# Statistics of utility-scale power generation in South Africa

**2022**
(1 Jan 2022 – 31 Dec 2022)

**CSIR Energy Centre**
v1.0

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Science and Innovation
REPUBLIC OF SOUTH AFRICA

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# Summary of 2022 statistics:
# Coal still dominates and provides about 80% of electricity generated, high diesel usage continues, renewables (excluding hydro) accounted for 7%

**By 2022 South Africa had 54 GW of wholesale/public nominal capacity**

- Coal is 39.8 GW (increased)
- Nuclear is 1.9 GW (unchanged)
- Diesel (OCGT) is 3.4 GW (unchanged)
- Hydro is 0.6 GW hydro and pumped storage is 2.7 GW (unchanged)
- Wind is 3.4 GW (unchanged)
- Solar PV is 2.3 GW (increased)
- CSP is 0.5 GW (unchanged)
- 720 MW of coal, 419 MW of wind and 75 MW of solar PV became operational in 2022

**The electricity mix is still dominated by coal-fired power generation which contributed about 80% to system demand in 2022**

- Coal energy contributed 80.1% (176.6 TWh)
- Nuclear energy contributed 4.6% (10.1 TWh)
- Renewable energy contributed 13.7% (30.2 TWh)
- Renewable energy contributed 7.3% (16.2 TWh) - excluding hydro
- The remaining 1.6% came from diesel (3.6 TWh)

NOTES: Nominal capacities reported as on 31 Dec 2022; Electricity mix given for 1 Jan 2022 – 31 Dec 2022; RSA = Republic of South Africa; OCGT – Open-Cycle Gas Turbine; CSP – Concentrating Solar Power; Excludes Embedded Generation (EG) and Distributed Generation (DG); Sources: CSIR Analysis; Eskom

# Summary of 2022 statistics:
# System demand very similar to previous year but not yet 2019 levels

**In 2022, system energy demand increased only by 0.2 TWh relative to the previous year, but was 5.2 TWh (2.2%) less than in 2019.**

- Peak system demand was 34.6 GW (vs 35.0 GW in 2021)
- Contributions of coal continued to decrease. Local hydro generation doubled. For the first time, there was a decrease in solar outputs, for both solar PV and CSP.

**In 2022, the VRE fleet of 6.2 GW (wind, solar PV, CSP) reduced high demand hours by ~ 70%**

- VRE fleet reduced peak demand by ~ 1.4 GW
- VRE fleet also reduced high-demand hours (hours with >30 GW system demand) from 583 hours to 177 hours (406 hours less, -70%)

**Flexibility needs are not yet significantly increased with the existing VRE fleet in 2022**

- Minimum system demand was 18.7 GW whilst residual demand minimum was 17.8 GW (relative to a minimum system demand of 18.5 GW and residual demand of 17.1 GW in 2021).
- For 10% of the year, system demand and residual demand was above 29.4 GW and 27.6 GW, respectively
- For 90% of the year, system demand and residual demand was above 21.6 GW and 20.4 GW, respectively

NOTES :Residual demand = System demand less variable renewable energy (solar PV, CSP and wind); VRE – Variable Renewable Energy; Excludes Embedded Generation (EG) and Distributed Generation (DG); stats for 1 Jan 2022 – 31 Dec 2022
Sources: CSIR Analysis; Eskom

# Summary of 2022 statistics:
# 3 773 hours of loadshedding, upper limit 11 529 GWh with actual 8 301 GWh

**In 2022, loadshedding occurred for 3 773 hours with an upper limit of 11 529 GWh relative to actual energy shed of 8 301 GWh**

- Intensive loadshedding has been experienced
- Loadshedding mostly Stage 4 type, first year not Stage 2
- Loadshedding occurred for 43% of the hours

**Eskom fleet EAF declining trend continues and drove loadshedding events in 2022 with specific concerns surrounding UCLF (unplanned outages) trends**

- Eskom fleet average EAF of 58.1% for 2022 (relative to 2021 of 61.7%, 2020 of 65%, 2019 of 66.9% and 2018 of 71.8%)
- EAF planned maintenance at 10.6% (PCLF), unplanned outages at 29.8% (UCLF) & other outages at 1.5% (OCLF)
- The best hourly EAF was 68.2% and worst was 45.4%, respectively occurring on 24 July 2022 and 31 Dec 2022

NOTES: PCLF - Planned capability Loss Factor; UCLF – Unplanned Capability Loss Factor; OCLF – Other Capability Loss Factor;
EAF - Energy Availability Factor; EAF = 100%-PCLF-UCLF-OCLF
Excludes Embedded Generation (EG) and Distributed Generation (DG); Statistics calculated for 1 Jan 2022 – 31 Dec 2022

# Agenda (2022)

1 Overview actual electricity production

2 Monthly electricity production

3 Weekly electricity production

4 Daily electricity production

5 Hourly electricity production

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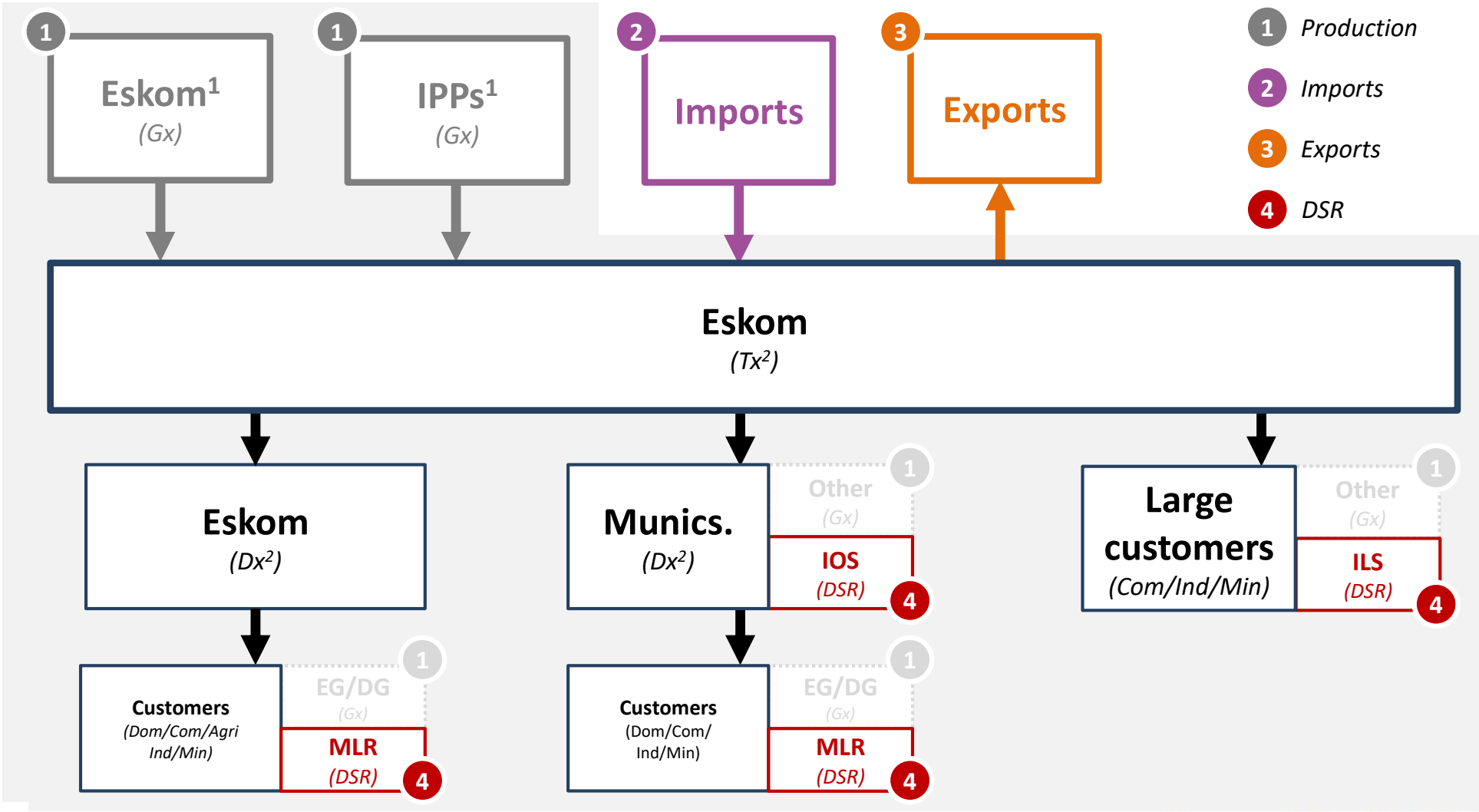
# Equivalent wholesale South African electricity production and demand as measured & published by Eskom




EG = Embedded Generation; DG = Distributed Generation; Gx = Generation; Tx = Transmission; Dx = Distribution;
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS);
NOTES: Items in light faded gray are NOT included in statistics presented in this publication.
[1] Power generated less power station load (auxillaries); Minus pumping load (Eskom owned pumped storage); [2] Transmission/distribution networks incur losses before delivery to customers



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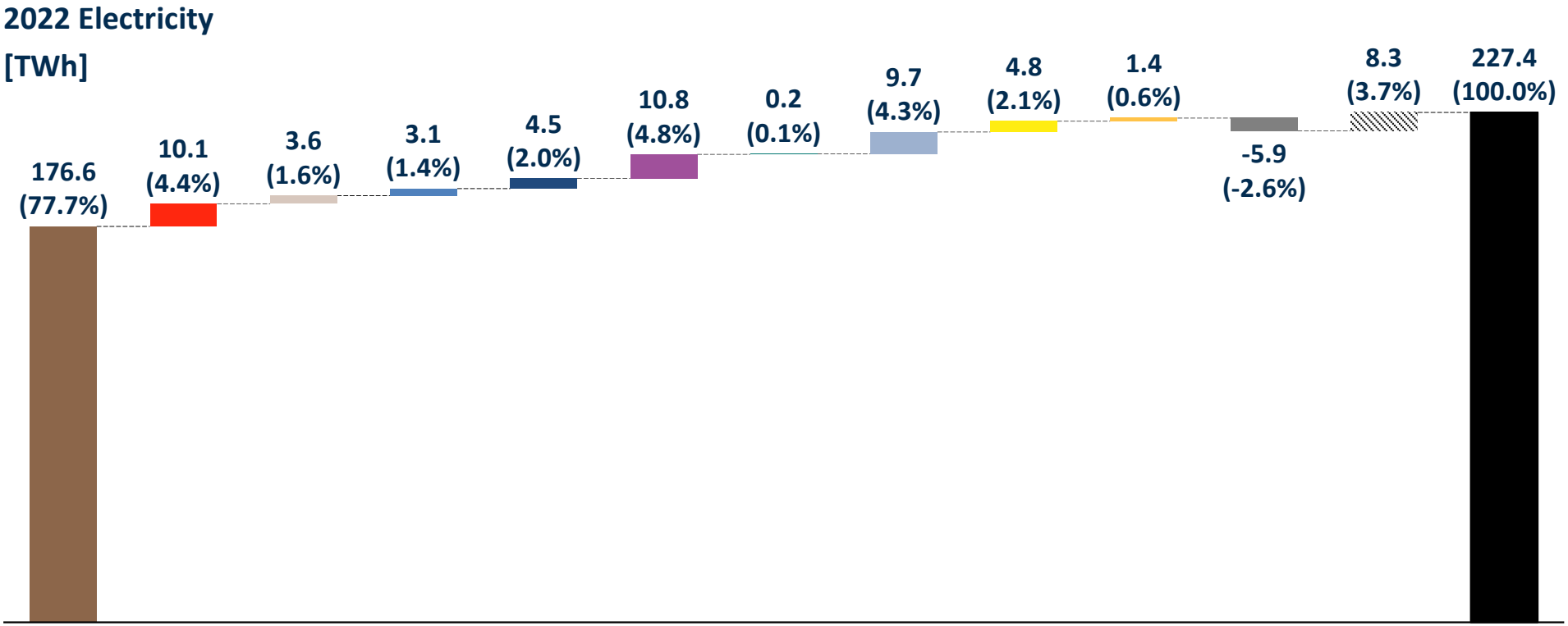
# In 2022, for the first time coal dropped below 80% of the ~228 TWh of total system load met, whilst PV, wind and CSP contributed 7%

Actuals captured in wholesale market for Jan-Dec 2022 (i.e. without self-consumption of embedded plants)

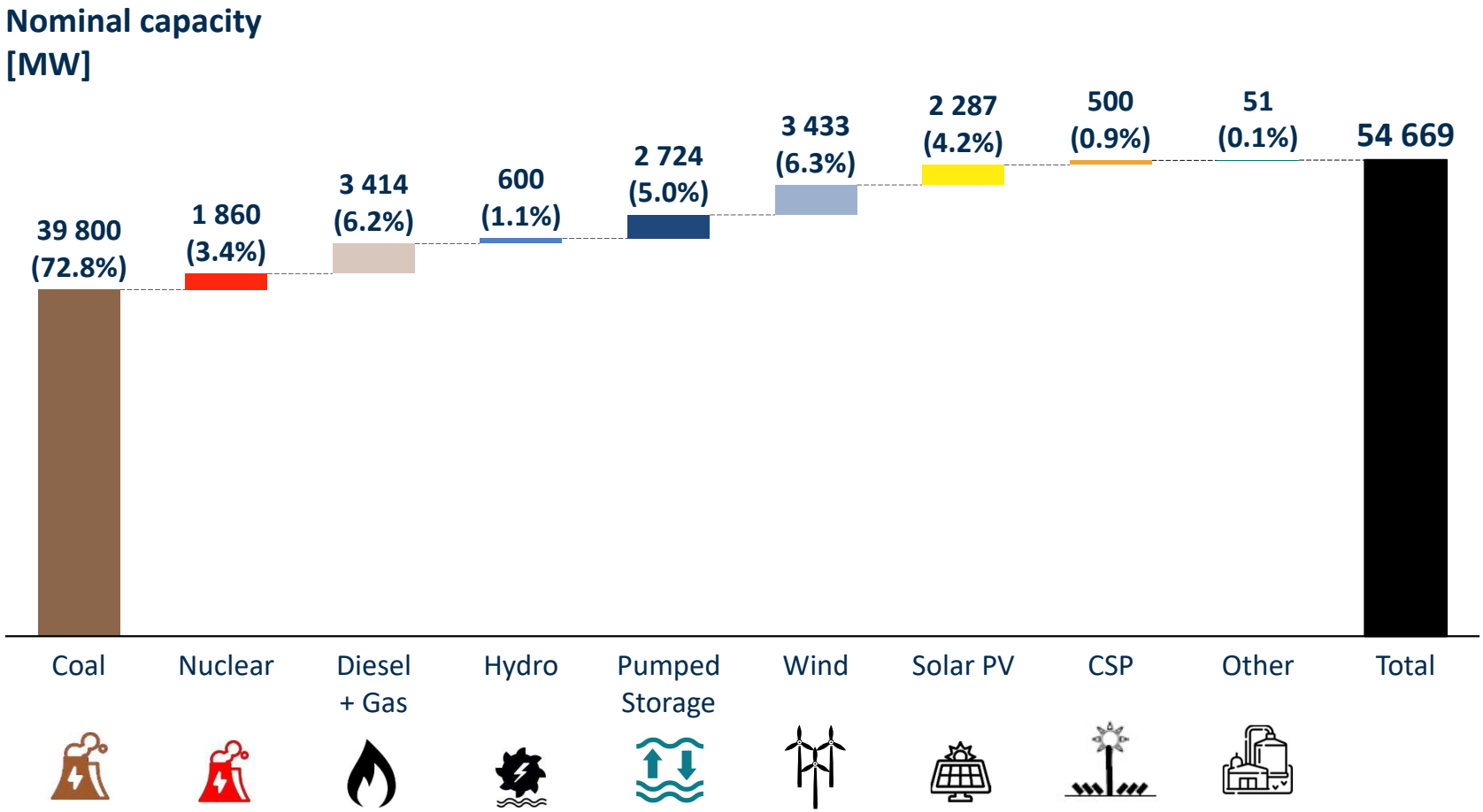



| | Coal | Nuclear | Diesel + Gas | Hydro | Pumped Storage | Imports | Other | Wind | Solar PV | CSP | Pump load | DSR | System Load (domestic & export) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 (full-year) | 184.7 | 12.2 | 3.2 | 1.6 | 4.9 | 10.2 | 0.1 | 8.4 | 5.1 | 1.7 | -6.6 | 1.9 | 227.2 |

Notes: Wind includes Eskom's Sere wind farm (100 MW). Wind and solar PV energy excludes curtailment and is thus lower than actual wind and solar PV generation. PS = pumped storage
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom

# Nominal capacity by end of 2022

Actual nominal installed capacity at 31 Dec 2022 (excluding embedded generation capacity and private capacity)




| | Coal | Nuclear | Diesel + Gas | Hydro | Pumped Storage | Wind | Solar PV | CSP | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **2021** (31 Dec 2021, MW) | 39 314 | 1 860 | 3 414 | 600 | 2 724 | 3 023 | 2 212 | 500 | 26 | 53 673 |

Notes: RE = Renewable Energy; Total nominal installed capacity = Eskom capacity + IPPs; Embedded generation and municipal-owned capacity excluded

Sources: Eskom



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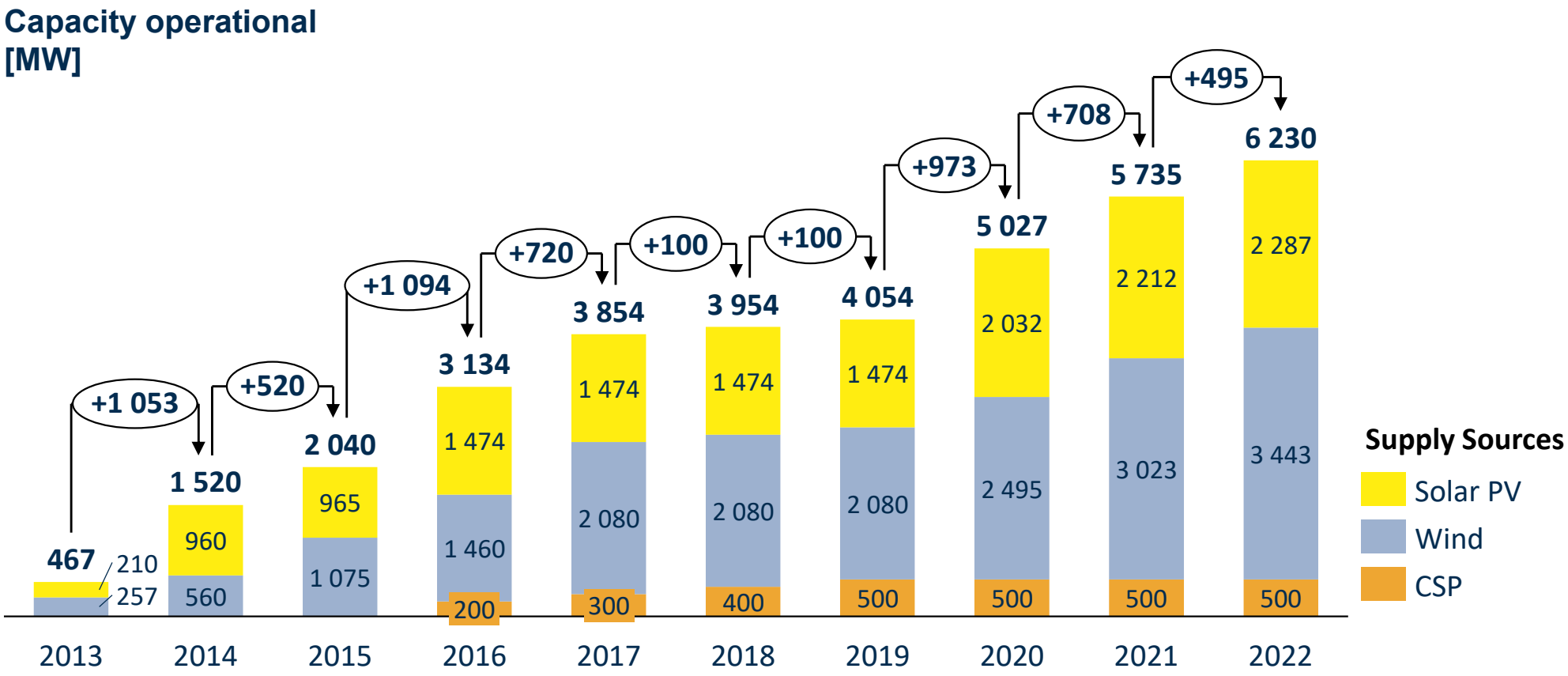
# From 1 Nov 2013 to 31 Dec 2022, 3 443 MW of wind, 2 287 MW of large-scale solar PV and 500 MW of CSP became operational in RSA




Notes: RSA = Republic of South Africa. Solar PV capacity = capacity at point of common coupling. Wind includes Eskom's Sere wind farm.
Sources: Eskom; DoE IPP Office



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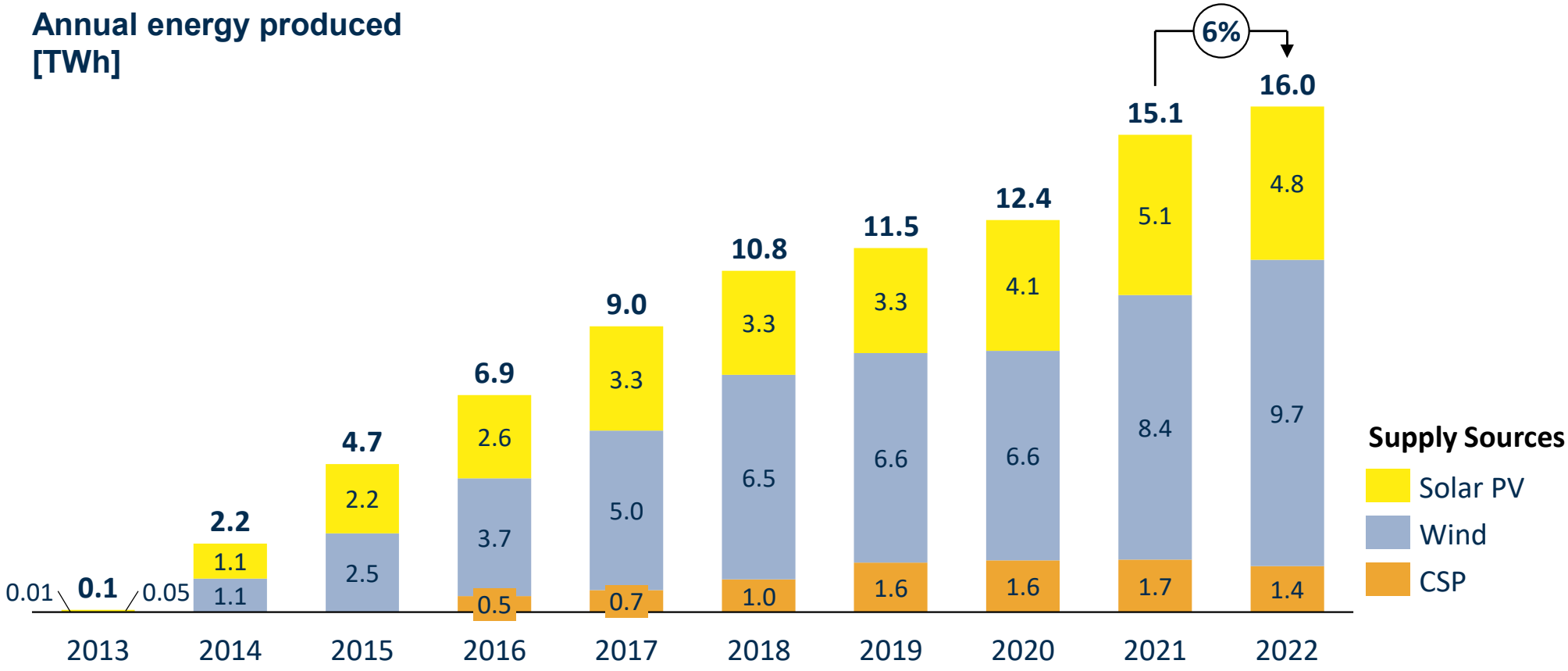
# In 2022, 16 TWh of wind, solar PV & CSP electricity was generated in South Africa, 2022 was the first year when solar output decreased




Notes: Wind includes Eskom's Sere wind farm (100 MW). CSP energy measured from date when more than two CSP plant were commissioned.
Wind and solar PV energy excludes curtailment and is thus lower than actual wind and solar PV generation
Sources: Eskom; DoE IPP Office



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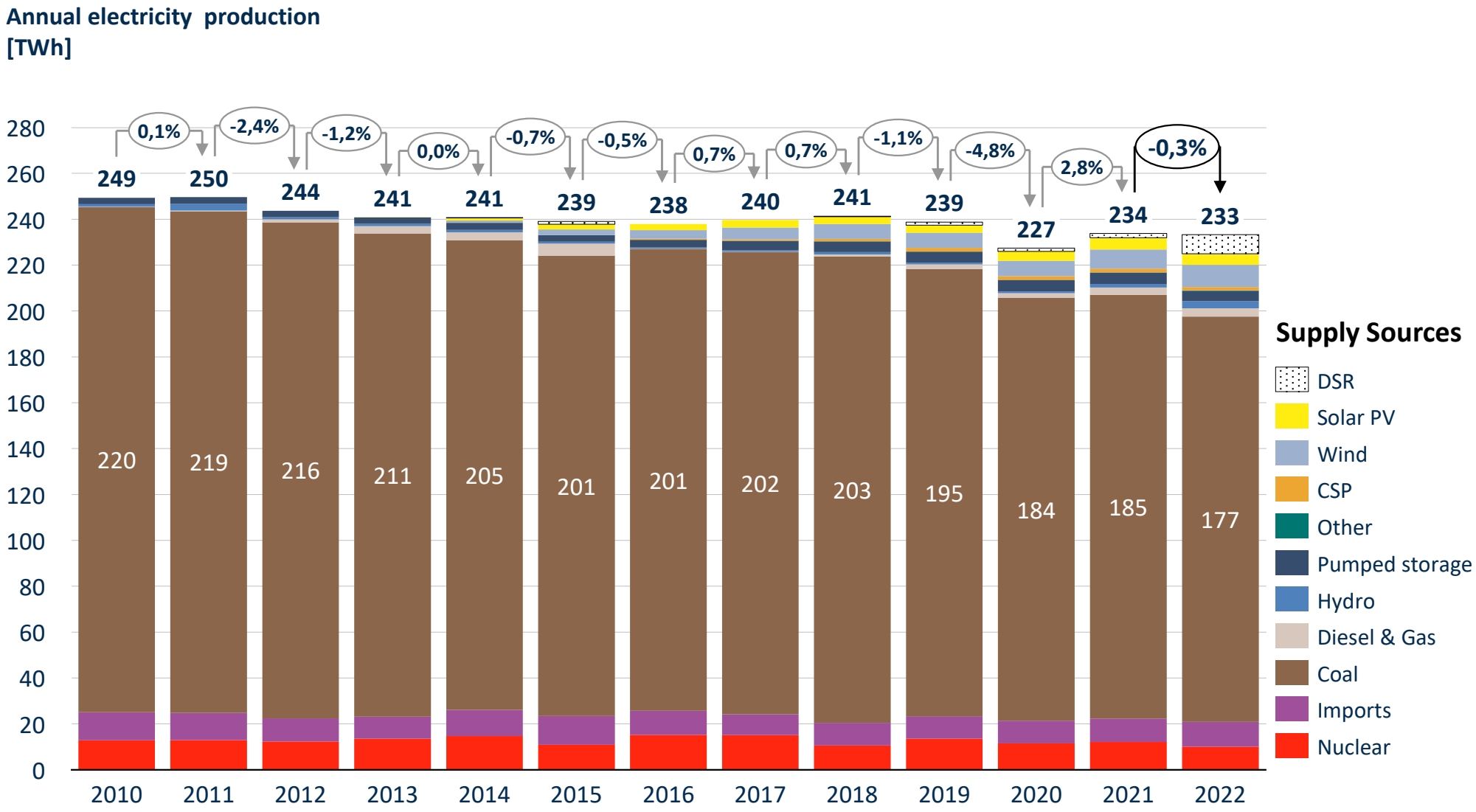
# Production in 2022 was constrained with diesel running extensively and significant increase in DSR (loadshedding)

Historical annual electricity production per supply source in TWh

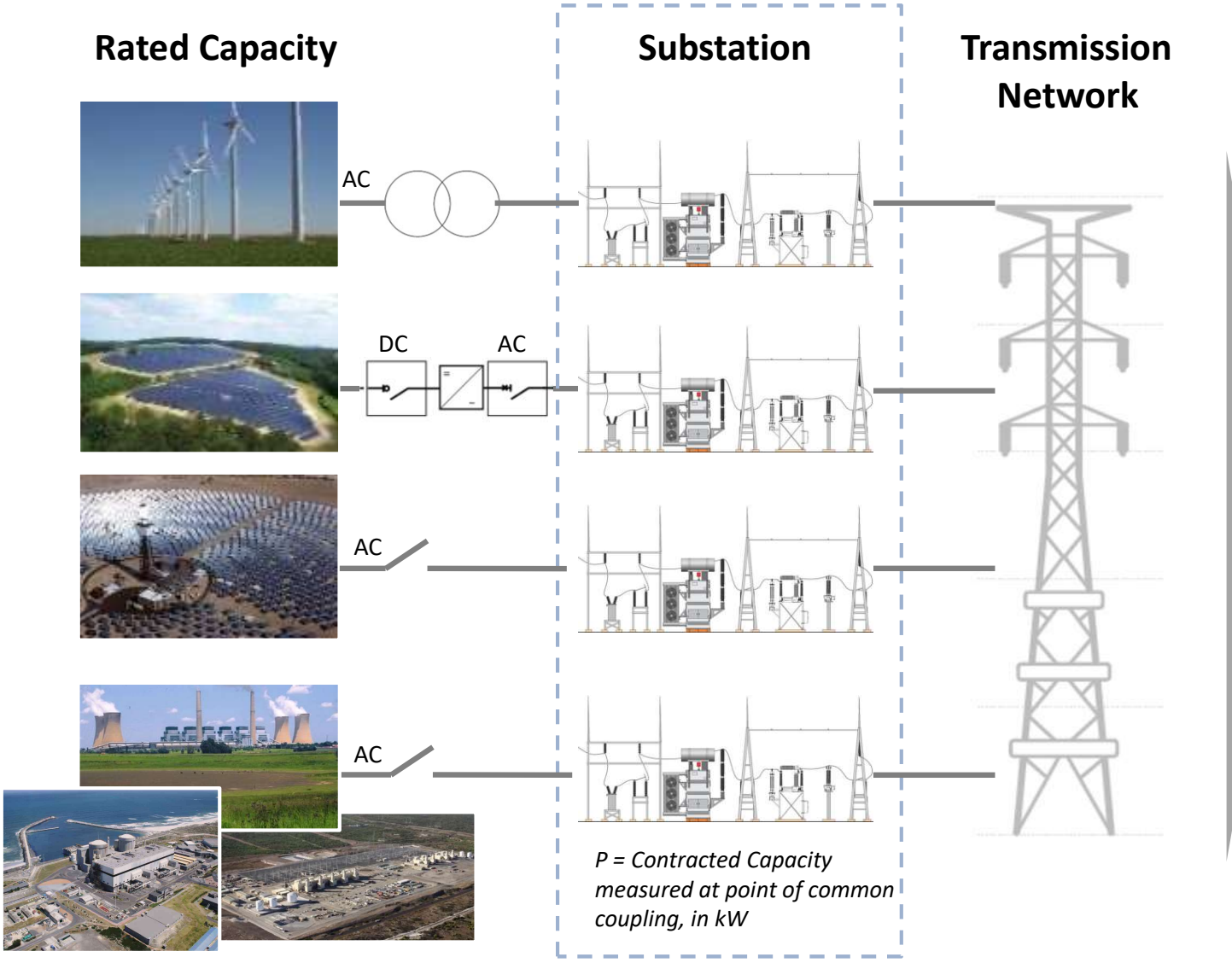





NOTES: Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS). DSR prior to 2018 has been estimated by the CSIR

Sources: Eskom; CSIR Energy Centre analysis

# Illustration: Calculation of the average capacity factor of operational power plant categories in RSA




**Average Capacity Factor (CF)**

$$CF = \frac{\frac{\sum_{t=1}^{n} E_t}{n}}{\frac{\sum_{t=1}^{n} P_t}{n}}$$

$$= \frac{Total\ Energy\ in\ time\ period\ (kWh)}{Average\ Capacity\ in\ time\ period\ (kW)}$$

*Where:*
*P = Contracted Capacity, in kW*
*E = Energy production, in kWh*
*t = Time period*
*n = Number of time periods*

Notes: RSA = Republic of South Africa. Simplified illustration of technology grid interconnections



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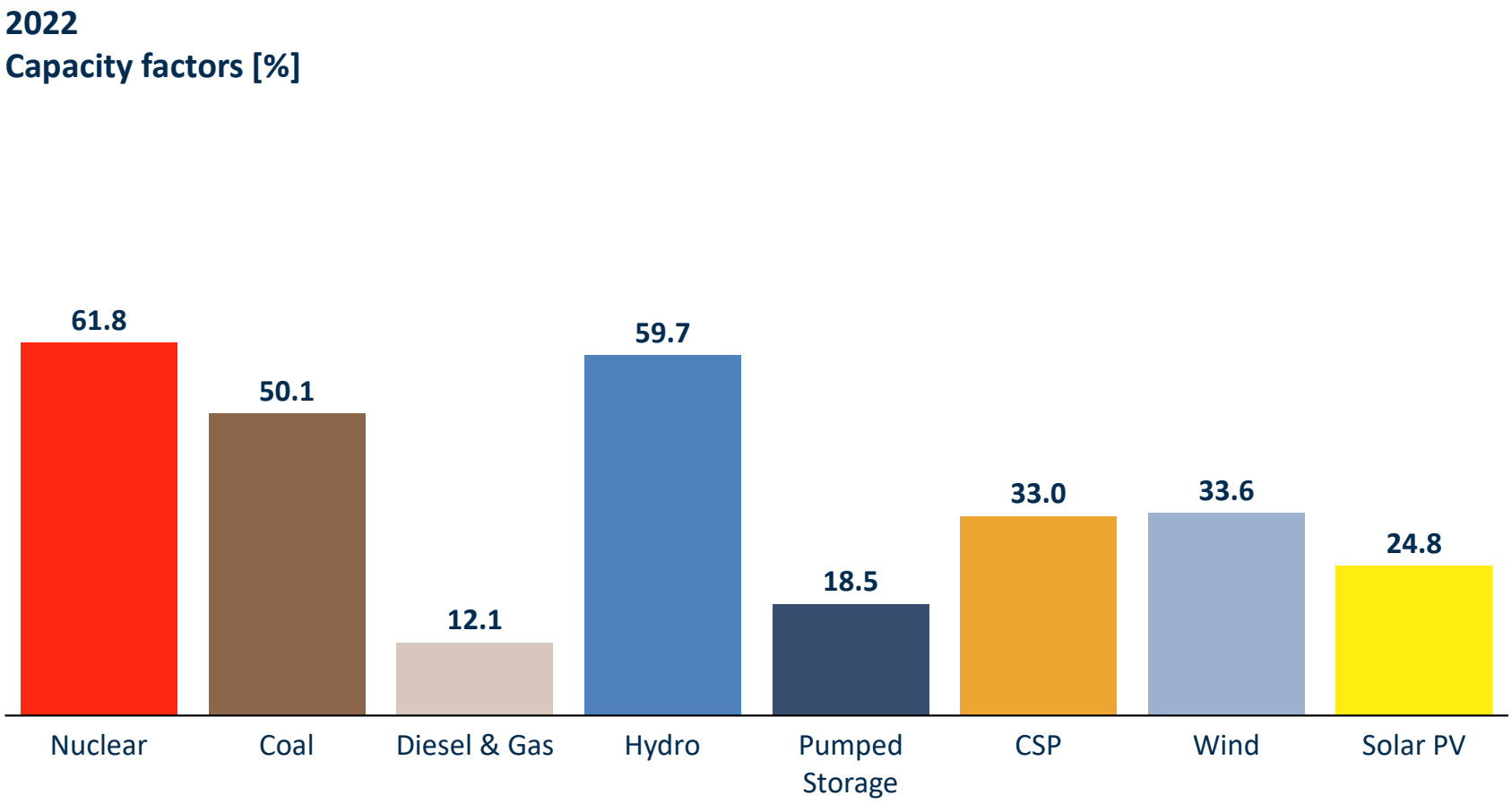
# Annual capacity factors per supply source in South Africa in 2022




Sources: Eskom



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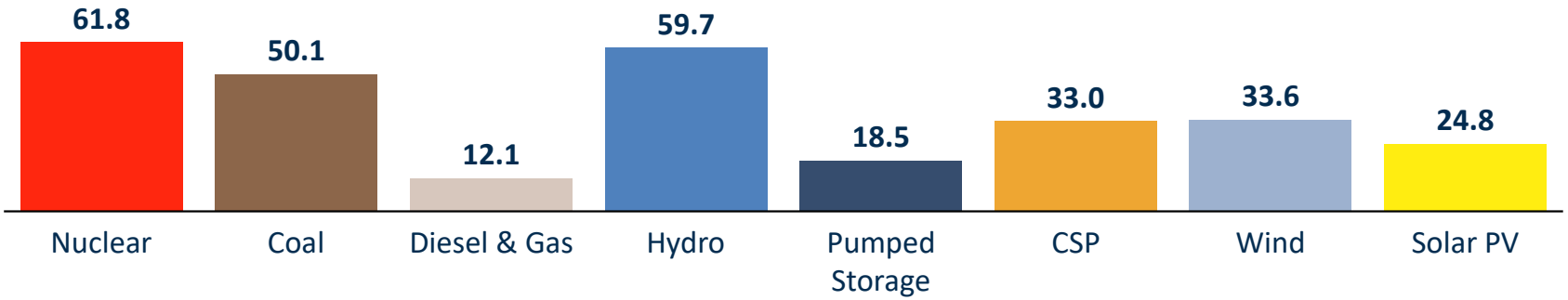
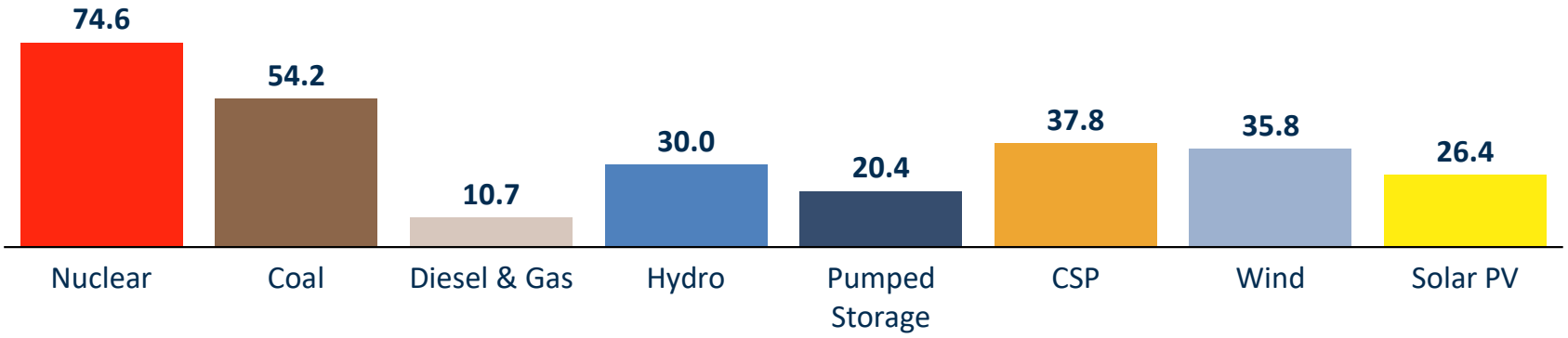
# Annal capacity factors per supply source in South Africa in 2022 and 2021

**2022**
**Capacity factors [%]**




**2021**
**Capacity factors [%]**





Sources: Eskom

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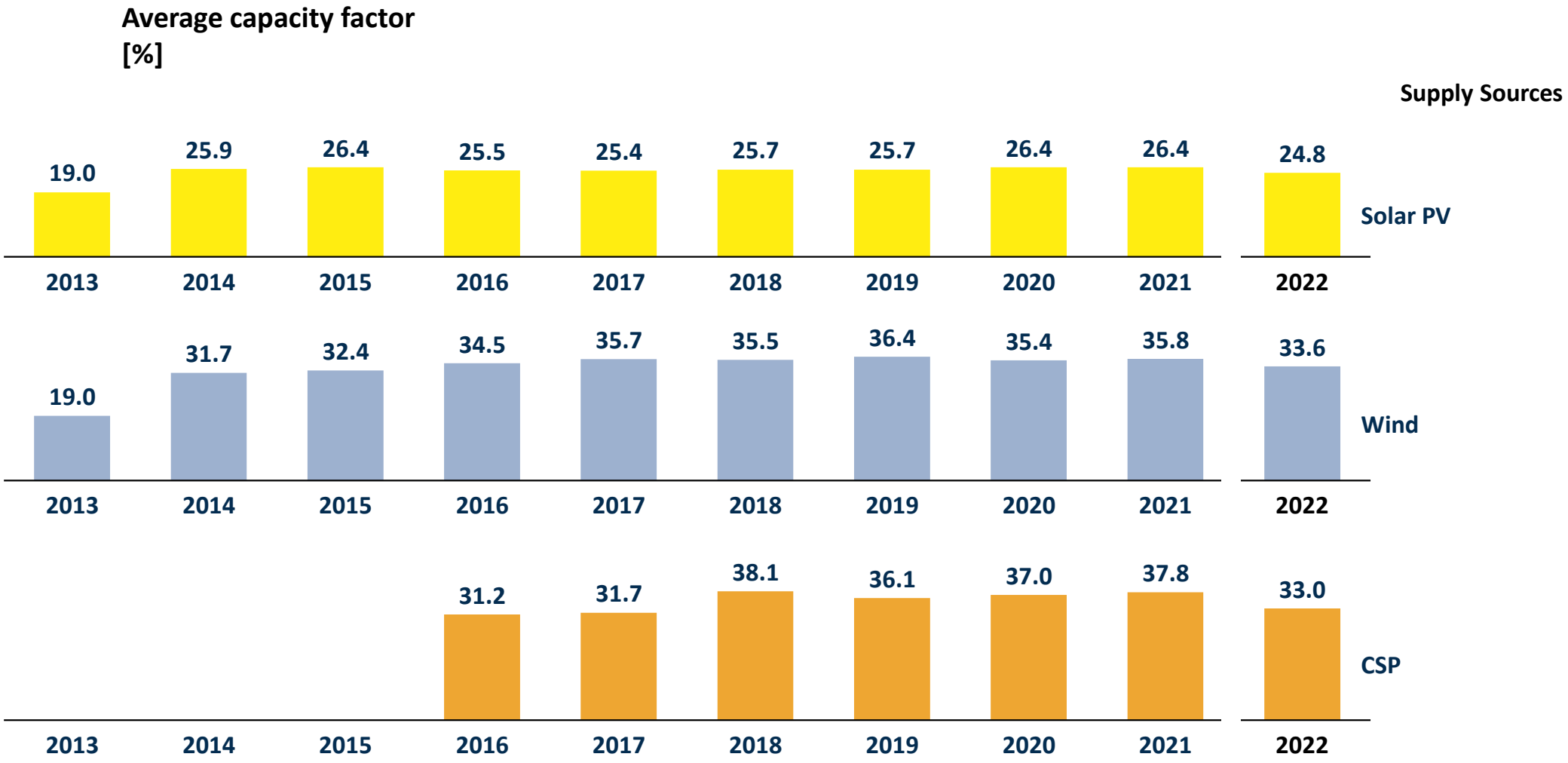
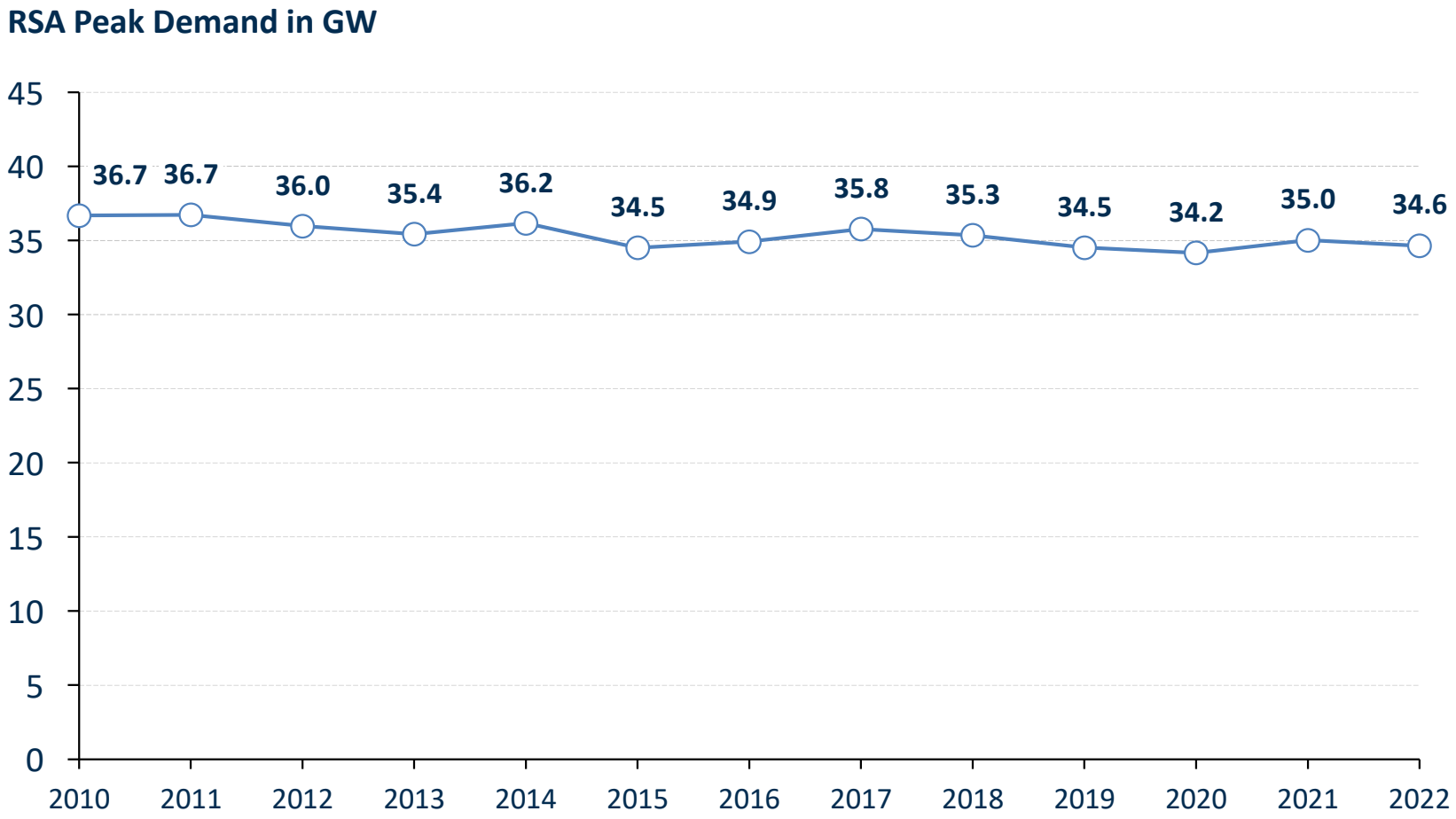
# In 2022, the average annual capacity factor of the solar PV, wind & CSP fleet was 25%, 34% and 33% respectively




NOTES: Historical capacity factors for other technologies were not available at the time of publication; Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants were commissioned. Wind includes Sere wind farm (100 MW). Wind and solar PV energy excludes curtailment and thus capacity factor is lower than actual wind and solar PV available.
Sources: Eskom; DoE IPP Office

# Annual peak demand in 2022 decreased slightly in comparison to 2021

Historical annual peak demand has been declining gradually for more than 10 years




Notes: Peak demand includes Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS).
Sources: Eskom



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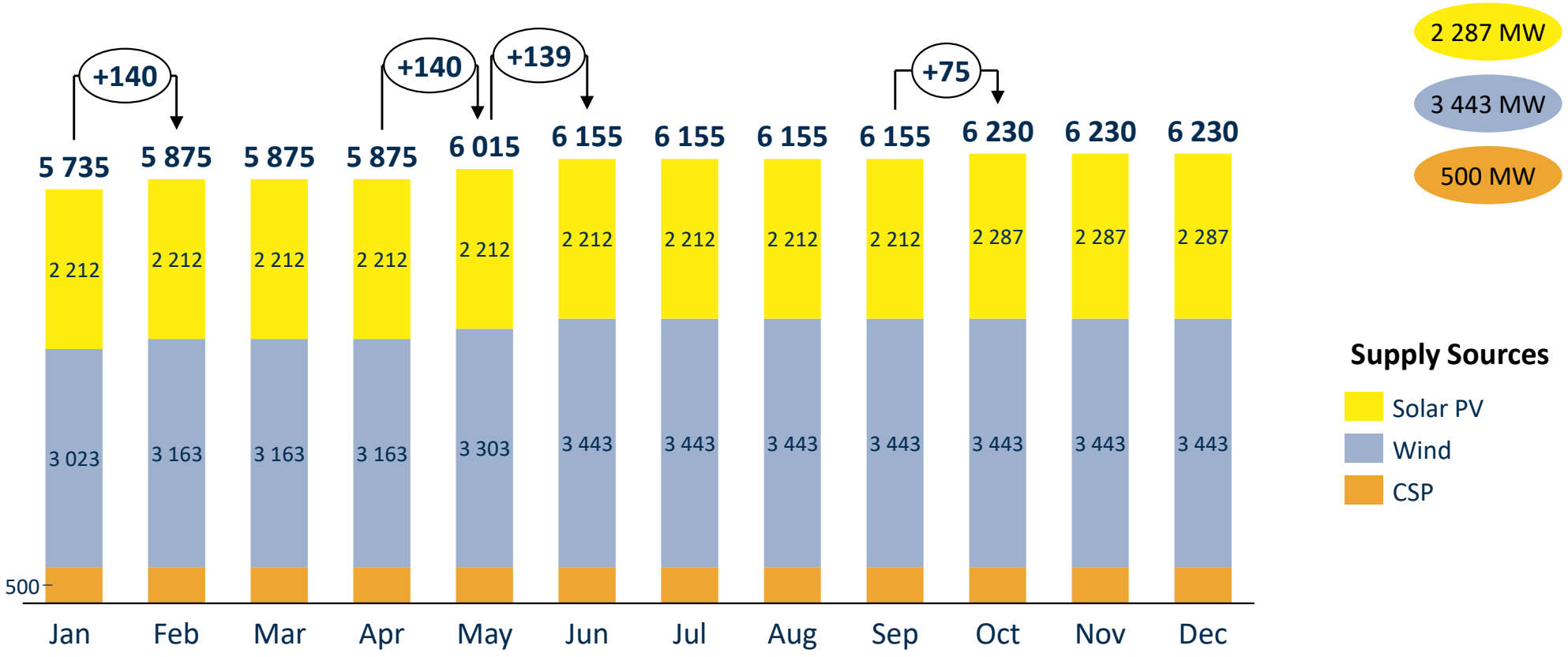
# In 2022, 419 MW of wind and 75 MW of solar PV was added to the grid

Total monthly installed capacity of utility-scale generation capacity in RSA from Jan to Dec 2022

**Capacity operational in 2022 [MW]**
(month end)






Sources: Eskom; CSIR analysis

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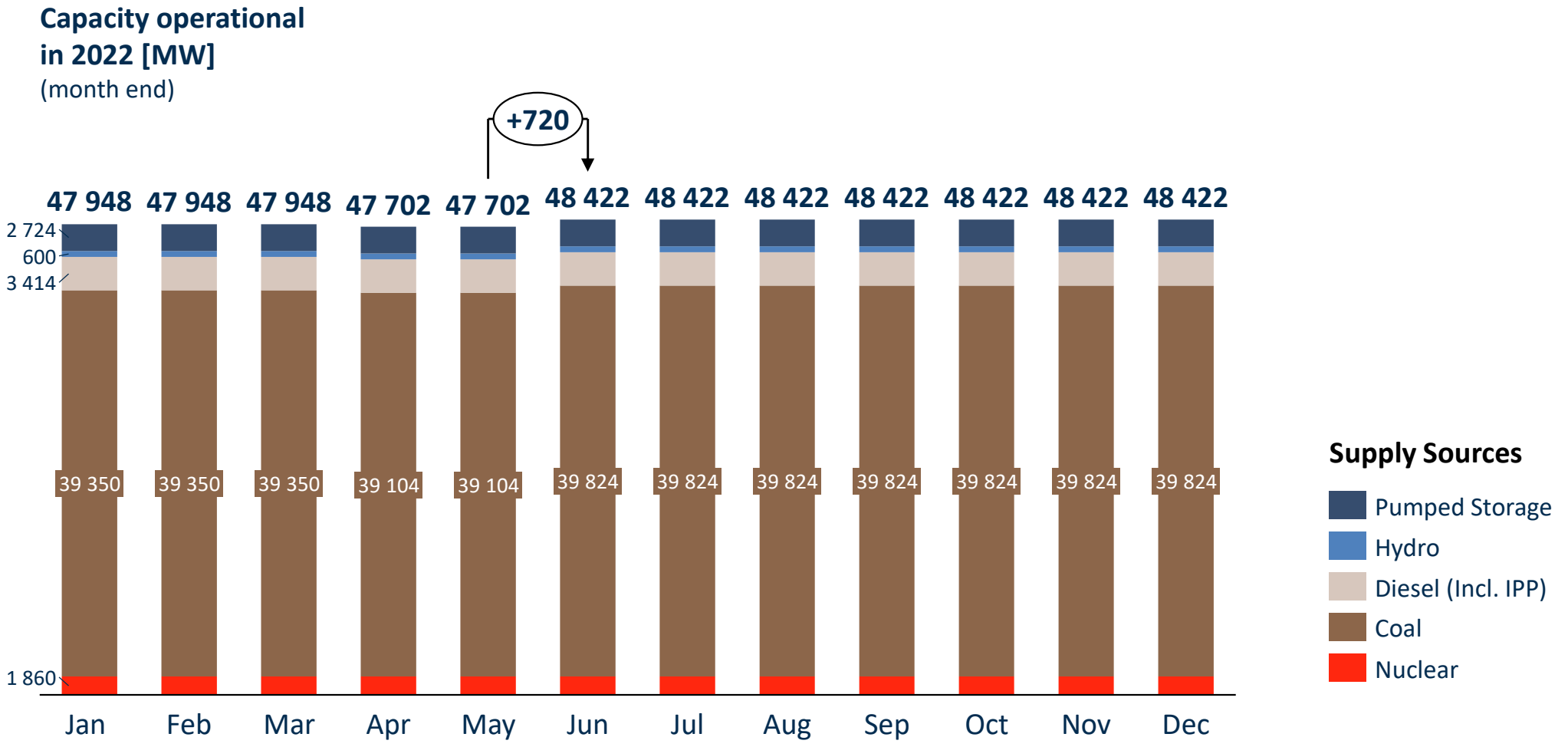
# In 2022, an additional 720 MW of coal (Kusile) was added to the grid

