Building a competitive and dynamic green industrial sector in South Africa after COVID-19

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Abstract

COVID-19 gave the world a glimpse of how devastating a pandemic can be to economies and livelihoods. Climate change, given its permanence, would be far more devastating, hence the renewed efforts at the global level to mitigate climate change. South Africa, one of the dirtiest producers in the world, faces the challenge of transitioning to a low-carbon and sustainable economy to meet its commitment to the Paris Agreement while satisfying domestic growth and development imperatives. South Africa has realised some progress in lowering the carbon content of its output, with the energy intensity of industrial production declining by 23 percent between 2002 and 2018. However, the country compares poorly relative to its BRICS peers, raising competitiveness concerns should carbon be penalised in trade. The electricity shortages bedevilling South Africa present an opportunity to change its energy mix, and thus carbon intensity of output, while the country's strong industrial base should propel it to lead the production of green goods in Africa (and beyond). This, however, requires policy coherence across government, and partnerships with private sector.

Keywords: Climate change, competitiveness, energy efficiency, green industry, sustainable development, South Africa, COVID-19

JEL classification: L60, O30, Q41, Q54, Q56

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1. Introduction[3,4]

The COVID-19 pandemic has brought the fragility of the global economy to the fore. Like many other economies around the globe, the South African economy was not spared by the pandemic. The lockdowns instituted to mitigate the spread of the virus have had large negative impacts on the economy. The economy was literally shut down in April 2020, under Alert Level 5 lockdown, and gradually reopened as of May 2020. The lockdowns and the uncertainty induced by the COVID-19 pandemic have resulted in severe impacts on the economy, manifested in firm closures, job losses, restricted people movement, heightened uncertainty, and large gross domestic product (GDP) decline in 2020.[5] GDP contracted by 7% in 2020, the largest annual contraction in a century.

However, climate change may pose a greater risk to global economies than the COVID-19 pandemic. While there are some similarities between the shocks caused by climate change and COVID-19, namely, high downside risk, the shocks are also quite distinct. Specifically, while the COVID-19 impact is immediate and sharp but with a strong prospect of a rapid recovery, climate change is persistent, long term, and more difficult to mitigate and recover from. Expressed differently, unlike the COVID-19 pandemic for which (hopefully effective) vaccination is already in progress, climate change is here to stay.[6] Once the temperature threshold is breached, the world will have to learn to live with a changed climate, with no possibility of reversal (Intergovernmental Panel on Climate Change (IPCC) 2007).

While efforts to address climate change predate the COVID-19 crisis, the pandemic has served as a reminder of the ravaging effects of natural disasters on economies and livelihoods, particularly given the interconnectedness of global economies today. The COVID shock caused unprecedented GDP contractions across major global economies. However, this could pale in

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4 The authors would like to thank an anonymous referee for their useful comments and suggestions as well as participants in a seminar at the SARB on 26 January 2021.

5 In quarter 2, South Africa's GDP declined by 51% (quarter on quarter SAAR) and more than 2 million jobs were lost (Statistics South Africa 2020).

6 Several COVID-19 vaccines have already been approved for emergency use across many countries, with the hope of vaccinating enough people to achieve herd immunity by the end of 2021. South Africa expects to have vaccinated about 67% of the population by the end of 2021, enough to achieve herd immunity. However, some believe that COVID-19 is just one round of multiple outbreaks which have been hitting the world with increasing frequency and are likely to continue.

comparison to climate shocks as they have the potential to bring about hitherto unknown disease burdens in addition to the direct impacts on livelihoods and economies, particularly agriculture and infrastructure.

Climate change is associated with extreme weather events, among them cyclones, hurricanes, droughts and extreme temperatures. The COVID-19 pandemic, having decimated large parts of the countries' economies, presents an opportunity and impetus to build better and smarter by 'greening' country development trajectories for sustainable growth and development. Such a reorientation would support more efficient production, make economies more resilient to shocks and enhance welfare.

This paper looks at the challenges and opportunities facing the South African industrial sector with respect to greening production and consumption post COVID-19. We argue that path dependence poses a challenge to South Africa's transition. We consider the energy efficiency of the country's manufacturing sector and then proceed to identify specific challenges and opportunities and the role that policy can play in promoting green industrialisation in South Africa. In particular, we look at different strategies to reduce the manufacturing sector's carbon footprint.

The paper is structured as follows. Section 2 explores the concept of green industrialisation and its relevance for South Africa. Section 3 discusses South Africa's emissions profile and environmental indicators. Section 4 presents the environmental policy and legal frameworks. Section 5 discusses the apparent trade-off between greening the economy and economic growth and development. Section 6 discusses the necessity of green industrial policy as a tool for structural transformation. Section 7 discusses the challenges and opportunities for South Africa in greening its industry, as well as progress achieved. The paper concludes with section 8.

2. Green industrialisation and why it matters for South Africa

The industrial sector, particularly manufacturing, is central to economic development and South Africa is no exception.[7] South Africa's National Industrial Policy Framework identifies

[7] Manufacturing has high economic multipliers due to its strong forward and backward linkages to both downstream and upstream production sectors. It is a major driver of research and development and associated spillovers. According to the Industrial Development Corporation (2019), the GDP multiplier of manufacturing equals 4 and the employment

industrial development as core to the diversification of the economy and achievement of the country's growth and development goals (Department of Trade and Industry 2006). However, a glaring gap in this framework is any consideration of sustainable industrialisation. There is virtually no mention of climate change or environmental considerations in relation to industrial development. As shown in Figure 1 below, the South African industrial sector is built around the so-called minerals-energy complex, which has made South Africa one of the major carbon emitters in the world (ranked 14th in 2018).[8]

South Africa, like many other developing economies, is confronted by climate change, environmental degradation and resource depletion, which are challenges that impinge on the country's ability to grow sustainably and reduce poverty (United Nations Industrial Development Organisation (UNIDO) 2011a). Recent climate change discussions, both at the global and national levels, have made it abundantly clear that South Africa, like many other countries, must reorient its economy towards sustainable production and consumption.

2.1 A closer look at the concept of 'greening of industry'

Given the pivotal role of the industrial sector in the South African economy, successful greening of industry should put the economy on a path to sustainable growth and development. According to UNIDO (2011b), "greening of Industry is a method to attain sustainable economic growth and promote sustainable economies. It includes policymaking, improved industrial production processes and resource-efficient productivity". In other words, greening of industry is a process of reducing the carbon footprint of producing (and consuming) goods and services. Such efforts involve policymakers developing the right policy mix to incentivise or push private enterprises towards contributing to a cleaner economy, and industry undertaking the right investments to reduce not only the energy intensity of production but also the amount of resources used in achieving a given level of output.

multiplier equals 5. Manufacturing also contributes directly to employment, exports and skills development, and jobs in this sector tends to be more highly paid and stable and less vulnerable to shocks compared to other sectors. See, for instance, OECD 2012.

[8] About 86% of South Africa's electricity is generated from coal. South Africa's manufacturing industry is dominated by three subsectors: namely, petroleum products, chemicals, rubber and plastic; metals, metal products, machinery and equipment; and agro-processing (see Figure 1).

The above suggests at least two distinct paths to realise industry greening. First, greening can be achieved through enhanced efficiency in the production of existing products: that is, using fewer and fewer inputs to produce a good or service. As an example, vehicles have over time become increasingly more efficient in terms of fuel burn, thus reducing their carbon footprint. Another example is increased energy efficiency in production whereby the same output is produced using less energy than before. Whether the input in question is energy or physical materials, as long as it takes fewer resources to produce the same amount of output, or more output can be produced with the same amount of inputs, the notion of greening of production holds.

The second approach to greening of industry is to develop wholly new industries and products using clean technologies. By definition, these industries should be resource efficient in the sense of low contributions to environmental pollution (air, water, land, etc.) and climate change. The fundamental idea is to decouple economic growth or GDP from resource use (UNIDO 2011a; Altenburg and Rodrik 2017; Schwarzer 2013). Examples include renewable energy (such as wind and solar), electric vehicles, and biodegradable bottles and carrier bags. Thus green industries comprise both existing industries and new industries.

2.2 Why South Africa should care

Green industrialisation (and green growth more generally) is a policy imperative the world over. The world is confronting a potential climate crisis, requiring major efforts by all countries to slow down the rate of climate change. Global efforts are focused on keeping temperature increases below 1.5 degrees Celsius above the pre-industrial level (IPCC 2007). It is believed that this level is the point of no return, above which temperature increases and climate change will be uncontrollable. For example, at 1.5 degrees Celsius about 50% of the coral reefs would simply vanish and at 2 degrees Celsius more than 90% would be destroyed (IPCC 2008; Banerjee and Duflo 2019). To realise this objective, virtually all countries in the world agreed to binding targets during the COP21 meeting in Paris, seeking to first contain and then reduce their emissions.[9] South Africa committed to reduce greenhouse gas emissions by up to 42 per cent relative to the 'business as usual' trajectory by 2030 (Environmental Affairs, 2018). South

[9] The United States withdrew from the Paris Agreement following the election of Donald Trump as president. The US has since rejoined following the inauguration of President Biden in January 2021.

