Deep decarbonization pathways in SOUTH AFRICA

Bryce Mc Call
Harro Von Blottnitz
Julia Tatham

February 2024

Lessons from the EU-funded research project IMAGINE

Table of contents

Introduction

This work takes place in a context where:

- *South Africa pledged in its 2020 Long-Term Low Emissions Development Strategy (SA-LEDS) to move towards a net zero CO2 economy by 2050 in a just and equitable manner. This study explores characteristics of potential emission pathways to 2050 under varying assumptions about mitigation ambition.*
- *National climate policy making is determined and contextualized by a wide range of factors, including international commitments and consideration of potential development of the multilateral climate regime. In the context of this study, two hypothetical future 'worlds' have been characterized to provide a comparison for domestic pathways within different global contexts:*
  - ***World A:** a more ambitious climate world with a strong multilateral rules-based regime, with stricter policies on carbon-intensive trade, a more rapid transition to EVs, reduced demand for fossil fuels and a greater market for 'green' export trade, and greater climate support for developing countries*
  - ***World B:** a more divergent climate world, with a slower transition to clean fuels, products and technologies, and more limited or no support to developing countries. This world comes with high risks that SA and other developing countries will be subject to greater pressure to mitigate than in World A.*

In this context and under the EU-funded research project IMAGINE, we defined a set of three development pathways :

- **The Current Policies Scenario (REF) : this scenario takes place in the World B**. It does not allow to meet carbon neutrality by 2050. Shares of fossil fuels in global energy production decline moderately, but not substantially, with prices and demand following the IEA Announced Pledges Scenario (APS) projections.
- **The 9 Gigatonnes cumulative carbon budget (9GT) and 2050 net zero CO2** : this scenario takes place in the World A. It allows to meet net zero CO2 economy wide by 2050. Fossil fuel shares of global energy production decline significantly, particularly coal, and demand and prices drop in line with the IEA Net Zero Energy scenario (NZE) projections. This scenario represents a reasonable level of ambition.
- **The 8 Gigatonnes cumulative carbon budget (8GT) and 2050 net zero CO2 :** this scenario takes place in the World A. It allows to meet net zero CO2 economy wide by 2050. Fossil fuel shares of global energy production decline significantly, particularly coal, and demand and prices drop in line with the IEA Net Zero Energy scenario (NZE) projections. This scenario represents a higher level of mitigation ambition.

Research questions for scenario framing

1) What are the additional transformations required to reach net-zero CO_2 emission before 2050 in the current South African context?

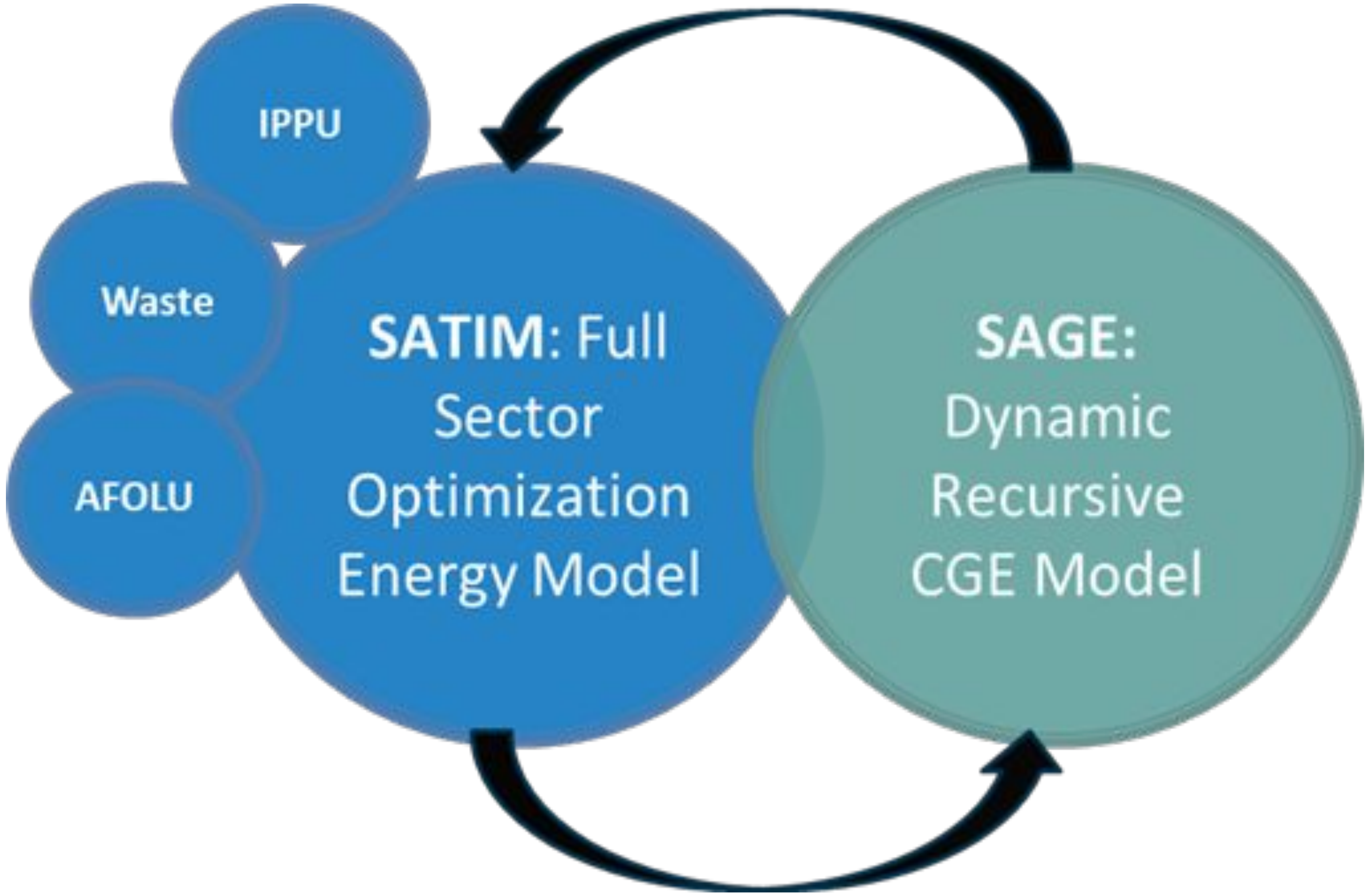
2) How to achieve this transition in an equitable manner?

The comparison of REF with 9GT will inform us on the additional transformations needed to reach carbon neutrality by 2050.

Other key country-specific questions aim to be informed by this work:

- What are the main emitting sectors and what sectors should be particularly address if we include all greenhouse gas emissions in the carbon neutrality target?
- How could this work support the revision of national development and climate policies and future UNFCCC's commitments?
- What key global and sectoral transformations must be considered to enable national Paris-compatible pathways?
- What are the key international enablers and cooperation needs for these sectoral transformations?

Modelling architecture & improvements



The modelling analysis for this study was performed using the Energy System Research Group (ESRG) SATIMGE modelling framework, which consists of two separate models – SATIM (energy) and SAGE (economy) – that are linked together and solved iteratively. Details of these models can be found in the Policy Brief on localization

Part 1

-

National overview of the deep decarbonization pathways

Nowadays, the power sector, energy-intensive industries and other energy industries are the most emitting sectors in South Africa

The power sector, energy-intensive industries and other energy industries are the most emitting sectors nowadays in South Africa, considering GHG emissions.

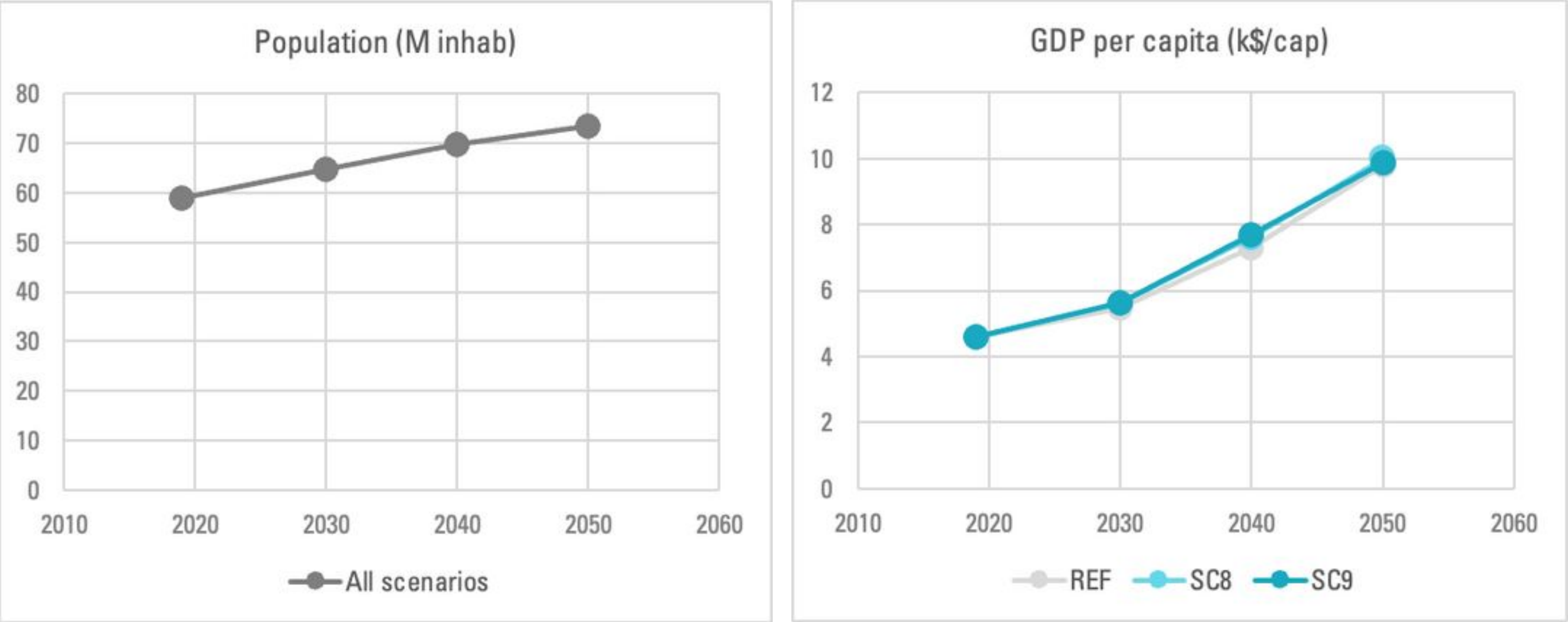
- The power sector is the most emitting sector (GHG & CO2) in South Africa due to the high reliance on coal-power plants. See slide 23 for the power generation and slide 24 for extractive activities.
- For the energy-intensive industries: this is due to both combustion and processed emission from the cement, iron & steel productions (see slide 18 for energy-intensive activities).
- The other energy industries is the 3rd most emitting sector (GHG) and 2nd most CO2 emitting sector due to combustion. Those emissions mostly come from the conversion of coal into coke and into synthetic liquids (gasoline, kerosene..). See slide 25 for the other energy industries decarbonization strategy.

Figure 1. Main indicators for 2019

Indicator	Value in 2019
GHG emissions (MtCO2)	468
CO2 emissions (MtCO2eq)	390
CO2 emissions per capita (MtCO2/cap)	7
Non-CO2 emissions (MtCO2eq)	77
Final energy consumption per capita (GJ/cap)	44
Population (Million)	59
GDP (billion $ 2010)	264
Most emitting sectors (GHG)	power, energy-intensive industries and other energy
Most emitting sectors due to combustion (CO2)	power, other energy industries and passenger transp

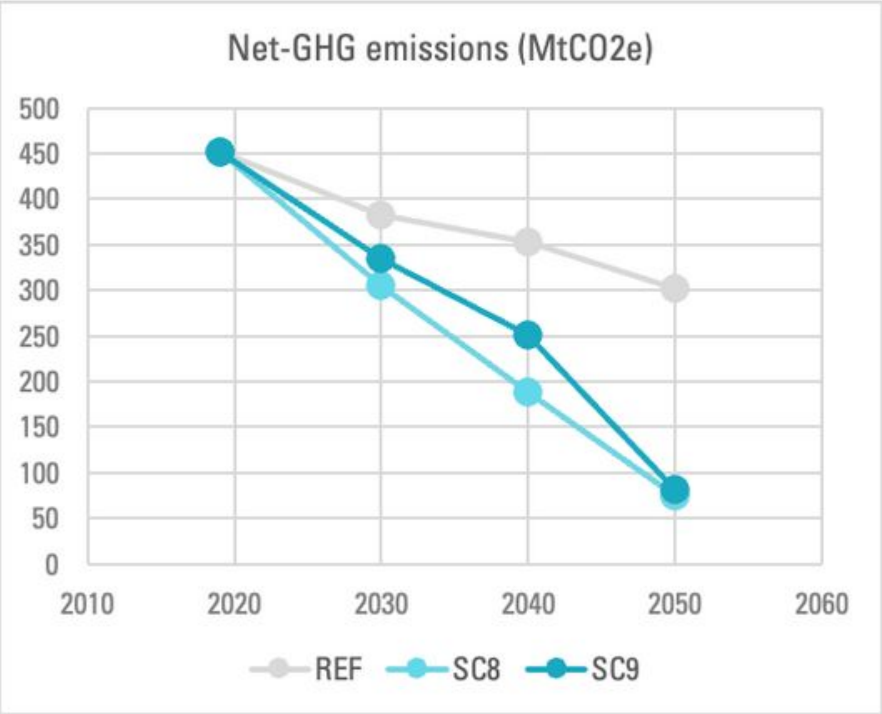
Reaching net-zero GHG emissions by 2050 is feasible, while ensuring socio-economic development

Figure 2. Socio-economic indicators (population, GDP per capita)



- The population of South Africa increases moderately, from 58.8Million in 2019, to 73.5Million by 2050.
- GDP per capita increases at an average pace of 2.5% pa. Unemployment declines in all scenarios as the economy grows in each scenario.
- Investment in the power sector in a 9Gt is roughly the same as the unconstrained REF scenario to mid 2030s. The 8Gt (higher ambition) scenario, requires more investment than these, starting in the late 2020s.