Total monthly installed capacity of utility-scale generation capacity in RSA from Jan to Dec 2022




Sources: Eskom; CSIR analysis



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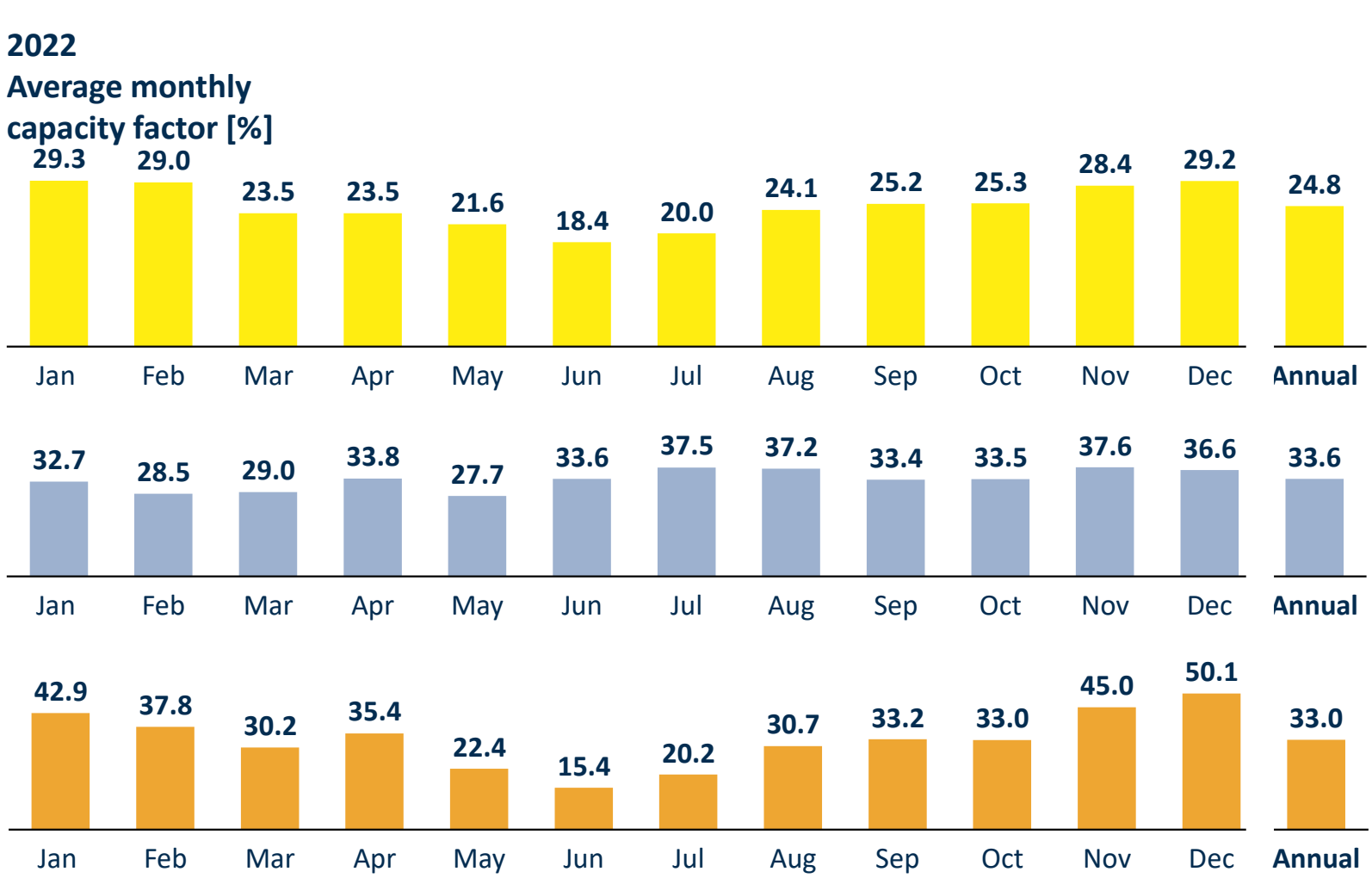
# Average monthly capacity factors for solar PV, wind and CSP

Average monthly capacity factors of solar PV, wind and CSP in RSA from Jan to Dec 2022




**Capacity operational** (31 Dec)

2 287 MW

3 443 MW

500 MW

**Supply Sources**

Solar PV

Wind

CSP

Notes: Capacity operational as per the actual start of operation (can differ from REIPPP contracted date).
Sources: Eskom



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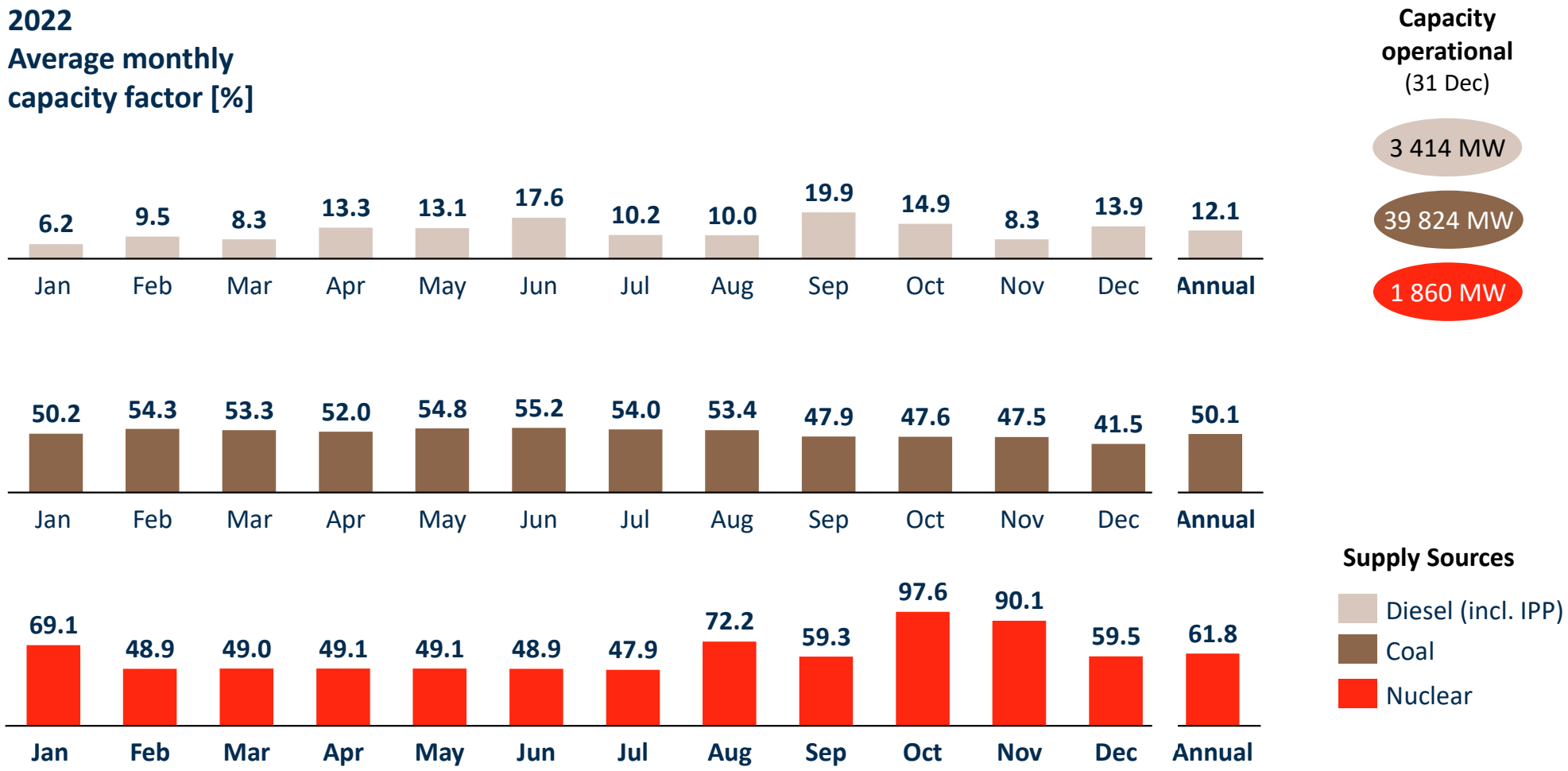
# Average monthly capacity factors for thermal plants

Average monthly capacity factors of thermal capacity in RSA from Jan to Dec 2022






Sources: Eskom

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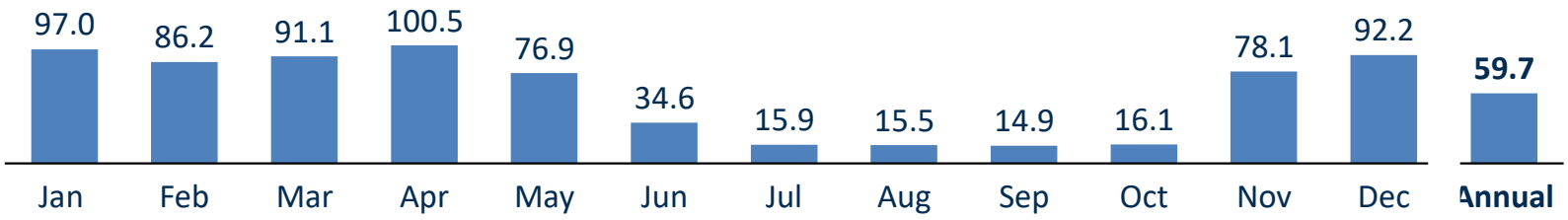
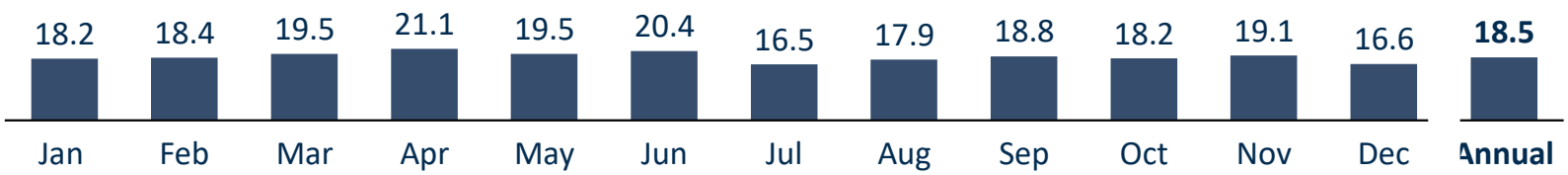
# Average monthly capacity factors for hydro and pumped storage plants

Average monthly capacity factors of hydro & pumped storage in RSA from Jan to Dec 2022

**2022**
**Average monthly capacity factor [%]**




**Capacity operational**
(31 Dec 2021)

600 MW

2 724 MW

**Supply Sources**

Hydro

Pumped Storage



Sources: Eskom

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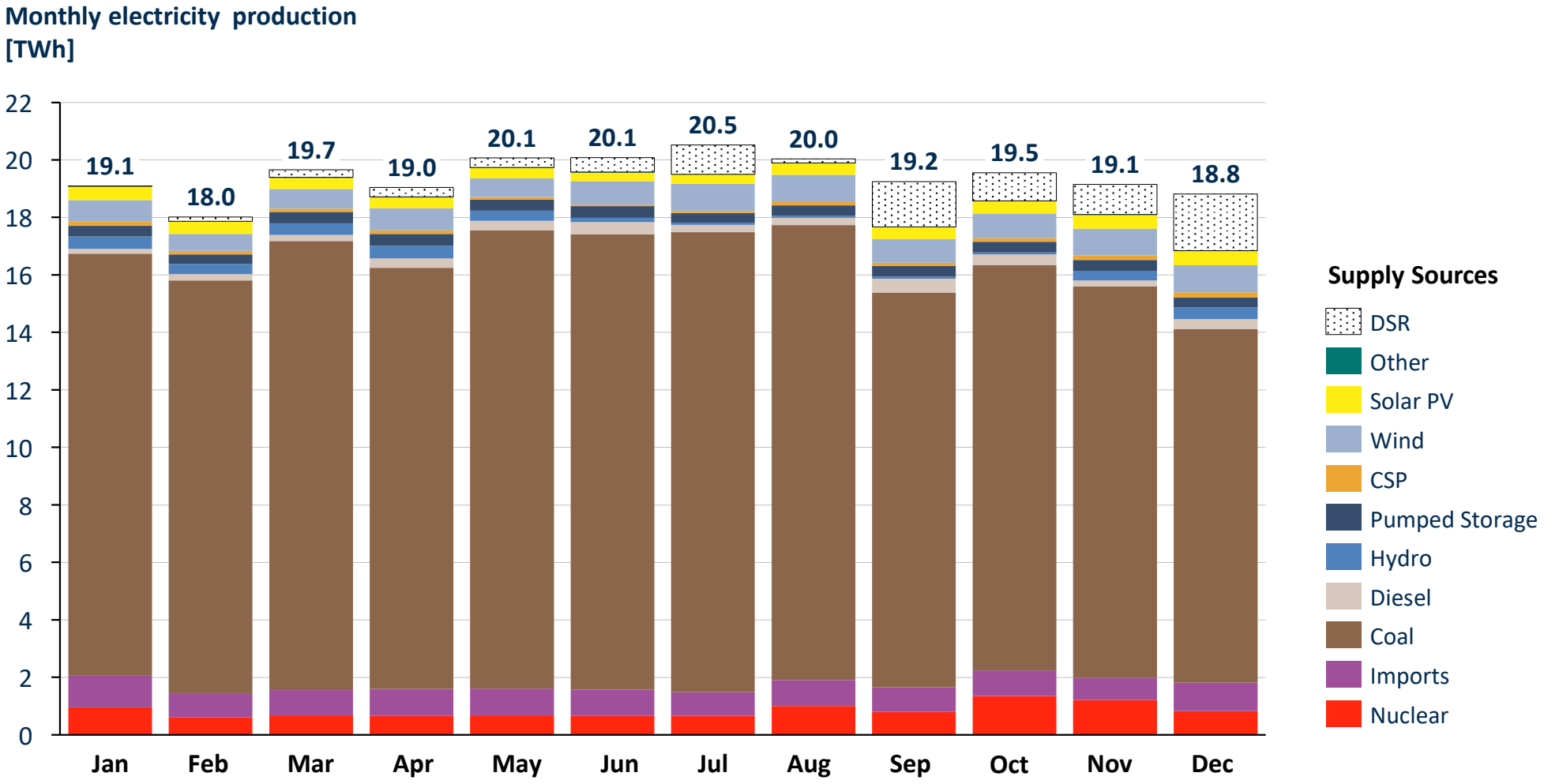
# Monthly electricity production from all power supply sources

Actual monthly electricity production for the period Jan to Dec 2022 from different supply sources




Notes: Pumping load excluded.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis



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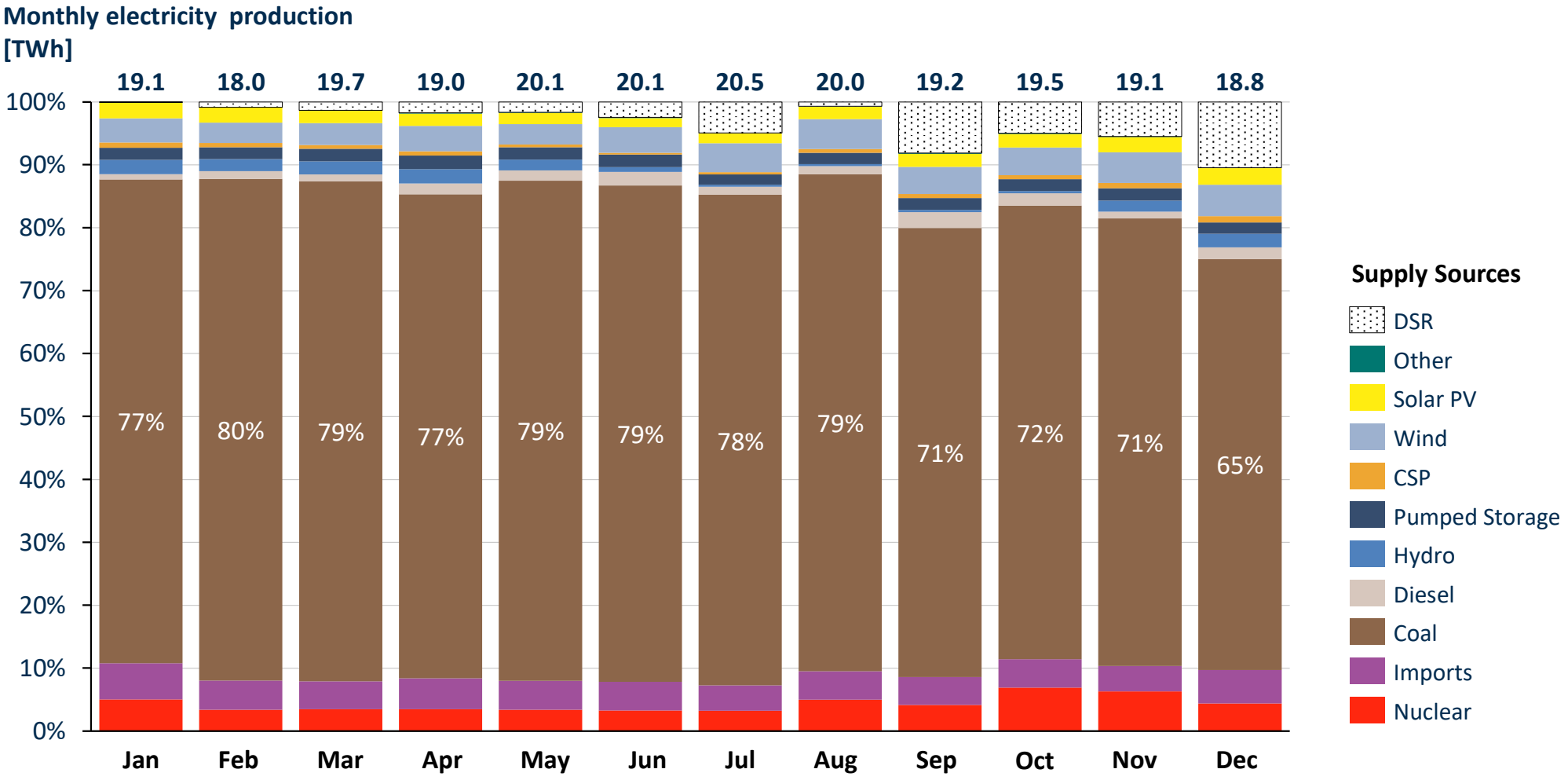
# Monthly electricity production from all power supply sources (share)

Actual monthly electricity production for the period Jan to Dec 2022 from different supply sources




Notes: Pumping load excluded.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis



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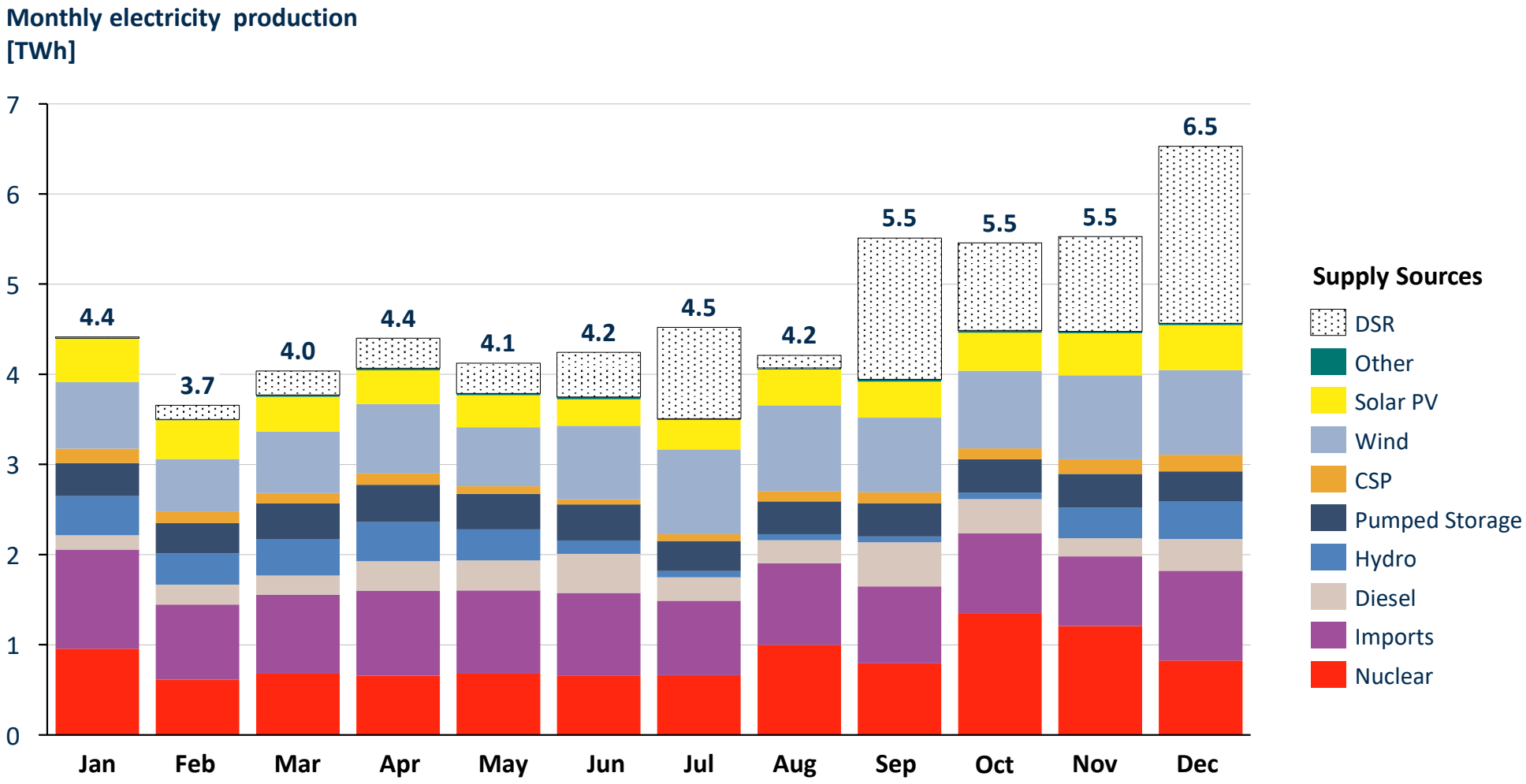
# Monthly electricity production from power supply sources, excluding coal

Actual monthly electricity production for the period Jan to Dec 2022 from different supply sources




Notes: Pumping load excluded.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis



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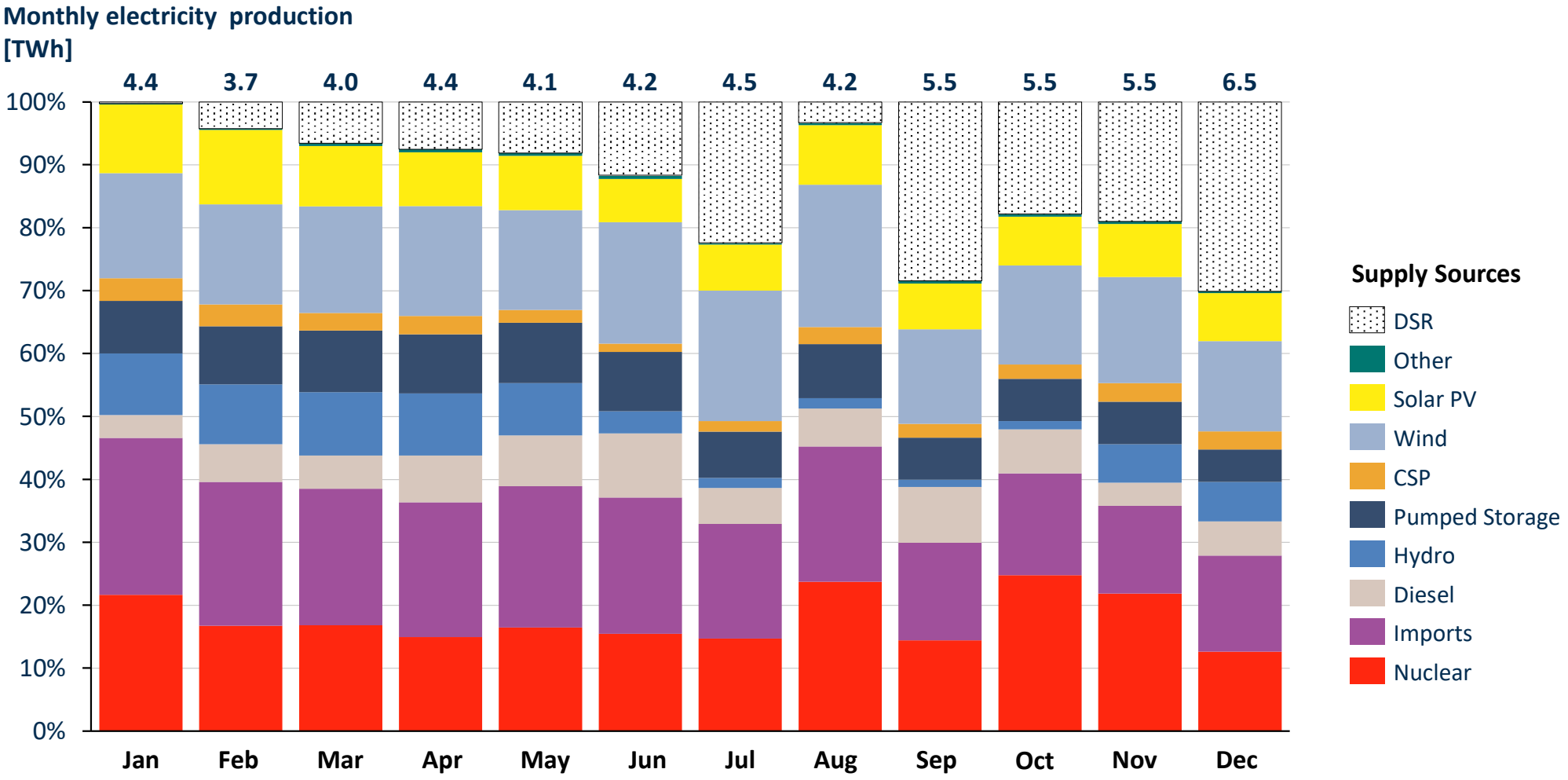
# Monthly electricity production from power supply sources (share), excluding coal

Actual monthly electricity production for the period Jan to Dec 2022 from different supply sources




Notes: Pumping load excluded.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis



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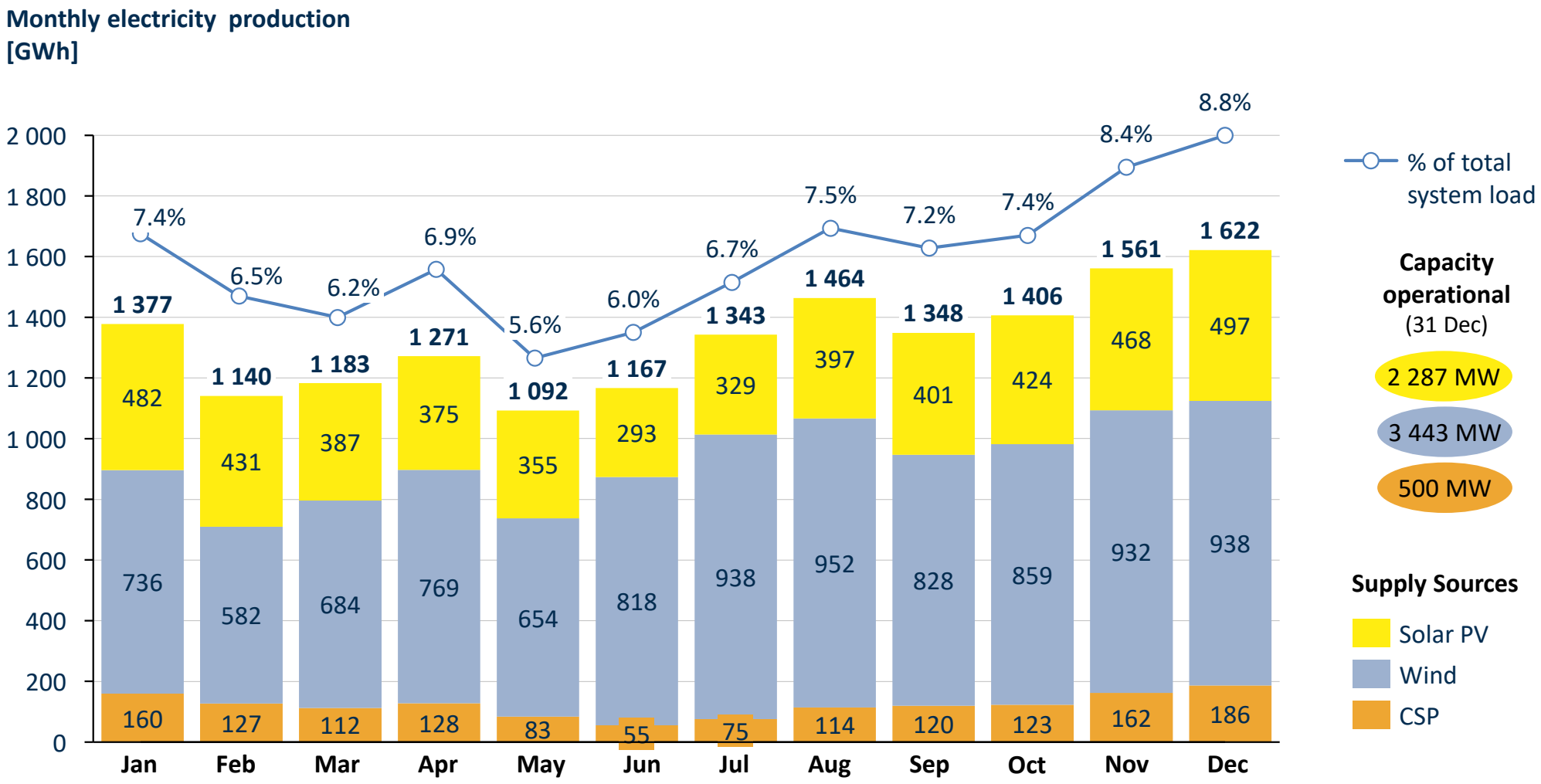
# Monthly electricity production of SA's wind, solar PV & CSP fleet

Actual monthly production from wind, solar PV and CSP plants in South Africa from Jan-Dec 2022




Notes: Wind and solar PV energy excludes curtailment and is thus lower than actual wind and solar PV generation.
Sources: Eskom; CSIR Energy Centre analysis



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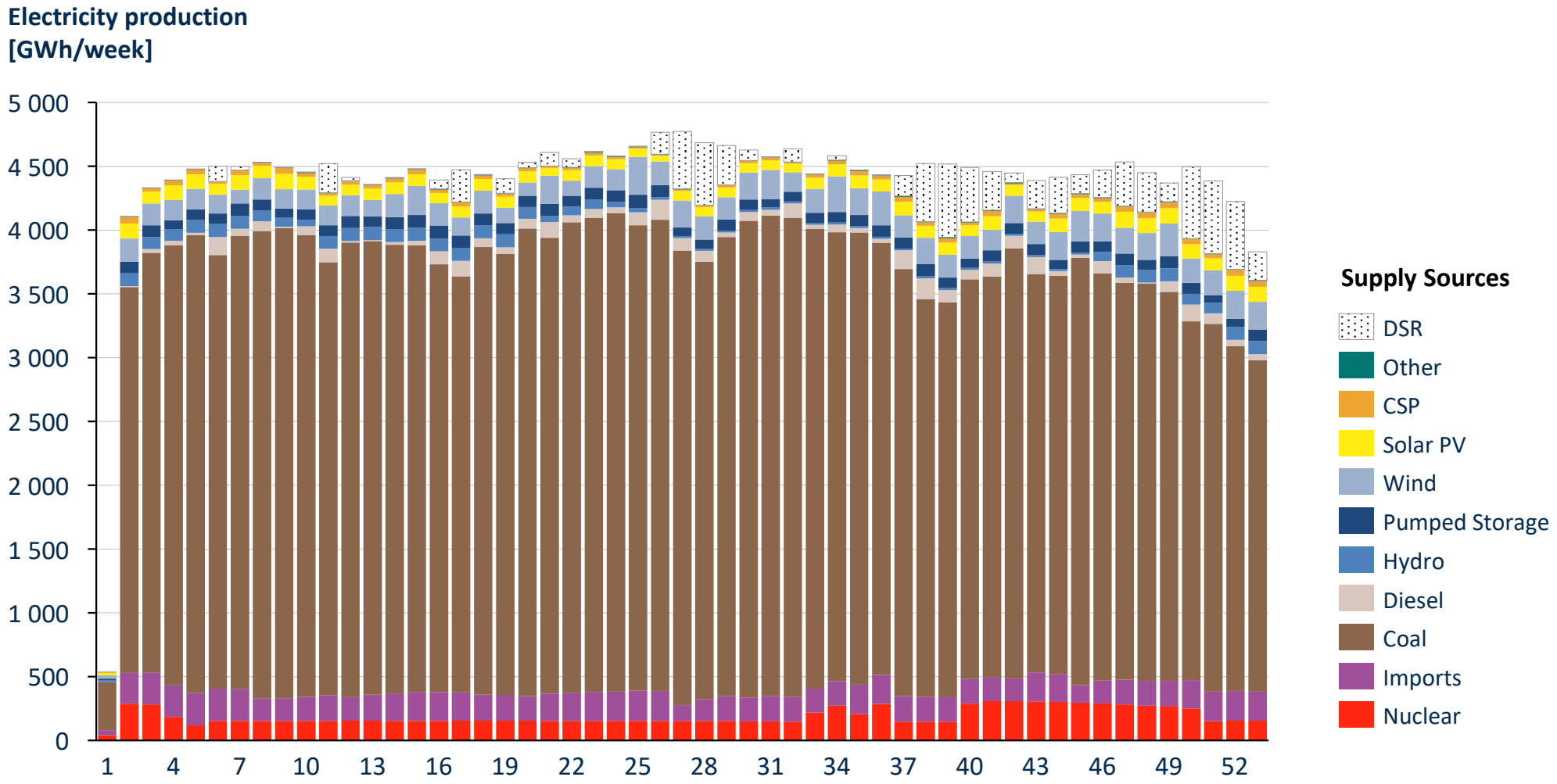
# Weekly electricity production for all power supply sources

## Actual weekly production: conventional fleet, wind, solar PV & CSP (Jan-Dec 2022)




Note: Pumping load excluded. First week and last week included not full weeks.
Sources: Eskom; CSIR Energy Centre analysis



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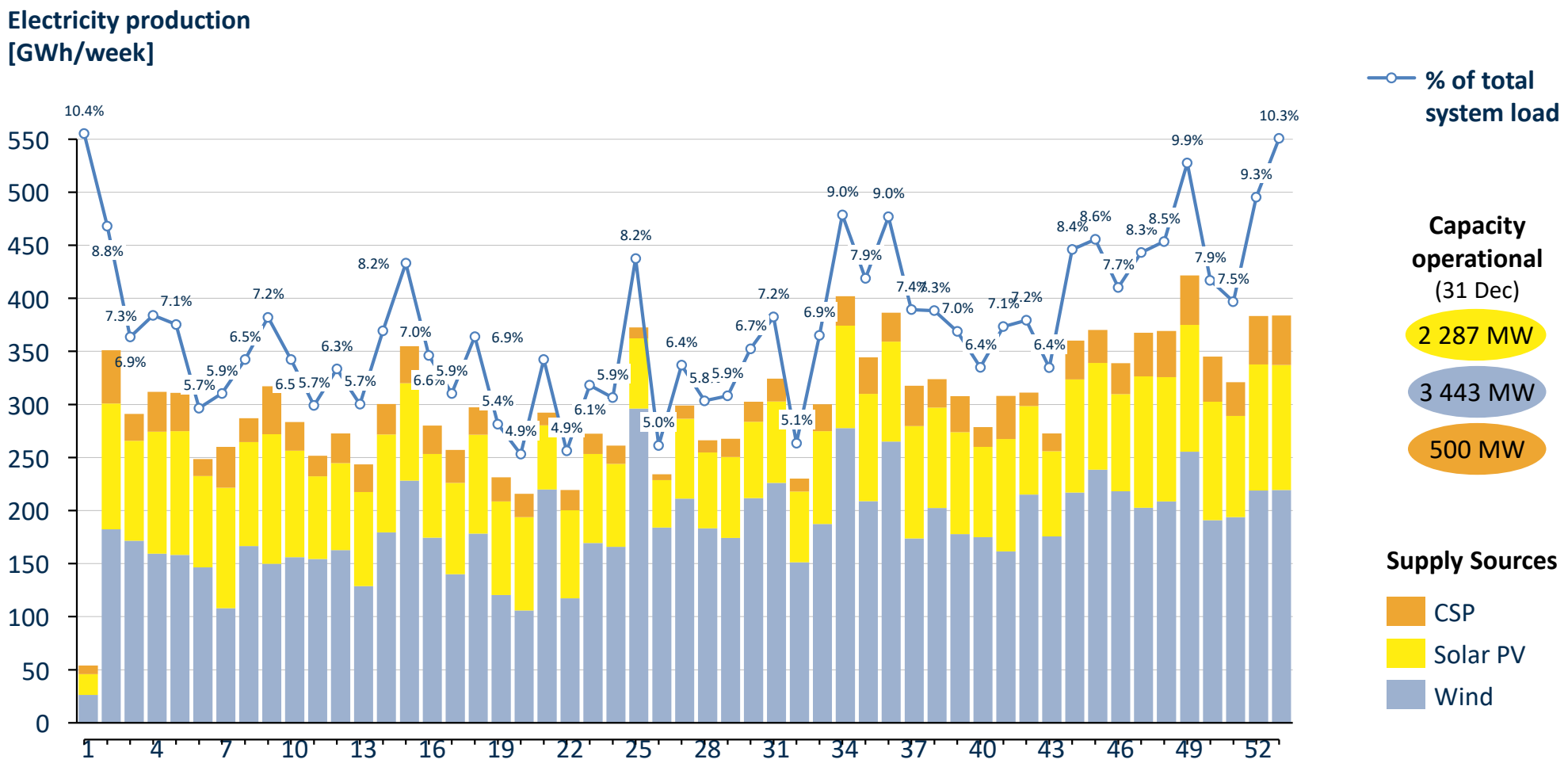
# Weekly electricity production of SA's wind, solar PV and CSP fleet

Actual weekly production from large-scale solar PV, wind & CSP plants under the REIPPPP from Jan-Dec 2022




- Maximum wind + solar PV + CSP weekly production of 421 GWh in a full week 49 (27 Nov – 3 Dec)
- Minimum wind + solar PV + CSP weekly production of 216 GWh in a full week 20 (8 May – 14 May)



Sources: Eskom; CSIR Energy Centre analysis

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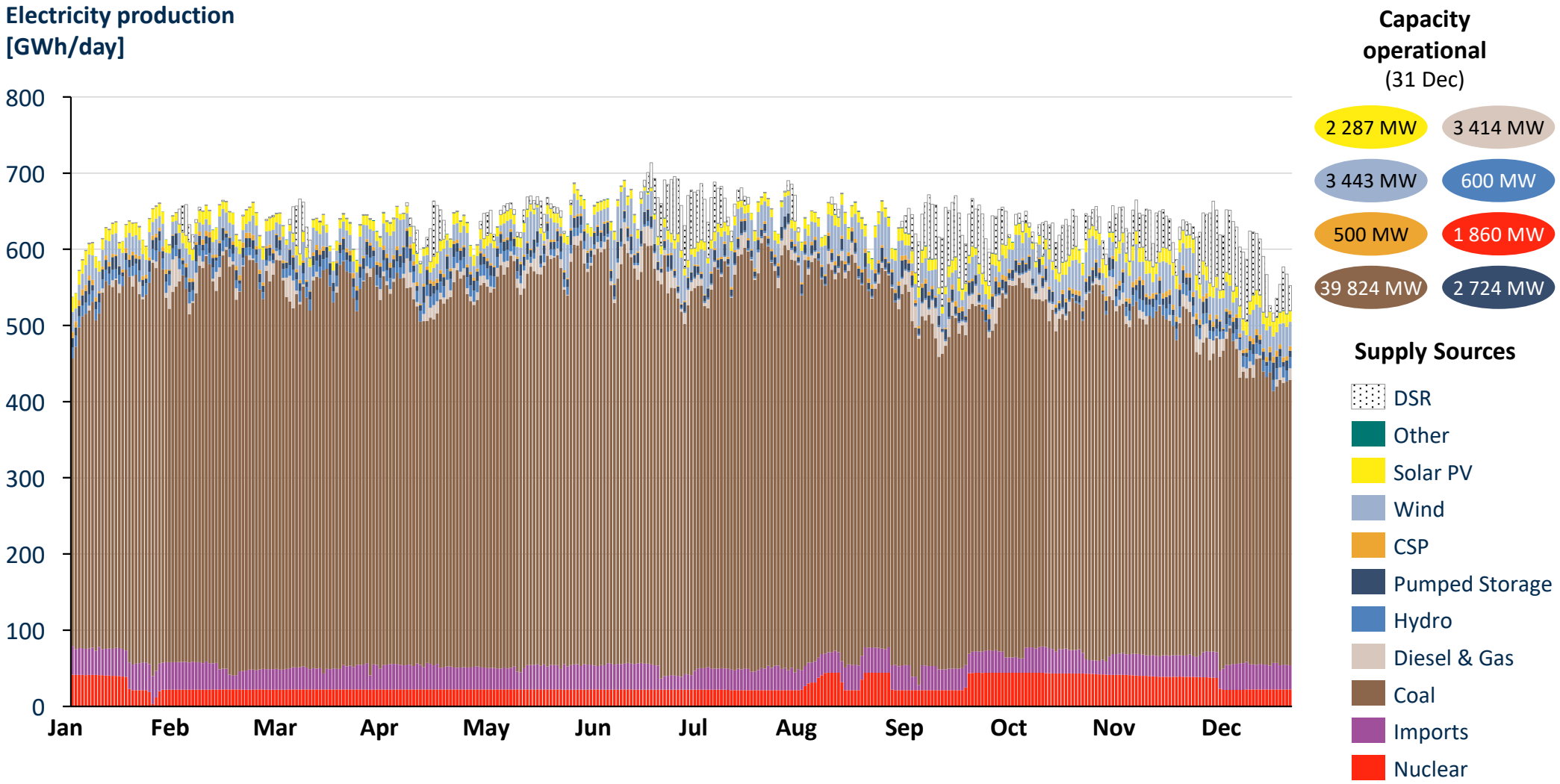
# Daily electricity production for all power supply sources

## Actual daily production: conventional fleet, wind, solar PV & CSP (Jan to Dec 2022)




Sources: Eskom; CSIR Energy Centre analysis



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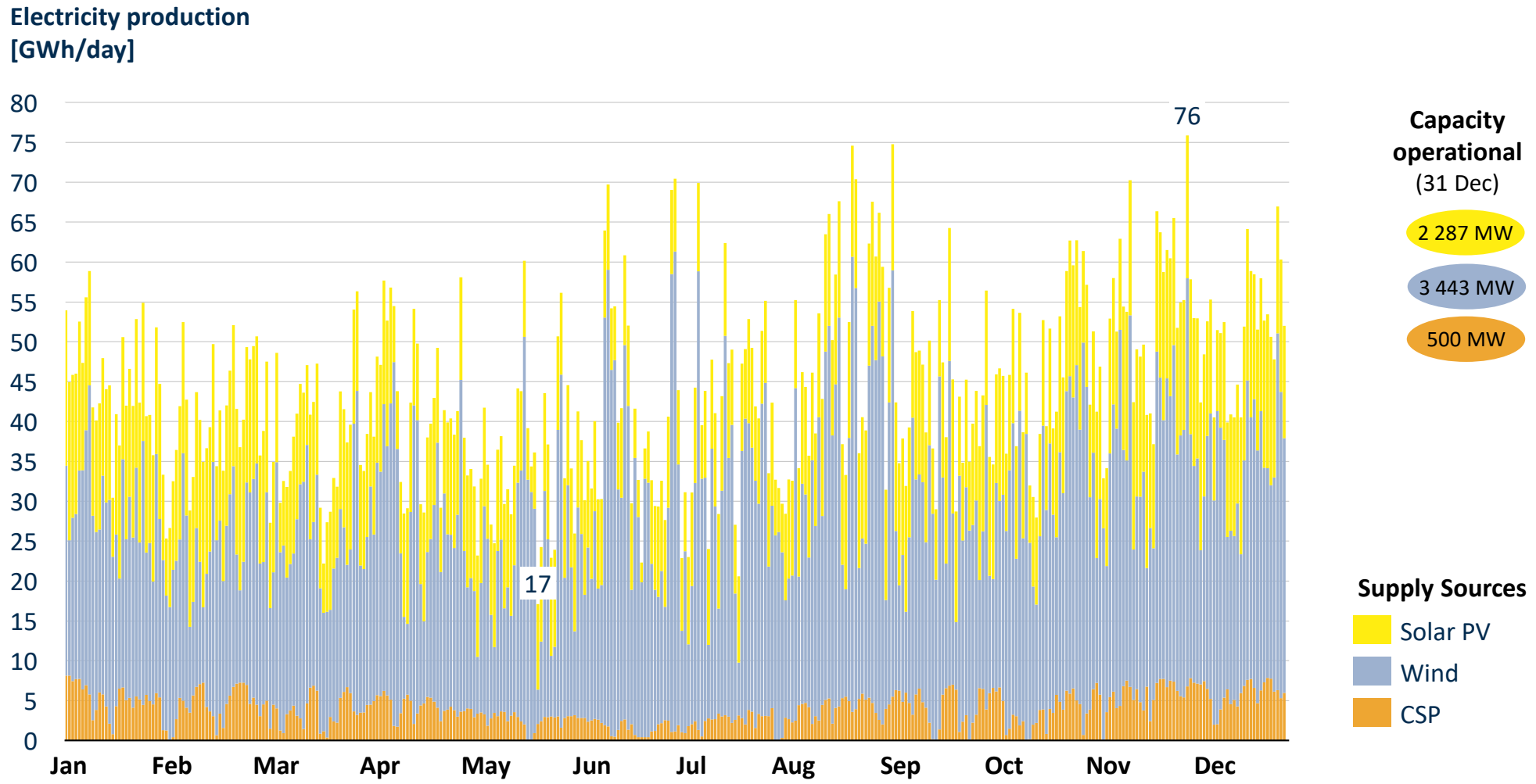
# Daily electricity production of wind, solar PV & CSP fleet

Actual daily production from large-scale solar PV, wind and CSP plants under the REI4P from Jan to Dec 2022




- Maximum daily production of 76 GWh on 2 Dec 2022 (Friday)
- Minimum daily production of 17 GWh on 22 May 2022 (Sunday)



Sources: Eskom; CSIR Energy Centre analysis

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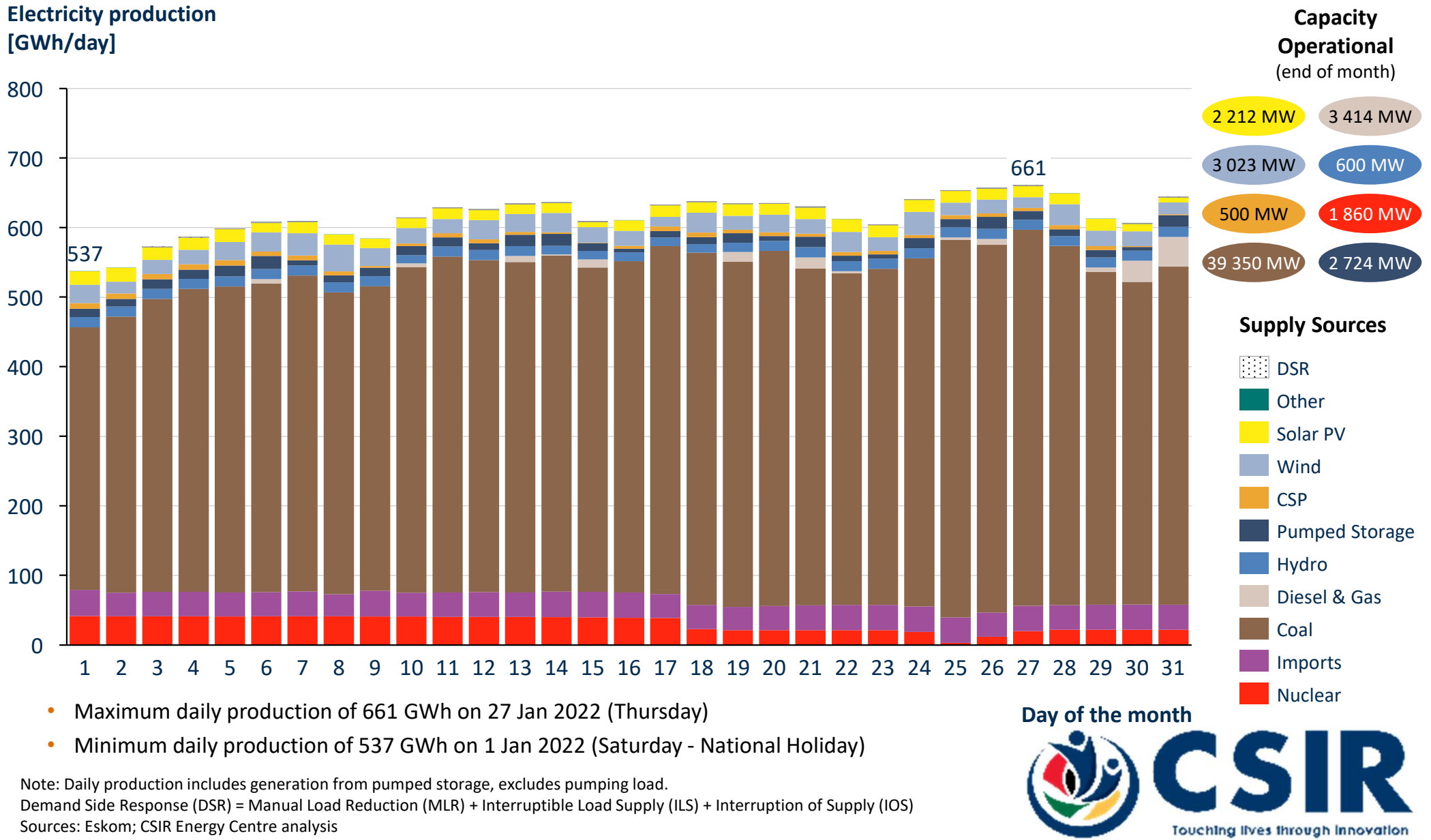
# Daily electricity production between 537-661 GWh in Jan 2022

Actual daily production from all power supply sources in South Africa for January 2022




- Maximum daily production of 661 GWh on 27 Jan 2022 (Thursday)
- Minimum daily production of 537 GWh on 1 Jan 2022 (Saturday - National Holiday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis



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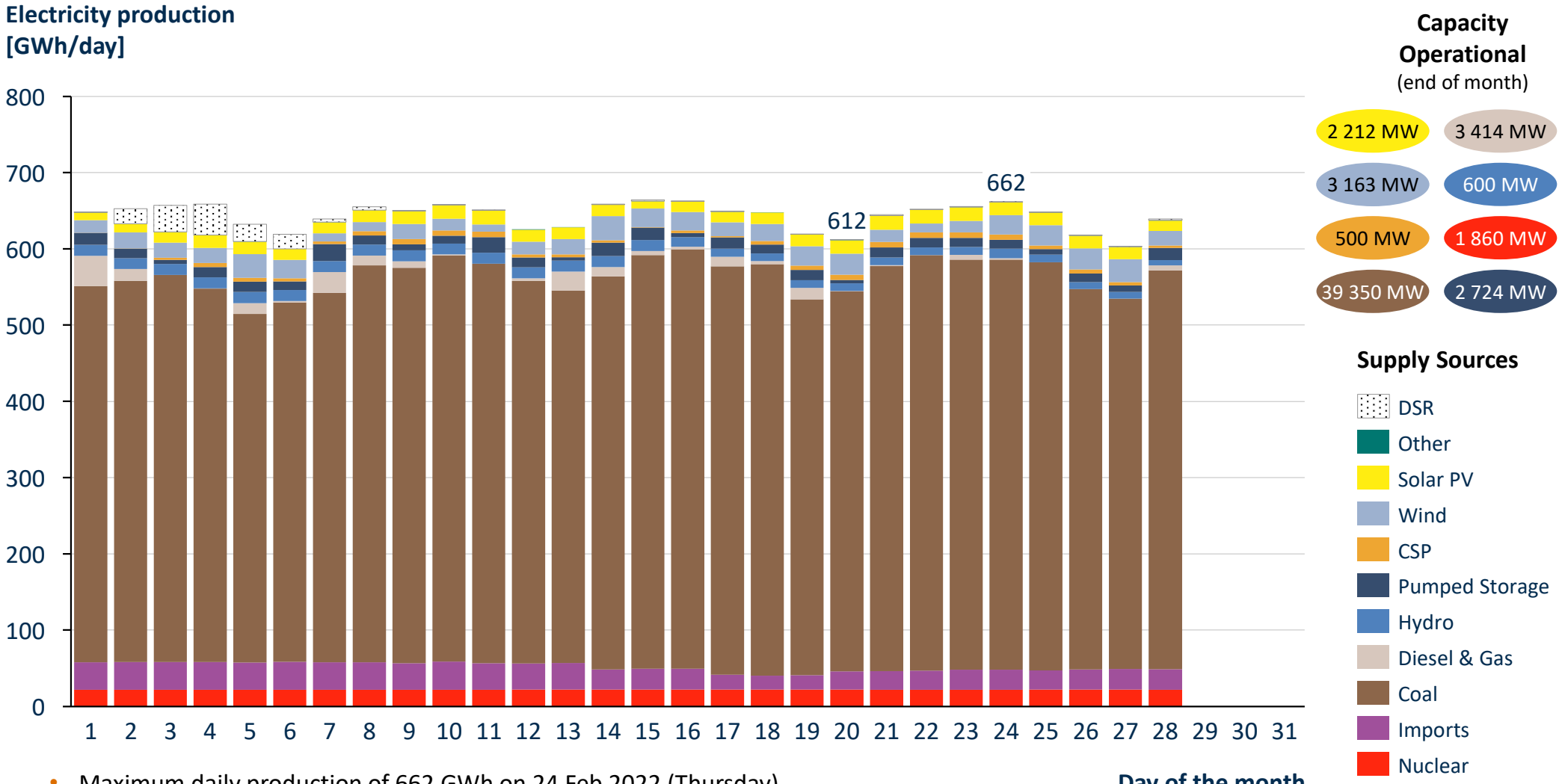
# Daily electricity production between 612-662 GWh in Feb 2022

