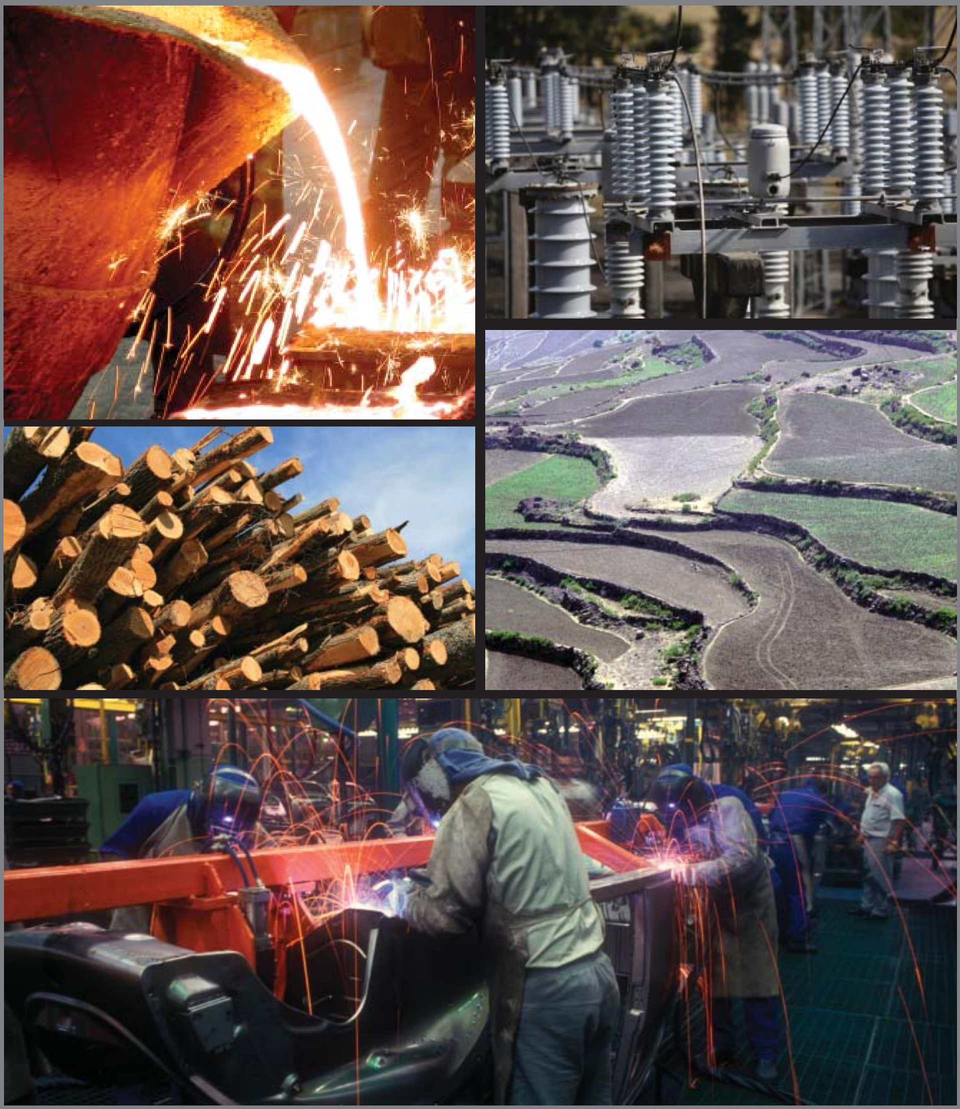
WORLD RESOURCES INSTITUTE

WRI REPORT



ROB BRADLEY

KEVIN A. BAUMERT

BRITT CHILDS

TIM HERZOG

JONATHAN PERSHING

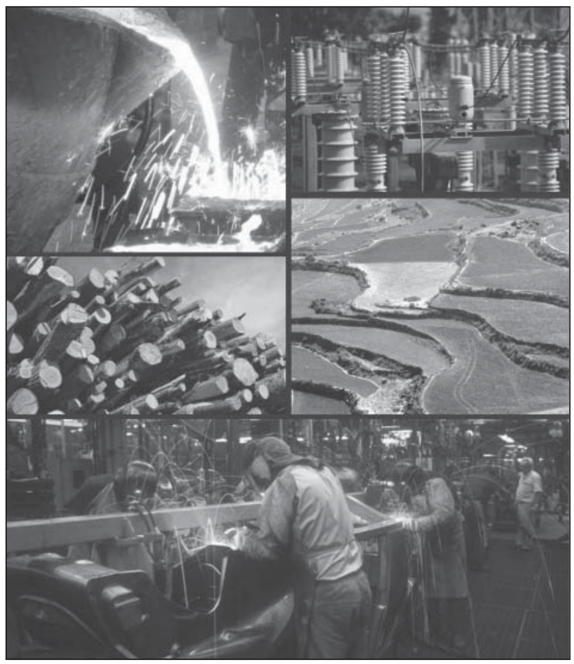
SLICING THE PIE: SECTOR-BASED APPROACHES TO INTERNATIONAL CLIMATE AGREEMENTS

Issues and Options

SLICING THE PIE

SECTOR-BASED APPROACHES TO INTERNATIONAL CLIMATE AGREEMENTS

Issues and Options



ROB BRADLEY

KEVIN A. BAUMERT

BRITT CHILDS

TIM HERZOG

JONATHAN PERSHING

December 2007

WORLD RESOURCES INSTITUTE

WASHINGTON, DC

GREG FUHS
EDITOR

HYACINTH BILLINGS
PUBLICATIONS DIRECTOR

MAGGIE POWELL
LAYOUT

Each World Resources Institute report represents a timely, scholarly treatment of a subject of public concern. WRI takes responsibility for choosing the study topics and guaranteeing its authors and researchers freedom of inquiry. It also solicits and responds to the guidance of advisory panels and expert reviewers. Unless otherwise stated, however, all the interpretation and findings set forth in WRI publications are those of the authors.

ISBN 978-1-56973-668-5

Library of Congress Control Number: 2007941145

Printed in the United States of America on elemental chlorine free and acid free paper with recycled content 10% post consumer waste.

Cover Photo Credits:

Agricultural plots of terraced land: World Bank/Bill Lyons, 2002.

All others: iStockphoto.com

CONTENTS

ACKNOWLEDGMENTS

The authors would like to express their gratitude to a number of people whose insightful comments and patient help made this a much better analysis. As always, remaining faults are those of the authors, but the reader has far fewer of them to grapple with thanks to our benefactors. Among our colleagues at the World Resources Institute, Andrew Aulisi, Florence Daviet, Al Hammond, David Jhirad and Jeff Logan made important contributions. Richard Baron, Jane Ellis, Trevor Houser, and Murray Ward all contributed their considerable expertise.

The authors would also like to thank Greg Fuhs for his masterful editing, Maggie Powell for the design and layout, and Hyacinth Billings, Natalie Bushell, and Jennie Hommel for their patience and assistance during the production of this report.

This report would not have been possible without the generous support of the Oak Foundation, the Wallace Foundation. It also draws heavily on work supported by the governments of Canada, Norway and the Netherlands.

FOREWORD

The challenge of climate change is enormous and complex, and the need for urgent and meaningful action to address it at the global level is now obvious to governments around the world. Mitigating climate change and avoiding some of the most severe impacts will require significant reductions in global greenhouse gas emissions; achieving these reductions will require cooperation and participation from all of the world's major emitters. These include not only the major industrialized countries, Annex I and OECD countries, but also a significant number of emerging economies.

Ultimately this will mean bringing together all major emitters in a comprehensive climate agreement. However, we still have some way to go before this will be feasible. Large wealthy countries, such as the US and Australia, have refused to join the Kyoto Protocol, and negotiators have still not reached an agreement for incorporating rapidly growing economies like India and China into international mitigation efforts. The result is that the Kyoto Protocol, though a vital first step, still falls well short of what is needed. Can we find some way of limiting some of these international emissions while a comprehensive agreement remains out of reach?

In this context, focus has increasingly turned towards dividing the mitigation challenge up into more manageable pieces by focusing on action within specific sectors. Under the sectoral approach, governments and/or companies would agree on measures to limit or reduce emissions from key GHG generating sectors such as transportation, power, land use, steel, cement, or other emissions-intensive industries or activities. Advocates argue that such agreements are an attractive concept as they could a) simplify negotiations, b) reduce international competitiveness concerns, c) increase effectiveness through increased participation and reduced leakage.

This paper explores the concept of international sectoral commitments in climate negotiations. It examines the form that such commitments might take, analyzes which sectors are best suited to sectoral approaches to climate mitigation, and evaluates several different models for how sectoral agreements might be integrated into the broader climate regime.

Sectoral approaches will always remain a second-best solution. A more comprehensive climate policy is more efficient economically and more effective environmentally. But with so much at stake no options should be left off the table. Sectoral approaches could be used to complement, but not to supplant, a global climate arrangement.

Climate change is an unprecedented challenge, and no simple solutions exist. The World Resources Institute has always believed that the best way to shape smart policy is to get the facts right. We hope that this report and the analysis it presents will help policymakers understand more easily the potential and the limitations of sectoral approaches to climate policy.

JONATHAN LASH
PRESIDENT
WORLD RESOURCES INSTITUTE

EXECUTIVE SUMMARY

The concept of sector-based climate agreements has become a staple of climate policy discussions in recent years, in part perhaps because of the daunting difficulty in negotiating a comprehensive climate agreement for the post-2012 period. Faced with the technical complexities of sectors such as forestry, the political sensitivities and competitiveness concerns of trade-exposed industries such as steel, and the political challenges in persuading major developing countries to take on more comprehensive climate commitments, there is an obvious appeal in trying to address the problem in a more piecemeal manner, or in alternative fora.

There is an irony in this. Negotiations for the first commitment period of the Kyoto Protocol were characterized largely by the unwillingness of most Parties to engage in more detailed discussion of specific approaches to reducing emissions. Better, they argued, to accept national targets and then leave individual countries to work out for themselves how to meet those targets efficiently and in line with national circumstances and priorities. What, then, could have persuaded them to change their minds?

SECTORAL APPEAL

Proponents of sector-based agreements point to several potential advantages. First, sectoral cooperation holds the potential to *increase participation* in international efforts to control GHGs. Although the Kyoto Protocol is comprehensive in scope, the lack of commitments for emerging economies and the non-ratification of the United States and Australia mean that it meaningfully covers less than 27 percent of global anthropogenic GHG emissions—mainly those from Canada, Europe, Japan, and Russia. At a sectoral level, more countries might be able to contribute to climate mitigation in part because sector agreements may be more politically manageable (though technically very demanding) across North-South lines. While developing countries will likely be reluctant to agree to economy-wide emission limits, they may be open to adopting targets, standards, or harmonized policies at the sector level. This may be due to factors such as increased institutional capacity, easier monitoring, and higher cost-certainty at the sector level.

Second, sectoral agreements could help alleviate concerns about *international competitiveness*. The sense among some stakeholders is that it is inappropriate for internationally competitive sectors (e.g., steel) in some countries to be bound by emission limits while emissions of their overseas competitors are unconstrained. Thus, sectoral agreements might help provide a more level regulatory playing field in areas where cross-border trade and investment is significant. This could ease some concerns over loss of jobs and economic output that may be caused by restricting GHG emissions. The extent to which such concerns are eased would depend on the ambition of the sector agreements, whether similar agreements were made for competing products, and other factors. A closely related concern is that agreements that do not cover all major emitters may lead to cross-border emissions, known as *leakage*. By applying policies and their related costs more evenly across countries in certain carbon-intensive and trade-exposed sectors, sectoral agreements may minimize the relocation of production facilities in these sectors to less heavily regulated jurisdictions.

Finally, and more generally, sectoral agreements could help the international community *target key problem areas* where technological breakthroughs are especially needed, where capital investment is particularly rapid and long-lived, or where incentives to constrain emissions are inadequate. This might include electric power, transport, and land-use change and forestry, among others.

Underlying all of these potential advantages is an expectation that breaking the challenge of climate policy down on a sector-by-sector basis will present a more manageable task for negotiators—either by removing more difficult aspects of climate mitigation from discussion altogether, or by allowing them to be addressed separately.

THE SEARCH FOR MEANING

Can sectoral agreements help us do all this? What makes it hard to say is that there are almost as many definitions of the term "sector" as there are advocates. These may range from activities as well-defined as iron and steel production to sweeping categories such as power generation or land use, land-use change and forestry (LULUCF), which can represent the vast majority of emissions in many countries. Definitions of sectoral agreements include voluntary initiatives within a particular industry (such as that of the International Aluminium Institute) and workshops for exchanging experience such as those under the auspices of the Asia-Pacific Partnership on Clean Development and Climate. They also include baseline and crediting-based approaches (such as an extension of the Clean Development Mechanism), negotiated agreements, mandatory caps, and sweeping technology mandates.

Finally, it is important to distinguish between agreements in which the "sectoral" component is a question of the *scope* of the policy or activity in question (e.g. limiting coverage to one sector as opposed to negotiating an economy-wide agreement), and those in which the sector itself (meaning its constituent companies or representative bodies) is an actual negotiating partner in designing policies. The Asia-Pacific Partnership takes this latter approach, as does the E.U.'s ACEA agreement for automobile efficiency. Of course, any significant policy will have industry input as well as lobbying—witness for instance the intense activity surrounding the national allocation plans under the E.U. emissions trading system (ETS)—but this is distinct from giving industry a formal seat at the table.

Arguably, a term that means so much means nothing at all. In this report we have remained fairly inclusive, though as our focus is on government policy we have given limited consideration to purely voluntary industry measures. Nevertheless, this variety is important to keep in mind.

WHAT ARE SECTORAL APPROACHES MEANT TO ACHIEVE?

Sectoral approaches are advocated for a wide range of reasons. In some cases the issue is emissions from the end use of widely traded energy-consuming products. In other cases there are real problems of attribution or genuinely different technical issues (e.g., aviation, LULUCF). In still others there are sectors that could easily be included in a comprehensive agreement in principle, but which argue for separate treatment in practice. Finally, there is the need to target emissions from rapidly growing sources in countries that are not yet ready to make broader commitments.

One of the most common reasons for proposed sectoral agreements is concern over competitiveness. Their potential advantage is that they will encompass more players from more countries than would be engaged through a comprehensive agreement. For sectors in Annex I countries facing increased costs from emission limits, this has the potential to level the playing field somewhat with their competitors from non-Annex I countries. However, depending on what measures are actually implemented, they may or may not help deal with competitiveness issues.

Competitiveness is a tricky concept. Some competitiveness impacts might legitimately worry countries, particularly if the net impact is to simply "offshore" emissions to jurisdictions without emission controls, in other words, trigger carbon leakage. However, climate policy is *supposed* to put carbon-intensive products at a competitive disadvantage, and a policy framework that seeks to avoid any such competition between products and processes risks being somewhat redundant. In any case, sectoral policies can be designed to minimize international leakage while maintaining downward pressure on highly emitting sectors.

WHERE MIGHT SECTORAL APPROACHES BE VALUABLE?

While a range of sectoral initiatives or agreements may be useful, it is apparent that many sectors and activities that emit large quantities of emissions are not especially conducive to international cooperation. Considerations such as international competitiveness, uniformity of products/processes, and concentration of actors are likely to influence whether sectoral agreements or other initiatives are feasible or appropriate. Given the variety of possible sectoral approaches and the varied reasons for undertaking them, any generalized assessment is likely to be incomplete. However, certain characteristics are clearly important in resolving specific concerns. For instance, measures to deal with competitiveness impacts are likely only applicable where international trade plays an important role. The sector-by-sector evaluations from Section 4 are summarized in Table 1. (See Section 4.2 for discussion of these criteria).

A *Sector-Only* approach to international cooperation is not likely to be desirable or feasible. A purely sectoral approach would leave international climate policy without a strong "center of gravity" upon which other initiatives or agreements could build. Such a center of gravity is particularly important if nascent international emission markets are to flourish. A reasonably robust comprehensive agreement covering all or most sectors and gases from some but not all countries—accompanied by special sectoral provisions and/or additional agreements to engage other countries—offers greater promise than a sector-by-sector approach. As the cooperation models in Section 2 show, the choice between a "comprehensive" or "sectoral" approach is a false one, as most approaches involve both comprehensive and sectoral agreements.

There are a variety of ways to incorporate sectoral considerations into an international climate policy framework. These include the *Addition*, *Complementary*, *Carve-Out*, and *Integration* models, which are explained in detail in Section 2. All of these are compatible with one another and some are already being used in the current policy framework. Which model of cooperation is most desirable depends on the characteristics of the particular sector.

For those sectors where international cooperation seems appropriate and feasible, there is no single policy approach that is most likely to foster international cooperation. Some sectors are conducive to targets and trading, whereas others that involve standardized products or commodities may be amenable to harmonized standards. Ideally, the choice of sectors and policy

TABLE 1 | SUMMARY OF SECTOR ANALYSIS

SECTOR	GHG EMISSIONS ISSUES	SHARE OF GLOBAL INTERNATIONAL EXPOSURE	CONCENTRATION OF ACTORS	UNIFORMITY OF PRODUCTS/ PROCESSES	GOVERNMENT ROLE	GHG MEASUREMENT / CALCULATION ISSUES	GHG ATTRIBUTION
Electricity & Heat	24.6%		–	+	–		
Transport	13.5%						
Motor Vehicle Manufacture	9.9%	+	+	+	+		
Aviation	1.6%	+	+	+		+	+
Industry	21.1%						
Chemicals	4.8%	+	–	–			+
Cement	3.8%		+	+			
Steel	3.2%	+	+	+			+
Aluminum	0.8%	+	+	+			+
Buildings	15.4%		–	–	+		
Agriculture	14.9%		–	–	–	+	
Waste	3.6%		–	+	–	+	
Land-Use Change & Forestry	18.2%			–	–	+	

Notes: Sectors shown do not comprise 100 percent of global emissions, nor are all sectors mutually exclusive. A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is mixed, ambiguous, or not relevant.

responses should be crafted to maximize the benefits and minimize the disadvantages of sectoral cooperation discussed in Sections 1.1 and 1.2.

CONCLUSIONS

There are no simple solutions to addressing global GHG emissions, and sectoral solutions do not offer a panacea. A sectoral perspective can be helpful when considering the future evolution of the international climate policy framework. Perhaps most importantly, sectoral analysis helps illuminate which sectors—and which activities, fuels, and processes within sectors—are contributing most to the buildup of GHGs in the atmosphere. Understanding emissions in this manner, as well as the range of other attributes that characterize a given sector, can help policymakers and investors focus on areas of critical importance and shape effective response strategies. However, this does not mean that there is always a case for *international sectoral cooperation*. The main policy findings and conclusions with respect to international sectoral cooperation are summarized below.

Future policy discussion needs to be much more specific in discussing "sectoral agreements"

The term "sectoral" as applied to policy design has become so widely used that it is of limited use as a category. Mandatory emission caps, voluntary industry initiatives, crediting mechanisms, and other policy structures have strengths and weaknesses inherent more to the type of policy instrument chosen than to the fact of being applied to a specific sector. The term "sector" is similarly used to describe both discrete economic activities (e.g., cement production, oil refining) and large and diverse sets of human activity (e.g., transport, land-use change). We propose that terms for specific types of action—sectoral crediting, mandatory sector emission caps, technology standards, etc.—be used in describing policies. Below, where we refer to "sectoral approaches" we intend to make more generic comments.

Sectoral approaches should be used with caution

In general, there is strong reason to prefer more comprehensive approaches over a sector-by-sector breakdown. For a given level of ambition, dividing climate effort into sectoral approaches will tend to increase cost, reduce transparency, and increase the negotiating burden for governments.

Three concerns are particularly prominent:

- There is a sharp information asymmetry between governments and sector representatives, which can make negotiating appropriate targets difficult. Markets are generally a better means of identifying true costs and abatement opportunities than government-industry negotiations. Whereas under a comprehensive approach targets can be set with reference to an environmental goal, sectoral agreements leave governments to make difficult decisions as to the appropriate level of effort from each sector.
- An efficient response to the climate challenge will include displacement of some inherently emission-intensive products and processes by less emission-intensive alternatives. Policy design that weakens this competition between products will raise the cost of emission abatement. Sector agreements therefore should not be a means of relieving the pressure on a particular emission-intensive product relative to competing products.
- There is a strong political imperative to see the climate process driven primarily by the environmental goal of keeping climate change at acceptable levels. Relying heavily on carving out specific sectors for separate agreements makes it extremely difficult to maintain this focus.

Governments should temper inclinations to carve out a sectoral agreement for any emissions that prove remotely challenging; otherwise the system moves toward a *Sector-Only* approach, with its attendant difficulties.

Sectoral crediting approaches may be challenging in sectors sensitive to international competition

Some commentators have suggested that crediting mechanisms applied at the sector level (such as a sectoral application of the Clean Development Mechanism, or a "no regrets" cap) might abate competitiveness concerns by drawing all competitors from a sector into a single system. The opportunity cost of increasing emissions is made notionally the same in both developed and developing countries. However, it is not clear that this addresses the underlying concern of competitiveness: that the cost profiles of producers under a genuine emissions cap are different from those under "no regrets". Nor is it clear that developed countries will have the political appetite for enabling significant net financial transfers through a carbon trading mechanism to international competitors in globally traded sectors. Accordingly, sectoral crediting mechanisms and no-lose targets seem to be most appropriate for domestically oriented sectors such as electricity and buildings, which are addressed in more depth in Section 4.

Technology approaches have considerable potential, and may be negotiated without direct sector involvement

Vehicle efficiency standards, renewable energy mandates, appliance standards, collaborative research and development (R&D), and similar initiatives fall under some usages of the term "sectoral agreements". These initiatives offer considerable scope for contributing toward climate protection efforts, and international coordination can be beneficial—for instance, in spreading the cost of R&D efforts, or in gaining economies of scale for emerging technologies such as wind turbines or hybrid vehicles. Conversely, detailed international negotiation among governments is not essential to implement such measures. Most OECD countries and many developing countries already have targets for renewable energy technologies. All benefit from the economies of scale that the others bring, but each country established their own systems independently. Further consideration is needed to determine under what conditions more explicit international collaboration is useful.

Both the UNFCCC and external processes have a potential role as fora for sectoral approaches, but the greater negotiating burden may prove challenging

Specific arrangements are made for certain sectors under the UNFCCC and Kyoto Protocol, in particular for bunker fuels (air and sea transport) and for land-use change and forestry. However, other kinds of specific treatment for sectors have been resisted as unduly compromising the rights of sovereign Parties to choose how to reduce emissions. It is plausible that the UNFCCC may introduce recognition for sectoral approaches agreed in other fora. However, this raises questions of equity and inclusiveness for Parties to the UNFCCC that are excluded from these alternative fora. For instance, countries outside the G8 may resent the use of G8 processes as the venue for defining new technology agreements. The negotiating burden of too wide a use of sectoral approaches may also be excessive. Finally, less comprehensive coverage within a major climate agreement may remove some of the potential for trade-offs between sectors that make agreements possible. An additional question is whether "sectors" as such—i.e., groups representing the industry itself—have a place at the negotiating table. Under a UNFCCC structure only governments are negotiating Parties. Some approaches, such as the Asia-Pacific Partnership, have included companies or other industry representatives as partners in negotiation. However, this approach has yet to produce significant results by which it might be judged.

