CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT

Visualisation of South African Energy Data

October 2024

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ENERGY MIX

The majority of South Africa's electrical energy in 2023/24 was generated from coal (82.8% of total system demand), with renewable energy providing 8.8%. The South African system was unable to provide 2.2% of the electricity demand (mostly load shedding at the beginning of the year). This data is for the latest year up to the end of 2024 Q3 (quarter 3).

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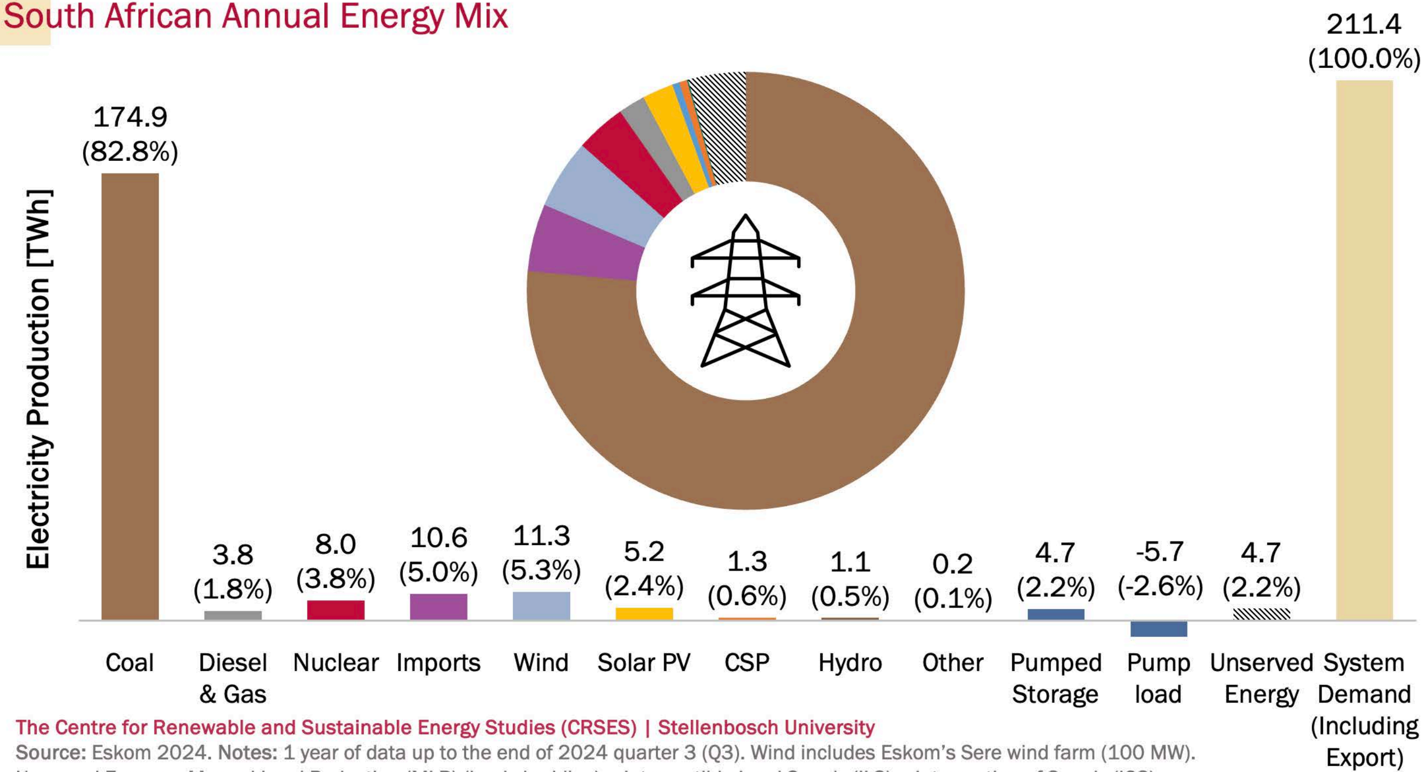
South African Annual Energy Mix



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Source: Eskom 2024. **Notes:** 1 year of data up to the end of 2024 quarter 3 (Q3). Wind includes Eskom's Sere wind farm (100 MW). Unserved Energy = Manual Load Reduction (MLR) (load shedding) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS).

No additional utility-scale installed generation capacity was added in 2023/24. Note that the figure below, however, excludes embedded and private generation.

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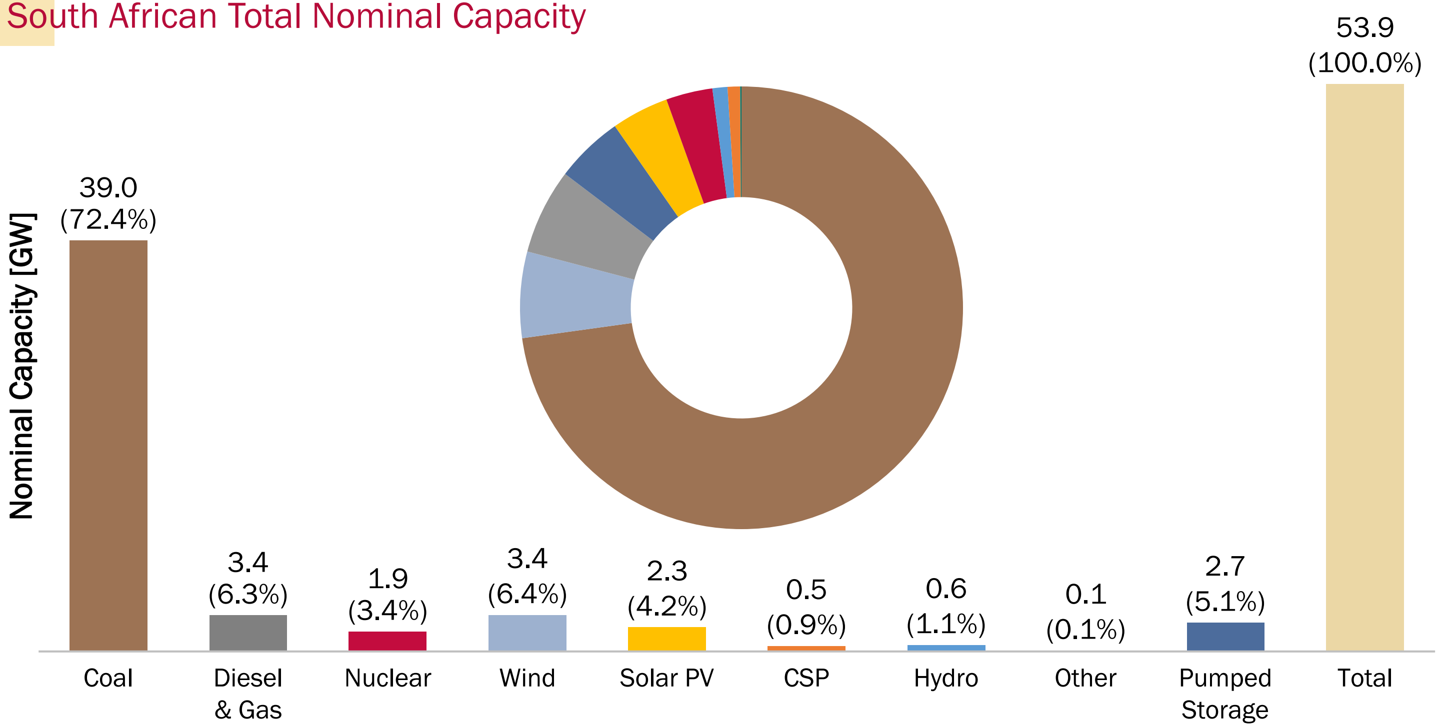
South African Total Nominal Capacity



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Source: Eskom 2024. **Notes:** 1 year of data up to the end of 2024 quarter 3. Total nominal installed capacity = Eskom capacity + IPPs.

Annual electricity production from coal as a percentage of total production continued to decrease in 2023, with a corresponding increase in unserved energy. Note that there is a slight downward trend in national energy requirements.

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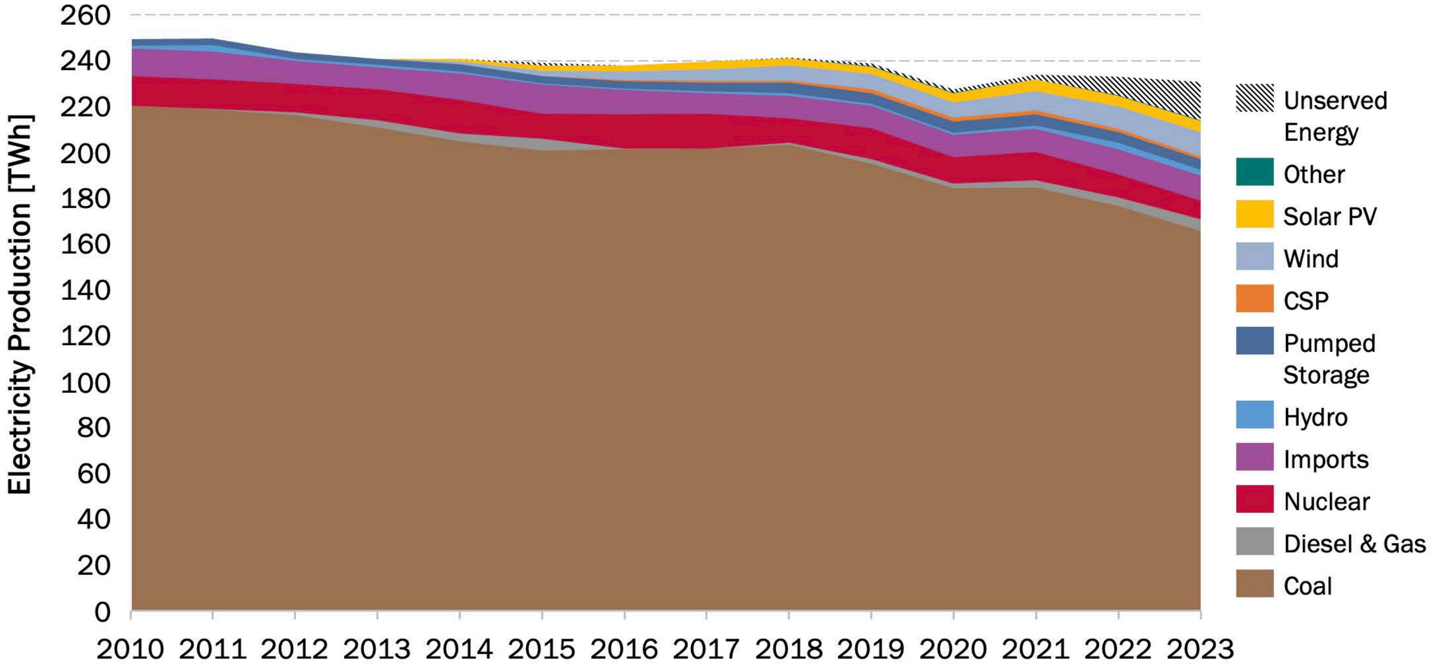
South African Annual Electricity Production



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Source: Eskom 2024. **Notes:** Unserved Energy = Manual Load Reduction (MLR) (load shedding) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS).

Electricity peak demand and energy production both trended downwards since 2010.

