Voortrekker Road corridor densification in Cape Town: Energy and Carbon emissions analysis

Sustainable Energy Africa

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Summary

The Voortrekker Road Corridor is one of the key routes in Cape Town's transport network, and the City is currently prioritising the densification of the corridor to promote a more efficient transport system amongst other goals. This report assesses the energy, carbon emissions (CO_2) and energy cost implications of such densification compared with a 'business as usual' approach of more sprawling, low density urban expansion. The densification assessment assumes just over a doubling of the population along the corridor in 20 years (by 2034), or alternatively accommodating this population increase in more outlying areas such as Fisantekraal or WestCape.

A spreadsheet model was developed for this purpose, populated with existing cordon count and other data, and expert opinion used to estimate the future transport system characteristics for the densification and the sprawling scenarios.

The results point to the impact of densification being highly significant, with around 50% reduction in energy and carbon emissions associated with the Voortrekker transport corridor anticipated by 2034 compared with the sprawling scenario (or around 35% cumulative reduction over all the years leading up to 2034). The financial savings in 2034 due to reduced expenditure on transport energy also appear to be significant (ZAR 623 million per year if energy prices remain stable, or around ZAR 2 billion per year with a 6% p.a. real energy price escalation), with resulting potential welfare and economic benefits.

This study points to the importance of urban form, densification in particular, as a critical part of an overall approach to sustainability and carbon mitigation in Cape Town.

Impression of densification of Voortrekker Rd corridor (Source: City of Cape Town Spatial Planning website)

Background

The City of Cape Town is pursuing a sustainable energy path as outlined in their Energy and Climate Change Strategy (2011) and the associated Energy and Climate Action Plan (ECAP). Amongst the key aspects of this strategy is the reduction in energy use and carbon emissions to support national carbon mitigation intentions as outlined in the National Climate Change Response White Paper (2011). In addition, the City's latest Spatial Development Framework (SDF) recognises resource efficiency and climate pressures as being central imperatives. An important component of resource efficiency relates to optimal densification of the city, as it is currently relatively low-density, as with most South African cities, leading to high transport infrastructure costs per capita, and higher resulting energy and carbon emissions figures. Cape Town's Densification Strategy guides the process of densification. The SDF is linked with the Integrated Transport Plan, since coordinated planning between Spatial Planning and Transport Departments is necessary to realise the benefits of densification – although this coordination has sometimes been lacking in the past.

A key area of focus linked to city densification is the densification of particular transport corridors which form the mobility arteries of the urban area. Amongst these, the Voortrekker Road corridor is one of the most important, and is a significant focal point for densification at present (see Figure 1).

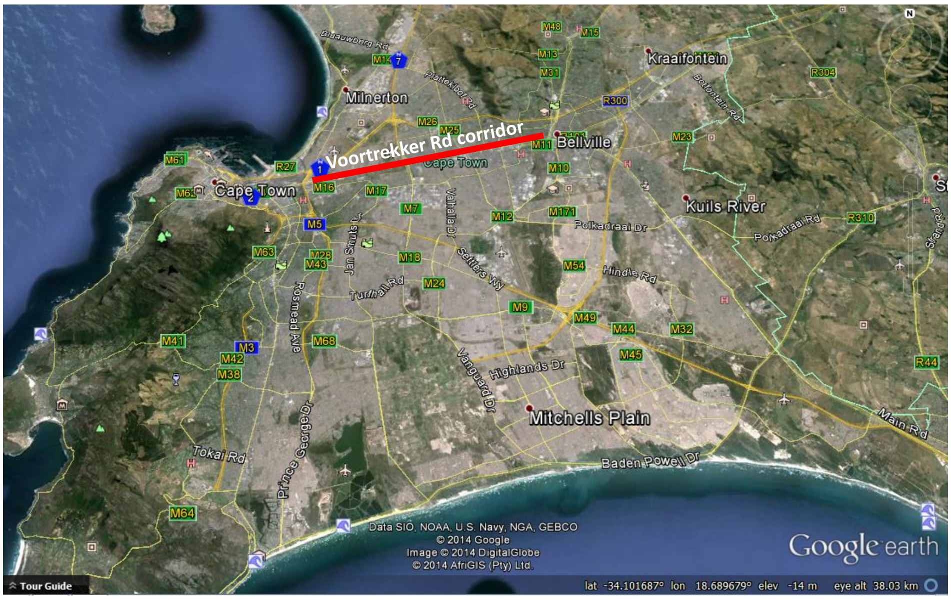


Figure 1: The Voortrekker Rd corridor – linking the city centre with the important node of Belville

Objectives of the study

The City of Cape Town regards the densification of the Voortrekker corridor as important, but lacks clear information on the various benefits thereof, particularly environmental benefits. Densification efforts often encounter resistance from residents where it is being applied, in spite of its broader social, economic and environmental benefits. For this reason it can be difficult to implement in any significant way. This analysis hopes to boost the evidence base of the impacts of densification by exploring the energy and carbon emissions implications of such densification, and quantifying these changes.

