Statistics of utility-scale solar PV, wind and CSP in South Africa in 2017

CSIR Energy Centre

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Agenda

1. Overview and status of REIPPPP
2. Overview actual electricity production data for 2017
3. Monthly electricity production
4. Weekly electricity production
5. Daily electricity production
6. Hourly electricity production and gradients
7. Actual load shedding in 2017

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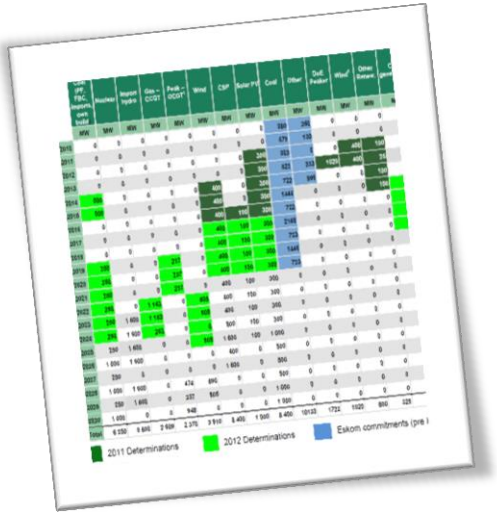
South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) started in 2011

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

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 energy 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) contributing 6.3 GW total and recently an additional BW 4 Expedited, contributing 1.8 GW
- Power Purchase Agreements (PPAs) signed for BW 1,2,3 and 3.5 (1 project)

Sources: https://www.ipp-projects.co.za; http://www.energy.gov.za/files/aboutus/DoE-Annual-Performance-Plan-2017-17.pdf;

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

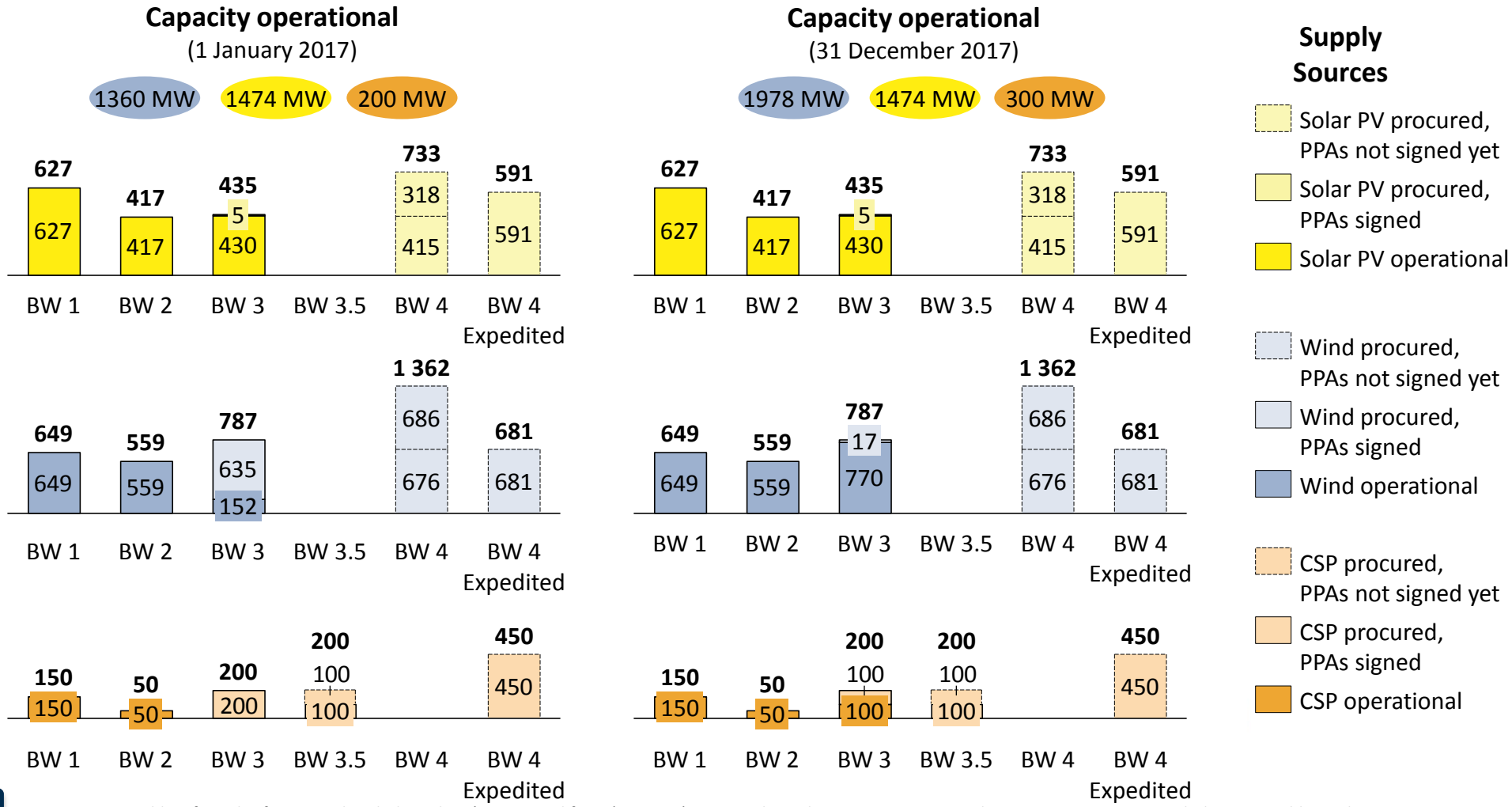
- To date, renewable energy projects in South Africa have resulted in 20 000 jobs for South Africans and have attracted R 192.6 billion in investment.
- Furthermore, IPPs have committed a total of R 19.1 billion toward socio-economic development initiatives within the communities in which they operate, thereby positively contributing to livelihoods and income generation
- The main evaluation criterion for the bid selection process is pricing, with a 70% weighting, and a 30% weighting for other factors such as job creation, local content and black economic empowerment
- Prices have dropped over the four bidding phases with average solar PV tariffs decreasing by 83%, wind by 59% and CSP dropping by 43%
- The REIPPPP includes onshore wind, solar PV, CSP, small hydro, biomass, biogas, landfill gas, small hydro and co-generation (from agricultural waste / by-products)

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

- … of this, 6.3 GW have achieved preferred bidder status
- … of this, 4.0 GW have financially closed and signed the Power Purchase Agreements with Eskom
- … of this, 1 978 MW of wind, 1 474 MW of solar PV and 300 MW of CSP were operational and fed energy into the grid by Dec 2017

Sources: http://www.energy.gov.za/files/aboutus/DoE-Annual-Performance-Plan-2017-17.pdf

Procured and operational capacity under RSA's RE IPP Procurement Programme (REIPPPP) in 2017

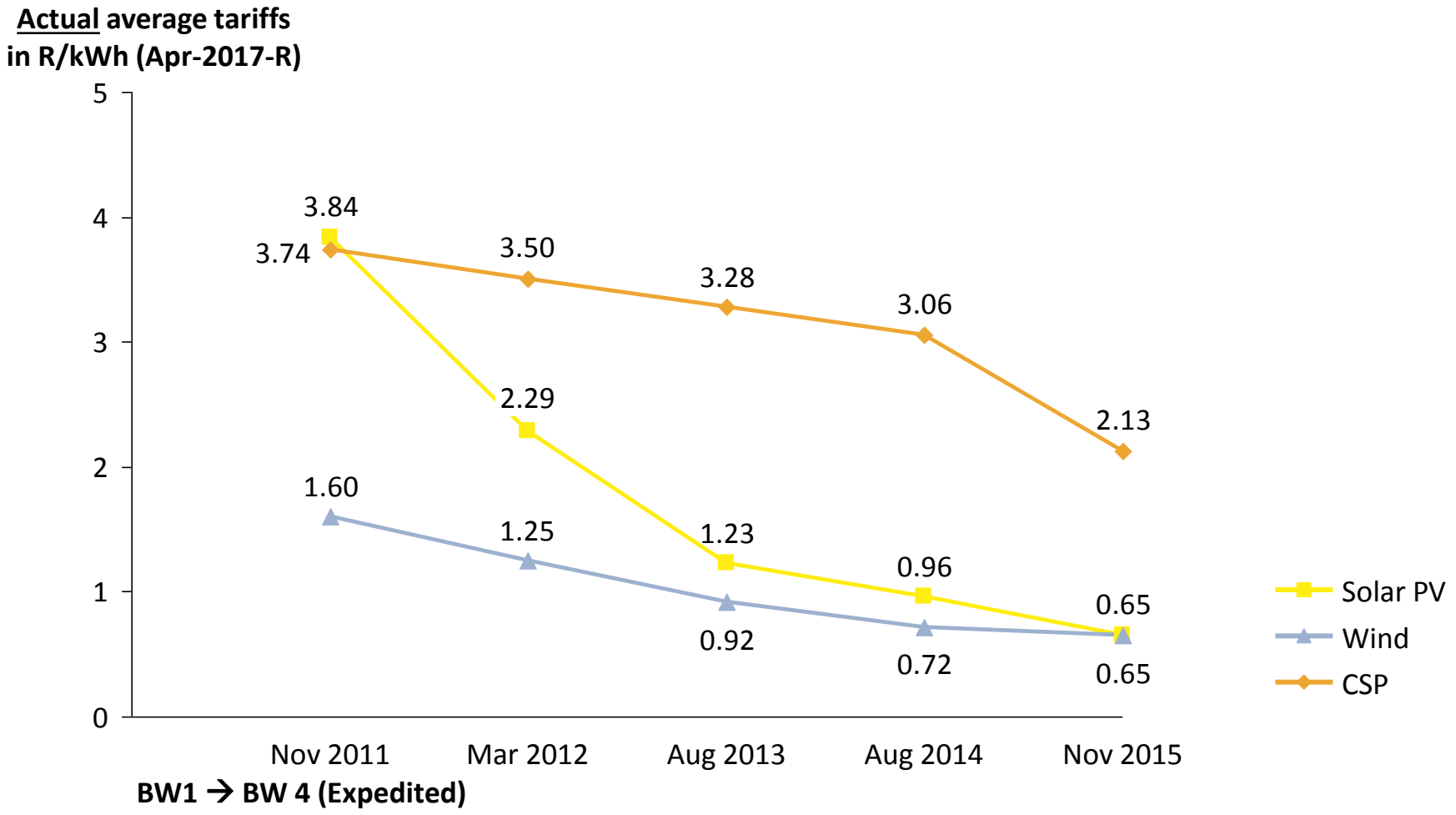


Notes: RSA = Republic of South Africa. Wind excludes Eskom's Sere wind farm (100 MW). BW = Bid Window. PPA = Power Purchase Agreement. BW 4 includes BW 4 additional.

Sources: Eskom; DoE IPP Office; http://www.energy.gov.za/files/renewable-energy-status-report/Market-Overview-and-Current-Levels-of-Renewable-Energy-Deployment-NERSA.pdf

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

Results of Department of Energy's RE IPP Procurement Programme



Sources: http://www.energy.gov.za/files/renewable-energy-status-report/Market-Overview-and-Current-Levels-of-Renewable-Energy-Deployment-NERSA.pdf; http://www.saippa.org.za/Portals/24/Documents/2017/Coal%20IPP%20factsheet.pdf; http://www.ee.co.za/wp-content/uploads/2017/10/New_Power_Generators_RSA-CSIR-14Oct2017.pdf; StatsSA on CPI; BW = Bid Window; Dates shown are the bid submission dates; CSIR analysis

Summary of 2017 statistics:
3.8 % of system load supplied from wind, solar PV & CSP in RSA

In Dec 2017, a total of 2 078 MW wind, 1474 MW of solar PV and 300 MW of CSP capacity were operational

- An additional 618 MW of wind and 100 MW of CSP became operational during 2017

From Jan-Dec 2017, total wind, solar PV and CSP production was 9 TWh, supplying 3.4% of SA's system load

- Maximum daily total energy from solar PV, wind & CSP combined was 47 GWh, which occurred on 25 Dec 2017
- Wind power achieved a maximum peak power production of 1 708 MW between 18h00-19h00 on 25 Dec 2017
- Solar PV power reached a maximum peak power production of 1 432 MW between 12h00-13h00 on 27 Oct 2017
- CSP power reached a maximum peak power production of 302 MW between 10h00-11h00 on 7 Nov 2017
- Maximum instantaneous power contribution of wind, solar PV & CSP was 12.7% on 25 Dec 2017 between 15h00-16h00
- Maximum instantaneous power contribution of wind alone was 8.0% on 25 Dec 2017 between 18h00-19h00
- Maximum instantaneous power contribution of solar PV alone was 5.7% on 25 Dec 2017 between 13h00-14h00
- Maximum instantaneous power contribution of CSP alone was 1.4% on 25 Dec 2017 between 16h00-17h00

Total monthly wind, solar PV and CSP production from Jan to Dec 2017 varied between 592 GWh and 1036 GWh

- The monthly wind production from Jan to Dec 2017 varied between 318 and 579 GWh
- The monthly solar PV production from Jan to Dec 2017 varied between 211 and 336 GWh
- The monthly CSP production from Jan to Dec 2017 varied between 24 and 120 GWh

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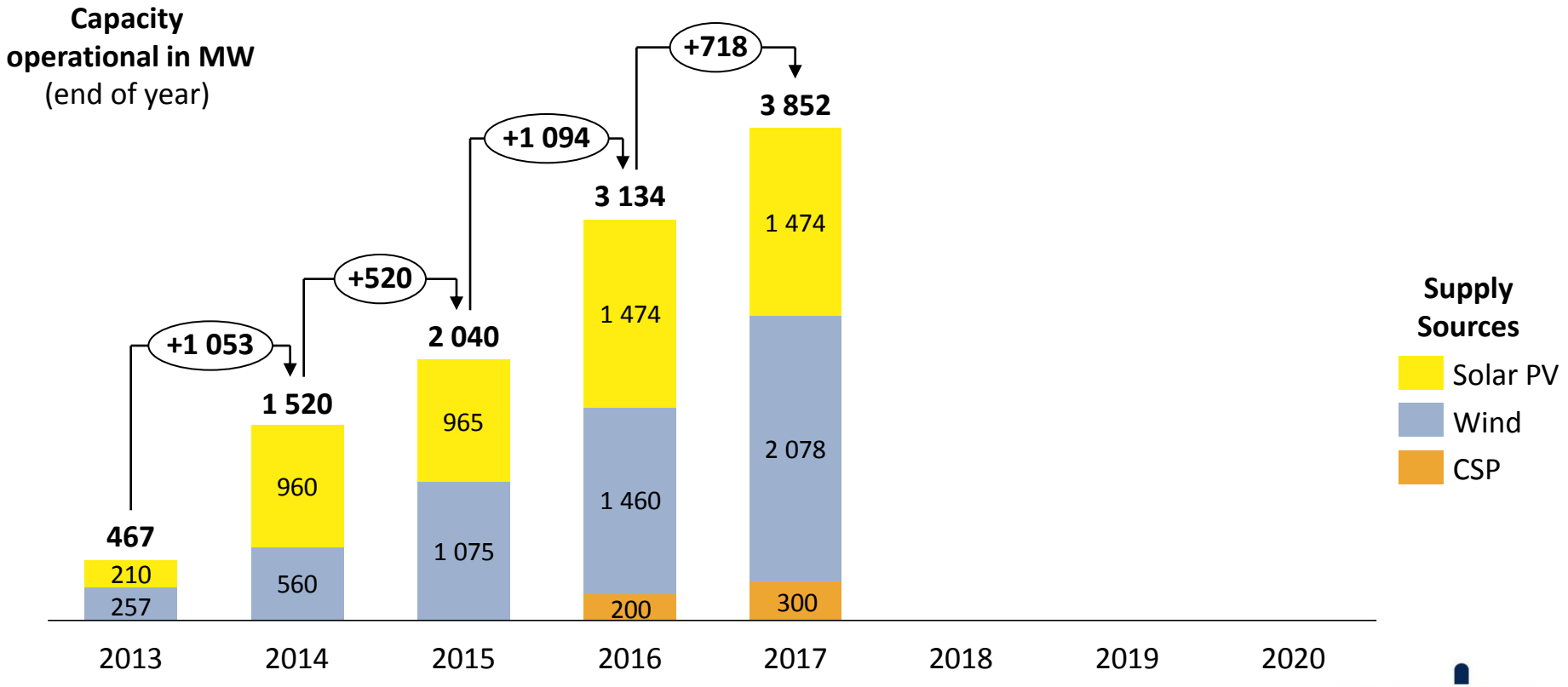
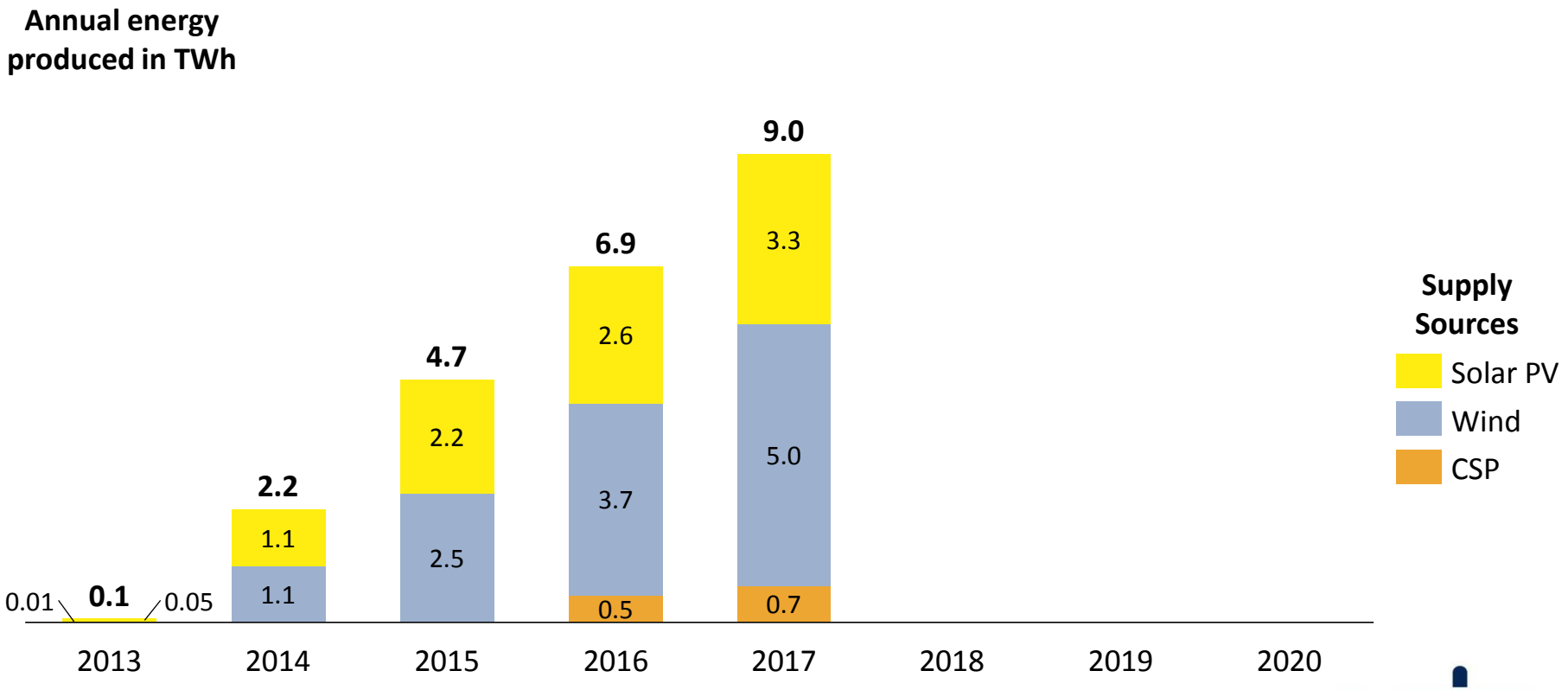
Notes: RSA = Republic of South Africa.
Sources: CSIR Analysis; Eskom; DoE IPP Office

From 1 November 2013 to 31 Dec 2017, 2 078 MW of wind, 1 474 MW of large-scale solar PV and 300 MW of CSP became operational in RSA



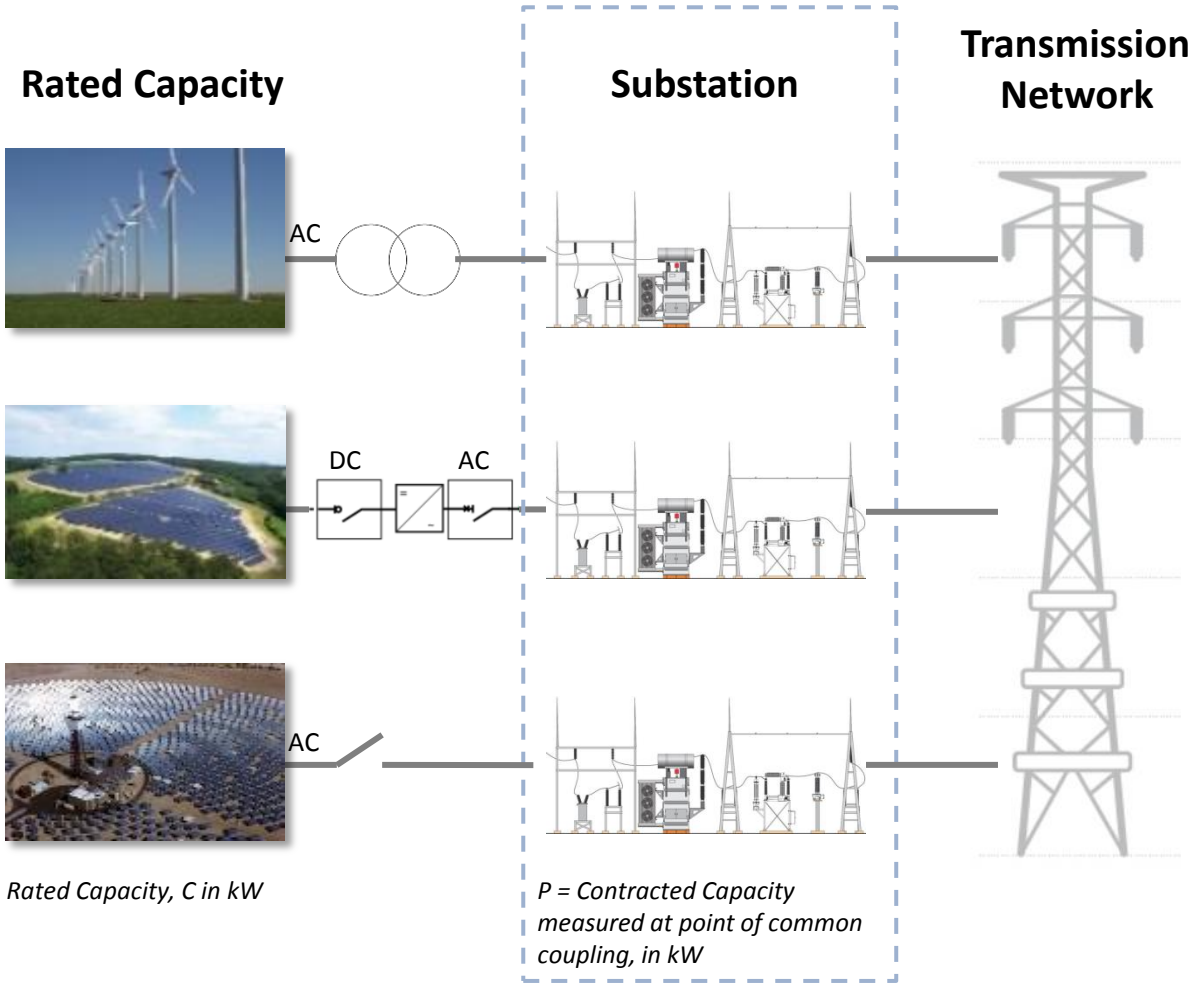
Notes: RSA = Republic of South Africa. Solar PV capacity = capacity at point of common coupling. Wind includes Eskom's Sere wind farm (100 MW).
Sources: Eskom; DoE IPP Office

In 2017, 9.0 TWh of wind, solar PV and CSP energy produced in RSA



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

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



Average Capacity Factor (CF)

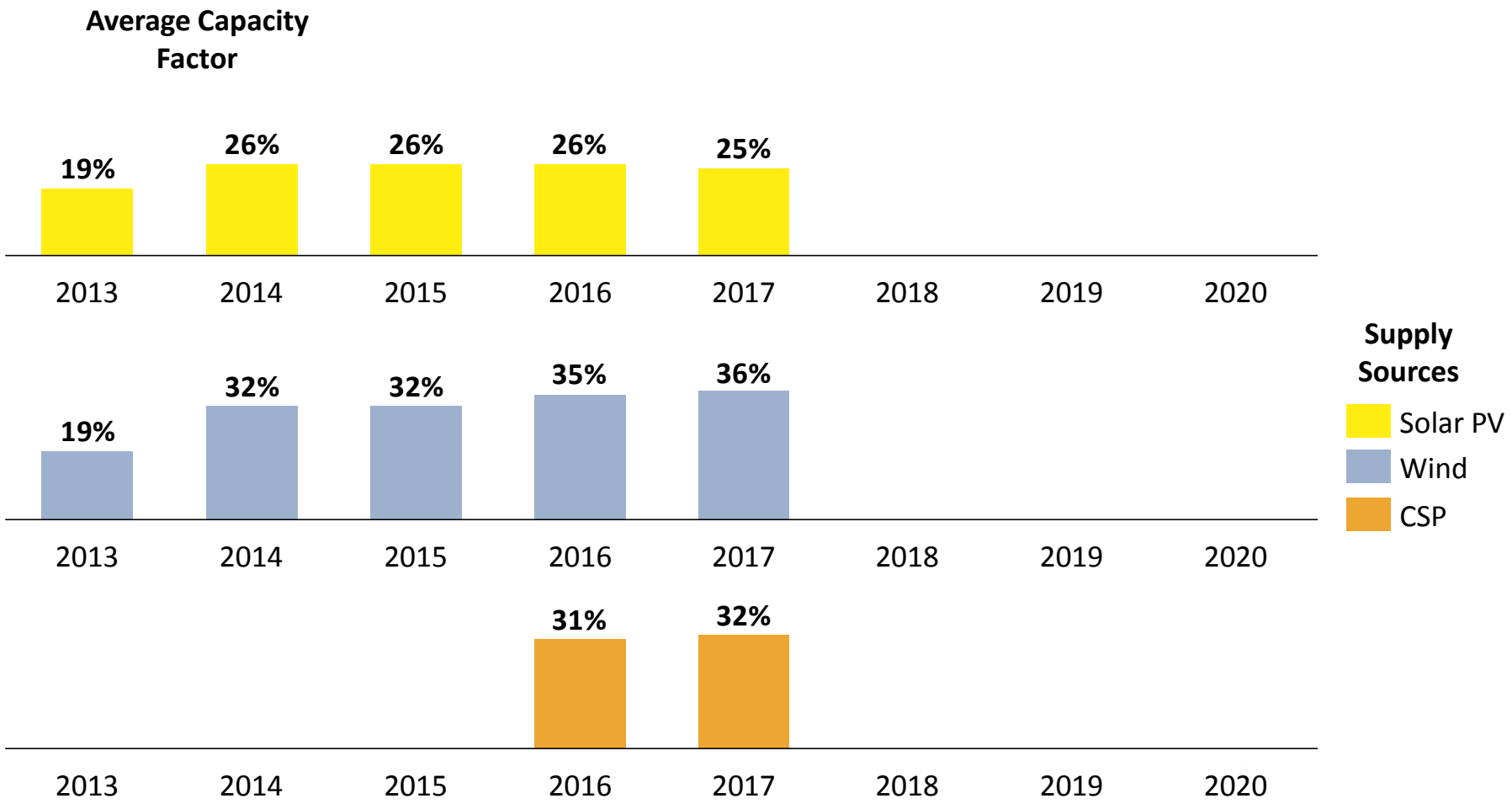
$$CF = \frac{\frac{\sum_{t=1}^{n} E_t}{n}}{\frac{\sum_{t=1}^{n} P_t}{n}}$$

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

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 wind, solar PV and CSP grid connections

In 2017, the average annual capacity factor of the solar PV, wind and CSP fleet was 25%, 36% and 32% respectively



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; DoE IPP Office

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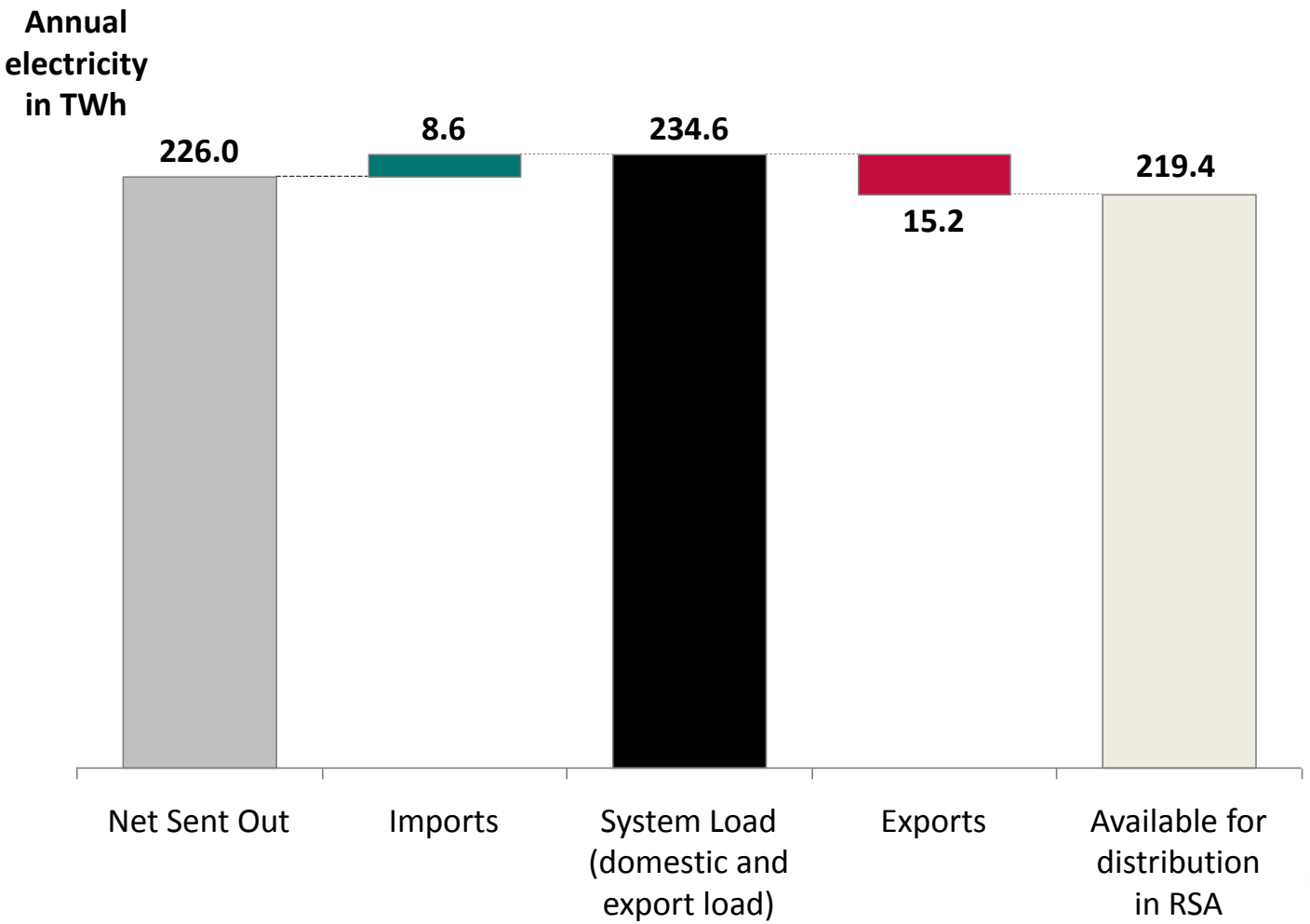
From Jan-Dec 2017, 226 TWh of net electricity were produced in SA

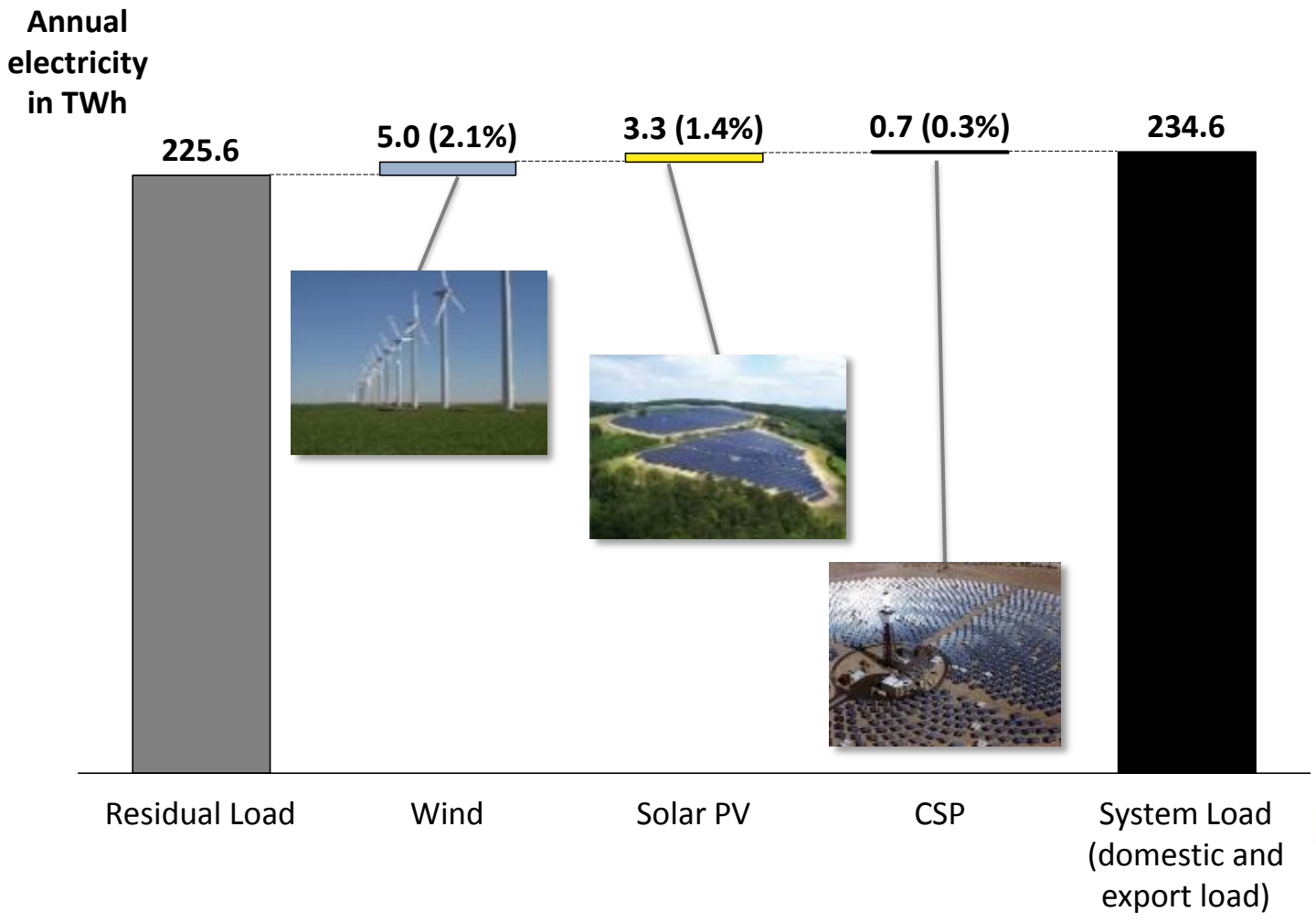
Actuals captured in wholesale market for Jan-Dec 2017 (i.e. without self-consumption of embedded plants)



Notes: "Net Sent Out" = Total domestic generation (Sent Out) minus pumping load (not shown seperately)
Sources: Eskom; Statistics South Africa for imports and exports

In 2017, wind, solar PV & CSP supplied 3.8% of total SA system load

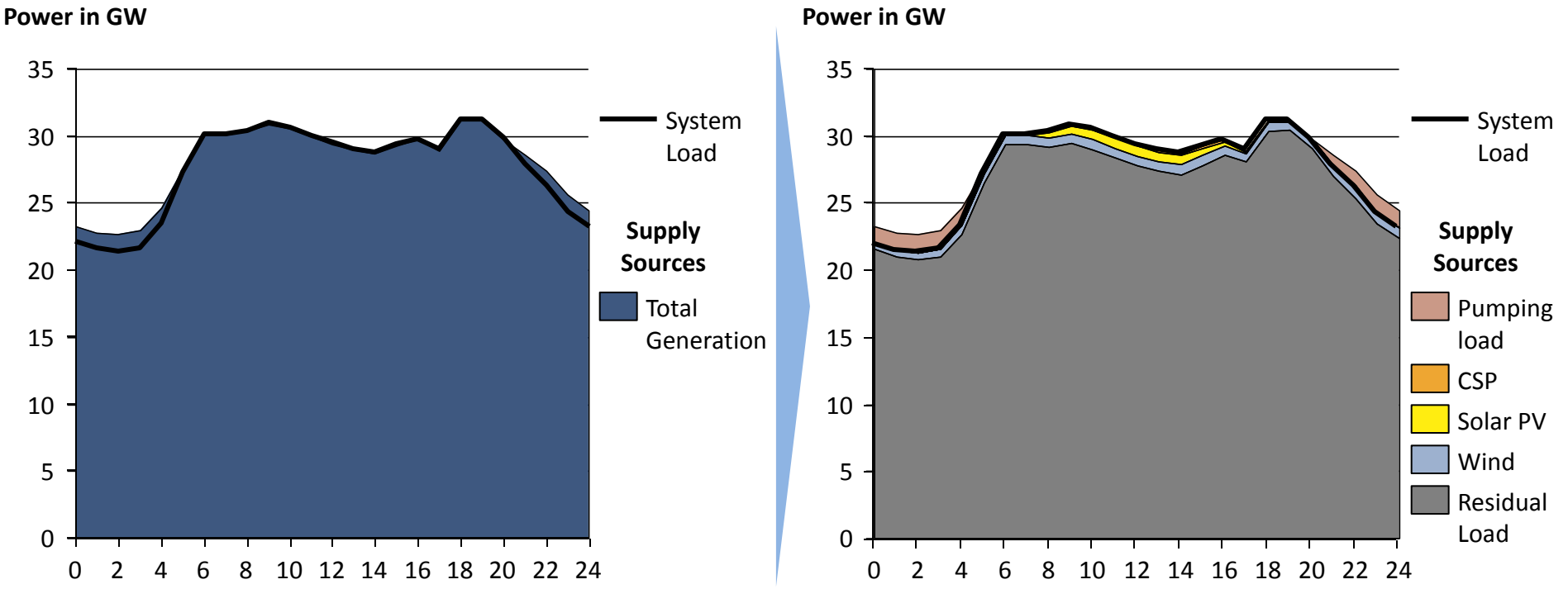
Actuals captured in wholesale market for Jan-Dec 2017 (i.e. without self-consumption of embedded plants)



Notes: Wind includes Eskom's Sere wind farm (100 MW).
Sources: Eskom

Illustrative day explaining terminologies used in this presentation

Hourly South African supply structure for a random day



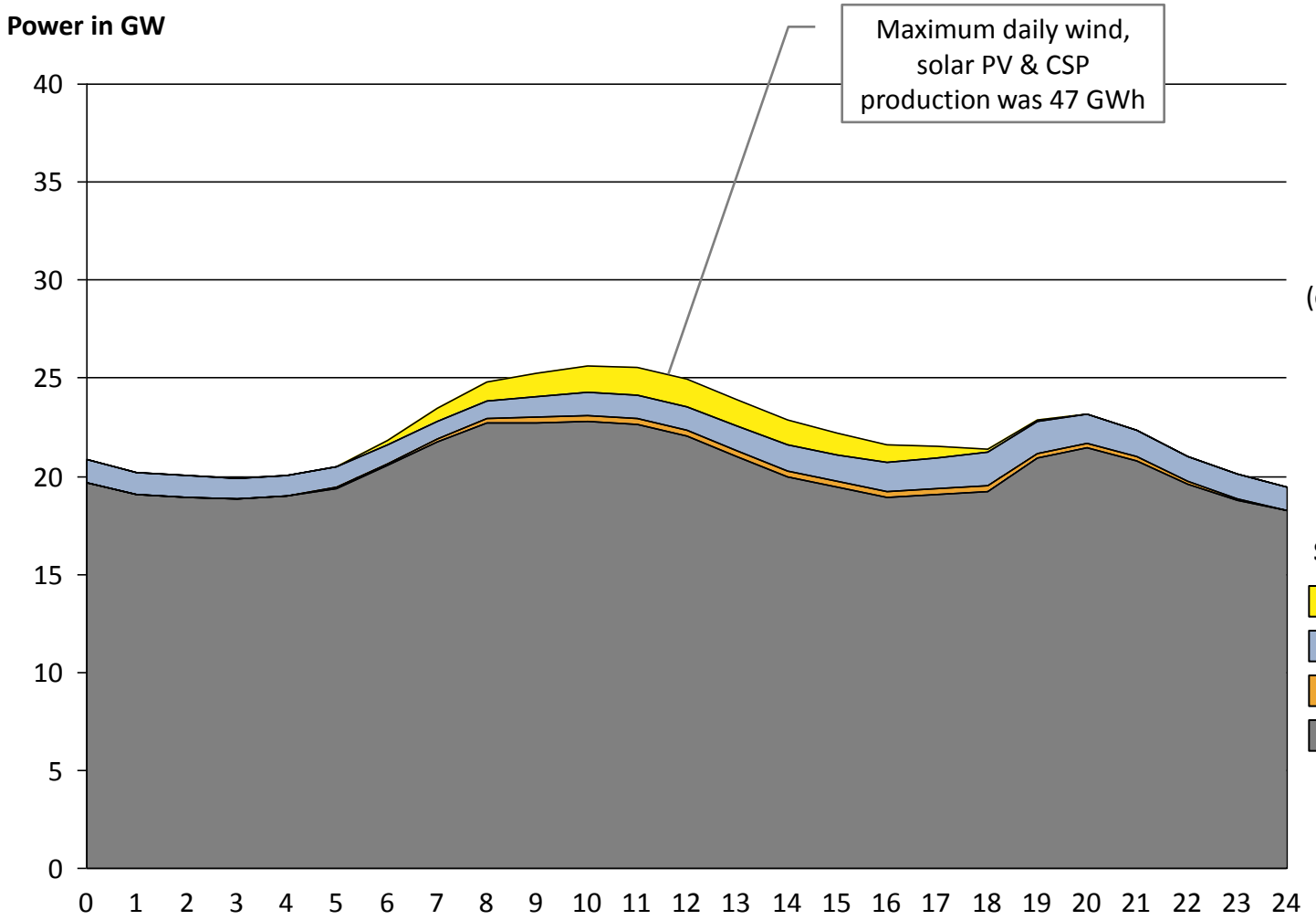
Total Generation	**= domestic generation (Eskom + IPPs) + imported generation**
System Load	**= domestic generation (Eskom + IPPs) + imported generation – pumping load** **= domestic customer load without pumping load (also referred to as simply "domestic load") + export load**
Residual Load	**= System Load – wind – solar PV - CSP**

IPPs: Independent Power Producers; pumping load: demand from pumped storage scheme when operated in pumping mode

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily wind, solar PV & CSP energy of 47 GWh on 25 Dec '17

Actual hourly wind, solar PV & CSP energy production in South Africa on 25 December 2017 (Monday)



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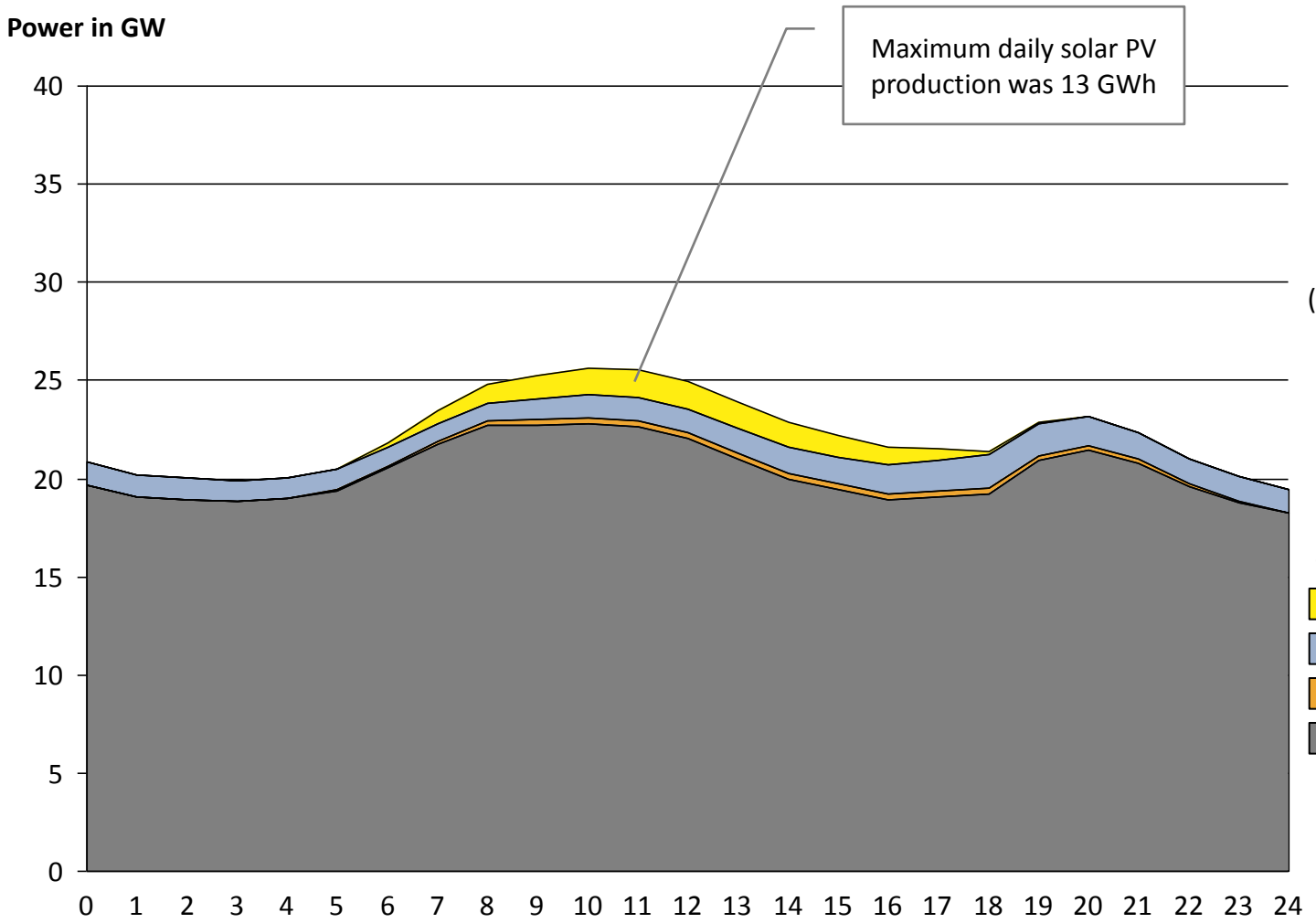
Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily solar PV energy of 13 GWh achieved on 25 Dec 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 25 December 2017 (Monday)

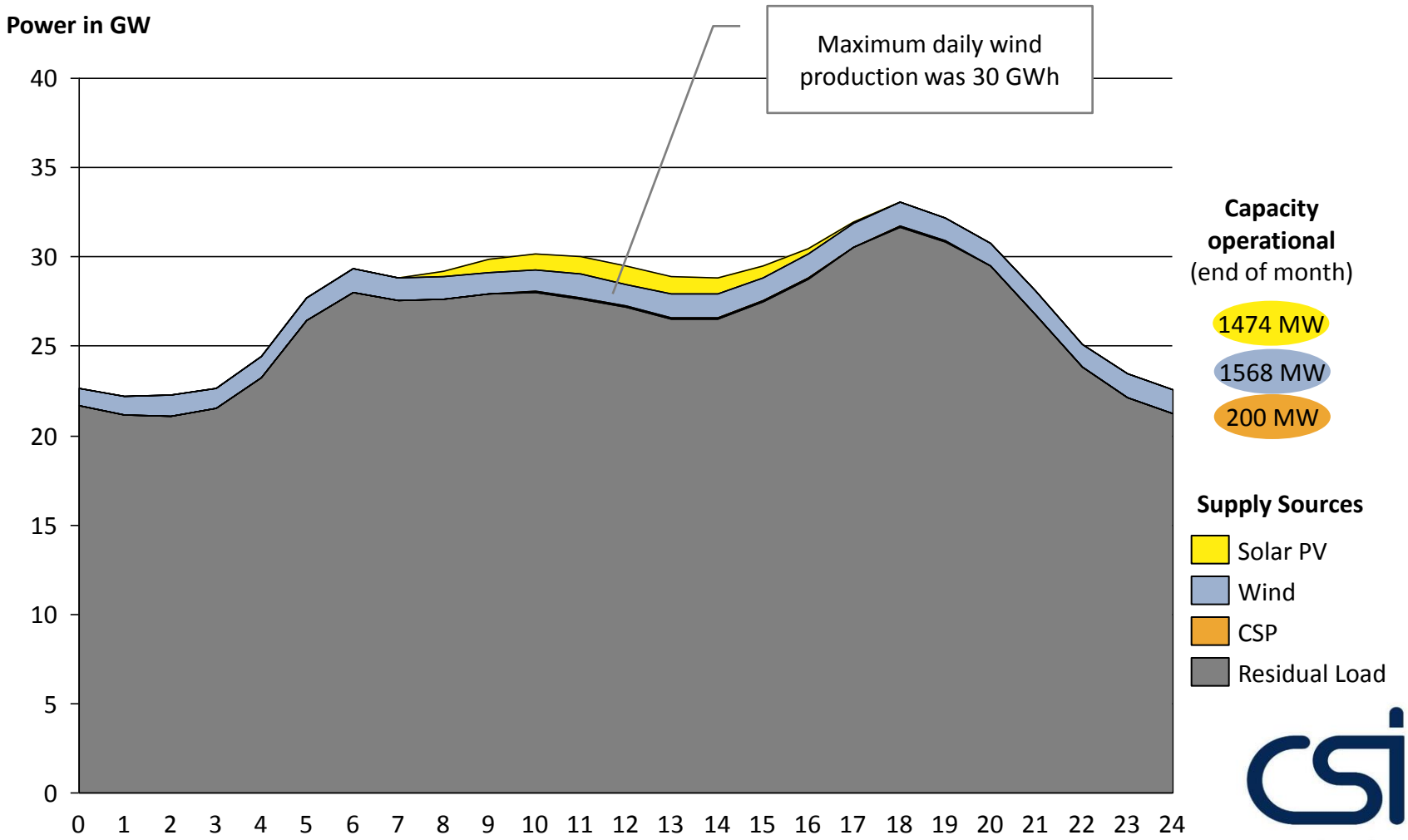


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily wind energy of 30 GWh achieved on 7 Jun 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 7 June 2017 (Friday)

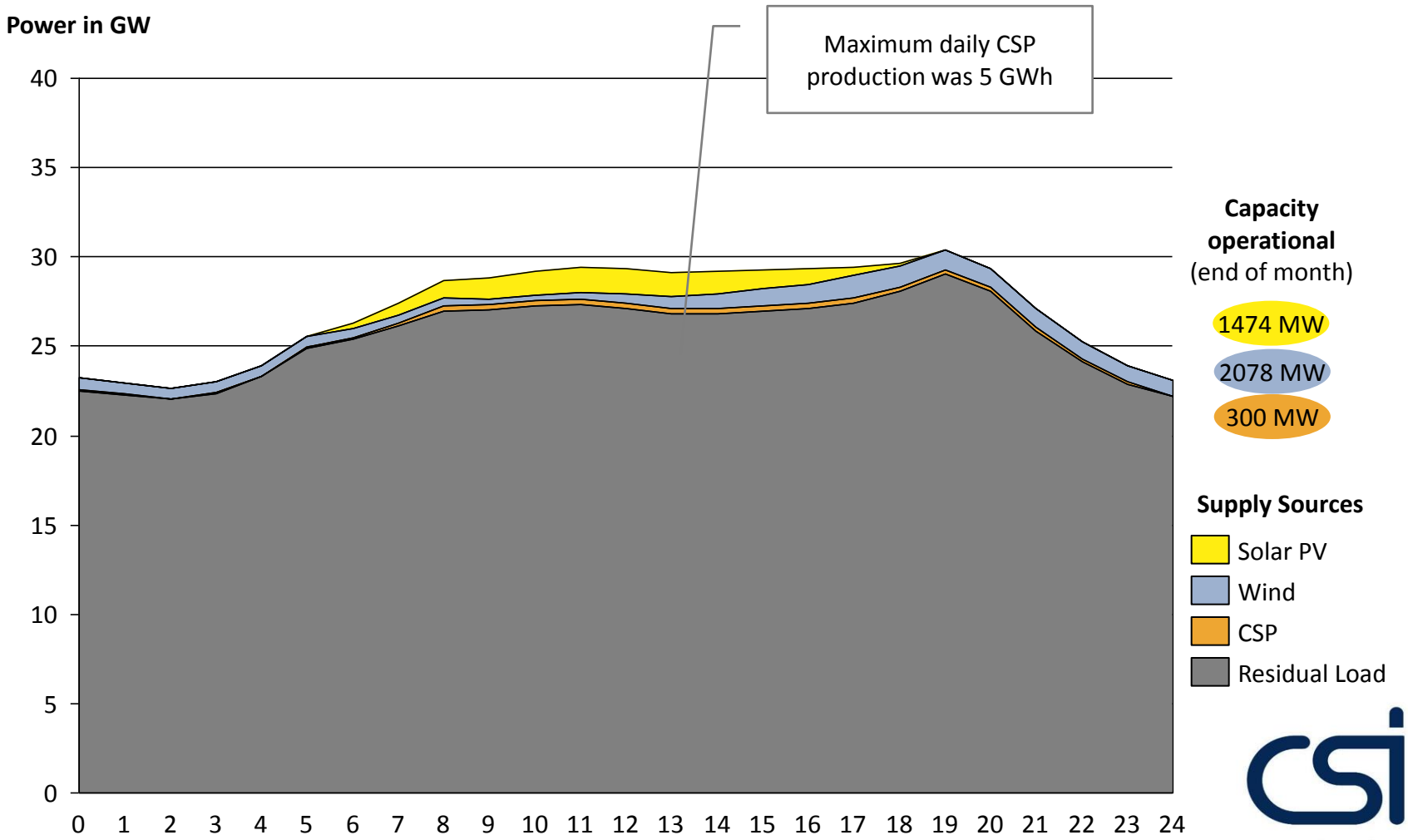


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily CSP energy of 5 GWh achieved on 12 Dec 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 12 December 2017 (Tuesday)

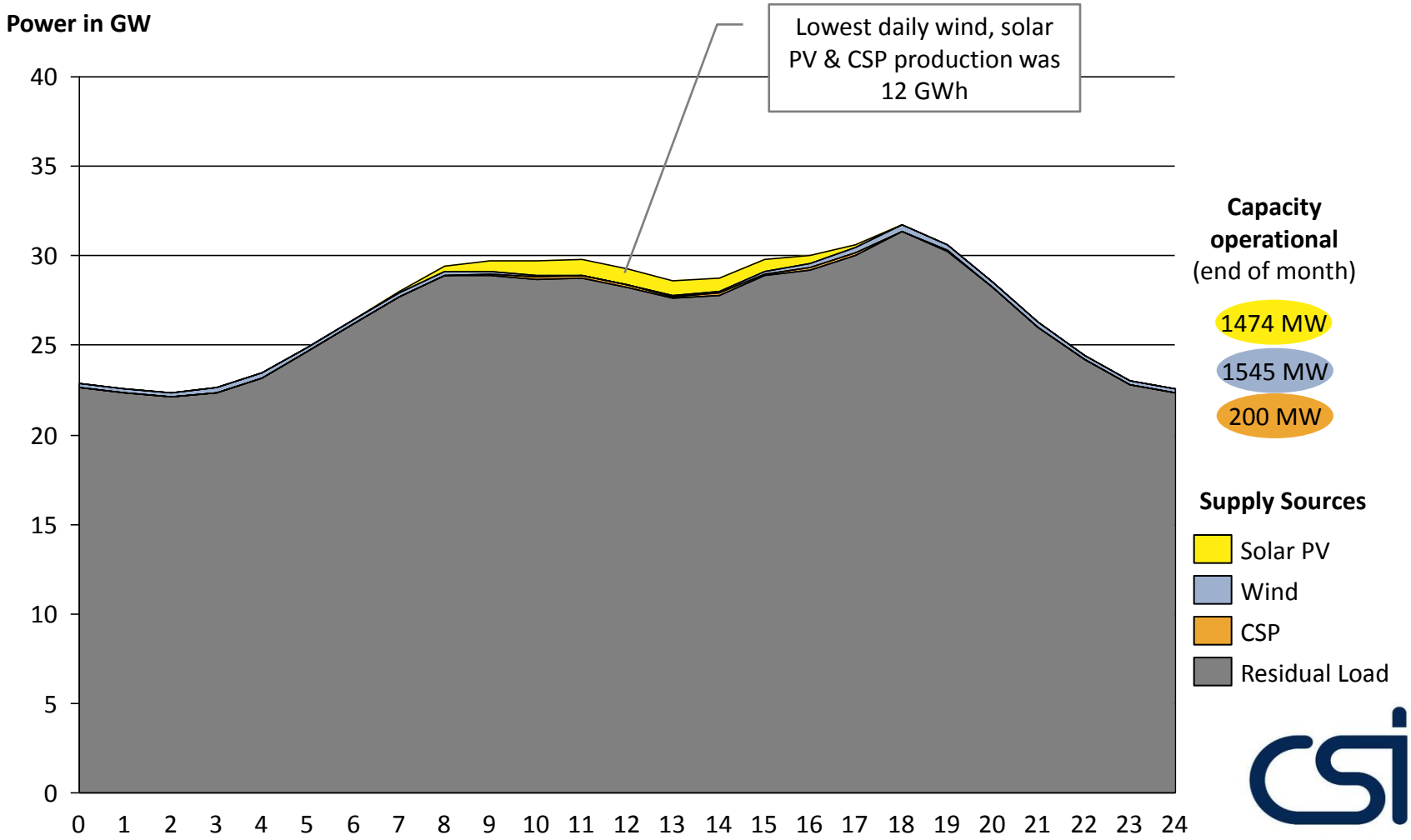


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest combined wind, solar PV & CSP energy = 12 GWh on 11 Apr '17

Actual hourly wind, solar PV & CSP energy production in South Africa on 11 April 2017 (Tuesday)

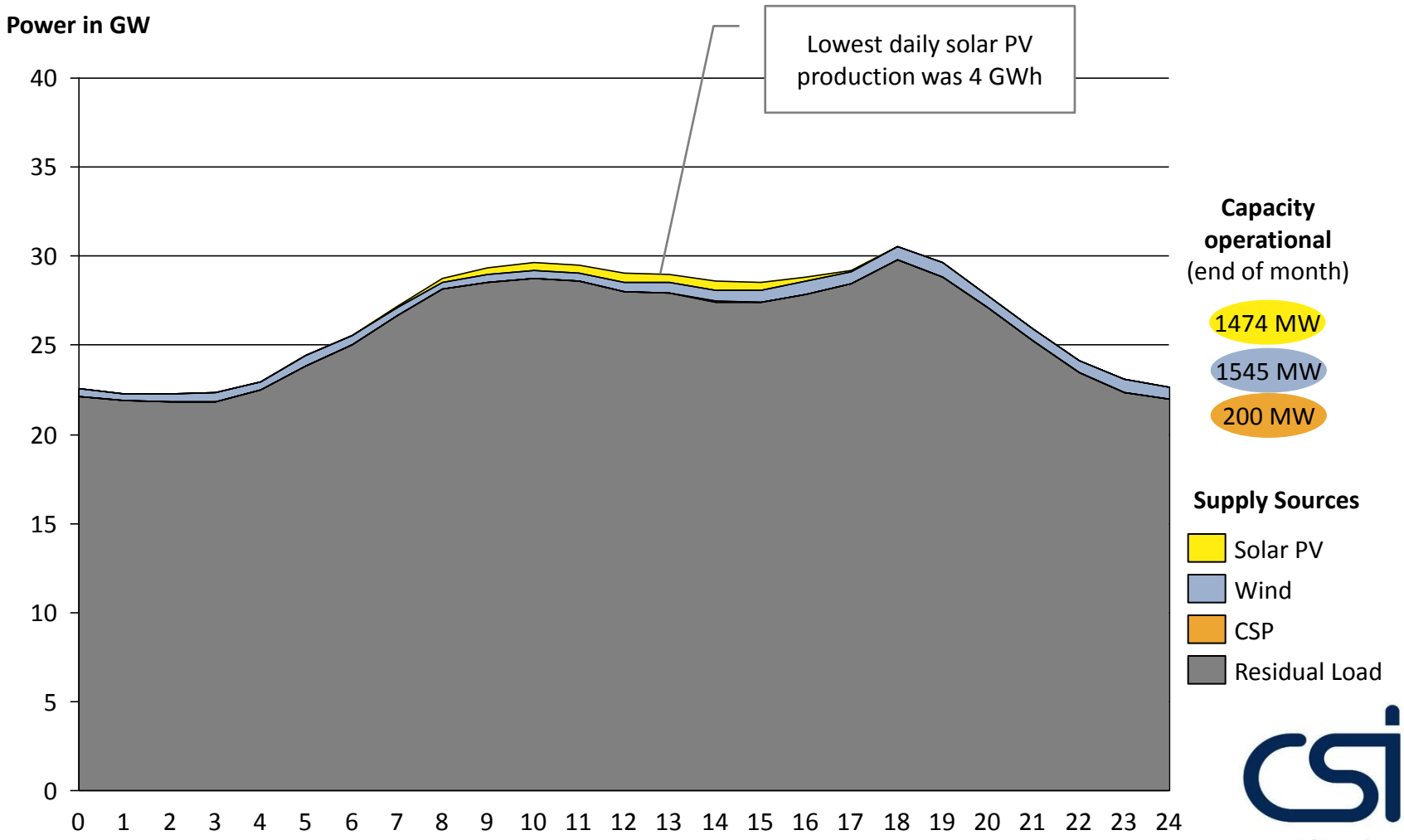


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest solar PV energy production of 4 GWh occurred on 7 Apr 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 7 April 2017 (Friday)

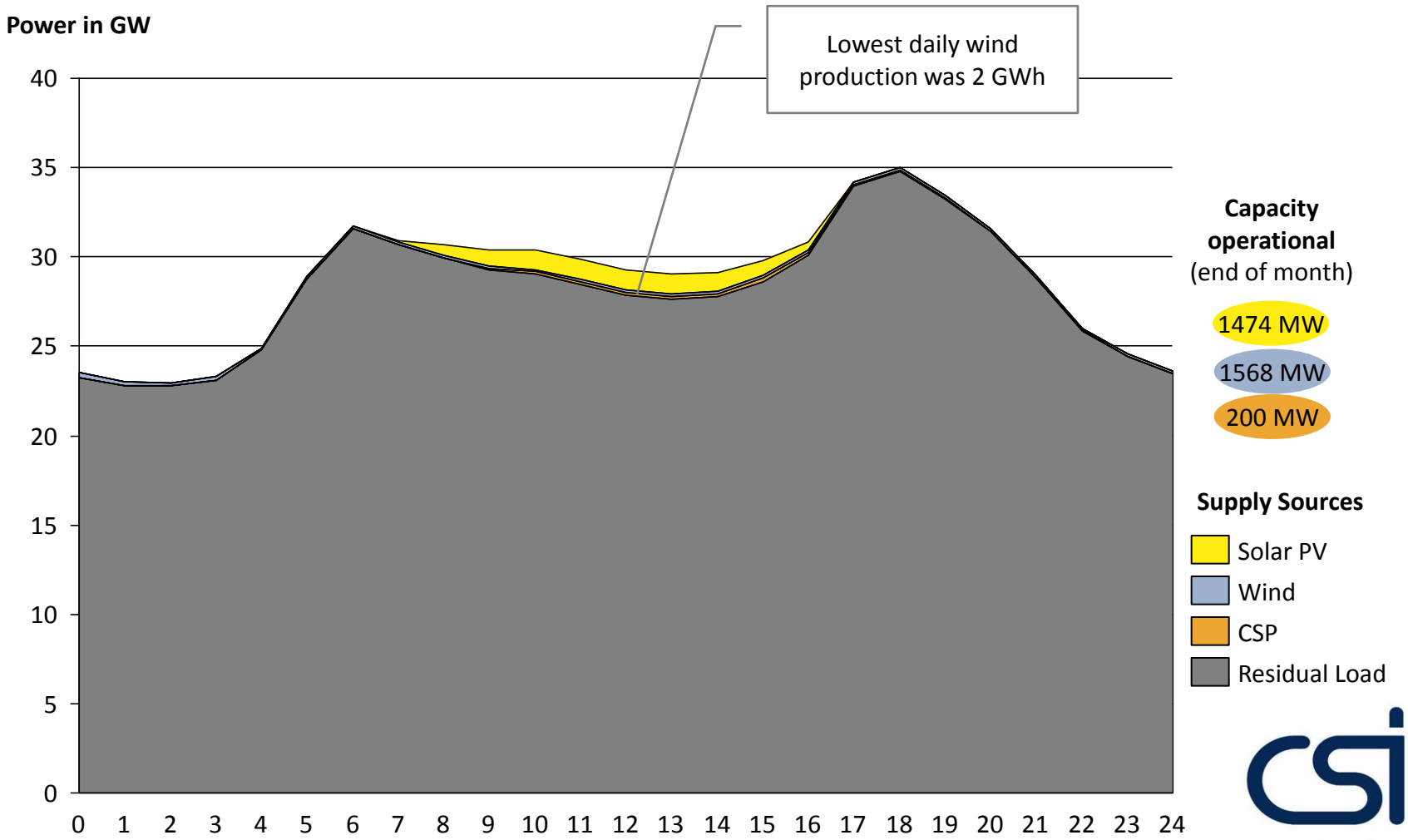


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest wind energy production of 3 GWh occurred on 18 May 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 18 May 2017 (Thursday)

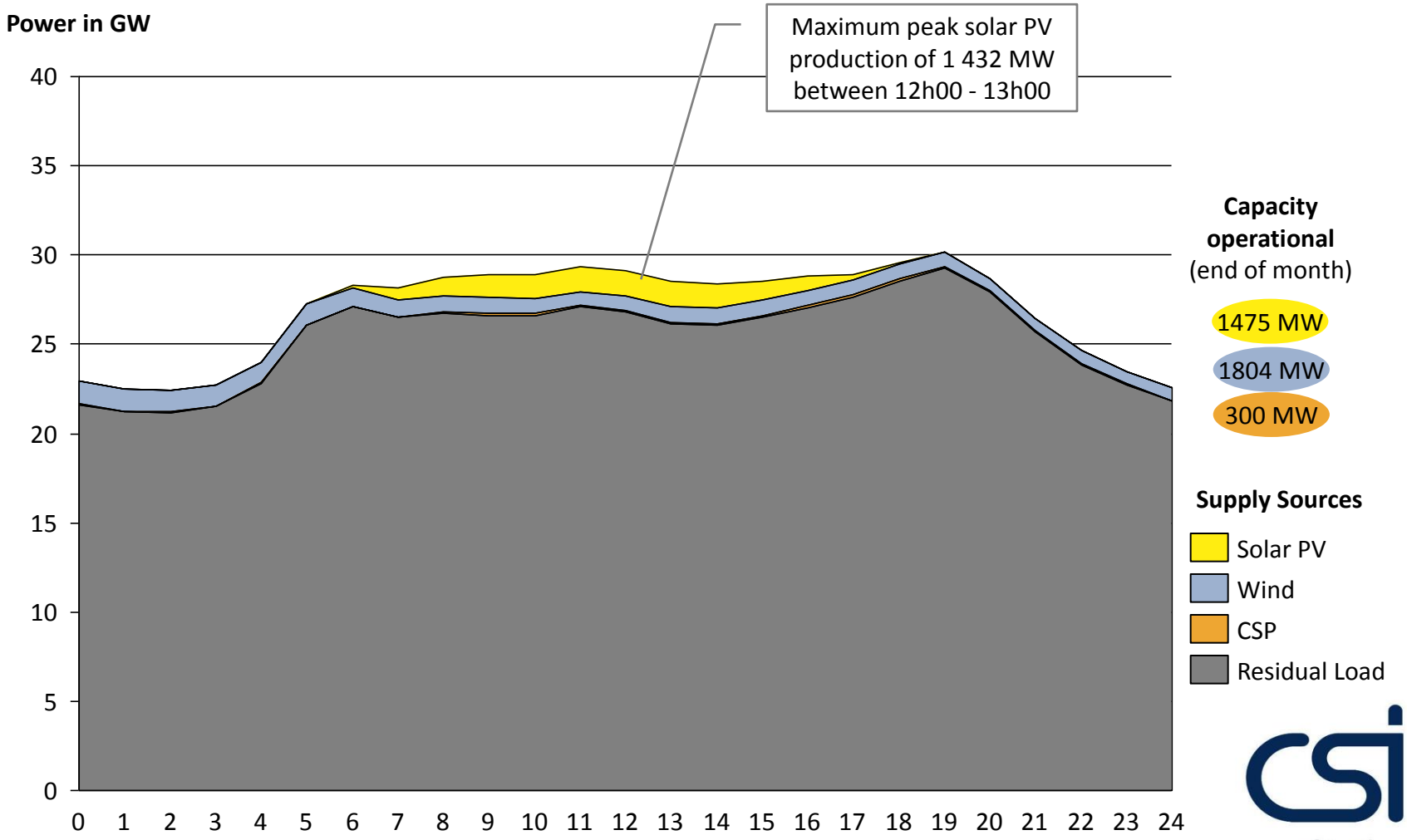


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum solar PV power output of 1 432 MW occurred on 27 Oct '16

Actual hourly wind, solar PV & CSP energy production in South Africa on 27 October 2017 (Friday)

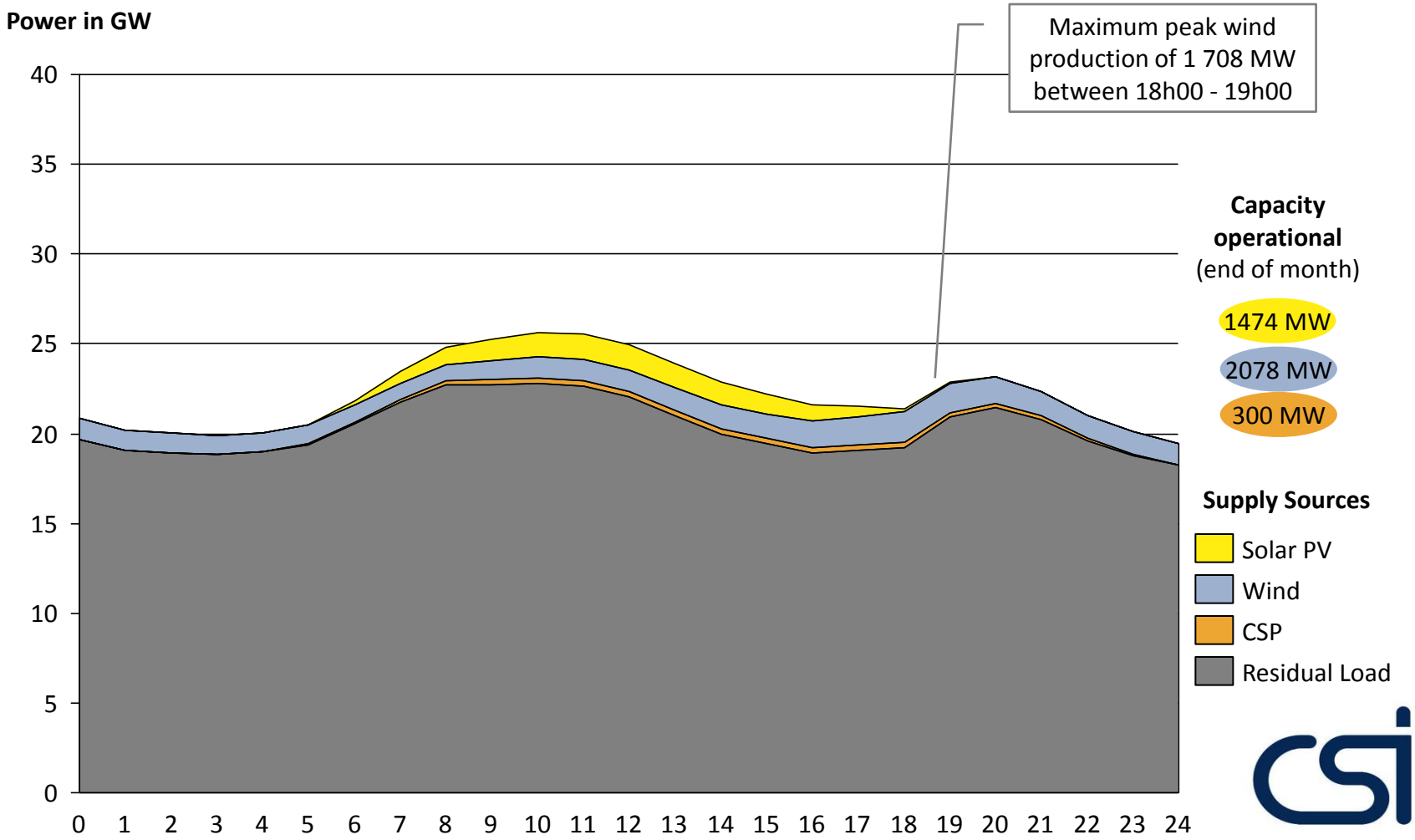


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum wind power output of 1 708 MW occurred on 25 Dec 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 25 December 2017 (Monday)

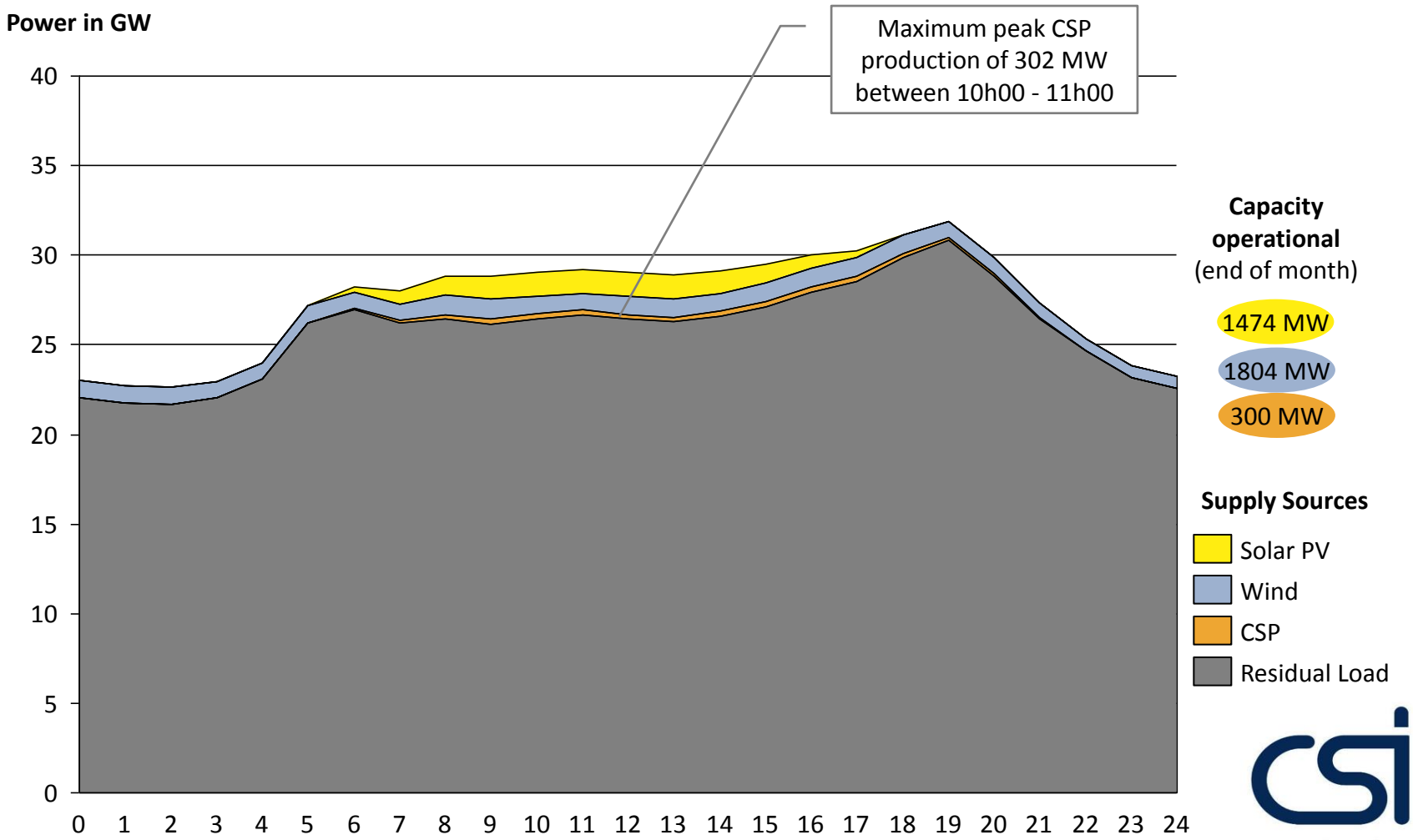


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum CSP power output of 302 MW occurred on 7 Nov 2017

Actual hourly wind, solar PV & CSP energy production in South Africa on 7 November 2017 (Tuesday)

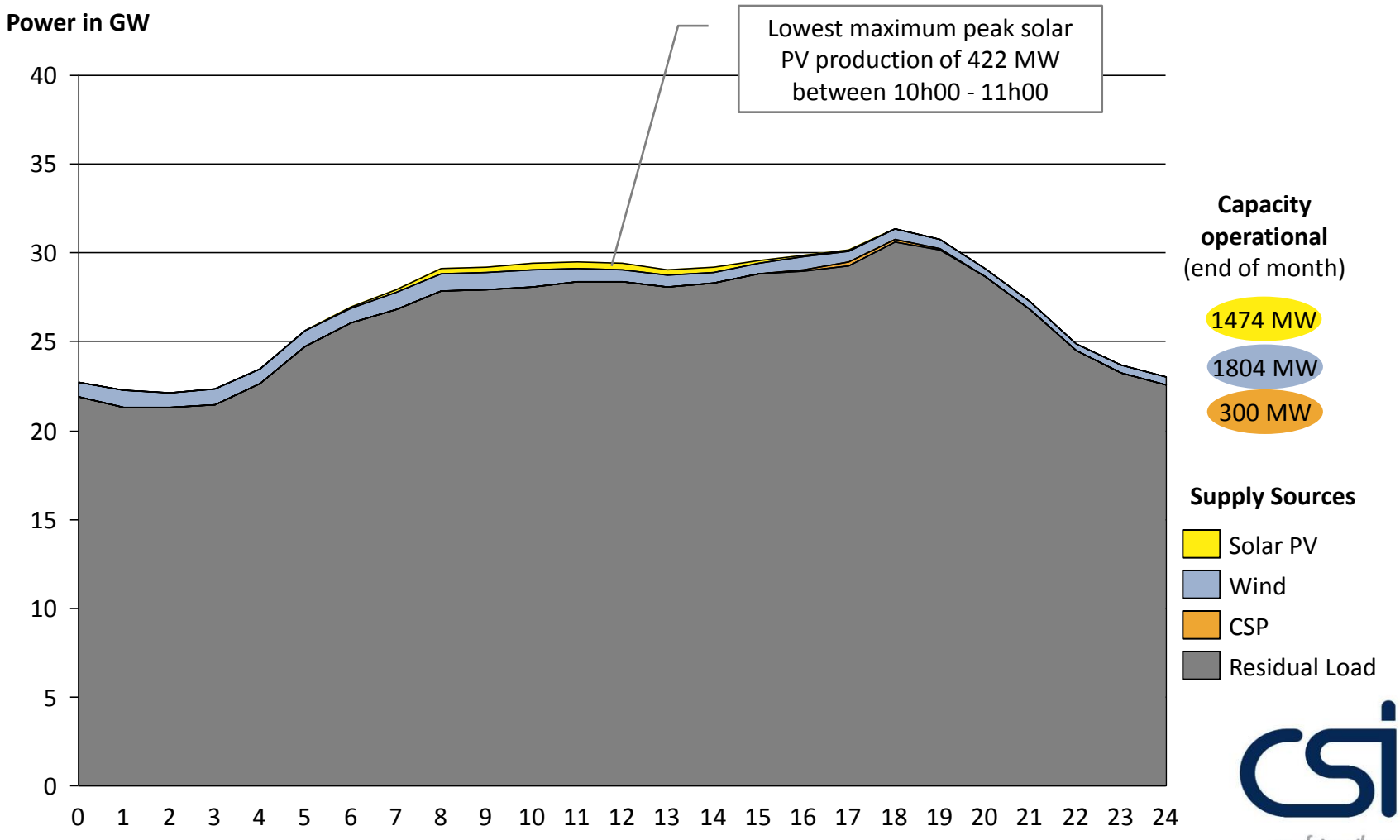


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest daily peak solar PV power output of 422 MW on 4 Oct 2017

Actual hourly wind and solar PV energy production in South Africa on 4 October 2017 (Wednesday)



Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

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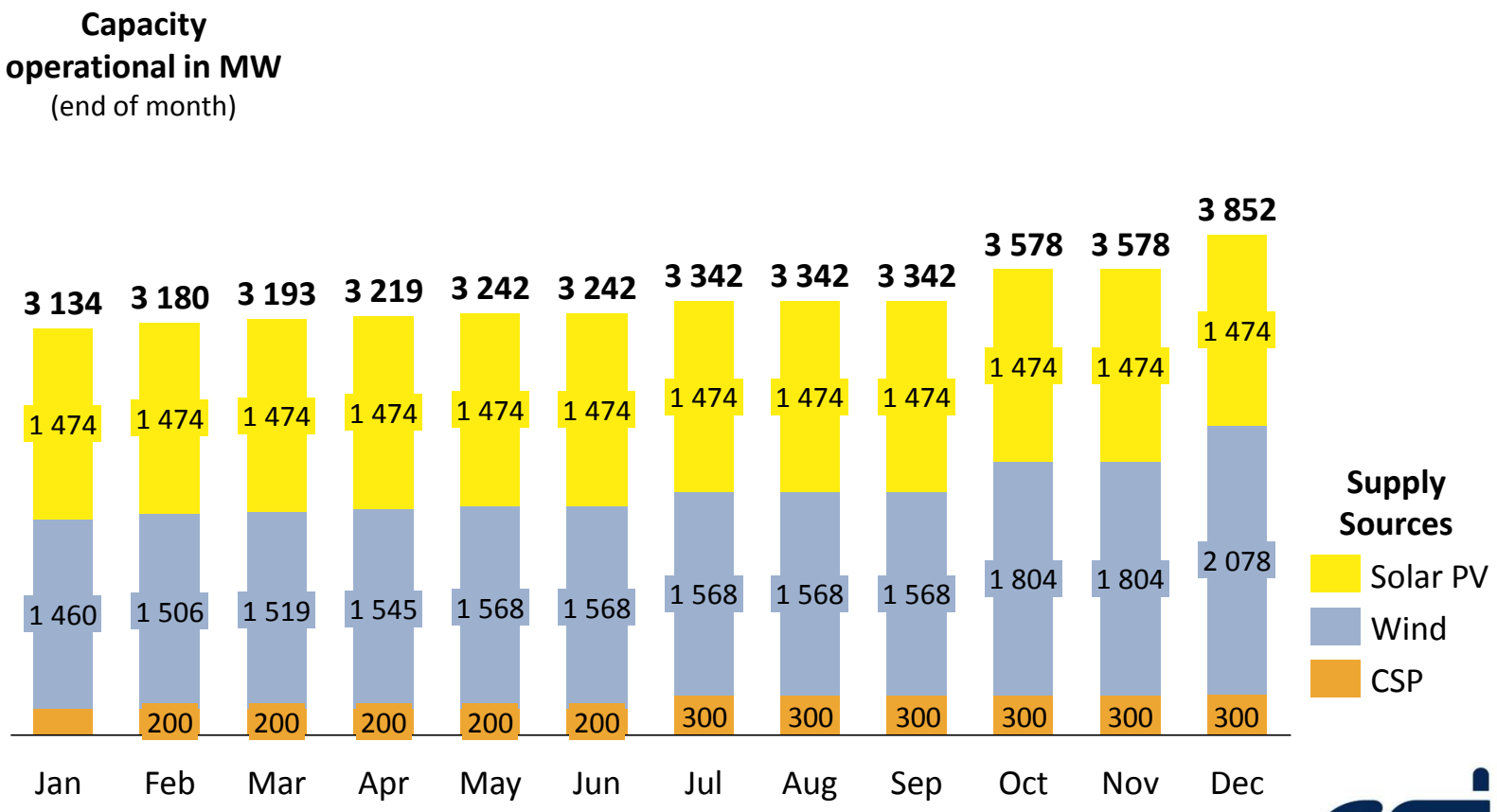
In 2017, 618 MW of wind and 100 MW of CSP was added to the grid

Total monthly installed capacity of solar PV, wind and CSP in MW in RSA from Jan-Dec 2017

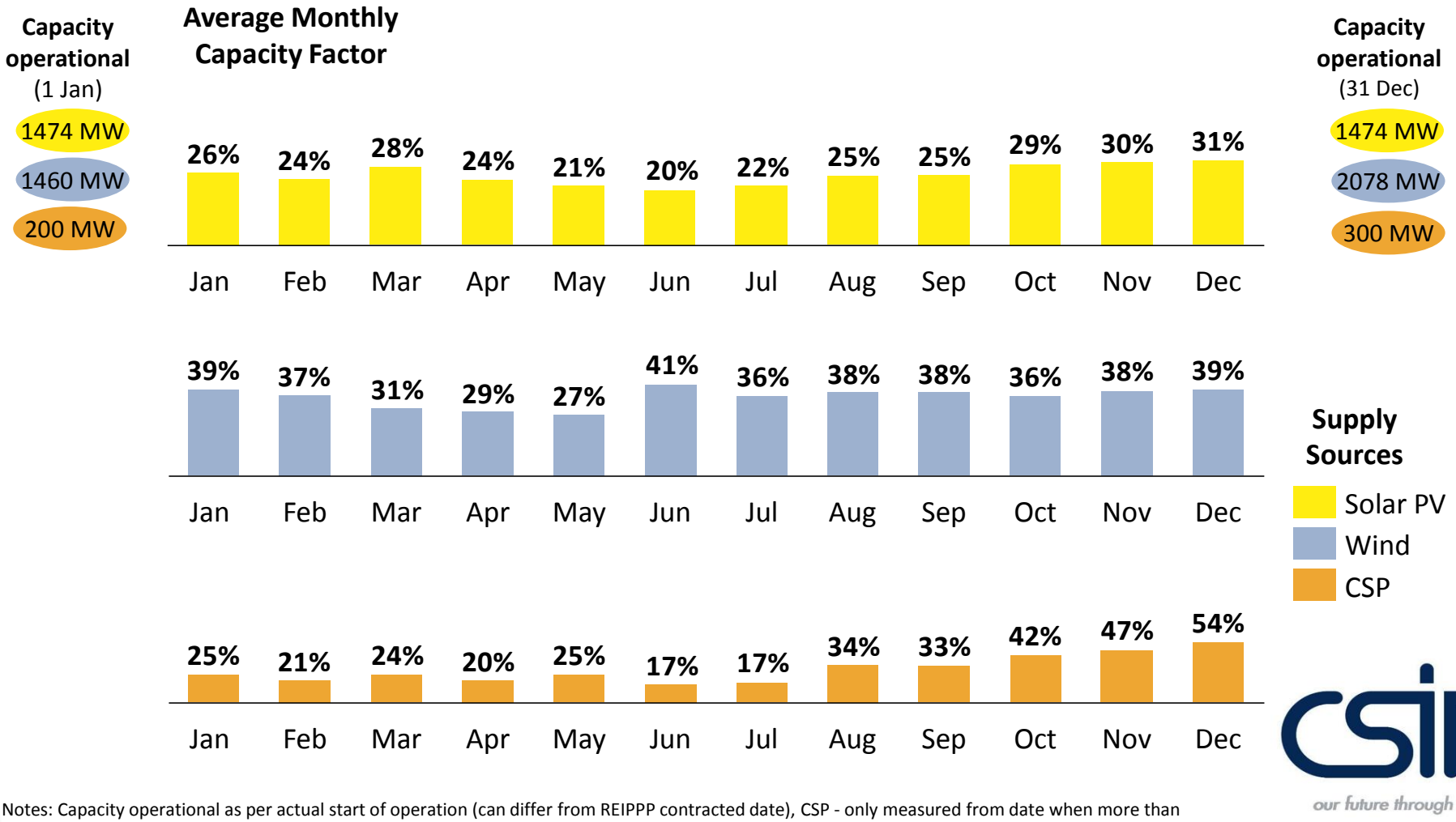


Notes: Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants commissioned. Wind includes Sere wind farm (100 MW).