Actual daily production from all power supply sources in South Africa for February 2022




- Maximum daily production of 662 GWh on 24 Feb 2022 (Thursday)
- Minimum daily production of 612 GWh on 20 Feb 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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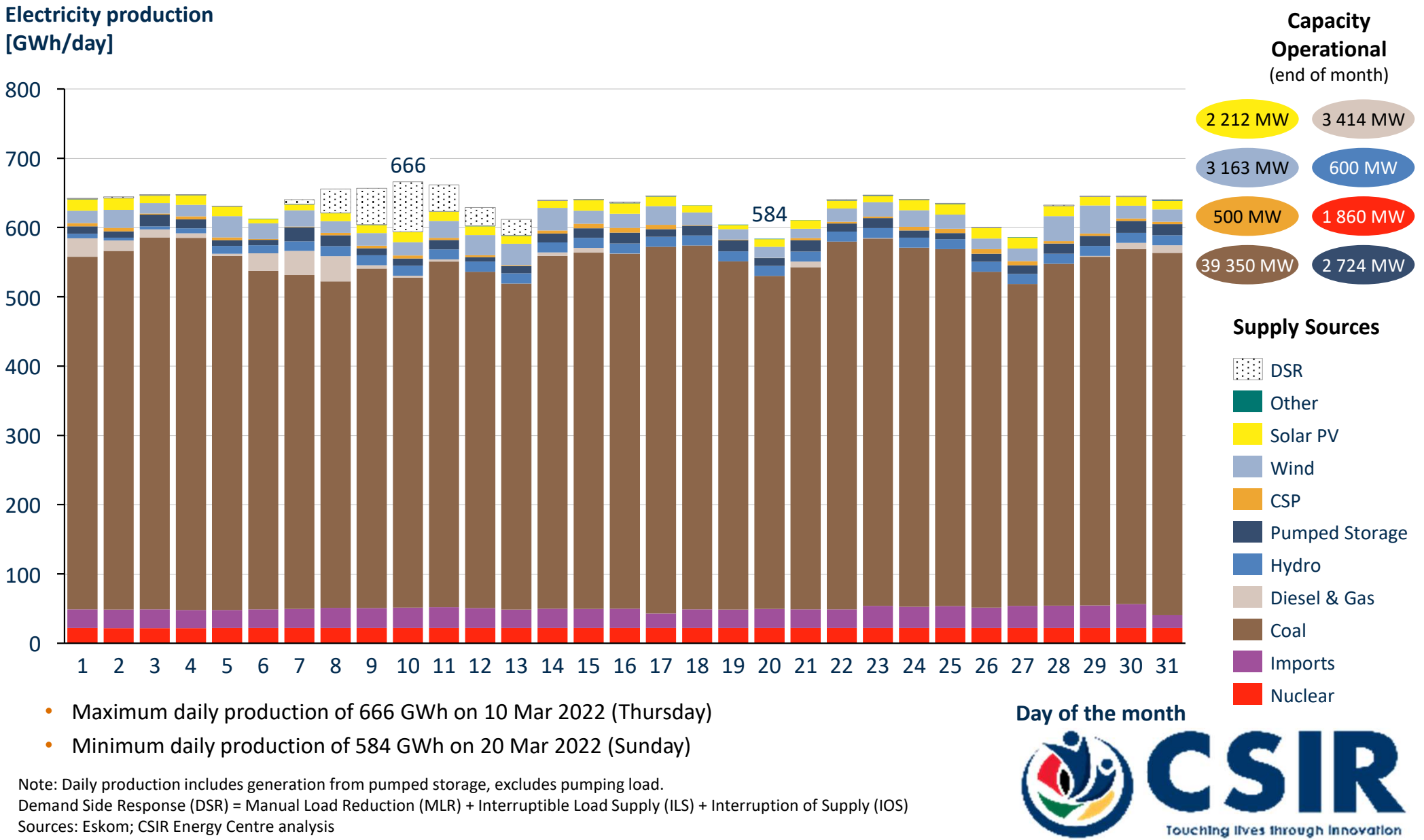
# Daily electricity production between 584-666 GWh in Mar 2022

Actual daily production from all power supply sources in South Africa for March 2022




- Maximum daily production of 666 GWh on 10 Mar 2022 (Thursday)
- Minimum daily production of 584 GWh on 20 Mar 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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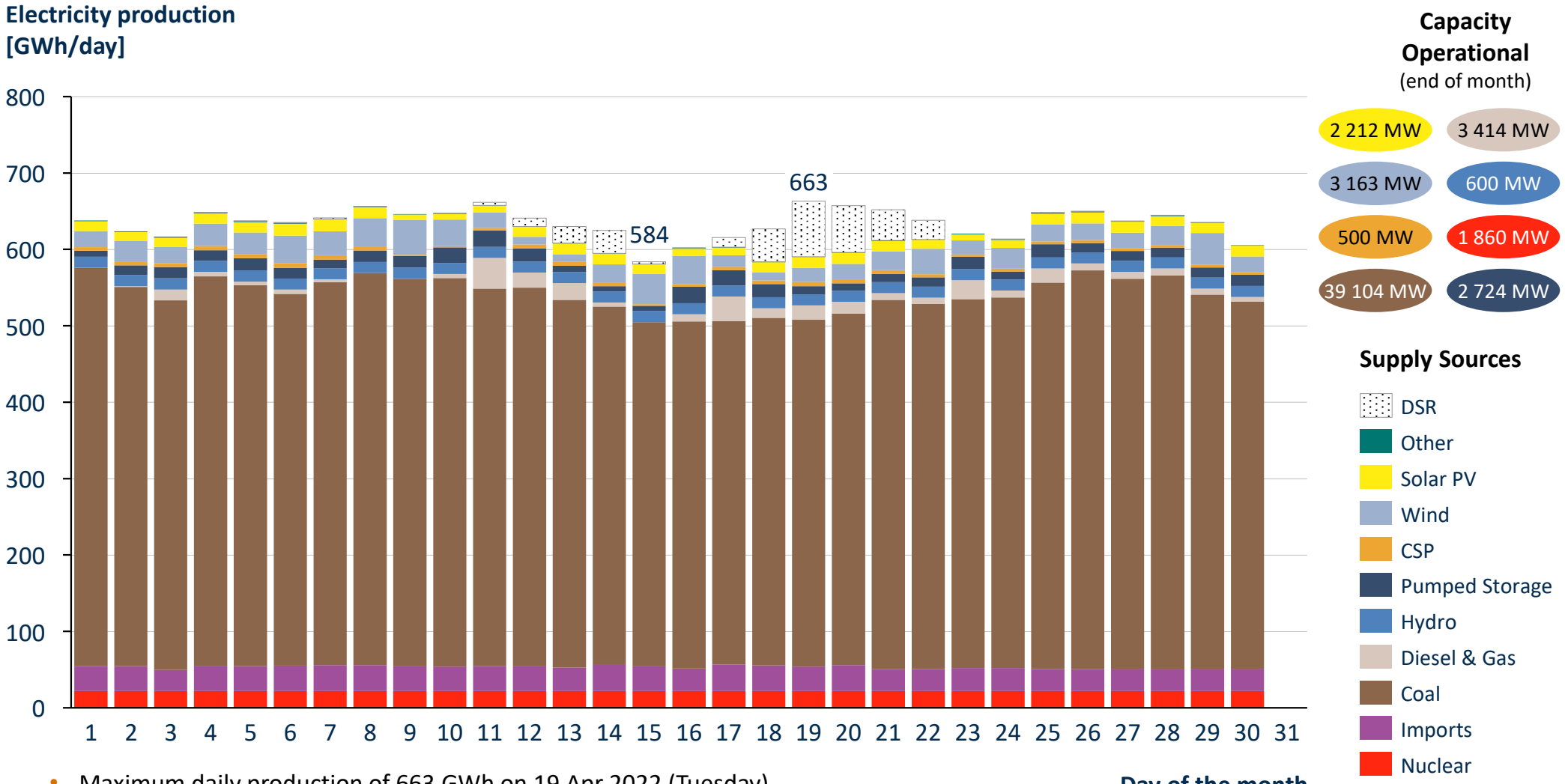
# Daily electricity production between 584-663 GWh in Apr 2022

## Actual daily production from all power supply sources in South Africa for April 2022




- Maximum daily production of 663 GWh on 19 Apr 2022 (Tuesday)
- Minimum daily production of 584 GWh on 15 Apr 2022 (Friday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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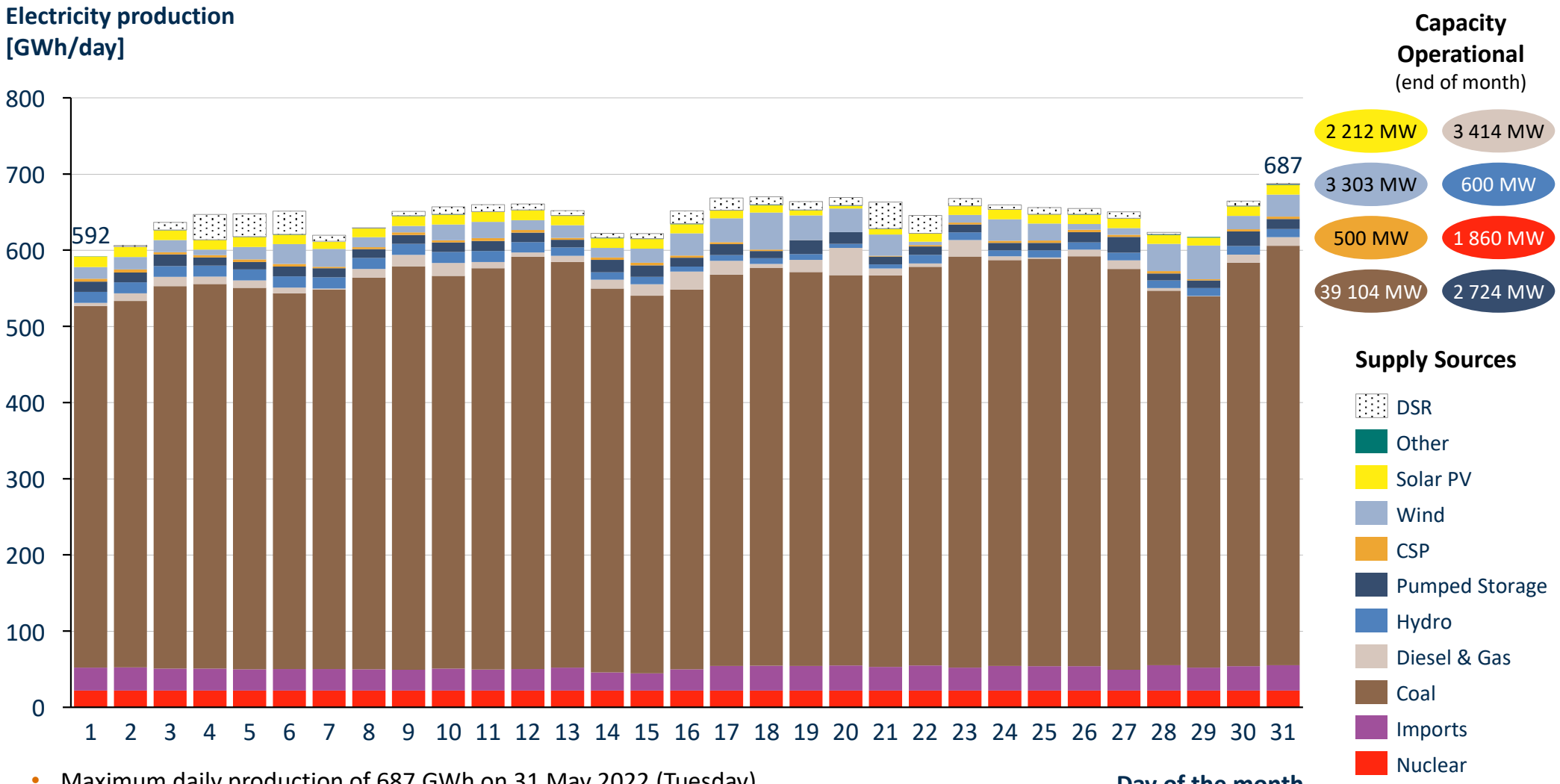
# Daily electricity production between 592-687 GWh in May 2022

Actual daily production from all power supply sources in South Africa for May 2022




- Maximum daily production of 687 GWh on 31 May 2022 (Tuesday)
- Minimum daily production of 592 GWh on 1 May 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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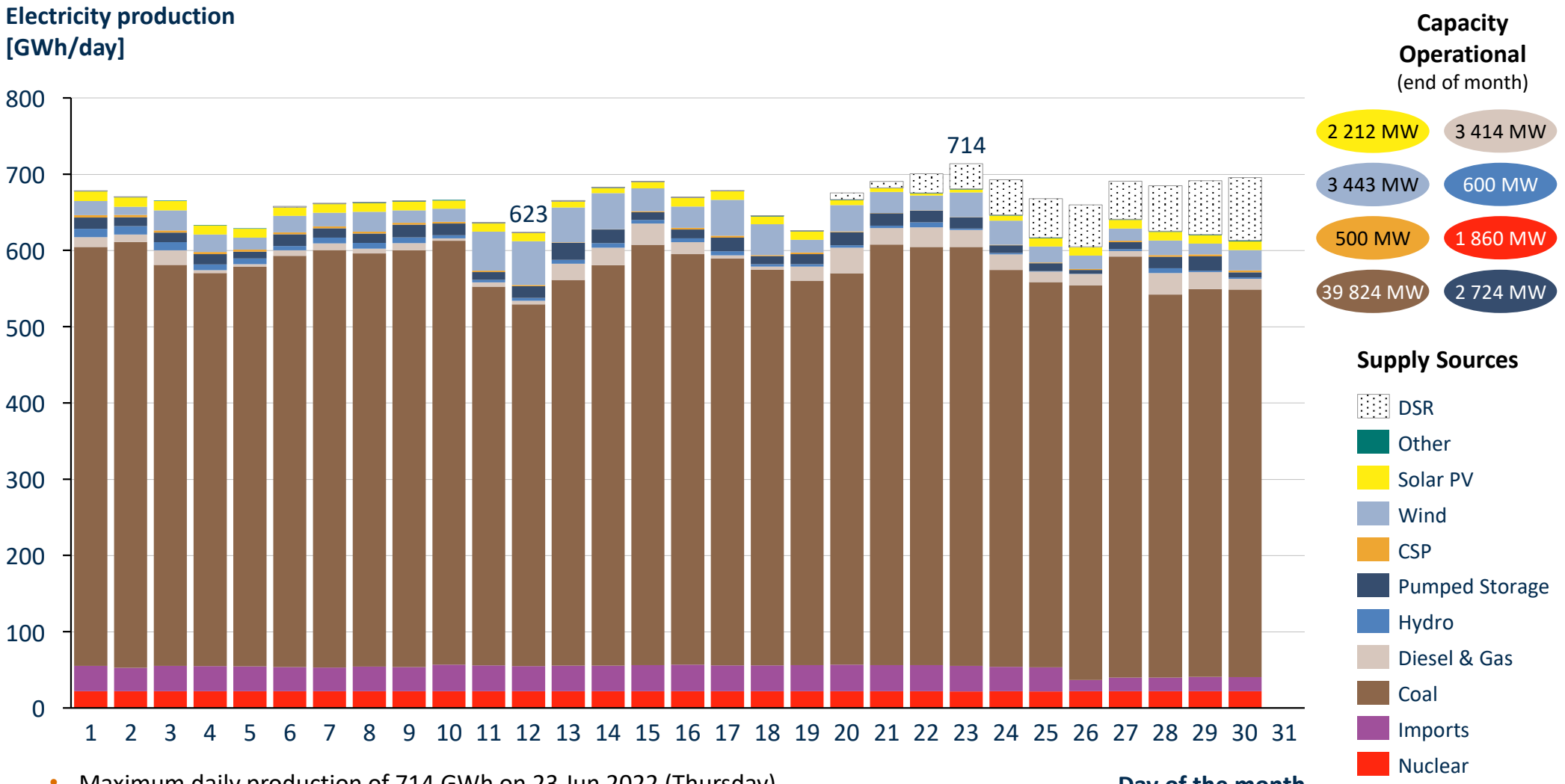
# Daily electricity production between 623-714 GWh in Jun 2022

Actual daily production from all power supply sources in South Africa for June 2022




- Maximum daily production of 714 GWh on 23 Jun 2022 (Thursday)
- Minimum daily production of 623 GWh on 12 Jun 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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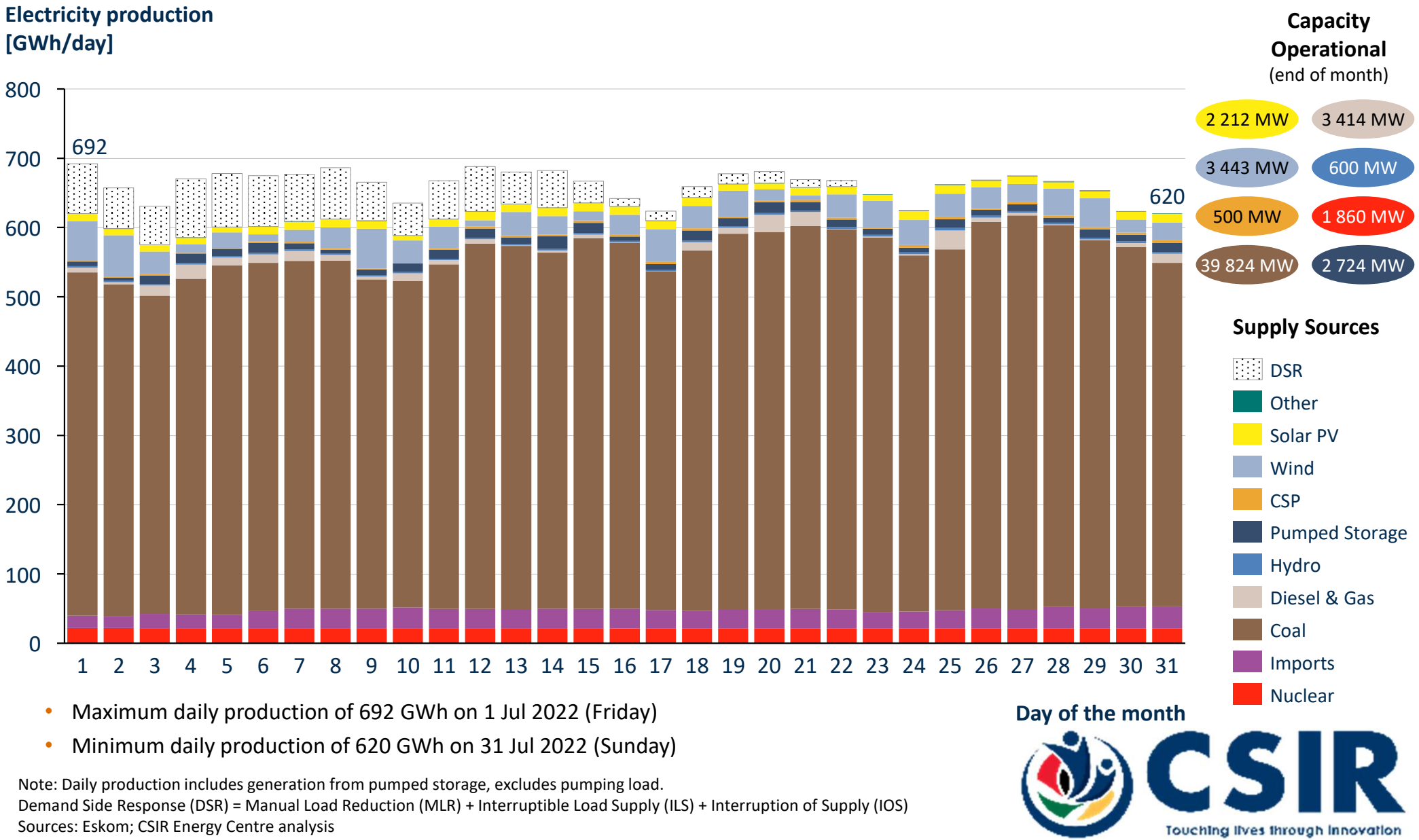
# Daily electricity production between 620-692 GWh in Jul 2022

## Actual daily production from all power supply sources in South Africa for July 2022




- Maximum daily production of 692 GWh on 1 Jul 2022 (Friday)
- Minimum daily production of 620 GWh on 31 Jul 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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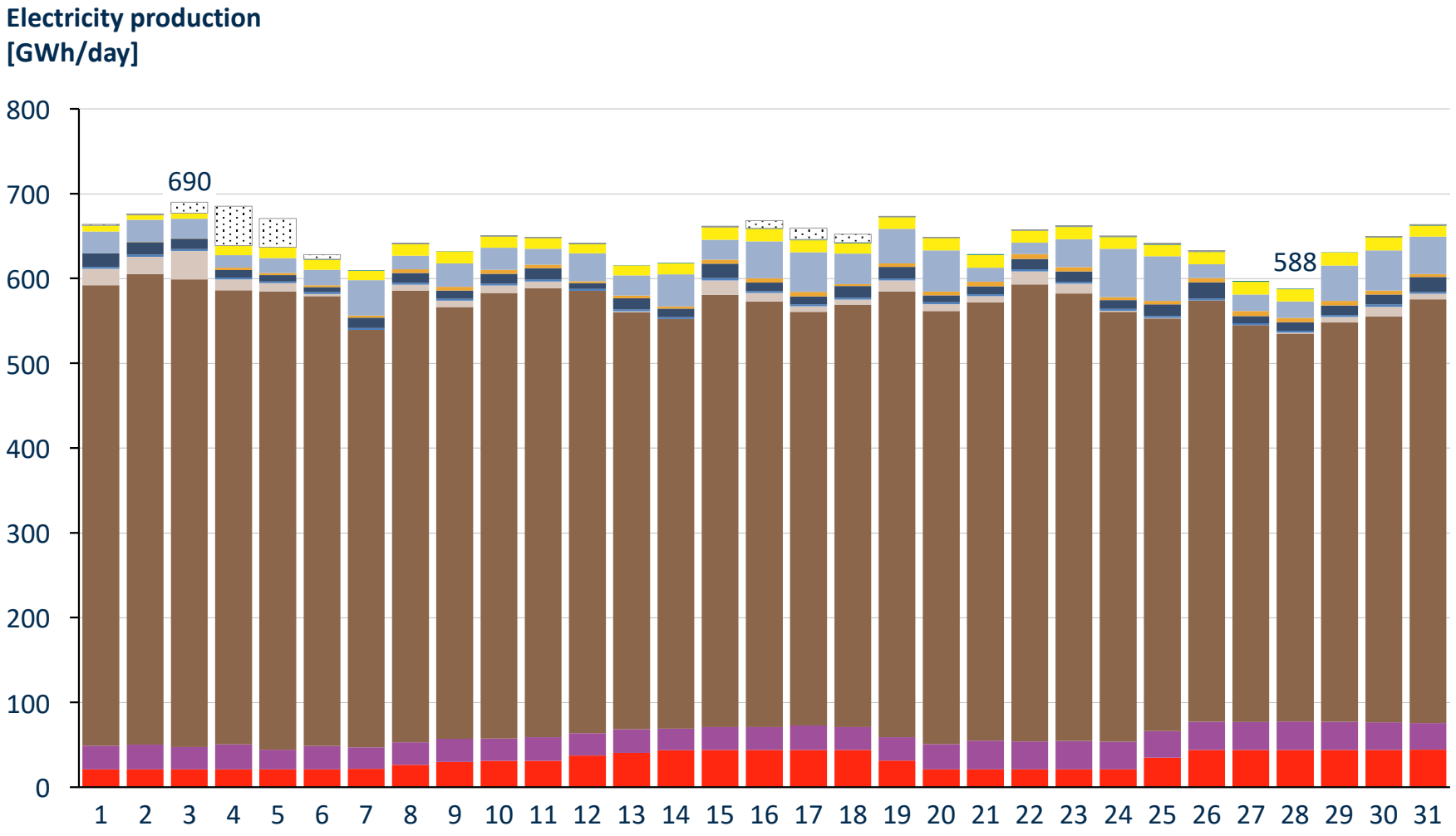
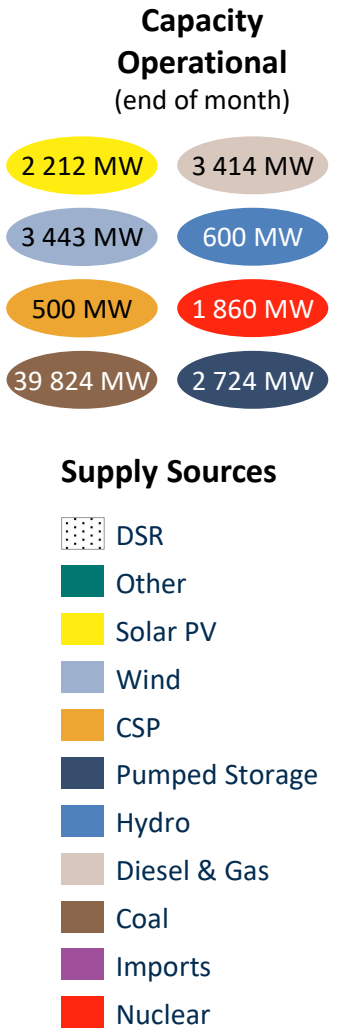
# Daily electricity production between 588-690 GWh in Aug 2022

Actual daily production from all power supply sources in South Africa for August 2022




- Maximum daily production of 690 GWh on 3 Aug 2022 (Wednesday)
- Minimum daily production of 588 GWh on 28 Aug 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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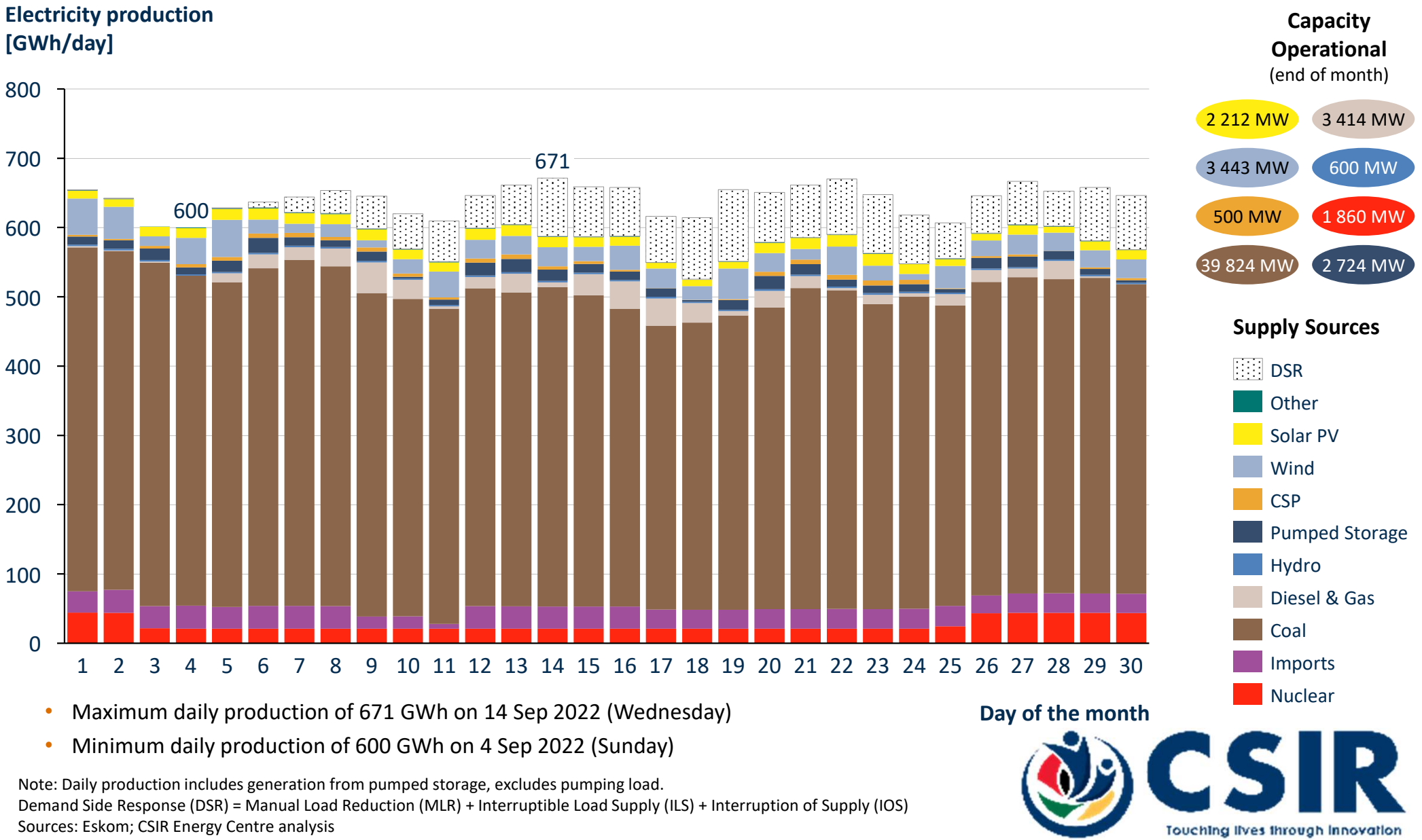
# Daily electricity production between 600-671 GWh in Sep 2022

Actual daily production from all power supply sources in South Africa for September 2022




- Maximum daily production of 671 GWh on 14 Sep 2022 (Wednesday)
- Minimum daily production of 600 GWh on 4 Sep 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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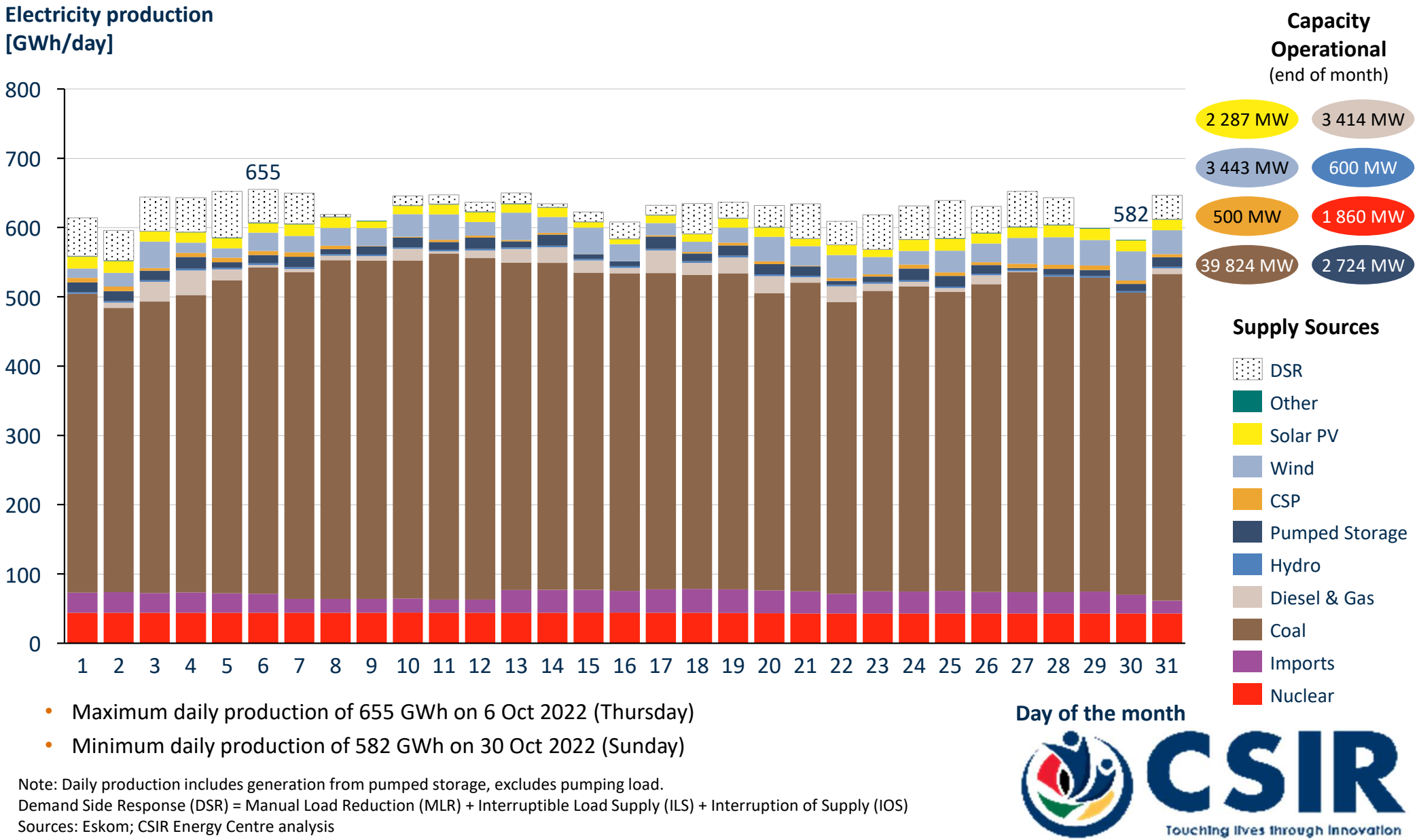
# Daily electricity production between 582-655 GWh in Oct 2022

Actual daily production from all power supply sources in South Africa for October 2022




- Maximum daily production of 655 GWh on 6 Oct 2022 (Thursday)
- Minimum daily production of 582 GWh on 30 Oct 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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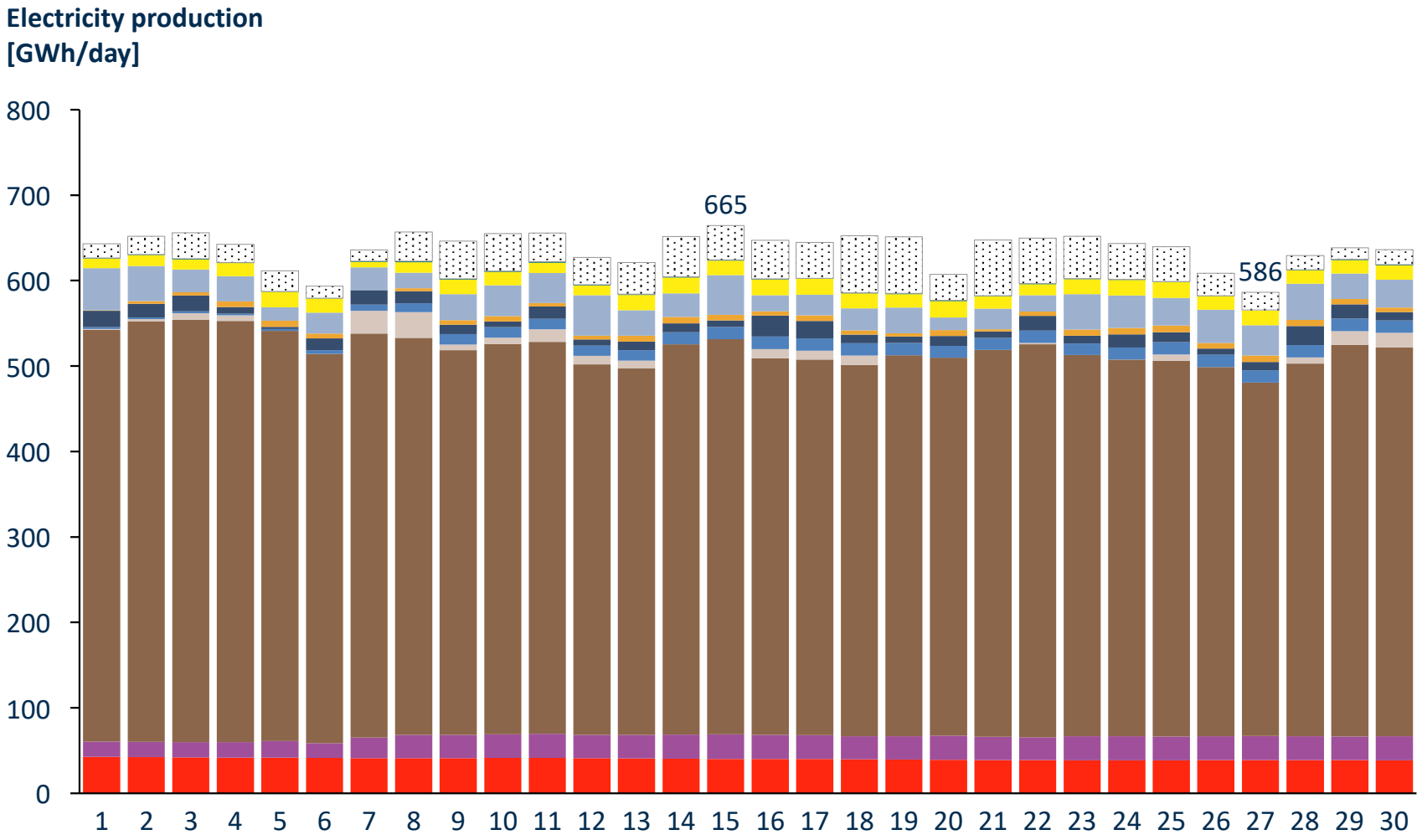
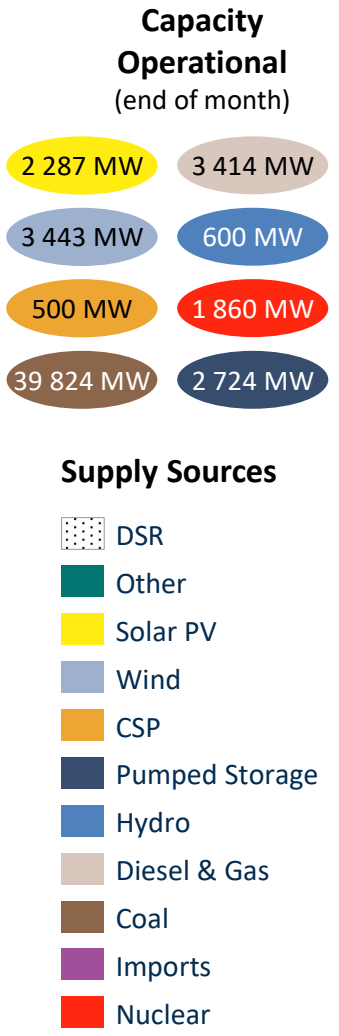
# Daily electricity production between 586-665 GWh in Nov 2022

## Actual daily production from all power supply sources in South Africa for November 2022




- Maximum daily production of 665 GWh on 15 Nov 2022 (Tuesday)
- Minimum daily production of 586 GWh on 27 Nov 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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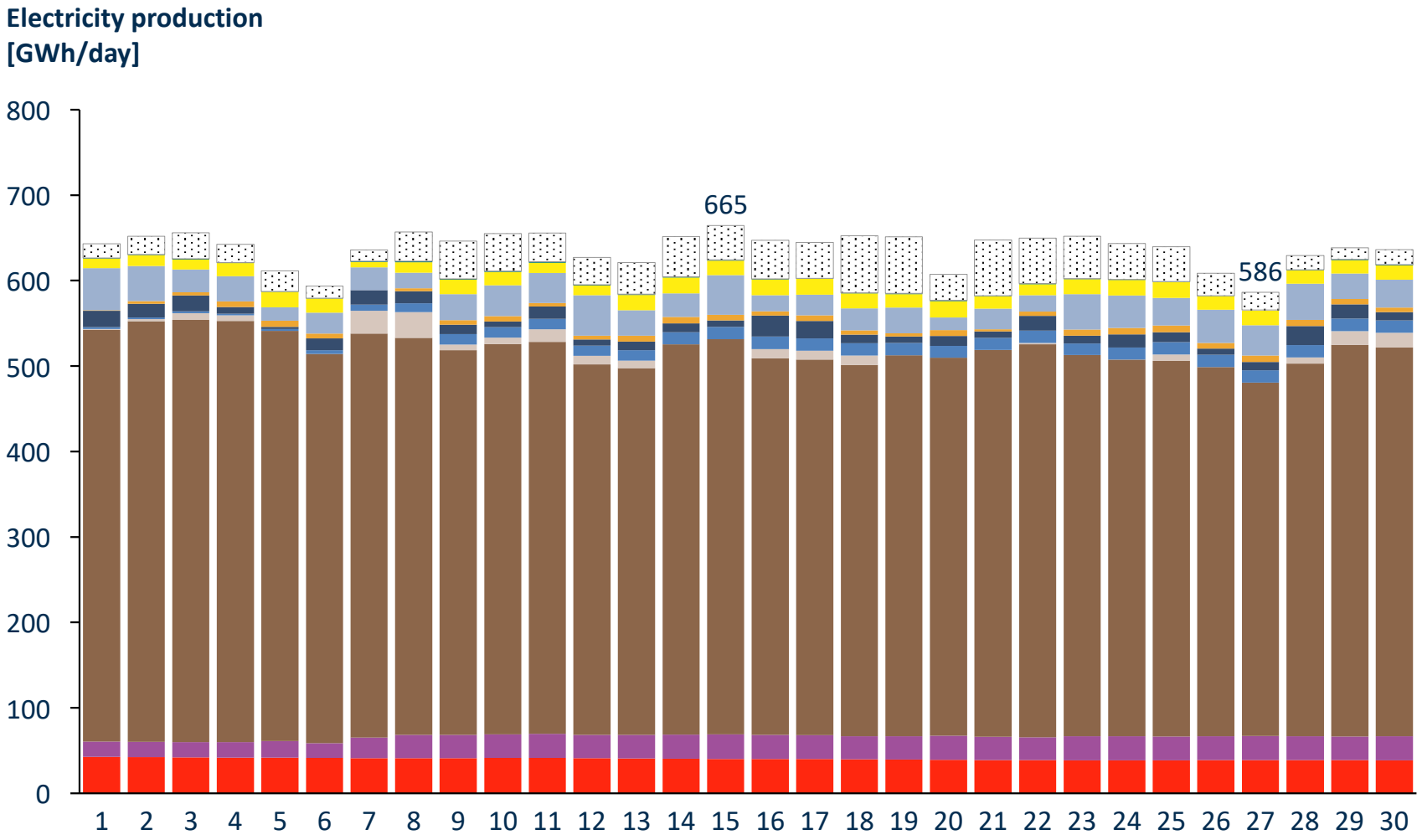
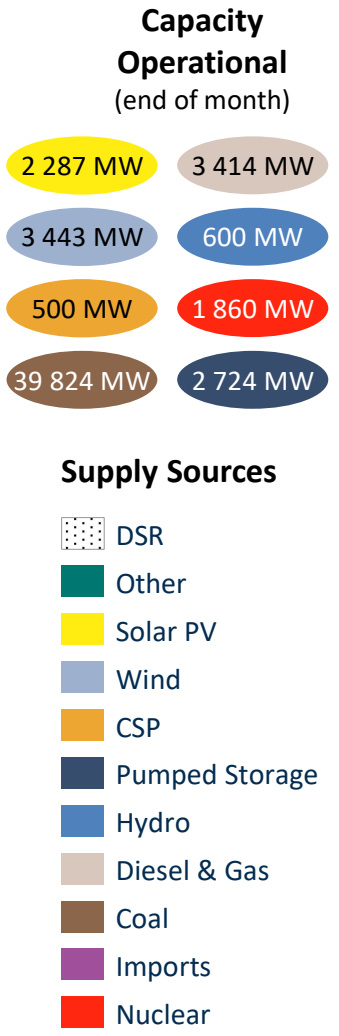
# Daily electricity production between 586-665 GWh in Nov 2022

## Actual daily production from all power supply sources in South Africa for November 2022




- Maximum daily production of 665 GWh on 15 Nov 2022 (Tuesday)
- Minimum daily production of 586 GWh on 27 Nov 2022 (Sunday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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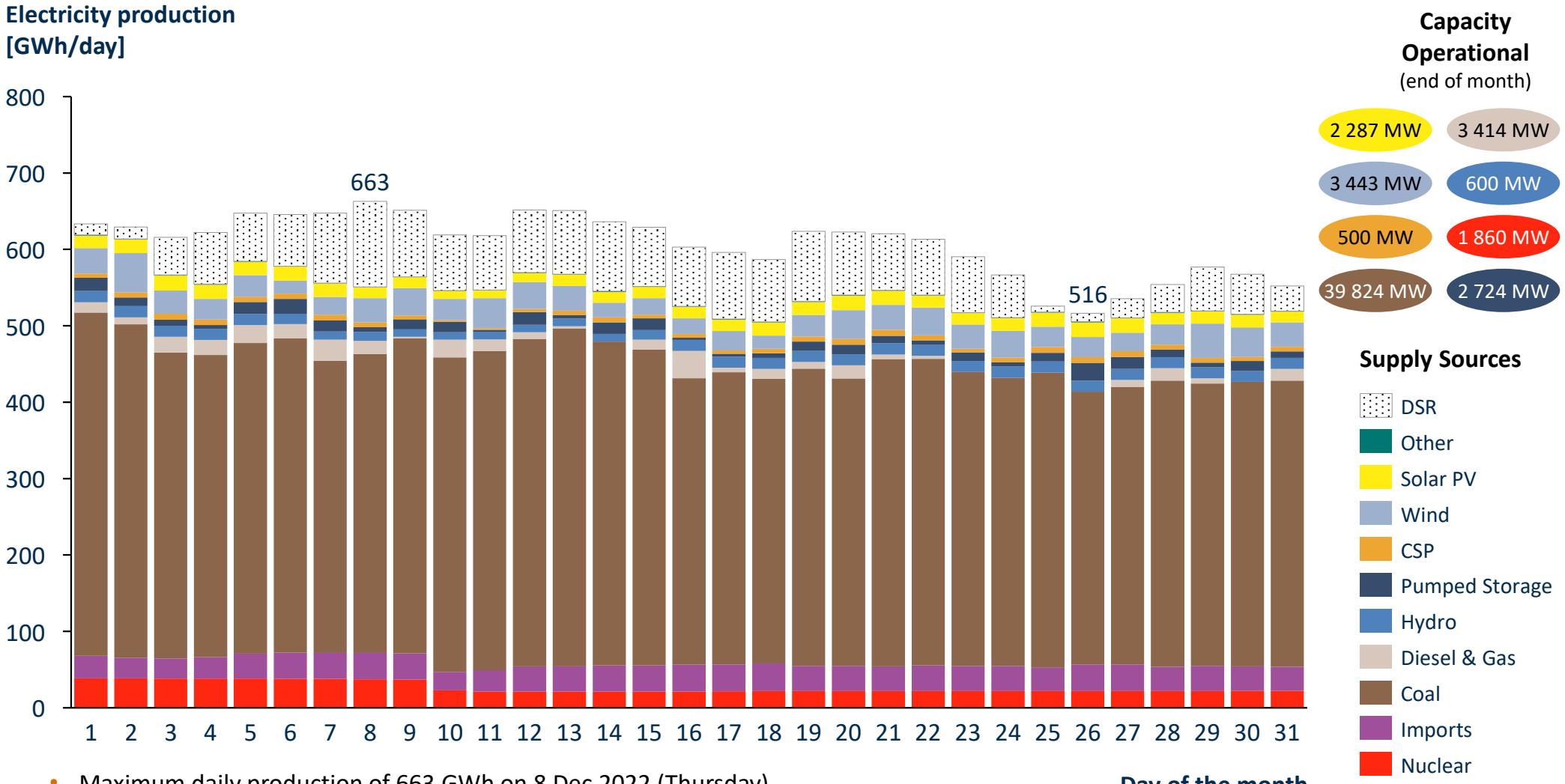
# Daily electricity production between 516-663 GWh in Dec 2022

## Actual daily production from all power supply sources in South Africa for December 2022




- Maximum daily production of 663 GWh on 8 Dec 2022 (Thursday)
- Minimum daily production of 516 GWh on 26 Dec 2022 (Monday – National Holiday)

Note: Daily production includes generation from pumped storage, excludes pumping load.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

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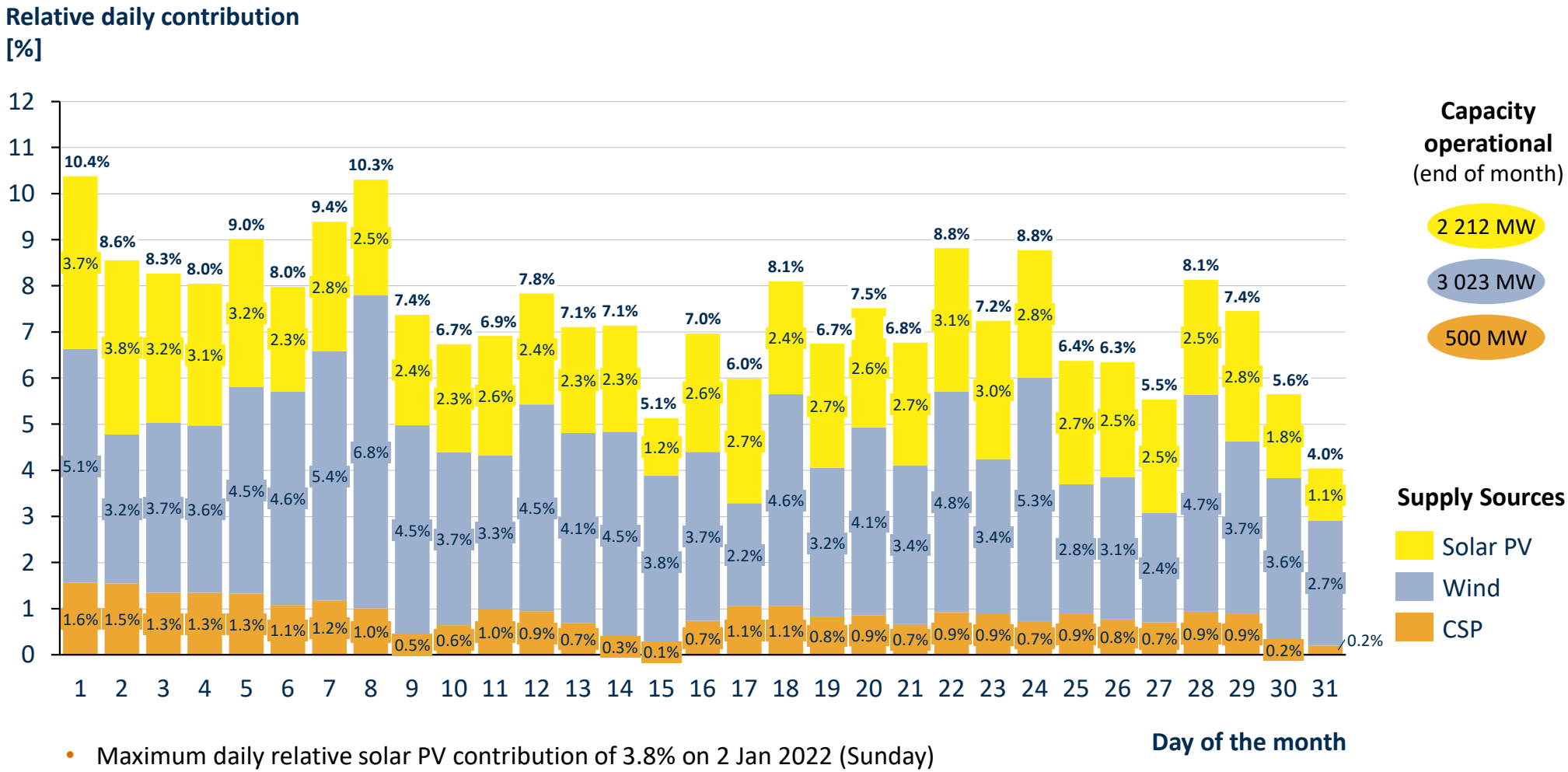
# Daily solar PV, wind & CSP contribution of 4.0-10.4% in Jan 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for January 2022




- Maximum daily relative solar PV contribution of 3.8% on 2 Jan 2022 (Sunday)
- Maximum daily relative wind contribution of 6.8% on 8 Jan 2022 (Saturday)
- Maximum daily relative CSP contribution of 1.6% on 1 Jan 2022 (Saturday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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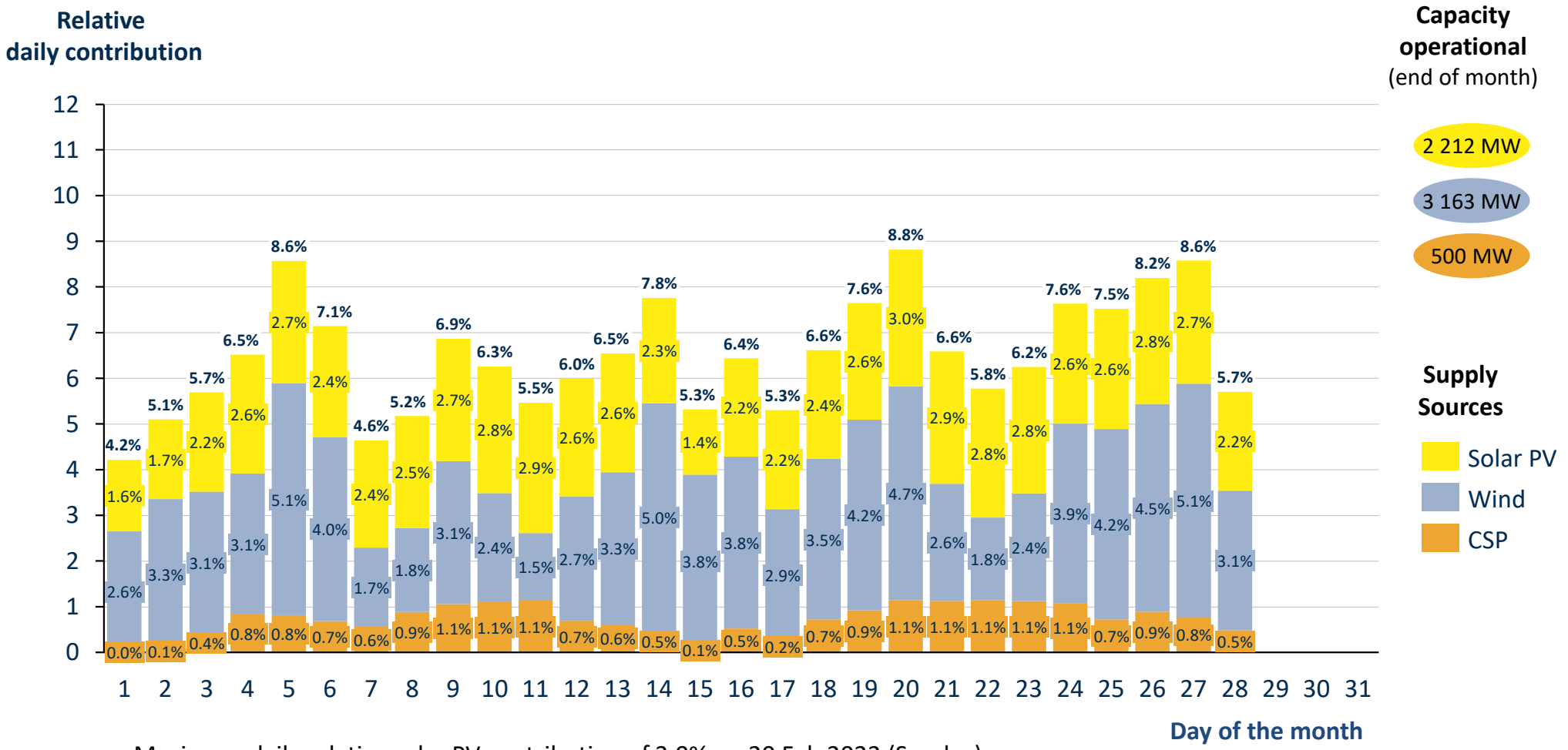
# Daily solar PV, wind & CSP contribution of 4.2-8.8% in Feb 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for February 2022




