and payment for production, or reduced demand.

4.1.2 Identification and qualitative assessment of interaction between policy, carbon price signal and emissions

The SCC in Poland ensures security of supply and may facilitate a transition away from thermal generation, but in the short term it has the potential to countervail the carbon price signal. In Poland, the compensation of stranded costs imposed by the cancellation of PPAs results in fossil fuel power plants being supported and their operational feasibility being prolonged as they are shielded from

[7] 2007 USD

[8] Exchange rate: https://www.oanda.com/currency/average

normal market conditions. The SCC thus has the potential to interact negatively with the carbon pricing signal and may result in higher emissions than would have otherwise been the case in the short run. On the other hand, it is unclear if thermal power plants would have closed in the absence of the support. The compensation also allowed for ensuring a secure supply of electricity throughout the process of removing support to these plants and so may facilitate decarbonisation in the long term. As a mechanism designed to facilitate the liberalisation of Poland's power system, the SCC has a clearly defined end-date (2025) and it has been designed to not inhibit the entrance of new, cost-efficient generators into the market (OECD, 2011); this sends a policy signal and allows carbon price signals to influence the entrance decision of new generators.

Funding for coal stockpiles in Spain has an ambiguous interaction with the EU ETS carbon price signal. The policy could be expected to be a countervailing policy given it is a transfer to emissions intensive generators and could interact with the ETS to undermine the carbon pricing signal. However, the judgement of a court case brought against the Spanish government by the owner of a combined cycle gas turbine (CCGT) power plant suggests that the overall impact was ambiguous. The court found that the support mechanism may have had a marginal impact on emissions given the country's dispatch model resulted in cleaner domestic coal substituting more emissions intensive imported fossil fuels, which may have resulted in a negligible difference in emissions (General Court of the European Union, 2014).

The design of the capacity payment mechanism in Spain may have been complementary to the EU ETS. Payments are similar to stranded investment compensation, in that capacity revenues received by fossil fuel power plants have ensured they remain profitable in unfavourable market conditions and hence emissions have increased (Oren, 2000). However, the costs of the capacity payments are passed onto consumers through higher electricity prices, which suggests a complementary demand-side interaction with the carbon price signal.

In the UK, capacity payments are intended to maintain energy security consistent with the transition to a low carbon economy, and so are intended to be an overlapping policy to its carbon price mechanisms. A combination of a rapid increase in renewable energy technology, the impending retirement of baseload electricity generation power plants (mainly coal and nuclear), and a lack of interconnections in transmission systems has resulted in concerns growing about the reliability of electricity supply in the UK (Coibion, 2014). The capacity market was implemented as a solution to this problem and aims to secure supply, ensure reliable energy generation to support intermittent, low-carbon sources, and to incentivise investment in conventional power infrastructure, while also supporting demand management (UK Government, 2016).

The capacity mechanism has succeeded in its objectives but has had a complex interaction with carbon pricing in the UK, and its impacts have raised distributional concerns. In terms of energy security, the capacity mechanism has succeeded given almost 50GW of capacity were secured in each of the first two auctions (Orme, 2016). However, it remains unclear if the auctions represent a cost-effective mechanism to secure supply given excessive focus on supporting existing electricity generation supply over efficient demand side reductions (DSR): over the course of both auctions, only £8 million has been diverted to demand side reduction. A suggested cause of this has been the limitation of DSR contracts to only one year. On the other hand, the desirability of longer term contracts for DSR is debatable as they imply increasing delivery risk and price lock-in that may be inefficient (DECC, 2014; Orme, 2016; WWF-UK, 2015). Distributional concerns have also been raised, given consumers must pay both the carbon price and the capacity support (Orme, 2016).

The mechanism's short run impact on emissions is uncertain, but it has ensured power system reliability that would otherwise be threatened by rapid decarbonisation and renewables penetration and, in the long term, may support a transition away from carbon-intensive generation. Financial support to fossil fuel electricity generation through the market totalled £2.8 billion since 2014, including £373 million to old coal-fired power stations. Of this total, 95% has supported existing capacity (Orme, 2016). Although the impact on emissions depends on fossil-generated investment in a counterfactual, there is some evidence that suggests the capacity market prolonged the feasibility of the UK's existing old and inefficient coal power plants (WWF-UK, 2015). However, the capacity mechanism may also support the efficient exit of some coal-fired power stations as secured gas-fired capacity increased to fulfil more baseload electricity demand. Three coal-fired power stations have already closed in 2016 and two more with plans on hold to close (Evans, 2016). While the capacity payment mechanism may provide some support for fossil fuel thermal generation in order to ensure short term electricity supply security, over the medium term it may not undermine the carbon price signal and can be a transitional support during decarbonisation.

4.1.3 Corrective measures and/or harmonisation of interacting instruments

European corrective measures to eliminate countervailing interactions have focused on the gradual phase-out of many supports for thermal generators. The recent Clean Energy for all Europeans package gives impetus for the removal of fossil fuel subsidies, describing how the EC will regularly monitor fossil fuel subsidies in the EU and will expect Member States to monitor their own subsidy phase-out using their energy and climate plans (European Commission, 2016). Indeed, the EU has legislated that subsidies to the coal sector must be phased out in all Member States as soon as 2018.

The UK government is considering methods of reforming the capacity market to ensure it continues to succeed in supporting electricity supply and decarbonisation objectives. Separating the capacity market into an old capacity and a new capacity market might allow different prices to be paid to new and existing electrical capacity generators so that existing fossil fuel capacity does not receive windfall gains. Similarly, the capacity market might be more aligned to the carbon price signal by introducing an emissions performance standard threshold for capacity bidders or by requiring large new gas plants to be built with the intention of incorporating CCS technology (Orme, 2016). The transitional auction is also being run to try improve outcomes for DSR within the capacity market. In these auctions, DSR participants will be able to test the market before committing to any longer term contracts (Proffitt, 2016).

Similarly, suggested improvements for the Spanish capacity mechanism may also hold relevance for Brazil. The Spanish capacity market has been criticised for being excessively costly.

These costs might be reduced by allowing smaller DSR participants in the market to increase competition. This could be achieved by increasing transparency in the criteria used to determine the eligibility of DSR participants (Wynn & Julve, 2016).

4.1.4 Implications

In many developed countries, direct financial support for fossil fuel generators coexists with carbon pricing instruments. While financial supports for fossil fuel generators may create policy inconsistencies with the carbon pricing signal, the evidence from many developed countries is that they can both be contained in the same market. Instead, in most countries the focus has been on gradually phasing out fossil fuel support over a period of time in order to avoid costly disruption to the market. Indeed, other elements of climate policy can create the necessary political constituencies which facilitate their gradual withdrawal (World Bank, 2016b).

Capacity markets can provide a useful mechanism to enhance reliability if a carbon price might support significant amounts of variable renewables generation but need to be designed well in order to avoid unduly disrupting the carbon price signal. Key design features to encourage the synergy between carbon pricing and capacity markets include command and control emission intensity regulations as backstops, splitting new capacity markets from markets for existing capacity, and designing the market, for example in terms on contract duration, so that engagement of DSR options is encouraged.

4.2 Distributional impacts

4.2.1 Case study jurisdictions and background

The implications of carbon pricing on distributional issues, and the possible measures to address harmful distributional issues is considered in the context of two carbon pricing systems: the EU ETS and Australia's Carbon Pricing Mechanism. These are two of the systems that have given greatest attention to the distributional implications of carbon pricing especially as a result of the cost increases it can impose on thermal power generators.

The EU's Emissions Trading System (ETS) is the largest carbon pricing instrument in the world. The EU ETS began in 2005 and covers 28 EU Member States and 3 European Economic Area-European Free Trade Association (EEA-EFTA) states. The case study below focuses on two aspects of the EU ETS that have had particularly important distributional implications:

1. Free allocation was initially used to support the power sector to reduce compliance costs and as a form of transitional assistance; but
2. More recently, these free allowances have generally been removed from the power sector, but the European Commission (EC) has provided a special 'derogation' so that plants in some countries continue to receive allowances.

Australia implemented a carbon pricing instrument from 2011. The Clean Energy Act introduced the Carbon Pricing Mechanism (CPM), Australia's first pricing instrument which was subsequently repealed in 2014. It placed a fixed price of AUD$23/t$CO_2$ on emissions with the view to become an ETS with a market determined price thereafter. In its place, the Direct Action Plan was developed which implemented a baseline and credit scheme.

Australia implemented two measures to address distributional impacts on households and thermal generators as a result of the CPM. These were:

- As the impact of the CPM fell disproportionately on lower income households, the government enacted targeted transitional assistance through tax benefit, allowance and pension measures, and;
- Transitional assistance in the form of closure payments to coal-fired power plants and Free Carbon Units (FCUs) based on a formula incorporating historical emissions and emissions intensity. These were designed in a different way to the allowance allocation for emission intensive trade exposed (EITE) industries where allowances varied as output levels changed. This was because policymakers did not wish to incentivise additional coal fired generation, but did want to facilitate increased EITE production, or maintain existing production. In total, AUD$5.5 billion in assistance was planned for emissions-intensive electricity generators and contracts for closure of up to 2GW of coal-fired generation (AER, 2011).

4.2.2 Identification and qualitative assessment of interactions between policy, carbon pricing signal and emissions

Free allocation of allowances in the EU ETS to the power sector resulted in windfall profits as they did not face higher carbon costs but nonetheless passed through potential carbon cost impacts to consumers. Cost-pass-through in the power sector is generally possible because it is not exposed to international competition, possibly leading to windfall profits due to free allocation of allowances as discussed in Box 1. The UK power sector alone made a €1 billion windfall profit in 2005 from the implementation of the EU ETS (Grubb & Neuhoff, 2006). This redistributive effect was amplified for lower-income households, whose electricity bill takes up a larger proportion of total costs (European Commission, 2014).

Box 1. **The economics of cost pass through of freely allocated emissions allowances in the power sector**

Allocating free allowances to the electricity sector can allow electricity generators to earn windfall profits due to 'opportunity cost pricing'. When allowances have been freely allocated, electricity generators bid to produce electricity at prices which include the opportunity cost of surrendering emissions allowance rather than selling it on the ETS market. This raises the price at which generators are willing to produce electricity, as they could earn revenue below a certain threshold from merely selling allowances (European Commission, 2015). However, because allowances have been received for free, increased revenue from higher prices represents a windfall profit.

As wholesale electricity prices are generally determined by a marginal fossil fuel generator, the consumer electricity price will rise by the value of carbon price. All dispatched generators with marginal costs below the marginal generator, even carbon-emitting generators, receive extra revenues due to the price increase, and thus earn windfall profits. This represents a redistribution of welfare away from consumers to electricity producers. If electricity were traded in the international market, then generators would be forced to surrender free allowances to price competitively against generators in markets without carbon pricing.

Furthermore, freely allocating allowances to the power sector reduced the impact of the carbon price signal by reducing the incentive to abate. As generators were not facing the full cost of their emissions, they required little capital to comply with the ETS. The method of free allowance allocation also gave the largest emitters a larger initial stock of allowances, thereby penalising generators who abated early (European Commission, 2015).

Reform of allocation methods during Phase III led the EC to introduce a 'derogation' policy to account for geographic and income differences in generation mixes in the bloc. The lessons learnt from Phase I and Phase II of the EU ETS led to the EC ending free allocation during Phase III. However, due to the varied electricity generation mixes across Europe, this would result in a variable impact between Member States. Moreover, lower GDP per capita countries have generally more carbon intensive grids. As a result, a derogation policy was introduced to address regional distributional impacts.