Voortrekker corridor characteristics

Voortrekker Rd is an approximately 17km stretch of road which is an important transport route between the suburbs of Maitland, which is close to the City Centre, and Belville – a large

Figure 2: A typical stretch of Voortrekker Rd

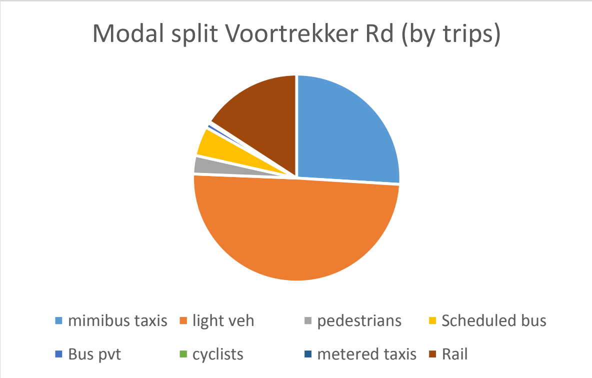
economic centre to the East of Cape Town centre. It is a key route for commuters, as 70% of jobs in the city are linked in some way to this corridor[1]. The road runs through mixed-use areas of commercial and residential zones. In addition, there is a suburban rail line running close to the road, making this corridor an arterial transport route, drawing an estimated 285 000 passenger trips per day and about 2% of Cape Town's total passenger-kilometers of travel.

Residential densities are mostly low – between 15 and 20 dwelling units per hectare (du/ha) – and are generally single residential, mid-income plots. Densification objectives note that public transport starts to become more viable at density figures of around 75 dh/ha. Although this is a generic figure and the viability of public transport is a more complex issue, it is clear that significant increases over current density levels are necessary to facilitate public transport. Currently, the population on the northern side of the road is around 3600 persons per 'km-run' of the road (assuming a 500m deep catchment), which would need to increase by around threefold to approach 75du/ha.

There is also some underutilised Defence Force land on Voortrekker Rd, and a large cemetery running along the road for over 3km. The former would be ideal for higher-density housing, although its release for these purposes is far from certain.

[1] Pers comm. Gerhard Hitge, City of Cape Town Transport Department, November 2014.

Transport characteristics along the road indicate the dominance of private vehicles, with minibus taxis, train and GABS busses[2] capturing progressively reducing shares of commuters (see Figure 3).



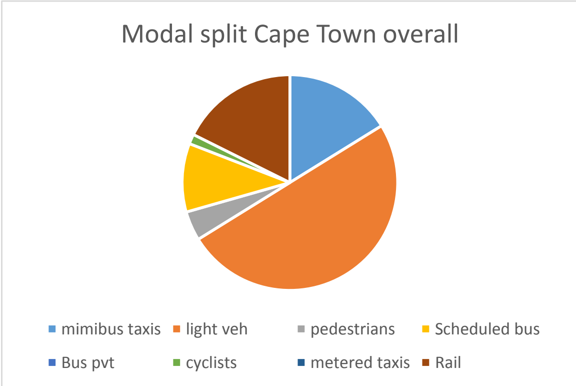


Figure 3: Transport modal shares along Voortrekker Rd compared with that of the total city.

Methodology

Evidence from other studies indicates that transport is by far the most significant driver of energy and emissions changes in densification initiatives (see PDG 2011 and Figure 5). This study therefore focuses on transport impacts. A spreadsheet model was developed to assess the impact of densification on transport use and emissions. The basic scenario was that densities would increase by close to 130% in 20 years, leading to a doubling in passenger-kilometers (pass-km) along this road[3]. The pass-km increase is accommodated by higher vehicle occupancies as well as additional vehicles or rail carriages on the route.

