Accounting for Greenhouse Gas Emissions Associated with the Supply of Fossil Fuels

Introduction and background

Current climate policies and accounting frameworks for climate change mitigation focus largely on the demand, or use, side of the fossil fuel equation. GHG emissions inventories quantify the emissions associated with fossil fuel use by each country or entity. Climate policies such as emissions trading systems or emissions standards tend to regulate or price GHG emissions at the point of fossil fuel combustion (e.g. power plants or industrial facilities) or distribution (oil and gas supply).

This demand-side focus leads to a conundrum: countries (and individual entities) can increase fossil fuel supply and infrastructure, potentially locking-in substantial future emissions, with often little effect on their own emissions accounts.[1] Generally, the only carbon emissions attributed to fossil fuel production are those emitted when energy is used to locate, extract, process, and transport fuel. This is usually a small amount, because even as fossil fuel *combustion* accounts for about 85% of global CO_2 emissions,[2] fossil fuel *production* accounts for only about 5% of CO_2 emissions (and close to 10% of overall GHGs).[3] Countries that are large net exporters of fossil fuels can thus greatly increase their fossil fuel extraction activities with limited impact on their own GHG emissions. Yet clearly, increasing the production of fossil fuels can pose a threat to achieving global climate change mitigation goals.

Complementary analytical frameworks that better account for the GHG implications of existing and new fossil fuel supplies could help to address this conundrum. This discussion brief explores how one such framework, extraction-based emissions accounting (Davis et al. 2011), tracks and accounts for the emissions associated with fossil fuels as they are brought into the world economy.

Extraction-based emissions accounting

GHG inventories submitted by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are based on the emissions released within the country, such as the CO2 released by combustion of fuels for power generation, industrial production, or transportation. Existing GHG reduction targets (such as those submitted by countries under the Copenhagen Accord), including those on a carbon-intensity basis, use this "territorial" accounting.

However, there are other ways to account for GHG emissions. For example, carbon "footprinting", or consumption-based emissions accounting, attributes the emissions associated with producing and delivering goods and services to households (and countries) that consume them, rather than to the businesses (and countries) that produce and transport them (see, e.g., Peters 2008). Consumption-based emissions inventories can help account for emissions leakage, and have been proposed as one way of assigning responsibility for emission reductions (Grubb 2011).

Oil industry infrastructure in Puerto La Cruz, Venezuela.

Risks of and responses to the new fossil fuel economy

This discussion brief is part of a two-year SEI project that aims to deepen understanding of the risks posed by new investments in fossil fuel infrastructure, and of the possible responses by policy-makers and civil society to mitigate or avoid these risks. In particular, this initiative examines major decisions regarding new investments in fossil fuel extraction and trade infrastructure, especially in venues where green growth or low-emission development strategies (LEDS) are under development or consideration. Our aim is to provide resources and tools to help planners and policy-makers assess the risks of, and responses to, fossil development, as part of low-carbon and green growth planning.

1 In the case of emissions-intensive extraction processes, such as those associated with oil sands, emissions are more significant, but still a fraction of emissions associated with eventual combustion of the fuel.

2 Most of the remaining CO_2 emissions are from land use change and process emissions from industry (especially cement production).

3 Based on the fossil fuel industry's "own use" of energy (IEA 2011), CO_2 emission factors from the World Energy Outlook (IEA 2012), non-CO_2 emissions from fossil fuel production from the U.S. EPA (2012), and global CO_2 and GHG figures from the World Resources Institute's CAIT tool (WRI 2013).

