Center for Clean Air Policy Interim Report

SECTORAL APPROACHES: A PATHWAY TO NATIONALLY APPROPRIATE MITIGATION ACTIONS

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This interim report is the result of the activities carried out under a grant agreement of the Enterprise and Industry Directorate-General of the European Commission. The work has been conducted by staff from CCAP-Europe, CCC, CEPS, IDDRI and ZEW together with sector and country experts.

Although the study has been carried out with support from the EC, the views expressed do not necessarily represent the opinion of the European Commission.

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CCAP Sectoral Interim Report Executive Overview

The primary objective of the United Nations Framework Convention on Climate Change (UNFCCC) is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Achieving this objective will require the collective effort of the global community and necessitates a well functioning international climate change plan that combines the active participation of both developed and developing countries.

Sectoral approaches, described in the Bali Action Plan as "cooperative sectoral approaches and sector-specific activities," have emerged as a promising tool to motivate developing countries and industry to reduce greenhouse gas (GHG) emissions in key economic sectors. The Bali Plan further envisions such mitigation actions to be two-way packages in which developing countries commit to undertake "unilateral actions" to reduce their GHG emissions growth, in the context of sustainable development, in return for technology and finance incentives from developed countries.

To contribute to an understanding of the potential of sectoral approaches as a tool for climate change mitigation in developing countries and what it would take for them to become operational under a post-2012 climate agreement, the Center for Clean Air Policy–Europe and a team of international partners – the Centre for European Policy Studies (CEPS), Climate Change Capital, the Centre for European Economic Research (ZEW) and the Institute for Sustainable Development and International Relations (IDDRI) – have undertaken a "proof-of-concept" study of sectoral approaches. This study seeks to provide a "road test" of different sectoral approaches by working with key developing countries (China, Mexico and Brazil) to assess mitigation potentials and costs for their energy-intensive, internationally competitive sectors, to evaluate the associated data, and in the end, to explore what features of the various sectoral approaches may or may not work in practice.

Overview of Sectoral Approaches

Three different designs for sectoral approaches were initially proposed for analysis:

1. A ***transnational sectoral approach***, where an international framework would be established that would adopt similar standards or benchmarks for a global industry;
2. A ***sectoral carbon financing approach***, which would broaden today's project-by-project Clean Development Mechanism (CDM) to encompass all of the emissions sources within an entire sector of a country; and
3. A ***sectoral bottom-up approach***, under which developing countries would adopt, for key sectors, voluntary "no-lose" GHG intensity targets that are informed by industry energy-intensity or other performance benchmarks and country-specific cost assessments.

Under each of these three approaches, a country that outperforms its sectoral target would be able to sell its excess emissions reductions in the international carbon market.

Current View of the Three Sectoral Approaches

As this study has progressed, it has become apparent that the transnational sectoral approach is not viable, as it is rejected by nearly all developing countries. In addition, the sectoral carbon finance approach and the sectoral bottom-up approach have evolved to become much more similar than originally envisioned and now simply represent different methods for setting a sectoral crediting baseline. The key remaining difference between the two is the bottom-up approach's provision of up-front technology or financial assistance to a developing country to encourage the country to undertake a stronger commitment.

Because support from developed countries is required under the Bali Action Plan, this study is focusing on the bottom-up sectoral approach but is also considering a new feature suggested by various developing country experts – the potential to set sectoral targets in terms of technology deployment goals rather than using emissions intensity targets.

Analysis and Preliminary Results – the Cement Sector

This interim report presents the preliminary results of the first phase of the study – an evaluation of sectoral approach issues and opportunities in the cement sectors in China, Mexico and Brazil. For the analysis, the study teams collected plant-level data and developed baseline production, energy use and emissions projections through 2025. They also calculated average marginal abatement cost curves for a wide variety of potential mitigation options in each country and modeled the impacts of scenarios in which packages of mitigation measures were implemented.

For a number of countries, the IEA and Ecofys have each recently estimated the emissions reduction potential of implementing today's best available practices or technologies in the cement sector. It today's growth rates of cement production in China, Brazil and Mexico continue through 2020, the CCAP study team's analysis suggests that strong mitigation efforts could capture two-thirds to four-fifths of the potential emissions reductions identified by these two comparison studies. Our results also suggest that implementation of stringent no-lose targets in the cement sectors in these three countries would produce emissions reductions of more than 15% from BAU in 2020, within the range that the IPCC and others have suggested is needed from developing countries in 2020 to keep GHG emissions on a path that can limit global warming to 2ºC.

Interim Lessons and Conclusions

The key lessons learned from this study to date include the following:

- The plant level data needed to perform a bottom-up analysis of a sector is scarce and is often considered to be confidential when it does exist. This is particularly true of cost data and indicates a need for extensive capacity building in developing countries to obtain the necessary data in a manner which industry finds acceptable.
- Due to this lack of data, sectoral approaches that adopt technology deployment targets, or couple intensity targets and technology deployment goals, may be more viable than intensity-based targets alone, in the near term.
- Flexibility in the design of a sectoral approach will be critical to its ability to access the full suite of mitigation opportunities available to participating countries.
- Although critics have argued that bottom-up sectoral targets are far too complicated to be included in an international treaty, the lesson of this proof-of-concept study so far is that designing sectoral targets for developing countries is simply a process of: (1) understanding emission reduction opportunities and costs within a domestic policy and political context, (2) setting a sector-wide target, and (3) defining the domestic policies and international incentives necessary to achieve compliance with that target. In the final analysis, it is no different than the process a developed country must go through to define its approach to regulation of these same energy-intensive sectors.

Overall, the results of the current study and other related efforts undertaken by CCAP-Europe and its partners suggest that sectoral approaches must have clearly defined objectives, build on ongoing unilateral mitigation actions and support national sustainable development strategies. To achieve this, they must produce material participation and material emission reductions across sectors and countries, be flexible, take national and local circumstances into account and produce technological innovation and transfer.

In addition, since our study has found a wide range of production efficiencies among developing countries, much as is the case among developed nations, sectoral efforts should focus on the most inefficient sectors in the key developing countries. Ultimately, however, the primary determinants of the success of emission reduction efforts in the post-2012 commitment period will be the degree of leadership exhibited by both developed and developing countries and the level of targeted support provided by developed countries to assist developing countries in the implementation of their “nationally appropriate mitigation actions,” which may include sectoral approaches, as required by the Bali Action Plan.

