Emissions Targets - Modelling Incentives

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CONTENTS

1 Introduction

This paper examines the incentives faced by firms in accepting targets for binding emissions limits. It is based on the discussion of such incentives in the Incentives Working Group of the Emissions Trading Group and provides the costings of the options for incentivisation which have been developed by the Group.

The paper does not review the reasons why such incentives are likely to be necessary if emissions trading is to become established, nor the benefits to the UK of an early establishment of targets and trading. These have already been developed in the paper on *Incentives, Emissions Trading and Climate Change*, prepared by the Incentives Working Group and the main conclusions have been accepted by the Emissions Trading Group. We do not therefore propose to rehearse these arguments again.

Rather we concentrate on the possible design of the various incentive options and investigate their impact, costs and effectiveness.

The paper first summarises the incentive options that have been investigated and then sets out the principles on which the models have been based. Third, we set out the data that has been used as the basis of the models, while the final section shows the results of the modelling exercise.

2 The Options

There are three principal options that have been considered as incentives for firms to take on binding emission reduction targets. These are:

Option One – Tax Rate Reductions

- This is possible either against CCL or general taxation (e.g. Corporation Tax or National Insurance Contributions). This option would reduce the tax rate for firms which take on a binding emissions limit. Reductions on the rate of general taxation are rather distant from the business decision to be made, while the CCL rate reduction greatly limits the potential scope of the market through the exclusion of the oil, gas & power sectors.
- We have calculated the reduction in tax rate of CCL that would be necessary to cover abatement costs for firms to induce them to sign up for reductions on a 2000 baseline which add up to 2 million tonnes. The incentive of the CCL itself is included. A trading market is not explicitly included and here becomes a risk management tool. We have not directly modelled the impact of a reduction in general tax rates because of the objection of the distance that such changes have from the decision in question and the very small changes in rates that would be involved.

Option Two – Tax Allowance

- This option gives the right to set permits against CCL tax liabilities or obtain allowances for approved investment projects. Tax allowances against CCL has the same limitation in application as a rate reduction, and if linked directly to permits allows scope for the government to be faced with considerable demand led risk to CCL revenue. For example, if an incentive were offered that permits bought in the market could be offset against CCL obligations, this would effectively set a maximum price equivalent to the CCL rate. Above that price, companies would prefer to pay the tax rather than purchase.
- Allowances on investment require the government to define allowable projects and potentially rules out effective actions which require limited capital investment.
- We have looked at how CCL revenues would be affected if firms could use permits bought in the market to offset against their CCL liabilities. This option requires assuming, one, that a market exists, and two, the price at which trades might take place. We have not specifically costed the impact of the investment allowance approach, since this requires knowing what projects would be allowable.

Option Three – Performance Credit

- A performance incentive payment/credit linked to delivery of targets. Companies would receive a pre-determined payment/credit for delivering a specific binding target. The amount could be:
  - a simple monetary payment: this would be most certain for business but appears to be the least politically acceptable. It may be seen as contravening the principle that the polluter pays
  - a credit against a universal tax, such as CT. This remains certain for business but incurs some transaction costs to both business and Government. It also involves Government expenditure from the general revenue.
  - a credit against CCL. CCL is revenue neutral and the principle of recycling revenue to deliver climate change objectives is established. However, CCL is not paid by all companies which would ideally be included in a trading scheme (energy companies and electricity generators, for example). Therefore, if CCL performance credits are used as an incentive, it is proposed that they should be transferable, allowing non-CCL payers to realise that value of the incentive by sale of the credit to those with CCL liabilities. This may be the most politically acceptable form of performance payment but it carries additional risks and costs to business.
- Two forms of this option have been taken. In the first, the government announces a price per tonne that it will make available for every tonne of guaranteed reduction. We calculate the price necessary to induce sufficient firms to sign up for percentage reductions of their emissions to deliver 2 million tonnes in total. A variant of this is that firms bid a price at which they are willing to make such reductions, rather than the government announcing one. In theory, this will be cheaper as firms bid what their actual costs are, rather than there being the possibility of being paid more than their costs.
- The model does not distinguish between making a direct payment and the right to a tax credit. For individual firms, we therefore implicitly assume that these are equivalent. This clearly means that a firm has a countervailing liability for the appropriate tax against which to set the credit, or is able to transfer it at full value. If the value of the credit were thought by firms to be lower than the value of a direct payment, such a shift could easily be factored in. If, for example, a credit were thought to be worth 10 per cent less, then a given emissions reduction would cost 10 per cent more.

Other Policies

The model makes no explicit allowance for other policy constraints. There are necessary judgements to be made about how far there are constraints to the operation of these incentives which arise from other rules. Examples of these include:

- Rules governing the treatment of public expenditure – some forms of incentives can be treated as a reduction in tax revenue and others as an increase in spending. This distinction is not considered
- State aids and competition legislation may be relevant to the details of some schemes
- Energy policies may operate to reduce the willingness of some sectors to sign up for targets, this is not explicitly modelled

3 The Principles of the Models

Cost Benefit Calculation

The modelling exercise has been fundamentally based on the financial cost benefit calculation made by individual firms facing different cost structures. Firms examine the costs / benefits of accepting a fixed target and compare them to the costs / benefits of continuing as present. The decision of a firm to accept a target for emissions is a voluntary one and will depend on:

- The cost of reducing emissions to the firm concerned
- The risk of being unable to meet targets
- The expected price of trading permits in the market once it starts
- Other benefits, such as IPPC flexibility, credit for early action and access to international mechanisms

The model concentrates on the first two of these and the third where it is specifically relevant. It does not attempt to value any of the other benefits for individual firms. To the extent that these are important, they will increase the effectiveness of any of the incentives which are modelled here, since they will raise the likelihood of at least some firms signing up for any given incentive.

The model principles also start from the conclusions drawn from the work of the Incentives Working Group. This has shown that trading by itself is insufficient to provide an incentive for firms to sign up to the targets that would make it possible. In the context of the model, therefore, the existence of a possible trading system is not included in the calculation that a firm makes in deciding whether to accept a target or not.

Such inclusion is not possible, since inclusion of the benefit of being able to sell permits would only be one-sided – firms could sign up to sell but no-one would sign up to buy and hence the market would be empty. However, this does not mean that a market that could develop once targets were accepted is irrelevant. It is here a risk management tool, since the existence of a market can lower the risk premium attached to a failure to meet targets, as it provides the option to buy permits if targets are breached and the potential to sell if they are unexpectedly easy. There is only one case where the market is a central element in the scheme (CCL permit offset) and this is examined further below.

The Firms

The model is based around the incentives faced by a sample of representative but aggregated firms. These are characterised in a variety of ways.

First, we have established the average size and emissions by each of 19 sectors, covering manufacturing in some detail and services more broadly. In order to capture the variation in industrial structure, we have had to concentrate on CO2 emissions, since the distribution of other GHGs is not known in detail. In each case we estimate:

- The average emissions of CO2 per firm in the sector
- Whether it pays CCL or not
- Whether it is in a Negotiated Agreement or not
- Whether the sector is likely to participate in a scheme or not

The last of these is a judgement on how interested a firm in the sector will be in taking on a target in return for an incentive. The judgement essentially depends on the sector's energy intensity: for example in the commercial sector energy costs and carbon emissions are relatively low compared to output and hence firms are less likely to be interested in making the calculations about costs and benefits and sign up to a scheme. We therefore assume that only 10 per cent of firms will be potential entrants.