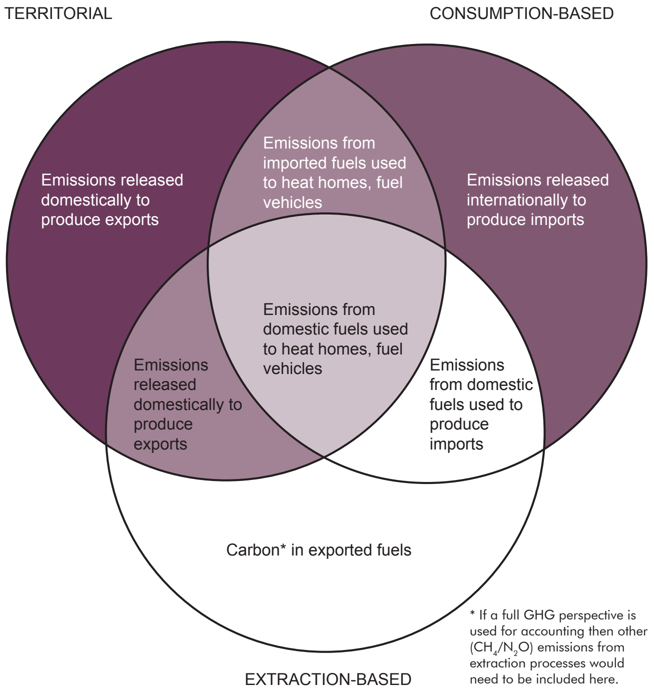

Figure 1: Comparison of territorial, consumption, and extraction-based GHG accounting

More recently, a third way of accounting for emissions has been suggested, associated with carbon extraction (Davis et al. 2011; Peters et al. 2012).[4] In this approach, CO_2 emissions from burning fossil fuels are attributed to the country where the fuels are extracted. This approach can be used to reflect a principle of producer responsibility, as is often applied to manufacturing, to promote accountability for the environmental impacts of the use and disposal of products (Sander et al. 2007). It can also provide insights regarding the design and implications of international efforts to address CO_2 emissions (Davis et al. 2011), and for economic competitiveness in a future low-carbon global economy, as discussed further below.

The territorial, consumption, and extraction-based approaches have considerable complementarities, as illustrated by the unique categories of CO_2 emissions depicted in Figure 1 for each approach.[5] The consumption approach, for example, captures the extent to which a country or region relies upon emissions in other countries to meet its demand for goods and services, a perspective missing from other accounting approaches.

Methods and results of extraction-based accounting

Extraction-based emissions accounting is perhaps the easiest to implement of the three approaches depicted in Figure 1. Extraction-based emissions can be calculated by multiplying primary energy extraction data for coal, oil and gas by location-specific (or default) carbon contents, and adjusting for the fraction of fossil fuels that are not combusted (e.g. used for other, non-energy purposes such as lubricants or plastics, transportation and handling losses, or incomplete combustion oxidation). Such data are widely available at national and other geographic scales, and are often reported by individual fossil fuel producers.[6]

In principle, the global sum of extraction-based emissions should equal the global sum of territorial emissions (and in turn, consumption-based emissions). In other words, if proportional to emissions, the sizes of large circles in Figure 1 would differ at a country level, but should be the same at a global level. In that sense, as with consumption-based emissions, extraction-based emissions are simply a reallocation of fossil fuel emissions from the location of combustion to the location of extraction. Indeed, Davis et al. (2011) calculate extraction emissions for 112 countries (or groupings thereof) using a methodology that reallocates territorial emissions (based on fossil fuel trade data in their GTAP 7-based model), rather than one that uses country-specific fossil fuel extraction figures, as noted above.[7]

Consider the example of Mongolia, which has been rapidly expanding its mining and exports of coal. Here, we estimate energy-related CO_2 for each of three accounting approaches for Mongolia, based on data for 1990–2008 compiled in the global Eora database (Lenzen et al. 2012) and on coal extraction statistics published by the International Energy Agency (IEA 2011). Figure 2 presents time-series results for each approach on the same graph.

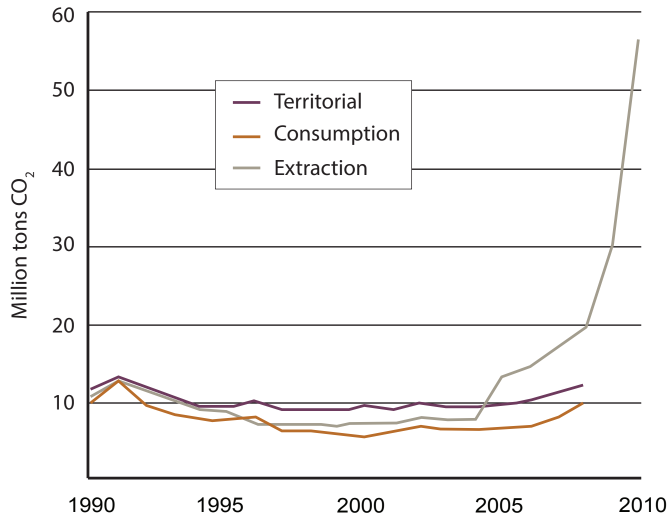

Figure 2: Energy-related CO_2 emissions for Mongolia from a territorial, consumption, and extraction-based accounting perspective

