Portfolio Committee on Mineral Resources & Energy

Impact of the increasing fuel prices on the economy and possible alternatives and/or considerations in addressing increases in fuel prices

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science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

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AGENDA

- Overview CSIR
- Key takeaways
- Context of the South African energy system
- Transportation system impacts
- Liquid fuels in electricity generation
- Liquid fuels in mining
- Alternatives to traditional liquid fuels
- CSIR R&D to support new and emerging opportunities
- Key takeaways

Overview CSIR

(supporting industry and a capable state through directed R&D)

CSIR mandate

CSIR MANDATE

"The objects of the CSIR are, through **directed** and **particularly multi-disciplinary research** and **technological innovation**, to foster, in the **national interest** and in fields which in its opinion should receive preference, **industrial** and **scientific development**, either by itself or in **co-operation with principals** from the **private** or **public sectors**, and thereby to contribute to the **improvement of the quality of life** of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

(Scientific Research Council Act 46 of 1988, amended by Act 27 of 2014)

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Strategic objectives

Conduct research, development and innovation of transformative technologies and accelerate their diffusion

Collaboratively improve the competitiveness of high-impact industries to support South Africa's re-industrialisation

Drive socioeconomic transformation through RD&I that supports the development of a capable state

Build and transform human capital and infrastructure

Diversify income and maintain financial sustainability and good governance

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Technology – Sector Clusters

Positioned to drive SA's industrialisation

Industry advancement clusters

Advanced Agri & Food
Innovate to strengthen primary production, agro-processing and advance rural economies

Future Production Chemicals
Establish state-of-the-art (bio)-chemistry to drive local pharmaceutical and the broader chemical industries

NextGen Health
Develop technologies to drive improved health outcomes and patient-centric healthcare delivery

Future Production Manufacturing
Strengthen manufacturing value chain to enhance Industry Competitiveness

Future Production Mining
Support the growth and revitalisation of the mining industry

Defence & Security
Build resilient defence and security capabilities to strengthen national security technology capacity

Industry and society enabling clusters

SMART Places
Effect smarter resource use, sustainable economic growth and smart infrastructure and service developments

SMART Mobility
Enable South Africa to have an efficient, effective and integrated logistics systems and infrastructure

NextGen Enterprises & Institutions
Support the digitalisation of government, public institutions and private sectors

The clusters are technology industry convergences that represent the CSIR's strategic focus.
They have been selected based on national priorities, potential for socioeconomic impact and the fourth industrial revolution.

Key takeaways

(Specific opportunities for South Africa)

Key takeaways/actions (immediate context)

- **Mining operations consume 2.2 billion liters** of fuel per annum. Large multi-national Mining Houses are pioneering decarbonization to reduce cost and achieve product premiums. Need to **support Junior Miners, local medium-size and large Miners and local OEMs to achieve their decarbonization targets and localize the value chain**
- **Transportation consumes 24 billion liters**. **Structural shifts** are required in transportation sector and **Eco-Mobility to improve efficiency and social cohesion**, reducing the volumes of liquid fuels and related price shocks
- In **2021 Eskom used 1 billion liters of diesel** for Peaker power production due to a seriously constrained power system resulting in an **additional cost of R10.8 billion. Additional power generation capacity is urgently required**

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Key takeaways/actions (emerging opportunities)

- **Bioenergy has relatively limited potential** due to rainfall constraints, food security and variability of supply in South Africa
- **Opportunity to transition from domestic Coal-to-liquids to Biomass-to-liquids** through **repurposing of Sasol and PetroSA infrastructure**
- **Global decarbonisation is driving innovation and markets in Power-to-X** (sustainable fuels and chemicals from renewable energy). South Africa can **produce Power-to-X products at competitive cost** into a range of **export markets that are prepared to pay a premium for green products**. Such infrastructure can also **support and develop the local markets**

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Key takeaways/actions (strategic investment required)

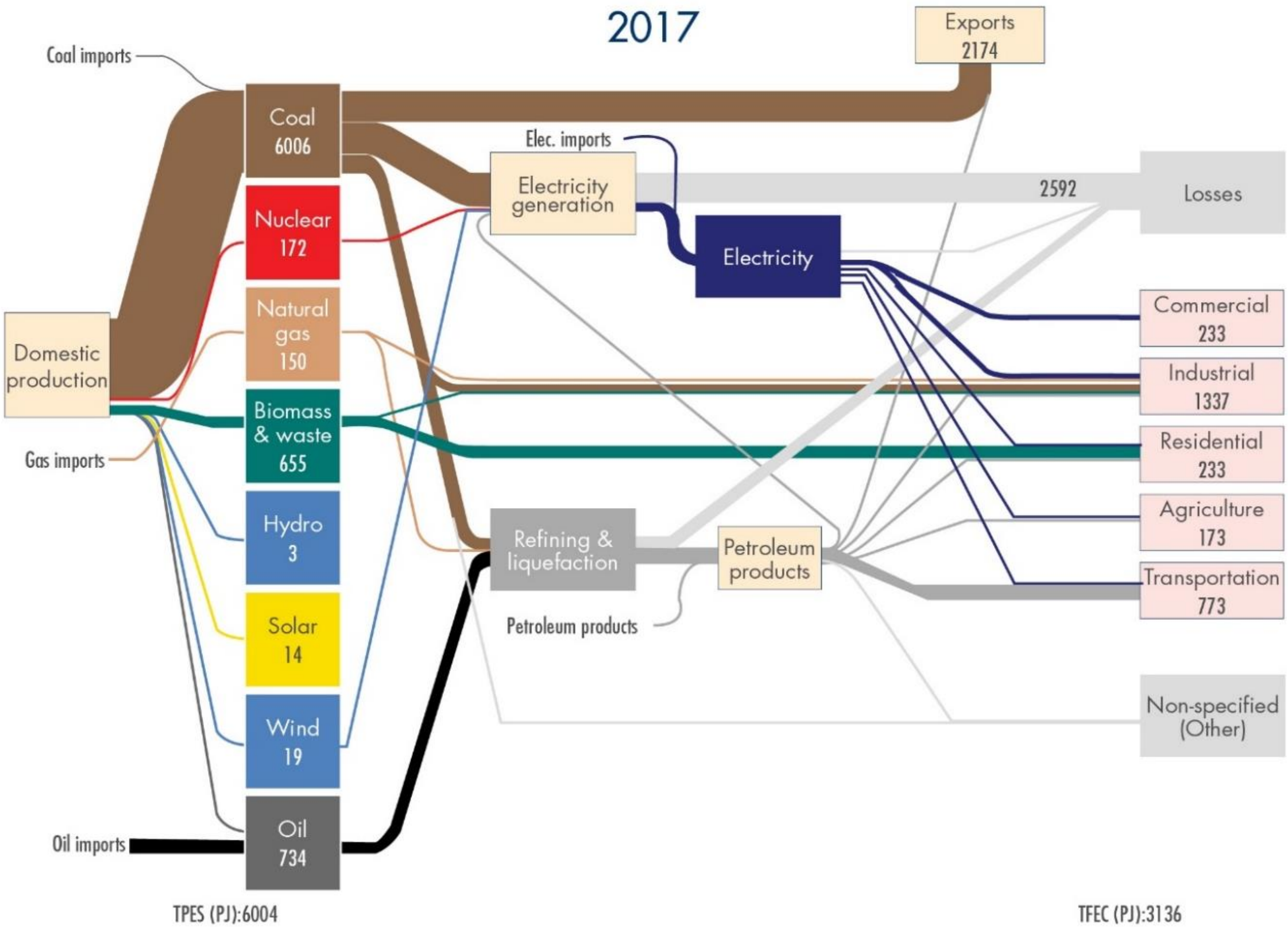
- Need to **implement and accelerate the Hydrogen Society RoadMap (HRSM) for South Africa**
- As aligned with the HRSM, there are **local markets/technologies with specific opportunity**:
  - **Mining** through accelerated **battery and hydrogen** technology adoption
  - **Battery electric vehicles** for light vehicle transportation
  - **Hydrogen electric vehicles** for long haul road transportation
  - **Hydrogen powered locomotives** for rail
  - **Sustainable bunker fuels** for maritime shipping
  - **Sustainable aviation fuels** for long haul aviation
- **CSIR R&D to support this market and technology development requires support and acceleration**

Context of the South African energy system

(Relative role of liquid fuels in our energy system)

SANKEY Diagram of South African Energy system

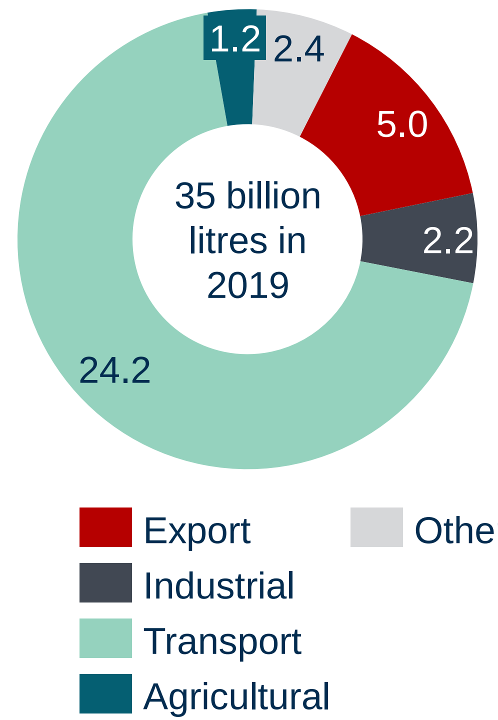
Majority of liquid fuels used in transportation (sourced from imported oil and coal and gas to liquid)



South African Sankey drawing

Flows in units of PJ/yr = Petajoules per year; TPES = Total Primary Energy Supply; TFEC = Total Final Energy Cosumption; All information in this graphic is based on offically published DMRE Energy Balance data.

End-use of petroleum products



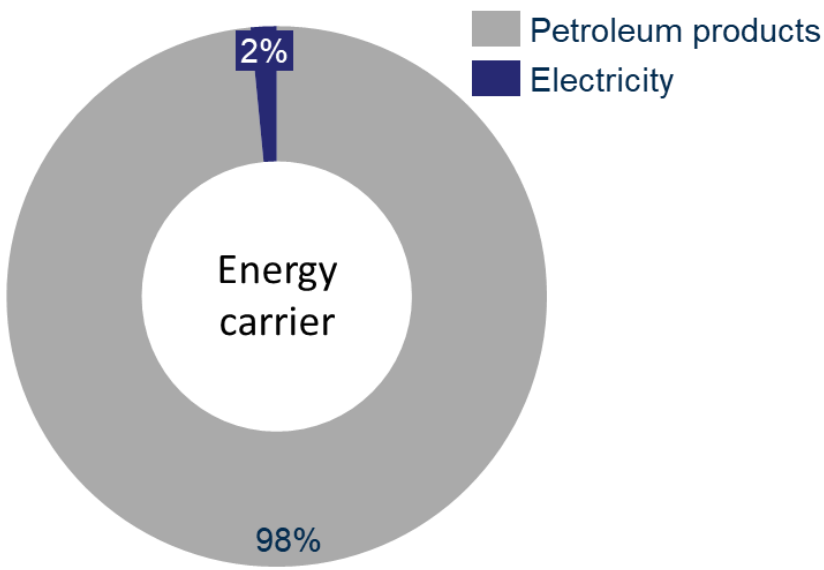
Source: SAPIA and FTI 2020

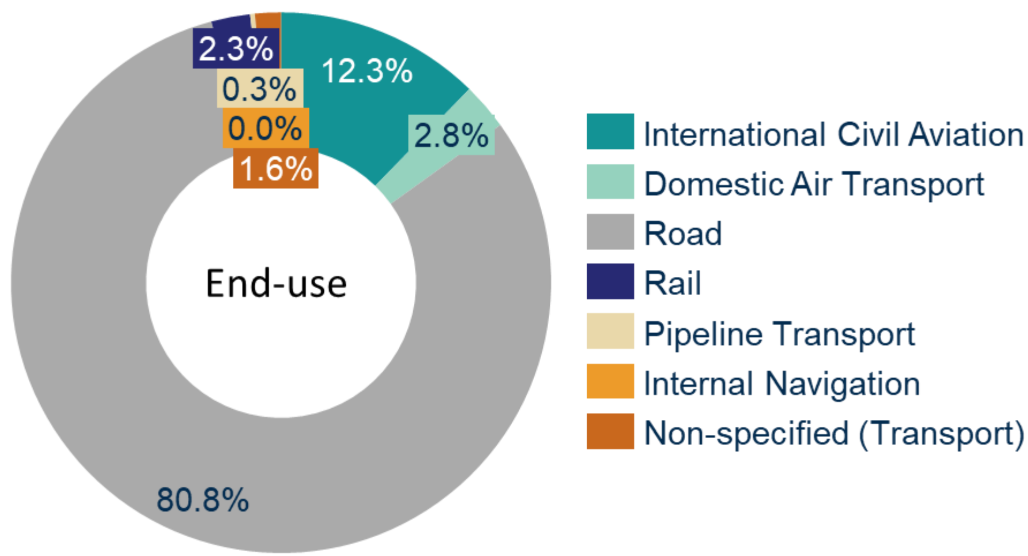
Transportation system impacts

(CSIR work on transportation opportunities and the implications of fuel costs)

Energy balances for the transport sector
98% dependence on petroleum productions for the transport sector

Energy carrier and end-use in transport from the 2017 DMRE Energy Balances.

