Statistics of utility-scale solar PV, wind and CSP in South Africa in 2016

CSIR Energy Centre

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Joanne Calitz JRCalitz@csir.co.za
Crescent Mushwana CMushwana@csir.co.za
Dr Tobias Bischof-Niemz TBischofNiemz@csir.co.za

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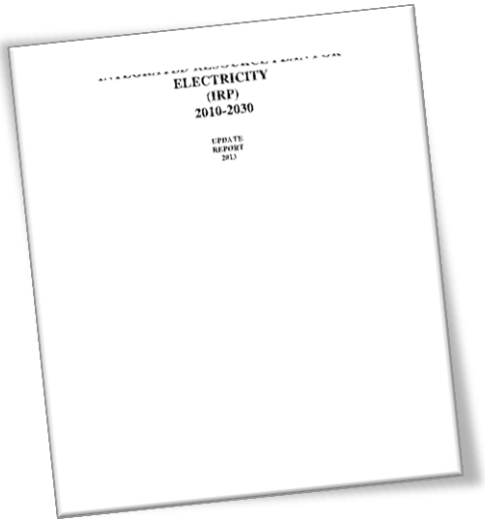
South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) started in 2011

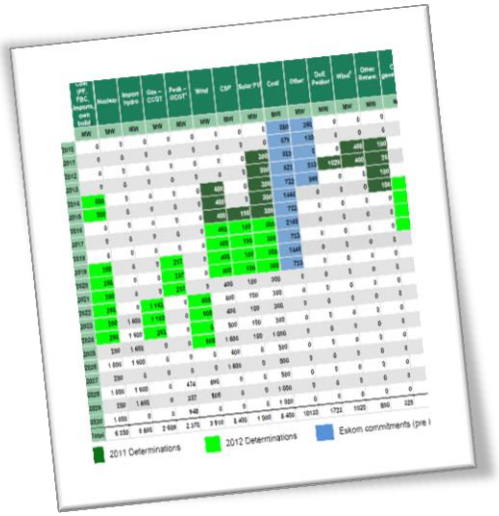
Integrated Resource Plan (IRP) 2010

- 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-2016-17.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

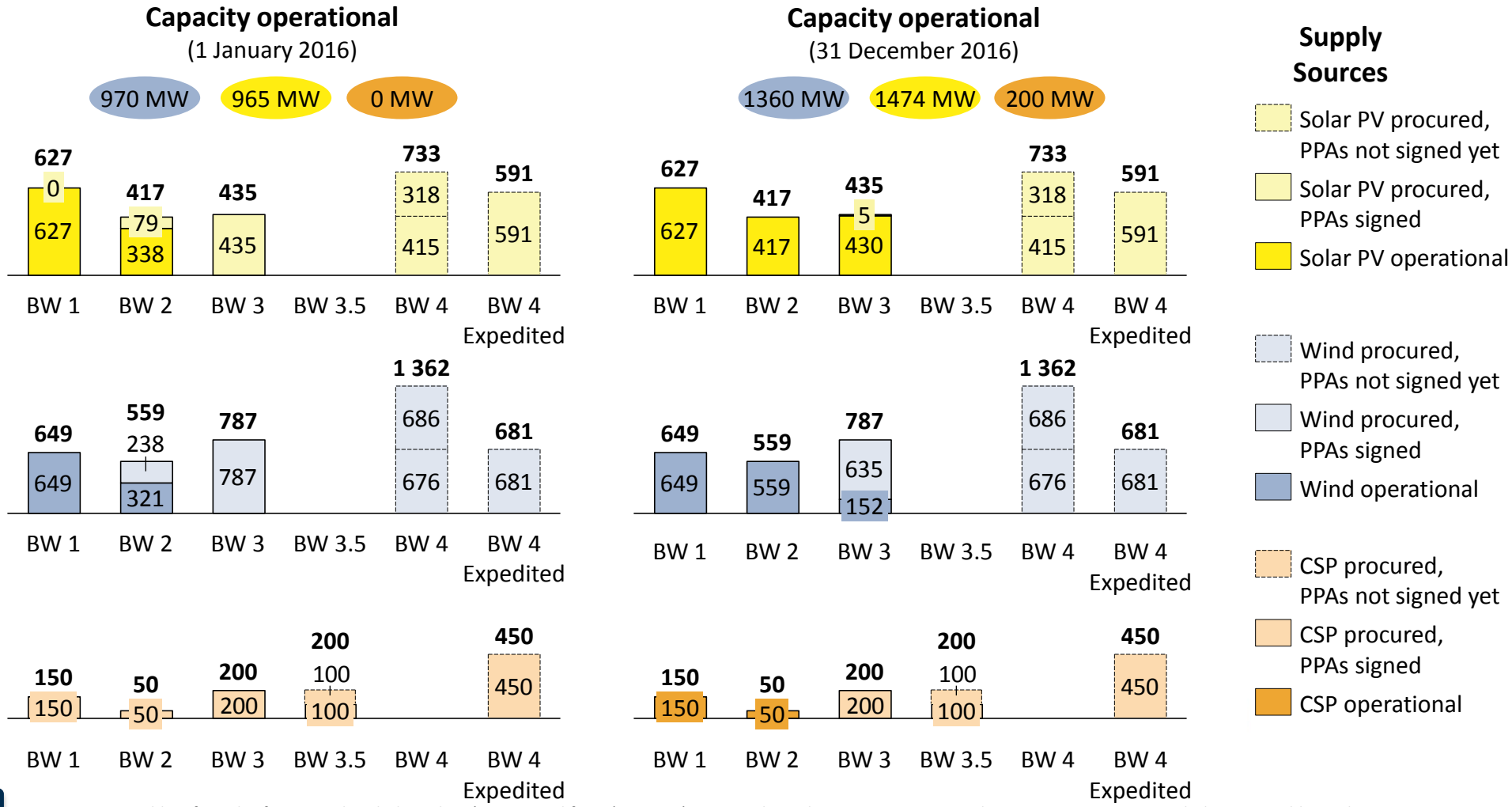
- To date, renewable energy projects in South Africa have resulted in 20 000 jobs for South Africans and have attracted R 192.6 billion in investment.
- Furthermore, IPPs have committed a total of R 19.1 billion toward socio-economic development initiatives within the communities in which they operate, 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 cogeneration (from agricultural waste / byproducts)

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, 1 460 MW of wind, 1 474 MW of solar PV and 200 MW of CSP were operational and fed energy into the grid by Dec 2016

Sources: http://www.energy.gov.za/files/aboutus/DoE-Annual-Performance-Plan-2016-17.pdf

Procured and operational capacity under RSA's RE IPP Procurement Programme (REIPPPP) in 2016

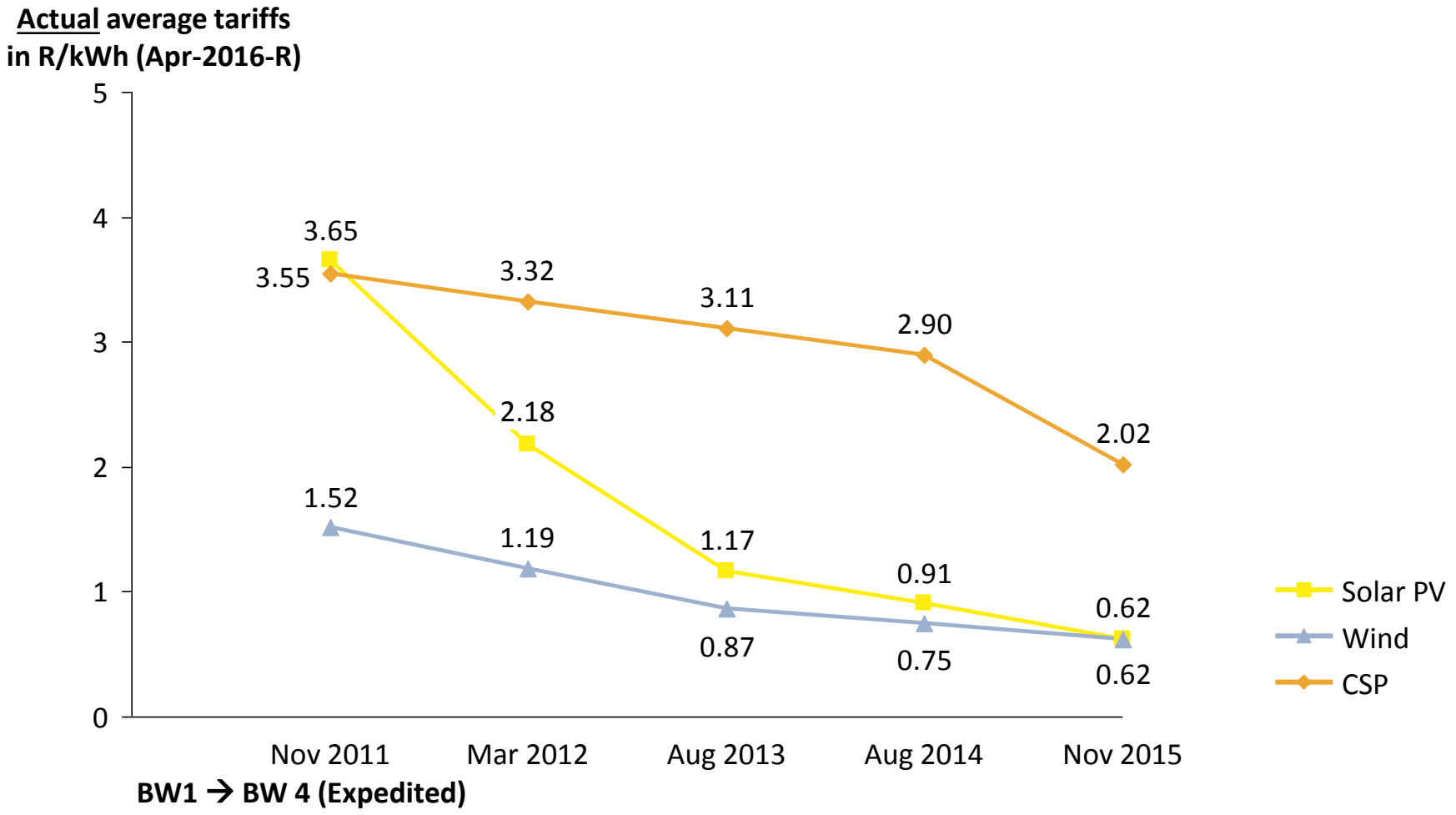


Notes: RSA = Republic of South Africa. Wind excludes Eskom's Sere wind farm (100 MW). BW = Bid Window. PPA = Power Purchase Agreement. BW 4 includes BW 4 additional.

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/2016/Coal%20IPP%20factsheet.pdf; http://www.ee.co.za/wp-content/uploads/2016/10/New_Power_Generators_RSA-CSIR-14Oct2016.pdf; StatsSA on CPI; BW = Bid Window; Dates shown are the bid submission dates; CSIR analysis

Summary of 2016 statistics:
2.9 % of system load supplied from wind, solar PV & CSP in RSA

In Dec 2016, a total of 1 460 MW wind, 1474 MW of solar PV and 200 MW of CSP capacity were operational

- An additional 385 MW of wind, 509 MW of solar PV and 200 MW of CSP became operational during 2016

In 2016, total wind, solar PV and CSP production was 6.9 TWh, supplying 2.9% of SA's system load

- Maximum daily total energy from solar PV, wind & CSP combined was 35 GWh, which occurred on 13 Nov 2016
- Wind power achieved a maximum peak power production of 1 230 MW between 12h00-13h00 on 23 Dec 2016
- Solar PV power reached a maximum peak power production of 1 351 MW between 11h00-12h00 on 16 Dec 2016
- CSP power reached a maximum peak power production of 200 MW between 13h00-14h00 on 11 Aug 2016
- Maximum instantaneous power contribution of wind, solar PV & CSP was 9.6% on 23 Dec 2016 between 12h00-13h00
- Maximum instantaneous power contribution of wind alone was 5.4% on 25 Dec 2016 between 17h00-18h00
- Maximum instantaneous power contribution of solar PV alone was 5.0% on 31 Dec 2016 between 11h00-12h00
- Maximum instantaneous power contribution of CSP alone was 0.8% on 27 Aug 2016 between 14h00-15h00

Total monthly wind, solar PV and CSP production from Jan to Dec 2016 varied between 431 GWh and 765 GWh

- The monthly wind production from Jan to Dec 2016 varied between 226 and 390 GWh
- The monthly solar PV production from Jan to Dec 2016 varied between 150 and 330 GWh
- The monthly CSP production from Jan to Dec 2016 varied between 29 and 58 GWh

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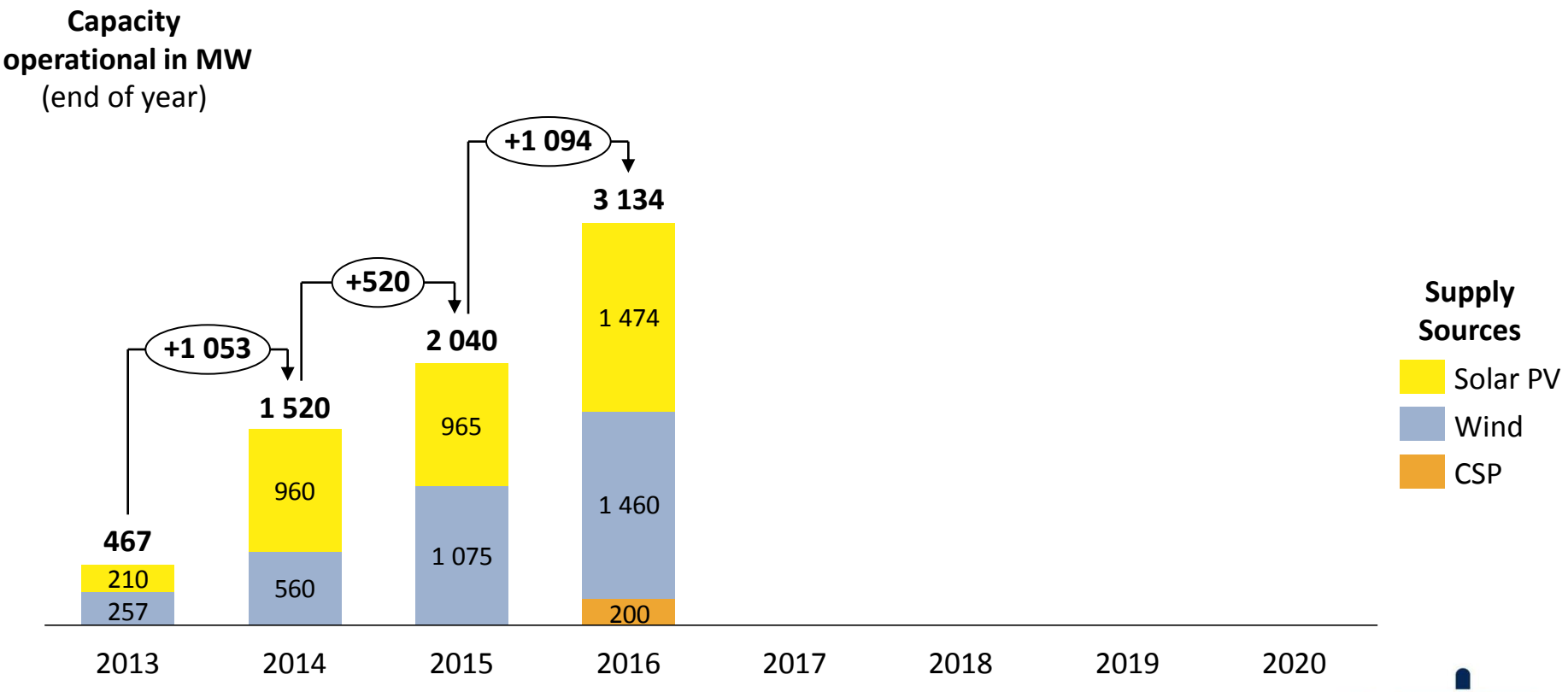
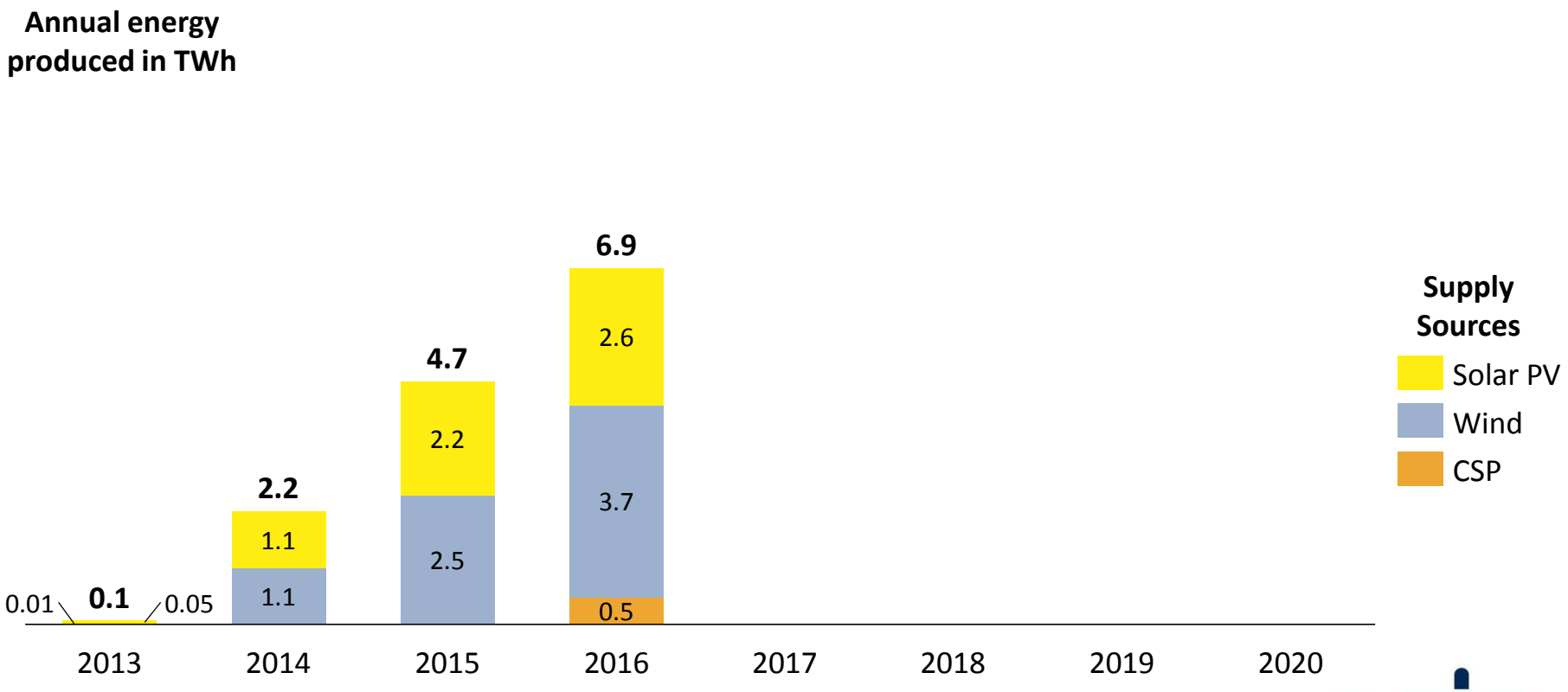
Notes: RSA = Republic of South Africa.
Sources: CSIR Analysis; Eskom; DoE IPP Office

From 1 November 2013 to 31 Dec 2016, 1 460 MW of wind, 1 474 MW of large-scale solar PV and 200 MW of CSP became operational in RSA



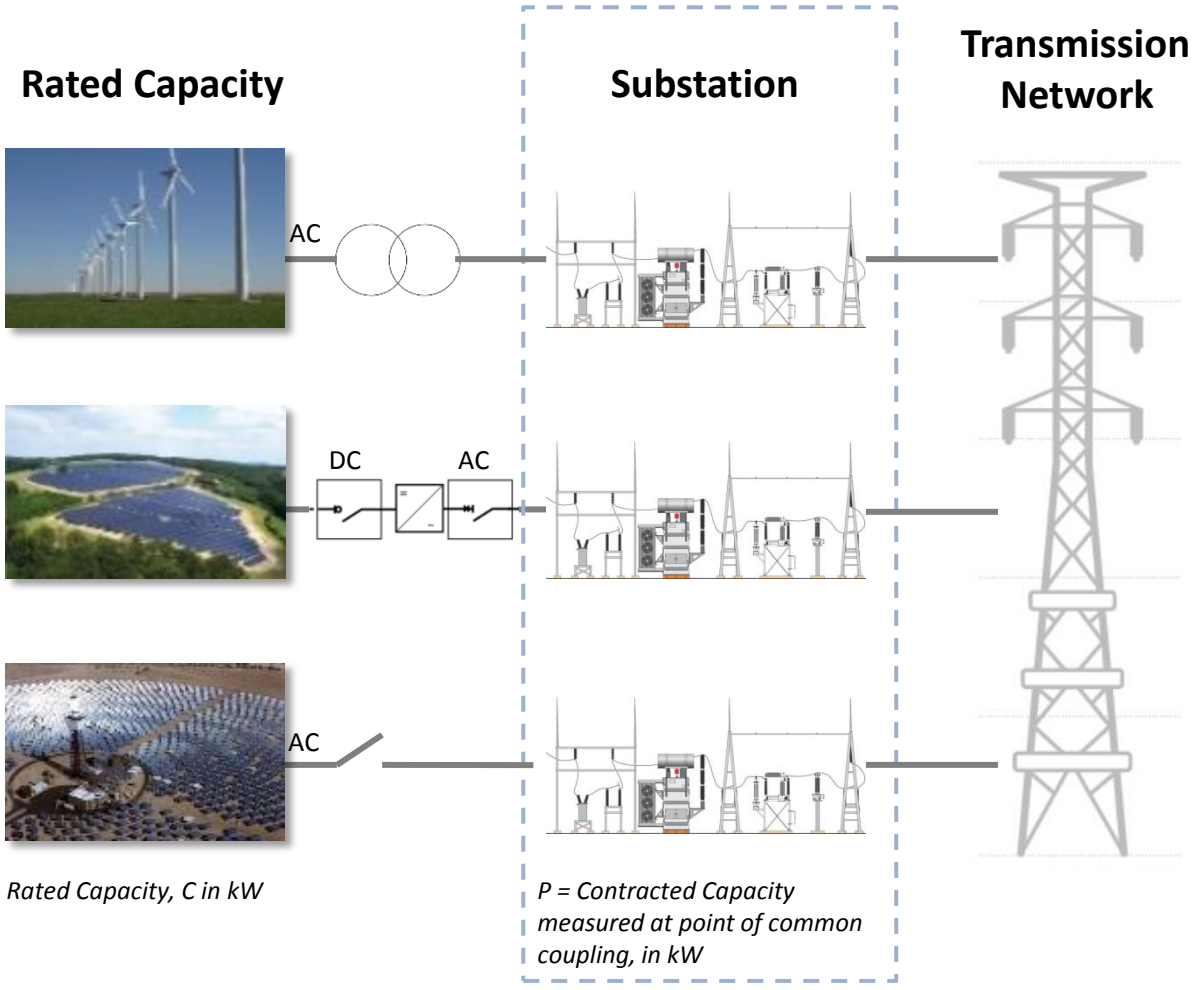
Notes: RSA = Republic of South Africa. Solar PV capacity = capacity at point of common coupling. Wind includes Eskom's Sere wind farm (100 MW)
Sources: Eskom; DoE IPP Office

In 2016, 6.9 TWh of wind, solar PV and CSP energy produced in RSA



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

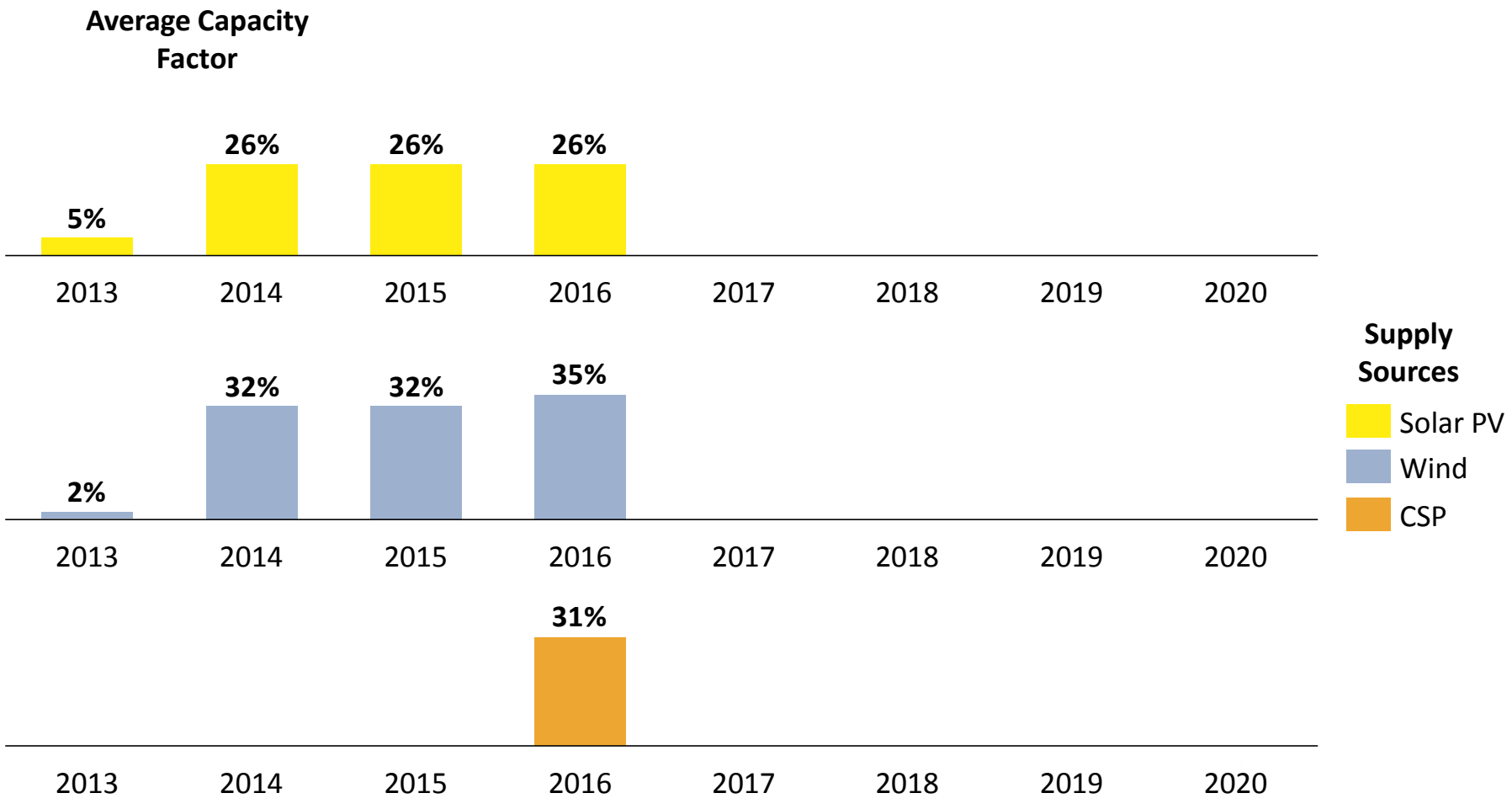
$$CF = \frac{\frac{\sum_{t=1}^{n} E_t}{n}}{\frac{\sum_{t=1}^{n} P_t}{n}}$$

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

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 2016, the average annual capacity factor of the solar PV, wind and CSP fleet was 26%, 35% and 31% 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