- Maximum daily relative solar PV contribution of 3.0% on 20 Feb 2022 (Sunday)
- Maximum daily relative wind contribution of 5.1% on 27 Feb 2022 (Sunday)
- Maximum daily relative CSP contribution of 1.1% on 22 Feb 2022 (Tuesday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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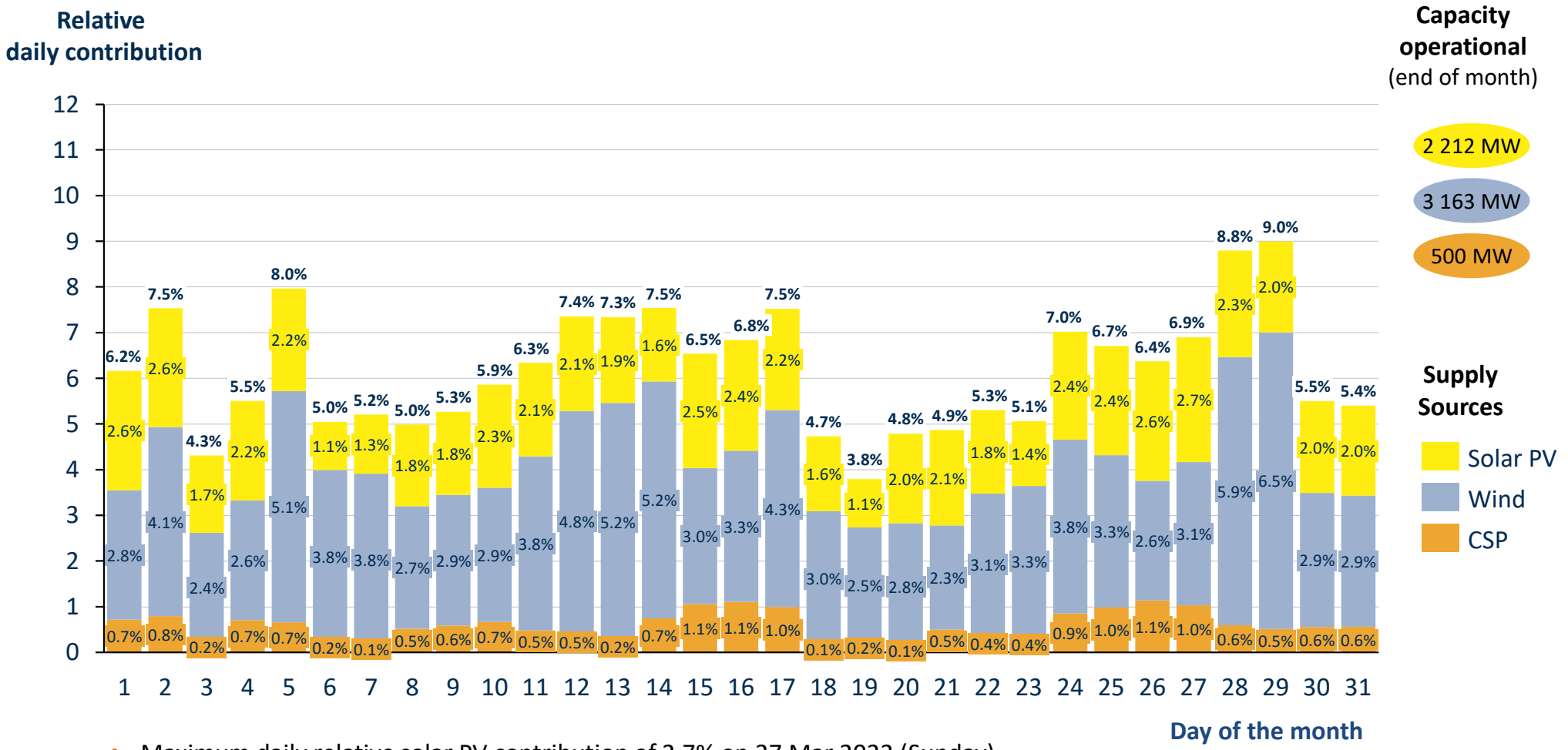
# Daily solar PV, wind & CSP contribution of 3.8-9.0% in Mar 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for March 2022




- Maximum daily relative solar PV contribution of 2.7% on 27 Mar 2022 (Sunday)
- Maximum daily relative wind contribution of 6.5% on 29 Mar 2022 (Tuesday)
- Maximum daily relative CSP contribution of 1.1% on 26 Mar 2022 (Saturday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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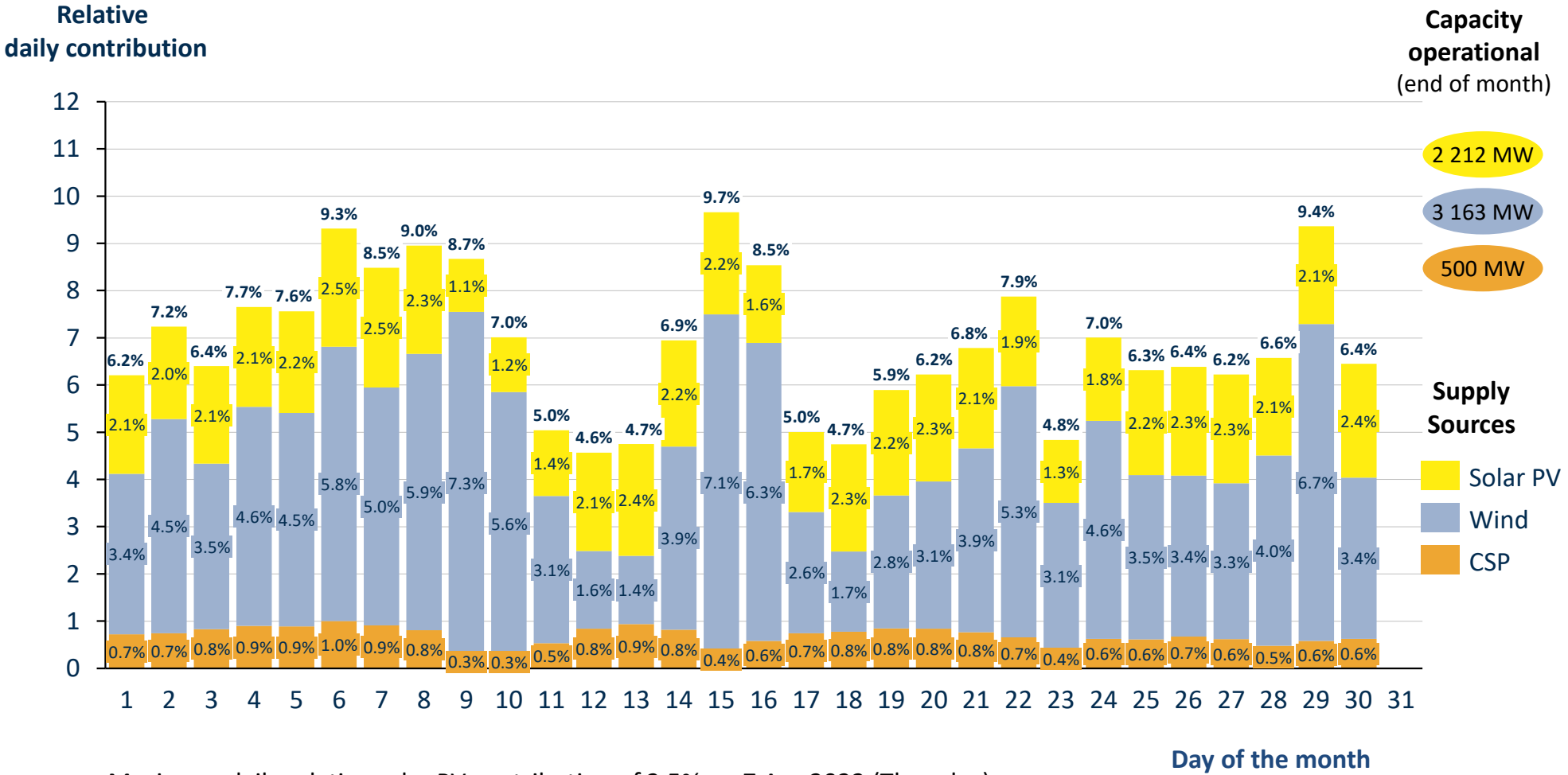
# Daily solar PV, wind & CSP contribution of 4.6-9.7% in Apr 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for April 2022




- Maximum daily relative solar PV contribution of 2.5% on 7 Apr 2022 (Thursday)
- Maximum daily relative wind contribution of 7.3% on 9 Apr 2022 (Saturday)
- Maximum daily relative CSP contribution of 1.0% on 6 Apr 2022 (Wednesday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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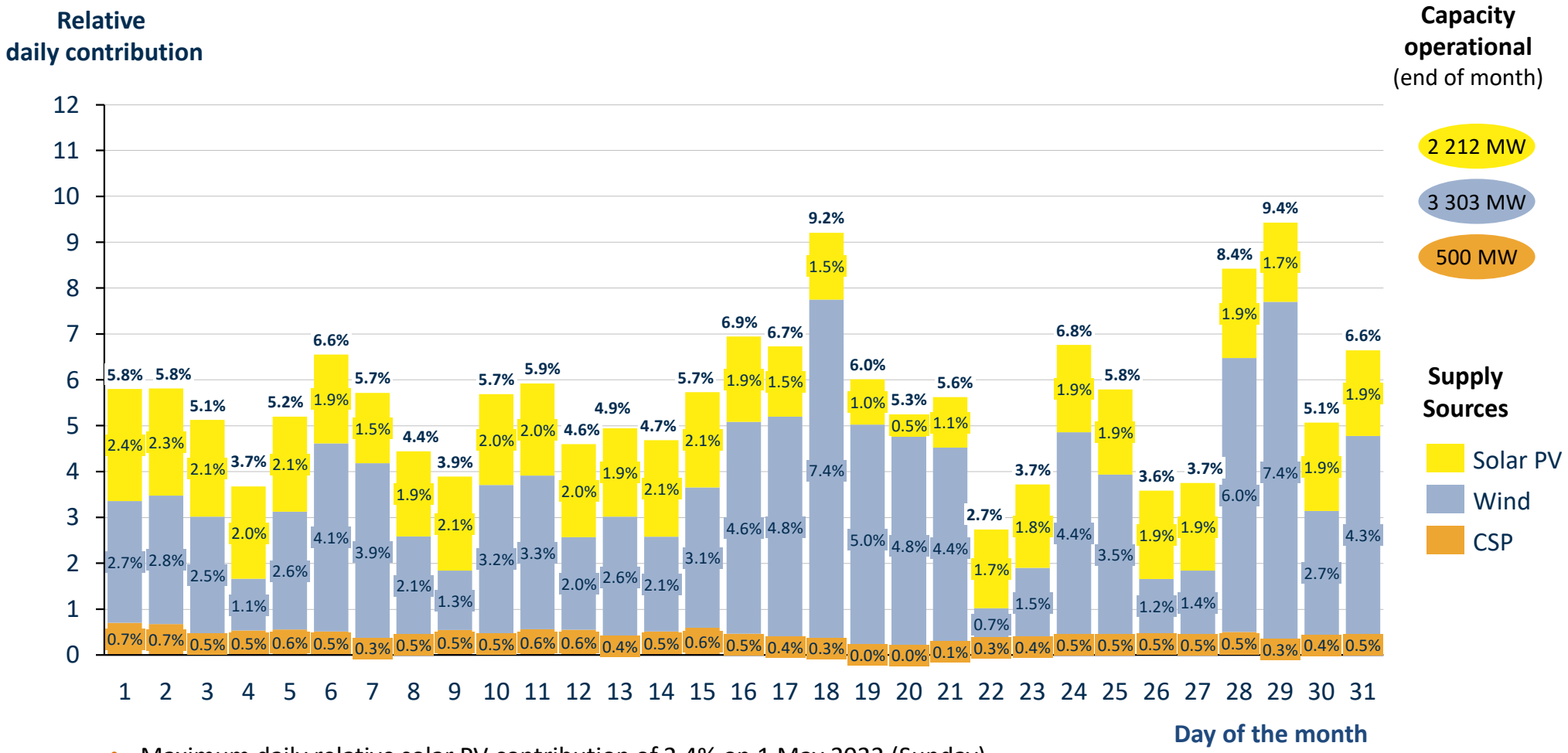
# Daily solar PV, wind & CSP contribution of 2.7-9.4% in May 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for May 2022




- Maximum daily relative solar PV contribution of 2.4% on 1 May 2022 (Sunday)
- Maximum daily relative wind contribution of 7.4% on 18 May 2022 (Wednesday)
- Maximum daily relative CSP contribution of 0.7% on 1 May 2022 (Sunday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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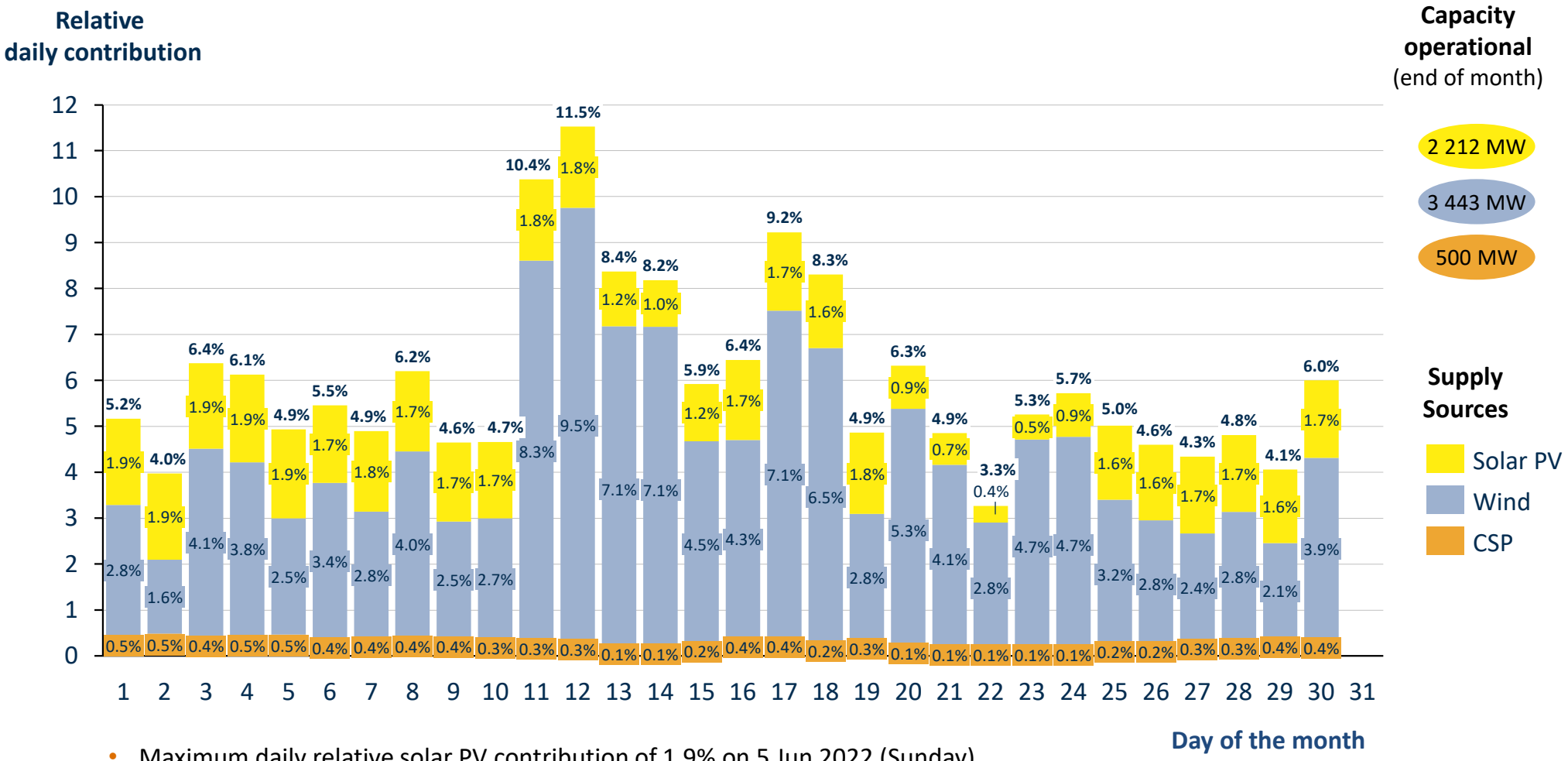
# Daily solar PV, wind & CSP contribution of 3.3-11.5% in Jun 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for June 2022




- Maximum daily relative solar PV contribution of 1.9% on 5 Jun 2022 (Sunday)
- Maximum daily relative wind contribution of 9.5% on 12 Jun 2022(Sunday)
- Maximum daily relative CSP contribution of 0.5% on 2 Jun 2022 (Thursday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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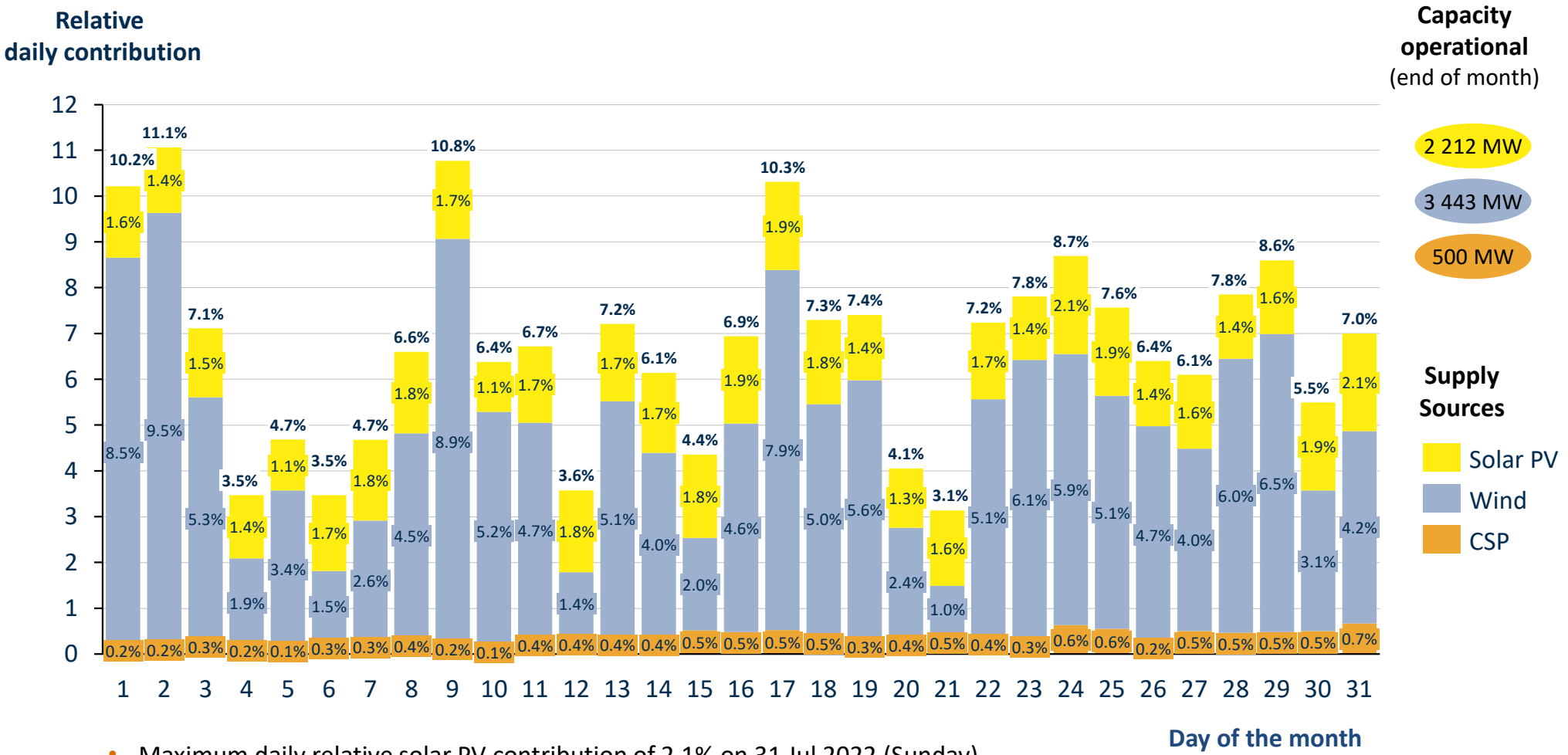
# Daily solar PV, wind & CSP contribution of 3.1-11.1% in Jul 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for July 2022




- Maximum daily relative solar PV contribution of 2.1% on 31 Jul 2022 (Sunday)
- Maximum daily relative wind contribution of 9.5% on 2 Jul 2022(Saturday)
- Maximum daily relative CSP contribution of 0.7% on 31 Jul 2022 (Sunday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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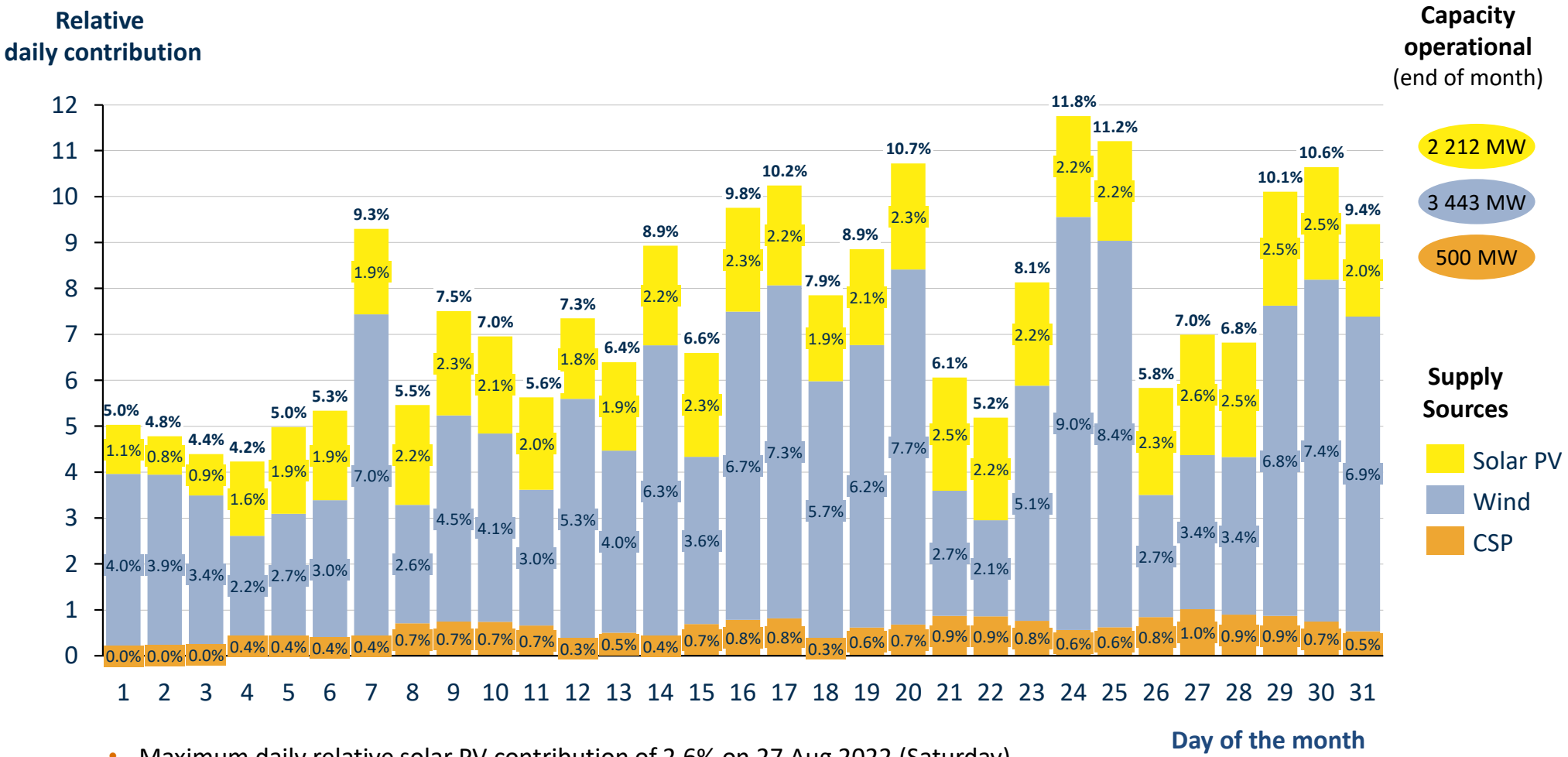
# Daily solar PV, wind & CSP contribution of 4.2-11.8% in Aug 2022

## Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for August 2022




- Maximum daily relative solar PV contribution of 2.6% on 27 Aug 2022 (Saturday)
- Maximum daily relative wind contribution of 9.0% on 24 Aug 2022(Wednesday)
- Maximum daily relative CSP contribution of 1.0% on 27 Aug 2022 (Saturday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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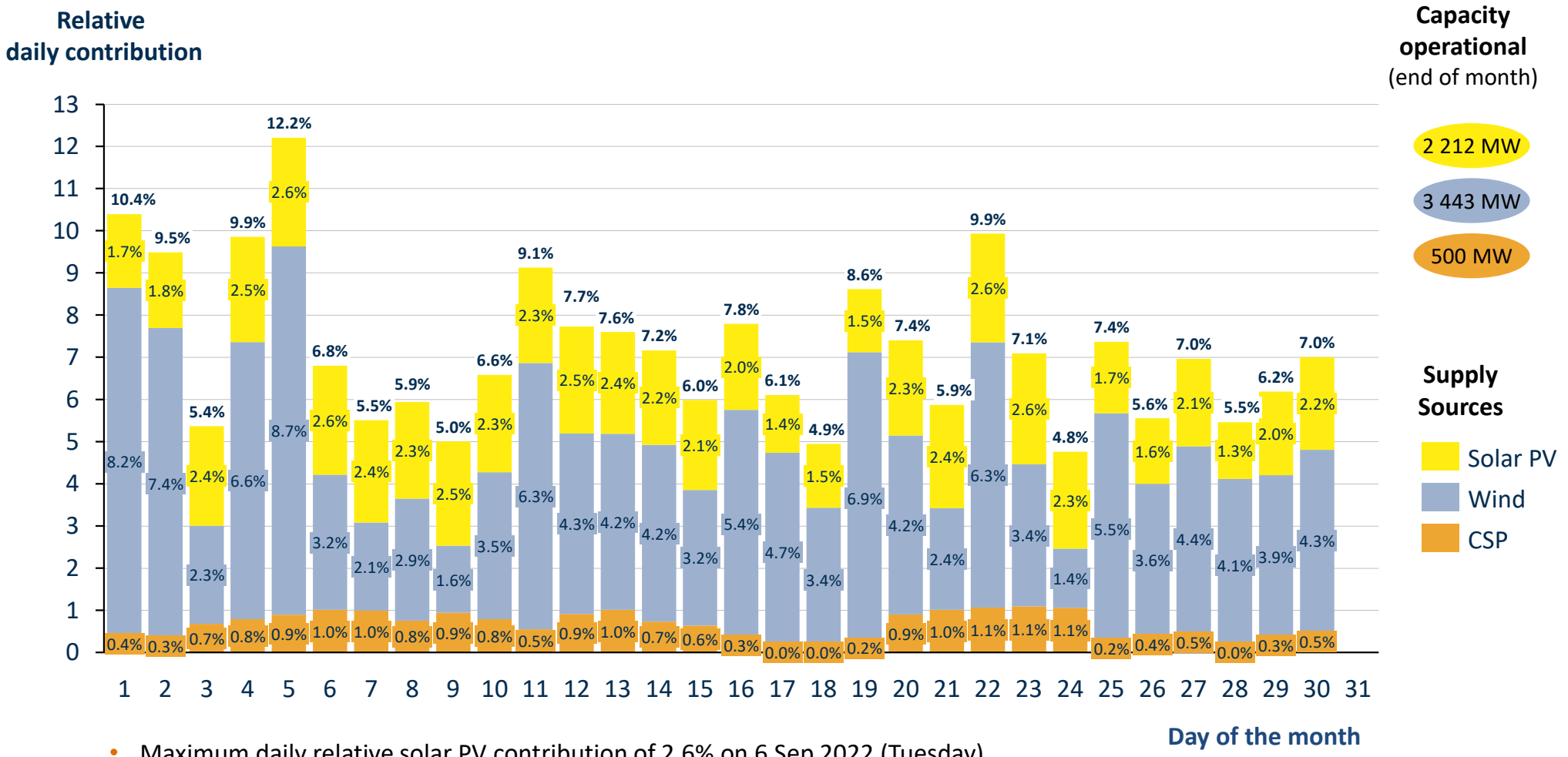
# Daily solar PV, wind & CSP contribution of 4.8-12.2% in Sep 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for September 2022




- Maximum daily relative solar PV contribution of 2.6% on 6 Sep 2022 (Tuesday)
- Maximum daily relative wind contribution of 8.7% on 5 Sep 2022(Monday)
- Maximum daily relative CSP contribution of 1.1% on 23 Sep 2022 (Friday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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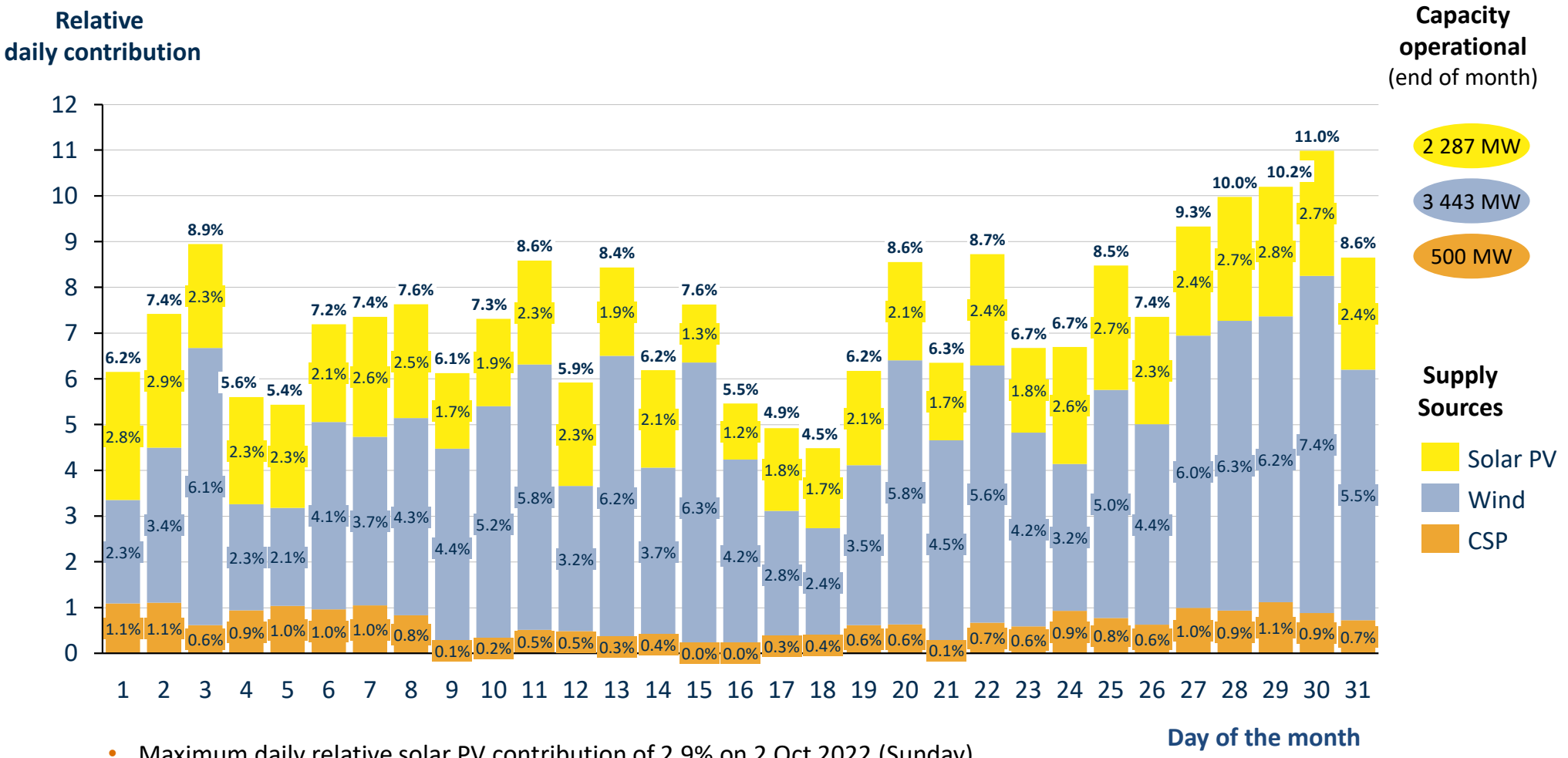
# Daily solar PV, wind & CSP contribution of 4.5-11.0% in Oct 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for October 2022




- Maximum daily relative solar PV contribution of 2.9% on 2 Oct 2022 (Sunday)
- Maximum daily relative wind contribution of 7.4% on 30 Oct 2022(Sunday)
- Maximum daily relative CSP contribution of 1.1% on 29 Oct 2022 (Saturday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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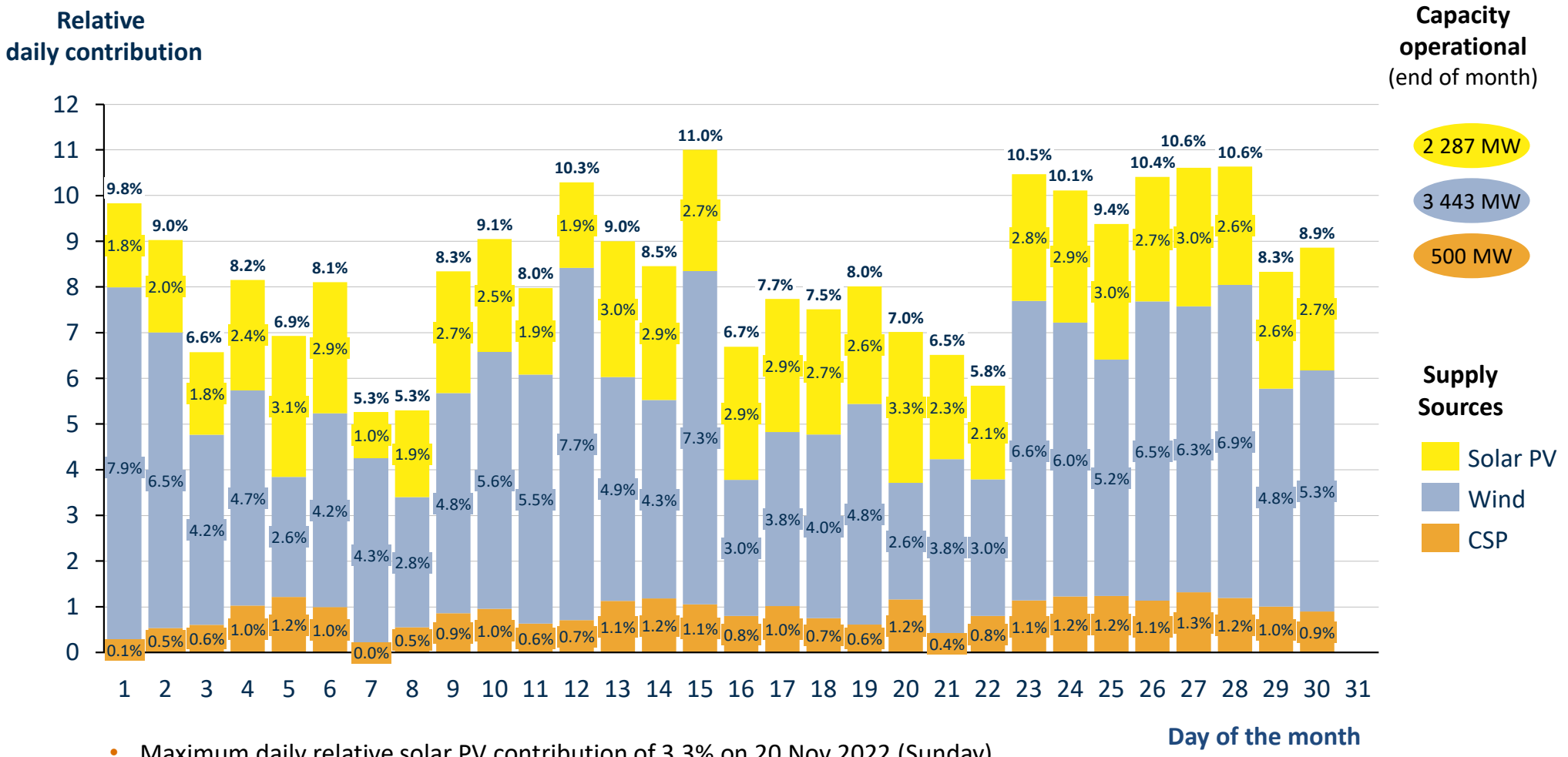
# Daily solar PV, wind & CSP contribution of 5.3-11.0% in Nov 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for November 2022




- Maximum daily relative solar PV contribution of 3.3% on 20 Nov 2022 (Sunday)
- Maximum daily relative wind contribution of 7.9% on 1 Nov 2022(Tuesday)
- Maximum daily relative CSP contribution of 1.3% on 27 Nov 2022 (Sunday)



Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis

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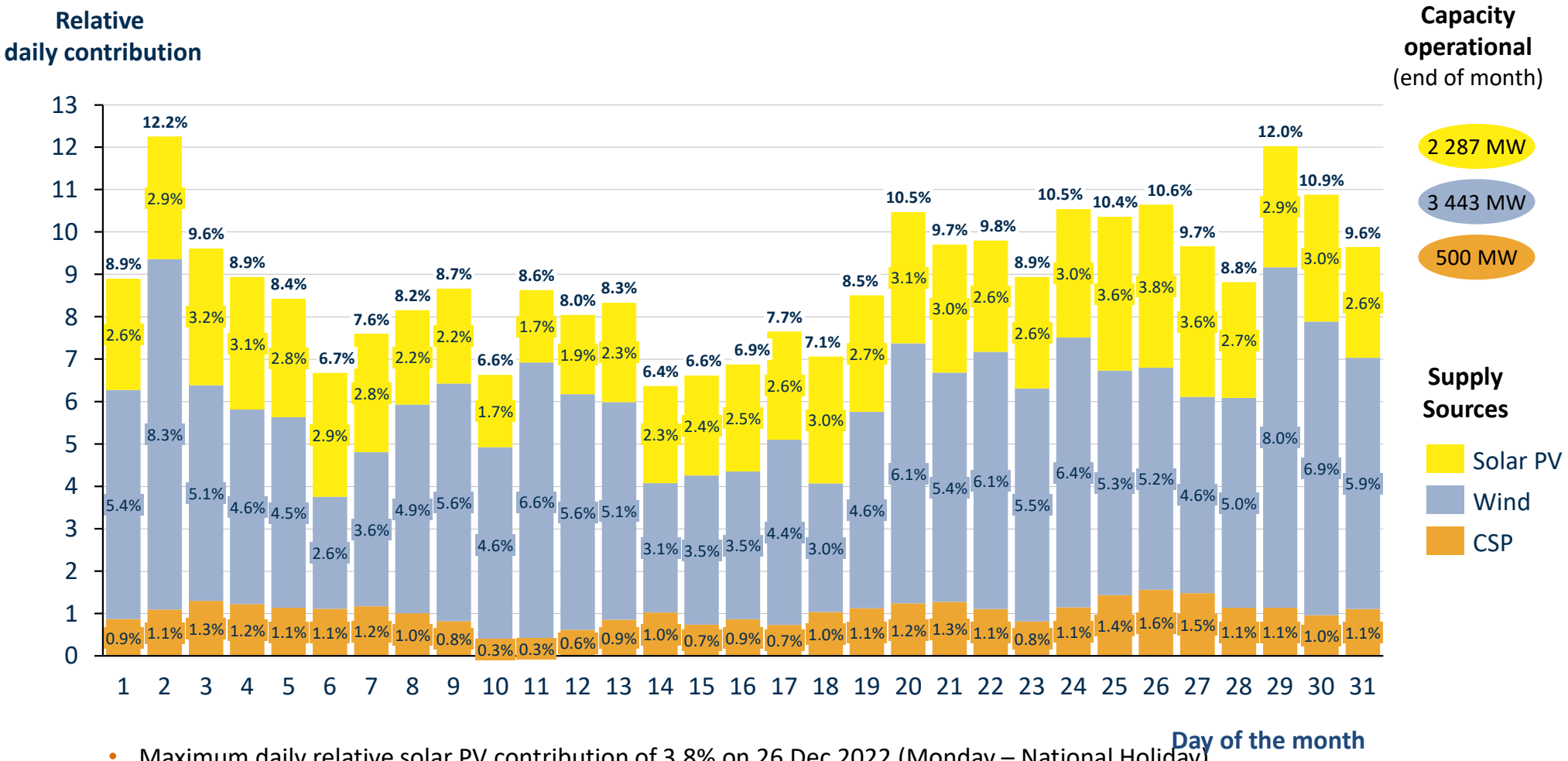
# Daily solar PV, wind & CSP contribution of 6.4-12.2% in Dec 2022

Actual daily relative solar PV/wind/CSP contribution as a % of total supply in RSA for December 2022




- Maximum daily relative solar PV contribution of 3.8% on 26 Dec 2022 (Monday – National Holiday)
- Maximum daily relative wind contribution of 8.3% on 2 Dec 2022(Friday)
- Maximum daily relative CSP contribution of 1.6% on 26 Dec 2022 (Monday – National Holiday)

Note: Total supply includes generation for pumping load
Sources: Eskom; CSIR Energy Centre analysis



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# Agenda (2022)

1 Overview actual electricity production

2 Monthly electricity production

3 Weekly electricity production

4 Daily electricity production

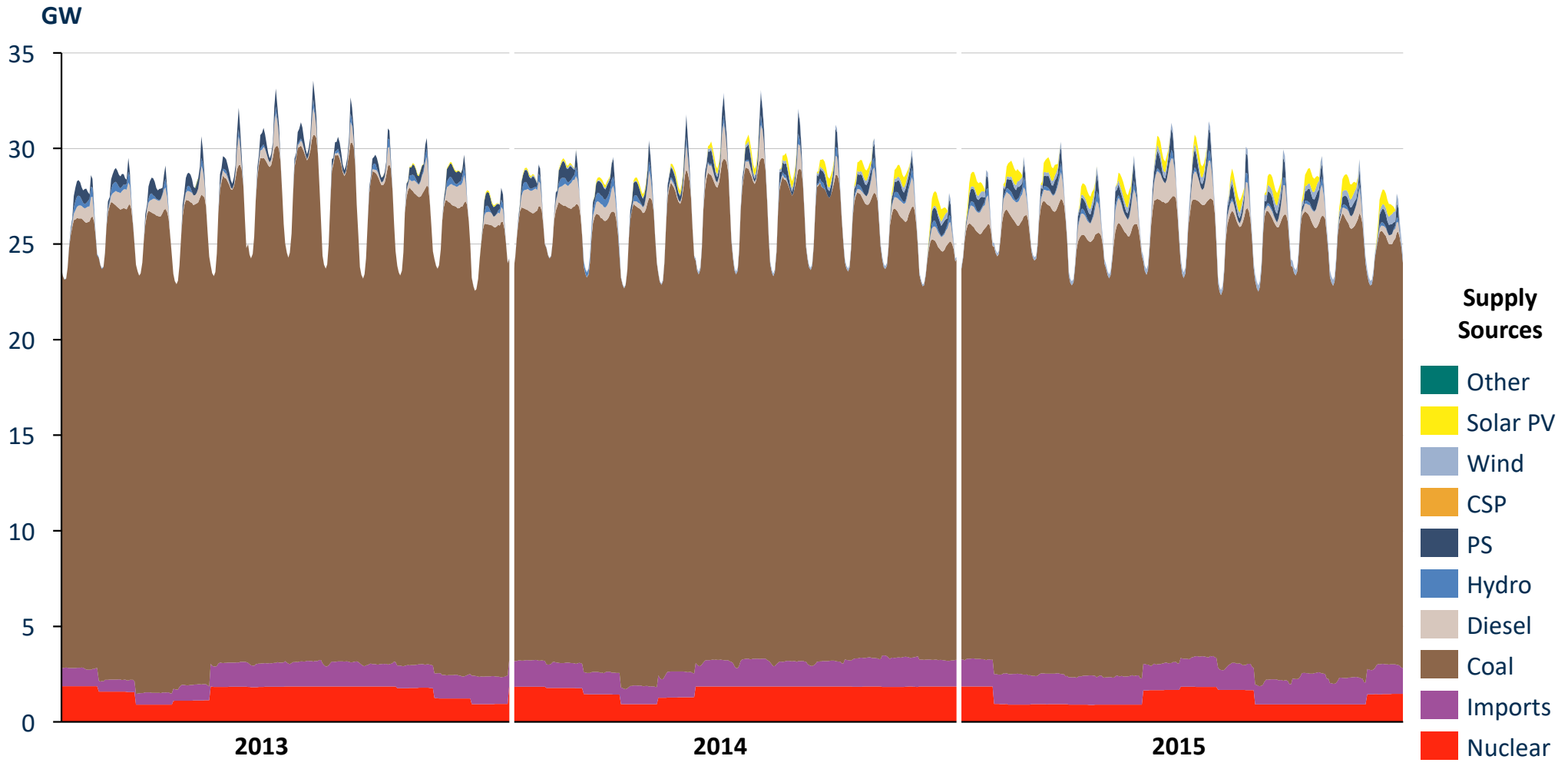
5 Hourly electricity

6 Loadshedding

7 Other power system statistics

# Diurnal courses of electricity supply sources in RSA

Actual monthly average diurnal courses of total power supply in RSA Jan 2013-Dec 2015




Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis



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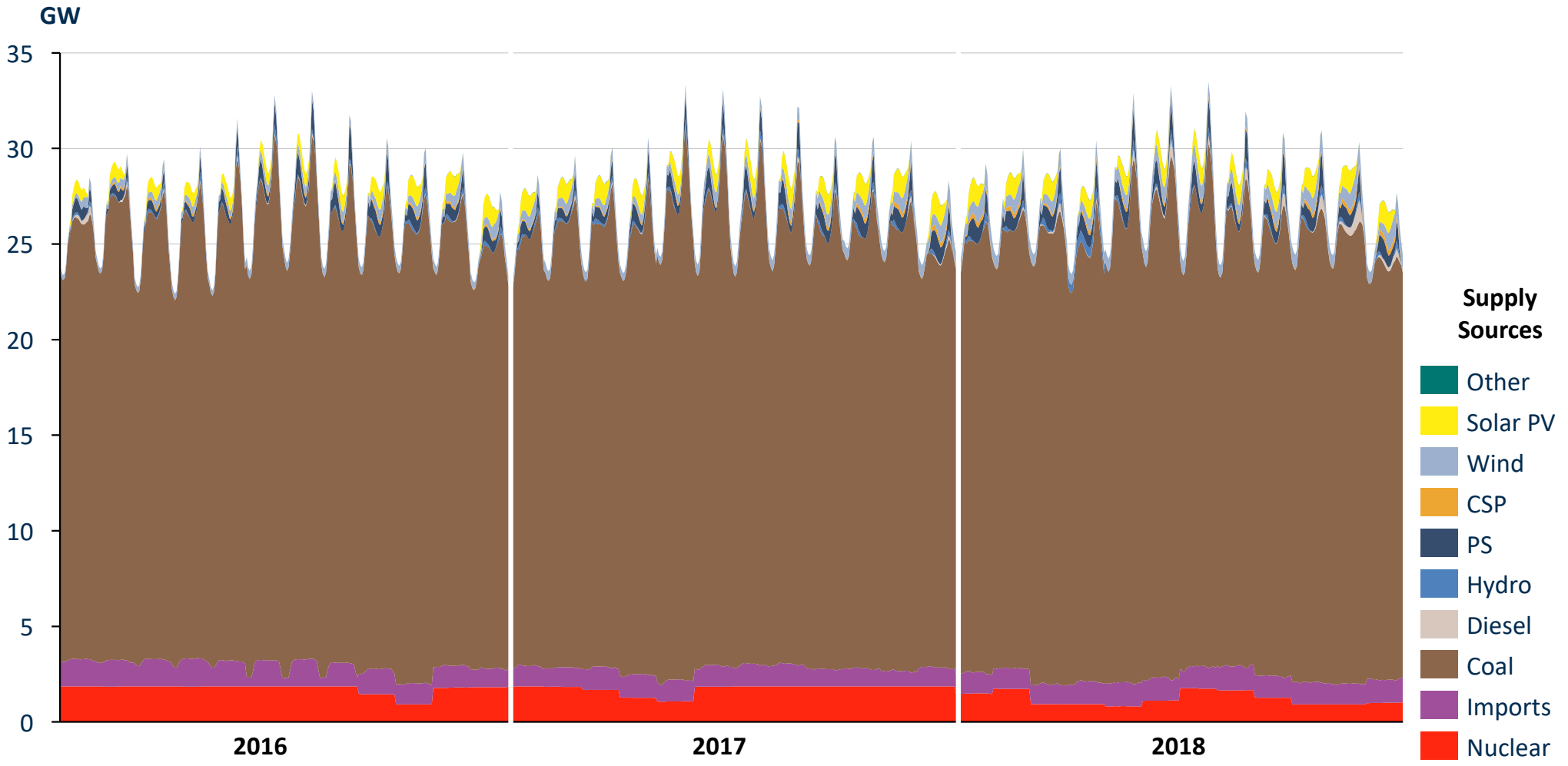
# Diurnal courses of electricity supply sources in RSA

Actual monthly average diurnal courses of total power supply in RSA Jan 2016-Dec 2018




Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis



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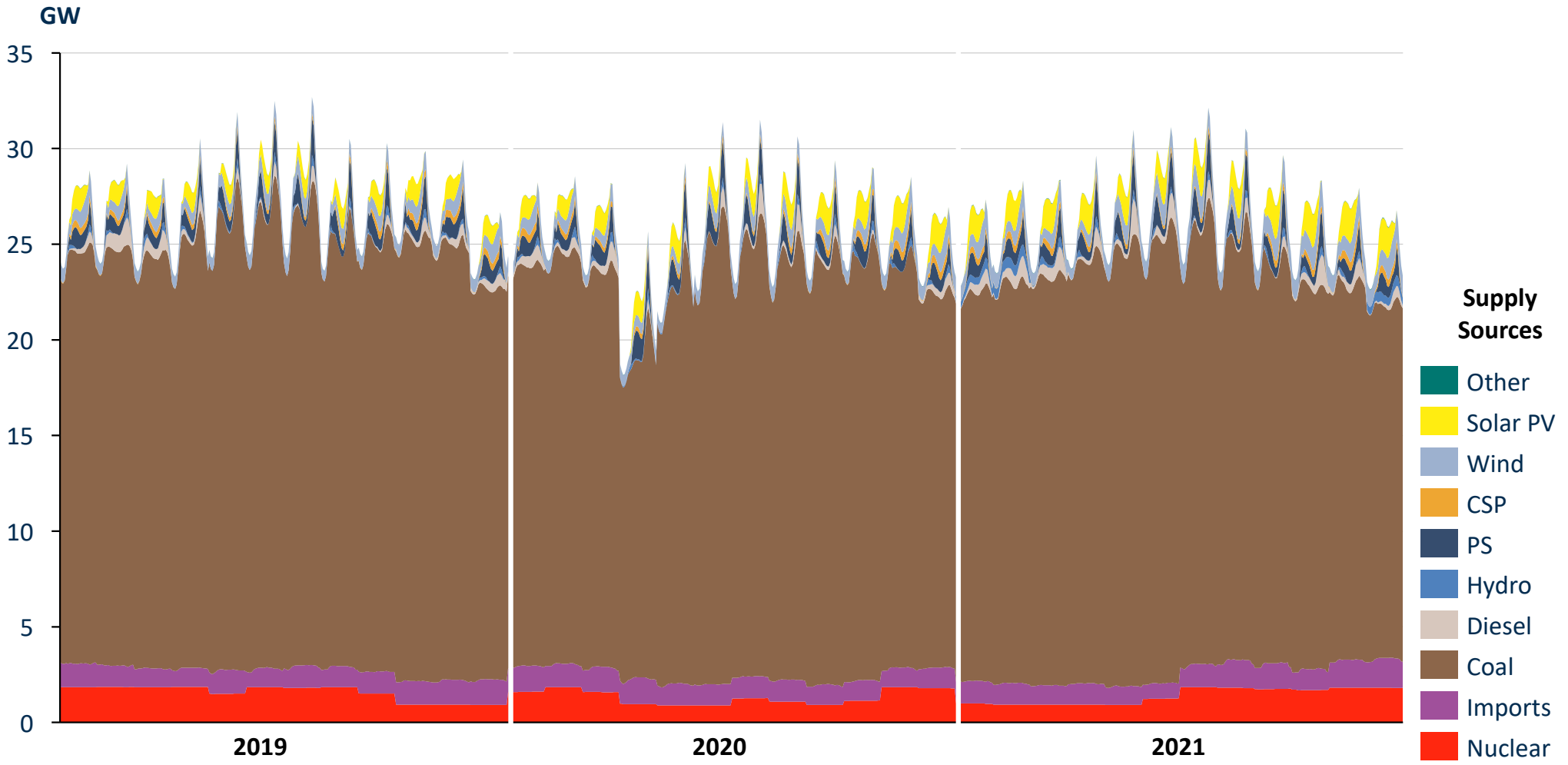
# Diurnal courses of electricity supply sources in RSA