Africa has since ratified the Paris Agreement, meaning that it is now government policy to realise the commitments entered into in Paris. The policies to address climate change are designed to either mitigate the impacts or help countries adapt to climate change.[10] Industry, as a major consumer of energy in South Africa, will be a major source of mitigation.

There are numerous reasons why the greening of the economy is in South Africa's interest. First, high concentrations of greenhouse gas emissions are associated with health complications, particularly respiratory problems, and indirectly, negative economic impacts.[11] Second, since South Africa made public commitments during COP21 and proceeded to ratify the agreement, it now has an obligation to deliver on its promises. In other words, transition to a greener economy has become an imperative, with potential to impinge on government's credibility if not executed. Third, and perhaps more important, greening the economy has implications for competitiveness, particularly given that consumers are becoming increasingly environmentally conscious. In addition, some countries/regions are mooting changes to global trading regimes to explicitly account for carbon content in trade, with the possibility of penal codes directed at non-conformers.[12, 13] Countries that move last are likely to face larger adjustment costs as a result. Lastly, greening of the economy can be growth enhancing, as it involves efficient use of resources and development of new technologies, both of which can push out the production possibility frontier. Green industrialisation presents a new source of growth opportunities for South Africa, a country that presently suffers from anaemic economic growth.

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10 The policy menu to address climate change typically consists of both market-based measures such as pricing of externalities and non-market measures such as regulation. Where markets exist and are functional, price measures can support efficiency in resource use. However, with climate change, markets may not exist or may not be complete, rendering the price mechanism ineffective. Regulations can be more potent in such situations.

11 Zar, Ehrlich and Workman (2007) find that 5% more South African children and adolescents suffered from asthma in 2002 than in 1995, while Nkosi, Wichmann and Voyi (2015) demonstrate that people living close to mine dumps in South Africa suffer more from respiratory diseases. Schwarzer (2013) states that health costs arising from mostly air pollution in the US range between 0.7% and 2.8% of GDP. To the extent that pollution may affect health outcomes, it impacts on firm productivity and also on labour supply (Hanna and Oliva 2011). Such costs apply to South Africa too.

12 The EU, in its 'European Green Deal' (EU Commission 2019), is already working on a plan to impose a carbon border adjustment mechanism (carbon tax) on goods perceived to be produced in non-environmentally friendly ways. The mechanism seeks to ensure that the price of imports more accurately reflects their carbon content. Should this come into effect, countries like South Africa with high carbon content in their goods stand to lose market share in the lucrative EU market as competitiveness is eroded by the carbon adjustment. The return of the US to multilateralism, and to the Paris Agreement in particular, should give this EU initiative a 'shot in the arm'.

13 Some South African banks (e.g. Standard Bank and Nedbank) are no longer financing coal-powered electricity projects. See https://www.gov.za/speeches/media-statement-minister-energy-jeff-radebe-renewable-energy-independent-power-producer.

Indeed, South Africa's current electricity constraints present an opportunity for the country to add new, low-cost energy in the form of renewable energy. The country cannot afford to waste this crisis.

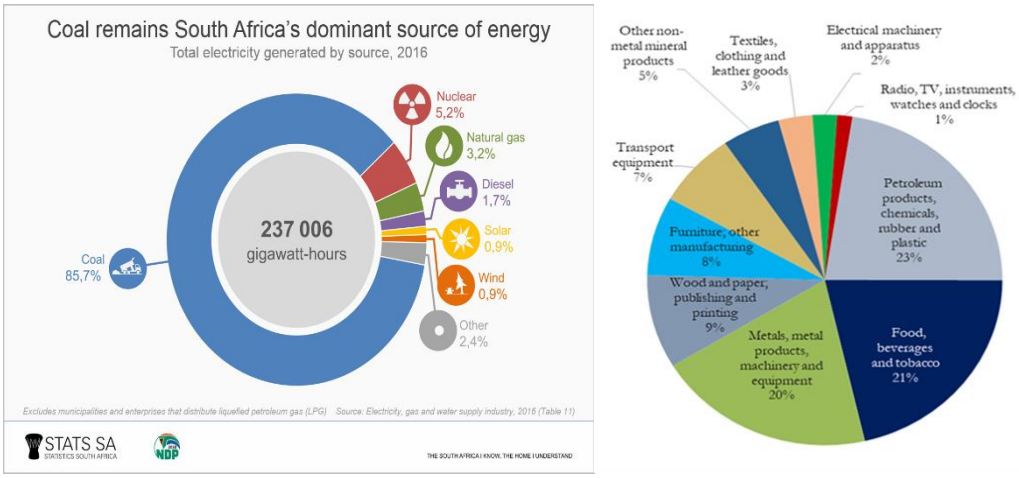
3. South Africa's emissions profile

South Africa is among the major polluter countries globally, ranking 14th in the world in 2018 in terms of total greenhouse gas emissions (Carbon Brief 2018) despite ranking 37th in the world in terms of per capita GDP (South African Market Insights 2019).[14] This constellation suggests that the South African economy is carbon intensive. Figure 1, which shows the country's energy profile and the manufacturing sector's structure, provides further evidence of carbon intensity. The energy sector alone contributes close to 80% of the country's total emissions, of which 50% is from electricity generation and liquid fuels production.

3.1 South Africa's energy profile and industry structure

Figure 1 presents the profiles of South Africa's energy and manufacturing sectors. Energy is dominated by coal while manufacturing is dominated by metals and chemicals.

Figure 1: South Africa's energy profile and industry structure



Source: Mnguni and Simbanegavi, 2020

[14] The top ten polluters as of 2020 are China, the US, the EU, India, Russia, Japan, Germany, South Korea, Iran and Saudi Arabia, in that order (World Population Review 2021). With emissions of 8.9 tonnes per capita, South African is among the countries with the highest per capita emissions in the developing world (Legg 2011).

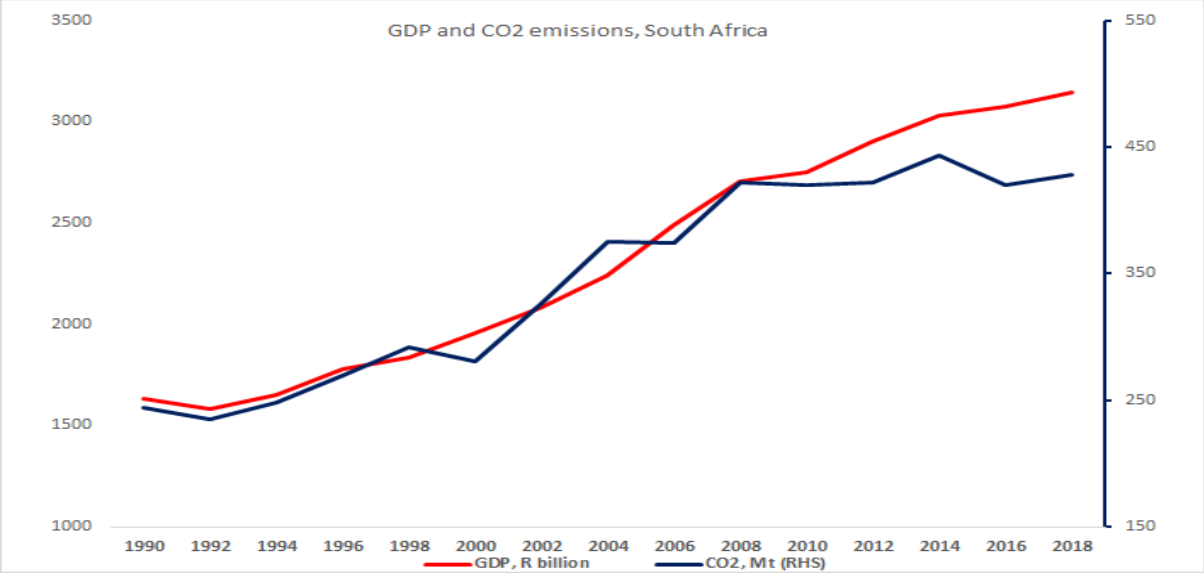
The major sources of greenhouse gas emissions in South Africa include the primary (mining) and secondary (energy generation and manufacturing) sectors. Transport also contributes significantly to emissions. Electricity generation in South Africa is largely from coal (86%), with the balance distributed between nuclear (5%) and renewables (9%) (Statistics South Africa 2018). South Africa is also among the global leaders in synthetic fuel production, producing about 25% of its liquid fuel needs from coal. The value chain involves several other chemicals. The South African industry is also a major source of greenhouse gas emissions for various reasons. First, it is reliant on 'dirty' energy (coal). Second, industrialisation in South Africa since the 1940s was anchored around the so-called minerals-energy complex—leveraging cheap electricity to process mineral products. This meant high energy consumption per unit of output. Cheap electricity incentivised investments in energy-intensive production methods, including smelters, resulting in lock-in and path dependence which still bedevils the country today.[15]

While the government has enacted policies around green growth and climate resilience, there hasn't been the necessary coherence in policy, particularly between industrial policies and environmental policies, to incentivise industry to modernise. South Africa has thus been slow to adopt more modern, energy-efficient systems and production methods due to poor policy signals. In particular, electricity prices remained too low for too long. The recent increases in electricity prices, which have had the effect of 'forcing' energy efficiency across the whole spectrum of electricity consumers, are largely a result of underinvestment in energy, requiring market-based rationing of electricity, rather than deliberate policy signals to internalise carbon externalities. Indeed, one could argue that there has been vacillation around carbon taxes which, while adopted as government policy, are still to be implemented. Transport is another major contributor to greenhouse gas emissions for South Africa. To government's credit, the carbon tax on motor vehicles was implemented nearly a decade ago with the goal of incentivising the production and sale of cleaner vehicles.