Agenda

Overview actual electricity production data for 2016

Monthly electricity production

Weekly electricity production

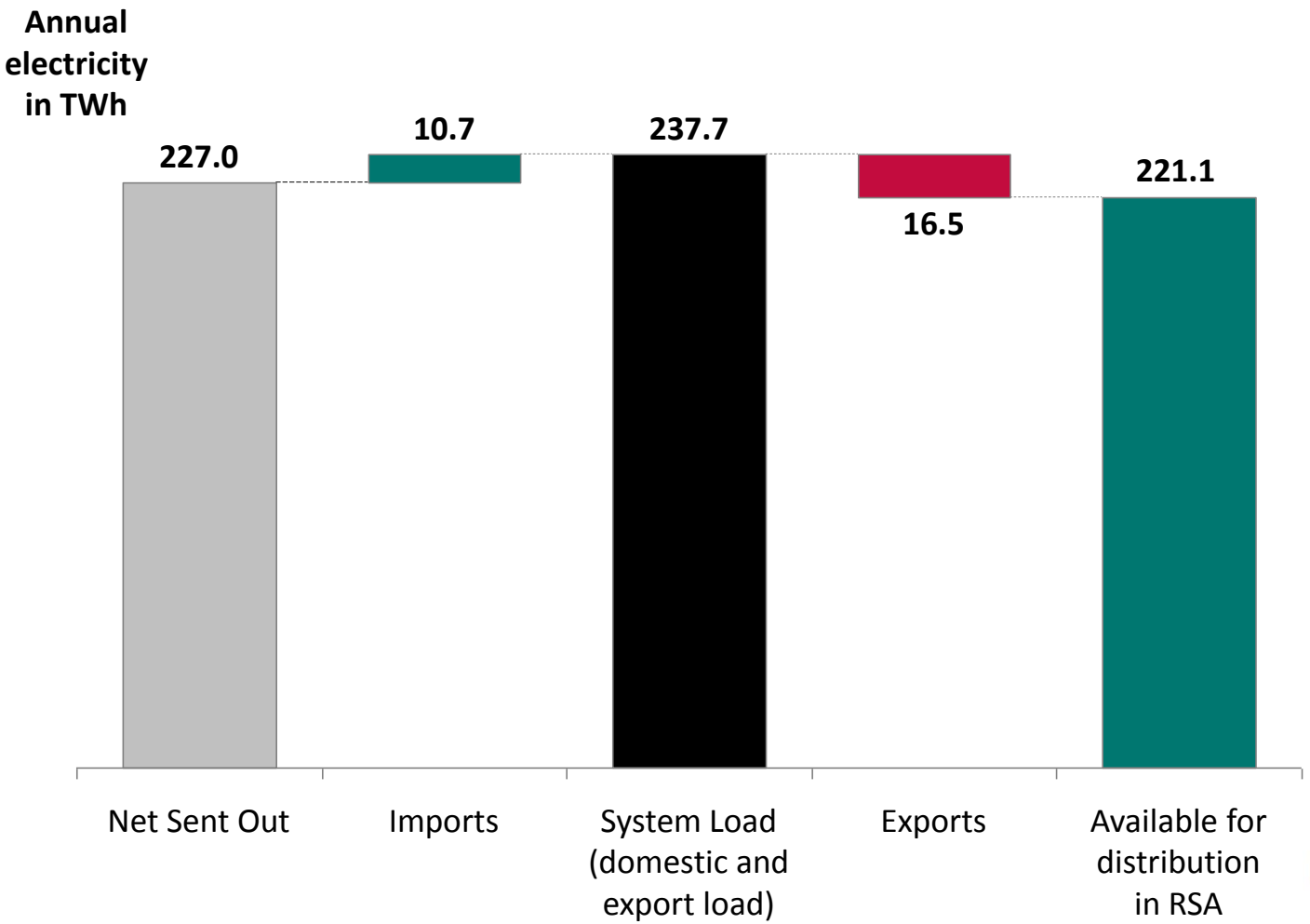
Daily electricity production

Hourly electricity production and gradients

Actual load shedding in 2016

In 2016, 227 TWh of net electricity were produced in SA

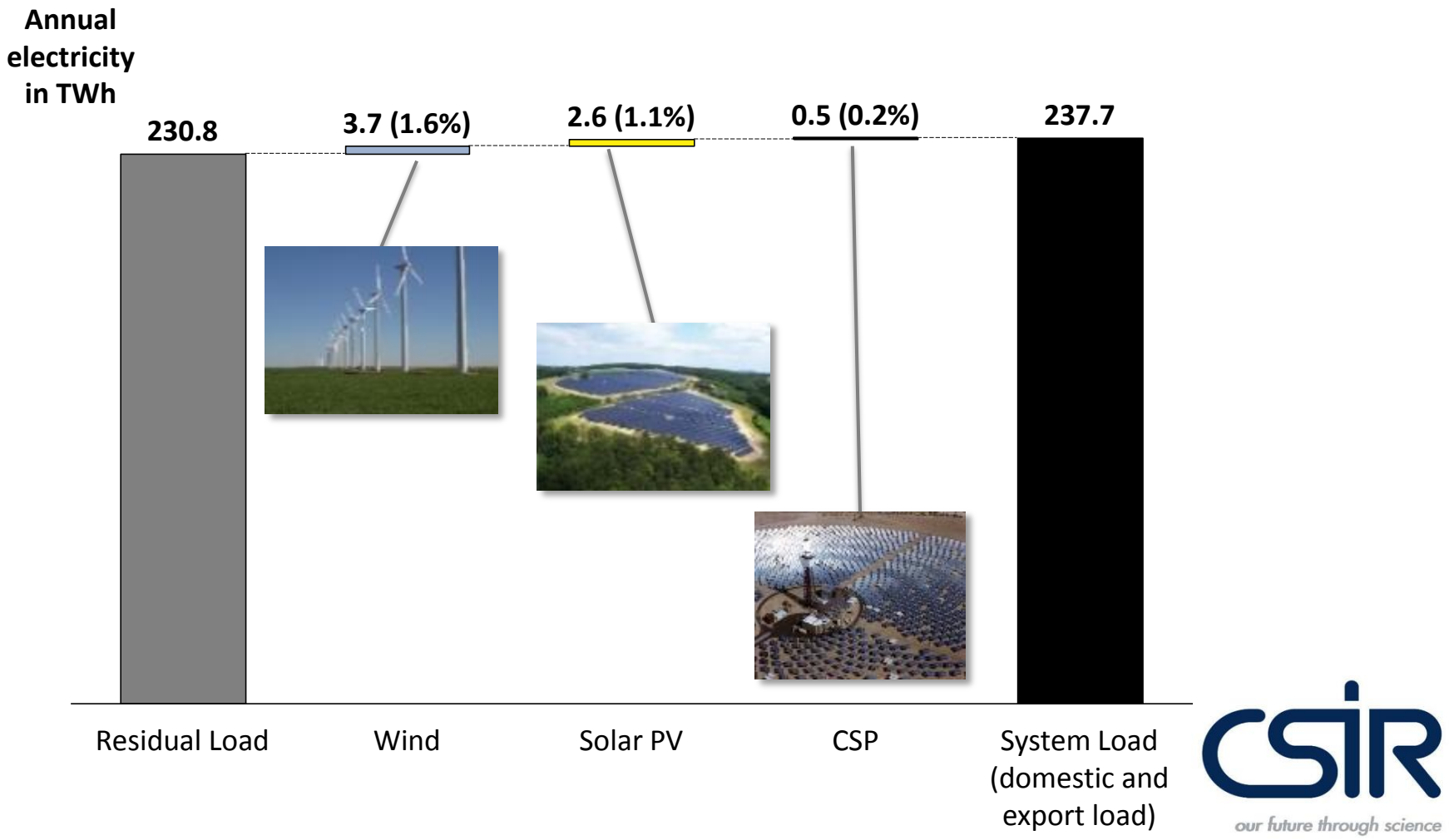
Actuals captured in wholesale market for Jan-Dec 2016 (i.e. without self-consumption of embedded plants)



Notes: "Net Sent Out" = Total domestic generation (Sent Out) minus pumping load (not shown seperately)
Sources: Eskom; Statistics South Africa for imports and exports (Dec 2016 estimated)

Wind, solar PV and CSP supplied 2.9% of total SA system load in 2016

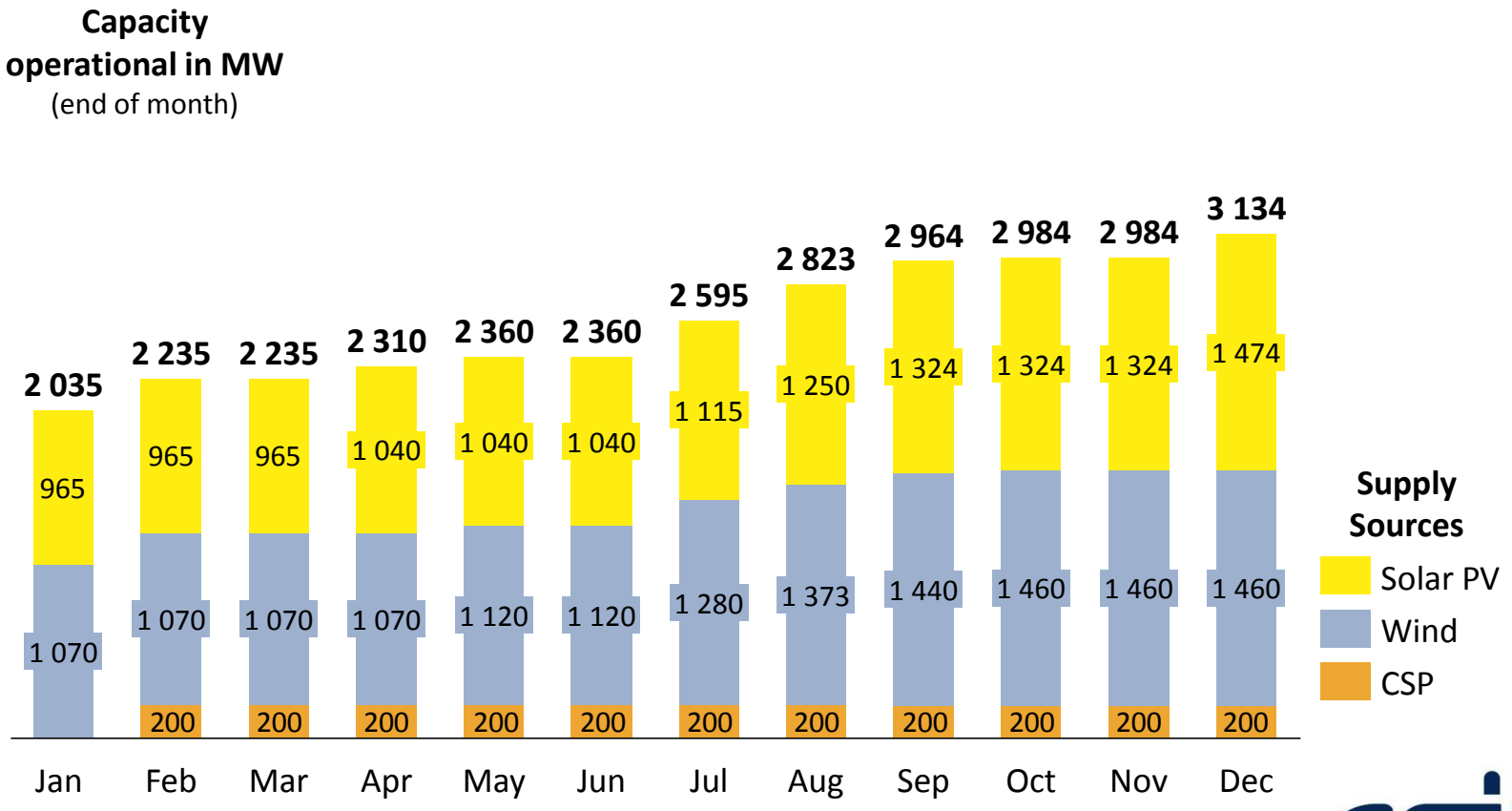
Actuals captured in wholesale market for Jan-Dec 2016 (i.e. without self-consumption of embedded plants)



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

In 2016, 385 MW of wind and 509 MW of solar PV were added to grid

Total monthly installed capacity of solar PV, wind and CSP in MW in RSA from Jan-Dec 2016

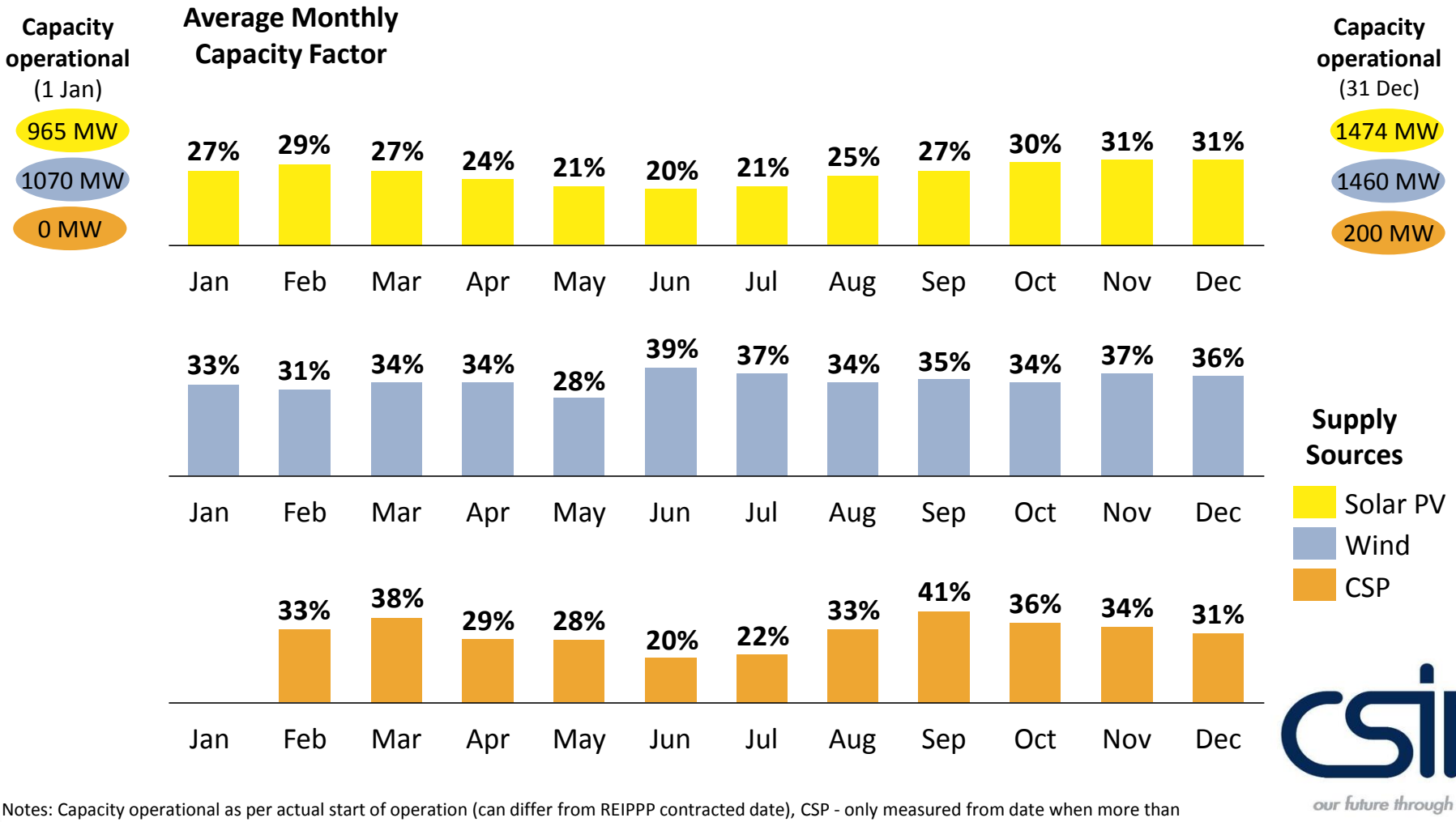


Notes: Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants commissioned. Wind includes Sere wind farm (100 MW).

Sources: Eskom; DoE IPP Office

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 2016

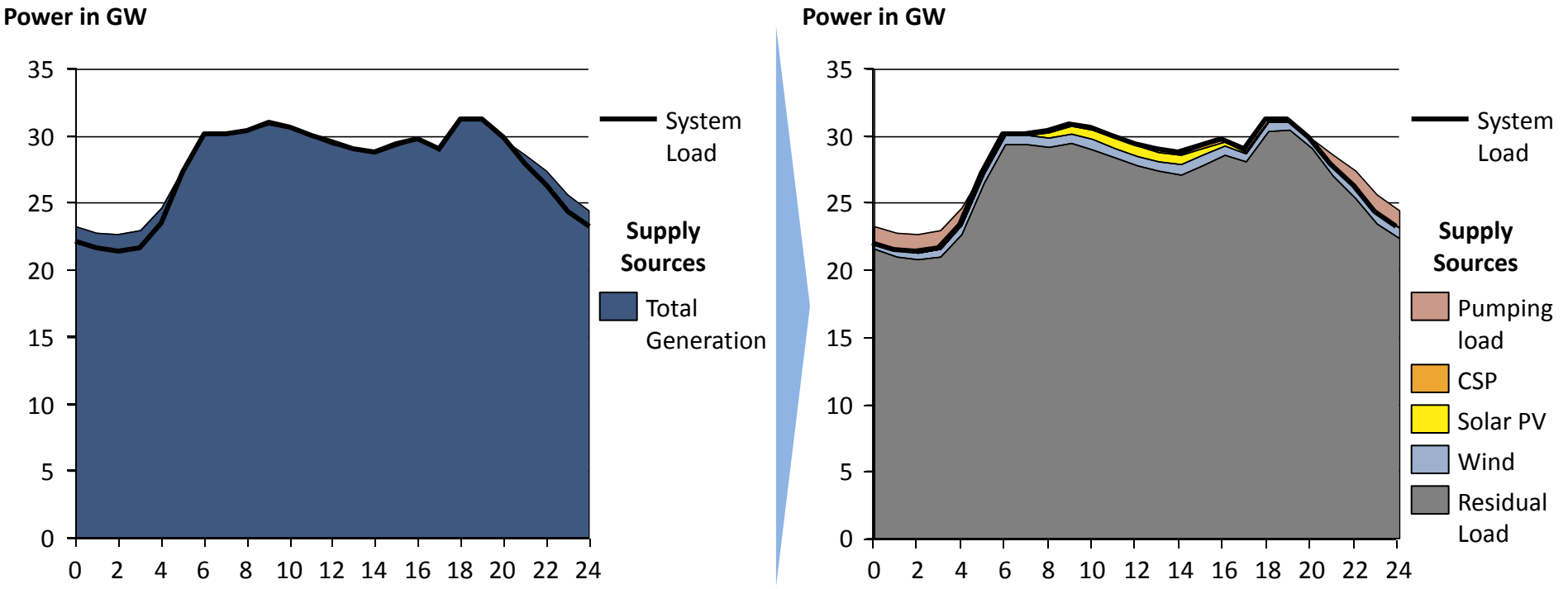


Notes: Capacity operational as per actual start of operation (can differ from REIPPP contracted date), CSP - only measured from date when more than two CSP plants commissioned. Wind includes Sere wind farm (100 MW).

Sources: Eskom; DoE IPP Office

Illustrative day explaining terminologies used in this presentation

Hourly South African supply structure for a random day



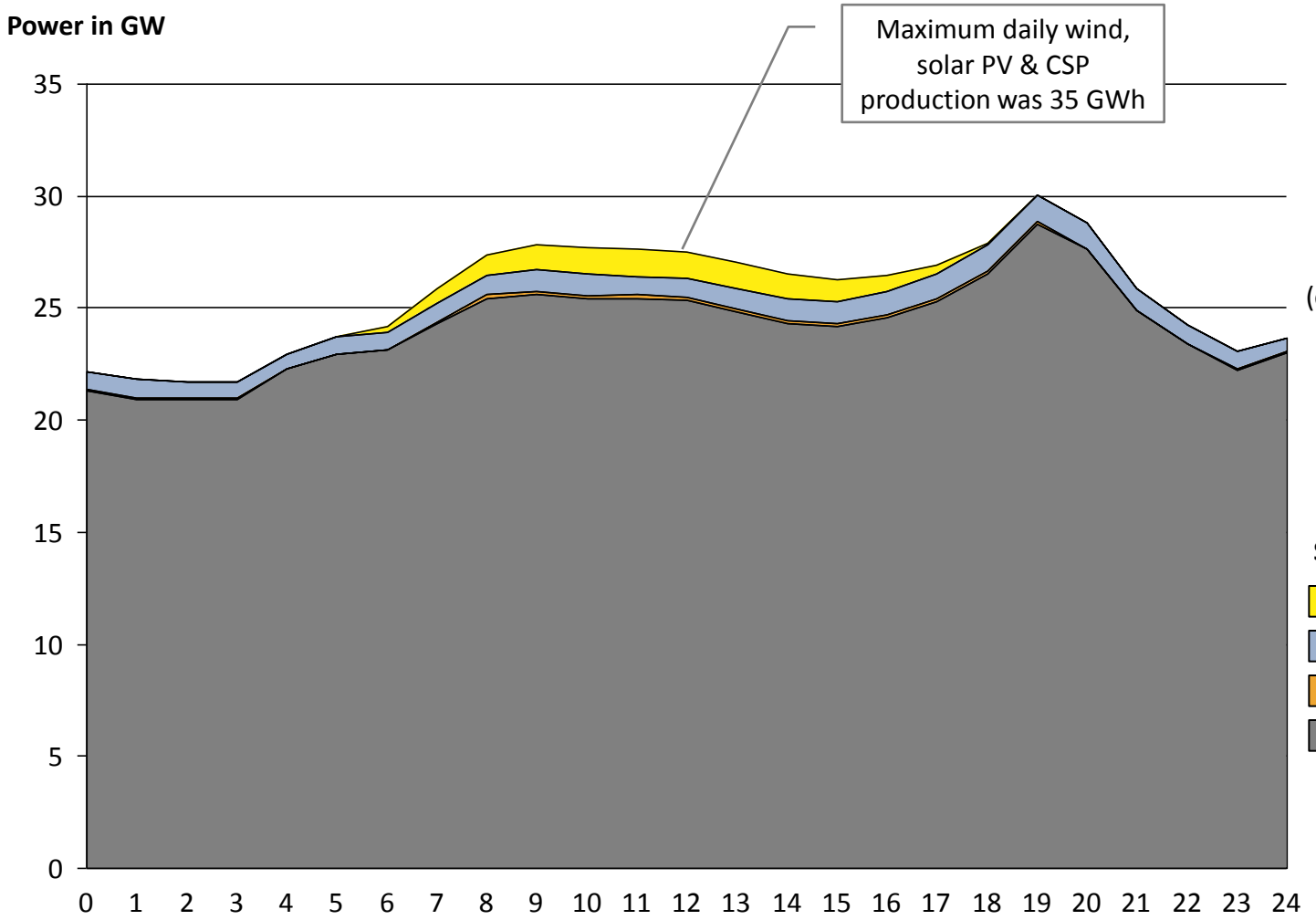
Total Generation	**= domestic generation (Eskom + IPPs) + imported generation**
System Load	**= domestic generation (Eskom + IPPs) + imported generation – pumping load** **= domestic customer load without pumping load (also referred to as simply "domestic load") + export load**
Residual Load	**= System 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 35 GWh on 13 Nov '16

Actual hourly wind, solar PV & CSP energy production in South Africa on 13 November 2016 (Sunday)

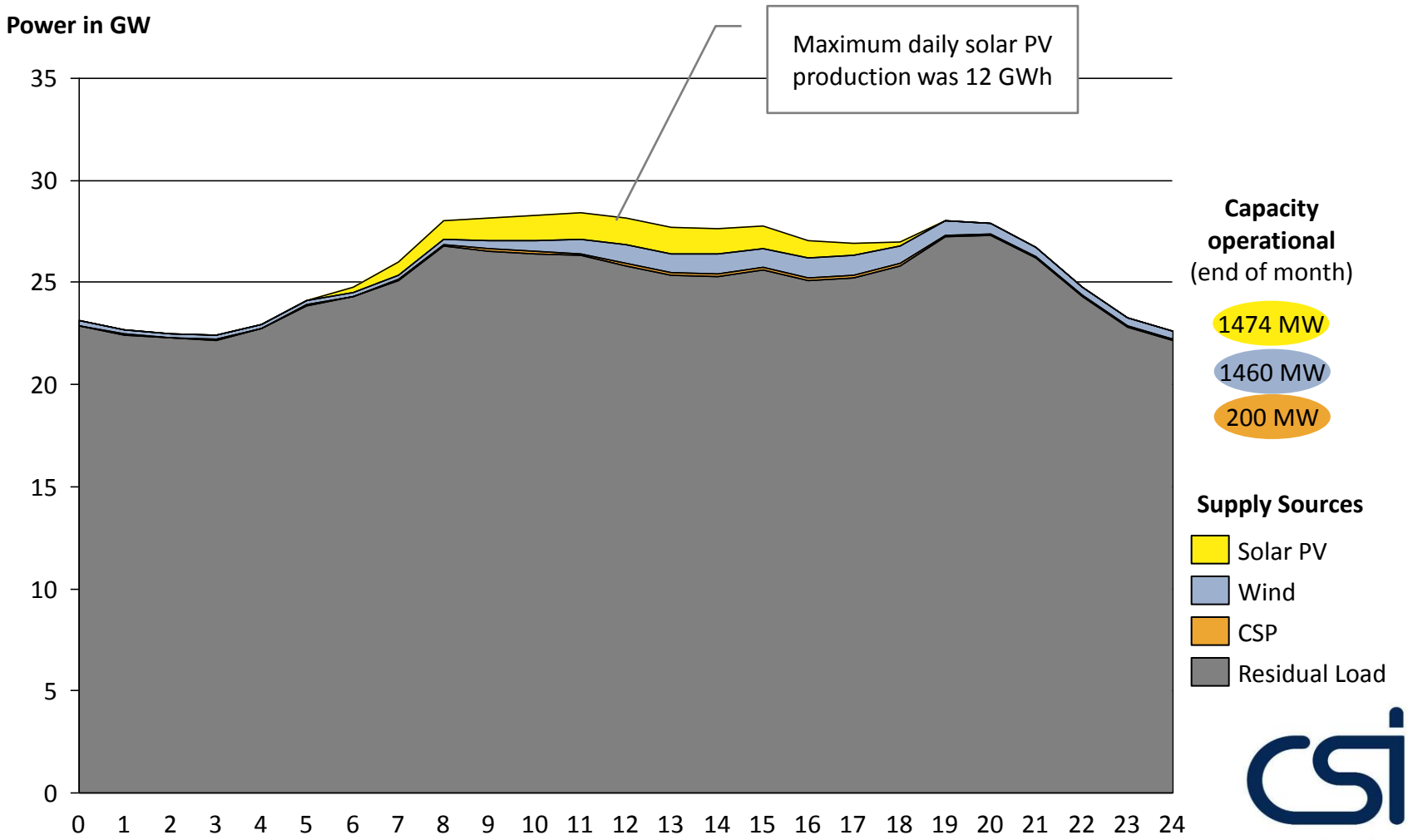


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily solar PV energy of 12 GWh achieved on 22 Dec 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 22 December 2016 (Thursday)