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 2017

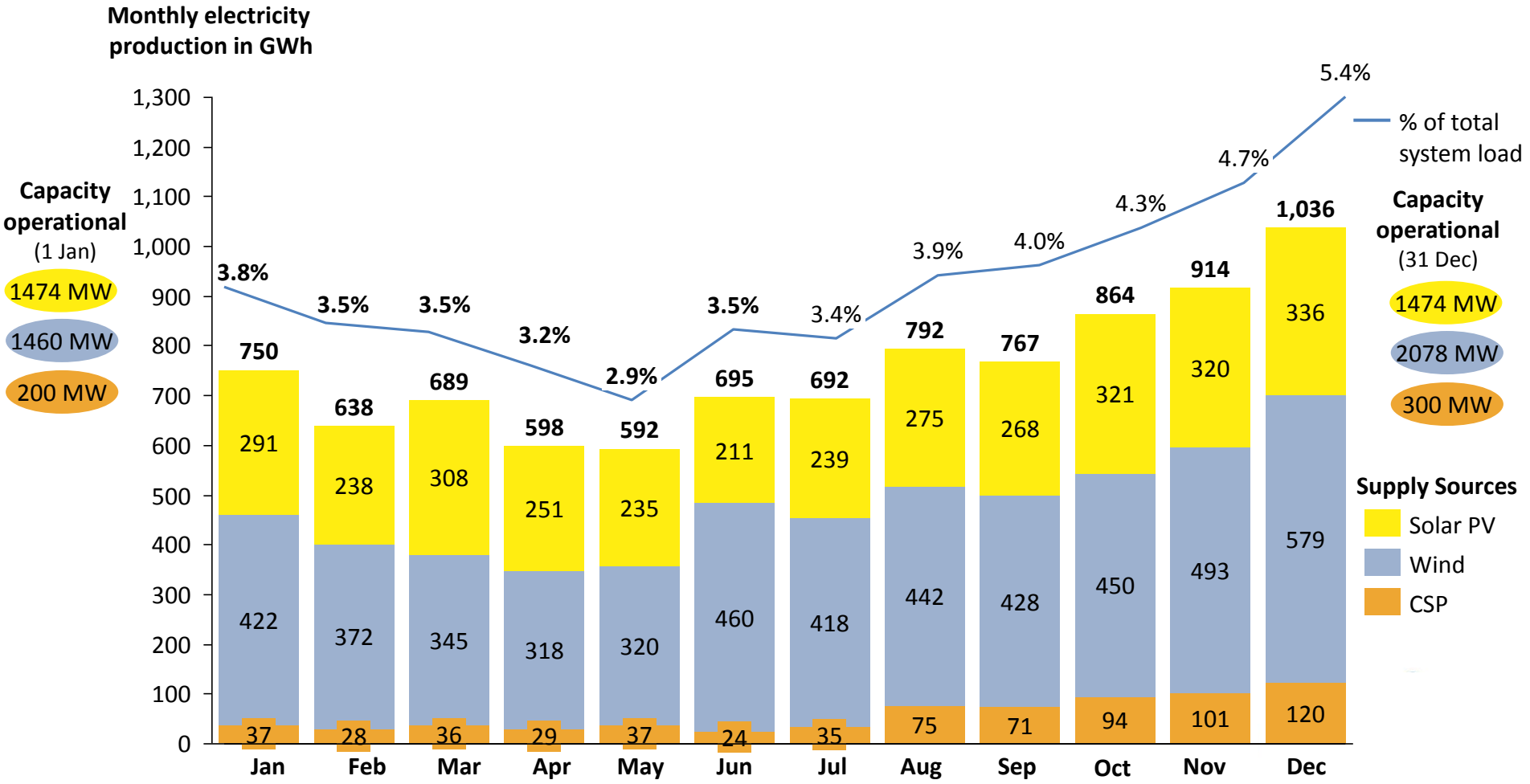


Notes: Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants commissioned. Wind includes Sere wind farm (100 MW).

Sources: Eskom

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

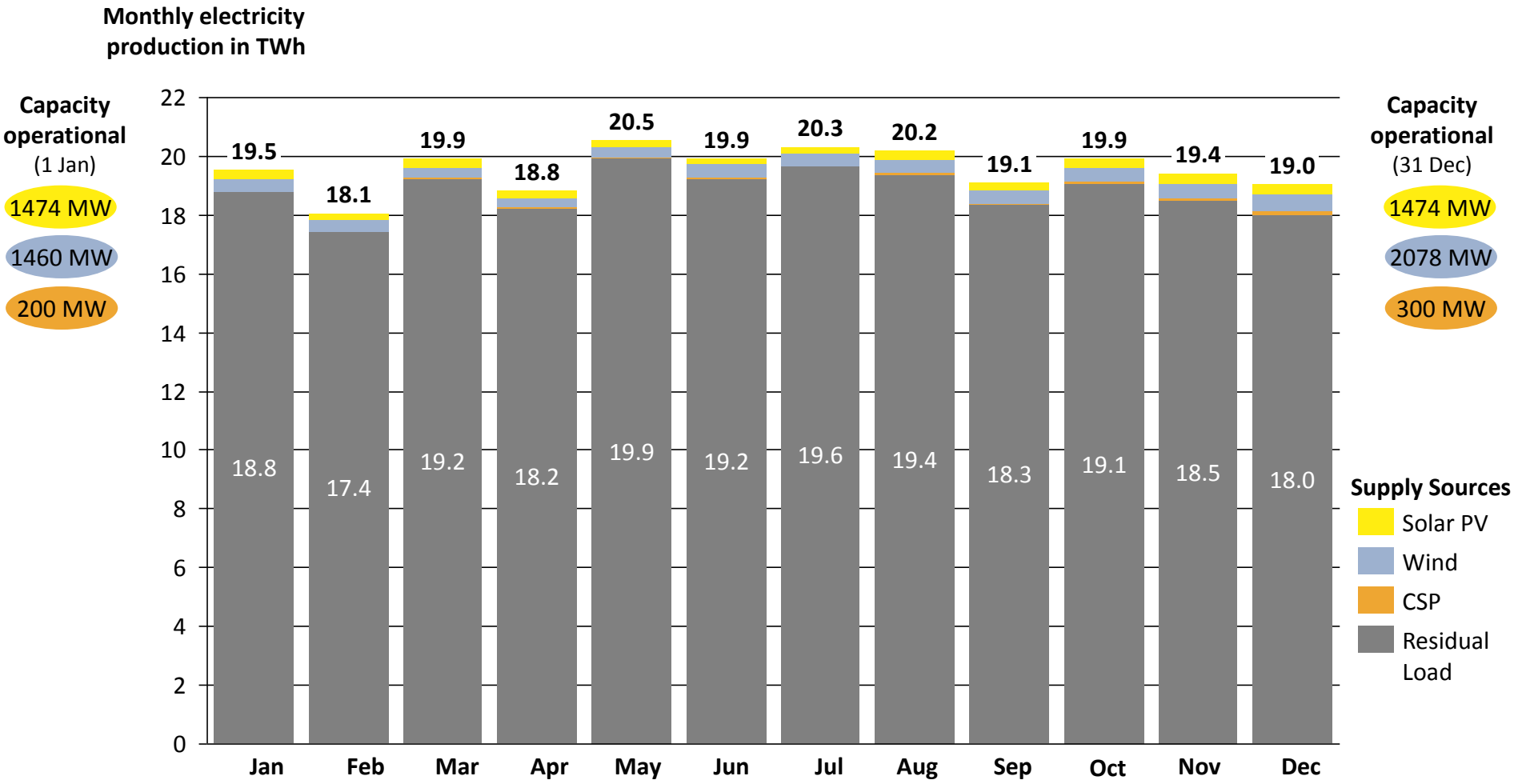
Actual monthly production from wind, solar PV and CSP plants in South Africa from Jan-Dec 2017



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.
Sources: Eskom; CSIR Energy Centre analysis

Monthly electricity production wind, solar PV, CSP and residual load

Actual monthly electricity production for Jan-Dec 2017 from the different supply sources in South Africa



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

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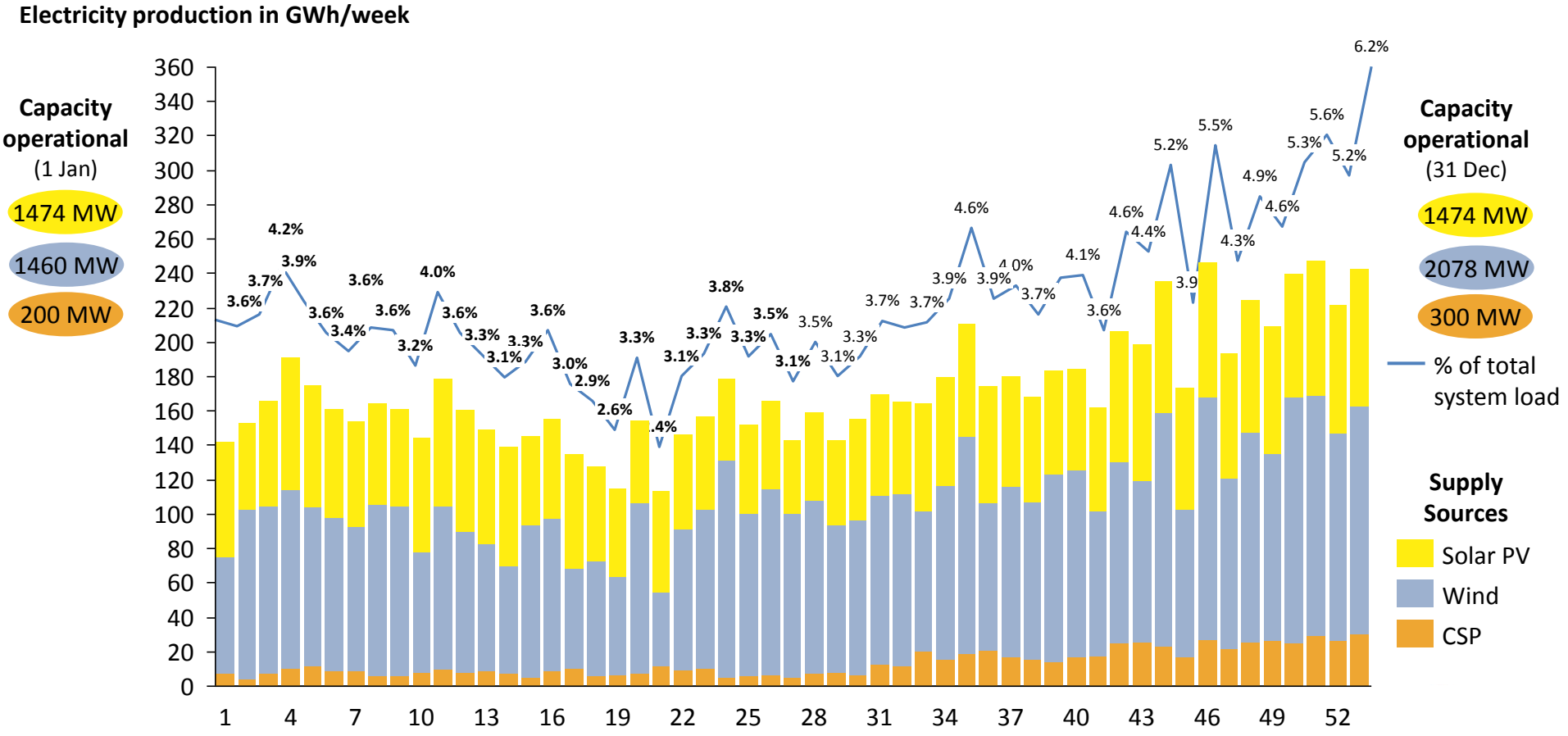
Weekly electricity production of SA's wind, solar PV and CSP fleet

Actual weekly production from large-scale solar PV, wind & CSP plants under the REIPPPP from Jan-Dec 2017

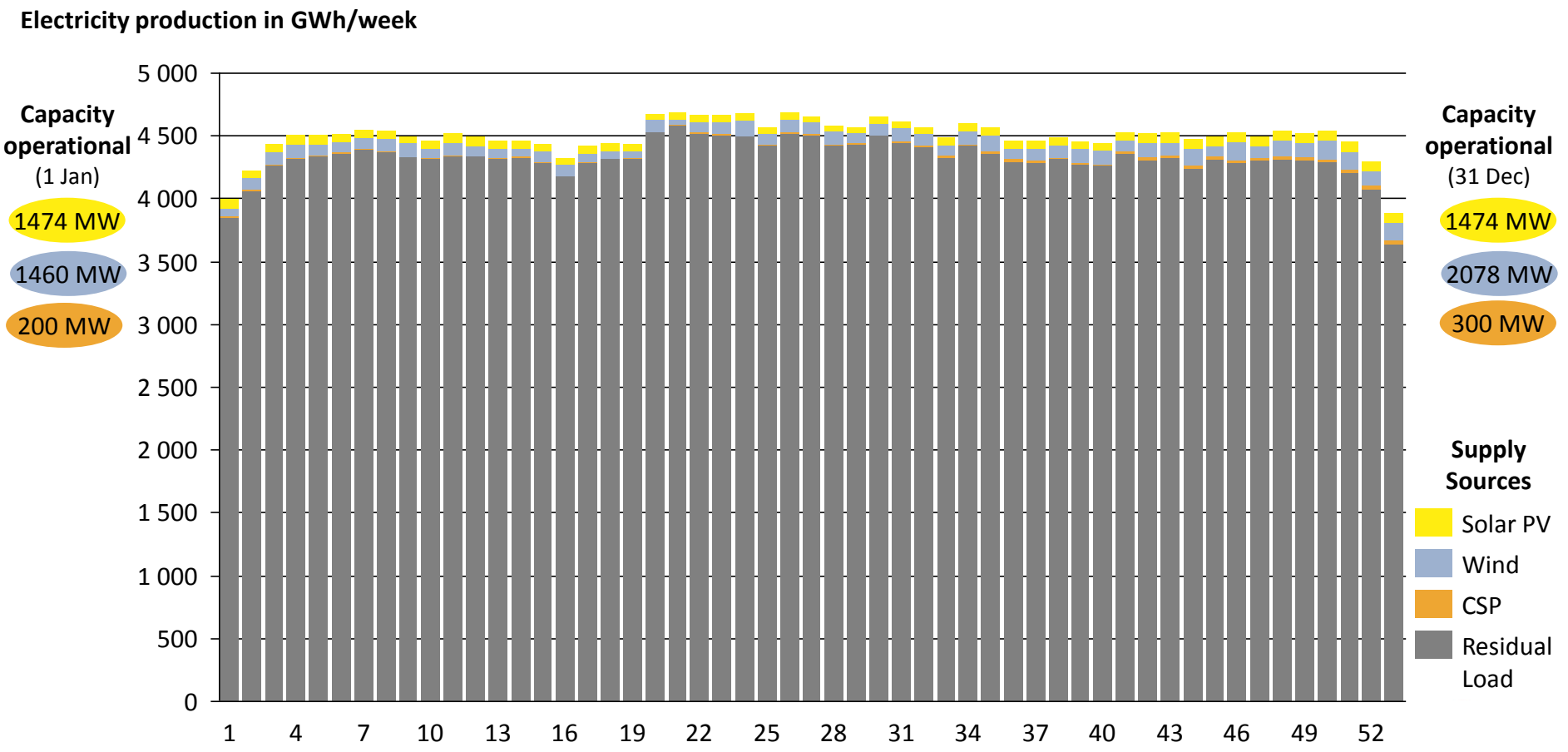


- Maximum wind + solar PV + CSP weekly production of 247 GWh in week 51
- Minimum wind + solar PV + CSP weekly production of 112 GWh in week 21

Note: Design as per Fraunhofer ISE. Week 1 adjusted/scaled to 7 day week.
Sources: Eskom; CSIR Energy Centre analysis

Weekly electricity production wind, solar PV, CSP and residual load

Actual weekly production: conventional fleet, wind, solar PV & CSP plants under REIPPPP from Jan-Dec 2017



Note: Design as per Fraunhofer ISE. Week 1 adjusted/scaled to 7 day week. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

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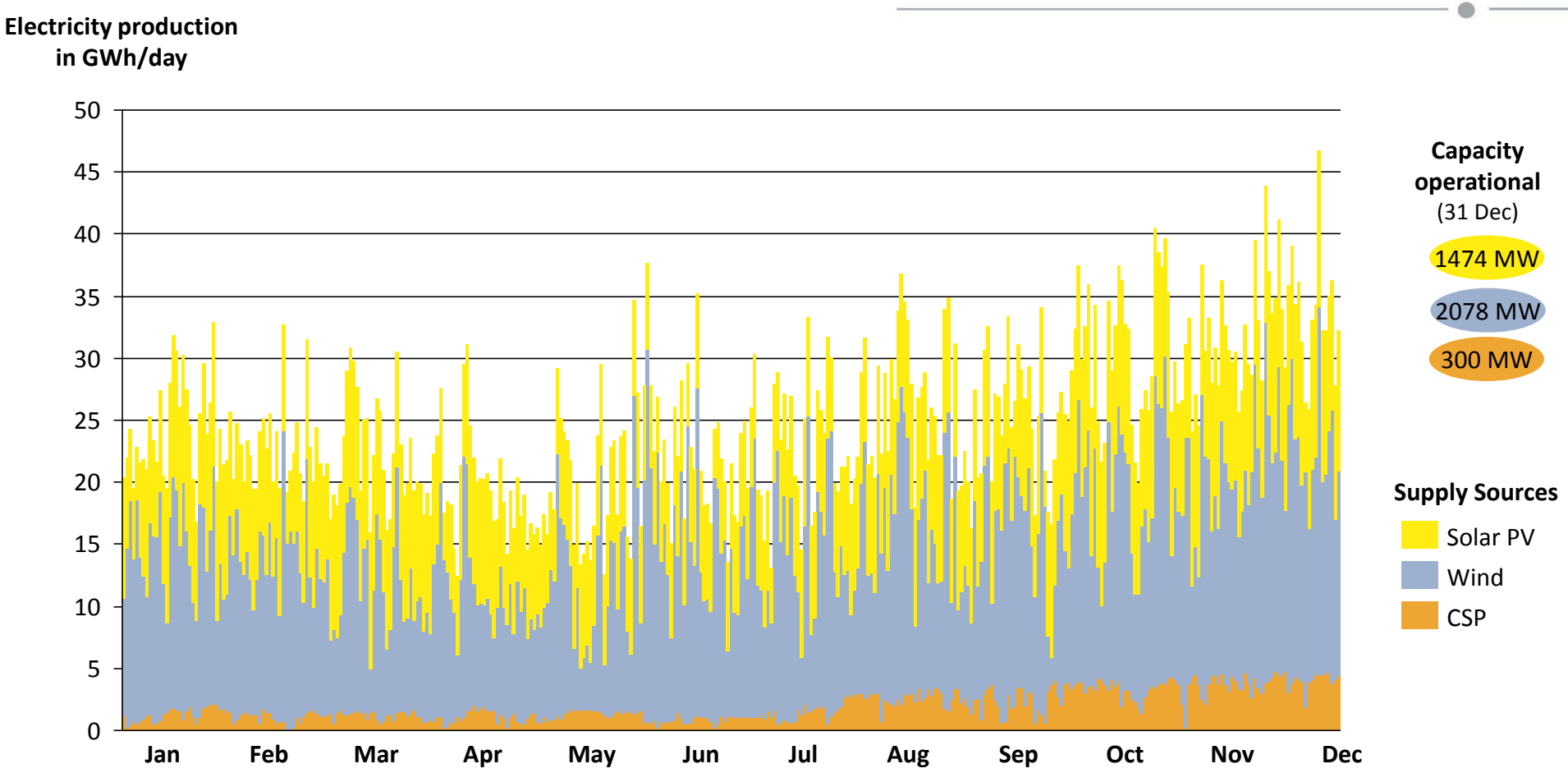
Daily electricity production wind, solar PV & CSP fleet Jan to Dec 2017

Actual daily production from large-scale solar PV, wind and CSP plants under the REIPPPP from Jan-Dec 2017

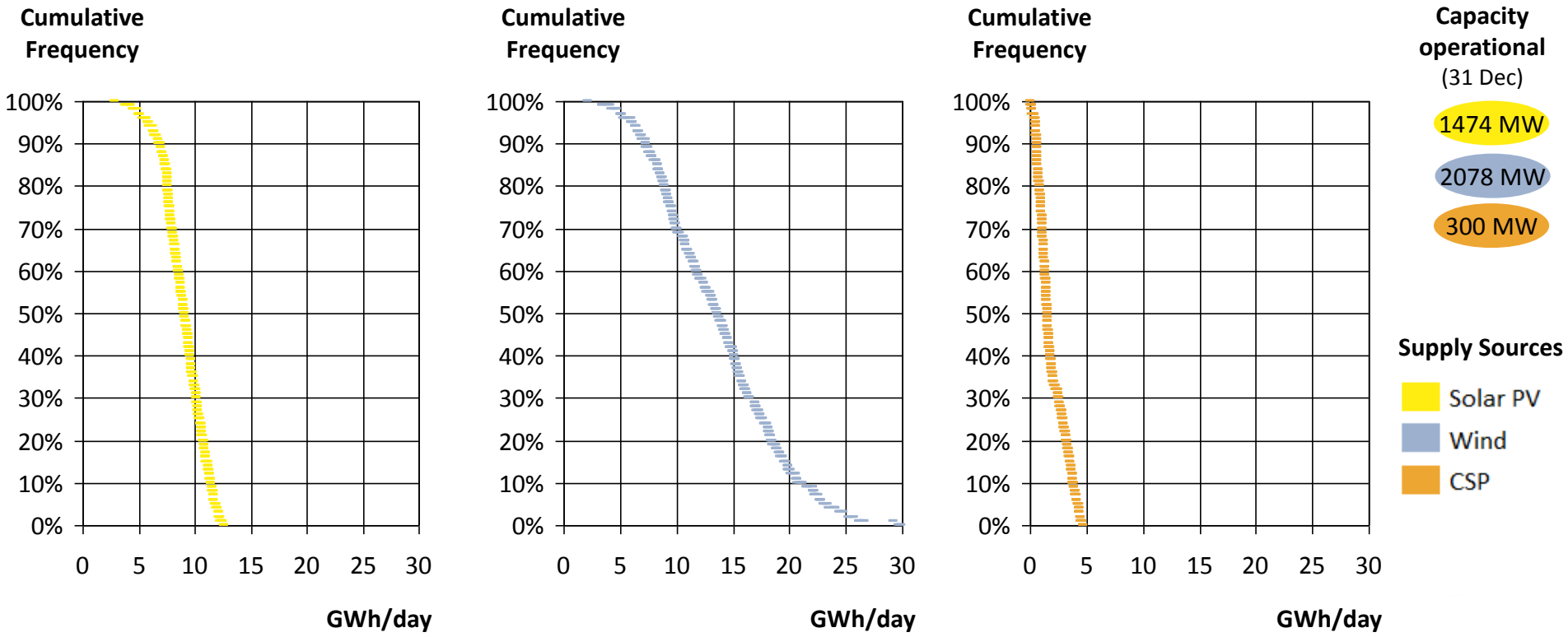


- Maximum daily production of 46.7 GWh on 25 Dec 2017 (Monday)
- Minimum daily production of 12.4 GWh on 11 Apr 2017 (Tuesday)

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 2017, solar PV and wind had a daily energy production of 7 GWh or more

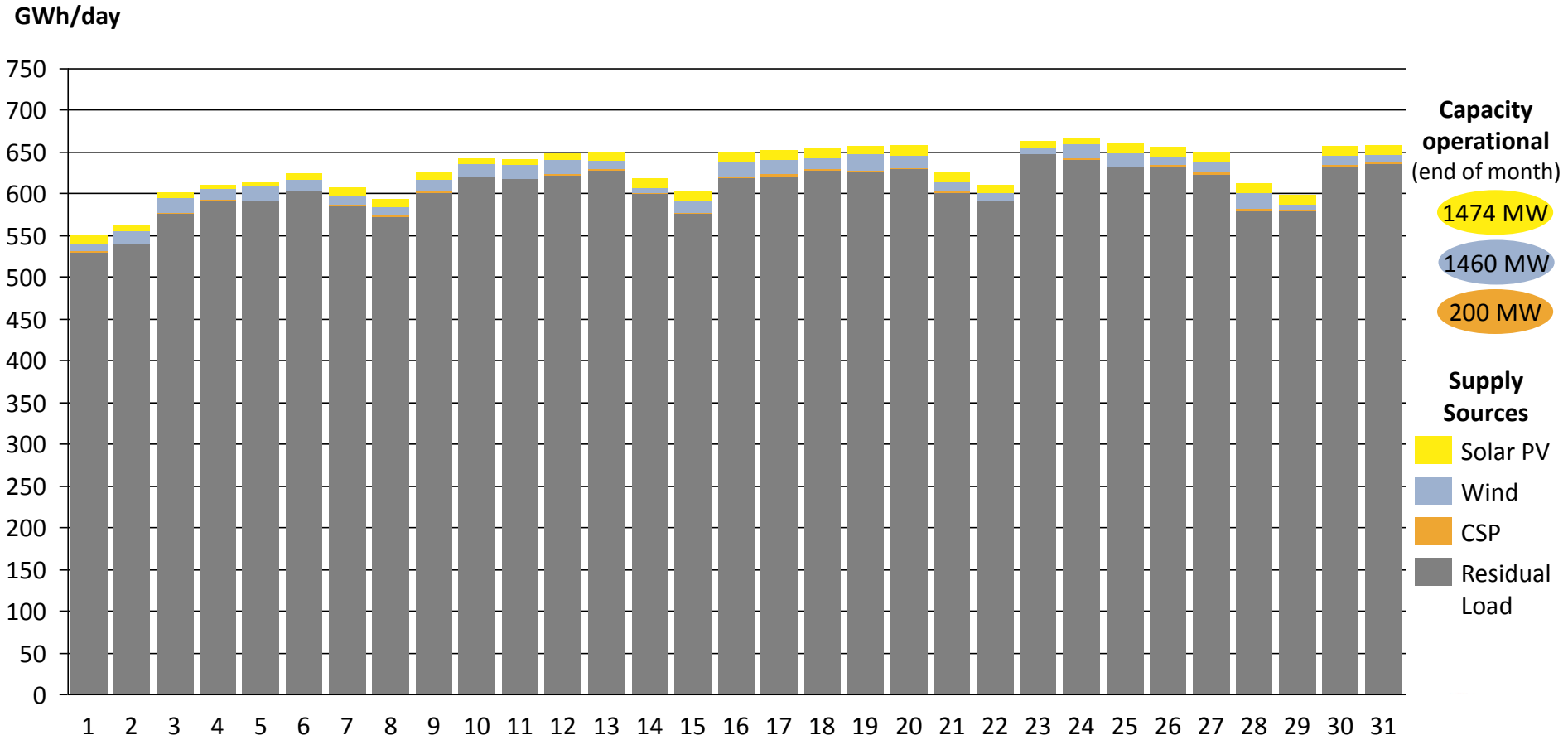
Frequency distribution of daily solar PV, wind and CSP electricity production for January - December 2017



Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 550-666 GWh in Jan 2017

Actual daily production from all power supply sources in South Africa for January 2017

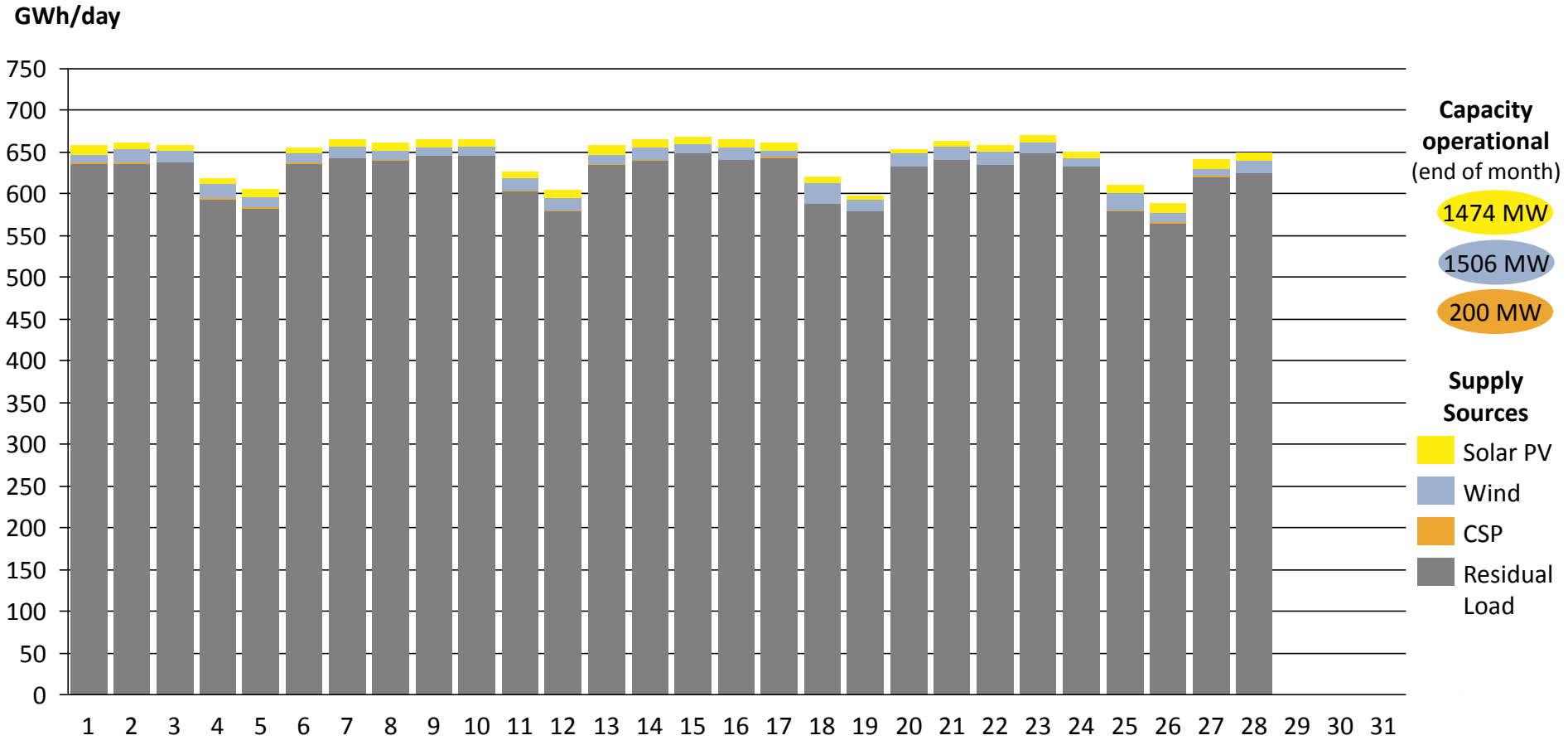


- Maximum daily production of 666 GWh on 24 Jan 2017 (Tuesday)
- Minimum daily production of 550 GWh on 1 Jan 2017 (Sunday)

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

Daily electricity production of between 587-668 GWh in Feb 2017

Actual daily production from all power supply sources in South Africa for February 2017

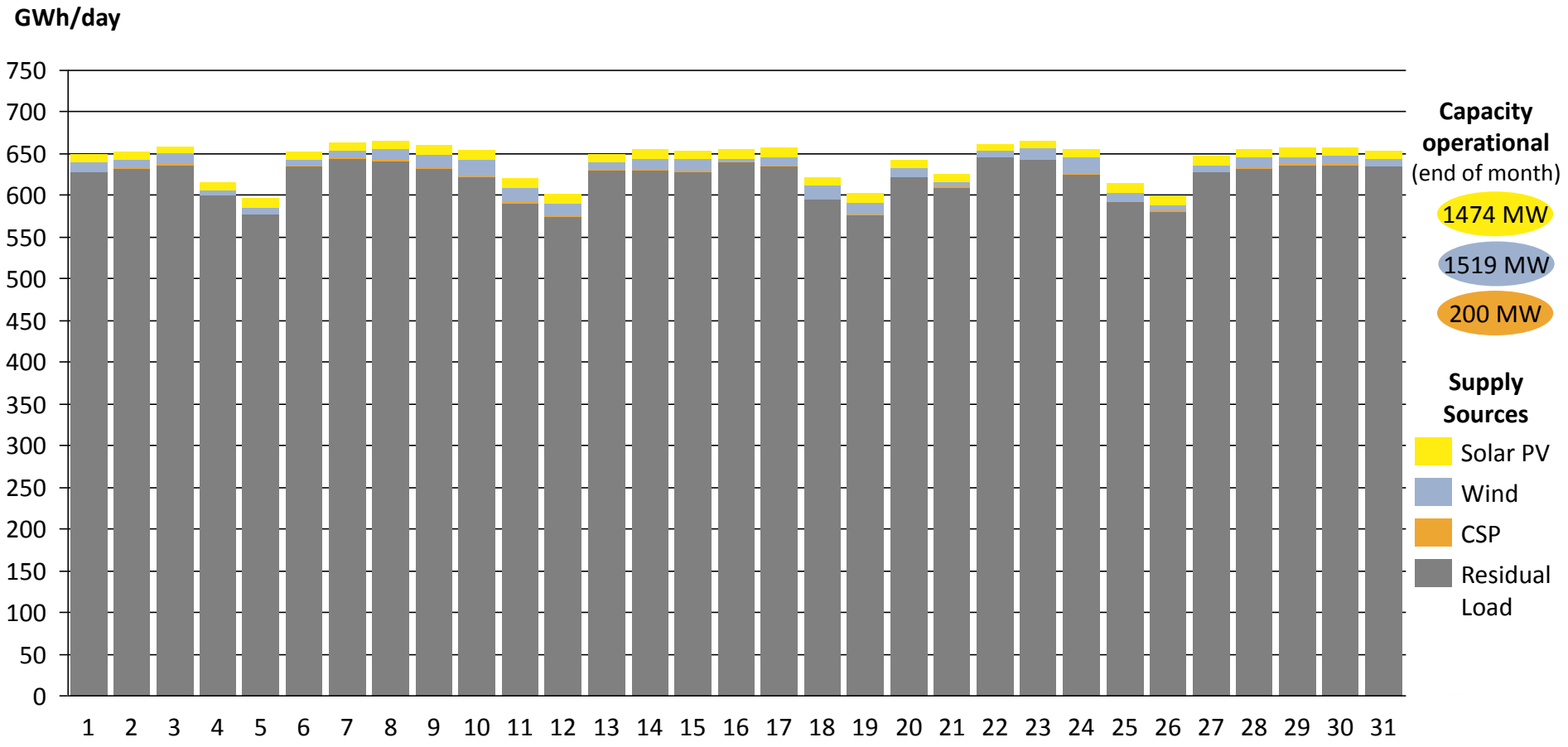


- Maximum daily production of 668 GWh on 23 Feb 2017 (Thursday)
- Minimum daily production of 587 GWh on 26 Feb 2017 (Sunday)

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

Daily electricity production of between 596-664 GWh in Mar 2017

Actual daily production from all power supply sources in South Africa for March 2017

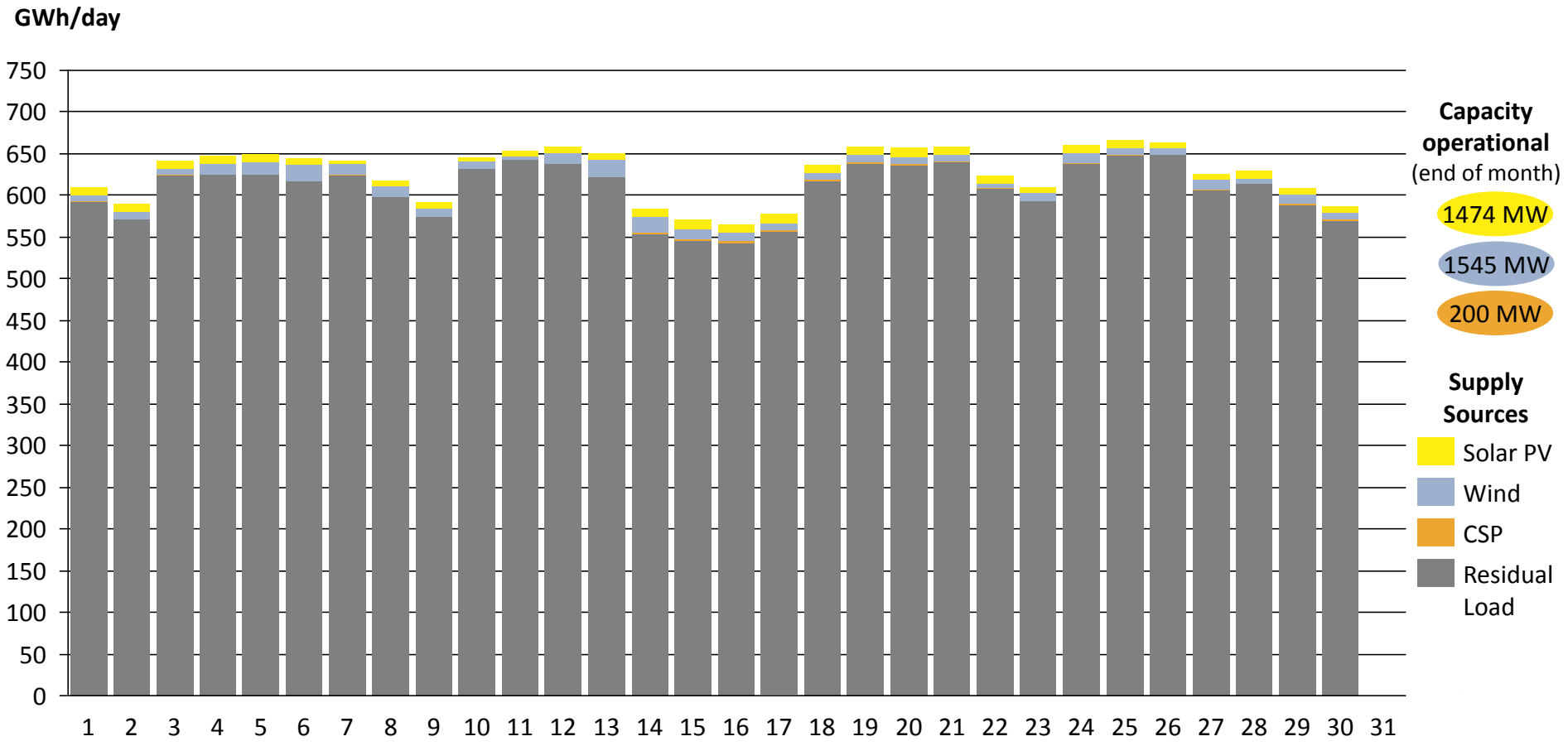


- Maximum daily production of 664 GWh on 8 Mar 2017 (Wednesday)
- Minimum daily production of 596 GWh on 5 Mar 2017 (Sunday)

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

Daily electricity production of between 564-665 GWh in Apr 2017

Actual daily production from all power supply sources in South Africa for April 2017

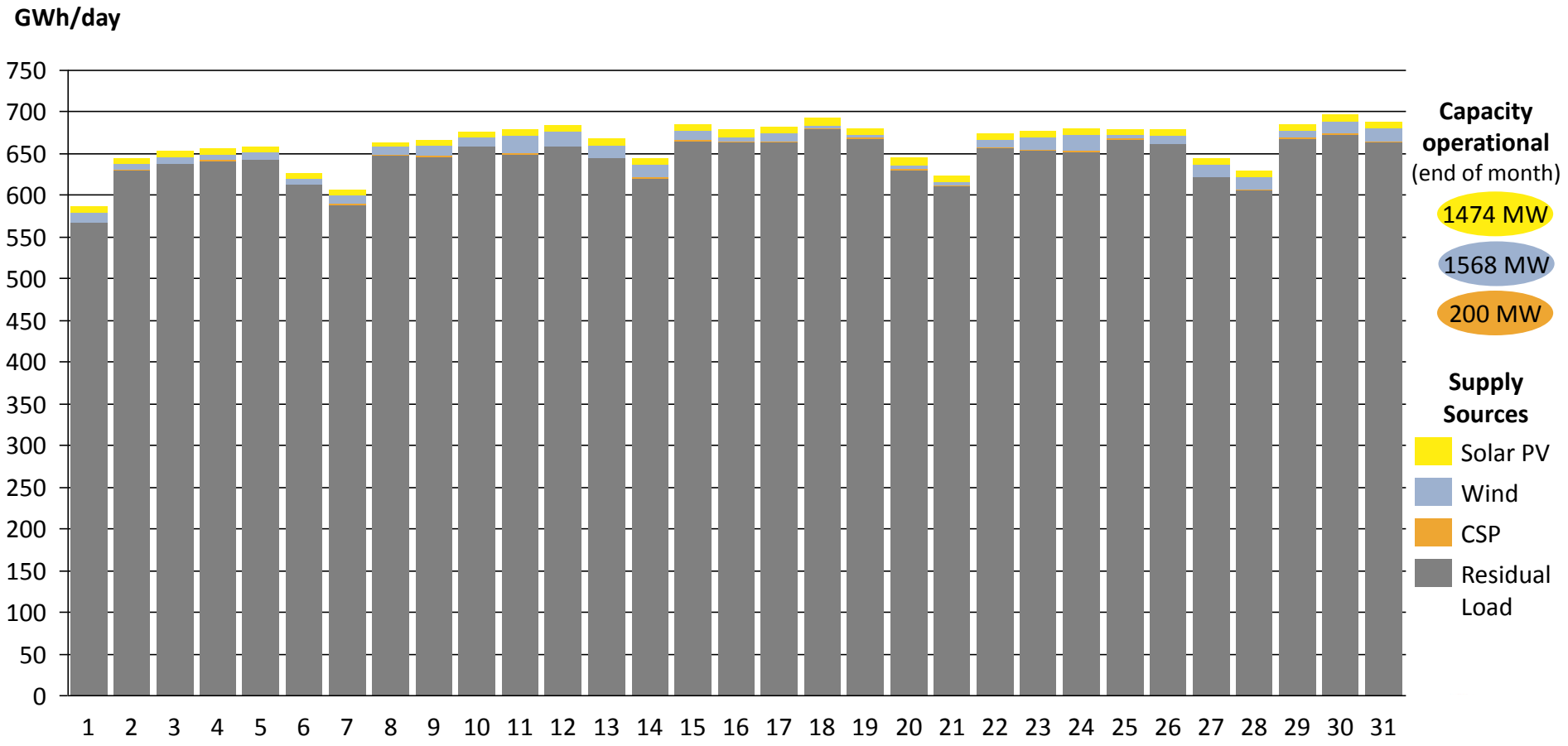


- Maximum daily production of 665 GWh on 24 Apr 2017 (Tuesday)
- Minimum daily production of 564 GWh on 16 Apr 2017 (Sunday)

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

Daily electricity production of between 587-696 GWh in May 2017

Actual daily production from all power supply sources in South Africa for May 2017

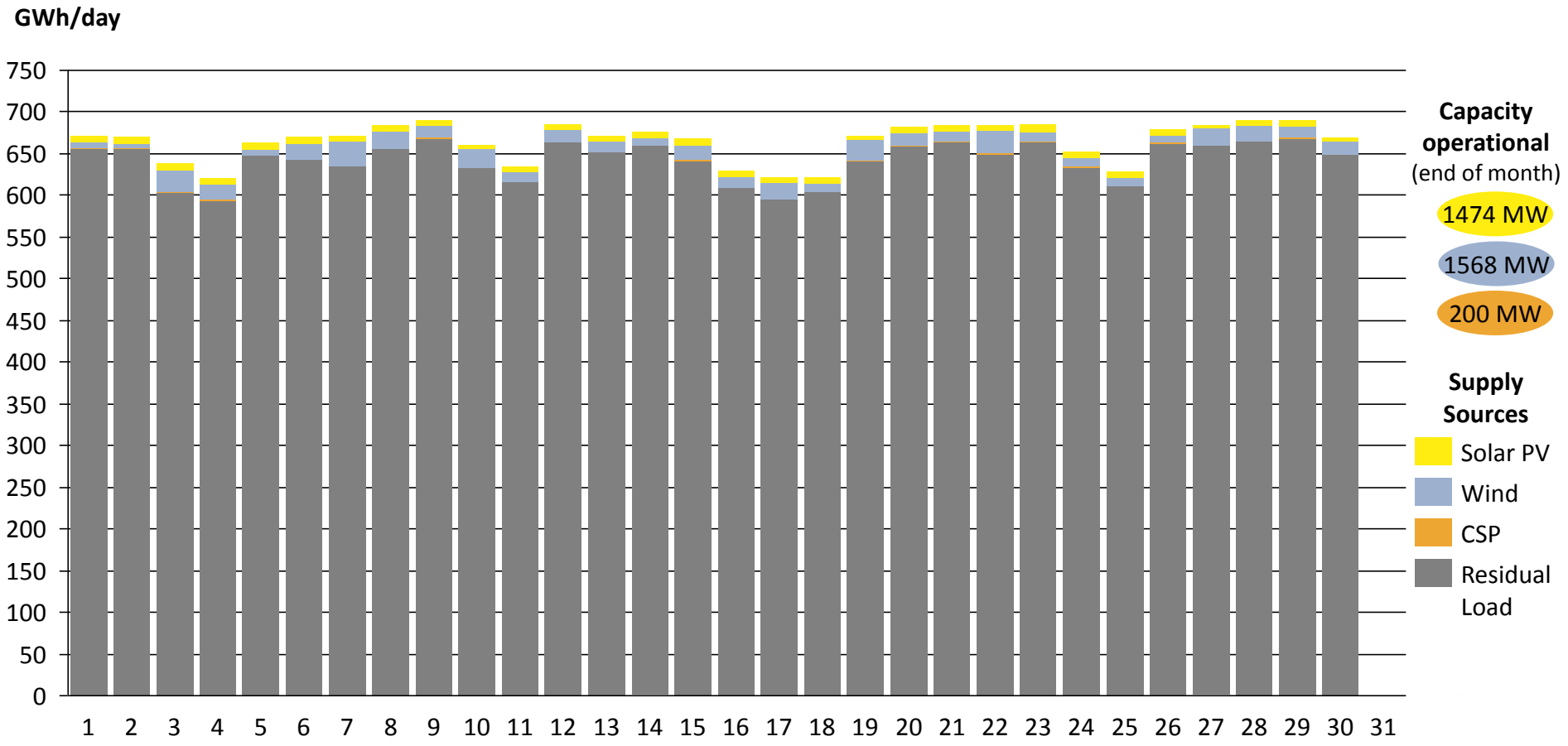


- Maximum daily production of 696 GWh on 30 May 2017 (Tuesday)
- Minimum daily production of 587 GWh on 1 May 2017 (Sunday)

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

Daily electricity production of between 619-690 GWh in Jun 2017

Actual daily production from all power supply sources in South Africa for June 2017

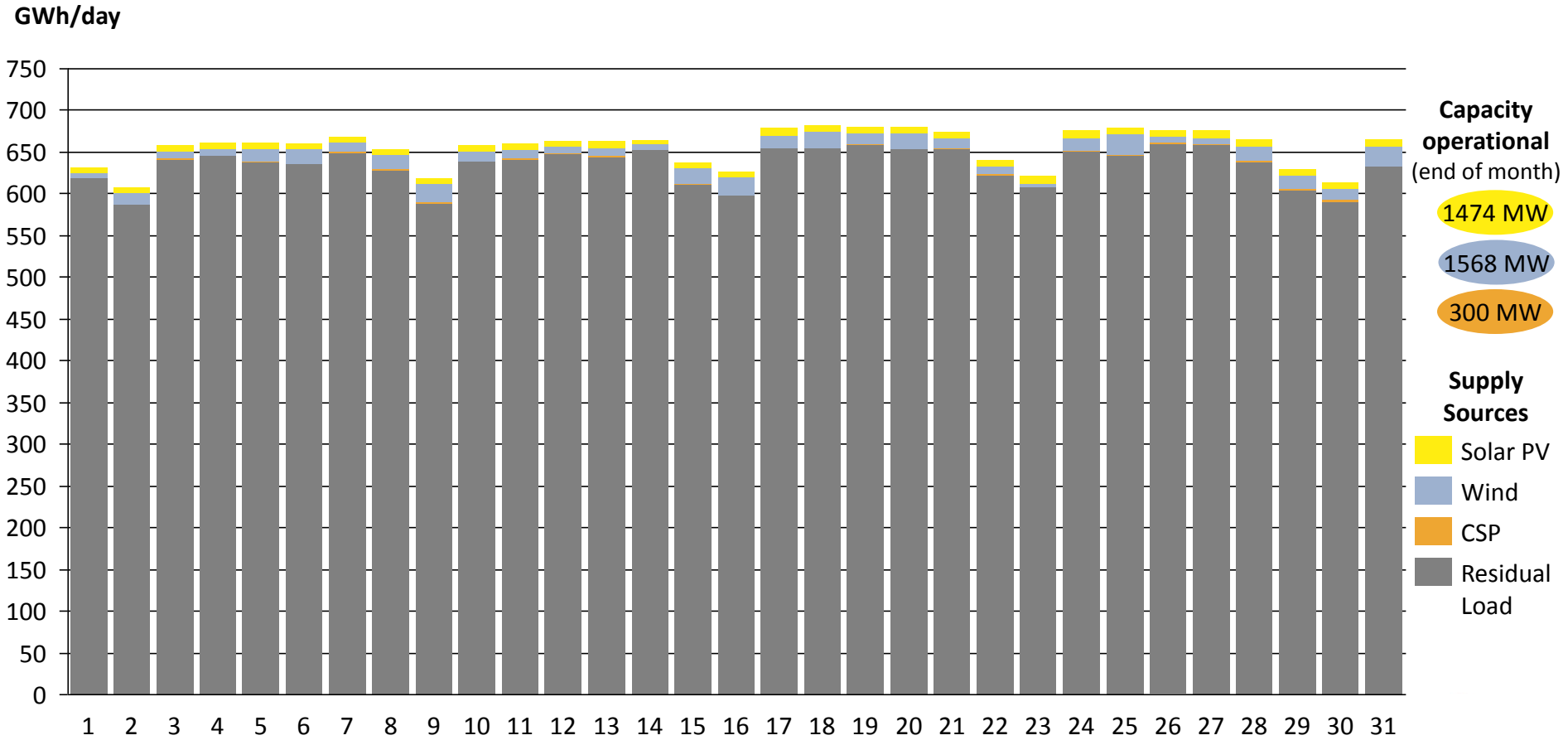


- Maximum daily production of 690 GWh on 9 Jun 2017 (Friday)
- Minimum daily production of 619 GWh on 4 Jun 2017 (Sunday)

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

Daily electricity production of between 607-682 GWh in Jul 2017

Actual daily production from all power supply sources in South Africa for July 2017

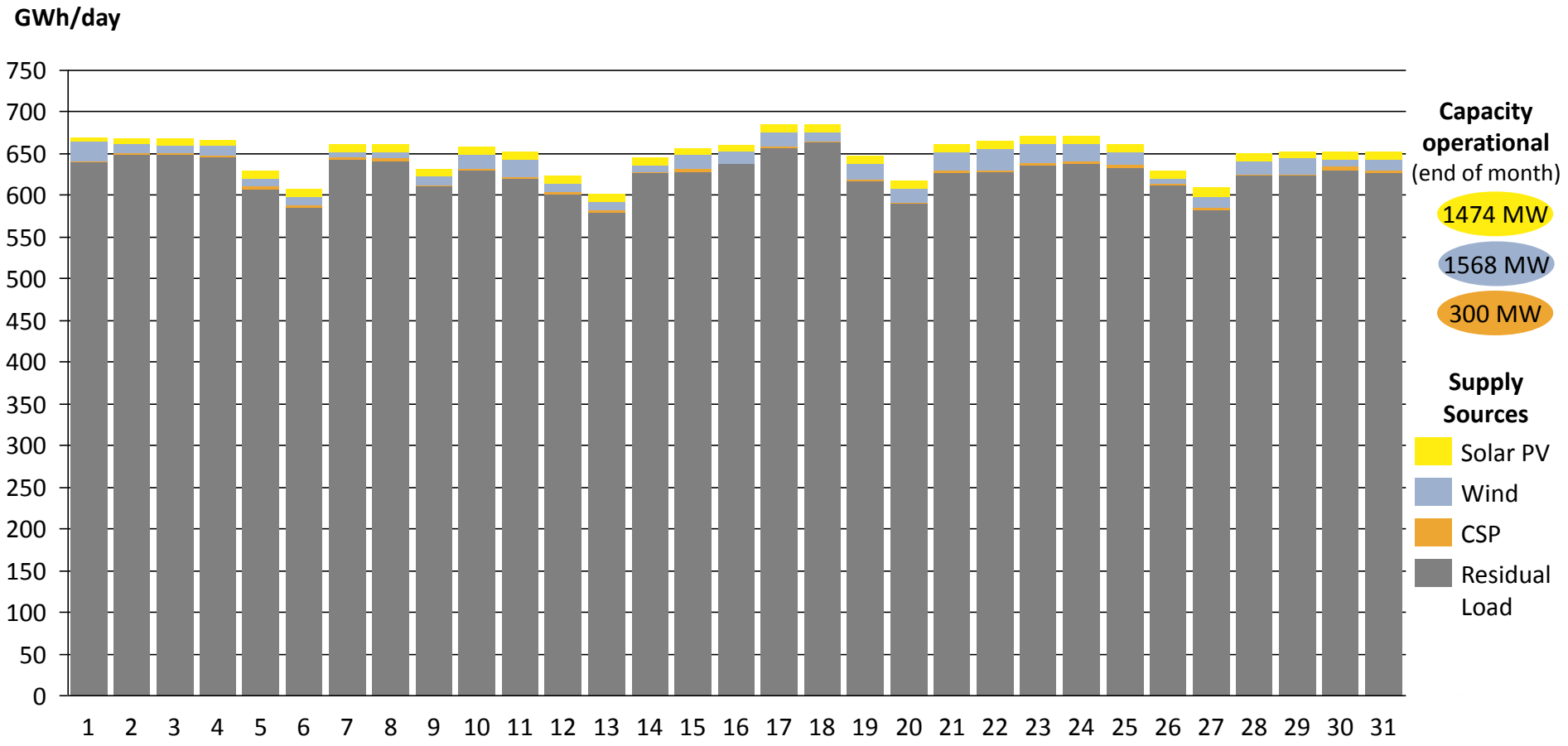


- Maximum daily production of 682 GWh on 18 Jul 2017 (Tuesday)
- Minimum daily production of 607 GWh on 2 Jul 2017 (Sunday)

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

Daily electricity production of between 601-685 GWh in Aug 2017

Actual daily production from all power supply sources in South Africa for August 2017

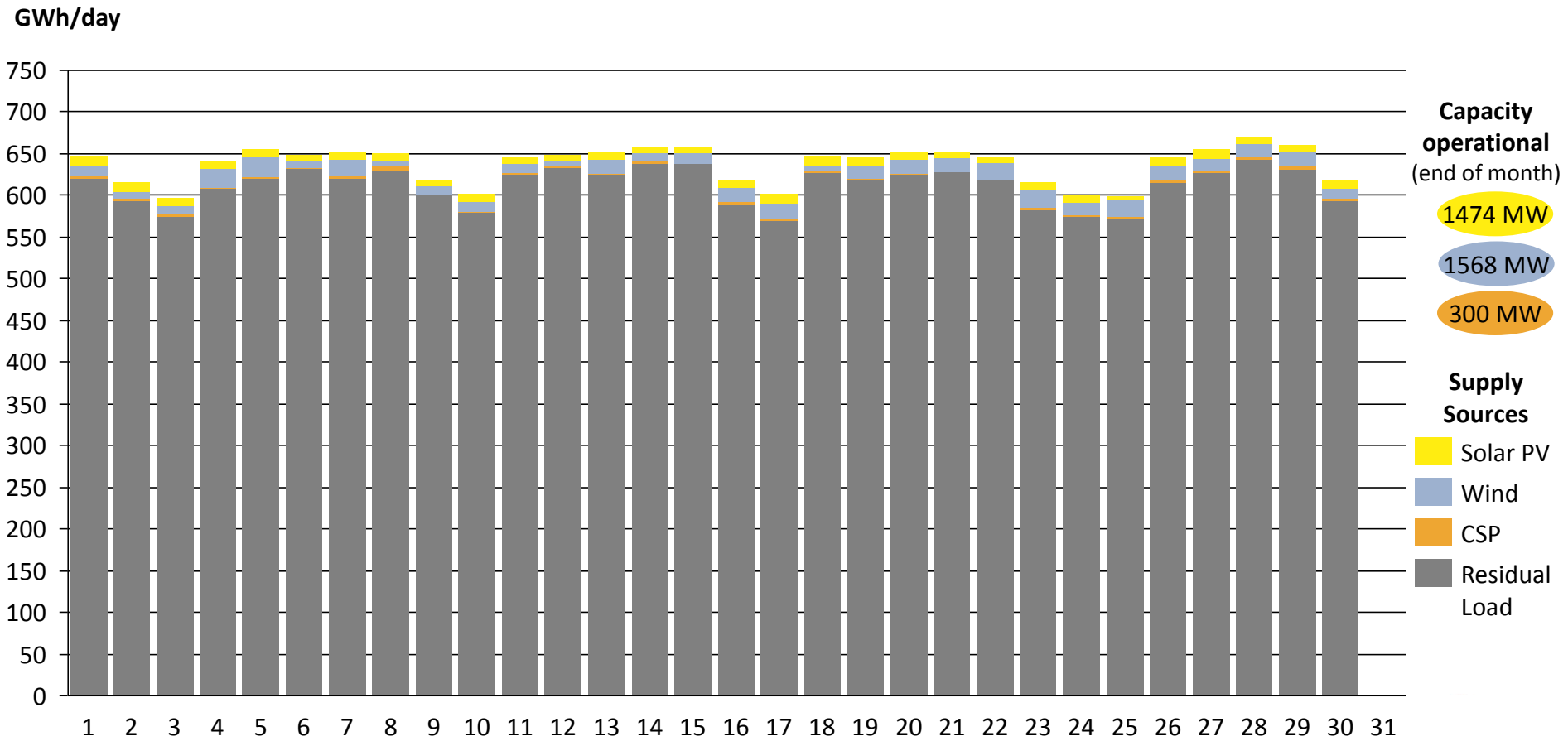


- Maximum daily production of 685 GWh on 18 Aug 2017 (Friday)
- Minimum daily production of 601 GWh on 13 Aug 2017 (Sunday)

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

Daily electricity production of between 596-669 GWh in Sep 2017

Actual daily production from all power supply sources in South Africa for September 2017

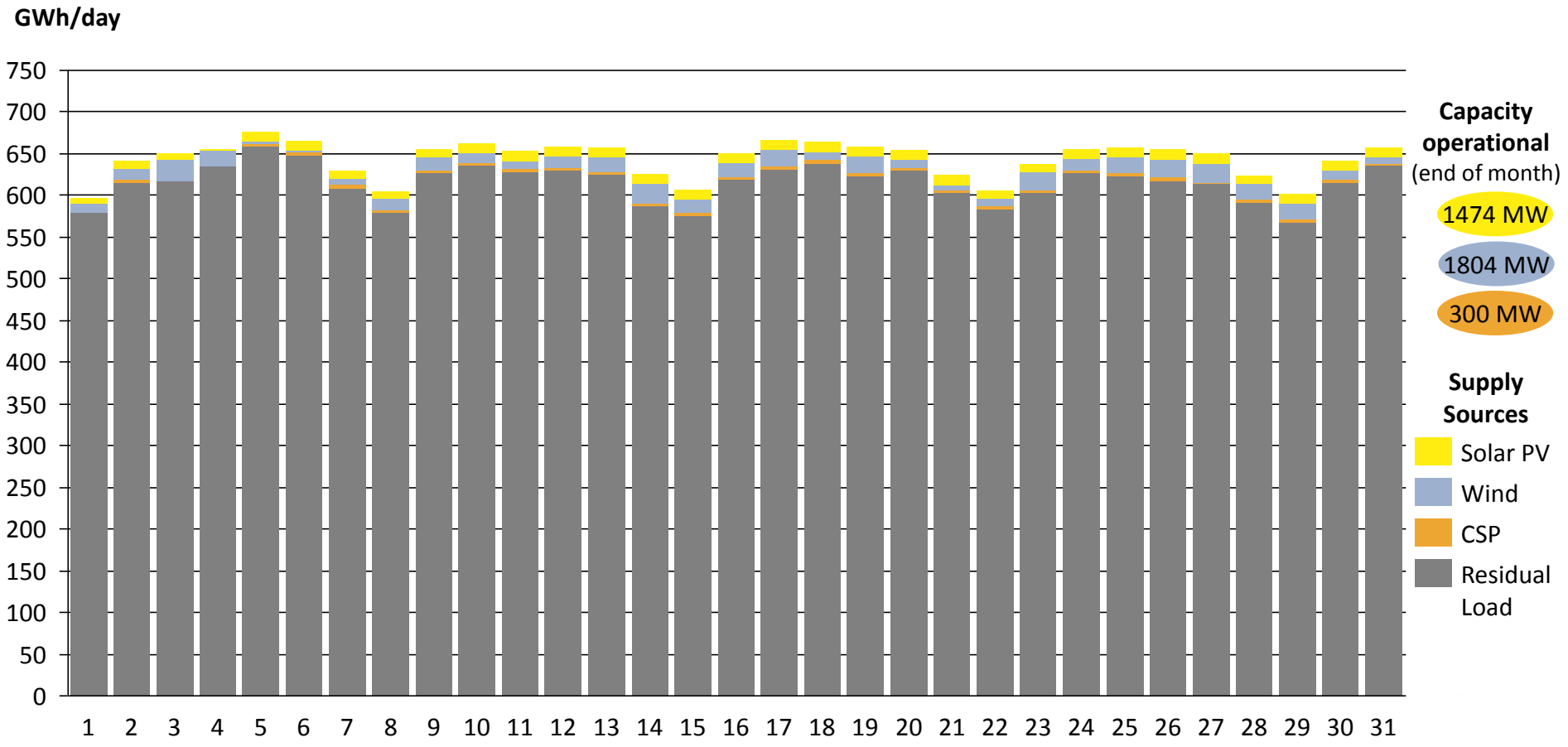


- Maximum daily production of 669 GWh on 28 Sep 2017 (Thursday)
- Minimum daily production of 596 GWh on 3 Sep 2017 (Sunday)

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

Daily electricity production of between 596-675 GWh in Oct 2017

Actual daily production from all power supply sources in South Africa for October 2017

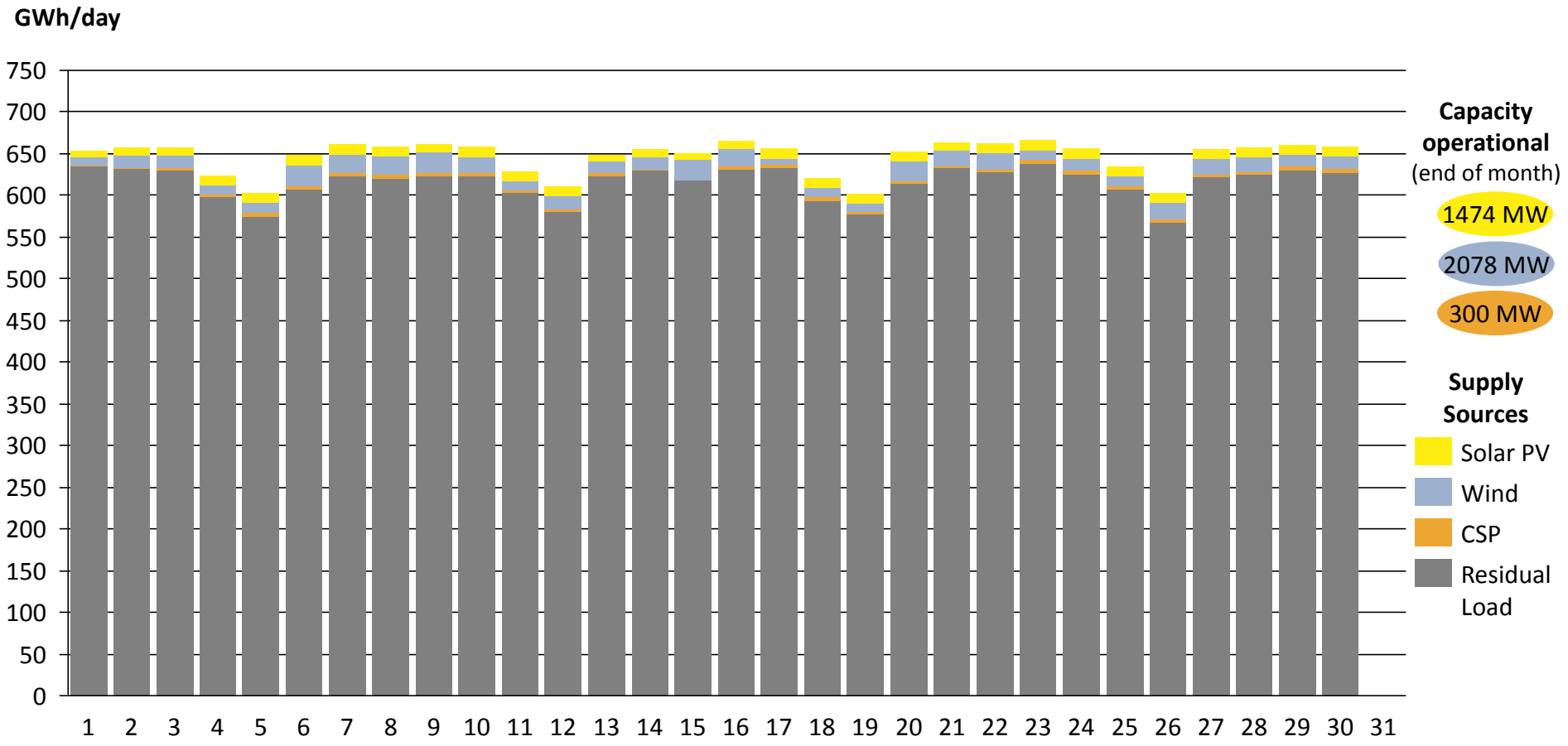


- Maximum daily production of 675 GWh on 5 Oct 2017 (Thursday)
- Minimum daily production of 596 GWh on 1 Oct 2017 (Sunday)

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

Daily electricity production of between 601-665 GWh in Nov 2017

Actual daily production from all power supply sources in South Africa for November 2017

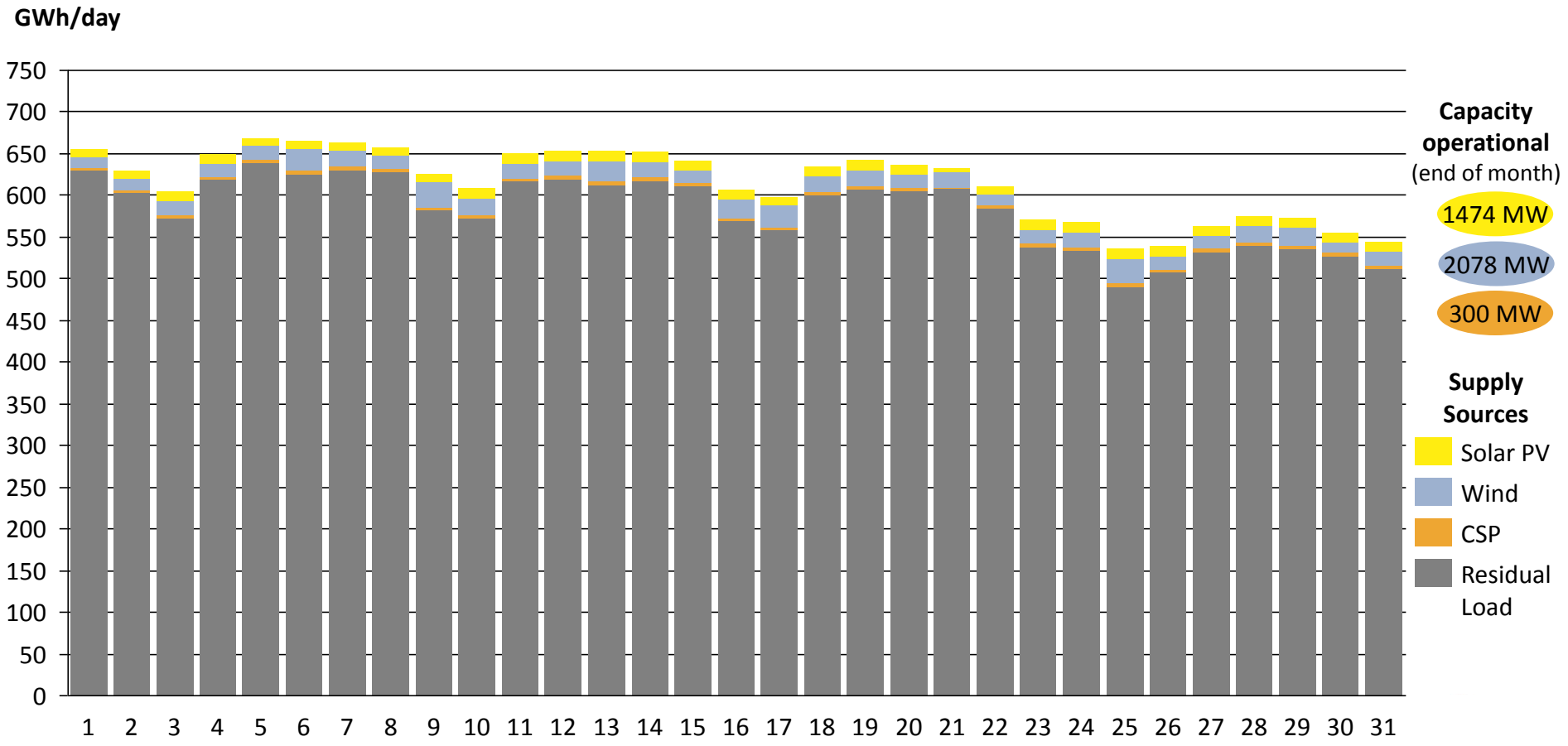


- Maximum daily production of 665 GWh on 23 Nov 2017 (Thursday)
- Minimum daily production of 601 GWh on 19 Nov 2017 (Sunday)