Actual monthly average diurnal courses of total power supply in RSA Jan 2019-Dec 2021




Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

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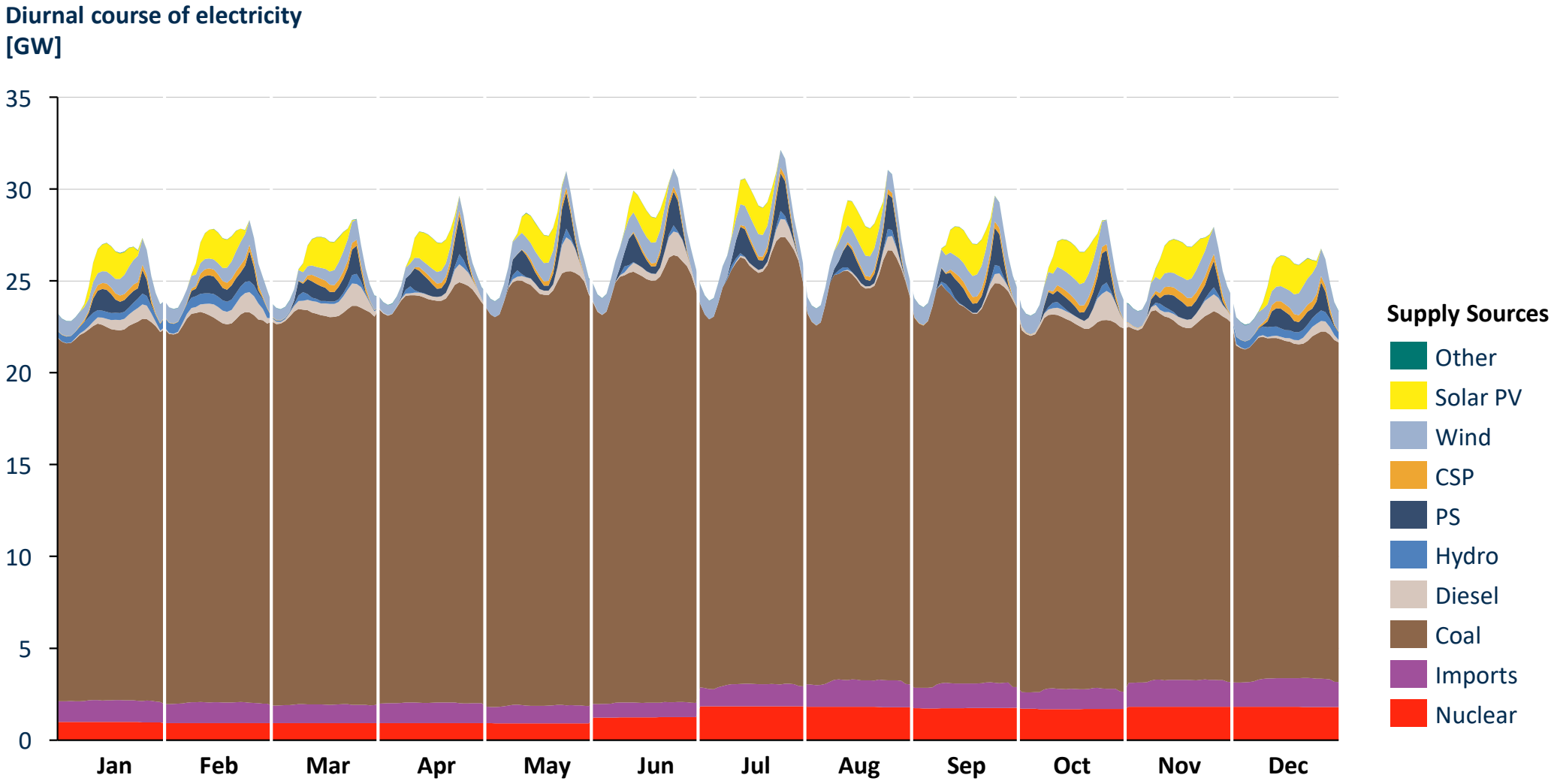
# Diurnal courses of electricity supply sources in RSA in 2021

Actual monthly average diurnal courses of the total power supply in RSA from Jan-Dec 2021




Note: Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis



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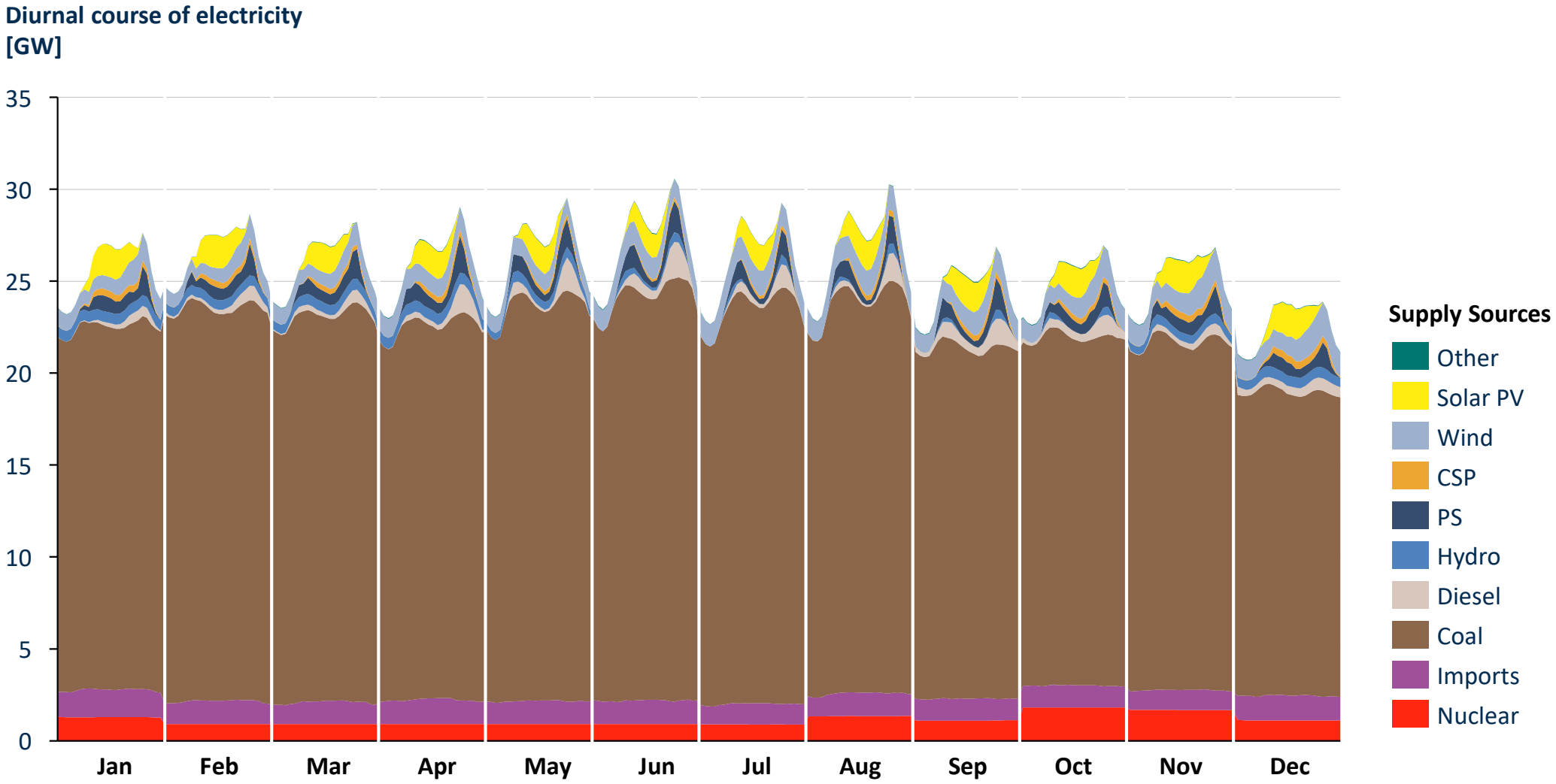
# Diurnal courses of electricity supply sources in RSA in 2022

Actual monthly average diurnal courses of the total power supply in RSA from Jan-Dec 2022






Note: Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

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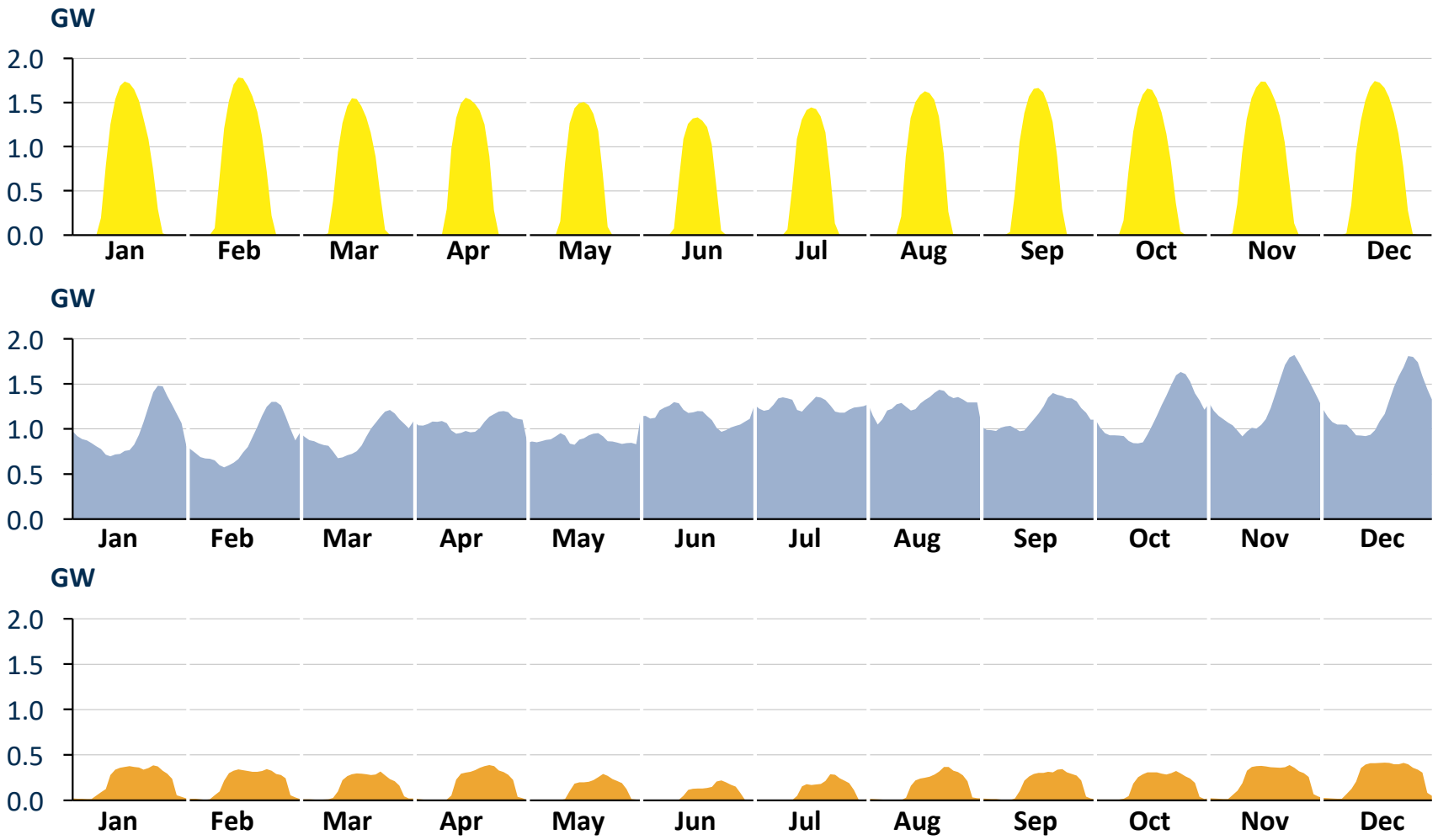
# Diurnal courses for renewable energy supply

## Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for 2022




**Capacity operational** (31 Dec)

2 287 MW

3 023 MW

500 MW

**Supply Sources**

Solar PV

Wind

CSP



Note: Design as per Fraunhofer ISE

Sources: Eskom; CSIR Energy Centre analysis

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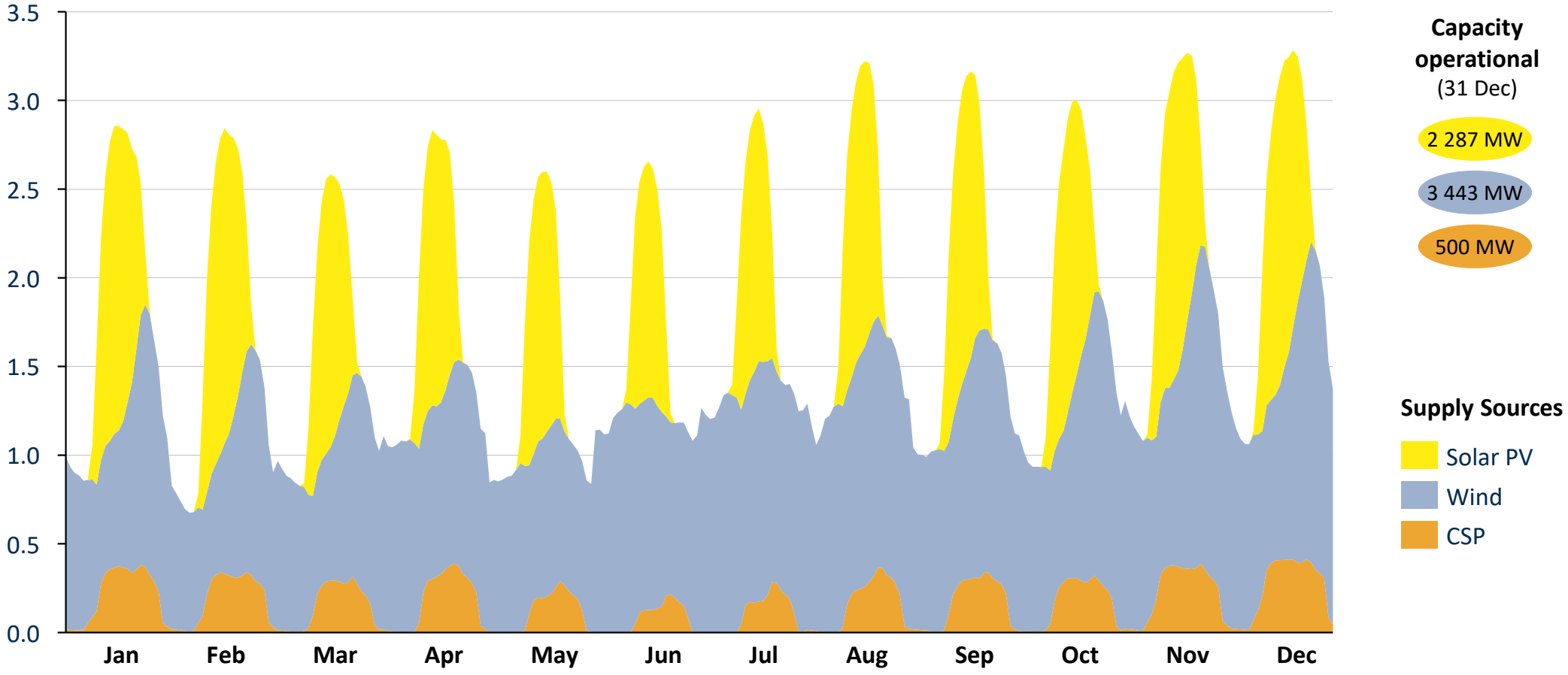
# Diurnal courses for renewable energy supply

## Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for 2022

**Diurnal course of electricity [GW]**






Note: Design as per Fraunhofer ISE
Sources: Eskom; CSIR Energy Centre analysis

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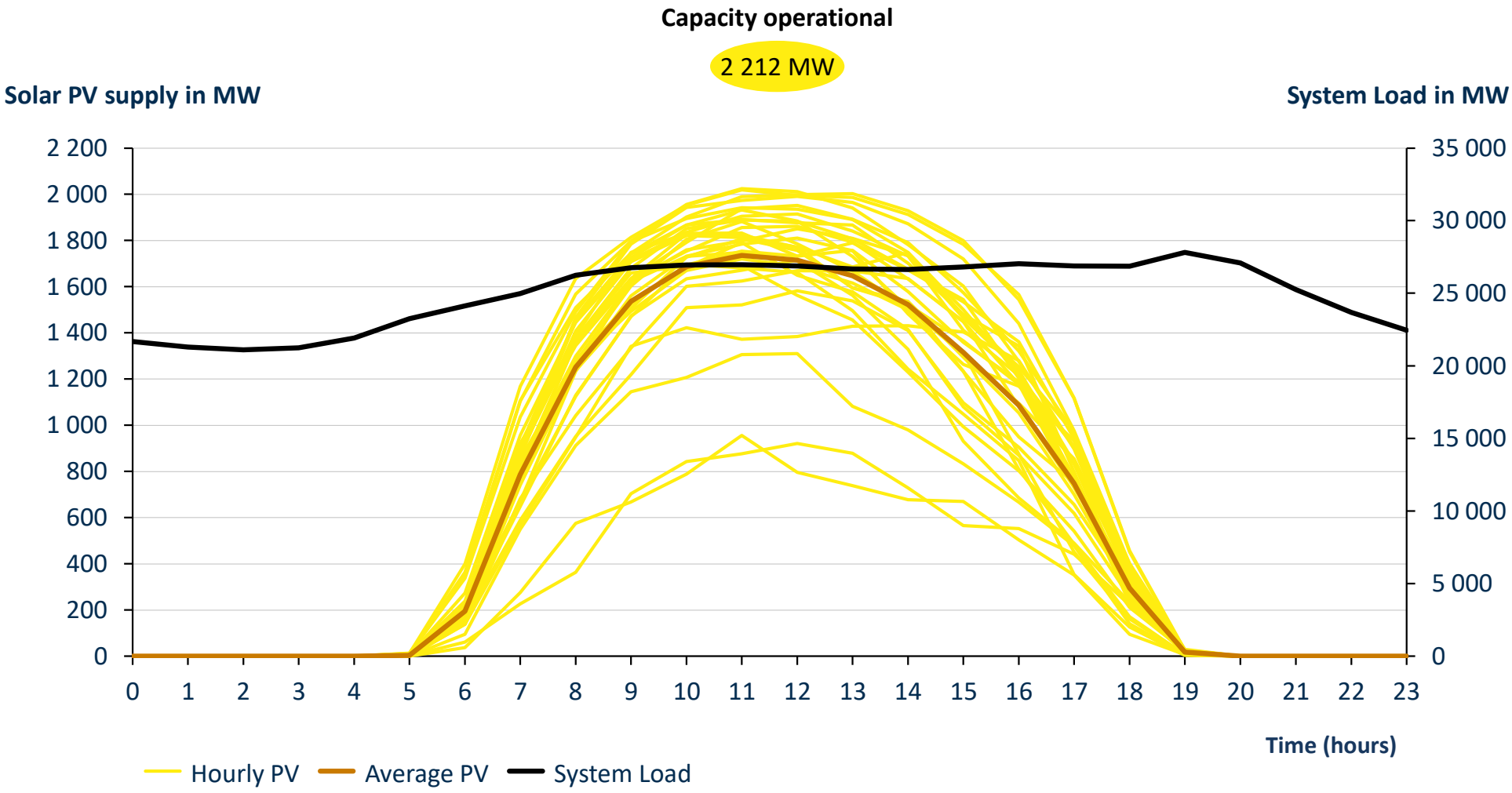
# Solar PV supply in Jan 2022

Hourly solar PV production for all 31 days of January 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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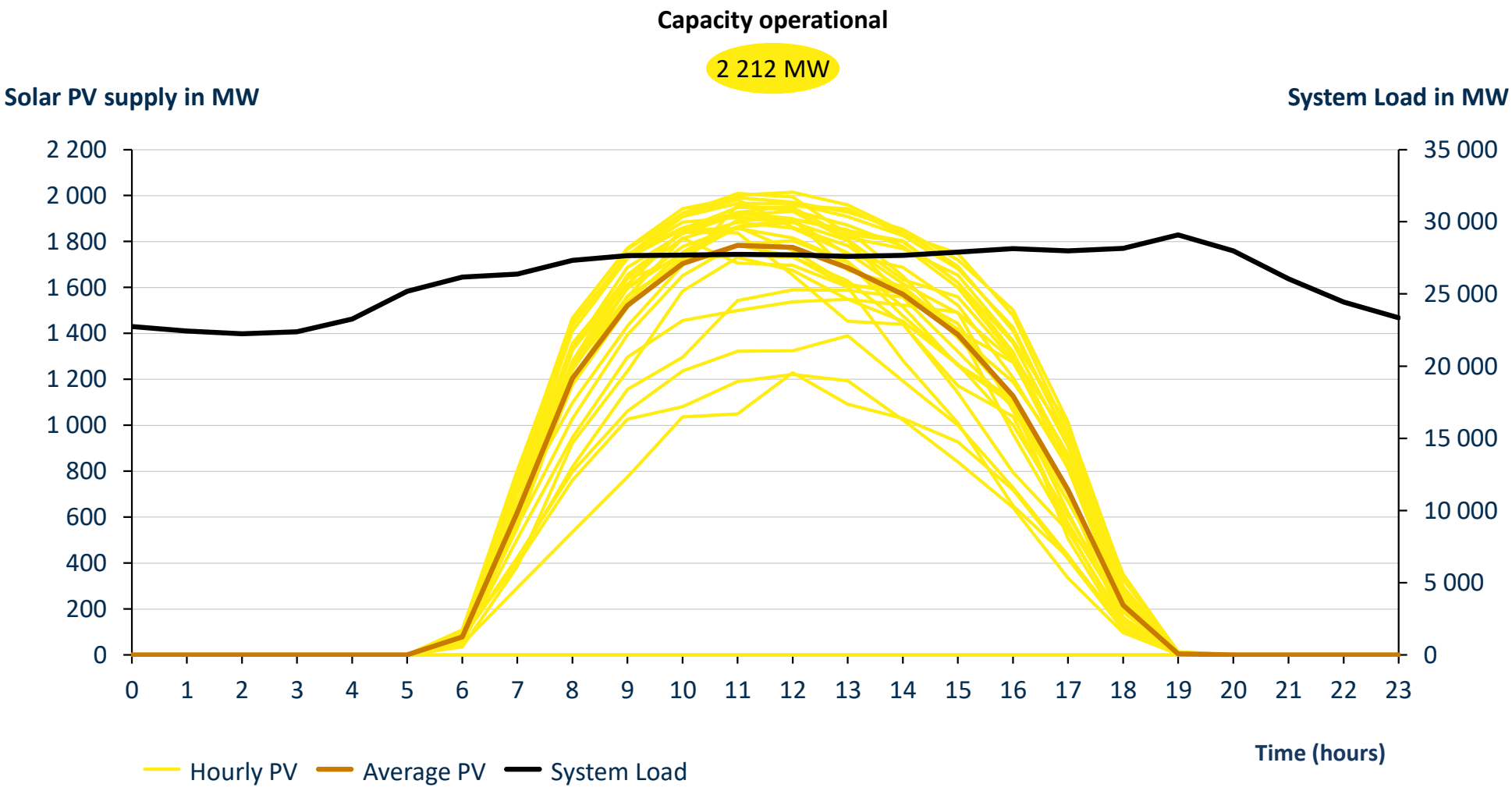
# Solar PV supply in Feb 2022

Hourly solar PV production for all 28 days of February 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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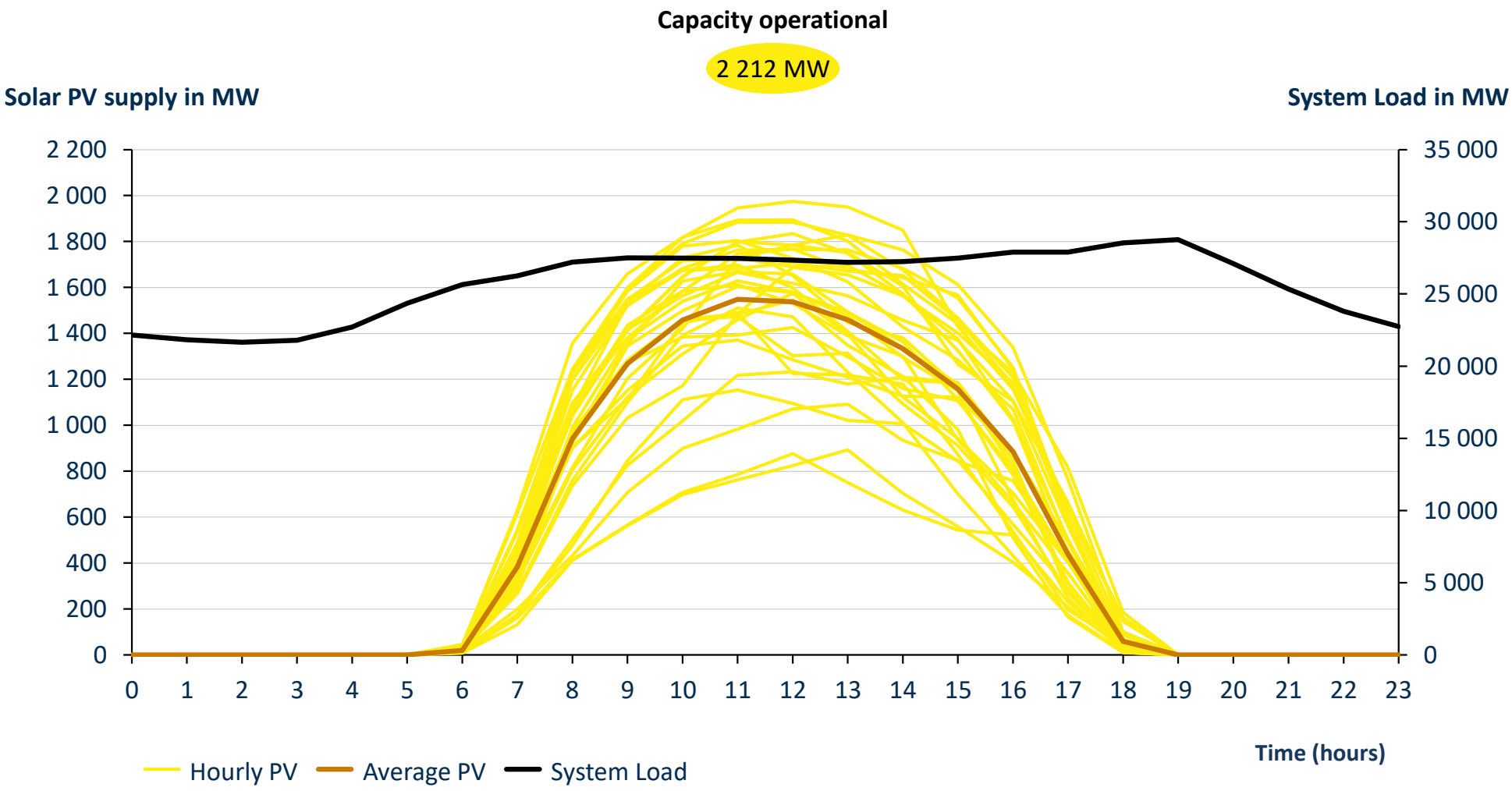
# Solar PV supply in Mar 2022

Hourly solar PV production for all 31 days of March 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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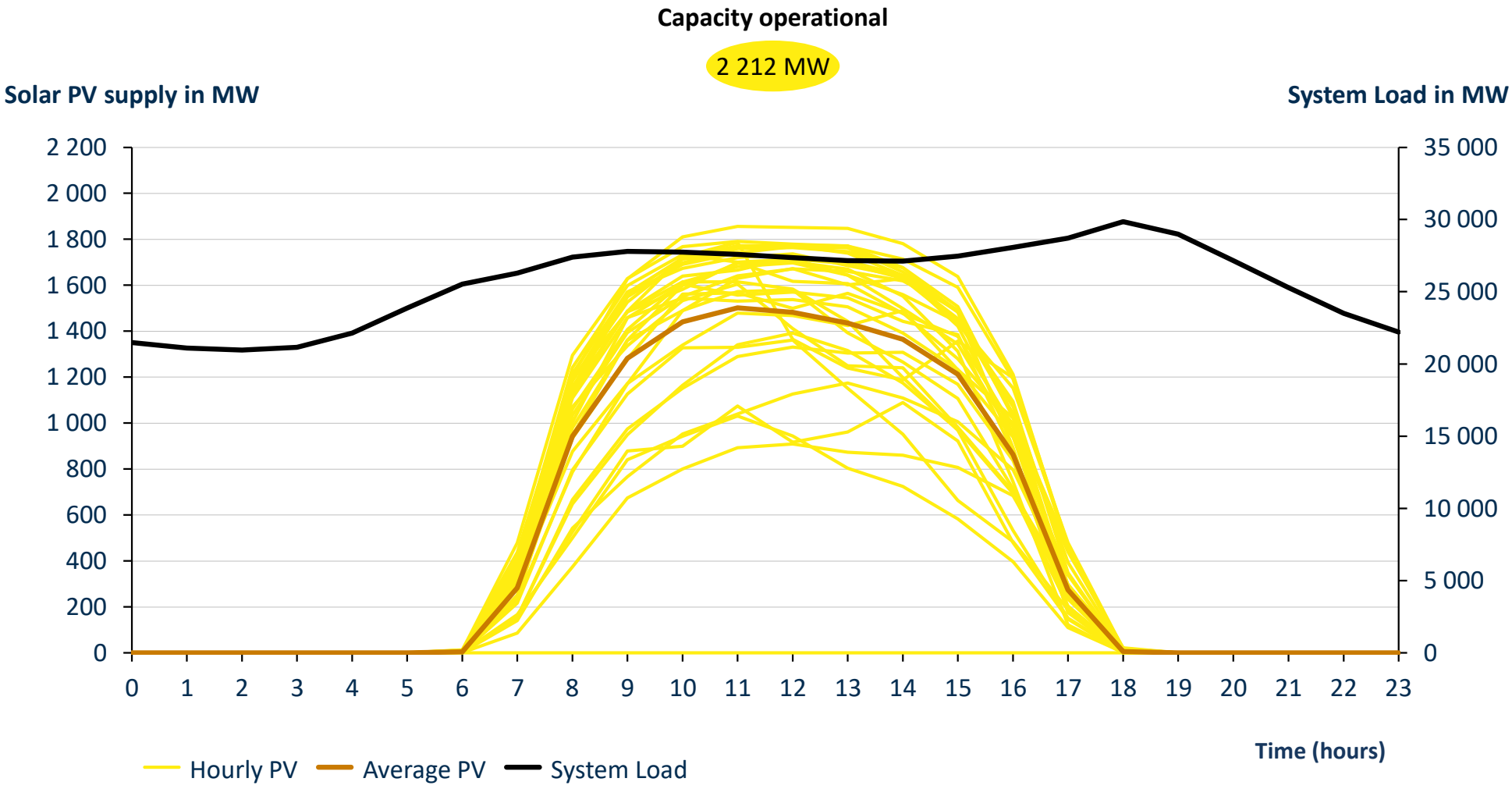
# Solar PV supply in Apr 2022

Hourly solar PV production for all 30 days of April 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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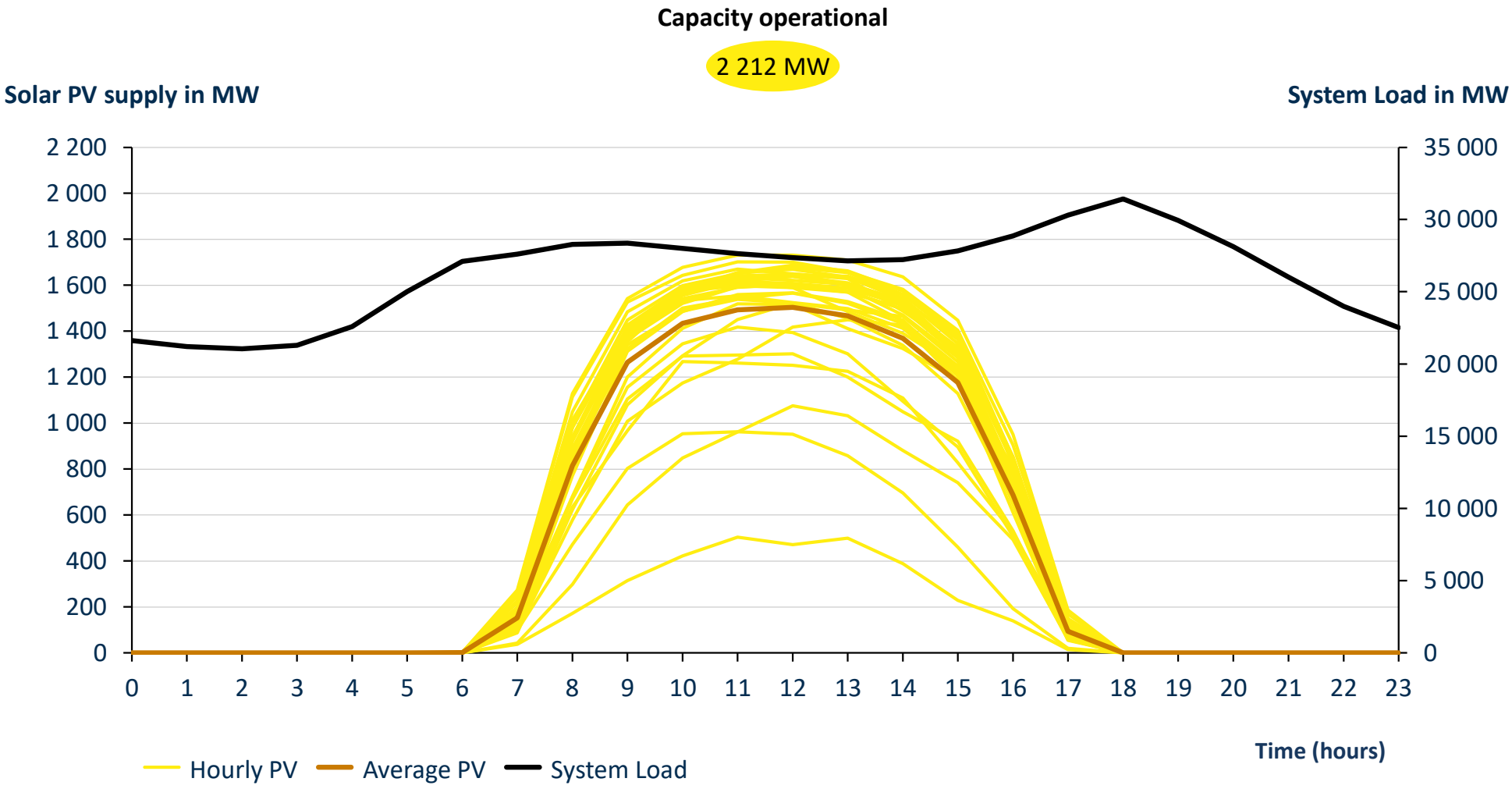
# Solar PV supply in May 2022

Hourly solar PV production for all 31 days of May 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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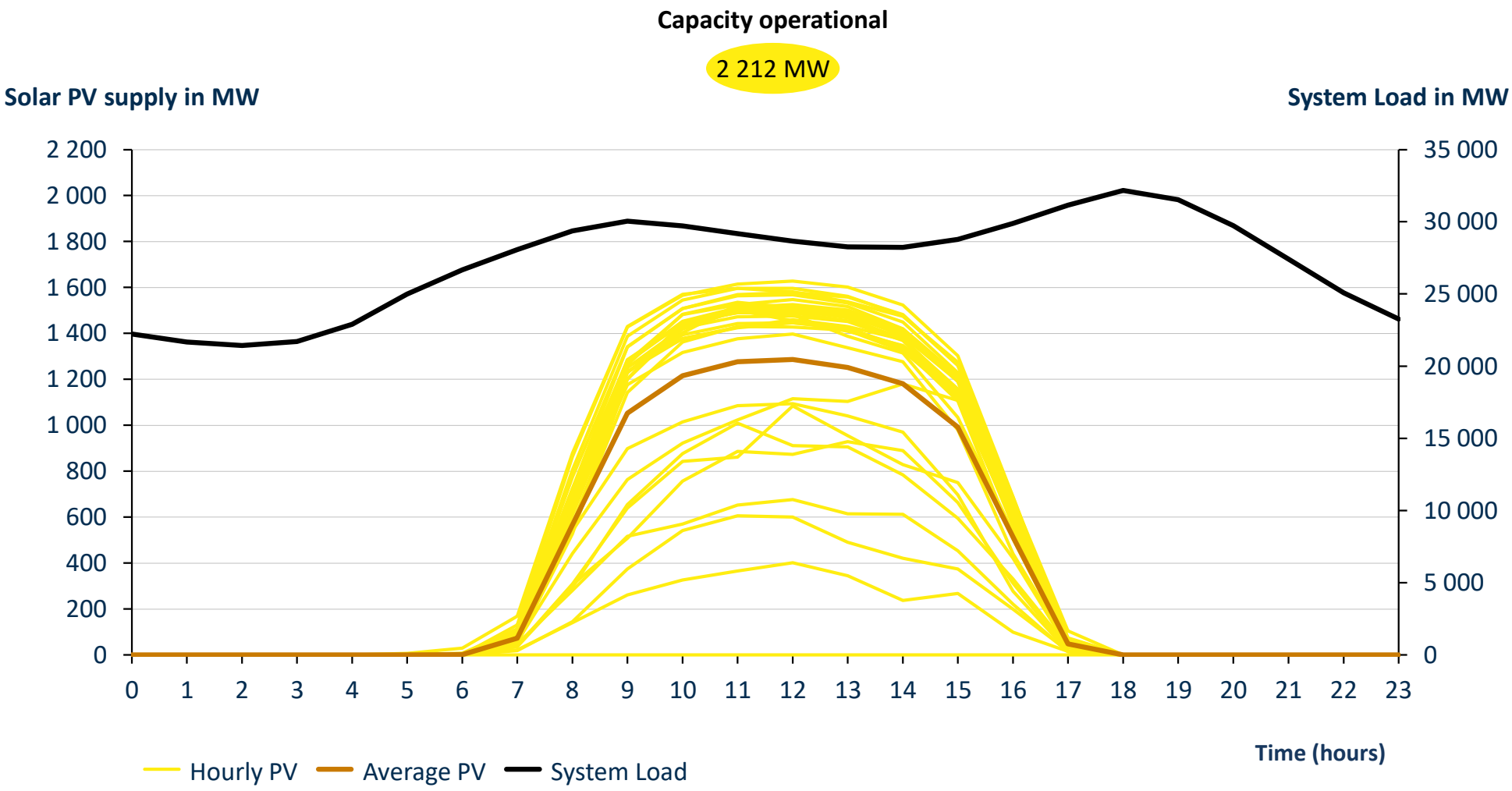
# Solar PV supply in Jun 2022

Hourly solar PV production for all 30 days of June 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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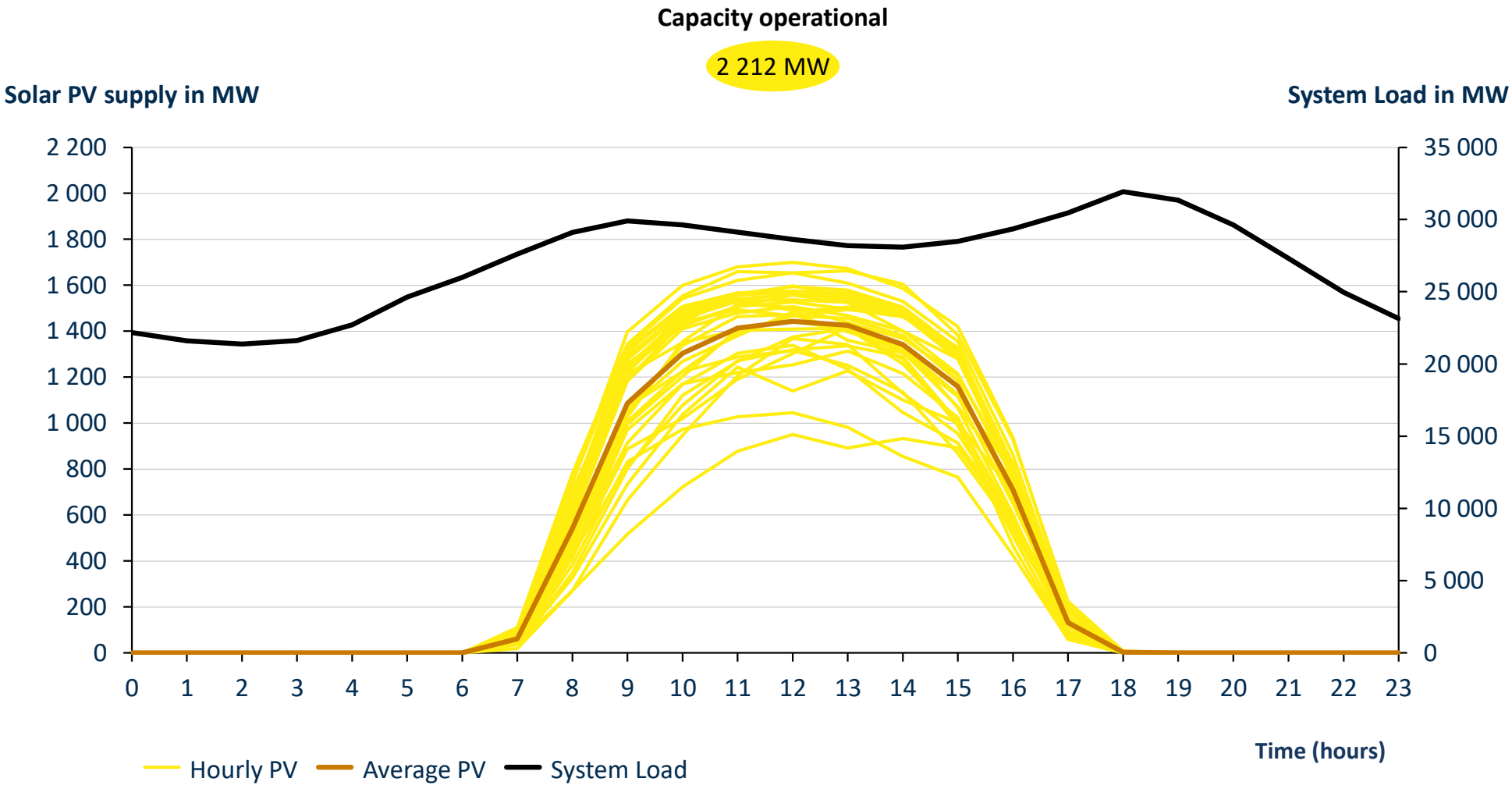
# Solar PV supply in Jul 2022

Hourly solar PV production for all 31 days of July 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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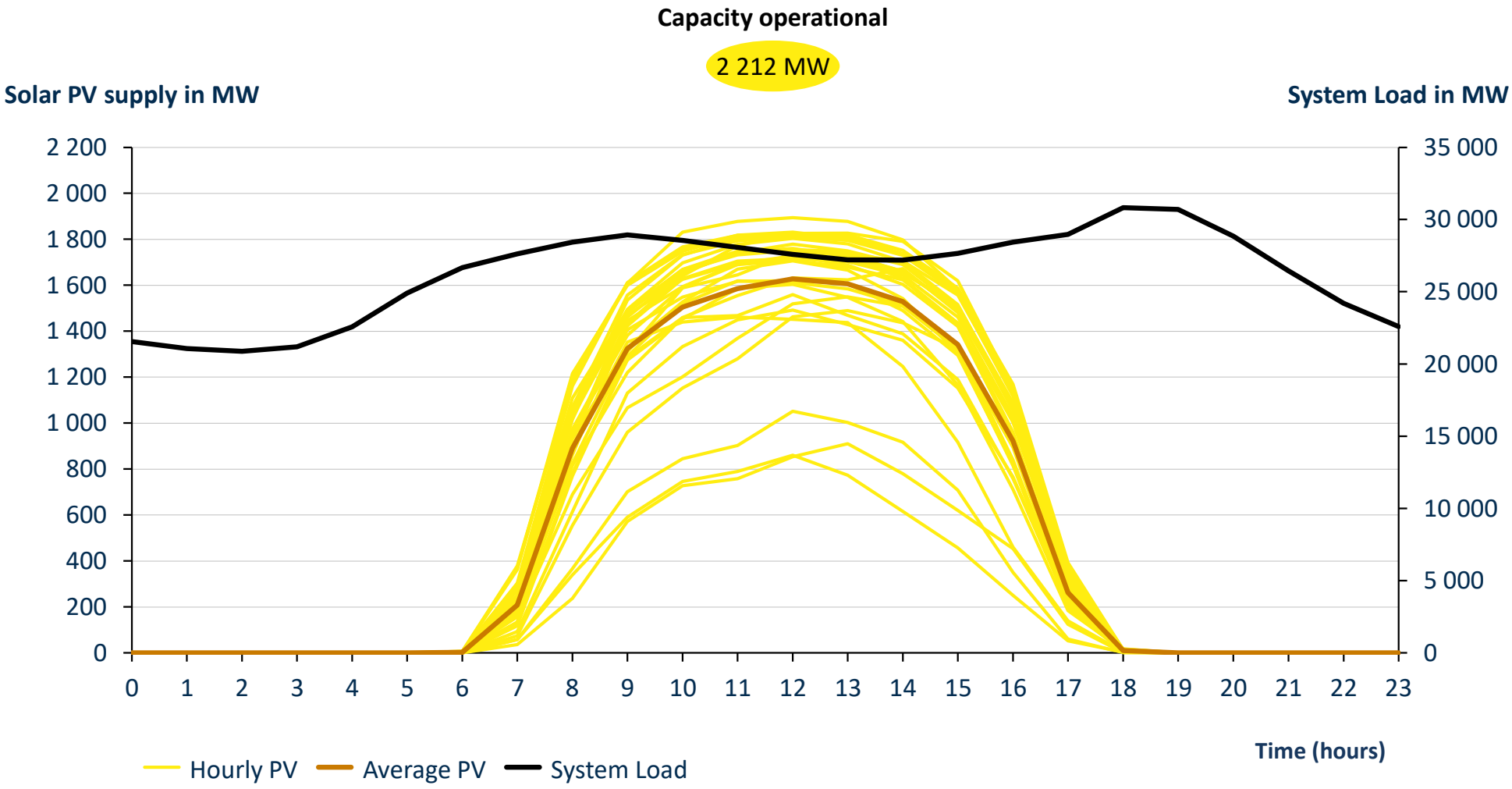
# Solar PV supply in Aug 2022

Hourly solar PV production for all 31 days of August 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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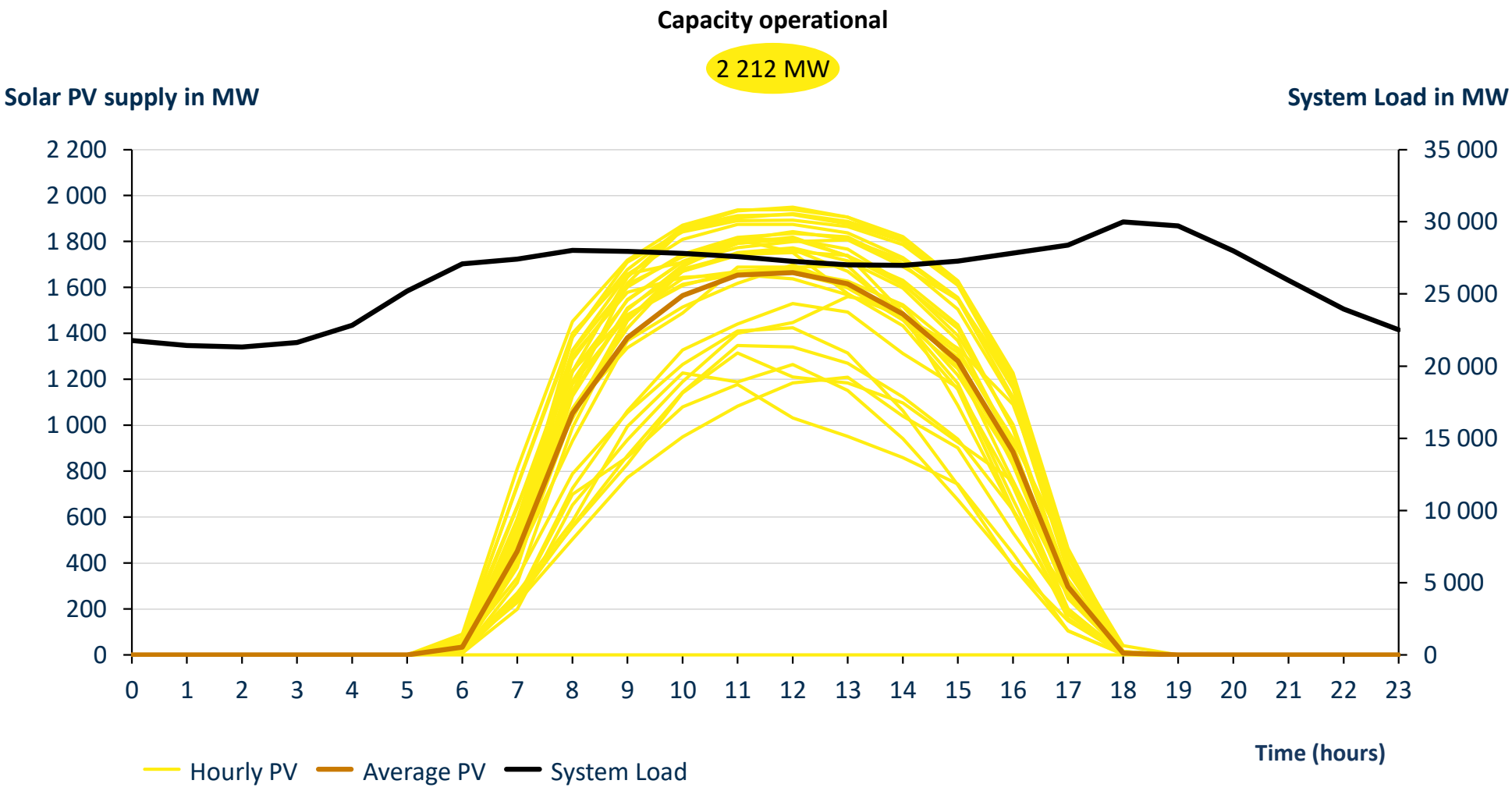
# Solar PV supply in Sep 2022

Hourly solar PV production for all 30 days of September 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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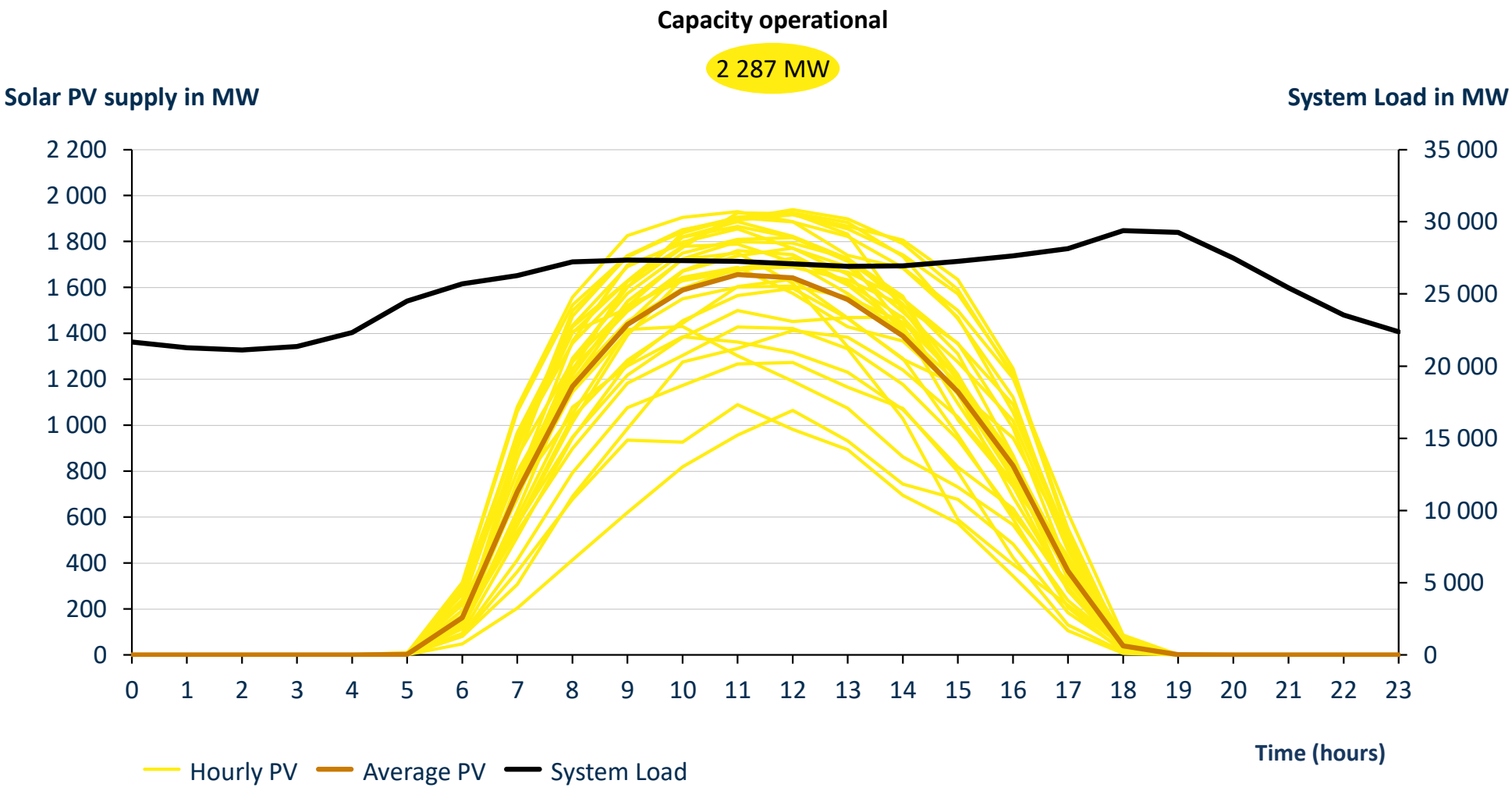
# Solar PV supply in Oct 2022