CCAP Sectoral Interim Report: Policy Summary

1 Introduction

The primary objective of the United Nations Framework Convention on Climate Change (UNFCCC) is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." This objective can only be achieved through a collective effort to reduce greenhouse gas (GHG) emissions by the global community, so a well-functioning international climate change plan requires active participation from both developed and the developing countries.

Sectoral approaches have emerged as one of the most promising tools to motivate countries and industry around the world to deliver the necessary emission reductions. These types of mitigation actions have been codified in the Bali Action Plan as "cooperative sectoral approaches and sector-specific activities." The Bali Plan further envisions that mitigation actions be two-way packages in which developing countries, for the first time, essentially agree to undertake "unilateral actions" to reduce their GHG emissions growth in a specific economic sector, in the context of sustainable development, in return for technology and finance incentives from developed countries.

Since the power sector generally produces the majority of GHG emissions in developing countries (excluding land use change and forestry), it is critical to design an effective sectoral approach for this sector. Energy-intensive industries are a particularly attractive focus for sectoral approaches as well because they account for eight to 15 percent of the world's CO^2 emissions. These industries produce materials that are needed to build a modern society, such as aluminium, cement and steel, and demand for these materials is expected to rise significantly with increasing wealth and urbanization in the developing world. At the same time, electricity demand will rise in developing countries, as this service is brought to more people, improving standards of living and aiding economic development. Thus, reducing the energy (and carbon) intensity of these sectors, while ensuring sustainable growth, is a challenge for developed and developing countries alike but is essential to achieving the goals of the UNFCCC.

Properly-designed sectoral approaches have the potential to address a number of practical issues that are of concern to both developed and developing countries. By focusing on energy-intensive industries, sectoral approaches can be developed that will reduce energy and emissions intensities while enabling continued economic growth in developing countries. In this sense, sectoral approaches are seen as a promising, flexible tool to deliver joint and concerted action on climate change. They have the potential to do this because they can be tailored to target any specific sector. When starting to think about what can be achieved within a sector, the discussion becomes tangible: specific low-emission technologies can be considered; business tools, such as performance standards and benchmarks, as well as business best practices, can be accessed; and specific regional resource constraints can be taken into account. This all helps build a very real picture of what can be achieved and how best to make that happen. Sectoral approaches can also provide an avenue for developed nations to meet their responsibilities for financing, sustainable development, and technology transfer, including opportunities for technological innovation that can move world industries to next-generation performance levels. Additionally, sectoral approaches can be designed to address the concerns of internationally competitive, trade-sensitive industries and, in particular, to minimize the associated potential for GHG leakage, both from one country to another within a sector and from one sector to another.

2 Purpose of the Study

To contribute to an understanding of the potential of sectoral approaches as a tool for climate change mitigation in developing countries and to develop a viable concept that could become operational under a post-2012 climate agreement, the Center for Clean Air Policy–Europe (CCAP–Europe) and a team of international partners and consultants has undertaken a "proof-of-concept" study of sectoral approaches in China, Mexico and Brazil[1]. This study has been made possible through the support of the European Commission.

This proof-of-concept study is intended to bridge the gap between academic concept and real-world conditions. In recent years, considerable effort has been spent in developing conceptual sectoral approaches and proposing how they might work in a post-2012 framework. This study seeks to "road test" different sectoral approaches by working with developing countries, energy-intensive industries, and the associated data to explore what may or may not work in practice. Issues relating to data availability, access and accuracy; the definition of sectoral boundaries; the use of benchmarks for comparisons or target-setting; and the design and structure of financing mechanisms for mitigation activities each take on a heightened importance in such feasibility assessments, shedding light on problems and opportunities that may not be as obvious in a conceptual stage. Similarly, such analyses provide insight into potential stumbling blocks to sectoral approaches that can be overcome through capacity-building and related efforts.

In this study, we focus on specific industry sectors that have high levels of energy use and/or GHG emissions. This focus on energy-intensive industries recognizes not only that they account for a significant share of the world's GHG emissions, but also that they may offer significant potential for GHG reductions in a timely and relatively cost-effective manner. Our proof-of-concept study focuses on four of these industries – cement, iron and steel, electric power, and aluminum.

This interim report presents the preliminary results of the first phase of the study – an evaluation of sectoral approach issues and opportunities in the cement sector. The first phase of the analysis focused on cement because the cement industry is relatively uncomplicated, with a limited number of production processes, and the primary product is reasonably uniform. Coupled with the past efforts and advances in GHG emissions reporting made under the Cement Sustainability Initiative (CSI), these factors allow cement to serve as a good test case to illustrate both the potential advantages and difficulties of sectoral approaches. In 2009, the study will be expanded to include similar analyses of the iron and steel, electric power, and aluminum industries in China, Brazil and Mexico.[2]

1. The study team is being led by the Center for Clean Air Policy – Europe (CCAP-Europe), and includes as partners CEPS, IDDRI, ZEW, and Climate Change Capital (CCC). Consultants on the study include ICF Consulting, a team from the Department of Environmental Science and Engineering at Tsinghua University, Dan Klein, and John Newman.

2. Because Mexico has no aluminum production facilities, sectoral approaches for the oil industry are being analyzed for Mexico as part of a complementary CCAP study.

3 Overview of Sectoral Approaches

As mentioned above, sectoral approaches provide a developing country with an opportunity to contribute to climate change mitigation by focusing on reducing emissions growth within a specific economic sector, in return for assistance from developed nations. At the outset of this study, three different designs for sectoral approaches were proposed for analysis – a transnational sectoral approach, a sectoral carbon finance approach (also know as Sectoral CDM), and a bottom-up sectoral approach. These three designs represent different concepts for accessing opportunities for GHG progress within a sector and for establishing policy frameworks for achieving this progress in the post-2012 period. In terms of their distinct properties, the approaches can be described as follows:

- In a ***transnational sectoral approach***, an international framework would be established that would apply similar standards or benchmarks to a global industry. These benchmarks would be chosen to improve efficiency and/or reduce emissions below projected levels and would be applicable to all participating countries, but certain parameters associated with this approach – such as the financial and technological assistance to be provided by Annex I countries and the deadline for reaching the benchmark – could vary from nation to nation.

