Statistics of utility-scale power generation in South Africa

H1*-2022

(1 Jan 2022 – 30 June 2022)

*with loadshedding and EAF (energy availability factor) data up until 30 September 2022

CSIR Energy Centre

v1.0

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Summary of H1-2022 statistics:
Coal still dominates and provides more than 80% of electricity generated and renewables (excluding hydro) accounted for 6.5%

By H1-2022 South Africa had 54 GW of wholesale/public nominal capacity

- Coal is 39.3 GW (unchanged)
- 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 (increased)
- Solar PV is 2.2 GW (unchanged)
- CSP is 0.5 GW (unchanged)
- 419 MW of wind became operational in H1-2022

The electricity mix is still dominated by coal-fired power generation which contributed over 80% to system demand in H1-2022

- Coal energy contributed 81.3% (91.1 TWh)
- Nuclear energy contributed 3.8% (4.2 TWh)
- Renewable energy contributed 13.4% (15 TWh)
- Renewable energy contributed 6.5% (7.3 TWh) - excluding hydro
- The remaining 1.5% came from diesel (1.7 TWh)

NOTES: Nominal capacities reported as on 30 June 2022; Electricity mix given for 1 Jan 2022 – 30 June 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 H1-2022 statistics:
System demand recovered slightly in H1-2022 but not yet to 2019 levels

In H1-2022, system energy demand increased only by 0.1 TWh relative to H1-2021 but was 3.0 TWh (2.5%) less than that experienced in H1-2019.

- Peak system demand was 34.6 GW (vs 34.3 GW in H1-2021)
- Contributions of coal have decreased in comparison to H1-2021

In H1-2022, the VRE fleet of 6.2 GW (wind, solar PV, CSP) reduced peak demand and high demand hours by ~ 60%

- VRE fleet reduced peak demand by ~ 1.4 GW
- VRE fleet also reduced high-demand hours (hours with >30 GW system demand) from 272 hours to 108 hours (164 hours less, -60%)

Flexibility needs are not yet significantly increased with the existing VRE fleet in H1-2022

- 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 H1-2021).

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); H1 stats for 1 Jan 2022 – 30 Jun 2022
Sources: CSIR Analysis; Eskom

Summary of 2022-H1 statistics:
876 hours of loadshedding, upper limit 2 184 GWh with actual 1 598 GWh

In H1-2022, loadshedding occurred for 876 hours with an upper limit of 2 184 GWh relative to actual energy shed of 1 598 GWh

- Intensive loadshedding has been experienced
- Loadshedding mostly Stage 2 type
- Loadshedding occurred for 20% of the hours

In 2022 Jan to Sep, loadshedding occurred for 1 949 hours with an upper limit of 5 761 GWh relative to actual energy shed of 4 315 GWh

- Intensive loadshedding has been experienced, the most ever
- Loadshedding mostly Stage 4 type, first time not Stage 2
- Loadshedding occurred for 27% 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 59.4% for H1-2022 (relative to 2021 of 61.7%, 2020 of 65%, 2019 of 66.9% and 2018 of 71.9%)
- EAF planned maintenance at 10.5% (PCLF), unplanned outages at 28.7% (UCLF) & other outages at 1.5% (OCLF)
- The best hourly EAF was 66.7% and worst was 50.9%. For 2022 Jan to Sep, the best hourly EAF was 68.2% and worst was 48.6%.

NOTES: EAF - Energy Availability Factor; PCLF - Planned capability Loss Factor;
Excludes Embedded Generation (EG) and Distributed Generation (DG); Statistics calculated for 1 Jan 2022 – 30 Jun 2022
UCLF – Unplanned Capability Loss Factor; OCLF – Other Capability Loss Factor; EAF = 100%-PCLF-UCLF-OCLF

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6 Actual load shedding (2022 – up until September)

7 Other power system statistics (2022 – up until September)

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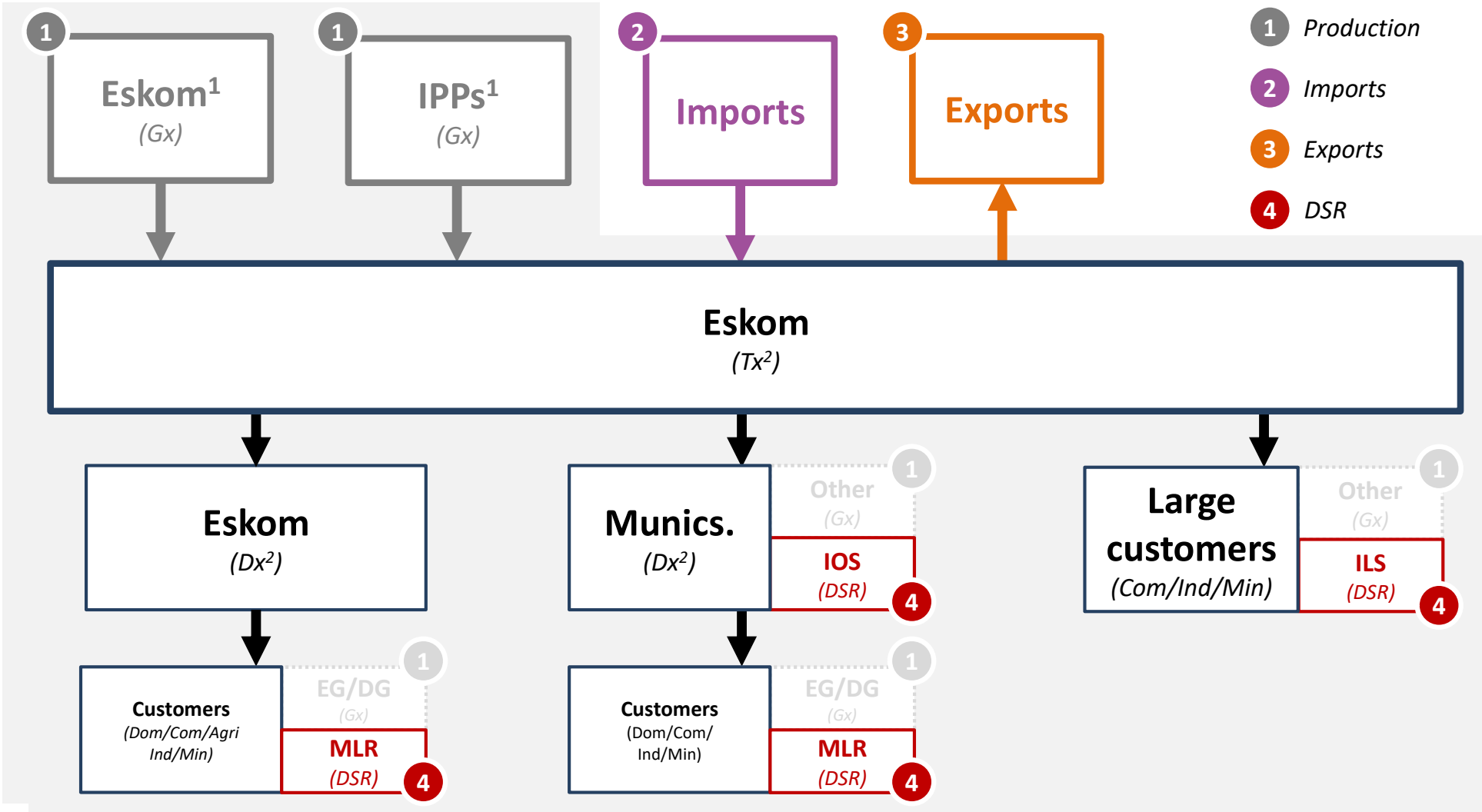
Equivalent wholesale South African electricity production and demand as measured & published by Eskom



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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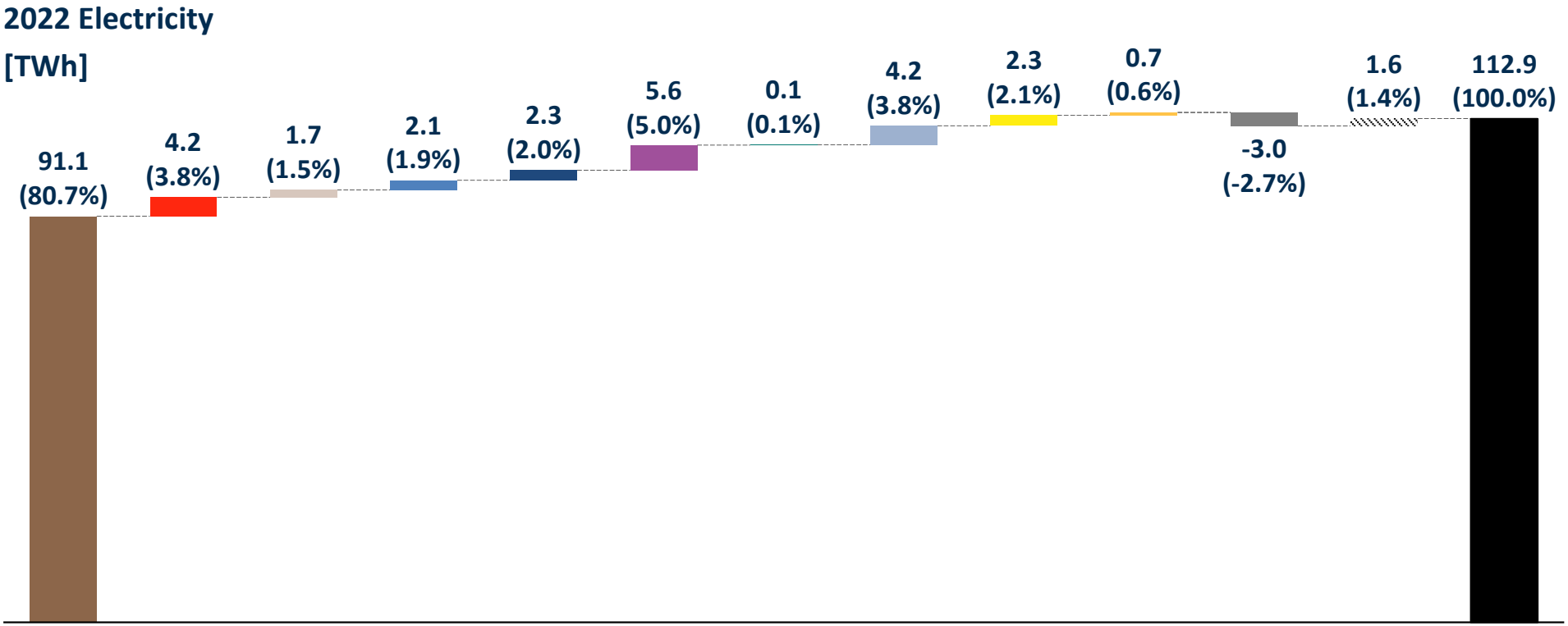
In 2022, coal dominated the energy mix at 80.7% of the ~113 TWh of total system load met whilst PV, wind and CSP contributed 6.5%

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

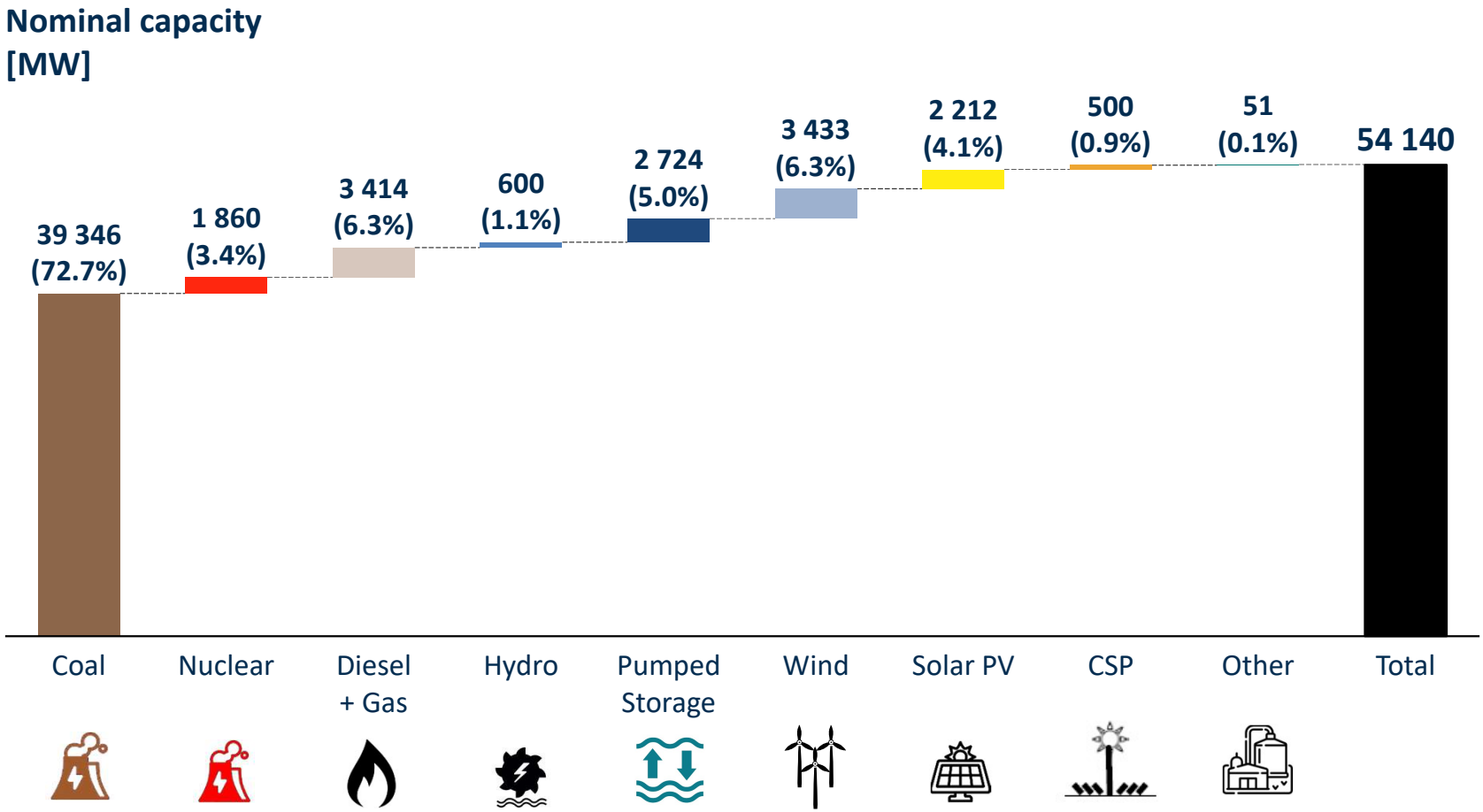


	Coal	Nuclear	Diesel + Gas	Hydro	Pumped Storage	Imports	Other	Wind	Solar PV	CSP	Pump load	DSR	System Load (domestic & export)
2021 (full-year)	184.7	12.2	3.2	1.6	4.9	10.2	0.1	8.4	5.1	1.7	-6.6	1.9	227.2

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 H1 - 2022

Actual nominal installed capacity at 30 Jun 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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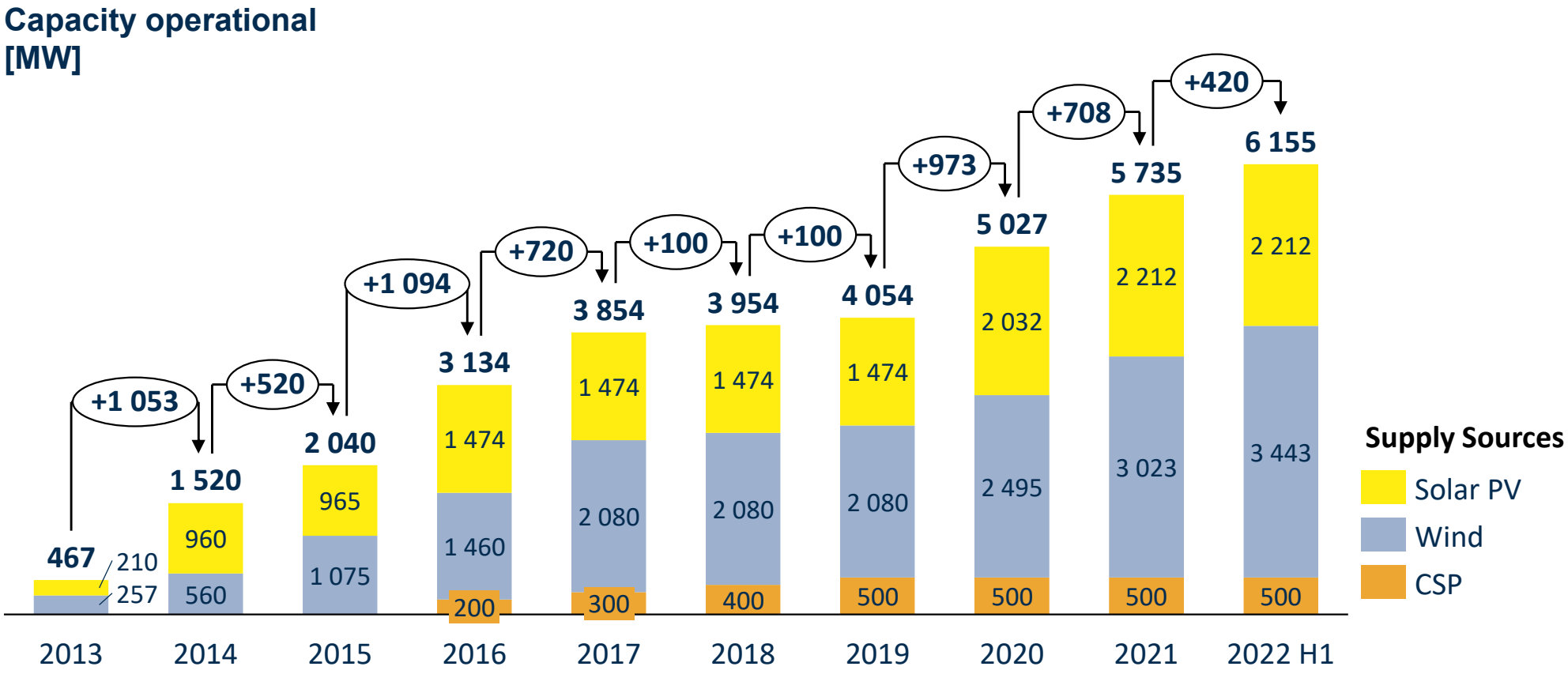
From 1 Nov 2013 to 30 Jun 2022, 3 443 MW of wind, 2 212 MW of large-scale solar PV and 500 MW of CSP became operational in RSA



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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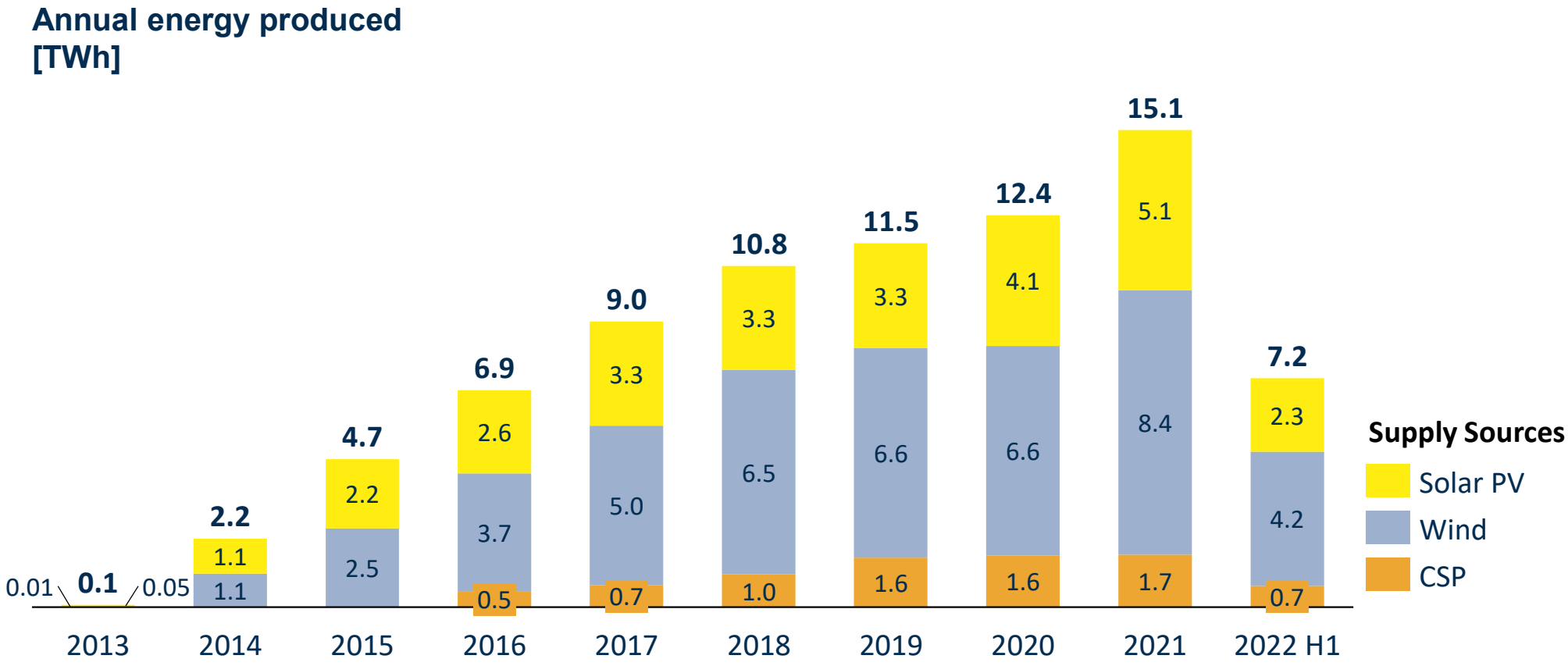
In H1-2022 ~ 7.2 TWh of wind, solar PV & CSP energy was produced in South Africa



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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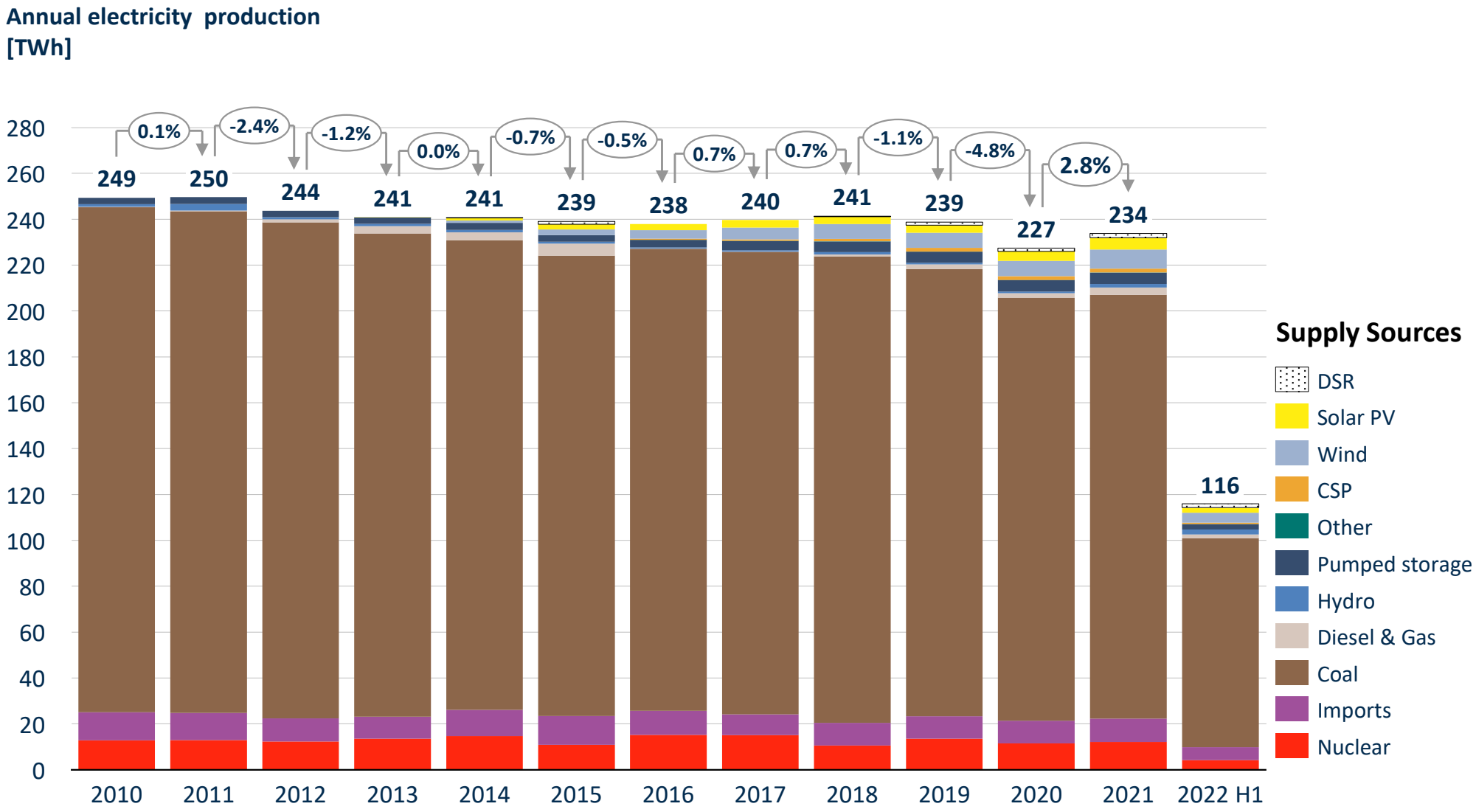
Production in H1-2022 was constrained with diesel & gas running extensively and notable DSR activated

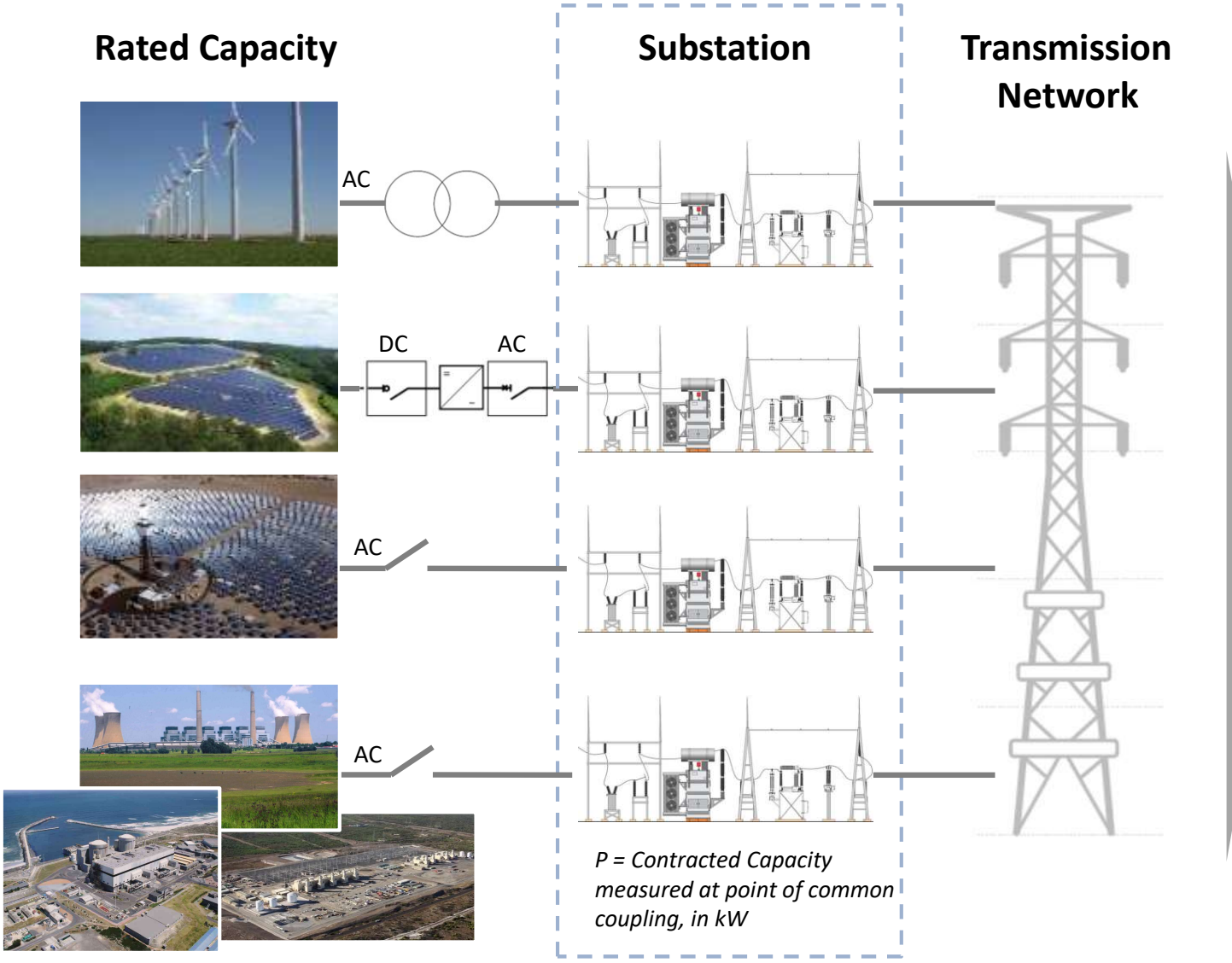
Historical annual electricity production per supply source in TWh



NOTES: Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS). DSR prior to 2020 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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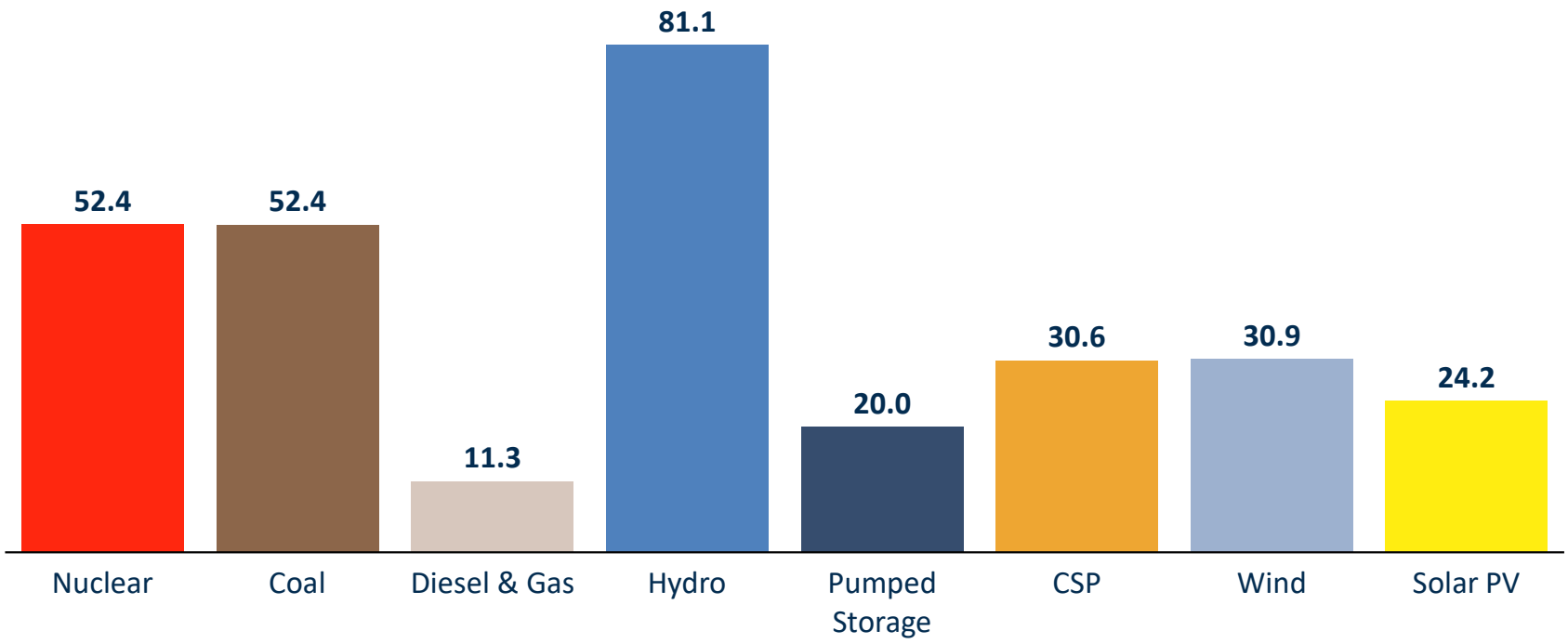
Annual capacity factors per supply source in South Africa in H1-2022

2022-H1
Capacity factors [%]



Wind includes Sere wind farm (100 MW). Previous Diesel & Gas did not include IPPs, from this version on IPP Peakers (Diesel) are included
Sources: Eskom

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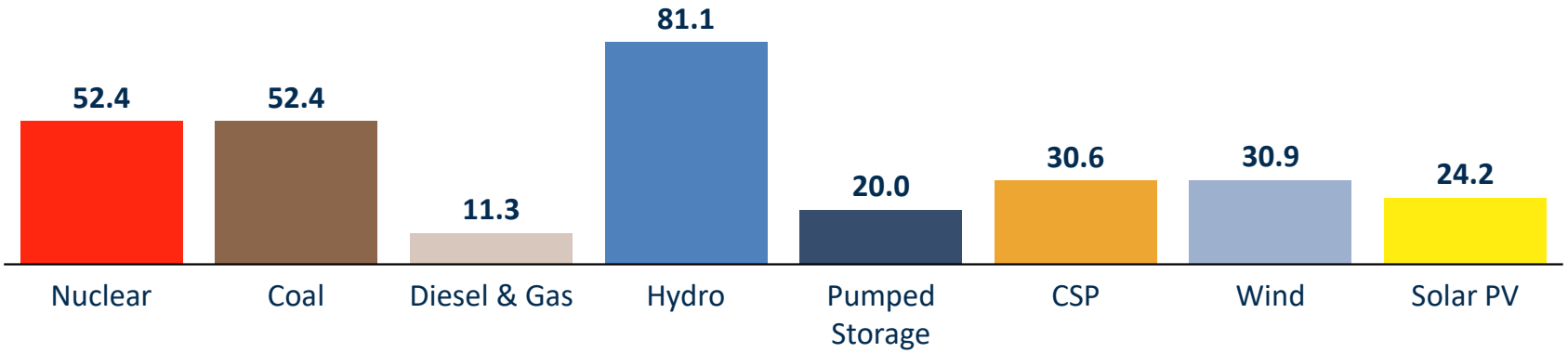
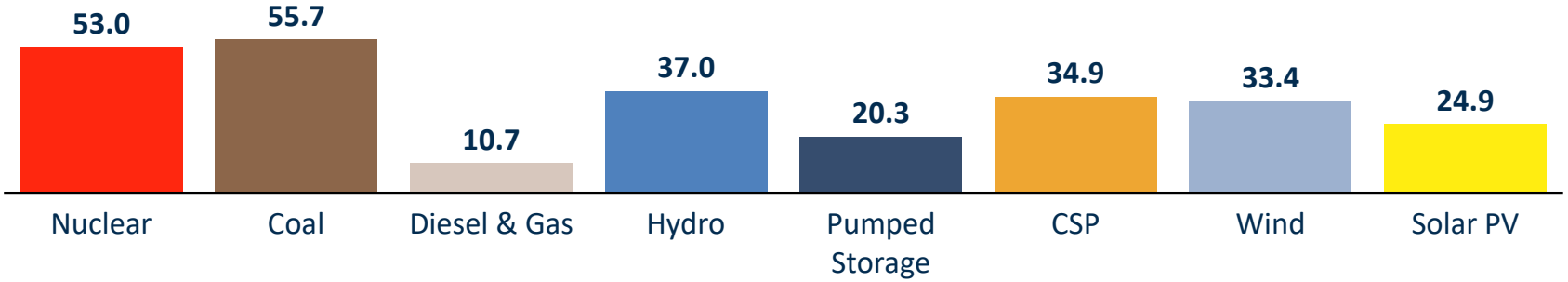
Capacity factors per supply source in South Africa in H1-2022 and H1-2021

2022-H1
Capacity factors [%]



2021-H1
Capacity factors [%]



Wind includes Sere wind farm (100 MW). Previous Diesel & Gas did not include IPPs, from this version on IPP Peakers (Diesel) are included.
Sources: Eskom

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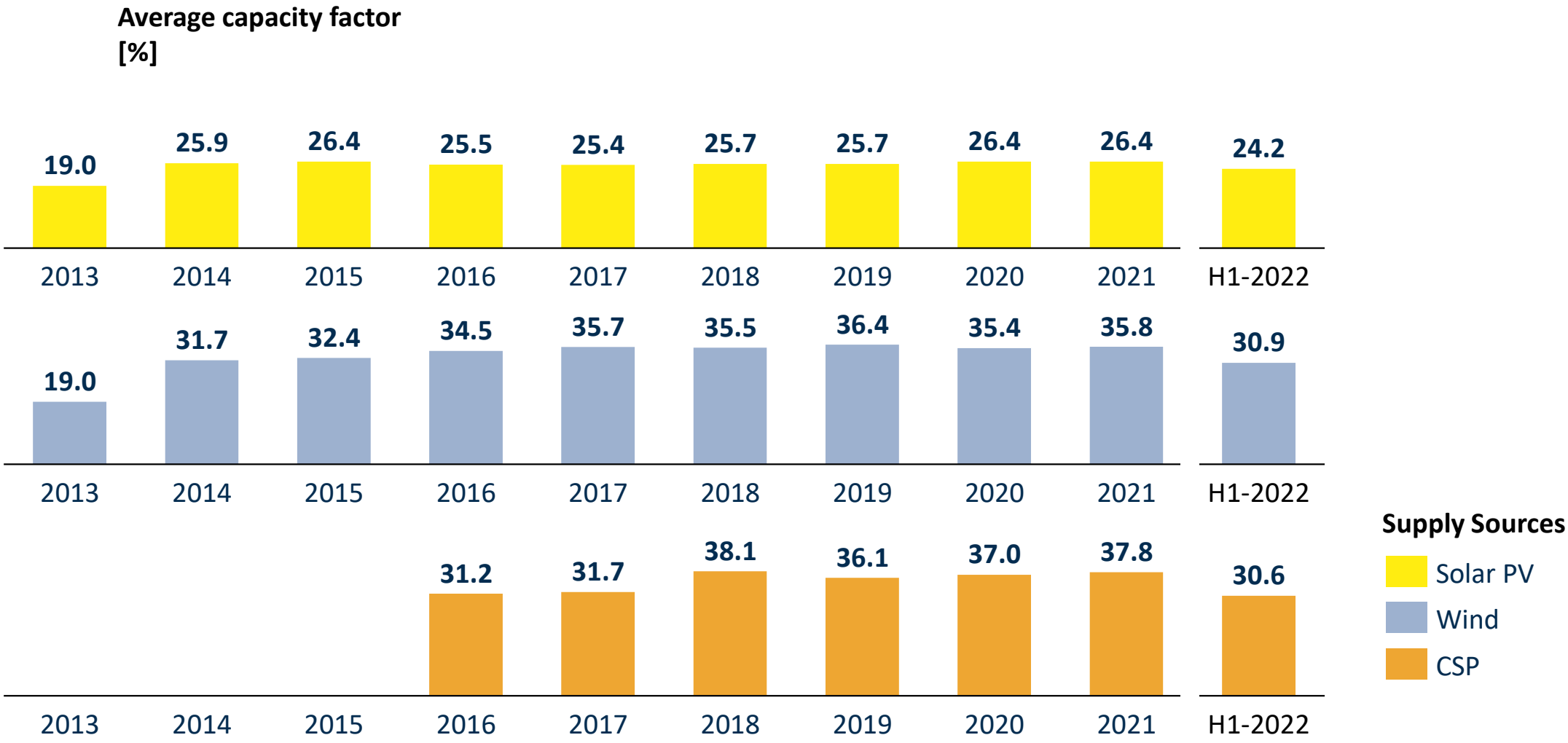
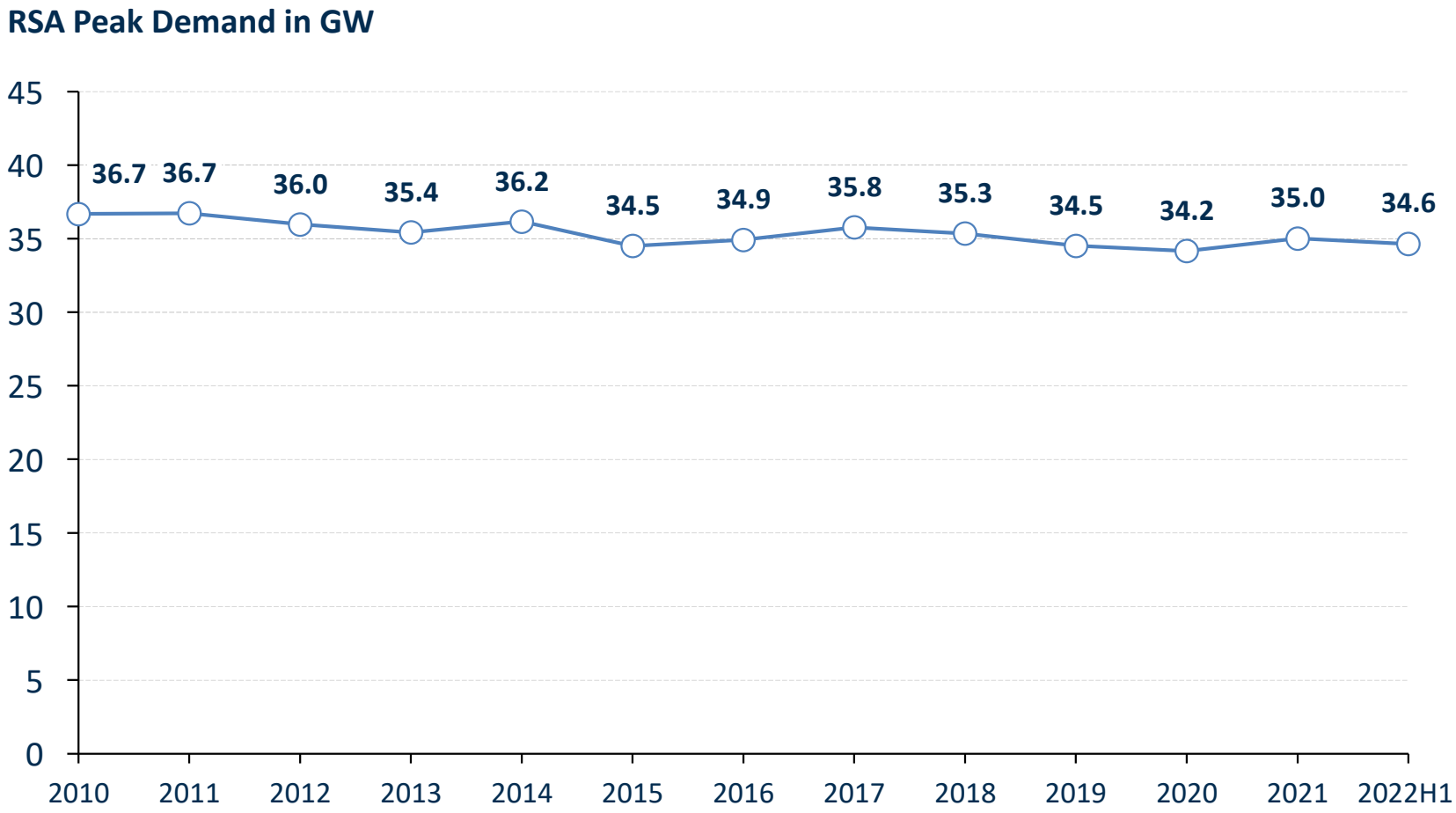
In H1-2022, the average annual capacity factor of the solar PV, wind & CSP fleet was 24%, 31% and 31% respectively



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 H1 2022 decreased slightly in comparison to 2021

Historical annual peak demand in GW; annual peak demand has been declining over the last 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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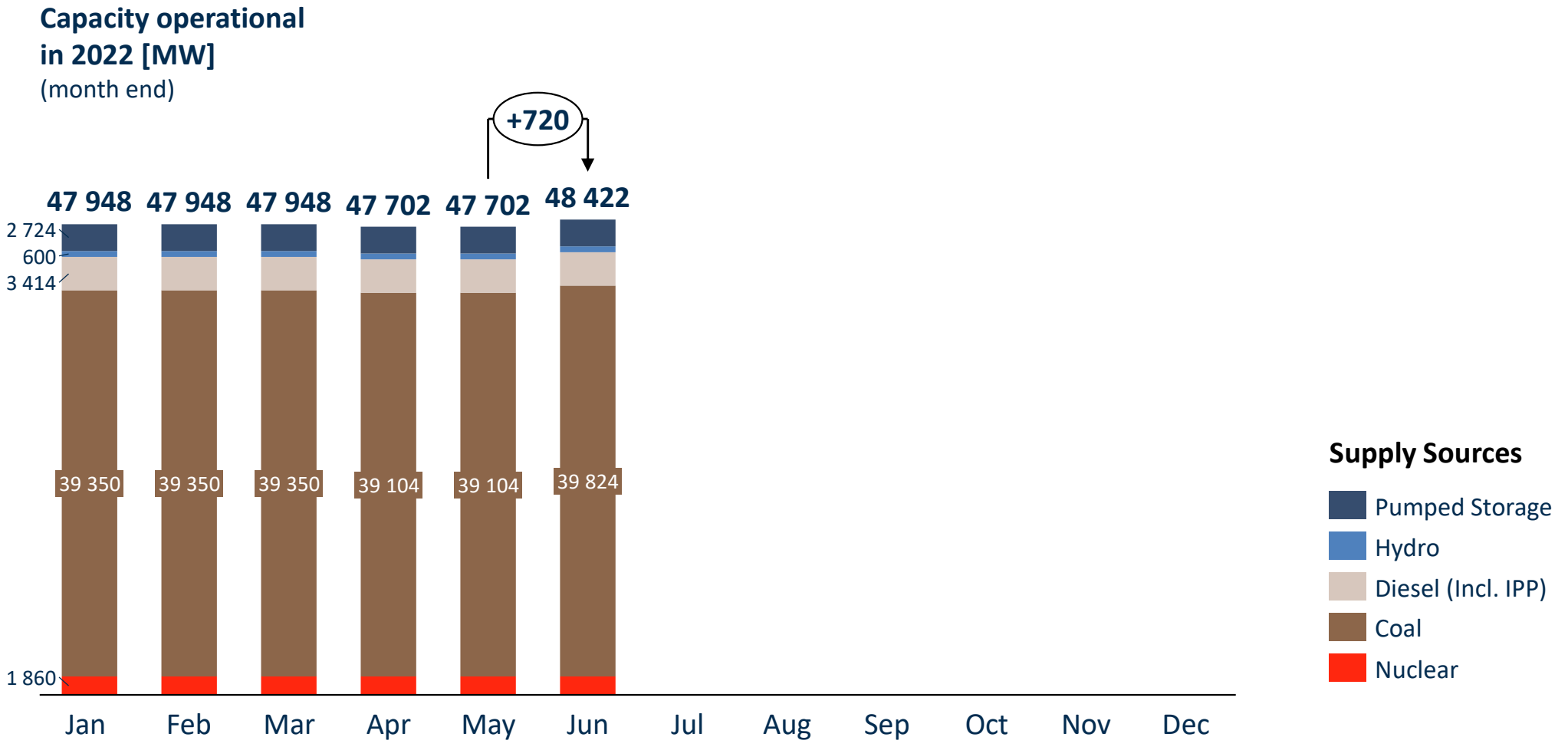
In H1-2022, an additional 720 MW of coal (Kusile) was added to the grid

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



Sources: Eskom; CSIR analysis

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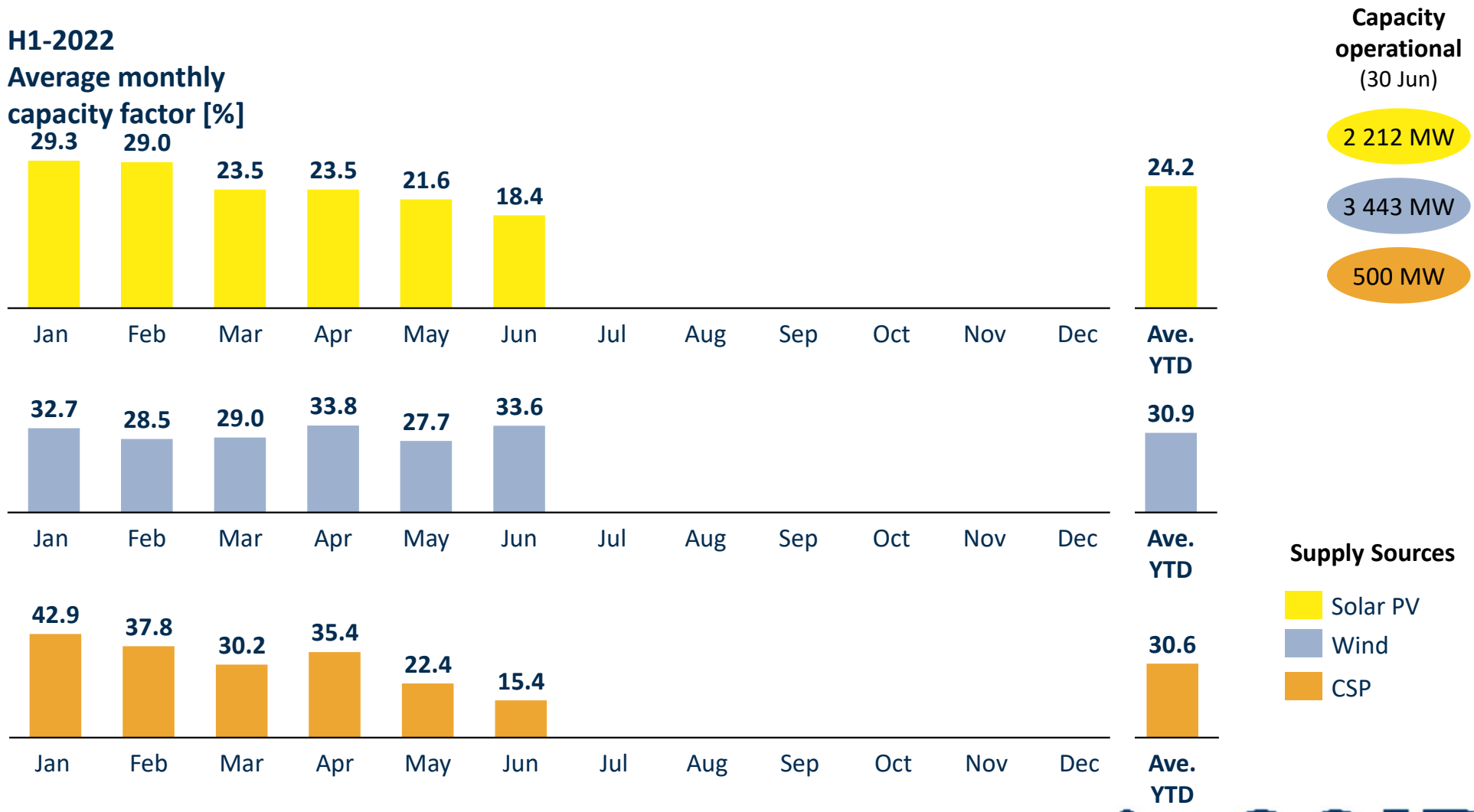
Average monthly capacity factors for solar PV, wind and CSP

