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Emissions trading in China: Principles, design options and lessons from international practice

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Abstract
China is considering a national emissions trading scheme, to follow several pilot schemes, as part of the suite of policies to reduce the growth of greenhouse gas emissions. A carbon tax or tax-like scheme could be an alternative. However there are special challenges in a fast-growing economy where the energy sector is heavily regulated. This paper analyses policy design options based on principles, China's circumstances, and Australian and European experiences. The main findings are the following. (1) Features such as variable permit supple, price floor/ceiling or a fixed permit price are desirable to provide a stable price signal, especially in China's case. A carbon tax can be a viable alternative or complement to emissions trading. (2) Any free permits or other assistance to industry should be carefully designed to preserve incentives to cut emissions, limited so that governments can use carbon revenue to support households or pay for other policy measures, and regularly reviewed to avoid lock-in of unnecessary payments. (3) Broad coverage of emissions pricing is necessary for effectiveness, including in electricity supply and demand. Carbon pricing can be partly effective in the electricity sector ahead of comprehensive energy sector reform, ultimately however market-based energy pricing is needed. (4) Carbon pricing should be seen in the broader context of economic policy reform. It offers opportunities to support broader goals of fiscal, energy and environmental policy.

Keywords

China; emissions trading; carbon tax.

JEL Classification
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Emissions trading in China:
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China is considering a national emissions trading scheme, to follow several pilot schemes, as part of the suite of policies to reduce the growth of greenhouse gas emissions. A carbon tax or tax-like scheme could be an alternative. However there are special challenges in a fast-growing economy where the energy sector is heavily regulated. This paper analyses policy design options based on principles, China's circumstances, and Australian and European experiences. The main findings are the following. (1) Features such as variable permit supple, price floor/ceiling or a fixed permit price are desirable to provide a stable price signal, especially in China's case. A carbon tax can be a viable alternative or complement to emissions trading. (2) Any free permits or other assistance to industry should be carefully designed to preserve incentives to cut emissions, limited so that governments can use carbon revenue to support households or pay for other policy measures, and regularly reviewed to avoid lock-in of unnecessary payments. (3) Broad coverage of emissions pricing is necessary for effectiveness, including in electricity supply and demand. Carbon pricing can be partly effective in the electricity sector ahead of comprehensive energy sector reform, ultimately however market-based energy pricing is needed. (4) Carbon pricing should be seen in the broader context of economic policy reform. It offers opportunities to support broader goals of fiscal, energy and environmental policy.

Table of contents

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Summary

China has ambitious goals to limit the growth of greenhouse gas emissions. China's energy and climate policy to date has relied largely on a direct regulatory approach. China is now considering a national emissions trading scheme, and proposals for a national carbon tax have also been raised. Several pilot emissions trading schemes are in preparation. A move towards market based policy instruments is significant, in a fast-growing economy where command and control approaches to policy have dominated, and where many aspects of energy pricing are heavily regulated. China has the opportunity to move to world best practice on carbon pricing, and if successful could encourage other countries to emulate the experience.

This paper examines policy design issues for national emissions pricing in China, through emissions trading or alternatively a carbon tax. The paper analyses issues of policy design, in the light of economic principles, China's circumstances and Australian and European experiences. It finds that:

- Market based instruments for climate change mitigation should be seen in the broader context of economic policy reform and tax reform. These new approaches offer opportunities to support broader goals of economic policy reform, energy policy, environmental and climate policy.
- Achieving emissions reductions at least cost, as typically assumed in economic modelling, in practice requires carefully designed policy frameworks.
- Broad coverage of carbon pricing can improve cost effectiveness. Not all emitters need to be included directly in emissions trading. Upstream permit liability and equivalent emissions charges or taxes may allow increasing coverage while minimising transaction costs and administrative complexity.
- China's dynamic growth and uncertainty about the response of emissions to carbon pricing presents challenges for translating the national intensity target into an absolute cap on emissions in a national emissions trading scheme. The cap (amount of permits issued) may need periodic adjustment in light of GDP growth. Conversely, a carbon tax may result in greater or lesser abatement than anticipated.
- Under a pure trading scheme there would be significant uncertainty about price levels, and potentially large price variability. It is desirable to manage prices at least in the early phases of emissions trading. This could be achieved in a variety of ways. One option is a fixed price model, where government sells permits at a predetermined price; transition to a market based trading scheme is straightforward. A straight carbon tax may also be a viable option. Within a trading scheme, the price can be constrained by a price floor and ceiling; or the permit supply could be made variable to respond to market prices.
- Assistance to industry in the form of free permits (or tax exemptions) to industry needs to be carefully calibrated, in view of incentive effects, the opportunity costs to the budget,

and risk of lock-in of assistance arrangements. It is best practice for governments to retain a substantial share of the overall value of emissions permits and in turn to support households, reduce other taxes, or finance other policy measures. Where free permits and other assistance are given to industry, incentives to reduce emissions need to be preserved, and provisions for review and phase-out of industry assistance are advisable.

- Carbon pricing in electricity supply and demand is necessary for an overall cost-effective response, but presents complex issues for mechanism design and policy implementation because of the interplay with existing regulatory structures in the energy sector, in particular fixed electricity supply prices and mandated dispatch schedules. There are ways to make carbon pricing at least partly effective ahead of comprehensive energy sector reform. Ultimately however, energy sector reform leading to market-based energy pricing is needed.
- The introduction of market mechanisms for greenhouse gas emissions control could act as a catalyst for other market-based reform in the energy sector. This could in itself yield large economic benefits.

1 Introduction

China has a goal of reducing the emissions intensity of its economy by 40 to 45 percent from 2005 to 2020, among other goals in the 12th Five-Year Plan to modernise the economy. This is likely to require a significant policy effort (Stern and Jotzo, 2010), and takes place in the context of its international pledge to reduce emissions intensity the Chinese economy (Stern and Jotzo, 2010), objectives to limit climate change risks, improve energy security and gain technology leadership (Boyd, 2012). It also takes place against the backdrop of a broader vision of 'green growth' for China (Zhang and Brandon 2012, Jotzo and Zhang 2013).

It is technically feasible for China to constrain the growth of its energy use and carbon emissions in the short term, and achieve a peak and decline in emissions in the medium term (Jiang et al 2013). China's economic structure might relatively rapidly shift towards more high-value added industries and the services sector (Garnaut 2012). If combined with effective policy mechanisms, modernisation could result in faster rates of de-carbonization than targeted now. Calls are emerging from academic commentators for stronger 2020 commitments on emissions and absolute emissions targets in line with global emissions reductions (Zhang 2013).

A key question is which policy instruments to apply, and how to design them. China's new leadership has re-iterated the country's ambition to limit the growth in energy consumption and carbon dioxide emissions (NPC 2013). These objectives can be addressed simultaneously by putting a price on carbon emissions. NDRC has re-iterated that "we will promote trials and demonstrations for low carbon development, steadily improve the pilot projects in the trade of carbon emissions, and research and establish a national emissions trading scheme" (NDRC 2013a). A blueprint for the design effort towards a national emissions trading scheme was released in April 2013 (NDRC 2013b).

Pricing greenhouse gas emissions through emissions trading scheme or an emissions tax could make a significant contribution to China's goal of reducing emissions intensity of its economy, and in turn to curbing global greenhouse gas emissions. A move towards market based policy instruments is significant, in a fast-growing economy where climate change mitigation policy has been predominantly by command and control approaches, and where energy pricing is regulated.

Pilot emissions trading schemes are in preparation in seven of China's provinces and cities (Lo, 2012; Wang, 2012). In 2010 the pilot cities and provinces accounted for around 19% of China's population, 33% of its GDP, 20% of its energy use, and 16% of its carbon dioxide emissions or about 1.3 Gt carbon dioxide (CO_2) emissions (see Appendix for data and sources). It is not yet clear what share of emissions in the pilot schemes will be covered by emissions trading. The pilot schemes with their different features (see Appendix for an overview) are set to provide a laboratory for gathering experience with different designs and implementation methods, and the effect of emissions pricing in different regional economies.

The bigger opportunity for effective and cost-effective climate change mitigation however is in a national system of emissions pricing. The Chinese government has announced its intention to implement national emissions trading, and analysis on design options is in preparation (PMR 2013).

Emissions pricing holds the promise to reduce emissions at least cost. Yet to be effective in reducing emissions growth at low economic cost, emissions trading needs to be designed to give the correct incentives and according to economic and institutional circumstances, which in China's case poses particular challenges. China has a number of policies in place that constrain carbon emissions, including widespread mandatory standards for energy efficiency and support for renewable energy. It is likely that a price on carbon in China would exist alongside significant non-pricing mitigation policies for some time to come. Depending on the level of the carbon price, non-pricing policies in many sectors could have significantly greater effects than carbon pricing.

This paper sets out principles and investigates options for key design features in China's national and pilot emissions trading schemes. The paper covers the extent of coverage of the carbon market and alternative ways of implementing a carbon price (section 2); how to set emissions caps in the context of fast economic growth and targets framed in intensity terms (section 3); whether and how to manage prices in emissions markets (section 4); methods of allocating permits and decisions about using revenue (section 5); and some of the particular issues arising for the electricity sector in the context of regulated prices (section 6).

The paper draws on experience in existing carbon pricing schemes, in particular the Australian carbon pricing scheme (Australian Government, 2011a; Australian Parliament, 2011; Garnaut, 2011, 2008; Jotzo, 2012) and the European Union's emissions trading scheme (Ellerman and Buchner, 2007; European Commission Climate Action, 2012). Each section includes a consideration of principles on specific issues of policy design, a brief summary of relevant international experiences, a brief indication of future research needs, and a discussion of implications for a potential future Chinese national emissions trading scheme. The analysis is to a large extent equally applicable to pilot emissions trading schemes.

2 Coverage of emissions trading

Key messages:

- *For overall effectiveness and cost effectiveness, it is important to cover a large share of emissions under a carbon pricing scheme.*
- *Direct permit liability under ETS is not the only option for carbon pricing. Alternatives such as upstream liability for fossil fuel emissions or carbon price equivalent charges for other emissions can overcome hurdles to inclusion and improve overall cost effectiveness.*

The primary aim of a carbon market is to provide incentives to reduce emissions at lowest cost. In principle, the broader the application of a homogenous emissions price, the greater the cost effectiveness of the overall abatement response. This applies both to regions, with cost savings from uniform application of carbon pricing across China's provinces (Zhang et al., 2012), as well as to coverage of different sectors of the economy, which is examined here. However, it can be preferable not to include small emissions sources directly in the permit scheme because transaction costs are likely to be too high. It may be possible to include them indirectly through upstream permit liability on fossil fuel distribution, or through carbon equivalent charges or taxes. Furthermore, there may be specific sectors where other policy instruments are needed in addition to, or instead of, a carbon price.

2.1 Sectoral coverage

Carbon markets can create a consistent price signal across a wide range of economic activities. The broader the coverage of emissions sources, the broader the incentive to reduce emissions.

However, carbon pricing will also result in transaction costs, in particular for the monitoring, reporting and verification (MRV) of emissions levels from each individual source (installation) covered. Where sources are small and/or difficult to monitor because of the nature of their activity, effective inclusion may not be possible, or only at large transactions costs. An overall cost-effective carbon pricing scheme may exclude some sources for this reason.

There is also a role for non-pricing instruments. Standards and other regulations may usefully apply in sectors such as agriculture where emissions pricing is impracticable because of measurement issues at the business level; in promoting greater energy efficiency in end-use applications where price signals cannot overcome the hurdles to adoption of efficient technology even if they are economical, for example because of incentive structures or institutional barriers; and in areas such as transport where public investment in infrastructure may be the most important mechanism for climate change mitigation.

Prerequisites for inclusion

The prerequisites for inclusion of a source of greenhouse gas emissions in a trading scheme include the following:

- Emissions data: emissions from each source of emissions need to be measurable to a sufficient degree of accuracy and reliability.
- Transaction costs: the cost of monitoring, reporting and verification (MRV) of emissions, and fulfilling the administrative requirements for taking part in emissions trading, needs to be lower than the gain in overall cost effectiveness from including a particular emissions source. Where direct coverage is uneconomical, upstream coverage or coverage through carbon-equivalent charges or taxes (discussed below) may be appropriate.

It is possible to extend the sectoral coverage of an ETS over time, for example starting with sectors where MRV is relatively straightforward and that cover a relatively large share of emissions. Plans for future expansions in scope should be clearly signposted so the market can anticipate potential changes in market conditions. This is similar as for changes over time in the scheme cap (see Section 3).

International practice

Most existing emissions trading schemes (ETS) cover emissions from fossil fuel combustion in electricity production and industry, as well as fuel use in heavy industries. This is in line with these emissions sources being large; measurement being relatively accurate, easy and low cost; and there being plentiful abatement options in response to a price on emissions.