- ***A sectoral carbon finance approach*** would broaden today's project-by-project Clean Development Mechanism (CDM) to encompass an entire sector (or perhaps subsector) within a country. The target baseline adopted here would represent some performance level better than BAU. Thus, a sectoral carbon finance program would require tracking the emissions performance of all of the sources within a sector, rather than monitoring only a selected group of isolated projects, and CERs could be earned only if the sector as a whole beats the adopted target baseline. Beating the baseline on a sector-wide basis would be considered sufficient to determine additionality.

- Under a ***sectoral bottom-up approach***, developing countries would adopt voluntary "no-lose" GHG intensity targets (e.g., tons of CO^2e/ton of steel) in key sectors; these targets would be informed by industry energy-intensity or other performance benchmarks and country-specific cost assessments. Here, a developing country would make a commitment to undertake specific mitigation activities unilaterally and would then negotiate a more stringent "no-lose" target. Up-front financing, capacity-building or technology assistance would be available and serve as an incentive for a developing country to set a tougher no-lose target. Access to the carbon market by beating the no-lose target would provide a second incentive for developing country action.

This study was originally intended to provide a proof of concept for each of these three sectoral approach designs. However, during the course of this study, and during international climate negotiations and various discussion platforms, the visions of the three approaches have evolved, such that they can now be viewed as more similar than originally proposed. All three approaches could employ "no-lose" sectoral targets, meaning that no international penalties apply if the targets are not achieved. Also, each approach could allow a developing country that beats its target to sell the excess emissions reductions on the carbon market

While different sectoral approaches may have relative strengths as well as weaknesses, the suitability of each will likely depend upon the specific sector and country under consideration. Broadly, it can be said that, considering the range of conditions across countries, industries, technologies, and data, a "one size fits all" sectoral approach design cannot be found, and that concepts for sectoral approaches need to be adaptable to the real-world conditions that are encountered in each developing country.

4 Design Elements of Sectoral Approaches

For any given sector, the architectural structure of a sectoral approach will be dictated by a number of important design elements. These include the types of targets to be adopted, the definition of the boundaries of the sector, the role of benchmarks, and the types of incentives employed. Each of these elements is discussed further below.

Goal-setting

Traditionally, sectoral targets in developing countries have been proposed in terms of either GHG emissions intensity or energy intensity because these types of targets allow for continued economic development and industry growth. During the course of this study, however, experts in China and elsewhere have suggested an alternative target-setting approach that is instead based upon technology deployment commitments. Under this type of approach, China could pledge, for example, that it would employ waste heat recovery in 80% of its cement plants by 2020. Up-front financing would then be tied to the cost of achieving these technical deployment goals, which become the sectoral targets against which performance is measured. Such a technology-based target could still be converted into an equivalent emissions-intensity target or level of GHG emissions reductions, giving China the potential to earn CERs as well. However, the emissions intensity target would again be expressed as a no-lose target, with no sanctions attached if it is not attained.

Each of these approaches to target-setting – intensity-based and technology-based – is now being analyzed as part of this sectoral study. The specific conditions and priorities prevailing in each participating country are guiding the determination of the suitability and feasibility of each approach there.

Sector boundaries

If a sector is to be brought into a sectoral framework of any design, the definition of the sector's measurement boundary or "fence" has important implications.

Poor choices of boundaries can limit the potential benefits of sectoral approaches by allowing attractive opportunities to be overlooked, good actions to be ignored, unproductive activities to be rewarded, and gaming to occur, which can undermine confidence. In the cement industry, for example, opportunities to achieve significant reductions in GHG emissions include plant energy efficiency, alternative fuel use, blending, reduced electricity use, improved materials transport, and carbon capture and storage (CCS). If the focus is only on kiln operations and clinker production and the sector boundary is defined accordingly, opportunities for cement blending using fly ash and slag, as well as reducing the use of cement in concrete would be overlooked. Another boundary issue involves whether to cover direct fuel emissions only, or to include purchased electricity, which may make emissions more difficult to estimate. For this study, the proposed cement-sector boundary includes the impacts of actions to reduce emissions associated with direct fuel consumption and purchased electricity, as well as blending.

Each country/sector pairing may opt for different sectoral boundary definitions, but as a matter of principle, boundaries should be kept as wide as possible – to provide industry and government with a range of mitigation options, maximize flexibility and reduce costs – but at the same time should be as close to the core business as possible. The sectoral study analysis also suggests a broader recommendation: future sectoral programs under the UNFCCC should define a minimum boundary for each sector that all countries must adopt (e.g., include direct fuel and electricity use at the cement production plant) but should allow developing countries the option to submit proposals to expand the boundaries to include additional sources.

Benchmarks

Benchmarks can play a key role in framing the design, execution, monitoring and verification of any adopted sectoral approach. In benchmarking, ***measurement protocols*** focus on how and what to measure and include the accounting frameworks, data collection guidelines, data compilation tools, and the data reporting, verification, security and validation processes and institutions used to assess plant-level energy use and GHG emissions. Benchmarks can also take the form of ***performance metrics*** that facilitate comparison of emissions intensity and energy efficiency across countries. These metrics can be based on best practice standards in a way that supports the design, negotiation, monitoring and verification of effective programs.

Benchmarks can provide guidance to countries and industries in designing their respective sectoral proposals, providing a common language for communicating action among parties during negotiations, helping parties compare and understand the relative magnitudes of the required efforts, incentives and impacts, and enhancing monitoring and verification. . In this context, they provide guidance as to what is reasonably possible, what has to be done to achieve that potential, and what the GHG benefits may be as a result.

In theory, benchmarks can describe the best available technologies in different industries and then be used as a measuring stick to conduct cost and policy analysis. For illustration, assume that the cement industry best practice for dry kiln production emits 0.8 tons of CO^2 per ton of cement, and that the industry average in a particular country is 1.0 tons CO^2 per ton of cement. The difference between the benchmark and the current situation (0.2 tons CO^2 per ton of cement) helps us to estimate the relative and absolute improvements that may be technically possible and the aggregate savings if applied sector-wide. Benchmarks at a sub-process level help us to hone in on the particular actions that may help us achieve these gains, such as greater use of alternative fuels, improvements in kiln efficiency, and/or increased blending with supplemental cementitious materials. Coupled with information on the costs of various measures, we can better understand the comparative desirability of actions within the cement sector and, relative to other sectors, the costs of a sectoral program, the potential need for up-front assistance, and potential policy reforms that may be required.

