

# THE SOUTH AFRICAN CARBON TAX

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Presentation based on modelling and results in the  
PMR country paper for South Africa prepared by Vivid Economics and  
Van Heerden et al. (2016)

PMR Technical Workshop, Costa Rica, December 2016  
with an additional section on the way forward prepared for  
ESSA Conference, Rhodes University, August 2017

**Searching for Triple Dividends in South Africa:  
Fighting CO<sub>2</sub> pollution and poverty while promoting growth**

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*A CGE model of South Africa is used to find the potential for a double or triple dividend if the revenues raised from an energy-related environmental tax are recycled to households and industry through lowering existing taxes. Four environmental taxes and three revenue-recycling schemes are compared. The environmental taxes are (i) a tax on greenhouse gas emissions, (ii) a fuel tax, (iii) a tax on electricity use, and (iv) an energy tax. The four taxes are constructed such that they have a comparable effect on emissions. The revenue is recycled through either (i) a direct tax break on both labour and capital, (ii) an indirect tax break to all households, or (iii) a reduction in the price of food. A triple dividend is found – decreasing emissions, increasing GDP, and decreasing poverty – when any one of the environmental taxes is recycled through a reduction in food prices.*

**1. INTRODUCTION**

Although classified as a developing country, the South African economy resembles a developed economy in many respects. It is not surprising that the country's economy has been referred to as a “double-decker” economy, meaning an economy with different layers of income (Sparks 2003). According to the United Nations Development Programme (UNDP, 2003), South Africa is a country of two societies, one ranked 18th in the world (the top deck) and the other 118th (the bottom deck) based on gross domestic product per capita. Depending on the poverty measure used, between 45 and 55% of all South Africans lived in

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**CARBON TAX POLICY PAPER**

**Reducing greenhouse gas emissions and  
facilitating the transition to a green economy**

**DRAFT CARBON TAX BILL**

**MEASURING THE CARBON INTENSITY OF  
THE SOUTH AFRICAN ECONOMY**

CHANNING ARNDT<sup>†</sup>, ROB DAVIES<sup>‡</sup>, KONSTANTIN MAKRELOV<sup>§</sup> AND JAMES THURLOW<sup>\*</sup>

**Introducing carbon taxes in South Africa<sup>☆</sup>**

Theresa Alton<sup>a</sup>, Channing Arndt<sup>b,\*</sup>, Rob Davies<sup>a</sup>, Faaiqa Hartley<sup>a</sup>, Konstantin Makrelov<sup>a</sup>, James Thurlow<sup>c</sup>, Dumebi Ubogu<sup>a</sup>

**THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF A CARBON TAX  
IN SOUTH AFRICA: A DYNAMIC CGE MODELLING APPROACH**

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Accepted September 2016



COUNTRY PAPER | SEPTEMBER 2016

**Modeling the Impact on  
South Africa's Economy of  
Introducing a Carbon Tax**

# AIM OF THE RESEARCH (PART 1)



- Isolate and measure the effect of the carbon tax in helping achieve South Africa's emissions target...
- Determine who the winners and losers will be of the proposed carbon tax...
- Test various tax recycling scenarios that minimize any unintended negative consequences...
- Using a modified version of UPGEM, we believe we have made a reasonably satisfactory effort on this front

# CARBON TAX

An emission tax designed to get firms to internalize the negative externalities only imposed on society i.e. production of emission from factories using fossil fuels that contribute to extensive droughts, flooding and rising sea levels.



Effective carbon tax rate will be between

**R6 - R48** /tCO<sub>2e</sub>

once the tax free allowances are taken into account.

The tax will have no net impact on electricity prices until 2020.



South Africa as a developing economy has ratified the Paris Agreement which requires sizable reductions in energy-greenhouse gas emissions in large emitters, including in developing economies.



## WHY?

It is a cost effective instrument, as part of a package of measures, to nudge our economy onto a more sustainable growth path.



## WHO WILL BE AFFECTED?

Industry | Business | Citizens



## SO WHAT?

The simulations suggest that the introduction of carbon tax would lead to estimated decrease in emissions in South Africa of...

**13% TO 14.5% BY 2025**  
& **26% TO 33% BY 2035.**

This will also lead to a reduction in local air pollution and restructuring of the SA economy to being less emissions intensive.



**national treasury**

Department:  
National Treasury  
REPUBLIC OF SOUTH AFRICA



# AIM OF THE RESEARCH (PART 2)

- Use an updated and regional dynamic version of UPGEM
- Integration with detailed energy models (SATIM)
- Closer look at the business-as-usual baseline scenario to include latest projections on renewable energy costs and the cost of inaction on climate change
- Testing of more detailed tax recycling scenarios following improvements to UPGEM
- Why? In terms of the economic policy response to climate change and overall effects thereof, policymakers, stakeholders and society (sometimes) demand updated, unbiased and state-of-the-art analysis

# SOUTH AFRICA OVERVIEW

- Middle-income country with a population of 55+ million
- Coal-fired power stations have traditionally dominated the country's electricity generation-mix
- South Africa supports climate change action as evidenced through its Integrated Resource Plan and NDC
- National Treasury is committed to implementing a carbon tax as part of a suite of policies intended to create the necessary incentives to shift the country's electricity generation-mix towards low-carbon technologies

# INTRODUCTION TO CGE MODELLING

CGE modelling is a challenging field. It requires mastery of economic theory, meticulous preparation of data and familiarity with underlying accounting conventions, knowledge of econometric methods, and an understanding of solution algorithms and associated software for solving large equation systems. However, the most important requirement is the ability to communicate. **CGE modelling is primarily about shedding light on real-world policy issues.** For CGE analyses to be influential, modelers must explain their results in a way that is comprehensible and convincing to their fellow economists, and eventually to policy makers.

While CGE modelling is challenging, it is also rewarding. CGE models are used in almost every part of the world to generate insights into the effects of policies and other shocks in the areas of trade, taxation, public expenditure, social security, demography, immigration, technology, labor markets, environment, resources, infrastructure and major-project expenditures, disasters, and financial crises. CGE modelling is the only practical way of quantifying these effects on industries, occupations, regions and socioeconomic groups.

*Peter B. Dixon and Dale W. Jorgenson*  
*Handbook of Computable General Equilibrium Modeling*

# WHAT IS UPGEM?

- Large-scale dynamic economic **model** designed to provide quantitative estimates of the **economy-wide** effects of policy proposals
- The UPGEM database, in combination with the model's rigorous theoretical specification, describes the main real inter-linkages in the **South African** economy
- The theory of the model is then, essentially, a set of equations that describe how the values in the database move through time and move in response to any given policy shock
- Dynamic CGE models such as UPGEM represent a significant improvement over input-output models by allowing for **price-induced behaviour** and **resource constraints**; also over static CGE models by allowing for explicit **BAU projections** and detail on the **adjustment path** over time

