

Statistics of utility-scale solar PV, wind and CSP in South Africa in 2019

CSIR Energy Centre

Pretoria, May 2020

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The logo for the Council for Scientific and Industrial Research (CSIR) of South Africa. It features the letters 'CSIR' in a bold, dark blue, sans-serif font. The 'C' and 'S' are connected, and the 'I' and 'R' are also connected. The letters are set against a white background.

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Agenda

- 1 Overview and status of REIPPPP
- 2 Overview actual electricity production data for 2019
- 3 Monthly electricity production
- 4 Weekly electricity production
- 5 Daily electricity production
- 6 Hourly electricity production
- 7 Actual load shedding in 2019

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South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) started in 2011

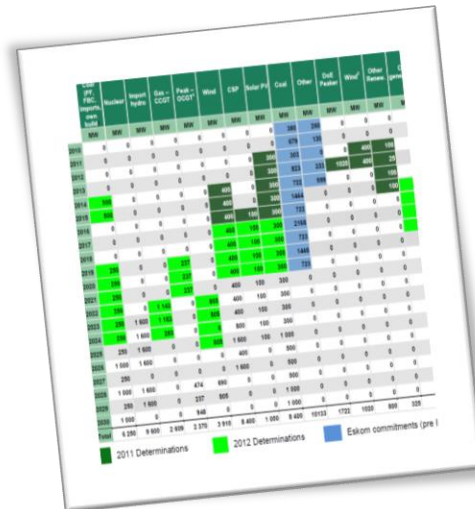
Integrated Resource Plan (IRP) 2010

- Promulgated in 2011, the IRP developed the preferred energy mix with which to meet the forecasted electricity needs over a 20 year horizon
- The plan included 9.2 GW of wind, 8.4 GW of solar PV and 1.2 GW of CSP by 2030 (amongst a range of other new-build capacity)



Ministerial Determination

- In May 2011, the Department of Energy (DoE) gazetted the New Generation Regulations under the Electricity Regulation Act (ERA) and made a determination for new capacity
- Second determination was made on 18 August 2015



IPPPP

- The IPPPP is a key vehicle for securing electricity capacity from the private sector for renewable and non-renewable energy sources as determined by the Minister of Energy
- The DoE, National Treasury (NT) and the Development Bank of Southern Africa (DBSA) established the IPP Office for the specific purpose of delivering on the IPP procurement objectives
- Since 2011, there have been 5 main Bid Windows (BW 1, 2, 3, 3.5, 4) planned to contribute 6.3 GW
- Power Purchase Agreements (PPAs) signed for BW 1, 2, 3, 3.5 and 4

Following the finalisation of the IRP 2019, Ministerial Determinations would follow - allowing required new-build capacity to be procured

Integrated Resource Plan (IRP) 2019

- Promulgated in October 2019, the IRP 2019 updated the IRP 2010 (promulgated in 2011) to establish the preferred energy mix over a 10 year horizon to 2030
- The plan includes a range of new-build technologies incl. 14.4 GW of wind, 6.0 GW of solar PV, 1.5 GW coal, 3.0 GW of gas, 2.1 GW storage and 4.0 GW DG/EG



Ministerial Determination

- Similar to previous ministerial determinations, the Department of DMRE would make determinations for new capacity and gazette these
- These are still forthcoming following the finalisation and promulgation of the IRP 2019 in November 2019

	Coal	Coal (Decommissioning)	Nuclear	Hydro	Storage	PV	Wind	CSP	Gas & Diesel	Other (Distributed Generation, Cogeneration, Biomass, Landfill)
Current Base	37 589		1 800	2 100	2 922	1 474	1 900	300	3 820	409
2019	2 375	2 272					244	500		
2020	1 431	2 272				115	300			
2021	1 431	2 272					300			
2022	711	2 272			512	430	1 000	1 000		
2023	711	2 272				1 000	1 000			
2024			1 800						1 000	
2025						1 000	1 000		1 000	
2026							1 000		1 000	
2027	200	2 272							2 000	
2028	412	2 272					1 000		1 000	
2029	412	2 272			1 070		1 000		1 000	
2030	412	2 272		2 100			1 000		1 000	
TOTAL INSTALLED CAPACITY by 2030 (GW)	33 366		1 800	4 200	5 000	8 288	17 742	4 000	6 380	
% Total Installed Capacity (% of MW)	62		2.36	5.84	6.35	10.52	22.53	6.76	8.3	
% Annual Energy Contribution (% of MWh)	58.8		4.5	8.4	1.2*	6.5	17.8	0.6	1.3	

Installed Capacity
 Committed / Already Contracted Capacity
 Capacity Decommissioned
 New Additional Capacity
 Extension of Koeberg Plant Design Life
 Includes Distributed Generation Capacity for own use

IPPPP

(and other procurement/deployment options)

- The IPPPP is expected to continue as a vehicle for securing capacity from the private sector for new-build capacity as determined by the responsible Minister
- IPP Office expected to be the agency for delivering on IPP procurement objectives
- New BWs would result from Ministerial Determination(s)
- To be supplemented by DG/EG procurement or deployment options (across customer segments and municipalities)
- Emergency short-term generation needs identified in IRP 2019 also being led by DMRE along with Nersa, Eskom and IPP Office

Overview of South Africa's REIPPPP

The REIPPPP is designed to contribute to meeting the national renewable energy target while encouraging foreign investment and developing socio-economic and environmentally sustainable growth

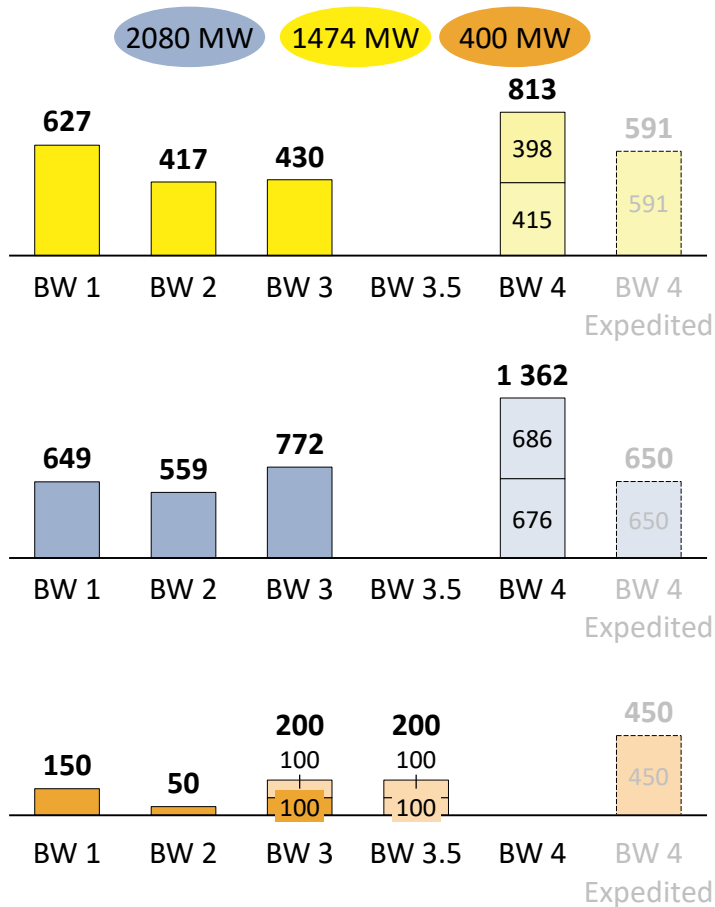
- The REIPPPP includes onshore wind, solar PV, CSP, small hydro, biomass, biogas, landfill gas, small hydro and co-generation (from agricultural waste / by-products)
- To date, renewable energy projects as part of the REIPPPP in South Africa have resulted in ≈42 800 jobs for South African citizens and have attracted R 209.7-billion in investment (20% of which is foreign – R41.8-billion)
- Furthermore, IPPs have thusfar contributed R927.8-million of a total commitment of R 19.1 billion toward socio-economic development initiatives within the communities in which they operate, thereby positively contributing to livelihoods and income generation
- The main evaluation criterion for the bid selection process is pricing (70% weighting) and the remaining 30% weighting for other factors such as job creation, local content and black economic empowerment
- Prices have dropped over four bid windows with average PV tariffs decreasing by 83%, wind by 59% and CSP by 43%

The South African Department of Mineral Resources and Energy (DMRE) has already allocated a total of 8.1 GW of renewables (mainly wind and solar PV) for procurement from Independent Power Producers (IPPs)

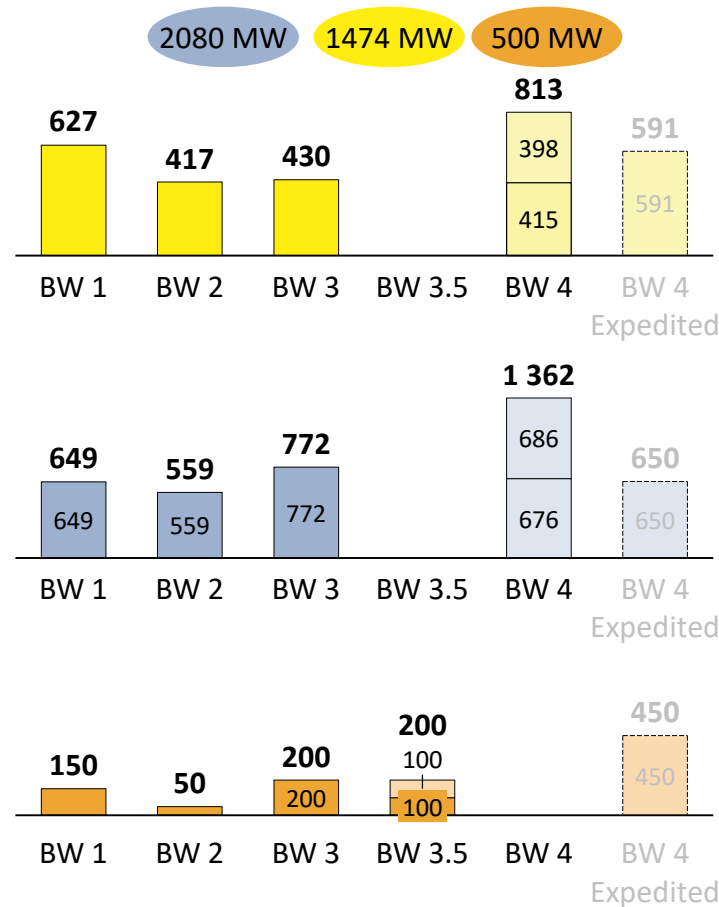
- ... of this, 7.5 GW have achieved preferred bidder status
- ... of this, 6.3 GW have signed Power Purchase Agreements (PPAs) with Eskom
- ... of this, 2.1 GW of wind, 1.5 GW of solar PV and 0.5 GW of CSP were operational by December 2019

Procured and operational capacity under RSA's RE IPP Procurement Programme (REIPPPP) in 2019

Capacity operational
(1 January 2019)



Capacity operational
(31 December 2019)



Supply Sources

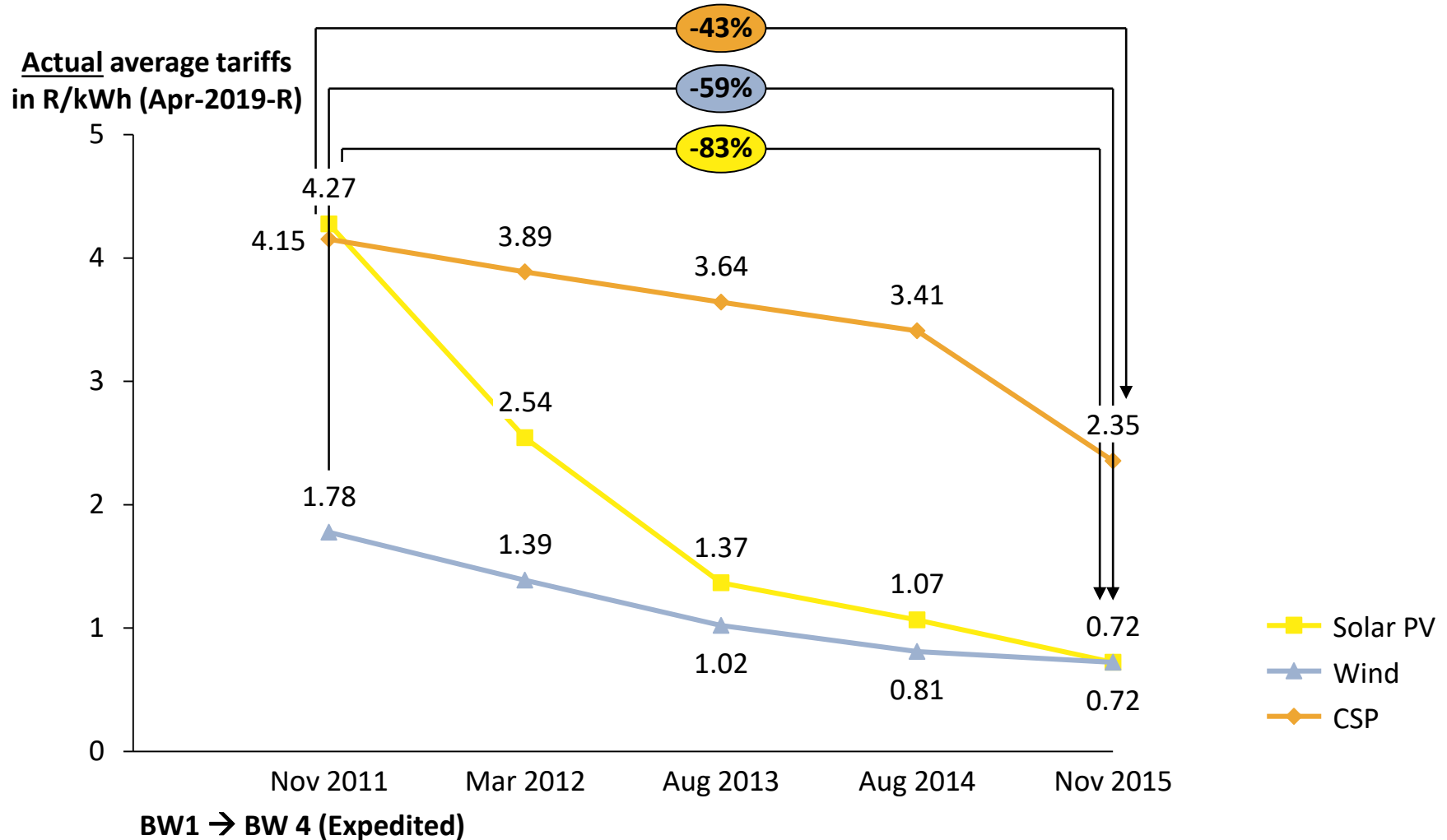
- Solar PV procured, PPAs not signed yet
- Solar PV procured, PPAs signed
- Solar PV operational

- Wind procured, PPAs not signed yet
- Wind procured, PPAs signed
- Wind operational

- CSP procured, PPAs not signed yet
- CSP procured, PPAs signed
- CSP operational

Actual tariffs: Reductions in tariff for new wind, solar PV and CSP

Results of Department of Energy's RE IPP Procurement Programme



Sources:

Summary of 2019 statistics:

5% of system load was supplied by wind, solar PV & CSP in RSA

By end 2019 - a total of 2 080 MW wind, 1 474 MW of solar PV and 500 MW of CSP capacity were operational

- No additional wind or solar PV became operational in 2019 whilst 100 MW of additional CSP became operational

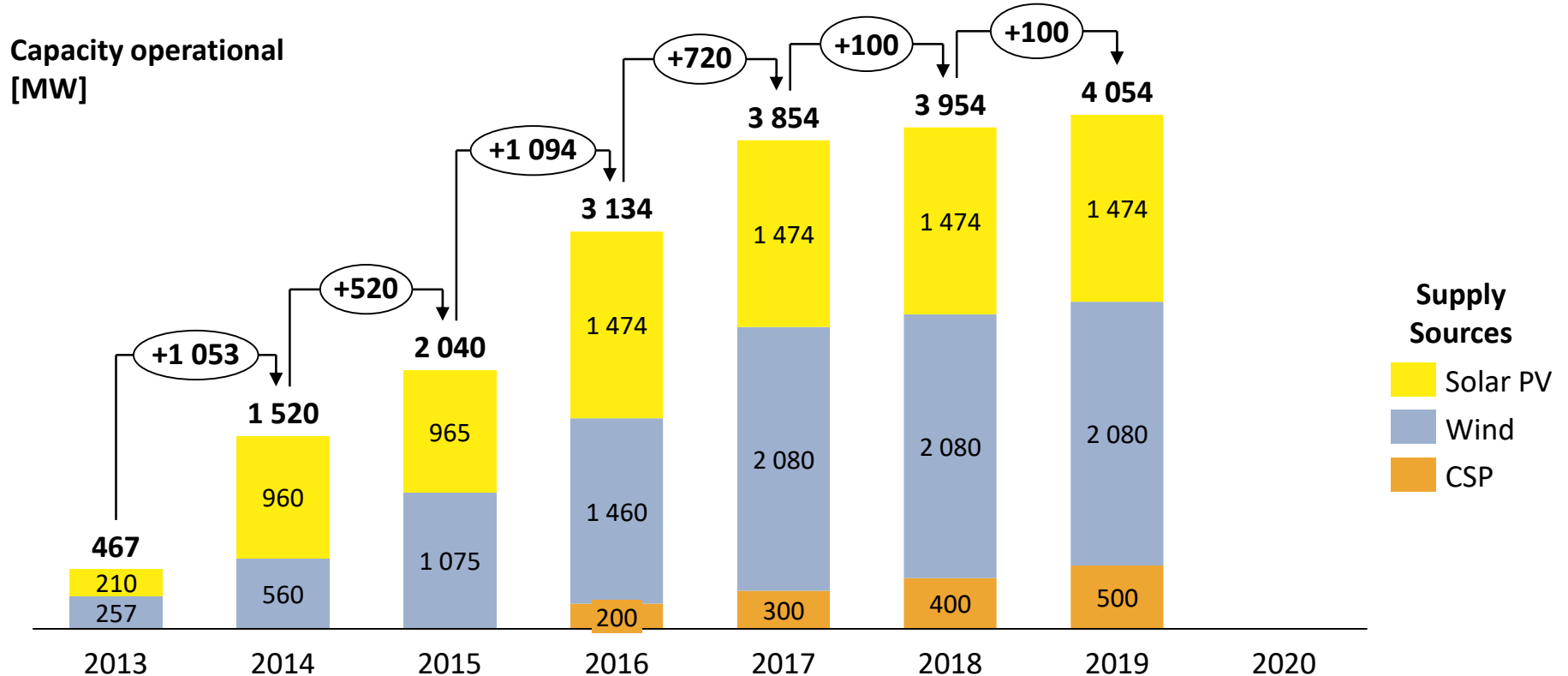
By end 2019- total wind, solar PV and CSP production was 11.5 TWh, supplying 5% of SA's system load

- Maximum daily total energy from solar PV, wind & CSP combined was 50 GWh *(14 Dec 2019)*
- Wind power achieved a maximum peak power production of 1 872 MW *(15h00-16h00, 14 Dec 2019)*
- Solar PV power reached a maximum peak power production of 1 376 MW *(12h00-13h00, 19 Jan 2019)*
- CSP power reached a maximum peak power production of 502 MW *(11h00-12h00, 24 Sep 2019)*
- Maximum instantaneous contribution of wind, solar PV & CSP was 13.8% *(14h00-15h00, 14 Dec 2019)*
- Maximum instantaneous power contribution of wind alone was 7.9% *(01h00-02h00, 23 Apr 2019)*
- Maximum instantaneous power contribution of solar PV alone was 5.3% *(12h00-13h00, 17 Mar 2019)*
- Maximum instantaneous power contribution of CSP alone was 2.1% *(17h00-18h00, 25 Dec 2019)*

By end 2019 - monthly wind, solar PV and CSP production combined varied between 784 GWh and 1161 GWh

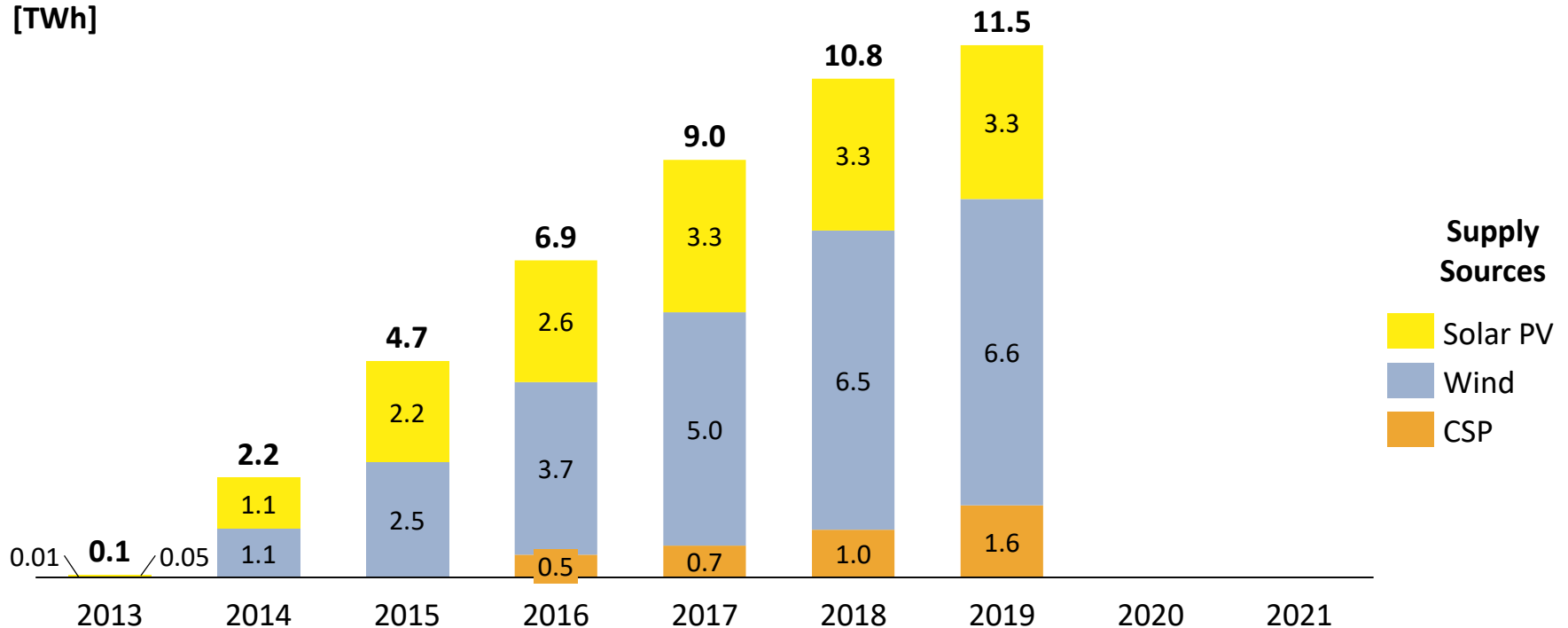
- Monthly wind production from Jan to Dec 2019 varied between 472-667 GWh
- Monthly solar PV production from Jan to Dec 2019 varied between 219-337 GWh
- Monthly CSP production from Jan to Dec 2019 varied between 71-176 GWh

From 1 November 2013 to 31 Dec 2019, 2 080 MW of wind, 1 474 MW of large-scale solar PV and 500 MW of CSP became operational in RSA



In 2019 - 11.5 TWh of wind, solar PV and CSP energy produced in RSA

Annual energy produced [TWh]

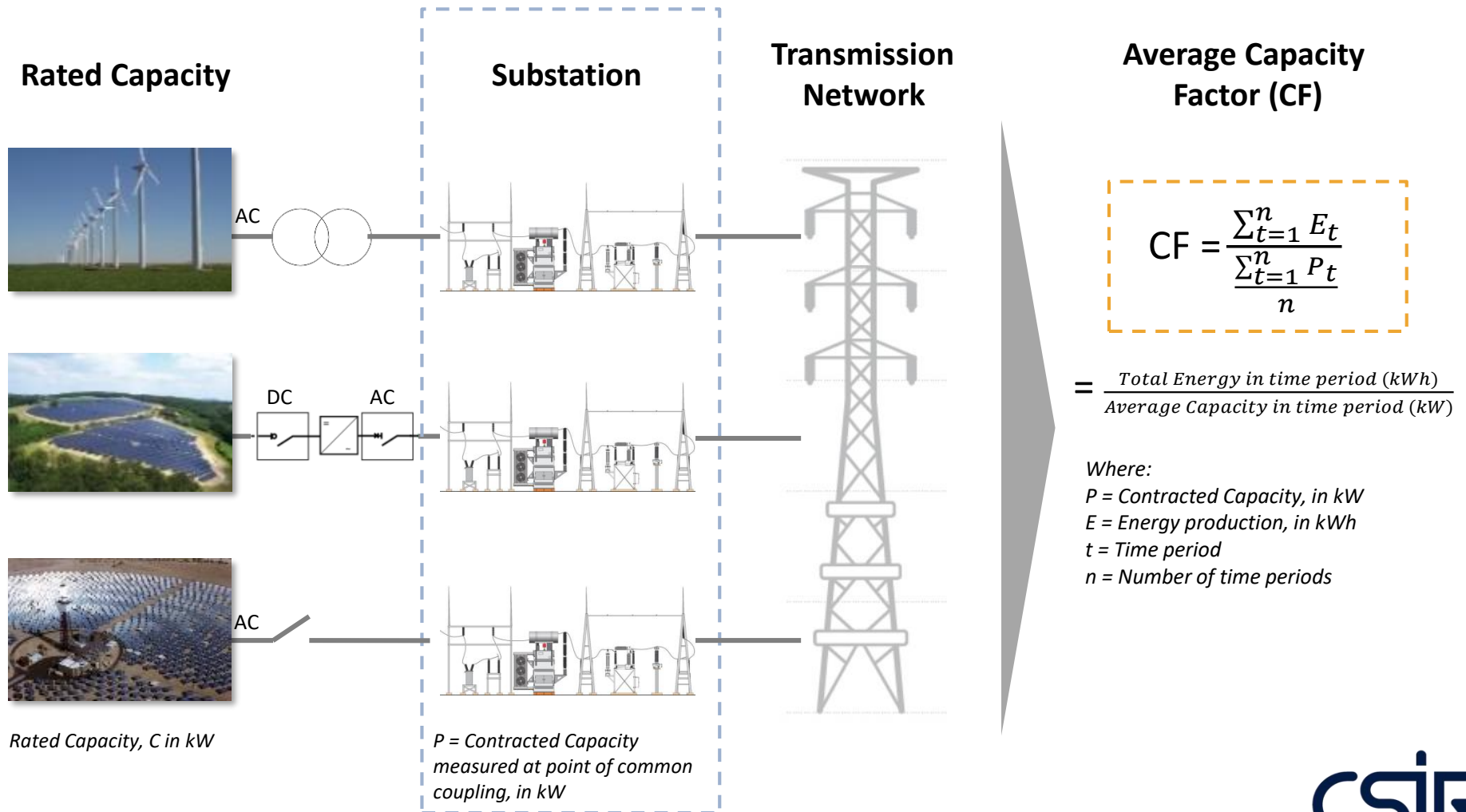


Notes: Wind includes Eskom's Sere wind farm (100 MW). CSP energy measured from date when more than two CSP plant were commissioned.

Wind and solar PV energy excludes curtailment and is thus lower than actual wind and solar PV generation

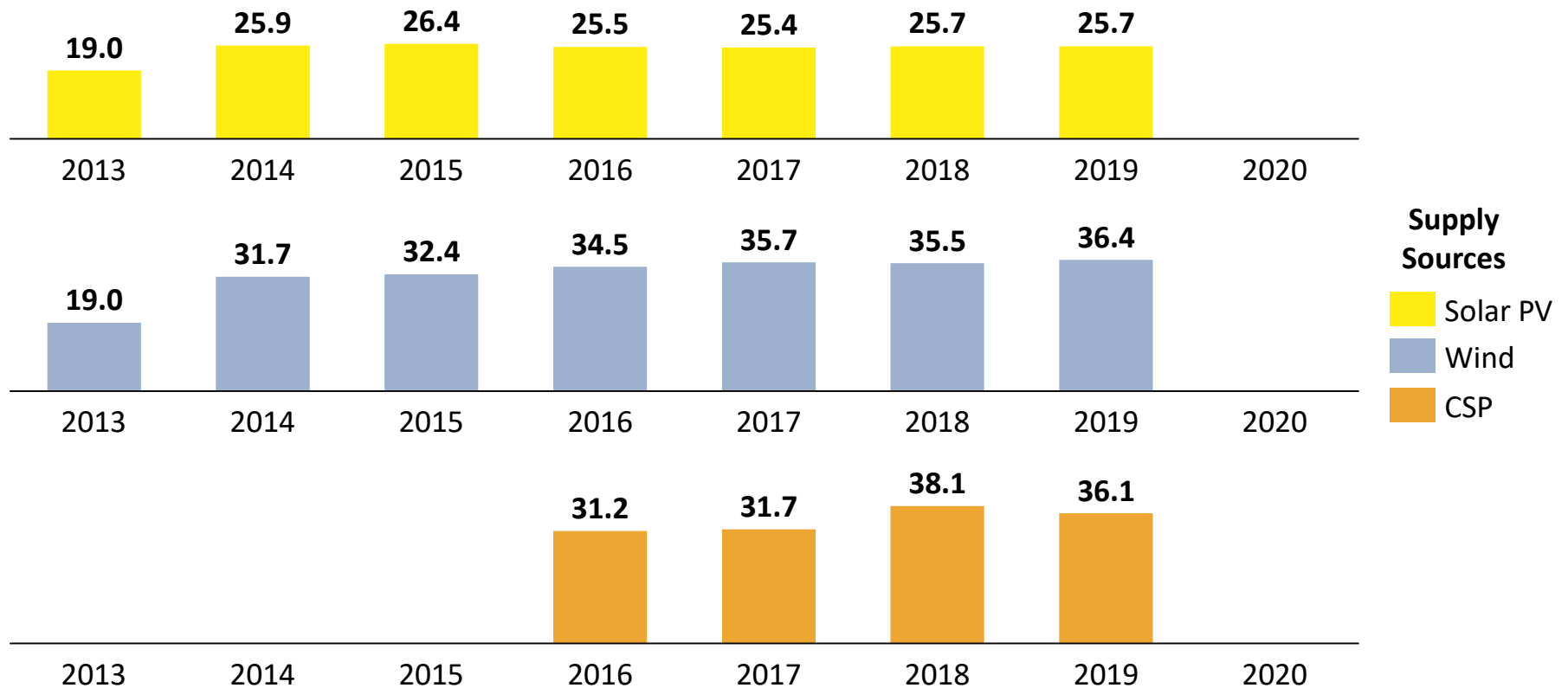
Sources: Eskom; DoE IPP Office

Illustration: Calculation of average capacity factor of operational wind, solar PV and CSP in RSA



In 2019, the average annual capacity factor of the solar PV, wind and CSP fleet was 26%, 36% and 36% respectively

Average Capacity Factor



Notes: 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 commissioned. Wind includes Sere wind farm (100 MW). Wind and solar PV energy excludes curtailment and is thus capacity factor is lower than actual wind and solar PV available. Sources: Eskom; DoE IPP Office

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3 Monthly electricity production

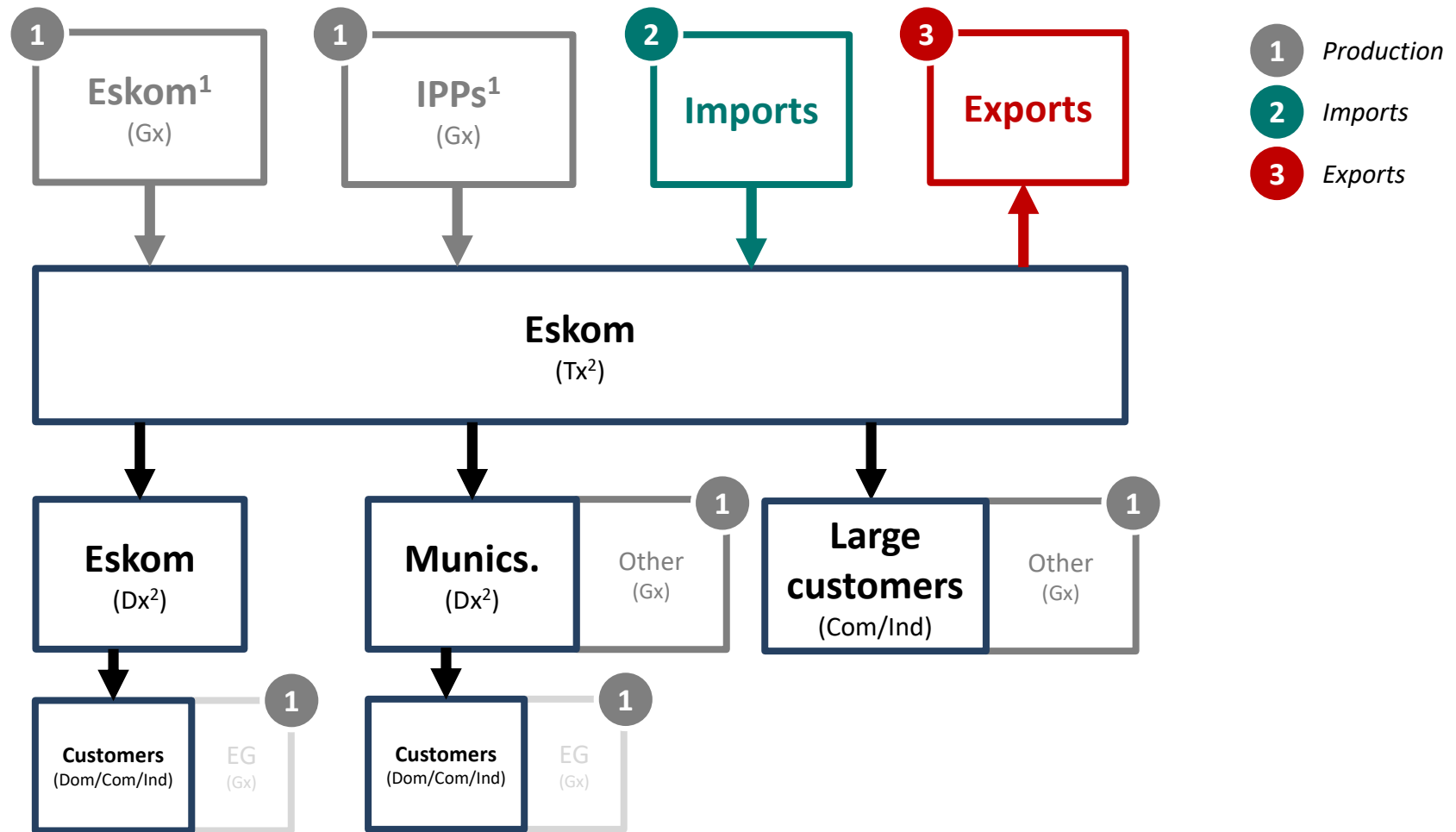
4 Weekly electricity production

5 Daily electricity production

6 Hourly electricity production

7 Actual load shedding in 2019

Equivalent demand as measured and published by Eskom is expressed as equivalent demand



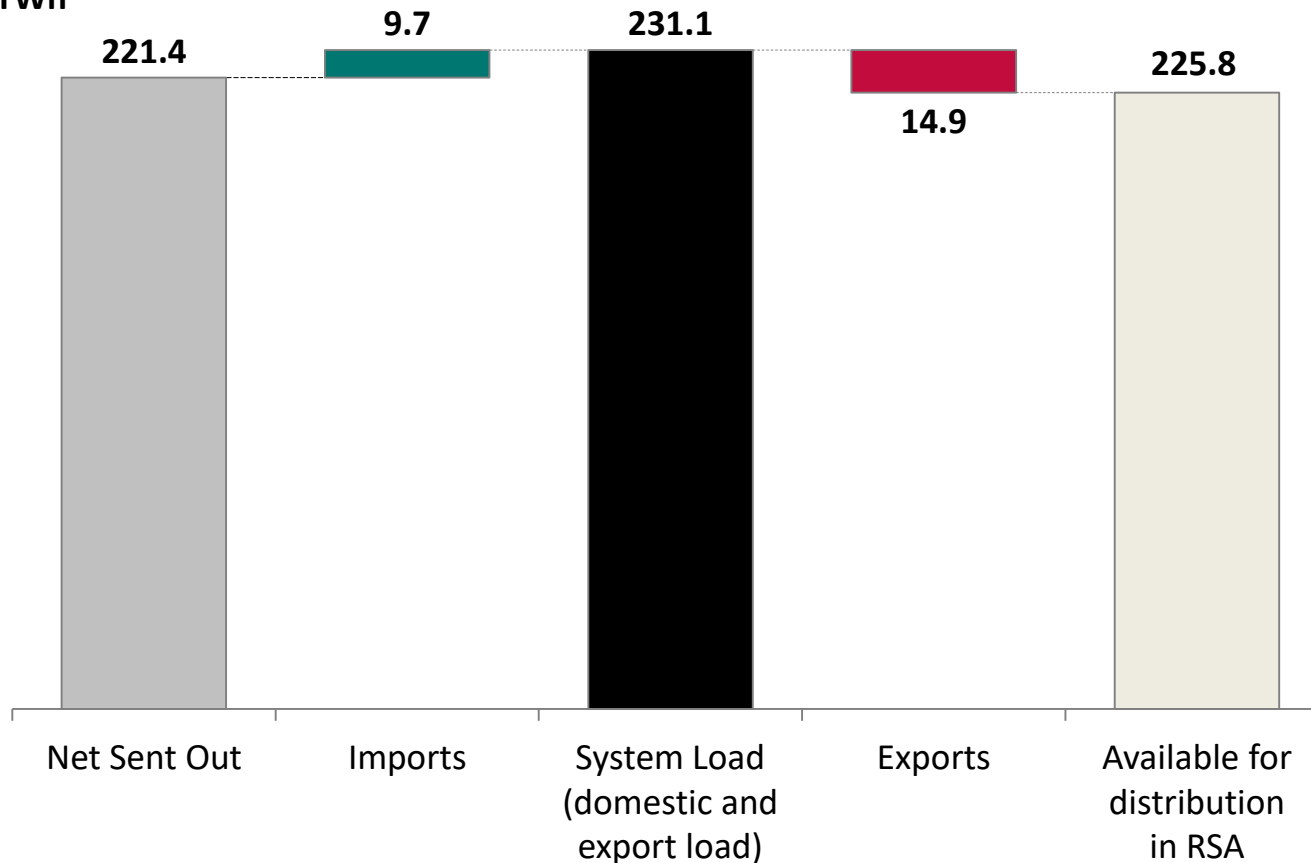
EG = Embedded Generation; Gx = Generation; Tx = Transmission; Dx = Distribution

¹ Power generated less power station load; Minus pumping load (Eskom owned pumped storage); ² Transmission/distribution networks incur losses before delivery to customers

From Jan-Dec 2019, 221 TWh of net electricity was produced in SA

Actuals captured in wholesale market for Jan-Dec 2019 (i.e. without self-consumption of embedded plants)

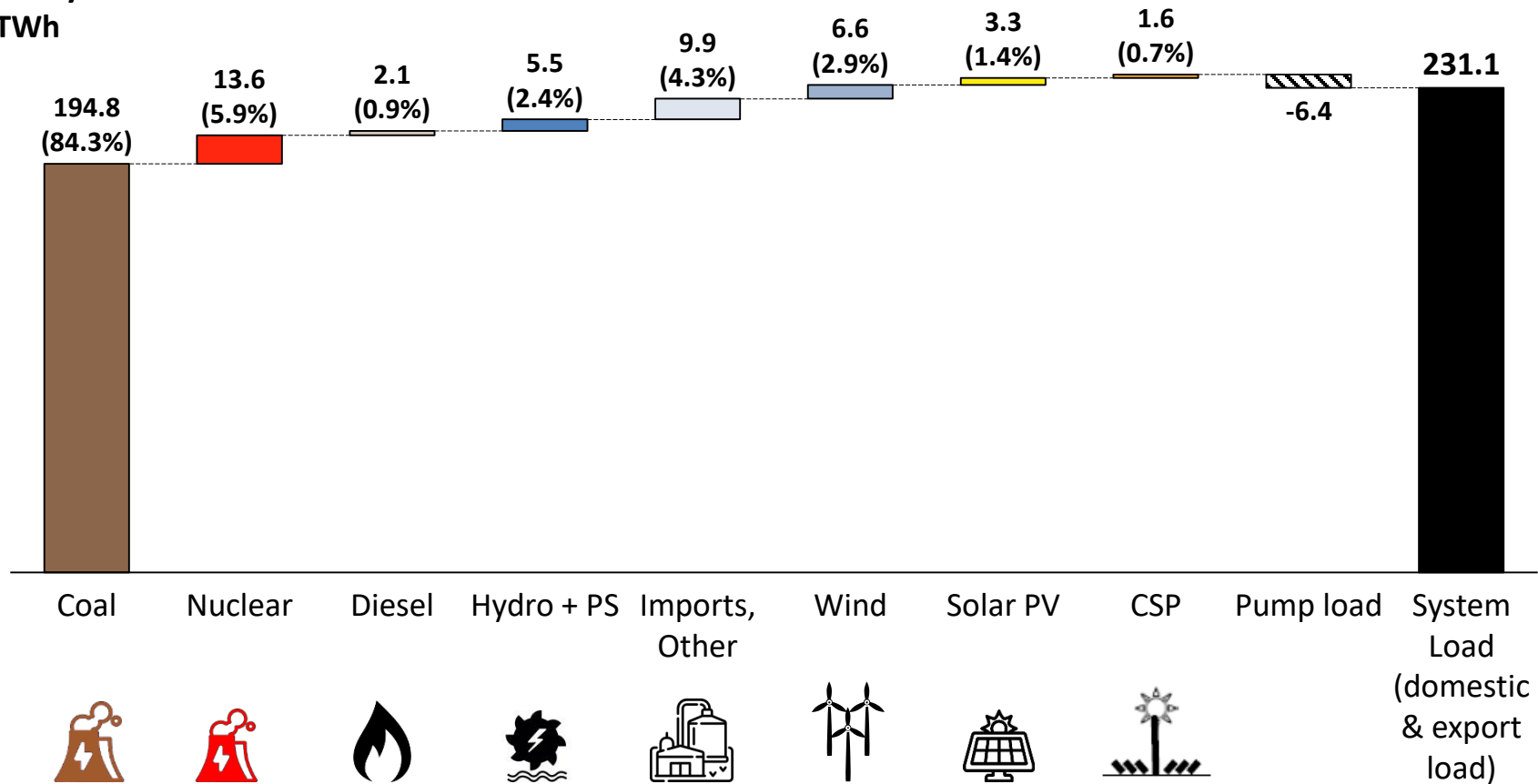
Annual
electricity
in TWh



In 2019, coal still dominated the energy mix at 195 TWh of the 231 TWh of total system load whilst PV, wind and CSP contributed 11.5 TWh (5.0%)

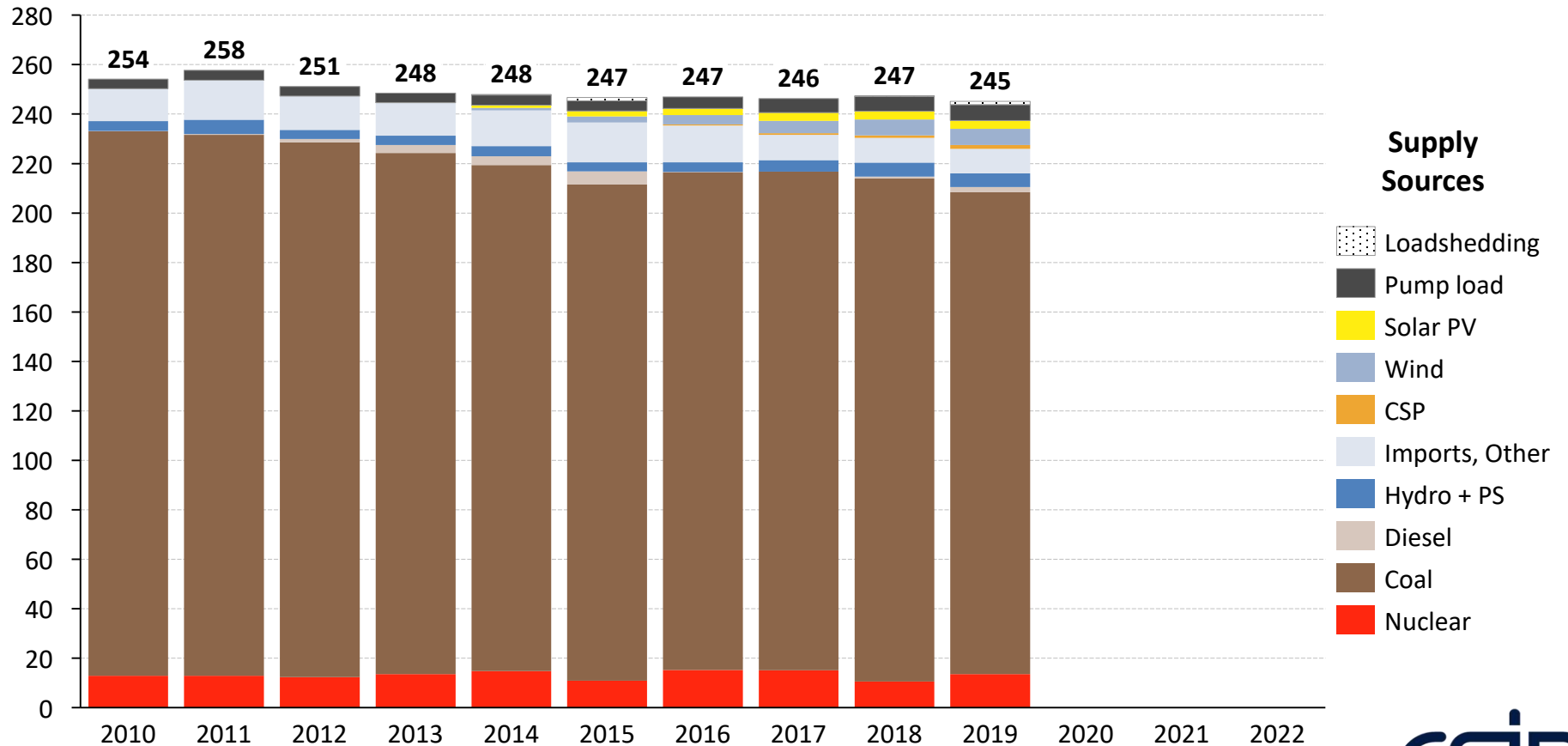
Actuals captured in wholesale market for Jan-Dec 2019 (i.e. without self-consumption of embedded plants)

Annual electricity in TWh



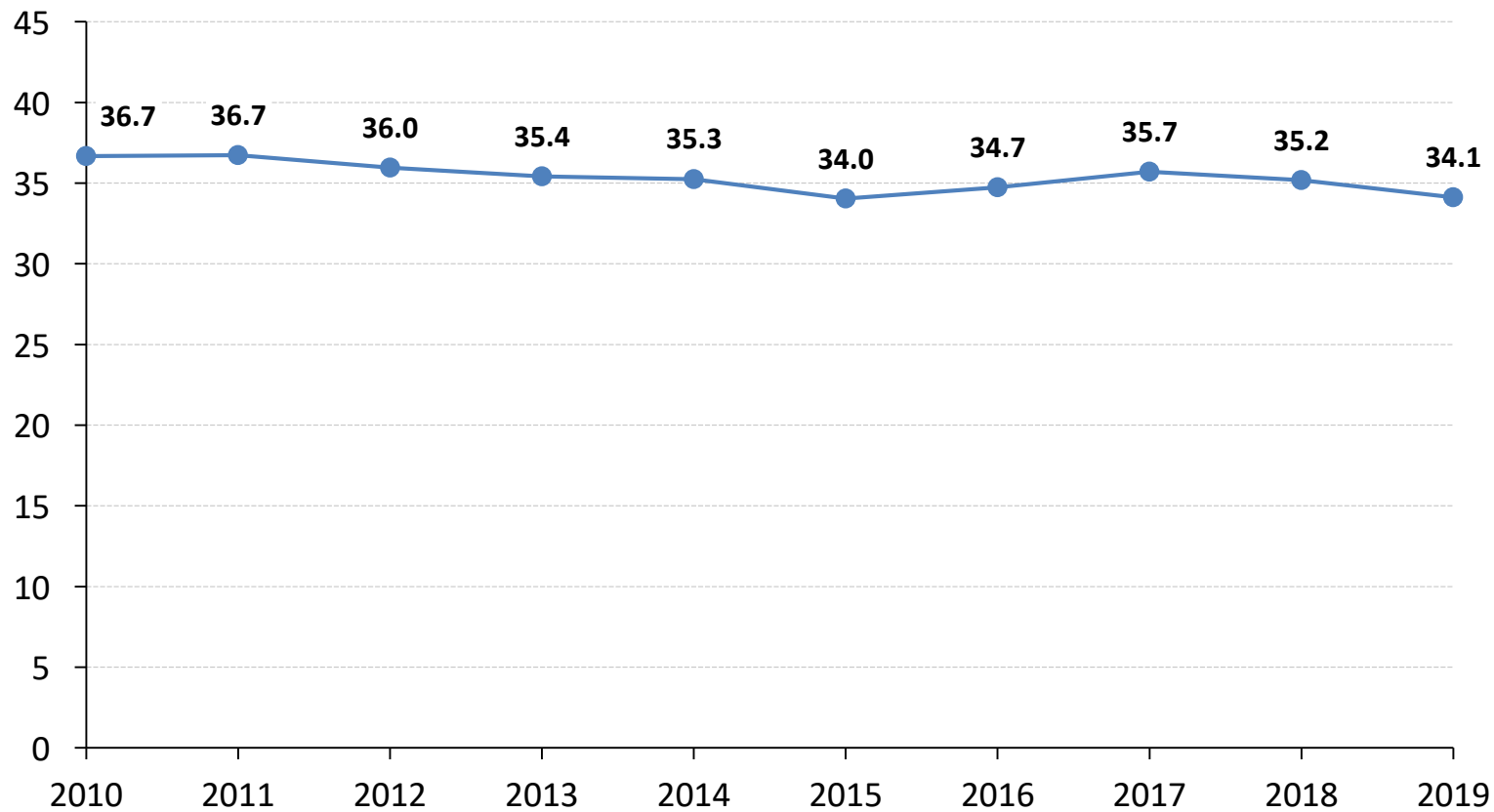
Historical annual electricity production per supply source

Annual electricity production in TWh



Historical annual peak demand

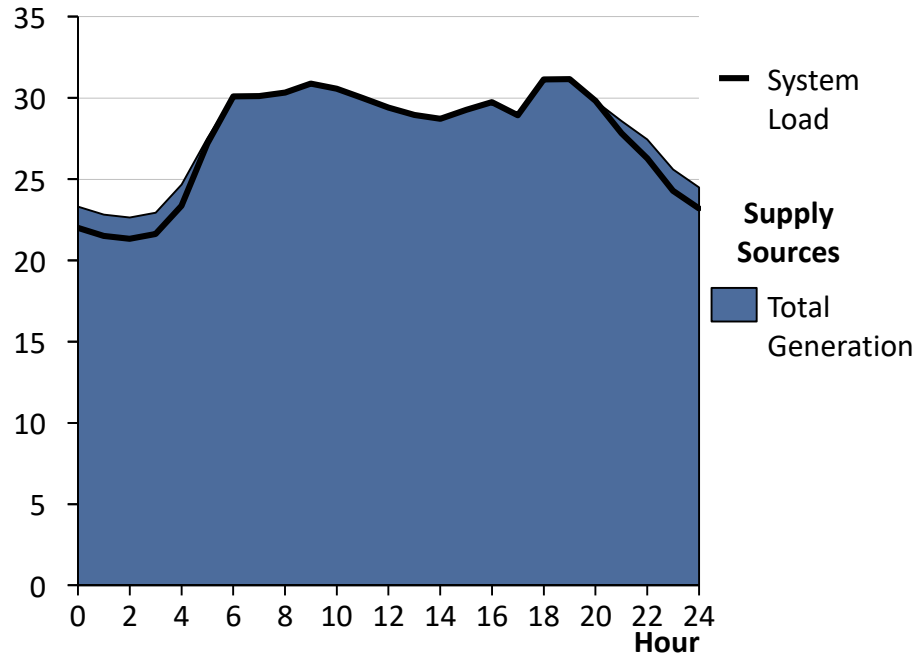
Peak Demand in GW



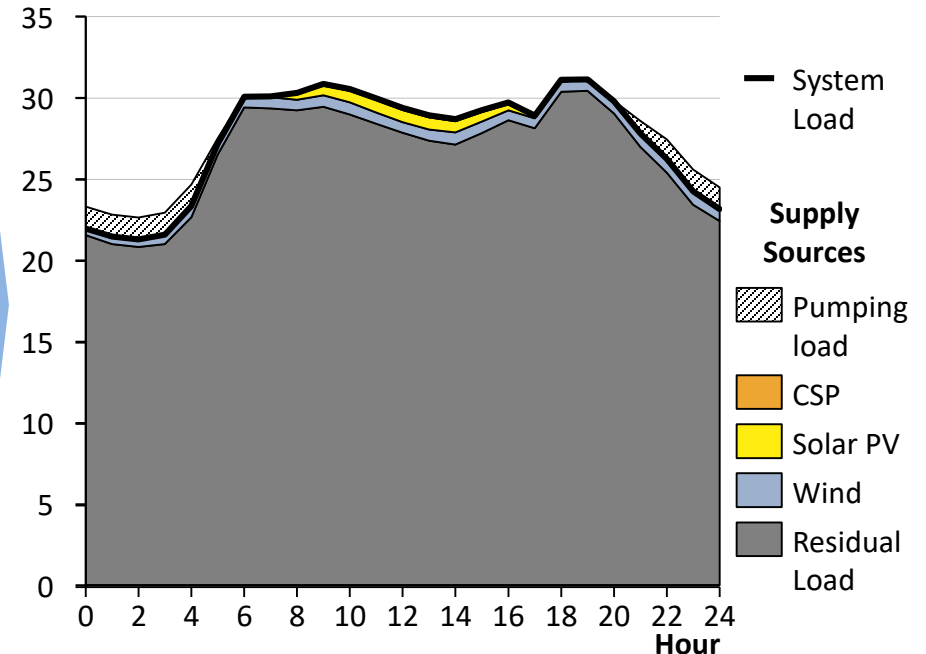
Illustrative day explaining terminologies used in this presentation

Hourly South African supply structure for a random day

Power in GW



Power in GW



Total Generation

= domestic generation (Eskom + IPPs) + imported generation

System Load

= domestic generation (Eskom + IPPs) + imported generation – pumping load

= domestic customer load without pumping load (also referred to as simply "domestic load") + export load

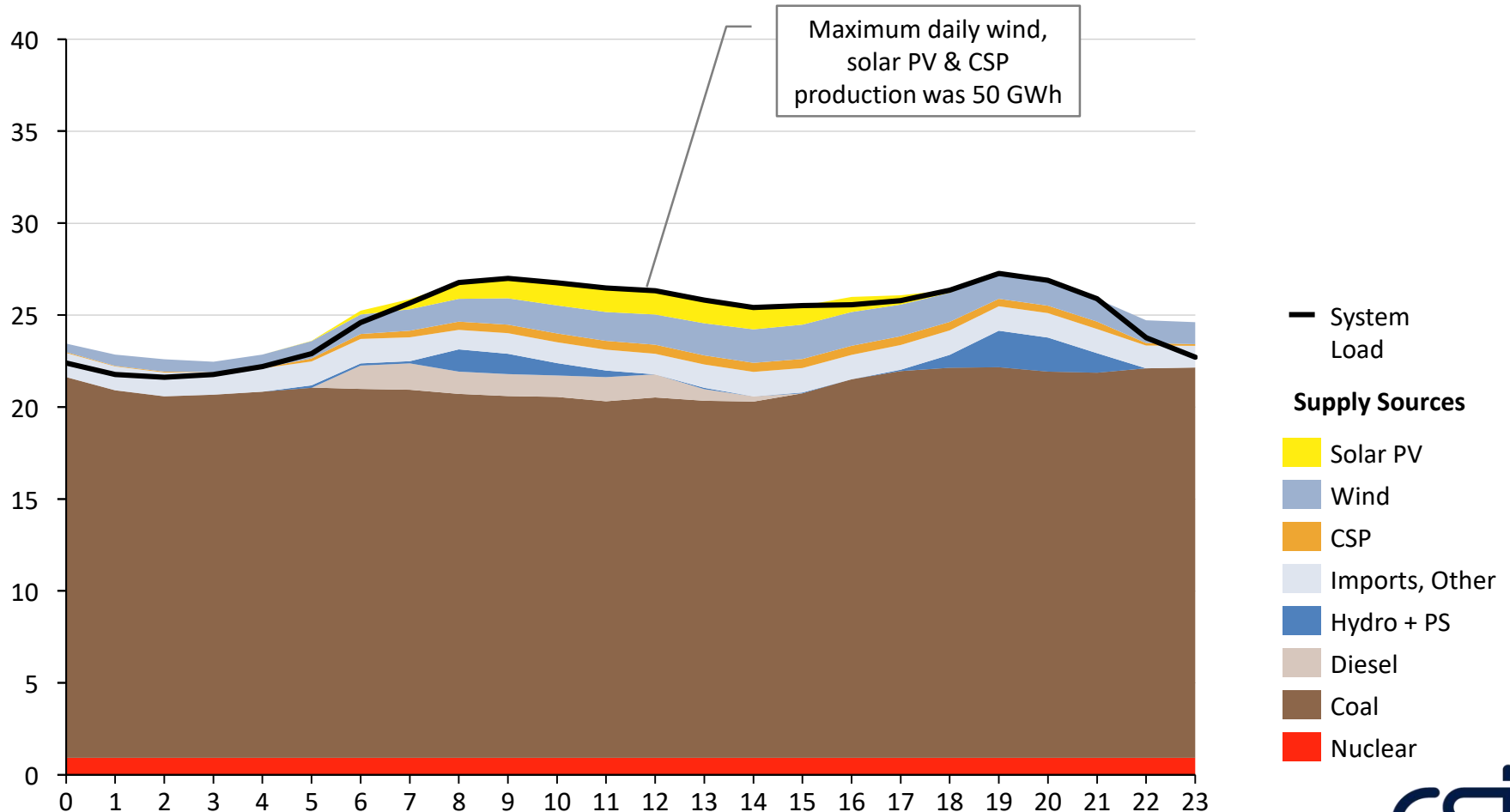
Residual Load

= System Load – wind – solar PV - CSP

Maximum daily wind, solar PV & CSP energy of 50 GWh on 14 Dec '19

Actual hourly energy production in South Africa on 14 December 2019 (Saturday)

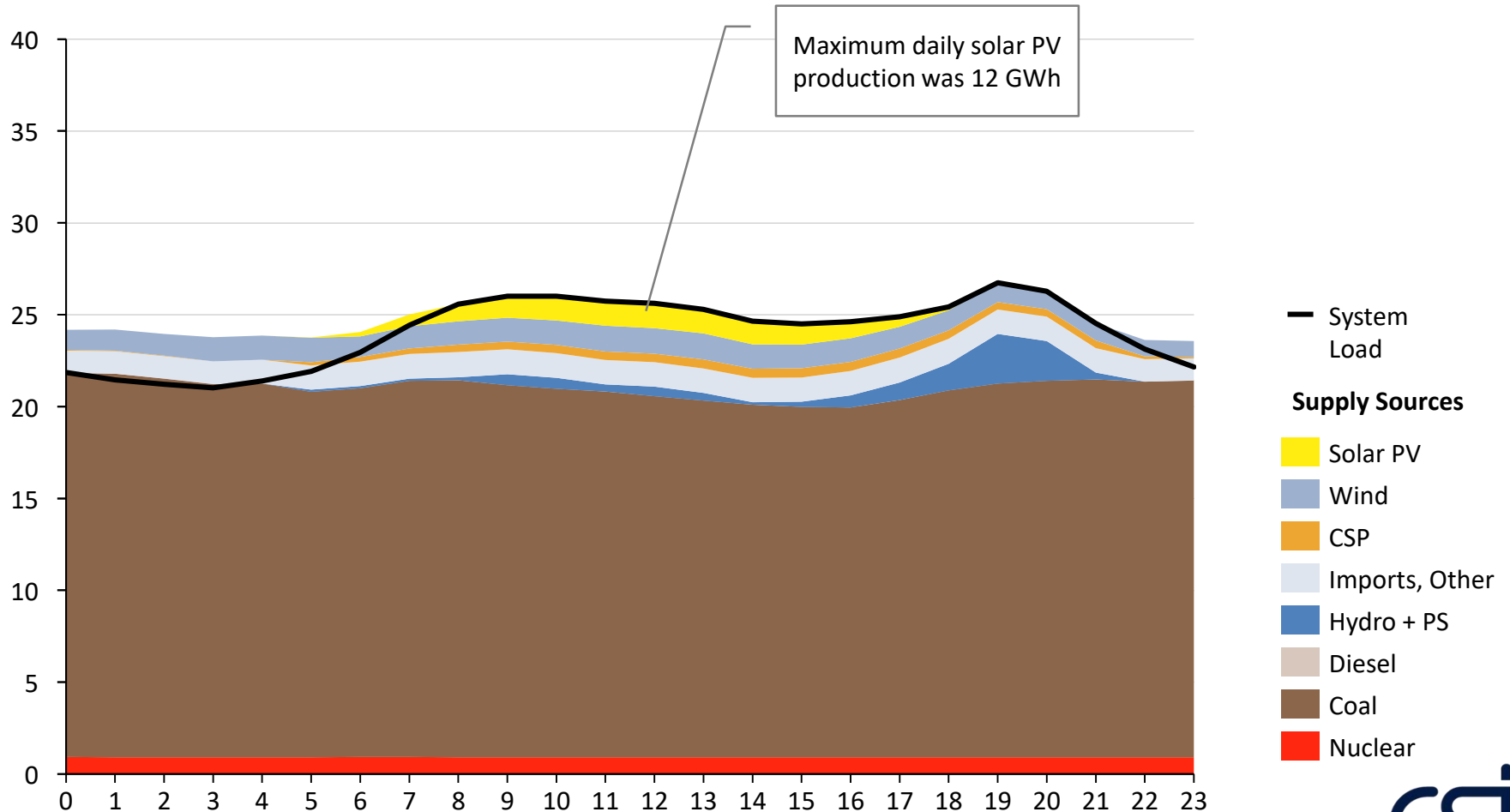
Power in GW



Maximum daily solar PV energy of 12 GWh achieved on 15 Dec 2019

Actual hourly energy production in South Africa on 15 December 2019 (Sunday)

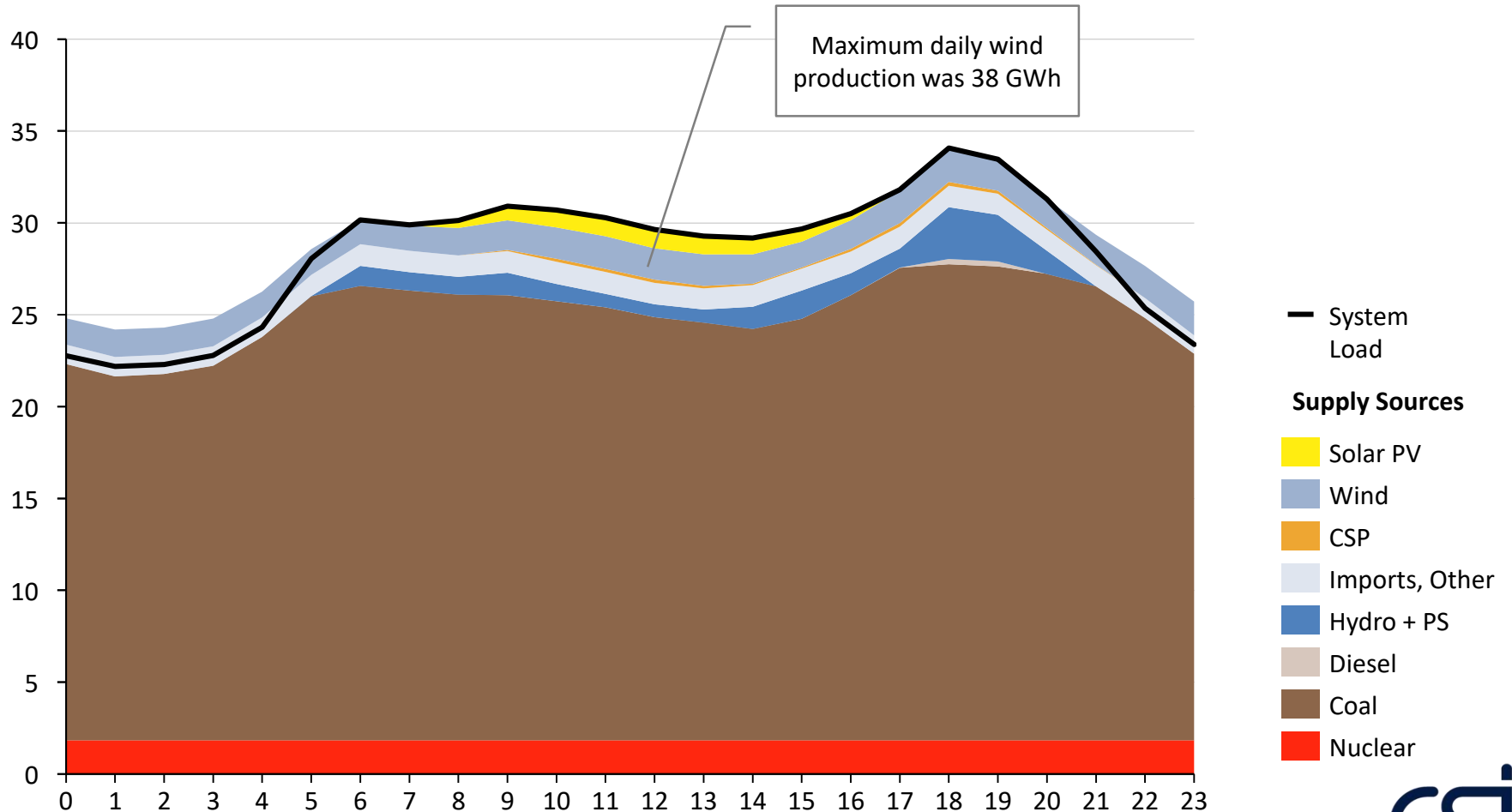
Power in GW



Maximum daily wind energy of 38 GWh was achieved on 23 Jul 2019

Actual hourly energy production in South Africa on 23 July 2019 (Tuesday)

Power in GW

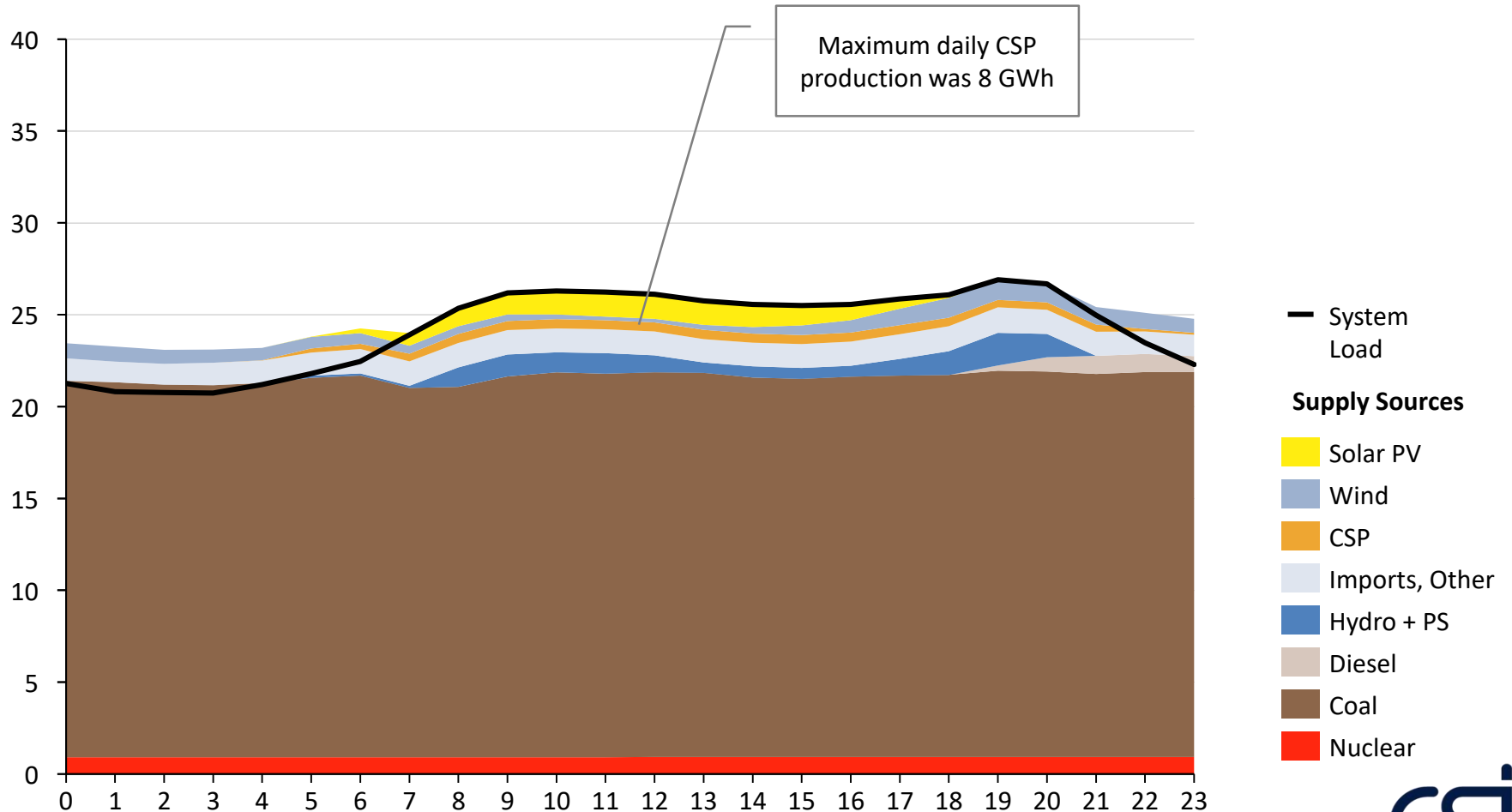


- System Load
- Supply Sources**
- Solar PV
- Wind
- CSP
- Imports, Other
- Hydro + PS
- Diesel
- Coal
- Nuclear

Maximum daily CSP energy of 8 GWh was achieved on 16 Dec 2019

Actual hourly energy production in South Africa on 16 December 2019 (Monday)

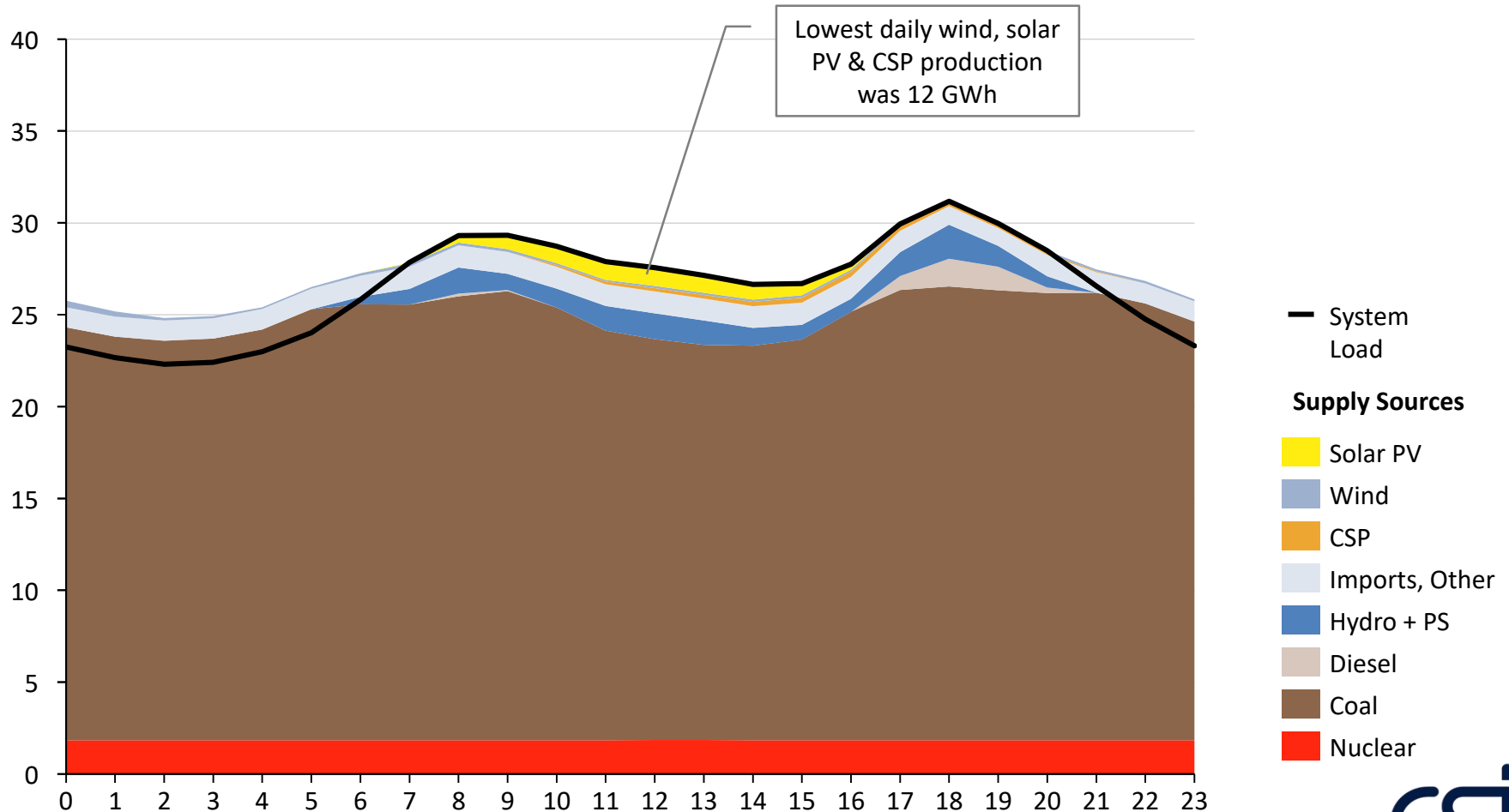
Power in GW



Lowest combined wind, solar PV & CSP energy of 12 GWh on 1 Jun '19

Actual hourly energy production in South Africa on 1 June 2019 (Saturday)