While useful, benchmarks do not provide a hard "solution," and judgement is needed in properly interpreting data and using it in sectoral analyses. Much of the data for benchmarking is at a specific process level, and may be too fine-grained to inform industry-wide assessments. Conversely, data collected at a more aggregate level increasingly represents a mixture of activities and processes, making it more difficult to identify which differences are opportunities for improvement, versus those differences that simply reflect site-specific conditions.

Additionally, benchmarking efforts can be a very data-intensive effort, and data that are complete and accurate are often out of reach. In some cases, measurement protocols are not well-implemented, and in these situations capacity-building efforts could improve our knowledge base. But in other situations, competitiveness concerns and anti-trust requirements limit the availability of information for analysis. In sectoral approaches, one challenge is to develop ways of usefully working with the available information, recognizing its incompleteness.

The CCAP sectoral study reviewed and evaluated a number of the relevant benchmarking research studies and analyses (including measurement standards, guidance and tools) that have already been conducted for the selected sectors and countries. It then outlined a systematic framework for developing the most appropriate and suitable sectoral approach benchmarks possible, given real-world plant and data circumstances. Our findings and recommendations for the development of benchmarks include:

- Different sectors and countries show a wide range of characteristics, making it unlikely that a "one size fits all" solution for developing industry benchmarks can be found. As a consequence of this industry variation, performance levels are expected to vary by country and sector. There are likely to be programmatic differences between countries, and possibly between sectors within countries.

- The performance metrics and corresponding measurement protocols should span three parameters in two primary dimensions: fuel use, electricity use and GHG emissions (direct combustion and process) on both relative and absolute bases.
- The boundaries, configurations, production activities and measurement protocols for each country/sector pairing should be set in a manner that promotes consistency, avoids double counting, and is reflective of real-world plant conditions.
- Similarly, the performance levels of each country/sector pairing should be set in a way that is consistent with the sector characterization and reflective of real-world plant conditions.

In the next phase of the sectoral study, CCAP and its partners will continue to evaluate options for benchmarks and their role in the implementation of sectoral approaches. This work will be further informed by the results of the analysis to be conducted in the iron and steel, electric power and aluminum sectors.

Financing Options and Other Incentives

Along with a number of other studies, the 2007 UNFCCC report, ***Investment and Financial Flows to Address Climate Change***, demonstrates that significant additional financing is needed to address climate change in the post-2012 period. This report estimates that global additional investment and financial flows of $200-210 billion will be needed for mitigation in 2030 to return GHG emissions to current levels.

There are a wide variety of potential sources of this finance that could be applied to sectoral approaches. Some Annex I countries, including Norway and Germany, have developed policies to auction allowances from domestic cap-and-trade systems and earmark a portion of the revenues to international purposes, such as support for sectoral approaches in developing countries. Multilateral support, provided through international financial institutions or through a proposed UNFCCC-sponsored multilateral fund, is another option. An additional recent and important source of funding is the carbon market.

In the discussions that CCAP and its study partners have had with developing country policymakers, three main financing approaches have been identified that could be utilized to promote sectoral mitigation actions:

- For advanced technology deployment, international assistance could be provided to write down the costs of high-cost, not-yet-commercial technologies, such as CCS, or to provide technical assistance to small- or medium-sized enterprises to build their capacities to utilize advanced technologies and to pay for some or all of the associated operation and maintenance costs.
- Another option would be to create new financing tools, such as special purpose vehicles (SPVs), to reduce or eliminate barriers to finance. An example would be SPVs to assist in financing efficiency improvements that commercial banks in the developing countries do not have the capacity to support.
- A third alternative would be financing to reduce the domestic cost of incentive-based policies, such as feed-in tariffs, for mitigation options such as renewables and energy efficiency.

In all likelihood, an intermediary or broker, such as an international financial institution like the World Bank, the Asian Development Bank or the Interamerican Development Bank, would be tasked with negotiating and implementing the financing details associated with any sectoral target proposed by a developing country.

To implement sectoral approaches, domestic policymakers have a wide range of policy options at their disposal to create incentives for investment in advanced technologies. Market-based instruments include price instruments (taxes, charges, subsidies) or quantity instruments (cap-and-trade programs).

Regulatory instruments, such as standards and norms, as well as bans on products, can all help channel investments toward specific actions and technologies. Our experience suggests that successful technology support measures have the following specific characteristics:

- The instrument should be based on the delivery of the required objective (e.g., verified permanent storage of CO^2).
- Given that the private sector is often more willing to take on capital and operating risks than policymakers realize, support mechanisms should be aimed at writing down the costs of projects so that they can become commercial.
- A support instrument should provide payment over the operating lifetime of the project if there is an additional operating cost associated with the technology.
- The ideal mechanism will be a time- and volume-limited, rules-based allocation mechanism, where developers know that, if they have an eligible project operational by a certain date, then they will automatically qualify for the support.

Such features will help to ensure that policy options provide the maximum level of support and incentives for the successful implementation of sectoral approaches in industry. However, the specific choice of assistance will depend on a particular developing country's needs and preferences and the willingness of developed countries to provide that type of assistance. For this reason, a major focus of this study is tailoring the design of financial and other incentive mechanisms to the circumstances of each participating developing country, so as to maximally incentivize the implementation of GHG emissions reduction measures.

5 Analysis and Preliminary Results – the Cement Sector

To date, the sectoral study has focused on the cement industries in Brazil, China and Mexico. This analysis consisted of four steps:

1. Collection of plant-level data (age; annual production, energy use, and emissions; technologies in use; operating costs, etc.);
2. Development of baseline production, energy use and emissions projections to 2025;
3. Calculation of average marginal abatement cost (MAC) curves for a wide variety of potential mitigation options in each country; and
4. Modeling the impacts of scenarios in which packages of mitigation measures were implemented.

Thus, the analysis began with an assessment of the availability of both plant-level and aggregate data in the three countries. For the Mexico and Brazil cement sectors, ICF Consulting was able to collect and compile some recent plant-level data from numerous sources, but neither of these country's data sets were comprehensive. In China, the data for individual cement plants that the Tsinghua University team was able to obtain were even more limited.

