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A greenhouse gas emissions inventory for South Africa: A comparative analysis

R. Seymore*, R. Inglesi-Lotz, J. Blignaut

Department of Economics, University of Pretoria, South Africa

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ABSTRACT

An energy-based greenhouse gas (GHG) emissions inventory for South Africa for various years is presented, but most notably an estimate for 2008, in terms of industrial sectors using the energy balances of South Africa is given. This figure is estimated to be between 470,000 and 550,000 Gg of CO_2-equiv. with the higher number probably being a more realistic reflection. This information is compared to six other inventories to (i) assess the robustness of the results presented, and (ii) to comment on the stability of the inventories available.

From this comparative analysis it is evident that major discrepancies exist among the inventories both in terms of scope (i.e. sectors and gas composites included) as well as method of estimation used. These differences hamper the efficacy of, among others, any economic modelling exercise related to carbon emissions, such as estimating the impact of carbon taxes on the country. It is therefore argued that a consistent, robust and replicable framework for estimating GHG emissions that would also render timeous results, should be adopted.

Contents

* Corresponding author. Tel: +2712 420 3464.
E-mail address: reyno.seymore@up.ac.za (R. Seymore).

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1. Introduction

South Africa, as the leading economy in the Sub-Saharan Africa, is also the negative leader in greenhouse gas emissions (GHG) in the continent. The high emissions profile of the country is linked with the economy's production and growth. Policy makers have made international commitments but also they have shown initiatives locally to reduce the country's GHG emissions. They appreciate highly the country's, as well as the continent's, vulnerability to climate change due to the geographical position and the more traditional nature of the African developing economies. However, a desire to improve is not adequate without knowledge of the current emitting profile of the country and its evolution through the years until now.

Here a comparative analysis among the various GHG emission inventories of South Africa is conducted, and in the process new inventories for 2007 and 2008 are constructed. In an effort to start with an holistic picture of the *status quo* of the country's inventories, we first analyse and review the South African Department of Energy (DoE), the South African Department of Environmental Affairs and Tourism (DEAT), the International Energy Agency (IEA), Scholes and van der Merwe [3], Howells and Solomon [4], and Blignaut et al. [5]. Not only are these emission inventories relatively dated and requiring an update, but they also make use of different methodologies and report on the emissions using different industrial classifications. All these locally and internationally sourced databases will be used as a reference and comparative points to our results. They will also serve as part of the motivation for the need or not of an all-inclusive, robust and easily updated new database.

This paper proposes a consistent and theoretical rigorous approach to construct a reliable and timeous GHG emissions inventory. To accomplish this task, this paper develops GHG emissions databases for 2007 and 2008 in terms of industrial sectors, using the energy balances of South Africa.

In the next section a brief overview of existing GHG inventories for South Africa is provided. The third section provides the inventory construction method used in this study. Thereafter, the results are discussed, followed by an analysis on the robustness of the results. Lastly, a conclusion with recommendations is provided.

2. Background

2.1. Introduction

South Africa is the 13th highest CO_2-equiv.-emitter among nations (according to annual emissions in 2008). This constitutes 1.4% of combined global anthropogenic GHG emissions [1]. In 2008, however, South Africa was ranked 28th in the world with respect to GDP and its global share in GDP was only 0.45% [2]. Therefore, there is a stark contrast between what the country contributes to GDP and what it contributes to GHG emissions. This anomaly is clearly reflected in the fact that the country's disproportionate contribution of global CO_2 is 3.1 times that of its contribution to global GDP. A careful analysis of South Africa's GHG emissions profile and subsequent action to reduce (mitigate) its emissions is needed. It also requires the construction of robust and timeous GHG emission inventories that underpins much of the mitigation analysis and action. To date there are six sources of GHG emission inventories, namely:

- The inventory published by Scholes and Van der Merwe [3] for 1988,
- The inventory published by Howells and Solomon [4] for 1994,
- The Department of Environmental Affairs and Tourism inventories for 1990, 1994 and 2000,
- The Department of Energy inventories for 2007 and 2008,
- The International Energy Agency's inventories for 1971, 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2007, 2008 and 2009, and
- The inventory published by Blignaut et al. [5] for 1998.

These inventories are briefly discussed below and summarised in Table 1.

2.2. The inventory based on Scholes and Van der Merwe [3]

Scholes and Van der Merwe [3] published the first comprehensive inventory of gas emissions from South Africa, for the year 1988. The inventory includes CO_2, CH_4, N_2O, NO_X, CO and NMVOC gas emissions by activity.[1] CO_2 emissions were calculated by a "top-down" approach, based on national energy balances. In other words, the energy values of the primary energy sources are converted to the amount of carbon that each source represents. CH_4, N_2O, NO_X, CO and NMVOC were calculated by a "bottom-up" approach, based on the type of activity and technology used. Emission factors for each gas were used to calculate the emissions of each gas from the various sources. The emissions factors of the Intergovernmental Panel on Climate Change (IPCC) were used where South African values were not available. Where a range of IPCC emissions factors existed, the average between the minimum and maximum values were used. An index of South Africa's contribution to global warming was calculated by converting CH_4 and N_2O to CO_2 equivalents by using their 20-year integrated global warming potentials.

The total emissions as calculated provides a useful reference point for 1988, but cannot be used for a comparative analysis on a more disaggregated level since the activity classification is not consistent with the current structure of national energy balances.

2.3. The inventory based on Howells and Solomon [4]

Howells and Solomon [4] published a GHG energy emissions inventory for the year 1994. A top-down CO_2 inventory was compiled according to the IPCC's reference approach and based on the official disaggregated national energy balance obtained from the Department of Minerals and Energy (DME). CO_2 emissions were estimated based on the amount of fossil fuels consumed in the country in a given year, the fuels' calorific values and their total carbon contents. The top-down approach reports CO_2 emissions by fuel type.[2]

A bottom-up GHG inventory was compiled for CO_2, CH_4, N_2O, NO_X, CO, NMVOC and SO_2 emissions per activity. Sectoral fuel consumptions were estimated and emissions factors were used to calculate carbon emissions. The total carbon emissions for each sector were calculated by summing carbon emissions from each fuel type used in each sector. These results were presented as percentage of CO_2, CH_4, N_2O, NO_X, CO, NMVOC and SO_2 emissions per activity.

[1] The activity categories used: Electricity generation, Industrial stationary combustion, Residential/domestic stationary combustion, Wood and bagasse-fired industrial process, Road, air, rail and sea transport, Coal mining, Cement and lime manufacturing, Land filling, Enteric fermentation, Decay of wild animal wastes, Nitrogenous fertilisers, Termites, Cultivation of virgin grasslands, Plantations, Non-sustainable fuel wood use, Burning of natural vegetation and Burning of agricultural crop wastes.

[2] Fuel types reported: Crude oil, Orimulsion, Natural gas liquids, Gasoline, Jet Kerosene, Shale oil, Gas/Diesel oil, Residual fuel oil, LPG, Ethane, Naphtha, Bitumen, Lubricants, Petroleum coke, Refinery feed stocks, Other oil (aviation gasoline), Anthracite, Coking coal, Sub-bit coal, Lignite, Oil shale, Peat, BKB and patent fuel, Coke oven/Gas coke, Natural gas (dry), Solid biomass, liquid biomass and Gas biomass.