The derogation policy grants eight countries[9] decreasing yearly levels of allowances to allocate freely to their power sector, in exchange for investment plans to modernise and diversify their energy mix over time. The derogation policy, Article 10c, aims to support the power sector to move towards low-carbon generation in countries with limited opportunities to move away from fossil fuel generation in the short-run; only generators operational or undergoing investment before 2009 would qualify (European Commission, 2015). The expected outcome of this policy was that the power sectors in these eight

[9] 8 countries met defined eligibility criteria and participated: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania. Latvia and Malta were also eligible but declined to participate.

countries would become upgraded, more efficient, and generated from more diverse sources (Fallmann et al., 2015)

However, the derogation policy may have been countervailing to the ETS price signal and resulted in higher emissions, especially in Poland. Poland received the most free allowances under the derogation policy, receiving free allowances valued at €7.4 billion for the period 2013-2019. (Michalak, Blanken, & White, 2014). However, around 70% of the investment in Poland resulting from the derogation policy has been in coal combustion infrastructure, with zero investment into solar or wind projects and virtually all investment categorised as renewable going into support for co-firing coal with biomass (Carbon Market Watch, 2016; Kenig-witkowska, 2015). This is because the implementation of the policy did not require transparency in terms of the investments made to modernise power sectors. While the policy may have successfully addressed some of the distributional issues arising from carbon pricing, it has failed to induce investment into diversifying and reducing dependence on coal-fired electricity generation. It may even be contributing to carbon lock-in, and thus higher emissions in the long-term (Carbon Market Watch, 2016).

In Australia, distributional impacts of the CPM on lower income households led to the government introducing transitional measures to support them. The Australian Government (2011) estimated that the implementation of the carbon price would raise electricity prices over 2013-2017 by an average of 10-17%. This price increase was predicted to impact lower income households more, as they spend a larger proportion of their budget on electricity. In order to support these vulnerable households most affected by the CPM, the government provided transitional assistance by increasing the Family Tax Benefit[10], pensions, allowances, and tax cuts.

The measures were intended to be a complementary policy to carbon pricing in order to support decarbonisation objectives. The assistance provided by the Australian government was progressive and, as it was delivered through a tax and direct cash transfer system, allowed the electricity consumption reduction incentive to be retained (O'Gorman & Jotzo, 2014). The Australian household transitional assistance policy thus succeeded in supporting the transmission of the carbon price signal while ensuring that the most vulnerable households were supported in the transition to a low-carbon economy.

The Australian government also aimed to provide assistance to thermal generators that were impacted by the CPM. The government's objective was to provide transitional support to the power sector to ensure energy security and the effective move to cleaner technologies (Australian Government, 2015). An Energy Security Fund was to provide payments for the closure for 2GW of coal power capacity by 2020, provide support packages for affected workers, and give free carbon units worth AU$5.5 billion to particularly emissions intense electricity generators in exchange for the development of clean energy investment plans (Australian Government, 2011a; C2ES, 2011). The payments for the closure of coal

[10] Cash transfers to parents or caregivers with dependent children or full-time dependent students (C2ES, 2011).

power stations policy was proposed to manage the timing of the closure of plants, to provide investor certainty, and ensure the transition was cost-effective.

However, the contracts for closure policy was halted in 2012 due to political economy considerations. The contracts for closure policy was perceived to be too costly to implement, leading to political pressure to end negotiations without agreement in 2012 (The Australian, 2012). However, shortly after this, all companies which would have received payments for closure announced closures or reduced operations without any government funding (O'Gorman & Jotzo, 2014). Thus, had the contracts been agreed, the policy might have acted to increase emissions as it would have prolonged these thermal generators' lifespan.

4.2.3 Corrective measures and/or harmonisation of interactions

Phase III of the EU ETS indirectly reduced adverse distributional impacts on households by ending free allocation to the power sector. This auctioning of allowances prevents windfall profits occurring as power generators have to bear the full cost of their emission allowances, which incentivises least-cost abatement and rewards low-emission electricity generation. Revenues from auctions can then be used by governments to support low-income households and thereby lessen distributional impacts. The only exception is the derogation for certain Member States as discussed.

The EU is also attempting to improve the derogation policy through the Modernisation Fund, which aims to address the negative regional distributional impacts of the EU ETS. The Modernisation Fund, to be implemented from 2021 to 2030, aims to support the modernisation of low-income countries' energy systems. It will be financed by the auction of 310 million allowances, with modernisation projects above €10 million to be selected through a transparent and competitive bidding and smaller projects based on objective criteria (Erbach, 2016). It is intended that these rules will impose more stringent control on how funds are spent in order to modernise eligible countries' energy sectors, in contrast to the derogation policy.

Finally, given the Australian CPM was repealed in 2014 and the government adopted a more regulatory approach, it is unclear how new safeguard mechanisms will impact households. The safeguard mechanism requires compliance with a single electricity baseline for electricity generators (Australian Government, 2016). This implies a more complex impact on the costs of generators and greater uncertainty about how these costs may be passed onto consumers (Ashurst, 2015).

4.2.4 Implications

The experience from other countries suggests that to facilitate the transition towards a carbon pricing regime, Brazil could implement temporary transitional assistance to thermal generators, but distributional impacts must be managed. This transitional assistance could take the form of initial free allocation of emission allowances, with a clear policy signal that this will be phased out. Early stage free allocation could be provided based on grandfathering (historical emissions) with the view to moving towards a benchmarking methodology of free allocation in the future. The move to benchmarked allocation of allowances would reward entities that are most efficient. This clear policy signal would incentivise generators to use early phase windfall profits to invest in abatement in order to reduce their costs in future phases with expected less free allocation (PMR, 2015).

The EU's derogation policy also holds lessons for Brazil given the contrast between the south and north's electricity generation mix. The EU justified geographically differentiated support given differences in countries' dependence on thermal generation. However, supporting mechanisms should be designed to be coherent with the carbon pricing mechanism. Furthermore, in order to avoid carbon lock-in and potentially unexpected investment decisions exhibited in Poland, Brazil may need to provide comprehensive oversight on modernisation investments, so that competitive bidding, transparency in procurement and public participation are guaranteed, similarly to the aims of the Modernisation Fund.

Distributional impacts of carbon pricing on low-income households can be addressed with direct transfers, while still maintaining the carbon price signal on thermal generators. Australia provided assistance to low-income households through direct cash transfers and tax cuts, financed largely by the CPM itself, which were designed such that the emission reduction incentive of the carbon price signal was retained. This lesson could prove important for Brazil given the large proportion of the population that is socially vulnerable. Moreover, given the political sensitivity of energy prices in the country, transfers should be provided transparently and in a targeted way.

The objective of providing transitional support to coal-fired generators is different from the objective of providing support to EITE sectors, but political economy issues still need to be managed. In Australia, different methods of support were provided to EITE sectors and electricity generators. EITE sectors were provided with free allocation in proportion to output so as to achieve the policy objective of preventing a loss of international competitiveness and incentivising increased production. However, coal-fired power generation was allocated allowances based on a combination of previous levels of emissions and current efficiency. This was because emissions reductions through improving emissions-intensity of thermal generators was the main objective. Australia's contracts for closure policy, however, indicates that providing transitional assistance to thermal generators as a result of carbon pricing will be unsuccessful unless political economy considerations are appropriately managed.

4.3 Merit order issues

4.3.1 Case study jurisdictions and background

The implications of carbon pricing on merit order issues is considered in reference to three electricity markets:

- **The UK short-term electricity where the dispatch order is competitively determined an hour before delivery.** The market co-ordinator, NGET acts as a residual balancer to accommodate last minute changes in supply and demand (Ofgem, 2017).
- **Germany's short-term electricity market is a spot market whereby the dispatch order of generation is competitively determined a day ahead.** Unforeseen movements in day supply

and demand are handled by reserve and balancing markets which are determined by separate longer term contracts auctions (Šumbera & Dlouhý, 2015).

- **Australian National Electricity Market (NEM) - a wholesale spot market in eastern and southern Australia where generators bid to supply quantities for five-minute intervals ahead of delivery.** The NEM uses a centralised dispatch model as the Australian Energy Market Operator (AEMO) stacks generators' bids from low to high price until supply meets demand, so as to minimise system costs (AER, 2011).

4.3.2 IDENTIFICATION AND QUALITATIVE ASSESSMENT OF INTERACTIONS BETWEEN POLICY, CARBON PRICING SIGNAL AND EMISSIONS

Competitive dispatch of electricity generation should be complementary to carbon pricing mechanisms. It incentivises low variable cost electricity generation which is dispatched first in order to minimise system costs. This augments the emissions reduction potential of the carbon price by providing a clear mechanism through which more emissions intensive generation is deployed less frequently. It is also a mechanism that can incentivise increased investment in renewables that can receive infra-marginal rents as a result of market prices in excess of renewables' marginal costs of production.

In Germany and the UK, the dispatch mechanism helped to drive fuel-switching to lower carbon-intensive sources. Over the period of 2005 to 2013, emissions from power plants in the EU ETS decreased cumulatively by 18 percent (approximately 215 $MtCO_2e$) mainly due to fuel-switching in electricity generation, given electricity generation only decreased by 2 percent over this period (EEA, 2015). The majority of this fuel-switching occurred in the UK and Germany where abundant dispatchable gas generation capacity was coupled with an initial reliance on coal (Agnolucci & Drummond, 2014; Delarue, Ellerman, & D'haeseleer, 2008). Thus, the complementarity between competitive dispatch and carbon pricing is supported under conditions of excess, dispatchable generation and initial reliance on relatively carbon-intensive electricity.

In Australia, the complementarity between the competitive dispatch of electricity generation and carbon pricing was evident. The fuel-switching effect was evidenced just a few months into the implementation of the CPM. Hydro electricity generation increased its market share by almost two percentage points, black and brown coal generation lost approximately two and one percentage points respectively, while gas-fired electricity generation remained the same (AEMO, 2012). The carbon price caused emission reductions on the supply side of the electricity market of 3 - 4.5 $MtCO_2$ in 2012/13 and 3.4 - 5.1 $MtCO_2$ in 2013/2014, which represents approximately 60% of all Australian electricity sector emission reductions due to the CPM in each of the years 2012/13 and 2013/14 (O'Gorman & Jotzo, 2014).

However, the fuel-switching impact of the carbon price signal can be diminished by commodity price volatility or an insufficiently high carbon price. For example, if coal prices fall relative to gas prices, then this will induce a switch to coal, increasing emissions. This occurred in the EU ETS over 2010. This was exacerbated by the ETS carbon price not being flexible enough to accommodate increasing allowance demand from coal plants (Stokes & Spinks, 2016), as discussed further below.

4.3.3 Corrective measures and/or harmonisation of interactions

An ETS can respond to fossil fuel price fluctuations better than a carbon tax, as long as there is not an oversupply of allowances, which itself can be prevented with a price floor. Under a well-designed ETS, unlike under a carbon tax, the impacts of a fall in the price of a carbon-intensive fuel like coal, which would otherwise undermine fuel-switching, is somewhat reduced: the increased demand for coal will lead to an increased demand for allowances, raising the allowance price. However, this relies on the allowance market not being oversupplied. In turn, a carbon price floor can help avoid the impact of an oversupply of allowances in an ETS. For example, the UK implemented a carbon price floor in 2011 to mitigate low EU ETS prices in order to secure low-carbon investment, and has since seen some of the highest levels of coal to gas fuel switching in electricity generation in the EU (Ares & Delebarre, 2016).