Given the lack of comprehensive plant-level data, the study teams combined the available data with projected production levels and aggregate expected fuel consumption and emissions patterns to estimate the BAU baselines. Each team then developed MAC curves for key mitigation options using a range of in-country and international sources to estimate the sector-wide penetration levels and emissions reduction potentials for each option. The MAC curves were then employed to develop a set of scenarios to model – both potential unilateral emission reduction commitments and no-lose reduction targets that could be undertaken by each country in the cement sector. The types of scenarios considered included the following:

- Unilateral commitments:
  - Implementation of all net negative marginal cost options;
  - Beginning with the lowest-cost option, implementation of progressively more costly mitigation measures until the total cost of the combined measures is zero; and
  - Implementation of all mitigation measures with a net negative marginal cost plus enough positive marginal cost measures to bring the total cost to a certain level.
- No-lose targets:
  - Implementation of all mitigation measures (including those in the unilateral scenarios) up to a specified cost level higher than that adopted for the latter unilateral scenario; and
  - Implementation of all mitigation measures up to a specified cost level, plus implementation of select high-cost measures that require transfer of advanced technology, significant financing or training for implementation.

For the unilateral scenarios, the emissions reductions from the baseline represent the entirely self-financed contribution of the developing country's cement-sector to global emission reductions. In the no-lose scenarios, the emissions reductions again signify the country's contribution to the protection of the atmosphere, but in this case, a portion of the additional cost above the unilateral scenario is assumed to be met through the provision of international assistance (the precise share would be determined through negotiations). Emissions reductions achieved beyond the no-lose target would be eligible for sale on the international carbon market and thus only serve to offset emissions from other nations.

The baselines and the results for each scenario modeled are discussed below for each country. All results are presented for 2020, and costs are expressed in year 2008 Euros, using a 10% discount rate. For the present analysis, CCAP and the study team estimated the average annual costs for 2020 only, based on the average lifetime net present value (NPV) cost. These costs will appear in the full interim report. In the next phase of the analysis, CCAP and the team will also estimate and evaluate the up-front capital costs for each scenario, as well as the total lifetime NPV cost.

China

In China, the analysis by Tsinghua University projects that business-as-usual (BAU) GHG emissions in the cement sector will increase rapidly, more than quadrupling from 2005 to 2020. This growth rate is significantly higher than previous estimates because, in November of 2008, the Chinese government declared an ambitious plan for economic growth, including a major investment in infrastructure development. If this plan is implemented as envisioned, it could potentially stimulate even further growth of cement production. Due to this uncertainty, CCAP and the Tsinghua team will follow any further adjustments in the expected growth rate and revise the results for China's cement sector as appropriate.

The scenario analysis for 2020 indicates that, although China has made significant strides in increasing the energy efficiency of its cement sector, a large GHG reduction potential remains. From a simple cost perspective, it appears that China could achieve significant reductions (on the order of 10% or more) from unilateral actions undertaken as part of a sectoral program. In addition, if China were to adopt a no-lose target by implementing measures costing no more than a few Euros per ton, it could achieve a 14% reduction in emissions from BAU in 2020. While some portion of the mitigation cost associated with the latter target would be borne by China, the international funding required could still be very large, and the negotiation of the appropriate unilateral commitment will have a major impact on the assistance needed. For example, if China were to choose a less aggressive unilateral commitment under the same no-lose target, the total incremental cost of achieving the no-lose target could increase by as much as a factor of ten. Although this quantitative analysis is meant simply to highlight the issues involved, rather than to suggest how the incremental costs of further mitigation actions might be shared, the results point up the central importance and the potential implications of the negotiation process between key developing countries like China and the Annex I countries.

Mexico

ICF Consulting conducted the analysis of the mitigation potential in Mexico's cement sector. Mexico's cement plants are already relatively advanced and energy efficient, so the opportunities were more limited than those evaluated for China. Under BAU, annual GHG emissions from cement production in Mexico are expected to increase by about 50% from 2006 to 2020.

The results of the scenario analysis for the cement sector in Mexico are:

- Implementation of the primary unilateral scenario, which includes two positive cost measures but has a negative total cost overall, would reduce cement emissions in Mexico by 3% from BAU in 2020.
- Including some higher cost measures beyond those in the unilateral scenario would lower emissions by 5% from BAU in 2020 while still producing a net annual cost savings overall.
- To reduce the emissions of Mexico's cement sector further, very high-cost measures such as kiln conversions, are necessary. A package of mitigation measures that includes kiln conversions can reduce emissions in 2020 by 7.3% to 8.3 % from BAU, but these options would not be pursued by the industry in the normal course of business and would thus require international assistance or domestic regulation to proceed.

As expected from the advanced state of Mexico's cement plants and production technologies, these results indicate only a modest reduction potential for Mexico's cement sector. In this simulation, Mexico's unilateral reductions are small in both absolute and proportional terms relative to BAU in 2020. The reductions that could be achieved from adoption of a sectoral approach in Mexico would thus be low. In addition, more than one-third of the reduction potential identified would entail a high cost and would thus likely require significant international assistance to achieve.

CCAP and its partners are presently working with the Mexican government and its cement industry to set a sectoral target for both the cement and oil refining sectors that Mexico could potentially propose to the international community in the near future. During this process, Mexican cement companies have identified an additional mitigation opportunity that they are interested in pursuing but which ICF Consulting did not analyze – the construction of renewable energy facilities, such as wind farms, to reduce the indirect emissions associated with its use of electricity (and to potentially produce a net surplus of electricity and garner credit for the excess supplied to the national electric system). This option has been included in the recommendations for a sectoral approach for Mexico's cement industry, and it represents one of the real-world circumstances described in Box 1 that illustrate the need for flexibility in the design of sectoral approaches.

Brazil

Brazil's cement sector is similar to that of Mexico: its plants are relatively efficient, and its total emissions are approximately the same. Brazil's annual BAU GHG emissions from cement production are projected to increase by more than 40% from 2007 to 2020. The scenario analysis for Brazil indicates that:

- A unilateral scenario that includes two positive cost options would decrease emissions by 4% from BAU in 2020.
- No-lose scenarios that include higher-cost mitigation options could decrease emissions in 2020 by 5% to 6.9% from BAU.