Greenhouse gas emissions from various industrial processes are covered under the Australian scheme. In the EU ETS, coverage is extended to some industrial processes in the scheme's third phase from 2013.Emissions from transport are covered within the existing schemes only in Australia and there only partially. However all countries with carbon pricing schemes also have fuel taxation for transport in place, at much higher levels per unit of fuel than a carbon equivalent price would pose. Carbon pricing needs to be considered in the context of existing taxes and subsidies, a point discussed further below.

Among the existing carbon trading schemes, at this stage only the NZ ETS includes parts of agriculture, as well as forestry (on an opt-in basis). Usually, practical difficulties in MRV of small and dispersed sources is the reason, however political considerations in imposing costs on agriculture may also have played a role in the policy decision not to include the sector. Technical difficulties with inclusion of agriculture as well as forestry include the accurate measurement of emissions at the farm or plot level, and enforcement of permit liability. It can also be politically difficult to impose permit liabilities on the land-based industries.

The Australian scheme also covers emissions of carbon dioxide (CO_2) and other greenhouse gases from industrial processes, mining and landfills. This represents more comprehensive coverage than any other existing ETS. Gas combustion by households and parts of the transport sector is also included, by way of upstream coverage and carbon equivalent tax changes (see below).

2.2 Size threshold for inclusion in ETS

Existing ETS have a cut-off for the size of individual installations included with direct permit liability. This allows including only the larger emitters as liable entities, limiting the number of participants in the market. It limits the administrative effort for government and overall compliance costs to industry.

But limiting inclusion to large emitters creates distortions between large and small emitters. There is a threshold effect whereby installations may have an incentive to reduce their operations so that emissions are below the cutoff; and reduced overall effectiveness because small sources do not have incentives to reduce emissions.

A lower threshold for inclusion means a much larger number of liable entities, but only a modest increase in the share of total emissions covered; conversely a higher threshold reduces the number of liable entities by much more than the share of emissions covered. In other words, the incremental gain in coverage is small as the threshold is reduced, while the incremental increase in transaction costs is large.

International practice

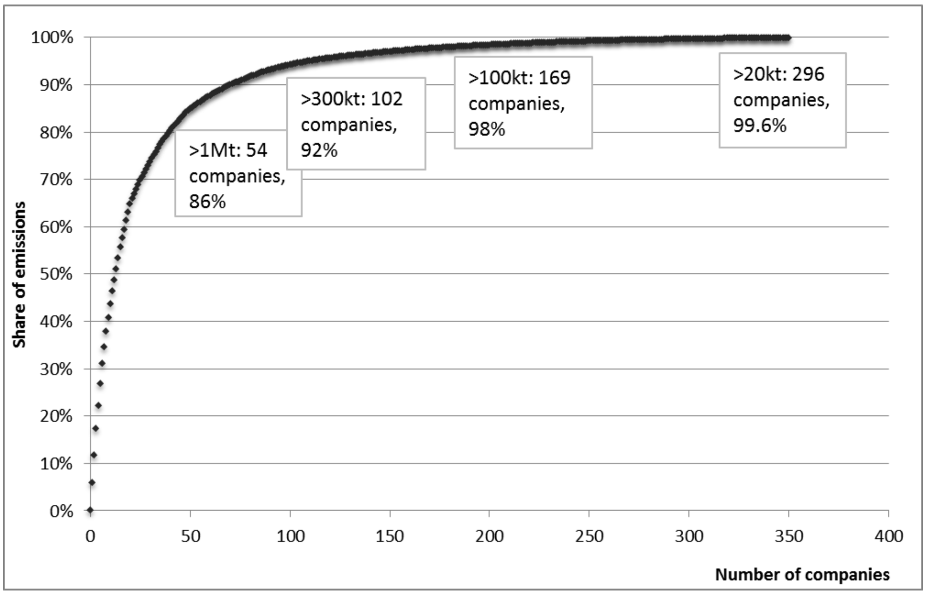
The cut-off for direct liability in the EU ETS is 25 kt CO_2 per year, with over 11,000 installations covered; and equally it is 25 kt CO_2-equivalent per year in the Australian scheme, with 374 installations covered.[2] There are some indications that the EU scheme includes many installations that are too small to effectively take part in emissions trading, with a large share of emitters having neither evaluated their options to reduce emissions nor implemented reduction measures, and transaction costs amounting to a significant share of total compliance costs for the small emitters included in the scheme.

As illustrated in Figure 1, in Australia a threshold of 300kt/year would have covered 92% of emissions under the National Greenhouse Gas Reporting System (fossil fuel and industrial emissions, during 2010-11), from around 100 companies; whereas a threshold of 20kt/year encompasses around 300 companies, with the extra 200 companies raising the amount of covered emissions by only 8 percentage points. This suggests that choosing a higher threshold might have reduced the administrative cost without greatly diminishing abatement, though excluding more emitters would create greater overall distortions between companies of different size.

Higher thresholds are a particularly promising proposition if there are provisions for covering smaller emitters, as discussed below.

[2] As of 10 April 2013.

Figure 1 Cumulative emissions for Australia's largest emitting companies



Data source: Australia's National Greenhouse Gas Reporting System, 2010-11 data (emissions from fossil fuel and industrial processes).

2.3 Upstream coverage of emissions from fossil fuels

As an alternative to the standard model of covering emissions at the point where CO_2 is emitted into the atmosphere, emissions from fossil fuel use can be covered at an earlier point of the carbon supply chain. Specifically, a carbon price can be imposed at the level of coal mines and coal import terminals; oil refineries; and gas distribution hubs. This is referred to as 'upstream' coverage, in contrast to 'downstream' coverage where emissions are subject to a permit liability at the point of fuel combustion.

Under upstream carbon pricing, the suppliers of fossil fuels have to acquit carbon permits for the emissions embodied in the fuels that they sell to their customers. They reflect the cost of the carbon in the price they charge their customers. As a result, the same incentives and distribution of costs as under downstream coverage is achieved: the carbon cost is borne by industries that use energy and end users of the resulting products and services rather than by the fuel suppliers. The users of fuels have the incentive to reduce energy consumption and move to lower-carbon energy.

The advantage of upstream coverage is that it can drastically reduce the number of compliance points compared to downstream coverage. It thereby makes MRV easier and reduces transaction costs. It also allows coverage of practically all uses of fossil fuels, even by very small users such as small companies and households, which would not be practically possible under a pure downstream system.

The prerequisite is that carbon costs imposed on fuel distributors can effectively be passed on to fuel users by way of price increases, so that the end users have the correct incentives to reduce their use of emissions intensive energy. If cost-pass through is ruled out through regulation – for example where fuel supply prices are fixed – upstream emissions pricing will reduce suppliers' profits without resulting in changed consumption patterns, because end users to not see an price signal for their emissions. Where price pass-through is only partial, for example because of market power in fuel or electricity supply, upstream emissions pricing will generally result in a partial price signal for end users.

Upstream and downstream permit liability can be combined, by implementing upstream liability while also covering large users of fossil fuels directly and exempting their fuel supplies from the upstream liability. This can be desirable in the case where large users of fossil fuels prefer to manage their own permit liability rather than paying higher prices. Reasons may include that large emitters can then integrate permit liability for all sources of emissions from their operations, or because they feel can better manage financial risks through strategies such as forward purchases of permits.

International practice

In the Australian carbon pricing mechanism, a mixed upstream/downstream system is in place for the use of natural gas in the economy. Individual installations with emissions greater than 25 kt CO_2-equivalent per year are under a direct liability for their emissions. The suppliers of natural gas get an exemption from carbon liability for the gas supplied to large users who manage their own permit liability.

2.4 Equivalent carbon charges or taxes

An ETS operating in some parts of the economy can be complemented by carbon taxes or charges, on other sources of emissions.

This may be suitable in cases where

- it is not feasible or desirable to include certain types of emissions sources in the trading scheme,
- emissions accounting does not achieve the level of reliability required in the ETS overall but to an acceptable level for taxation of individual emissions sources, and/or
- there are systems for charges or taxation of the relevant activities already in place which can easily be adapted to put a price on emissions, thus saving on transaction costs.

An equivalent tax or levy system applied to some sectors may create the need for periodic adjustment of tax rates which may be undesirable; conversely it creates the opportunity for more price stability which may be desired.

Arrangements for assistance to industry can be designed equivalent to those under ETS. Under a permit scheme, assistance is typically delivered in the form of free permits. Under carbon taxes or charges, assistance can take the form of tax-free thresholds[3], or a defined cash subsidy.

[3] For a fully efficient abatement response, these tax thresholds should be allocated as a right that is tradable between emitters (Pezzey, 1992).

The key advantages (compared to inclusion in the ETS) are greater administrative simplicity, the potential to cover a greater extent of sources, as well as potentially the greater stability in prices over time and leeway to let prices deviate from ETS prices. Potential disadvantages compared to inclusion in ETS (where this is possible) are that the depth of the domestic carbon market is diminished, and that sectors covered by a tax and charges are not able to directly participate in international permit markets. Furthermore if carbon charges deviate strongly from market prices there may be some overall losses in efficiency of the mitigation response.

The factors for the choice of different forms of coverage – direct permit liability, upstream liability, and equivalent charges – are summarised in Table 1.

International practice

Australia is imposing an equivalent carbon levy on some synthetic greenhouse gases, and on liquid fuels used for some types of transport. In both cases, tax or levy arrangements already exist that cover the production or use of products that cause greenhouse gas emissions.

Several European countries have had separate carbon taxes on parts or all of their fossil fuel use, and have kept them in place once the ETS started. This leads to a higher effective carbon price in these countries, and for the relevant activities, than where only the emissions trading scheme applies.

Table 1 Different forms of coverage

	Direct permit liability	Upstream liability for fossil fuels	Equivalent charges/taxes
Key features	Companies are liable to acquit permits for emissions from their installations.	Distributors of fossil fuels are liable to acquit permits for emissions inherent in the fuels they sell. Point of liability: fuel distribution (or alternatively fuel production and imports).	A tax or levy is applied to particular emissions sources not included in an emissions trading scheme.
Applicability	Any greenhouse gas emissions. Impractical for very small sources of emissions.	Natural gas, diesel, petrol; possibly coal. Large emitters can be exempt from upstream coverage and manage their own permit liability.	Any sources of greenhouse gas emissions. Attractive where MRV is not of a high enough standard to enter ETS, or where charges or taxes already exist for the relevant emitting activities.
Prerequisites	MRV at the level of emitting installations.	Pass-through of permit costs to users of fossil fuels. MRV at the level of fuel distributors.	MRV at the level of emitting installations.
Advantages	Maximum depth of emissions trading market. Ensures that all emitters face the same carbon price.	Allows coverage of 100% of fossil fuel emissions at modest transaction costs. The number of liable entities is much smaller than for direct coverage.	Expands coverage of carbon pricing without including extra participants in ETS.
Disadvantages	High transaction and administrative costs for small sources of emissions.	Less depth in the emissions trading market (though this can be addressed by allowing direct liability for large emitters).	Less market depth. Efficiency losses if carbon charges deviate strongly from market prices.
Examples	All existing ETS	Australia: natural gas	Australia: some transport fuels and industrial gases

2.5 Considerations for China on ETS coverage

Sectoral coverage

On the basis of principles and international experience, it is advisable for China to seek broad coverage of its carbon pricing scheme, including the production and consumption of electricity, direct use of fossil fuels in industry, industrial process emissions, and possibly fossil fuels used for transports and by households.

However, this is not necessarily best achieved through direct permit liability of all emitters. Rather, China should consider extensive use of upstream liability for emissions inherent in fossil fuels, at the refinery or fuel distribution level; and equivalent carbon taxes or charges for selected other types of emissions. This can serve to expand coverage while reducing administrative complexity and transaction costs.

Phased introduction of carbon pricing to different sectors may be advisable. Carbon pricing can start out covering a core group of sectors, and then be expanded as experience is gained and as the prerequisites for inclusion of other sectors and greenhouse gas emitting activities are established.

Upstream coverage and thresholds for direct inclusion

For China it is advisable to consider a relatively high threshold level for direct inclusion in an ETS, and in turn to include smaller entities through upstream coverage of fossil fuel use. This approach could achieve up to 100% coverage of emissions from fossil fuel use, while keeping the number of market participants manageable, and transactions costs and administrative burdens low.

For pilot schemes in cities, where the majority of overall emissions will typically come from a relatively large number of medium to small emitters rather than a small number of large emitters, upstream approaches may be particularly attractive.

A key prerequisite for the upstream approach is that fuel providers are able to raise their product prices in order to accurately reflect the carbon costs. This is best achieved in liberalised energy markets. In a system of regulated energy prices, an approximate outcome can be achieved if the mandated energy prices are adjusted for the cost of carbon permits. The special case of power generation is discussed in more detail in Section 6 below.

Equivalent carbon taxes or charges

China may want to consider raising taxes or charges on greenhouse gas emissions equivalent to a carbon price under the ETS where direct inclusion in the carbon market is not desired, or not possible for example because of difficulties in MRV. Examples may include industrial process emissions.

Special considerations for pilot schemes

Decisions about coverage of emissions in China's pilot ETS schemes should generally follow the criteria laid out above. However, there are particular issues to be considered with regard to the power sector and heavy industries.