[15] The increases in electricity prices and the frequent power outages may have affected this dependence. For example, a large number of smelters were forced to close.

3.2 Environmental Indicators for South Africa

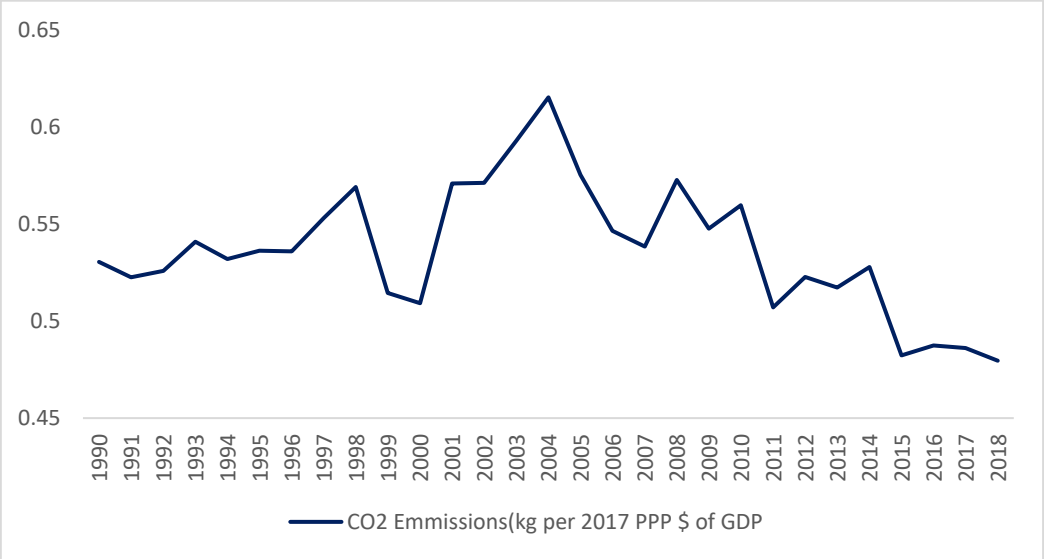
Figure 2: Has South Africa's GDP decoupled from CO2?



Source: Authors' calculations based on World Development Indicators and International Energy Agency (IEA) online databases.

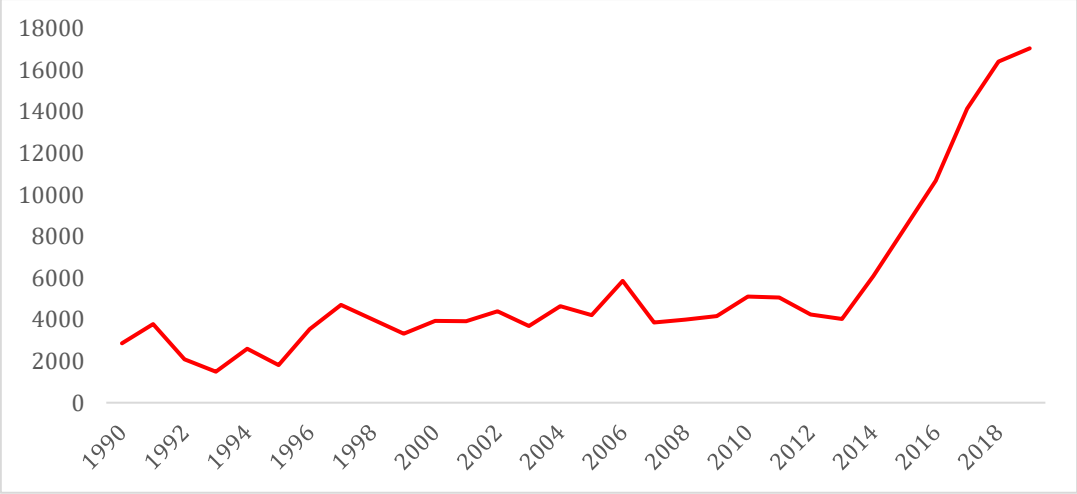
Figure 2 shows the relationship between GDP and CO2 emissions in South Africa. The figure shows very high correlation between GDP and CO2 emissions up until 2008, and noticeable decoupling of GDP from resource use, particularly energy, thereafter. This is corroborated by Figure 3, which considers CO2 emissions per unit of GDP. In PPP terms, emissions per unit of GDP sharply increased between 2000 and 2004, but have been trending downwards since then, though the rate of decline is rather slow. Specifically, emissions per unit of output declined from about 0.57 kg in 2009 to about 0.48 kg in 2018 – a 16% decline. This period coincides with the government's strong drive towards renewables. Figure 4 shows that while renewable energy grew sharply, it still accounts for a small proportion of total electricity generated in South Africa. Renewable electricity's share hovered around 2% during the period 1990–2013, but sharply increased after 2013 to reach about 7% in 2018.

Figure 3: South Africa C02 emissions 1990–2018 (kg per 2017 PPP $ of GDP)



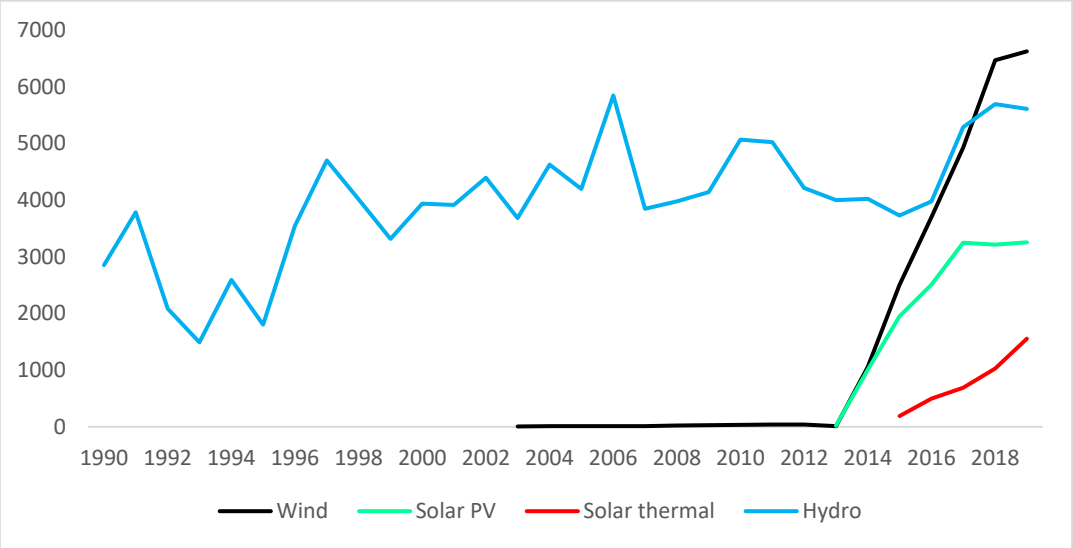
Source: Authors' calculations based on World Development Indicators and IEA online databases.

Figure 4: South Africa's renewable electricity output (% of total electricity output)



Source: Authors' calculations based on IEA online database.

Figure 5: South Africa's renewable electricity mix (GWh)



Source: Authors' calculations based on IEA online database.

Figure 5 shows the composition of renewables supply for South Africa. Hydro has been steady over the years, but there has been an impressive increase in the supply of wind, solar PV and solar thermal energy since 2013. Government has expressed its commitment to renewables through the various rounds of independent power producers procurements, with over 6400 MW procured to date.

What explains these encouraging trends and can they be sustained? Section 7 explores in some detail the possible factors explaining these positive trends. Table 1 shows the government's efforts to reorient South Africa's energy mix and carbon footprint more generally. While there are questions regarding the institutional and political economy challenges to implementation of these policies (WWF 2018), at least the signal is reasonably clear as to the preferred trajectory for the economy. The Integrated Resource Plan of 2010 set the tone by articulating the need to add some 17 800 MW of renewable electricity to the grid by 2030 – a goal that is highly achievable. The electricity outages experienced in 2008, which remain unresolved today, have also forced the government and electricity users to invest in energy-saving production and consumption methods, as discussed in section 7. The sharp increase in electricity prices since 2008 has provided further impetus for firms (and households) to reduce energy intensity. Thus a combination of policy and market-rationing mechanisms seem to explain the positive developments with respect to renewable electricity generation and

declining energy intensity. We are however unable to quantify the relative impacts of particular initiatives and policies.