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

Daily electricity production of between 536-668 GWh in Dec 2017

Actual daily production from all power supply sources in South Africa for December 2017

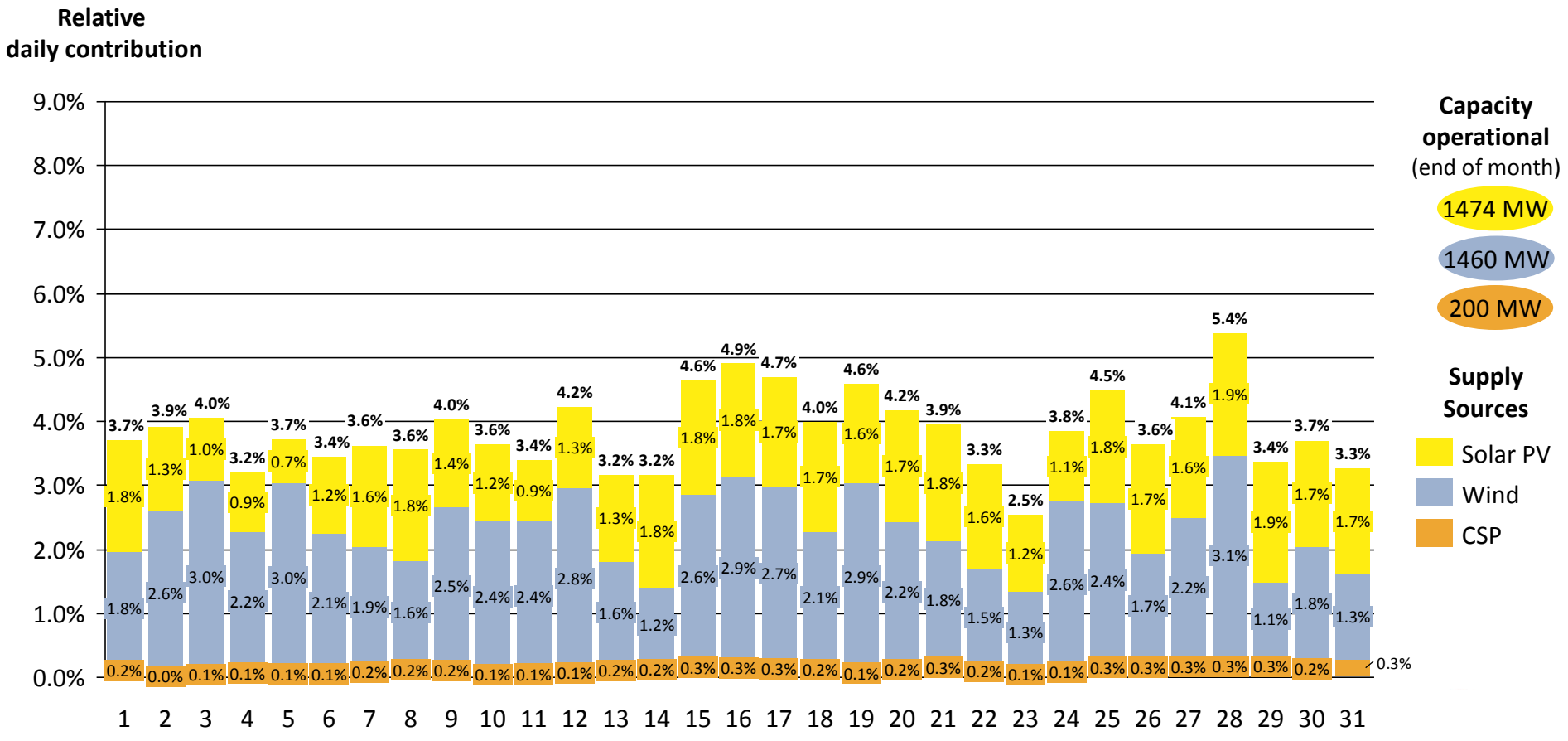


- Maximum daily production of 669 GWh on 5 Dec 2017 (Tuesday)
- Minimum daily production of 536 GWh on 25 Dec 2017 (Monday)

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

Daily solar PV, wind & CSP contribution of 2.5-5.4% in Jan 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for January 2017

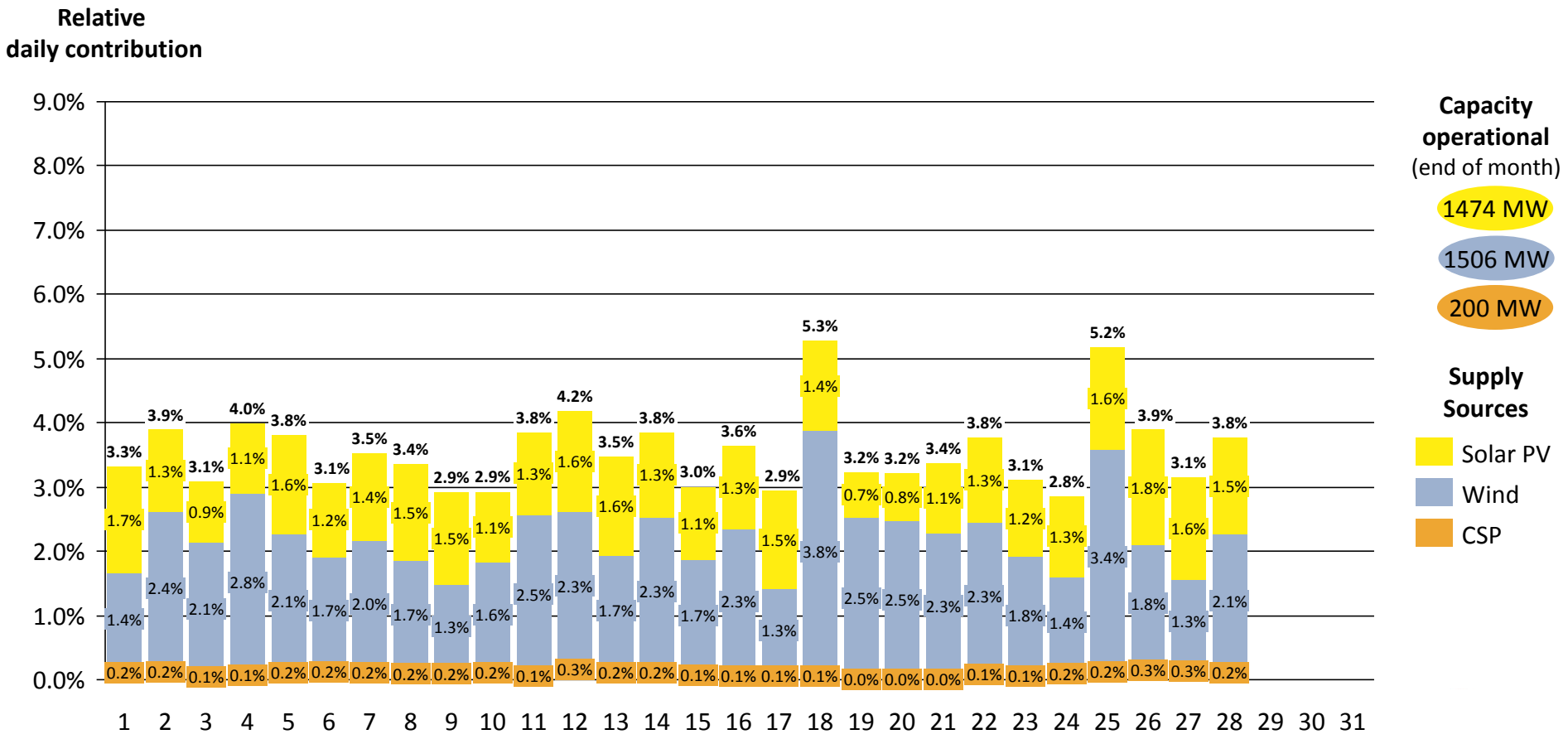


- Maximum daily relative solar PV contribution of 1.9% on 28 Jan 2017 (Saturday)
- Maximum daily relative wind contribution of 3.1% on 28 Jan 2017 (Saturday)
- Maximum daily relative CSP contribution of 0.3% on 29 Jan 2017 (Monday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.8-5.3% in Feb 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for February 2017

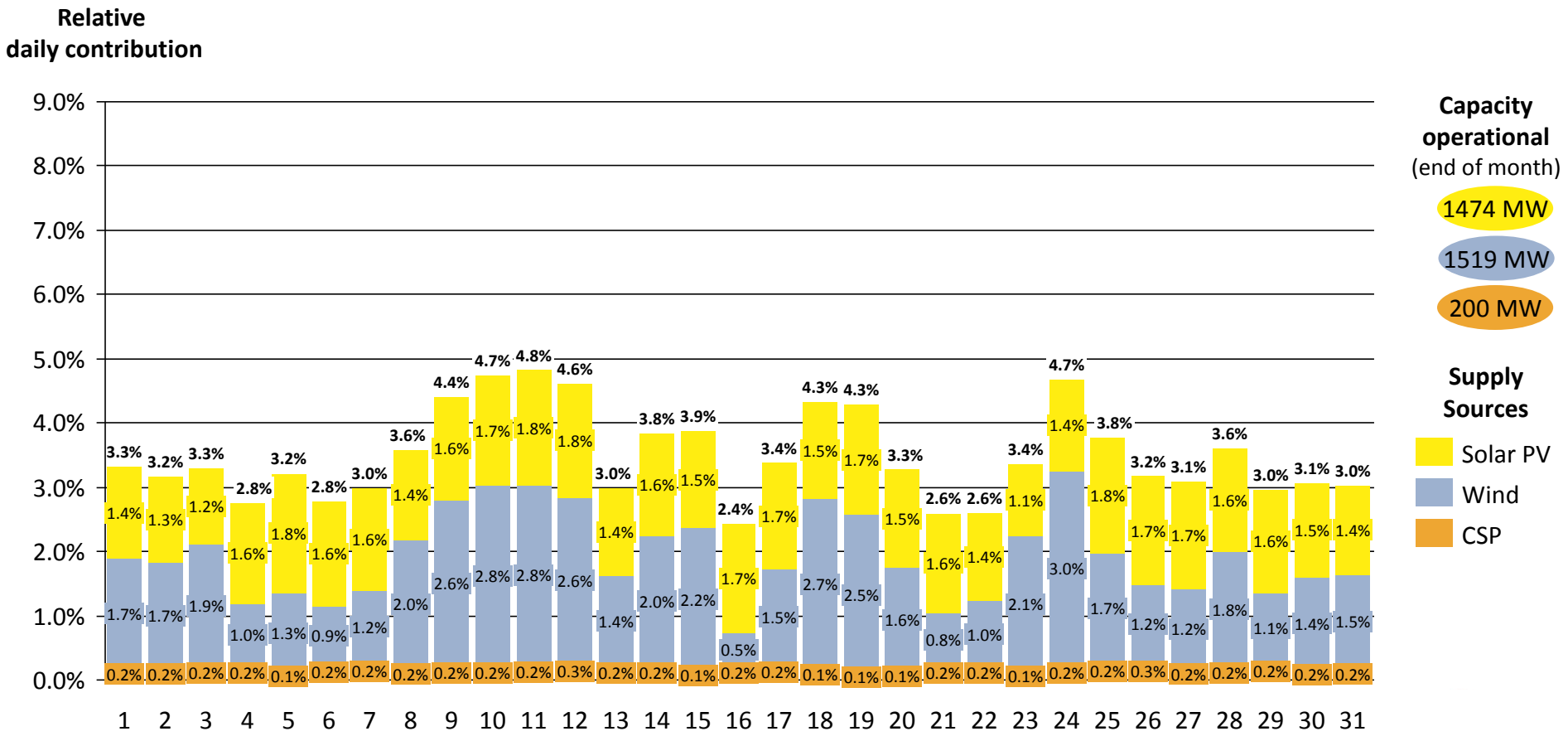


- Maximum daily relative solar PV contribution of 1.8% on 26 Feb 2017 (Sunday)
- Maximum daily relative wind contribution of 3.8% on 18 Feb 2017 (Saturday)
- Maximum daily relative CSP contribution of 0.3% on 12 Feb 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.4-4.8% in Mar 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for March 2017

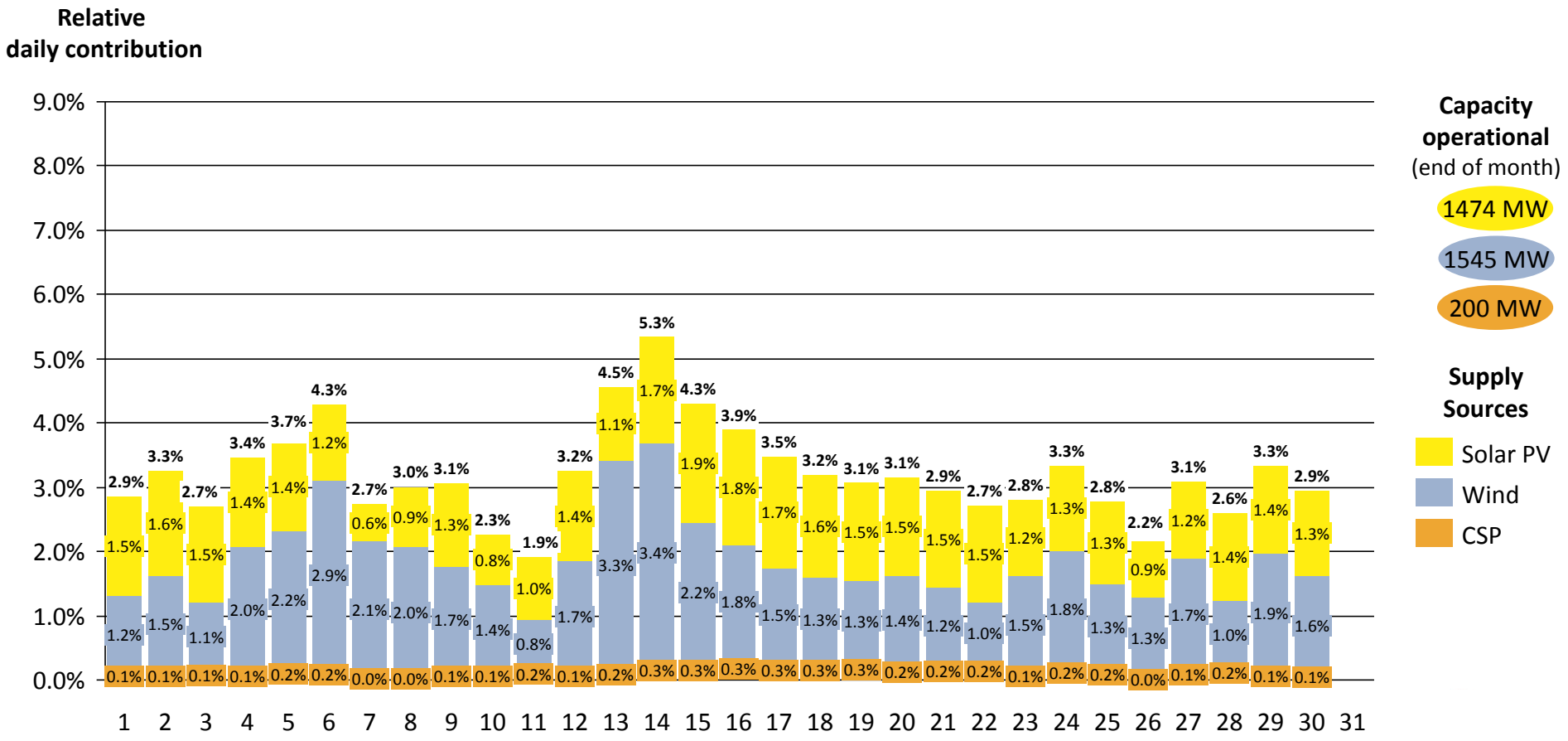


- Maximum daily relative solar PV contribution of 1.8% on 5 Mar 2017 (Sunday)
- Maximum daily relative wind contribution of 3.0% on 24 Mar 2017 (Friday)
- Maximum daily relative CSP contribution of 0.3% on 12 Mar 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.9-5.3% in Apr 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for April 2017

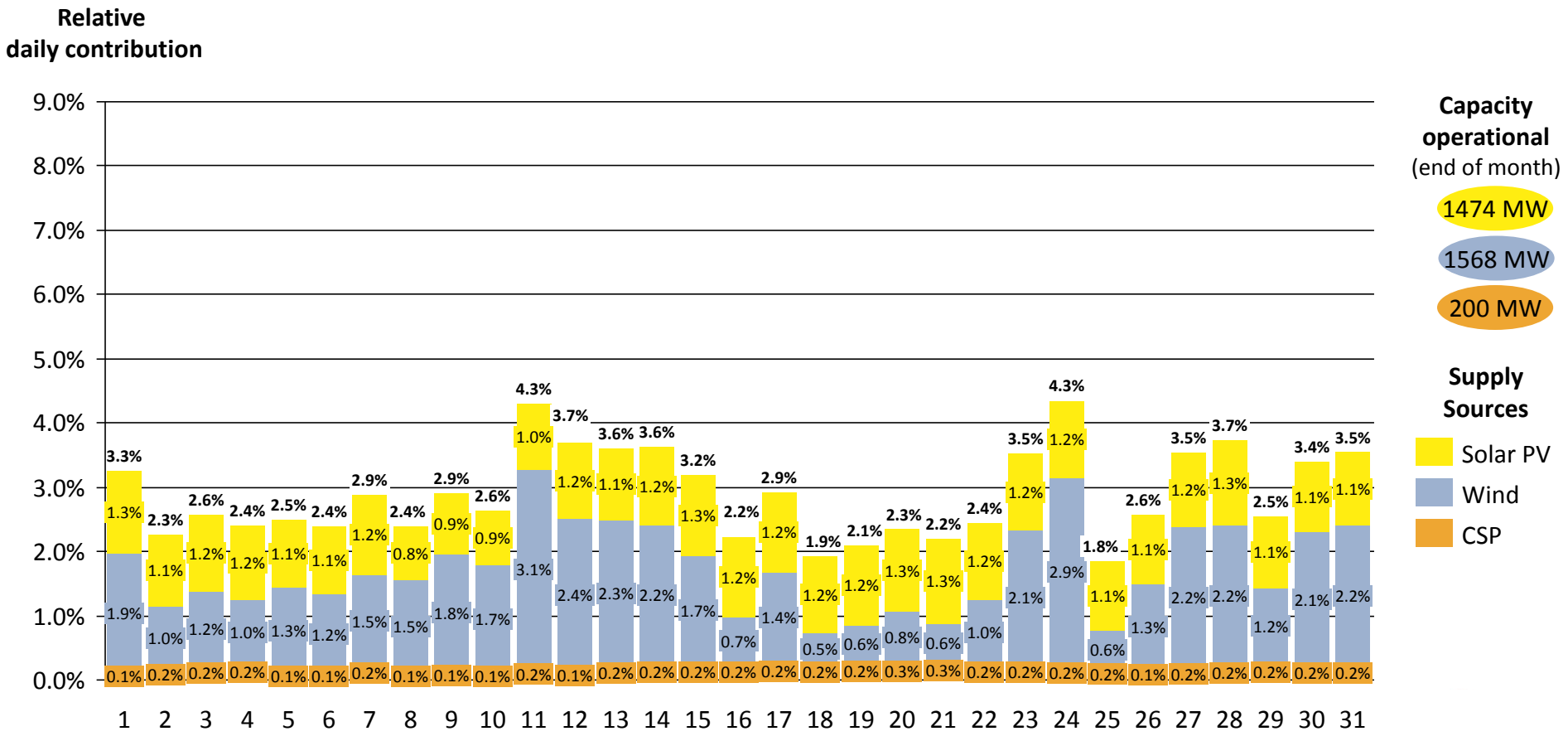


- Maximum daily relative solar PV contribution of 1.8% on 15 Apr 2017 (Saturday)
- Maximum daily relative wind contribution of 3.4% on 14 Apr 2017 (Friday)
- Maximum daily relative CSP contribution of 0.3% on 16 Apr 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.8-4.3% in May 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for May 2017

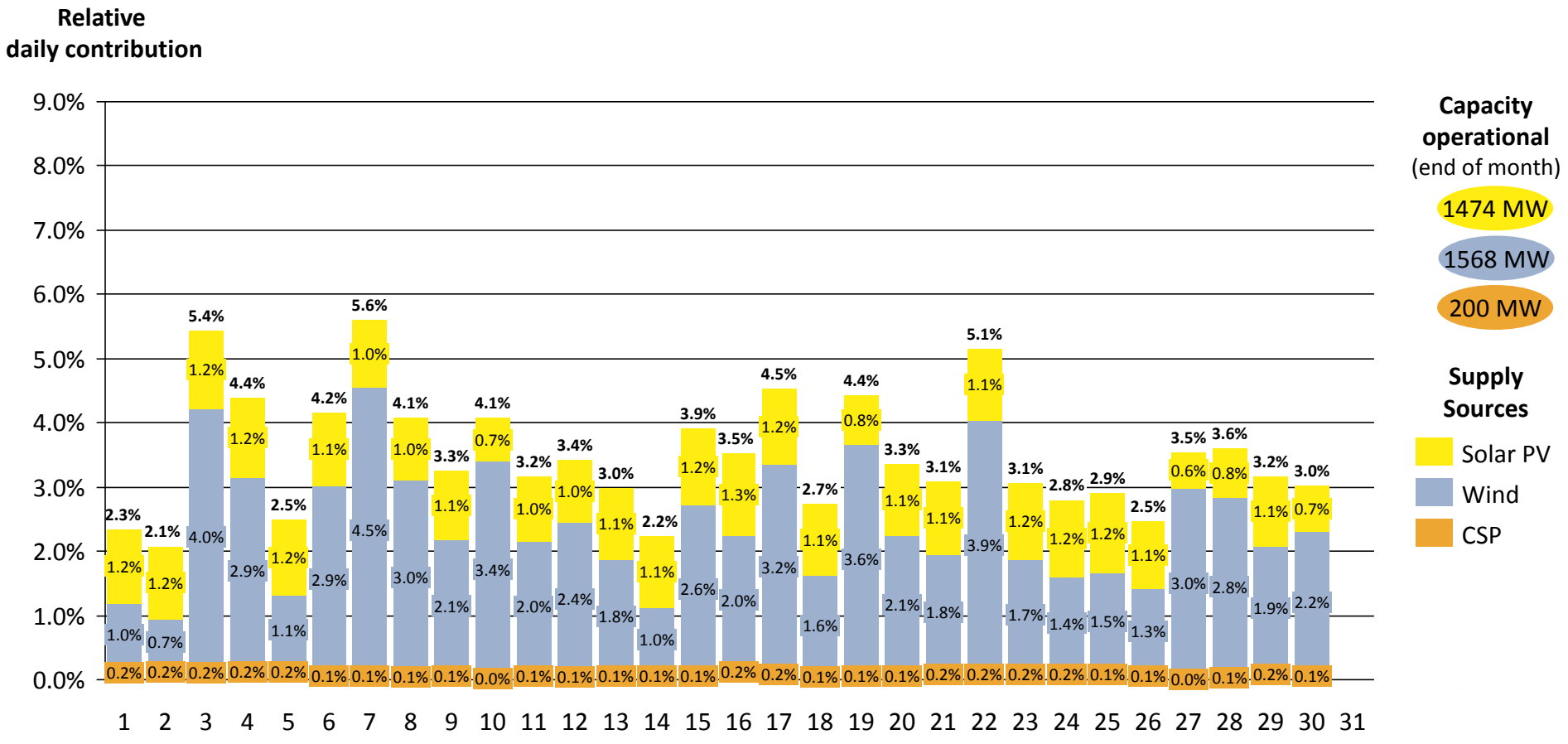


- Maximum daily relative solar PV contribution of 1.3% on 28 May 2017 (Sunday)
- Maximum daily relative wind contribution of 3.1% on 11 May 2017 (Thursday)
- Maximum daily relative CSP contribution of 0.3% on 21 May 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.1-5.6% in Jun 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for June 2017

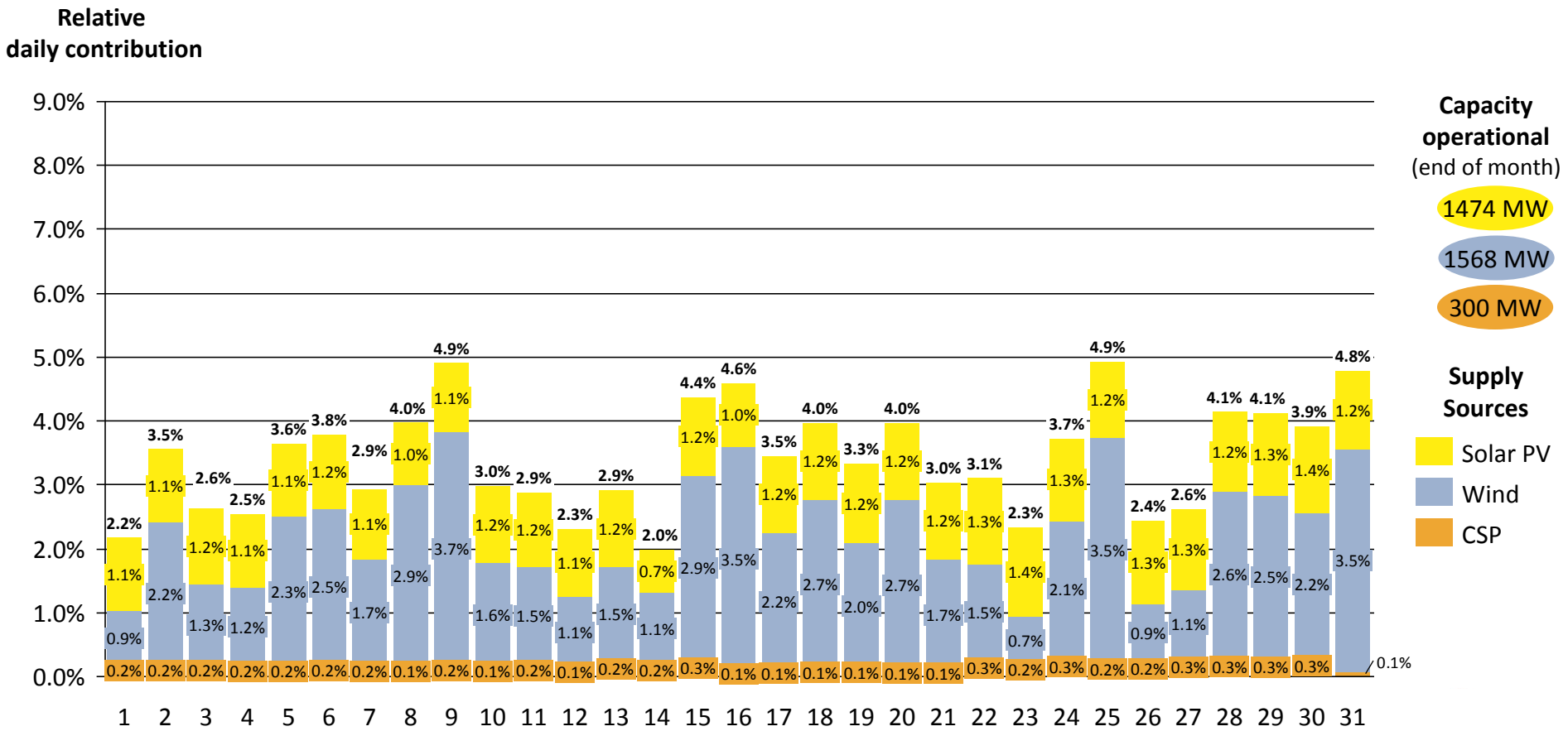


- Maximum daily relative solar PV contribution of 1.3% on 16 Jun 2017 (Friday)
- Maximum daily relative wind contribution of 4.5% on 7 Jun 2017 (Wednesday)
- Maximum daily relative CSP contribution of 0.2% on 4 Jun 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.0-4.9% in Jul 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for July 2017

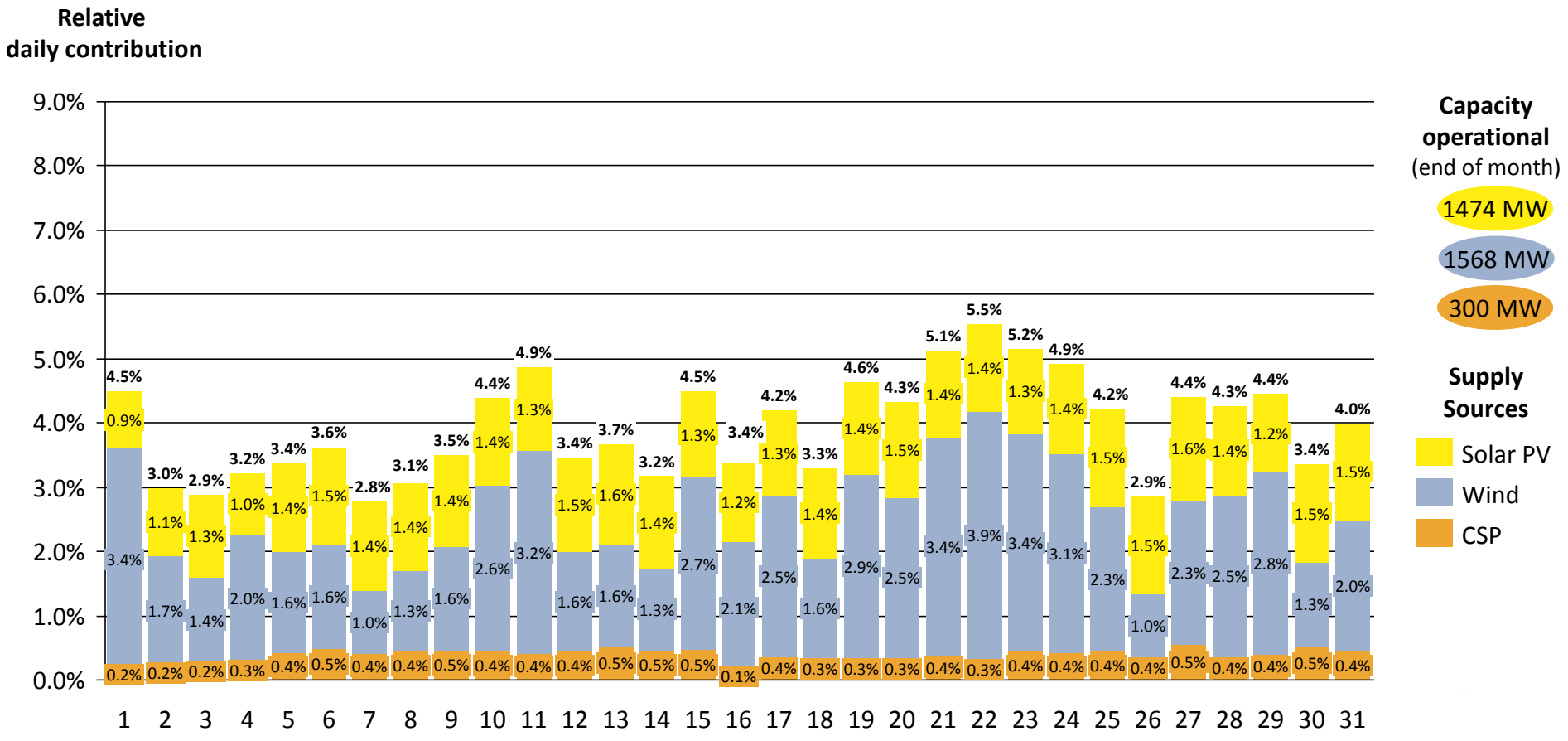


- Maximum daily relative solar PV contribution of 1.4% on 23 Jul 2017 (Sunday)
- Maximum daily relative wind contribution of 3.6% on 9 Jul 2017 (Sunday)
- Maximum daily relative CSP contribution of 0.3% on 30 Jul 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.8-5.5% in Aug 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for August 2017

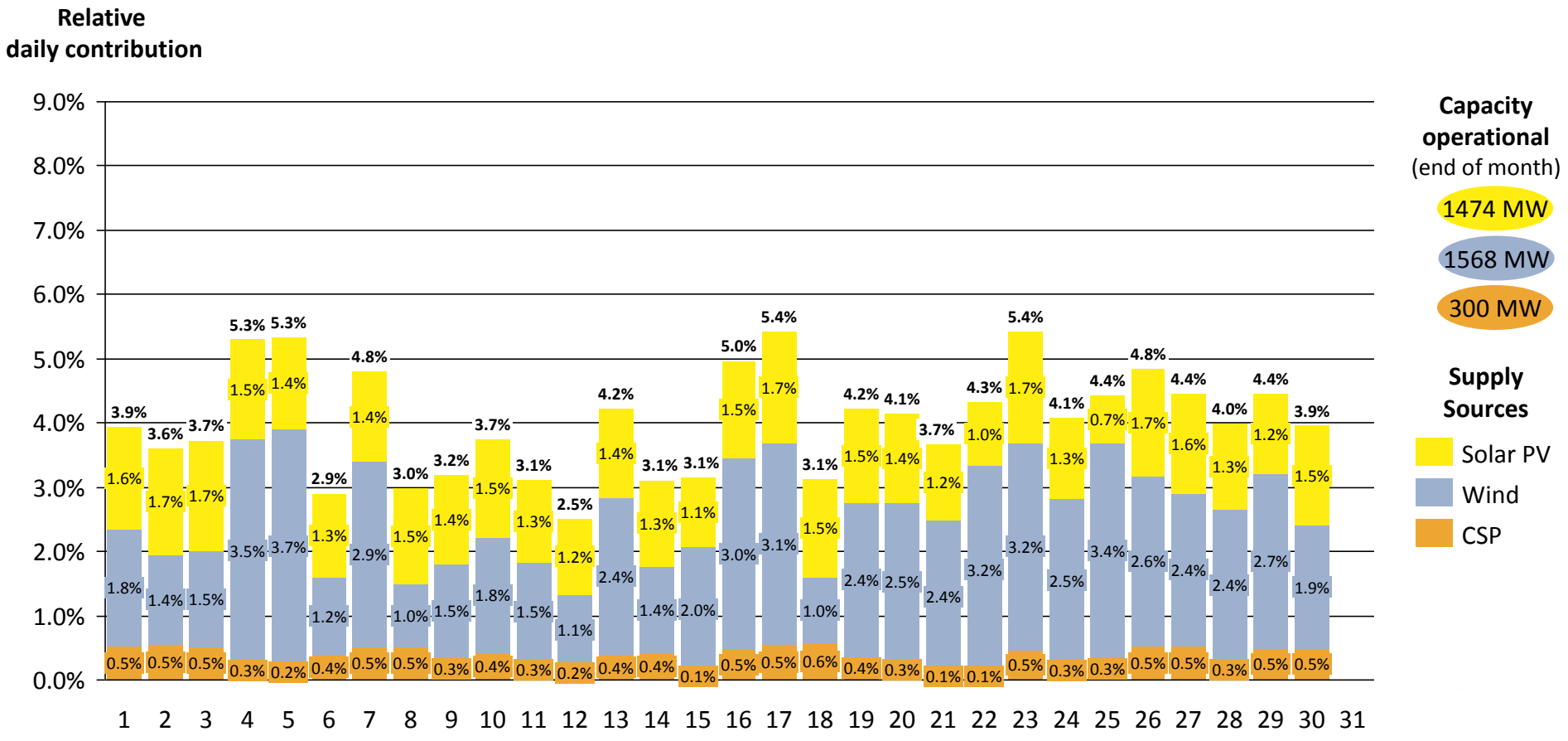


- Maximum daily relative solar PV contribution of 1.6% on 27 Aug 2017 (Sunday)
- Maximum daily relative wind contribution of 3.9% on 22 Aug 2017 (Tuesday)
- Maximum daily relative CSP contribution of 0.5% on 27 Aug 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.5-5.4% in Sep 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for September 2017

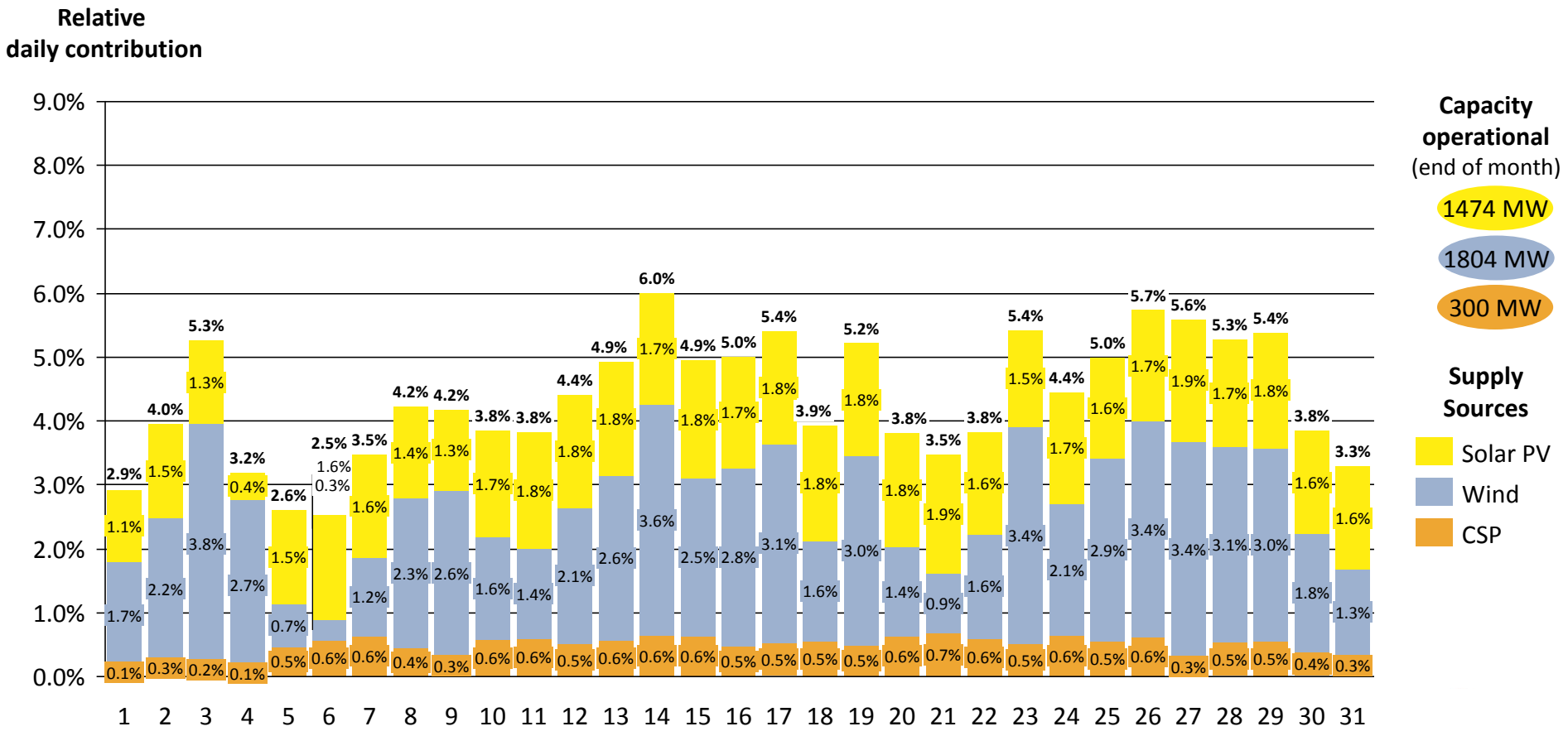


- Maximum daily relative solar PV contribution of 1.7% on 17 Sep 2017 (Sunday)
- Maximum daily relative wind contribution of 3.7% on 5 Sep 2017 (Tuesday)
- Maximum daily relative CSP contribution of 0.6% on 18 Sep 2017 (Monday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.5-6.0% in Oct 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for October 2017

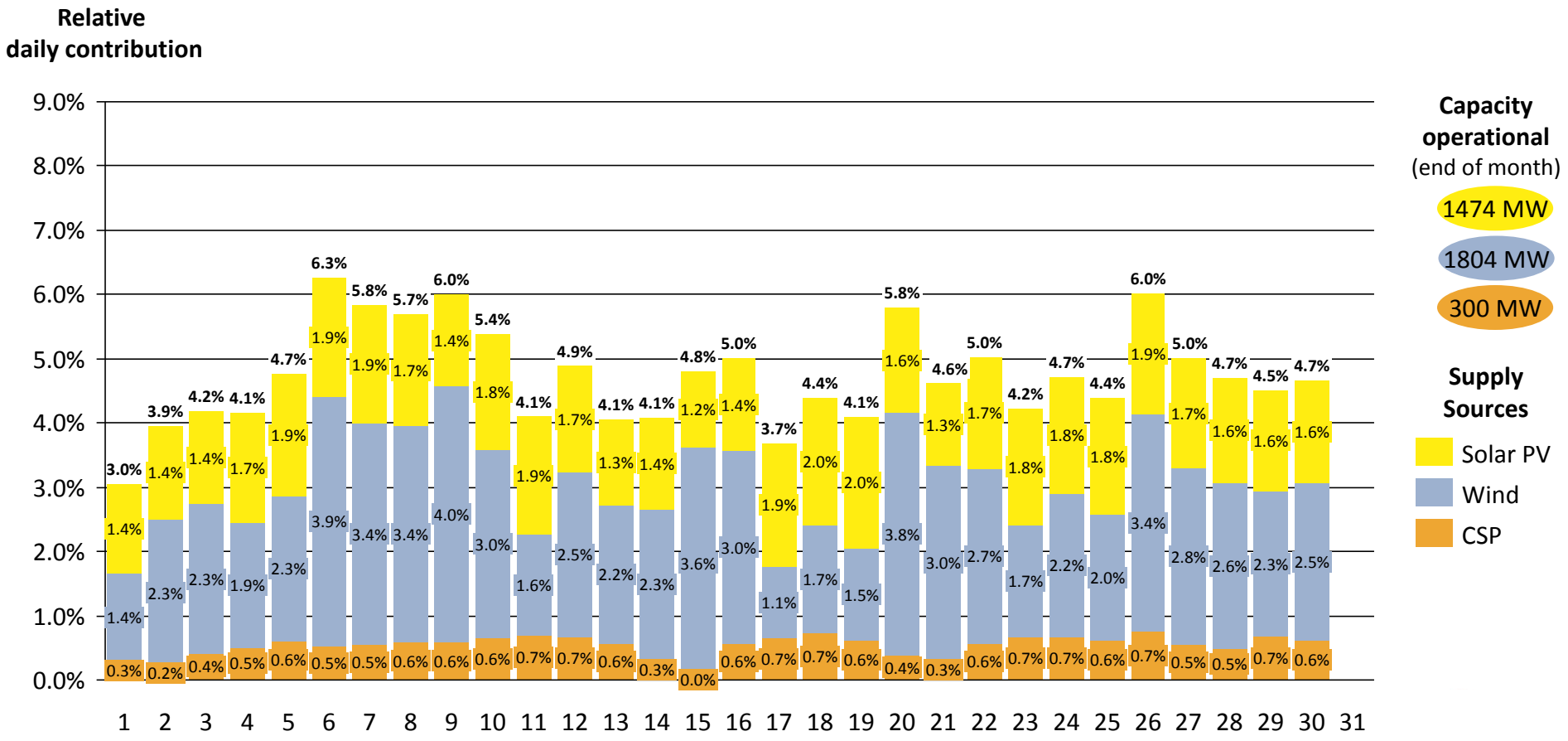


- Maximum daily relative solar PV contribution of 1.9% on 27 Oct 2017 (Friday)
- Maximum daily relative wind contribution of 3.7% on 3 Oct 2017 (Tuesday)
- Maximum daily relative CSP contribution of 0.7% on 21 Oct 2017 (Saturday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 3.0-6.3% in Nov 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for November 2017

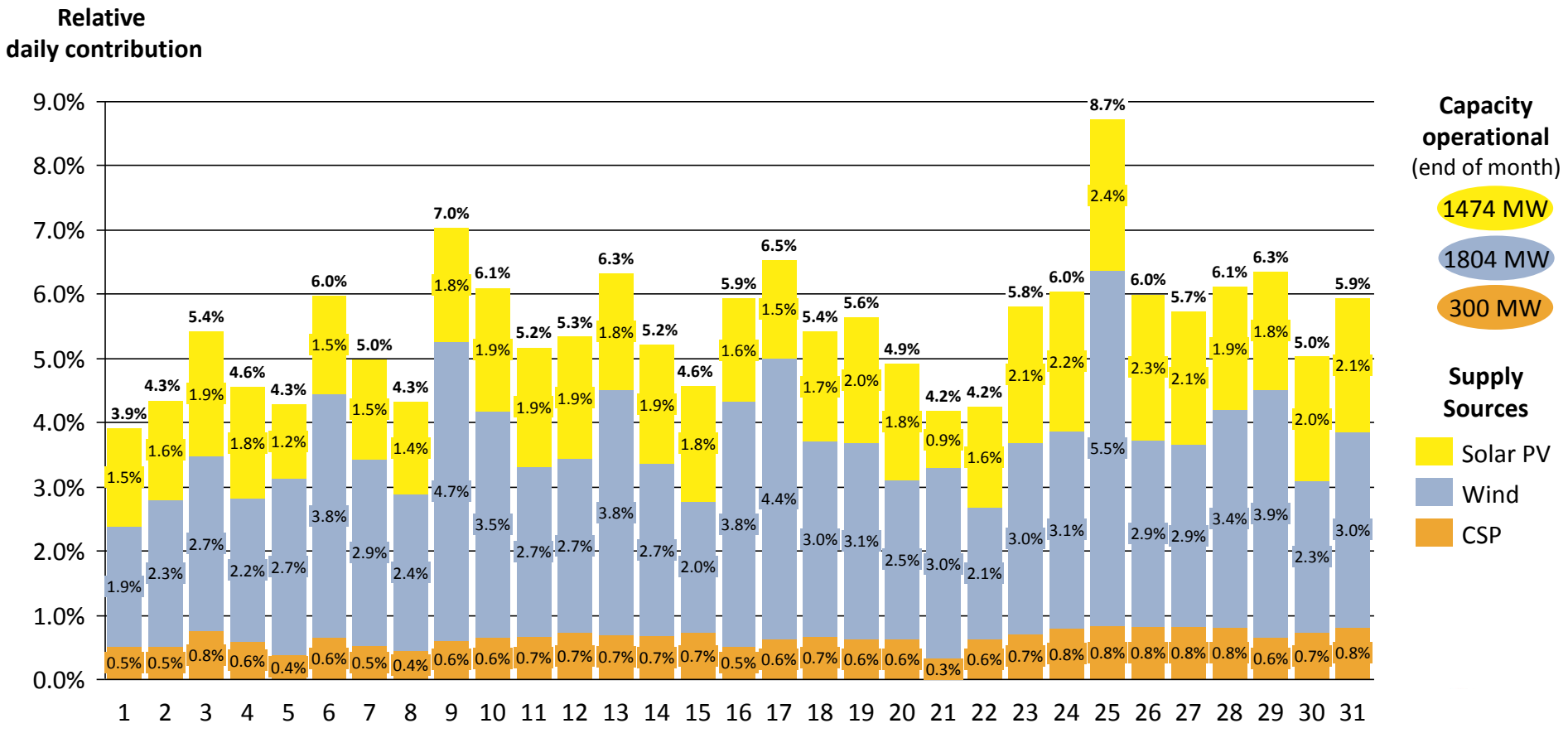


- Maximum daily relative solar PV contribution of 2.0% on 19 Nov 2017 (Sunday)
- Maximum daily relative wind contribution of 4.0% on 9 Nov 2017 (Thursday)
- Maximum daily relative CSP contribution of 0.7% on 26 Nov 2017 (Sunday)

Sources: Eskom; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 3.9-8.7% in Dec 2017

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for December 2017



- Maximum daily relative solar PV contribution of 2.4% on 25 Dec 2017 (Monday)
- Maximum daily relative wind contribution of 5.5% on 25 Dec 2017 (Monday)
- Maximum daily relative CSP contribution of 0.8% on 25 Dec 2017 (Monday)

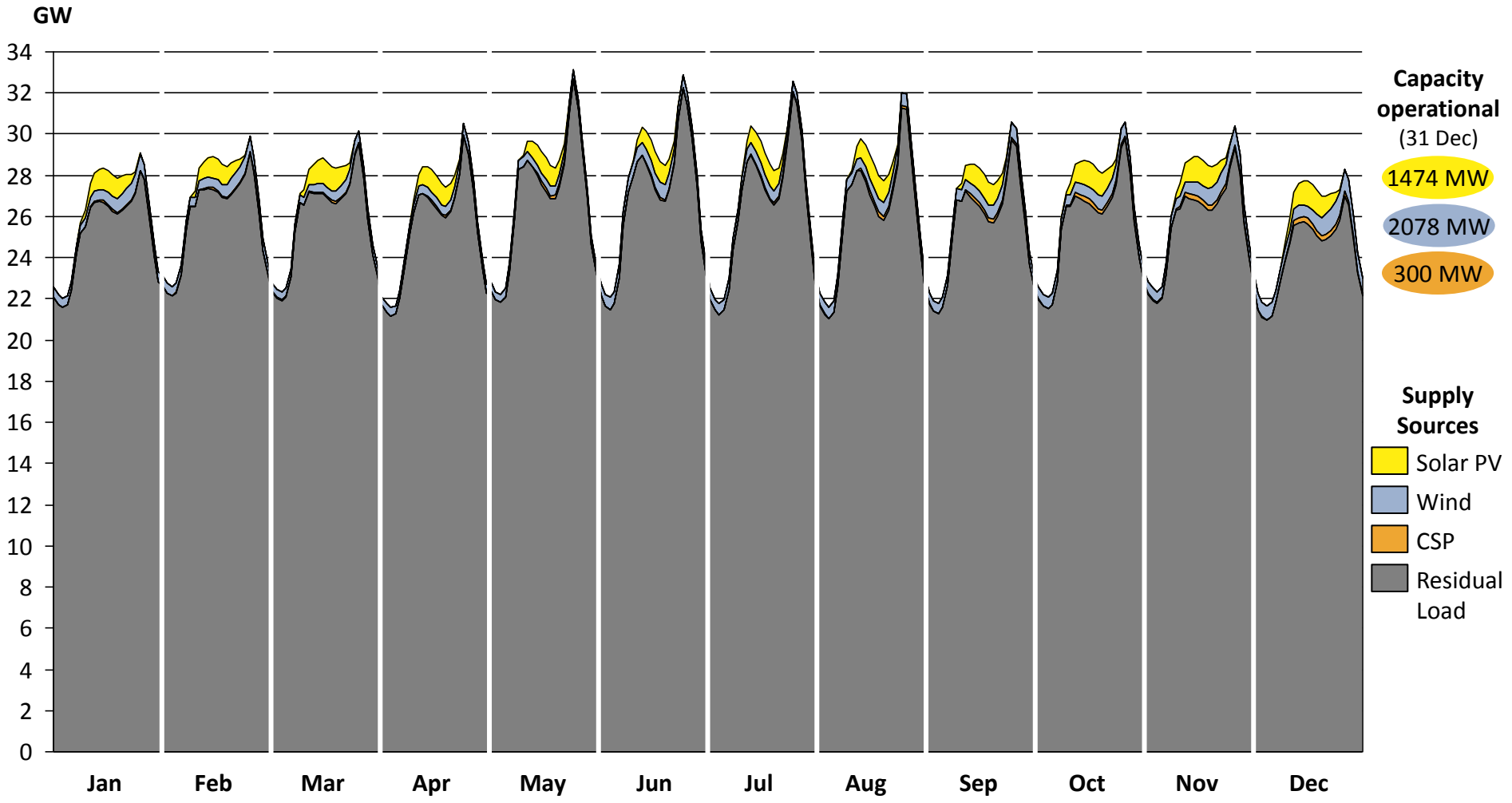
Sources: Eskom; CSIR Energy Centre analysis

Agenda

1. Overview and status of REIPPPP
2. Overview actual electricity production data for 2017
3. Monthly electricity production
4. Weekly electricity production
5. Daily electricity production
6. Hourly electricity production and gradients
7. Actual load shedding in 2017

Diurnal Courses

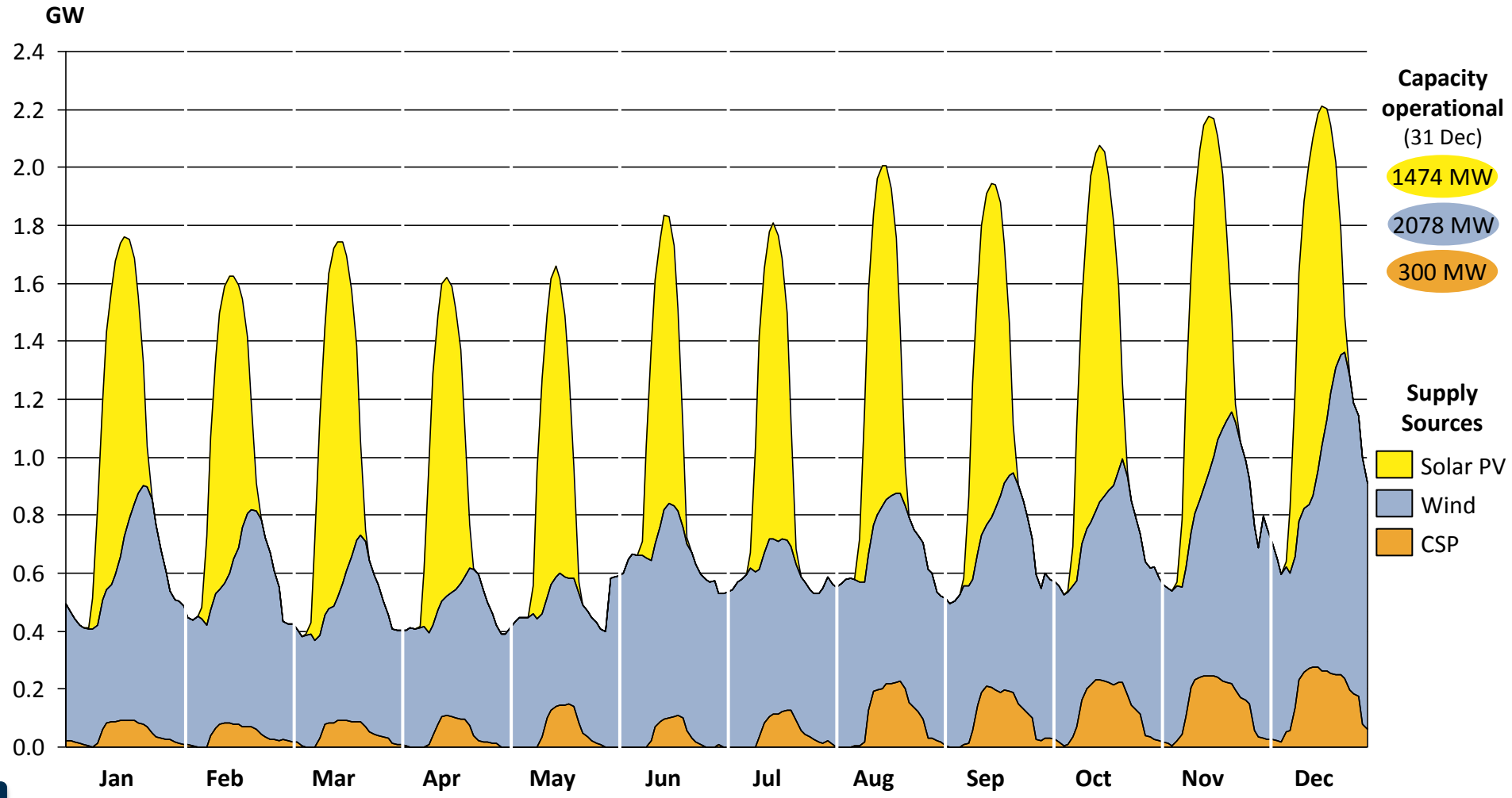
Actual monthly average diurnal courses of the total power supply in RSA for the months from Jan-Dec 2017



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

Diurnal Courses

Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for the months from Jan-Dec 2017

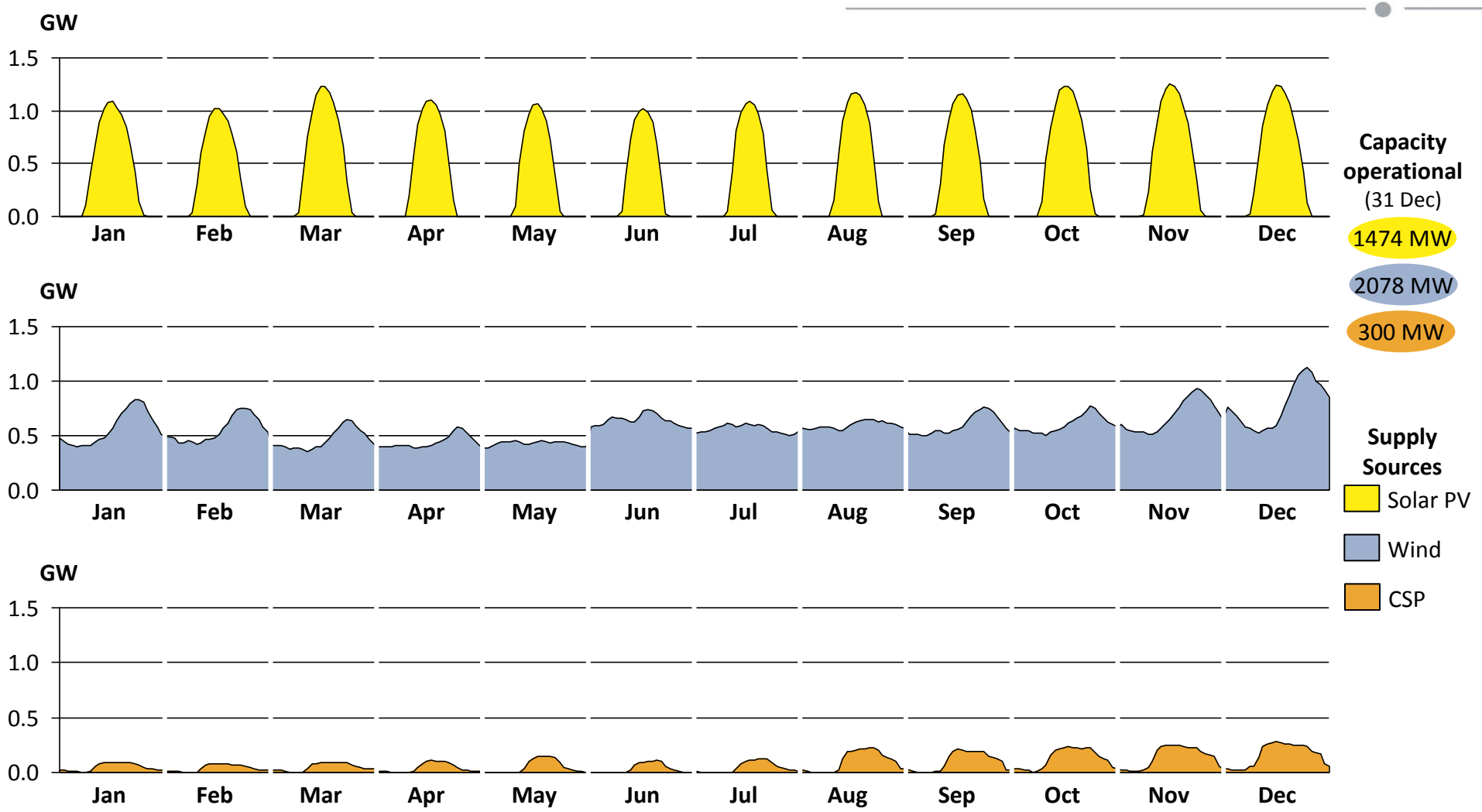


Note: Design as per Fraunhofer ISE

Sources: Eskom; CSIR Energy Centre analysis

Diurnal Courses

Actual monthly average diurnal courses of solar PV, wind and CSP in RSA for the months from Jan-Dec 2017

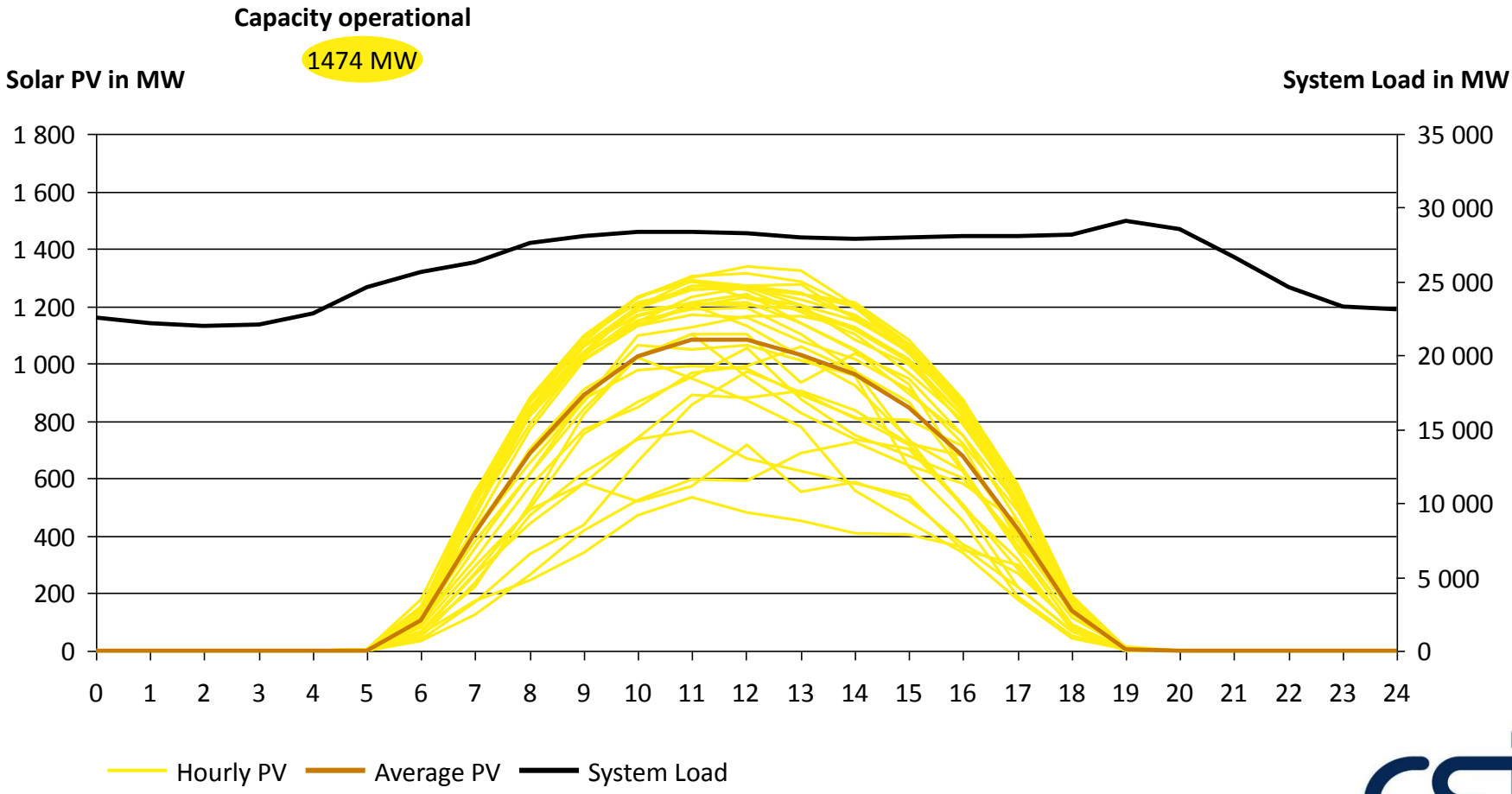


Note: Design as per Fraunhofer ISE

Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Jan 2017 was very stable

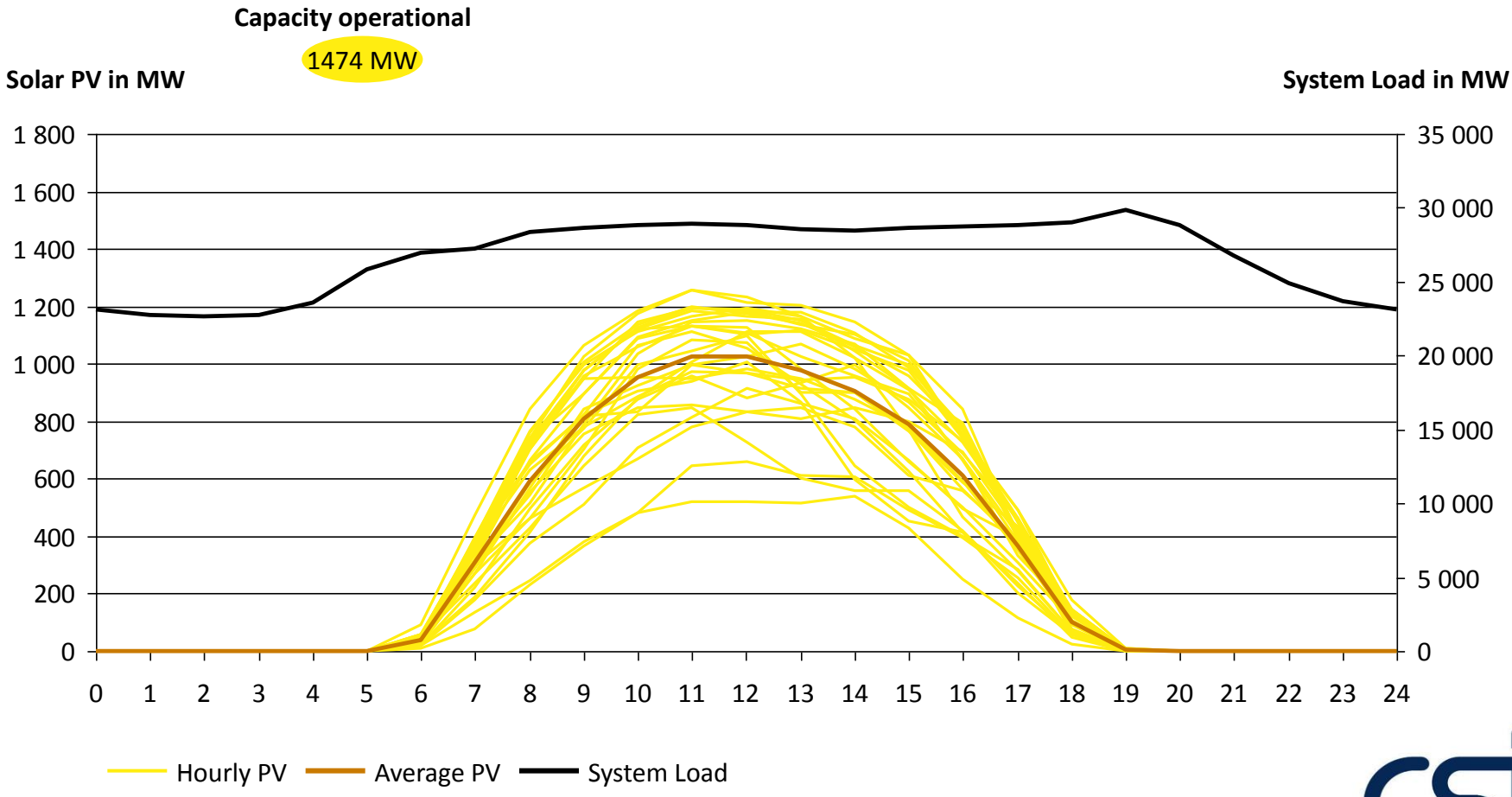
Hourly solar PV production for all 31 days of January 2017 and average system load diurnal course



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

Solar PV supply in Feb 2017 was very stable

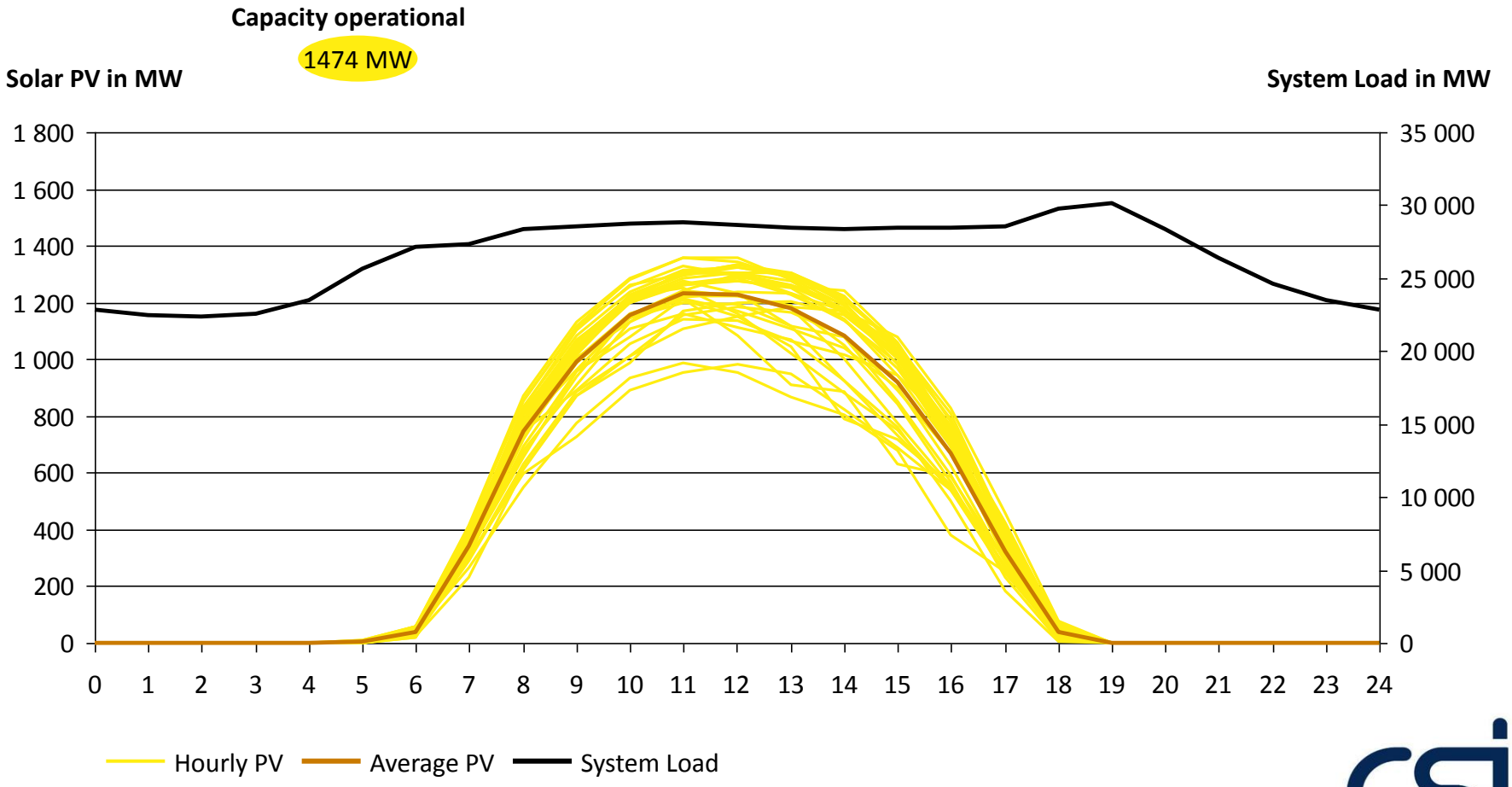
Hourly solar PV production for all 28 days of February 2017 and average system load diurnal course



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

Solar PV supply in Mar 2017 was very stable

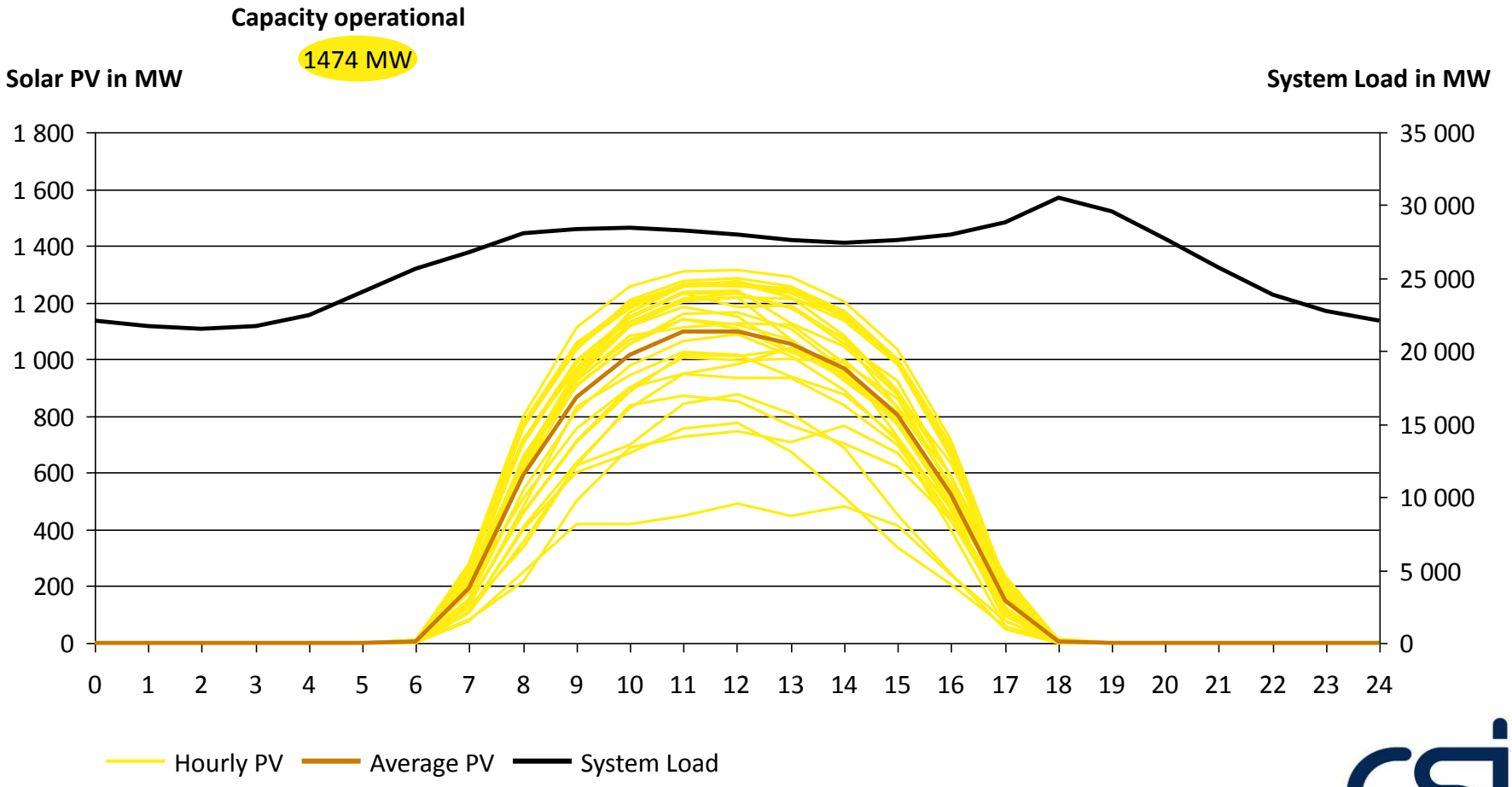
Hourly solar PV production for all 31 days of March 2017 and average system load diurnal course