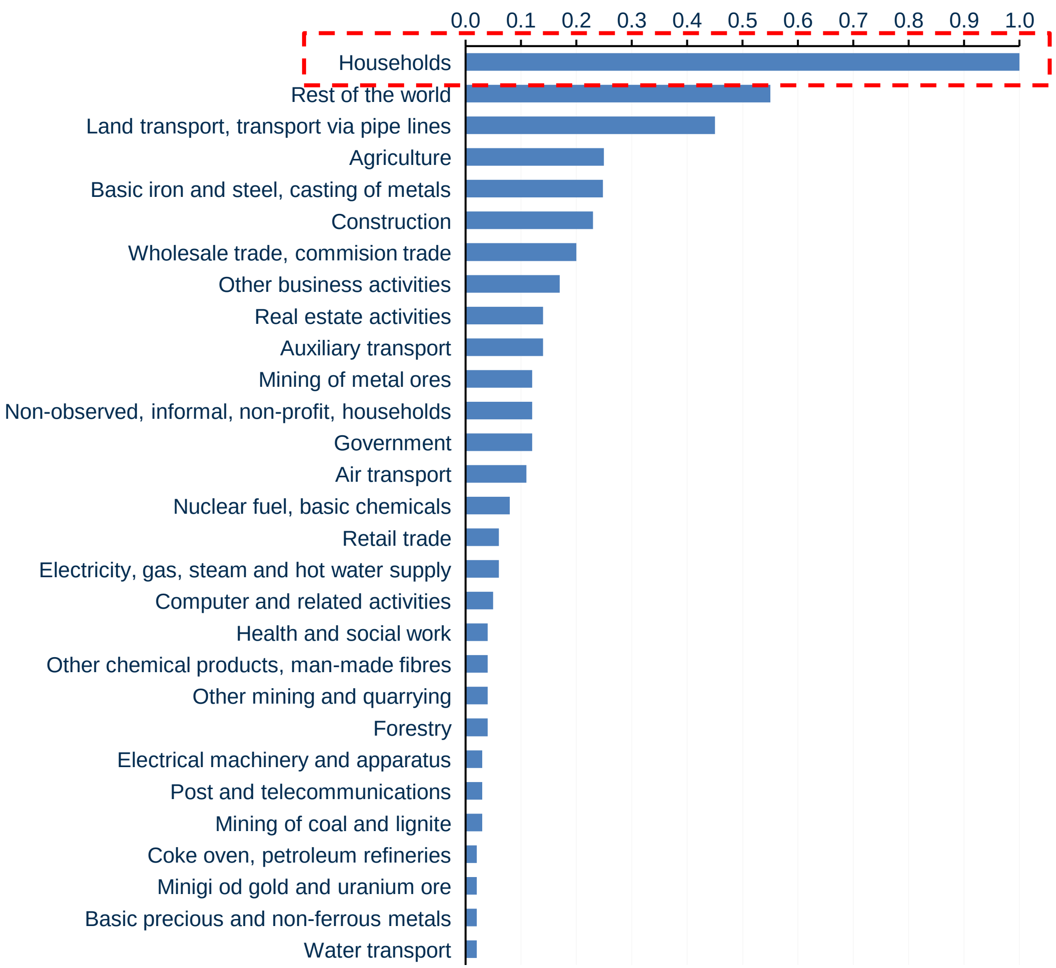




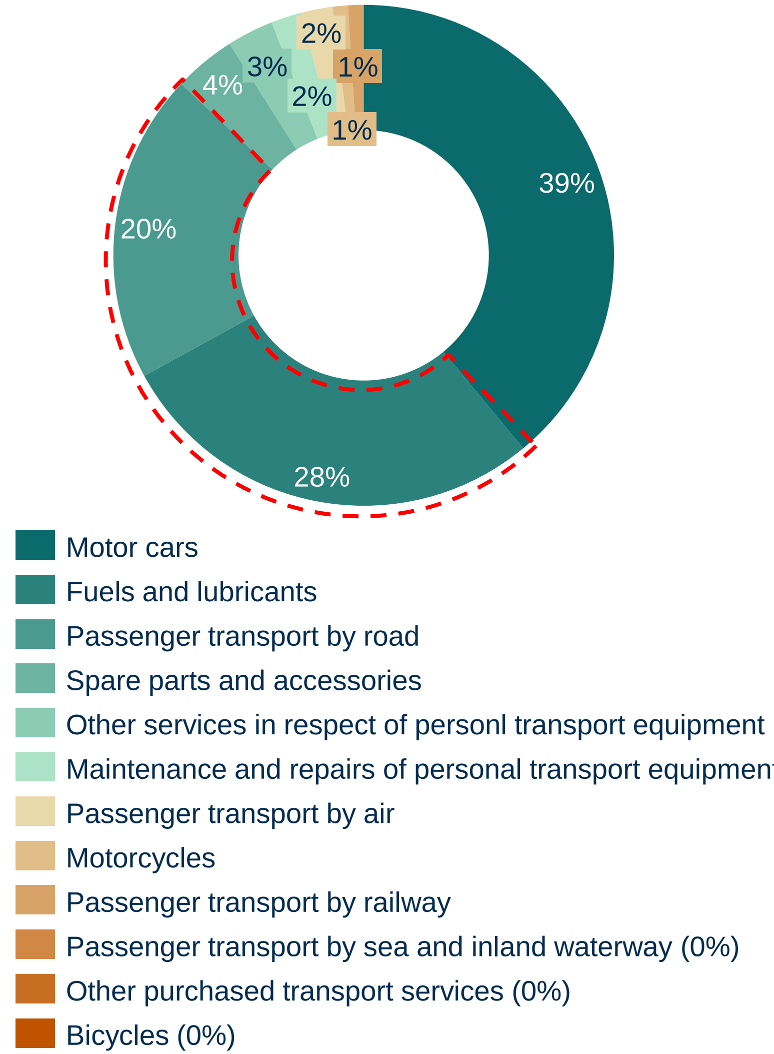
Relative petroleum product consumption sold in South Africa

Households are the largest consumers of petroleum prod. (passenger transport)

Relative petroleum products consumption by economic activity

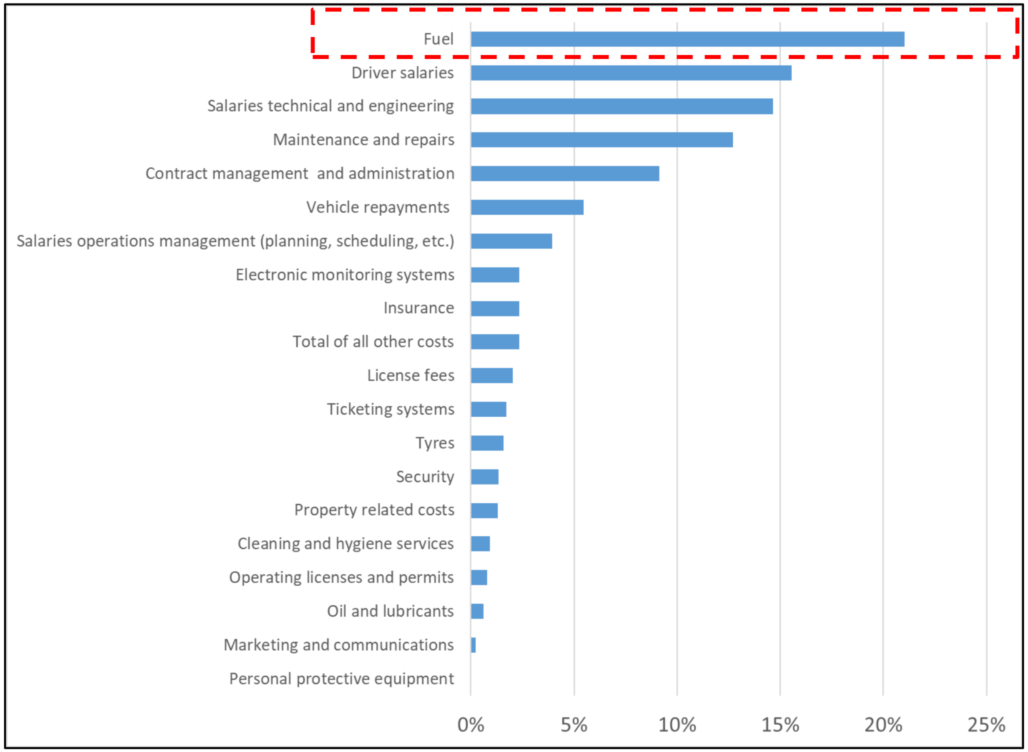


Household transport expenditure profile

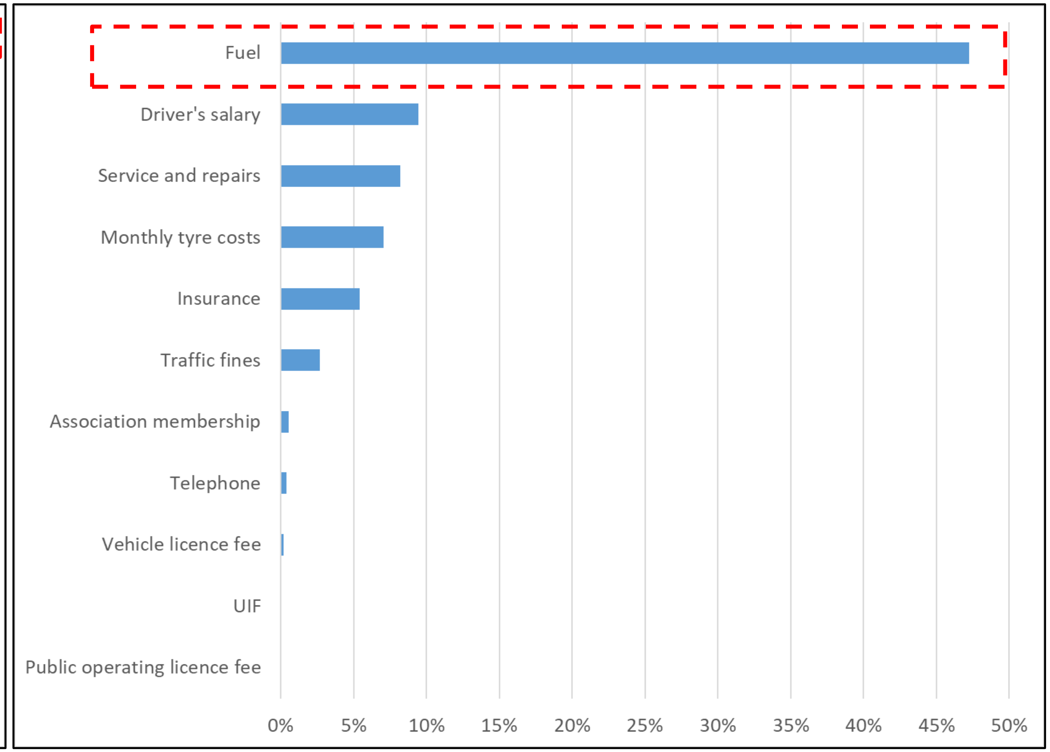


Typical cost structures of road-based public transport services - Fuel is the leading cost driver