Hourly solar PV production for all 31 days of October 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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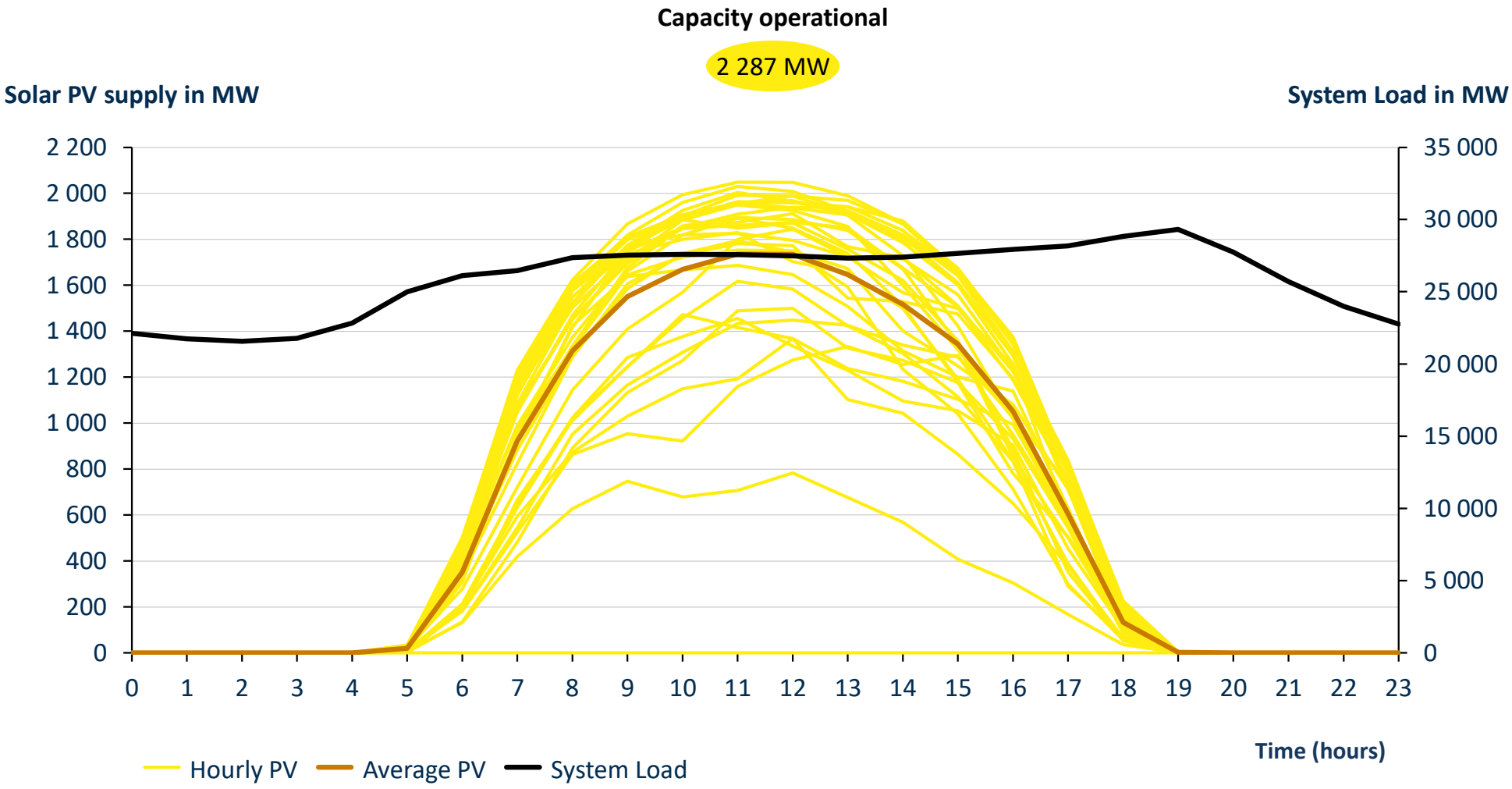
# Solar PV supply in Nov 2022

Hourly solar PV production for all 30 days of November 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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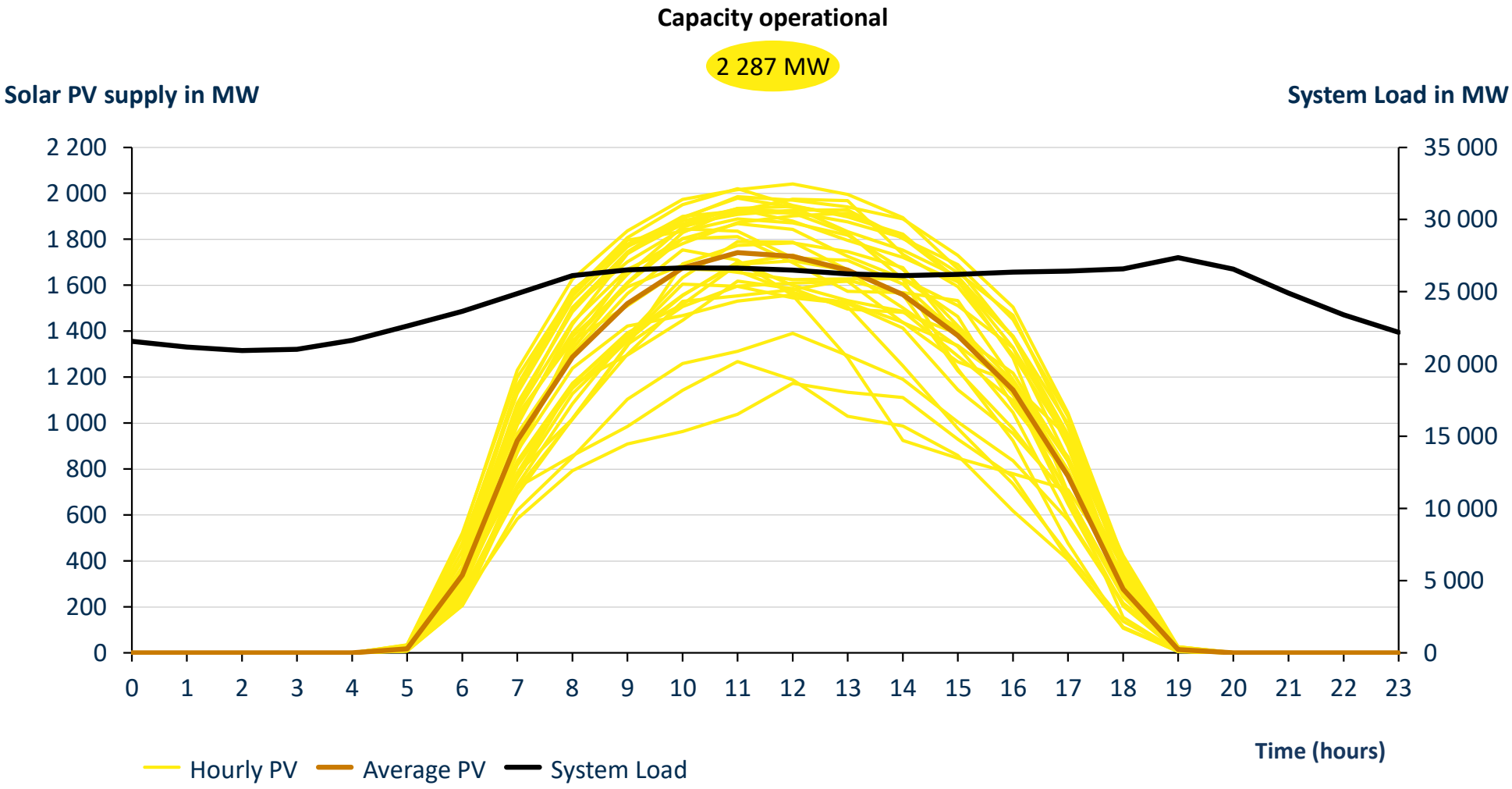
# Solar PV supply in Dec 2022

Hourly solar PV production for all 31 days of December 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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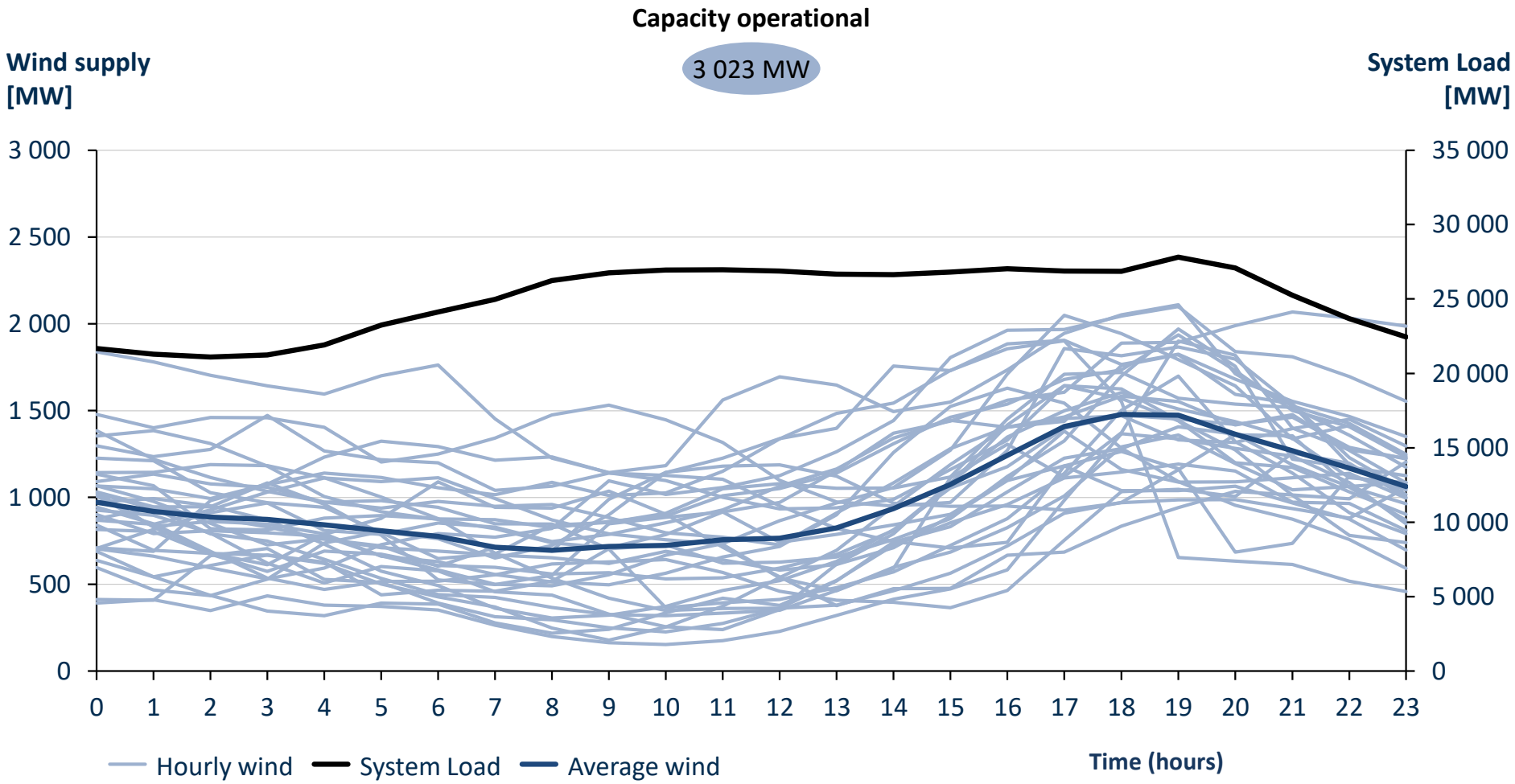
# Wind supply in Jan 2022

Hourly wind production for all 31 days of January 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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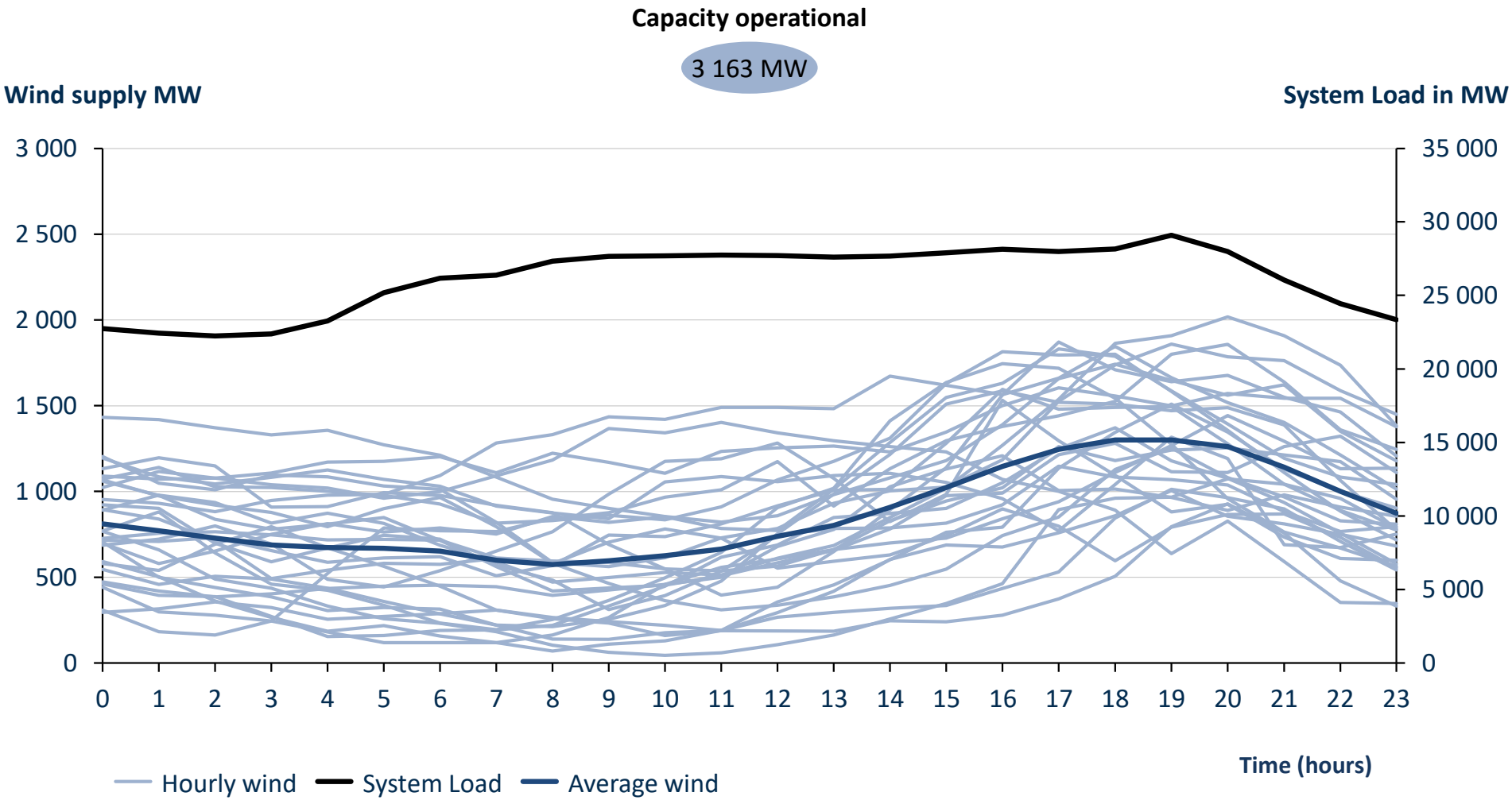
# Wind supply in Feb 2022

Hourly wind production for all 28 days of February 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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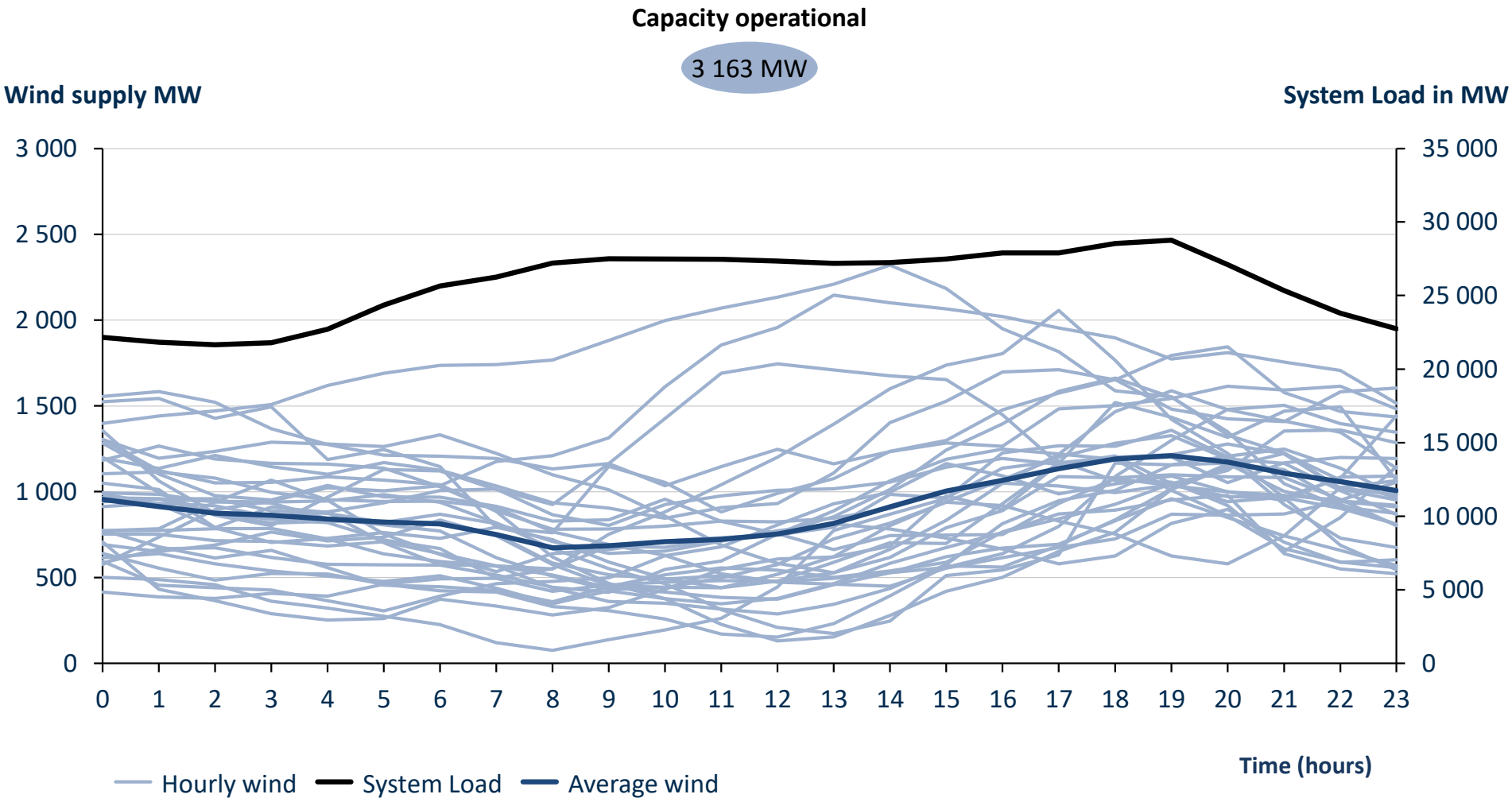
# Wind supply in Mar 2022

Hourly wind production for all 31 days of March 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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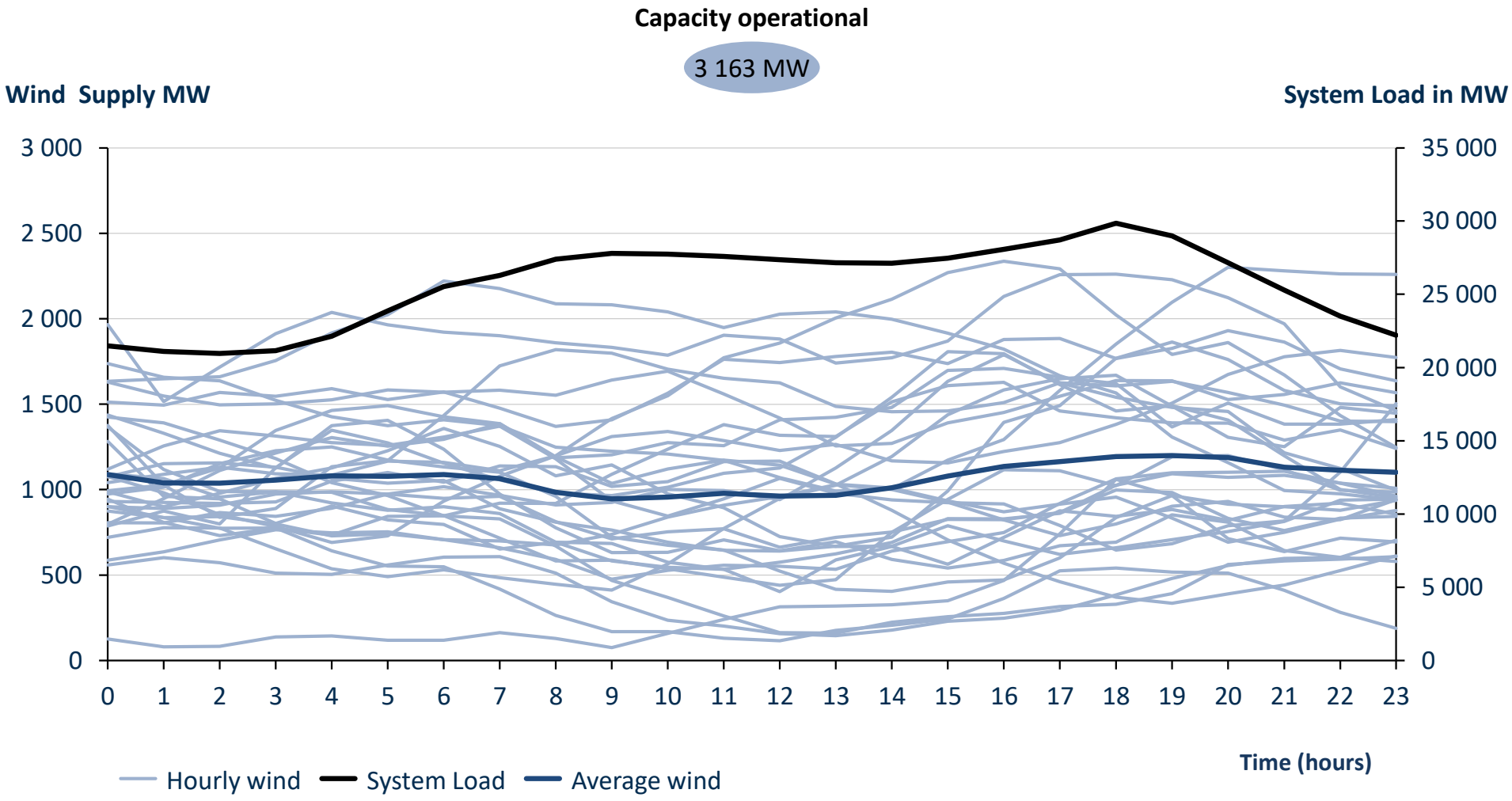
# Wind supply in Apr 2022

Hourly wind production for all 30 days of April 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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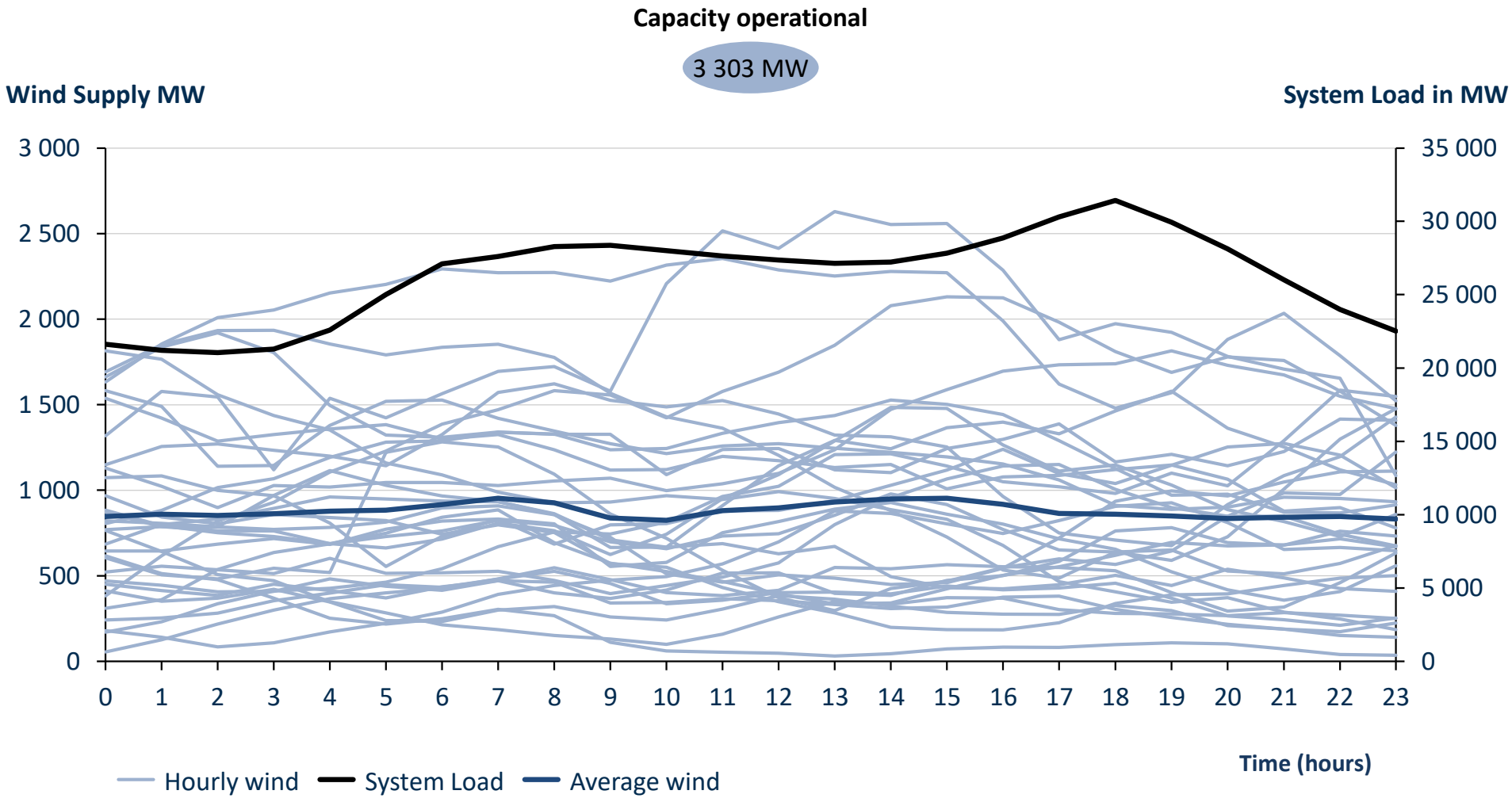
# Wind supply in May 2022

Hourly wind production for all 31 days of May 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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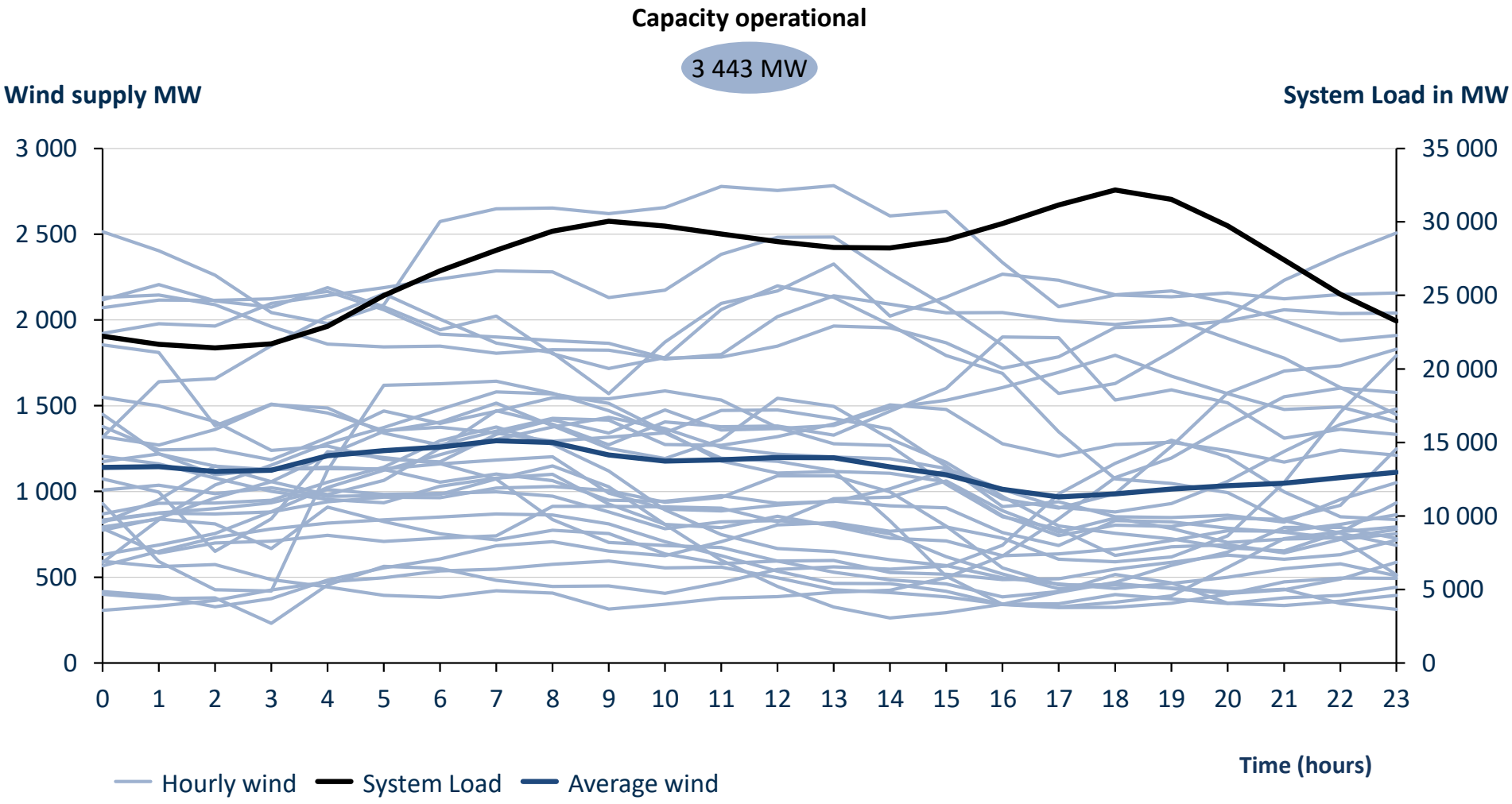
# Wind supply in Jun 2022

Hourly wind production for all 30 days of June 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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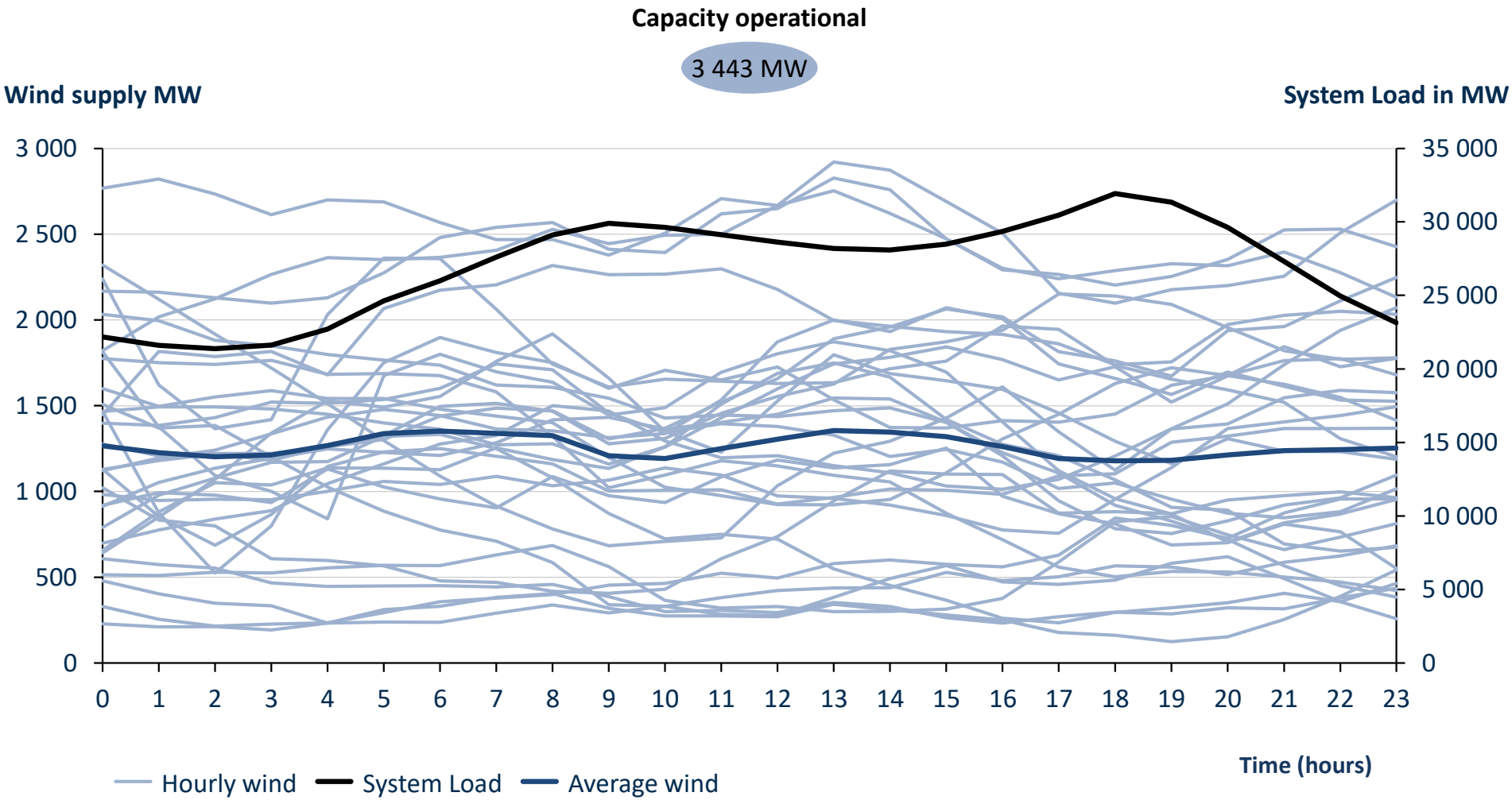
# Wind supply in Jul 2022

Hourly wind production for all 31 days of July 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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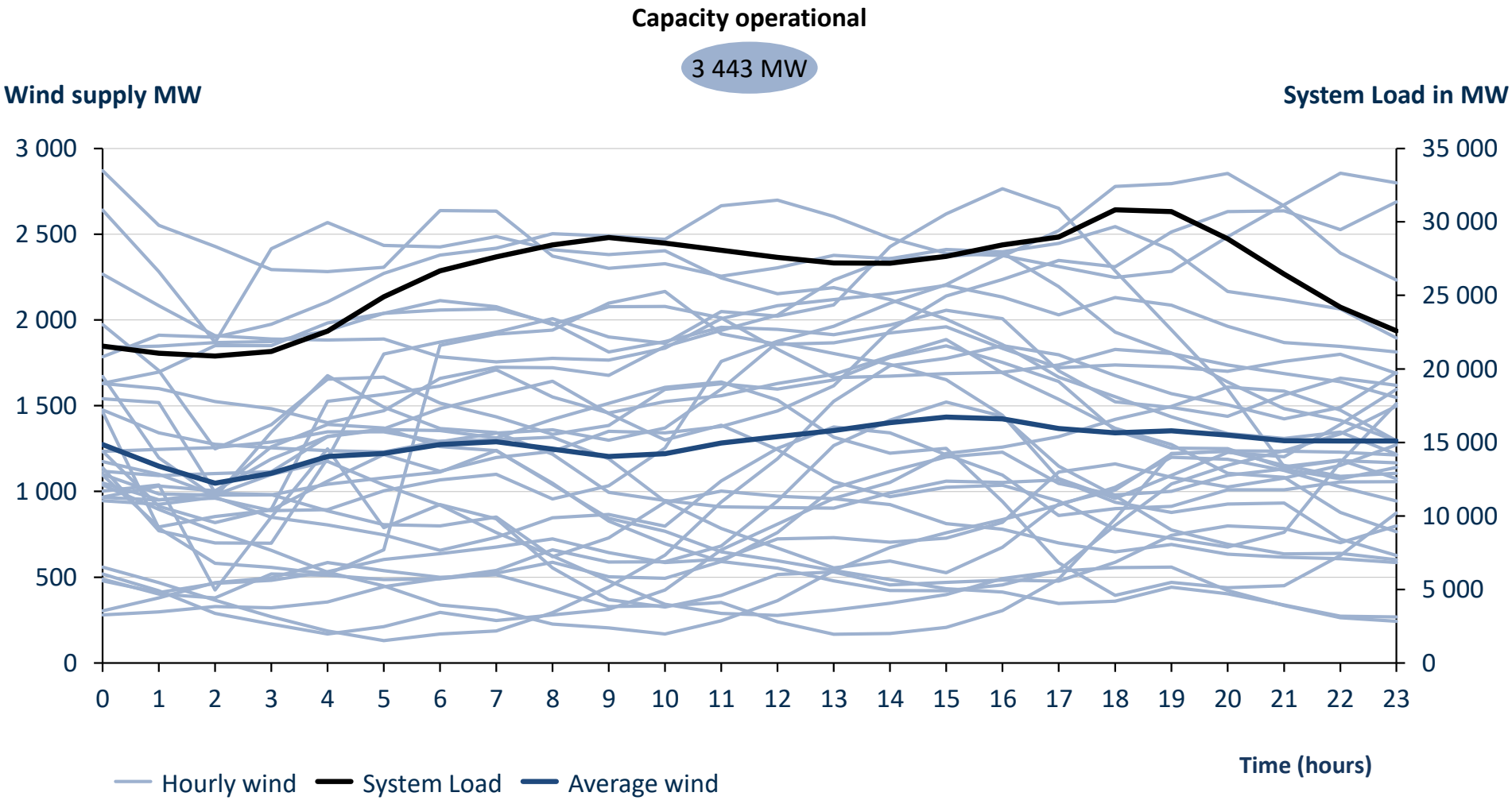
# Wind supply in Aug 2022

Hourly wind production for all 31 days of August 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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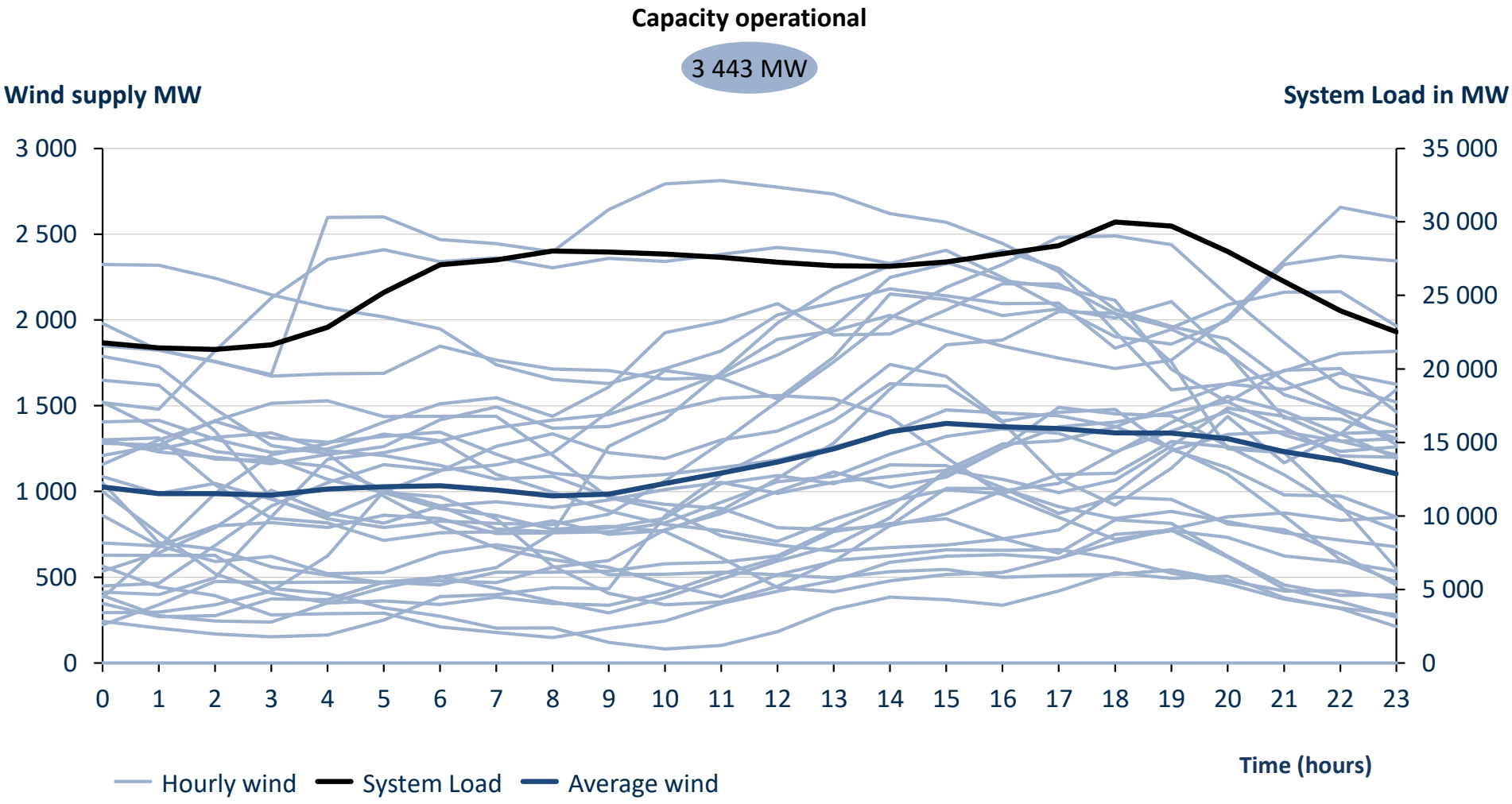
# Wind supply in Sep 2022

Hourly wind production for all 30 days of September 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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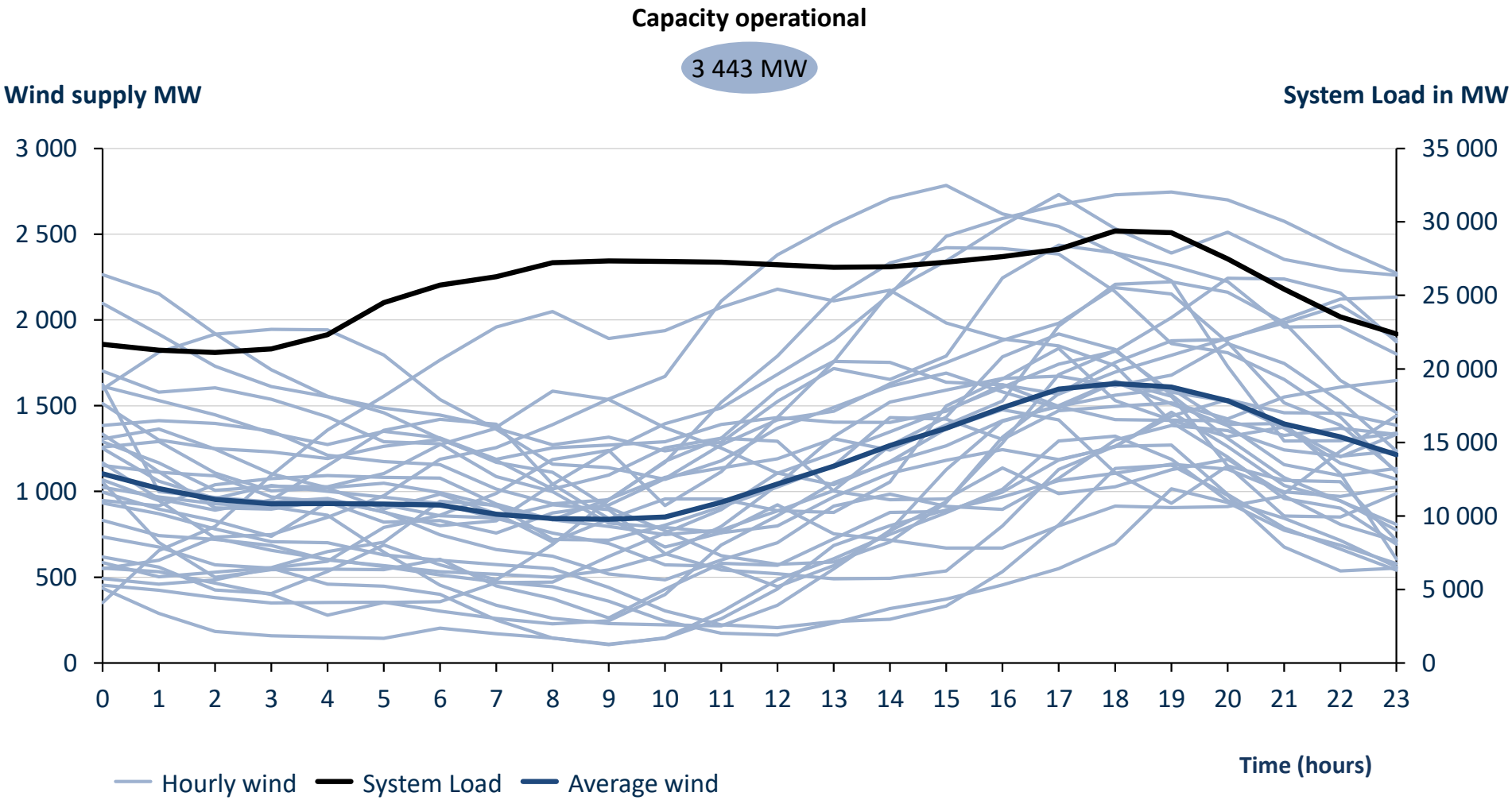
# Wind supply in Oct 2022

Hourly wind production for all 31 days of October 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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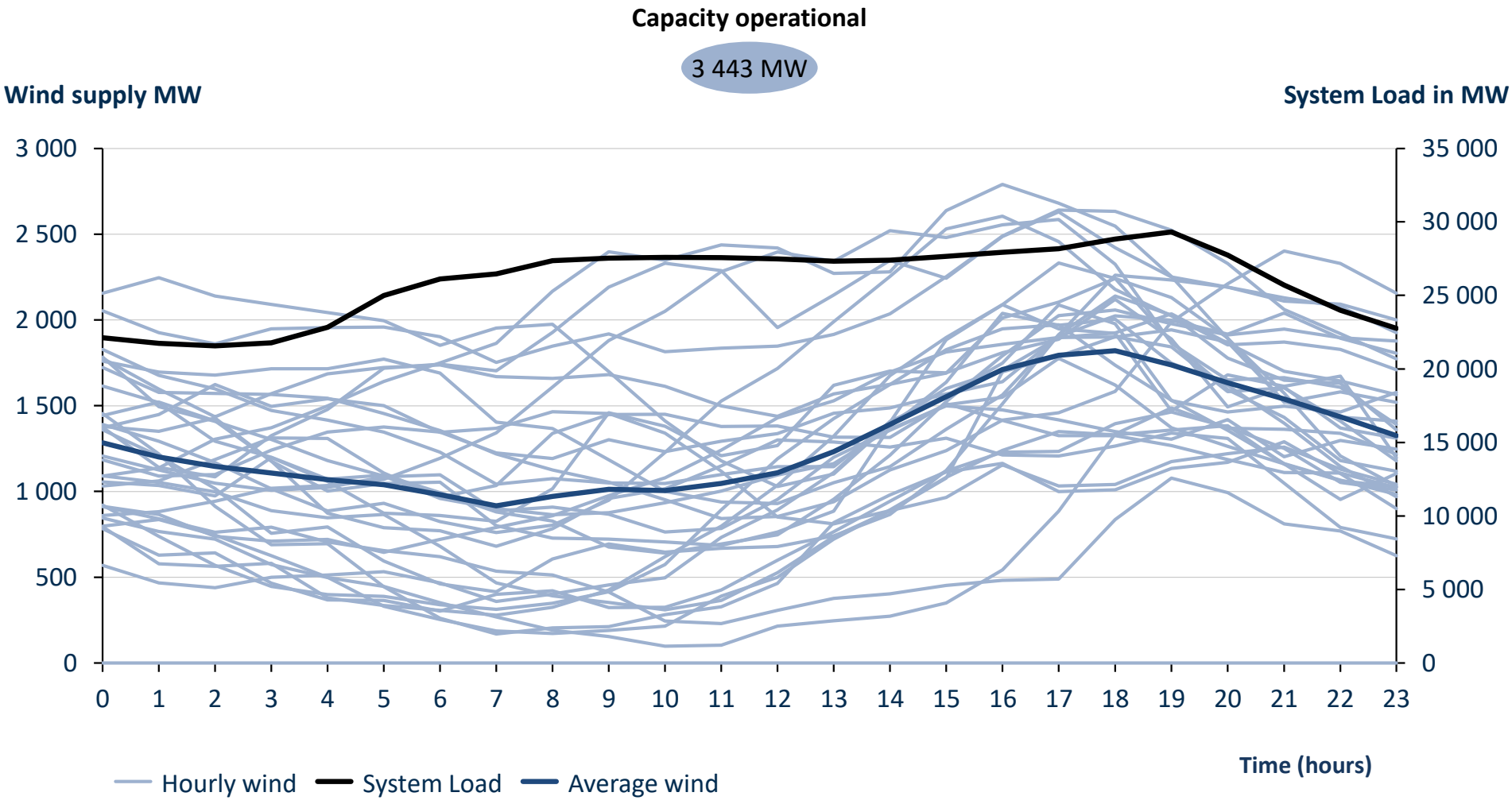
# Wind supply in Nov 2022

Hourly wind production for all 30 days of November 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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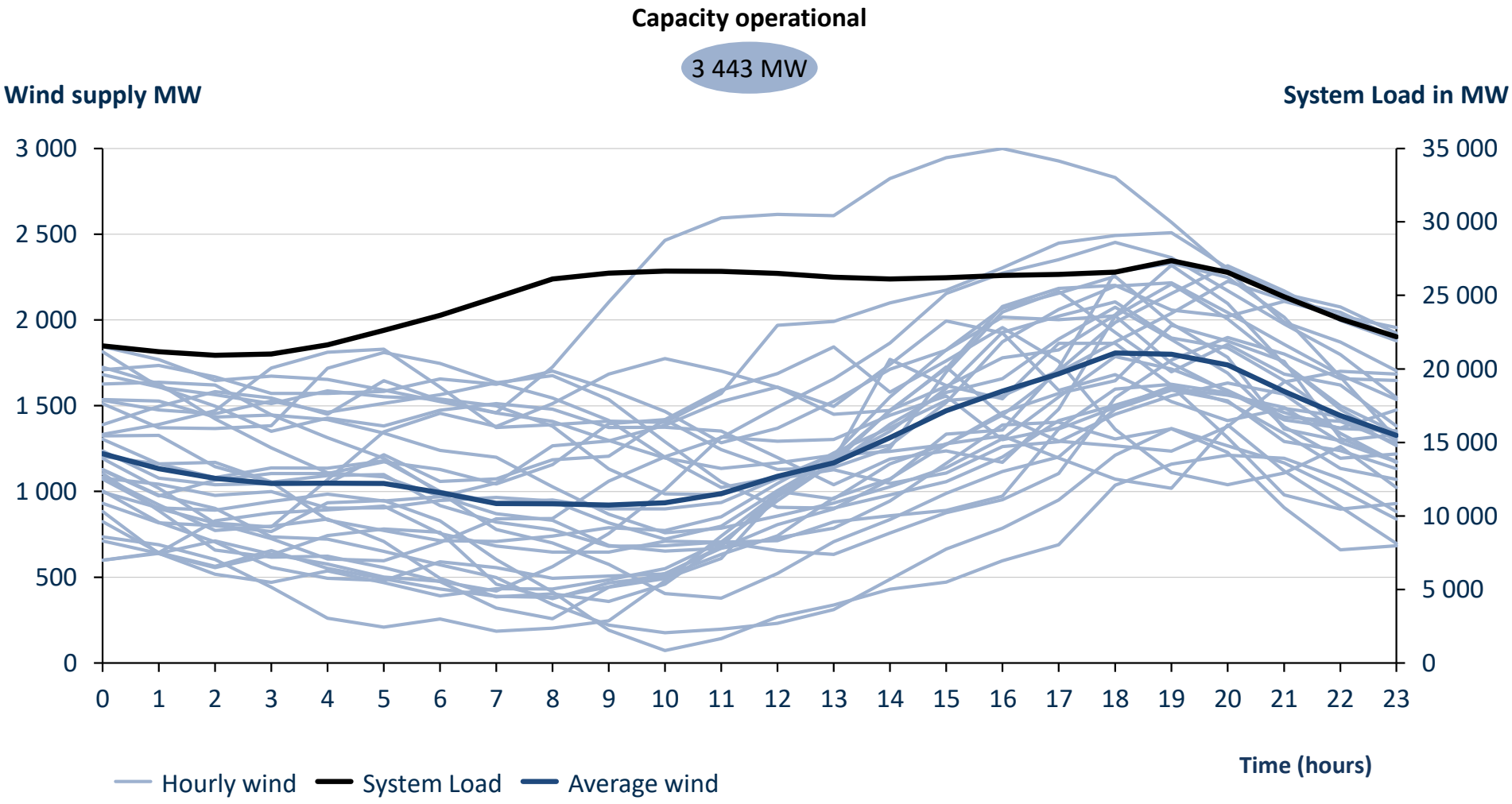
# Wind supply in Dec 2022

