City-Wide Mitigation Potential for South Africa

Published by Sustainable Energy Africa

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This document has been developed by Sustainable Energy Africa, through the participation of a wide range of stakeholders, however Sustainable Energy Africa is responsible for the views expressed herein.

The research for this publication was funded by:

German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as part of the International Climate Initiative (IKI) and under the project "Vertical integration and learning for low-emission development (V-LED) in Africa and Southeast Asia". This four-year project is led by adelphi, a Berlin-based think-tank. In South Africa, the implementing partners of the V-LED project are Sustainable Energy Africa (SEA) and OneWorld Sustainable Investments (OneWorld). The main South African Government counterpart for the V-LED is the Department of Environmental Affairs (DEA). The project is predicated by the strong, mutually beneficial bilateral partnership between South Africa and Germany in the energy and climate change sector.
Additional funding support was provided by Heinrich Böll Stiftung.

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Layout: dotted line design

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Produced by Sustainable Energy Africa

December 2018

SEA SUSTAINABLE ENERGY AFRICA

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

V-LED STIMULATING URBAN CLIMATE ACTION

HEINRICH BÖLL STIFTUNG SOUTHERN AFRICA

Photo: Bablu Virinder-Singh

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with urban population over 100 000
including
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Executive summary

This report provides an update on a 2016 modelling exercise that was undertaken to provide an overview of the energy consumption and energy-related greenhouse gas emissions of urban centres in South Africa, and to determine the extent to which these cities can reduce their emissions into the future, based on various energy efficiency and renewable energy interventions. Inputs that were changed in the update include renewable energy costs and the future electricity mix, based on the updated Integrated Resource Plan (IRP)[1]. Findings are listed below.

Status quo:

- **South African cities' emissions intensity is relatively high when compared to the level of economic development**, as a result of an energy-intensive and energy-inefficient economy based largely on emissions-intensive coal.
- **Cities are intense nodes of economic activity, energy consumption and emissions production.** The cities covered in this report only occupy only 6% of land area, but house 53% of the population, produce 55% of GDP and account for 40% and 39% of energy consumption and emissions respectively.
- **The transport sector dominates city-level energy consumption,** contributing to 57% of energy consumption in urban centres, as a result of urban sprawl, where people and goods have to be moved across large distances.
- **The passenger transport system is very inefficient and unequal,** with most passenger transport energy consumption (81%) and road space given over to the car, while most (62%) of the passenger travel in urban centres takes place using public transport or walking.
- **South Africa's electricity is incredibly emissions intensive, with electricity as the largest contributor towards city emissions**, at 65% of all energy-related emissions in urban centres. This is because most electricity is produced by coal-fired power stations, which is an emission-intensive process.
- **Energy consumption is very unequal within cities – the poor consume too little and the rich too much.** Half of all households (mid- to high-income) consume two-thirds of households energy; the other half (low-income) consume only a third.

The future:

- **The growth of energy consumption and emissions production into the future is very sensitive to economic growth projections.** The model update, adjusting for lower economic growth, dropped the 2050 energy consumption projection from a tripling (vs. 2012) to less than a doubling.
- **Proceeding along a business as usual scenario carries significant socio-economic risks.** Reliance on finite fossil fuel sources increases the risk of rapidly-escalating costs and price shocks, and carries a high cost with regards to health and climate impacts.
- **A low-carbon scenario, based on energy efficiency and renewable energy, is cheaper and results in a more competitive economy.** The case is so compelling that the country is already shifting, as evidenced by the stronger role for renewable energy in the latest IRP, net zero carbon goals within four major metros, and sustainability targets within retail giants. Partnerships and citizen responsibility play key roles in driving climate response.
- **Significantly improved public transport is essential to a sustainable city,** as the transport sector represents the largest energy-savings potential, and moving people from cars to public transport the major intervention. This is difficult, as it needs a long-term focus on urban planning, to create denser, mixed-use cities concentrated around transport corridors.

1 The Integrated Resource Plan is South Africa's country electricity plan.

- **New technology options and low-carbon responses will be disruptive,** with renewables, such as rooftop PV, and electric vehicles having the potential for large disruptive impacts on jobs, companies and entire industry clusters. **The policy and regulatory environment will need to change** to keep up with on-the-ground changes and manage the transition. Rapid take-up of disruptive technologies is inevitable as prices drop, as evidenced by recent rooftop PV uptake in the commercial sector.
- **Policy interventions can keep urban centres within the Peak, Plateau, Decline (PPD) emissions trajectory.** The latest IRP update had a substantial impact on the ability to remain within the emissions limits as set by the PPD trajectory.

The transition to a low-carbon economy will need to be managed carefully. This will entail a commitment to multi-level governance, alignment of policies and adaptation of the regulatory and financial environment. In other words, co-ordination and consistency are fundamental to effective climate action.

Background

South Africa's economy and power sector have been built around the abundance of coal and various minerals, such as gold and platinum; resulting in an energy-intensive economy with a heavy focus on mining, smelting, and electricity and liquid fuel production from coal. Coal contributes to about 77%[2] of the country's primary energy needs; thus energy consumption patterns need to be addressed in order to move towards a sustainable, low-carbon and equitable country. This is a substantial task for a country with an economy dependent on coal for 88% of its electricity generation, an energy-intensive industrial sector, and an energy sector responsible for 83% of total greenhouse gas emissions[3] contributing to South Africa being ranked 15th globally in carbon dioxide emissions production[4].

The country is currently 68% urbanised[5], with much of the growth seen in the emergence of secondary cities and the expansion of metros as people migrate to cities in pursuit of employment and a better way of life. South African cities are not compact; distinguished by low-density sprawl and high levels of poverty, resulting in transport and energy inefficiencies[6].

Since democracy in 1994, South African policy development across all spheres of government has focused on transforming and growing the economy, building a unified society and, above all, reducing poverty and inequality. This led to the development of many pro-poor policies, including the impressive electrification programme, whereby today 87%[7] of the population have access to electricity compared to 36% in 1994, and the building of close to 3 million houses for the poor.

Prior to 1994, climate change response was low on the government's agenda. Today the country has international climate commitments, as well as many national policies and plans focussed on climate change and sustainable energy development. The Long Term Mitigation Scenarios (LTMS), was endorsed by the South African government in 2008, and a Peak, Plateau, Decline (PPD) emissions trajectory was adopted as the country's strategic direction.

National government more recently undertook a Greenhouse Gas Mitigation Potential Analysis for South Africa, building on the LTMS. It indicated that, at a national level, the key sectors for emissions-reduction were the electricity supply and industrial sectors.

South Africa's Nationally Determined Contribution (NDC), under the United Nations Framework Convention on Climate Change, moves from a relative "deviation from business as usual to an absolute peak, plateau and decline greenhouse gas emissions trajectory range". The NDC talks to the developmental needs of the country as well as the need to deal with climate change imperatives. To this end, it has three components: mitigation, adaptation and investment support; anchored in the principles of sustainable development.

While reducing emissions associated with power production is largely outside of the direct control of cities, they do have the opportunity to leverage their influence over national- and regional-level energy supply and demand decisions. This is where the potential for transformation lies.

2 CSIR. 2017. The Future of the Energy System in South Africa. Presentation for the GTAC seminar at National Treasury. Pretoria, 4 August 2017.

3 DEA. 2014. GHG National Inventory Report South Africa 2000-2010.

4 EDGAR. 2017. JRC Science for Policy Report: Fossil CO2 & GHG emissions of all world countries. Includes emissions from fossil fuels and cement production, but excludes emissions from land use, land use change and forestry.

5 Statistics South Africa. 2011. Census 2011.

6 SEA (Reddy, Y., Wolpe, P.). 2014. Tackling Urban Energy Poverty.

7 Statistics SA General Household Survey 2017. Using "electricity use for lighting" as a proxy of access to electricity, regardless of whether the connection is legal or not.

Until recently, very few national policies and frameworks have recognised cities nor identified a role for local government explicitly in lowering national emissions. This is changing, as cities are increasingly recognised both nationally and globally as key implementers. While reducing emissions associated with power production is largely outside of the direct control of cities, they do have the opportunity to leverage their influence over national- and regional-level energy supply and demand decisions. This is where the potential for transformation lies. In fact, many municipalities have developed local-level policies and plans focussing on climate change response and energy, and many have started to collect emissions-related data and are pioneering climate-related projects.

The challenge that remains, however, is alignment across the spheres of government and the implementation and financing of climate-responsive work at scale. Recent developments point to the need for strong multi-level governance to take the initiatives forward. Climate change and sustainable energy are cross-cutting areas; requiring regulatory changes, financial support, strong leadership and capacity development amongst others in order to see the level of transformation that is indicated by this study. The potential illustrated in the study will only be achieved through a co-ordinated and collaborative transformation.

About this study

A modelling exercise was undertaken to provide an overview of the energy consumption and energy-related greenhouse gas emissions, based on 2011/12 data, of urban centres in South Africa, and to determine the extent to which these cities can reduce their emissions and impact the emissions trajectory of the country into the future, based on various energy efficiency and renewable energy interventions.

This model includes data from 27 major urban municipalities across South Africa, including the 8 metros (see "Appendix 2: City profiles" for the list), based on an urban population of 100,000 or greater[8] and data previously available in the State of Energy in South African Cities 2015 report[9].

The model used is the Long-range Energy Alternatives Programme. The results of the first round of modelling was completed in 2016. These results and the detailed methodology can be found in the technical report.

There have been major developments within the past two years. One is the change in renewable energy costs and uptake, and the release of the 2018 update of the Integrated Resource Plan (IRP) (the country's electricity plan), which provides a more substantial role for renewables. Another is the pursuit of ambitious greenhouse gas emissions reduction programmes by some major metros, e.g. the C40 Cities South Africa Buildings Programme, which aims for net zero carbon new buildings by 2030.

Given the changes, the model was rerun with updated assumptions. The results are presented in this report, in two sections: (1) the status quo in 2011, with its related issues; and (2) potential future development paths and proposed responses.

Findings

1. The status quo

1.1 South African cities' emissions intensity is relatively high when compared to the level of economic development

South Africa's emissions intensity (emissions per person or per economic unit) is high in comparison to the world average (Figure 1 and Figure 2). The average emissions intensity per person (7.9) is similar to, or higher than that of some developed nations, such as Denmark (6.5), the U.K. (7.4) and New Zealand (7.7)[10].

8 According to Statistics South Africa 2011 Census data

9 Source: http://www.cityenergy.org.za/uploads/resource_444.pdf

10 Source: World Bank. Only takes into account emissions from fossil fuels and cement manufacture.

This high intensity is as a result of South Africa's energy-intensive and energy inefficient economy, bolstered by cheap (until very recently) and largely coal-fired electricity. The urban centres that form part of this study have a lower emissions intensity, largely due to the fact that most of the energy-intensive industries (mining, smelting, etc.) sit outside of these areas.

