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Assessing emissions levels and costs associated with climate and air pollution policies in South Africa

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HIGHLIGHTS

- Estimates of emissions and costs provided for eight policy scenarios in South Africa.
- Integrated assessment was performed using the GAINS model.
- SA can exploit co-benefits of climate change mitigation and air pollution policies.
- Unintended policy contradictions can negatively impact air pollutant emissions.

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ABSTRACT

Affordable energy supply and reductions in emissions of local air pollution and greenhouse gases are each important aspects of South Africa's goals. Many traditional solutions, however, work in contradiction to one another. This work investigates effects on estimated emissions and costs of mitigation strategies using the Greenhouse Gas and Air Pollution Interaction Synergies (GAINS) model to identify policies that satisfy multiple goals. Eight scenarios that describe air pollution control options and mixes of energy production technologies are implemented in GAINS, which quantifies country-wide air pollution and greenhouse emissions and costs of controls. Emissions and costs trajectories are compared to the business as usual case, which projects CO_2 emissions to increase by 60% by 2050 compared to 2015. Results show that replacing all coal generation with renewables reduces CO_2 emissions in 2050 by 8% compared to 2015, and that aggressive policy targeting the whole energy sector reduces CO_2 emissions in 2050 by 40%. GAINS is used to show co-benefits and tradeoffs of each scenario, such as reductions in emissions control costs that accompany a switch to renewables. The approach provides supporting evidence for policies that exploit co-benefits and avoid contradictions by assessing multiple aspects of the energy sector within the integrated framework provided by the GAINS modeling platform.

1. Introduction

South Africa is committed to growing their economy. A key component of this goal is to provide and expand access to affordable energy to all its citizens and to industries. This energy, however, must be produced in a manner that both protects the health of citizens and the environment, and upholds the country's international commitments to address emissions of greenhouse gases (GHGs).

Many air pollutants are emitted when fossil fuels are combusted. Particulate matter (PM) has been linked in a number of studies to negative health effects. Exposure to household air pollution from solid fuels and ambient airborne PM ranked second and eighth in attributable disease burden in the 2013 Global Burden of Disease study (Lim et al., 2013). Other air pollutants, such as sulfur dioxide (SO_2) and oxides of nitrogen ($NO_x = NO + NO_2$), contribute to formation of secondary PM and ozone (O_3), a second air pollutant with known health effects, respectively.

Besides air pollutants that affect local human and ecological health, South Africa is concerned with reducing its contribution to rising GHGs concentrations in the atmosphere. Fossil fuel use in South Africa contributes to the country's standing as the world's 13th largest emitter of GHGs (U.S. EIA, 2013).

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The complex regulatory frameworks of energy, air pollution, and GHG policies are all related, and it is necessary to investigate them under a common framework. An integrated approach allows for co-benefits to be identified and exploited and for contradictions to be avoided. The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model provides such a framework (IIASA, 2012). This study presents an impact analysis of policies targeting the energy sector in South Africa, and investigates potentials for air pollutant and GHG emissions reductions under various pollution control and energy activity scenarios. To maintain coherence with the continuing national discussion on mitigation of climate change, the selected scenarios have been styled on commonly used scenarios in order to simulate policy options, such as those presented in the report "Study to Examine the Potential Socio-Economic Impact of Measures to Reduce Air Pollution from Combustion" (Scorgie et al., 2004) and the Long Term Mitigation Strategies (LTMS) report, a policy document that describes options available to South Africa to curb its carbon dioxide (CO_2) emissions (Energy Research Centre, 2007). Emissions of SO_2, particulates with diameter less than 2.5 μm ($PM_{2.5}$), NO_x, and CO_2 are estimated for each scenario along with the cost of air pollution controls.

The paper begins with a review of relevant energy policy in South Africa. A companion paper provides a more detailed analysis of the policy and legal framework in South Africa (Klausbruckner et al., In preparation). A description of the GAINS model precedes a detailing of the scenarios modeled and their relevance to policy options that South Africa has. Results from the GAINS model for each of these scenarios are summarized in Section 4 and analyzed further in the Section 5. The results will inform policy makers and future studies on impacts of energy systems both in South Africa and other countries that wish to apply the GAINS model for an integrated analysis to shape policy.