The pilot scheme areas are linked into power grids that are supplied in large part by electricity generators located outside of each scheme. This complicates the application of carbon pricing on electricity generators. Meanwhile most pilot schemes are planning to put a price on "indirect emissions" from electricity. Such demand side carbon pricing is possible through the modes of direct liability of large users, upstream liability, or equivalent charges, and the same considerations as laid out above apply. Section 6 provides further detail.

Effects on emissions intensive traded goods industries within the pilot schemes could be of interest for the two pilot provinces, which have significant heavy industries, and less so for the five pilot cities. Depending on the scheme design, emissions-intensive industries could be at a competitive disadvantage relative to producers in provinces that do not impose a carbon price. However, given the expectation of a national carbon pricing scheme this is only a temporary issue that is unlikely to lead to significant unwanted relocation of industrial production. Any temporary distortions also need to be considered in the broader context of existing non-pricing policies, which will often have a much larger effect on location decisions than temporary differences in carbon prices.

In many cases, local jurisdictions may even wish to speed up the process of industrialing restructuring towards higher value added, less energy intensive and less polluting industries.

Research needs

Quantitative research is needed on the amount and cost of abatement likely to be achieved from different sectors. This can be done using top-down computable general equilibrium models, and bottom-up engineering-economic models. Useful research questions for modelling applications include

- What is the relative contribution of different sectors of the economy to overall abatement, at different carbon price levels – in absolute and percentage terms?
- What is the relative importance of different aspects of abatement action, eg fuel switching, energy efficiency improvements, and changes in the composition of supply and demand for goods and services as a result of a carbon price?
- How does the cost of achieving a given amount of overall abatement depend on the extent of coverage; what is the cost advantage of broader coverage?

Further quantitative research is indicated on the likely magnitude of transaction costs and administrative costs in various sectors, for different thresholds for inclusion in ETS, and for the different modes of coverage. These aspects of cost are usually not included in the modelling of mitigation, but need to be considered in deciding optimal coverage.

This research needs to be complemented with qualitative research on the institutional feasibility of coverage through different modes of coverage in different sectors, to help decide what extent of coverage is feasible in practice. Experiences in the pilot schemes can be a valuable source of information in making coverage decisions for a national scheme. Research could investigate the actions taken, and transaction costs incurred, of companies of different sizes and in different industries.

3 Setting an emissions cap and trajectory

Key messages:

- *In order to help achieve a national emissions intensity target, the caps on permits will usefully be indexed in some form to realised GDP growth.*
- *Flexibility mechanisms such as banking or borrowing of permits are desirable in principle.*
- *Because of uncertainty about future growth and abatement responses, it may be desirable to combine the cap on emissions with price control mechanisms that may override the cap.*

3.1 The function of the cap

A carbon market is created by government requiring emitters to cover their carbon emissions with permits, and by issuing a limited amount of permits. The ‘cap’ is the amount of emissions permits issued over the period of one year, with a succession of annual caps amounting to a ‘trajectory’. Government can allow emissions permits issued in earlier years to be used in later years, or vice versa (banking and borrowing respectively, see Section 3.4).

Setting an emissions cap and future trajectory presents particular challenges for China, for two reasons.

Firstly, national and regional emissions targets are framed in emissions intensity terms, while an ETS would usually function on the basis of permits for absolute amounts of emissions. The sectors under the cap may amount to a significant portion of the total national (or regional) emissions target, and so the absolute cap should follow the overall intensity target. How an absolute cap could be set on the basis of an intensity target is discussed in 3.2.

Secondly, China faces large uncertainties about future emissions trajectories because of its rapid economic growth and rapid structural change, change in policy settings that affect energy use and carbon emissions, and because there is not yet any experience with the effect of carbon pricing on emissions levels. As a result, projections of future emissions levels and thus the abatement task from a given cap, and projections of emissions price resulting from a given cap, are highly uncertain.

Policymakers and industry may not be comfortable with a the possibility that the carbon price in markets may be either very high or very low, and instead may want to put bounds on the price – which in turn means overriding the cap. Price management mechanisms are discussed in Section 4.

3.2 The relationship between the permit cap and a national emissions target

An ETS will not cover all emissions sources in an economy and it will usually also not include all emissions covered by a national emissions target. Therefore, the percentage reduction change under the cap is not necessarily the same as the percentage change targeted for national emissions. In other words, setting a specific cap for the carbon market does not automatically assure that a specific national target will be met, because there could be surprises in the non-covered sector. If the non-covered emissions grow faster than the overall target, then the emissions under the cap need to grow more slowly, implying a smaller cap (and vice versa).

In China's case, the national emissions target for 2020 as currently defined ranges only over carbon dioxide from fossil fuel combustion. As a result, it is more readily possible for a carbon market to cover a large share of emissions under the target, because other greenhouse gases, agriculture and forestry are separate from the headline target. If a national carbon market covers most or all of the emissions under the target, then setting the cap in accordance with the target assures that the target will be met.

However, the fact that China's national target is framed in terms of emissions intensity introduces specific complexities in setting caps for a carbon market.

International practice

In the EU ETS, an annual decrease in the emissions cap is legislated. The rate of decrease of 1.74% per year is calibrated to the EU target of a 20% reduction in emissions from 1990 to 2020.

In the Australian scheme, there is a legislated default trajectory for the scheme cap. The default reduction in the cap over the years 2015-20 is about one third. Beyond the initial period of scheme caps, there will be rolling 5-year periods of scheme caps. The government will be required to make regulations each year for the following five years, taking into account recommendations by the independent Climate Change Authority. This approach strikes a balance between providing predictability to the market, and adjusting the cap over time to take account of changed circumstances. Furthermore, Australia expects international trading to play a large role in covering the gap between emissions under the ETS and the overall national target.

3.3 Absolute caps and intensity targets

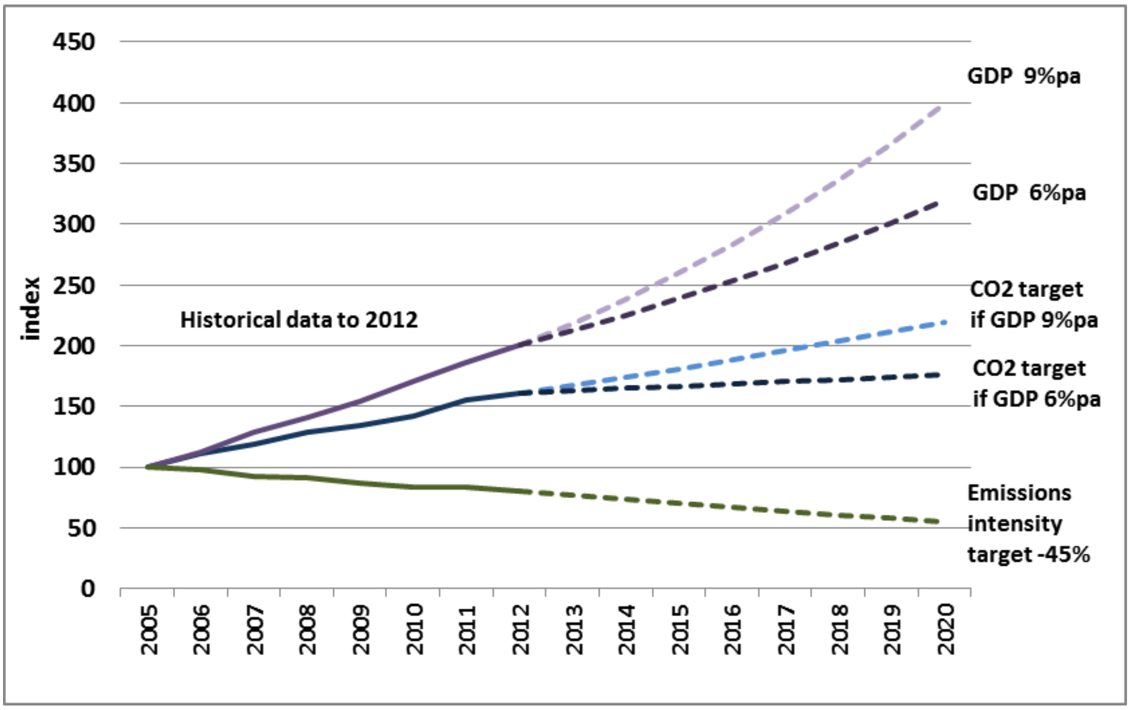
China's national target is framed as an intensity target (40 to 45% reduction in the ratio of emissions to GDP, from 2005 to 2020). This can be translated into a target framed in absolute emissions levels, by assuming a future rate of growth of GDP (Jotzo and Pezzey 2007). However, the actual amount of emissions allowed under the target will inevitably differ from forecasts, as realised GDP growth invariably will differ from that assumed.

Given China's high growth rates and rapid structural change, uncertainty over future GDP growth rates is substantial, and so is uncertainty over the absolute amount of emissions under the national target. For example, if GDP were to grow at an average annual rate of 9% between 2013 and 2020, then reducing emissions intensity by 45% over the period 2005 to 2020 implies that absolute emissions in China are allowed to increase by 36% from 2012 levels to 2020, or about 4% per year.

By contrast, if GDP were to grow at an average rate of just 6% per year during 2013 to 2020, the same intensity target implies an increase in emissions of only 9% over 2012 levels, or just 1% per year over the remainder of the decade. This is illustrated in Figure 2.

In previous years such "slow" growth scenarios have often been seen as unrealistic, however signs are emerging that Chinese GDP growth is moderating, and that the Chinese government may prioritise the quality of growth over maximising the rate of economic expansion. Several institutions sees Chinese growth potential for the decade in the range of 6% to 8% per (Huang 2013).

Figure 2 Illustrative trajectories for GDP and emissions to meet a 45% reduction in emissions intensity from 2005 to 2020



Note: Computed on the basis of a 100% increase in GDP from 2005 to 2012, and a 59% increase in China's CO_2 emissions from fossil fuel combustion from 2005 to 2012, implying a 21% reduction in emissions intensity from 2005 to 2012. Data: GDP – IMF World Economic Outlook database October 2012 (GDP in constant local currency); emissions - IEA "CO2 highlights 2012" to 2010, IEA media release for 2011, Chinese government announcements in January 2013 of GDP growth 7.8% during 2012 and a 5% reduction in emissions intensity during 2012.

It should be noted that continued structural change towards less energy and emissions-intensive activities (Garnaut, 2012) is a key opportunity for China to meet, and potentially exceed, its 2020 emissions target. If coupled with continued improvements in energy efficiency and a sustained shift to lower-carbon energy sources, it may enable China to begin reducing absolute emissions levels.

There are two in-principle ways to deal with this issue in setting a cap:

1. A fixed, pre-defined absolute cap based on expected GDP. The eventual difference with the national target would be covered through other means – such as greater or lesser policy action in sectors not covered by the ETS, international trading of emissions units, or simply accepting a divergence between actual emissions and the national target.
2. Indexation of the cap to GDP. Either by defining the cap as an absolute amount of permits based on expected future GDP, and making adjustments to the cap over time, based on actual GDP growth; or by making the scheme cap a direct function of GDP growth, in line with the national intensity target.

If an ETS were to be used as the principal means of achieving a national emissions intensity target, then it is logical to calibrate the cap for emissions permits to the actual level of emissions allowed under the national target, and thereby to actual GDP growth.

There are a variety of possible ways how the scheme cap could be indexed to GDP, and possibly to changed expectations about future GDP. One way would be to define a default cap trajectory based on expected GDP growth rates, and to adjust the cap for each year by correcting for the difference between expected and actual GDP for the previous year:

$$adjusted\_cap_t = default\_cap_t * \left(\frac{actual\_GDP_{t-1}}{expected\_GDP_{t-1}}\right)$$

Whichever form of GDP indexation is chosen, the cap should be computed in accordance with rules that are defined in advance, rather than through ad-hoc adjustments (as could be the case with proposed changes to the EU ETS cap). This is in order to allow carbon markets to form clear expectations about the amount of permits that will be available, on the basis of observable variables, without introducing policy uncertainty.

3.4 Permit banking and borrowing

Banking and borrowing of permits provide inter-temporal flexibility in the compliance with an emissions cap. They effectively allow markets to smooth prices over time, by defining emissions caps over longer time periods than the annual amount of permits released.

The owners of emissions permits may decide to hold onto it for future use ('banking' of permits). Banking of permits effectively means that a share of the permit supply is taken out of circulation, keeping present emissions levels below the cap, but potentially increasing future emissions levels above the cap. Conversely, a government may decide to allow emitters to defer the fulfilment of part of their emissions liability by handing in extra permits in future years. This amounts to 'borrowing' of permits.

The theory and practical experience of commodity and financial markets suggests that (absent any shocks technological changes, new information or changes in policy) intertemporal flexibility by way of banking and borrowing will allow the market price of permits to rise smoothly along a forward price curve ('Hotelling' curve). Any new information about abatement costs, technological changes or policy changes is then represented as an upward or downward shift of the entire forward price curve, rather than larger adjustments during shorter time periods as would be the case without banking or borrowing.