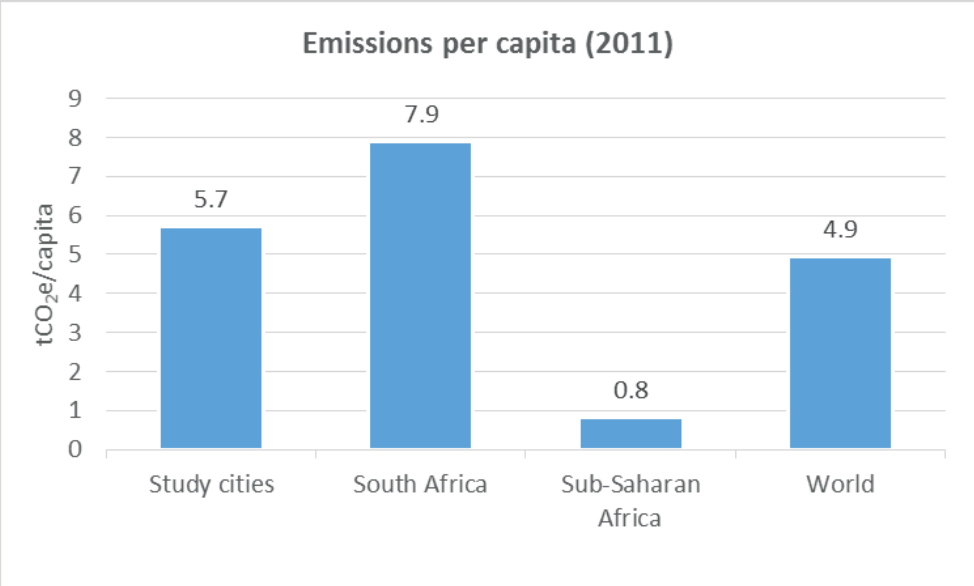


Figure 1: Emissions per capita in study cities vs. South Africa, Sub-Saharan Africa and the world[11]

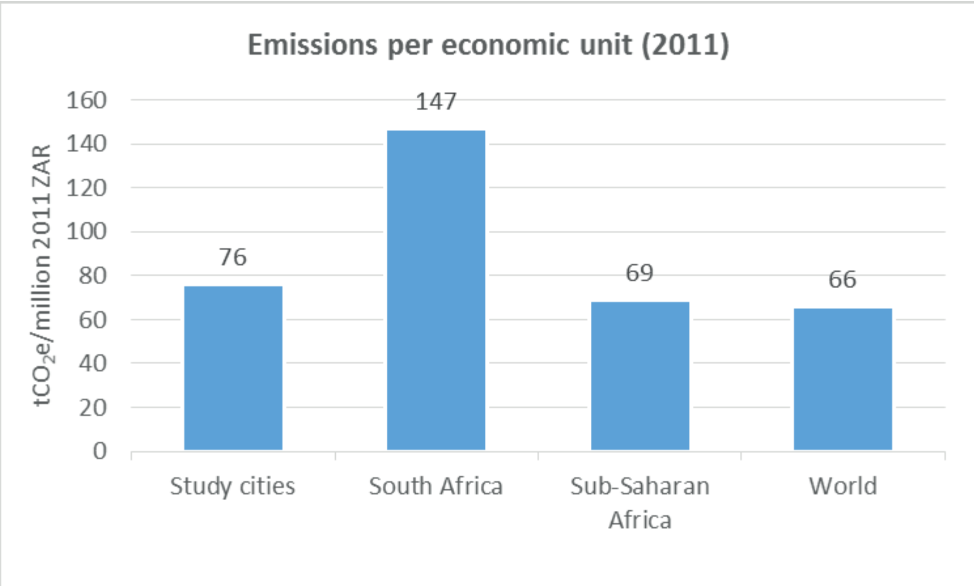


Figure 2: Emissions per economic unit in study cities vs. South Africa, Sub-Saharan Africa and the world[12]

11 SSource of Sub-Saharan African and world figures: World Bank. These include cement manufacture. Source link: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC.

12 Source of Sub-Saharan African and world figures: World Bank. These include cement manufacture. Source link: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC.

1.2 Cities are intense nodes of economic activity, energy consumption and emissions production

The 27 urban municipalities, including the 8 metros, are home to 53% of the population, produce 55% of GDP, account for 40% of national energy consumption and generate 39% of the country's emissions (Figure 3). This highlights cities as the place where the greatest potential for change lies. It is now recognised globally that cities play a crucial role in addressing climate change.

The energy consumption and emissions production is proportionally lower than what one would expect, given the high proportion of GDP and population that falls within these areas, but, as mentioned previously, this is due to the fact that many energy-intensive industries are located outside the boundaries of the study cities.

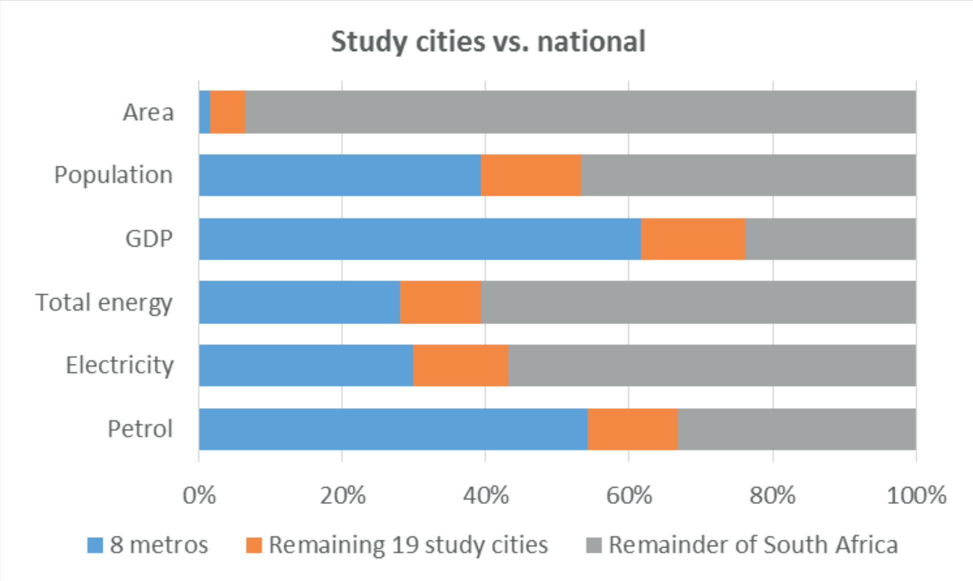
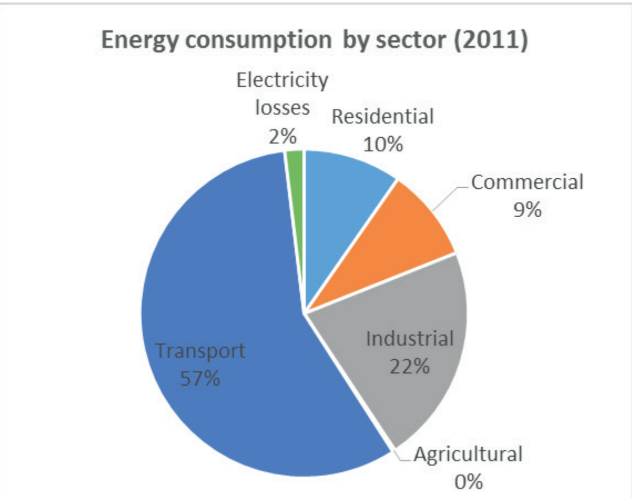


Figure 3: Various indicators of study cities (including metros) as a proportion of national

1.3 The transport sector dominates city-level energy consumption

The majority (57%) of energy consumption in South African urban centres is by the transport sector (Figure 4). This is a reflection of the sprawling nature of South African cities, where people and goods have to be moved across large distances. Urban areas also have a higher proportion of population that own cars (Figure 5) and cars are a particularly energy inefficient means of transport (issue covered more fully in section 1.4).



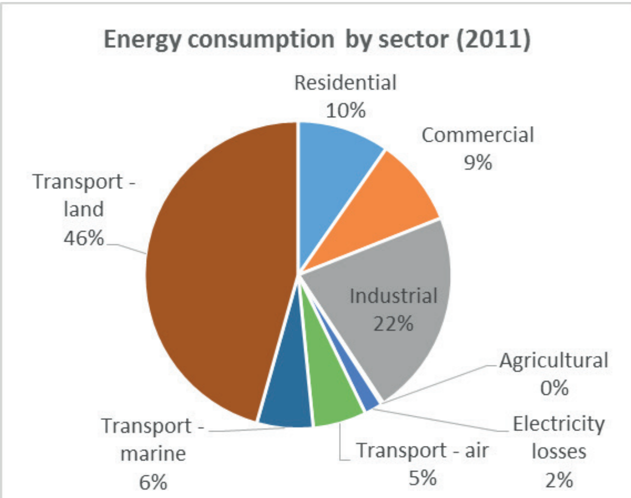


Figure 4: Energy consumption by sector and fuel

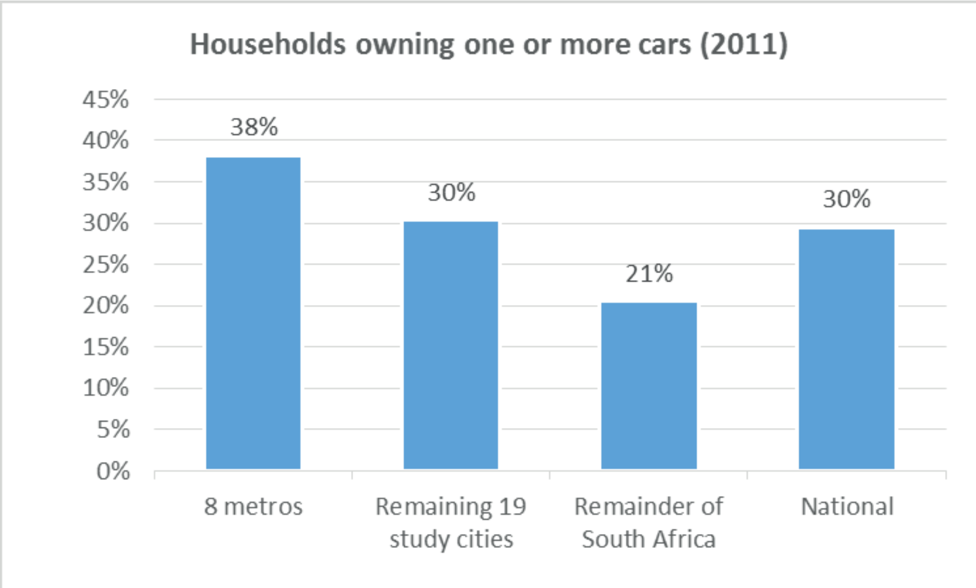


Figure 5: Car ownership

The majority of transport energy is consumed by land-based transport - 46% of total energy consumption (Figure 4). In turn, land-based transport energy consumption is dominated by the passenger transport sector; at 66% of land-based transport (Figure 6) and 30% of total energy consumption.

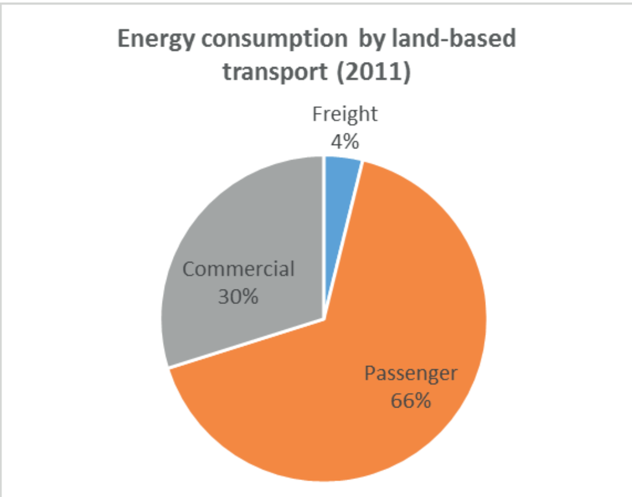


Figure 6: Land-based energy consumption by sub-sector

This picture of a dominant transport sector is not radically different to many of the individual city profiles[13] except in the case of large industrial cities, where the industrial sector accounts for the majority of the energy consumed.

13 State of Energy in South African Cities 2015, SEA

1.4 The passenger transport system is very inefficient and unequal

Within passenger transport, the vast majority of energy is consumed by cars, despite the fact that most people travel either by public transport or on foot (Figure 7) and most households do not even own a car (Figure 9).