Government subsidised bus service



Minibus taxi service



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Sensitivity of households to changes in transport service attributes through detailed surveys

Attribute	Relative elasticity	t-ratio
PublicTransport_ Cost	**-1.034**	-24.254
PublicTransport_ Quality	-0.979	-26.323
PublicTransport_ Access	-0.78	-21.034
Car_Access	0.856	10.57
MinibusTaxi_ Constant	0.845	11.076
Car_Constant	-3.173	-15.84
Car_Cost	-1.18	-21.156
Bus_Constant	0.288	3.565
NewPublicTransport _Constant	0.397	4.99

The CSIR conducted country-wide surveys and modelling on sensitivity of population to transport service attributes:

- South Africans **relatively more sensitive to public transport cost** more than quality, ease of access
- Therefore, providing better quality services and more accessible services **must not cost disproportionately more**
- **Increasing prices without a better service becomes gross injustice**
- **Price increases vulnerability**: increased safety and security risk for those choosing to walk; longer travel times (operators using less vehicles); increased unemployment (reduced demand for goods; lower number of job seekers)

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Summary of CSIR conversations with cities on what should be done to improve sustainability (Appropriate Mitigation Actions)

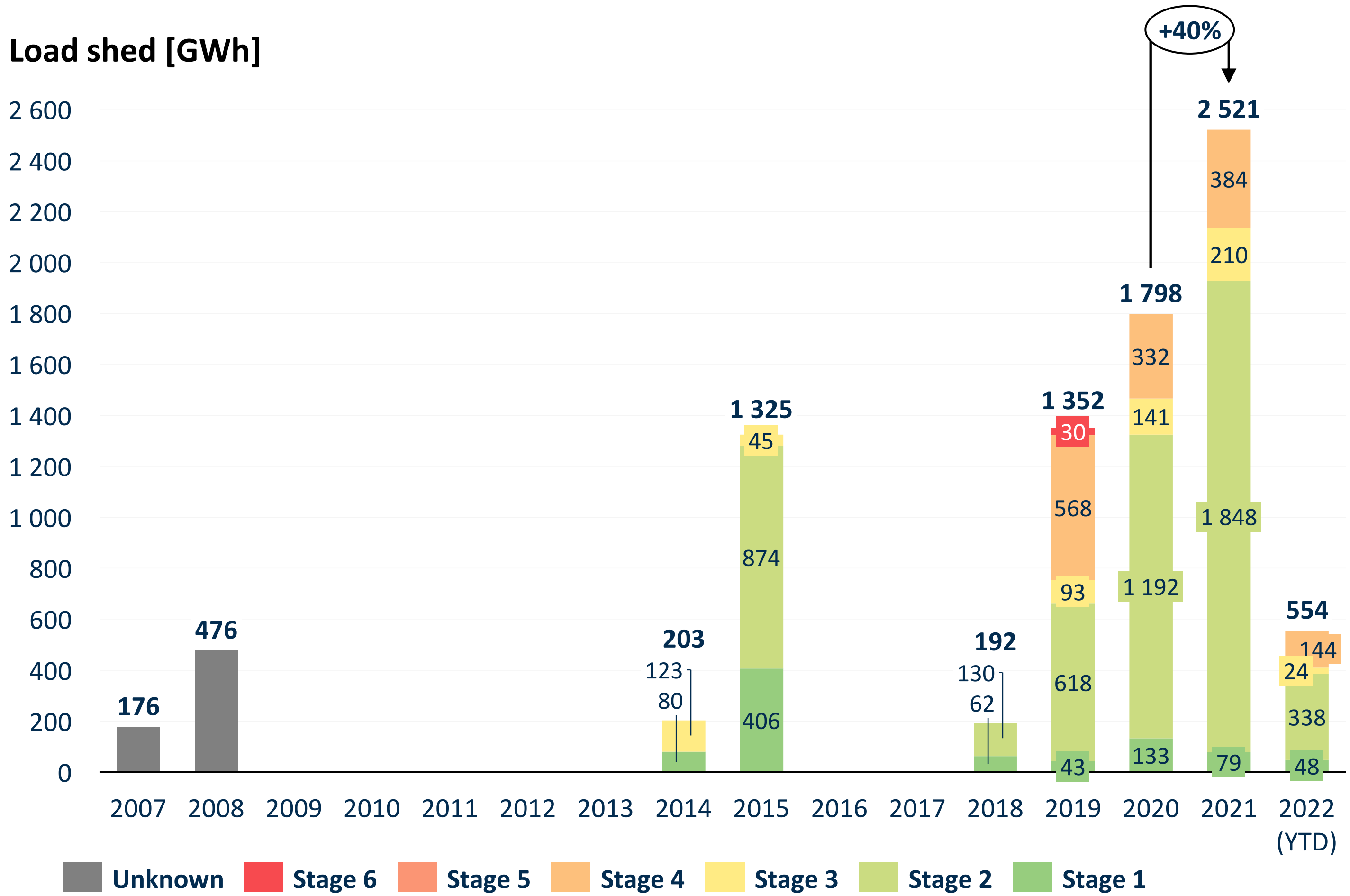
Structural	Encourage shifts to more sustainable travel	Improve infrastructure and systems
1. Densification and land use diversification around public transport nodes **2. Location of government housing programmes near rail stations** 3. Increase use of telecommunications as a substitute for physical travel 4. Improved planning and implementation capacity in local government 5. Introduce compressed work week and staggered shifts, starting/ending outside of peak periods and/or allowing employees to work flexitime	1. Investment in quality high-capacity public transport services 2. Park and ride facilities near high-capacity public transport services 3. Rail should be increasingly used to transport freight 4. Package and market public transport and develop effective user information systems 5. Improved technological support for existing ridesharing platforms 6. Priority lanes for all public transport **7. Implement public transport subsidy policy** 8. Introduce improved bicycle parking and storage facilities: bicycle racks for temporary bicycle parking, close to the destination that is partially or fully protected from weather. Long term bicycle parking facilities should include well designed racks in covered locations along with lockers, showers and storage rooms 9. Introduce bicycle rental facilities and bike sharing systems (public bike systems), especially for short trips 10. Introduce pedestrian facilities such as wider sidewalks, crosswalks, midblock crossing should in order to enhance walkability 11. Implement a Large Employer Trip Reduction Plan. This entails a policy change, whereby the City passes a bylaw requiring all large employers, typically above 300 or 500 employees, to submit a plan to reduce the private travel to and from their place of work	**1. Capital subsidy for energy efficient public transport vehicles** 2. Encourage cleaner technologies (hybrid or electric vehicles) through carbon taxes or incentives 3. More intelligent traffic lights/intersection controls **4. Phase electric vehicles into the government-owned fleet in order to increase public confidence** 5. Ensure charging stations are more accessible.

Liquid fuels in electricity generation

(implications of power system constraints on liquid fuel use and costs)

2021 was most intensive loadshedding year and 2022 has not started well. .

A clear indication of a critically constrained power system



Year	Duration of outages (hours)	Energy shed (GWh)
2007	-	176
2008	-	476
....	....	....
2014	121	203
2015	852	1325
2016	-	-
2017	-	-
2018	127	192
2019	530	1352
2020	859	1798
2021	1169	2521
2022 (YTD)	261	554

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 MW, Stage 5 = 5 000 MW, Stage 6 = 6 000 MW; Cost to the economy of load shedding is estimated using COUE (cost of unserved energy) = 87.50 R/kWh

Sources: Eskom Twitter account; Eskom Hld SOC Ltd FaceBook page; Eskom se Push (mobile app); Nersa; CSIR analysis, Data last updated 13 March 2022 20:00

Diesel usage for open cycle gas turbines has steadily increased and reached a peak in 2022

Eskom

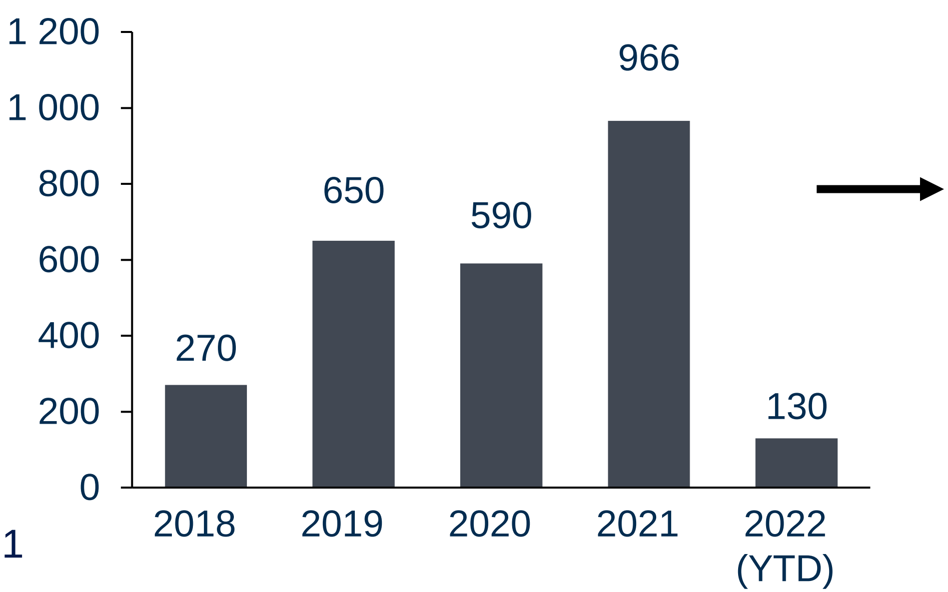
- Ankerlig: 1332 MW
- Gourikwa: 740 MW

Independent Power Producers

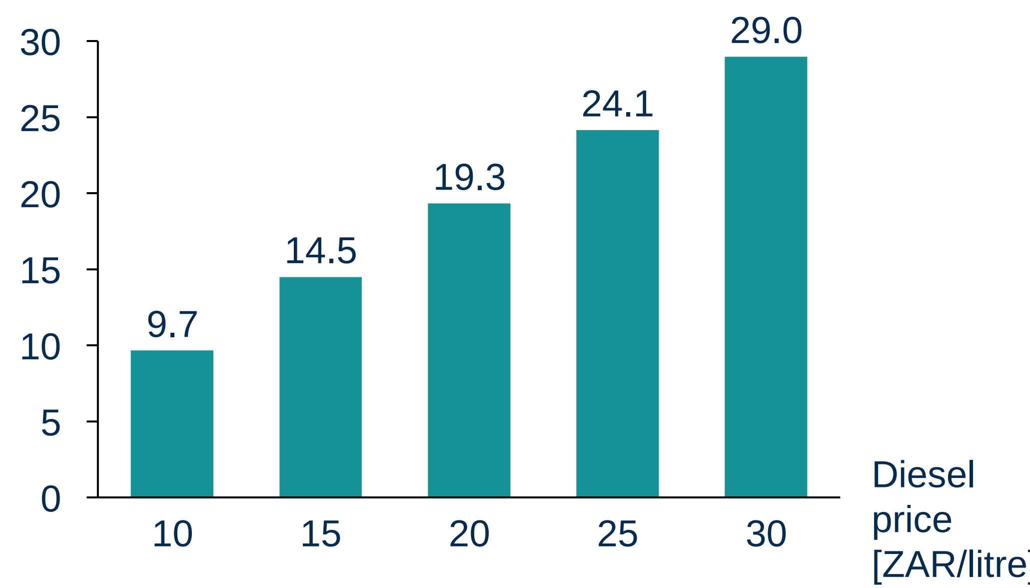
- Avon: 670 MW
- Dedisa: 335 MW

Ankerlig power station

Annual diesel consumption [M litres]