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



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

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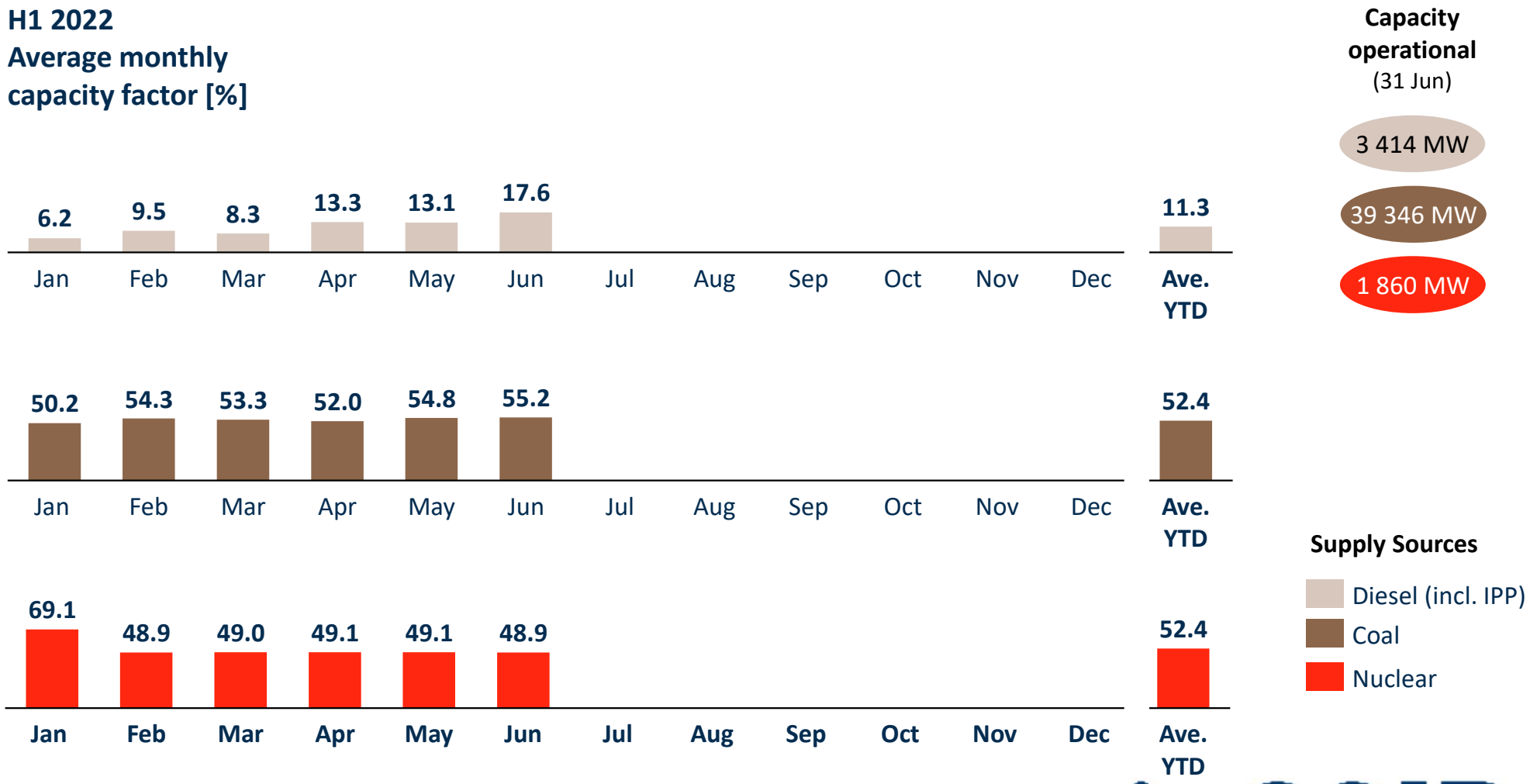
Average monthly capacity factors for thermal plants

Average monthly capacity factors of thermal capacity in RSA from Jan-Jun 2022



Sources: Eskom

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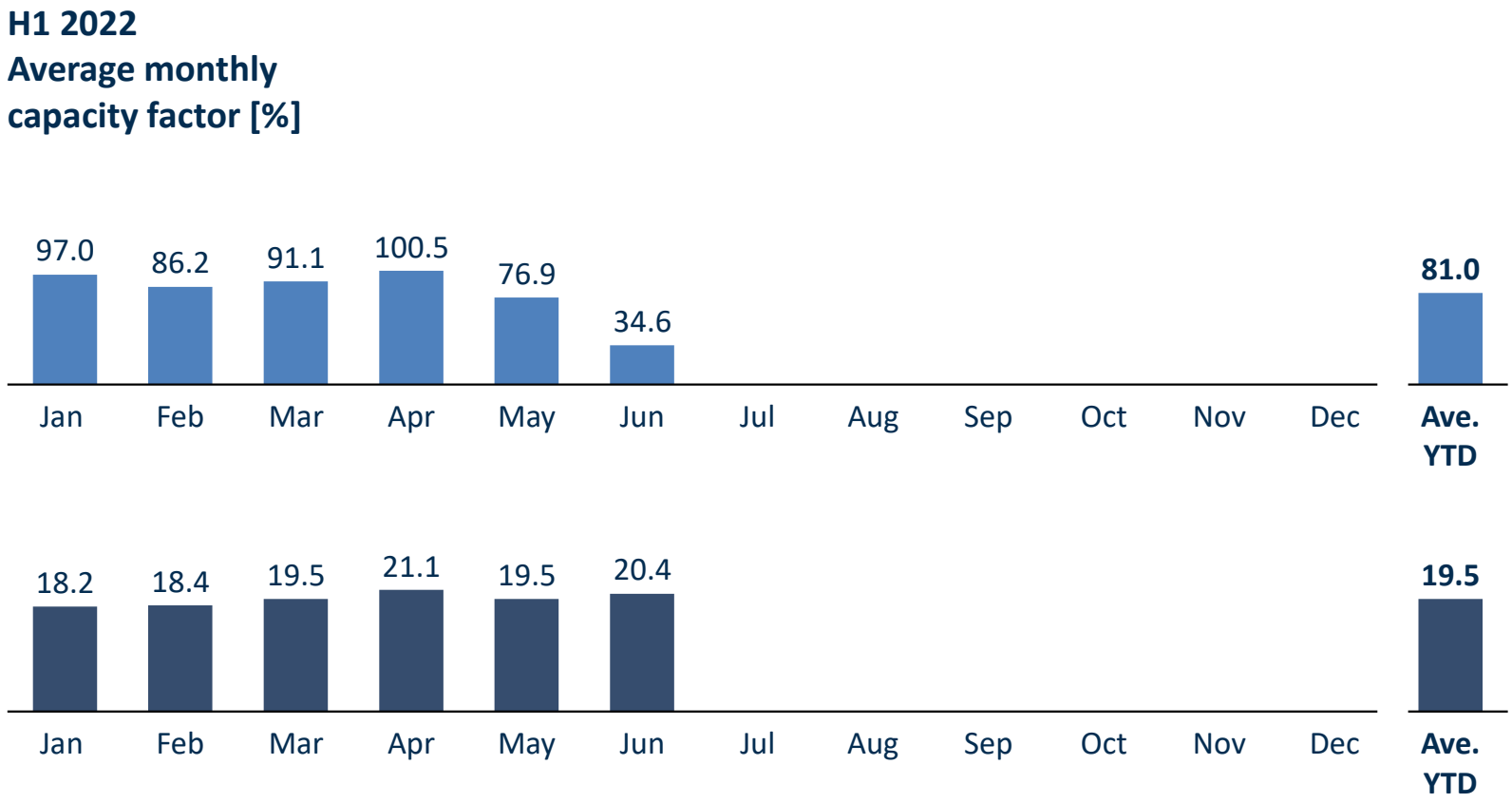
Average monthly capacity factors for hydro and pumped storage plants

Average monthly capacity factors of hydro & pumped storage in RSA from Jan-Jun 2022



Capacity operational (31 Dec 2021)

600 MW

2 724 MW

Supply Sources

Hydro

Pumped Storage

Sources: Eskom

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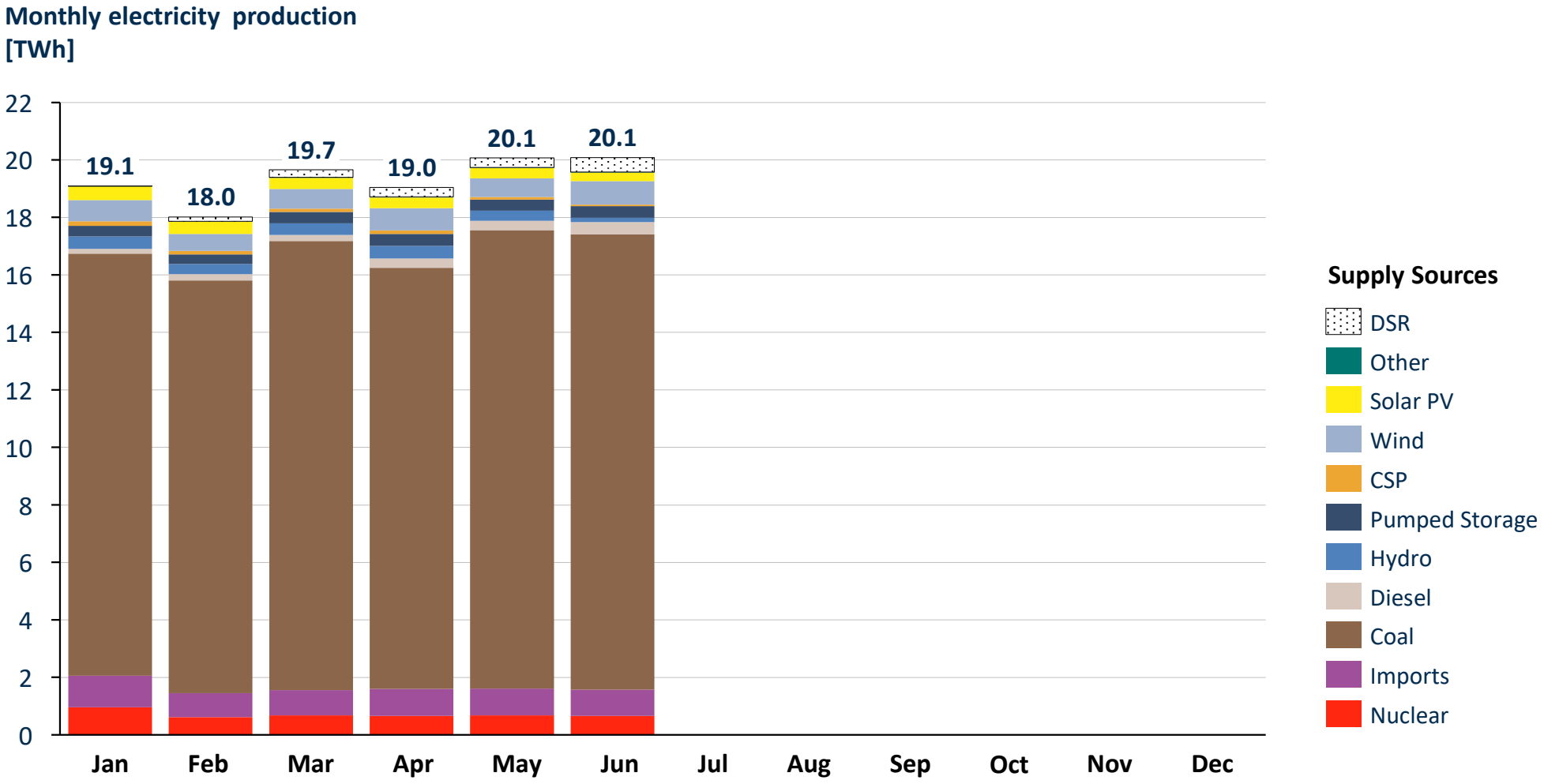
Monthly electricity production from all power supply sources (absolute)

Actual monthly electricity production for the period Jan-Jun 2022 from the different supply sources in RSA



Notes: Pumping load excluded. Wind generation includes Eskom's 100 MW Sere wind farm.
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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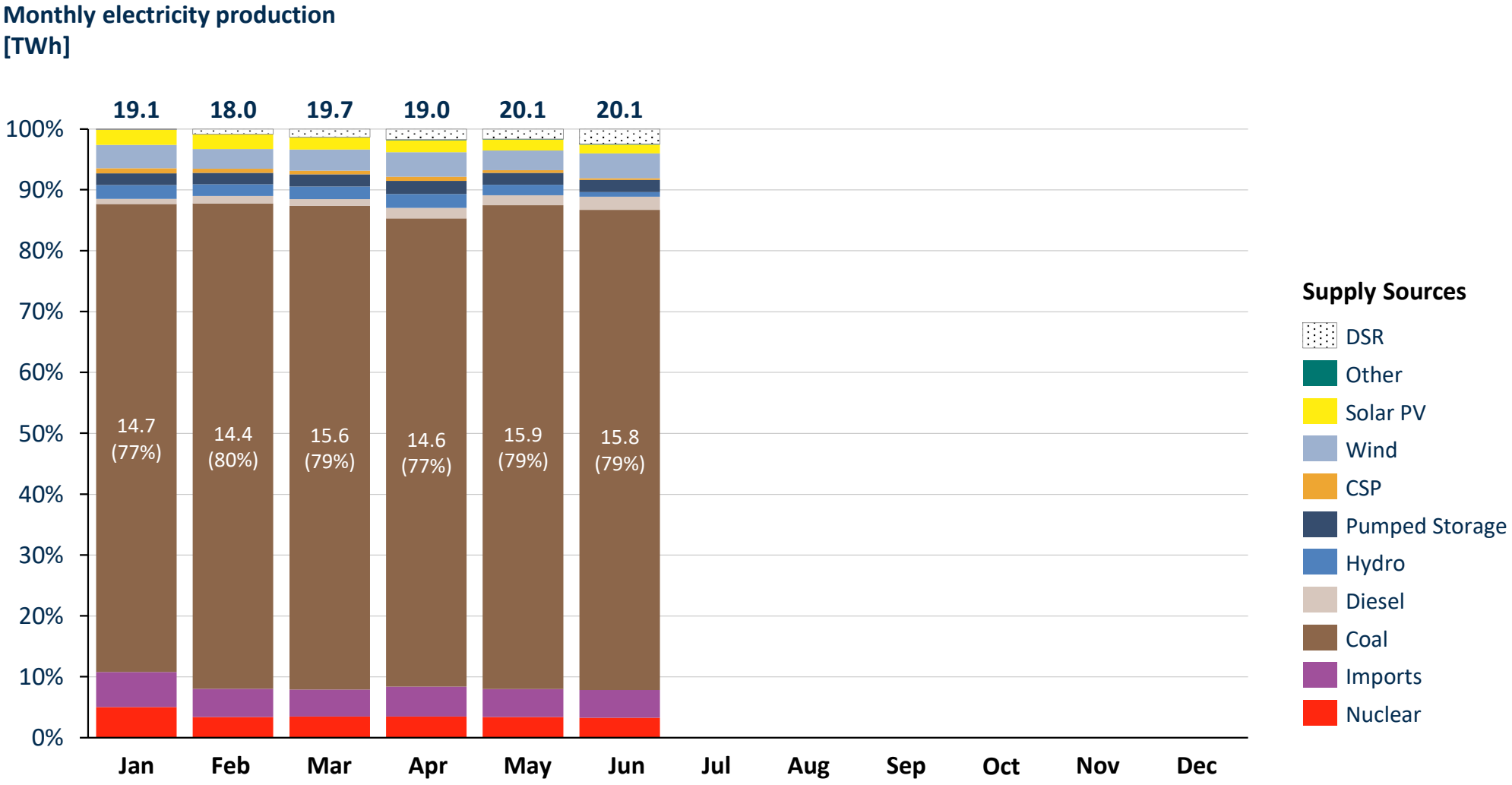
Monthly electricity production from all power supply sources (share)

Actual monthly electricity production for the period Jan-Jun 2022 from the different supply sources in RSA



Notes: Pumping load excluded. Wind generation includes Eskom's 100 MW Sere wind farm.
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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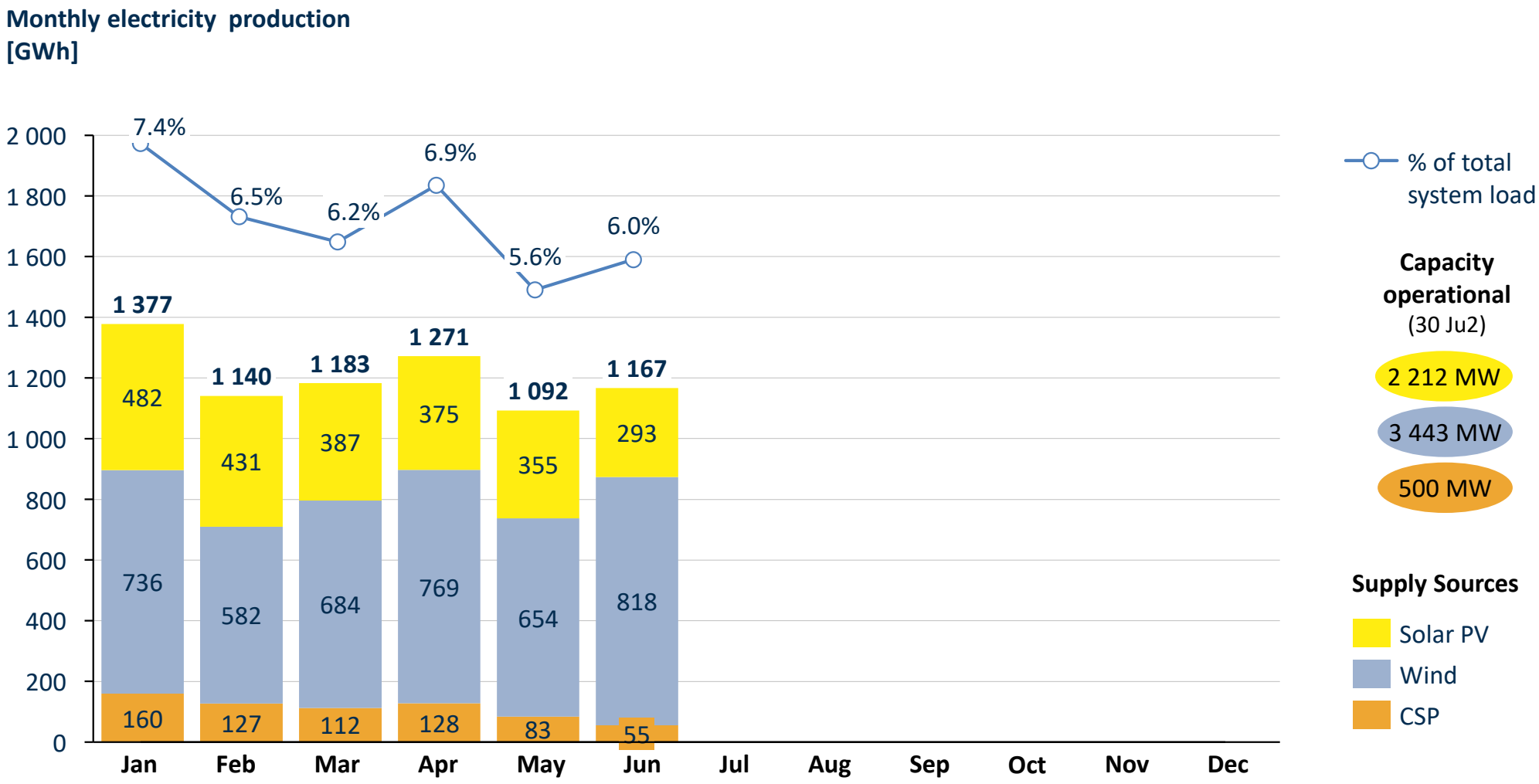
Monthly electricity production of SA's wind, solar PV & CSP fleet

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



Notes: Wind generation includes Eskom's 100 MW Sere wind farm. CSP energy only 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; CSIR Energy Centre analysis

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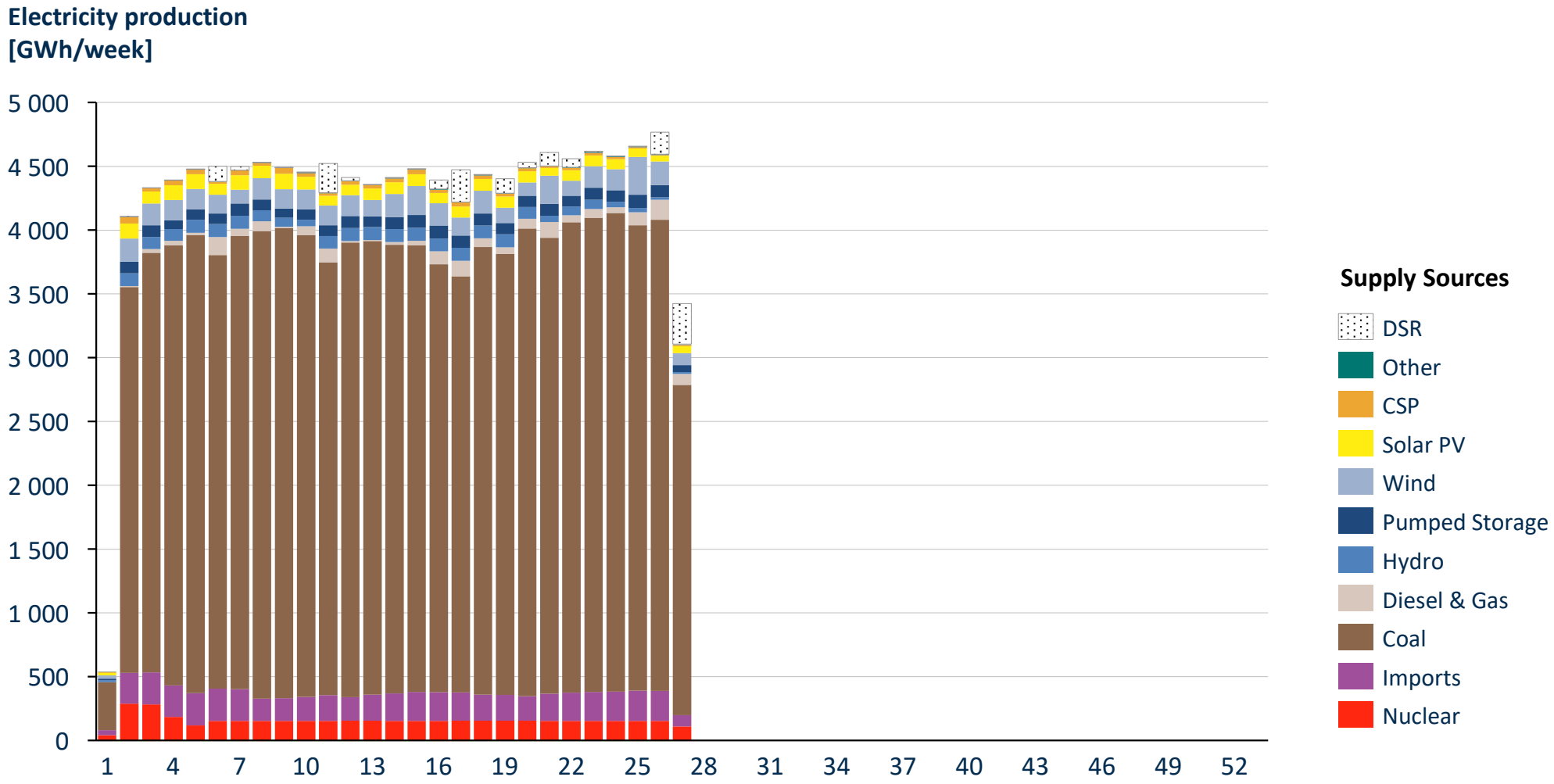
Weekly electricity production for all power supply sources

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



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

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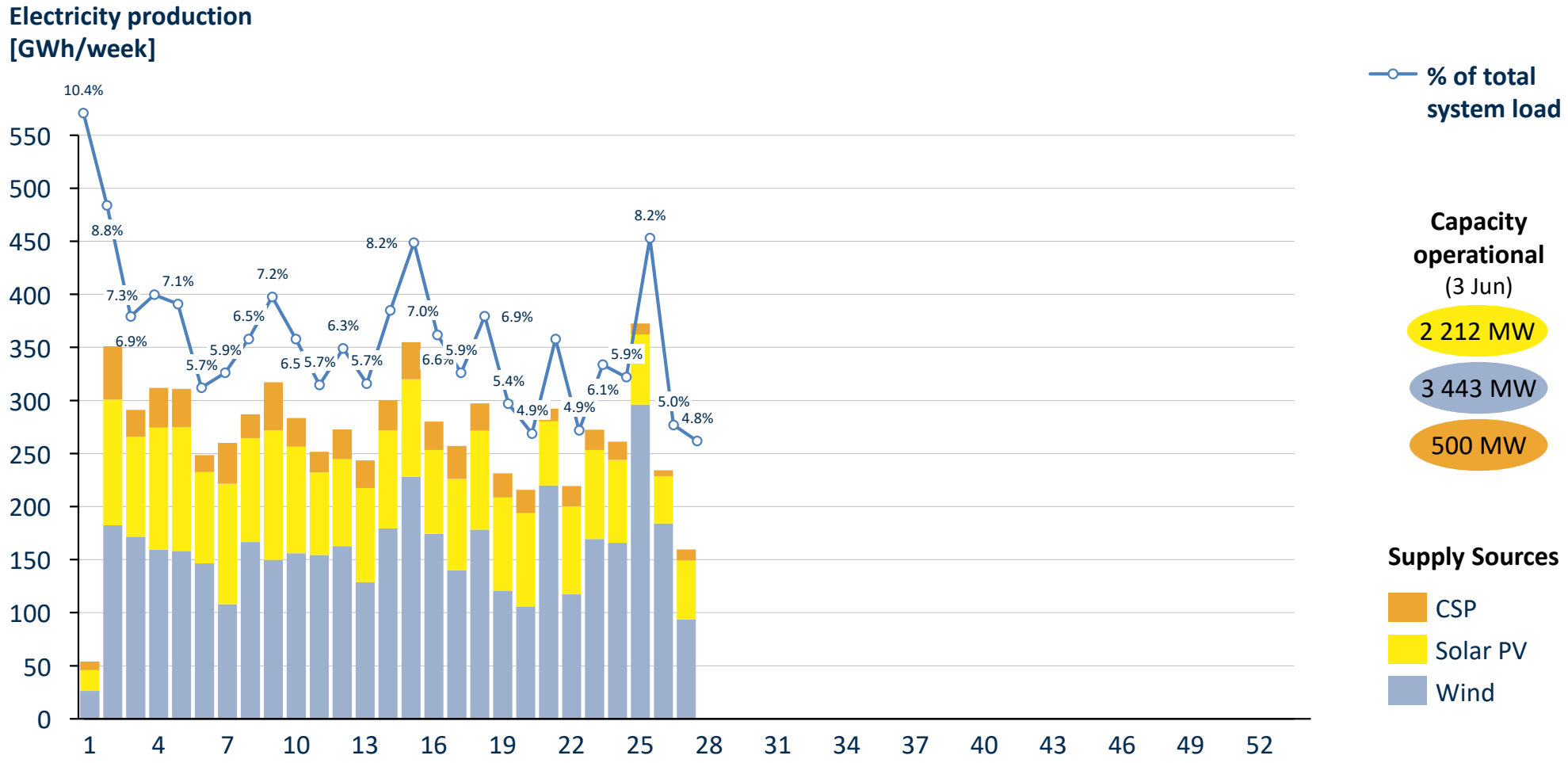
Weekly electricity production of SA's wind, solar PV and CSP fleet

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



- Maximum wind + solar PV + CSP weekly production of 373 GWh in week 25 (19 June – 25 Jun)
- Minimum wind + solar PV + CSP weekly production of 54 GWh in week 1 (3 Jan – 9 Jan)

Sources: Eskom; CSIR Energy Centre analysis

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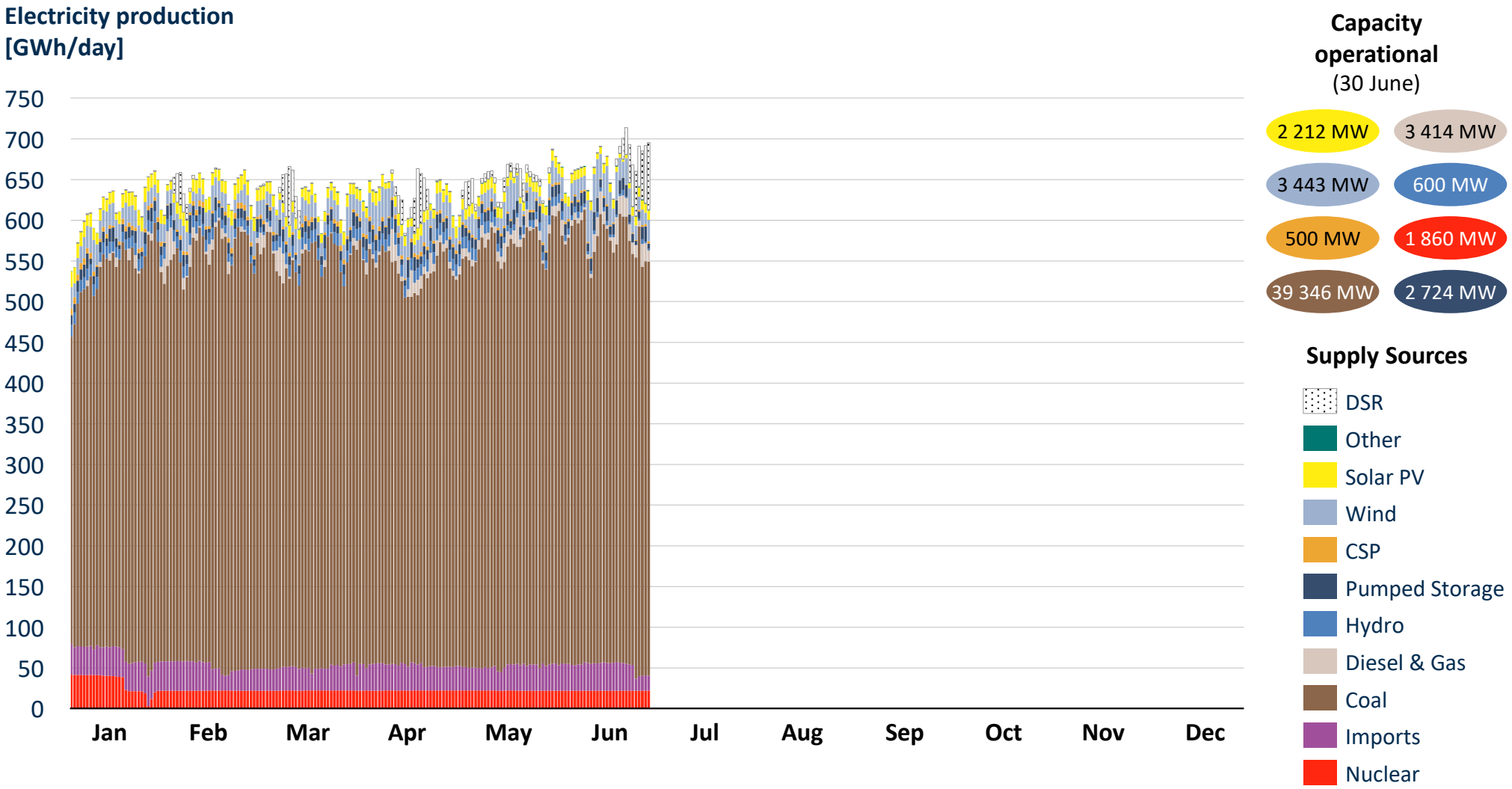
Daily electricity production for all power supply sources

Actual daily production: conventional fleet, wind, solar PV & CSP (Jan-Jun 2022)



Note: Wind includes Eskom's Sere wind plant.
Sources: Eskom; CSIR Energy Centre analysis

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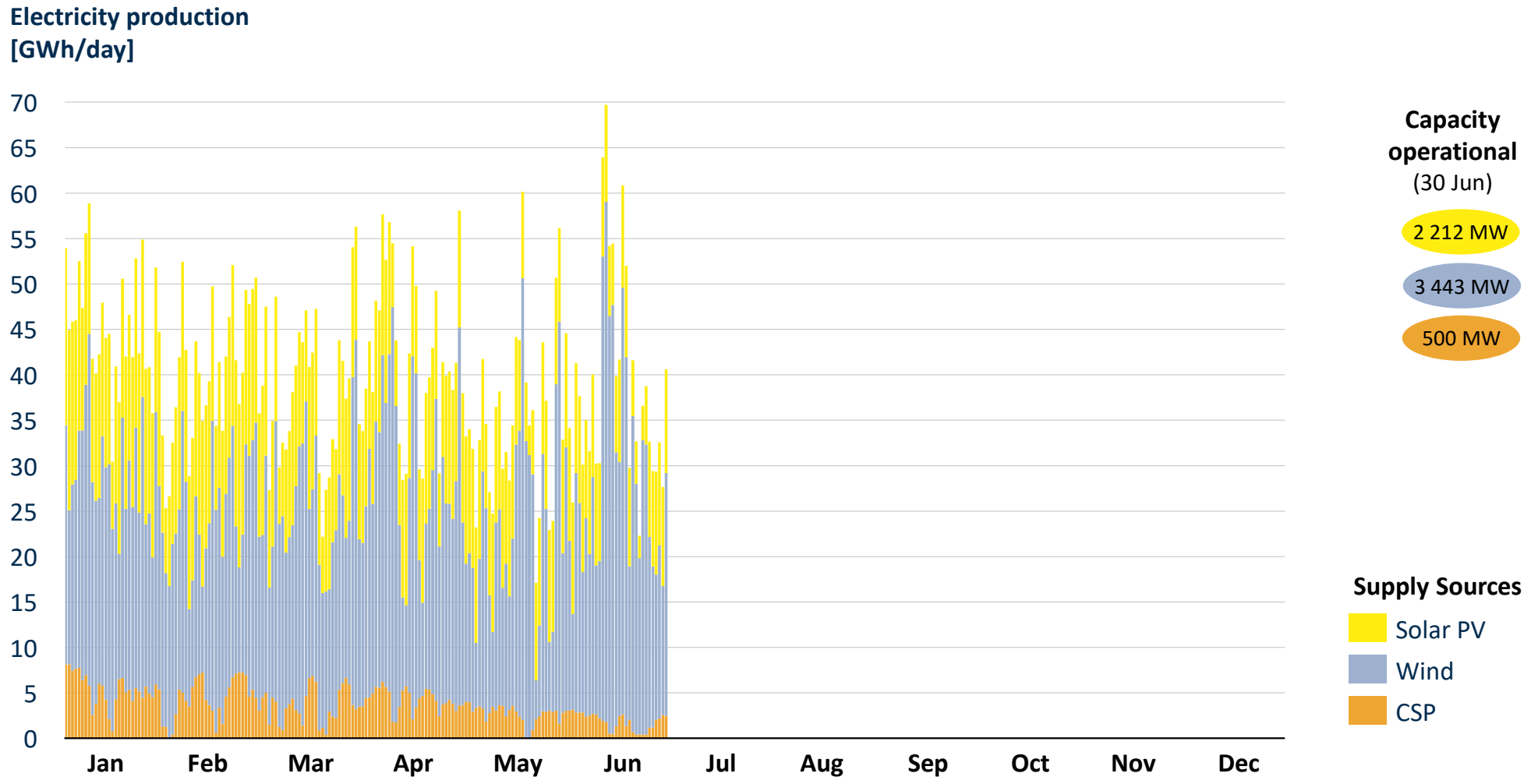
Daily electricity production of wind, solar PV & CSP fleet

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



- Maximum daily production of 70 GWh on 13 Jun 2022 (Monday)
- Minimum daily production of 17 GWh on 23 May 2022 (Monday)

Note: Design as per Fraunhofer ISE.Wind includes Eskom's Sere wind plant.
Sources: Eskom; CSIR Energy Centre analysis

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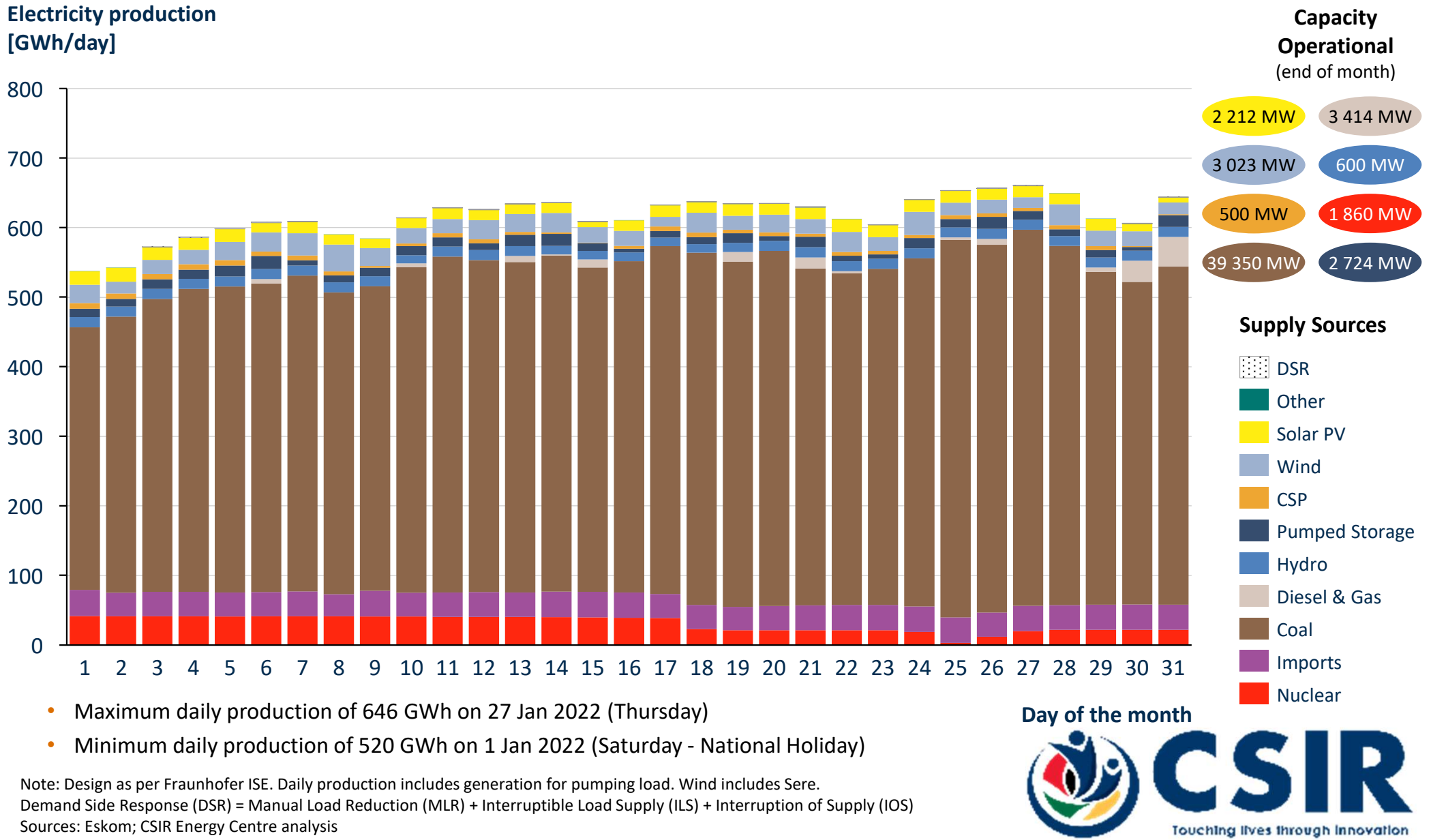
Daily electricity production between 520-646 GWh in Jan 2022

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



- Maximum daily production of 646 GWh on 27 Jan 2022 (Thursday)
- Minimum daily production of 520 GWh on 1 Jan 2022 (Saturday - National Holiday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
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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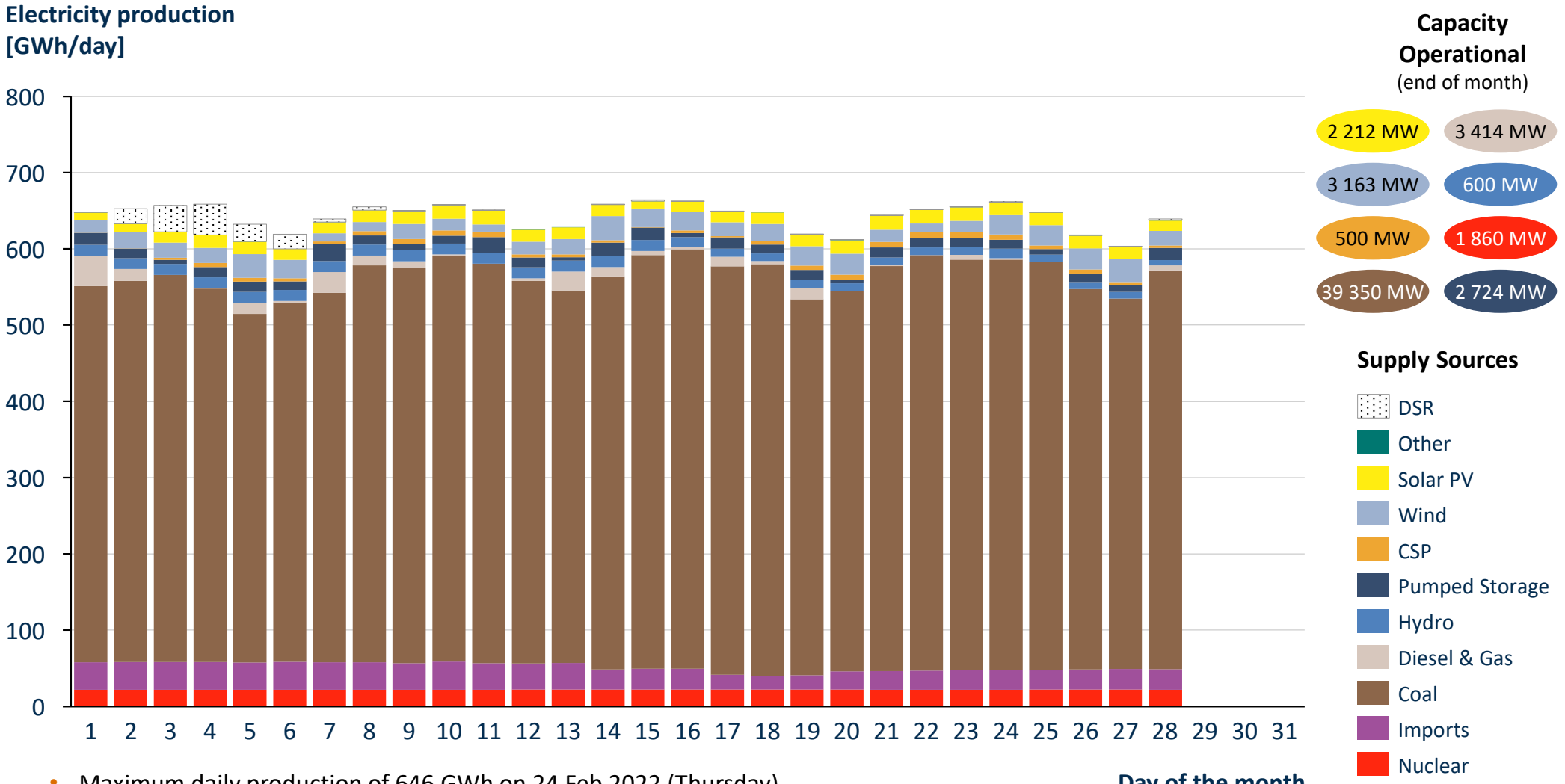
Daily electricity production between 590-646 GWh in Feb 2022

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



- Maximum daily production of 646 GWh on 24 Feb 2022 (Thursday)
- Minimum daily production of 590 GWh on 20 Feb 2022 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
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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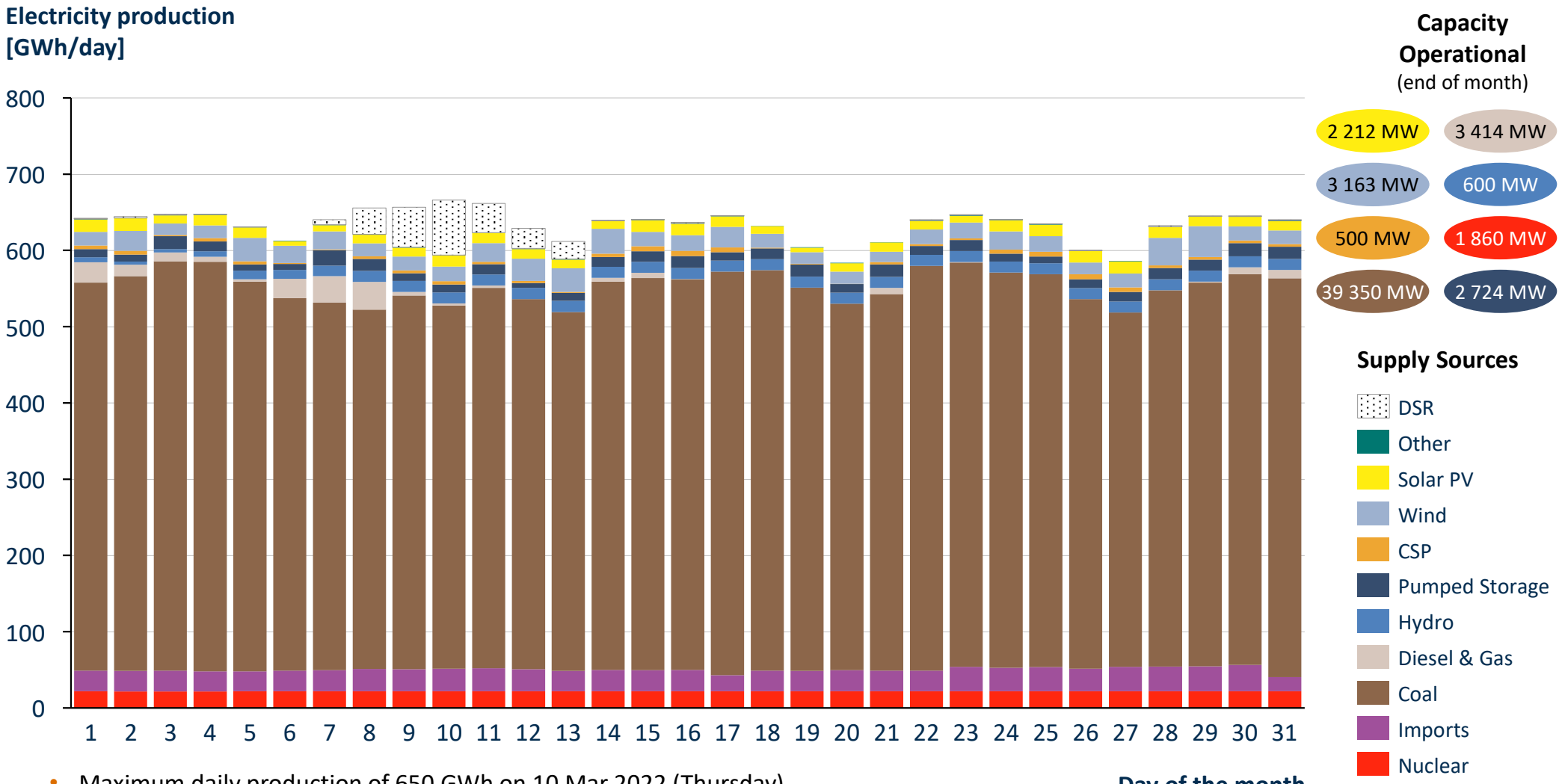
Daily electricity production between 571-650 GWh in Mar 2022

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



- Maximum daily production of 650 GWh on 10 Mar 2022 (Thursday)
- Minimum daily production of 571 GWh on 20 Mar 2022 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

CSIR
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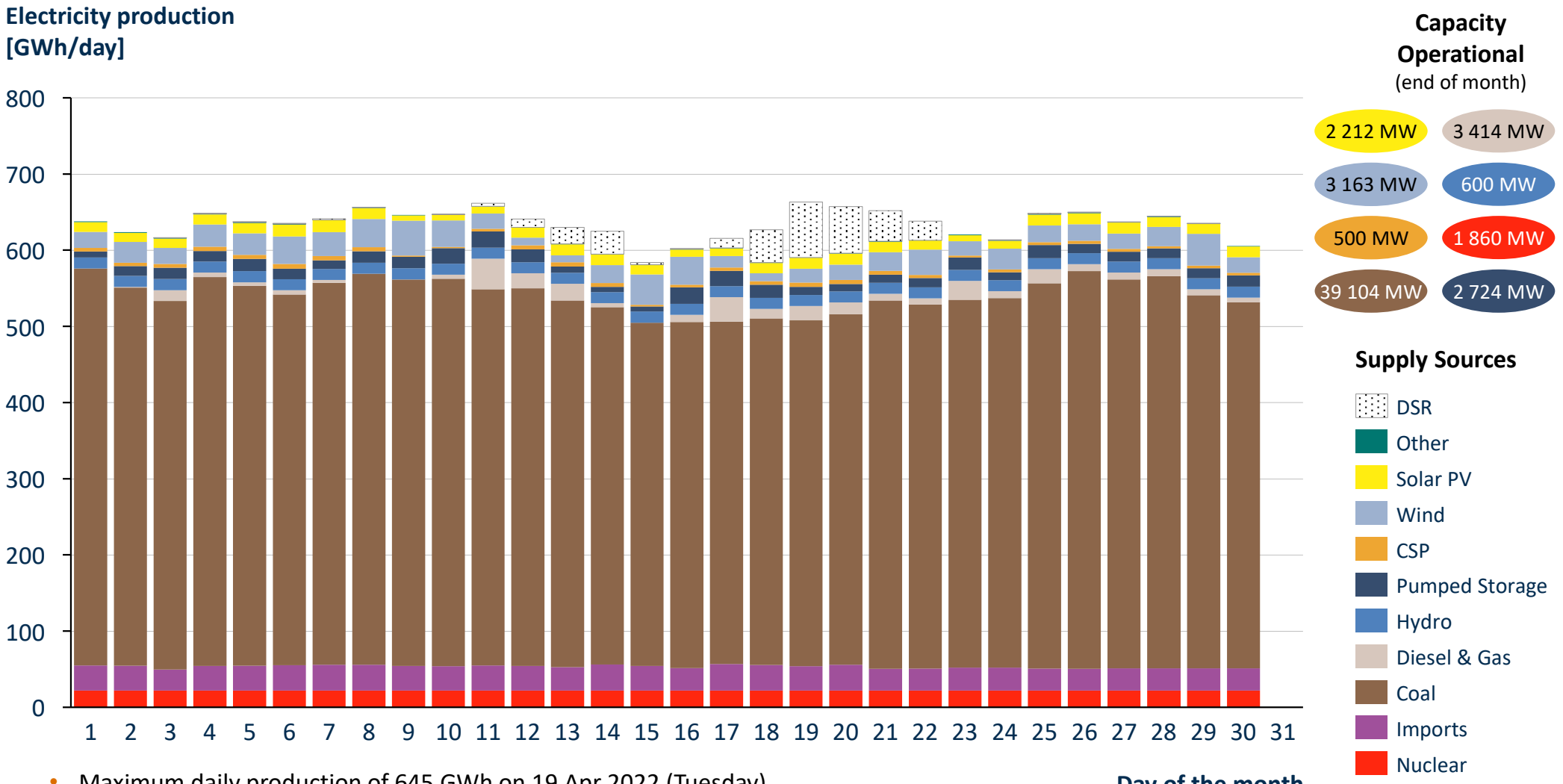
Daily electricity production between 561-645 GWh in Apr 2022