Furthermore, banking and borrowing allows for a smooth transition between different phases of an emissions trading scheme, where the effective stringency of the mitigation commitment will differ (eg 2013-15, 2015-2020, and so forth). If banking or borrowing is not allowed between different periods of a trading scheme, then the market price will show a discontinuity between the different phases.

International practice

Banking tends to be allowed in practice, but often with limits. Banking has sometimes not been allowed past a specific point in time, leading to disjointed price trajectories over time. For example, the price of permits in the first phase of the EU emissions trading scheme (2005-07) fell to zero when it became clear that there was an oversupply. Banking into the second phase (2008-12) was prohibited, and so the permit demand in second demand could not support prices in the first period.

Borrowing in existing schemes is typically restricted to small amounts, for fear that large amounts of borrowing could defer mitigation action too far into the future, and that it might create a self-fulfilling expectation that governments will not enforce the policy.

3.5 Considerations for China on setting caps

Given China's national emissions intensity target, it may be useful to adjust annual emissions caps in a national emissions trading scheme in the light of realised GDP, so that the emissions cap more closely tracks the national emissions target. This should ideally be done using transparent, pre-announced formulas so that markets can form expectations about future permit supply without additional policy uncertainty.

Allowing banking and borrowing of permits between years, and ideally between phases of the ETS, provides intertemporal flexibility and allows a smooth movement of the permit price through time. Some extent of banking, and possibly borrowing, is likely to be desirable in order to reconcile the trajectory of annual caps with the level of actual emissions which cannot be known in advance.

Research needs

Quantitative analysis and modelling will be needed on various aspects of likely future emissions trajectories and mitigation responses in order to inform the setting of ETS caps and rules such as for banking and borrowing.

Research questions include:

- What is the likely range of emissions growth scenarios of emissions outside of the ETS, given the policies that apply to these emissions sources (this determines the allowable emissions under the cap for a given overall target)
- How does the extent of coverage of the ETS affect emissions growth outside of the ETS

- How does the underlying growth rate in emissions, inside and outside of the ETS, change in response to slower or faster GDP growth
- What is the likely trajectory of emissions growth inside the ETS, in response to an emissions price (this in part determines banking and borrowing).

CGE modelling, and partial sector specific models and projections – in particular for the energy sector – and regression-based analysis can all be useful in conducting such analysis. The analysis will generally be need to be conducted from a stochastic viewpoint, identifying ranges and likelihoods rather than just expected values.

4 Price management and market stabilisation

Key messages:

- *Hybrid schemes with elements of both emissions control by quantity and price instruments are possible.*
- *There are different options for price management within an emissions trading scheme, including fixed price permit schemes, price floors and ceilings, and variable permit supply.*
- *For China, letting the market price float in line with other international markets and long-term price expectations could be desirable in the longer term.*
- *During the early phases of a national ETS however, there is likely to be significant uncertainty over the relationship between emissions caps and permit prices, and potentially high permit price variability. This may make it desirable to implement price management mechanisms to retain the carbon price within a "comfort zone".*

4.1 Price control, quantity control and hybrid schemes

An emissions trading scheme is traditionally predicated on the notion that emissions should not exceed a predetermined level within the scheme (the cap). However, it is *ex ante* unclear what will be the required emissions price to achieve this outcome, so the permit price resulting in markets may diverge significantly from prior expectations.

If underlying emissions trends turns out lower than the target, and/or emissions reductions turn out be cheap, then the price will be lower than anticipated, and could even be zero. In this case, it may be desired to increase the abatement ambition of the scheme to achieve greater emissions reduction, because a lower level of emissions can be achieved at the expected cost. Conversely, if underlying growth is stronger than expected and/or the cost of reducing emissions is higher, the emissions trading price could be very much higher than expected. In that case, it may be desired to ease off on the ambition of the abatement target, in order to avoid a cost-overrun.

On the basis of expected costs and benefits under uncertainty, economic theory provides a clear case that for global greenhouse gas emissions by price control is preferable to quantity control (Weitzman, 1974).

However from the perspective of applied climate policymaking for one country, the arguments from economic theory about global mitigation mechanism choice do not hold strong relevance because global efficiency of mitigation effort is typically a secondary consideration for individual national governments, and because emissions targets can be adjusted over time. There is often a preference for trading schemes over taxes, either because of negative political perceptions of taxes, because of a desire to frame mitigation action in terms of its quantitative outcomes, or because of an objective to manage business liabilities in markets.

However, notwithstanding the preferences for quantity control that may underlie the choice of ETS rather than carbon taxes as the preferred policy instrument, governments and business often also have a preference for controlling the permit price, at least to some extent. There may be a sense of a “comfort zone” for the carbon price within which an adequate amount of mitigation is achieved, while avoiding overly high costs. A related issue is market stabilisation in the sense of avoiding overly large fluctuations in the permit price.

Together, these factors point to a preference for ‘hybrid’ instruments of emissions control (Roberts and Spence, 1976), and shown to have economically desirable properties in empirical analysis (Philibert, 2009; Pizer, 2002).

4.2 Uncertainties about the abatement task and the cost of reducing emissions

The amount of effort needed to achieve a given emissions target depends on the underlying growth momentum of emissions. This in turn depends on the rate of economic growth, the nature and speed of structural change, and of technological innovations. All of these are uncertain, and reality often deviates from projections by much more than analysts and policymakers think it might. Recent examples include the economic slowdown and resulting drop in energy demand in the United States and Europe, as well as the rapid development of unconventional natural gas.

The second factor of uncertainty is about the response of the economy to a given carbon price, or conversely the cost of achieving a given amount of abatement. Experiences with market-based instruments for pollution control have shown that abatement is usually cheaper than expected ex-ante, in many cases much cheaper than projected (Daley and Edis, 2010).

Together, these two sources of uncertainty mean that there is great uncertainty about the permit price that might result in a ETS from a given cap and trajectory.

The recent dramatic fall in EU ETS permit prices, and the collapse in the price for credits from the Clean Development Mechanism, are powerful examples.

The uncertainty is likely to be particularly large for Chinese pilot trading schemes, because variability in underlying emissions growth is greater than in most developed countries; because there is not yet any experience with the effect of carbon pricing on emissions in China; and because uncertainty about future policy settings can limit price smoothing through time by way of banking or borrowing .

In the case where emissions targets (caps) are set relatively close to the expected business-as-usual emissions trajectory, there can be a significant probability of emissions remaining below the cap even without any mitigation action induced by a price signal. In this case, the permit price could remain at or close to zero.

4.3 Fixed price permit scheme

It is possible to fully determine the price in a permit scheme. In this case, the carbon price is effectively equivalent to a carbon tax, but it uses the institutional infrastructure of a permit price. This allows to easily transform the scheme to trading with a market price, and also makes it readily possible to allocate free permits.

To implement a fixed price permit scheme, emitters are placed under a liability to acquit permits for their emissions just like in an ETS. However rather than buying permits at auction or in markets at a market price, permits are for sale from government at a predetermined ('fixed') price. There is no cap on the amount of overall permits, the government sells however many permits are demanded by emitters. There would usually not be banking of permits for future periods, otherwise the fixed price in one year could put a lower bound on the permit price in future years. There would usually also not be any trading of emissions permits with other jurisdictions. Companies needing to purchase permits would usually make their purchases at the same time that their permit liability comes due.

The advantage of full price control by way of a fixed price scheme is that it provides greatest possible predictability of the economic effects of the scheme, such as impacts on consumer prices and compliance costs for emitters. It can thereby be useful to better calibrate cash payments that are independent of market prices, and help in communicating the likely effects of the policy before introduction. It does however provide no feedback loop from emissions levels to the stringency of the carbon price. A fixed price scheme may turn out to achieve much greater or much smaller emissions reductions than desired.

International practice

Australia's carbon pricing scheme starts with a fixed price, applicable during an initial three-year period (Australian Government, 2011a) . From mid-2012 to mid-2015, the scheme operates with a government determined price starting at A$23 per tonne of CO_2 equivalent and rising to A$25.40/t. The Australian government sells an unlimited amount of permits at this price, so there is no cap on the amount of permits issued. Neither international trading nor banking of permits is allowed.

Thus, during the first three years the scheme acts like a carbon tax, but it uses the institutional and legal infrastructure of a permit system. It therefore allows ready transition to a market-based trading scheme. The fixed price model allowed breaking a deadlock in negotiations between the government and Greens party, who could not agree on Australia's national target and a quantitative cap for the permit scheme, but could agree on a price to get the scheme started (Australian Government, 2011a). Australia's fixed price also makes fiscal revenues and impacts on price levels more predictable, and allows more time to prepare for market-based trading. No other significant ETS to date has used a fixed price model. Initial experiences from Australia show that the fixed price in practice functions as expected.

4.4 Price floor and price ceiling (hybrids)

Emissions control by quantity and price instruments can be combined in 'hybrid' schemes. The classic form is a system that confines the market price to a range between a minimum (floor) and maximum (ceiling) price. This is sometimes referred to as a 'price collar' (Jotzo, 2011; McKibbin et al., 2009).

A *price floor* ensures that a minimum extent of incentives to reduce emissions is achieved, independent of market conditions (Wood and Jotzo, 2011). A floor price prevents the permit price to fall below a predetermined threshold, and thereby provides more confidence for investment in low-emissions equipment. It will tend to encourage more investment, because it eliminates the risk that a possibly very low market price for emissions could render low-carbon investments unprofitable.

In a scheme that is not linked to other jurisdictions' permit schemes or offset schemes, a price floor can be implemented by way of a reserve price at auction of permits, which acts to reduce the amount of permits sold into the market, thus retaining the value of existing permits at that level. Implementation is more complex if the aim is to simultaneously import lower-cost international emissions units, but this is unlikely to be relevant in the case of Chinese regional pilot schemes.

A *price ceiling* protects emitters from overly high carbon prices. It is implemented by issuing additional permits at a predetermined threshold price. Upholding a 'hard' price ceiling requires issuing a potentially unlimited amount of extra permits if demand for permits drives the market price to the ceiling. This is how a price ceiling is usually conceived or implemented. The effect is the same as that of a compliance penalty, where emitters are charged a fixed penalty for every unit of emissions that they do not cover with a permit.

It is also possible to implement a 'soft' price ceiling, by issuing a limited number of additional permits at a given threshold price, and let the price rise further if demand is still not satisfied. It is possible to define several steps of price ceilings, with specific amounts of additional permits issued as the price reaches each step. This concept is found in the US Waxman-Markey draft legislation (which was not passed by the US Congress), where it took the shape of an 'allowance reserve', a share of permits set aside from normal permit release and held in reserve to be released if the market price reached a certain level.

International practice

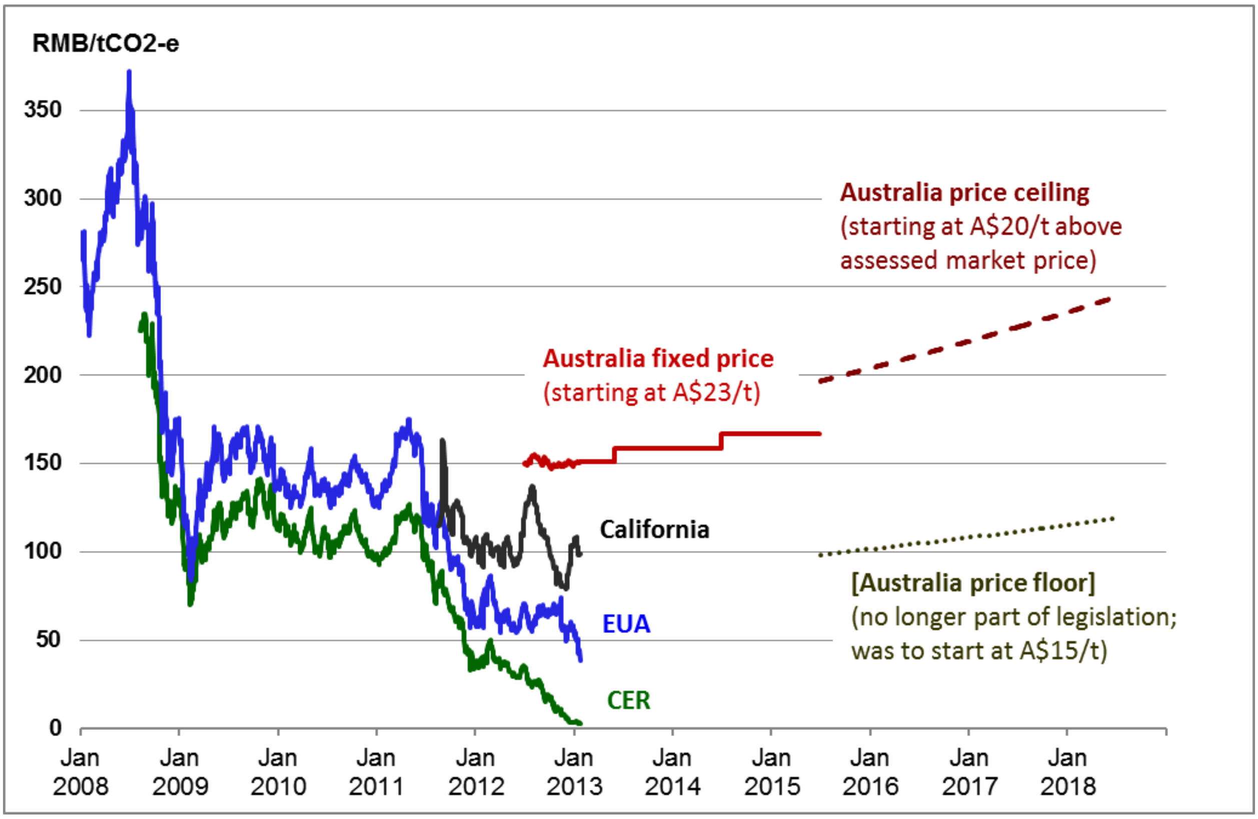
Australia's carbon pricing mechanism was originally legislated to have both a price floor and a price ceiling, during a three-year period after the end of the fixed price (2015 to 2018). The rationale for the price floor is to foster confidence for low-carbon investments and to achieve a minimum level of domestic effort, in the context of open access to international markets for CDM offset credits traded at very low levels (Jotzo and Hatfield-Dodds, 2011). Government proposed to implement the price floor through a variable top-up fee on the use of international emissions units, to bring the effective cost of using low-cost international units up to the floor price scheme (Australian Government, 2012).