The first stage in the modelling process is to look at the emissions reduction associated with CCL. For this purpose, the modelled firms are grouped together according to whether they pay CCL, at what rate, and for non-CCL payers, whether they are covered by IPPC or not.

For each group, we examine the expected reduction associated with CCL itself. This reduction depends on the CCL burden (based on £30 per tonne of carbon equivalent) against the cost to the firm of reducing its emissions. The figure of £30 per tonne has been estimated by BGplc based on average energy use.

Abatement Costs

Each firm faces a cost curve – the greater the amount by which it reduces its emissions, the higher the average cost of doing so. Little is actually known about the shape of these cost curves and how they differ across firms. Although benchmarking exercises have taken place for some sectors under negotiated agreements, these are the result of a variety of exercises and there is still uncertainty about real costs.

We have therefore had to make assumptions about the cost structures. These have been based on:

- An average cost of £50 per tonne if emissions are reduced by 10 per cent for any individual firm

- Increasing cost as greater cuts are made
- Variation of costs around this average for firms within each sector, based on 10 per cent random variation around the average

Since firms make decisions based on their assessment of these costs, the results of the model are clearly sensitive to the average level at which they are pitched. If the costs were only half the level that we have assumed, then the incentives would be twice as effective (but see Appendix 2).

4 The Data

Industries and Services were split into 19 sectors as shown in the following table. Each sector has its predicted levels of emissions and contains a different number of firms. Sectors can then be assumed to have different abatement costs and so different motivations for participating in the scheme. The assumption about participation levels reflects a view that some firms will not be interested in accepting absolute targets, whatever the incentives. If emissions are not terribly important to the firm, it will be simpler to pay the CCL rather than put time and effort calculating the costs and benefits of entering a scheme. Our estimate of willingness to participate is based on a qualitative assessment of such opinions, and could easily be adjusted with further information. In each sector, the level of emissions multiplied by the participation rate gives the level of emissions that might be affected by an incentive scheme.

Numbers used in the Model

The data on carbon emissions in the following table was taken from the table showing *Estimated 1998 UK GHG Emissions by final use (MTC equivalent*), in Appendix 1. The number of firms in each sector was obtained from the Department of Trade and Industry Statistical Bulletin, *'Small and Medium Enterprise Statistics for the United Kingdom, 1998'*. The participation rates were then estimated in accordance with current beliefs.

Sector	CO2 Emissions mT	Covered by CCL NA	CCL not NA	Number of Firms	Participation Rate
Metals	11	8.6	2.4	2450	0.9
Non-metallic Mineral Products	2.9	2.7	0.2	5065	0.5
Chemicals	5.9	5	0.9	3915	0.5
Mech. Engineering	1.8	0.3	1.5	38975	0.5
Elec. Engineering	0.9	0	0.9	7955	0.5
Vehicles	1.8	0.3	1.5	3140	0.5
Food, Drink & Tobacco	3.5	0.8	2.7	7345	0.5
Textiles, Leather and Clothing	1.2	0.6	0.6	13735	0.5
Paper	3.8	2.4	1.4	2585	0.5
Plastics & Rubber	1.6	0.1	1.5	6800	0.5
Other Manufacturing	1.8	0	1.8	56280	0.5
Water	0.8	0	0.8	75	0.5
Construction	1	0	1	124680	0.5
Mining	0.6	0	0.6	1270	0.5
Oil / Gas / Coke	9.1	0	0	255	0.9
Power	13.5	0	0	215	0.9
Agriculture	3	0	3	64535	0.1
Public Sector	8.1	0	8.1	153350	0.1
Commerce	13.9	0	13.9	822715	0.1
Totals	86.2	20.8	42.8	1315340	

The figures in the above table were then scaled to provide the actual data used in the model. The number of firms in each sector was divided by 500 and then scaled according to the emissions in the sector, to obtain the number of firms used in the model but if this left less than three firms in a sector with high emissions, this number was increased to three. This procedure produces a manageable number of firms for the model, but results in the need to be careful in interpreting the results. The firms in the model are representative of their sector but also in each case represent a group of firms rather than an individual one. A more accurate representation could be made if information were available on the distribution of emissions across individual firms within a sector – but since this is lacking, another way of creating firm based data had to be used.

Within each sector, the firms were divided to reflect the coverage of different tax types and to ensure that each firm's emissions were covered by one tax type. The resulting average emissions for each firm in each sector were then calculated and are shown below.

Sector	**Number of Firms**	**Tax type**	**Av. Emissions**	**Total**	**Beta**	**Lambda**
Metals	3	NA	2.6	7.8	175	2
Metals	1	CCL	2.2	2.2	200	2
Non-metallic Mineral Products	3	NA	0.5	1.5	900	2
Chemicals	3	NA	0.8	2.4	700.0	2
Mech. Engineering	3	NA	0.1	0.3	5000.0	2
Elec. Engineering	4	CCL	0.1	0.4	5000.0	2
Vehicles	1	CCL	0.8	0.8	700.0	2
Food, Drink and Tobacco	1	NA	0.4	0.4	1500.0	2
Food, Drink and Tobacco	3	CCL	0.5	1.5	900.0	2
Textiles, Leather and Clothing	3	NA	0.1	0.3	5000.0	2
Textiles, Leather and Clothing	3	CCL	0.1	0.3	5000.0	2
Paper	1	NA	1.2	1.2	450.0	2
Plastics & Rubber	1	CCL	0.8	0.8	700.0	2
Water	3	CCL	0.1	0.3	5000.0	2
Mining	3	CCL	0.1	0.3	5000.0	2
Oil / Gas / Coke	3	none	3	9	150.0	2
Power	3	none	4.5	13.5	100.0	2
Agriculture	1	CCL	0.3	0.3	1750.0	2
Public Sector	3	CCL	0.3	0.9	1750.0	2
Commerce	16	CCL	0.1	1.6	5000.0	2
Total	62			45.8		

The model therefore contains 62 firms of different types which together account for 45.8 tonnes of emissions. These firms are representative of those which could be interested in carbon targets and trading and the emissions covered represent about 30 per cent of CO2 emissions in the UK. The last two columns of the above table give the abatement cost parameters of each of the firms in the model.