Potential insights and benefits of extraction-based accounting

Accounting for GHG emissions associated with fuel extraction and trade not only provides another perspective on countries' contributions to global GHG emissions, but might also help them assess potential future economic competitiveness. For example, some analysts have argued that countries that are strongly dependent on high-carbon exports may be less prepared for a future low-carbon economy

4 Peters et al. (2012) term this accounting "physical carbon", which may be included in fossil fuels, petroleum-derived products, harvested wood products, crops, and livestock.

5 Broadly speaking, methods for all three approaches are to multiply fuel or activity data by emission factors for each. In a territorial inventory, this involves multiplying fuel consumptions statistics with the carbon content of those fuels with methods and default data set forth by the Intergovernmental Panel on Climate Change (IPCC). (Methods for other territorial sources vary somewhat, such as for animal methane, which involves multiplying the number of livestock by expected emissions from each.) Consumption-based inventories are assembled by multiplying consumption data (usually economic spending, e.g. in USD) by the emissions intensity of that consumption (e.g. CO_2 per USD) based on economic models. Extraction-based accounting is performed by multiplying the fuels produced by the carbon content of those fuels.

6 It is most straightforward, when estimating extraction-based emissions and comparing them with territorial and consumption-based emissions, to consider only CO_2 emissions.

7 As a result, their methodology enables directly comparisons and differences with territorial and consumption-based emissions, as illustrated at: http://supplychainco2.stanford.edu.

(Vivid Economics 2009). If countries were to curtail fossil fuel consumption, those reliant on fossil fuel exports – especially coal and oil – would be economically vulnerable.

To help assess alternative pathways of energy demand, the IEA has outlined a range of possible future scenarios. For example, the scenarios for coal use range from continued growth in demand, to one where global coal use peaks before 2020 and declines steadily after that (IEA 2012). As shown in Figure 3, recently announced ("New") policies in major economies have lowered the IEA's forecasts of future coal demand, and further action by countries to address GHG emissions, through caps on coal usage (as in China), carbon pricing (as in Europe and under development in China), and other measures (such as emissions limits on new power plants in the United States) could lead to declining coal demand, as in the IEA's 450 ppm scenario.

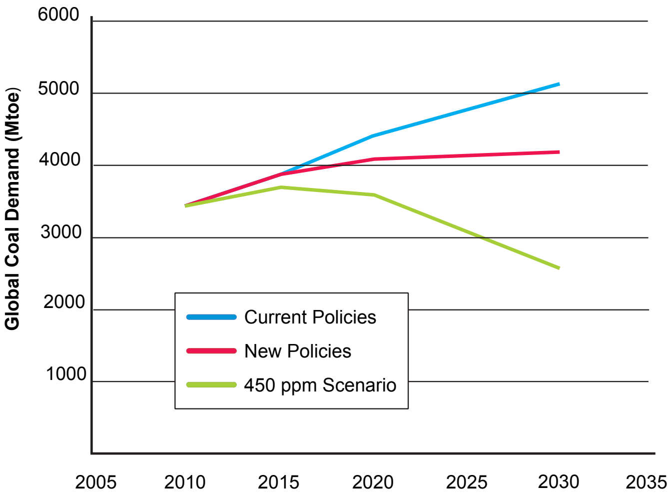

Figure 3: Scenarios of global coal demand (IEA 2012)

Declines in coal demand such as in the IEA's 450 ppm scenario could depress prices and introduce new economic risks to countries that are highly dependent on coal exports or are considering introducing new expansions of coal export infrastructure, potentially also leading to coal extraction assets being "stranded" (HSBC 2012; Leaton 2012). In contrast, economies that develop low-carbon energy systems and low-carbon exports may benefit from a higher degree of "low-carbon competitiveness" if major economies take serious action to address climate change (Vivid Economics 2009).[8]

Accounting for emissions on an extraction basis could provide a simple measure of low-carbon competitiveness: countries whose extraction-based emissions are significantly larger than their territorial emissions could be deemed to face elevated economic risk associated with fossil fuel exports.