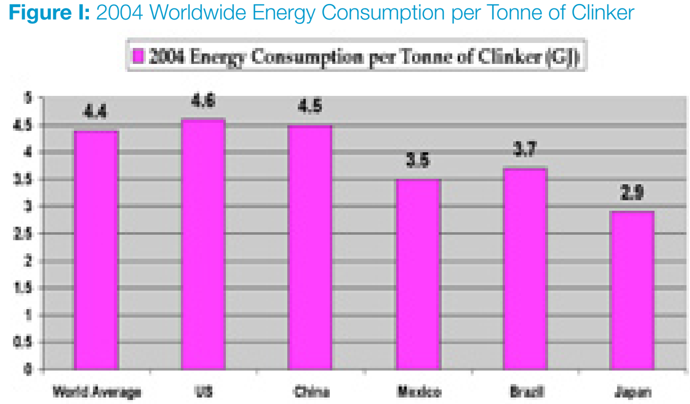
6 Global Significance of Sectoral Reductions in the Cement Sector

The cement sector was responsible for over two billion tons of carbon dioxide emissions in 2007, representing over eight percent of the global CO^2 emissions and an amount roughly equivalent to all of the CO^2 emissions from passenger cars worldwide. To estimate the potential impact of sectoral approaches on global cement-sector emissions, the CCAP study team utilized two sets of data: (1) data reported by Ecofys (Höhne et al. 2008), and (2) a combination of data taken from the IEA (2007, 2008) and Wartmann and Höhne (2003). For this sector, Ecofys provides data for the six major developing countries – China, India, Brazil, Mexico, South Korea, and South Africa – while the IEA data cover only four of these countries (China, India, Brazil and South Korea).

For the cement sector, each of these data sets indicates that the potential emissions reductions that could be achieved through a sectoral approach in major developing countries are 15-18% of BAU in 2020, if today's best practices or best available technologies are adopted. If this is taken as the global average reduction proportion for cement, the preliminary results of CCAP's bottom-up study suggest that the potential for China (14%) is close to this average, while those of Mexico and Brazil are only about one-half of the global average. This is due to the advanced state of Mexican and Brazilian cement plants compared to those in China. In fact, the emissions reductions achieved from any sectoral program in cement will be dictated by China's efforts, for two reasons: (1) China's industry is currently less efficient than those of the other major developing countries, thus providing more potential for emissions reductions, and (2) if current growth trends continue, their emissions are expected to increasingly dominate those of the other major developing countries, as China is projected to contribute nearly 90% of the cement-sector emissions of this group in 2020.

As shown in Figure I, developing countries like China, Mexico, and Brazil are actually performing better than the United States in terms of energy consumption per ton of clinker produced. Although the Chinese and US efficiencies were similar in 2004, the US cement industry consumed slightly more energy than China per unit of clinker produced and considerably more than either Brazil or Mexico in that year (the use of clinker-based data eliminates the impacts of different blending practices among the countries). Both Mexico and Brazil's energy intensity in the cement sector were better than the world average in 2004, and Mexico in particular had a high energy efficiency level, close to that of Japan. This points up two key findings of this study: (1) a sectoral approach analysis provides a good way to compare performance across countries, and (2) a sectoral approach will not necessarily produce large emission reductions in all developing countries. In fact, as this cement comparison reveals, some developed nations may have much larger opportunities for cost-effective CO^2 emissions reductions in energy-intensive sectors than do key developing countries.

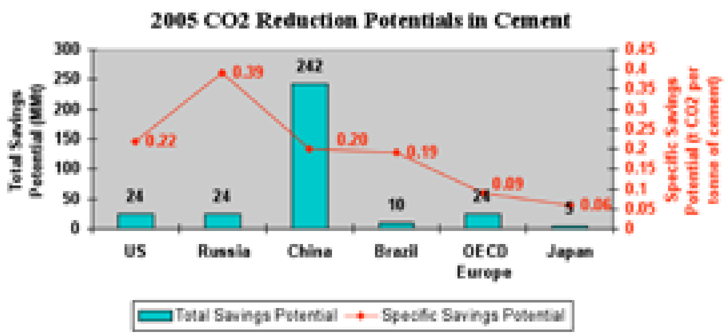
Figure I: 2004 Worldwide Energy Consumption per Tonne of Clinker



Source: IEA. 2008. Worldwide Trends in Energy Use and Efficiency

The analysis in Mexico also reveals the critical importance of the boundary definition adopted for a sector. If clinker production serves as the boundary for the cement sector, Mexico clearly has limited opportunities to achieve significant emissions reductions. However, if a broader boundary is permitted, one that encompasses electricity production by the cement industry, our results suggest that the Mexican cement industry could achieve significant emission reductions by constructing its own wind farms

Figure 2: 2005 worldwide CO2 Reduction Potentials in Cement Sector



Source: IEA. 2008. Worldwide Trends in Energy Use and Efficiency

in lieu of continuing to purchase fossil-fuel-based electricity from the Mexican national utility, CFE. While self-generation, when coupled with sales to the national grid of electricity production that exceeds self-supply, could be quite cost-effective, the study also reveals that policy barriers, in the form of low tariffs offered by CFE for electricity generated by independent producers, effectively bar this option currently. A sectoral program for cement that includes the broader boundary definition plus electricity-pricing policy reform in Mexico can be quite attractive and provide a much greater opportunity for emissions reductions (see Box 1).

On an absolute basis, the sectoral study's emission reductions from the most advanced no-lose targets in China, Mexico and Brazil total about 460 million (metric) tons carbon dioxide equivalent (MtCO^{2}e) in 2020. If current growth rates in cement production persist, then the reductions for 2020 inferred by the IEA and Ecofys data would be about 560 MtCO^{2}e and 720 MtCO^{2}e, respectively. The CCAP study team's analysis thus suggests that strong mitigation efforts could capture two-thirds to four-fifths of the potential emissions reductions identified by these two comparison studies. The results also suggest that implementation of stringent no-lose targets in the cement sectors in these three countries could achieve 7-16% of the total reductions that IPCC scenarios indicate are needed from developing countries in 2020 to keep GHG emissions on a path that can limit global warming to 2ºC.[3]

Figure II, which is drawn from work by the International Energy Agency, sheds some additional light on the comparative potential impacts of actions, if taken in 2005, in the cement sector in leading developing countries and selected developed nations. As seen in that chart, which shows the impacts of adopting best available technologies and practices for cement (not just clinker) production in various countries in 2005, China has the largest aggregate CO^2 reduction potential in the global cement industry because of its large number of plants and dominant position in global production. Considering the vast market share of China's cement production, all other countries' absolute reduction potentials are dwarfed by China's. However, in terms of emissions reduction potential per unit of cement production, China and Brazil were at almost the same level (0.20 and 0.19 tCO^2/t cement) in 2005, and they both were lower than the US's reduction potential (0.22 tCO^2/t cement). This suggests that the US cement industry has a relatively large space to improve its technology level. China's specific savings potential from Figure II indicates that it could mitigate more than one-fifth[4] of its current CO^2 emissions from the cement sector if all of its plants were upgraded to the BAT level.