1

INTRODUCTION: INTERNATIONAL SECTORAL COOPERATION

International cooperation under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol faces major challenges. On the one hand, many developing countries are not yet prepared politically or economically to take on emission reduction commitments. On the other, many developed countries are sensitive to competitiveness impacts on key economic sectors of potential future binding commitments. Some sectors, such as steel, are politically sensitive (in that they are major employers in politically influential regions) and subject to stiff international competition. Others, such as aviation, are so international in scope that individual countries have difficulty addressing them with national-level policies alone.

In response to these concerns, many analysts and governments have expressed increasing interest in "sectoral" cooperation.[1] To date, no single model for a sectoral approach has emerged. Rather, existing ideas and proposals differ with respect to the basic policy and design assumptions. This report evaluates sector-based approaches to future international cooperation on climate change. In doing so, the concept of "sectoral cooperation" is construed broadly to encompass almost any agreement or other cooperation between governments that attempts to address emissions, technologies, or processes associated with a particular economic sector. We do not in this report give much consideration to voluntary sectoral initiatives. While companies may organize themselves at a sectoral level to implement specific emission reduction measures, these approaches are subject to limits that are due more to their voluntary nature than to their sectoral organization. Nevertheless, it is worth remembering that the term "sectoral cooperation" or "sectoral approach" is so broadly inclusive in its definition that it can often cause confusion.

Sectoral cooperation is not entirely new. Although the Kyoto Protocol covers most greenhouse gas (GHG) emissions and absorptions from its industrialized country Parties, the Protocol has adopted special sectoral provisions for the international aviation and land-use change and forestry sectors. Outside the UNFCCC framework, six countries have formed the Asia-Pacific Partnership on Clean Development and Climate. This initiative has not yet produced any tangible agreements or commitments, but it is focused on expanding clean energy trade and investment across eight specific sectors, including power generation, steel, and cement.[2] More broadly, support for sector-specific approaches to addressing worldwide GHG emissions seems to be growing.

International sectoral cooperation on climate change is a complex topic. The sheer number of sectors and policy approaches create a wide array of possibilities. This report identifies the main issues that policymakers are likely to confront when considering sectoral cooperation and the tools available to address those issues.

1.1. WHY SECTORAL COOPERATION?

Sectoral cooperation is typically advanced for a series of reasons. First, sectoral cooperation holds the potential to *increase participation* in international efforts to control GHGs. Although the Kyoto Protocol is comprehensive in scope, the lack of commitments for emerging economies and the non-ratification of the United States and Australia mean that it meaningfully covers less than 27 percent of global anthropogenic GHG emissions—mainly those from Canada, Europe, Japan, and Russia.[3] At a sectoral level, more countries might be able to contribute to climate mitigation in part because sector agreements may be more manageable across North-South lines. The expectation among some is that by targeting specific sectors—like transport or power generation—more appropriate and tailored agreements could be reached among key countries, helping to eventually drive a global decline in emissions. While developing countries will likely be reluctant to agree to economy-wide emission limits, they may be open to adopting targets, standards, or harmonized policies at the sector level. This may be due to advantages such as increased institutional capacity, easier monitoring, and higher cost-certainty at the sector level.[4]

Second, sectoral agreements could help alleviate concerns about *international competitiveness*. The sense among some stakeholders is that it is inappropriate for internationally competitive sectors (e.g., steel) in some countries to be bound by emission limits while emissions of their overseas competitors are unrestrained. Thus, sectoral agreements might help provide a more level regulatory playing field in areas where cross-border trade and investment is significant. This could ease some concerns over loss of jobs and economic output that may be caused by restricting GHG emissions.[5]

A third and related concern is that future GHG limitation agreements that do not cover all major emitters may lead to cross-border emissions *leakage*. In its review of this issue in the context of the Kyoto Protocol, the Intergovernmental Panel on Climate Change (IPCC) concluded that "relocation of some carbon-intensive industries to developing countries and wider impacts on trade flows in response to changing prices may lead to leakage in the order of 5–20 percent."[6] In other words, the worst case (20 percent leakage) suggests that a 5 percent reduction in GHG output in the industrialized world is equivalent to a 4 percent reduction once the consequent increases in developing world emissions are accounted for. Although not completely undermining the environmental goal, this leakage would likely be concentrated in a handful of politically sensitive sectors—a problem which could be addressed through international agreements in those sectors. Such agreements could, at least in theory, cover all the significant emitting countries, thereby stemming leakage.[7]

Finally, and more generally, sectoral agreements might help the international community target key problem areas where technological breakthroughs are especially needed or where incentives to constrain emissions are inadequate. This might include electric power, transport, and land-use change and forestry.

1.2. CHALLENGES

There are no simple solutions to addressing global GHG emissions, and sectoral solutions do not offer a panacea. International sectoral cooperation faces several challenges. First, sectoral cooperation could entail complexity and transaction costs that are prohibitively high. To take an extreme case, if sectoral agreements replaced a comprehensive approach entirely, achieving anything near full coverage of global emissions could require many agreements, some of which may be highly technical and difficult to negotiate.[8] If there were a comprehensive agreement, the advantages of excluding a sector from that agreement would have to be weighed against the additional burden of negotiating a separate accord for that sector.

Second, sector-specific cooperation could reduce cost-effectiveness.[9] In general, comprehensive agreements* that cover all sectors—either in terms of targets and trading or a taxation system—would be expected to be more cost-effective than sector-specific standards or targets, as they allow for reductions to occur in the sectors of the economy where the costs are lowest, rather than mandating reductions in specific sectors. It might be possible to link different agreements that allowed for emissions trading but, as will be seen, not all sectors are amenable to emission targets imposed multilaterally.

Third, environmental effectiveness might also be harder to achieve. It would not always be possible to establish sectoral agreements that provide the full range of incentives to reduce emissions. For instance, a motor vehicles agreement that was focused on improving fuel efficiency would do little to discourage driving or promote alternative transport modes or fuels. By contrast, when countries face comprehensive requirements, they are encouraged to seek reductions by any means possible. Inter-sectoral substitution effects might also present environmental concerns. For instance, stringent requirements in one sector might lead to increased emissions in other sectors that produce substitute products (e.g., for building materials), yet those substitute products may produce more GHGs either through their production or subsequent life cycle. Alternatively, sectoral agreements that are less stringent might shelter some inherently high-emitting sectors (e.g., cement and steel), thereby inhibiting substitution toward cleaner products or processes.

* "Comprehensive agreement" here and throughout refers to an agreement that covers all or most emissions from participating countries. The Kyoto Protocol is an example of a comprehensive agreement, although it is comprehensive only in its coverage of Annex I emissions, and has a large number of Parties that are not subject to emission constraints.

Fourth, and more generally, sectoral agreements are more intrusive than some alternative approaches that deal with multiple sectors simultaneously. One characteristic of the Kyoto Protocol that fostered diplomatic consensus was that it did not unduly interfere with sensitive domestic policy decisions (e.g., in the electricity or agriculture sectors). Rather, individualized national emission targets were agreed upon, with governments free to achieve their targets in any way they deemed appropriate, including using regulatory approaches crafted to their own national circumstances.

Like any approach to addressing climate change, sectoral approaches have both advantages and disadvantages. For instance, on the one hand, sector agreements may be easier to negotiate than complex comprehensive agreements. On the other hand, there will be many more sectoral agreements required. A more detailed examination, presented below, might help illuminate ways in which the advantages can be harnessed and disadvantages avoided.

The sheer diversity of measures covered by the term "sectoral approaches" makes it difficult to generalize about their relative strengths and weaknesses. In this report we will explore how the environmental effectiveness, economic efficiency, and ease of negotiation of sectoral approaches compare with more comprehensive agreements. We will attempt to identify which sectors are most conducive to being singled out in this way. And we will explore how sectoral approaches, where they are used, interact with comprehensive agreements.

1.3. ORGANIZATION OF THIS REPORT

Section 2 describes and evaluates five "models" of international sectoral cooperation, focusing on how the climate regime might evolve to appropriately account for sectoral considerations. For instance, would a global regime emerge whereby GHG mitigation in each sector is dealt with discretely (a *Sector-Only* model)? Alternatively, would sectoral agreements exist side-by-side with a more comprehensive agreement covering all or most sectors? Examples from the present climate change regime as well as proposals for the post-2012 period are used to illustrate different ways in which sectoral approaches can be developed.

Section 3 discusses the different forms that sectoral commitments might take. Options include emission targets of various kinds, fiscal policies, and technology standards. This section also addresses further issues that accompany policy considerations, such as monitoring, reporting, market mechanisms, compliance, institutional arrangements, and so forth. The treatment of different policy approaches is relatively brief, given coverage elsewhere in the climate policy literature.

Section 4 provides a sector-by-sector analysis, building on previous work by WRI.[10] Each sector (or sub-sector) is evaluated across a range of criteria, with the overall aim of assessing the appropriateness and conduciveness of international cooperation in a given sector. This section also describes what policy approaches, described in Section 2, might be appropriate for particular sectors.

Section 5 summarizes our thoughts and provides conclusions.

NOTES

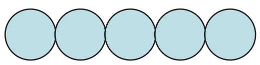
1. *See e.g.*, Samaniego and Figueres, 2002 (proposing a "sector-based CDM"); Schmidt et al., 2004:11 (proposing a crediting system "where a specific policy in a developing country would be eligible" to generate credits.); Bosi and Ellis, 2005 (discussing "sectoral crediting mechanisms"); and CCAP, 2005 (advocating a "sectoral pledge approach").
2. For more information on the Asia-Pacific Partnership on Clean Development and Climate see http://www.asiapacificpartnership.org/ and http://www.state.gov/g/oes/climate/app/.
3. WRI, 2005. CAIT, 3.0. This calculation uses 2000 emission figures, and includes all six Kyoto gases.
4. *See e.g.*, Bosi and Ellis, 2005: 10; Philibert, 2005: 11; Pew, 2005: 15; Schmidt et al., 2005: 1-2.
5. *See e.g.*, Bosi and Ellis, 2005:12-13, 39; Philibert, 2005: 11; Pew, 2005: 15; Schmidt et al., 2005: 2.
6. IPCC, 2001.
7. IPCC, 2001c: 10, 11, 542-43. *See also* Philibert, 2005: 11.
8. *See e.g.*, Philibert, 2005: 11.
9. *See e.g.*, Philibert, 2005: 11; Schmidt et al., 2005: 2.
10. Baumert et al., 2005. See Part II.

2

FIVE MODELS OF SECTORAL COOPERATION

When governments or observers discuss "sectoral approaches" or "international sectoral cooperation" they may mean different things. What is meant by these terms with respect to the evolution of the climate regime? This section examines five different ways in which sectoral cooperation could play a role in the international climate policy framework.

2.1. SECTOR-ONLY MODEL

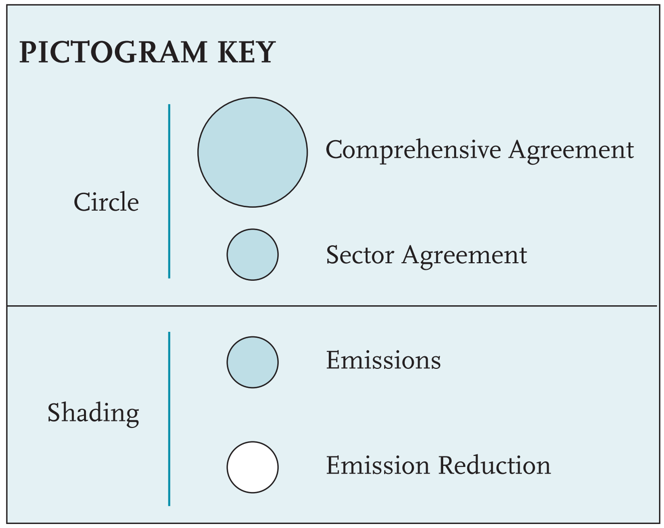


2.1.1. Description

A *Sector-Only* model would entail the negotiation of multiple sector agreements that, when taken collectively, cover a significant share of total emissions (or processes giving rise to emissions). Under this model, an agreement that is comprehensive (or nearly comprehensive) in covering emission sources and sinks—such as the Kyoto Protocol—would not exist. Here, only sectoral cooperation would be present. Such an approach would entail a series of agreements tailored to the particular circumstances of individual sectors, in a bottom-up fashion. Each agreement would be separate from one another, although linkages between them might be created, for example, through offset and emissions trading mechanisms. Most likely, key stakeholders such as the major emitters in a given sector would play a role in shaping the form and substance of these agreements.

2.1.2. Evaluation

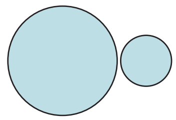
A successful *Sector-Only* model is difficult to envision. Perhaps most significantly, this approach would require a large number of agreements, or a single, extremely complex agreement. In addition, as the sector-by-sector analysis in Section 4 illustrates, there is no common template for sectoral cooperation that could be used across many sectors; rather, each sector has unique characteristics and sector-specific agreements would likely employ a range of different policy approaches.



A *Sector-Only* model would need to overcome each of the challenges of sectoral cooperation discussed in Section 1.2. In addition to complexity, this list includes concerns over cost-effectiveness and environmental effectiveness. Given the range of different kinds of agreements that would characterize a *Sector-Only* approach, it would be hard to achieve linkages between those agreements that promote abatement where it is least costly across all sectors. Similarly, such a structure would mute competition *between* sectors, which may mean that opportunities to shift to less carbon-intensive materials and processes may be missed. Likewise, it would be hard to provide the full range of incentives to reduce emissions. This model also has the highest level of intrusiveness into the domestic policy affairs of national governments.

Overall, when considering the future design of global climate agreements, the *Sector-Only* model represents one extreme. The other extreme would be a single comprehensive accord that covers all GHG emissions from all countries. Both extremes seem unlikely. Instead, a more nuanced approach, involving one or more of the models discussed below, is more likely to successfully curb global GHG emissions in a practical and cost-effective manner.

2.2. ADDITION MODEL



2.2.1. Description

An *Addition* model would entail the progressive expansion of an inclusive climate regime on a sectoral basis. This model differs from *Sector-Only* in that it involves a comprehensive agreement (large circle) that covers all or some sectors for one group of countries (probably industrialized ones). This agreement would then be supplemented by sectoral agreements (small circle) that engage additional countries. For instance, an agreement with a scope similar to the Kyoto Protocol (i.e., covering all sectors in most industrialized countries) might be supplemented with one or more additional sectoral agreements (e.g., in electricity) that apply to countries *not* covered by Kyoto. This could enable a gradual expansion of the system to cover more countries and sectors, and therefore more emissions.

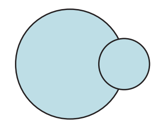
2.2.2. Evaluation

This approach has some commonalities with the World Trade Organization's General Agreement on Trade in Services (GATS).[1] Under the GATS, countries may undertake commitments that apply to all sectors of the economy (i.e., "horizontal commitments"). However, where such an economy-wide commitment has *not* been made, countries are encouraged to progressively make "sector-specific commitments" (e.g., to remove market access limitations). This approach has the advantage of enabling progressive expansion of the system.

An *Addition* model may not be well suited to sectors and products directly exposed to international competition. The reason is that those sectors and products would be covered under two different agreements—one comprehensive and one sectoral—that do not overlap (i.e., one country would only be party to one agreement). Without a given sector being covered under a common global sectoral framework, it might be more difficult to create a level playing field. Accordingly, this approach may work better for "domestic" sectors, such as electric power production, buildings, waste, and certain elements of the agriculture and forestry sectors.

One difficulty is that once a comprehensive agreement has been established, incentives for "progressive expansion" may be weak. Two elements could help partially overcome this dynamic. First, supplementary agreements might be negotiated at the same time as a comprehensive agreement. Thus, Parties could allocate perceived costs and benefits in a single negotiation, as is already commonly done (although in this case, the sectoral agreement might simply be considered part of the comprehensive one, rather than a separate accord). Second, the linking of emissions trading systems between the comprehensive regime and new supplementary systems might encourage some countries to subject sectors to emissions or other constraints. This could be the case for countries with low abatement costs.[2]

2.3. COMPLEMENTARY MODEL



2.3.1. Description

Under a *Complementary* model, certain sectors might be covered by two distinct agreements simultaneously, but in a complementary manner. One agreement would likely be a comprehensive agreement (large circle) which covers all or most emission sources (e.g., similar to the Kyoto Protocol). Subsequent agreements (small circle) would be sector-specific and contain provisions that complement the broader agreement, without unduly interfering with it. This model differs from the *Addition* model in that some countries here would participate in both agreements. One possibility is that only some countries (e.g., industrialized ones) would be subject to comprehensive GHG limitations, but major emitting countries would be subject to certain complementary sectoral agreements.

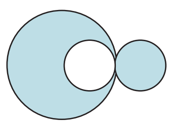
In the transport sector, for instance, an agreement on vehicle efficiency standards could coexist with an agreement that establishes economy-wide limitations on GHG emissions. The sector agreement would require cleaner vehicle technologies, with associated emission reductions that would help achieve compliance under the comprehensive agreement. Yet the comprehensive agreement could also cover transport emissions and therefore stimulate a different set of transport policy incentives—such as public transit or biofuels.

2.3.2. Evaluation

One purpose of this model is to address the likely reality that a comprehensive agreement, if negotiated, is unlikely to include all major countries. Large developing countries—especially China and India—are unlikely to agree to national emission caps, for a variety of reasons.[3] In the coming years, many governments will try to persuade the United States and Australia to join a comprehensive emission limitation (and trading) system, but there are no guarantees as to what future climate policy will look like in these countries.

Thus, like the *Addition* model, a *Complementary* model could enable countries that are not included in a comprehensive agreement nevertheless to participate internationally in GHG abatement. Unlike the *Addition* model, however, a *Complementary* model seems more appropriate for certain international sectors because it would provide a common global framework under which all key countries would engage. This might include technology or performance standards that apply to products—such as motor vehicles and appliances—that are traded internationally. Common energy (or GHG) efficiency standards could help address competitiveness issues and, for those countries participating in a comprehensive agreement, help meet emission limits. Perhaps most significantly, agreements in these areas would have non-climate justifications; namely, they would reduce costs and encourage energy conservation.

2.4. CARVE-OUT MODEL



2.4.1. Description

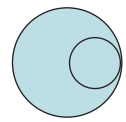
A *Carve-Out* model involves a single comprehensive agreement that would *exclude* particular sectors. A "carved out" sector could then be the subject of a separate agreement. This approach is virtually identical to the *Complementary* model, with the notable difference that here the emissions targeted by the sectoral agreement are excluded from the comprehensive accord. The Kyoto Protocol has adopted a *Carve-Out* approach toward emissions pertaining to international aviation and marine fuels ("bunker fuels"), which are not included in industrialized country emission caps.[4]

2.4.2. Evaluation

This approach provides a means for dealing with certain sectors that may be interfering with the negotiation of a comprehensive accord. Such troublesome areas would accordingly be excluded from a larger agreement and dealt with discretely on a global basis.

As experience with international transport (aviation and marine) emissions suggests, the *Carve-Out* approach might be applicable to sectors where emissions are difficult to measure and attribute. It might also be appropriate for sectors where international competition is fierce and, accordingly, it makes sense only to deal with those emissions on a global basis (e.g., through product, technology, or emission standards). At the same time, governments should temper inclinations to continuously carve out any emissions that prove remotely challenging; otherwise the system moves toward a *Sector-Only* approach, with its attendant difficulties. It is also worth noting that, so far, carving out bunker fuel emissions has not led to successful mitigation in that sector.

2.5. INTEGRATION MODEL



2.5.1. Description

Under an *Integration* model, special sectoral provisions could be integrated within an otherwise comprehensive agreement. The Kyoto Protocol employs an *Integration* approach in the land-use change and forestry sector (LUCF). Emissions and absorptions from this sector are not carved out of the agreement, nor are they subject to a distinct agreement. Instead, they are included in the Protocol but subject to special rules. Subsequent decisions of the Parties specify which kinds of emissions and absorptions from LUCF are included in Kyoto, and what additional accounting safeguards are required.[5] Should the Kyoto Protocol's Clean Development Mechanism (CDM) evolve into a sectoral crediting mechanism (see Section 3.2), as suggested by some, this would also constitute an integration of sectoral policy provisions into the Protocol.

2.5.2. Evaluation

The *Integration* model is about fashioning sector-specific rules within a broader agreement to enable differentiated sectoral treatment or other guidance on implementation. The difference between this approach and the preceding ones is partly procedural and partly substantive.

From a procedural point of view, the preceding three models (*Addition*, *Complementary*, and *Carve-Out*) involved multiple agreements. *Integration* involves only one agreement. Integrating sectoral rules into a comprehensive accord would be more complex, but would also enable governments to make more trade-offs given the wider scope of potential bargaining. An *Integration* approach may also make sense when new sectoral rules expand existing policies already embedded in an established agreement. Such would be the case if the CDM were expanded to include an explicit sectoral dimension.

From a substantive dimension, an *Integration* approach is more likely to be appropriate for matters such as definitions, accounting procedures, and other measures that fall short of articulating a new policy approach. It is difficult to imagine, for instance, how an agreement on automotive technologies would be integrated into the UNFCCC and Kyoto Protocol framework. Such an agreement would implicate new interests and actors and likely require an alternative negotiating forum. On the other hand, one can imagine specifying rules that apply to emissions from international transport activities (e.g., on accounting, measurement, global warming potential, etc.) and that could be accommodated within the UNFCCC and Kyoto system.

NOTES

1. *For a description, see e.g.,* Matsushita et al., 2003.
2. Two cautions, however, are worth noting. First, as a procedural matter, agreement among all Parties to the comprehensive agreement would likely be required. Second, as a substantive matter, there is a significant risk of enticing countries by granting hot air (i.e., excess emission allowances via generous emission targets).
3. There are two principal reasons that developing countries are unlikely to adopt emission caps: lack of capacity to implement and comply with such commitments, and technical limitations on the ability to reasonably forecast emissions. *See* Baumert et al., 2005: Chapters 3 and 7.
4. Kyoto Protocol, 1997. Gases covered under the Montreal Protocol on Substances that Deplete the Ozone Layer are also carved out of the Protocol, in that they are not listed in Annex A of the Protocol.
5. Kyoto Protocol, 1997. *See* Arts. 3.3 and 3.4.

3

POLICY DESIGN OPTIONS

Sector agreements could involve different forms of substantive commitments, such as emission targets, technology standards, or policy harmonization. Agreements could be legally binding or non-binding and have various degrees of environmental stringency. Depending on the nature of the commitments, issues pertaining to monitoring, reporting, market mechanisms, compliance, and institutional arrangements also could arise. This section briefly summarizes some policy design options and approaches, with a focus on policy approaches that might be employed and their respective benefits and drawbacks.