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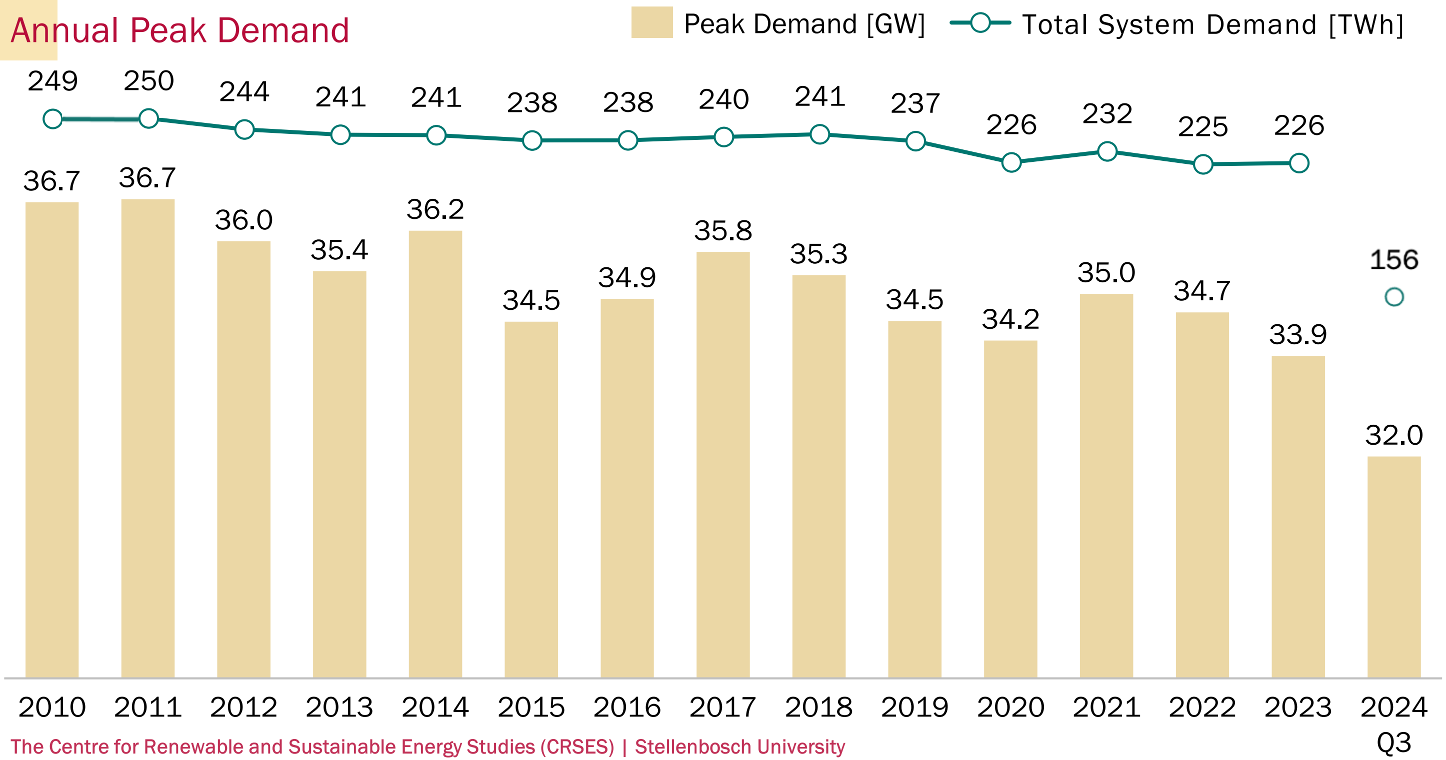
Annual Peak Demand



Source: Eskom 2024. **Notes:** Q3: quarter 3.
Unserved Energy = Manual Load Reduction (MLR) (load shedding) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS).

Renewable energy installed **capacity** and **energy production** are **increasing** in South Africa, but still constitute a **small portion** of the **total capacity** and **energy mix**. **CSP** costs are **high** and have more **variability** than **wind** and **solar PV** costs, which are both on a stable **downward trend**.

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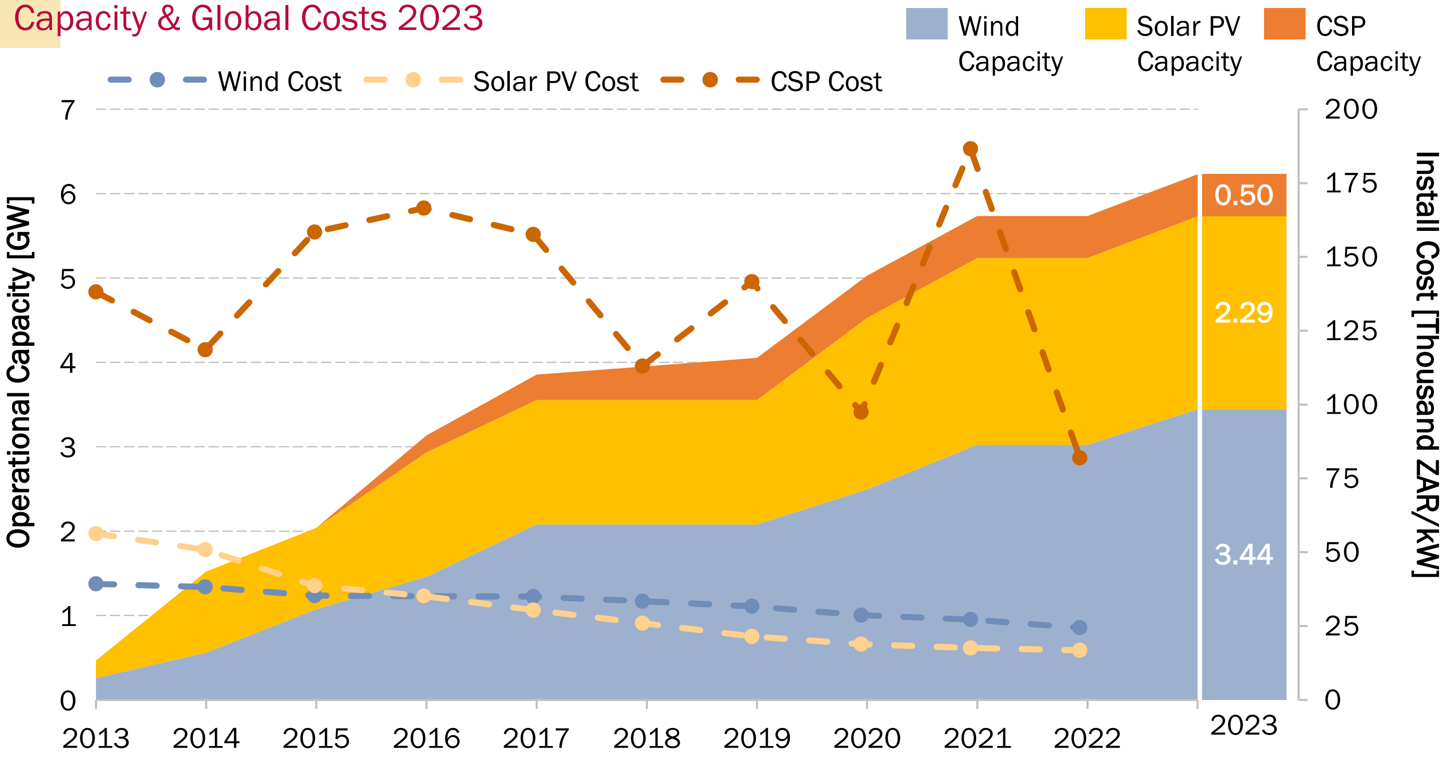
Capacity & Global Costs 2023



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Source: Eskom 2024 | IRENA 2023. **Notes:** Costs are in 2023 value. Solar PV capacity is at the point of common coupling.

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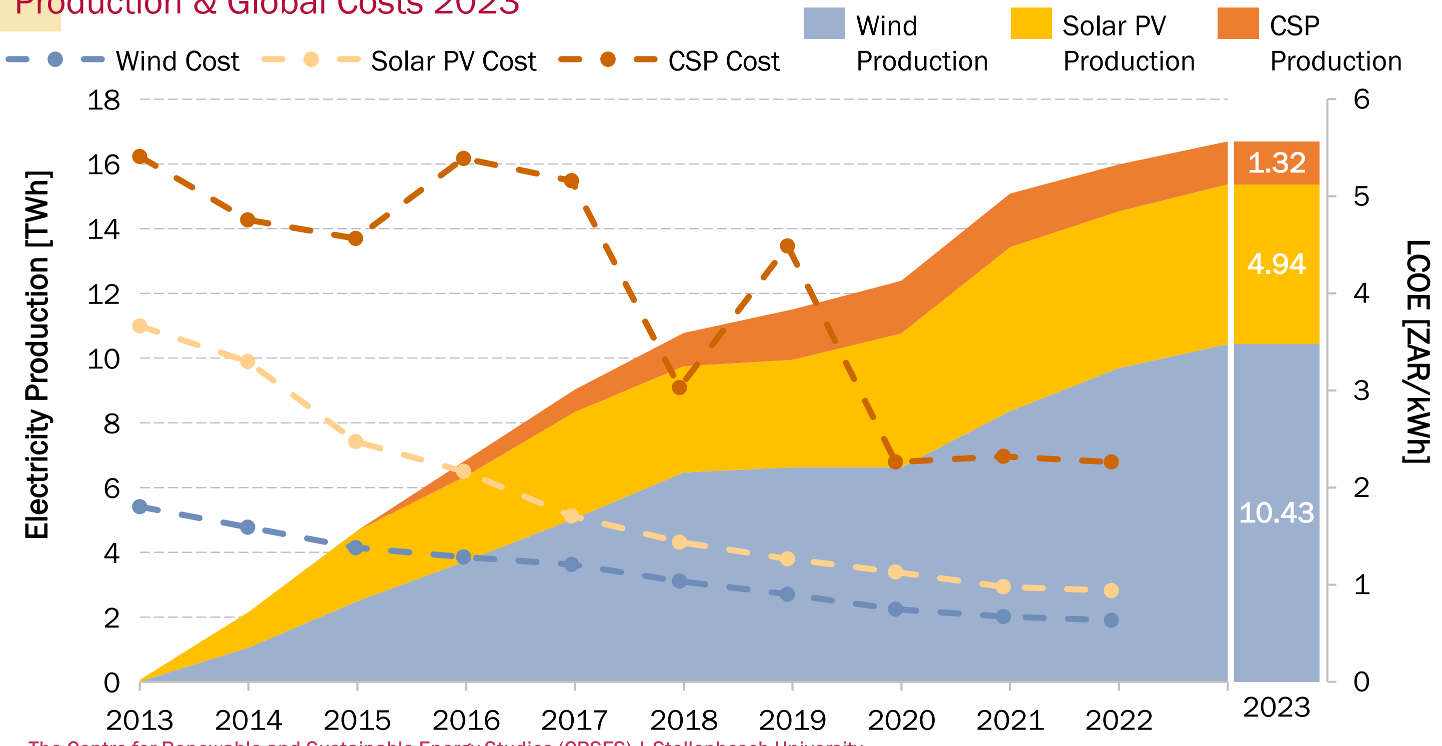
Production & Global Costs 2023



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Source: Eskom 2024 | IRENA 2023. **Notes:** Costs are in 2023 value. Solar PV capacity is at the point of common coupling.

2
MONTHLY ELECTRICAL PRODUCTION

The following figure is zoomed in for clarity - see y-axis.