The price floor has been replaced with a binding quantitative limit on the use of CDM credits (up to 12.5% of the permit liability of any liable entity), and provisions for linking the Australian scheme with the EU ETS. There is to be one-way linking (Australian emitters allowed to use EU permits) from mid-2015, and two-way linking from 2018.

The rationale for the price ceiling is to eliminate the risk to emitters of unaffordable prices. The price ceiling remains in the Australian scheme, but is thought to be unlikely to apply. The ceiling price is to start at A$20/t above the expected international price for 2015, and rise by 5% real per year.

Carbon price levels in the Australian scheme, compared to EU permit prices, CDM credit prices and Californian ETS prices, are shown in Figure 3.

Figure 3 Carbon market prices and Australia's system of managed prices



All prices are in nominal RMB. EUA: EU Emissions Allowances for Dec 2012 delivery (2008-11) and Dec 2013 delivery (2012-13). CER: Certified Emissions Reductions for Dec 2012 delivery (2008-11) and Dec 2013 delivery (2012-13). Price data from PointCarbon. Last data point is 23 January 2013. Historical exchange rate data from Deutsche Bank and Reserve Bank of Australia, assuming 0.1526 A$/RMB for all future dates. Price ceiling assumes an assessed market price of A$10/tCO2 in mid-2015, thus price ceiling starts at A$30/t; rising at 7.5% nominal per year (5% real, assuming 2.5% inflation). Price floor was to start at A$15/t and is shown here rising at 6.5% nominal per year (4% real, assuming 2.5% inflation). The price floor was removed from Australia's Clean Energy Future legislation and replaced with a quantitative limit on CERs and linking to the EU ETS.

4.5 Price targeting through variable permit supply

The various options for price control discussed above all effectively override predetermined cap on the supply of permits into the market, depending on the permit price:

- a fully flexible amount of permits in the case of a fixed price,
- fewer permits than the cap to uphold a price floor (unless there are imports of emissions reductions units, in which case the price floor reduces import levels), and
- more permits than under the cap to implement a price ceiling.

Considering hybrid approaches from the starting point of the cap leads to the possibility of price stabilisation by way of adjusting the effective permit cap if prices are unexpectedly high or low (Newell et al., 2005). Rather than determining hard limits for the permit price, a scheme could define an indicative cap for emissions as well as a target price range. The actual supply of permits issued into the market could then be flexibly increased or decreased, in order to keep the price within (or close to) the targeted price range.

Such a system could be implemented using one of two basic approaches:

- a rules-based system of permit supply, where the amount of permits issued for a particular period is increased from the default if the price is higher than some threshold level, and fewer permits are issued if the price is lower than desired; or
- a target price range could be published, and a dedicated (ideally independent) body makes the permit supply decisions in such a way as to target a permit price in the published range. This is the 'carbon central bank' model, similar to inflation targeting by varying money supply as practiced by existing central banks.

International practice

The European Union has been considering measures to delay the issuance of a share of permits slated for release in future years ('set-aside' of permits), thus deviating from the pre-announced EU ETS cap and trajectory. The rationale is to increase the EU permit price, which has plummeted in response to a dimmer economic growth outlook. If implemented, this would amount to varying the cap in response to observed prices.

In Australia, legislation provides for the possibility that the national emissions target for the year 2020 may be changed at a future point in time, and with it the scheme cap in the emissions trading scheme. The Australian Climate Change Authority is to make recommendations to future governments on such adjustments.

4.6 Considerations for China on price management

For a Chinese national ETS, letting the market price float in line with other international markets and long-term price expectations could be desirable in the longer term. This would ensure minimization of divergences in carbon prices, improving the cost-effectiveness of global abatement, and minimizing any distortions in international competitiveness of emissions-intensive industries.

However during the early phases of a national ETS, there is likely to be significant uncertainty over the relationship between emissions caps and permit prices, and potentially high permit price variability. At the same time, opportunities for linking with other countries' schemes could be limited during the early phases of a Chinese trading scheme. This may make it desirable to implement price management mechanisms to retain the carbon price within a "comfort zone".

Carbon price management may be needed as an essential feature of Chinese carbon trading schemes, in particular during the start-up phase, and in pilot trading schemes.

Suitable options for China to achieve these goals is could be (1) a form of hybrid emissions pricing scheme, either by way of a price collar (price floor and ceiling), or by way of flexible supply of permits aimed to keep the price in a pre-defined range; or (2) starting out with a fixed price scheme and shifting to emissions trading if and when conditions are right.

It is possible to shift over time between the different modes of managed and non-managed emissions trading. For example, it may be suitable to start a national scheme as a fixed price permit scheme, in order to provide initial price certainty and gain extra time to develop the necessary systems for nation-wide permit trading. This could then be transformed into a trading scheme with a price floor and price ceiling or trading with variable permit supply. Over time, it may be desirable to gradually phase out the price control elements, for example by widening the price range. Integration in international permit markets may be desirable over time, once markets in other countries have matured and policy uncertainties that currently bedevil schemes in Australia as well as Europe are resolved.

An alternative phased approach would be to start out with a fixed price scheme, and at an appropriate point in time to move directly to fully floating pricing, possibly including trading with international markets when the preconditions are established in other countries.

Price controls may be particularly relevant for China's pilot carbon market schemes and a possible national emissions trading scheme, because the market price is especially difficult to predict for a number of reasons.

- Economic growth tends to be variable both in its speed and its sectoral composition, making it impossible to reliably forecast a 'business-as-usual' emissions trajectory. In turn, it is not possible to reliably quantify the emissions reduction task inherent in any given emissions target.
- The cost of achieving abatement using a market-based scheme in China is not yet known. Together with the uncertainty about the abatement task, this translates into significant uncertainty about the cost of achieving any given emissions target, and about

the price in a carbon market.

- The price uncertainty is especially strong in new schemes such as the proposed pilot trading schemes, because of a lack of market information; because predictability at the city and province level is likely to be more limited than for China overall; and because of limited information about future policy settings; and because of the possibility of expectations that the duration of the initial phase of the schemes could be limited.
- If the ambition inherent in targets were relatively limited in the initial stages, and if future price expectations are not reflected in early stage prices, then there is a distinct possibility that actual emissions could be lower than the target even with a zero carbon price, as happened in the first phase of the EU ETS. This would make the carbon market inoperative and send a negative signal about its future operation.

On the other hand, if the price is capped, this implies exceeding the emissions cap, with flow-on effects on the national emissions target. This in turn may require stronger mitigation policies in non-covered sectors, and/or purchases of international emissions units. To the extent that either option takes place at higher marginal costs than the regulated emissions price, this may lead to higher overall costs than if the price was free to adjust.

Research needs

Quantitative modelling is needed of the effect that various levels of minimum and maximum prices under a Chinese ETS may have on emissions levels. This is in order to be able to inform decisions about permit price ranges that are likely to allow meeting China's emissions target range of a 40 to 45% reduction in emissions intensity. Research methods are closely related to those for modelling of emissions caps, discussed in Section 5. They comprise CGE modelling, partial sector specific models and projections, and regression-based analysis.

In addition, surveys of experts and potential market participants ahead of the introduction of pilot schemes or a national scheme could be useful in gauging market expectations (Jotzo et al., 2012).

5 Permit allocation and revenue use

Key messages:

- *The decision about permit allocation is separate from the decision about an overall cap for an emissions trading scheme.*
- *Carbon pricing can provide a source of revenue for government, which can be used to channel revenue to assist households with any additional costs, to finance other government spending including support for innovation in low-emissions goods, services and processes, or to lower other taxes. Carbon pricing can be fiscal policy reform.*
- *While schemes such as the EU ETS have started out allocating most permits for free to emitters, it will usually be a better option to allocate only a share of permits for free, on the basis of clearly defined rules and where there are good economic reasons for free allocation. The Australian carbon pricing scheme is an example of this approach, as is the third phase of the EU ETS.*
- *Assistance to industry should be provided in a way that does not compromise incentives to reduce emissions. The choice between lump-sum allocation of free permits and output-based allocation needs to be considered carefully. Assistance arrangement should be carefully calibrated, regularly reviewed, and phased out over time wherever appropriate.*

5.1 Revenue from carbon pricing

From an analytic perspective, the question whether and to what extent to allocate carbon revenue back to emitters depends primarily on whether emitters can pass on their increased costs of production (arising from the carbon price) to their consumers. If they can fully pass on their extra costs, then there is no case for free permits, tax exemptions or cash refunds. On the other hand if producers cannot change their product prices at all – for example because they compete directly with producers that are not subject to carbon levies – then there can be a valid economic case for allocating permit revenue back to them (see below on options how to do this).

Existing carbon pricing schemes allocate an increasing share of overall revenue to these purposes, rather than returning the money to emitters. The Australian scheme allocates about half of initial scheme revenue to industry, with the share expected to shrink in future years. The EU is shifting from predominantly free allocation of permits (Phases I and II, 2005 to 2012) to a greater role of auctioning and retaining revenue for member state governments, with around 40% of permits expected to be auctioned in 2013, the first year of Phase III of the EU ETS.

Revenue use

To the extent that net revenue is generated for government (rather than returning revenue to emitters) this can be used in a variety of ways. One classification of the options is the following:

- Finance other climate change mitigation programs;
- return carbon revenue to households, including through tax reform;
- use revenue towards the general government budget (no earmarking).

The first option (earmarking for climate change programs, such as subsidies for renewable energy or investments in highly energy efficient equipment) has clear attractions in terms of introducing carbon pricing as part of a package of policies, which overall may be able to be kept revenue neutral. However, it may create fiscal distortions, and unnecessarily link otherwise unrelated policies. For example, if carbon pricing was to be removed or the price to fall, this could cause financing deficits for other programs that are meant to be continued.

The second option (revenue distribution to households) may be called for from an equity perspective, if carbon pricing results in higher prices for energy and goods. In that case, consumers foot the ultimate bill for the economic costs of the carbon emissions policy, and there is a case to compensate them for the increased cost of living.

There are typically prominent distributional considerations as well. Governments usually will want to shelter the poor, as well as low to middle income earners from adverse impacts on their standard of living. Depending on available fiscal instruments, targeted assistance can be provided through taxation, welfare payments or possibly regulated prices for some commodities or services.

The third option (carbon revenue to general budget) is in line with what is generally seen as best fiscal practice. It treats carbon pricing as another source of government revenue, with any decisions about how to use the revenue completely separate. This allows, in principle, to achieve the most efficient or societally optimal use of the carbon pricing revenue. It seems plausible that over time, carbon pricing will be treated as part of the overall fiscal revenue mix.

International practice: Australia's tax reform for household assistance

The Australian scheme is the first large carbon pricing mechanism where a substantial share of the gross revenue is re-allocated to households with the explicit aim of offsetting increased cost of living for lower-income households.

Roughly half of the value of the permits will be given to industry as assistance, and half to households particularly in the lower to middle income range, during the first few years of the phase (Australian Government, 2011a).

Around A$5 billion per year (on average over the first three years) will be returned to households in the form of lower income taxes and higher welfare payments. Just under half of the household assistance is delivered through increased welfare payments, for example to the elderly without other sources of income, and those who cannot participate in the workforce, and the unemployed, and just over half through changes to the income tax system. As a result, the majority of lower income households will be overcompensated for the increase in living costs that they will experience, even if they do not change their consumption patterns. Households in higher income brackets will bear most of the net costs, as their tax reductions will typically be smaller than their additional costs of living. Targeting household assistance at lower income groups directly tackles the most widespread concern about the scheme, namely increases in the costs of electricity.