# UPGEM DATABASE STRUCTURE

		<i>ABSORPTION MATRIX (USE TABLE)</i>							<i>EMISSIONS</i>		
		1	2	3	4	5	6	7	SIZE	IND	
		PRODUCERS	INVESTORS	HOUSEHOLD	EXPORT	GENGOV	STOCKS	TOTAL	COMxSRC	CO2	
SIZE		IND	IND	HOU	1	1	1	ALL USERS			
BASIC FLOWS	COMxSRC	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS	V0BAS BASIC			
MARGINS	COMxSRCxMAR	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	N/A	V0MAR MARGINS			
INDIRECT TAXES	COMxSRC	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	N/A	V0TAX TLSP			
BAS + MAR + TAX = PUR VALUES	COM	V1PUR INTERMED USE	V2PUR INVESTMENT	V3PUR PRIV CONS	V4PUR EXPORTS	V5PUR PUB CONS	V6BAS STOCKS	TOTAL COM DEMAND			
LABOUR COSTS	OCC	V1LAB									
PRODUCTION TAXES	1	V1PTX									
CAPITAL RENTALS	1	V1CAP									
V1PUR + V1PRIM = TOTAL COST	1	TOTAL IND COSTS									
		<i>PRODUCTION MATRIX (SUPPLY TABLE)</i>									
		SIZE	IND	1	1	1	ALL SOURCES				
		COM	MAKE SUPPLY TABLE	V0IMP IMPORTS	V0MAR MARGINS	V0TAX TLSP	TOTAL COM SUPPLY				
		1	TOTAL IND SALES								
		COM	V0TAR								
		SIZE	1								
		COM	V0TAR								

# UPGEM EMISSIONS DATABASE

- The energy and emissions database linked to the model's core economic database implies the **input-output-emissions** relationship for each industry in the model
- The energy and emissions inventory for UPGEM is based on Blignaut et al. (2005) and Seymore et al. (2014) and was developed using emission factors from various South African sources, including DEA, which are in line IPCC default factors
- Fugitive emissions were not captured in the database

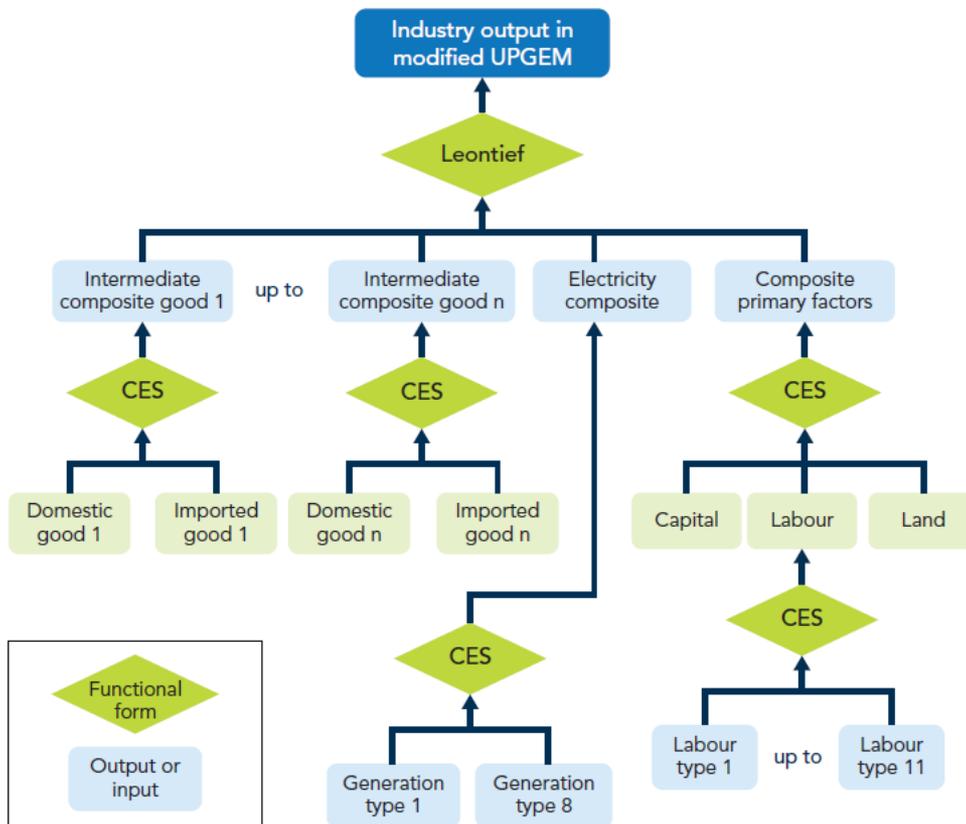
# UPGEM THEORETICAL STRUCTURE

- The theoretical structure of UPGEM is based on the well-documented **MONASH** model developed by the **Centre of Policy Studies**
- Industries minimise costs subject to input prices and a constant returns to scale production function
- Households maximise a Klein-Rubin utility function subject to their budget constraint
- New industry-specific capital are constructed as cost-minimising combinations of domestic and imported commodities
- Export demand is inversely related to the foreign-currency price
- Government demand and the details of direct and indirect taxation are also recognised in the model

# UPGEM THEORETICAL STRUCTURE

- In policy simulations, the labour market follows a lagged adjustment path where wage rates respond over time to gaps between demand and supply for labour across each of the different occupation groups
- Disequilibrium in the labour market over the short to medium term is therefore allowed
- Capital accumulation is specified separately for each industry and linked to industry-specific net investment in the preceding period; investment in each industry is positively related to its ERoR
- Fiscal account dynamics relates public sector debt to debt incurred during a particular year and interest payments on previous debt; adjustments to the national net foreign liability position are related to the annual investment/savings imbalance, net asset revaluation, and remittance flows during the year

# UPGEM PRODUCTION STRUCTURE



- Industries in UPGEM combine various intermediate composite goods, an electricity composite good and a primary factor composite in fixed proportion
- For each top-level composite in the production recipe, **CES sub-nests** allow price induced substitution between imported and domestic versions of each good, electricity generation types, primary factors and labour types
- The **electricity** composite sub-nest distinguishes various electricity generation technologies

# UPGEM SIMULATION BASICS

- Our aim was to **isolate and measure** the impact of introducing the proposed carbon tax policy on the economy
- A good way to do this is to compute the differences between a scenario in which the tax was imposed – the policy simulation – and a counterfactual business-as-usual scenario in which the tax did not occur – the baseline scenario
- Results are then reported as **percentage change deviations** over time between the first ‘baseline’ run and the second ‘policy’ run
- Great care must be taken in converting policy run results to their levels values as they are sensitive to baseline forecast assumptions

# KEY ASSUMPTIONS: BASELINE

- Main baseline scenario based on available projections (in 2014) for selected macroeconomic variables up to 2030
- Alternative baseline scenario accounts for recent economic slowdown
- Due to endogeneity concerns, we did **not** make any explicit assumption or projection regarding potential changes to the electricity generation-mix in the baseline
- We also did **not** make any explicit assumptions regarding technical change or efficiency gains of clean technologies relative to fossil fuel based sources in the electricity generation-mix
- These assumptions dictate that the electricity generation-mix and the input-output-emissions relationship specified in the base data will remain largely **unchanged** over the baseline forecast period



# KEY ASSUMPTIONS: BASELINE

- In principle, two key variables determine the level of emissions projected in the baseline: how much we will produce (GDP), and at what level of technology and efficiency
- Given the assumptions imposed on the baseline forecast, emissions grow in line with projected GDP, which explains why the main baseline scenario generates such high emissions growth over the forecast period (see figure 1)
- The most consequential assumption we make in the baseline, in terms of its impact on the policy results (both in  $\% \Delta$  deviation and levels terms), is that we do not allow renewable technologies to become cheaper or more efficient over time