2. Policy framework

2.1. Energy policy in South Africa

South Africa has an energy-intensive economy. The country's index of primary energy supply per US dollar of gross domestic product (GDP) based on purchasing power parity is 11.7 mega joules (MJ), which outranked both Asia (7.9 MJ/USD) and Latin America (6.7 MJ/USD) in 2007 (Winkler, 2007). Over 90% of the electricity in South Africa is produced by burning coal (Edkins et al., 2010). Industry, transport, mining, and agriculture make up the top four demand sectors (Winkler, 2007).

Historically, South Africa had an excess of electricity generation capacity to supply the demand, which contributed to the country having among the lowest electricity prices in the world ($0.02/kWh or less). For diverse reasons, including a protracted period of 20 years in which no new generating plants were built, this situation has changed in recent years (2008 onwards) so that supply has not always been able to meet demand. From 2008 onwards, the country saw increasing prices and intermittent load shedding (scheduled blackouts on a planned regional basis) (Edkins et al., 2010; Tait and Winkler, 2012). In 2015, Eskom, the state-owned electricity utility, planned to begin operation of the first of two new coal-fired power plants currently under construction, each with a planned capacity of 4800 MW electric (MWe) (Kiratu, 2010).

In 2007, the South African Government commissioned the LTMS report, to investigate pathways that the country could take to mitigate national emissions of GHGs (Energy Research Centre, 2007). This report presented scenarios and policy options that would allow the country to follow a "required by science" emissions pathway that aligns with worldwide emissions reductions of 30–40% below 2003 levels in 2050 necessary to keep global warming below 2 °C (IPCC, 2001). Four policy timeline options are proposed as necessary for achieving the required by science pathway in the report – "Start Now," "Scale Up," "Use the Market," and "Reach for the Goal". Each of these describes a suite of policies that, if each implemented in full, would achieve 64% of the reductions in GHG emissions needed in the "required by science" scenario. The options suggest a combination of investment in both positive and negative cost technologies (i.e., technologies that do not repay their value over time), taxes and incentives, and behavioral change. This document has formed the basis for national climate change policy since 2007, however, there has been a lack of coordinated effort to implement these policies. The LTMS, for instance, proposed eliminating the commissioning of new coal plants, and Eskom has since begun building the two new plants mentioned above (Kiratu, 2010), while the low-carbon (but otherwise still controversial) nuclear power option has been subjected to repeated delays, although a tentative deal was reached in 2014 with the Russian company Rosatom to supply 9.6 GWe of nuclear capacity to South Africa by 2030 (World Nuclear Association, 2014).

2.2. Air quality policy in South Africa

South Africa routinely experiences levels of air pollution that are detrimental to human health in many areas of the country. Besides ambient air quality issues caused by industrial and mobile sources, many poorer communities suffer negative health outcomes due to exposure to high levels of pollution from fossil fuels used for cooking, heating, and lighting (Scorgie et al., 2004; Pauw et al., 2008).

The National Environmental Management Air Quality Act, promulgated in 2004, formed the legal basis for defining Minimum Emissions Standards (MES) for regulating gaseous and particulate emissions from industrial operations. The MES apply to both new and existing plants in industrial and electricity generating sectors, were amended in 2013 and come into effect in 2015. The effectiveness of this regulation may be limited; however, as many of the major emitters have applied for deferments of the date of compliance with the MES (Myllyvirta, 2014). Extensions through 2020 have been granted to certain plants for SO_2 and NO_x emissions.

Regarding mobile emissions, the sale of fuel with high sulfur content (up to 500 ppb) has limited the ability of automobile manufacturers to sell vehicles with engines that employ the current cleanest technology. In 2012, the government issued a Government Notice specifying the compulsory introduction of fuels that meet EURO 5 standards (less than 10 ppm sulfur) by July 2017. While there has been some effort to begin marketing these fuels already, the enforcement of regulations on low-sulfur fuels may be postponed, which would delay widespread introduction of higher-standard fuels (SAPIA, n.d.). A recent agreement by South Africa suggests that enforcement of low-sulfur fuels will occur begin in 2020 (Workshop, 2015).

2.3. Climate change mitigation policy in South Africa

In 2009, at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP 15) in Copenhagen, South African President Zuma pledged a target of CO_2 emissions reductions below "business as usual" of 34% by 2020 and 42% by 2025 (Kiratu, 2010) (subject to conditions on the provision of financial support). These targets came as a surprise to