Integrating socio-economic development and decarbonisation in South Africa

South Africa is one of the few countries in the world with both high unemployment and low employment elasticities, largely owing to a low-skilled labour force and an economy geared to high-skilled, high-productivity growth. On top of this, it has much higher than average greenhouse gas emissions than similar developing countries both per capita and per unit economic output, these emissions being the result of an energy- and emissions-intensive economy historically formed to exploit South African mineral and coal resources

DOI 10.12910/EAI2016-018

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Since 2013 until 2015, South Africa participated in a collaborative effort called the Deep Decarbonisation Pathways Project (DDPP), aimed at exploring the technological and economic feasibility of a global low-carbon economy consistent with the international goal of limiting anthropogenic warming to less than 2 degrees Celsius (°C). A general finding of the project was that deep decarbonisation of these economies is technically achievable while accommodating other national priorities.

A central feature of the organisation of the DDPP was that a bottom-up approach was followed, whereby country teams autonomously chose their objectives and methods and then fed these into a common 'dashboard' developed jointly by the teams. The results are not forecasts, but largely 'backcasts' where aspects of desirable futures are identified and the analysis involves exploring how, and to what extent, these aspects might be realised.

From the outset, the South African team at the University of Cape Town's Energy Research Centre, set its own targets and priorities for decarbonisation and developed appropriate methods and modelling functionality to explore and illustrate these. Details are provided in the 50-page 'Pathways to deep decarbonisation in South Africa' report [3]. The rest of this article is based on this report (unreferenced statistics in this paper can be found in the report) and focuses on the approach taken to setting priorities and targets and modelling and illustrating potential futures.

South African background

South Africa is classified as a middle-income developing country, with a population of some 53 million. It has a history of centuries of gross social and economic inequality and widespread poverty. Significant gains in the extension of basic services and social grants to the poor have been made since the first democratic elections in 1994, but the middle-income categorisation masks South Africa's status as one of the most unequal societies in the world, with a Gini co-efficient of 0.69: 45.5% of the population lives below the upper-bound poverty line [13], and the unemployment rate is 24% using the strict measure and 40% using the broad measure which includes discouraged workseekers. Moreover, income poverty has not decreased significantly over the past 20 years [11]. South African growth, which averaged some 3% per annum since 1994, has stagnated since the 2007/2008 international financial crisis and there is a strong probability this will persist if structural issues are not attended to.

While the tertiary sector makes up 70% of GDP, mining, minerals and secondary beneficiated products account for almost 60% of export revenue [4]. The initial shift of the economy in the late 19th and 20th centuries from being primarily subsistence and agricultural was driven by these minerals and related industries which are strongly interlinked with the rest of the economy. Most importantly, related to the main concern of integrating socio-economic development with decarbonisation, is that this group of industries is highly energy- and emissions-intensive, relying on coal either directly

or indirectly through coal-powered electricity for their energy supply.

Among these industries, electricity generation, some 95% of which is powered by coal, is critical both for powering industrial development and for basic services for residents and the commercial/tertiary sectors. The electricity sector accounts for about 50% of total emissions.

The combined effect of South Africa's socio-economic situation and its energy-intensive economy is a significant variance between emissions per capita and levels of development and those of most developing countries. While emissions of similar developing countries are typically below 5 t CO_2 per capita, South Africa's emissions intensities per capita are similar to those of much richer industrialised countries such as Italy, UK and Japan, at some 8–10 t CO_2 per capita. Emissions intensities for GDP are also much higher, at some 1.6 kg CO_2 per US$ GDP, compared to 0.2–0.3 kg CO_2 per US$ GDP for typical industrialised countries.

Integrated approach

Against this background, the essence of the South African challenge can be stated as: How to decarbonise a highly emissions-intensive developing economy while addressing issues involving a deeply unequal economy and society with high levels of poverty and unemployment. The primary objective of the DDPP was thus defined as illustrating, based on economic research and quantitative analysis, how both income poverty and unemployment could be significantly reduced while complying with a specified limit on CO_2 emissions from the energy sector [6,12].

Quantitative analysis involving both economic futures and energy sector emissions had previously been carried out at the ERC using linked economic and energy-system modelling [7] but this analysis had not set its objectives as reducing unemployment and income-poverty and did not provide the necessary results or data on which to base DDPP analysis. The models also simulated existing government policies which are questionable in terms of achieving the combined challenges set by the ERC DDPP team.