The disproportionate use of energy by cars is as a result of the incredibly inefficient use of energy by largely single-occupancy cars when compared to public transport modes (Figure 8). It also highlights the inequality of energy consumption and public space use (roads are classified as public space), considering that the majority of energy consumed and road-space used is by cars; almost exclusively used by higher-income households.

Another aspect of transport inequality within South African cities, is that the poor are generally located on cheap land on the city margins, in dormitory towns far away from work opportunities. This adds a great transport cost burden onto these households.

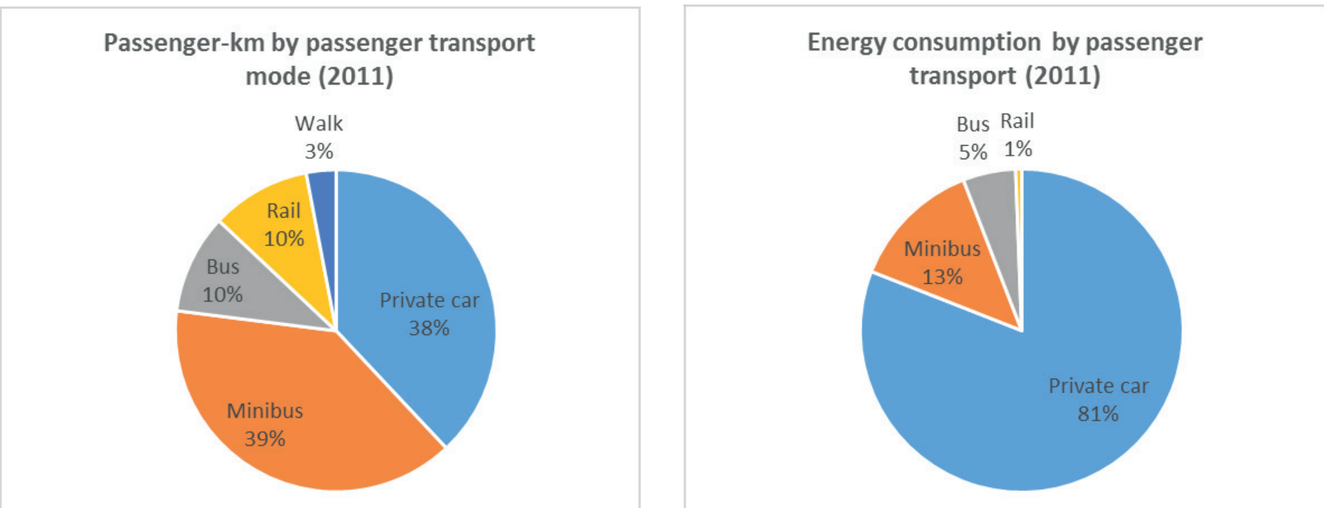


Figure 7: Passenger-km and energy consumption by passenger transport mode

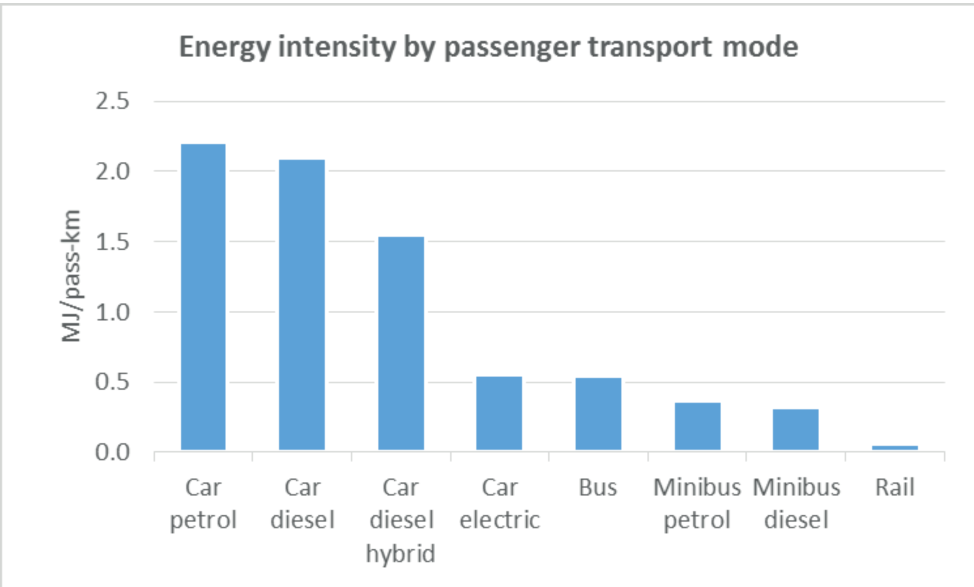


Figure 8: Passenger transport mode energy intensities

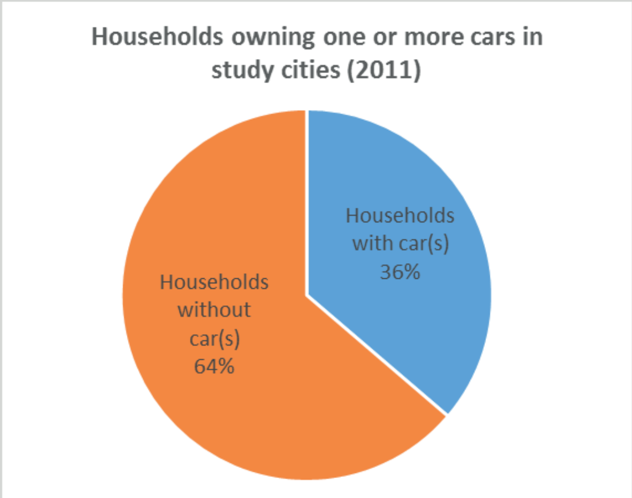
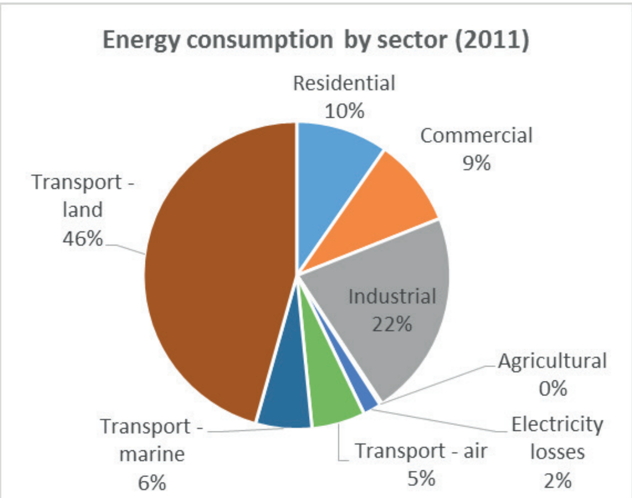


Figure 9: Household car ownership in study cities

1.5 South Africa's electricity is incredibly emissions intensive, with electricity as the largest contributor towards city emissions

While the majority of energy is consumed by the transport sector, the majority of energy-related emissions is produced by the industrial sector (Figure 10). This is because the industrial sector relies on fuels that produce a very high amount of emissions per unit energy; namely coal and electricity - which is largely produced from coal-fired power stations. In comparison, diesel and petrol (largely used by the transport sector) do not produce as much emissions per unit energy.

Despite substantially higher energy use, the transport sector contributes proportionally less to emissions than the built environment – the residential, commercial and industrial sectors (Figure 10). This is due to the fact that electricity (mostly used by the built environment) is largely generated by coal-fired power stations, an inefficient process that results in electricity having much higher emissions per unit energy when compared with liquid fuels, such as diesel and petrol, which are mostly used by the transport sector (Figure 11).



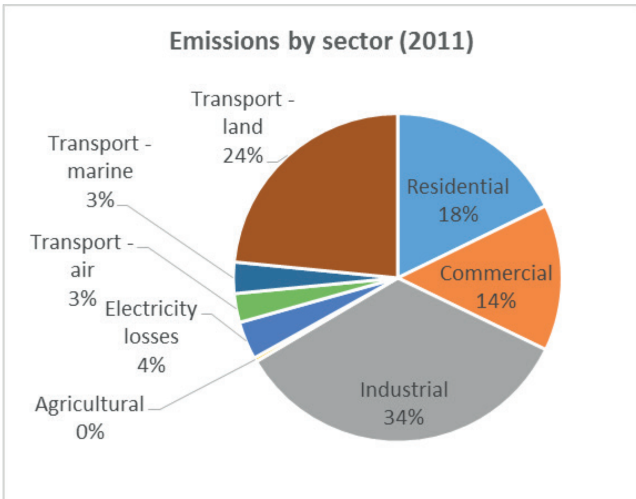


Figure 10: Energy consumption and emission production by sector

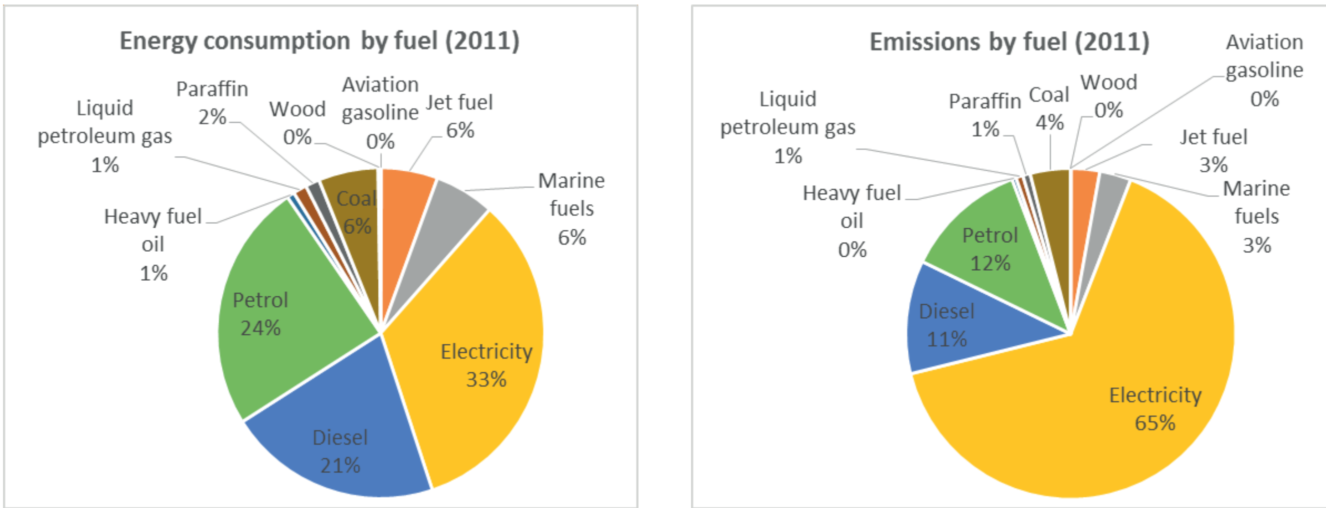


Figure 11: Energy consumption and emissions by fuel

Most cities show a similar consumption and emissions by fuel result as the average shown, except – again – industrial cities; where electricity use is even more dominant than liquid fuel (e.g. petrol and diesel) use, because heavy industry largely consumes electricity and coal, rather than liquid fuels such as petrol and diesel.

1.6 Energy consumption is very unequal within cities – the poor consume too little and the rich too much

Mid- to high-income households, while representing slightly less than half of all households, consumes two-thirds of all household energy. Conversely, low-income households – slightly more than half of all households – consume only a third of household energy (Figure 12). This inequality highlights a dual problem: inefficient overconsumption among higher-income households, and under-consumption among the low-income households as a result of affordability or lack of access.