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



- Maximum daily production of 645 GWh on 19 Apr 2022 (Tuesday)
- Minimum daily production of 561 GWh on 15 Apr 2022 (Friday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Demand Side Response (DSR) = Manual Load Reduction (MLR) + Interruptible Load Supply (ILS) + Interruption of Supply (IOS)
Sources: Eskom; CSIR Energy Centre analysis

CSIR
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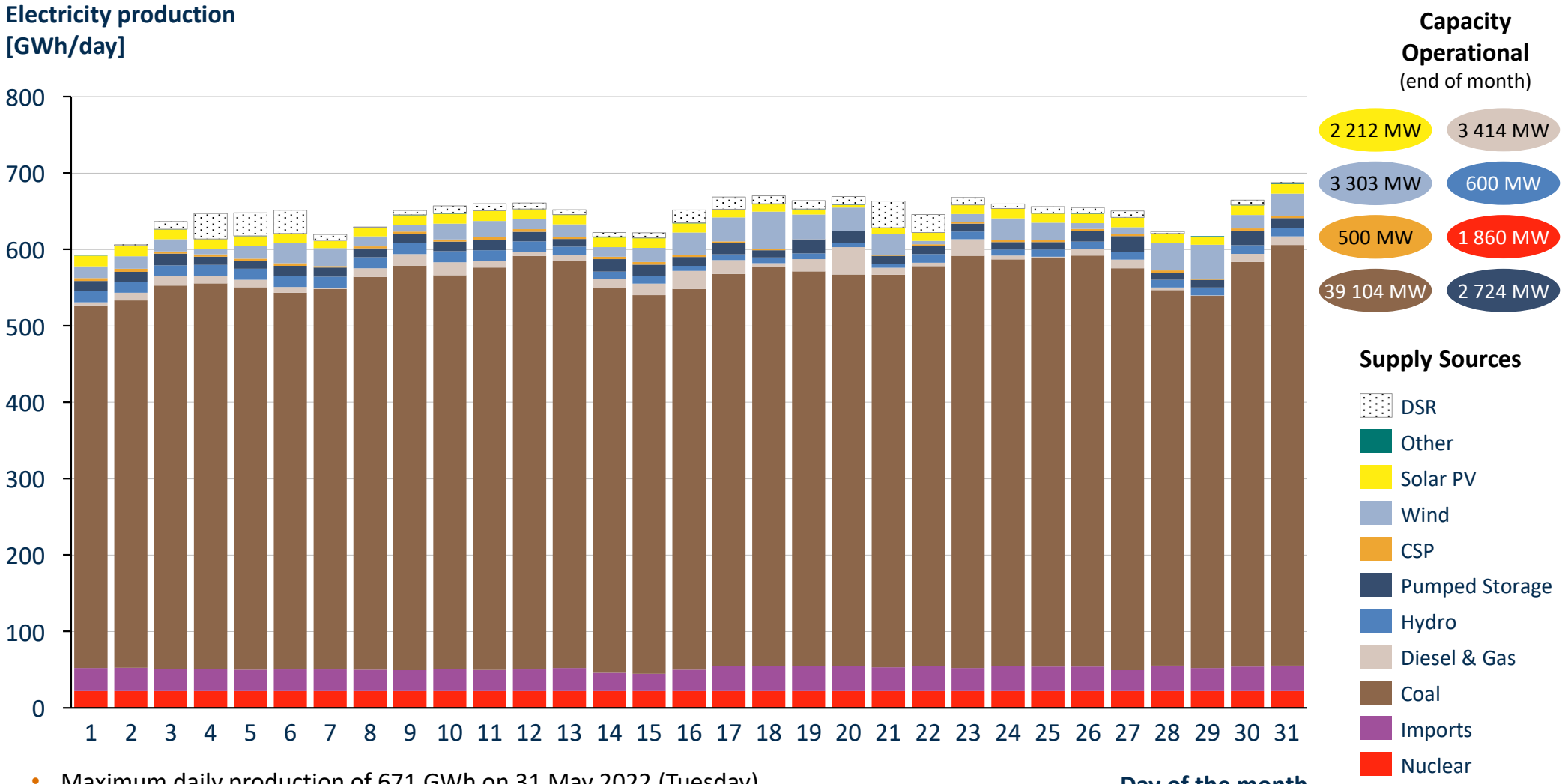
Daily electricity production between 573-671 GWh in May 2022

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



- Maximum daily production of 671 GWh on 31 May 2022 (Tuesday)
- Minimum daily production of 573 GWh on 1 May 2022 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
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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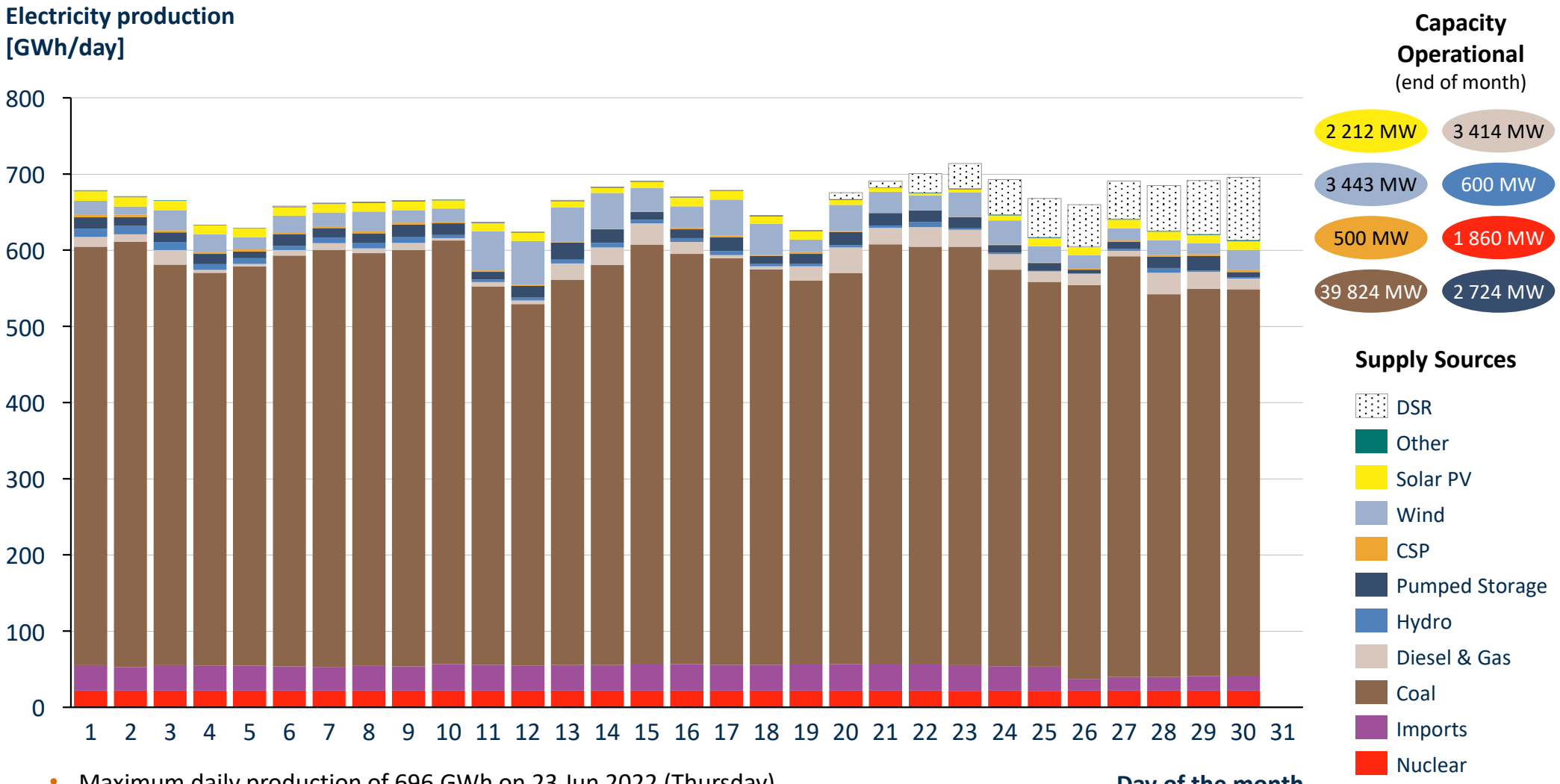
Daily electricity production between 605-696 GWh in Jun 2022

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



- Maximum daily production of 696 GWh on 23 Jun 2022 (Thursday)
- Minimum daily production of 605 GWh on 12 Jun 2022 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
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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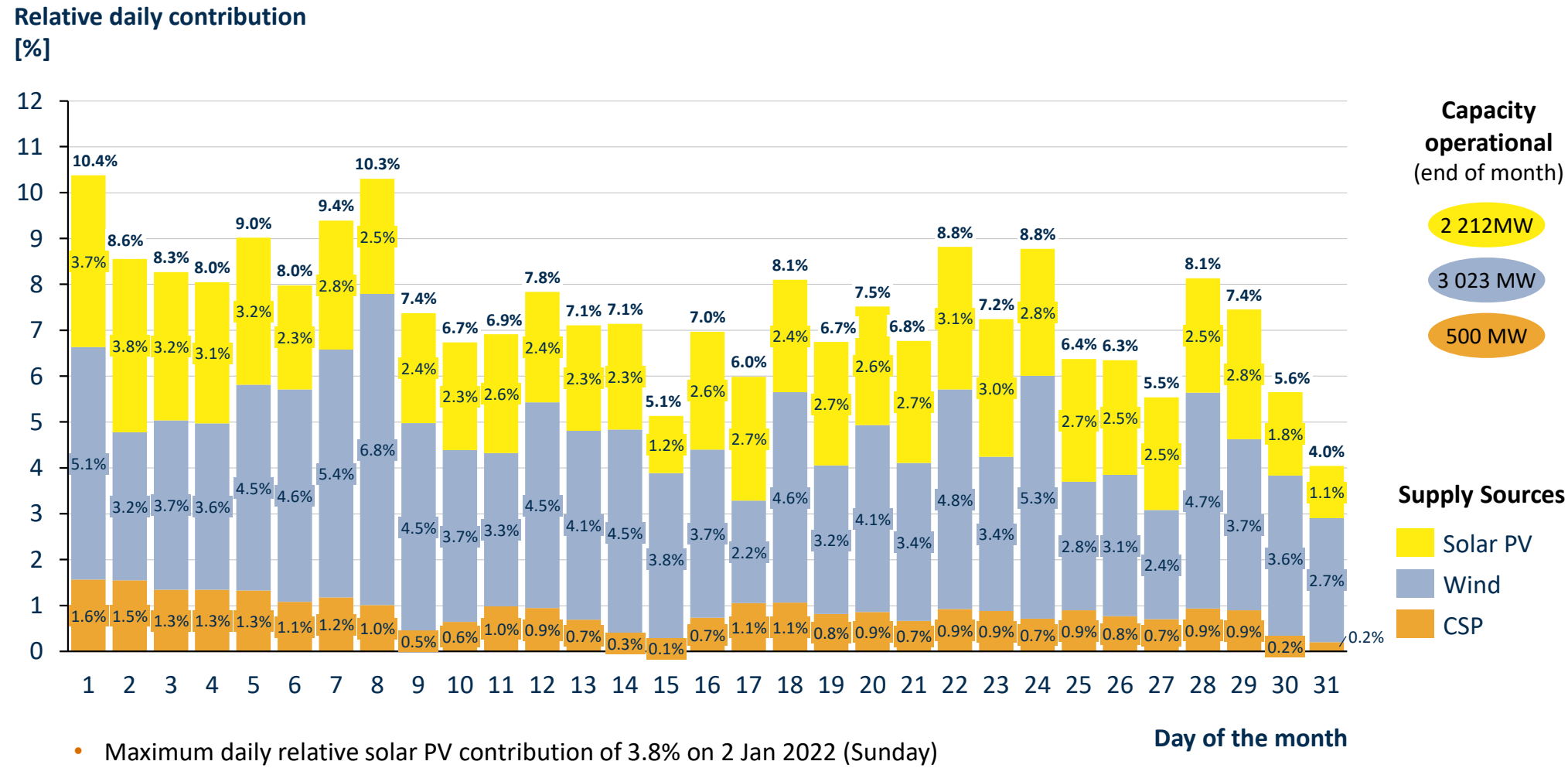
Daily solar PV, wind & CSP contribution of 4.0-10.4% in Jan 2022

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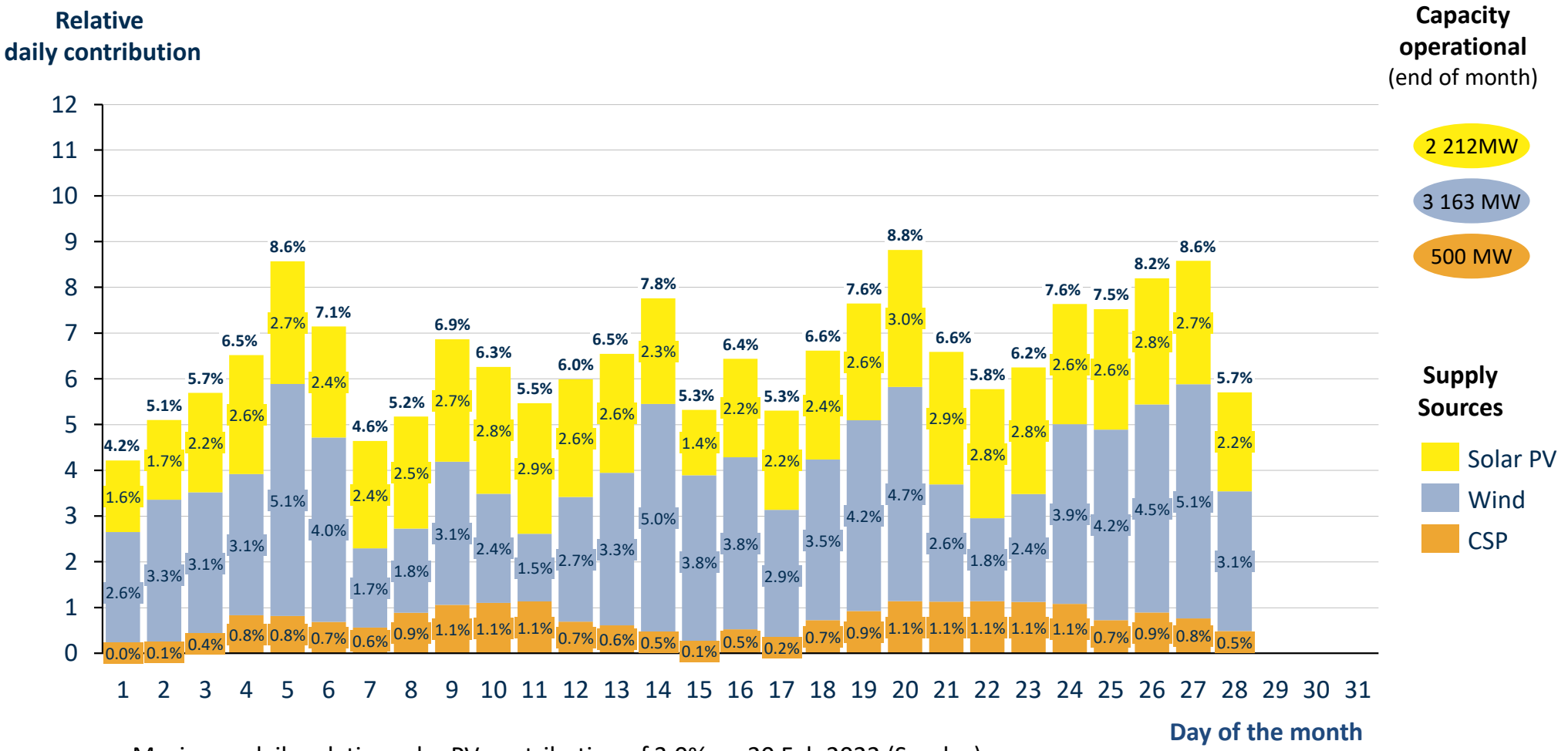
Daily solar PV, wind & CSP contribution of 4.2-8.8% in Feb 2022

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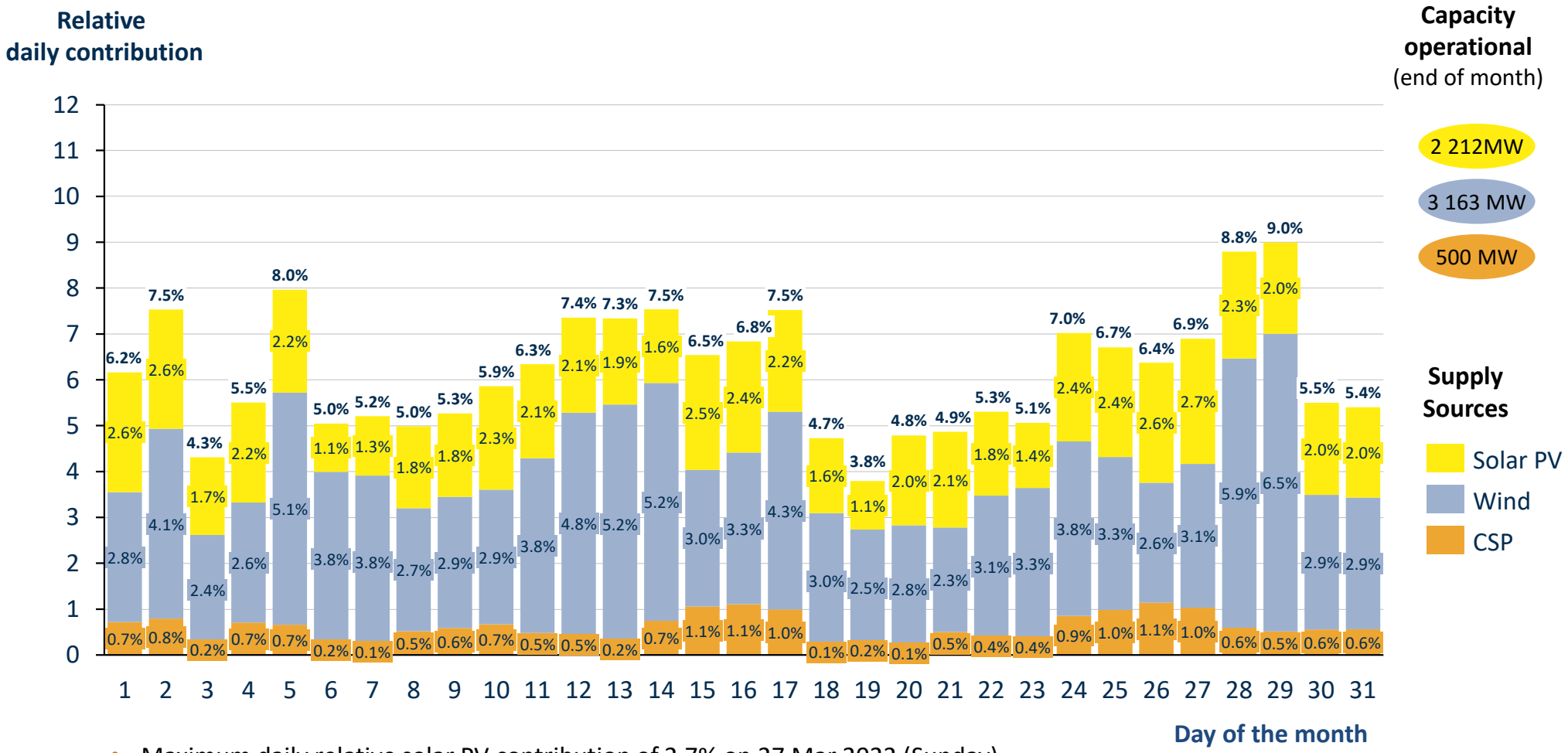
Daily solar PV, wind & CSP contribution of 3.8-9.0% in Mar 2022

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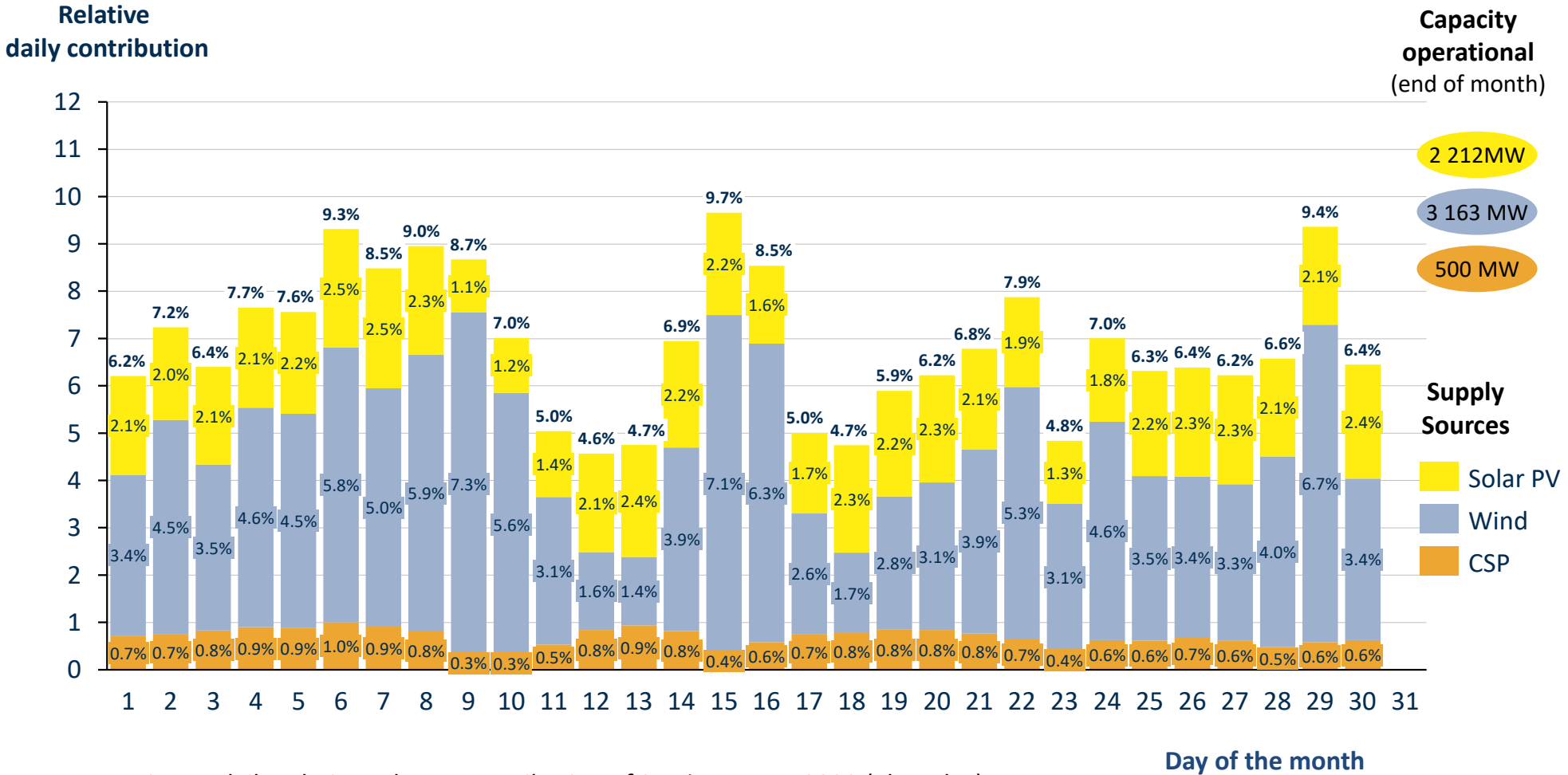
Daily solar PV, wind & CSP contribution of 4.6-9.7% in Apr 2022

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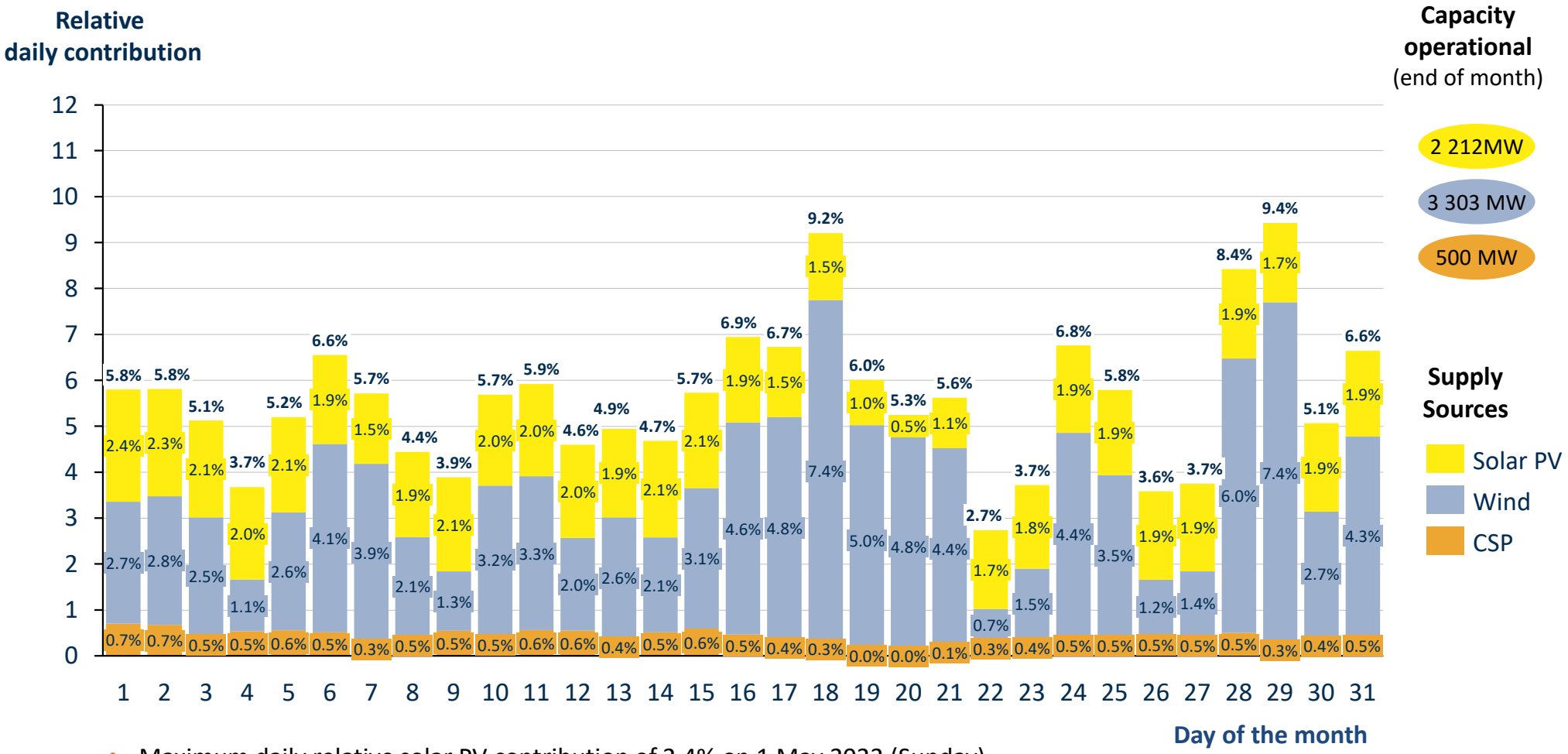
Daily solar PV, wind & CSP contribution of 2.7-9.4% in May 2022

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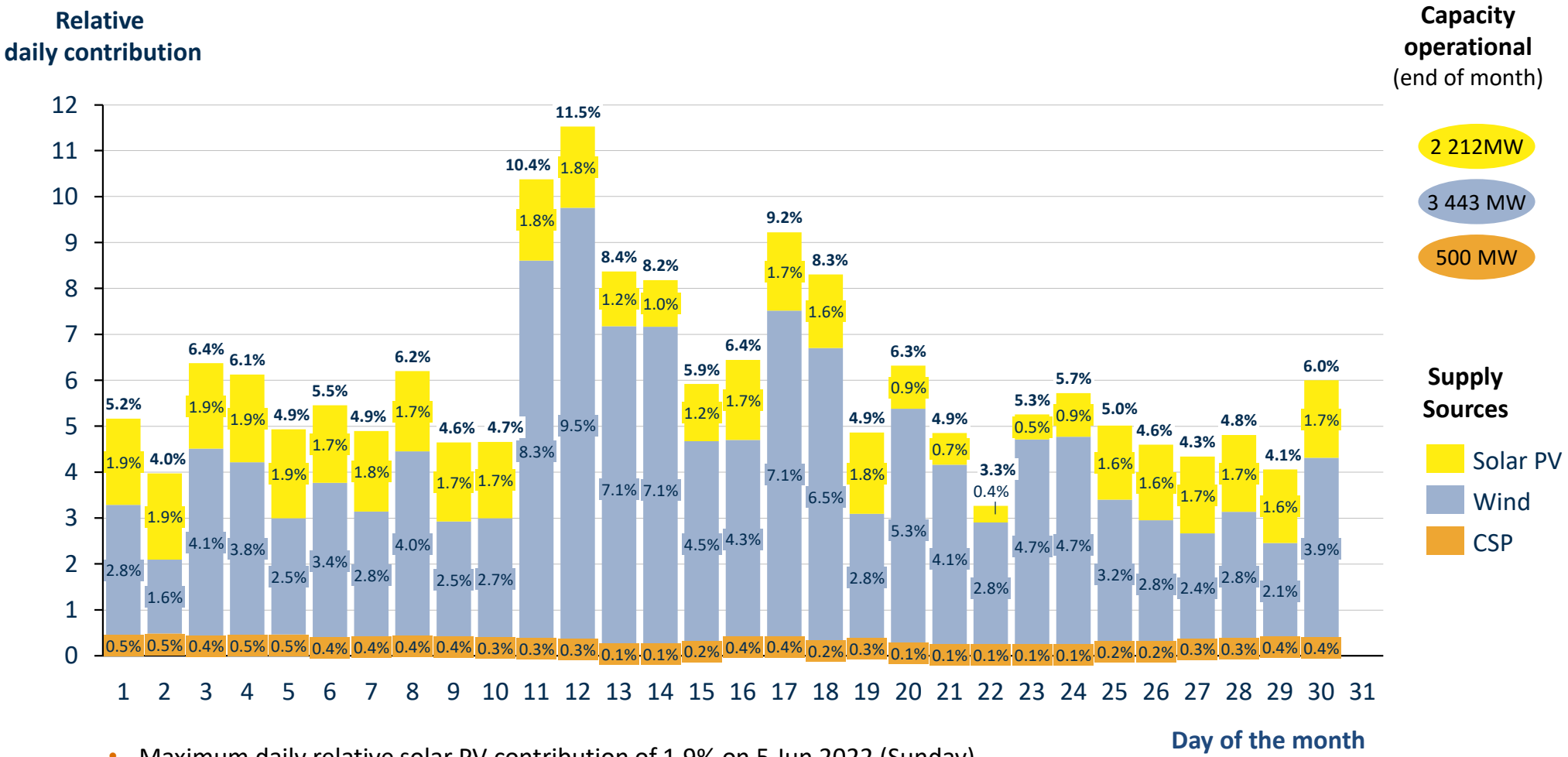
Daily solar PV, wind & CSP contribution of 3.3-11.5% in Jun 2022

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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Agenda

1 Overview actual electricity production (2022 – H1)

2 Monthly electricity production (2022 – H1)

3 Weekly electricity production (2022 – H1)

4 Daily electricity production (2022 – H1)

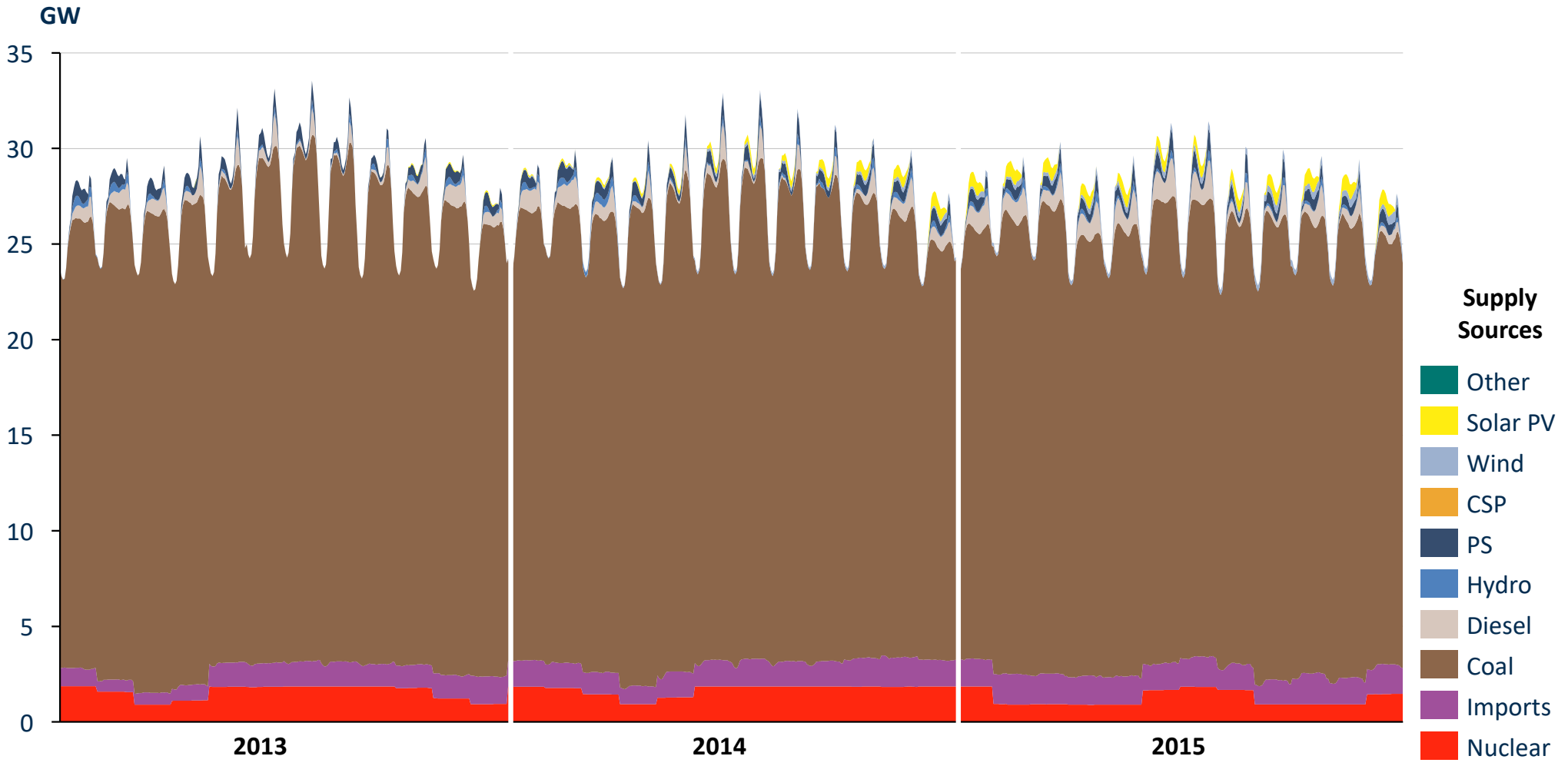
5 Hourly electricity production (2022 – H1)

6 Actual load shedding (2022 – up until September)

7 Other power system statistics (2022 – up until September)

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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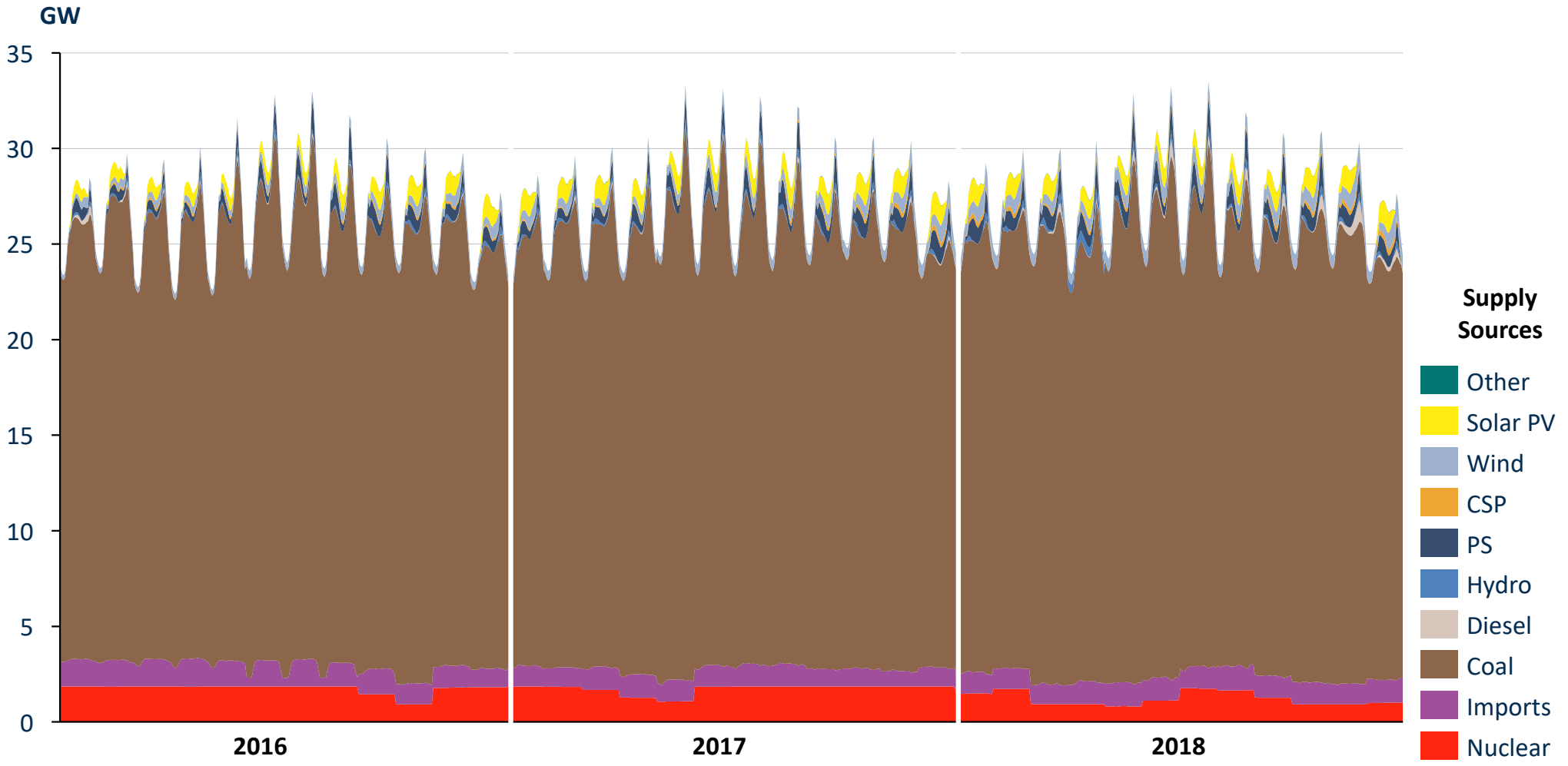
Diurnal Courses of electricity supply sources in RSA

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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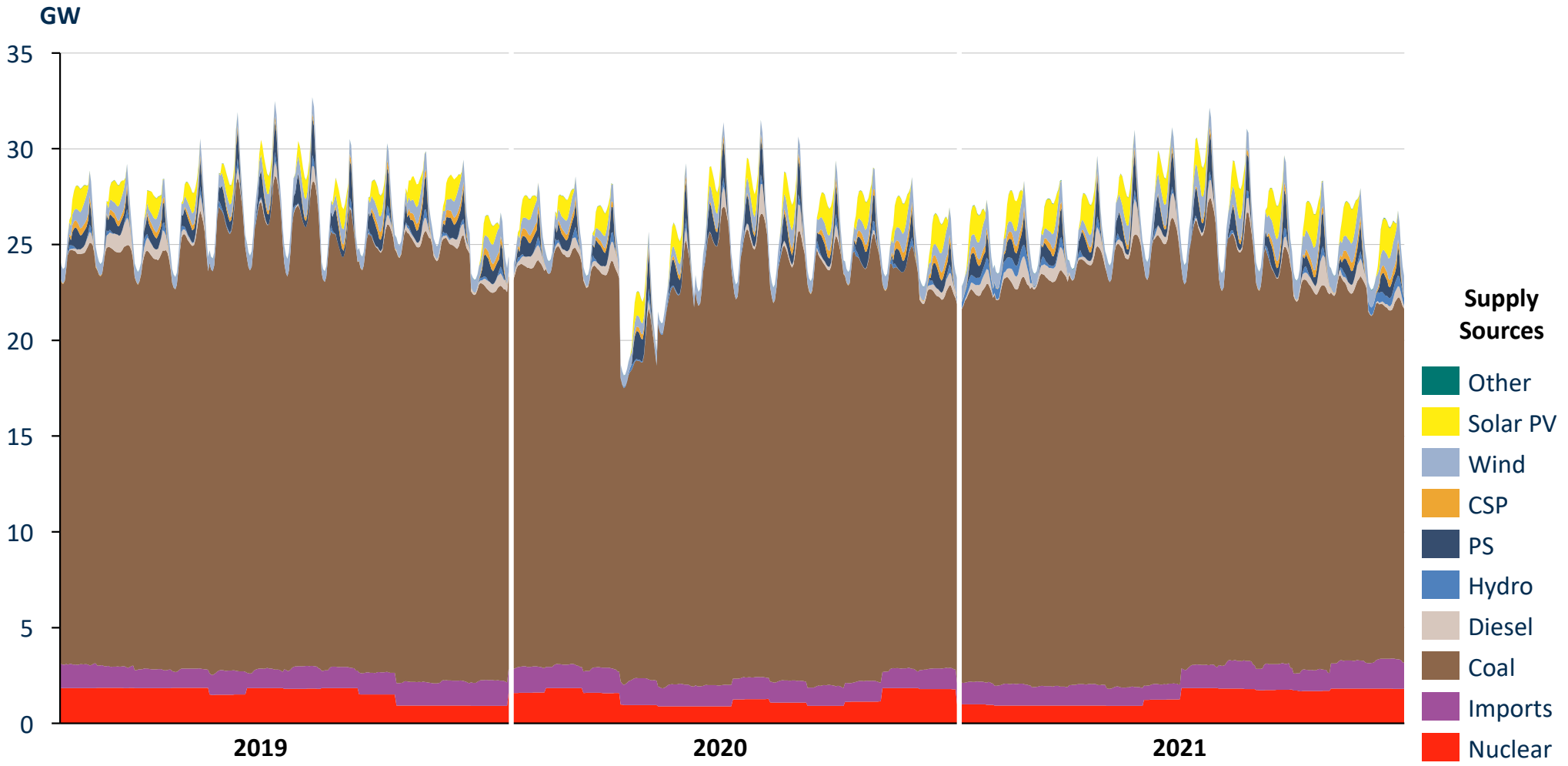
Diurnal Courses of electricity supply sources in RSA

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



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

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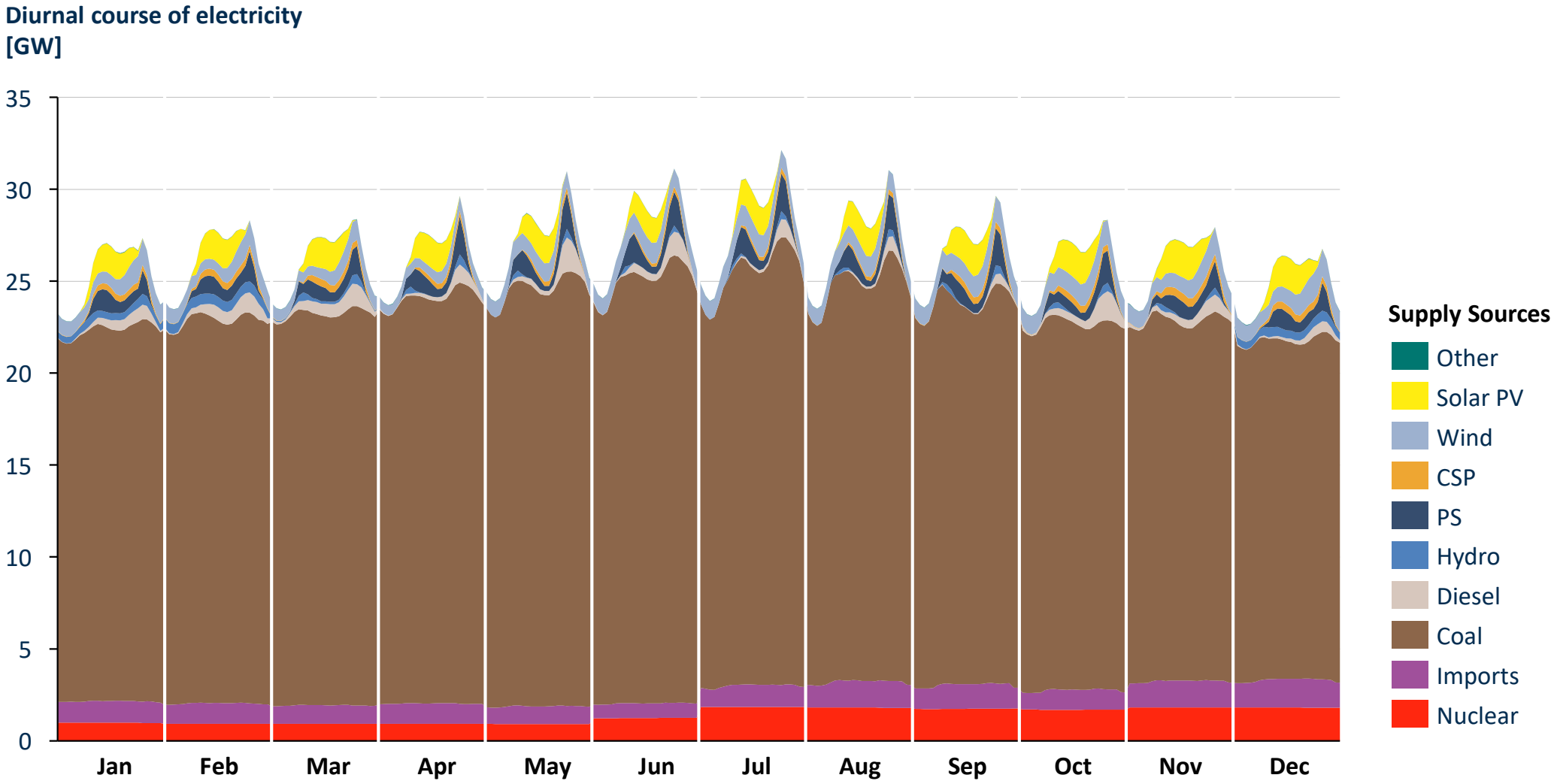
Diurnal Courses of electricity supply sources in RSA in 2021

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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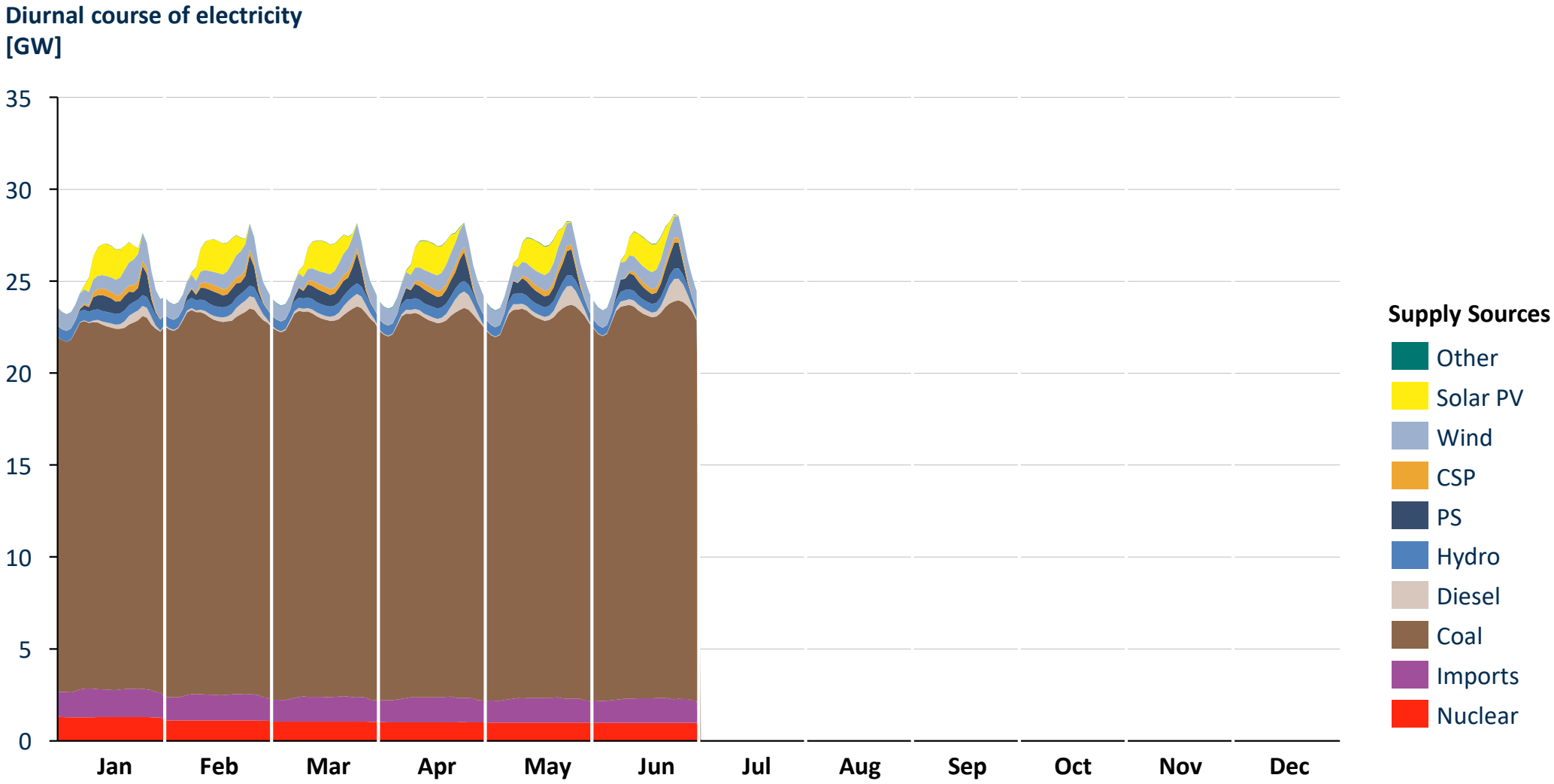
Diurnal Courses of electricity supply sources in RSA in H1-2022