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

Solar PV supply in Apr 2017 very stable

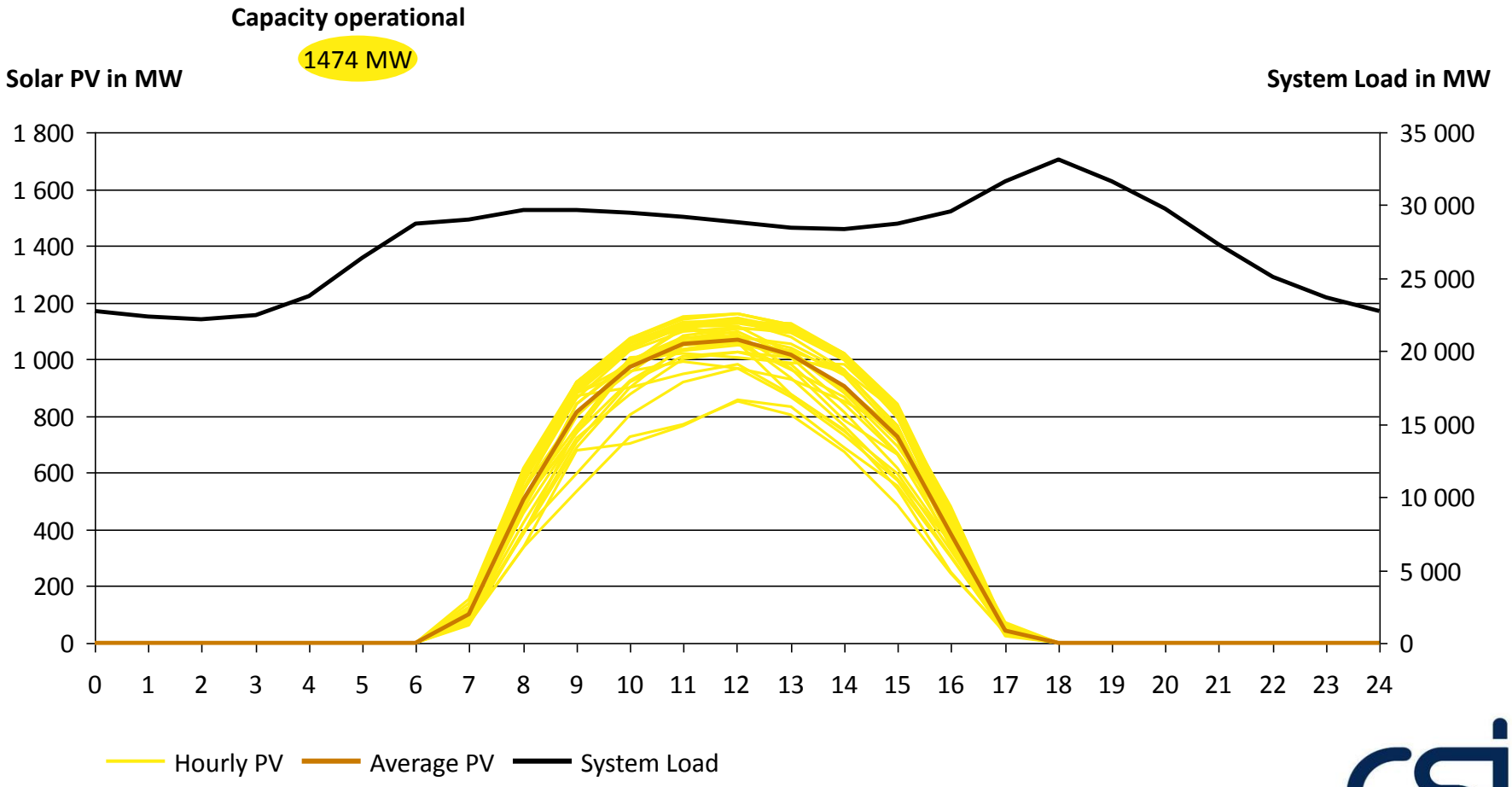
Hourly solar PV production for all 30 days of April 2017 and average system load diurnal course



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

Solar PV supply in May 2017 very stable

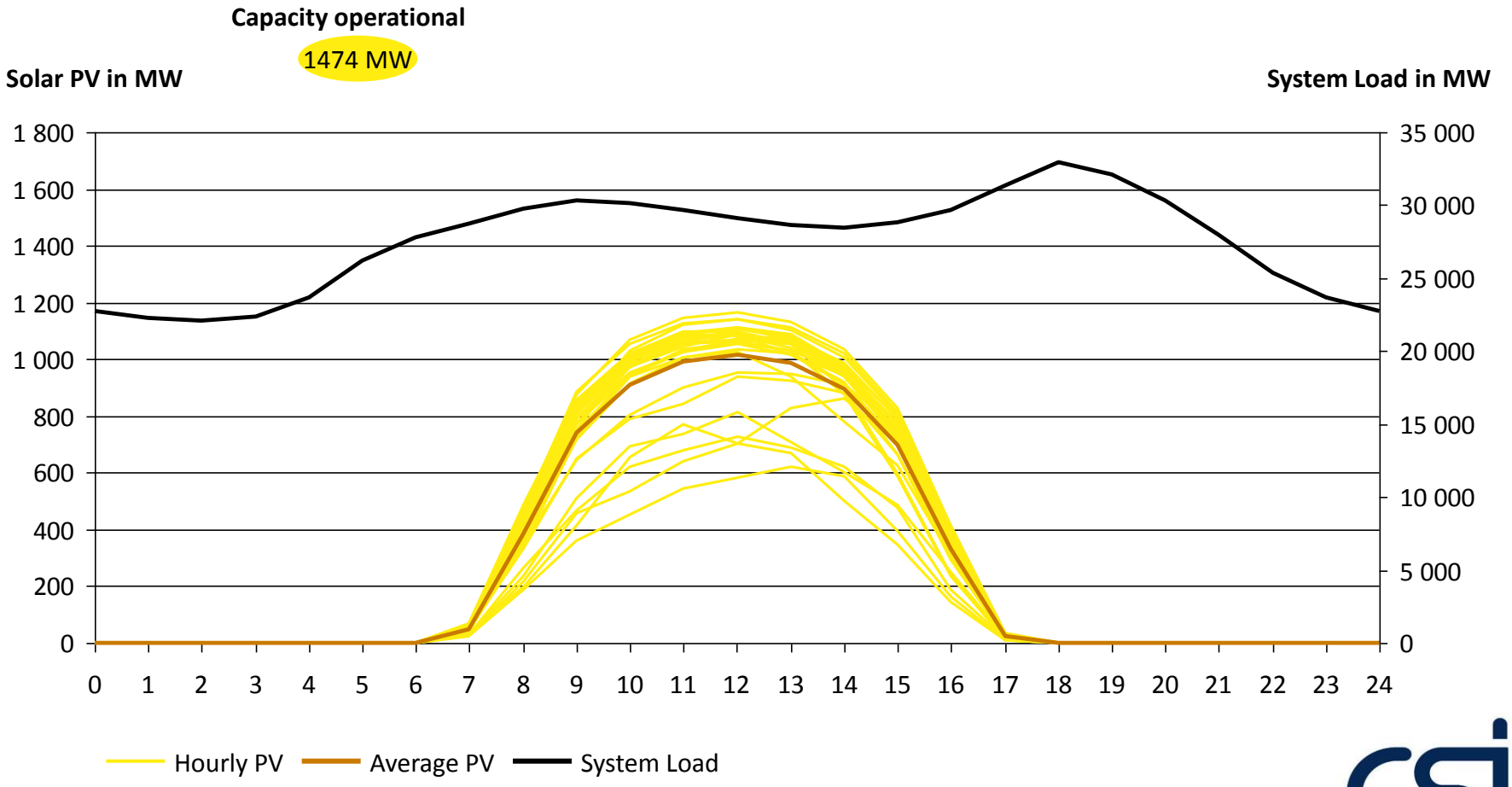
Hourly solar PV production for all 31 days of May 2017 and average system load diurnal course



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

Solar PV supply in Jun 2017 very stable

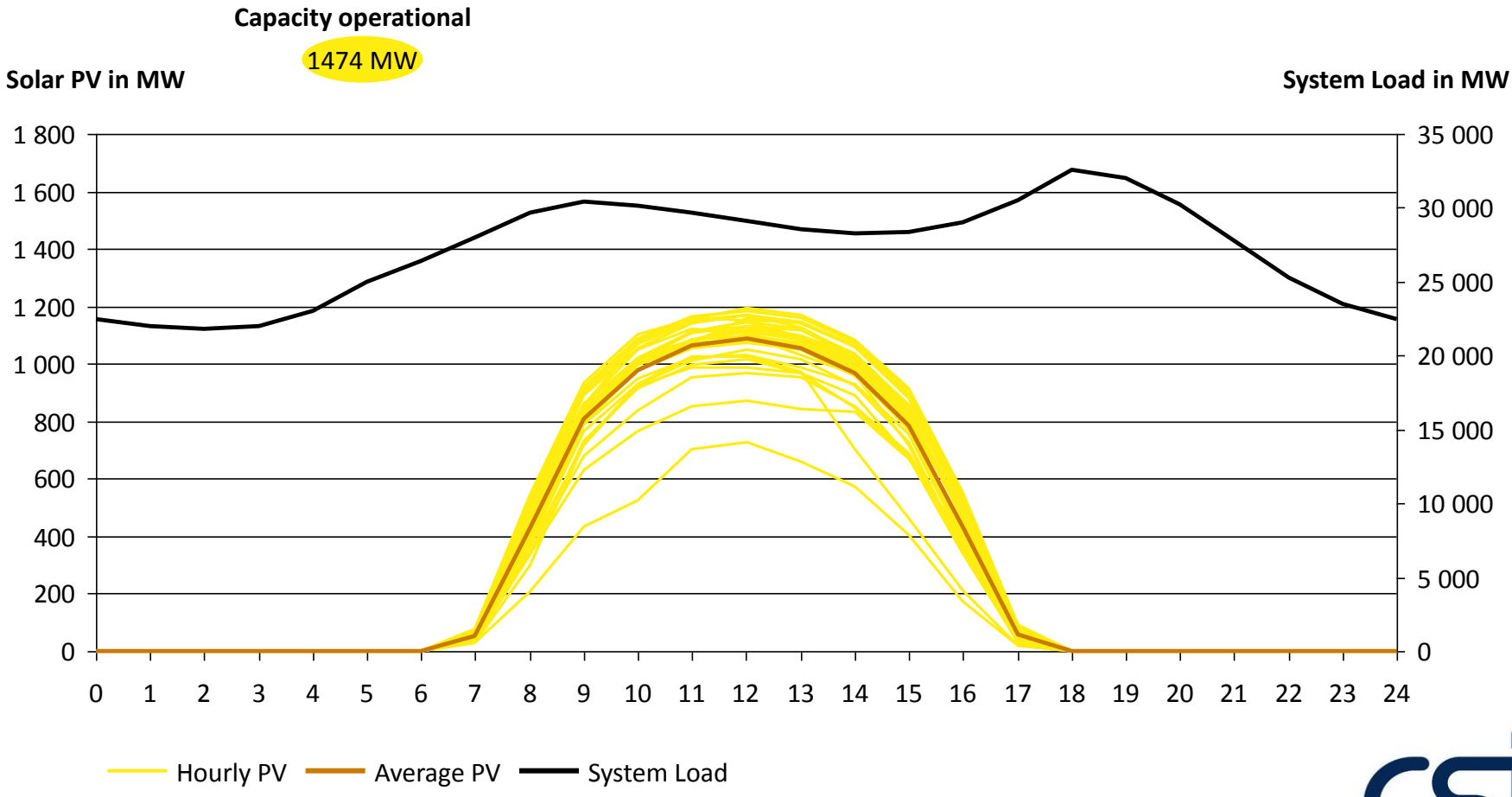
Hourly solar PV production for all 30 days of June 2017 and average system load diurnal course



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

Solar PV supply in Jul 2017 very stable

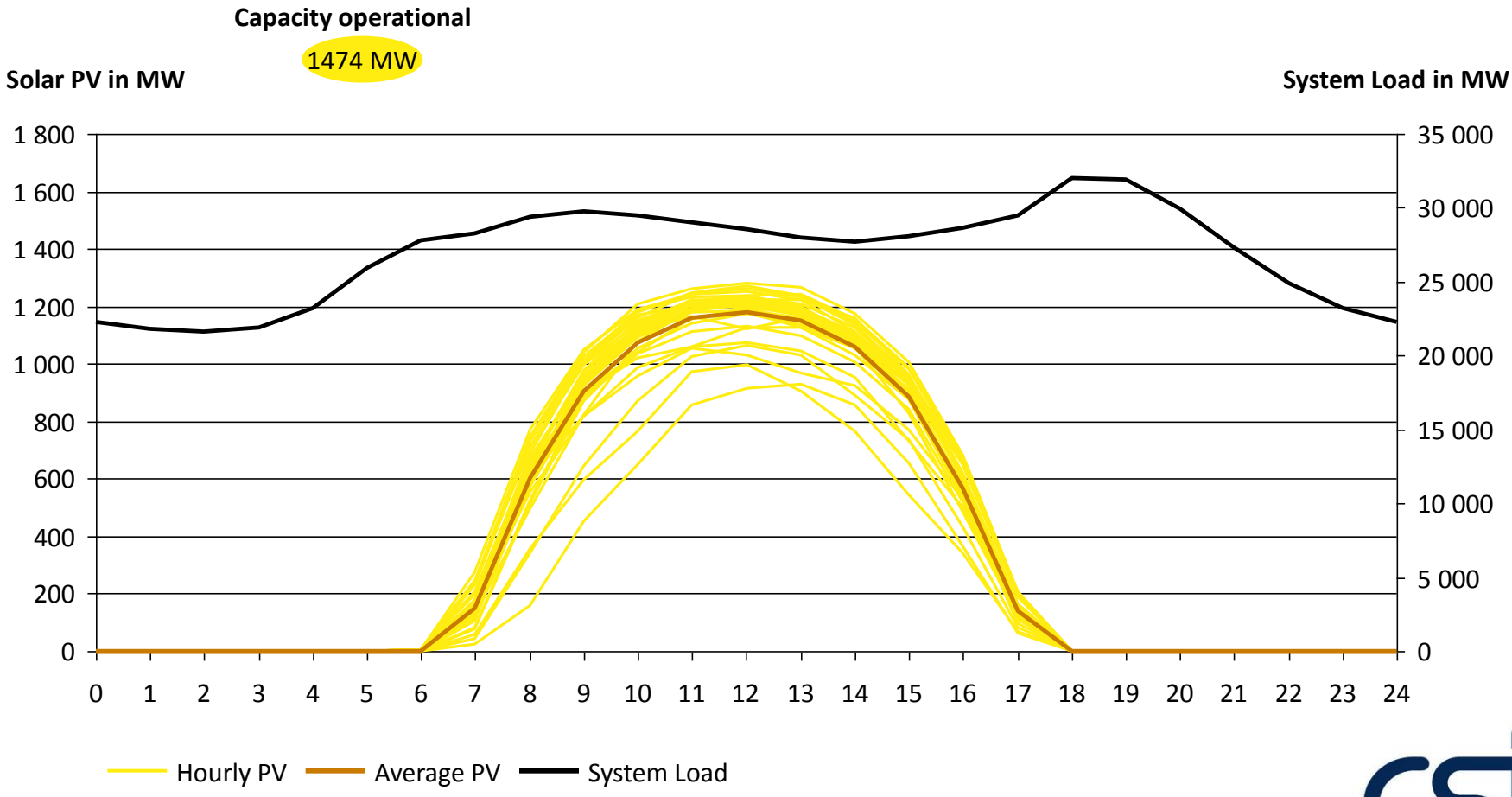
Hourly solar PV production for all 31 days of July 2017 and average system load diurnal course



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

Solar PV supply in Aug 2017 very stable

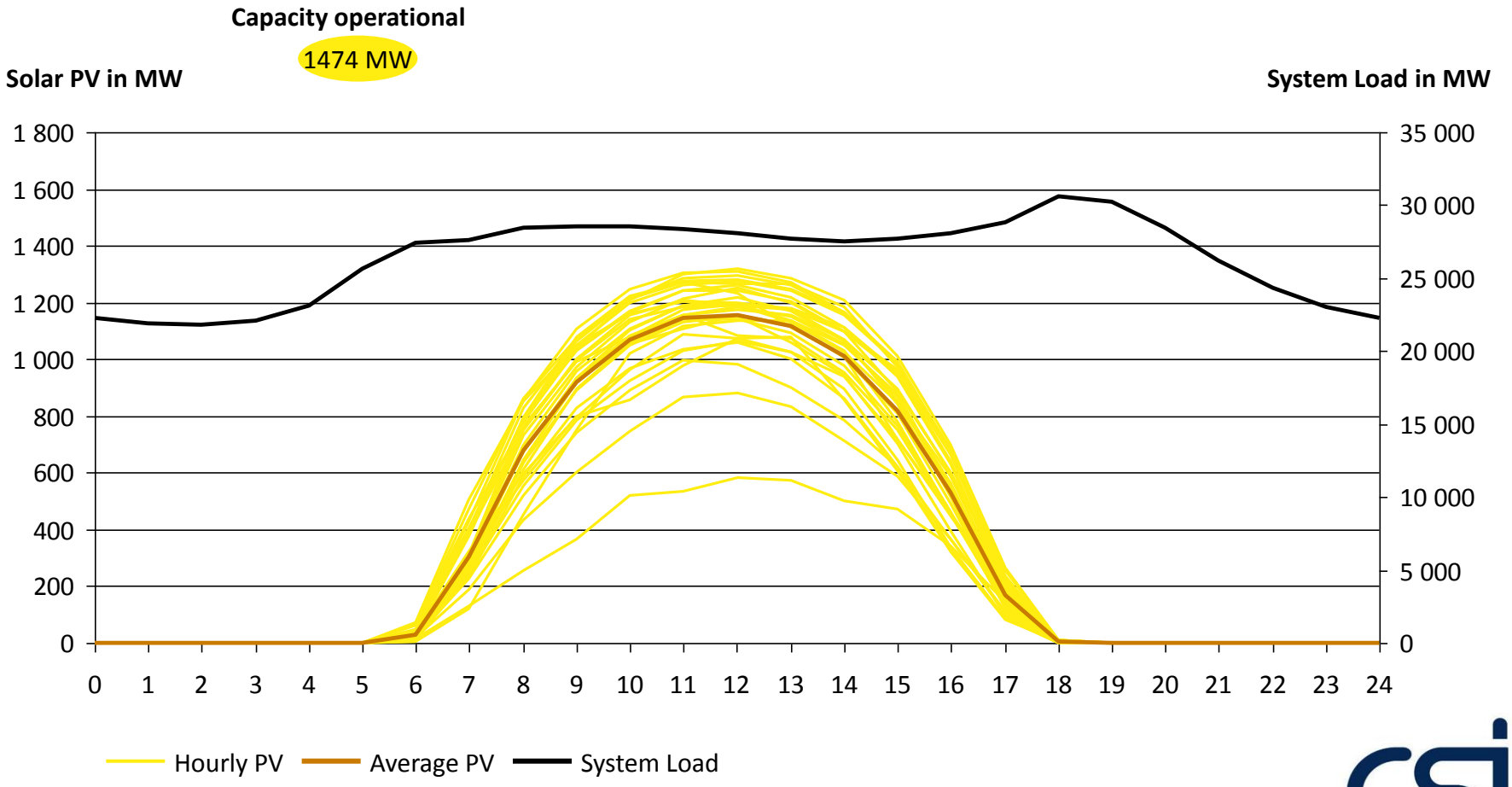
Hourly solar PV production for all 31 days of August 2017 and average system load diurnal course



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

Solar PV supply in Sep 2017 very stable

Hourly solar PV production for all 30 days of September 2017 and average system load diurnal course

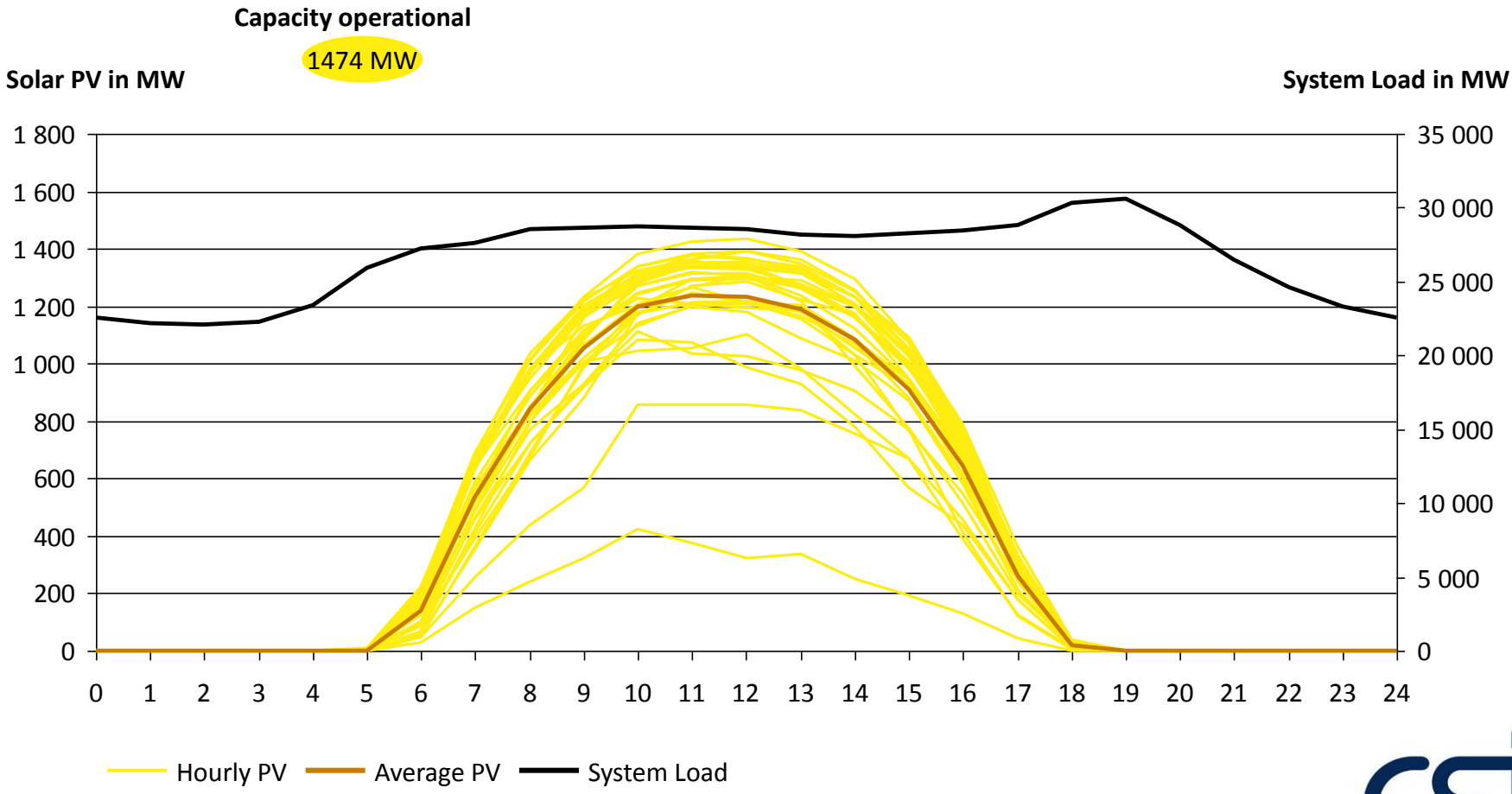


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

Solar PV supply in Oct 2017 very stable

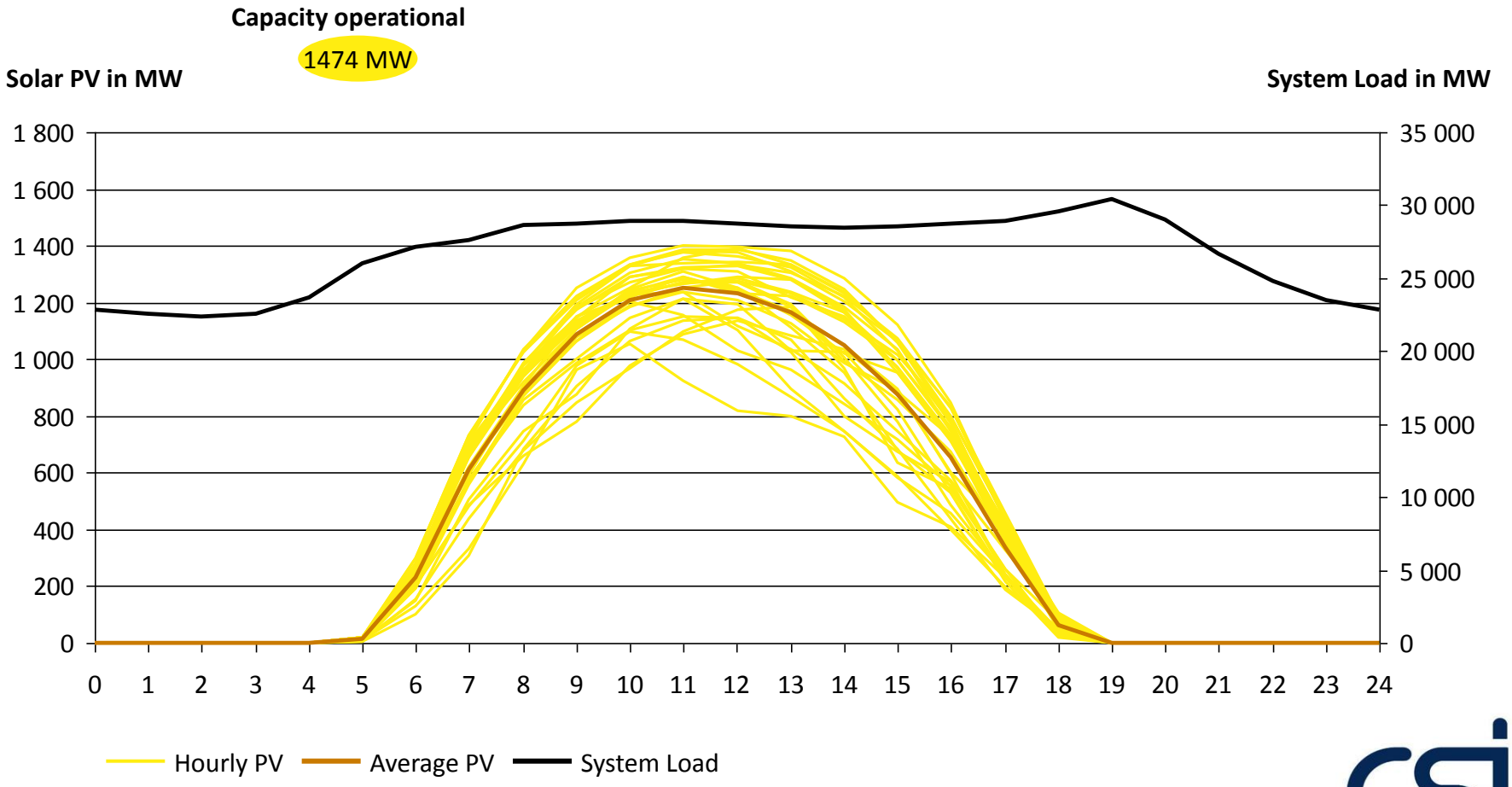
Hourly solar PV production for all 31 days of October 2017 and average system load diurnal course



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

Solar PV supply in Nov 2017 very stable

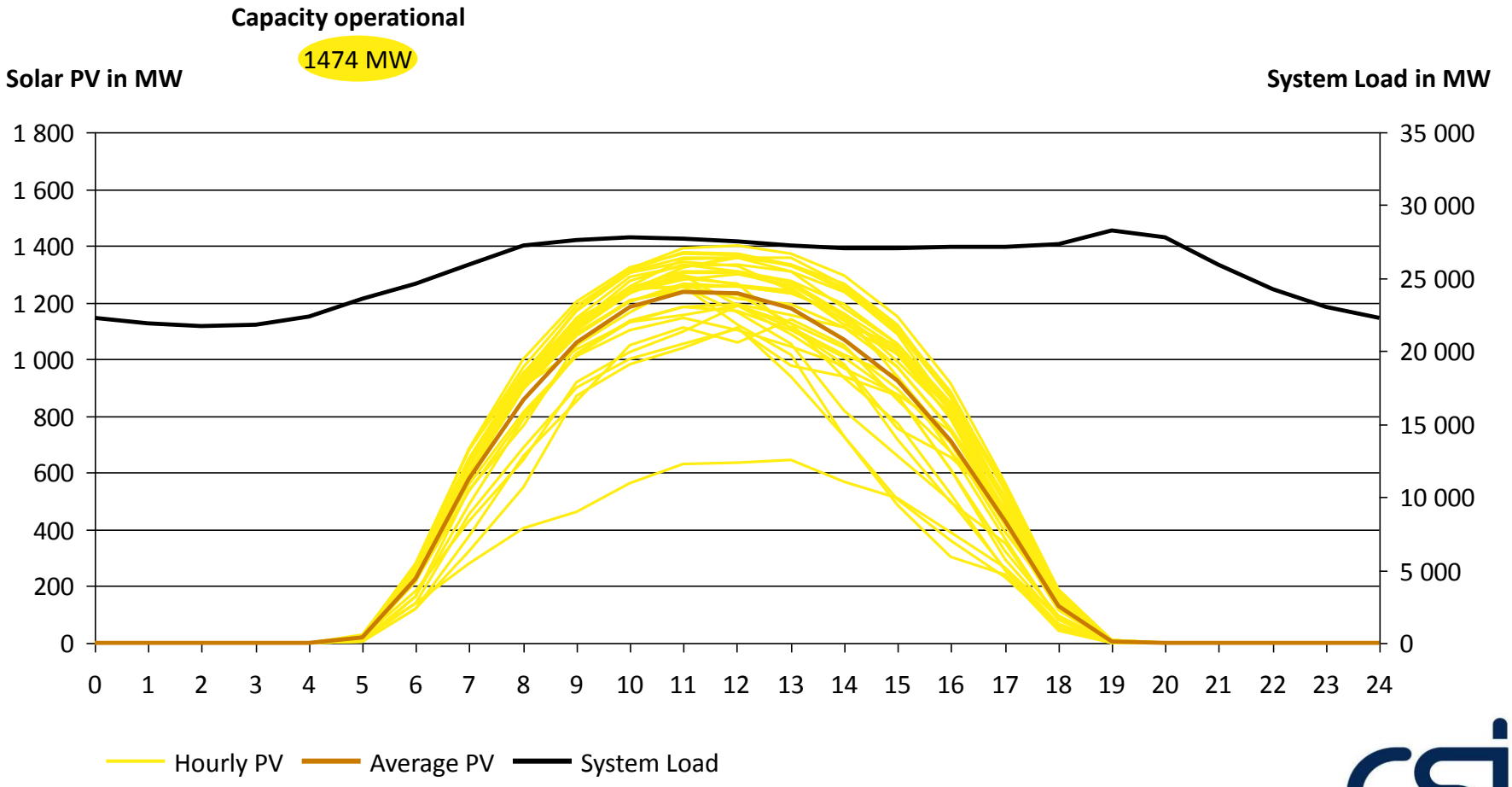
Hourly solar PV production for all 30 days of November 2017 and average system load diurnal course



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

Solar PV supply in Dec 2017 very stable

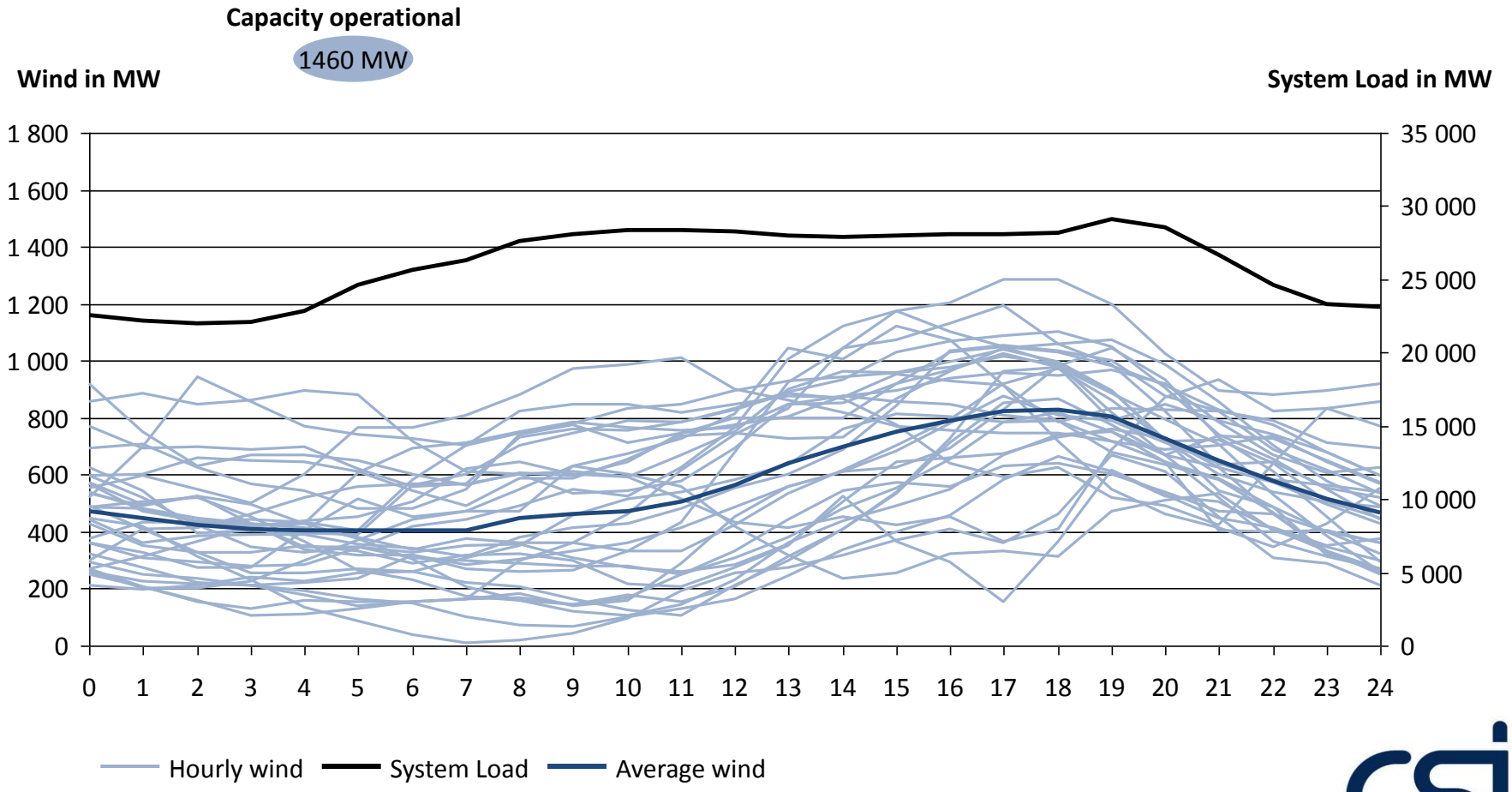
Hourly solar PV production for all 31 days of December 2017 and average system load diurnal course



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

In Jan 2017, wind supplied in the evenings

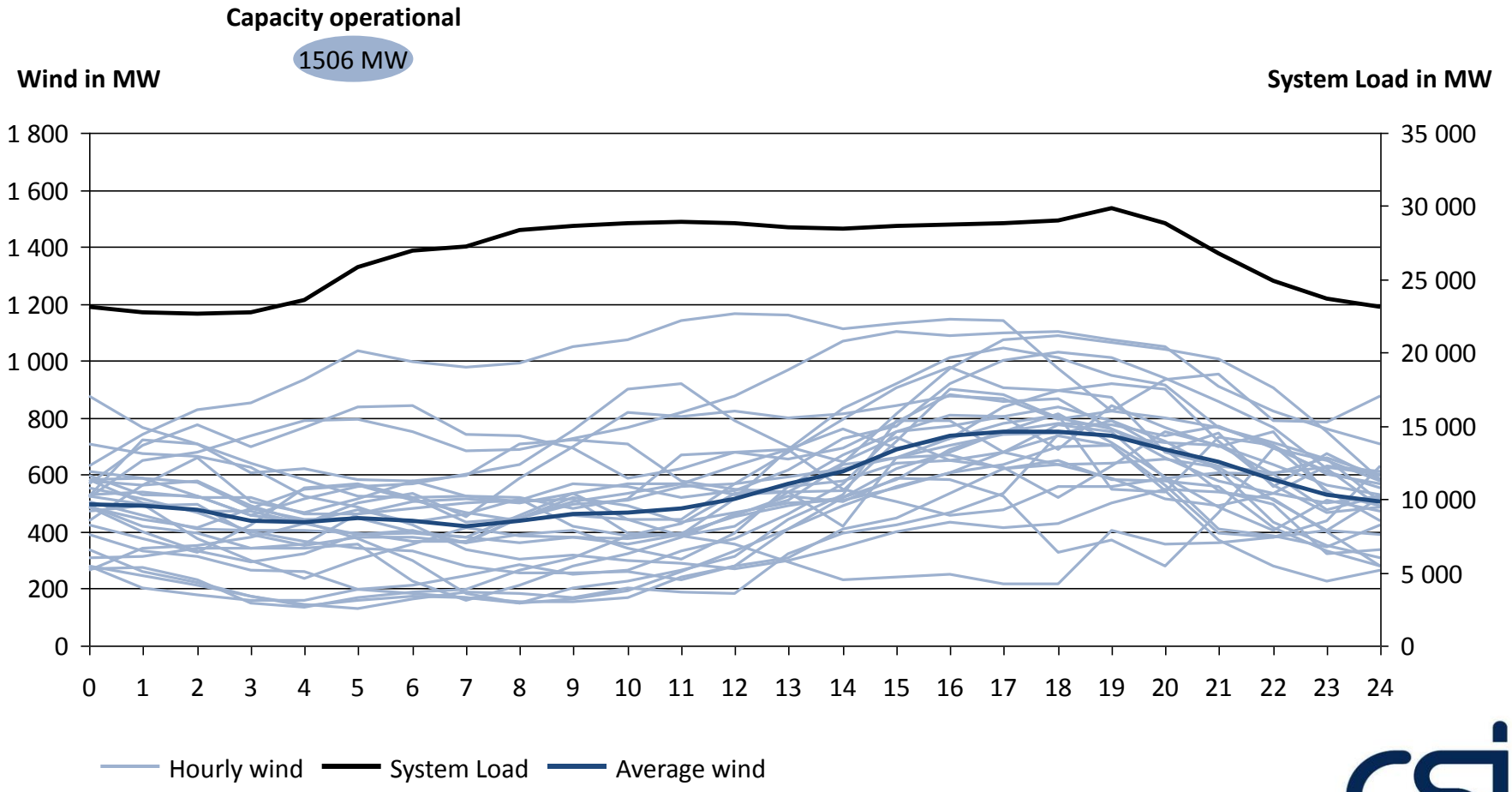
Hourly wind production for all 31 days of January 2017 and average system load diurnal course



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

In Feb 2017, wind supplied in the evenings

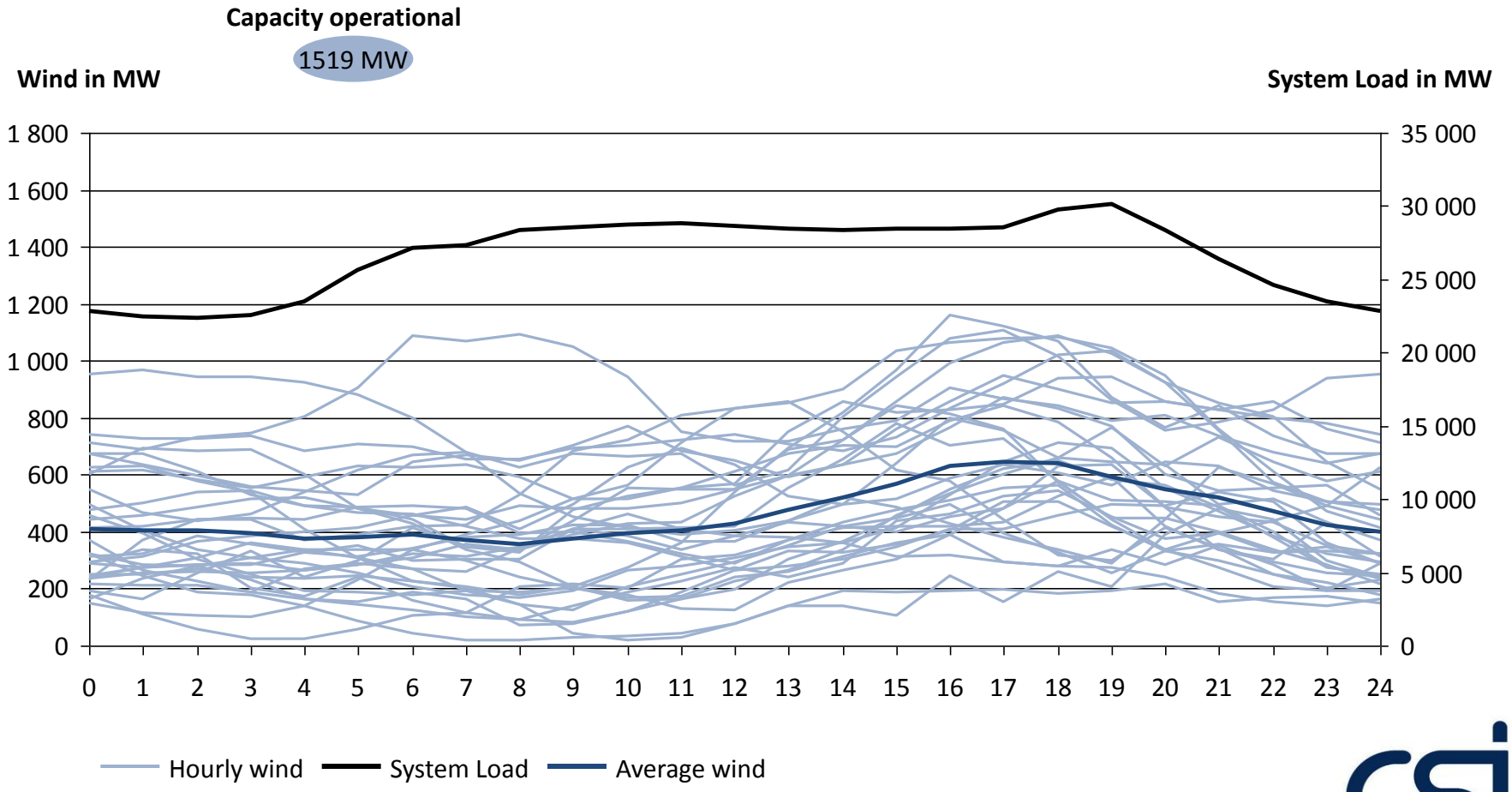
Hourly wind production for all 28 days of February 2017 and average system load diurnal course



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

In Mar 2017, wind supplied in the evenings

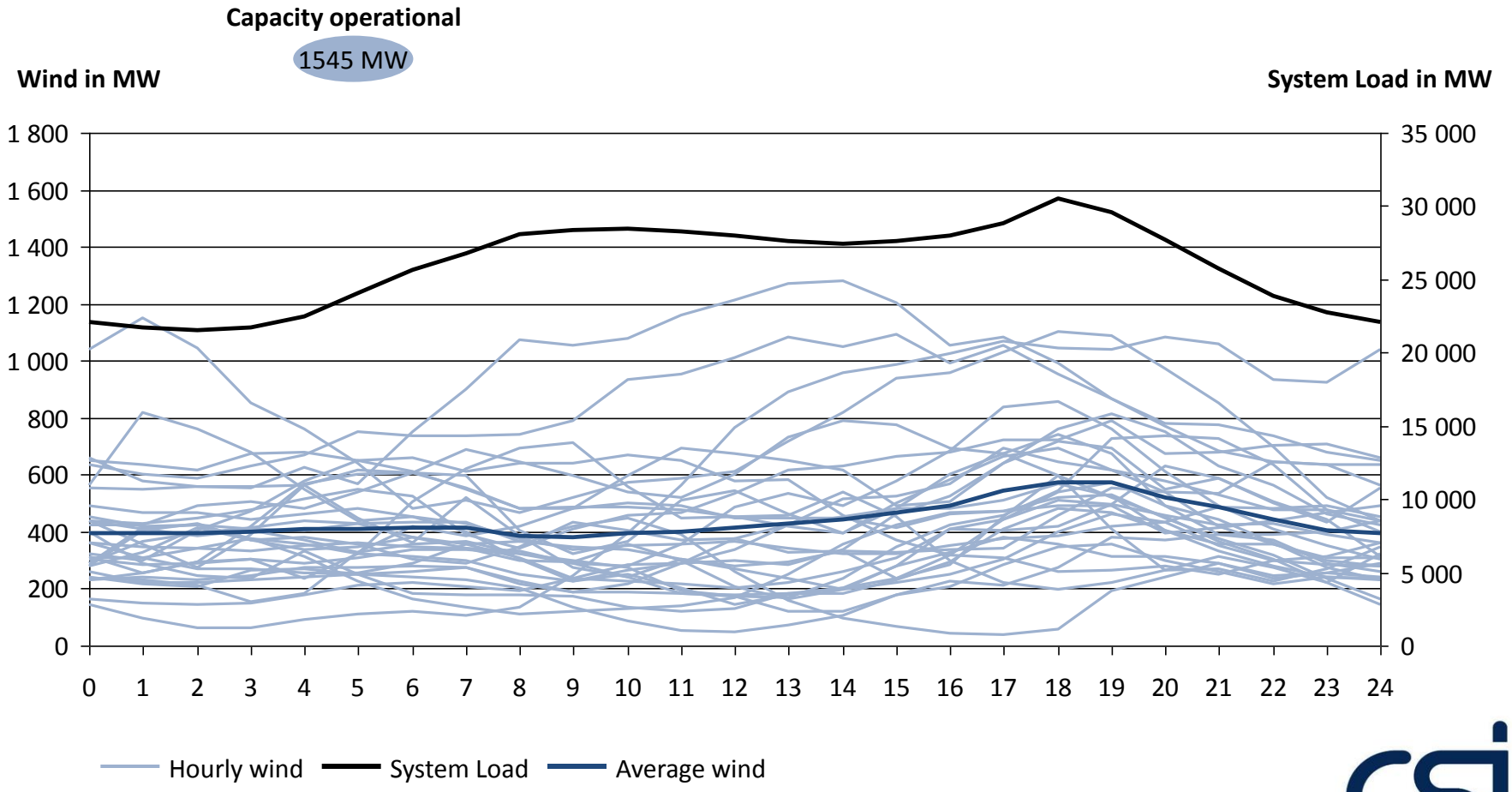
Hourly wind production for all 31 days of March 2017 and average system load diurnal course



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

In Apr 2017, wind supplies in the evenings

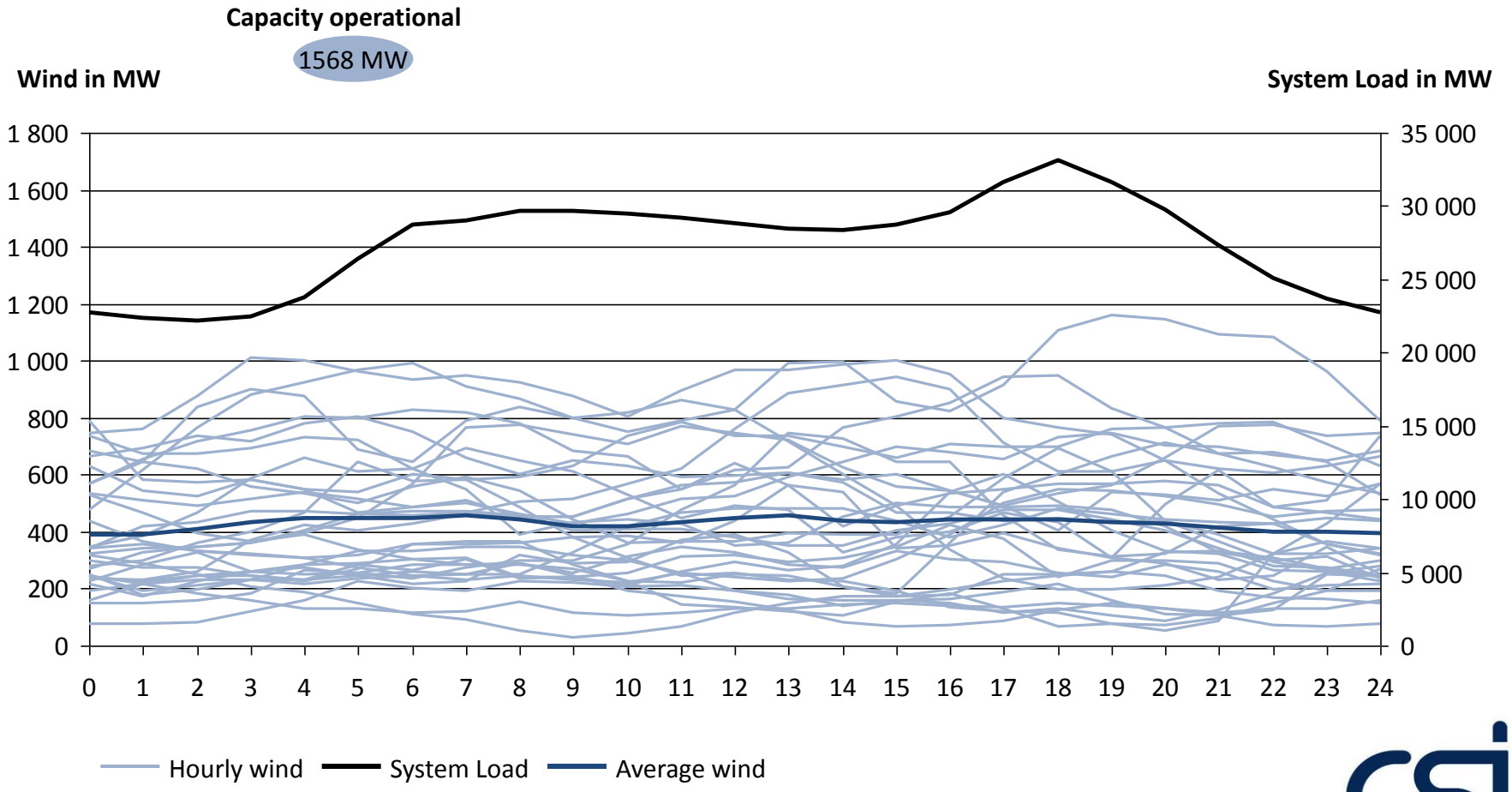
Hourly wind production for all 30 days of April 2017 and average system load diurnal course



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

In May 2017, wind fluctuated day-to-day

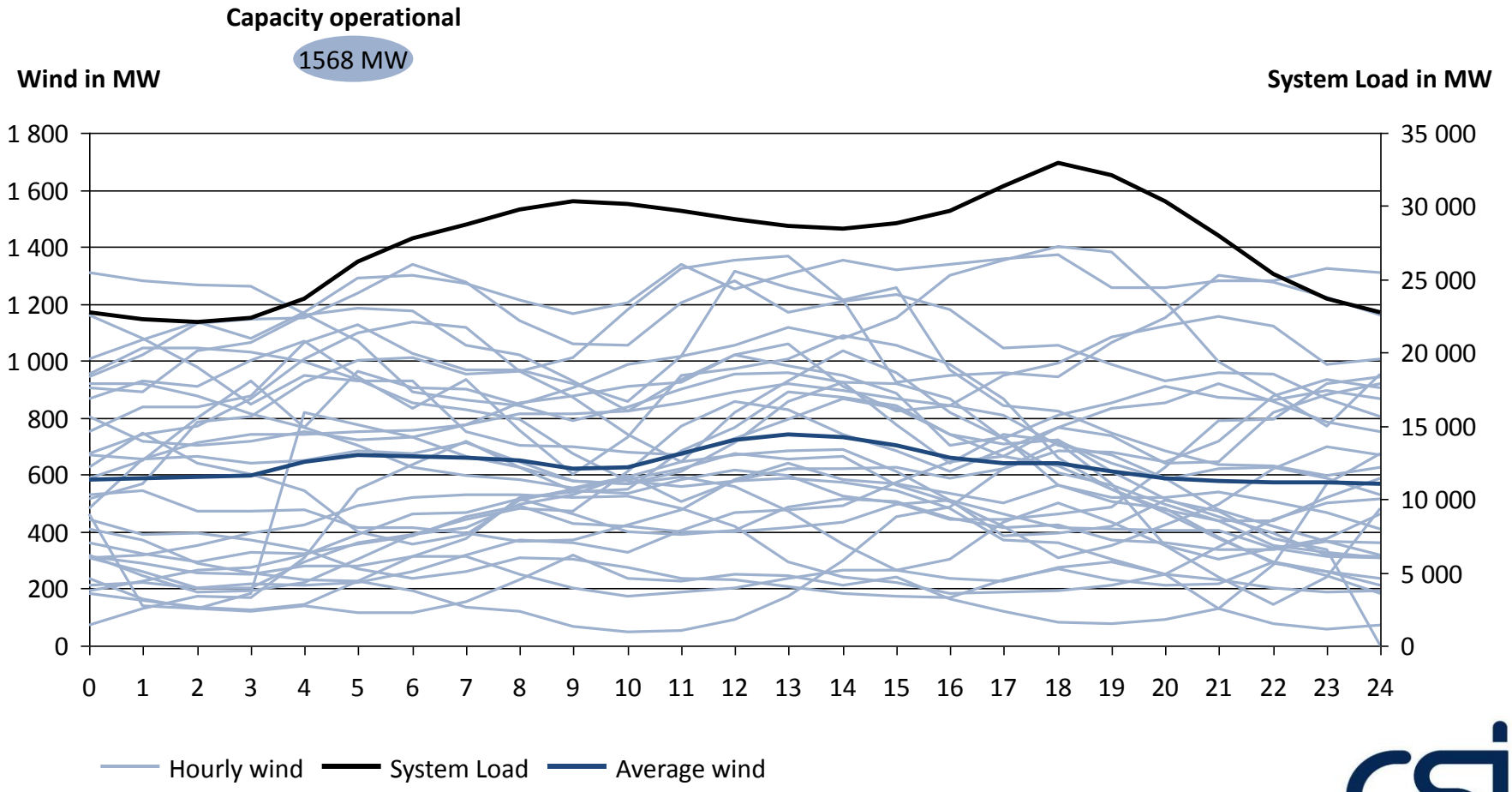
Hourly wind production for all 31 days of May 2017 and average system load diurnal course



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

In Jun 2017, wind fluctuated day-to-day

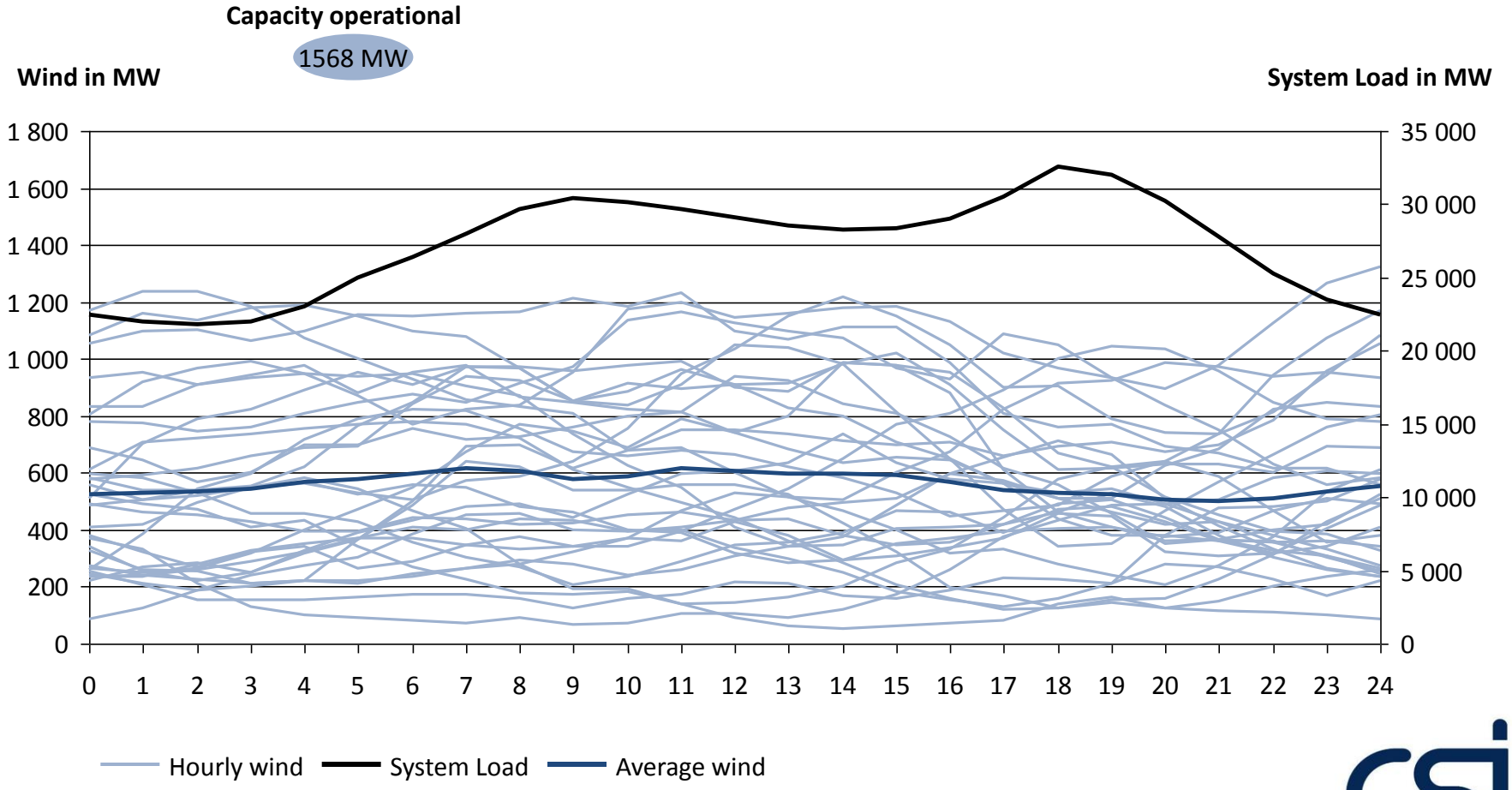
Hourly wind production for all 30 days of June 2017 and average system load diurnal course



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

In Jul 2017, wind fluctuated day-to-day

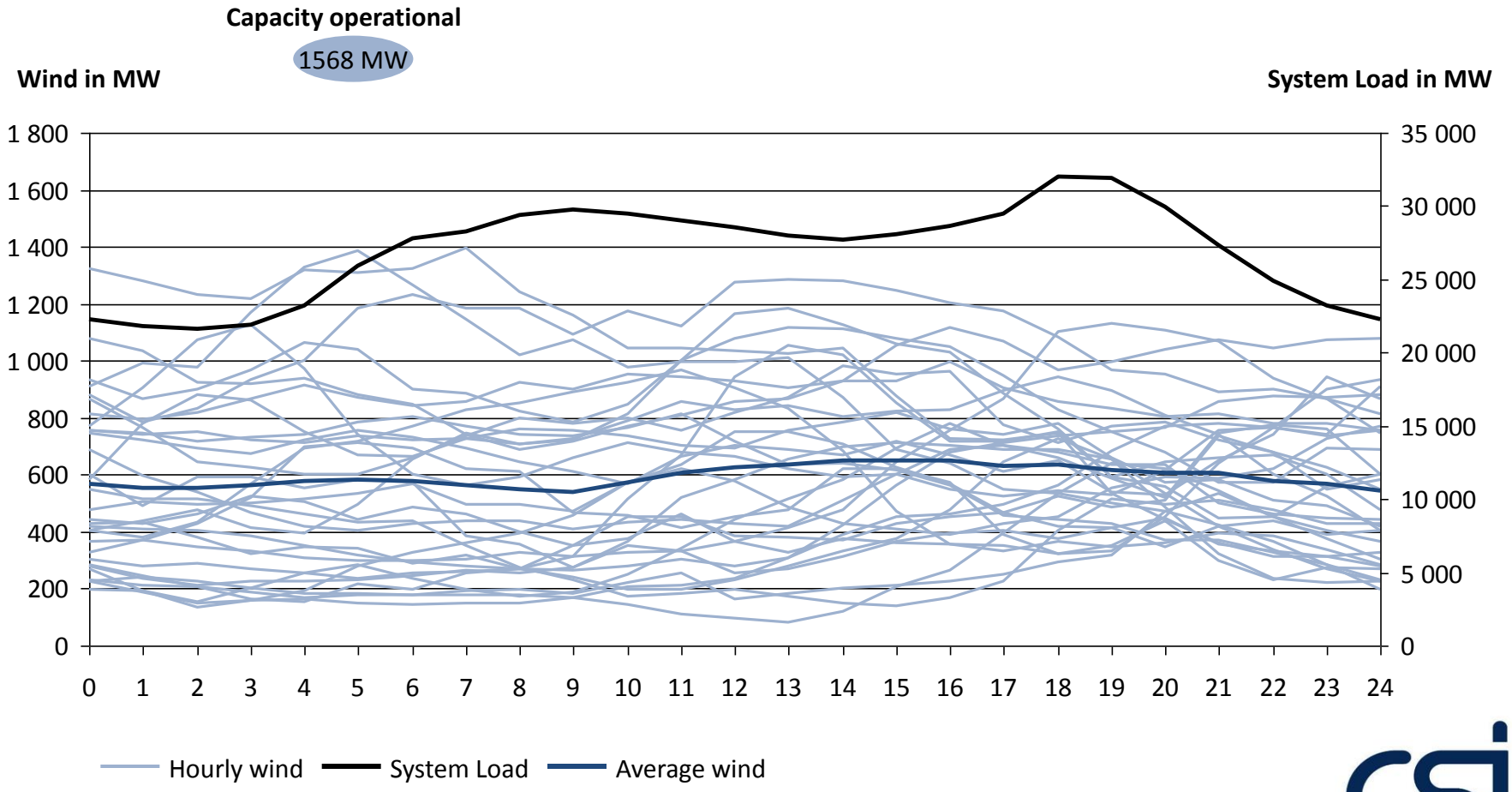
Hourly wind production for all 31 days of July 2017 and average system load diurnal course



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

In Aug 2017, wind fluctuated day-to-day

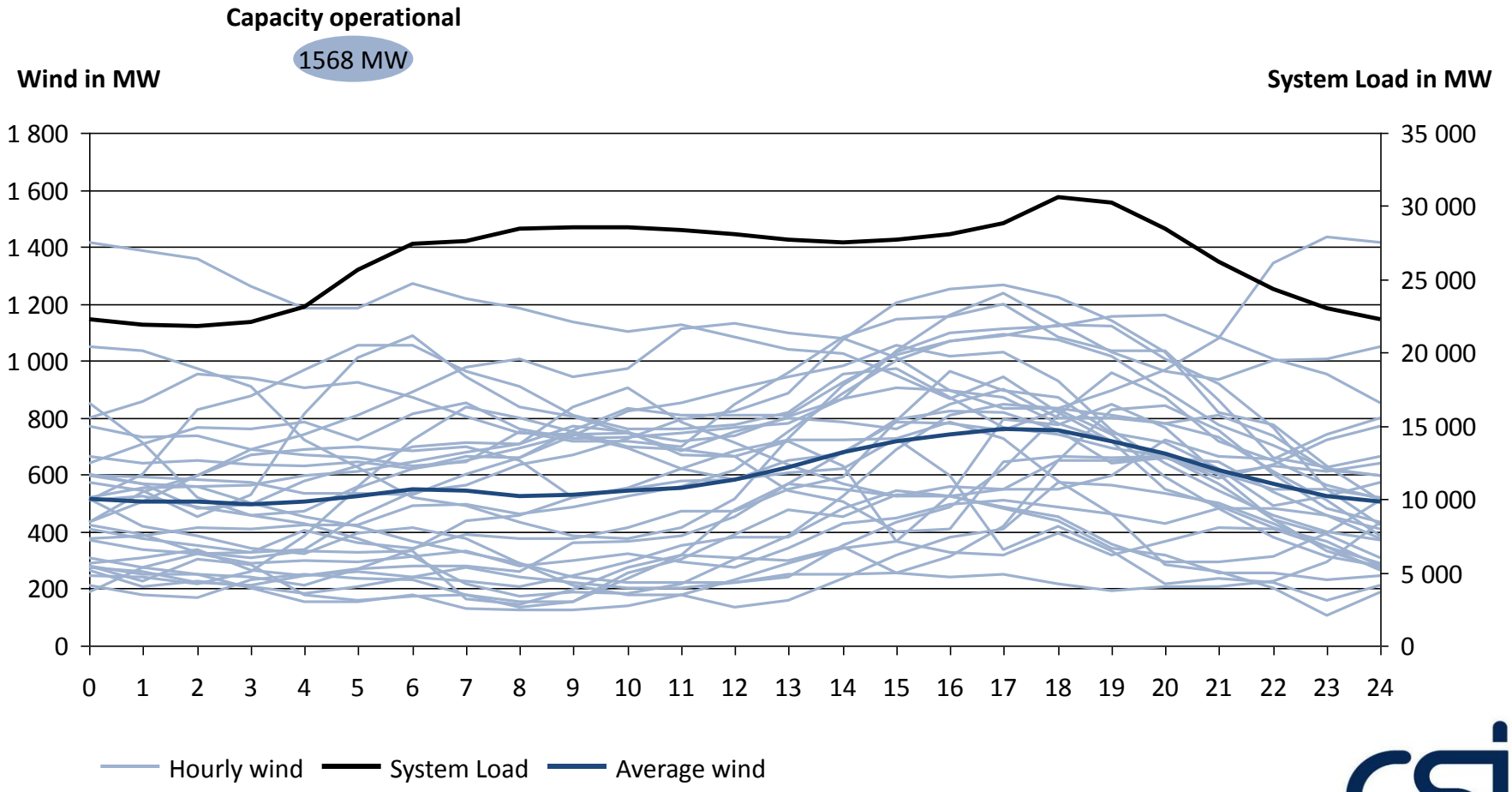
Hourly wind production for all 31 days of August 2017 and average system load diurnal course



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

In Sep 2017, wind supplied in the evenings

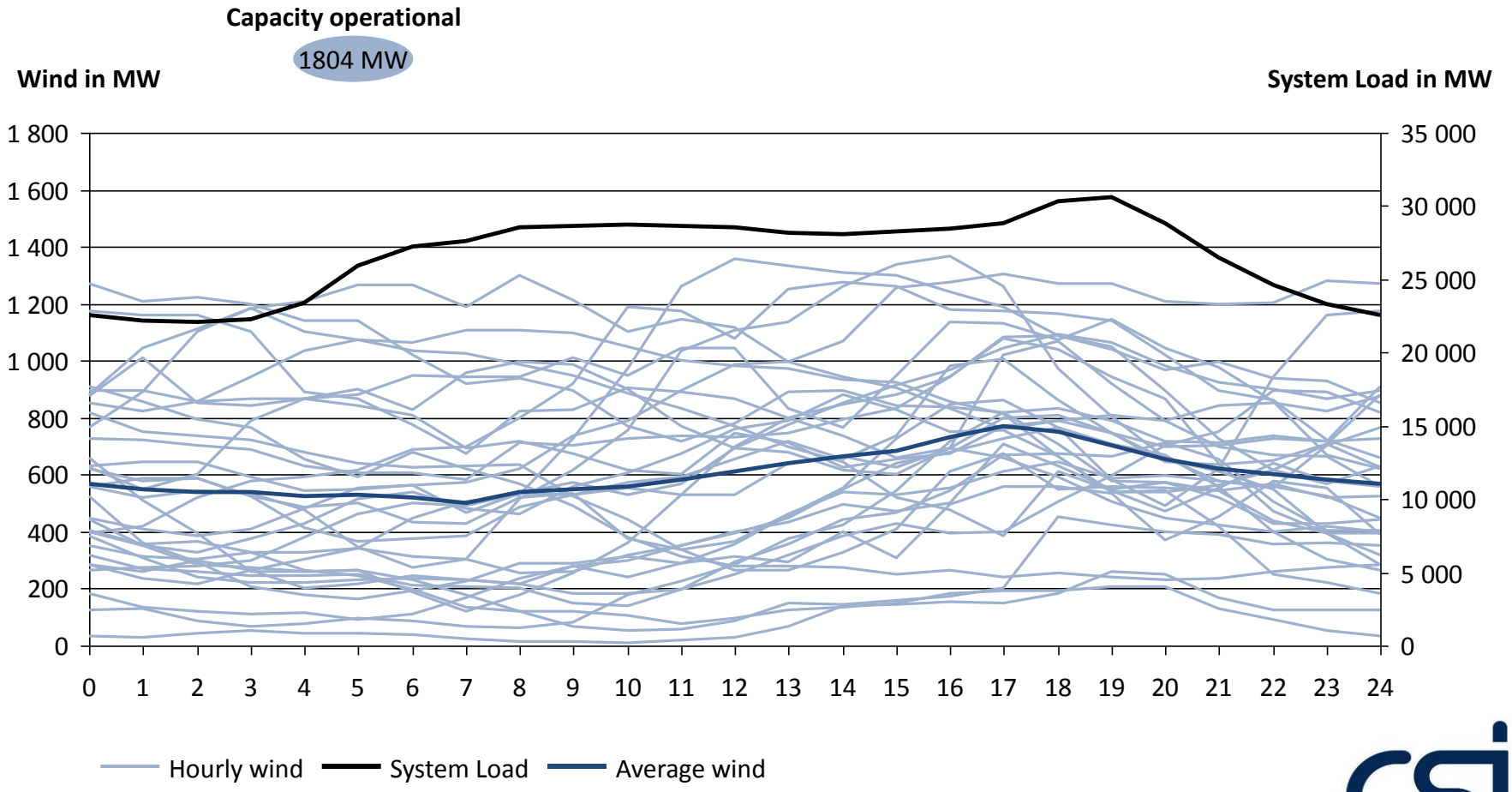
Hourly wind production for all 30 days of September 2017 and average system load diurnal course



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

In Oct 2017, wind supplied in the evenings

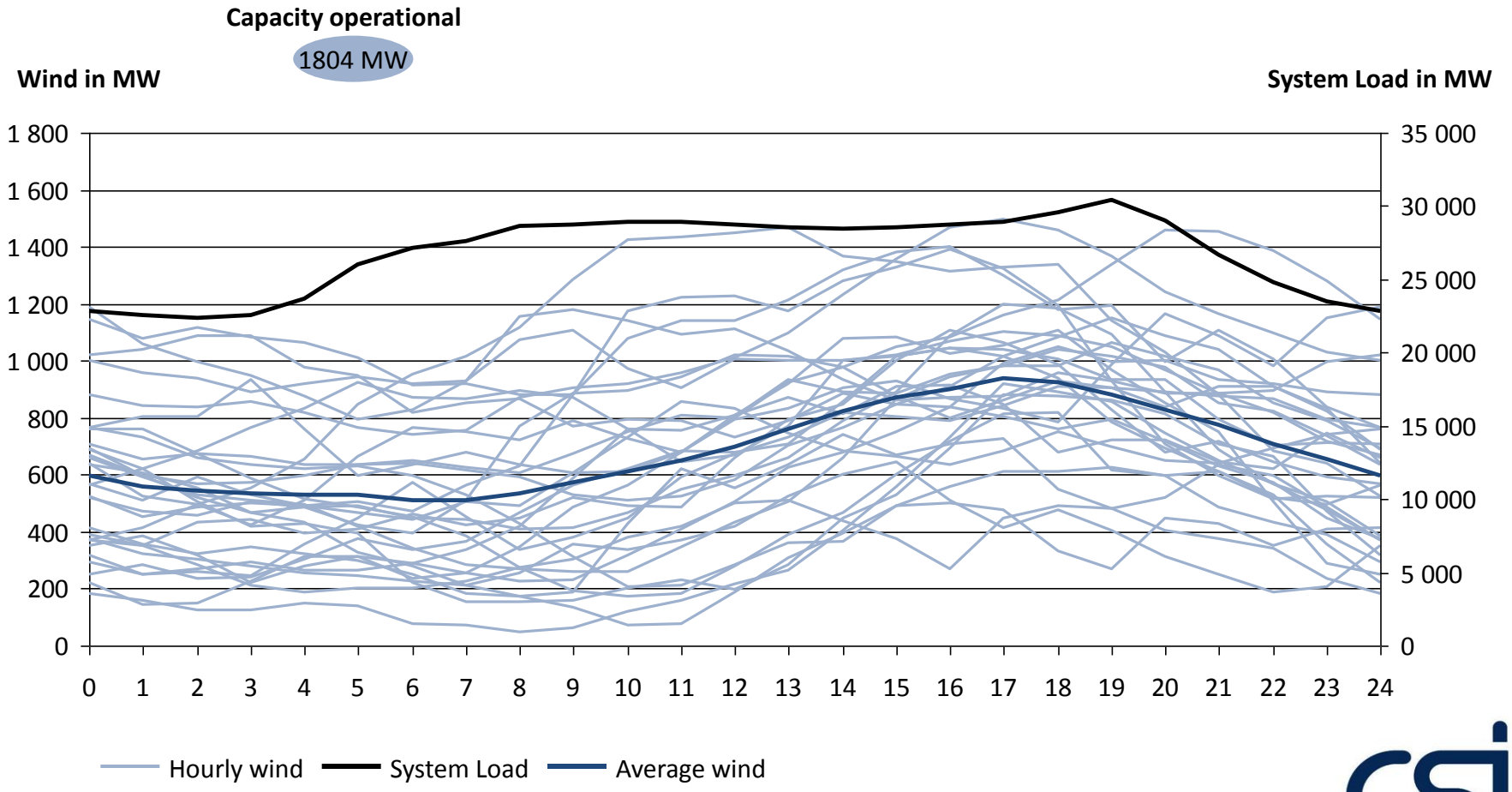
Hourly wind production for all 31 days of October 2017 and average system load diurnal course



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

In Nov 2017, wind supplied in the evenings

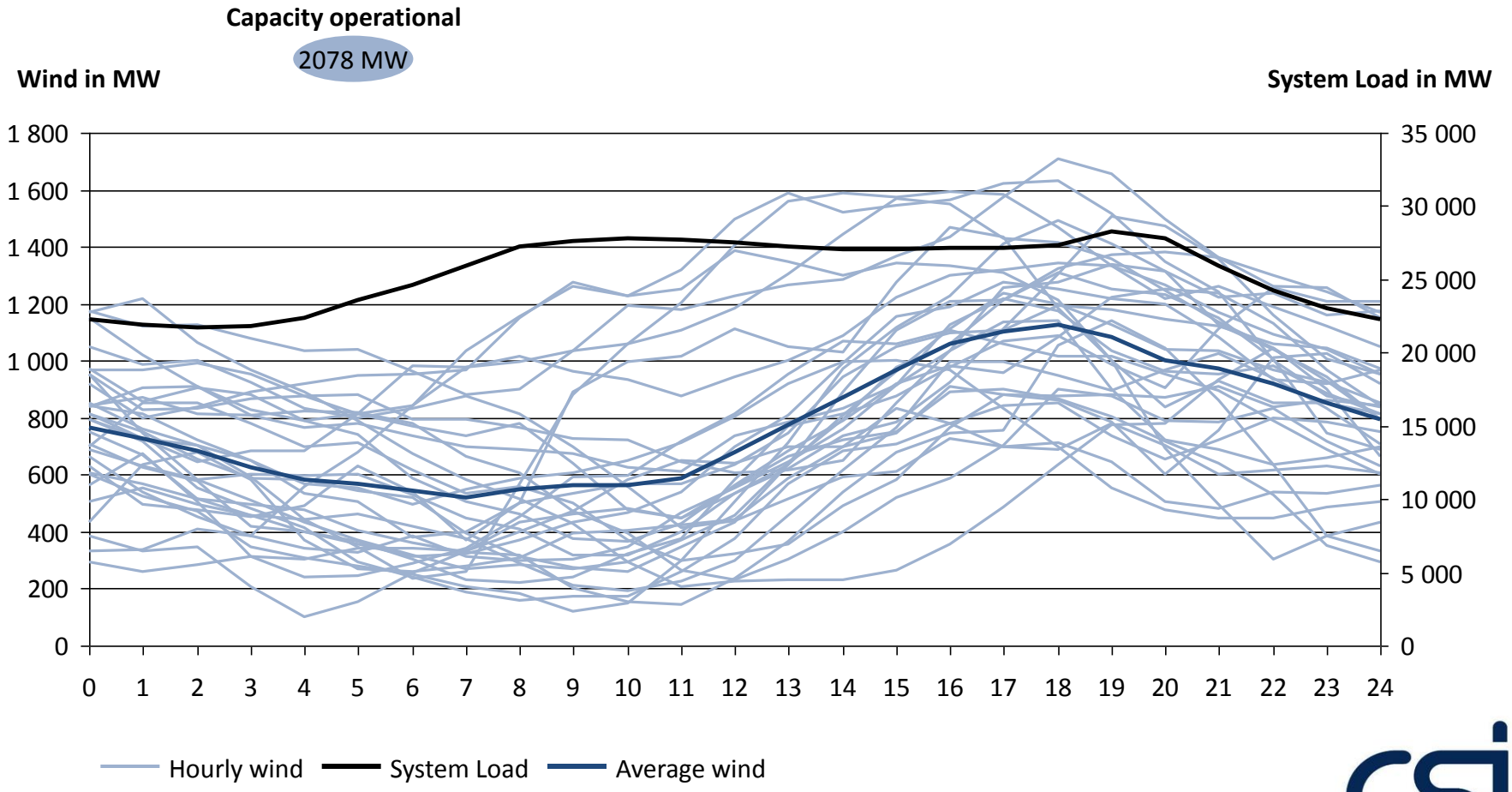
Hourly wind production for all 30 days of November 2017 and average system load diurnal course



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

In Dec 2017, wind supplied in the evenings

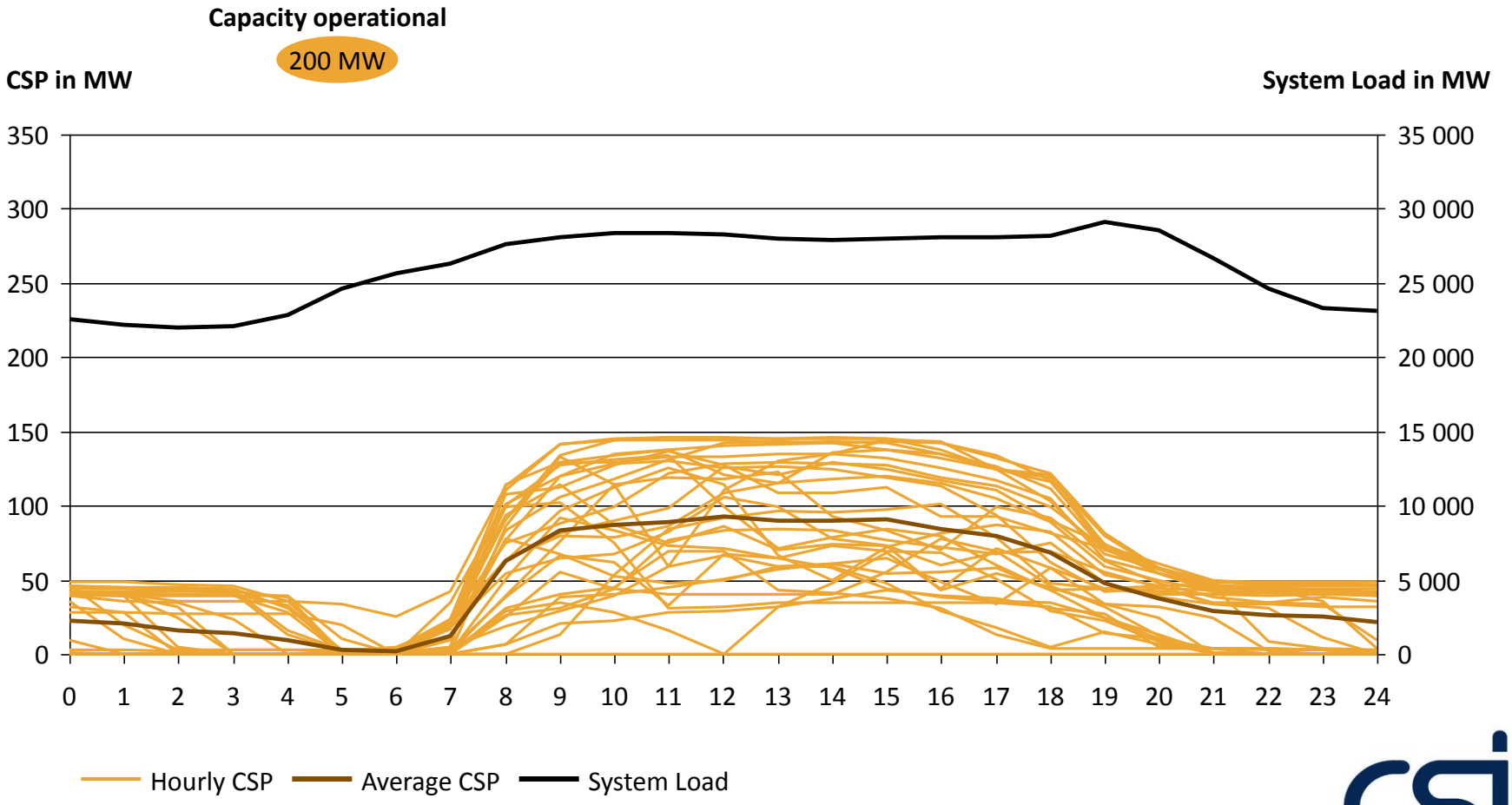
Hourly wind production for all 31 days of December 2017 and average system load diurnal course