Hourly wind production for all 31 days of December 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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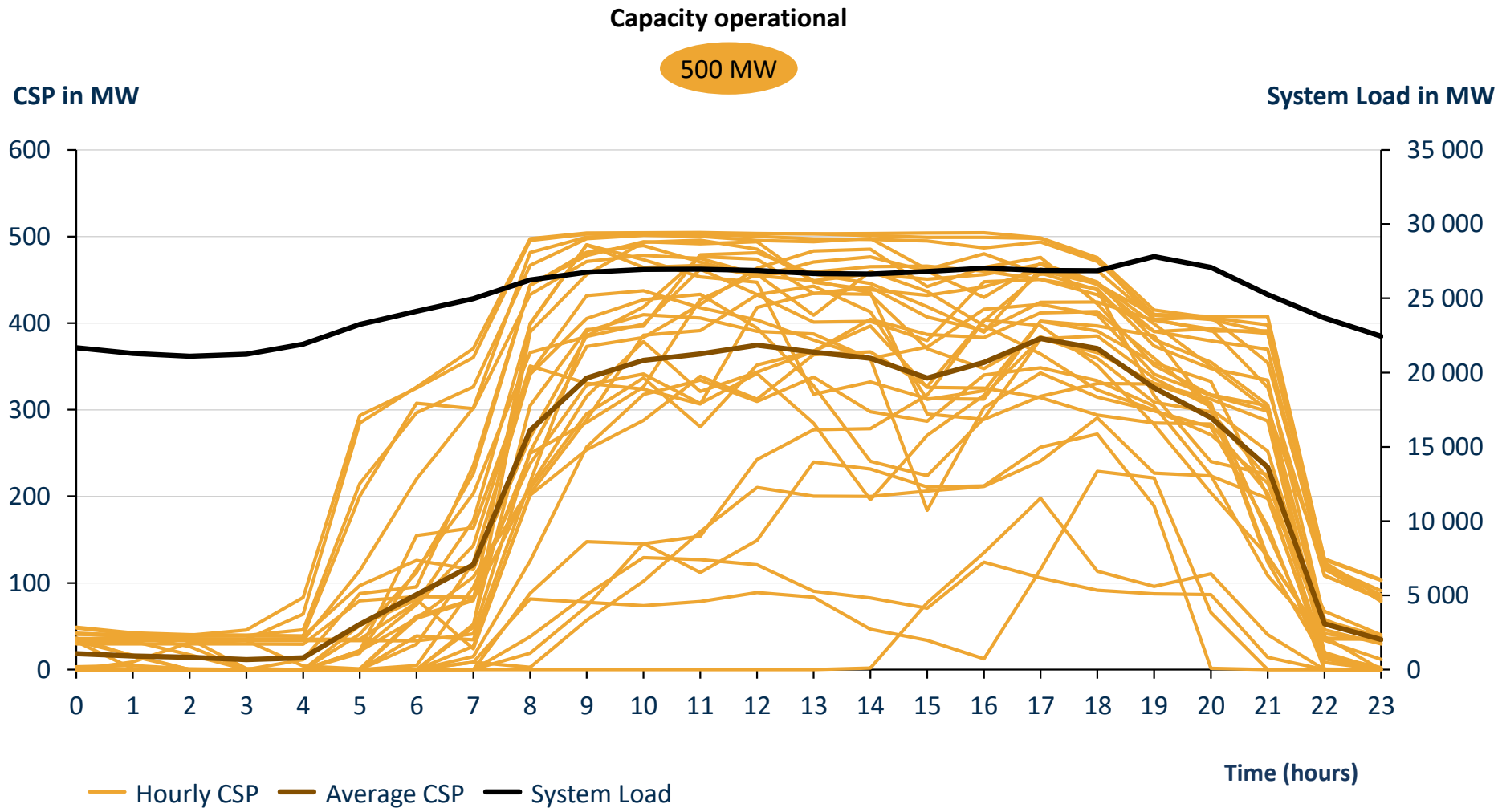
# CSP supply in Jan 2022

Hourly CSP production for all 31 days of January 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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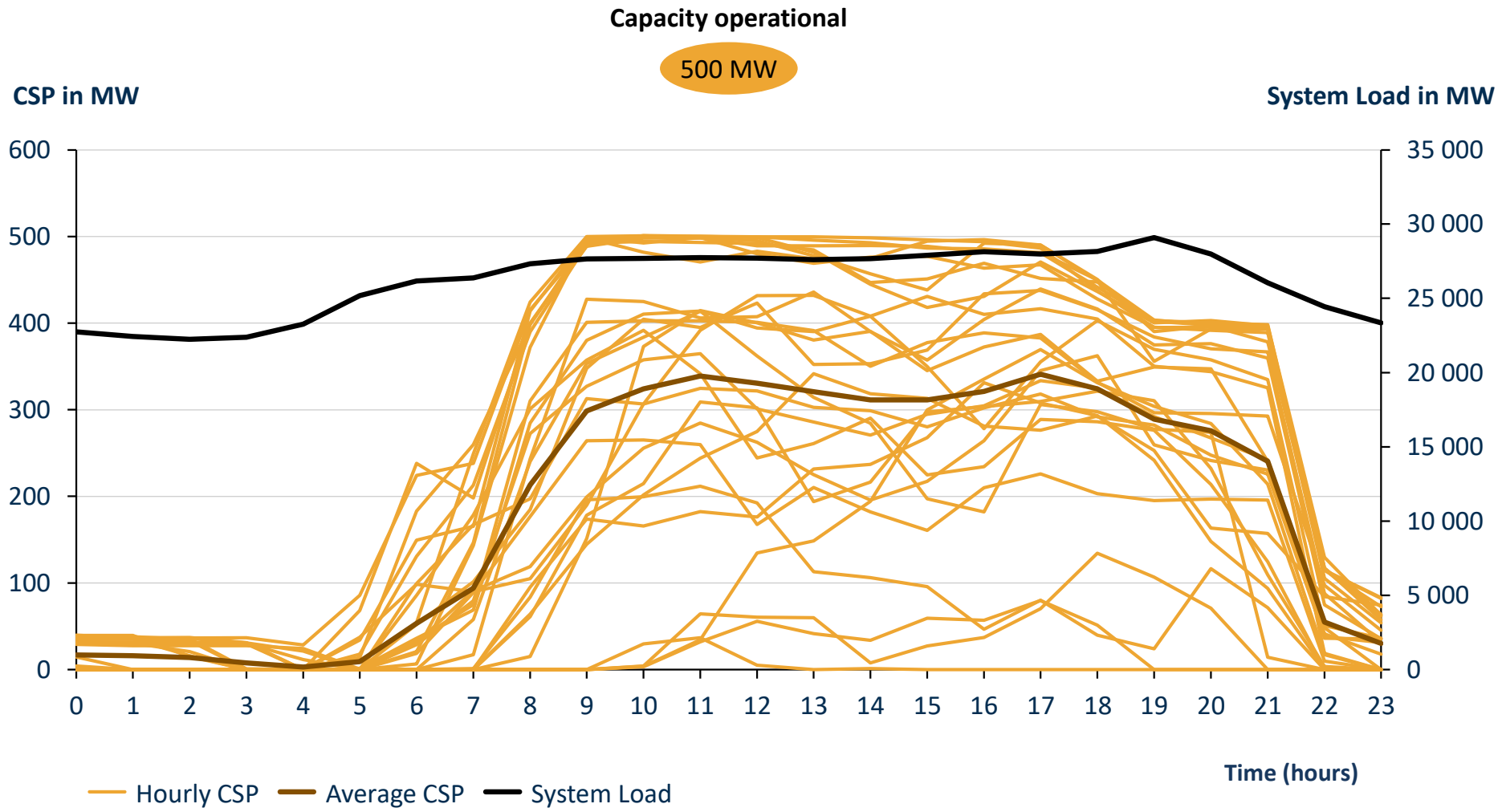
# CSP supply in Feb 2022

Hourly CSP production for all 28 days of February 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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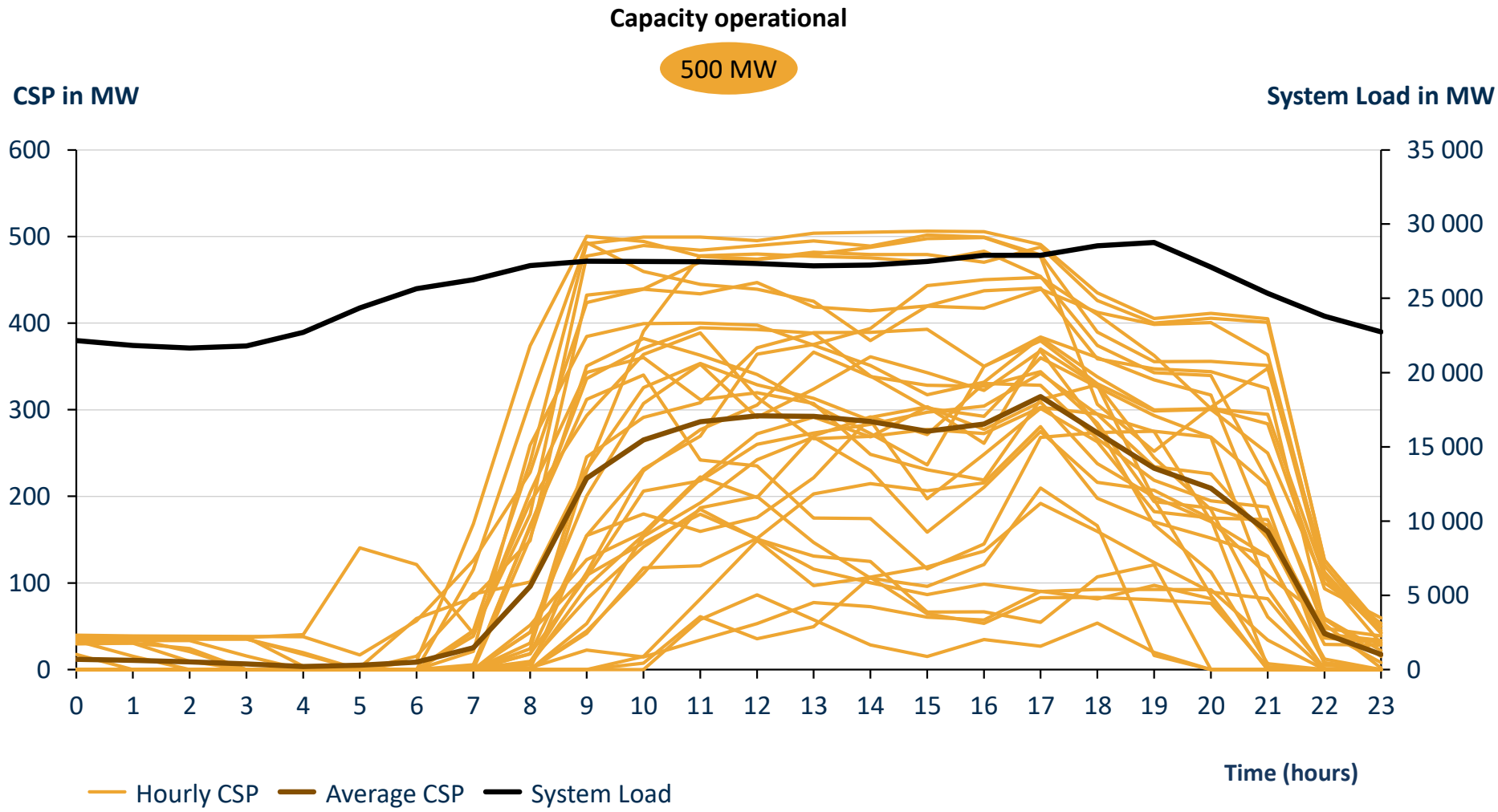
# CSP supply in Mar 2022

Hourly CSP production for all 31 days of March 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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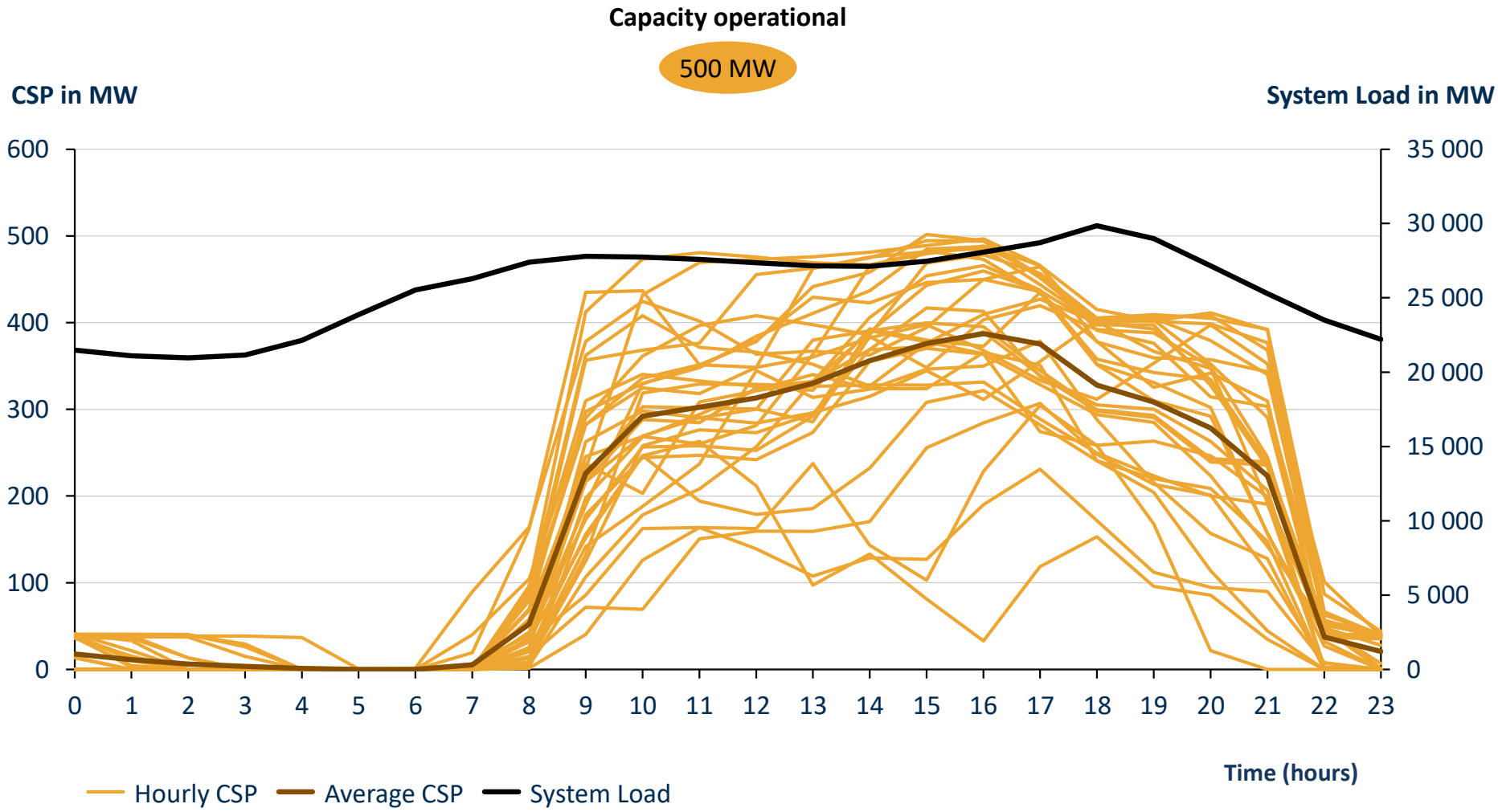
# CSP supply in Apr 2022

Hourly CSP production for all 30 days of April 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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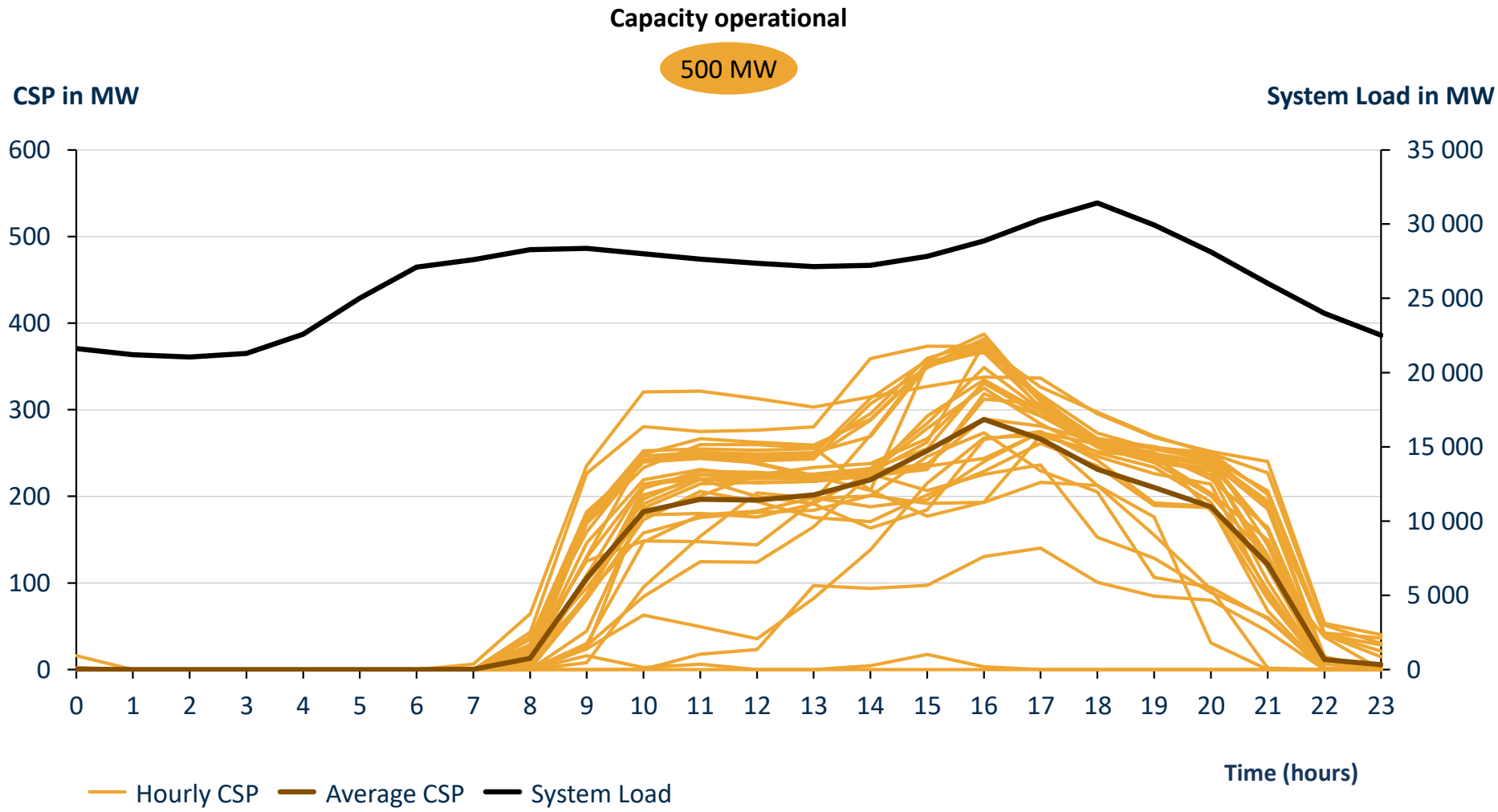
# CSP supply in May 2022

Hourly CSP production for all 31 days of May 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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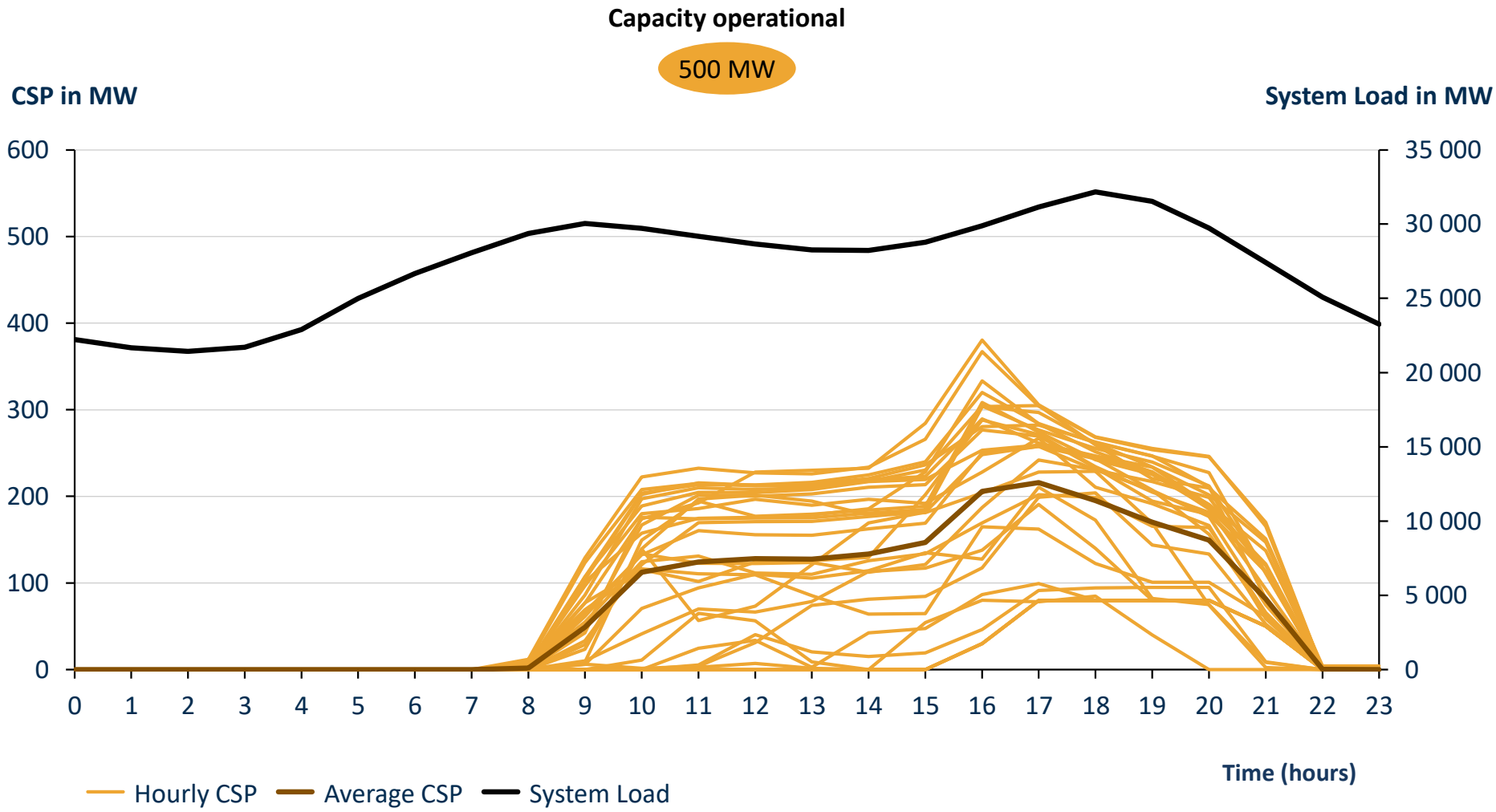
# CSP supply in Jun 2022

Hourly CSP production for all 30 days of June 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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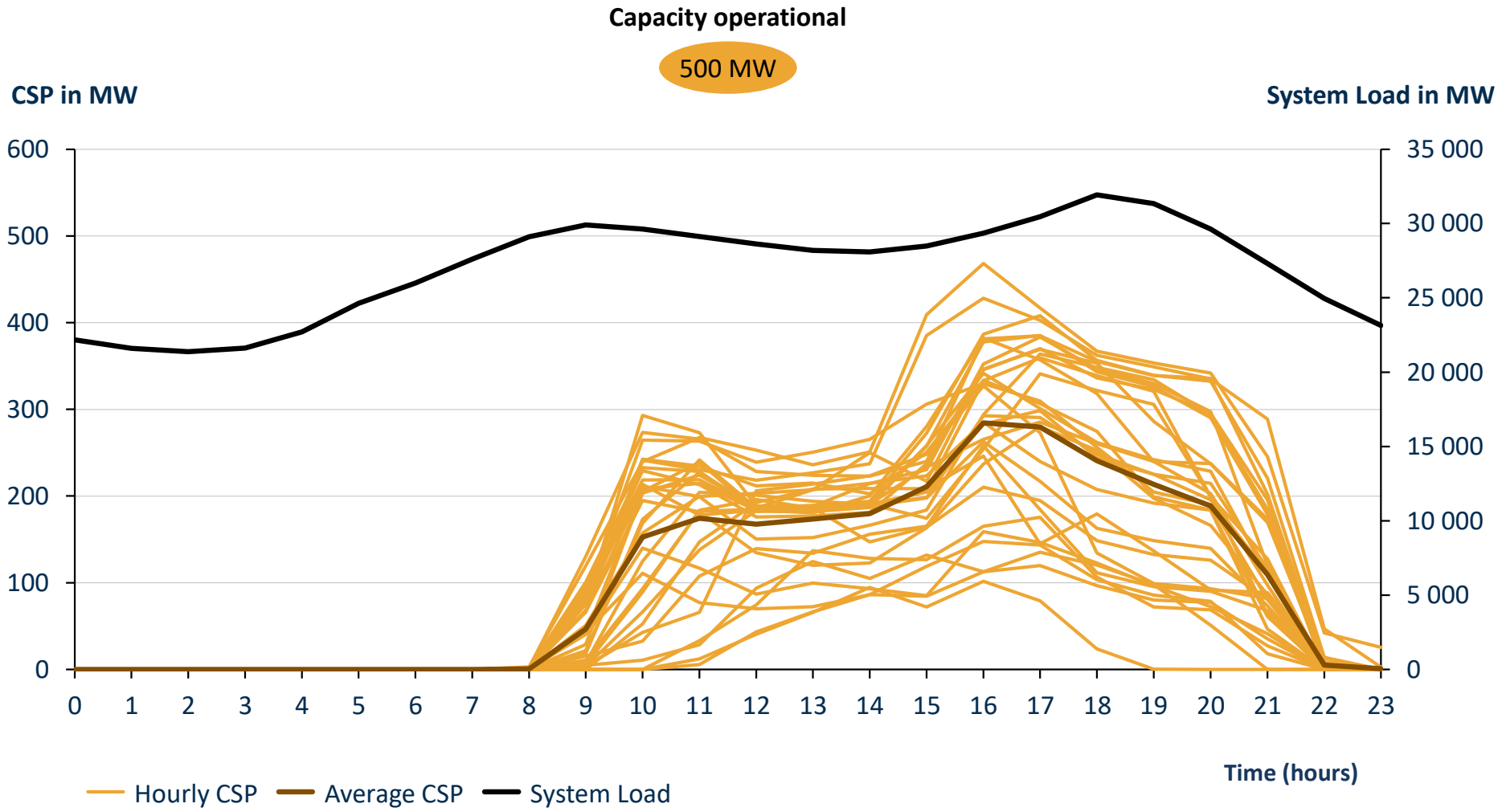
# CSP supply in Jul 2022

## Hourly CSP production for all 31 days of July 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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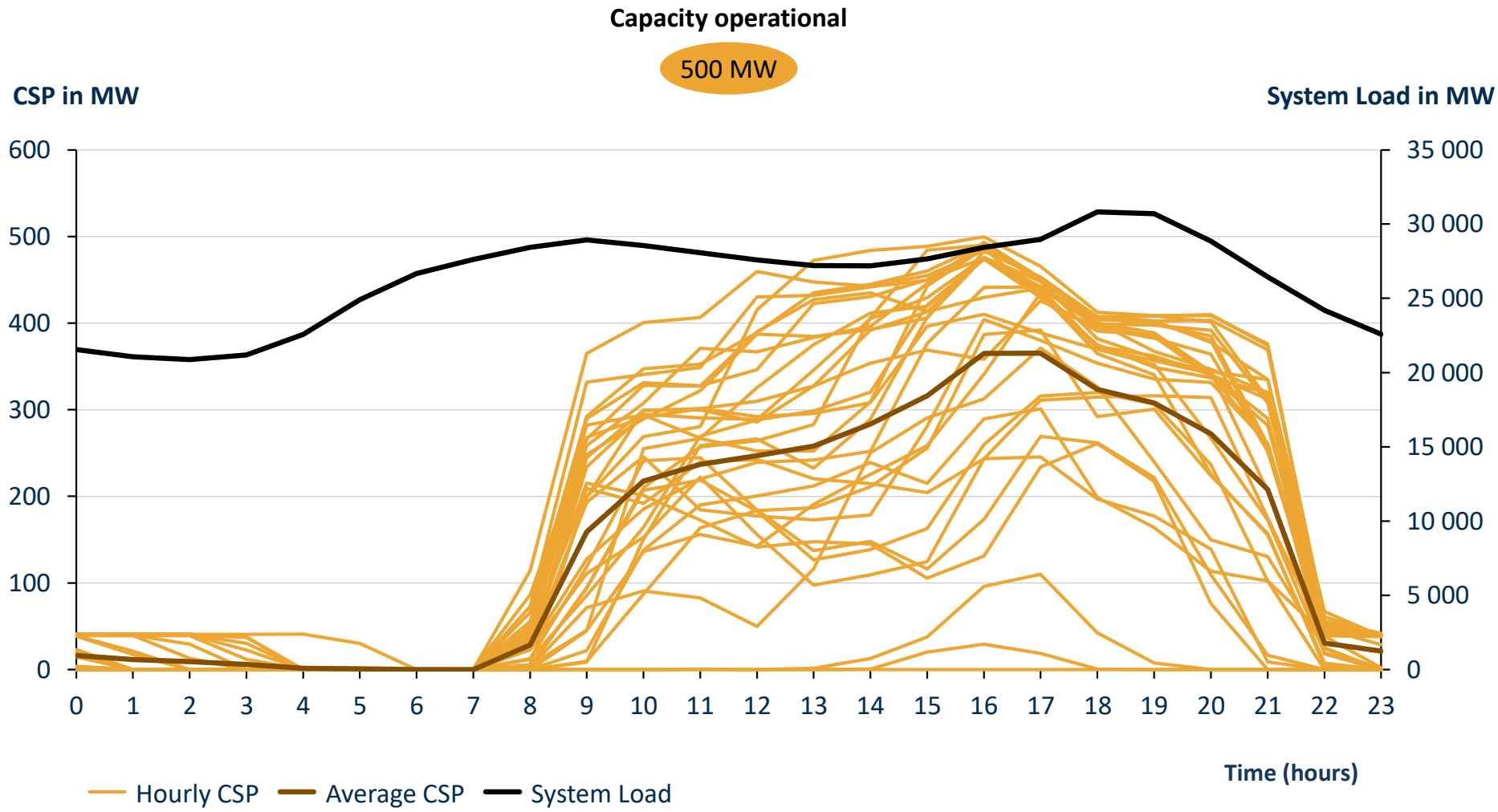
# CSP supply in Aug 2022

Hourly CSP production for all 31 days of August 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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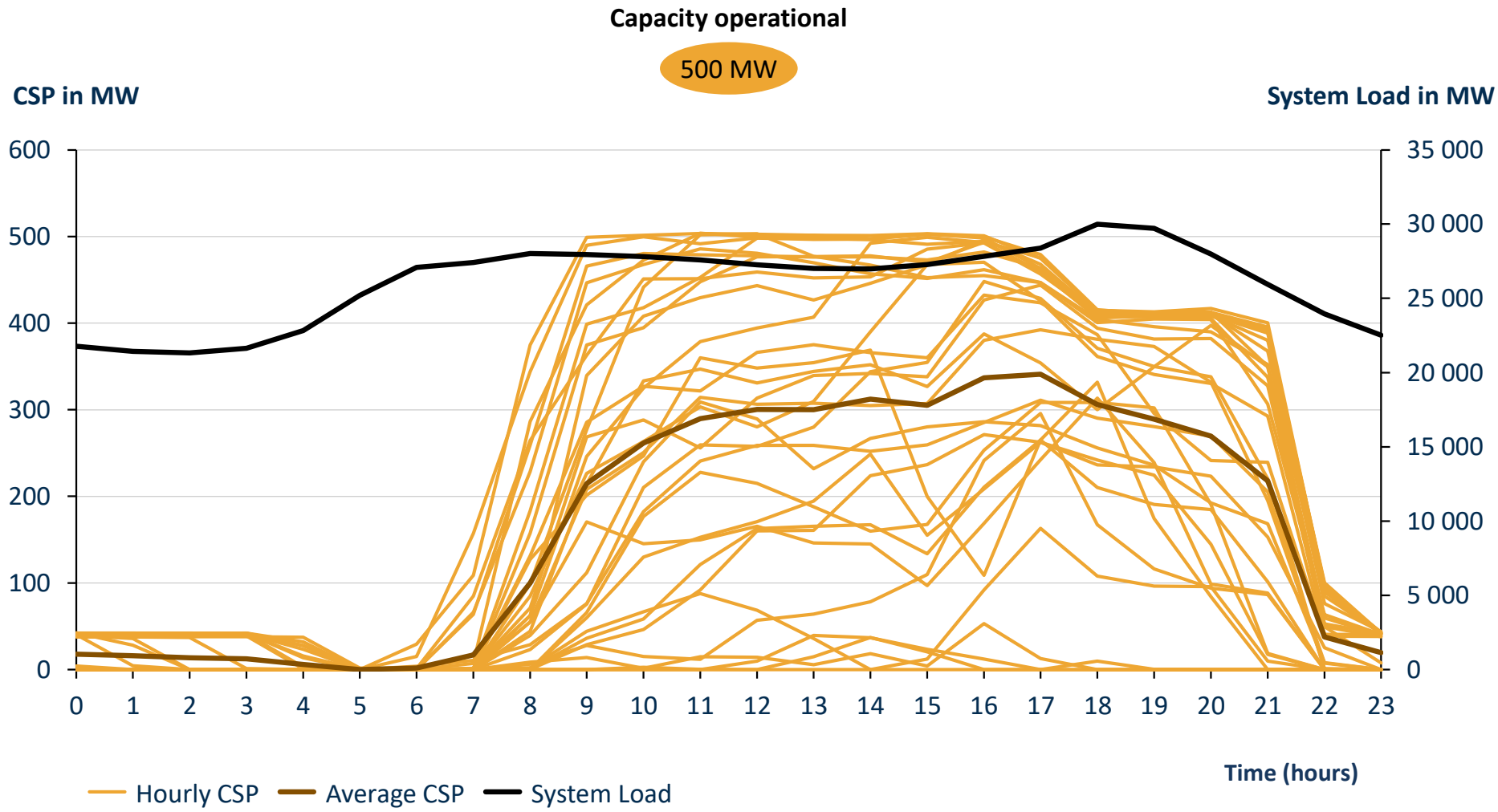
# CSP supply in Sep 2022

## Hourly CSP production for all 30 days of September 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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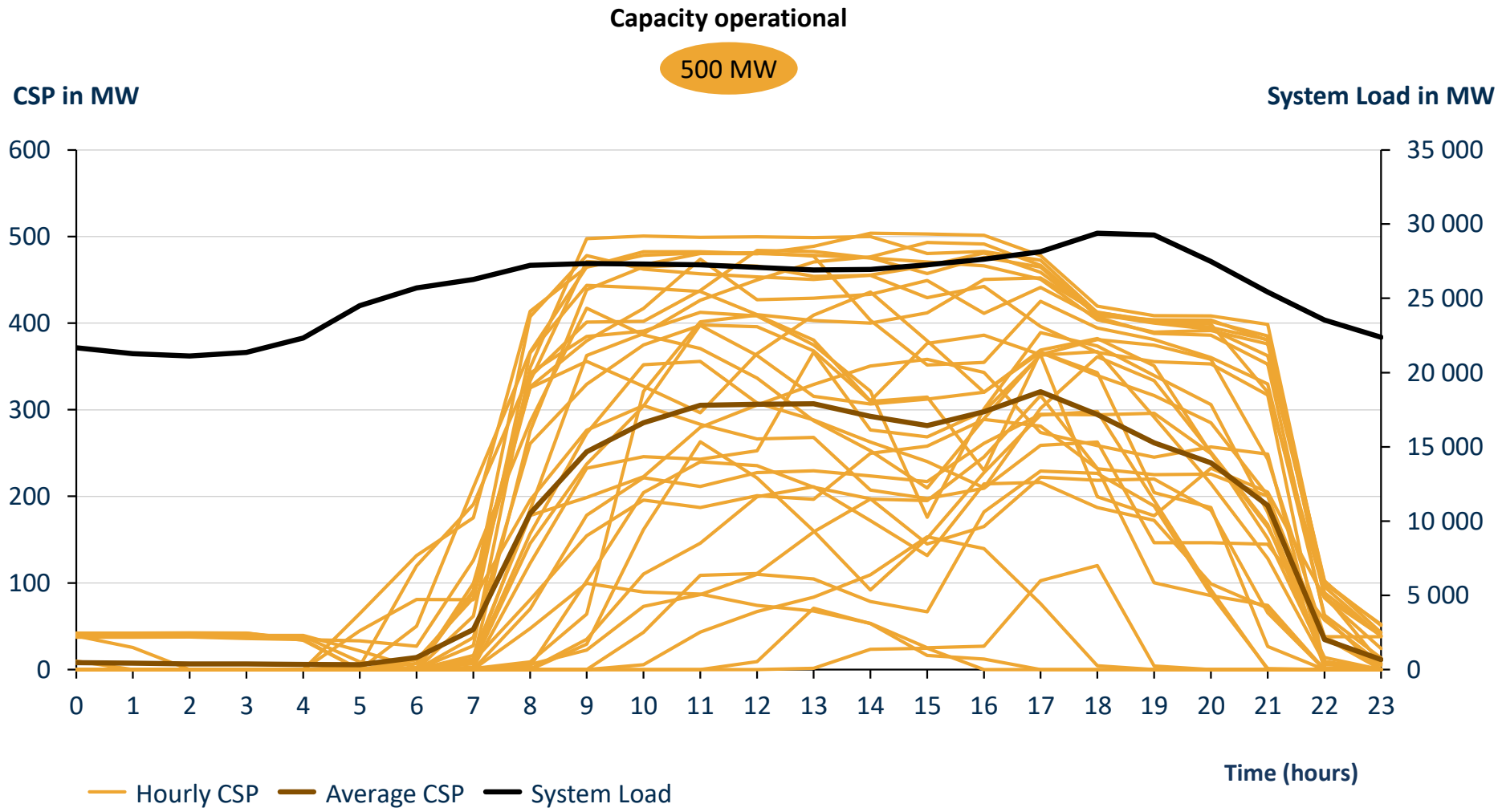
# CSP supply in Oct 2022

Hourly CSP production for all 31 days of October 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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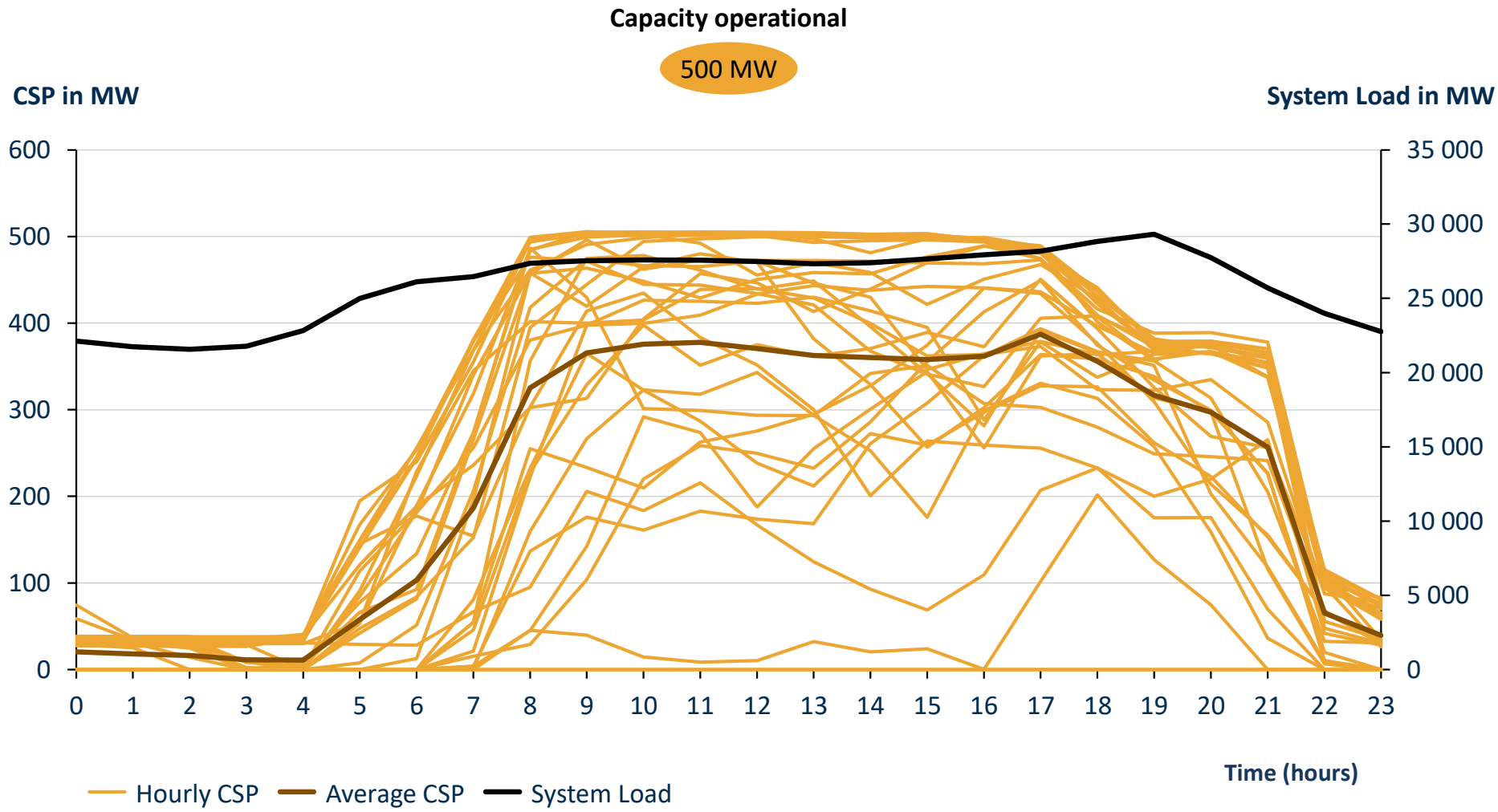
# CSP supply in Nov 2022

Hourly CSP production for all 30 days of November 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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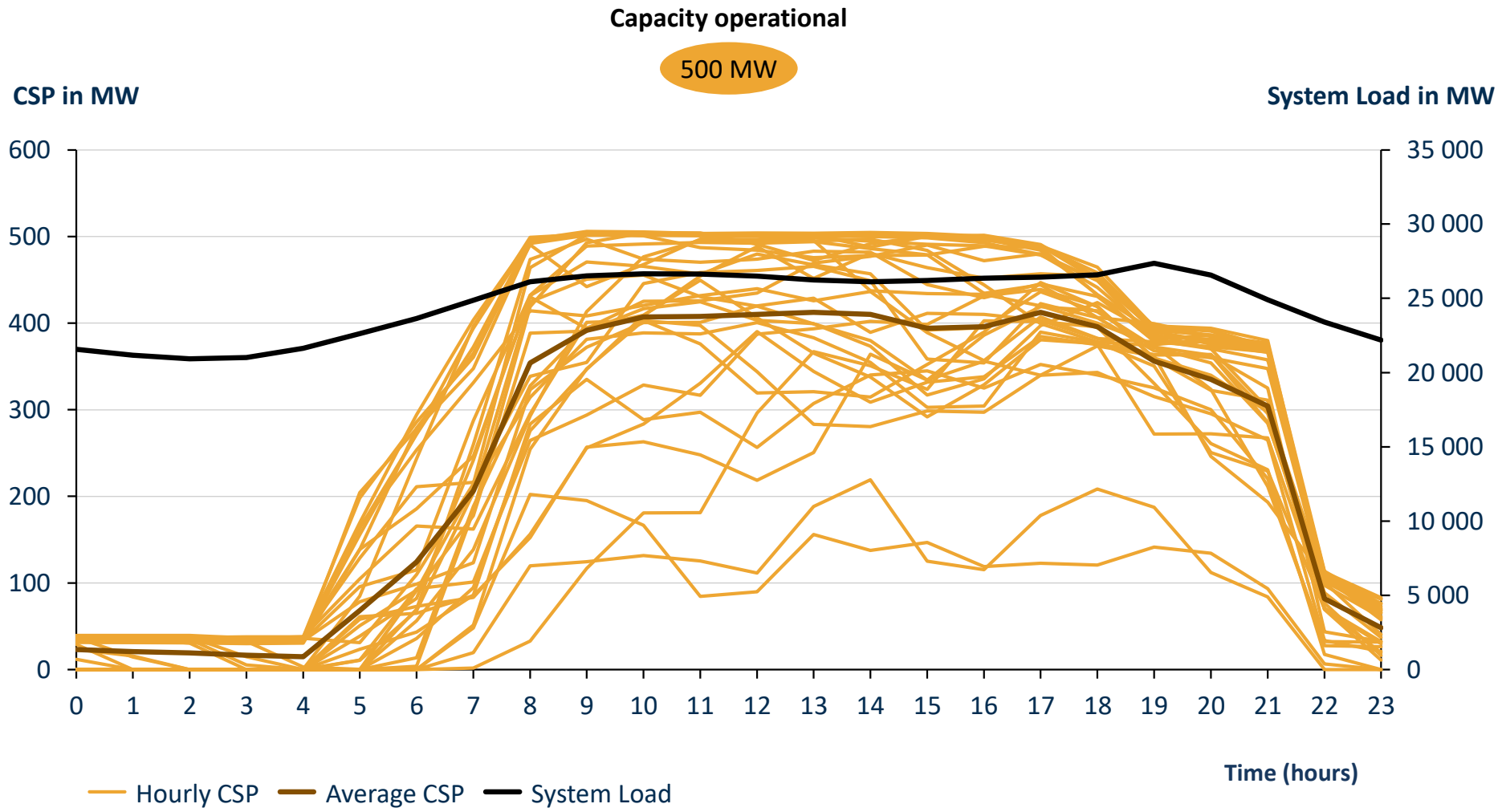
# CSP supply in Dec 2022

Hourly CSP production for all 31 days of December 2022 & average system load diurnal course




Note: System load excludes hydro pumping load (represented as the average for the month)
Sources: Eskom; CSIR Energy Centre analysis



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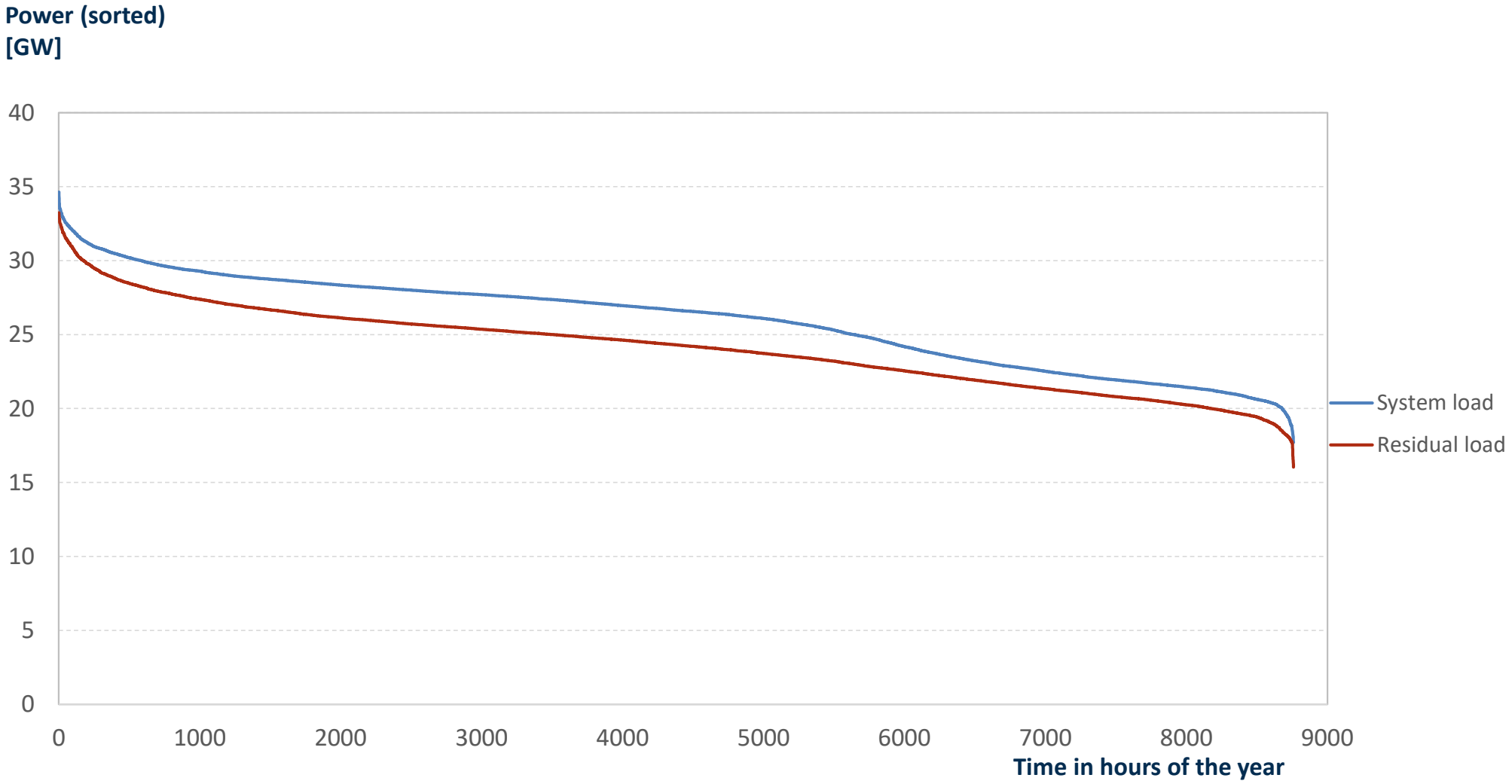
# 2022 system load and residual load duration curves






Notes: Residual Load = System Load - wind - Solar PV - CSP
Sources: Eskom; CSIR Energy Centre analysis

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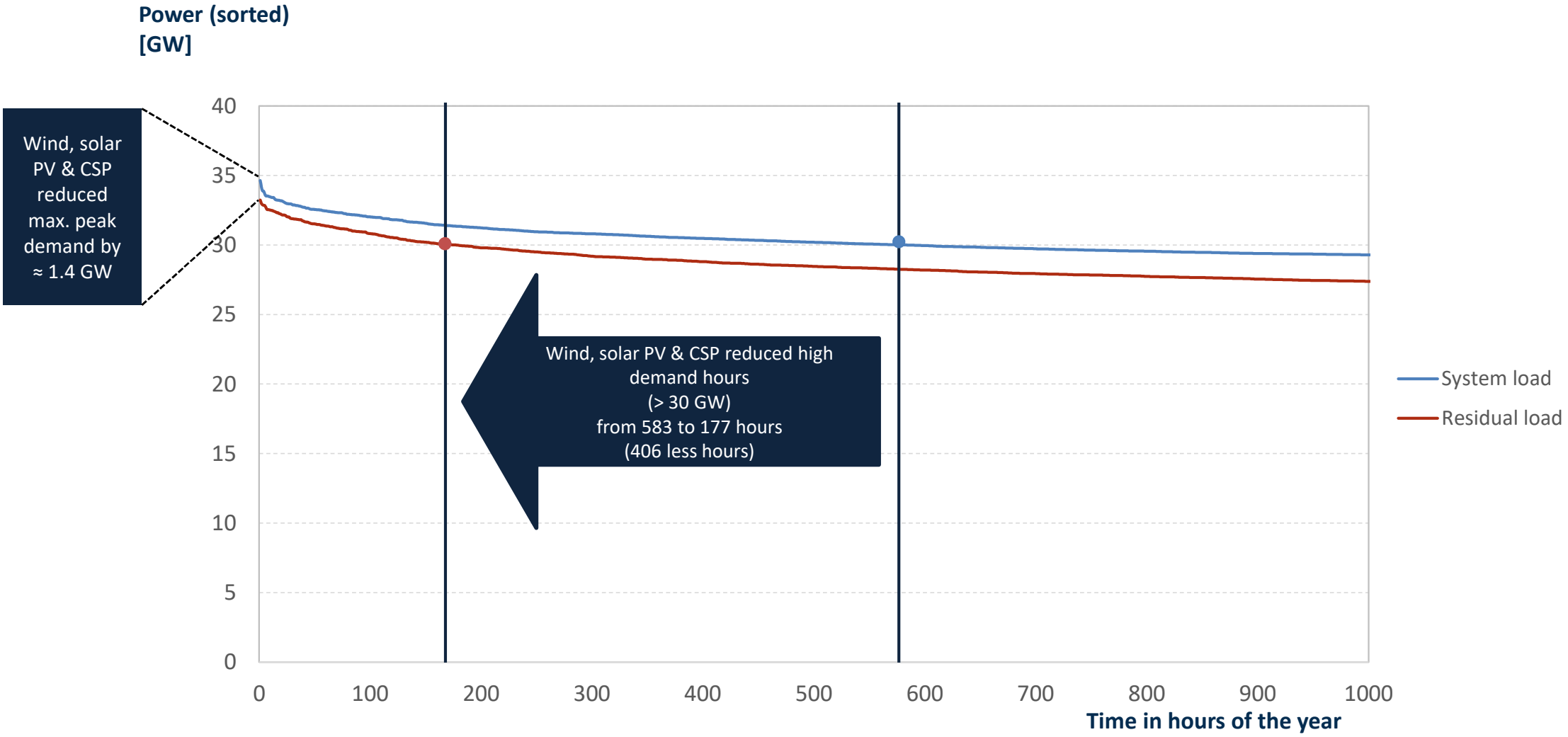
# In 2022 wind, solar PV & CSP reduced the number of hours with >30 GW total load by 70% (406 less hours)






Notes: Residual Load = System Load - wind - Solar PV - CSP
Sources: Eskom; CSIR Energy Centre analysis

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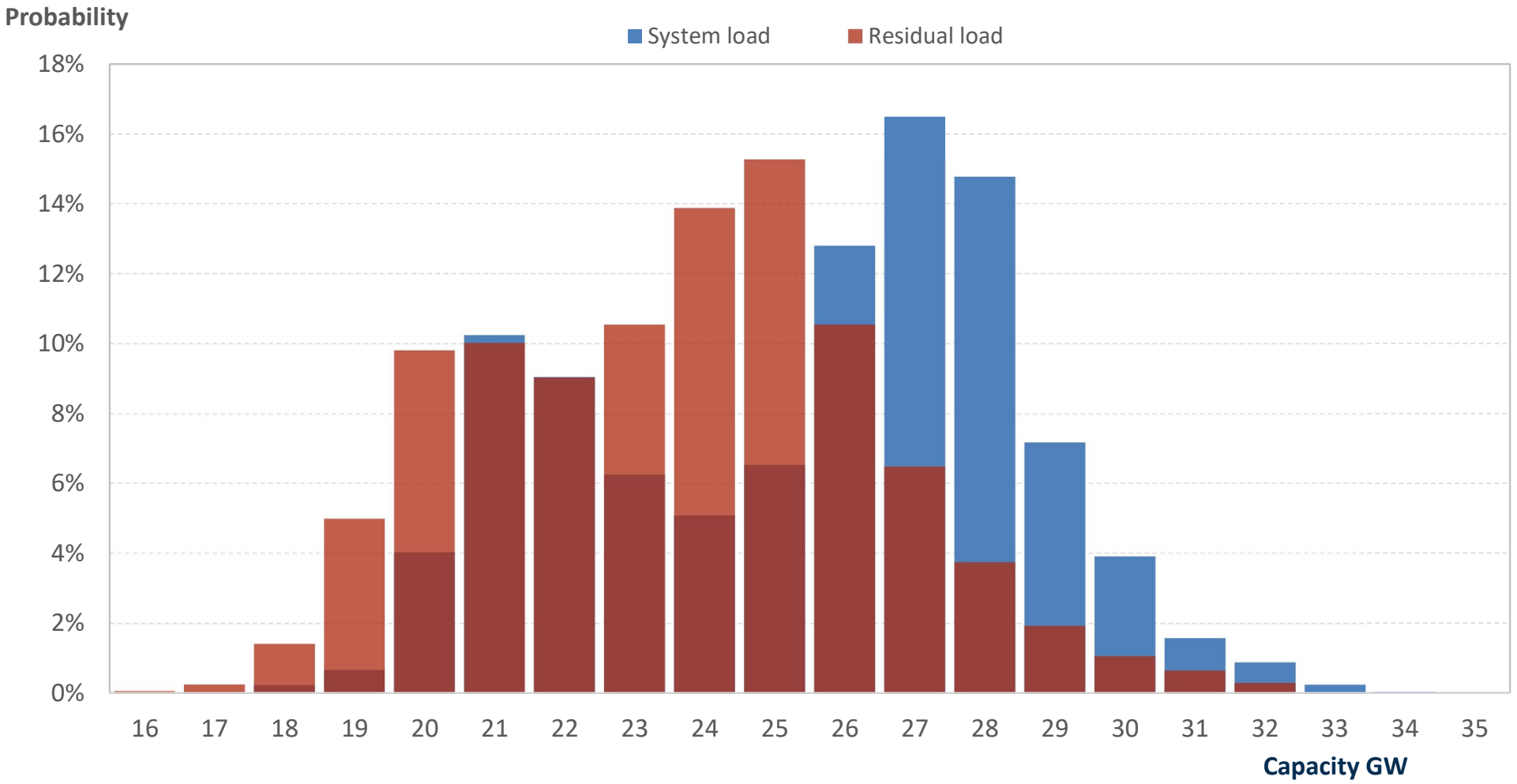
# Shift of residual demand to lower demand levels as VRE contributes during demand periods for 2022