Abatement Costs

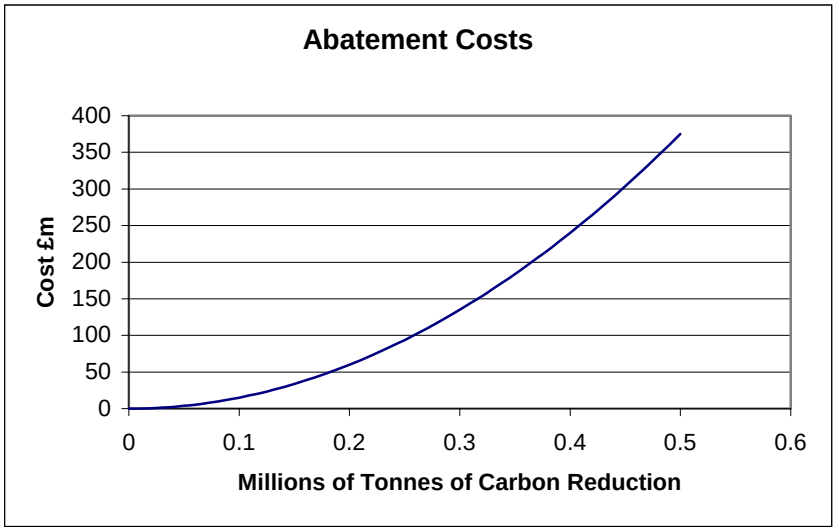
All firms are assumed to face emissions abatement costs equal to the number of millions of tonnes by which they wish to reduce, raised to the power of a constant lambda, all multiplied by a constant beta. I.e. the cost of reducing emissions by x million Tonnes is:

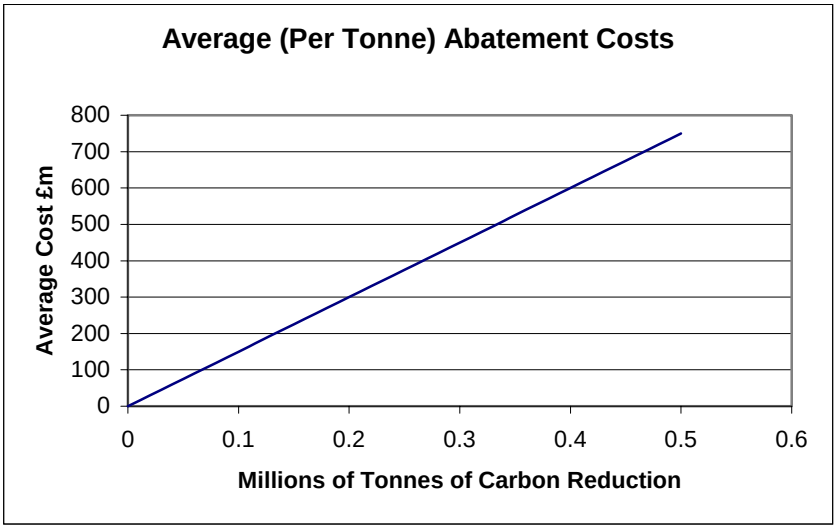
beta*(x^lambda)

Lambda was fixed at 2 for all firms as this gives an abatement cost curve which increases with volume, but not so steeply as to reduce the capacity to reduce emissions very sharply above a particular volume. Betas were then chosen to reflect likely actual values (actual abatement costs are unknown often even by firms themselves). The values of Beta and Lambda combined give average abatement costs based around £50 per tonne of carbon when emissions are reduced by 10 per cent. Average abatement costs are straight line increasing with a gradient of Beta.

One implication of this structure is that larger firms tend to have flatter cost curves in terms of tonnes of carbon, although they are similar to smaller firms when costs are looked at in relation to percentage reductions. Since a tonne of carbon represents a higher percentage reduction to a smaller firms, the cost of cutting out this tonne will generally higher. This seems a reasonable way of modelling abatement costs in general, even though there may well be some smaller firms for which abatement cost curves are fairly flat, and equally some larger firms who may face steep increases in costs as emissions reductions rise.

The following charts show absolute and average abatement costs for, as an example, the firm in the Food, Drink and Tobacco Sector with Beta equal to 1500 and Lambda equal to 2.




Average (Per Tonne) Abatement Costs
Average Cost £m
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Millions of Tonnes of Carbon Reduction

5 The Results

The Workings of the Model

The targets to which firms sign up are set in advance by the government and are a fixed percentage reduction by 2008 on their current emissions levels, achieved by a straight line reduction from 2001. Costs and benefits are calculated for each year and the benefit/credit is made in the year in question. For modelling purposes, this is the most straightforward way to do the calculations. It does not prevent an approach which in practice uses a series of milestones and makes credits in particular years during the period.

We have also, for simplicity, taken a percentage reduction from the beginning of the period. In practice, there could be a bigger reduction taken from a grandfathered baseline. Such a target would give credit for early action. The issues surrounding the choice of baseline have been discussed elsewhere in the Emissions Trading Group. The period over which grandfathering could be possible depends on data availability, industrial restructuring and corporate changes, and we have abstracted from these issues here.

There are a number of additional assumptions which are made to make the model operational. They are as follows:

- If firms are not subject to CCL or any targets it is assumed that they would continue to produce the same amount of emissions in every year.
- All firms are assumed to be profit maximisers and to decide on whether to agree to absolute permits by considering only changes in costs and revenues.
- The only costs that change under the schemes are costs directly related to changes in emissions levels.

The firms that face CCL charges have an incentive to reduce their pollution levels up to the amount where the reduction in CCL charges equals the pollution abatement costs. This gives a level of pollution produced and an associated amount of government revenue.

For each firm the reduction in carbon emissions due to CCL is worked out by finding the minimum of its cost function including abatement and CCL costs. Since we are assuming that without CCL costs a firm will continue to produce the same amount of pollution in all future years, CCL costs will be the same each year and so the reduction in emissions due to CCL costs will be the same in every year (i.e. will not be cumulative).

The reduction in emissions due to CCL given by our model is **0.38 million Tonnes** of carbon for the firms included.

These estimates are those produced for the firms which are covered by the model because they are assumed to be likely to be interested in an incentive scheme. They are therefore only a subset of all firms, and thus the results above should not be confused with the overall effects of CCL, which affects a large amount of emissions not taken into account in this model.

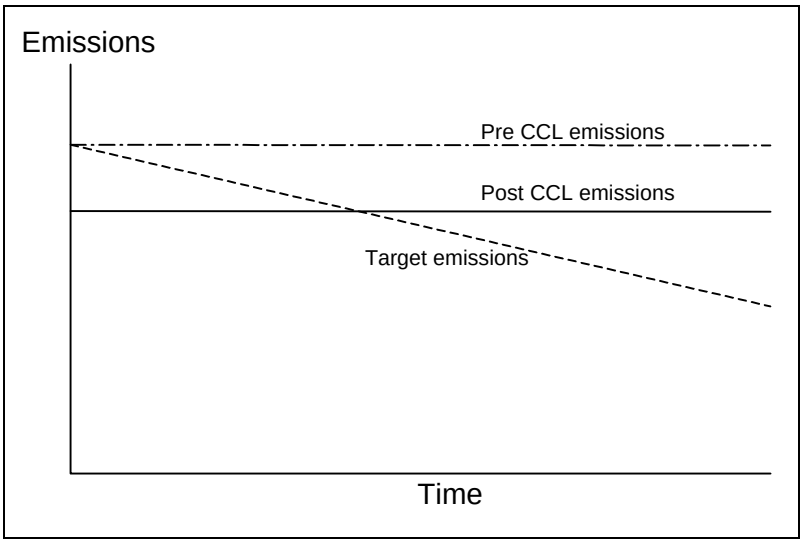
The incentive to accept a binding target operates in addition to this. The model takes into account the effect of any additional reductions in carbon emissions on the cost to the firm and on government revenues.