# KEY ASSUMPTIONS: POLICY CLOSURE

- Variables that we believe will not be directly influenced as a result of the policy shock are set as exogenous, that is, they do not deviate from their baseline path despite the introduction of the carbon tax
- Naturally exogenous variables in the policy run typically include technical change variables, tax rates, shift variables such as the positions of foreign export demand curves, and variables that force certain economic relationships or behaviours to hold in the long-run
- The policy shock must be applied to an appropriate exogenous variable as identified in the simulation design phase based on the policy brief, in this case a **tax on specific carbon-emitting energy inputs** (coal, gas, petroleum)

# TAX POLICY DESIGN

The modelling considers a range of scenarios. We identify one combination as the **focus scenario**, but all sensitivities are explored

## Tax scenarios

- T1: tax rate increasing by 10% per annum over the period 2016–21, and thereafter by the assumed inflation rate (5.5%); tax-free thresholds are held constant for the duration of the modeling period 2016–35. Agric and waste exempt.
- T2: as T1, but the tax-free allowances are gradually removed at a rate of 10% points per annum from 2021. Agric and waste exempt.
- T3: as T1, except for the agricultural sector where the exemption is removed at a rate of 10% points per annum from 2026
- T4: T2+T3, tax-free allowances are gradually removed at a rate of 10% points per annum, starting in 2021, for all industries except agriculture, for which phasing out begins in 2026

## Revenue recycling scenarios

- R1: Recycling of tax revenues is applied through an output-based rebate on all production across all sectors
- R2: tax revenue is recycled through a decrease in the VAT rate on all the goods that make up household spending
- R3: a combination of R1 and R2 (split 50:50)
- R4: subsidy on the production of renewable electricity generators (for modeling purposes, directed towards solar PV)
- R5: The tax revenue is used to decrease the VAT rate on agricultural goods, food, transport services, and beverages and tobacco

# TAX POLICY DESIGN

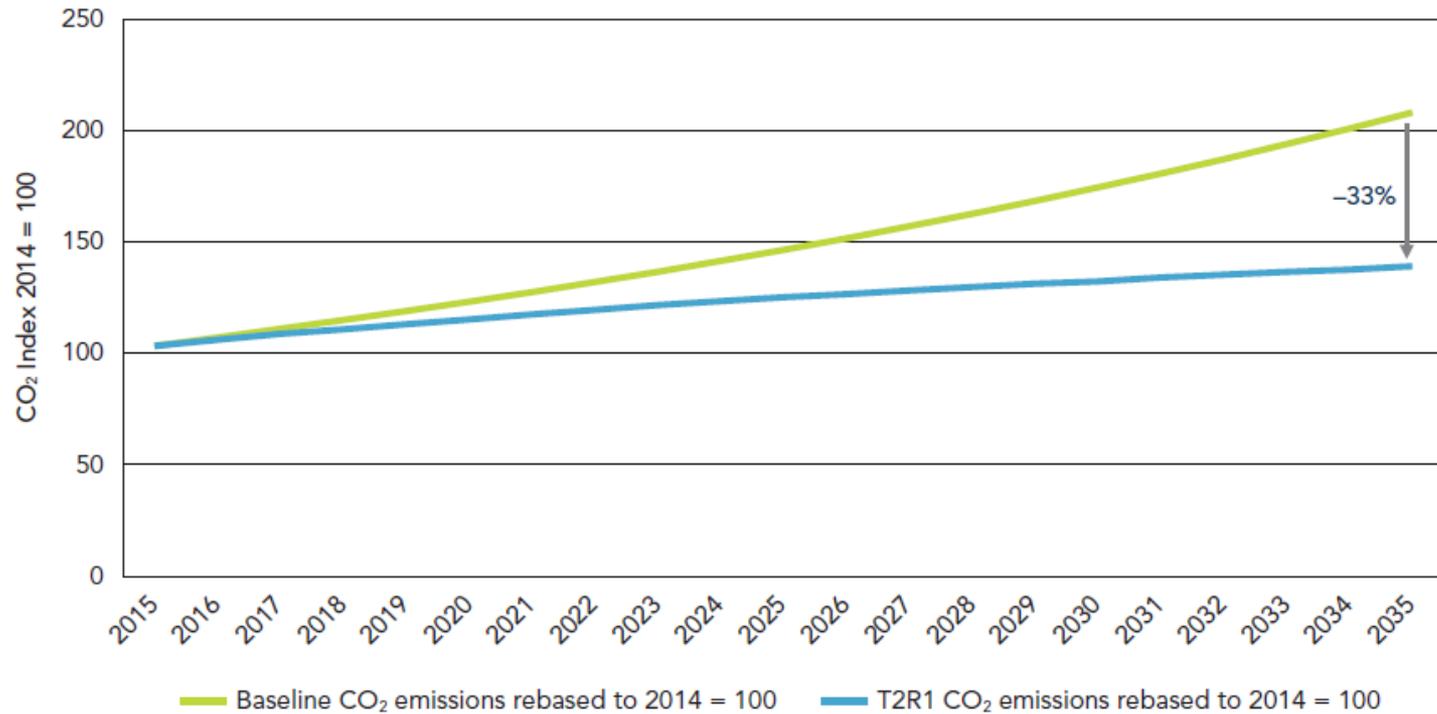
- All policy scenarios modelled are based on a carbon tax of R120/tCO<sub>2</sub> equiv. (before any exemptions) being imposed on all industries that use three specific fuel inputs – coal, gas and petroleum
- The 60% to 70% tax-free allowance, which includes the basic and trade-exposure exemptions, was modelled
- Performance offset and carbon budget allowances were not modelled
- Different closure settings were used to control how the tax revenue was **recycled** back into the economy, with various recycling schemes tested

# TAX POLICY DESIGN

- The T2 scenario captures all the main tax design elements in the National Treasury **Carbon Tax Policy Paper** with gradual removal of tax-free allowances from 2021 but exemption for the agricultural sector maintained throughout
- The R1 recycling scheme broadly targets industries/production via an output-based rebate, whilst other schemes (R2 to R5) focus more narrowly on households and renewable energy producers, with expected results
- By looking at selected policy results, particularly for the T2R4 scenario, the role of certain modelling assumption can further be highlighted and interrogated