Australia's dispatch complemented the carbon price signal; however, the abolition of the CPM and policy uncertainty have since undermined long-term thermal generation investment and abatement. Policy uncertainty over the future of the carbon price in Australia resulted in low levels of investment into low-carbon electricity generation. (O'Gorman & Jotzo, 2014). Nelson *et al.* (2010) estimate that the lack of policy certainty in Australia could cause between 1.9 - 6.3GW less investment into optimal technology open cycle gas turbine (OCGT) electricity generation over 2010-2020, which could raise electricity prices in 2020 by AU$ 3.97 - 8.60/MWh.

4.3.4 Implications

The case studies show that liberalised power markets based on competitive despatch can be complementary to a carbon pricing mechanism without undermining energy security. Carbon pricing increases the operating costs of carbon-intensive generators such that they are replaced in the dispatch order by lower carbon electricity generation, reducing the overall emissions-intensity of the electricity system. Furthermore, as the carbon price increases wholesale price of electricity, low carbon electricity generators' profits may drive increased investment to reduce emissions in the medium term, and potentially increase overall energy security.

The impact of the carbon price on the extent of fuel-switching in a competitive market is influenced by the flexibility of the instrument and external factors. From this perspective, an ETS may be a preferable carbon pricing instrument, as the allowance price will be responsive to changes in fossil fuel prices in a way that a carbon tax will not. However, as the case of the EU ETS reveals, this relies on well-functioning markets without oversupply of emission allowances.

4.4 Lessons learnt from international experience

Support for thermal generation capacity growth implies a trade-off between electricity price management and abatement. Liberalising prices to allow cost pass-through or providing thermal generators free allowances in the CPI both achieve emissions intensity reductions, but do not reduce the price impact on consumers. Whereas keeping CPI prices low in general reduces the price impact on consumers but does not contribute significantly to reducing the emissions intensity of electricity generation. The interaction between CPIs and (thermal) generation capacity growth thus faces a trade-off against three policy objectives: Incentivising investment into new thermal generation, which generates emissions, to cover rising demand; reducing emission intensity; reducing the price impact on consumers (and distributional impacts between generators).

Direct financial support to fossil fuel generation is evident in many countries implementing CPIs, but this countervails the CPI and is generally being phased out. This support is provided for reasons such as providing transitional support, managing electricity prices, and increasing access to electricity. In particular, fossil fuel thermal generation has been supported in Poland through a scheme called the stranded costs compensations (SCC), Spain supports fossil fuel electricity generation through funding coal stockpiles, and Australia supported thermal generation through payments for plant closures and the provision of free carbon units. However, this form of support countervails the CPI and in most countries the focus has been on gradually phasing out fossil fuel support over a period of time in order to avoid costly disruption to the market.

Well-designed capacity markets can increase electricity security and have minimal overlap with a CPI. Capacity markets, such as in the UK and Spain, can enhance security of electricity supply in the presence of large amounts of intermittent renewable generation. Lessons learnt in terms of design can also improve the functioning of capacity market and limit the overlap with a CPI. These improvements include implementing command and control emission intensity regulations as backstops, splitting new capacity markets from markets for existing capacity, and designing the market so that engagement of demand-side reduction options is encouraged.

Distributional impacts on thermal generators are addressed by supporting or exempting the sector or re-distributing revenue. In many ETS, concerns about the negative impacts of the carbon price has led regulators to provide free allowances to thermal generators. If cost pass-through is allowed, electricity prices increase (due to opportunity cost pricing), and generators gain windfall profits. An alternative approach is to exempt energy sources from the carbon pricing instrument. Mexico exempted natural gas, and Chile exempted biomass thermal generation from their respective carbon taxes, while the UK exempted electricity derived from renewable sources from its Climate Change Levy over 2001-15. Distributional impacts on thermal generators can also be reduced by redistributing carbon revenues. Infra-marginal rents accruing to low carbon generation can be taxed and redistributed to mitigate distributional impacts, or carbon revenues can be recycled back into sectors to encourage certain technologies, such as Alberta’s new technology fund or the EU ETS’s NER 300 programme.

CPIs may cause regional distributional impacts if electricity generation technology varies geographically, but targeted, direct support may reduce these impacts. In the EU, lower-income regions faced higher costs due to reliance on more emissions intense electricity generation technology. The Derogation Policy mitigated these distributional issues by granting the lower income countries extended periods of free allocation for the power sector, in exchange for investment plans to modernise and diversify their energy mix. However, this policy may have countervailed the carbon price and led to higher emissions and, especially in Poland where most of the support went into fossil fuel generation.

The Modernisation Fund is aimed as an improvement on the Derogation Policy and supports low-income countries during the low-carbon transition through the sale of 310 million allowances. Funding will be based on transparent and competitive bidding with smaller projects measured against objective criteria This could be particularly relevant for Brazil, where the remote north regions receive electricity mainly from isolated oil thermal generating plants (IAEA, 2016).

Competitive dispatch facilitates fuel-switching, which supports the CPI. Carbon pricing increases the operating costs of carbon-intensive generators such that they may be replaced in the dispatch order by lower carbon electricity generation, reducing the overall emissions intensity of the electricity system. Significant fossil fuel switching in the electricity sectors of the UK and Germany was witnessed in the EU ETS over 2005-13. Similarly, Australia's electricity sector witnessed fuel-switching away from black and brown coal generation, while the market share of hydro generation increased.

The extent of fuel-switching is influenced by the flexibility of the CPI and other exogenous factors. Commodity price volatility, for example, can reverse fuel-switching. In the EU ETS over 2010, coal prices fall relative to gas prices, which induced fuel-switching towards coal, increasing emissions. CPI inflexibility to changing market conditions can exacerbate this, as is the case in ETSs with significant oversupply of allowances.

5 HYDRO GENERATION AND GROWTH IN ELECTRICITY DEMAND

This note considers the international experience on the implications of introducing carbon pricing instruments (CPIs) in electricity markets that either have a large share of hydro-electricity generation and/or are expected to see significant increases in electricity demand that it is expected will be met by thermal generation. In particular, it sets out to answer three questions:

1. How effective are CPIs in reducing emissions intensity of electricity when hydro generation forms the majority of generation?
2. What are the distributional impacts for owners of thermal generation in CPIs where hydro forms a large share of generation – and how have these impacts been addressed?
3. How can CPIs be designed to allow for growth – and investment – in thermal electricity demand?

The analysis identifies relevant jurisdictions, based on similarity with the sectoral/country characteristics, and distils the key implications from the international experience for each of the three questions. This will provide the background for the Brazilian team to consider the impacts and interactions of carbon pricing instruments they consider.

The results are synthesized interactions that provide lessons for designing a carbon price instrument in Brazil. This will be undertaken jointly with the Brazilian team during their design recommendations for Brazil.

5.1 How effective are carbon pricing instruments in countries with large hydro generation?

5.1.1 Case study jurisdictions and background

The following jurisdictions implemented carbon pricing instrument in electricity markets with a large share of hydro and/or nuclear (zero-carbon technologies):

- Finland, with an ETS and carbon tax;
- Norway, with an ETS and carbon tax;
- Sweden, with an ETS;
- British Columbia, with a carbon tax;
- Quebec, with an ETS.

Finland, Norway and Sweden have multiple carbon pricing instruments, are part of one larger electricity market, and obtain the majority of their electricity generation from zero-carbon sources. The power sector in the Nordic countries is dominated by large (often state-owned) companies, but electricity prices are market-determined. All countries participate in the EU ETS, are part of the regional Nordic Power

Market (together with Denmark) and the Central European Market (with Germany and the UK), and all but Sweden also have a carbon tax that applies to electricity generation:

- Finland introduced a carbon tax in 1990 to, among other goals, encourage the use of biomass and low emissions heating fuels and improve the competitive position of peat and natural gas, especially compared to coal. The tax applies to the combustion of fuels for power production. In 2013, the tax on heating fuels was US$48/t$CO_2$ and US$83/t$CO_2$ for liquid transport fuels (PMR, 2017b). Wood or other biomass in energy generation are exempted from the tax while a 50% reduction applies for 'sustainable' biofuels and second-generation biofuels (waste-based, non-food (ligno) cellulosic materials) are completely exempted. A 50% reduction in levies on Combined Heat and Power (CHP) plants was also introduced in 2011 to improve the competitiveness of CHP relative to separate heat production. Finland derives approximately 50% of its generation from zero-carbon technologies: 27% nuclear, 20% hydro and 3% wind in 2015. Electricity generation accounts for 44.8 percent of total CO_2 emissions in 2011 (IEA 2013).
- Norway introduced a carbon tax in 1991 and an ETS in 2005, which it formally linked to the EU ETS in 2009. Its electricity generation is almost exclusively hydro.
- Sweden's electricity generation is virtually without fossil fuels: 46% hydro- and 35% nuclear power, with gas and coal only contributing 1% each with the remainder from biofuels. Electricity generation is exempt from the carbon tax to avoid overlap with the EU ETS, but there is an electricity consumption tax levied on consumers. In 2016, Sweden abolished a tax on electricity generation from nuclear sources.

Scottish power generators, as part of the United Kingdom, participate in the EU ETS and face the UK carbon price floor with the vast majority of electricity generation derived from nuclear, renewables and hydro. In 2015, electricity generation amounted to 51.2TWh. Less than 25 percent came from fossil fuels: hydropower (12%), other renewables (30%) and nuclear (35%) accounts for the bulk of generation (Scottish Government, 2016).

British Columbia introduced a carbon tax in 2008. About 70 percent of total emissions are covered by the scheme. Tax rates are CAD$30/t$CO_2$e and the scheme requires emitters responsible for more than 10 ktCO_2e/year to comply (Osler, 2017). The carbon tax is revenue neutral and proceeds are rebated to low income households via income tax reductions. Hydropower accounts for more than 90 percent of electricity generation while there is a target that renewables accounted for 93% of generation in 2016, while the Clean Energy Act mandates self-sufficiency. Less than five percent of carbon emissions are from electricity generation. The market is dominated by a state monopoly, BC Hydro.

Quebec implemented an ETS (Cap-and-Trade program) with the first compliance period starting in 2013. The cap on emission is set to achieve a 20% target reduction in GHG emissions below 1990 in 2020 and has been reduced every year since 2015. During the first compliance period, only emissions from electricity and industry were included, but from 2015 fossil fuel distributors have also been included. The system formally linked with California in 2014. A minimum price is set by the higher minimum price of the two systems at current exchange rates. A small number of free allowances is distributed to industrial emitters exposed to foreign competition to limit carbon leakage, but electricity producers and fossil fuel distributors are exempted from this scheme (Gouverneament du Québec, 2015).[11] Quebec's electricity generation is based almost exclusively on hydropower which provided 96% of available electric power in 2015 (IETA 2015). Québec's hydro market is dominated by Hydro-Québec a state-owned monopoly which makes strategic investment to cover future electricity demand from hydro as well as maintaining an export surplus with neighbouring provinces and the US.