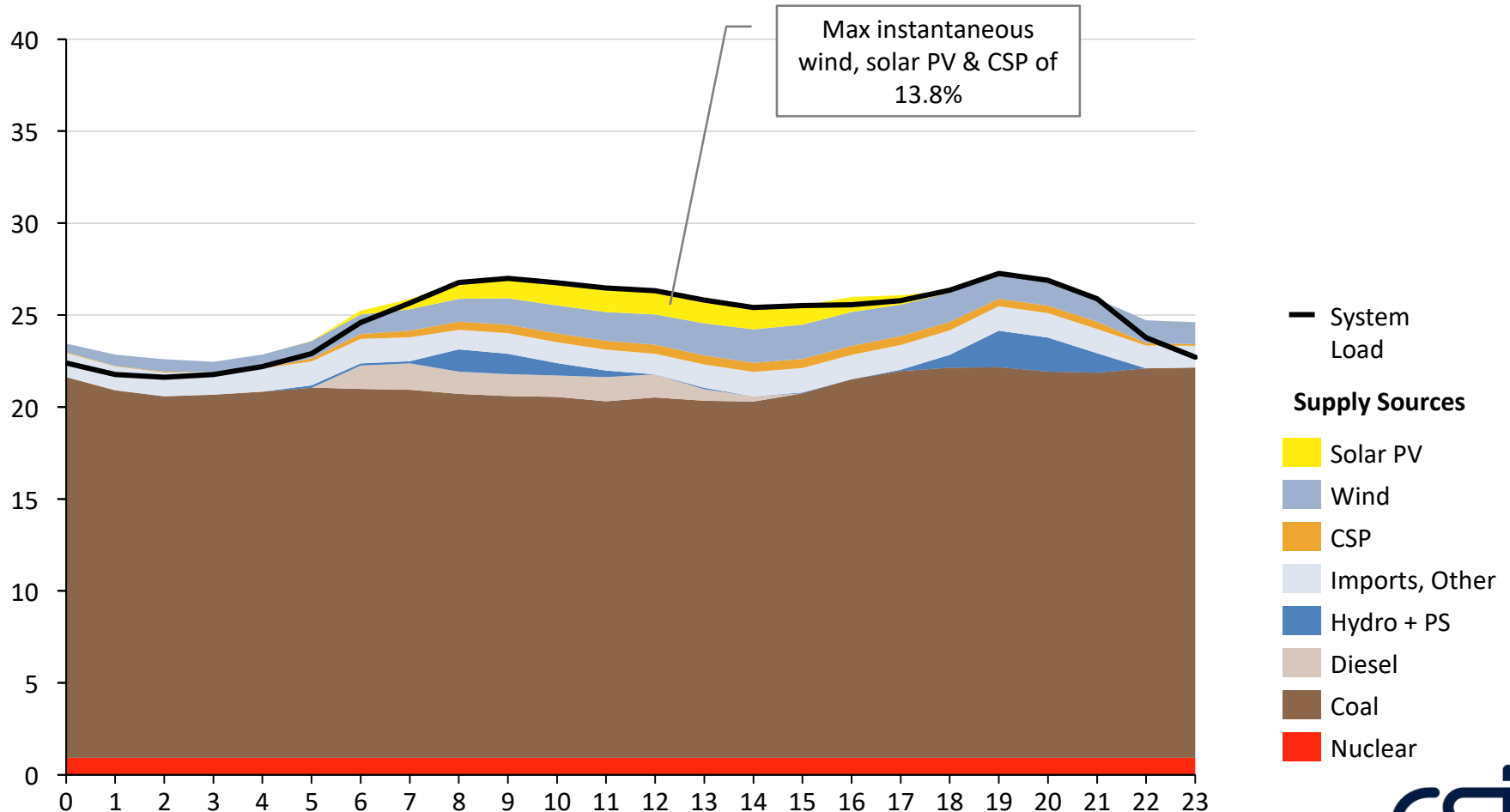
Power in GW



Maximum inst. Solar PV, wind & CSP power of 13.8% on 14 Dec '19

Actual hourly energy production in South Africa on 14 December 2019 (Saturday)

Power in GW



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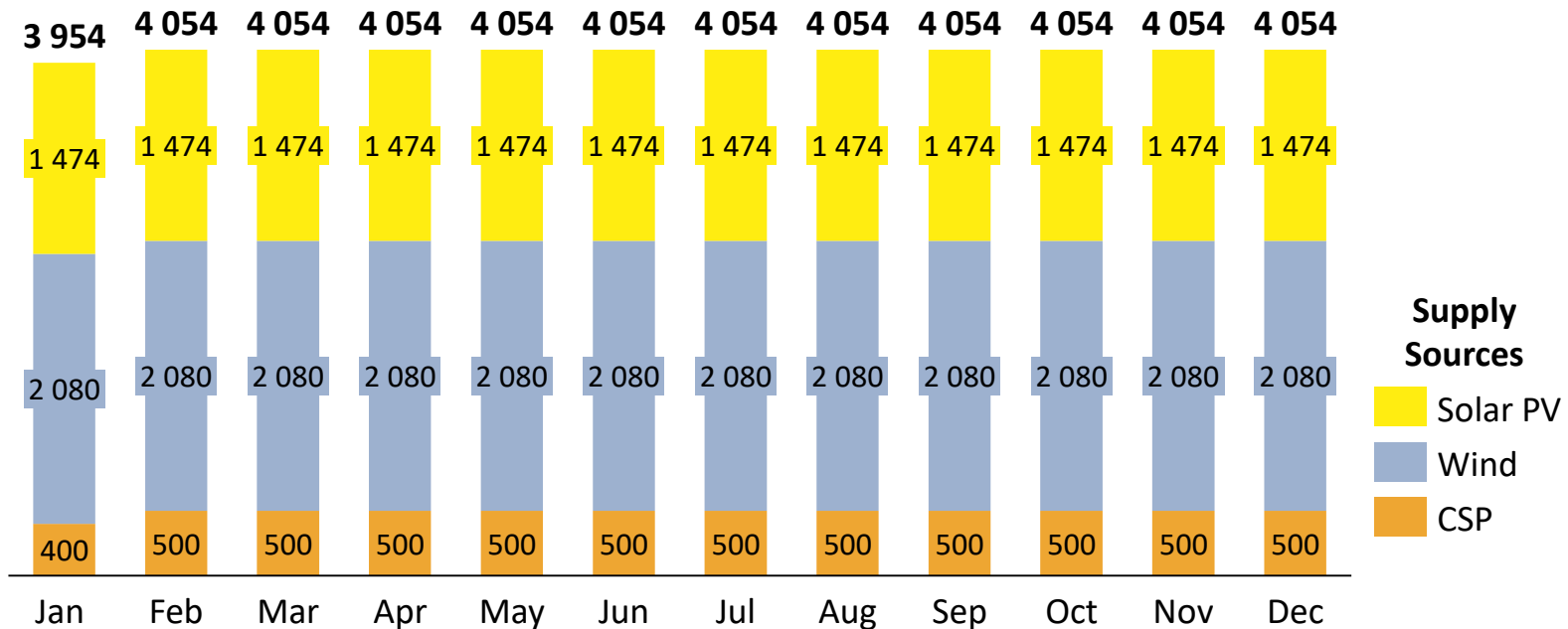
- 3 Monthly electricity production

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2019: 100 MW CSP was added to the grid, no new wind or solar PV

Total monthly installed capacity of solar PV, wind and CSP in MW in RSA from Jan-Dec 2019

Capacity operational in MW
(end of month)

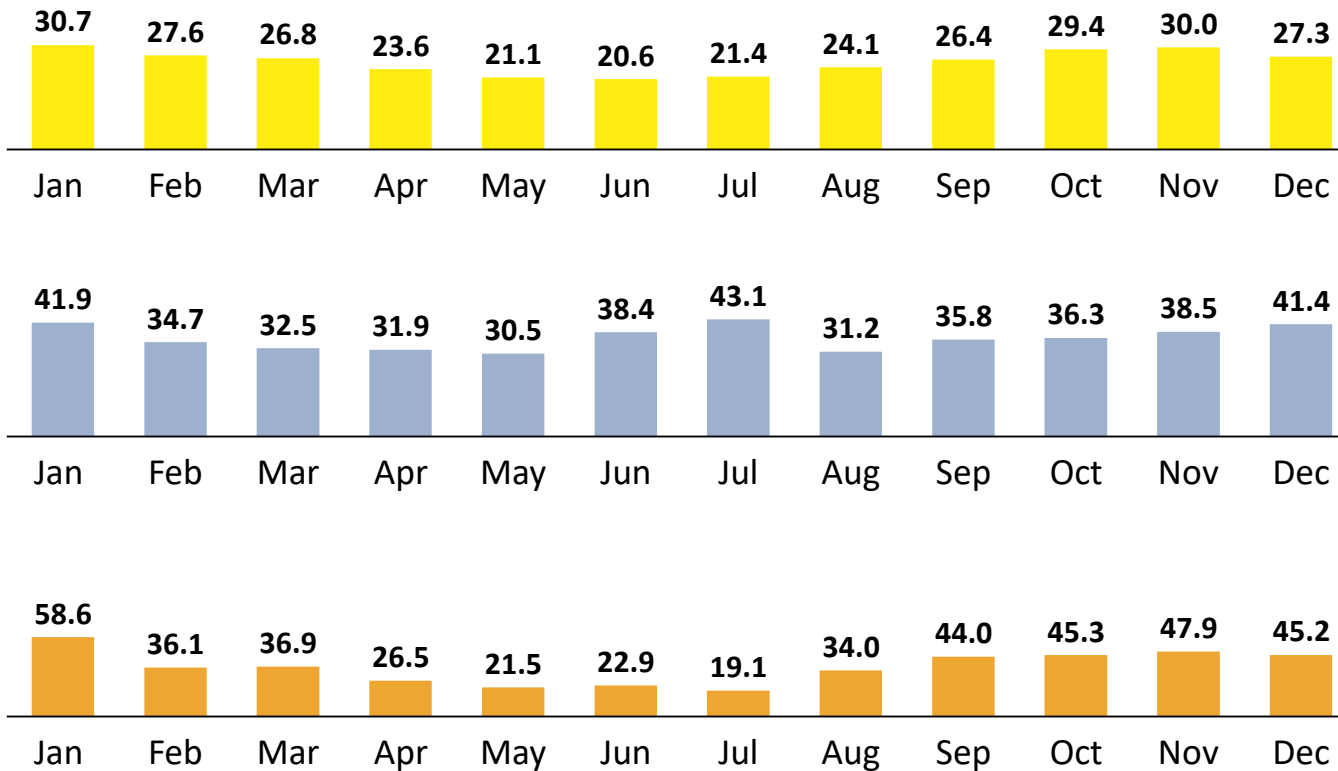


Notes: Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants commissioned. Wind includes Sere wind farm (100 MW).
Sources: Eskom

Average monthly capacity factors for solar PV, wind and CSP

Average monthly capacity factors of solar PV, wind and CSP in RSA from Jan-Dec 2019

Average Monthly Capacity Factor [%]



Capacity operational (31 Dec)

1474 MW

2080 MW

500 MW

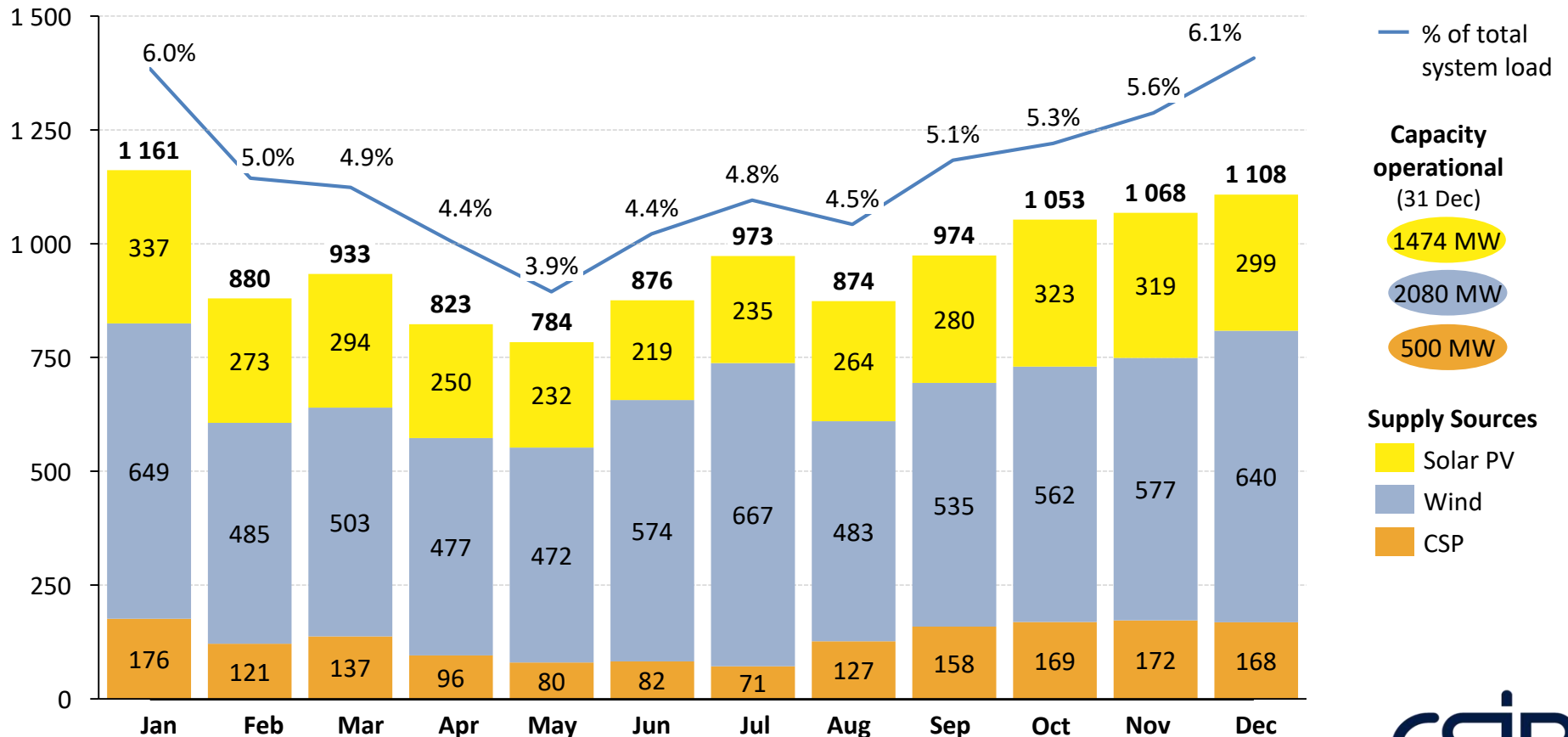
Supply Sources

- Solar PV
- Wind
- CSP

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

Actual monthly production from wind, solar PV and CSP plants in South Africa from Jan-Dec 2019

Monthly electricity production in GWh



— % of total system load

Capacity operational (31 Dec)

1474 MW

2080 MW

500 MW

Supply Sources

Solar PV

Wind

CSP

Note: Wind generation includes Eskom's 100 MW Sere wind farm. CSP energy only measured from date when more than two CSP plant were commissioned.

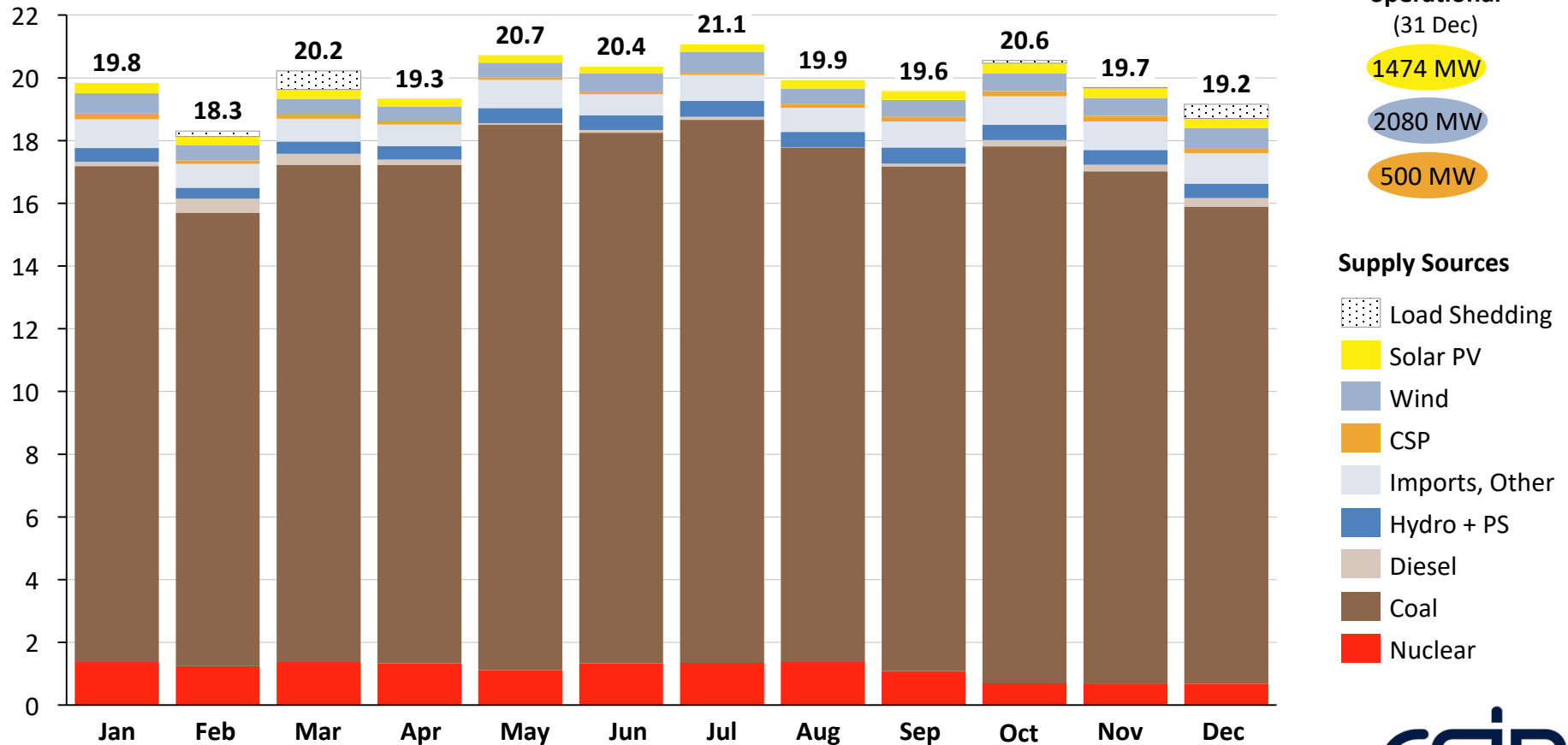
Wind and solar PV energy excludes curtailment and is thus lower than actual wind and solar PV generation.

Sources: Eskom; CSIR Energy Centre analysis

Monthly electricity production all power supply sources

Actual monthly electricity production for Jan-Dec 2019 from the different supply sources in South Africa

Monthly electricity production in TWh



Notes: Pumping load excluded. Wind generation includes Eskom's 100 MW Sere wind farm.
Sources: Eskom; CSIR Energy Centre analysis

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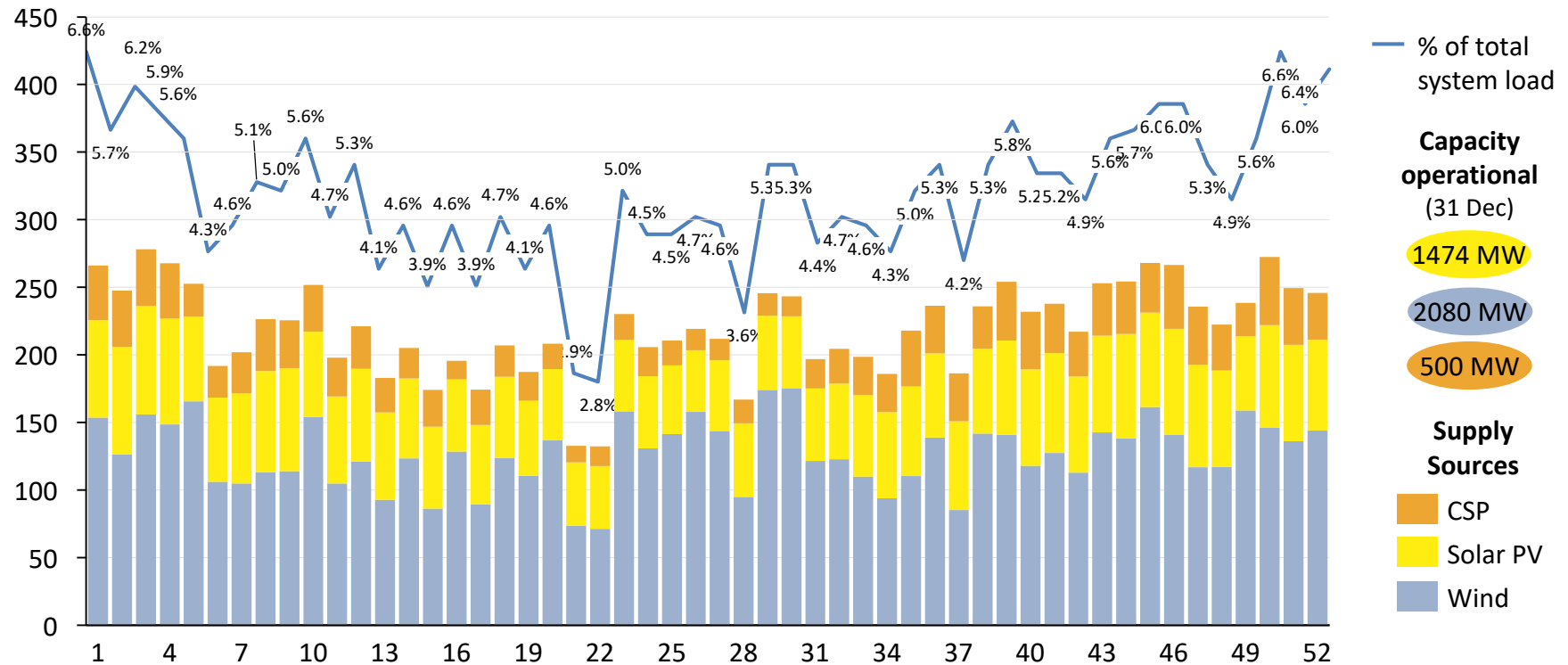
- 4 Weekly electricity production

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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 2019

Electricity production
in GWh/week



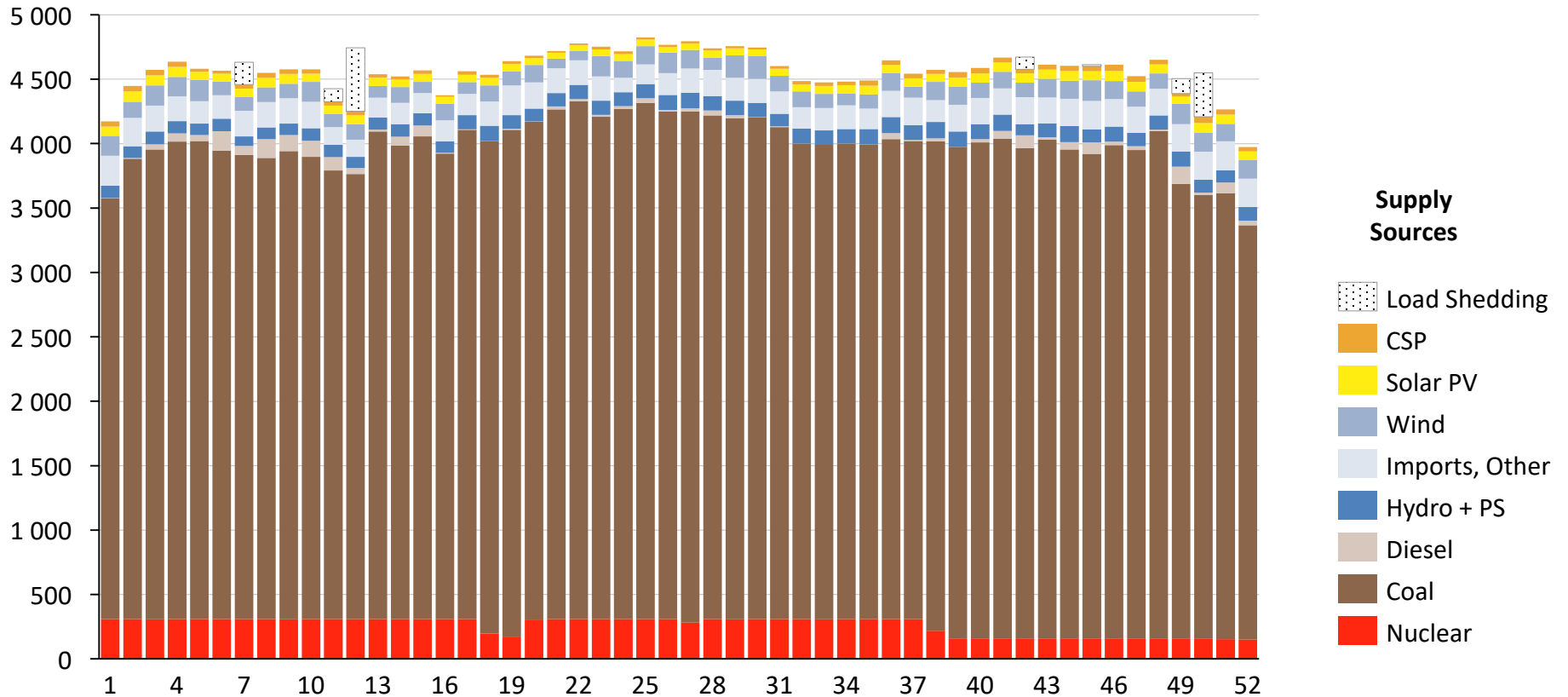
- Maximum wind + solar PV + CSP weekly production of 278 GWh in week 3 (15 Jan - 21 Jan)
- Minimum wind + solar PV + CSP weekly production of 132 GWh in week 22 (28 May - 3 Jun)

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

Weekly electricity production all power supply sources

Actual weekly production: conventional fleet, wind, solar PV & CSP plants under REIPPPP from Jan-Dec 2019

Electricity production
in GWh/week



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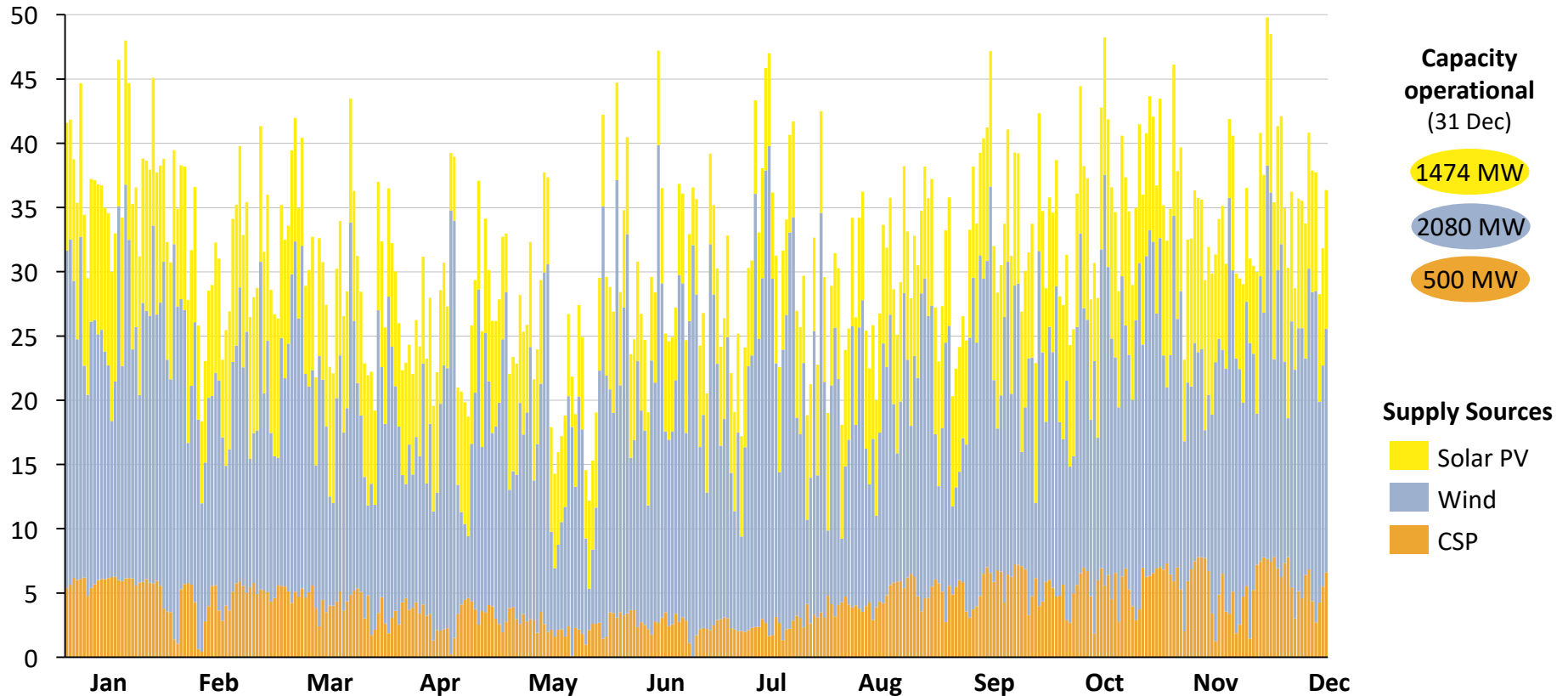
- 5 **Daily electricity production**

- 6 Hourly electricity production
- 7 Actual load shedding in 2019

Daily electricity production wind, solar PV & CSP fleet Jan to Dec 2019

Actual daily production from large-scale solar PV, wind and CSP plants under the REIPPPP from Jan-Dec 2019

Electricity production
in GWh/day

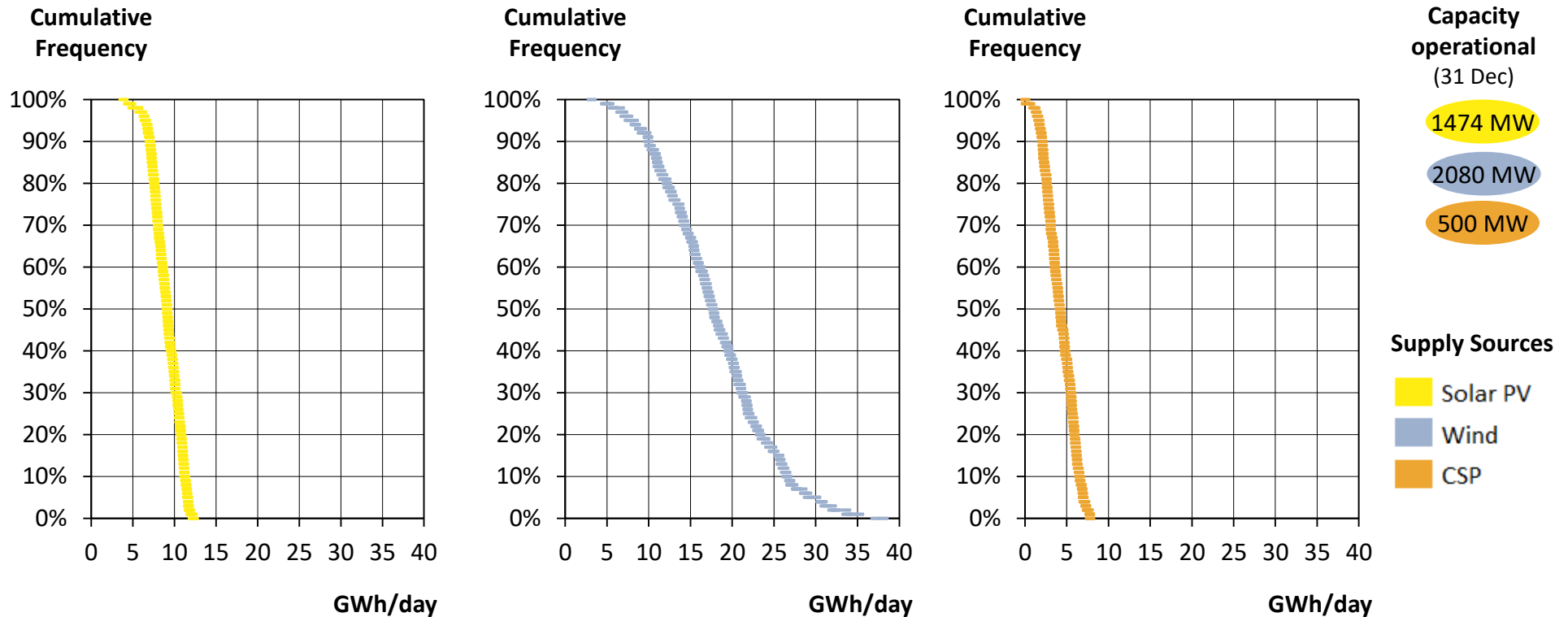


- Maximum daily production of 50 GWh on 14 Dec 2019 (Saturday)
- Minimum daily production of 12.2 GWh on 1 Jun 2019 (Saturday)

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

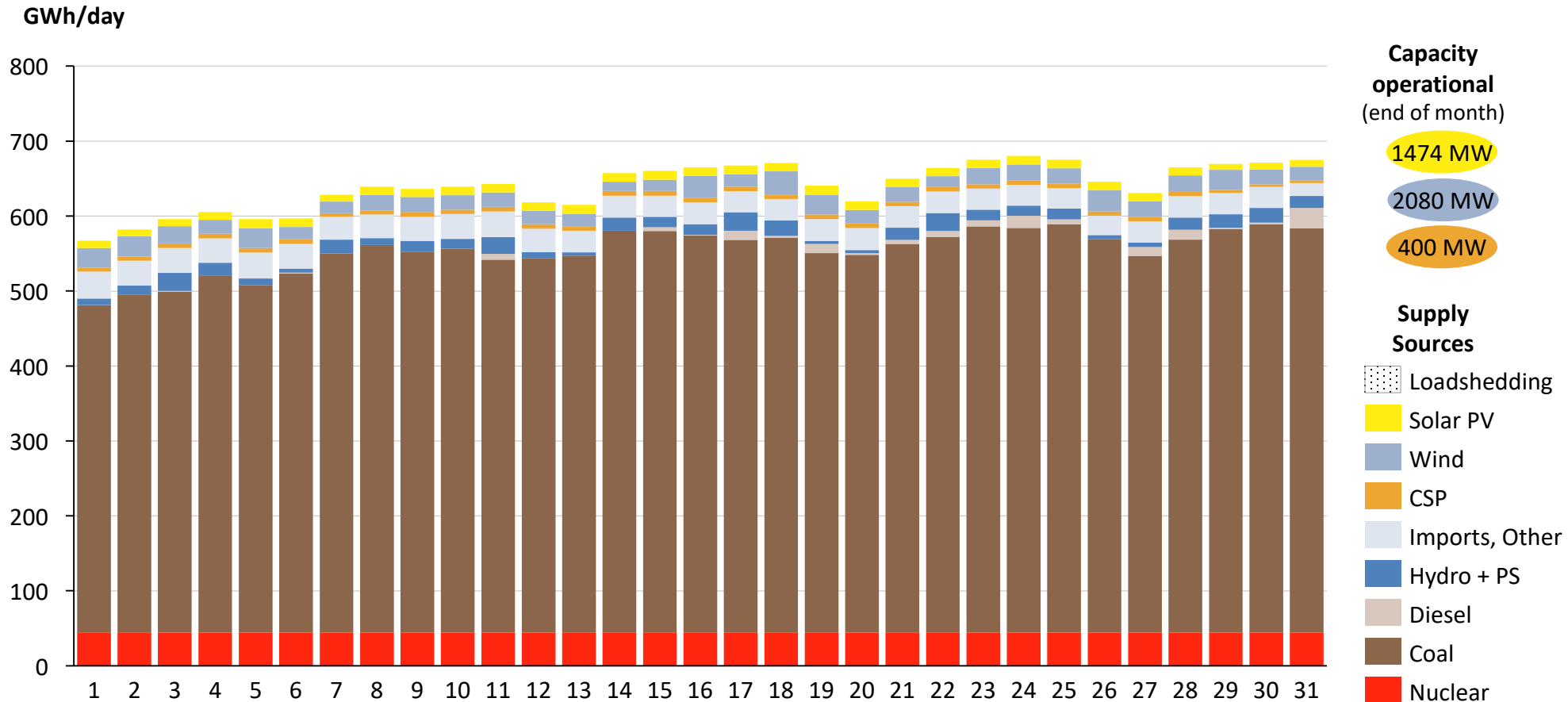
On 90% of the days from Jan - Dec 2019, solar PV and wind had a daily energy production of 7 GWh or more

Frequency distribution of daily solar PV, wind and CSP electricity production for January - December 2019



Daily electricity production of between 567-680 GWh in Jan 2019

Actual daily production from all power supply sources in South Africa for January 2019

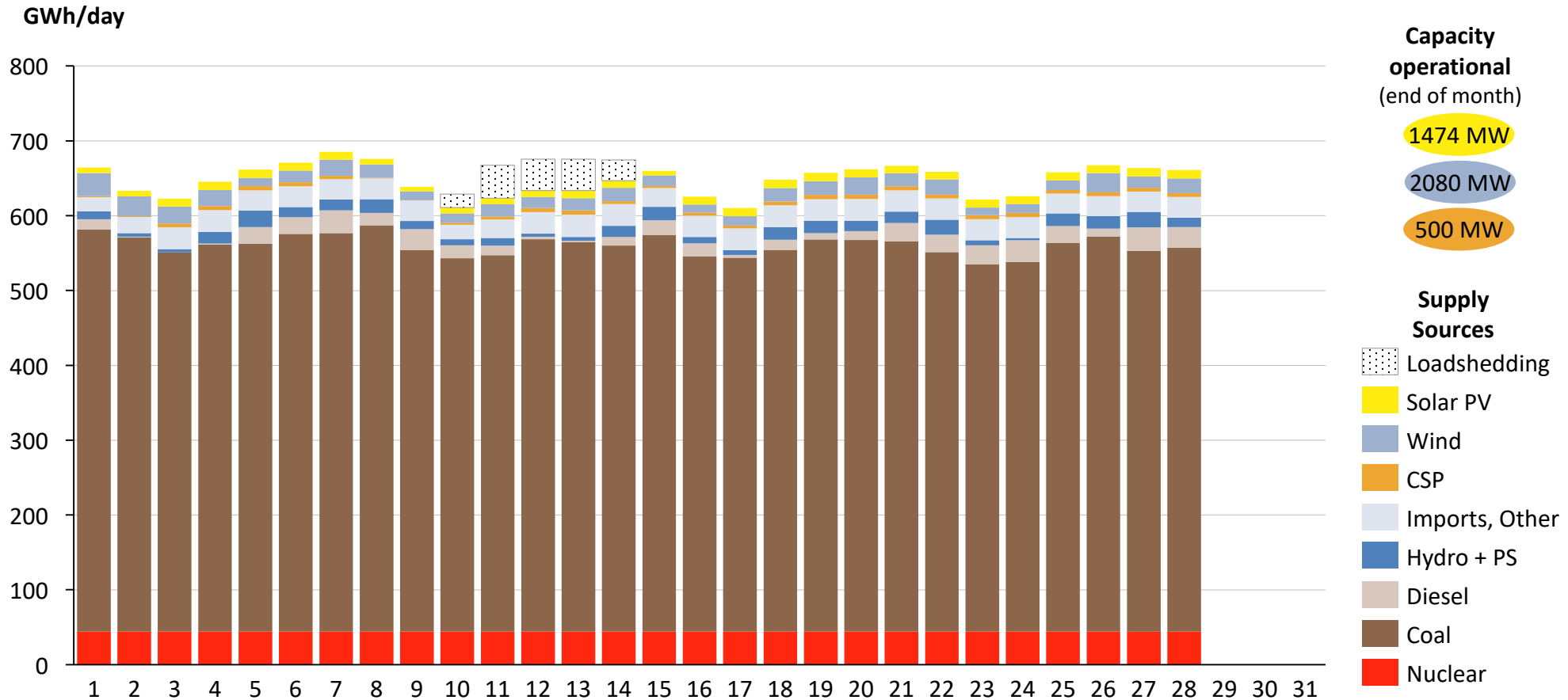


- Maximum daily production of 680 GWh on 24 Jan 2019 (Thursday)
- Minimum daily production of 567 GWh on 1 Jan 2019 (Tuesday - National Holiday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 610-685 GWh in Feb 2019

Actual daily production from all power supply sources in South Africa for February 2019

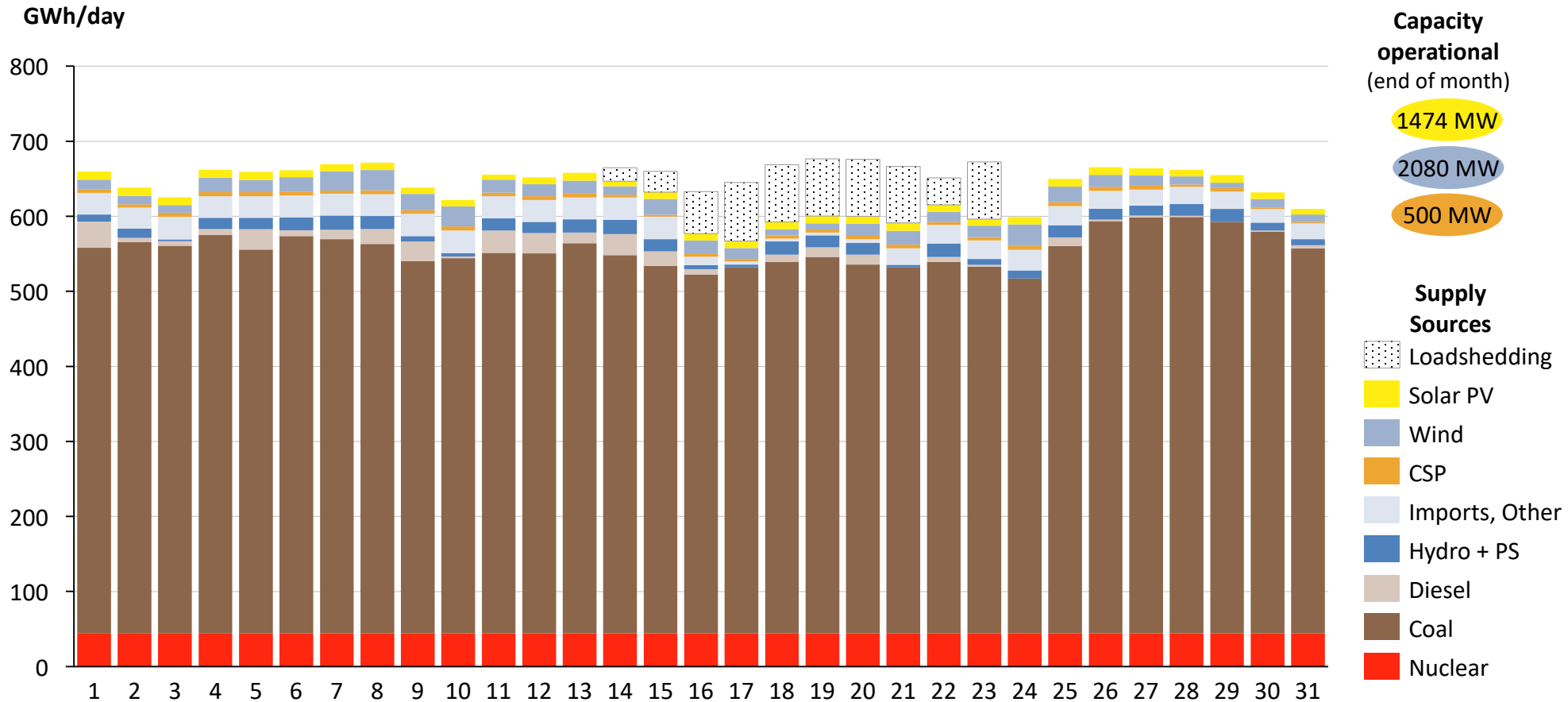


- Maximum daily production of 685 GWh on 7 Feb 2019 (Thursday)
- Minimum daily production of 610 GWh on 17 Feb 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 538-670 GWh in Mar 2019

Actual daily production from all power supply sources in South Africa for March 2019

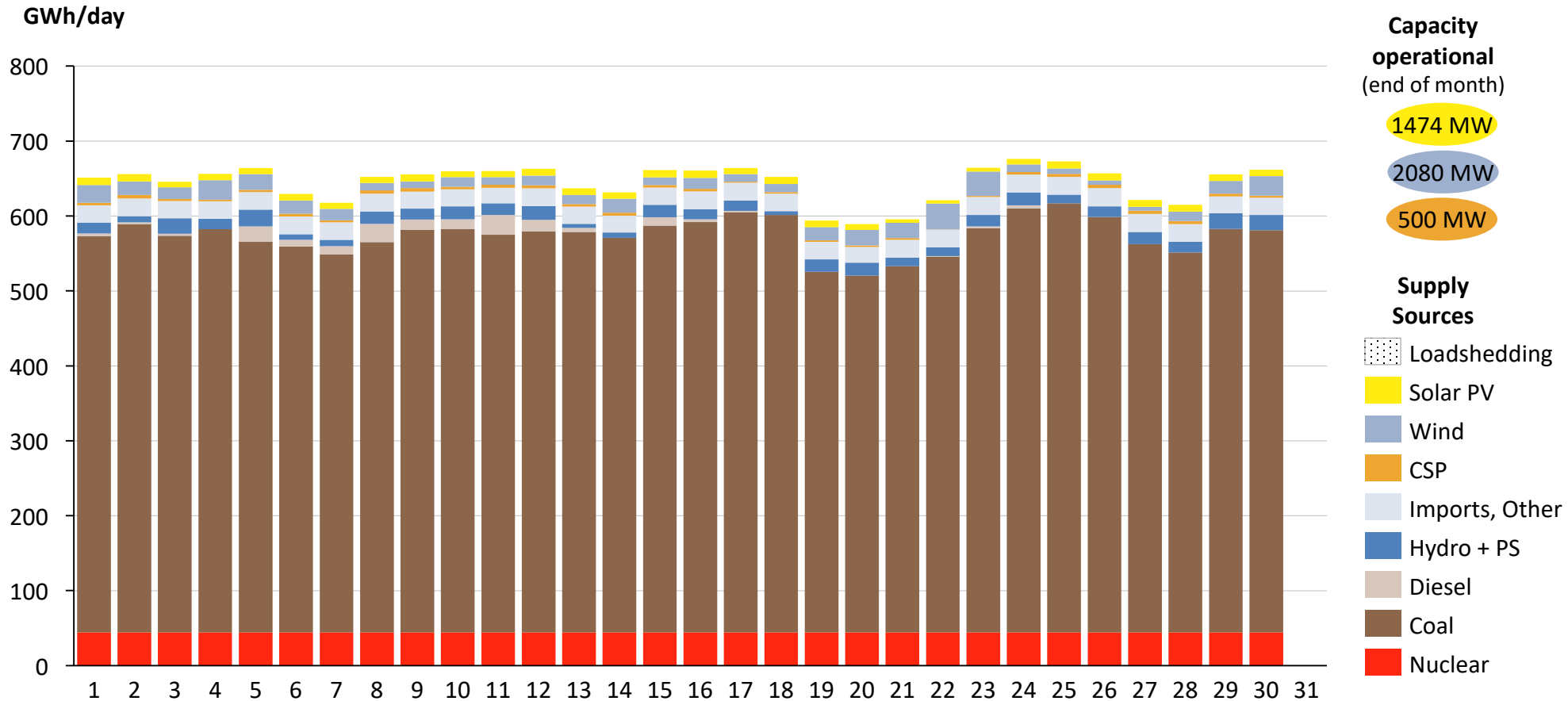


- Maximum daily production of 658 GWh on 7 Mar 2019 (Thursday)
- Minimum daily production of 538 GWh on 17 Mar 2019 (Sunday) ~78 GWh of load shed on this day

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 589-676 GWh in Apr 2019

Actual daily production from all power supply sources in South Africa for April 2019

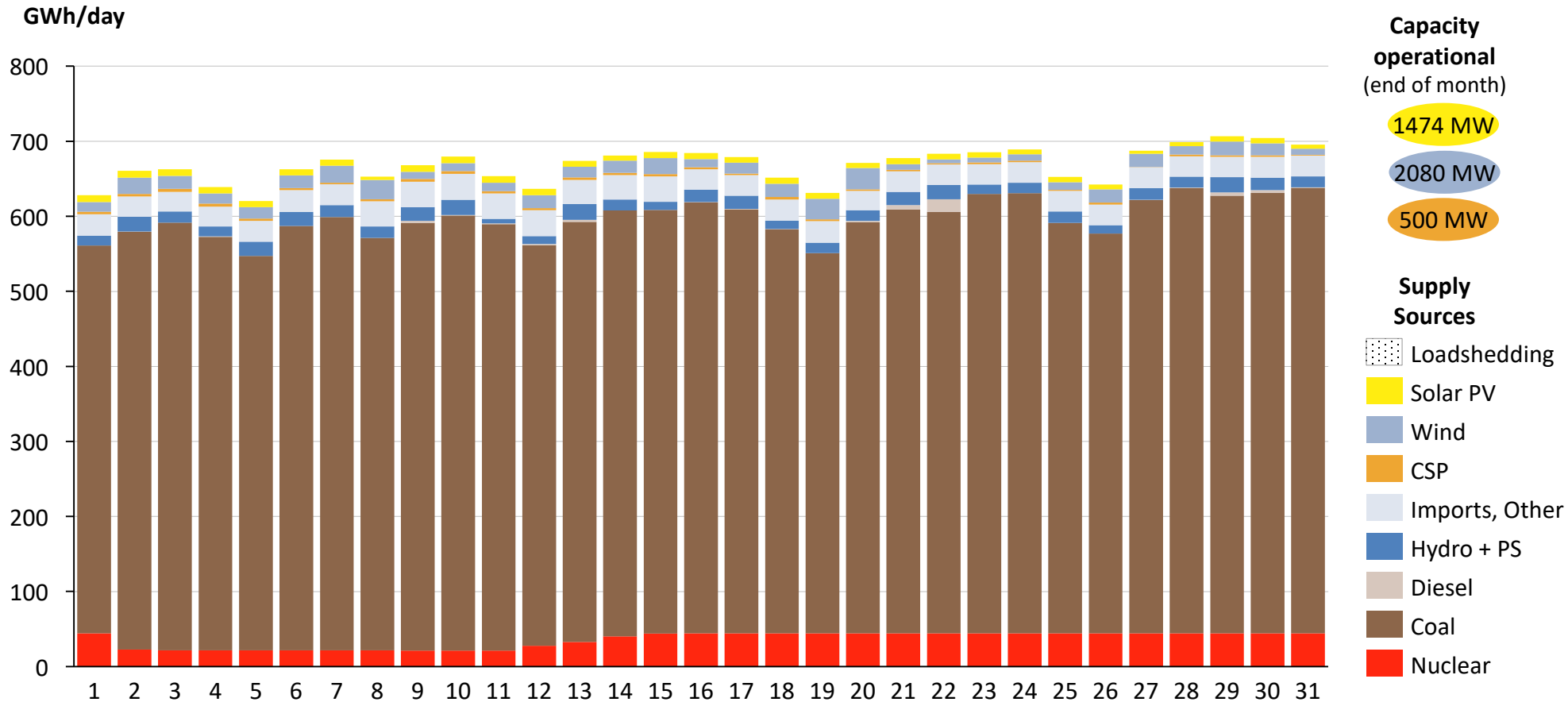


- Maximum daily production of 676 GWh on 24 Apr 2019 (Wednesday)
- Minimum daily production of 589 GWh on 20 Apr 2019 (Saturday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 620-707 GWh in May 2019

Actual daily production from all power supply sources in South Africa for May 2019

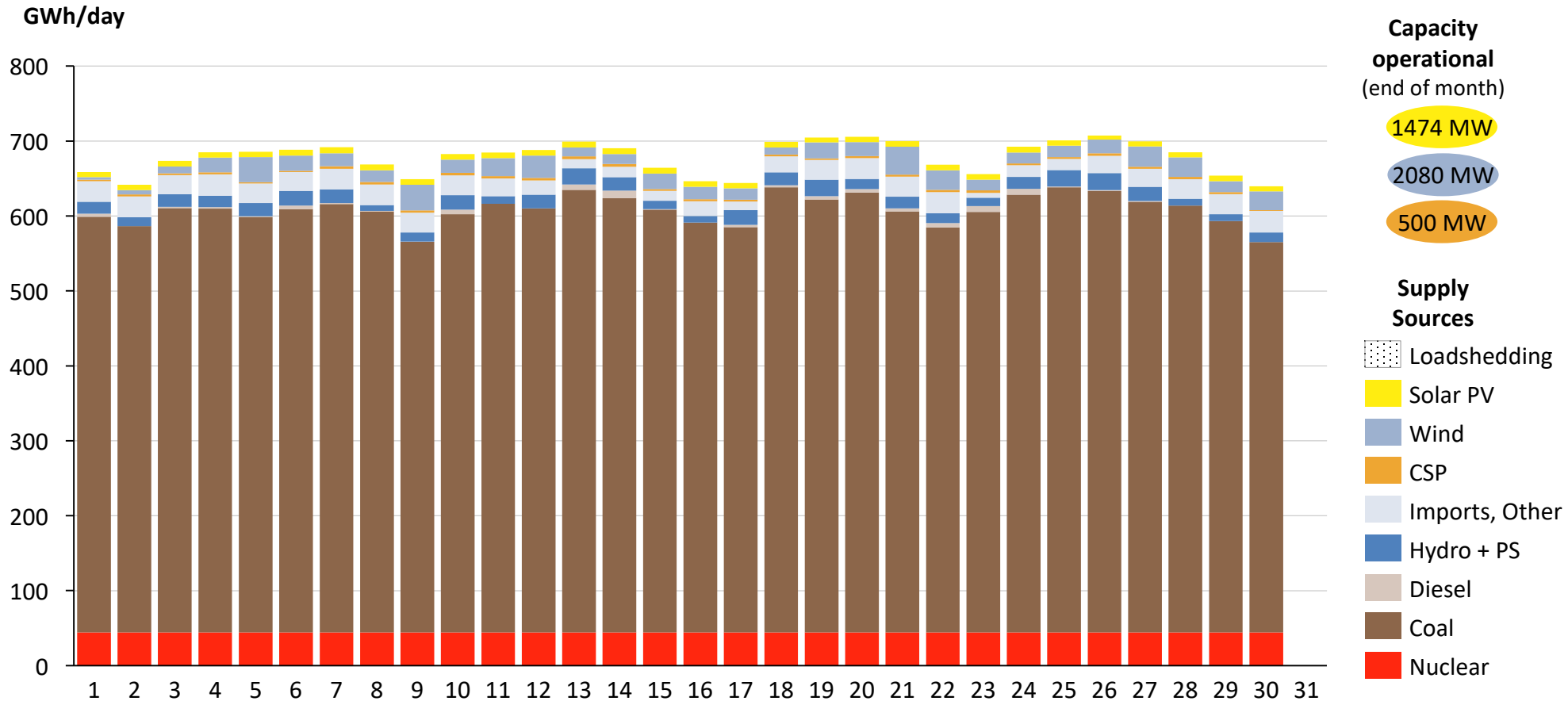


- Maximum daily production of 707 GWh on 29 May 2019 (Wednesday)
- Minimum daily production of 620 GWh on 5 May 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 640-707 GWh in Jun 2019

Actual daily production from all power supply sources in South Africa for June 2019

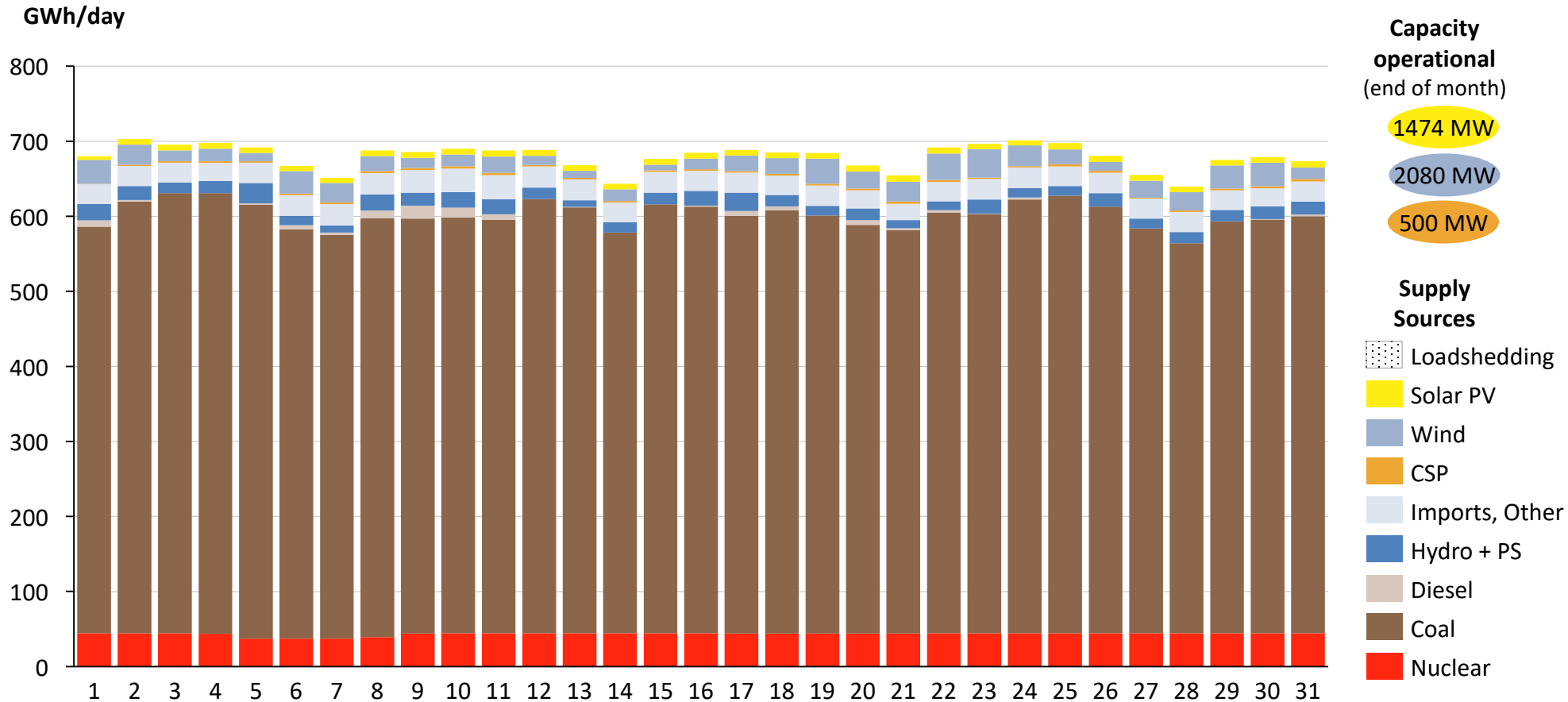


- Maximum daily production of 707 GWh on 26 Jun 2019 (Wednesday)
- Minimum daily production of 640 GWh on 30 Jun 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 640-703 GWh in Jul 2019

Actual daily production from all power supply sources in South Africa for July 2019

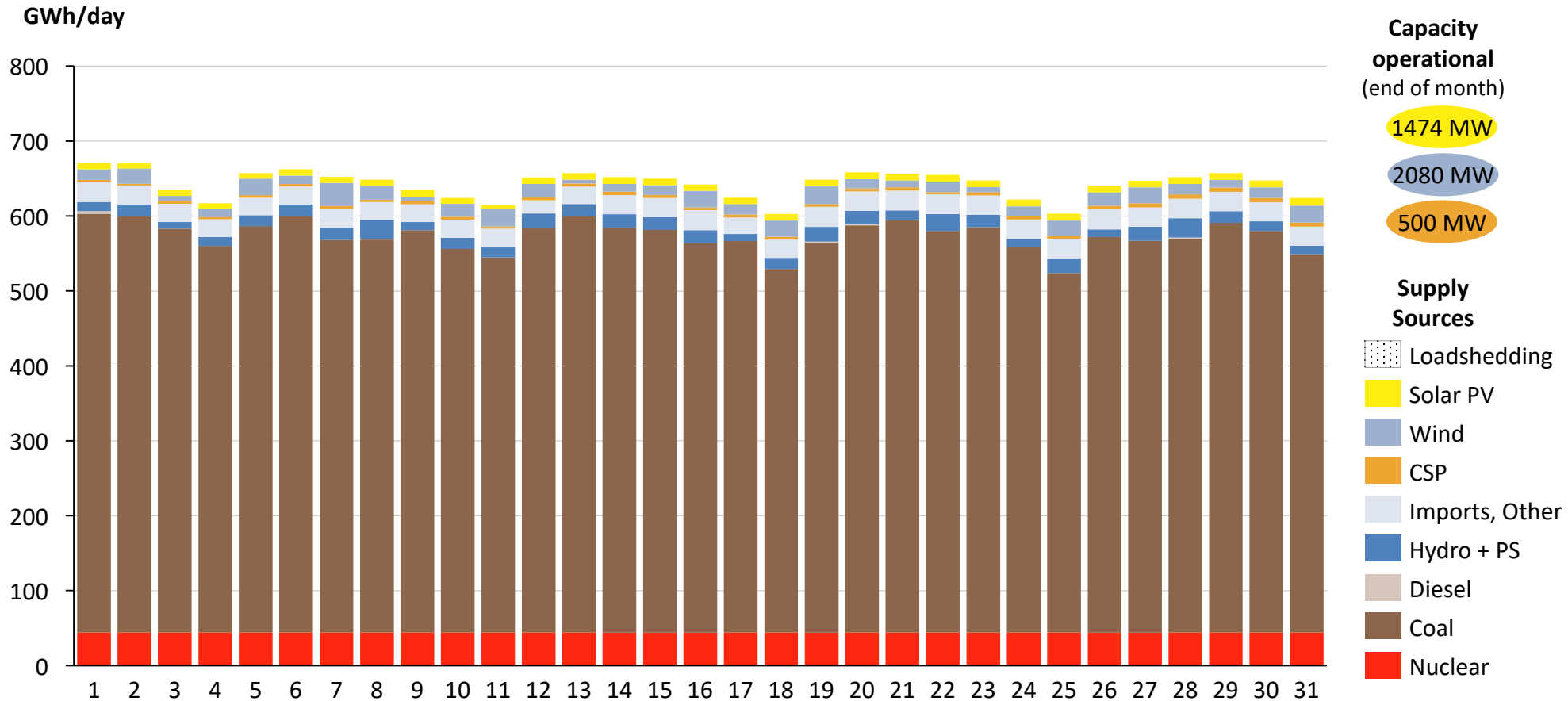


- Maximum daily production of 703 GWh on 2 Jul 2019 (Tuesday)
- Minimum daily production of 640 GWh on 28 Jul 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 603-671 GWh in Aug 2019

Actual daily production from all power supply sources in South Africa for August 2019

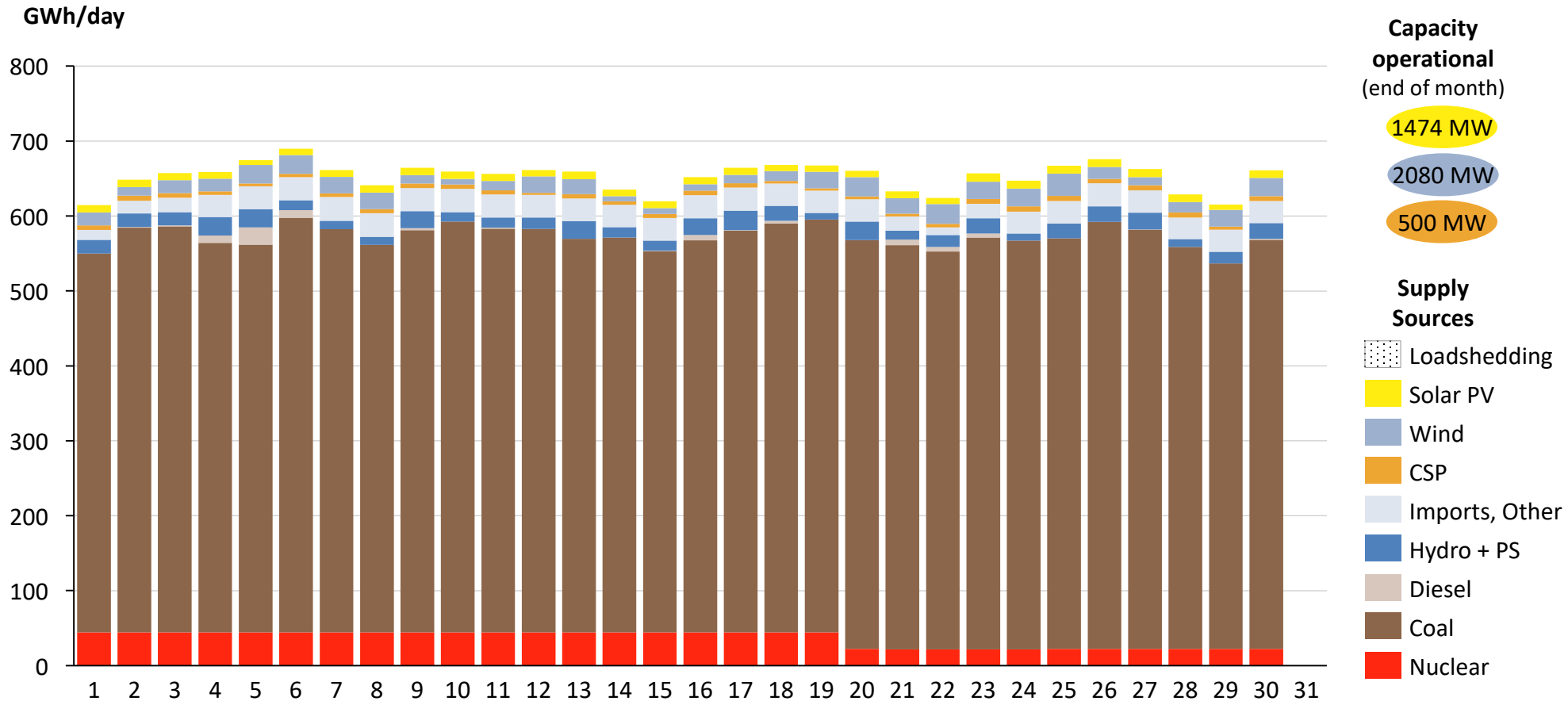


- Maximum daily production of 671 GWh on 1 Aug 2019 (Thursday)
- Minimum daily production of 603 GWh on 18 Aug 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 615-690 GWh in Sep 2019

Actual daily production from all power supply sources in South Africa for September 2019

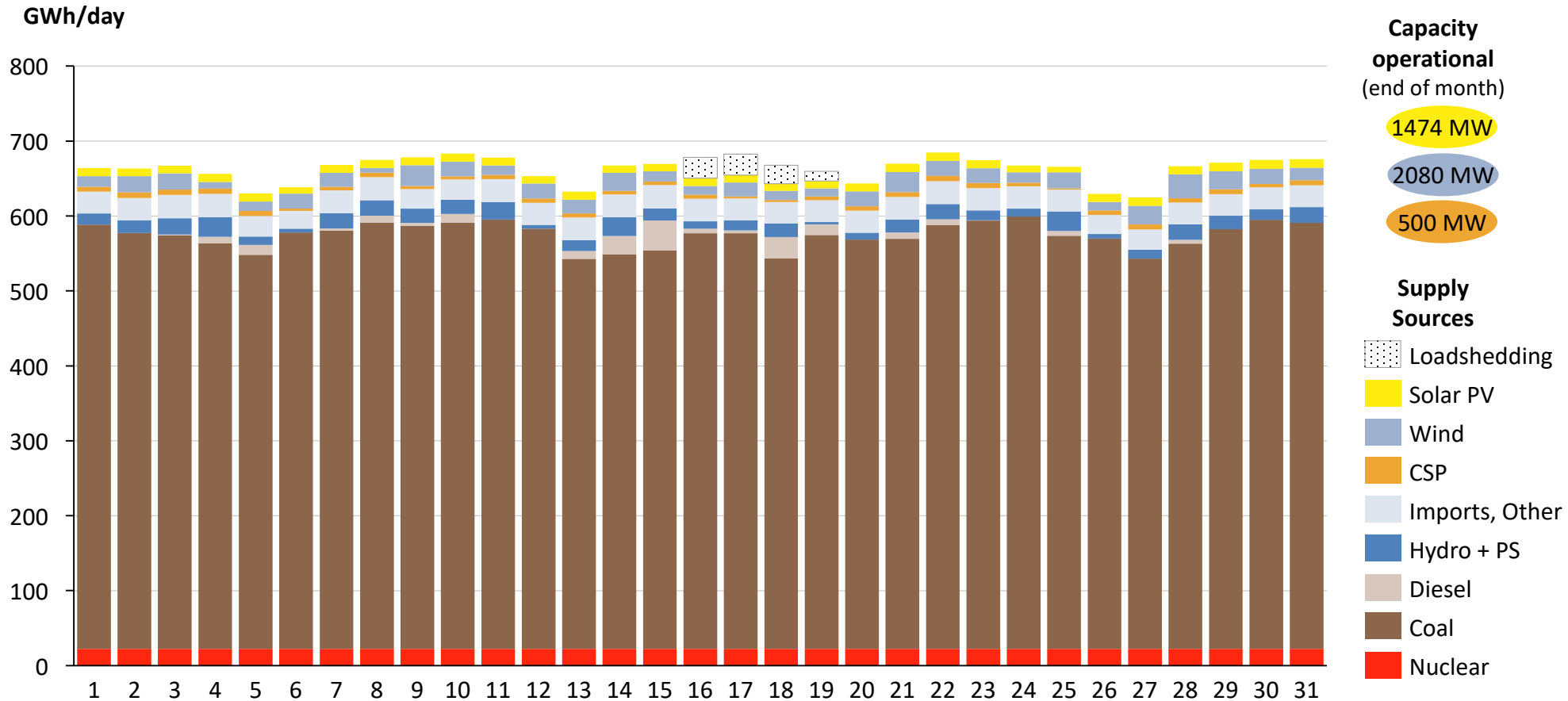


- Maximum daily production of 690 GWh on 6 Sep 2019 (Friday)
- Minimum daily production of 615 GWh on 29 Sep 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 625-685 GWh in Oct 2019

Actual daily production from all power supply sources in South Africa for October 2019

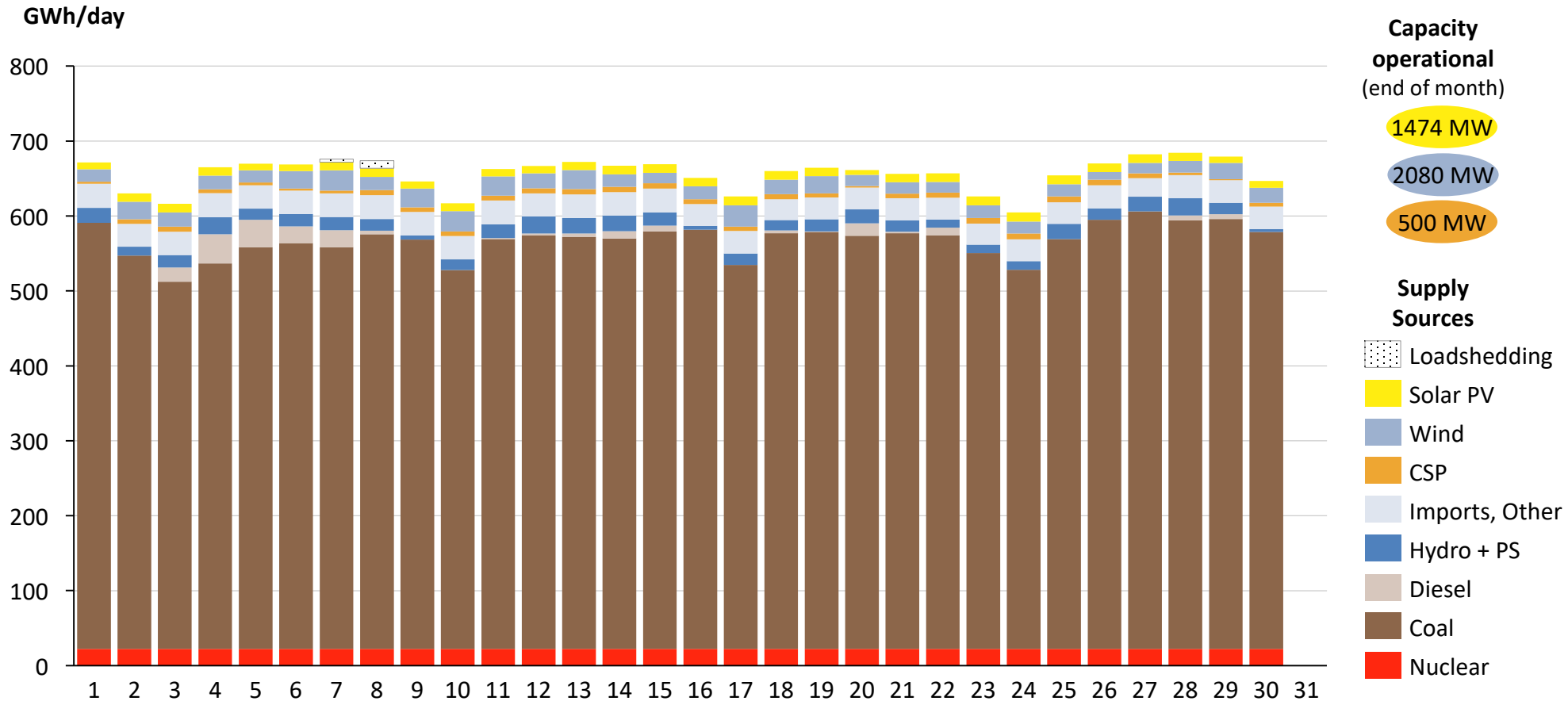


- Maximum daily production of 685 GWh on 22 Oct 2019 (Tuesday)
- Minimum daily production of 625 GWh on 27 Oct 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 605-684 GWh in Nov 2019

Actual daily production from all power supply sources in South Africa for November 2019

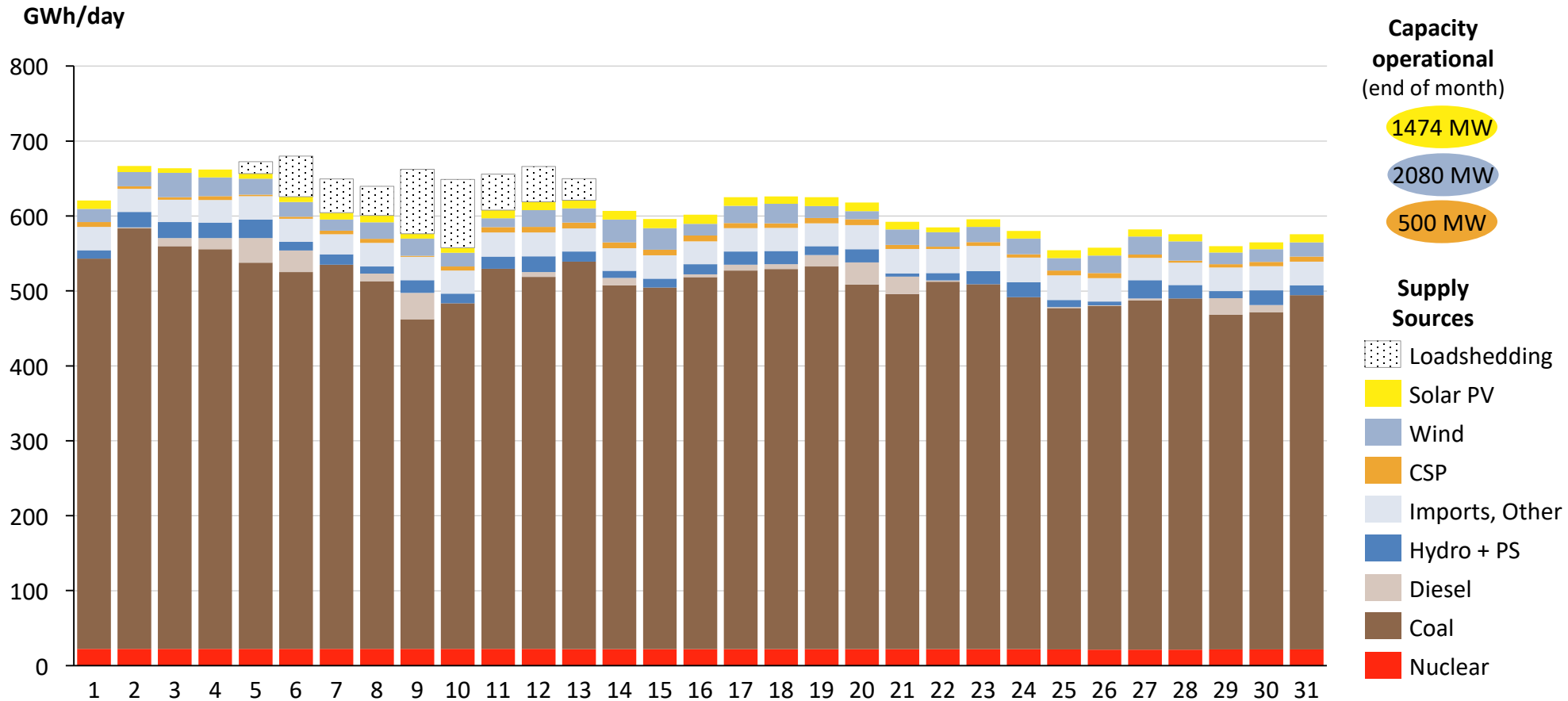


- Maximum daily production of 684 GWh on 28 Nov 2019 (Thursday)
- Minimum daily production of 605 GWh on 24 Nov 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 605-684 GWh in Dec 2019

Actual daily production from all power supply sources in South Africa for December 2019