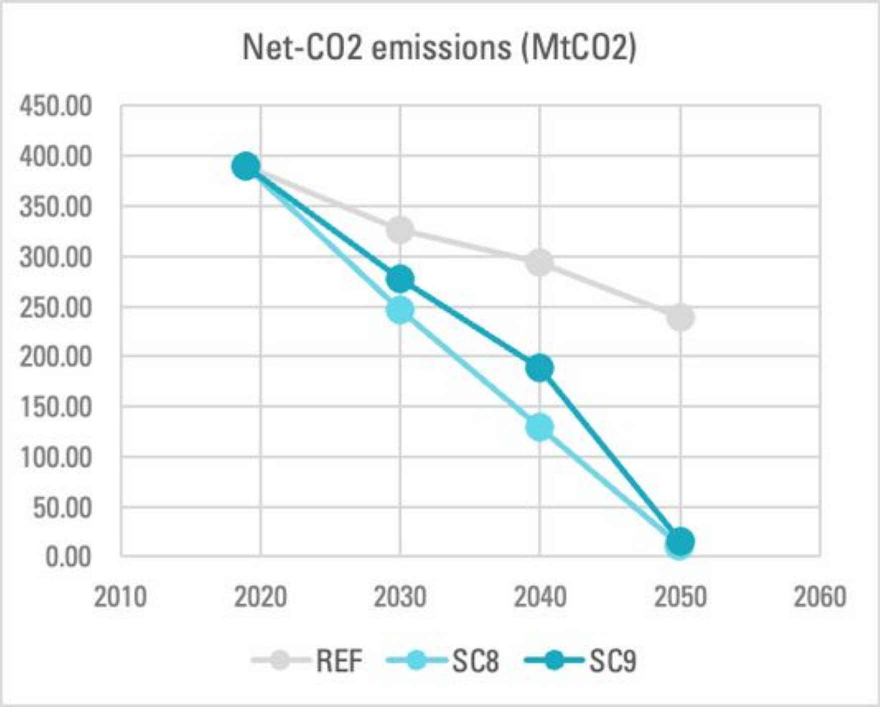
Figure 3. National net GHG emissions

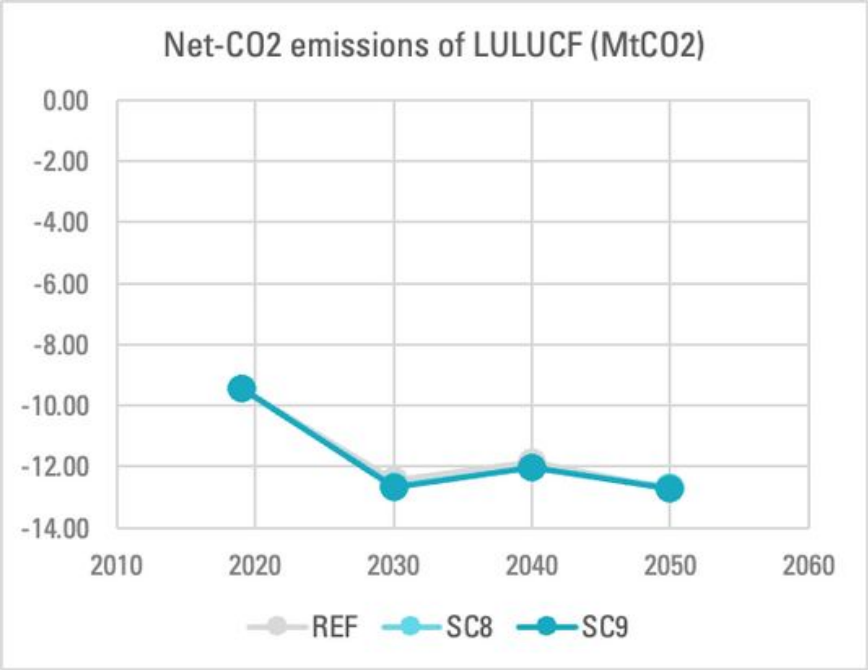


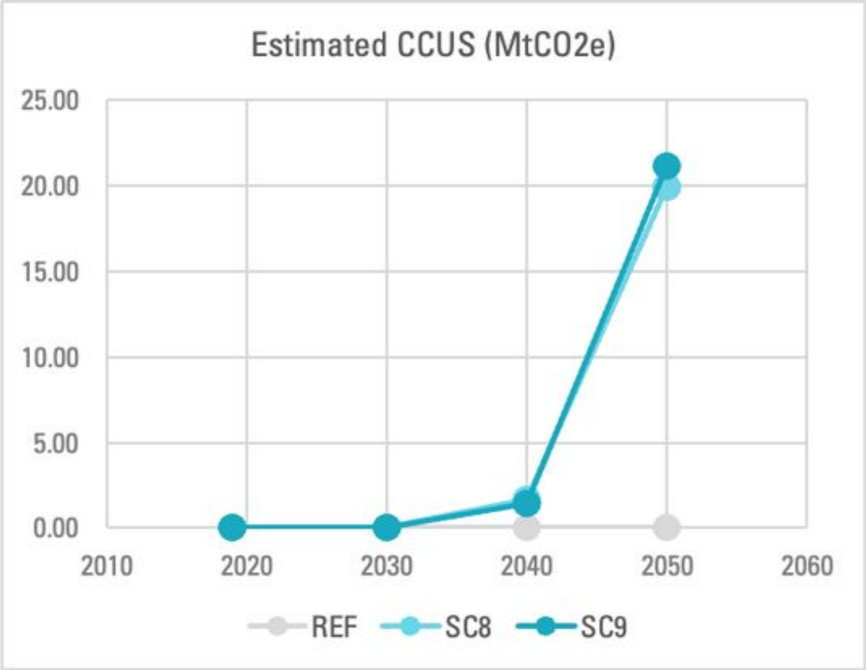
- Net GHG emissions decrease in all scenarios, with wide ranges in 2030 from 412 MtCO2-eq in REF to 362 MtCO2-eq in 9GT and 331 MtCO2-eq in 8GT
- GHG emissions for both 9GT and 8GT are around 89 MtCO2-eq in 2050 (comprised of CH4, N2O and other non-CO2 emissions)
- CO2 emissions reach net zero in both 9GT and 8GT in 2050

Total net-CO2 emissions represent about 86% of all net-GHG emissions and could become slightly net-negative by 2050

Figure 4. National net-CO2 emissions. Top: net-CO2 emissions. Bottom: net-CO2 emissions of LULUCF (left) & estimated CCS (right)







More than 90% of gross CO2 emissions (excluding LULUCF) comes from fuel combustion and are mainly driven by the energy consumption and the current reliance on fossil fuels notably on coal. Emissions from industrial process represent around 7% of the gross CO2 emissions. Agriculture (excluding fuel combustion) represents 0.4% the total CO2 emissions. Waste emissions are not accounted. LULUCF sinks absorb 12% of the CO2 emissions in 2030(8GT).

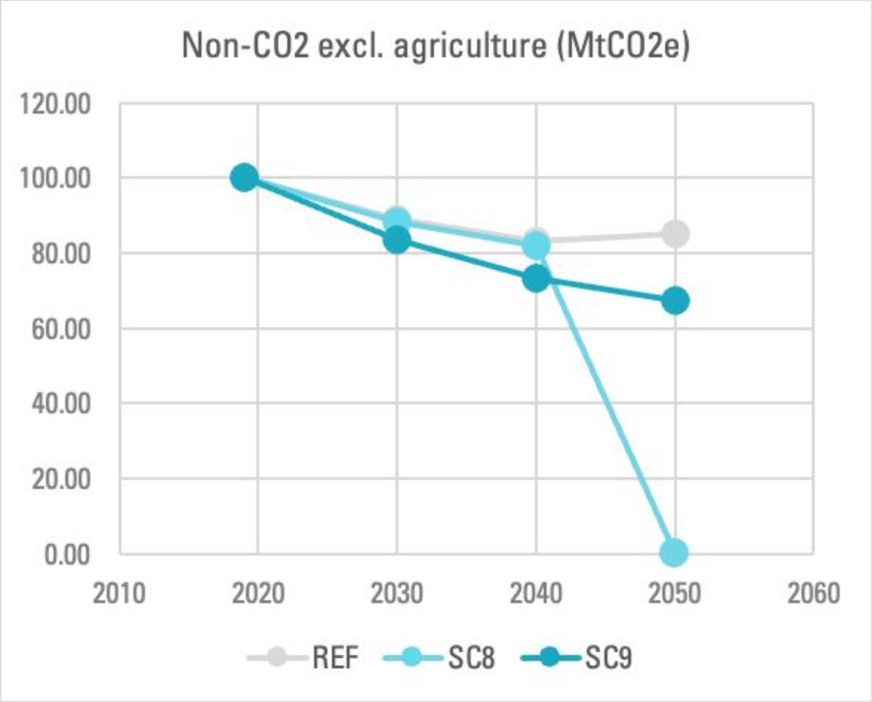
CO2 emissions sources excluding LULUCF are expected to decrease in all scenarios. The 8GT reaches carbon neutrality in 2050, with the land sink accounting for -13 MtCO2 and CCS -22 MtCO2. The REF scenario decreases to 227 net MtCO2 in 2050 (incl. LULUCF and CCS)

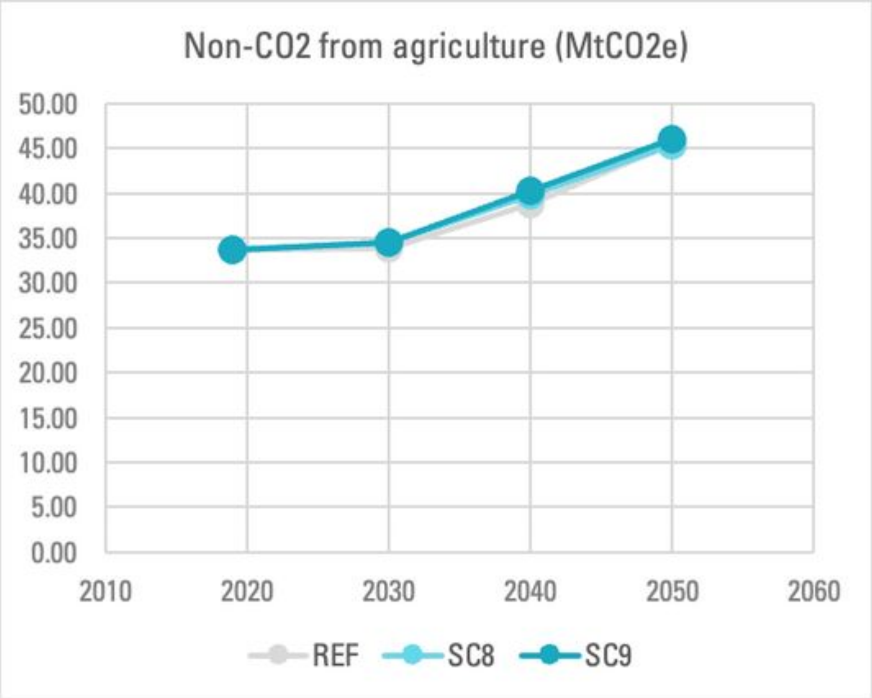
The main decarbonization drivers are :

- the development of and transition to non-fossil-based power production (mainly solar and wind, and a small amount of nuclear in the 2040s),
- the development of CCS infrastructures by 2040, to reach 22 MtCO2 captured in 2050 in the 8GT. It will allow to capture gas power plants' emissions and cement and chrome IPPU emissions in both 8GT and 9GT.
- Improvements in energy efficiency in industry, residential and commerce sectors, and switch to EVs (powered by low carbon electricity) in the 9GT and 8GT scenarios

Total non-CO2 emissions represent 14% of all GHG emissions and 80% of the in 2050

Figure 5. National non-CO2 emissions.





- Total non-CO2 emissions increase by 7% (REF) during 2020-2050, while they decrease in the decarbonization scenarios, by 16% (8ton) and 15% (9ton). 43% of non-CO2 emissions come from agriculture in 2020, and 37% come from the waste sector in 2020. 12% are from IPPU and 7% from energy combustion.

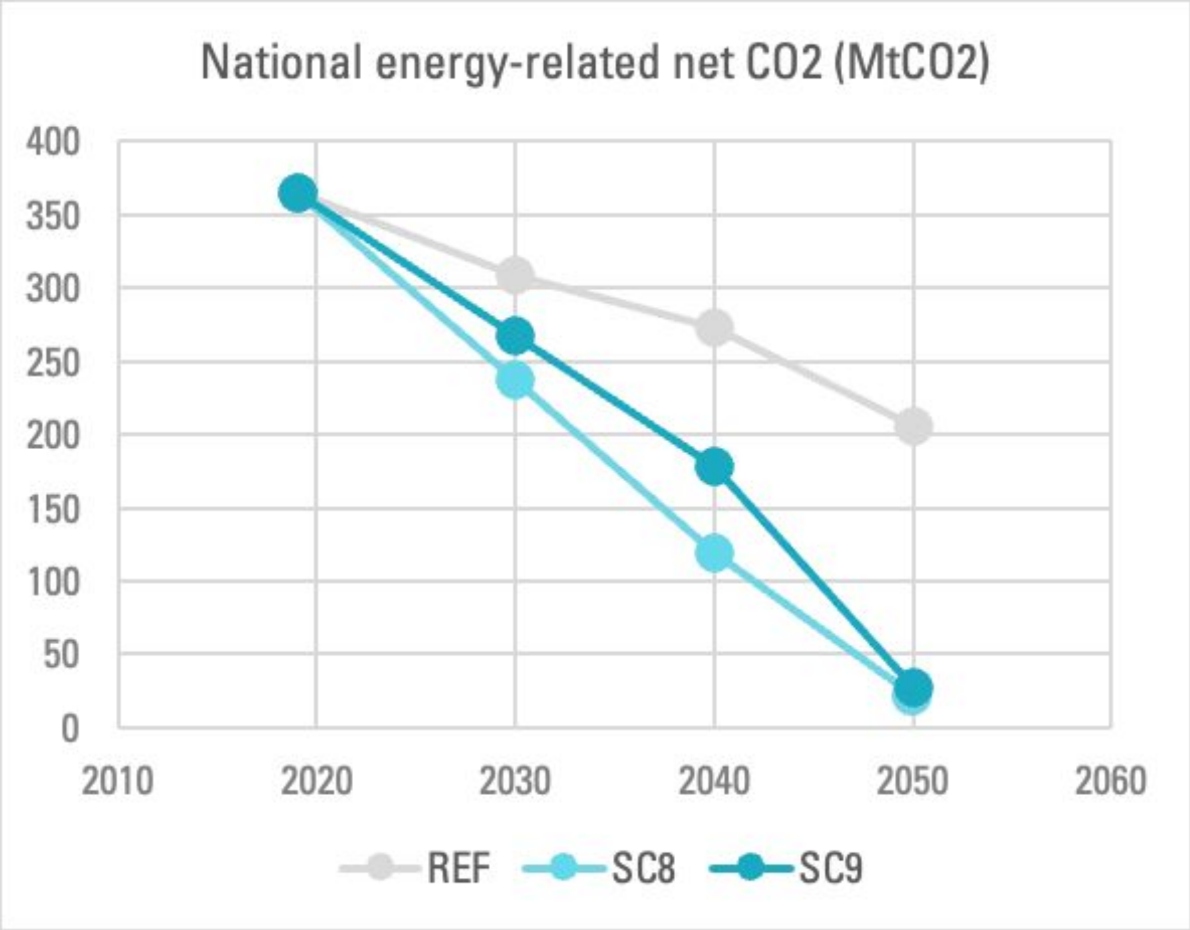
- Without mitigation efforts in these sectors for non-CO2 gases, by 2050 these gases represent 25% of South Africa's GHG emissions, and these are mostly in the AFOLU sector.

- Agriculture : as the population increases, and thus the overall agriculture activity, non-CO2 emissions from agriculture increase by 37% in the 9GT scenario.

- Waste (not shown here) : with improved waste management policies, non-CO2 emissions from waste could reduce by 34%.

Total energy-related CO2 emissions represent 80% of all GHG emissions and could be reduced by 96% by 2050 (1/3)

Figure 6. National energy-related CO2 emissions



- Energy demand is expected to increase in all scenarios, and especially in mitigation scenarios where clean electricity can provide the energy for economic activity.