4. South Africa's green economy, environmental policies and legal framework

The efforts by the South African government to protect the environment and facilitate the transition to a greener economy are reflected in the different policies and enacted legal instruments. The main policies are: The National Climate Change Response Policy (NCCRP) of 2011, The National Strategy for Sustainable Development of 2011, the National Climate Adaptation Strategy of 2017, the Working Paper on Integrated Pollution and Waste Management of 2000, and the Environmental Management Policy working paper of 1998. These are supported by economic policies such as the National Development Plan (see Table 1).

Table 1: Policies supporting the transition to a low carbon economy in South Africa

Year of publication	**White paper, strategy or policy**	**Responsible department**
1998	White Paper o on Environmental — Management Policy for South Africa	Department of Environmental Affairs
2000	White Paper on Integrated Pollution and Waste Management	Department of Environmental Affairs
2003	Annual Industrial Policy Action Plans	Department of Trade and Industry
2005/2015	National Energy Efficiency Strategy	Department of Energy
2011	The National Climate Change Response Policy	Department of Environmental Affairs
2011	Green Economy Accord	Economic Development Department (now the Department of Trade and Industry)
2011[16]	Independent Power Producer Procurement Programme	Department of Energy
2016	Integrated Energy Plan of 2016 (plus earlier iterations)	Department of Energy
2017	National Climate Change Adaptation Strategy	Department of Environmental Affairs
2019	Carbon Tax Policy	National Treasury
2019	Integrated Resource Plan 2019 (plus earlier iterations)	Department of Energy

Source: Authors' own compilation

[16] The Independent Power Producer Procurement Programme is a vehicle to procure electricity from the private sector. The first bids were received in 2011.

The government's national policy is guided by the white paper on Environmental Management Policy for South Africa of 1998, which is in line with the Constitution, the Environmental Conservation Act of 1989 and the National Environmental Management Act (NEMA) of 1998 and entrenches environmental sustainability. It emphasises that integrated and sustainable management of the environment is essential for sustainable development, and aims to ensure sustainable economic growth.

South Africa's detailed response to climate change is enunciated in the NCCRP. This white paper explains the government's plans to transform the country into a low-carbon and climate resilient economy (Department of Environmental Affairs 2011). Its main objectives are (i) to manage climate change impacts through sustainable interventions, and (ii) to significantly contribute to global efforts to stabilise greenhouse gas emissions. The NCCRP also stipulates the need to identify sectoral adaptation interventions and to facilitate coordination across sectors.[17] When it comes to mitigation, the NCCRP stipulates the need for each sector to establish emission reduction targets, with identified firms and sectors required to submit mitigation plans. It proposes that the right incentives be developed to reduce emissions (e.g. carbon tax and emission reduction trading permits).

The main legal instruments aimed at environmental protection in South Africa are the Environmental Conservation Act of 1989 (ECA) and the National Environmental Management Act of 1998 (NEMA). ECA and NEMA, together with the country's Constitution, provide the legal framework for the protection of the environment. NEMA, in particular, provides for the enforcement of instruments and what is required to ensure compliance.[18] For example, there are a number of environmental impact assessment regulations in place to ensure firms do not embark on environmentally damaging activities; where firms are considering activities that may damage the environment, these activities need to be assessed and approved before going ahead. Under NEMA there are other more specific instruments like the National Environmental Management: Waste Act of 2014 and the National Environmental Management: Air Quality Act of 2004. The National Environmental Management: Waste Act focuses on the generation

17 The country's climate change adaptation efforts are articulated in the National Climate Change Adaptation Strategy of 2017.

18 In terms of NEMA requirements, the government, through the Department of Environmental Affairs, is required to prepare environmental implementation plans and environmental management plans.

and disposal of waste while the National Environmental Management: Air Quality Act is aimed at preventing negative air quality related environmental impact.

In addition to NEMA and ECA there is the recently enacted Carbon Tax Act of 2019 and the National Water Act of 1998. Table 2 shows the main legal instruments aimed at protecting the environment and ensuring the economy transitions to a low carbon economy.[19, 20]

Table 2: Main legal instruments protecting the environment in South Africa

Legislation	Main emphasis
Constitution of South Africa of 1996	Provides the foundation for environmental regulation and policy, while promoting sustainable development.
Environmental Conservation Act of 1989	Provides the framework for the protection of the environment; provides for enforcement and compliance.
Environment Conservation Act of 1989: Waste Tyre Regulations (2008)	To regulate the management and disposal of waste tyres.
National Environmental Management Act of 1998	Currently the main legal instrument governing the protection of the environment in South Africa, it addresses a number of weaknesses of the Environmental Conservation Act.
National Environmental Management: Waste Act of 2001 and its 2014 Amendment	To prevent environmental impacts related to waste.
National Environmental Management: Air Control Act of 2004	To prevent environmental impacts related to negative air quality.
Carbon Tax Act of 2019	To sustainably reduce greenhouse gas emissions; it gives effect to the polluter-pays principle.
National Water Act of 1998	To ensure that the nation's water resources are protected, used and developed in ways that take sustainable use into account, reducing and preventing their pollution and degradation.

Source: Authors' own compilation

5. Greening of industry/economy and attendant trade-offs

Should South Africa prioritise the greening of its industry and thus economy or should it prioritise economic growth and development, leaving greening for later? In other words, is there a trade-off between green growth/industrialisation and economic growth & development?

[19] The Department of Environmental Affairs is also developing some carbon budgets.

[20] In addition to the discussed laws, there are by-laws promulgated by local municipalities.

On the face of it, this question is a difficult policy challenge for many policymakers, but as we argue here, it is a false choice, for it is premised on a misconception of sustainability.

It is not debatable that one of the major reasons for developing countries' failure to realise meaningful development has to do with inadequate resourcing. There is not enough spending in key development areas such as health, housing, education and social welfare. Africa generally suffers from inadequate infrastructure, particularly transport and energy, which has stifled economic growth in the continent.[21] At the same time, African policymakers must confront the challenges of climate change, and the necessary investments to mitigate and adapt. However, many climate-related investments tend to have long payback periods (Arndt et al. 2020). For these reasons, many African policymakers regard environmental protection as a luxury to be dealt with at a later stage, once the more urgent development challenges are addressed (Altenburg and Rodrik 2017). Thus promises and commitments aside, there is likely to be less drive to push environmental protection and climate change mitigation policies, particularly where there are perceived conflicts with other development imperatives.

South Africa has made some bold statements around climate change and environmental protection, with the government publishing various climate change policy papers and enacting acts of parliament to effect these policies (see Tables 1 and 2). However, as they say, the proof of the pudding is in the eating. There appears to be tension in the body politic, given the prospects of job losses in some carbon-intensive activities, including coal mining. Indeed, policy (or at least its implementation) doesn't seem to be well-coordinated across government. For instance, Eskom, the state monopoly in the electricity sector, recently embarked on a massive build programme with two mega coal-fired power plants – Medupi and Kusile. These plants will likely remain operational (and thus polluting) for the next three to five decades, if the lifespan of the existing coal plants is anything to go by. This step has been taken despite government's expressed commitment to green the economy, and clear opportunities provided by renewable energy to close the electricity supply gap from the perspectives of cost, construction time and technology leapfrogging. It would thus appear that South African

21 The African Development Bank assesses Africa's infrastructure gap at about US$100 billion per annum (African Development Bank, 2018). South Africa has the most developed infrastructure on the continent and is thus not as constrained as most other African countries.

policymakers also perceive a trade-off between green industrialisation and economic development.[22,23]

There are however strong reasons to believe that the perceived trade-offs being acted on by policymakers are based on a misconception of sustainable growth and development. Altenburg and Rodrik (2017: 7) articulate six arguments for why greening of growth is fundamental for sustainable development. For instance, failure to transform and green the South African economy while other countries transform would mean that South Africa would continue to produce goods for which demand will be declining, reducing the country's ability to effectively compete in the medium to long term, affecting its growth and employment. Also, given the awareness about climate change and measures being taken by various countries to reduce their carbon footprint, the world is likely to see trade regimes that penalise carbon in international trade in the near future.[24] Furthermore, failure to transform now means South Africa would deepen the carbon lock-in effect, raising the costs of switching to a greener economy in the future. Equally, the failure to transform the economy will result in the country missing out on opportunities to leverage green technologies for growth and development. First, green industrial policies drive innovation and thus productivity growth (Altenburg and Rodrik 2017). Given its relatively advanced industrial capacity, South Africa should be able to realise some of the new green innovations. Second, by reducing pollution green technologies support better health outcomes, which support better quality of life and in turn enhances productivity (UNIDO 2011a). Thus the perceived trade-off between green industrialisation and status quo-based development is largely a fallacy.[25]

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22 However, there are some encouraging developments. First, the share of renewables in the country's energy basket continues to increase, with a total of 6400 MW already procured (Department of Energy 2019). Second, South Africa has adopted a carbon tax (signed into law in 2019 but still to be made operational) to disincentivise production and consumption of carbon-intensive goods. Critics, however, argue that the rates are too low to force behaviour change (WWF 2018). Perhaps the point that is being missed here is that there is signalling value in the promulgation of the carbon tax, in the sense that the government has made a tangible commitment to transition the economy to a low carbon trajectory.