3.1. EMISSION TARGETS AND TRADING

There are at least three possible forms of sector targets, each examined below. Such targets are usually proposed in connection with emissions trading, which has the potential to promote GHG abatement where it is least costly. Trading programs can work under any of the target forms discussed here, although the options differ with respect to the ease of trading. The working assumption in this section is that some countries (presumably industrialized ones) have more comprehensive targets. However, even some industrialized countries may seek a sector approach in some cases.

3.1.1. Fixed Targets

The first form of target is a fixed limit on emissions within a particular sector; i.e., a sector-wide emissions cap. This approach would be similar in form to targets adopted in the Kyoto Protocol, although the scope of the target would be confined here to one or more individual sectors. An agreement might involve absolute reductions or limitations on future growth in a particular sector, perhaps with targets differentiated by country. Once fixed sectoral targets were established at the country or entity level, allowable emissions could be tradable.

Fixed emission targets are attractive policy instruments because they can be coupled with emissions trading programs, which can reduce GHG abatement costs (and therefore enable more abatement over the long term). Unfortunately, the principal barrier to adopting fixed targets at the national level also exists at the sectoral level. Namely, in most sectors, it is difficult to predict future emission levels. Uncertainties are especially acute in developing country economies, which tend to be more volatile and vulnerable to external shocks. This makes target setting problematic, since governments and firms cannot evaluate with reasonable certainty the stringency or economic cost associated with a proposed fixed target. Thus, an important question when considering a fixed sectoral target is whether sectoral emissions can be forecast with reasonable accuracy.[1] These projections matter because in growing sectors (and few sectors will admit to declining), targets are generally set relative to an emissions forecast that both constrains emissions and allows for economic growth within the sector.

3.1.2. Intensity Targets[2]

The second approach involves establishing emissions intensities to be achieved in a given sector; i.e., the quantity of emissions per unit of economic output. The measure of economic output would vary by sector, and sectoral intensity indicators would most likely be expressed in terms of physical output, such as emissions per kilowatt-hour or per ton of steel, cement, or aluminum. Countries could agree to achieve certain reductions in their emission rate in a particular sector. Here, each country might have different target emission rates (a *differentiation* approach); alternatively, the agreement might establish single target emissions rate based on a particular high-performing technology or other aspirational benchmark (a *harmonization* approach).

Changes in sectoral intensities tend to be driven by changes in energy efficiency, technologies, and fuels, rather than by physical output (which tends to be uncertain). Thus intensity targets, particularly at the sectoral level, can avoid some of the economic uncertainty associated with fixed targets, because it may be relatively clear *ex ante* what kind of technology, process, or other changes would be needed to meet a sectoral intensity target.

While they alleviate concerns about economic uncertainty, intensity targets are often criticized for their uncertain environmental performance: emissions reductions are ultimately determined by the actual output (e.g., GDP, steel production) of a country rather than by setting a specific level of allowed emissions. However, this critique perhaps overemphasizes the value of the target's form (e.g., absolute or intensity). In fact, environmental outcomes under absolute or intensity targets may be either good or bad, depending on the stringency of the target and the legal nature of the commitment.[3]

However, emissions trading under intensity targets, while possible, is not as straightforward as trading under fixed targets.[4] With fixed targets, the allowable amount of emissions is specified (for a country's sector or an entity within that sector), and these emission allowances can be purchased and sold. This contrasts with intensity targets, where the allowable amount of emissions is a function of output (e.g., tons of steel, electricity, or cement produced), which is not known in advance. Thus, the central challenge for emissions trading is resolving the incompatibility between the metric of a target (a relative amount, e.g., tons of CO_2 per kilowatt-hour) and the metric of a tradable unit (an absolute amount, e.g., 1 ton of CO_2). This can be done either through pre-commitment period output projections or post-commitment period verification of actual output.[5] Either of these methods will transform an intensity target into an absolute quantity of emissions, thereby enabling trading. However, this is achieved at the expense of added complexity and possibly reduced market liquidity (for post-verification trading).[6] In addition, there is not yet enough experience with such an approach to know how markets would respond to this uncertainty, or how serious a challenge it might prove.

3.1.3. Action Targets

A third quantity-based approach for sectoral agreements is action targets. These targets differ from emission caps in that they commit a country to undertake activities leading to a set quantified reduction from business as usual (BAU)—rather than to achieve a given emission level.[7] For example, if a country adopted an action target of "2 percent" for the period 2013-2017, it would need to demonstrate that it had undertaken specific activities that reduced emissions by the equivalent of 2 percent of its actual emissions during this period. In this way, an action target defines the amount of GHG abatement to be achieved. This differs from caps or intensity targets, which define a level of *emissions* (or *emissions per unit of output*) to be achieved during a particular period.[8]

Action targets are potentially attractive to countries that are uncertain about their future emissions growth, or that are more confident in their ability to implement specific measures than in their control over the development of a sector. The main challenge of action targets is similar to baseline and crediting approaches, discussed below. Namely, action targets require a GHG accounting system that defines what constitutes an "emission reduction" as opposed to BAU.

There seems to be no compelling rationale to implement action targets on a sectoral basis, given that this would only constitute a limitation on how a country could undertake abatement. If accounting systems existed in all sectors, it would seem appropriate to allow emission reductions in any sector. This dynamic does not apply to fixed or intensity targets.[9]

3.1.4. Regulatory and Institutional Requirements

A system of emission targets and trading entails significant institutional requirements.[10] Emissions from covered sectors must be measured and reported regularly to some central body. Systems for measurement and reporting must not only be in place, but they must also meet international quality standards. Emission targets, by their nature, require quantitative precision and certain common methodologies across entities participating in the system. Once emissions (or emission intensities) are properly inventoried, a compliance assessment is needed to evaluate whether actual emissions exceeded the emission level allowed under the agreement. Where there is non-compliance, the system must entail a meaningful consequence, in terms of a cost imposed on the non-complying country and/or a withholding of benefits (e.g., suspension of trading rights).

For intensity targets, additional regulatory requirements are needed.[11] In particular, sectoral output (e.g., production of electricity, steel, or aluminum) must also be subject to measurement, reporting, and verification. Although formal reporting requirements on such factors may be additional, in practice these data would likely be gathered even under systems using absolute targets.

Many of these accountability mechanisms are prerequisites for a trading system to function properly. Otherwise, a single non-complying entity could undermine the efficacy of the entire system. Other mechanisms are also needed to support a trading system. For example, countries must create a system of registries to record transfers and acquisitions of tradable units, such as the system developed under the Kyoto Protocol.[12]

Overall, a targets and trading approach has significant virtues with respect to transparency and cost-effectiveness but also implementation challenges in the areas of monitoring, reporting, and compliance. This is a challenge particularly in developing countries where institutional capacity—including financial, technical, and administrative dimensions—may be insufficient.

3.2. CREDITING MECHANISMS

3.2.1. Baseline and Crediting

A system of "baseline and crediting" could be an important policy option at the sector level.[13] A baseline is a level of *future* sectoral emissions (or emissions intensity) against which *actual* levels are later compared. Where actual performance is superior to the baseline, tradable emission credits would be generated and accrue to the government or private entities. This policy option is predicated on the adoption of binding targets by some countries (either at the sectoral or national levels). These countries—probably industrialized countries—would constitute the source of demand for credits on the emissions market.

Crediting mechanisms operate by incentivizing emission reductions in a manner analogous to the Kyoto Protocol's CDM.[14] The key distinction is that the CDM is a project-based mechanism and does not yet include explicit provisions under which a country could establish a baseline for an entire sector, although recent decisions suggest that such a development is possible.[15]

Like the CDM, the purpose of sectoral crediting is to reduce the costs of mitigating GHG emissions by allowing reductions to take place where they are cheaper (probably in developing countries).[16] At the same time, this approach could successfully engage a wider range of countries in worldwide GHG mitigation efforts. More countries might be willing to participate in a regime that offers commitments with an "upside" under which they might benefit economically but little "downside" (although there are costs associated with measurement, reporting, institutional capacity building, and the like).

Baseline and crediting has similarities with so-called "no-lose" or "no-regrets" sector targets.[17] Under a no-lose target, a developing country that adopts a target (fixed or intensity) is allowed to sell emission reductions that are achieved below the target (creating an incentive to reduce emissions), but faces no penalty if the target is not met. Of course, "no lose" is something of a misnomer: although economic losses are avoided, the climate does stand to lose when the target is breached. Conceptually, there is one important distinction between a sectoral crediting mechanism and a no-lose sector target. A sector target would be negotiated within a comprehensive agreement at the same time as targets for industrialized countries, whereas a sectoral crediting mechanism (e.g., expanded CDM) might approve sector baselines through an administrative process, analogous to the approval of CDM project baselines. Conversely, they have much in common: each is voluntary, and each generates tradable emission reduction credits if emissions (or emissions intensity) are below a baseline.

3.2.2. Implementation Challenges and Limitations

If a sectoral crediting system is adopted, a range of issues arise with respect to setting baselines, emissions (and perhaps output) measurement, verification, and issuance of credits.[18] In brief, determining baselines is a difficult and controversial undertaking, even at the project level. Sector-wide baselines would in some cases be more difficult, although GHG intensity baselines in certain industrial sectors might be feasible. One open question is whether baselines or no-lose targets would be set by an administrative or executive body (like the CDM Executive Board) on the one hand, or alternatively whether they would need to be the subject of multilateral negotiations among governments.

Proponents of sectoral crediting[19] have argued that by applying a uniform carbon price (and thus a uniform opportunity cost) to GHG emissions, this approach helps alleviate competitiveness concerns. One proposal, for instance, advocates the use of no-lose targets in industrial sectors while stating that the aim is to "promote the use of best practices in internationally competitive industries worldwide [and] . . . achiev[e] a level playing field...."[20] Another analysis states that "sectoral crediting mechanisms will tend to lower competitiveness concerns on the part of those actors that are now covered by a GHG constraint and incur costs as a result" provided that all actors *within* a sector are covered with equal stringency. [21]

Yet crediting mechanisms and no-lose targets maintain the "uneven playing field" that Kyoto critics discuss: entities in one group of (industrialized) countries face emission constraints while competitors in other (developing) countries do not. The fact that developing country producers do not have any cost imposed on them means that expanding capacity in such countries will always remain more attractive than doing so in rich countries. Crediting and no-lose targets may actually further tip the field in favor of developing country producers by providing the option to reduce emissions and sell credits if doing so is economically advantageous (if it is not, they can do nothing). Accordingly, sectoral crediting mechanisms and no-lose targets seem to be most appropriate for domestically oriented sectors such as electricity and buildings, which are addressed in more depth in Section 4.

A final consideration for all kinds of crediting mechanisms is that they depend on a significant demand for credits that arise from these mechanisms. This means that industrialized countries adopt targets that result in large net financial transfers to the sectors covered by the crediting mechanism—whether Chinese steel, Indian electricity or Indonesian forests. It is not clear that the political will to accept such transfers exists in developed countries, where those constituencies that advocate deep emission cuts also prefer domestic action. However, such political will is presumably more likely for sectors that are primarily domestic, such as power, than for those in which the financial transfers would be to international competitors in sensitive sectors such as steel or chemicals. In principle, baselines could be set so as to avoid large net financial transfers. However, uncertainties with projected emissions make such "fine-tuning" of the baseline unlikely to be possible. In practice, active incentives for the developing country would likely be tied to significant financial flows.

3.3. STANDARDS

Standards are a second kind of substantive commitment that could characterize a sectoral agreement. Standards tend to focus on technologies, processes, or products, rather than the resulting emissions.

3.3.1. Different Kinds of Standards

There are various forms of standards. *Technology standards* might mandate the use of a specific technology or process. For instance, a requirement that all or some motor vehicles be equipped with a particular engine technology (e.g., hybrid-electric) would constitute a technology standard. As discussed in Section 4, there are literally thousands of technologies and processes that contribute to or reduce GHG emissions. A sectoral agreement could contain a series of technology standards for a given sector. As with many technology-specific policy options, technology lock-in is a risk, and agreements must be carefully designed to avoid such an outcome. A further concern is that the track record of government policies in picking optimal technologies is not particularly strong.

Alternatively, *performance standards* might be technology neutral. This kind of standard, for example, might require a certain level of energy efficiency in appliances or motor vehicles. A performance standard could be applied at the level of a technology (e.g., refrigerators) or in some cases at the broader sectoral level (e.g., all electric power production). Performance standards can also overlap conceptually with harmonized emissions rates—or, benchmarks—discussed above, which can be viewed as an *emission* performance standard.

Some critics of the Kyoto Protocol maintain that a standard-setting approach, unlike Kyoto, has a self-enforcing quality that would promote compliance and global participation.[22] This dynamic is achieved through "network externalities." For instance, if the U.S. and E.U. enacted automobile performance standards (for domestic production and sale), other countries would find it in their economic interests to also adopt those standards. Otherwise, cross-border trade and investment would be impeded. The catalytic converter is one example of a common technology standard that has achieved widespread global adoption, even though its purpose it to address a local environment problem.[23]

3.3.2. Implementation Challenges and Limitations

An international standard—technology or performance—probably entails less regulatory and institutional machinery at the international level than targets and trading or sectoral crediting mechanisms. This is mainly due to the fact that emissions do not need to be monitored and reported (with the exception of *emissions* performance standards). Further, where monitoring is needed, it tends to be easier—for instance, requirements that new coal plants capture and sequester CO_2 (or be capture-ready) or that new automobiles be equipped with hybrid-electric or other low-emitting technologies. For these measures, enforcement is mainly at the domestic and local levels. In addition, without any trading mechanisms, there is no need to scrutinize international transactions to maintain the system's environmental integrity.

Overall, a standards approach does have implementation and enforcement virtues, along with positive incentives to increase participation in GHG mitigation. However, significant difficulties exist in negotiating the many agreements potentially needed to address emissions across all sectors. As will be seen in Section 4, there are numerous technologies contributing to global GHG emissions. Some of these technologies might need to be phased out entirely. Picking winning and losing technologies in a multilateral negotiating setting might be unworkable. Further, some major sources of GHG emissions—like agriculture and land-use change—may not be conducive at all to technology or performance standards.

3.4. POLICY HARMONIZATION/COORDINATION

3.4.1. Different Kinds of Coordination

Substantive commitments within sectoral agreements could also take other forms, such as agreements pertaining to product taxation, subsidies, or treatment of waste. While such unilateral reforms might be justified, it is also the case that "[i]nternationally coordinated action can facilitate the process of removing environmentally damaging subsidies."[24] For instance, common subsidy reforms could help level the playing field to promote renewable energy technologies.[25]

Other kinds of policy harmonization and coordination might include product recycling requirements (e.g., aluminum) or government procurements requirements (e.g., for low-emission vehicles). Finally, cooperative efforts on research and development of specific technologies—such as carbon capture and storage or nuclear power—might also be considered "sectoral," although they are not the focus of this report.

3.4.2. Implementation Challenges and Limitations

This category is extremely diverse, and some forms of international coordination of this type are already well developed. For instance, the OECD and IEA are important venues for both international collaboration on energy R&D[26] and (somewhat less successfully) on subsidy reform.

3.5. NEGOTIATING FORA

The UNFCCC has always included specific provisions for named sectors. In the case of "bunker fuels"—i.e., fuels for international transport such as air and shipping—this has been a simple exclusion of these emissions from coverage. In the case of LUCF, the sector's complexities have given rise to a number of specific measures, including different credits within the CDM[27] and limitations on the use of forest management activities within Annex I countries toward meeting their targets.[28]

These, however, are effectively complete or partial exemptions of chosen sectors, not measures to actually limit emissions. Could the UNFCCC be a venue for a more proactive framing of sector-based commitments? The post-2012 climate architecture is likely to be a considerably more varied one than in the Kyoto Protocol's first commitment period, as more countries with more markedly differing national circumstances adopt appropriate policies to limit emissions. The cap-and-trade model applied to Annex I Parties under Kyoto will not be appropriate for all major emitters, at least in the near term, so the question of how to accommodate different types of commitments is an important one. It is conceivable that the UNFCCC will take on an additional role as a forum for Parties to present, register, and perhaps even formally review a wide range of policies and measures, which may include sectoral agreements. These policies and measures may be initially negotiated in other fora.

The UNFCCC is a purely intergovernmental forum. While governments routinely solicit the advice of their major industry sectors (and those sectors are generous in giving it), the UNFCCC does not allow for industry representatives to be formal Parties to the negotiations. However, to the extent that Parties use the UNFCCC as a forum for presenting agreements negotiated elsewhere, industry representatives may take on a more active role in negotiating policies. This has been undertaken at a national level in many countries, but has little track record of success at the international level to date.

Using the UNFCCC to recognize agreements brokered in other fora is not fundamentally problematic, and indeed a number of such fora already have such an aim.[29] However, to the extent that such deals take a major role in framing the ambition and shape of a multilateral climate architecture, this approach may be challenged. Since such deals tend to be made among a smaller group of countries, they raise issues of representation for smaller Parties, who are unlikely to appreciate merely endorsing agreements reached elsewhere.

Finally, we must consider the burden on negotiators of a large number of deals. Sector agreements are sometimes advocated on the grounds that they remove some especially contentious activities and interests from blocking a larger deal. However, at the least this remains unproven. Experience with the UNFCCC to date finds that few agreements are reached until a final phase in which Parties are able to make concessions in some areas to achieve wins in another. The more pieces of the puzzle that are given separate treatment, the less scope and incentive there is for countries to work toward such a grand bargain. The question of these negotiating dynamics is one that demands further study.

NOTES

1. *For a more in-depth discussion of setting fixed targets, see* Baumert et al., 2005: Chapter 3.
2. *For an extensive discussion of intensity targets, see* Herzog et al., 2006.
3. *See* Herzog et al., 2006.
4. *See* Kim and Baumert, 2002: 122-124.
5. *See* Kim and Baumert, 2002: 123.
6. Other challenges may also accompany trading under intensity targets, such as devolving tradable units to domestic entities.
7. *See* Baumert and Goldberg, 2005.
8. To illustrate, suppose Country A agrees to an action target (AT) of 5 percent for the year 2015. If Country A's emissions (E) in that year are 100 million tons of carbon (MtC), then the required amount of reductions is 5 MtC (5 percent of 100). It follows that, if emissions are actually 100 MtC in 2015 and the country has demonstrated 5 MtC of domestic reductions, then emissions would have been 105 MtC in the absence of any actions taken to reach the target. In this way, action targets would have the effect of bending the emissions trajectory of a country downward. Baumert and Goldberg, 2005.
9. Compare, for example three hypothetical targets adopted in a country's power sector: (1) a fixed target of 50 million tons of CO_2; (2) an intensity target of 80 units of CO_2 per kilowatt hours; and (3) an action target of 5 million tons of CO_2. These three targets might entail identical levels of stringency and emission reductions. But, by definition, the fixed and intensity targets could only be achieved in the power sector. The action target, since it is denominated in *emission reductions*, could hypothetically be achieved through *any* reductions, not just power sector reductions. For this reason, action targets seem more appropriate as an economy-wide policy instrument, even if the country adopting the target chooses to comply with the target through actions in only one or two sectors.
10. *See* Willems and Baumert, 2003: 24-28. The focus of Section 2.1.4 is on fixed and intensity targets, rather than action targets.
11. *See* Willems and Baumert, 2003: 28-32.
12. Willems and Baumert, 2003: 28.
13. *See e.g.*, Bosi and Ellis, 2005; Figueres and Samaniego, 2002.
14. *See e.g.*, Figueres and Samaniego, 2002.
15. *See* UNFCCC, 2006: 97. FCCC/KP/CMP/2005/8/Add.1 (referring to "a local/regional/national policy or standard" under which a "programme of activities" could be registered as a single CDM project activity).
16. However, if baselines are set stringently, a net reduction in global emissions may be achieved by this approach because actual emission reductions will exceed the number of credits generated.
17. This concept is also referred to as "non-binding targets" with emissions trading. Philibert, 2000.
18. A good source of discussion of these questions in greater detail is Ellis and Baron, 2005.
19. *See for instance* Ward, 2006.
20. CCAP, 2005.
21. Bosi and Ellis, 2005: 12. The definition of sectoral crediting mechanisms used by Bosi and Ellis includes the concept of "binding baselines," which seems to be synonymous with "binding targets" and inconsistent with the concept of crediting as it is widely understood. A target approach would seem to be the only way of alleviating competitiveness issues.
22. *See* Barrett, 2001 and 2002; Benedick, 2001.
23. Barrett, 2001.
24. Pershing and MacKenzie, 2004.
25. Pershing and MacKenzie, 2004.
26. The IEA Implementing Agreements, the International Partnership for the Hydrogen Economy, and the Carbon Sequestration Leadership Forum are examples.
27. Under the CDM, afforestation and reforestation projects are awarded "temporary Certified Emission Reductions" (tCERs), which have a lifetime of 5 years, after which they need to be renewed by demonstration of the ongoing integrity of the forest in question, or replaced by CERs from another source.
28. Annex Z of the Marrakech Accords established limits to the use of Article 3.4 for generating forest management credits in Annex I countries.
29. For instance, the Gleneagles Process initiated by the G8, the Asia-Pacific Partnership and the U.S.-led Large Economies dialog.

4

SECTORS

In this section various sectors are evaluated with respect to whether they are conducive to or appropriate for international cooperation, and why. Definitional considerations and the criteria used by WRI to evaluate sectors are also explained below. In addition, the various forms of cooperation (Section 2) are considered here within the context of specific sectors and subsectors.

4.1. DEFINING SECTORS

There is no uniform definition for what constitutes a "sector" that could be the subject of international cooperation on GHG mitigation. The IPCC has developed sector definitions;[1] however, these were created for the purpose of emissions reporting, and thus may not be appropriate as a basis for sectoral agreements. (For instance, emissions from a single activity, cement manufacturing, are covered under three different IPCC sectors.) A list of "sectors/source categories" that is similar to the IPCC's appears in Annex A of the Kyoto Protocol.

For the purpose of international cooperation on GHG mitigation, governments could define a sector however they wish. In transport, for instance, a sector could be defined as encompassing all direct emissions from all modes of transport or, alternatively, only *road* transport, *air* transport, *international air* transport, or some combination. Sectors could include only direct on-site emissions or also include indirect emissions (e.g., from public electricity and heat consumption). In some cases, sectors might encompass a small number of emitting processes or end products (for example, cement manufacture); in other cases, thousands of processes or products might be aggregated together (e.g., chemical manufacture).