- With mitigation effort, South Africa's energy system and CO2 would need to decarbonize by ~24% by 2030 relative to an already decarbonizing REF trajectory.

- The 9Gt scenario represents an effort to decarbonize South Africa in line with global efforts to meet Paris Agreement goals of "less than 2C", while the 8Gt scenario could be seen to be an effort by South Africa in line with a global effort to keep 1.5C target alive. This level of effort would require much faster decarbonization after 2030 – with additional 20% decarbonization effort over the 9Gt.

Total energy-related CO2 emissions (2/3): Reducing energy-related CO2 emissions requires systemic and technological changes to improve energy efficiency and reduce the fuel carbon content

Figure 7. Energy consumption (PJ/capita)

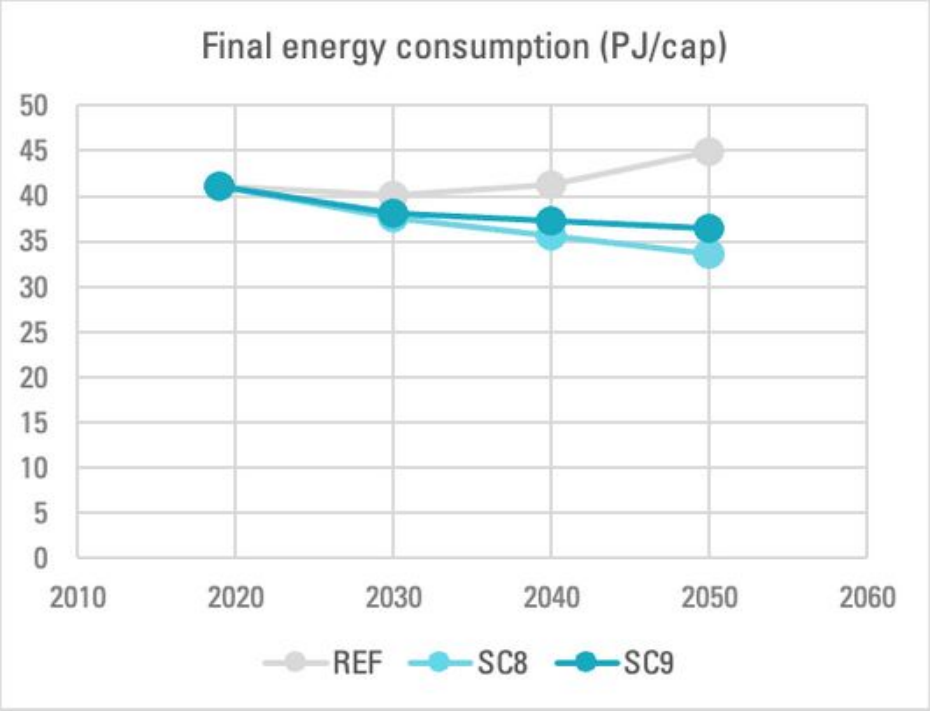


Figure 8. Energy consumption (PJ/2022 ZAR)

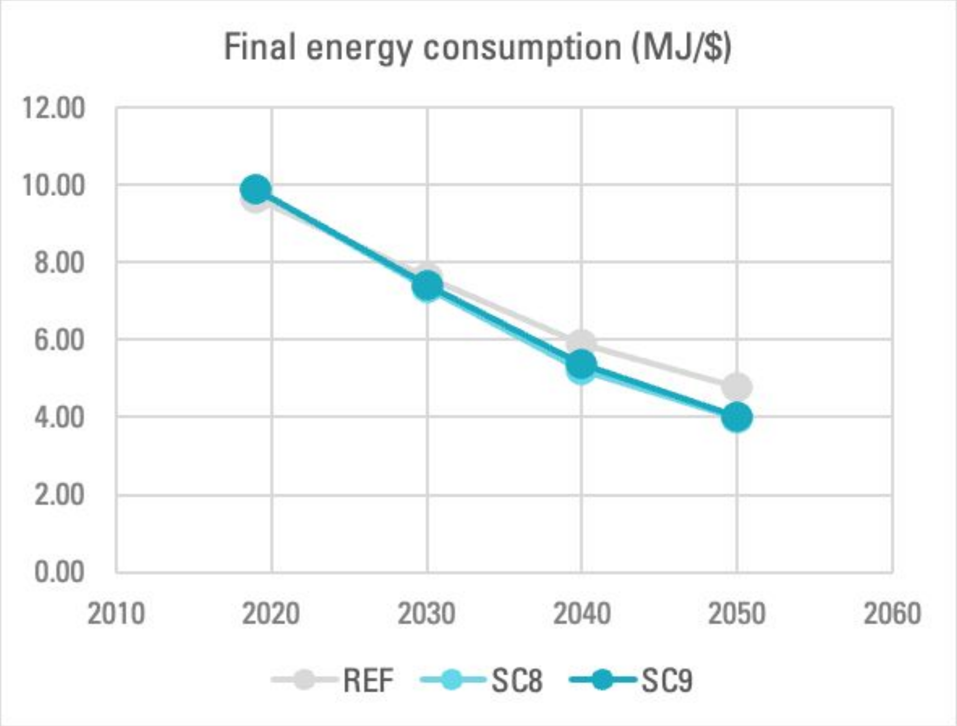
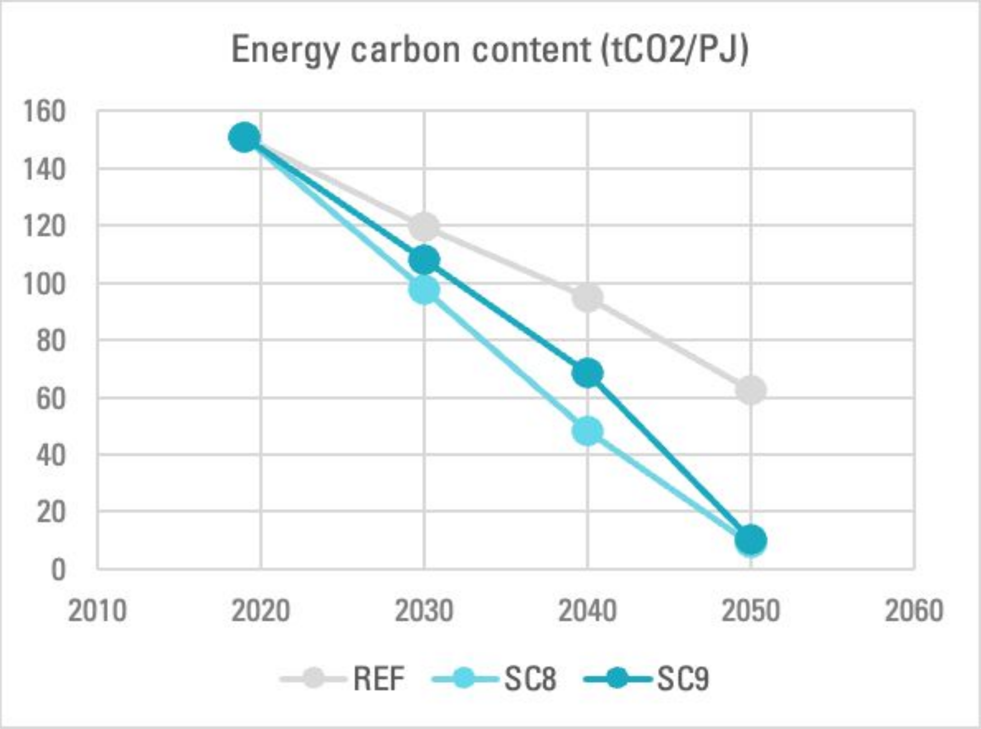


Figure 9. Energy carbon content (tCO2/PJ)



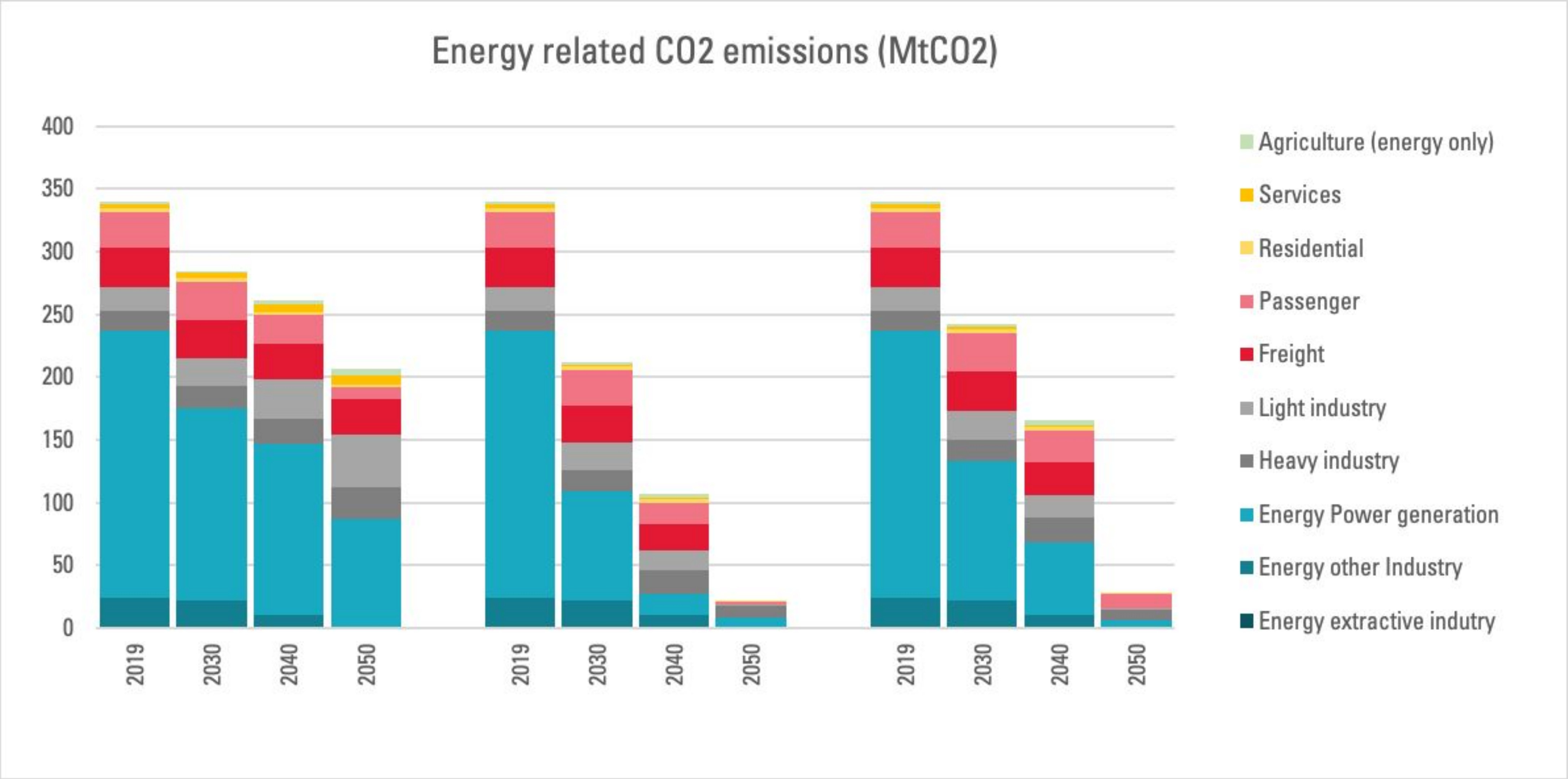
- Final energy consumption per capita increases 10% by 2050 in the REF case relative to 2019 levels, while it decreases by 14% and 16% over the same period for the 9GT and 8GT respectively. Energy intensity (measured as final energy consumption (GJ) relative to GDP (thousand 2022 ZAR) decreases across all scenarios, with a 41% reduction from 2019 to 2050 in the REF scenario and 54% and 55% reductions in 9GT and 8GT respectively.

- These results show that energy consumption becomes more efficient across all scenarios, and particularly in climate constrained scenarios where adoption of more efficient technologies is a decarbonization driver.

- Across all three scenarios, the emissions intensity of the energy sector reduces significantly with the uptake of cost competitive renewable generation technologies, and this accelerates in the 9GT and 8GT scenarios. By 2050, emissions intensity of energy has reduced 60% below 2019 levels in the REF case. The reduction is 98% in each of the 9GT and 8GT scenarios where coal is phased out in the early to mid 2040s.

Total energy-related CO2 emissions (3/3): The key energy-related sectors for deep decarbonization are the power sector, transport, and other energy industries

Figure 10. Energy related CO2 emissions



From now until 2030, the sectors with the highest emissions are the power sector and transport, both freight and passenger and other energy industries. To get closer to the NDC objectives, the majority of the decarbonization effort is from the power sector shifting to renewables. Electric vehicle uptake in transportation sector both utilizes the cleaner electricity from the power sector and uses less of the synthetic coal-based liquid fuels (Other Energy Refining).