23 In the case of South Africa, UNECA (2015) argues that there is apparent competition for financial resources between green growth interventions and general development challenges facing the country.

24 The EU is working on such a regime – the carbon border adjustment mechanism.

25 To the extent that externalities are under-priced in the global economy, unilateral greening efforts by firms in one country (e.g. internalising externalities) raise relative production costs and reduce short-term competitiveness. In this case, one could argue that there exists a trade-off between green industrialisation and welfare. But again, the real issues here are that the externalities are under-priced and firms are unilaterally internalising externalities, thus causing them to lose competitiveness in a relative sense.

In the case of South Africa, which is facing a binding electricity constraint, greening the energy grid should complement the government's development efforts. Presently, the electricity supply shortage is negatively impacting production, as was shown by the many brownouts (planned power outages) during winter of 2020, even as the country was under lockdown. The power shortages disincentivise new investment, particularly in the more energy-intensive industrial sectors. Indeed, inadequate electricity is one of the main factors explaining declining potential growth in South Africa (Heinemann 2019).

Lifting the energy constraint should have a multiplier effect across all sectors of the economy, unleashing growth and employment. Policy could for instance encourage private sector renewable electricity generation with access to the grid to offload excess power or to wheel energy to potential customers. This, however, requires reforming Eskom's integrated electricity system – in particular, unbundling generation, transmission and distribution and creating an open (competitive) electricity market. Such interventions should help lift the electricity constraint on growth, increase the share of renewables in the grid and enable competitive pricing of electricity. This is especially important given that the cost of constructing new renewable energy plants significantly decreased during the period 2010–2019, and this trend is expected to continue.[26]

6. Green industrial policy as a tool for structural transformation of the economy

Markets are not good at identifying and implementing transformation opportunities, and often must be cajoled by policy to allocate investments in a manner consistent with the country's development imperatives (see, for instance, Rodrik 2004).[27] Industrial policy – government actions to alter the structure of an economy, encouraging resources to move into particular sectors that are perceived as desirable for future development – is one of the important tools for effecting structural transformation of an economy (Altenburg and Rodrik 2017; Aghion, Boulanger and Cohen 2011). It can be deployed in the climate change fight to help countries

26 According to the International Renewable Energy Agency (2020), between 2010 and 2019 the cost of new solar photovoltaic projects went down by between 47% and 82% while that of wind went down by between 29% and 39%. This corroborates findings by a South African asset management firm (Future Growth Asset Management) that "compared to the most competitively priced new coal plant construction today, a renewable energy plant is at least 30% cheaper to build, when translated to a cost per unit of electricity produced by each technology."

27 It is well known in welfare economics that markets are good at generating efficient outcomes but such outcomes are not necessarily desirable. This is a point that is often missed by the proponents of 'free' markets.

transition to low-carbon economies or to reduce environmental pollution more generally. The argument for (green) industrial policy rests on the existence of, and the need to correct, market failures impeding (green) transformation. Externalities are often cited as the rationale for industrial policy, particularly self-discovery externalities, coordination externalities, learning-by-doing externalities and environmental externalities.[28]

6.1 Industrial policies necessary to address externalities

***Self-discovery externalities*:** Entrepreneurs must experiment with 'new products' and/or new ways of producing available products using domestic resources. Whereas the activity of discovering the cost structure of 'new' products has high social value to the economy, the entrepreneur is often unable to appropriate most of this value. Furthermore, the risk of carrying out such an activity is borne solely by the investor. This lopsided risk allocation disincentivises entrepreneurs, resulting in under-investment in self-discovery, a low range of green products and under-diversified economies.[29]

Coordination externalities arise when there is failure to properly coordinate and/or sequence investments in a way that makes private investments profitable. This is particularly the case with high fixed-cost investments if such investments are to be undertaken sequentially and by different firms (Rodrik 2004). The sequential nature of the investments creates hold-up problems for the early investors. Under these conditions the private sector may not be able to coordinate its investments in a way that makes it worthwhile for each individual entrepreneur to invest, especially if the profitability of each firm's investment depends in part on investments by other firms. This is likely to be the case with green goods as the existing infrastructures may not support production of such goods, requiring completely new investments across the value chain. Government can intervene to remove hold-up problems by either guaranteeing a certain

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[28] While the presence of market failures provides the rationale for government intervention in the economy, government failure is rife and can itself be a stumbling block to (industrial) development. Government failure may arise due to lack of capacity to formulate policy or capture of policy by vested interests, or due to political considerations. Even if the policy design were to be optimal, government failure can still occur in the implementation phase. South Africa's lethargic electricity sector reforms are a good illustration of government failure.

[29] New innovations associated with research and development (R&D) expenditures get rewarded through the patent system, hence there are no market failures associated with R&D-induced innovations. 'Self-discovery' investments as discussed here generate non-patentable 'innovations', hence competitors can immediately imitate successful innovations, denying the 'innovator' the opportunity to recoup costs.

return for the initial investors in sequential investment projects or by directly undertaking the basic investments (e.g., green infrastructure) itself[30].

Learning-by-doing externalities also matter for green industrial development. Khan (2015) points out that "owners, managers, and supervisors often do not know how best to set up the factory, align the machinery, set up systems for quality control, reduce input wastage and product rejection, manage inventories, match order flows with production cycles, maintain after sales services, and approach a host of other internal team coordination and management issues that are essential for achieving competitiveness". Firms can only build capabilities through 'learning by doing'. Like any other new sector, building a competitive green industrial sector will undoubtedly require significant learning by doing. However, to the extent that learning by doing is associated with low profitability or losses, it can become a constraint to green industrial development, especially in an environment where externalities are not correctly priced, if at all. However, as Khan (2015) notes, the 'doing' is necessary but not sufficient for 'learning' to take place. Owners or management often need to be cajoled to exert high levels of effort in the learning process. Indeed, the history of industrial policy is littered with examples of 'infants' that never grew despite government support.

Environmental externalities – the costs (benefits) associated with the production or consumption of goods and services that are borne by (accrue to) third parties – have a bearing on the structure of economies as they may favour certain sectors over others. Because of the inability to properly assign property rights, markets generally fail to adequately price the environmental effects of economic activity, and this can lead to economically viable but socially undesirable economic activity (Schwarzer 2013).[31] In addition, overexploitation of natural resources undermines their ability to support future economic development and could cause a reversal of the gains realised to date (Altenburg and Rodrik 2017 citing Fay et al. 2015). Environmental externalities are major sources of green transformation inertia, whereby industries are constrained by carbon-intensive technologies acquired years earlier owing to path dependence. Such path dependence gives these technologies an unfair advantage (e.g. coal-generated electricity) as externalities are not (adequately) priced. As we will discuss further

30 Or, in the case of South Africa, simply agreeing to enable and purchase renewables.

31 For negative externalities, social costs exceed private costs and as a result there is excessive provision of the externality-generating activity.

below, where pricing of externalities is not feasible or inadequate to level the playing field, the government can, and should, use (green) industrial policies to achieve the desired reconfiguration of the economy, with market forces ensuring efficiency along this new path. This approach is consistent with the second theorem of welfare economics, which argues that the market can achieve resource efficiency for any given initial allocation of endowments.

There are several reasons why green industrialisation is unlikely to develop to the optimal level without government intervention. First, in most cases the markets for green goods are not well developed (possibly due to both self-discovery and coordination externalities) – a case of incomplete markets.[32] An example is the market for low emissions vehicles (LEVs), where these vehicles have a small share of the market despite being environmentally friendly. In 2019, electric cars accounted for 2.6% of global car sales while the global stock of electric cars stood at 1% of global car stock (IEA 2020). The low stock points to market incompleteness as governments in the past did not have strong policy measures to support the development of this market. Recently, many governments have increased fuel taxes and also imposed carbon taxes which have encouraged technological innovations in LEVs and raised the relative prices of vehicles propelled by fossil fuels.

A related but different reason why green industries may fail to develop or flourish is unfair competition from carbon-intensive goods. Governments have, through their actions or inactions, inadvertently incentivised production and consumption of carbon-intensive goods, making it difficult for green goods to effectively compete.[33] Again, a good example is the market for LEVs.[34] Because the free market does not penalise fossil-fuel-based vehicles for the emissions they produce, and because fossil fuels are relatively inexpensive and in some cases even subsidised, LEVs (electric cars, hydrogen cars, etc.) cannot quite compete with established fossil-fuel-powered cars. Policy could help strengthen the market for LEVs by fully pricing in carbon through, for instance, fossil fuel/carbon taxes, standards regulations,

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32 An incomplete market is said to exist when "certain goods or services cannot be traded because there is no organized market on which to trade; e.g., when there are too few people interested in trading goods of a given type to make an organized market in them worth the costs of operating it" (Oxford Reference, *A dictionary of economics*).