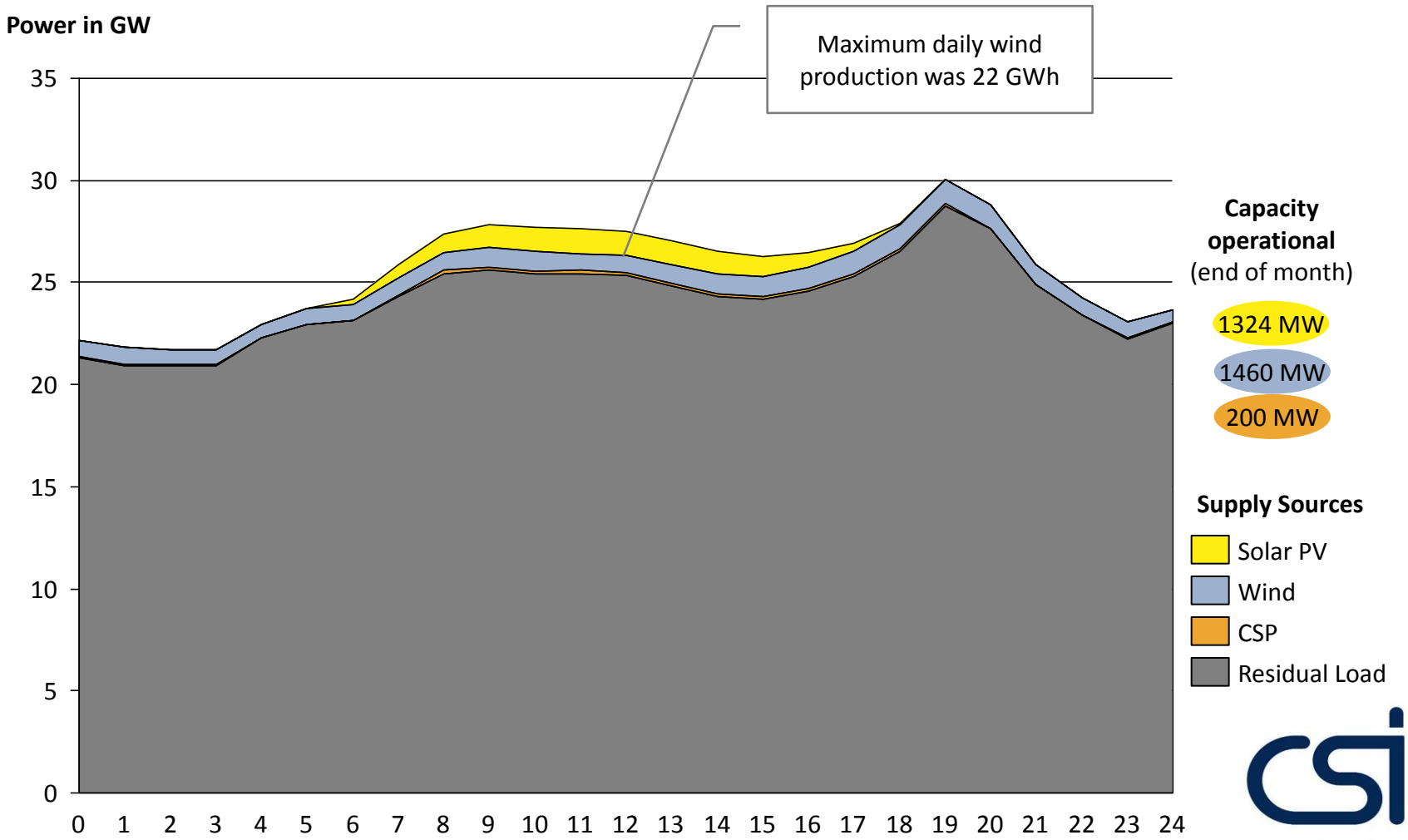


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily wind energy of 22 GWh achieved on 13 Nov 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 13 November 2016 (Sunday)

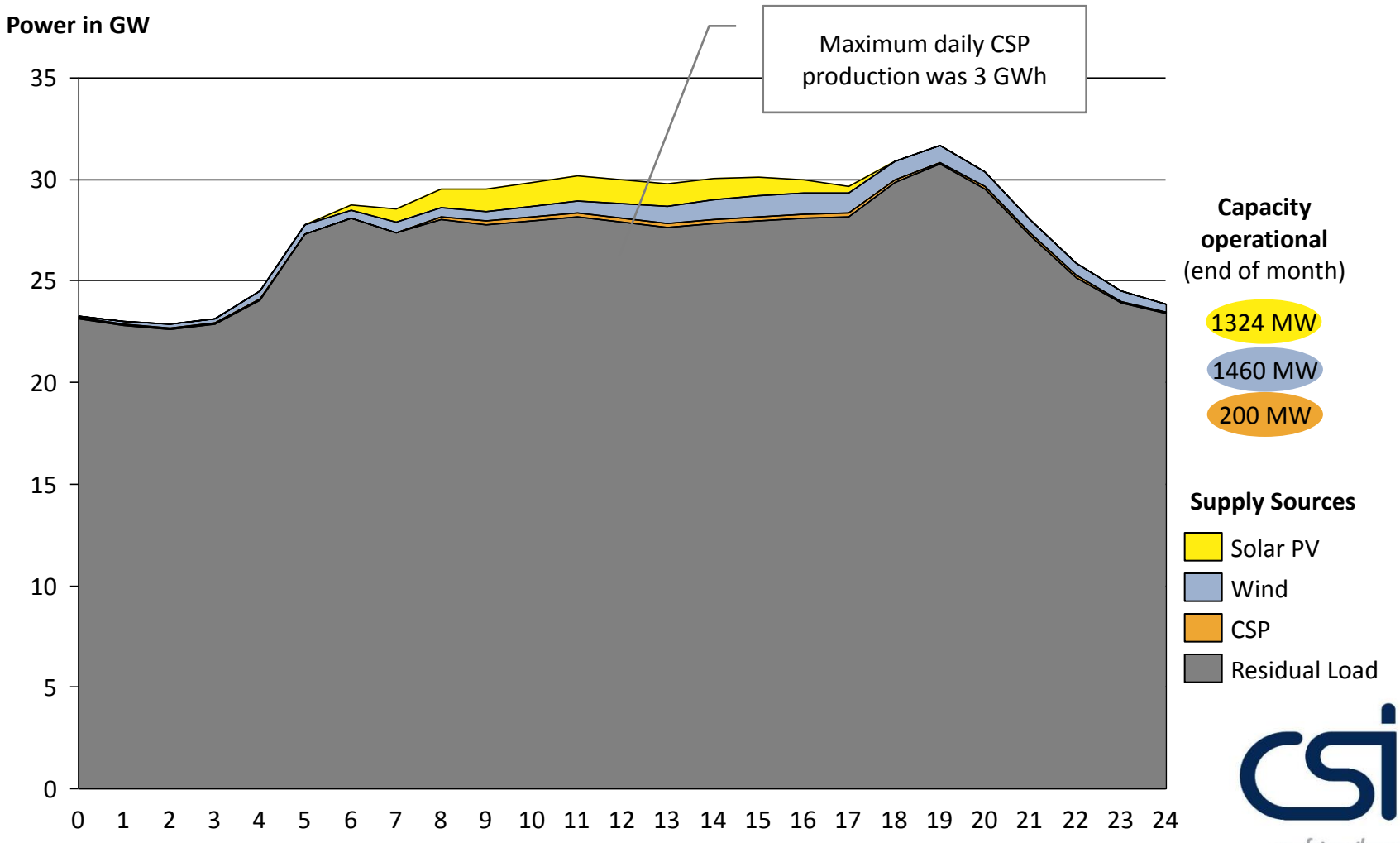


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum daily CSP energy of 3 GWh achieved on 27 Oct 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 27 October 2016 (Sunday)

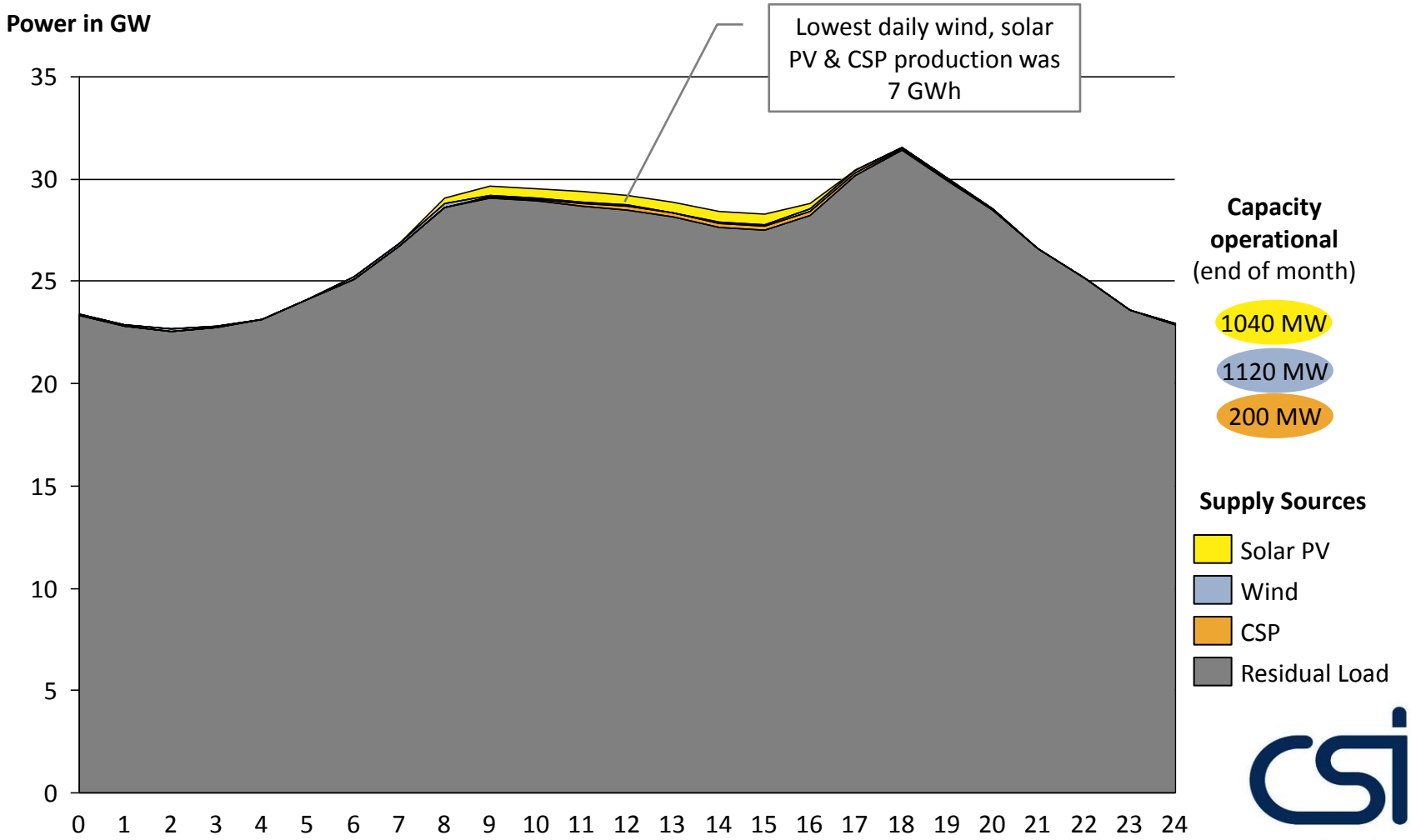


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest combined wind, solar PV & CSP energy of 7 GWh on 14 May '16

Actual hourly wind, solar PV & CSP energy production in South Africa on 14 May 2016 (Saturday)

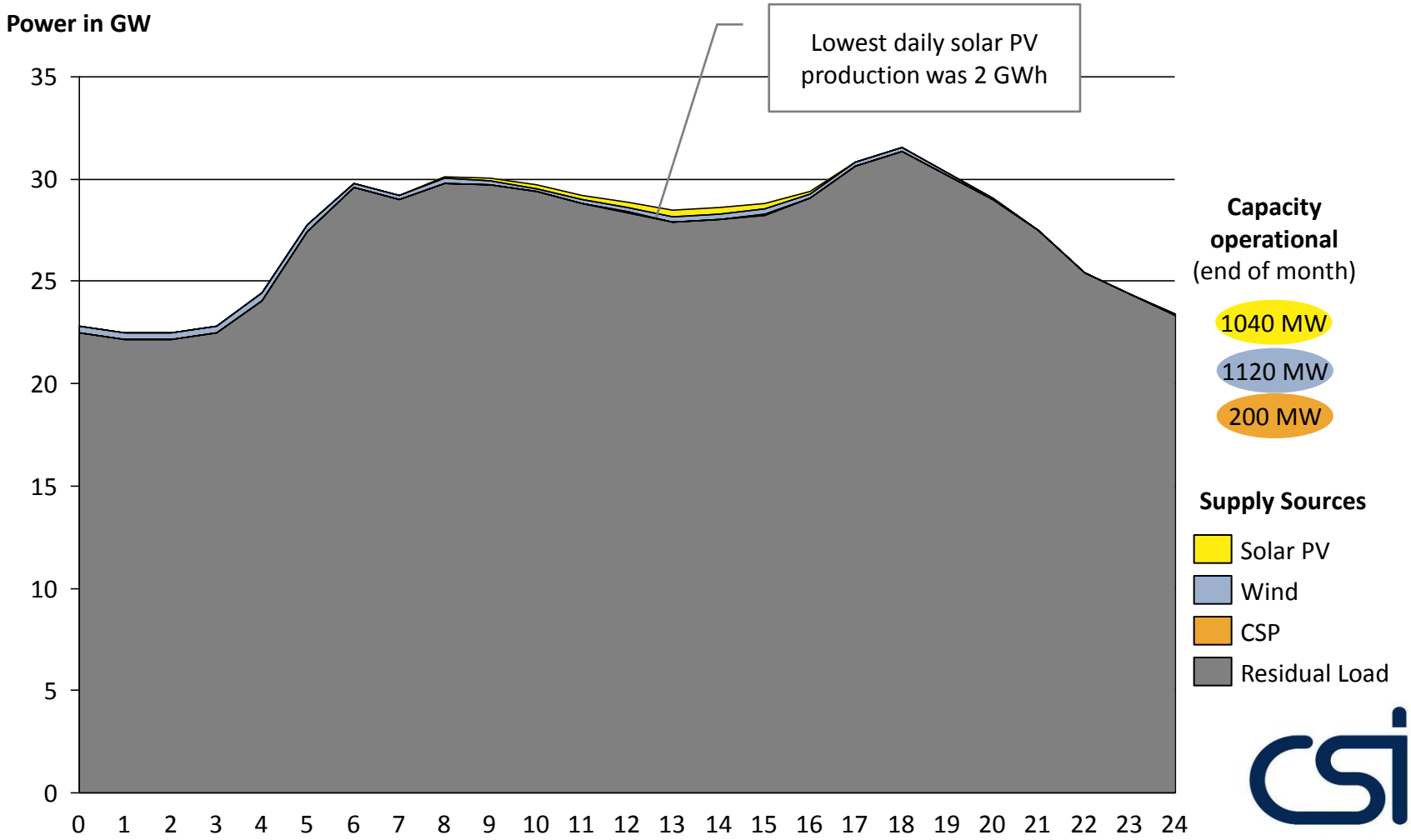


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest solar PV energy production of 2 GWh occurred on 13 May 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 13 May 2016 (Friday)

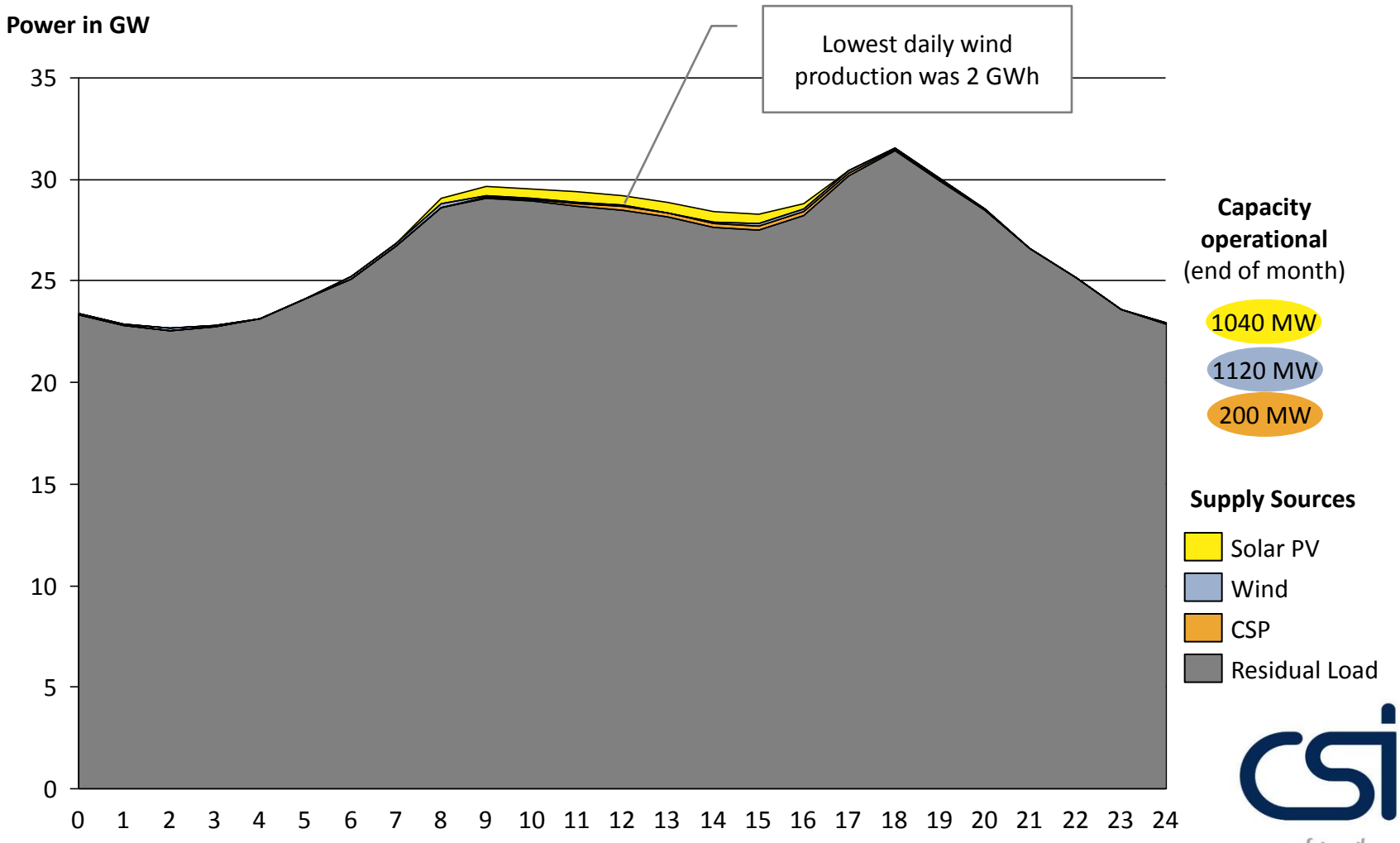


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest wind energy production of 2 GWh occurred on 14 May 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 14 May 2016 (Sunday)

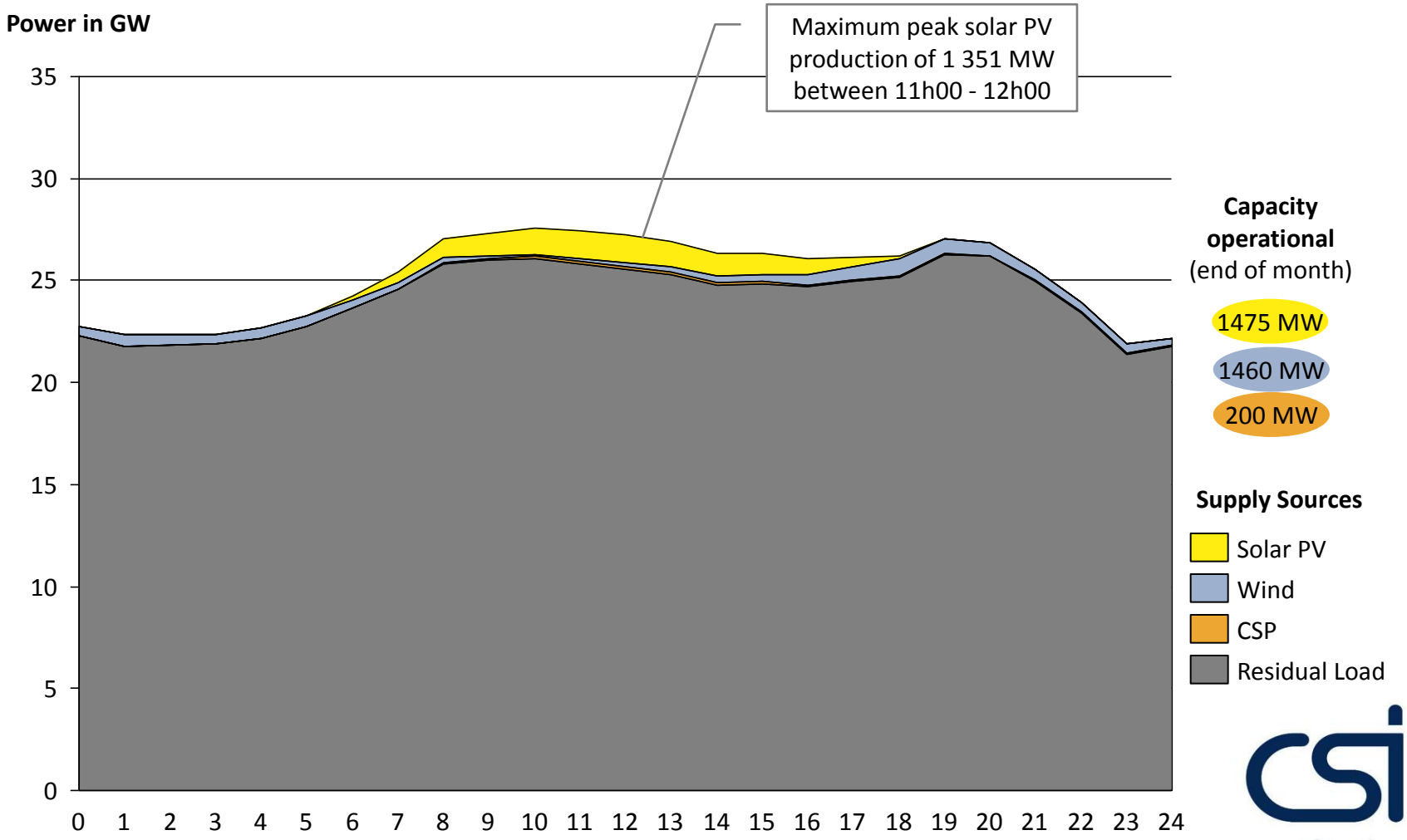


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum solar PV power output of 1 351 MW occurred on 16 Dec ‘16

Actual hourly wind, solar PV & CSP energy production in South Africa on 16 Dec 2016 (Friday)

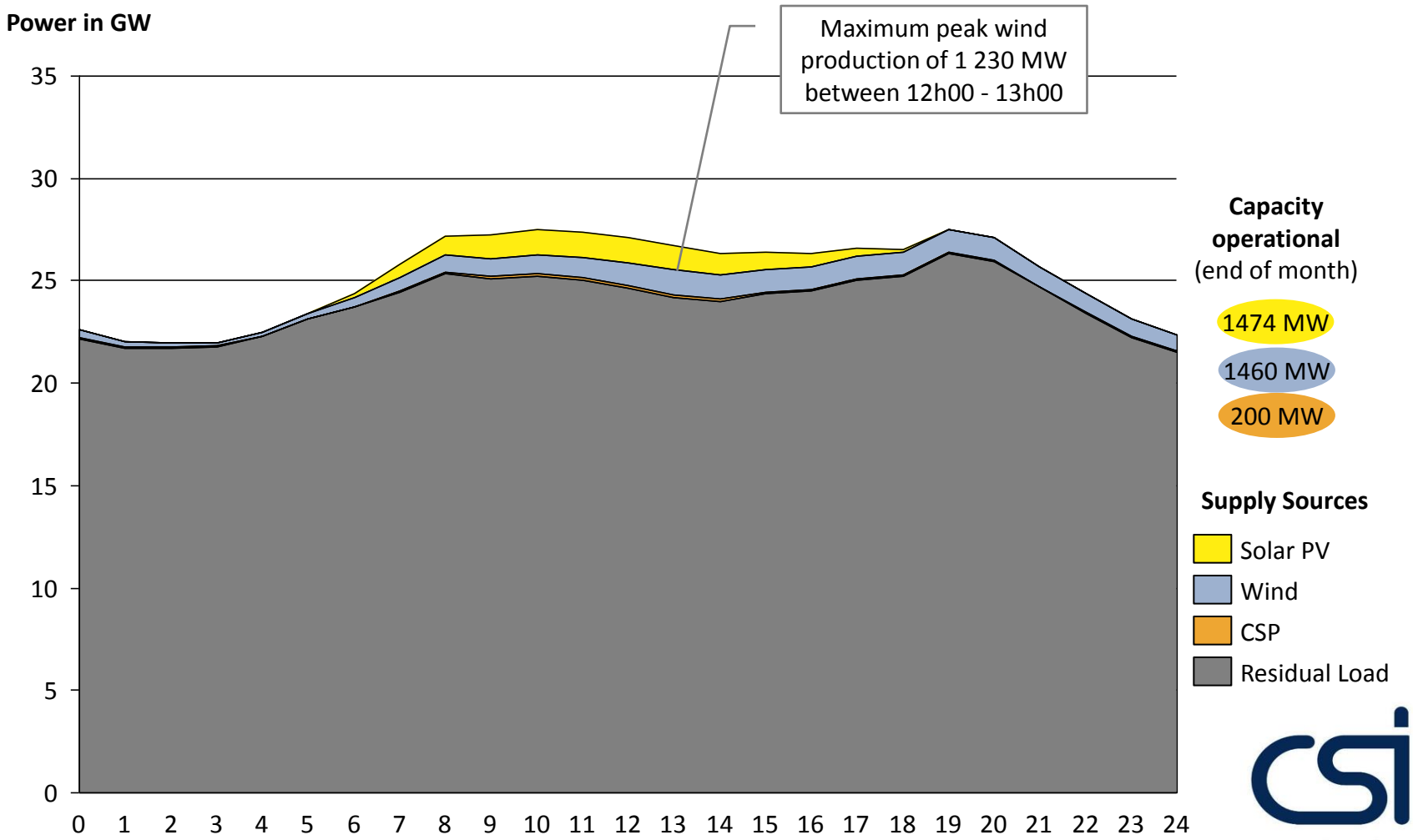


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum wind power output of 1 230 MW occurred on 23 Dec 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 23 Dec 2016 (Friday)