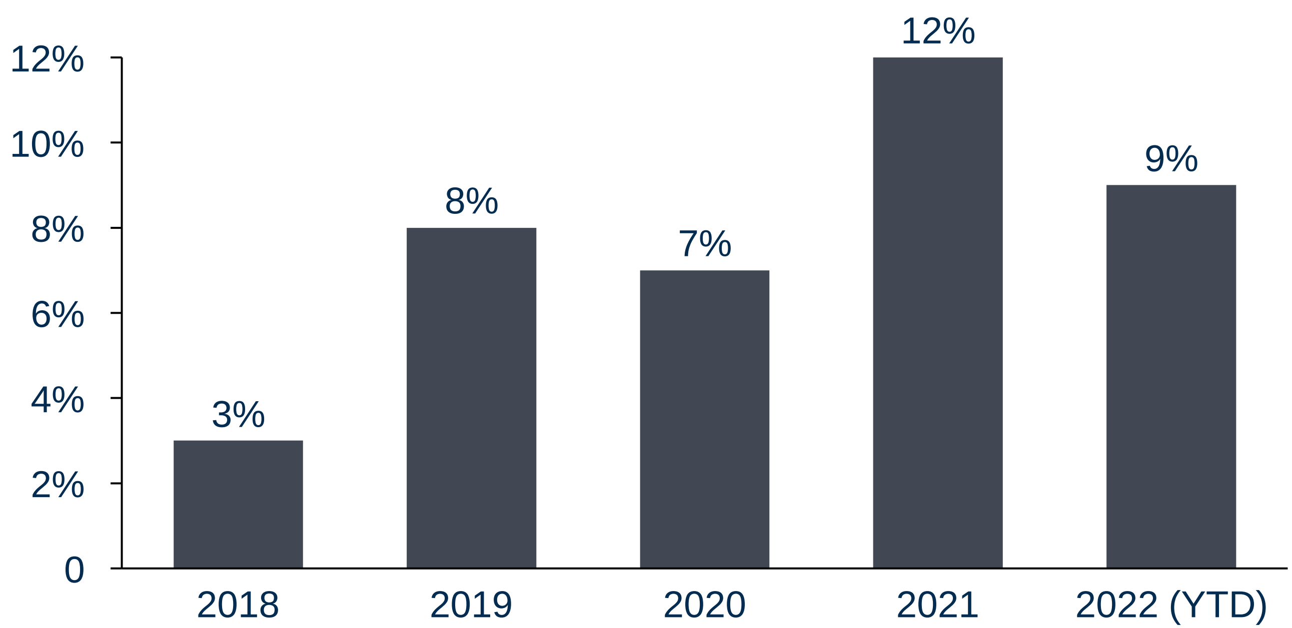
Annual diesel consumption for 970 M litres Cost [ZAR bln]



Diesel usage is in excess of normal system capacity factors and is a consequence of a highly constrained power system

- **Target/typical capacity factors for Peakers (OCGT) is about 3%**
- Due to **electricity crisis** (both capacity and energy constraints), the **usage of diesel-fired generation (OCGT) is much higher to avoid/reduce loadshedding**
- The current limitation on the utilisation of Peakers is **fuel logistics**

Increasing usage of diesel-fired Peakers (capacity factor)



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Increased usage of diesel fired peakers cost the South African power system an additional R10.8bln in 2021

- At R15/litre for diesel, **fuel cost is approximately R4.50/kWh**. For R20/litre, it is **R6.00/kWh**
- Currently **using four times more diesel burnt for Peakers due to constrained power system**
- In 2021 an **additional (but needed) 723 million litres of diesel** was burnt to reduce loadshedding. At R 15/litre, this **cost the country more than R 10 billion**
- In 2021, Eskom's total electricity operating expenditure was R 196 billion. The diesel cost 'premium' was, thus, approx. **7.5% of the operating expenditure**
- At R 20/litre and if Peakers are utilised as in 2021, the additional cost the country is **R 15 billion**

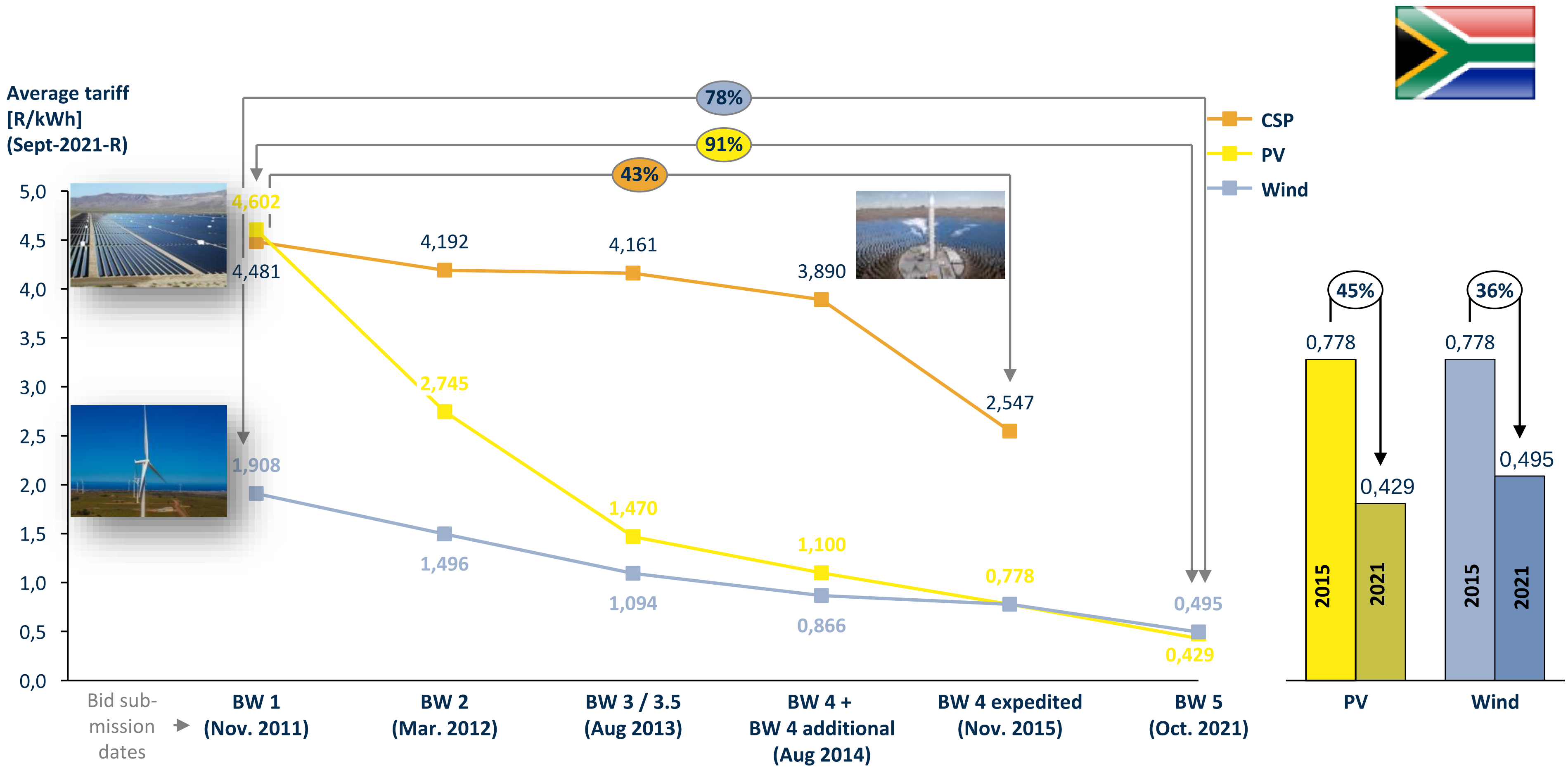
Year	Eskom Peakers GWh	IPP Peakers GWh	Total Peakers GWh	Diesel burnt [million liters]	Diesel cost R billion (R15/liter)	'Extra' diesel burnt [million liters]	Diesel cost premium R billion
2018	510	389	899	270	4.1	27	0.4
2019	1,538	611	2,149	646	9.7	403	6.0
2020	1,251	661	1,912	575	8.6	331	5.0
2021	2,235	976	3,212	966	**14.5**	**723**	**10.8**
2022 (YTD)	*247*	*191*	*438*	*132*	*2.0*	*90*	*1.3*

Urgent action is required to address the power system constraints and reduce the usage of expensive peaking plant

- **Improve the operational performance of the existing Eskom fleet** (Energy Availability Factor)
- **Mega-projects (Medupi, Kusile) need to deliver the 'planned' capacity**
- The market in South Africa has been quick to respond to government's **highly acclaimed Renewable Energy Independent Power Producer Procurement Program** (REI4P).
  - A total IPPs of 7,300 MW has been procured. **The program should be accelerated**.
  - Consider doubling the MW allocations in the short-term (for instance BW6): 3,200 MW for Wind and 2,000 MW for PV.
  - The project size limits could be increased (currently 140 and 75 MW for Wind and PV, respectively).
- **Risk Mitigation IPP projects (around 2,000 MW) need to come online** (or alternatives accelerated)
- **Promote Customers to procure their own generation capacity**, such as embedded generation. Recent 100 MW exemption should see an increase in this resource, **but processes remain bureaucratic and slow**

Renewable energy provides an attractive solution to address the immediate crisis and long term transition of the power system

Results of South African Department of Mineral & Energy REIPPPP



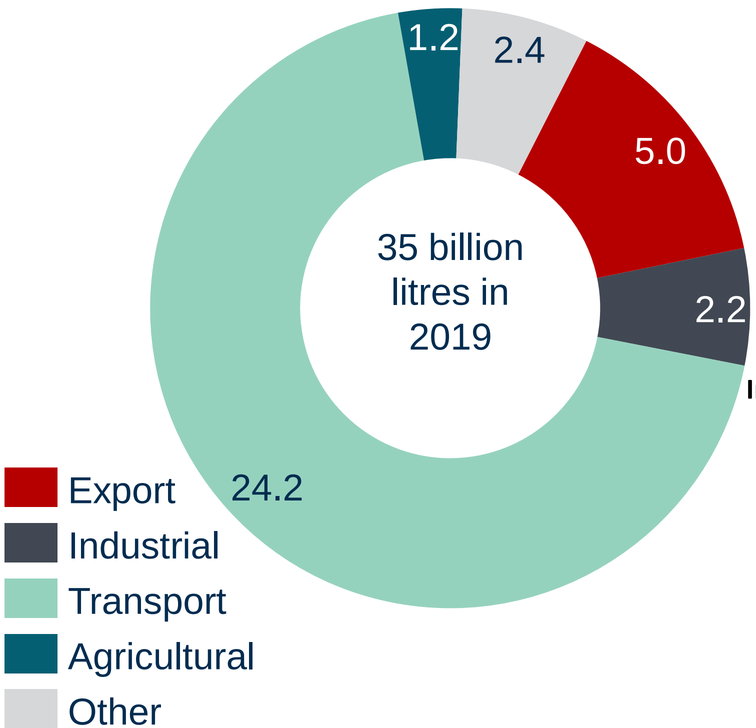
Notes: For CSP Bid Window 3 and 3.5, the weighted average of base and peak tariff is indicated, assuming 50% annual capacity factor and 64%/36% base/peak tariff utilisation ratio; BW = Bid Window;
Sources: Department of Mineral & Energy's publications on results of first four bidding windows http://www.energy.gov.za/IPP/List-of-IPP-Preferred-Bidders-Window-three-04Nov2013.pdf; http://www.energy.gov.za/IPP/Renewables_IPP_ProcurementProgram_WindowTwoAnnouncement_21May2012.pptx; http://www.ipprenewables.co.za/gong/widget/file/download/id/279; StatsSA on CPI (http://www.statssa.gov.za/publications/P0141/CPIHistory.pdf); CSIR analysis

Liquid fuels in mining

(implications and opportunities for mining operations)

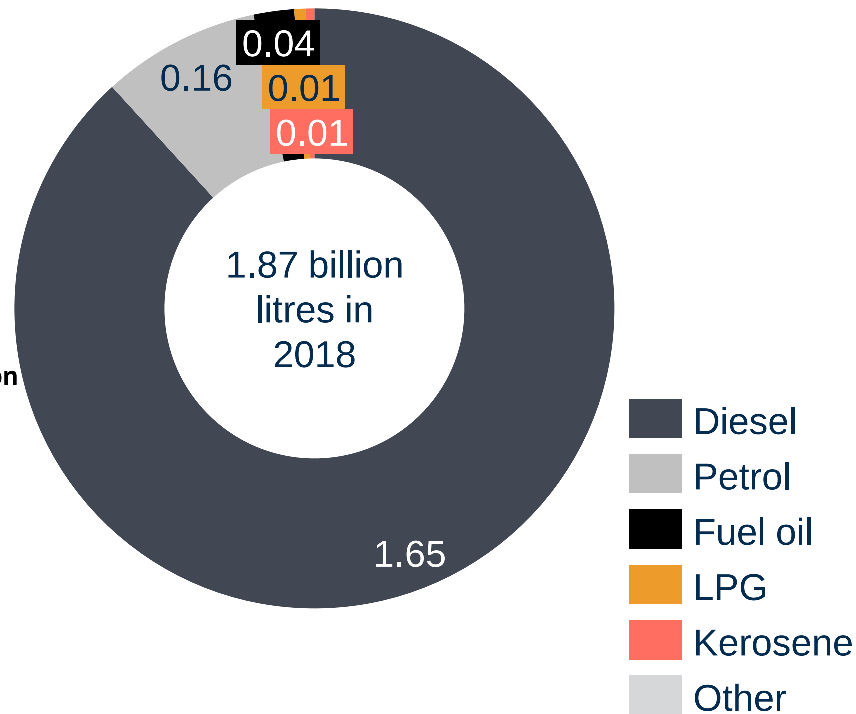
Liquid fuels demand in mining and quarrying