A single technology or fuel might not be considered a sector. Thus, agreements with a very narrow scope—such as coal-based power generation, carbon capture and storage, or biofuels—might best be considered "technology" agreements.[2]

For many sectors the "direct" emissions (those derived on site from the process itself) may be less important than the "indirect" emissions (those associated with the production of raw materials, electricity or other factors used in the process). While the technical challenges are greater with a more inclusive system boundary (e.g., one that captures sources of power generation), it is more environmentally effective and better speaks to competitiveness concerns. Industry monitoring standards such as the Greenhouse Gas Protocol use a tiered approach to potentially include such indirect emissions, but note the greater complexity they can present.[3]

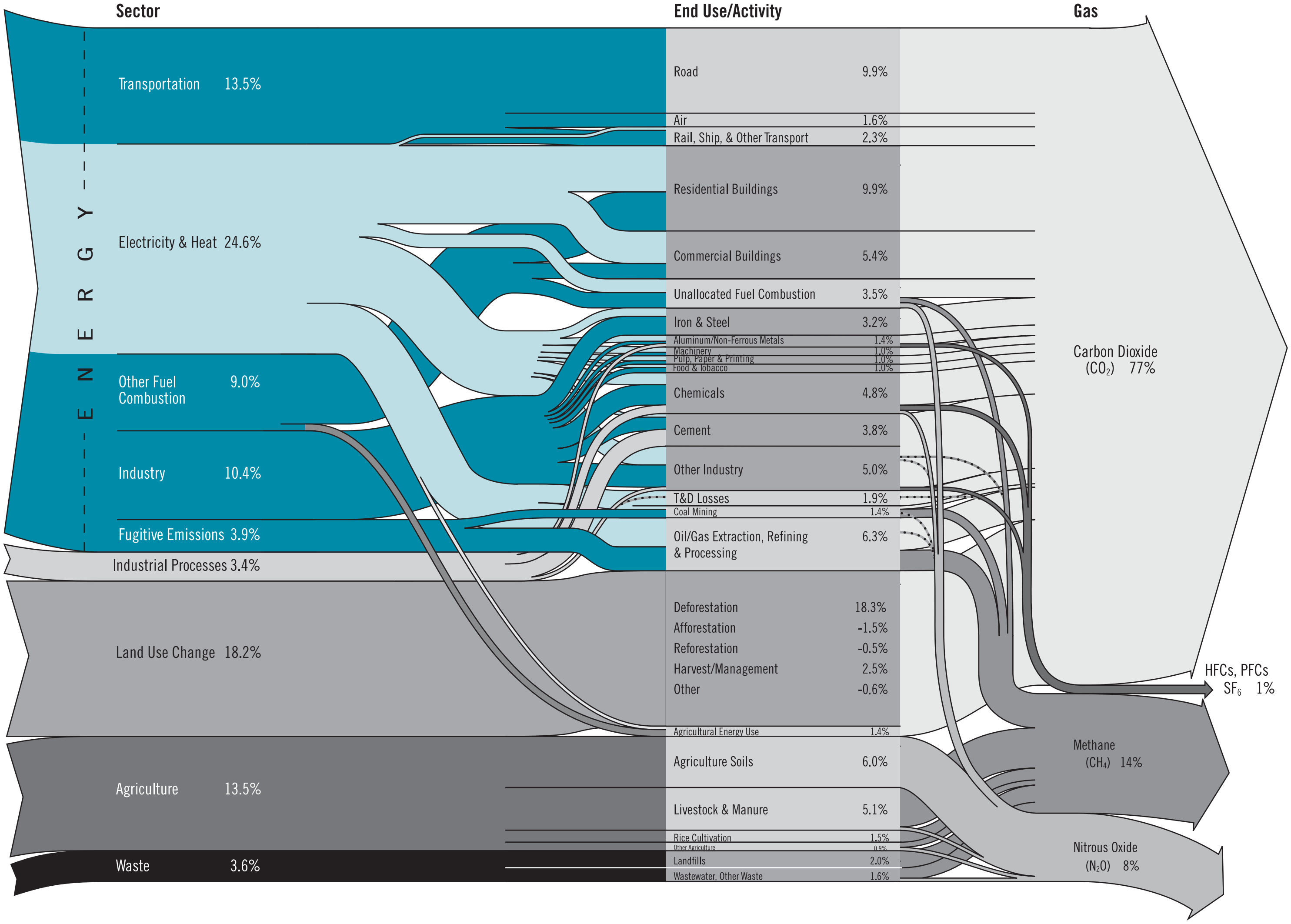
Sector definitions adopted here, for illustrative purposes, are a mix of IPCC categories and WRI's own definitions of "end use" activities (e.g., all cement emissions aggregated together).[4] Some sectors examined below are not mutually exclusive; electricity, for instance, is treated both as a discrete sector and a component of other power-consuming activities. The World GHG Emissions Flow Chart (Figure 1) gives a sense of how sectors can be defined—for the purposes of reporting on sector (column 1), end use/activity (column 2), and gas (column 3)—and how various sectors interrelate.

4.2. SECTORAL EVALUATION METHODOLOGY

Table 2 lists criteria used by WRI to evaluate the suitability of different sectors for sectoral cooperation; each is summarized below and explored within specific sector contexts in the remainder of Section 4. Whether a sectoral initiative or agreement is appropriate is likely to depend substantially on these criteria, but also on some others not listed, such as competitiveness between rival firms and technological potential to achieve emissions reductions within a particular sector.

The criteria shown in Table 2 were used to evaluate sectors and subsectors using a combination of available data, literature review, and solicited expert opinion. The

FIGURE 1 | WORLD GHG EMISSIONS FLOW CHART



Source: Baumert et al., 2005. All data are for 2000. Calculations are based on CO_2 equivalence, using 100 year global warming potentials from the IPCC (1995), based on a total global estimate of 41,755 $MtCO_2$ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent less than 0.1% of total GHG emissions.

evaluation involves analyzing GHG emissions, the nature of the emitting sources, and the quality of emissions data, as well as production, trade, and other sectoral data. Precise proxies for the different criteria are not available in every case, and quantitative precision is not possible. Accordingly, a qualitative assessment has been adopted to convey the inclination of each sector toward a sectoral approach for each of the criteria. This is done by applying one of three relative grades: "+" (positive), no score, or "–" (negative). A "+" grade is used in cases where available evidence strongly indicates appropriateness or conduciveness to an international sectoral approach, consistent with the rationale for each criterion. A "–" grade is assigned in cases where the evidence suggests barriers to sectoral cooperation. No grade is assigned in cases where evidence is mixed, ambiguous, or the criterion is irrelevant. Given the diversity of possible sectoral approaches, a uniform grading system of this type is inevitably no more than an approximate guide, and there are likely exceptions. For instance, as discussed in Section 3.2.2, sectoral crediting mechanisms may be most advantageous where there are fewer concerns of international competition. However, as a starting point for exploring where sectoral approaches may offer significant advantages over a more comprehensive treatment, these criteria are those most often encountered.

TABLE 2 | CRITERIA FOR EVALUATING SECTORS

CRITERION	EVALUATION INDICATOR(S)	GRADING (+ /–)
GHG Emissions	Share of global total; trends	
International Exposure	Scale of trade flows; scale of international investment; role of multinational corporations	High international exposure may suggest appropriateness (+) for a sectoral approach
Concentration of Actors	Number of emitting sources (companies, countries) or producers	High concentration may suggest conduciveness (+) to sectoral approach; low concentration may suggest a barrier (–)
Uniformity of Products/Processes	Number of distinct products, processes, and end products	High uniformity may suggest conduciveness (+) to sectoral approach; low uniformity may suggest a barrier (–)
Government Role	Regulations, subsidies, and other requirements	Existing regulations may suggest receptivity (+) to sectoral cooperation; government protections may be evidence of constituencies that would be a barrier (–) to sectoral approach
GHG Measurement Issues	Measurement errors; degree of uncertainty	Measurement challenges suggest appropriateness (+) of sectoral approach
GHG Attribution Issues	Trade in energy-intensive raw materials; diffuse production / consumption patterns	Attribution difficulty may suggest appropriateness (+) of sectoral approach

Note: No grade is assigned in cases where evidence is ambiguous or the criterion is not relevant.

4.2.1. GHG Emissions

The first criterion is the share of global GHG emissions encompassed by a particular sector. This factor does not relate directly to whether a particular sector is conducive to or otherwise appropriate for sectoral cooperation, but it does point to the issue of environmental significance and therefore the importance of sectors in terms of policy priority. The largest sectors are, in order: electricity & heat, industry, land-use change and forestry, agriculture, buildings, and transport. Future growth is expected to be most rapid in electricity and transport. The share of emissions will of course depend on the sector definition and boundaries for which, as discussed, there are virtually unlimited possibilities.

An additional important criterion is the anticipated growth in emissions. This is particularly the case for sectors that are seeing rapid growth in capital-intensive processes that will increase emissions and keep them high if not addressed in the near term.

4.2.2. International Exposure

Exposure to international competition may be a strong rationale for international sectoral cooperation in the climate regime. As discussed in Section 1, one of the main rationales for advancing sectoral cooperation is to address concerns about international competitiveness and emissions leakage. Certain forms of sectoral cooperation might promote a more level regulatory playing field within a given sector, thereby keeping governments from shielding that sector domestically, which they may be likely to do with economy-wide (i.e., Kyoto-style) targets.

These concerns, shared by many Parties, are particularly acute when international agreements, such as the Kyoto Protocol, do not include major emitting countries. International exposure is assessed here by evaluating international trade and investment flows (including those associated with multinational corporations), through which emissions may shift to countries that afford comparative advantages for production. Sectors with a high degree of trade and investment flows may indicate appropriateness for a sectoral approach.

Subsectors that are especially exposed to international competition include those that produce widely traded products or materials. Of the areas examined in this report, this includes motor vehicles, aircraft, steel, chemicals, and aluminum. These subsectors tend to be characterized by a significant amount of international trade as well as cross-border investment, and, in some cases, a strong presence of multinational corporations.

4.2.3. Concentration of Actors

Sectors with fewer actors are likely to be more conducive to international sectoral initiatives. In this case, cooperation tends to be easier and relevant actors can be readily identified and brought to the table in a coordinated manner.[5] This criterion is evaluated by assessing the number of companies responsible for the majority of economic activity within each sector, including multinational corporations. The concentration of emissions across *countries* is also a relevant consideration for this criterion. Almost half of global cement emissions, for example, come from a single country, China. A high concentration or relatively small number of significant firms or countries may suggest that a sector is conducive to a sectoral approach. Conversely, a low concentration or dispersed activity may suggest barriers to sectoral approaches.

With respect to this criterion, actors tend to be concentrated in industry subsectors such as steel, cement, and aluminum. Producers of motor vehicles and aircraft are also relatively few, although the use of these products (where most emissions occur) is widely dispersed. Key actors in other sectors (and subsectors)—such as electricity, chemicals, buildings, agriculture, and waste—tend to be dispersed either across countries, firms, or domestic jurisdictions (for example, state and local actors).

4.2.4. Uniformity of Products/Processes

Sectors may produce diverse or uniform products, or may employ diverse or similar production processes. Sectors characterized by uniformity may be more conducive to sectoral initiatives, since abatement techniques or efficiency improvements are more easily transferred between like products and processes. Sectors producing uniform products may likewise be conducive to internationally harmonized policy approaches such as efficiency standards, technology standards, or performance benchmarks. This criterion is assessed by examining the number of distinct products, processes, and end products that exist within a sector or subsector. High uniformity of products and processes may indicate opportunities for sectoral approaches, while low uniformity may signal a barrier to such approaches.

Certain industry subsectors (e.g., chemicals, machinery, and food) include a huge range of products. Similarly, the drivers and emissions sources in the buildings, agriculture, and land-use sectors are diverse and scattered. On the other hand, many emissions are associated with relatively uniform products and processes, including cement, unwrought metals (e.g., steel and aluminum), motor vehicles, aircraft, gas flaring, and waste processing.

4.2.5. Government Role

Governments often intervene in, privilege, or shelter different sectors to protect particular interests or those of the public at large. This criterion is evaluated by examining the nature and extent of government interventions in particular sectors. Public ownership of industries, regulation, subsidies, and trade protections are examples of such interventions. Whether the government role is conducive (+) or a barrier ( ) to sectoral agreements usually depends on the type of intervention within particular sectors. National governments are more likely to have vested political and economic interests in sectors in which they have intervened through public ownership, subsidies, or trade protections, and thus may be less likely to change policy via multinational agreements. Accordingly, sectors in which governments are significant stakeholders may not be good candidates for sectoral agreements, and may be more disposed to frameworks that preserve greater national autonomy. Such sectors might include electricity, forestry, agriculture, and waste. In these areas, provision of public services or protection of vested interests is commonplace.

Conversely, particular patterns of government regulation within countries could provide a model for international cooperation, so long as those regulations have not created entrenched constituencies. For instance, government-established efficiency standards in motor vehicles, appliances, and buildings may be comparable across international lines, and thus might form the basis of international harmonization in these areas. It may also be the case that agreements in sectors lacking significant government involvement or active constituencies are less likely to meet with political resistance or efforts to protect autonomy.

4.2.6. GHG Measurement Issues

Certain sectors and activities present significant challenges to measuring and understanding emissions. For example, emissions from the land-use change and forestry sector have proven difficult in this regard. Imprecise emissions measurements are problematic for policy instruments such as emissions trading systems, which are predicated on detailed and accurate GHG inventories. Such uncertainties may undermine the effectiveness of some policies within comprehensive agreements, and therefore signal the appropriateness of more tailored sectoral approaches. In addition to the LUCF sector, challenges associated with GHG measurement are prevalent in agriculture, waste, and aviation.[6]

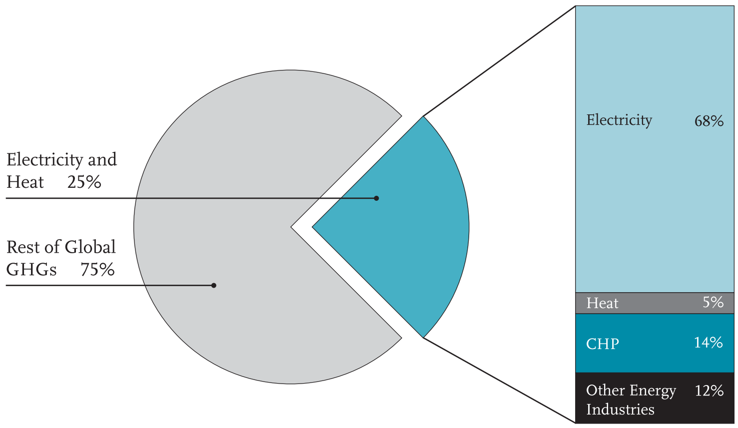
Of course, while GHG measurement problems may signal the appropriateness (+) of a sector-specific approach, this does not mean that crafting sector-specific agreements is easier. The LUCF sector provides an example where all stakeholders acknowledge the need for sector-specific rules, but actual agreement on those rules has not been forthcoming.

4.2.7. GHG Attribution Issues

Even where measurement is relatively certain, some sectors and activities present unique challenges concerning attribution of emissions to particular countries or other actors. This issue tends to arise where emissions occur in international territory (for example, aviation and seaborne shipping) or where there is a high degree of international trade in emissions-intensive products. For countries with transit hubs or energy-intensive exports, the prevailing national GHG accounting systems may yield unfavorable results and therefore pose political challenges. Chemicals, steel, and aluminum are sectors that may warrant special sectoral treatment to address inequities in this regard. A sectoral approach has already been initiated for emissions from international bunker fuels, which are not covered under the Kyoto Protocol.

4.3. Electricity and Heat

GHGS FROM ELECTRICITY AND HEAT



Sector Context Analysis

	International Exposure
–	Concentration of Actors
+	Uniformity of Products/Processes
–	Government Role
	GHG Measurement Issues
	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.3.1. Sector Context

Emissions. Electricity and heat[7] account for about 25 percent of global GHG emissions, making it the largest sector. This is equivalent to 32 percent of global CO_2 emissions and 43 percent of CO_2 emissions from energy-related sources (figures exclude land-use change and forestry). Within this sector, electricity generation accounts for the largest share, at 68 percent of the sector and 17 percent of global GHG emissions. Heat (including combined heat and power) amounts to about 5 percent of worldwide emissions, and other energy industries[8] account for roughly 3 percent.

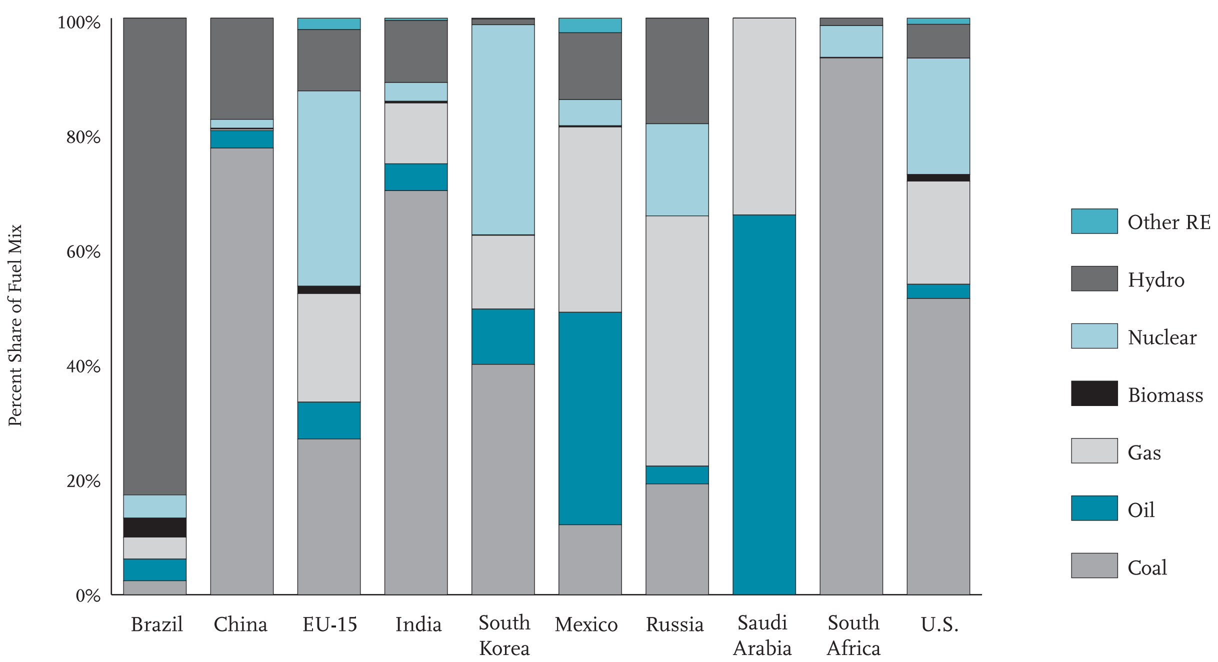
At the country level, the 10 largest emitters account for 81 percent of global electricity and heat emissions.[9] The United States, China, and the E.U.-25[10] are by far the largest emitters (with 25, 16, and 14 percent, respectively, of the global total for this sector). The largest per capita emitters, in order, are Australia, the U.S., Saudi Arabia, and Russia. The large cross-country differences in power generation are explained by (1) different levels of affluence and access to electricity (resulting in large disparities in power consumption), (2) differences in power generation efficiencies, and (3) significantly different fuel mixes (Figure 2).

Electricity and heat provide vital and enabling services, playing a dominant role in the economic life of industrialized and many other countries. More than 40 percent of all electricity is consumed in buildings, either residential (23 percent) or commercial and public (19 percent, collectively). Industry accounts for an additional 35 percent of all electricity use.

International Exposure. The electricity and heat sector has a low overall level of international exposure. Trade plays only a minor role, with just over 3 percent of world electricity production traded across borders and virtually no trade in heat.[11] This is due partly to the need for geographic contiguity, which inherently limits trade in this sector. Other significant limiting factors include governmental preferences to exploit domestic resources and limited cross-border electric transmissions systems. Most electricity trade is within Europe and North America.[12] Although actual trade flows are small, some African countries are heavily reliant on electricity imports. Of course, electricity is used to produce many products that are exposed to international trade and investment, but except for a few products (e.g., aluminum) electricity constitutes a relatively small share of production costs.

Because electric transmission systems are not deeply integrated internationally in most parts of the world (though Europe is a growing exception), sales of electric power in most countries are not exposed to international competition. Due to trends in liberalization and regulatory

FIGURE 2 | FUEL MIX IN THE ELECTRICITY SECTOR, 2002



Source: Baumert et al. 2005.

restructuring, however, power companies have been expanding their international investment portfolios. Many U.S. and European power companies have established assets in other countries that are liberalizing their power sectors, such as the United Kingdom, Argentina, Australia, and Chile.[13] The South African utility Eskom has operations in other African countries, and seeks to become the pre-eminent African energy-related service company.[14]

Concentration of Actors. As noted above, despite the growing presence of multinational enterprises, electric power generation, transmission, and distribution is typically dominated by a diverse range of local and national entities. Some entities focus on particular generation technologies (e.g., wind or nuclear), while others are vertically integrated state monopolies.

Government Role. The government role remains heavy in electricity and heat generation, despite liberalization and international investment trends. In most countries, electricity and heat production for public consumption is either publicly owned or a regulated enterprise. This is due to the public benefits associated with power and heat, linkages to economic and national security issues, and the natural monopoly characteristics of transmission and distribution services.

Uniformity of Products/Processes. In terms of product and process uniformity, the electricity and heat sector has mixed characteristics. On the one hand, electricity itself is almost completely fungible; the end product is the same regardless of the fuels and processes used to generate it. Similarly, the components of generating technologies, such as turbines, are fungible and may offer large advantages for harmonization. The number of basic fuels used to produce electricity is also relatively small. However, the fuels and conversion technologies used to generate electric power are very diverse. The majority use fossil fuels to drive a thermal process—principally coal and natural gas for large-scale power generation, and diesel for smaller applications. However, these compete directly with extremely low-carbon sources such as nuclear, hydroelectricity, wind, solar, geothermal, biomass and others. A sector approach might target just fossil generation sources or may attempt to provide more direct incentives for low-carbon ones.

GHG Measurement and Attribution. Emissions from the electricity and heat sector are dominated by fossil fuel consumption (the remainder being mainly fugitive emissions from pipelines or coal mines). Practices for estimating emissions from these processes are well understood and estimates are easily calculated when fuel consumption data are available. Consequently, there is little difficulty with respect to GHG measurement from this sector. Large hydroelectric dams are an exception, particularly in tropical countries where methane (CH_4) emissions may be significant.[15] GHG attribution likewise does not present large challenges, since most (but not all) emissions occur when fuels are combusted, not when they are extracted or refined. (Extraction and refining, while more complex, are covered by IPCC methodologies.) However, regional trade may hold some potential for attribution controversy, as emissions associated with electricity trade would tend to be allocated only to the producer country.

4.3.2. Implications for Sectoral Agreements

The above factors suggest that the possibilities for international cooperation in this sector are mixed: certain forms may be fruitful, while others are likely to encounter substantial government and private sector resistance. Electricity is so central to economic and social development that the political barriers to adopting commitments in this sector may be no less than for adopting economy-wide commitments. Typically, when a sector implicates such vital domestic interests, as electricity does, governments are reluctant to make important policy changes via international agreements, and often seek to exempt "sensitive sectors" from multilateral accords.