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



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

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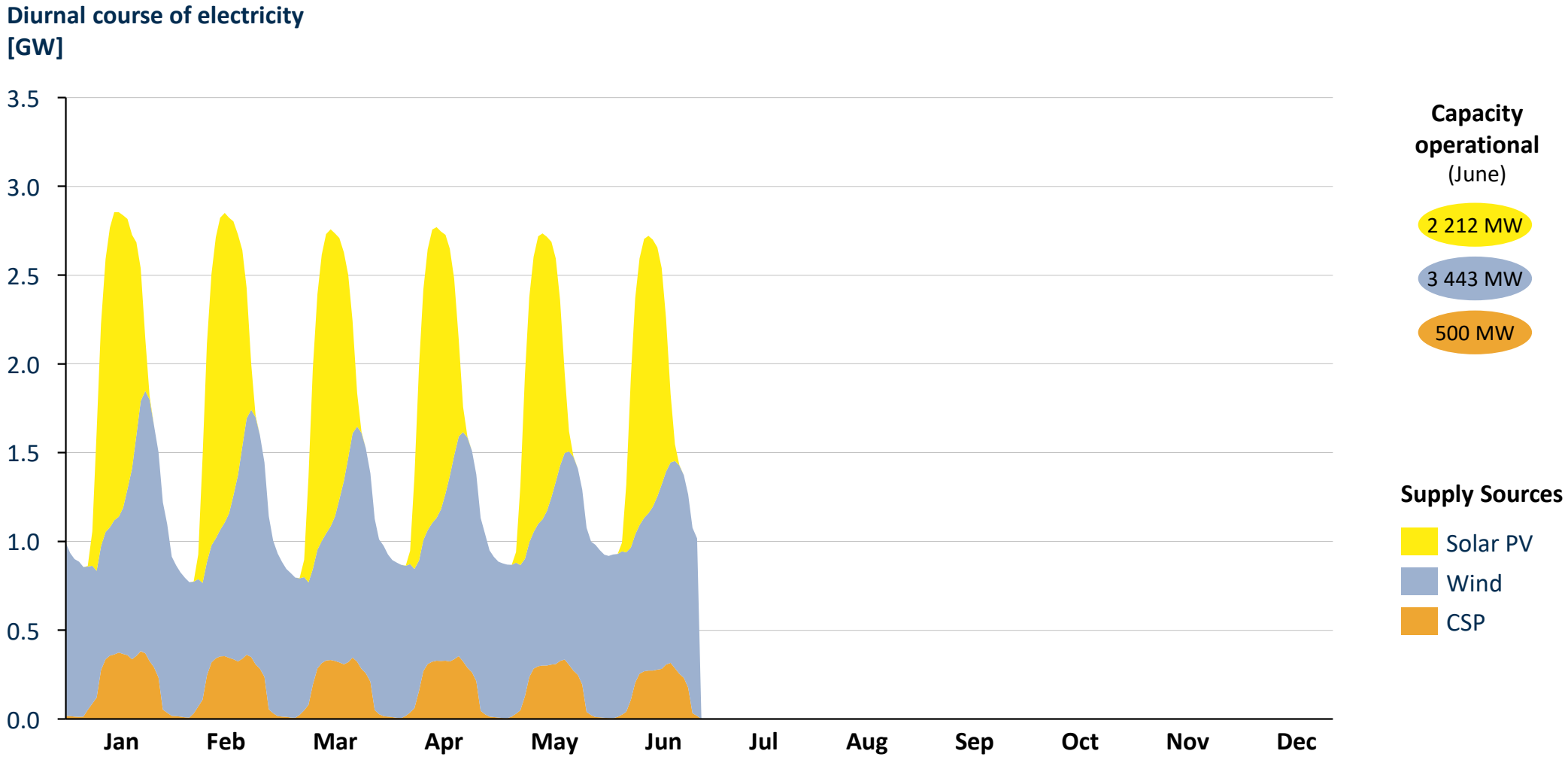
Diurnal Courses for renewable energy supply

Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for the months Jan-Jun 2022



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

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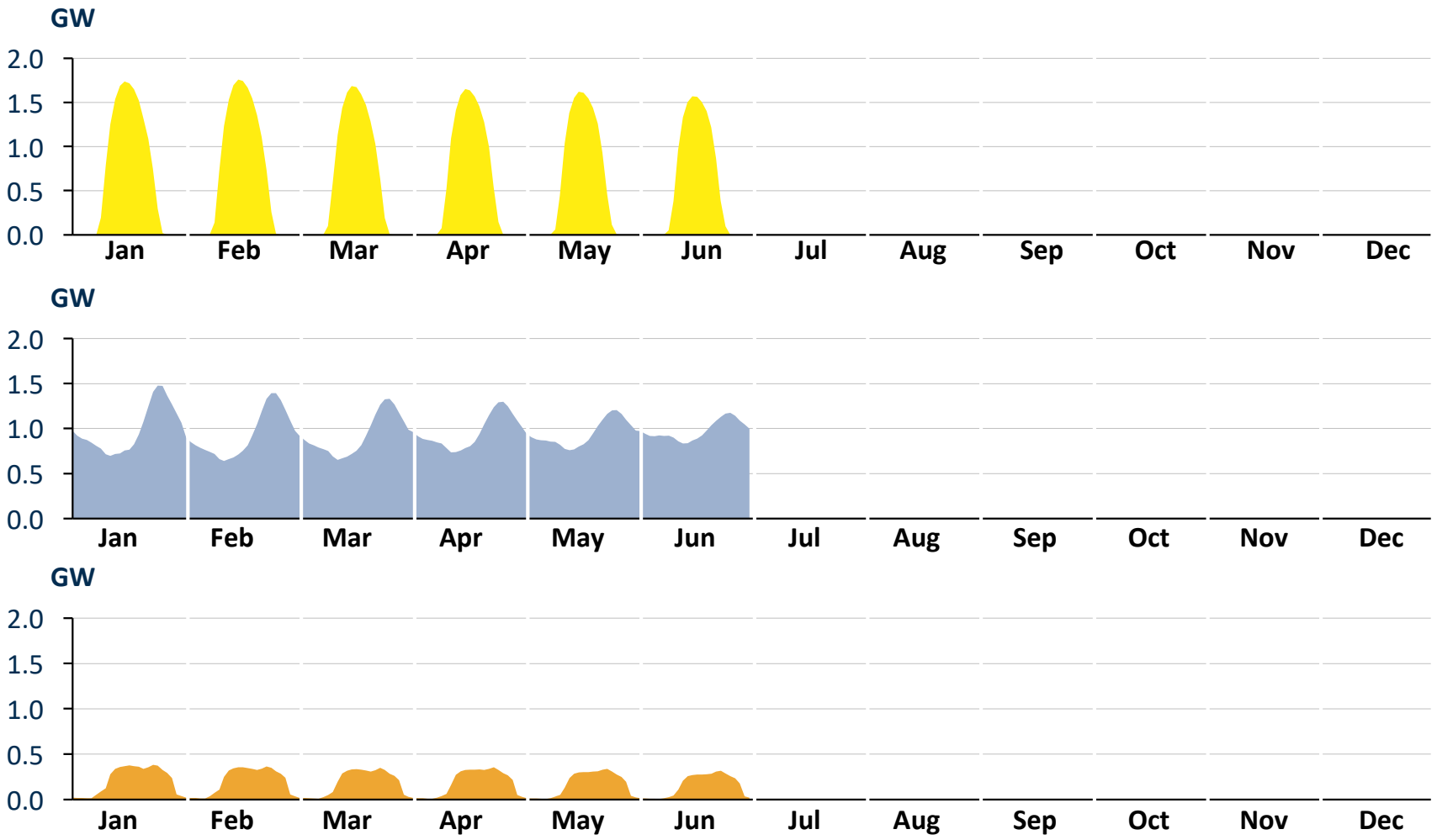
Diurnal Courses for renewable energy supply

Actual monthly average diurnal courses of solar PV, wind & CSP in RSA from Jan-Jun 2022



Capacity operational (H1)

2 212 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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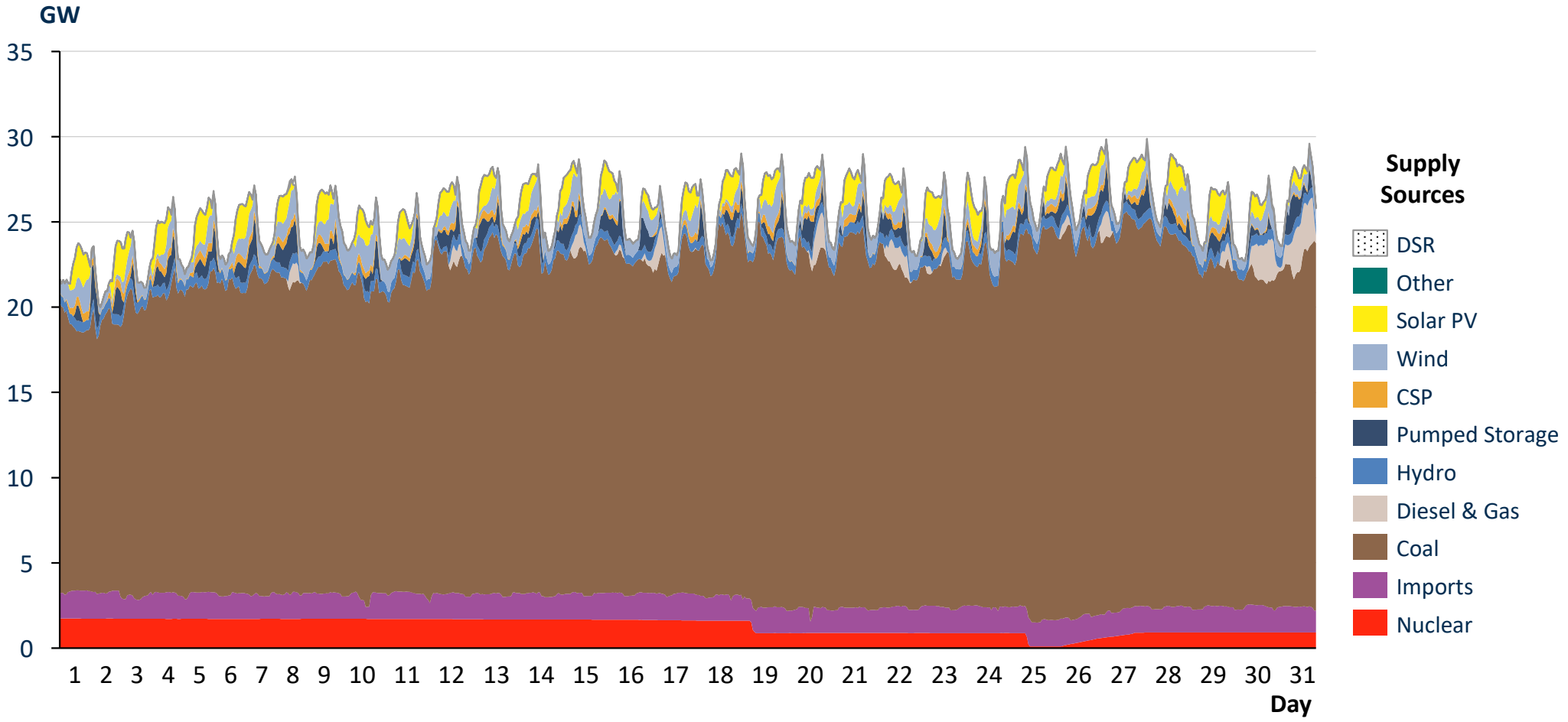
Hourly electricity production in Jan 2022

Actual hourly production from all power supply sources in RSA for January 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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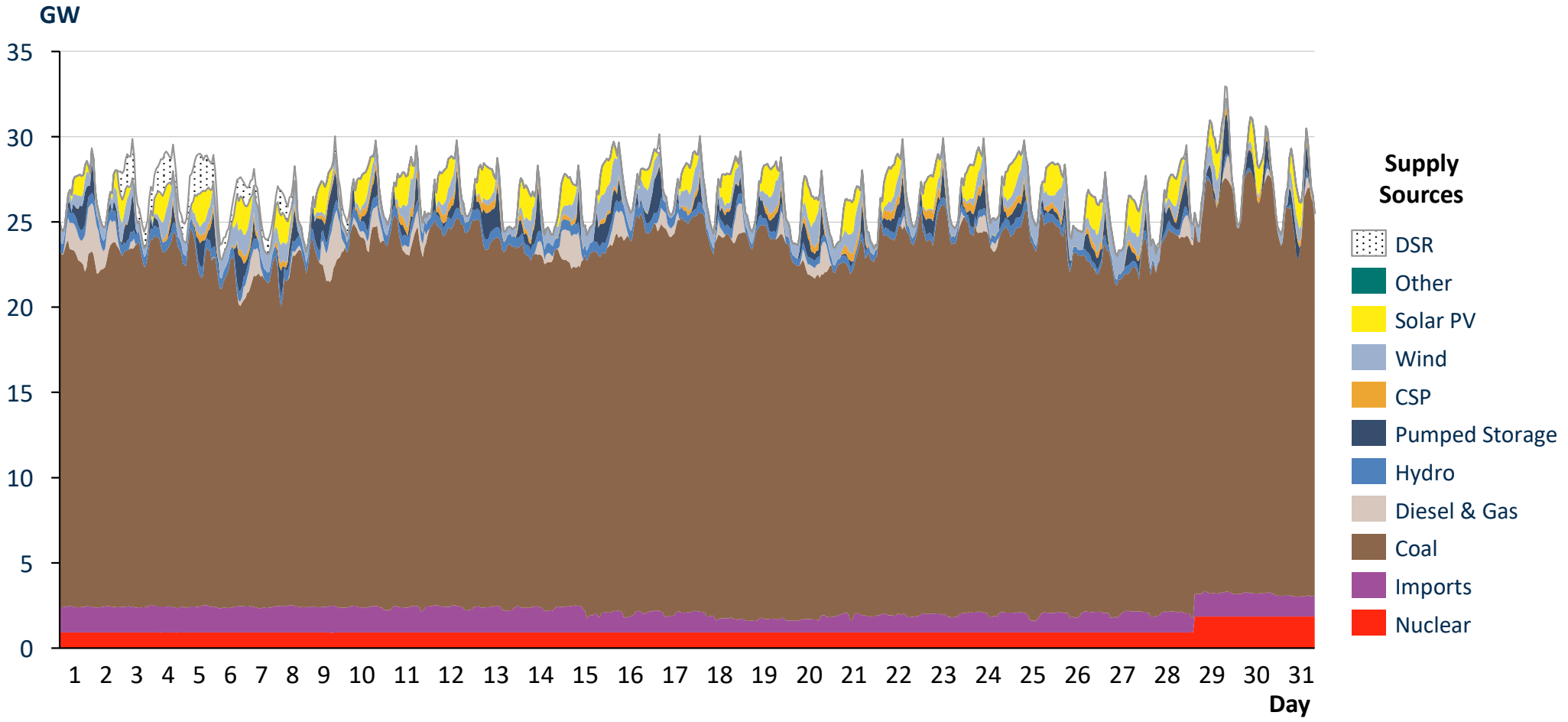
Hourly electricity production in Feb 2022

Actual hourly production from all power supply sources in RSA for February 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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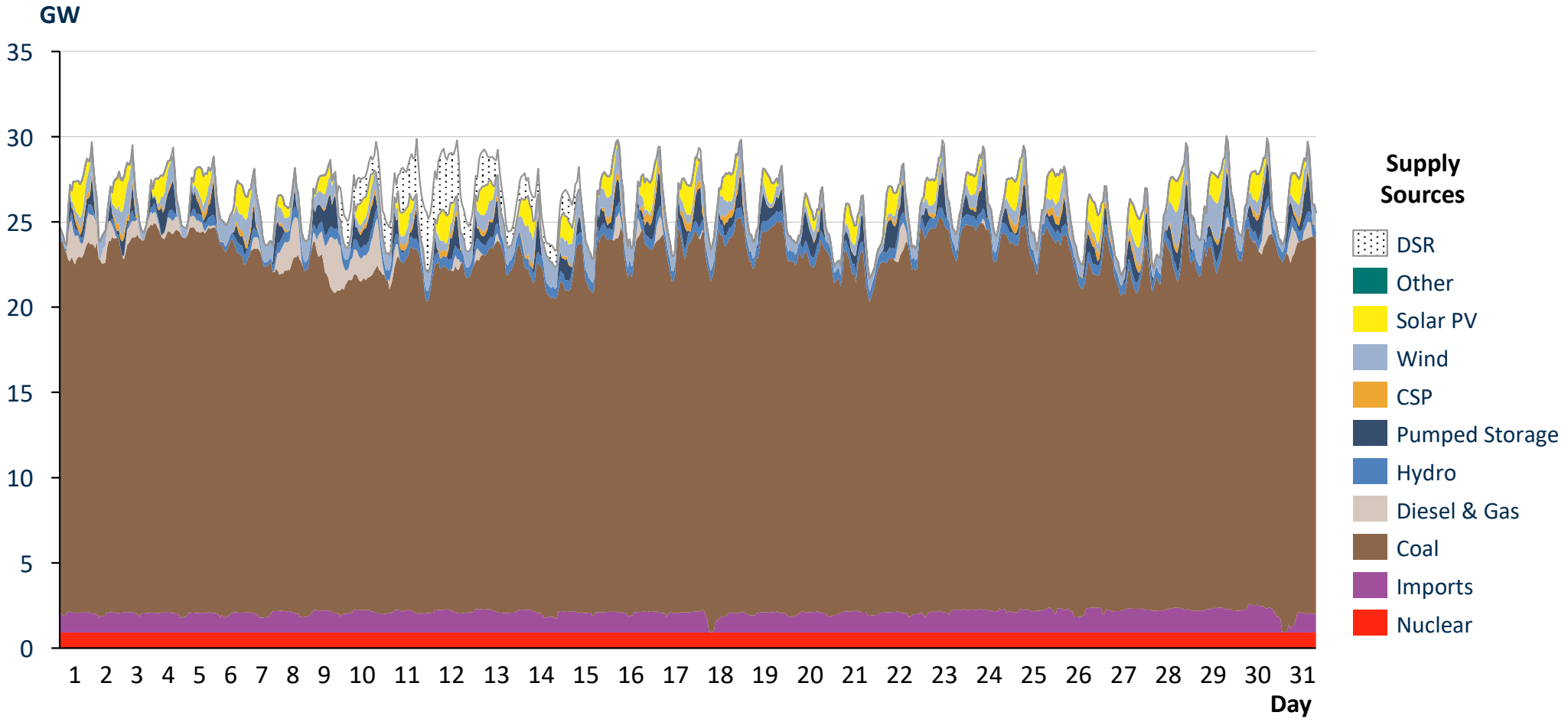
Hourly electricity production in Mar 2022

Actual hourly production from all power supply sources in RSA for March 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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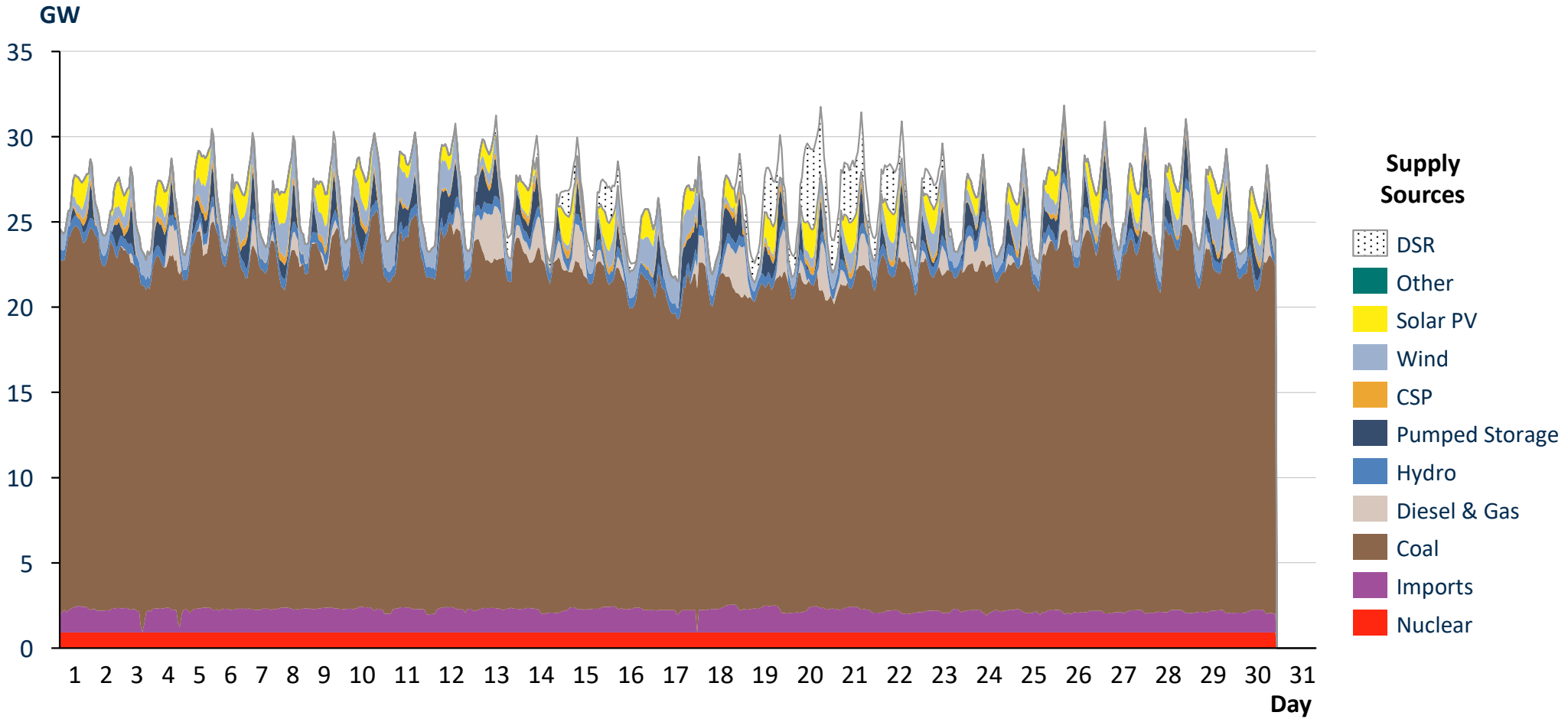
Hourly electricity production in Apr 2022

Actual hourly production from all power supply sources in RSA for April 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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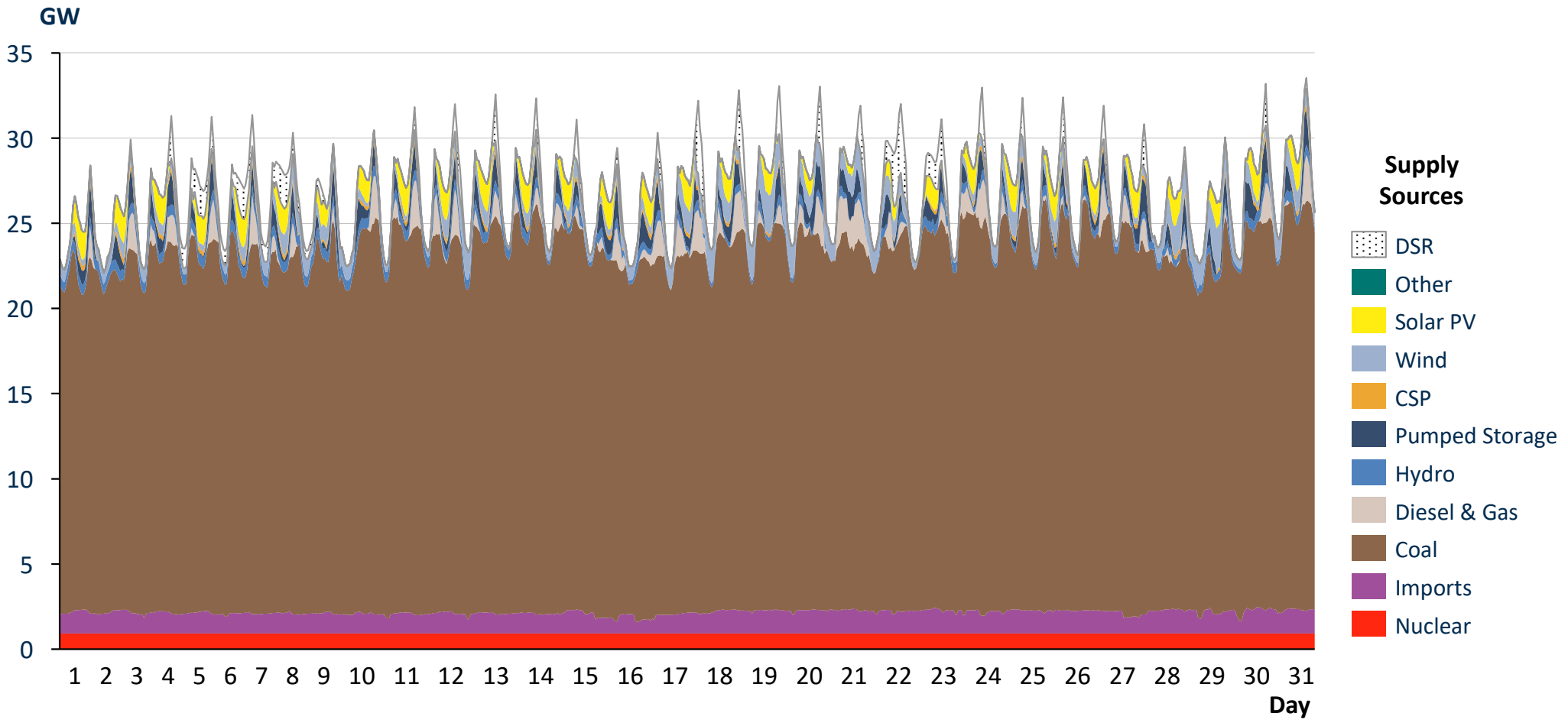
Hourly electricity production in May 2022

Actual hourly production from all power supply sources in RSA for May 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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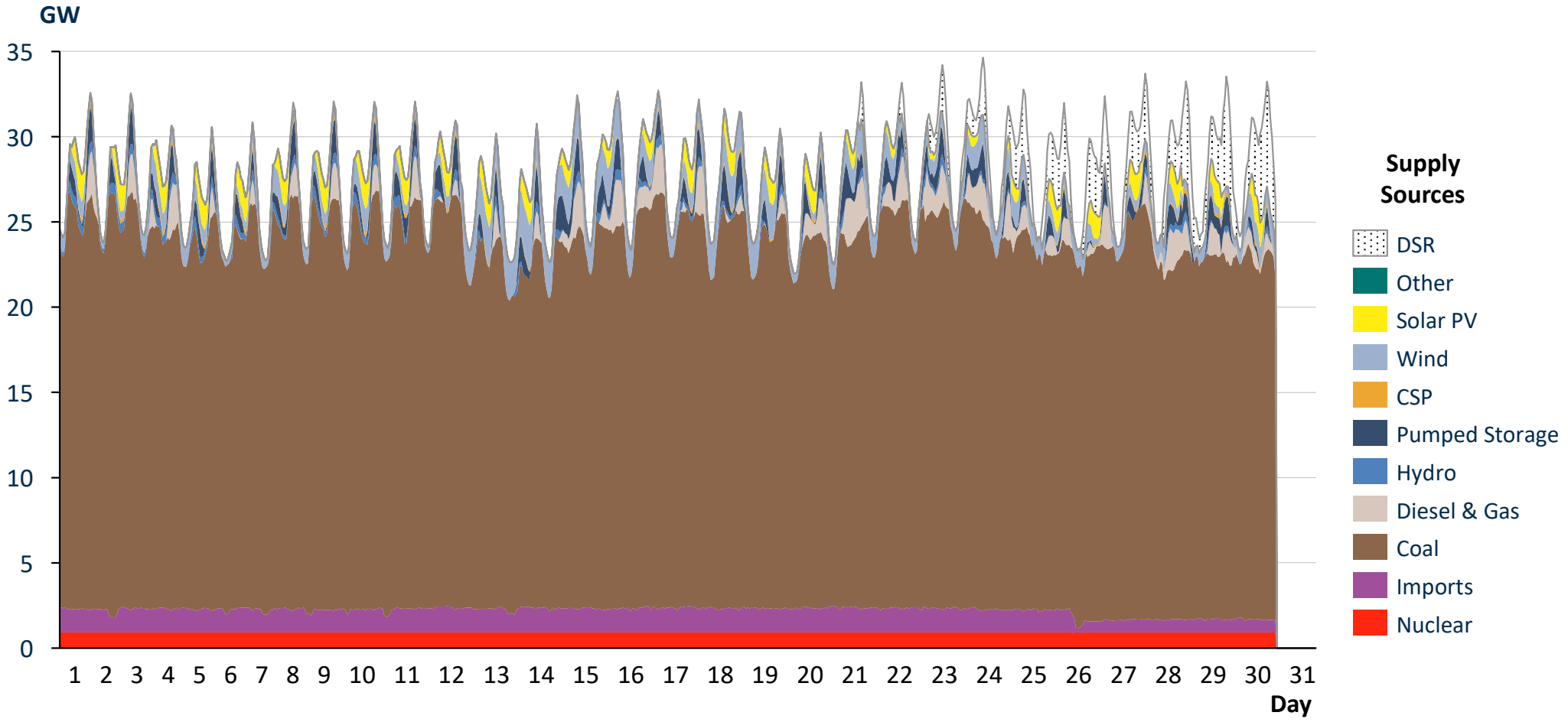
Hourly electricity production in Jun 2022

Actual hourly production from all power supply sources in RSA for June 2022



Note: Daily production includes generation for pumping load. Wind includes Sere.
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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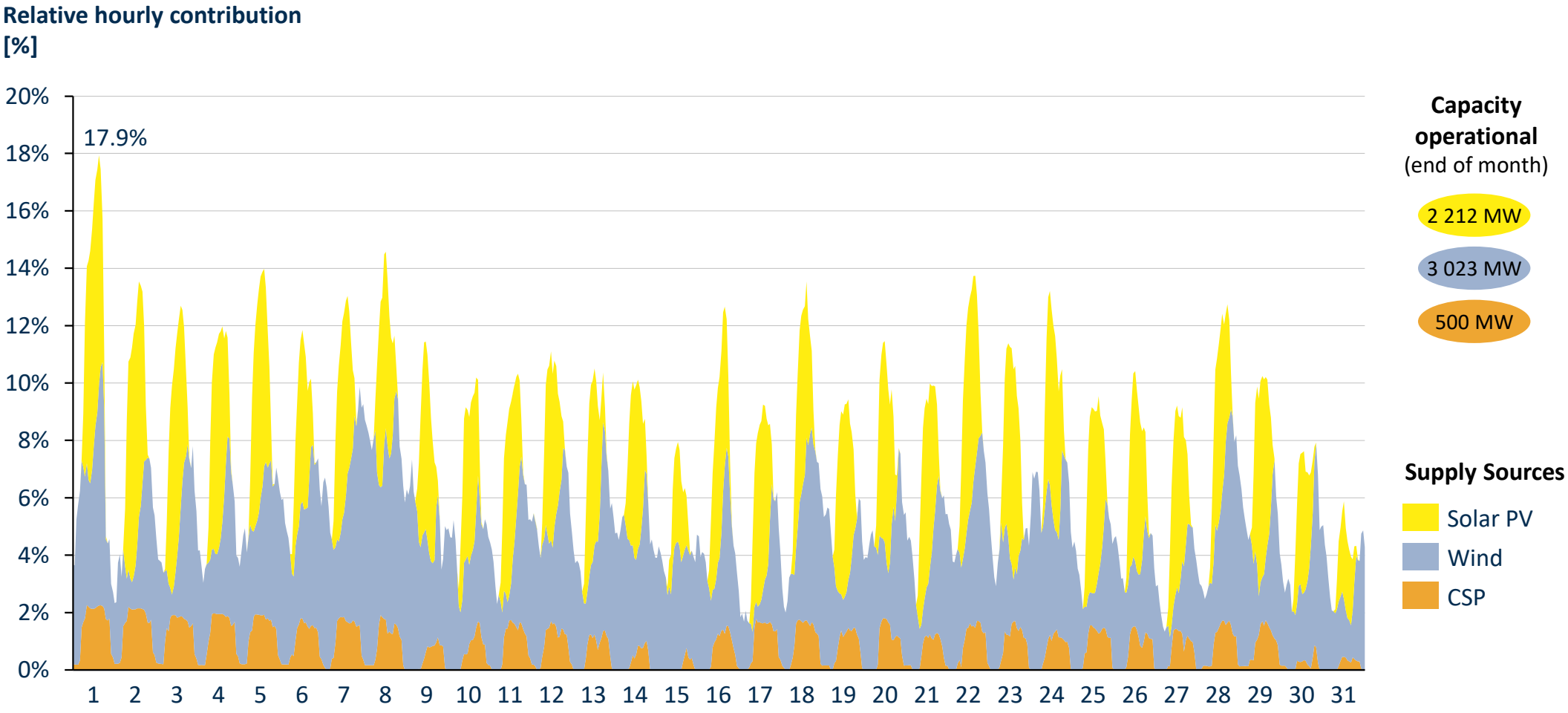
Hourly solar PV, wind & CSP contribution of 1.3-17.9% in Jan 2022

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



- Solar PV maximum relative contribution of 8.6% between 13h00 and 14h00 on 1 Jan 2022
- Wind maximum relative contribution of 8.9% between 23h00 and 24h00 on 8 Jan 2022
- CSP maximum relative contribution of 2.3% between 08h00 and 9h00 on 1 Jan 2022

Sources: Eskom; CSIR Energy Centre analysis

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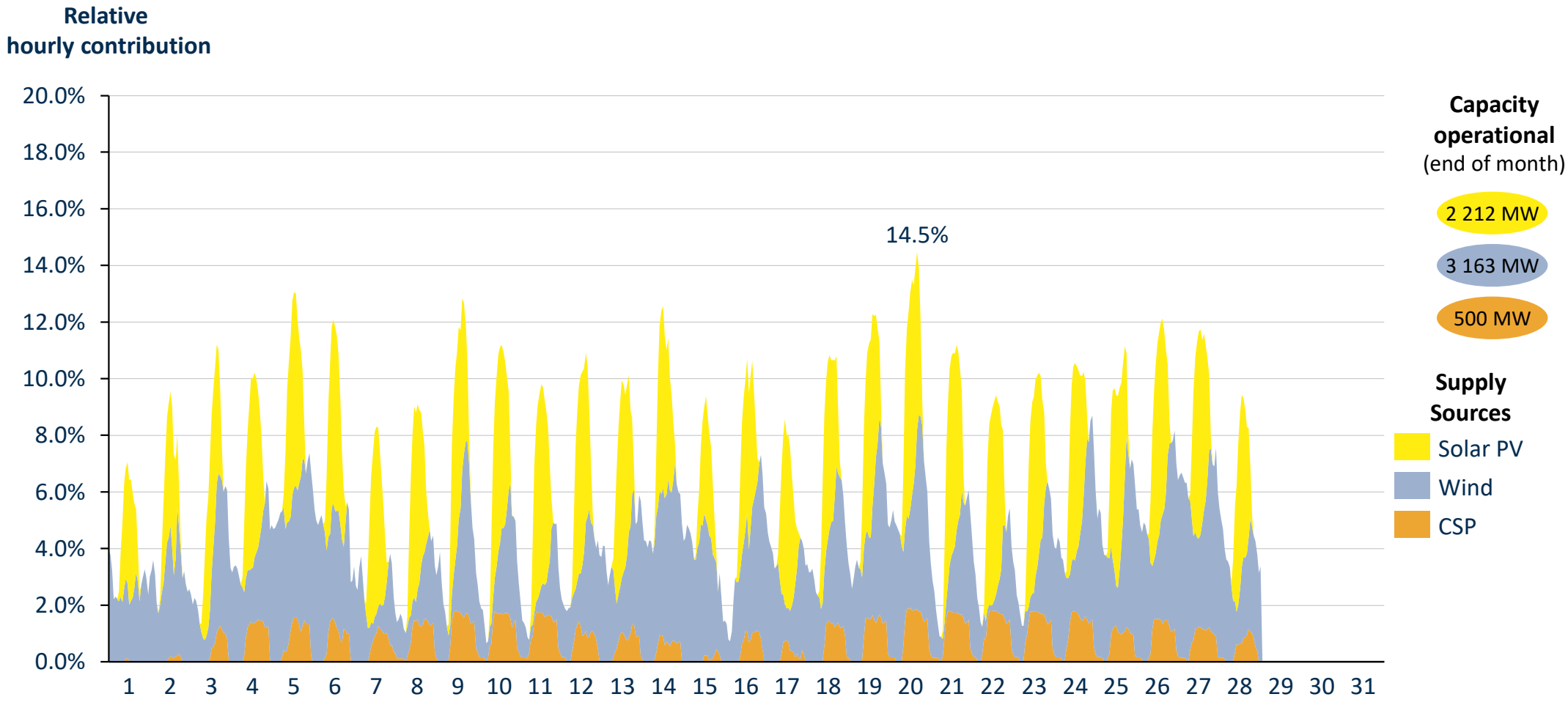
Hourly solar PV, wind & CSP contribution of 0.6-14.5% in Feb 2022

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



- Maximum solar PV relative contribution of 7.7% between 11h00 and 12h00 on 20 Feb 2022
- Maximum wind relative contribution of 7.2% between 21h00 and 22h00 on 24 Feb 2022
- Maximum CSP relative contribution of 1.9% between 11h00 and 12h00 on 20 Feb 2022

Sources: Eskom; CSIR Energy Centre analysis

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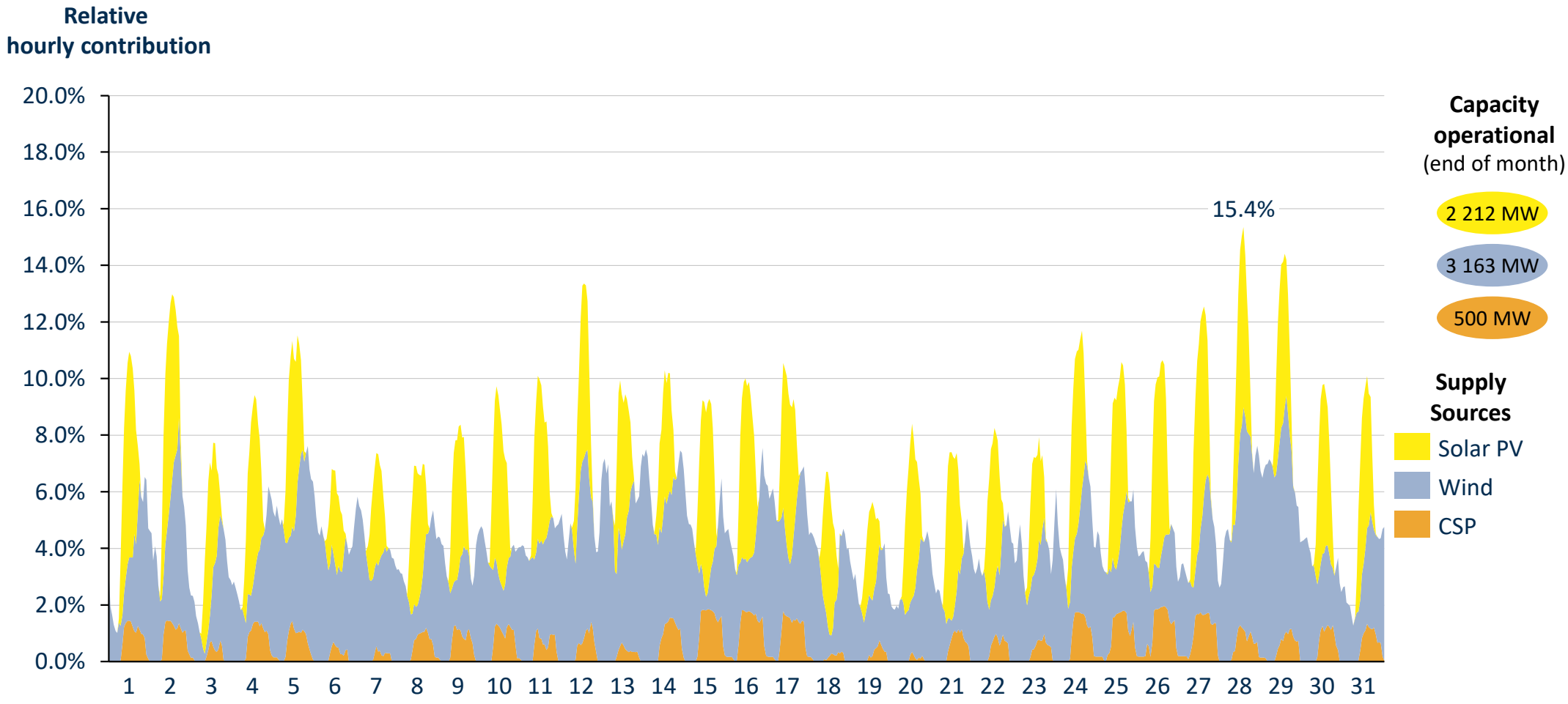
Hourly solar PV, wind & CSP contribution of 1.0-15.4% in Mar 2022

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



- Maximum solar PV relative contribution of 7.3% between 12h00 and 13h00 on 27 Mar 2022
- Maximum wind relative contribution of 8.3% between 14h00 and 15h00 on 29 Mar 2022
- Maximum CSP relative contribution of 2.0% between 15h00 and 16h00 on 26 Mar 2022

Sources: Eskom; CSIR Energy Centre analysis

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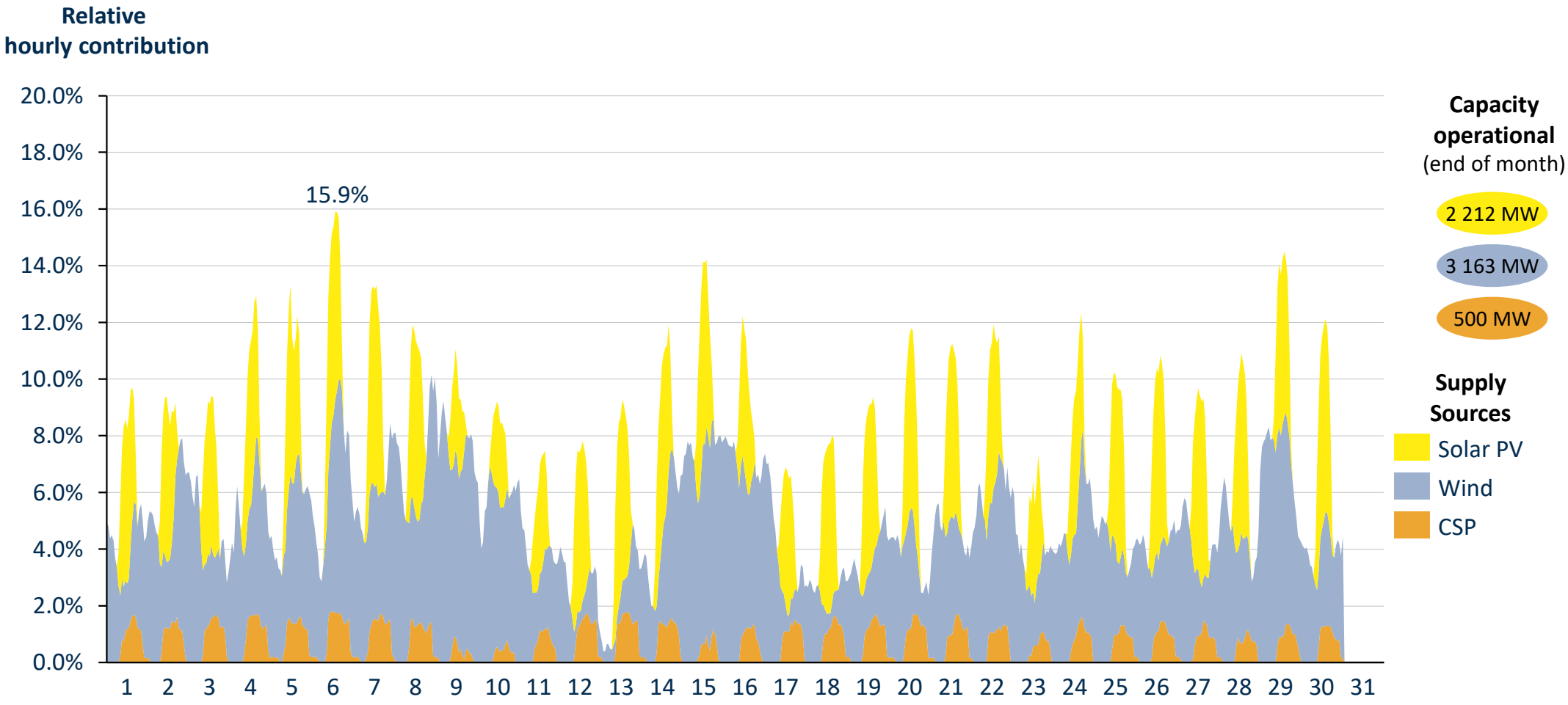
Hourly solar PV, wind & CSP contribution of 0.4-15.9% in Apr 2022

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



- Maximum solar PV relative contribution of 7.0% between 13h00 and 14h00 on 7 Apr 2022
- Maximum wind relative contribution of 9.9% between 23h00 and 24h00 on 9 Apr 2022
- Maximum CSP relative contribution of 1.8% between 11h00 and 12h00 on 6 Apr 2022

Sources: Eskom; CSIR Energy Centre analysis

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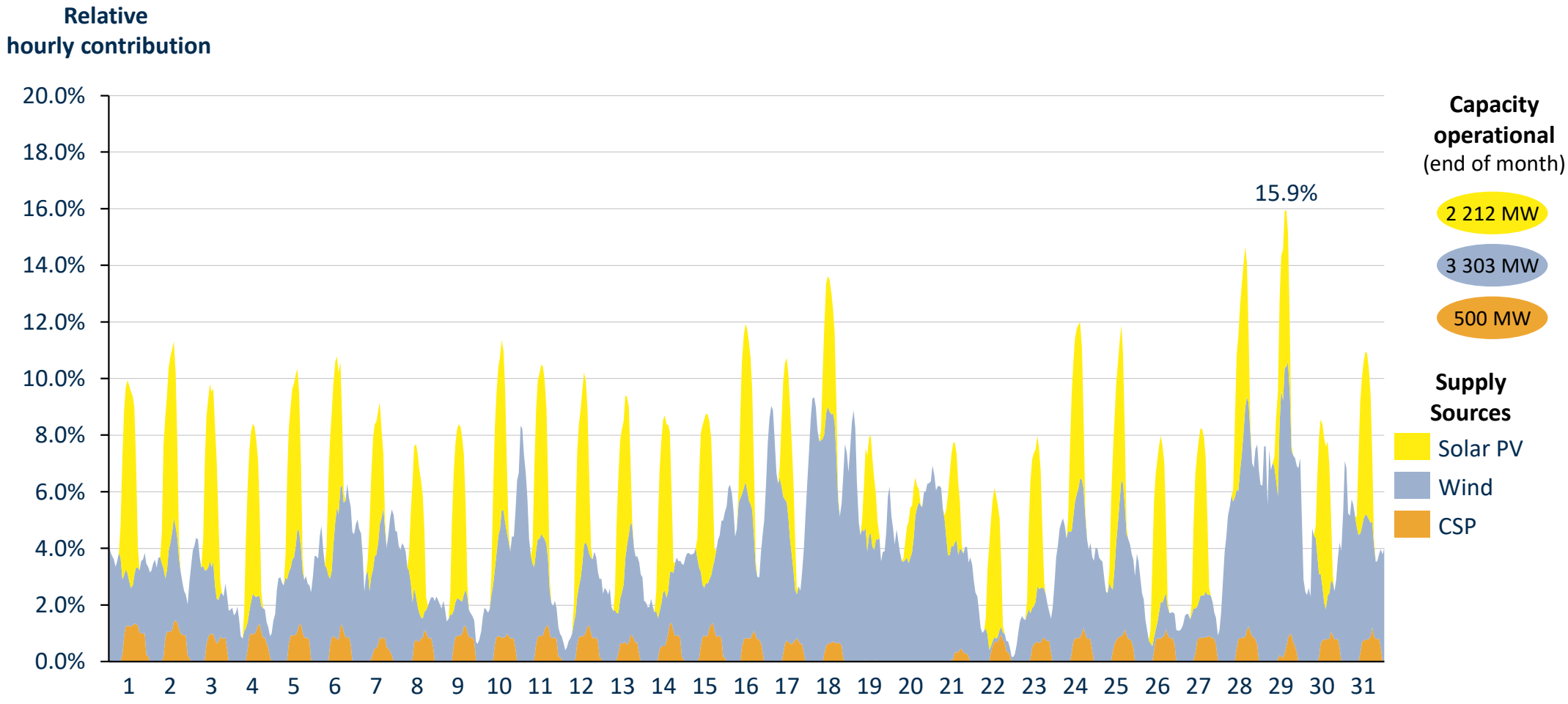
Hourly solar PV, wind & CSP contribution of 0.2-15.9% in May 2022

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



- Maximum solar PV relative contribution of 7.0% between 13h00 and 14h00 on 1 May 2020
- Maximum wind relative contribution of 10.1% between 13h00 and 14h00 on 29 May 2022
- Maximum CSP relative contribution of 1.4% between 15h00 and 16h00 on 2 May 2022

Sources: Eskom; CSIR Energy Centre analysis

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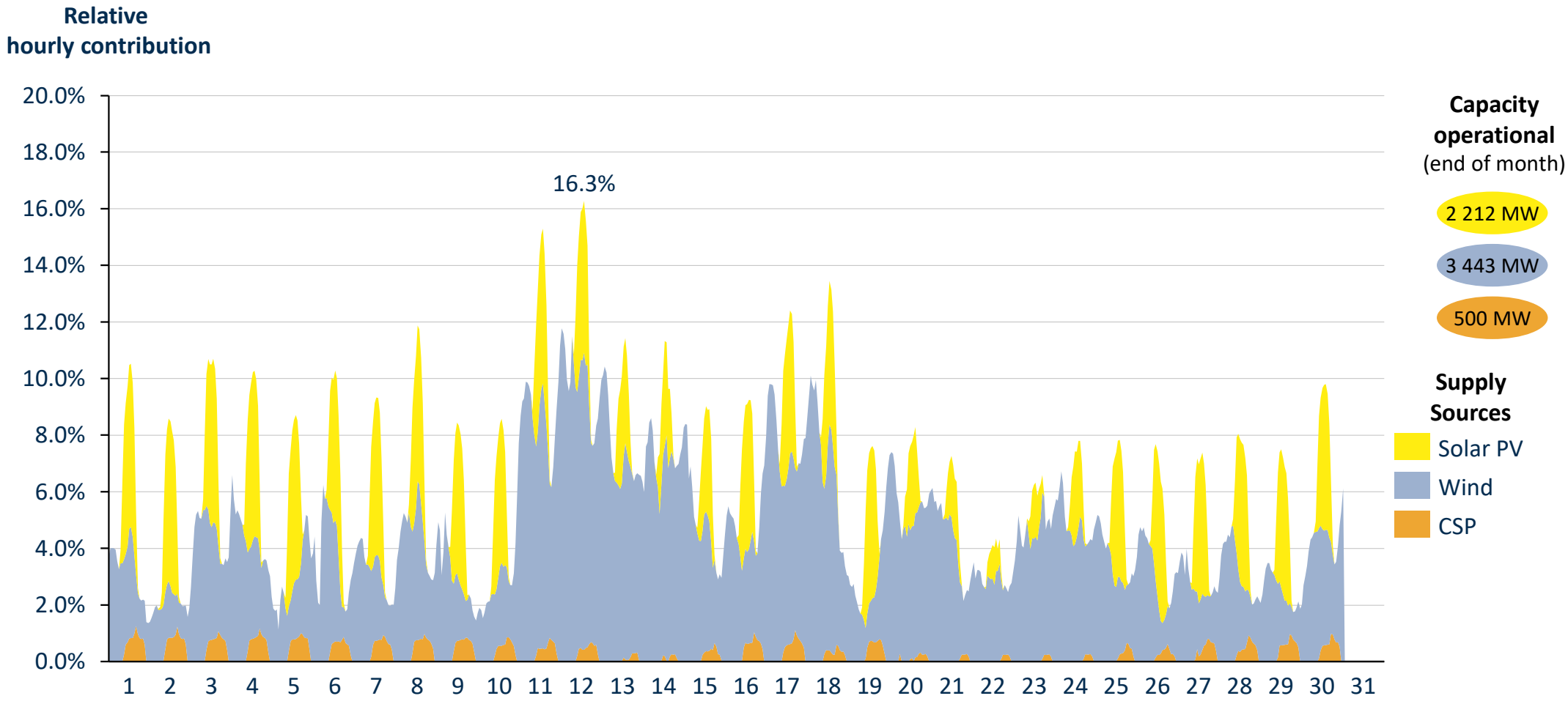
Hourly solar PV, wind & CSP contribution of 1.1-16.3% in Jun 2022