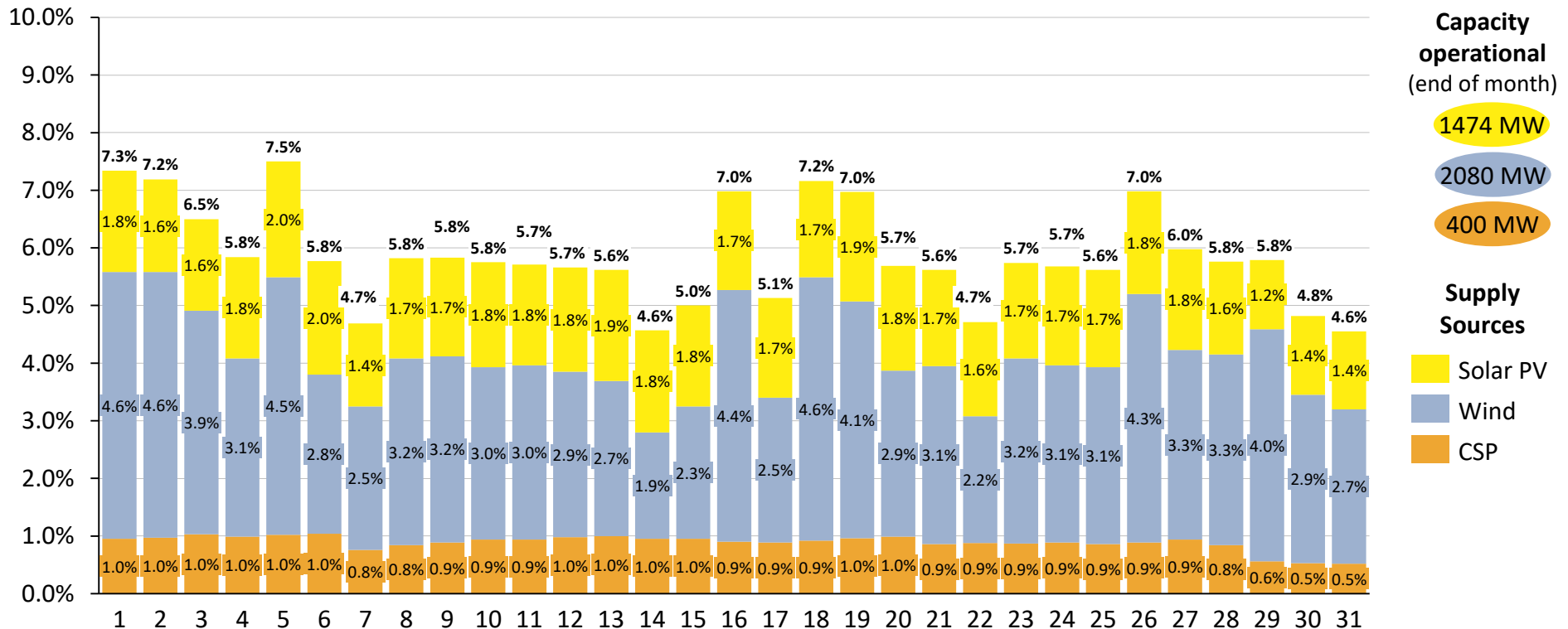
- Maximum daily production of 684 GWh on 28 Dec 2019 (Thursday)
- Minimum daily production of 605 GWh on 24 Dec 2019 (Sunday)

Note: Design as per Fraunhofer ISE. Daily production includes generation for pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 4.6-7.5% in Jan 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for January 2019

Relative daily contribution

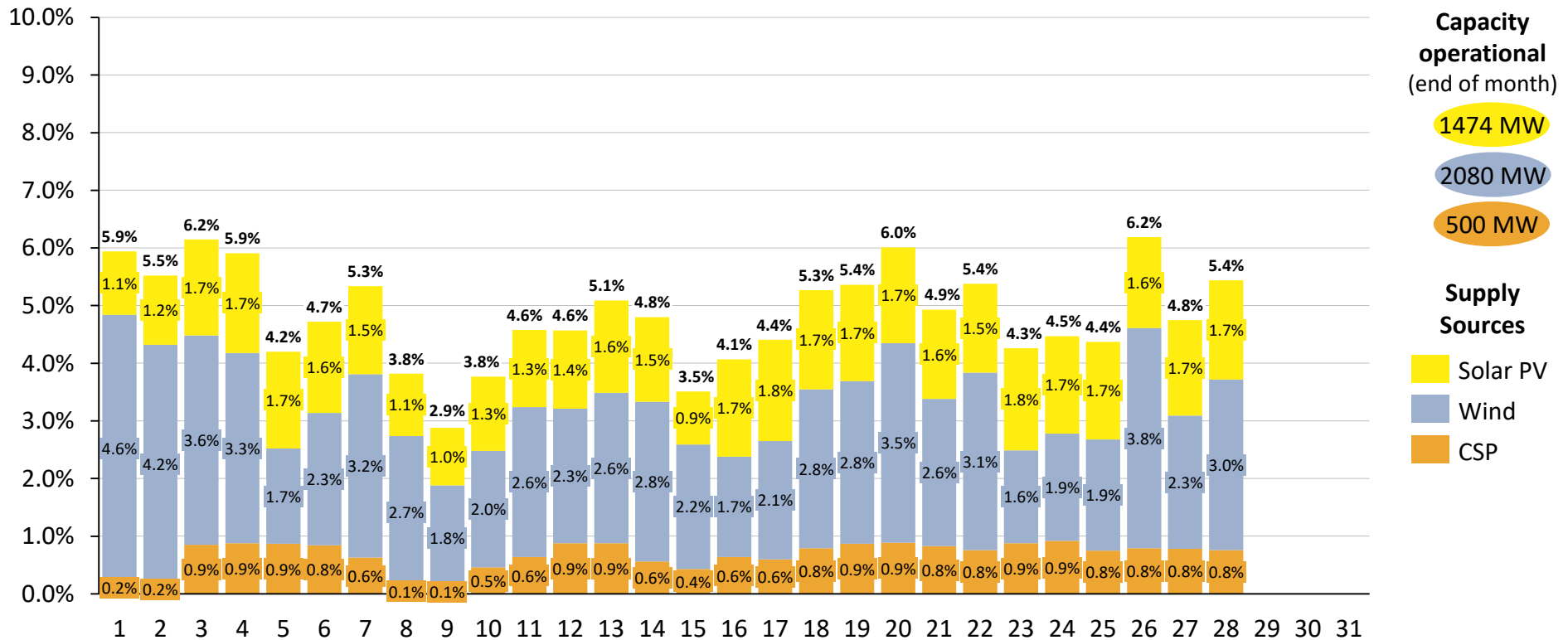


- Maximum daily relative solar PV contribution of 2.0% on 5 Jan 2019 (Saturday)
- Maximum daily relative wind contribution of 4.6% on 1 Jan 2019 (Tuesday - National Holiday)
- Maximum daily relative CSP contribution of 1.0% on 6 Jan 2019 (Sunday)

Daily solar PV, wind & CSP contribution of 2.9-6.2% in Feb 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for February 2019

Relative daily contribution

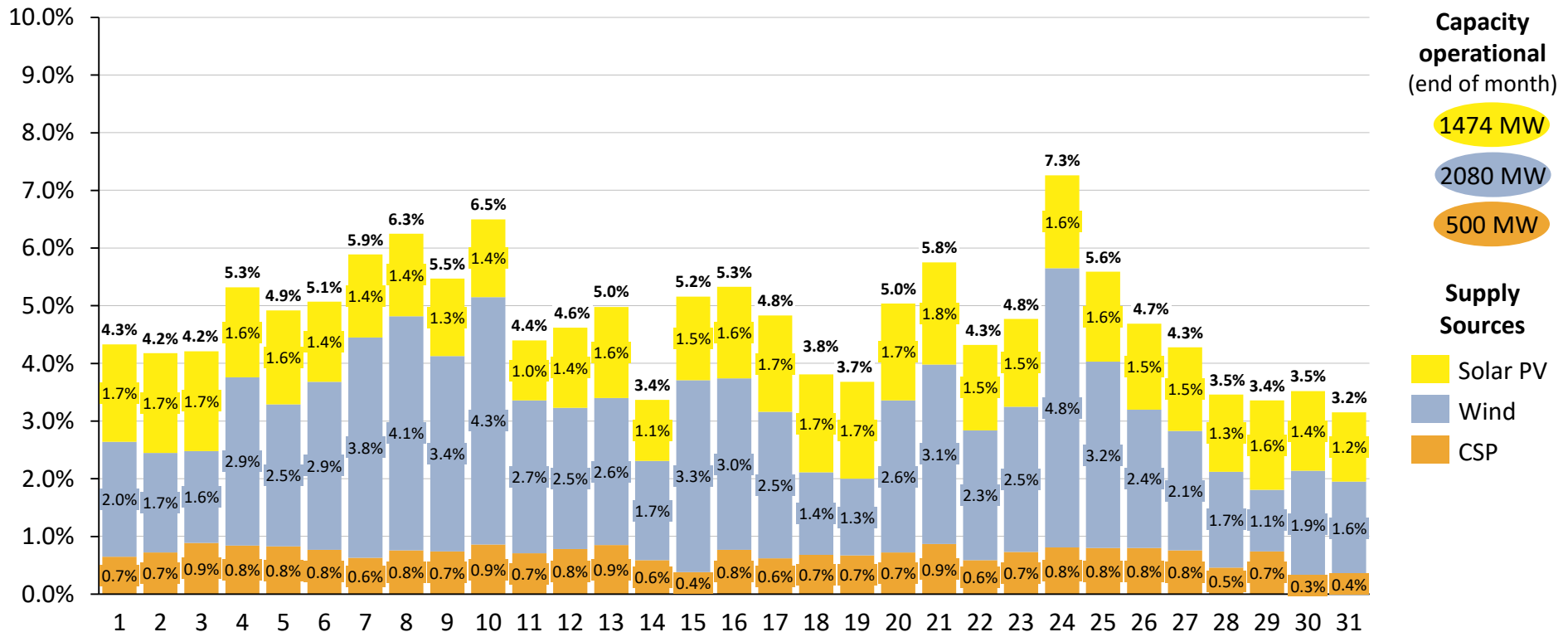


- Maximum daily relative solar PV contribution of 1.8% on 23 Feb 2019 (Saturday)
- Maximum daily relative wind contribution of 4.6% on 1 Feb 2019 (Friday)
- Maximum daily relative CSP contribution of 0.9% on 24 Feb 2019 (Sunday)

Daily solar PV, wind & CSP contribution of 3.2-7.3% in Mar 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for March 2019

Relative daily contribution

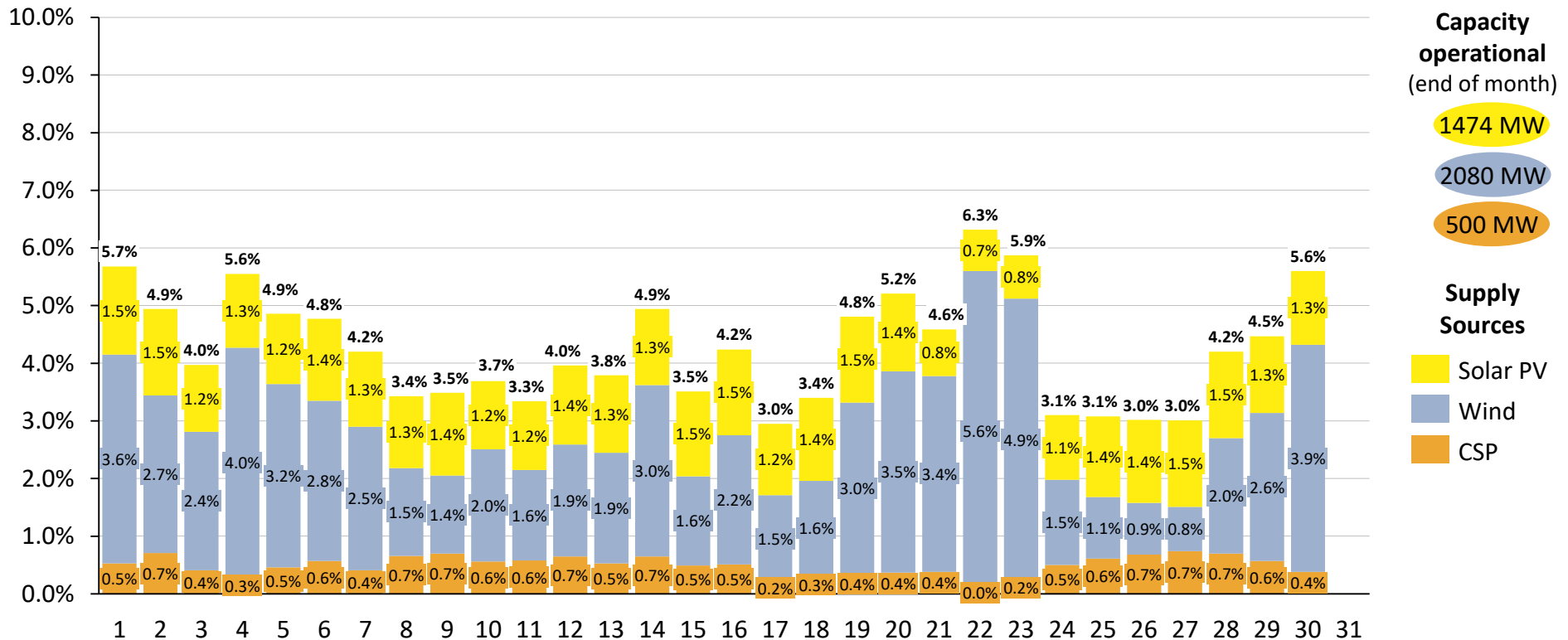


- Maximum daily relative solar PV contribution of 1.8% on 21 Mar 2019 (Thursday)
- Maximum daily relative wind contribution of 4.8% on 24 Mar 2019 (Saturday)
- Maximum daily relative CSP contribution of 0.9% on 3 Mar 2019 (Sunday)

Daily solar PV, wind & CSP contribution of 3.0-6.3% in Apr 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for April 2019

Relative daily contribution

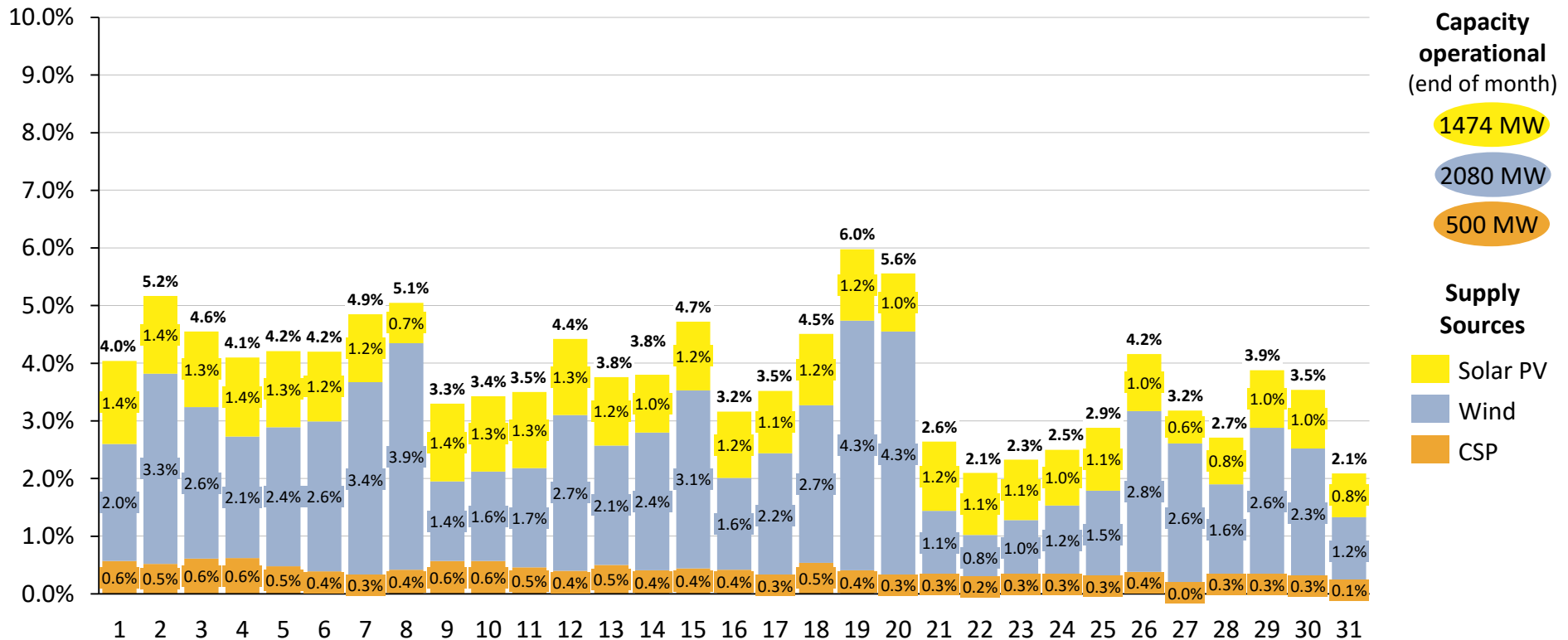


- Maximum daily relative solar PV contribution of 1.5% on 1 Apr 2019 (Monday)
- Maximum daily relative wind contribution of 5.6% on 22 Apr 2019 (Monday)
- Maximum daily relative CSP contribution of 0.7% on 27 Apr 2019 (Saturday)

Daily solar PV, wind & CSP contribution of 2.1-6.0% in May 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for May 2019

Relative daily contribution

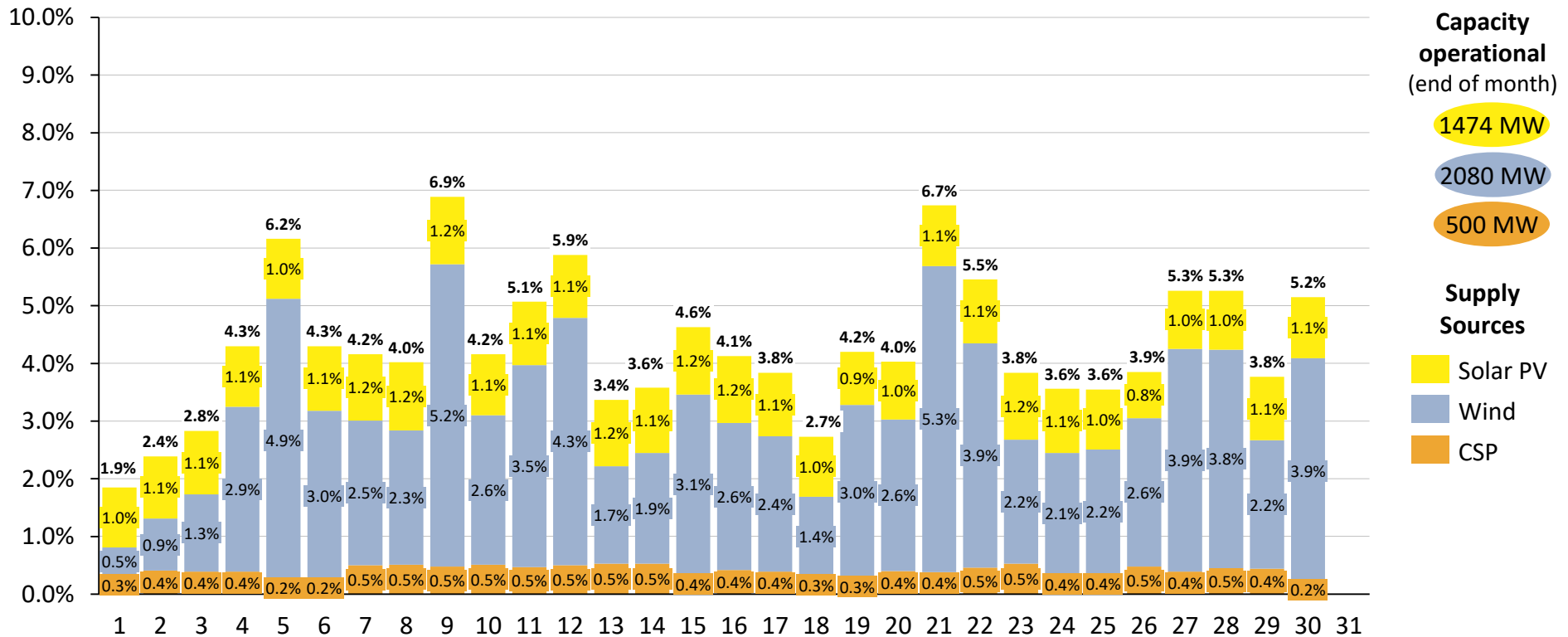


- Maximum daily relative solar PV contribution of 1.4% on 1 May 2019 (Wednesday)
- Maximum daily relative wind contribution of 4.3% on 19 May 2019 (Sunday)
- Maximum daily relative CSP contribution of 0.6% on 4 May 2019 (Saturday)

Daily solar PV, wind & CSP contribution of 1.9-6.9% in Jun 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for June 2019

Relative daily contribution

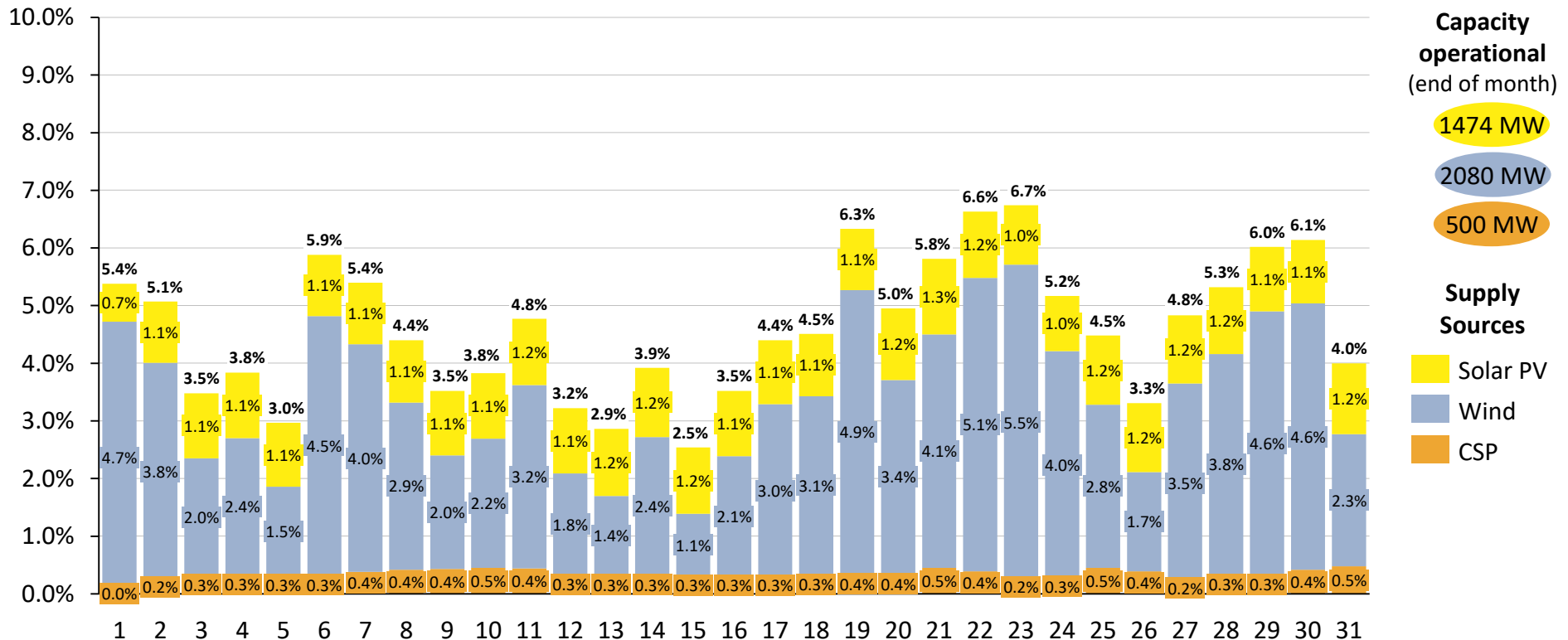


- Maximum daily relative solar PV contribution of 1.2% on 8 Jun 2019 (Saturday)
- Maximum daily relative wind contribution of 5.3% on 21 Jun 2019 (Friday)
- Maximum daily relative CSP contribution of 0.5% on 23 Jun 2019 (Sunday)

Daily solar PV, wind & CSP contribution of 2.5-6.7% in Jul 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for July 2019

Relative daily contribution

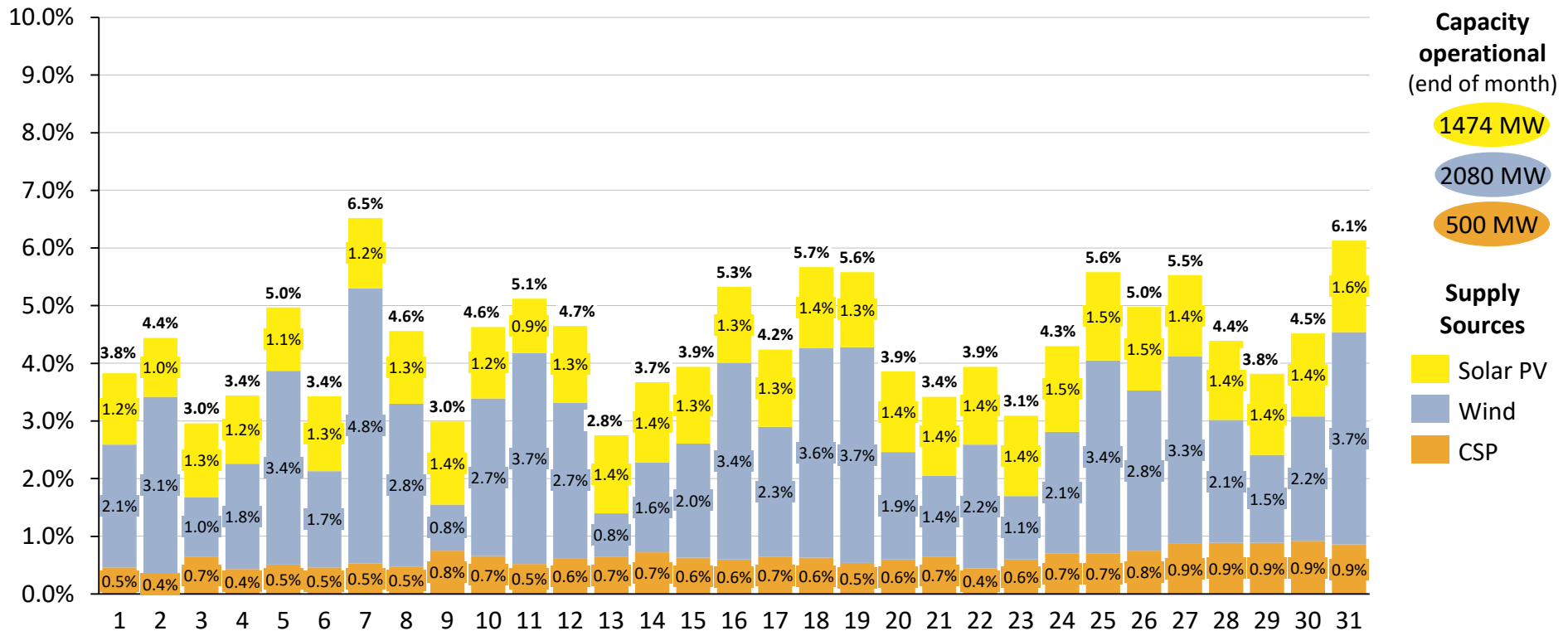


- Maximum daily relative solar PV contribution of 1.3% on 21 Jul 2019 (Saturday)
- Maximum daily relative wind contribution of 5.5% on 23 Jul 2019 (Tuesday)
- Maximum daily relative CSP contribution of 0.5% on 31 Jul 2019 (Wednesday)

Daily solar PV, wind & CSP contribution of 2.8-6.5% in Aug 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for August 2019

Relative daily contribution

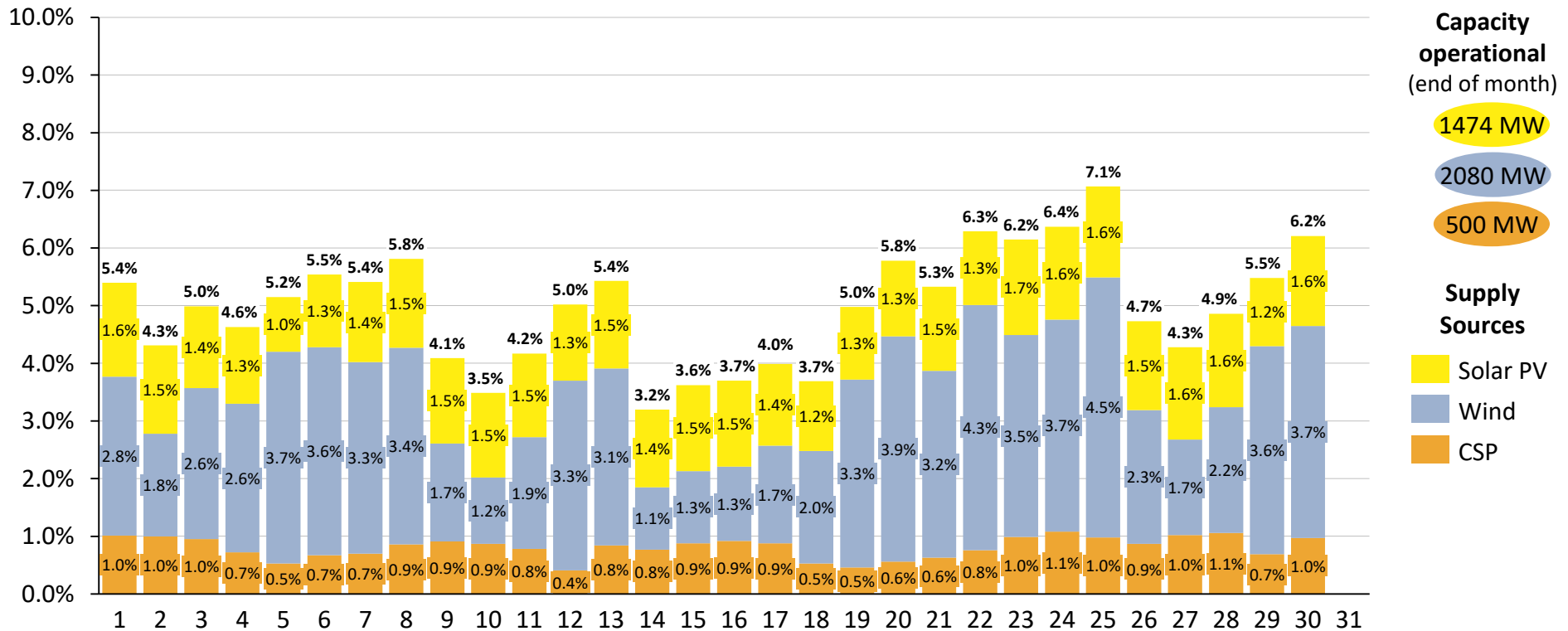


- Maximum daily relative solar PV contribution of 1.6% on 31 Aug 2019 (Saturday)
- Maximum daily relative wind contribution of 4.8% on 7 Aug 2019 (Wednesday)
- Maximum daily relative CSP contribution of 0.9% on 30 Aug 2019 (Friday)

Daily solar PV, wind & CSP contribution of 3.2-7.1% in Sep 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for September 2019

Relative daily contribution

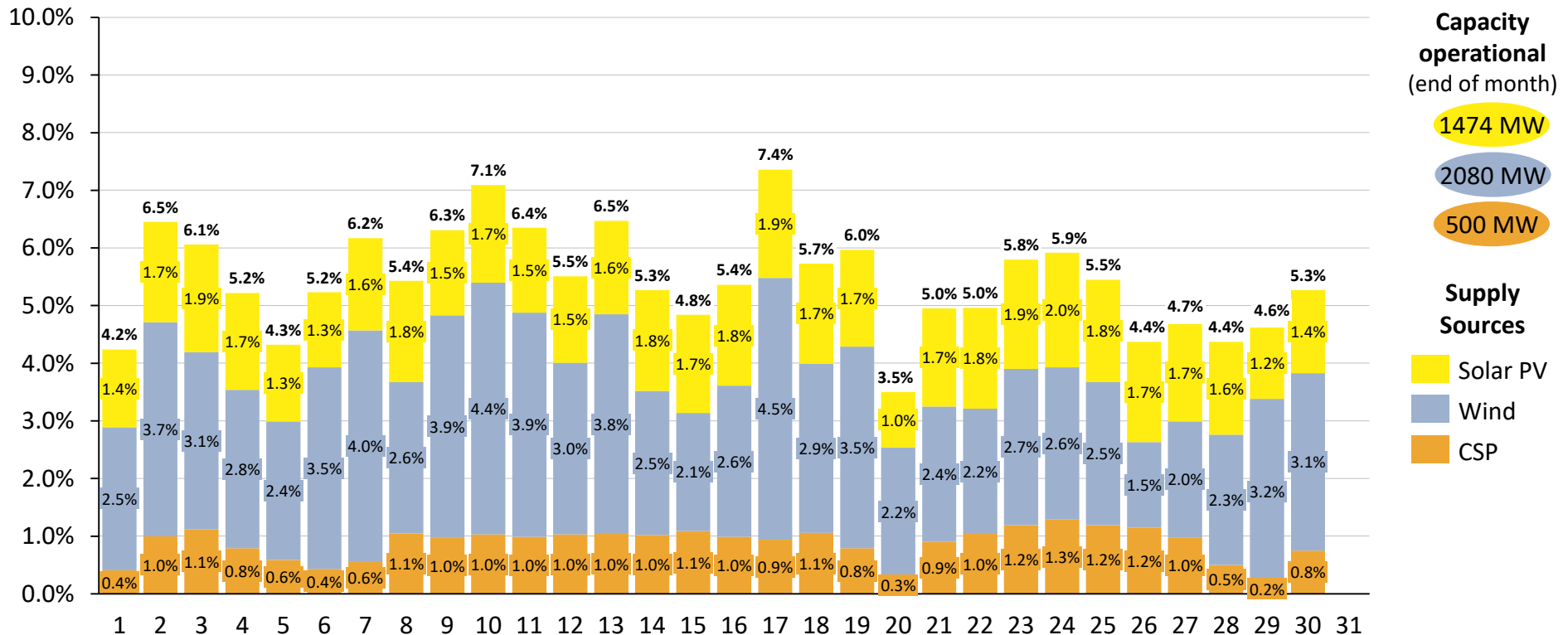


- Maximum daily relative solar PV contribution of 1.7% on 23 Sep 2019 (Monday)
- Maximum daily relative wind contribution of 4.5% on 25 Sep 2019 (Wednesday)
- Maximum daily relative CSP contribution of 1.1% on 24 Sep 2019 (Tuesday)

Daily solar PV, wind & CSP contribution of 3.5-7.4% in Nov 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for November 2019

Relative daily contribution

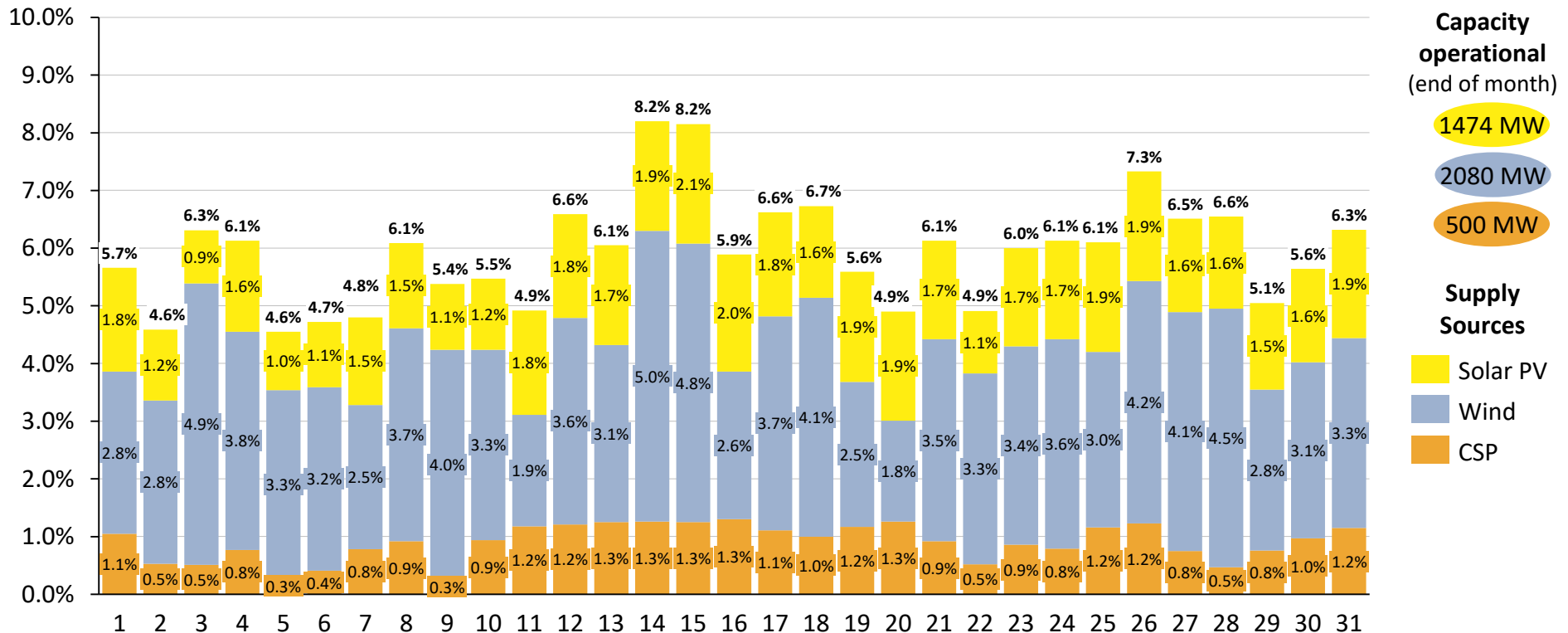


- Maximum daily relative solar PV contribution of 2.0% on 24 Nov 2019 (Sunday)
- Maximum daily relative wind contribution of 4.5% on 17 Nov 2019 (Sunday)
- Maximum daily relative CSP contribution of 1.3% on 24 Nov 2019 (Sunday)

Daily solar PV, wind & CSP contribution of 4.6-8.2% in Dec 2019

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for December 2019

Relative daily contribution



- Maximum daily relative solar PV contribution of 2.1% on 15 Dec 2019 (Sunday)
- Maximum daily relative wind contribution of 5.0% on 14 Dec 2019 (Saturday)
- Maximum daily relative CSP contribution of 1.3% on 16 Dec 2019 (Monday)

Agenda

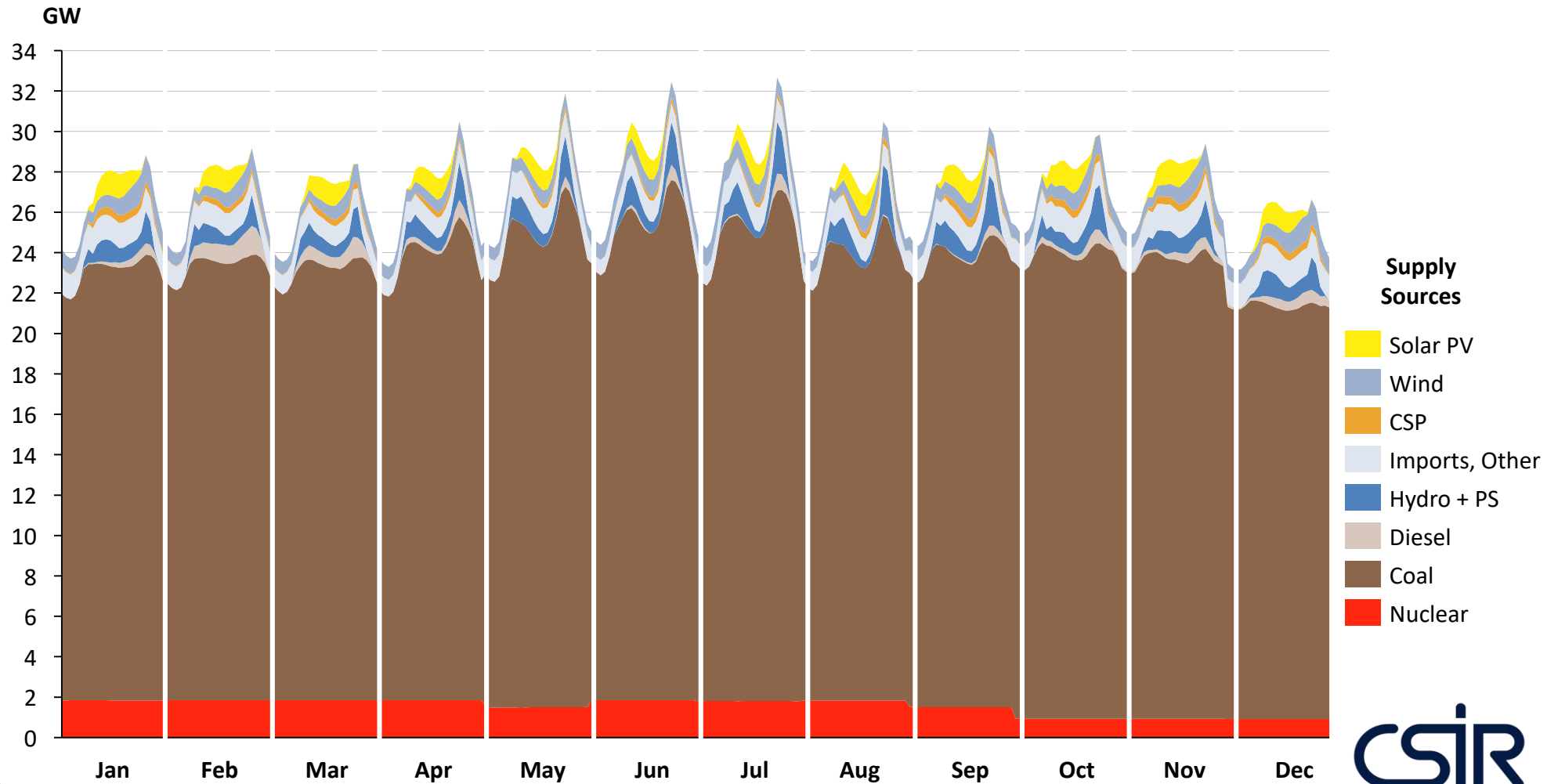
- 1 Overview and status of REIPPPP
- 2 Overview actual electricity production data for 2019
- 3 Monthly electricity production
- 4 Weekly electricity production
- 5 Daily electricity production

- 6 Hourly electricity production

- 7 Actual load shedding in 2019

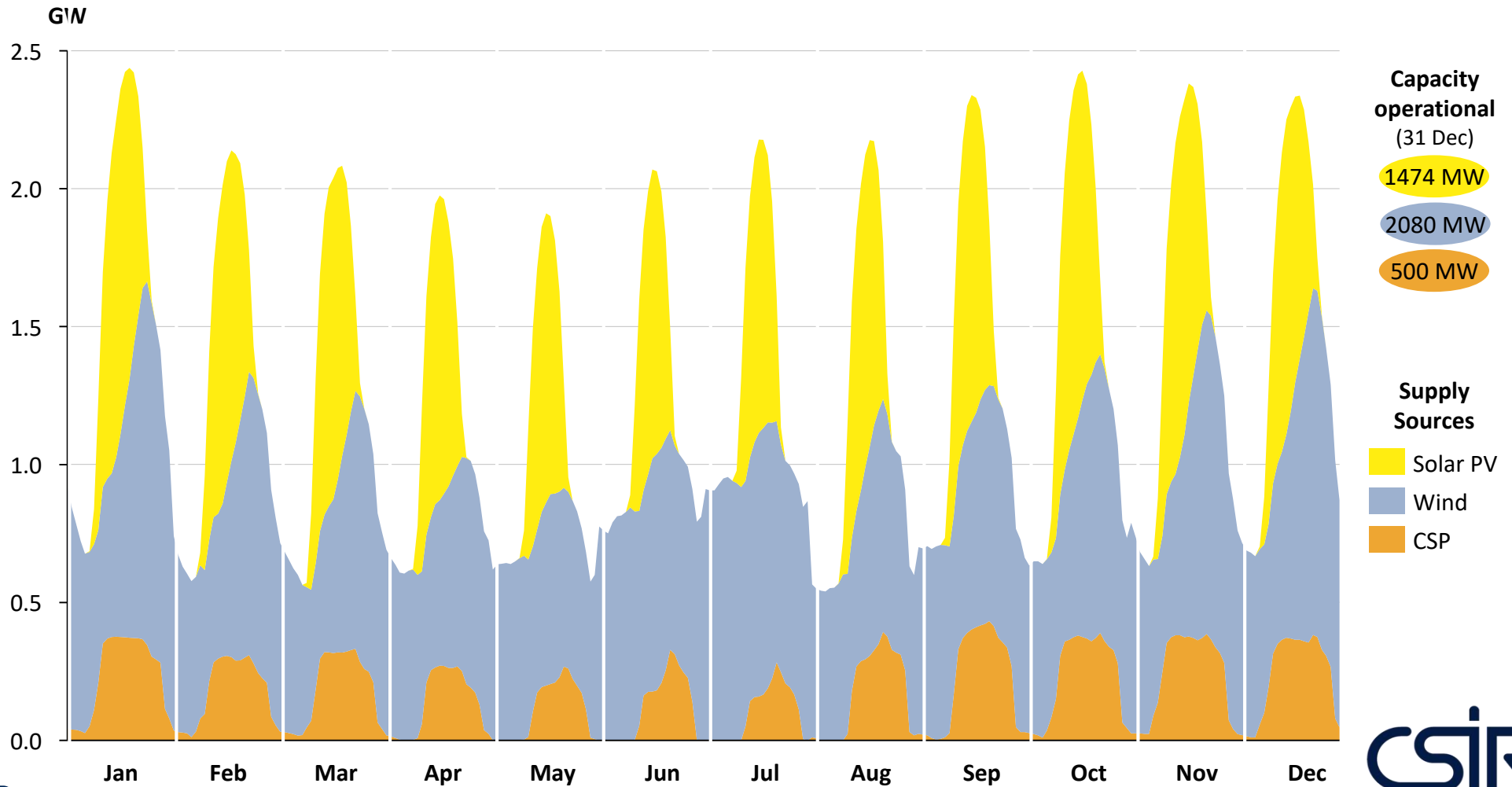
Diurnal Courses

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



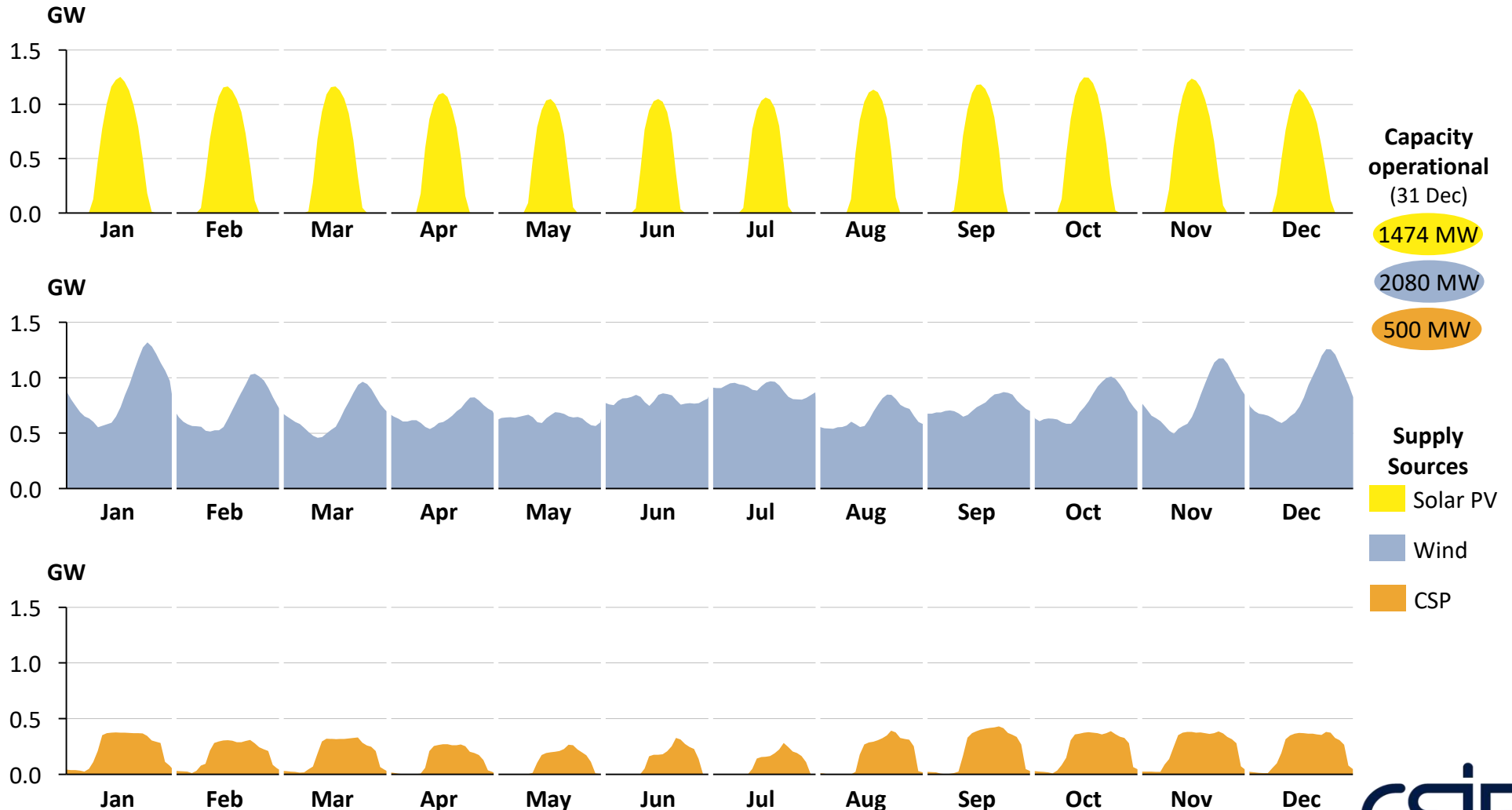
Diurnal Courses

Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for the months from Jan-Dec 2019



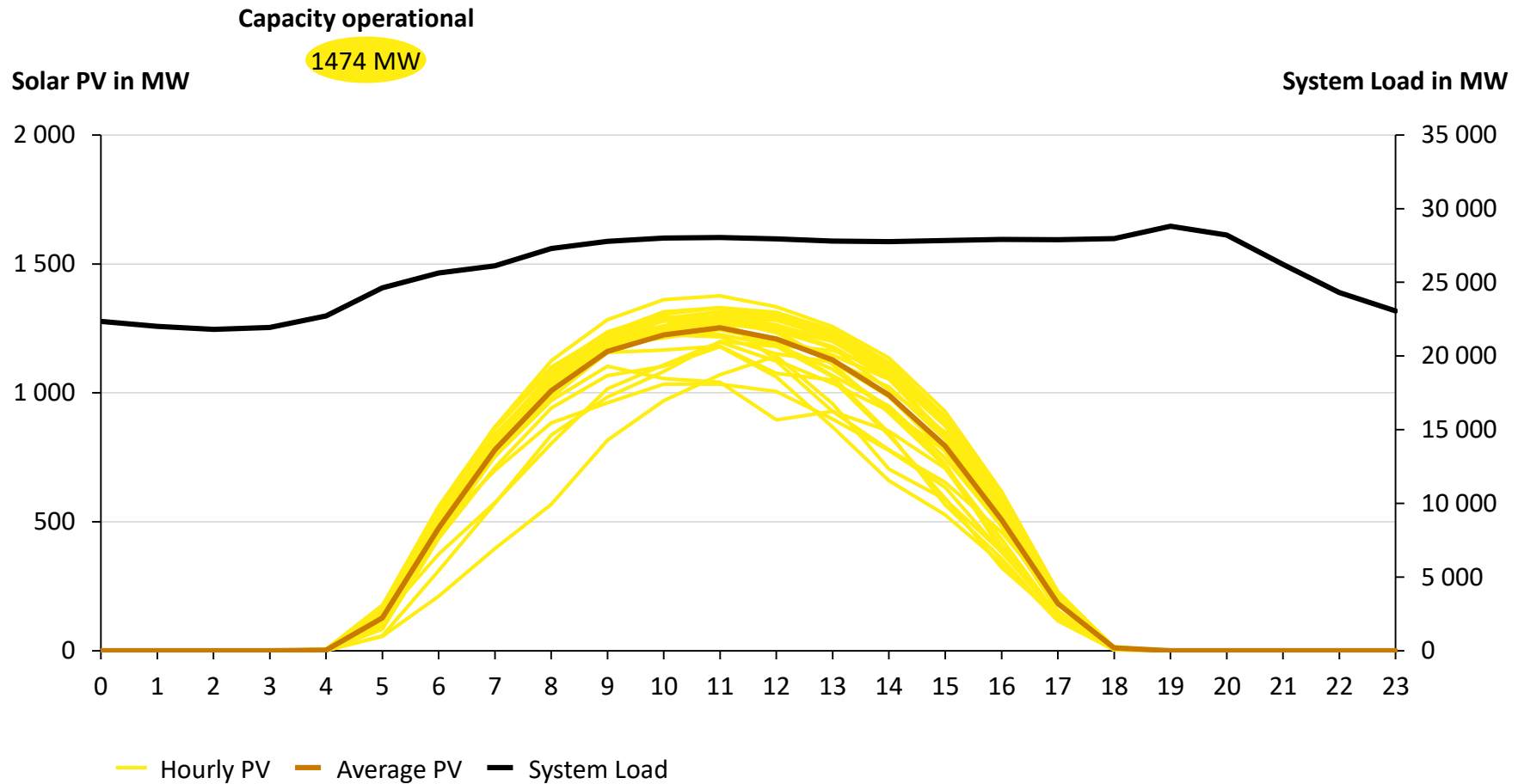
Diurnal Courses

Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for the months from Jan-Dec 2019



Solar PV supply in Jan 2019 was very stable

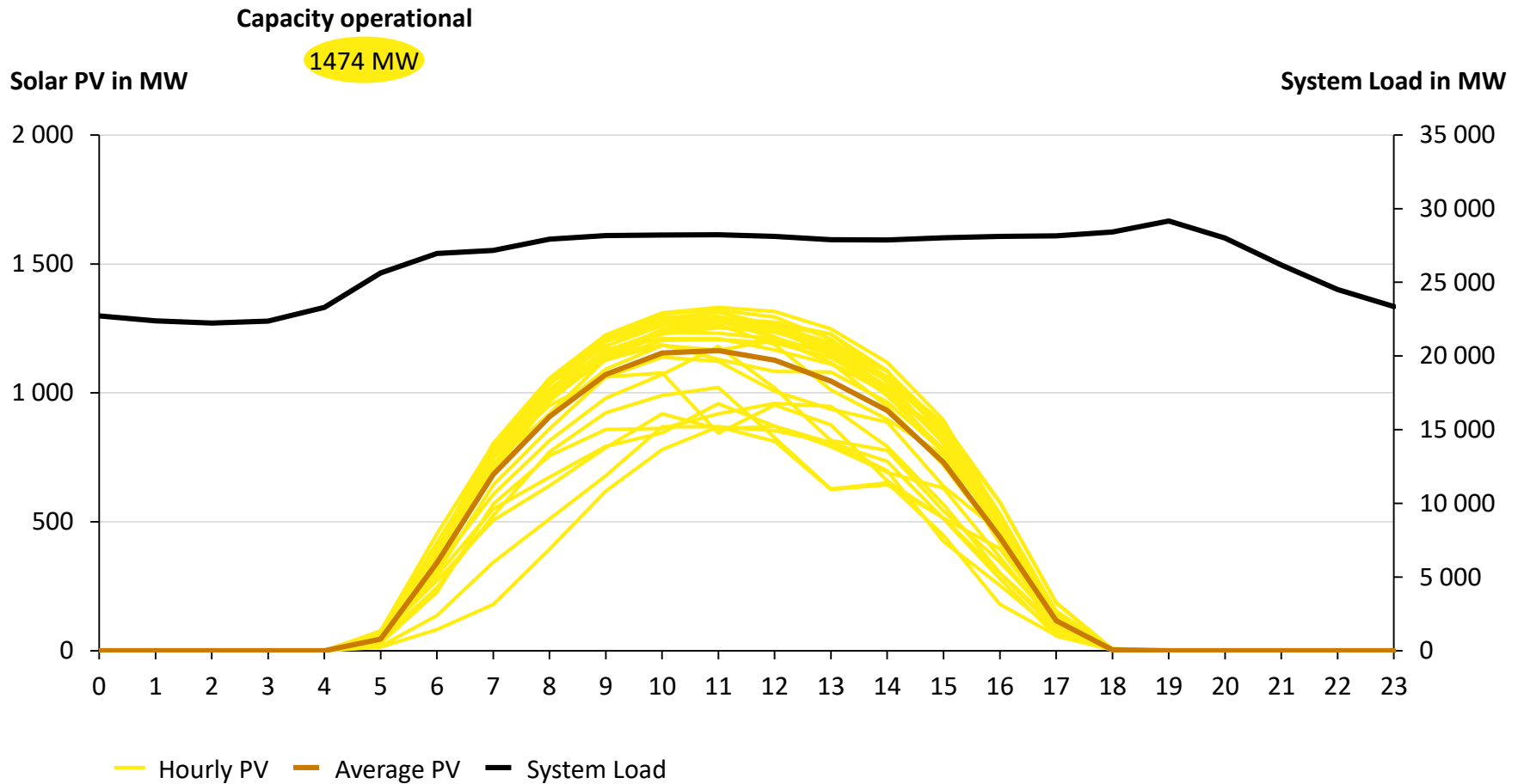
Hourly solar PV production for all 31 days of January 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Feb 2019 was very stable

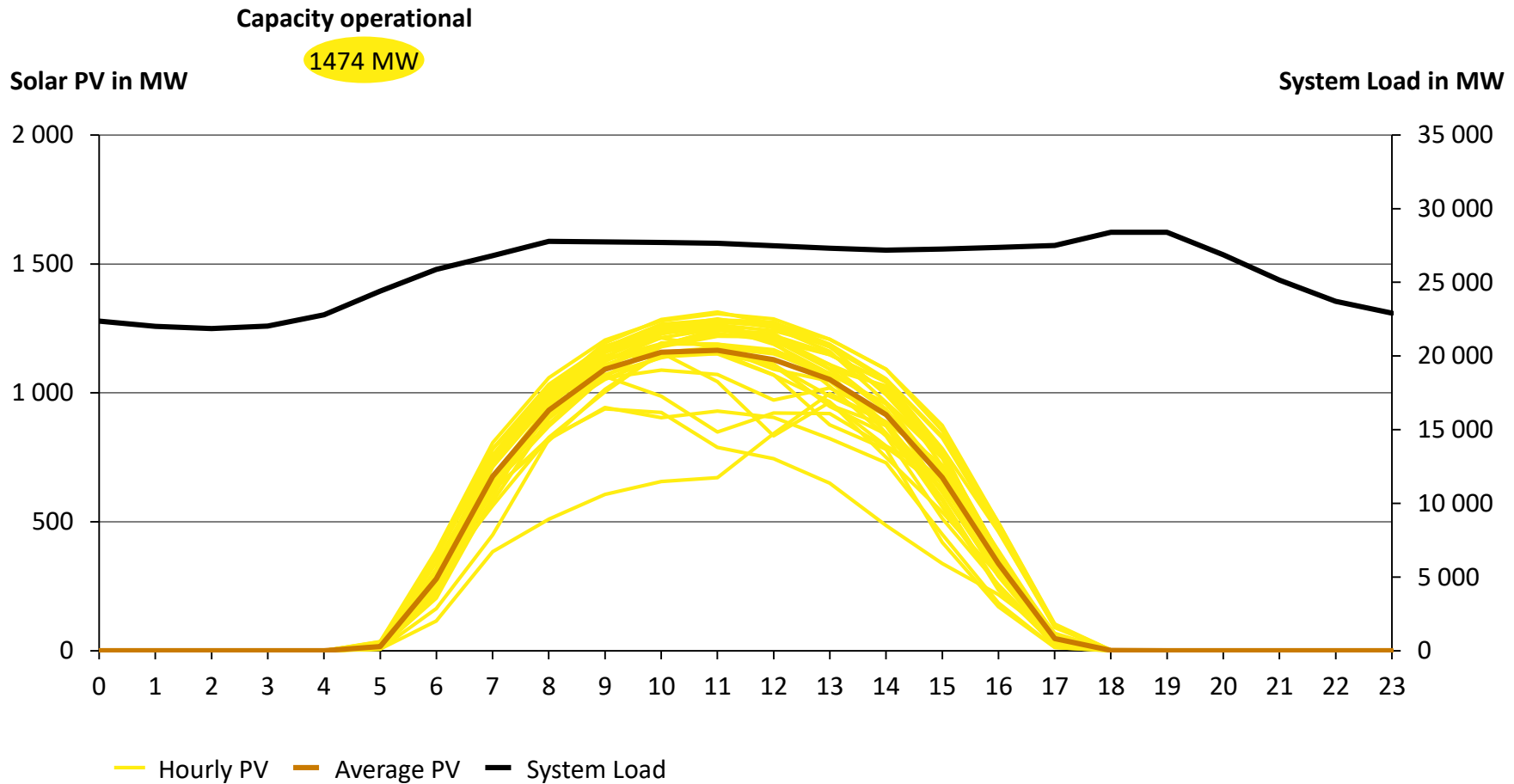
Hourly solar PV production for all 28 days of February 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Mar 2019 was very stable

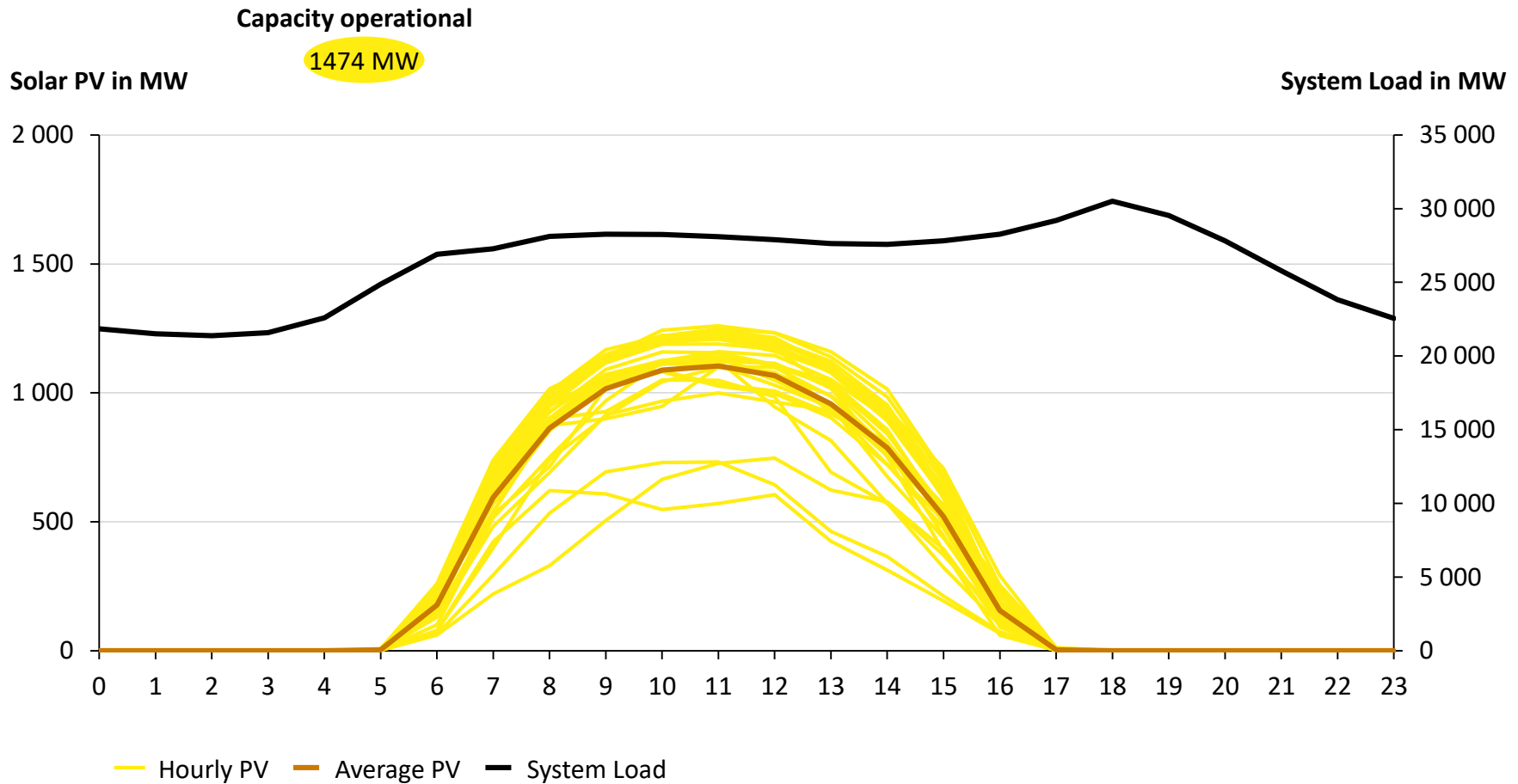
Hourly solar PV production for all 31 days of March 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Apr 2019 very stable

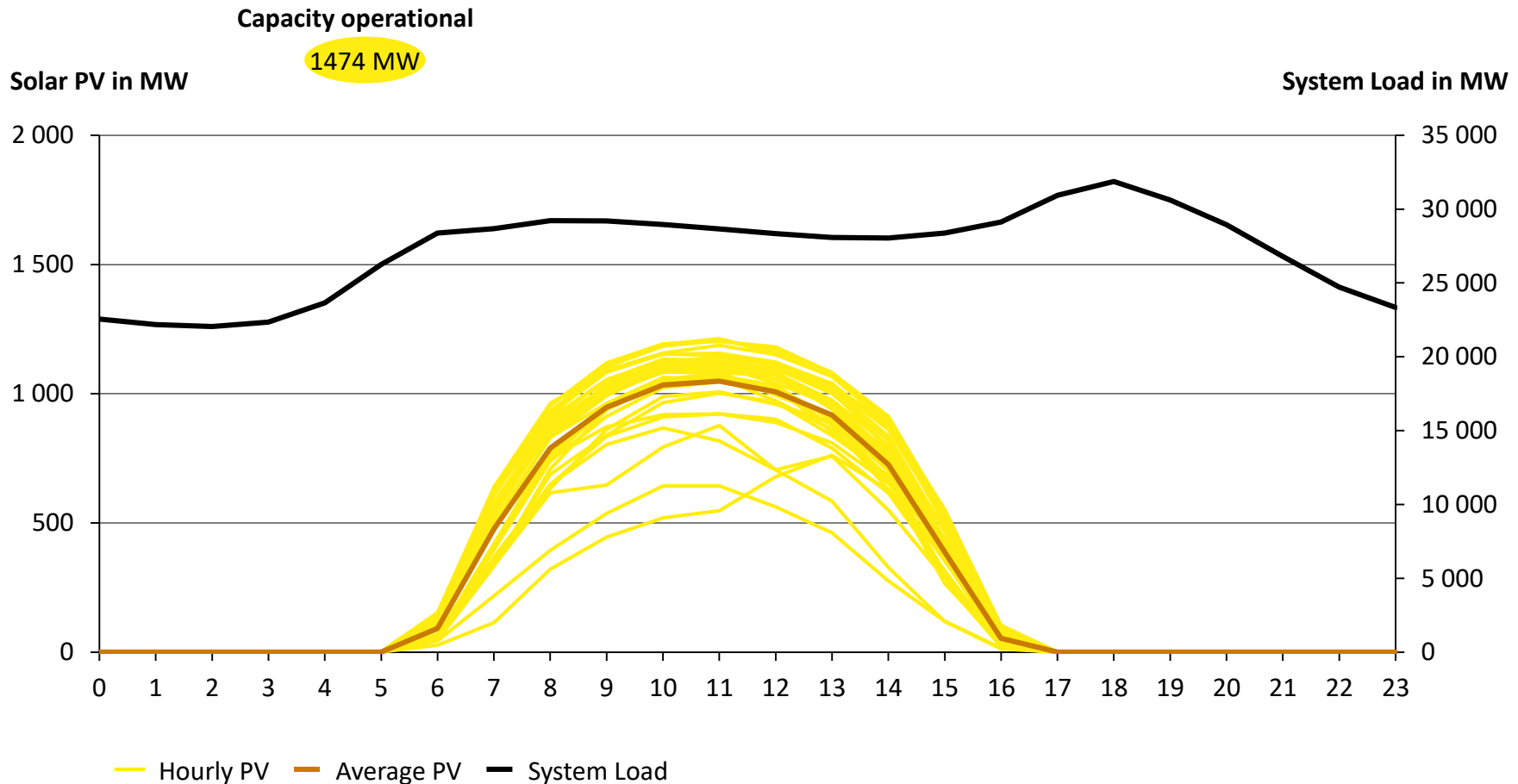
Hourly solar PV production for all 30 days of April 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in May 2019 very stable

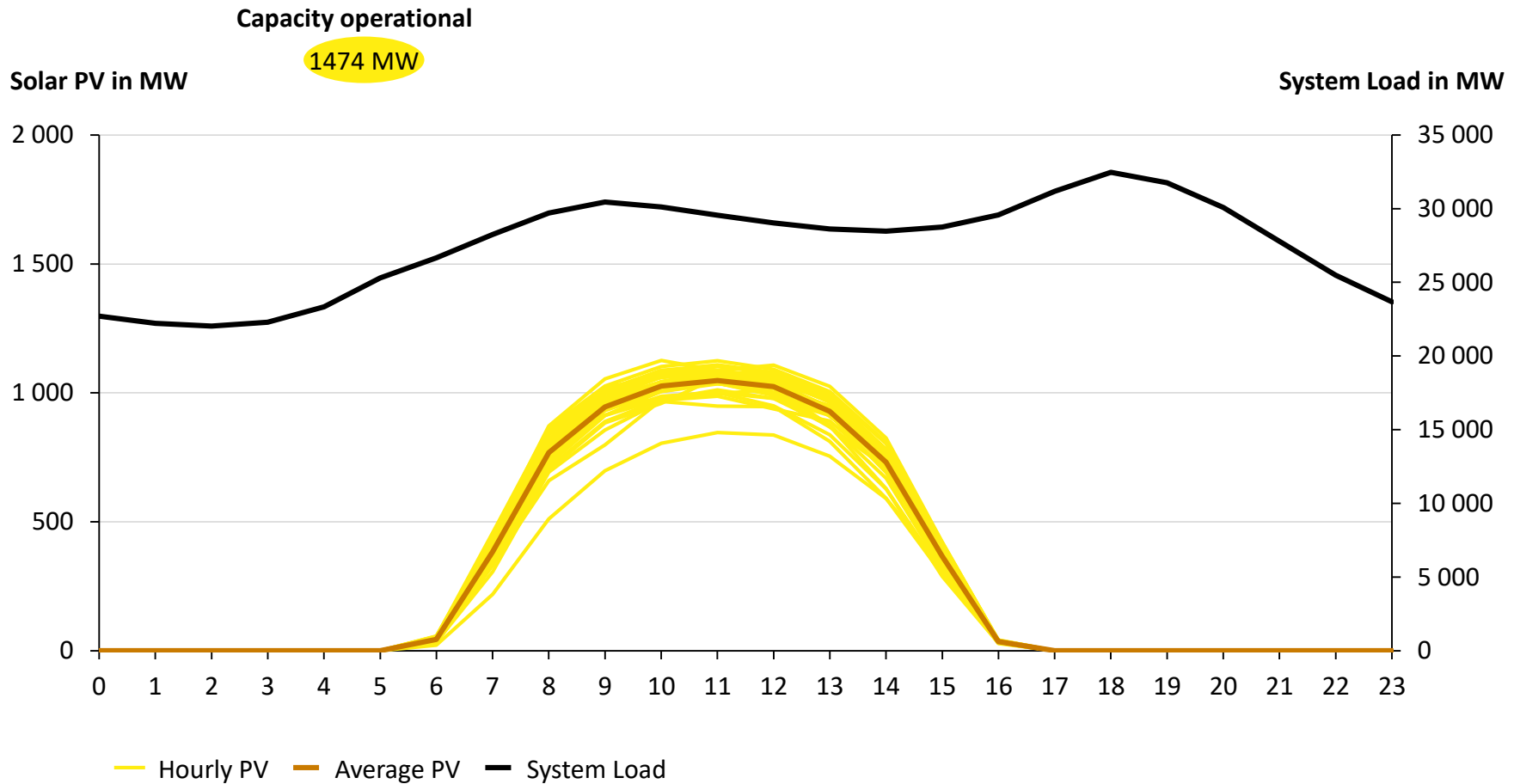
Hourly solar PV production for all 31 days of May 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Jun 2019 very stable

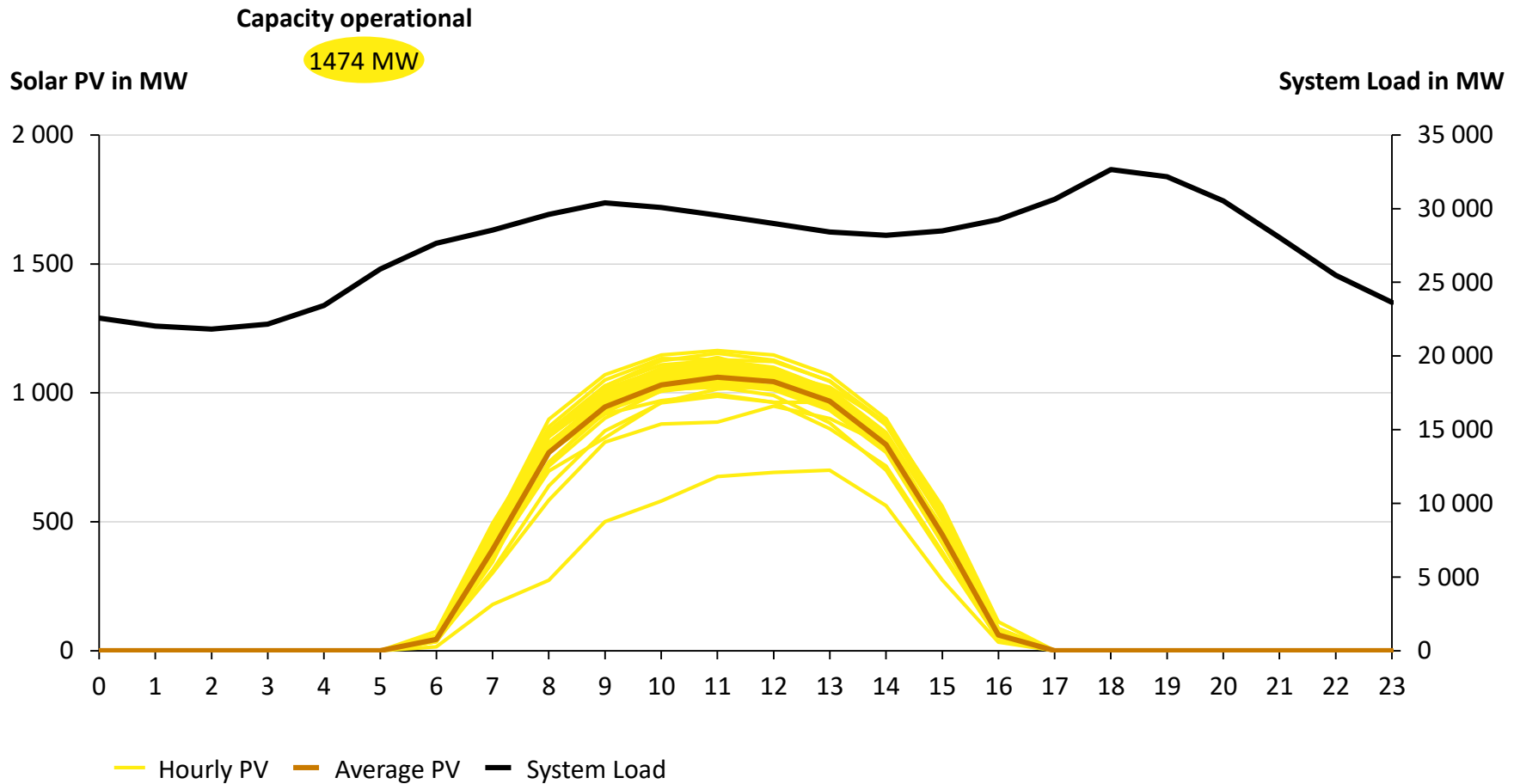
Hourly solar PV production for all 30 days of June 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Jul 2019 very stable