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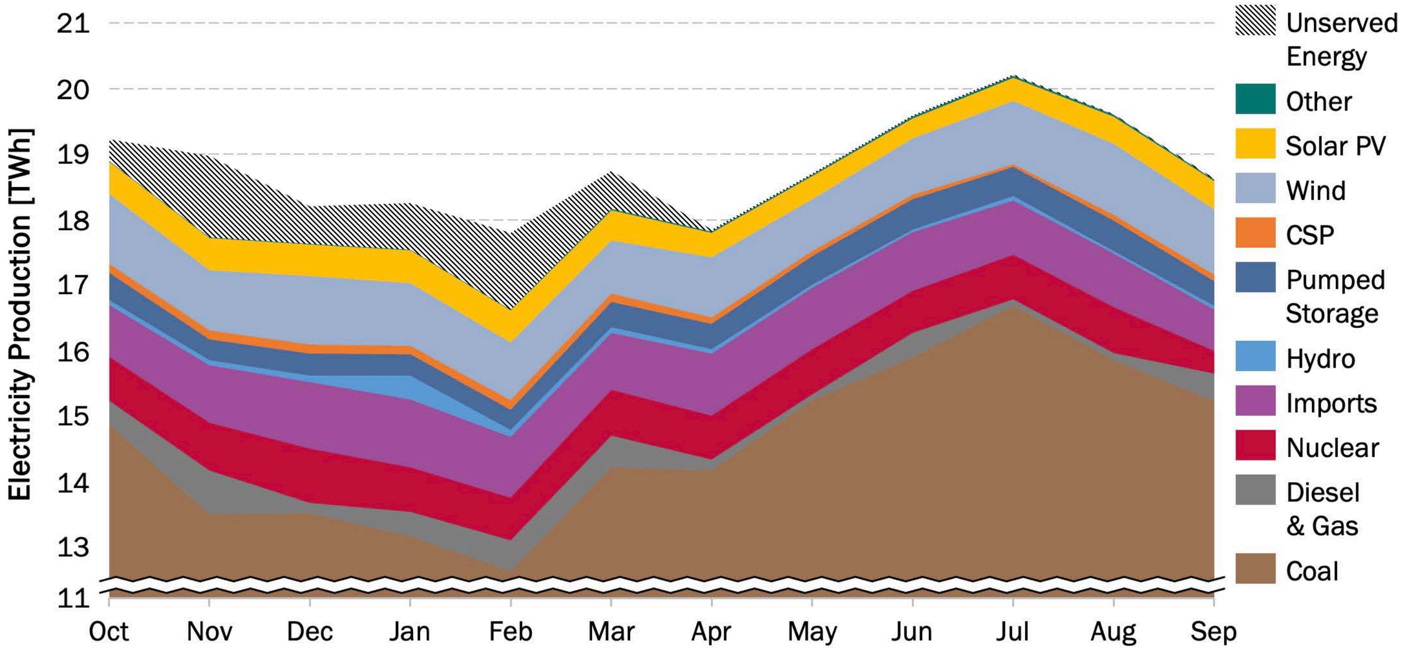
Monthly Electricity Production



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Source: Eskom 2024. **Notes:** 1 year of data up to the end of 2024 quarter 3 (Q3). Pumping load excluded.

Unserved Energy = Manual Load Reduction (MLR) (load shedding) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS).

The Energy Availability Factor (EAF) is the amount of energy a generator was able to produce compared to its capacity over a period. From the figure below it is clear that the EAF has decreased from 2018 to 2023.

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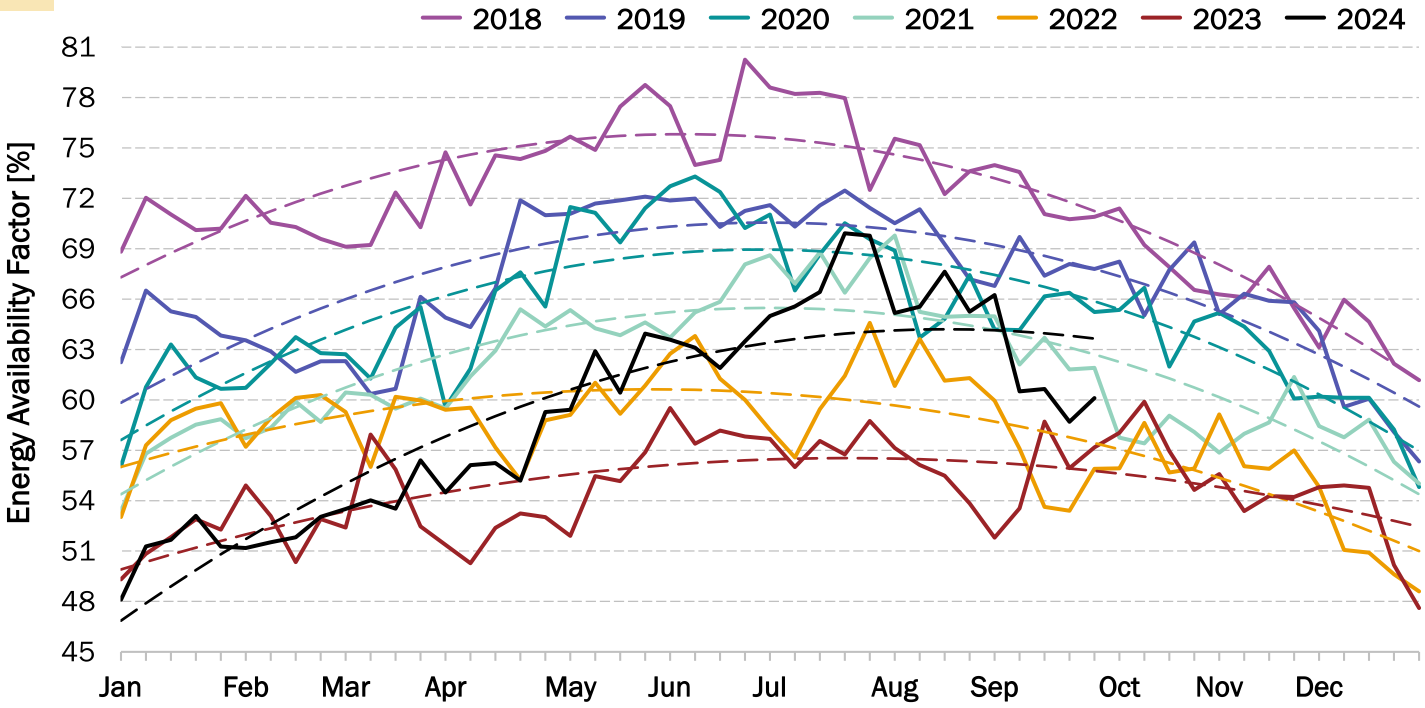
Average Weekly EAF



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Source: Eskom 2024.

Considering the EAF, the remaining unserved capacity is considered loss.
This loss is split into planned, unplanned, and other losses.

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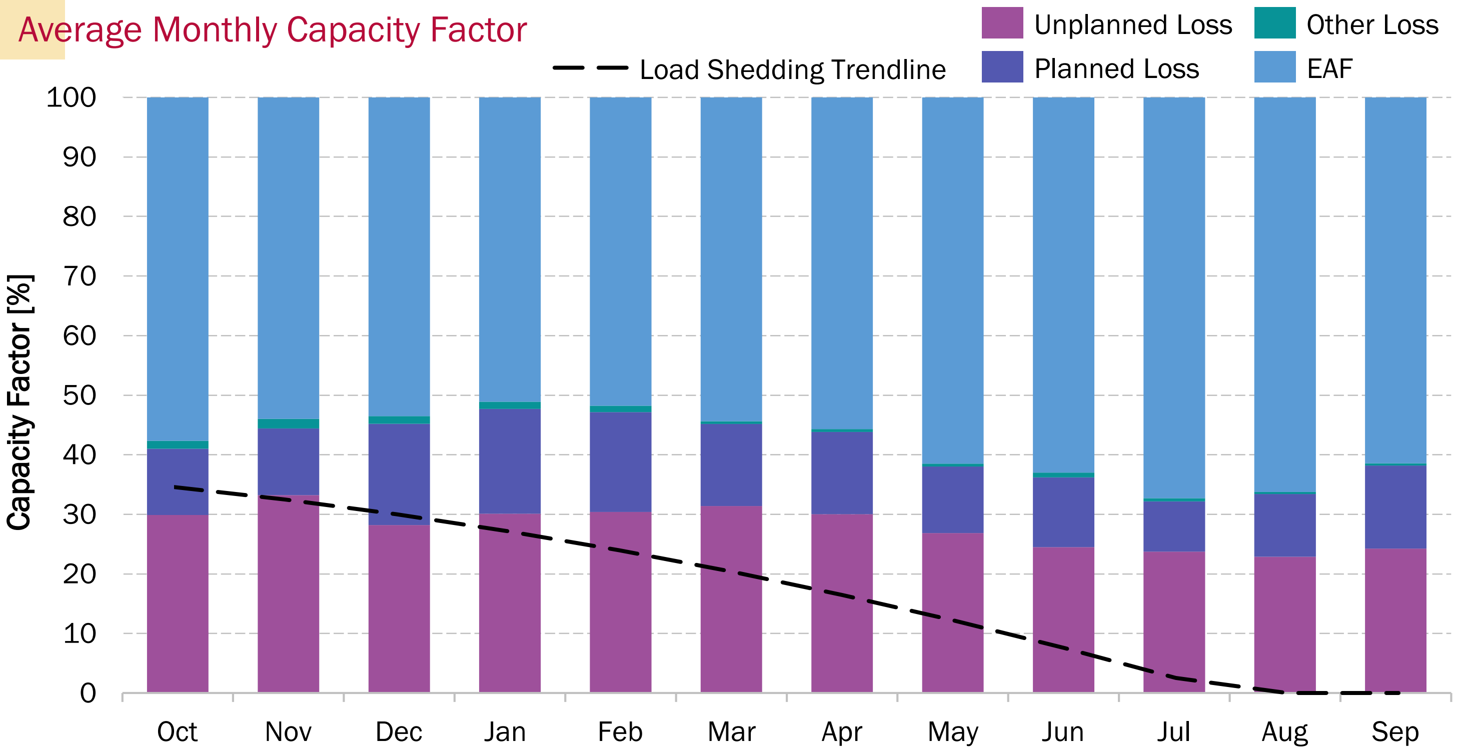
Average Monthly Capacity Factor



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Source: Eskom 2024. **Notes:** 1 year of data up to the end of 2024 quarter 3 (Q3). EAF: Energy Availability Factor.

Monthly capacity factor for 6 of the primary energy sources for the latest year up to 2024 Q3.