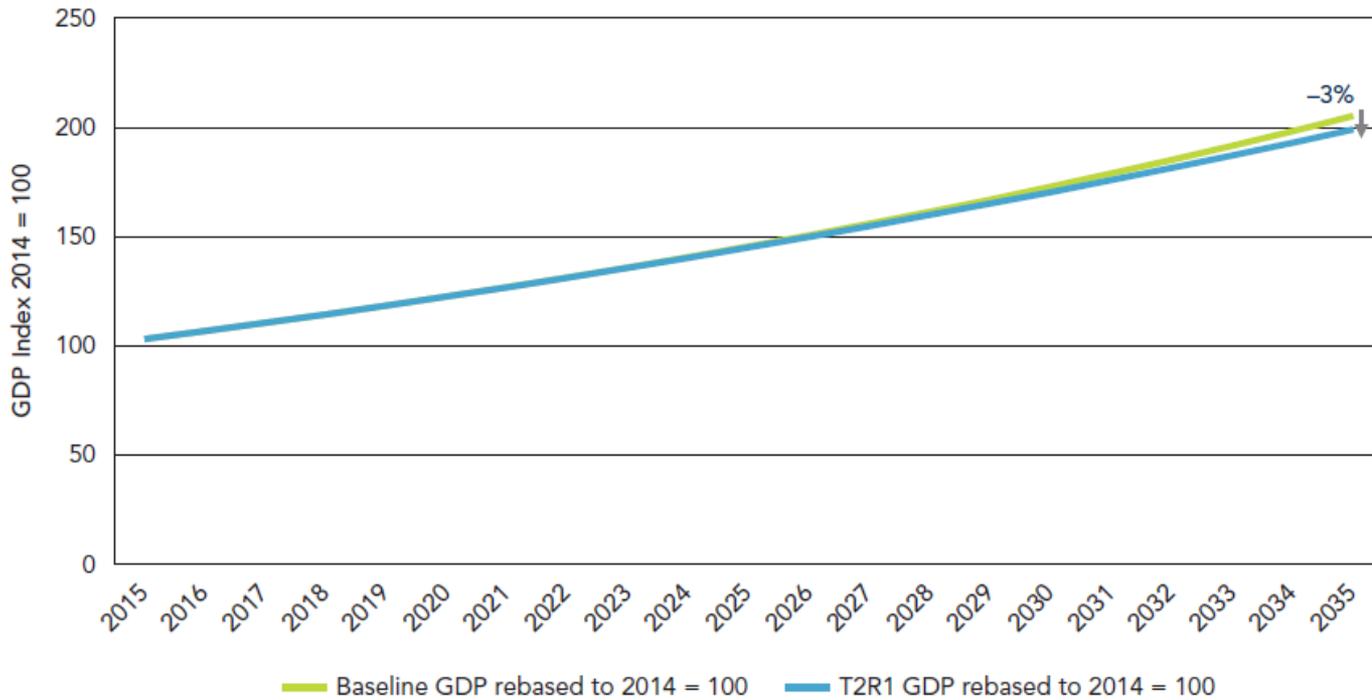
# RESULTS: FOCUS SCENARIO

**FIGURE 1.** In scenario T2R1, emissions in 2035 are expected to be 33 percent lower in 2035 than under the baseline assumptions



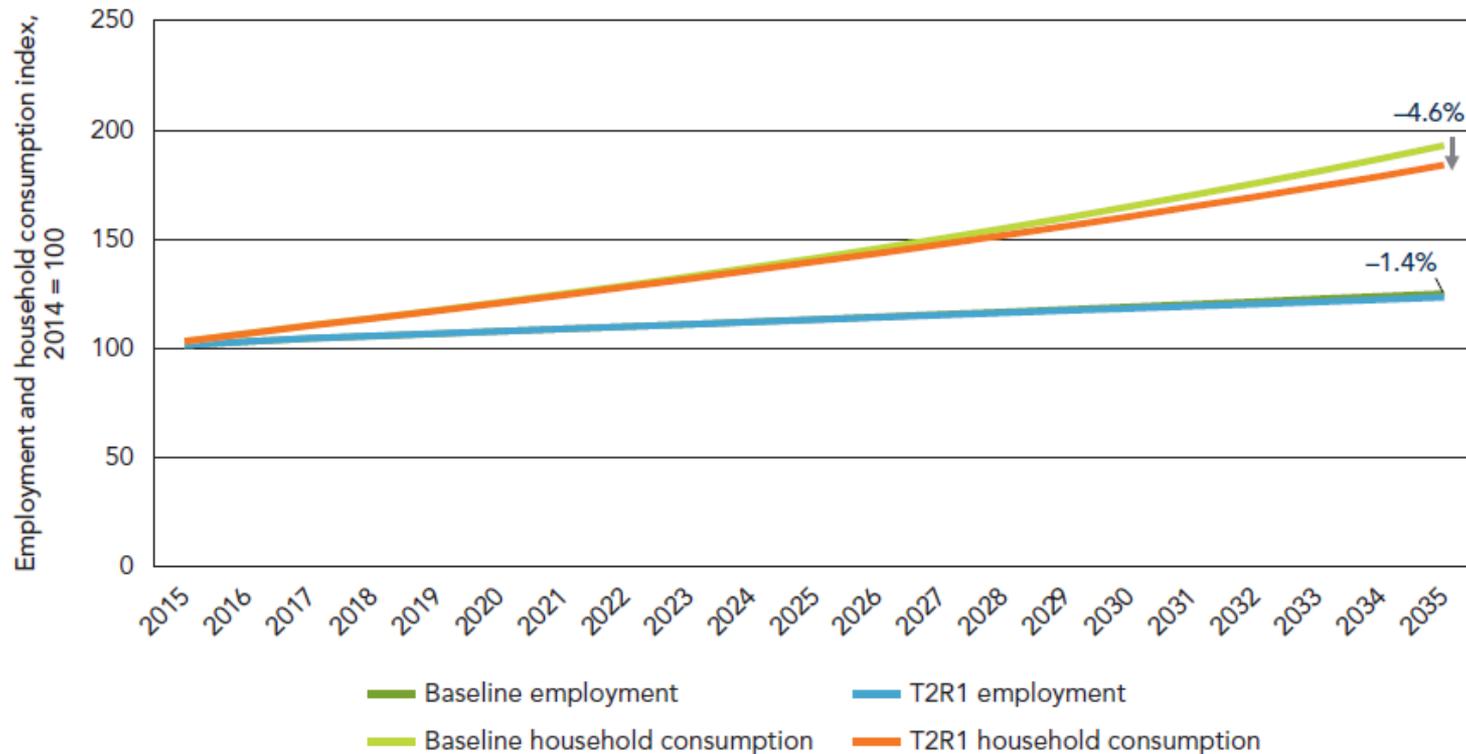
# RESULTS: FOCUS SCENARIO

**FIGURE 2.** In the context of the expected growth of the economy, the impact of the carbon tax is small (T2R1 scenario)