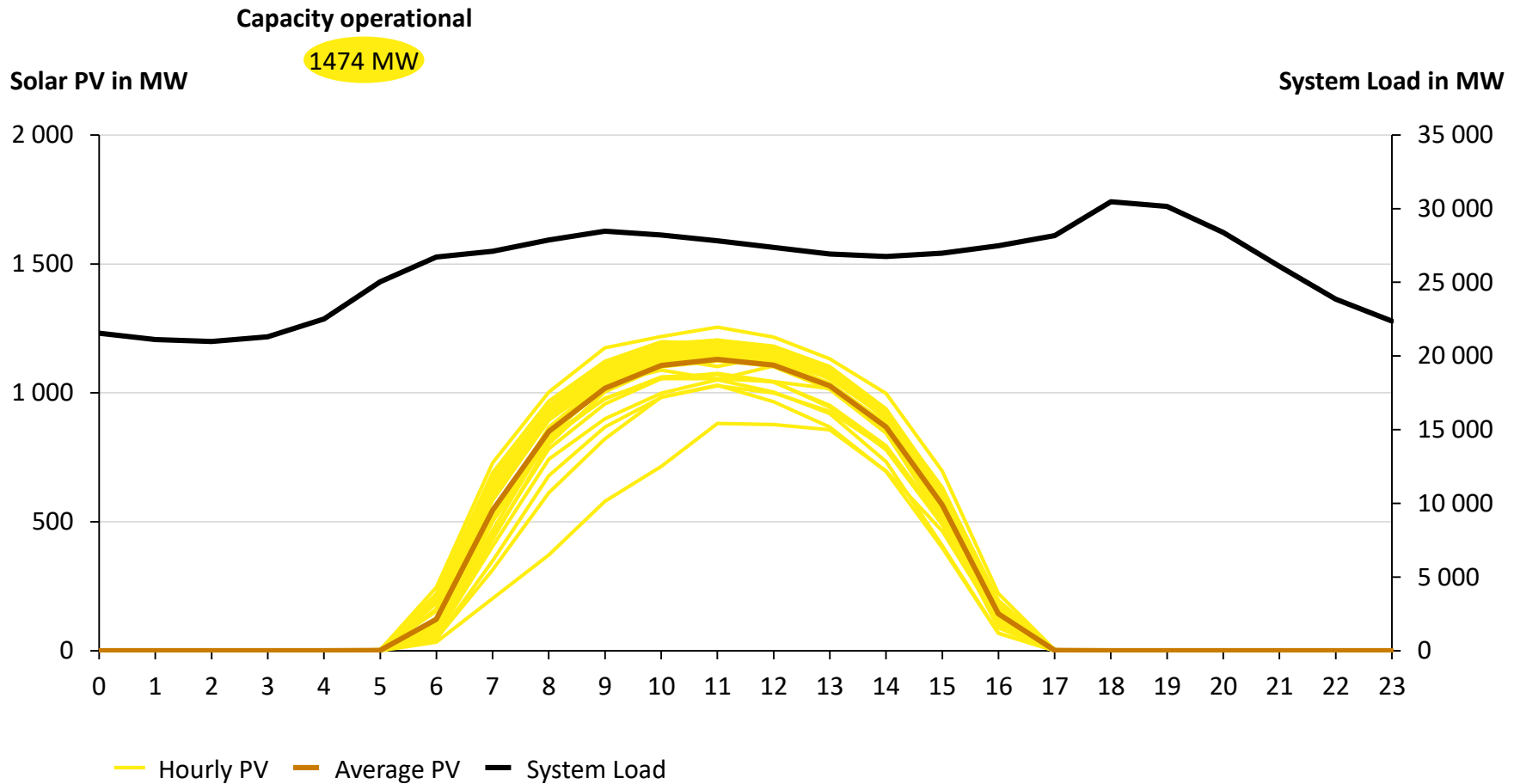
Hourly solar PV production for all 31 days of July 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Aug 2019 very stable

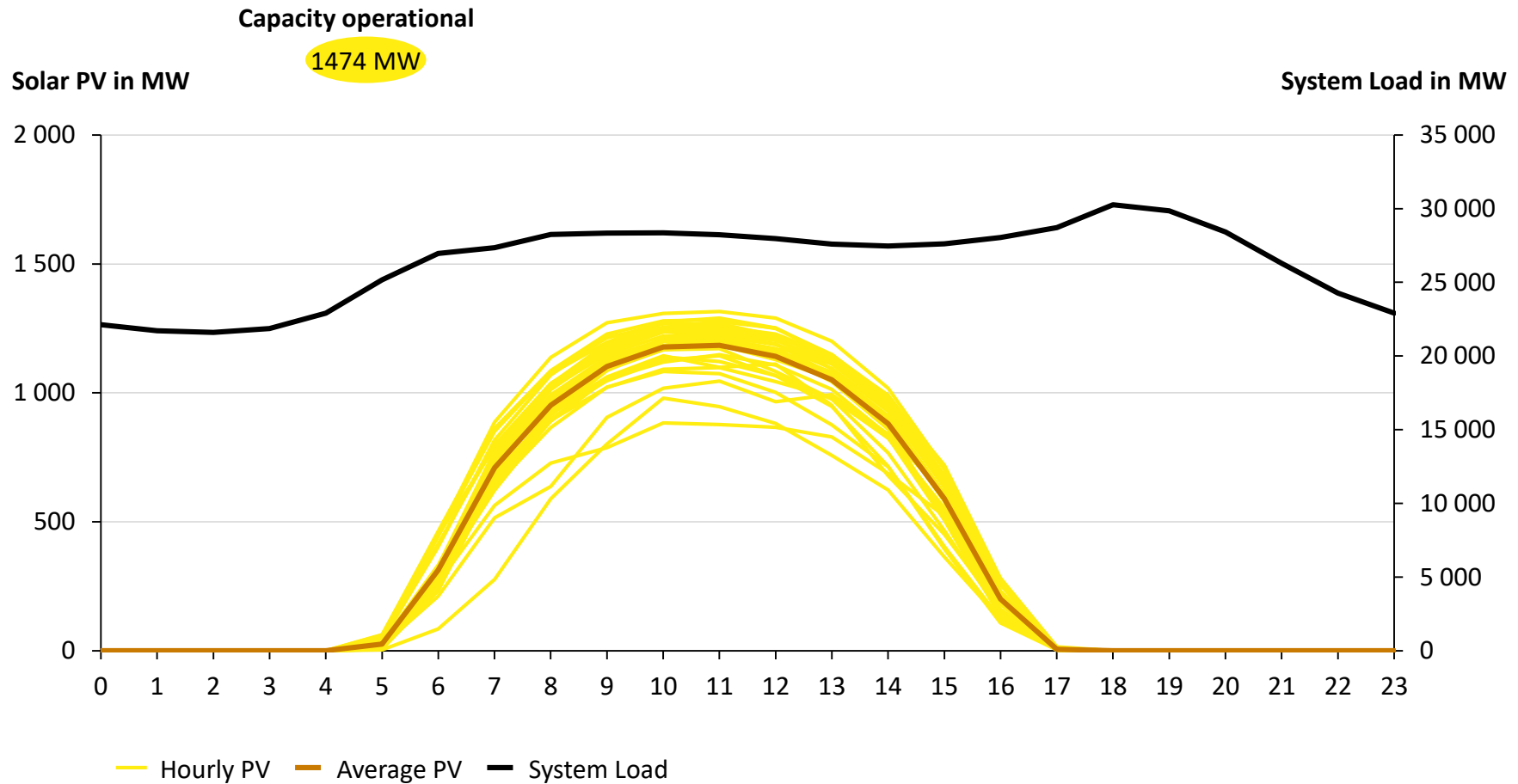
Hourly solar PV production for all 31 days of August 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Sep 2019 very stable

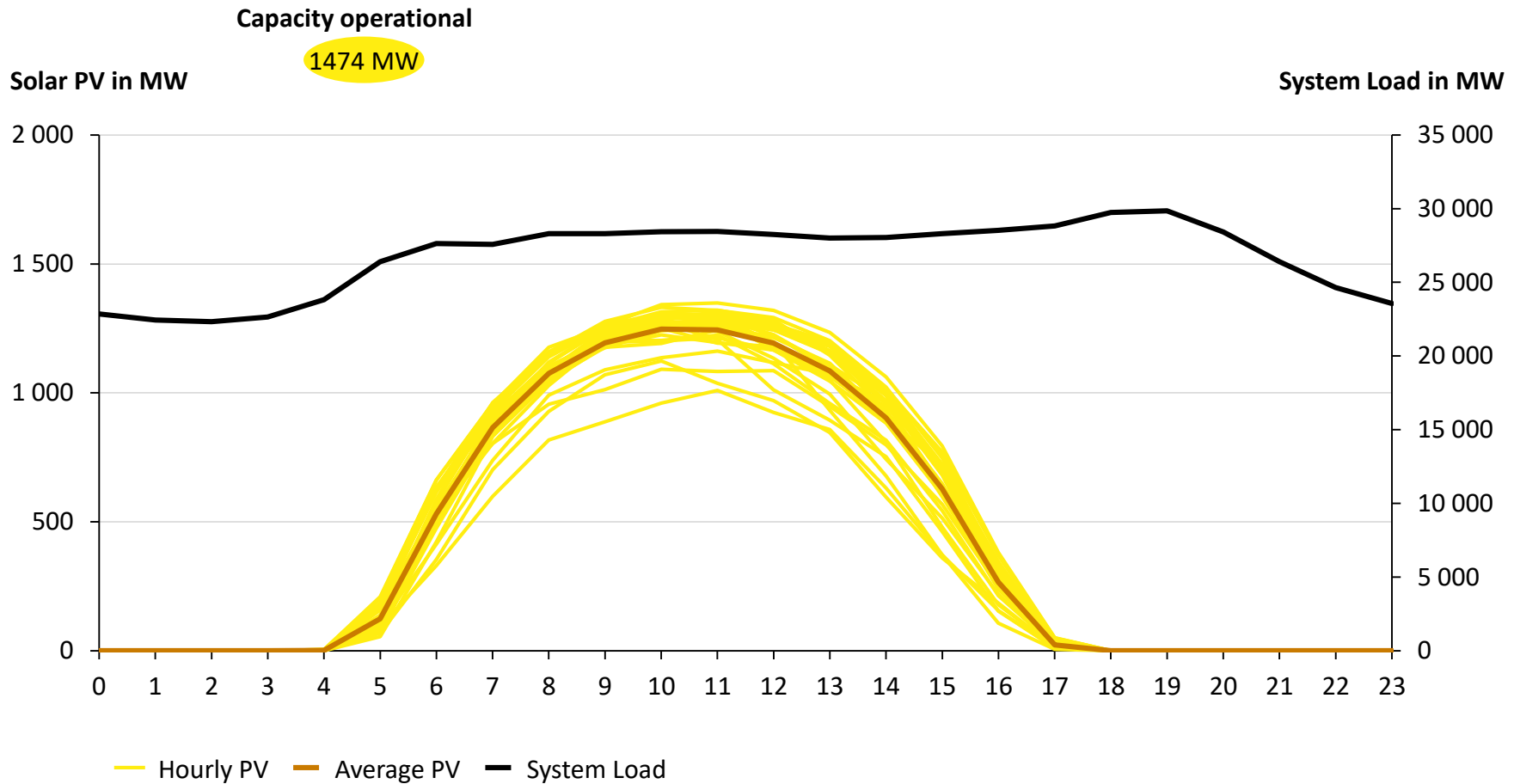
Hourly solar PV production for all 30 days of September 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Oct 2019 very stable

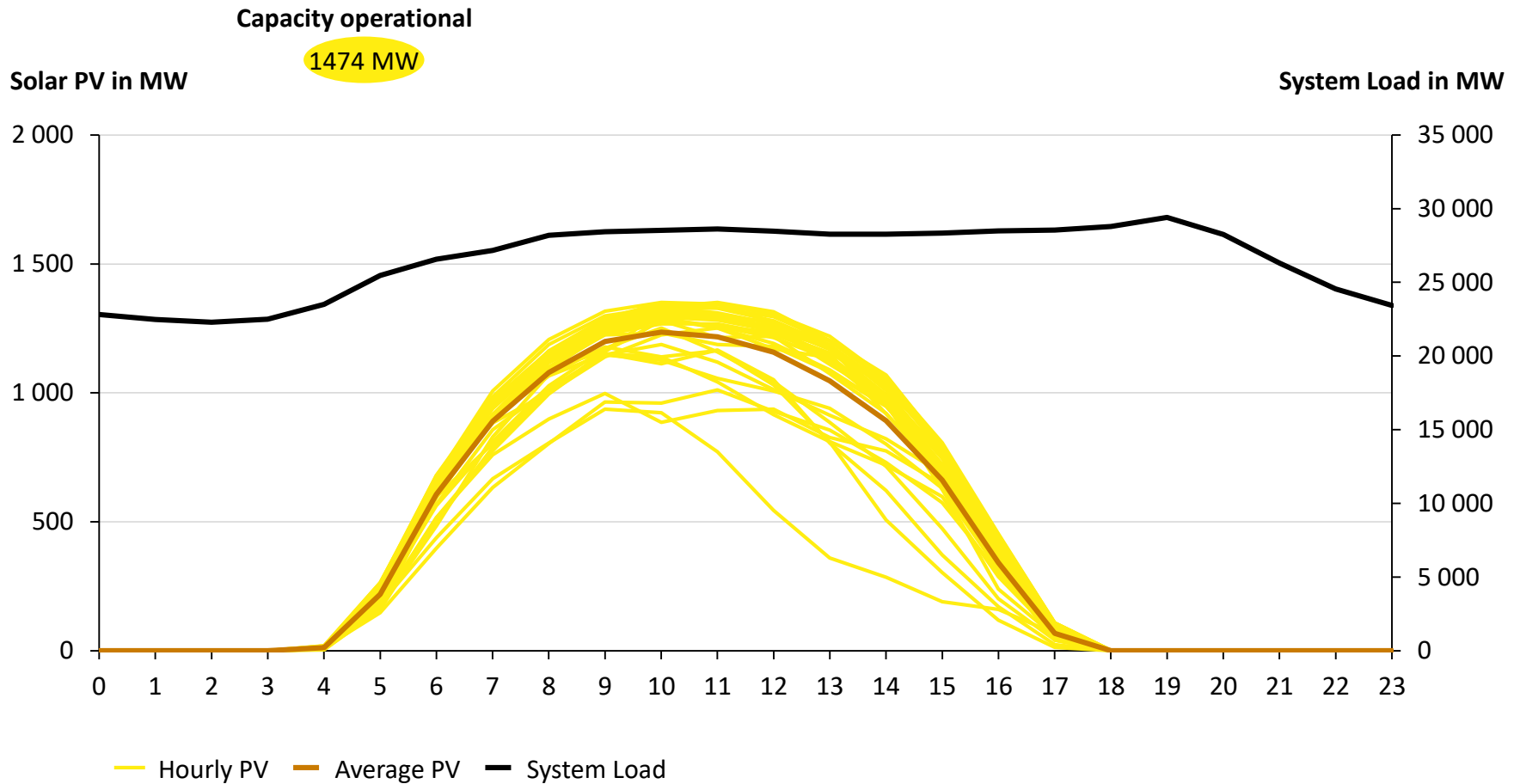
Hourly solar PV production for all 31 days of October 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Nov 2019 very stable

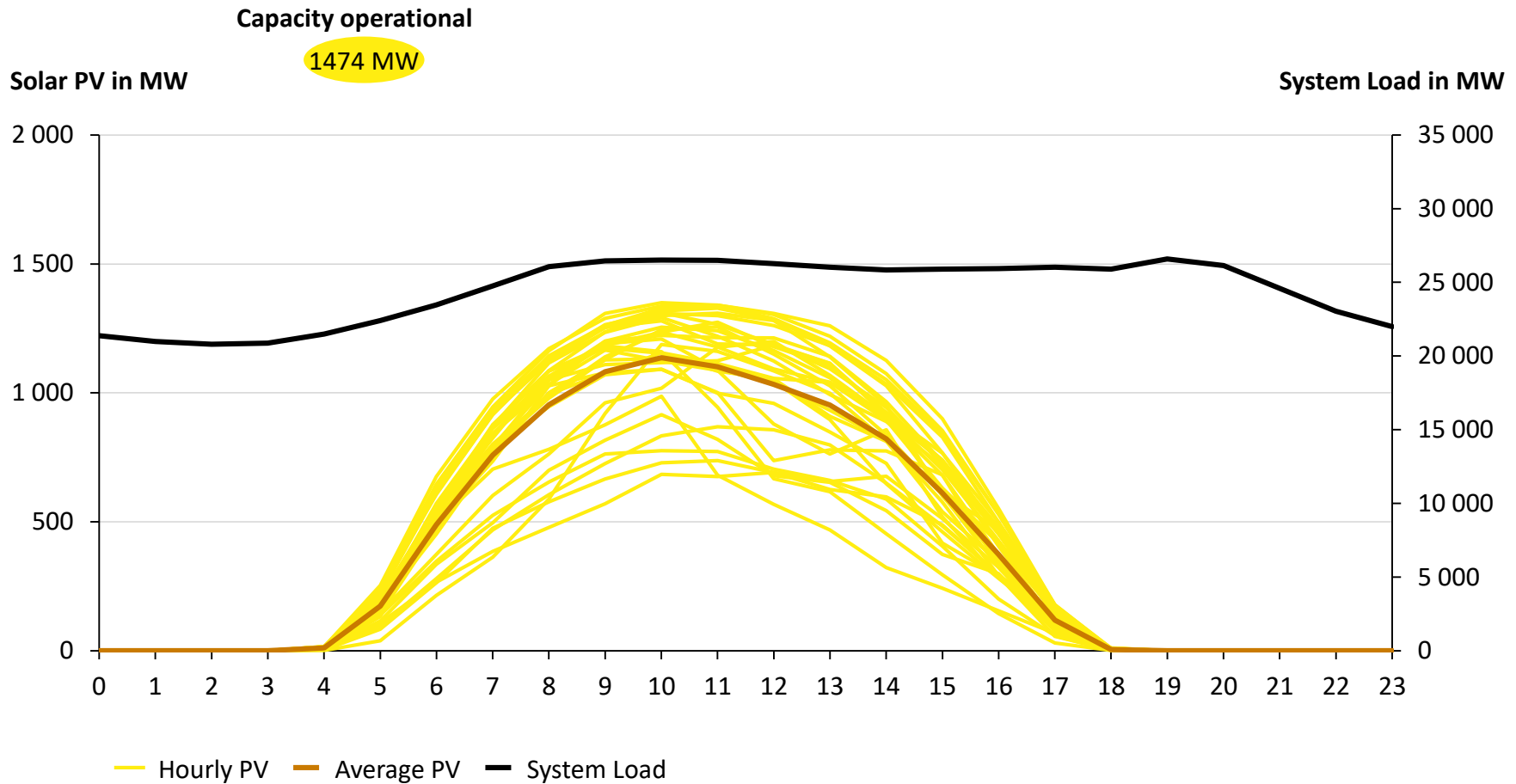
Hourly solar PV production for all 30 days of November 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Dec 2019 very stable

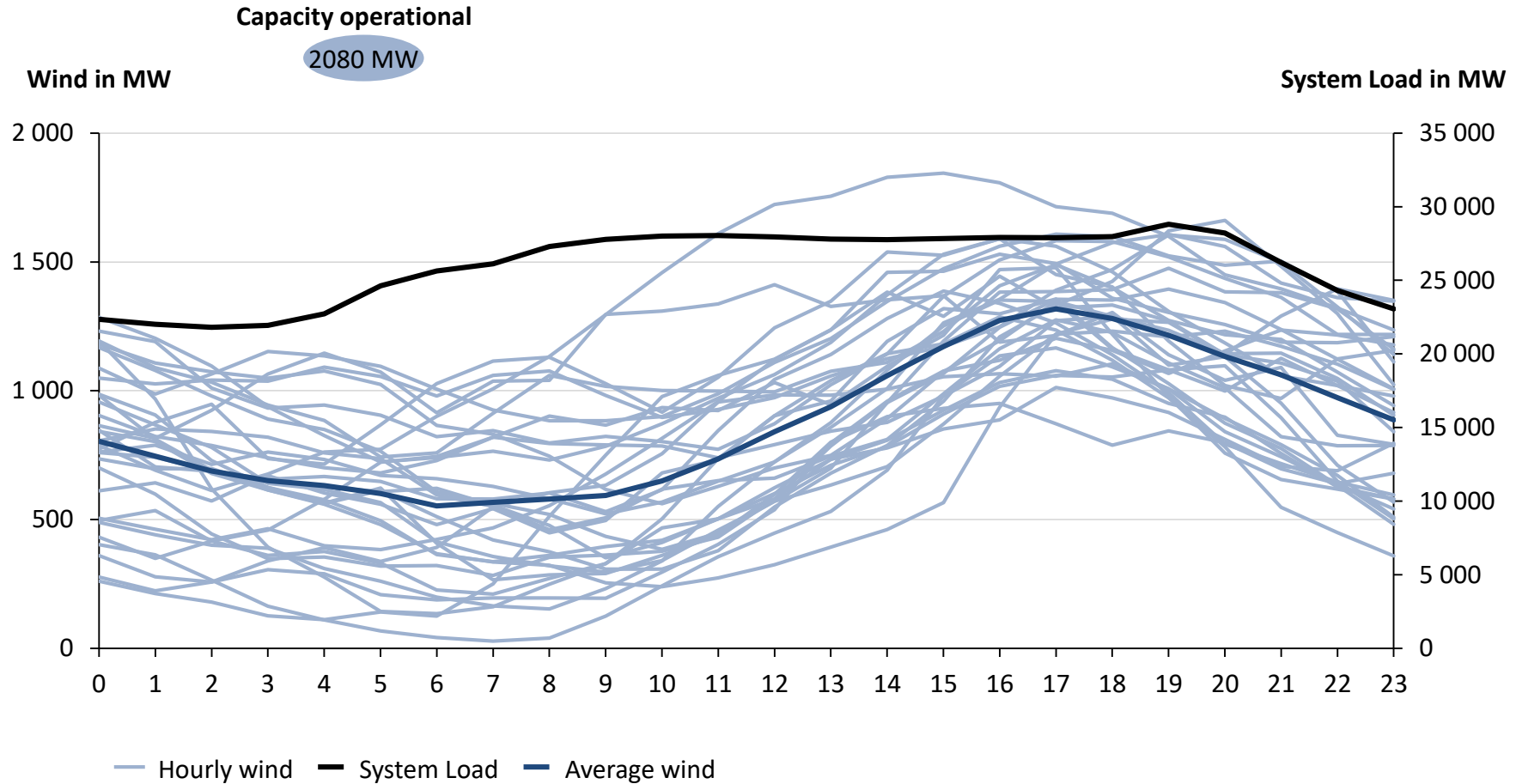
Hourly solar PV production for all 31 days of December 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

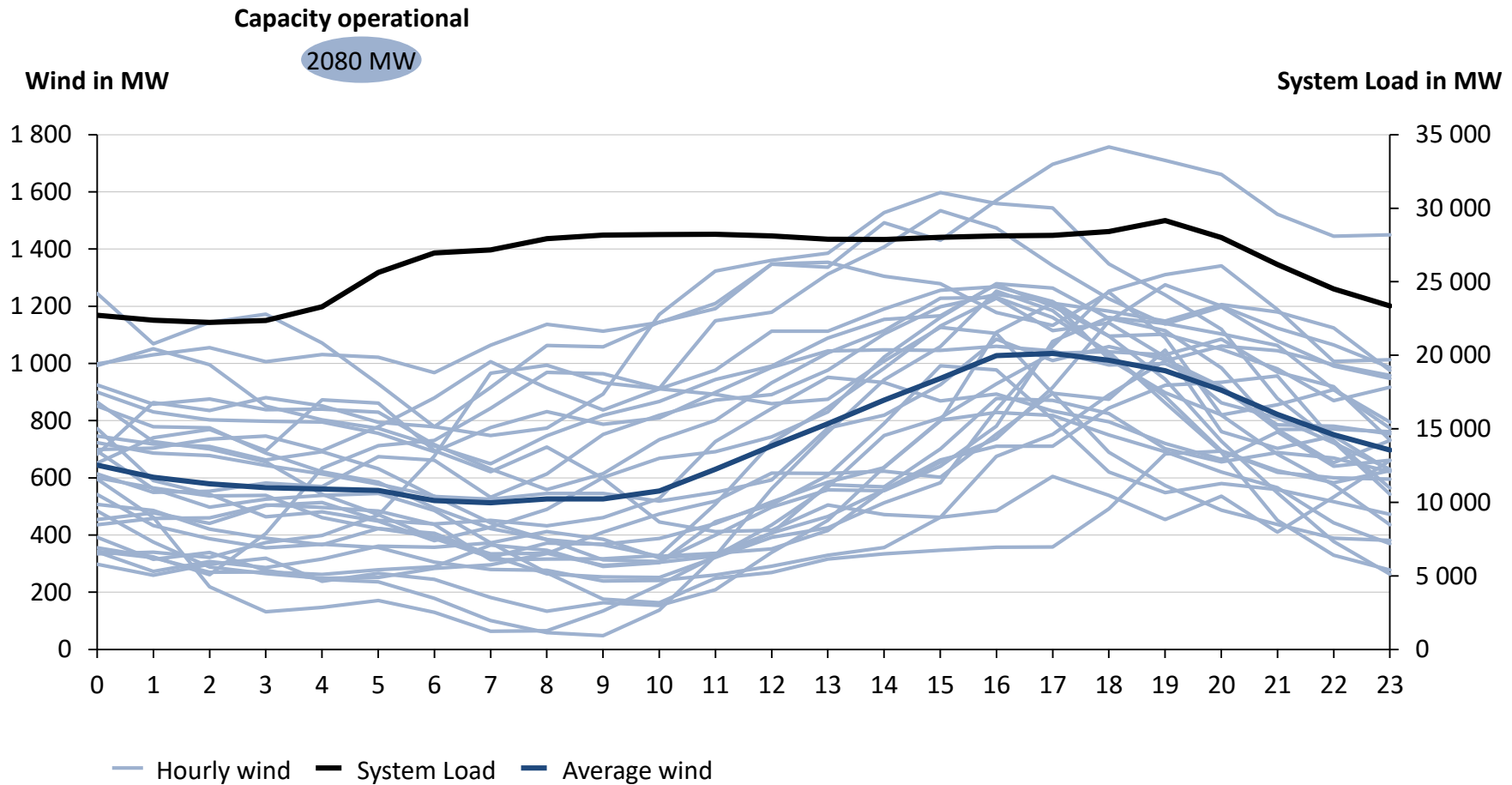
In Jan 2019, wind supplied in the evenings

Hourly wind production for all 31 days of January 2019 and average system load diurnal course



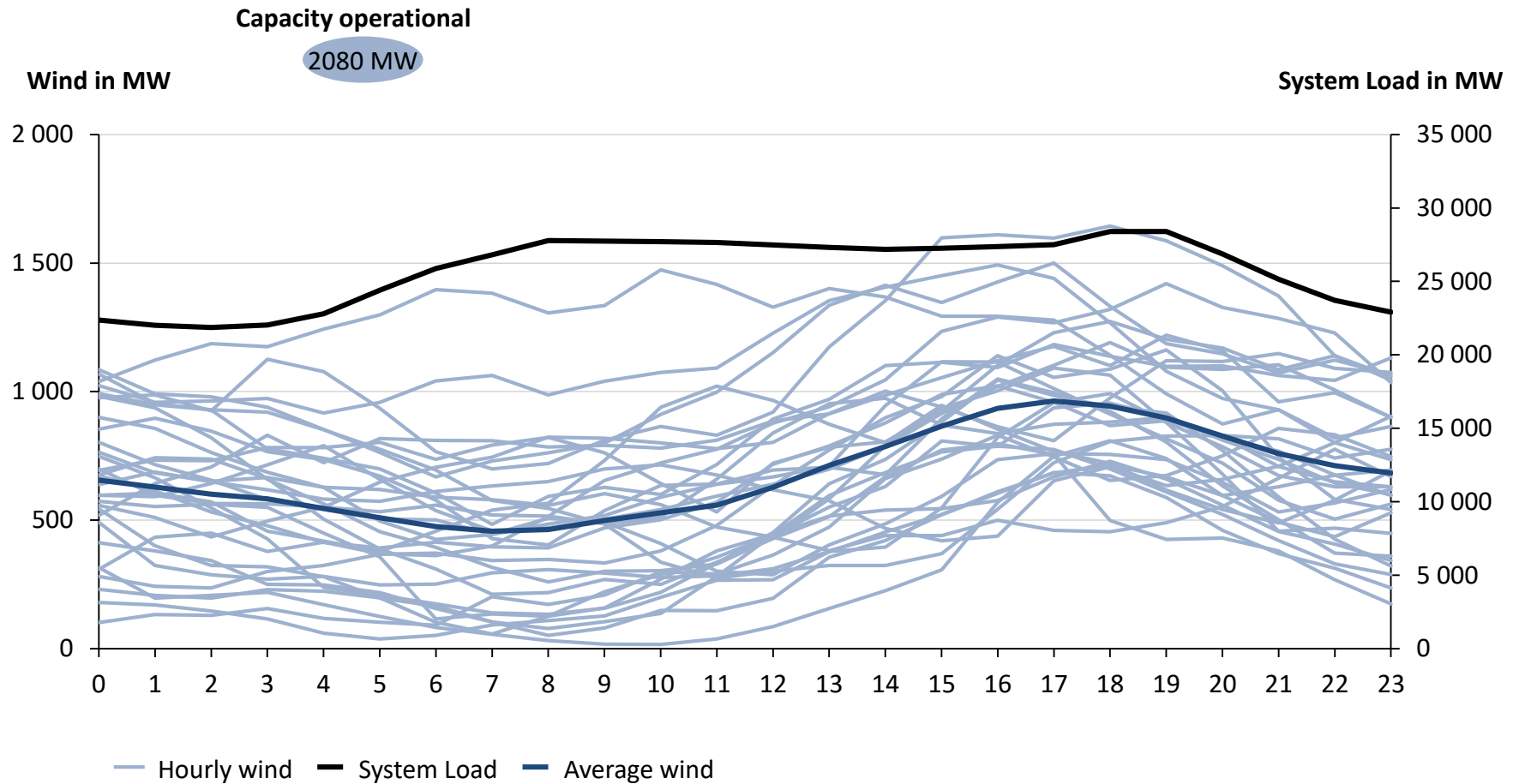
In Feb 2019, wind supply increased during the evening peak

Hourly wind production for all 28 days of February 2019 and average system load diurnal course



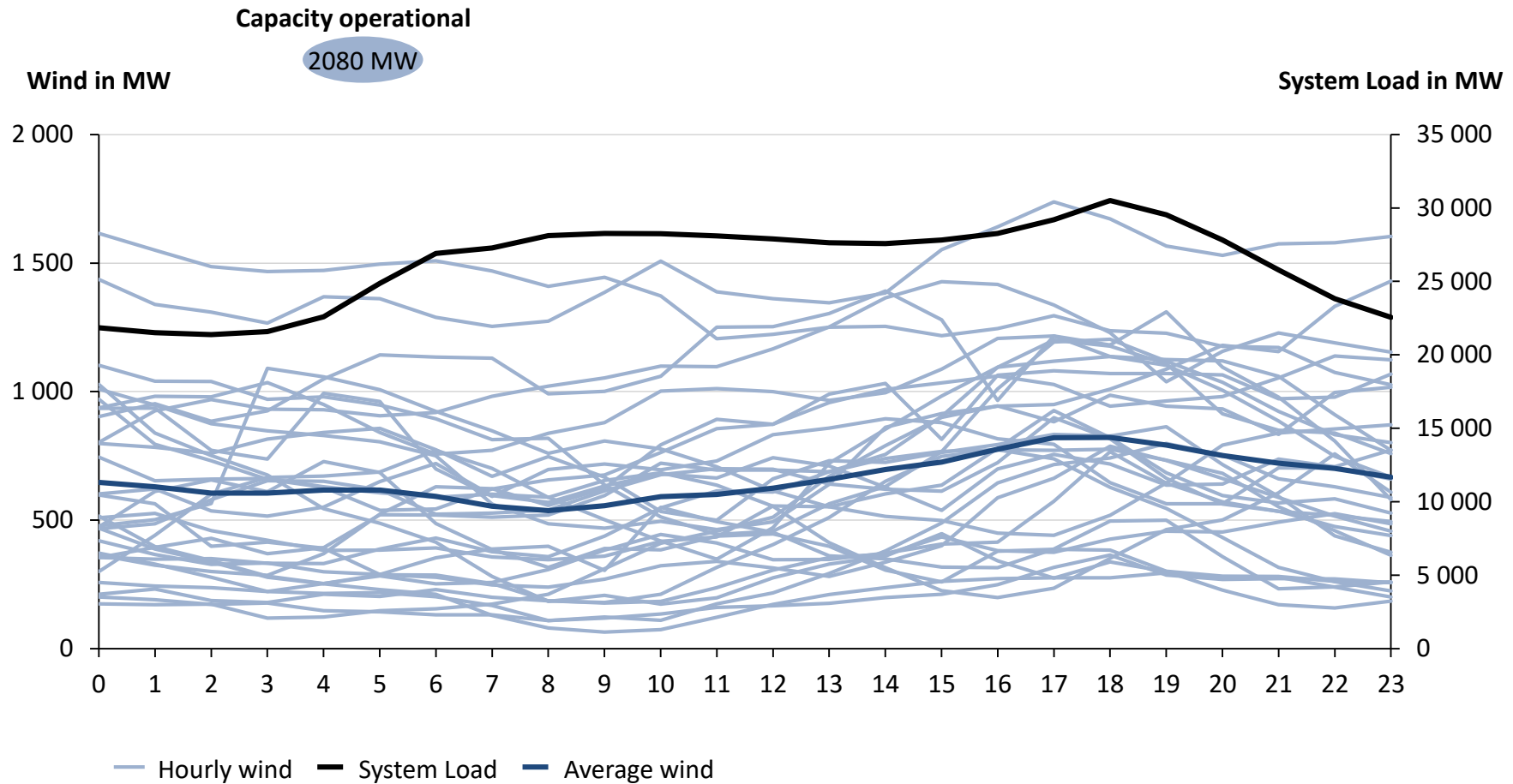
In Mar 2019, wind supply increased during the evening peak

Hourly wind production for all 31 days of March 2019 and average system load diurnal course



In Apr 2019, wind supply increased during the evening peak

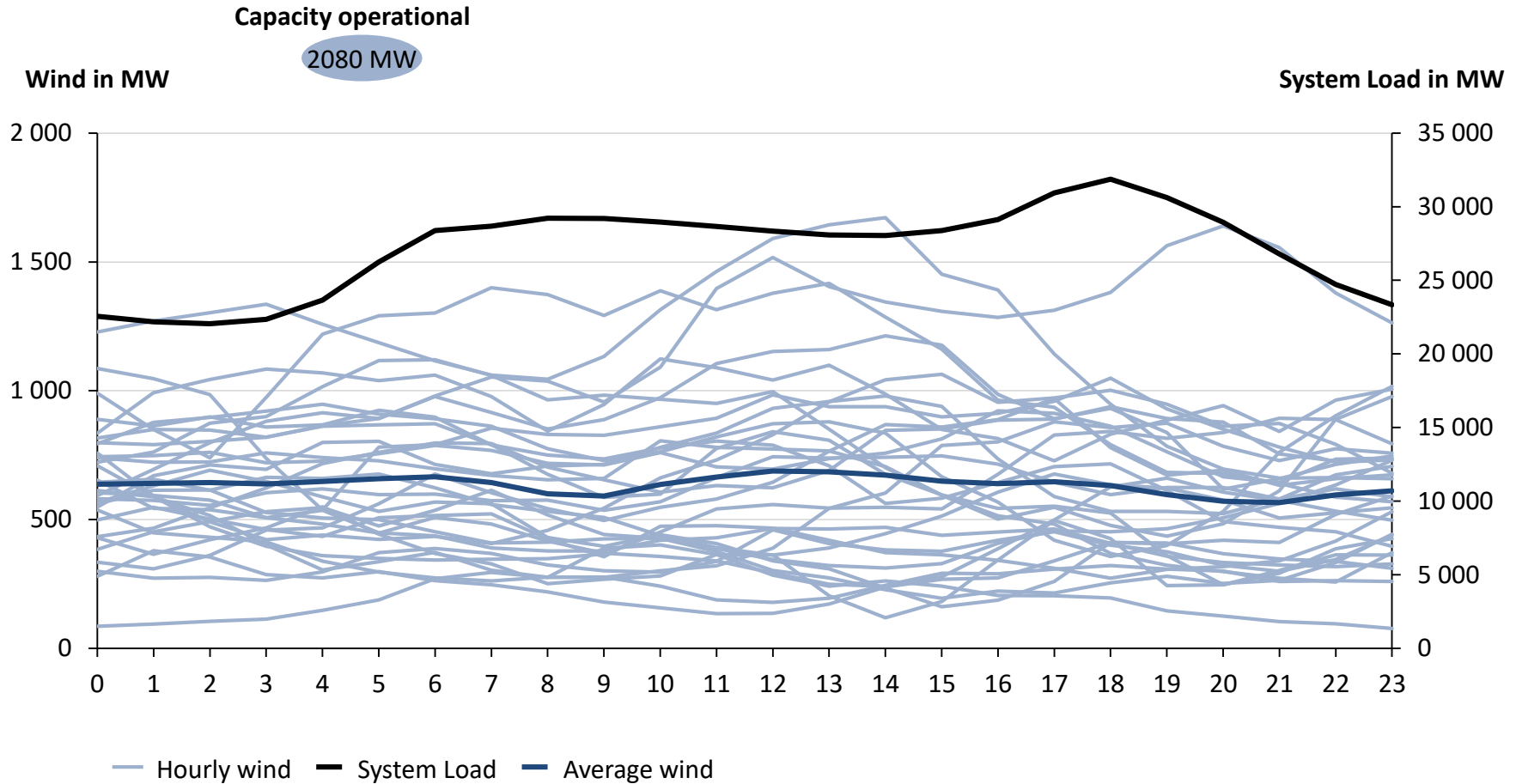
Hourly wind production for all 30 days of April 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In May 2019, wind fluctuated day-to-day

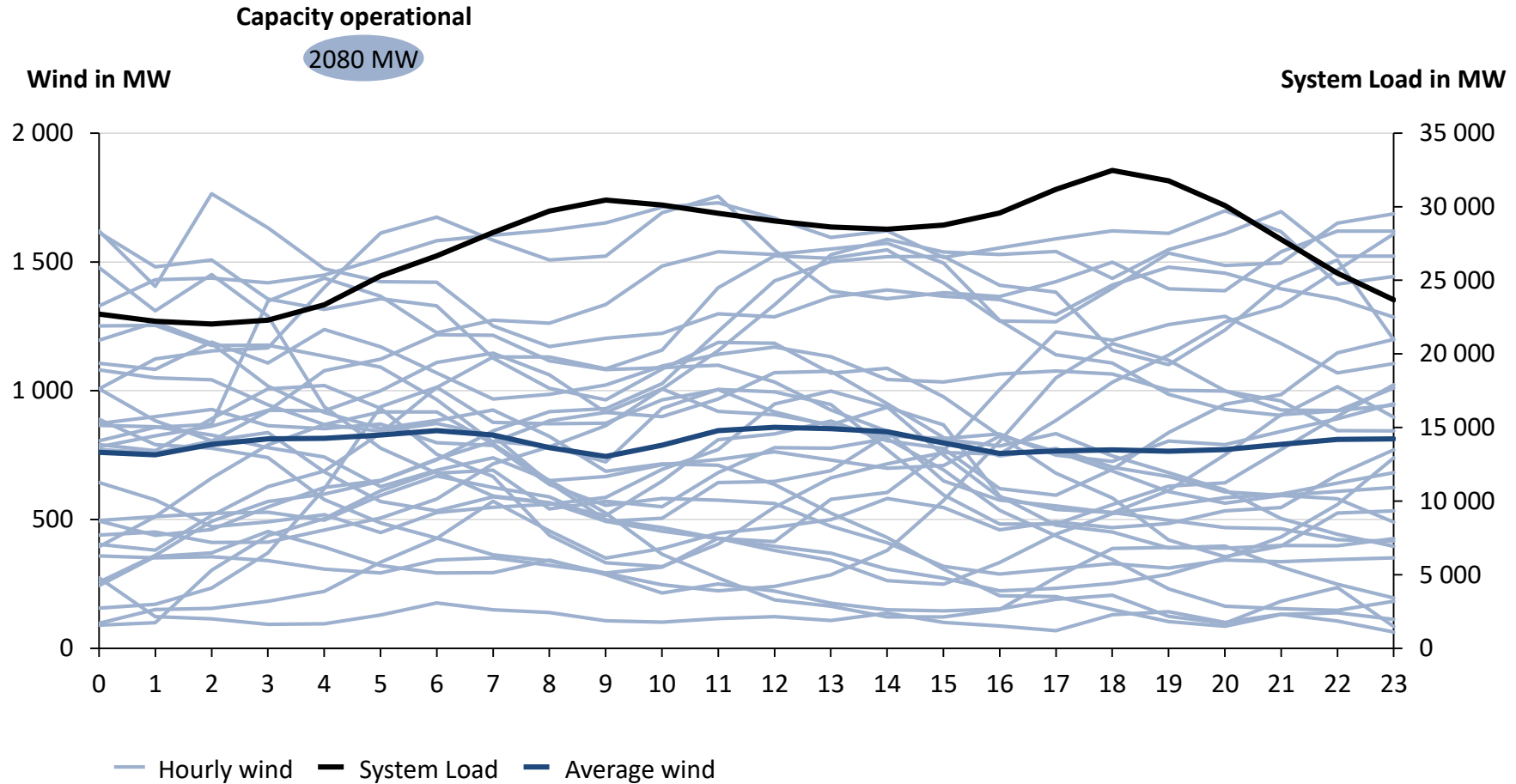
Hourly wind production for all 31 days of May 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Jun 2019, wind fluctuated day-to-day

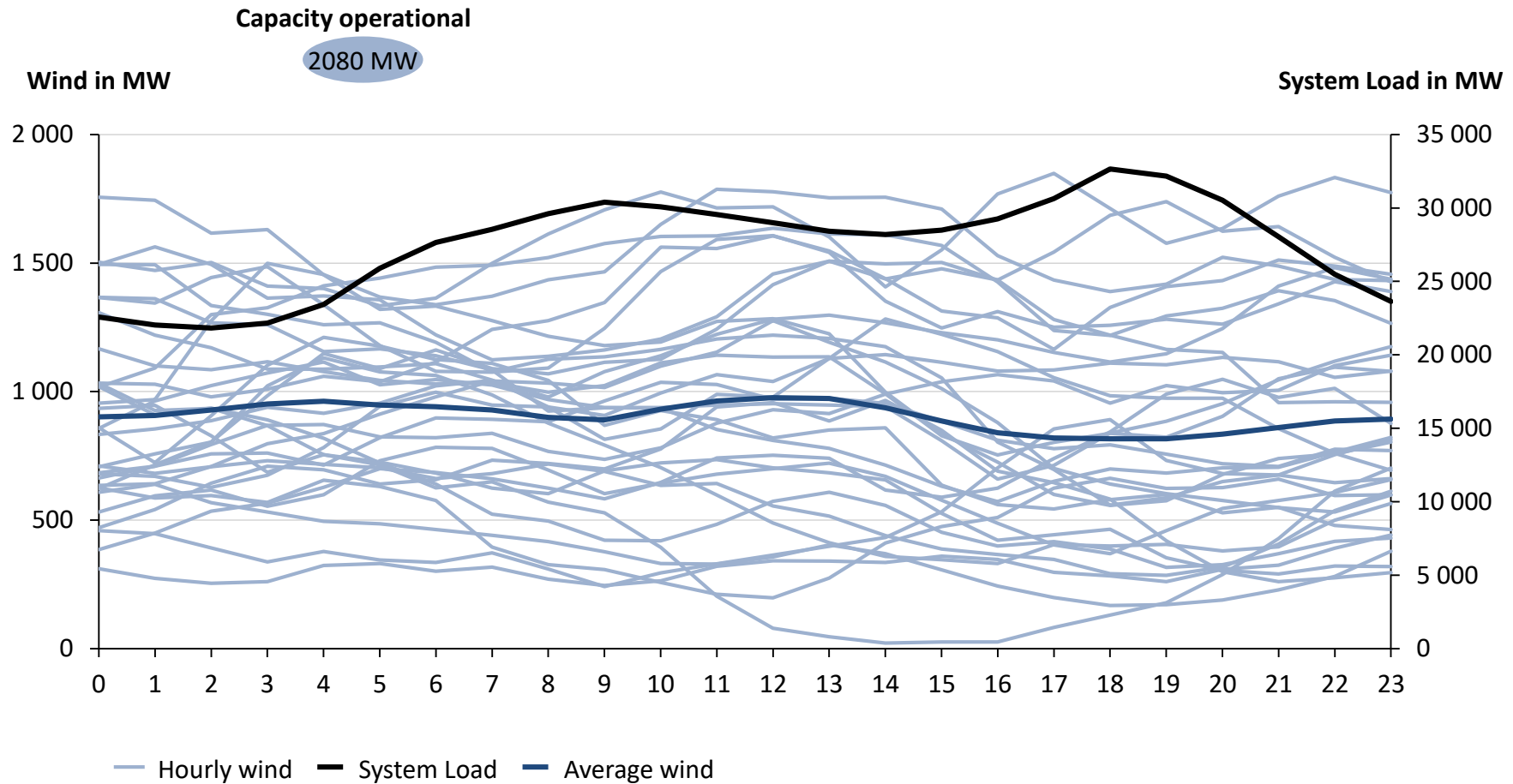
Hourly wind production for all 30 days of June 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Jul 2019, wind fluctuated day-to-day

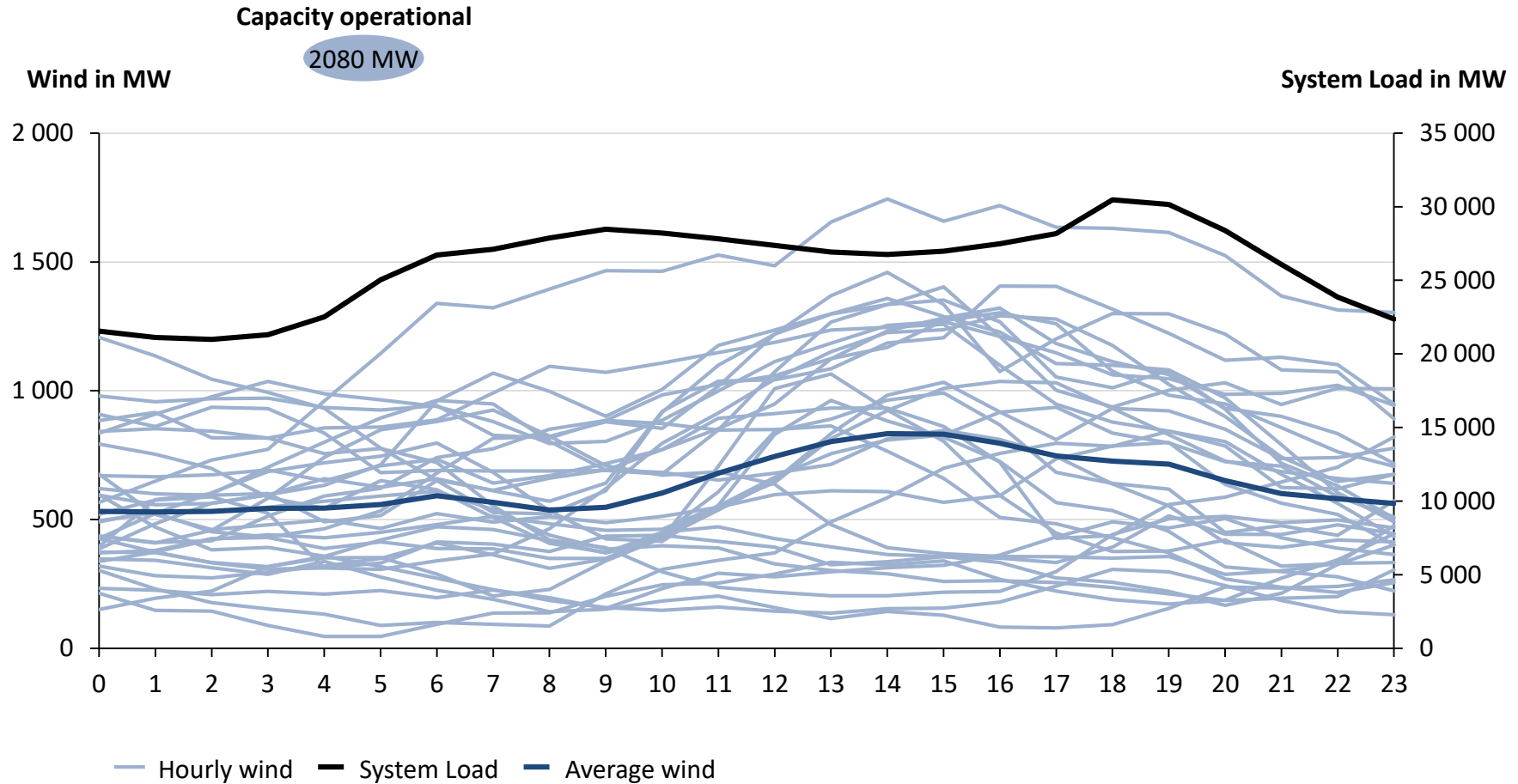
Hourly wind production for all 31 days of July 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

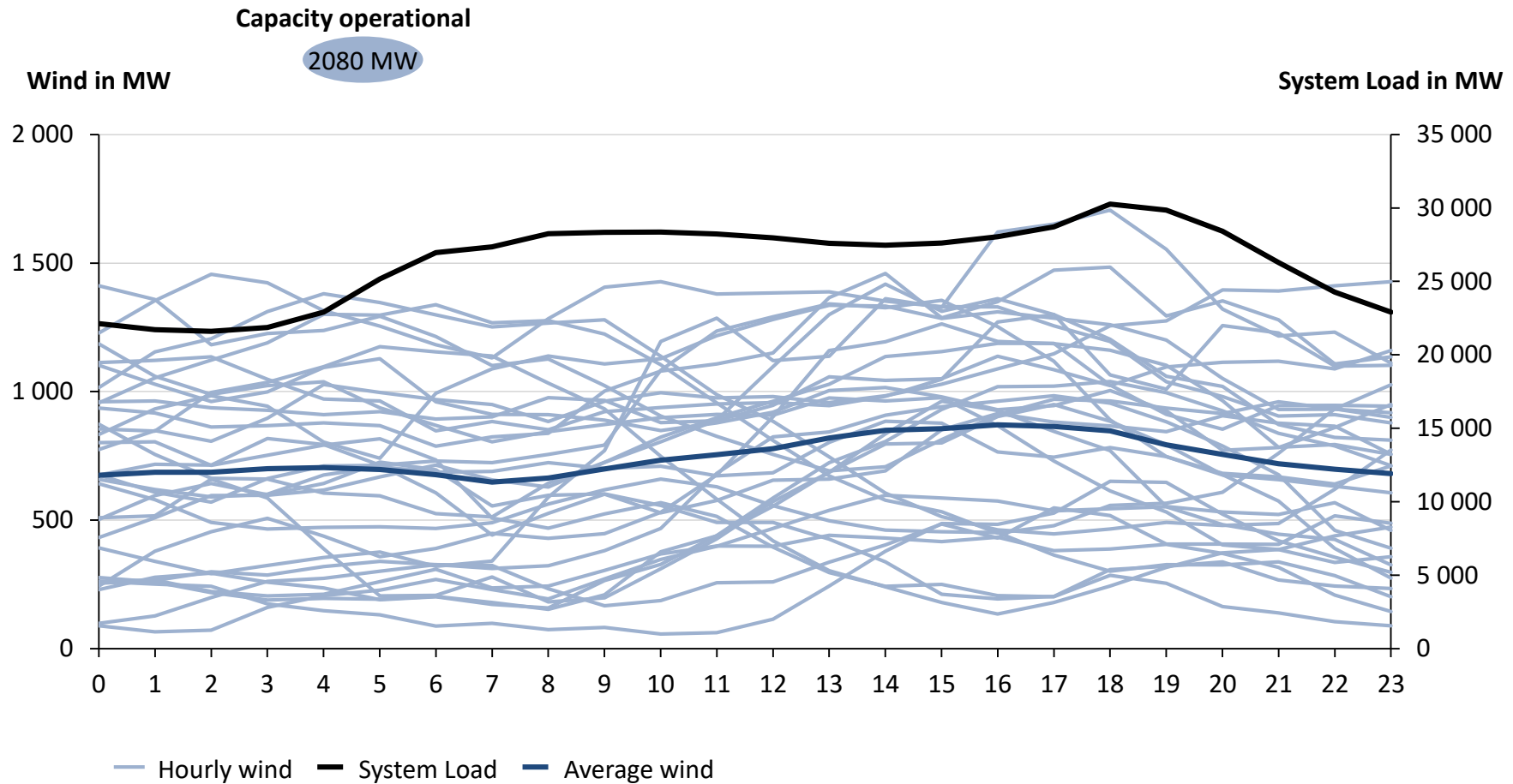
In Aug 2019, wind fluctuated day-to-day

Hourly wind production for all 31 days of August 2019 and average system load diurnal course



In Sep 2019, wind fluctuated day-to-day

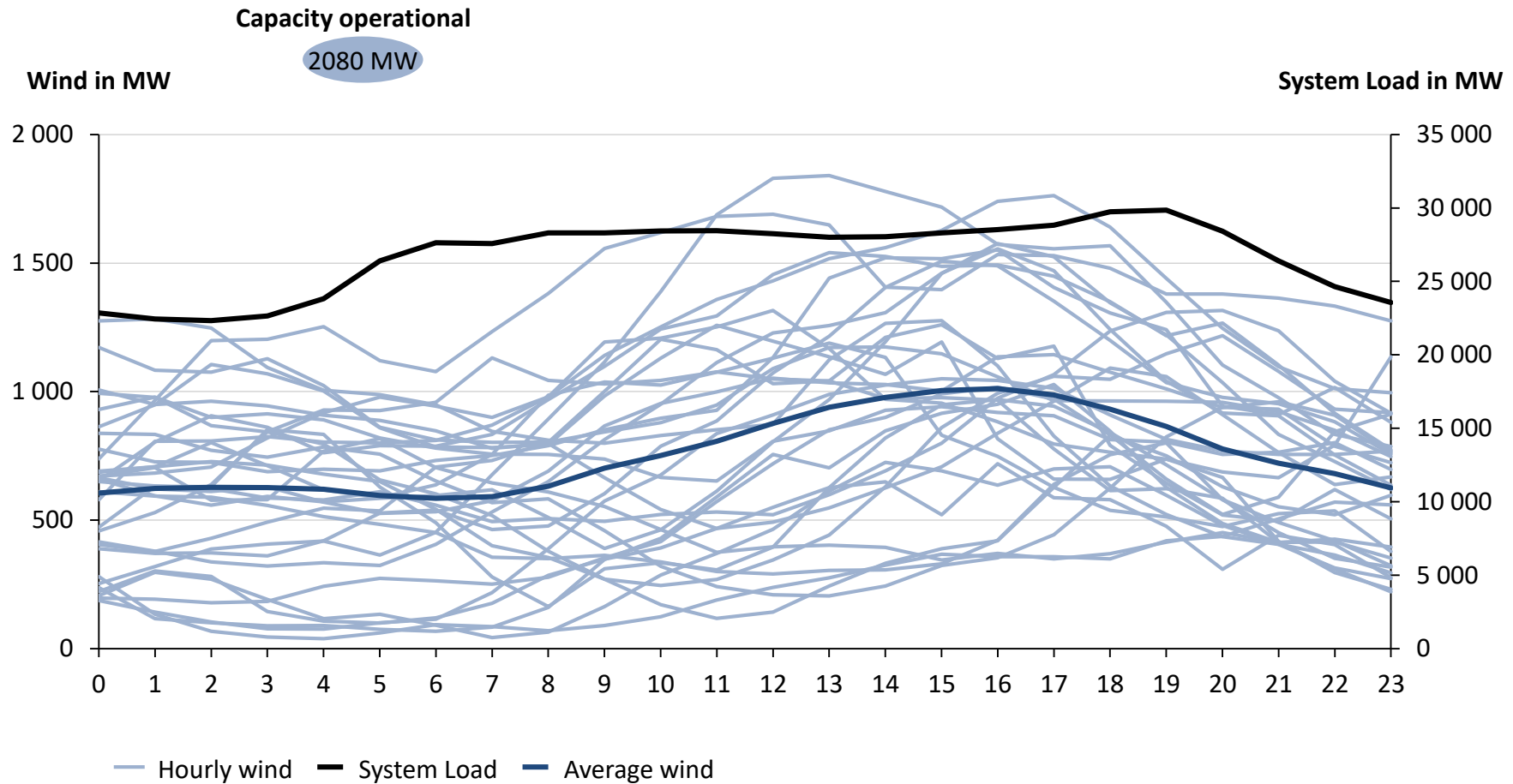
Hourly wind production for all 30 days of September 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

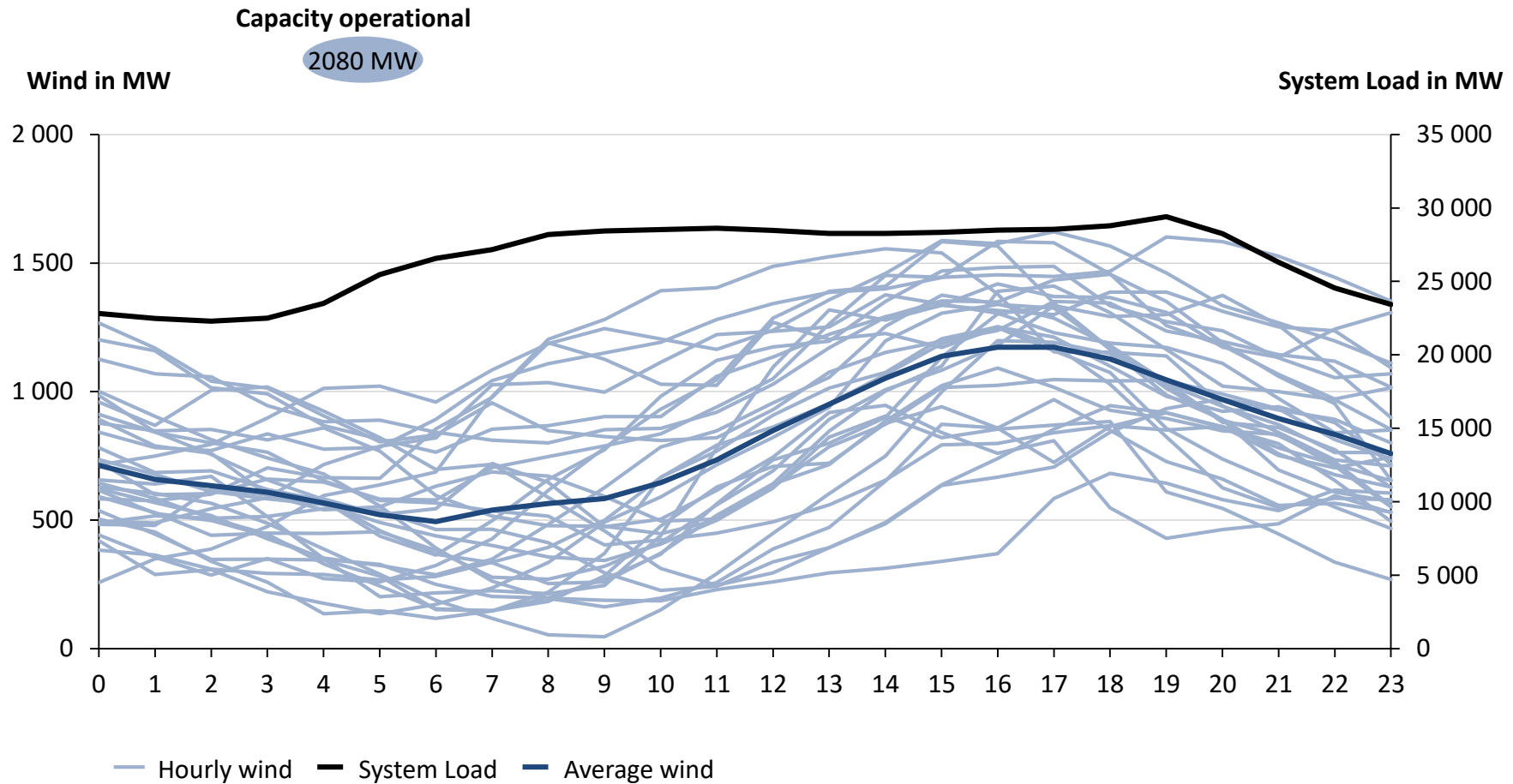
In Oct 2019, wind increased towards the evening peak

Hourly wind production for all 31 days of October 2019 and average system load diurnal course



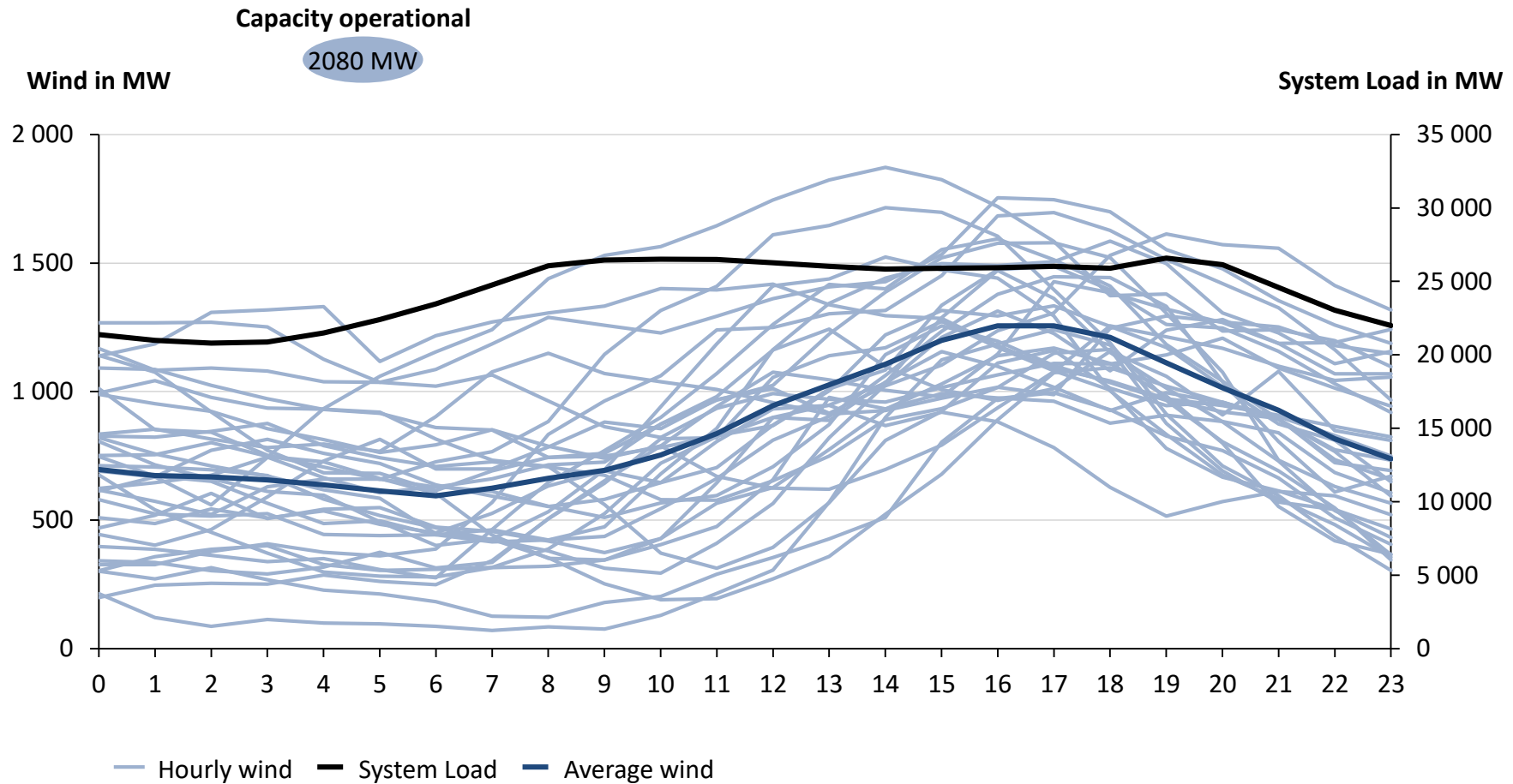
In Nov 2019, wind increased during the evening peak

Hourly wind production for all 30 days of November 2019 and average system load diurnal course



In Dec 2019, wind increased during the evening peak

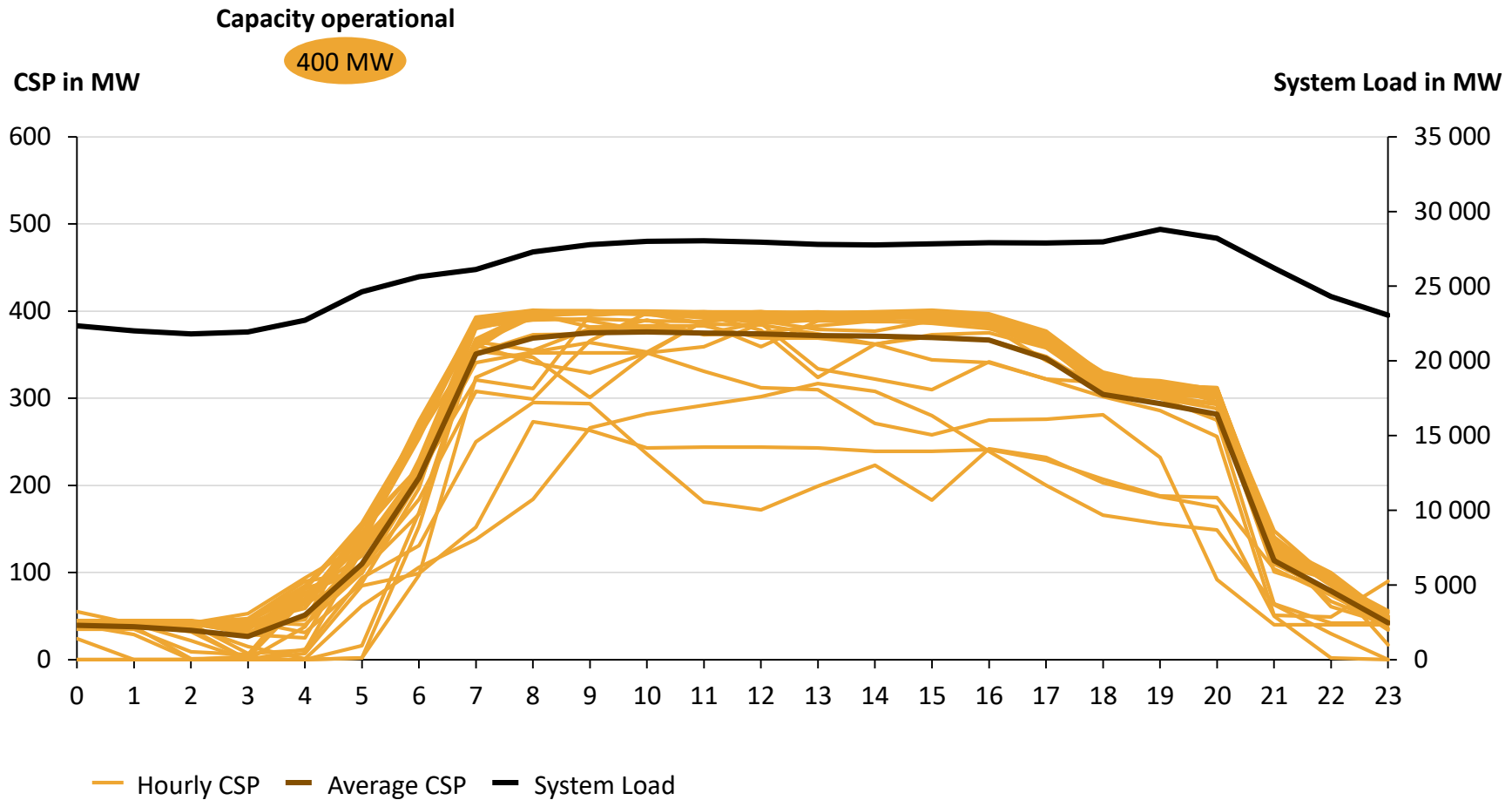
Hourly wind production for all 31 days of December 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Jan 2019, CSP storage used in evenings

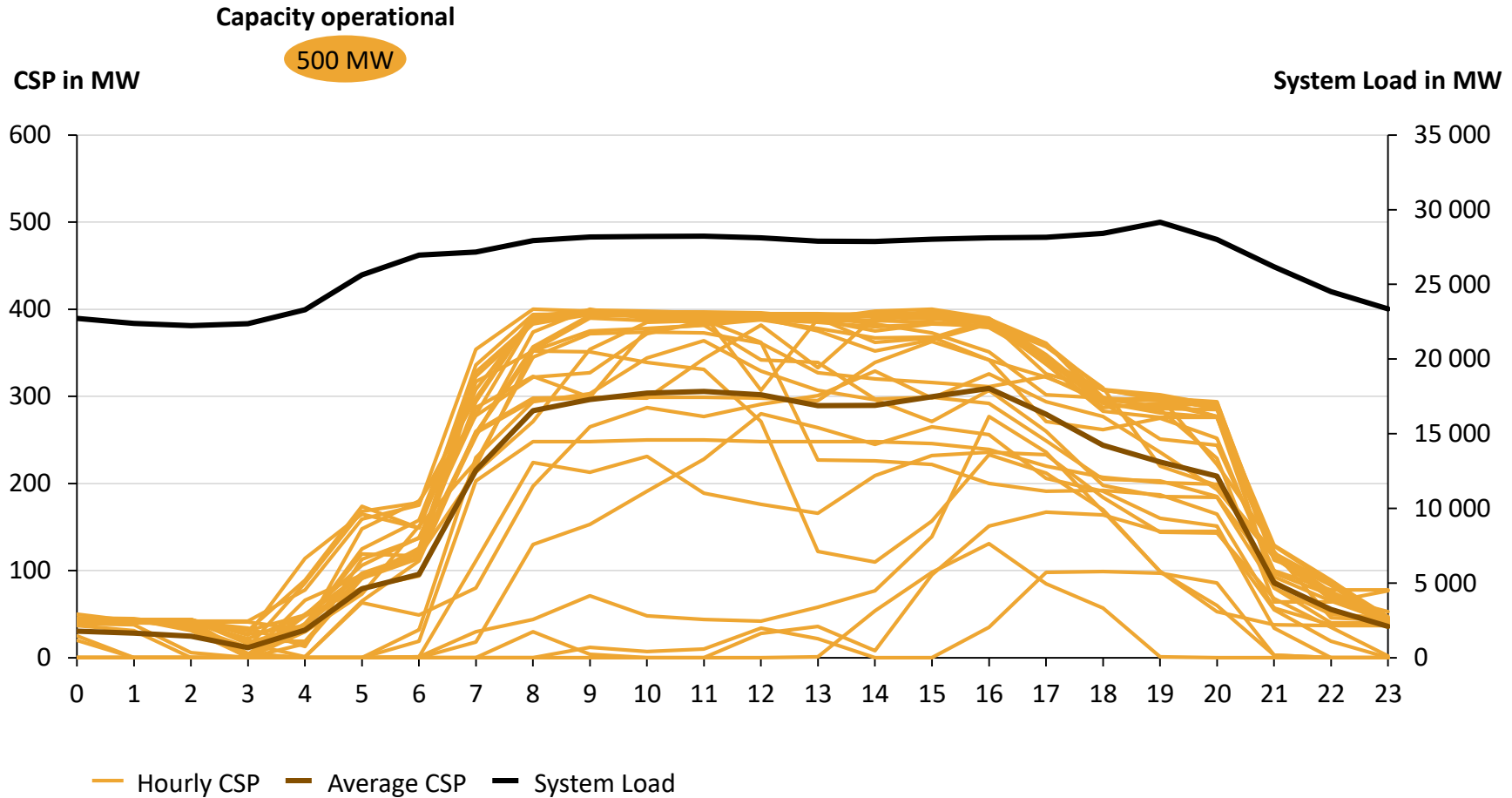
Hourly CSP production for all 31 days of January 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Feb 2019, CSP storage used in evenings

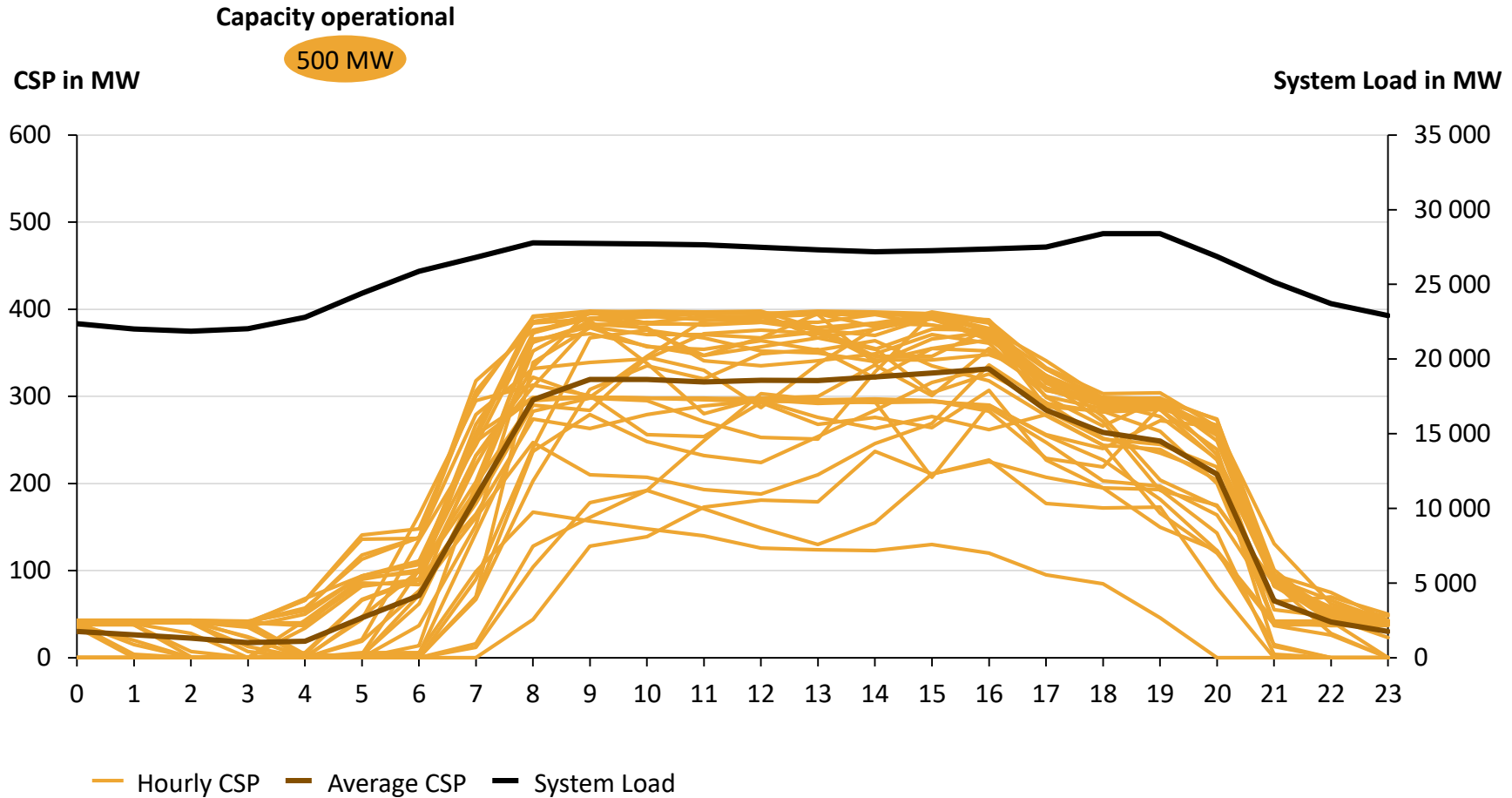
Hourly CSP production for all 28 days of February 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Mar 2019, CSP storage used in evenings