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

In Jan 2017, CSP storage used in evenings

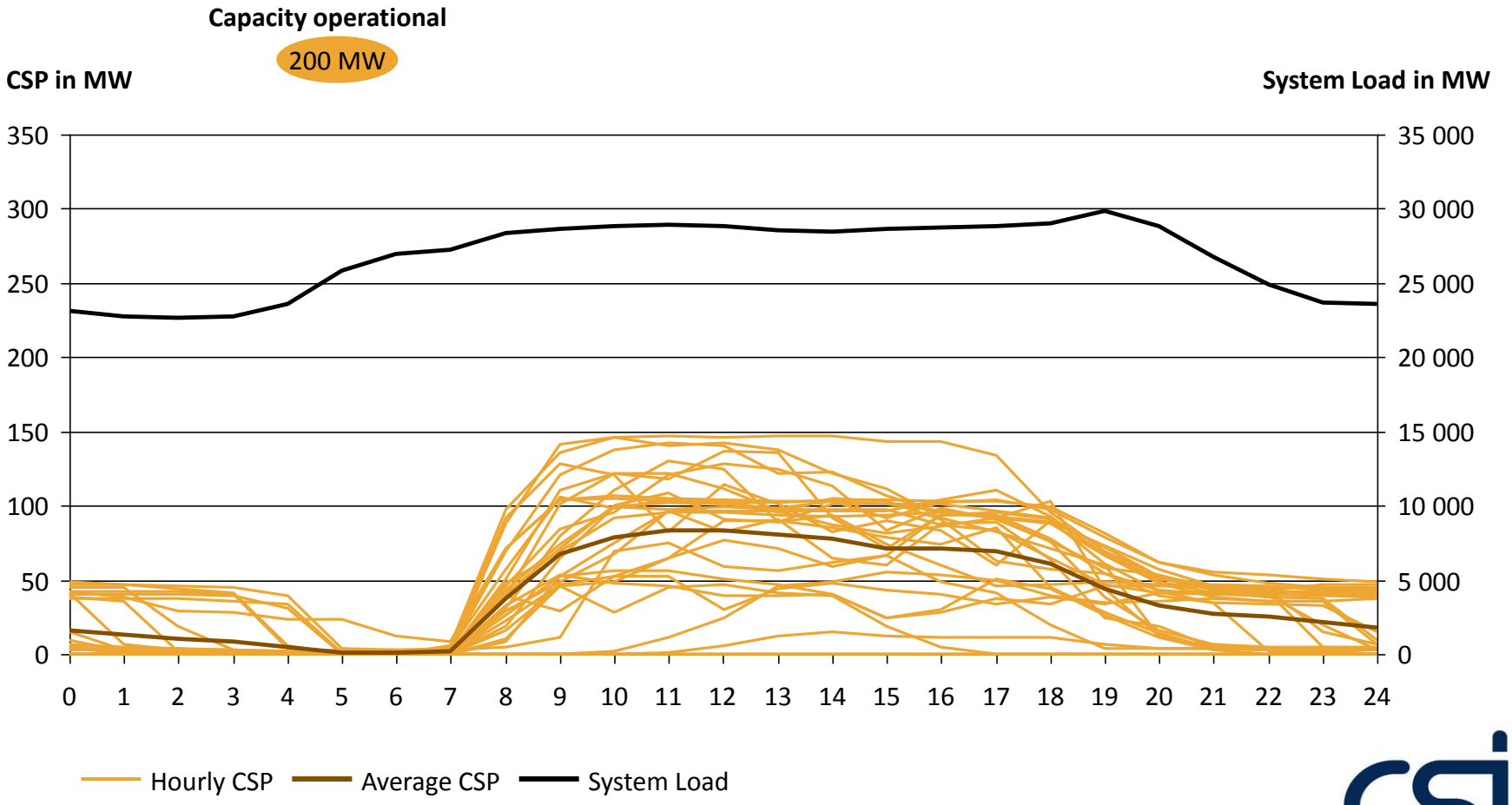
Hourly CSP production for all 31 days of January 2017 and average system load diurnal course



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

In Feb 2017, CSP storage used in evenings

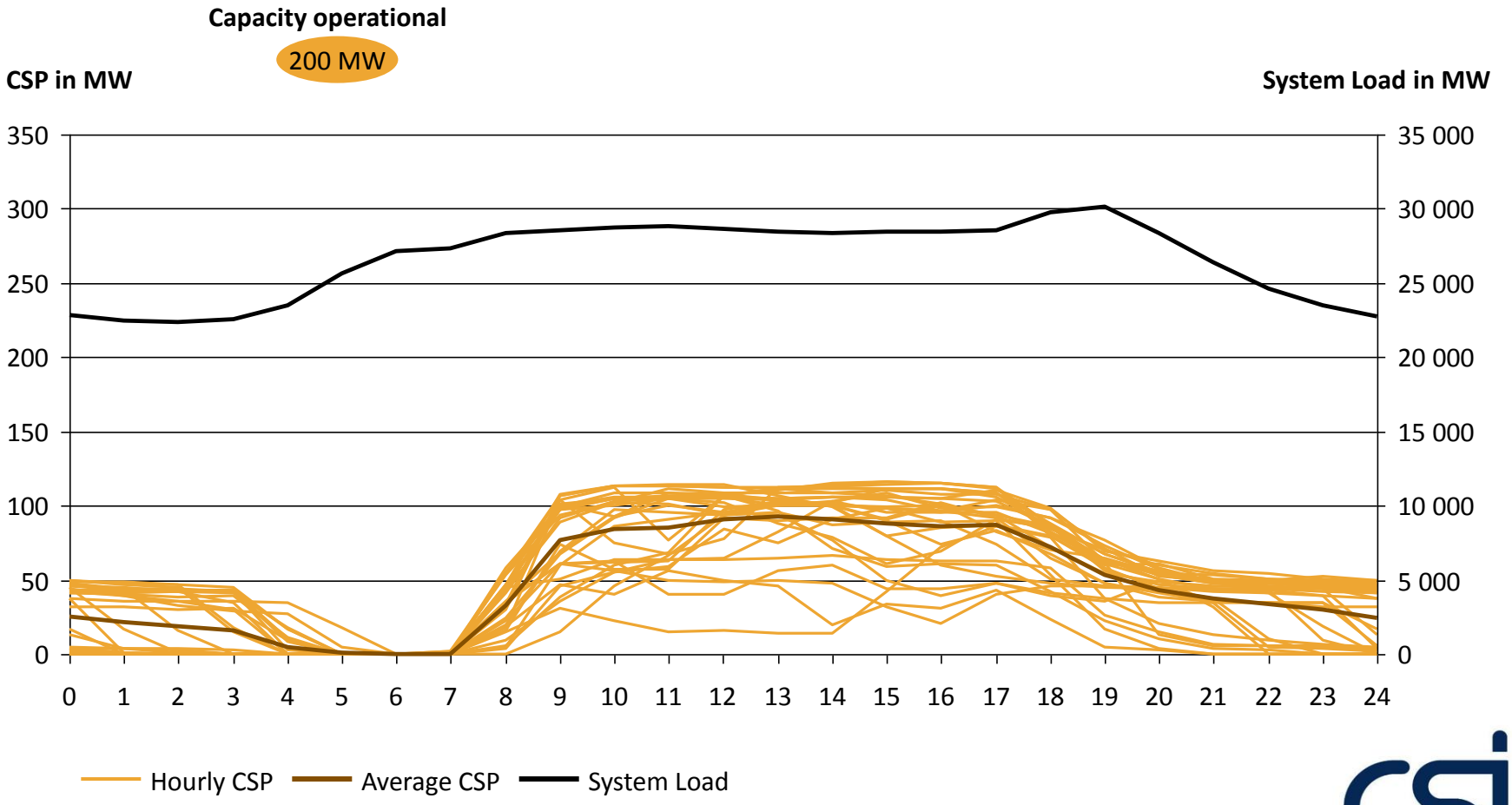
Hourly CSP production for all 28 days of February 2017 and average system load diurnal course



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

In Mar 2017, CSP storage used in evenings

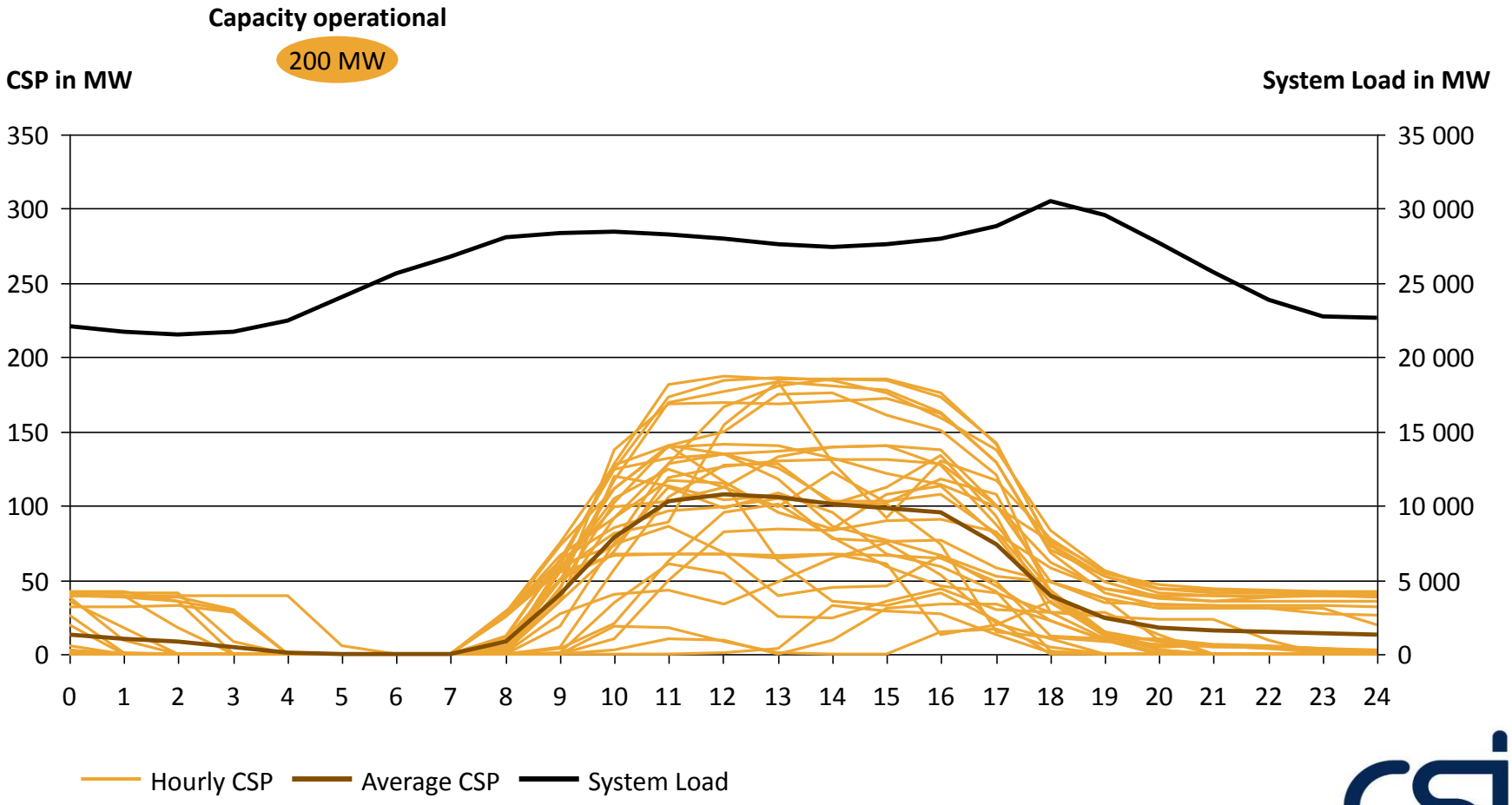
Hourly CSP production for all 31 days of March 2017 and average system load diurnal course



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

In Apr 2017, CSP storage used in evenings

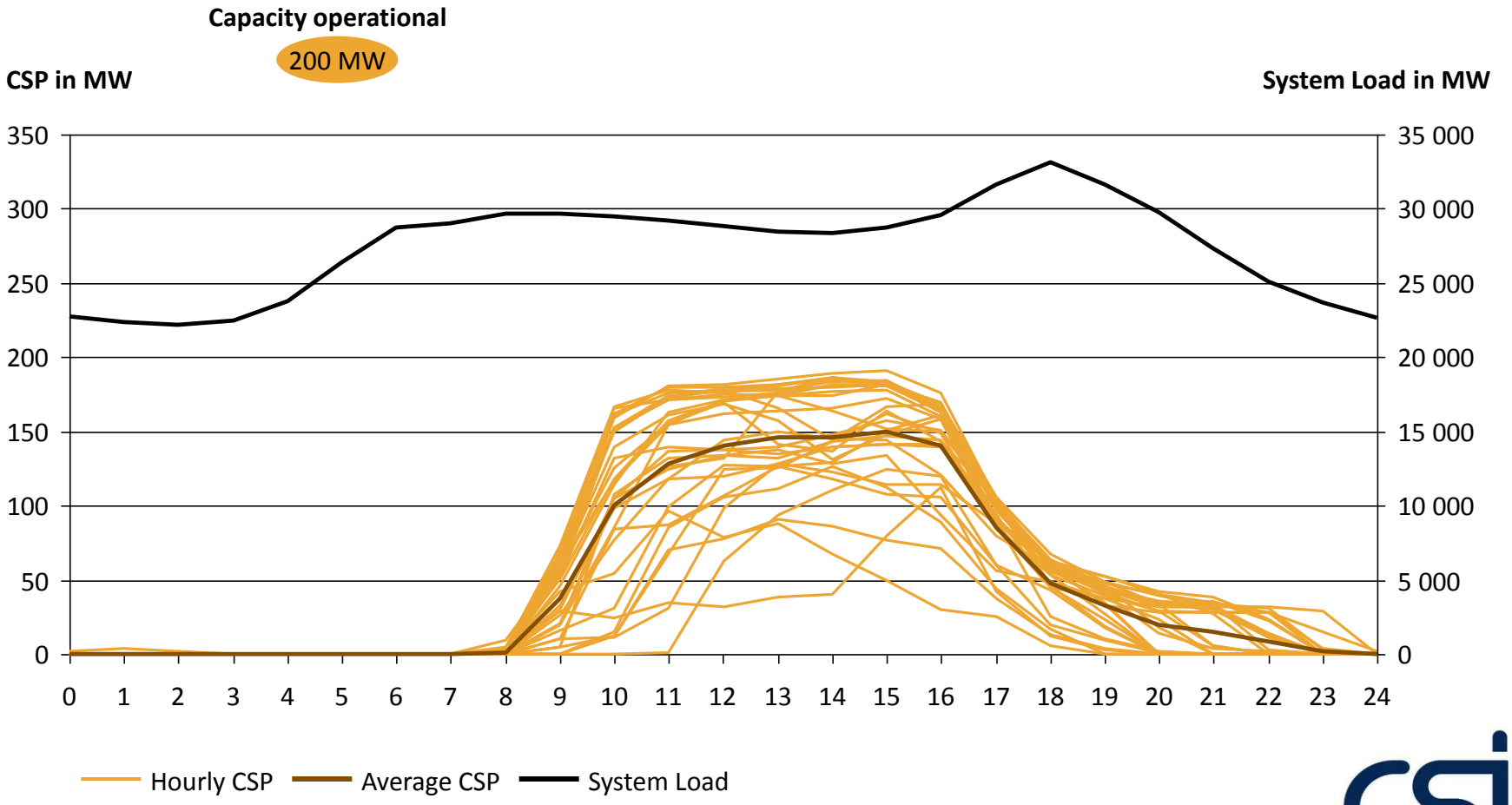
Hourly CSP production for all 30 days of April 2017 and average system load diurnal course



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

In May 2017, CSP storage used in evenings

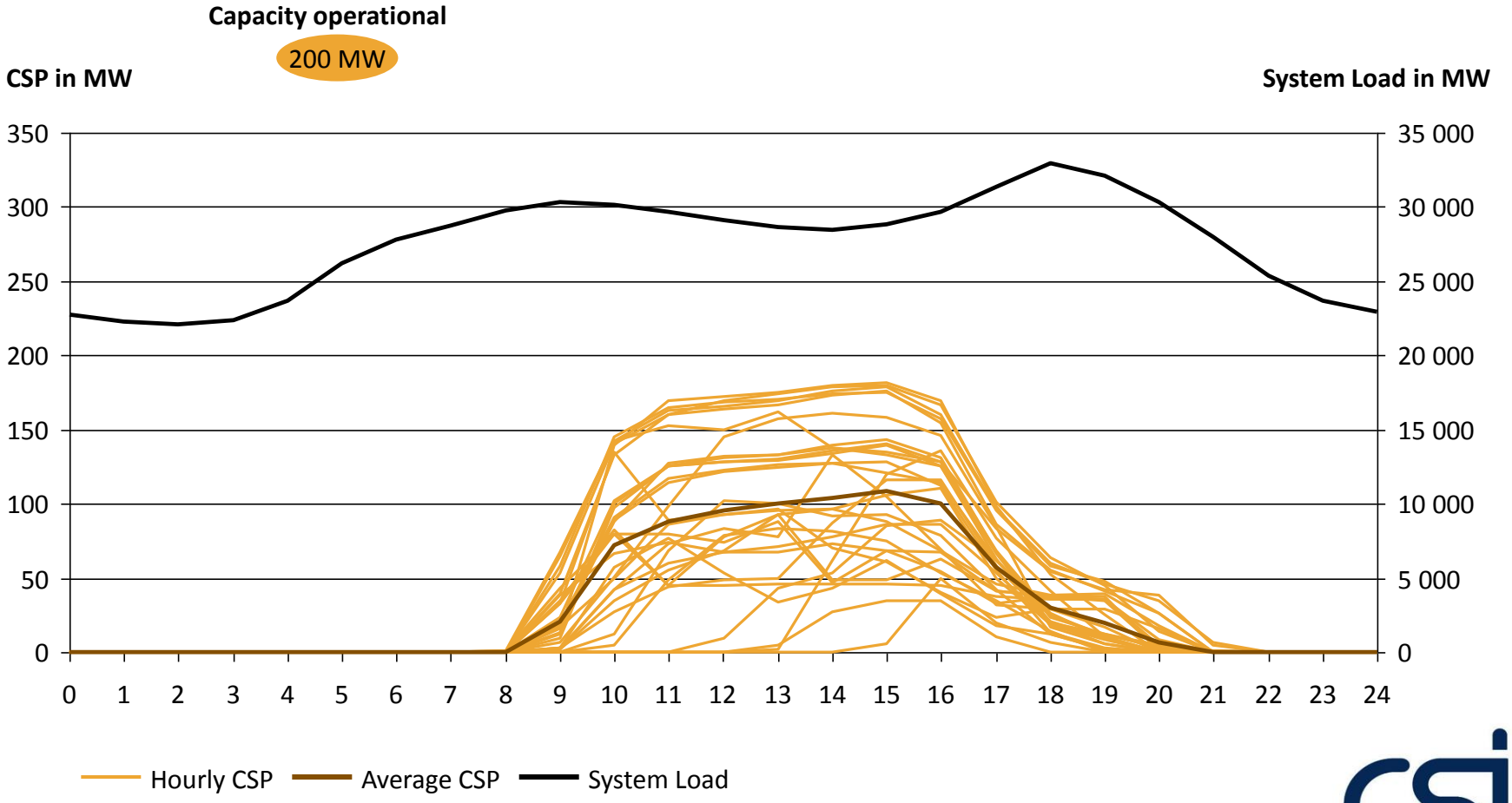
Hourly CSP production for all 31 days of May 2017 and average system load diurnal course



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

In Jun 2017, CSP storage used in evenings

Hourly CSP production for all 30 days of June 2017 and average system load diurnal course

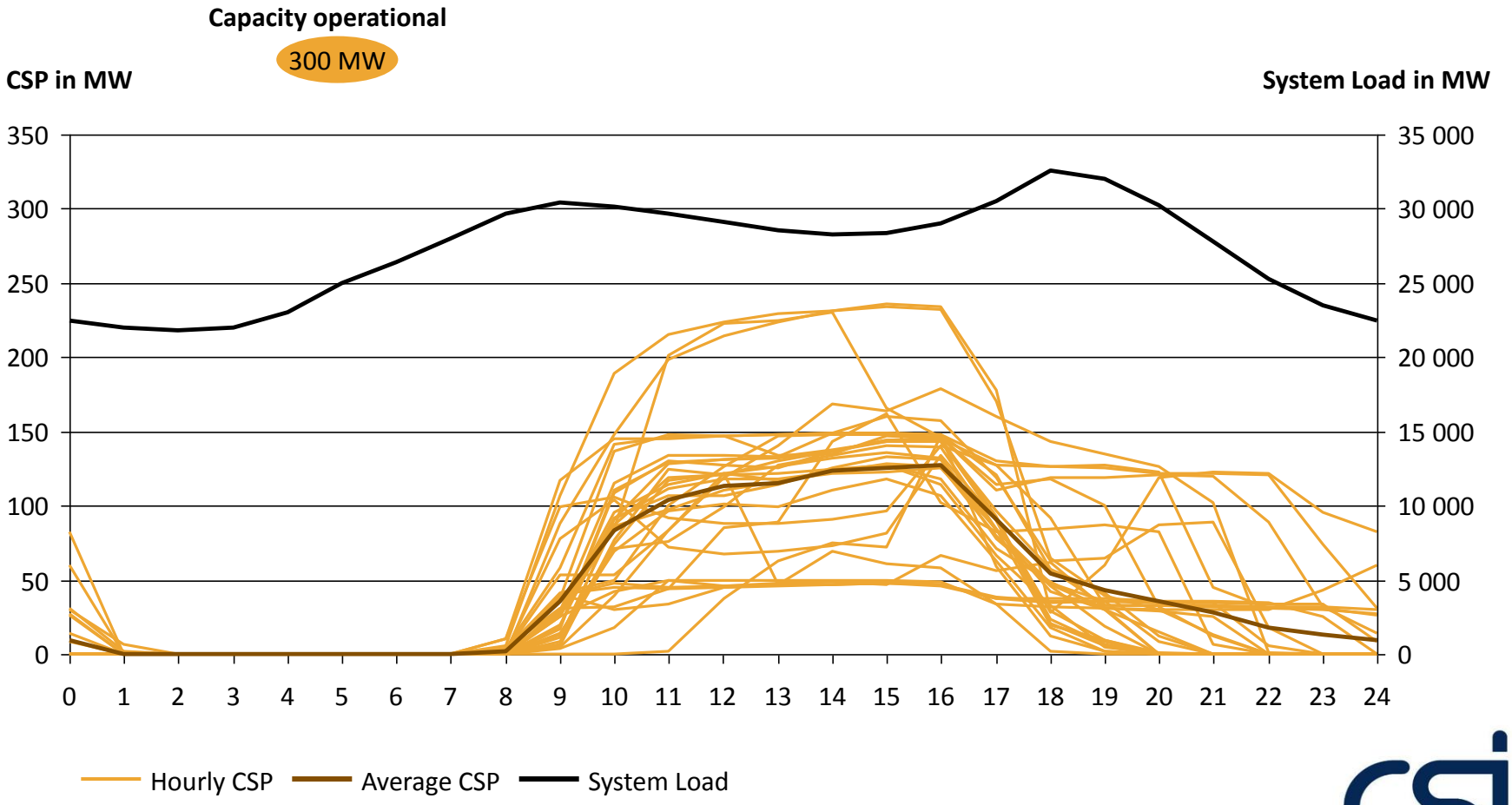


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

In Jul 2017, CSP storage used in evenings

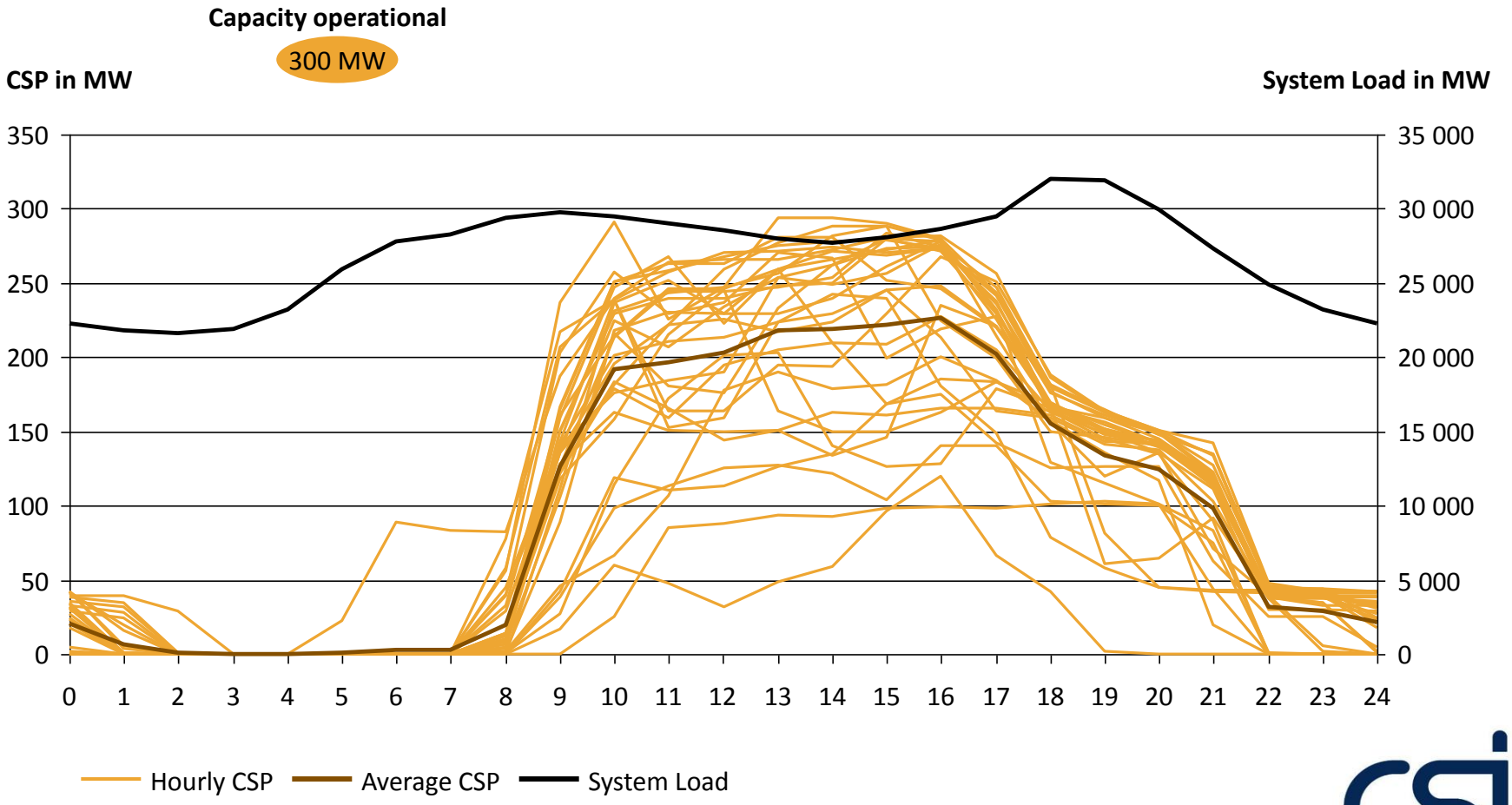
Hourly CSP production for all 31 days of July 2017 and average system load diurnal course



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

In Aug 2017, CSP storage used in evenings

Hourly CSP production for all 31 days of August 2017 and average system load diurnal course

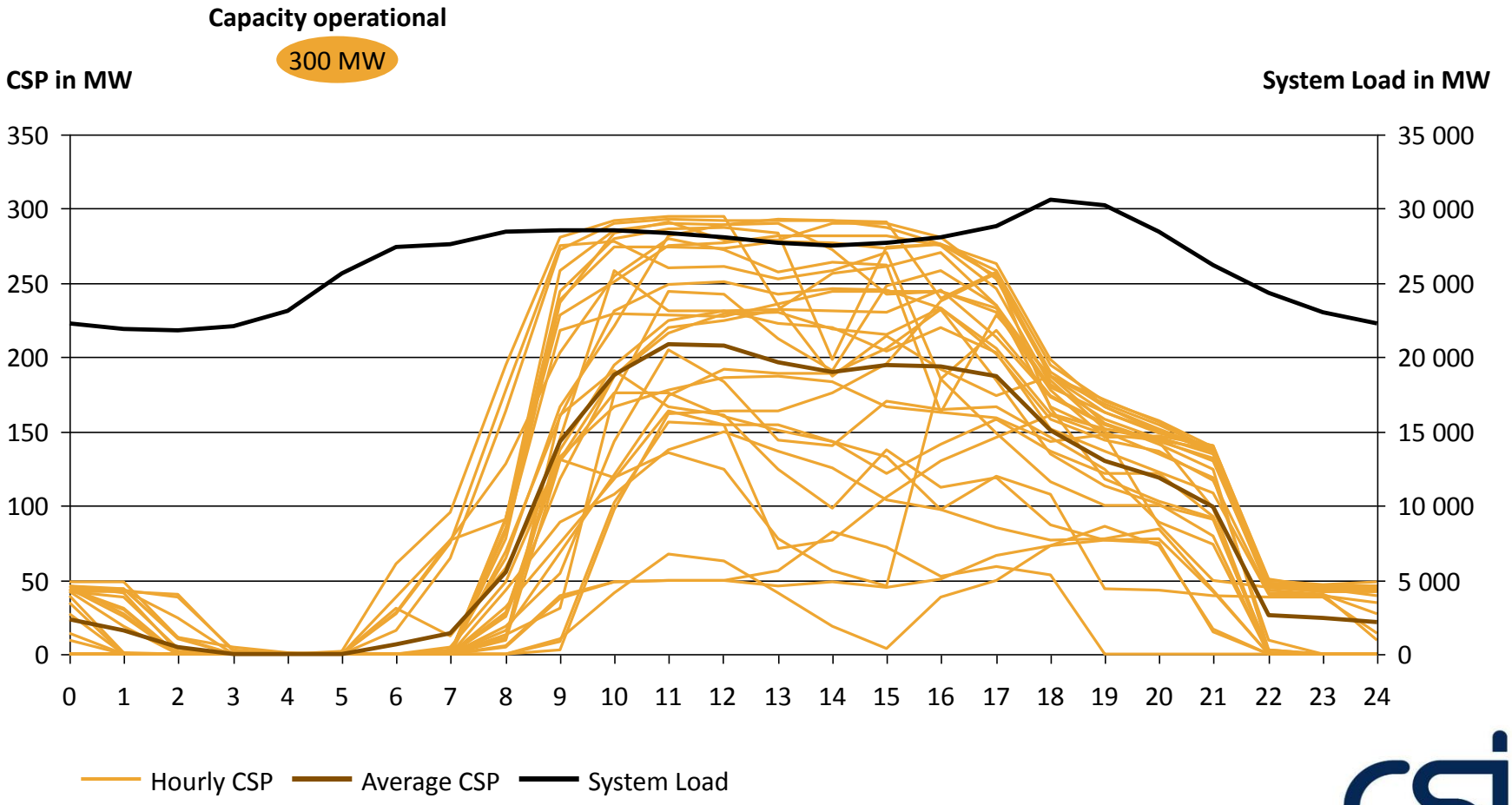


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

In Sep 2017, CSP storage used in evenings

Hourly CSP production for all 30 days of September 2017 and average system load diurnal course

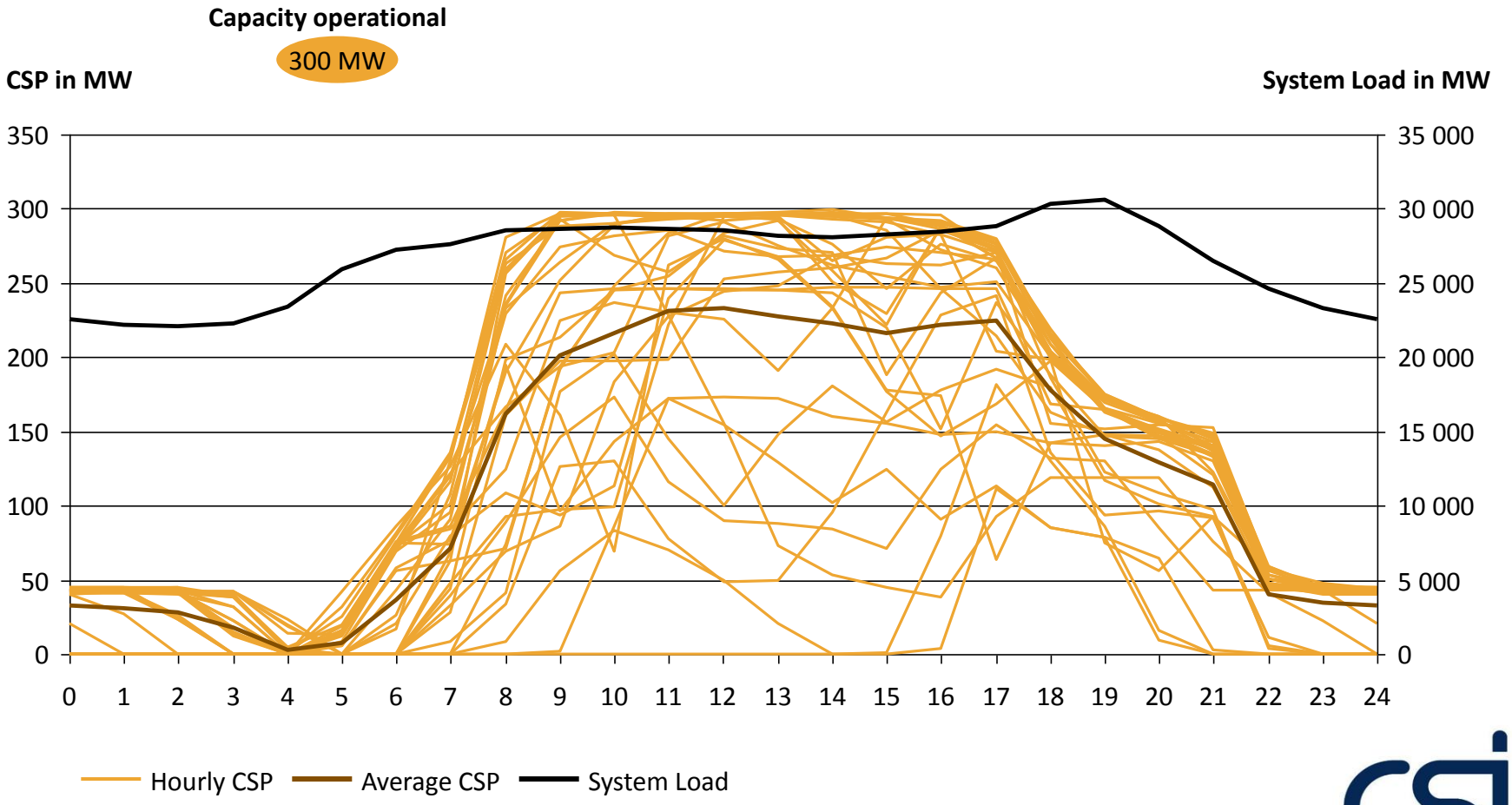


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

In Oct 2017, CSP storage used in evenings

Hourly CSP production for all 31 days of October 2017 and average system load diurnal course

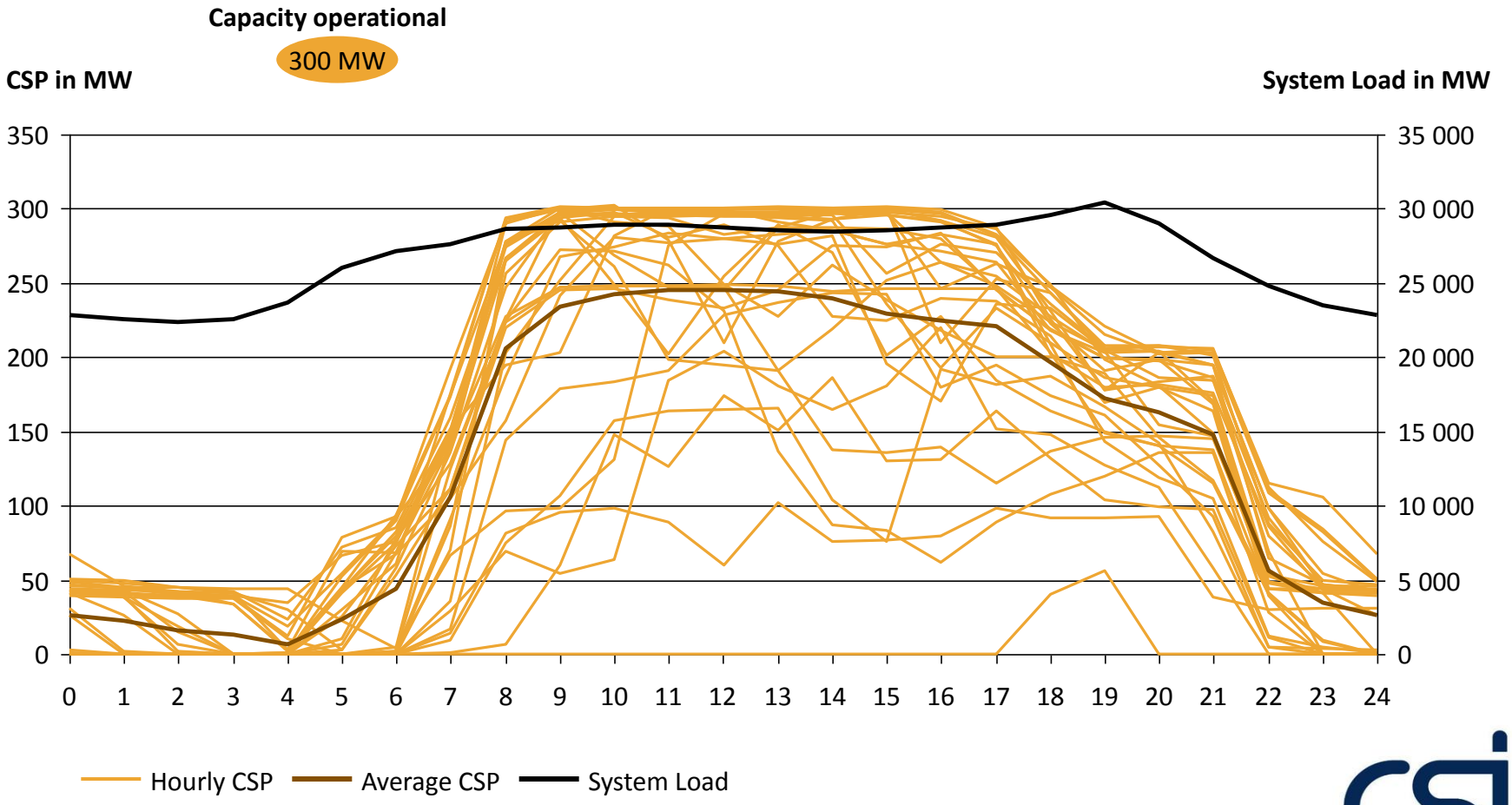


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

In Nov 2017, CSP storage used in evenings

Hourly CSP production for all 30 days of November 2017 and average system load diurnal course

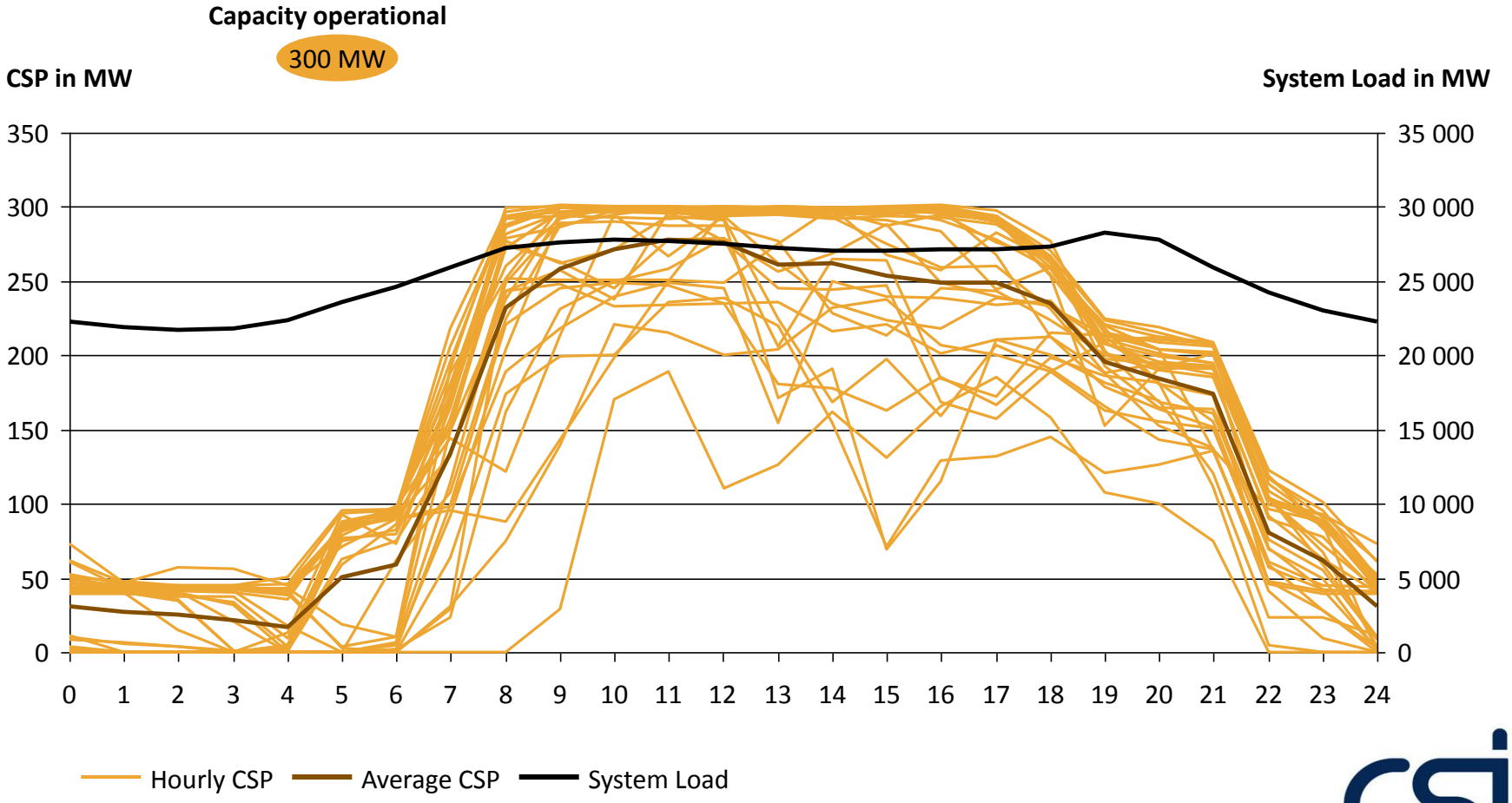


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

In Dec 2017, CSP storage used in evenings

Hourly CSP production for all 31 days of December 2017 and average system load diurnal course

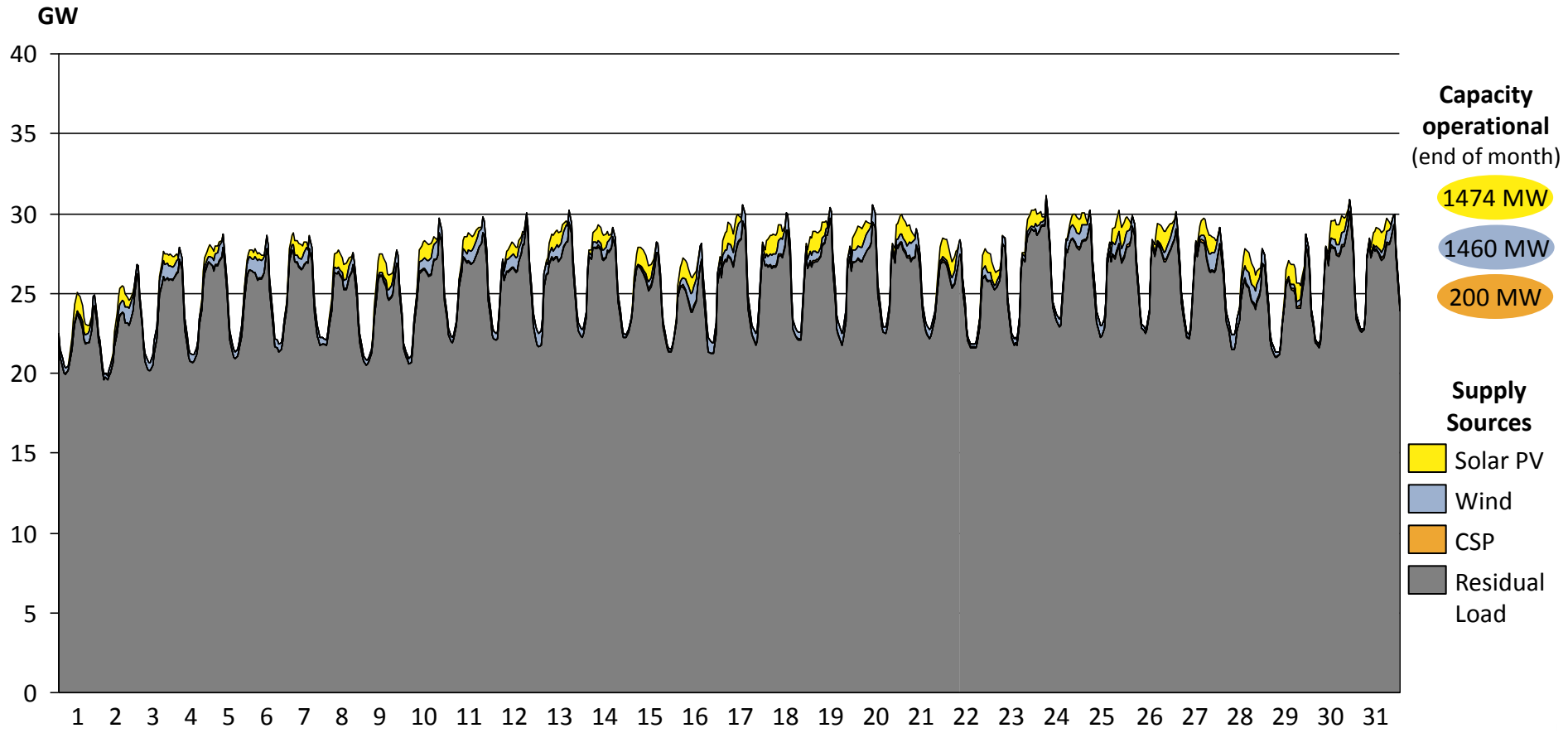


Note: System load excludes hydro pumping load

Sources: Eskom; CSIR Energy Centre analysis

Hourly electricity production in Jan 2017

Actual hourly production from all power supply sources in RSA for January 2017

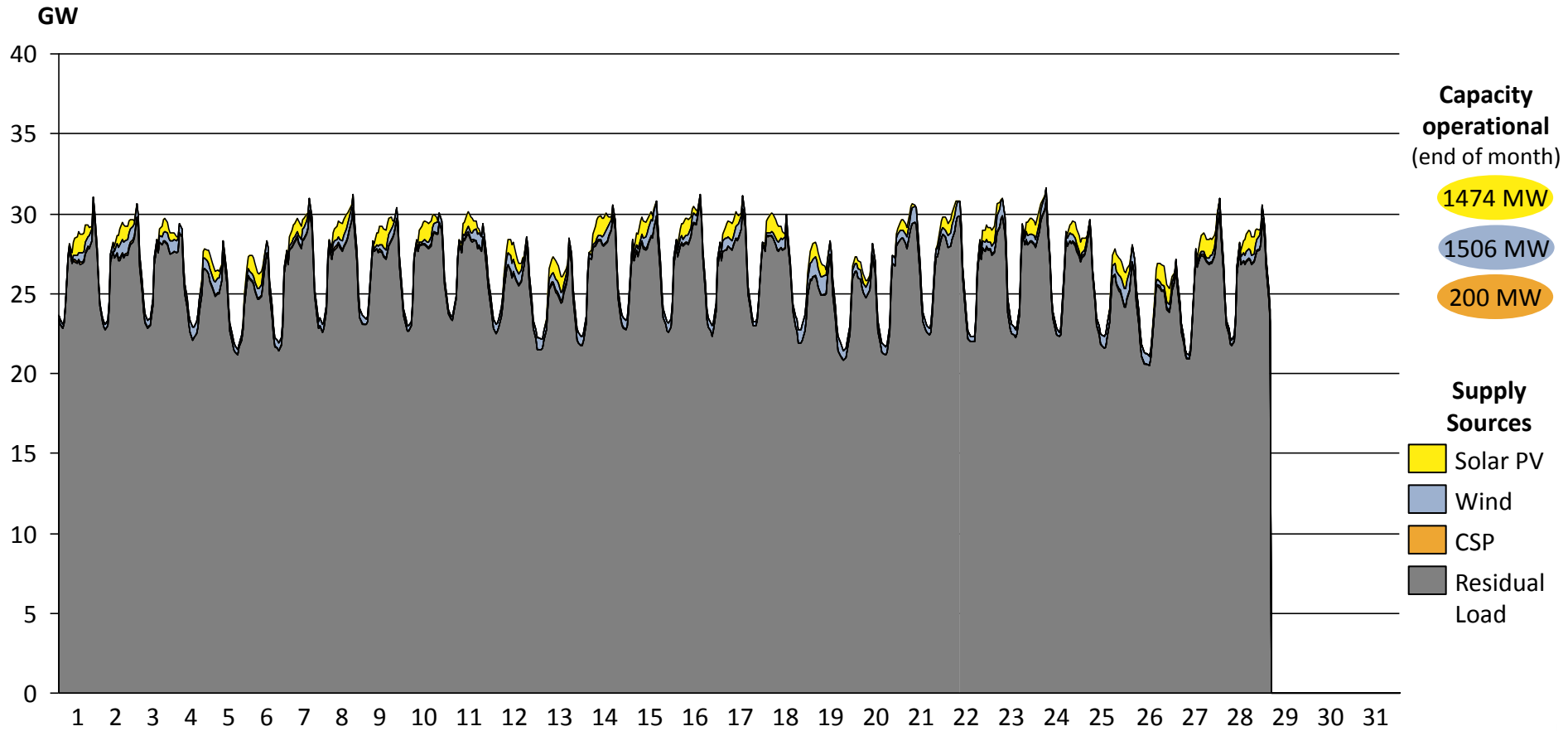


- Maximum power of 31.1 GW between 19h00 and 20h00 on 23 Jan 2017
- Minimum power of 19.9 GWh between 03h00 and 04h00 on 2 Jan 2017

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

Hourly electricity production in Feb 2017

Actual hourly production from all power supply sources in RSA for February 2017

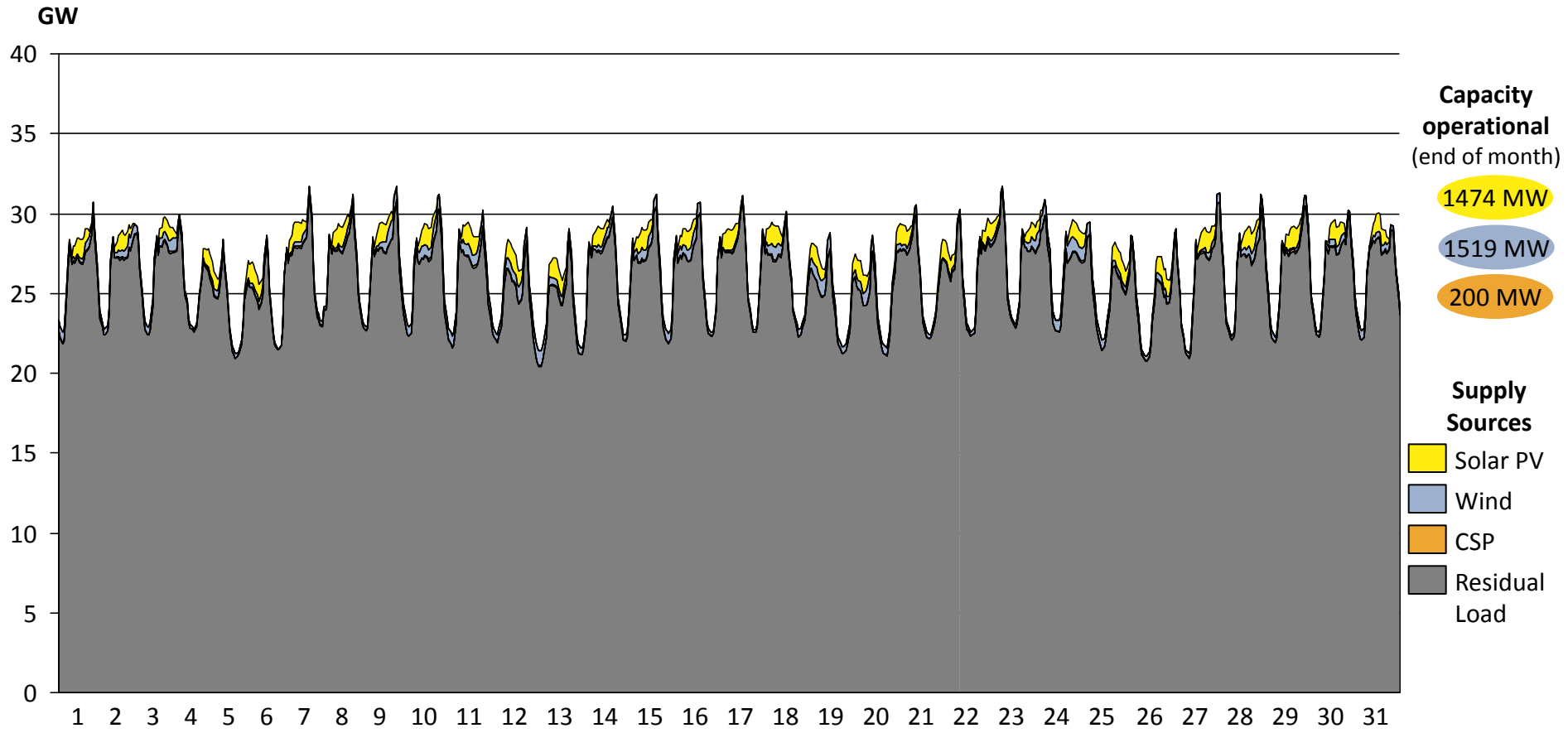


- Maximum power of 31.6 GW between 19h00 and 20h00 on 23 Feb 2017
- Minimum power of 21.1 GWh between 04h00 and 05h00 on 26 Feb 2017

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

Hourly electricity production in Mar 2017

Actual hourly production from all power supply sources in RSA for March 2017

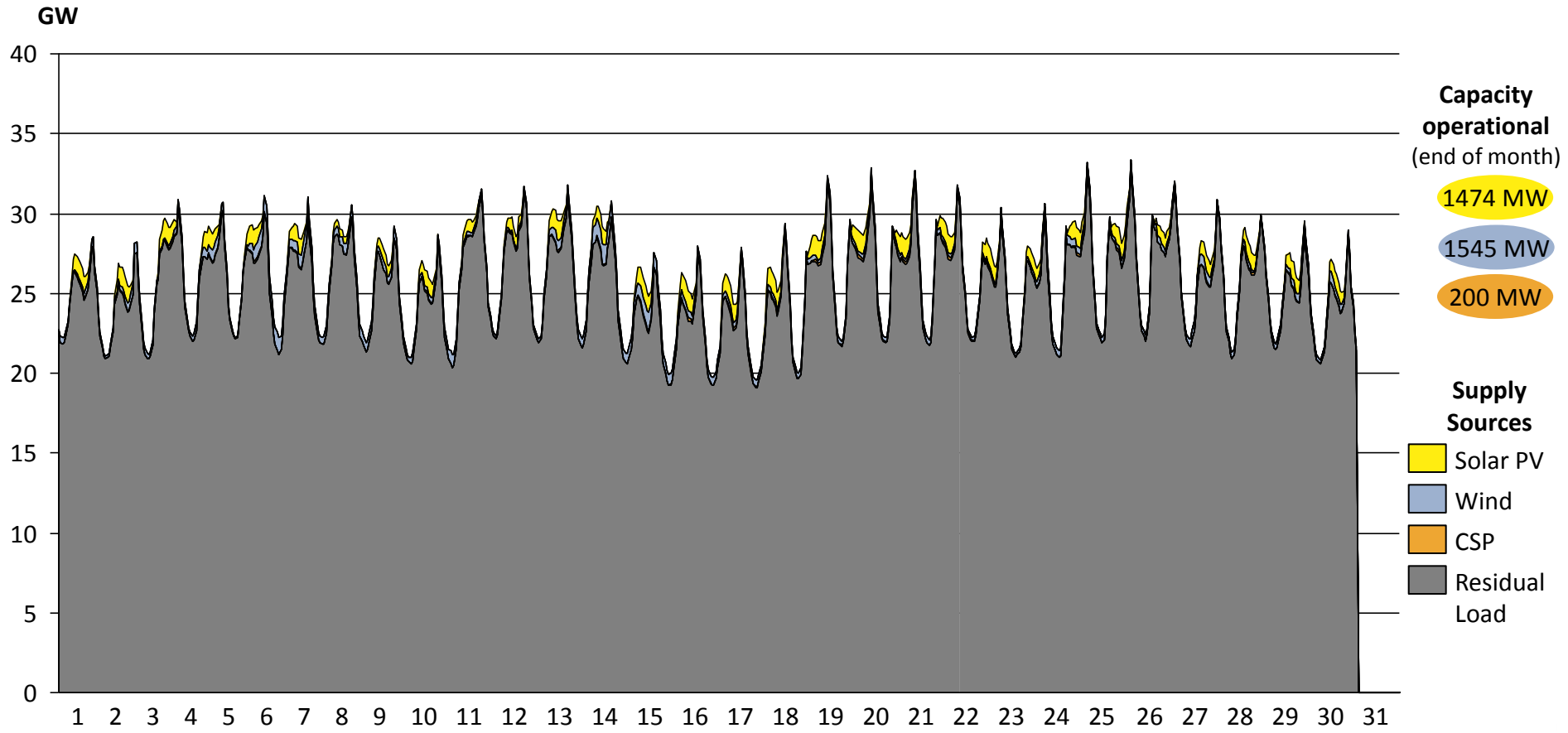


- Maximum power of 31.7 GW between 19h00 and 20h00 on 22 Mar 2017
- Minimum power of 21.0 GWh between 03h00 and 04h00 on 26 Mar 2017

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

Hourly electricity production in Apr 2017

Actual hourly production from all power supply sources in RSA for April 2017

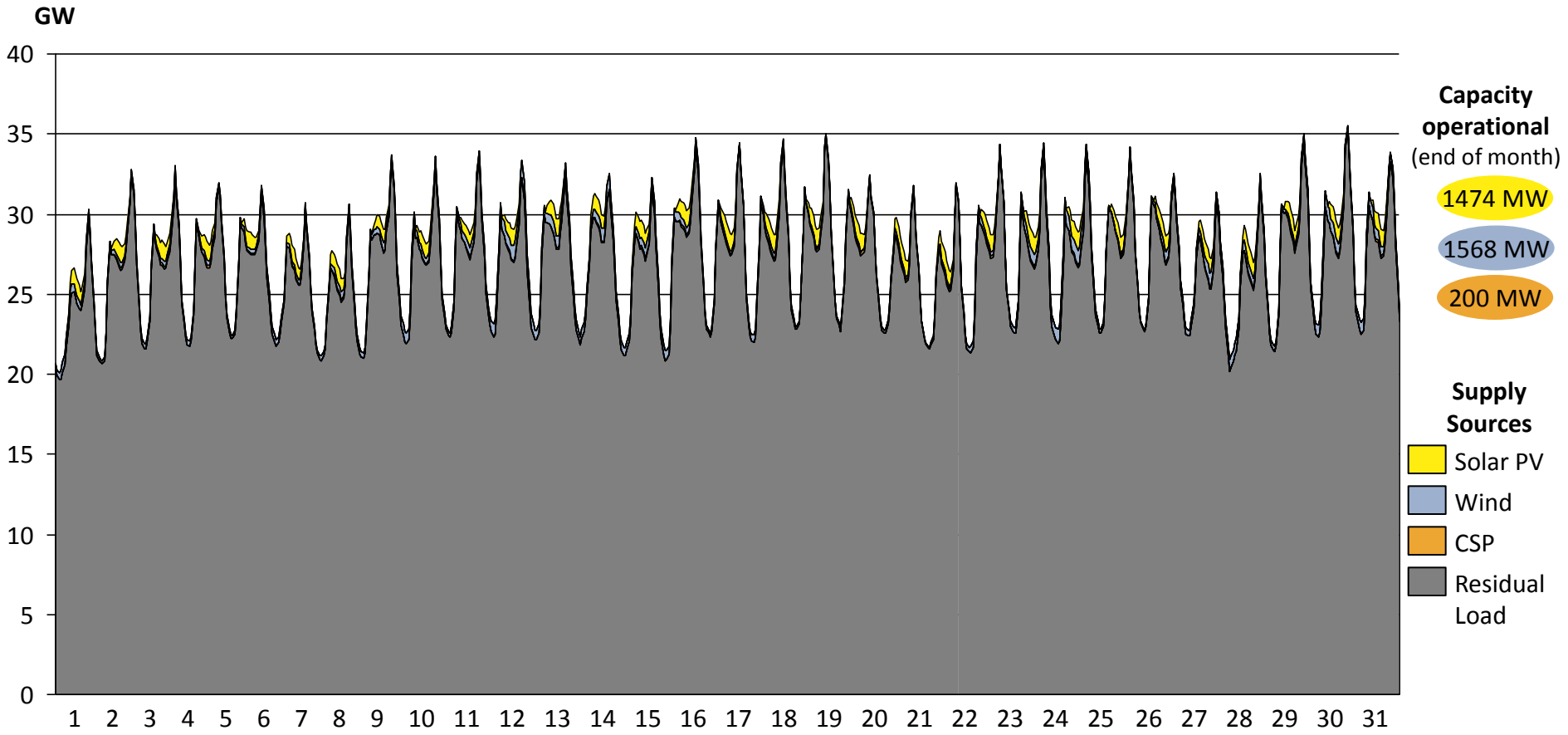


- Maximum power of 33.3 GW between 18h00 and 19h00 on 25 Apr 2017
- Minimum power of 19.5 GWh between 02h00 and 03h00 on 17 Apr 2017

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

Hourly electricity production in May 2017

Actual hourly production from all power supply sources in RSA for May 2017

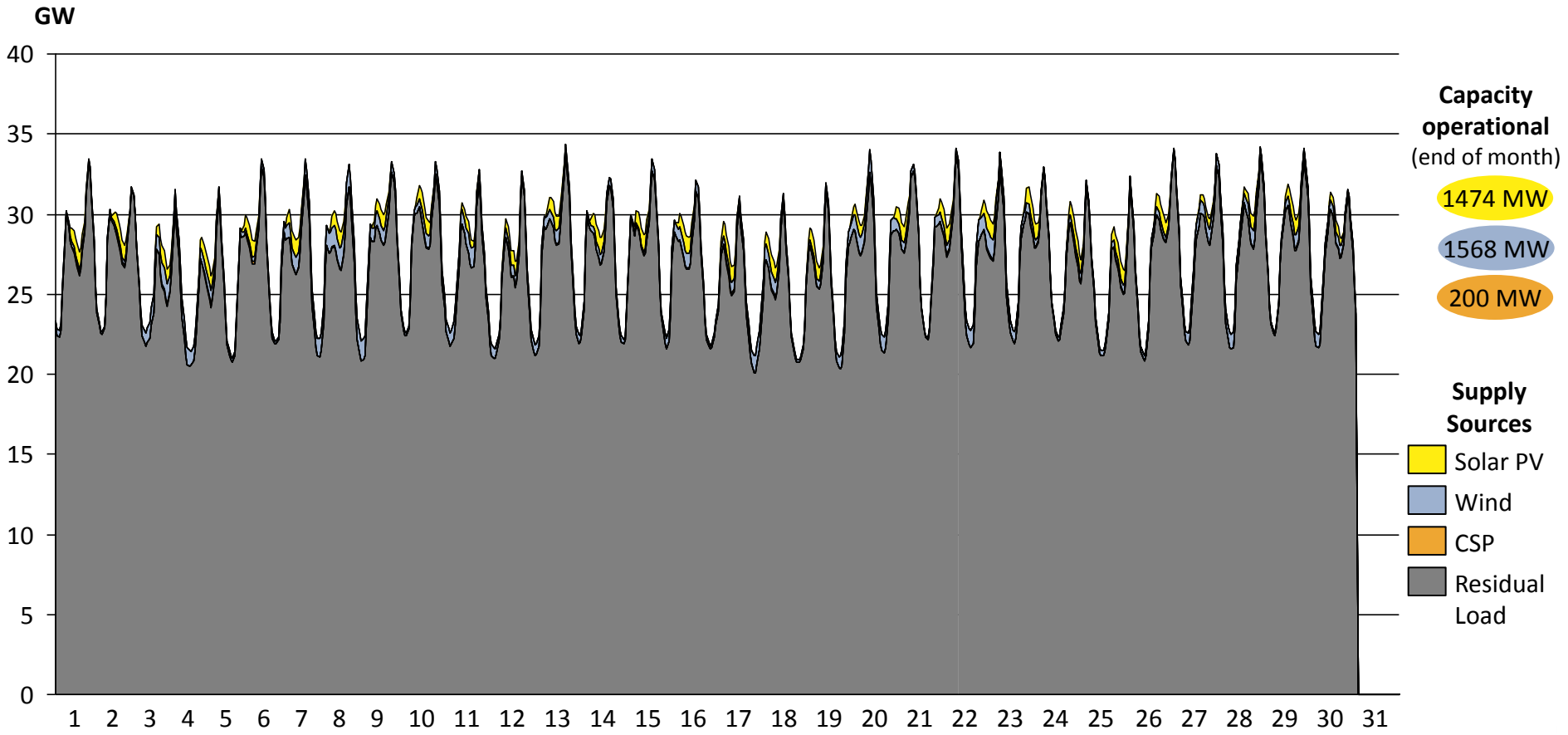


- Maximum power of 35.5 GW between 18h00 and 19h00 on 30 May 2017
- Minimum power of 20.1 GWh between 02h00 and 03h00 on 1 May 2017

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

Hourly electricity production in Jun 2017

Actual hourly production from all power supply sources in RSA for June 2017

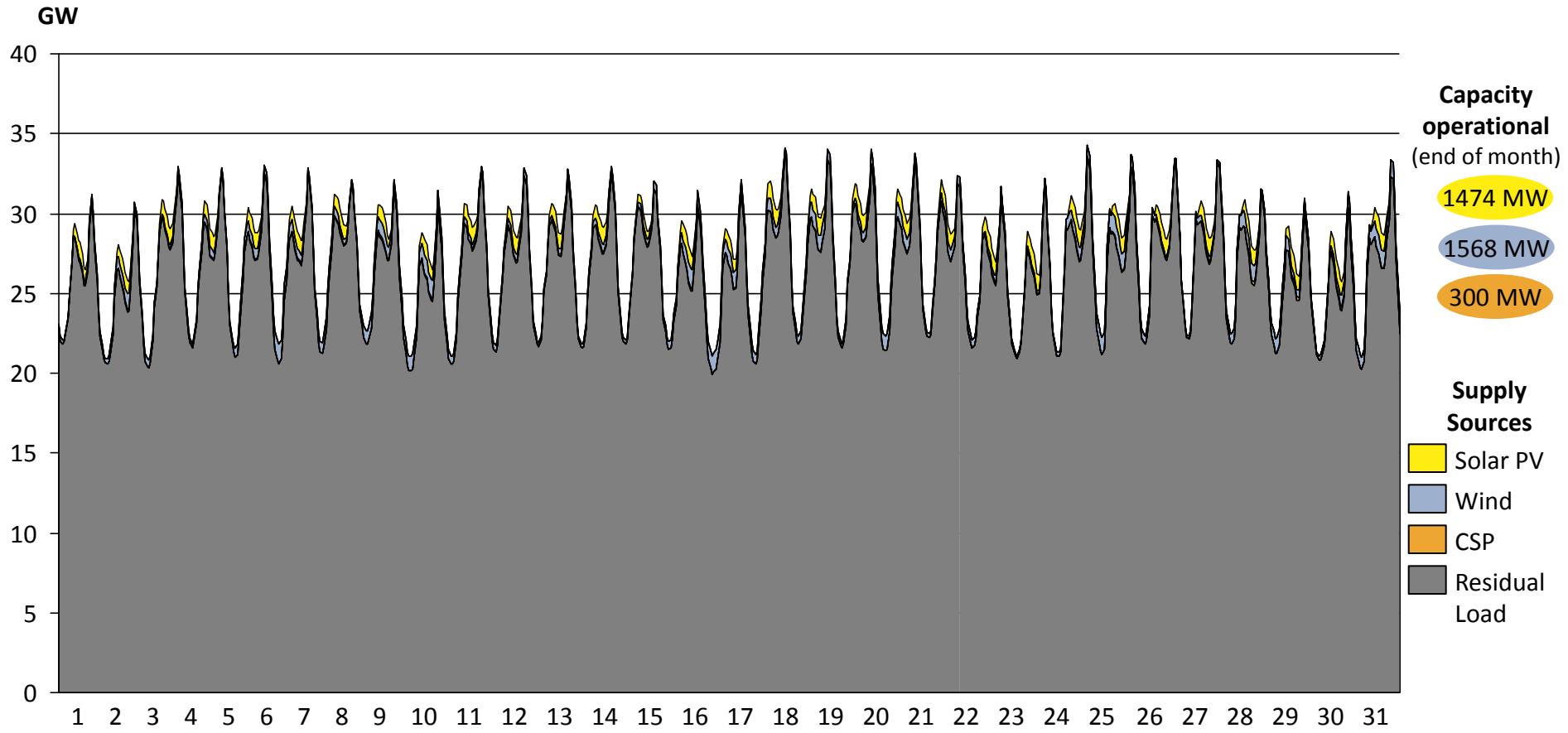


- Maximum power of 34.4 GW between 18h00 and 19h00 on 12 Jun 2017
- Minimum power of 20.9 GWh between 02h00 and 03h00 on 18 Jun 2017

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

Hourly electricity production in Jul 2017

Actual hourly production from all power supply sources in RSA for July 2017

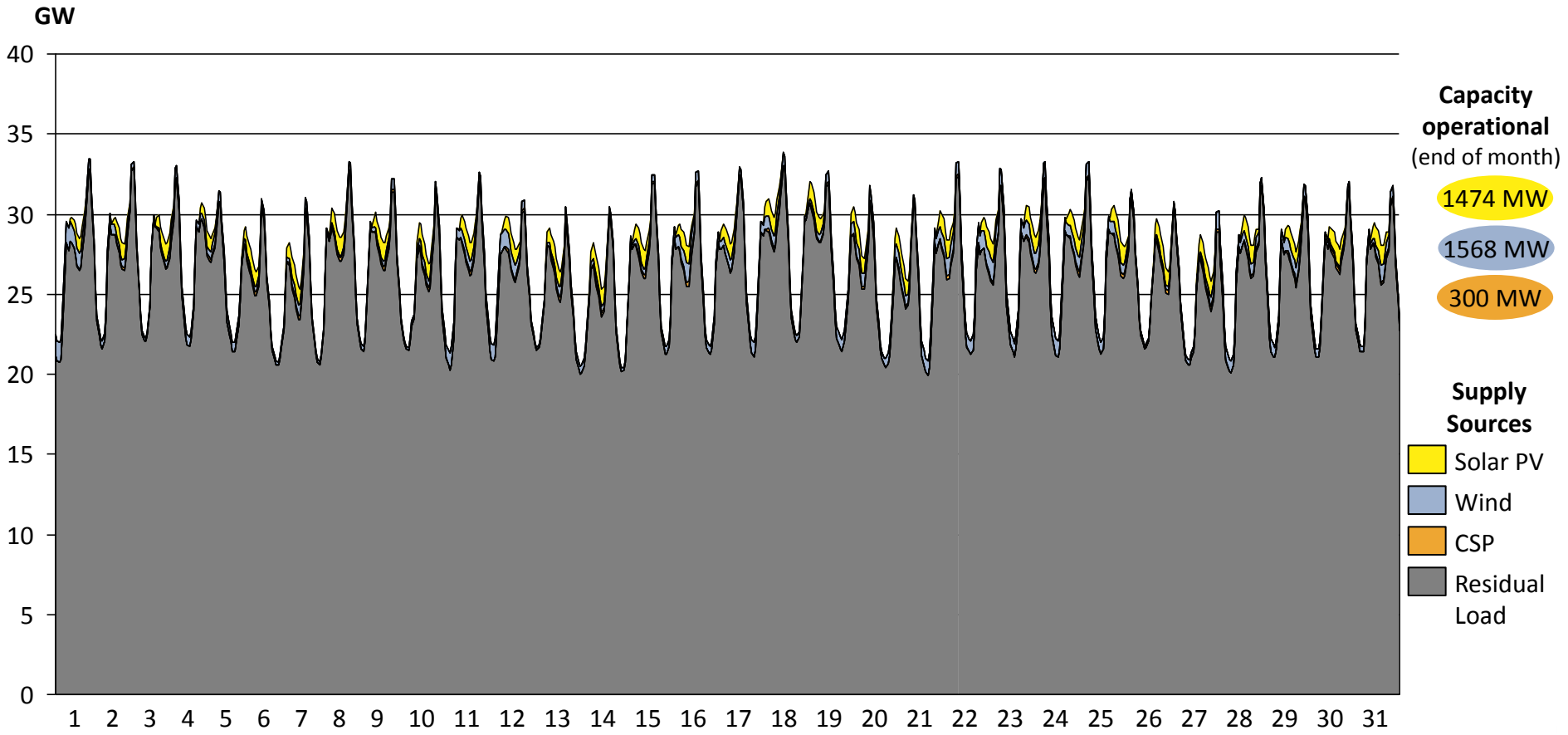


- Maximum power of 34.2 GW between 18h00 and 19h00 on 24 Jul 2017
- Minimum power of 20.8 GWh between 02h00 and 03h00 on 3 Jul 2017

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

Hourly electricity production in Aug 2017

Actual hourly production from all power supply sources in RSA for August 2017

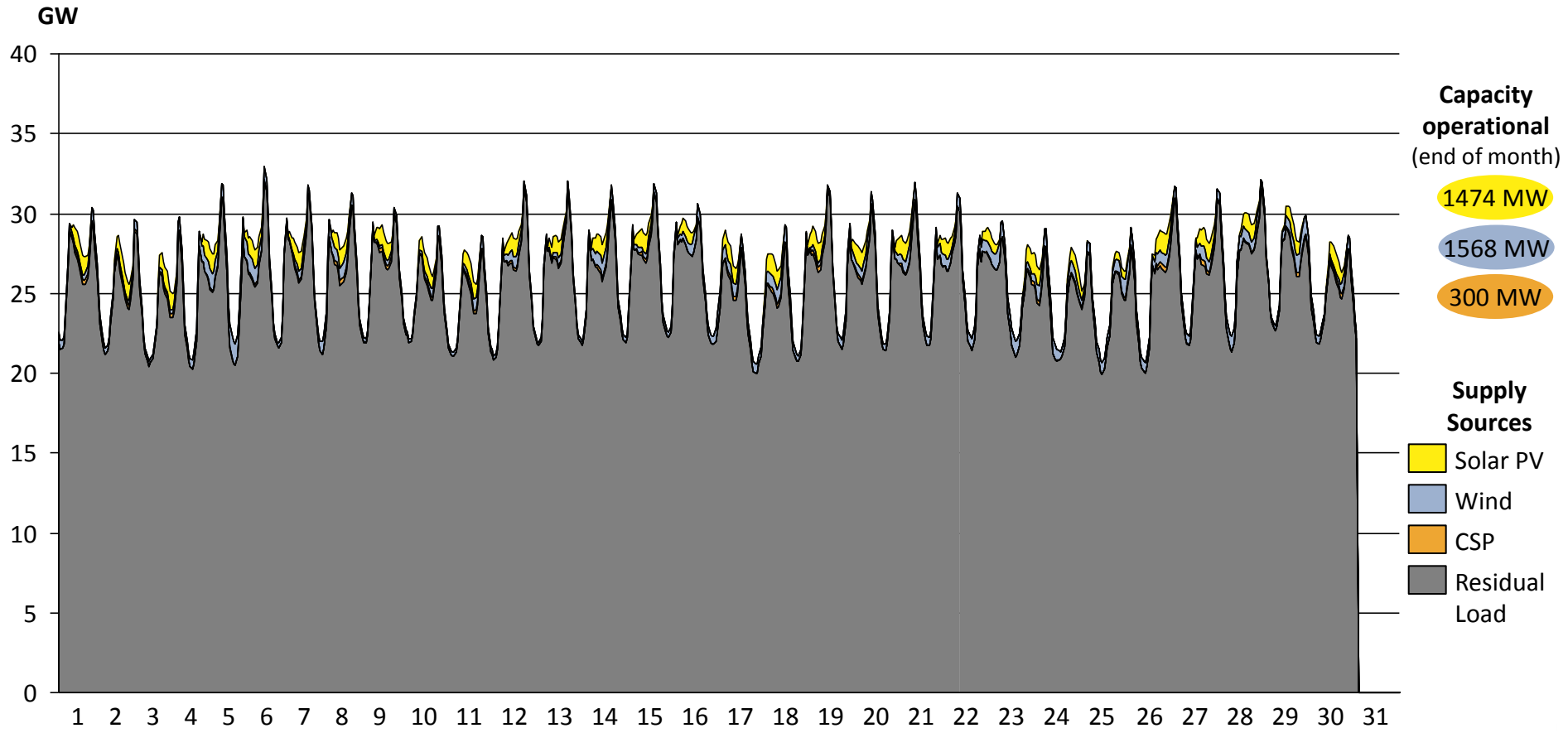


- Maximum power of 33.7 GW between 18h00 and 19h00 on 17 Aug 2017
- Minimum power of 20.4 GWh between 02h00 and 03h00 on 14 Aug 2017