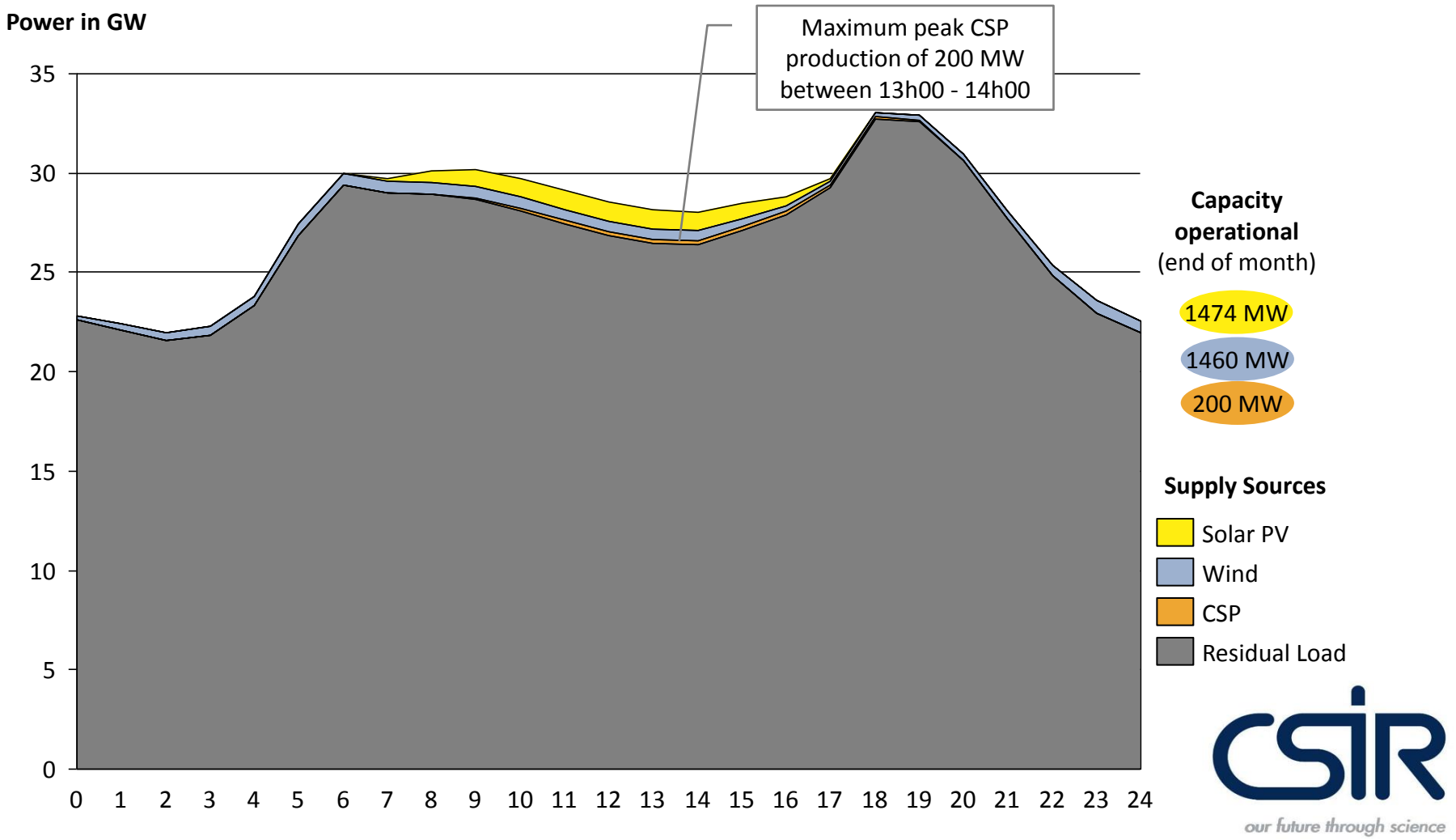


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Maximum CSP power output of 200 MW occurred on 11 Aug 2016

Actual hourly wind, solar PV & CSP energy production in South Africa on 11 Aug 2016 (Thursday)

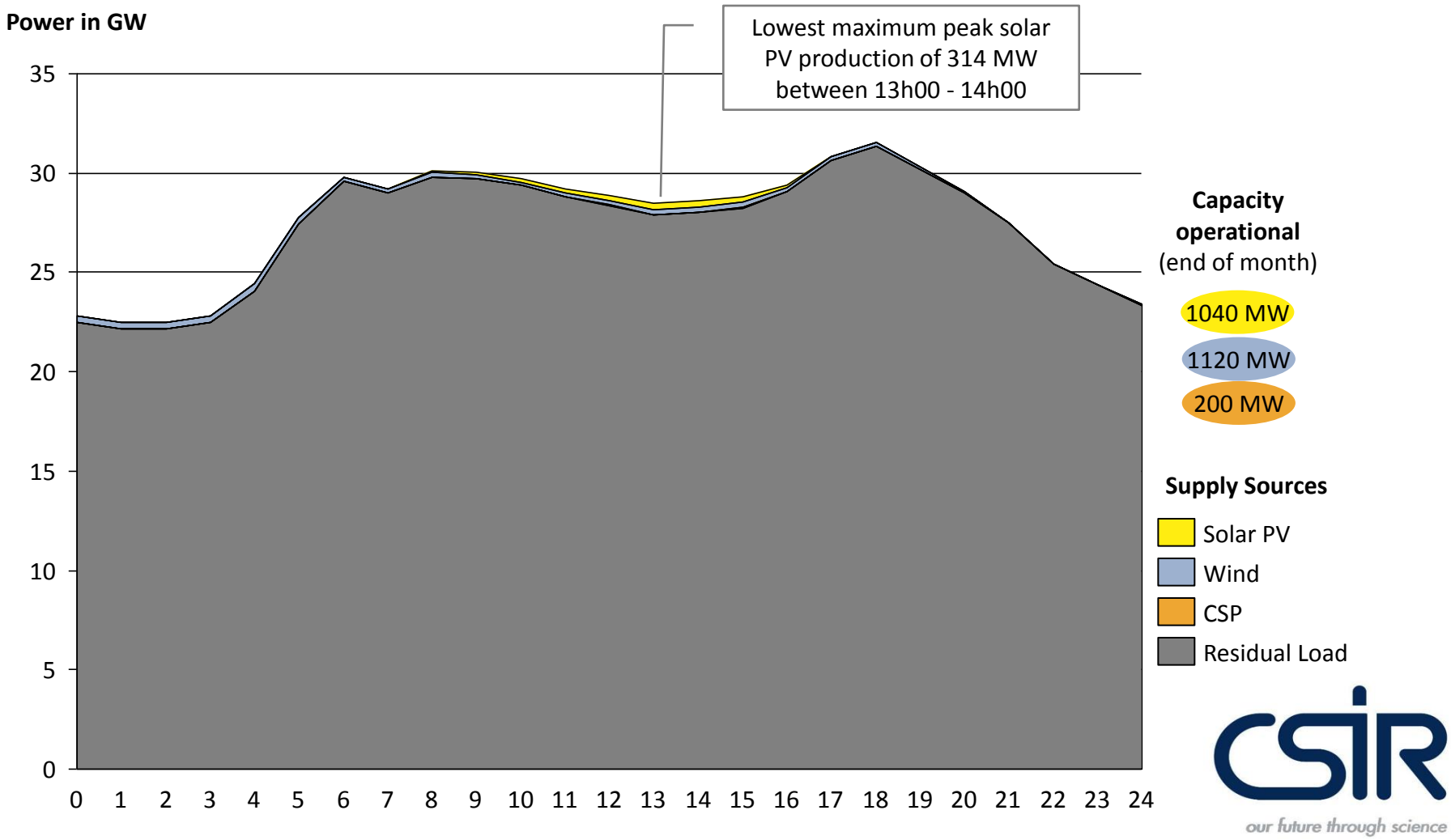


Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Lowest daily peak solar PV power output of 314 MW on 13 May 2016

Actual hourly wind and solar PV energy production in South Africa on 13 May 2016 (Friday)



Note: Total daily production excludes hyrdo pumping load

Sources: Eskom; CSIR Energy Centre analysis

Agenda

Overview actual electricity production data for 2016

Monthly electricity production

Weekly electricity production

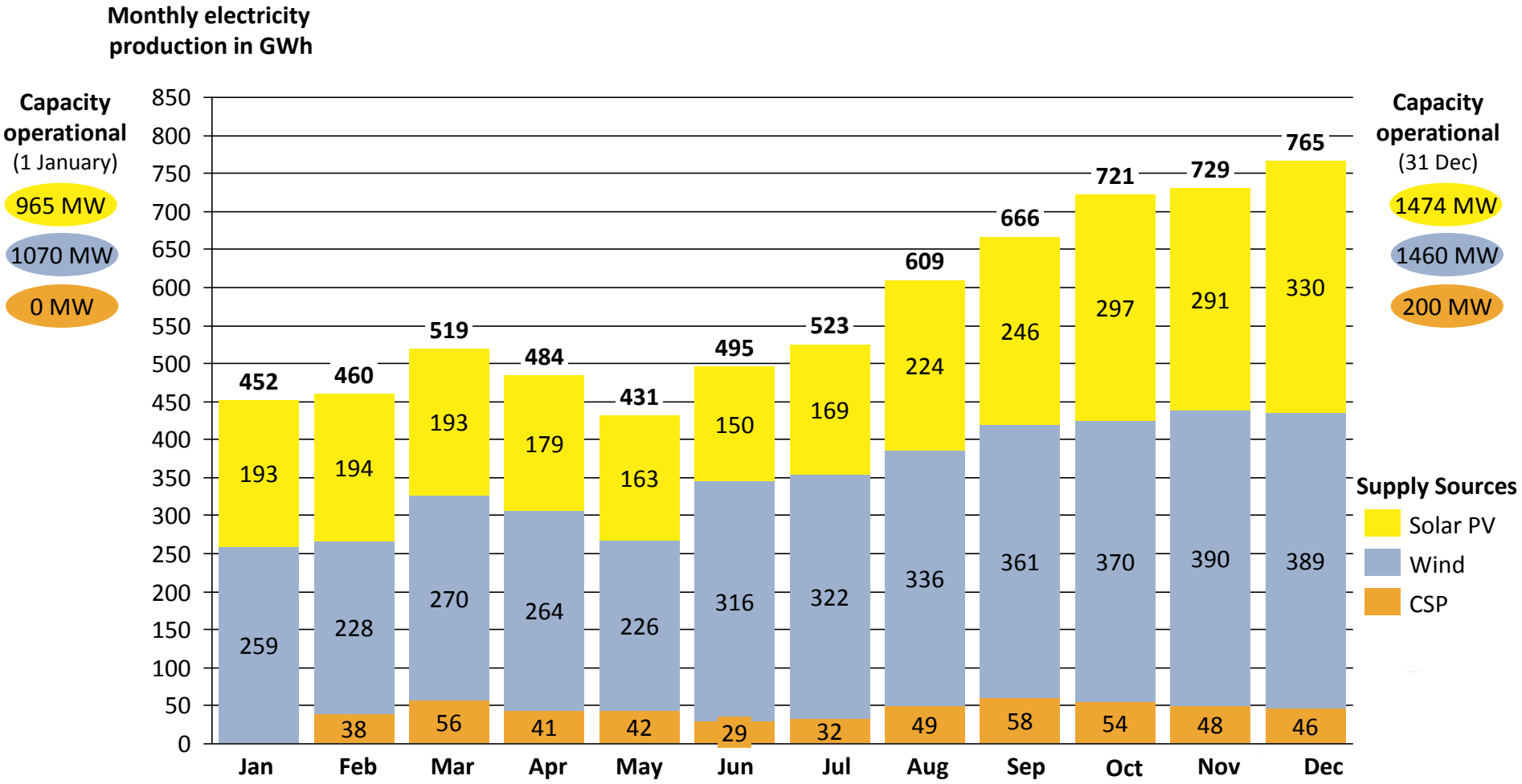
Daily electricity production

Hourly electricity production and gradients

Actual load shedding in 2016

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

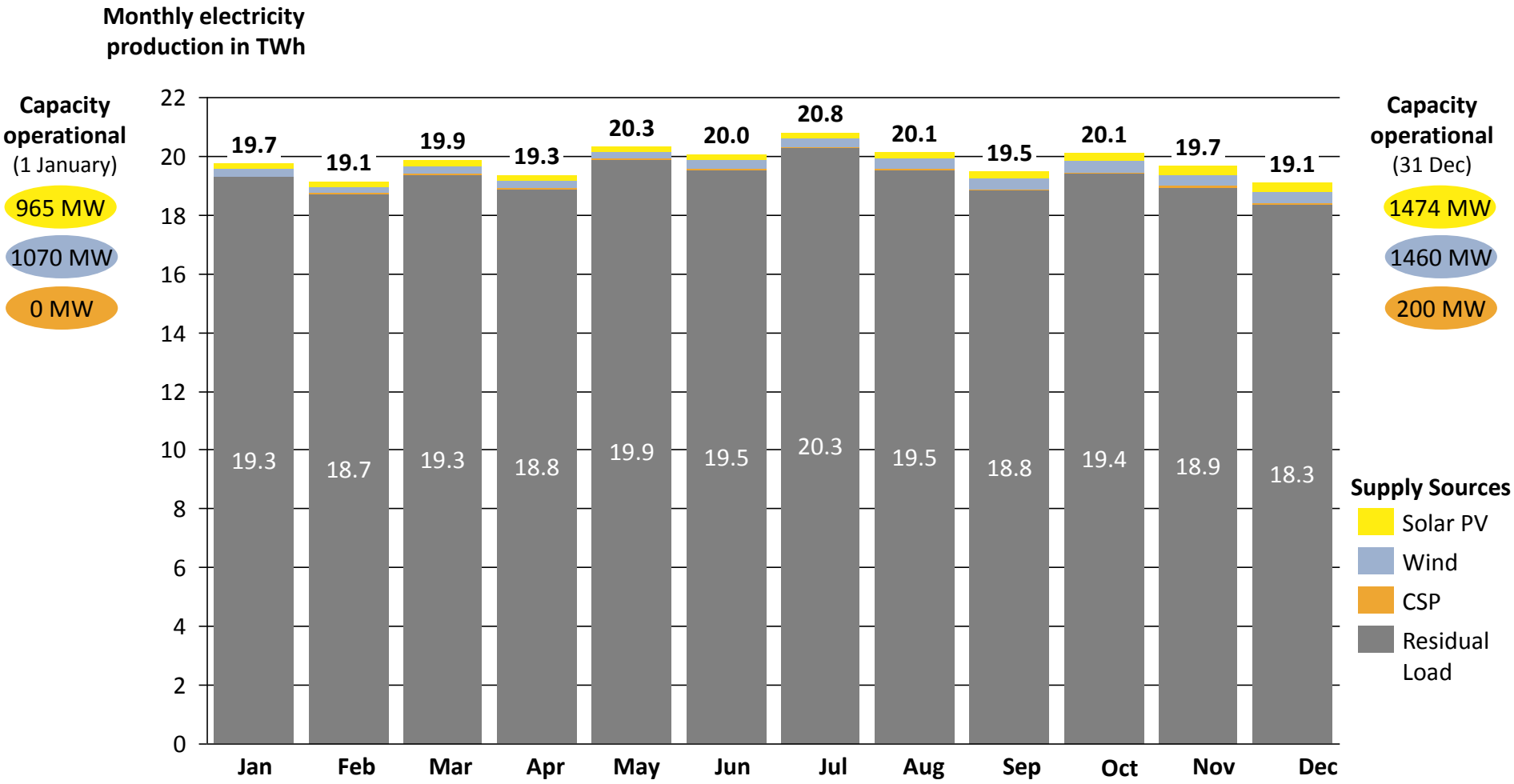
Actual monthly production from wind, solar PV and CSP plants in South Africa from Jan-Dec 2016



Note: Wind generation includes Eskom's 100 MW Sere wind farm. CSP energy only measured from date when more than two CSP plant was commissioned.
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

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

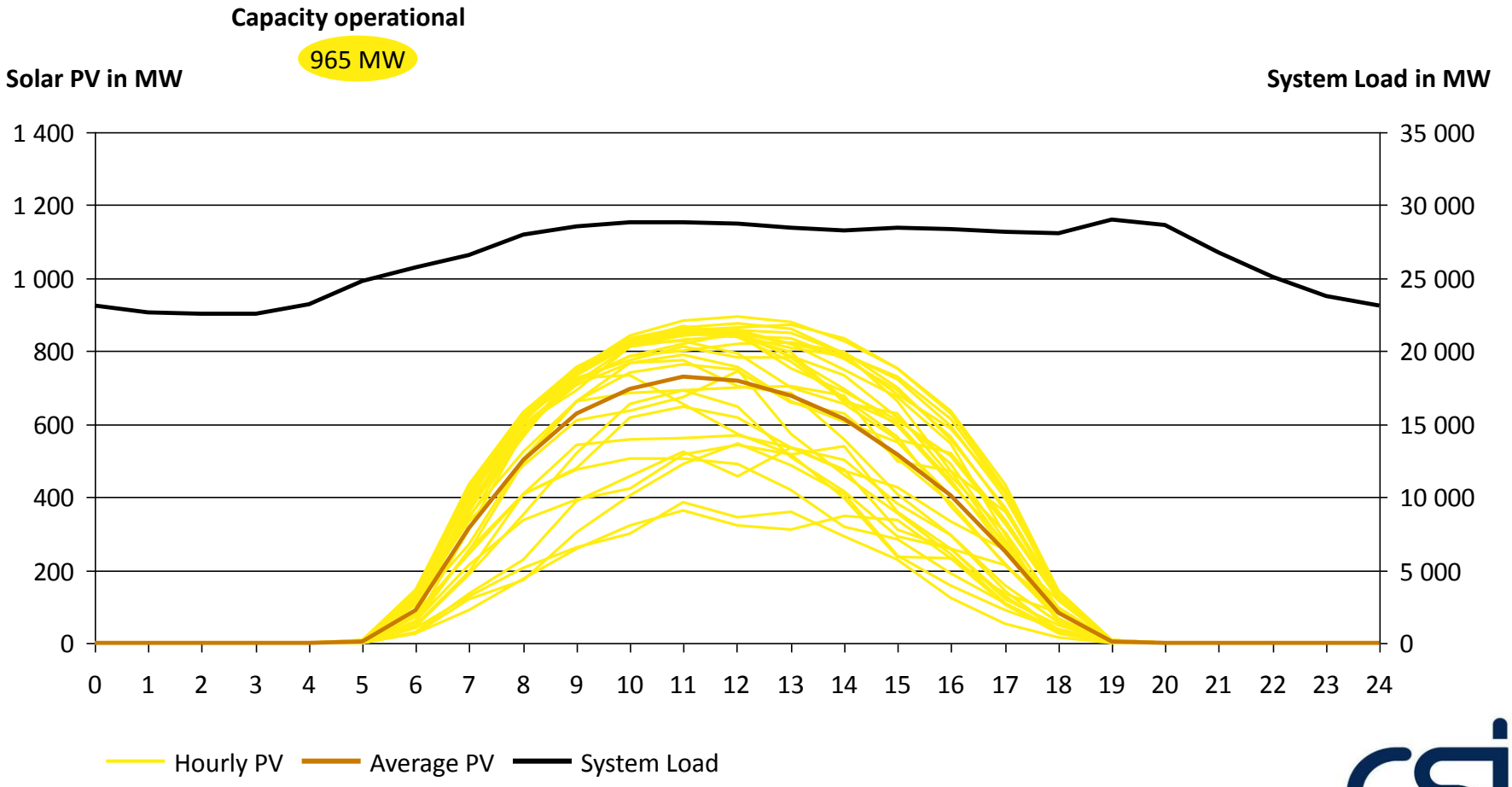
Actual monthly electricity production for Jan-Dec 2016 from the different supply sources in South Africa



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

Solar PV supply in Jan 2016 was very stable

Hourly solar PV production for all 31 days of Jan 2016 and average system load diurnal course

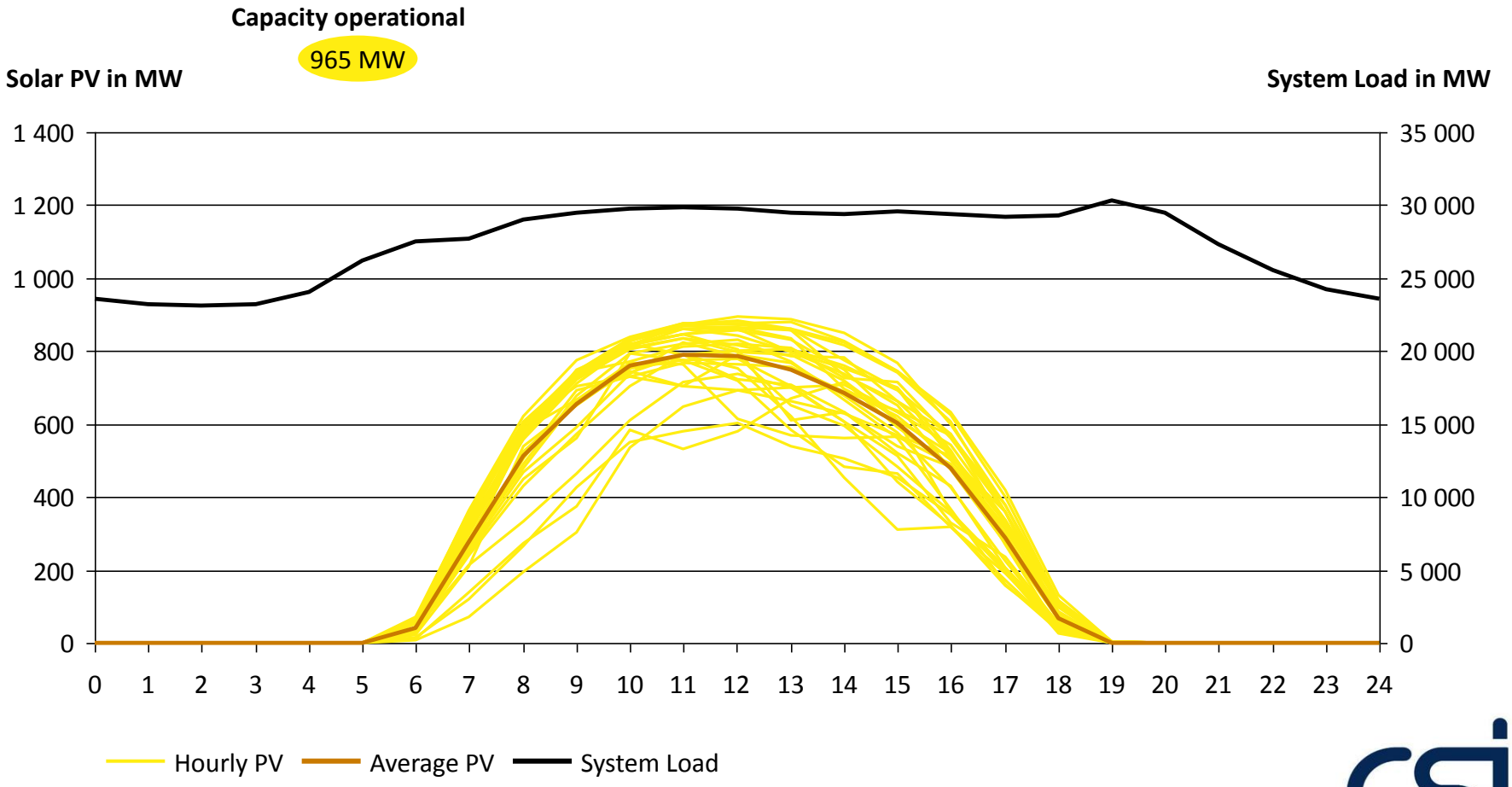


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Feb 2016 was very stable

Hourly solar PV production for all 29 days of Feb 2016 and average system load diurnal course

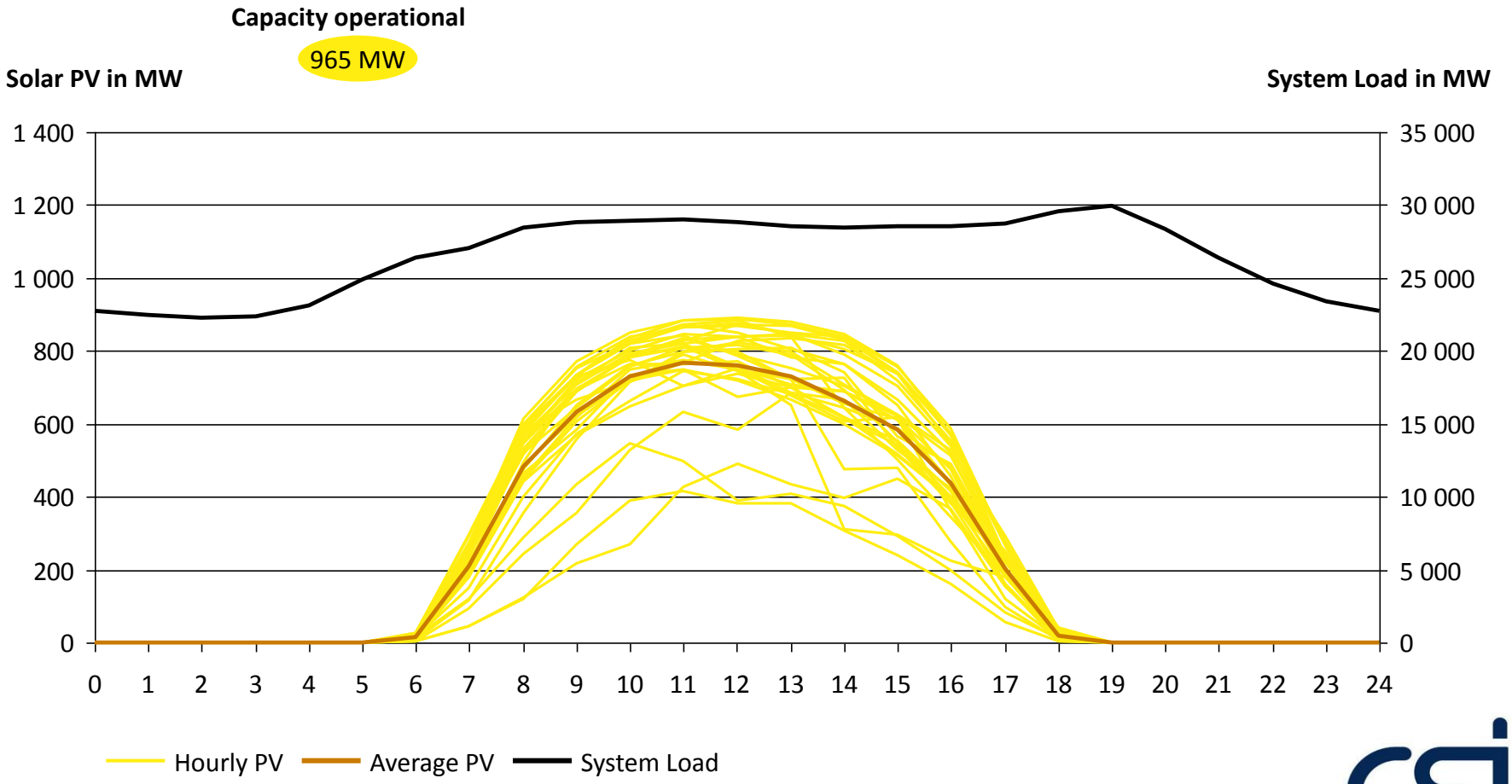


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Mar 2016 was very stable

Hourly solar PV production for all 31 days of Mar 2016 and average system load diurnal course