Other available illustrations of economic futures also did not provide the necessary credible analysis or results sought by the DDPP team. For example, the South African National Development Plan (NDP) and NDP Diagnostic Report [4,5] provide accurate information on the socio-economic situation but, in the view of the ERC team, the NDP does not provide a credible set of futures for a number of reasons. GDP growth rates of more than 5% (much higher than growth in recent decades) were used as a central panacea in how the NDP addressed unemployment and income-poverty. Known structural issues were not adequately addressed and accessible quantitative analysis was not provided.

Another shortcoming of the existing ERC linked modelling and the

NDP was that their timeframes were until 2030 and DDPP had a 2050 timeframe. Especially in the case of large industrial fixed-infrastructural assets such as those at the core of the South African energy- and emissions-intensive economy, the impacts of investments in massive plant, structural economic changes and technology changes involved in decarbonisation require a timeframe of at least 30 years to be properly considered.

The ERC team therefore carried out dedicated qualitative economic research to explore options to reduce poverty and unemployment and also, where necessary, to extend the functions of the models to analyse these. This involved three interlinked areas of work. Firstly, the dynamics and features of the existing economy in terms of its potential and its limitations to address income poverty and unemployment needed to be sufficiently understood to identify credible options to reduce these with a more moderate and realistic GDP growth rate than that of the NDP. Secondly, these options needed to be modelled quantitatively to illustrate their operation in a credible economic analysis framework. Thirdly, this all had to be done while considering and modelling CO_2 emissions quantitatively to illustrate an energy sector that would remain within the emissions constraint while providing the economy with an adequate energy supply.

South African economy – current dynamics

The first area of work was to gain the necessary understanding of the dynamics and features of the existing economy. A key feature and challenge of the socio-economic structure is the entrenched marginalisation and effective exclusion of a large part of the population. South Africa is one of only a few countries in the world with high unemployment rates and low employment elasticities. Even when there is higher growth there is not a corresponding increase in employment – so called 'jobless growth'. In the absence of a fundamental change in the historic (and still prevailing) growth path, 'such countries are unlikely to grow themselves out of their employment crises any time soon' [8].

A second social and economic exclusion relates to education, skills and the economy. While experiencing high unemployment South Africa actually has a shortage of skilled workers and this acts as a limit on economic growth. One of the questionable simplifications of some futures, such as the NDP, that rely on high GDP growth to address unemployment (and poverty) is the assumption that the demand for the skilled positions needed to achieve this growth will be met. South Africa has been attempting for many years, unsuccessfully, to implement a policy of high-growth, high-productivity. The lack of skills acts as a limit to growth.

Recent comprehensive analyses of the performance of South Africa's education system indicates that it is prudent to consider futures that involve the South African labour force continuing to have a large unskilled component. While this may be overly pessimistic about the potential for success in the changes to the education system that most agree are necessary, it is a relevant and realistic possibility. This means, firstly, that, in the short term, limits on growth related to skill shortages in the existing economic structure can be relieved only by relaxing tight visa requirements on foreign skilled workers. But even if this were done, the indigenous unskilled workforce would still face high employment rates. Even if the performance challenges of the education system were to be effectively addressed, this would only lead to a gradual improvement of the labour force skills profile starting in more than 10 years.

The central point of departure in the ERC team's approach to formulating

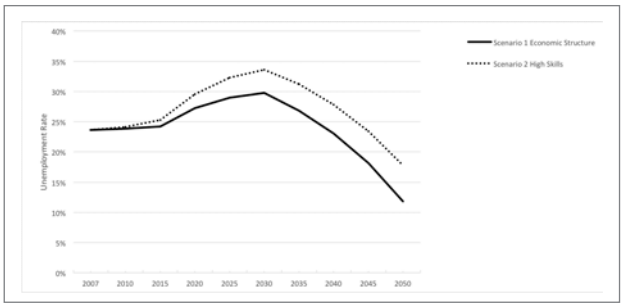

Fig. 1 Economic modelling results: unemployment

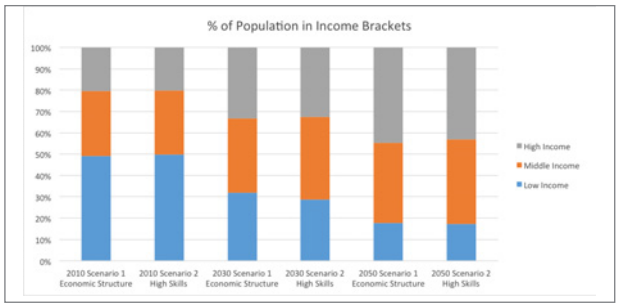

Fig. 2 Economic modelling results: income

options for credible and acceptable futures was a commitment to exploring credible ways that a largely unskilled labour force could be accommodated in the economy while at the same time reducing income-poverty; and this not to be done by increasing employment by reducing wages below living-wage levels or by continuing the current jobless growth and extension of additional welfare grants funded by taxes. While welfare grants are seen as an interim necessity they are not seen as a medium-to-long-term solution for income poverty: only employment at at least living-wage levels is seen as an acceptable solution. This did not mean that improving the performance of the education system was not seen as a key priority, but prudent futures did not rely on this, and addressed futures where this did not necessarily occur.