Liquid fuel by end use sector



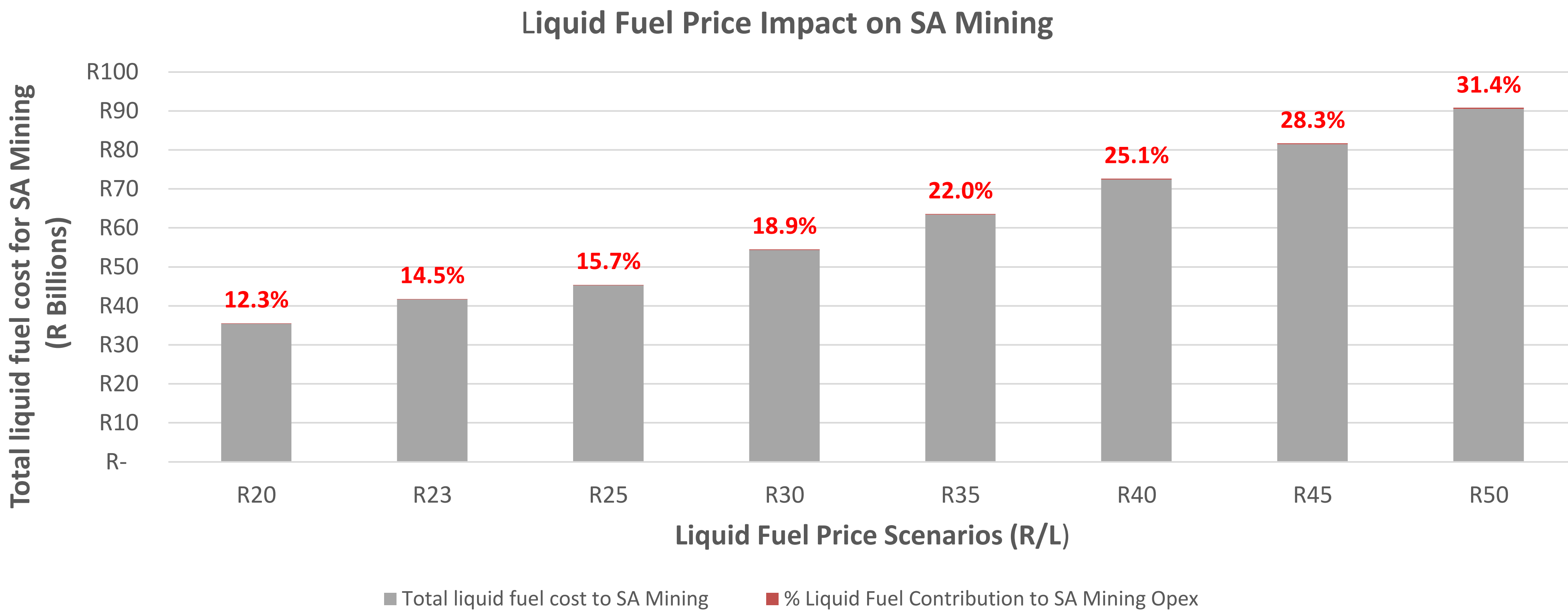
Industrial direct consumption is predominantly mining

Liquid fuel consumption in mining and quarrying



Source: DMRE Energy Balances 2018, SAPIA and FTI 2020

Increasing liquid fuel prices will have a high impact on the profitability and viability of Major and Junior Miners in South Africa



- **Impact focused on fuel consumption alone** – does not take increases in goods and services into account
- A significant fuel price increase would have a **high impact on the profitability and viability of Major, Medium-sized and Junior Miners in South Africa**.

Global and Local Mining Houses are shifting away from Fossil Fuels to Decarbonize their operations

Mining Industry is a significant consumer of energy

- The mining industry is responsible for 4-7% of global greenhouse gas emissions – 1% of these are from Scope 1 and 2 emissions, caused directly or indirectly by mining operations

What has the mining industry committed to?

- Local mines are actively developing net zero and carbon neutrality plans for the next 18 – 28 years

Descriptions	Anglo American	Exxaro	Seriti	Sibanye Stillwater	Glencore
Market Cap	R 1.05 trillion	R 75 billion	Pvt	R 186 billion	R 1.3 trillion
Commodities	PGM, Iron Ore, Coal, Copper	Coal, Zinc and Iron Ore, Ferro Alloys	Coal	Platinum, Gold	Copper, Cobalt, Nickel, Zinc, Lead, Ferroalloys
Carbon Neutrality	2040	2050	2050	2040	2050

What is driving Global and Local Mining Houses behavior?

Positive impact on operating costs

- avoid carbon tax of R 0.5 - 4 billion per annum (R6 – R48/ton CO_2)
- renewables will provide buffer energy for potential interruptions and stabilize energy costs
- enable operational improvements e.g. Dynamic ventilation usage

Positive impact on share price

Reduced cost of capital

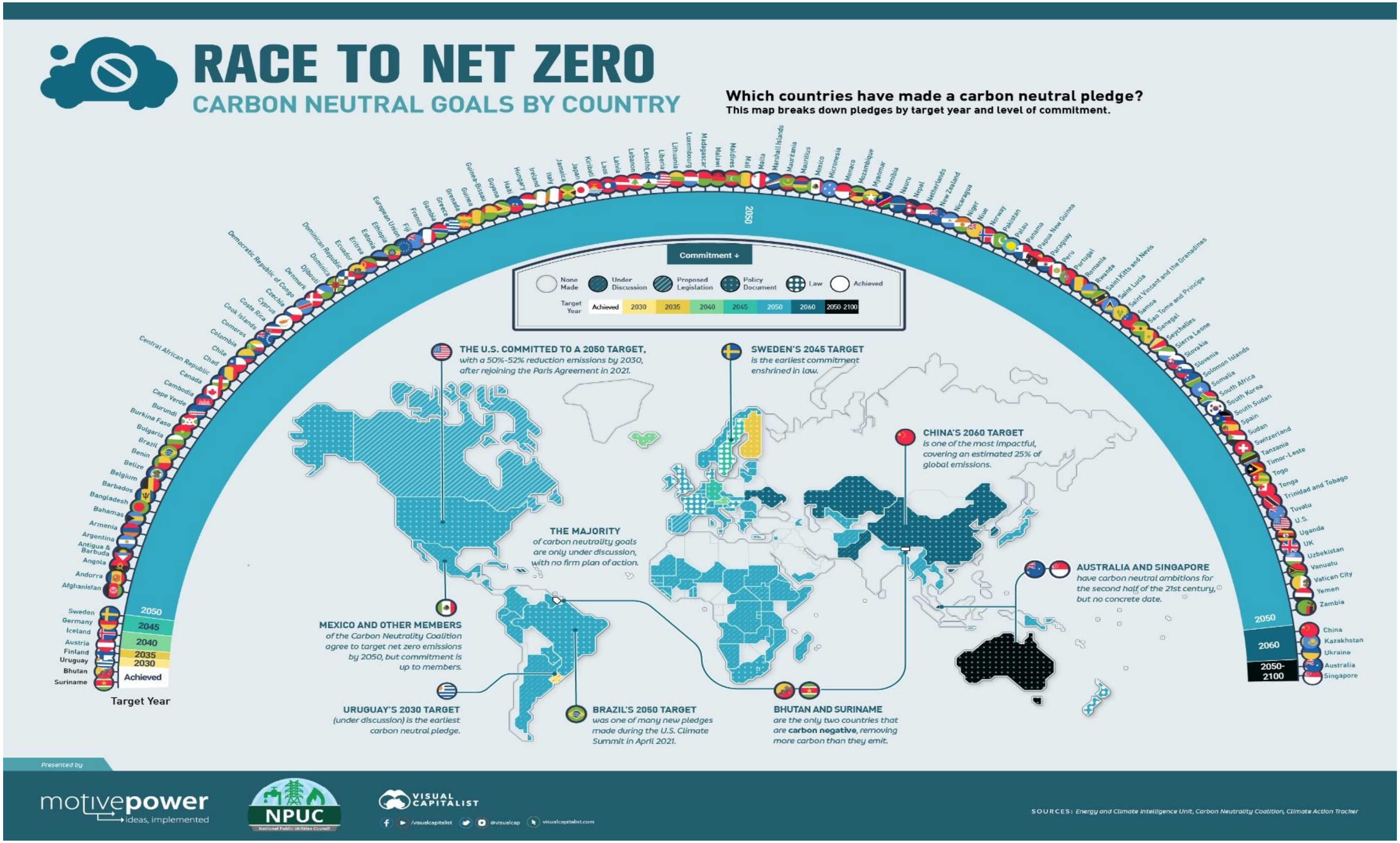
- potential benefit of 5-10% on interest payments

Vital for license to operate

Environment being a key driver for new greenfields projects

Healthier and safer work environments for employees

Mining House clients’ and host jurisdictions have committed to a Net Zero target and are actively working towards it

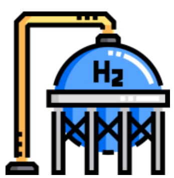


[Race to Net Zero: Carbon Neutral Goals by Country (visualcapitalist.com)](visualcapitalist.com)

What work is CSIR Mining doing in liquid fuel alternatives for Mining?

Battery

- CSIR Mining is working with **<u>local South African</u>** Mining Truck and Equipment Manufacturers to accelerate battery technology integration and adoption
- Local Mining Truck and Equipment Manufacturers are actively looking to develop fit for purpose battery technology for their equipment



Hydrogen

- CSIR Mining is working with **<u>local South African</u>** Mining Truck and Equipment Manufacturers to develop hydrogen fuel cell enabled vehicles ideally using **South African manufactured Fuel Cells and membranes**
- CSIR Mining is looking to collaborate with HySA (Systems, Catalysis and Infrastructure) to execute conversions and new product developments

*TMM – Trackless Mobile Machinery
**OEM – Original Equipment Manufacturer
***UG - Underground

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South African Truck and Equipment Manufacturer landscape

Manufacturer	Country	Lithium-Ion Battery	Hydrogen
Fermel	South Africa	🟡	🔴
Rham Equipment	South Africa	🟢	🟡
Bird Machines	South Africa	🟡	🔴
Aard Mining Equipment	South Africa	🟡	🔴
JA Engineering	South Africa	🟡	🔴
Battery Electric	South Africa	🟡	🟡
Bell Equipment	South Africa	🔴	🔴

🔴 No development

🟡 Development in progress

🟢 Products available

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Alternatives to traditional liquid fuels

(Short, medium and long term technical alternatives to imported liquid fuels)

Primary options to reduce dependency on imported liquid fuels range from traditional to new emerging technologies

Improve efficiency (use less)
- Move road to rail
- Eco-mobility

Biomass and biofuels
- Biodiesel and fuel blending
- Transition from Coal-to-liquids to Biomass-to-liquids

Electrification of transportation
- Continued electrification of rail
- Battery electric vehicles
- Hydrogen electric vehicles

Power-to-X
- Sustainable fuels
- Sourced from electrolysis of water using renewable based electricity

Biomass: Biofuels can play a relatively small role

- **Bioenergy has relatively limited potential** due to rainfall constraints, food security and variability of supply in South Africa. There are niche applications for cultivated energy crops
- Biofuels **can be blended with existing diesel and petrol** (5-10%)
- Despite biofuel blending targets and mandates in SA, **this sector has grown slowly mainly due to not being cost-competitive with petroleum fuels**
- Above the 100 USD/barrel oil prices, biofuels are more feasible (currently 112 USD/barrel), plus benefits of carbon tax-offsets and mitigating the volatility of oil prices
- **Approximately 5% of current diesel consumption can realistically be sourced from biomass**