# RESULTS: FOCUS SCENARIO

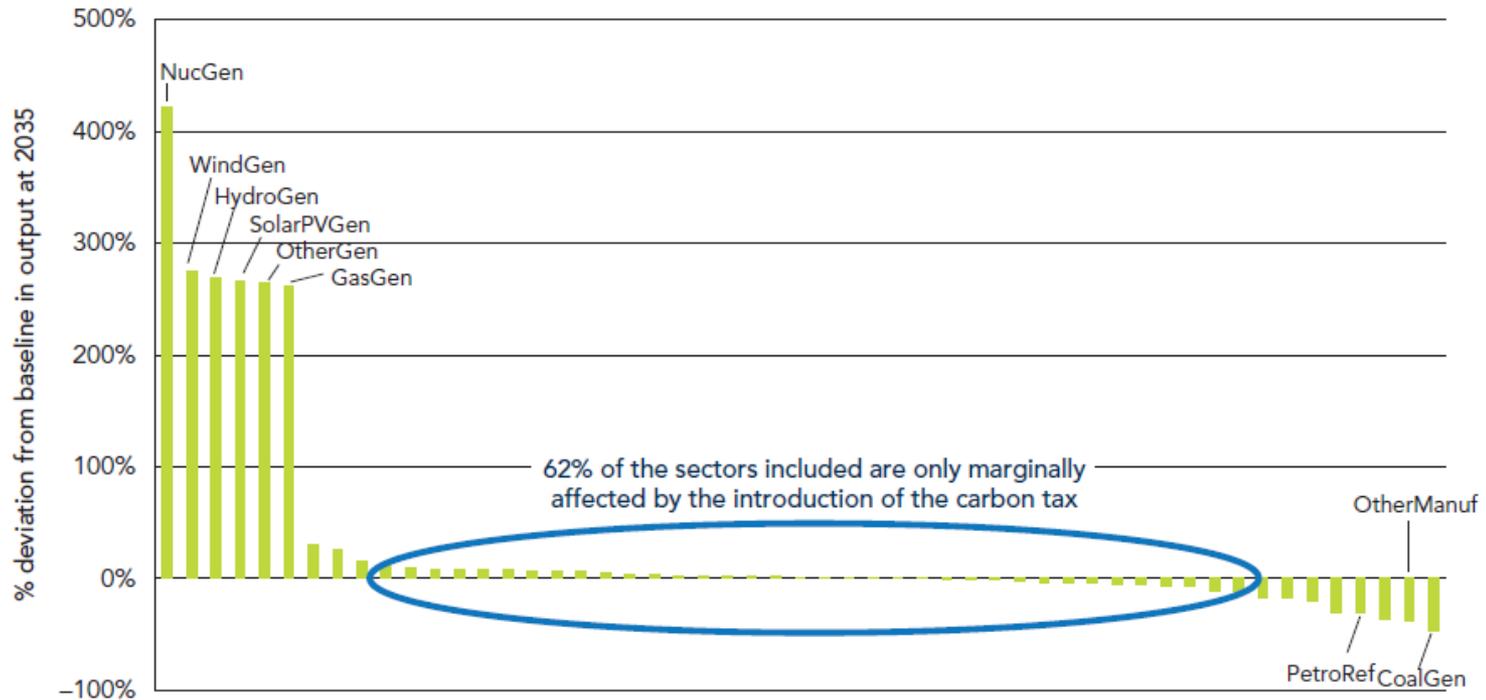
**FIGURE 3.** Household consumption and employment deviations are in line with GDP impact



Note: The two employment projections overlap almost completely, with a difference of 1.4 percentage points by 2035.

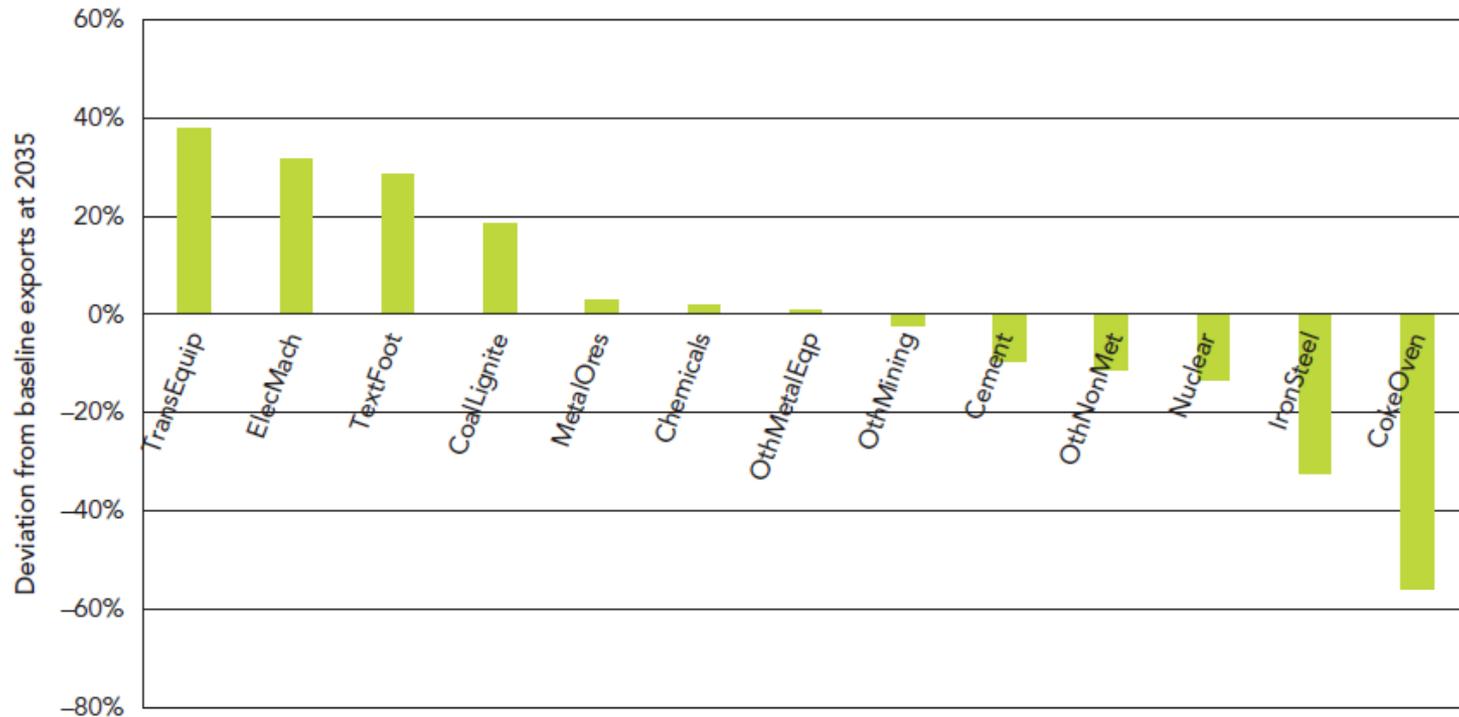
# RESULTS: FOCUS SCENARIO

**FIGURE 4.** The impact of the tax, in terms of expected change in output in 2035 relative to the baseline, is small for most sectors