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

Hourly electricity production in Sep 2017

Actual hourly production from all power supply sources in RSA for September 2017

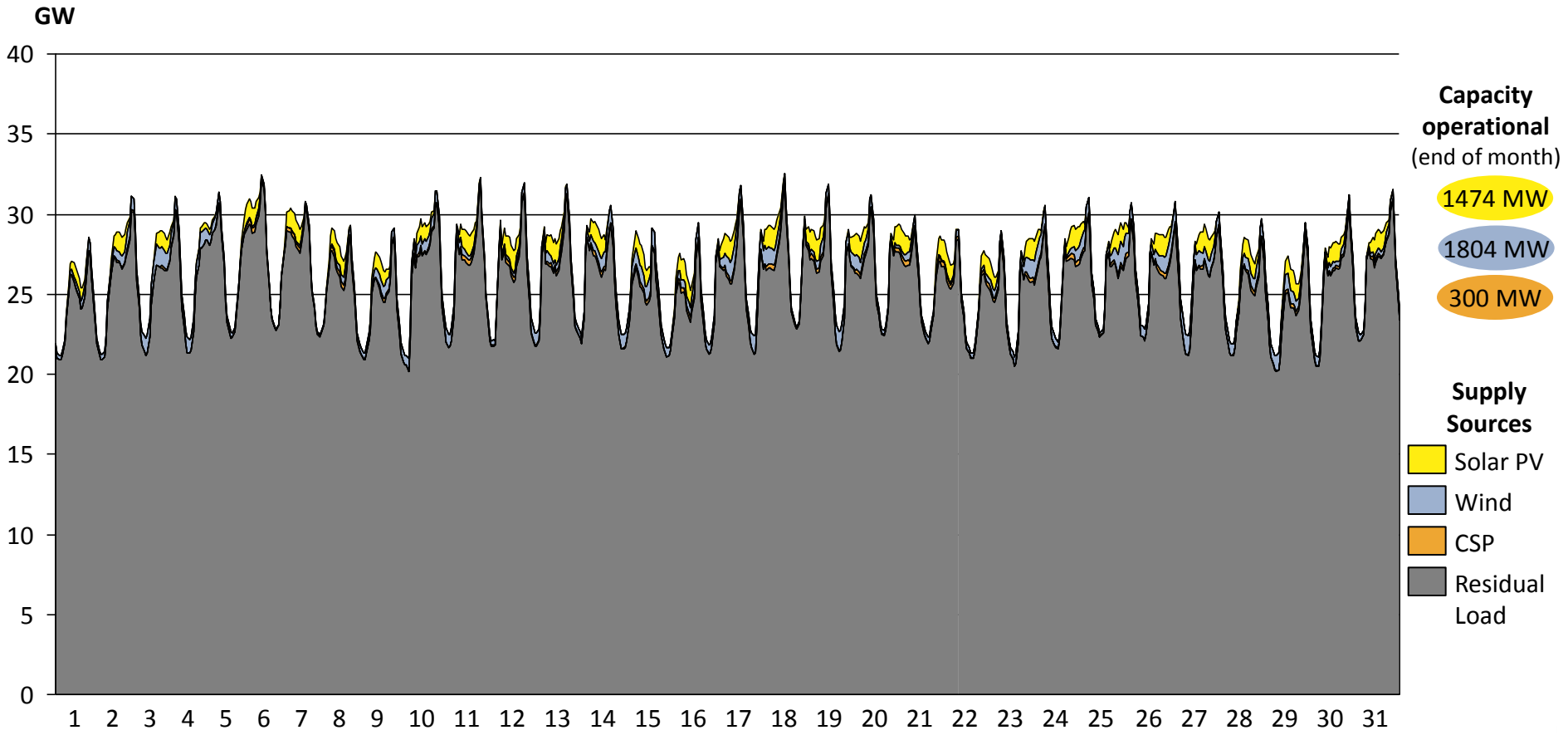


- Maximum power of 32.8 GW between 18h00 and 19h00 on 5 Sep 2017
- Minimum power of 20.5 GWh between 02h00 and 03h00 on 17 Sep 2017

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

Hourly electricity production in Oct 2017

Actual hourly production from all power supply sources in RSA for October 2017

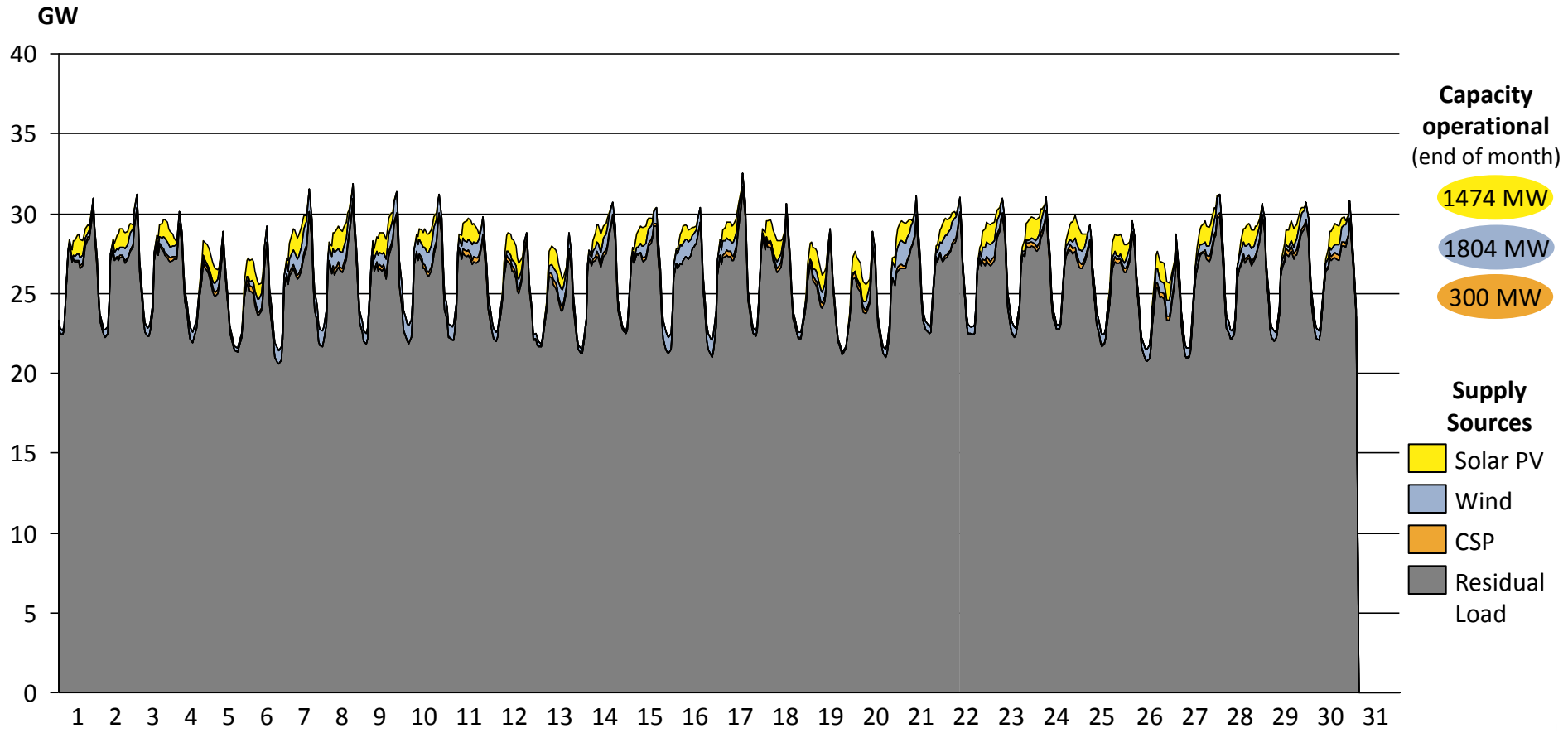


- Maximum power of 32.3 GW between 19h00 and 20h00 on 17 Oct 2017
- Minimum power of 21.0 GWh between 03h00 and 04h00 on 9 Oct 2017

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

Hourly electricity production in Nov 2017

Actual hourly production from all power supply sources in RSA for November 2017

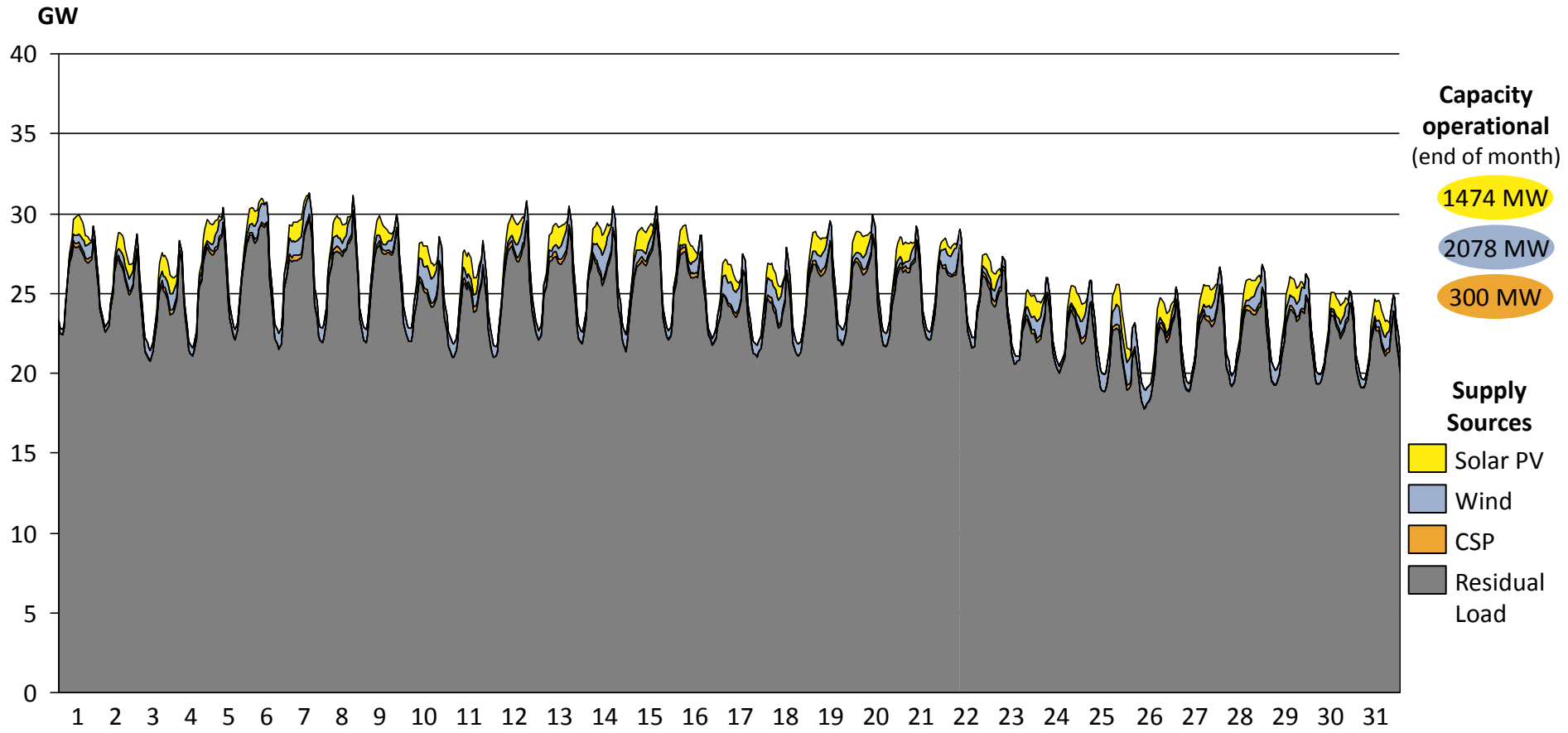


- Maximum power of 32.3 GW between 19h00 and 20h00 on 16 Nov 2017
- Minimum power of 21.3 GWh between 02h00 and 03h00 on 19 Nov 2017

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

Hourly electricity production in Dec 2017

Actual hourly production from all power supply sources in RSA for December 2017

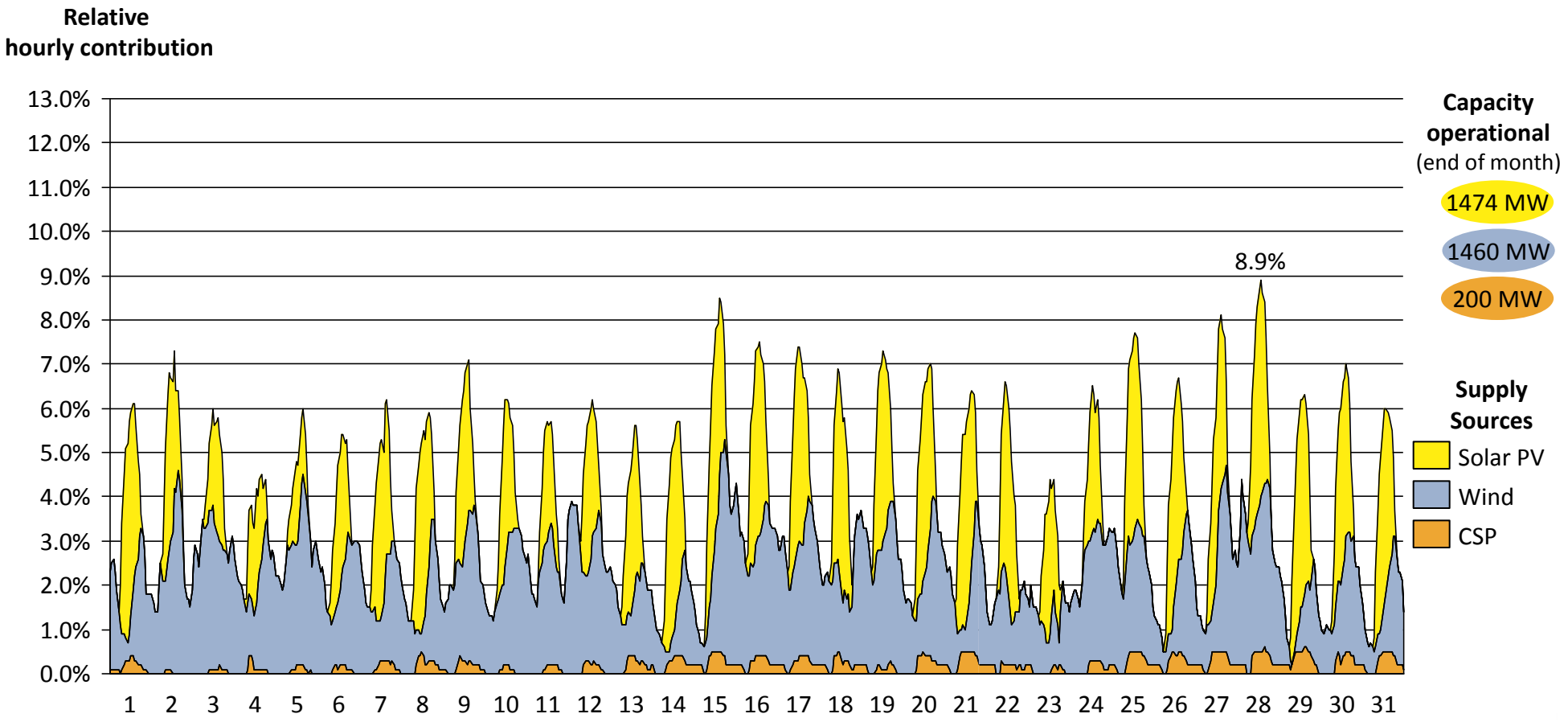


- Maximum power of 31.1 GW between 19h00 and 20h00 on 6 Dec 2017
- Minimum power of 19.0 GWh between 02h00 and 03h00 on 26 Dec 2017

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

Hourly solar PV, wind & CSP contribution of 0.5-8.9% in Jan 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for January 2017

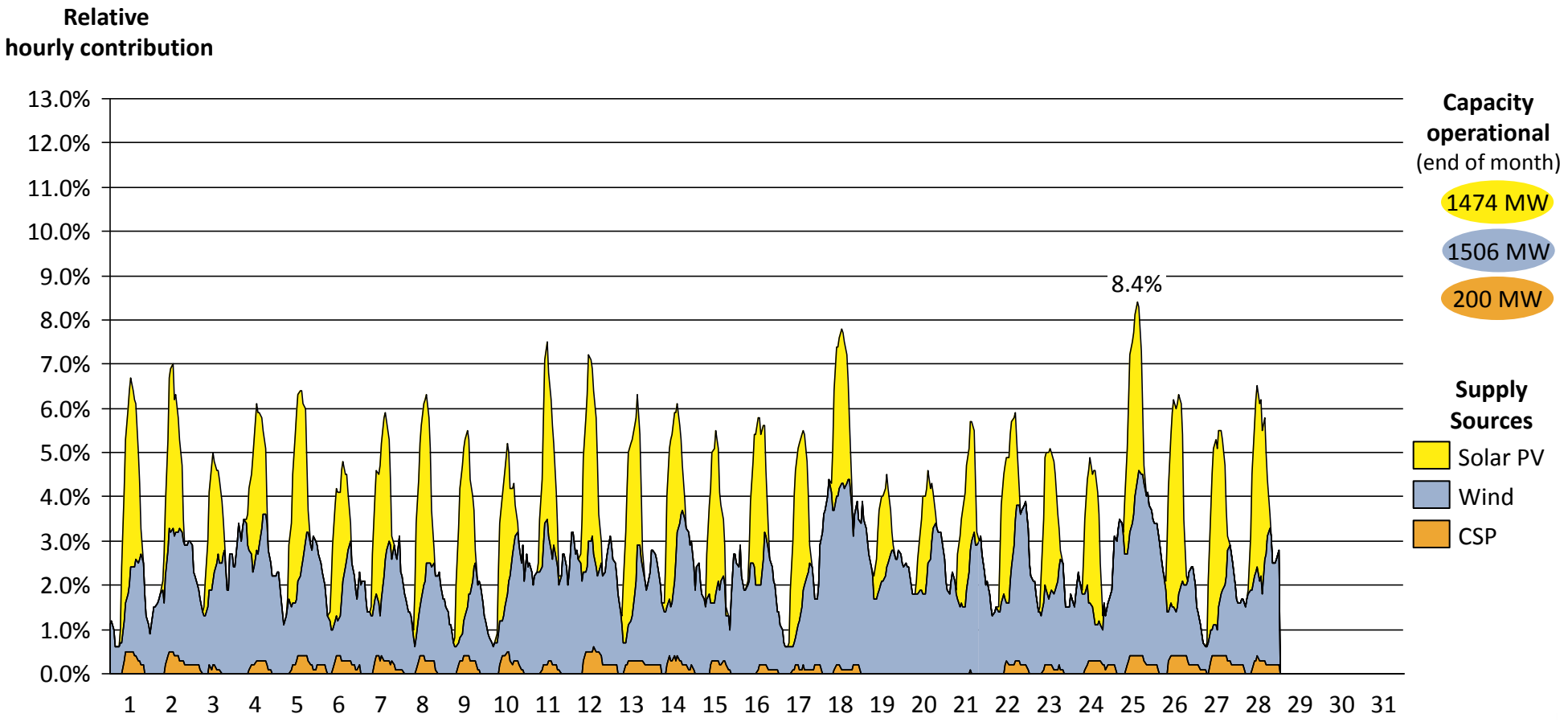


- Maximum solar PV relative contribution of 4.9% between 13h00 and 14h00 on 28 Jan 2017
- Maximum wind relative contribution of 4.9% between 17h00 and 18h00 on 15 Jan 2017
- Maximum CSP relative contribution of 0.6% between 15h00 and 16h00 on 29 Jan 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.6-8.4% in Feb 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for February 2017

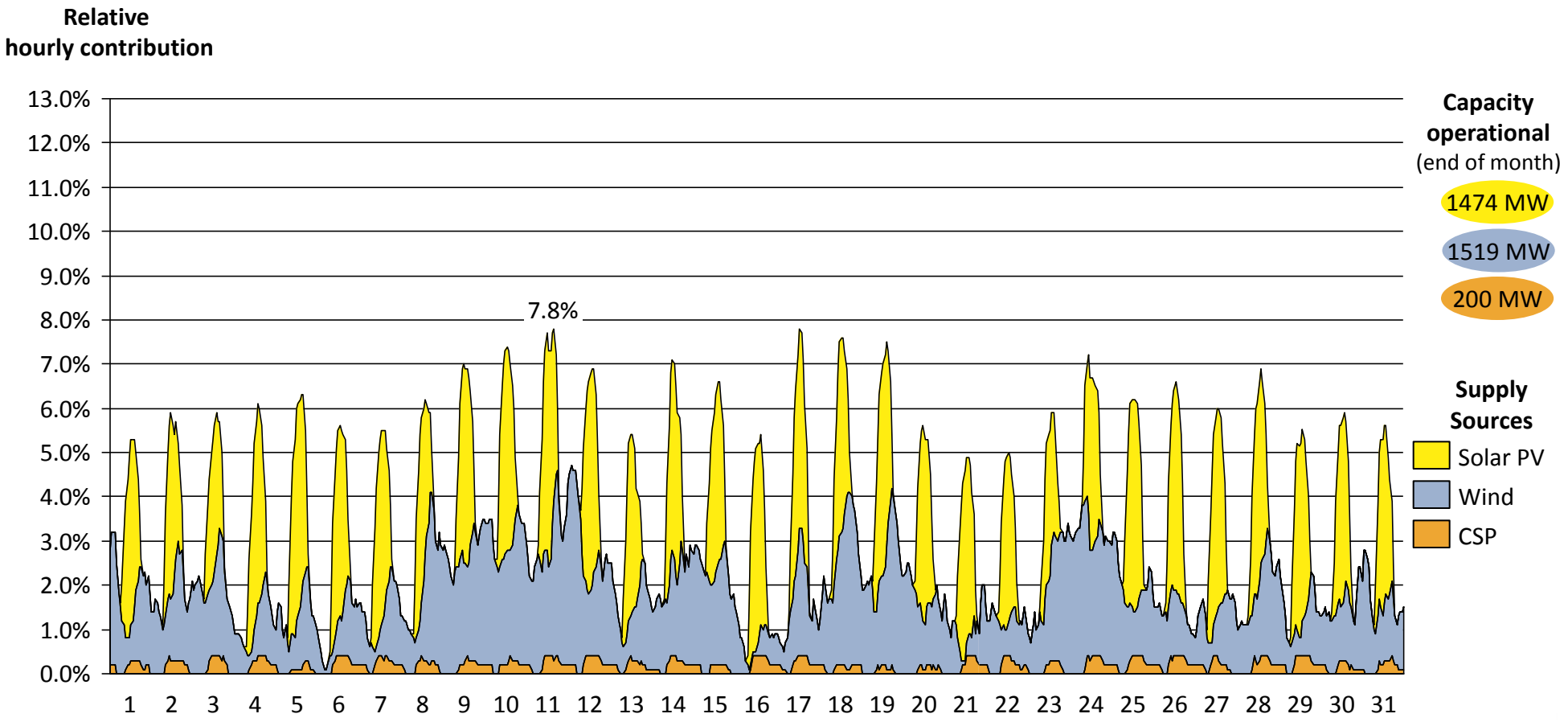


- Maximum solar PV relative contribution of 4.7% between 11h00 and 12h00 on 26 Feb 2017
- Maximum wind relative contribution of 4.4% between 05h00 and 06h00 on 18 Feb 2017
- Maximum CSP relative contribution of 0.6% between 14h00 and 15h00 on 12 Feb 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-7.8% in Mar 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for March 2017

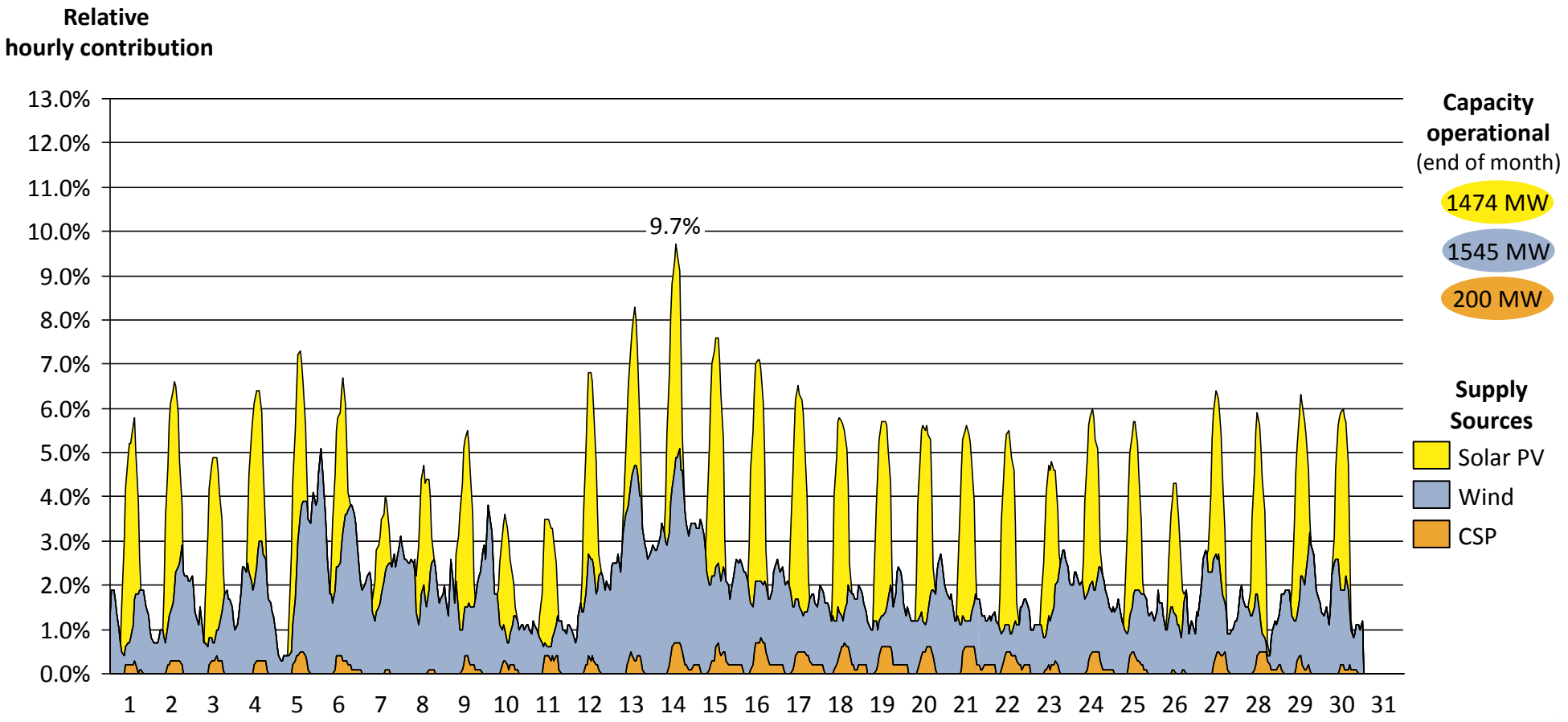


- Maximum solar PV relative contribution of 4.9% between 12h00 and 13h00 on 12 Mar 2017
- Maximum wind relative contribution of 4.5% between 01h00 and 02h00 on 12 Mar 2017
- Maximum CSP relative contribution of 0.4% between 15h00 and 16h00 on 25 Mar 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-9.7% in Apr 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for April 2017

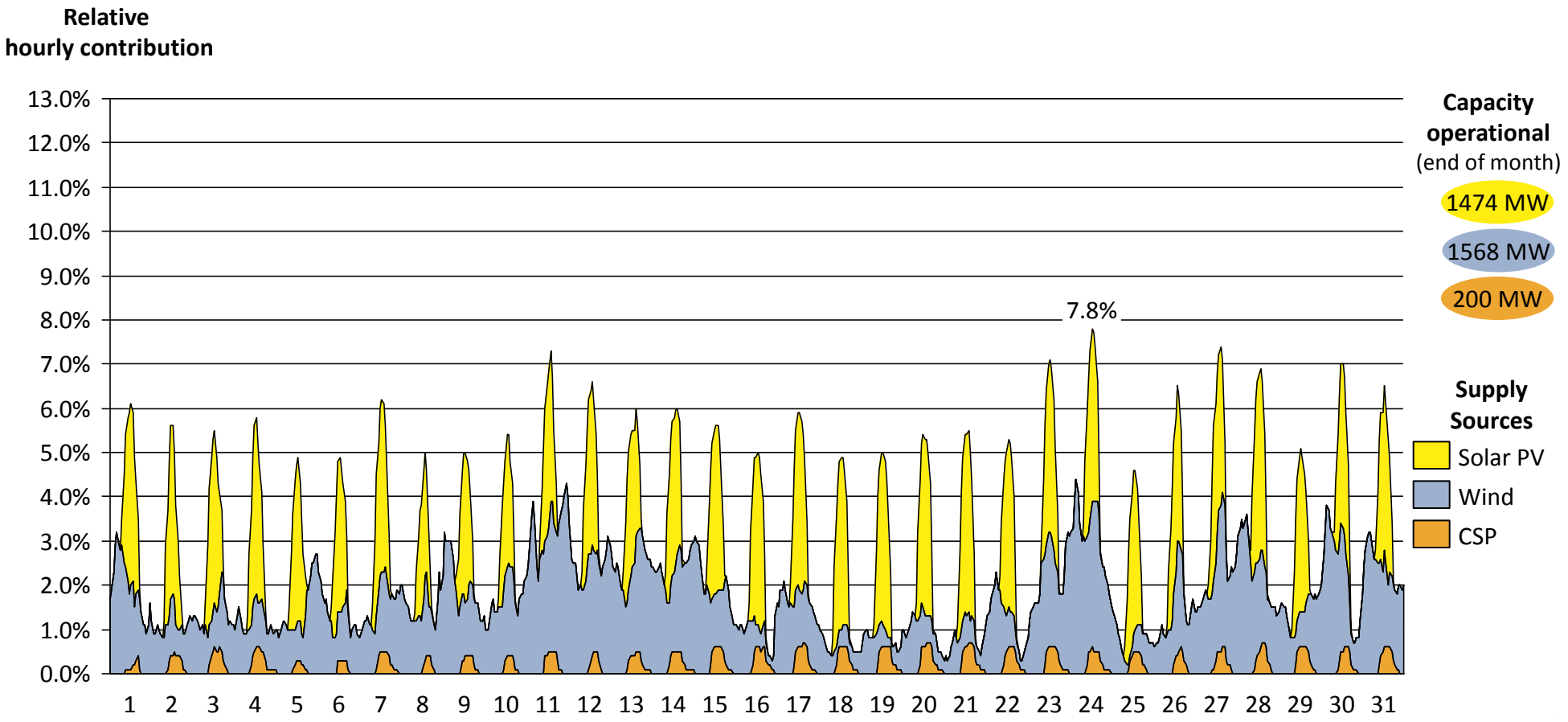


- Maximum solar PV relative contribution of 5.2% between 12h00 and 13h00 on 15 Apr 2017
- Maximum wind relative contribution of 5.1% between 01h00 and 02h00 on 6 Apr 2017
- Maximum CSP relative contribution of 0.8% between 14h00 and 15h00 on 16 Apr 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-7.8% in May 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for May 2017

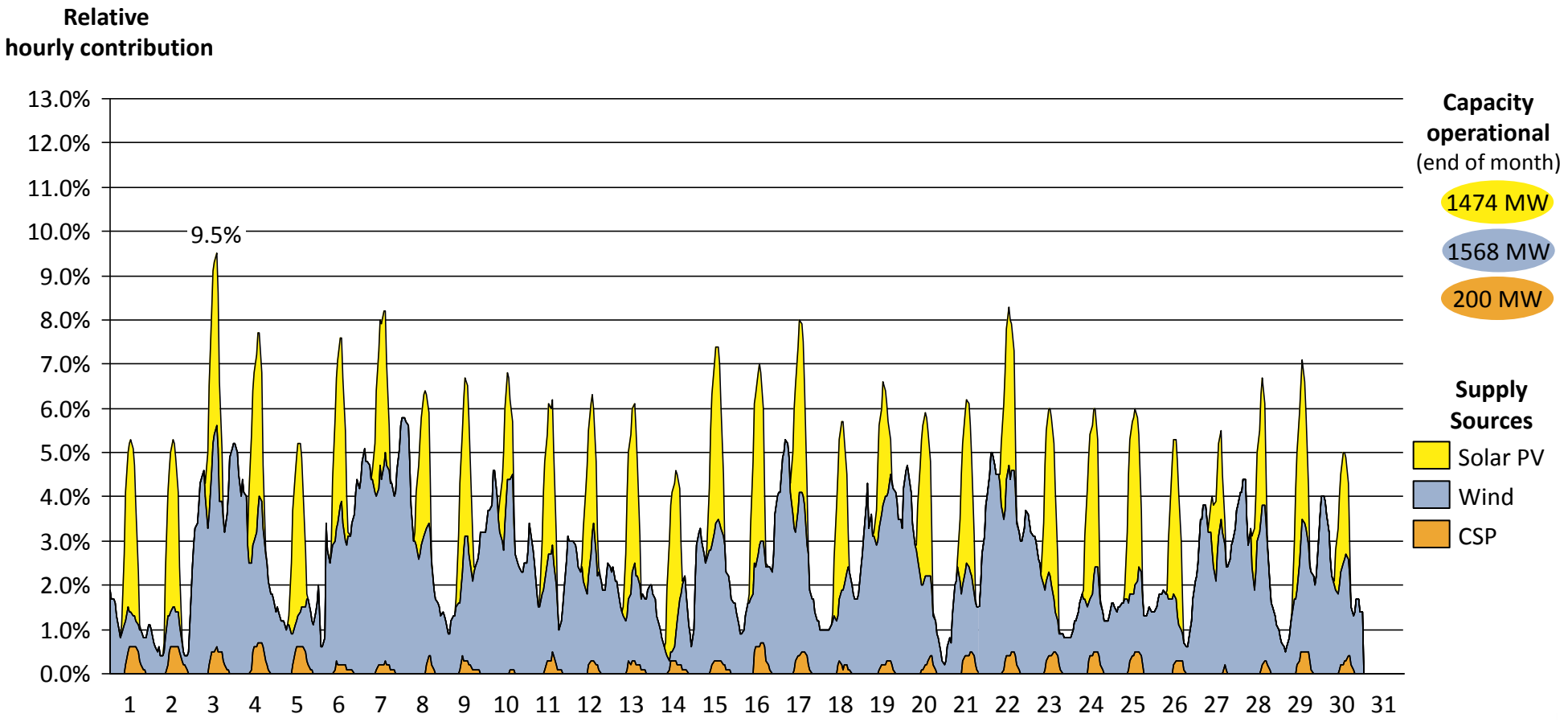


- Maximum solar PV relative contribution of 4.2% between 12h00 and 13h00 on 28 May 2017
- Maximum wind relative contribution of 4.4% between 03h00 and 04h00 on 24 May 2017
- Maximum CSP relative contribution of 0.7% between 15h00 and 16h00 on 21 May 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.2-9.5% in Jun 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for June 2017

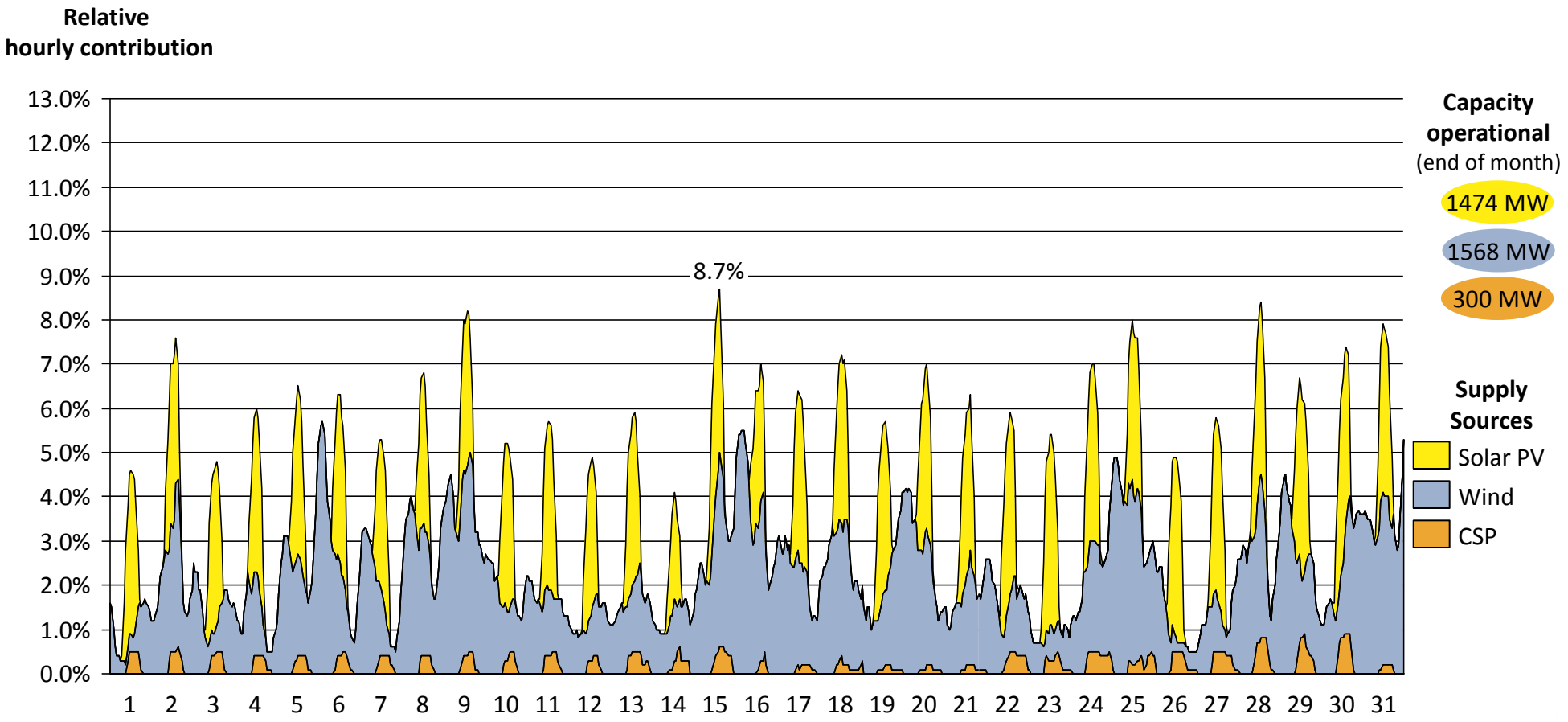


- Maximum solar PV relative contribution of 4.1% between 12h00 and 13h00 on 16 Jun 2017
- Maximum wind relative contribution of 5.8% between 00h00 and 01h00 on 8 Jun 2017
- Maximum CSP relative contribution of 0.7% between 14h00 and 15h00 on 4 Jun 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-8.7% in Jul 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for July 2017

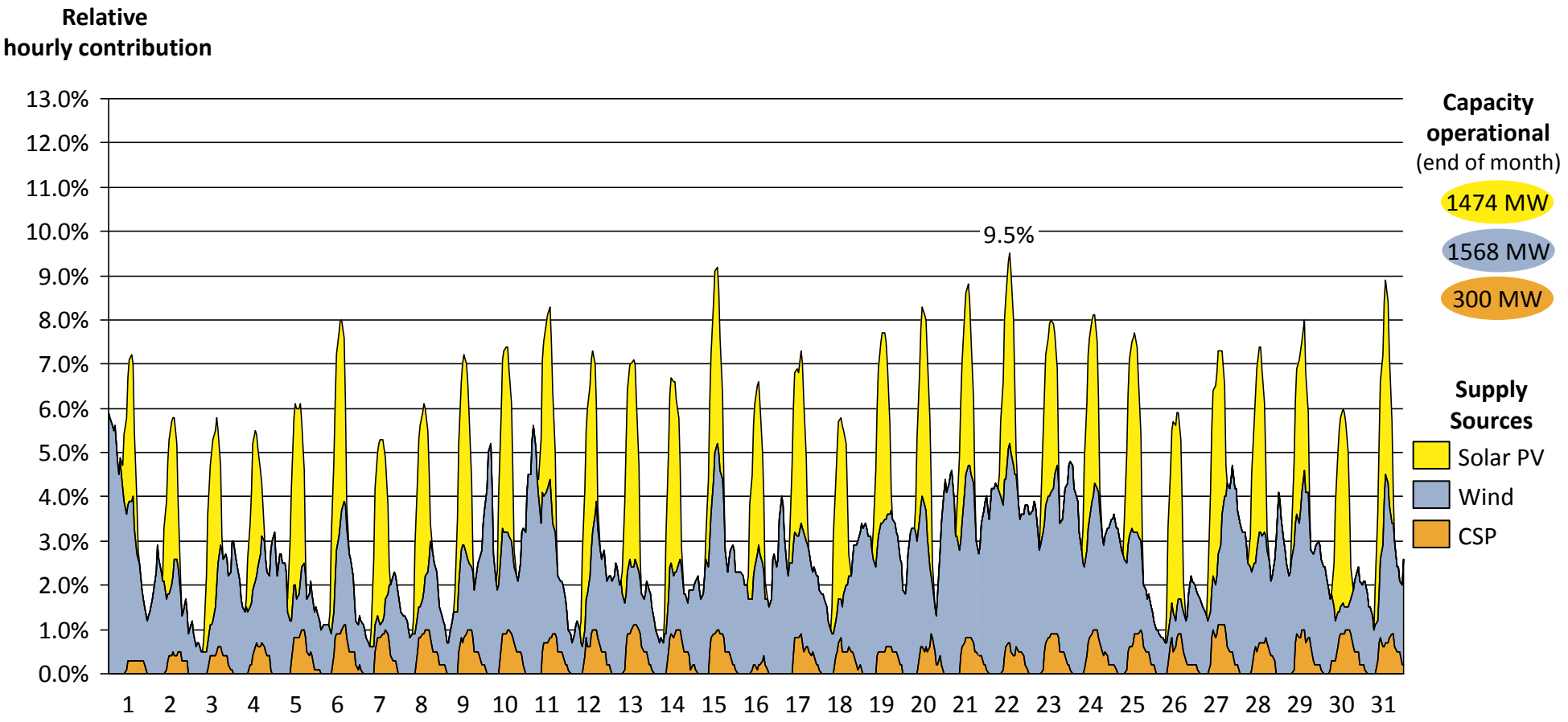


- Maximum solar PV relative contribution of 4.3% between 13h00 and 14h00 on 23 Jul 2017
- Maximum wind relative contribution of 5.7% between 02h00 and 03h00 on 6 Jul 2017
- Maximum CSP relative contribution of 0.9% between 15h00 and 16h00 on 30 Jul 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.5-9.5% in Aug 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for August 2017

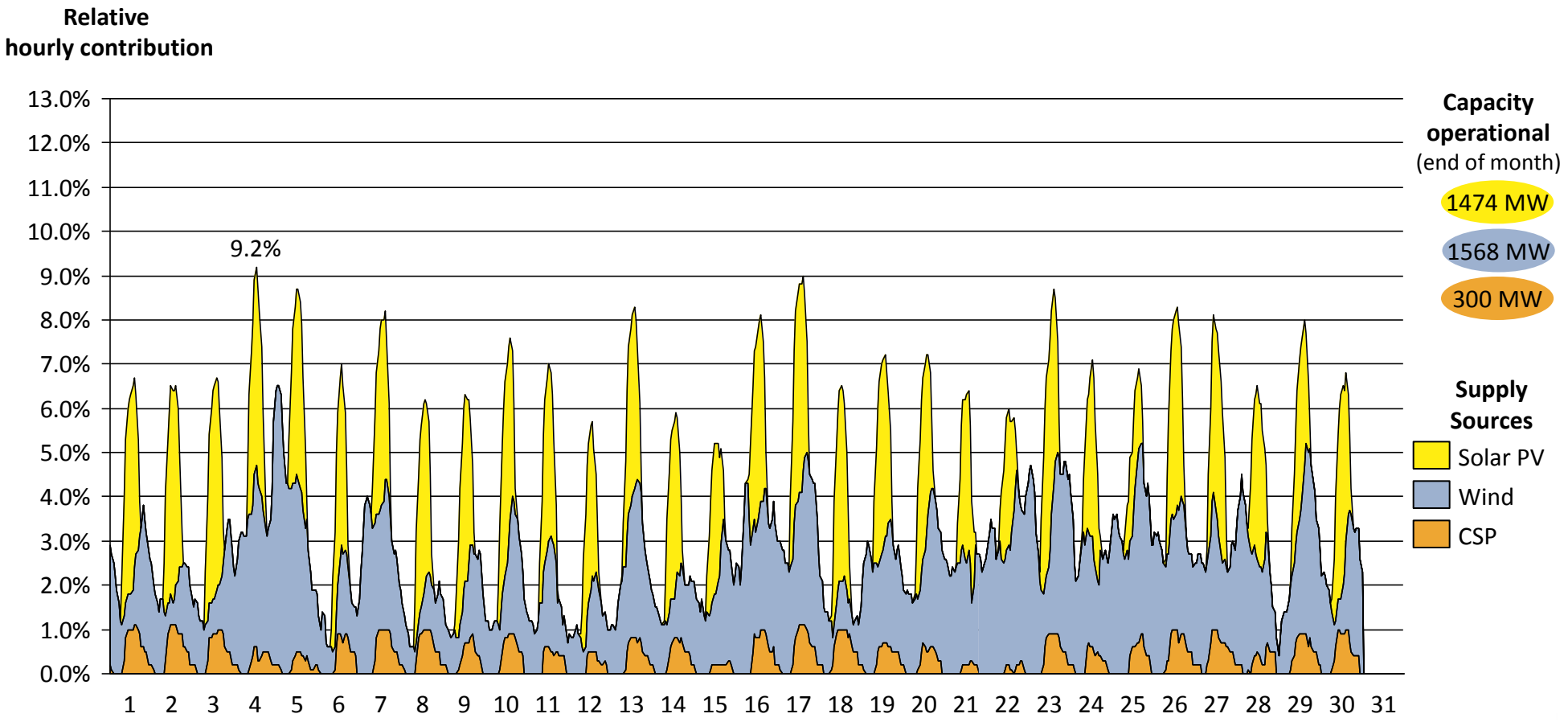


- Maximum solar PV relative contribution of 4.7% between 13h00 and 14h00 on 13 Aug 2017
- Maximum wind relative contribution of 5.9% between 00h00 and 01h00 on 1 Aug 2017
- Maximum CSP relative contribution of 1.1% between 15h00 and 16h00 on 27 Aug 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.4-9.2% in Sep 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for September 2017

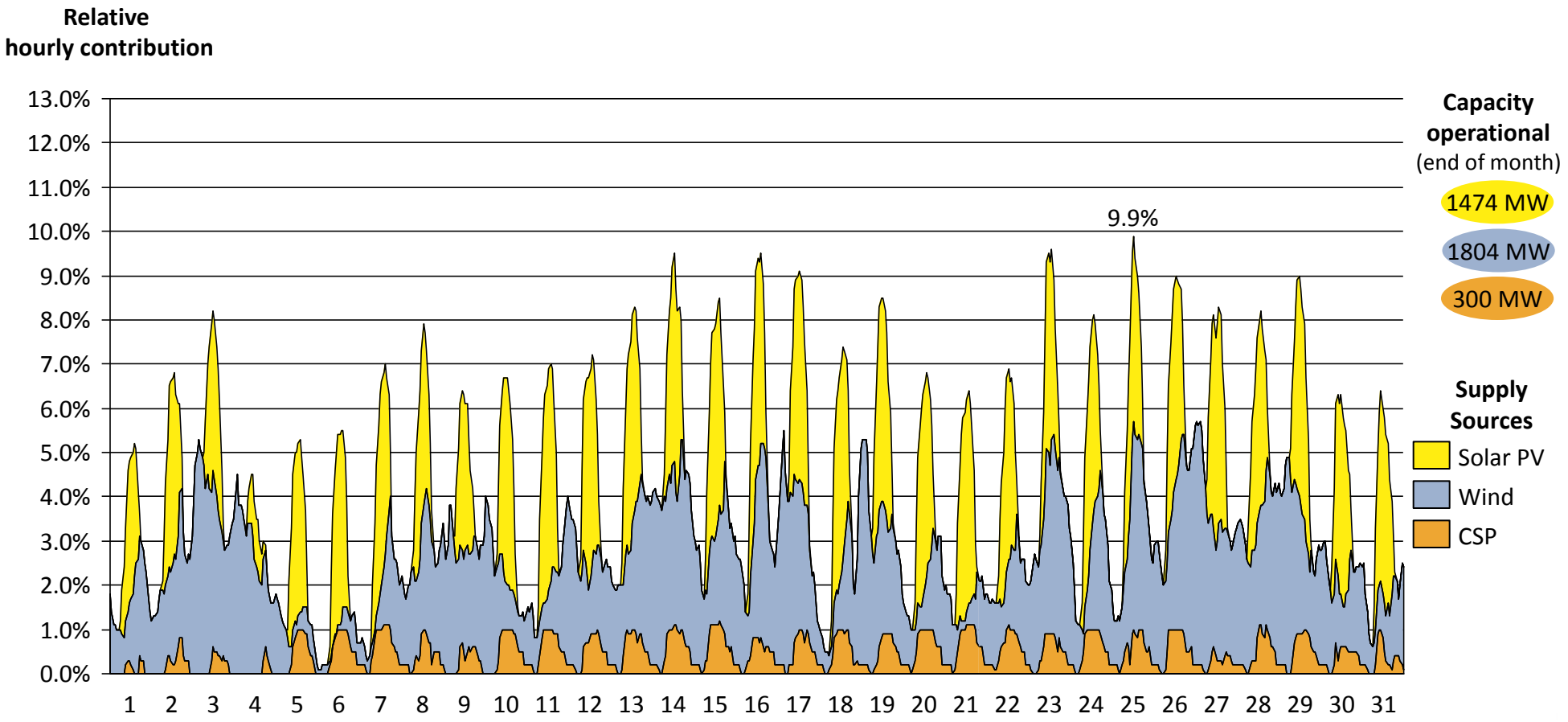


- Maximum solar PV relative contribution of 4.8% between 12h00 and 13h00 on 3 Sep 2017
- Maximum wind relative contribution of 6.3% between 00h00 and 01h00 on 5 Sep 2017
- Maximum CSP relative contribution of 1.1% between 14h00 and 15h00 on 17 Sep 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-9.9% in Oct 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for October 2017

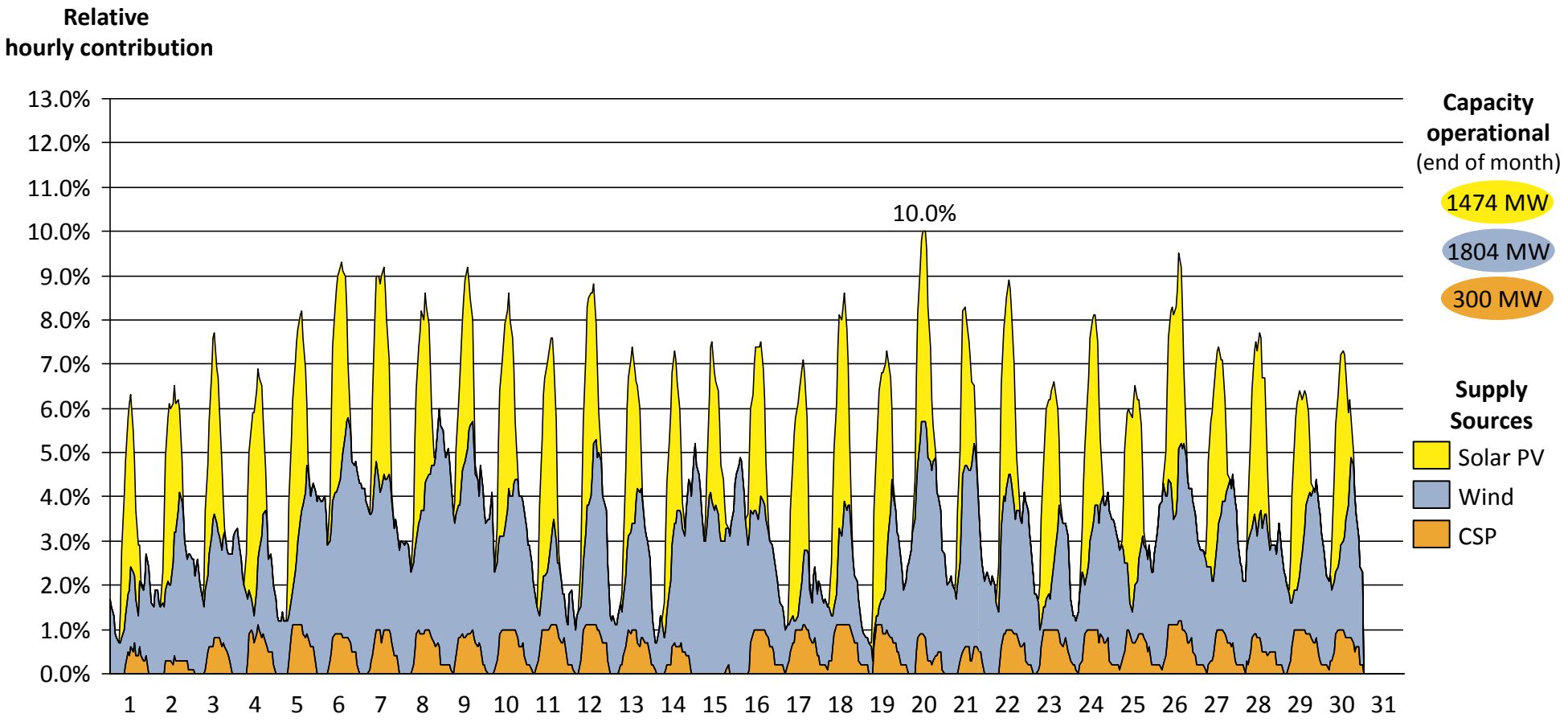


- Maximum solar PV relative contribution of 5.0% between 11h00 and 12h00 on 29 Oct 2017
- Maximum wind relative contribution of 5.5% between 00h00 and 01h00 on 27 Oct 2017
- Maximum CSP relative contribution of 1.2% between 14h00 and 15h00 on 15 Oct 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.7-10.0% in Nov 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for November 2017

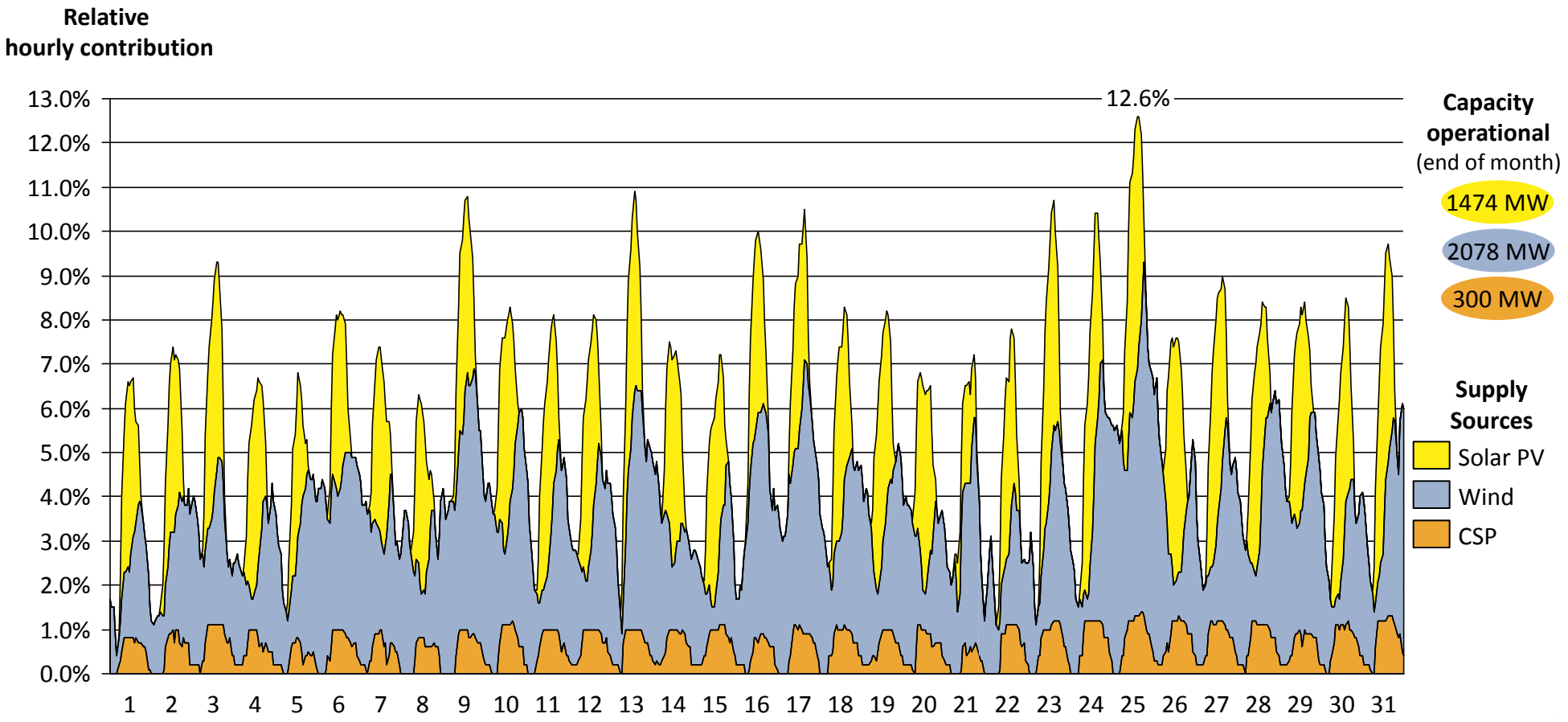


- Maximum solar PV relative contribution of 5.1% between 12h00 and 13h00 on 19 Nov 2017
- Maximum wind relative contribution of 5.4% between 22h00 and 23h00 on 8 Nov 2017
- Maximum CSP relative contribution of 1.2% between 15h00 and 16h00 on 26 Nov 2017

Sources: Eskom; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.4-12.6% in Dec 2017

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for December 2017

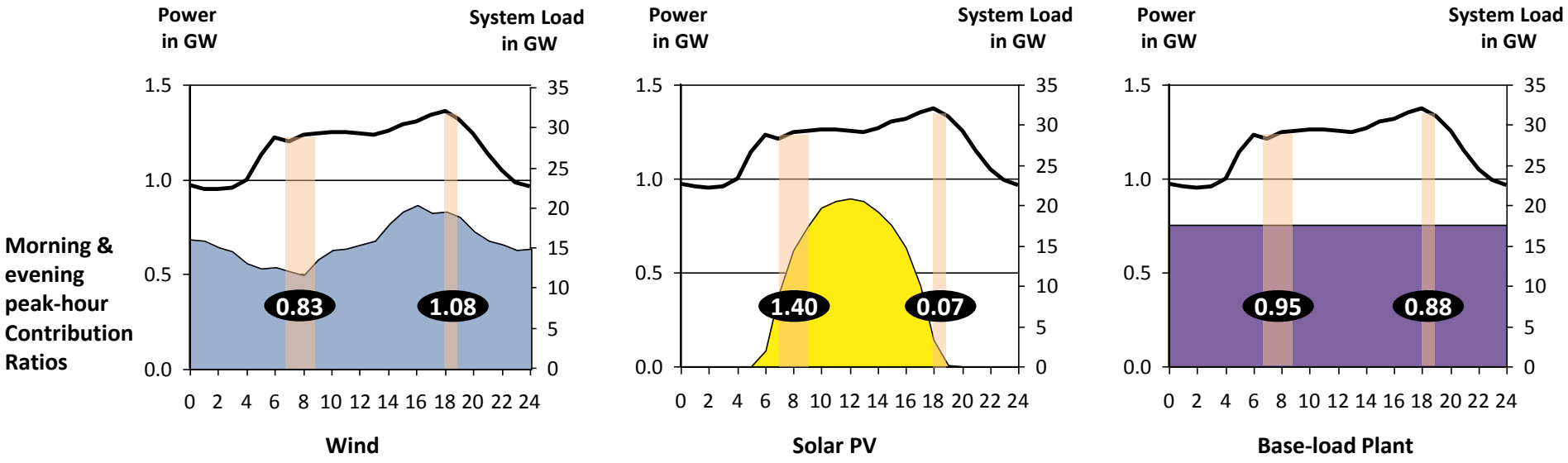


- Maximum solar PV relative contribution of 5.7% between 13h00 and 14h00 on 25 Dec 2017
- Maximum wind relative contribution of 8.0% between 18h00 and 19h00 on 25 Dec 2017
- Maximum CSP relative contribution of 1.4% between 16h00 and 17h00 on 25 Dec 2017

Sources: Eskom; CSIR Energy Centre analysis

The peak-hour contribution ratios of solar PV & wind were higher than a base-load plant in the morning & evening peaks respectively

Illustrative days showing the overlap of wind, solar PV 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 and solar PV morning and evening peak-hour contribution ratios (for all hours from Jan-Dec 2017) show that:

- Wind contributes 8% more energy during the evening peaks than it does during the other hours of the day
- Solar PV contributes 40% more energy in the morning peaks than it does during the other hours of the day

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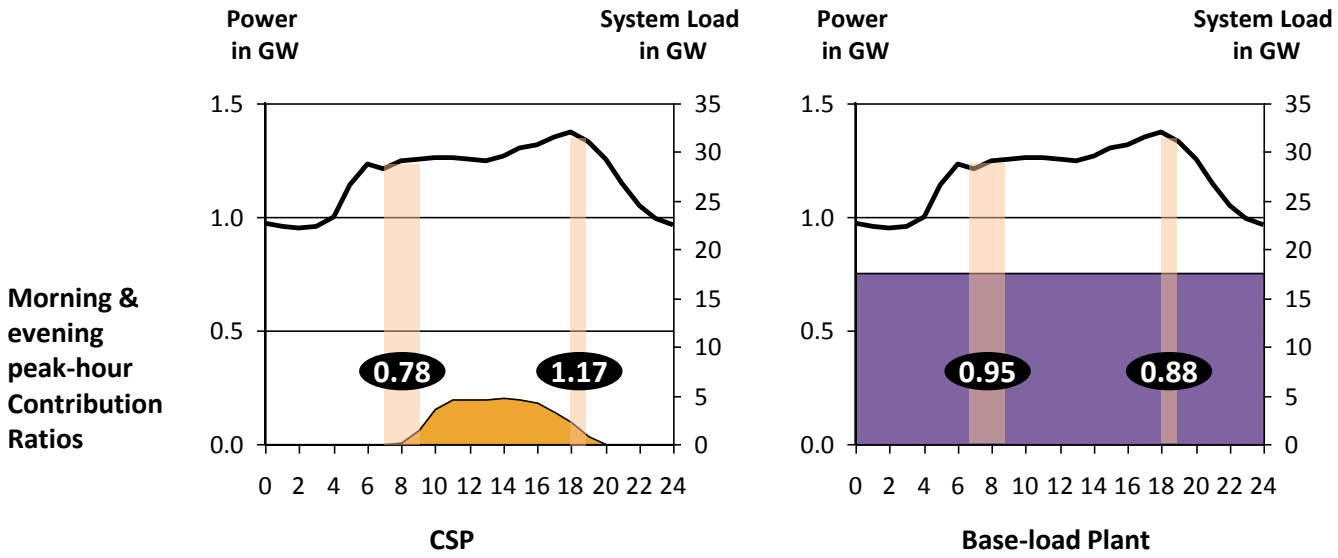
Notes: Morning and evening peak hours classified as per Eskom's 2017 Time of Use Tariff's
Sources: Eskom; CSIR Energy Centre analysis

The peak-hour contribution ratio of CSP was higher than a base-load plant in the evening peak

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



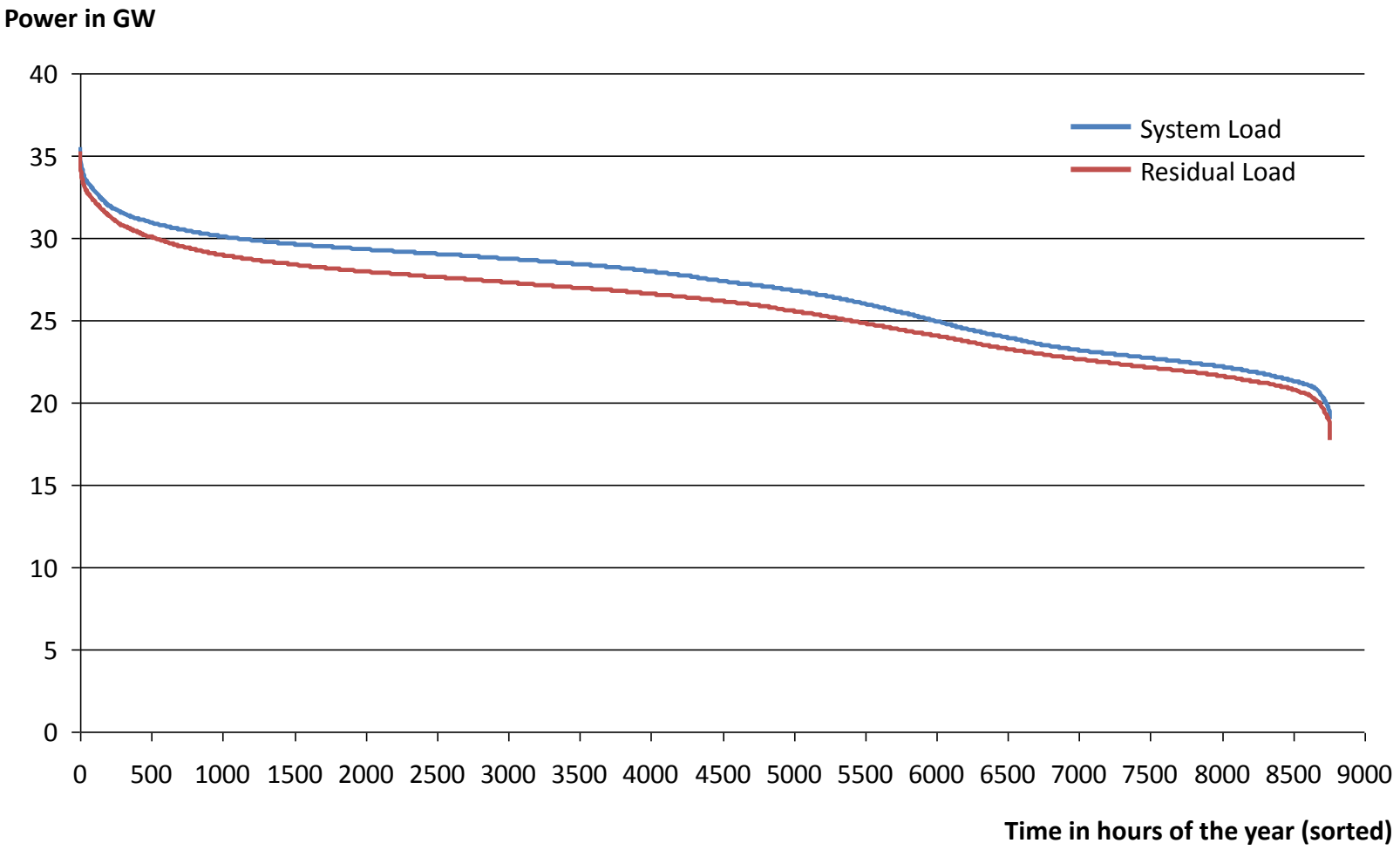
Peak-hour contribution ratio = relative energy contribution during peak / relative total energy contribution

CSP morning and evening peak-hour contribution ratios (for all hours from Jan-Dec 2017) show that:

- CSP contributes 17% more energy during the evening peaks than it does during the other hours of the day

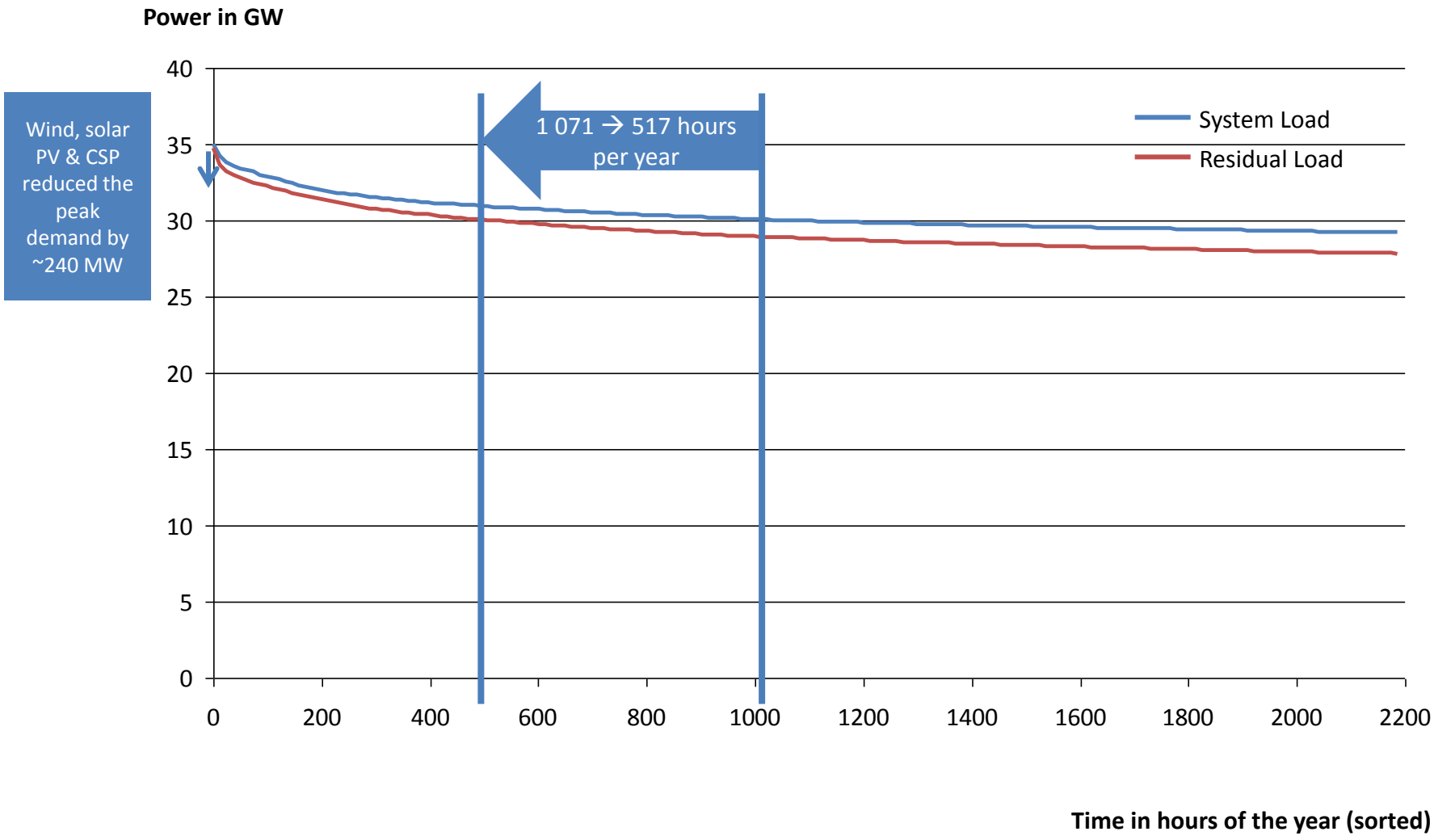
Notes: Morning and evening peak hours classified as per Eskom's 2017 Time of Use Tariff's
Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2017 system and residual load duration curves



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

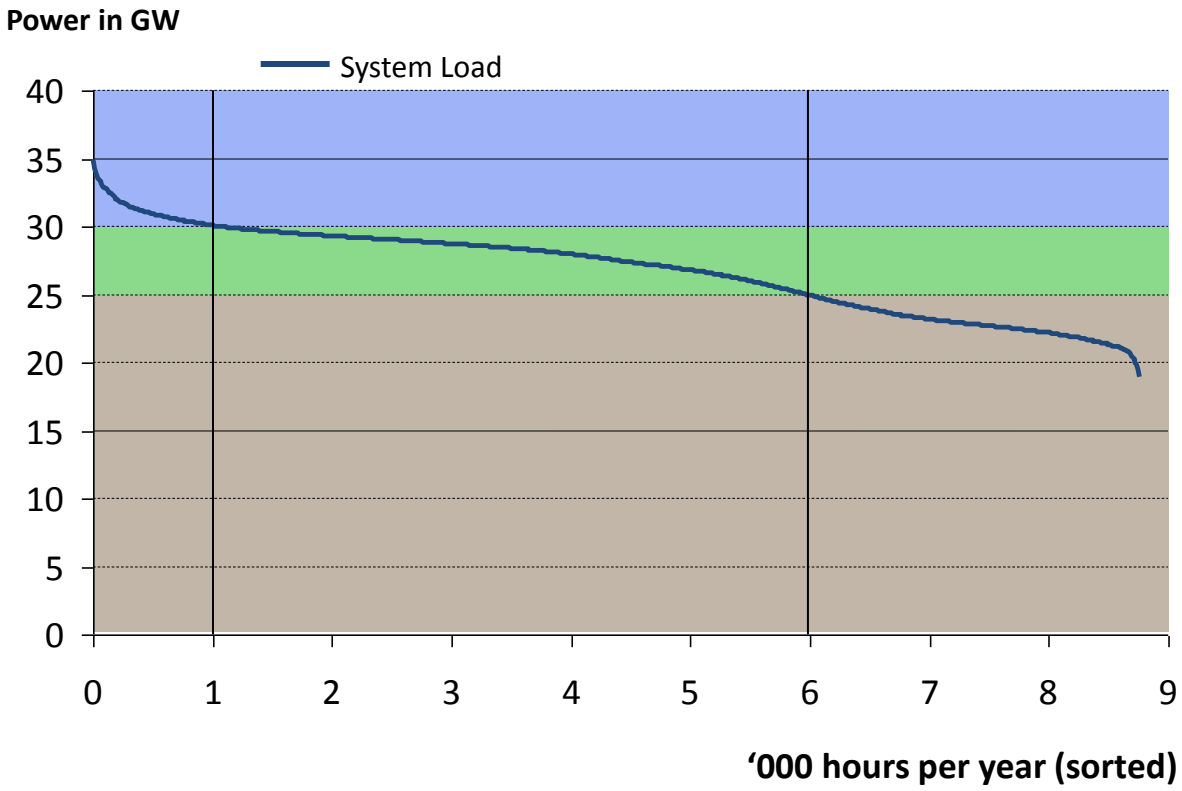
From Jan-Dec 2017, wind, solar PV & CSP reduced the number of hours with > 30 000 MW total load from 1071 to 517 (~554 hours less)



Sources: Eskom; CSIR Energy Centre analysis

The system load from Jan to Dec 2017 had a peak demand of 5.4 GW, mid-merit of 5.1 GW, and base-load demand of 24.9 GW

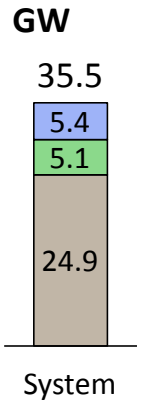
Load Duration Curve for Jan to Dec 2017 as per actual data



Peak-load
(< 1 000 hrs/yr)

Mid-merit load
(> 1 000 & < 6 000 hrs/yr)

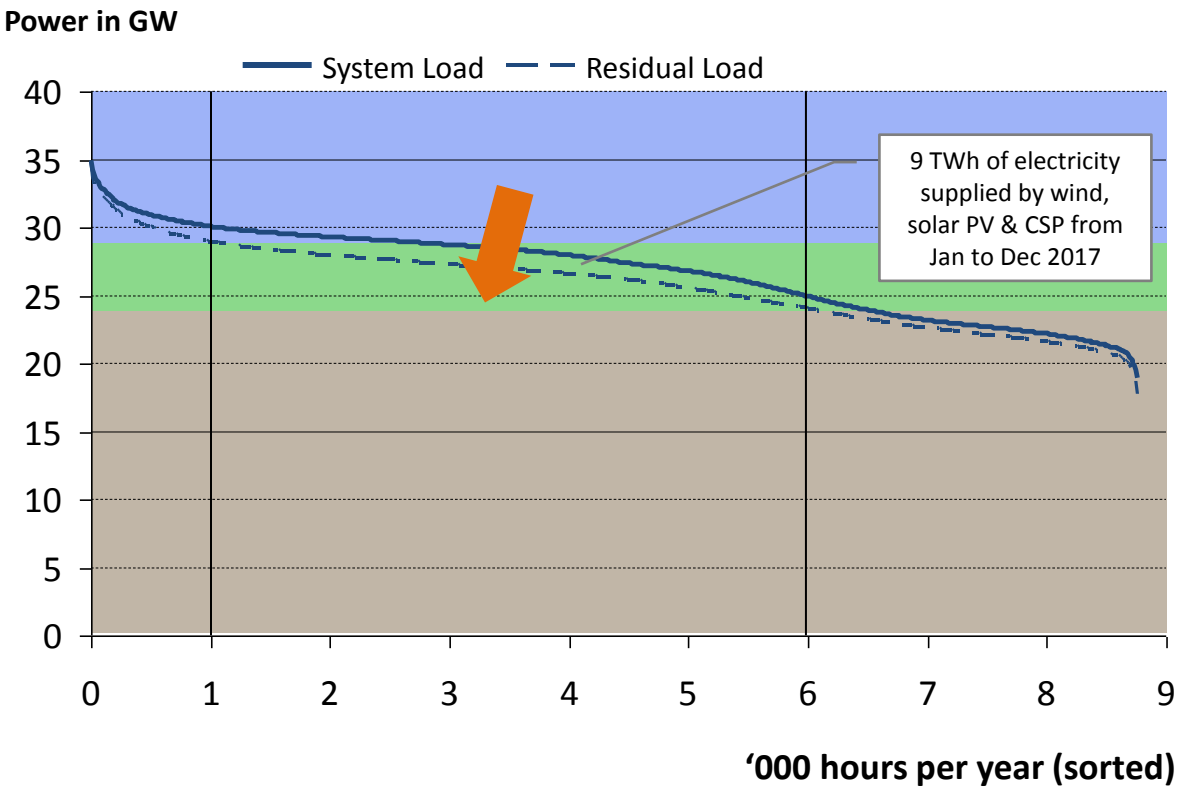
Base-load
(> 6 000 hrs/yr)