Reduction in CCL rate

Firms which sign up to absolute targets receive a reduction in the rate of CCL that they pay on each tonne of carbon produced. Therefore they have lower CCL costs both because they produce less emissions and because they pay a lower rate of CCL on their emissions.

The results depend on the scale of the reduction in CCL and the percentage reduction of emissions which is built in to the target. Care needs to be taken over the firms in negotiated agreements as they will already receive an eighty percent reduction in CCL rate, thus any further reduction cannot be greater than twenty percent. To make the incentives fair, these firms must have the same absolute reduction in CCL paid per tonne of CO2 as firms not in negotiated agreements.

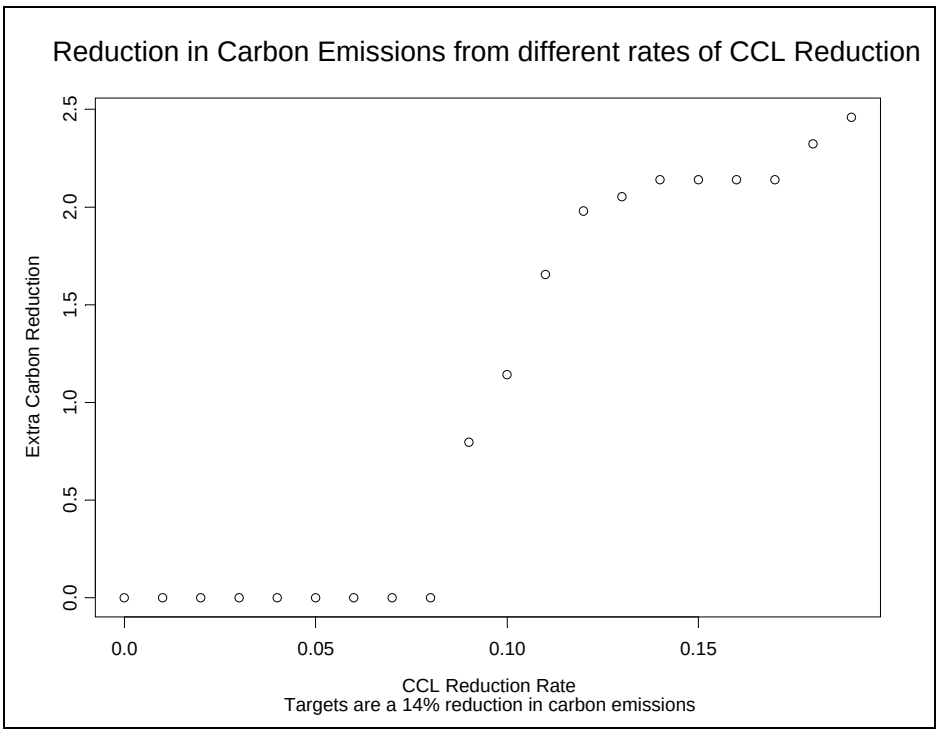
For each firm, the firm's costs if it signs up to the scheme can be calculated using the combination of the new CCL costs and the firm's abatement costs. Each firm minimises its cost function and produces the associated level of pollution emissions, unless the firm's target requires it to produce less emissions in which case the firm produces at the target level. The graph below illustrates this with the dot-and-dash line being the level of emissions the firm would produce in the absence of any incentives or CCL, the solid line being the level of emissions after the effects of CCL (at the new lower rate) and the dashed line being the target that the firm as to meet. Thus if the firm signs up to this scheme then the emissions it produces will be equal to the lowest line on this diagram, which will be below its target in earlier years, and on target thereafter.



Government revenue from this firm is the revenue from CCL at the new rates.

If a firm's costs under the incentive scheme are lower than its costs outside the scheme, it signs up for the scheme. If this is not the case, it remains outside and so behaves as it would under the normal CCL regime.

The total cost to the government and extra carbon reduction (in addition to the original effects of CCL) is then worked out according to which firms sign up to the scheme.



The target reduction in the chart is set to 14 % since this is the level that minimises the cost to the government of achieving 2 mT of emissions reduction.

Reduction in Emissions mT	% reduction in CCL rate	Target % Reduction	Average per year cost to Gov. £m	Beta value	Reduction due to CCL	Number sign up
2	12	14	67	Beta	0.38	16
1	7	11	26	Beta	0.38	6
2.6	19	18	106	Beta	0.38	18

In the first two rows of the table, the % Reduction in CCL rate and the Target % Reduction were chosen to minimise the cost to the government of achieving the given reduction in emissions. The last row of the table shows the maximum reduction that can be achieved (2.6 million Tonnes). The maximum reduction depends in part on the percentage target: the higher the percentage target, the larger the potential reduction. However, the total achieved will also depend on whether it is possible to induce all firms to sign up to such a target.

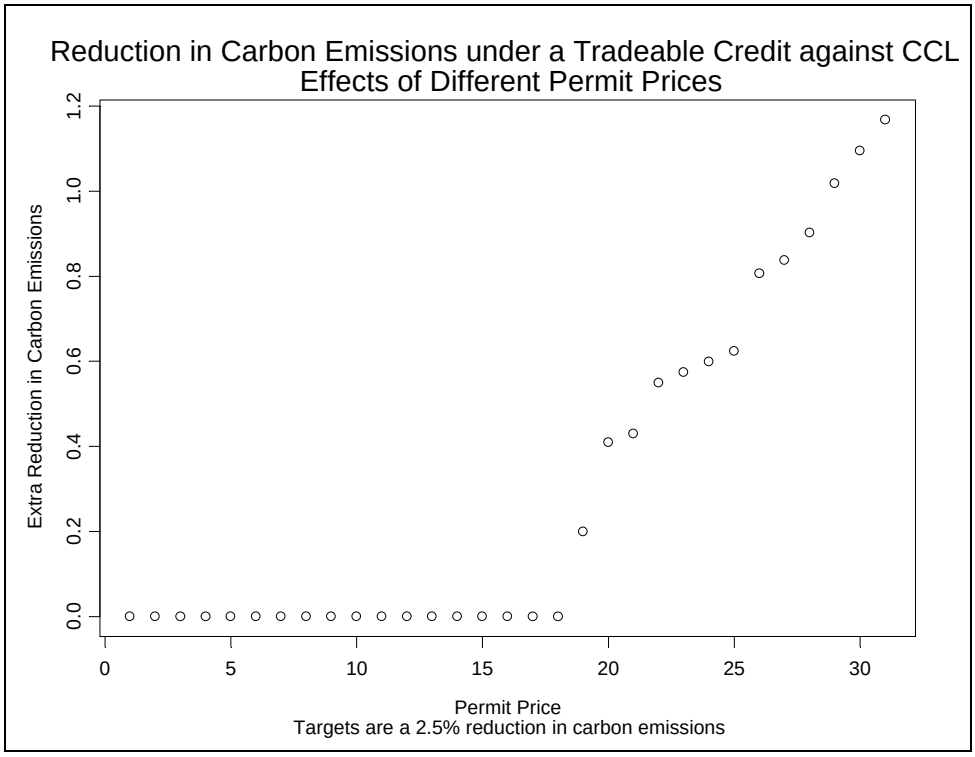
Tradable Credit Against CCL

If firms agree to sign up to absolute targets, for each tonne of carbon they produce below their target, they are given a credit to offset CCL payment, which they can sell to another firm. Thus if firms produce below their targets they gain both the benefits of paying less CCL and the money from selling permits. If firms produce above their targets then they pay less abatement costs and must buy credits to offset their CCL above their target. This incentive requires there to be a market for these credits in which there are sufficient buyers and sellers. Determining the properties of such a market is beyond this paper and thus in this model we have assumed that all desired trades can take place.