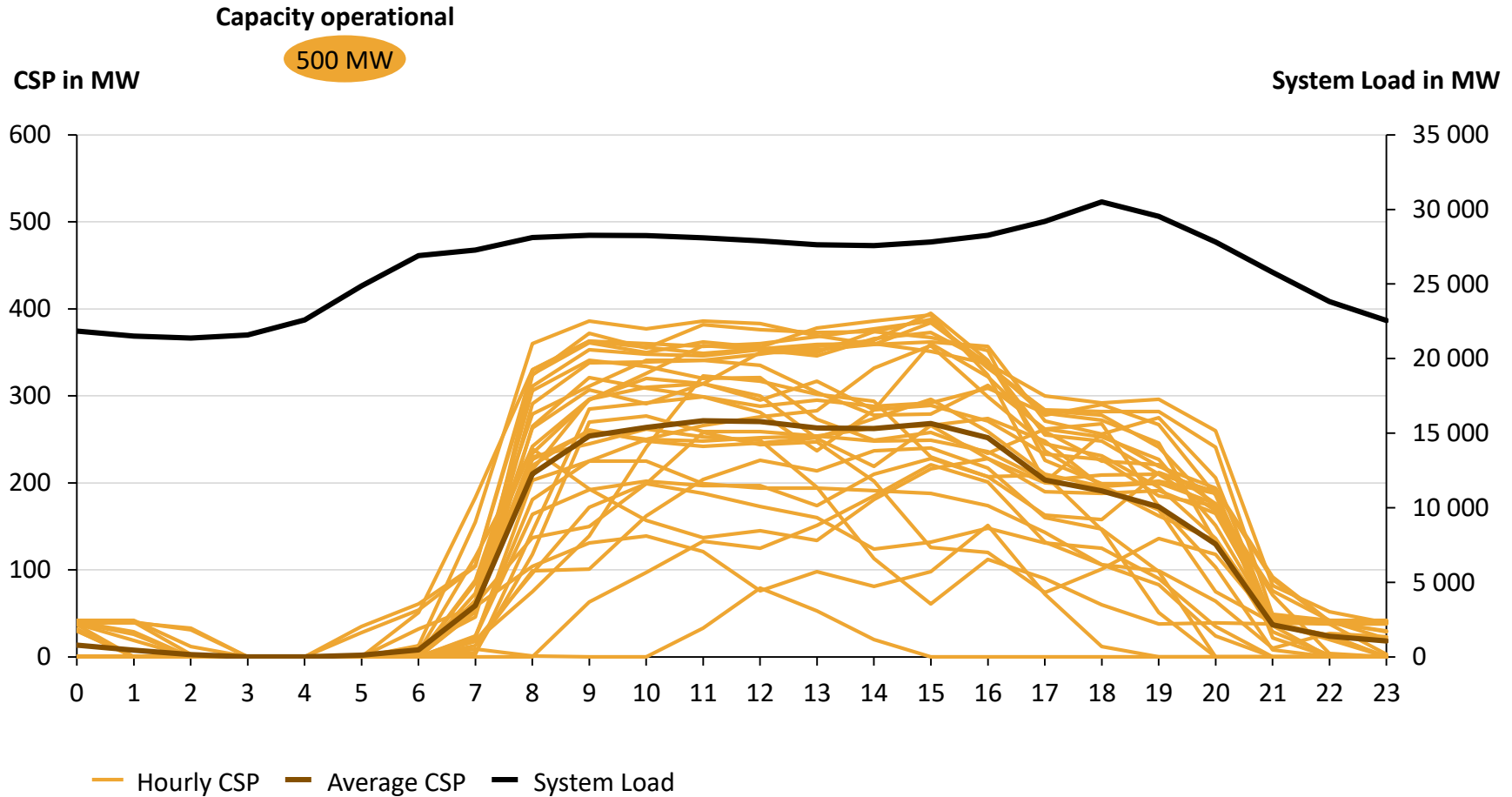
Hourly CSP production for all 31 days of March 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

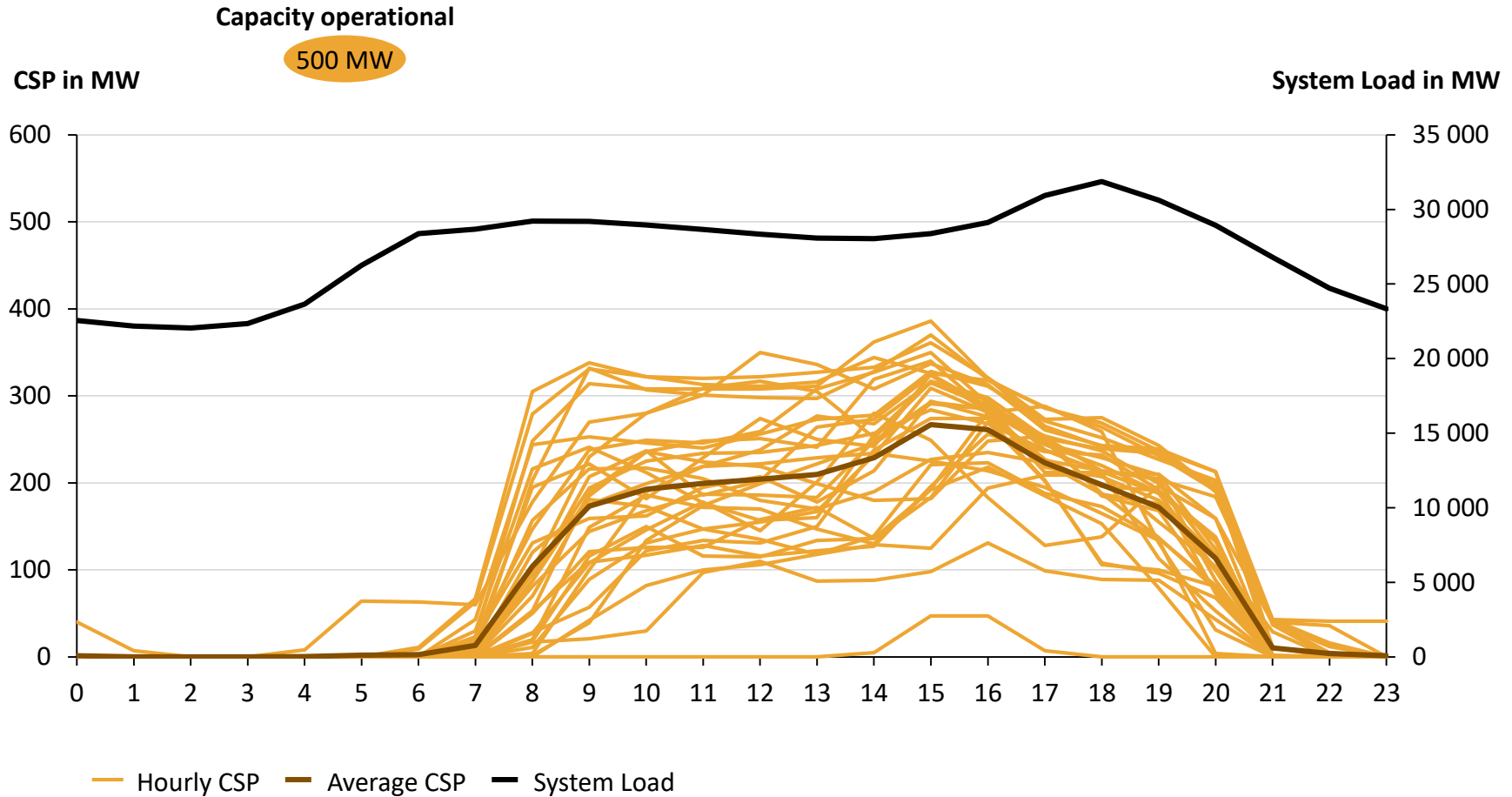
In Apr 2019, CSP storage used in evenings

Hourly CSP production for all 30 days of April 2019 and average system load diurnal course



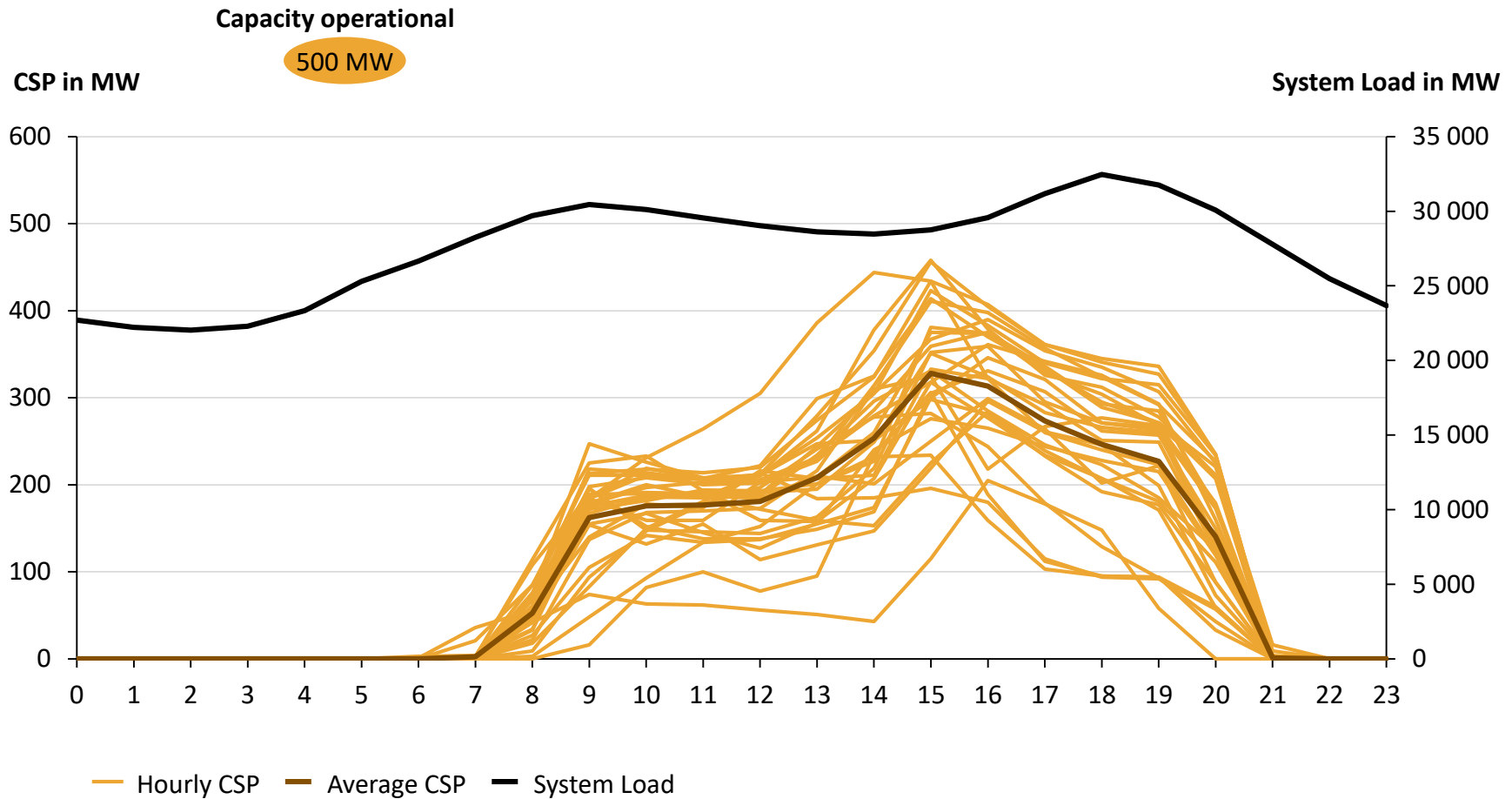
In May 2019, CSP storage used in evenings

Hourly CSP production for all 31 days of May 2019 and average system load diurnal course



In Jun 2019, CSP storage used in evenings

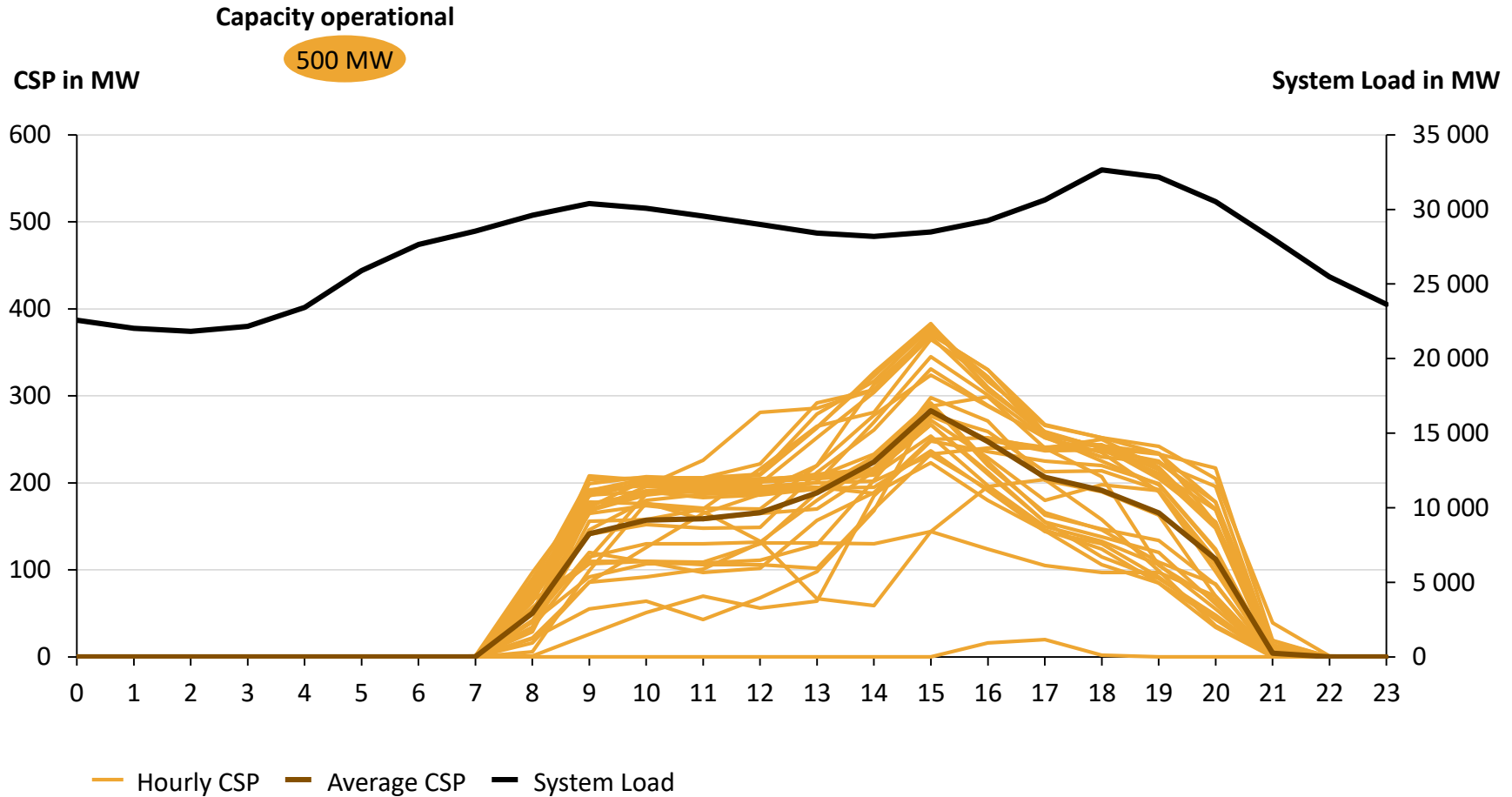
Hourly CSP production for all 30 days of June 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Jul 2019, CSP storage used in evenings

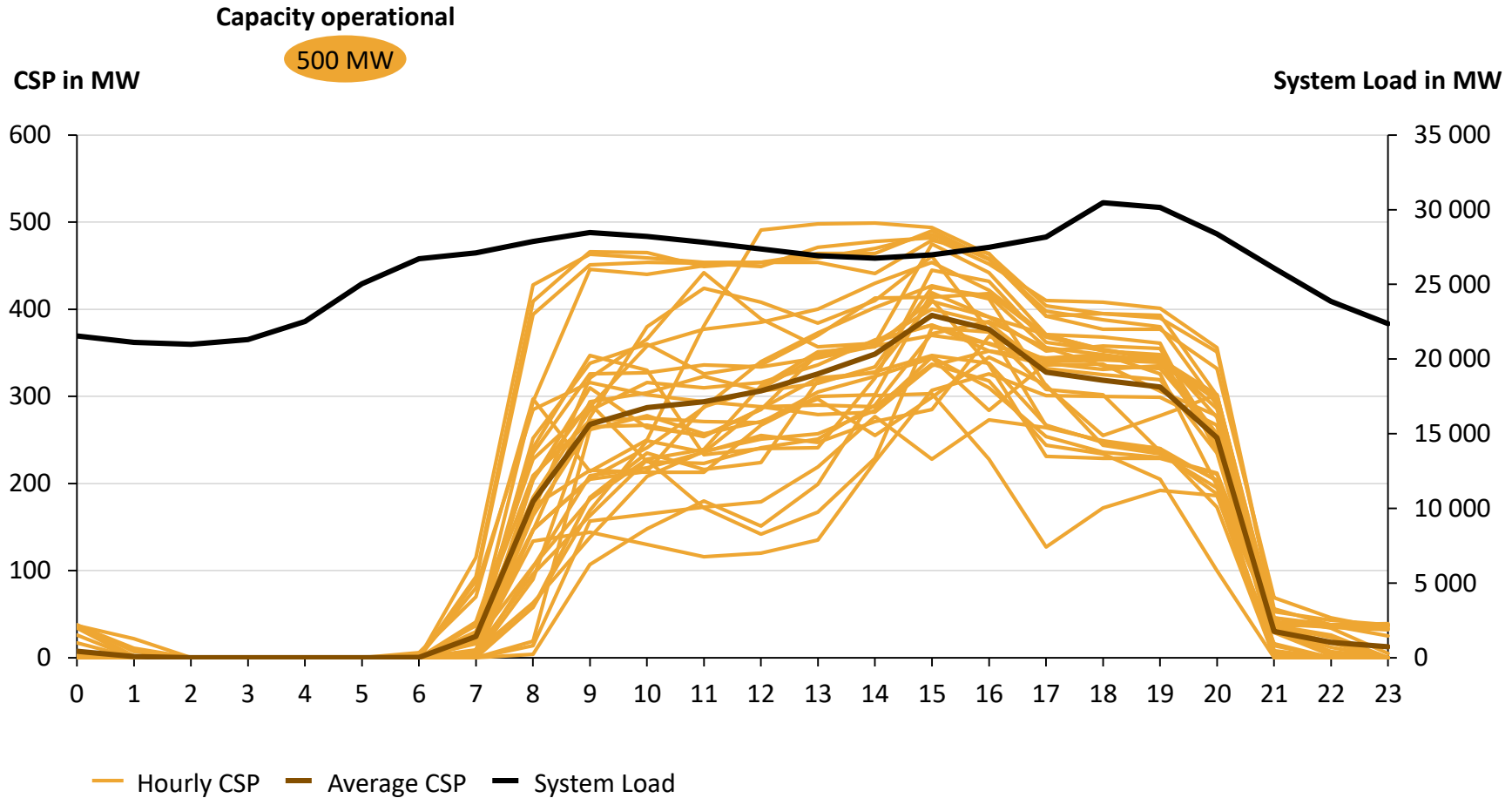
Hourly CSP production for all 31 days of July 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

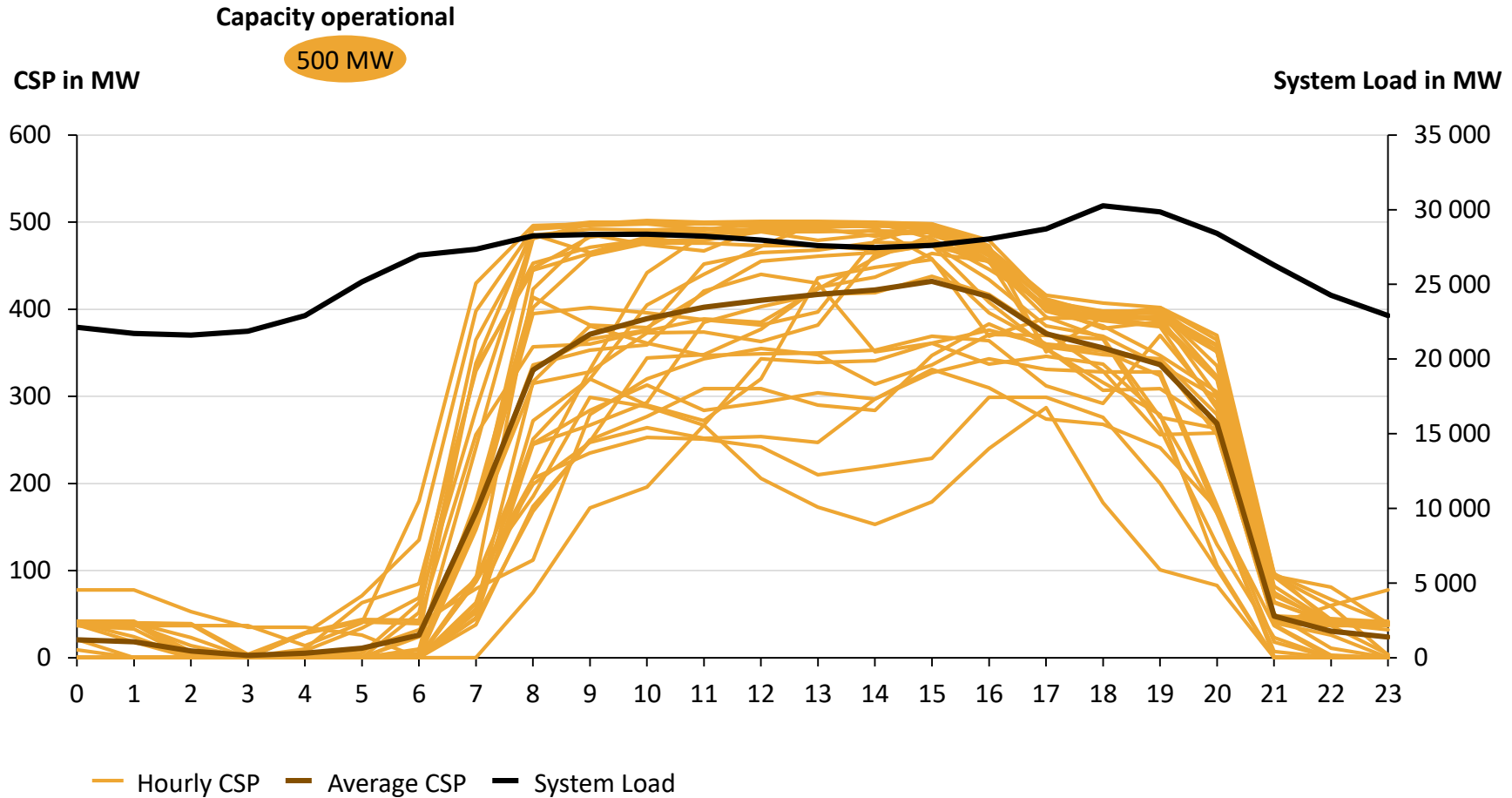
In Aug 2019, CSP storage used in evenings

Hourly CSP production for all 31 days of August 2019 and average system load diurnal course



In Sep 2019, CSP storage used in evenings

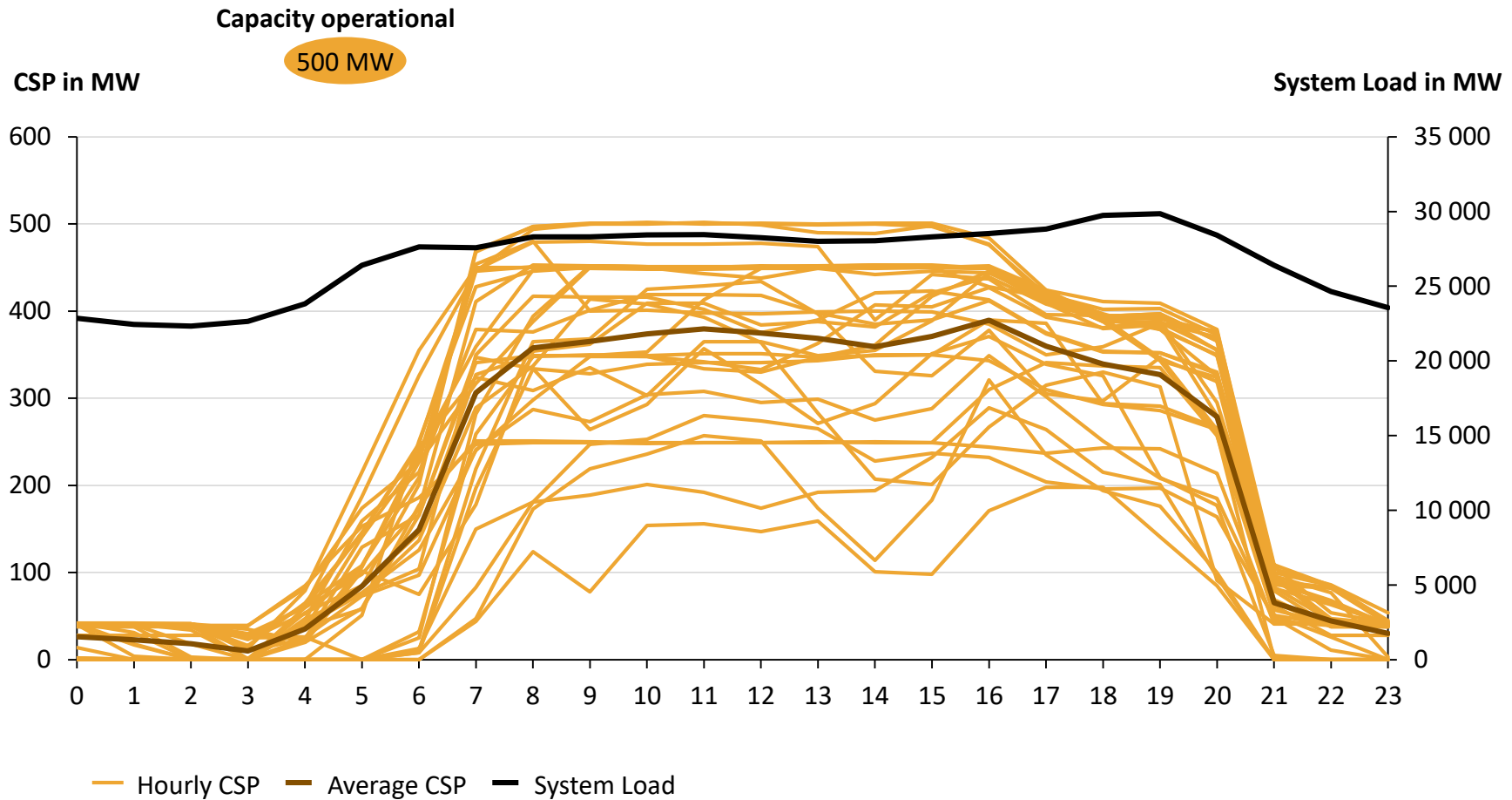
Hourly CSP production for all 30 days of September 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

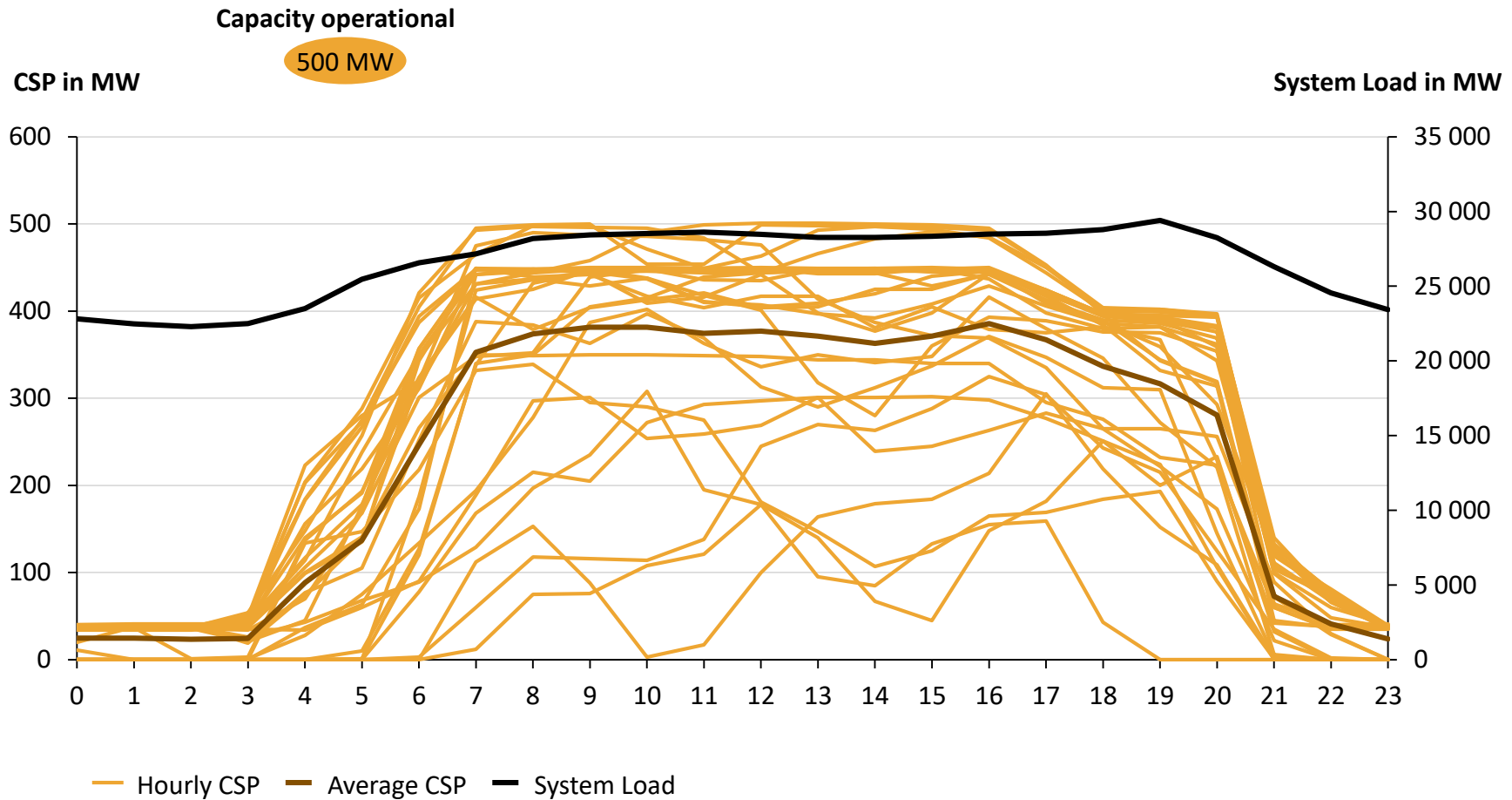
In Oct 2019, CSP storage used in evenings

Hourly CSP production for all 31 days of October 2019 and average system load diurnal course



In Nov 2019, CSP storage used in evenings

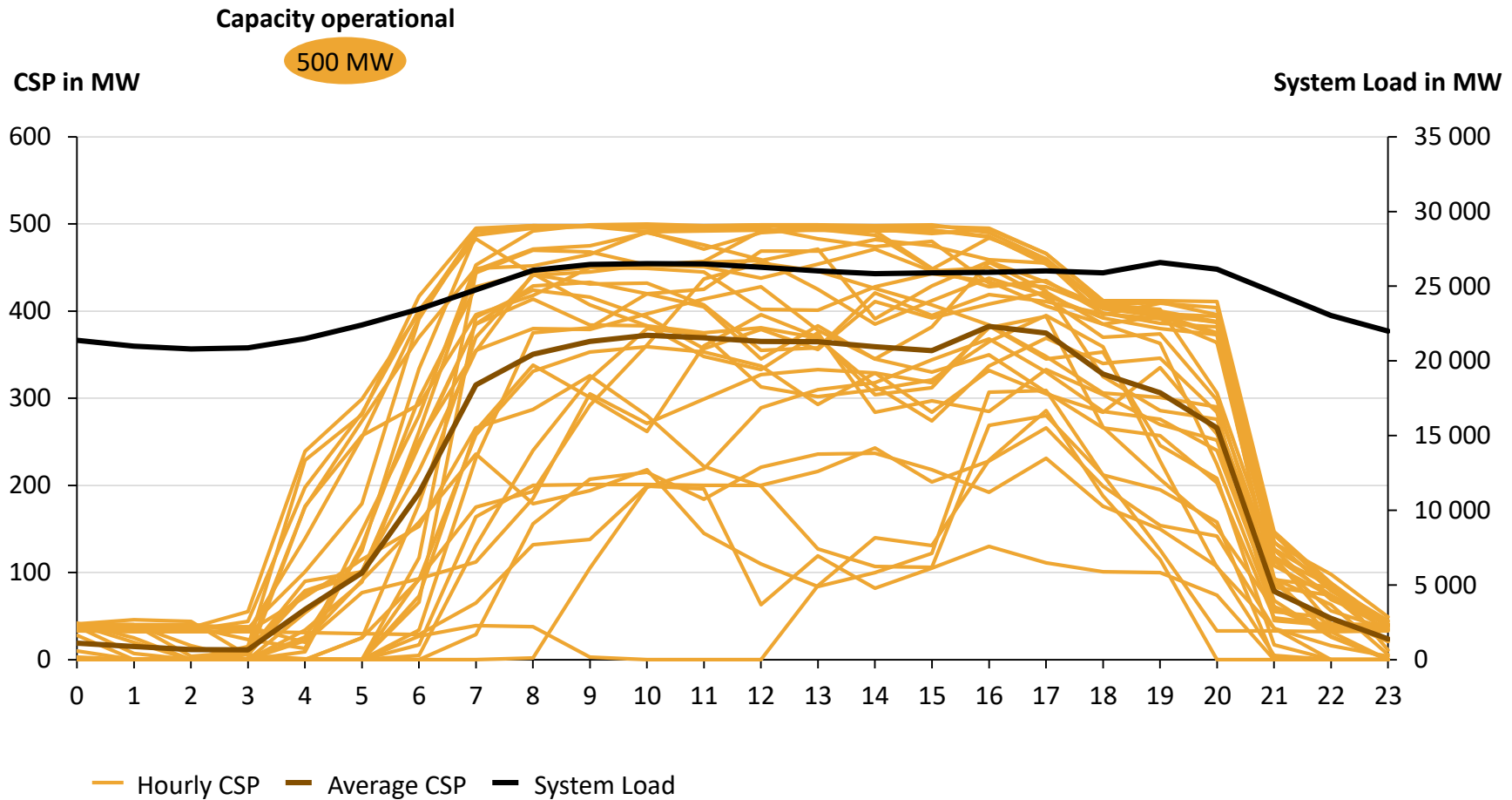
Hourly CSP production for all 30 days of November 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

In Dec 2019, CSP storage used in evenings

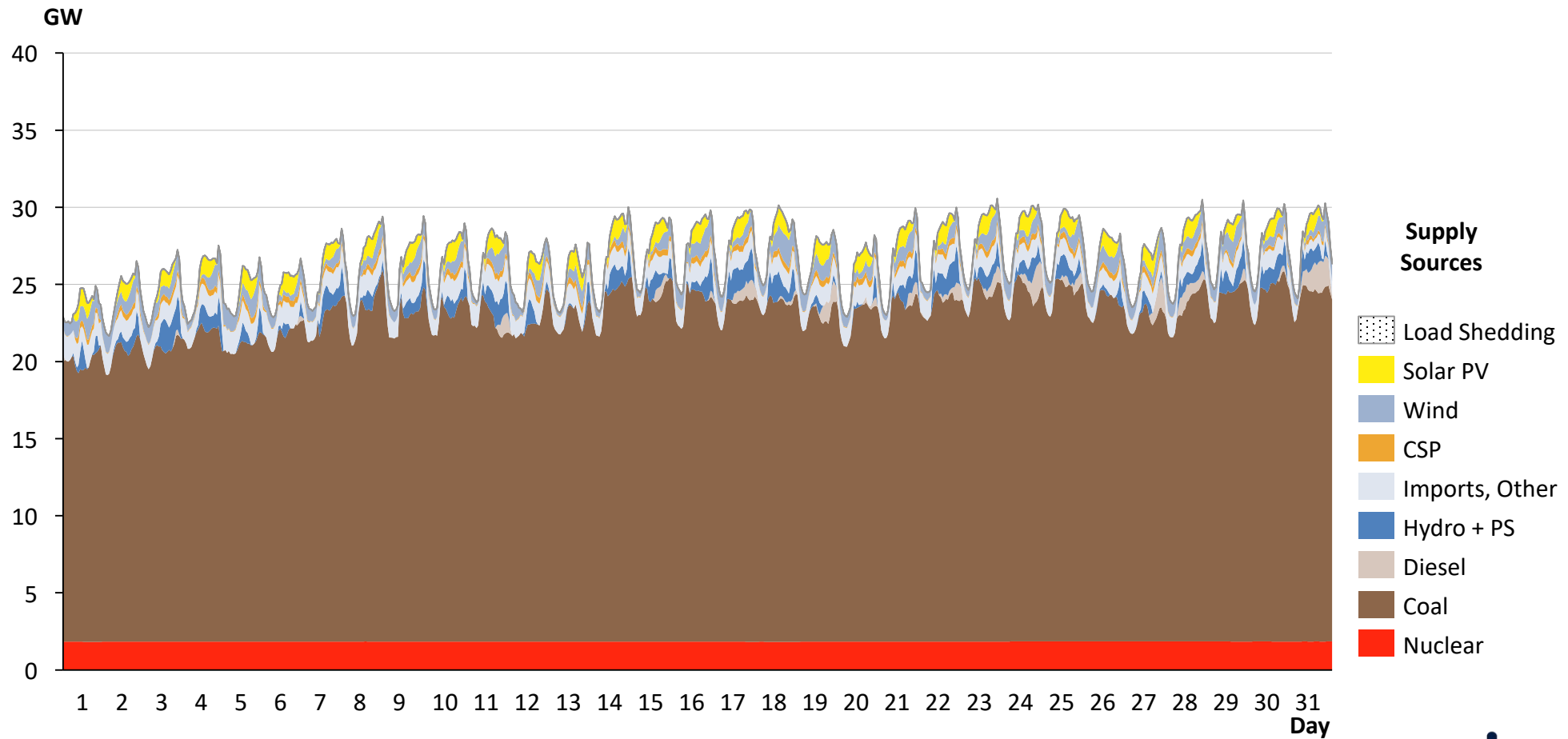
Hourly CSP production for all 30 days of December 2019 and average system load diurnal course



Note: System load excludes hydro pumping load
Sources: Eskom; CSIR Energy Centre analysis

Hourly electricity production in Jan 2019

Actual hourly production from all power supply sources in RSA for January 2019

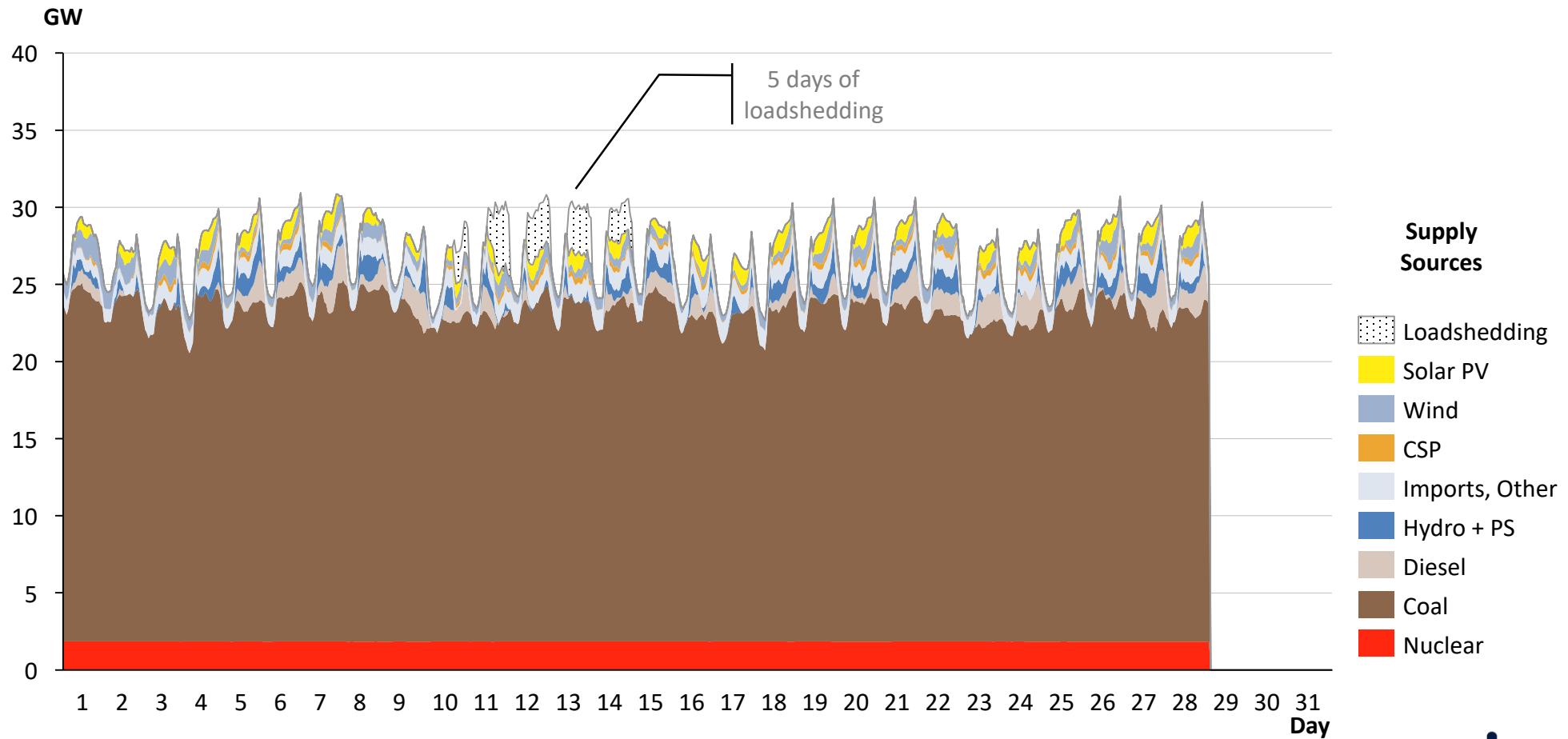


- Maximum power of 30.6 GW between 19h00 and 20h00 on 23 Jan 2019
- Minimum power of 19.1 GWh between 03h00 and 04h00 on 2 Jan 2019

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

Hourly electricity production in Feb 2019, 5 days of load shedding

Actual hourly production from all power supply sources in RSA for February 2019

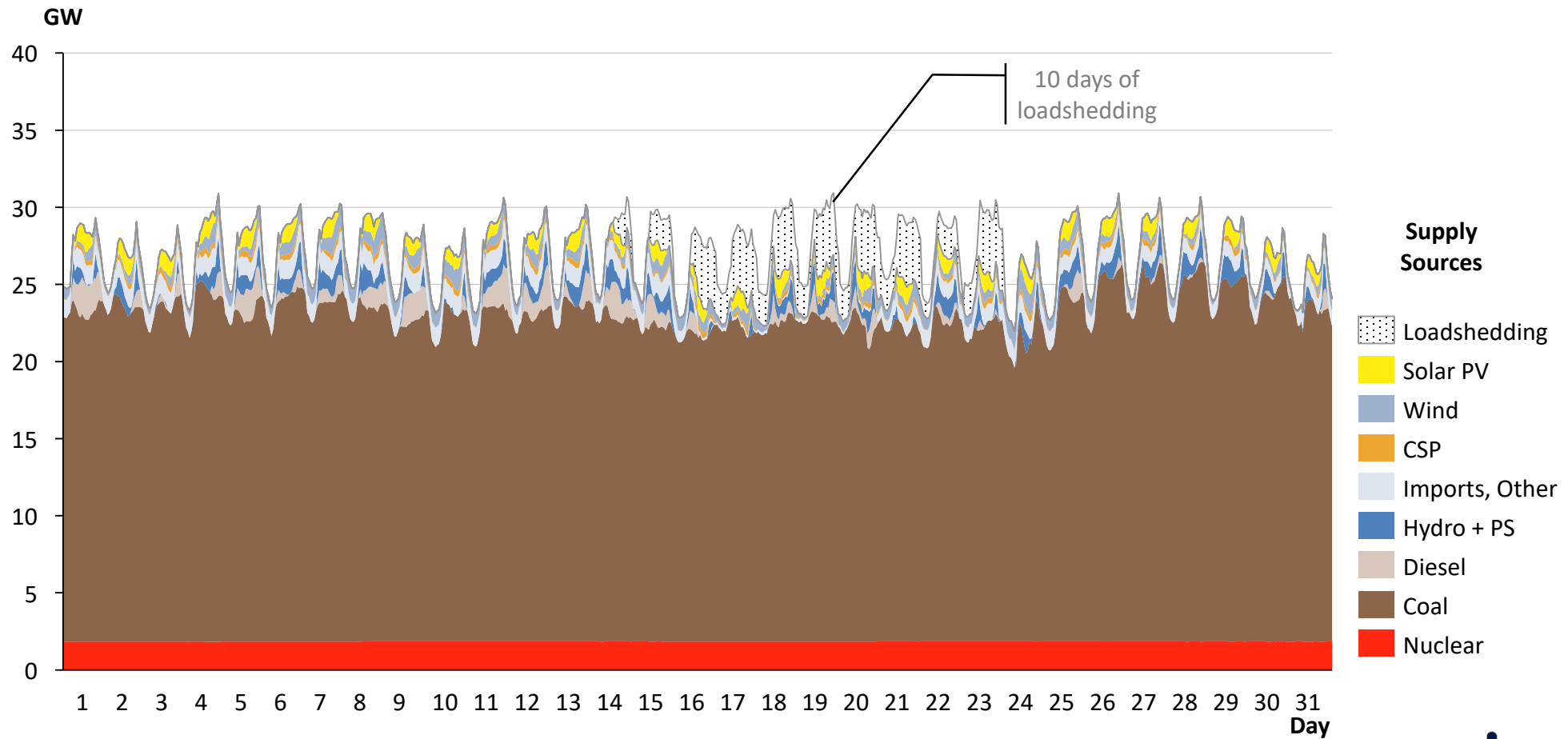


- Maximum power of 31.0 GW between 19h00 and 20h00 on 6 Feb 2019
- Minimum power of 21.0 GWh between 02h00 and 03h00 on 4 Feb 2019

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

Hourly electricity production in Mar 2019, 10 days of load shedding

Actual hourly production from all power supply sources in RSA for March 2019

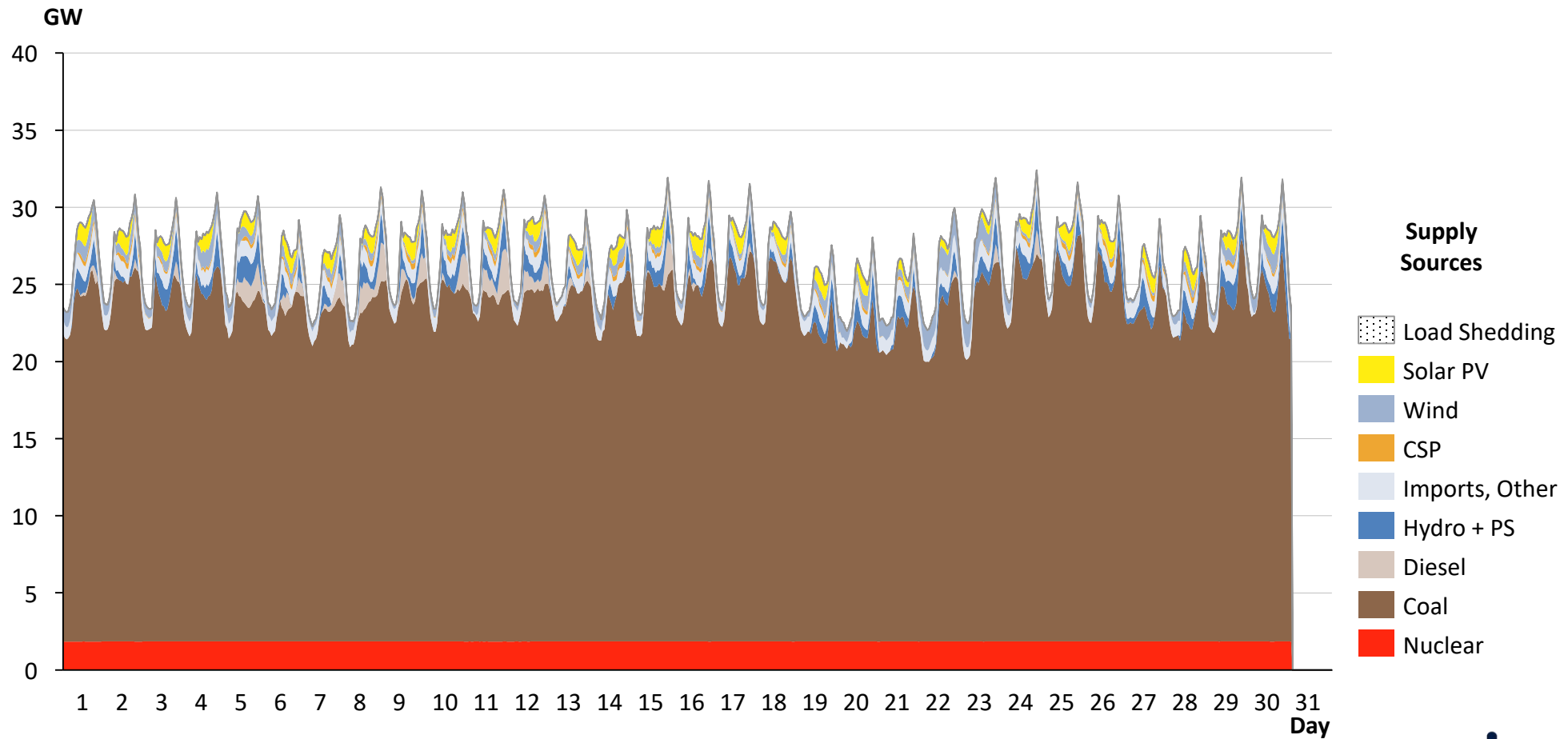


- Maximum power of 31.0 GW between 18h00 and 19h00 on 26 Mar 2019
- Minimum power of 21.0 GWh between 02h00 and 03h00 on 18 Mar 2019

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

Hourly electricity production in Apr 2019

Actual hourly production from all power supply sources in RSA for April 2019

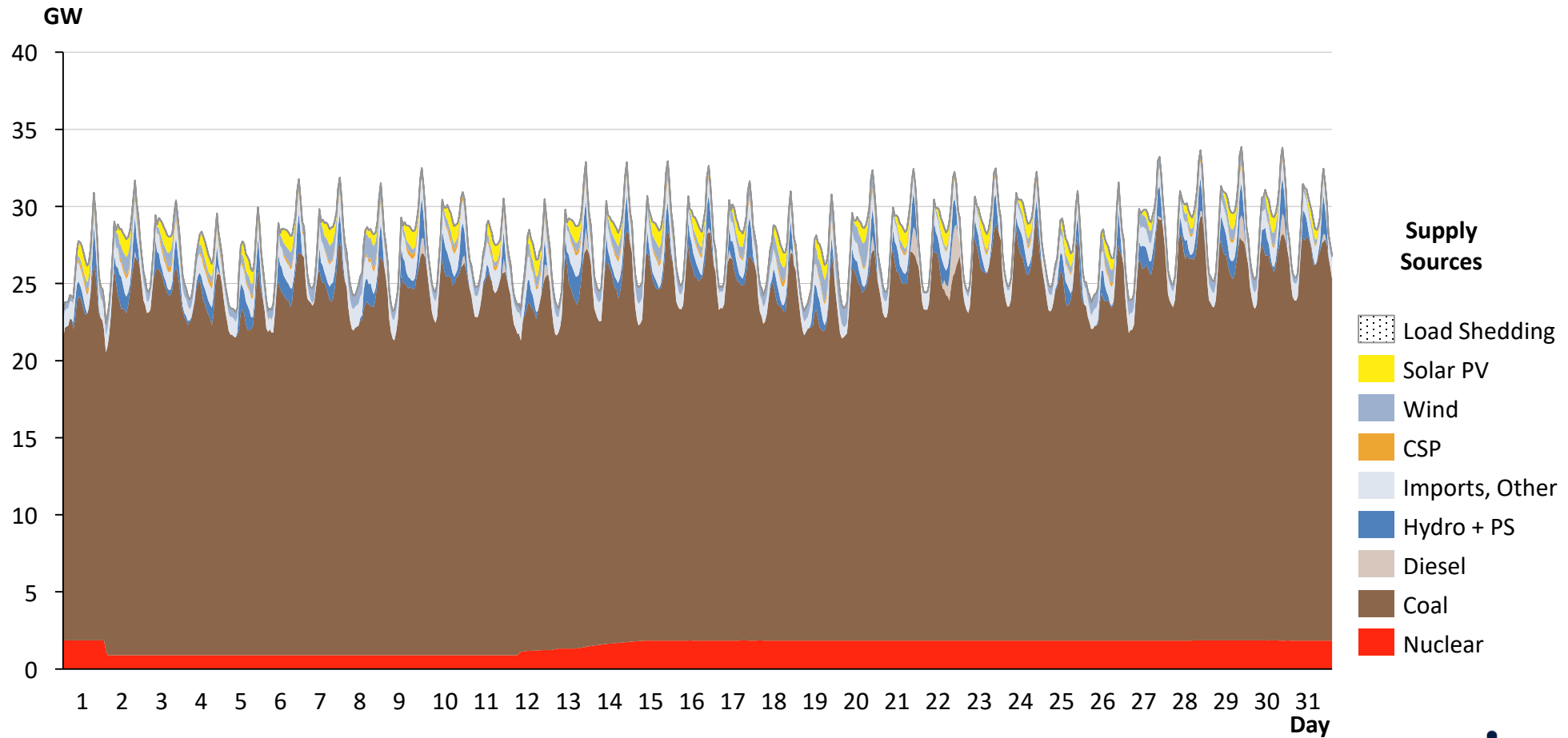


- Maximum power of 32.4 GW between 18h00 and 19h00 on 24 Apr 2019
- Minimum power of 19.9 GWh between 02h00 and 03h00 on 22 Apr 2019

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

Hourly electricity production in May 2019

Actual hourly production from all power supply sources in RSA for May 2019

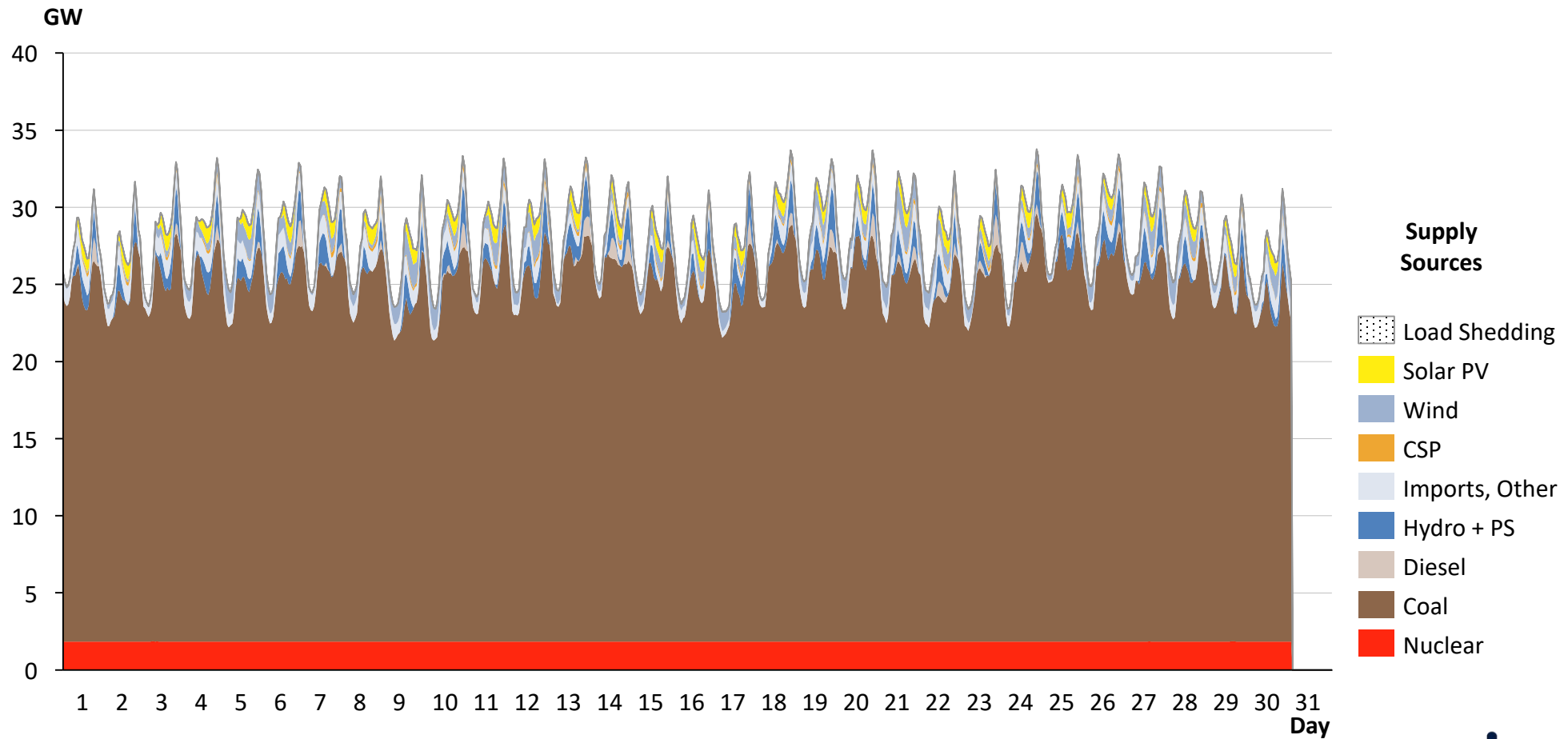


- Maximum power of 33.9 GW between 18h00 and 19h00 on 29 May 2019
- Minimum power of 21.0 GWh between 02h00 and 03h00 on 2 May 2019

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

Hourly electricity production in Jun 2019

Actual hourly production from all power supply sources in RSA for June 2019

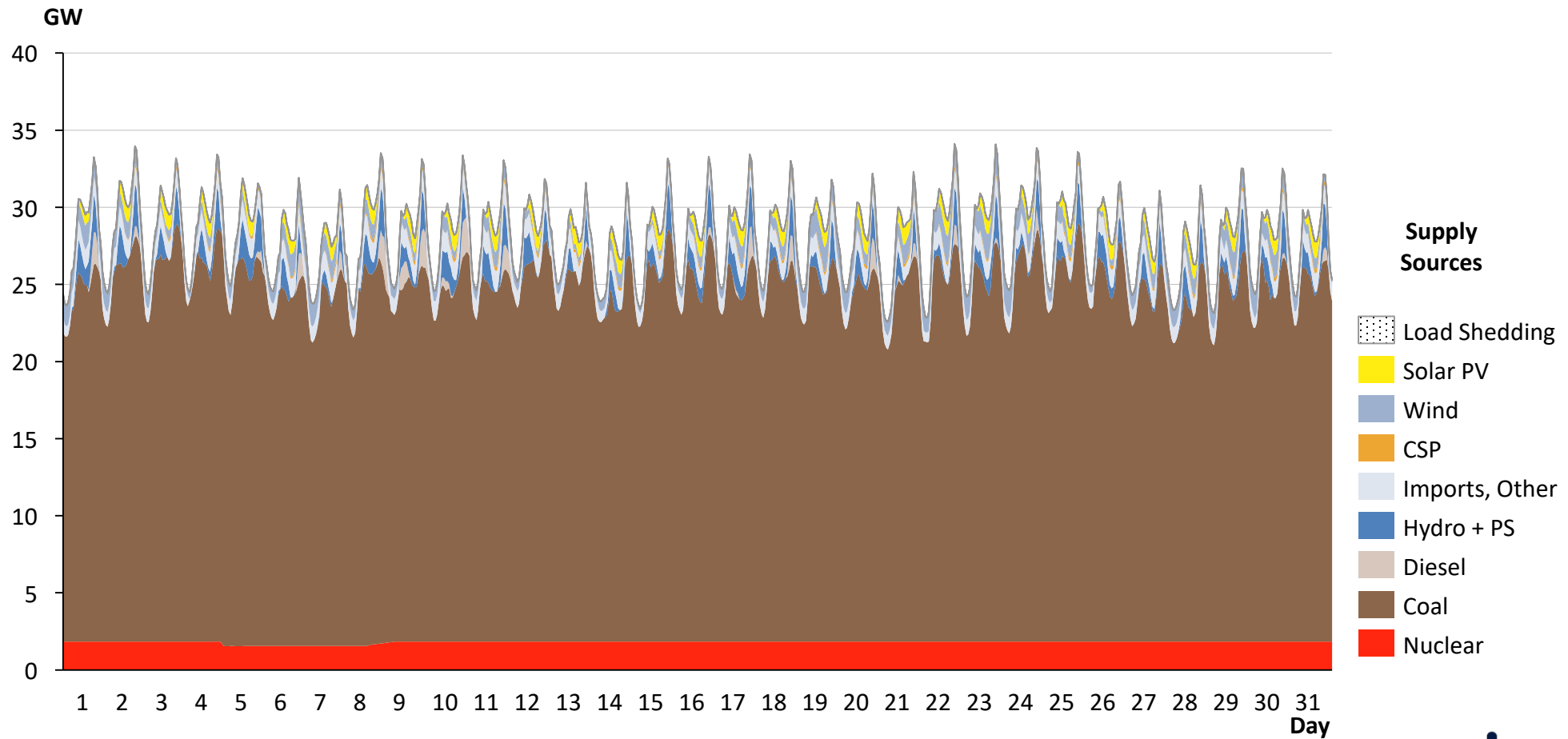


- Maximum power of 33.8 GW between 18h00 and 19h00 on 24 Jun 2019
- Minimum power of 20.8 GWh between 02h00 and 03h00 on 17 Jun 2019

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

Hourly electricity production in Jul 2019

Actual hourly production from all power supply sources in RSA for July 2019

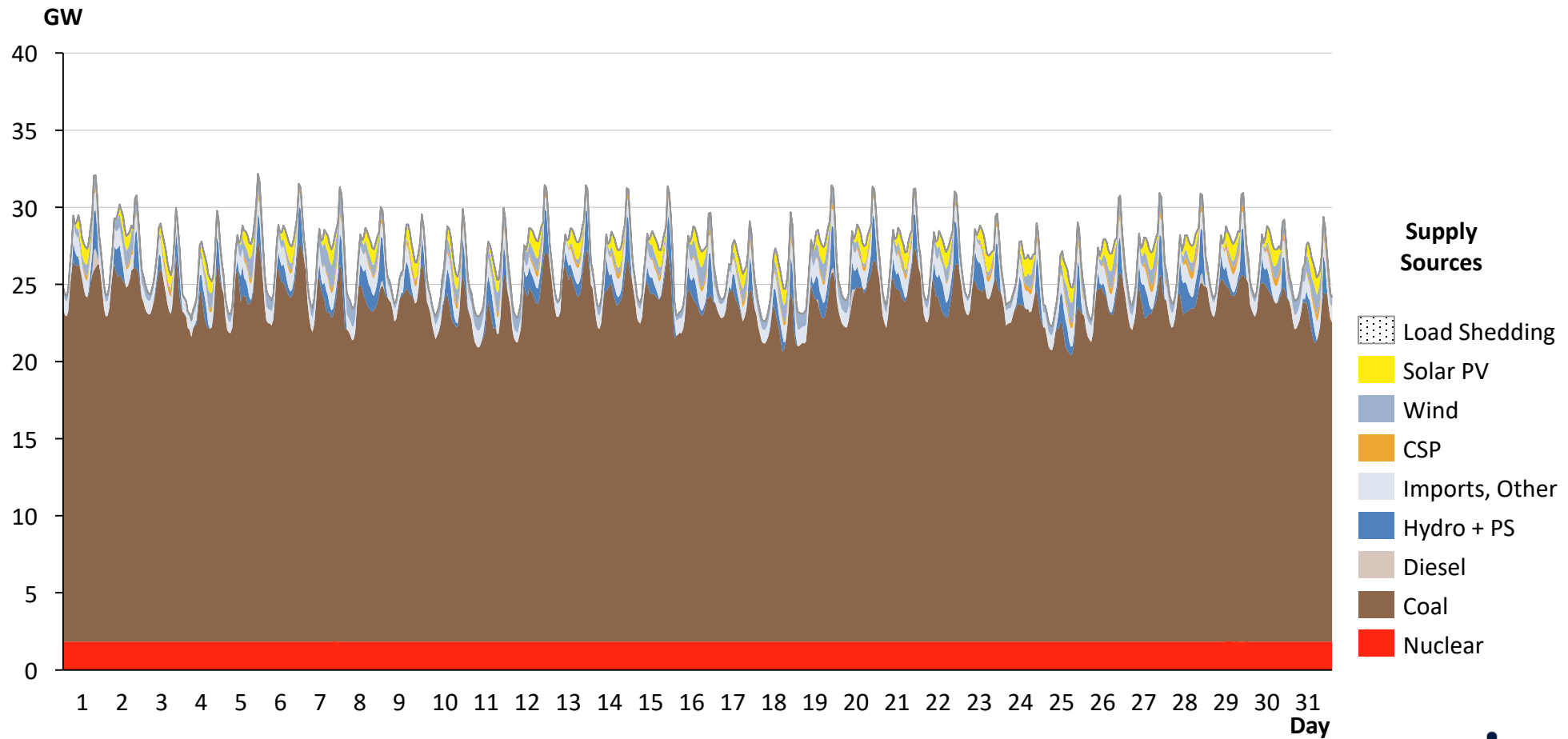


- Maximum power of 34.1 GW between 18h00 and 19h00 on 22 Jul 2019
- Minimum power of 20.7 GWh between 02h00 and 03h00 on 15 Jul 2019

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

Hourly electricity production in Aug 2019

Actual hourly production from all power supply sources in RSA for August 2019

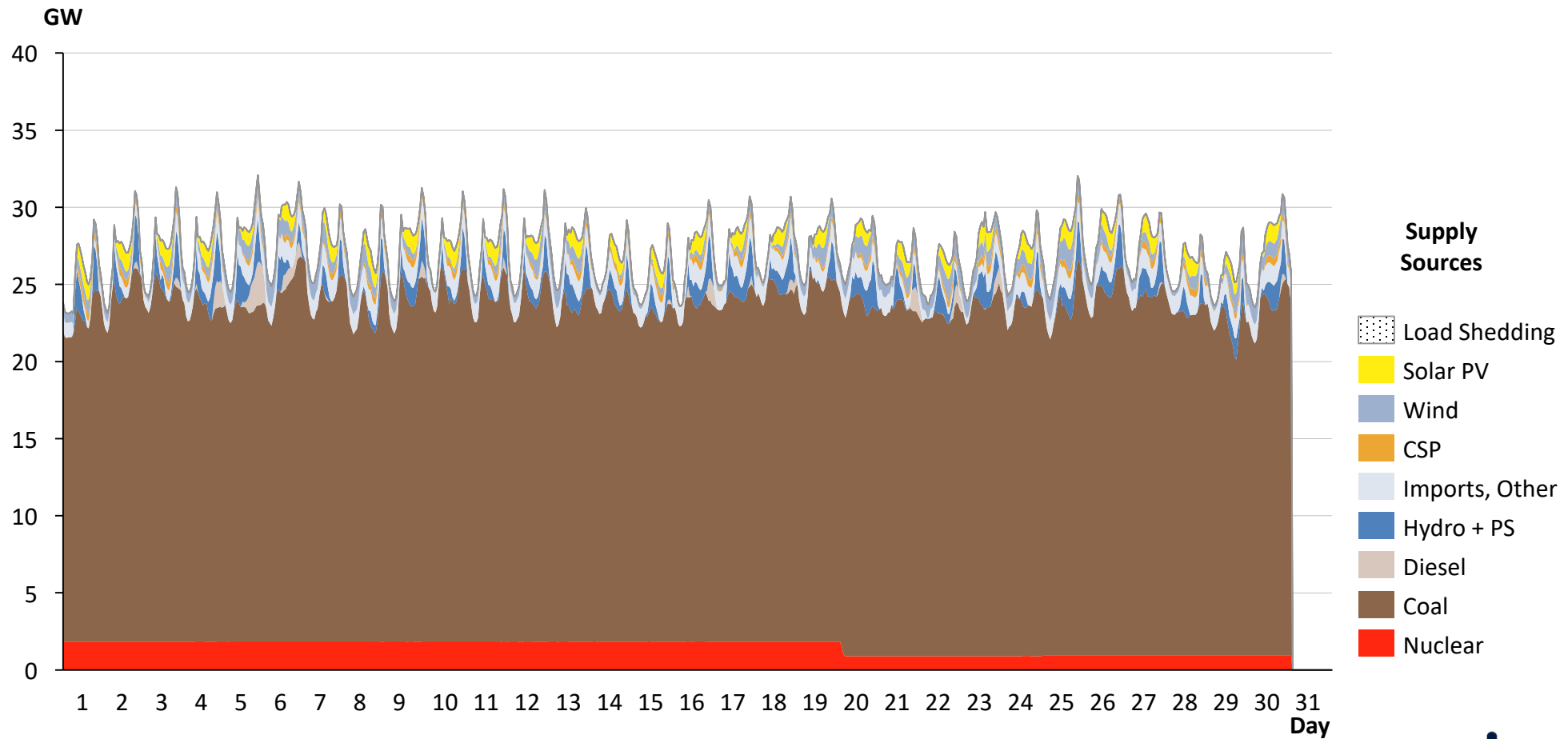


- Maximum power of 32.2 GW between 18h00 and 19h00 on 5 Aug 2019
- Minimum power of 19.9 GWh between 03h00 and 04h00 on 18 Aug 2019

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

Hourly electricity production in Sep 2019

Actual hourly production from all power supply sources in RSA for September 2019

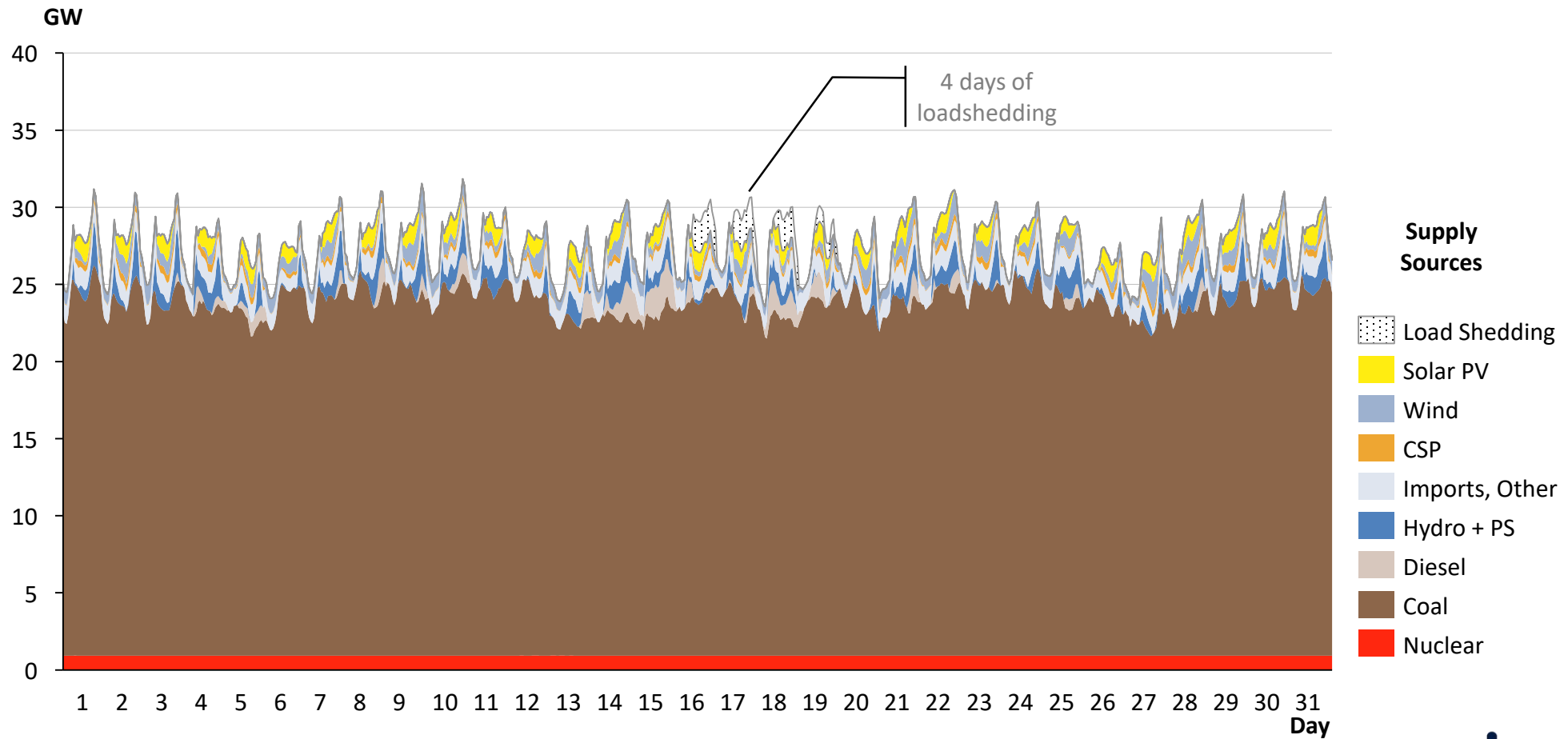


- Maximum power of 32.1 GW between 18h00 and 19h00 on 5 Sep 2019
- Minimum power of 20.4 GWh between 02h00 and 03h00 on 2 Sep 2019