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



- Maximum solar PV relative contribution of 5.9% between 12h00 and 13h00 on 4 Jun 2022
- Maximum wind relative contribution of 11.8% between 24h00 and 01h00 on 12 Jun 2022
- Maximum CSP relative contribution of 1.3% between 16h00 and 17h00 on 1 Jun 2022

Sources: Eskom; CSIR Energy Centre analysis

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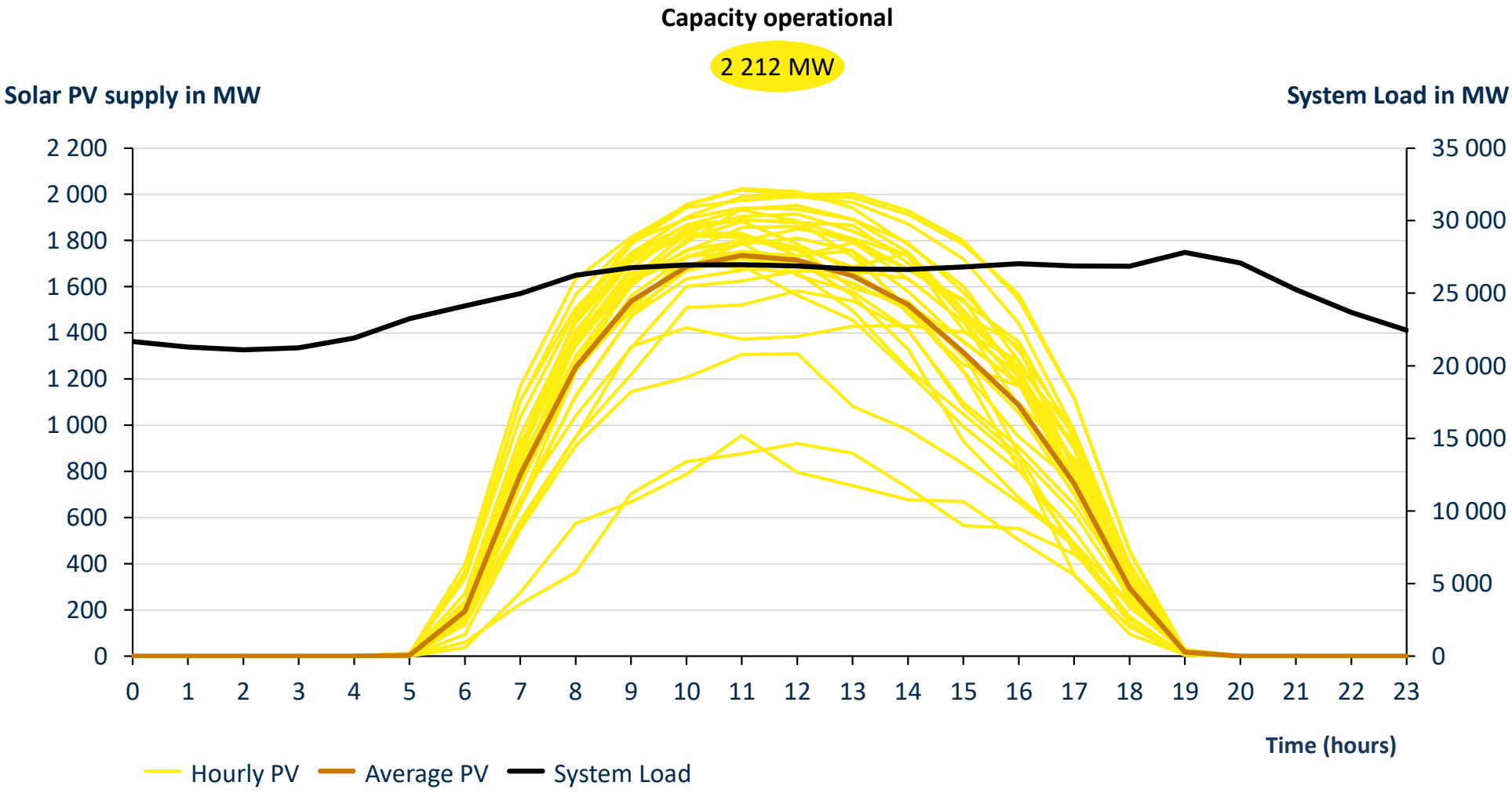
Solar PV supply in Jan 2022

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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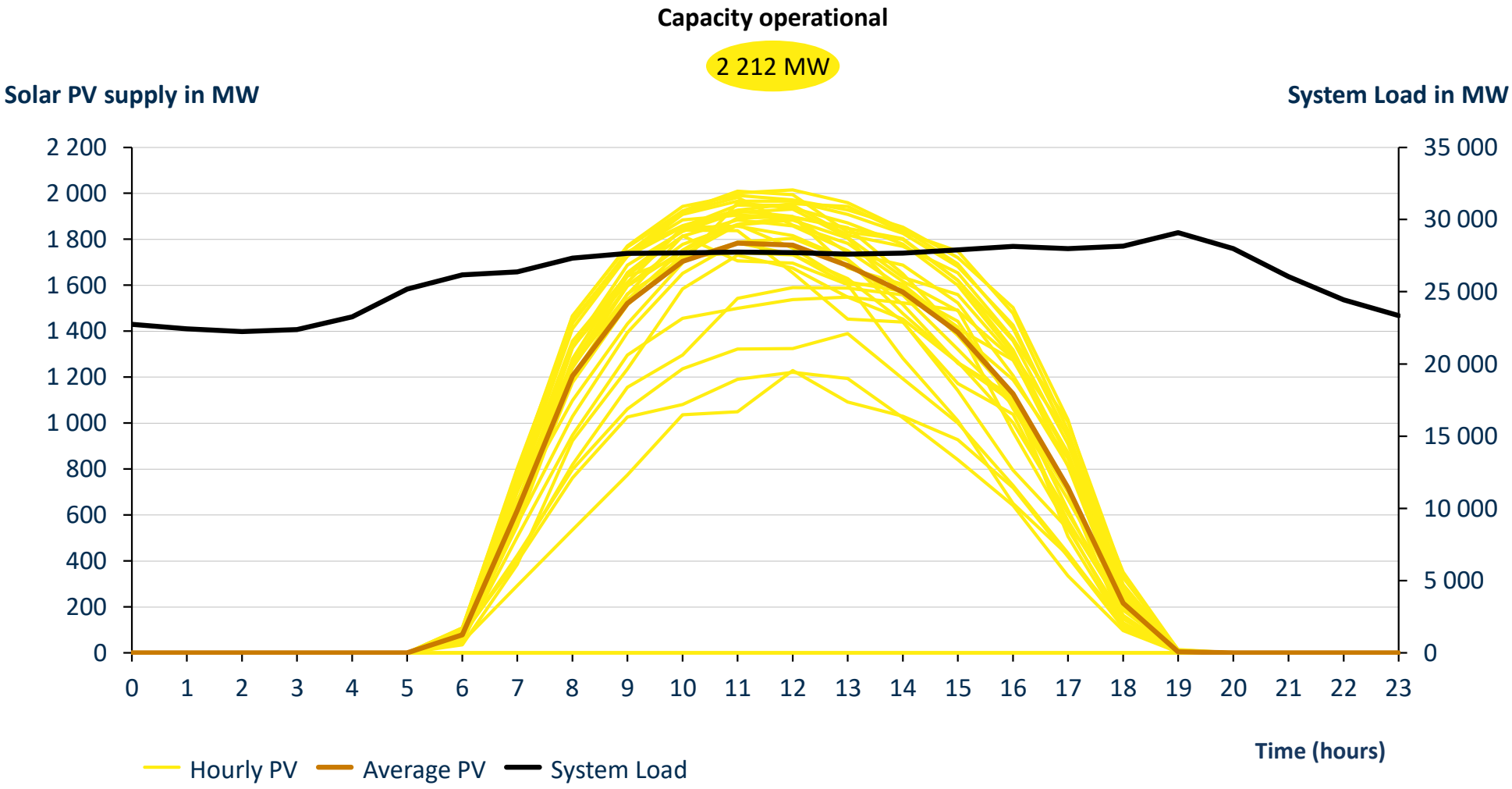
Solar PV supply in Feb 2022

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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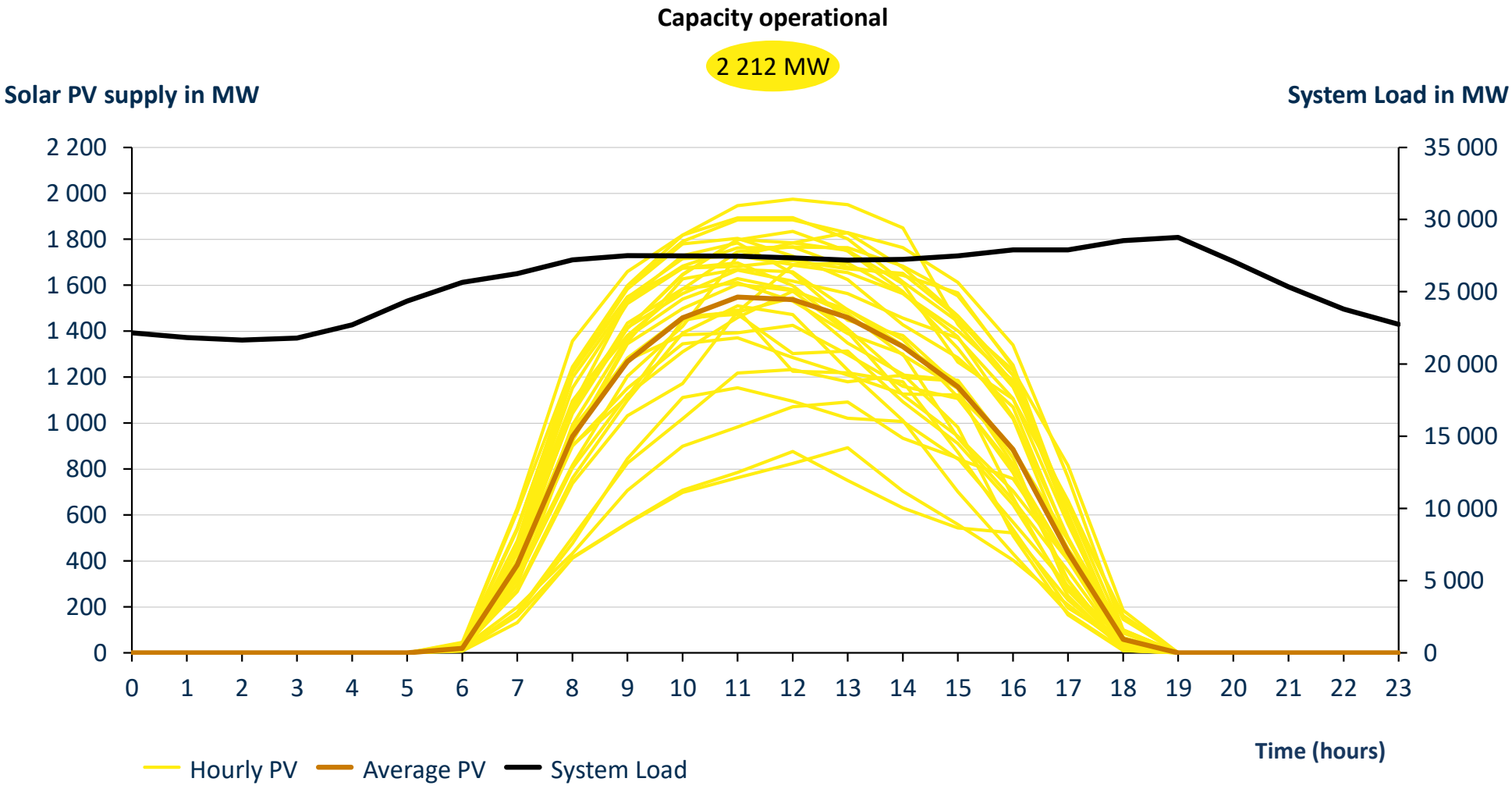
Solar PV supply in Mar 2022

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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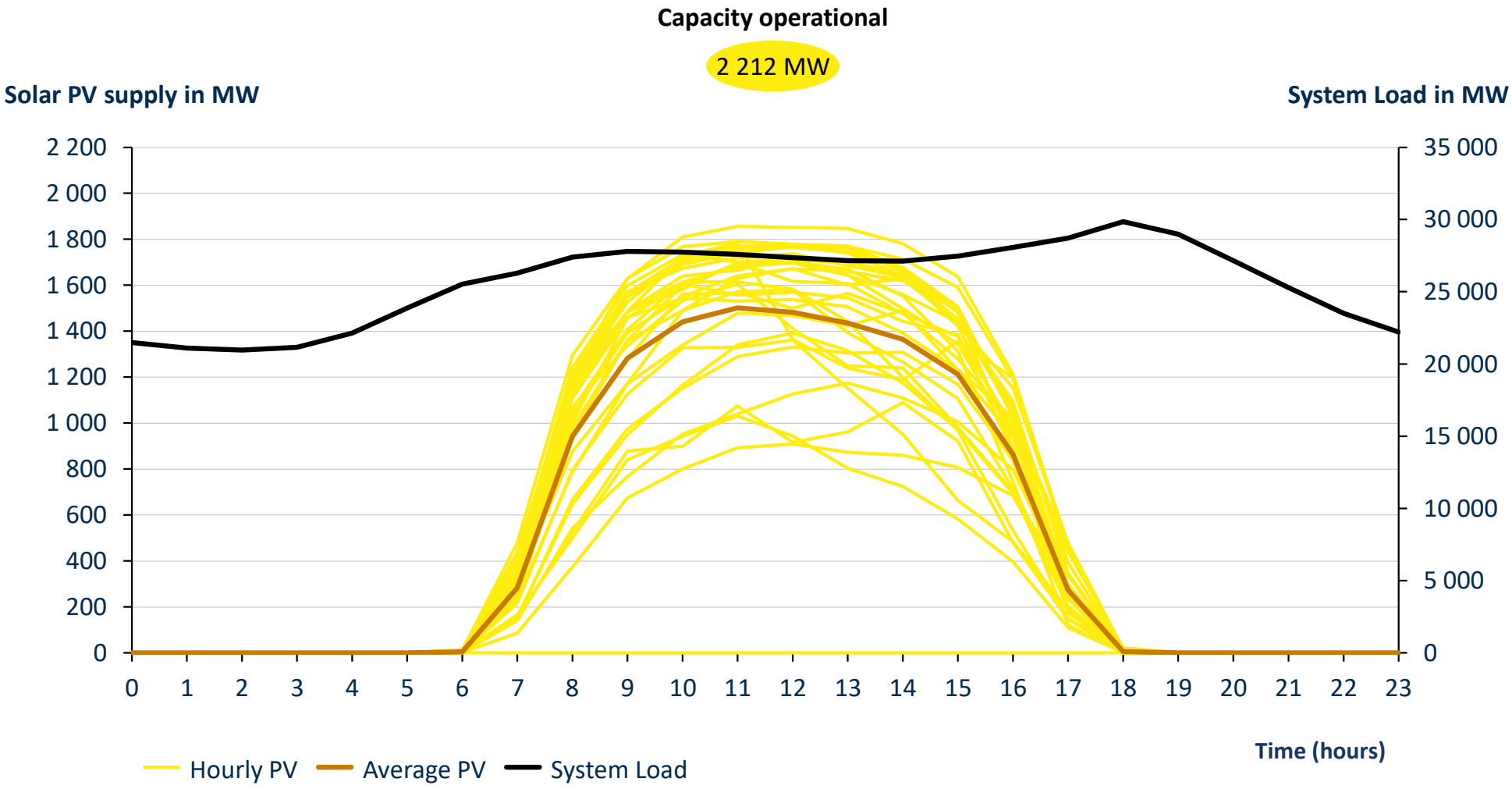
Solar PV supply in Apr 2022

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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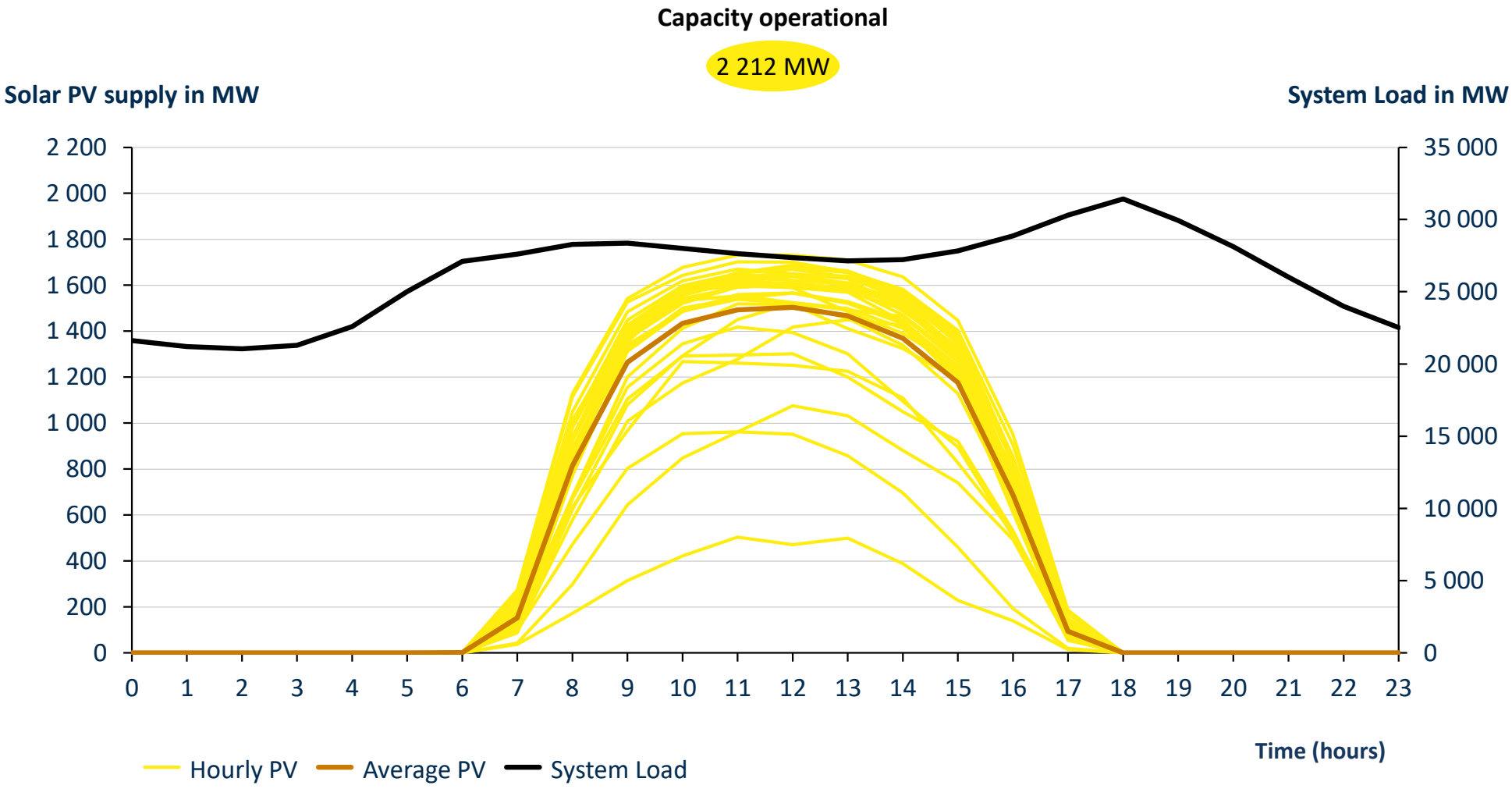
Solar PV supply in May 2022

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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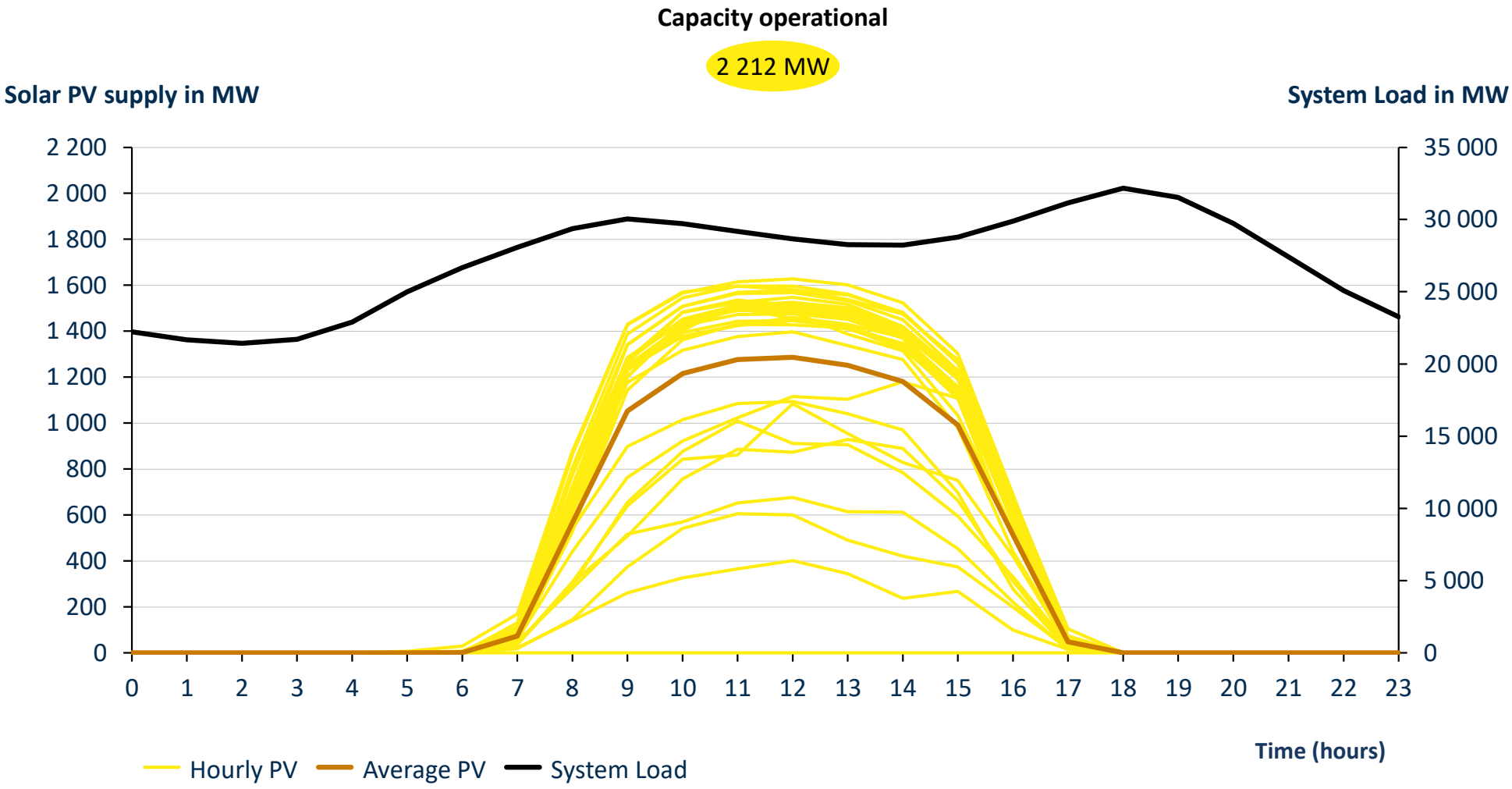
Solar PV supply in Jun 2022

Hourly solar PV production for all 30 days of Jun 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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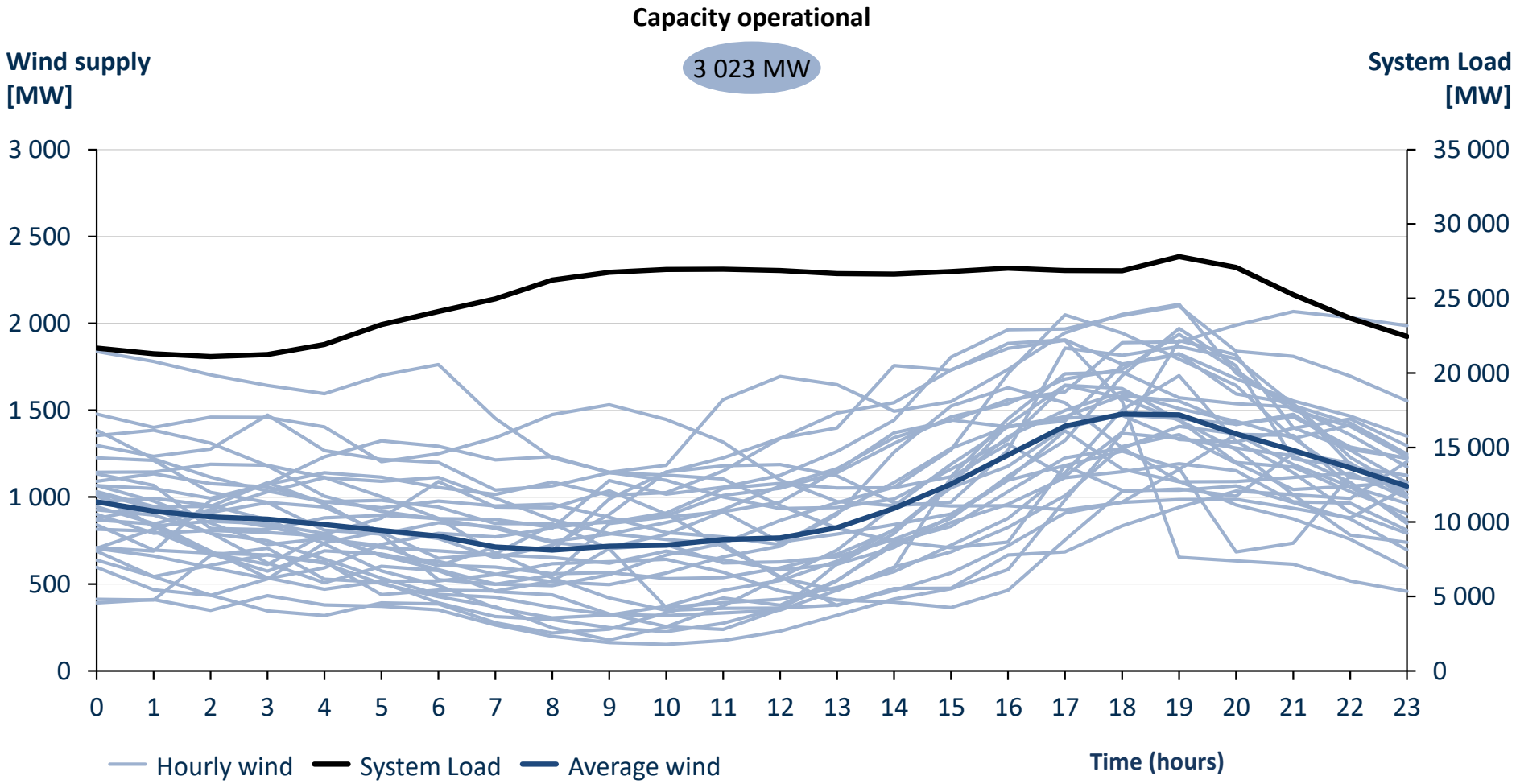
Wind supply in Jan 2022

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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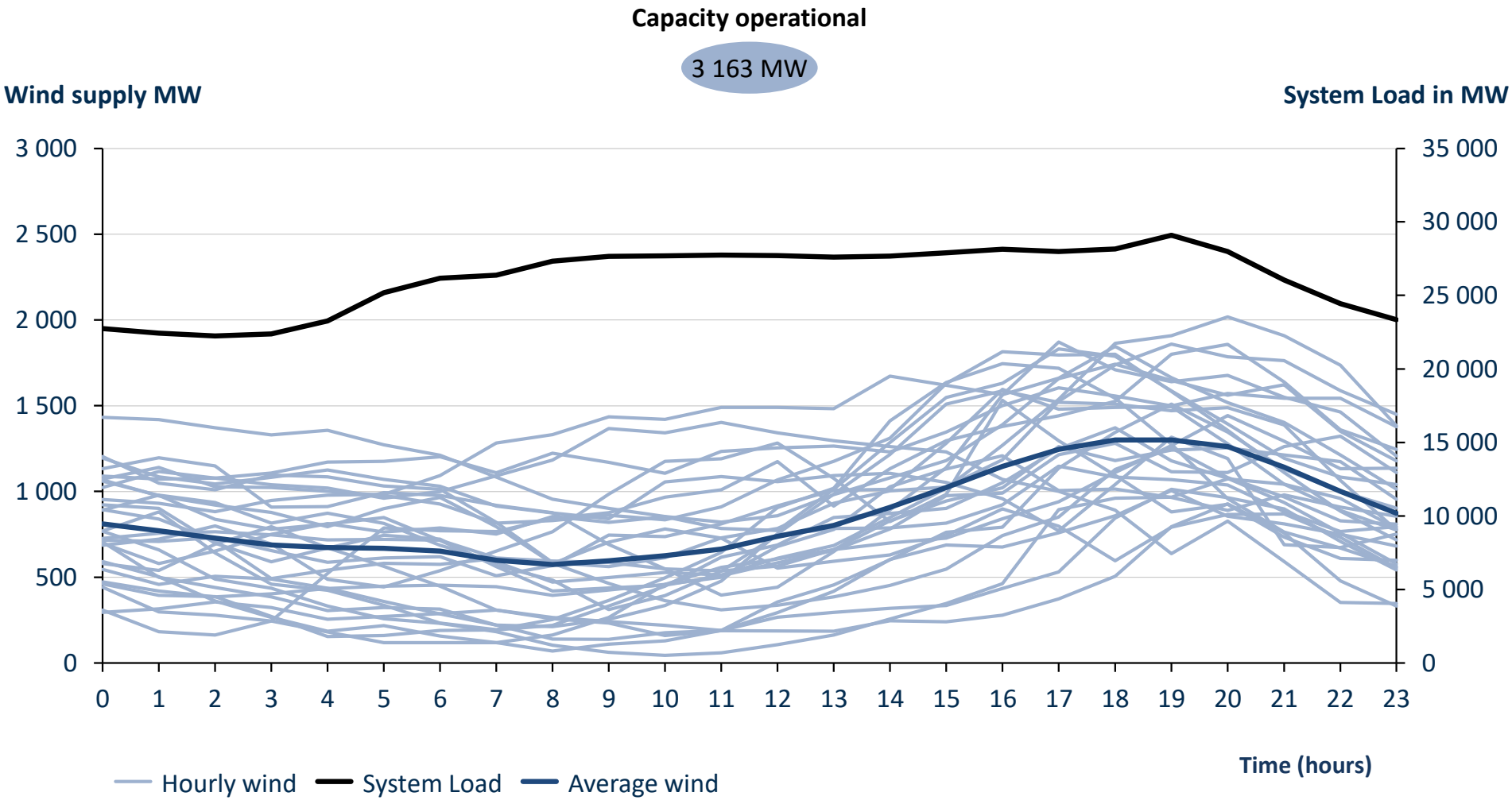
Wind supply in Feb 2022

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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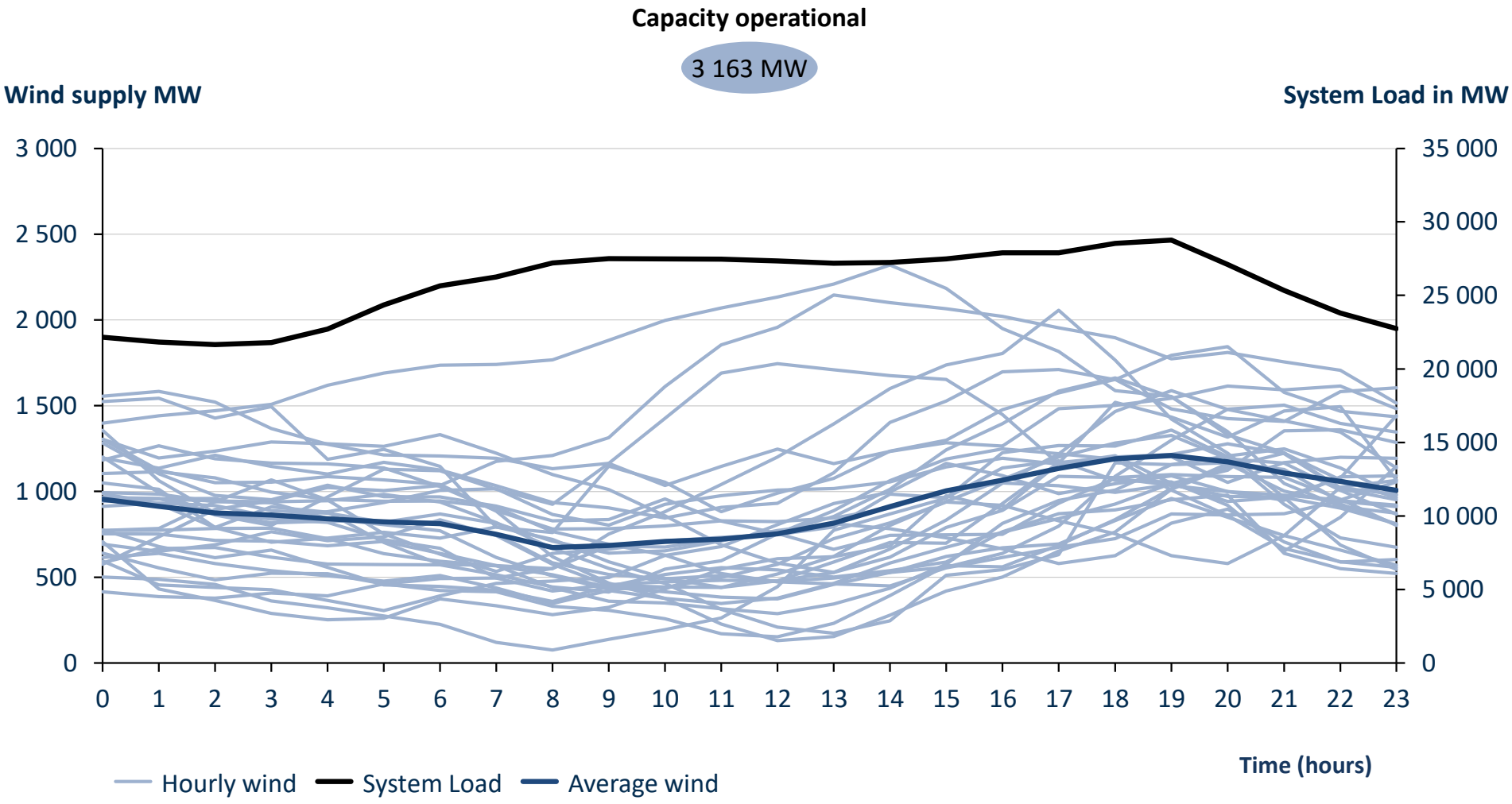
Wind supply in Mar 2022

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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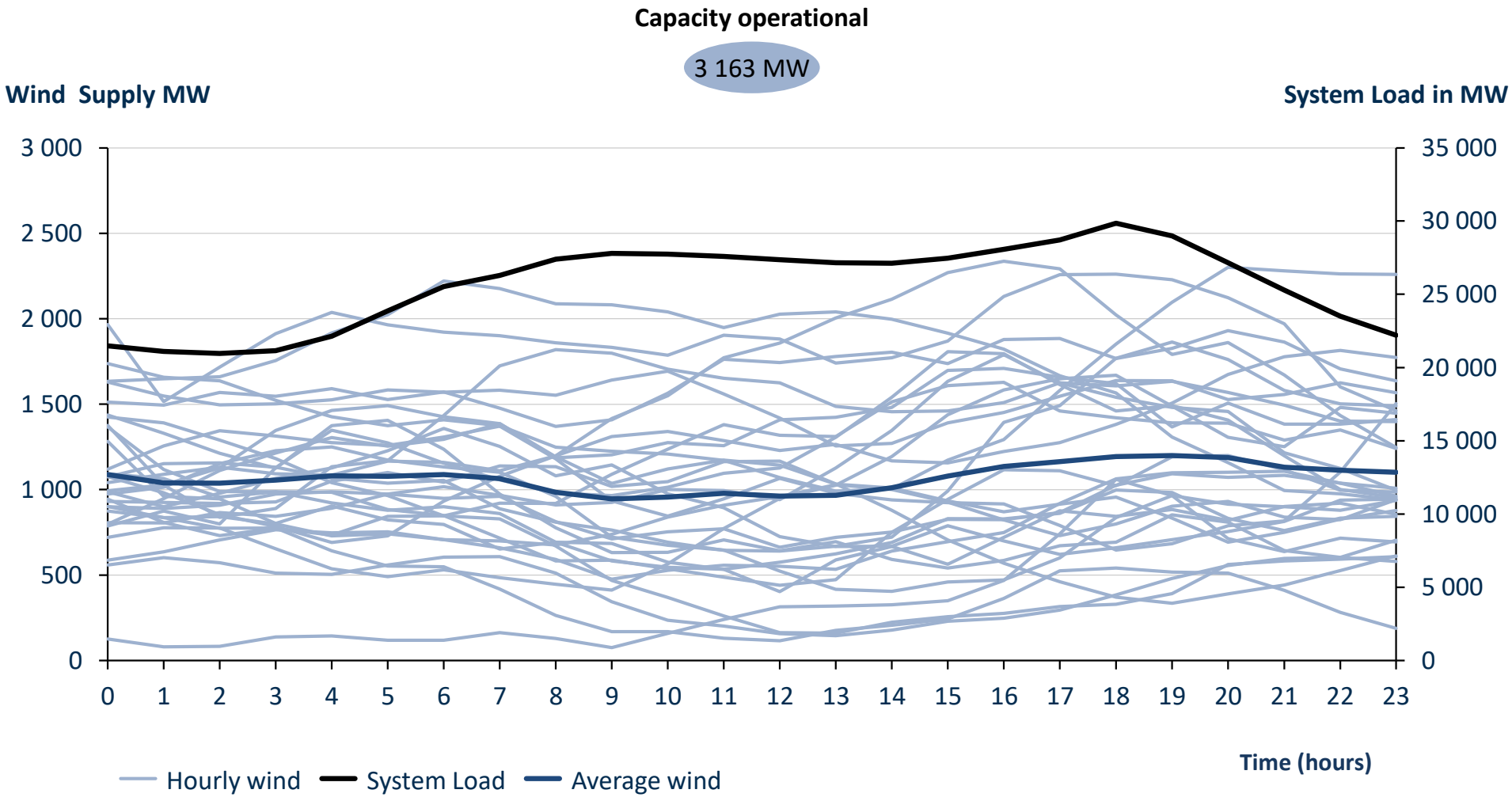
Wind supply in Apr 2022

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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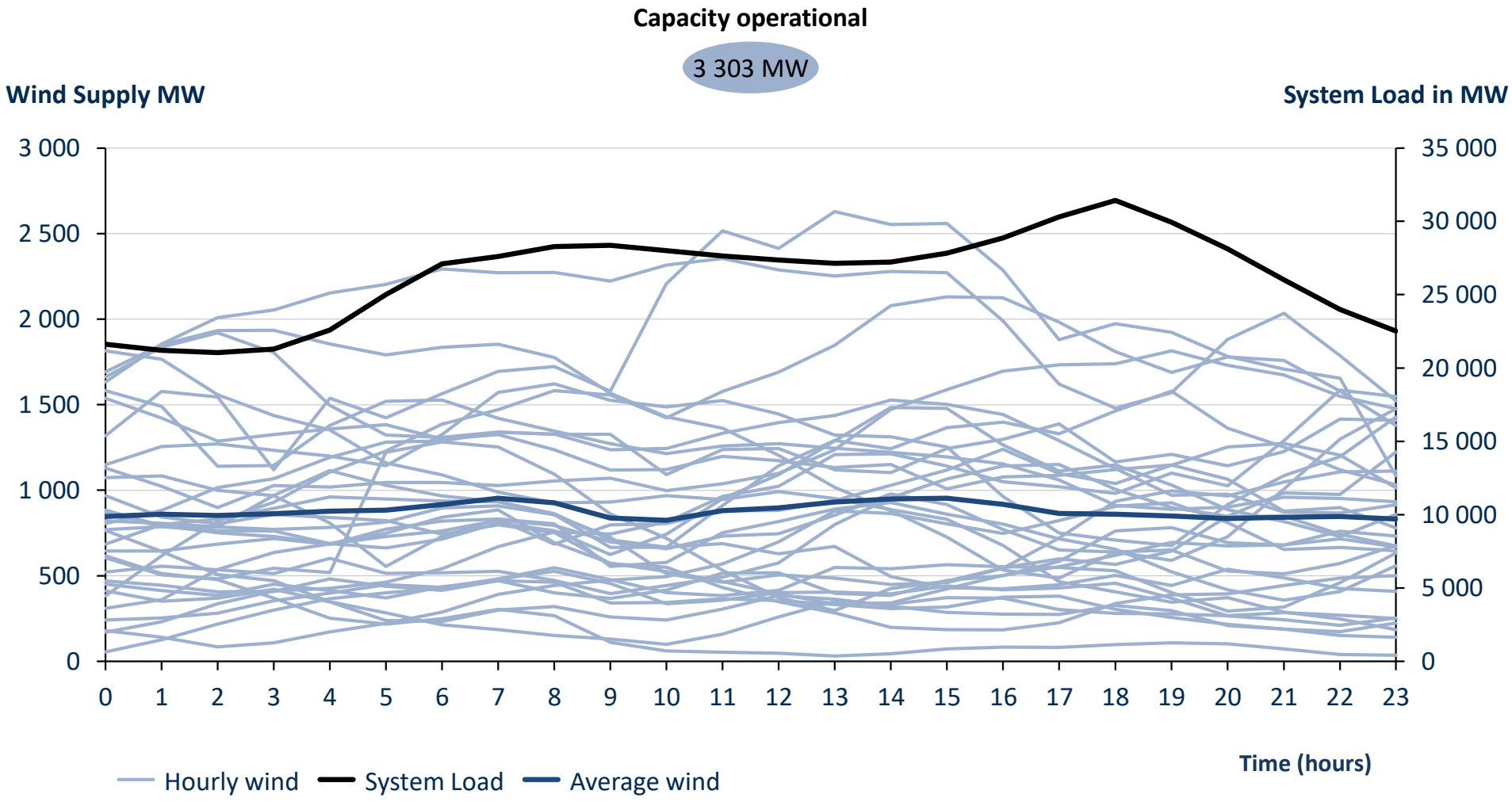
Wind supply in May 2022

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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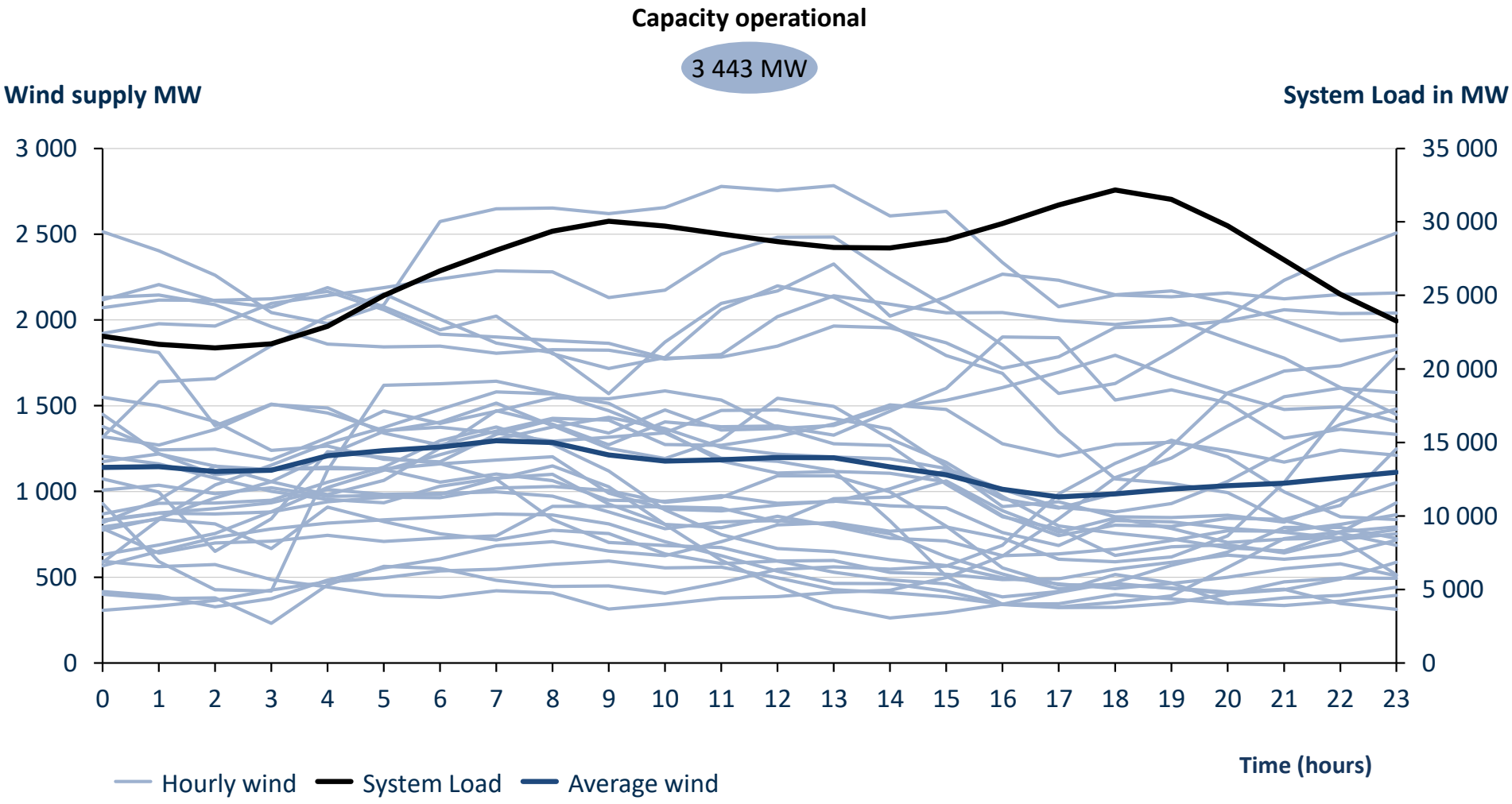
Wind supply in Jun 2022

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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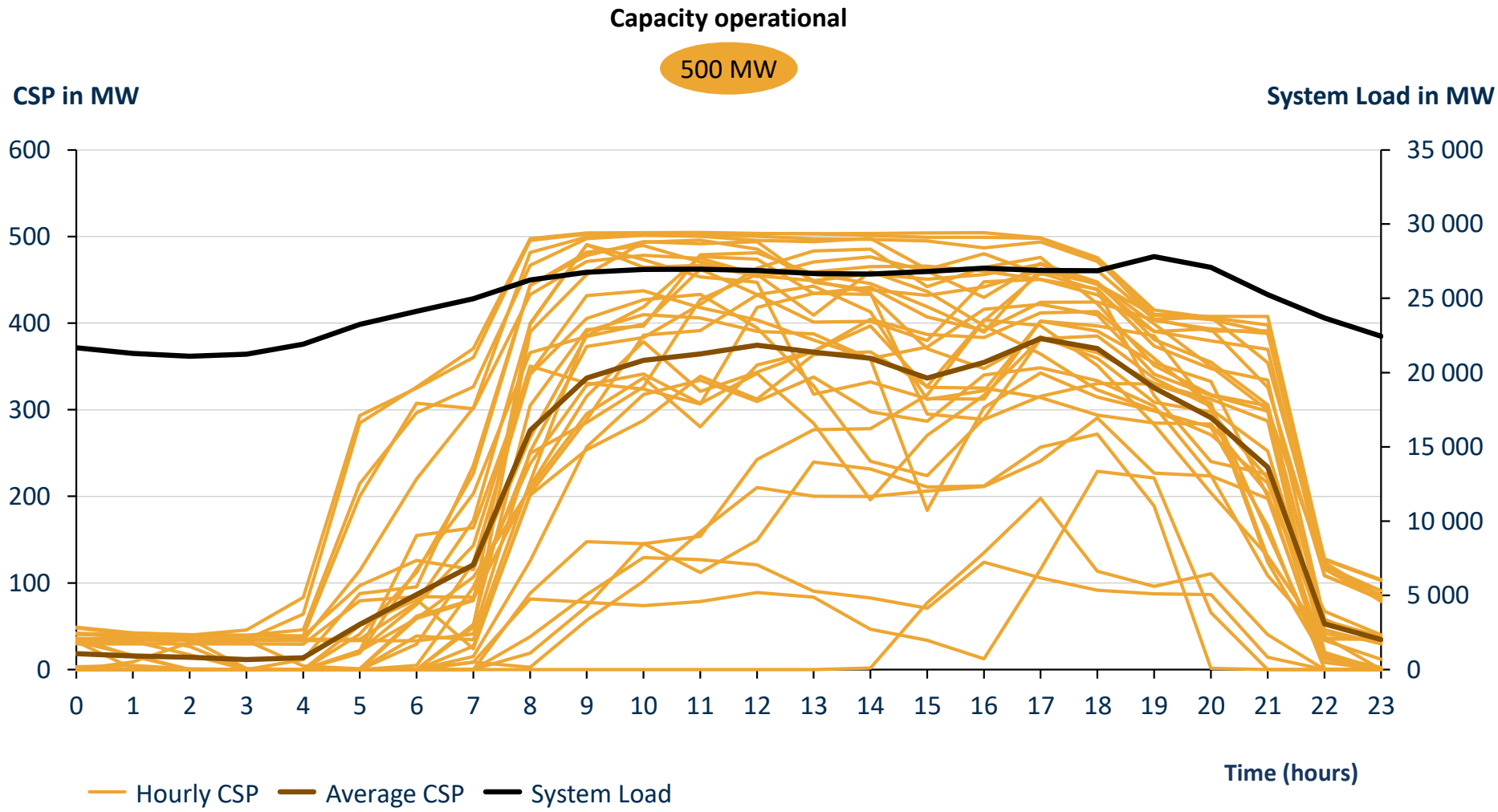
CSP supply in Jan 2022