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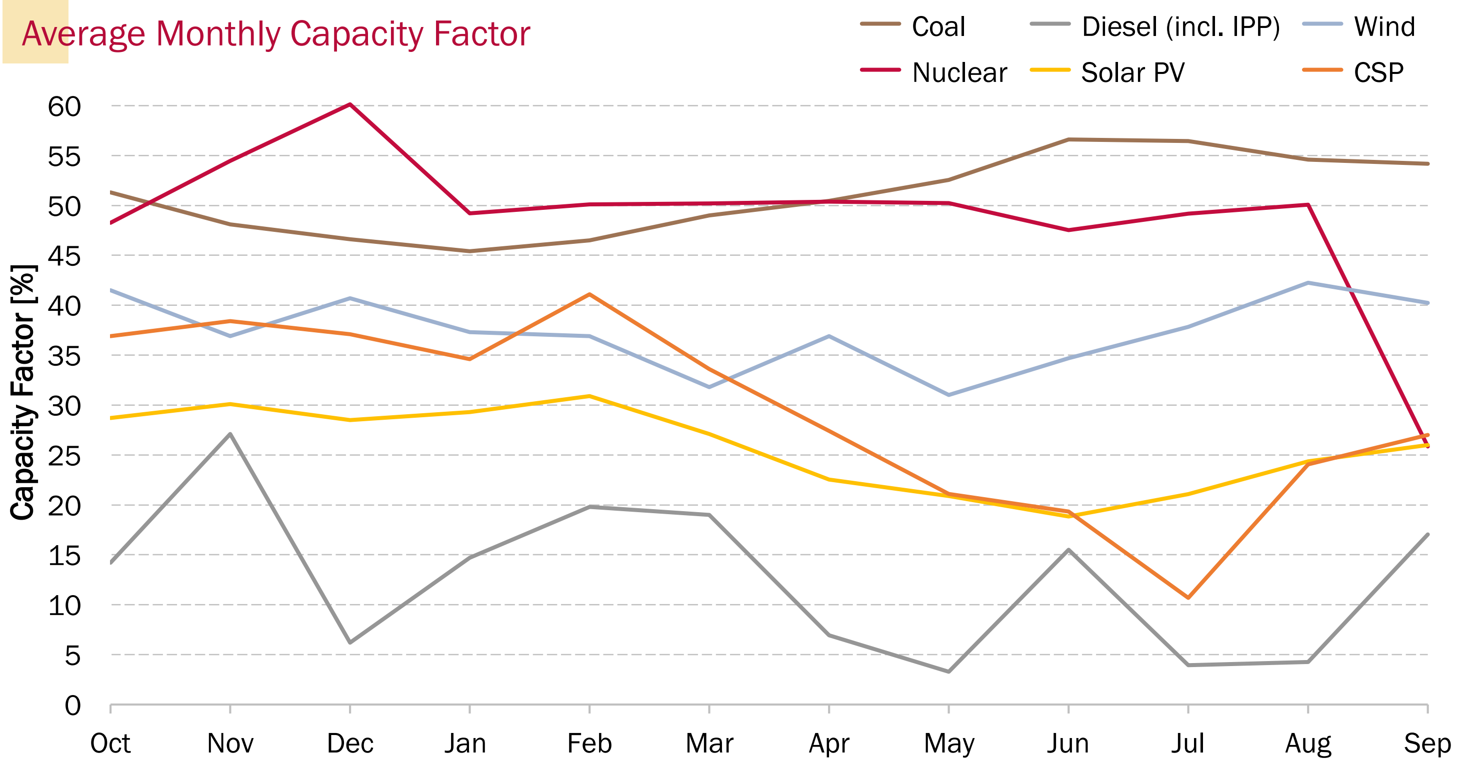

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Source: Eskom 2024. **Notes:** 1 year of data up to the end of 2024 quarter 3 (Q3).

Research is currently being conducted at the CRSES to investigate the correlation between diesel usage and load shedding. Until this research is complete, the two metrics are plotted together here.

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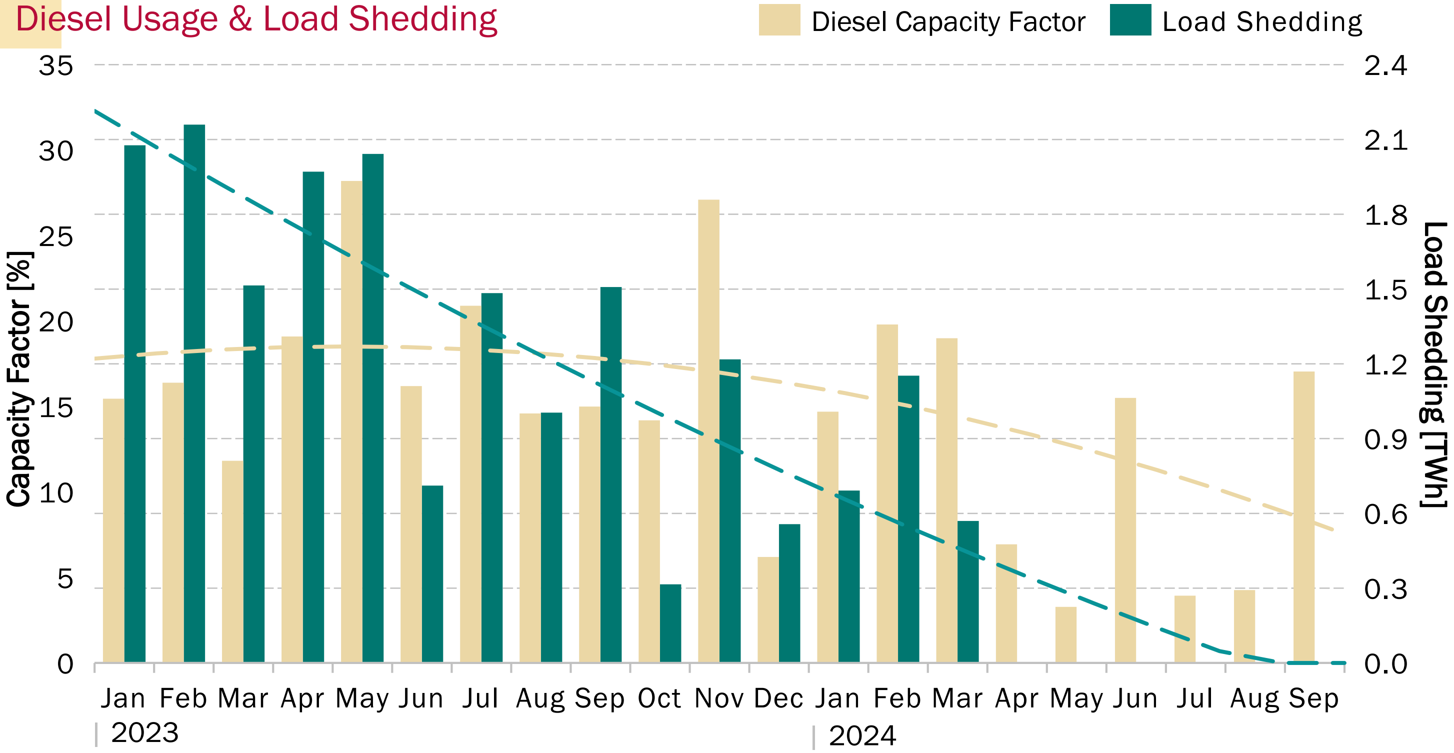
Diesel Usage & Load Shedding



Source: Eskom 2024 | Eskom se Push 2024. **Notes:** Trendlines shown as dashes.

The contribution of renewable energy varies both daily and seasonally. Solar PV is not well aligned to the typical system electricity demand, as seen in the figures below.

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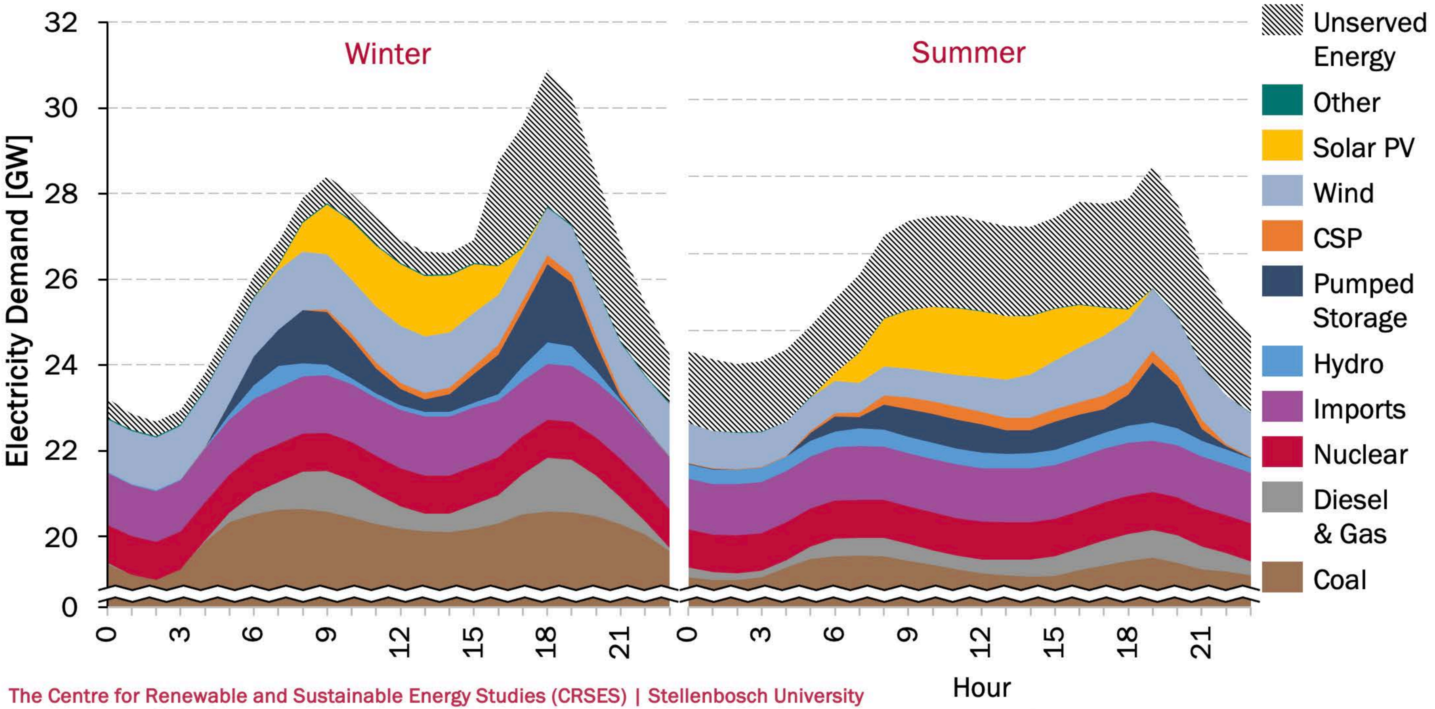
Typical-Day Energy Production 2023



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Source: Eskom 2024. **Notes:** Winter daily average uses data from June, July, and August; while summer uses data from December, January, and February.

The introduction of PV into the electricity system (both on a utility scale and as embedded generation) will result in increased ramping being required from the rest of the system in the morning and evening. This phenomenon is commonly referred to as the duck curve. This can become a problem when the size of the required ramp starts to strain the ramping capabilities of the system.

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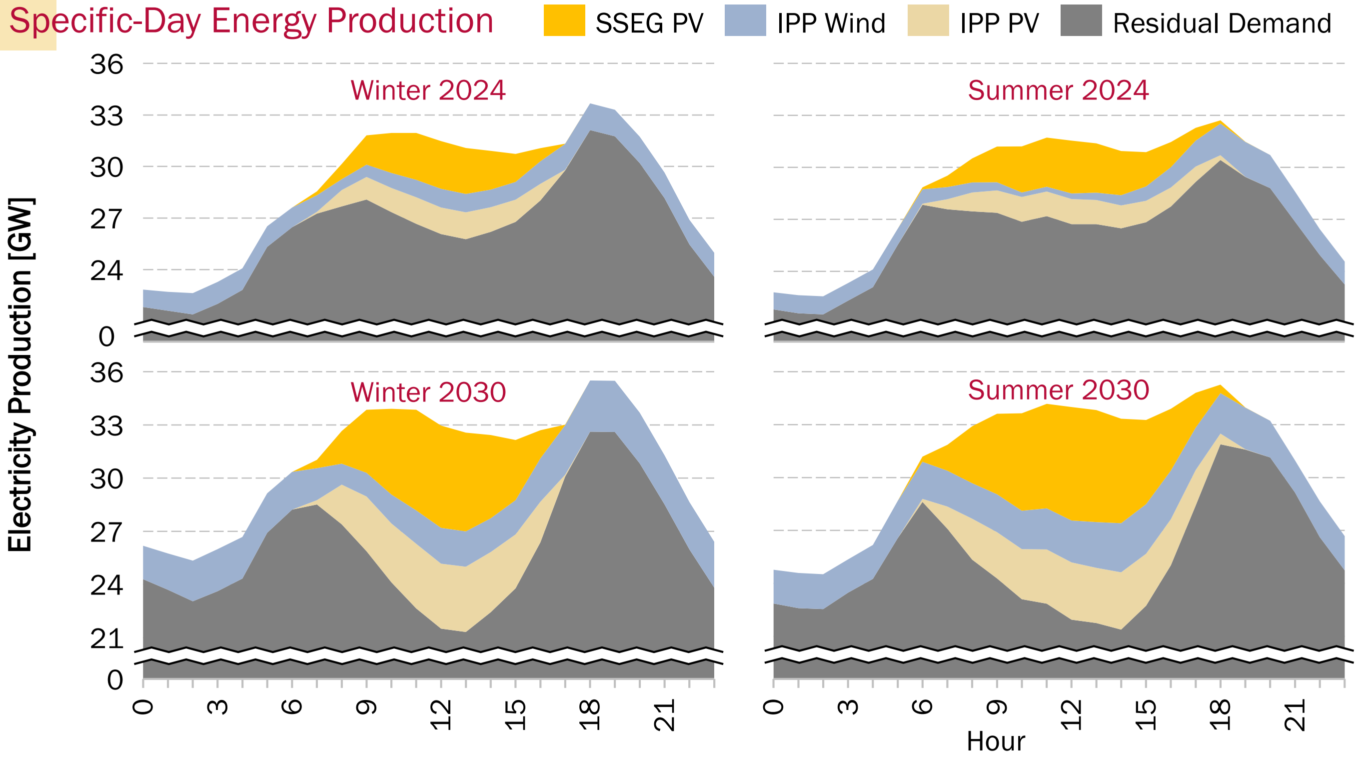
Specific-Day Energy Production



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Source: DMRE 2023. **Notes:** SSEG: Small-Scale Embedded Generation; IPP: Independent Power Producer.