5.1.2 Identification and qualitative assessment of interaction between policy, carbon price signal and emissions

Unsurprisingly, carbon pricing appears to have had limited influence on the emissions profile of electricity sectors that have significant quantities of non-emitting power. Indeed, many of the relevant jurisdictions that report on the impact of the carbon price tend not to report on its impact in the electricity sector. Emissions intensities are already low and further reductions have not been the reason for establishing economy-wide carbon pricing instruments or covering the electricity sector. In particular, the EU ETS has not had significant impacts on Sweden's electricity sector's emissions intensity, possibly due to minimal available short run abatement opportunities (Widerberg & Wräke, 2009).

Carbon pricing instruments have raised the electricity price in the case study countries. Virtually all the case studies countries above have some thermal generation, which tends to have the highest marginal cost but is still dispatched at some time. Carbon pricing raises the marginal cost of thermal generation further. Given cost pass through - estimated in the EU at between 60 and 100% – this has raised electricity prices in the EU (European Commission, 2014) and anticipated to do the same in jurisdictions with a large share of hydro generation, such as Washington State USA (Energy Strategies, 2016). These impacts can be present – and indeed exacerbated – when a jurisdiction with limited fossil fuel generation has a power market that is integrated with a jurisdiction with more generation. Evidence and modelling results for Norway, whose almost 100-per-cent hydro-power system is linked to the Central European power pools, show that when the EU ETS led to increased electricity prices in Central Europe, this fed through to the Norwegian market and raised the profits of hydro-generators (THEMA Consulting Group, 2011). While these price increases may help stimulate some form of demand side response, it can also raise a series of distributional and investment challenges as discussed further below.

Strikingly, many of the countries with large proportions of hydroelectricity have tended to rely on command and control regulations to minimise the intensity of the remaining fossil fuel generation sources. For example, Norway imposes strict authorisation criteria for new generation investments that consider environmental issues while Scotland, as the UK, has a requirement to install CCS for fossil fuel stations once it is available (Hassan & Majumder-Russell, 2014). This may reflect that, in these contexts. the greatest opportunity to influence the emissions intensity of the generation sector is when new plants are commissioned, and that as these opportunities are relatively infrequent, policymakers may be

[11] Free allowances are reduced by 1-2% from 2015 to incentivize further emission reductions.

attracted to the relative certainty about emissions (at the plant level) which is provided by command and control instruments.

5.1.3 Implications

In markets with large share of non-emitting technologies, the potential to reduce absolute emissions and emissions intensity of electricity generation is low. Emissions largely stem from peaking plants that often are gas-fired and hence are relatively low emissions intensity already. However, the jurisdictions identified with high shares of hydro generation have experienced little, if any, growth in demand for thermal generation. For example, Sweden's annual electricity generation varied little between 380-420 TWh over 2005-15[12] (Swedish Energy Agency, 2015).

Command and control mechanisms can help reduce the emissions intensity of existing and planned thermal generators. This may be more successful than carbon pricing given that it can provide greater certainty about fuel choice and can also include local air pollution and other negative impacts of thermal generation. However, command and control mechanisms may be cost inefficient as they do not consider the cost of compliance. Regulatory approaches in the power sector include mandatory norms, technology or emissions standards and technology bans or moratoriums for new developments (Emission standards for new plants, carbon technology ban, renewables portfolio standards, CO_2 storage regulation)[13].

5.2 What are the distributional impacts on owners of thermal generation when hydro forms a large share of generation – and how have these impacts been addressed?

5.2.1 Case study jurisdictions and background

This issue is addressed using the same case studies as in section 5.1

5.2.2 Identification and qualitative assessment of interaction between policy, carbon price signal and emissions

Carbon pricing instruments increase the cost of thermal power generators. Case study evidence shows that the impact that these increased costs have on owners of thermal generation depend on four factors:

- the carbon intensity of the fossil fuel plant

[12] Except for the year 2009 where electricity generation dipped to 354 TWh, which may be attributable to the impact of the financial crisis.

[13] This is reformulated from Reconciling carbon price report, pp. 47-48.

- the impact of the carbon price on the 'merit order' of electricity generators, which will affect both the extent to which costs are passed through into prices and the frequency with which thermal plants rare dispatched
- the extent to which owners of thermal power plants also own other plants that benefit from higher carbon prices
- the design of other aspects of the carbon pricing instrument

The first three of these are considered in this subsection, the last in the subsequent subsection on corrective measures.

More carbon intensive plants see larger cost increases than less carbon intensive plants; the owners of more carbon intensive plants tend to see larger negative distributional impacts. This is in line with intuition. For example, a study of the impact of the EU ETS on German power production showed that older generation plants, which were more carbon intensive, faced the largest negative impact and became unprofitable in all scenarios (IAE 2014).

The introduction of a carbon price in an electricity market influences the merit order of production: this can influence both the price at which electricity is sold and the frequency with which plants run. In competitive electricity markets, the price of electricity not sold under long-term contract will be set by the marginal plant providing the last unit of supply needed to meet demand. This is often thermal generating plant and can mean that carbon pricing leads to an increase in wholesale electricity prices. For instance, Benavente (2016) estimates that a carbon price of US$26/t$CO_2$e in Chile[14] would increase electricity prices by 8%. The extent to which an individual thermal operator's carbon liability is offset through an increase in electricity prices will therefore depend on its carbon intensity relative to the carbon intensity of the marginal plant after taking into account the carbon price: in cases where the carbon intensity of the non-marginal thermal plant is lower than the carbon intensity of the marginal plant, owners of that plant will see an increase in their profit margin, if cost pass-through is allowed. The converse also applies. The overall impact on profits (rather than profit margins) will also depend on whether the carbon price has any impact on how frequently the plant is sufficiently cost competitive to run. As a result, the ultimate impact of a carbon price on the profits of thermal owners depends on the precise dynamics within the electricity sector – in some cases, efficient, relatively low carbon intensive fossil fuel operators that are in the middle of the merit order have seen increases in profits from carbon pricing, even before the provision of free allowances (see next section) (IEA 2014).

Owners of thermal generation may benefit from higher infra-marginal rents on any renewable plant that they own. Following the logic above, owners of hydroelectric power are likely to see large increases in profits that can help support new investment. This is because they benefit from the increase in electricity price without any increase in costs and at the same time because they remain low marginal

[14] This is the carbon price that it is estimated would be necessary to achieve an emissions reduction of 20%. Magnitudes are similar to studies for other emerging markets with high shares of fossil fuels such as South Africa, Australia, and Canada.

cost producers, that can reliably supply power, they face no decline in output. Evidence shows that Norwegian hydro-generators earned rents as a result of the EU ETS (Zakeri et al., 2016). The overall size of these infra-marginal rents will depend on the make-up of the power market: in cases where hydroelectricity accounts for a large proportion of electricity, there will be substantial transfers towards owners of hydroelectric power stations. If these power plants have the same ownership as any thermal plant that see a decrease in profits, it can act as compensation. If hydroelectric and (adversely affected) thermal plant have different owners, then the redistributive impact of carbon pricing will be greater.

The existence of interconnected transmission capacity and regional transmission capacity can affect these dynamics. In Chile, there is an intention to connect the northern (SING) grid - almost exclusively developed for the mining industry and dominated by thermal capacity - and the central (SIC) electricity grid where most of the population is based and where supply is largely met by hydropower. Without the connection, the planned carbon price in SING would lead to an increase in electricity price as the marginal plant after the impact of the carbon price would often be highly carbon intensive. However, with the connection, prices in SING could increase by less, as some of the demand in SING might be met by hydropower from SIC, likely reducing the carbon intensity of the marginal plant in the combined grid, at least in some points in time. At the same time, SIC accounts for the major share of electricity demand in Chile and is also projected to be the main source of electricity demand growth during the next decade. This increases the likelihood that more carbon intensive thermal generators will be the marginal plants more often in the combined grid.

5.2.3 Corrective measures and/or harmonisation of interacting instruments

A key way to reduce the negative impact of carbon pricing on thermal generators (in systems with significant hydro capacity) is, in the case of an ETS, to provide free allowances; however, this often provides over-compensation. In many ETS, concerns about the negative impacts of the carbon price has led to regulators providing free allowances to thermal generators. However, in cases where these free allowances are provided as a lump sum amount (not varying according to output levels), economic theory and ETS practice have demonstrated that the provision of free allowances will have little or no impact on the output and pricing behaviour in competitive electricity arrangements. This can lead to windfall profits from thermal generators who benefit both from significant cost pass-through and yet also receive allowances for free. This is at the expense of taxpayers who would otherwise benefit from the revenues associated with auctioning allowances. While in theory it may be possible to calibrate the percentage of emissions that thermal generators receive for free in order to provide compensation for negative impacts but no more, in practice this has proven to be analytically demanding.

An alternative approach is to exempt energy sources from the carbon pricing instrument. Mexico exempted natural gas from its carbon tax in 2014 to support natural gas as an important thermal source in its future energy mix, and – in part – to support domestic development of natural gas resources. Chile’s carbon tax covers thermal generators, but exempts power plants using biomass as a feedstock (ICAP, 2017). The UK’s Climate Change Levy taxes electricity usage to promote energy efficiency and reduce GHG emissions, but initially exempted electricity generated from renewable sources in order to support the renewables sector. However, this exemption was removed in 2015 due to the implementation of more direct support measures (HMRC, 2015). However, if electricity generation is not covered by the CPI, generators will not have incentives to invest in low carbon technology, conflicting with a policy goal to reduce emissions intensity via investment in lower carbon fuels such as natural gas or investment in zero carbon alternatives (nuclear energy and renewables).

Distributional impacts on thermal generators can also be reduced by redistributing carbon revenues. The size of increased infra-marginal rents accruing to low carbon generators can be measured, taxed, and redistributed to thermal generators to reduce distributional impacts. The financial flows generated from carbon pricing have often been used to fund new technologies, such as carbon capture and storage, provide additional investment for renewables, or to incentivise energy efficiency, as illustrated by four countries:

- Mexico established the Energy Sustainability Fund that uses revenues from a levy on oil sales to fund renewable energy research and technology projects.
- Alberta's Specified Gas Emitters Regulation (SGER) requires facilities emitting over a threshold to reduce their emissions intensity or pay into a new technology fund at a rate of CA$15/t$CO_2$ that invests into low- and zero-carbon technologies (Read, 2014).
- In the EU ETS, the New Entrant Reserve (NER) 300 programme is a fund which aims to catalyse innovation into low carbon energy demonstration projects, with particular emphasis on CCS and renewable energy, and is funded by the sale of 300 million emissions allowances from the NER beginning in phase 3 of the EU ETS (European Commission, 2017).
- Similarly, in California's cap-and-trade program, a portion of revenues generated from allowances auctions is recycled into spending on energy efficiency and renewable energy projects in public buildings, as well as low carbon transportation and natural resource conservation programmes (LAO, 2014).

5.2.4 IMPLICATIONS

Carbon pricing will create impacts based on the distribution of thermal generation and the price increase. Some generators will gain as their infra-marginal rents rise. For example, hydro-generators and renewables face zero or virtually-zero marginal cost and as such use the electricity sales profits to finance their comparatively large capital investment. The carbon price raises the electricity price and hence the infra-marginal rents, allowing them to recover investments faster and/or expand. In contrast, the impact on thermal generators is more nuanced. For generators with higher emissions intensity and that are marginal plant after the impact of the carbon price, costs are higher and operational profits tend to decline. Lower emissions intensity thermal plant and/or mid-merit order thermal plant may benefit, depending on the specific demand-supply dynamics in the market.