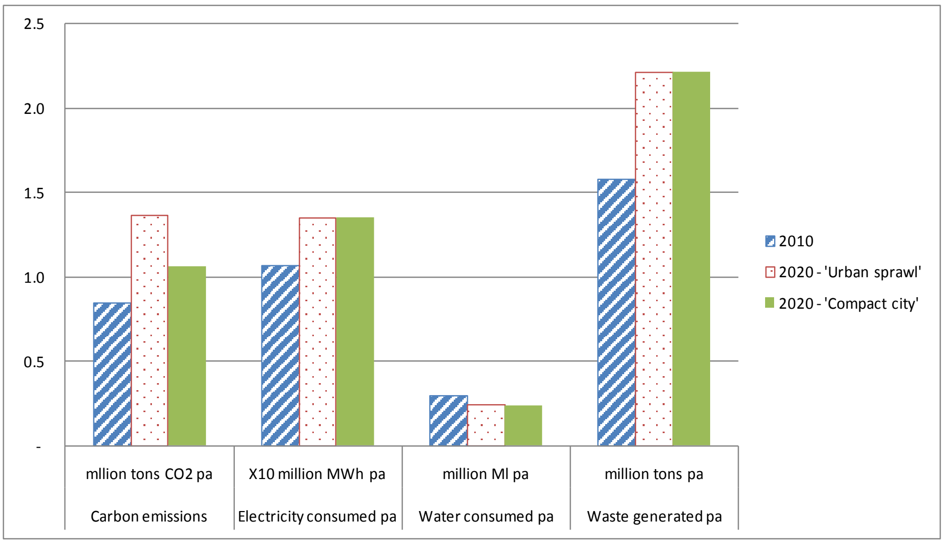
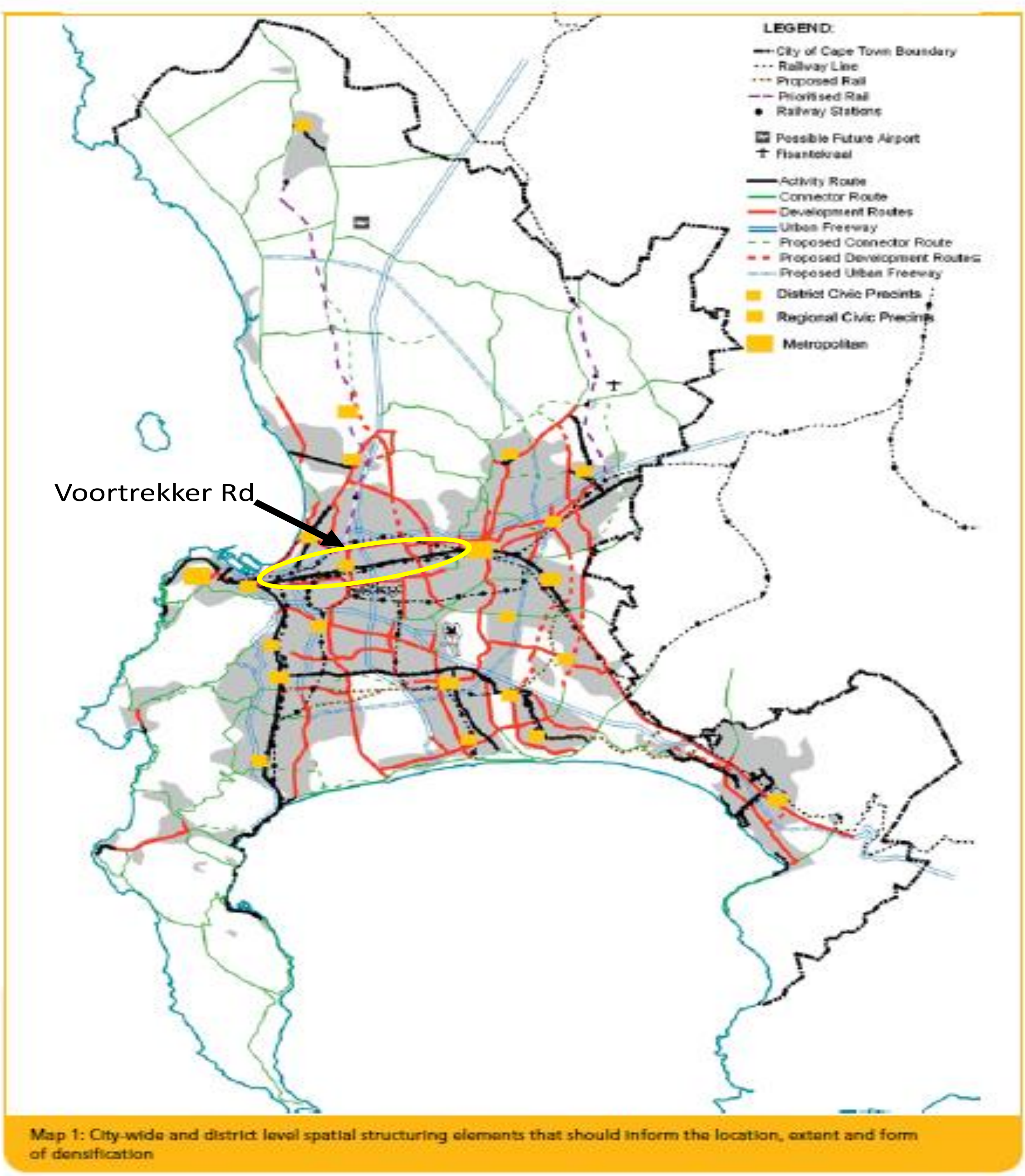