For low to middle income earners, there will be a slight increase in the real wage (nominal wage divided by price levels) as the reduction in income taxes outweighs the inflationary effect of the carbon price. This is expected to have positive effects on workforce participation, and thereby offset some of the economic costs of the policy overall (Australian Government, 2011c; Phillips, 2012). In particular, part-time employees in low-wage jobs may find it more attractive to offer their services in the workforce.

Conversely, if household assistance had been provided in the form of lump-sum payments rather than tax cuts, the incentive effect from tax reform would have been lost. In that case, the increased price level in the economy would have led to a decrease in the real wage (even if people would be kept equally well off through assistance payments). Industry also receives substantial payments, discussed in the following Section.

5.2 Free permit allocation and industry assistance

Early indications are that most Chinese pilot schemes are planning to allocate most or even all of the carbon permit revenue back to emitters (Appendix Table 2). This would typically take the form of giving emissions permits for free to emitters. It can equivalently be done by selling or auctioning all permits, and in return making cash payments to emitters.

For traded products, industry assistance can be understood in the context of limited degree of cost-pass through in markets, because there is competition with producers in cities and provinces that do not impose carbon levies. Provincial or pilot city governments may want to limit or avoid any disadvantage in production costs arising from the carbon pricing scheme relative to producers outside of the boundaries of the scheme. On the other hand, the extent of 'carbon leakage' from pilot schemes is likely to be very limited because of the expected transient nature of differential carbon pricing between Provinces and cities.

For electricity generators, this can be understood in the context of existing state-controlled pricing systems that may not allow generators to raise their prices even if they face additional costs. For carbon payments for indirect emissions in electricity, the justification for free permits can be lesser. For example in the building sector, owners of buildings liable for carbon payments for electricity may be able to pass the increased cost on in the form of higher rents.

Grandfathering or lump-sum payments

Carbon revenue can be returned to emitters by way of free permits or cash payments on the basis of historical emissions levels or any other basis that is not linked to emissions or output during the period of the carbon pricing scheme. It provides full incentives for liable entities to reduce emissions, both by reducing emissions intensity and potentially by reducing output. This is because every tonne of emissions reduced means a reduction in production costs equal to the carbon price, while the amount of free permits (or cash assistance) remains the same.

For full effectiveness of the incentives, it requires that payments (or free permits) are allocated even if companies or installations close down, otherwise some highly emissions intensive facilities might continue operating only because of the payments that are received. Provisions need to be made for free permits or payments to new entrants to an industry, in order not to disadvantage them relative to existing emitters.

This model is suitable for industries that can pass their carbon costs on to customers in the form of higher prices. This is typically the case for domestic industries that operate in competitive markets.

However, it must be noted that in these industries, payments will usually not be necessary for economic efficiency, because the industry as a whole does not become less competitive or profitable. Payments will typically be made only for political or distributional reasons, essentially to compensate the owners of carbon intensive assets. If large amounts of free permits are distributed for free, this can lead to windfall profits, as was the case in the first two phases of the EU ETS.

A specific form of 'historical' permit allocation that is to be avoided is to link the amount of free permits given in a future year to the level of emissions or production of a facility during a previous year *after* the announcement or start of the scheme. An example is giving out free permits during 2014 amounting to *x*% of actual emissions during 2013. While this may seem in line with the logic of gradual year-to-year emissions reductions, in fact it negates the incentive to reduce emissions. If a company knows that their amount of free permits in 2014 depends directly on the level of emissions in 2013, then they have no incentive to reduce emissions in 2013, because any savings in permit costs during 2013 would be outweighed be getting a smaller allocation in 2014.

To preserve incentives to reduce emissions is important to avoid linking assistance payments or free permits to the level of actual emissions. No major existing carbon pricing scheme provides assistance in this manner. However proposals for assistance to energy users (especially households) are sometimes framed in this way, for example using carbon revenue to subsidise electricity prices for private users back down to the level that would prevail without a carbon price. This would mean that energy consumers have no financial benefit from reducing energy use.

Output-based allocation

Output-based allocation is an option where free permits or payments are linked to the amount of output of a specific product or activity level in a specific process. It provides incentives to reduce emissions intensity of an activity, because the amount of free permits is only dependent on the amount of output, not the amount of emissions; but it provides reduced or no incentives to reduce output. Payments to trade-exposed emissions-intensive industries under the EU ETS (Phase 3) and in Australia use output-based allocation of free permits.

Output-based allocation is suitable in situations where industries cannot pass their increased costs through to the customers, and governments want to counteract changes in competitiveness due to carbon pricing. It retains supply-side incentives to shift to more efficient equipment, lower-emissions processes and lower-carbon energy sources. This is typically the desired result in industries where companies cannot reflect their carbon costs in higher product prices, because they compete with producers in other jurisdictions that do not face comparable constraints or penalties on emissions. Such a system gives an advantage to installations that have relatively high efficiency, and puts low efficiency producers at a disadvantage. It does not, however, discourage the production of the goods in question (or discourages it only to the extent that less than 100% of emissions are covered by free permits).

Benchmarking

In practice, output-based allocation is usually best implemented by way of benchmarks for the output of specific industrial products or specific industrial production activities. For example, *x* free permits may be allocated for each tonne of a particular type of steel produced, where *x* is benchmarked to the average emissions intensity for that production, or to best practice in an industry.

In the EU ETS, the benchmark is calibrated to the 90th percentile of producers ranked by efficiency. In the Australian scheme, benchmarks are calibrated to the industry-wide average emissions intensity of production, and free permits are then allocated for a defined share of the benchmark (94.5% for the most emissions intensive activities, 66% for some other categories of production; both assistance rates are reduced by 1.3% each year). For optimum operation, a fine-grained activity level, rather than output of broad product categories, needs to be used as a basis for allocating free permits.

Table 2 Models of allocating free permits to emitters

	Grandfathering or lump-sum allocations/payments	***Output-based allocation***
Basis for allocating free permits (or cash assistance payments)	Linked to past emissions or output, or determined on any other basis. May be in form of free permits or cash.	Linked to production levels during the period of the scheme, usually defined as benchmark for an industrial activity
Link to levels of activity during the emissions trading scheme	No link to contemporaneous emissions or output	No link to contemporaneous emissions but link to output
Payments made even if business closes	Yes (if not, then incentives to reduce emissions are distorted)	No
Treatment of new entrants	Needs to be defined separately	Same treatment as existing emitters in same industry
Incentive effect of carbon price	Full incentives to reduce emissions intensity and to reduce output (provided payments made also if facilities close down)	Incentives to reduce emissions intensity, but incentives to reduce output are reduced or eliminated (depending on the rate of assistance)
Examples of applications	Australia's power sector, EU Phase I and II	Australian and EU Phase III assistance for trade-exposed emissions intensive industries
Caveats on application	Payments will usually not be necessary for economic efficiency, only for political or distributional reasons. High amounts of free permits can lead to windfall profits. Sunset clauses are	High rates of free permits can lead to windfall profits (subsidisation of output), and incentives to expand production above efficient levels. Allocations should be reviewed over

	useful.	time.

If rates of free permits given out for each unit of product output (benchmarks) are set at high levels, this can lead to a situation where a producer receives a greater amount of permits for each unit of output of an emissions intensive good than required to cover actual emissions. This amounts to a subsidy to output, giving distortionary incentives to expand production beyond the efficient level. This will have the opposite effect of that desired, namely to increase emissions.

Overly large allocations of free permits can also result in windfall profits. It has been documented that a number of energy intensive industries in the EU significantly increased their profits as a result of getting permits for free amounting to, on average, nearly the full amount of emissions in preceding years.

Border tax adjustments

An alternative to output-based allocation is *border tax adjustments*. Under this model, exports of emissions intensive goods receive a rebate for the carbon costs, and imports for are subject to a levy on the embodied carbon emissions. There is then no need for allocating free permits or making payments based on production. Border tax adjustments can be seen as a theoretically appealing solution to the issue of differential carbon pricing between different jurisdictions, but would typically be difficult to implement both for legal and political reasons, and for practical reasons such as the need to estimate the embodied carbon emissions in imported goods.

A considerable potential problem with border tax adjustment is that they are likely to be even more prone to capture by interest groups than free permits. They could easily be used for protectionist purposes. Even if implemented solely for the purpose of correcting for differentials in carbon costs between countries, there could still be the appearance of discriminatory trade policies justified by environmental policy.

Furthermore, nations may decide against using border tax adjustments because they can be seen as a protectionist measure, and might risk that trading partners implement trade restrictions that go beyond compensating for carbon pricing related changes in competitiveness. This is likely to be a particular concern in China which is heavily engaged in international trading of manufactured goods.

International practice: Australia

In Australia, emissions intensive trade-exposed activities (such as steel making, aluminium smelting and others) will get free permits, benchmarked by product category and linked to levels of output. Benchmarks and outputs are defined at the level of specific industrial activities rather than companies or industries.

The aim is to compensate companies operating in international product markets for losses in competitiveness, while giving these companies incentives for improving efficiency. Free permits are provided for 94.5% of the industry benchmark emissions for high emissions intensive activities, and for 66% of benchmark emissions for some other activities. These rates are to be reduced by 1.3% per year. The arrangements are also subject to periodic review, with Australia's Productivity Commission charged with analysing and reporting whether assistance is needed in light of policy settings in other countries and market conditions.

The empirical case for shielding trade-exposed industries in Australia has been found to be limited (Australian Government, 2008; Clarke and Waschik, 2012; Garnaut, 2008).

Cash and free permits will also flow to the most emissions-intensive coal fired power stations (A$5.5 billion over five years) and coal mines (A$1.3 billion over six years). The cash payments to generators have been criticised for not having an economic basis because there is no threat of carbon leakage to other countries, and for providing financial transfers from consumers to the assets of the most carbon intensive electricity generators. The power sector in Australia can pass through carbon costs to consumers.

International practice: EU

The EU ETS started out with a system of grandfathering almost all permits to existing emitters. Almost all permits were given out for free by EU member states to their emitters during the years 2005-12, which resulted in windfall profits in a range of industries (Sijm et al., 2006).

Starting with Phase III in 2013, a significant share of permits will be auctioned rather than be given away for free. Emissions-intensive trade-exposed activities will get free permits based on output and with activity-specific benchmarks. The power sector in most countries will no longer get free permits. This change will allow member states to retain some of the carbon revenue for their general budgets.

5.3 Considerations for China on revenue use and permit allocation

In establishing ETS, Chinese governments ought to carefully consider the need to provide assistance in the form of free permits to industry, and the alternative of using revenue to assist households or to use revenue from carbon pricing to pay for other programs. Allocating too large a share of permits for free to industry has opportunity costs.

China has a larger influence on world prices of traded energy intensive goods than most other countries, and so the concern about lack of price pass-through in international markets is a lesser one.

Chinese governments may be able to retain a significant and growing share of permit revenue for purposes such as paying for other climate change policy measures and assisting households through tax relief and welfare payments. In the longer term, carbon pricing can be seen as part and parcel of fiscal policy reform.

Where free permits or other forms of assistance are given to industry, the modalities for this should be carefully designed to preserve incentives to reduce emissions. Assistance arrangements should be regularly reviewed, with an expectation to reduce the extent of industry assistance over time.

Research needs

To inform allocation decisions, firstly qualitative analysis is needed of the in-principle issues facing different industries in China – for example to what extent is it expected that there will be price pass-through to end users that will allow emitters to recoup carbon costs, what if any is the risk of inefficient relocation of industry (carbon leakage), and where assistance payments are necessary, what design will achieve efficient outcomes.

Secondly, detailed quantitative modelling is needed to understand the likely nature and magnitudes of distributional impacts on different industries and different types of households. The modelling undertaken by the Australian Treasury, consisting of a detailed domestic CGE model coupled with household expenditure models, can be a guide to such a modelling effort. In addition, modelling using sector specific partial equilibrium models will be useful, in particular for the electricity sector.

International experience suggests that assistance arrangements including permit allocation could become the area that is most hotly contested in domestic policy formulation. Reliable analysis is needed to facilitate good policy design.

6 Carbon pricing for China's electricity sector

Key messages:

- *The electricity sector should be included in order to maximise opportunities for cost-effective emissions reductions. All major carbon pricing schemes include the power sector through permit liability on electricity generation.*
- *Ideally, carbon pricing is needed both for the supply-side (direct emissions) and demand-side (indirect emissions) in the electricity sector, at the same emissions price.*
- *If there is full cost pass-through in the power sector, then a carbon price on generators achieves both incentives on the supply and demand side. In China this will require energy pricing reform, which would be usefully pursued in parallel with the introduction of carbon pricing.*
- *If power prices are fixed and electricity generation is covered by a carbon price, then generators may need financial assistance. Models for free allocation of permits need to be carefully calibrated to avoid compromising incentives for operations of existing power plants and new investments, and to avoid introducing distortions.*
- *Introducing emissions pricing to China's power sector could help accelerate broader market reform, which in itself could yield large economic benefits through more efficient allocation of resources.*

Electricity production accounts for around half of China's total energy related CO_2 emissions (IEA, 2012), and therefore needs to be included if broad coverage of total emissions and abatement opportunities under carbon pricing is to be achieved. To achieve a full and efficient abatement response, a carbon price signal needs to apply both in electricity generation (supply side) and electricity use (demand side).