33 For example, in South Africa, Eskom has significant monopoly power in the electricity market which it derives from government regulation, and not necessarily from economies of scale.

34 The energy market - coal vs. renewable energy, is also a good example where policy inaction or complicity has slowed the decarbonisation of the energy sector.

providing research and development (R&D) incentives to support technological advancements in the sector as well as demand-side incentives to shift consumer tastes.[35]

7. Green industrialisation in South Africa: Challenges, progress and opportunities

7.1 The challenges

As mentioned earlier, South Africa is one of the world's dirtiest producers with 86% of its electricity generated from coal. The energy sector therefore has an important role to play in the government's climate change mitigation efforts, as decarbonisation of the sector would have ripple effects across the economy. *The Integrated Resource Plan 2019* details the country's planned energy transition and the changing energy mix with a view to significantly reducing emissions.

South Africa faces various challenges in its attempt to green the economy, among them skills, financing, technology, institutional arrangements and political economy (WWF 2018).[36] The political economy challenge looms large, and is compounded by high unemployment (around 30%), high poverty and high inequality (a Gini coefficient of 0.65), low skills, powerful trade unions, and an inefficient state-owned electricity company (Eskom) which has vast market power. In addition, the structure of the economy, centred on heavy industries in the minerals extraction and processing value chains, gives policymakers pause. This constellation explains government's reluctance to aggressively force transition; instead preferring a gradual approach to decarbonisation (Amis et al. 2018).

As an example, while the government has expressed strong interest in shifting electricity generation from coal to renewables through various iterations of the Integrated Resource Plan,

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35 The IEA (2020) notes: "Ambitious policy announcements have been critical in stimulating the electric-vehicle rollout in major vehicle markets in recent years. In 2019, indications of a continuing shift from direct subsidies to policy approaches that rely more on regulatory and other structural measures – including zero-emission vehicles mandates and fuel economy standards – have set clear, long-term signals to the auto industry and consumers that support the transition in an economically sustainable manner".

36 WWF (2018) argues that the country lacks a common national narrative and reference point of the green economy which has seen different government institutions focusing on different and sometimes conflicting goals. One example is the misalignment between "the ethos of the green economy, industrial policy, and the structure of the financial system", with the financial system not adapted to support investment in low-carbon technologies, except perhaps in the renewable energy sector. Moreover, South Africa faces a binding skills constraint, and has over the last few decades morphed into a technology adopter rather than a technology leader. South Africa also spends relatively little on R&D (less than 1% of GDP).

the country faces the challenge of potentially stranded assets if the shift happens too quickly. Equally, demand for electricity currently exceeds supply, which has resulted in the country experiencing rolling brownouts which have constrained investment and growth. As such, there is little appetite by policymakers to retire these coal plants at this point, even as procurement of renewable energy has progressed. Perhaps the silver lining is the fact that most of the coal plants (except for Medupi and Kusile) are now approaching the end of their useful life, which naturally allows for a low cost switch to clean energy.

Another consideration relates to the jobs in the coal sector supporting these aging plants.[37] Decommissioning these plants would see a substantial decline in the demand for coal in the domestic market, and with it the loss of associated jobs.[38] While new jobs are expected to be created in the renewable energy sector as it expands, the skills challenge could potentially limit labour mobility across activities, and to the extent that the new jobs are skill intensive, unemployment could worsen as the laid-off workers might not be able to reskill to take advantage of the green opportunities (Wakerford, Hasson and Black 2016). Furthermore, renewable energy jobs are likely to be capital intensive whereas coal jobs tend to be labour intensive.

While any job losses are unwelcome, the jobs argument above is static and thus largely flawed. As pointed out earlier, the status quo is already costing the country jobs – both existing and potential – as the instability in the electricity grid is impacting production and competitiveness and also forestalling investment. Important as they are, there is thus the danger of over-emphasising the existing jobs at the expense of growing the economy and expanding opportunities (the insider/outsider problem). As argued by Simbanegavi and Mnguni (2019), "without building competitiveness and viability, policy efforts aimed at 'protecting jobs' can

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37 Transition in the energy sector will, among other things, require reforming of the electricity sector. After dragging its feet for a long time, government finally appointed a Chief Restructuring Officer at Eskom in 2019.

38 Demand for coal at the global level has been declining and is projected to decline further (Chamber of Mines 2018). This will likely put pressure on the government to support coal jobs in the domestic market, delaying the needed transition. Electricity generation from coal in South Africa has become expensive, particularly if one considers the incessant blackouts, which cost investment, growth and jobs. Over and above the high prices paid by consumers, Eskom has literally pushed the government to a fiscal cliff through the many bailouts afforded to the entity to help keep the lights on. Things only get worse for coal if one also consider externalities, which we should.

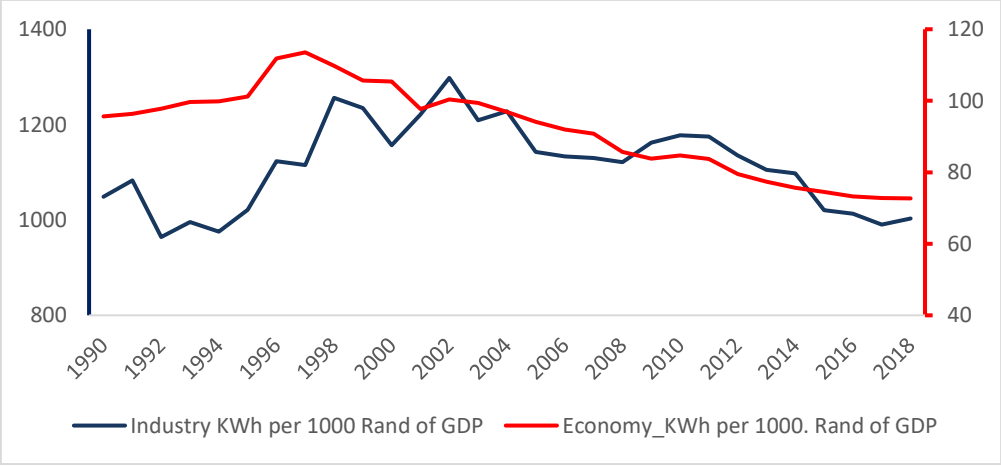
only delay, but not prevent, the demise of the struggling incumbent firms, and at a high cost to society".[39]

There are potentially strong multiplier effects from relieving the energy constraint. Pursuing renewable energy has multiple benefits. It not only relieves the energy constraint, but also allows the government to realise its Paris commitment, supports investment and employment growth, supports technological innovations thereby enhancing spillovers and competitiveness, and possibly technology leap-frogging. This should expand green job opportunities in the rest of the economy (The New Growth Path 2010).

7.2 Progress

How much progress has South Africa made in greening its industry and economy? Amis et al. (2018) give South Africa a score of 5 out of 10, arguing that the efforts have largely been a "public relations exercise" as opportunities to green the economy have not been properly exploited. Notwithstanding this negative assessment, we show below that some commendable progress has indeed been realised. Figure 6 shows a sustained reduction in the energy intensity of production.

Figure 6: Energy intensity of production (KWh/1000 rand of GDP)



Source: Authors' calculations based on IEA 2020 and World Bank 2020 data

[39] It is apparent that the coal industry is now a subset industry by any measure. Where possible, policy should support restructuring and reskilling of workers to soften the landing, but still allow for 'creative destruction'. Tying resources in declining sectors through subsidies not only costs the fiscus, but also constrains the economy's potential to grow as the opportunity cost of resources is higher outside the declining sectors.

Owing to advancements in technology, policy support and rapid declines in costs, renewable energy technologies have been adopted widely around the world, and are by and large cost competitive vis-à-vis fossil-fuel-based technologies (IRENA 2019). Indeed, in terms of new investments globally, renewable energy beats all forms of fossil fuel investments combined (Renewable Energy Policy Network for the 21st Century 2017). South Africa has taken advantage of these positive developments in the global energy technologies space, with some appreciable diversification of the energy pool in the recent time period (see Figure 5). To date, 6 422 MW has been procured from more than 100 independent power producers, of which 3 776 MW is already feeding into the national grid (Department of Energy 2019).[40] As mentioned elsewhere in this paper, a shift in the energy mix towards renewables supports the greening of production, particularly with respect to manufacturing, since manufacturing in South Africa is energy intensive.[41] Other notable initiatives to reduce the carbon content of output include industrial energy efficiency, demand-side management policies and market-based incentives. We discuss these initiatives below.

7.2.1 South Africa's industrial energy efficiency project

One might ask: What has the South African government done to support energy efficiency by firms (and households) and thus reduce the country's carbon footprint? Is it all talk and no action, as Amis et al. (2018) suggest? The answer, in our view, is that the government has done quite a bit, though there still is a long way to go. The industrial energy efficiency project is the flagship thus far and, as we discuss later, is world pioneering.