Sources: CSIR Energy Centre analysis

Wind/PV/CSP changed shape of residual load: new peak-demand goes up to 6.6 GW, mid-merit & base-load demand go down to 4.9/24.1 GW

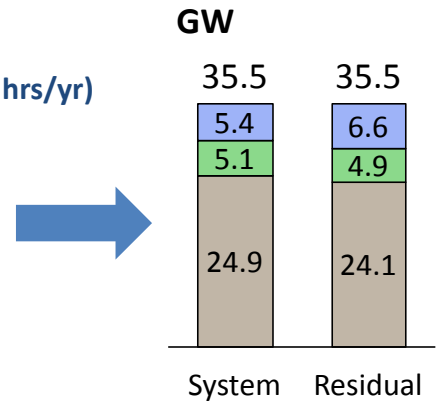
Load Duration Curve for Jan to Dec 2017 as per actual data



Peak-load
(< 1 000 hrs/yr)

Mid-merit load
(> 1 000 & < 6 000 hrs/yr)

Base-load
(> 6 000 hrs/yr)



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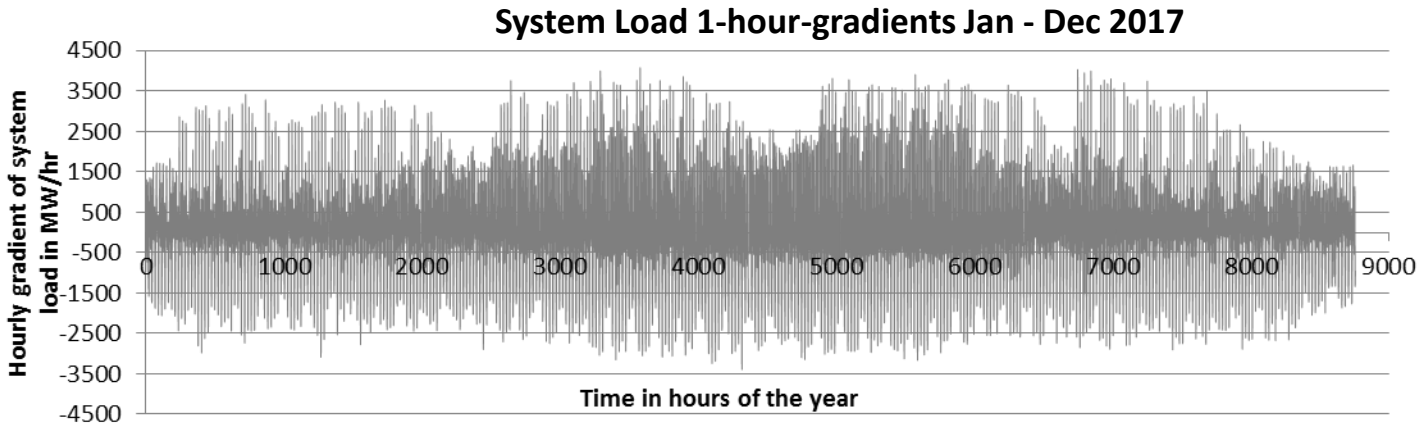
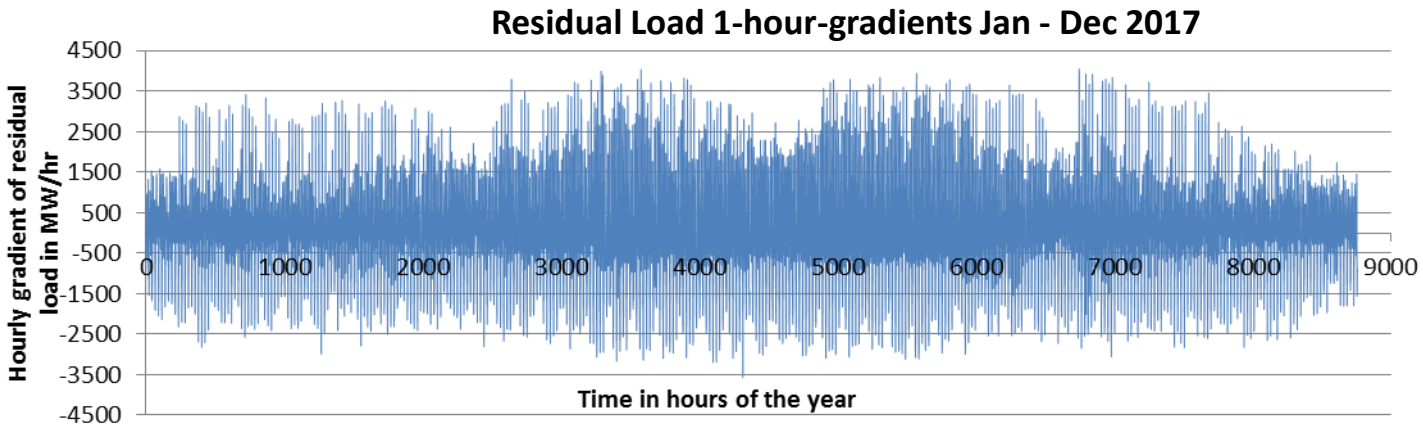
Sources: CSIR Energy Centre analysis

1-hour gradients minimally affected by 3.9 GW of wind, solar PV & CSP



- Max gradient of 4 051 MW/h on 30 May 2017 between 05h00 and 06h00
- Min gradient of -3 392 MW/h on 29 June 2017 between 22h00 and 23h00



- Max gradient of 4 048 MW/h on 9 Oct 2017 between 04h00 and 05h00
- Min gradient of -3 567 MW/h on 29 June 2017 between 22h00 and 23h00

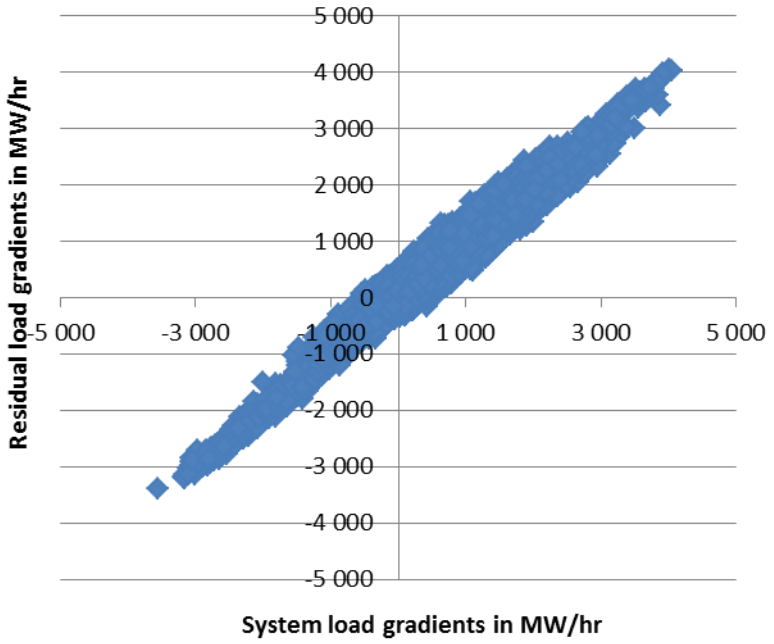
Residual load = **System load - Solar PV - Wind - CSP**

Notes: System and Residual load excludes pumping load for all data points throughout the year. $Load\ gradient_t = load_t - load_{t-1}$

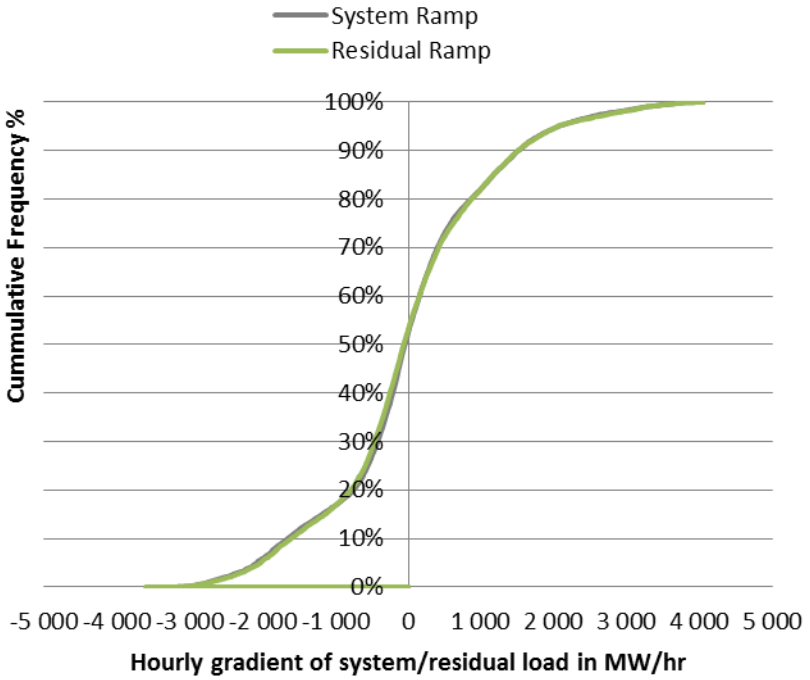
Sources: Eskom; CSIR Energy Centre analysis

1-hour gradients did not increase due to 3.9 GW of wind, solar PV & CSP

System load 1-hour gradients vs. residual load 1-hour gradients for all hours from Jan – Dec 2017

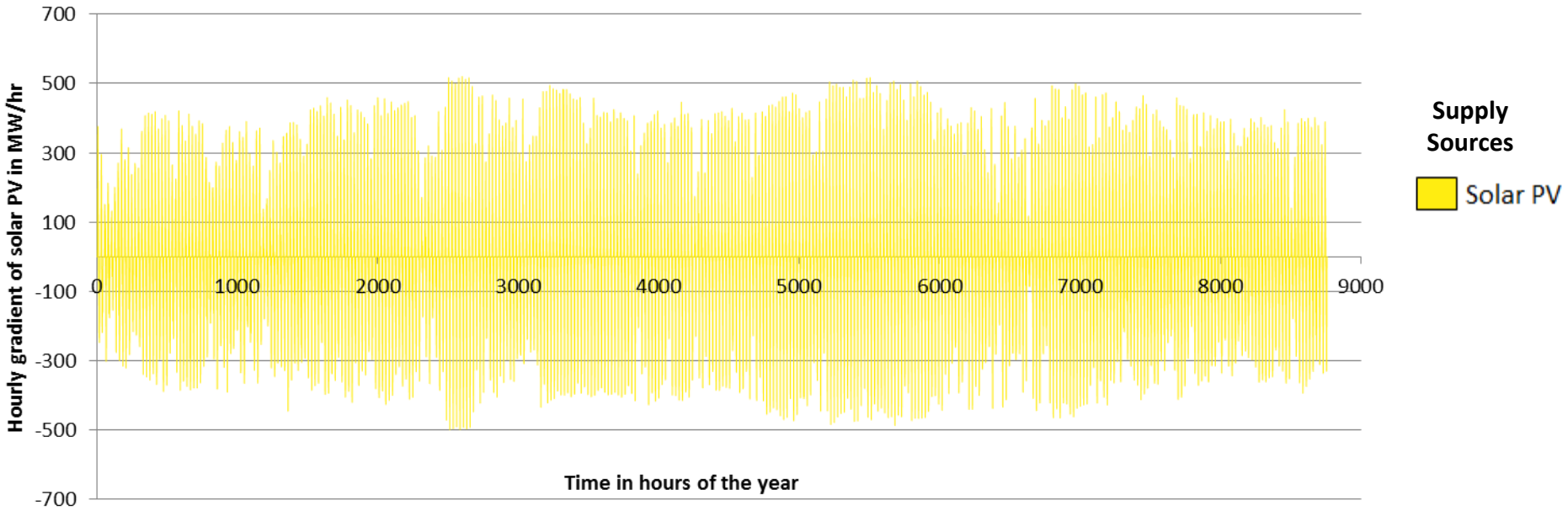


Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2017



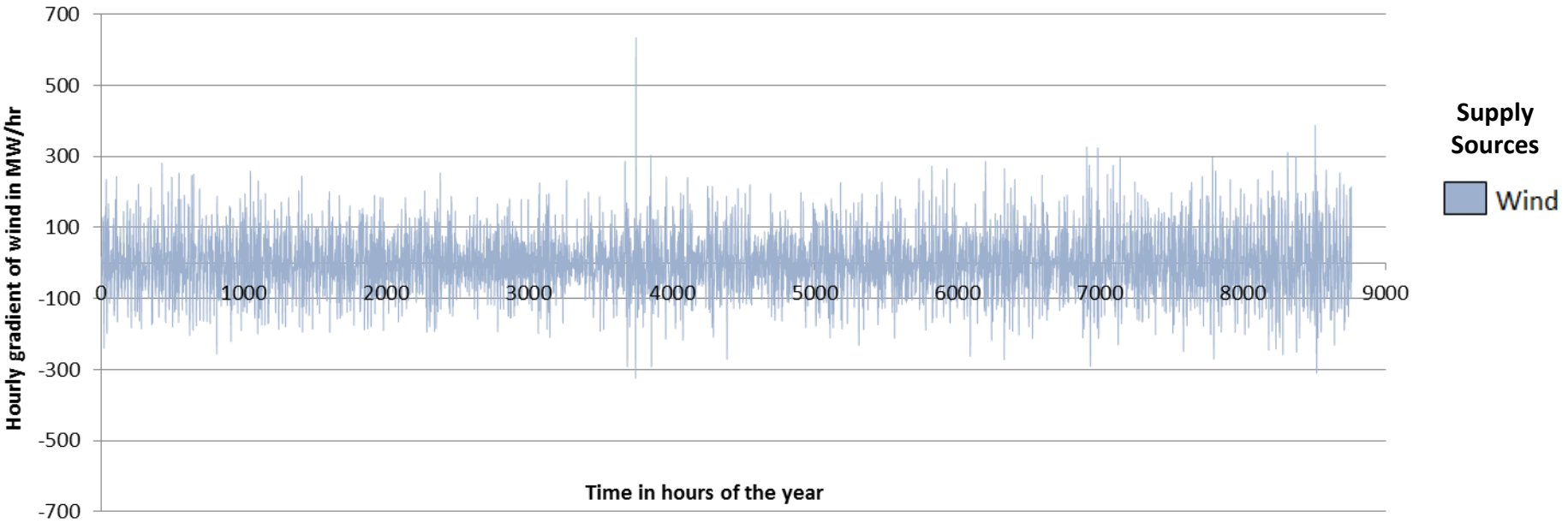
Notes: System and Residual load excludes pumping load for all data points throughout the year
Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2017 1-hour gradients of solar PV supply



Sources: Eskom; CSIR Energy Centre analysis

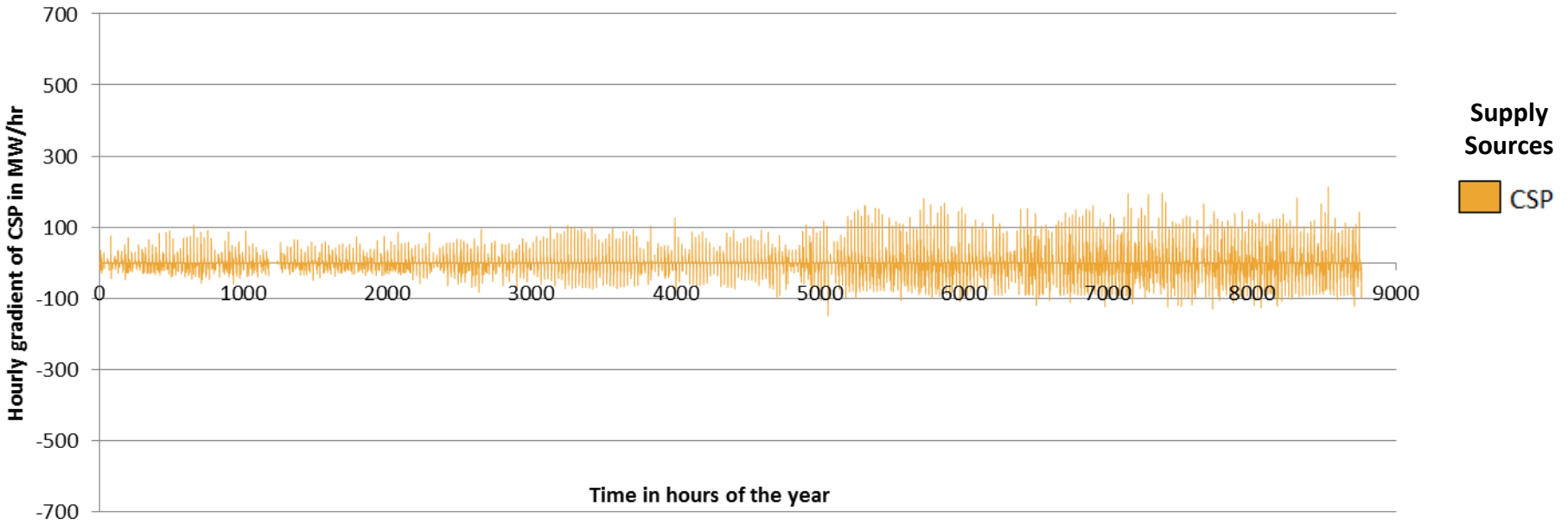
Jan - Dec 2017 1-hour gradients of wind supply



- *Large wind gradient spike of 625 MW on 6 June 2017 between 03h00 and 04h00 due to System Operator curtailment of wind IPPs in response to a combination of minimum thermal generation constraints and low demand*

Sources: Eskom; CSIR Energy Centre analysis

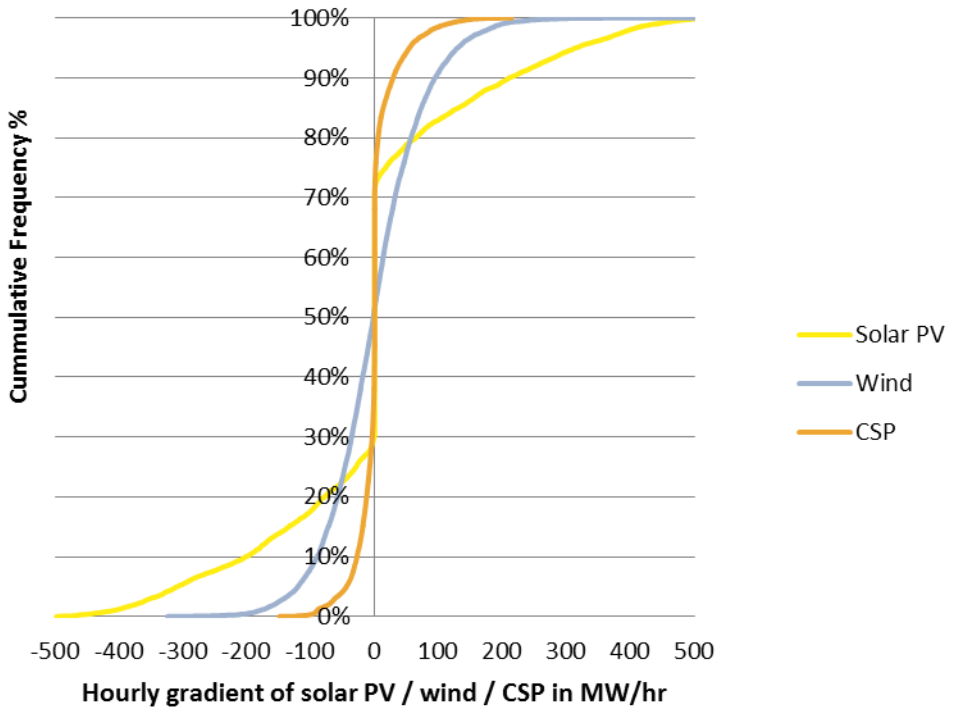
Jan - Dec 2017 1-hour gradients of CSP supply



Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2017 wind, solar PV and CSP frequency distribution of 1-hour gradients

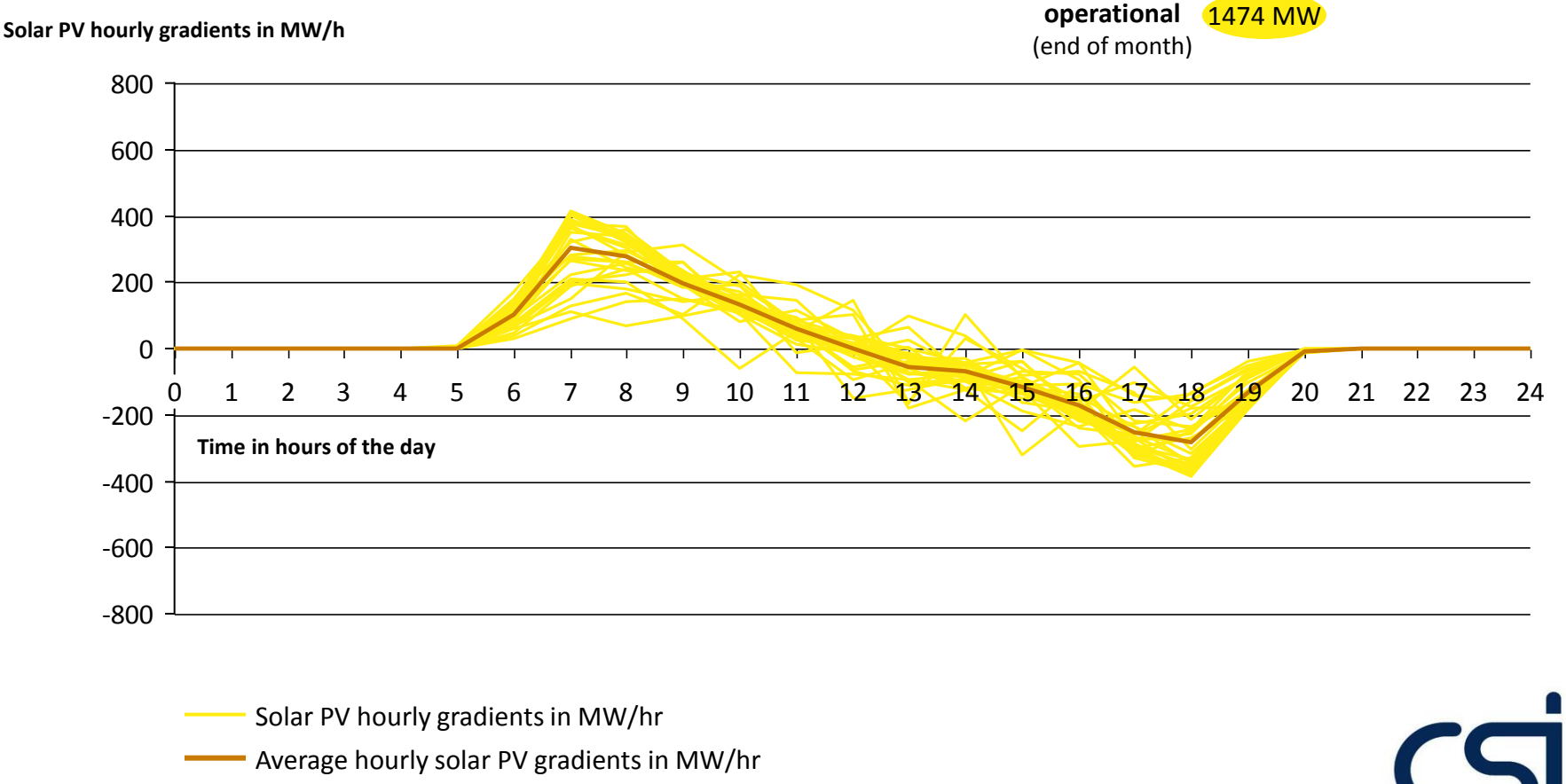
- Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2017



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in January 2017

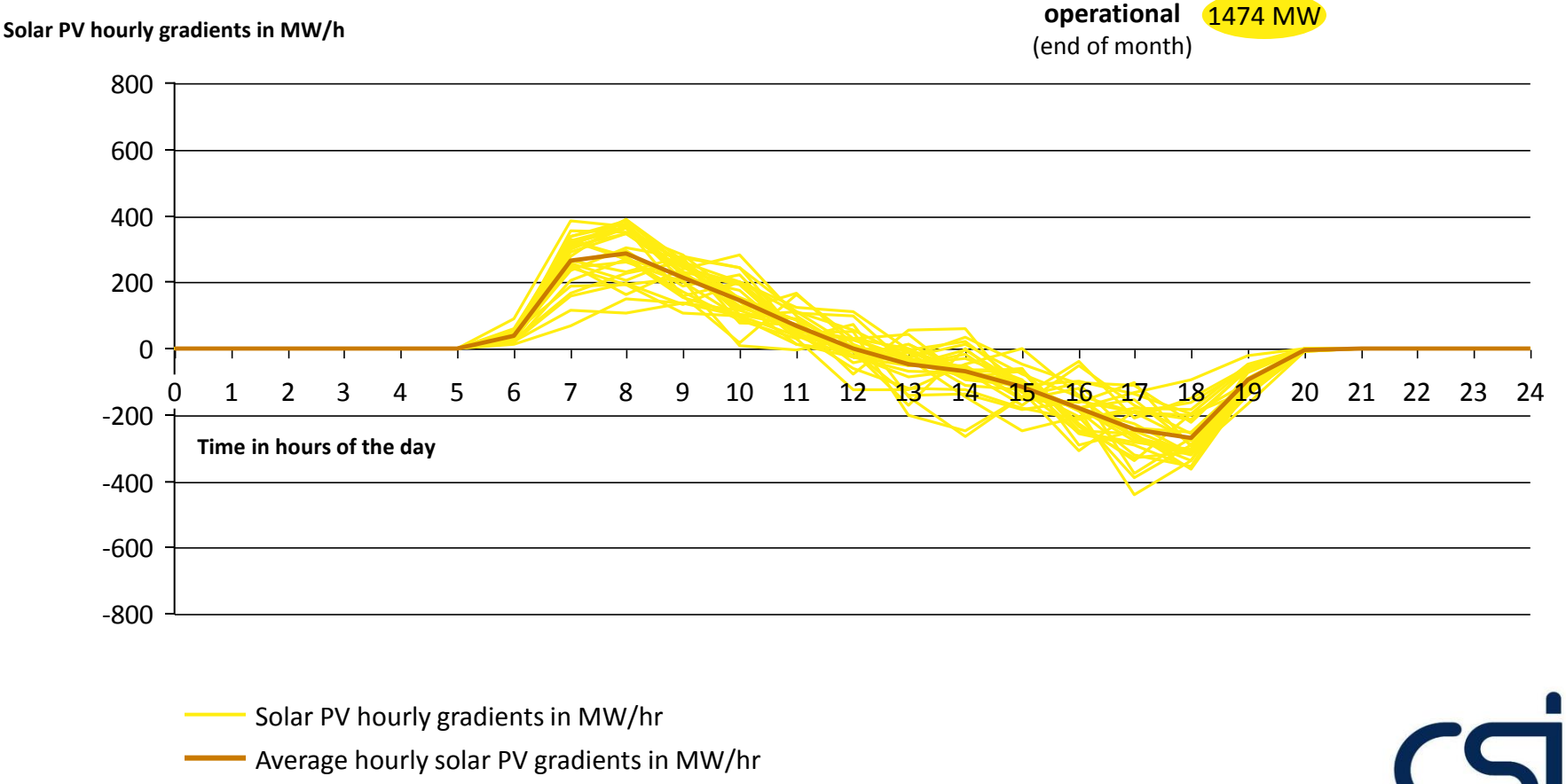
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in February 2017

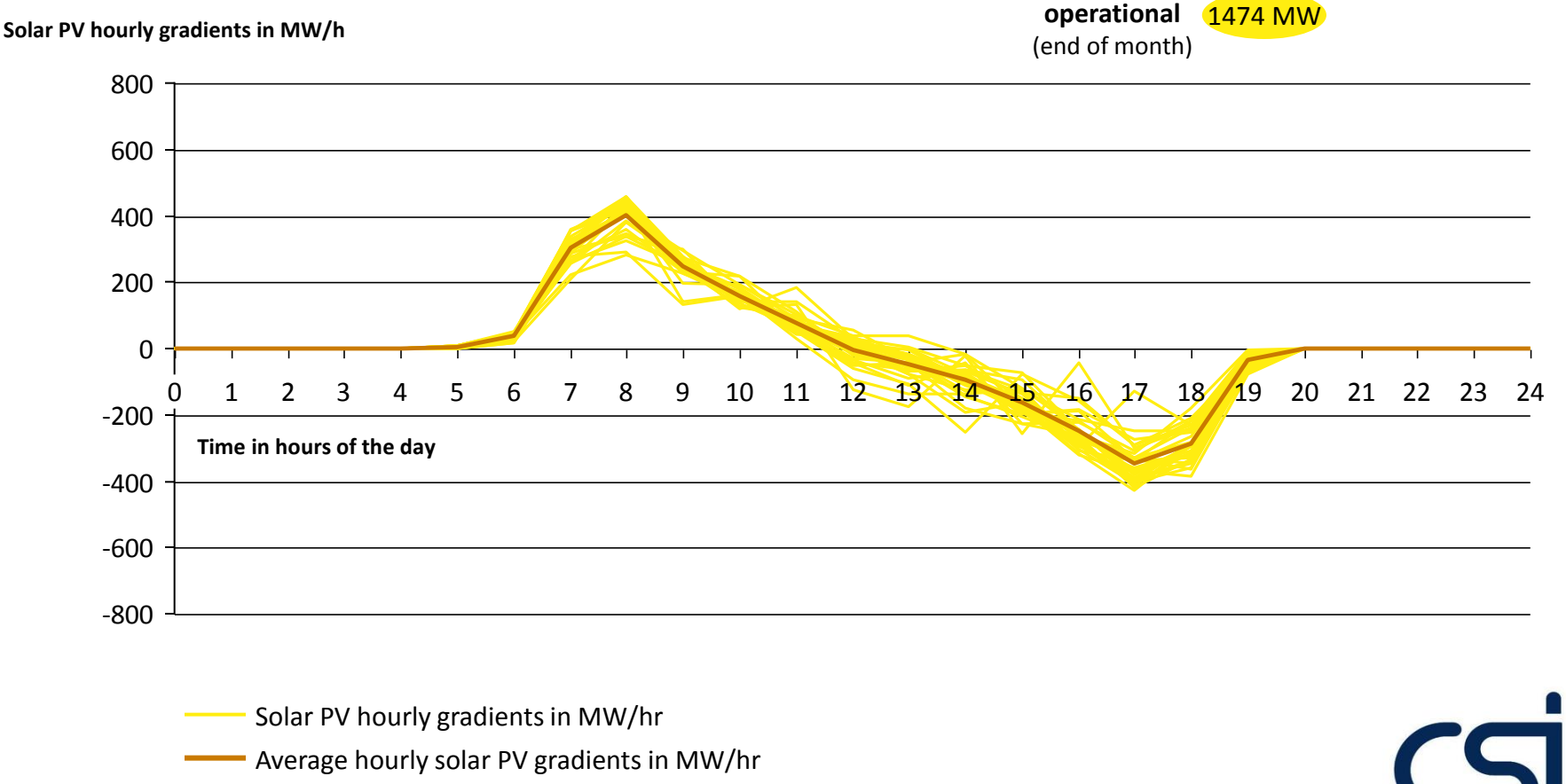
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in March 2017

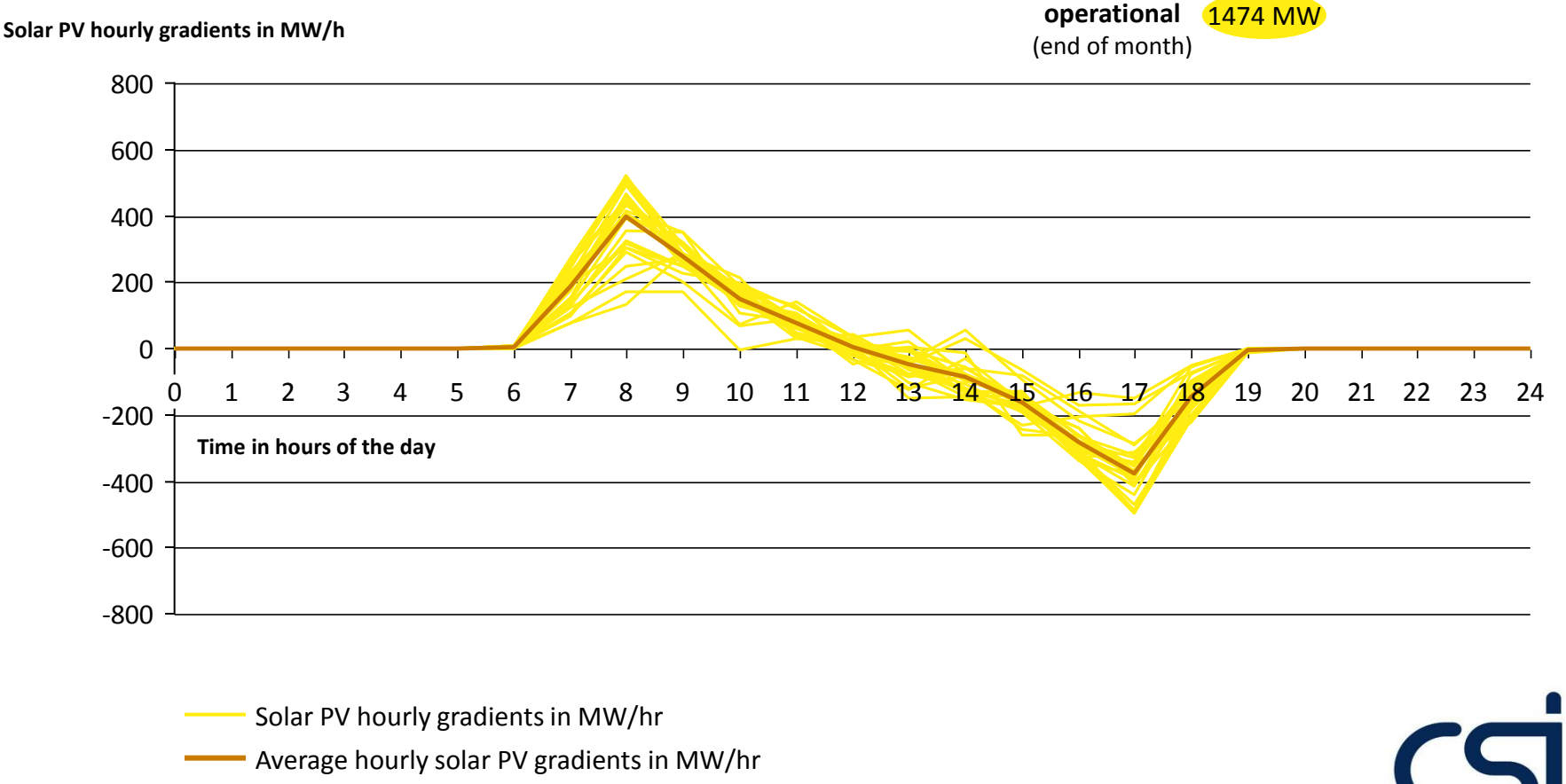
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in April 2017

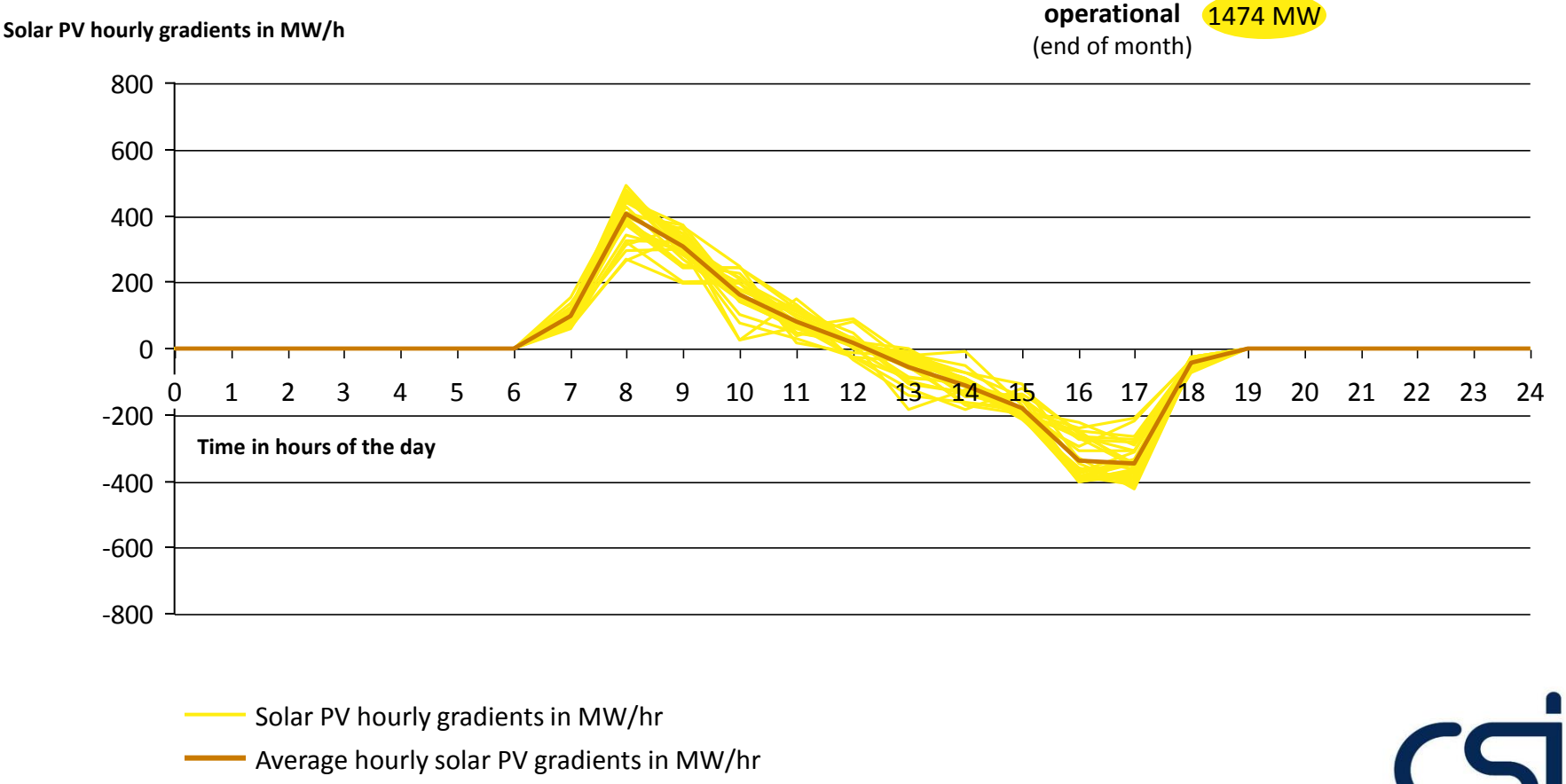
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in May 2017

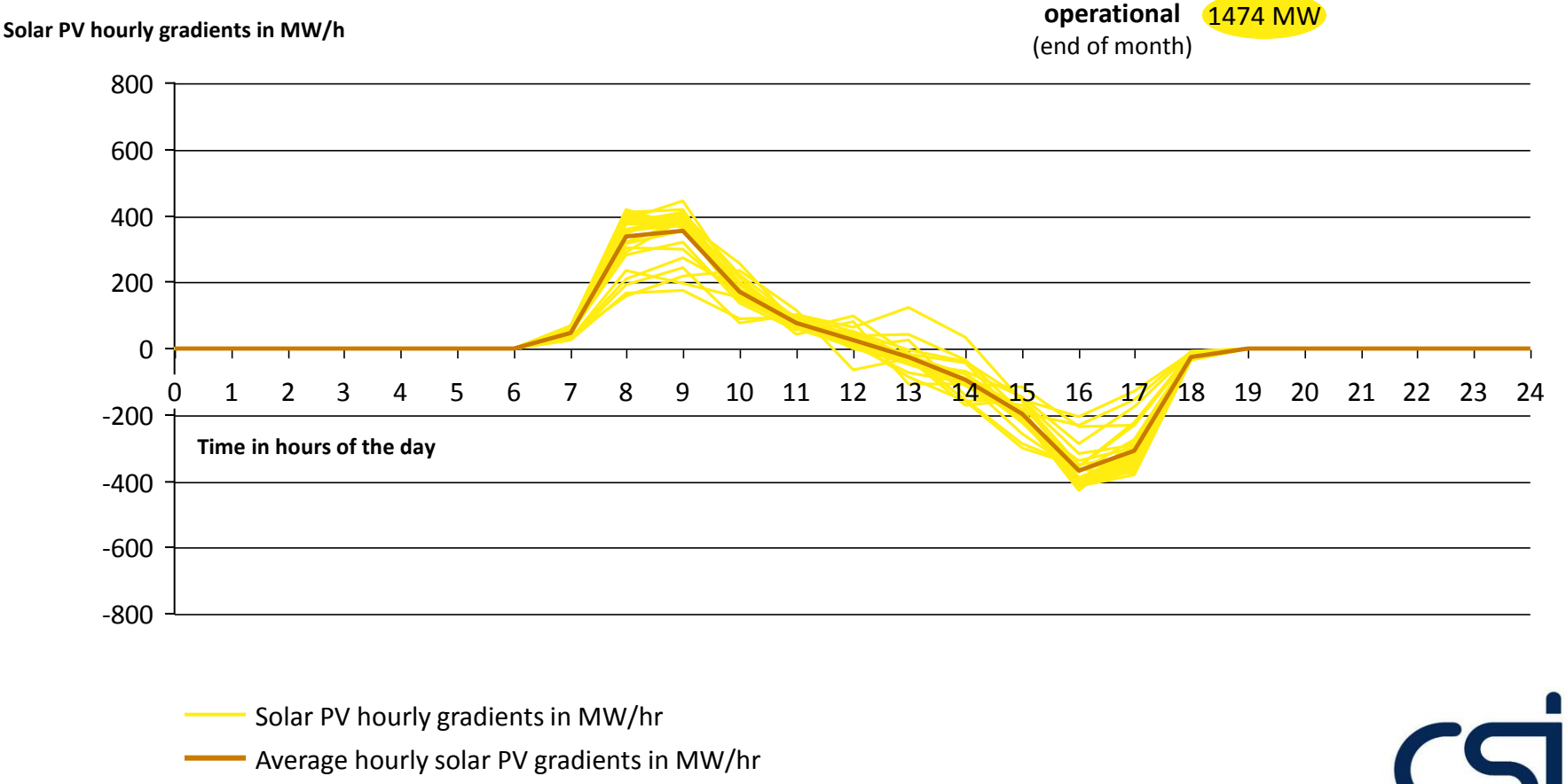
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in June 2017

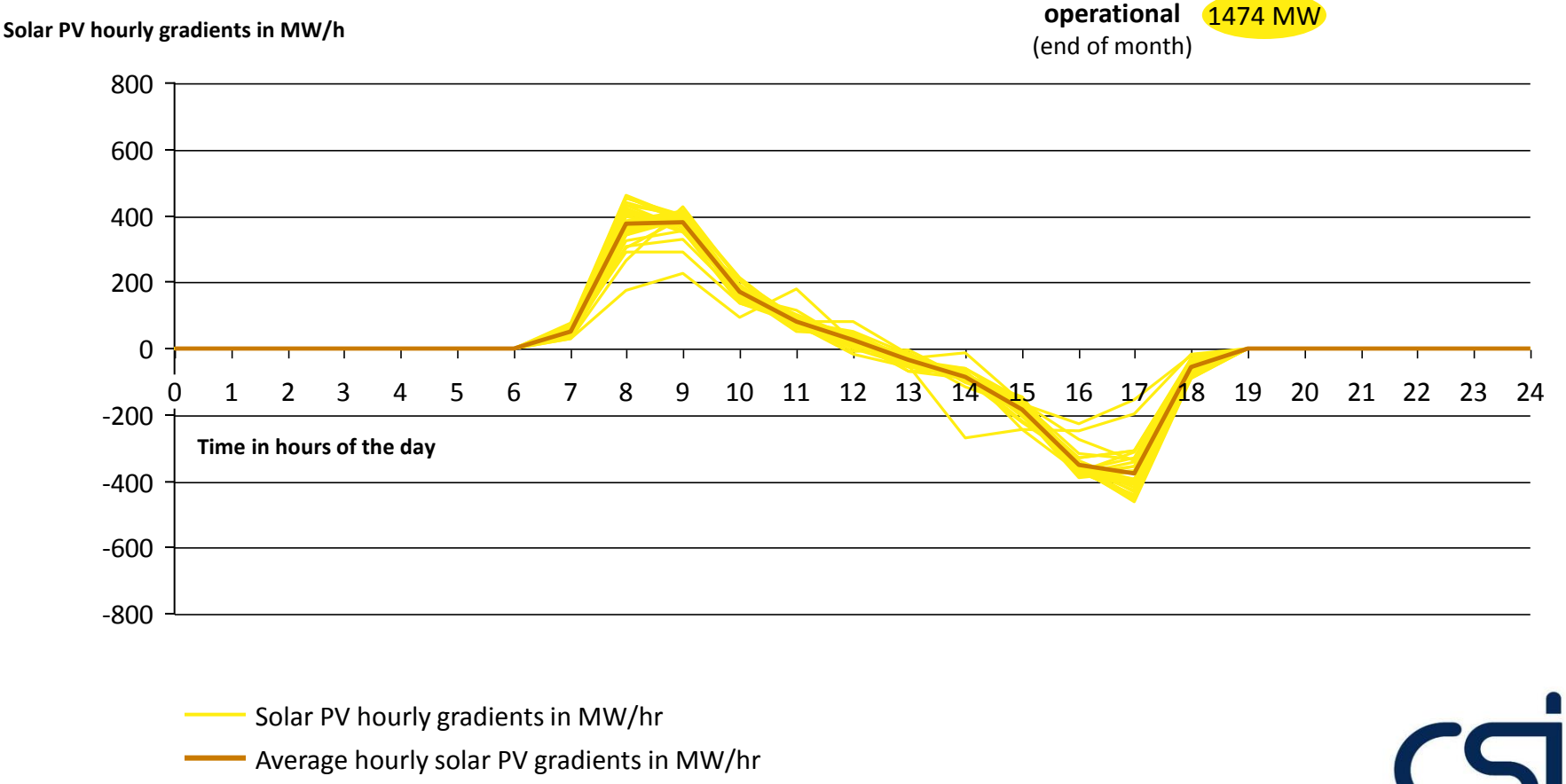
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in July 2017

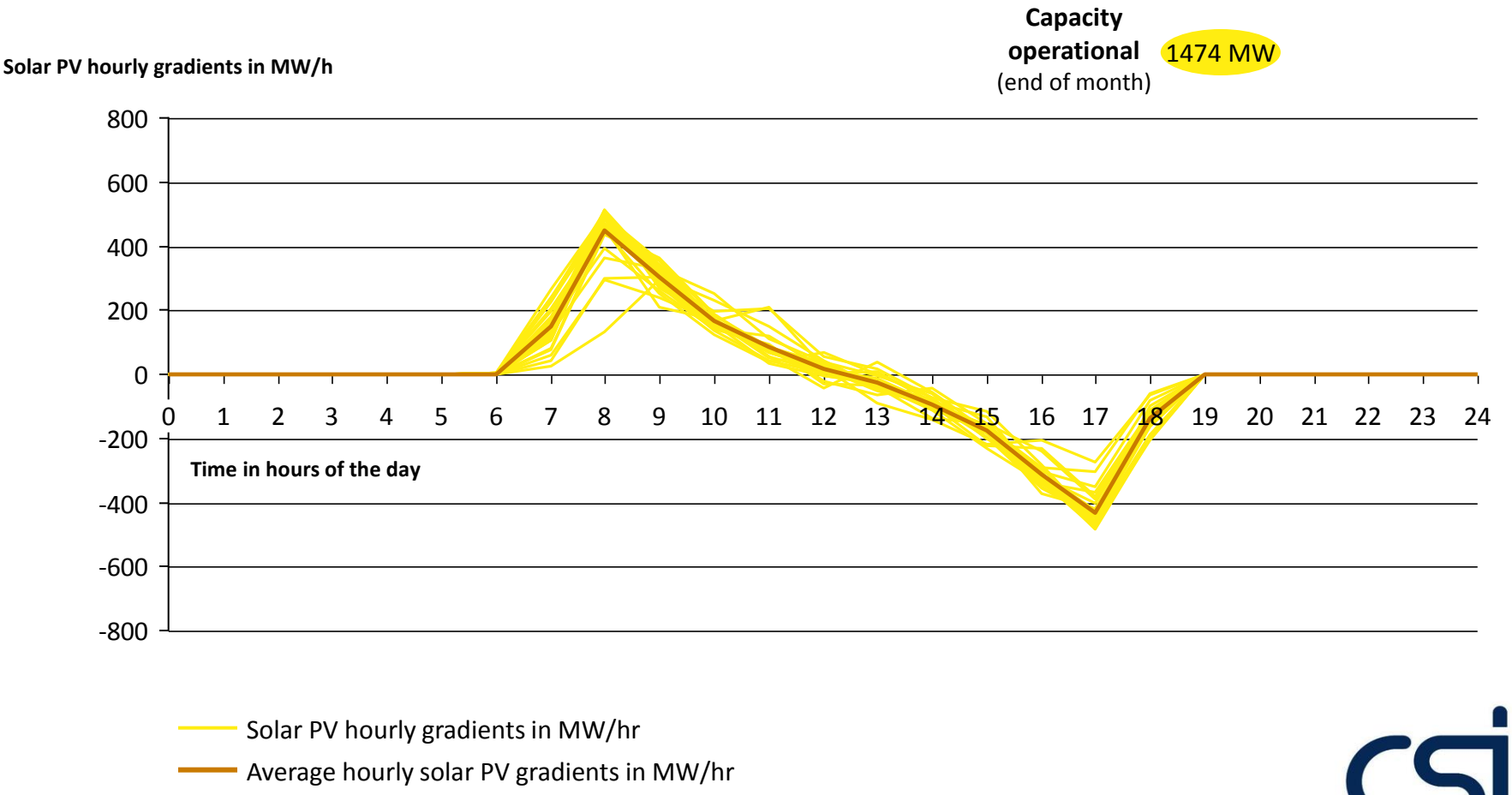
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in August 2017

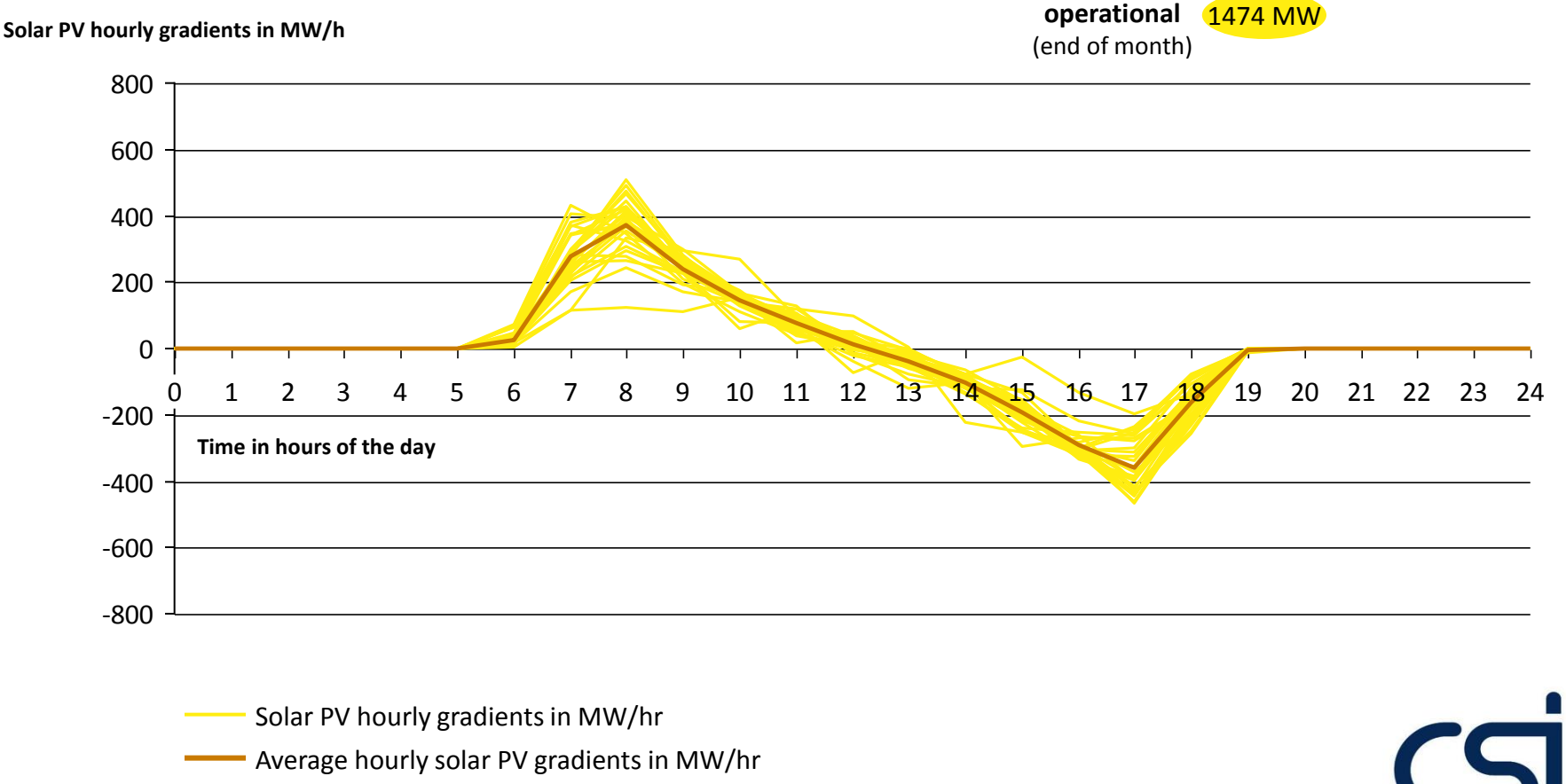
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in September 2017

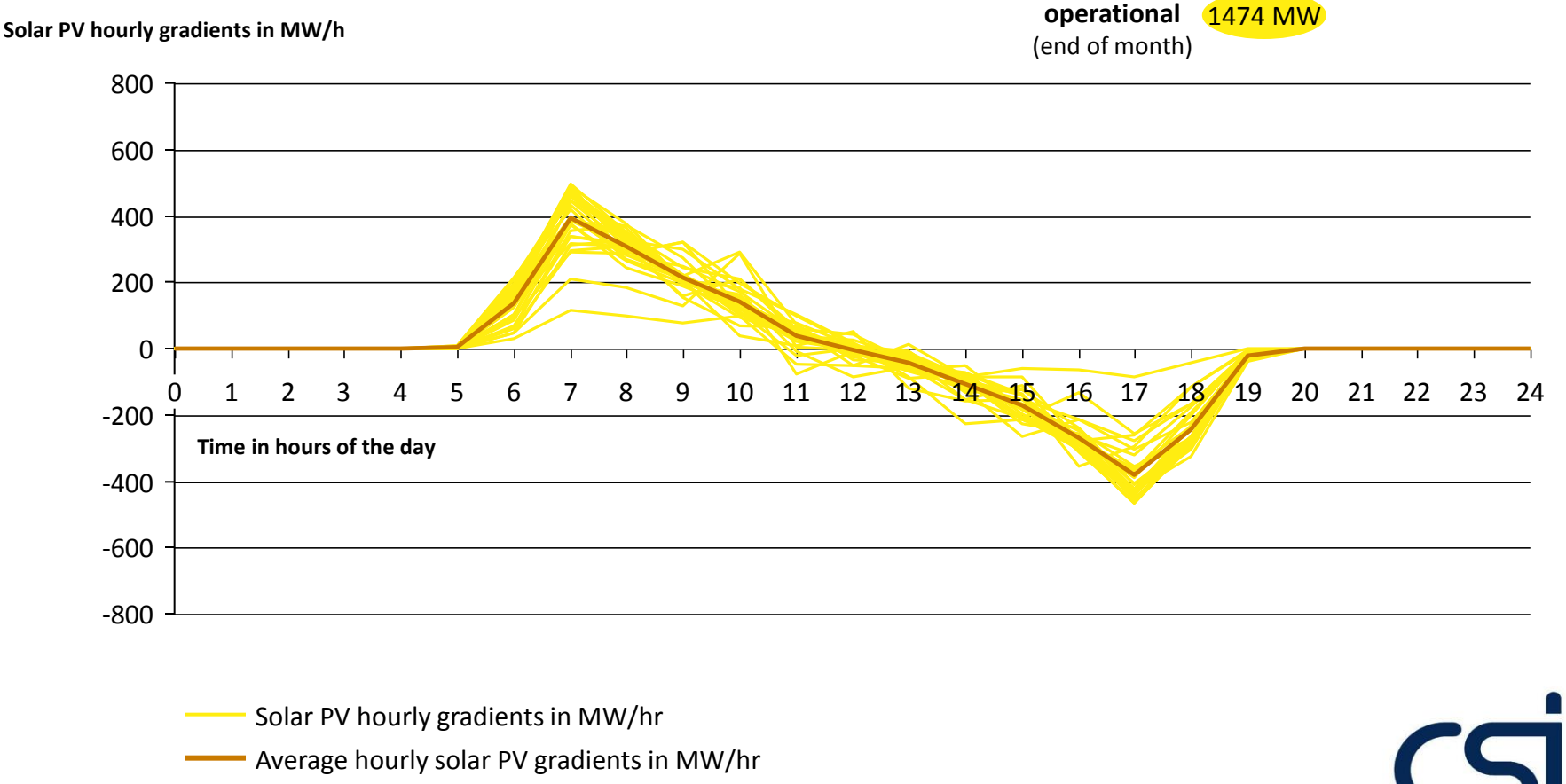
Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

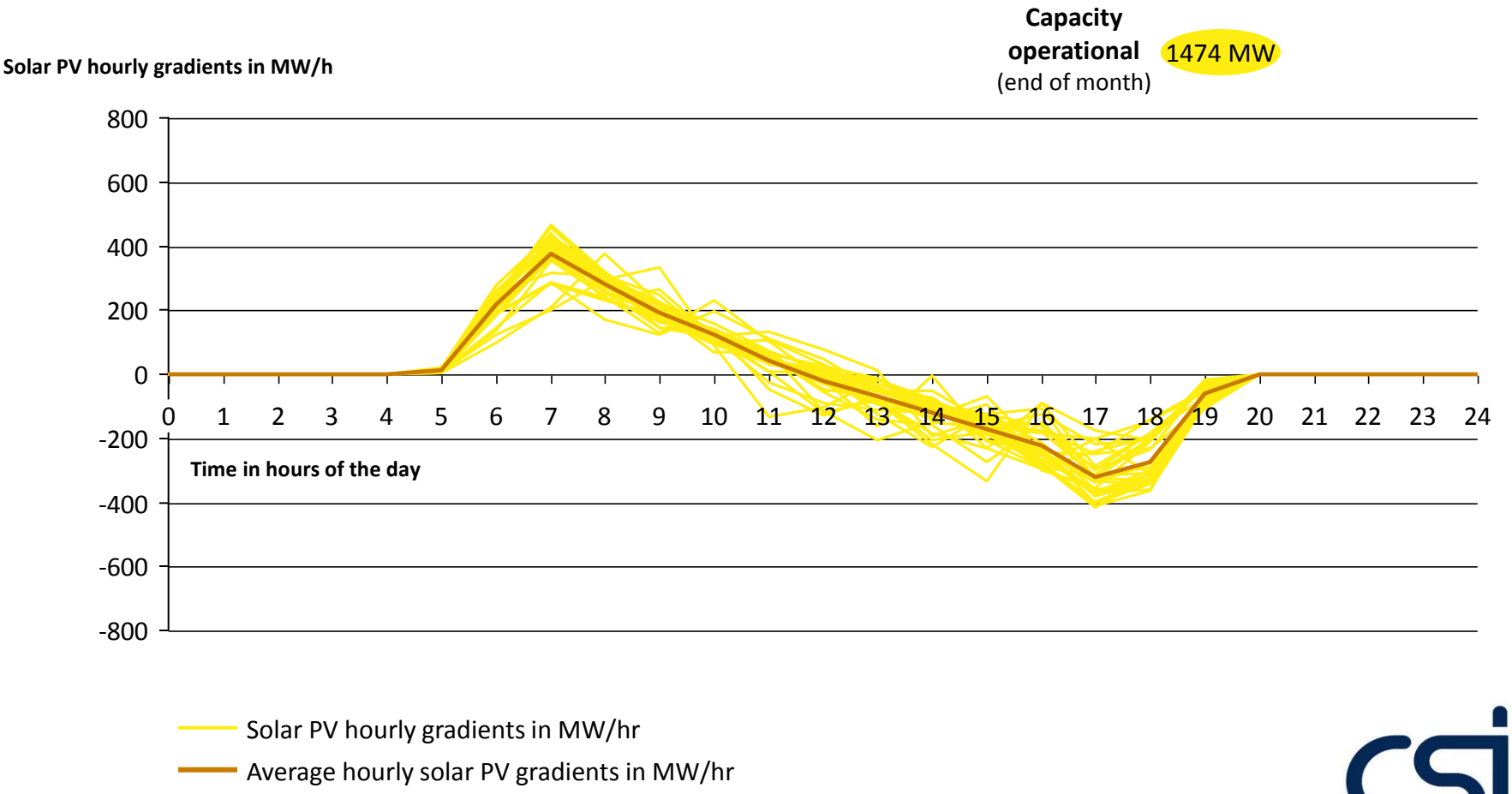
Solar PV 1-hour gradients in October 2017

Capacity operational (end of month) 1474 MW



Sources: Eskom; CSIR Energy Centre analysis

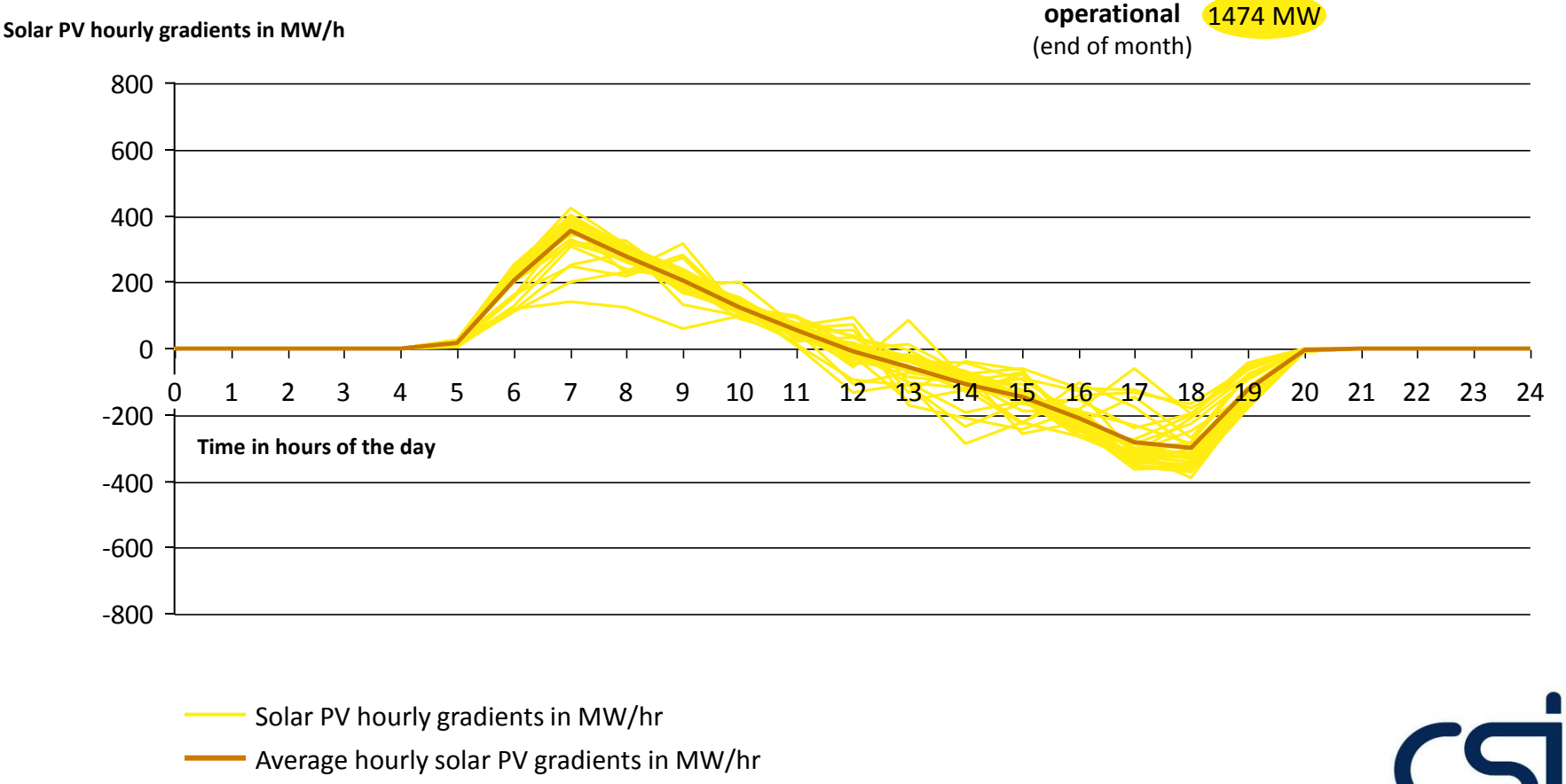
Solar PV 1-hour gradients in November 2017



Sources: Eskom; CSIR Energy Centre analysis

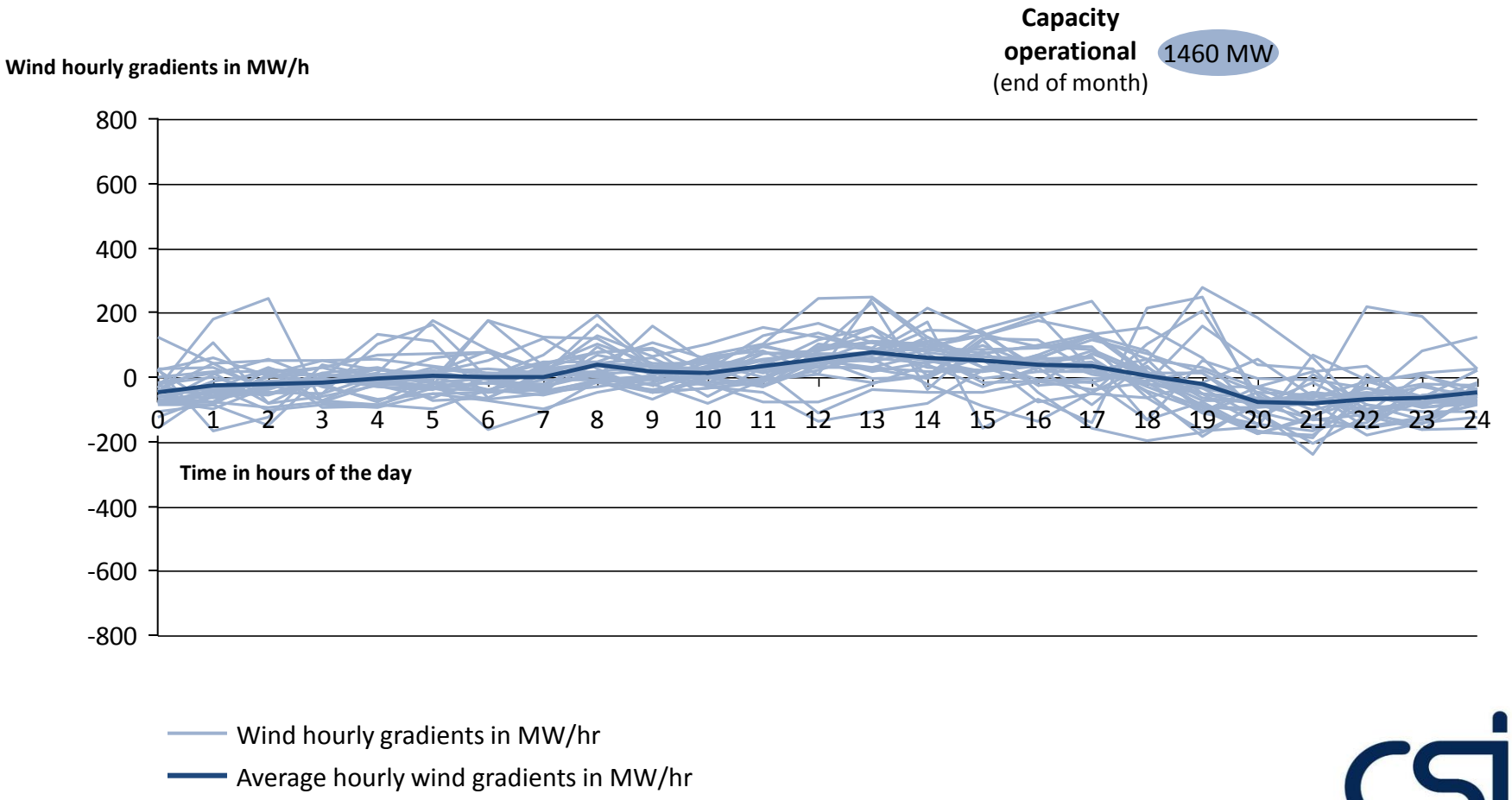
Solar PV 1-hour gradients in December 2017

Capacity operational (end of month) 1474 MW



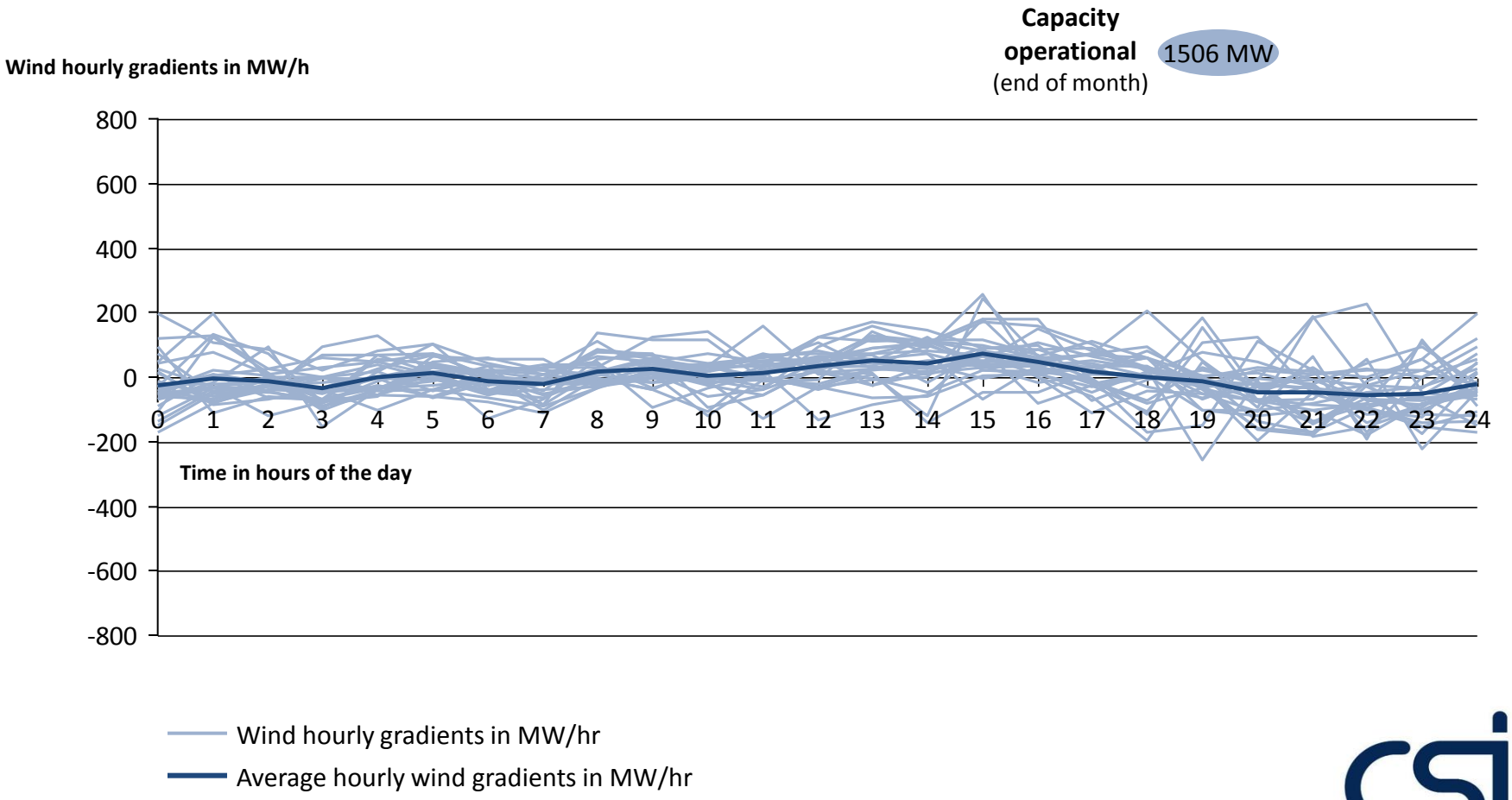
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in January 2017



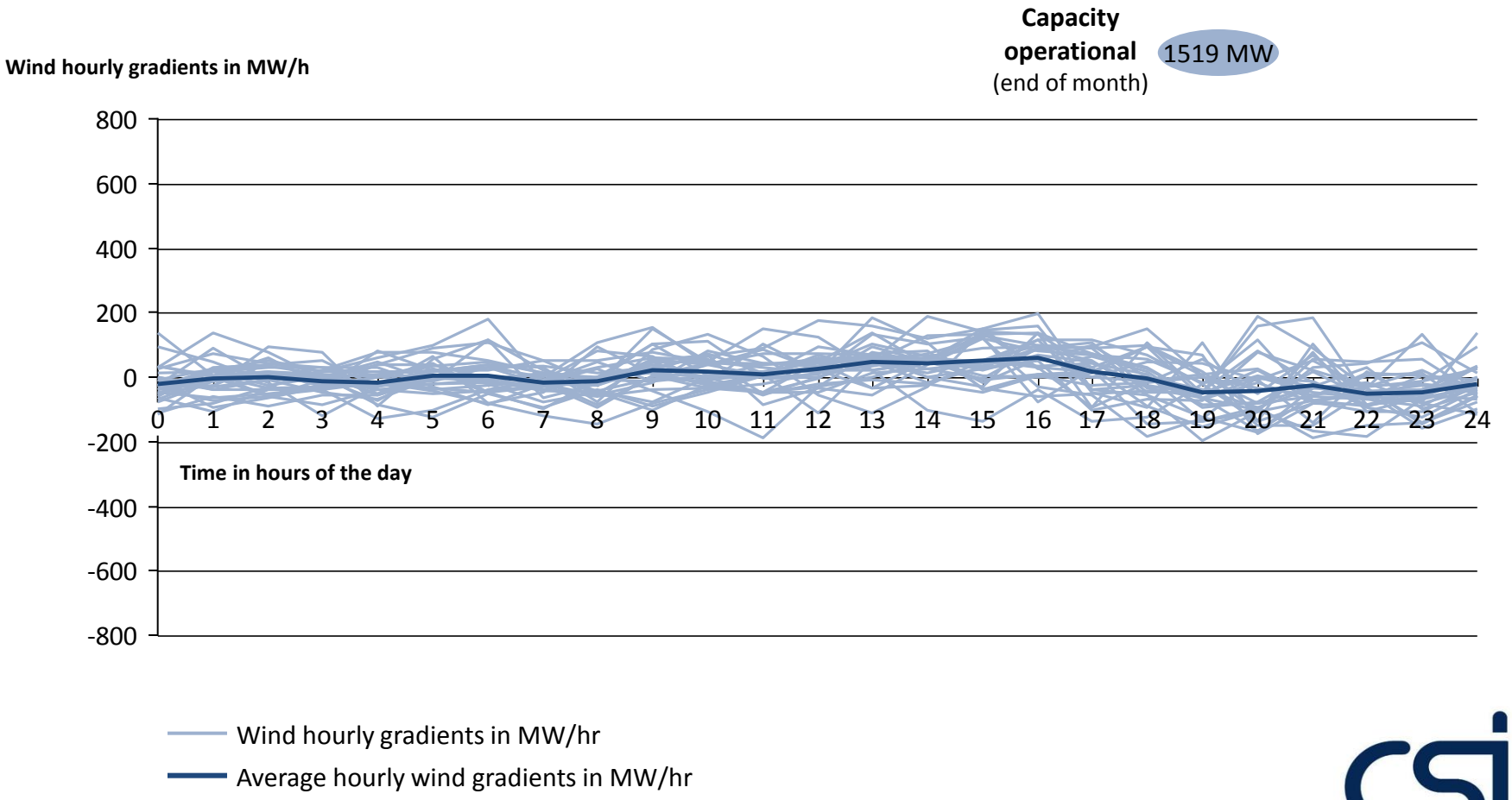
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in February 2017