# RESULTS: FOCUS SCENARIO

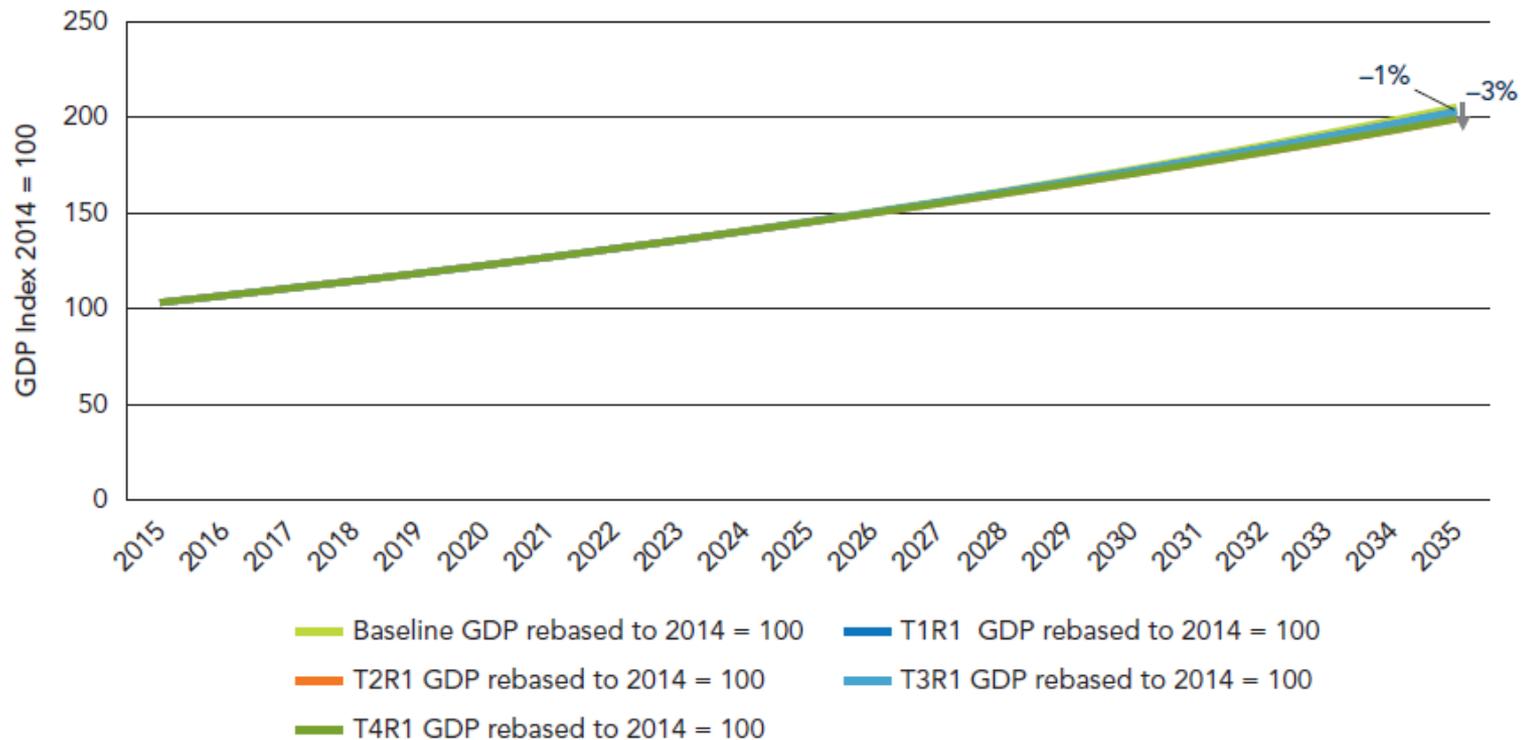
**FIGURE 5.** There are as many key export sectors that see an increase in exports as a result of the carbon tax as there are sectors that suffer a decrease in exports



Note: Sectors are selected on the basis of export size as of February 2015.

# RESULTS: ALT TAX POLICY

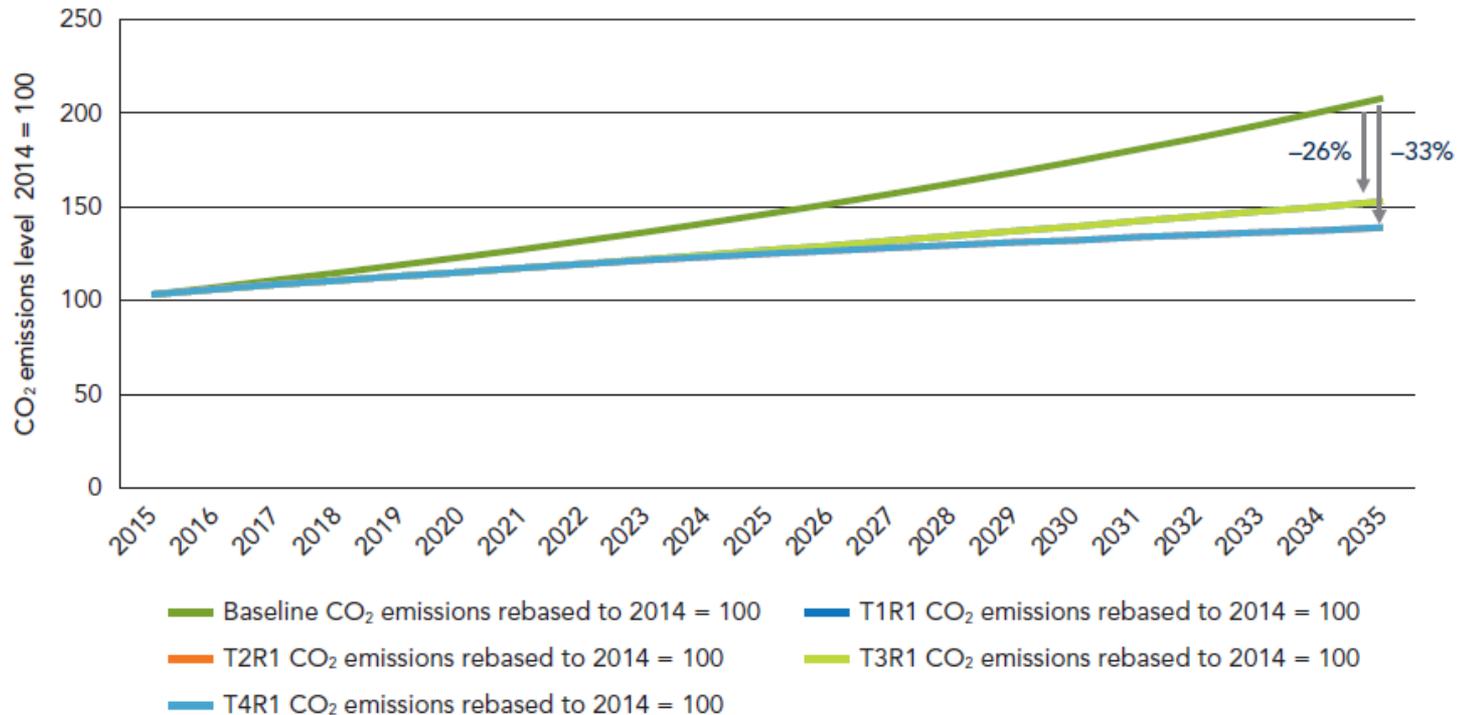
**FIGURE 6.** The impact on GDP is small for all four tax scenarios



Note: T1R1 and T3R1 overlap, as do T2R1 and T4R1.