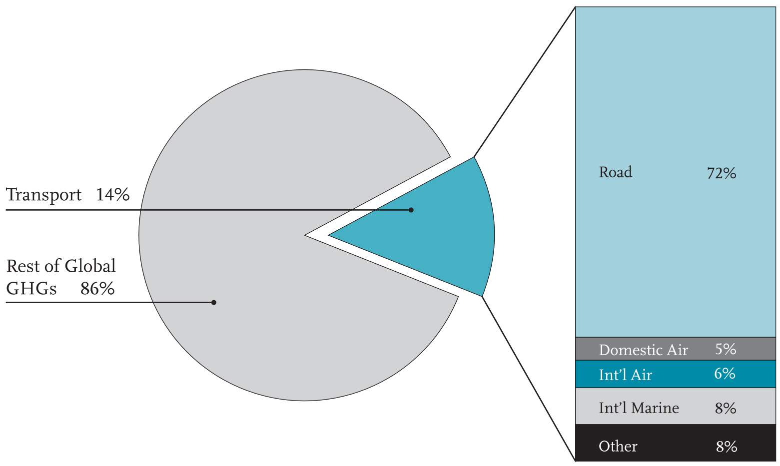
Electric power and heat production is for the most part a "domestic" sector. The low level of international exposure does not create a barrier *per se* to international cooperation, but it does suggest that there may be no compelling reason to pursue sectoral agreements in this area. Challenges are particularly acute for potential agreements calling for technology mandates or policy harmonization, given the cross-country variations in fuel mix and generation technologies.

Perhaps more fruitful opportunities for international cooperation are those that utilize country-specific emission targets. The experience with the Kyoto Protocol supports this, as governments were unwilling to agree to specific measures (in any sector) and instead agreed to national emission limits. A similar approach might work for electric power, but more narrowly. However, Kyoto-style fixed targets would be difficult for many developing countries, due to substantial uncertainties in future emission levels (see Section 3.1.1). One possible alternative would be to craft a sectoral target in terms of emissions intensity (e.g., CO_2 per kilowatt-hour). Intensity targets could take into account country-specific fuel mixes and other national circumstances, and might be appropriate as binding targets, or as baselines against which credits might be earned (i.e., a sectoral crediting mechanism or "no-lose" target, as discussed in Section 3.2.1). Global standards might also be possible under a crediting mechanism; for instance, all new renewable energy generation might receive a certain level of credits per kilowatt-hour.

There are many other possibilities for power sector agreements based on specific technologies or processes, the full examination of which is beyond the scope of this report. These include specific renewable energy technologies, biomass, co-generation, hydrogen, coal-to-gas fuel switching, and carbon capture and storage, among others.

4.4. Transport: Motor Vehicles

GHGS FROM TRANSPORTATION



Motor Vehicles (Road)

- \+ International Exposure
- \+ Concentration of Actors
- \+ Uniformity of Products/Processes
- \+ Government Role
- GHG Measurement Issues
- GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.4.1. Sector Context

Emissions. Transport[16] accounts for about 14 percent of global GHG emissions, making it a major contributor to global climate change. This is equivalent to 18 percent of global CO_2 emissions and 24 percent of CO_2 emissions from energy-related sources. Within this sector, road transport accounts for the largest share, at 72 percent of sector and 10 percent of global GHG emissions. Aviation (domestic and international) amounts to about 12 percent of transport emissions, and 2 percent of overall GHGs. With respect to energy sources, transport is dominated by oil, which amounts to 96 percent of energy supply and 97 percent of emissions.

Five countries account for two-thirds of global transport emissions. The United States far outranks all other countries, with 35 percent of global emissions—about twice the E.U.'s total and seven times the emissions of the next highest country, Japan. In some countries, transport is the fastest growing source of GHG emissions. From 1990 to 2002, transport-related emissions grew 20–25 percent in most industrialized countries, but much faster in many developing countries. The fastest growth is in South Korea, Indonesia, and China, where transport emissions doubled over the 12-year period. By 2020, the IEA expects global transport emissions to increase by 50 percent.[17]

International Exposure and Concentration of Actors. The transport sector—and motor vehicles in particular—is notable for its high concentration of actors and significant international integration among manufacturers (though end users are, of course, hugely diverse). Motor vehicle production (which includes passenger cars, light commercial vehicles, heavy duty trucks, and buses) is concentrated among relatively few countries and companies. Production is dominated by the U.S., E.U.-25, and Japan, with China rapidly increasing its production levels. From 1999 to 2004, China's vehicle production increased more than 175 percent, approaching half of Japanese levels by 2004. South Korea, Canada, and Brazil also have significant vehicle production. At the company level, five multinational automakers—Toyota, General Motors, Ford, Volkswagen, and DaimlerChrysler—produce about half of all motor vehicles. Major auto companies are largely headquartered in the United States, Japan, Europe, and South Korea. Virtually all manufacturers, however, have assembly and production facilities in multiple countries. Joint ventures are also common among major manufacturers, particularly in developing countries.

Motor vehicles, parts, and related accessories are heavily traded products. In 2003, world trade in automotive products reached $724 billion, amounting to 10 percent of all global trade.[18] The E.U.-15, Japan, and the U.S. are the largest exporters, with export product values in 2003 of $125 billion, $103 billion, and $69 billion, respectively.[19] Some developing countries are increasingly producing automobiles for export, often through joint ventures with major automakers. The largest importers are the U.S., E.U.-15, and Canada, with import product values of $181 billion, $67 billion, and $49 billion, respectively.[20]

Government Role. In different ways governments play as much of a role in the transport sector as in electricity. Interventions tend to be oriented around safety and fuel efficiency regulations—particularly in developed countries—and around transportation infrastructure like roads, highways, seaports, and airports. Furthermore, many governments are inclined to treat the automotive industry as a "strategic" one, entitled to government promotion and protection.

Uniformity of Products/Processes. Uniformity is high for all transport products. Most automobiles, trucks, and buses are produced on assembly lines, with similar production methods employed by different firms. Furthermore, while vehicle models may vary widely, the number of propulsion technologies involved is very small. Almost all road vehicles use one of a few major types of internal combustion engine fueled by gasoline, diesel, or natural gas.

GHG Measurement and Attribution. Road transport is relatively easy to attribute. Although there are some exceptions, such as in Europe, emissions almost always occur within the same national boundaries where fuels are purchased.[21] Accordingly, measurement and attribution challenges do not provide a rationale for pursuing sectoral strategies (nor is this a barrier).

4.4.2. Implications for Sectoral Agreements

The factors discussed above suggest that certain cooperative ventures may be potentially fruitful in the area of motor vehicle production. In particular, motor vehicles are more conducive than electric power production to technology or performance standards, provided that these are structured appropriately. The dominance of relatively few countries and producing companies, coupled with high international trade and investment, suggests that if common standards could be agreed upon, they would likely have global effects (see Section 3.3). Given the high concentration of actors, it would be relatively easy to bring the relevant stakeholders to the table. Existing national fuel efficiency regulations, for instance, may provide a pathway for coordinated international action at the sectoral level. Common technology standards, either for hybrid-electric or other low-emitting technologies, might also be pursued.

Of course, international cooperation on GHGs in the transport sector is hardly a foregone conclusion, despite some apparently positive conditions. The automobile sector is fiercely competitive, and any technology or performance standard is likely to implicitly benefit one manufacturer relative to another (just as the effect of higher fuel costs has done). Given the sector's iconic status, governments may also be more likely to protect the parochial interests of their national manufacturers. Furthermore, selecting the appropriate technology standard is a persistent challenge for technology-based policies. Similarly, policies should avoid technological lock-in, whereby incentives for further innovation are reduced.

4.5. Transport: International Aviation

Aviation

+	International Exposure
+	Concentration of Actors
+	Uniformity of Products/Processes
	Government Role
+	GHG Measurement Issues
+	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduceveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevant.

4.5.1. Sector Context

Emissions. Aviation represents approximately 12 percent of CO_2 emissions from transport when international flights are included (and about 1.6 percent of the world GHG total).[22] Emissions from international flights are more than half of overall air emissions.[23] Air travel—and associated CO_2 emissions—have grown at tremendous rates over the past few decades. Since 1960, passenger traffic has grown at about 9 percent per year, though the rate has slowed in recent years as the industry has matured.[24] Looking ahead, passenger and freight traffic are expected to grow at rates well in excess of GDP growth.[25]

Not surprisingly, the countries with the highest levels of international transport are the U.S. and the E.U. However, smaller countries that are large air transit hubs, such as Hong Kong, Thailand, and Singapore are also significant emitters.

GHG Measurement and Attribution. The global warming effect of aviation is larger than suggested by the numbers and emissions trends discussed above, which are based on fossil fuel consumption. The climate impacts of air travel are amplified when ozone-producing NOx emissions, contrail formation, water vapor release, and other high-altitude effects of aircraft use are accounted for. Most of these effects are characterized by high levels of uncertainty and are difficult to account for. The IPCC estimates that although aircraft accounted for only 2 percent of anthropogenic emissions in 1992, they produced an estimated 3.5 percent of total radiative forcing from human activities.[26] IPCC projections suggest that radiative forcing from aircraft may increase by a factor of nearly four by 2050, accounting for 5 percent of total radiative forcing from human activities.[27]

International Exposure and Other Factors. While measurement and attribution of emissions is more problematic for aviation than for motor vehicles, the two transportation subsectors examined in this report have otherwise similar characteristics. Aviation products are highly uniform, as nearly all medium and large commercial aircraft rely on jet engine propulsion. Production is highly concentrated. Nearly all commercial jet aircraft are manufactured by five companies operating primarily in North America and Europe. Boeing Corporation, headquartered in the United States, and Airbus S.A.S, headquartered in France, manufacture almost all large (100+ seat) commercial jet aircraft. Smaller jet aircraft, including regional corporate jets, are manufactured mainly by Bombardier (Canada), Embraer (Brazil), and Gulfstream, a division of General Dynamics (United States). According to industry sources, these manufacturers accounted for nearly all of the approximately 16,000 commercial jet aircraft in service worldwide in 2003.[28] Industry forecasts project demand for almost 24,000 new jet aircraft through 2023.[29]

Given the high concentration of actors, it is not surprising that cross-border trade is significant. The U.S. exports 40 percent of its production of aircraft, nearly half of which goes to developing countries.[30] Other significant producers, such as France, Germany, Canada and the United Kingdom, export over 50 percent of their domestic aircraft production.[31]

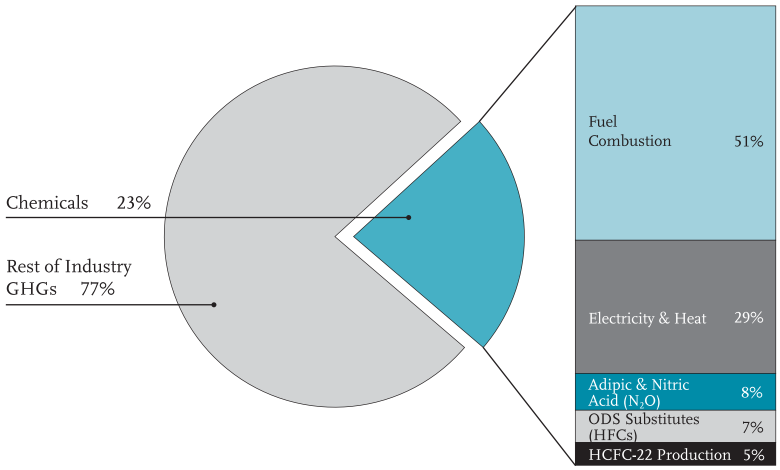
4.5.2. Implications for Sectoral Agreements

Aviation emissions are measured at the point of refueling and do not depend on subsequent destinations or nationalities of passengers, nor on high-altitude effects. Accordingly, attributing aviation emissions to particular countries is controversial, and for this reason emissions in this sector are excluded from the Kyoto Protocol. Parties to the Climate Convention have requested assistance in dealing with air emissions from the International Civil Aviation Organization (ICAO), although no formal agreements have been reached. The aviation subsector is an excellent example of how—even where conditions seem to be ripe for a sector-specific agreement—such cooperation is nonetheless challenging.

In considering policy options, the characteristics of the aviation subsector, as with motor vehicles, suggest that technology or performance standards may be appropriate. However, actors in the aviation subsector already have significant financial incentives to operate the most efficient aircraft on the most efficient routes, which would suggest limited scope for standards to impact aviation emissions in the short term. To date, most discussions have focused on emission targets, which might be integrated into Kyoto's trading system. The European Union has taken this approach furthest, and has developed proposals to link the aviation sector to the E.U.'s emission trading system during the period 2008–2012. This could include a limited link to the wider ETS such that the aviation sector can be a net buyer from other sectors. The challenge, even more than for other sectors, is that there is not yet any viable alternative to the high-emitting technologies presently used for long-distance international travel.

4.6. Industry: Chemicals

GHGS FROM CHEMICALS AND PETROCHEMICALS



Chemicals and Petrochemicals

- \+ International Exposure
- – Concentration of Actors
- – Uniformity of Products/Processes
- Government Role
- GHG Measurement Issues
- \+ GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.6.1. Sector Context

Emissions. GHG emissions associated with manufacturing and construction industries[32] represent approximately 21 percent of world GHG emissions. Within the industry sector, chemical manufacture accounts for the largest share of emissions: 23 percent, or almost 5 percent of global GHG emissions.

Emissions in the chemicals sector pertain to the direct production and use of chemicals, and include direct (on-site) CO_2 emissions from fossil fuel combustion, indirect emissions from electricity consumed during production, and release of non-CO_2 gases from various industrial processes. Emissions pertaining to some chemicals may derive more from use than manufacture (e.g., HFCs).

Uniformity of Products/Processes. The most notable attribute of the chemicals sector is the diversity of products and production processes. As defined here, this industry includes fertilizers, pesticides, pharmaceuticals, plastics, resins, synthetic rubber, refrigerants, paints, solvents, soaps, perfumes, and synthetic fibers, as well as chemicals derived from fossil fuels, such as ethylene, propylene, and butylene.[33] Some particular products and processes, such as steam cracking and ammonia production, may be sufficiently important emitters to be treated separately, though a proliferation of such highly specific agreements may prove difficult to handle.

International Exposure and Concentration of Actors. Chemical production is highly concentrated geographically, with the E.U.-25, United States, Japan, and China accounting for three-quarters of global chemical production. Corporate presence is also geographically concentrated, with all but two of the 30 largest chemical companies headquartered in the E.U., United States, or Japan.[34]

However, because of the diversity of products, overall there is a low concentration of actors in this subsector. The 15 leading chemical companies worldwide account for less than 20 percent of global sales, and often operate in very different markets such as pharmaceuticals, petrochemicals, and basic and consumer chemicals. Small and medium-sized enterprises, which may have a single facility producing a single product, are common. The E.U., for instance, has 31,000 chemical enterprises, 96 percent of which have fewer than 250 employees.[35]

Some companies in this sector are among the largest in the world. German companies BASF and Bayer have operations in 74 and 61 countries, respectively, while U.S.-based Dow Chemical and DuPont each operate in 32 countries.[36] Accordingly, there is considerable cross-border investment in this sector, in part by large transnational corporations. Overall foreign direct investment in chemicals reached $420 billion in 2002, a more than doubling since 1990 and a 20 percent share of total foreign direct investment in manufacturing (the largest sector).[37]

International trade in chemicals has increased steadily over the past two decades, with double-digit annual growth rates.[38] An estimated 30 percent of chemical production is traded across borders.[39] In 2003, chemicals constituted about 15 percent of all manufacturing exports, with a world trade value of approximately $800 billion (about 40 percent of which is intra-Europe).[40] Because of the diversity of products, many countries are both significant importers and exporters.

Government Role. Government regulations in this sector vary widely between product and process types, and between jurisdictions. In the E.U., for instance, the REACH regulation applies strict monitoring and permitting requirements to some 30,000 chemicals. In the case of chemicals for pharmaceutical properties, regulation is particularly stringent, and indeed regulatory constraints constitute a large part of the industry's costs.[41] Other substances, such as plastics or fertilizers, are less heavily regulated for producers, but are subject to other types of regulation that apply to the consumer (e.g., recycling requirements or control of nitrogen runoff from fields). This diversity reinforces the conclusion that "chemicals" as a single sector is difficult to characterize consistently.

GHG Measurement and Attribution. Very high trade volumes in the chemicals sector raises some challenges related to attribution of emissions, as chemicals traded may already have undergone GHG-intensive production processes before export. This is particularly challenging to assess due to the thousands of chemical production processes. GHG measurement issues are relatively well established, although there are uncertainties that pertain to measurement of some non-CO_2 greenhouse gases.

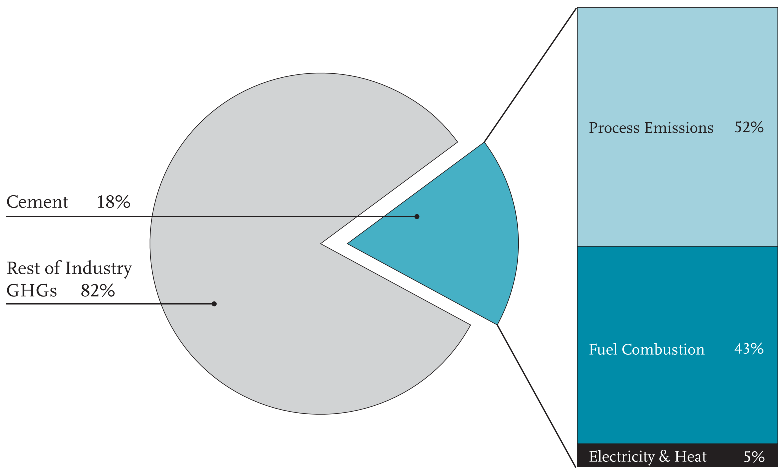
4.6.2. Implications for Sectoral Agreements

The high degree of international trade and competitiveness in this sector, coupled with the importance of energy as a production input, suggests that there is a sound rationale to promote a level playing field on GHG abatement through international cooperation. However, given the sheer number of products, markets, and actors in this sector, it is hard to imagine what such cooperation might look like in the chemicals sector, or how it could be negotiated. This sector is also poorly organized and lacks a global governing body.

One approach would be to cover the sector under country-specific emission caps. However, this would prove unpopular, particularly in developing countries where growth is uncertain and there is a desire to attract foreign direct investment. Another approach would involve adopting technology or performance standards. However, the sheer diversity of products may mean that the number of different technical standards would be so large as to make negotiations implausible. Overall, international agreements on GHG emissions or energy technologies are not promising in the chemicals sector as a whole. On the other hand, several production processes that are of particular concern from the climate perspective may be significant enough in themselves to justify an agreement.

4.7. Industry: Cement

GHGS FROM CEMENT MANUFACTURE



Cement

	International Exposure
+	Concentration of Actors
+	Uniformity of Products/Processes
	Government Role
	GHG Measurement Issues
	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.7.1. Sector Context

Emissions. GHG emissions associated with cement manufacturing, including both process emissions and energy use, account for approximately 4 percent of global GHG emissions and 5 percent of global CO_2. Cement amounts to about 18 percent of all manufacturing emissions, with CO_2 emitted at a variety of points in the production process, including (1) the chemical process of making clinker (a key component of cement); (2) the direct, on-site burning of fossil fuels; and (3) indirect emissions from electricity consumed during the cement production process. Although energy-related emissions depend on the fuels used (both for direct energy use and electricity purchases), chemical process emissions do not. Generally, about half of cement emissions come from the chemical process and 40 percent come from direct fossil fuel combustion, with the remainder coming from electricity purchases and on-site transport.[42]

Collectively, the top 12 cement-producing countries account for about 81 percent of the world total. China is by far the largest cement producer, accounting for 43 percent of the world total in 2004. The fastest growth is in East and South Asia, while cement emissions in the U.S. and Middle East are also rising significantly. In Europe, Japan, and Australia, cement production (and thus related emissions) is stagnant or declining.

International Exposure and Concentration of Actors. In terms of international exposure, the cement sector is mixed. Given the abundance of limestone and other primary materials, along with the high density and low value of cement, the sector is not conducive to international trade. Less than 6 percent of global cement production is exported across borders.[43] Transport costs, particularly over land, are likely to ensure that this remains the case, though transportation by sea is somewhat more viable and affects exposure to concentration in certain coastal markets. One major exception stands out: in the U.S., imports account for 25 percent of consumption.[44]

However, cross-border investment in the cement sector is significant and growing. In particular, the sector is increasingly characterized by the presence of large multinational firms. The growth of multinationals and foreign direct investment is also leading to a gradual increase in concentration of actors in the sector. The six leading multinational companies account for an estimated 21 percent of global cement production.[45] The two largest, LaFarge and Holcim, operate in 75 and 70 countries, respectively. Factoring in China and some other developing countries, however, suggests a sector with a much lower concentration of actors. China has some 5,000 cement manufacturing facilities, many of which are rural township enterprises with low production levels.[46] There are nevertheless trends toward more private ownership, foreign investment, and consolidation, including the development of large Chinese cement conglomerates.[47]

Government Role. Cement manufacturing is not a heavily regulated enterprise. Where governments do play a prominent role (e.g., state-owned enterprise in China), this role is somewhat in decline, given the trends in private ownership and foreign investment.

Uniformity of Products/Processes. The cement sector employs a limited set of production processes and produces a limited range of products. Production processes range from "wet" to "dry" with intermediate variations, characterized by the amount of moisture content used during blending.[48] The main ingredient in cement is clinker—derived from limestone, iron oxide, silicon dioxide and aluminum oxide—and cement products are distinguished by the ratio of clinker to other additives.[49]

GHG Measurement and Attribution. There is little difficulty in measuring emissions from cement manufacturing. Because production occurs at stationary facilities and is not heavily traded across borders, there is likewise little difficulty in attributing cement emissions to specific countries or companies.

4.7.2. Implications for Sectoral Agreements

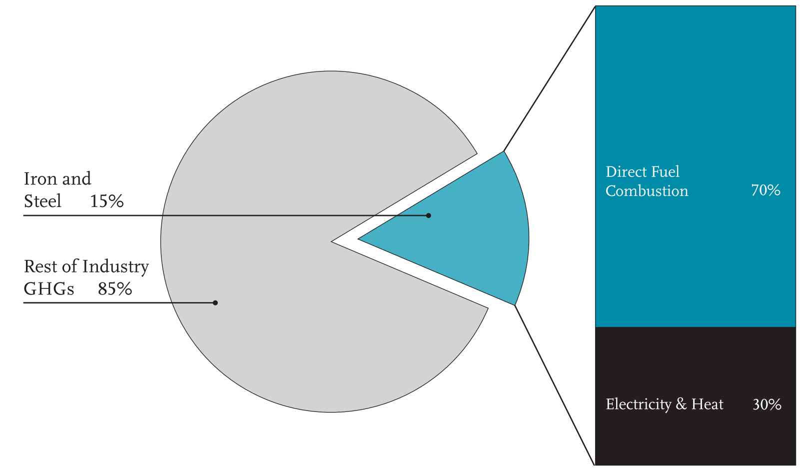
The cement sector has reasonably favorable conditions for international cooperation. Portions of the cement industry have also organized themselves under the World Business Council for Sustainable Development's Cement Sustainability Initiative (CSI).[50] The CSI includes 16 companies representing about 50 percent of global cement production outside of China. The Initiative includes a component on "climate protection and CO_2 management," under which members have produced a CO_2 protocol that establishes a common approach to monitoring and reporting CO_2 emissions from cement production. The group is also investigating "public policy and market mechanisms for reducing CO_2 emissions," although no initiative-wide targets or standards have been adopted.