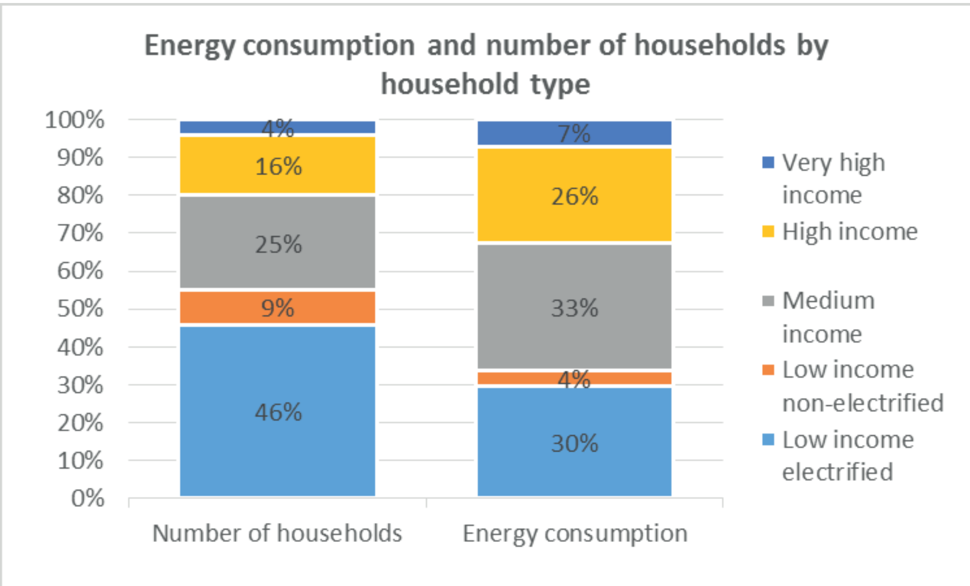


Figure 12: Energy consumption and household numbers by household income and electrification status

Photo: Mark Lewis

2. The future

2.1 The growth of energy consumption and emissions production into the future is very sensitive to economic growth projections

A strong driver of energy consumption growth is that of economic growth. The original energy and emissions model, completed in 2016, was based on a more rosy economic growth outlook. The 2018 update adjusted growth rates downwards based on more recent economic growth trends. The impact was large. The initial model showed energy demand more than tripling (Figure 13), while in the latest update energy consumption did not double (Figure 14).

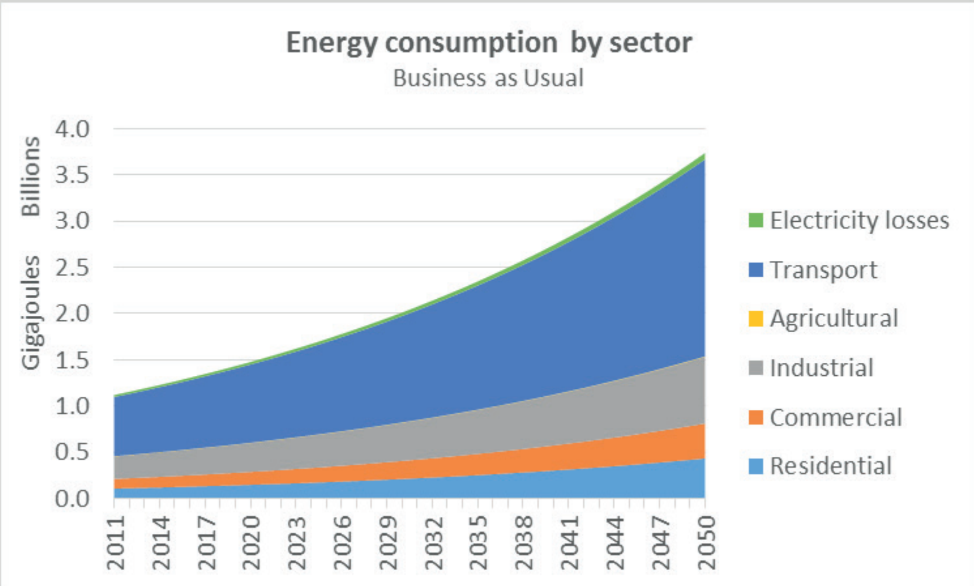


Figure 13: Energy consumption by sector in a Business as Usual scenario (high growth)

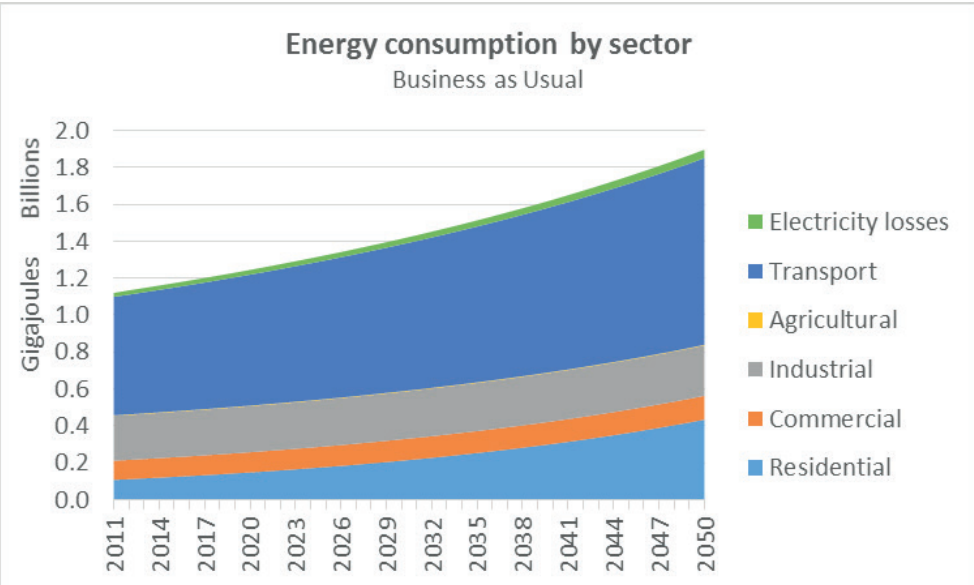


Figure 14: Energy consumption by sector in a Business as Usual scenario (low growth)

It must be noted that there has been a recent decoupling between electricity consumption growth and economic growth, i.e. the growth in electricity consumption is lower than expected, even with the lower economic growth. Possible reasons include suppressed demand, increased efficiency, fuel switching and the uptake of rooftop PV, all in response to rapidly-increasing electricity prices.

2.2 Proceeding along a business as usual scenario carries significant socio-economic risks

A future reliant on the costly energy-intensive use of fossil fuels is untenable from a socio-economic perspective. Reliance on finite and in some cases imported fossil fuels increases the risk of rapidly-escalating costs and price shocks. South Africa recently experienced its single-largest liquid fuel price hike in history.

The use of fossil fuels comes at a high health and economic cost. For example, at a household level, paraffin use for cooking results in death and property loss from poisoning (accidental consumption by children) and fires. At a provincial level, Mpumalanga is a global pollution hotspot, with the Witbank area having the world's dirtiest air[14] thanks to the high number of large coal-fired power stations in the vicinity.

The impact of extreme events (wildfires, droughts, floods) is severe and their frequency will only increase if climate change mitigation through emissions-reduction actions are not undertaken. A business as usual scenario will mean that the country does not achieve its international emission-reduction targets.

In fact, a "business as usual" scenario has become so unpalatable that much of the market, as well as government, is already responding (see section 2.3 below).

2.3 A low-carbon scenario, based on energy efficiency and renewable energy, is cheaper and results in a more competitive economy

"Business as usual" is already shifting to "business unusual". In the previous model, "business as usual" still meant an electricity mix heavily reliant on fossil fuels such as coal, based on the 2011 version of the IRP. This, alongside a stronger economy, resulted in rapid emissions growth over time (Figure 15).

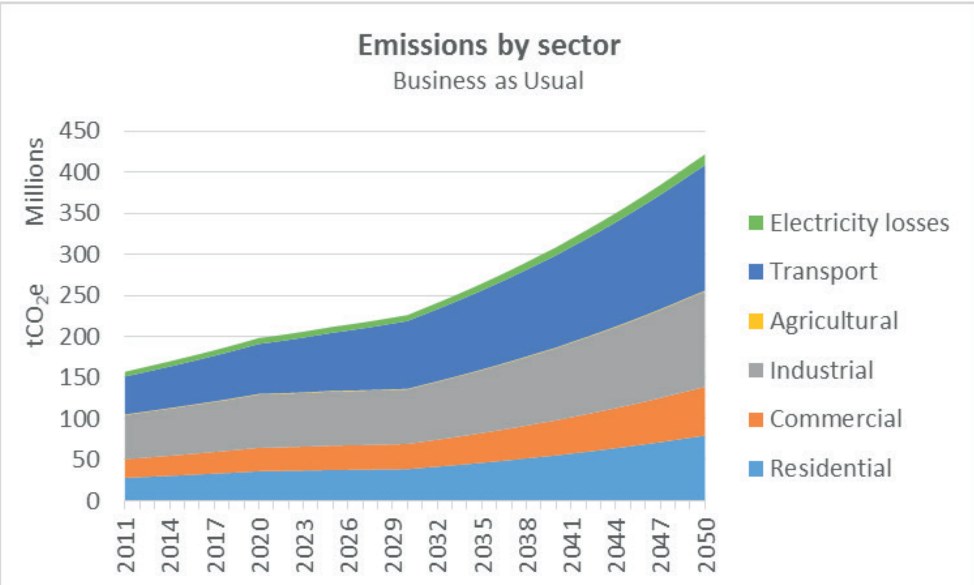


Figure 15: Emissions production by sector in previous Business as Usual scenario

The latest version of "business as usual" includes the least-cost scenario[15] contained in the recently-released draft IRP 2018. This presents a large break from previous plans: renewables, not fossil fuels, are now the lowest-cost and dominant new-build option (Figure 16). Building this supply mix into the model results in ***decreasing*** emissions over time (Figure 17), despite increasing energy consumption (Figure 14).

14 Fourth annual "Brown to Green Report", ERC, UCT

15 It must be noted that this scenario was not the preferred option and that the preferred one included already-contracted power such as that from Inga and the coal IPPs. Given the financially dire situation of Eskom, the lowest-cost option was chosen for this modelling exercises.