Estimates of available biomass resources for energy

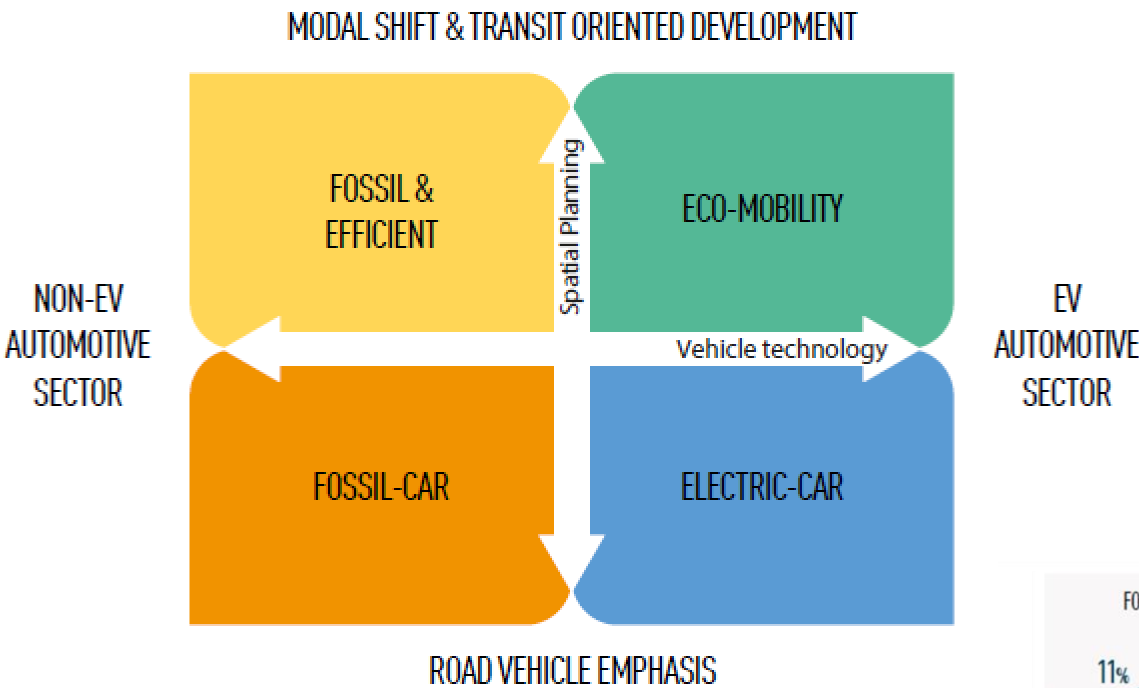
Source	Energy equivalent available now (PJ/a)
Agricultural residues	57.95
Sugar cane field residues	0.00
Sugar cane bagasse	6.02
Plantation residue	18.75
Pulp and paper mill residues	0.09
Black liquor	0.00
Sawmill waste (bark included)	9.88
Invasive species	118.63
Fuelwood	58.80
Organic solid waste component	58.23
Organic sewage sludge	22.77
Purposely cultivated crops	136.12
Total	**487.24**

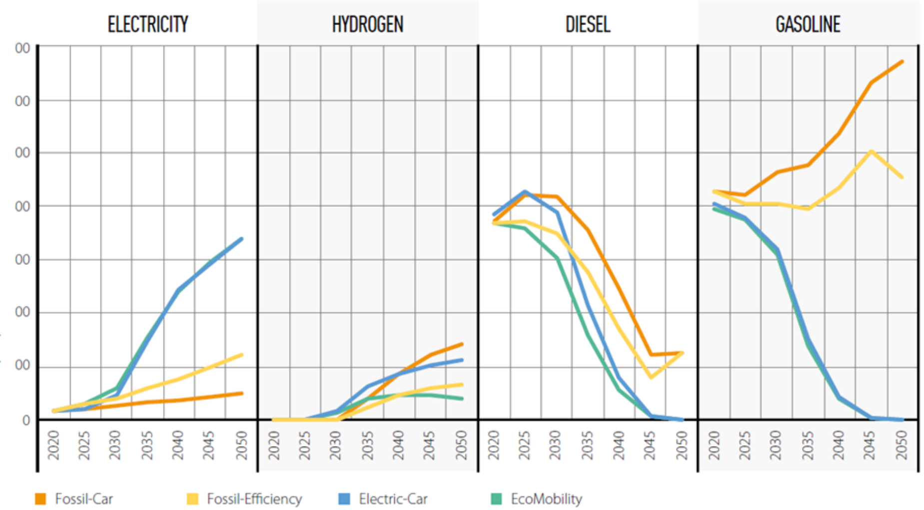
Source and credit: adapted from Bioenergy Atlas for South Africa, 2016 (http://dx.doi.org/10.15493/SAEON.BEA.DOCS.10000001)

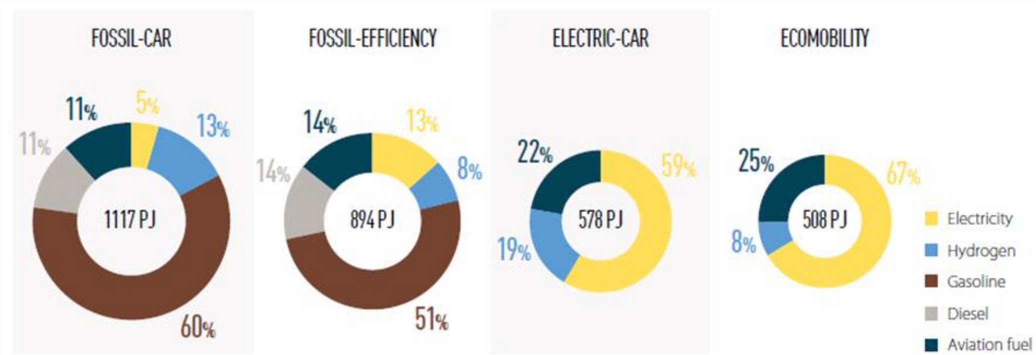
Biomass: Opportunity to transition from Coal-to-liquids to Biomass-to-liquids

- **Opportunity for Sasol and PetroSA – (partial) replacement of coal for biomass**. Sources: dedicated crops (canola, soya, Solaris tobacco), woody Invasive Alien Plants, forestry residues and organic fraction municipal solid wastes
- Links to Power-to-X with **biomass providing the carbon feedstock**
- Good **market in Green diesel and paraffinic fuels, especially liquid aviation fuels** that has few viable alternatives and a growing global market (with policy targets) for low-carbon aviation, but fuel costs estimated R35-R55/L

Electrification of Transportation: Future transportation shift towards direct electrification and hydrogen in transportation







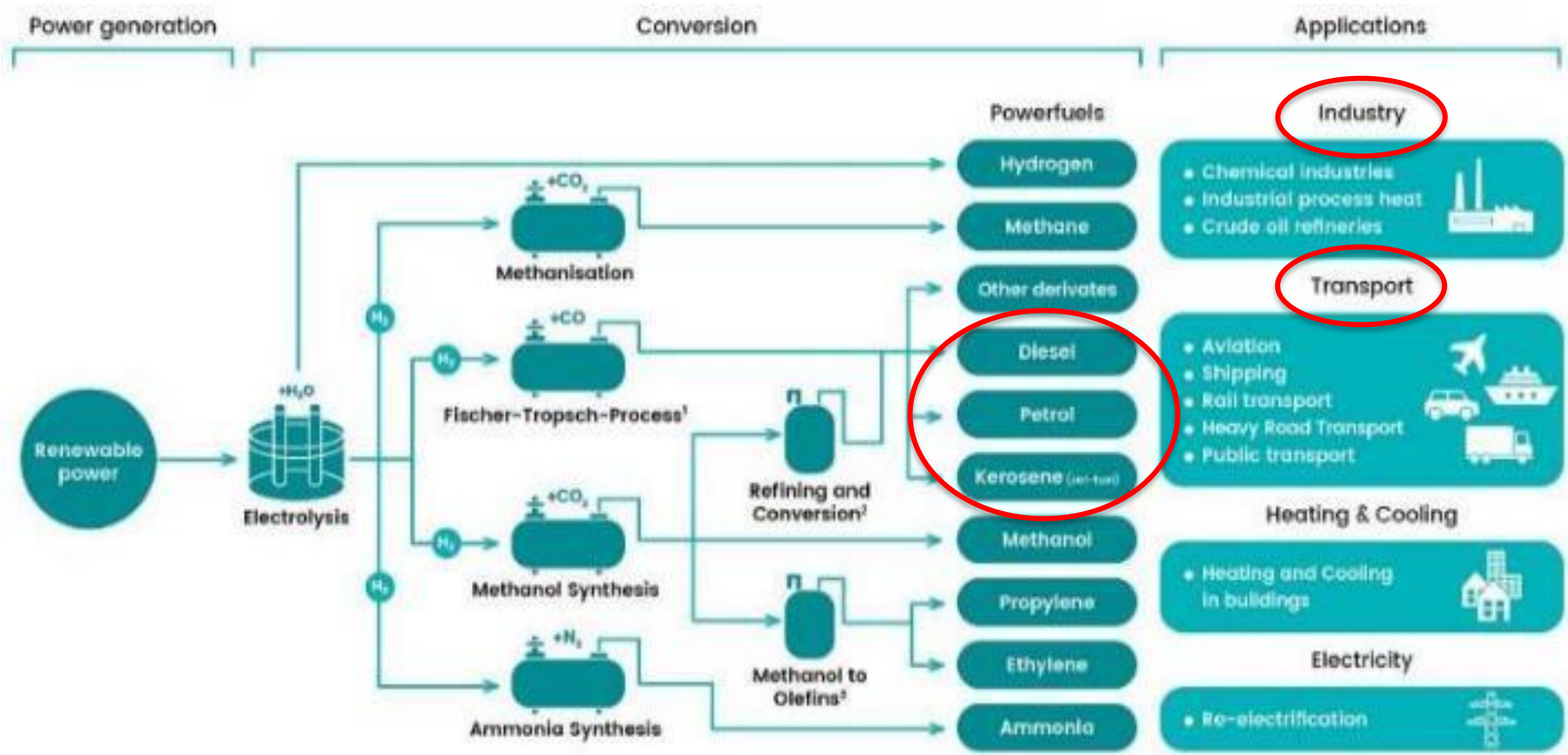
- 4 scenarios tested in study
- For Electric-Car and Eco-Mobility – complete decarbonization of the transport sector by 2050
- Resulting increase in demand to **95 TWh/yr (20% increase)** by 2050

Ahjum, F. et al., 2020. *A Low-Carbon Transport Future for South Africa: Technical, economic and policy considerations*, South Africa: Energy Systems Research Group, University of Cape Town.

ERC
ENERGY RESEARCH CENTRE
University of Cape Town

Power-to-X: What is PtX? Or Powerfuels?

All based on H_2 from the electrolysis of water using RE



Source: https://www.powerfuels.org/powerfuels/

- Renewable synthetic fuels (gas or liquid) alternative to fossil fuel
- Grey and Blue hydrogen can be a pathway towards green hydrogen

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Power-to-X: Why is green hydrogen and PtX becoming more prominent?