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

Hourly electricity production in Oct 2019

Actual hourly production from all power supply sources in RSA for October 2019

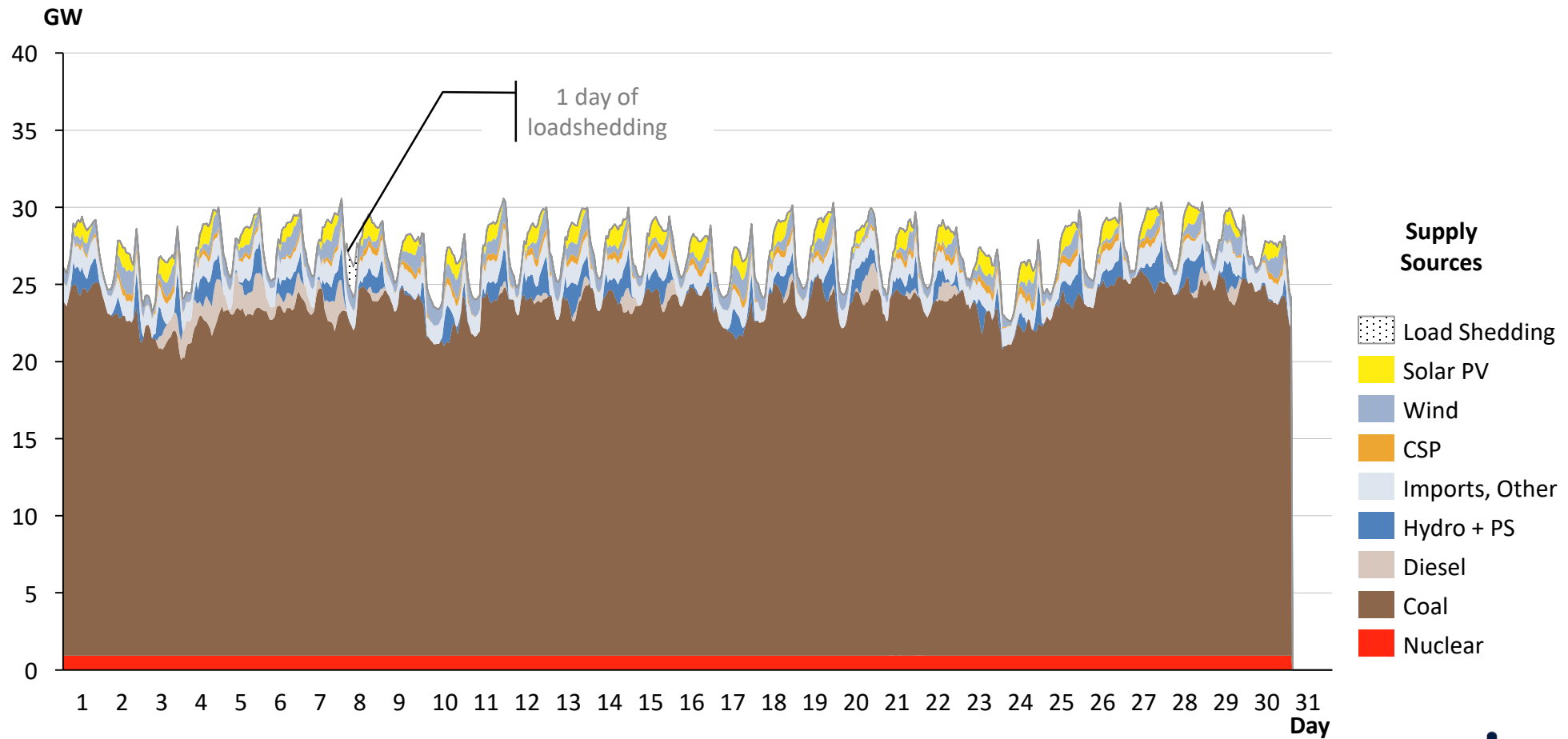


- Maximum power of 31.8 GW between 18h00 and 19h00 on 10 Oct 2019
- Minimum power of 20.9 GWh between 02h00 and 03h00 on 27 Oct 2019

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

Hourly electricity production in Nov 2019

Actual hourly production from all power supply sources in RSA for November 2019

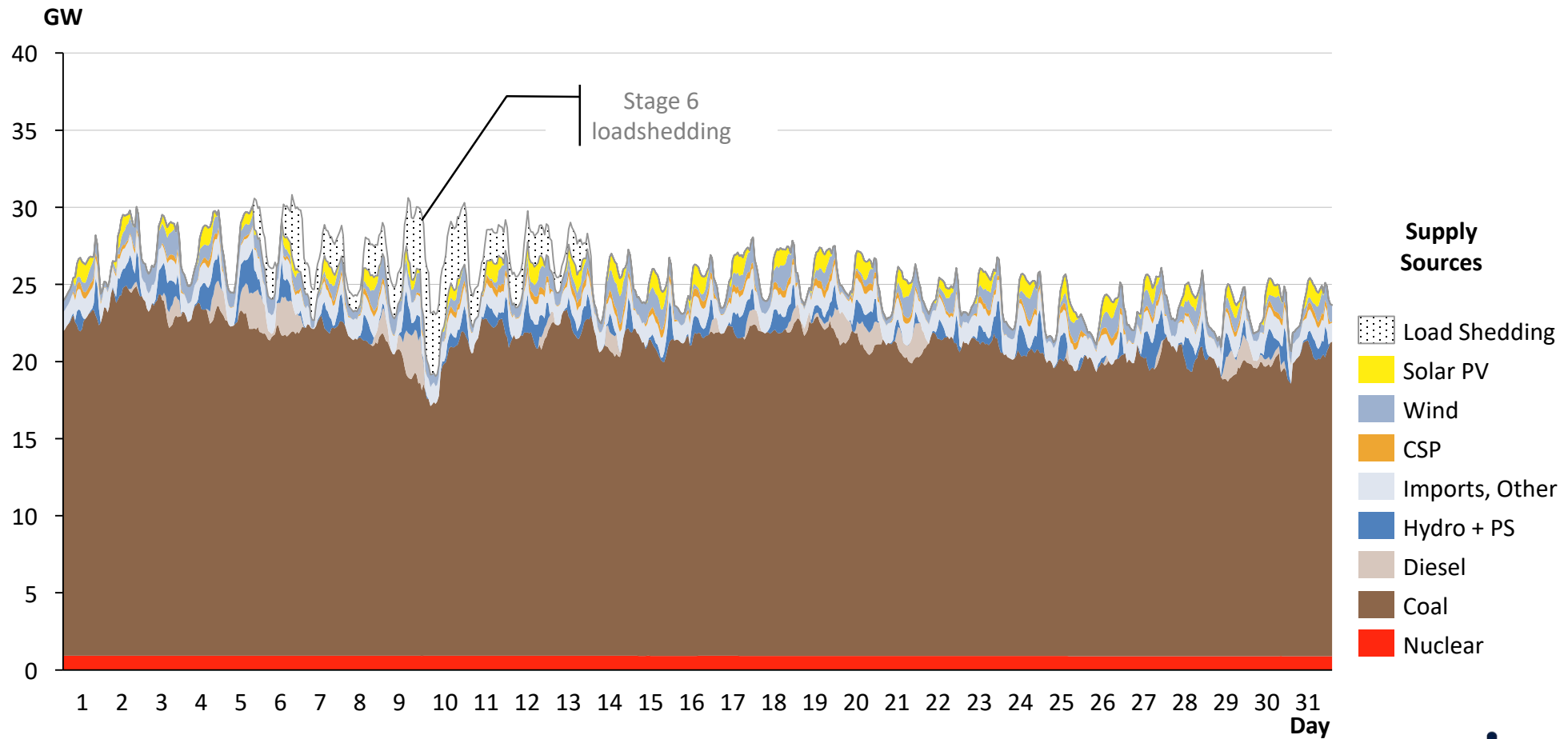


- Maximum power of 30.6 GW between 18h00 and 19h00 on 7 Nov 2019
- Minimum power of 21.2 GWh between 03h00 and 04h00 on 24 Nov 2019

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

Hourly electricity production in Dec 2019

Actual hourly production from all power supply sources in RSA for December 2019



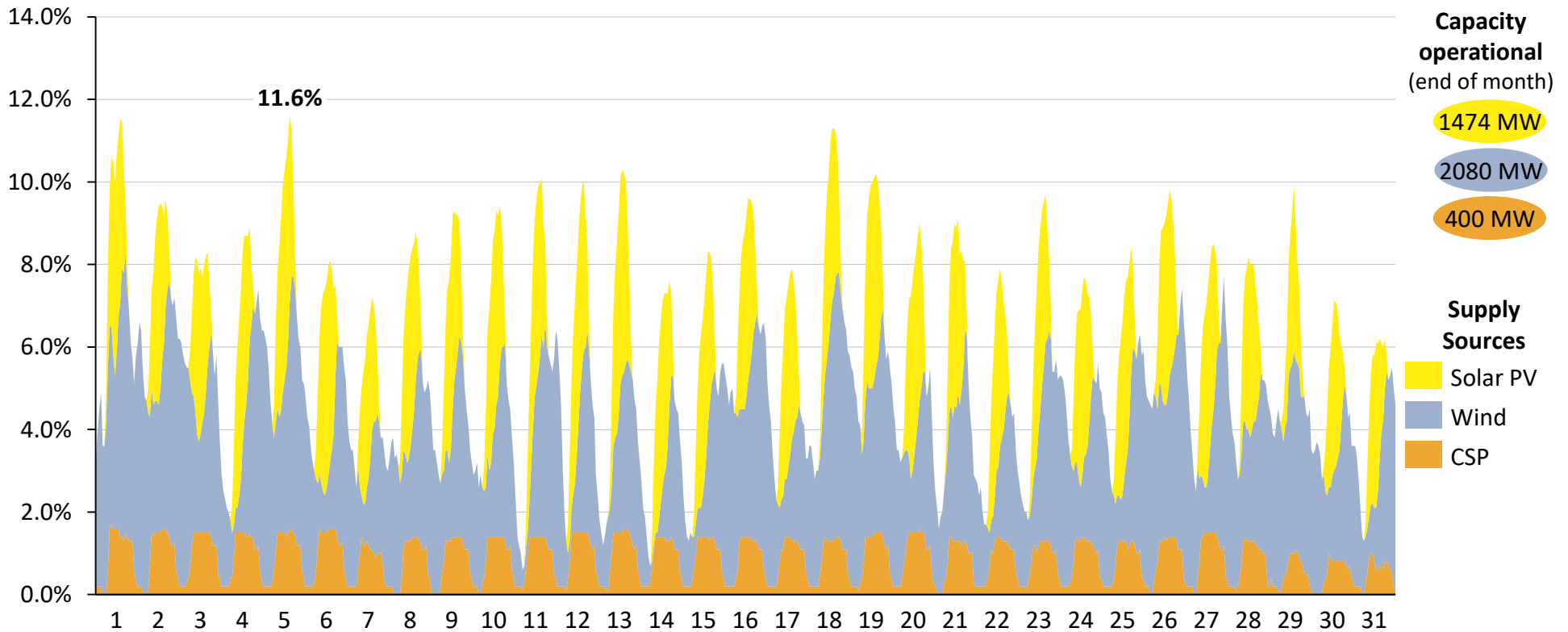
- Maximum power of 30.1 GW between 15h00 and 16h00 on 5 Dec 2019
- Minimum power of 19.1 GWh between 02h00 and 03h00 on 10 Dec 2019

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

Hourly solar PV, wind & CSP contribution of 0.7-11.6% in Jan 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for January 2019

Relative hourly contribution

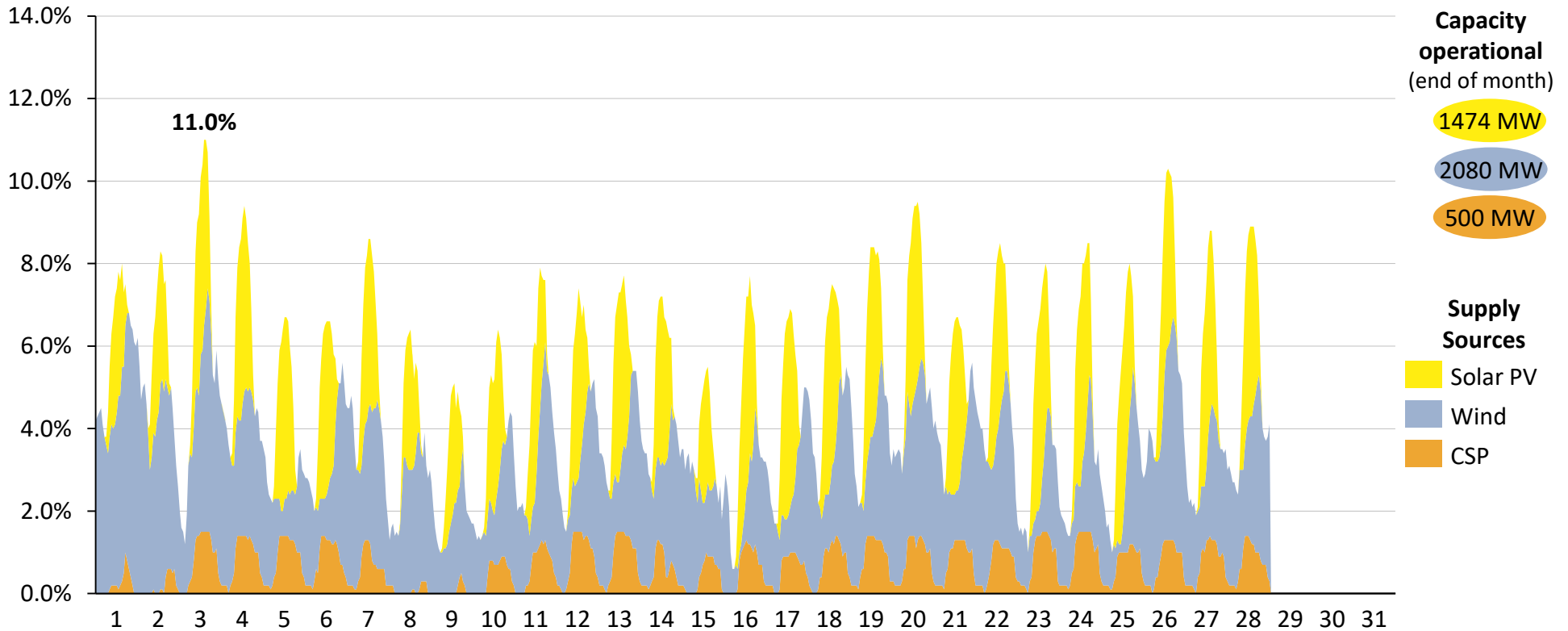


- Solar PV maximum relative contribution of 5.1% between 13h00 and 14h00 on 5 Jan 2019
- Wind maximum relative contribution of 6.8% between 17h00 and 18h00 on 1 Jan 2019
- CSP maximum relative contribution of 1.7% between 09h00 and 10h00 on 1 Jan 2019

Hourly solar PV, wind & CSP contribution of 0.6-11.0% in Feb 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for February 2019

Relative hourly contribution

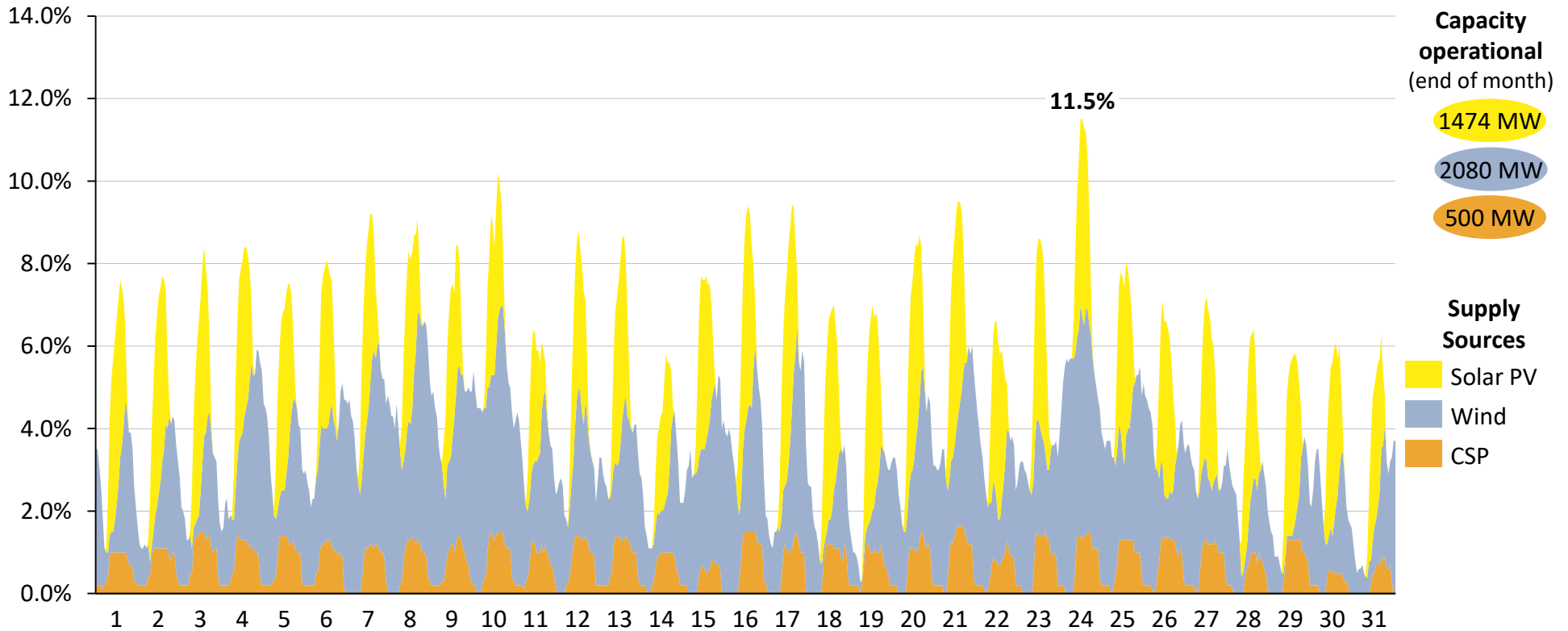


- Maximum solar PV relative contribution of 4.8% between 12h00 and 13h00 on 24 Feb 2019
- Maximum wind relative contribution of 6.2% between 21h00 and 22h00 on 2 Feb 2019
- Maximum CSP relative contribution of 1.5% between 12h00 and 13h00 on 12 Feb 2019

Hourly solar PV, wind & CSP contribution of 0.3-11.5% in Mar 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for March 2019

Relative hourly contribution

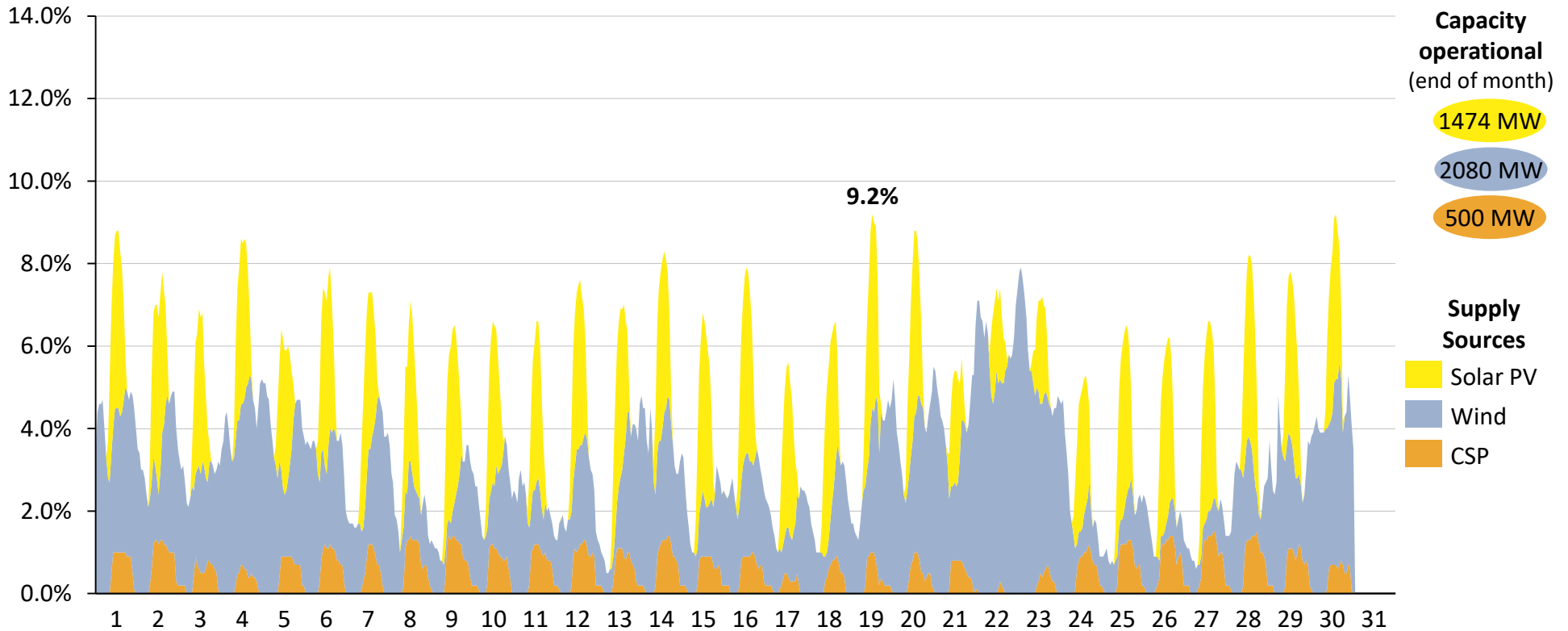


- Maximum solar PV relative contribution of 5.3% between 12h00 and 13h00 on 17 Mar 2019
- Maximum wind relative contribution of 5.7% between 06h00 and 07h00 on 24 Mar 2019
- Maximum CSP relative contribution of 1.7% between 14h00 and 15h00 on 21 Mar 2019

Hourly solar PV, wind & CSP contribution of 0.5-9.2% in Apr 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for April 2019

Relative hourly contribution

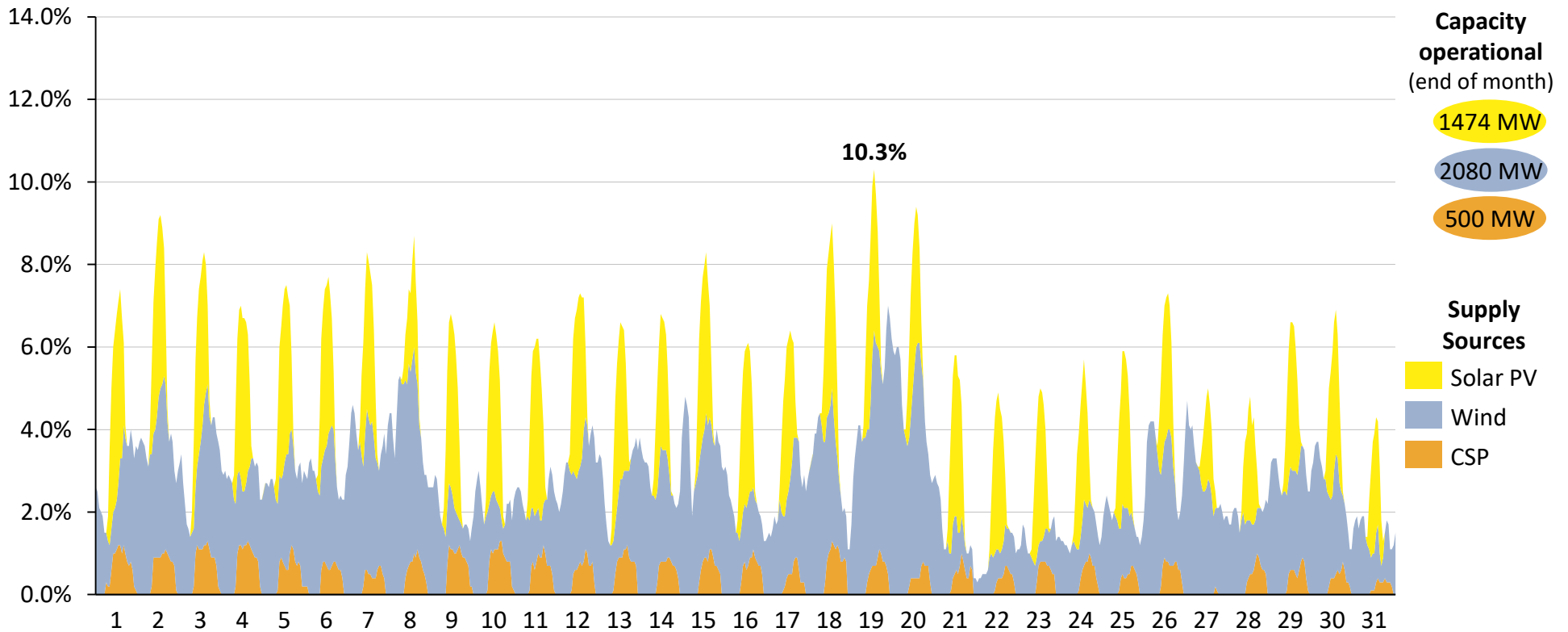


- Maximum solar PV relative contribution of 4.7% between 11h00 and 12h00 on 19 Apr 2019
- Maximum wind relative contribution of 7.9% between 01h00 and 02h00 on 23 Apr 2019
- Maximum CSP relative contribution of 1.5% between 16h00 and 17h00 on 27 Apr 2019

Hourly solar PV, wind & CSP contribution of 0.3-10.3% in May 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for May 2019

Relative hourly contribution

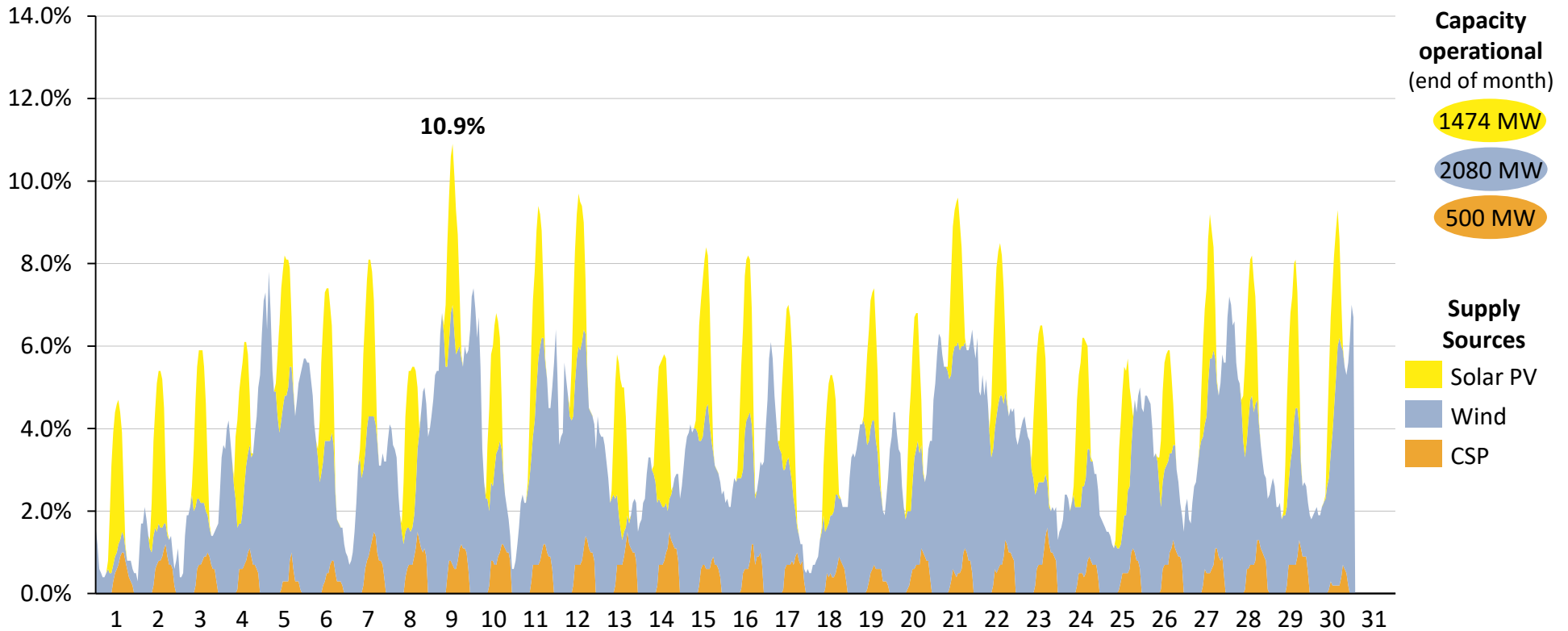


- Maximum solar PV relative contribution of 4.5% between 12h00 and 13h00 on 1 May 2019
- Maximum wind relative contribution of 6.7% between 22h00 and 23h00 on 19 May 2019
- Maximum CSP relative contribution of 1.3% between 16h00 and 17h00 on 10 May 2019

Hourly solar PV, wind & CSP contribution of 0.3-10.9% in Jun 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for June 2019

Relative hourly contribution

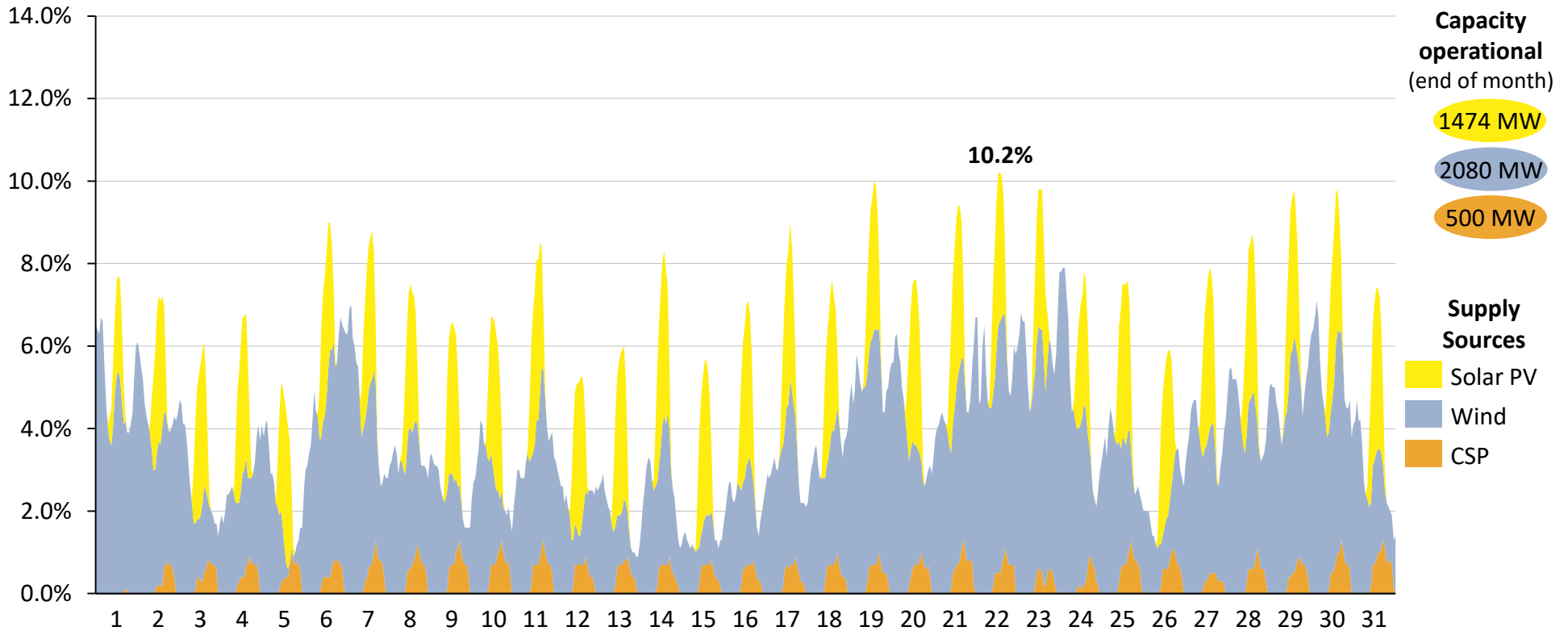


- Maximum solar PV relative contribution of 3.9% between 12h00 and 13h00 on 16 Jun 2019
- Maximum wind relative contribution of 7.8% between 03h00 and 04h00 on 5 Jun 2019
- Maximum CSP relative contribution of 1.6% between 16h00 and 17h00 on 23 Jun 2019

Hourly solar PV, wind & CSP contribution of 0.9-10.2% in Jul 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for July 2019

Relative hourly contribution

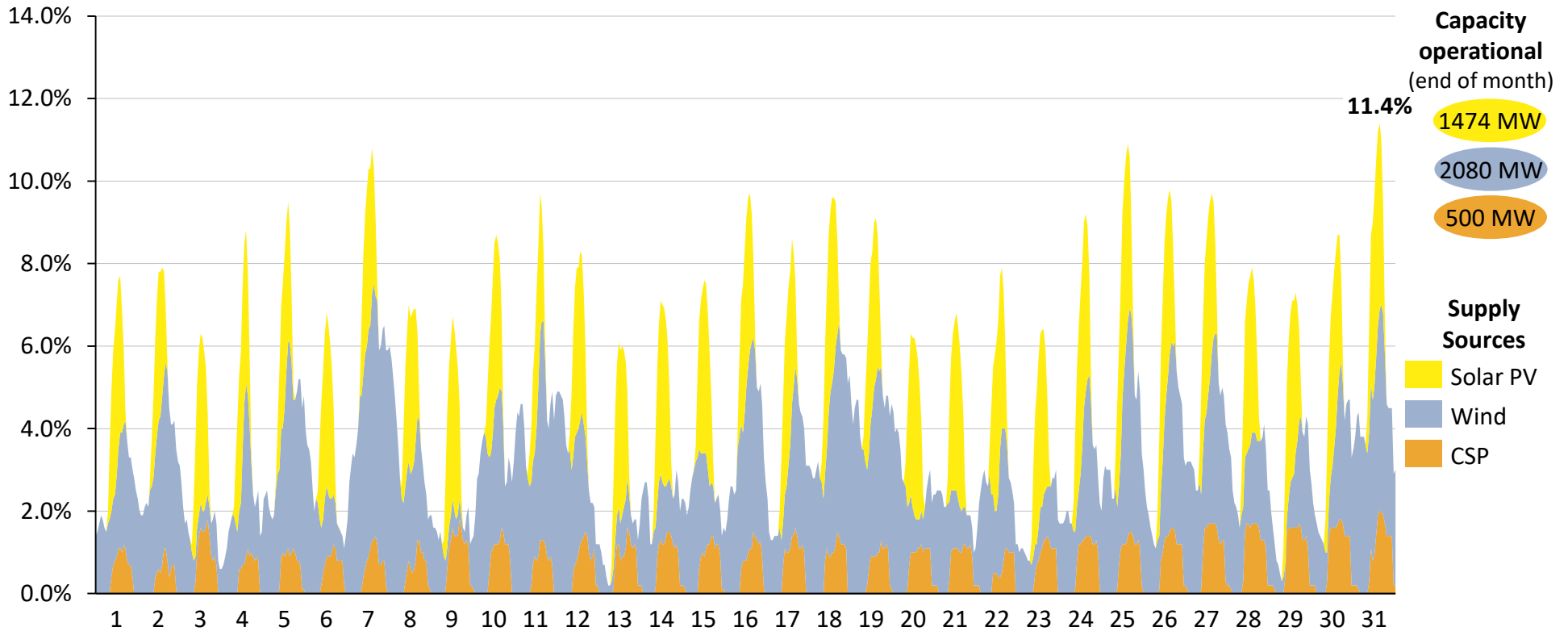


- Maximum solar PV relative contribution of 4.1% between 13h00 and 14h00 on 21 Jul 2019
- Maximum wind relative contribution of 7.9% between 01h00 and 02h00 on 24 Jul 2019
- Maximum CSP relative contribution of 1.3% between 16h00 and 17h00 on 27 Jul 2019

Hourly solar PV, wind & CSP contribution of 0.2-11.4% in Aug 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for August 2019

Relative hourly contribution

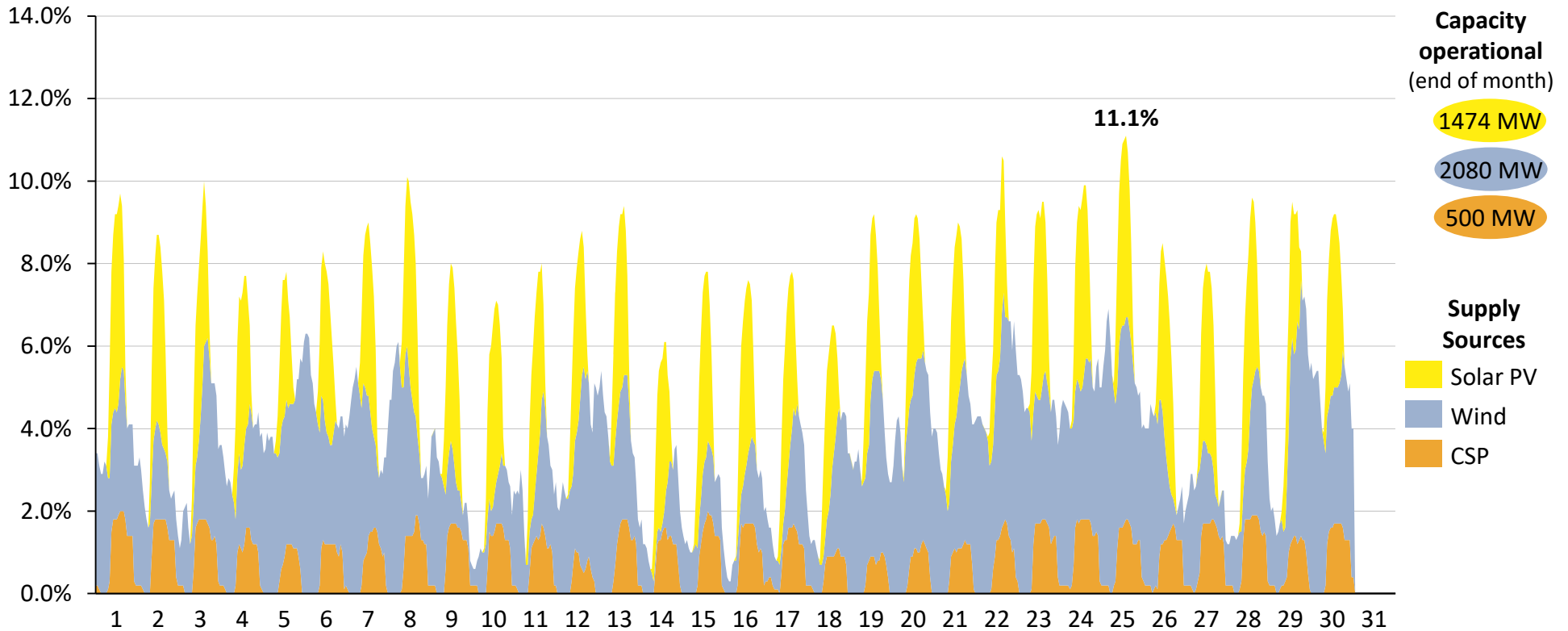


- Maximum solar PV relative contribution of 4.8% between 12h00 and 13h00 on 31 Aug 2019
- Maximum wind relative contribution of 6.2% between 15h00 and 16h00 on 7 Aug 2019
- Maximum CSP relative contribution of 2.0% between 15h00 and 16h00 on 31 Aug 2019

Hourly solar PV, wind & CSP contribution of 0.3-11.1% in Sep 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for September 2019

Relative hourly contribution

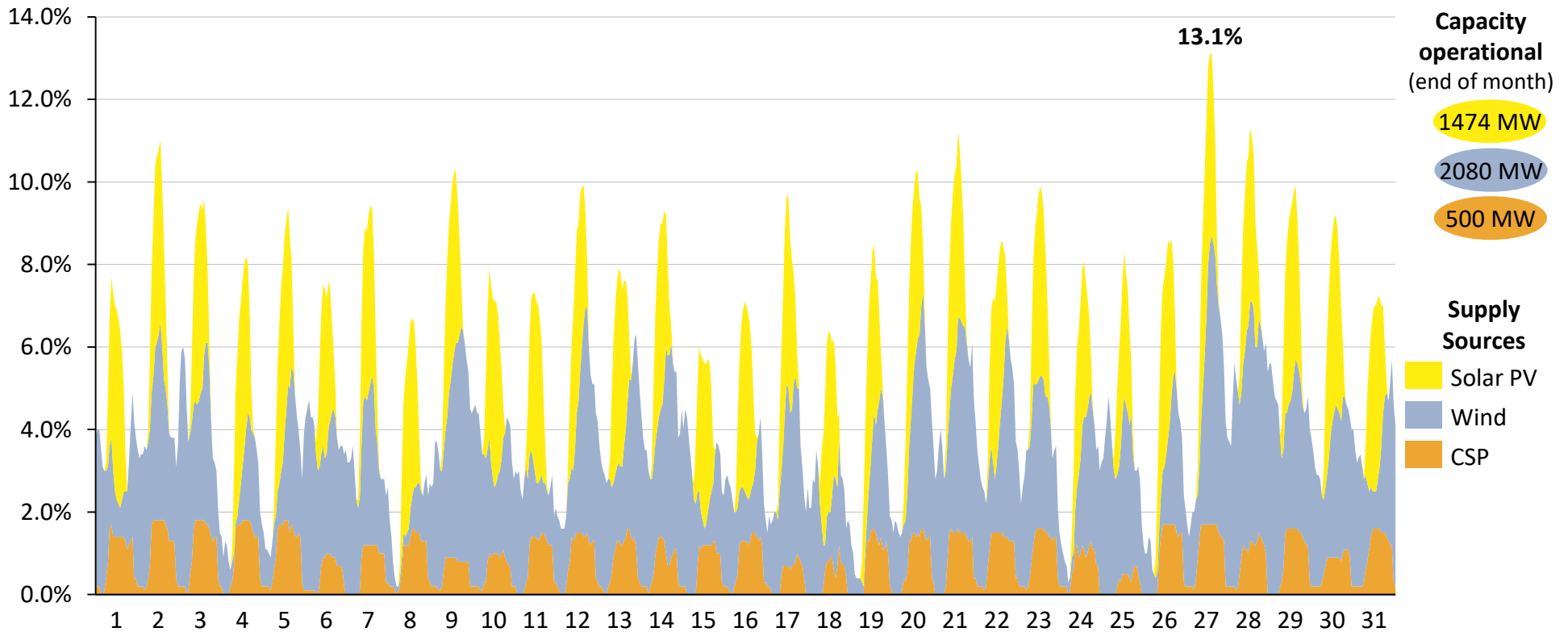


- Maximum solar PV relative contribution of 4.8% between 12h00 and 13h00 on 1 Sep 2019
- Maximum wind relative contribution of 6.7% between 03h00 and 04h00 on 25 Sep 2019
- Maximum CSP relative contribution of 2.0% between 15h00 and 16h00 on 1 Sep 2019

Hourly solar PV, wind & CSP contribution of 0.2-13.1% in Oct 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for October 2019

Relative hourly contribution

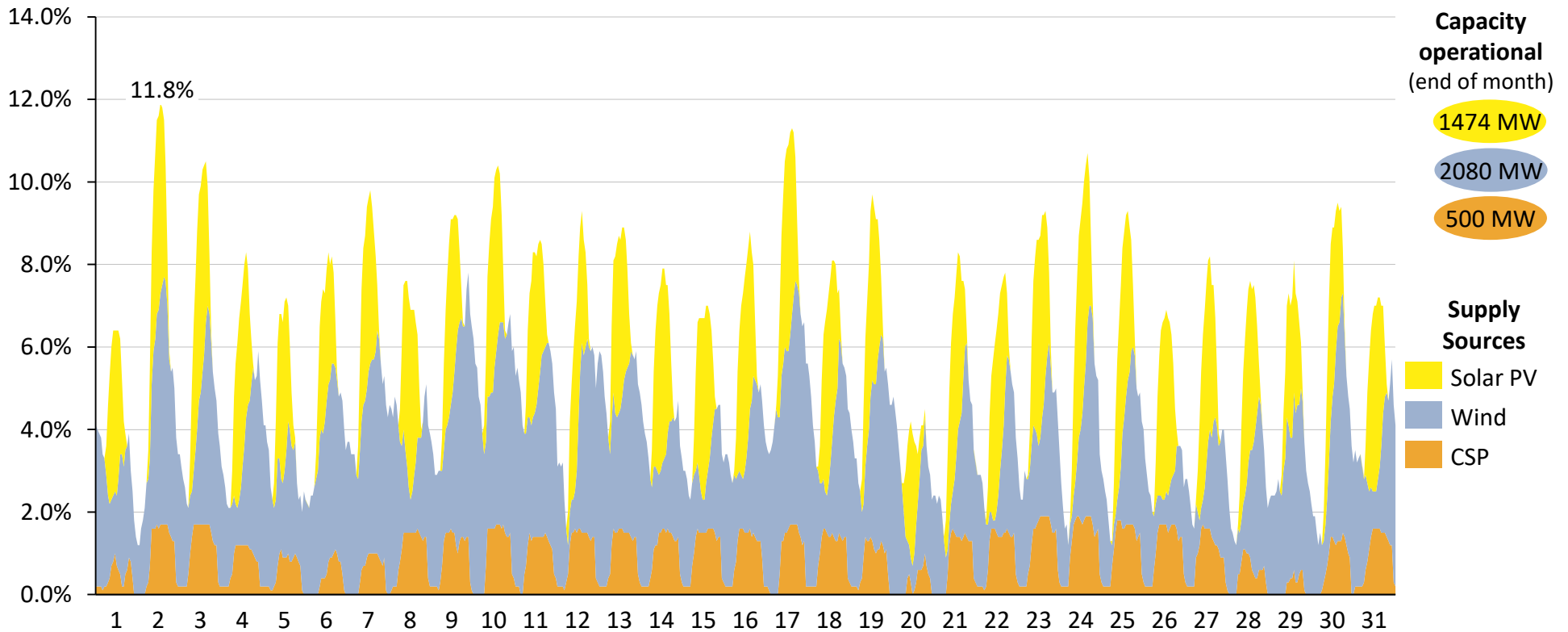


- Maximum solar PV relative contribution of 4.8% between 11h00 and 12h00 on 27 Oct 2019
- Maximum wind relative contribution of 7.0% between 14h00 and 15h00 on 27 Oct 2019
- Maximum CSP relative contribution of 1.8% between 14h00 and 15h00 on 5 Oct 2019

Hourly solar PV, wind & CSP contribution of 1.2-11.8% in Nov 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for November 2019

Relative hourly contribution

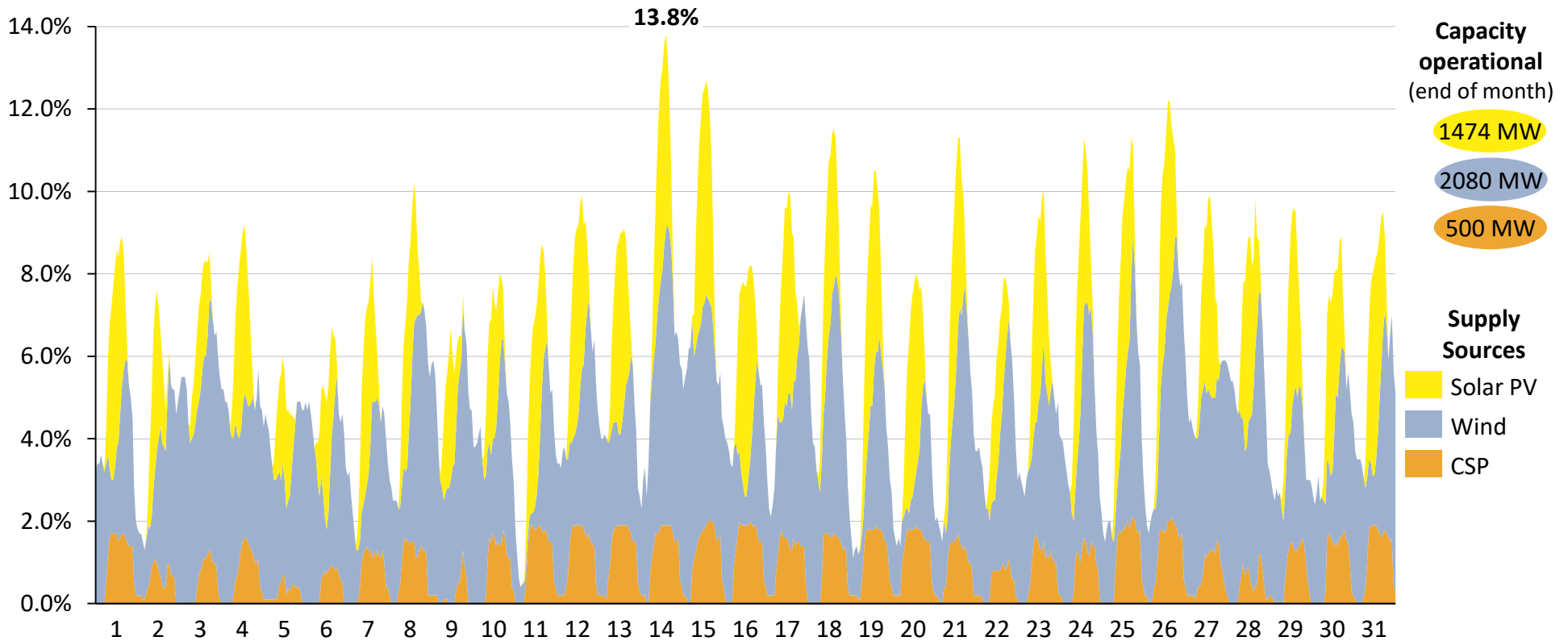


- Maximum solar PV relative contribution of 5.1% between 12h00 and 13h00 on 24 Nov 2019
- Maximum wind relative contribution of 6.5% between 22h00 and 23h00 on 9 Nov 2019
- Maximum CSP relative contribution of 1.9% between 15h00 and 16h00 on 24 Nov 2019

Hourly solar PV, wind & CSP contribution of 0.4-13.8% in Dec 2019

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for December 2019

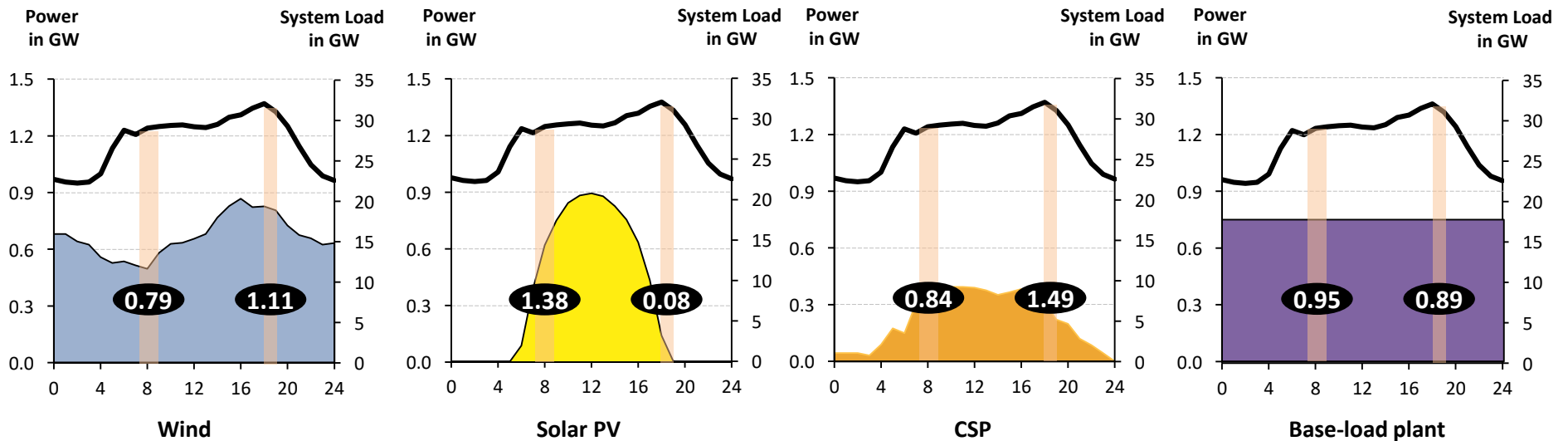
Relative hourly contribution



- Maximum solar PV relative contribution of 5.2% between 11h00 and 12h00 on 15 Dec 2019
- Maximum wind relative contribution of 7.3% between 15h00 and 16h00 on 14 Dec 2019
- Maximum CSP relative contribution of 2.1% between 17h00 and 18h00 on 25 Dec 2019

The peak-hour contribution ratio of solar PV was higher than a base-load plant in the morning, wind & CSP higher than base-load in evening peak

Illustrative days showing the overlap of wind, solar PV, CSP and a base-load plant with the morning and evening peak hours

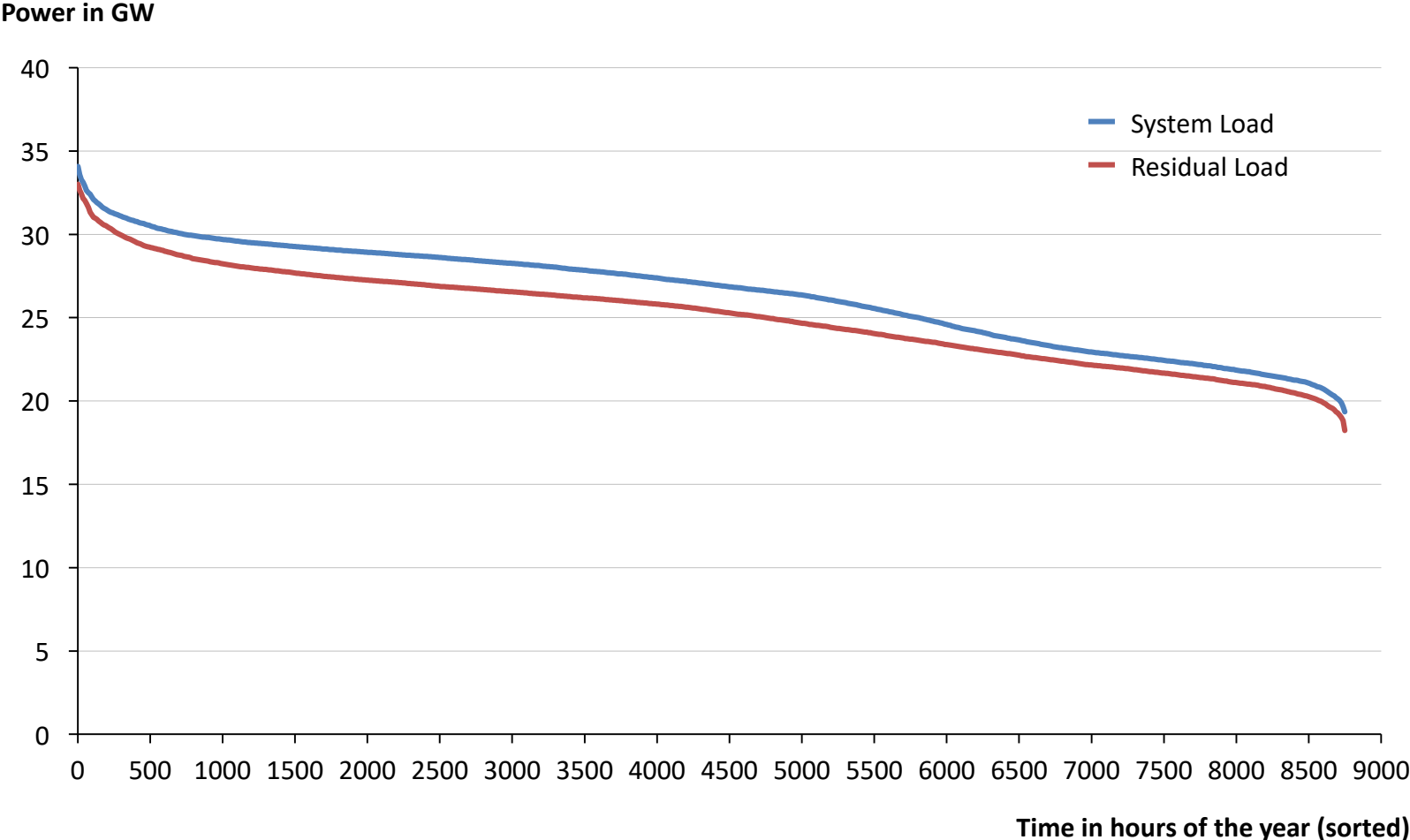


Peak-hour contribution ratio = relative energy contribution during peak / relative total energy contribution

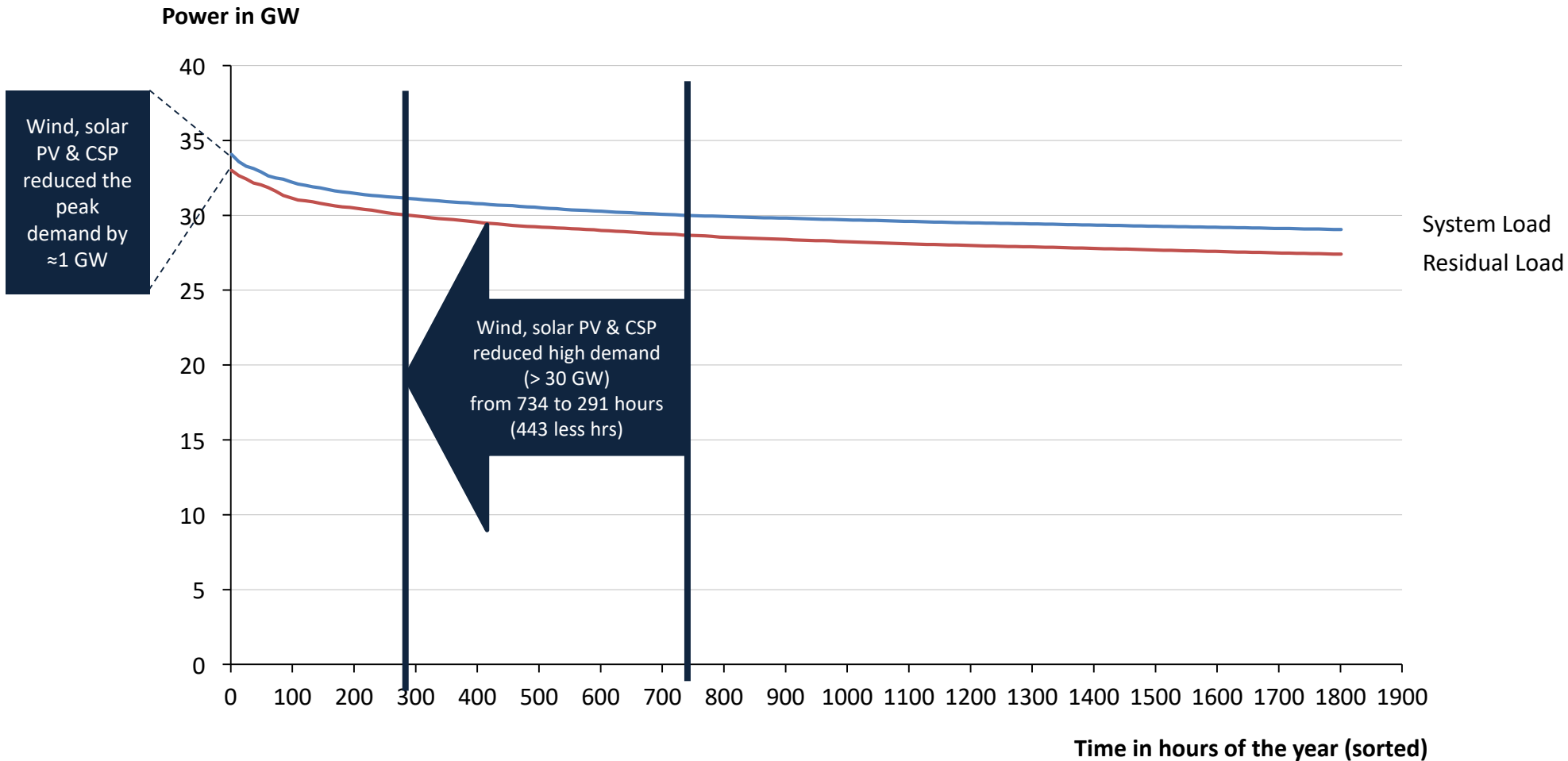
Wind, solar PV and CSP morning and evening peak-hour contribution ratios (for all hours from Jan-Dec 2019) show that:

- Wind contributes 11% more energy during the evening peaks than it does during the other hours of the day
- Solar PV contributes 38% more energy in the morning peaks than it does during the other hours of the day
- CSP contributes 49% more energy during the evening peaks than it does during the other hours of the day

Jan - Dec 2019 system load and residual load duration curves

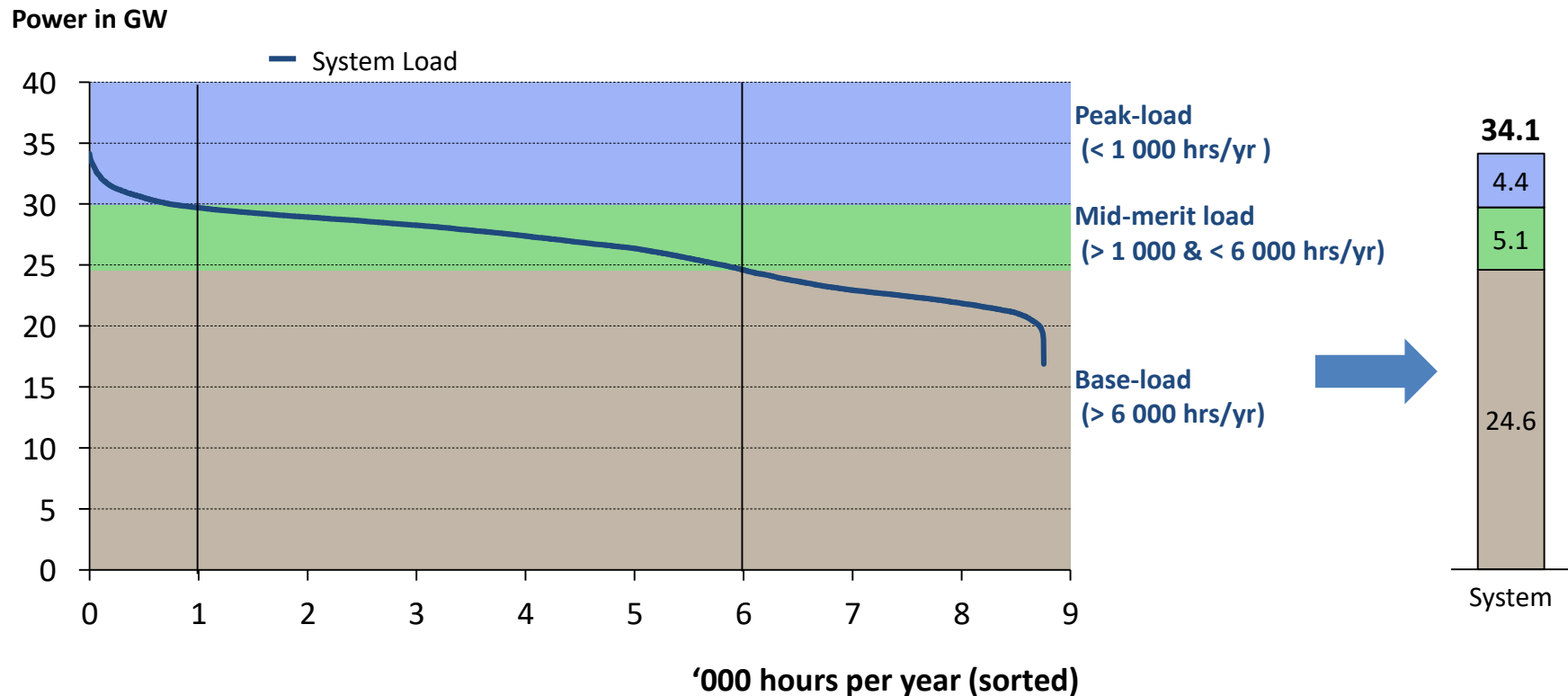


From Jan-Dec 2019 - wind, solar PV & CSP reduced the number of hours with > 30 GW total load from 734 to 291 (~443 hours less)



System load for 2019 meant peaking type capacity of 4.4 GW, mid-merit capacity of 5.1 GW, and base-load capacity of 24.6 GW

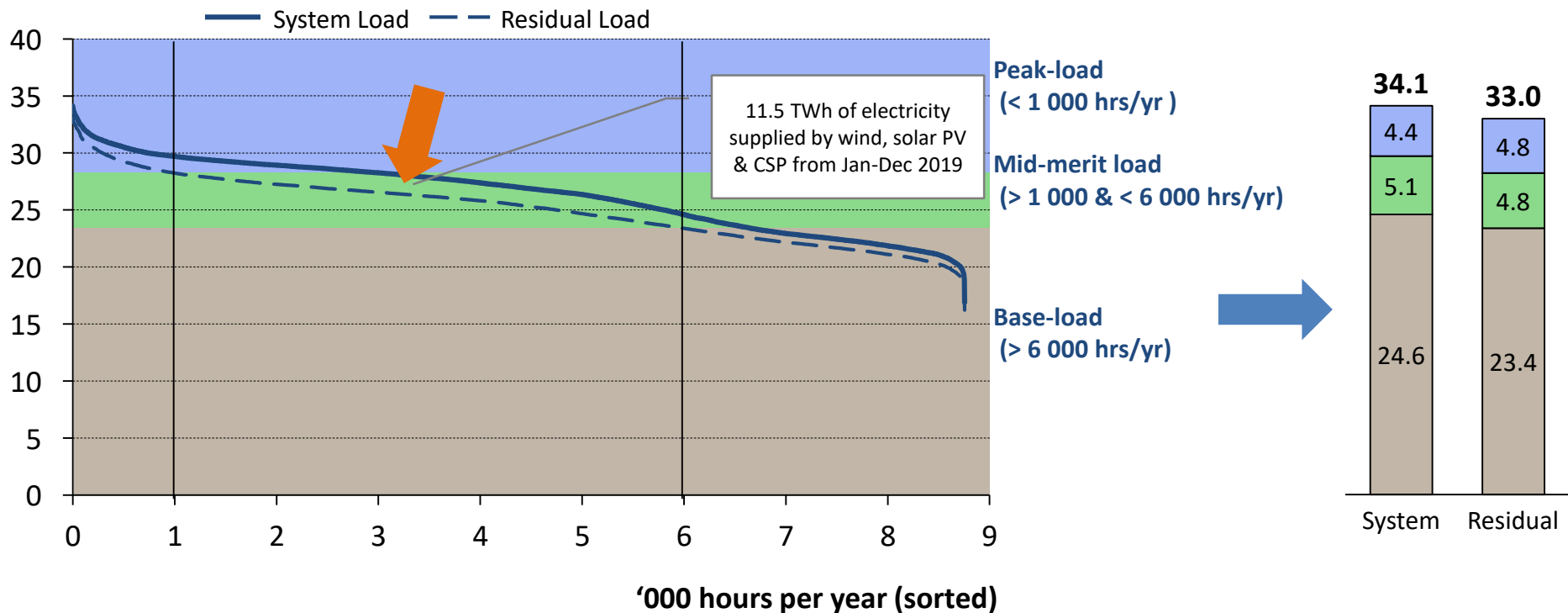
Load Duration Curve for Jan to Dec 2019 as per actual data



Wind/PV/CSP changes shape of residual load to require more peaking type capacity, less mid-merit and notably less base-load type capacity

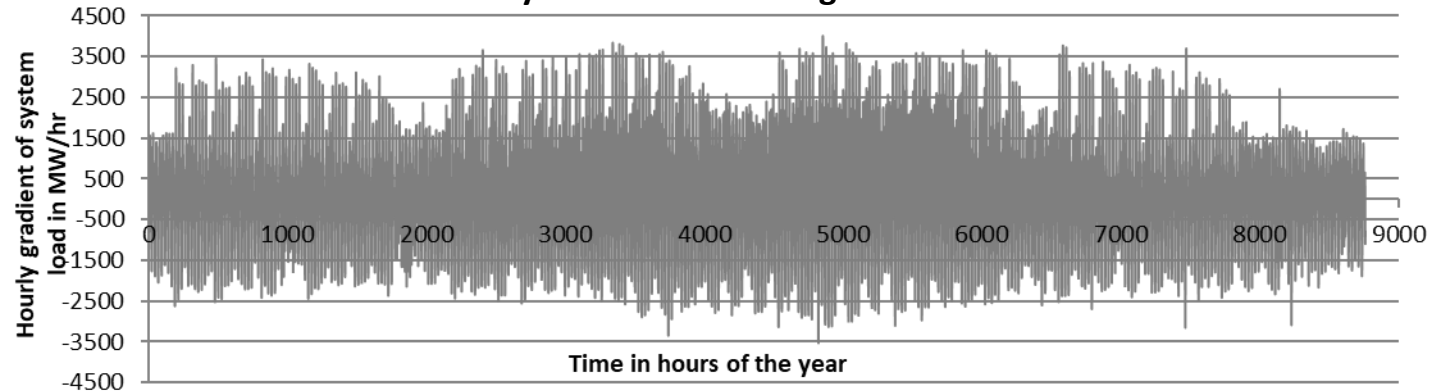
Load Duration Curve for Jan to Dec 2019 as per actual data

Power in GW



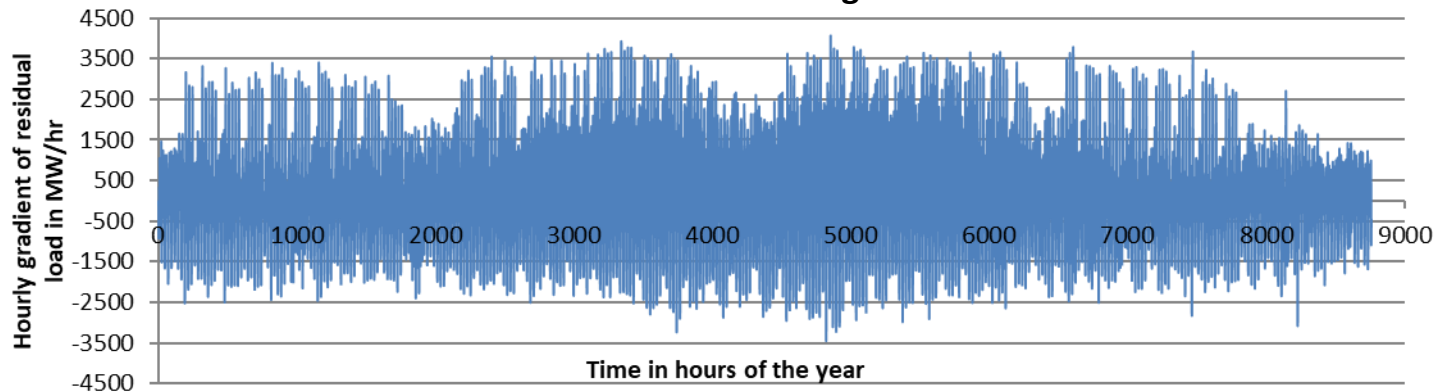
1-hour gradients minimally affected by 4 GW of wind, solar PV & CSP

System Load 1-hour-gradients Jan - Dec 2019



- Max gradient of 4 015 MW/h on 22 July 2019 between 05h00 and 06h00
- Min gradient of -3 521 MW/h on 20 July 2019 between 21h00 and 22h00

Residual Load 1-hour-gradients Jan - Dec 2019

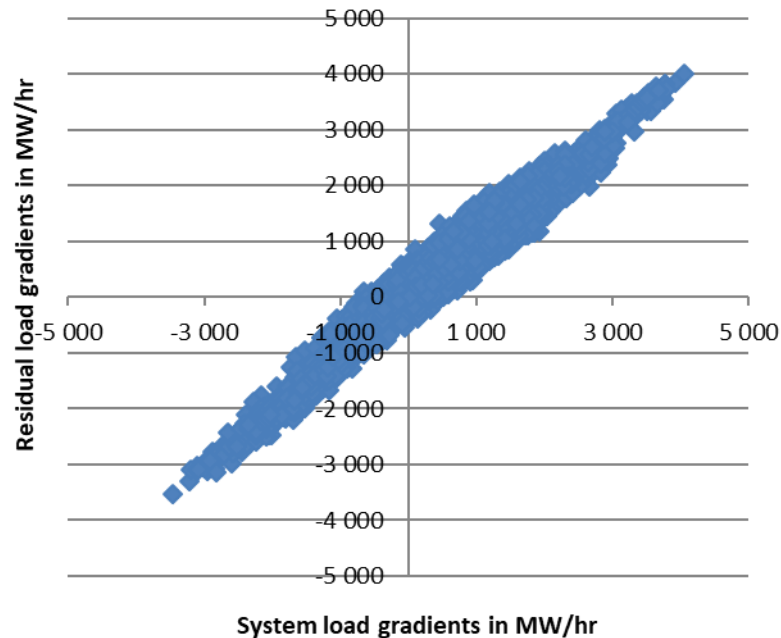


- Max gradient of 4 059 MW/h on 22 July 2019 between 05h00 and 06h00
- Min gradient of -3 456 MW/h on 20 July 2019 between 21h00 and 22h00

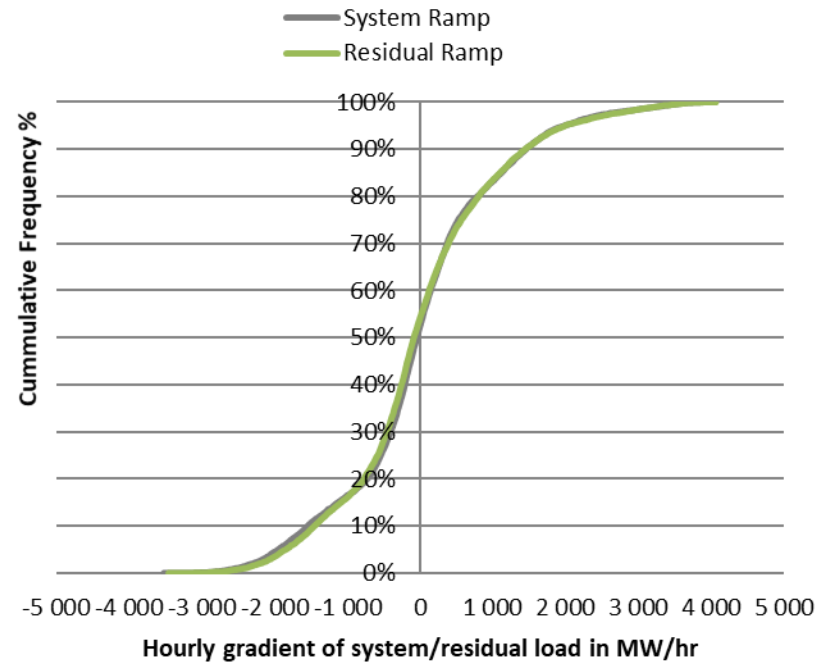
Residual load = System load - Solar PV - Wind - CSP

1-hour gradients did not increase due to 4 GW of wind, solar PV & CSP

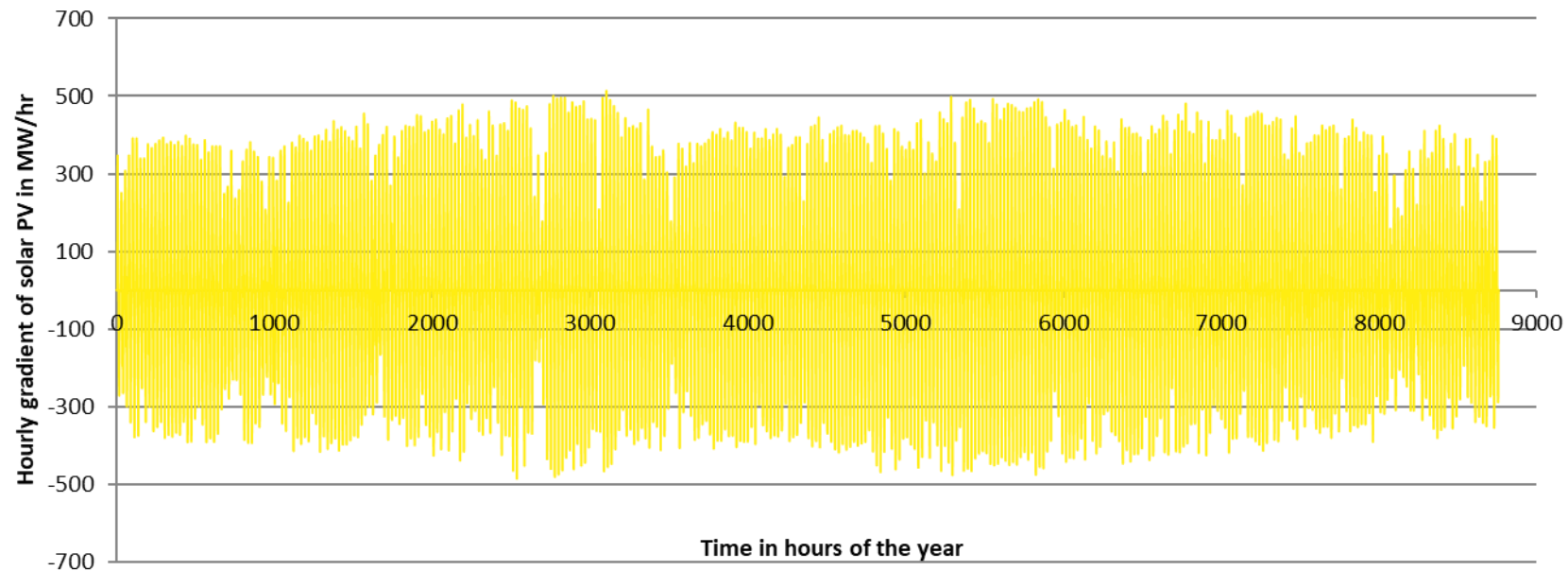
System load 1-hour gradients vs. residual load 1-hour gradients for all hours from Jan – Dec 2019