In addition to redistributing rents within the power sector, carbon pricing can raise power prices for consumers (in an open market) or impact utility profitability and investment (in regulated markets). Carbon pricing in liberalised power markets where thermal generators are often the 'marginal plant'-

likely in markets with significant intermittent hydroelectricity which require reliable baseload generation – will lead to higher consumer prices and competitiveness concerns. If prices are regulated, and carbon costs are not allowed to be passed through, then the profit margin will fall, although it may create a more stable market for thermal generation to invest, as has been suggested in the case of China (SIPA, 2013 and Yang et al., 2016).

Based on the experience from EU ETS and considering Canadian grid linkages, an exemption of the electricity sector in Brazil could mitigate hydropower rents that would occur due to an increase in the electricity price. Norwegian hydropower generators benefitted from a price increase due to grid linkages with European thermal based markets and Québec exports its hydropower to bordering provinces in Canada and the US. In a semi-liberalized market of Brazil, where small consumers are subject to regulated tariffs, this would mostly affect large consumers. The investment incentives for thermal generators in Brazil are already partly aligned with a lower emission intensity - because of its large domestic gas exploitation potential - while oil and diesel are only available for electricity generation to a limited extent. This suggests that careful attention should be given to the role of carbon pricing in the Brazilian electricity sector, given its current predominance of hydro-electricity.

5.3 How to design CPIs so they can allow for growth in thermal electricity demand?

5.3.1 Case study jurisdictions

This question covers jurisdictions that are facing growing electricity demand while having introduced a carbon pricing instrument. These are:

- Chile with a carbon tax;
- China with an ETS;
- Mexico with a carbon tax and potentially, in the future, an ETS.

Chile introduced a carbon tax in 2014 in effect from 2017. The carbon price is \$5/tCO_2e on CO_2-related emissions and tax on local pollutants (SO_2, NO_X and particulate matter). About 42% of total emissions are included in the scheme (World Bank, 2016a). The point of regulation is at generation (midstream). Thermal power generators (boilers and turbines) using oil, natural gas and coal with thermal input equal to or above 50MW are obliged to be regulated, but biomass power plants are exempt. An ETS is also under consideration (ICAP, 2017). About 60% of Chile's electricity generation relies on fossil fuels, with 35% generated by coal.

Chile's electricity sector is largely privatized but concentrated. The electricity grid structure is peculiar due to long distances, different demand structures and generation sources (IEA, 2012). The northern (SING) grid is thermal-based with large solar development potential and serves the mining industry, and the central (SIC) grid is a hydrothermal system with 70 percent of the generation and 90% of the population. They are scheduled to be connected in 2017 and will together cover more than 90%

of the consumption. Industry accounts for 70% of the electricity demand. The SIC has suffered from energy shortages during the last decades due to drought periods, insufficient emergency response mechanisms and difficulties in obtaining natural gas. There has been a strong shift towards coal recently, while petroleum uses also surged temporarily until two LNG terminals in the north (Mejilliones) and centre (Quintero) were able to substitute for a reduction in Argentinian gas imports. The electricity generation share in total GHG emissions was 74.7% in 2010 (PMR, 2017a).

Chile is facing particular challenges due to their reliance on hydropower and lack of hydrocarbon reserves. Following a period of overinvestment in the 1990, indicators of self-sufficiency declined for all generation sources (OECD/IAE). Chile's fuel mix recently changed from a high reliance on natural gas to coal, and imports from Argentina were substituted with oil, leading to an increase in emissions intensity.[15] In addition, high oil prices and difficult climatic conditions for hydropower supply led to energy rationing and a 600% increase in the electricity price during the late 2000s, challenging the viability of their hydrothermal system without the ability to exploit domestic hydrocarbon reserves.

China will introduce a national ETS in 2017, covering emissions from the power sector (IETA). Seven pilot regional ETS are already in place (IETA, 2015a).[16] These pilot ETS cover the power sector and also include electricity generated outside boundaries. Allowances were almost entirely allocated for free, based on historical emissions.

Chinese electricity demand is estimated to increase 9-10% per year, and output by about 7.5%. In recent years, demand growth averaged at 8% and electricity generation more than doubled between 2005 and 2014 (IEA, 2015). In 2015, China generated 5,682 TWh of electricity, out of which 24.7% are from renewables (mainly hydropower and wind) – which have grown from a share of about 15% in 2007 (EIA, 2014; Enerdata, 2017).[17] Coal remains the primary source of electricity generation with. The Power sector is based on regional single buyers (regional grid companies) and still largely controlled by the state. More than half of generation assets are owned by ten large state-owned power companies. The NDRC controls on-grid and end-user prices, and dispatch. Both PPAs and end-user pricing are redistributive, charging more profitable generators more to incentivize investment, following an ability-to-pay strategy. Further, the dispatch regime is mostly based on an equal share rule and PPAs feature must-run provisions (SIPA 2013; Jotzo, and Löschel, 2014). The Chinese government has prioritized the expansion of nuclear, natural gas-fired and renewable power plants as well as the electricity transmission system to connect more remote power sources to densely populated areas along the coasts.

Mexico introduced a carbon tax with the first compliance period starting in 2014 and plans to implement an ETS in 2018. The carbon tax is approximately US$3.5/t$CO_2$ and the tax rate is capped

[15] The establishment of two new LNG terminals in 2010 could substitute for the missing imports from Argentina and the share of oil fell subsequently.

[1616] Compliance thresholds and caps differed across systems, but they shared common features regarding sectoral coverage, use of free allowances, CCER and flexible provisions (e.g. banking of allowances).

[17] The database on international energy statistics only has figures on net generation, which makes hydro from pumped storage negative and there are no other figures for hydro, just aggregate. Detailed figures for 2013 are available from NDRC (2014).

at 3% of sales price of fuel (IETA, 2015b). 46% of total emissions are covered jointly by the carbon tax and energy taxes (OECD, 2014b), but only 3% non-road emissions are taxed – in part because natural gas is exempted from the tax.

Mexico's electricity sector was subject to substantial reforms and a significant part of new capacity will be added. Current policy projections for Mexico indicate that annual growth in capacity and generation from renewables[18] will be 7.4 percent (GW capacity) and 6.3 percent (TWh generation) from 2014 until 2030, with the share of renewable electricity generation rising from 17 percent in 2014 to 31 percent in 2030. Yet despite this growth in renewables, gas-fired thermal generation (capacity) is also expected to experience an annual growth of 2.9 (4.6) percent over 2014 to 2030. This is needed in order to meet burgeoning electricity demand which is anticipated to rise by 147 TWh (2.5 percent annual growth) over the same period (IEA, 2016).

5.3.2 Implications of interaction of carbon pricing and growth in thermal generation

The interaction between carbon pricing and growth in thermal generation faces three trade-offs:

1. Incentivise investment into new thermal generation that generates emissions to cover rising demand
2. Reduce emission intensity
3. Reduce the price impact on consumers (and distributional impacts between generators, as laid in Section 5.2)

Electricity market regulation needs to allow the pass-through of carbon cost to reduce the financial impacts on thermal generators and incentivise electricity efficiency in consumers. For regulated markets, PPAs without flexible prices and cost-based dispatch might need to be revised upon introduction of a carbon pricing instrument. A problem could arise from the long-term contracts of existing plants when the carbon pricing mechanism is introduced. If there is no provision to revise PPAs to take into account the carbon cost for the reimbursement of variable costs when the plant is dispatched, the operation of these plants could become financially unsustainable if the cost is not passed through. The revision of the existing contracts is necessary in this respect to avoid early retirements of some equipment.

Some countries chose to keep the carbon price level and its impact low. Chile has a comparatively low carbon price of US$5/tCO2e that will be insufficient to incentivise fuel switching, which is predicted to require US$70/tCO2e (Ministerio de Energia - Gobierno do Chile, 2014). At the same time, this comparatively low carbon price limits the price impact on consumers and thermal generators. Mexico's carbon tax is set at comparatively low prices as well and it exempts natural gas, which incentivises investment in natural gas capacity compared to alternatives and is aligned with the broader electricity and energy plans for Mexico.

[18] Renewables being: hydro, bioenergy, wind, geothermal, solar PV, CSP

The alternative to low carbon prices has been to provide free allowances, which may lead to distributional issues laid out in the question in Section 5.2. A transitional arrangement with free allowances will send a signal to demand-side mitigation but lead to windfall profits for power generators and little scope for low-carbon investment in hydropower rich systems. During the first two phases of the EU ETS, free allowances were allocated to power generators. This led to large windfall profits for all generators as electricity prices increased because generators priced in the opportunity cost of selling their free allowances. In the EU ETS, the carbon price was low[19] and upon introduction led to fuel switching from coal to gas mostly in countries where initial gas-fired capacity was sufficiently high (Germany), and stronger with more liberalized electricity market (UK).[20]

Capacity markets that incentivise investment into new capacity and preserve the carbon price have been used when electricity markets changed to include a larger share of (intermittent) renewable generation. The UK implemented a capacity market to secure electricity supply by incentivising investment into thermal generation. The impending retirement of aging thermal capacity coupled with increasing shares of intermittent renewable electricity generation produced a risk that electricity supply will become insecure in the UK as revenues from the energy-only market may be insufficient to induce investment into capacity (DECC, 2014). The capacity market is aimed as a solution to electricity security of supply by incentivising investment into traditional power infrastructure to support low-carbon electricity generation, while also incentivising demand-side management (UK Government, 2016). The market works with competitive auctions whereby generators and flexible consumers bid to provide capacity and reduced demand, respectively, when required. The first two auctions in 2014 and 2015 have succeeded in securing approximately 100 GW of capacity, most of which was derived from existing gas-fired capacity (Orme, 2016). Winners of the auction bids receive a lump-sum payment and payment for actualised production, or reduced demand.

5.4 Lessons learnt from international experience

Carbon pricing has had a low impact on reducing emissions in international jurisdictions with electricity sectors which have high shares of hydropower. Carbon pricing instruments in electricity sectors with similar shares of hydropower in electricity generation have had little impact on emission reductions. The emissions intensity of these sectors is generally already low. In particular, the EU ETS has not had significant impacts on Sweden's electricity sector's emissions intensity, possibly due to minimal available short run abatement opportunities (Widerberg & Wräke, 2009).

[19] The main reasons for the low carbon price during the first two phases of the EU ETS were relatively low caps, low electricity demand due to the economic crisis, increasing shares of renewable energy and unexpected high inflows of certificates from CDM projects (IEA, 2013c).

[20] The evidence is limited for 2005-2007 and not many ex-post studies exist for 2008 onwards. Relative fuel prices and the low carbon price present important confounding factors in evaluating the effect of the ETS on fuel switching.

However, the jurisdictions identified have experienced little, if any, growth in thermal generation demand which is not the case for Brazil. For example, Sweden's annual electricity generation varied little between 380-420 TWh over 2005-15 (Swedish Energy Agency, 2015).[21] While Brazil's electricity sector emissions intensity is currently 97 tCO_2e/GWh, less than a fifth of the world average of 580 tCO_2e/GWh, it is also expecting a 40% increase in coal, oil, and natural gas thermal generation capacity growth over 2014-24, as shown in Figure 1. This implies that natural gas utilisation, in particular, will decrease from around 73% in 2014, to 38% in 2024. Thermal capacity growth will likely vary depending on the region, for example the remote northern regions generate electricity mainly through isolated oil-fired power plants (IAEA, 2016).