Figure 4: Environmental impacts of a dense vs sprawling 'generic city', showing that the most significant differences arise from transport carbon emissions (source: PDG 2011).

[2] GABS busses: Golden Arrow Bus Service - the contracted service provider for public busses.
[3] Passenger-kilometer increase is assumed to be less than population increase due to increased local job availability associated with denser urban areas.



Map 1: City-wide and district level spatial structuring elements that should inform the location, extent and form of densification

Figure 4: Voortrekker Rd corridor in relation to Cape Town's key transport infrastructure (Source: Cape Town Spatial Development Framework)

The building blocks used for the analysis were as follows:

1. **Current situation** on Voortrekker Rd – using current modal splits and vehicle occupancy.
2. **Densification of population on Voortrekker Rd**: higher occupancy of taxis, busses and trains, and approximately double the pass-km on Voortrekker rd – i.e. the increased population being accommodated by increased transport capacity along Voortrekker Rd.
3. **Sprawling, low density development**: The additional population is located elsewhere in Cape Town, not along the corridor, but rather in lower density areas with limited train access and longer trip distances (since such new developments such as

Fisantekraal and WestCape are inevitably further from economic hubs and thus employment opportunities). This would reflect the 'business as usual' situation without densification along Voortrekker Rd.

Key data sources on which the analysis drew included *Energy Scenarios for Cape Town* (Technical Report and Decision-makers Reports) (2011); the *Cape Town Integrated Transport Plan* (ITP) 2013-2018, and the *Densification Strategy of Cape Town* (2010).

Operation of the model and assumptions used

The model first establishes the energy, CO_2 emissions and energy cost of the current situation along the corridor:

- The model uses energy/fuel consumption for different transport modes together with occupancy levels observed in recent cordon counts along Voortrekker Road to determine energy consumption and CO_2 emissions of different modes of transport.
- Together with the modal share from the cordon counts, the total energy and CO_2 situation is calculated.
- Standard CO_2 emissions factors for South Africa are used.

The model then computes the energy, CO_2 emissions and energy cost situation for the densification and sprawling scenarios described above:

- Expert opinion guided the varying of occupancy levels and modal shares of each transport option according to the anticipated change as a result of each scenario.
- Average trip lengths were also increased for the sprawling scenario according to the expected location of new residential developments (e.g. at Fisantekraal and WestCape).
- It was assumed that the scenarios developed over 20 years – to 2034, and linear population and resulting transport pattern shifts occurred over this period.

Some of the key transport and energy data used in the analysis is shown in the tables below.

Table 1: Basic transport data used in the model for the 'Current situation'

	Total passenger trips*	av. occupancy per vehicle*	Capacity per vehicle	% occupancy	% modal share/trip	km/trip**	total pass-km	modal share pas-km
mimibus taxis	73,858	9.8	15	65%	26.0%	10	738,580	27%
light veh	141,205	1.5	5	30%	49.7%	10	1,412,050	51%
pedestrians	8,203	1.0	1	100%	2.9%	3	24,609	1%
Scheduled bus	13,127	34.0	90	38%	4.6%	10	131,270	5%
Bus pvt	2,188	5.0	90	6%	0.8%	10	21,880	1%
cyclists	538	1.0	1	100%	0.2%	5	2,690	0%
metered taxis	218	2.0	5	41%	0.1%	10	2,180	0%
Rail	45,000	608.1	1100	55%	15.8%	10	450,000	16%
	284,337				100.0%		2,783,259	100%
* - from Cape Town Transport Department Cordon Counts								
** - based on the Cape Town Integrated Transport Plan								