# RESULTS: ALT TAX POLICY

**FIGURE 7.** The different tax policy options give varying degrees of abatement

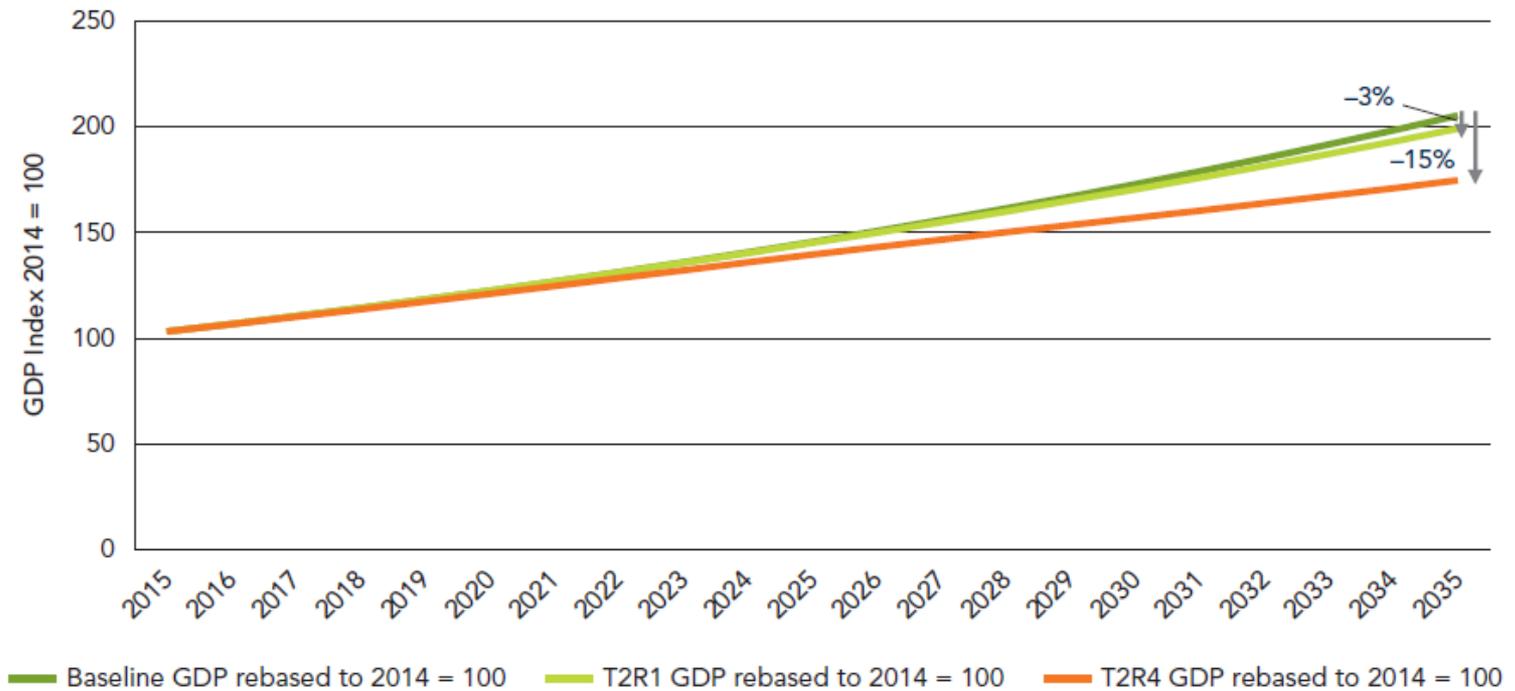


Note: T1R1 and T3R1 overlap, as do T2R1 and T4R1.