The introduction of a carbon price in the electricity sector can create infra-marginal rents for hydro generators. If the marginal electricity generator burns fossil fuels, then it will face an increase in costs and therefore raise the selling price of electricity. Zero (and low) carbon generators dispatched receive additional infra-marginal rents as the price of their output increases without any change in their costs. This depends crucially on the marginal generator being able to pass-through costs and raise electricity prices.

Distributional impacts depend on the structure of the electricity market, in particular the dispatch model and price regulation. Competitive electricity dispatch models facilitate distributional impacts on generators. In the UK, Germany, and Australia the merit-order is competitively determined and electricity prices reflect the marginal cost of generation. Whereas, in Brazil the dispatch model is centrally coordinated to minimise costs and take into account water scarcity and transmission issues. Electricity prices often vary from the marginal cost of generation. The level of electricity price regulation also influences distributional impacts. Fully liberalised electricity prices allow cost pass-through resulting in higher consumer prices, potential consumer competitiveness issues, and increased infra-marginal rents for hydro generators. Regulated electricity prices only allow a certain 'regulated' amount of cost pass-through, which limits the increase in electricity prices, and thereby lowers the profit margins of thermal generators.

[21] Except for the year 2009 where electricity generation dipped to 354 TWh, which may be attributable to the impact of the financial crisis.

6 LESSONS FOR BRAZIL FROM INTERNATIONAL EXPERIENCE WITH CARBON PRICING IN THE ELECTRICITY SECTOR

6.1 INTERACTION OF ELECTRICITY TARIFF POLICIES AND CPIS

A CPI in the electricity sector has the potential to reduce GHG emissions by providing three different incentives. These include incentives for fuel switching, for increased investments in renewables and for rational use of energy.

Key conditions for effectiveness of carbon pricing in the electricity sector may be absent in Brazil. The introduction of a carbon price will cause fuel switching if the signal is strong enough, merit order dispatch is affected, and the installed generation capacity of the country is flexible enough to absorb short-term changes by influencing dispatch decisions.

However, switching from fossil fuel to hydro generation in the short term might be challenging in Brazil due to recent drought conditions. Hydro capacity has been low in the past few years, and all the available thermal capacity in Brazil is running. It is unclear whether any spare capacity is available to allow for a short-term switch from coal to gas. Regarding dispatch, this is controlled by a central body in Brazil, ONS, individual generators currently have no control over this process. Therefore, any possible fuel switching from high to low carbon sources can only be brought about by including this as a criterion in decision-making for dispatch by ONS. In the long-term a carbon price could influence prices and thereby influence ONS decision-making process for dispatch.

Carbon pricing may have an impact on the competitiveness thermal generation favouring renewables in government auctions where they compete directly. Brazil's centralised auctions in the regulated market guarantee power producers a route to market. The rules of the auctions vary from auction to auction. Some of them are technology specific (e.g. only solar compete) or for broader categories (e.g. renewables) and in others are opened to more types of generators, in which case thermal and renewables do compete. In the latter case, introducing a carbon price may have an impact on the competitiveness of thermal generators favouring lower carbon generation. The situation may be different in the free market if power producers of different technologies compete more directly.

However, the Brazilian Electricity sector experts who are counterparts for this study indicated that Brazil may be considering an electricity market reform. This could include a move from technology-specific to attribute-specific auctions for the regulated market. Attributes include characteristics of the generation, including for example ramp up time or GHG emissions per unit of electricity produced. If a carbon price were imposed in this scenario, lower carbon generation with similar attributes may have a competitive advantage.

If the carbon price can be passed down to consumers, this may provide an incentive for more rational use of energy resulting in GHG reductions. Brazil has a tariff realism policy in place that incentivises consumers to ration and use their electricity more efficiently. This policy was designed to deal with periods of drought where electricity supply from hydropower is low. The policy functions by giving a signal to consumers when a drought is expected to reduce their consumption. Electricity prices in these times of drought are then higher to reflect the shortage in supply. The objective of a carbon price to incentivise more rational use of energy is in line with the objective of the tariff realism policy. It may be possible to pass through the carbon price to final consumers.

However, electricity price rises would be unpopular in the current climate in Brazil where prices are already high due to high thermal load factors. Moreover, rises in prices could also contradict policies in Brazil that are aimed at keeping tariffs low and to protect lower income households. In the design of a possible carbon price in Brazil it will therefore be important to understand how disproportional impacts on low-income consumers can be avoided. Additionally, more research is needed to understand the level at which a carbon price will incentivise rational use of energy and reduce GHG emissions, without having any negative impacts.

By compensating other electricity tariff policies, a carbon tax can function as an effective revenue recycling tool thereby also minimizing adverse socio-economic impacts. The South Africa case study shows that a carbon tax can be designed in such a way that it does not have an impact on electricity prices but does solely act as a revenue collection tool. This could create an earmarked pot of money for renewable energy support and energy efficiency measures. This might be a possible option for Brazil if it does not want to affect electricity prices to avoid impact on vulnerable groups or have other adverse socio-economic impacts. Simultaneously with the carbon tax, South Africa does signal to utilities to prepare for future costs and see how they could bring about efficiencies. This would potentially prepare the country for the next phase to pass through costs and increase carbon/electricity prices: However, there is also a possibility to have full pass through of costs as shown by New Zealand, which will allow for more efficient use of electricity.

6.2 Interaction of support for renewable generation and CPIs

The following lessons may be drawn from international experience studied in theme 2.

A carbon price on its own may not lead to strong enough incentives to stimulate increased generation capacity from renewable energy. Given the need to expand generation capacity in Brazil, additional incentives for increased investment into renewables are therefore important for the Brazilian context, including the renewable energy schemes that are designed to stimulate these increased investments and make them more favourable than thermal generation options. The case studies illustrate that renewable energy schemes are generally set out to achieve other policy objectives than CPIs and therefore add additional value next to market-based mechanisms to reduce GHG emissions. It will thus be important in Brazil to have strong policies in place to incentivise investments in renewables. One such an option may be to organise more central auctions that are specifically targeted at renewable energy generators.

In addition, CPIs need to be continually adjusted to harmonise policy objectives. The international case studies describe the importance of including emission reduction expectations from renewable energy support schemes into the design of the carbon pricing mechanism and to keep this regularly updated. Moreover, other corrective measures to avoid negative overlap between policies include a mechanism to account for uncertain changes to control the amount of carbon allowances and a high transparency and disclosure of objectives and mechanisms of the policies. Therefore, if a carbon price is introduced in Brazil, careful design of the instrument and its incentives is crucial to avoid overlap and increased (administrative) costs. It will be especially important to account for any additional renewable energy generation that is brought about via other policies and to account for this when setting emission reduction targets of the CPI.

Finally, additional costs from the overlap of policies may disproportionally impact low-income consumers. Both RES and CPI typically pass on costs to consumers, thereby making it likely that interaction between the policies will have distributional impacts. Moreover, overlap between policy objectives, such as double incentives for generators to take up renewables, can cause higher administrative costs that can possibly be passed on to consumers. Increased costs to bring about emission reductions, or significant rises in electricity prices may impact low-income consumers disproportionally, as they spend the largest proportion of their income on electricity.

Additionally, the case studies highlight the importance of corrective measures by the government to ensure that incentives for renewable energy are additional. It also shows how revenue recycling and exemption of certain industries can counter-act negative distributional and competitiveness impacts. Even though the carbon tax in South Africa still needs to be implemented, the design of the tax that considers a detailed description of renewable energy support schemes can ensure all policies achieve their objectives.

These findings are relevant to consider for Brazil, where policy is aimed at keeping prices low and minimising distributional impacts. It will be important for Brazil to consider possible distributional impacts of policy interactions when designing a CPI and including mechanisms in the design of the CPI that can avoid any negative impacts. Lessons can also be learned from South Africa on the use of the carbon tax as a revenue recycling tool to mitigate any possible distributional impacts of the CPI.

6.3 Limitations of CPIs in Brazil's thermal electricity sector

Implementing a CPI in Brazil's electricity sector as it currently stands may lead to negative distributional impacts, which could be reduced by liberalising electricity prices. The dual context of the Brazilian electricity market could result in a CPI creating uneven cost distribution. In the regulated market, households and other small consumers are largely protected from price increases, but thermal generators bear the burden. In the unregulated market, large consumers face increased prices while generators bear less of a burden and low-carbon generators reap increased infra-marginal rents. Additionally, in the presence of geographic variation in generation technology, a CPI would lead to regional cost disparities which would need to be mitigated by revenue redistribution. This is particularly relevant for isolated consumers in the north, whose energy demand is primarily supplied by thermal generators using diesel oil (ONS, 2017). Liberalising prices in the sector could help minimise the distributional impacts on thermal generators in the regulated market but may cause worsen the geographic distributional impacts on consumers served by more emissions-intensive generators.

6.4 Lessons for emissions regulation in Brazil's hydro-dominated electricity sector

Emissions regulation should focus on future capacity in hydro-dominated electricity markets expecting growth in thermal generation. Currently, due to the dominance of Hydro generation, electricity emissions currently comprise only 3.5% of Brazil's national GHG. International experience suggests that CPIs have little effect on emissions reductions in such sectors. However, significant additional thermal generation capacity will be required in the future to meet rising electricity demand. As such regulating the emissions of future capacity additions, potentially through command and control mechanisms or well-designed capacity markets, may be more effective than carbon pricing given that this can provide greater certainty about fuel choice and can also include local air pollution and other negative impacts of thermal generation. However, command and control mechanisms may be cost inefficient as they do not consider the cost of compliance. Regulatory approaches in the power sector include mandatory norms, technology or emissions standards and technology bans or moratoriums for new developments. For example, Norway imposes strict authorisation criteria for new generation investments that consider environmental issues, and Scotland, as the UK, has a requirement to install CCS for fossil fuel power stations once it becomes available.

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A. APPENDIX - MECHANISMS TO ALLEVIATE ENERGY PRICE RISES DUE TO CARBON PRICING ON LOW-INCOME HOUSEHOLDS

Additional research was requested on the topic of "Mechanisms to alleviate energy price rises due to carbon pricing on low-income households". This section seeks to answer the following four questions:

1. Which households are eligible for support to mitigate impacts of carbon pricing on energy prices?
2. What are the mechanisms to support households, particularly for electricity price increase?
3. What is the role of revenue recycling in the support mechanisms?
4. What have been the results and impacts on low-income households?

A. 1 AUSTRALIA

A. 1. 1. HOUSEHOLDS ELIGIBLE FOR SUPPORT

The Australian government expected the carbon price to increase electricity prices, and hence consumer, prices. Australia introduced a AU$23/t$CO_2$e carbon price in 2012 and estimated that the impact on consumer electricity prices would be 0.7%, or around $9.90 on average per week for households in 2012-13. The implementation of the carbon price was also expected to raise electricity prices over the period 2013 to 2017 by an annual average of 10-17%.

The Household Assistance Package helped lower income households offset cost increases associated with the carbon price. The overall objective of the assistance package was to offset the expected average price impact of the carbon price for low and middle-income households. .Australia developed its household assistance package to provide tax cuts to all individuals earning under AU$80,000 per annum – 60% of taxpayers (Australian Government, 2011b). Low-income households[22] and middle-income households received the assistance to meet their average electricity cost increase, while fewer high-income households received financial support (Commonwealth of Australia, 2011). This is due to the fact that low-income households spend proportionally more of their income on electricity than high-income families[23]. The Australian Bureau of Statistics noted that from 2009 to 2012,

[22] Australia categories households based on net disposable income quintiles. Low-income households are the two lowest quintiles, middle income households as those in the third quintile, and high-income households as those in the highest quintile.