3. Estimated from a CCAP study based on Ecofys data that assumes total Annex I emissions are reduced to 20% below 1990 levels in 2020, and global emissions are limited to 20%-30% above 1990 levels in that year.

4. Chinese cement industry's emission intensity in 2005 is 0.909 t CO2/t cement, according to Tsinghua University estimates. The US cement industry has an emission intensity around 0.78t CO2/t cement when blending is included (CCAP calculation using data from IEA, 2007, Tracking Industrial Energy Efficiency and CO2 Emissions).

Box 1. Tailoring Sectoral Targets to National Circumstances

As part of this sectoral study, CCAP and its partners are working with Mexico to develop recommendations for that country's unilateral commitments and no-lose sectoral targets in the cement and oil refining sectors. This process has made clear the need to build some flexibility into any sectoral approach to account for differing national circumstances. For Mexico, the utility of providing flexibility in terms of sectoral boundaries, the ability to adopt both intensity-based and technology-based targets for a sector, and some of the provisions of international assistance is described below.

Broadening sectoral boundaries: As illustrated by the Mexico case study, the cement sector in Mexico is already one of the world's most efficient. Thus, a sectoral approach that incorporates the traditional boundary for cement activities – at the level of the individual cement plant – can achieve only modest emissions reductions in Mexico, and many of these entail a relatively high cost. For this reason, we have recommended that the cement industry in Mexico be allowed to expand its sectoral boundary to include lower-emitting electricity production via waste heat recovery or renewable resources. At least one Mexican cement company, CEMEX, is already pursuing this option through the CDM by constructing wind farms. Allowing similar activities to qualify under a sectoral approach provides a much greater opportunity for emissions reductions, which has led us to further recommend that all industrial sectors in developing countries be given the option to expand their boundaries in such a manner, under a consistent set of rules and conditions.

Multiple targets: For oil refining, the global industry employs the well-known Solomon Energy Intensity Index (EII) to measure its energy efficiency. However, oil companies often have significant emissions reduction opportunities that do not impact, or are at least not fully reflected in, their Solomon EII. In Mexico, the key mitigation option that falls into this category is cogeneration. Thus, we have recommended that PEMEX, Mexico's national oil company, develop two sectoral targets for its oil refining operations. The first is based upon improvements in its energy intensity and incorporates the Solomon EII. The second target is technology-based and is specified in terms of the number of cogeneration units that PEMEX will construct at its refineries, both unilaterally and as a no-lose commitment. Allowing PEMEX to develop multiple targets in this manner provides it with a greater opportunity to access its full complement of mitigation measures under a sectoral approach.

Linking international assistance to policy reform: The net cost of implementing cogeneration at Mexico's oil refineries depends upon the revenue that PEMEX can earn from the sale of power produced beyond its self-supply. However, Mexican law constrains the rates that its national electricity company, CFE, can offer for this electricity. If this rate is deemed to be unreasonably low by international standards, we have recommended that any international assistance pledged to Mexico to facilitate cogeneration at its oil refineries be contingent upon policy reform that allows CFE to offer a better rate to PEMEX. This prevents international assistance from serving to support unfair pricing practices.

Addressing domestic barriers: Under most conditions, mitigation activities in developing countries that have a net negative cost are unlikely to be granted assistance from Annex I nations. However, even if cogeneration at oil refineries in Mexico appears theoretically profitable over the long-term, such projects face two principal domestic barriers: 1) difficulty in obtaining up-front financing from Hacienda, Mexico's finance ministry, and 2) the need for electricity pricing reform that sets tariffs paid to independent power producers at a level sufficient to insure profitability. We have therefore proposed that loans be provided to PEMEX to cover these initial costs, with the principal and interest repaid using the revenues generated by the electricity sales. This illustrates the importance of considering domestic barriers, in addition to costs, when determining the assistance needed by a developing country to achieve its sectoral emissions reduction goals.

7 Next Phases of the Sectoral Study

In 2009, the sectoral study will proceed in the following manner:

- The cement analysis will continue to be refined as better and more complete data is obtained. A focus will also be placed on an examination of alternative cost criteria (such as up-front capital costs) that could be used to determine the amount and type of assistance that a developing country would need to achieve a specific no-lose sectoral target.

- Analysis of the iron and steel, electricity and aluminum sectors will be performed in a manner similar to that described for the cement sector in this report.[6] Collection of plant-level data for these industries in Mexico, China and Brazil has already begun.

- Workshops will be held with domestic policymakers, industry representatives and other interested stakeholders in China, Mexico and Brazil in the Spring of 2009 to present results of the study and garner feedback.

- Workshops will also be held with global industrial stakeholders from each of the sectors being analyzed.

- Modeling will be performed by ZEW to assess the impacts of different sectoral approach designs on international trade and competitiveness in the cement sector.

The sectoral analyses listed above are expected to be completed by June of 2009, and the final integrated report describing the results will be released at the COP meeting in Copenhagen in December of 2009.

5. The aluminum sector will not be studied in Mexico, since Mexico has no aluminum production facilities.

8 Key Lessons Learned to Date

In performing this analysis of sectoral approaches for the cement sector, important insights have been gained by the study team. The key lessons learned from this analysis to date are:

- Access to the plant-specific data needed to perform a bottom-up analysis of sectoral approaches is limited in even the most developed of the developing countries. In some cases, the data simply does not exist. In others, it is collected by individual plants or companies but not in a coordinated manner across the sector. Thus, significant and immediate capacity building is needed in developing countries to collect plant-level data in a manner that both the industry and the international community find to be credible and acceptable.

- However, even in those cases in which the data is recorded and reported in a consistent manner sector-wide, such as in the ***Getting the Numbers Right*** program of the Cement Sustainability Initiative, confidentiality and competitiveness issues keep the plant-level data from becoming publicly available. Further, cost data is not collected in these industry data efforts, posing additional challenges in estimating mitigation costs. Accordingly, even with improved data coverage and quality, our knowledge of what can be done, and at what cost, will be imperfect, and sectoral approaches need to be flexible enough to accommodate these imperfections.