Despite positive efforts by segments of the cement industry, in many ways cement is still a "local business," even with the increased presence of multinational enterprises. This makes the case for international harmonization or coordination somewhat less compelling. Such cooperation would also be challenging given market conditions in China, which accounts for an astounding share of global production.

Given uncertainties in future emissions and cement's importance for the infrastructures of rapidly growing developing countries, fixed emission targets are unlikely to be attractive to either industry or governments. Cement lends itself best to a policy approach that uses emission intensities or CO_2 performance standards. Emission intensities in the cement sector range from about 1 ton of CO_2 per ton of cement in the U.S. to 0.73 tons of CO_2 per ton of cement in Japan.[51] In many cases, methods are available to reduce CO_2 intensities, and even Japan has an estimated reduction potential of 35 percent.[52] If a common performance benchmark proved infeasible, an alternative option would be country-specific reduction requirements (percentage reductions relative to current intensities). Another alternative would be to focus technology and financial assistance toward China and several countries, where most future growth will occur. If appropriate intensity metrics can be developed, this could be done in part through a crediting mechanism such as the CDM.

4.8. Industry: Steel

CO_2 FROM IRON AND STEEL



Iron and Steel

- \+ International Exposure
- \+ Concentration of Actors
- \+ Uniformity of Products/Processes
- Government Role
- GHG Measurement Issues
- \+ GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.8.1. Sector Context

Emissions. Iron and steel is the largest energy-consuming industry sector in the world.[53] CO_2 is emitted at various points in the steel-making process, including the on-site combustion of fuels and indirect emissions from electricity and heat consumed during the production process. Taking all emissions into account, iron and steel account for an estimated 4.1 percent of total world CO_2 emissions, and about 3.2 percent of all GHGs.[54] Steel amounts to about 15 percent of all manufacturing emissions, with about 70 percent of emissions coming from direct fuel use and the remaining coming indirectly from electricity and heat.

Twelve countries produce 90 percent of the world's steel. China, the E.U.-25, and Japan are the three largest steel producers (55 percent of the global total). China's steel sector has grown at about 25 percent annually over the past few years[55] and, according to the Chinese Iron and Steel Association, is facing overinvestment and potential excess capacity.[56] Crude steel capacity, as well as production, has more than doubled since 2001 in China.[57]

International Exposure and Concentration of Actors. In terms of both trade and investment, this sector has gradually become more internationalized over the past few decades. Mittal Steel, the world's most global steel producer, has steel-making capacity in 14 countries including South Africa, Algeria, Kazakhstan, and Trinidad and Tobago, as well as North America and Europe.[58] Other companies, such as Nippon Steel, POSCO, and most Chinese companies, do not have overseas production operations, relying instead on trade to disseminate their products. Collectively, the top 25 steel-making companies accounted for roughly 43 percent of global production in 2006.[59] While the sector is characterized by many large companies, there are also a large number of small steel producers.[60] This is true in particular for the Chinese market, where there are 7000 firms, the top three of which account for only 14 percent of production.[61]

The share of steel traded across international borders has increased steadily, from 22 percent in the mid-1970s to 40 percent by 2000.[62] This amounts to a trade product value of about $180 billion, or 2.5 percent of all global trade.[63] However, since 2005 the steel trade has begun to decline globally, due largely to new production capacity located near consumption centers.[64] China's role in the industry underlines the volatility of trade patterns in the steel market. China has grown into a dominant player in today's steel industry, accounting for 34 percent of global steel production, and since 2000 accounting for 75 percent of global industry growth. Chinese steel imports have declined significantly as domestic capacity has expanded. In 2003 China was the second largest net importer of steel (behind the U.S.) at about 11 percent of world steel trade, but by 2005 China was effectively self-sufficient while the U.S. and Thailand were the largest net importers.[65] The largest exporters are Japan, Russia, and Ukraine, which account for roughly 7 percent each.[66]

Government Role. The steel industry is not a heavily regulated enterprise, although some governments, including the United States, consider steel to be a strategic sector requiring government interventions such as trade protection measures. In addition to having symbolic value, steel is important from the standpoint of employment.

Uniformity of Products/Processes. Steel production techniques do not vary widely globally, and are now dominated by only two processes: integrated steel mills that use either a blast furnace/open hearth or blast furnace/basic oxygen furnace, and mini-mills that use scrap in electric arc furnaces.[67] However, there are a range of steel products, including ingots, semi-finished products, hot-rolled and cold-finished products, tubes, wire, and unworked castings and forgings, which have a wide variety of manufacturing and construction applications.

GHG Measurement and Attribution. The steel industry's trade volume raises some difficulties in attributing emissions to specific countries, since exported products embody significant amounts of CO_2 emissions. Otherwise, there are no GHG measurement or attribution issues.

4.8.2. Implications for Sectoral Agreements

The steel sector is reasonably well organized internationally. The 190 member companies of the International Iron and Steel Institute (IISI) represent about 60 percent of global steel production. This might assist industry coordination in negotiating CO_2 emission controls. However, the IISI has not adopted a particularly proactive stance on climate change. Rather than advance proposals to reduce GHGs, the IISI has emphasized "the considerable uncertainty on the relationship between carbon dioxide levels and climate change" and the need for voluntary programs.[68]

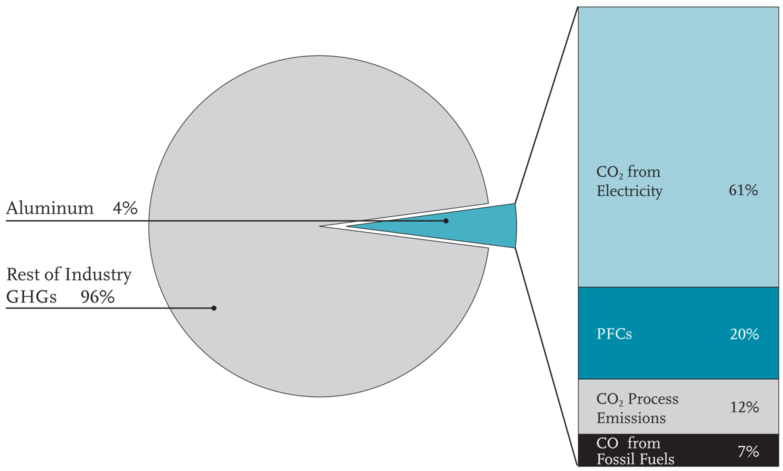
As with cement, the steel sector lends itself more to carbon intensity benchmarking and less to fixed emission targets. If set stringently enough, a carbon intensity benchmark could incentivize improvements in plant efficiencies, the use of lower-carbon fuels, and greater shifts to electric arc furnace steelmaking (which emits about 75 percent less CO_2 per ton than integrated mills). Setting uniform benchmarks may be problematic, however, as different countries use different mixes of these processes. Further, the better GHG performance of electric arc furnaces is predicated on the availability of scrap iron as a feedstock, which is not uniform among countries.

Given the competitiveness and high trade volumes in the steel industry, any carbon intensity benchmarks in this sector would best be applied as mandatory targets, rather than as baselines against which developing country firms could earn credits (e.g., via the CDM). Specifically, "no-lose" sector targets for developing countries or a sectoral crediting mechanism analogous to the Kyoto Protocol's CDM would exacerbate rather than alleviate competitiveness concerns, undermining a key rationale for sectoral cooperation (see Section 3.2 for additional discussion).

The E.U.-funded Ultra Low CO_2 Steelmaking (ULCOS) project provides an example of an alternative approach to sectoral cooperation focused on longer term R&D. ULCOS is a consortium including 48 of the major players in the European steelmaking industry and 15 E.U. member states. The project focuses on research into breakthrough technologies that could reduce specific CO_2 emissions by 50 percent below the levels of a modern blast furnace.

4.9. Industry: Aluminum

GHGS FROM ALUMINUM MANUFACTURE



Source: Baumert et al. 2005.

Aluminum

- \+ International Exposure
- \+ Concentration of Actors
- \+ Uniformity of Products/Processes
- Government Role
- GHG Measurement Issues
- \+ GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

4.9.1. Sector Context

Emissions. GHG emissions associated with aluminum production account for approximately 0.8 percent of global GHG emissions, which amounts to about 4 percent of all emissions from manufacturing industries.[69] Greenhouse gases are emitted at various points in the production process, including (1) fossil fuel use in refining bauxite (the raw material input used to produce alumina), (2) electricity consumption in the smelting process (where alumina is reduced to aluminum metal), and (3) perfluorocarbon (PFC) and CO_2 emissions due to chemical processes during smelting. Most emissions occur in the smelting process, which requires large amounts of electricity—typically about 15,000 kilowatt-hours per ton of metal produced.[70] This collectively amounts to about 2.4 percent of global electricity consumption.[71]

Twelve countries represent 82 percent of global aluminum production. China, Russia, the E.U.-25, Canada, and the United States account for 61 percent of total production. Secondary aluminum production from recycled scrap aluminum fills some 40 percent of global aluminum demand.[72] By re-melting aluminum scrap, GHG emissions are reduced more than 95 percent relative to primary aluminum production.

International Exposure and Concentration of Actors. The aluminum sector is perhaps the most internationalized industry sector in terms of both trade and investment. An estimated 45 percent of global production is exported as unwrought aluminum, with significant additional trade volumes for aluminum products.[73]

More than other commodities, however, aluminum production is dominated by a small number of companies, mostly multinationals. The ten leading companies produce 55 percent of the world's aluminum, with Alcan, Alcoa, and Rusal constituting one-third of global production. Alcan and Alcoa each operate in more than 25 countries and have a majority of their employees working outside their home countries.[74]

Government Role. Aluminum manufacturing is not heavily regulated, nor is it considered an especially strategic sector in most countries—particularly in the OECD. However, energy tariffs play a large part in the cost structure of aluminum production, and in many countries new facilities are attracted in part with attractive pricing regimes.

Uniformity of Products/Processes. Aluminum production processes and technologies do not vary widely. There are only two basic smelting technologies—Söderberg and pre-bake. The phasing in of newer variants of pre-bake technology (Point Fed and Centre Worked Prebake plants, which now dominate) has resulted in substantial reductions in PFC emissions.[75] While unwrought aluminum is considered a standardized international commodity, there are of course a diverse array of final aluminum products, such as foils, cans, construction materials, and automotive components.[76]

GHG Measurement and Attribution. GHG emissions are routinely measured from aluminum production to a reasonable degree of accuracy. The aluminum industry's heavy trade volume, however, does raise difficulties in attributing emissions to specific countries or companies, since exported products embody significant amounts of electricity consumption and GHG emissions (aluminum is sometimes called "solid electricity").

4.9.2. Implications for Sectoral Agreements

Among all sectors examined in this report, aluminum appears to be the most conducive to international cooperation. The strong concentration of multinational corporate actors, along with attractive mitigation options, may have influenced the sector's adoption of voluntary climate change targets. These targets also exist due to the presence of a proactive international industry association and some member companies. The International Aluminium Institute (IAI) has developed a voluntary initiative on key issues related to sustainability, including climate change.[77] The initiative is global in scope, covering IAI's 26 member companies, which collectively account for 80 percent of global primary aluminum production.

Key climate change targets are framed in terms of intensity reductions, including an 80 percent reduction in PFC emissions per ton of aluminum produced and a 10 percent reduction in smelting energy usage per ton of aluminum produced. Both targets apply to the industry as a whole and are to be reached by 2010 (using a 1990 base year). The IAI has a team of experts that advise and assist member companies, as well as report on overall results.

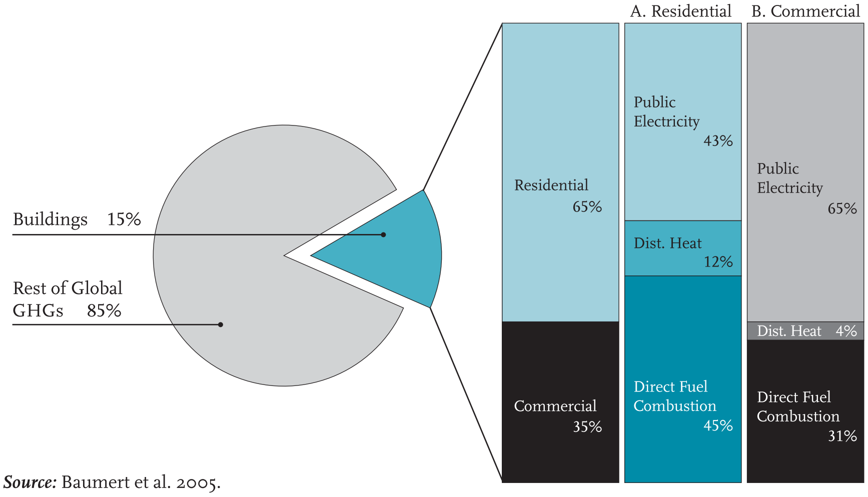
For several reasons, this sector is unique in positioning itself at the global level to play a leadership role in climate protection. First, cost-saving technologies are available that substantially reduce PFC and CO_2 emissions. IAI surveys show that in 2003 participants had already reduced PFC emissions per unit of production by 73 percent compared to 1990 levels. Second, aluminum is conducive to recycling, which avoids 95 percent of emissions compared to primary manufacture. (Indeed, most aluminum ever produced is still in use, as the metal can be recycled and re-used repeatedly without deterioration in quality.) Third, aluminum can replace higher density materials in transport, leading to energy efficiency improvements (and CO_2 reductions) through lighter-weight vehicles.

Presently, the IAI's initiative is not connected to the international climate regime. Thus, emissions from aluminum manufacture in most industrialized countries are covered under the Kyoto Protocol, and aluminum manufacture in developing countries is eligible for credit generation through the CDM. In other words, aluminum emissions (unlike aviation) have no special status under the current climate regime.

It remains to be seen whether this will change, and whether the IAI's emission targets move beyond the voluntary stage. As these targets suggest, the most suitable policy options seem to be common efficiency benchmarks or GHG-intensity reductions.[78] However, differences in production technologies and fuel sources make it difficult to develop technology standards or performance benchmarks that can apply across the sector globally.

4.10. Buildings

CO$_2$ FROM BUILDING USE



Source: Baumert et al. 2005.

Buildings

	International Exposure
–	Concentration of Actors
–	Uniformity of Products/ Processes
+	Government Role
	GHG Measurement Issues
	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

4.10.1. Sector Context

Emissions. The buildings sector[79] encompasses both residential and commercial (including institutional) buildings. The sector accounts for 15.3 percent of global GHG emissions, including 9.9 percent for residential buildings and 5.4 percent for commercial; CO_2 accounts for nearly all emissions.

Emissions from the buildings sector are predominantly a function of energy consumption for diverse purposes that can be organized into three broad categories: (1) public electricity use, (2) direct fuel combustion, and (3) district heating. *Public electricity use* includes lighting, appliance use, refrigeration, air conditioning, and, to some extent, space heating and cooking. These activities account for 65 percent of commercial building emissions and 43 percent of residential building emissions. Globally, the buildings sector is responsible for more electricity consumption than any other sector, 42 percent,[80] so to a significant extent, this sector implicates the electricity sector at large (see Section 4.3). *Direct fuel consumption* results primarily from space heating, with modest contributions from food preparation (gas-driven cooking) as well as gas-driven air conditioning and refrigeration systems. This source accounts for 45 and 31 percent of emissions in residential and commercial buildings, respectively. *District heating* includes centrally operated heating (and sometimes cooling) systems that service entire cities or other large areas. Certain activities in the buildings sector such as cooking, air conditioning, space heating and refrigeration may generate either direct (on-site) or indirect (public electricity and heat) emissions, depending on the technology used.

Emissions from the buildings sector vary widely by country in both absolute and per capita terms and depend on many factors, including degree of electrification, carbon intensity of the electric power and heat sector, level of urbanization, amount of building area per capita, and prevailing climate, as well as national and local policies to promote efficiency. For example, building emissions in Australia and South Africa are generated almost completely from coal-based electricity use, while the electricity shares of emissions in France and Brazil are much lower due to their reliance on nuclear and hydropower, respectively. District heat use is concentrated in the transition economies of Russia, Ukraine, and Poland, as well as in Scandinavian countries.

International Exposure and Concentration of Actors. International trade and a small number of multinational corporations play a significant role in producing and distributing most building appliances, including cooking appliances, lighting, heating, and cooling systems. However, the opposite is true for building construction, which is dominated by small local firms. Many materials essential to building efficiency, such as cement and timber, are not heavily traded (aluminum and steel are notable exceptions).

Government Role. One consistent quality in the buildings sector is that it is highly regulated. Building codes often influence materials use, and appliance standards (both mandatory and voluntary) have a significant effect on energy efficiency. Regulatory regimes, to the extent that they exist, may therefore provide a pathway to improve efficiency for both building construction and a variety of building appliances. Furthermore, government operations in commercial buildings often constitute a significant share of total building use, as government activity at all levels is building-dependent. By choosing energy-efficient designs and materials for their own use, governments can thus exert significant influence over the buildings sector as a whole.

Uniformity of Products/Processes. As discussed above, building emissions come from a wide array of activities and sources, including lighting, cooking, appliance use, and space heating. Building practices and materials also vary widely across countries and regions, depending on available resources, customs, and prevailing climate.

GHG Measurement and Attribution. GHG measurement and attribution issues are not significant in the buildings sector. This sector is considered a "domestic" one from which emissions can be relatively easily measured, based on fossil fuel and electric power consumption.

4.10.2. Implications for Sectoral Agreements

Analysis of the buildings sector produces mixed conclusions on international cooperation. The sector encompasses a diverse set of end-use activities, each with different implications in terms of policy choices and incentives for international cooperation. Space heating, space cooling, and lighting, which together account for a majority of building energy use in industrialized countries, depend not only on the energy efficiency of temperature control and lighting systems, but also on the efficiency of the buildings in which they operate.[81] Accordingly, building designs and materials have a significant effect on energy consumption and therefore CO_2 emissions.

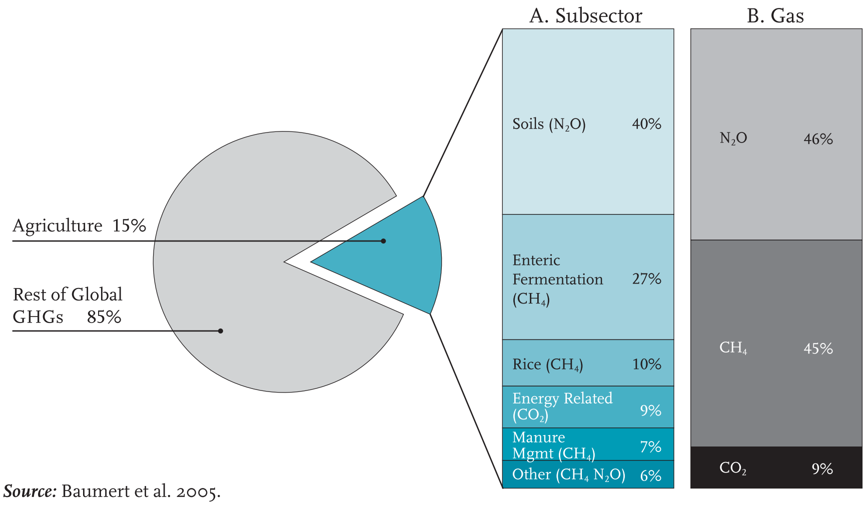
As noted, some governments establish building codes that promote energy efficiency, although enforcement is often weak. International standards could be possible in this area, although it would be difficult given the significant variation in climate, building materials, and building customs across countries. Further, the inherently local nature of buildings provides a weak rationale for international cooperation.

On the other hand, building design does not affect the energy use of appliances, which are a major source of electricity and fuel consumption. For appliances, governments (including some in developing countries) routinely establish energy efficiency standards, as well as other requirements such as product labeling and stand-by power policies, which could help lay the groundwork for international cooperation. Here, efforts at international standardization are more likely to bear fruit, given the presence of multinational manufacturing firms and the existence of international trade in some appliances. Indeed, there is already a meaningful sharing of experiences and international collaboration, such as use of the U.S. EPA's Energy Star in Japan and Europe for office equipment.[82]

The OECD and IEA identify further reasons for international collaboration and policy harmonization in the area of appliances.[83] First, one country "rarely has the capacity to design original standards that would address the whole complexity of the technical and legal stakes for each particular appliance type." Second, even where such capacity does exist, it is not "efficient to work out a scheme completely independent from existing ones. Beside the fact that the work would then have been done twice, the lack of harmonization amongst national or regional policy measurement methods and thresholds is likely to weaken the global combined effect." The challenges associated with the continued need to develop new, and revise existing, product standards also can be addressed though international cooperation.

4.11. Agriculture

GHGS FROM AGRICULTURE



Source: Baumert et al. 2005.

Agriculture

-   International Exposure
- – Concentration of Actors
- – Uniformity of Products/Processes
- – Government Role
- \+ GHG Measurement Issues
-   GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

4.11.1. Sector Context

Emissions. The agriculture sector[84] accounts for about 15 percent of global GHG emissions. This is divided almost evenly between CH_4 and N_2O (about 45 percent each), with CO_2 from fossil fuel combustion and electricity use accounting for the remaining share. At the activity level, the largest agricultural source is soils management (40 percent of the sector total), where emissions result from particular tillage and cropping practices, such as fertilizer application.[85] The second largest source is methane emissions from livestock (27 percent of the total), which is a byproduct of the digestive process of cattle and other livestock. Other important agricultural sources include wetlands rice cultivation (CH_4) and manure management (CH_4), as well as land clearing and burning of biomass (CO_2). Due to data limitations and classifications, however, these latter contributions are not readily quantifiable, or are included in the land-use change sector (Section 4.13).

China and India are the two largest agriculture sector emitters, together accounting for 29 percent of the global total. The United States, E.U.-25, and Brazil collectively account for another 25 percent. All other countries individually constitute less than 2 percent each of the world total.

International Exposure and Concentration of Actors. Agricultural products are heavily traded. In 2003, world trade in such products totaled $674 billion, amounting to 9 percent of all global trade.[86] However, agriculture itself remains a relatively local and national enterprise. Production is highly decentralized, consisting mostly of loosely organized individuals and small interests, with relatively few multinational companies involved in food production.