Part 2

-

Sectoral deep decarbonization pathways in the 9GT scenario

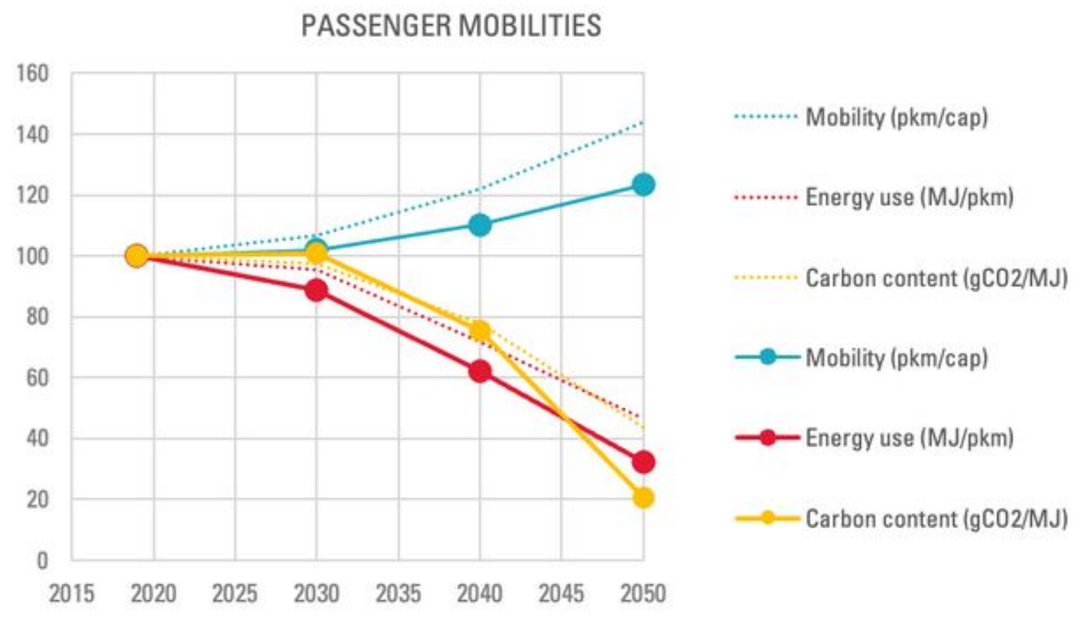
Part 2.1

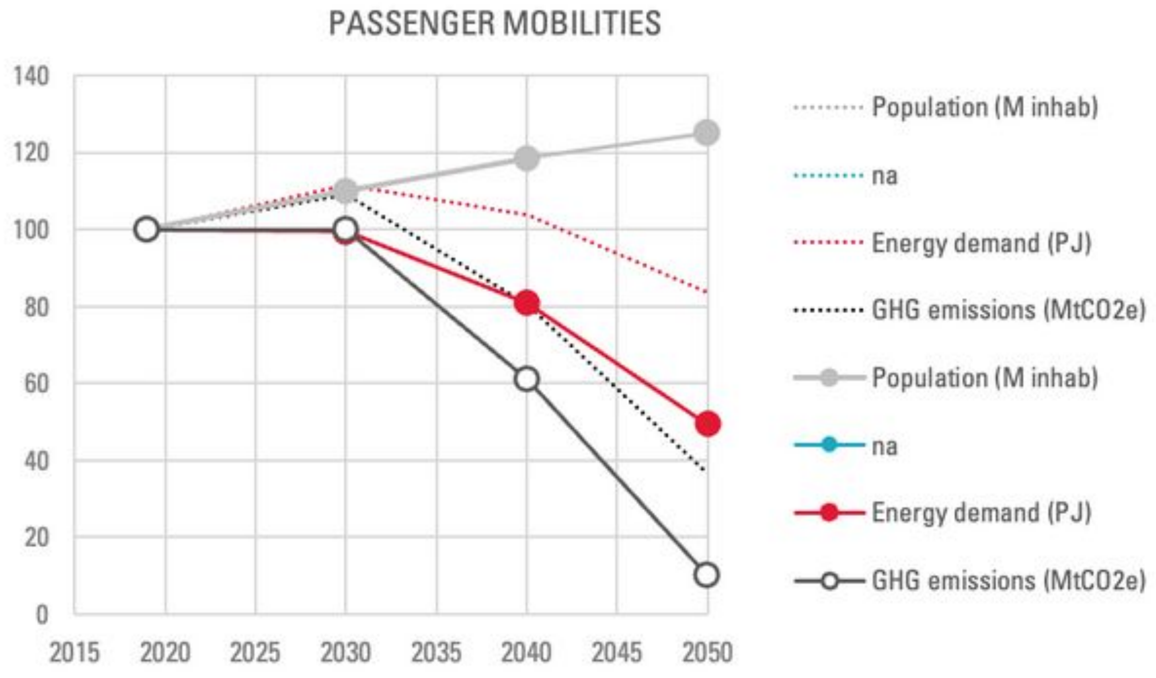
-

Transition of energy-related emission sectors: Transport, Buildings, non-energy producing Industries

Developing Paris-compatible PASSENGER MOBILITIES

Figure 11. Sectoral emission drivers and main aggregates (Index, 2019 base year)





Notes: Non-motorized mobility, IWWC and national aviation are not represented in pkm/cap, but national aviation and IWWC energy and emissions are integrated.

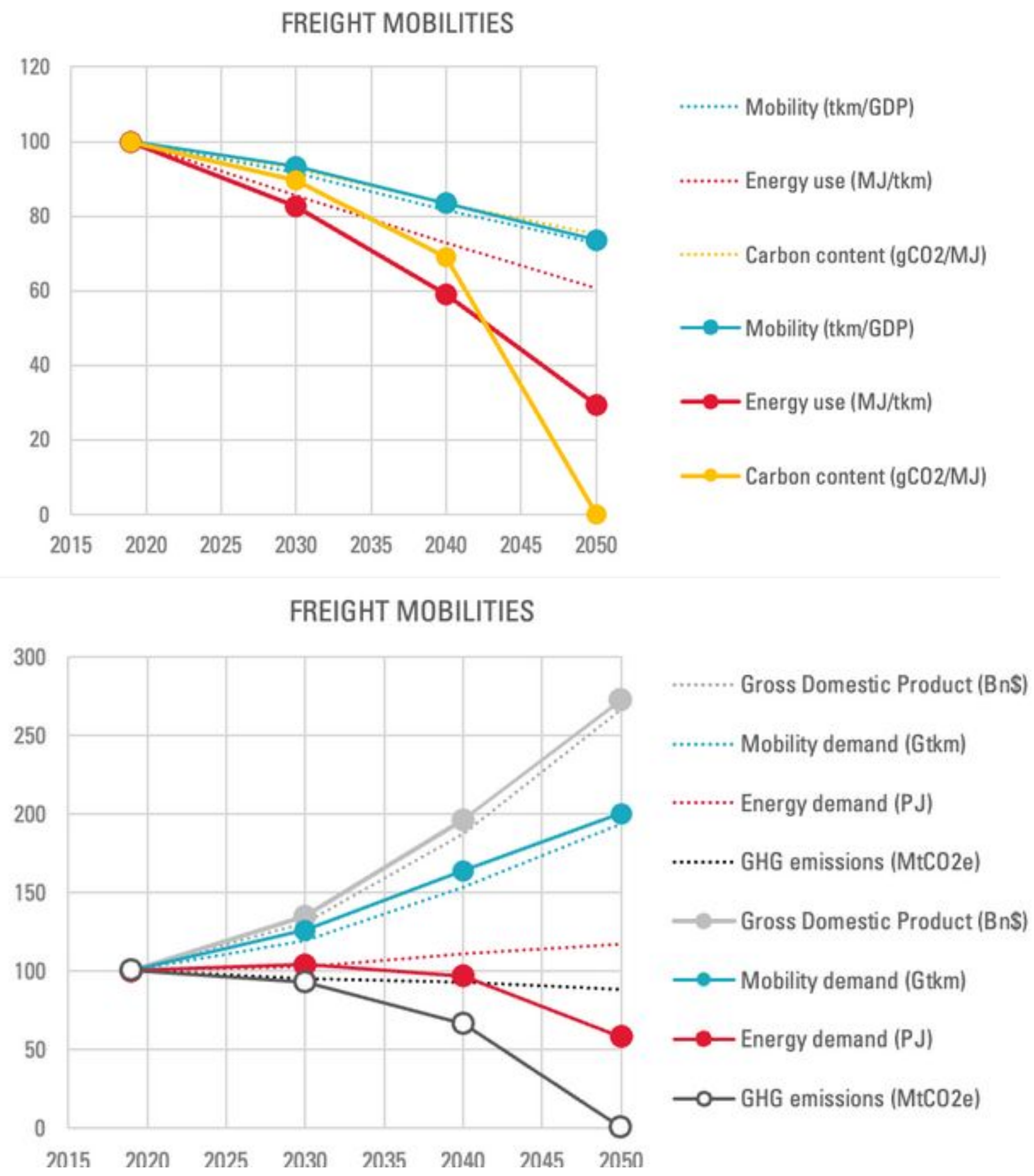
- Mobility demand and kilometers travelled are increasing in both scenarios, but lower in the 8GT scenario than in the 9GT. In the REF, unplanned urban sprawl is expected, while urban, spatial and transport development policies are better planned in the 9GT with the long-term perspective to create more mixed-use neighborhoods where daily necessities are within a 15-minute walk, bike ride or accessible with public transport. It will allow to moderate the shift to individual private cars in the 9GT scenario. This approach not only addresses social issues but also contributes significantly to reducing carbon emissions, aligning with the principles of a Just Transition.

- Regarding the vehicle and fuel transition, the share of non-fossil fuels reaches up to 65% by 2050 compared to 62% in the REF with only aviation and maritime accounting for fossil fuel use. This is due to an accelerated shift towards electric and hydrogen-based vehicles. To boost EV adoption in the short-term, subsidies for non-luxury EVs are essential given their current high cost and the establishment of charging stations around all main metropolitan areas. In addition, South Africa's rich mineral resources could make it a significant player in the Sub-Saharan Africa EV mineral supply chain, if the country adopts EV manufacturing regulations to attract investment in local EV production and transform the existing automotive industry.

- Combined these additional transformations enable to divide passenger transport energy consumption by two compared to REF. In addition, it enables to cut emissions by 64% over the period 2020-2050, while the current policies could reduce it by 61%.

Developing Paris-compatible FREIGHT MOBILITIES

Figure 12. Sectoral emission drivers and main aggregates (Index, 2019 base year)



Notes: IWWC and air freight are not included.

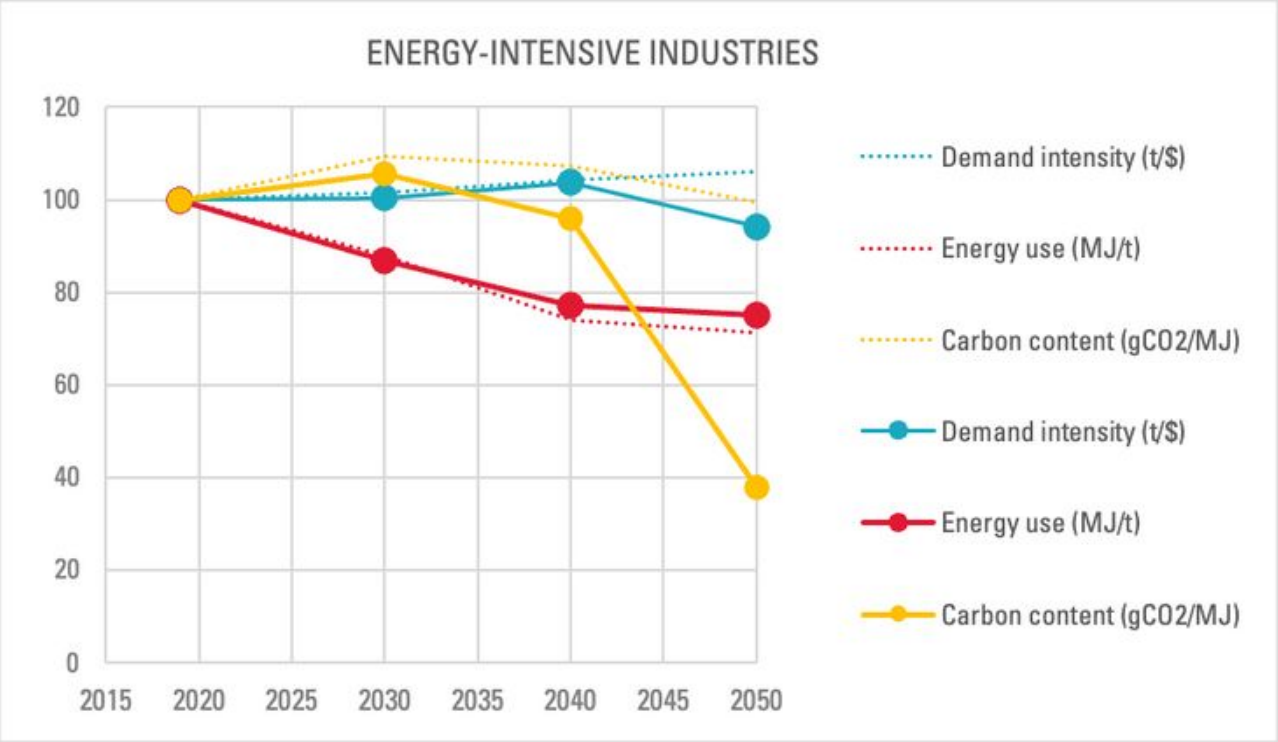
- In both scenarios REF and 9GT, the industrial and economic system follows a similar evolution with a reducing share of non-agricultural and non-service industries in GDP over time which mostly explained a slight decrease in freight transport intensity to GDP over time. However, as real income levels increase, as well as population and overall production, this leads to an increased national consumption of goods and a doubling of freight transport demand in ton.kilometers (tkm) over the period 2020-50.

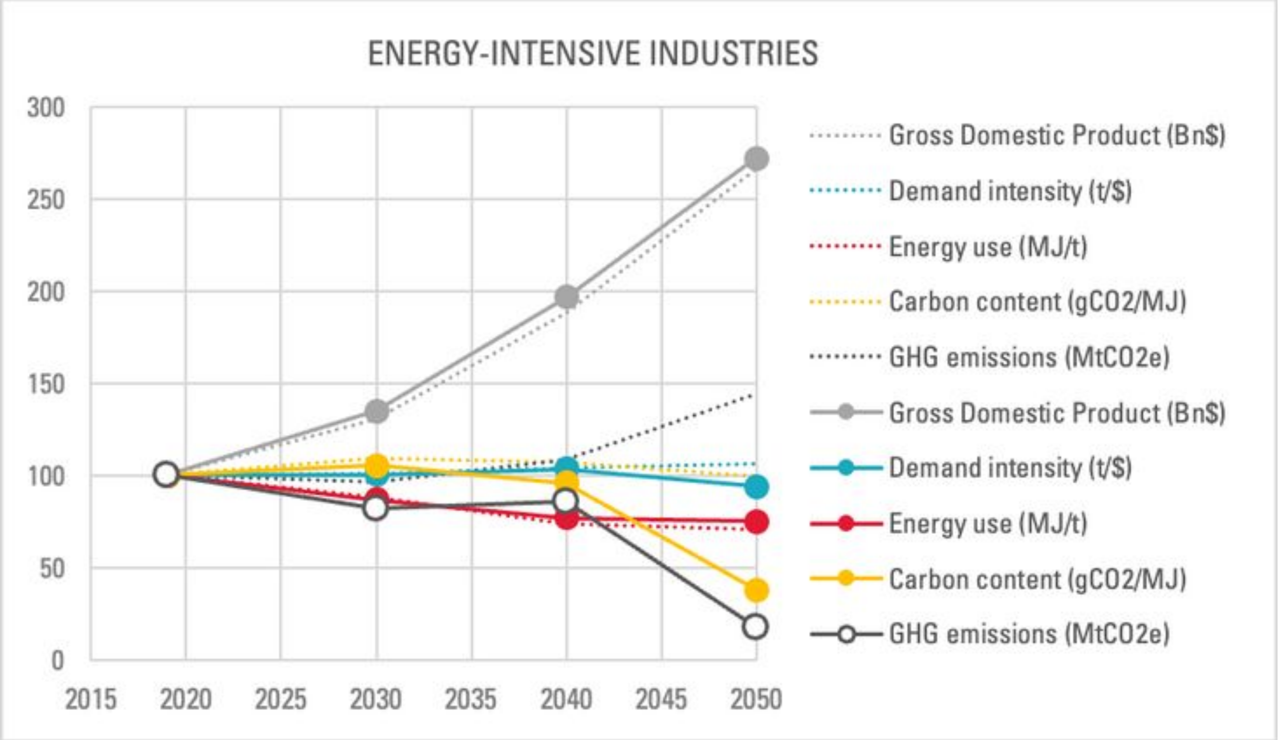
- However, the logistics organizations are evolving differently. The industrials are increasing their use of rail freight in the 9GT scenario, which will make up to 42% of all tkm compared to 33%. But at the same time, the use of light commercial vehicles will explode driven by final consumer demand, e-commerce. While this shift could create additional traffic and congestion challenges, it also facilitate the electrification of road vehicles. Finally, the decarbonization of fuels is accelerated compared to REF and non-fossil fuel energy represents up to 24% vs 19% of final energy consumption by 2040 and 100% vs 25% by 2050. This is mainly due to strong electrification of road vehicles

- Combined these additional transformations enable to divide freight transport energy consumption by two compared to REF. In addition, it enables to cut completely emissions over the period 2020-2050, while the current policies could only cut it by 10%.