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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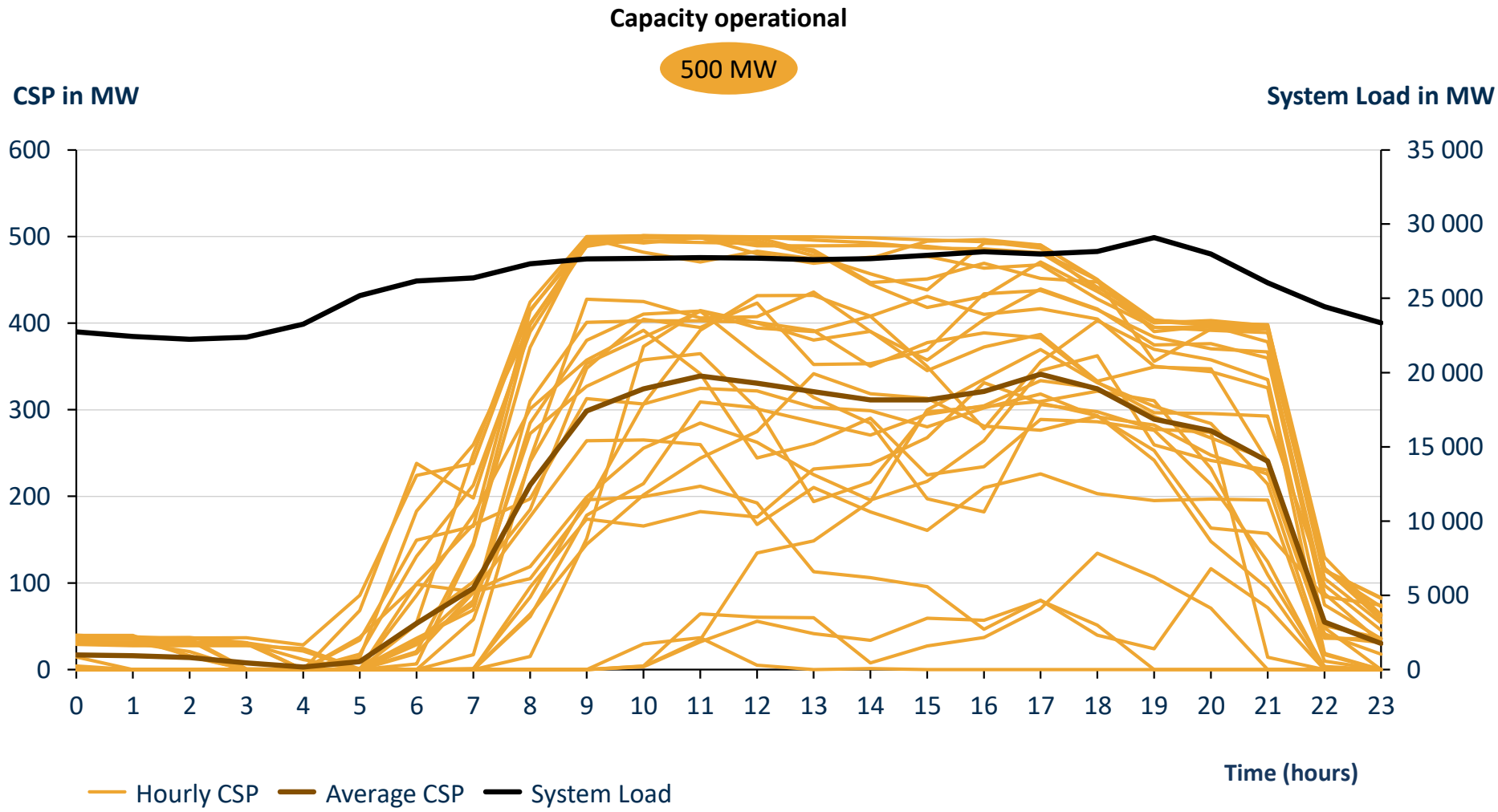
CSP supply in Feb 2022

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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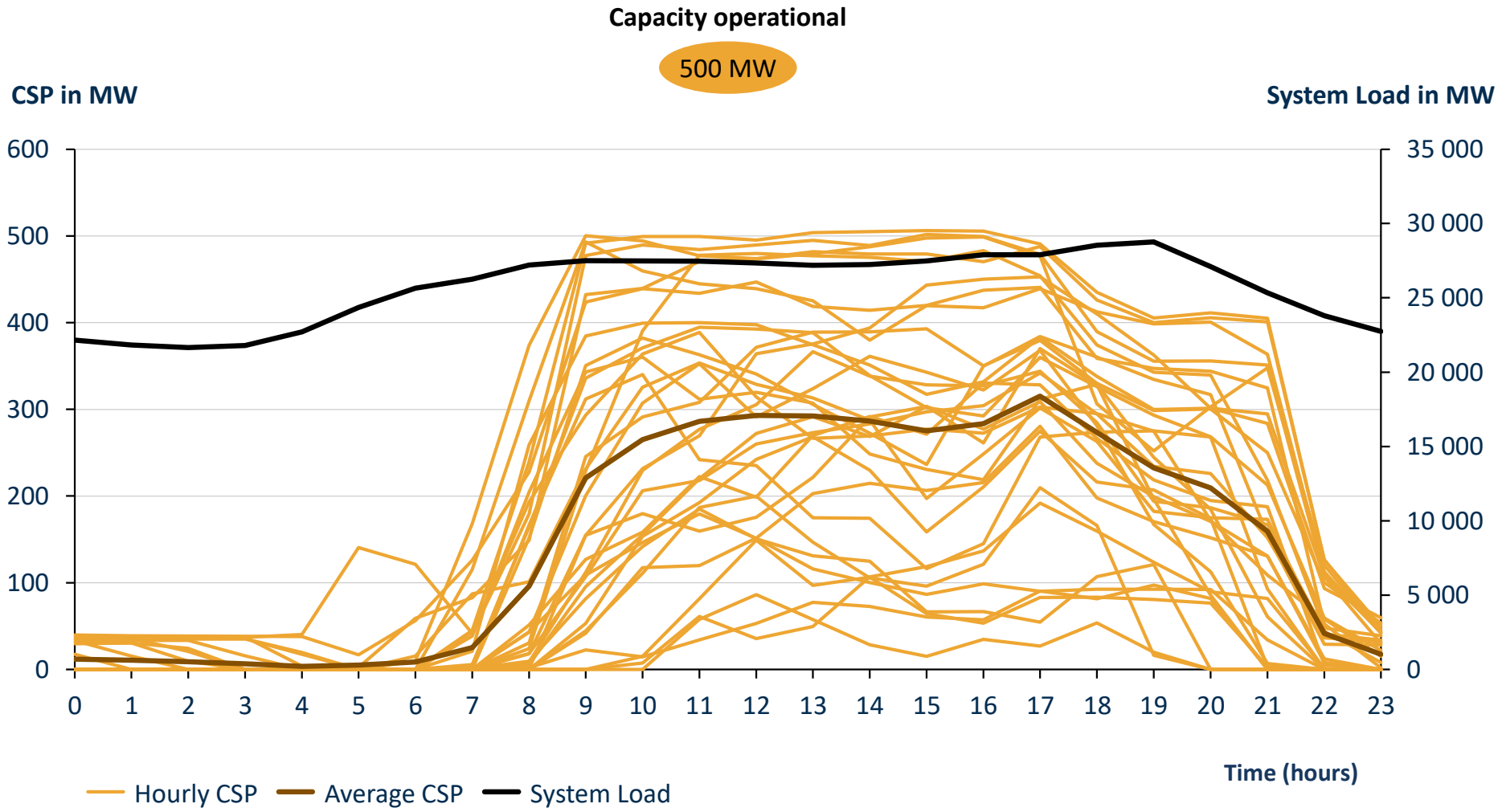
CSP supply in Mar 2022

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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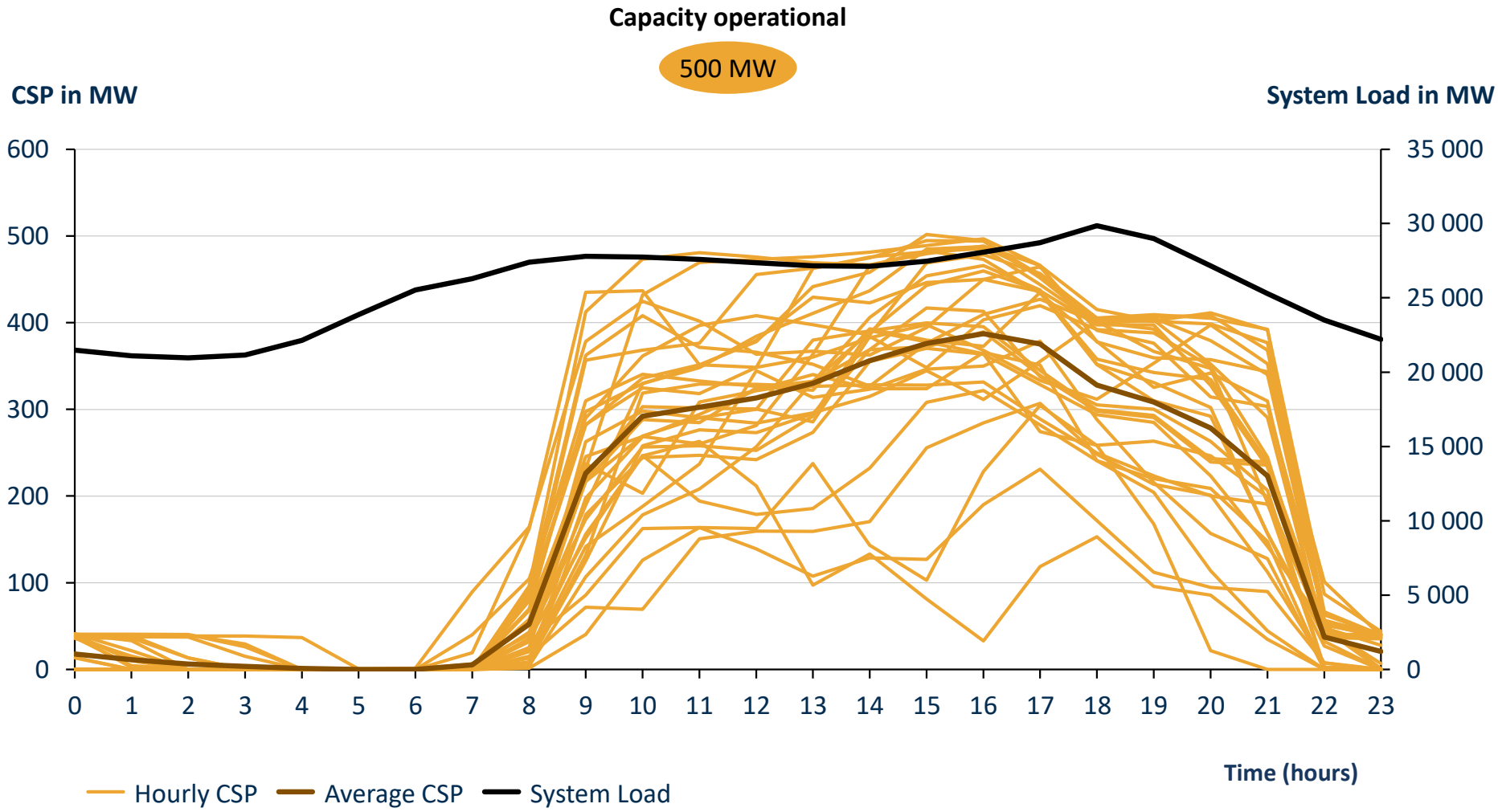
CSP supply in Apr 2022

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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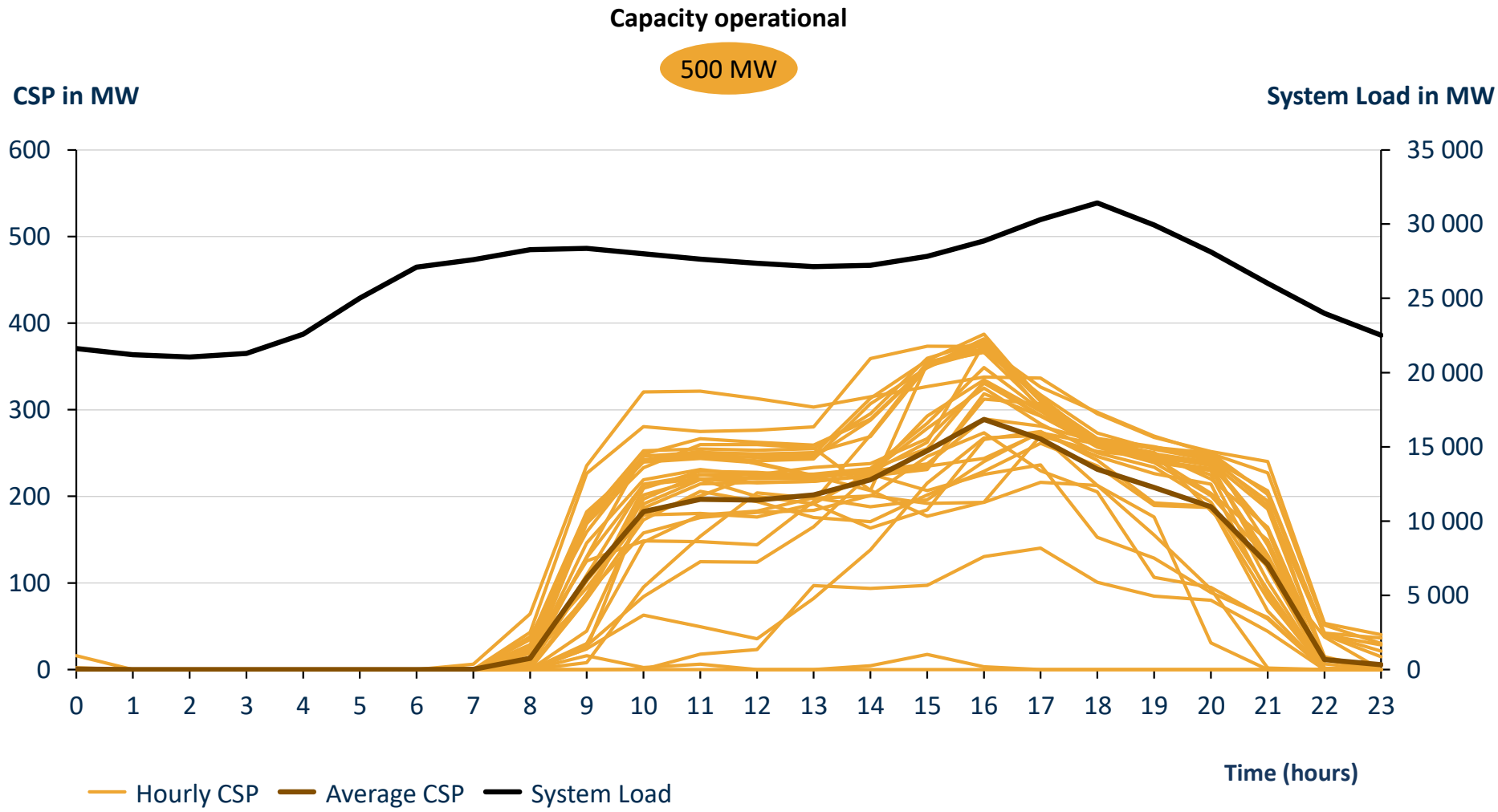
CSP supply in May 2022

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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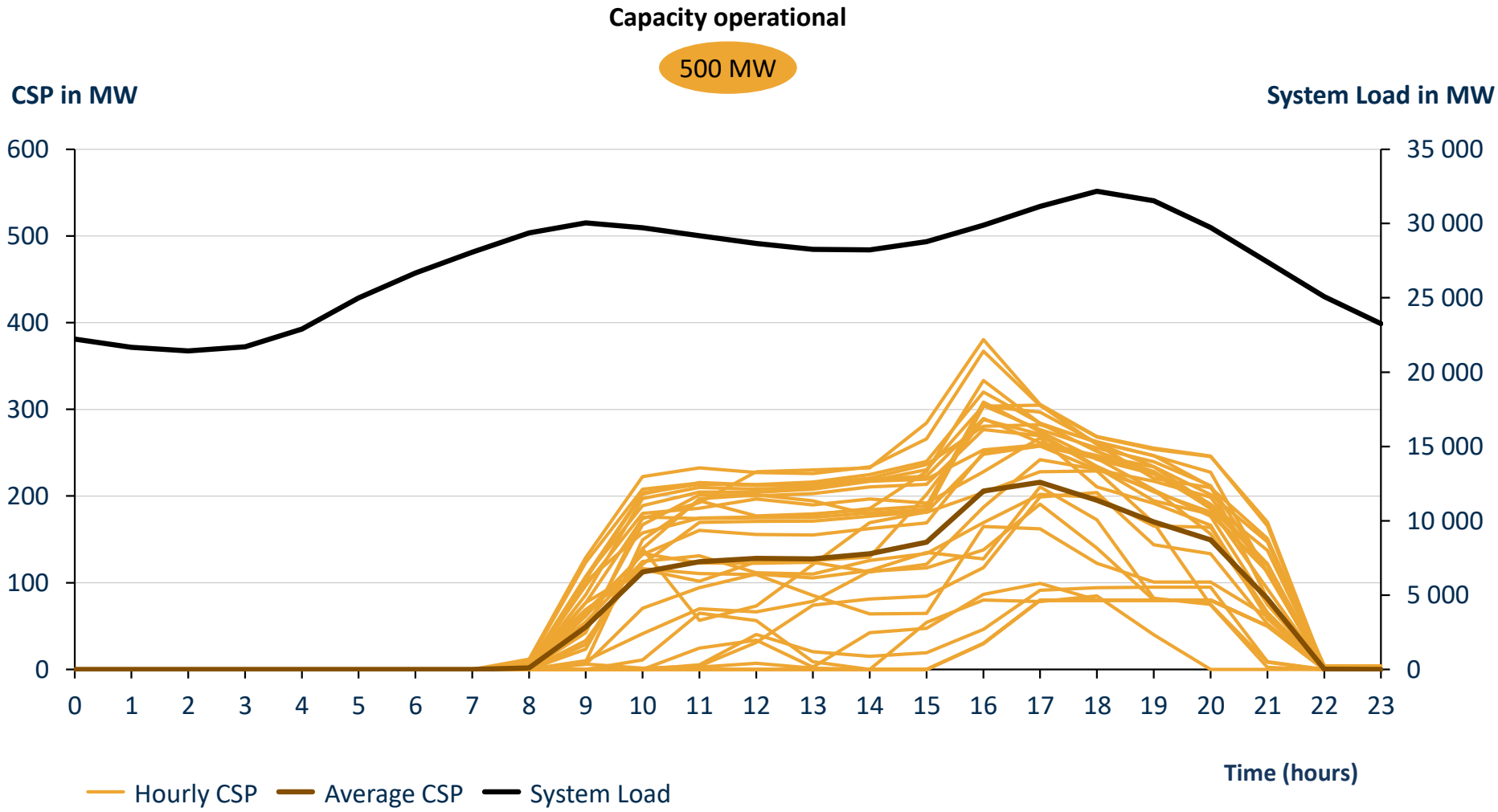
CSP supply in Jun 2022

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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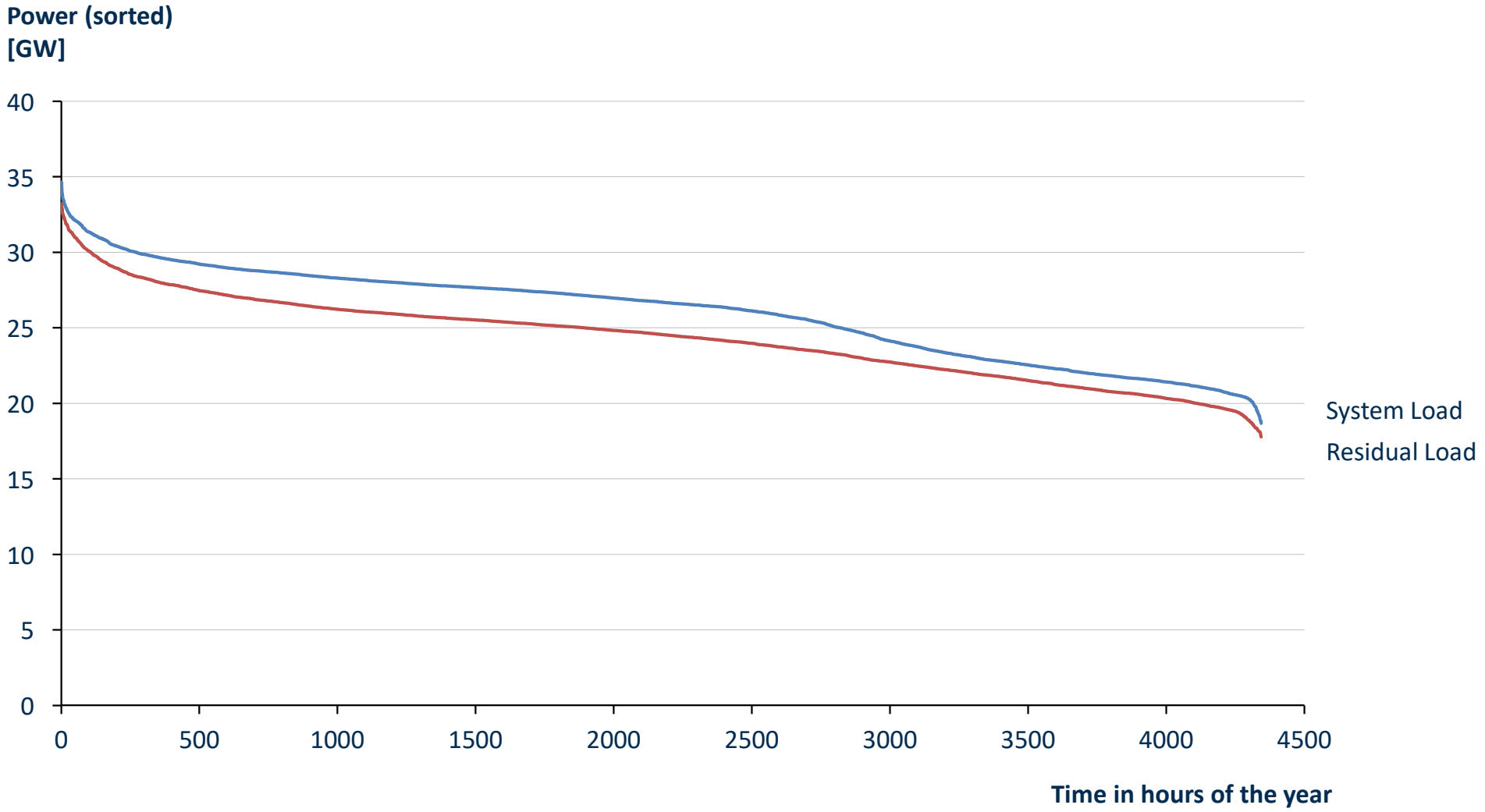
Jan-Jun 2022 system load and residual load duration curves



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

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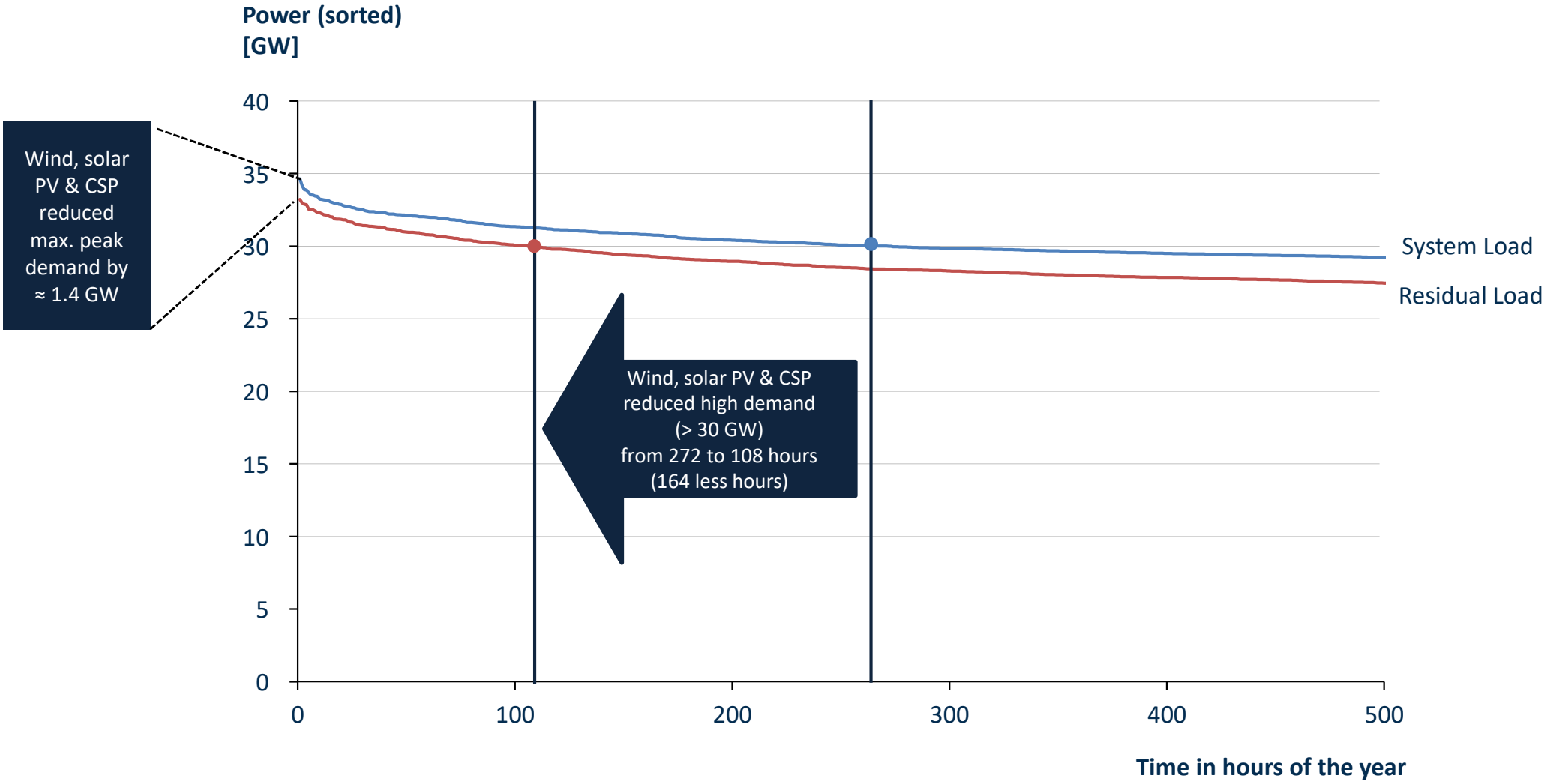
From Jan-Jun 2022 – wind, solar PV & CSP reduced the number of hours with >30 GW total load by 60% (~164 less hours)



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

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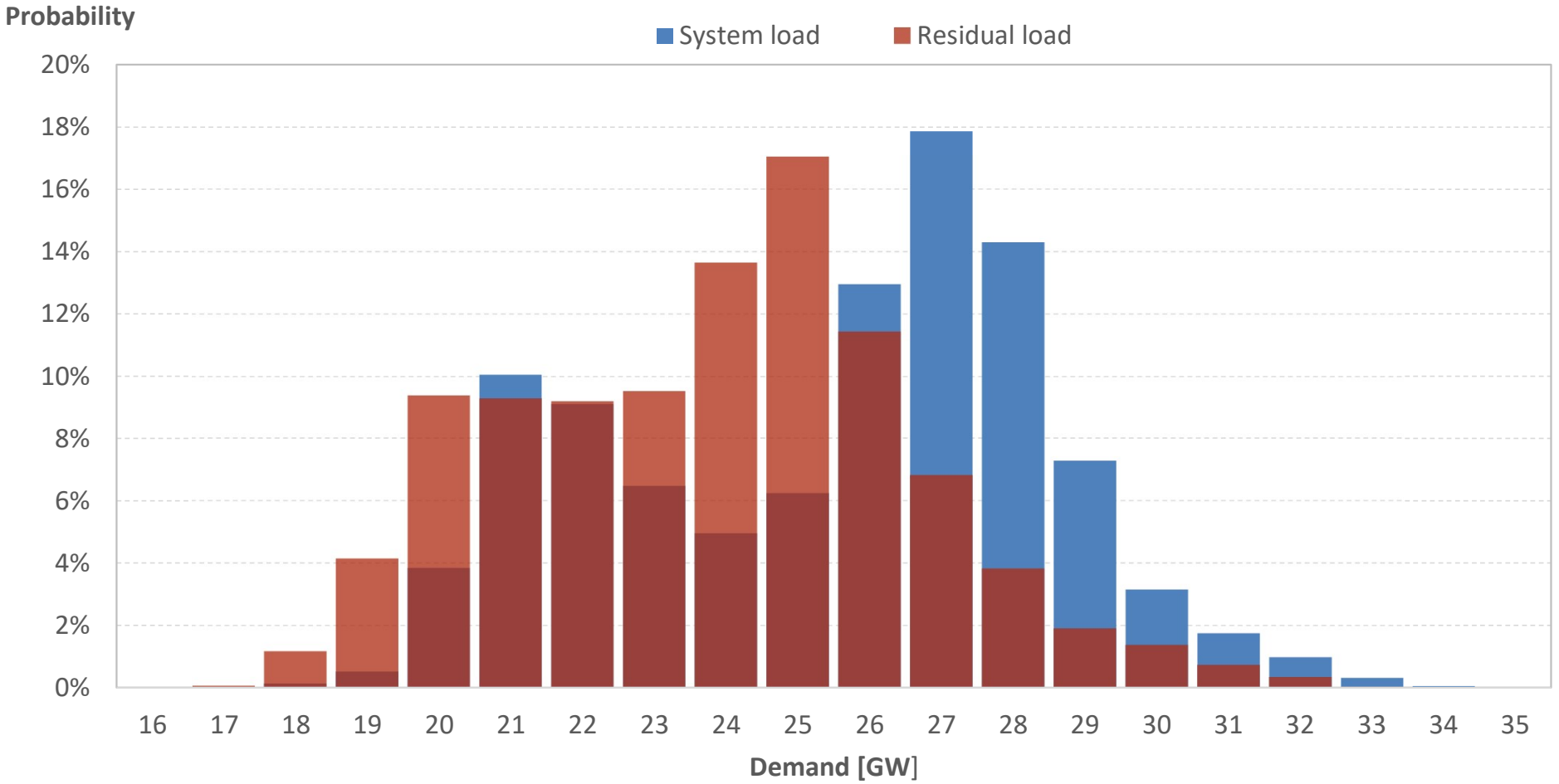
Shift of residual demand to lower demand levels as VRE contributes during demand periods for H1-2022



Sources: Eskom; CSIR Energy Centre analysis

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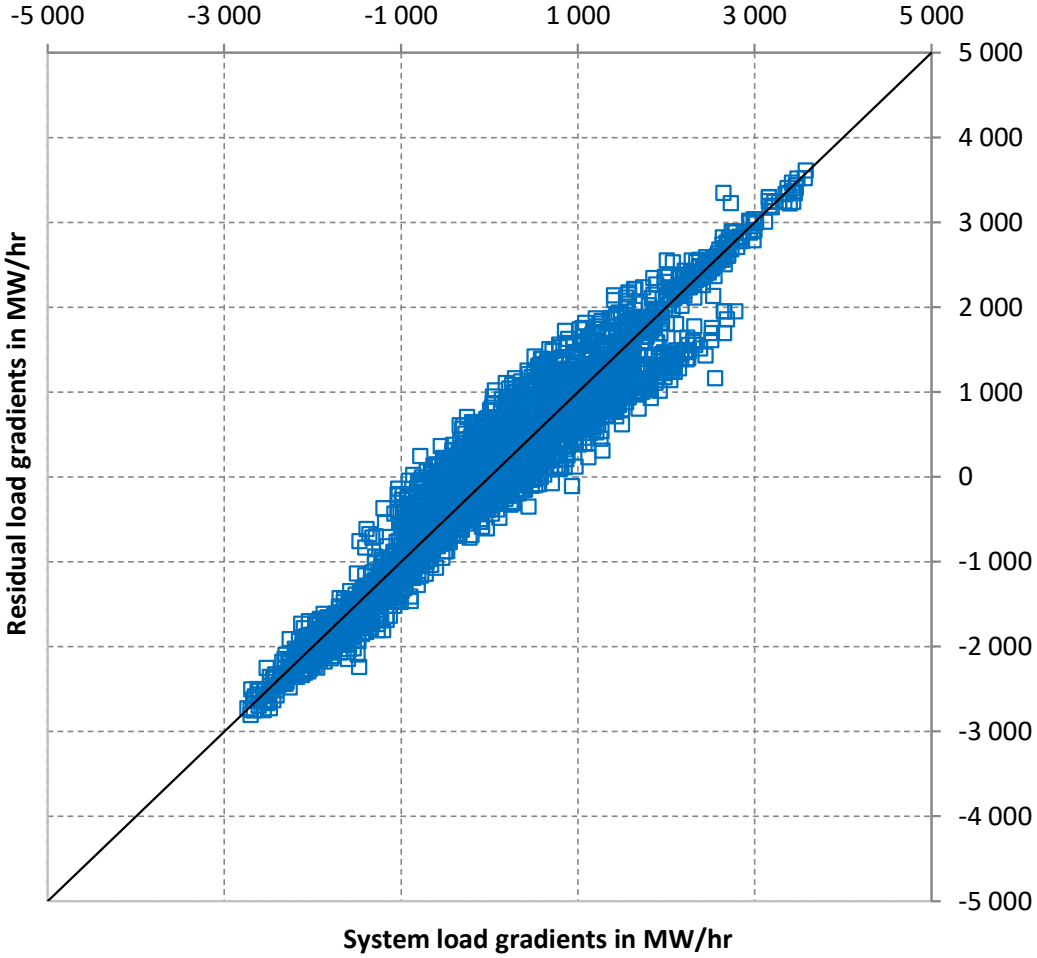
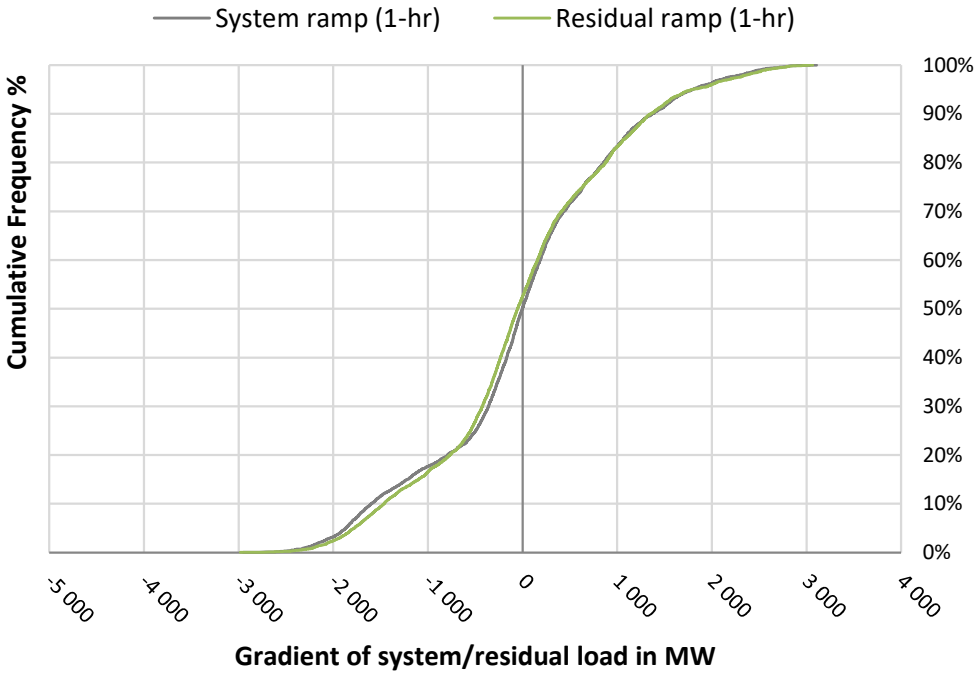
1-hour gradients did not significantly increase due to collective 6.2 GW of wind, solar PV & CSP

System load 1-hour gradients vs. residual load 1-hour gradients for all hours from Jan-Jun 2022



Cumulative frequency distribution of 1-hour gradients for all hours from Jan-Jun 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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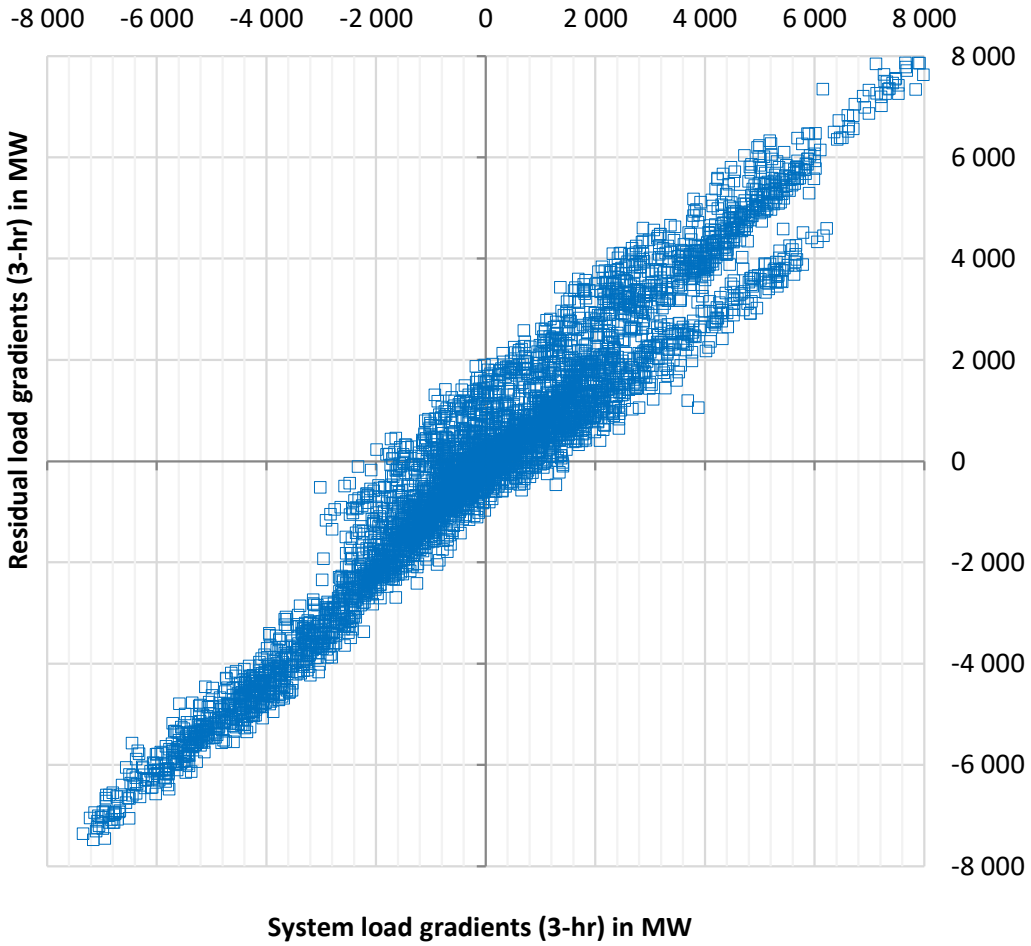
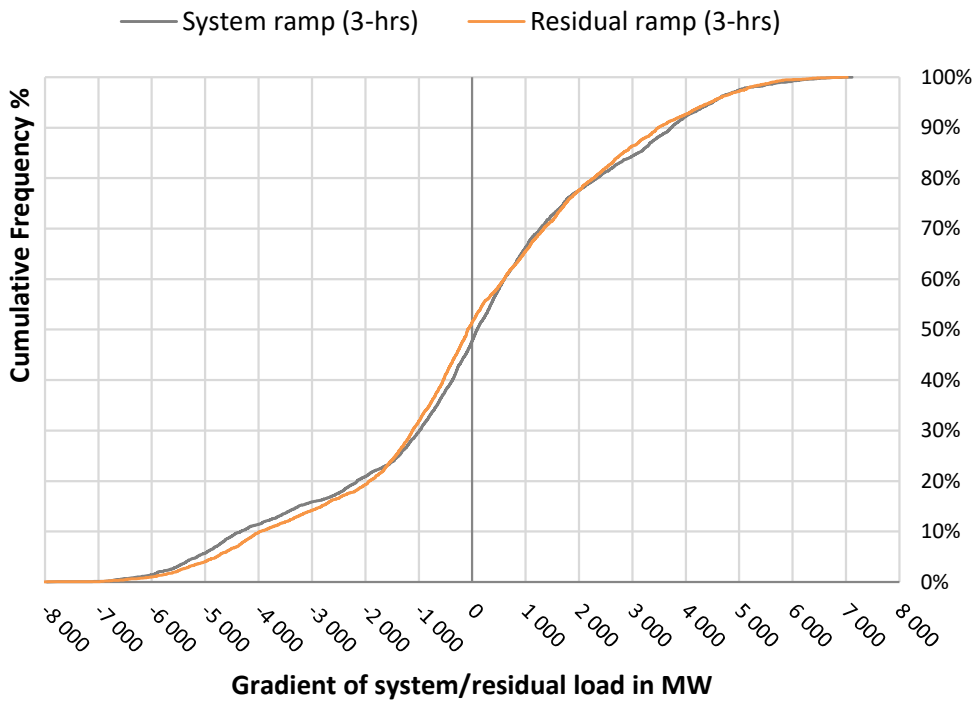
Similarly, 3-hour gradients did not significantly increase due to collective 6.2 GW of wind, solar PV & CSP

System load 3-hour gradients vs. residual load 3-hour gradients for all hours from Jan-Jun 2022



Cumulative frequency distribution of 3-hour gradients for all hours from Jan-Jun 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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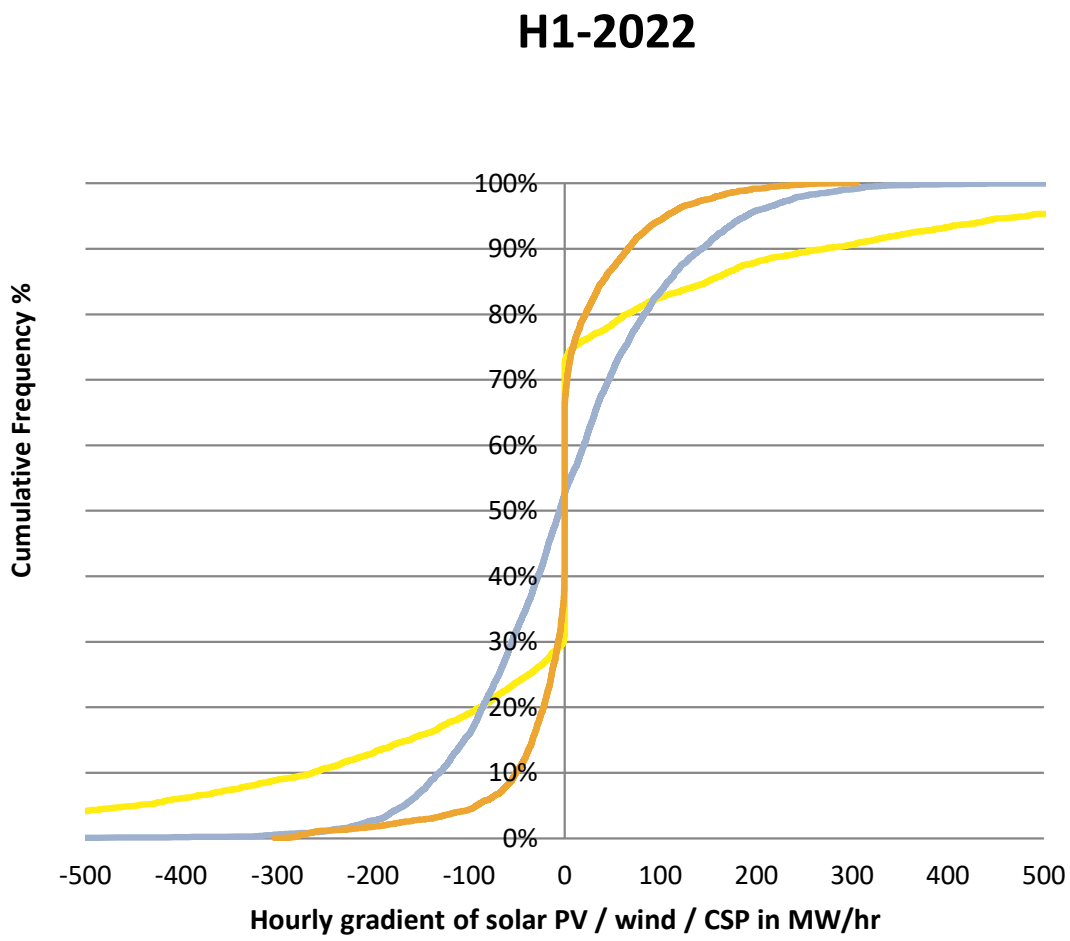
Wind, solar PV & CSP frequency distribution of 1-hour gradients in H1-2022



Capacity operational (30 Jun)

2 212 MW

3 443 MW

500 MW

Solar PV

Wind

CSP

Sources: Eskom; CSIR Energy Centre analysis

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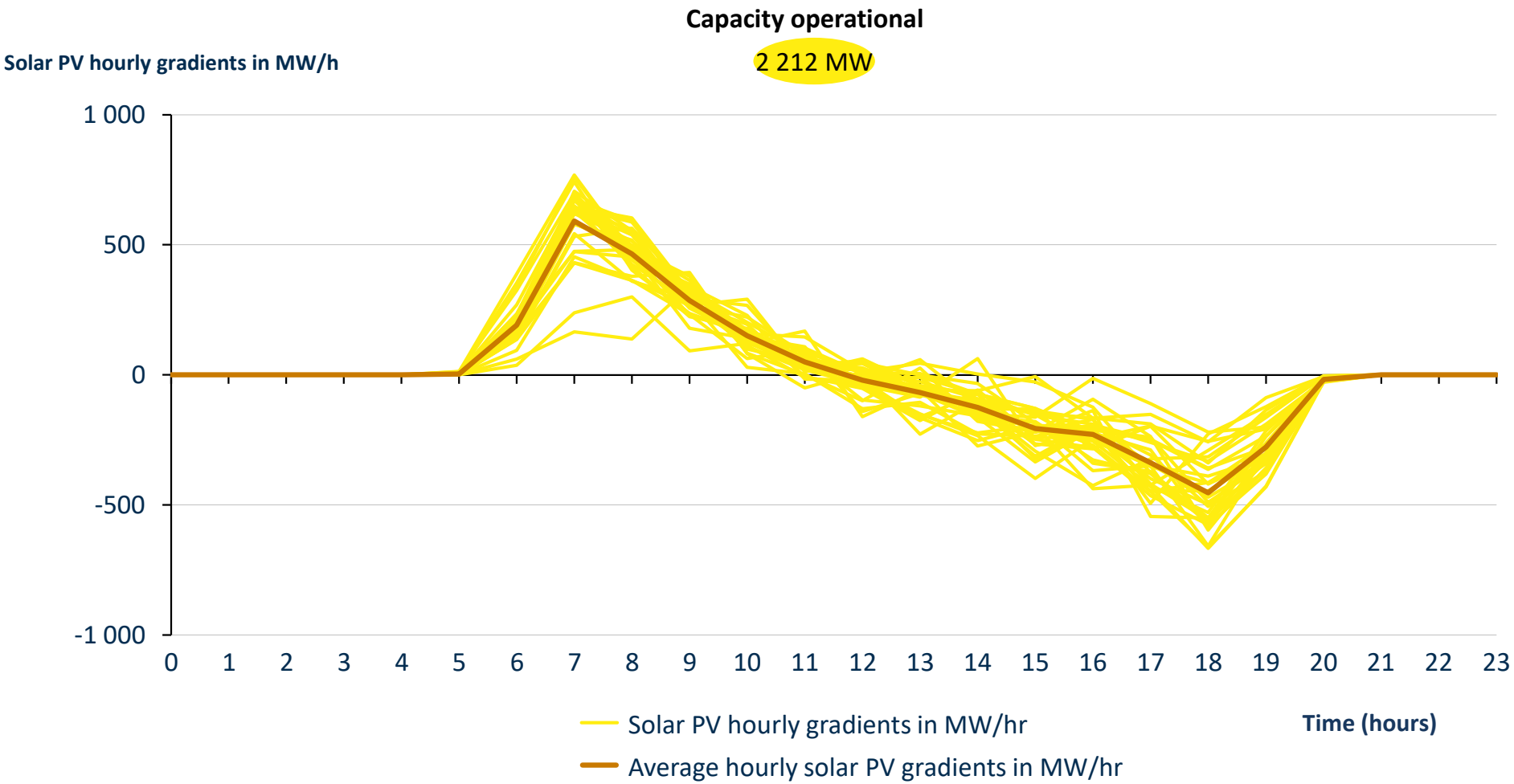
Solar PV 1-hour gradients in January 2022



Sources: Eskom; CSIR Energy Centre analysis

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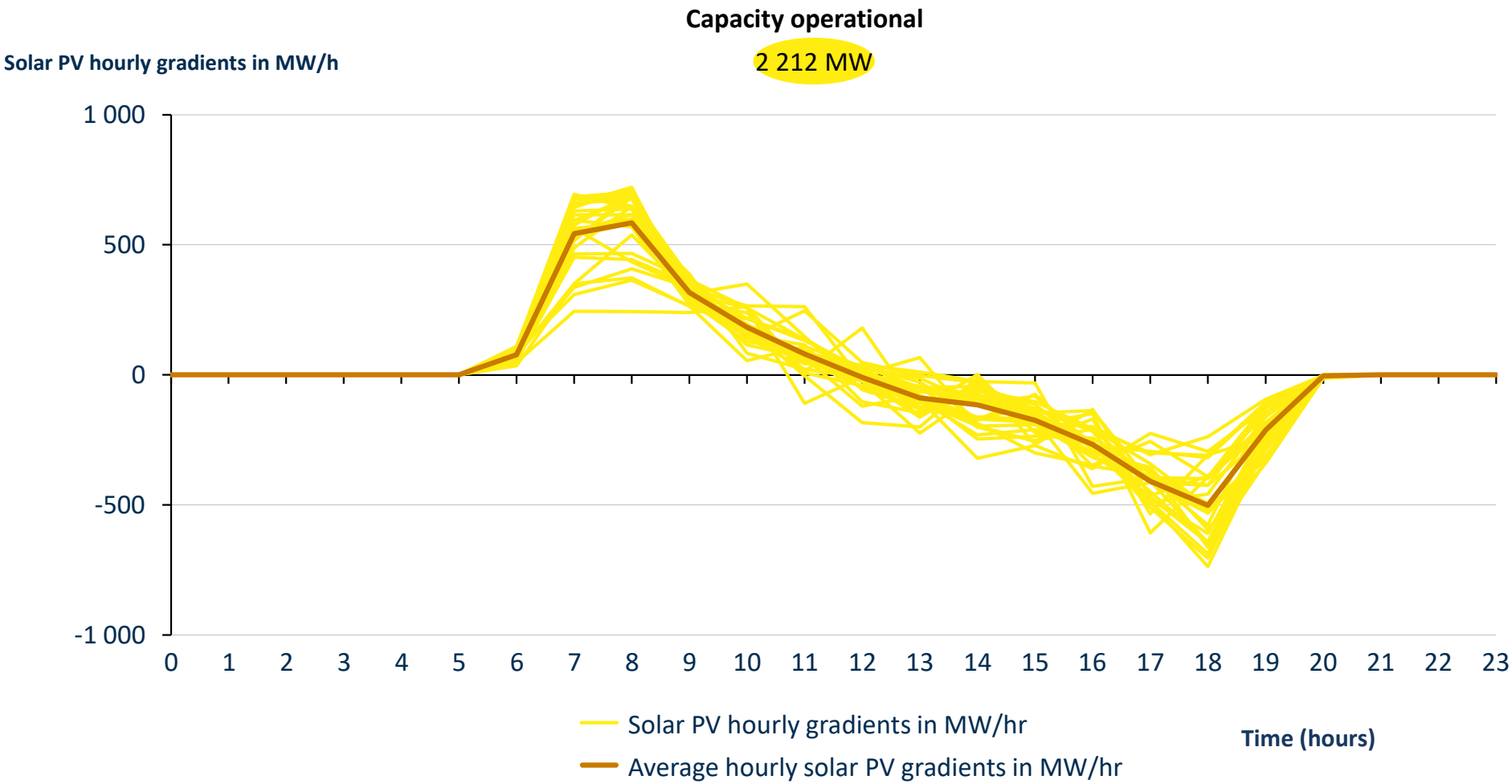
Solar PV 1-hour gradients in February 2022