The reduction in carbon emissions each firm makes is obtained from the minimum of the firm's cost function, balancing the amount of CCL paid and the amount of money obtained (lost) through trading in permits against the costs of abatement. Firm costs are then the combination of abatement costs, money from trading to meet the target and CCL costs. Government revenue is the CCL revenue (adjusting for the reduction in CCL revenues which is produced by firms buying permits). Firms sign up if costs are lower under the scheme than simply paying CCL.

This scheme has some odd consequences, as when firms buy permits, it reduces their tax burden. Since permit trading allows firms to produce carbon above their target levels, tax reduction continues to be possible even when this is the case. The maximum price for a permit is £30, since if the price is higher than this, it would be better to pay CCL than buy a permit. Hence the maximum value that firms can get per tonne of carbon reduction from this scheme is £30 saved in CCL payments and a further £30 by selling the permit. However, the actual price may be lower than this if enough permits come onto the market.

However, the impact of trading in this particular case is to limit the total reduction in actual pollution. This is because of the interaction between the ability to offset permits, the price of permits and abatement costs. As targets become harder over time, the cost of abatement rises while the permit price has a maximum. Thus, firms choose to buy permits rather than reduce pollution. This produces a limit value – so long as firms can buy as many permits as they need. In practice of course this is unlikely, but such a phenomenon increases the uncertainties of a scheme of this type.



The target reduction in the chart is set to 2.5 % since this is the level that minimises the cost to the government of achieving 2 mT of emissions reduction.

Extra Reduction in Emissions mT	Value of Permit	Target % Reduction	Average per year cost to Gov. £m	Beta value	Reduction due to CCL	Number sign up
1	30	2.5	26	Beta	.38	17
1.2	30	1	38	Beta	0.38	24

In the first row of the table, the Value of the Permit and the Target Reduction were chosen to minimise the cost to the government of achieving 1m Tonnes of Emissions reductions. The second row shows the maximum emissions reductions possible under this scheme.

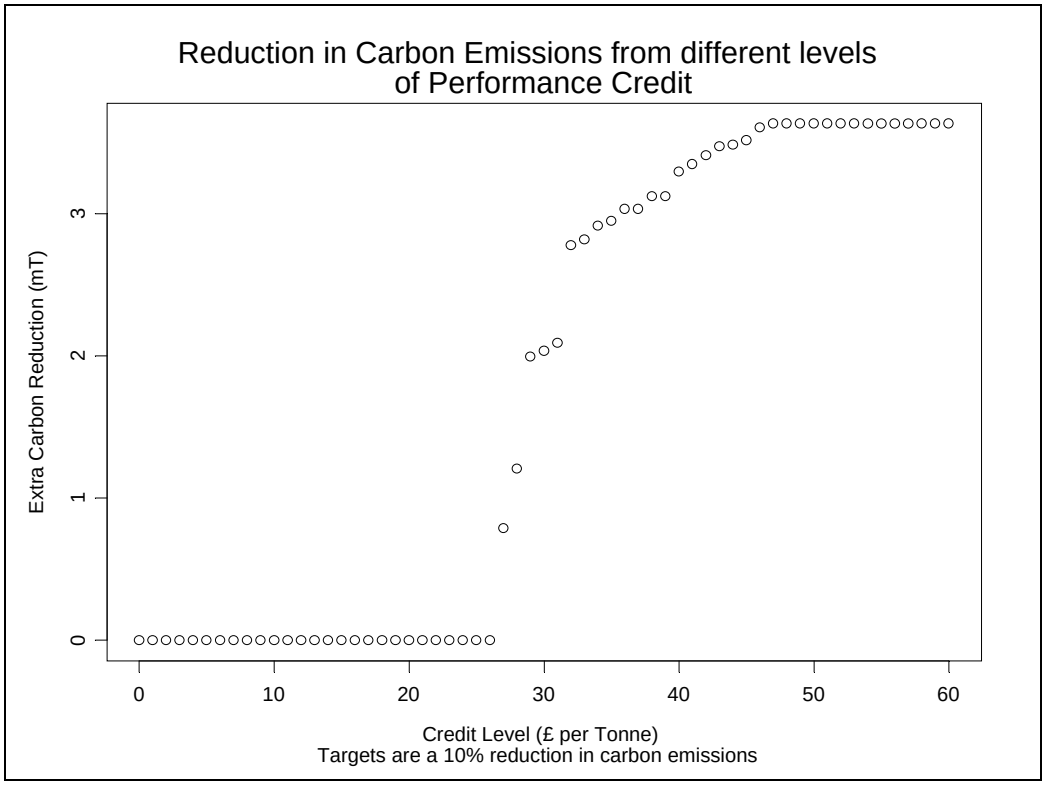
Performance Credit

If a firm accepts a target, in each year it receives a credit, which is equal to the level of credit per tonne multiplied by the number of tonnes of carbon emissions that its target is below its initial production. This is a simplification, since a grandfathered target would give a target based on production at a previous date. Here, the parameters that can be changed are the level of credit per tonne and the rate of the target reduction.

Under a direct incentive scheme, the firms receive a credit from the government (whether a grant or derived from a reduction in the CCL charge) to sign up to a given target and so cannot produce more emissions than the target. Thus they will face additional costs in reducing their emissions to the level of the target. Each firm balances these costs and benefits to decide whether they will accept the target. There is an extra risk premium included in these costs since uncertainty about future emissions levels will become important under an absolute target.

A firm reduces its emissions as a result of CCL. Additional emissions reduction occurs if it signs up for a target which is more demanding than what it would do anyway. The difference between these two can be summed across the firms that participate in a scheme to estimate the total reduction achieved. If the target is less demanding than the incentives under CCL alone, the firm will still sign up for the scheme but no additional reduction will be achieved. The money credited to each firm is the difference between the firm's current emissions and the target level multiplied by the amount of credit per tonne. A firm's costs is then its abatement costs plus the costs of CCL at the new level of production minus this credit. Government revenue is revenue due to CCL minus the amount of the credit.

If firms sign up to the scheme then there will be a different overall level of pollution and the government will face the costs of the scheme plus a change in the revenues from CCL.



The target reduction in the chart is set to 10 % since this is the level that minimises the cost to the government of achieving 2 mT of emissions reduction.

The chart shows that no one signs up until the Credit Level reaches £27 a tonne, then the firms with cheaper abatement costs sign up (Power and Oil / Gas / Coke). As the Credit Level increases more firms sign up until at £47 a tonne everyone has signed up.