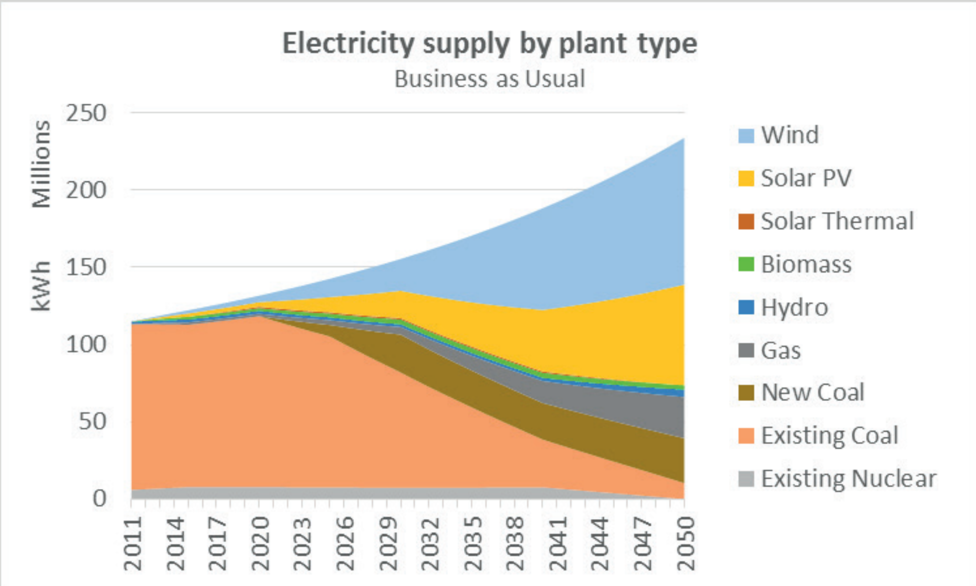


Figure 16: Electricity supply using least-cost scenario in draft IRP 2018

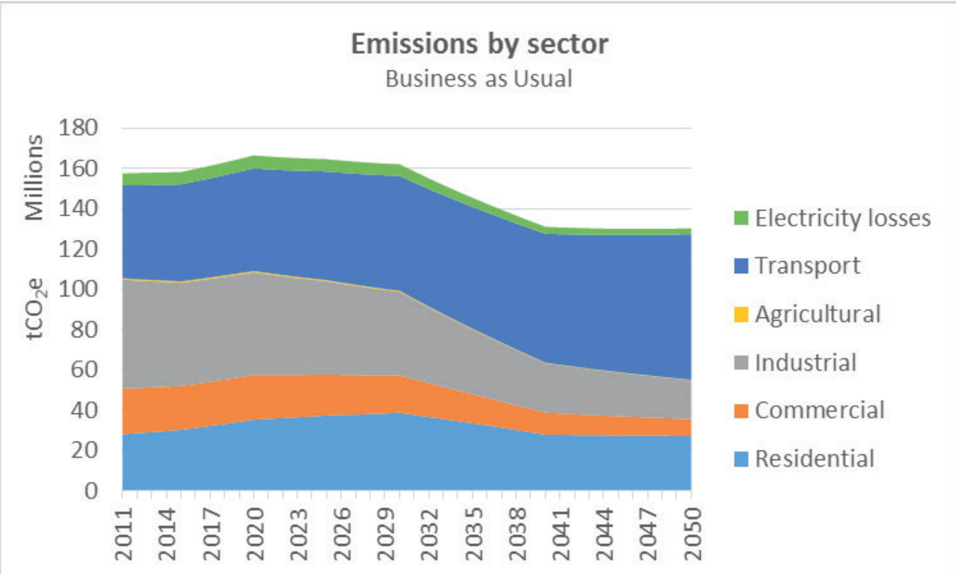


Figure 17: Emissions production by sector in new Business as Usual scenario

The above indicates that the transformation is already underway, with momentum in the electricity sector. This mirrors the international situation, where renewable energy is rapidly overtaking conventional options (coal, diesel, nuclear, etc.) as the cheapest source of new power generation. It is estimated that by as early as 2020, renewables will be cost competitive or cheaper than fossil fuel across most of the world[16]. Renewables already account for a quarter of global electricity generation[17]. In 2017, the largest contributor to new global generating capacity was PV, with some power purchase agreements at record-low prices equivalent to 30 c/kWh[18].

It is far cheaper to save energy than to generate new energy, no matter how cheap that new energy is. Hence energy efficiency across all sectors is a key intervention not only in reducing emissions (if the energy used is fossil-based), but also in increasing economic competitiveness. Efficiency across all sectors decreases greenhouse gas emissions by a further 33% from the already-reduced "business as usual" by 2050 (Figure 18).

16 IRENA's 2017 Renewable Power Generation Costs Analysis

17 IEA, 2017. Of this, 65% is hydro and 35% from remaining renewables (solar, wind, geothermal, etc.).

18 Trends in Photovoltaic Applications, 23rd edition, IEA PVPS. Cost of $0.02/kWh at R15/USD.

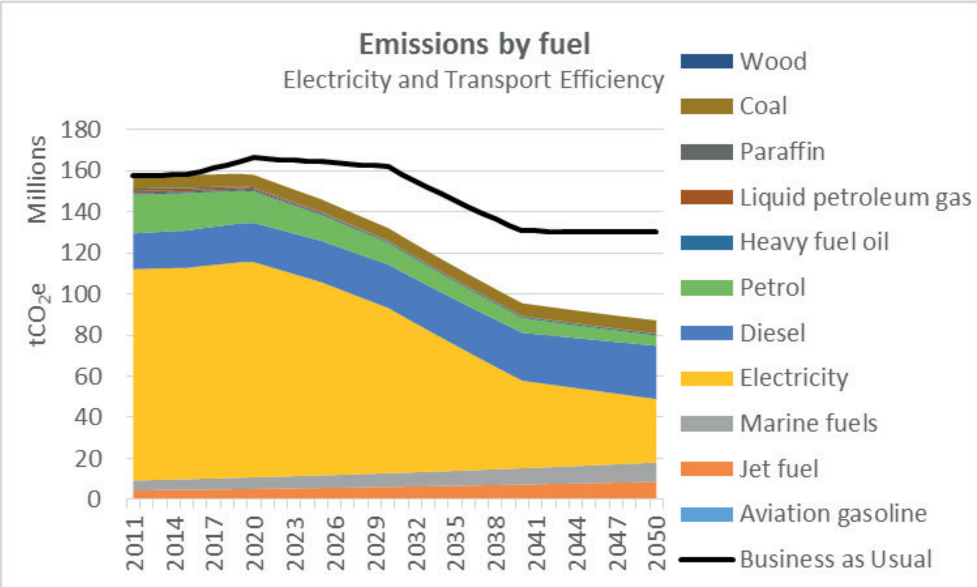


Figure 18: Emissions reduction from electricity and transport efficiency interventions[19]

In recognition of the imperative need to respond to climate change, four major metros (Cape Town, eThekwini, Johannesburg and Tshwane) are already aiming for a goal of net zero carbon new buildings – all buildings; not just municipal-owned/rented – by 2030 and a net zero carbon goal for their entire city, across all sectors, by 2050[20].

An aggressive low-carbon and efficient scenario may seem daunting to implement, but government does not need to hold sole responsibility, though it does have a strong regulatory and awareness-raising role. Partnerships and citizen responsibility can and is driving response. For example, large property owners and retail giants such as Growthpoint, Woolworths, Virgin Active, etc., already have resource use reduction, sustainability and renewable energy targets. Internationally, corporates across 75 countries sourced 465 TWh of renewable energy in 2017[21]. This equates to double the electricity distributed in South Africa during the same year[22]. This shift is not necessarily always caused by policy, but simply due to the economics of an efficient and renewable path.

The low-carbon intervention modelled in the 2018 model is contained within Appendix 1: Scenario interventions.

19 Also includes an increase in access to electricity for households.

20 Through the C40 Green Buildings Programme South Africa and the C40 Climate Action Planning Programme, in support of Deadline 2020.

21 IRENA: https://www.esi-africa.com/irena-renewables-are-the-key-to-a-climate-safe-world/

22 Statistics South Africa

2.4 Significantly improved public transport is essential to a sustainable city

The sector with the largest energy-savings potential is the transport sector (Figure 19), with the single-largest impact intervention being a shift from private to public transport. Yet this is possibly one of the most difficult interventions to implement.

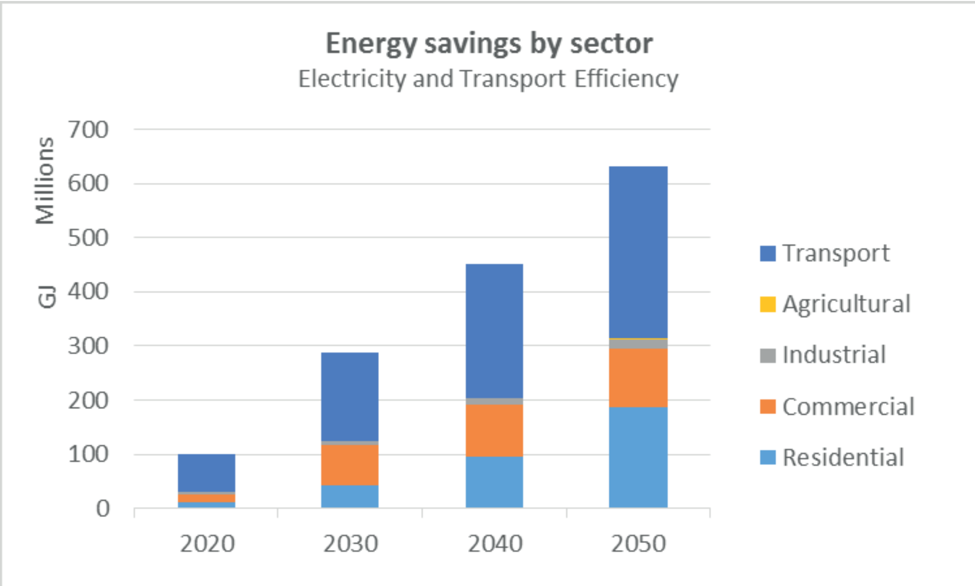


Figure 19: Energy savings potential by sector

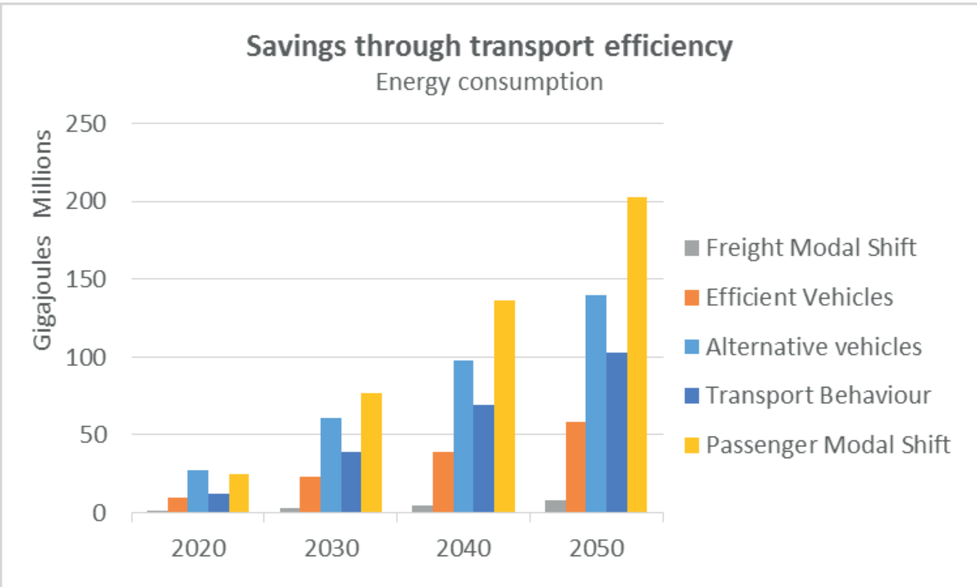


Figure 20: Energy savings from various transport interventions

Public transport infrastructure costs, such as those linked with Bus Rapid Transit systems, are high. It can be argued that the costs of private transport are even higher, when taking into account, for example, the cost of setting aside huge amounts of space for parking, but this cost is often borne by the private sector or by society as a whole, while public transport costs are borne by the public sector.

Denser and mixed-use cities that are concentrated around transport corridors can decrease the need for travel in the first place (by decreasing travel distances) and increase the financial viability of public transport. This will require a strong focus on urban planning; including zoning restrictions to enforce the urban edge (to prevent urban sprawl), policies such as densification or tall buildings policies, and engagement with developers. Urban planning costs are not high, but indications are that political interference is high when it comes to large-scale developments[23].

2.5 New technology options and low-carbon responses will be disruptive

Renewables (large-scale and small-scale embedded) as well as electric vehicles (EVs) will be disruptive to the current electricity business model and the economy, but both technologies inevitable as these technology costs fall. The policy and regulatory environment will need to change to keep up with on-the-ground changes and manage the transition.