Hosted by the National Cleaner Production Centre of South Africa, the project was established in 2010 in collaboration with UNIDO, the Swiss Secretariat for Economic Affairs and the United Kingdom's Department for International Development (which is now the Foreign, Commonwealth & Development Office).[42] The project contributes to the sustainable transformation of industrial energy usage practices in South Africa by, among other things, formulating and implementing an enabling policy framework that supports energy efficiency;

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40 The share of renewable energy in total energy production in South Africa has now reached 7% (Figure 4).

41 Given that the manufacturing sector has very high economic and employment multipliers, greening in this sector may significantly affect the greening of other economic sectors (Wakeford, Hasson and Black 2016).

42 The concept of industrial energy efficiency was first developed and implemented in South Africa, and now is widely implemented in other countries.

creating institutional capacity to implement the energy management standards; raising awareness around the importance and impact of industrial energy efficiency; and energy audits. Five major industrial sectors were targeted for the pilot project on account of their potential to bring about a reduction in energy consumption and thus emissions: namely, agro-processing; chemicals and liquid fuels; metals processing and engineering; the automotive industry; and mining (UNECA 2015).

According to the National Cleaner Production Centre (2020), the benefits of the industrial energy efficiency project up to 2020 include a saving of 6.5 TWh of energy, mitigation of 6.4 million tonnes of CO2e and a saving of R5.3 billion in energy costs for the participating companies. In addition, nearly 6 500 engineers, technicians and managers were trained in energy efficiency while over 200 experts were trained in energy management standards and energy systems optimisation. The industrial energy efficiency project won the International Energy Award 2020 in recognition of its achievements.

7.2.2 Energy efficiency (demand-side management) policies.

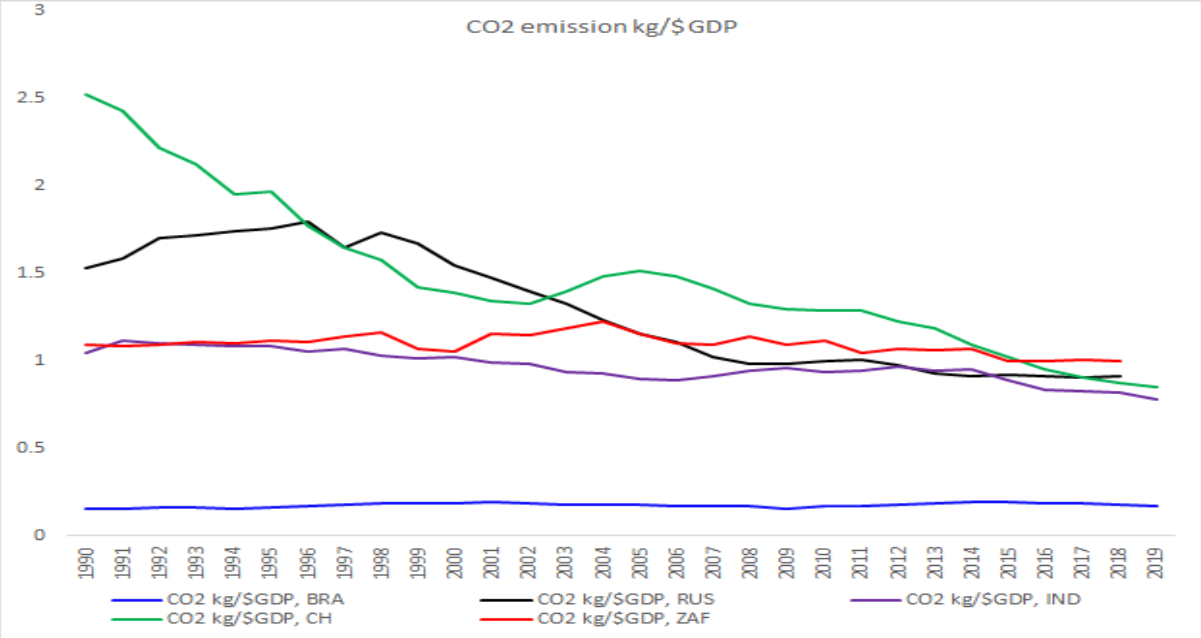
The government also intervened to support energy efficiency by households and small firms through the municipal Energy Efficiency and Demand Side Management (EEDSM) programme. The programme included retrofitting of existing facilities such as street lighting, traffic signals, municipal buildings, water pumps and waste water treatment (UNECA 2015). Among the expected benefits were reduced electricity demand and thus reduced greenhouse gas emissions. One of the main elements of the EEDSM is the National Solar Water Heater Programme (NSWHP), which targeted the installation of 1 million solar water geysers between 2010 and 2015, with the goal of saving 3500 GWh per annum. The programme, funded by the Department of Energy and implemented by Eskom, integrated the three dimensions of sustainable development (economic, social and environmental), allowing for job creation in project management, solar water heater manufacturing and installation and maintenance (UNECA 2015).

The question, however, is whether the programme goals and objectives were met. It turns out that the programme fell far short. Only 400 000 units were installed under the rebate programme by 2014 against a target of 1 million solar water heaters – a 40% success rate (*The Citizen*, 7 June 2018; Netshiozwi 2019). Apart from low uptake, another challenge with the

programme was the extensive use of imported geysers or components, which created both quality issues and undermined localisation efforts, reducing the sustainability of the programme. The Department of Energy has since taken over the programme from Eskom and has set a new cumulative target of 1.75 million units by 2019, and five million units by 2030 (*The Citizen*, 7 June 2018). On a positive note, the establishment and growth of the solar factory in Atlantis (Cape Town), and at least six other solar water heater manufacturers nationwide, was nurtured by the state programme, with manufacturers benefitting from the programme's 70% local content requirement.

While South Africa has made notable progress in lowering the energy intensity of production (Figure 6), it is instructive to assess its performance relative to peers, particularly the BRICS countries (Brazil, Russia, India and China). Figure 7 shows the CO2 emissions per unit of GDP (in constant 2010 US$).

Figure 7: CO2 emissions per unit of GDP, South Africa vs the BRICS countries



Source: Authors' calculations with data from the World Bank's World Development Indicators and IEA databases.

Figure 7 is illuminating. Brazil is an outlier, with very low emissions per unit of output. This is explained by Brazil's reliance on hydro power for the bulk of its electricity supply. Coal is an insignificant source of electricity for Brazil. China and Russia have shown strong

decarbonisation over the period. China reduced its CO2 emissions from over 2.5 kg per US$ of GDP in 1990 to under 1 kg per US$ of GDP by 2018. Given that China is the second-largest economy in the world, this augurs well for world greening. India and South Africa are the worst performers in the group, with South Africa ranking lowest, showing very marginal improvement in the carbon intensity of its GDP over a 30-year period. Although South Africa began significantly below China and Russia in 1990 (1.1 kg/US$ of GDP for South Africa versus 1.5 for Russia and 2.5 for China), by 2018 South Africa had the most CO2 emissions per unit of GDP of all BRICS countries.[43] This poor performance can be attributed to South Africa's excessive reliance on coal for its electricity. Also, policy implementation to improve the energy mix has been weak, despite promising policies on paper. With the EU working on a border carbon tax adjustment, and the US re-joining the Paris Agreement, South Africa's export competitiveness could be in jeopardy.

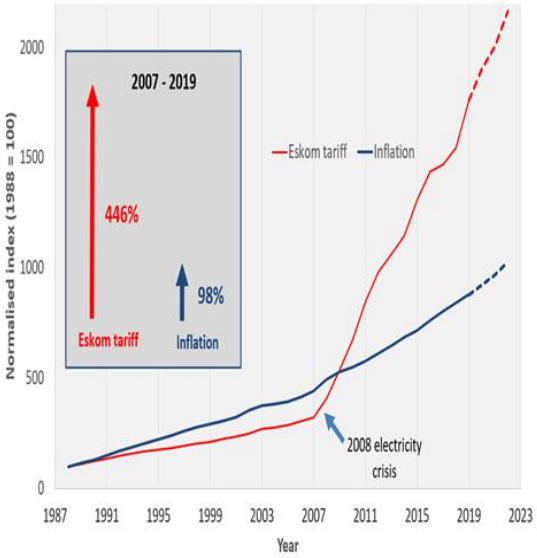
7.2.3 Market-rationing mechanism

In 2008, South Africa experienced debilitating blackouts and brownouts which affected industry and households. Prior to that, electricity prices in South Africa were among the lowest in the world, and these low prices not only encouraged energy-intensive investments, but also incentivised inefficient consumption of electricity. The industrial energy efficiency project and the EEDSM programme were largely a response to the high energy consumption per unit of output in South Africa. At the same time that these programmes came into effect, electricity prices began increasing to fully reflect the costs of providing the service (Figure 8a). This increase in prices cajoled firms and households to conserve electricity, reinforcing the impacts of the industrial energy efficiency project and EEDSM.