Extra Reduction in Emissions mT	Credit Level £T	Target % Reduction	Average Per Year Cost to Gov. £m	Beta value	Reduction due to CCL	Number sign up
1	19	6	11	Beta	0.38	6
2	29	10	31	Beta	0.38	7
3	35	11	58	Beta	0.38	17

In the above table, the value of the Credit Level and the Target % Reduction were chosen to minimise the cost to the government to achieve the given extra Reduction in Emissions. There is no maximum reduction in this case in the model, since payments to each firm can be increased until firms accept the targets.

Variable credit per tonne of carbon reduction

In this case, firms are given a target and bid an amount which they have to be paid to accept this target. The government then accepts the bids which are the lowest per tonne of carbon reduction up to the desired level of total reduction.

However, the cost to the government of this scheme can be directly calculated from the fixed credit scheme. We assume firms bid their cost curves so they make no excess profit under the scheme. Thus if we take away firms excess profits from the cost to the government under the fixed credit scheme, we are left with the cost under the variable credit scheme.

Reduction in Emissions mT	Target % Reduction	Average Per Year Cost to Gov. £m	Beta value	Reduction due to CCL	Number sign up
1	6	10	Beta	0.38	6
2	10	31	Beta	0.38	7
3	11	52	Beta	0.38	17

In the above table, Target % Reduction was chosen to minimise the cost to the Government of achieving the given Reduction in Emissions.

6 Comparisons

The preceding section has set out the way in which firms decide to participate in binding targets in reaction to various different incentives. In conclusion, we compare the various schemes by analysing the average annual cost to HMG for the period 2001-12 of achieving an additional 2 million tonnes of carbon reduction (i.e. beyond the reductions from CCL alone) through the scheme during the Kyoto commitment period.

The cost to the government is the difference between the revenue that would be received before the change and that received afterwards. It is given as an average yearly figure over the period from 2001 to 2008 (there is no discounting). For each form of incentive, we choose the mix of target and incentive which gives the cheapest solution.

Incentive / Target Setting method	Estimated Cost p.a.	Cost per tonne
CCL Tax Rate Reduction	£70m	£35
Tax Allowance*	£40m	£33
CCL Performance credit	£30m	£15.5
Fixed Performance Incentive	£30m	£15.5
Variable Performance Incentive	£30m	£15.5
** refers to 1.2mT of reduction*		

Sectors which do not pay CCL would have no incentive to sign up under the CCL rate reduction scheme. Firms in these sectors would only sign up for other reasons – to access project credits for example, or to trade in international markets. In our model, all the CCL paying firms sign up under this scheme with these levels of incentive. However, CCL payers generally individually produce less emissions than non-CCL payers which are not incentivised by this scheme, so it is generally, per tonne, more expensive for them to reduce emissions. This explains the cost premium to the government of this scheme.

Under the permit allowance scheme, the maximum reduction in emissions obtainable would be one and a fifth million tonnes. This would cost the government £38m a year. The firms which would sign up under this scheme would tend to be the higher polluting firms with cheaper abatement costs, i.e. the Oil / Gas / Coke, Power and Metals industries. As the targets set become easier to meet more firms would sign up but fewer tonnes of carbon would be saved.

The companies which would take part under the performance credit scheme would be: all of the Power sector, most of the oil and gas sector and some of the firms in the Metals sector which are covered by Negotiated Agreements.

The small number of firms, compared to the real world, in our model means that the reduction in cost to the government of a variable credit will be under-estimated in our model. However, the model takes no account of administrative costs which will be higher for firms and the government under a variable credit scheme. The firms which sign up are the same as for the fixed credit incentive.

CCL Financial Credit

In terms of the costs in the model, there is no difference between the costs of a grant or a tax credit. The calculation that a firm undertakes does not depend on how the benefit is received. The only difference is whether the firm has a tax burden against which to set the credit. If the tax credit is only available against CCL payments, this means that only CCL payers would be incentivised. The analysis above therefore assumes that the credit is either available against general taxation or can be transferred to those who do pay such tax.

7 Conclusions

The models suggest that a performance credit per tonne is more effective than a cut in tax rates in reducing emissions. It must be stressed that the results depend crucially on the assumptions made – especially those about the abatement costs. It would have been possible to improve the model if more accurate data had been available about abatement costs. However, improved information about abatement costs will be one of the benefits accruing from the introduction of an emissions trading scheme. Appendix 2 shows the effect of different abatement cost patterns on the results for each incentive scheme. These are only a partial analysis however, as different abatement costs would induce a different choice of target and credit.

Whichever method is used for target setting and incentives, the annual cost of supporting these schemes is small when compared to an expected CCL take of £1 billion. We believe that the cost of the less expensive schemes compare well with the funding already set aside for energy savings schemes. It would be possible to introduce the auctioning of permits as an adjustment to longer term targets set under any of the methods discussed.

The CCL discount is the most expensive, largely because it induces CCL payers to sign up and these are smaller emitters than non-CCL payers, who are not incentivised. Hence to achieve a 2 million tonne reduction is more difficult. The Permit Tax Credit is potentially ineffective. As more companies sign up, the incentive to buy permits becomes greater compared to the incentive to reduce emissions. We do not therefore recommend this option.

The performance credit schemes set a value of £29 per tonne on carbon and firms from the oil and gas sectors, the power sector and some energy intensive sectors are likely to sign up, so long as the credit can be transferred between CCL payers and non payers. In this case, the analytical solution is the same regardless of whether a credit is made or a direct payment.

If this is not the case, then the CCL financial credit looks more like a CCL discount. Finally, the variable performance incentive is slightly cheaper as firms bid their cost curves, but since these are larger firms, the curves are fairly flat and this makes little difference.

For reasons of efficiency and acceptability, we believe that a focus on transferable performance credits is the best way forward.

Appendix 1

This appendix was prepared by BP Amoco on the basis of their own research and that commissioned by them. We are grateful for this assistance.

Background

In order to assess the impact of the proposed trading scheme on the UK economy it is necessary to understand the distribution of UK GHG emissions between economic sectors. Unfortunately there appears to be no one set of consistent data available. The tables below set out the assumptions that we have made and their derivation. It is recognised that these assumptions are disputable, and that, of necessity the base data used to make them is not truly consistent - however it is felt that they are a reasonable basis to make "broad brush" statements about the potential impact of the scheme and for modelling purposes.

Total UK GHG emissions

The Table below sets out the split of total UK GHG emissions that was included in the Marshall Report (Economic instruments and the business use of energy - November 1998).

Estimated UK GHG Emissions		
Total Emissions (MTC)	**1990**	**2000**
CO2	168	157
Other GHGs[1]	48	32
Total	216	189
1: Methane, Nitrous Oxide, HFCs, PFCs, Sulphur hexaflouride. Carbon equivalent.		

Sector Split of CO2 by final energy use

Various estimates exist for the split between sectors. BP Amoco commissioned a report from London Economics (Meeting UK targets for CO2 emissions - November 1999). In this report London Economics collated their best estimate for CO2, using existing DTI & DETR data as follows.

Estimated UK CO2 Emissions (by sector - final energy use)		
Total Emissions (MTC)	**1990**	**1998**
Industry	52.0	47.7
Transport	39.3	41.5
Domestic	48.9	43.5
Agriculture	3.4	3
Public Sector	8.9	8.1
Commercial	15.5	13.9
Total	168	157.7

Given the similarity of the 1998 and 2000 total numbers - it seems appropriate to treat the London Economics split as applicable to 2000.