Developing Paris-compatible ENERGY-INTENSIVE INDUSTRIE S

Figure 13. Sectoral emission drivers and main aggregates (Index, 2019 base year)





The economy continues to grow, and develop, and the need for products, infrastructure, and other goods continues to grow with it. Thus, industrial activity increases as well.

Emissions in the EII's decline in the mitigation scenarios owing to technology changes, the main drivers of change are:

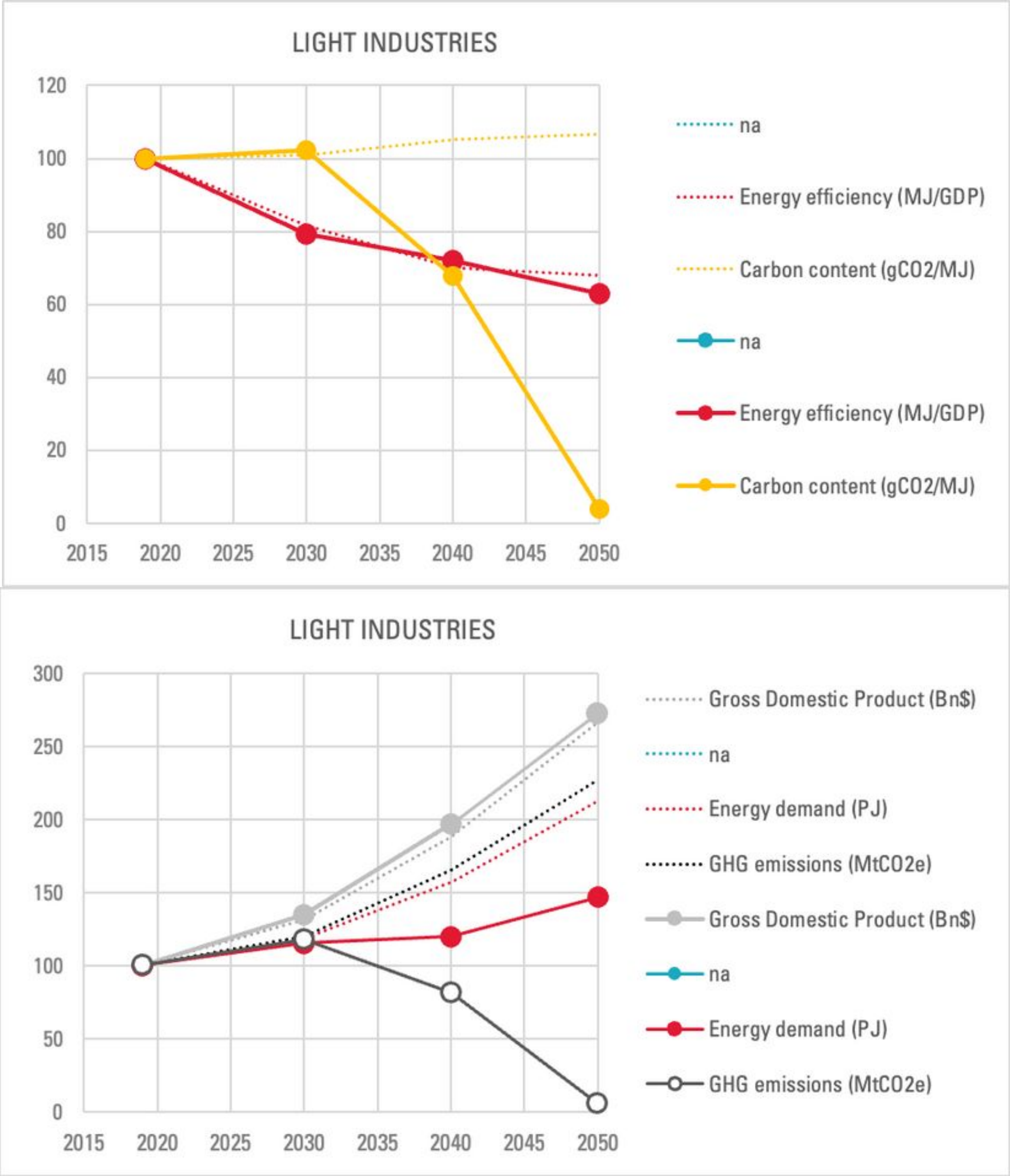
- Switching to new technologies for large EII's like hydrogen for steel production, biocarbon for other hard to abate sectors like chrome,
- the development of CCS infrastructures – notably for cement industries.
- Electrifying industries where-ever possible to electrify

Generally, for heavy industry, thermal requirements make switching to electricity more expensive than burning coal or gas, and the decarbonization in this sector (apart from steel) does not move quickly.

Energy Intensive Industries owing to the risk they are exposed to with their long investment cycles for new are expensive, and no production facilities (technologies) will need support for investment into new technologies that t yet fully proven commercially.

Developing Paris-compatible LIGHT INDUSTRIES

Figure 14. Sectoral emission drivers and main aggregates (Index, 2019 base year)



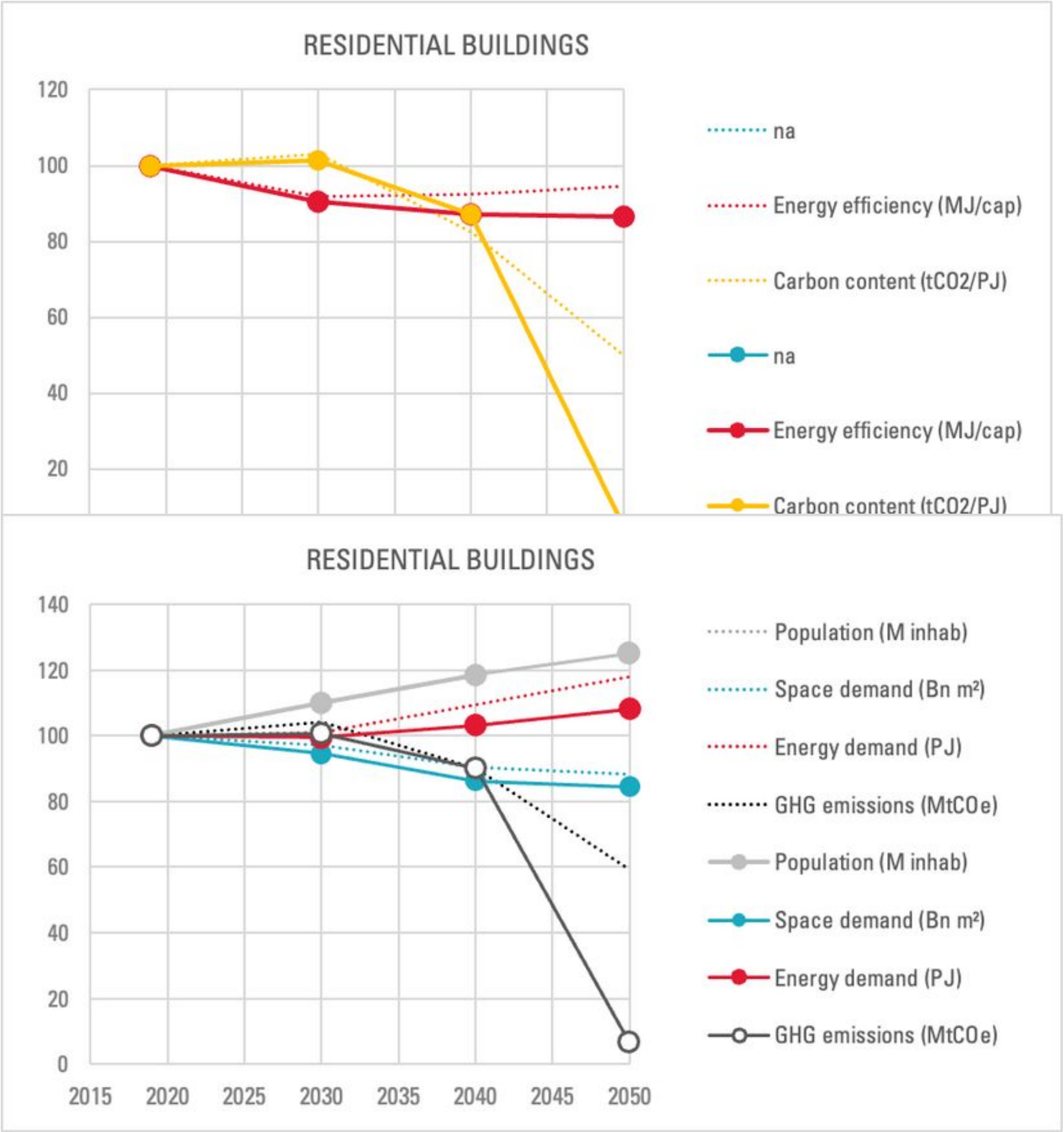
- Most of the emissions in light industries is from the burning of coal for heat requirements for various production processes.

- The main driver of decarbonization is electrifying these heat requirements, but this is expensive even with cheap renewable electricity generation.

- Key enablers for decarbonization in light industry will be energy efficiency measures that will be key to lowering production costs, enabling more electrification, and deployment of technologies like heat pumps, electric boilers across manufacturing, and electricity technologies for the mining industry.

Developing Paris-compatible RESIDENTIAL BUILDINGS

Figure 15. Sectoral emission drivers and main aggregates (Index, 2019 base year)



- According to the REF, surface heating is the main emission source and will make up to 72% of the sector's emission by 2050. Population and household growth, as well as assumed improvements in electrification levels and gradual reduction in the ratio of formal to informal housing applies in this scenario over both the period to 2035 as well as the period 2035 to 2050.
- The decarbonization strategy in the 9GT relies on the reduction of the carbon content mostly.

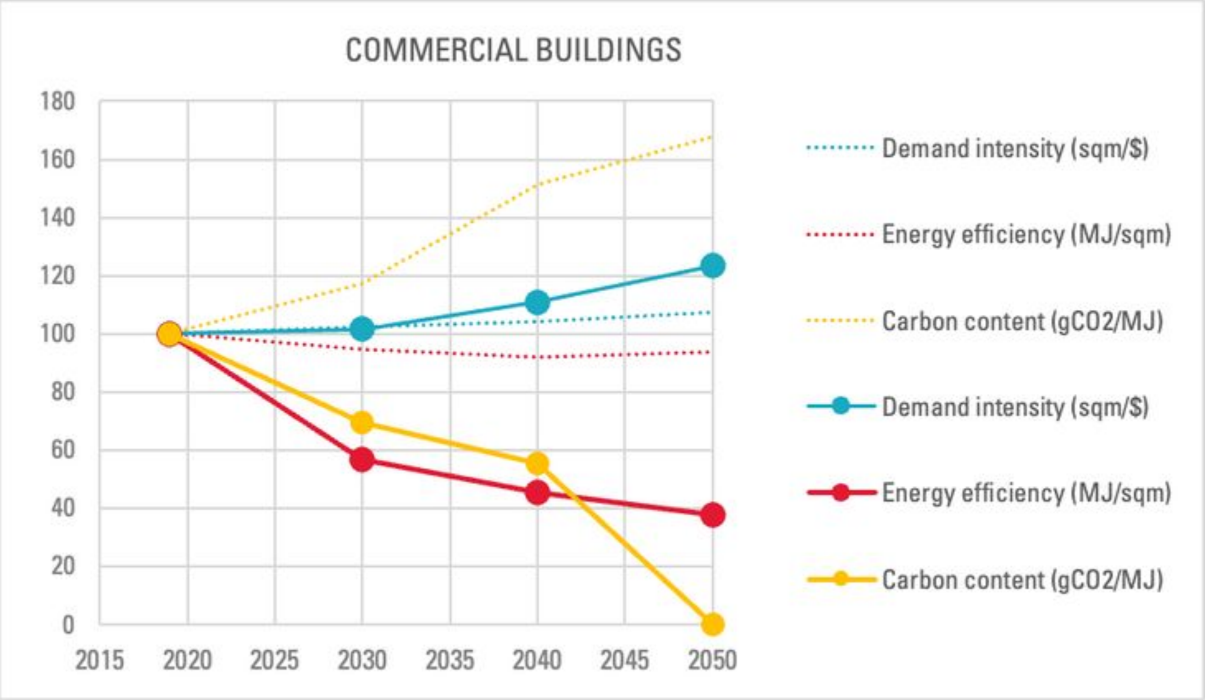
The main drivers are :

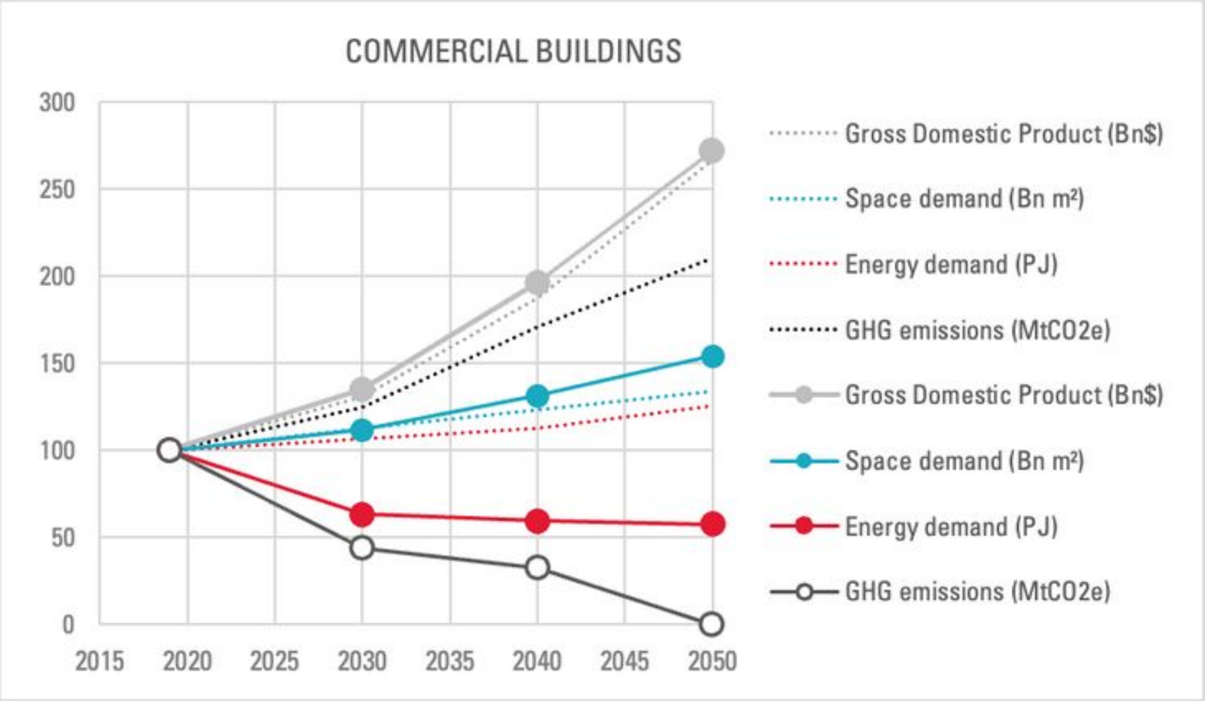
- the development of energy-efficient systems and a decrease of the energy consumption in comparison to the REF, notably in surface heating, even though the overall energy consumption is increasing.
- a massive electrification, replacing coal and other fossil-fuels notably in cooking and surface heating. there is a reduction in the use of coal by households, although wood use remains the same. Coal is used primarily by lower income households.