Extraction-based accounting could also prove helpful for designing and understanding the implications of future climate policies. Regulating emissions at the point of extraction could provide a more straightforward way to limit the risk of emissions leakage – the movement of emitting activities among

8 Furthermore, climate concerns aside, reliance on natural resource extraction has not always led to long-term economic growth in major economies – and sometimes has proved a hindrance (Barma et al. 2012; van der Ploeg 2011). One of the risk factors identified for over-dependence on natural resources in economic growth has been the ratio of natural resource rents to GDP. One threshold that has been proposed is 15%, which at least 20 countries surpassed in 2011 based on fossil fuel rents alone (Jarvis et al. 2011).

Hamble Oil Terminal, UK.

countries as the result of variations in the stringency of emissions pricing and regulation – given the concentration of fossil fuel deposits in among a few large economies and more limited ability to shift the location of fossil fuel extraction than of fossil fuel use (Davis et al. 2011).

Using life-cycle assessment to account for the relative GHG emissions of fossil fuel supplies

Extraction-based GHG emissions accounting, described above, is perhaps the most straightforward means of accounting for emissions associated with the supply of fossil fuels. It counts the carbon contained within the fuel itself. As such, it does not provide much insight into the relative GHG emissions along the full "life cycle" of fuel extraction, processing, transportation, distribution and combustion. Yet the full life-cycle emissions associated with different sources of coal, oil, and gas can vary significantly. For example, the upstream (pre-combustion) emissions associated with crude oil from Canadian oil sands or Venezuelan heavy oils are roughly three times greater than those associated with more conventional light crude oils from Saudi Arabia, equivalent to up to 30% of the emissions from burning the fuel on a CO_2e basis (CARB 2012). This type of "attributional" life cycle assessment (LCA) is common in the literature for comparing the GHG emissions associated with one fuel to another, and is usually conducted from the perspective of the final user of the fuel, to compare the "upstream" emissions associated with alternative fuel choices.[9]

LCA can offer an added perspective to extraction-based emissions accounting. For example, multipliers to account for these "upstream" emissions, including fugitive methane releases, could be added to the (CO_2-based) extraction-based emissions accounts.[10]

9 Attributional life cycle assessment (LCA) focuses on attributing sources of emissions to products, such as fuels. Another branch of LCA, consequential LCA, focuses on evaluating the incremental impacts of changes in product choice (Earles and Halog 2011) For example, attributional LCA can assess the GHG emissions associated with shale gas or conventional natural gas, whereas consequential LCA could assess the changes in GHG emissions associated with a shift from conventional to shale gas.

10 LCA could also provide a basis for determining the full, relative emissions associated with developing and using a given fossil resource, as well as its competitiveness in a low-carbon context. For example, the EU and California have adopted a fuel quality directive (FQD), and low-carbon fuel standard (LCFS), respectively, that place a limit on the upstream GHG emissions associated with individual fuel sources, and rely on LCA results for implementation. Such policies may pose challenges for Canadian oil sands and other high upstream emissions suppliers.

Exploring alternative development paths

Extraction-based GHG emissions accounting may be particularly useful for countries (or sub-national areas) considering alternative future development paths, such as in the context of Low-Emissions Development Strategies (LEDS) or "green growth" initiatives (Clapp et al. 2010; GGKP 2013). Given the large amounts of revenue that countries can derive from exploiting their fossil fuel reserves, it is hard to resist doing so, even though it is increasingly clear that to avoid dangerous levels of climate change, large shares of those fuels will need to be left in the ground (Gurría 2013; IPCC 2013). The extraction-based approach to CO_2 emissions accounting can help offer a more complete picture of a region's contribution to global GHGs and, in so doing, help introduce possible ethical and economic considerations of alternative development pathways.

Lamberts Point Coal Terminal, Norfolk, VA.

References

Barma, N., Kaiser, K., Le, T. M. and Viñuela, L. (2012). *Rents to Riches? The Political Economy of Natural Resource-led Development.* The World Bank, Washington, DC.