23 According to the Australian Bureau of Statistics, in 2012, low-income households spent around 10% of their gross income on energy, almost three times the share of households from the highest quintile. In 2012, low income households spent AU$77 per week on energy, while middle and high-income households spent AU$111 and AU$116 per week, respectively.

low-income households spent a share of their income 3 to 4 times larger than do households from the highest quintile (Australian Government, 2011 and Australian Bureau of Statistics, 2017).

The Household Assistance Package also provided direct transfer support through the Clean Energy Supplement (CES). As a pre-cursor to the ongoing support provided by the CES, a once-off Clean Energy Advance (CEA) was made available to low-income households. The CEA was a tax-free increase in direct payments added to the support already received by groups such as low-income families, pensioners and other individuals such as job-seekers. From March 2013 until early 2014, this extra support became a regular part of government payments through the Clean Energy Supplement. Households with high home energy costs due to essential medical equipment, pensioners, and other groups already receiving government income support were eligible for this additional assistance.

A. 1. 2. MECHANISMS TO SUPPORT HOUSEHOLDS

Support to households in Australia is traditionally provided to households through state governments' rebate policies. State Governments were originally the primary provider of support for low-income households with deductions from the energy bill, so called rebates and concessions (both discounts), assistance through electricity credit, and temporary financial assistance measures (Chester, 2013). Table A1 lists Australian state policies, benefits provided, and eligibility.

Table A1 - States have been the primary provider of household support in Australia

State	Policy	Benefit	Eligibility
New South Wales	Low income household rebate	AU$225 per annum paid in instalments taken off each electricity bill	Recipients of several government payments
	Family Energy Rebate	AU$75 per annum	Recipients of several government payments
Queensland	Electricity Rebate	AU$ $282.54 per annum	Seniors and pensioners
Victoria	Annual Electricity Concession	17.5% off electricity bills. Not applied to the first $171.60 of a household's annual bill.	All households
South Australia	Energy Bill Concession	Up to $165 per annum	Recipients of several government payments who must not be living with anyone with an income of over AU$ 3,000 per annum
Western Australia	Account Establishment Fee Rebate	AU$33.80	Recipients of several government payments

State	Policy	Benefit	Eligibility
	Dependent Child Rebate	69.28 cents per day: 1 child 87.44 cents per day: 2 children 105.60 cents per day: 3 children 123.76 cents per day: 4 children	Parents
	Air-conditioning rebate	AU$47.07 per applicable month	Recipients of several government payments
	Cost of Living Assistance	$208 per annum credited to electricity bills on a daily basis	Recipients of several government payments

Source: Vivid Economics.

The main element of the Household Assistance Package provided support to eligible households through tax reform and direct transfers. Tax reforms for individuals began in 2012 and entailed tax cuts and increases in the tax-free threshold. The reform resulted in a total of AU$7 billion of tax cuts over 2012-2013, targeted at low and middle-income earners (Australian Government, 2011b). Through this reform, the tax-free threshold rose from AU$6,000 to AU$18,200.

Another part of the Household Assistance Package, the CES, supported eligible households by providing increased direct transfers. The Clean Energy Supplement was equivalent to a 1.7% increase in the relevant annual maximum payment rate for groups receiving direct transfers. A Low-Income Supplement of AU$300 was available to people in low-income households who did not receive enough assistance through tax cuts or other household assistance payments. Pensioners received an initial payment of AU$250 for singles and AU$190 for each eligible member of a couple, while other individuals, such as job-seekers received an initial payment of AU$160 for singles and AU$150 for each eligible member of a couple

A. 1. 3. Revenue recycling

The recycling of carbon revenues funded the Household Assistance Package. The Package received over 50% of the carbon price revenue (C2ES, 2011). Estimates show that the Australian Carbon Tax netted AU$6.6 billion in the year 2012-2013 and AU$7.2 billion in the year 2013-2014, so the carbon price provided at least AU$7 billion in support (Financial Review, 2014).

A. 1. 4. Results

The recycling of the Australian carbon price allowed significant government expenditure. Revenues from carbon pricing made fungible tax cuts of AU$ 7 billion and financed a 1.7% increase in payments to pensioners and other recipients, including eligible families, self-funded retirees, students, and jobseekers.

A. 2 Eastern Europe – illustrated with Poland

A. 2. 1. Households eligible for support

All households in Poland received indirect support through maintained low electricity prices. Poland applied for the EU ETS derogation policy which allows power generators to continue receiving free allowances into Phase 3. As the power sector continues to receive free allowances, they are not faced with increased costs which they might pass through, and they are prevented from raising prices unjustifiably by the Polish national Energy Regulatory Office (ERO). Thus, all households are indirectly supported through avoided electricity price increases.

A. 2. 2. Mechanisms to support households

The EU ETS introduced allowance auctioning for the power sector in Phase 3, replacing the free allocation of the two previous phases. According to the European Commission (2017), the first two phases of the EU ETS showed that power generators had reaped windfall profits by passing on the costs of allowances to customers even though they received them for free. From the start of the third phase, companies in the electricity generation sector were no longer given free allowances but had to buy them at auction.

The derogation policy (Article 10c of the Directive 2009/29/EC) provides for the continuation of free allocation support in the power sector until 2019. The European Commission developed the policy to ease the burden on countries with limited short-run opportunities to shift away from fossil fuel generation. Countries may start with a maximum of 70% of power sector allowances allocated for free in 2013, decreasing annually until there is no free allocation in 2020. This policy is conditional on the power sector developing low-carbon, modernisation plans to stimulate the transition to a low-carbon future.

The Polish government applied for derogation as of the introduction of power sector allowance auctions in the EU ETS, arguing that it would increase electricity prices to households. As a member state of the European Union, Poland takes part in the EU ETS. Yet, in 2013, Poland relied on coal plants for 85% of electricity generation and argued that the cost of buying permits via auction would cause an unacceptable 200% rise in energy prices for households (Poland's Climate Coalition, 2012; IEA, 2017). Poland therefore applied for the continuation of free allocation for 176 installations in the power sector using the derogation policy. The total market value of free allowances requested for Phase 3 (2013-2020) was estimated at EUR 7.41 billion, corresponding to 404.6 MtCO2e (ClientEarth, 2015). Eight of the Member States which have joined the EU since 2004 – Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Romania and Poland – have made use of the derogation policy.

However, the Polish national ERO protects consumers from undue electricity price increases. In 2014, the share of energy expenditures for the lowest and highest quintiles was 13% and 10% of their disposable income, respectively (Eurostat, 2016). To protect households, the Polish Energy Law states that energy suppliers submit their tariffs on natural gas and electricity for approval. The law allows for tariffs to cover operational costs, return on capital, and any expenses incurred while implementing renewable energy and promoting energy efficiency. However, the law also mandates that tariffs are such that consumers do not face unjustified electricity prices. Since 2008, this obligation concerns only tariffs for households, as electricity prices for industry are no longer regulated.

Poland provided support thermal generators through direct financial support. The policy rationale for supporting thermal generation in Poland has been to manage electricity prices and to increase access for low-income households.

A. 2. 3. Revenue recycling

Recycling revenue from auctions may be an option to protect households when the power sector start buying allowances in 2020. The EU ETS provides for revenue recycling to households. As free allowances to the power sector decrease under the derogation policy, low-income households can be supported by the use of auction revenue. Member States have agreed that at least 50% of revenues from allowance auctions should be used for climate action inside or outside the EU. In this sense, climate action encompasses support for low-income households affected by increases in electricity prices, particularly support for the adoption of energy efficiency measures.

A. 2. 4. Results

There has been no evaluation of the impact of the derogation policy on Polish households, but electricity prices have been stable since 2010. Figure A1 shows that household electricity prices in Poland remained between EUR 13.41/kWh and EUR 15.29/kWh over 2010 to 2016 (Statista, 2017).

Figure A1 - Household electricity prices in Poland remained stable over 2010 to 2016

Source: Statista (2017).

The exact contribution of the derogation policy to electricity price stability is unclear. Several factors determine electricity prices. No studies have yet disentangled to what extent the EU ETS caused electricity price variation in Poland. Though Figure 3 suggests that Poland has been successful in keeping electricity prices stable over time.

From the introduction of the policy in 2013 to 2016, the share of coal in Poland’s electricity mix has fallen but is still predominant. The share of coal in Poland’s electricity generation mix has fallen from 85% in 2013, when the policy was implemented, to 81% in 2016. However, this number still shows that the country is quite far from cleaning its electricity matrix (IEA, 2017).

A. 3 South Africa

A. 3. 1. Proportion of low income consumers and mechanisms for protection

South Africa has an electrification rate of 85.3% in 2013 and has several mechanisms in place to protect consumers from electricity price rises. The existing methods in South Africa to reduce energy poverty in the country include two mechanisms, which predate the carbon tax:

The **free basic energy** (FBE) scheme for low income households:

- **This is a mechanism whereby households receive 50kWh per month of free electricity.** Households are selected via self-targeting with current limiting. This is a mechanism whereby only households that have applied for a low 10 Ampère (A) connection are eligible for the free allocation of electricity. This is based on the assumption that poorer households have a low demand for electricity and therefore typically have an electric current supply up to 10A. Households with these connections will automatically be allocated 50 kWh of electricity per month for free and will only have to pay for electricity consumed above this 50kWh. It thereby works as self-targeting as only poor households apply for lower Ampère connections. This method has been preferred rather than a broad-based allocation method whereby every single household would receive a free 50kWh allocation. However, the self-targeting method requires service providers to ask the service authority to transfer the costs of providing this FBE, as the service authority will be responsible for covering these costs. It therefore adds a lot of administrative burden and costs to service providers.
    - **Only a small number of municipalities use different allocation mechanisms for the FBE scheme.** These mechanisms include broad-based (i.e. everyone receives a free allocation of 50kWh) or self-targeting without current limiting, which means that only households applying for a capped consumption of not more than 150kWh are eligible for the FBE (this is not related to the amount of Ampère of the electricity connection) (Statistics South Africa, 2016).
- Estimations made in 2000, when the policy was designed, showed that around 37% of connected households would make use of the FBE via self-targeting with current limiting mechanism (Republic of South Africa Department of Minerals and Energy, 2003). However, the expectation was that with the high electrification trends from 2000 to 2015, the proportion of poor households from total connected households would increase significantly. In 2015, it was estimated that around 10.9 million consumer units in South Africa were provided with electricity from municipalities and about 2.7 million of those (25.2%) used the free basic electricity scheme (Eskom, 2016; Republic of South Africa Department of Minerals and Energy, 2003).
    - The costs related to allocating 50kWh of free electricity to low income households include the costs of the electricity, but also administrative and technical costs (e.g.

meter placements) (Department of Minerals and Energy, 2003). Eskom estimates that in 2015 870,060 MWh of free electricity were allocated in South Africa (Eskom, 2015). Assuming that all receiving consumers of this FBE usually pay a homepower or homelight (low usage) tariff, the capital costs of the FBE would total around 830 to 880 million ZAR in 2015 (64 – 69 million USD) (Eskom, 2015). In 2002 it was expected that the FBE scheme with broad allocation would cost 1.64 billion ZAR per year, while a self-allocation scheme would be around 600 million ZAR (Eskom, 2016)(Statistics South Africa, 2016). However, the expectation was for these costs to rise when electrification rates in South Africa would also increase in the 2000s. Other costs that need to be considered when implementing these schemes include updating of payment systems, meter replacements, upgrading (rural) electricity networks to supply the increased demand, increasing administrative capacity at the municipal level and for the service provider. It has been estimated that these additional costs would amount to 200 million ZAR per year under the self-allocation scheme in South Africa (Republic of South Africa National Treasury, 2011).