The key additional transformations to compared to the REF should focus on accompany the lower-incomes in fuel switching away from coal.

Developing Paris-compatible COMMERCIAL BUILDINGS

Figure 16. Sectoral emission drivers and main aggregates (Index, 2019 base year)





- The urban planning we anticipate is influenced by South Africa's significant urbanization trend. More people are relocating to urban areas in pursuit of improved economic prospects. The growth rate of new building construction is gradual, reaching its peak around 2040 with the addition of 3.82 million m2 between 2040 in the REF / 4.78 million m2 in the 9GT. This indicator displays a two-year temporal lag in response to fluctuations in GDP.
- The decarbonization strategy relies on the reduction of the carbon content, the improvement of the energy efficiency & the reduction of the demand intensity.

The main drivers are :

- the decreasing carbon content due to a further acceleration of sustainable designs and renewable energy solutions.
- Increased adoption of sustainable and energy-efficient designs.
- Urban planning addressing spatial inequalities and fostering social cohesion. A more compact urban planning will lead to also reduce transportation needs.

The key additional transformations to compared to the REF should focus on developing on compact urban planning, increase the access to essential utilities, and developing sustainable designs and smart grid technologies.

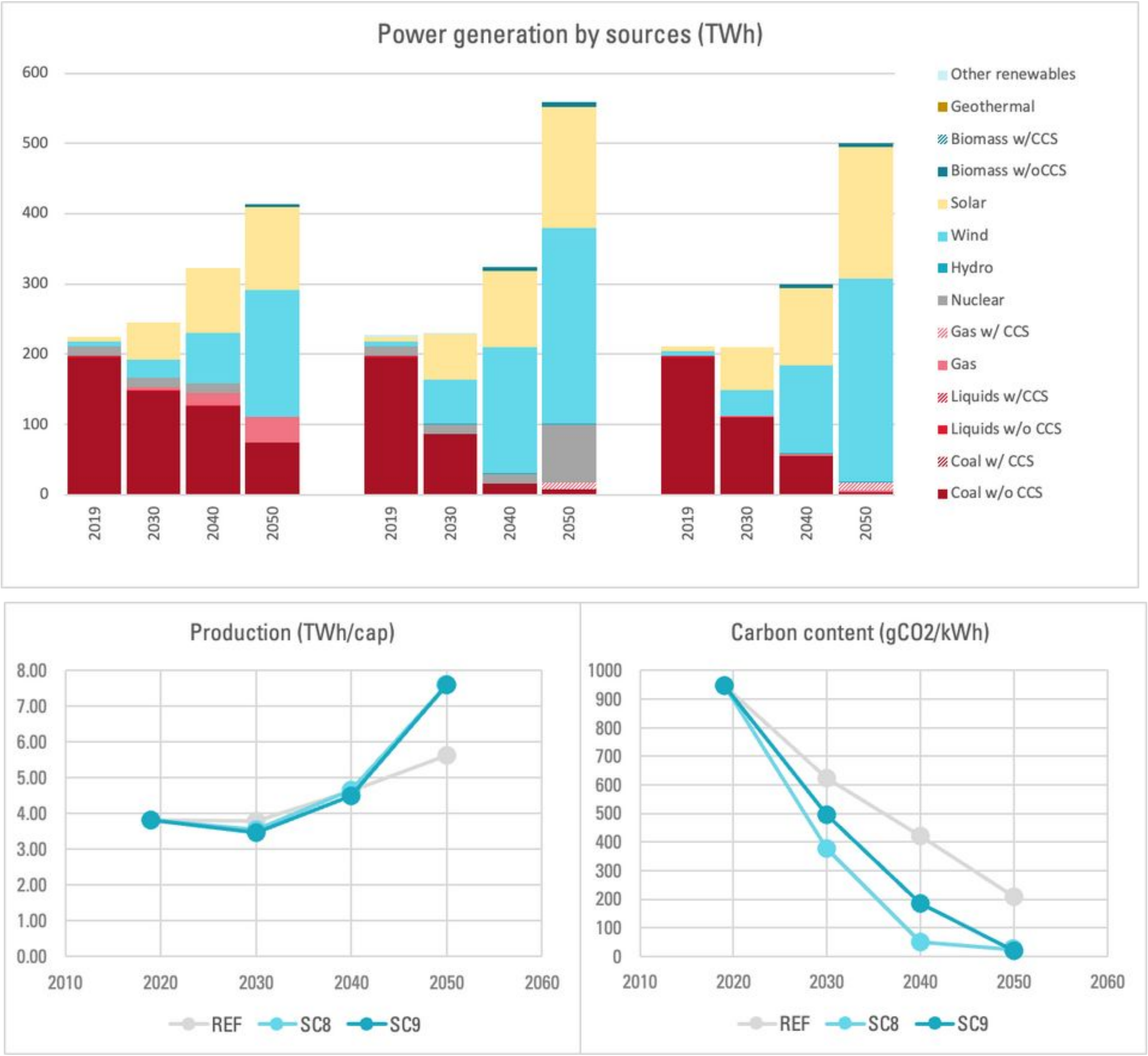
Part 2.2

-

Transition of energy-related emission sectors:
Power generation, Extractive energy industries, Other energy production industries

Decarbonizing POWER GENERATION

Figure 17. Power generation by sources (Top, in TWh) and production emissions / electricity carbon content (Bottom, in TWh/cap & gCO2/kWh) .



- Power production is expected to increase similarly in all three scenario until 2040 : the growth in electricity consumption until 2035 is primarily driven by increased industrial activity, some fuel switching, and initial electric vehicle (EV) penetration.
- After that, there is a significant increase in the 9GT & 8GT, reaching to 8,2 TWh/cap in 2050 : a fivefold growth in transport is driven by a large increase in EV uptake and the phase-out of internal combustion engines (ICEs). In all three scenarios we also observe a decarbonization of the carbon content, but his effect is stronger in the 9GT & 8GT, reaching 20gCO2/TWh.

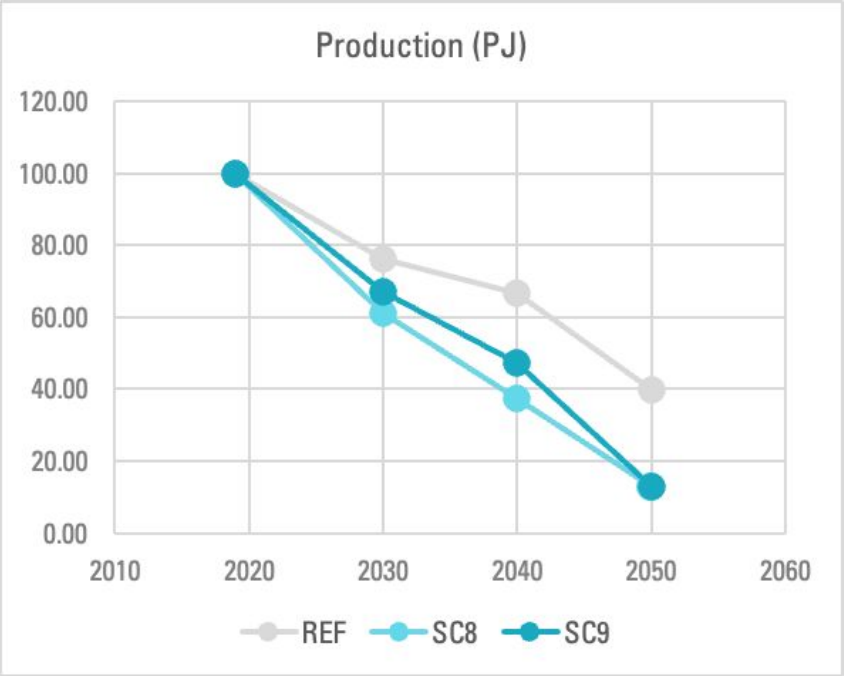
The main drivers are :

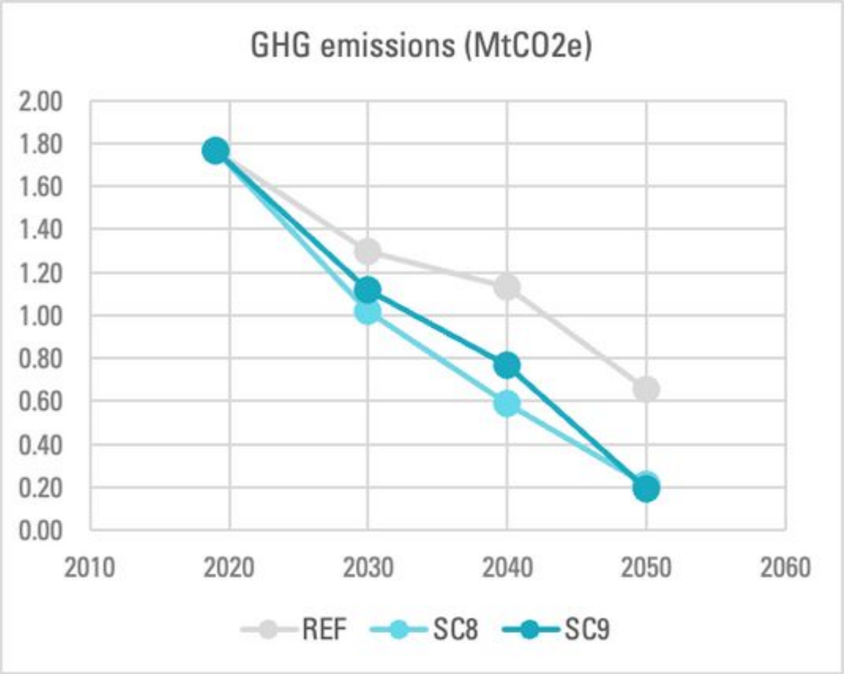
- a massive electrification, notably in residential buildings and light industries: electricity production per capita will be 40% higher in the 9GT in comparison to the REF in 2050, whereas the levels are similar in 2030.
- the decarbonization of electricity production with the decommissioning of coal power plants. and large-scale deployment of non-fossil fuels: wind, and solar and nuclear power.
- the development of CCS infrastructures for gas power plants in the 2040s.

The key additional transformations to compared to the REF should focus on implementing policies and regulations setting ambitious renewable energy targets, investing and advances in renewable technologies, transitioning away from coal, enhancements in grid infrastructure.

Decarbonizing EXTRACTIVE ENERGY INDUSTRIES

Figure 18. Coal, Oil and Gas production (Top, in PJ) and production emissions / carbon content (Bottom, in MtCO2e & MtCO2/MJ) .



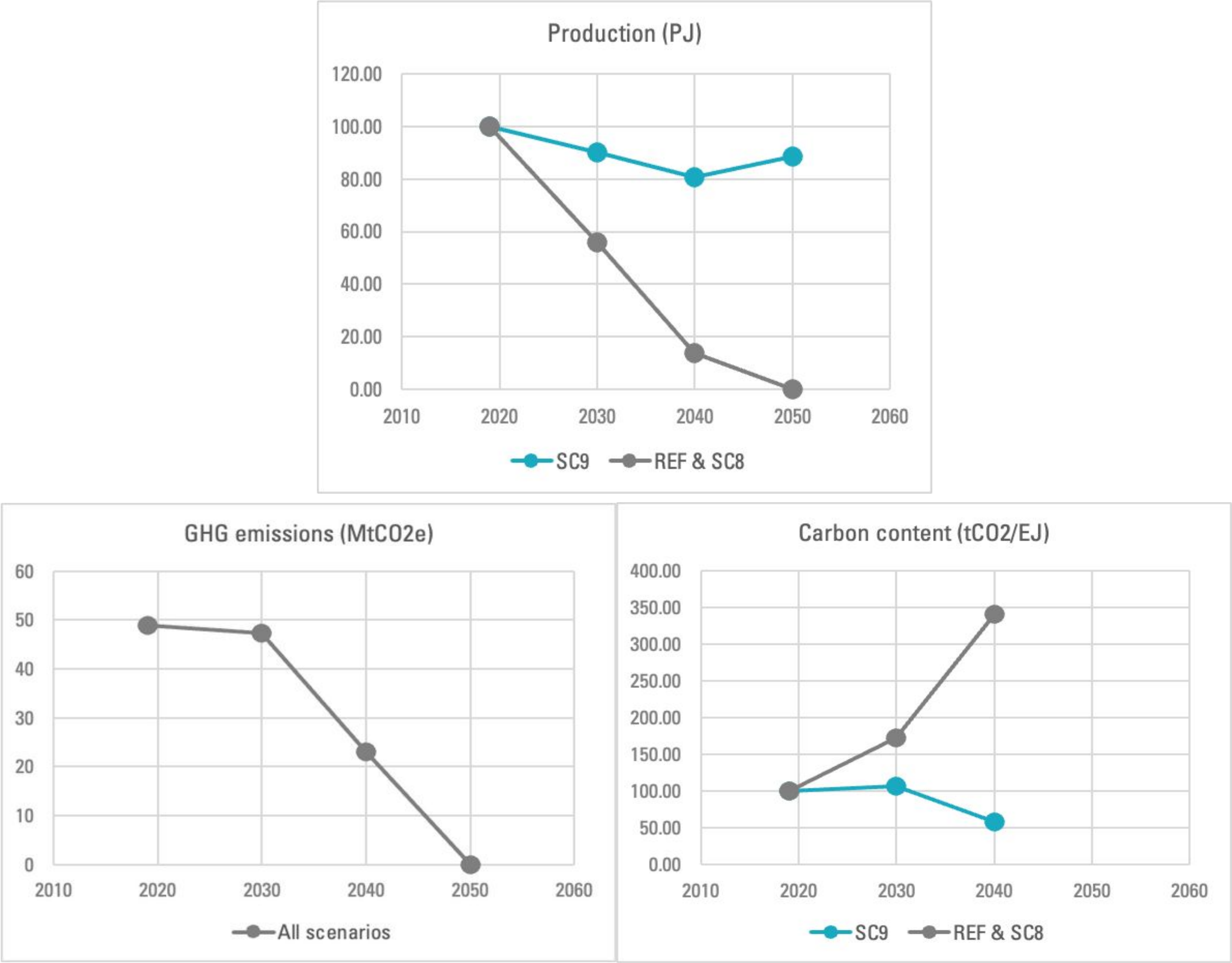


- Global production and GHG emissions are expected to decrease all scenarios : reaching 0,6 EJ& 0,2MtCO2e in 2050 in the 9GT.
- The 9GT scenario shows a decrease in coal production, for domestic uses & exports. Raw coal production is projected to decrease by 35% from 2020 levels by 2030, with significant declines in both the power sector and exports. It will then decrease by 70% in 2050 in comparison to 2020 levels, leading to its phase-down in power generation and refineries.