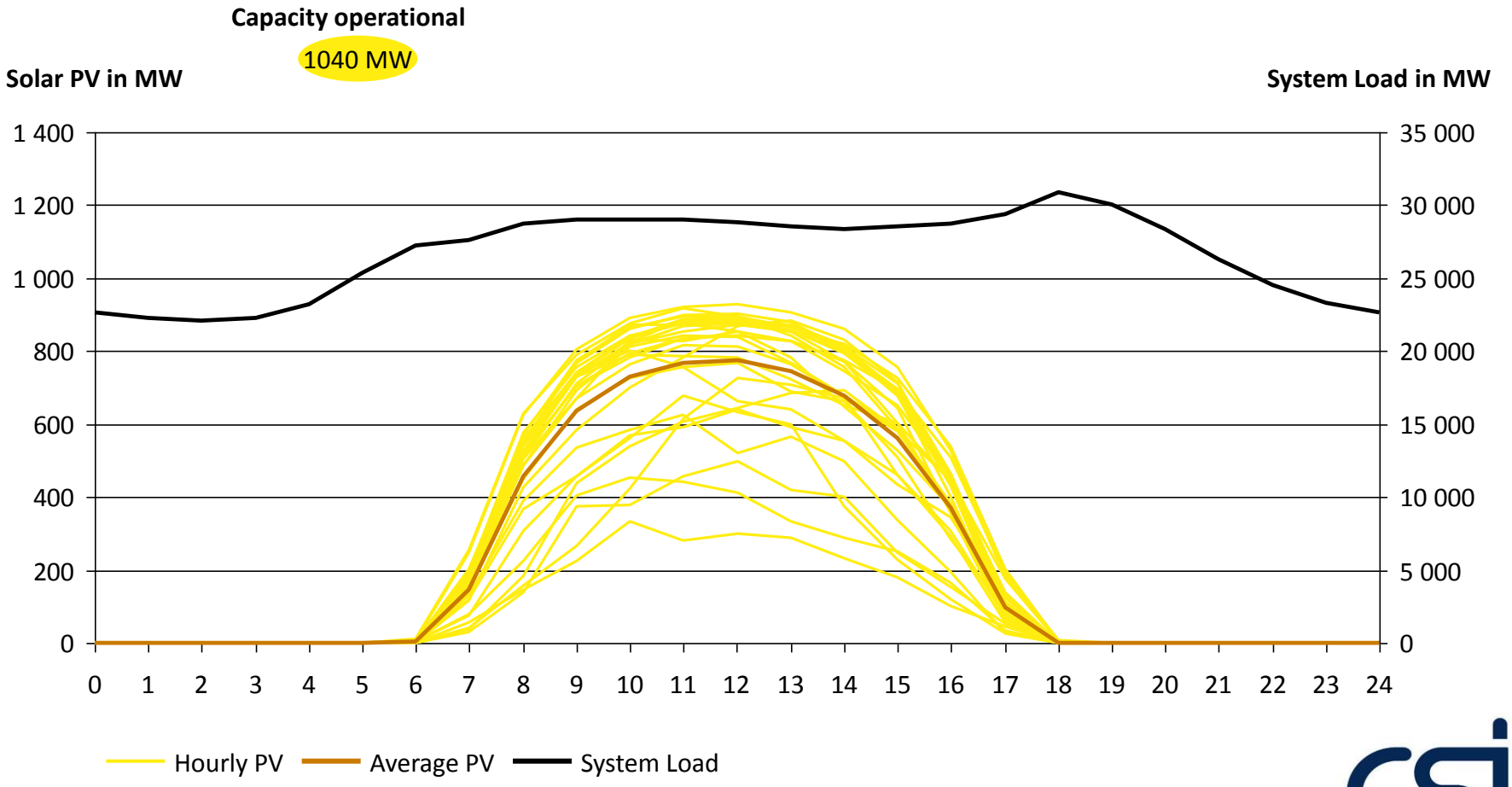


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Apr 2016 very stable

Hourly solar PV production for all 30 days of Apr 2016 and average system load diurnal course

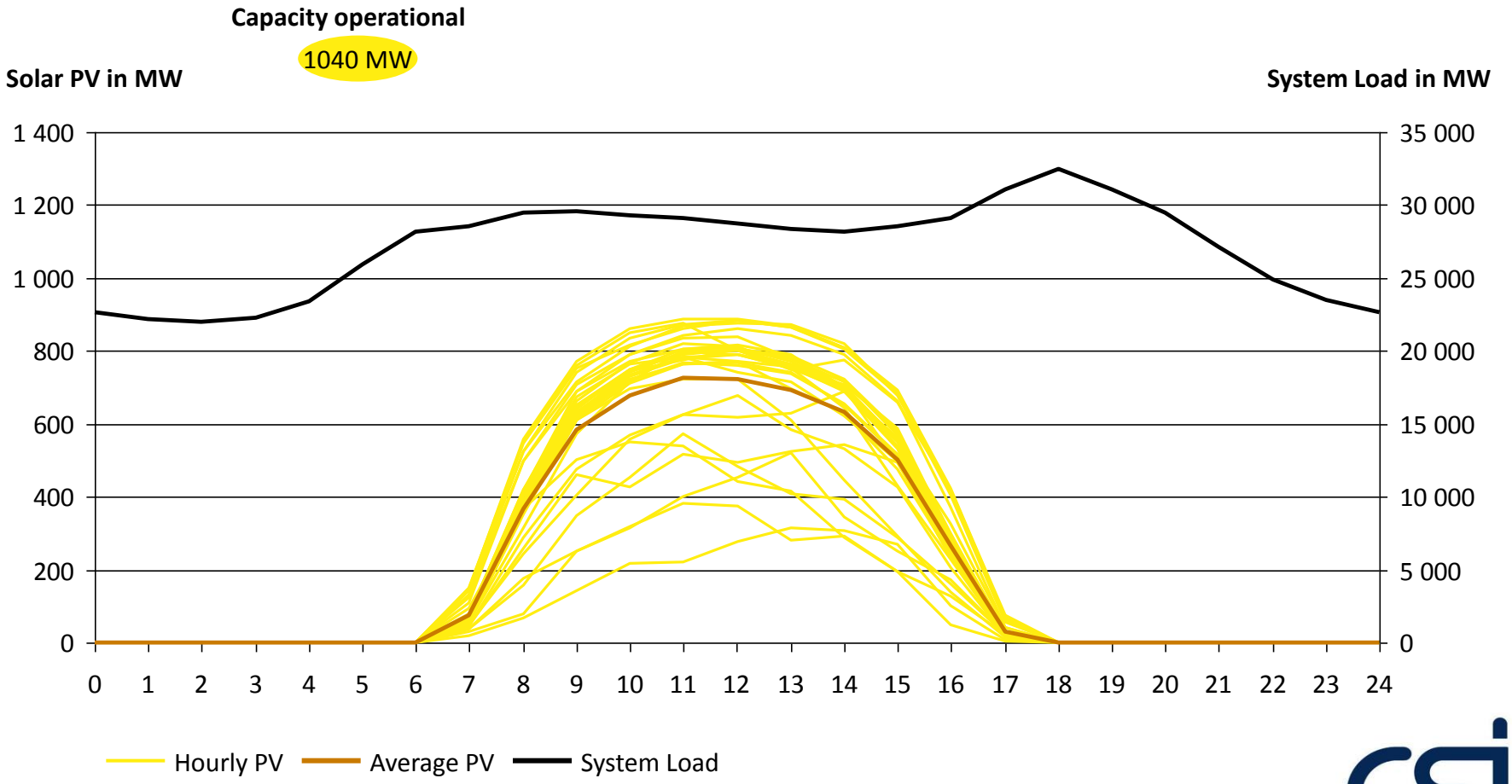


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in May 2016 very stable

Hourly solar PV production for all 31 days of May 2016 and average system load diurnal course

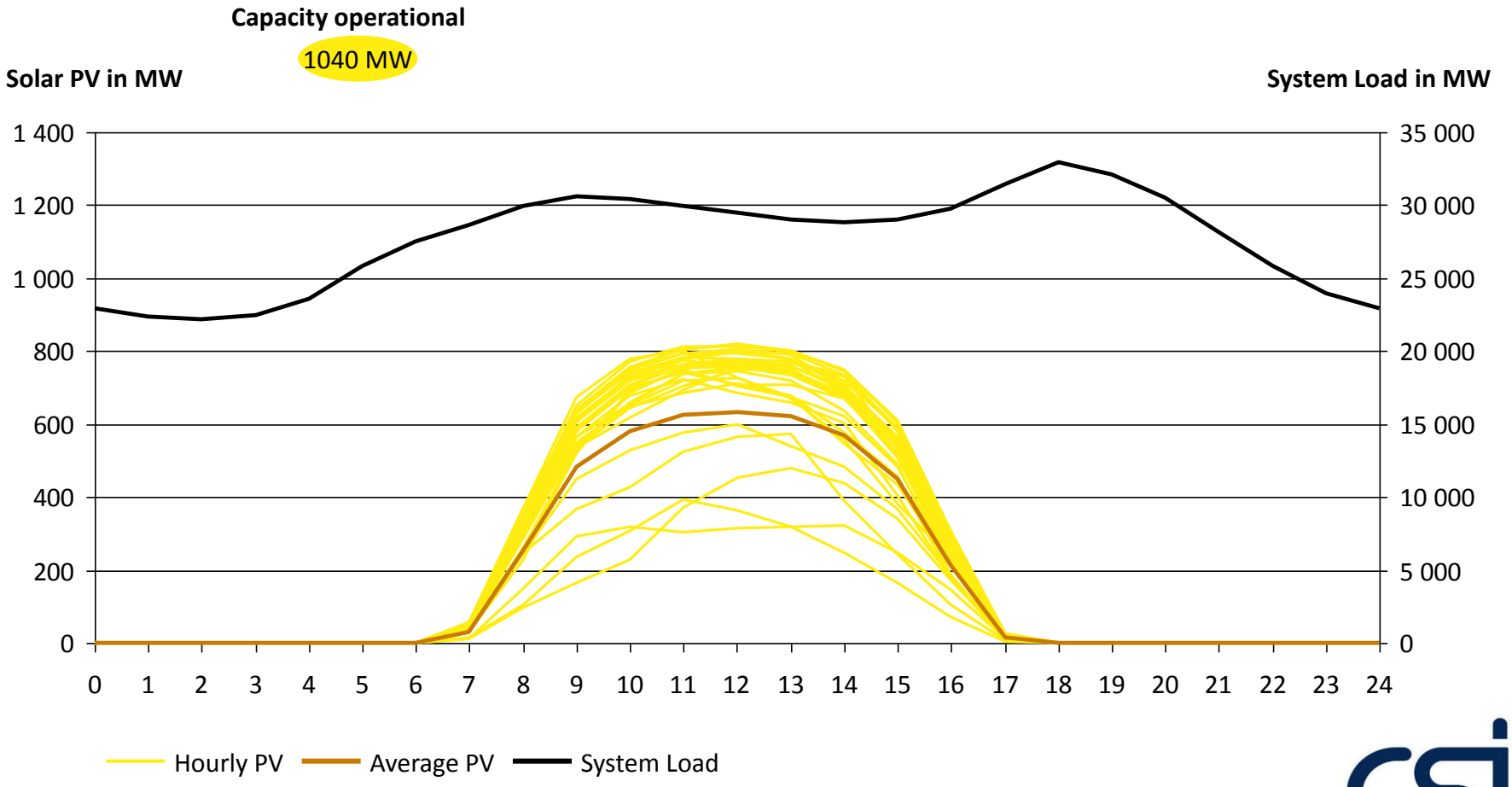


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Jun 2016 very stable

Hourly solar PV production for all 30 days of Jun 2016 and average system load diurnal course

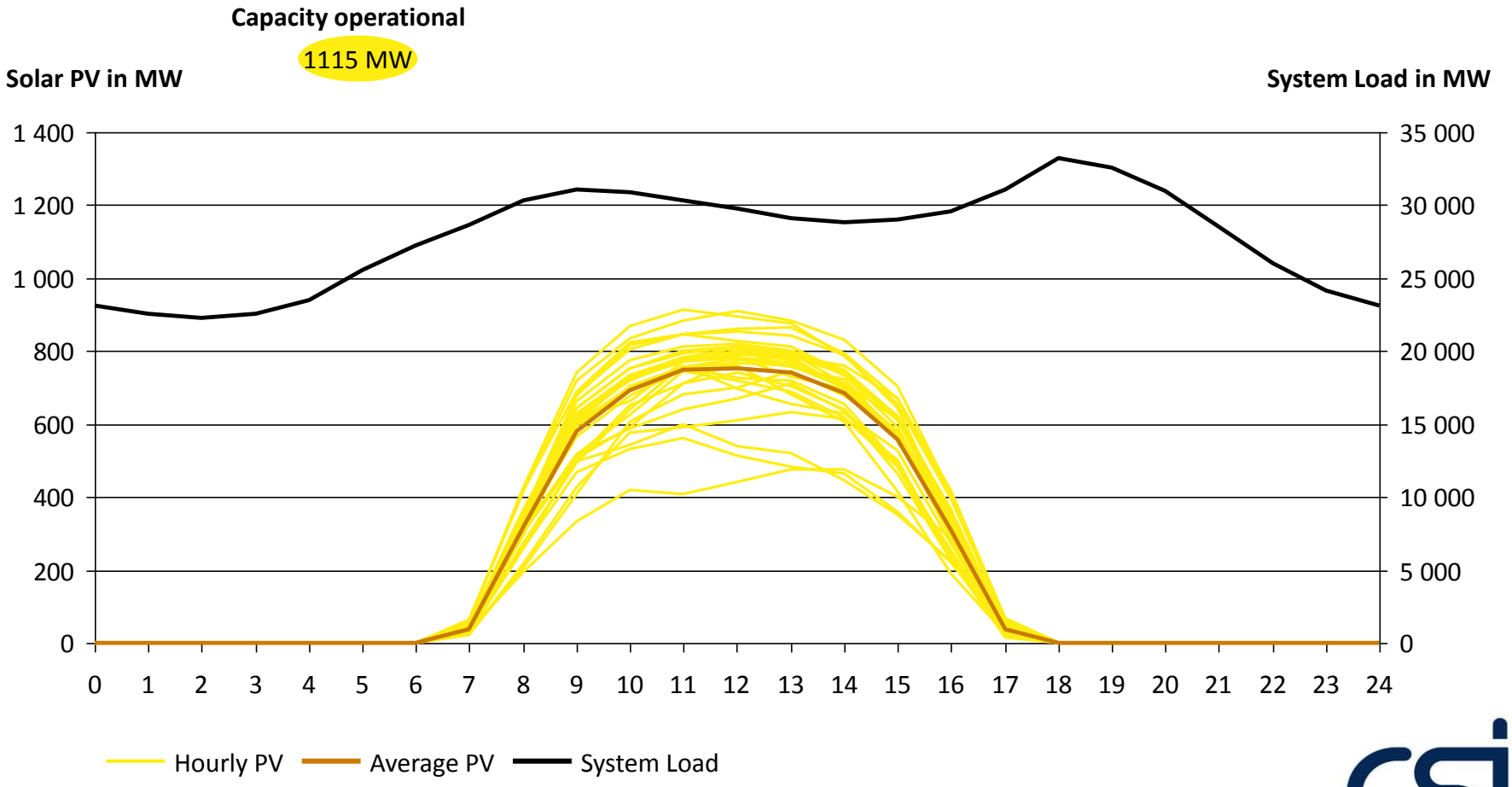


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Jul 2016 very stable

Hourly solar PV production for all 31 days of Jul 2016 and average system load diurnal course

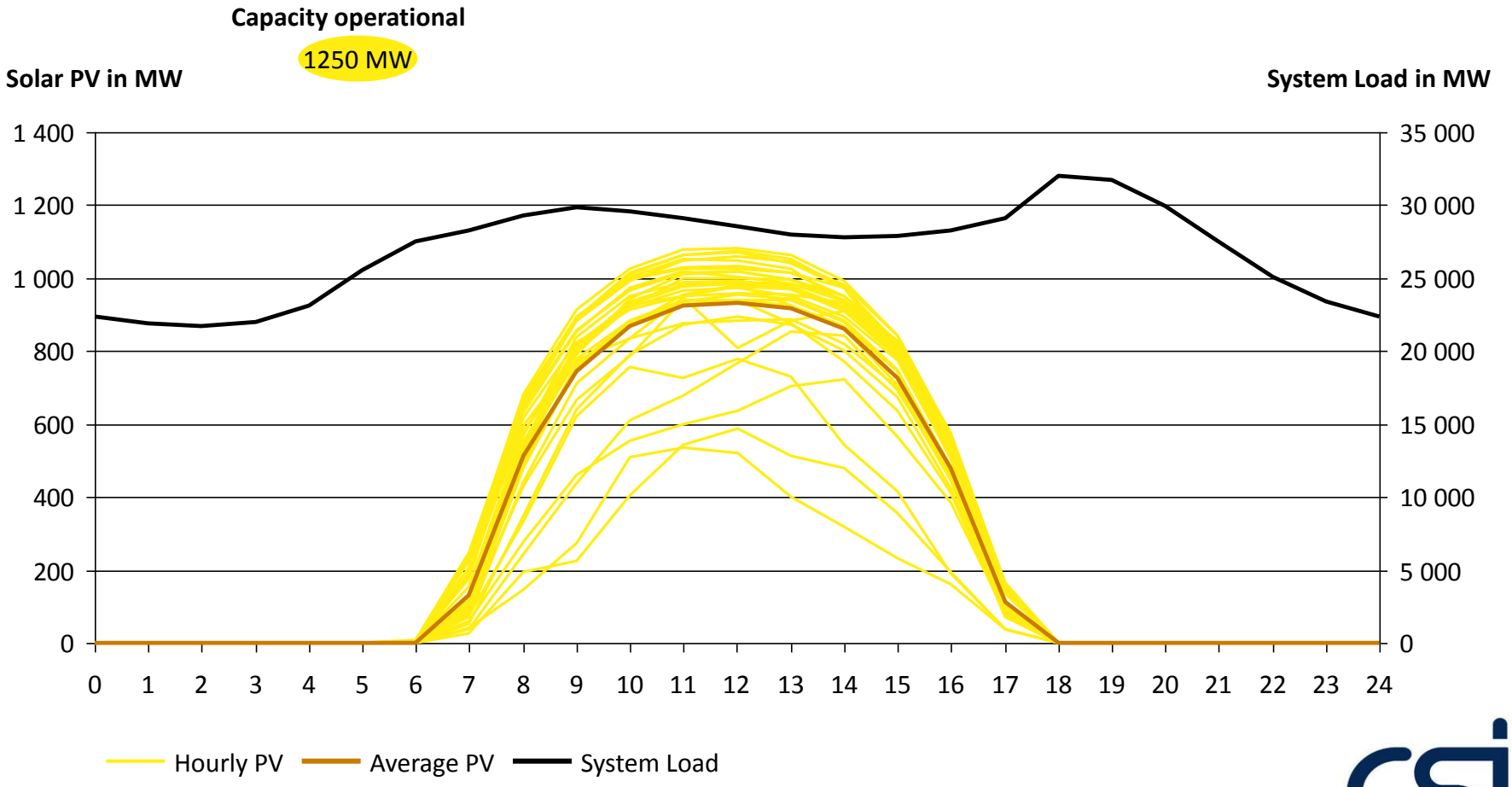


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Aug 2016 very stable

Hourly solar PV production for all 31 days of Aug 2016 and average system load diurnal course

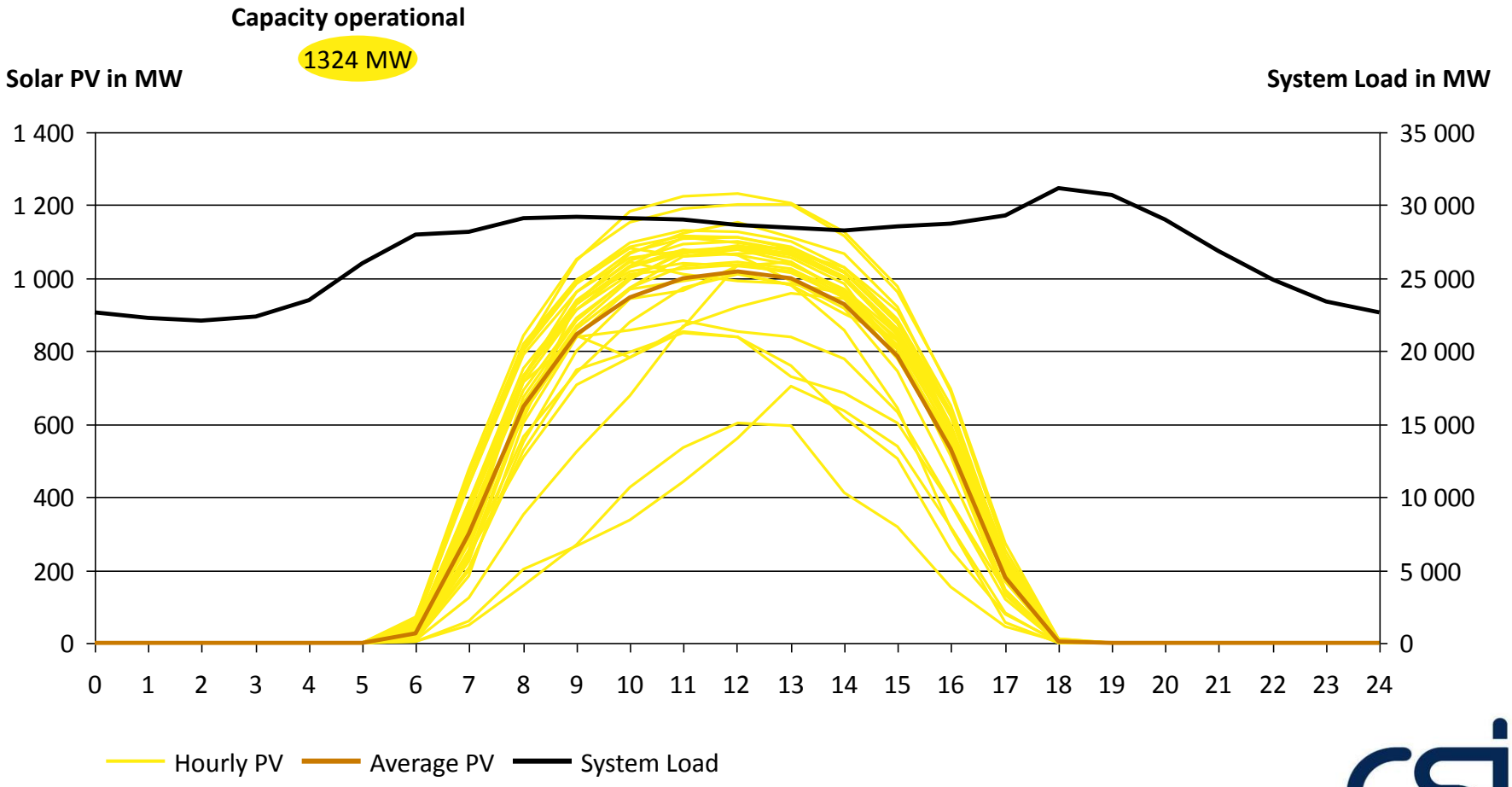


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Sep 2016 very stable

Hourly solar PV production for all 30 days of Sep 2016 and average system load diurnal course

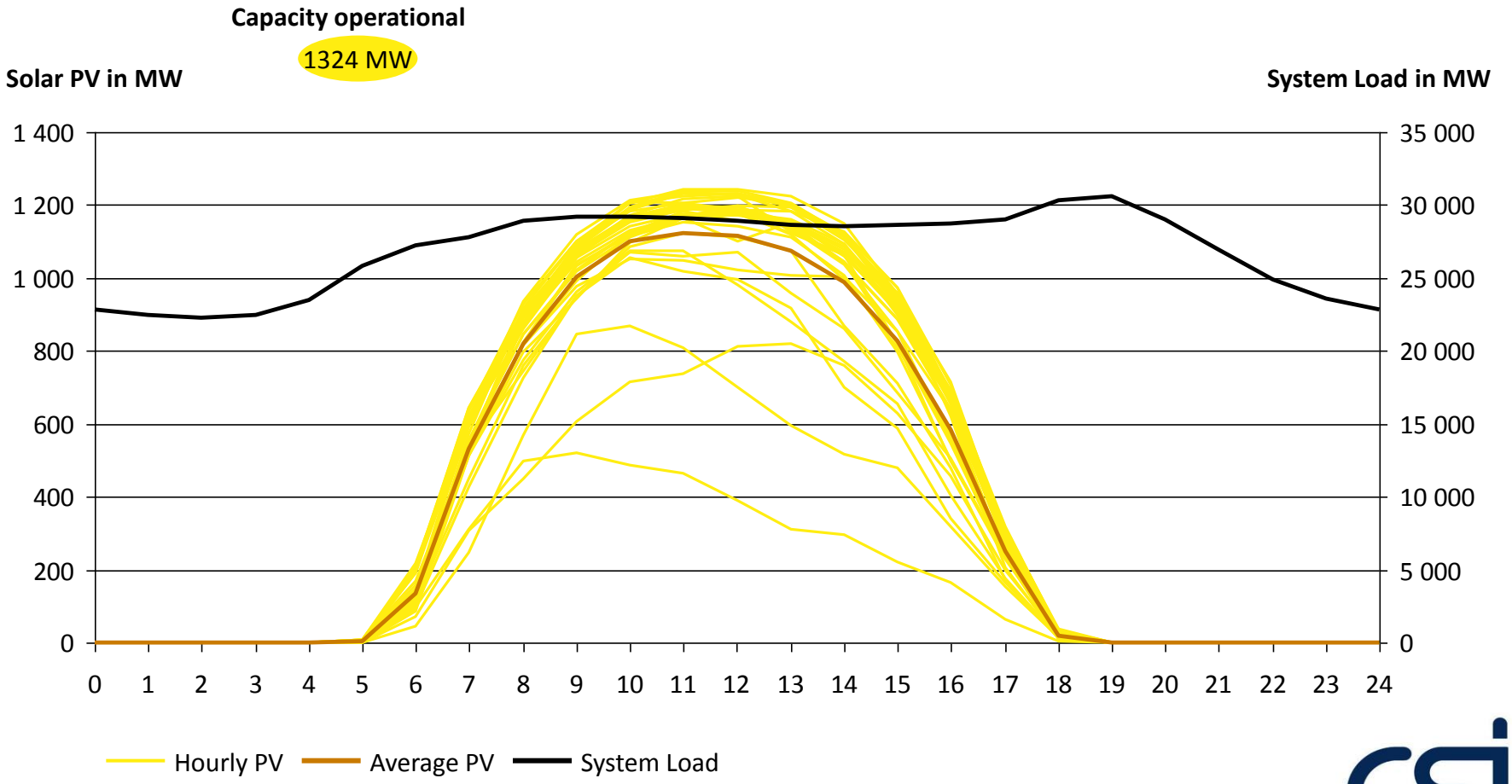


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Oct 2016 very stable

Hourly solar PV production for all 31 days of Oct 2016 and average system load diurnal course

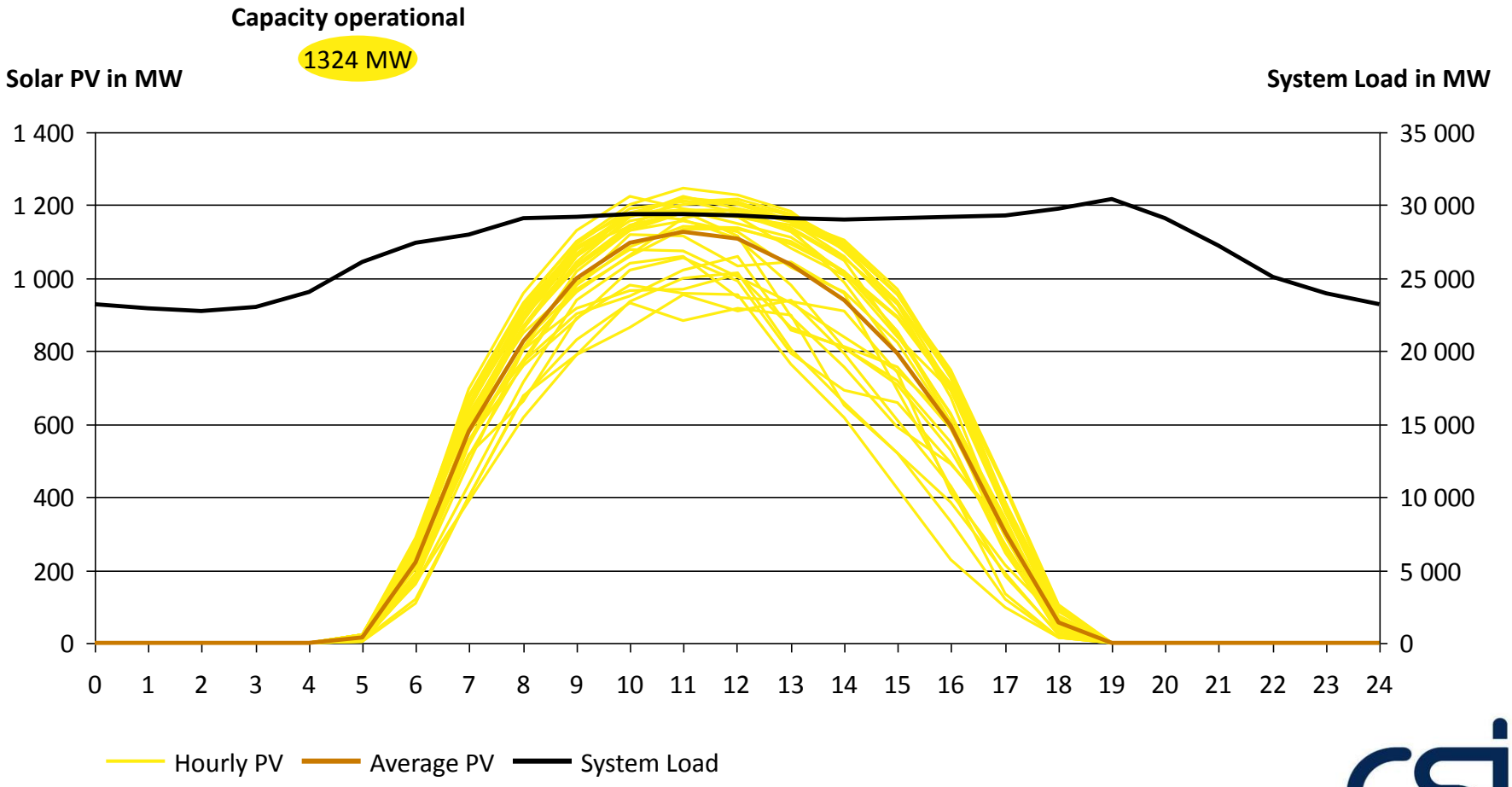


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Nov 2016 very stable

Hourly solar PV production for all 30 days of Nov 2016 and average system load diurnal course