Decarbonisation drivers

- Commitments (particularly developed world) at Paris Agreement and COP26
- Moving fossil-driven processes to Renewable Electricity (RE) is cheapest, most efficient path
- <u>But:</u> electrification is impossible or infeasible in some hard-to-abate sectors in transport & industry

Green hydrogen (GH_2) is

- Made when water is electrolysed with RE, so is a way of <u>storing</u> and <u>exporting</u> sunshine and wind from countries whose resource is good (e.g. SA) to those whose are poor (e.g. Japan)
- More expensive & less efficient than using RE directly: so best used in the hard-to-abate sectors:
    - **Heavy, long-distance transport**:
        - Long-distance trucking & buses (H_2 fuel cells), Maritime shipping fuel (ammonia/methanol made from GH_2), Commercial aviation fuel (green kerosene), and Rail (smaller routes not feasible for direct electrification)
    - **Heavy industry:**
        - Iron & steelmaking (GH_2 instead of coal), ammonia (GH_2 instead of fossil-based H_2), plastics, cement

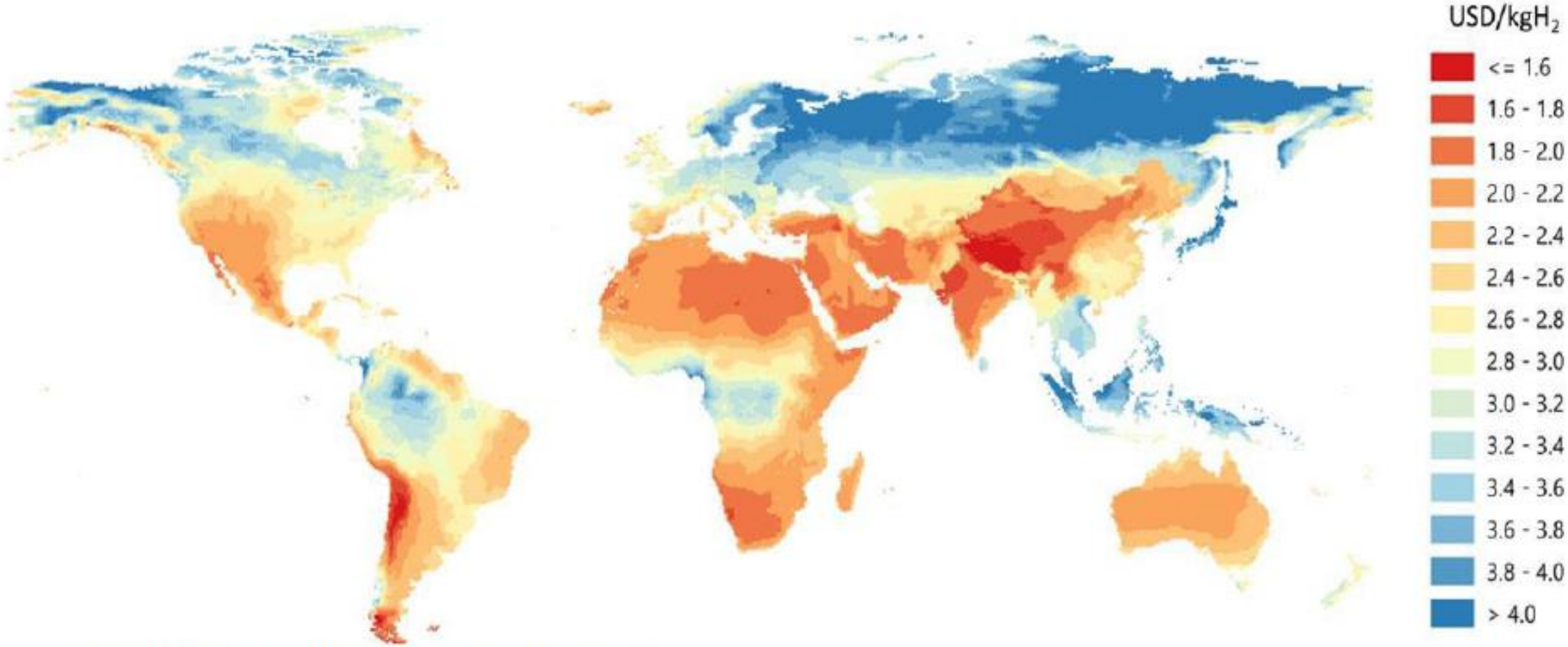
Power-to-X: Market opportunity - South Africa can produce PtX H_2 at competitive cost into a range of export markets

And support local market development via related infrastructure

Europe and Japan: both committed to bulk import of PtX H_2

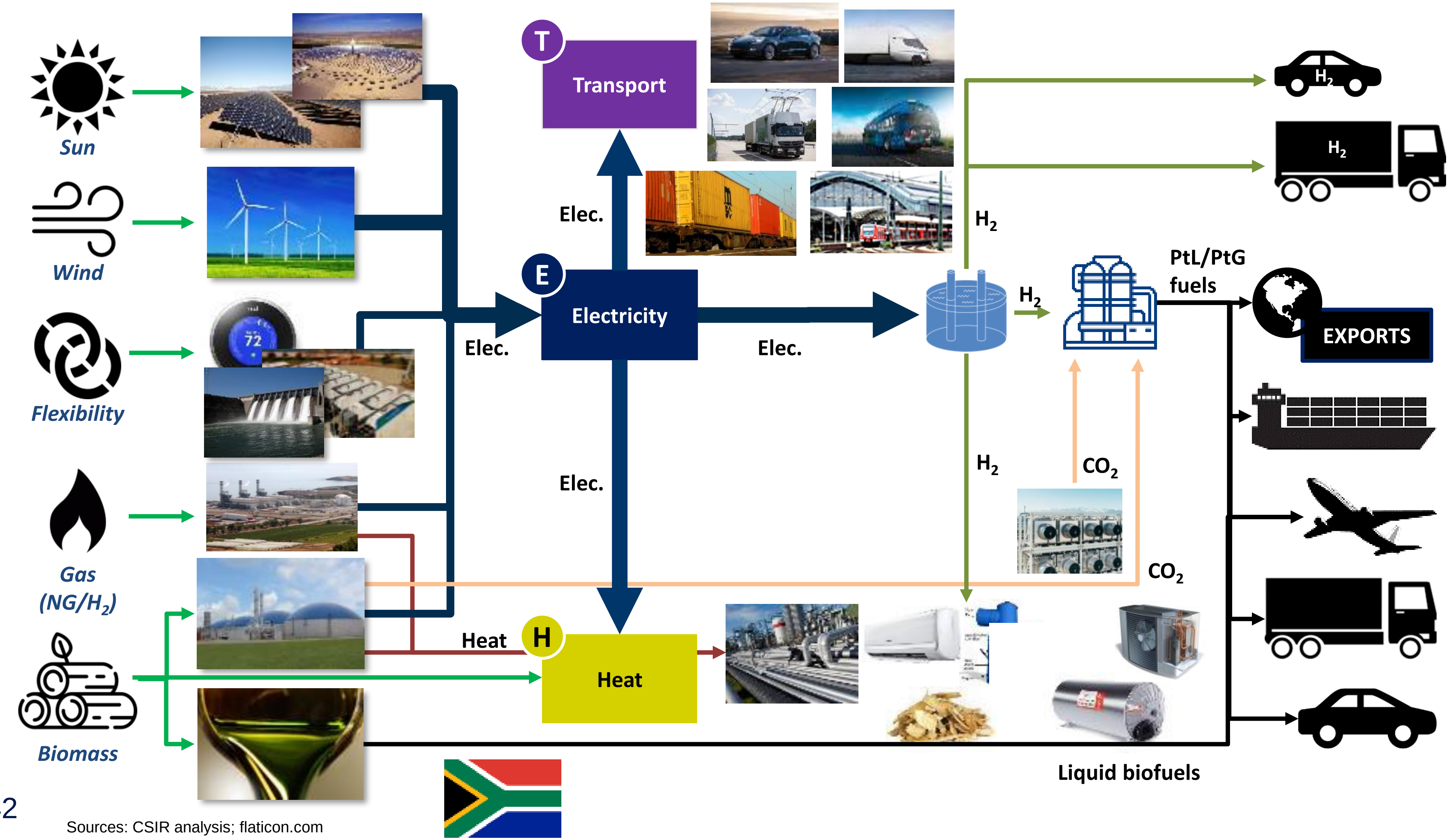
Excellent RSA solar <u>and</u> wind resources - bulk PtX H_2 could be produced competitively relative to other coastal countries

SA can give rise to a new industry, supplying new export and domestic markets



Source: IEA (2019), The Future of Hydrogen, Report to G20 meeting in Tokyo

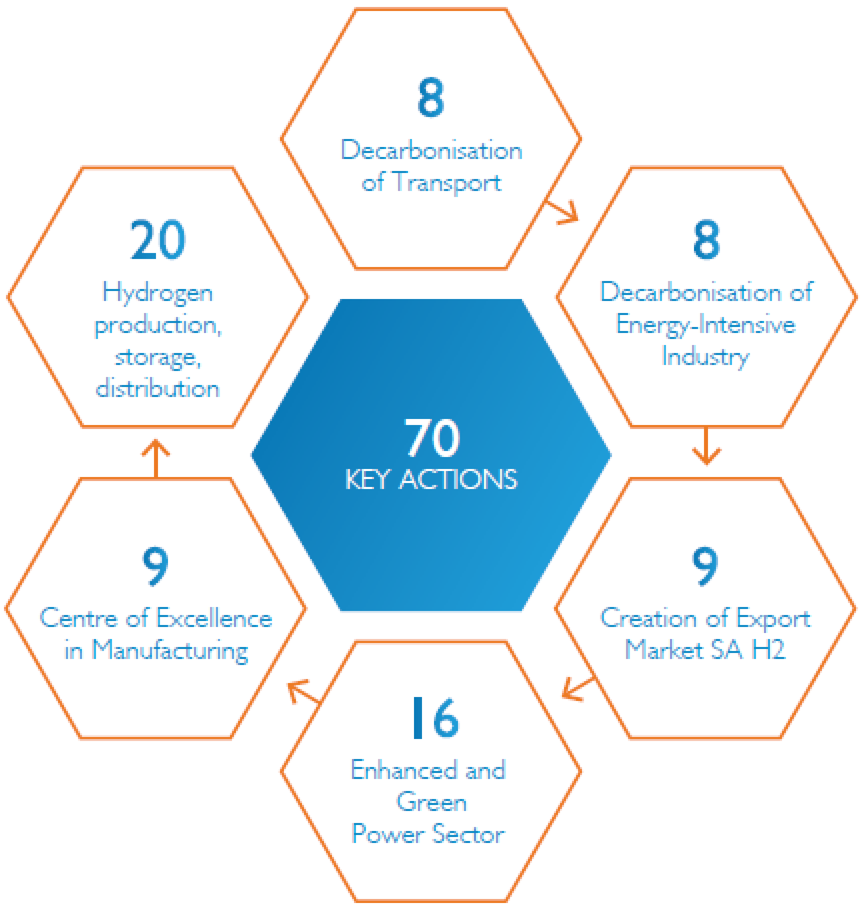
Conceptual (20xx): Clean electricity coupled to other sectors enabling transition to sustainable energy sector



Sources: CSIR analysis; flaticon.com

Hydrogen Society Roadmap

Provides a coordinated framework for the development of the South African hydrogen economy



The implementation of the HSRM is expected to **contribute to the goal of a just and inclusive net-zero carbon economic growth** for societal wellbeing by 2050 through the following high-level outcomes:

- **Decarbonisation of heavy-duty transport**;
- **Decarbonisation of energy-intensive industry** (cement, steel, mining, refineries);
- **Enhanced and green power sector** (main and micro-grids);
- **Centre of Excellence in Manufacturing** for hydrogen products and fuel cell components;
- **Creating an export market** for South African green hydrogen; and
- **Increase the role of hydrogen** (grey, blue, turquoise and green) in the South African energy system in line with the move towards a net-zero economy.