Modelling economic futures

The ERC 'linked economy and energy system model' mentioned earlier consists of the eSAGE computable general equilibrium (CGE) top-down model soft-linked to a South African instance of the TIMES bottom-up energy systems model called SATIM [7]. To explore options for achieving growth while reducing low-skilled labour unemployment, the CGE was first used to explore employment effects by calculating the jobs created by different economic sectors per additional unit of production to identify the best performers. Concurrently, the emissions per unit of product were also calculated. The unskilled labour effects were plotted against these emissions, which produced a set of favoured sectors that yielded most unskilled jobs per unit additional production with lowest emissions.

Two scenarios were modelled – the 'economic structure', which explored changes to the structure of South Africa's economy, and the 'high skills' scenario, which assumed that the labour force skills profile begin significantly improving after 2030. They both used the linked model and the energy demand for these modelled economies was met under a carbon constraint of 14Gt cumulative to 2050 for the energy sector[12].

In the 'economic structure' scenario, the CGE was used to explore structural changes to the economy. This involved adjusting the capital productivity of the favoured sectors while reducing the elasticity of substitution between labour and capital. The result of this was augmented growth in the favoured sectors and an increase in employment. At the same time, trade elasticities for these sectors were adjusted to simulate trade-openness causing increased trade demand and additional growth.

The 'economic structure' scenario achieved a decrease in population living under the poverty line from 45.5% to 17% by 2050 while the 'high skills' scenario achieved a decrease to 18%. Most notably, the economic structure scenario achieved 12% unemployment by 2050, down from 24% in 2013 compared with 18% for the 'high skills'. Both resulted in an initial increase in unemployment which is caused by the 'youth bulge' and expected increase in labour participation in 2030.

For both scenarios the economy grows significantly, roughly doubling by 2050, with the 'high skills' scenario growing at 2.6% p.a. marginally less than the 'economic structure' at 2.8% p.a.. All sectors grow, although the energy- and emissions-intensive sectors grow more slowly in the 'economic structure' scenario as more investment flows to the favoured sectors. The biggest proportional change in the 'economic structure' scenario is in agriculture, which is twice as big as in the 'high skills' scenario and, while it accounts for most of the unemployment reduction, is still only 7% of GDP in 2050.

It must be emphasised that the focus was on modelling the effects of changing the structure of the econo-

my and increasing skilled labour, not on practical policies that could implement these. Implementation is a complex matter and is not dealt with here. However, South Africa does have a successful history of stimulating economic sectors through a wide variety of policies and mechanisms, and the current energy- and emissions-intensive industries have been and remain a key beneficiary of such policies [9]. Implementation would involve re-directing resources and expertise towards sectors that can support the top priority of reducing employment among the unskilled while also increasing economic production, i.e. not sacrificing growth. To improve plausibility, in addition to the modelling, the thinking and results were shared with a number of eminent South African economists and CGE modellers to check the validity and plausibility of the adjustments and the results of this exercise were incorporated in the modelling.

Modeling energy system and emissions futures and the link with the economic model

ERC has built and operates a bottom-up energy systems model for South Africa, SATIM, with detailed information on both the demand and supply sides [10]. In addition to being able to identify the optimal mix of technologies that make up energy systems to meet the useful energy needs of all sectors of the economy fed through from the CGE model, SATIM also has a high level of detail on the end-uses of all sectors. For example, it models details of household energy usage based on extensive previous ERC research. This information was used to inform the assumption made in DDPP that

by 2050 the economy and the energy system make provision for 100% household electricity connection and adequate energy production.
As well as being adequately detailed on the demand-side, SATIM also has detailed supply-side modelling. SATIM 'builds' an energy system, optimising both supply- and demand-side elements on costs while applying a cumulative emissions constraint of 14 Gt [12]. Through the linked modelling, required investments in new electricity generation plant are fully accounted for in price effects in both the SATIM energy model and eSAGE CGE and also, the capital investment requirements for the electricity sector are accounted for in the CGE through the link.
Of special relevance is the electricity supply system because it accounts for about 50% of current emissions. A central element of decarbonisation is the shift from 95% coal-powered electricity supply to zero coal in 2050. Coal is substituted by a mix of wind-power, photo-voltaics, concentrated solar power with storage and gas-powered generation. This is achieved without early retirement of coal plant.