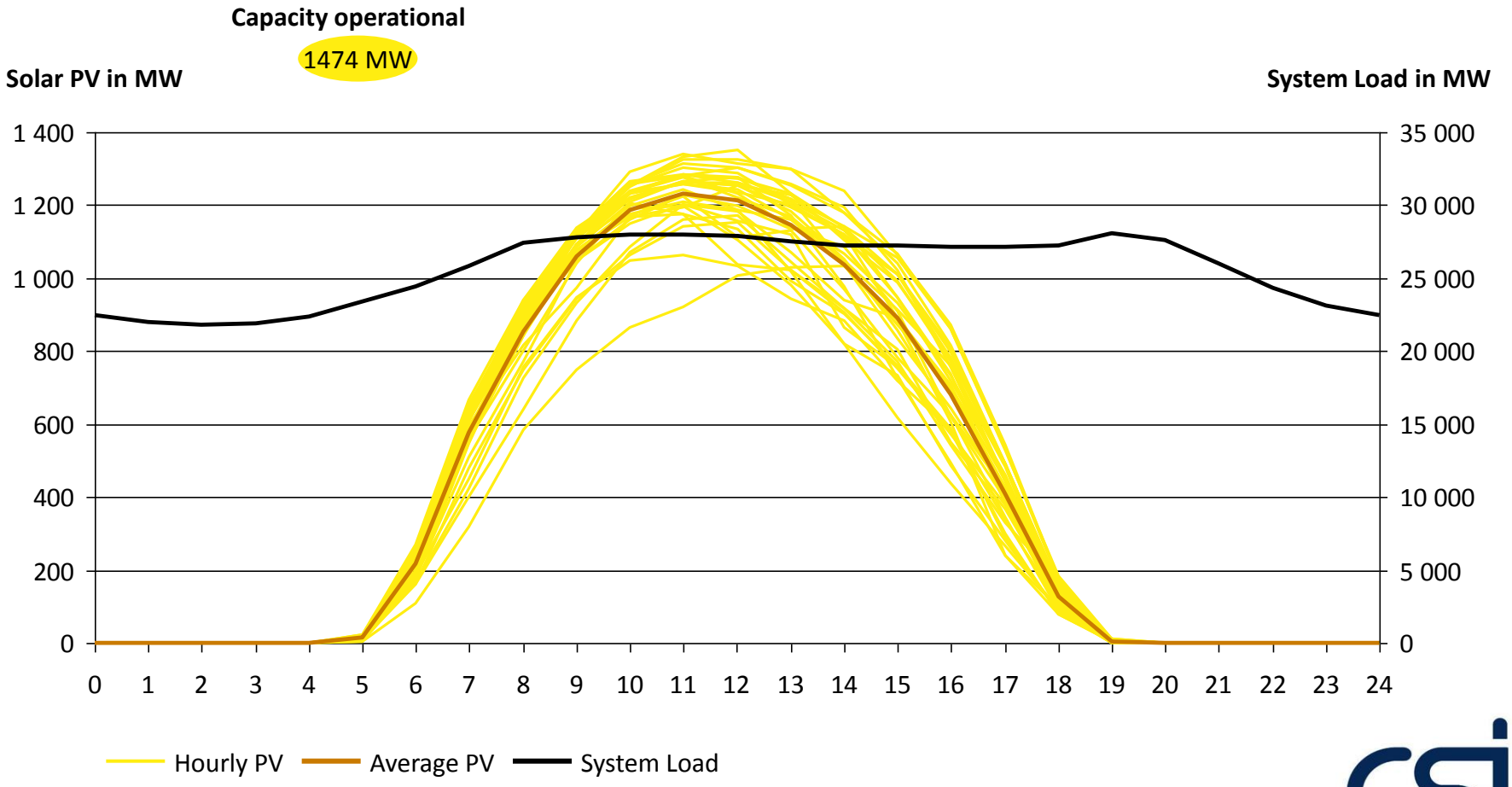


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Solar PV supply in Dec 2016 very stable

Hourly solar PV production for all 31 days of Dec 2016 and average system load diurnal course

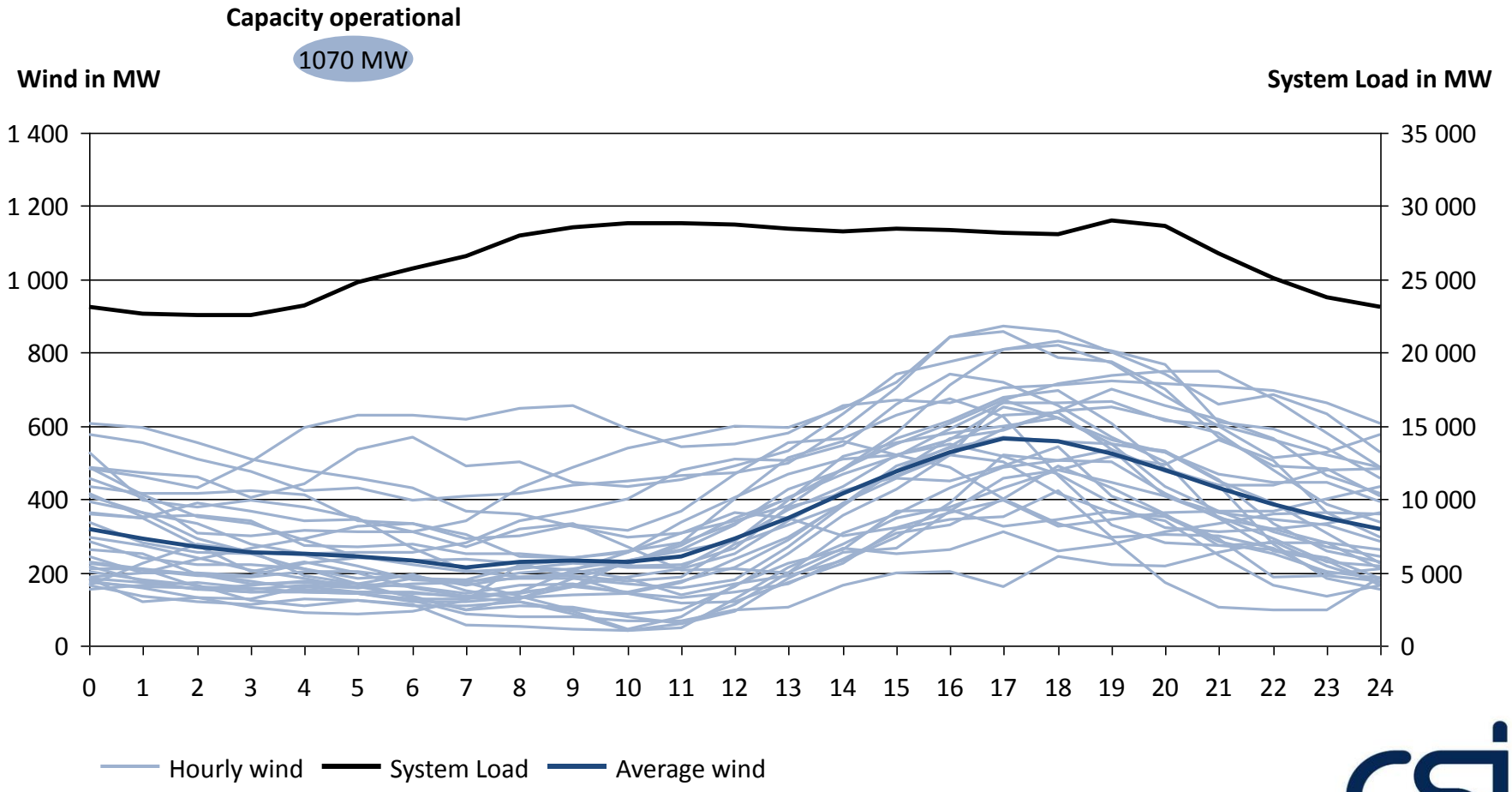


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Jan 2016, wind supplied in the evenings

Hourly wind production for all 31 days of Jan 2016 and average system load diurnal course

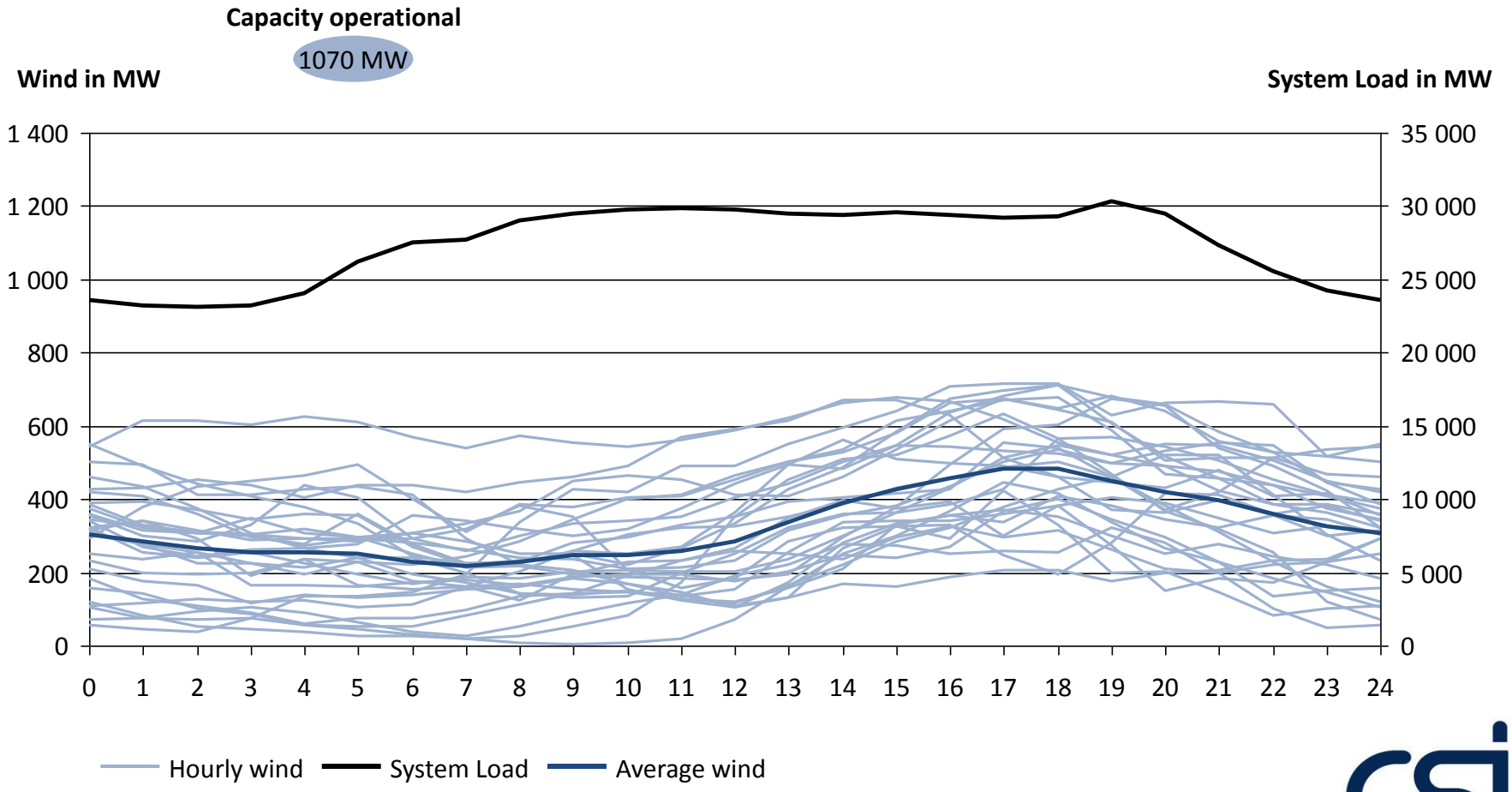


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Feb 2016, wind supplied in the evenings

Hourly wind production for all 29 days of Feb 2016 and average system load diurnal course

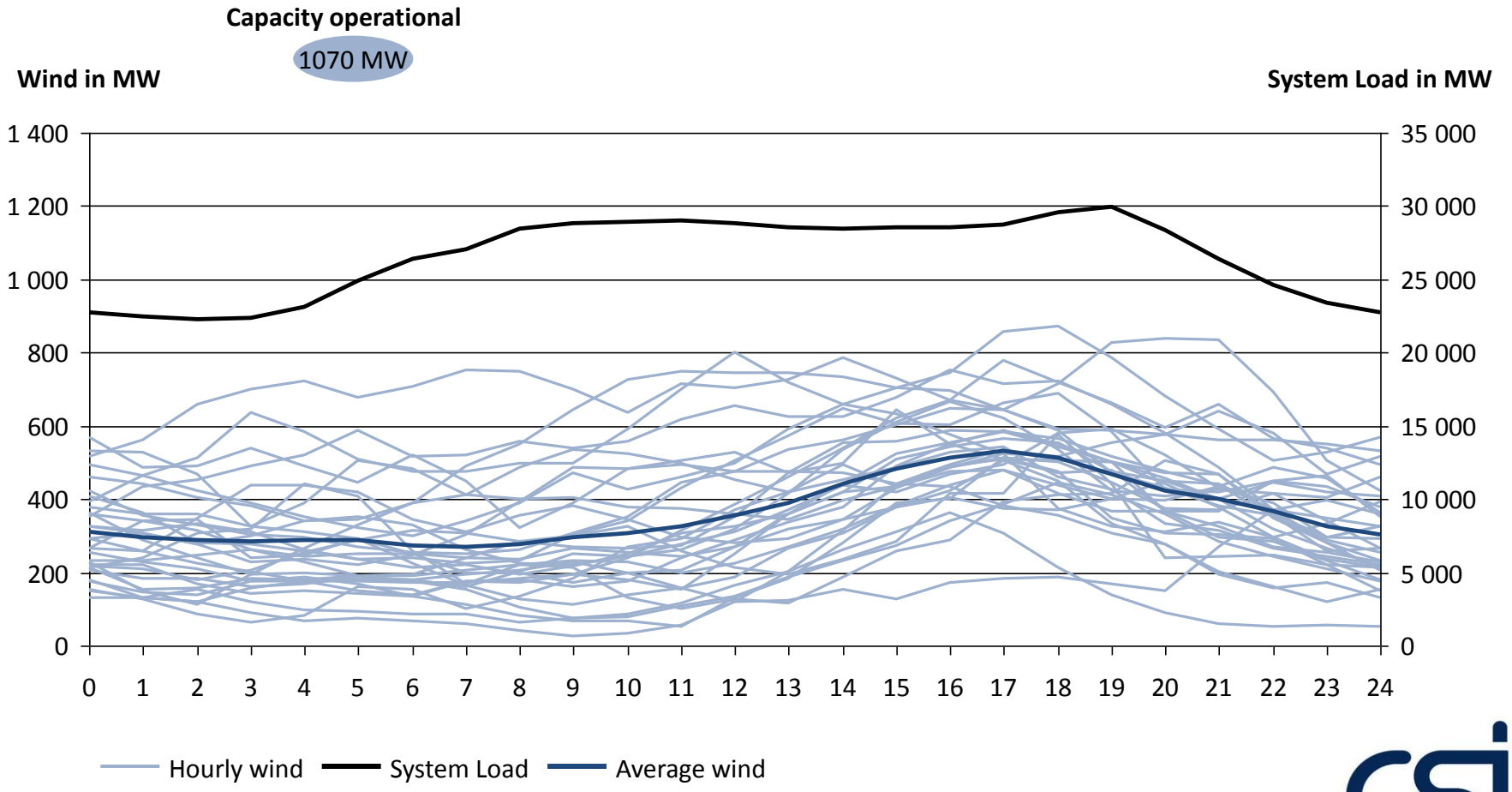


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Mar 2016, wind supplied in the evenings

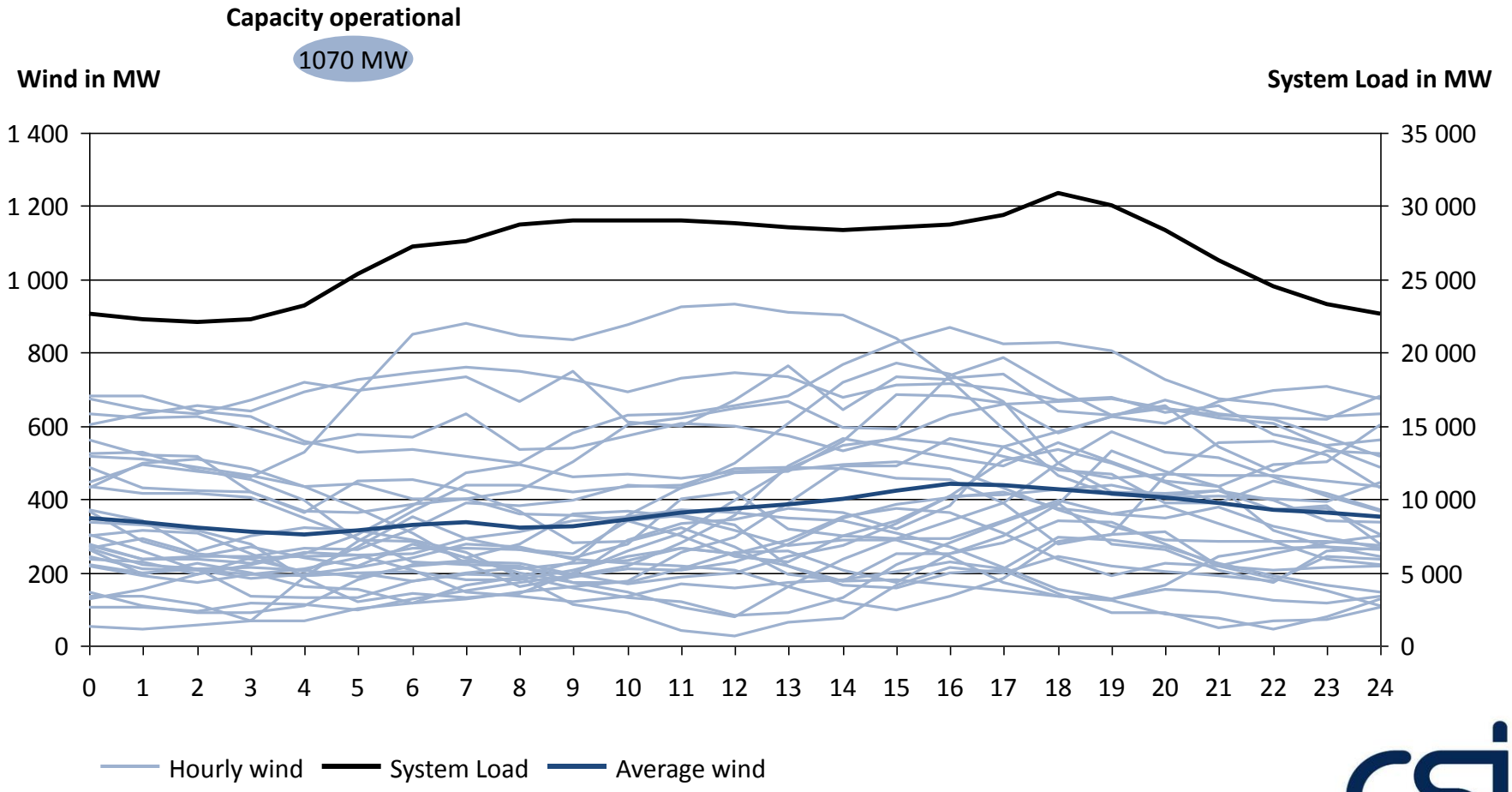
Hourly wind production for all 31 days of Mar 2016 and average system load diurnal course



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

In Apr 2016, wind fluctuated day-to-day

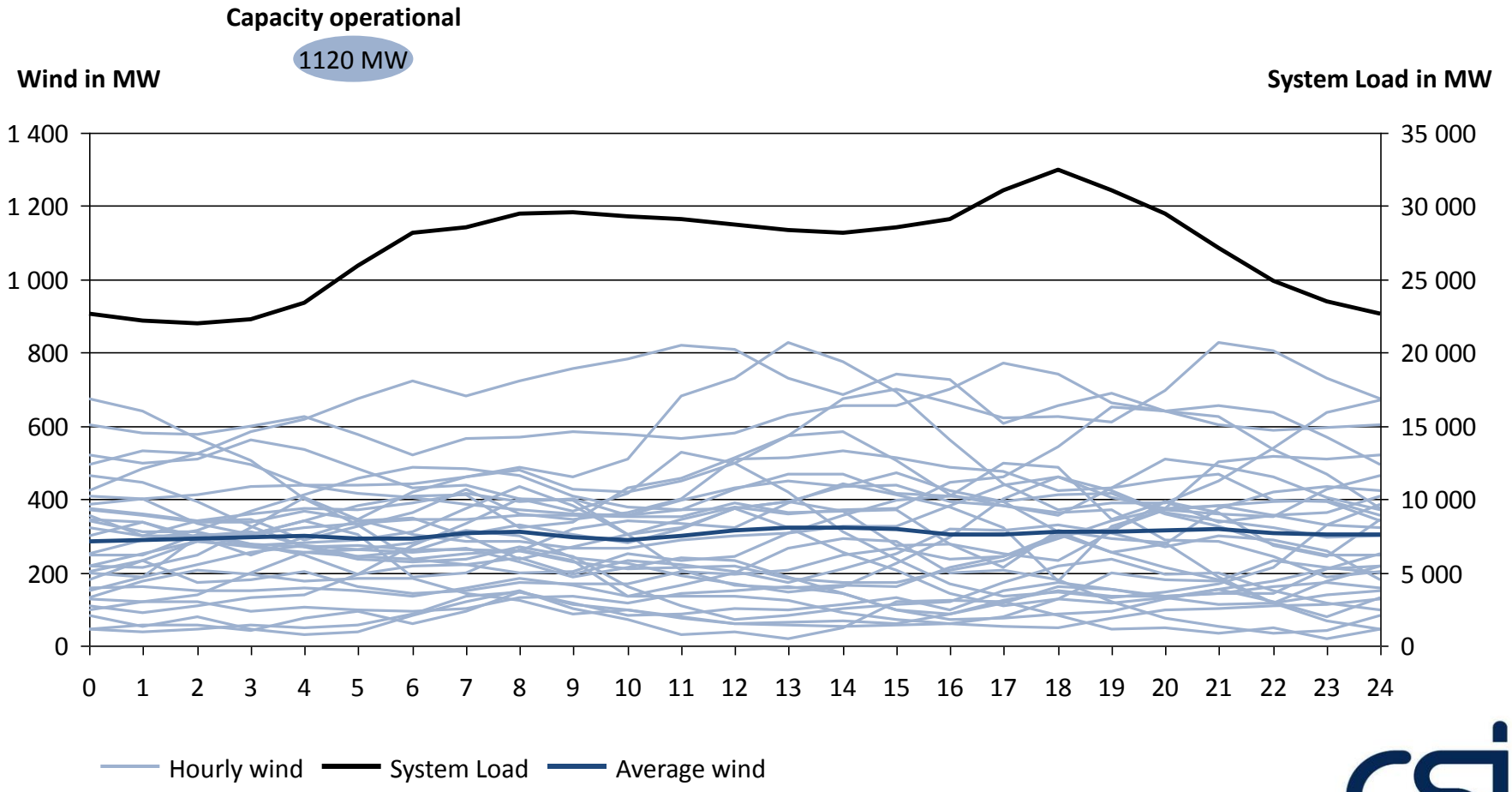
Hourly wind production for all 30 days of Apr 2016 and average system load diurnal course



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

In May 2016, wind fluctuated day-to-day

Hourly wind production for all 31 days of May 2016 and average system load diurnal course

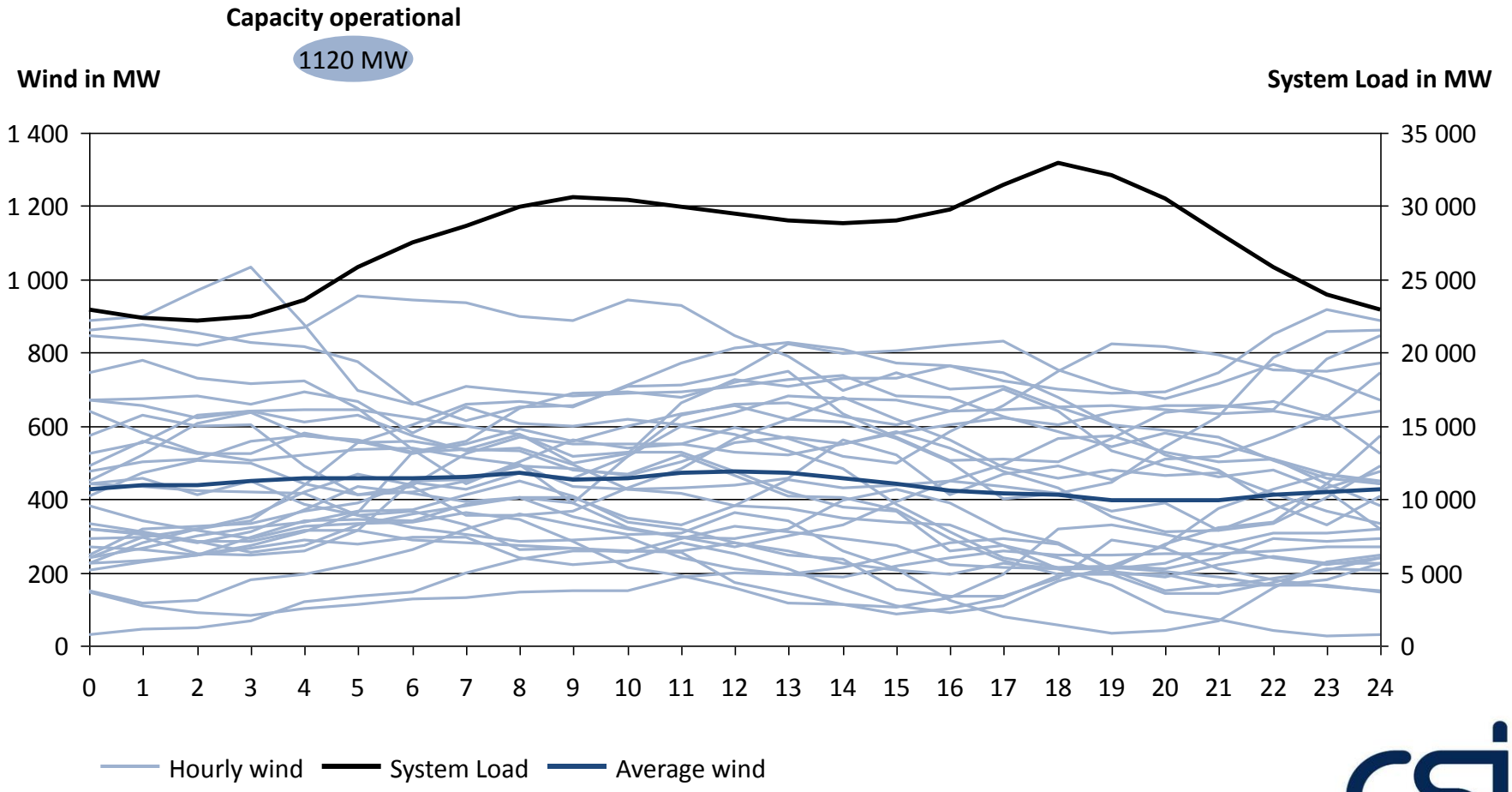


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Jun 2016, wind fluctuated day-to-day