Sector Split of other GHGs

Data on the sectoral spilt of other GHGs is included in the DETR consultation paper on the UK Climate Change Programme. This gives a sectoral breakdown for other GHG emissions for 1990. We have assumed the same percentage split between sectors for each gas for 2000. This results in the following distribution of other GHGs.

Estimated UK Emissions other GHGs (by sector)		
Total Emissions (MTCequiv)	**1990**	**2000(est)**
Business	19.0	11.4
Energy (Power, Oil, Gas, Coke)	9.0	6.4
Domestic	4.1	3.1
Agriculture	15.0	10.1
Public Sector	0.9	0.7
Transport	0.6	0.4
Total	**48**	**32**

Split between industrial sectors

The following table sets out the data for carbon emissions from UK industrial sectors that can be derived from Table C2 & D1 of the Marshall report. This covers the split between sectors and the proportion of emissions estimated to come from sites covered by IPPC. (There appear to be some inconsistencies in this data between the two tables - where this has occurred we have used the data from table D1).

In order to assess the incremental impact of trading on UK emissions it is necessary to identify the extent to which UK industrial emissions will be covered by the CCL negotiated agreements. This involves identifying the emissions of those sectors subject to CCL, and the share of those sectors' emissions that will actually be affected by negotiated agreements. Neither of these pieces of data are readily available. We have therefore taken the following simplifying assumptions.

- The full emissions of all industrial sectors other than upstream energy are covered by CCL. (i.e. no allowance made for exempt processes).
- All IPPC sites in these sectors will be included in the negotiated agreements.

These two assumptions will tend to exaggerate the size of the negotiated agreement sector somewhat, however not excessively so.

The negotiated agreements will not cover greenhouse gas emissions other than CO2, and therefore these have been added to the total emissions of the industrial sector outside of the Negotiated Agreements - it has also been assumed that the vast bulk of other GHG emissions identified as "business" emissions by DETR are attributable to Industry, rather than the commercial sector.

Methane and NO2 emissions from the energy sector are attributed in the DETR consultation paper mainly to the oil and gas sector, and therefore, for simplicity these emissions are attributed 100% to this sector.

Estimated 1998 UK GHG Emissions by final use (MTC equivalent)

Sector	CO2 emissions	% of CO2 IPPC sites	Other GHG emissions	Covered by CCL NA	Emissions not covered	Total Emissions
Iron & Steel	8.6	86%		7.4		
Non-ferrous metals	1.7	63%		1.1		
Non metallic metals	0.7	10%		0.1		
Bricks	0.4	95%		0.4		
Cement	1.6	100%		1.6		
Glass	0.6	95%		0.6		
Potteries	0.3	20%		0.1		
Chemicals	5.9	83%		5.0		
Mech. Engineering	1.8	16%		0.3		
Elec. Engineering	0.9	0%		0		
Vehicles	1.8	16%		0.3		
Food, Drink & Tobacco	3.5	24%		0.8		
Textiles, leather & clothing	1.2	54%		0.6		
Paper	3.8	63%		2.4		
Plastics & Rubber	1.6	5%		0.1		
Other Manufacturing	1.8	0%		0		
Water	0.8	0%		0		
Construction	1.0	0%		0		
Mining	0.6	n/a		0		
Industry excl energy	**38.6**		**11.4**	**20.8**	**29.2**	**50.0**
Coke	0.7	100%				
Oil refining	5.6	100%				
Gas production	2.8	100%				
Total Energy	**9.1**		**6.4**	0	**15.5**	**15.5**
Total UK Industry	**47.7**		**17.8**	**20.8**	**44.7**	**5.5**
Transport	41.5		0.4		41.9	41.9
Domestic	43.5		3.1		46.6	46.6
Agriculture	3		10.1		13.1	13.1
Public Sector	8.1		0.7		8.8	8.8
Commerce	13.9				13.9	13.9
Total UK Emissions	**157.7**		**32.0**	**20.8**	**168.9**	**189.7**
CCL paying[1]	63.6		0	20.8	42.8	63.6
Non-CCL	94.1		32.0	0	126.1	126.1

1: All sectors CO2 emissions except Domestic, Transport and Energy.

Emissions from Electricity Generation

The figures above all reflect estimates of emissions by final energy use. However, in order to assess the potential impact of the power sector on the trading market we need to make a sector split on the emissions associated with electricity use. For this we have used the DTI data in "UK Energy in Brief - July 1999". This puts CO2 emissions from power stations in 1998 at 40 million tonnes of carbon. For estimation purposes we have divided this between the sectors in proportion to their energy use (also derived from "UK Energy in Brief" as follows.

Electricity demand by Sector 1998		
Sector	**Consumption TWh**	**Associated CO2 Emissions**
Energy Industry	7.6	0.9
Other Industry	107.2	13.2
Domestic	109.6	13.5
Services	99.9	12.3
Total	**324.3**	**40**

Potential for acceptance of targets and participation in UK Emissions Trading Scheme

The above data provides us with the basis for estimating the potential size of a UK Emissions Trading Scheme. Clearly any such estimate must be highly provisional and depends strongly on the assumptions that are made about the motivation of different sectors to join. We assume the following:

- **Industrial Companies in CCL Negotiated Agreements (20.8MTC)**. As these companies will have already committed to binding energy efficiency targets, we would expect a high level of participation in trading if agreements can be structured in a way that allows for it.
- **Energy Companies (15.5MTC)**. These companies tend to be large and accustomed to trading regimes. We would assume a high level of participation, supposing that suitable incentives are in place.
- **Other Industry (29.2MTC)**. Companies range in size, and it is not likely that very small companies will find it worth their while to join the scheme, given suitable incentives. However there are also many medium/large companies in these sectors with significant emissions. Participation from this sector would be expected to increase over time as the market was established.
- **Agriculture/Commerce/Public Sectors (35.8MTC)**. Some larger players in these sectors may be potential participants, given suitable incentives, but in the main it is expected that most participants in these sectors are too small and have too low energy consumption to find trading of interest.