Emissions

Along with focusing on reducing income-poverty and unemployment as key objectives, a central decision taken by the ERC team in the initial research was to model emissions by placing a fixed constraint on the energy systems model of 14Gt cumulative to 2050 for energy sector emissions [12]. This was a departure from most other DDPP teams that implemented various policies such as carbon prices and other mechanisms to achieve feasible technology switches and/or economic structure changes and then (typically) assessed what the 'cost' to GDP growth would be. The emissions reductions were seen as feasible if this impact on GDP growth was acceptable.
Similar questions were posed by the ERC team but in a different order, fo-

cussing on the socio-economic challenges, namely: first, what plausible economic pathways could achieve significant rates of income-poverty and unemployment reduction, for a plausible labour market? And second, what does it take to build an energy system that provides adequate energy for these economic pathways with a 14Gt cumulative CO_2 constraint? Using the linked model the DDPP analysis illustrates such plausible economic pathways and the details of existing commercially available technologies that could provide an energy system for these economic pathways.

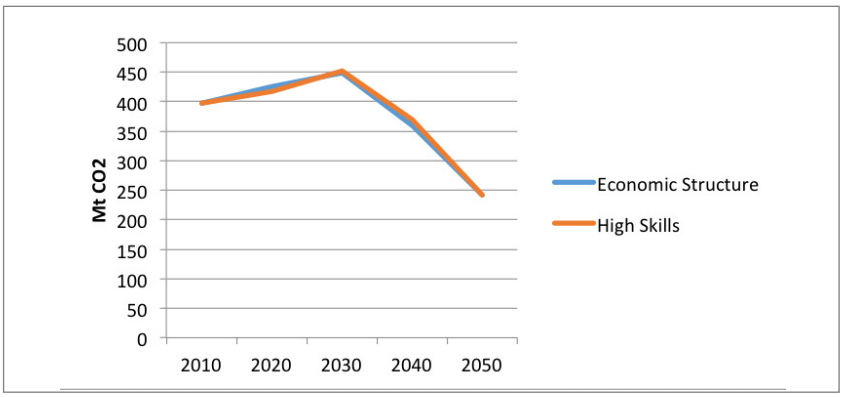

Fig 3 Energy related CO_2 emissions

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[1] Pathways to deep decarbonization 2014 report, Deep Decarbonization Pathways Project. 2015. SDSN – IDDRI

[2] Pathways to deep decarbonization 2015 report, Deep Decarbonization Pathways Project. 2015. SDSN – IDDRI

[3] Altieri, K. et al. 2015. Pathways to deep decarbonization in South Africa, SDSN - IDDRI

[4] National Development Plan, November 2011. South African National Planning Commission (NPC). 2011

[5] Diagnostic Report, June 2011. South African National Planning Commission (NPC), 2011

[6] The energy sector in this context includes all combustion of fuels

[7] The operations of the linked model are describe in the paper: Economywide Implications of Energy Build Plans: A Linked Modeling Approach. Arndt et al. 2014. The 6th International Conference on Applied Energy – ICAE2014.

[8] Should and can labour-surplus, middle-income economies pursue labour-intensive growth? The South African challenge. Nattrass and Seekings. 2015. CSSR Working Paper No. 351, University of Cape Town

[9] Industrial policy and unemployment: Can South Africa do better in labour-demanding manufacturing? Black, A. 2012. Econ3x3, November 2012

[10] SATIM energy and emissions model:
http://www.erc.uct.ac.za/Research/esystems-group-satim.html

[11] Trends in South African income distribution and poverty since the fall of Apartheid. Leibbrandt, M., Woolard, I., Finn, A., Argent, J. 2010. OECD Social, Employment and Migration Working Papers No. 101, 2010

[12] This 14Gt figure is consistent with the mid-line for energy emissions of the official South African mitigation policy and Intended Nationally Determined Contribution (INDC). The ERC team took the early decision to avoid the highly charged debate on 'fair contributions' and to choose this official emissions constraint as exogenous, so as to fulfill its primary objectives of its participation in DDPP, namely exploring economic pathways that could achieve socio-economic objectives and illustrating energy systems that could feed these economic pathways while being aligned with official emissions mitigation policy

[13] ZAR 620 per capita per month in 2011 when the latest povery line determination was made. From: Poverty Trends in South Africa. An examination of absolute poverty between 2006 and 2011. 2014. Statistics South Africa, Pretoria. ISBN 978-0-621-41873-6