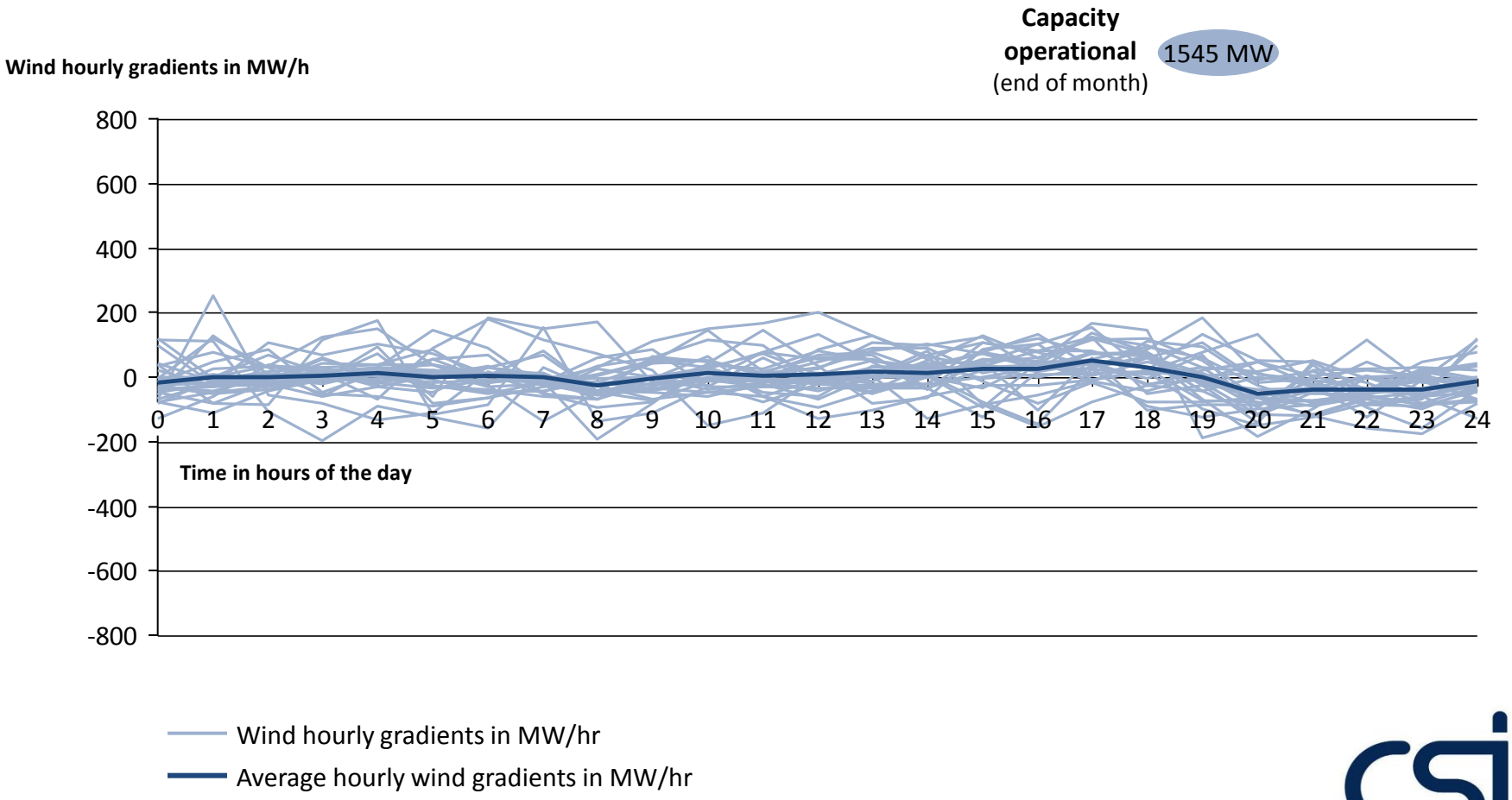
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in March 2017



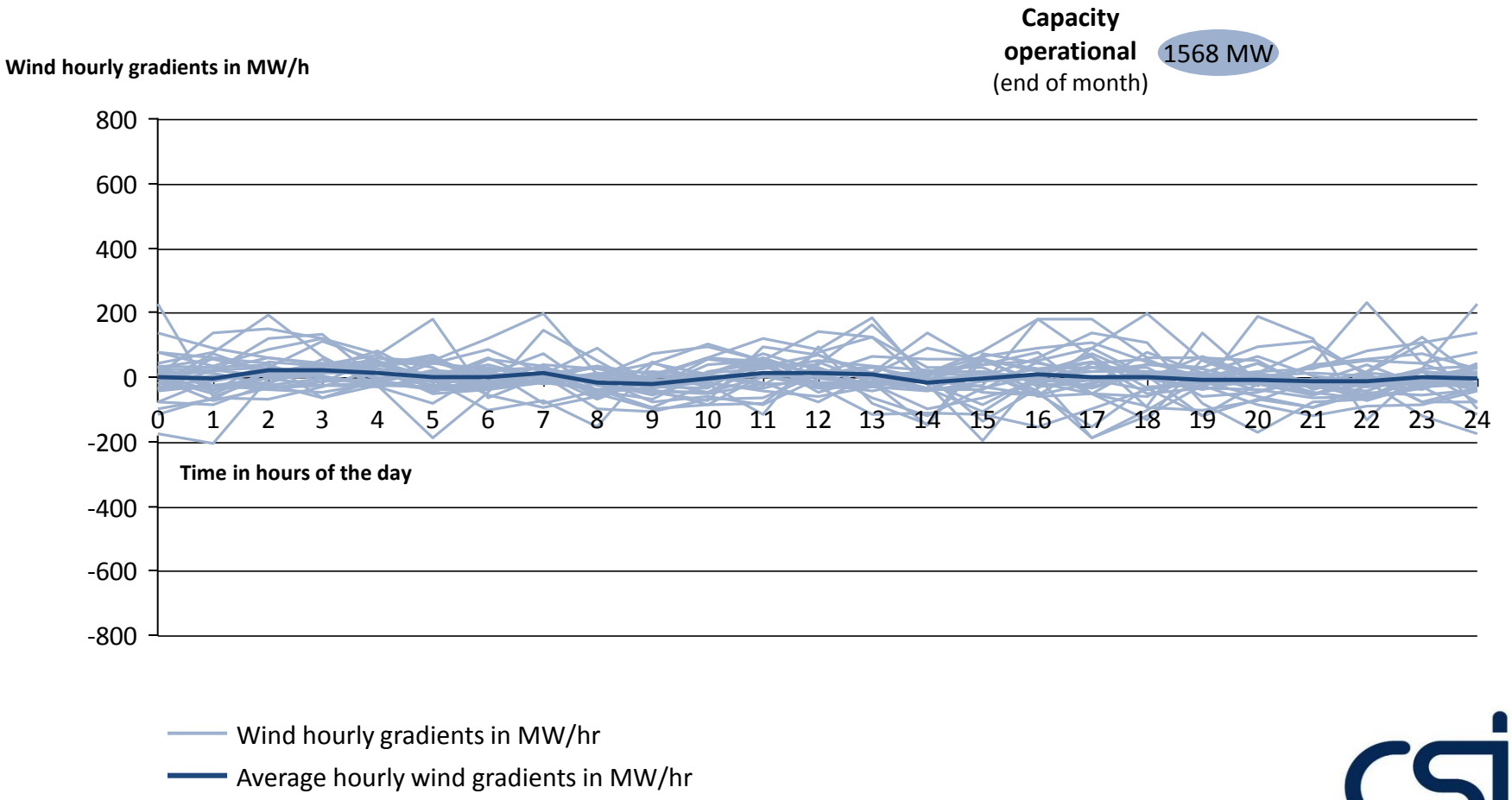
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in April 2017



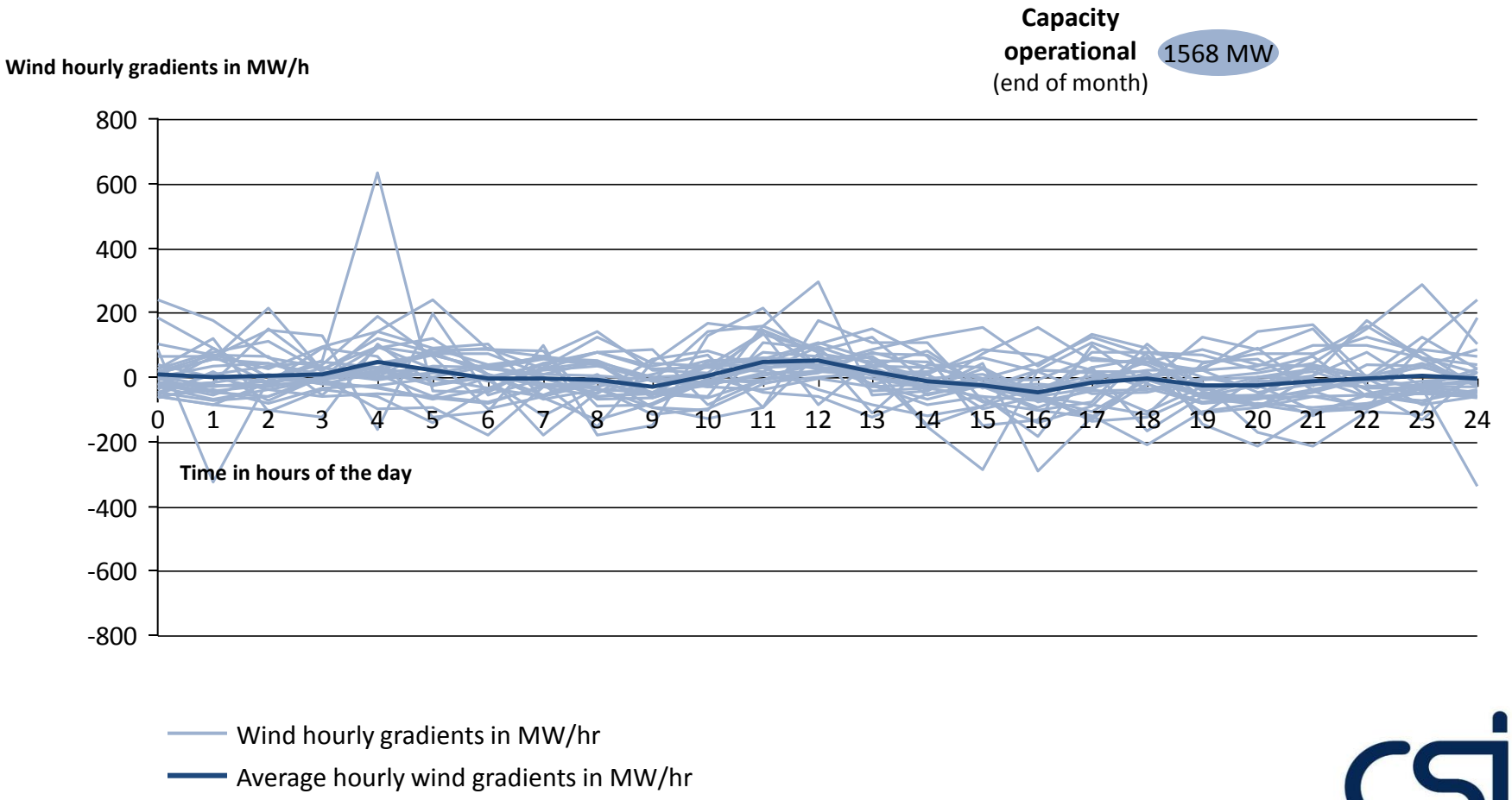
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in May 2017



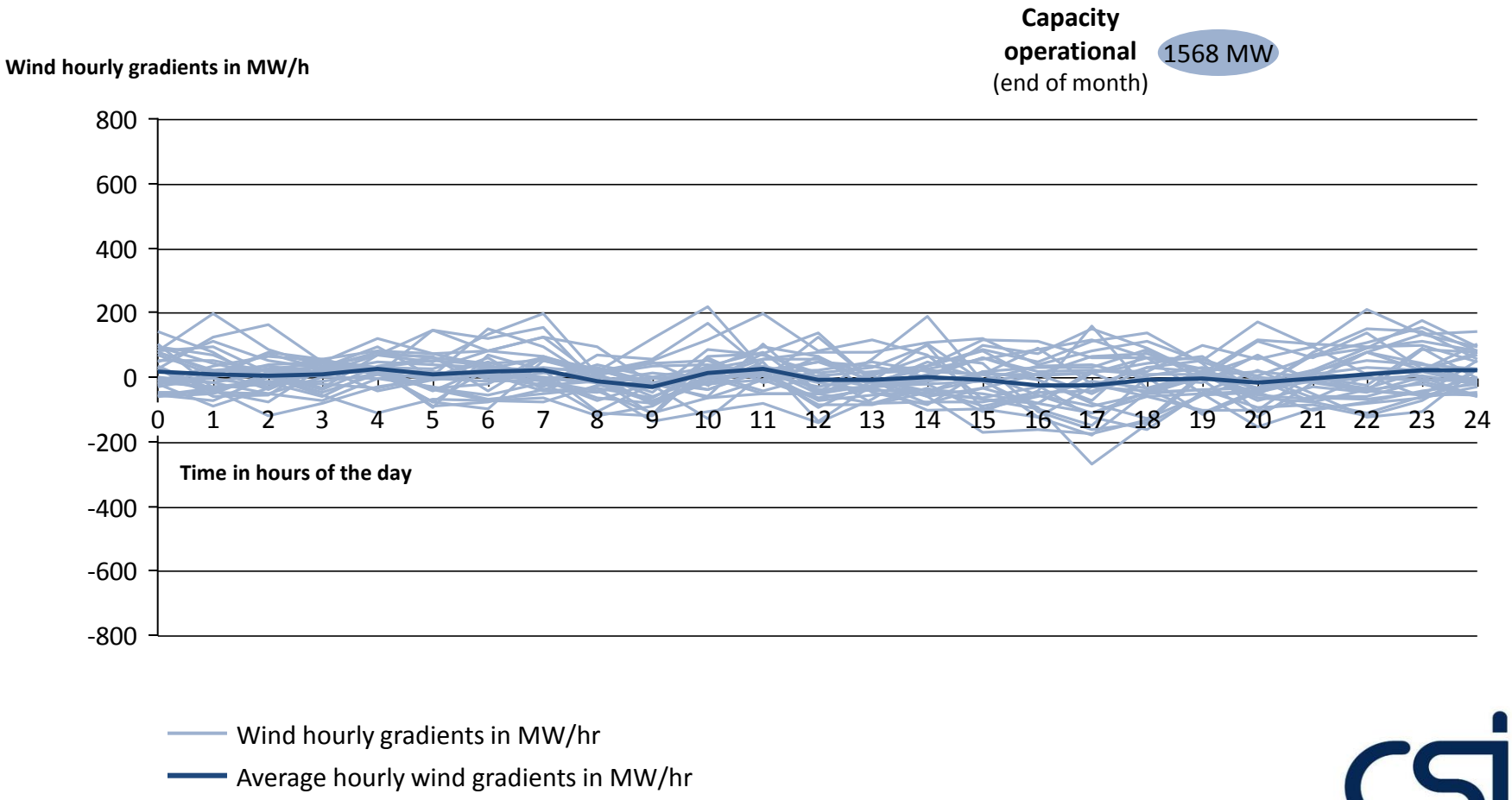
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in June 2017



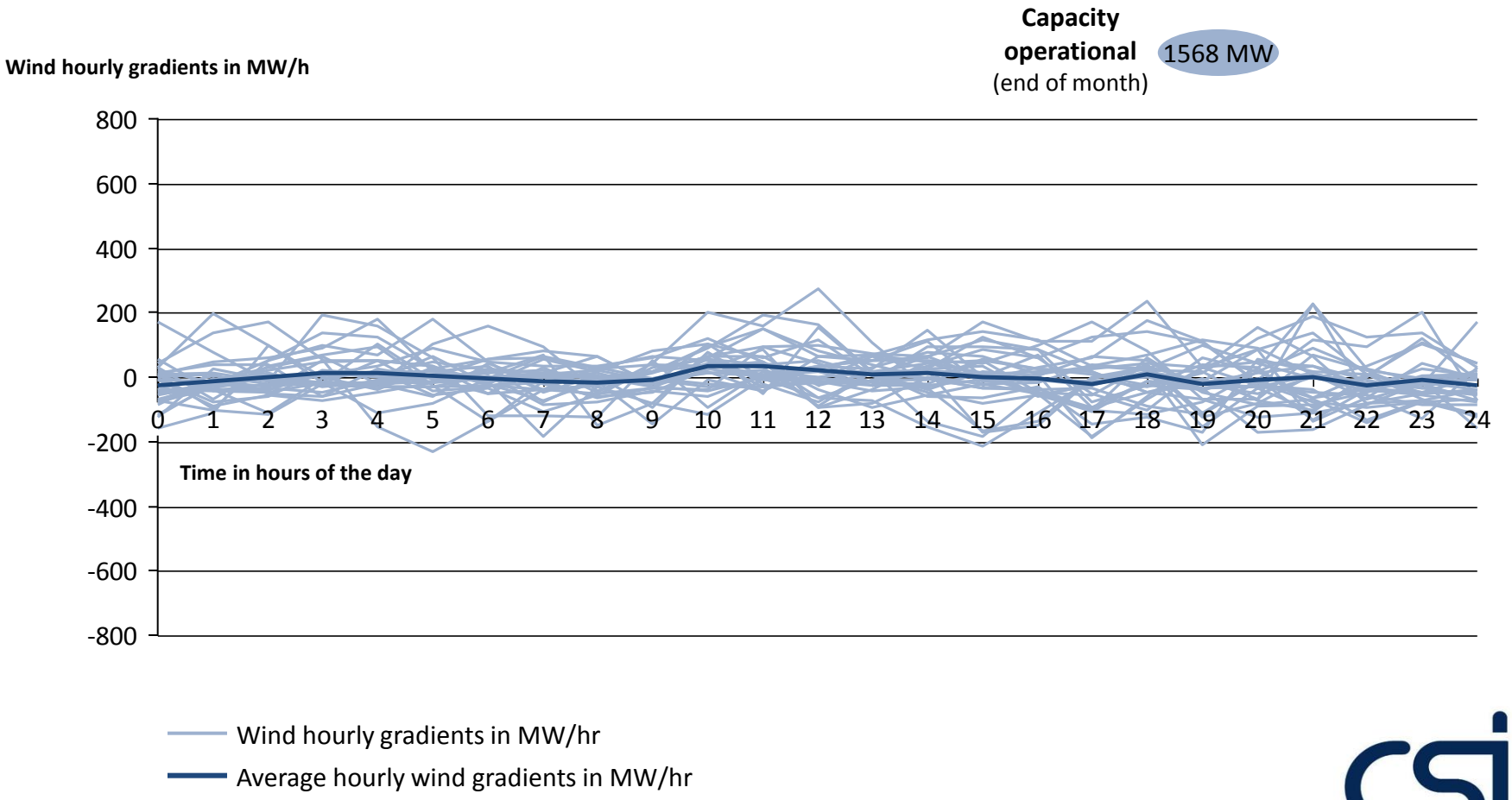
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in July 2017



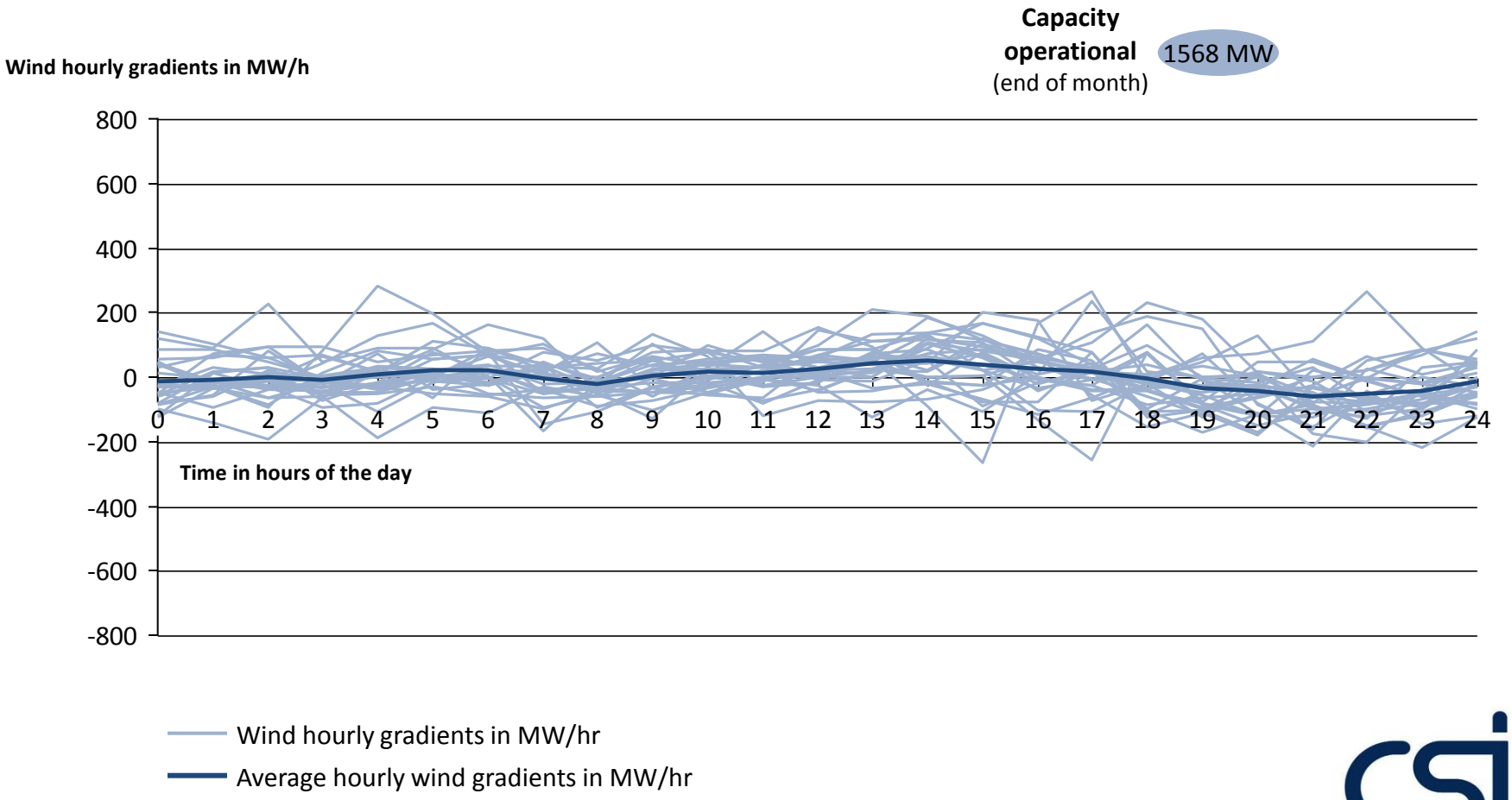
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in August 2017



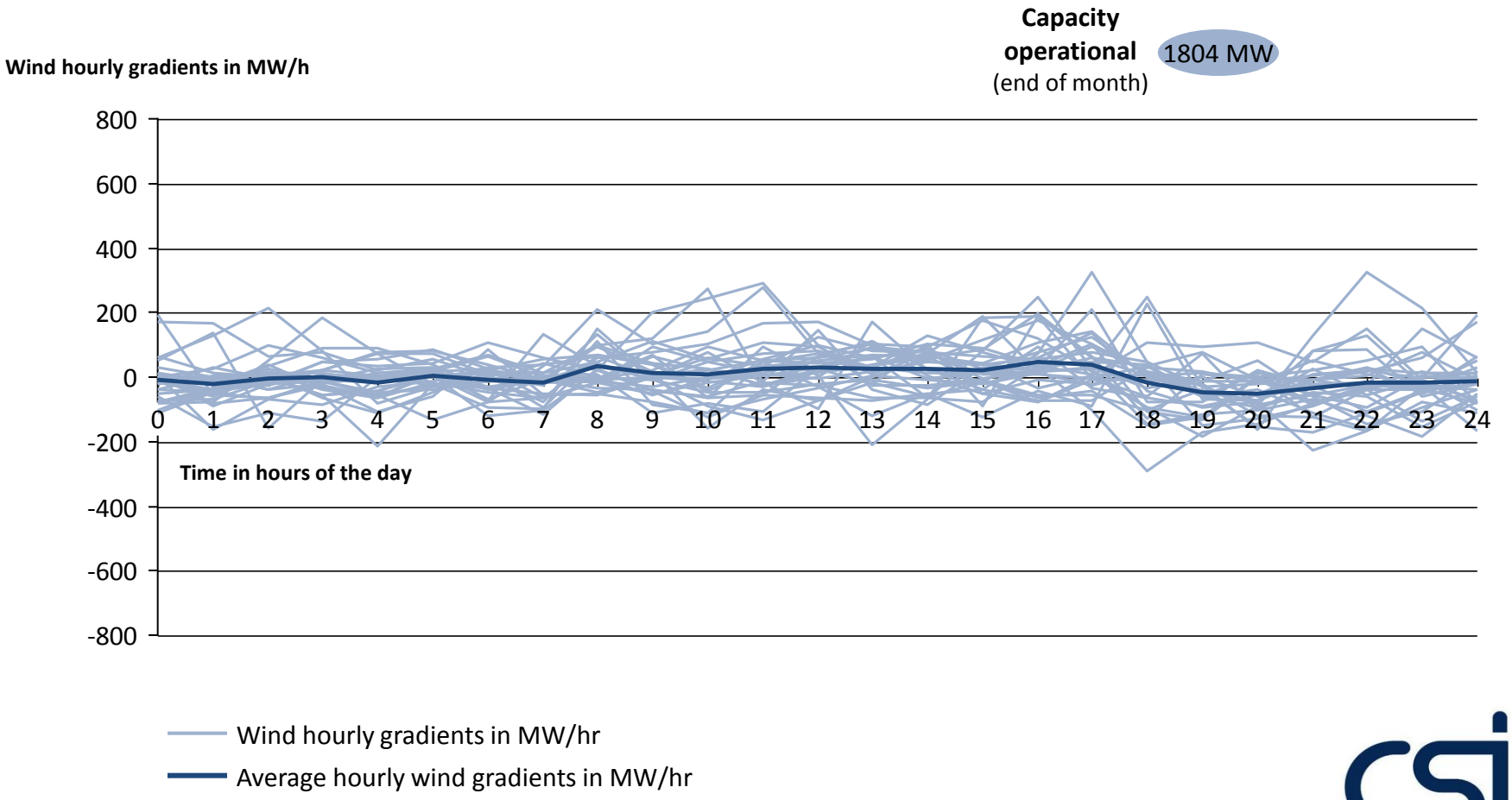
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in September 2017



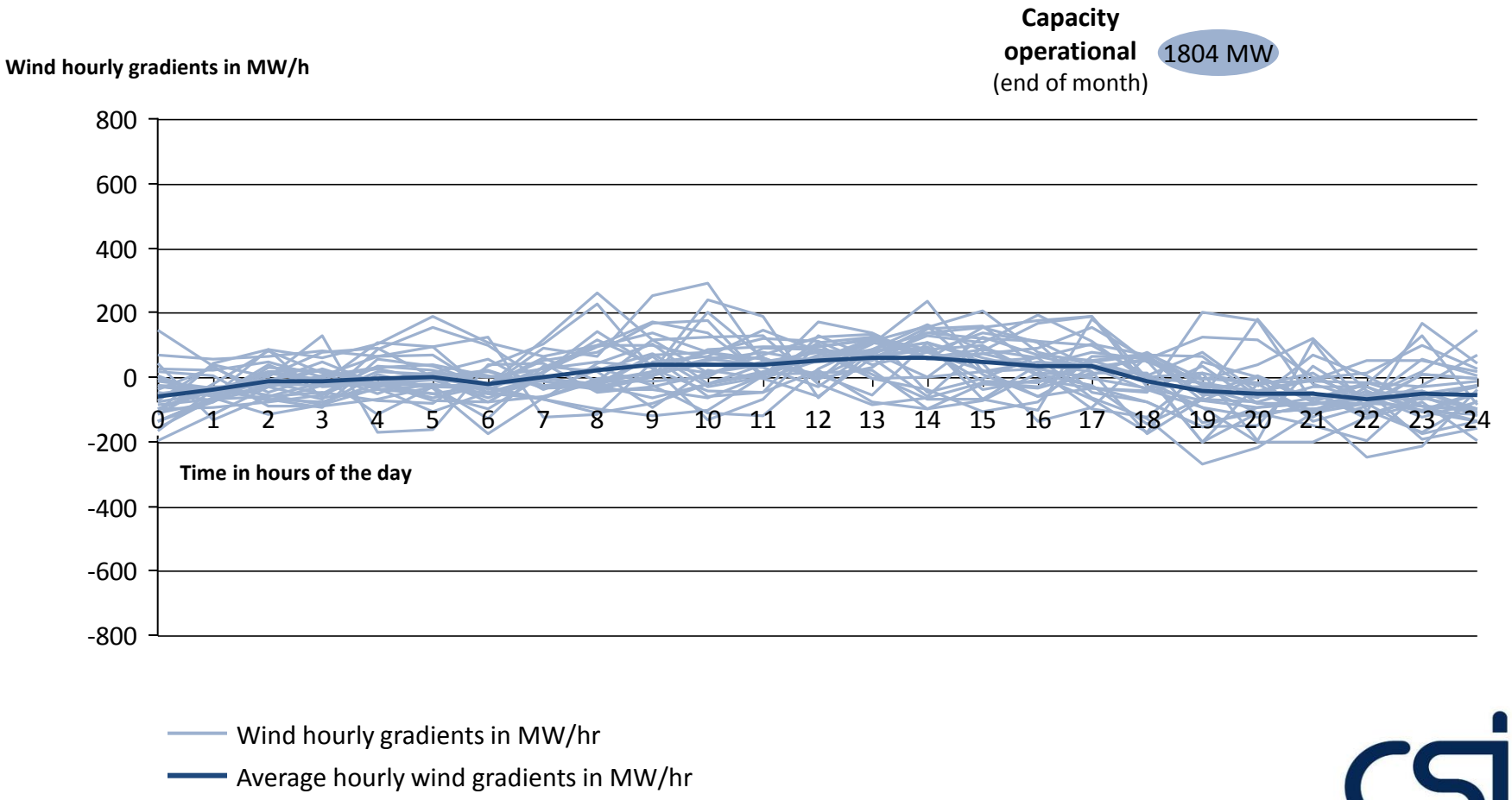
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in October 2017



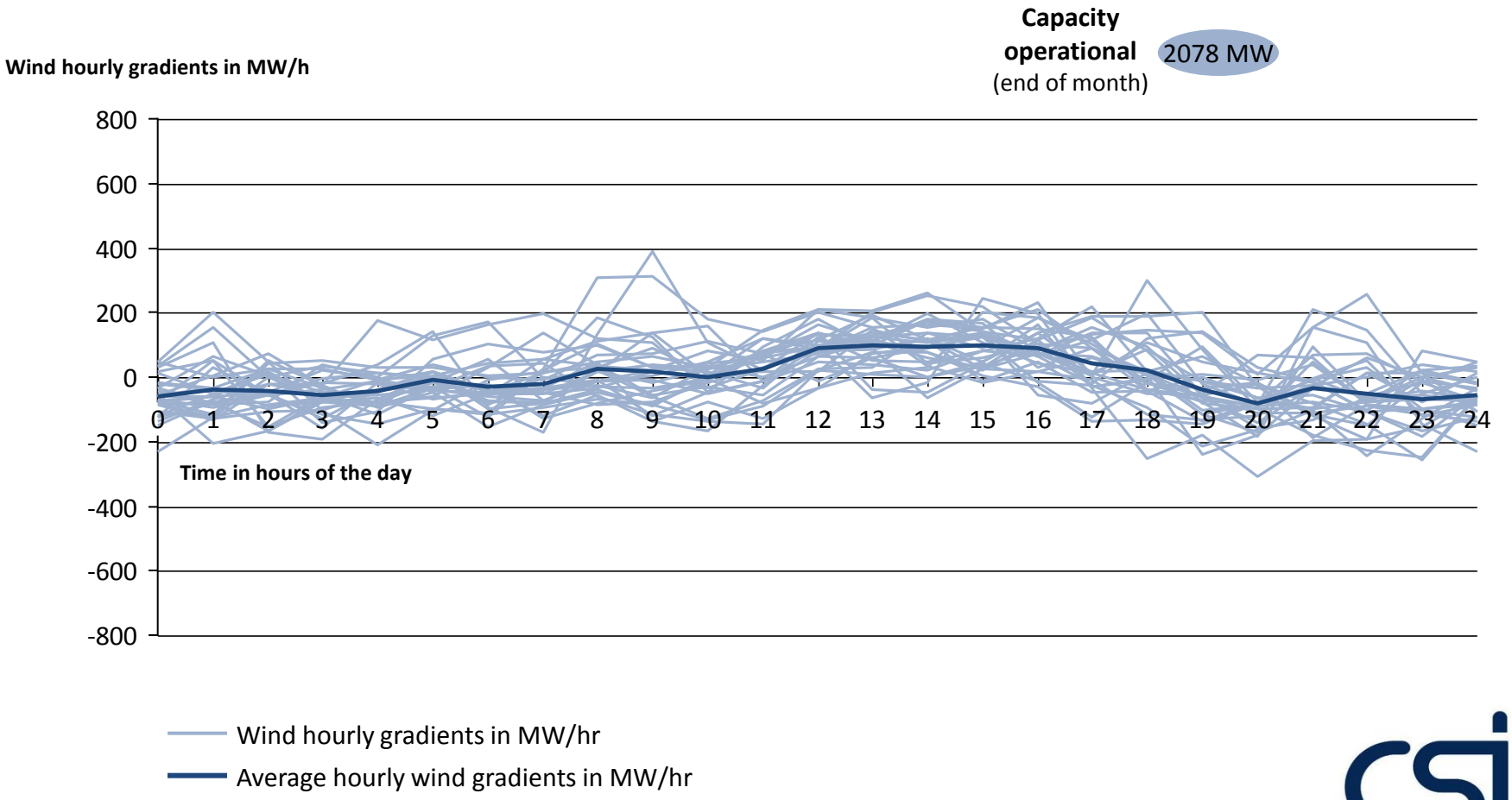
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in November 2017



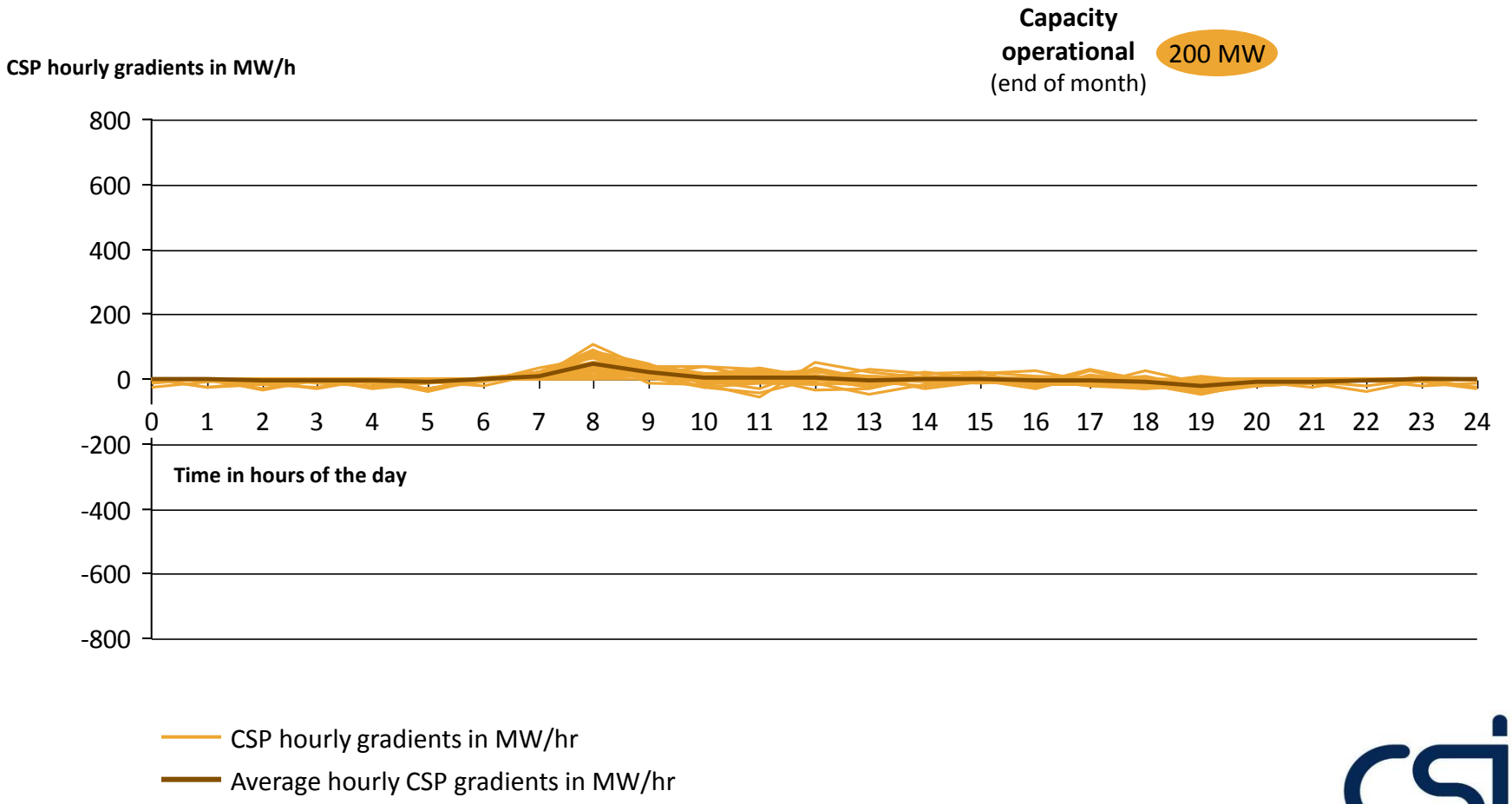
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in December 2017



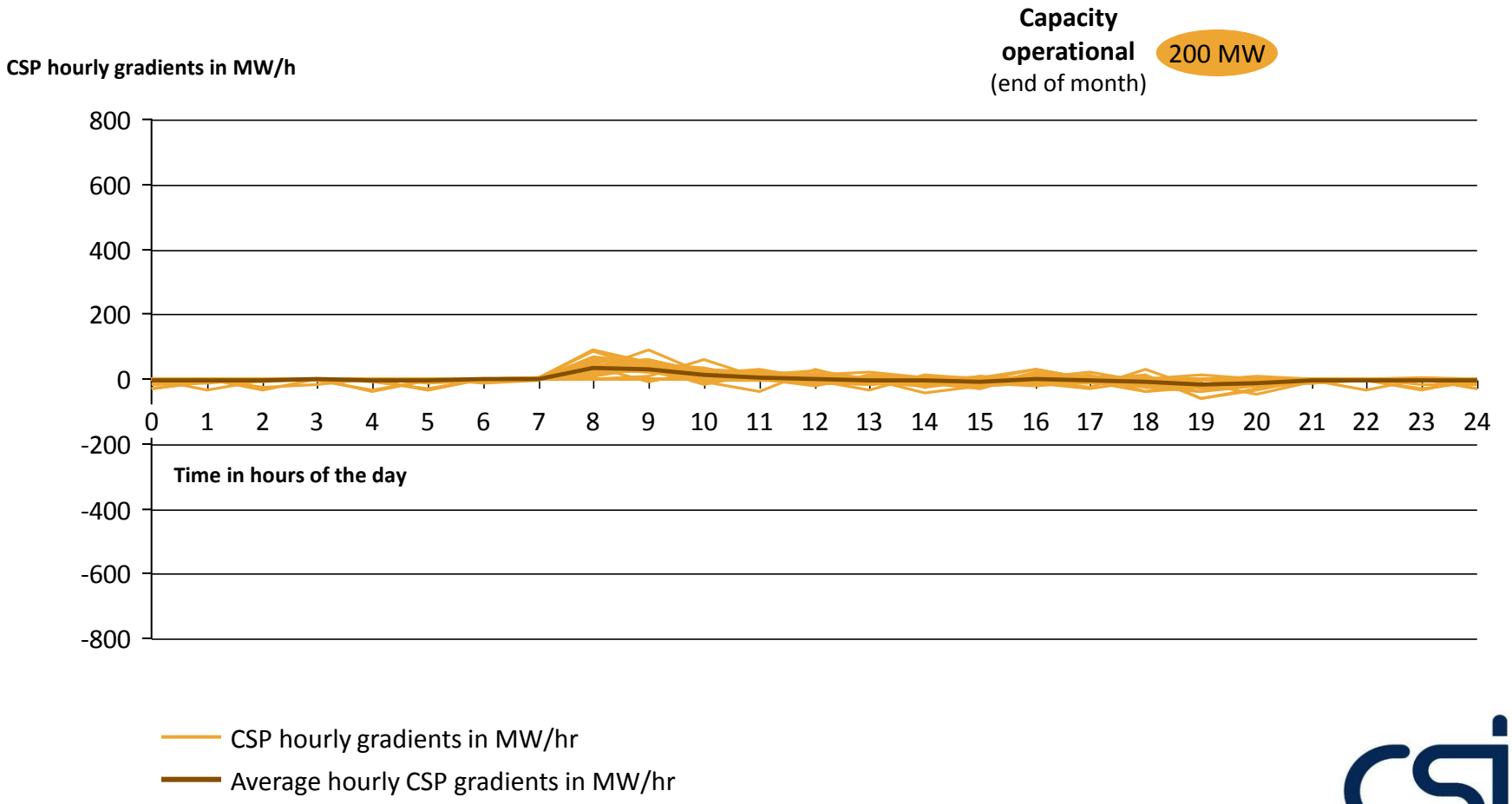
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in January 2017



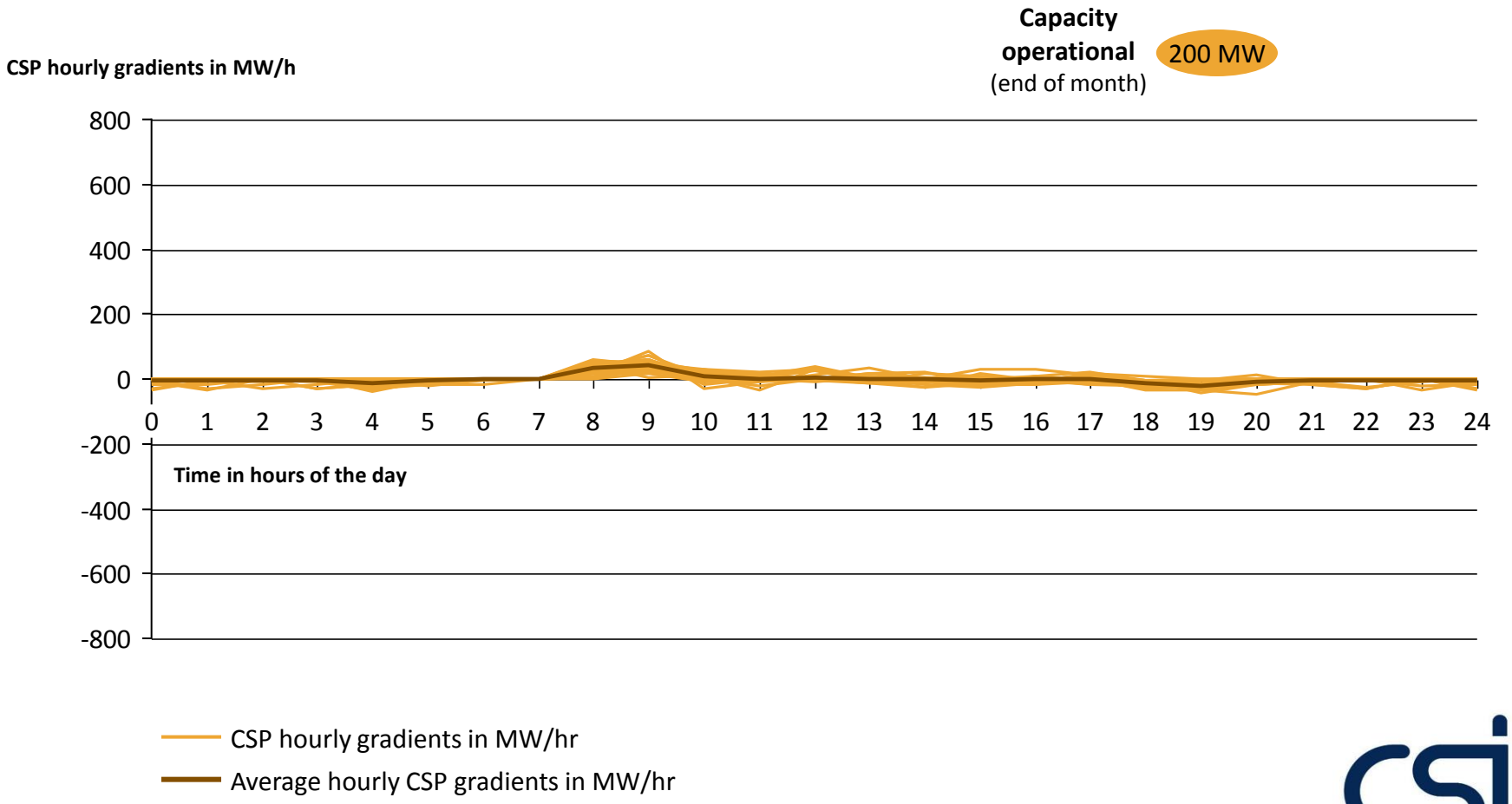
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in February 2017



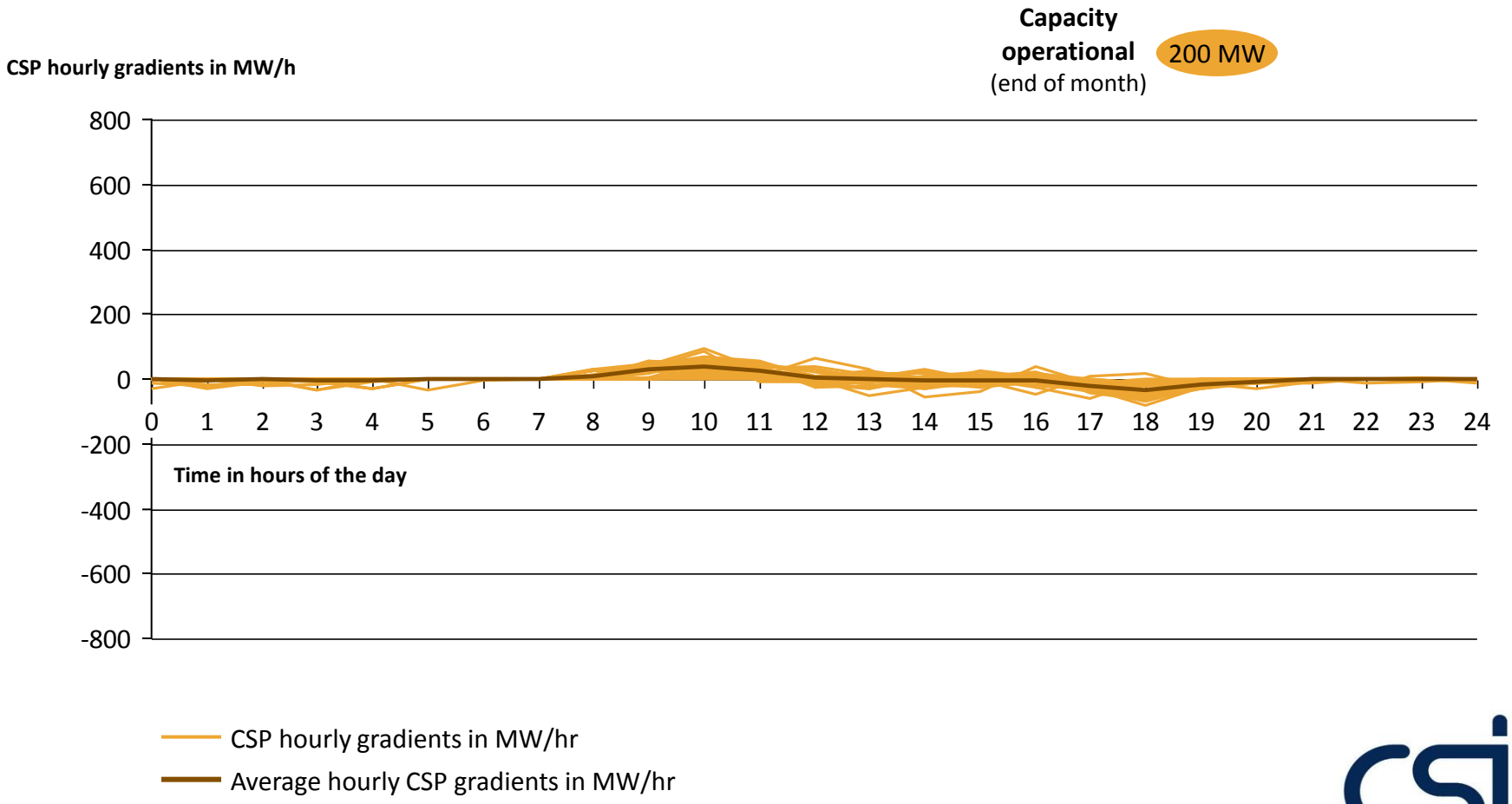
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in March 2017



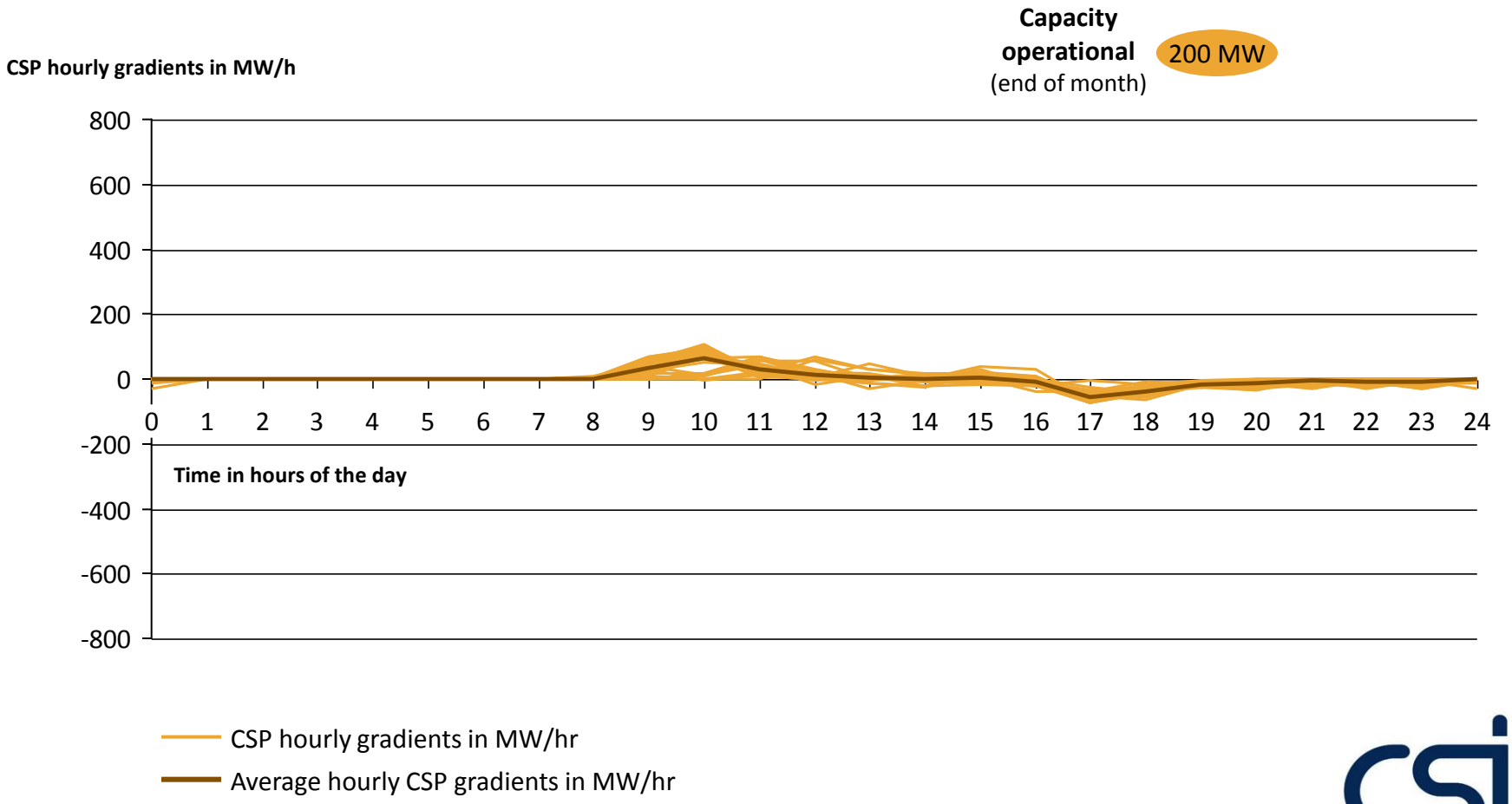
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in April 2017



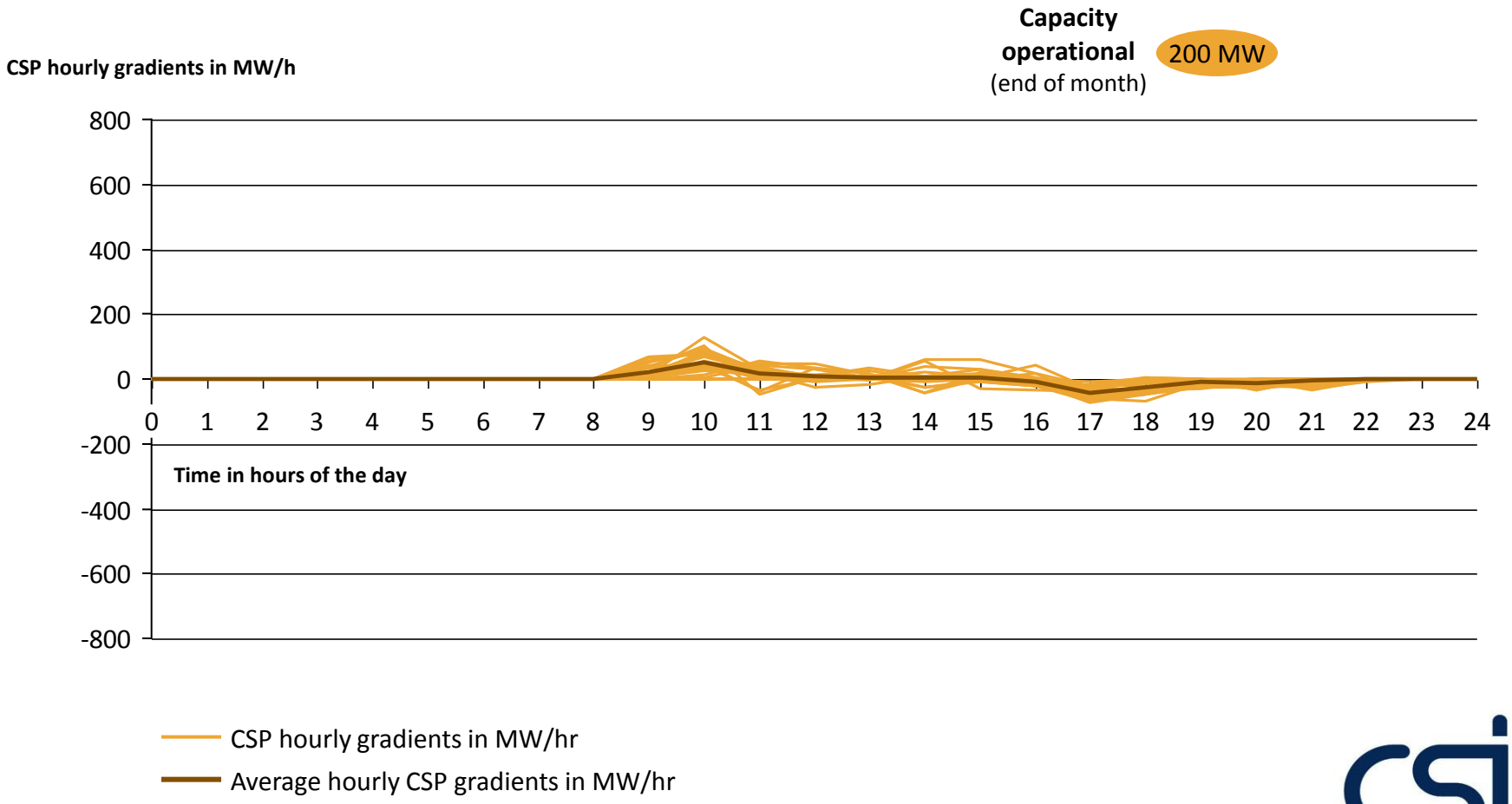
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in May 2017



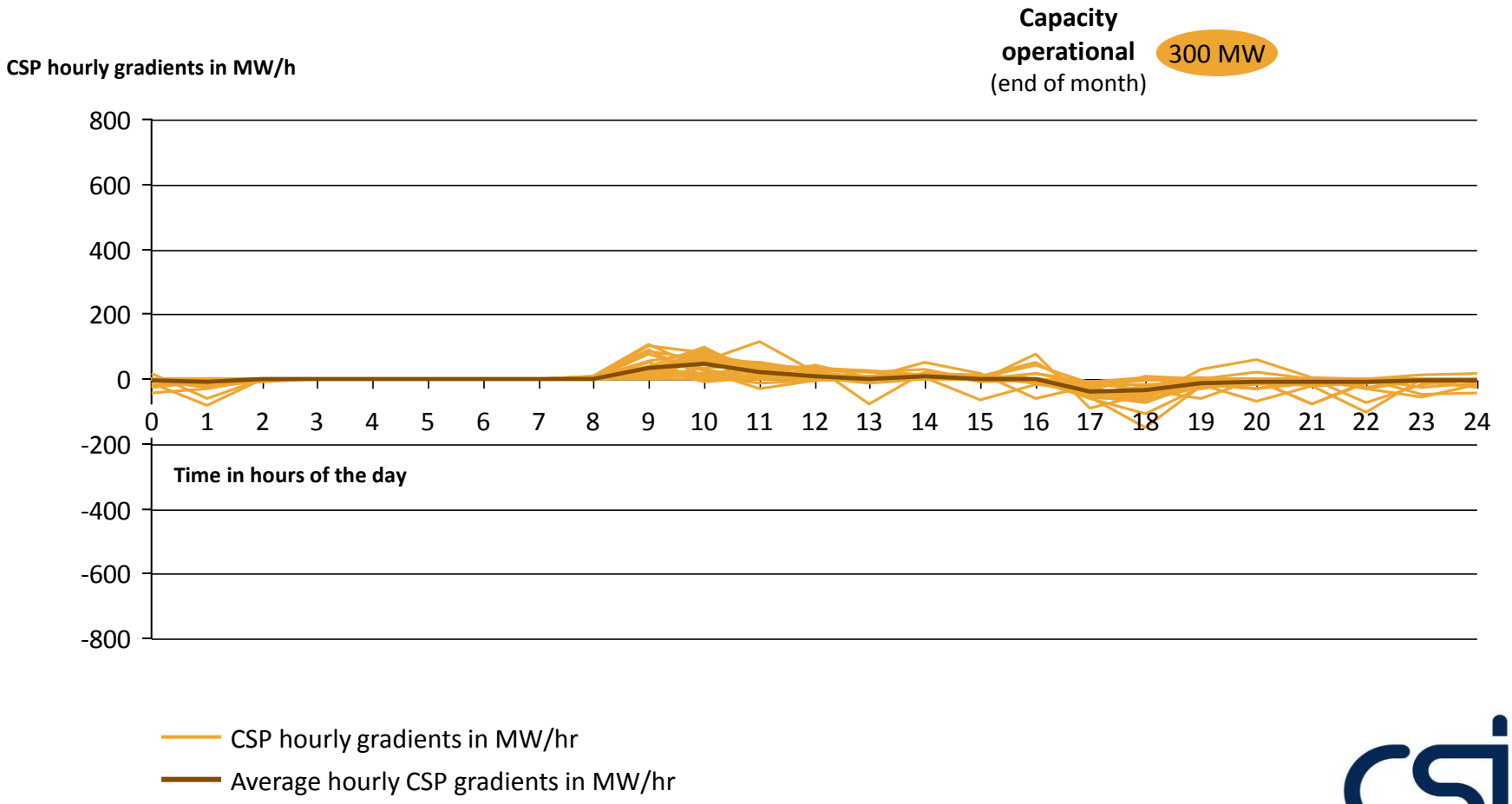
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in June 2017



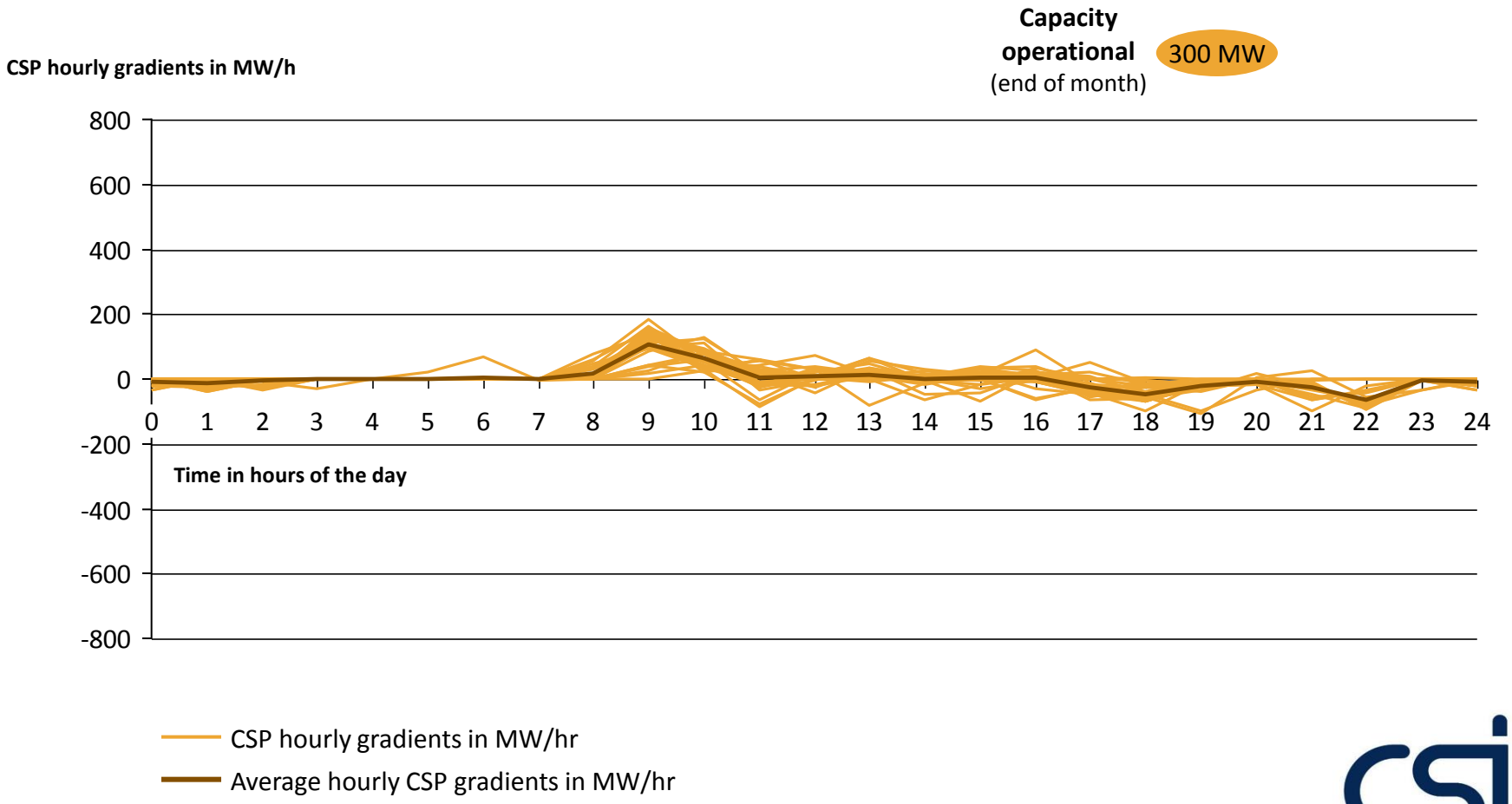
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in July 2017



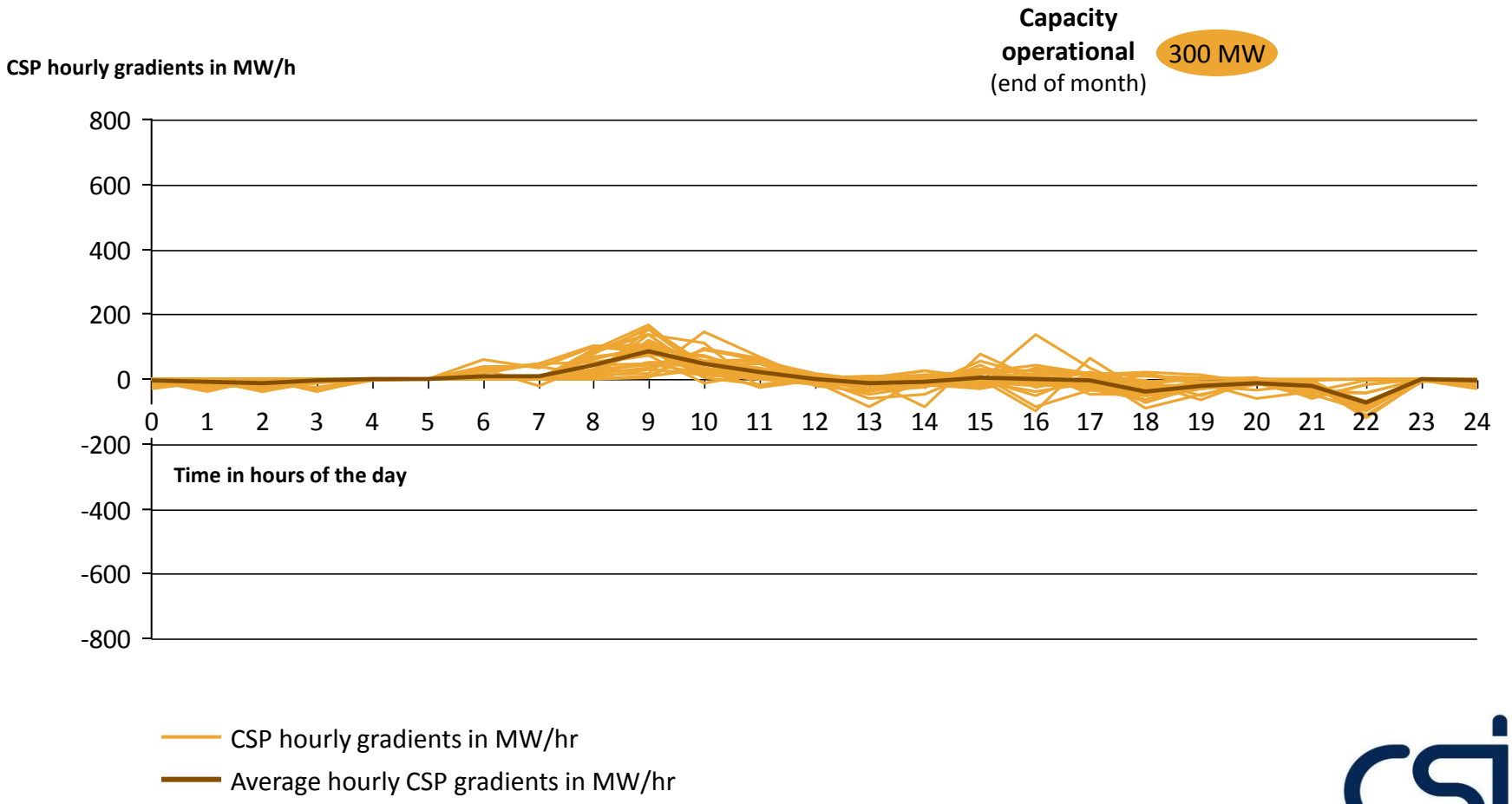
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in August 2017



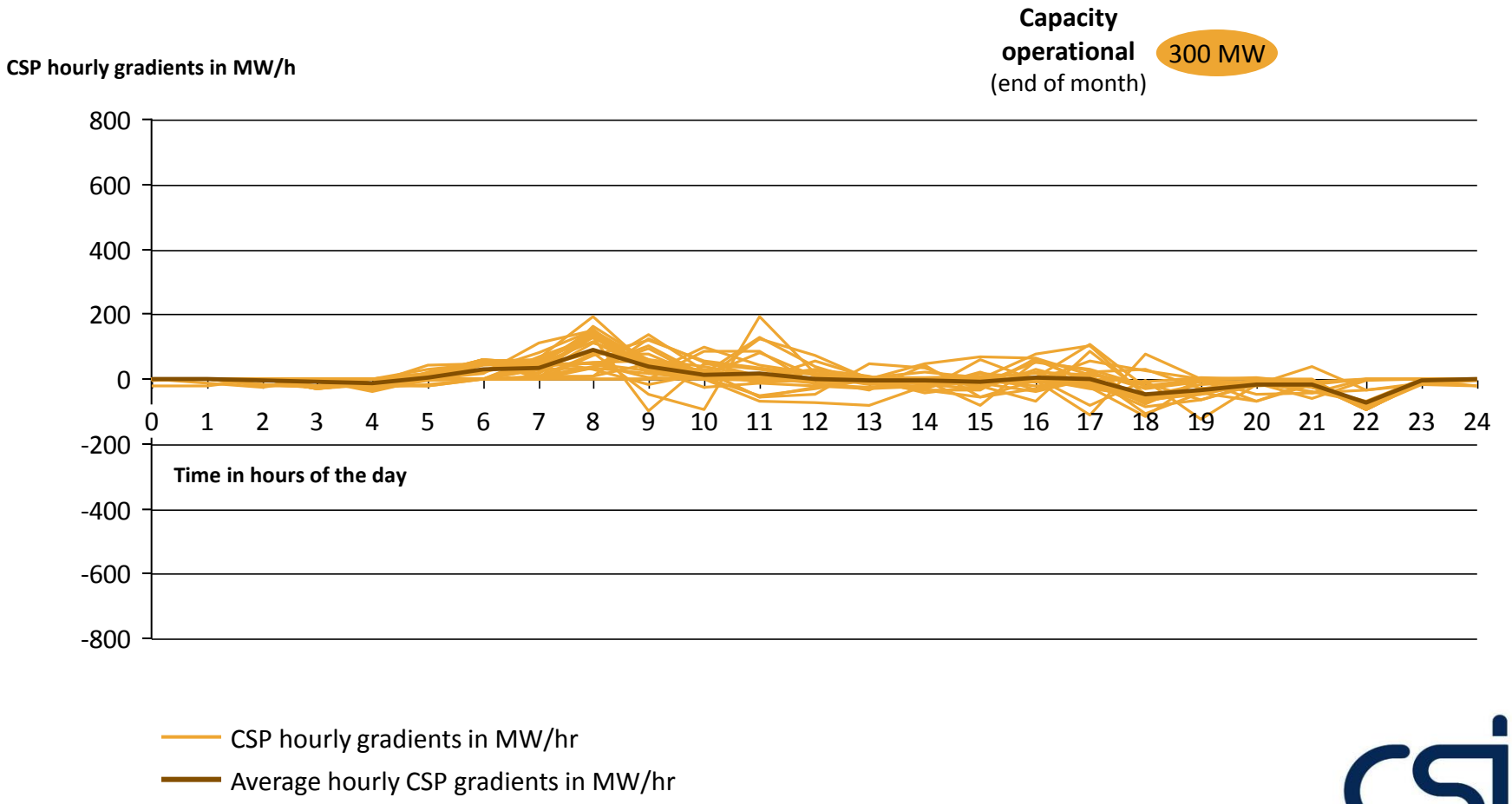
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in September 2017



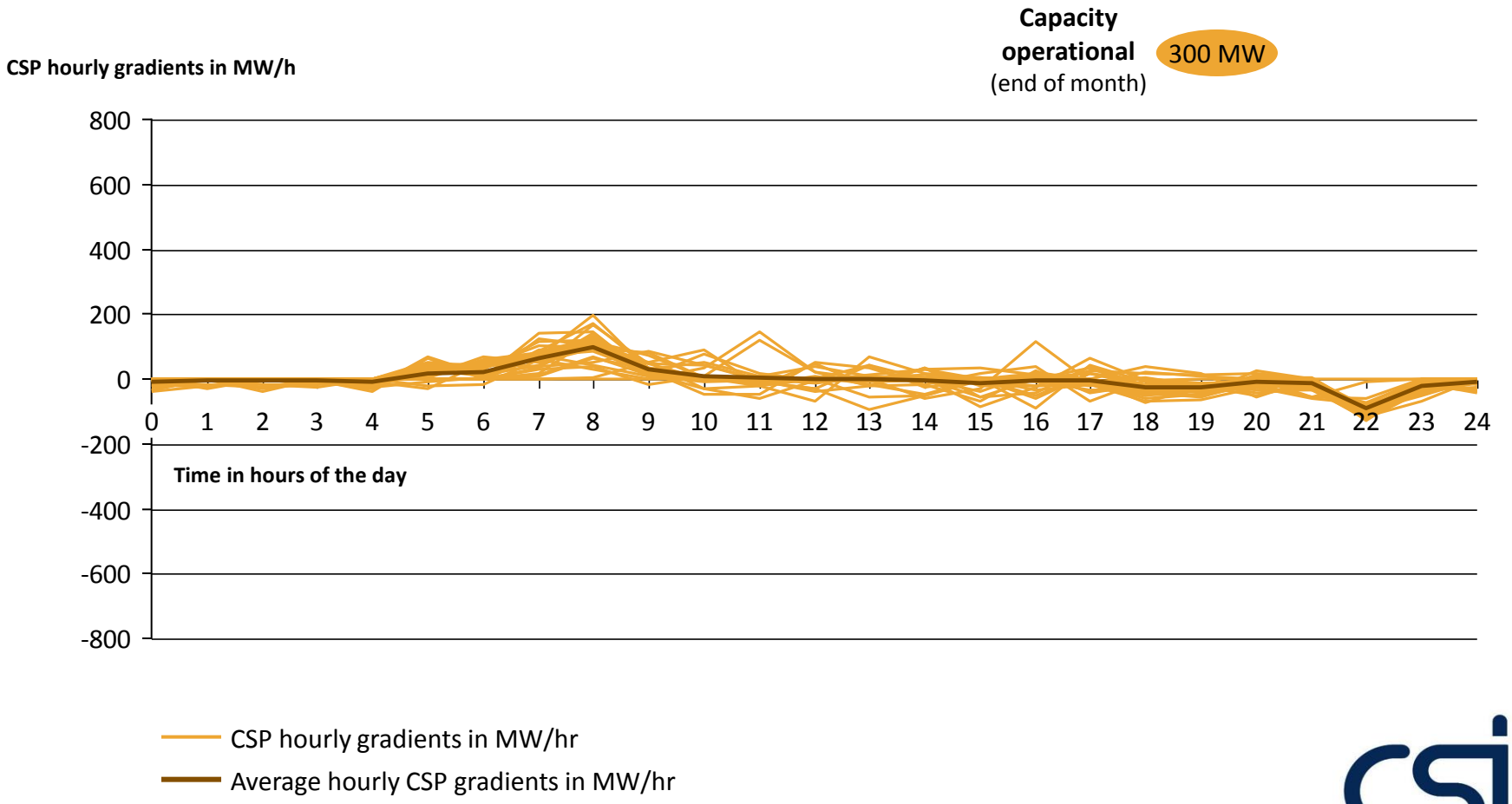
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in October 2017



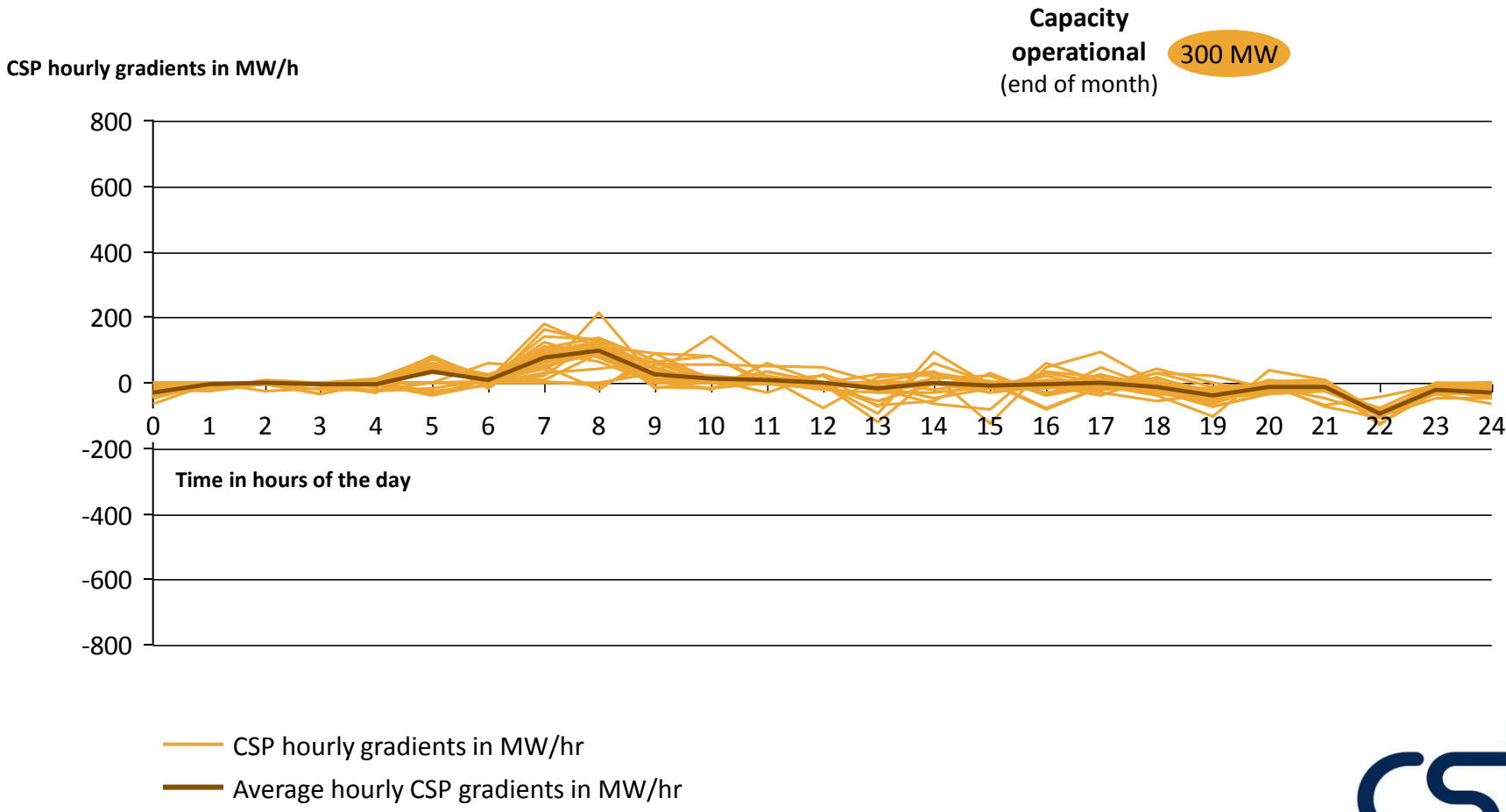
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in November 2017



Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in December 2017



Sources: Eskom; CSIR Energy Centre analysis

Agenda

1. Overview and status of REIPPPP
2. Overview actual electricity production data for 2017
3. Monthly electricity production
4. Weekly electricity production
5. Daily electricity production
6. Hourly electricity production and gradients
7. Actual load shedding in 2017

There has been no load shedding in 2017

0 days, 0 hours of load shedding

0 GWh of unserved energy

Sources: Eskom Twitter account; CSIR Energy Centre analysis

Data sources

Data sources

Actual production data of wind, solar PV and of the conventional fleet

- Data source: Eskom
- Type of data: Hourly system supply data for 2017 on aggregated level for all installed wind and solar PV
  Total hourly system energy for 2017, minus hydro pumping load

Total wind and solar PV capacity operational

- Data source: Eskom
- Type of data: Monthly total wind and solar PV IPPs operational

Actual load shedding data

- Data source: www.eskom.co.za

Re a leboha

Ha Khensa

Enkosi

Siyathokoza

Thank you

Re a leboga

Ro livhuha

Dankie

Siyabonga

Note: “Thank you” in all official languages of the Republic of South Africa