Government Role. Agriculture's importance to national economies differs greatly across countries. In India, China, and Indonesia, agriculture constitutes between 15 and 23 percent of GDP and employs half to two-thirds of the workforce. In industrialized countries, by contrast, agriculture is between 1 and 4 percent of GDP and of the workforce. Even in these countries, however, agriculture is considered an important sector—both for employment and cultural reasons—and is the subject of heavy government intervention. The most common government interventions in this sector are subsidies and trade protections.

Uniformity of Products/Processes. As discussed above, agriculture contains numerous drivers and sources of emissions. Agricultural techniques and processes vary greatly, not only by crop or livestock type but also according to local ecosystems, soil quality, available labor, and customs. However, certain agricultural practices, such as cropping techniques (e.g., no-till), crop switching, and irrigation practices, may be transferable.

GHG Measurement and Attribution. The level of trade in agriculture leads to difficulties in attributing responsibility, since food consumption in importing countries is indirectly responsible for agriculturally-based emissions in food-exporting countries. Measuring emissions in the sector is also problematic. Methodologies rely on estimates of crop harvests, levels of irrigated land, and numbers of livestock. The accuracy of these indicators and their emission factors is often uncertain, especially for developing countries with sizable agriculture production.

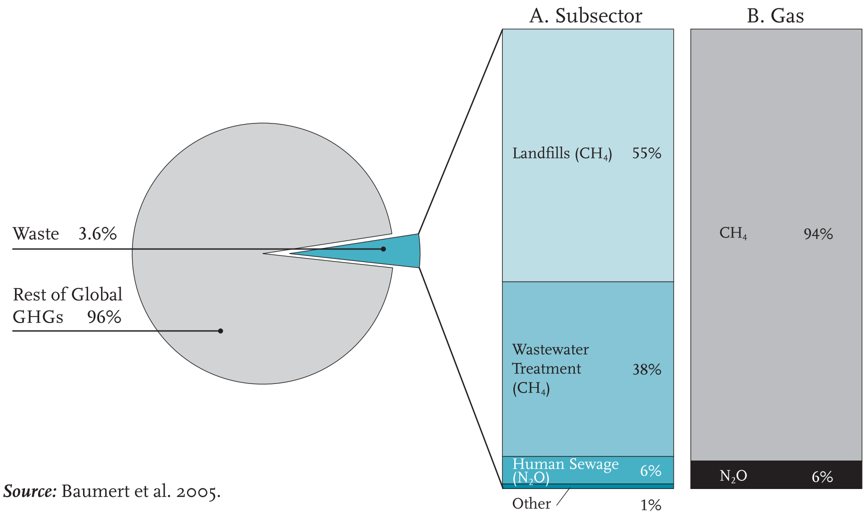
4.11.2. Implications for Sectoral Agreements

Agriculture is unlikely to be the subject of a sectoral agreement, as its characteristics present very large barriers to the policy options discussed in other sectors. First, there are few technologies or products that could readily be the subject of a performance or technology standard. Further, the difficulties associated with measuring, attributing, and forecasting emissions present problems for cap-and-trade proposals. Establishing baselines for use in crediting mechanisms is similarly difficult. In addition, the importance that governments attach to the sector makes it more likely that important decisions will be made through domestic processes rather than international fora. The challenges associated with addressing agriculture through the WTO are perhaps instructive.

It may be feasible to find specific agricultural techniques and management practices that could be replicated across borders to reduce GHG emissions. This could include low-till agricultural practices or other methods that avoid the need for fertilizer (thus limiting N_2O emissions), as well as livestock management practices that reduce CH_4 emissions.[87] Whether "good practices" in specific areas of the agricultural sector ripen into an international agreement of some kind remains to be seen.

4.12. Waste

GHGS FROM WASTE



Source: Baumert et al. 2005.

Waste

	International Exposure
–	Concentration of Actors
+	Uniformity of Products/ Processes
–	Government Role
+	GHG Measurement Issues
	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

4.12.1. Sector Context

Emissions. The waste sector accounts for just under 4 percent of global GHG output. The largest source of emissions from this sector is landfilling of solid waste, which emits CH_4 from the anaerobic decomposition of organic matter. These emissions can also be captured as methane-rich gas and channeled to productive purposes. Handling and treatment of wastewater, which also emits CH_4, is the second largest source. A small share of waste emissions also comes in the form of N_2O from treatment of human sewage. Overall, CH_4 accounts for the vast majority of emissions from this sector, at more than 90 percent. At the country level, the largest emitters in this sector are the United States and E.U.

International Exposure and Concentration of Actors. Waste disposal is typically a public sector function, often at the local or municipal level. This includes the operation of solid waste disposal sites as well as treatment facilities for industrial and residential wastewater. Accordingly, international competition and trade are not significant factors, nor are concerns over attribution, and actors tend to be dispersed at the local level.

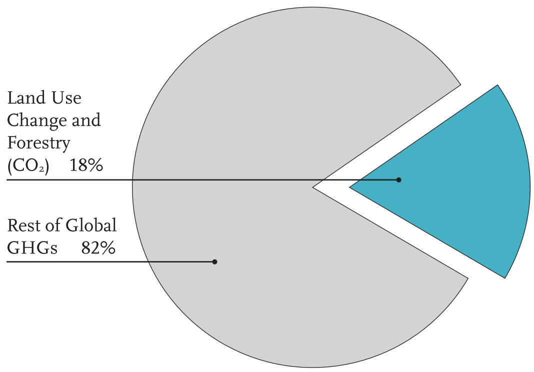
GHG Measurement and Attribution. Data uncertainties are high in this sector, as with agriculture and land-use change and forestry. Data from the waste sector is also less complete than others in terms of country coverage.

4.12.2. Implications for Sectoral Agreements

Given the attributes of the waste sector, there does not appear to be a compelling need for international cooperation. One area where there is some international collaboration, however, is in CH_4 recovery from landfills. Specifically, the Methane to Markets Partnership, initiated by the U.S. EPA in 2004, includes 14 government partners and aims to "advance the recovery and use of methane as a valuable clean energy source."[88] One of the Partnership's focal areas is CH_4 capture from landfills, where the group has developed an action plan to help identify and overcome barriers to landfill gas capture and use in Partnership countries. The Partnership is a "voluntary, non-binding framework for international cooperation" and, accordingly, does not entail requirements for governments.

4.13. Land-Use Change and Forestry

CO_2 FROM LAND-USE CHANGE AND FORESTRY



LUCF

	International Exposure
	Concentration of Actors
–	Uniformity of Products/Processes
–	Government Role
+	GHG Measurement Issues
	GHG Attribution Issues

A "+" grade suggests high appropriateness or conduciveness for international sectoral cooperation. A "–" grade suggests a barrier to international sectoral cooperation. No grade means evidence is ambiguous or not relevent.

Source: Baumert et al. 2005.

4.13.1. Sector Context

Emissions. An estimated 18 percent of global GHG emissions (and 24 percent of CO_2 emissions) are attributable to land-use change and forestry (LUCF).[89] This contribution is the largest for any single sector, with the exception of electricity and heat. Estimates reflect the CO_2 flux (emissions and sink absorptions) from the following activities: land clearing for permanent croplands (cultivation) or pastures (no cultivation), abandonment of croplands and pastures (with subsequent regrowth), shifting cultivation,[90] and wood harvest (industrial and fuelwood).[91] The largest emissions source is deforestation driven by conversion to agricultural lands, primarily in developing countries.

The pattern of emissions and absorptions across countries is unlike any other sector. Most countries have very small CO_2 fluxes that are either slightly positive (emitting more CO_2 than they sequester) or slightly negative (sequestering more CO_2 than they emit). Most LUCF emissions come from tropical countries;[92] estimates suggest the largest sources are Indonesia and Brazil, with 34 percent and 18 percent, respectively, of the global total.[93] Other major emitters include Malaysia, Myanmar, and the Democratic Republic of Congo. Industrialized countries, on the other hand, are presently believed to be net *absorbers* of CO_2. This is due to significant land clearing in North America and Europe prior to the 20th century. During this period, deforestation emitted significant quantities of CO_2, while today's forests are absorbing CO_2 through natural regrowth. Thus, the profile of emissions across countries has changed significantly over time.

International Exposure and Concentration of Actors. The forestry sector, like agriculture, is both local in nature but subject to international trade. This primarily takes the form of international demand for forest products[94]—including roundwood, sawnwood, pulp, and paper—although it is not clear to what degree this demand drives sector CO_2 emissions (compared to, say, forest clearing for agriculture). Forest products are estimated to contribute to about 1.2 percent of world GDP and 3 percent of international merchandise trade.[95] Trade volumes are expanding, with the largest importers for these products being Europe, the U.S., and China.[96]

Government Role. Government intervention in the forest sector is high. Generally, forests are viewed as a sector to be managed by governments, and in many cases the government itself owns most forested lands.[97] Since the 1990s, however, more governments in both developed and developing countries are privatizing forest resources as a means to improve economic performance and raise revenue.[98] Privatization takes many forms, including land ownership transfers, concessions and leases, volume permits or standing timber sales, outsourcing, and community-based approaches.[99] One consequence of this trend is increased ownership and administration of forests by local communities. As characterized by the FAO, "[i]n general, policy and regulatory functions remain with central governments, while the private sector and civil society are taking charge of operations."[100] However, regulatory effectiveness may be weak, as illegal logging and noncompliance with forestry law is not uncommon, particularly in certain tropical countries.[101]

Uniformity of Products/Processes. The degree to which different forces, such as those noted above, are driving worldwide CO_2 emissions in this sector is not well known, in part because of measurement uncertainties. However, the available evidence suggests that a diffuse set of processes, products, and actors contribute to forest degradation and consequent CO_2 emissions. For example, the practice of converting forest land to agricultural land is widespread. Likewise, wood energy—usually in the form of fuelwood or charcoal—is the most important source of energy for 2 billion people, mostly the poor that lack access to modern energy services.[102] In numerous other ways, forests directly influence livelihoods in developing countries, notably through ecotourism and harvesting of forest products (such as timber, rubber, coconuts, bamboo, and palm oil) for both local use and export.

GHG Measurement and Attribution. Emissions from the land-use change and forestry sector are subject to extraordinary measurement uncertainties.[103] The IPCC estimates that global LUCF emissions averaged 1.6 gigatons (GtC) per year, +/- 0.8 GtC, during the 1990s.[104] The 1.6 GtC figure amounts to 20 percent of global CO_2 emissions.[105] Taking uncertainties into account, however, CO_2 from LUCF may be as little as 0.8 GtC (12 percent of world emissions) or as high as 2.4 GtC (28 percent), a difference of a factor of three. Estimates used by WRI, based on Houghton and Hackler (2002) and Houghton (2003b), amount to 2.2 GtC per year (26 percent of CO_2 in the 1990s), which is in the upper range of IPCC estimates.[106] Uncertainties increase further for national-level figures, where estimates are uncertain on the order of $\pm$ 150 percent for large fluxes, and $\pm$ 180 $MtCO_2$ per year for estimates near zero.[107] A comparison of the data presented here with the official data submitted by governments to the UNFCCC helps illustrate the uncertainties.[108] In some cases, the two sources are close in their estimate (e.g., for Mexico and some small countries). However, for large emitters and absorbers, the estimates are significantly different, most notably in Indonesia, Brazil, and the United States.

These measurement uncertainties are compounded by three additional factors unique to the LUCF sector. First, while climate policy tends to focus on mitigating *anthropogenic* emissions, in the LUCF sector it is not always apparent what effects are "human induced." Emissions and absorptions of CO_2 in the terrestrial biosphere depend on complex interactions between the carbon cycle, nutrient cycles, and hydrological cycle.[109]

Second, absorptions are, by definition, reversible. If a forest absorbs CO_2 during a given year, those absorptions may be returned to the atmosphere in any subsequent year. This reversal may be due to human drivers, such as deforestation, or natural causes such as fires or forest die-off. The non-permanence of claimed emission reductions in this sector poses technical and legal challenges within policy-making contexts.

Third, more than other sectors, LUCF is leakage prone. Leakage occurs, for instance, when a new forest conservation measure in one area triggers deforestation in another area. Thus, successful conservation efforts need to address the root causes of deforestation, rather than simply cordon off a protected area. Stemming leakage may be difficult or impossible when deforestation is driven by timber or other forest-product exports to foreign markets. In such a case, the market may simply satisfy demand through purchases from other countries, shifting the CO_2 emissions from one country to another.

4.13.2. Implications for Sectoral Agreements

The unique characteristics of the LUCF sector make it especially challenging with respect to policy design and international cooperation. The Kyoto Protocol Parties, for instance, have recognized the sector's special nature by adopting sector-specific measurement and reporting rules, establishing limits on "emission reductions" from forest management activities, and limiting project eligibility in the CDM (most notably, by excluding crediting from avoided deforestation activities). But the LUCF sector has plagued the Kyoto negotiations for nearly a decade, with all decisions being hotly negotiated in an atmosphere of hostility and acrimony. Some stakeholders view integration of LUCF into the climate regime as a means to promote biodiversity conservation, ecotourism, and sustainable development; others see it as a loophole that would dampen incentives for the critical changes needed in the energy sector.

The fact that measurement uncertainties are very high, claimed emission reductions are reversible, and the sector is leakage-prone are perhaps the characteristics that should most heavily inform policy. Because of these factors, any policy approach that "equates" the emissions (or emission reductions) in LUCF with those in other sectors, such as transport or electricity, will face substantial obstacles. Experience under the Protocol bears this out. Expansion of a sectoral crediting mechanism into forest conservation practices, for instance, will be opposed on a range of reasonable grounds. Indeed, any kind of policy architecture that involves emissions trading between the LUCF sector and other sectors is likely to be problematic. While such an approach is hypothetically desirable (e.g., from a cost-effectiveness standpoint), it does not appear that the policy community has developed practical methodologies that adequately deal with the features of the LUCF sector. The exclusion of credits arising from LUCF projects under the CDM is a reflection of these concerns, as is the paucity of LUCF projects advanced so far under the CDM.

Several alternative approaches might be considered. First, given that emissions are concentrated in relatively few tropical countries, a program of country-specific policies and measures might be most appropriate, most likely with assistance from industrialized countries.[110] From a global perspective, tailoring policy responses and incentives that target deforestation in the Amazon region (mainly Brazil) and Southeast Asia (mainly Indonesia and Malaysia) would, to a large extent, address emissions of the entire sector. This would contrast with most current efforts, which are aimed at crafting global rules that integrate the sector into an international emissions trading system.

Second, the relationship between trade and sustainable forest management has already led to a variety of international responses. For example, measures such as product labeling and forest certification programs (e.g., Forest Stewardship Council) can impact national policies on forest management and wood processing.[111] Although the area of certified forests has increased substantially over the past decade, the total amounts to less than 4 percent of the world's forests.[112]

NOTES

1. IPCC, 1997.
2. Technology agreements are also discussed separately in the literature. *See e.g.,* the work of the Annex I Expert Group on "International Energy Technology Collaboration and Climate Change Mitigation" at http://www.oecd.org/document/5/0,2340,en_2649_34361_2515141_1_1_1_1,00.html.
3. The Greenhouse Gas Protocol was developed jointly by the World Resources Institute and the World Business Council for Sustainable Development. *See* http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=ODg4&doOpen=1&ClickMenu=Corporate%20Standard. Accessed October 2007.
4. *For more details, see* Baumert et al., 2005: Part II and Appendix 2.
5. Steiner, 1972.
6. Aviation measurement problems pertain less to emissions than *radiative forcing. See* Baumert et al., 2005: Chapter 12.
7. "Electricity & Heat," as used here, corresponds to IPCC Sector/Source category 1A1 (IPCC, 1997). Contents are described in Baumert et al., 2005: Appendix 2.B. It includes electric power and heat plants (primarily but not exclusively public plants) and "other energy industries."
8. "Other energy industries" includes emissions from fuel combusted in petroleum refineries and in fossil fuel extraction (IEA, 2004).
9. Baumert et al., 2005. *See* Chapter 11.
10. The European Union consists of 27 member states as of 2007, with Bulgaria and Romania acceding on January 1st 2007. This followed an earlier expansion from 15 members to 25 in 2004. Collected data sets do not always follow these expansions so quickly, and in this report we specify E.U.-15 for the pre-2004 membership, or E.U.-25 for later. We have not used aggregated data for the E.U.-27.
11. Author calculations, based on IEA, 2004b.
12. Bosi and Riey, 2002: 23-24.
13. In the U.S., this was made possible by the 1992 Energy Policy Act, which liberalized international investment rules for U.S. utilities. *See* EIA, 1997. *See also,* EdF, 2005.
14. Eskom, 2004.
15. WCD, 2000. These emissions are characterized by large uncertainties and poorly developed measurement methodologies. They are usually unaccounted for in GHG emissions inventories and statistics.
16. "Transport," as used here, pertains to IPCC Source Category 1A3, but also includes a small amount of energy-related CO_2 emissions from indirect sources (1A1), mainly electricity for rail transport. *See* Baumert et al., 2005: Appendix 2.B. Excludes bunker fuels.
17. Author calculations, based on IEA, 2004c.
18. WTO, 2004: 101.

19. WTO, 2004: 140. The E.U. figure includes only extra-E.U.-15 exports. Including intra-E.U. trade, the product value is $371 billion.
20. WTO, 2004: 140.
21. There are non-trivial impacts of international road traffic in Europe. This includes some gravitation toward purchasing fuels in low-priced countries, which has only a small impact in large countries, but a significant impact in some smaller countries like Luxembourg. In addition, roughly 10 percent of all trucking in continental Europe represents international transit traffic.
22. Under IPCC Guidelines (IPCC, 1997), emissions from international aviation are not counted against national emission totals and are not classified under national emissions from transport.
23. Author calculations, based on IEA, 2004a.
24. IPCC, 1999: 3.
25. IPCC, 1999: 3.
26. IPCC, 1999: 8. This figure reflects projected growth in all other sectors as well.
27. IPCC, 1999: 8.
28. E-mail correspondence with Michael Metcalf, President of International Society of Transport Aircraft Trading, February 11, 2005.
29. Airbus 2004; Embraer, 2004.
30. Author calculations, based on UNIDO, 2005. Based on ISIC class 3530, 2001 data; includes spacecraft.
31. Author calculations, based on UNIDO, 2005. Based on ISIC class 3530, 1999-2002 data; includes spacecraft.
32. "Industry," as used here, covers *energy*-related CO_2 emissions from direct sources (IPCC Source Category 1 A 2) as well as *industrial process*-related GHG emissions (IPCC Source Category 2). Where possible, indirect CO_2 emissions from electricity and heat are also included in this sector definition. *See* Appendix 2.B.
33. The sector definition corresponds with ISIC Rev.3 division 24 (Manufacture of chemicals and chemical products). ISIC, see http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2&Lg=1. *See also,* ICCA, 2002.
34. CEFIC, 2005. The two are SABIC (Saudi Arabia) and Sinopec (China).
35. CEFIC, 2005.
36. UNCTAD, 2004: 279.
37. UNCTAD, 2004: 302, 303.
38. WTO, 2004: 127.
39. ICCA, 2002.
40. WTO, 2004: 127.
41. Convover, 2003.
42. Holcim, 2004.
43. Watson et al., 2005, citing U.N. Commodity Trade Statistics. Author calculations based on UNIDO (2005) suggest even smaller amounts of trade (covering ISIC classes 2694 [cement, lime and plaster] and 2695 [articles of concrete, cement and plaster]).
44. USGS, 2007; United Nations Statistics Division, 2006.
45. Freedonia Group, 2004a.
46. Xuemin, 2004; Soule et al., 2002.
47. Xuemin, 2004; Soule et al., 2002.
48. Hendriks et al., 2004.
49. Price et al., 1999.
50. WBCSD, 2005.
51. Watson et al., 2005: 16.
52. Watson et al., 2005: 16-17.
53. OECD/IEA, 2001b.
54. OECD/IEA, 2001b, citing De Beer et al. (1999), estimated global iron and steel emissions in 1995 at 1442 $MtCO_2$, amounting to 7 percent of global CO_2. Our estimate for 2000 is less, at 1320 $MtCO_2$. One possible reason for the discrepancy is that some gas byproducts of iron and steel production (namely, coke oven gas, blast furnace gas, and oxygen steel furnace gas) are recovered and used outside the steel-making process (for example, in certain power plants). Because we account for "end use" emissions, emissions from those gas byproducts are not counted under iron and steel.
55. China Iron and Steel Association (CISA). Online at: http://www.chinaisa.org.cn/en/stat/stat.htm.
56. Haoting, 2005.
57. Mannato, 2005.
58. Mittal company profile. Online at: http://www.ispat.com/Company/Profile.htm
59. Author calculations, based on IISI, 2007.
60. Inferred from IISI, 2005. Top 40 companies represent 53 percent of global production; top 80 percent represent 69 percent.
61. Rosen and Houser, 2007.
62. IISI, 2005: 14. One quarter of this trade is within Europe.
63. WTO, 2004: 101.
64. Mannato, 2005.
65. IISI, 2005: 12. IISI, 2007.
66. IISI, 2007
67. OECD/IEA, 2001b.
68. For IISI's statement on climate change, see http://www.worldsteel.org/?action=storypages&id=116 (August 23, 2006).
69. *See* Appendix 2.B for more information.
70. IAI, 2005c. *See* "Environment/Aluminum's Lifecycle."
71. Author calculations, based on IEA, 2004b and IAI, 2005c (see "Environment").
72. IAI, 2005c. *See* "Production/Recycling."