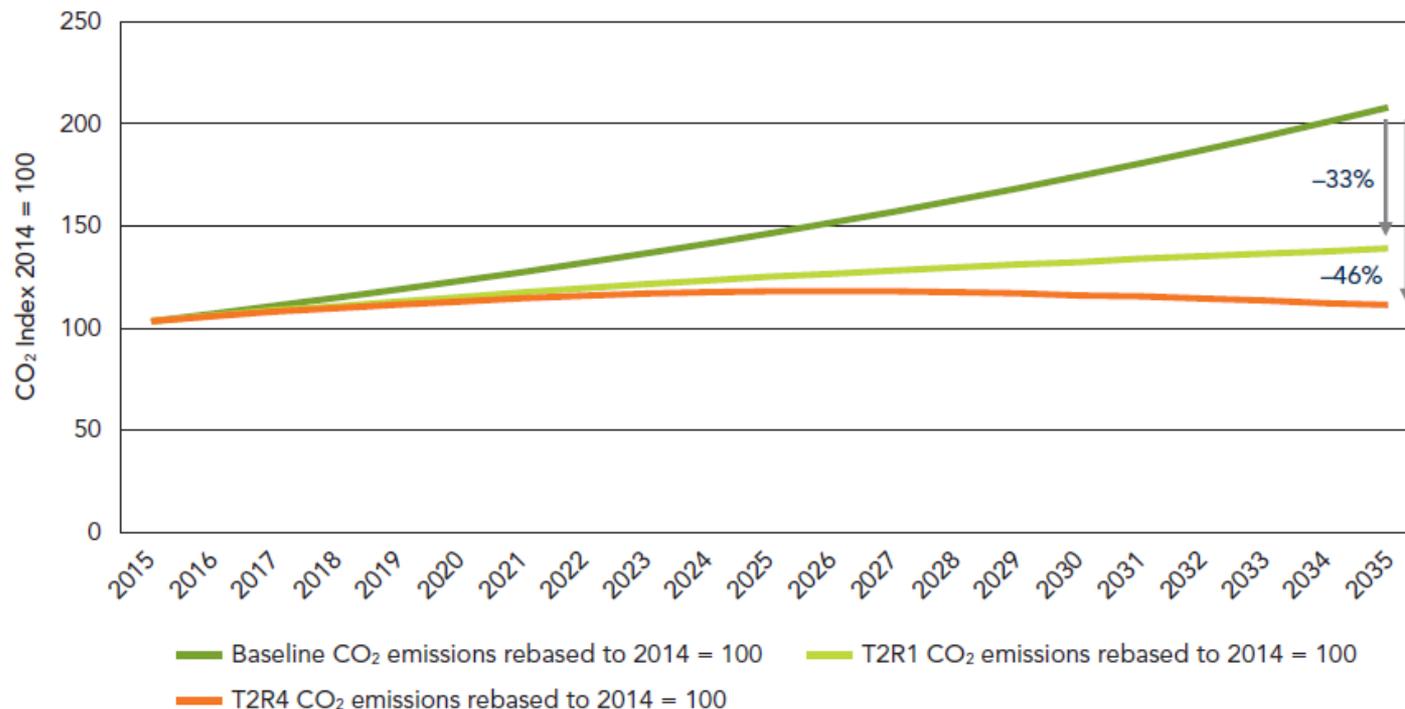
# RESULTS: ALT REVENUE RECYCLING

**FIGURE 8.** Broad revenue recycling schemes result in smaller deviations from baseline growth



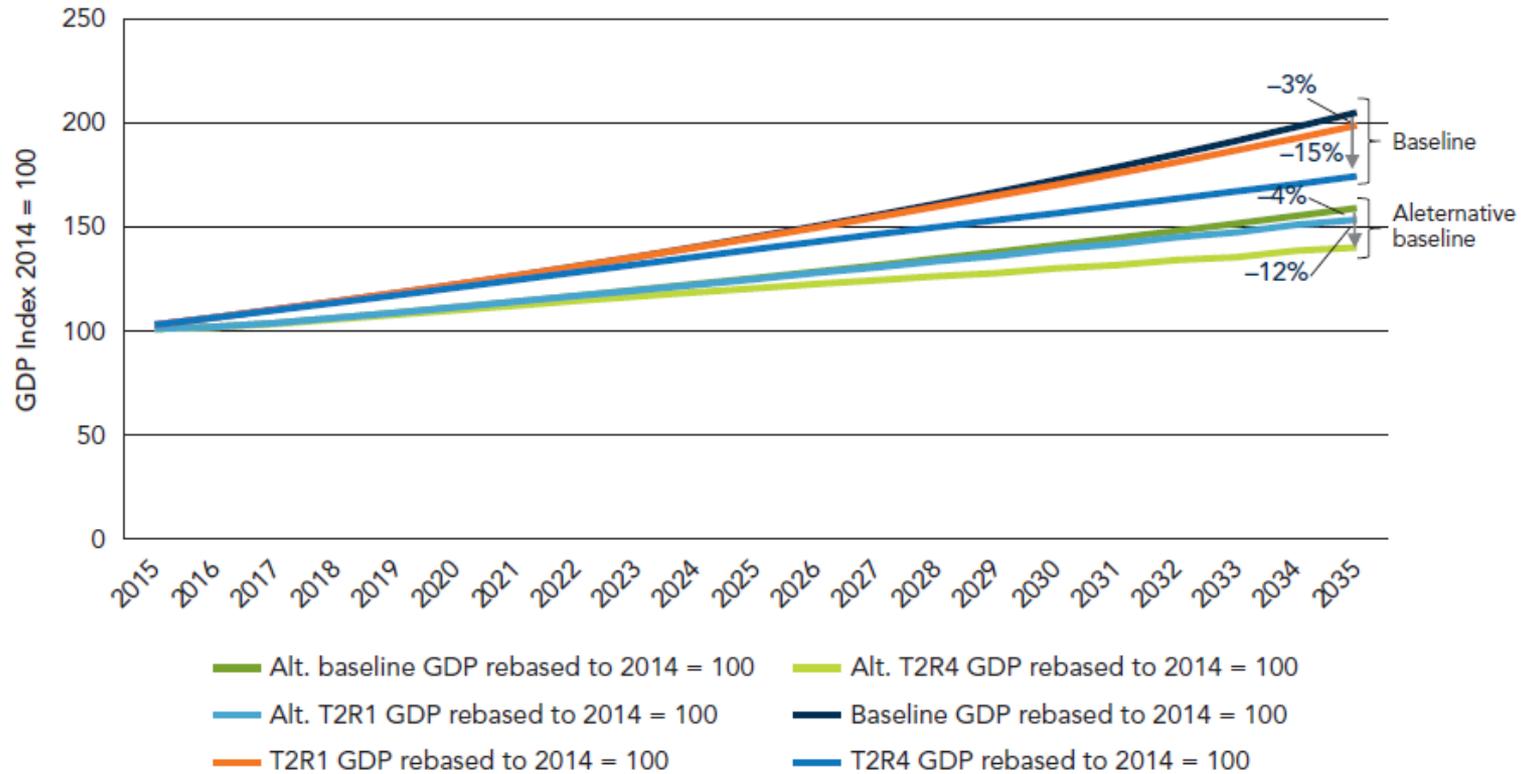
# RESULTS: ALT REVENUE RECYCLING

**FIGURE 9.** By focusing tax revenue recycling on the renewable sector emissions can be lowered further



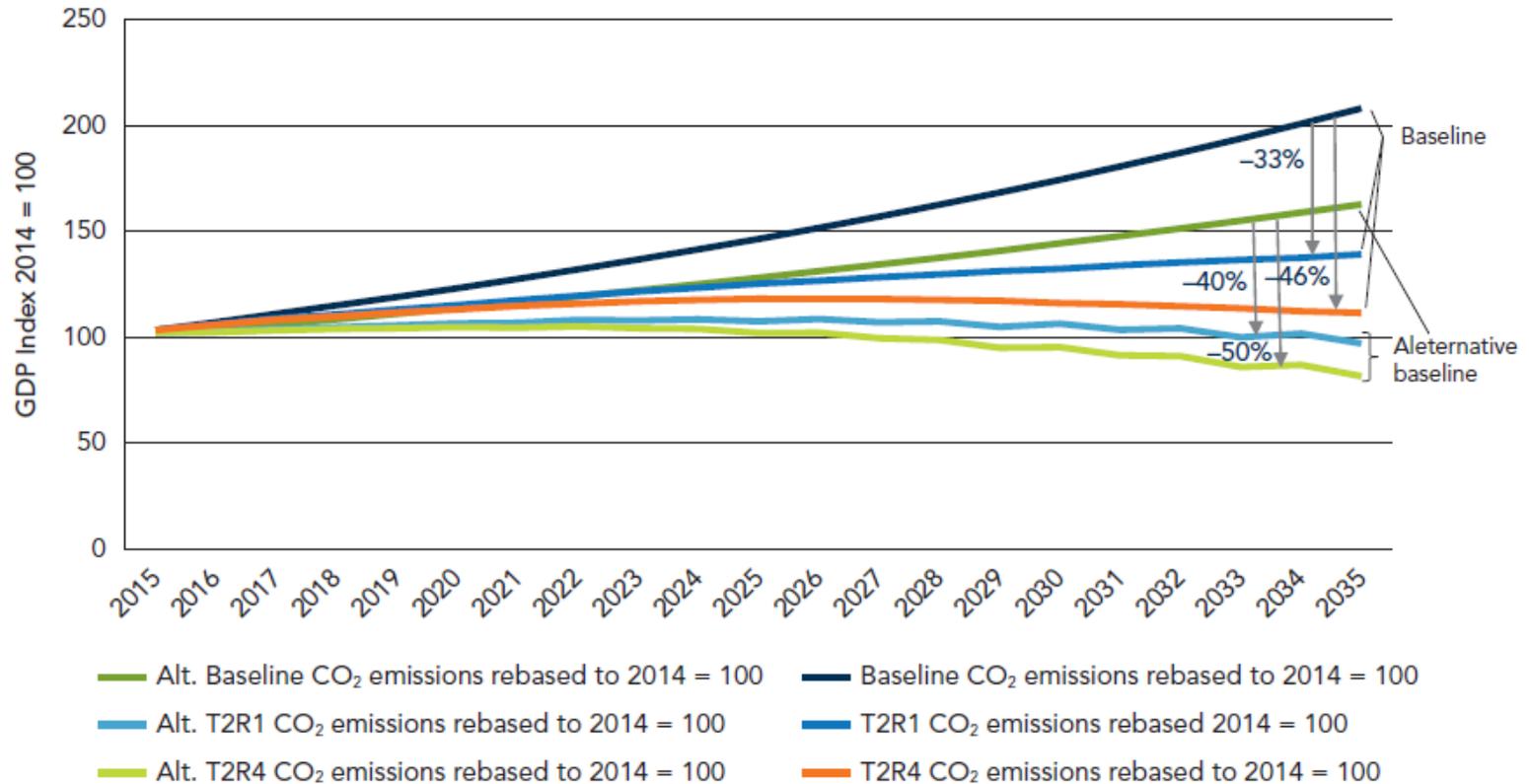
# RESULTS: ALT BASELINE

**FIGURE 10.** The deviation from baseline for the focus scenario is still small under revised growth assumptions



# RESULTS: ALT BASELINE

**FIGURE 11.** The magnitude of the reduction in emissions is similar under the revised baseline assumptions



# KEY POINTS TO REMEMBER

- Why are we doing this? To internalise the world's biggest **externality** and create the necessary **incentives** for change!
- Without even considering the benefits of counteracting climate change or efficiency gains in renewable technology, the effects of the carbon tax on most macroeconomic and industry-level variables are shown to be **minimal** in the long run
- When interpreting policy results, it is important not to confuse  $\% \Delta$  deviation with levels outcomes, for example, in our focus scenario even the worst affected industry (coal) will still be larger in absolute terms in 2030
- Concerns about relative competitiveness are best overcome through **appropriate policy design**, and growing **international action** on climate change

# MODELLING GOING FORWARD

- There are quite a few areas in which we need to do more/better...
- Updated economy-wide database with substitution between coal and non-coal electricity generation sources
- Appropriate integration with detailed partial-equilibrium energy models, particularly for the non-coal electricity generation sector
- Realistic baseline projections concerning different technology costs and investments
- Consideration of policies such as climate clubs and border carbon adjustments
- Consideration of the cost of inaction in the BAU baseline scenario
- Updated emissions database for UPGEM (Jessika's PhD research)
- Test a wide range of policy and tax recycling scenarios in an attempt to achieve a triple dividend scenario (Jessika's PhD research)



# THANK YOU

Question and comments welcome, or you may contact me at

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