Source: https://www.dst.gov.za/index.php/resource-center/strategies-and-reports/3574-hydrogen-society-roadmap-for-south-africa-2021

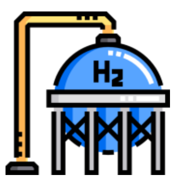
CSIR R&D to support new and emerging opportunities

(strategic investment in R&D to support energy security and the energy transition)

How can CSIR assist: Through a focus liquid fuel replacement and decarbonization programme

Battery

- **What**: Accelerate battery technology development, integration and adoption with a specific focus on **<u>local South African</u>** Mining Truck and Equipment Manufacturers
- **Required**: Additional Resources
- **Time for potential start**: 1-2 months
- **Duration**: 0.5 – 1 year



Hydrogen

- **What**: Accelerate the hydrogen fuels cell enabled UG and OP vehicles
- **Required**: Additional Resources
- **Start time**: 2-4 months
- **Duration**: 1 – 3 years

*TMM – Trackless Mobile Machinery
**OEM – Original Equipment Manufacturer
***UG – Underground
****OP – Open Pit

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Continued R&D to support liquid fuel replacement and decarbonization (acceleration required)

Transportation system evolution to **improve sustainability and implement appropriate mitigation actions**

Focused technology development in energy storage and Power-to-X, with a specific focus on **batteries and green methanol synthesis**

National energy system modeling and planning to **identify the local market opportunities and support the development of bankable projects**

Support Department of Science and Innovation in the **implementation of the South African Hydrogen Society Roadmap**

Continued R&D in sustainable energy sources that will drive the South African competitive advantage in Power-to-X for both local and global markets

Key takeaways

(Specific opportunities for South Africa)

Key takeaways/actions (immediate context)

- **Mining operations consume 2.2 billion liters** of fuel per annum. Large multi-national Mining Houses are pioneering decarbonization to reduce cost and achieve product premiums. Need to **support Junior Miners, local medium-size and large Miners and local OEMs to achieve their decarbonization targets and localize the value chain**
- **Transportation consumes 24 billion liters**. **Structural shifts** are required in transportation sector and **Eco-Mobility to improve efficiency and social cohesion**, reducing the volumes of liquid fuels and related price shocks
- In **2021 Eskom used 1 billion liters of diesel** for Peaker power production due to a seriously constrained power system resulting in an **additional cost of R10.8 billion. Additional power generation capacity is urgently required**

Key takeaways/actions (emerging opportunities)

- **Bioenergy has relatively limited potential due** to rainfall constraints, food security and variability of supply in South Africa
- **Opportunity to transition from domestic Coal-to-liquids to Biomass-to-liquids** through **repurposing of Sasol and PetroSA infrastructure**
- **Global decarbonisation is driving innovation and markets in Power-to-X** (sustainable fuels and chemicals from renewable energy). South Africa can **produce Power-to-X products at competitive cost** into a range of **export markets that are prepared to pay a premium for green products**. Such infrastructure can also **support and develop the local markets**

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Key takeaways/actions (strategic investment required)

- Need to **implement and accelerate the Hydrogen Society RoadMap (HRSM) for South Africa**
- As aligned with the HRSM, there are **local markets/technologies with specific opportunity**:
  - **Mining** through accelerated **battery and hydrogen** technology adoption
  - **Battery electric vehicles** for light vehicle transportation
  - **Hydrogen electric vehicles** for long haul road transportation
  - **Hydrogen powered locomotives** for rail
  - **Sustainable bunker fuels** for maritime shipping
  - **Sustainable aviation fuels** for long haul aviation
- **CSIR R&D to support this market and technology development requires support and acceleration**

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Extra slides

Thought exercise: what if REIPPPP BW5 had come online in Jan 2022?

- BW5 awarded projects
  - 12 Wind projects - 1,608 MW total capacity
  - 14 solar PV projects – 900 MW
  - Combined weighted average tariff of **R 473/MWh**
- Above projects will generate about 6,900 MWh in a year. Total annual payment for this is electricity is **R 3.3 billion**
- What 'relief' would this provide?
  - ✓ **Reduction in load-shedding**
  - ✓ Reduction in diesel consumption for Peakers – about **R 9.6 billion less** fuel costs
  - ✓ Reduction in Eskom general (mostly coal) costs – about another **R 2.8 billion less** fuel costs
- **Spend R 3.3 billon to save R 12.4 billion AND reduce load-shedding**
- Accelerated implementation of renewable energy is a no-regret option for South Africa

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An example is Anglo American's Decarbonization Plans they have committed to

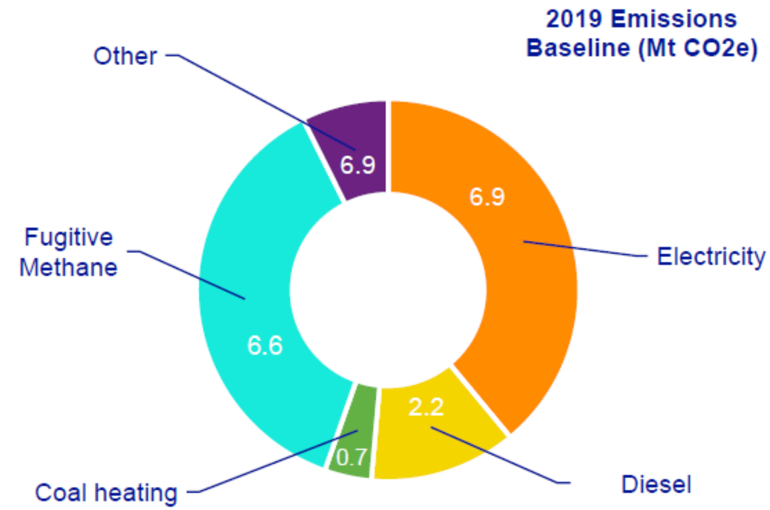
The carbon neutrality challenge offers a new mining landscape

Overview

- Strong, market-leading carbon neutrality agenda announced in 2020
- 3 main sources of GHG emissions provides focused effort
- Innovations, technical solutions and viability analysed

2020	2021-22	2030		2040
8% energy efficiency ✓ **22%** saving in GHG emissions ✓	SA Thermal Coal **In progress** ✓ South America electricity **100% renewable** Advisory Resolution on climate at 2022 AGM ✓	**30%** improvement in energy efficiency **8 sites** carbon neutral	**30%** net reduction in GHG emissions **Net positive** impact delivered on biodiversity	**Carbon neutral across our operations**

Improve efficiency → Invest in innovation → Switch to renewables → Transition the portfolio → Balance residual emissions



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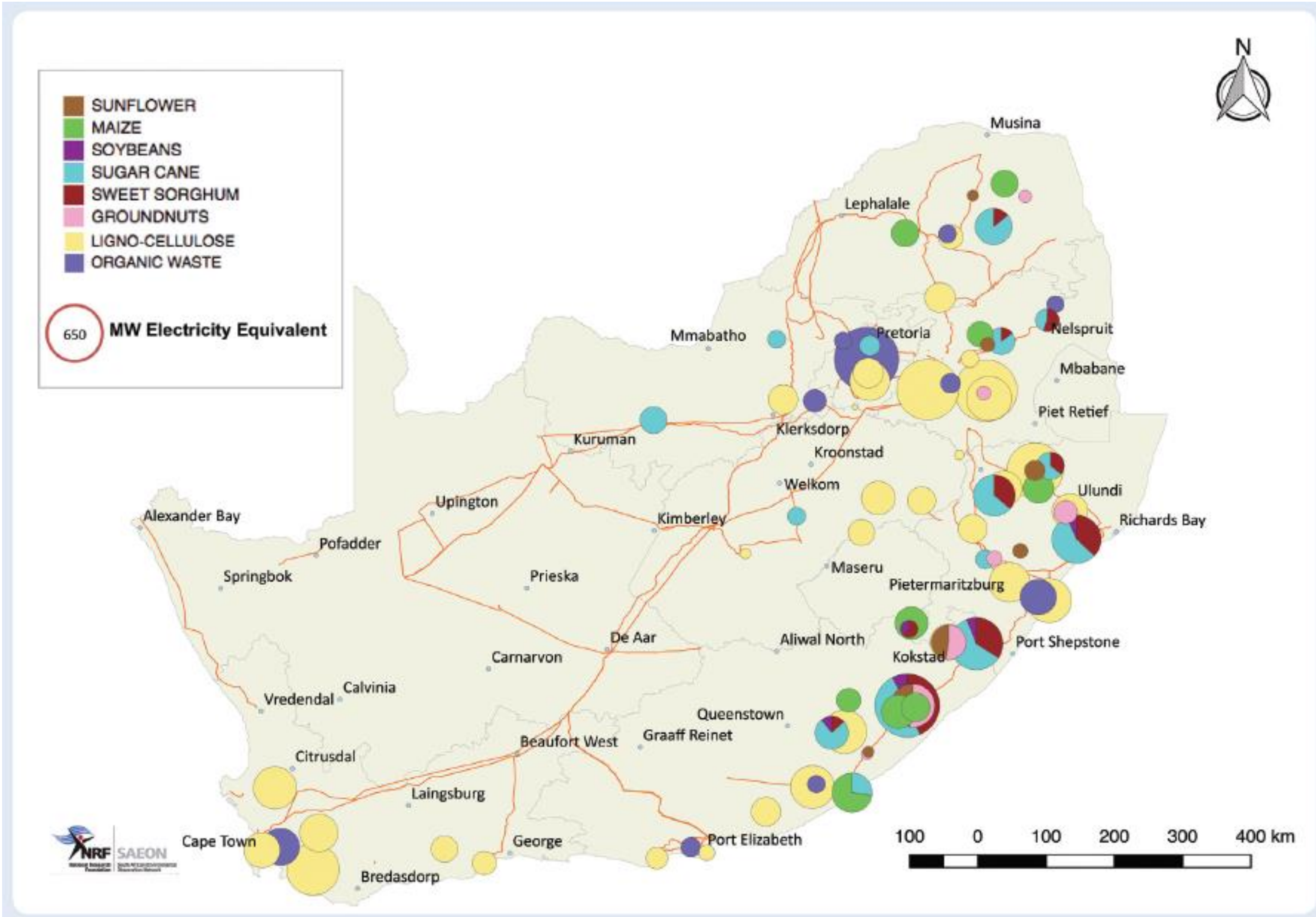
Eco-mobility will improve transport efficiency and reduce the demand for liquid fuels

What is EcoMobility?

EcoMobility is a term used to describe travel through integrated, socially inclusive, and environmentally friendly options: namely walking, cycling, wheeling and public transport options

https://sustainablemobility.iclei.org/

Bioenergy (biofuel and biomass-to-electricity) can open up new opportunities in agriculture and forestry



SAEON, Bioenergy Atlas, Wim Hugo 2012

Power-to-X: Green hydrogen export opportunities for South Africa

Countries planning hydrogen imports due to poor local resources

Germany:

- Will need ~3Mt/y by 2030, can only make < 420kt/y in-country, so is dependent on imports
- Is funding the development of the GH_2 economy in SA (and elsewhere):
  - KfW Development Bank:
    - €200 million concessional funding for GH_2 projects in SA; 55 bids, 7-12 finalists
    - Funding CSIR to assist Transnet develop a hydrogen strategy
  - PtX Pathways project: funding a study by CSIR on future impact of GH_2 on SA: economics (incl. at different sites- Namibia, Boegoebaai, Saldanha, Coega, EL, Richards Bay, inland sites), value chains, environmental impacts, jobs and just transition impacts, feasibility of transitioning Sasol and PetroSA to GH_2 and PtX
  - H2SA: support to SA in regulatory environment and strategy regarding GH_2
  - H2Global project: Providing funding to import GH2 to Germany

Japan:

- From 2030: will import 300kt/y of H_2, target price is \$3/kg (delivered in Japan)
- By 2050: imports will grow to 5-10Mt/y, at target price of \$2/kg
- CSIR calculates SA can meet these costs & deadlines

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Power-to-X: In-country green hydrogen opportunities for South Africa

(Assuming large GH_2 volumes from export industry at Saldanha Bay and Coega deepwater ports)

	Saldanha Bay	Ngqura
Transnet shipping fuel	498 kt/y	242 kt/y
Saldanha Steel	104 kt/y	N/A
PRASA MetroRail	6.6-11.0 kt/y	unknown
ACSA ground vehicles	0.0558 kt/y	unknown
MyCiti BRT	1.2 kt/y	N/A

Comparable to German and Japanese H_2 import volumes!
Calculations based on heavy, long-distance shipping currently calling at ports
Saldanha Bay supplies ports of Saldanha Bay and Cape Town
Coega supplies ports of Gqeberha and Ngqura/Coega

Green steel will allow Saldanha Steel to compete well against expensive EU green steel, instead of badly against cheap Chinese normal steel: saving 700 jobs!

Running on H_2 fuel cells, not direct electricity, would allow MetroRail to operate and transport workers despite cable theft

- Desalination: GH_2 needs water. These export and local GH_2 volumes would require significant coastal desalination infrastructure, strengthening water resilience
- PetroSA: in distress due to declining natural gas feedstock reserves. Sasol has embraced GH_2 to make sustainable aviation fuel (SAF). PetroSA could do the same, making sustainable shipping fuel and SAF with GH_2, using CO_2 from biomass and other sources. PetroSA will compete better in premium markets against more expensive EU SAF and bunker fuel than in conventional markets against oil majors selling fossil-based product.

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