Sources: Eskom; CSIR Energy Centre analysis

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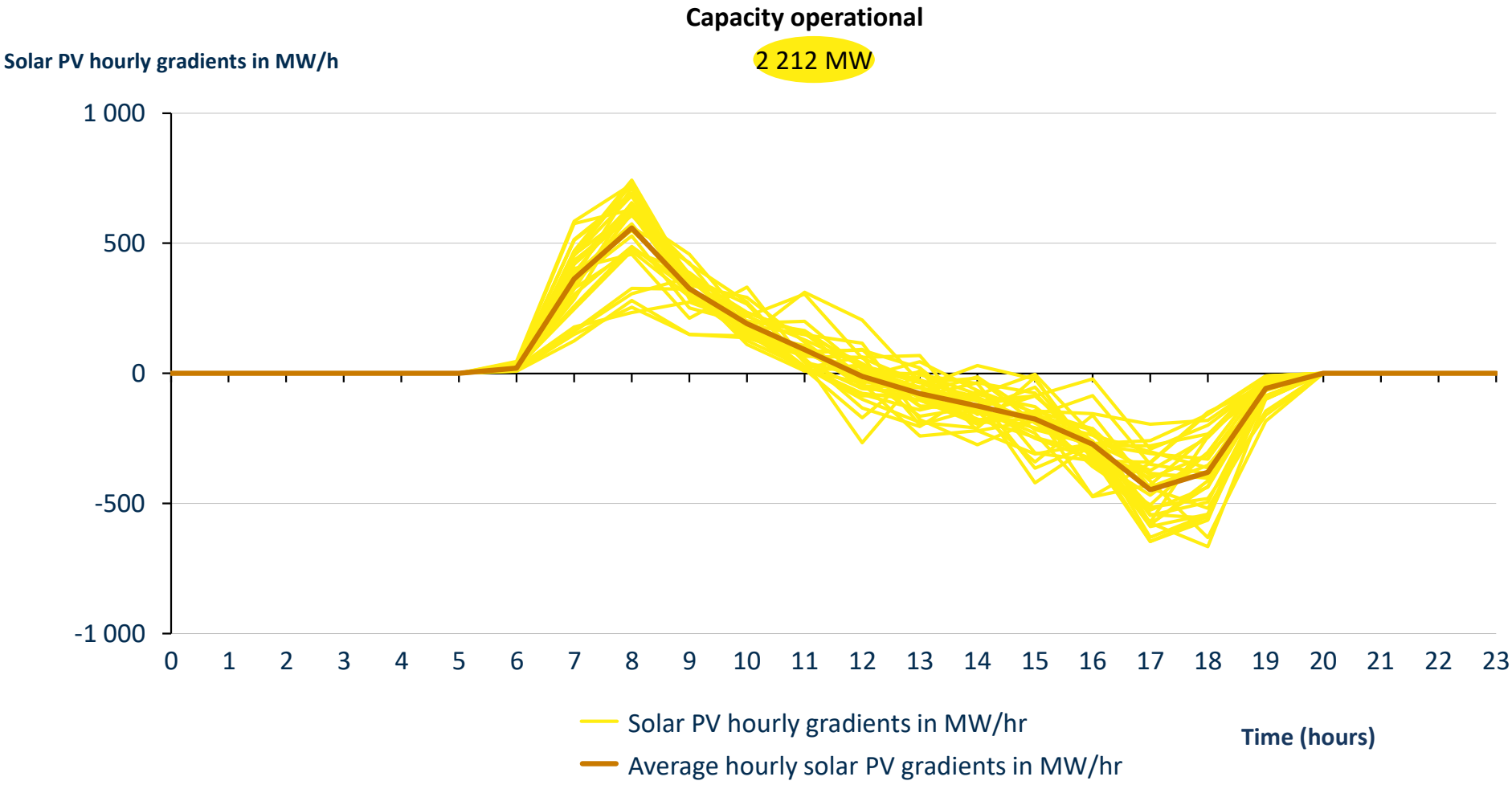
Solar PV 1-hour gradients in March 2022



Sources: Eskom; CSIR Energy Centre analysis

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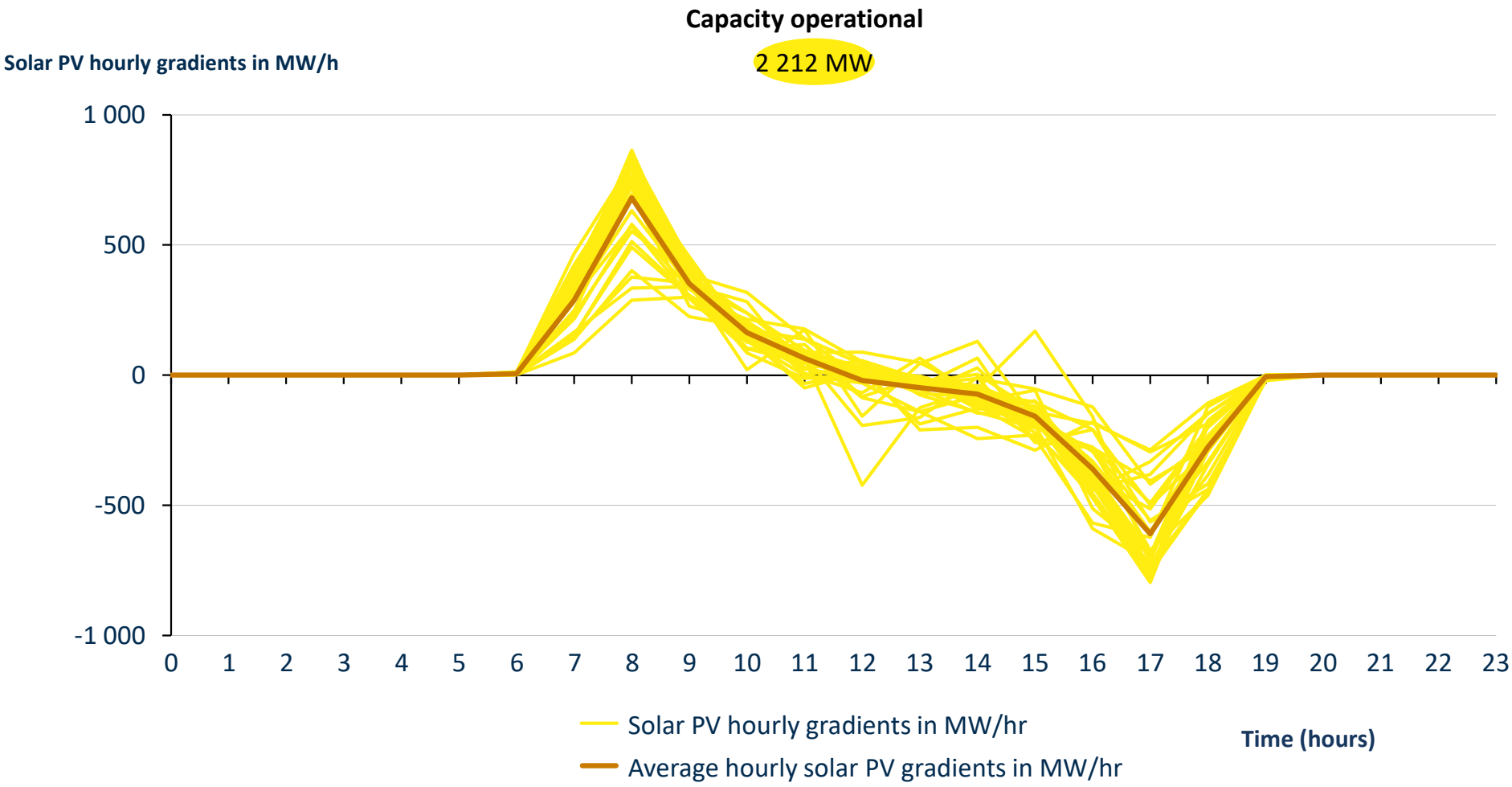
Solar PV 1-hour gradients in April 2022



Sources: Eskom; CSIR Energy Centre analysis

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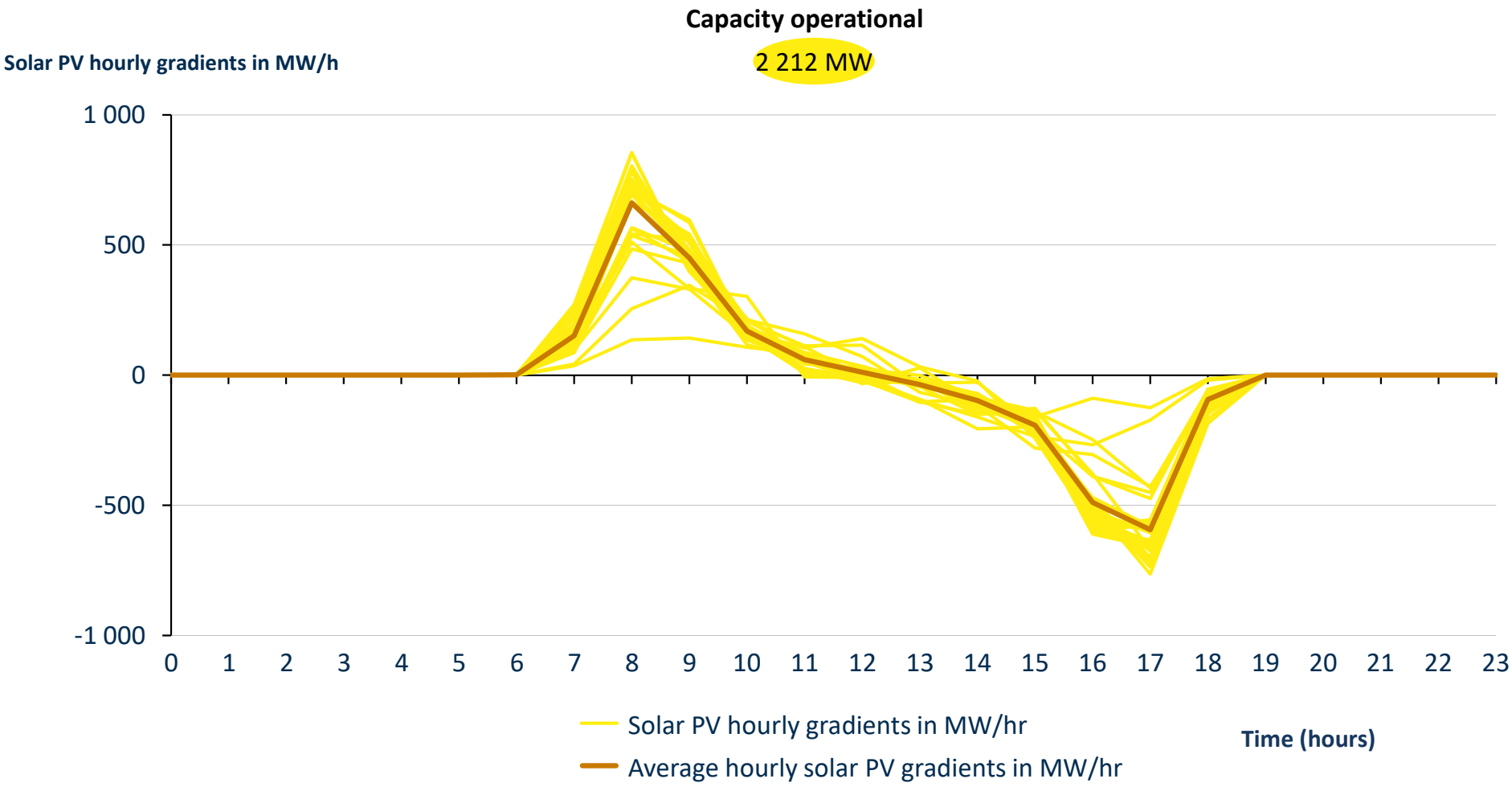
Solar PV 1-hour gradients in May 2022



Sources: Eskom; CSIR Energy Centre analysis

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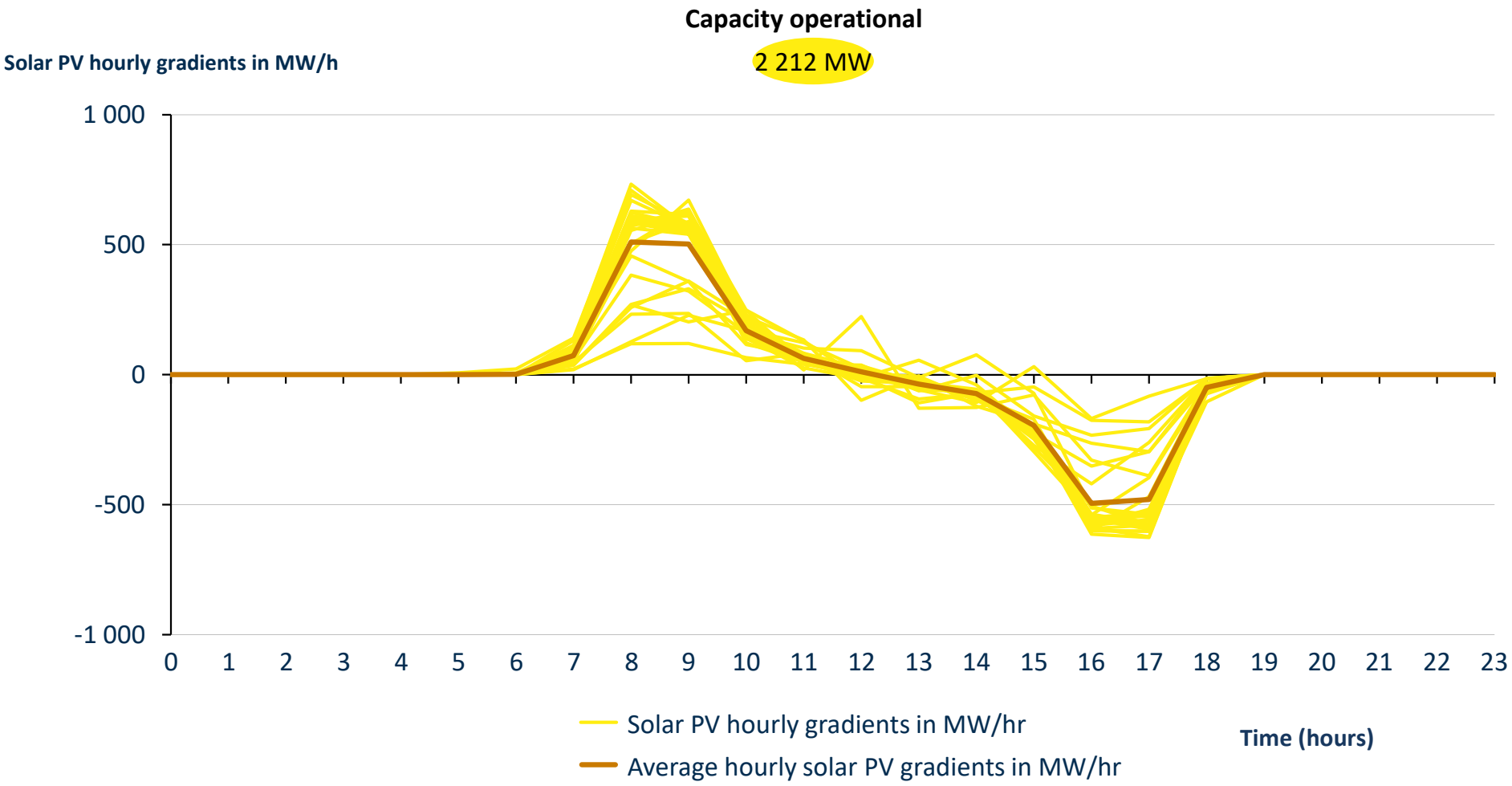
Solar PV 1-hour gradients in June 2022



Sources: Eskom; CSIR Energy Centre analysis

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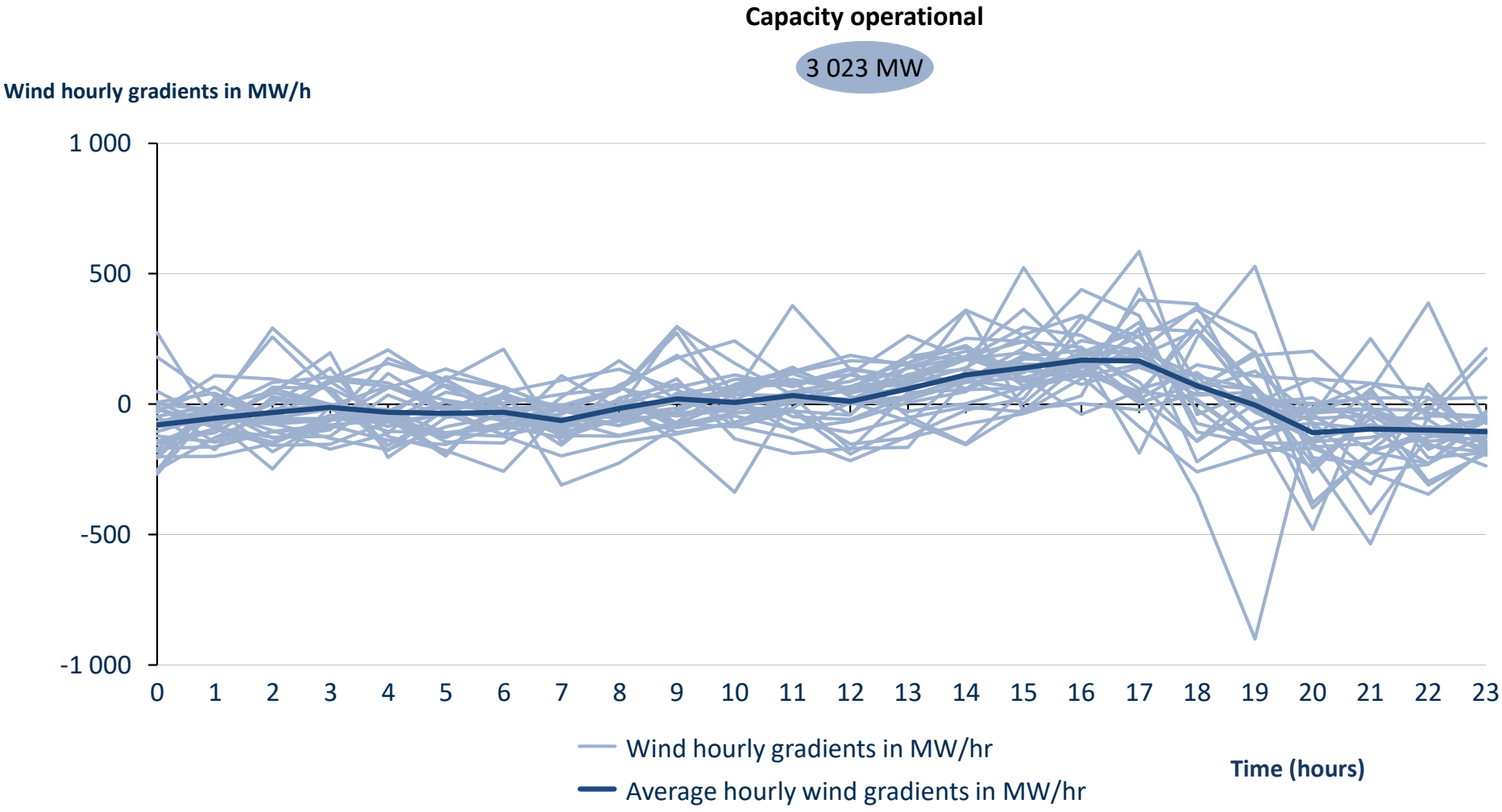
Wind 1-hour gradients in January 2022



Sources: Eskom; CSIR Energy Centre analysis

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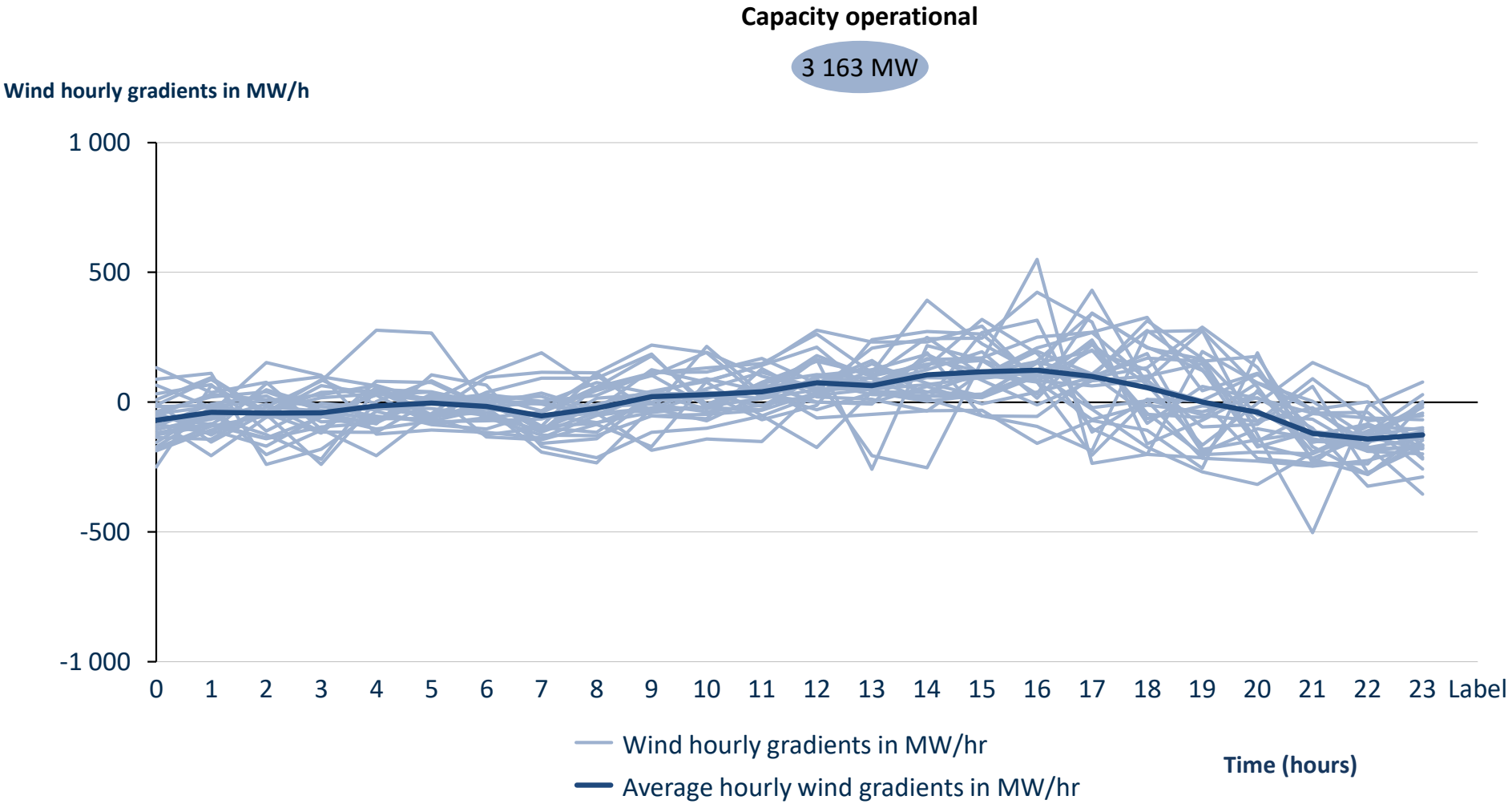
Wind 1-hour gradients in February 2022



Sources: Eskom; CSIR Energy Centre analysis

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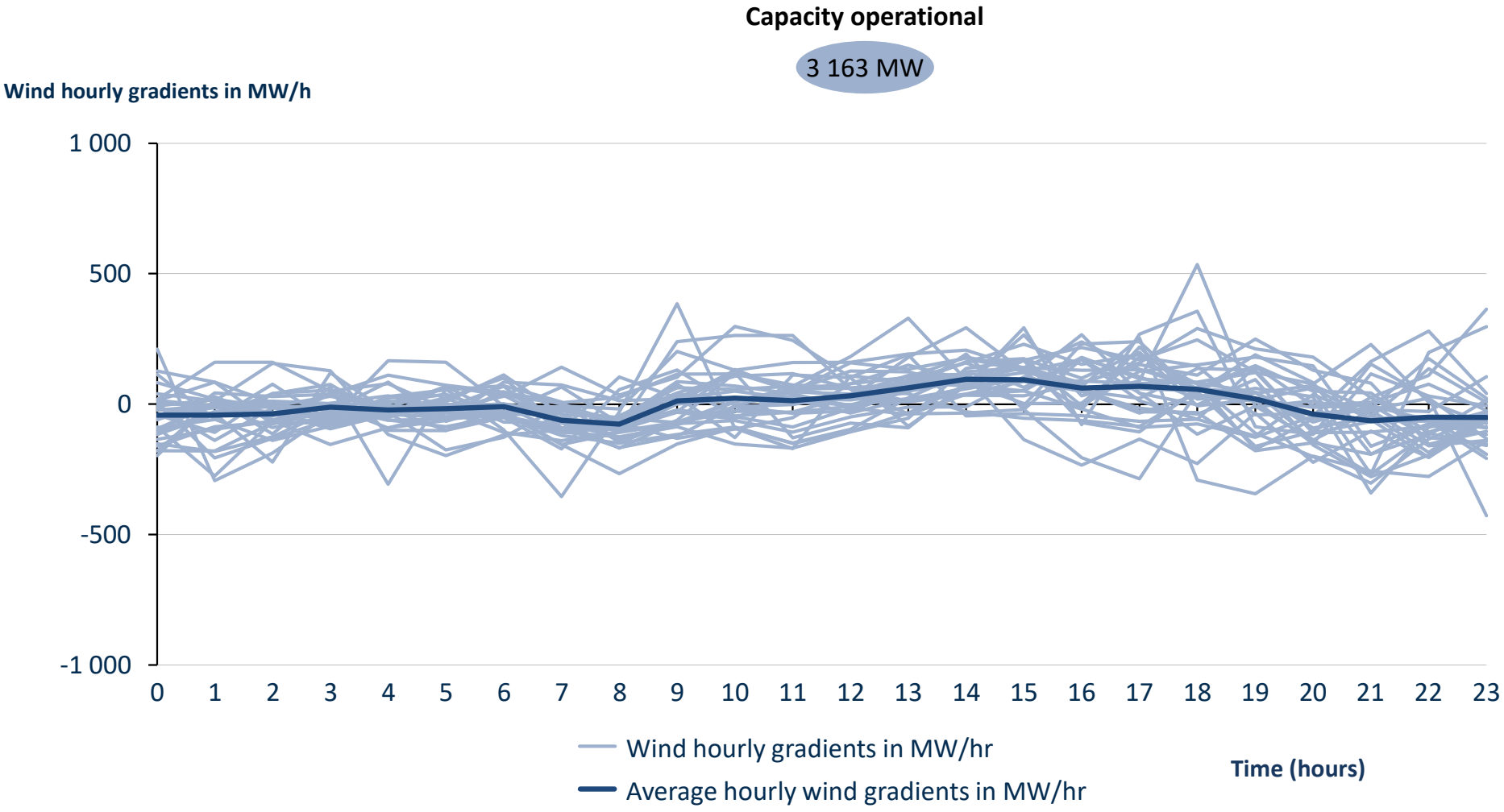
Wind 1-hour gradients in March 2022



Sources: Eskom; CSIR Energy Centre analysis

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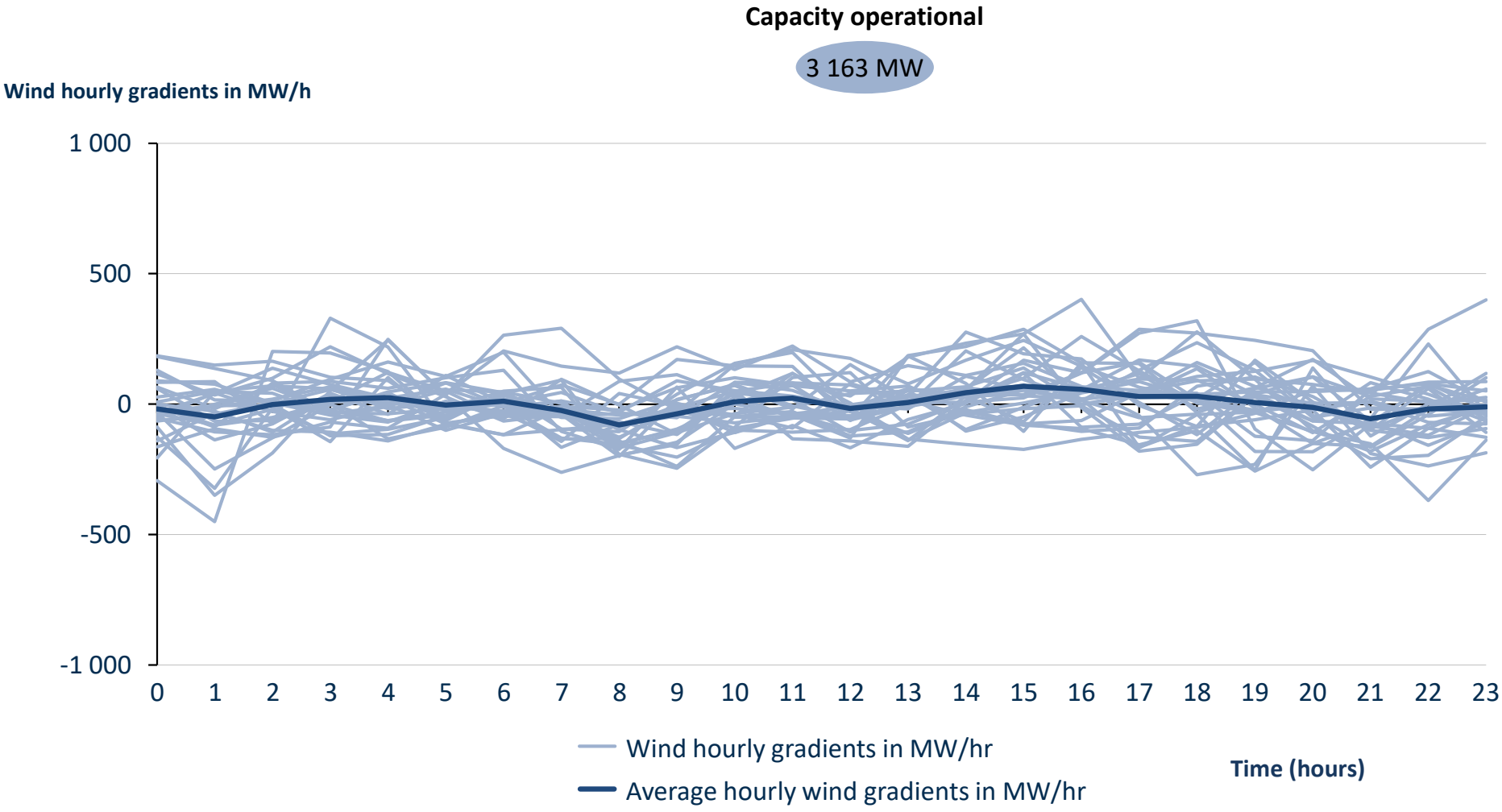
Wind 1-hour gradients in April 2022



Sources: Eskom; CSIR Energy Centre analysis

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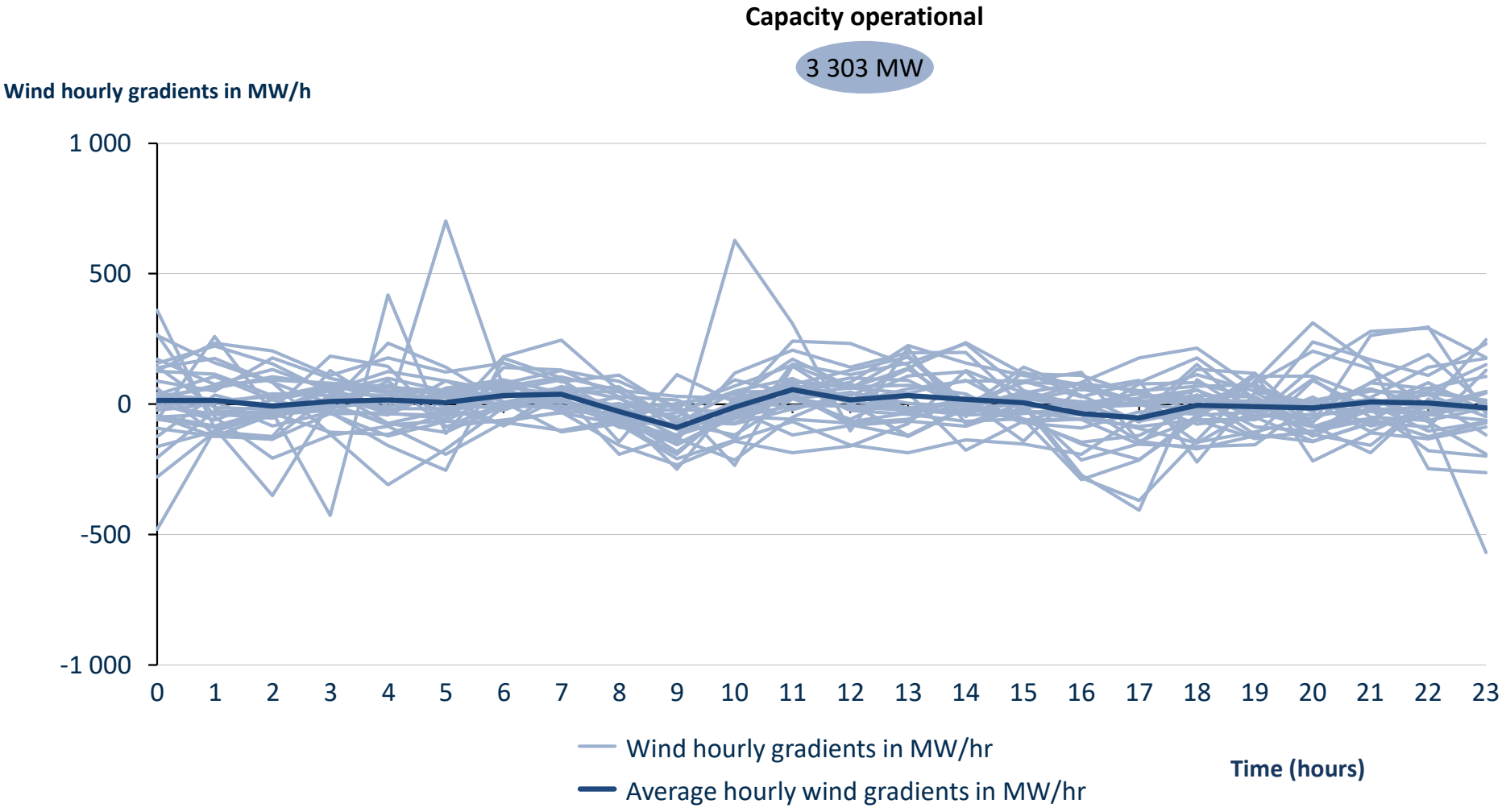
Wind 1-hour gradients in May 2022



Sources: Eskom; CSIR Energy Centre analysis

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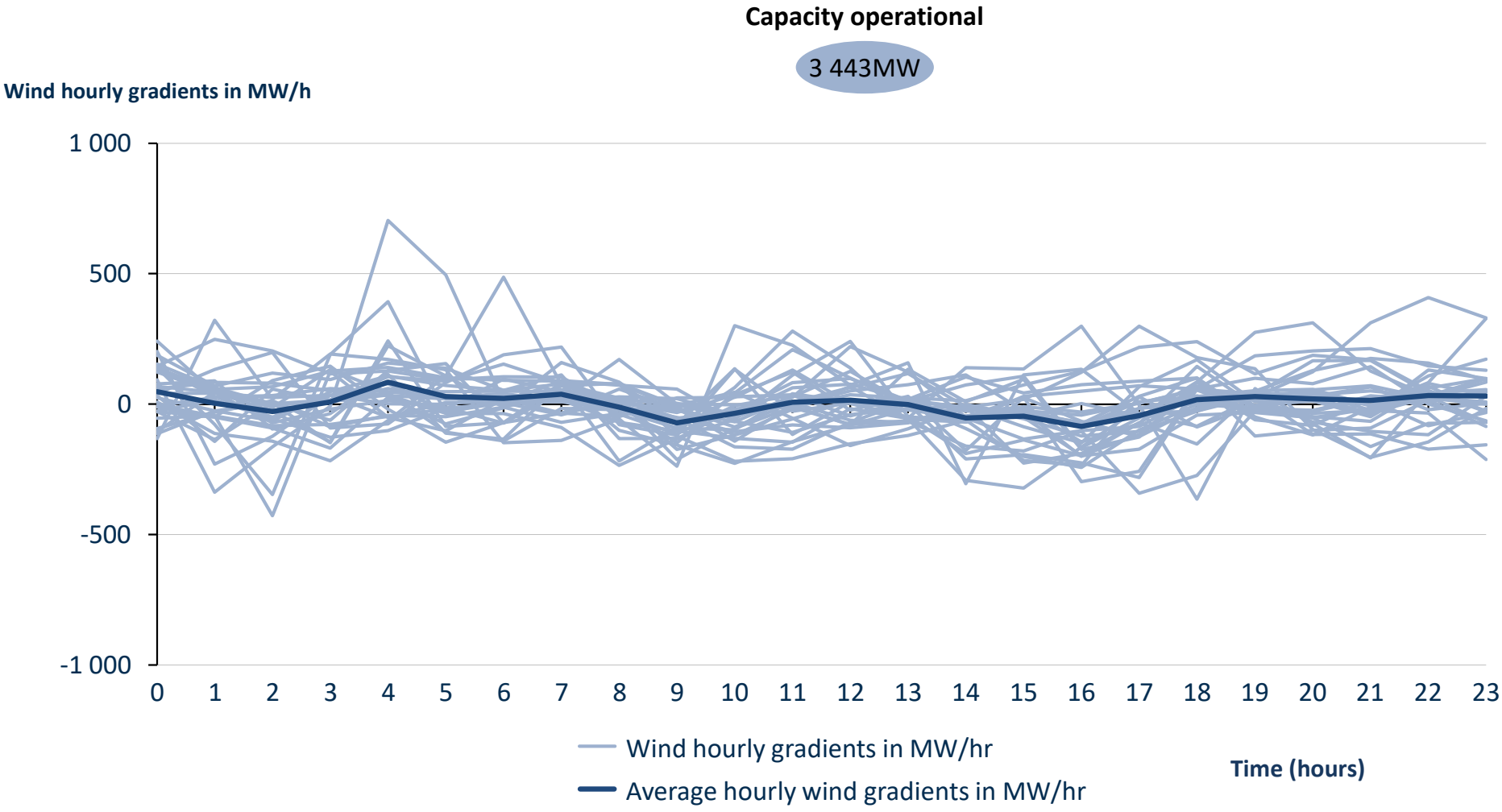
Wind 1-hour gradients in June 2022



Sources: Eskom; CSIR Energy Centre analysis

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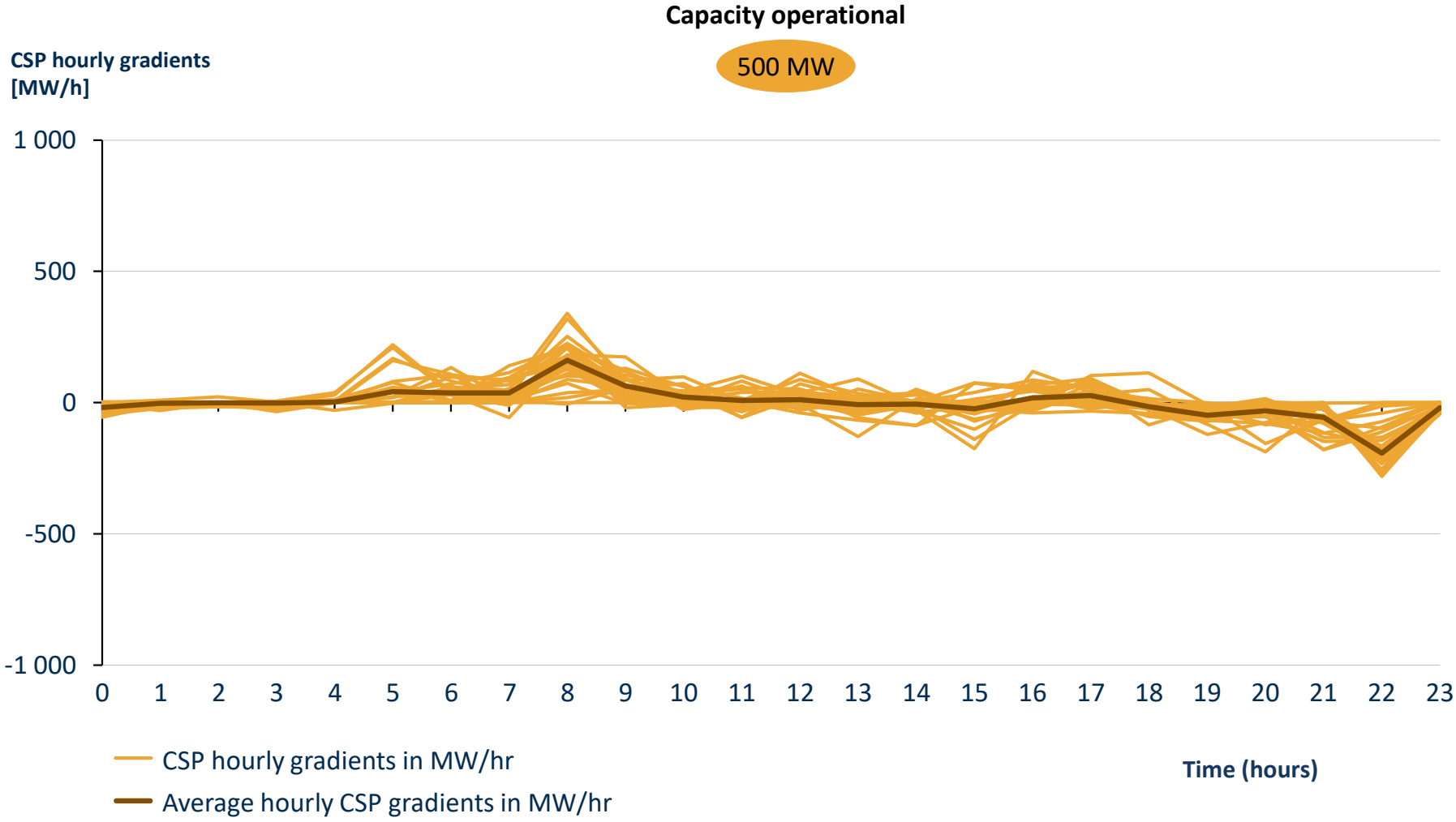
CSP 1-hour gradients in January 2022



Sources: Eskom; CSIR Energy Centre analysis

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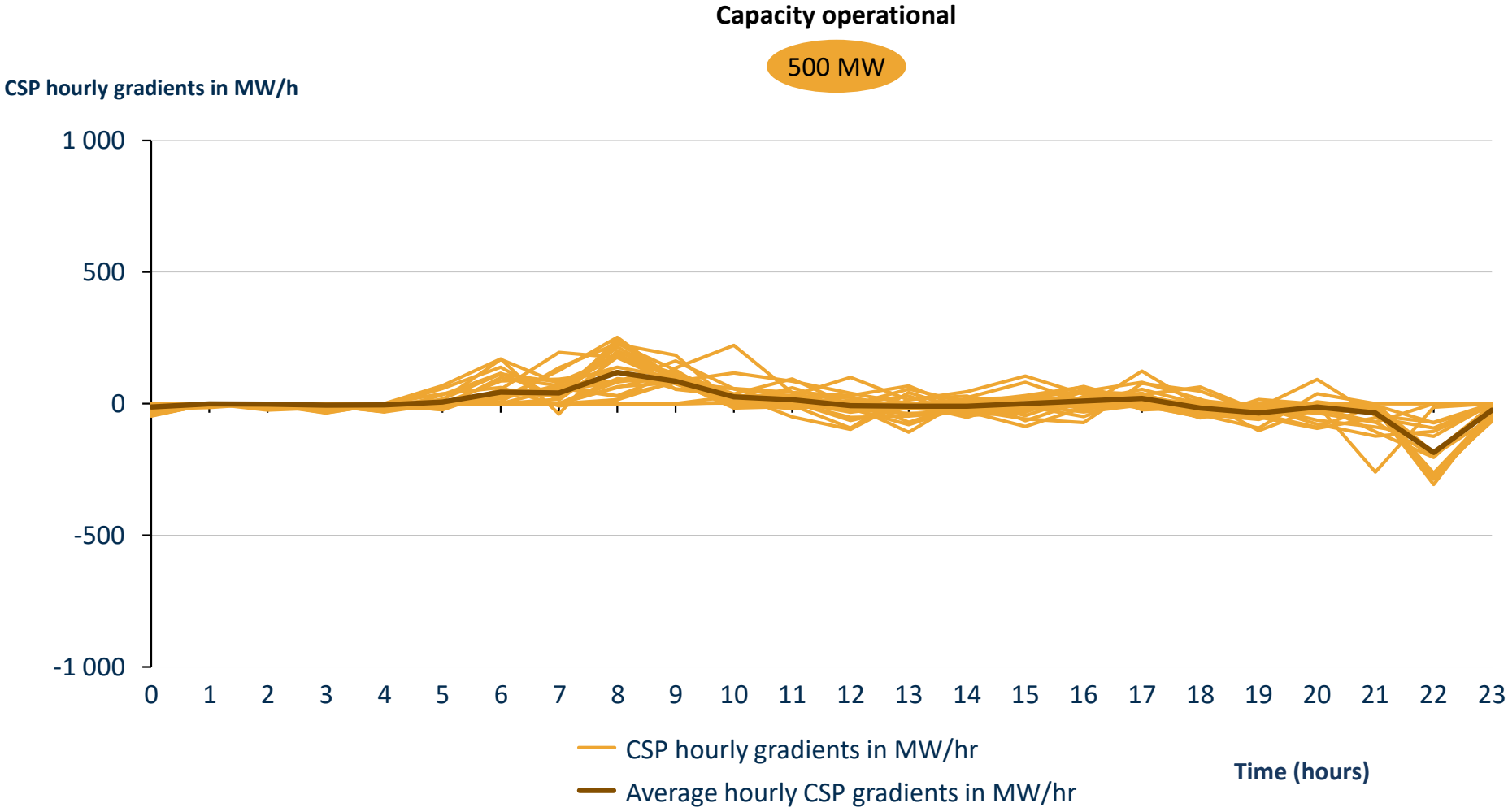
CSP 1-hour gradients in February 2022



Sources: Eskom; CSIR Energy Centre analysis

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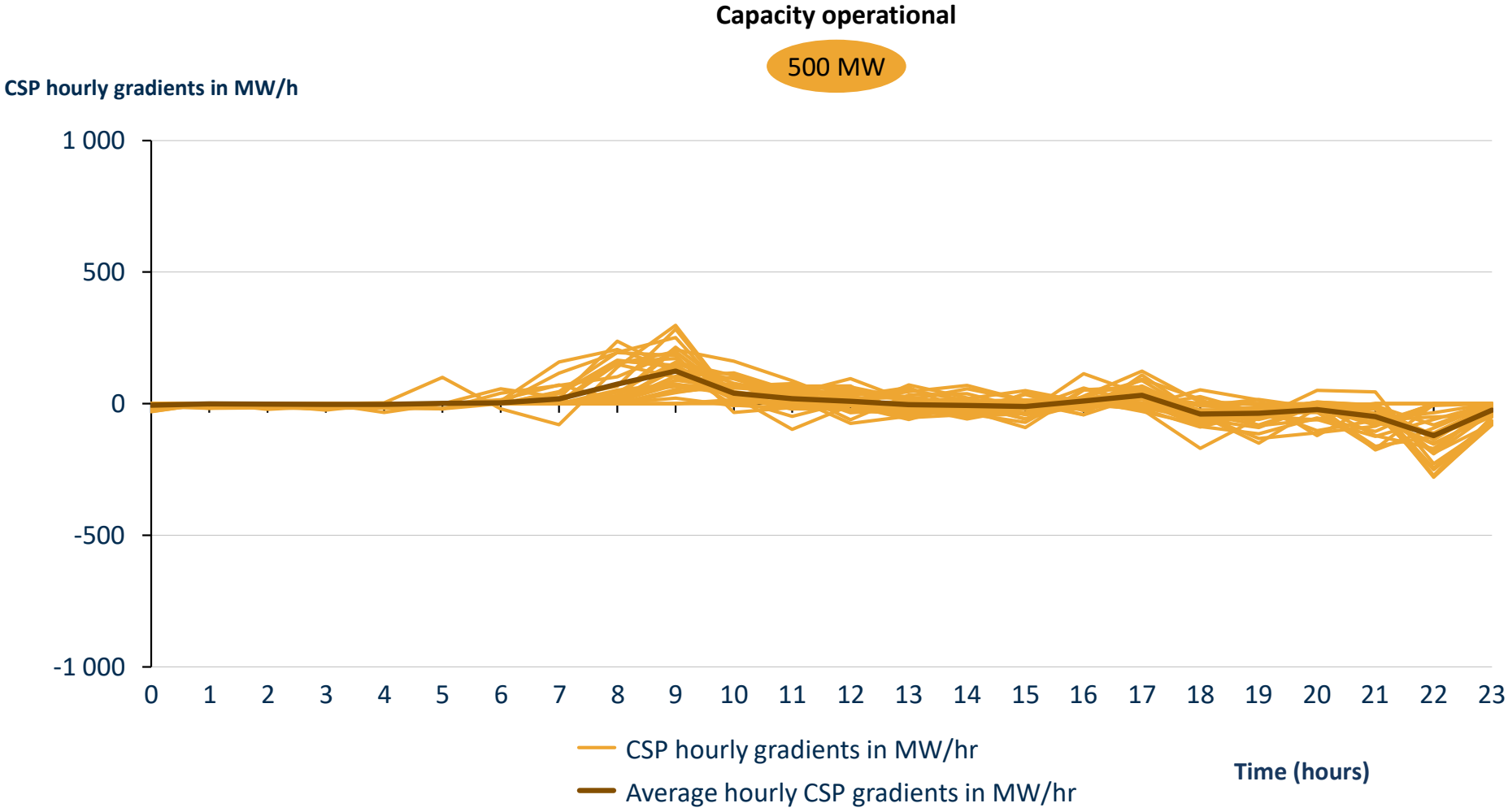
CSP 1-hour gradients in March 2022