- Domestic production of gas is negligible and there is no production of crude oil. Gas imports are expected to stay consistent through 2030, but imports of crude oil are anticipated to drop by approximately 50%.
- By 2050, crude oil imports will be nearly eliminated, and imports of finished petroleum products will initially increase in the 2030s then fall to about 30% of 2020 levels, whereas gas imports will increase and then decrease, but still be higher than 2030 levels, mainly due to their use in the power sector.

Decarbonizing OTHER ENERGY PRODUCTION INDUSTRIES

Figure 19. All other final fuel production* (Top, in PJ) and production emissions / carbon content of energy produced (Bottom, in MtCO2e & MtCO2e/MJ)



*All other solid, liquid, gaseous final fuel production activities (e.g. refineries, H2 generation, ...)

- Synthetic fuels production accounts for most of the emissions from this category. Sasol, the incumbent synthetic fuels and chemicals supplier has stated they will gradually phase out their emissions: and this accounts for the decline in the emissions in all three scenarios.
- CTL production is set to decrease steadily until 2050, adhering to current policies. Crude oil refineries shutting down by 2035. Meanwhile, hydrogen electrolysis is expected to increase significantly, reaching 0.11 EJ by 2050, with biomass extraction also nearly doubling from 2030 levels, primarily for industrial use as hard to abate sectors like chrome require it. Bituminous coal extraction continues to serve the power until the coal power generation is phased out. Industrial sectors still require heat, and coal is the cheapest source of heat.
- Biomass extraction is set to triple for industrial use to replace fossil carbon for chrome smelting, and for energy in other sectors like cement and pulp and paper.

- Crude oil imports dwindles as the shift to electric vehicles takes place. This happens at a much faster pace in the decarbonizing pathways. And gas (imported) plays a role in some industries but is most notably used for the power sector where it is used to provide stability and reliability to the largely RE based generation of electricity on the grid.

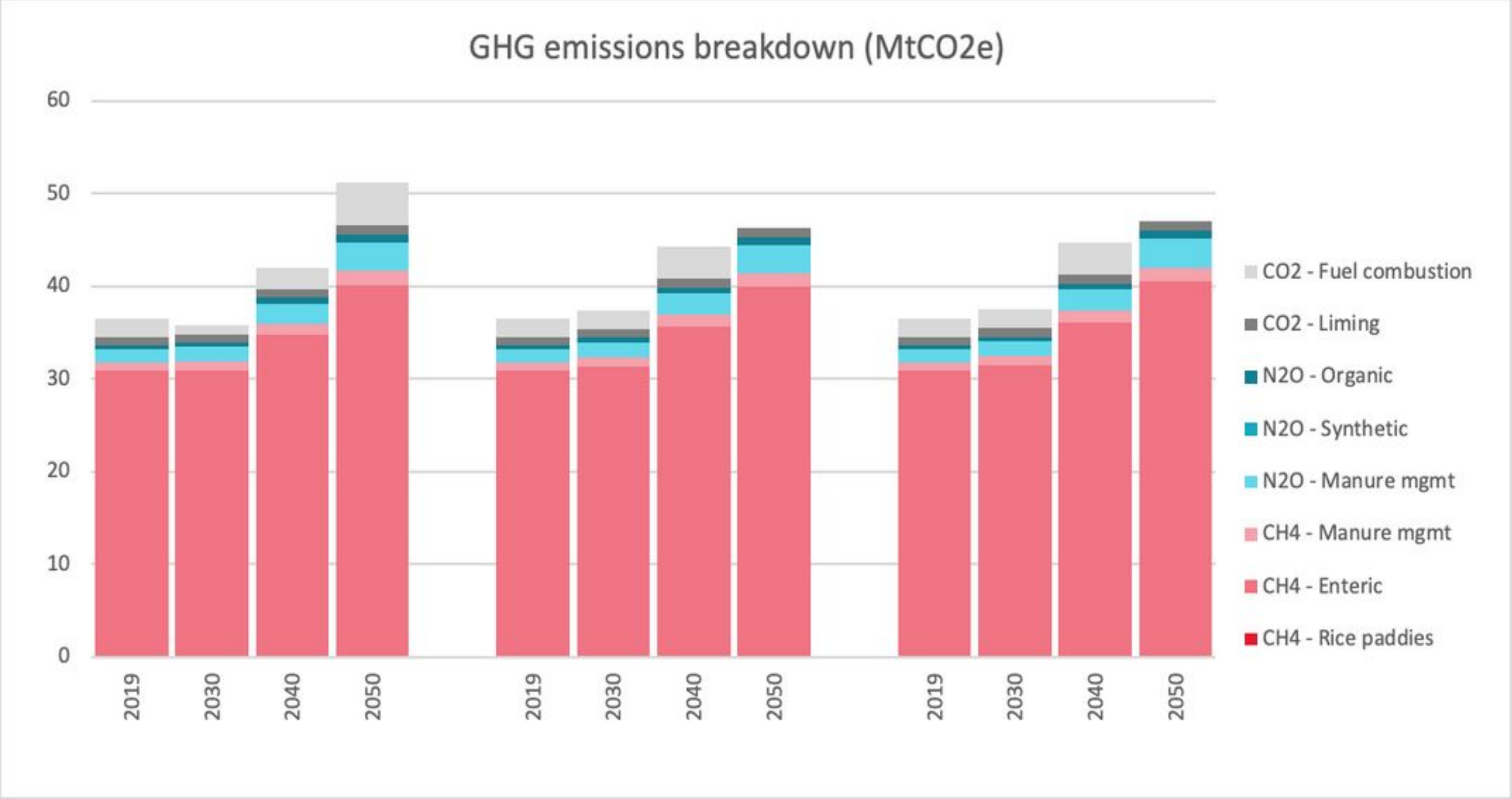
Part 2.3

-

Transition of non-energy related emission sectors:
Agriculture, Forestry and Land use change, Waste

Developing a Paris-compatible AGRICULTURE sec tor

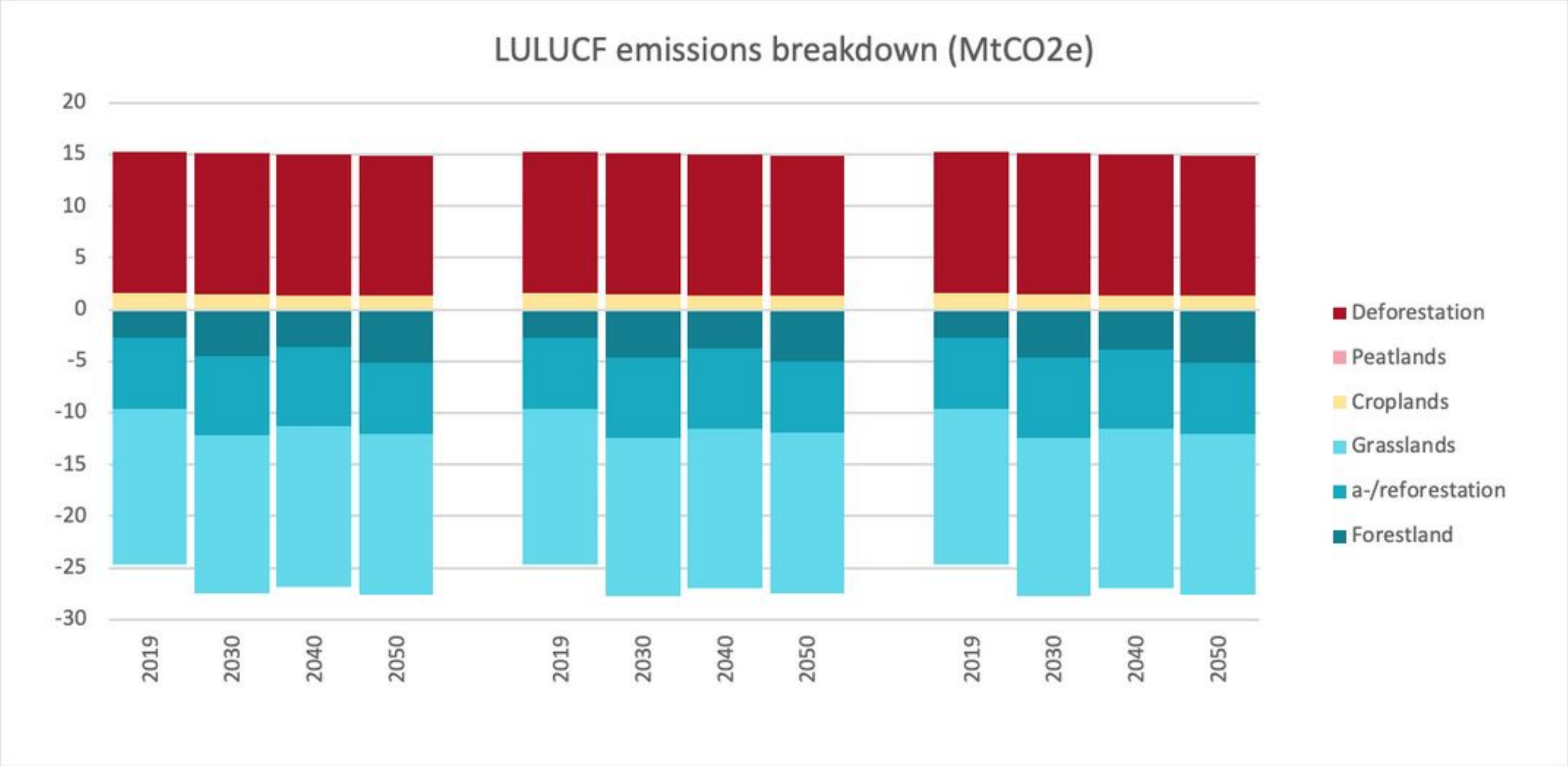
Figure 20. Sectoral emission drivers and main aggregates



- GHG emissions from agriculture increases in all scenarios, but less in the 8GT scenario (27%) and 9GT scenario (29%) than in the REF (40%).
- The main emission source is CH4 from enteric fermentation, which accounts for most emissions in all scenarios. The increase in enteric fermentation emissions is also the main source of the emission increase in all scenarios.
- Drivers of the emission increases include a controlled increase in meat consumption in the 9GT scenario compared to the REF scenario, where the increase is higher. Consumption of cereals and vegetables and fruits increase.
- Furthermore, demand for biomass increases energy and industrial purposes, especially for heating, and in the food and sugar industries, and pulp and paper.

Developing a Paris-compatible LULUCF sector

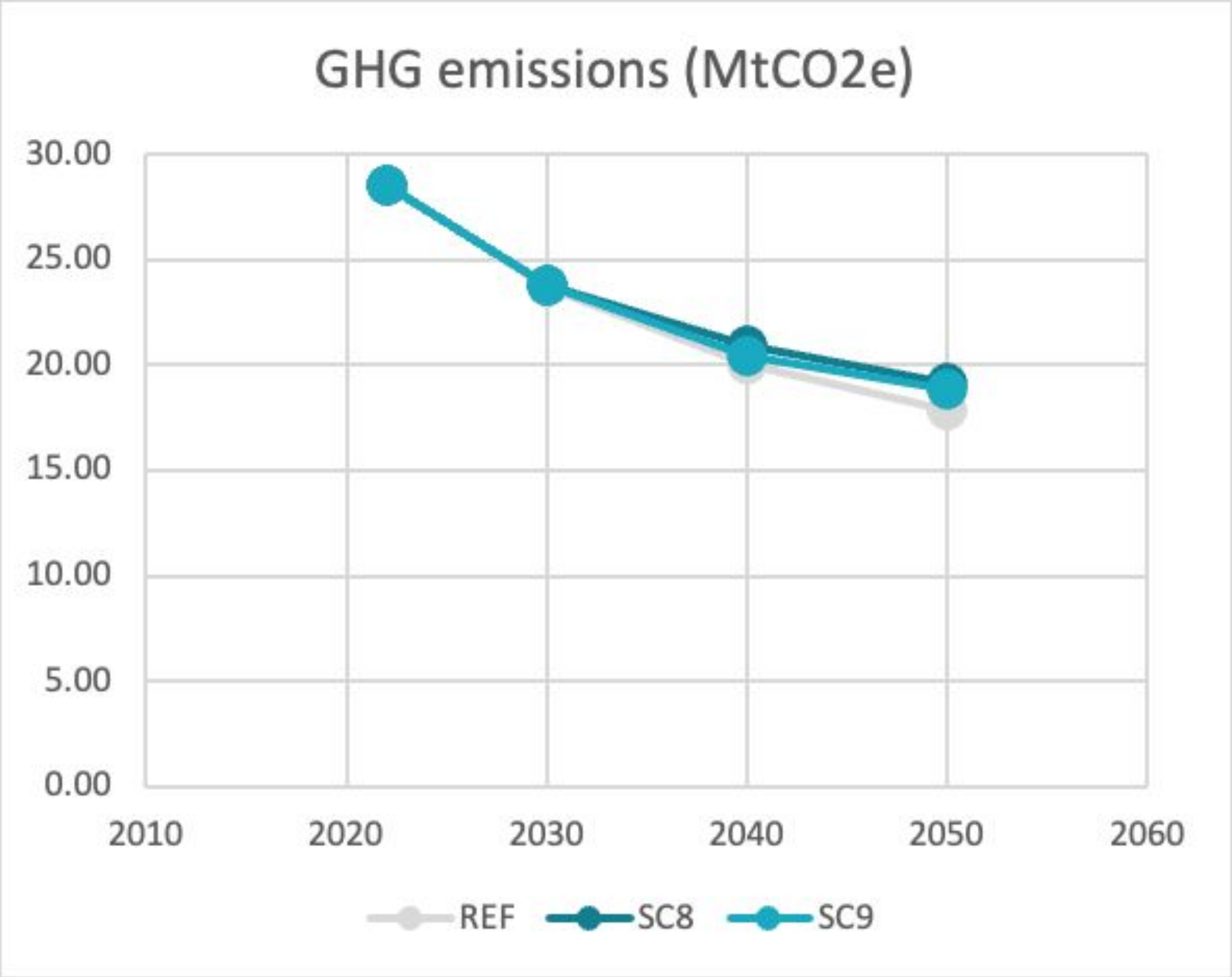
Figure 21. Sectoral emission drivers and main aggregates



- The LULUCF sector contributes as a carbon sink to South Africa's GHG inventory and thus plays an important role in the country's future climate ambition.
- A future decarbonized South Africa will require the LULUCF sector to remain a carbon sink if not to grow in the overall amount sequestered. This will require comprehensive land use policies integrated with agriculture sector. The role that biomass has in the energy sector also means that a bioenergy policy will also need to be considered from a LULUCF perspective and managed accordingly.

Developing a Paris-compatible WASTE sector

Figure 22. Sectoral emission drivers and main aggregates



- GHG emissions from the waste sector reduce similarly in all scenarios (by -30-35%), but slightly more in the REF scenario.