73. John Newman, personal communication, July 20, 2005 (citing U.N. Commodity Trade Statistics). Author calculations based on UNIDO (2005) also suggest similarly large trade flows (covering ISIC class 2720, non-ferrous metals). *See also* Watson et al., 2005.
74. UNCTAD, 2004: 278-280.
75. IAI, 2005c. *See* "Production/Smelting/Technology Types."
76. Shares by application are transport (26%), construction (20%), packaging (20%), electrical (9%) and other (26%). IAI, 2002.
77. International Aluminium Institute, 2004, 2005a,c.
78. *For a more complete discussion, see* Ellis and Baron, 2005.
79. "Buildings," as used here, pertains to IPCC Source Category 1A4a (commercial/institutional) and 1A4b (residential), as well as indirect emissions from *electricity and heat* (category 1A1) consumed in buildings. Contents are described in Baumert et al., 2005: Appendix 2.B.
80. IEA, 2004b.
81. EIA, 2005a; IEA, 2004d.
82. Guéret, 2005.
83. Guéret, 2005.
84. "Agriculture," as used here, pertains to IPCC Source Category 4, but also includes *energy*-related CO_2 emissions from direct sources (category 1A4) and indirect sources (1A1). Contents are described in Baumert et al., 2005: Appendix 2.B.
85. EPA, 2002: §4.1, noting that "N_2O is produced naturally in soils through the microbial process of denitrification and nitrification. A number of anthropogenic activities add nitrogen to the soils, thereby increasing the amount of nitrogen available for nitrification and denitrification, and ultimately the amount of N_2O emitted."
86. WTO, 2004: 101.
87. U.S. EPA, "Ruminant Livestock" at http://www.epa.gov/rlep/faq.html (August 24, 2006).
88. "Methane to Markets," at http://www.methanetomarkets.org/ (August 24, 2006).
89. "Land-Use Change and Forestry" pertains to IPCC Source Category 5. Contents are described in Baumert et al., 2005: Appendix 2.B.
90. These are farming systems that alternate periods of annual cropping with fallow periods, such as "slash and burn" systems, which use fire to clear fallow areas for cropping.
91. Houghton 2003a,b. Estimates do not include the indirect or natural effects of climatic change (for example, CO_2 fertilization) or changes in carbon stocks that may result from various forms of management, such as agricultural intensification, fertilization, the trend to no-till agriculture, thinning of forests, changes in species or varieties, and other silvicultural practices.
92. Houghton, 2003a; IPCC, 2000b: 4.
93. Houghton, 2003a.
94. For definitions of forest products, see http://www.fao.org/waicent/faostat/forestry/products.htm#1.
95. FAO, 2005: 108.
96. FAO, 2005: 108.
97. *See e.g.*, FAO, 2005:
98. FAO, 2005: 42-44.
99. FAO, 2005: 43.
100. FAO, 2005: 46.
101. *See, for example,* Bickel et al., 2003, and Barreto et al., 2006.
102. FAO, 2005: 98.
103. Houghton, 2003a; IPCC, 2000b.
104. A gigaton of carbon (GtC) is equivalent to 1000 MtC, or 3,664 million tons of CO_2 equivalent.
105. The remainder of CO_2 emissions are 6.3 GtC from fossil fuel combustion and cement manufacture. IPCC, 2000b: 5.
106. This sector also includes emissions and removals of CH_4 and N_2O, although there are no reliable global estimates of the influence of these gases on the LUCF sector. IPCC, 2000b: 4.
107. Houghton. 2003a.
108. *See* Baumert et al., 2005: 94 (Figure 17.4).
109. IPCC, 2000b: 3.
110. For an international policy framework on policies and measures, *see* Bradley and Baumert, 2005: Chapters 1 and 2.
111. *See* FAO, 2005: 109-110.
112. *See* FAO, 2005: 110.

5

SUMMARY AND CONCLUSIONS

There are no simple solutions to addressing global GHG emissions, and sectoral solutions do not offer a panacea. A sectoral perspective can be helpful when considering the future evolution of the international climate policy framework. Perhaps most importantly, sectoral analysis helps illuminate which sectors—and which activities, fuels, and processes within sectors—are contributing most to the buildup of GHGs in the atmosphere. Understanding emissions in this manner, as well as the range of other attributes that characterize a given sector, can help policymakers and investors focus on areas of critical importance and shape effective response strategies. However, this does not mean that there is always a case for *international sectoral cooperation*. The main policy findings and conclusions with respect to international sectoral cooperation are summarized below.

FUTURE POLICY DISCUSSION NEEDS TO BE MUCH MORE SPECIFIC IN DISCUSSING "SECTORAL AGREEMENTS"

The term "sectoral" as applied to policy design has become so widely used that it is of limited use as a category. Mandatory emission caps, voluntary industry initiatives, crediting mechanisms, and other policy structures have strengths and weaknesses inherent more to the type of policy instrument chosen than to the fact of being applied to a specific sector. The term "sector" is similarly used to describe both discrete economic activities (e.g., cement production, oil refining) and large and diverse sets of human activity (e.g., transport, land-use change). We propose that terms for specific types of action—sectoral crediting, mandatory sector emission caps, technology standards, etc.—be used in describing policies. Below, where we refer to "sectoral approaches" we intend to make more generic comments.

SECTORAL APPROACHES SHOULD BE USED WITH CAUTION

In general, there is strong reason to prefer more comprehensive approaches over a sector-by-sector breakdown. For a given level of ambition, dividing climate effort into sectoral approaches will tend to increase cost, reduce transparency, and increase the negotiating burden for governments.

Three concerns are particularly prominent:

- There is a sharp information asymmetry between governments and sector representatives, which can make negotiating appropriate targets difficult. Markets are generally a better means of identifying true costs and abatement opportunities than government-industry negotiations. Whereas under a comprehensive approach targets can be set with reference to an environmental goal, sectoral agreements leave governments to make difficult decisions as to the appropriate level of effort from each sector.
- An efficient response to the climate challenge will include displacement of some inherently emission-intensive products and processes by less emission-intensive alternatives. Policy design that weakens this competition between products will raise the cost of emission abatement. Sector agreements therefore should not be a means of relieving the pressure on a particular emission-intensive product relative to competing products.
- There is a strong political imperative to see the climate process driven primarily by the environmental goal of keeping climate change at acceptable levels. Relying heavily on carving out specific sectors for separate agreements makes it extremely difficult to maintain this focus.

Governments should temper inclinations to carve out a sectoral agreement for any emissions that prove remotely challenging; otherwise the system moves toward a *Sector-Only* approach, with its attendant difficulties.

SECTORAL CREDITING APPROACHES MAY BE CHALLENGING IN SECTORS SENSITIVE TO INTERNATIONAL COMPETITION

Some commentators have suggested that crediting mechanisms applied at the sector level (such as a sectoral application of the Clean Development Mechanism, or a "no regrets" cap) might abate competitiveness concerns by drawing all competitors from a sector into a single system. The opportunity cost of increasing emissions is made notionally the same in both developed and developing countries. However, it is not clear that this addresses the underlying concern of competitiveness: that the cost profiles of producers under a genuine emissions cap are different from those under "no regrets". Nor is it clear that developed countries will have the political appetite for enabling significant net financial transfers through a carbon trading mechanism to international competitors in globally traded sectors. Accordingly, sectoral crediting mechanisms and no-lose targets seem to be most appropriate for domestically-oriented sectors such as electricity and buildings, which are addressed in more depth in Section 4.

TECHNOLOGY APPROACHES HAVE CONSIDERABLE POTENTIAL, AND MAY BE NEGOTIATED WITHOUT DIRECT SECTOR INVOLVEMENT

Vehicle efficiency standards, renewable energy mandates, appliance standards, collaborative research and development (R&D), and similar initiatives fall under some usages of the term "sectoral agreements". These initiatives offer considerable scope for contributing toward climate protection efforts, and international coordination can be beneficial—for instance, in spreading the cost of R&D efforts, or in gaining economies of scale for emerging technologies such as wind turbines or hybrid vehicles. Conversely, detailed international negotiation among governments is not essential to implement such measures. Most OECD countries and many developing countries already have targets for renewable energy technologies. All benefit from the economies of scale that the others bring, but each country established their own systems independently. Further consideration is needed to determine under what conditions more explicit international collaboration is useful.

BOTH THE UNFCCC AND EXTERNAL PROCESSES HAVE A POTENTIAL ROLE AS FORA FOR SECTORAL APPROACHES, BUT THE GREATER NEGOTIATING BURDEN MAY PROVE CHALLENGING

Specific arrangements are made for certain sectors under the UNFCCC and Kyoto Protocol, in particular for bunker fuels (air and sea transport) and for land-use change and forestry. However, other kinds of specific treatment for sectors have been resisted as unduly compromising the rights of sovereign Parties to choose how to reduce emissions. It is plausible that the UNFCCC may introduce recognition for sectoral approaches agreed in other fora. However, this raises questions of equity and inclusiveness for Parties to the UNFCCC that are excluded from these alternative fora. For instance, countries outside the G8 may resent the use of G8 processes as the venue for defining new technology agreements. The negotiating burden of too wide a use of sectoral approaches may also be excessive. Finally, less comprehensive coverage within a major climate agreement may remove some of the potential for trade-offs between sectors that make agreements possible. An additional question is whether "sectors" as such—i.e., groups representing the industry itself—have a place at the negotiating table. Under a UNFCCC structure only governments are negotiating Parties. Some approaches, such as the Asia-Pacific Partnership, have included companies or other industry representatives as partners in negotiation. However, this approach has yet to produce significant results by which it might be judged.

ADDITIONAL RESEARCH

Additional work is needed on the subject of international sectoral cooperation. This report has presented some of the attributes of different sectors, different policy options for sectoral cooperation, and some "models" of how the overall regime might incorporate sector-specific provisions. The topic of sectoral cooperation, however, is extremely complex. If an actual agreement were to be negotiated in a given sector, the information provided here would be insufficient to form the basis of decision-making.

Additional work on sectoral cooperation might explore the following issues:

- What additional sectors should be explored (e.g., oil and gas)? What other ways might sectors be defined? Those discussed in this report do not represent the full range of sectors or options. Furthermore, as noted, there are no formal definitions and boundaries of sectors.
- What is the optimal form of international cooperation in a given sector from an environmental, economic, and political point of view? What are the views of key stakeholders? Additional sector-specific analysis is needed along the lines already begun by IEA and OECD.[1]
- Within specific sectors and policy choices, what is the appropriate level of stringency? What will deliver real emission reductions and move society toward the objective of the UNFCCC, without resulting in economic dislocation?
- How can sectoral agreements overcome the various disadvantages of sectoral cooperation discussed in Section 1.2; namely concerns over cost-effectiveness and environmental effectiveness (e.g., technological "lock-in" and adverse inter-sectoral substitution effects)?
- Which countries should participate in which kinds of agreements? As discussed in Section 1, one of the rationales offered in support of sectoral approaches is to increase *participation*; namely to engage the United States, Australia, and developing countries. What kind of comprehensive agreement and what combination of sectoral agreements would yield the highest levels of participation and emission reductions?

REFERENCES

Baron, Richard (2006). Sectoral Approaches to GHG mitigation: Scenarios for integration, OECD/IEA Information Paper, Paris.

Baron, R. and Ellis, J. (2006). Sectoral Crediting Mechanisms for Greenhouse Gas Mitigation: Institutional and Operational Issues. OECD/IEA Information Paper. COM/ENV/EPOC/IEA/SLT(2006)4, http://www.oecd.org/dataoecd/36/6/36737940.pdf.

Barreto, P., C. Souza Jr., R Nogueron, A. Anderson, R Salomao. 2006. *Human Pressure of the Brazilian Amazon Forests*. Washington, DC: World Resources Institute.

Barrett, S. 2001. "Towards a Better Climate Treaty." *Policy Matters* 01-29, Washington, DC, AEI-Brookings Joint Center for Regulatory Studies.

Barrett, S. 2002. *Environment and Statecraft*. Oxford: Oxford University Press.

Baumert, K.A., and Goldberg, D.M. 2006. "Action Targets: A New Approach to International Greenhouse Gas Controls." *Climate Policy*, Vol. 5, No. 6.

Baumert, K.A., T. Herzog, and J. Pershing. 2005. Navigating the Numbers: Greenhouse Gas Data and International Climate Policy. Washington, DC: World Resources Institute.

Benedick, R.E. 2001. "Striking a New Deal on Climate Change." *Issues in Science and Technology*. Fall: 71-76. Available at http://www.issues.org/18.1/benedick.html (August 22, 2006).

Bickel, U. and J. Maarten Dros. 2003."The Impacts of Soybean Cultivation on Brazilian Ecosystems." WWF-Forest Conservation Initiative. October. 2003 Online at: http://assets.panda.org/downloads/impactsofsoybean.pdf.

Bosi, M., and J. Ellis. 2005. "Exploring Options for Sectoral Crediting Mechanisms." Paris: OECD/IEA.

Bradley, R. and K. Baumert. 2005. *Growing in the Greenhouse: Protecting the Climate by Putting Development First*. Washington, DC: World Resources Institute.

CCAP (Center for Clean Air Policy). 2005. "The Sectoral Pledge Approach: A New Proposal for Stabilizing Global Emissions Post-2012 via Major Industry Sector Targets in Developed and Developing Countries." Washington, DC.

Conover, Christopher. 2003. "A Review and Synthesis of the Cost and Benefits of Health Services Regulations", Duke University.

Ellis, J. and R. Baron. 2005. "Sectoral Crediting Mechanisms: An Initial Assessment of Electricity and Aluminium." Paris: OECD/IEA.

Eskom. 2004. *Annual Report 2003*. Johannesburg. Online at: http://www.eskom.co.za/about/Annual%20Report%202003/index.html (July 25, 2005).

Hendriks, C.A.,, E Worrell, D. de Jager, K. Blok, and P. Riemer. 2004. "Emission Reduction of Greenhouse Gases from the Cement Industry." IEA GHG R&D Programme. Online at: http://www.wbcsd.ch/web/projects/cement/tf1/prghgt42.pdf (July 25, 2005).

Herzog, T., K.A. Baumert and J. Pershing. 2006. "Greenhouse Gas Intensity Targets: Lessons Learned and Future Prospects." Washington, DC: World Resources Institute.

Guéret, Thomas. 2005. "International Energy Technology Collaboration and Climate Change Mitigation. Case Study 3: Appliance Energy Efficiency." Paris: OECD/IEA. Available at http://www.oecd.org/dataoecd/22/39/34878217.pdf (August 24, 2006).

Holcim. 2004. *Annual Report 2003*. Online at: http://www.holcim.com. *See also* supporting information on company webpage ("Resource Utilization and CO_2") at http://www.holcim.com/CORP/EN/oid/47529/module/gnm50/jsp/templates/editorial/editorial.html (July 25, 2005).

Houghton, R.A. 2003a. "Emissions (and Sinks) of Carbon from Land-Use Change." (Estimates of national sources and sinks of carbon resulting from changes in land use, 1950 to 2000). Report to the World Resources Institute from the Woods Hole Research Center. Washington, DC: WRI. Online at: http://cait.wri.org/downloads/DN-LUCF.pdf.

Houghton, R.A. 2003b. "Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850-2000." *Tellus*. 55B: 378--390.

Houghton, R.A. and J.L Hackler. 2002. "Carbon Flux to the Atmosphere from Land-Use Changes." Oak Ridge, TN: CDIAC. Online at: http://cdiac.esd.ornl.gov/trends/landuse/landuse.htm (July 25, 2005).

International Aluminium Institute (IAI). 2002. *Aluminium: Industry as a Partner for Sustainable Development*. Paris: ICCA and UNEP. Online at: http://www.uneptie.org/outreach/wssd/docs/sectors/final/aluminium.pdf (August 26, 2005).

IAI. 2004. "The Global Aluminum Sustainable Development Initiative." London. Online at: http://www.world-aluminum.org/iai/publications/documents/aes_pfc_2003.pdf (July 25, 2005).

IAI. 2005a. "Report on the Aluminium Industry's Global PFC Gas Emissions Reduction Programme: Results of the 2003 Anode Effect Survey." Online at: http://www.world-aluminum.org/iai/publications/documents/aes_pfc_2003.pdf (July 25, 2005).

IAI. 2005b. "IAI Statistics." Online at: http://www.world-aluminum.org/iai/stats/index.asp (July 25, 2005).

IEA. 2004a. *CO2 Emissions from Fuel Combustion* (2004 edition). Paris. Online at: http://data.iea.org/ieastore/co2_main.asp (July 25, 2005).

IEA. 2004b. *Energy Balances for OECD Countries and Energy Balances for non-OECD Countries*; *Energy Statistics for OECD Countries and Energy Statistics for non-OECD Countries* (2004 editions). Paris.

IEA. 2004c. *World Energy Outlook 2004*. Paris: OECD/IEA.

IEA. 2004d. *Oil Crises and Climate Challenges: 30 Years of Energy Use in IEA Countries*. Paris.

IISI (International Iron and Steel Institute). 2007. *World Steel in Figures: 2007 Edition*. Online at: http://www.worldsteel.org/pictures/storyfiles/WSIF07web%20v4.pdf (July 11, 2007).

IPCC (Intergovernmental Panel on Climate Change). 1997. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (online at: http://www.ipcc-nggip.iges.or.jp/public/gl/ guidelin/ch1wb1.pdf) and Understanding the Common Reporting Framework. (online at: http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ ch1ri.pdf) (August 21, 2005).

IPCC. 2001. *Climate Change 2001: Mitigation*. Contribution of Working Group III to the Third Assessment Report of the IPCC, Metz et al., eds. Cambridge, U.K.: Cambridge University Press.

Kim, Y-G and K. Baumert. 2002. "Reducing Uncertainty through Dual-Intensity Targets." *In* Baumert et al. (eds.), *Building on the Kyoto Protocol: Options for Protecting the Climate*. Washington, DC: WRI.

Matsushita, M., T.J. Schoenbaum, and P.C. Mavroitis. 2003. *The World Trade Organization: Law, Practice, and Policy*. New York: Oxford University Press.

Mannato, F. 2005. *Global Steel Market Development*. Presentation at the "Outlook for Steel Conference," organized by the OECD in co-operation with the IISI. January 12-13, 2005, Paris.

Pershing, J. and J. Mackenzie. 2004. "Removing Subsidies: Leveling the Playing Field for Renewable Energy Technologies." Thematic Background Paper for *Renewables 2004*, Bonn.

Pew Center on Global Climate Change (Pew). 2005. "International Climate Efforts Beyond 2012: Report of the Climate Dialogue at Pocantico."

Philibert, C., 2000. "How Could Emissions Trading Benefit Developing Countries?" *Energy Policy*, vol.28, No. 13.

Philibert, C. 2005. *Approaches for Future International Cooperation*, IEA and OECD Information Paper, Paris.

Rosen, D. and T. Houser. 2007. *China: a guide for the perplexed*. Peterson Institute for International Economics. Washington, DC.

Samaniego, J. and C. Figueres. 2002. "A Sector-Based Clean Development Mechanism" in Baumert et al. (eds.), *Building on the Kyoto Protocol: Options for Protecting the Climate*. Washington, DC: WRI.

Schmidt, J. et al. 2004. "Sector-Based Greenhouse Gas Emissions Reduction Approach for Developing Countries: Some Options." Washington, DC: Center for Clean Air Policy.

Soule, M.H., J.S. Logan, and T.A. Stewart. 2002. *Trends, Challenges, and Opportunities in China's Cement Industry*. Independent study commissioned by the World Business Council for Sustainable Development. Online at: http://www.wbcsdcement.org/pdf/sub_china.pdf (July 25, 2005).

Steiner, I.D. 1972. Group Processes and Productivity. New York: Academic Press.

UNFCCC (United Nations Framework Convention on Climate Change). 1992. United Nations Framework Convention on Climate Change. Full text online at: http://unfccc.int.

UNFCCC. 1997. The Kyoto Protocol to the United Nations Framework Convention on Climate Change. Full text online at: http://unfccc.int.

UNFCCC. 2006. Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. UNFCCC Doc. FCCC/KP/CMP/2005/8/Add.1.

United Nations Conference on Trade and Development (UNCTAD). 2004. *World Investment Report 2004: The Shift Toward Services*. New York and Geneva.

United Nations Statistics Division. 2006. Commodity Trade Statistics Database (COMTRADE). New York. Online at: http://comtrade.un.org/db/ (October 20, 2007).

United States Geological Survey (USGS). 2007. *Mineral Commodity Summaries: Cement*. Full text online at: http://minerals.usgs.gov/minerals/pubs/commodity/cement/cemenmcs07.pdf (October 20, 2007).

Ward, M. *Climate Policy Solutions: A Sectoral Approach*. 2006. Available at http://homepages.paradise.net.nz/murrayw3/documents/pdf/A%20sectoral%20approach.pdf. Also see www.sectoral.org.

Watson, C. J. Newman, S. Upton, and P. Hackmann. 2005. "Can Transnational Sectoral Agreements Help Reduce Greenhouse Gas Emissions?" Round Table on Sustainable Development. Paris: OECD.

WBSCD (World Business Council for Sustainable Development). 2005. The Cement Sustainability Initiative Progress Report. Geneva. Available at http://www.wbcsdcement.org/ (August 23, 2006).

WRI (World Resources Institute). 2006. *Climate Analysis Indicators Tool* (CAIT), version 3.0.

Xuemin, Z., 2004. "Spotlight on China" (World Cement). Online at: http://www.worldcement.com/Cement/Assets/china.pdf. Palladian Publications, Ltd.

ABOUT THE AUTHORS

Rob Bradley is Director of the World Resources Institute's International Climate Policy Initiative. Prior to joining WRI in 2004, he has worked for 10 years on European and International climate and energy policy for private, public and NGO sector clients. He holds a BSc in Physical Sciences from University College London and an MSc in Environmental Sciences from the University of East Anglia.

Kevin A. Baumert was a senior associate in the Climate and Energy Program at the World Resources Institute. His research focused on the Kyoto Protocol and climate change policy instruments. Prior to joining WRI in 1998, he received a B.A. in Economics from the University of Notre Dame and a Masters degree from Columbia University's School of International and Public Affairs.

Britt Childs is a research analyst in the Climate and Energy Program at the World Resources Institute. Her research focuses on international climate policy, including in particular, sustainable development and clean technology deployment. She holds a bachelor's degree in international politics from Georgetown University's Walsh School of Foreign Service.

Timothy Herzog was an associate at the World Resources Institute working on domestic and international climate policy issues. Prior to joining WRI in 2004, Herzog worked in the private sector as a technology consultant to several leading U.S. companies. Herzog holds a master's degree in public policy from the Georgetown Public Policy Institute and a bachelor's degree in communications from Bethel University in Minnesota.

Jonathan Pershing is Director of the Climate and Energy Program at the World Resources Institute. He is active in work on domestic and international climate and energy policy, including emissions trading, energy technology and the evolving architecture of international climate agreements. Prior to his move to WRI, he served for five years as the Head of the Energy and Environment Division at the International Energy Agency in Paris, and in the US Department of State, where he was both Deputy Director and Science Advisor for the Office of Global Change. Dr. Pershing is the author of several books and numerous articles on climate change, energy, and environmental policy, has served as a Review Editor and lead author for the IPCC. He holds a doctorate in geology and geophysics from the University of Minnesota.

ABOUT WRI

The World Resources Institute (WRI) is an environmental think tank that goes beyond research to find practical ways to protect the earth and improve people's lives.

Our mission is to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations.

Because people are inspired by ideas, empowered by knowledge, and moved to change by greater understanding, WRI provides—and helps other institutions provide—objective information and practical proposals for policy and institutional change that will foster environmentally sound, socially equitable development.

WRI organizes its work around four key goals:

- **People & Ecosystems:** Reverse rapid degradation of ecosystems and assure their capacity to provide humans with needed goods and services.
- **Access:** Guarantee public access to information and decisions regarding natural resources and the environment.
- **Climate Protection:** Protect the global climate system from further harm due to emissions of greenhouse gases and help humanity and the natural world adapt to unavoidable climate change.
- **Markets & Enterprise:** Harness markets and enterprise to expand economic opportunity and protect the environment.

WORLD
RESOURCES
INSTITUTE

10 G Street, NE
Suite 800
Washington, DC 20002
www.wri.org

ISBN 978-1-56973-668-5

9 781569 736685 59000