Wind production is also variable throughout the year, but in general aligns better with the total system demand. The location of the wind farm can impact the daily and seasonal production profiles significantly.

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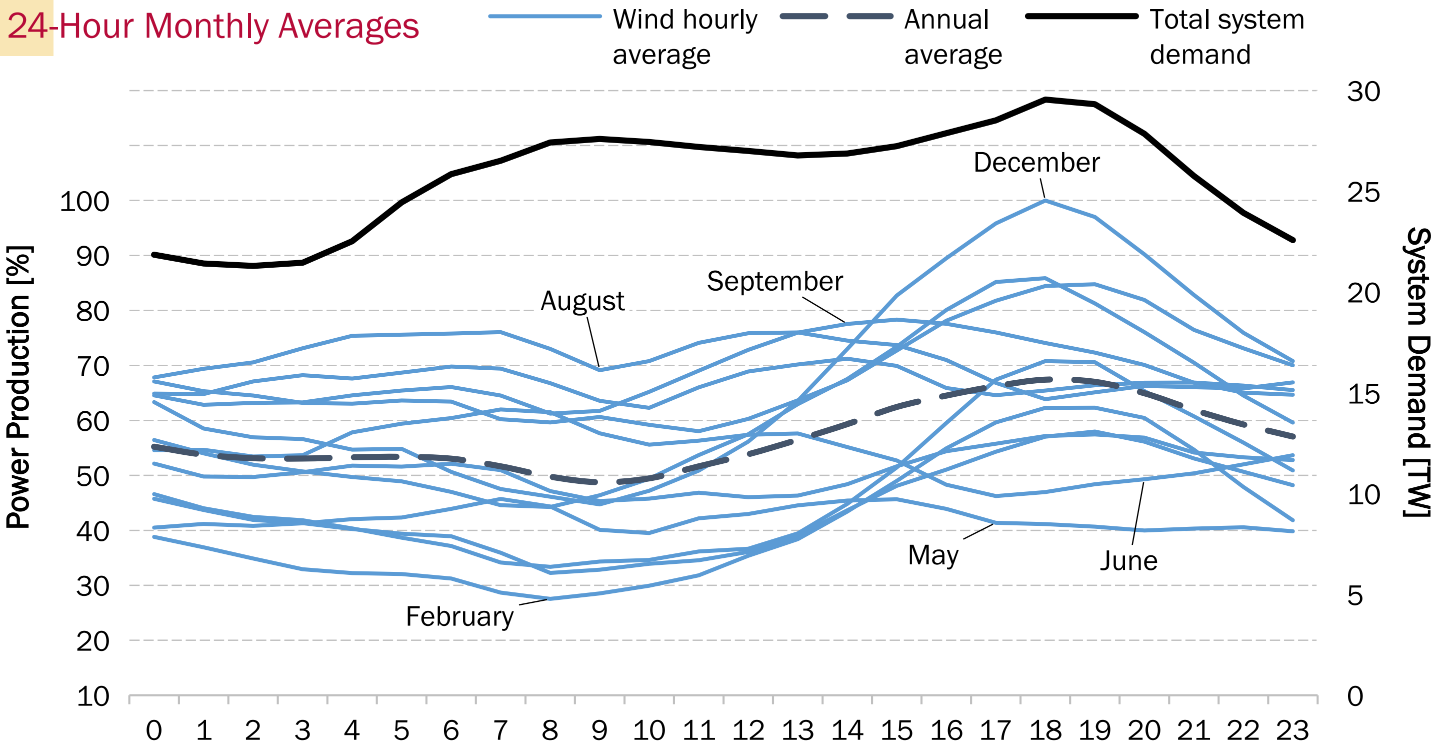
24-Hour Monthly Averages



Source: Eskom 2024.

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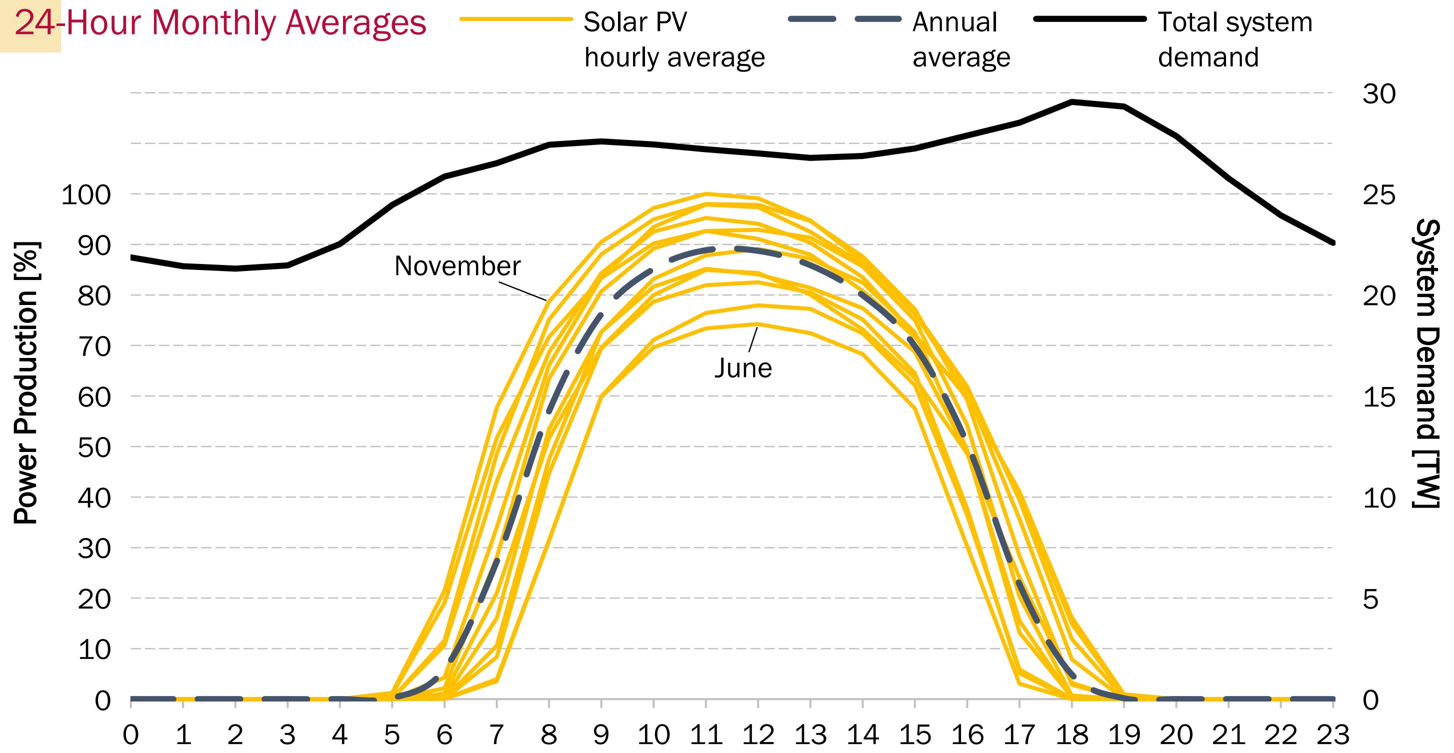

Source: Eskom 2024.

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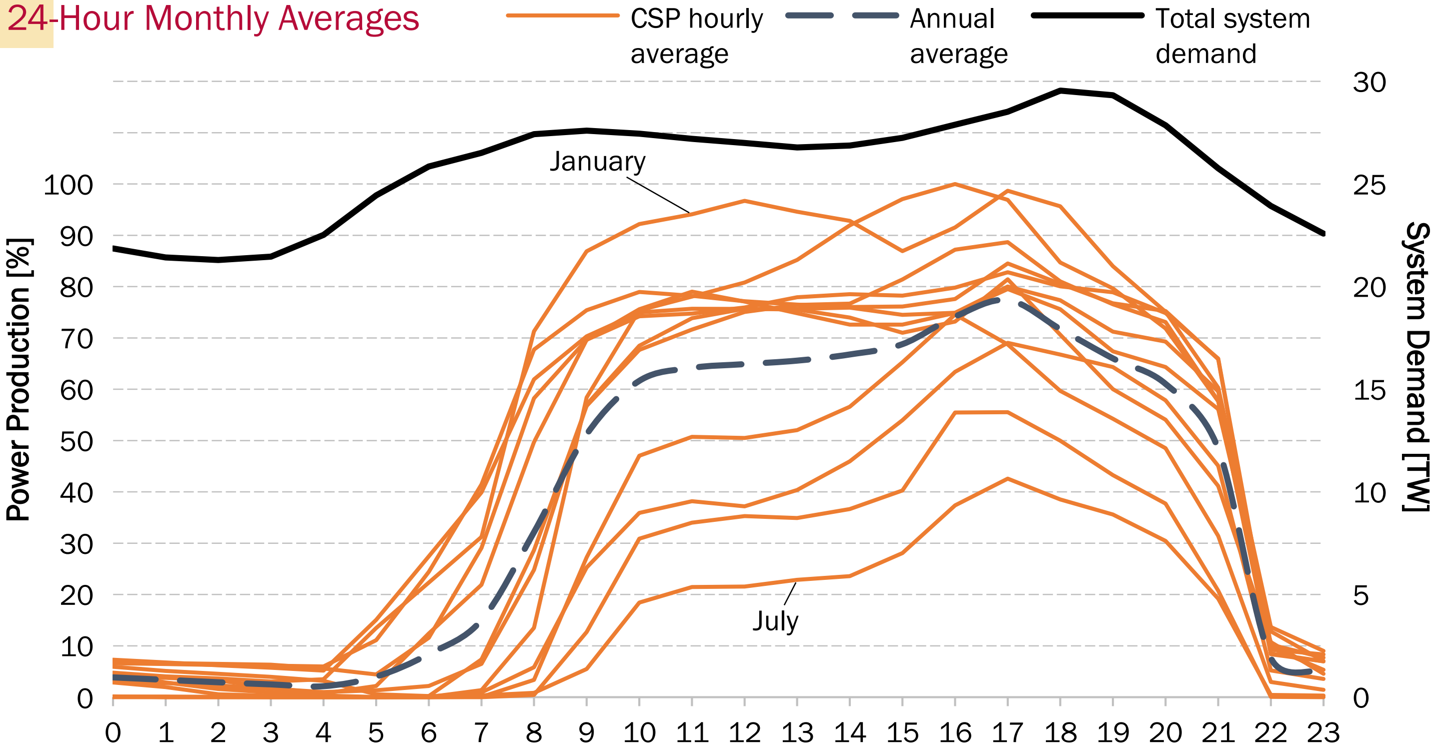

Source: Eskom 2024.