Renewables

Supply-side options modelled included additional local generation of 6000 MW of wind and 5000 MW of large-scale solar PV by 2050, as well as a substantial amount of rooftop PV – just short of 20,000 MW by 2050 (Figure 21). This drove down greenhouse emissions to 43% below the already-lower "business as usual" (Figure 22).

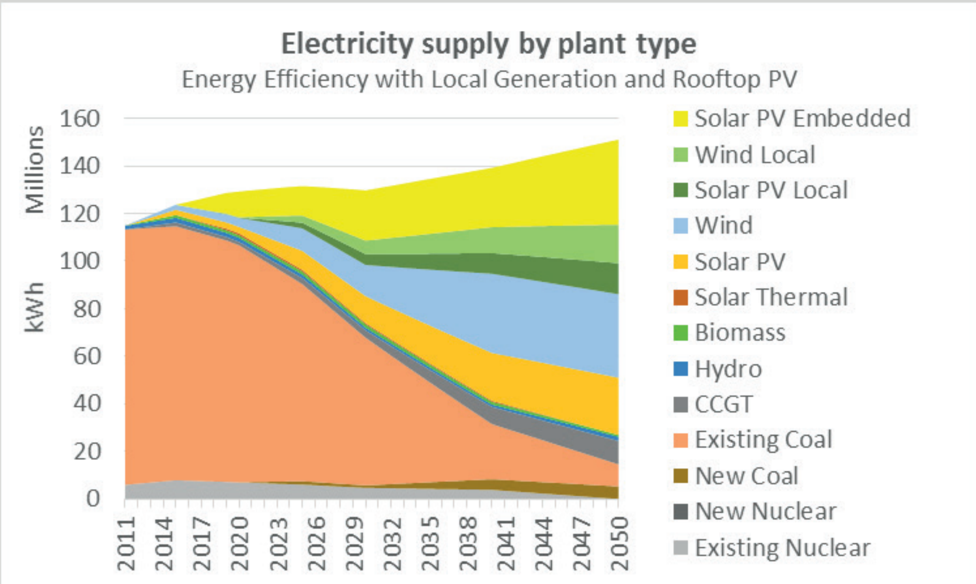


Figure 21: Electricity supply with local generation and rooftop PV

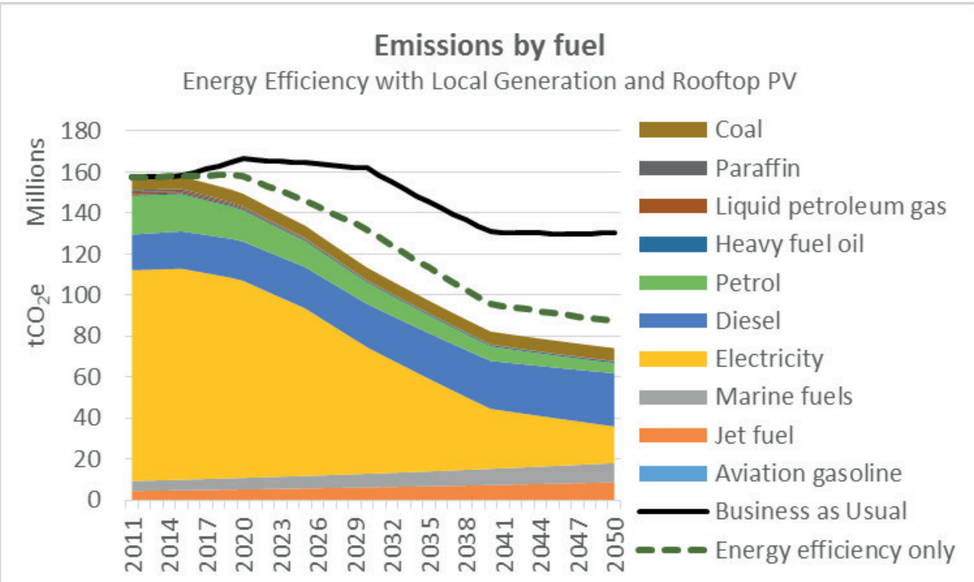


Figure 22: Emissions by fuel for an efficient scenario with local generation and rooftop PV

23 Feedback at numerous local-government-level workshops on integrating climate change into Integrated Development Plans.

Large-scale renewables

Concerns around a largely-renewable electricity supply mix have centred on power availability and balancing of the grid. Grid digitalisation will assist in rapid real-time assessments and responses, but this will require an upgrade of the grid infrastructure and a focus in cities on grid management skills. In the short to medium term, gas will facilitate the uptake of renewables, as it can be ramped up quickly in response to rapid changes in renewable power availability. In the longer term, battery-powered storage could provide a solution, as battery costs – similar to those of renewables – are decreasing.

The current role of cities with regards to electricity supply is that of distributor. A single-buyer Cabinet decision taken in 2009 prohibits cities from buying electricity from Independent Power Producers (IPPs), and cities require a Ministerial Determination in order to generate electricity. This means that cities are a "taker" of the national mix.

This regulatory environment is restrictive for cities who wish to implement a more aggressive emissions-reduction path than what is contained in the national electricity mix or who wish to buy cheaper electricity from IPPs in the face of ever-increasing Eskom electricity prices.

Some cities have taken the approach of enabling and encouraging the roll-out of renewables, as it is seen to provide local economic opportunities (manufacturing and installation jobs). Wheeling frameworks are in development[24], which will allow private generators to transport their electricity to customers across the city's grid for a fee. Other cities may feel that this is not enough and that a city should have the right to procure an optimal supply. The single-buyer status quo is currently being challenged in court.

Rooftop photovoltaic (PV)

Small-scale rooftop PV is rapidly reaching price tipping points. The return on investment in the commercial sector is high, with paybacks as low as 2 to 4 years, depending on local tariffs. This has resulted in exponential up-take (Figure 23). The estimated installed capacity on retail rooftops nationally in 2018 is between 600 and 700 MW[25], with the largest single systems of its kind in the Southern hemisphere on the Mall of Africa, at just short of 5 MW – the same size as South Africa's first commercial wind farm in Darling.

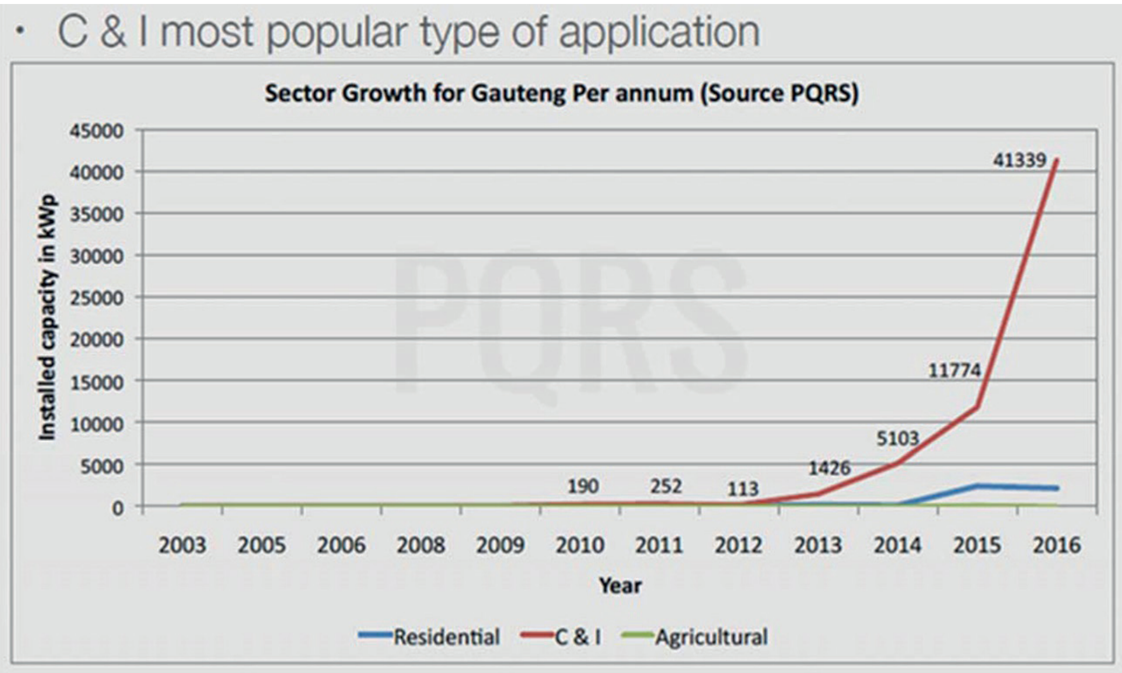


Figure 23: Rooftop PV installations in Gauteng (C & I = Commercial and Industrial)

24 Nelson Mandela Bay have completed their wheeling framework.

25 https://pqrs.co.za/data/apr-2017-shopping-centers-rooftop-and-pv-sales/

Cape Town, eThekwini, Johannesburg and Tshwane's goal of net zero carbon new buildings from 2030 onwards, has the potential to drive rooftop PV installation even faster than the current rate. It is also only a matter of time before a price tipping point is reached in the residential sector.

Municipalities are heavily reliant on electricity sales revenue to cross-subsidise services such as water provision and waste removal, as well as to cross-subsidise electricity infrastructure maintenance in low-income areas (national grants cover free basic electricity and the capital cost of the electricity connection). Municipal electricity tariff structures as well as overall business plans will need to be reviewed, given the decrease in electricity sales to high-use customers who install rooftop PV.

Many cities have implemented approved small-scale embedded generation tariffs to accommodate rooftop PV. These tariffs generally consist of a fixed monthly demand charge to maintain revenue for grid maintenance, a charge per unit electricity sold to the customer, and a feed-in tariff paid to the customer for electricity fed back into the grid.

The tariffs need to strike a balance between protecting city revenue and keeping rooftop PV payback low enough for customers. If the tariffs are not appealing to customers, the worst-case scenario of illegal rooftop PV connections will proliferate, where customers feed electricity back at the exact cost they pay for it – this will have the highest negative revenue impact on a city[26]. This illustrated that policy and an enabling regulatory framework need to keep up with developments on the ground. Trying to block this new technology will have the worst financial results.

Rooftop PV may offer opportunities for innovative service provision. Some cities, such as Johannesburg, are considering including rooftop PV as part of an energy services package – including grid electricity and gas – for the poor.

Electric vehicles

A modelled penetration rate of 50% EVs and 15% hybrid vehicles by 2050, as a proportion of all car passenger-kilometres travelled, increased overall city electricity consumption against business as usual by 6%, but decreased combined petrol and diesel consumption by 21%, resulting in an overall energy consumption reduction of 9% (Figure 24). This is because electric vehicles use less energy per kilometre when compared to conventional internal combustion engines (Figure 25).