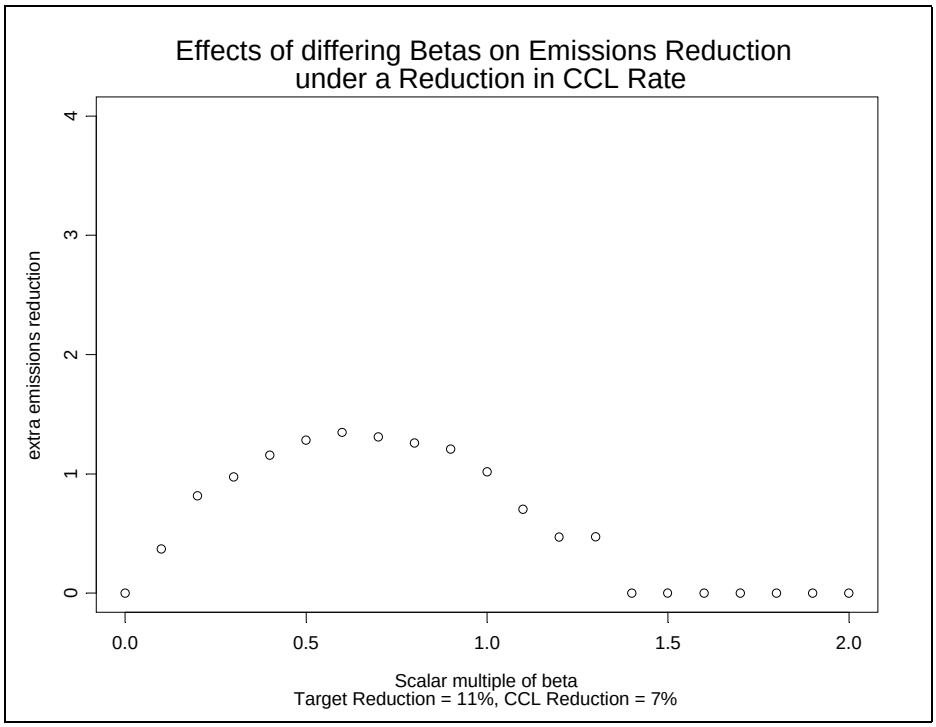
- **Domestic & Transport Sectors (88.5MTC)**. These are not expected to participate in the scheme directly, although initiatives in this area might be a source of project credits.
- **Power Sector (40MTC)**. Emissions from this sector are included in the above groups, however, given the significant size of companies in this area there is a high potential for them to participate if suitably incentives were in place. In this case the emissions associated with electricity consumed by non-participants in the scheme would still be covered.

Taking these assumptions and applying crude percentage participation assumptions we get the following potential base for the Emissions trading market.

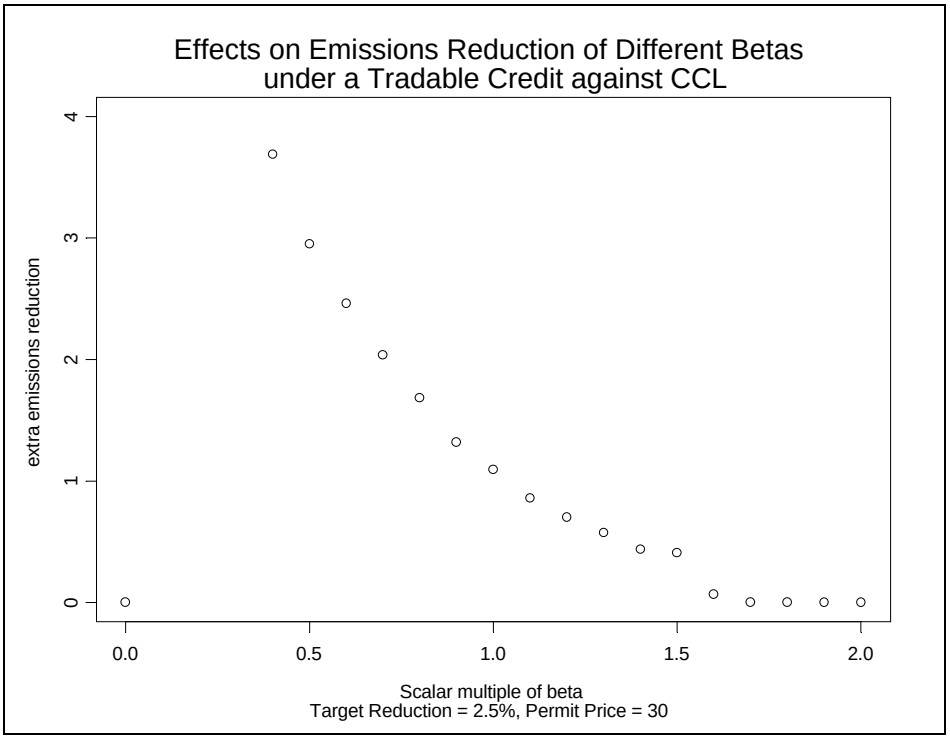
Sector	**1998 GHG Emissions (MTCe)**	**Potential Participation %**	**Potential Participation**
Negotiated Agreements	20.8	90%	18.7
Oil/Gas/Coke	15.5	90%	13.9
Other Industry	29.2	50%	14.6
Agriculture, Commerce, Public	35.8	10%	3.6
Domestic & Transport	88.5	0%	0
Power	*Included above 40*	90%	28.8*
Total	**189.7**	**42%**	**79.6**

** 100% Domestic consumption + 90% Services & 30% Industry.*

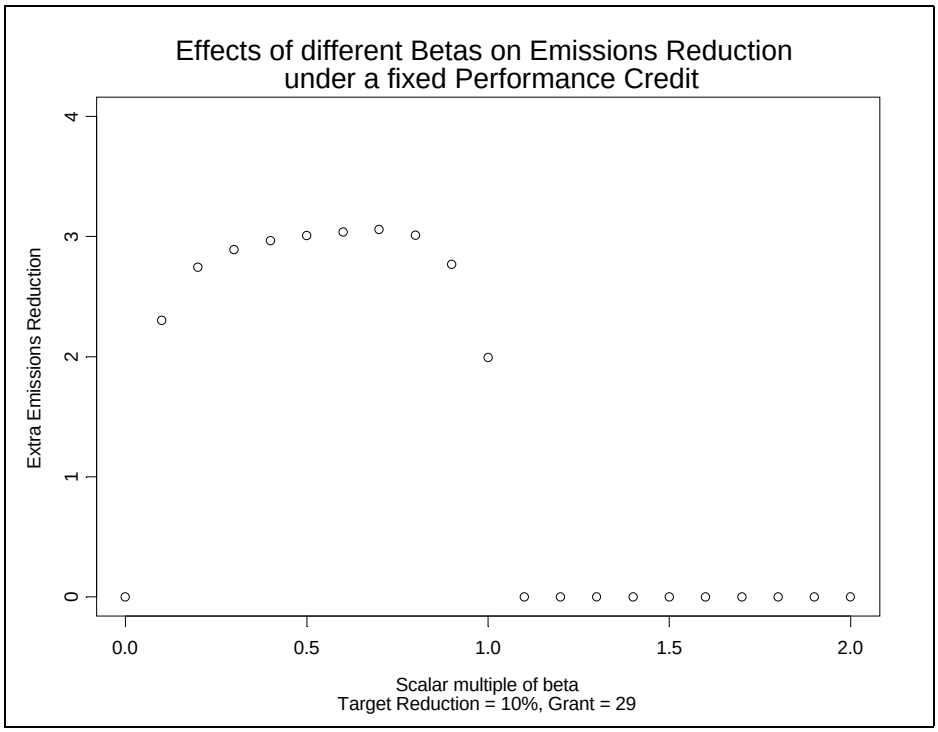
Appendix 2



Once abatement costs are 50 per cent higher than the costs assumed, the 7% cut in the CCL rate is not enough to induce any companies to sign up. On the other hand, when costs are very low, the CCL cut makes little extra difference to incentives.



As costs rise, it becomes harder to reduce emissions sufficiently to be able to sell permits and the incentive to sign up is reduced.



The willingness to sign up is based on the cost of reducing emissions in comparison to the size of any credit. As a result, the willingness to sign tails off quickly as costs rise.