3 EMBEDDED SOLAR PV CAPACITY

The installation of privately owned solar photovoltaics (PV), also known as embedded generation, has increased dramatically in recent years, driven by increasing electricity prices, decreasing PV technology costs and increased load shedding.

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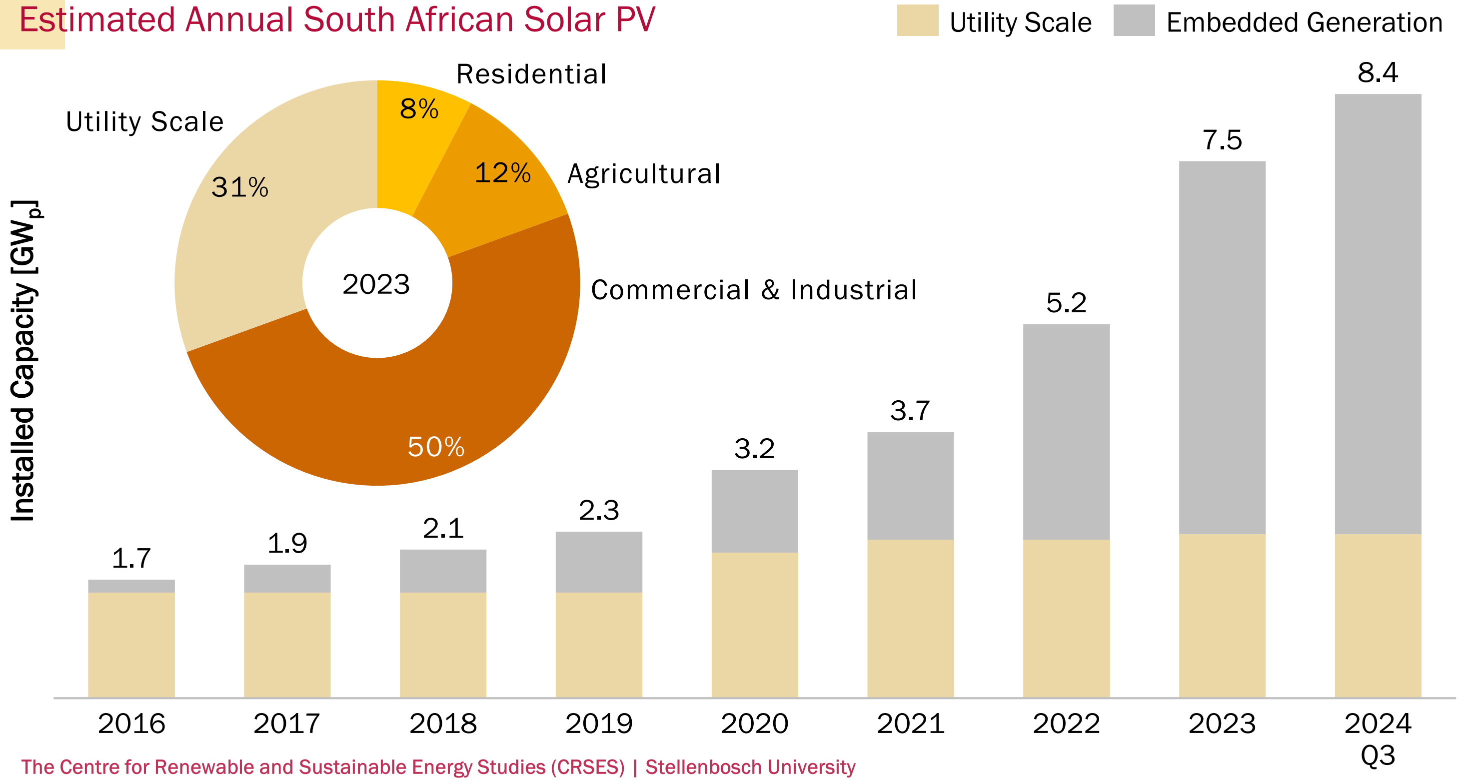
Estimated Annual South African Solar PV



Source: Eskom 2024 | SALGA 2023 | GreenCape 2023. **Notes:** Q3: quarter 3.

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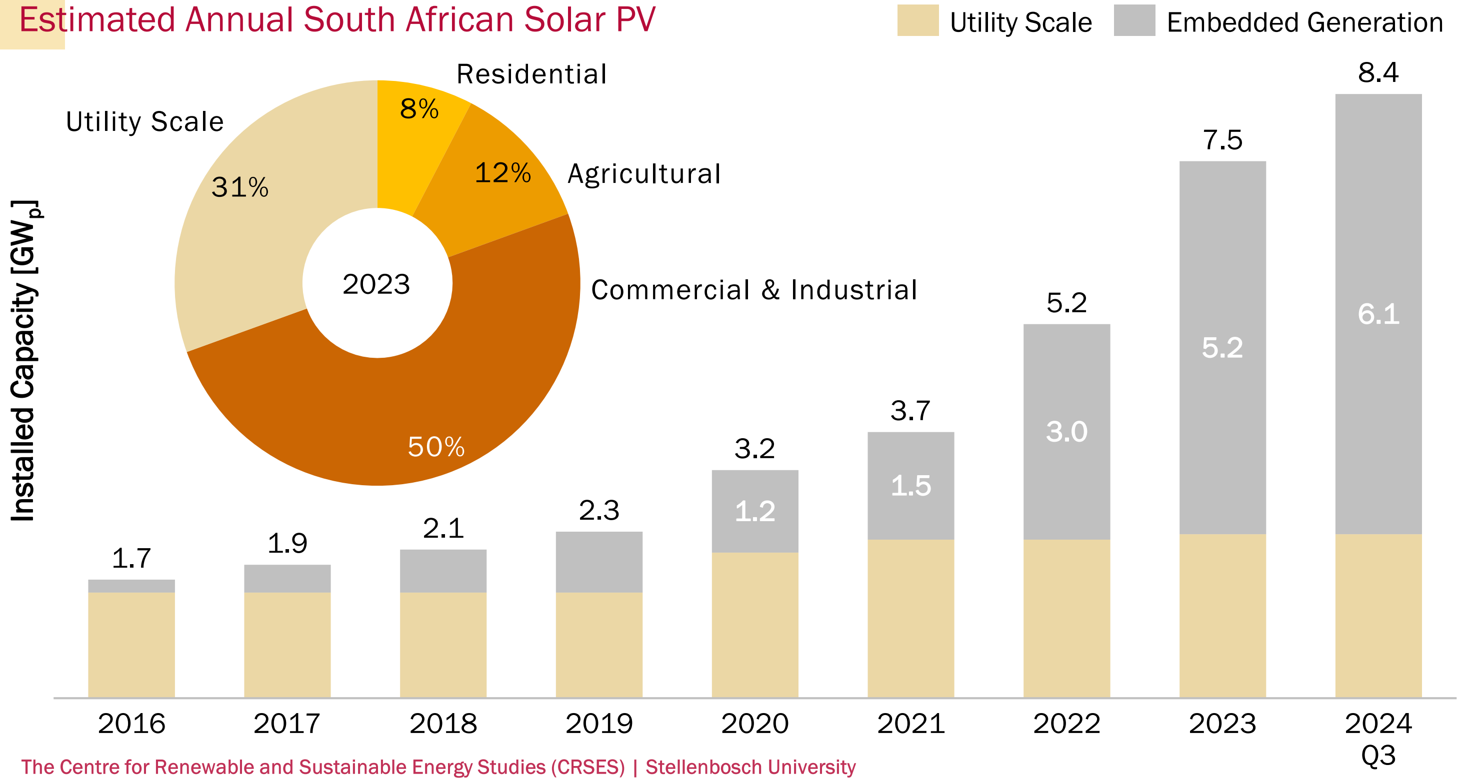

Source: Eskom 2024 | SALGA 2023 | GreenCape 2023. **Notes:** Q3: quarter 3.

By May 2024, the capacity of embedded PV was almost double that of utility-scale PV. This contributes to South Africa's generation capacity, assisting with the mitigation of generation adequacy problems resulting in load shedding.

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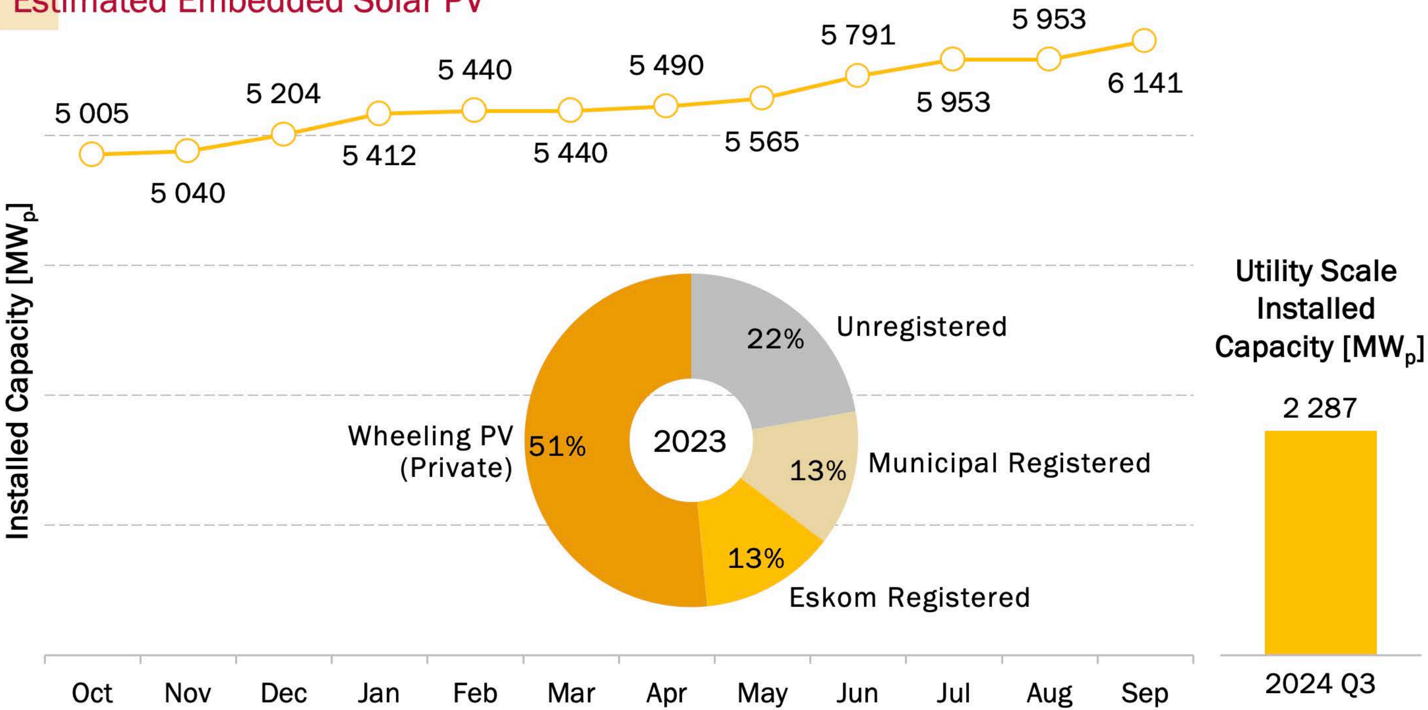
Estimated Embedded Solar PV



Source: Eskom 2024 | SALGA 2023. **Notes:** Q3: quarter 3.