Table 2: Key parameters varied for each scenario

SCENARIOS:	Current situation on Voortrekker Rd (from above table)		Higher occupancy of taxis, busses and trains AND incr pass-km (based on 127% population increase)		Situation if population located elsewhere in Cape Town, lower density, low train acess (and longer trip	
	% occupancy (100%=fully occupied)	Modal split (trip)	% occupancy	Modal split	% occupancy	Modal split
mimibus taxis	65%	26.0%	75%	31.5%	65%	28.0%
light veh dies	30%	18.9%	30%	14.0%	30%	21.0%
light veh petrol	30%	30.8%	30%	25.0%	30%	32.2%
pedestrians	100%	2.9%	100%	3.1%	100%	1.8%
Scheduled bus	38%	4.6%	45%	6.5%	38%	8.0%
Bus pvt	6%	0.8%	6%	0.8%	6%	0.8%
cyclists	100%	0.2%	100%	1.0%	100%	0.1%
metered taxis	41%	0.1%	41%	0.1%	41%	0.1%
Rail	55%	15.8%	65%	18.0%	55%	8.0%
		100.0%		100.0%		100.0%
Tot pass-km/day:		2,783,259		5,288,192		5,566,518
Standard trip dist:		10.0		10.0		20.0

Impacts not modelled

Environmental impacts which have not been modelled include resource use changes linked to different building structures and infrastructure economies of scale. Studies suggest that these do not result in significant environmental changes however, and are largely cost concerns rather than environmental ones (e.g. see PDG 2011).

In addition, some behaviour changes are difficult to model. For example, the higher concentration of people may result in greater economic activity in the immediate area, and appropriate mixed zoning may lead to more amenities and services in the locality, both leading to reduced travel needs. Issues such as these have only been considered in a superficial way.

There are also further efficiency gains to be made by measures which utilise the current low off-peak occupancies of trains and busses – effectively 'flattening' the peak. These have not been considered.

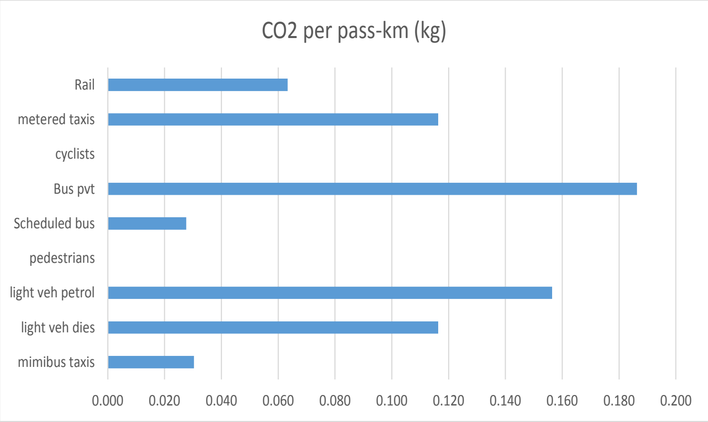
Results

The table below shows the proportion of total transport energy currently being consumed along the Voortrekker Rd corridor.

Table 3: Proportion of Cape Town's transport energy and CO2 emissions from the Voortrekker corridor

Totals per year	Total energy GJ	Total CO2 (tons)
Current situation on Voortrekker Rd	1,015,826	78,337
Cape Town transport total	63,822,564	5,548,547
Voortrekker as % of Cape Town total	1.6%	1.4%

The differences in energy and emissions from different modes of transport on Voortrekker Rd are shown in Figure 5 (note that this varies with vehicle occupancy, so the graphs are particular to the occupancies along the Voortrekker corridor).



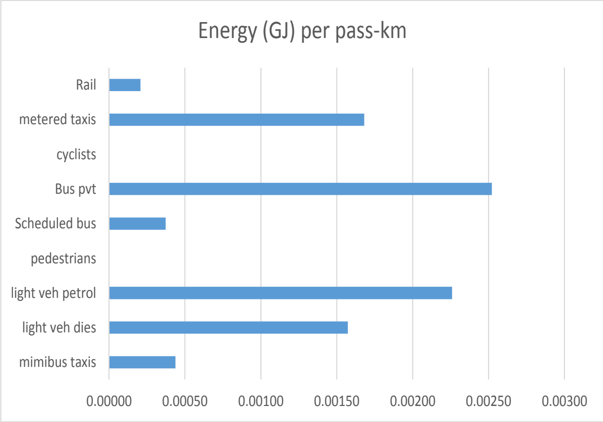


Figure 5: Energy and carbon emissions for different transport modes on Voortrekker Rd.