Sources: Eskom; CSIR Energy Centre analysis

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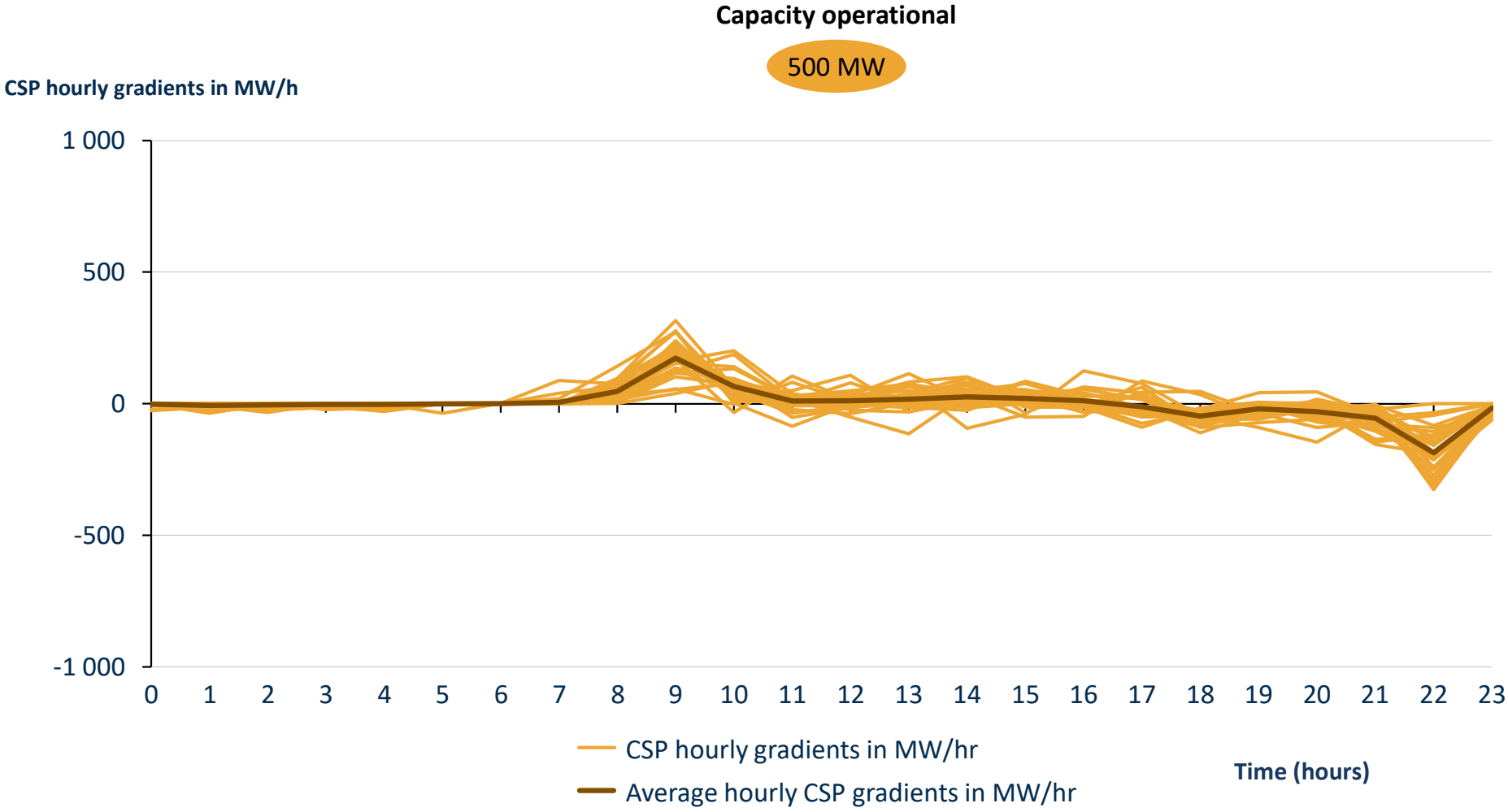
CSP 1-hour gradients in April 2022



Sources: Eskom; CSIR Energy Centre analysis

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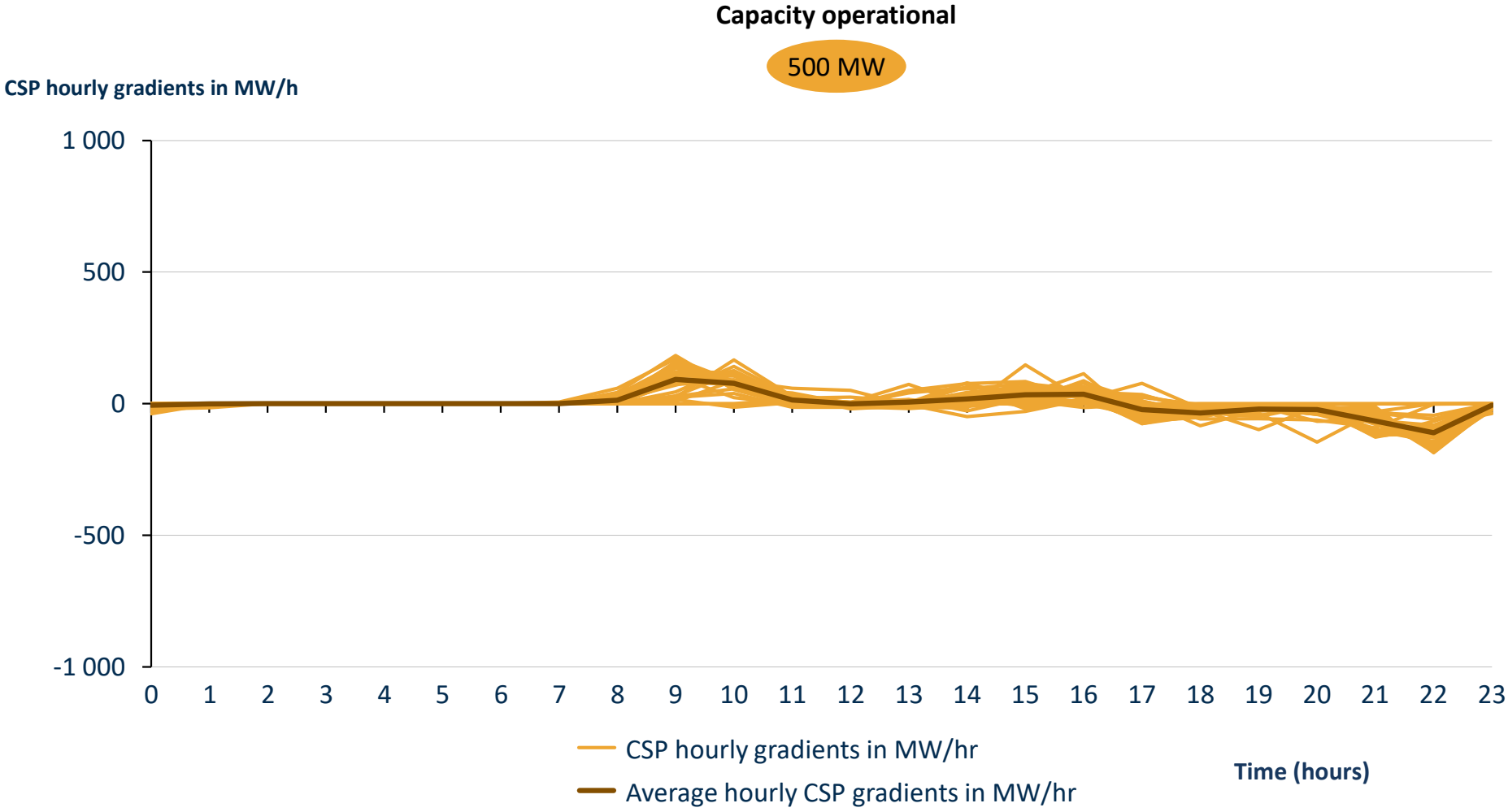
CSP 1-hour gradients in May 2021



Sources: Eskom; CSIR Energy Centre analysis

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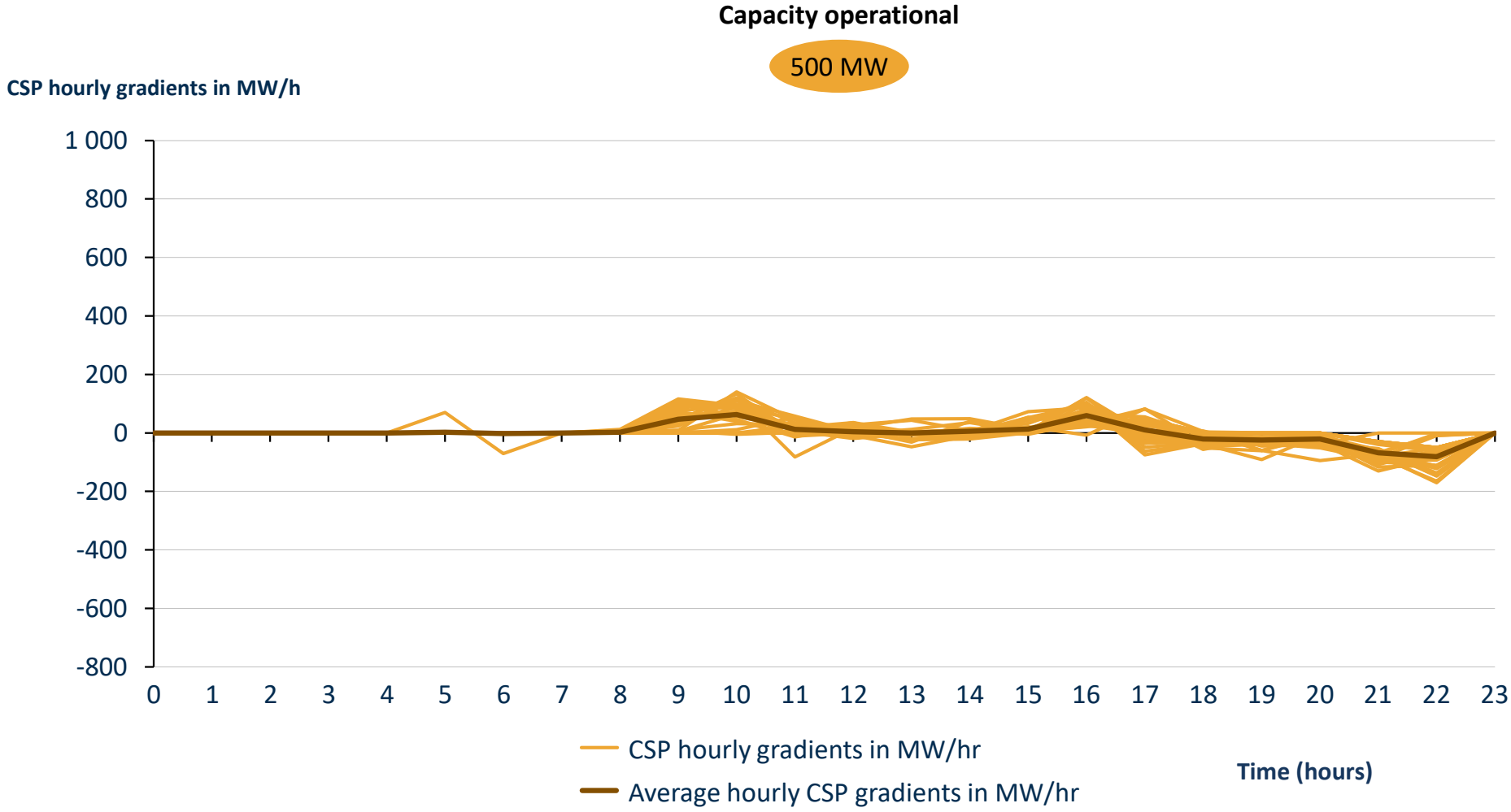
CSP 1-hour gradients in June 2022



Sources: Eskom; CSIR Energy Centre analysis

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Agenda

1 Overview actual electricity production (2022 – H1)

2 Monthly electricity production (2022 – H1)

3 Weekly electricity production (2022 – H1)

4 Daily electricity production (2022 – H1)

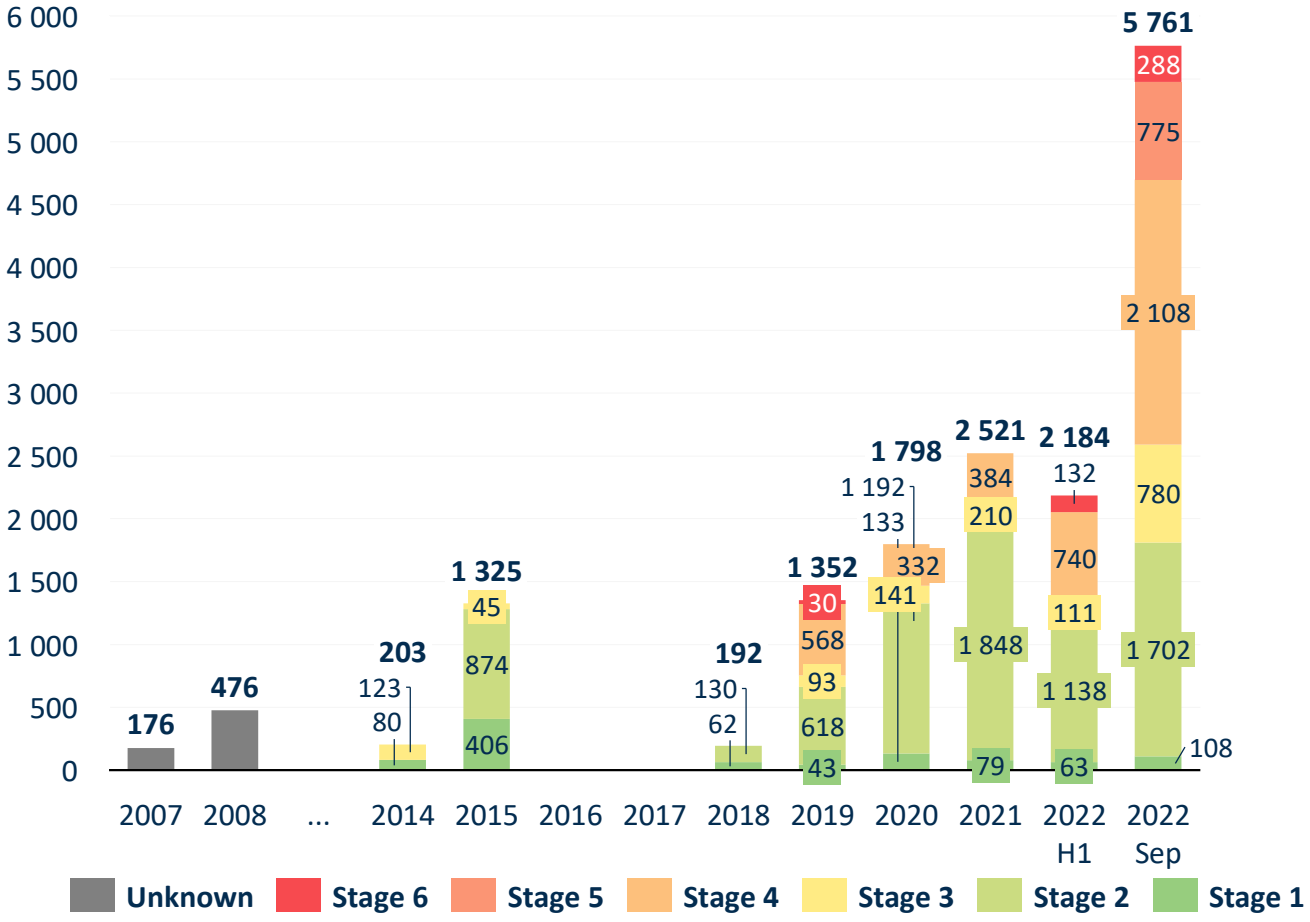
5 Hourly electricity production (2022 – H1)

6 Actual load shedding (2022 – up until September)

7 Other power system statistics (2022 – up until September)

This year overtook 2021 as the most intensive loadshedding year yet. Also, far exceeding 2019's stage 6 loadshedding by almost 10 times. The collective in the three months of Jul to Sep 2022 was more loadshedding experienced in any year before. September 2022 on its own was more loadshedding than in the whole of 2020.

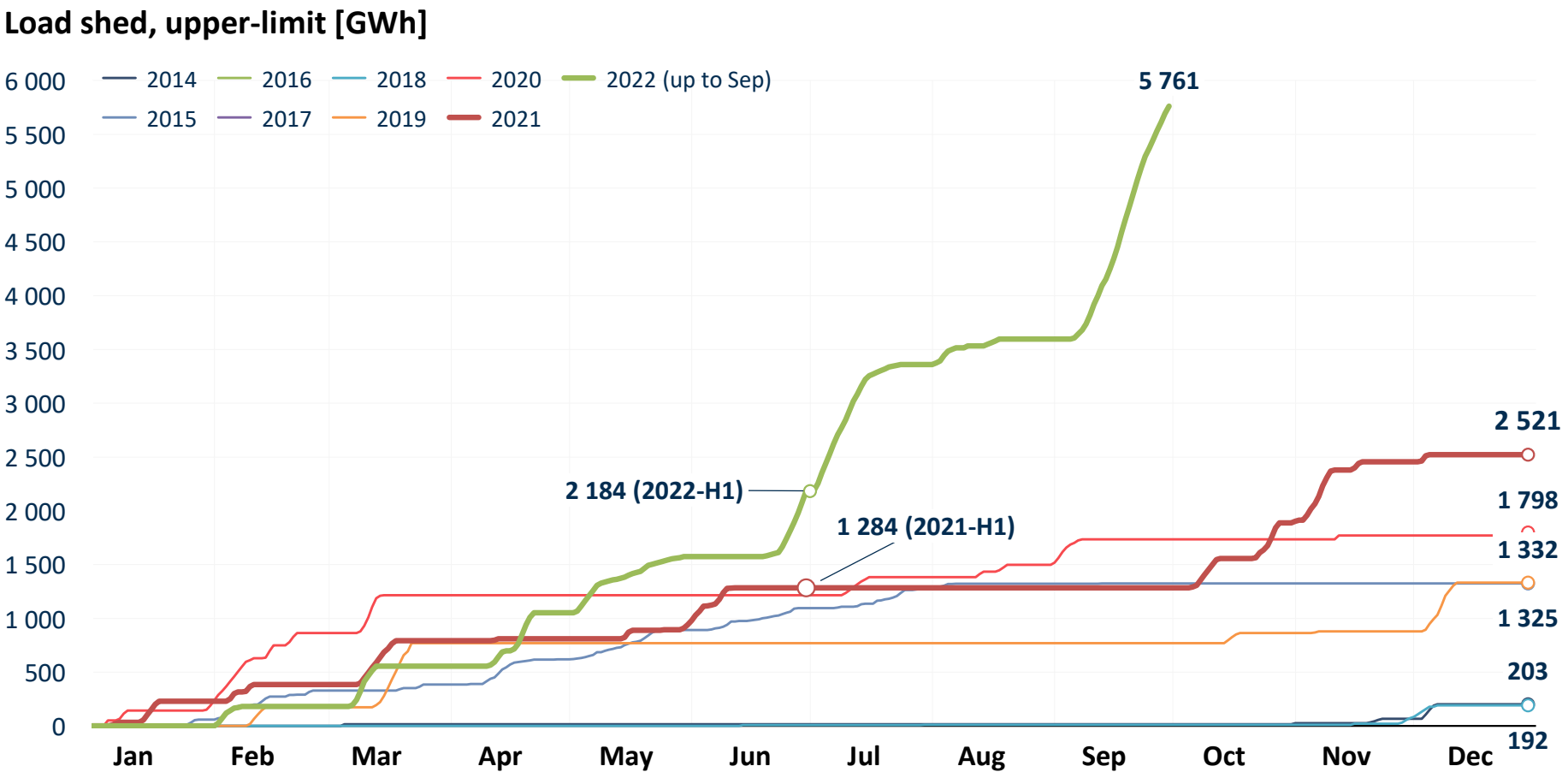
Load shed, upper-limit [GWh]



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-H1	**876**	**2 184**	**1 598**
2022-Sep (Jan-Sep)	**1 949**	**5 761**	**4 315**

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

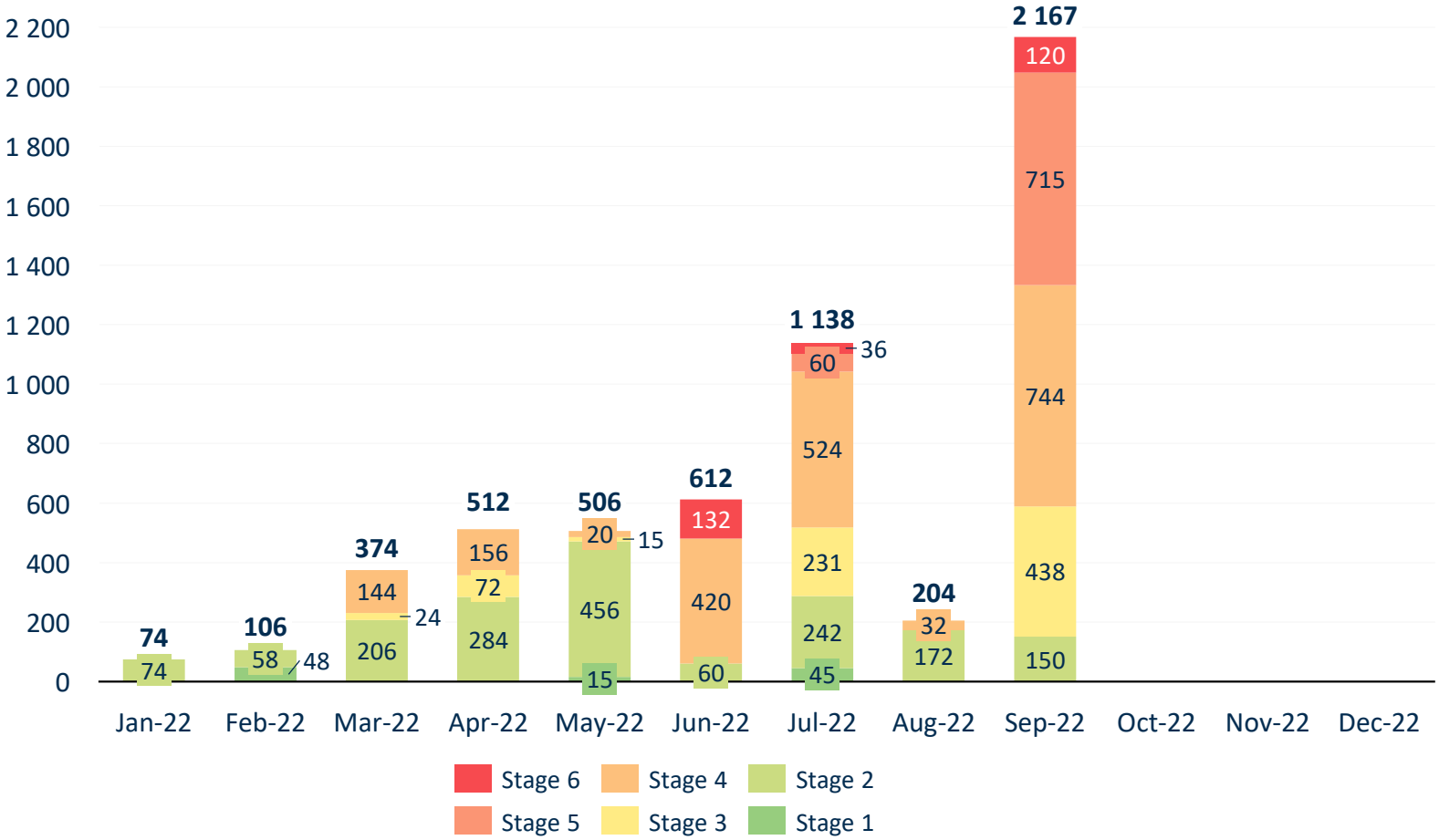
Upper limit of cumulative loadshedding annually Jan 2014 – Sep 2022



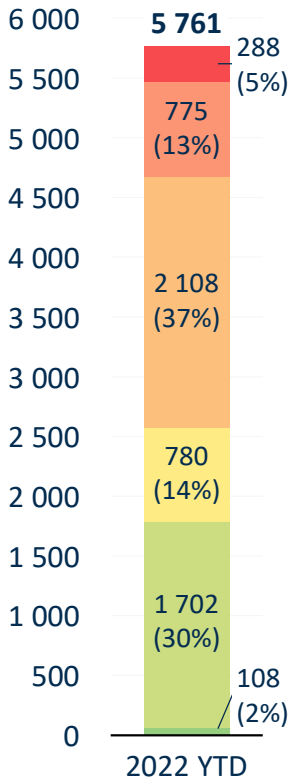
Notes: Loadshedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 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

September 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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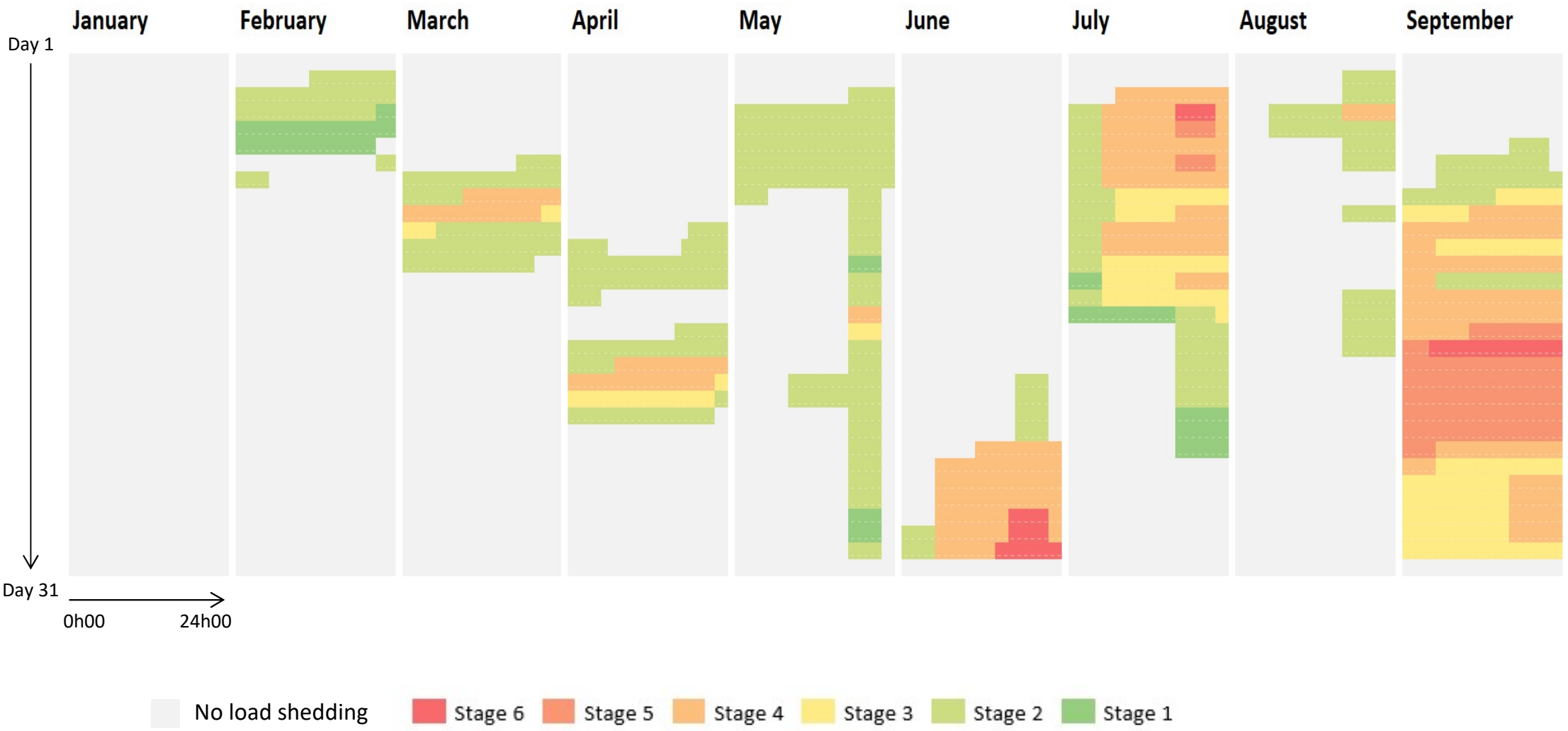
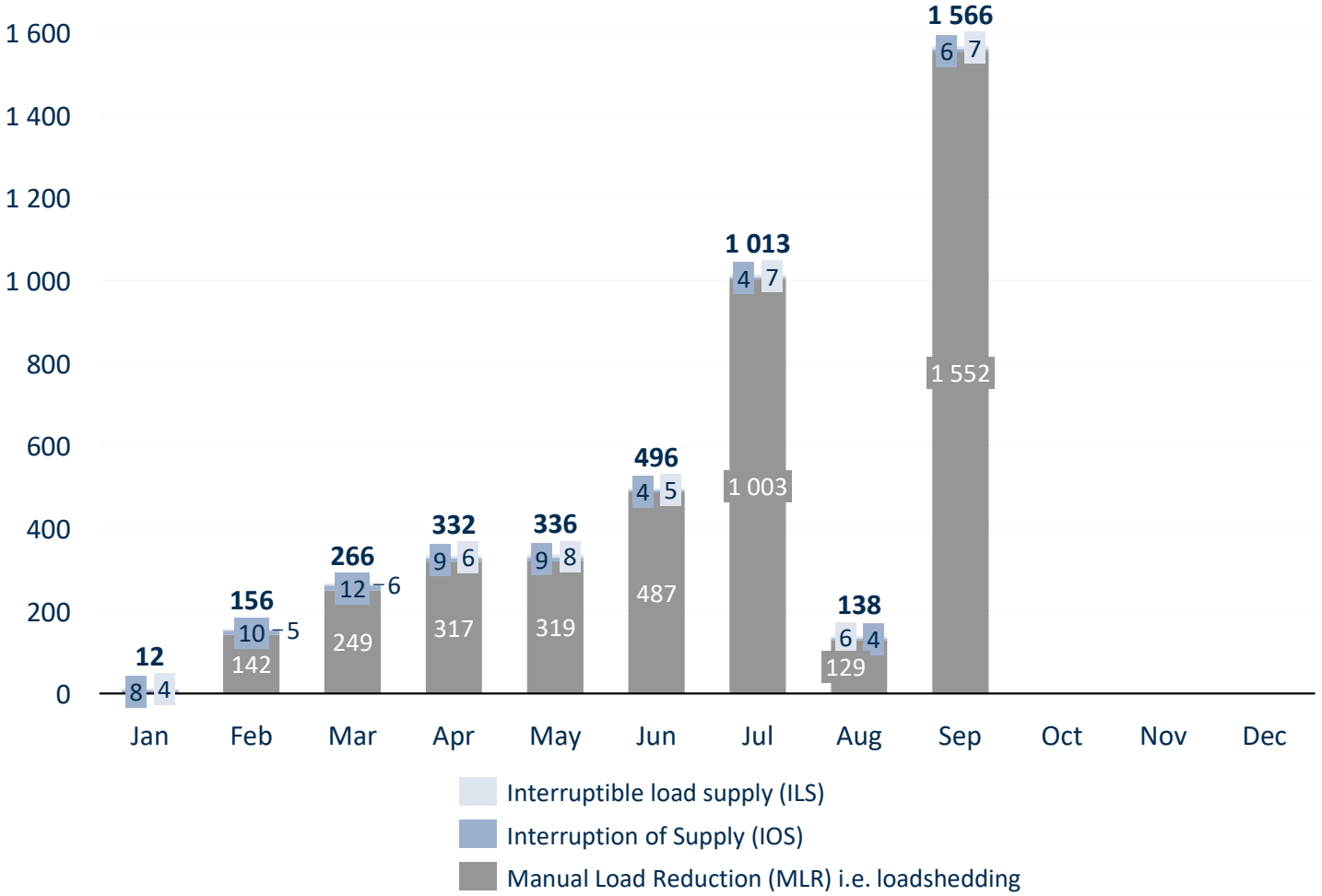
Hourly distribution of loadshedding January – September 2022



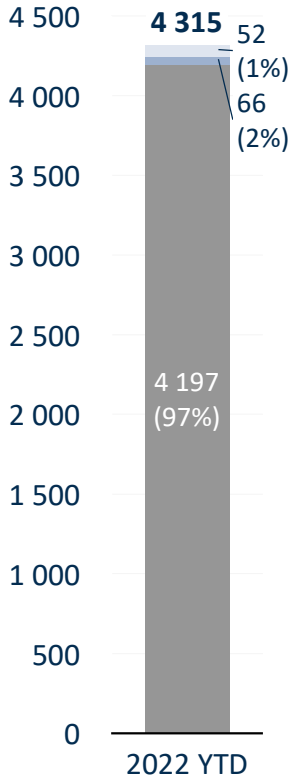
Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 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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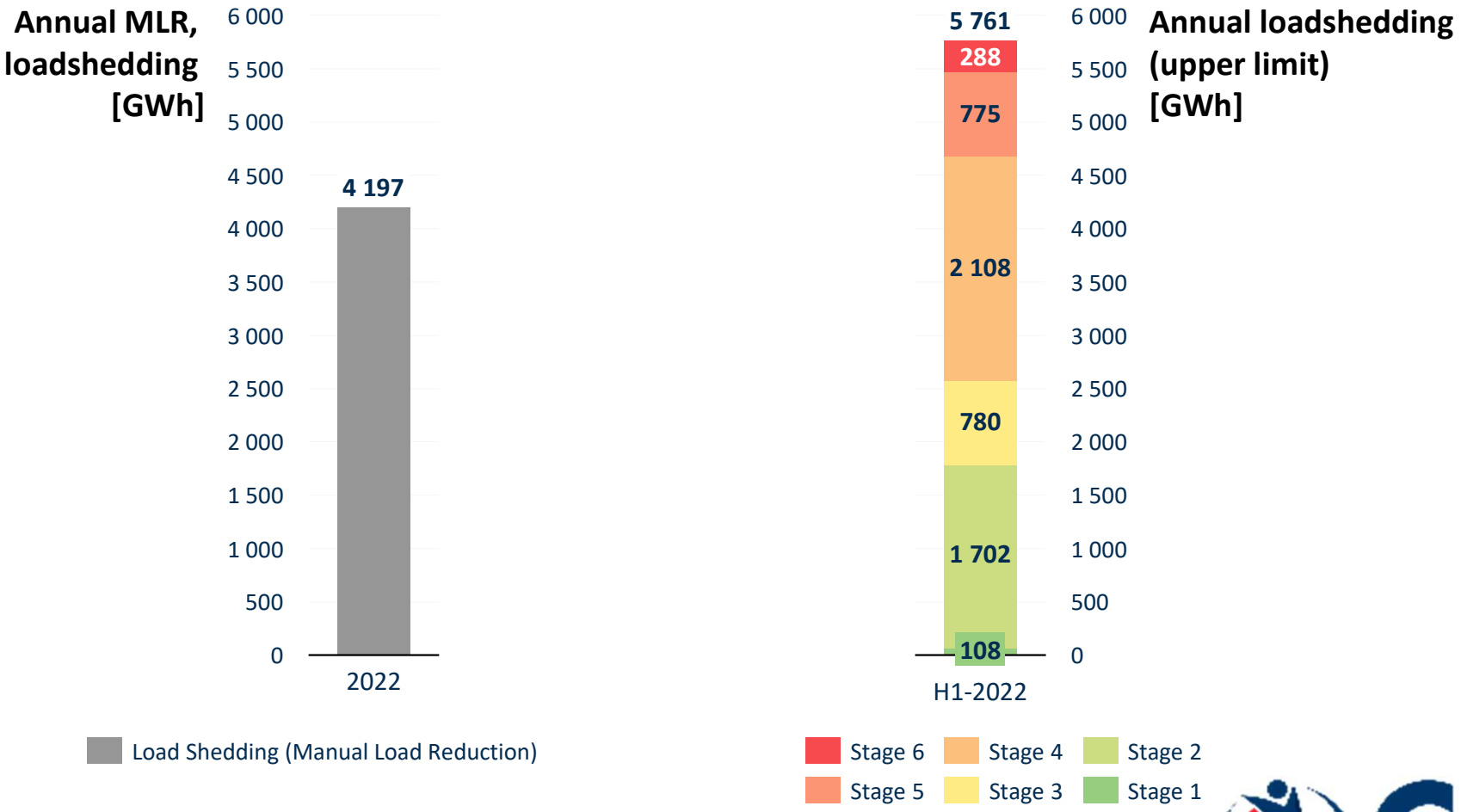
Actual manual load reduction (MLR) in 2022 was ~73% of announced levels of loadshedding



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

Agenda

1 Overview actual electricity production (2022 – H1)

2 Monthly electricity production (2022 – H1)

3 Weekly electricity production (2022 – H1)

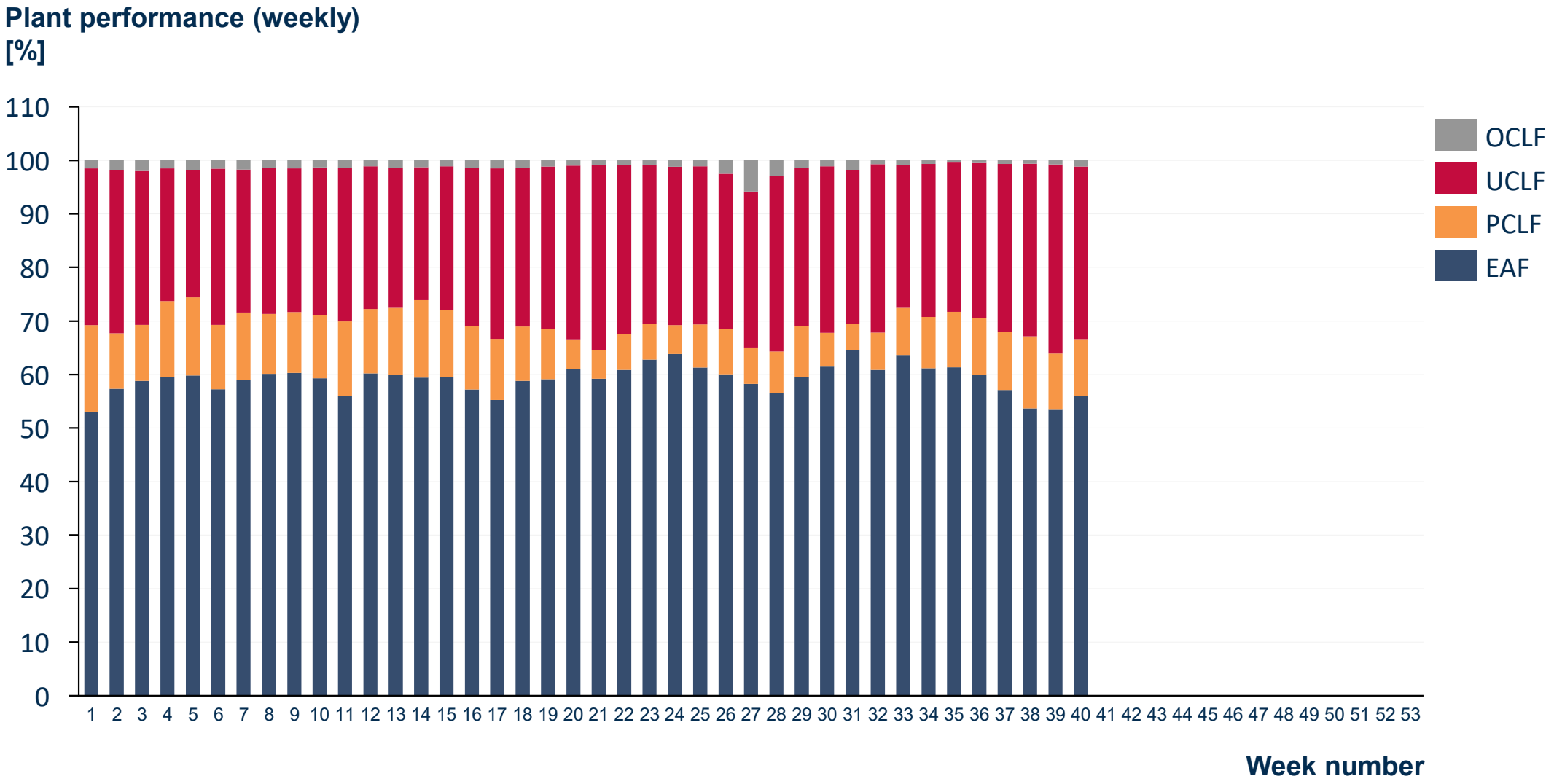
4 Daily electricity production (2022 – H1)

5 Hourly electricity production (2022 – H1)

6 Actual load shedding (2022 – up until September)

7 Other power system statistics (2022 – up until September)

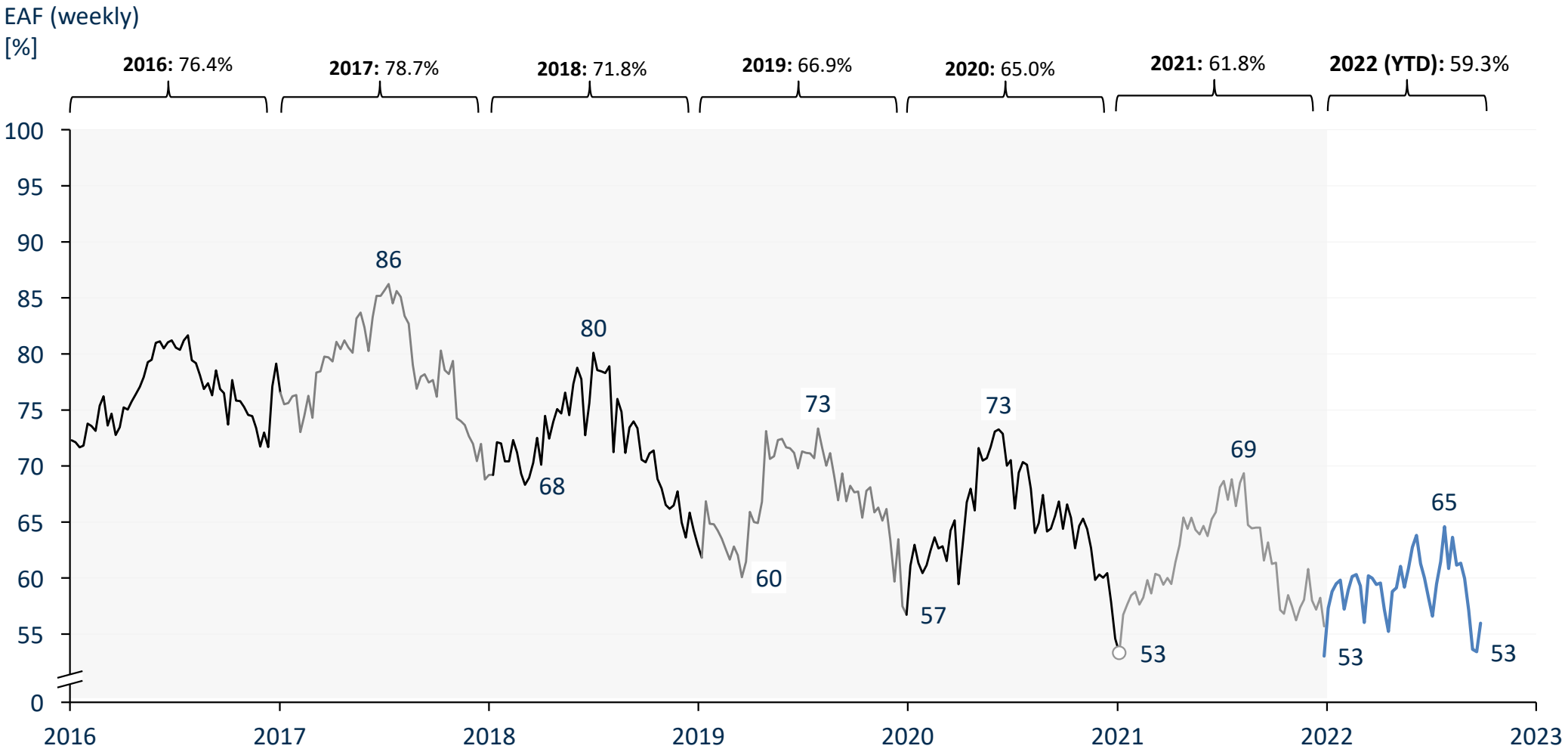
Eskom fleet performance up until September 2022 (weekly) reveals overall EAF of 59.3% with planned maintenance of 10.0%, unplanned outages of 29.3% and other at 1.4%



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 weekly EAF (YTD) of 59.1% but does seem to be 'flattening' out

The weekly average EAF hit a new low of 53.0% (very similar to previous low)



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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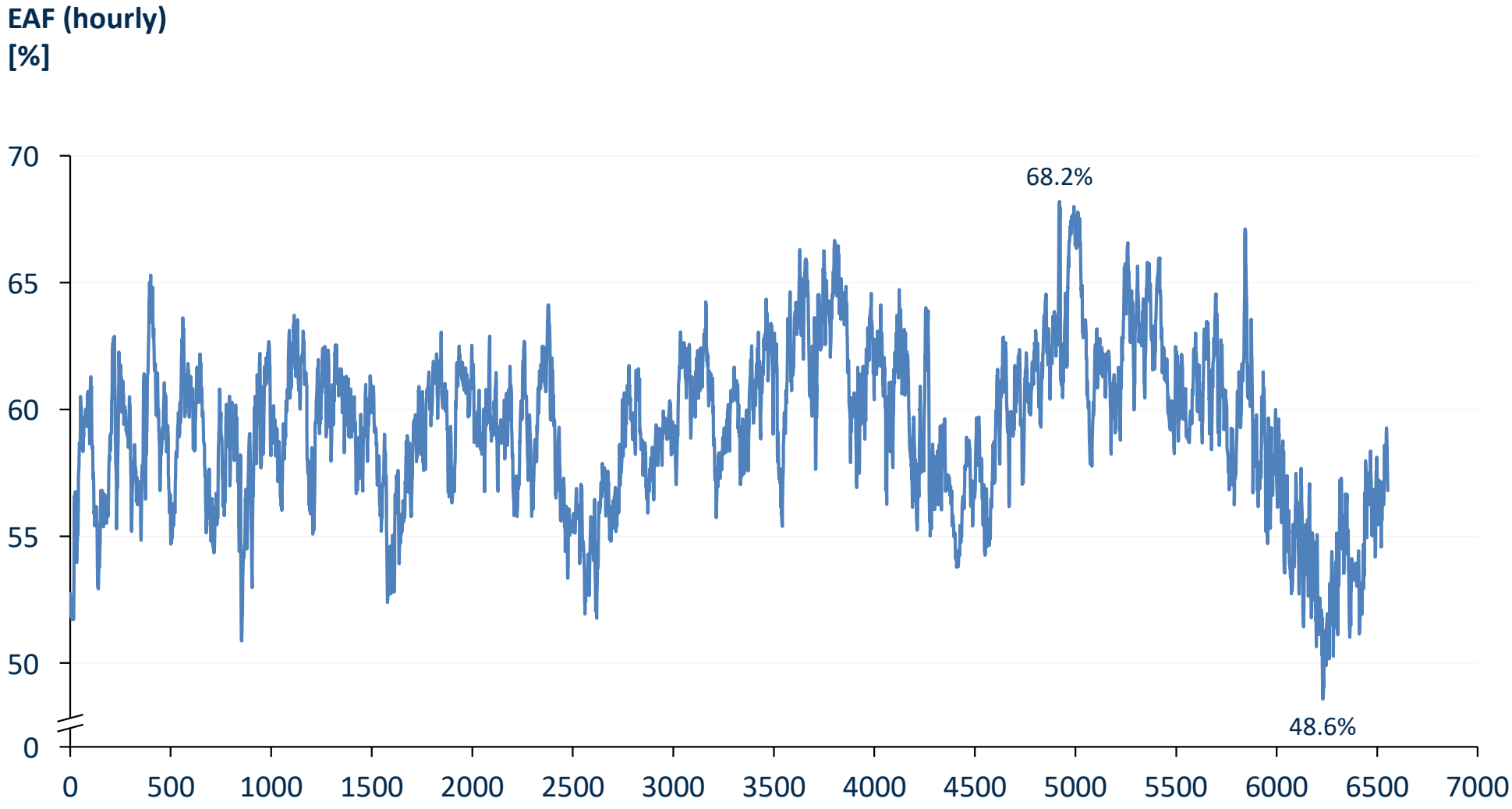
Declining EAF trend continues into 2022 to an hourly average EAF 59.3%. EAF does not exhibit similar seasonality as in other years but stays 'flat'

The hourly average EAF hit a new low of 48.6%



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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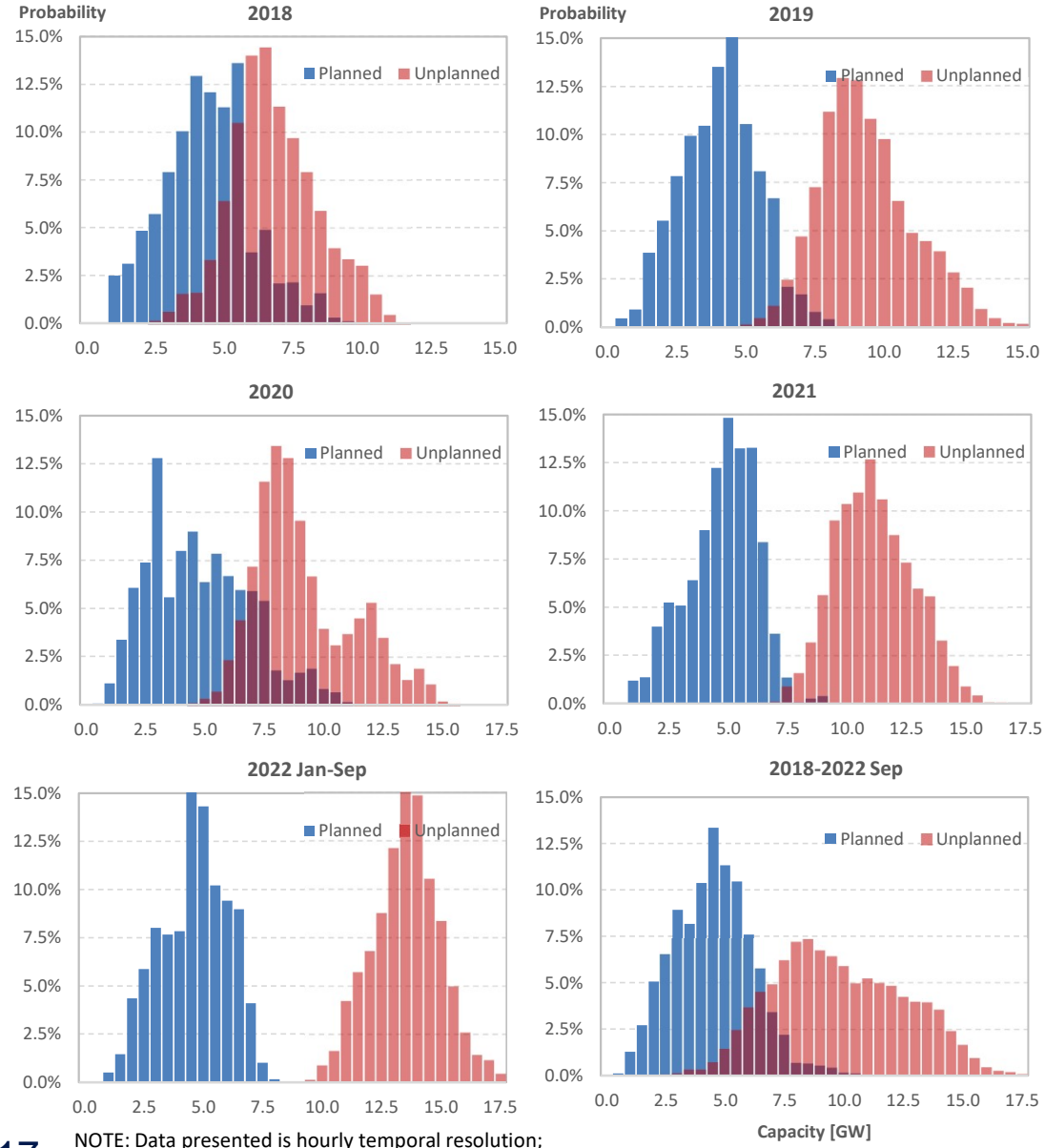
Unplanned outage component is increasingly trending in a worrying direction



- **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. 2022 (up until September) continues this trend.**

NOTE: Data presented is hourly temporal resolution;
Installed Eskom capacity is dynamic: [2017] 44.0-45.4 GW, [2018] 45.4-44.1 GW, [2019] 44.1-45.0, [2020] 45.0-45.6 GW, [2021] 45.6-46.4 GW

Thank you

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