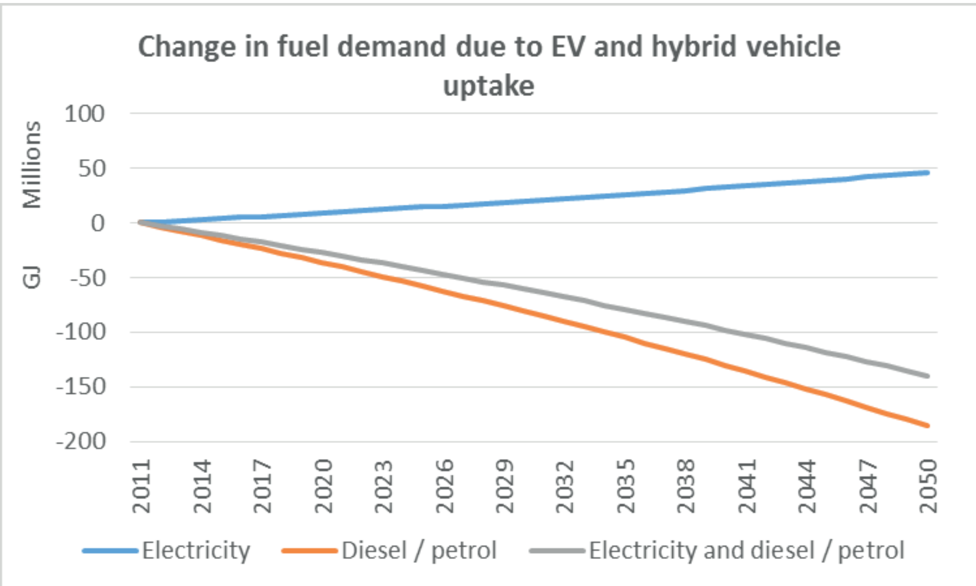


Figure 24: Impact of EV and hybrid vehicle scenario on electricity, petrol and diesel demand

26 Impact of Small Scale Solar PV Embedded Generation (SSEG) on Tshwane's revenue, SEA 2017. Link: http://www.cityenergy.org.za/uploads/resource_431.pdf

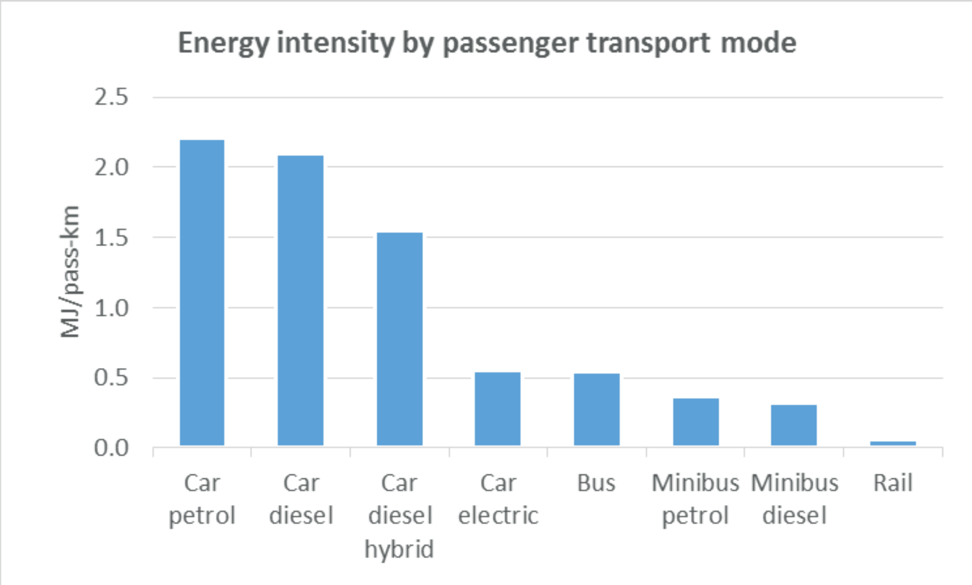


Figure 25: Energy intensity by passenger transport mode

EV technology and costs are changing rapidly. As a result, global growth has been strong, with sales increasing at an annual rate of 52% over the past five years[27]. Multiple countries have set deadlines for the banning of conventional internal combustion engine vehicles (Norway by 2025; Germany by 2030; Scotland by 2032; England and France by 2040).

Corporates are responding too. Volkswagen announced that it will discontinue internal combustion engine car manufacture (including hybrids) by 2026, focusing on plug-in electric vehicles only. Volvo announced that its entire line-up will be electrified (plug-in or hybrid) from 2019 onwards.

As noted in Figure 24, EVs will change energy consumption patterns. In 2015, petrol and diesel passenger cars consumed rough 300 and 38 PJ of energy respectively. If these vehicles were all switched to electric, it would amount to an electricity demand equivalent to 28 TWh – roughly 11% of what Eskom sends out[28]. This presents a potential revenue opportunity to cities. Liquid fuel consumption will drop dramatically, which will impact the local coal-to-liquids industry, but will also decrease reliance on fuel imports.

Cities, as well as national government, need to be proactive in responding to EVs. The grid needs to be decarbonised to avoid an emissions increase, because emissions produced by vehicles could increase when shifting from petrol and diesel to the current emissions-intensive electricity.

Cities will need to include EVs within their planning, regulatory and policy framework. Consideration should be given to charging tariffs, charging infrastructure, the management of impacts on the grid, smart metering and smart grids, registration and tracking, green energy and communications. Tariff-setting will be critical, as tariffs need to consider the cost of electricity supply, avoid being a subsidy for the rich, potentially contribute towards revenue, and offer a margin for private returns (for commercial charging stations), among others.

Transition management

The South African automotive industry contributed 7.2% to national GDP in 2015[29], which means that EVs have the potential for large disruptive impacts on jobs, companies and entire industry clusters.

A switch from a coal-dominant electricity supply mix to that of renewables will also impact whole industries. While indications are that the overall number of jobs will increase[30], the location and types of jobs will change, e.g. from coal mining in a rural area to rooftop PV installation in an urban area.

Detailed consideration needs to be given to the management of the transition towards a low-carbon economy.

27 IRENA. Link: https://www.esi-africa.com/irena-renewables-are-the-key-to-a-climate-safe-world/

28 Adrian Stone, SEA

29 https://city-press.news24.com/Business/r2567-billion-the-vehicle-industrys-massive-gdp-contribution-20170310

30 CSIR comment on draft IRP 2018

2.6 Policy interventions can keep urban centres within the Peak, Plateau, Decline emissions trajectory

The Peak, Plateau, Decline (PPD) emissions trajectory, which sets the national emissions-reduction commitments as contained in the Nationally Determined Contribution, was scaled down proportionally to the study cities.

In the 2016 model, despite energy efficiency and renewable energy interventions, the low-carbon pathway exceeded the maximum bounds of PPD after 2036, but did lower emissions in 2050 by 38% compared to a business as usual scenario (Figure 27).

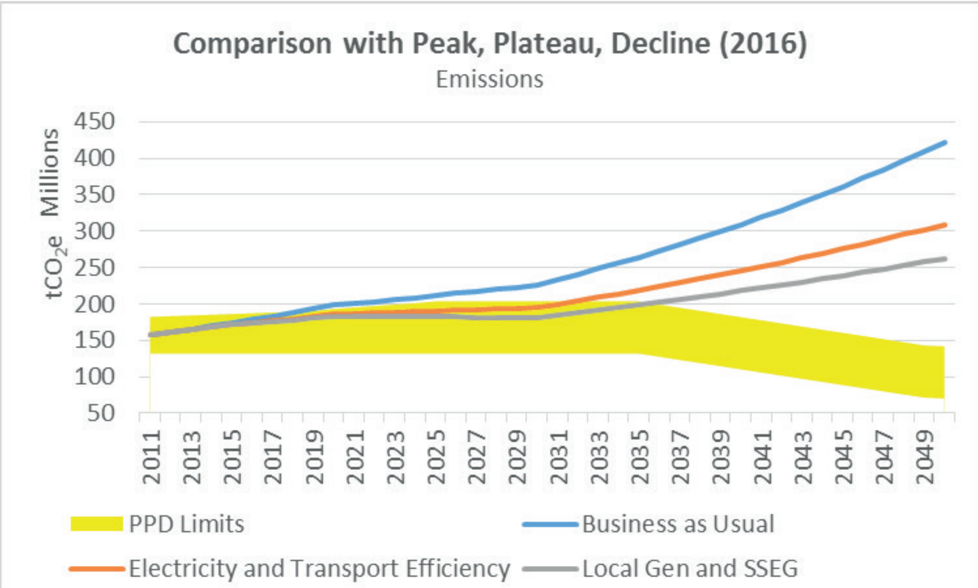


Figure 27: Scenarios versus Peak, Plateau, Decline limits (2011-2050) in 2016 model

In the 2018 model update, the picture is substantially different. A business as usual scenario that includes a least-cost national electricity supply mix as contained in the 2018 draft IRP (though not the recommended plan) remains below the PPD upper limit.

Energy efficiency measures across all sectors drops the emissions level considerably, while increased local-level renewable generation (large-scale or small-scale embedded generation) reduces emissions to the lower limit of PPD (Figure 28). Thus, overall emissions reduction by 2050 is 43% when compared to the 2018 model business as usual scenario, but a total of 82% when compared to the 2016 business as usual scenario.

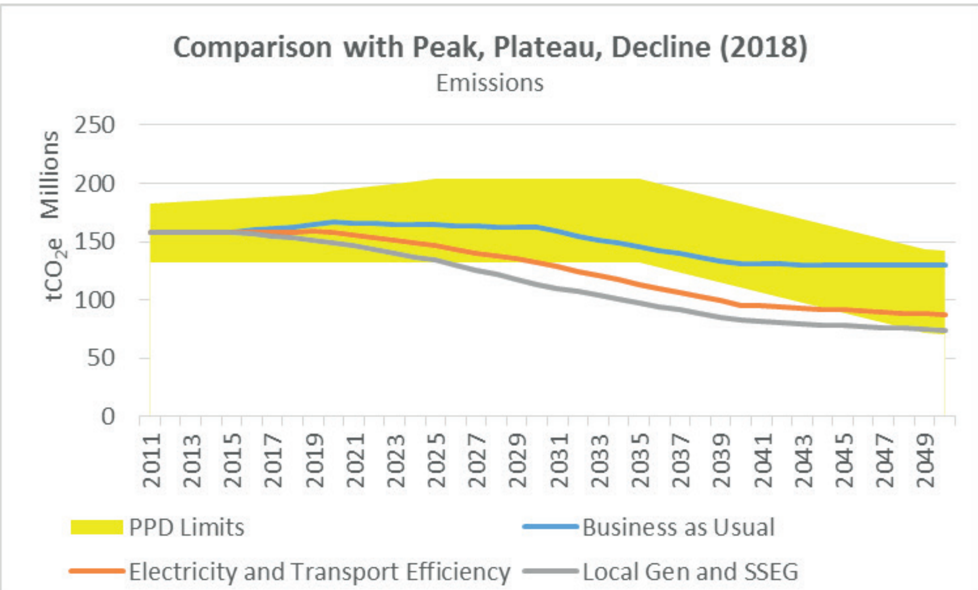


Figure 28: Scenarios versus Peak, Plateau, Decline limits (2011-2050) in 2018 model

Conclusion

It is clear that cities hold substantial power and opportunity to transform the energy profile of the country. Indeed the national trajectory cannot be transformed without transforming our cities. Cities are undertaking a variety of promising work that is slowly changing the local energy and carbon emissions profile. In many cases, cities have moved beyond pilot implementation and are mainstreaming more sustainable practices. While there are many promising initiatives towards a sustainable low-carbon development path, significant systemic changes within and amongst all three spheres of government need to take place in order to realise our energy-related welfare, carbon and economic sustainability objectives. In part, the problem lies in the fact that there is much disconnection between departments and spheres of government, hampering implementation. A multi-level climate governance approach can bring about greater alignment and co-ordination of climate action across government spheres, sectors and stakeholders.

Current trends in all metros indicate a substantial change in electricity sales, with sales either flat-lining or decreasing over the past decade[31]. Indications are that this decrease is a result of energy efficiency, behaviour change or fuel switching, in particular in the residential sector[32] and most likely in response to rapidly-escalating prices. In contrast, transport fuel use has escalated rapidly[33]. Yet, rapid changes in EV and battery technology and costs could herald potential rapid disruptions to this sector, much as the changes in renewable technology costs have caused disruptions in the electricity sector. The transition to a low-carbon economy will need to be managed carefully. This will entail a commitment to multi-level governance, alignment of policies and adaptation of the regulatory and financial environment. In other words, co-ordination and consistency are fundamental to effective climate action.