A fundamental difficulty for carbon pricing in China's electricity sector is that electricity supply prices are fixed. This means that changes in cost structures for generators are not automatically passed through the system to be reflected in higher prices for electricity, as they are in competitive electricity markets; and that without reform of electricity pricing systems, there is no carbon price signal on the demand side (Howes and Dobes, 2010).

Furthermore, electricity supply side decisions, such as the merit order of supply from individual power stations, are to an extent regulated, which dampens or eliminates the incentive effect of a carbon price to shift supply within the existing fleet of power stations to lower-emissions stations.

The in-principle solution to these obstacles is energy sector reform, with deregulated power pricing and removal of direct regulatory measures for electricity supply. Such reform would ensure that carbon pricing is fully cost effective, and could also harness efficiencies in the energy sector itself.

Ahead of comprehensive energy sector reform, carbon markets and other policy settings may be able to be designed in such a way that they partially compensate for the existing strictures. There are ways to design ETS and adjust regulatory settings that are likely to provide effective incentives for emissions reductions in power supply and demand, while leaving intact the overall operation of the power sector, and related policy objectives.

6.1 Supply-side carbon pricing in the electricity sector

Electricity supply decisions could ultimately be a larger source of emissions savings than the demand side. Analysis for Australia, where coal fired power has a similarly dominant position as in China, has indicated that changes in the sources of power supply are by far the largest source of emissions reductions that a carbon price would trigger over the medium to longer term. Reductions in power demand relative to the baseline would make the relatively larger contributions in the short term, but at much lower levels than the later supply-side reductions. Similar findings have been established for China (Jiang et al 2013).

Early application of carbon pricing in electricity supply is essential for a longer term effective and efficient carbon pricing policy. This is because any additional power sector investment that does not take into account carbon costs represents a sunk cost to the economy a long-term lock-in to higher than efficient carbon emissions.

An effective response to carbon pricing in the power sector entails three aspects:

- A change in investment, with relatively greater investment in lower emissions plants and relatively less investment in new higher-emissions plants. Again, the carbon price would favour lower-emissions options both in the choice between power plants using different fuels and technologies, and in the choice of technology and efficiency of equipment within a class of power station (in particular, favouring higher efficiency coal combustion technologies).

- A change in the dispatch of electricity, with lower-emissions plants moving higher up the merit order, and annual operating hours increasing for low-emissions plants and decreasing for higher-emissions plants. The cost increase is greatest for the highest emitting plants, making them a less financially attractive supply option. Where wholesale power prices are set in spot markets, higher-emissions plants will only be dispatched at times of elevated power demand when the wholesale price rises sufficiently to cover the operating costs, including carbon costs. This change in merit order applies both to the choice of plants of different technologies (eg coal, gas, nuclear or hydropower; renewable energy sources without storage such as solar and wind power will supply into the grid whenever they can produce power), as well as within technologies (eg higher efficiency vs lower efficiency coal fired plants).
- A reduction in electricity demand, through as end users face higher electricity prices.

In a system of fixed power prices and regulated (or partly regulated) power dispatch, as is the case in China, the first hurdle to overcome is existing regulations that result in a dispatch order that does not reflect carbon costs.

This could be achieved by imposing a carbon price and abolishinging dispatch regulation, or at least opening regulation up to the extent that supply decisions can be made partially as a result of the carbon price signal.

If dispatch regulation is retained, it could be changed to mimic the effects of a carbon price on the merit order of power stations – that is dispatching lower-emissions plants first, to the extent that their imputed carbon price advantage makes them the lower cost option. This would not in fact require the imposition of a carbon price on the generators, but would require regulations that act “as if” a carbon price was in place.

Imposing a carbon price on generators without raising electricity supply prices means that the profitability of fossil fuel based generators will decrease (or their losses increase) broadly in line with their carbon intensity, and the profitability of the power sector overall decreases by the extent of the overall cost of the emissions liability. In deregulated, competitive power markets, no loss in overall profitability of the industry occurs, as the carbon costs will be recouped from consumers through higher power prices. However the relative profitability of different technologies will be changed, giving the desired incentive effects both for dispatch and investment.

Carbon pricing with fixed power prices

Under a system of fixed power prices, as currently exists in China, the economic viability of power generating assets can be maintained by increasing regulated power prices, or by allocating free permits to generators based on the amount of power they produce. A mixed approach would also be possible.

The first option is to require generators to buy emissions permits and to increase power supply prices, so that the overall increase in revenue is equal to the total cost of emissions permits used by the power sector. No free permits need to be given to generators, and the revenue from permit sales is available to government. Nevertheless, the generating industry as a whole would be kept roughly profit neutral.

This approach covers both the supply and demand side, through the carbon price and the increase in power prices respectively. A potentially important difference to a fully market-based system is that the average power price applies at all times of the year (unless regulation differs), which is likely to introduce some distortions to the merit order with regard to emissions intensity. Furthermore, implementation may be possible only as an approximation: in an ETS with a floating price it will not be possible to exactly match the increase in power prices to the cost of permits, and frequent re-calibration of the regulated power price may be undesirable. Of course, the increase in power prices itself may be politically undesirable, but would be necessary to achieve an effective overall mitigation response.

If power prices were to remain unchanged and carbon pricing for generators introduced, and if there was a valid concern about generators' profitability, then free allocation of emissions permits to generators may need to be considered.

One option is to allocate lump sum amounts of free permits, allowing differential treatment of different power producers (IEA and ERI, 2012). This was done for example in Australia, giving lump sum payments to only the most emissions intensive power generating plants. Although described in terms of securing energy supply, this can be seen as a negotiated settlement with influential asset owners, arising out of political necessity.

A major difficulty with the lump sum approach is the treatment of new entrants. A number of permits can be set aside for new installations. However it is difficult to anticipate how many new generators of what type will come on stream, especially in a fast growing power sector like China's. Hence the new entrants' reserve may need to be very large, or the rules may need to be changed along the way if there is a risk that not enough permits are available; both options have obvious drawbacks.

An alternative is output-based allocations: each generator gets issued a defined number of permits for each unit of power produced. In this model, for full effectiveness it is important to include all generators under the permit liability, and provide free permits equally to all producers – even nuclear and renewable plants which will sell their permits to other emitters.

Output-based allocation of free permits provides the electricity generating industry as a whole with full incentives to reduce emissions intensity of electricity supply. It provides the correct incentives for the dispatch order, because lower emissions plants have lower carbon costs while getting the same amount of permits for free; and also for investments, as lower emissions plants will be relatively more profitable. Furthermore under this method, there is no artificial discrimination between different technologies, individual generators, or between existing plants and new entrants, as is inevitably the case with other methods of free allocation.

However, if using output-based allocation with a common benchmark across all technologies, it may be that in order to achieve levels of assistance payments that are deemed adequate for highly emissions intensive generators, overly large amounts of free permits would have to be allocated across the power sector as a whole.

6.2 Demand-side carbon pricing (coverage of indirect emissions)

The demand side of the power sector can be included through separate coverage with a carbon price of electricity users. Carbon pricing on "indirect emissions", that is emissions embodied in electricity, could be a complement to demand-side carbon pricing that does not by itself raise power prices. If a carbon price is established separately on the electricity supply and demand side, then in order to promote cost effectiveness, the carbon price in both should be the same, ideally by allowing permits to be tradable between both (Li and Zhang, 2012).

Alternatively, it could be a way to support energy efficiency in end use even if there is no effective carbon pricing on power supply. Most of China's pilot schemes are planning to put a carbon price on electricity use.

Upstream vs downstream coverage

Indirect emissions from electricity use could be covered in an ETS through either upstream coverage, imposing a carbon levy on all electricity sales within the pilot scheme, or placing distributors of electricity under a permit liability; or by downstream coverage, imposing a permit liability on large users of electricity within the scheme.

In either case, an average emissions factor (eg in tCO2 per Mwh) would be applied to all electricity sales or use. This could be calibrated to be in line with the average carbon intensity of electricity supply.

Under upstream coverage, all indirect emissions from electricity use within a pilot scheme could be covered. At its simplest, this could take the form of a carbon levy on all electricity sales. This however would not achieve the objectives of deepening the carbon market and creating experiences in trading permits.

The alternative for achieving upstream coverage is to place a permit liability on electricity distributors, equal to the amount of emissions inherent in the electricity they sell to their consumers. Under this model there would typically be only a small number of liable entities, but all forms of electricity use would be covered. From the point of view of cost-effectiveness and broad inclusion, this may be the preferable option. However, it would require that power distributors were allowed to raise supply prices to cover their carbon costs.

Under downstream coverage, a permit liability would be placed on large users of electricity. This can only cover a share of indirect electricity emissions, as small electricity users would be excluded. Depending on the cut-off point for inclusion in the scheme (which could for example be framed in terms of the amount of electricity used per year, or the inherent carbon emissions liability), there will either be a relatively small number of liable entities and relatively smaller coverage, or a larger number and larger share. Transaction costs increase with the number of entities covered, and for small facilities may outweigh efficiency gains. There will be distortions in incentives, as only 'large' facilities are covered and have the additional incentive to reduce their electricity use.

Table 3 Upstream and downstream coverage of indirect electricity emissions

	Upstream coverage	*Downstream coverage*
Implementation	Electricity distributors under permit liability, or levy on electricity sales	Large electricity users under permit liability
Coverage	100% of electricity use	Only a share of electricity use
Cost-effectiveness	Highly cost-effective: small number of direct participants, no distortions	Less cost-effective: large number of direct participants and consequently higher transaction costs, distortions because of partial coverage
Specific requirements	Letting electricity prices increase, either by allowing distributors to charge more, or through a levy on top of the mandated price	Participation of a large number of facilities in trading and permit allocation arrangements

The Tokyo metropolitan emissions trading scheme covers electricity use downstream, by including major electricity users with direct permit liability (Nishida and Hua, 2011). It started its mandatory phase in 2010 covering 1,300 facilities, of which 1,159 individual facilities reported emissions in its first year (970 commercial and service buildings and 189 large scale industrial facilities) which together account for 40% of total city commercial and industrial sector emissions. The scheme covers all facilities using more than 1,500 kiloliters of oil equivalent in their fuels, heat and electricity.

6.3 Special considerations for pilot schemes

A complicating factor for the pilot schemes is that they are linked into grids that are supplied in large part by electricity generators located outside of each scheme. All of the five pilot cities are net importers of electricity, Beijing being most import-dependent with an import share of more than two thirds (see Appendix Table 1).

To also achieve supply side incentives, firstly a permit liability would need to be placed on electricity generators within the scheme, in line with their actual emissions levels. This creates incentives to shift to cleaner fuels and higher efficiency power stations within the scheme.

However if this was implemented by itself and only within each scheme, then generators within the jurisdiction would be at a disadvantage compared to generators outside the scheme exporting electricity to within the scheme. Therefore, "imports" of electricity to the pilot scheme need to be subject to carbon pricing also.

Ideally, the carbon levy on imported electricity should also be calibrated to the emissions intensity of the plants generating the electricity. Thus, importers of electricity would need to pay higher carbon costs if they source electricity from high-emissions plants, and no carbon penalty for electricity from renewable or nuclear plants. They would thus prefer low-emissions sources of electricity.

However, differentiating by emissions intensity of plant would generally only be possible if power is supplied to within a pilot scheme from specific identifiable plants. It would not be possible if the power is drawn from a grid, without specific supply contracts, because it is then not possible to identify the sources of electricity supply. In that case, an average emissions factor could be applied to all electricity imports, for example calibrated to the average emissions intensity of power supplied to the grid.

The carbon liability would need to apply to the utilities that draw power from grid and distribute it, and to any large industrial users that may have direct arrangements for being supplied with electricity generated outside of the pilot scheme's jurisdiction.

6.4 Considerations for China

Including the electricity sector in China's ETS, especially in a future national scheme, is possibly the greatest challenge for market-based climate change mitigation in China. Inclusion of the power sector presents unusually complex challenges for mechanism design and policy implementation in the context of existing regulatory structures in the energy sector. It may also meet resistance from established economic interests. Nevertheless, inclusion is essential for the effective and cost-efficient operation of a carbon pricing scheme, and it is possible.

The overarching issue for the Chinese government to consider is a wholesale reform of the regulatory system governing the electricity sector, freeing up both power pricing and regulations for power dispatch. This is generally seen as a larger and longer term challenge than the introduction of a carbon price.

Carbon pricing can be made effective in the presence of regulated electricity prices. A promising option to consider on the supply side is full coverage of all power stations under an ETS, with permits allocated freely on the basis of the amount of electricity supplied.