- Due to the limited availability of plant-level data needed to develop sectoral targets in a bottom-up manner, a sectoral approach that employs technology-based targets is becoming more and more attractive. This may prove to be the most feasible type of sectoral approach target in the short term, at least until the capacity building described in the previous bullet point is extensive enough to allow credible intensity-based targets to be developed. A combination of technology targets and intensity targets in a sector may offer greater potential to achieve large emission reductions than a purely sector-wide carbon intensity target.

- Flexibility in the design of a sectoral approach will be critical to its ability to access the full suite of mitigation opportunities available to participating countries. Allowing developing countries some flexibility in the definition of sectoral boundaries, the types and numbers of targets to adopt, and other parameters associated with sectoral approaches will provide the maximum potential for emissions reductions. In addition, coupling targets with policies to reduce existing domestic barriers (such as electricity pricing and transmission access reform) will be essential to effective implementation.

- Critics have argued that bottom-up sectoral targets are far too complicated to be included in an international treaty. Yet the lesson of this proof of concept study so far is that designing sectoral targets for developing countries is simply a process of: (1) understanding emission reduction opportunities and costs within a domestic policy and political context, (2) setting a sector-wide target, and (3) defining the policies and financing incentives necessary to achieve compliance with that target. In the final analysis, it is no different than the process a developed country must go through to define its approach to regulation of these same energy-intensive sectors. The data challenges are also very much the same – the European Union embarked on its EU Emissions Trading System's pilot phase in 2005 with very little accurate data and cost information for the major industrial sectors to be capped. The pilot phase in effect "discovered" the information ultimately needed for the Kyoto period of the EU ETS, so we should expect no less of a process for determining bottom-up no-lose targets for energy-intensive industries in key developing countries.

9 Interim Conclusions and Recommendations

Achievement of the objective of the UNFCCC to prevent climate change will require significant action from developed and developing countries to reduce GHG emissions. Today, energy-intensive industries account for a large share of global GHG emissions, and these emissions are projected to increase rapidly in developing countries. While many developing countries have already made significant efforts to improve their energy efficiency and reduce emissions in these sectors, innovative international mechanisms will be needed to encourage and enable them to undertake further GHG mitigation efforts in the post-2012 period.

Sectoral approaches offer a promising tool to mobilise and assist developing countries in implementing effective GHG actions. In developing countries, sectoral approaches can help enhance efficiency and industry performance, support new technology deployment and promote sustainable economic development. They can also promote further cooperation between Annex I and developing countries on climate change and can help address competitiveness concerns among Annex I country industries and governments.

There is no "one size fits all" solution; rather, sectoral approaches must be adaptable depending on the situation in each industry and country in terms of industry structure, technology, energy consumption, emissions sources, existing regulatory policies, investment patterns, and other parameters. As a part of "proof of concept" for sectoral approaches, an explicit recognition that each situation is different encourages us toward a hybrid that is flexible and combines the best features of each.

To function as an effective GHG mitigation tool, however, sectoral approaches must be carefully designed and integrated into other national and international climate and development efforts. The results of the current study and other related efforts undertaken by CCAP and its partners to date suggest the following:

- Sectoral approaches will need to have clearly defined objectives and actions in each country and industrial sector that build on unilateral actions already underway in these countries or sectors. To be effective globally, such approaches will need to achieve material coverage of energy-intensive industries in key developing countries and will likely focus on new and large existing facilities.
- Sectoral approaches will need to be flexible and take national and local circumstances into account, consistent with the principle of "common but differentiated responsibilities and respective capabilities." Performance differences within and across countries often reflect site-specific characteristics and data anomalies, rather than differences in efficiency, and thus do not always present opportunities for improvement.
- Sectoral approaches should be designed to support existing national development programs and plans and to make positive and significant contributions to industrial development. Carbon intensity goals can be effective in this connection by driving reductions in the growth of emissions while simultaneously encouraging sustainable growth. Specific yet flexible technology development goals can also be a vital part of such national plans.
- Given the importance of the private sector as a source of technological innovation, financing and industrial know-how, sectoral approaches should include incentives to industry as well as to government to support actions in developing countries. They should also encourage collaboration between developing and Annex I governments and industry.
- The provision of up-front financing for advanced technology deployment and performance improvements will be a key element of any sectoral approach. Such financing can drive investment in and the deployment of step-change technologies, and in doing so, it can speed up the pace of change and innovation.

- The post-2012 climate agreement should include adequate incentives to move emissions reduction efforts in developing countries beyond the project-based approach of the Clean Development Mechanism and toward a mechanism that involves most or all facilities within a given sector in each developing country. Sectoral crediting via the carbon market for countries and companies who exceed their sectoral targets will be an important part of any incentive package.

- The success of sectoral approaches will also depend on the development of common data collection guidelines, standards and metrics to ensure that data is collected in an internationally consistent manner across countries and industries.

- Benchmarking will play a key role in framing the design, negotiation, and execution of sectoral targets. Benchmarking will be important in understanding what action is desirable and possible at the sectoral level and in providing a common yardstick for comparisons. The further development and discussion of potential benchmarks and their roles should be a primary focus of attention going forward.

- Capacity building will be one of the most vital components of any sectoral approach. The scale of effort likely to be required and the time needed to be able to get sectoral programs up and running will require significant near-term action in developing countries, with funding, technical assistance and training provided by Annex I countries as soon as possible in preparation for longer-term actions. Key actions will include data collection and emissions inventory development, definition of consistent sector boundaries, development of sector baselines, evaluation of mitigation options with an emphasis on cost estimation, and harmonization of measurement standards to ensure transparency and international acceptance. This will involve a range of activities, from developing data reporting institutions to training local staff in industries in developing countries, as well as the development and implementation of procedures for measurement, reporting and verification.

- Assistance from Annex I countries will also be crucial in the areas of technology deployment, policy development, and removal of financial and non-financial barriers. In particular, international funds can finance advanced technologies that have high up-front capital costs or high operating costs. For example, carbon capture and storage (CCS) technology is a potentially effective option to reduce emissions but is considerably more expensive and less energy efficient than conventional technologies. It has not been commercially demonstrated as yet and is unlikely to be financed by companies in developing countries. International financing (like the current EU grant in process to develop CCS demonstration plants in China) can be effective to help provide the incremental capital investment required, and potentially to speed the adoption of such technologies.