Hourly wind production for all 30 days of Jun 2016 and average system load diurnal course

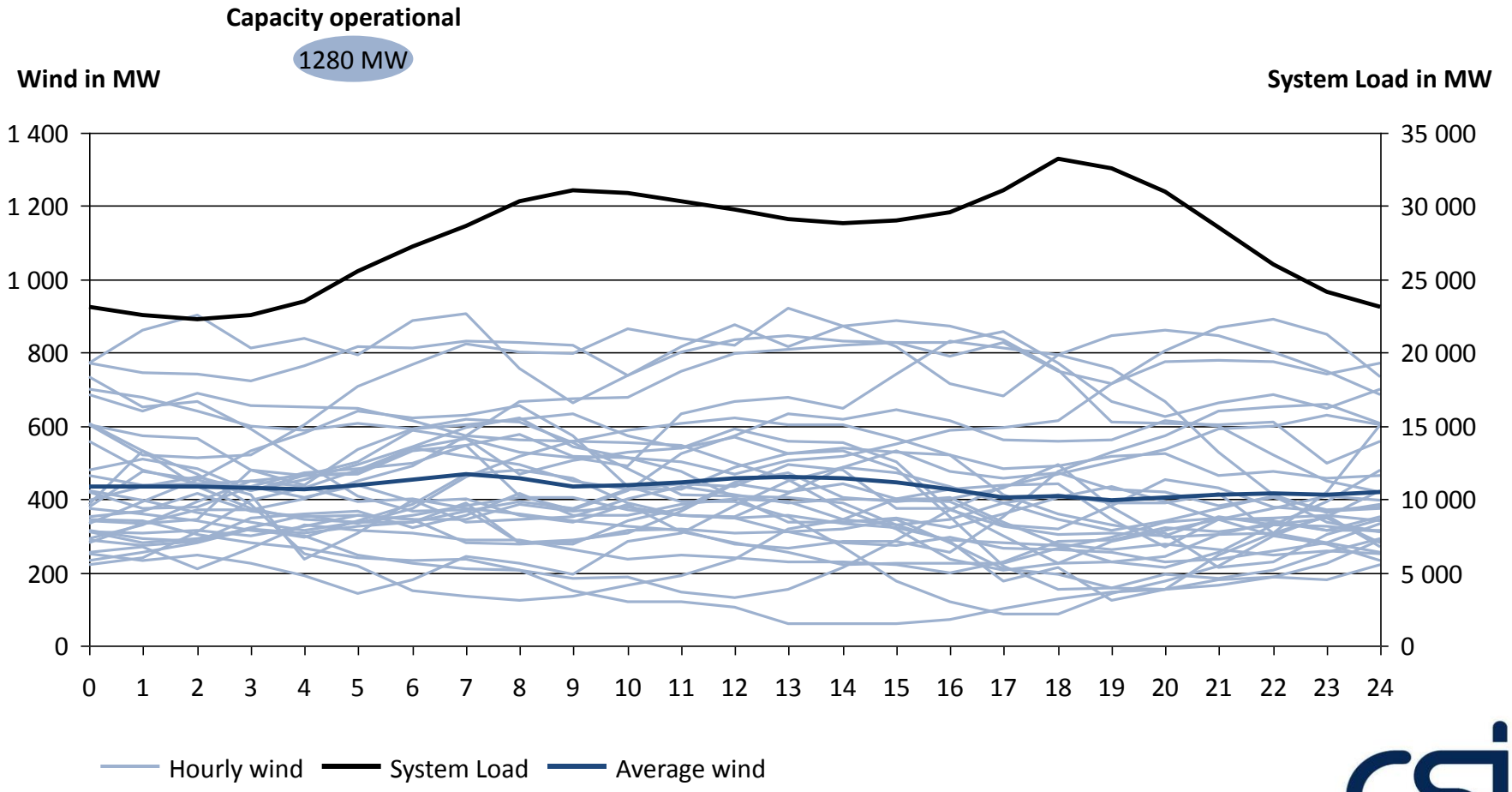


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Jul 2016, wind fluctuated day-to-day

Hourly wind production for all 31 days of Jul 2016 and average system load diurnal course

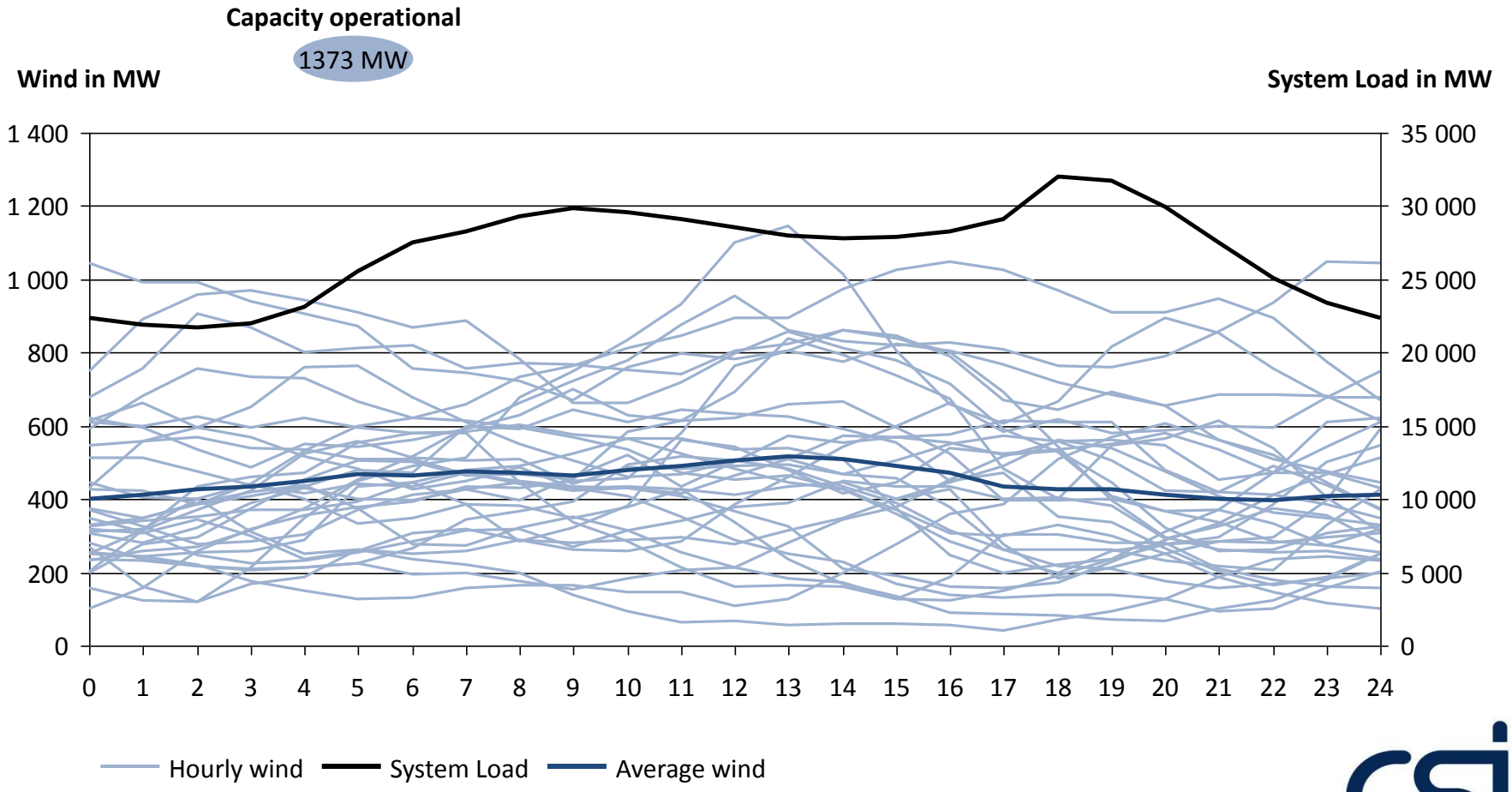


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Aug 2016, wind fluctuated day-to-day

Hourly wind production for all 31 days of Aug 2016 and average system load diurnal course

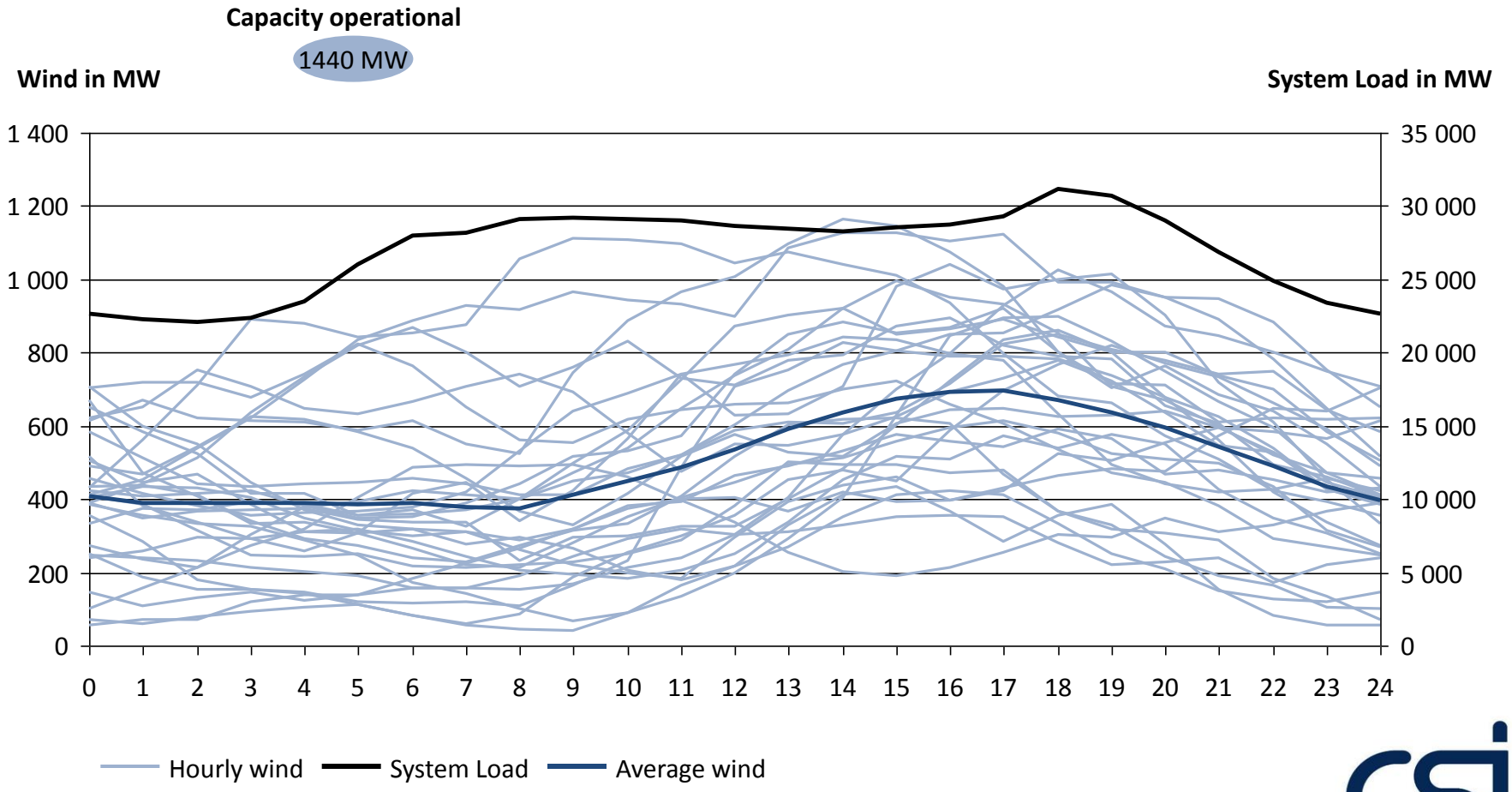


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Sep 2016, wind supplied in the evenings

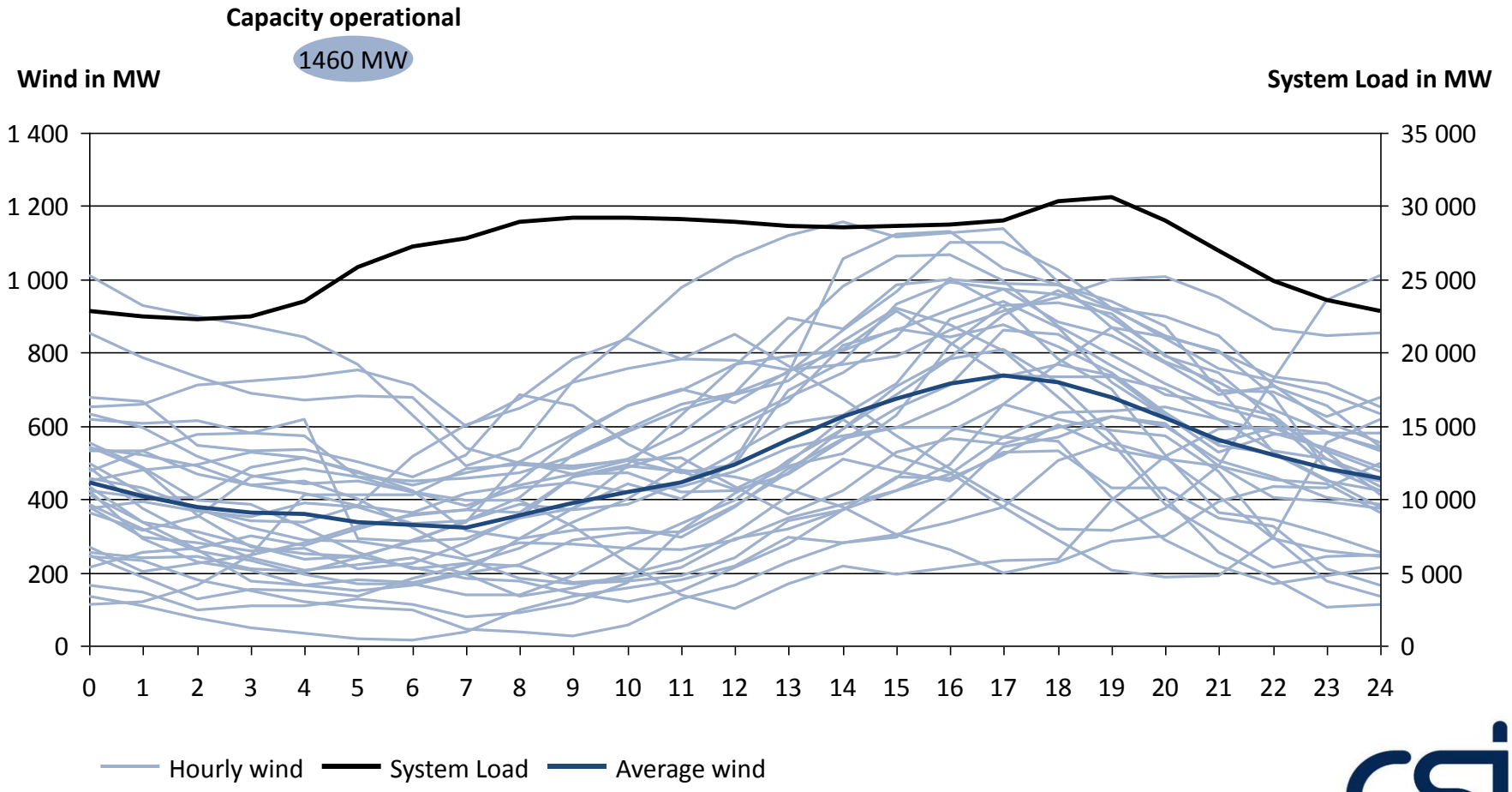
Hourly wind production for all 30 days of Sep 2016 and average system load diurnal course



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

In Oct 2016, wind supplied in the evenings

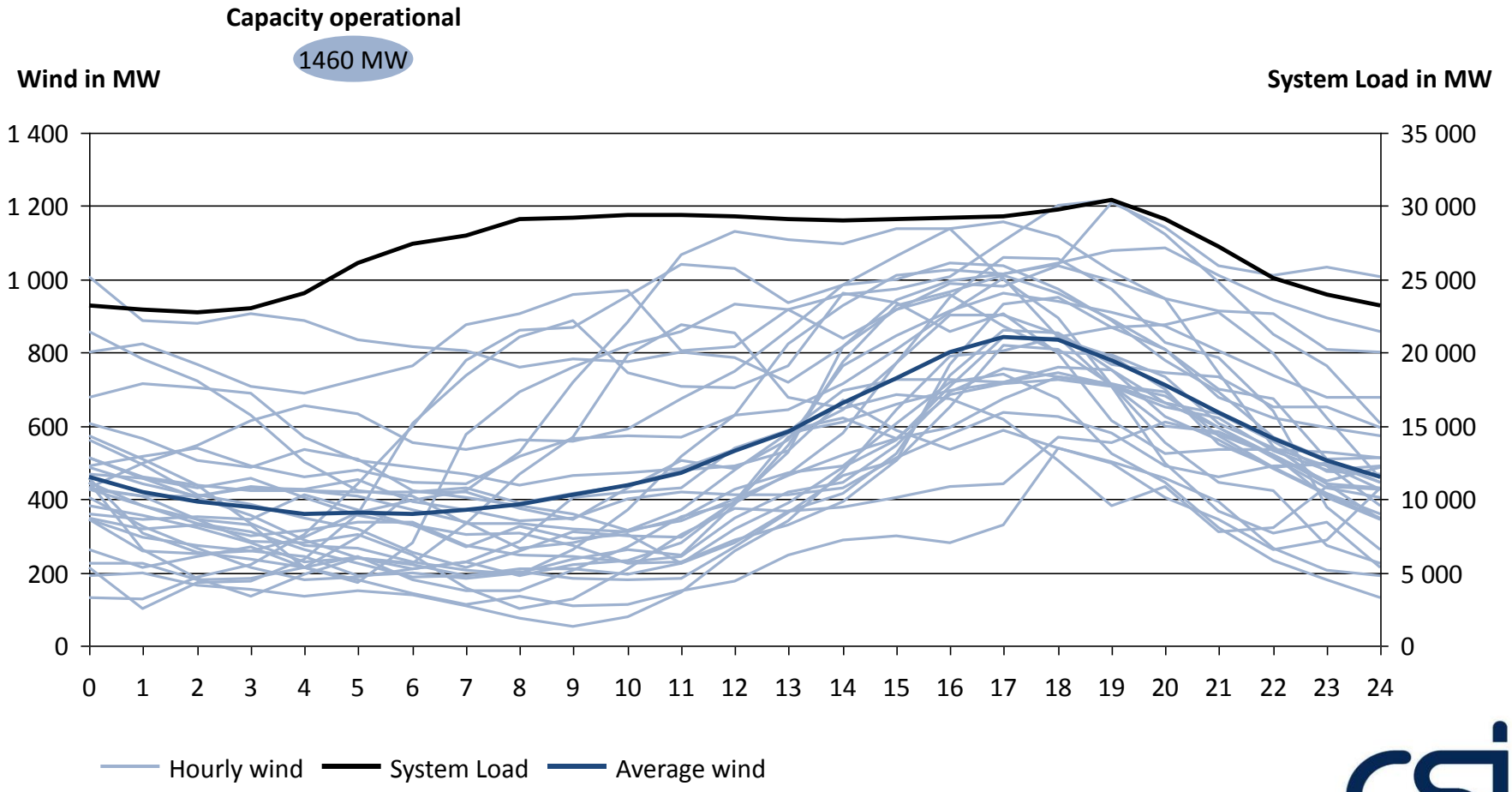
Hourly wind production for all 31 days of Oct 2016 and average system load diurnal course



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

In Nov 2016, wind supplied in the evenings

Hourly wind production for all 30 days of Nov 2016 and average system load diurnal course

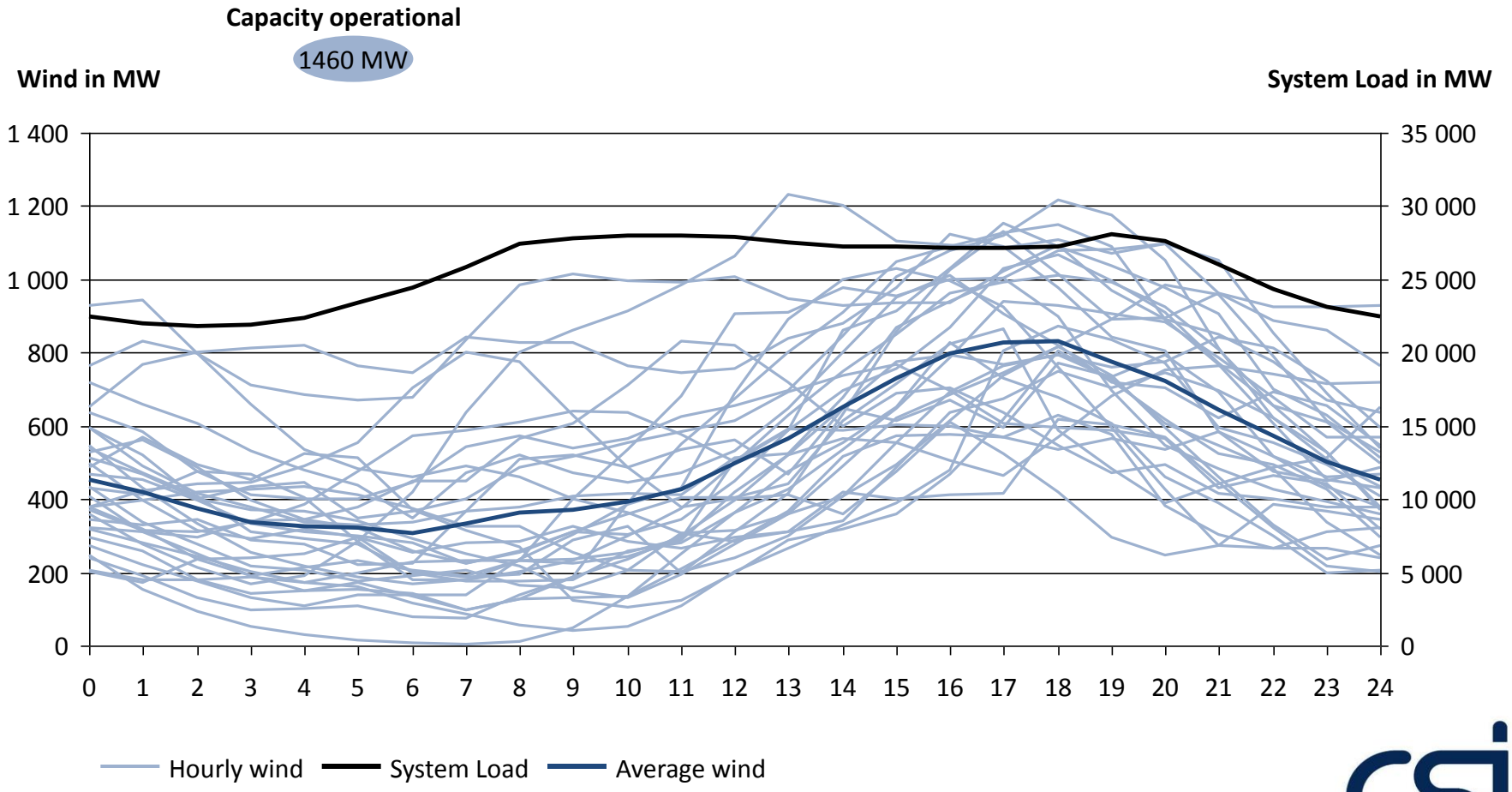


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Dec 2016, wind supplied in evenings

Hourly wind production for all 31 days of Dec 2016 and average system load diurnal course

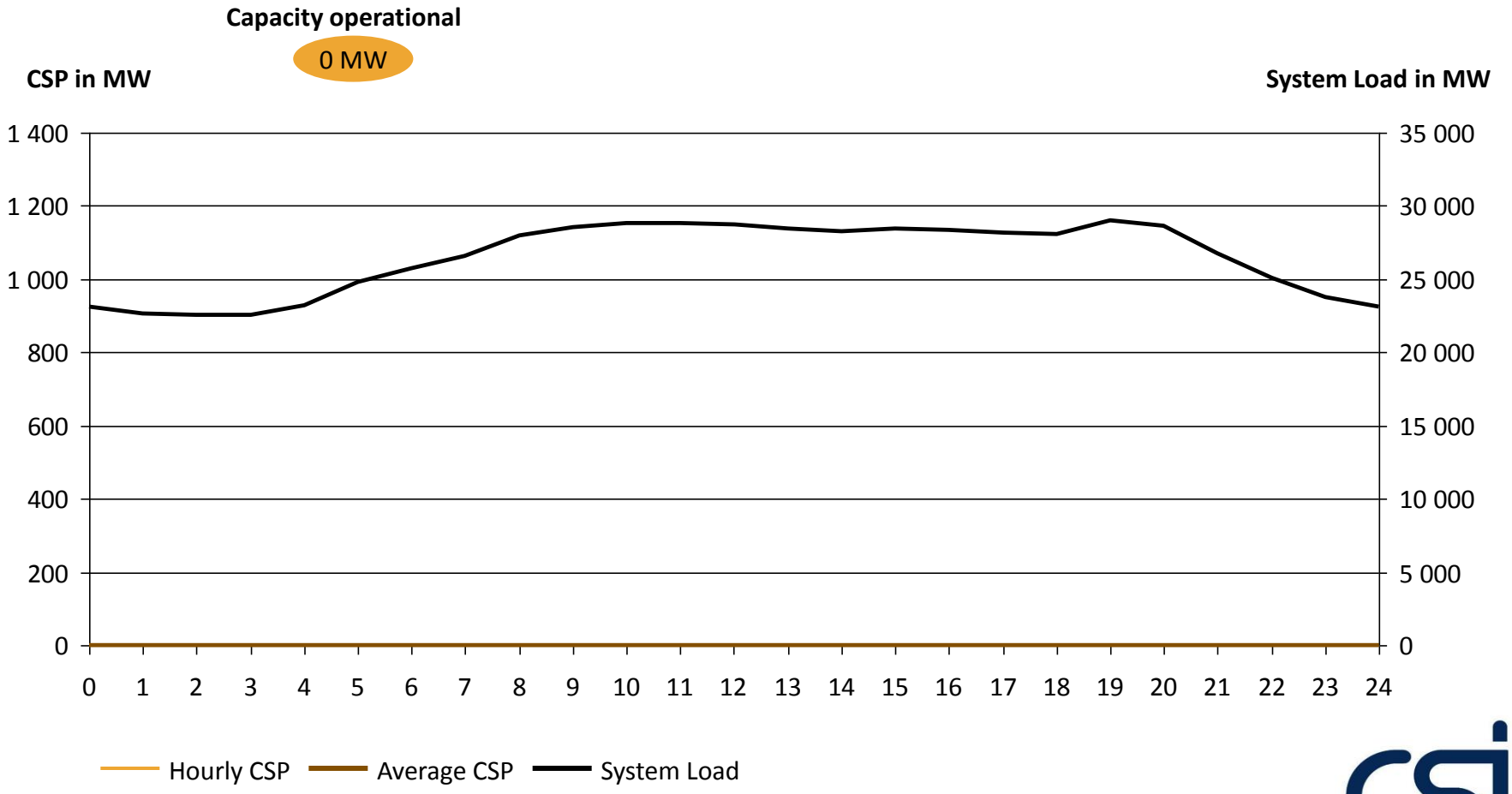


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

There was no CSP supply in Jan 2016

Hourly CSP production for all 31 days of Jan 2016 and average system load diurnal course