If there is no increase in supply prices as a result of carbon pricing on the supply side – or if there is no supply side carbon pricing – then electricity use can nevertheless be included on the basis of "indirect emissions". The option considered by several pilot schemes is to include large users of electricity with a permit obligation. However, such a "downstream" model misses out on a large share of overall power use, unless a very large amount of very small users are included which would be overly costly and impractical.

Research needs

To inform policy decisions about carbon pricing in China's power sector, quantitative analysis is needed of system-wide responses to different modes of carbon prices and related changes in regulations.

For such modelling to be of maximum use, it will need to include a reasonable representation of regulatory and pricing policies in China's power sector. This in turn will require a model that goes well beyond the extent of detail that is represented in standard CGE models. Nevertheless, CGE analysis will be useful to gauge economic flow-on effects of changes in the power sector, including effects that emanate from changes in power prices and electricity sector investments.

In addition to the quantitative modelling, qualitative work is needed to thoroughly understand the effects that various possibly changes in power pricing and regulatory structures will have, by themselves and in combination with various forms of carbon pricing.

7 Conclusions

A national emissions trading scheme for China offers very large opportunities for cost-effective climate change mitigation. The anticipated adoption of market based policy instruments for emissions control is significant, in a fast-growing economy where climate change mitigation policy has been predominantly by command and control approaches, and where many aspects of energy pricing are heavily regulated. The introduction of carbon pricing could also be a catalyst for further market reform, in particular in China's energy and electricity sectors. China has the opportunity to move to world's best practice on carbon pricing. However it faces challenges due to the unique regulatory and institutional environment.

This paper examines a range of policy design issues for a national emissions trading scheme in China, drawing on economic principle and international experience particularly in Australia and the European Union. It finds that

- Broad coverage of carbon pricing can improve cost effectiveness. Not all emitters need to be included directly in emissions trading. Upstream permit liability and equivalent emissions charges or taxes may allow increasing coverage while minimising transaction costs and administrative complexity.
- Translating the national intensity target into an absolute cap on emissions permits presents special challenges because of China's dynamic growth. The framing of the national target in emissions intensity terms may require periodic adjustment of absolute caps in a trading scheme.
- A floating market price float in line with emissions markets in other countries could be desirable in the longer term. In the early phases of emissions trading however there is a strong case for price management. This could be achieved through a fixed price model, price floor and ceiling, or variable permit supply. If price controls are enacted, then a phased approach may be appropriate, possibly starting with a fixed price and moving to internationally integrated trading at an appropriate time.
- Provision of assistance to industry in the form of free permits to industry needs to be carefully calibrated, in view of the opportunity costs and risk of lock-in of assistance arrangements. Current international best practice is for governments to retain a substantial

share of the overall value of emissions permits to support households, reduce other taxes or finance other policy measures. Where free permits and other assistance is given to industry, the modalities should be carefully designed to preserve incentives to reduce emissions. Built-in provisions for review and phase-out of industry assistance are advisable.

- Establishing an effective carbon price in the electricity sector is possibly the greatest challenge for market-based climate change mitigation in China. It is necessary for an overall cost-effective response, but presents complex issues for mechanism design and policy implementation in the context of existing regulatory structures in the energy sector. There are ways to make carbon pricing at least partly effective ahead of comprehensive energy sector reform. Ultimately, however market-based energy pricing is needed. Introducing emissions pricing to the power sector could help foster broader market reform of the energy sector, which in itself could yield significant economic benefits.

In-depth qualitative and quantitative research will be needed over coming years. The payoffs from applied research in this area could be very large. If China succeeds in establishing an effective, efficient and robust emissions pricing scheme, this could have a strong demonstration effect for the world, and encourage other countries to emulate the experience.

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Appendix: Data and overview of pilot schemes

Statistics for pilot provinces and cities, 2010

	Population (million)	GDP (RMB billion)	GDP per capita (RMB 1000's)	Energy use (million tonnes SCE)	Energy use per capita (tonnes SCE/ person)	Carbon dioxide emission (million tonnes)	Emissions per capita (tCO2/person /year)	Emissions intensity (kgCO2/ RMB)	Electricit y use (Gwh)	Electricity imports (-) or exports (+) (Gwh)
Shenzhen SEZ	10	903	87	49	4.7	n.a.	n.a.	n.a.	69	-11
Beijing	20	1182	60	70	3.5	103	5.2	87	83	-56
Tianjin	13	781	60	68	5.3	134	10.3	172	68	-11
Shanghai	23	1556	68	112	4.9	211	9.2	136	130	-35
Chongqing	29	616	21	79	2.7	125	4.3	203	63	-14
Hubei	57	1250	22	151	2.6	320	5.6	256	142	60
Guangdong	104	4016	39	269	2.6	444	4.3	110	406	-86
China	1341	31234	23	3895	2.9	8146	6.1	261	4193	na
Pilot schemes combined	*256*	*10303*	*40*	*798*	*3.5*	*1337*	*5.2*	*130*	*960*	*-142*
Pilot schemes share of national total	*19%*	*33%*		*20%*		*16%*			*23%*	

Data source: State Information Centre, China Statistical Yearbooks; (Guan et al., 2012) for emissions data (emissions data are not published as part official Chinese statistics). SCE stand for standard coal equivalent. Author's calculations.

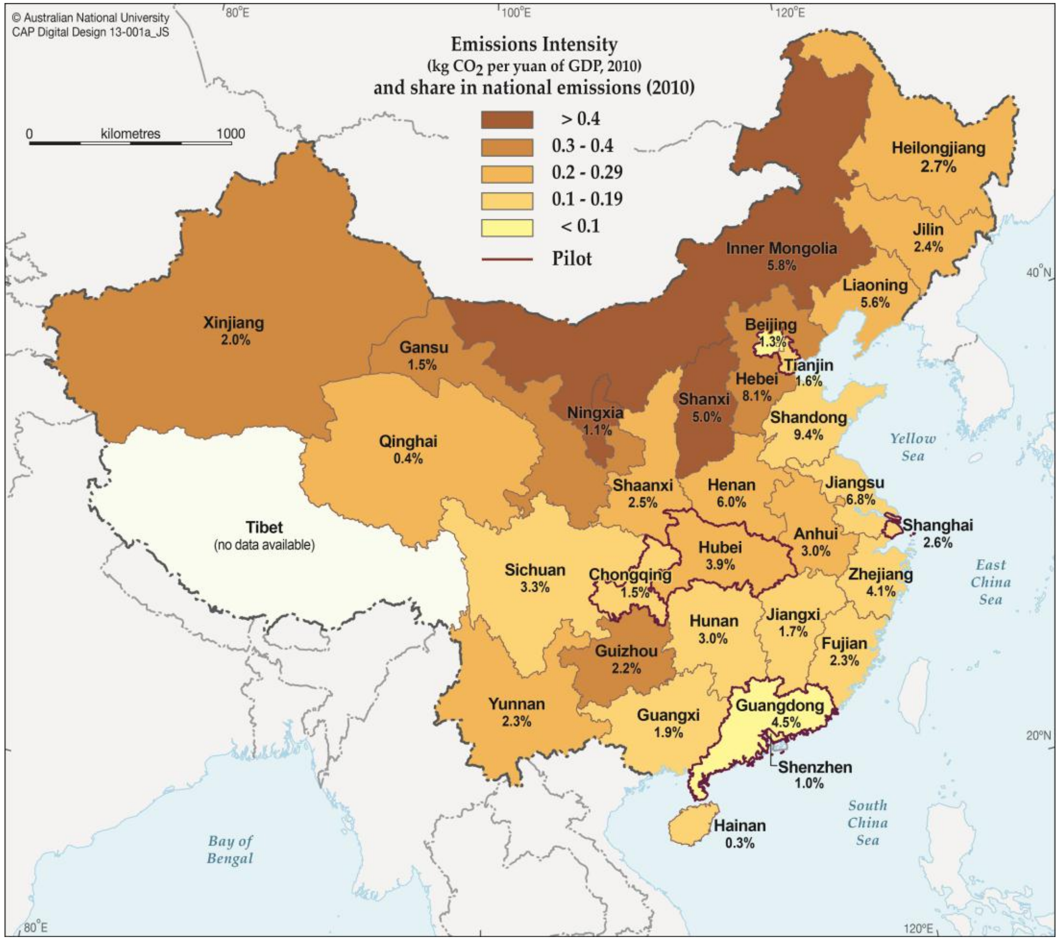
Overview of key features of pilot emissions trading schemes (as announced by mid-May 2013)

	Beijing	Tianjin	Shanghai	Hubei	Guangdong	Chongqing	Shenzhen
Threshold for inclusion	10,000 tonnes CO2 p/a. This threshold may change to 5,000 tonnes CO2 p.a. if more than 600 companies are chosen (in 41sectors).	20,000 tonnes CO2 p/a	20,000 tonnes for industrial sectors; 10,000 tonnes CO2 p/a for non-industrial sectors	120,000 tonnes CO2 p/a (60,000 tonnes p/a standard coal equivalent)	20,000 tonnes CO2 p/a	20,000 tonnes CO2 p/a for industrial sectors; 10,000 tonnes CO2 p/a for non-industrial sectors	20,000 tonnes CO2 p/a originally planned (100 of Shenzhen's largest companies) This threshold will be changed to below 10,000 tonnes CO2 p/a
Coverage	Initial plan was 420 – 600 companies, but from 2013 likely that coverage will be over 600 firms (of which 340-350 have been selected to trade). These incl. power & heating, building materials, steel & metal processing, oil refining, chemicals, chem. fibre, food, large public bldgs, & services/transport	120 large companies The ETS covers 60% of city CO2 emissions, of which industrial firms cover 40%. These include all top energy users, incl power, iron & steel, oil & gas, chemicals, petrochemicals, cement, non-Fe metals, metal processing, & large public & commercial building	197 companies or just over 50% of all emissions. 16 industrial sectors (over 20,000 tonnes p/a), incl power, iron/steel, non-Fe, metsls, chemicals, textiles, paper. Non-industrial & services sectors (over 10,000 tonnes p/a), incl large public bldgs, hotels, retail, finance, aviation & harbour services	153 large enterprises (power, iron & steel, chemicals, cement, glass, automobiles, aluminium, food processing, & paper). These large firms cover 36% of provincial CO2 emissions. The first 4 are responsible for 90% of the ETS emissions.	827 companies in 9 industrial sectors planned; 1,851 companies to report (power, cement, steel, textiles, plastics, p/chemicals, ceramics, non-Fe metals, & paper). This number covers 42% of emissions. Power sector includes 8 "cross-border" Shenzhen power stations. 310 companies will report, and 239 will take part in Phase 1 of trading, 2013-15.	The six high-emitting industry sectors include iron & steel, iron alloy, aluminium, chemicals, cement, and non-Fe metals	Over 800 firms in 9 sectors & 26 industries to report, and 635 to trade (54%/38% of emissions) incl. the services sector & large buildings, were initially planned. However, only 200-300 firms will actually be involved in ETS trading
Electricity sector	Direct and indirect emissions.	Direct and indirect emissions	Direct and indirect emissions.	Direct emissions only	Direct emissions only.	Unknown; possibly direct emissions only	Direct and indirect emissions.

Cap setting	Quotas allocated according to the previous year's emission levels. Caps to be set based on 2005-10 emissions and projections for 2015 and 2020.	Baselines to be set by group of experts.	Quotas based on 2009-11 emissions considering context, expected growth and previous abatement. Caps for 2013-2015 allocated at once.	Based on historical emissions. Mechanism to be set by group of experts.	Based on 2010-2012 emissions and characteristics of each industry. 2013-2015 quotas allocated at once. Reviewed annually by GD DRC.	Unknown	Mechanism still under discussion. Baselines to be set by group of experts.
Permit Allocation	Annual allowances. Large proportion of free permits through grandfathering.	Grandfathering likely for most industries. May be some auctioning, and benchmarking for industries with sufficient data.	Mostly grandfathered. Benchmarking for sectors with clear data. Aiming for timely introduction of auctioning.	Still under discussion. Likely to feature high level of free allocation through grandfathering.	Large proportion of free permits through grandfathering.	Unknown	Starting with a large proportion of free permits (some auctioning), reducing over time.
Price stabilisation	Safety valve: government auction and buy-back of quotas.	Safety valve likely, government auction and buy-back of quotas.	Potentially, similar to Beijing	Not yet decided.	Not officially disclosed.	Unknown	Not officially disclosed.
Emissions intensity target 2015 (compared with 2010)	18%	19%	19%	17%	19.5%	17%	21%

Sources: Thomson Reuters; China Beijing Environment Exchange; Tianjin Climate Exchange; Shenzhen Emissions Exchange; Provincial People's Government of Guangdong; Municipal People's Government of Shenzhen, and Tsinghua, Fudan, Wuhan and Universities. In some instances information is from personal communications with relevant officials and researchers.

Map of China with key emissions data and pilot emissions trading scheme areas highlighted



Data source: State Information Centre, China Statistical Yearbooks; (Guan et al., 2012) for emissions data. Author's calculations. Cartography by ANU College of Asia and the Pacific.