The total energy, carbon emissions and energy cost savings from densification of the corridor compared with low-density sprawling development are estimated to be significant – close to 50% – as shown in the table below (Note that these figures are the estimated difference for the year 2034, and *cumulative* reduction totals for years 2015-2034 will be less – around 35%).

Table 4: Energy, carbon and energy cost reductions from densification on Voortrekker Rd for the year 2034.

	TOTALS per day			TOTALS per year (x310 days)		
Population increases in the city can be accommodated via densification, or in low density manner:	Total energy GJ	Total CO2 (tons)	Total energy cost ZAR*	Total energy GJ	Total CO2 (tons)	Total energy cost ZAR*
Current situation on Voortrekker Rd	3,277	253	1,287,658	1,015,826	78,337	399,174,004
No significant densification on Voortrekker, and population increase is accommodated in standard low density manner	10,263	768	4,053,074	3,181,631	238,091	1,256,452,926
Densification along Voortrekker to accommodate roughly 127% additional population on road by 2034	5,201	406	2,041,517	1,612,380	125,879	632,870,134
Reduction per yr from densification:	5,062	362	2,011,557	1,569,251	112,212	623,582,792
Reduction %	49%	47%	50%	49%	47%	50%
* - energy costs in 2014 Rands, not discounted (0% discount rate appropriate for public money), not escalated above inflation						

A financial saving of ZAR 623 million per year (in 2014 Rands, at 2014 energy prices) is estimated for the densification scenario in 2034, although cumulative savings from 2015 to 2034 would be significantly higher. However energy costs are likely to escalate above inflation. If this escalation is 6% above inflation, which is reasonable[4], this financial saving will be around ZAR 2 billion in the year 2034, as illustrated in Figure 8.

The results over time for the gradual densification of the Voortrekker corridor over 20 years are shown in the below graphs.

[4] Basic fuel prices have consistently escalated above 5% (real) since 1994 (Source: Own calculations from Department of Energy historic fuel price data and StatsSA CPI data).