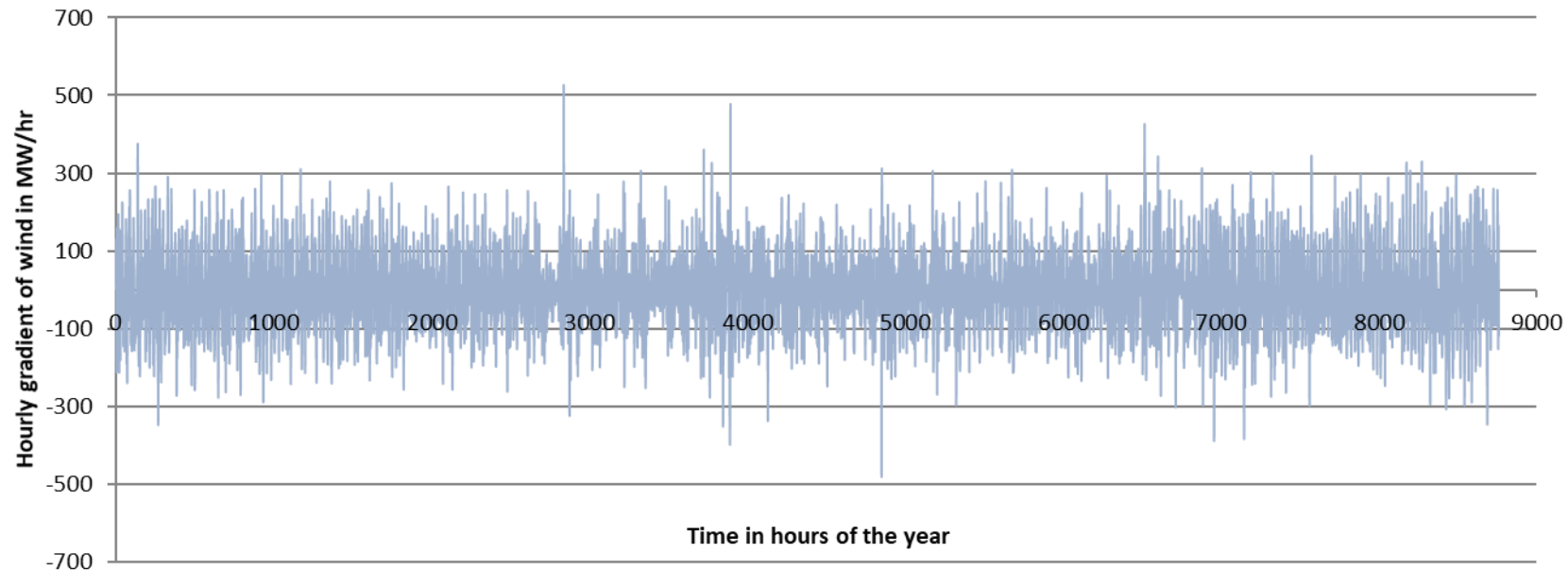
Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2019



Jan - Dec 2019 1-hour gradients of solar PV supply

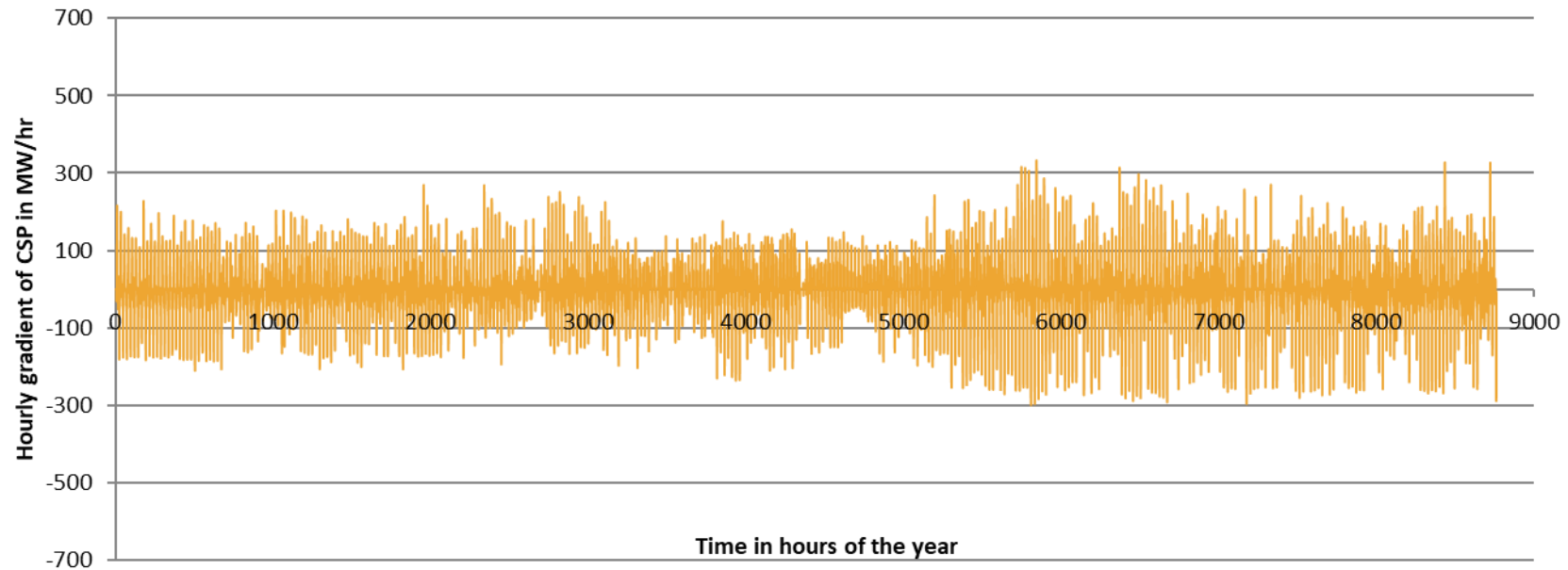


Jan - Dec 2019: 1-hour gradients of wind supply



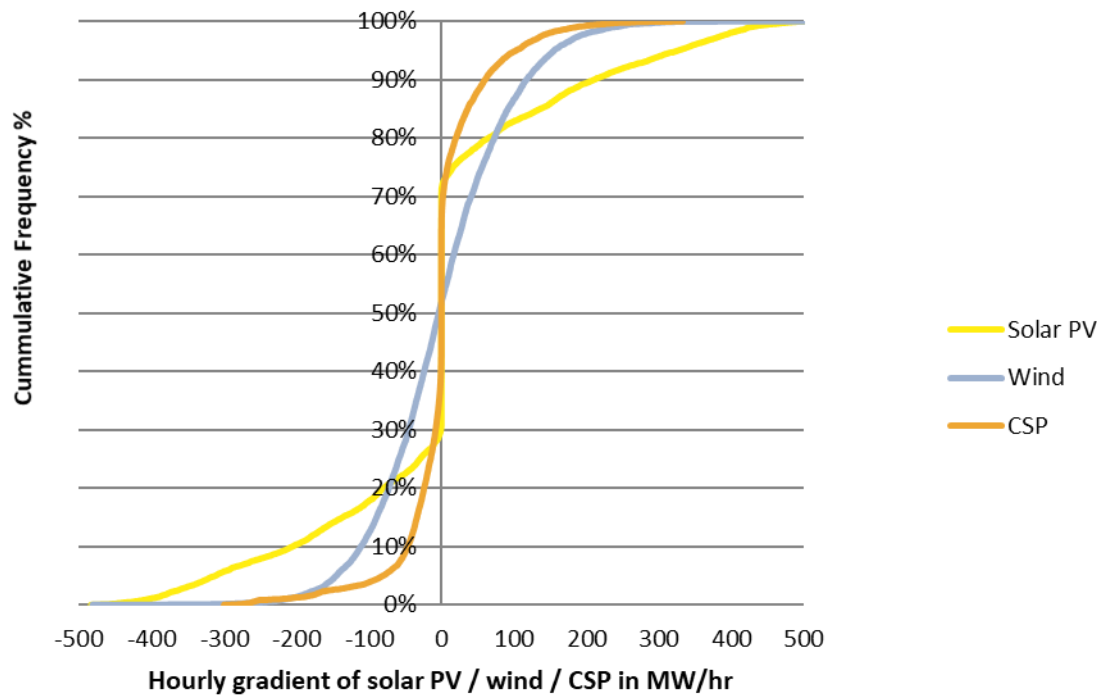
- *Large wind gradient spike of 564 MW on 28 Apr 2019 between 04h00 and 05h00 due to System Operator curtailment of wind IPPs in response to a combination of minimum thermal generation constraints and low demand*

Jan - Dec 2019 1-hour gradients of CSP supply

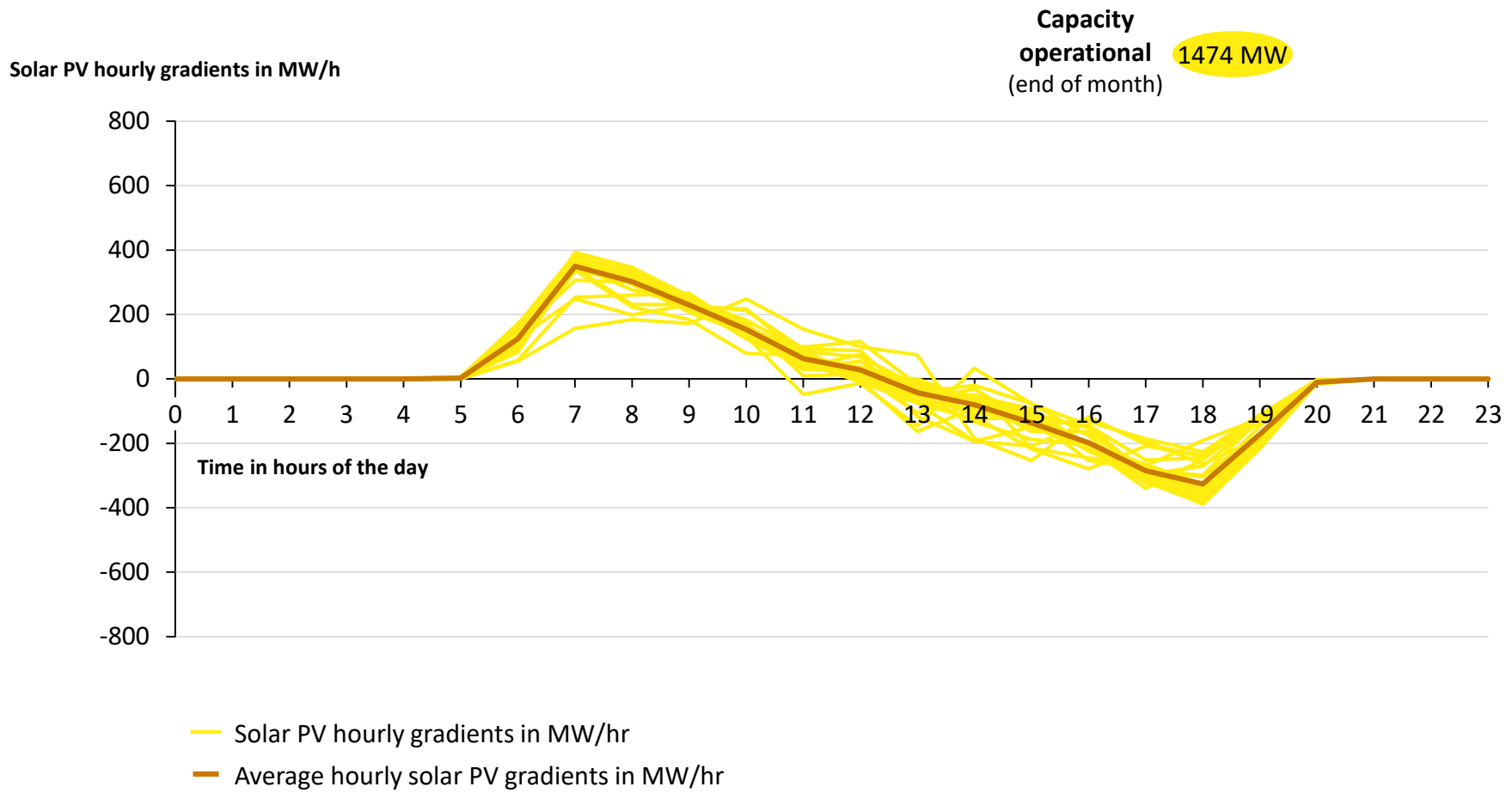


Jan - Dec 2019 wind, solar PV and CSP frequency distribution of 1-hour gradients

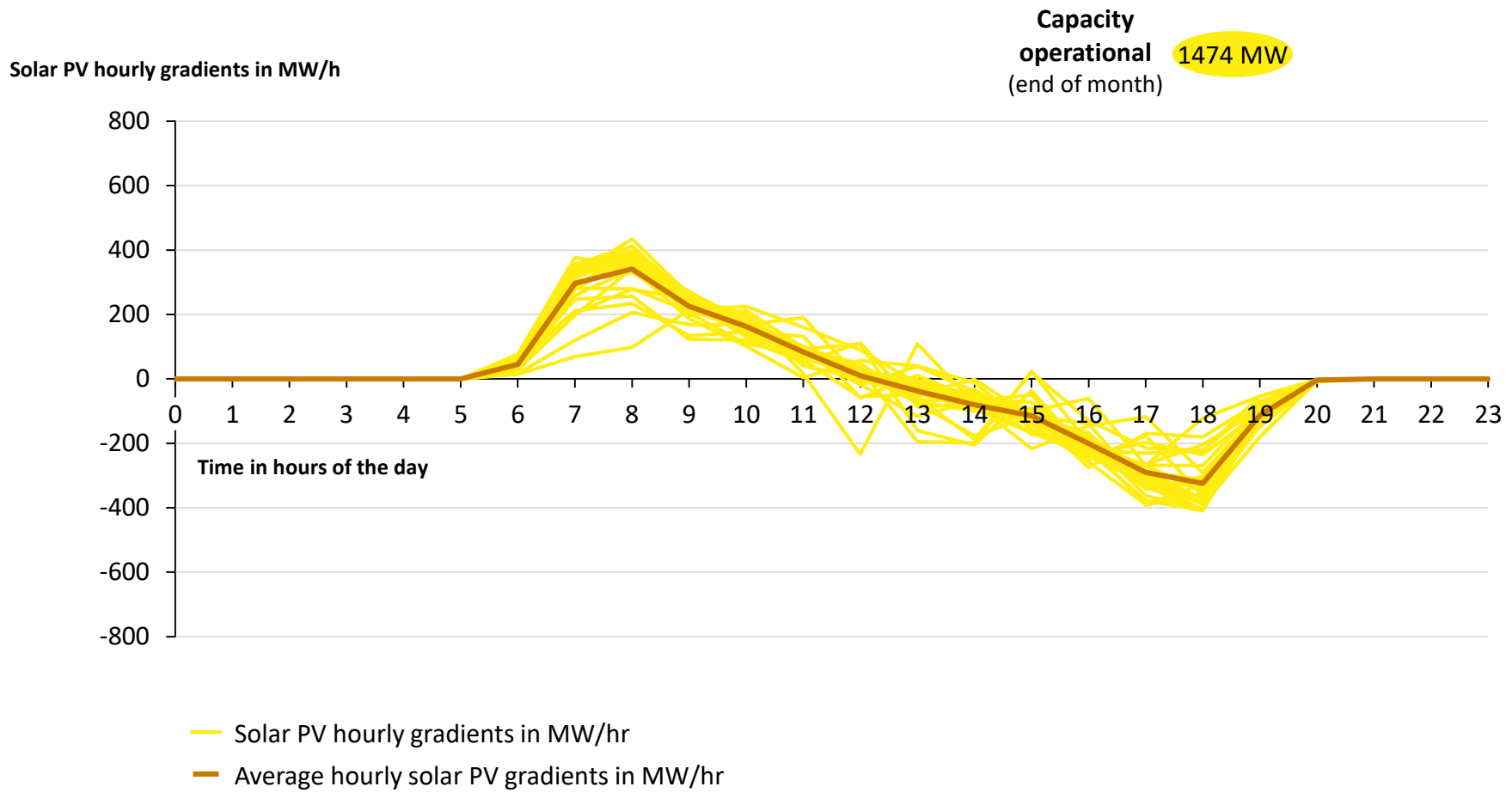
- Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2019



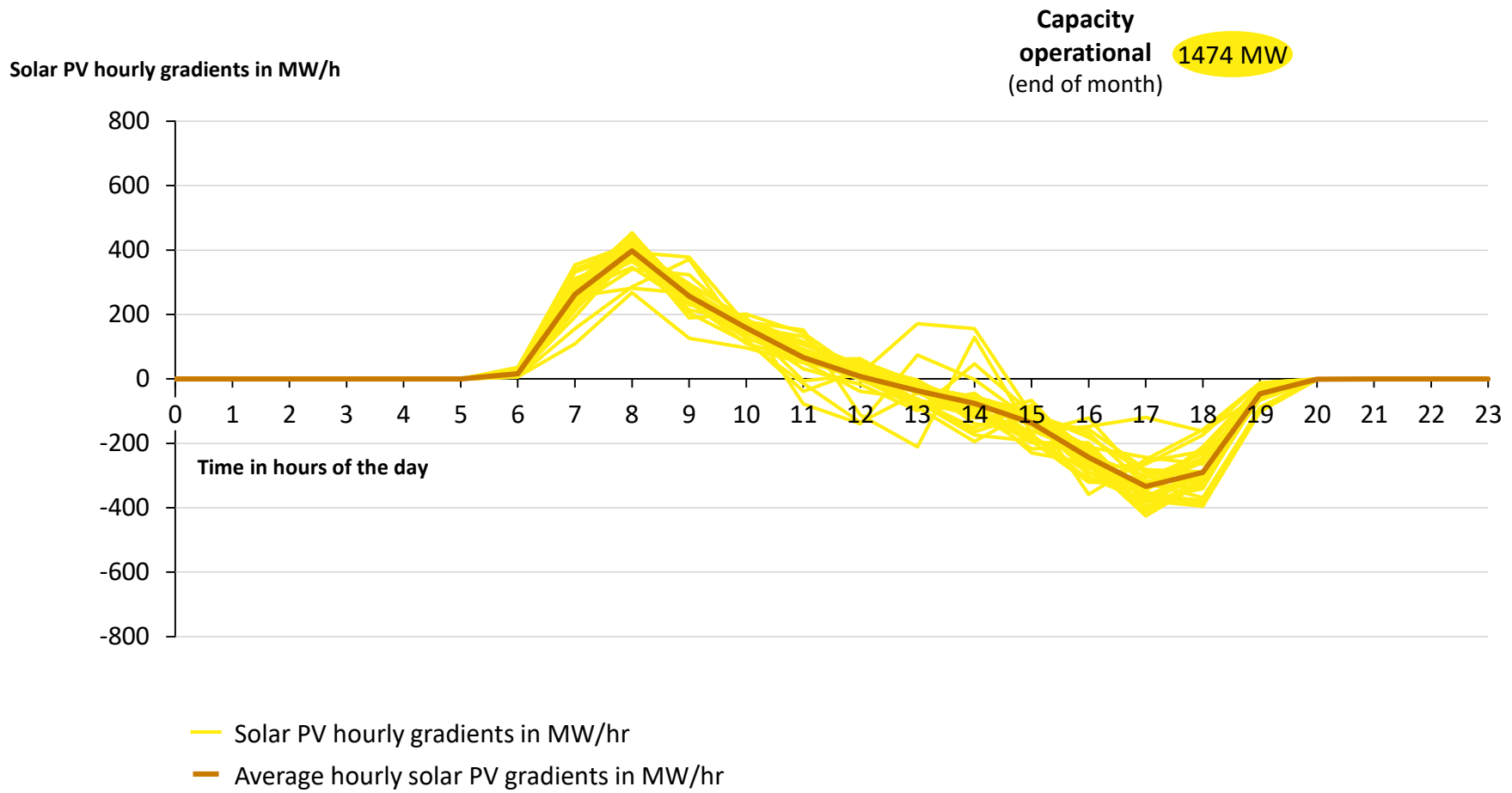
Solar PV 1-hour gradients in January 2019



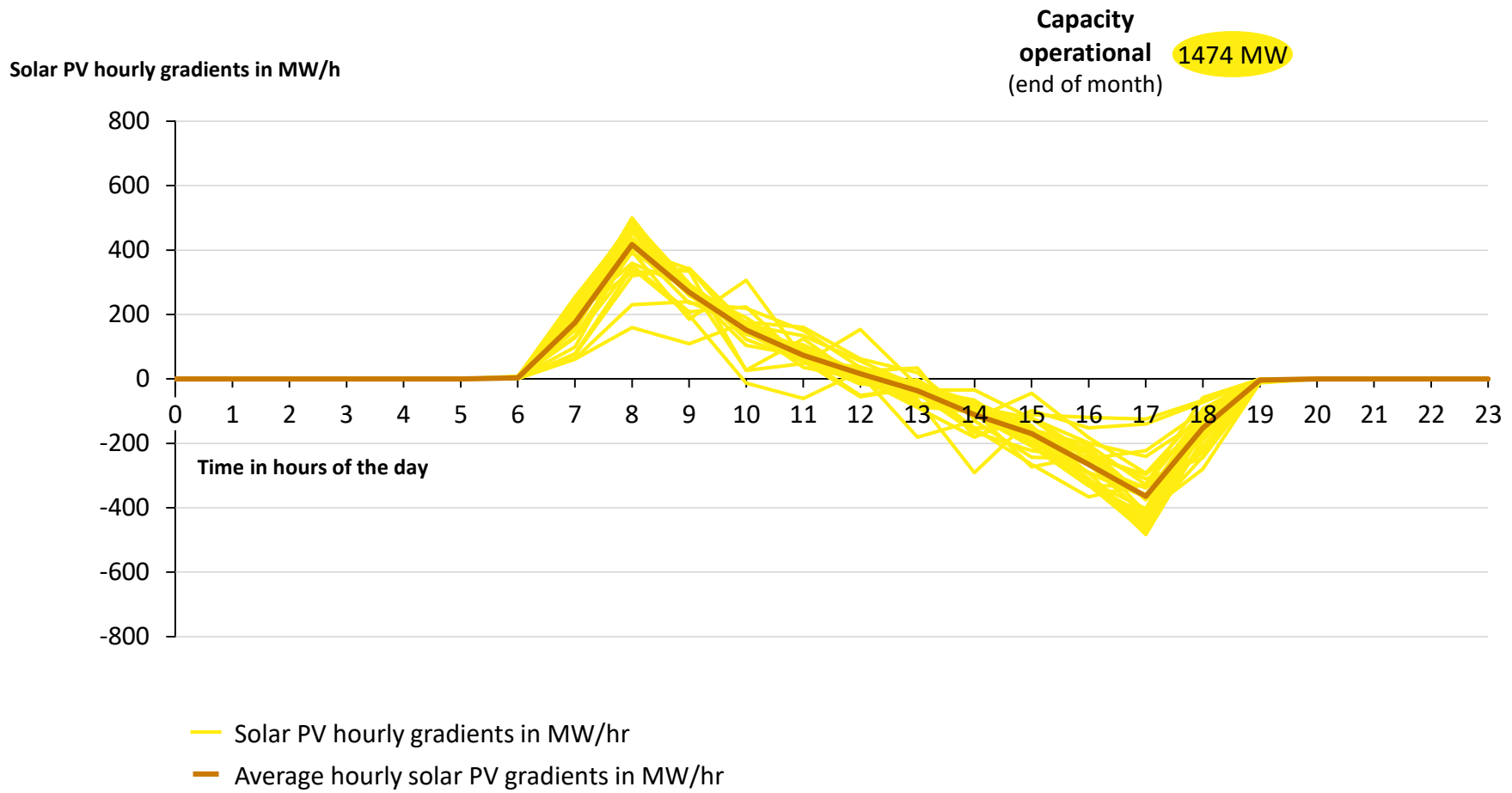
Solar PV 1-hour gradients in February 2019



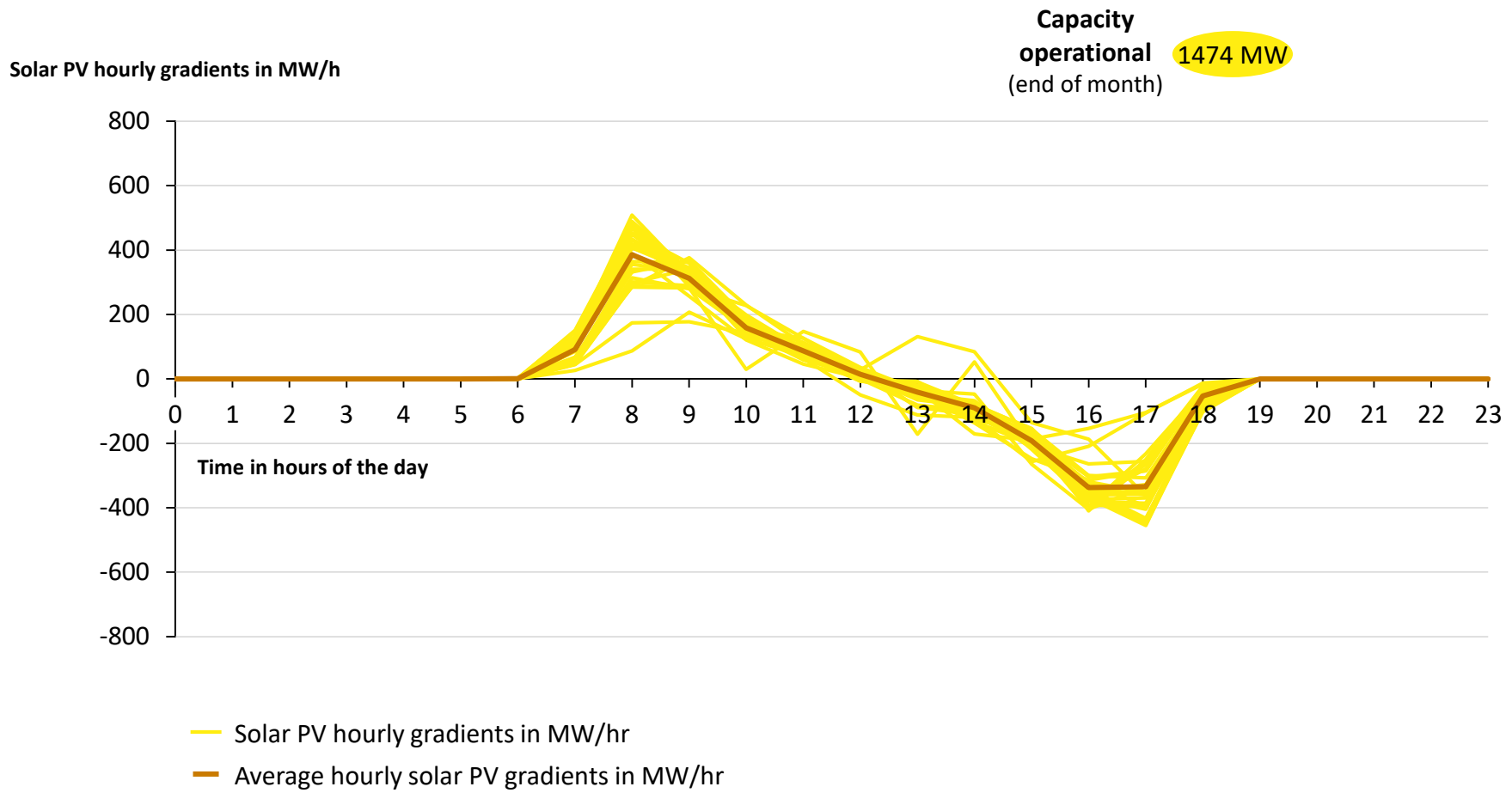
Solar PV 1-hour gradients in March 2019



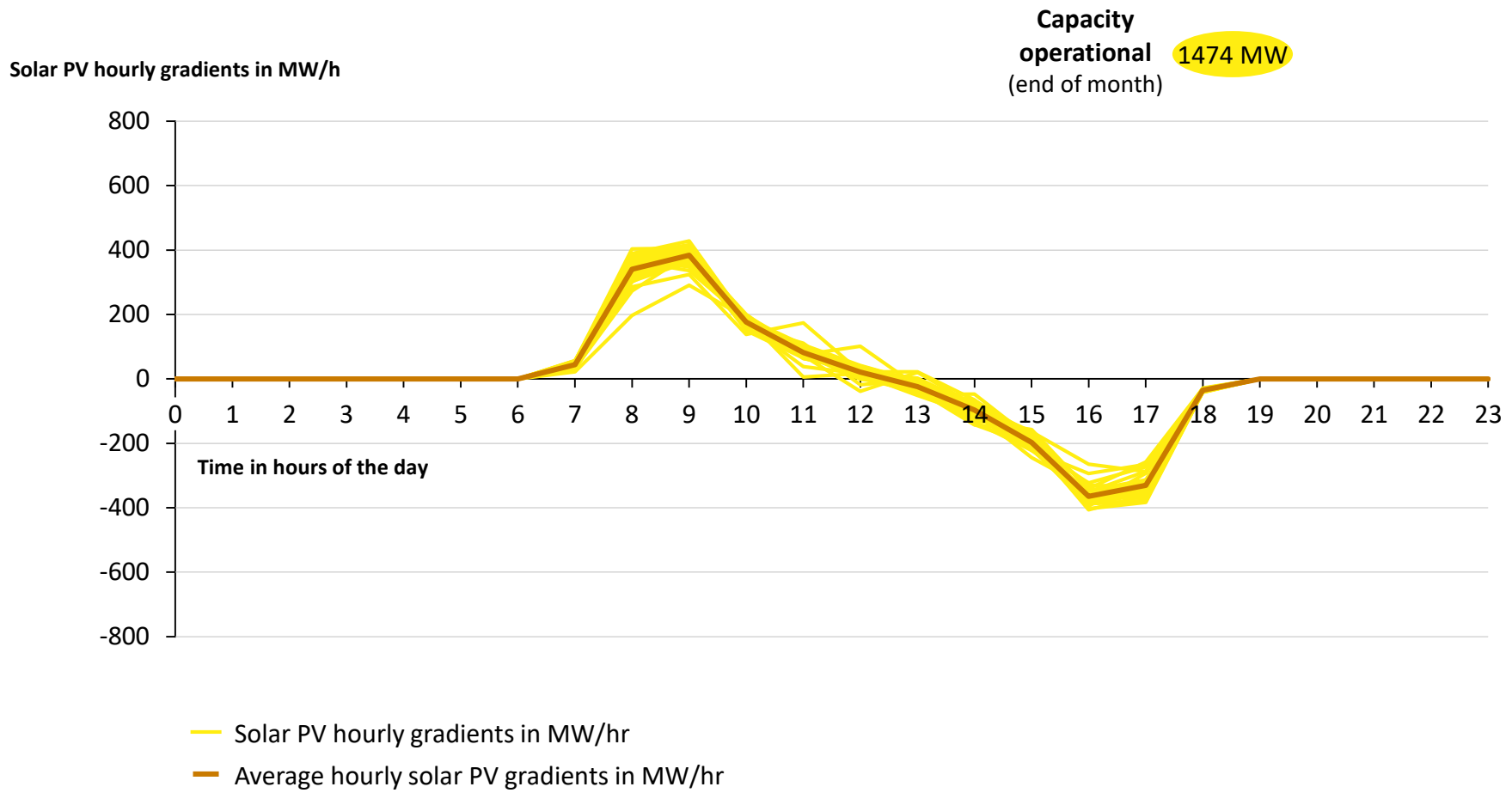
Solar PV 1-hour gradients in April 2019



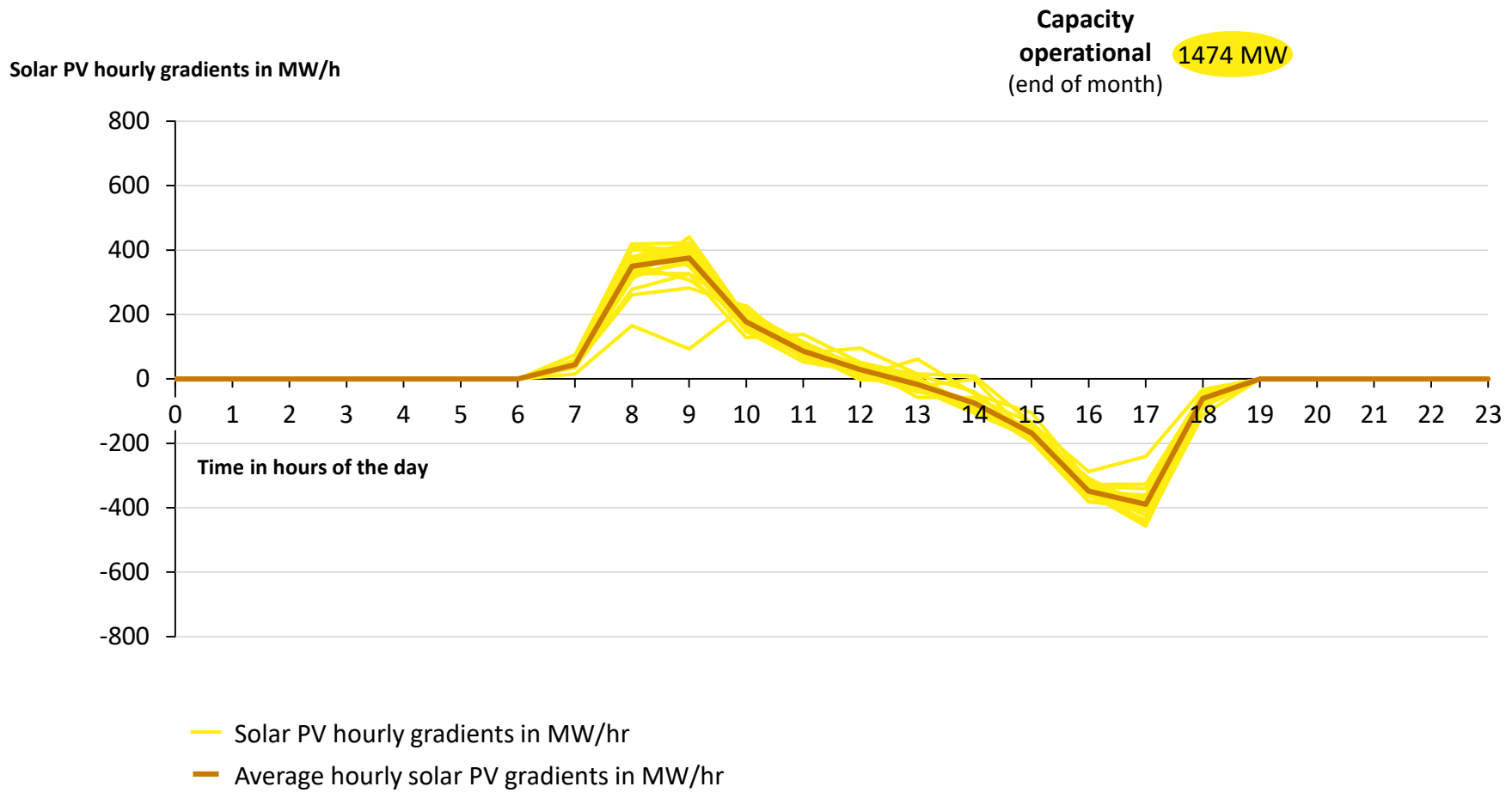
Solar PV 1-hour gradients in May 2019



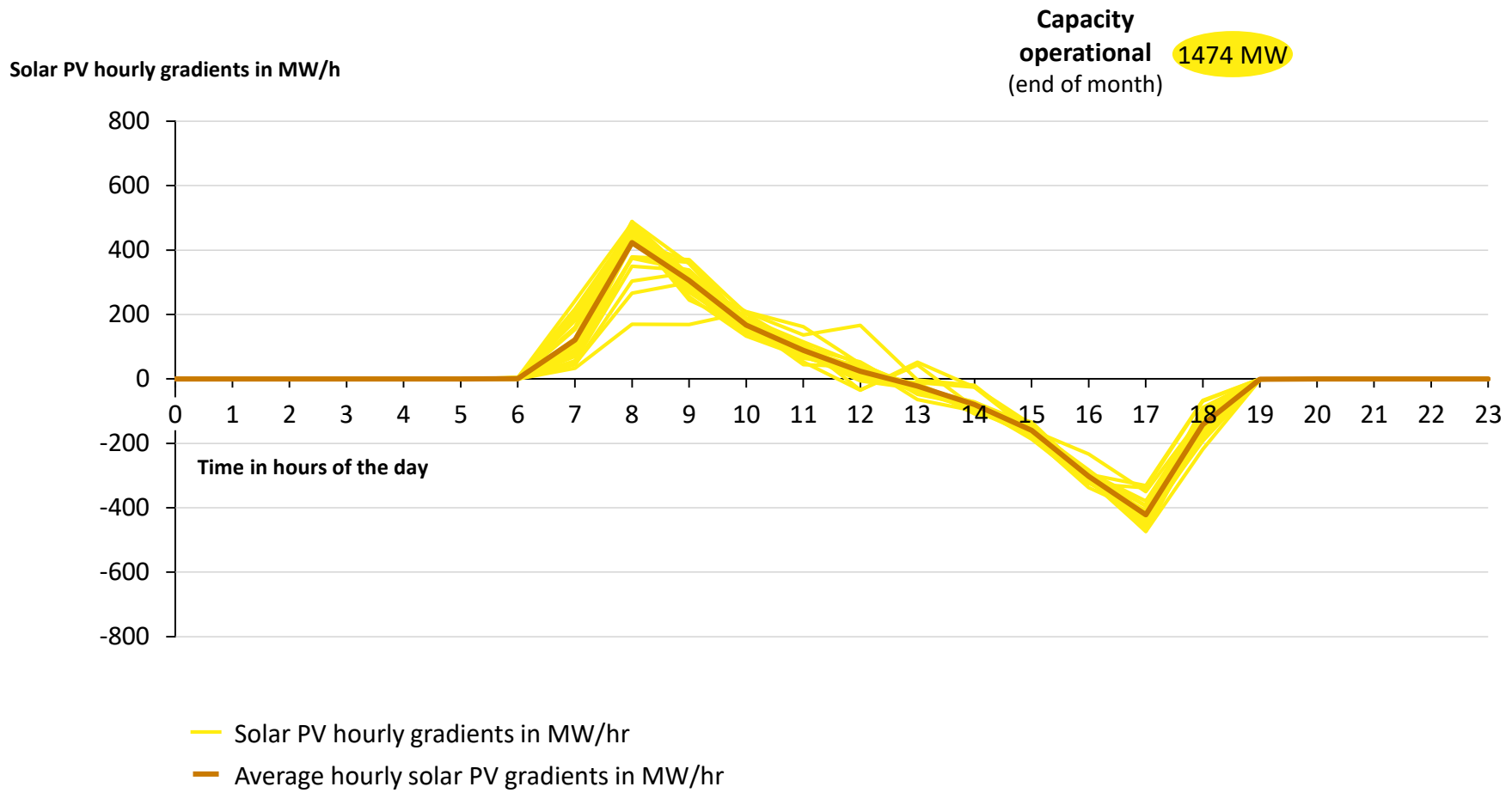
Solar PV 1-hour gradients in June 2019



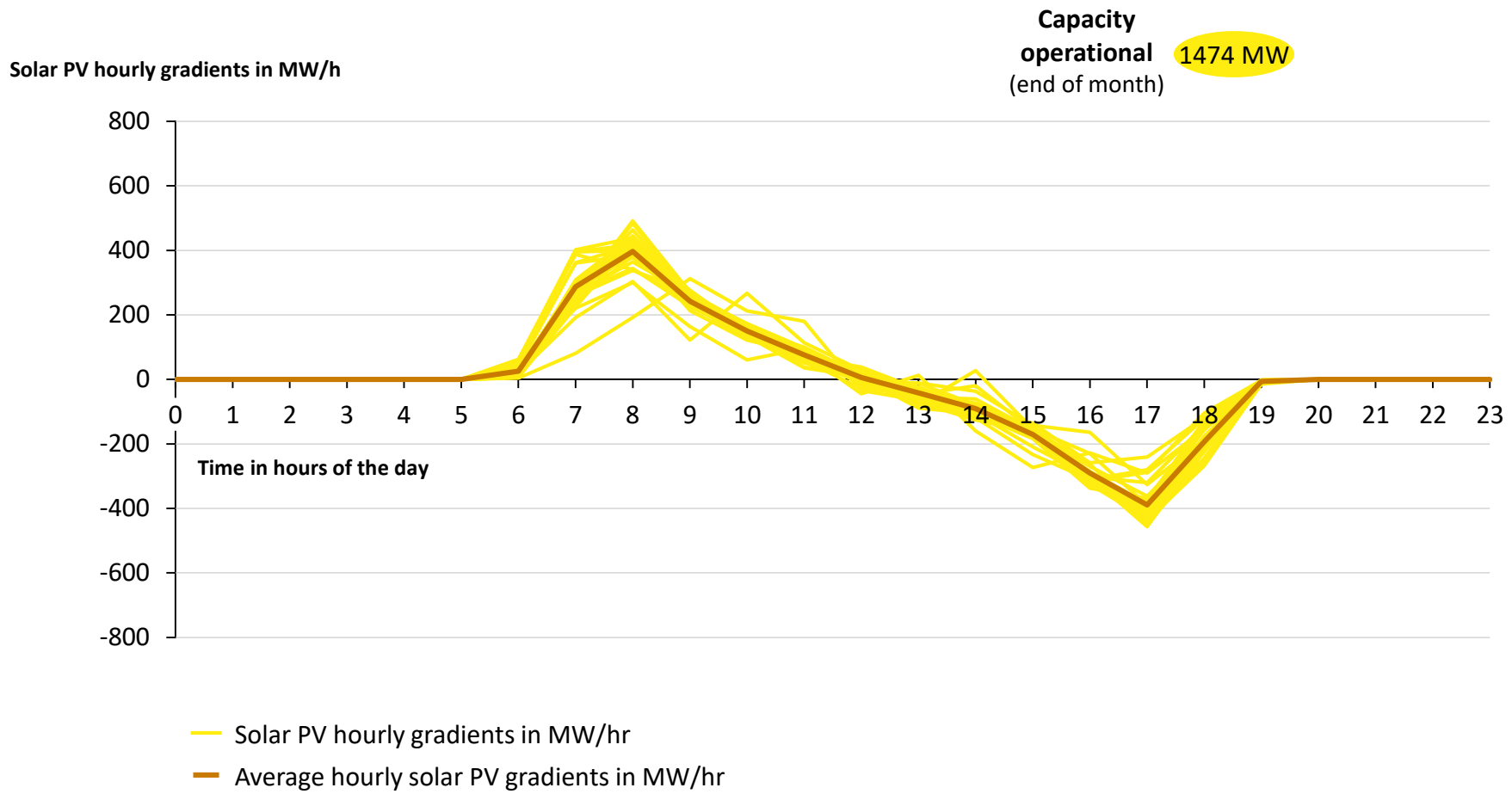
Solar PV 1-hour gradients in July 2019



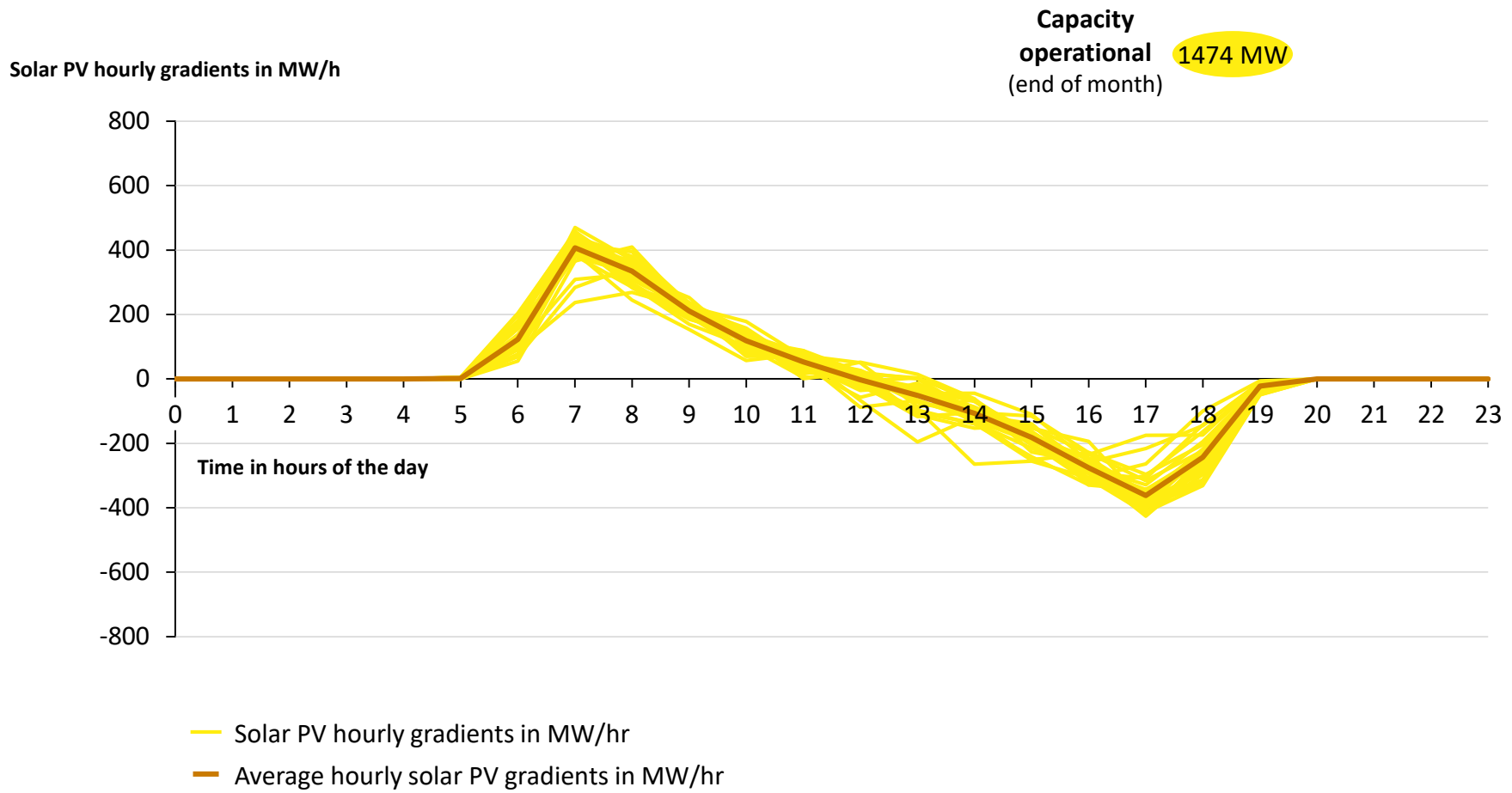
Solar PV 1-hour gradients in August 2019



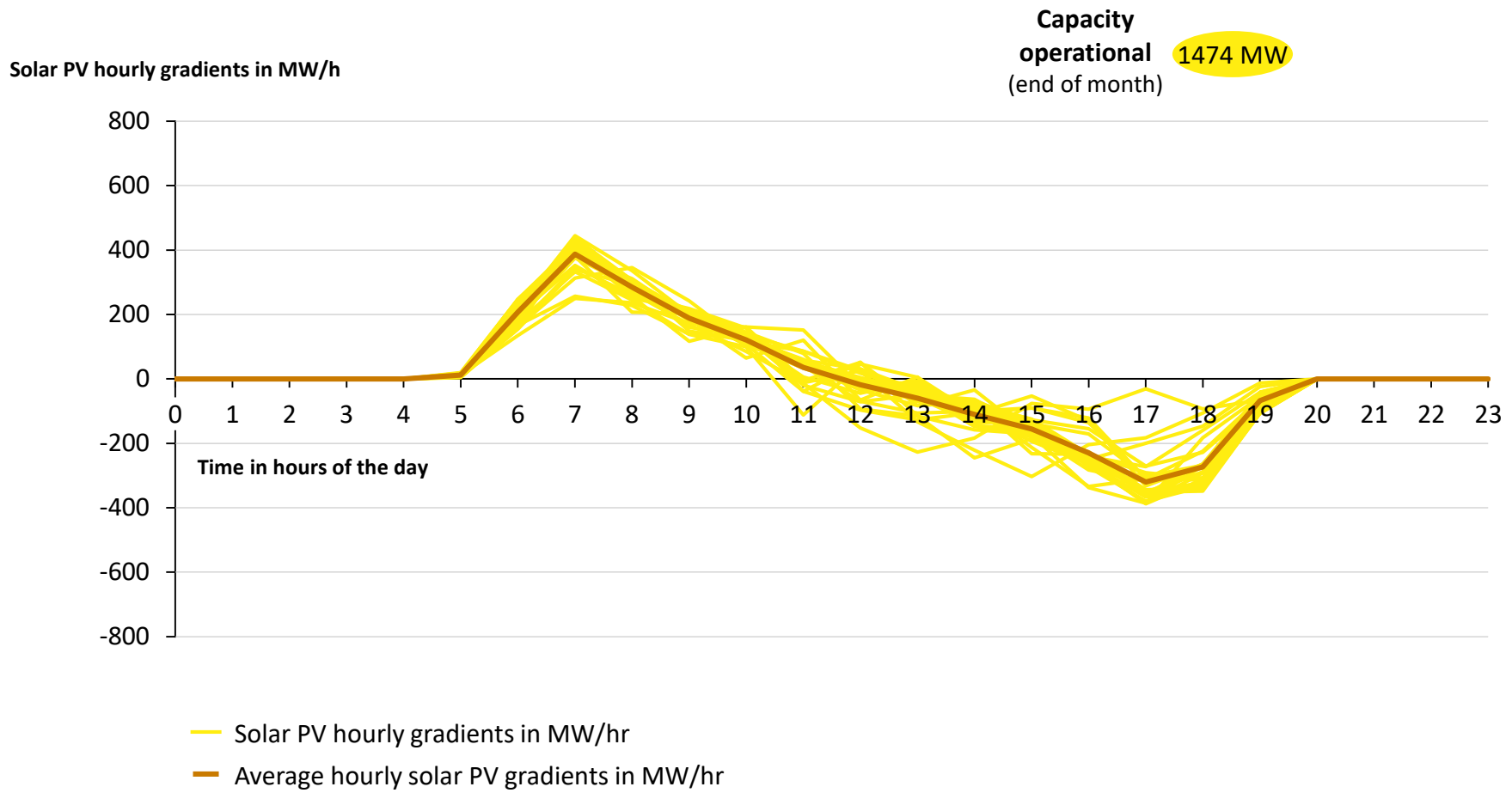
Solar PV 1-hour gradients in September 2019



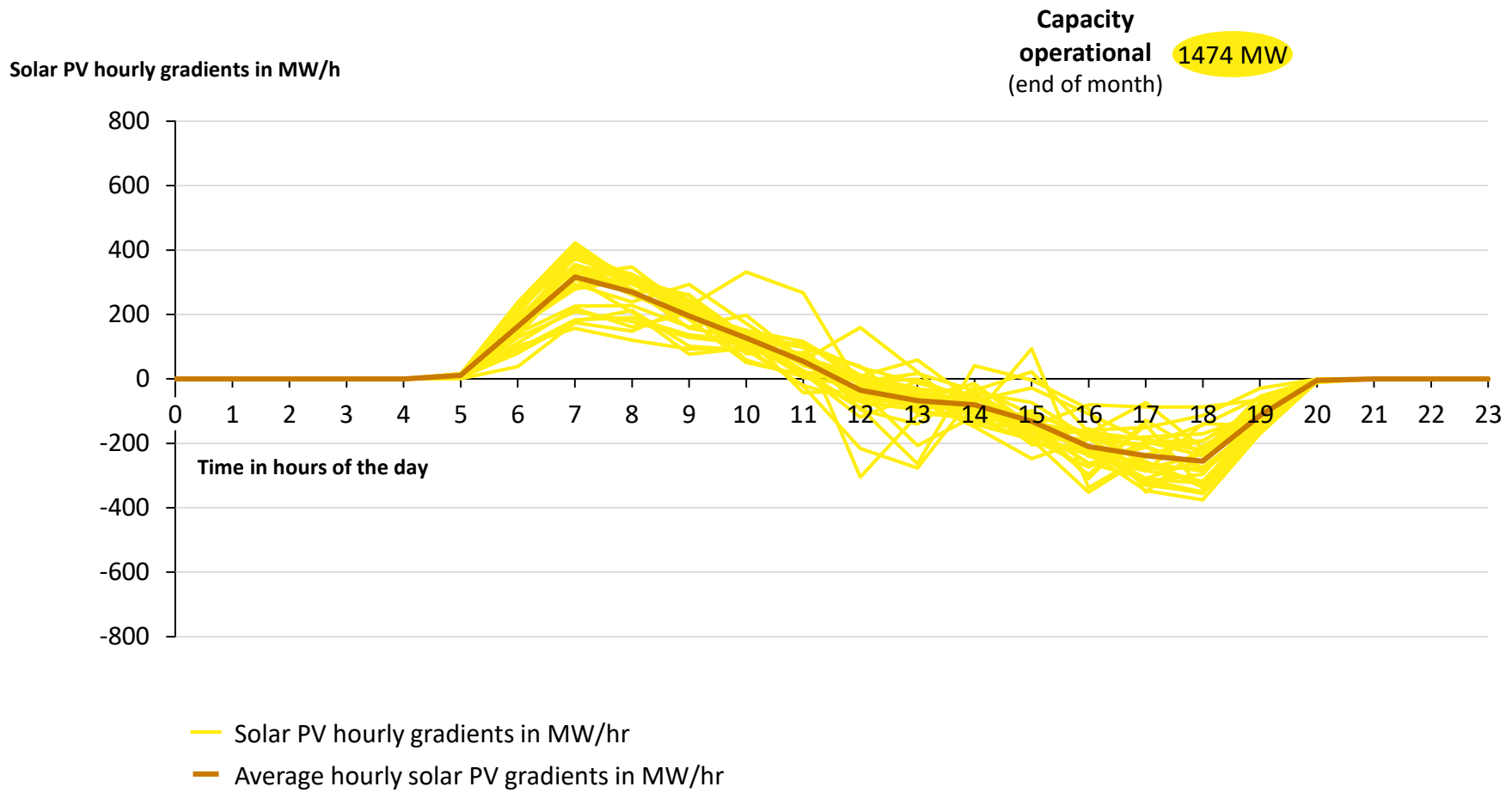
Solar PV 1-hour gradients in October 2019



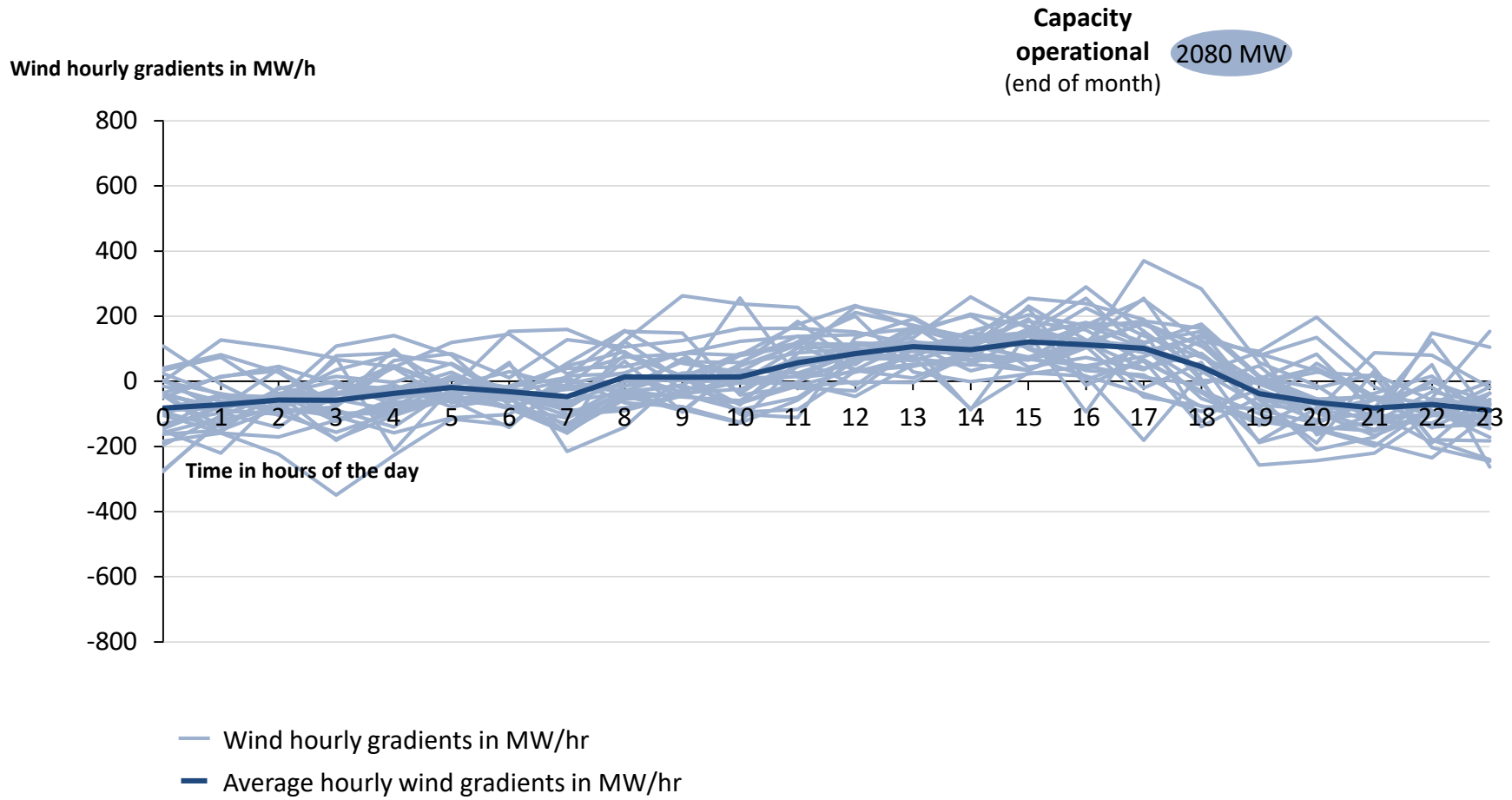
Solar PV 1-hour gradients in November 2019



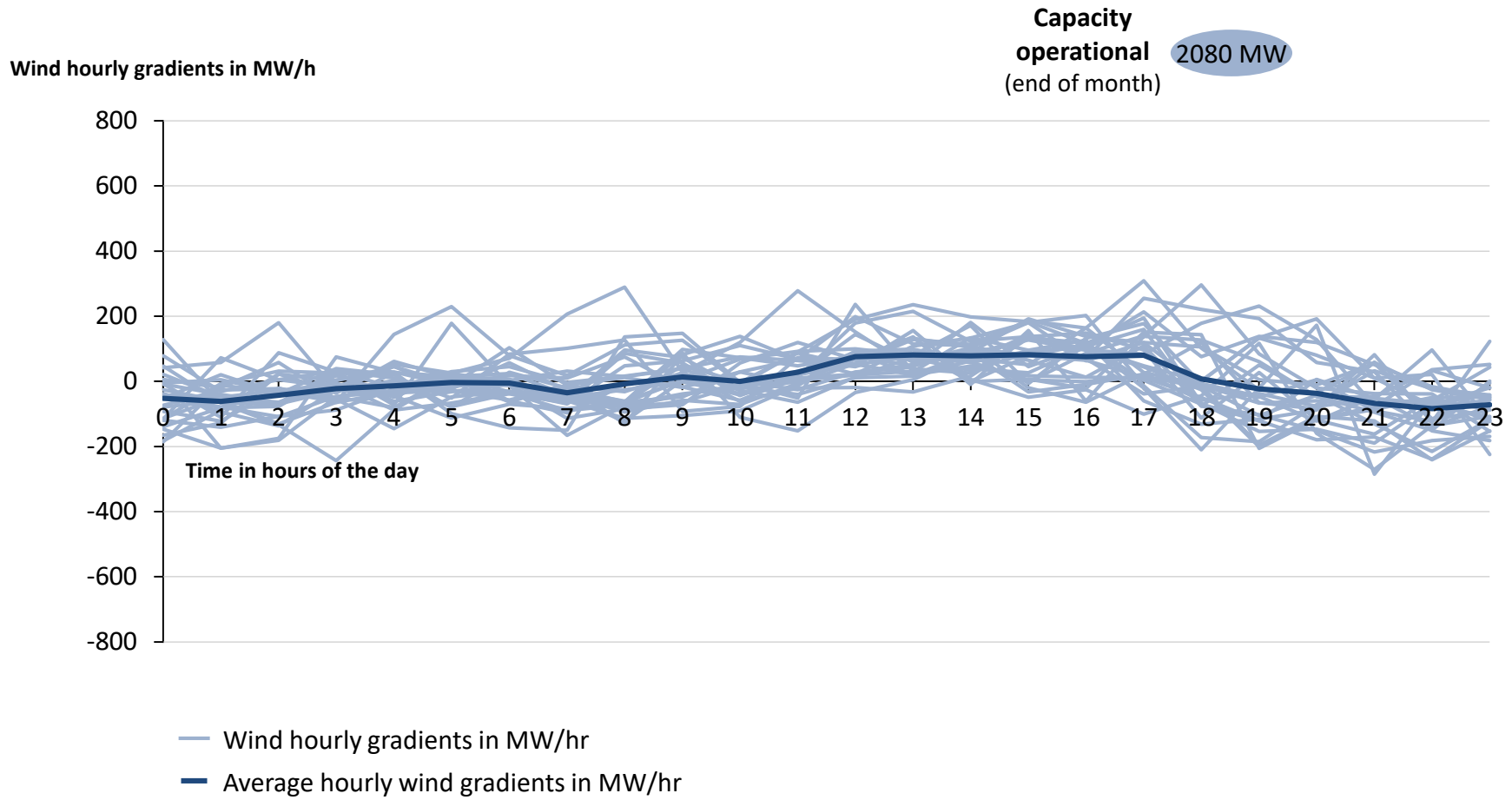
Solar PV 1-hour gradients in December 2019