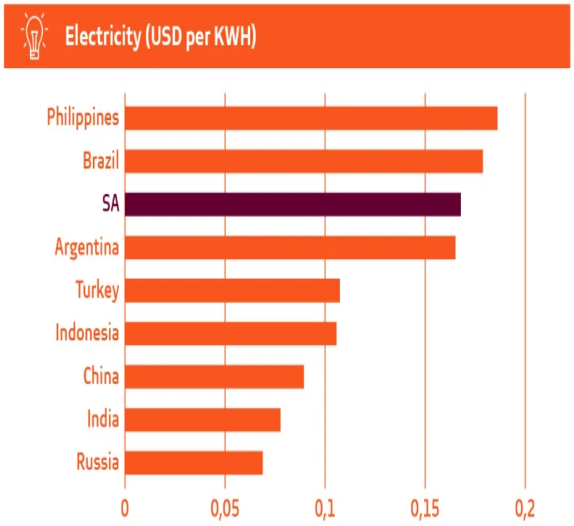
The sustained above-inflation electricity price increases since 2008 have moved South Africa from being among the countries with the cheapest electricity in the world to the middle tier. South Africa compares poorly among emerging market peers, which is concerning from a competitiveness point of view (Figure 8b). As of 2018, South Africa ranked as the third most expensive country among a group of peers, and the second most expensive among the BRICS countries (Figure 8b).

[43] When viewed in this context, the skepticism by Amis et al (2018) seems warranted.

Figure 8: Electricity prices in South Africa



Source: PowerOptimal.



Source: Absa WIMI (October 2018).

Looking at Figure 6 on its own one is tempted to argue that the energy efficiency initiatives have permeated the industrial sector and the economy more generally. The energy intensity of total GDP (red line) shows a strong downward trend since the mid-1990s. Similarly, the energy intensity of the industrial sector also shows a declining trend since the early 2000s, with the slope steepening since about 2010. This period coincides with a number of initiatives directed at reducing the energy intensity of production, including the industrial energy efficiency project, energy demand-side management policies and strong electricity price increases (Figure 8a). However, there are other factors that could just as well explain this pattern, including the exit of some high energy-intensive users in the metals, foundries and smelting subsectors as a result of the global financial crisis (weak demand) and lack of competitiveness (South African Institute of Foundrymen 2015).[44] An interesting question is how much scope remains for further improvements in energy efficiency and thus lower energy intensity in the industrial sector, particularly in the absence of a change in the energy mix.[45]

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44 According to the South African Institute of Foundrymen (2018), over 100 South African foundries have closed since 2003, and for those remaining, production has slowed by about 43% since 2007.

45 There must be limits to energy efficiency in production. Beyond a certain point firms are not able to meet regulatory standards through enhancing energy efficiency, hence new products or completely new ways of producing the product may be the only solution. For example, further tightening of vehicle emissions standards in such regions as Japan, EU and USA may force manufacturers to abandon or significantly modify the workings of the internal combustion engine (Altenburg and Rodrik 2017).

7.2.4 The Renewable Energy Independent Power Producer Procurement Programme

The South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) was established in 2011. It is a competitive procurement programme for renewable energy introduced to facilitate private sector investment into grid-connected renewable energy generation (Eberhard and Naude 2016). Its establishment was in line with the 2010 Integrated Resource Plan and the 2003 White Paper on Renewable Energy. According to Eberhard and Naude, the programme has been quite successful in terms of metrics such as capacity, investment and price outcomes. Between 2011 and 2019, a total of 6 422 MW was procured from more than 100 renewable independent power producers. Due to competition and innovation in the industry, the price offered by the independent power producers has continued to decrease. For example, for wind technology, the average bid price, which was 151c/kWh in 2011, had decreased to 62c/kWh by 2016. Supported by various government instruments, and the likely increased support from the financial institutions going forward, we are more likely to see renewable energy accounting for an increased proportion of the total electricity generated in the country.

7.3 Opportunities

Greening the energy sector, though important, is only one part of the greening process for the industrial sector. Cleaner energy implies, all other things being equal, lower energy consumed to produce a unit of output. Greening of production and consumption also requires the production of green goods (and services) and complementary policies to incentivise demand of the same. South Africa is the most advanced manufacturing economy on the African continent. It is ranked the regional lead in sub-Saharan Africa, and 45th globally with respect to the competitiveness and industrial development index (UNIDO 2018).[46] These capabilities mean that South Africa has potential to participate in many industries/sectors producing green goods (see Altenburg and Rodrik 2017: 8). Leading in the production of green manufactured goods, including green energy components, should not only expand the country's renewable energy significantly but also help fast-track the greening of the economy. Presently, efforts are under way to expand investments in concentrated solar power in South Africa, particularly in the

[46] This index is composed of three dimensions: dimension 1 assesses a country's capacity to produce and export manufactured goods, dimension 2 assesses technological deepening and upgrading, and dimension 3 assesses a country's world impact.

Northern Cape region. Table A1 in the Appendix shows the projects that are either under construction or already operational.

8. Conclusion

COVID-19 gave the world a glimpse of how devastating natural disasters can be to economies and livelihoods. Climate change would be far more devastating than the COVID shock, given its permanence and the difficulty that countries will have to adapt.[47] Countries globally have committed to engage in climate mitigation more concretely through the Paris Agreement. The South African government has made bold statements around climate change and environmental protection, as exemplified by various climate change policy papers and laws. This paper has explored how well these policies and regulations have been implemented and what the outcomes have been so far. We have considered the challenges and opportunities facing the South African industrial sector when it comes to greening production and consumption, and the role that policy can play in promoting green industrialisation.

One challenge the country faces is how to significantly shift electricity generation from coal to renewables without compromising on short-term economic growth and addressing the challenges of high unemployment and poverty. We argue that the current electricity shortages, which are constraining investment and growth, are a blessing in disguise as renewable energy can be ramped up without the need to decommission some coal-generating assets in the short term. In the short term, the trade-off between coal and clean energy is not at all binding. Furthermore, the concern that a transition to renewables-based electricity generation could create the risk of stranded generating assets in the medium term is also unfounded for South Africa, as most of these assets are already nearing the end of their lifespan. Policy should also address the apparent misalignment between green economy objectives and those of other key sectors. For instance, the government may need to create incentives for the financial system to increase its support of risky investments in low-carbon technologies or increase government spending on R&D.

[47] Although there are some that suggest that pandemics like COVID-19 may become more frequent in future.

The country has an opportunity to transition into renewables and a low-carbon economy. First, most coal plants are approaching their decommissioning state. Second, South Africa, as the most developed manufacturing economy in Africa, has the capacity to participate in a large number of sectors that produce green goods, and to lead the greening crusade in Africa, creating regional green value chains. In particular, South Africa can increase its participation in renewable energy technologies. These include high-tech components of solar photovoltaics, concentrated solar power, wind turbines and energy storage technologies such as the battery energy storage system being pioneered by Eskom. However, just because South Africa has the opportunity to produce renewables does not necessarily mean that it also has an inherent comparative advantage in the production of the related technologies. Areas (whether in terms of sectors or certain stages of the energy production value chain) where the country has a comparative advantage need to be identified and focused on. It may also be important to identify areas with potential and work on those to ensure future comparative advantage.

Although South Africa compares unfavourably to its BRICS peers with respect to the emissions intensity of output, the country has realised some successes. These include the renewable energy procurement from the independent power producers programme as well as carbon content-reducing initiatives by government (e.g. industrial energy efficiency policy, demand-side management policies and market-based incentives). The carbon intensity of GDP has decreased appreciably, though more remains to be done.

A major concern for South African policymakers ought to be the developments in the EU around the carbon border adjustment mechanism. If the country continues to dither on greening, there is a risk that South Africa will be heavily penalised in trade once the EU's carbon border adjustment mechanism takes effect. South Africa has no choice but to pursue green growth in general, and green industrialisation in particular, as failure to do so will undermine its growth prospects and carry major socio-economic ramifications. South Africa's position vis-à-vis its peers suggests it will likely experience substantial erosion of its competitiveness. Government needs to be decisive and remove any barriers to the development of the renewable energy sector. It also needs to put in place better incentives to encourage green industrialisation. More specifically, all government industrial support must be reviewed, with particular attention being given to aspects of policy that hinder change.

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10. Appendix

Table A1: Concentrated Solar Power (CSP) in South Africa

Project name	Technology	Capacity (MW)	REIPPPP Window	Nearest town	Status
Bokpoort CSP	Parabolic trough	50	2	Groblershoop	Operational
Eskom CSP	Tower	100	other	Upington	Construction
Ilanga CSP 1	Parabolic trough	100	3	Kimberley	Construction
Kathu Solar Park	Parabolic trough	100	3	Kuruman	Operational
Kaxu solar 1	Parabolic trough	100	1	Pofadder	Operational
Khi solar 1	Tower	50	1	Upington	Operational
Redstone CSP	Tower	100	3	Postmasburg	Planning
Xina CSP	Parabolic trough	100	3	Pofadder	Operational
Totals	8	700			

Source: Rycroft (2018), EE Publishers.