- In the 8-ton scenario, mitigation actions in the waste sector includes
  - Demand side action to reduce solid waste, for instance by changing packaging
  - Increasing the share solid of waste that is recycled (including into reusable nutrients via composting)
  - Improving waste collection and disposal services
  - Programs to improve the biological treatment of solid and liquid waste

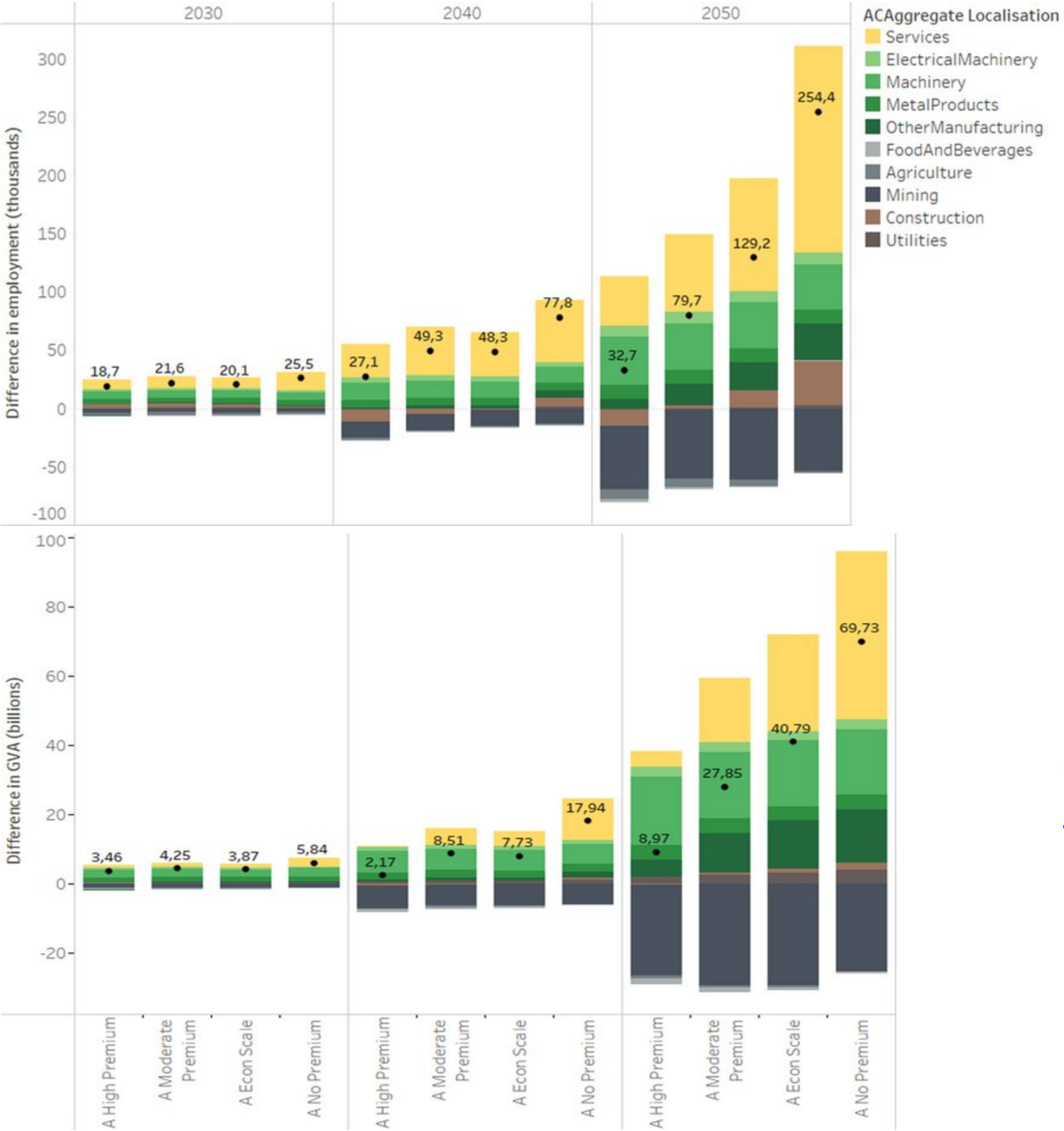
Part 2.4

-

Deep Dive on localisation of renewable energy technologies in South Africa

Positive impact of localisation

Figure 23. Impact of localisation on employment and on GDP



Key considerations for this outcome are:

- A consistent rollout of renewables (demand of MWs constructed) is essential to attract investment into the factories to produce the technologies in South Africa. Government has a key role to play in ensuring that consistent demand is a certainty, as investors will not see private sector demand for renewables to be sure enough to warrant investment risk.

- The price increase of local products affects how this impacts the economy, but up to a certain point a price increase still has a positive overall impact on the economy.

- Measures are needed to help identify how to mitigate this, and support industries to keep costs down, build capacity and skills, and be competitive in the longer term.

See additional details in the [ESRG working paper : Assessing the economy-wide effect of localizing renewable energy value chains in South Africa](#)

Conclusions

-

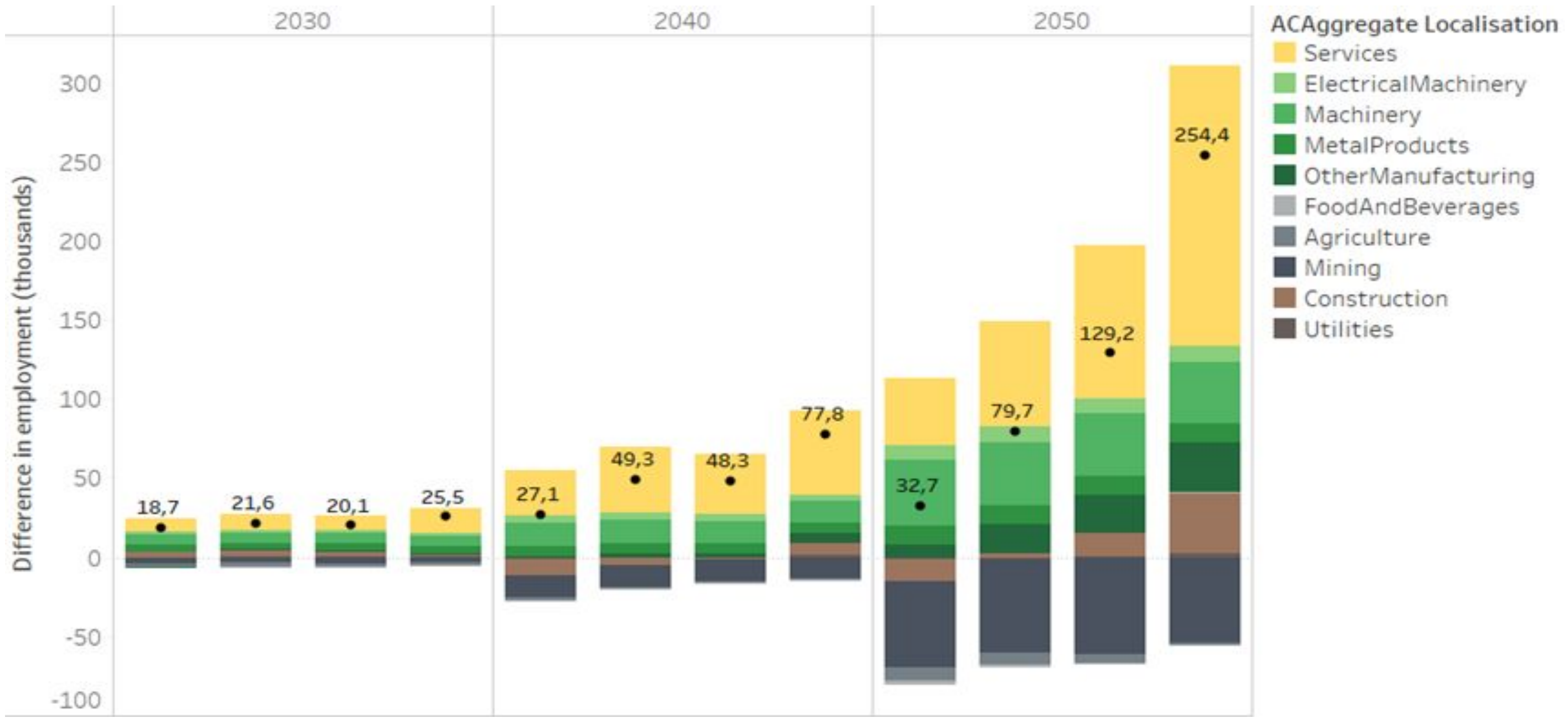
Key lessons for national & international climate and development decision processes

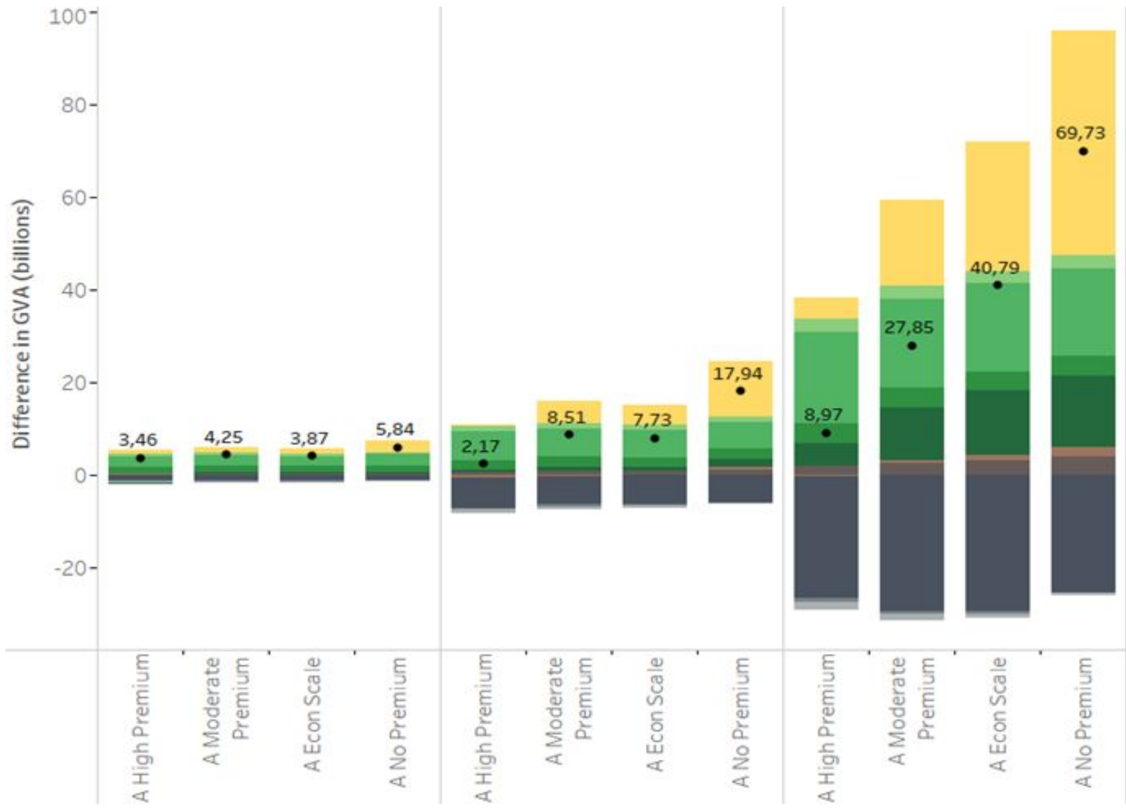
Lesson 1 - Key areas or sectors which require additional transformations

- South Africa’s Paris Compatible pathways analyzed here, show that a transition no matter at South Africa’s Paris Compatible pathways analyzed here, show that a transition no matter at what pace that is, requires clean electricity from solar PV and wind generating technologies.
- An increase in long term ambition translates simply to a faster deployment of these technologies to support the rest of the economy as industries, transportation, and other sectors electrify further.
- Some sectors like transport, within increasing mitigation pressure would see faster uptake of electric vehicles to harness the mitigating effect of a decarbonizing grid, while other sectors such as industry do not mitigate much faster (comparing 8Gt scenario to the 9Gt) owing to the added challenges in expensive technology transitions, and the fact that thermal requirements are still most economically met by burning coal.
- These transitions in each sector require dedicated transition plans that are just, and they need to be managed, or they could negatively impact the economy and development.

Lesson 2 - Key short-term national policy packages and priorities to implement them

- **A policy of supporting localization of the manufacturing of renewable technologies** within the country (technologies that the transition relies on) has been demonstrated to have economic benefits to the country through employment and economic development (See below). The benefit of a policy is evident in any pathway from now until 2050 as solar and wind technologies represent the cheapest source of electricity energy in the country; and the benefit of a localization strategy scales with increased ambition.
- A consistent rollout of renewables (demand of MWs constructed) is essential to attract investment into the factories to produce the technologies in South Africa. Government has a key role to play in ensuring that consistent demand is a certainty, as investors will not see private sector demand for renewables to be sure enough to warrant investment risk.
- The price increase of local products affects how this impacts the economy, but up to a certain point a price increase still has a positive overall impact on the economy. Measures are needed to help identify how to mitigate this, and support industries to keep costs down, build capacity and skills, and be competitive in the longer term.





Lesson 2 - Key short-term national policy packages and priorities to implement them

- South Africa's integrated resource plan (IRP) is the document at the heart of electricity planning in the country, and the latest draft (of 2023), shows more renewables are required in the coming few years, but is not likely to adequately address the serious electricity shortages. The IRP that government should adopt will need more expansion of capacity to meet electricity requirements, and with solar and wind technologies, this would be in line with a decarbonizing future South Africa.

- Transportation decarbonization relies largely on the adoption of electric vehicles in South Africa, and a key part of this adoption is the automotive manufacturing industry in the country and their shift to producing EV's. The EV White Paper outlines some aspects of how the industry in South Africa can transition to producing EV's, as well as the barriers to the transition. These barriers should be addressed early to ensure a faster and more economical mass adoption of electric vehicles.

- As electricity is the core part of the future in a decarbonized South Africa, energy efficiency policies will become more and more impactful and important to implement. It reduces cost to users and can play a role in helping the electricity system (grid). The current energy efficiency policies in South Africa are not finalized or adopted. Updating and formalizing EE strategy in South Africa is key to laying the foundation for future EE policies that will be vital in the future energy system.

Lesson 3 - Key international conditions to implement them

- For electricity, the transition to a lower carbon future will be next to impossible without social support for it and in particular the workers in the coal industry. This social support for the transition from coal requires the JETP to be fully funded and implemented, with particular emphasis on ensuring success in Eskom's JET efforts.

- A number of these transition elements require technology that is new (and potentially risky), such as hydrogen for steel, synthetic chemicals production, or not yet commercially proven CCS. In the case of transport – it requires EV adoption, but also investment in manufacturing locally. These elements are often in the domain of large multinational corporations that are based in other countries which means that for these transitions to happen in South Africa, favourable conditions for cooperation agreements in trade and investment is needed for companies to invest in South Africa facilities and markets.

- More broadly, underpinning all these elements of the transition in South Africa is the necessity of better and more access to finance options. For this to happen requires an international environment of multilateral cooperation on implementing the effort for climate mitigation is essential for this to happen. This is essential, for the transition to happen, to be just, and to be effectively managed by South Africa.

Annex 1 : DECARBONIZATION PATHWAY FOR SOUTH AFRICA - values

ZAF	2019	2030	2040	2050
Total GHG emissions (MtCO2e)	468	348	259	62
Total CO2 emissions (MtCO2)	390	275	181	-4
Total energy-related CO2 emissions (MtCO2)	365	265	171	22
Total final energy consumption (PJ)	2611	2528	2621	2650
Total Pop (Million)	59	65	70	74
Total GDP (Billion USD (2015))	264	341	486	662