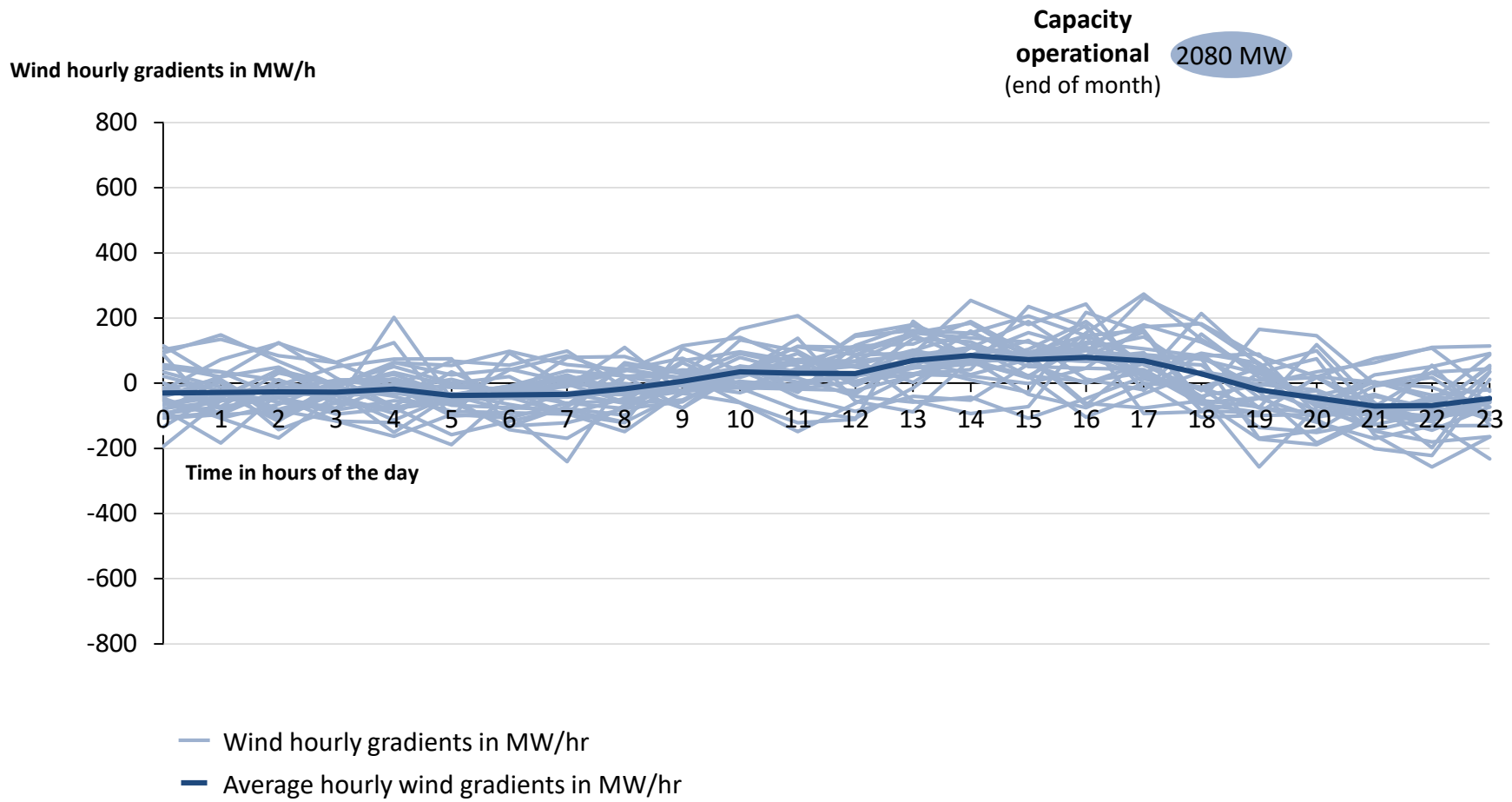
Wind 1-hour gradients in January 2019



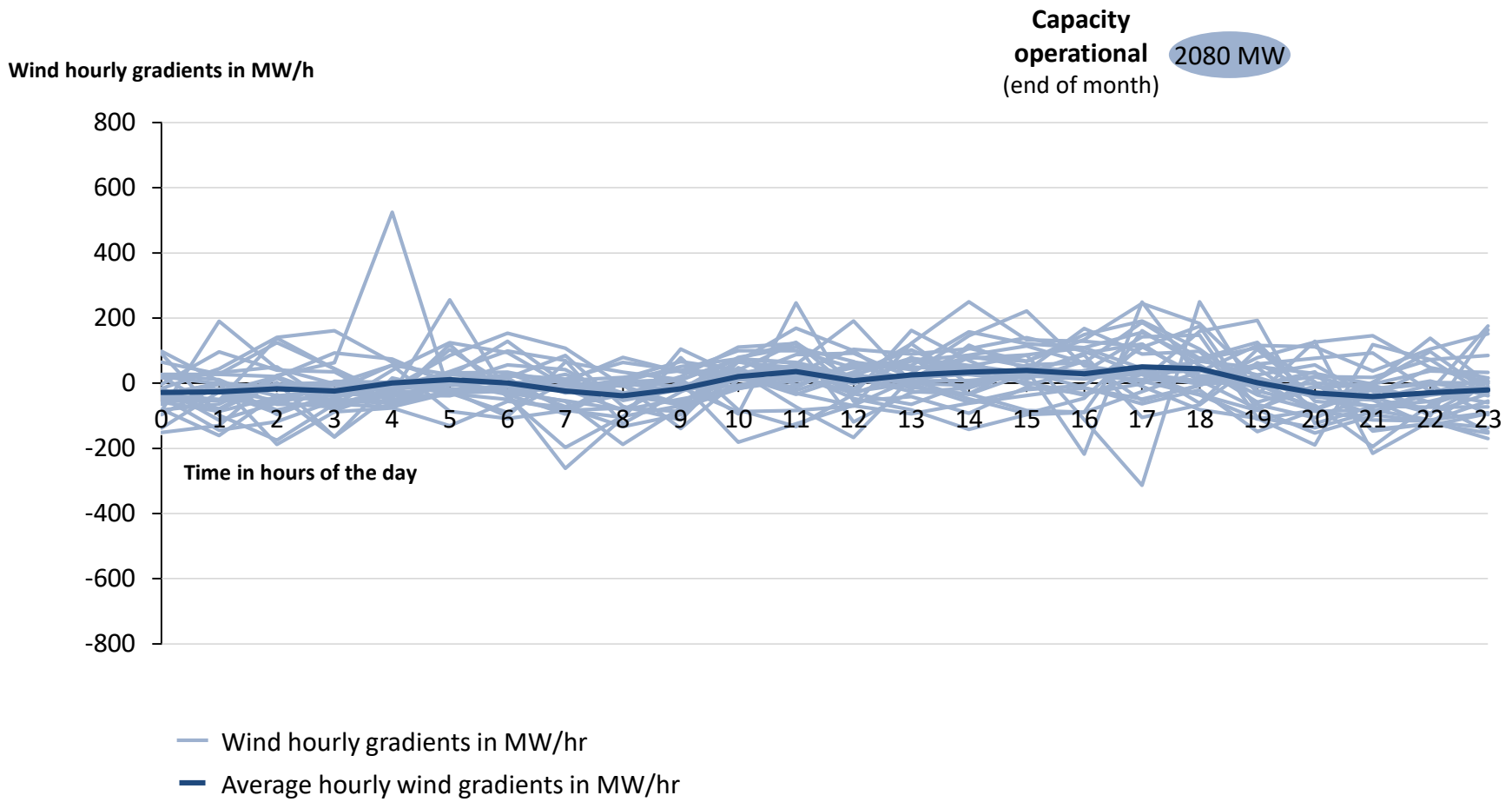
Wind 1-hour gradients in February 2019



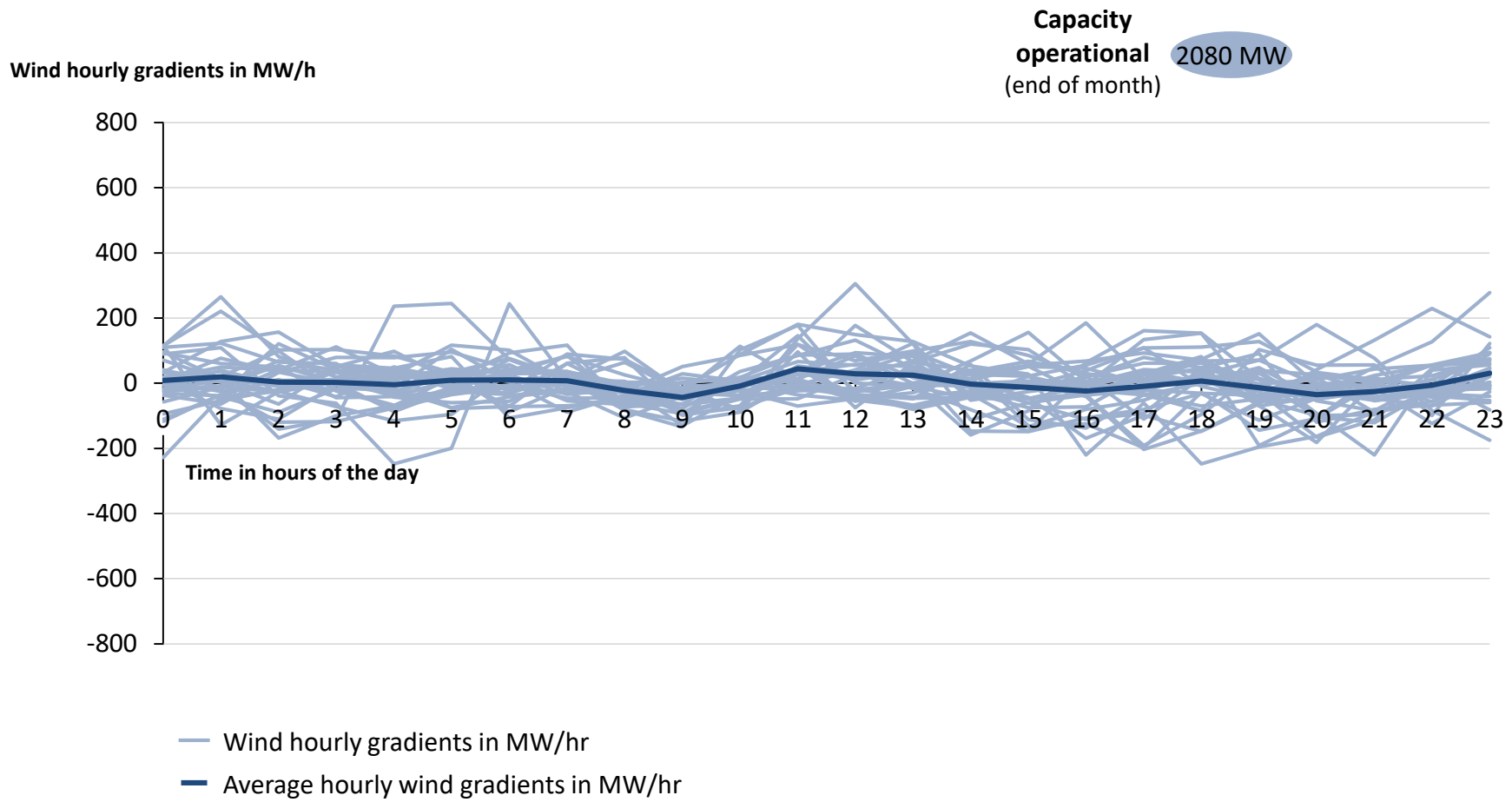
Wind 1-hour gradients in March 2019



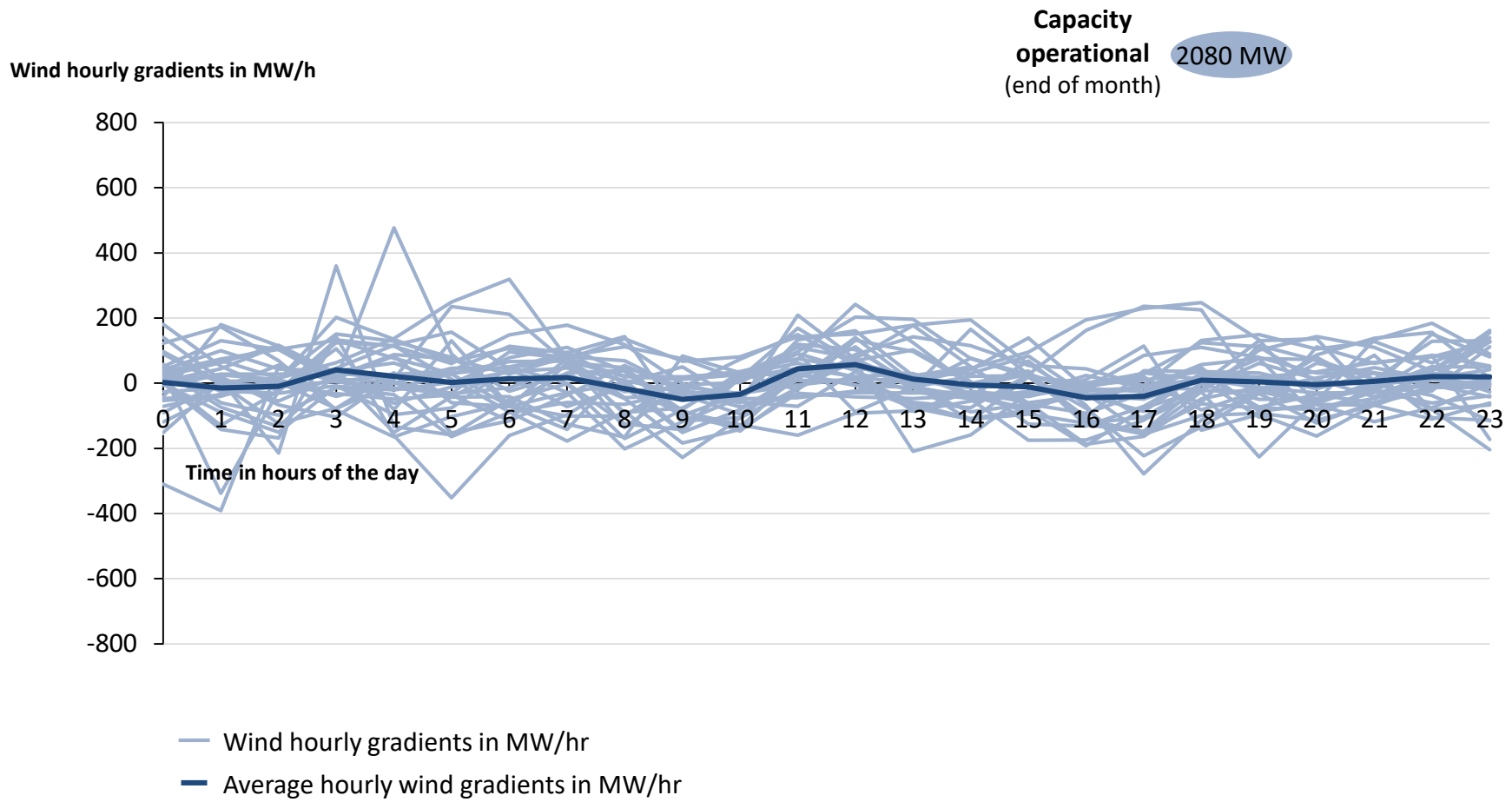
Wind 1-hour gradients in April 2019



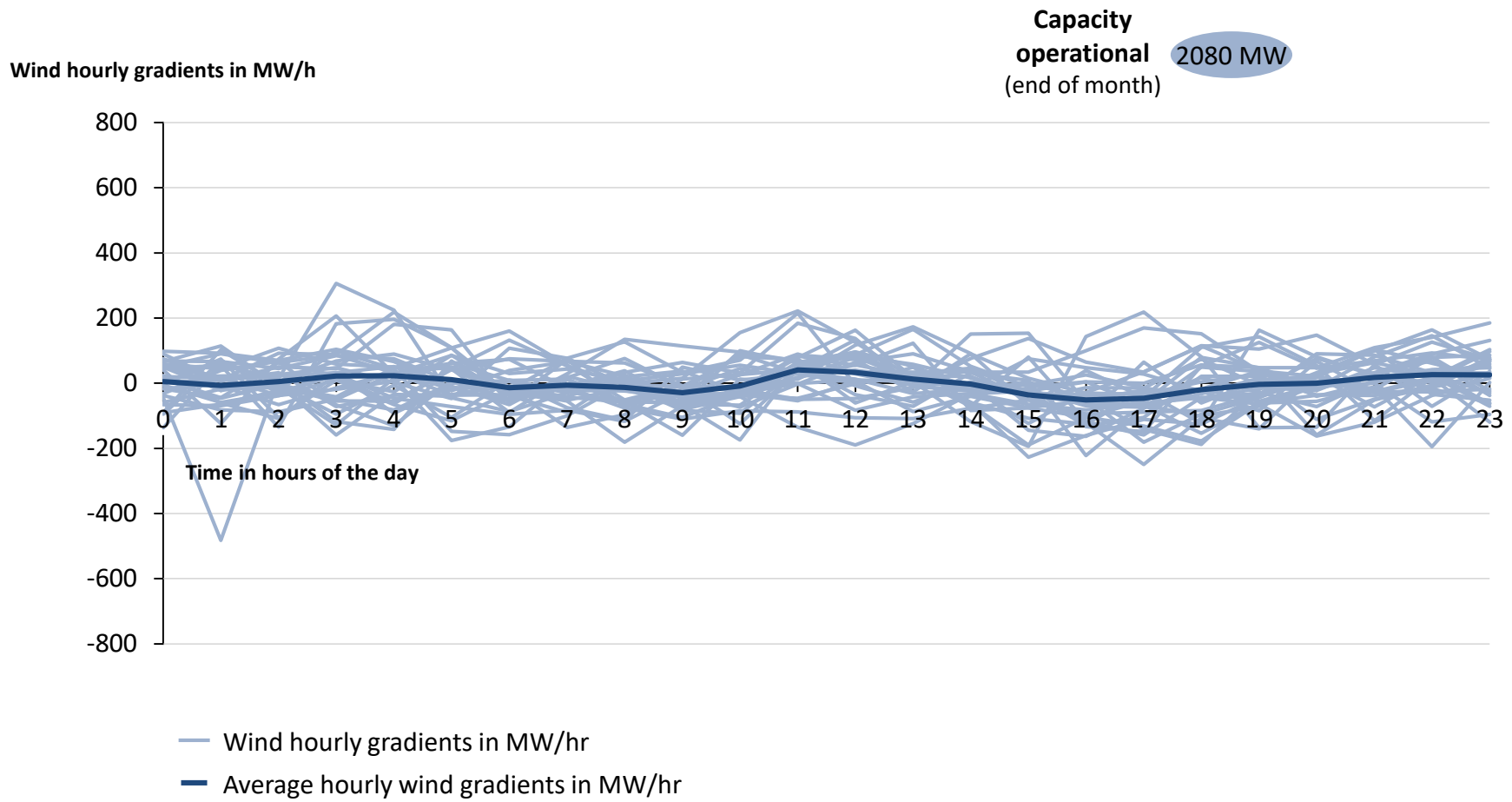
Wind 1-hour gradients in May 2019



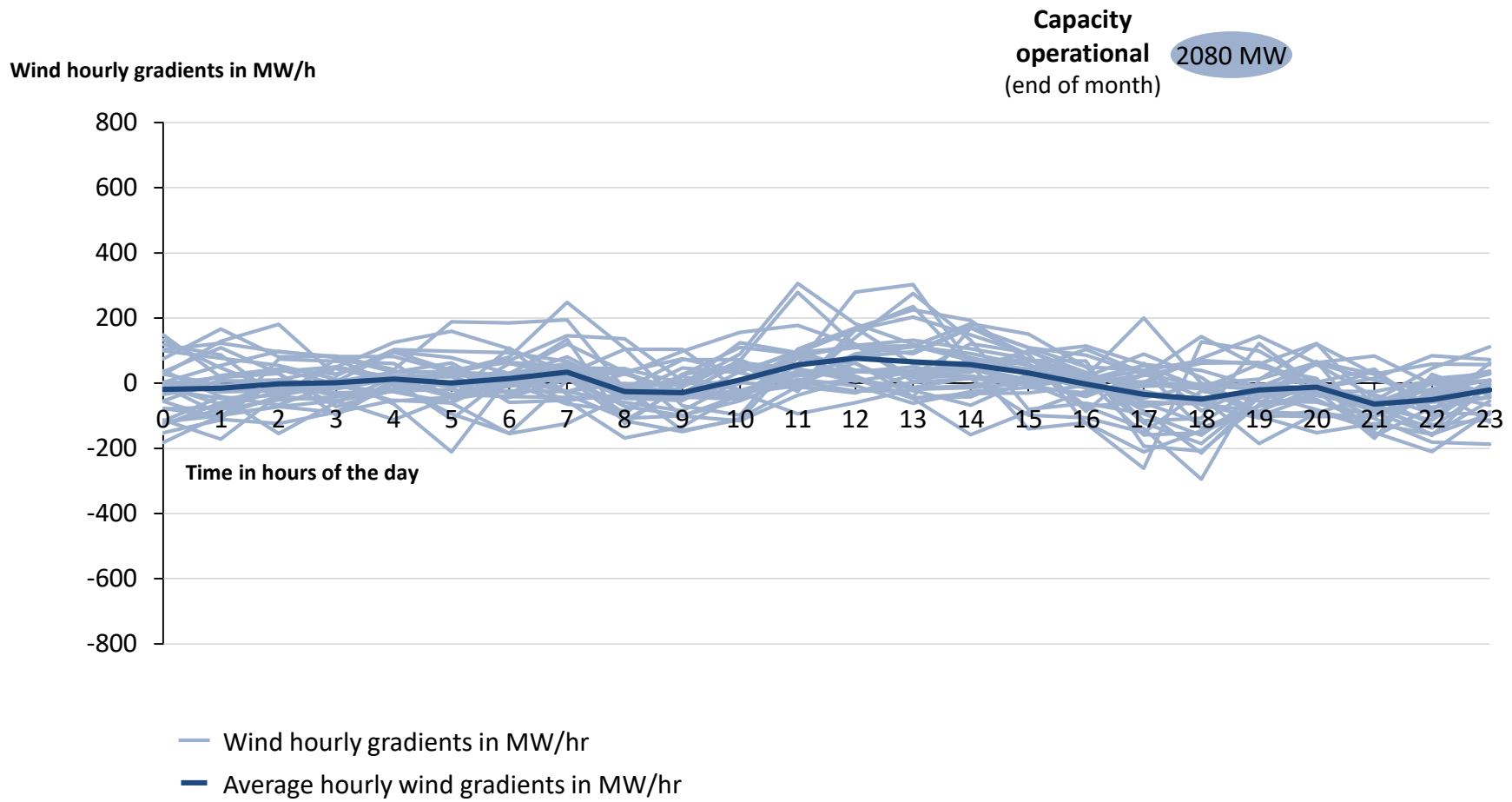
Wind 1-hour gradients in June 2019



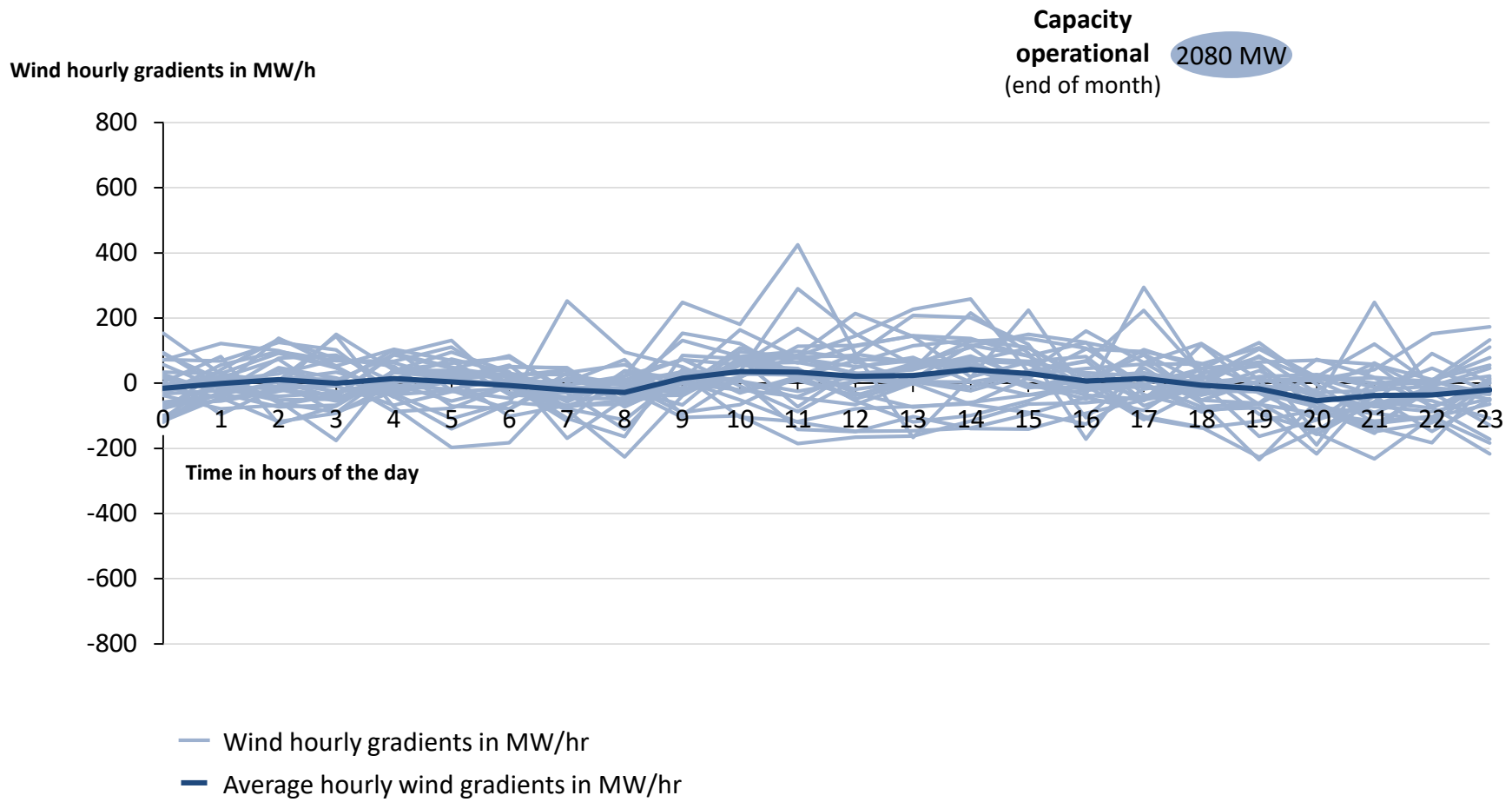
Wind 1-hour gradients in July 2019



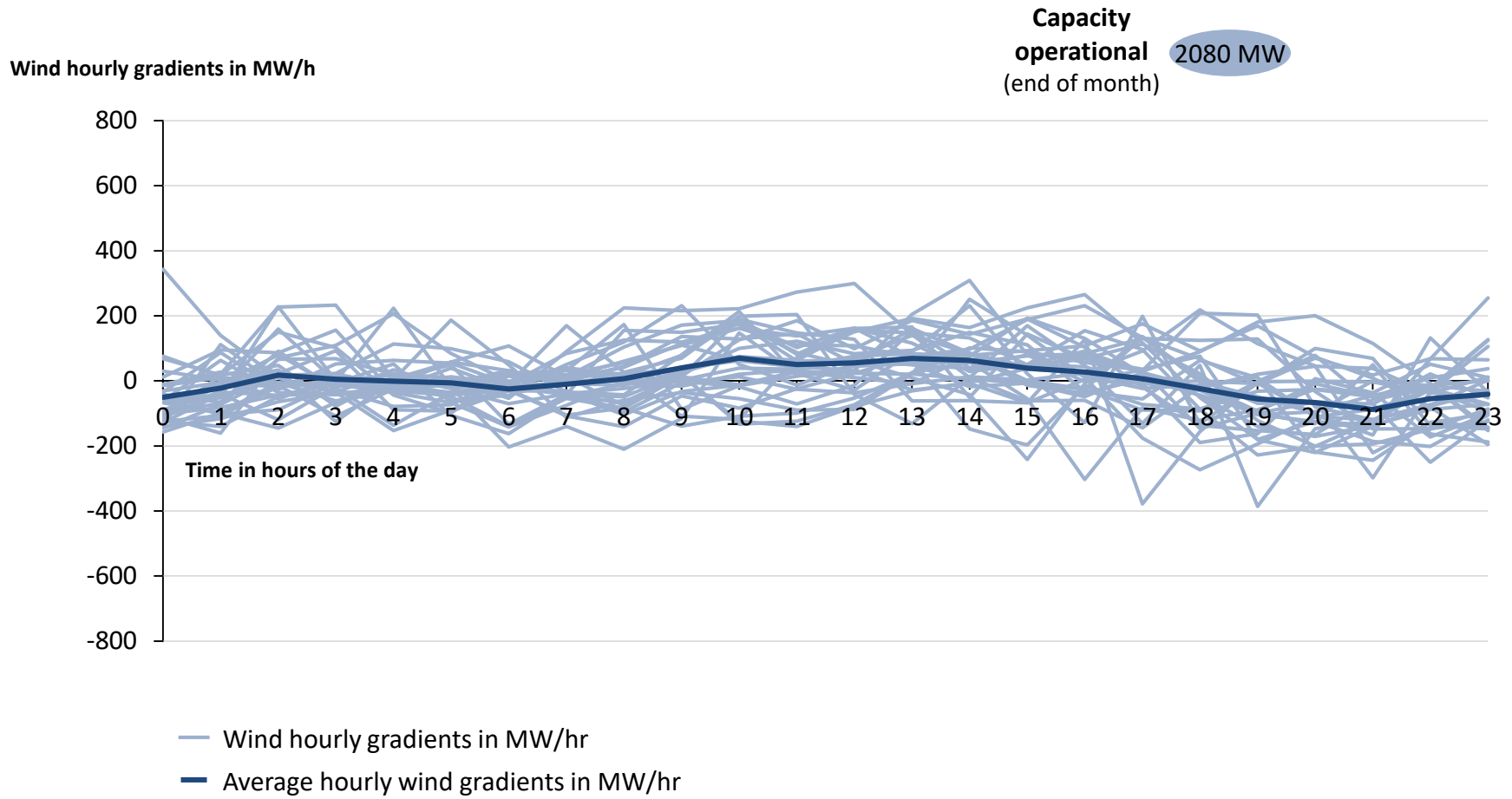
Wind 1-hour gradients in August 2019



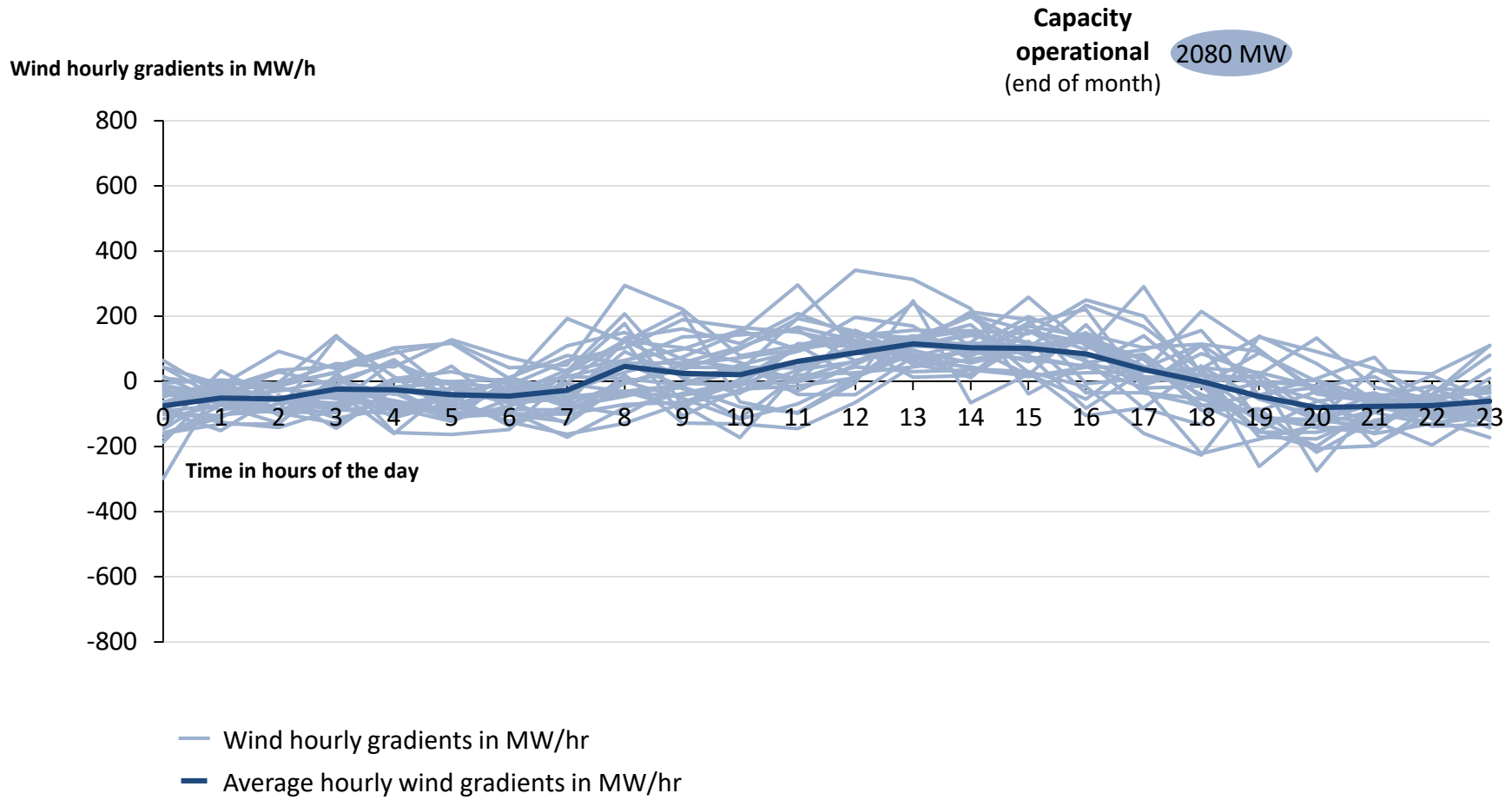
Wind 1-hour gradients in September 2019



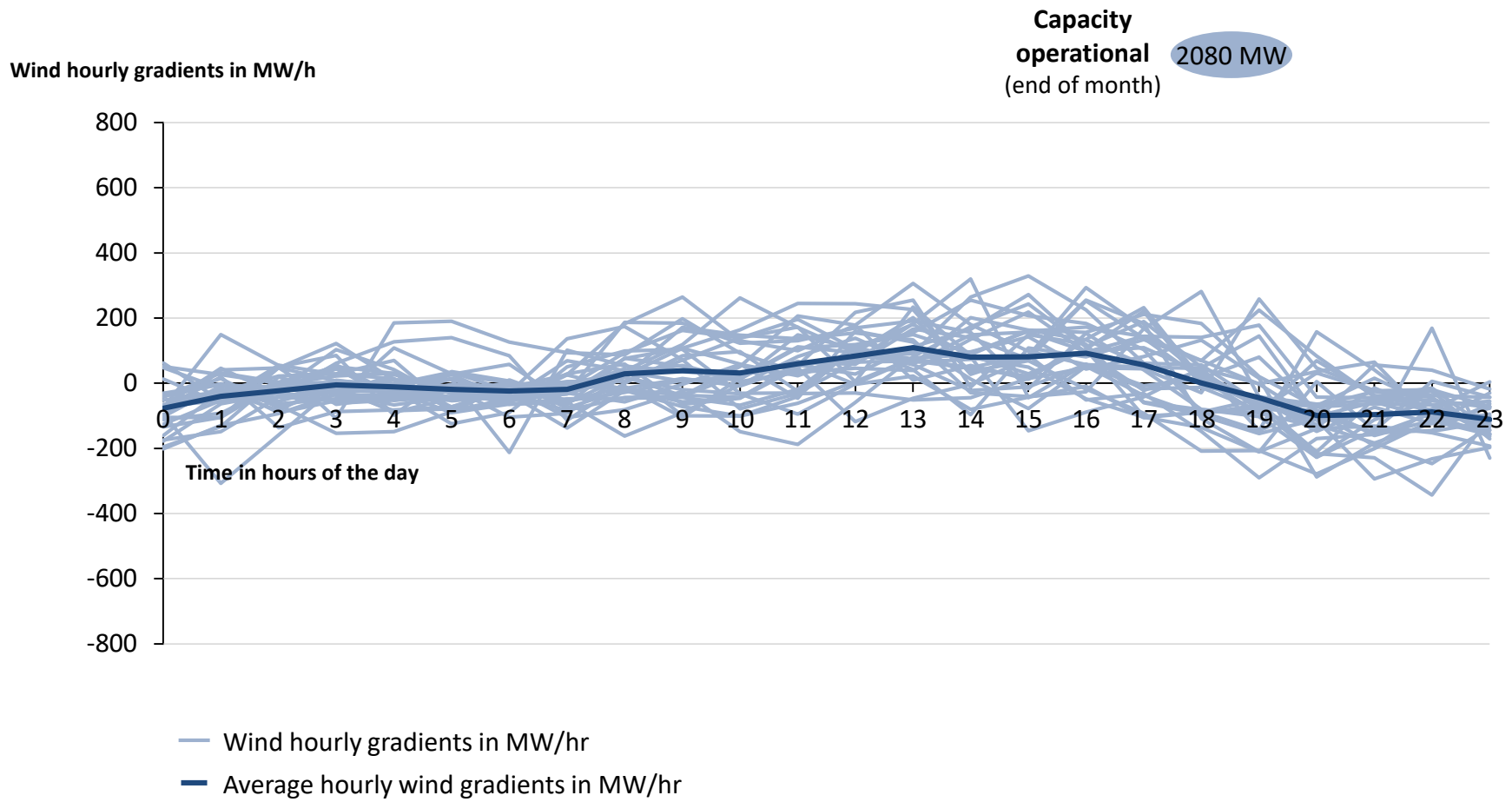
Wind 1-hour gradients in October 2019



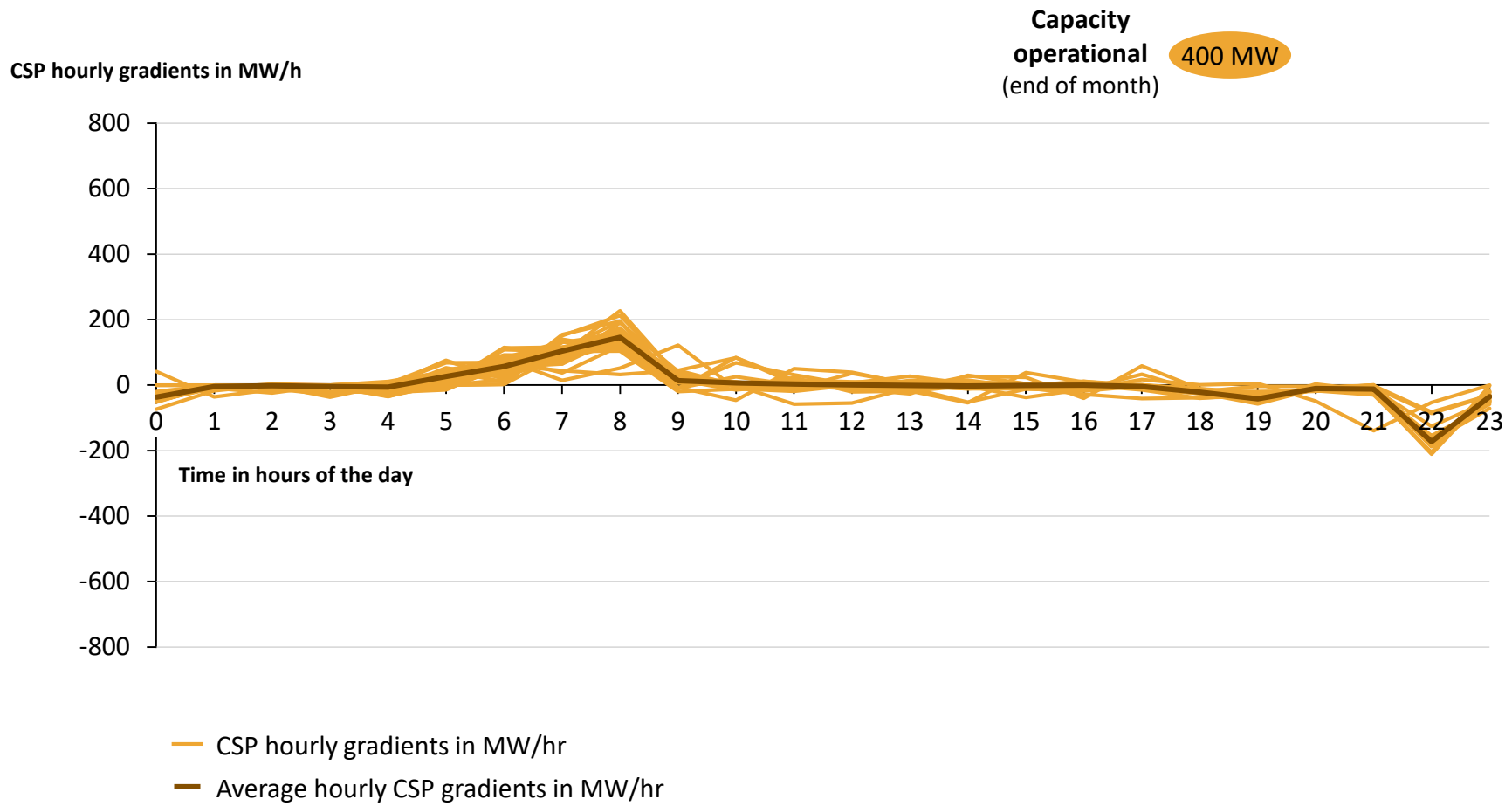
Wind 1-hour gradients in November 2019



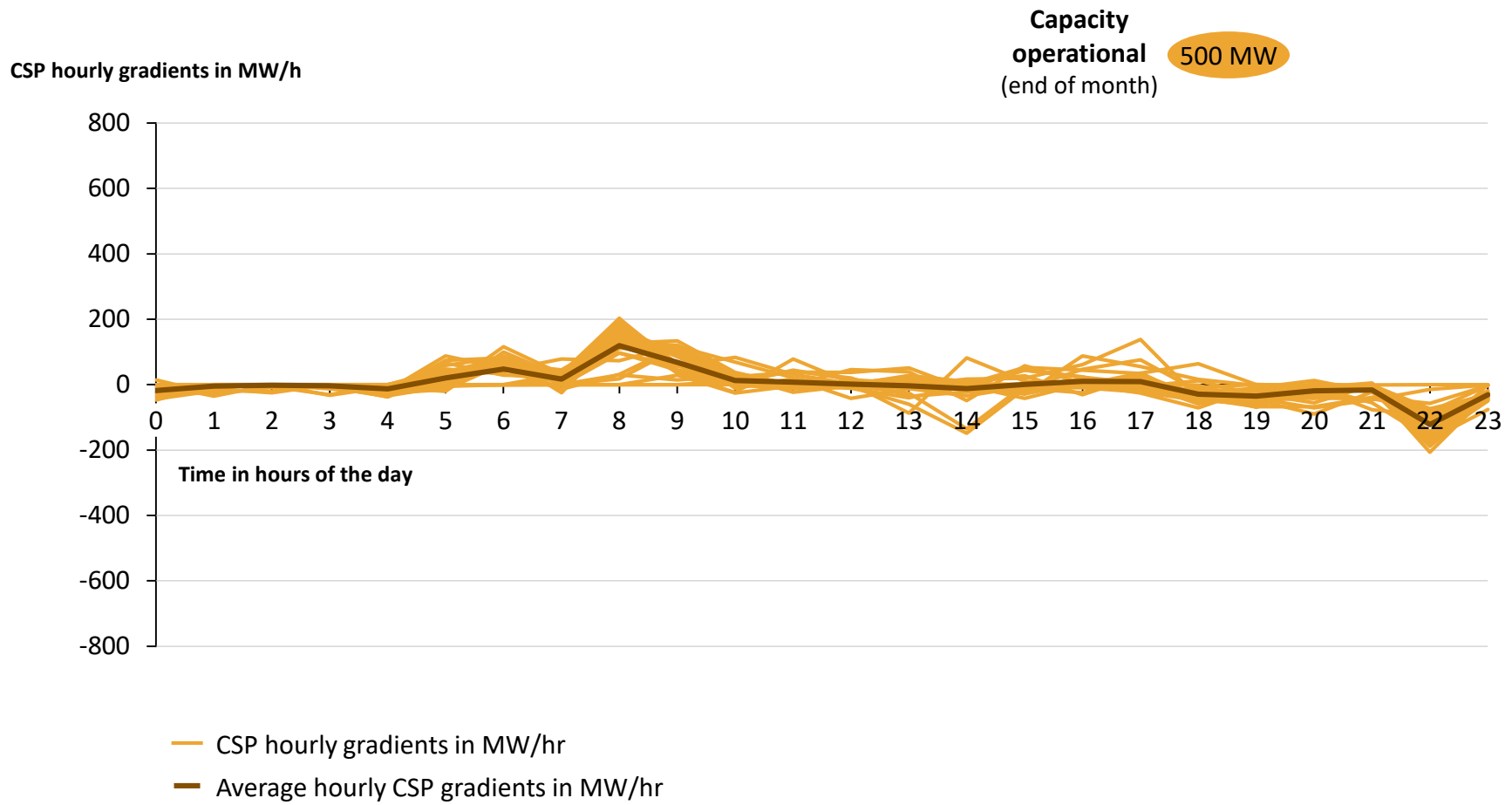
Wind 1-hour gradients in December 2019



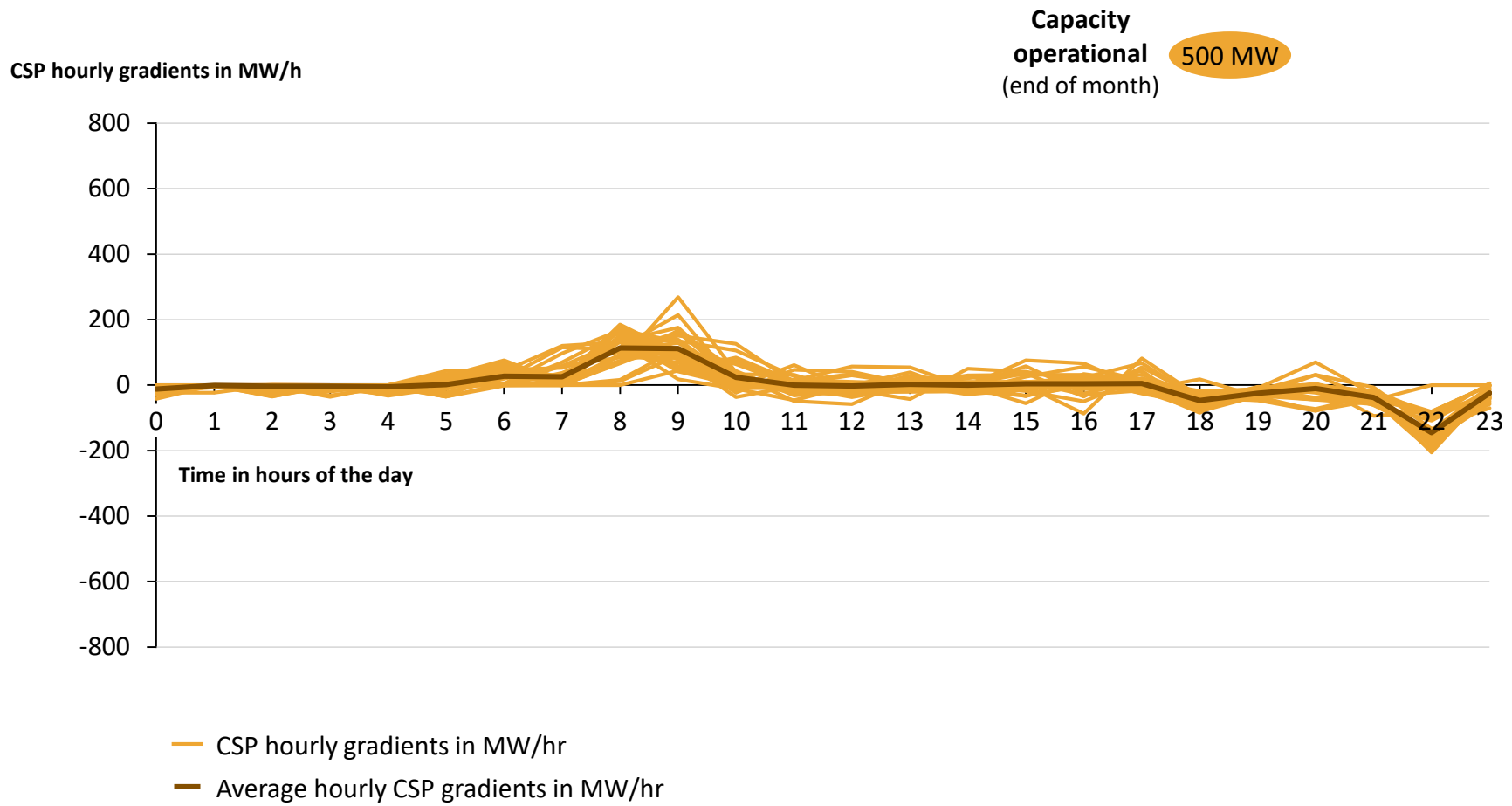
CSP 1-hour gradients in January 2019



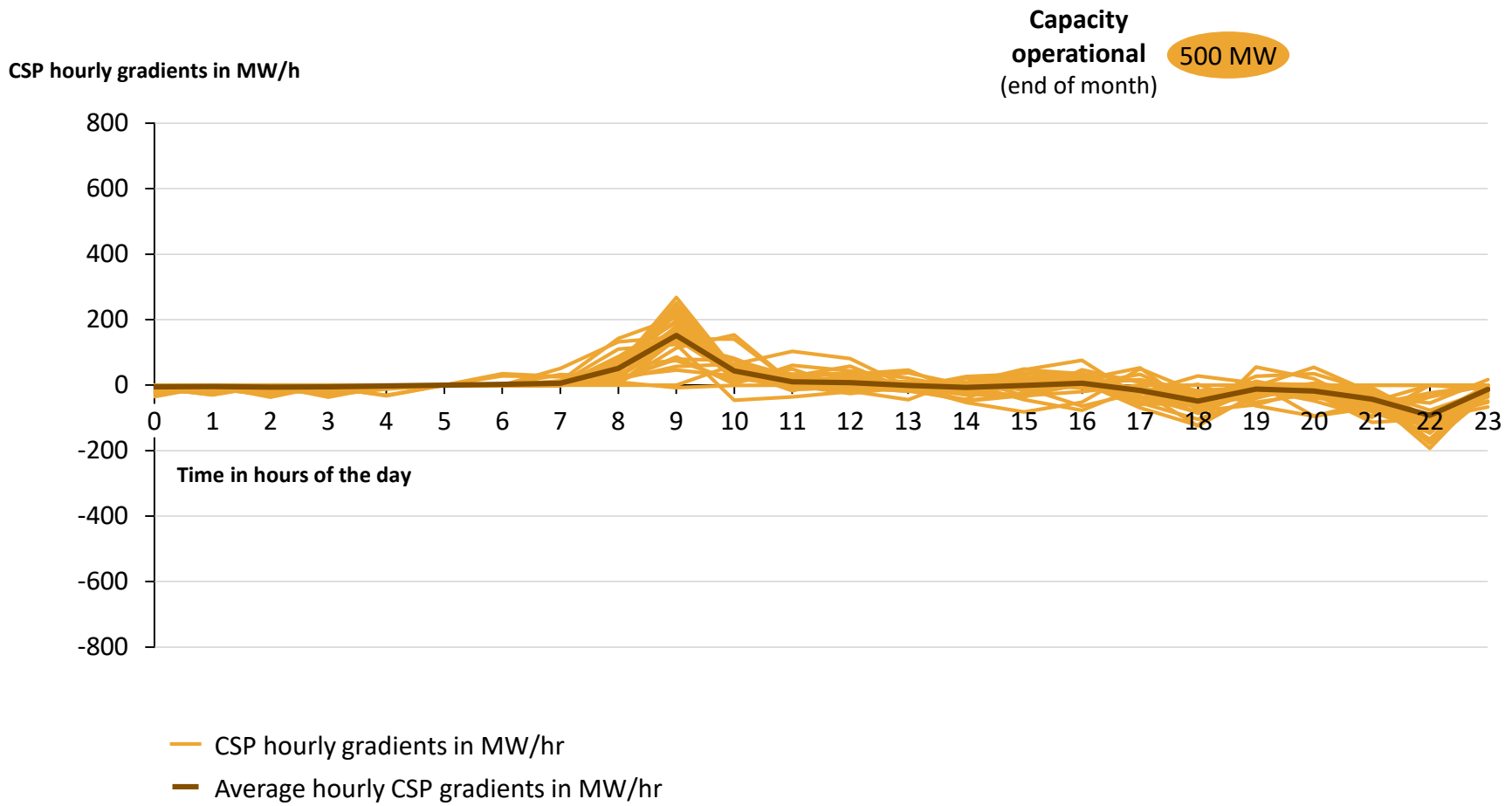
CSP 1-hour gradients in February 2019



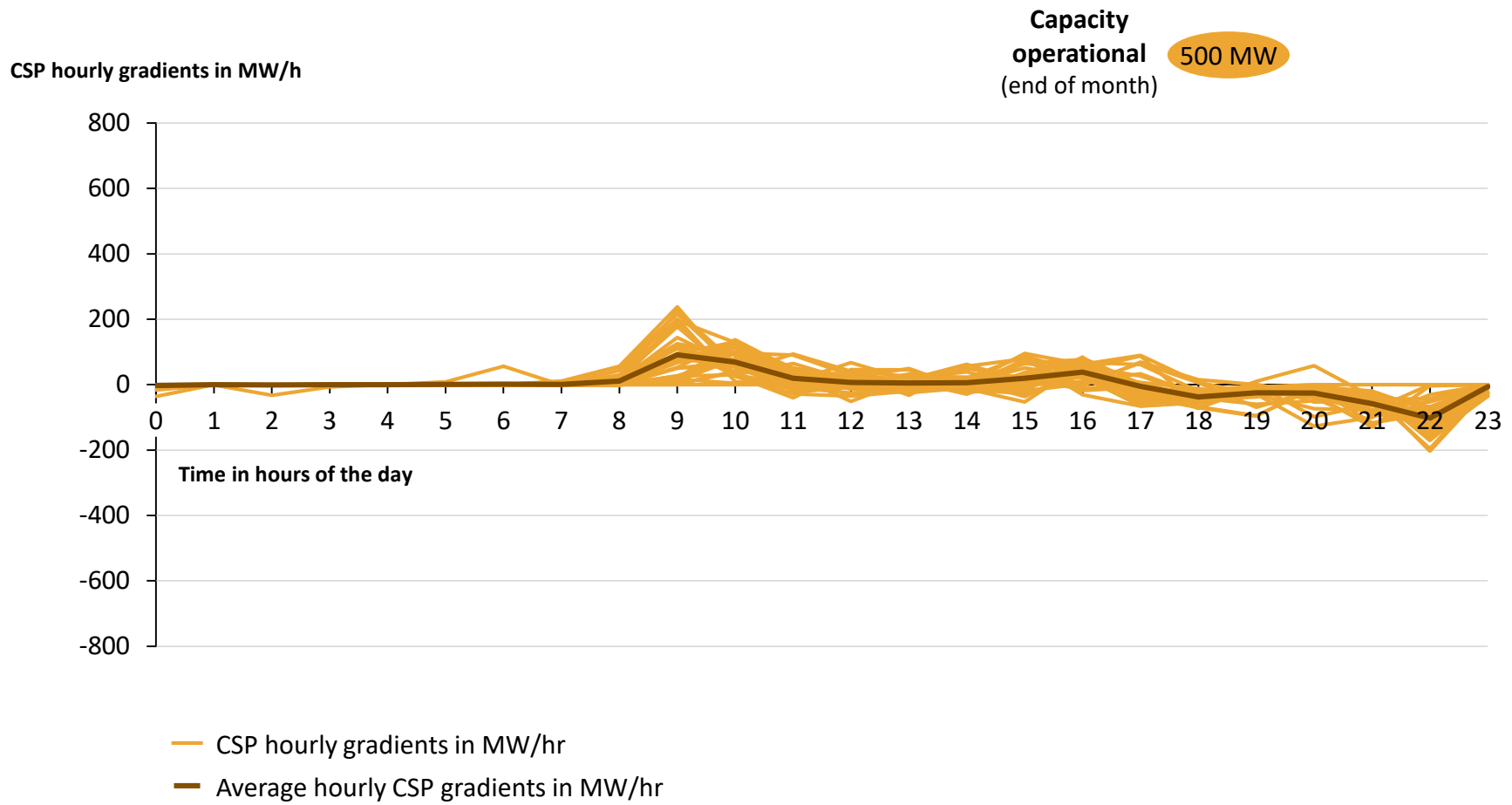
CSP 1-hour gradients in March 2019



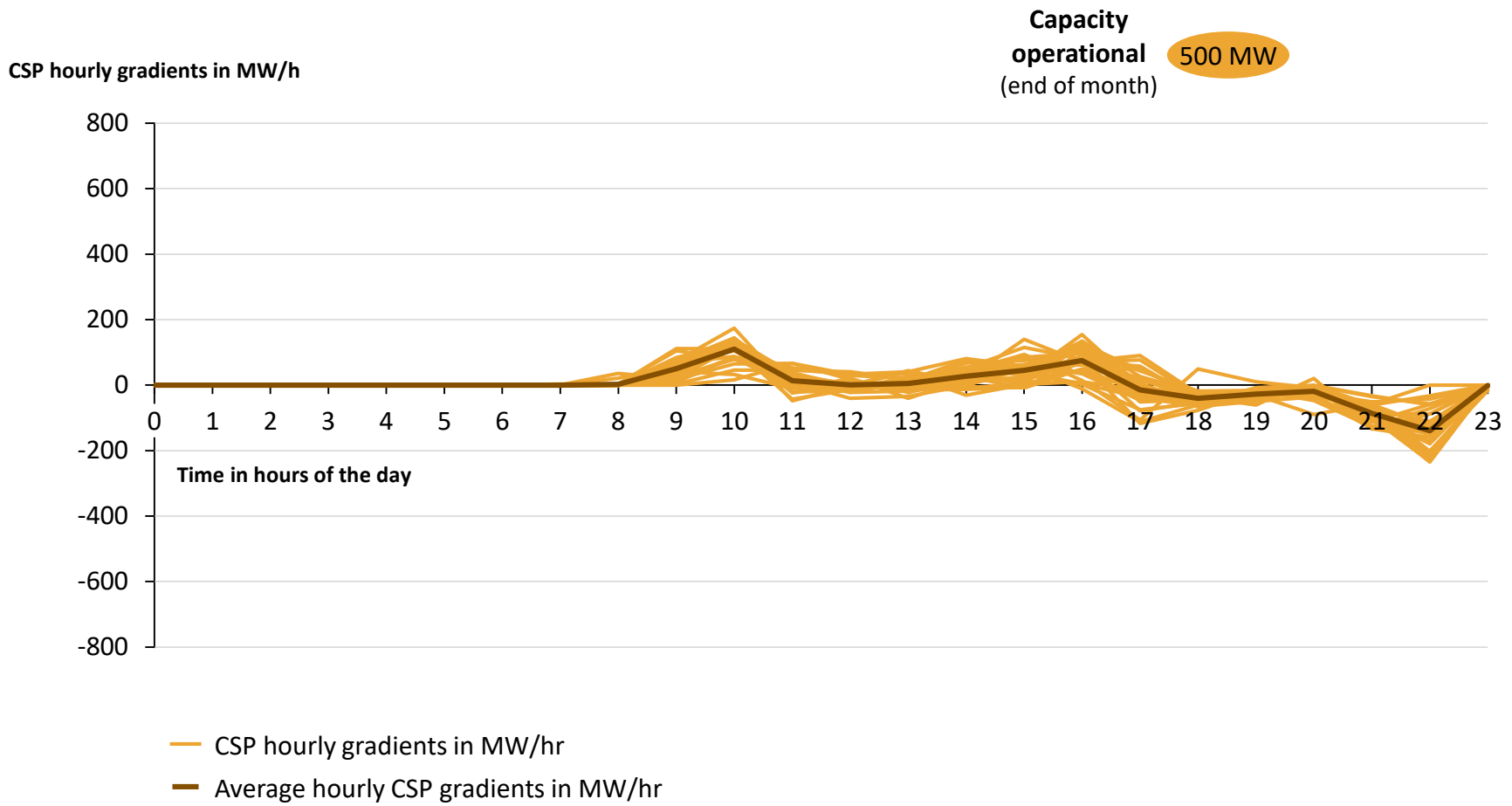
CSP 1-hour gradients in April 2019



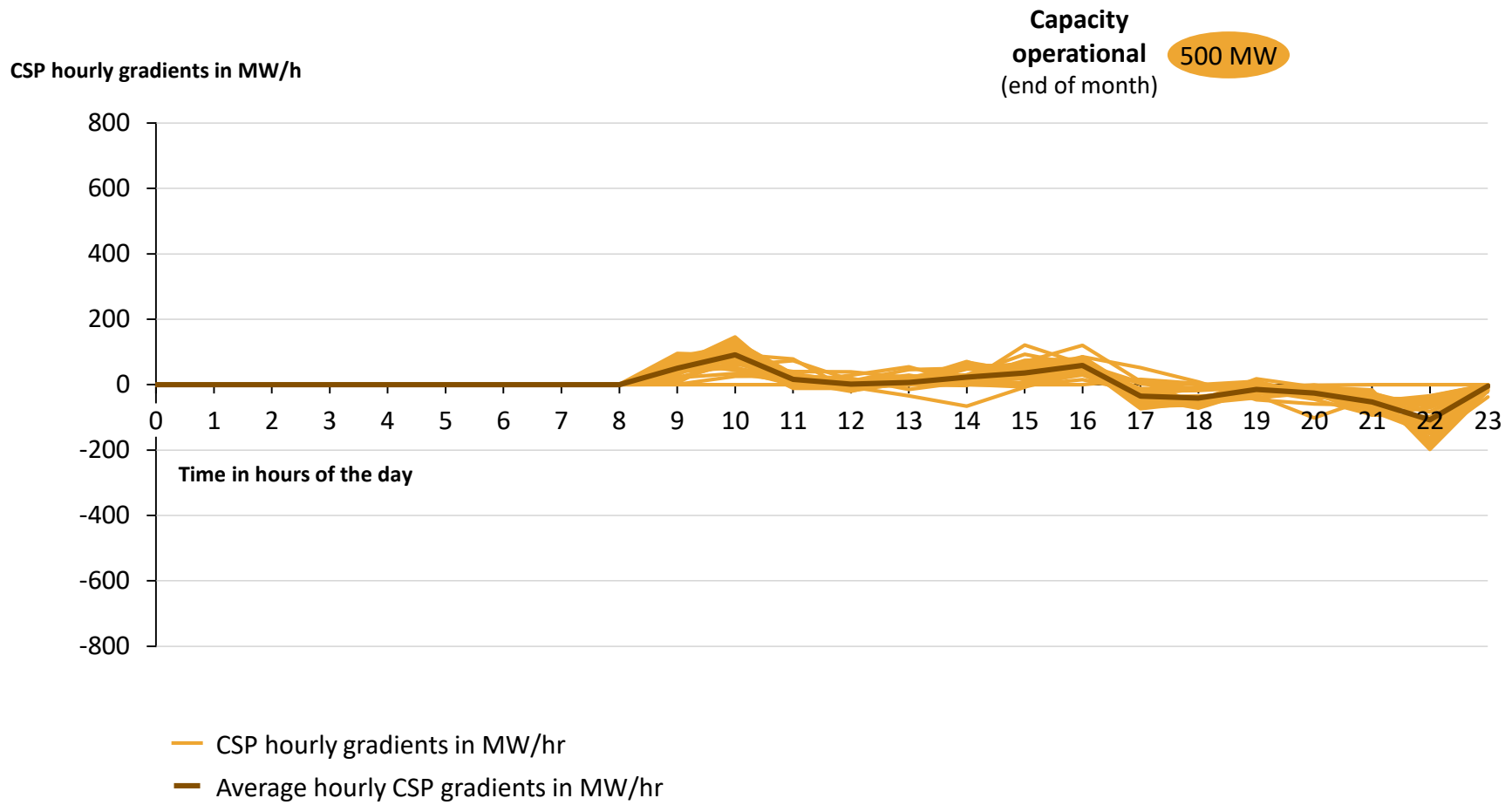
CSP 1-hour gradients in May 2019



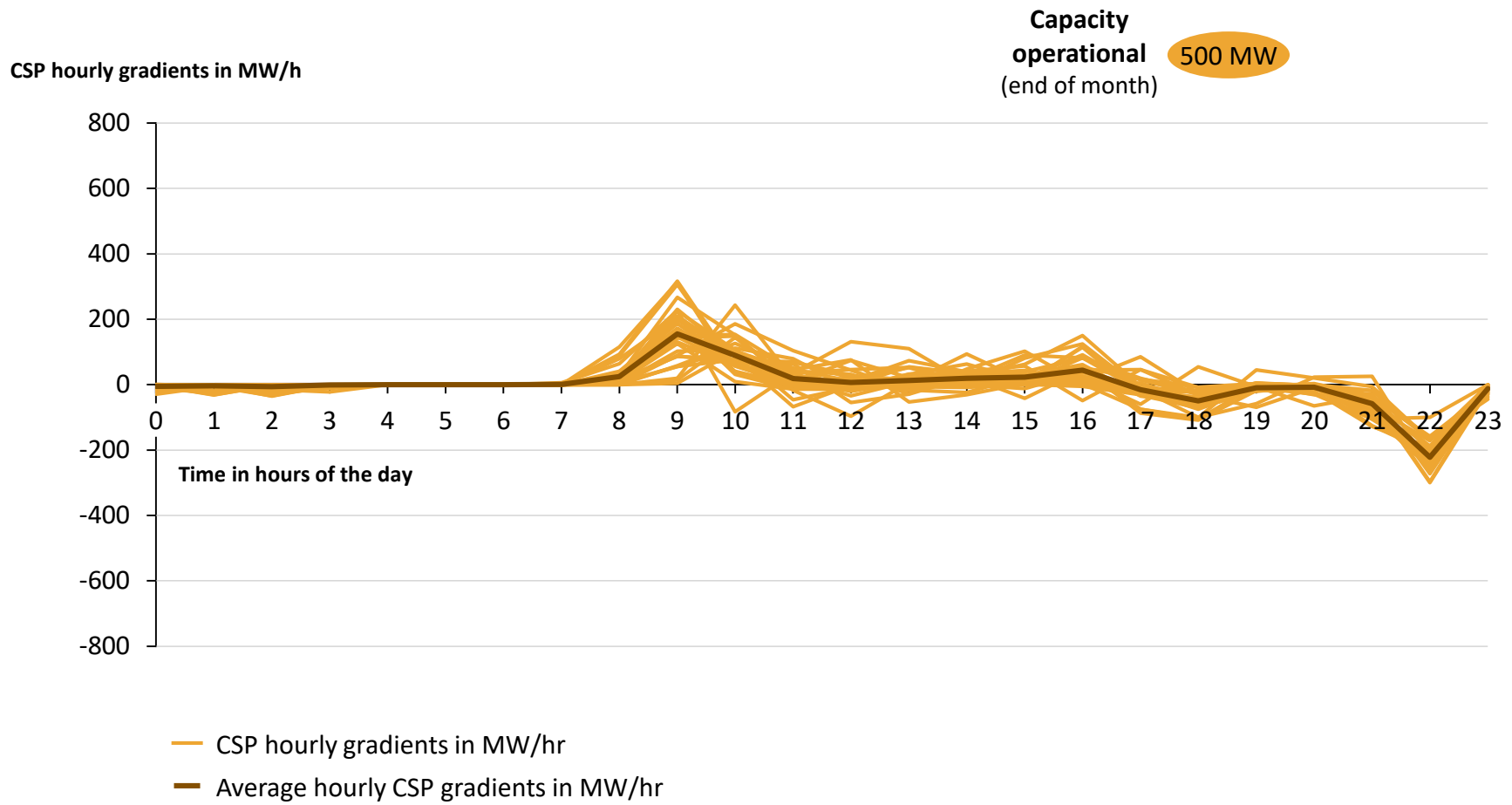
CSP 1-hour gradients in June 2019



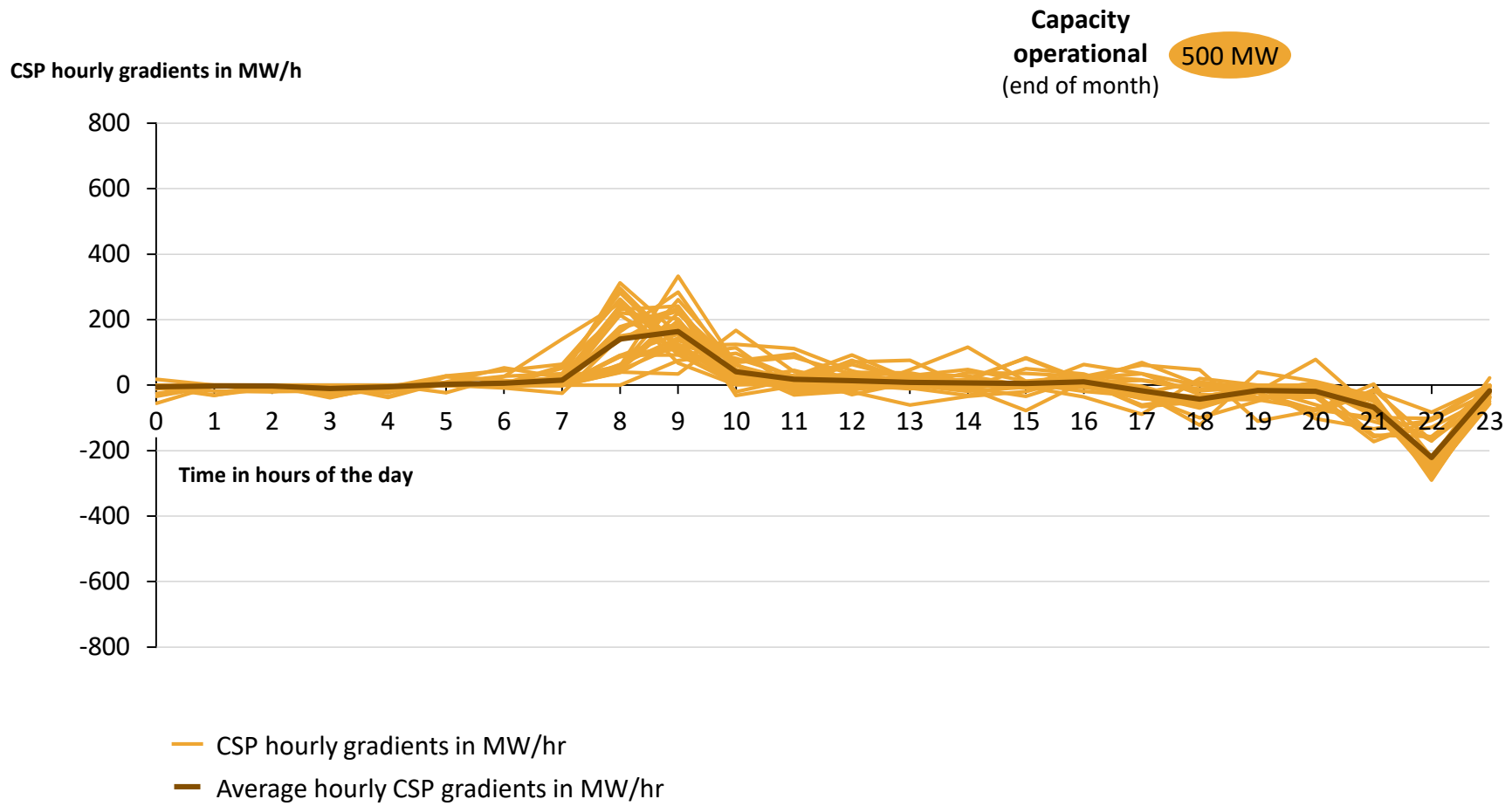
CSP 1-hour gradients in July 2019



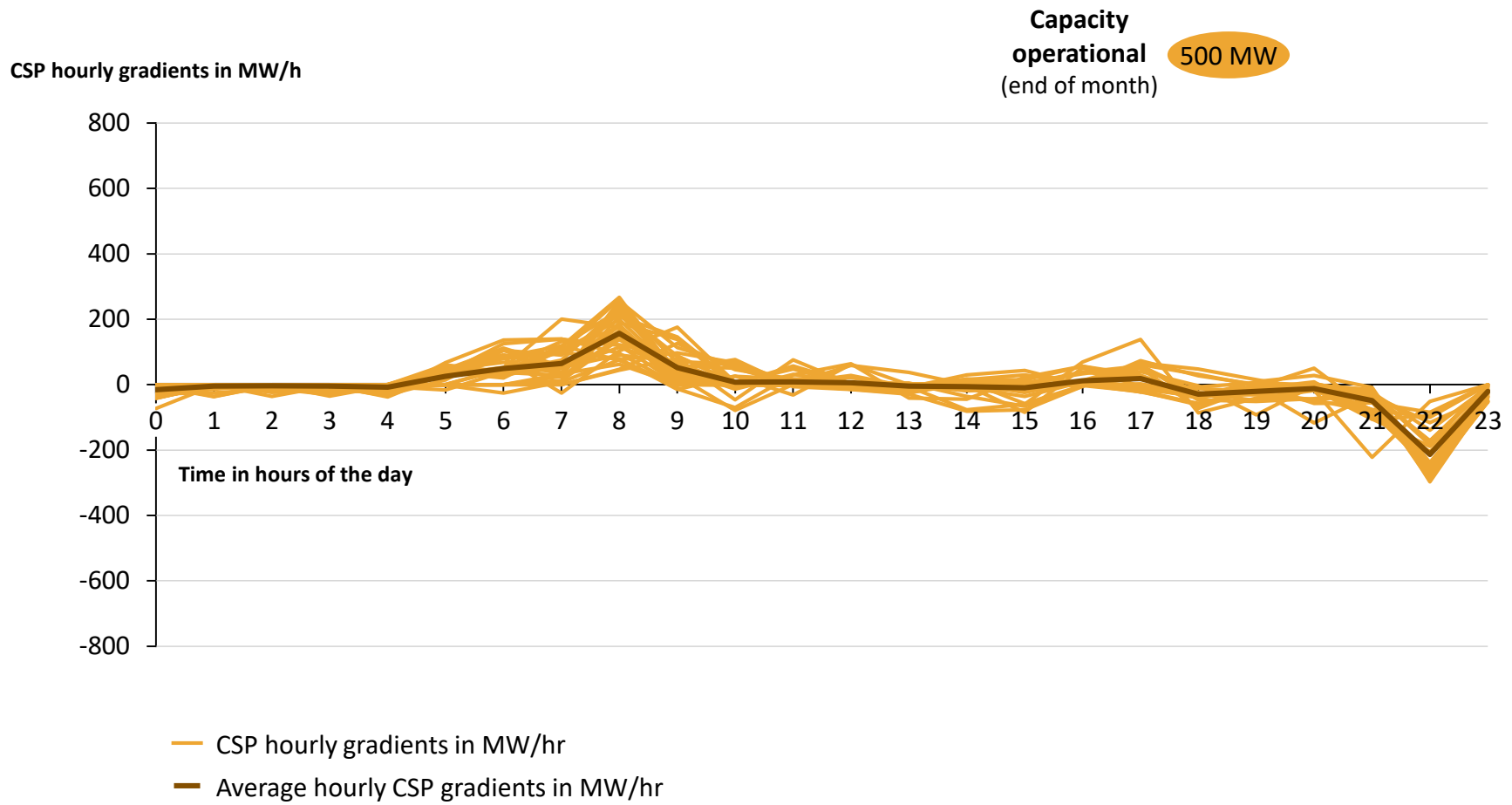
CSP 1-hour gradients in August 2019



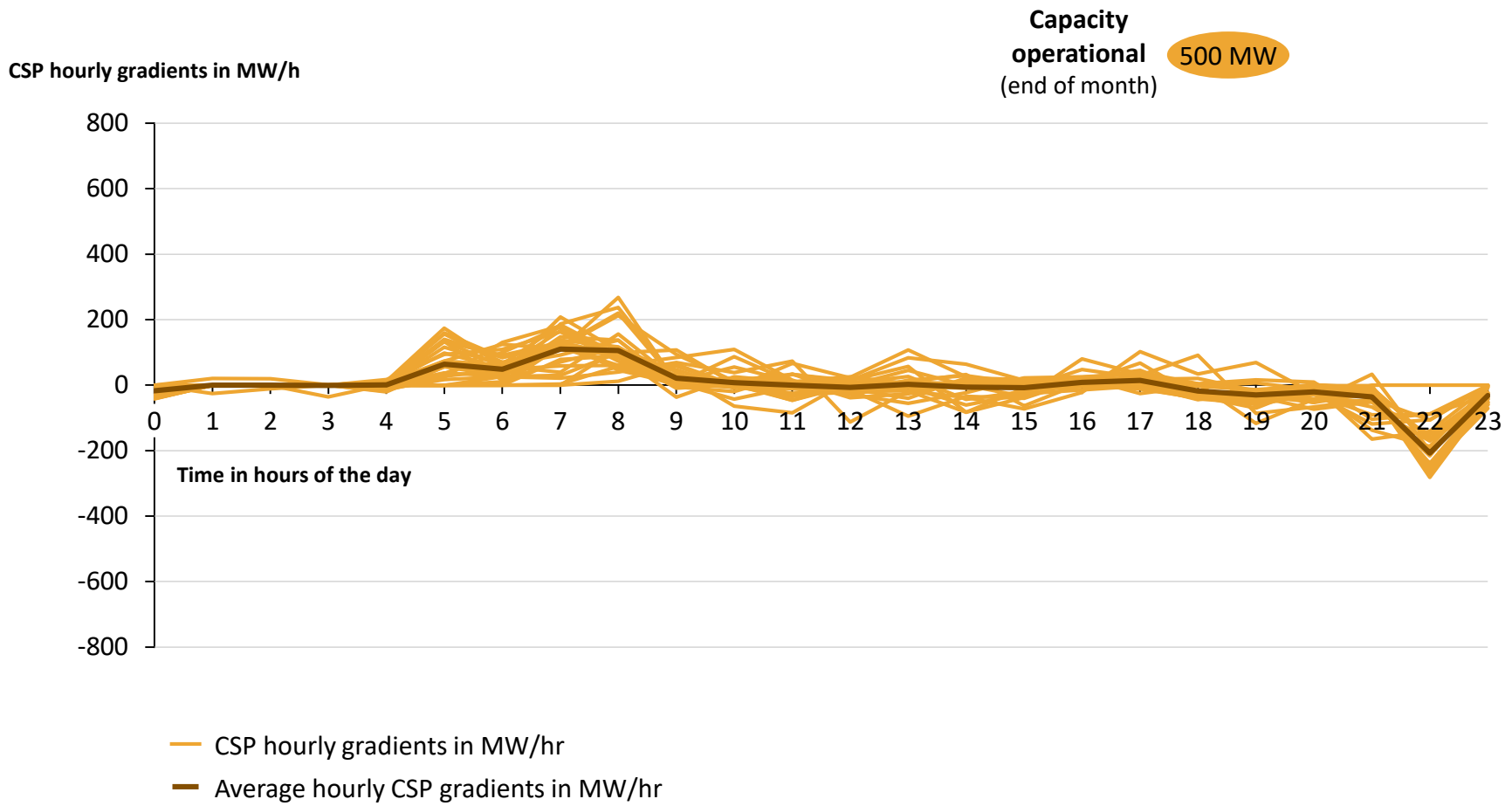
CSP 1-hour gradients in September 2019



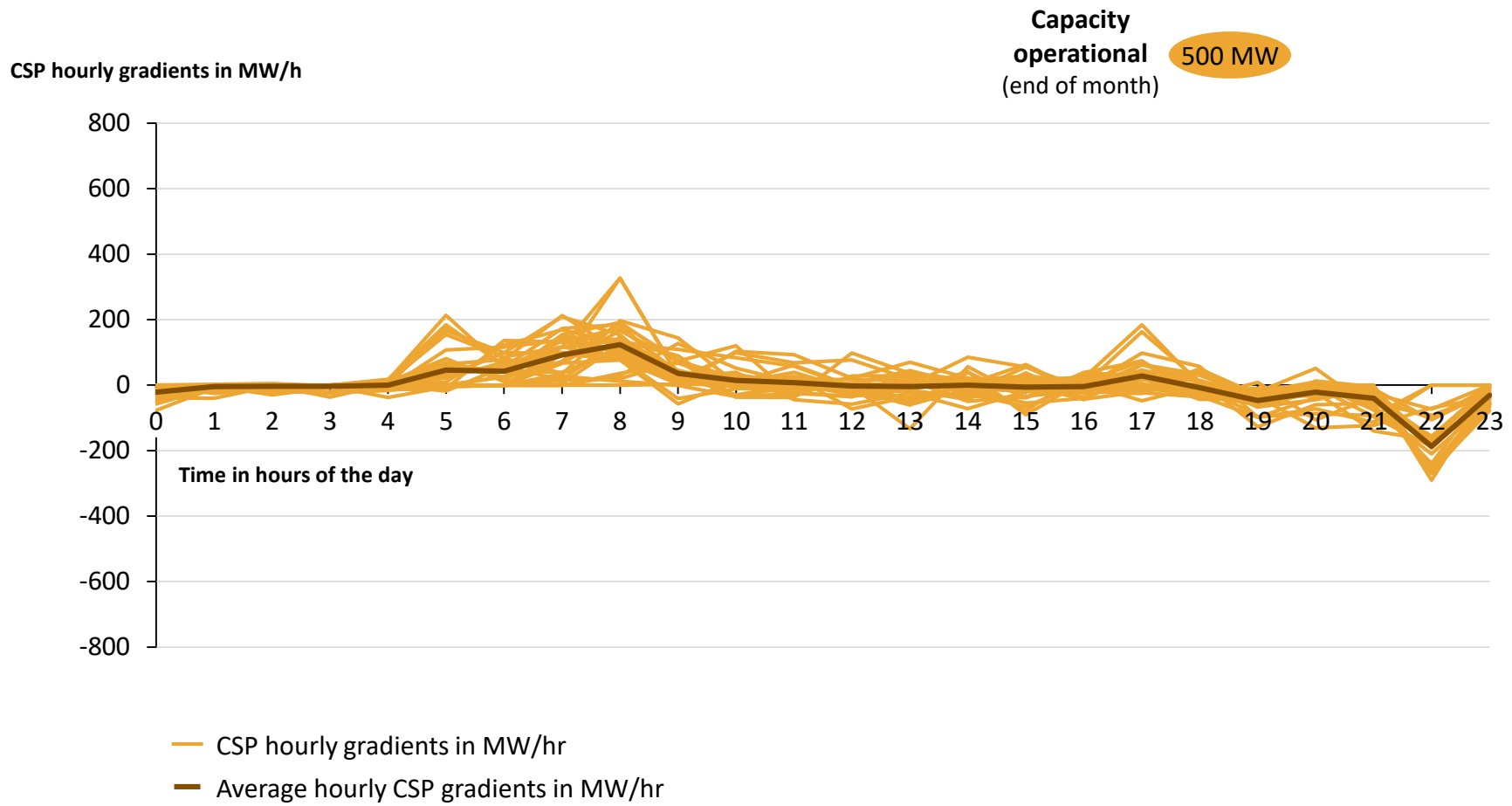
CSP 1-hour gradients in October 2019



CSP 1-hour gradients in November 2019



CSP 1-hour gradients in December 2019



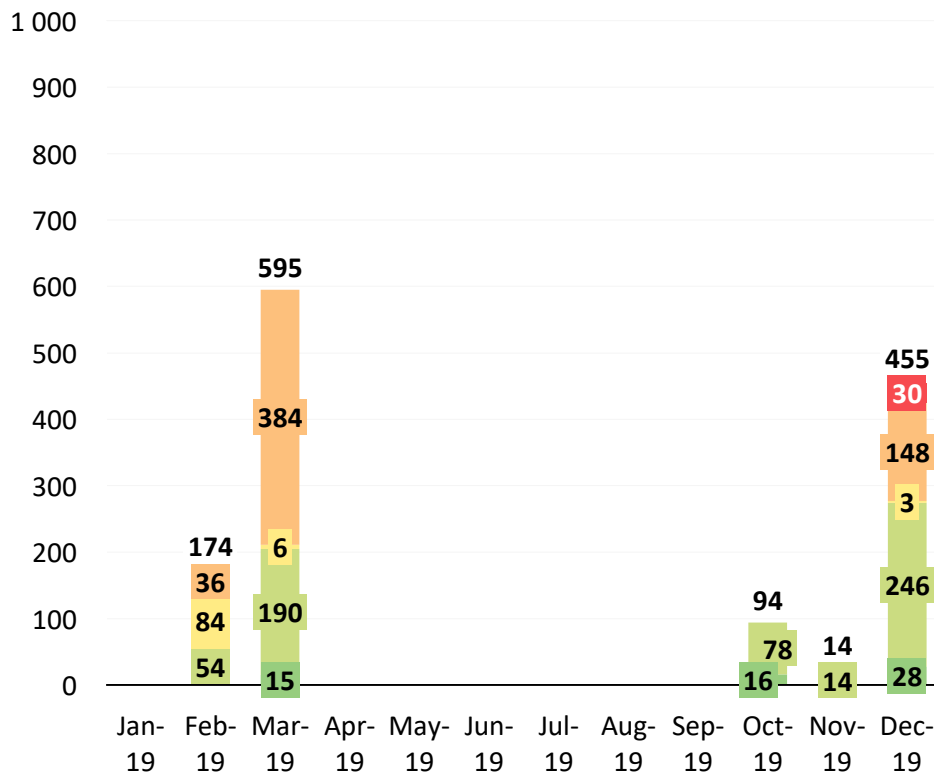
Agenda

- 1 Overview and status of REIPPPP
- 2 Overview actual electricity production data for 2019
- 3 Monthly electricity production
- 4 Weekly electricity production
- 5 Daily electricity production
- 6 Hourly electricity production

- 7 Actual load shedding in 2019

2019 was the most intensive year of loadshedding to date with Stage 6 being implemented in December 2019

Load shed [GWh]



■ Stage 6
 ■ Stage 5
 ■ Stage 4
 ■ Stage 3
 ■ Stage 2
 ■ Stage 1

Year	Duration of outages (hours)	Energy shed (GWh)	Est. econ. Impact (ZAR-bln)
2007	-	176	15
2008	-	476	42
....
2014	121	203	18
2015	852	1325	116
2016	-	-	-
2017	-	-	-
2018	127	192	17
2019	530	1352	118

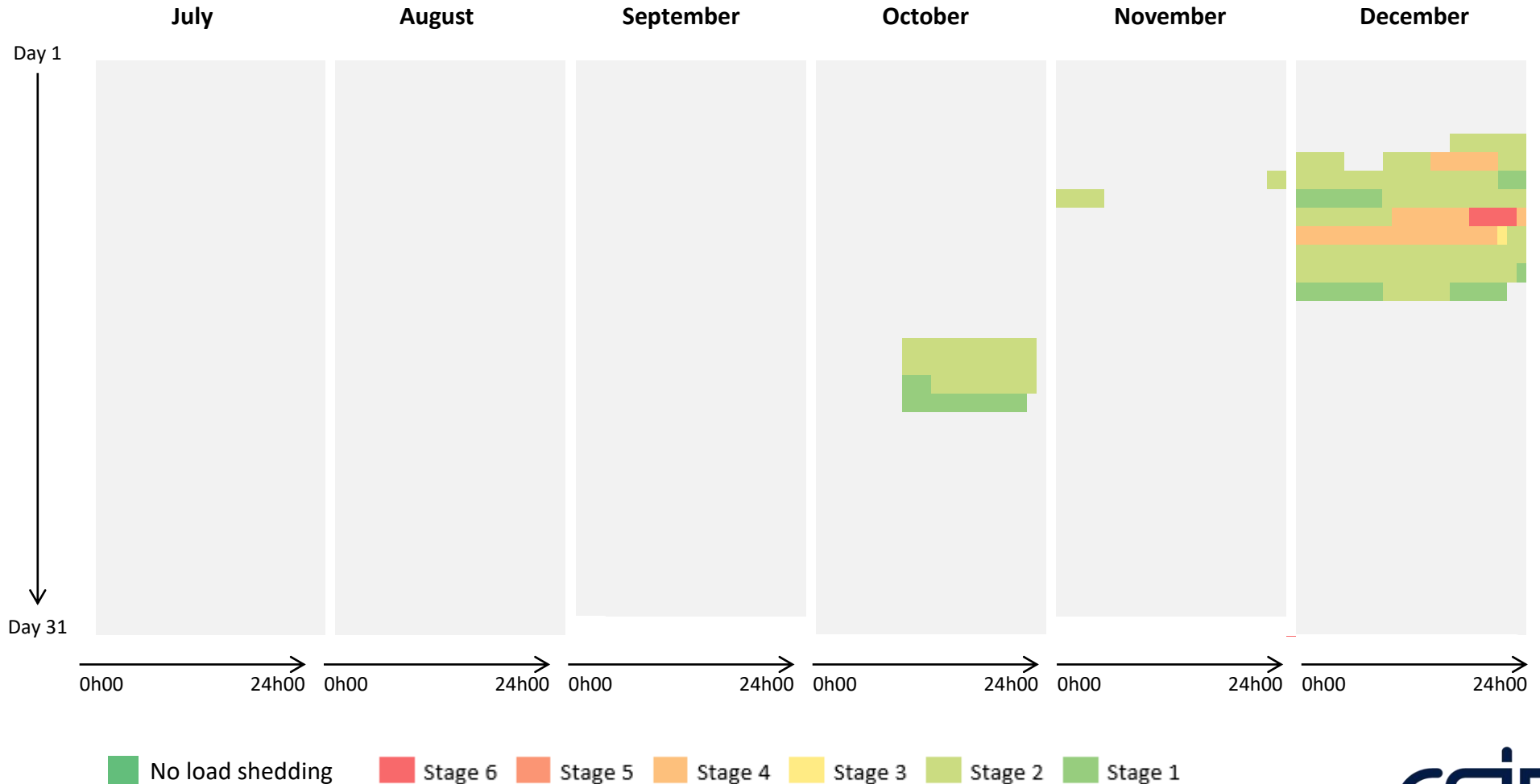
Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occasionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000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

Hourly distribution of actual load shedding January to June 2019



Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occasionally 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 se Push (mobile app); CSIR analysis

Hourly distribution of actual load shedding July to December 2019



Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occasionally 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 se Push (mobile app); CSIR analysis

A closer look at the load shedding events in December 2019

Actual hourly production from all power supply sources in RSA from 2-15 December 2019