Sources: Eskom; CSIR Energy Centre analysis



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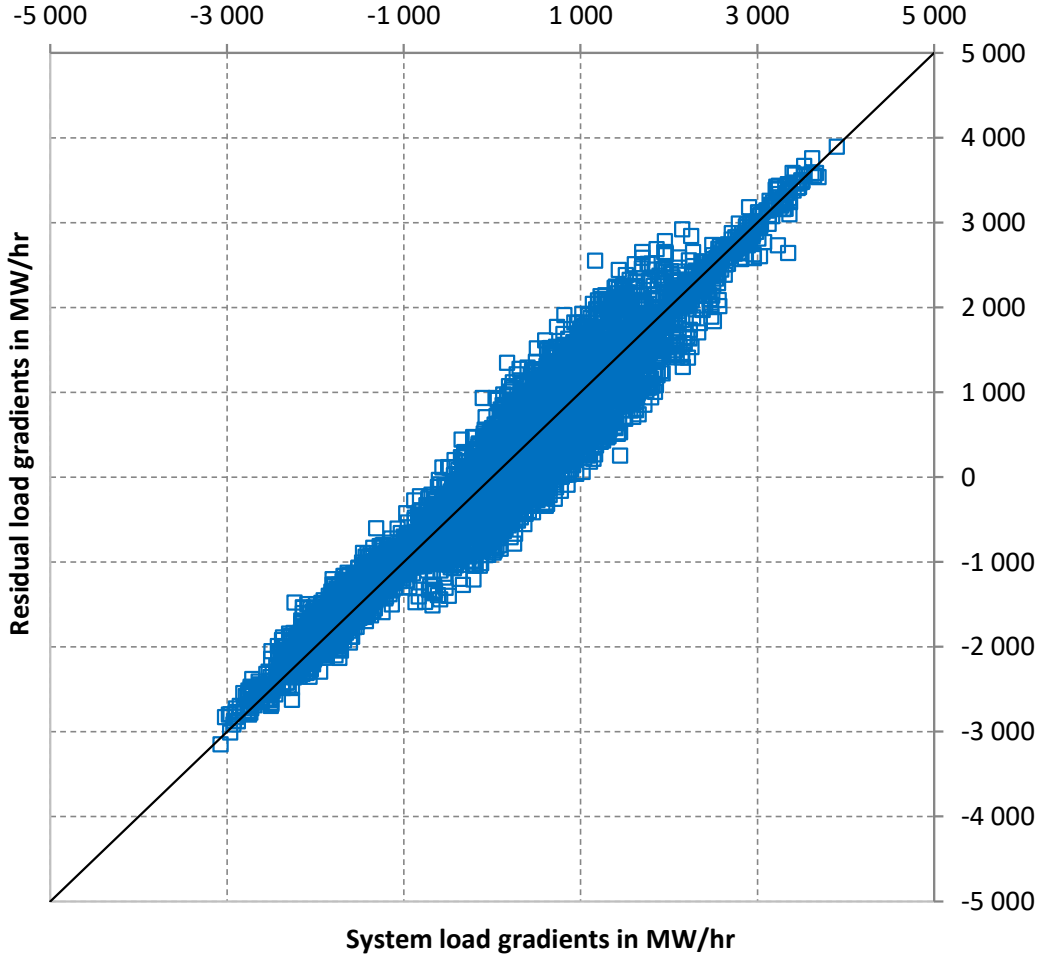
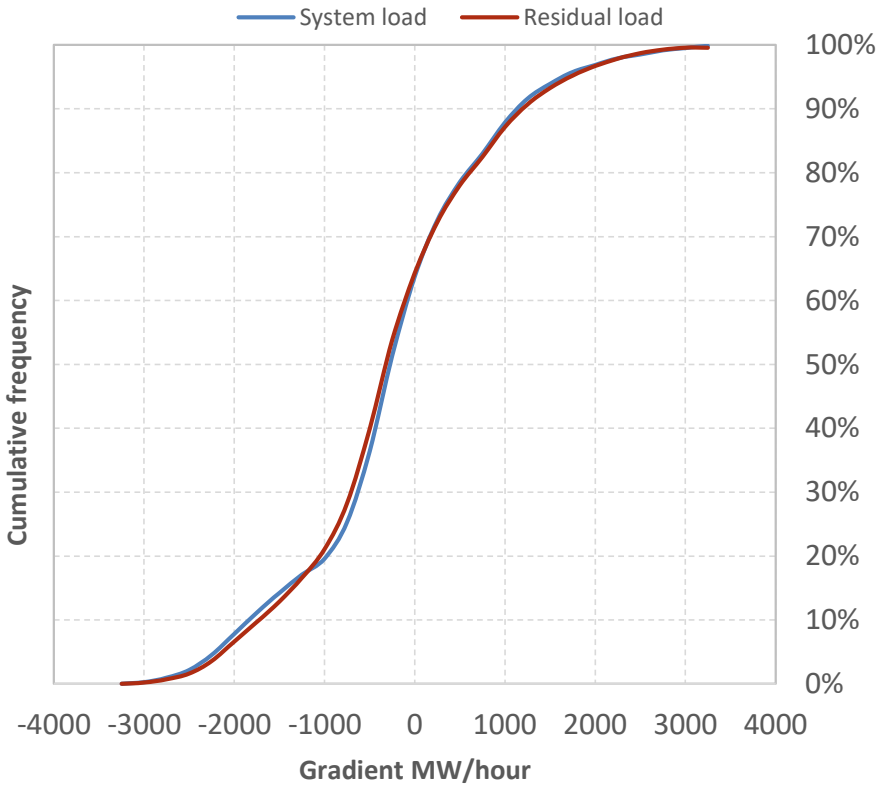
# 1-hour gradients did not significantly increase due to collective 6.2 GW of wind, solar PV & CSP

**System load 1-hour gradients vs. residual load 1-hour gradients for all hours in 2022**




**Cumulative frequency distribution of 1-hour gradients for all hours in 2022**




Notes: System and Residual load excludes pumping load for all data points throughout the year
Sources: Eskom; CSIR Energy Centre analysis



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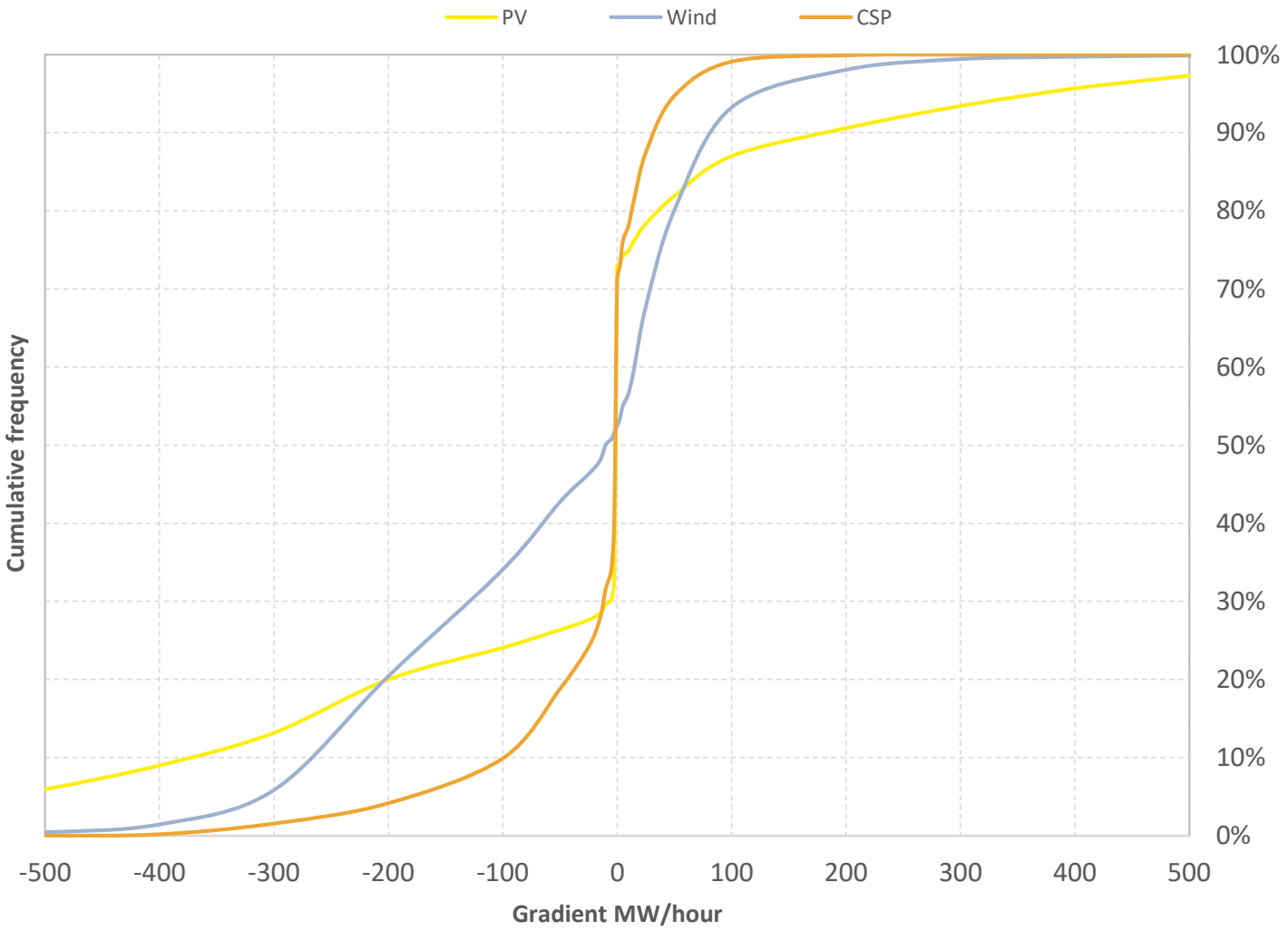
# Wind, solar PV & CSP frequency distribution of 1-hour gradients in 2022




**Capacity operational** (31 Dec)

2 287 MW

3 443 MW

500 MW



Sources: Eskom; CSIR Energy Centre analysis

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# Agenda (2022)

1 Overview actual electricity production

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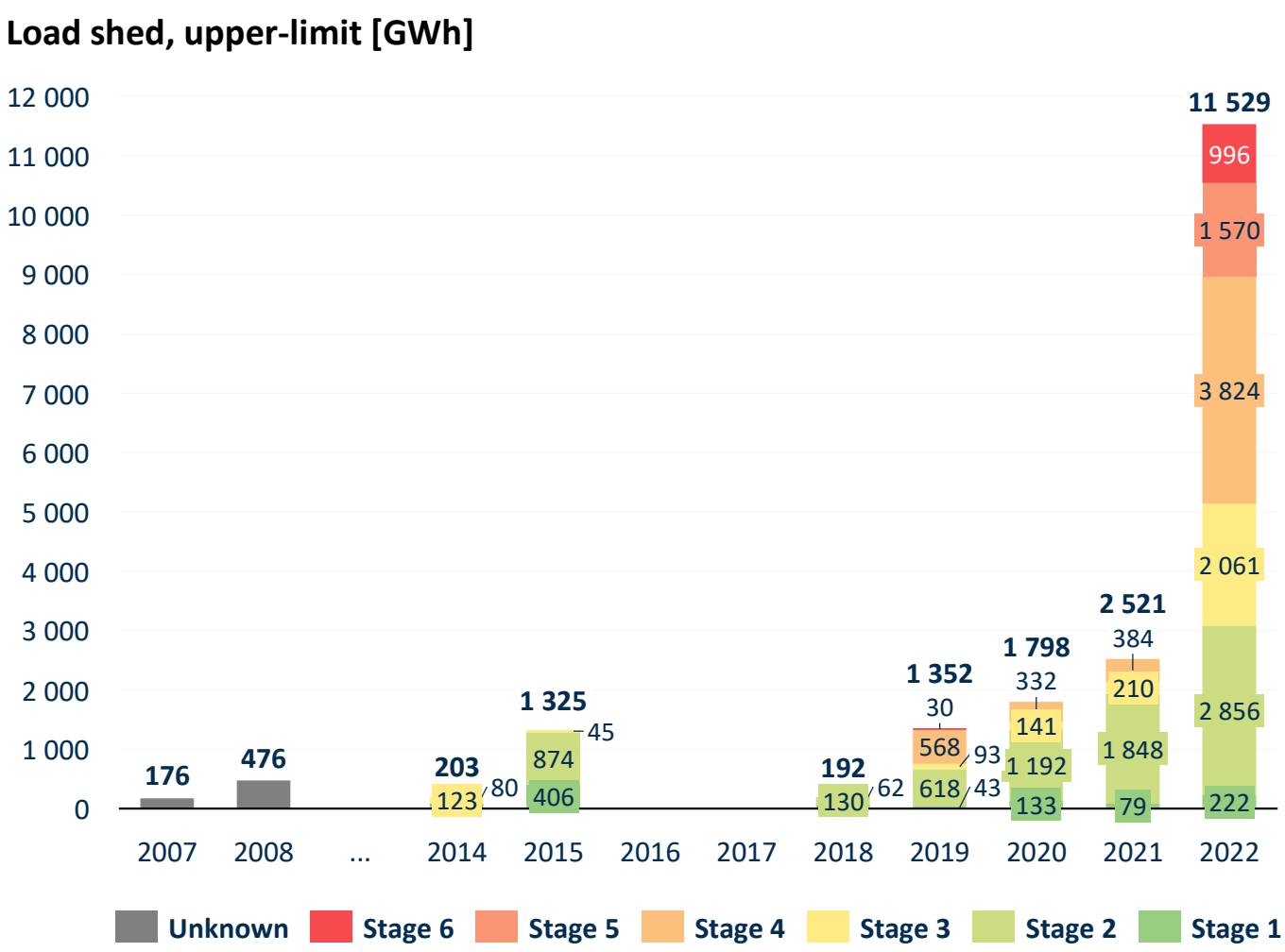
6 Loadshedding

7 Other power system statistics

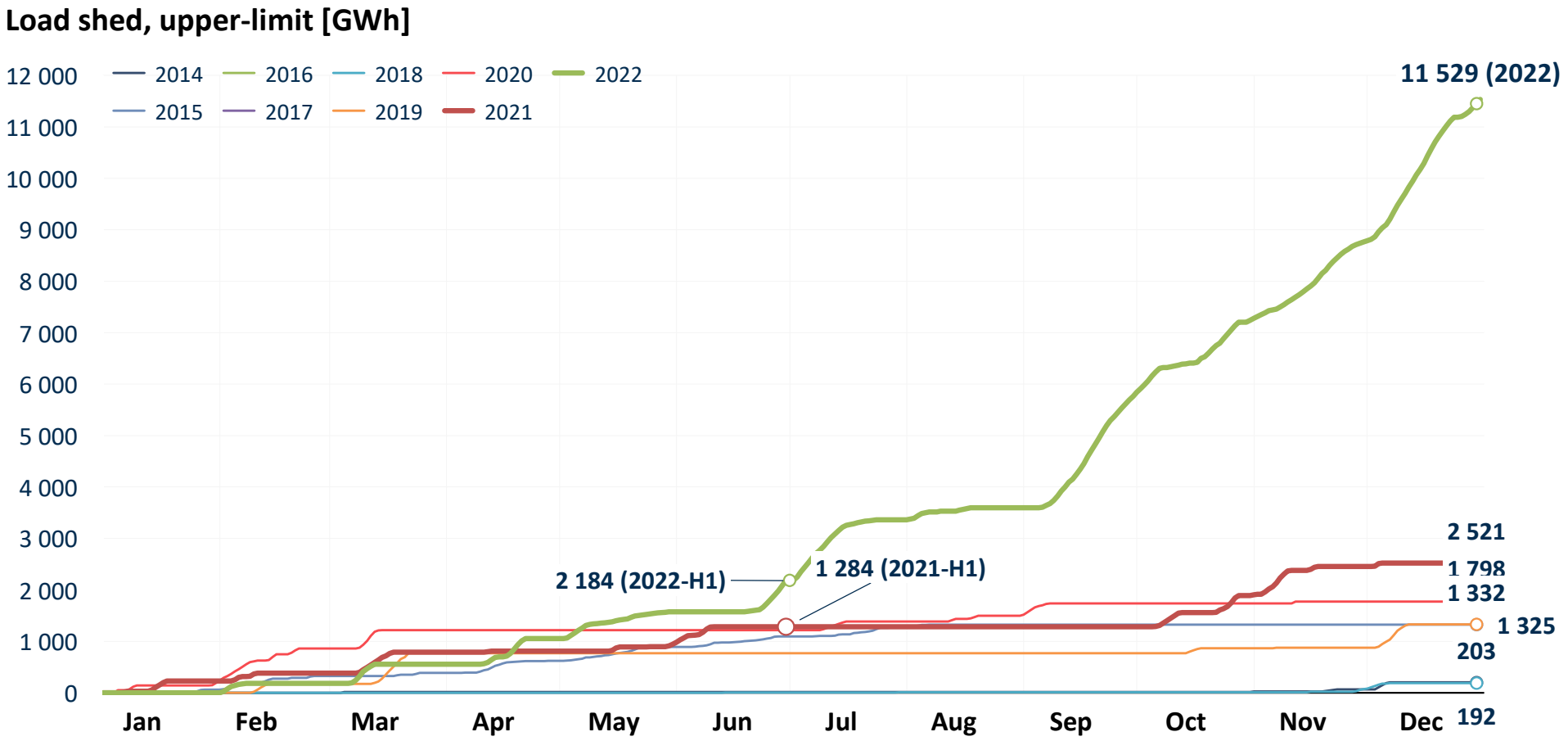
**This year overtook 2021 as the most intensive loadshedding year yet, more than 4 times more. Also, far exceeding 2019's stage 6 loadshedding. The collective in the three months of Jul to Sep 2022 was more loadshedding experienced in any year before. December 2022 on its own was more loadshedding than in any year before. It is the first year that most of the loadshedding was in stage 4, not stage 2.**




| Year | Duration of outages (hours) | Energy shed (GWh) | DSR (GWh) |
|---|---|---|---|
| 2007 | - | 176 | Not available |
| 2008 | - | 476 | Not available |
| .... | .... | .... | .... |
| 2014 | 121 | 203 | Not available |
| 2015 | 852 | 1 325 | Not available |
| .... | .... | .... | .... |
| 2018 | 127 | 192 | 392 |
| 2019 | 530 | 1 352 | 1 362 |
| 2020 | 859 | 1 798 | 1 426 |
| 2021 | 1 169 | 2 521 | 1 936 |
| 2022 | 3 773 | 11 529 | 8 301 |

Notes: Loadshedding 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
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS);
Sources: Eskom Twitter account; Eskom Hld SOC Ltd FaceBook page; Eskom se Push (mobile app); Nersa; CSIR analysis

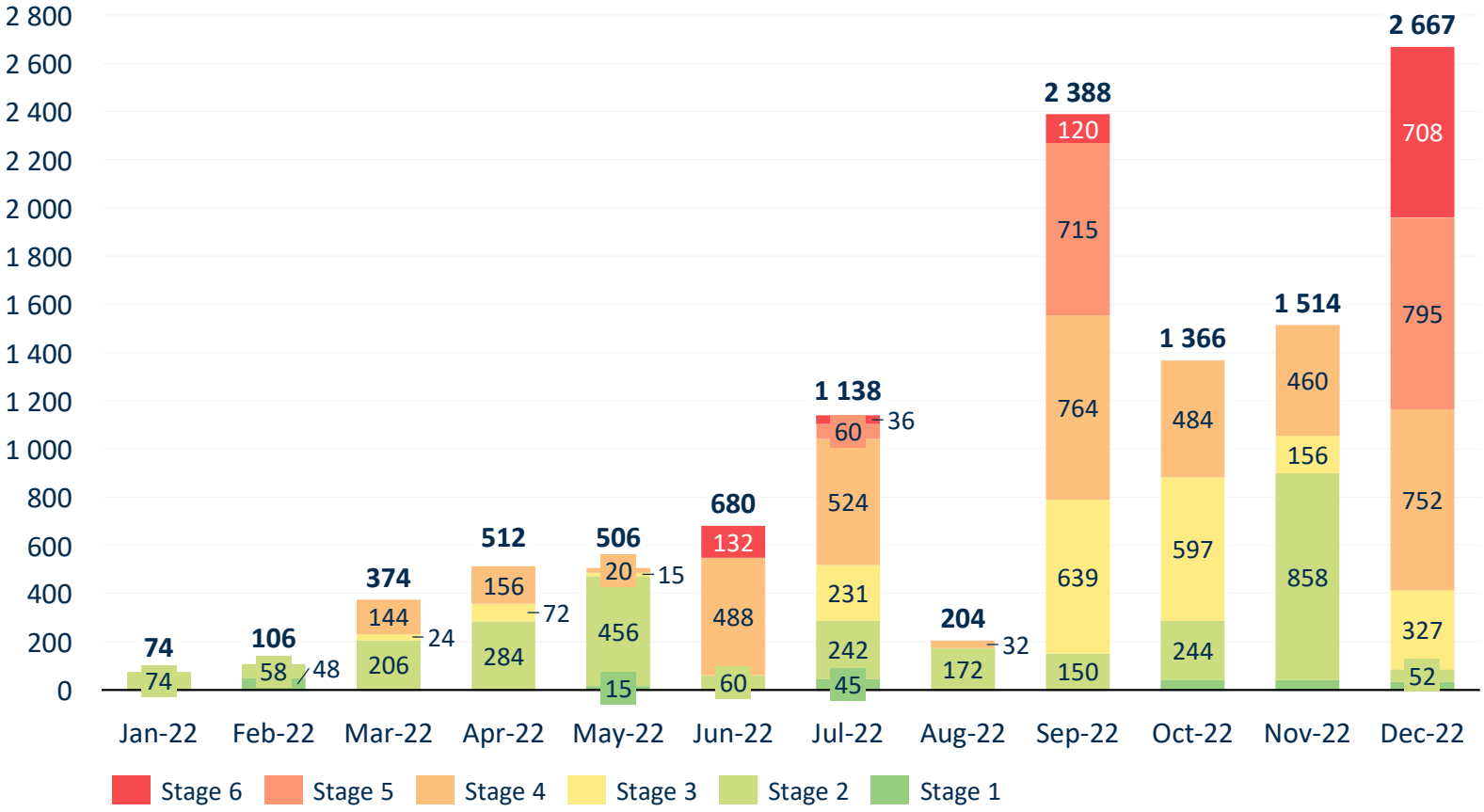
# Upper limit of cumulative loadshedding annually Jan 2014 – Dec 2022



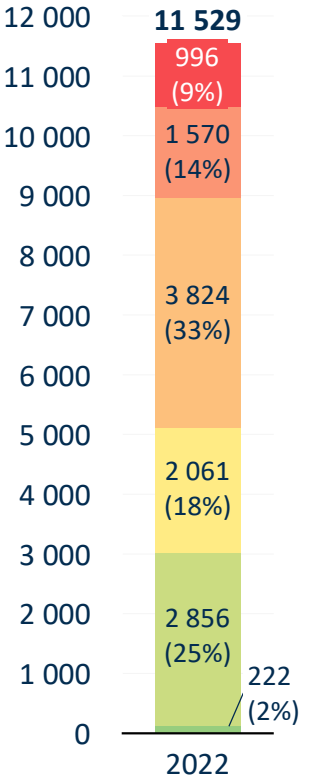

Notes: Loadshedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 MW, Stage 5 = 5 000 MW, Stage 6 = 6 000 MW;
Sources: Eskom Twitter account; Eskom Hld SOC Ltd FaceBook page; Eskom se Push (mobile app); Nersa; CSIR analysis

# December 2022 was an exeptionally high month in terms of loadshedding. 2022 is the first year that the majority of loadshedding has not been Stage 2, it was overtaken by Stage 4. Stage 6 loadshedding has far surpassed 2019, the only other year with Stage 6

## Monthly loadshedding (upper-limit) [GWh]




## Annual loadshedding (upper limit) [GWh]




Notes: Loadshedding 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



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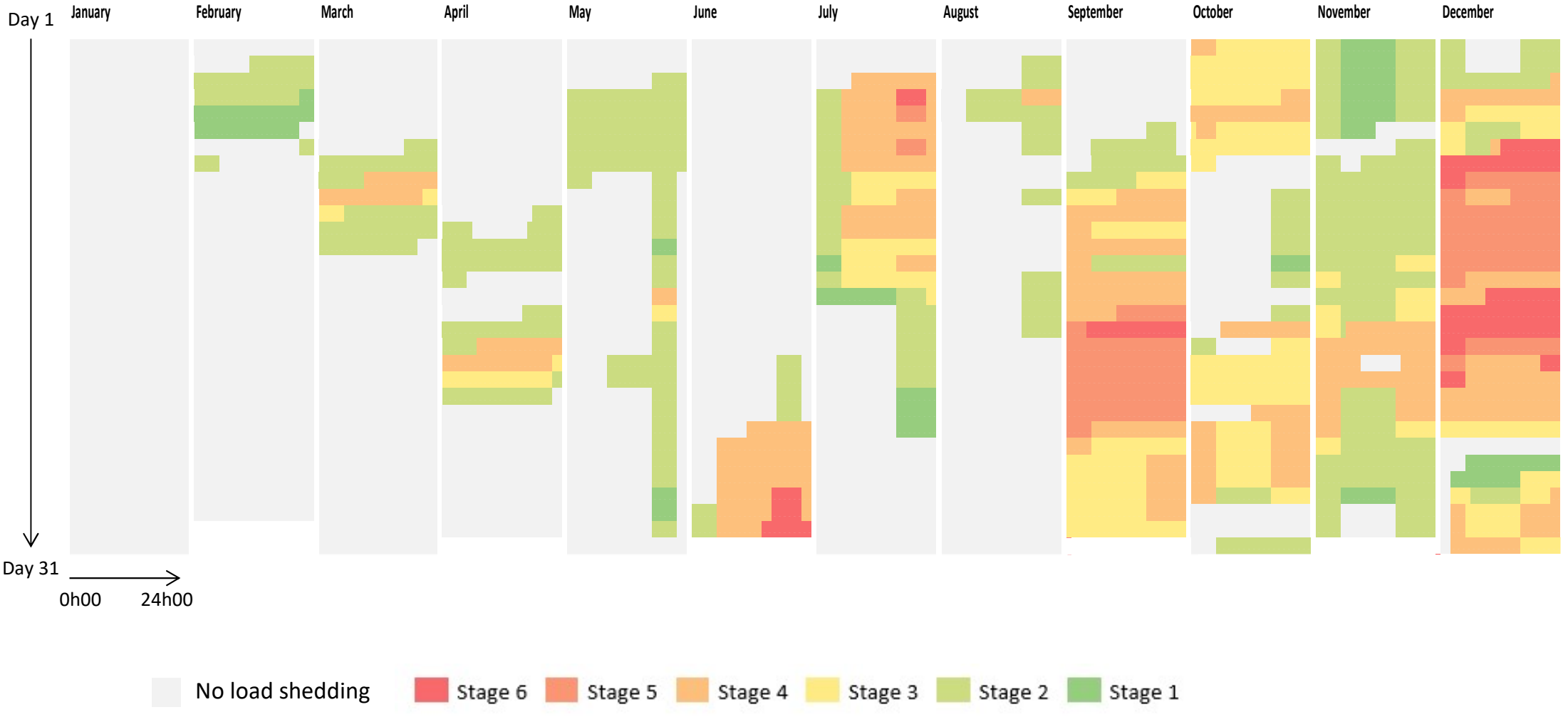
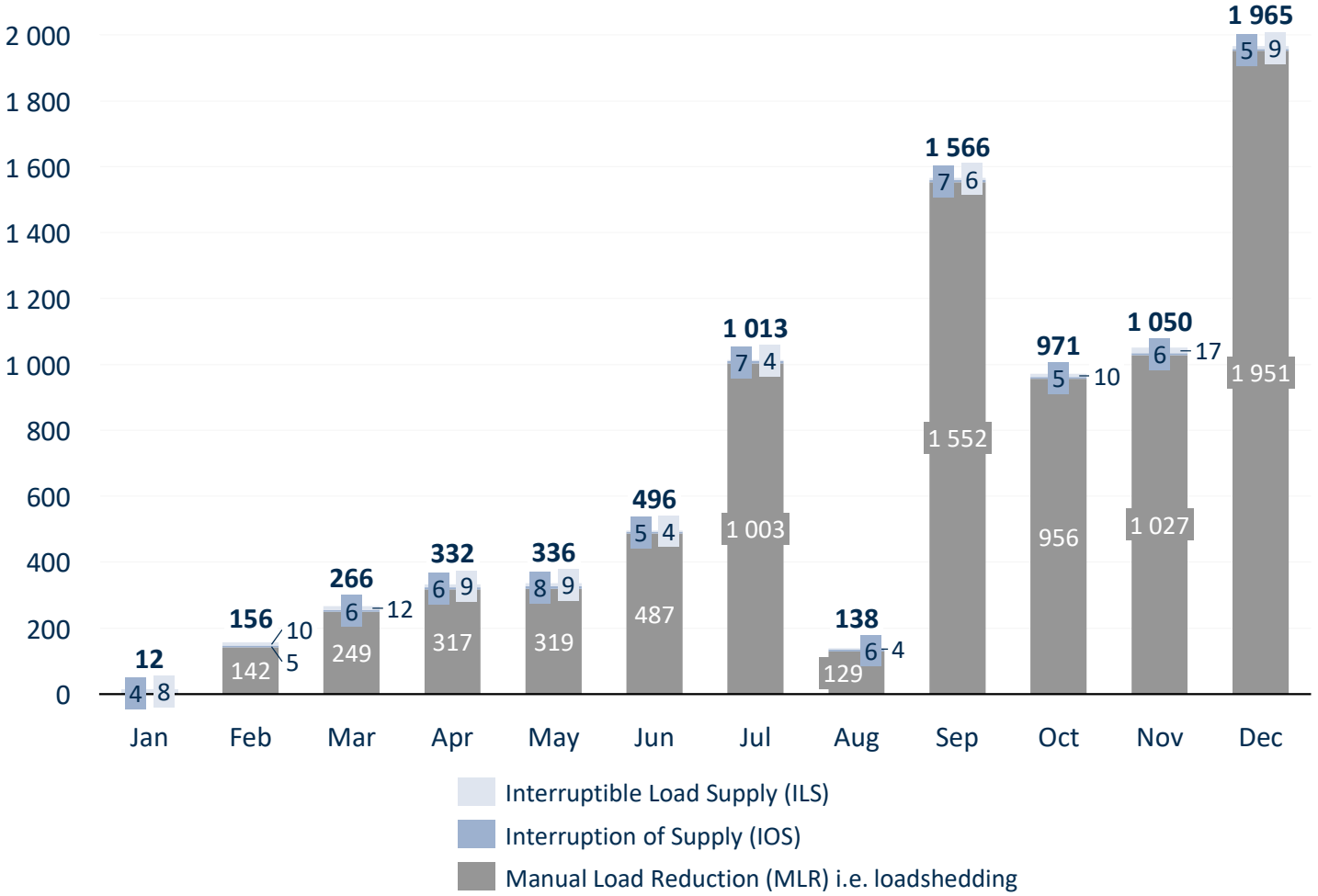
# Hourly distribution of loadshedding January – December 2022



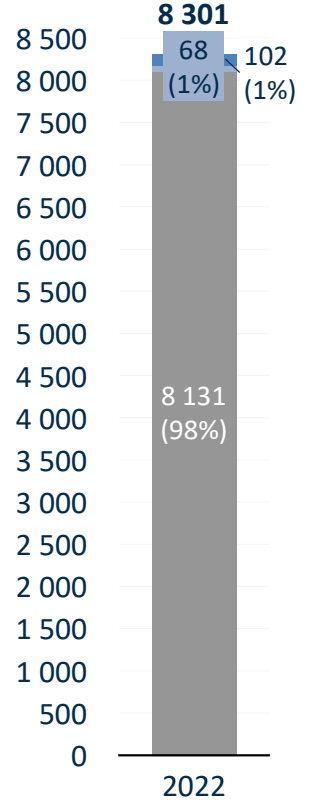

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 MW, Stage 5 = 5 000 MW, Stage 6 = 6 000 MW
Sources: Eskom Twitter account; Eskom Hld SOC Ltd FaceBook page; Eskom se Push (mobile app); CSIR analysis

# Actual demand side response (DSR) in 2022 reveals how actual MLR (loadshedding) dominated over other DSR interventions

**Monthly demand side response (DSR) [GWh]**




**Annual DSR [GWh]**






Notes: Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS);
Sources: Eskom; CSIR analysis

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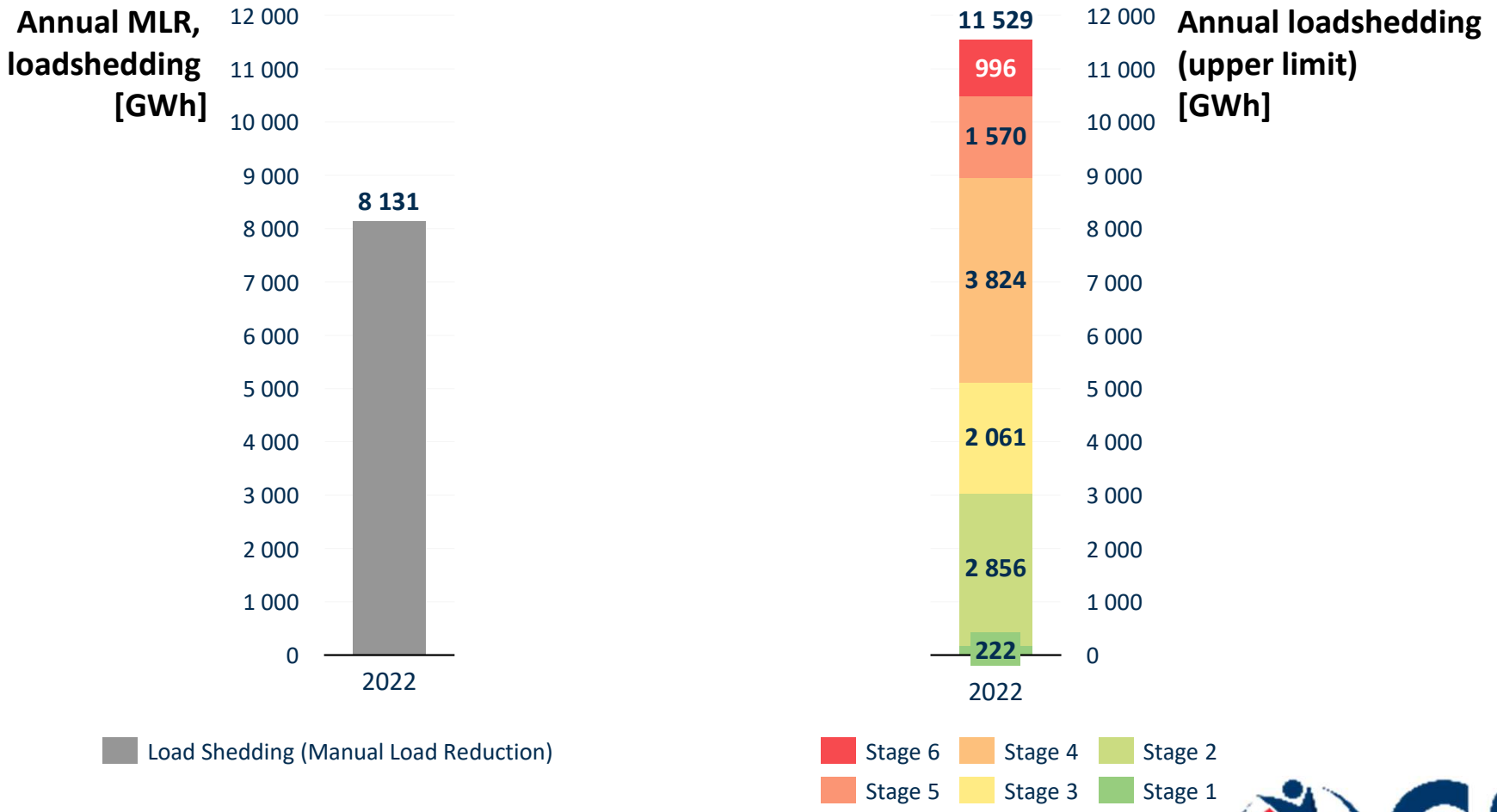
# Actual manual load reduction (MLR) in 2022 was ~71% of announced levels of loadshedding




Notes: Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS);
Sources: Eskom; CSIR analysis



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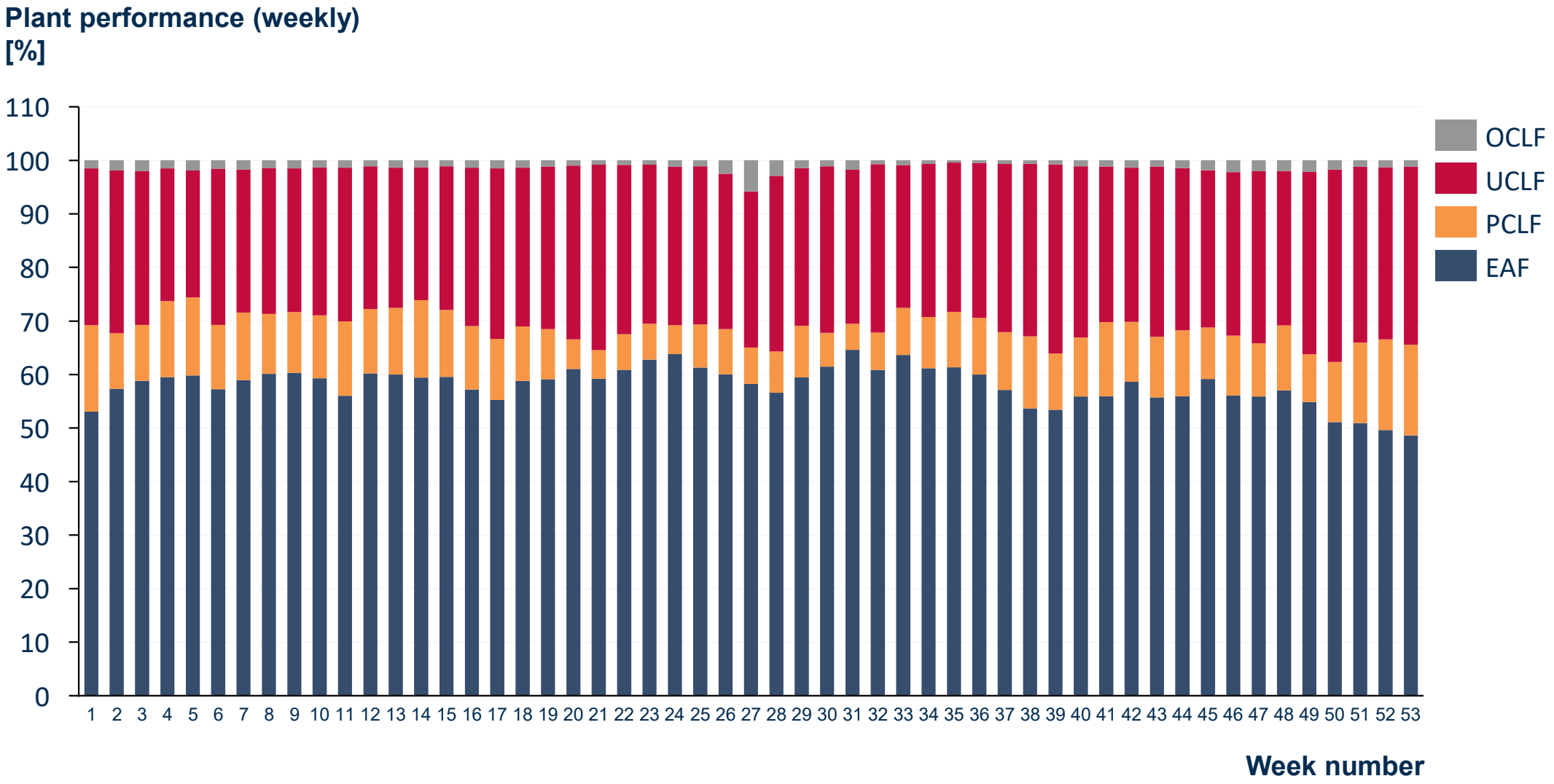
# Eskom fleet performance continues to decline with an annual EAF of 58.1% with planned maintenance of 10.6%, unplanned outages of 29.8% and other at 1.5% (weekly performance shown below)

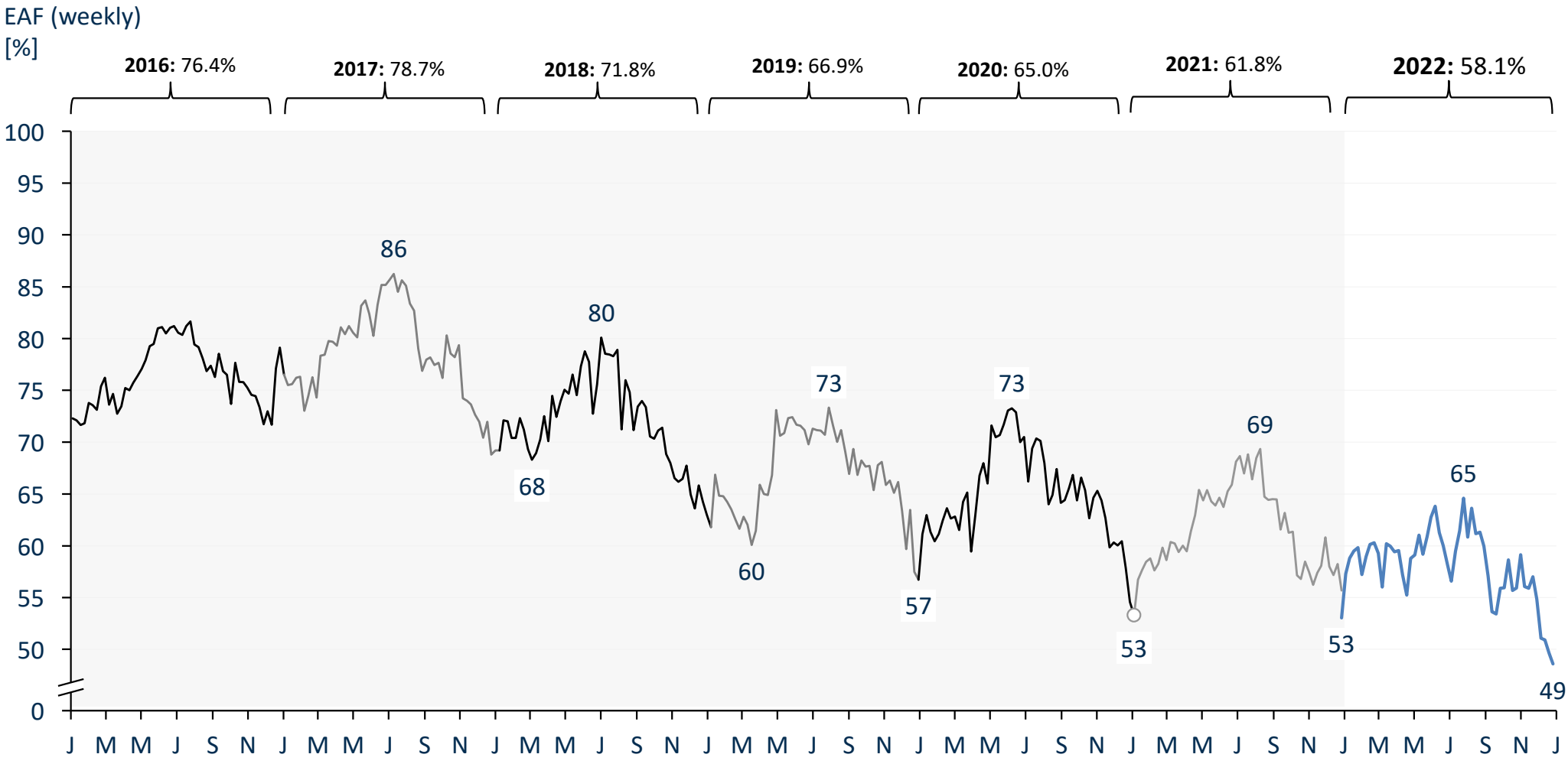





NOTES: EAF - Energy Availability Factor; PCLF - Planned capability Loss Factor; UCLF – Unplanned Capability Loss Factor; OCLF – Other Capability Loss Factor
Sources: Eskom; CSIR Energy Centre analysis

# Declining EAF trend continues into 2022, to an average of 58.1%

The weekly EAF hit a new low of 48.6% (first year that it dropped below 50%)






Notes: EAF - Energy Availability Factor. Average annual EAF is calculated as an average of the hourly EAF values.
Sources: Eskom; CSIR Energy Centre analysis

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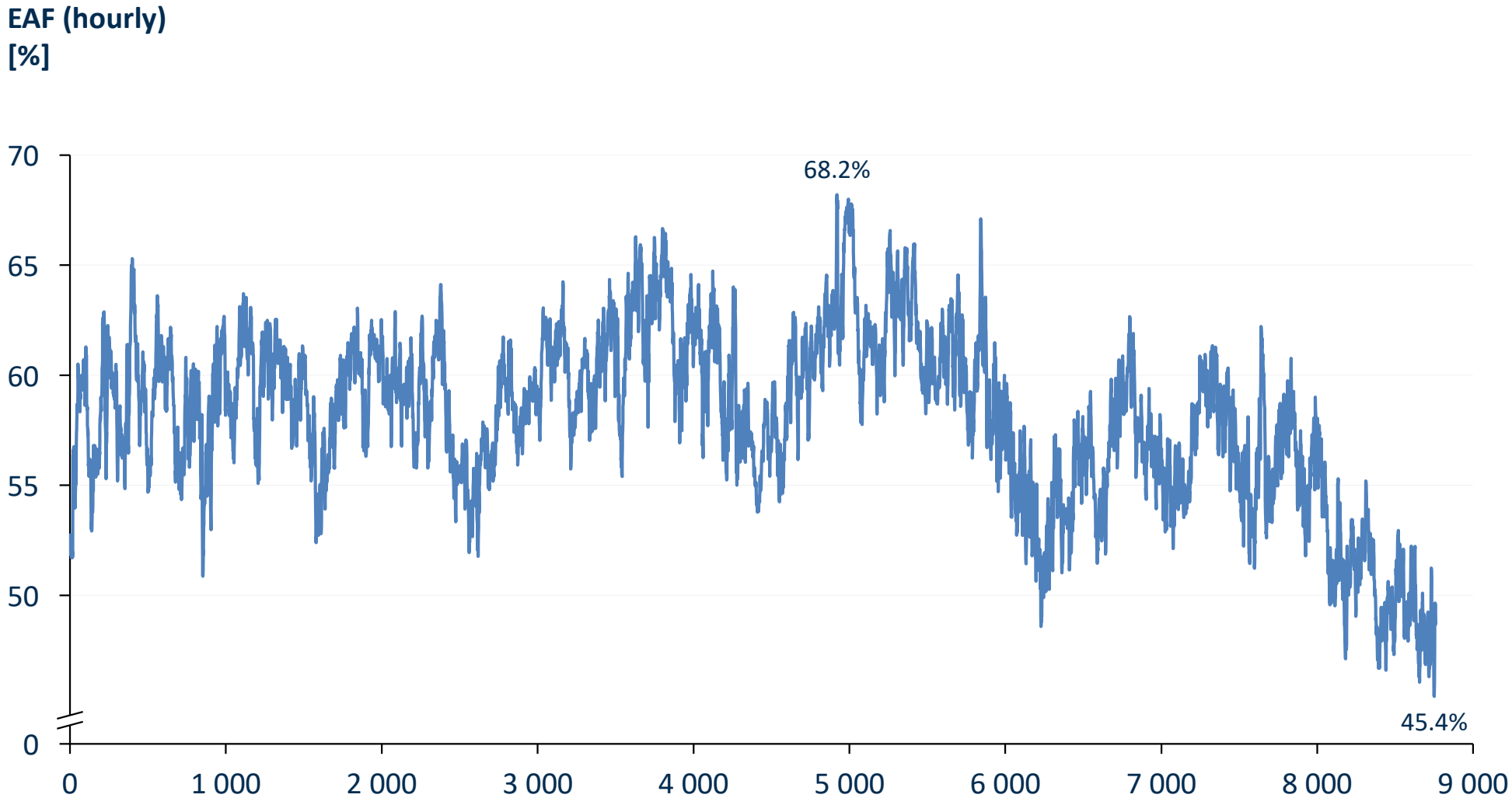
# EAF does not exhibit similar seasonality as in other years but stays ‘flat’ and then drops

The hourly EAF hit a new low of 45.4%






Notes: EAF - Energy Availability Factor. Average annual EAF is calculated as an average of the hourly EAF values.
Sources: Eskom; CSIR Energy Centre analysis

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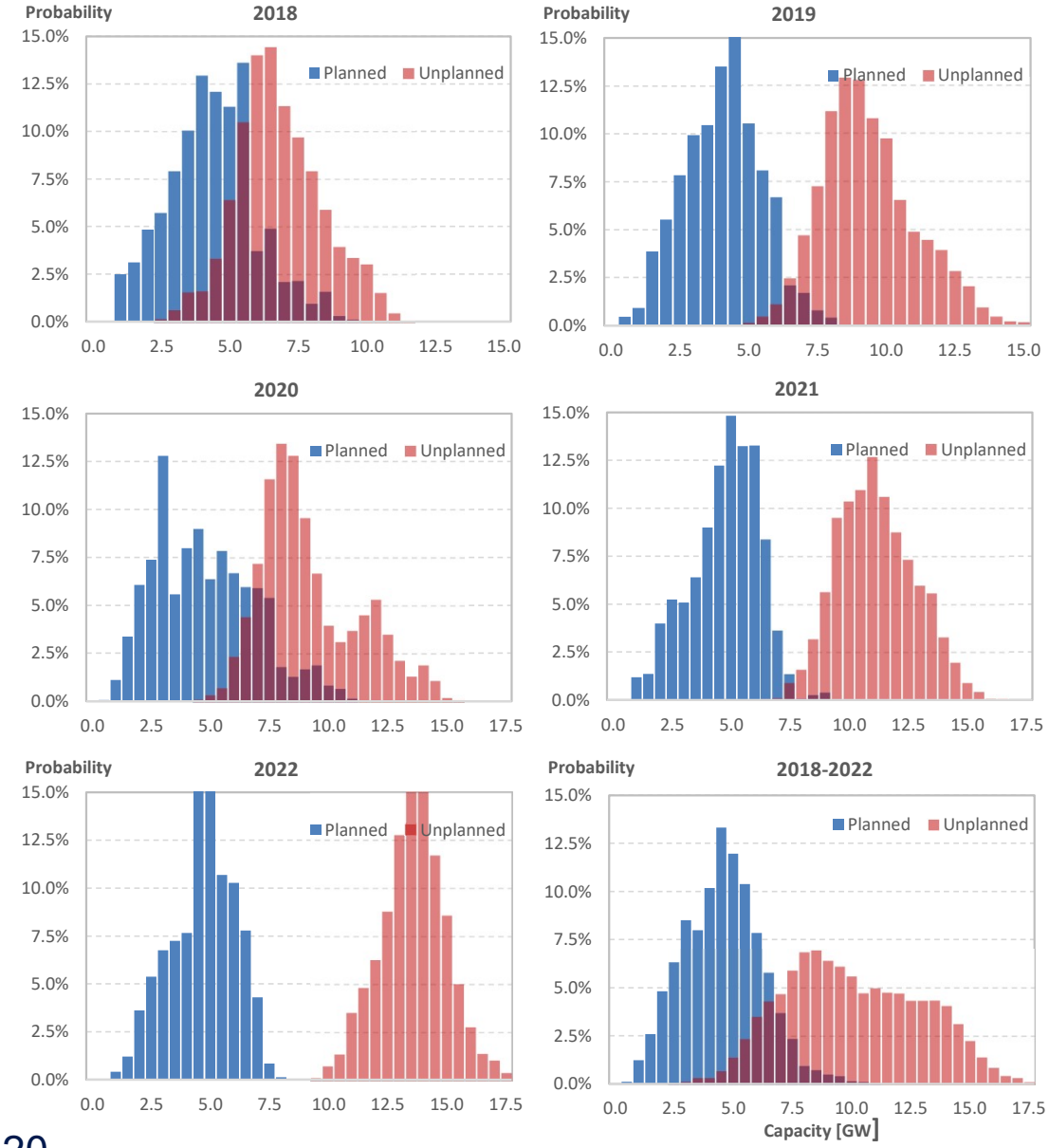
# Unplanned outages (breakdowns) component is increasingly trending in a worrying direction




- **Shift from similar levels of planned maintenance (PCLF) and unplanned outages (UCLF) in 2018 towards increasing distribution of UCLF as years progress**
- **2020 was an unusual year with a bimodal distribution (twin peaks) of UCLF**
- **2021 shows the distinct separation (in the statistical distribution) of UCLF and PCLF as unplanned outages continues to increase. The 'gap' widens in 2022.**

NOTE: Data presented is hourly temporal resolution;



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# Thank you

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