Cross-subsidies:

- This is a mechanism whereby high-income households are charged a higher tariff to subsidize electricity provision for lower income households. High income is defined by higher use of electricity than the average 500-600 kWh per month in South Africa. This means that the majority of residential consumers would pay a price for electricity that would be significantly lower than a cost reflective price. However, there are more than 2000 different tariffs in South Africa based on the region and municipality and the cross-subsidy scheme therefore lacks transparency of how and when it is applied (Chehore, 2014).
- 40% of revenues from cross-subsidies are allocated to benefit residential customers and 13% for industrial customers. However, many difficulties exist with cross-subsidies in South Africa including:
    - **Subsidies are allocated per municipality.** In many municipalities, there are not enough customers in the higher-use blocks to account for the subsidisation of the lower-use blocks.
    - **The low-use customers targeted are not always poor households,** for example holiday homes fall into the low-use category as well (Republic of South Africa National Treasury, 2011).
- The idea behind cross-subsidies is that they would help increase electricity prices to a cost reflective level while not affecting low and middle incomes disproportionally. It has been estimated that 40% of all residential consumers and 13% of industrial customers benefit in some form from cross-subsidies.

- This measure is also based on the idea that the high tariffs for high income households would incentivize the implementation of energy saving mechanisms (Republic of South Africa National Treasury, 2011; Swart & Deloitte, 2015).

A. 3. 2. MECHANISM OF COMPENSATION FOR ELECTRICITY PRICE INCREASE DUE TO CPI

The introduction of a carbon tax in South Africa was designed in such a way that it would not affect electricity prices in its first phase until 2020 and would therefore be ‘revenue neutral’. The tax was designed to redistribute taxes and to shift behaviour towards a low-carbon economy without impacting economic growth. The carbon tax will therefore be implemented alongside a reduction in the electricity levy, to have no net effect on electricity prices (Swart & Deloitte, 2015). In the first phase, the carbon tax is expected to increase electricity prices between 1 and 2 cents per kWh, but the electricity levy currently causing 3.5 cent increase per kWh for non-renewable sources will be phased out with the same amount. The carbon tax is expected to lead to a reduction in the economy’s average annual growth rate of 0.05–0.15 percentage points, compared to business-as-usual (Ward & De Battista, 2016).

It is expected however that after 2020 the carbon tax might not have a zero-net effect on electricity prices anymore, but instead the electricity price may increase by 1 cent/kWh for every R10 / tCO_2e charged as carbon tax.

A. 3. 3. REVENUE RECYCLING

As previously described, to reduce the impact of the carbon tax on low-income households, it is expected that the carbon tax will predominantly function as a revenue tool and not raise electricity prices. Revenue is planned to be invested in such a way that it will protect vulnerable communities from the impact of potential energy price increases, whilst supporting the transition to a low-carbon economy.

South Africa’s emphasis on revenue recycling means that the carbon tax is expected to be revenue-neutral for the first five years. Research suggests that the policy objectives the government sets do not only influence how revenue is recycled but also what effect the carbon tax will have on the economy and on GHG emission reductions. One study suggests that if all carbon tax revenue was recycled into the solar energy sector then abatement could be more significant, i.e. 46% lower than the baseline in 2035. However, under this scenario, economic growth is projected to be 2.7% instead of 3.3%. Reasons for this difference are believed to be due to limited ability for sectors to switch to such a specific focused scenario and thereby adding higher abatement costs than under a scenario where the technology is not specified (Simcock, 2016).

A. 3. 4. RESULTS

No results can be reported, as the carbon tax in South Africa has not been implemented yet.

A. 4 CHILE

A. 4. 1. PROPORTION OF LOW INCOME CONSUMERS AND MECHANISMS FOR PROTECTION

Chile has several subsidies in place to reduce the impact of high electricity tariff rises on low income households. For example, since 2005 there has been a law in place that subsidizes poor households when there is an electricity price rise of more than 5% in 6 months or less. When this subsidy was applied from June 2005 to March 2006, it covered around 40% of the population, or 1,250,000 households (Chile Central Energia, 2016). The subsidy is mostly used when rainfall is low, which causes a limited amount of hydropower generation and thereby high electricity prices (Chile Central Energia, 2016).

A. 4. 2. MECHANISM OF COMPENSATION FOR ELECTRICITY PRICE INCREASE:

The carbon tax in Chile was designed as part of a larger tax reform scheme that planned to collect 3% of GDP (Ministerio de Energia - Gobierno do Chile, 2014). The level of the tax was planned in 2014 to be between 1 and 3 USD/tonne of CO_2e. The low price was chosen to avoid any concerns on international competitiveness and the main purpose of the tax was revenue collection (Montero, 2015).

The carbon tax was implemented in 2014 and covers thermal generators equal or larger than 50MW. The targets of Chile include a 30% reduction of GHG emission intensity (CO_2e per unit of GDP) from 2007 to 2030, which could be increased to 35-45% if Chile receives international financial support (International Carbon Action Partnership (ICAP), 2015). No information seems to be available on how the tax will be recycled and whether there is a mechanism in place in Chile that compensates low income consumers for electricity price increases.

A. 4. 3. REVENUE RECYCLING

Chile has no current plans to recycle revenues from the carbon tax into the implementation of mitigation actions, energy programs or to compensate low-income households from rising electricity prices. The government is instead considering using the revenue from the carbon tax for another tax reform compensation plan, which is unrelated to electricity prices (International Energy Agency, 2009).

A. 4. 4. RESULTS

It has been argued that the impact of the carbon tax on electricity prices is mostly dependent on factors that are not in the control of policymakers. These include the amount of renewable energy investments, fossil fuel prices and the weather conditions affecting hydroelectric resources (Benavides et al., 2015). Since the carbon tax has been implemented in 2014, electricity prices have decreased in recent years in Chile due to high generation levels from renewable sources (Benavides et al., 2015).

A. 5 MEXICO

A. 5. 1. PROPORTION OF LOW INCOME CONSUMERS AND MECHANISMS FOR PROTECTION

The electricity subsidies in Mexico are among the largest in the world and are approximately around 1% of Mexican GDP in 2006. This adds up to approximately one-third of the total revenue of the electricity sector. About 66% of these subsidies are allocated to residential consumers. These subsidies to residential consumers increased in total value with 46% from 2002 to 2006. There has been some critique that this high level of subsidies causes price signal distortion. For example, it is argued that an artificial low price does not incentivize people to adopt energy saving measures. The electricity subsidies in Mexico originate from the 1970s, when the government divided tariffs into three blocks and compensated hotter areas of the country for higher electricity prices. This system has gradually become more and more complex, with 112 different tariffs for residential consumers now (Komives, Johnson, & Halpern, 2009).

Moreover, it has also been argued that a high proportion of subsidies are unintentionally allocated to the 'non-poor'. Currently, subsidies are allocated based on quantity consumed but there are proposals to shift it to a cash transfer programme whereby households are 'means' tested to allocate subsidies. The quantity of electricity consumed is not a correct measure for income of the household, as low-income households often have inefficient appliances or are living in hot climates where a lot of air-conditioning is necessary. On the other hand, higher income households might have lower electricity use due to holiday homes that are not always used or single professionals who are often not at home. Therefore, the government is considering changing this subsidy scheme to improve its targeting of low income households (Komives et al., 2009; Labeaga, Labandeira, & López-otero, 2016).

A. 5. 2. MECHANISM FOR COMPENSATION FOR ELECTRICITY PRICE INCREASE

Mexico introduced a carbon tax in 2014 at 3.50 USD per tCO_2e. This covered fossil fuel sales and imports, although natural gas is exempt. Companies are allowed to use offsets from domestic projects to fulfil their tax liability (Labeaga et al., 2016).

The government in Mexico has implemented two tax reforms simultaneously with the carbon tax. These measures include an elimination of subsidies from gasoline and the implementation of a gasoline tax (Labeaga et al., 2016).

A. 5. 3. REVENUE RECYCLING

The Mexican government has considered various revenue recycling options to reduce the impact of the CPI on low-income households. These include the transfer of an equal lump sum to all households, the transfer of an equal lump sum only to low-income households and the transfer of an amount inversely proportional to the household income level only for low-income households. These measures could be implemented by using the existing programs in Mexico to compensate low income households(Labeaga et al., 2016).

However, revenues from the carbon tax in Mexico are not earmarked at the moment. Carbon tax revenues are assumed to be used for general funds by the government, including a high level of subsidies allocated towards fossil fuels, as compared to the level of the carbon tax (Carl & Fedor, 2016).

A. 5. 4. RESULTS

President Nieto has implemented an energy reform in 2013 that caused significant fuel price rises. In 2016, fuel prices in Mexico rose by 20%, which led to unrest in the country. Regulated residential electricity prices increased by about 2.1% and are expected to increase further (Garcia, 2016). Electricity prices for high-consumption users, however, increased by 22% from 2015 to 2016 to incentivize energy conservation. The overall purpose of the energy reform is to increase private participation in Mexico's electricity sector and to make electricity prices more cost-reflective, improve the competitiveness of renewable energy and increase the development of new capacity (KPMG, 2016). These actual and forecasted price rises and their public reactions have made the ideas of increasing the carbon tax and implementing an ETS controversial.

A. 6 Lessons learnt from mechanisms to alleviate energy price rises caused by CPIs

CPIs can increase electricity prices significantly and thereby impact end-use consumers. As low-income households spend the largest proportion of their income on electricity typically, CPIs can potentially impact them disproportionally. The analysis of 5 case studies shows there are some general mechanisms that are effective in alleviating energy price rises caused by CPIs for low-income households.

If a CPI raises electricity prices, households face distributional impacts and can be supported through direct transfers without diluting the carbon price signal. The regressive impacts of electricity price increases necessitate support be given to certain groups. However, supporting mechanisms should be designed to be coherent with carbon pricing mechanism. Revenue recycling, such as direct transfers to households, can provide support while maintaining the carbon price signal. Australia, for example, provided assistance to low-income households through direct cash transfers and tax cuts, financed largely by the CPM itself, which were designed such that the emission reduction incentive of the carbon price signal was retained. Similarly, Phase 3 EU ETS no longer provided free allowances to the power sector and indirectly alleviated distributional impacts. While not reducing electricity prices, the increase in government revenue from auctions could be used to support low-income households

It is important to have a smart design of selecting households that are eligible for support to mitigate impacts of CPIs on energy prices. This is important to make the policy cost-effective. South Africa demonstrates that a self-selection method whereby households with a low ampere connection to the grid get guaranteed a free proportion of electricity works well. However, the mechanism should also include a revenue raising component to be able to afford this scheme, e.g. cross-subsidization.

Energy price rises can also bring about more rational use of energy and thereby GHG emission reductions. It will therefore be important to find a right balance between no significant price rises that impact low-income households disproportionally, but enough incentives for rational use of electricity. The case studies also demonstrate that revenue recycling is an effective mechanism to prevent negative impacts of a CPI on low-income households and could perhaps be used to find this balance.