31 Eberhard, R. (2015). Briefing Paper 1: Understanding Electricity Demand Patterns in South Africa's cities. Draft, 4 December 2015.

32 Electricity sales by customer type in Cape Town and eThekwini showed that the largest proportional decrease in electricity sales per customer occurred in high-income residential customers.

33 SEA (2015). State of Energy in South African Cities 2015

Photo: Bruce Sutherland

Photo: Bablu Virinder-Singh

Appendices

Appendix 1: Scenario interventions

Table 1: List of demand-side interventions

Sector	Interventions
Residential	**Electrification:** All households electrified by 2050 **Efficient lighting:** All lighting either CFL or LED by 2050. Rollout faster in higher-income households. **Efficient refrigeration:** 100% of fridges efficient by 2025 in very high income households, by 2030 in high-income households, by 2040 in mid-income households, by 2050 in low-income households **Cleaner fuels:** Use of harmful fuels such as paraffin and coal phased out by 2050. **Efficient water heating:** Roll-out of solar water heaters (90% in very high and high-income households by 2050, 70% in mid-income, 50% in low-income).
Commercial	**Existing office buildings:** Energy consumption decreases from 250 kWh/m2 in 2011 to 50 kWh/m2 in 2050. **Existing retail buildings:** Energy consumption decreases from 300 kWh/m2 in 2011 to 60 kWh/m2 in 2050. **New office buildings:** Energy consumption decreases from 210 kWh/m2 in 2012 to 24 kWh/m2 in 2050. **New retail buildings:** Energy consumption decreases from 250 kWh/m2 in 2012 to 32 kWh/m2 in 2050.
Industrial	**Efficient lighting:** All lighting efficient (either LED or efficient fluorescent) by 2025. All lighting LED by 2050. **Motors, pumps, fans, HVAC, mechanical equipment, refrigeration, etc.:** All other systems efficient by 2050 (long lead-in time, as assume only replaced as old systems breaks).
Agricultural	**Efficient lighting:** All lighting efficient (either LED or efficient fluorescent) by 2025. All lighting LED by 2050. **Pumps / irrigation, HVAC, fans:** All efficient by 2050.
Transport	**Freight modal shift:** Shift from road to rail (from 11% rail in 2011 to 40% rail by 2050). **Passenger modal shift:** Shift from private to public (conventional bus, BRT, rail, minibus) and NMT. Modal split remains static between 2011 and 2015, after which there's a 10% decrease in pass-km by private vehicles by 2030, decreasing at same rate thereafter (private pass-km reduces from 38% in 2015 to 28% in 2030, to 15% by 2050). Implicit in this scenario is the mixed-use densification of urban centres in order to increase the viability of transport. This is modelled by proxy through the increase in the use of higher-occupancy buses. **Efficient conventional vehicles:** All conventional vehicles (diesel, petrol) efficient (reduction by 10% in energy consumption per passenger-km) by 2050. **Alternative vehicles:** 15% of all private (car) passenger-km by hybrid vehicles by 2050, 50% by electric. **Transport behaviour:** Increased occupancy in cars (from 1.4 in 2011 to 2.0 in 2050). **Denser city:** Mixed-use densification increases viability of public transport. Modelled by increasing bus occupancy (higher ridership).

Table 2: List of supply-side interventions

Scenario	Interventions
Local Generation	6000 MW of large-scale wind and 5000 MW of large-scale solar PV locally generated / purchased by municipalities, i.e. not supplied by national grid.
Solar PV (SSEG)	**Residential sector:** 70% of high- and very-high-income households have installed 2kW rooftop PV systems. **Commercial sector:** In new buildings, 100% of energy requirements met by distributed renewables from 2030 onwards. In existing buildings, 100% of energy requirements met by distributed renewables by 2050. Distributed renewables is costed the same as rooftop PV (though most buildings will source off-site due to limited roof space). These ambitions are in line with those of the four metros (Cape Town, eThekwini, Johannesburg and Tshwane) taking part in the C40 Green Buildings Programme South Africa. **Industrial and agricultural sectors:** 20% of electricity requirements are met by distributed renewables by 2050.
Local Gen and SSEG	Combination of Local Generation scenario and Solar PV (SSEG) scenario, i.e. large-scale local renewables as well as rooftop PV.

Appendix 2: City profiles

#	Province	Municipality	Type	Population (2011)	Economy
1	Eastern Cape	Buffalo City	Metro	755,200	Large vehicle assembly plant located next to port of East London, producing vehicles for export.
2	Eastern Cape	King Sabata Dalindyebo	Other	451,710	Contains Mthatha K. D. Matanzima Airport. Economy in decline since 1994 (professionals moving to other areas). Economy dominated by community services - deduce that local government is the largest employer.
3	Eastern Cape	Nelson Mandela Bay	Metro	1,152,115	Major towns: Port Elizabeth, Uitenhage and Despatch. Major port. Vehicle assembly plants and automotive companies: General Motors, Ford, Continental Tyres. Volkswagen: largest car factory in Africa. Industries geared towards motor vehicle industry, e.g. catalytic converters, batteries, etc. Tourism. P. E. International Airport is 4^{th} busiest in South Africa. Harbours: Algoa Bay and Coega.
4	Free State	Mangaung	Metro	747,431	Much of economy based on canned fruit, glass products, furniture, plastics, and railway engineering. Large economic growth in mid-20^{th} century due to Free State goldfields 160km North-East of city.
5	Free State	Matjhabeng	Other	406,461	Main town is Welkom; second-largest city in Free State. Economy centres on mining of gold and uranium. Hub of Free State Goldfields. Significant coal reserves.
6	Gauteng	City of Johannesburg	Metro	4,434,827	One of world's leading financial centres. Heavy industries include steel and cement plants. City Deep is world's largest "dry port."
7	Gauteng	City of Tshwane	Metro	2,921,488	Major commercial centre. Important industrial centre. Main industries are iron and steel works, copper casting, and manufacturing of automobiles, railway carriages and heavy machinery.
8	Gauteng	Ekurhuleni	Metro	3,178,470	Contains O. R. Tambo Airport (Africa's busiest airport) and Rand Airport. One of South Africa's industrial centres. Steel manufacture and distribution are the largest industries. Large railway workshops, glassworks, engineering companies, gas distribution firms, etc.
9	Gauteng	Emfuleni	Other	721,663	Covers Vereeniging area; an important industrial and manufacturing centre. Chief products include iron, steel, pipes, bricks, tiles and processed lime. Contains several coal mines. Other mines include fire-clay, silica and buildings stone. Main city is Vanderbijlpark, an industrial city. 60% of town's workforce employed in factories.
10	Gauteng	Merafong City	Other	197,520	Main town: Carletonville. Some of richest gold mines in world. One of world's deepest mines. Economy dominated by mining sector.
11	Gauteng	Mogale City	Other	362,422	Seat: Krugersdorp. Gold, manganese, iron, asbestos and lime mined in area. Transport: Jack Taylor Airfield (airport). Tourism: Cradle of Humankind, Sterkfontein Caves, etc.
12	KwaZulu-Natal	EThekwini	Metro	3,442,361	Busiest container port in Africa. King Shaka International Airport is the 3rd busiest in South Africa. Large tourism sector. Strong manufacturing, tourism, transportation, finance and government sectors.

#	Province	Municipality	Type	Population (2011)	Economy
13	KwaZulu-Natal	KwaDukuza	Other	231,187	Commercial, magisterial and railway centre of an important sugar-producing district. Manufacturing sector dominates economy.
14	KwaZulu-Natal	Newcastle	Other	363,236	One of South Africa's main industrial centres. Economy dominated by Karbochem synthetic rubber plant, Arcelor Mittal steelworks, LANXESS Chrome Chemical Plant, Natal Portland Cement plant, clothing and textiles, and service and engineering industry. Considerable coal mining in area.
15	KwaZulu-Natal	The Msunduzi	Other	618,536	Seat: Pietermaritzburg (KZN capital). Situated on N3 highway at junction of an industrial corridor (Durban - Pietermaritzburg) and an agro-industrial corridor (Pietermaritzburg - Estcourt). Regionally important industrial hub, producing aluminium, timber and dairy products. Pietermaritzburg (Oribi) Airport.
16	Limpopo	Polokwane	Other	628,999	Largest urban centre North of Gauteng. Polokwane International Airport. Agricultural produce: tomatoes, citrus fruit, bananas, avocados. Hosts several major industries, e.g. Coca-Cola and SAB. Large commercial area - 4 largest banks in the country all having at least three branches in the city. Manufacturing facility in Seshego of Tempest Radios and Hi-Fis - largest employer in region.
17	Mpumalanga	Emalahleni	Other	395,466	Covers Witbank area. Industries include Evraz Highveld Steel and Vanadium (steel mill). Eskom coal-fired power stations within borders include Kendal, Kriel, Duvha and Matla. More than 22 collieries in area. Economy dominated by mining sector. Electricity sector also prominent.
18	Mpumalanga	Govan Mbeki	Other	294,538	Contains coal to oil refinery (Sasol Two), 5 coal mines (part of largest underground coal mining complex in SA). Economy dominated by manufacturing sector.
19	Mpumalanga	Mbombela	Other	588,794	Main town is Nelspruit; the financial and banking capital of Mpumalanga. Strong retail industry. One of largest manganese processing facilities in world. Key agricultural and manufacturing hub for North-Eastern South Africa. Sugarcane. Large forestry sector, including paper mill, saw mills, and manufacturing of furniture, crates and cartons. Situated on Maputo Corridor - major trade route between Johannesburg and Mozambique. Transport includes Buscor (largest bus operator - terminal one of largest in southern hemisphere), 2 airports (Nelspruit Airfield and Kruger Mpumalanga International Airport). Tourist stop-over.
20	Mpumalanga	Steve Tshwete	Other	229,831	Seat: Middelburg - large farming and industrial town. Mining and manufacturing sectors dominate. For years, industrial activities of the steel plant and its peripheral activities, such as coal and transport, provided much of the employment and largely drove the economy, although other sectors, such as agriculture, have gradually grown to be important. Out-migration trend. Eskom coal-fired power stations within borders: Hendrina, Komati and Arnot.

#	Province	Municipality	Type	Population (2011)	Economy
21	North West	City of Matlosana	Other	398,676	One of the hubs of South African gold mining industry (importance decreasing recently). Major contributor to agriculture (maize, sorghum, groundnuts, sunflower). Largest agricultural co-op in southern hemisphere.
22	North West	Rustenburg	Other	549,575	Two largest platinum mines in the world. World's largest platinum refinery. Economy dominated by mining sector.
23	Northern Cape	Sol Plaatje	Other	248,041	Initial hub of industrialisation in South Africa in late 1800s - first town in Southern hemisphere to install electric street lighting. Diamond mines (Kimberley hole). Major airport: Kimberley Airport. Services the mining and agricultural sectors of the region.
24	Western Cape	City of Cape Town	Metro	3,740,026	Finance sector dominates. Large tourism sector. Cape Town International Airport is the second-busiest in South Africa (after O. R. Tambo).
25	Western Cape	Drakenstein	Other	251,262	Economy based on viticulture (wine) and tourism.
26	Western Cape	George	Other	193,672	Popular holiday and conference centre. Administrative and commercial hub of the Garden Route. Major airport: George Airport.
27	Western Cape	Saldanha Bay	Other	99,193	Largest town: Vredenburg. Contains largest natural port in Africa, with iron ore quay. Saldanha Steel (steel mill). Grain, dairy, meat, honey and waterblommetjie farming.

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