CARB (2012). *LCFS Lookup Tables as of December 2012*. Low Carbon Fuel Standard. California Air Resources Board. http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

Davis, S. J., Peters, G. P. and Caldeira, K. (2011). The supply chain of CO2 emissions. *Proceedings of the National Academy of Sciences*, 108(45). 18554 –18559. DOI:10.1073/pnas.1107409108.

Earles, J. M. and Halog, A. (2011). Consequential life cycle assessment: a review. *The International Journal of Life Cycle Assessment,* 16(5). 445–53. DOI:10.1007/s11367-011-0275-9.

GGKP (2013). *Moving Towards a Common Approach on Green Growth Indicators*. Green Growth Knowledge Platform Scoping Paper. GGKP including staff from the Global Green Growth Institute, Organisation for Economic Co-operation and Development, United Nations Environment Programme, and World Bank, Paris. http://issuu.com/ggkp/docs/ggkp_moving_towards_a_common_approa.

Grubb, M. (2011). International climate finance from border carbon cost levelling. *Climate Policy*, 11(3). 1050–57. DOI:10.1080/14693062.2011.582285.

Gurría, A. (2013). The climate challenge: Achieving zero emissions. Lecture by the OECD Secretary-General, London, 9 October 2013. http://www.oecd.org/about/secretary-general/The-climate-challenge-achieving-zero-emissions.htm.

IEA (2012). *World Energy Outlook 2012*. International Energy Agency, Paris. http://www.worldenergyoutlook.org.

IEA (2011). *World Energy Balances 2011*. International Energy Agency, Paris. http://www.iea.org/stats/.

IPCC (2013). *Climate Change 2013: The Physical Science Basis – Summary for Policymakers*. Contribution of Working Group I to the Intergovernmental Panel on Climate Change Fifth Assessment Report, Stockholm, Sweden. http://www.climatechange2013.org.

Jarvis, M., Lange, G.-M., Hamilton, K., Desai, D., Fraumeni, B., et al. (2011). *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium.* The World Bank, Washington, DC. http://issuu.com/world.bank.publications/docs/9780821384886.

Leaton, J. (2012). *Unburnable Carbon - Are the World's Financial Markets Carrying a Carbon Bubble?* Carbon Tracker Initiative. http://www.carbontracker.org/wp-content/uploads/downloads/2012/08/Unburnable-Carbon-Full1.pdf.

Lenzen, M., Kanemoto, K., Moran, D. and Geschke, A. (2012). Mapping the Structure of the World Economy. *Environmental Science & Technology,* 46(15). 8374–81. DOI:10.1021/es300171x.

Peters, G. P. (2008). From production-based to consumption-based national emissions inventories. *Ecological Economics*, 65(1). 13–23. DOI:10.1016/j.ecolecon.2007.10.014.

Peters, G. P., Davis, S. J. and Andrew, R. (2012). A synthesis of carbon in international trade. *Biogeosciences*, 9(8). 3247–76. DOI:10.5194/bg-9-3247-2012.

Sander, K., Schilling, S., Tojo, N., Rossem, C. van, Vernon, J. and George, C. (2007). *The Producer Responsibility Principle of the WEEE Directive.* DG ENV. Study Contract N° 07010401/2006/449269/MAR/G4. Ökopol GmbH; International Institute for Industrial Environmental Economics, Lund University; and Risk & Policy Analysts. http://ec.europa.eu/environment/waste/weee/pdf/final_rep_okopol.pdf.

US EPA (2012). *Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2030.* EPA 430-R-12-006. U.S. Environmental Protection Agency, Washington D. C.

Van der Ploeg, F. (2011). Natural Resources: Curse or Blessing? *Journal of Economic Literature*, 49(2). 366–420. DOI:10.1257/jel.49.2.366.

Vivid Economics (2009). *G20 Low Carbon Competitiveness*. The Climate Institute and E3G. http://www.vivideconomics.com/index.php/publications/g20-low-carbon-competitiveness-report.

World Resources Institute (2013). *Climate Analysis Indicators Tool (CAIT 2.0)*. Washington, DC. http://cait2.wri.org/.

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