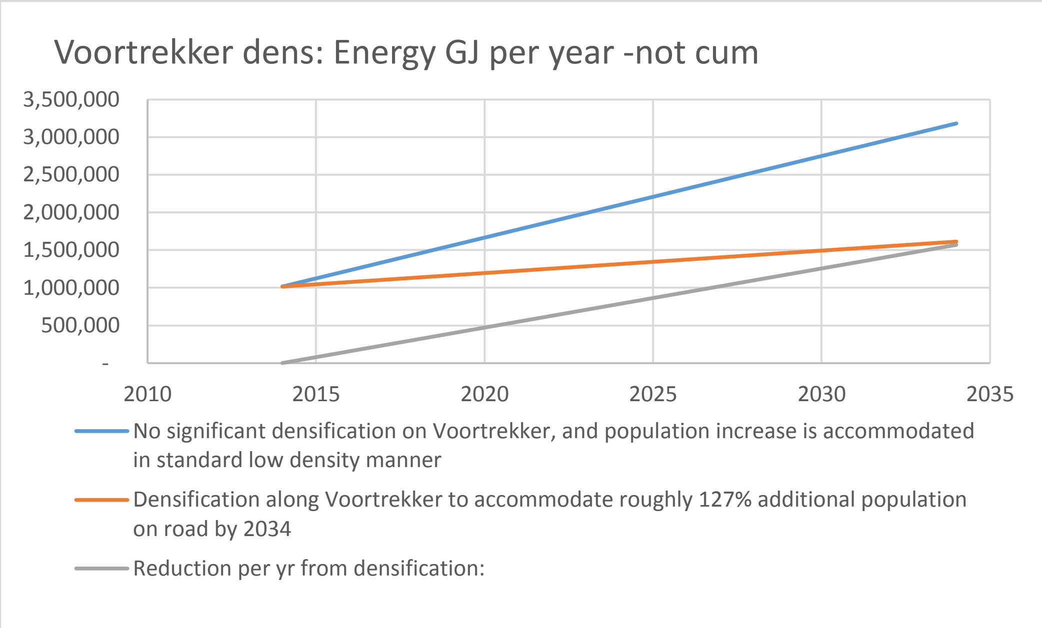


Figure 6: Estimated transport energy saving from densification

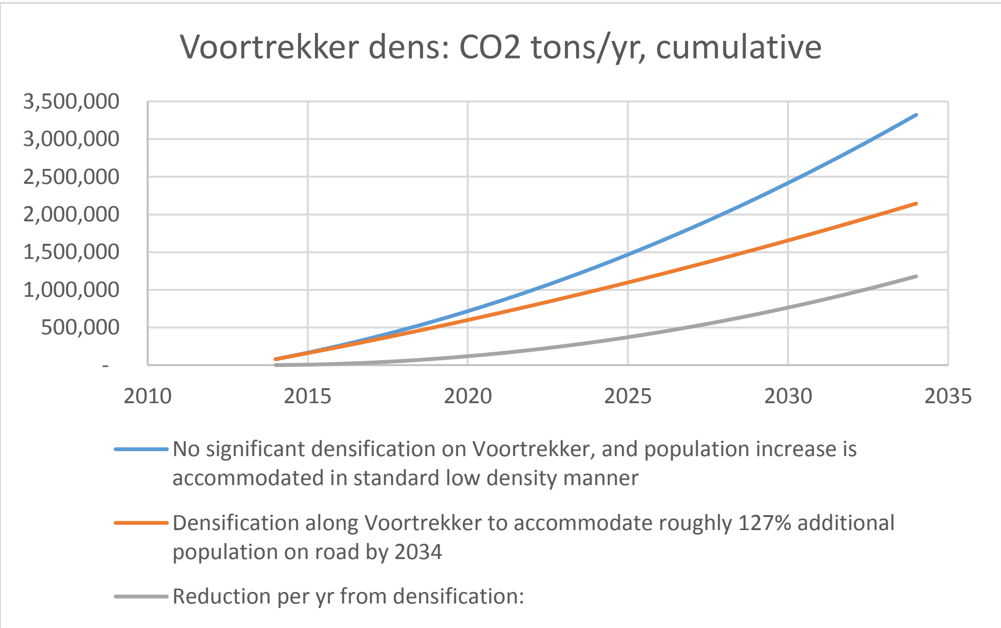


Figure 7: Estimated carbon emissions reductions from densification

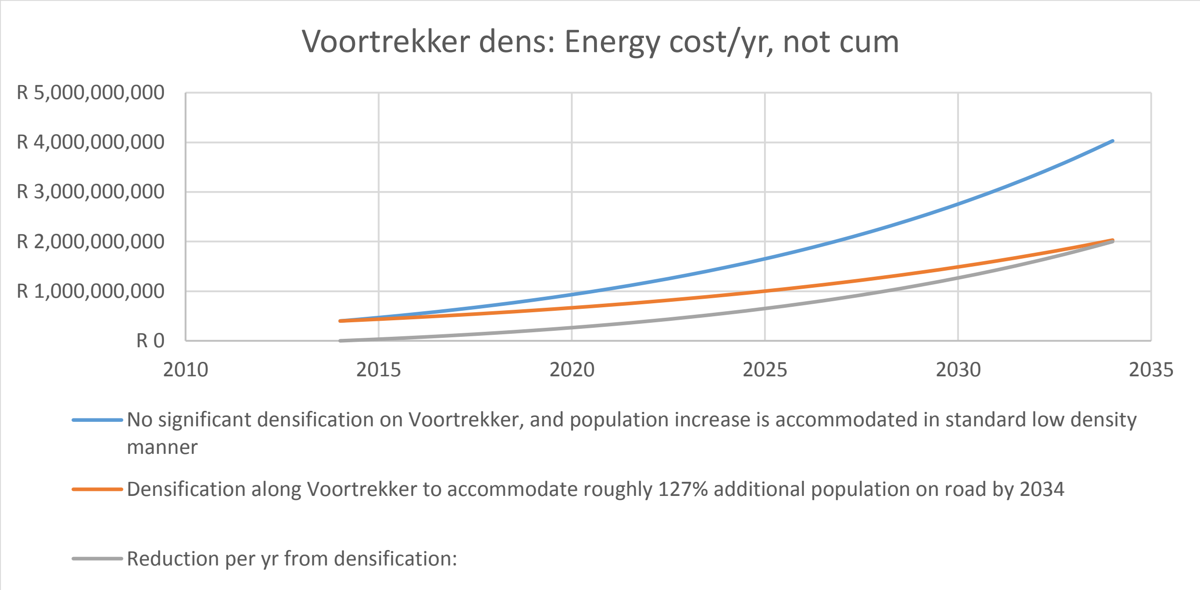


Figure 8: Estimated transport energy saving from densification (total expenditure on transport energy – future energy prices escalated at 6% above inflation)

Conclusion

The benefits of densification along the Voortrekker corridor appear to be significant, with around 50% reduction in energy and carbon emissions anticipated by 2034 (or around 35% cumulative reduction over all the years leading up to 2034). In addition, there will be associated local pollutant benefits (although not necessarily in the very localised area of the corridor, where local emissions will likely increase). The financial savings in the year 2034 due to reduced expenditure on transport also appear to be significant (potentially around ZAR 2 billion per year depending on the energy price escalation), with potential broader welfare and economic benefits.