A high penetration of embedded generation does, however, give rise to new challenges. Embedded generation systems, especially unregistered ones, are invisible to the utility during operation, and cannot be controlled easily. Power system operations (i.e. making sure that the system is stable) becomes more challenging.

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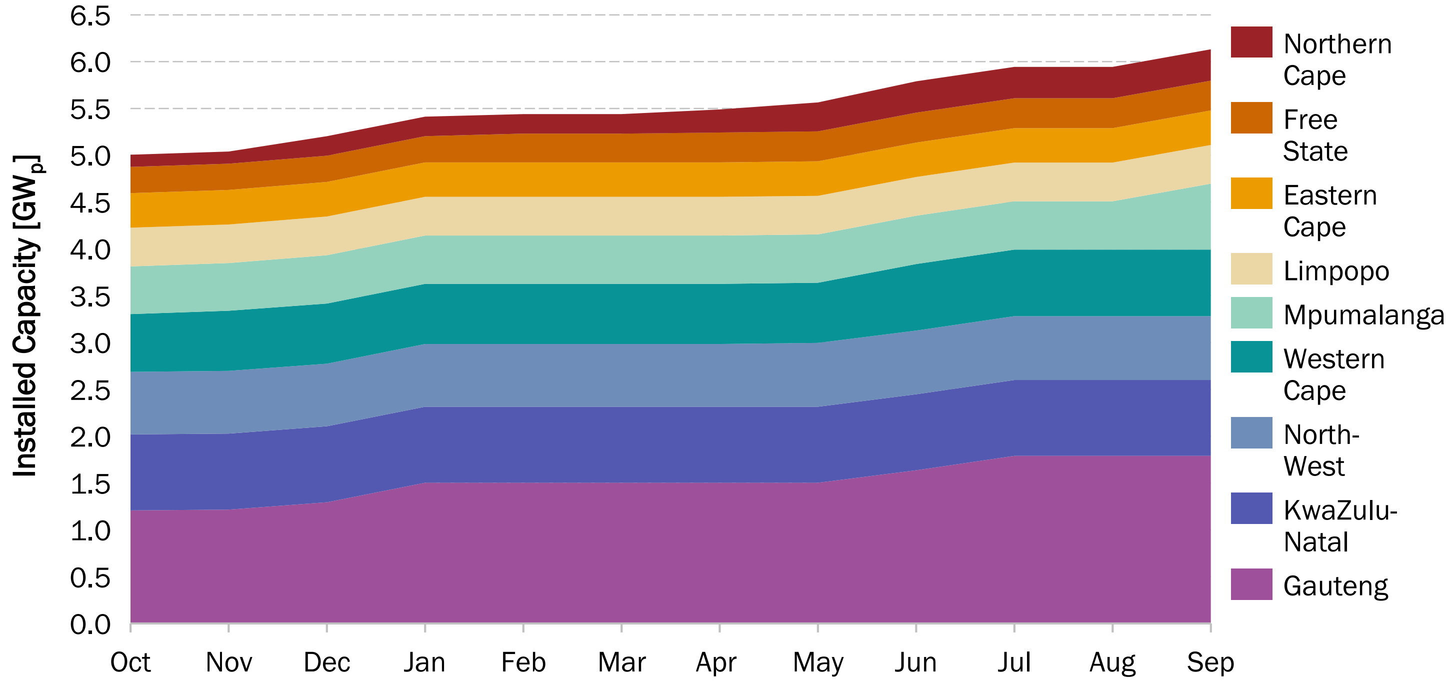
Estimated Embedded Solar PV



Source: Eskom 2024 | Department of Statistics South Africa.

Renewable Energy Integration Impact

International Experience

The integration of wind and PV into existing power systems impacts a variety of technical aspects on a local, regional, and system-wide (national) level. Some of these impacts are relevant from the first wind and PV installations on a network, while other impacts only start occurring as the share of renewables on the network grows. In South Africa we need to investigate constrained flexibility, while stability will only become a challenge in the 2030s (based on our existing electricity policy).

This illustrates the constraints experienced by the system as there is increased integration of renewable energy.

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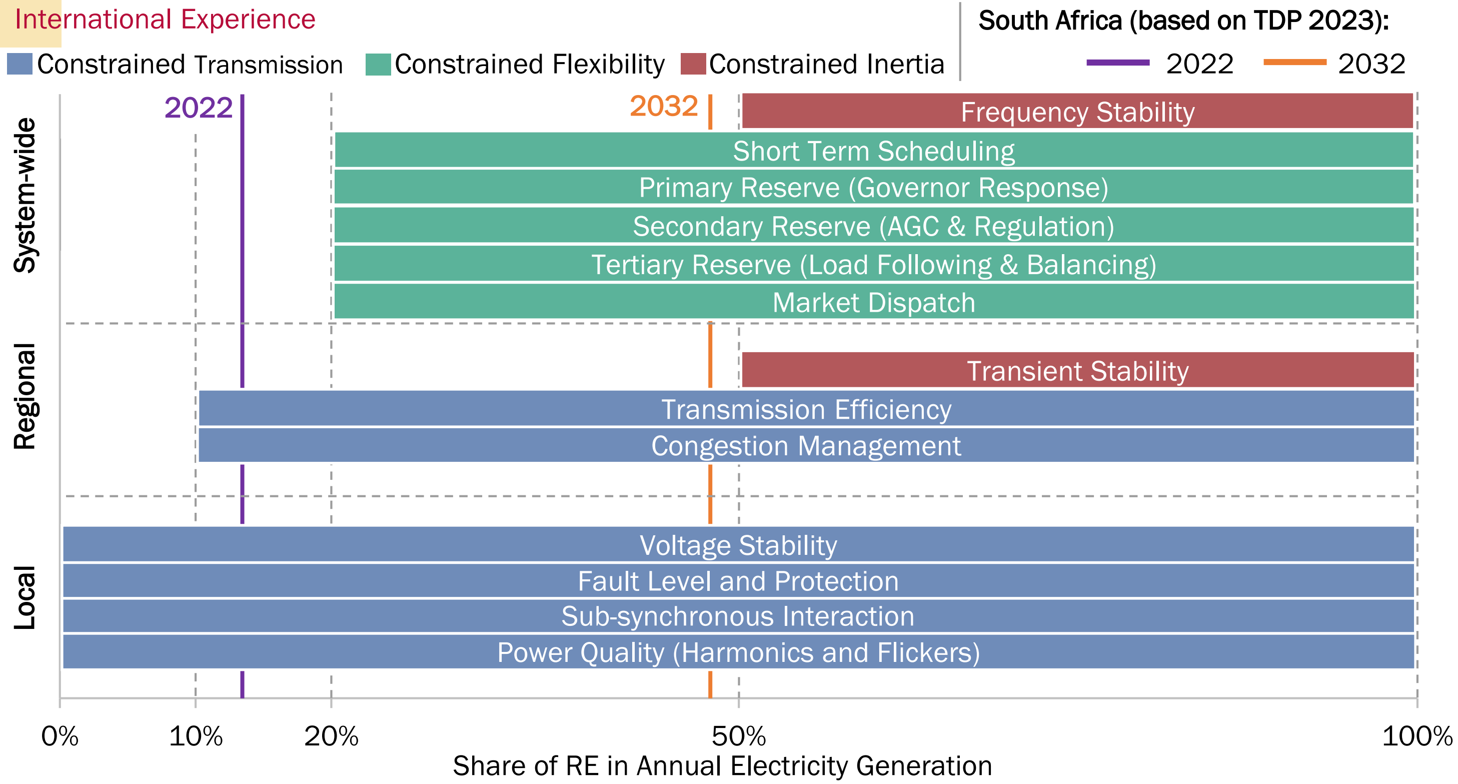
Renewable Energy Integration Impact

International Experience



Source: Mararakanye & Bekker 2019 | Eskom 2022 (TDP 2023 – 32).

4
LOAD SHEDDING STATISTICS

Load shedding is increasing exponentially in recent years. In 2023 we experienced 6 838 hours (78%) of load shedding out of the 8 760 hours in the year.

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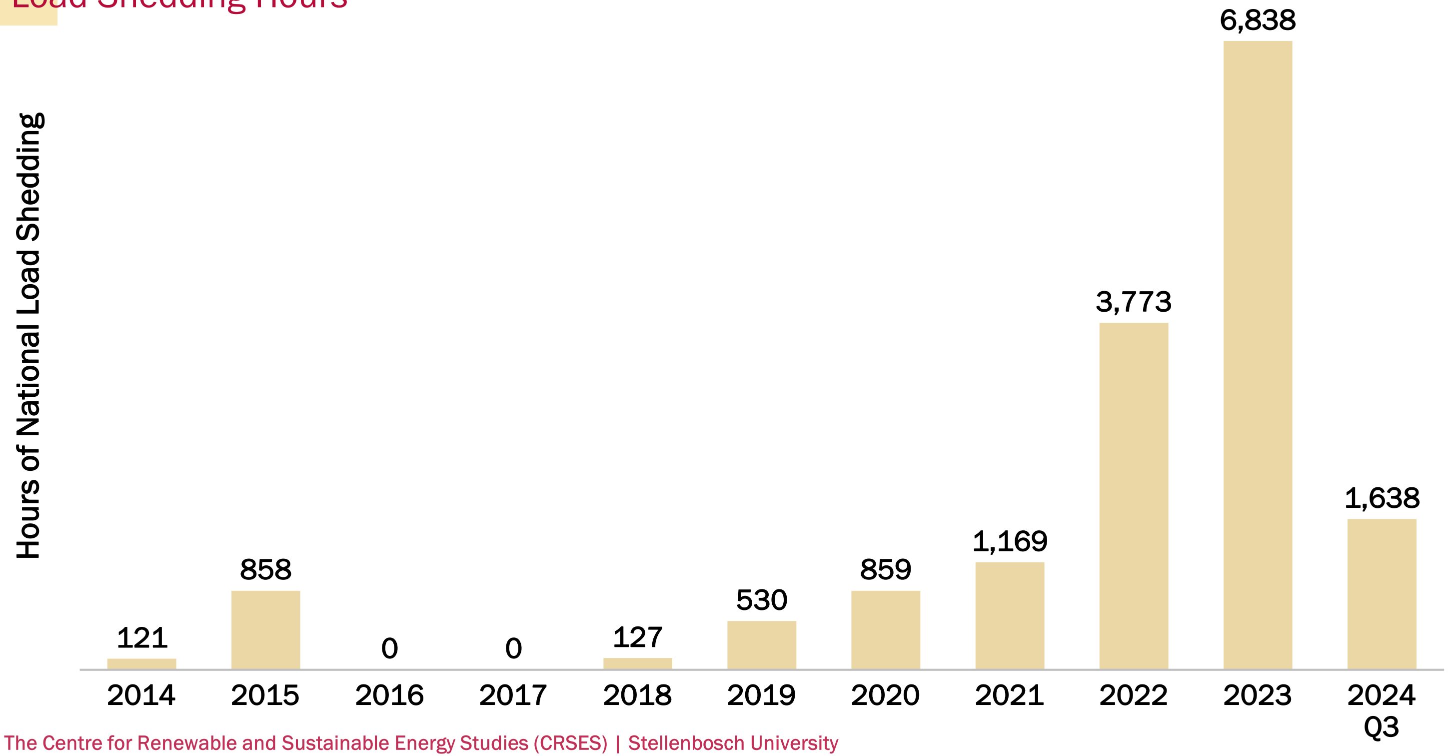
Load Shedding Hours



Source: Eskom 2024 | Eskom se Push 2024 | NERSA 2023. **Notes:** Q3: quarter 3.