This study points to the importance of urban form, densification in particular, as a critical part of an overall approach to sustainability and carbon mitigation in Cape Town.

REFERENCES

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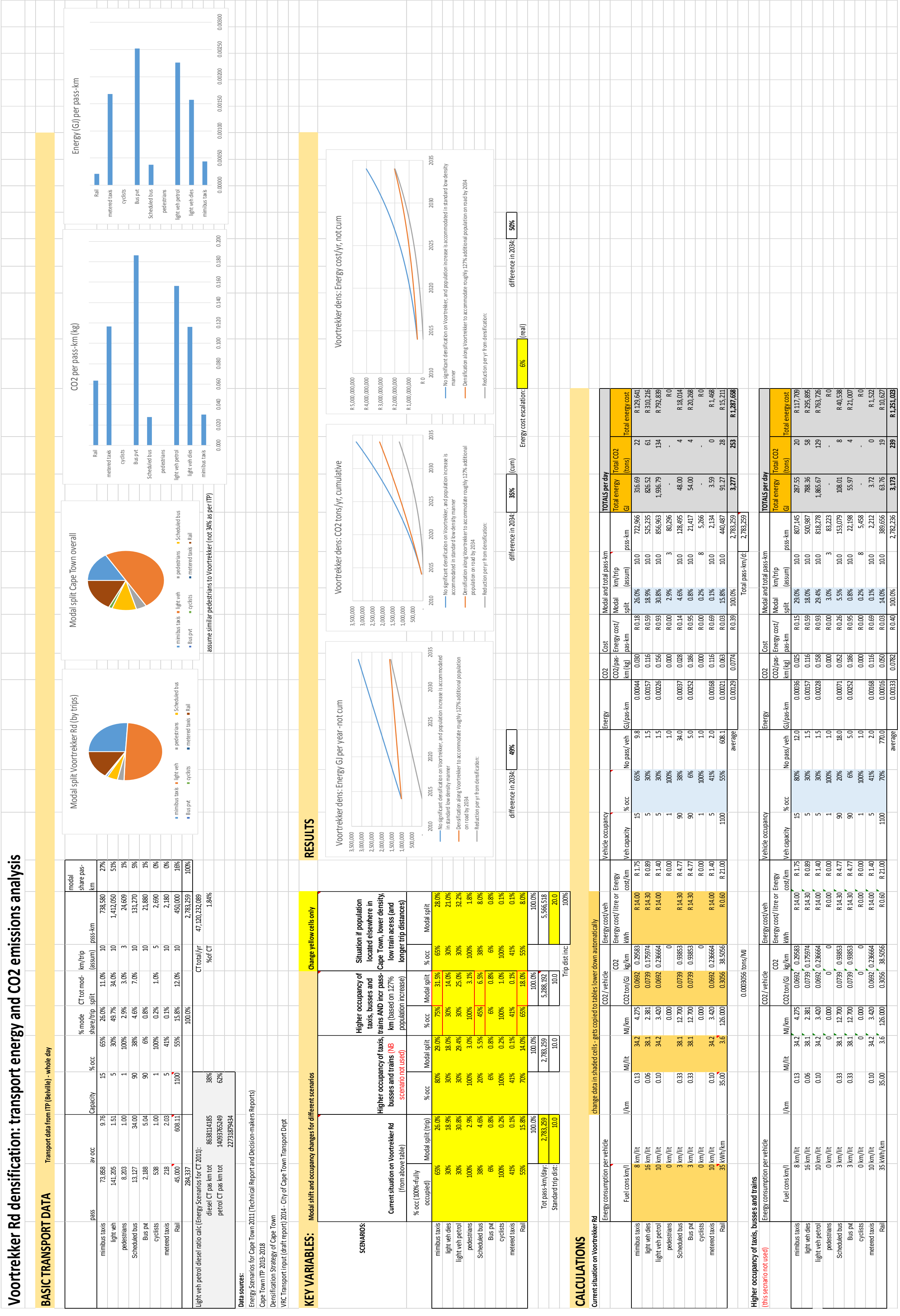
APPENDIX 1: Screengrab of part of the spreadsheet model



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