We can now zoom in on the last few years and categorize the load shedding by stage. There was an 81% increase from 2022 to 2023 in the total number of hours. Stage 6 increased significantly from 2022 to 2023, by 505%.

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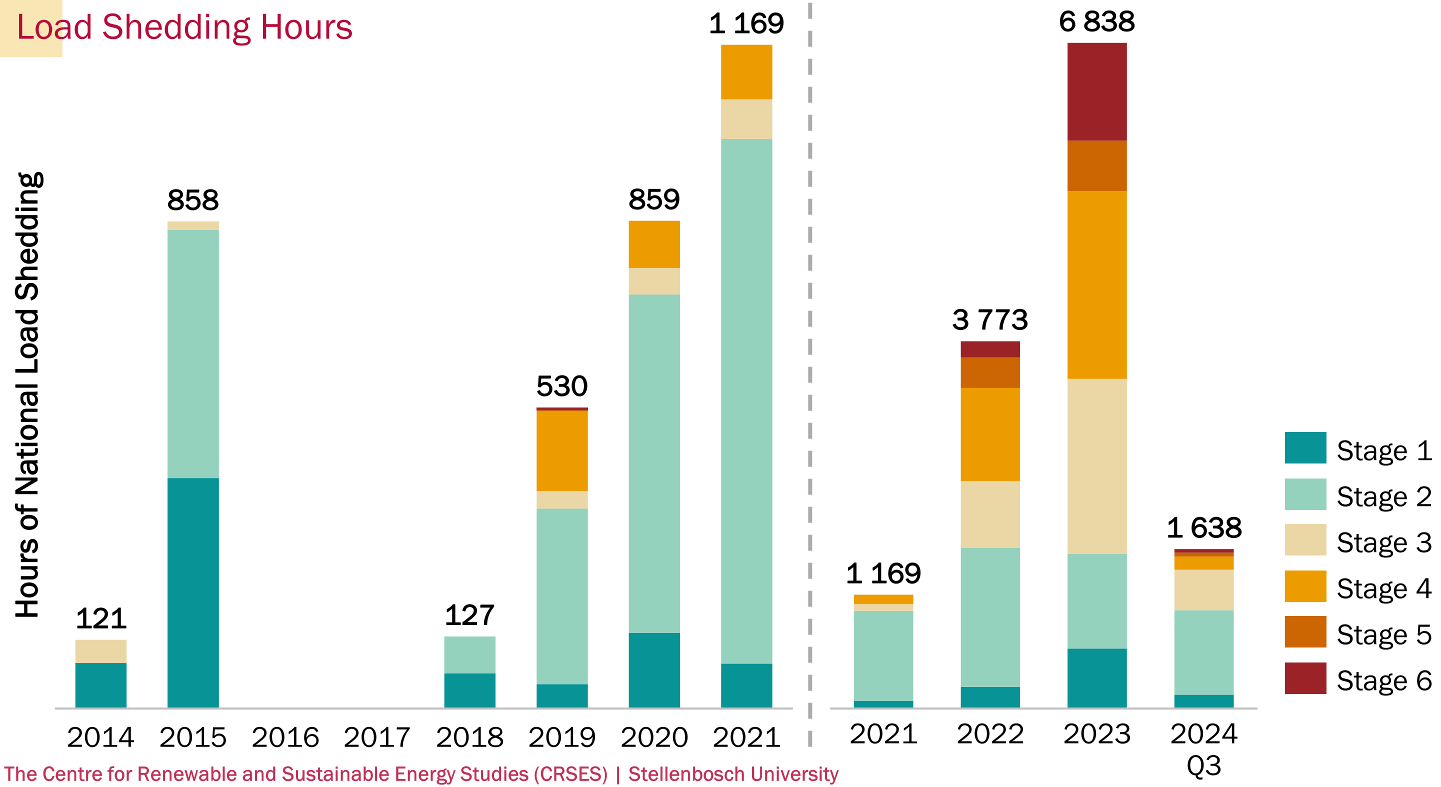
Load Shedding Hours



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Source: Eskom 2024 | Eskom se Push 2024 | NERSA 2023. **Notes:** Q3: quarter 3.

Load shedding suddenly disappeared in April.

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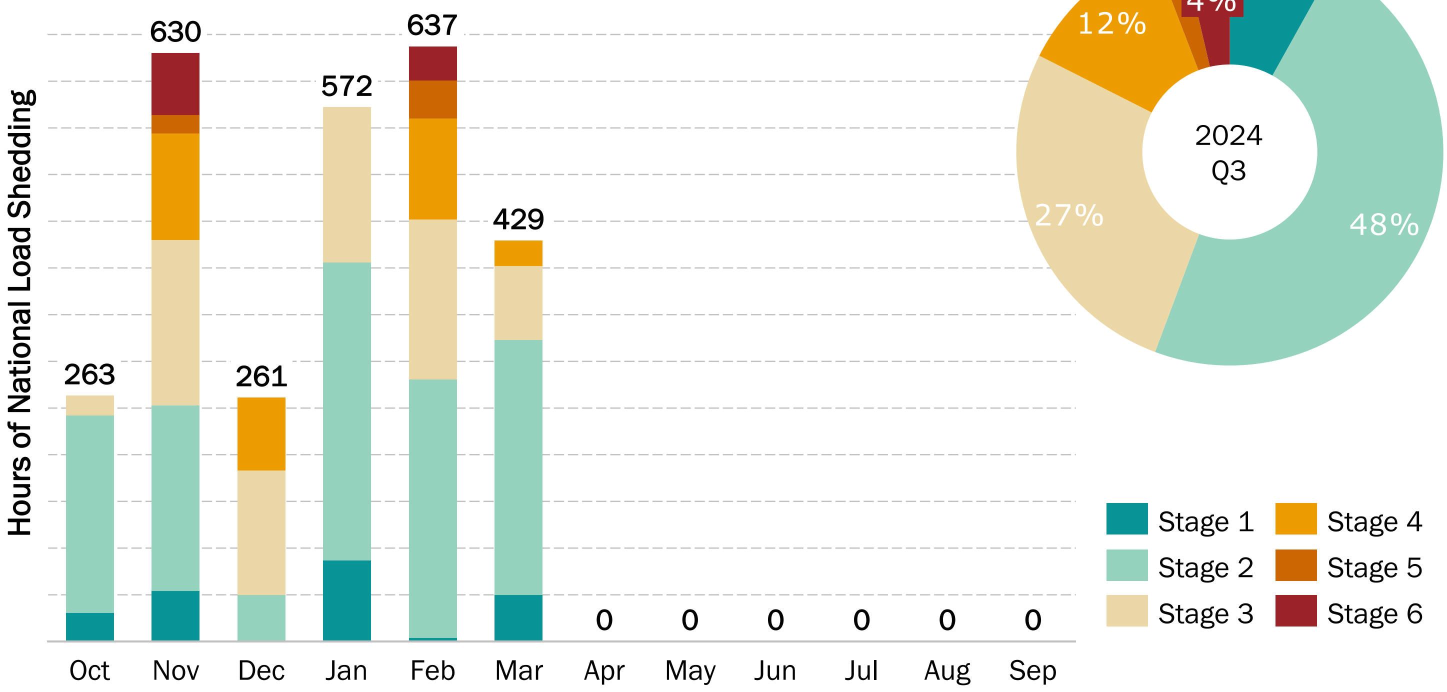
Load Shedding Stage Hours



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Source: Eskom 2024 | Eskom se Push 2024 | NERSA 2023. **Notes:** Q3: quarter 3.

The upper limit of load shedding refers to the maximum load that could be shed during a specific stage. Stage 1 has a load shedding upper limit of 1000MW, stage 2: 2000MW, stage 3: 3000 MW and so on. Therefore, the unserved energy (what was actually shed) is lower than the upper limit of that stage. Now we can compare the unserved energy with this upper limit for each month. These are also correlated to the load shedding hours.

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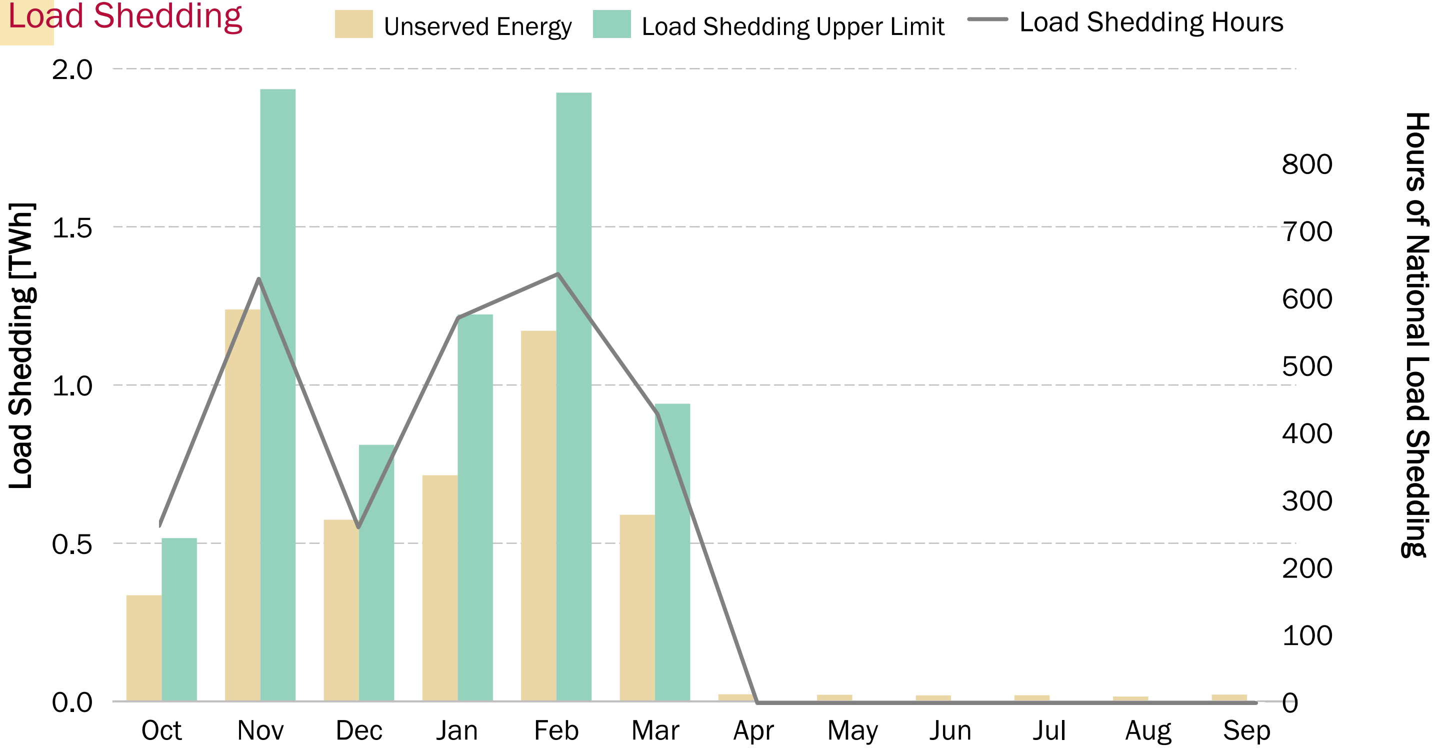
Load Shedding



Source: Eskom 2024 | Eskom se Push 2024 | NERSA 2023. **Notes:** Q3: quarter 3.

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