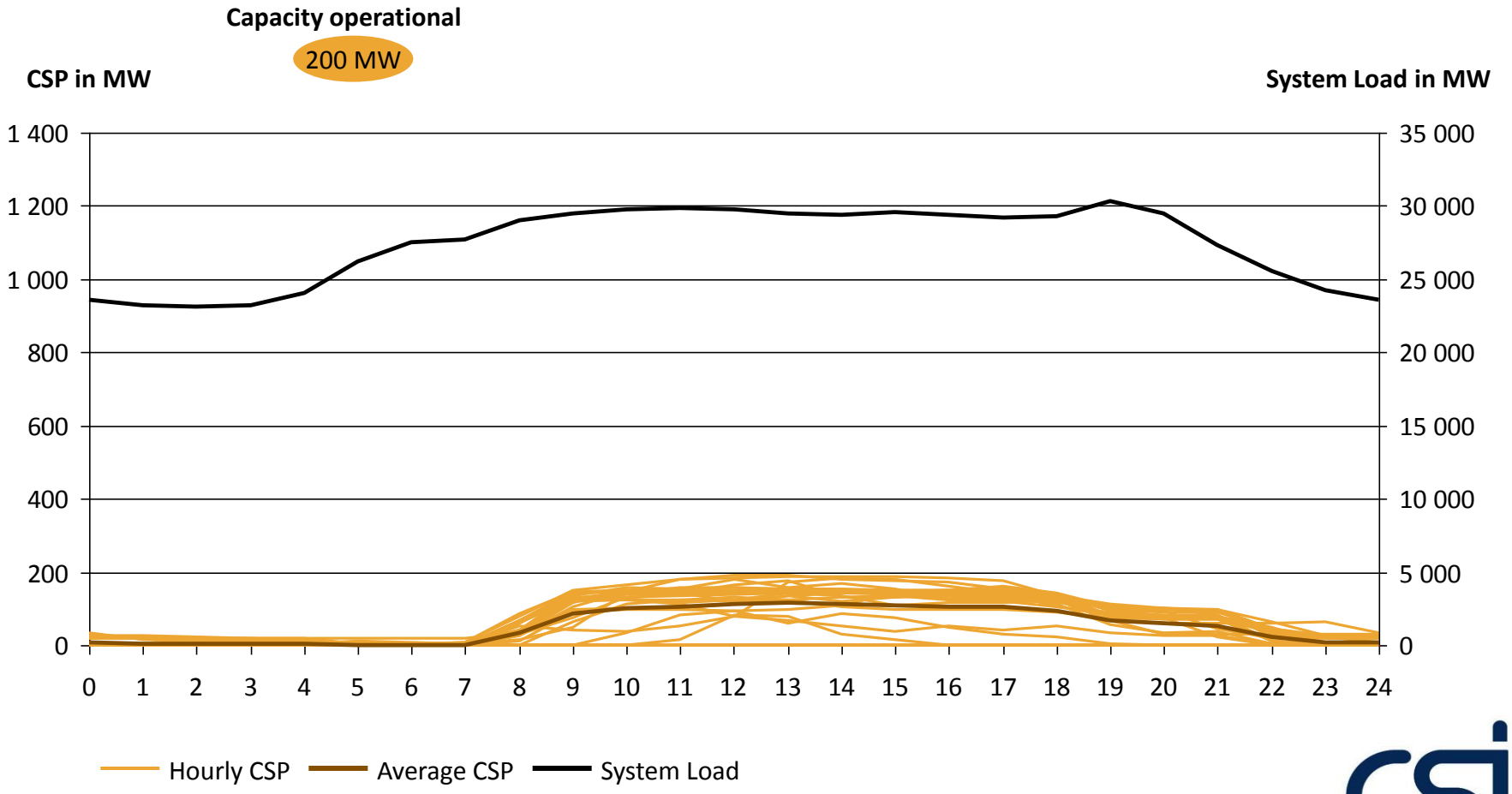


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Feb 2016, CSP storage used in evenings

Hourly CSP production for all 29 days of Feb 2016 and average system load diurnal course



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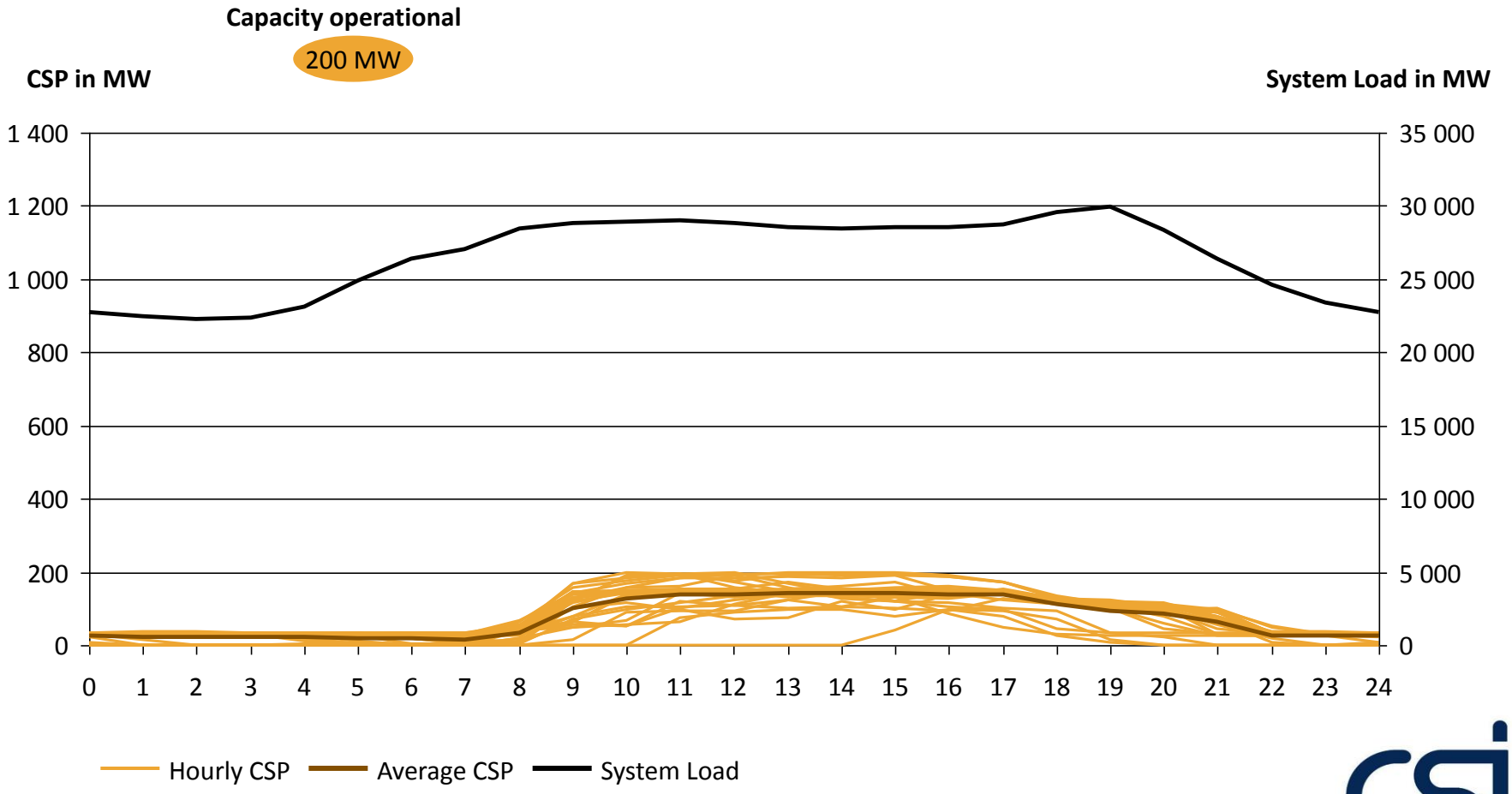
Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Mar 2016, CSP storage used in evenings

Hourly CSP production for all 31 days of Mar 2016 and average system load diurnal course



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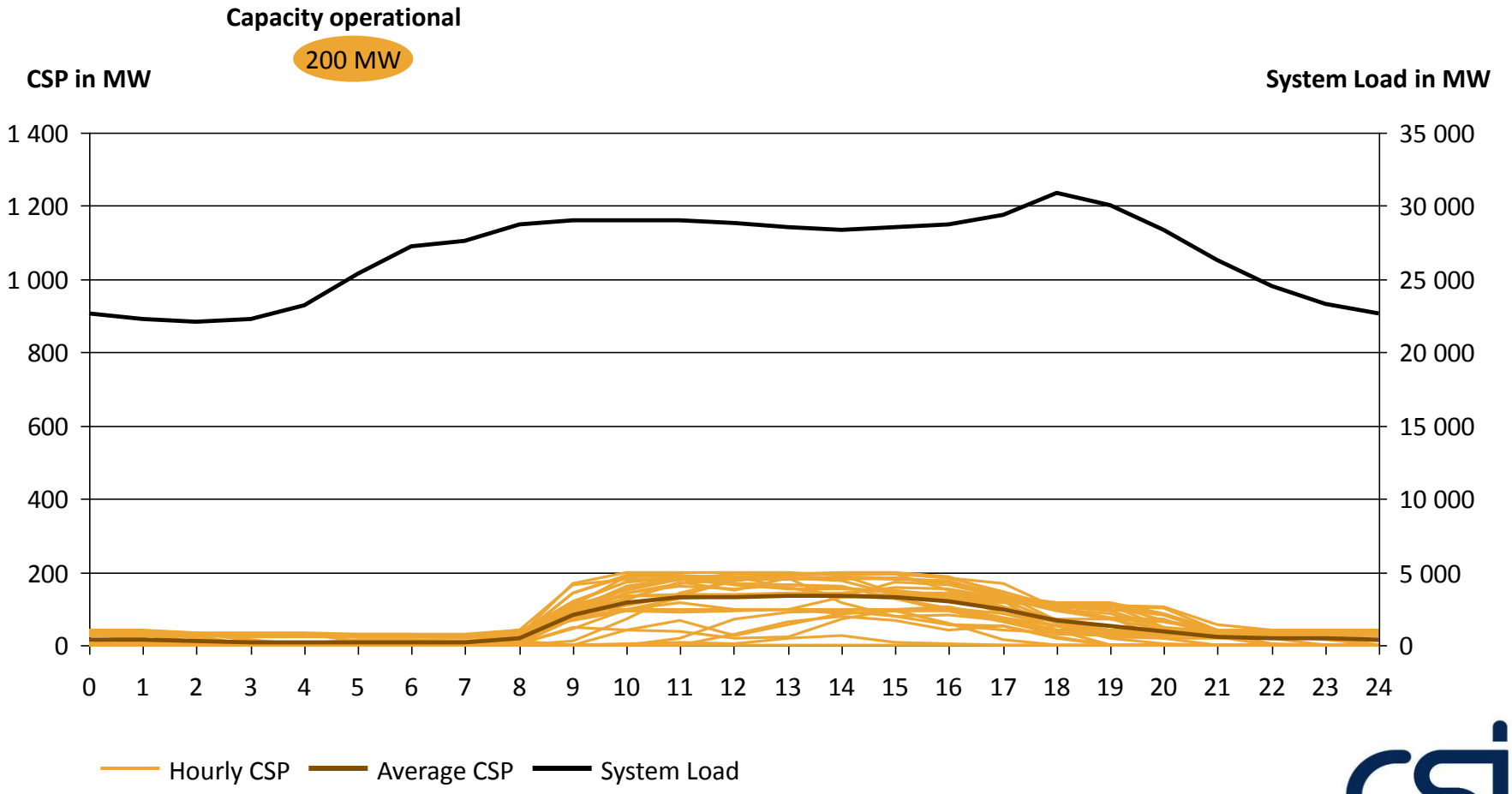
Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Apr 2016, CSP storage used in evenings

Hourly CSP production for all 30 days of Apr 2016 and average system load diurnal course

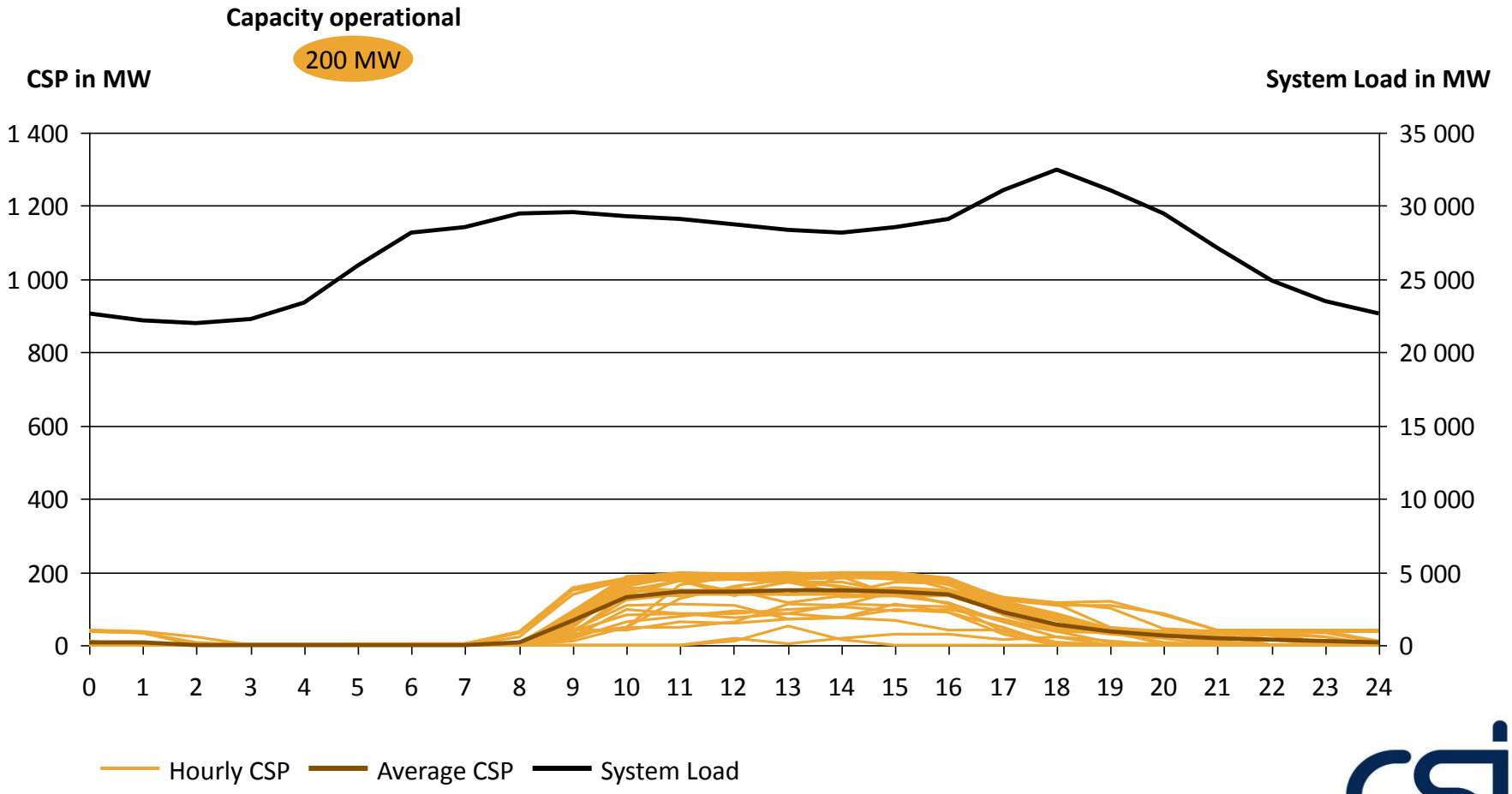


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In May 2016, CSP storage used in evenings

Hourly CSP production for all 31 days of May 2016 and average system load diurnal course

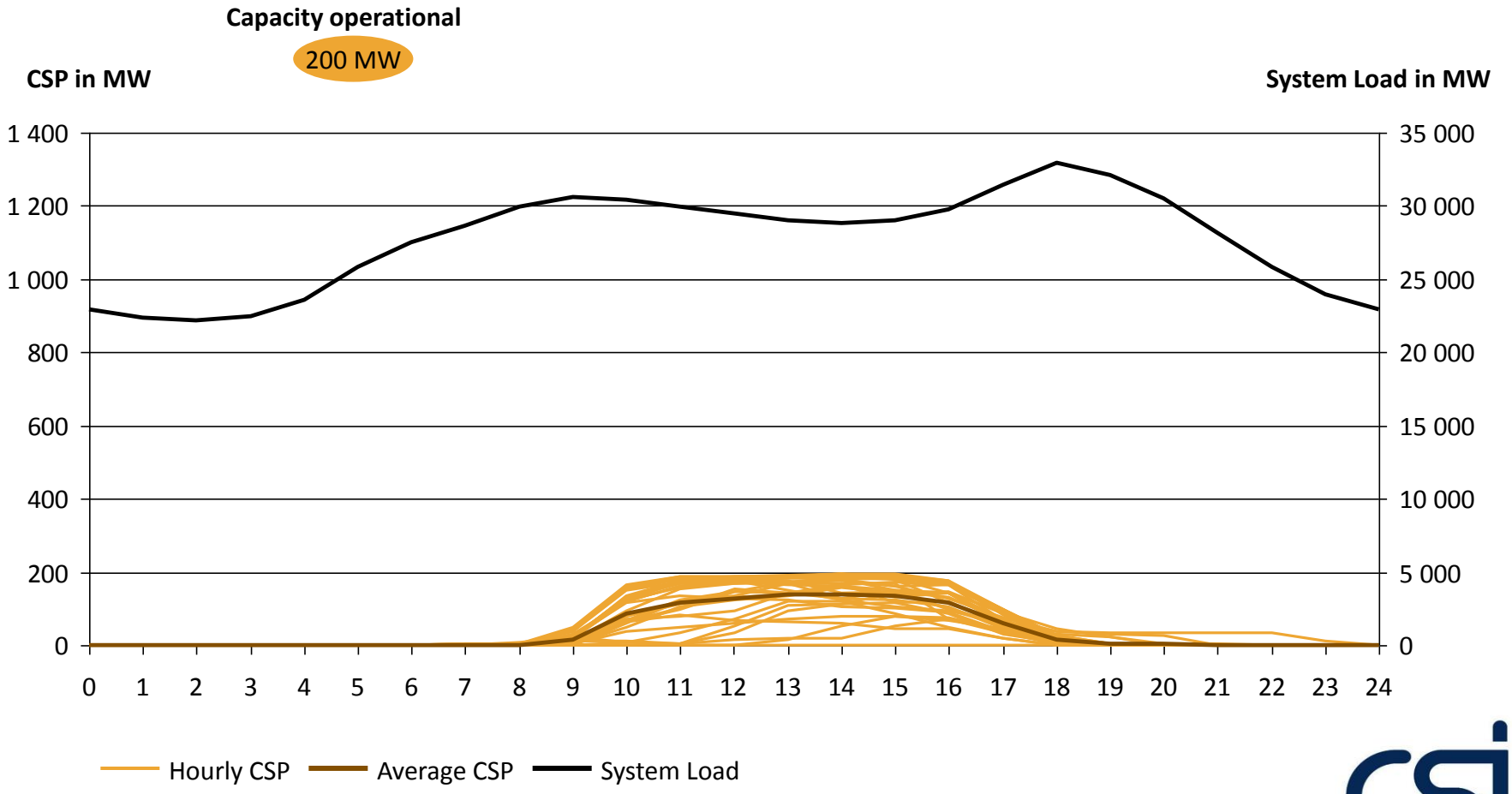


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Jun 2016, CSP storage used in evenings

Hourly CSP production for all 30 days of Jun 2016 and average system load diurnal course

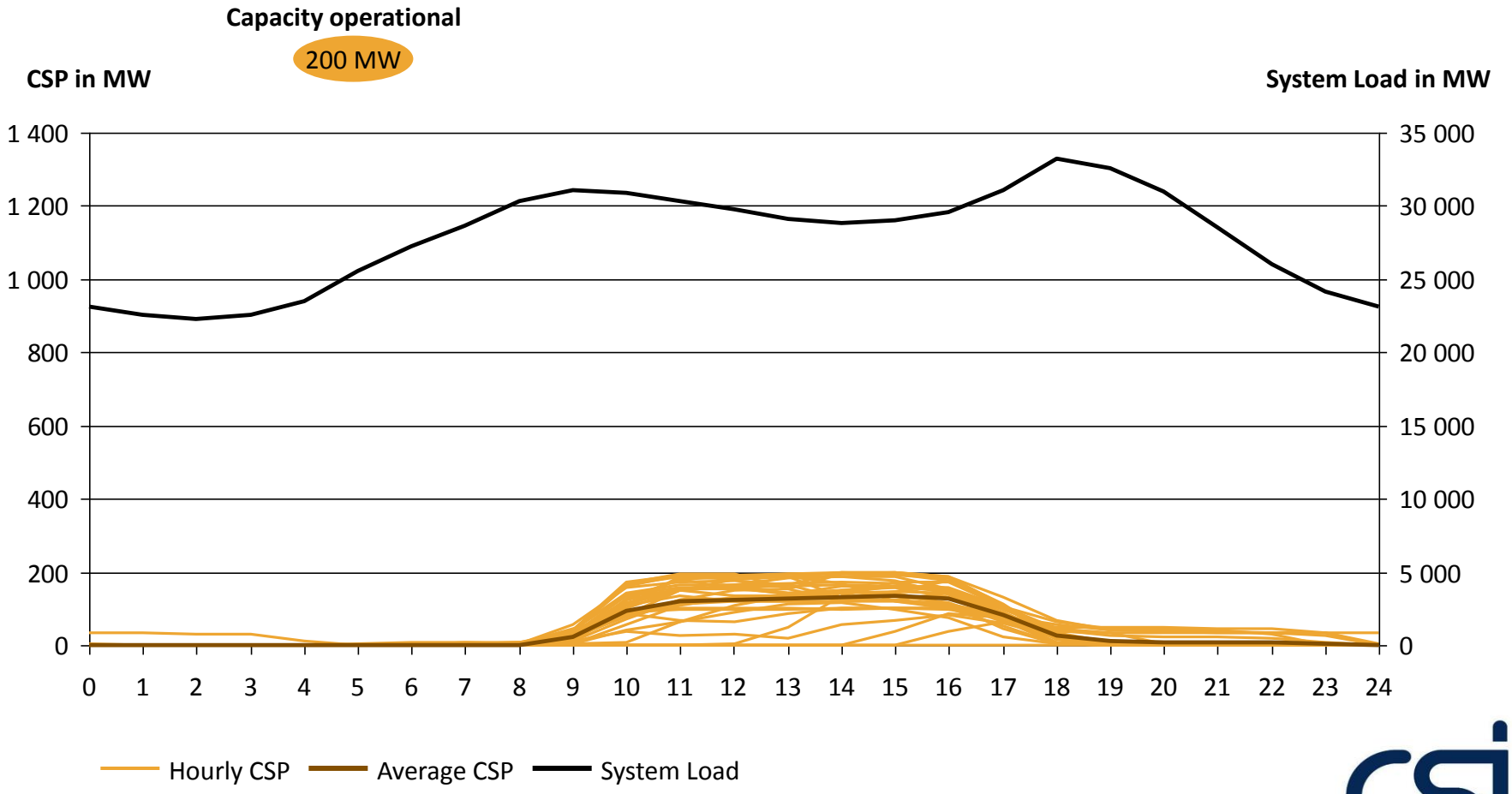


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Jul 2016, CSP storage used in evenings

Hourly CSP production for all 31 days of Jul 2016 and average system load diurnal course

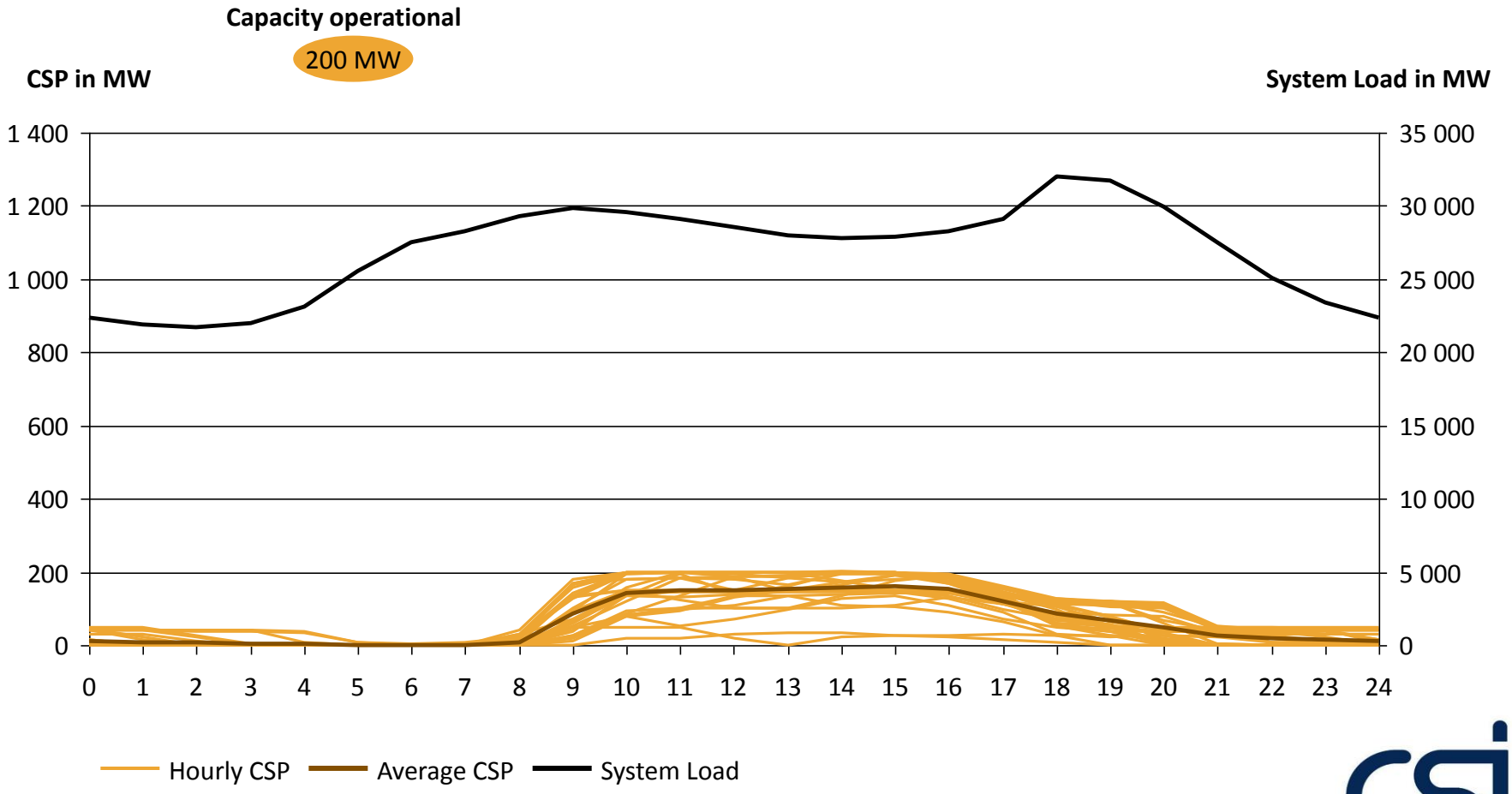


Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Aug 2016, CSP storage used in evenings

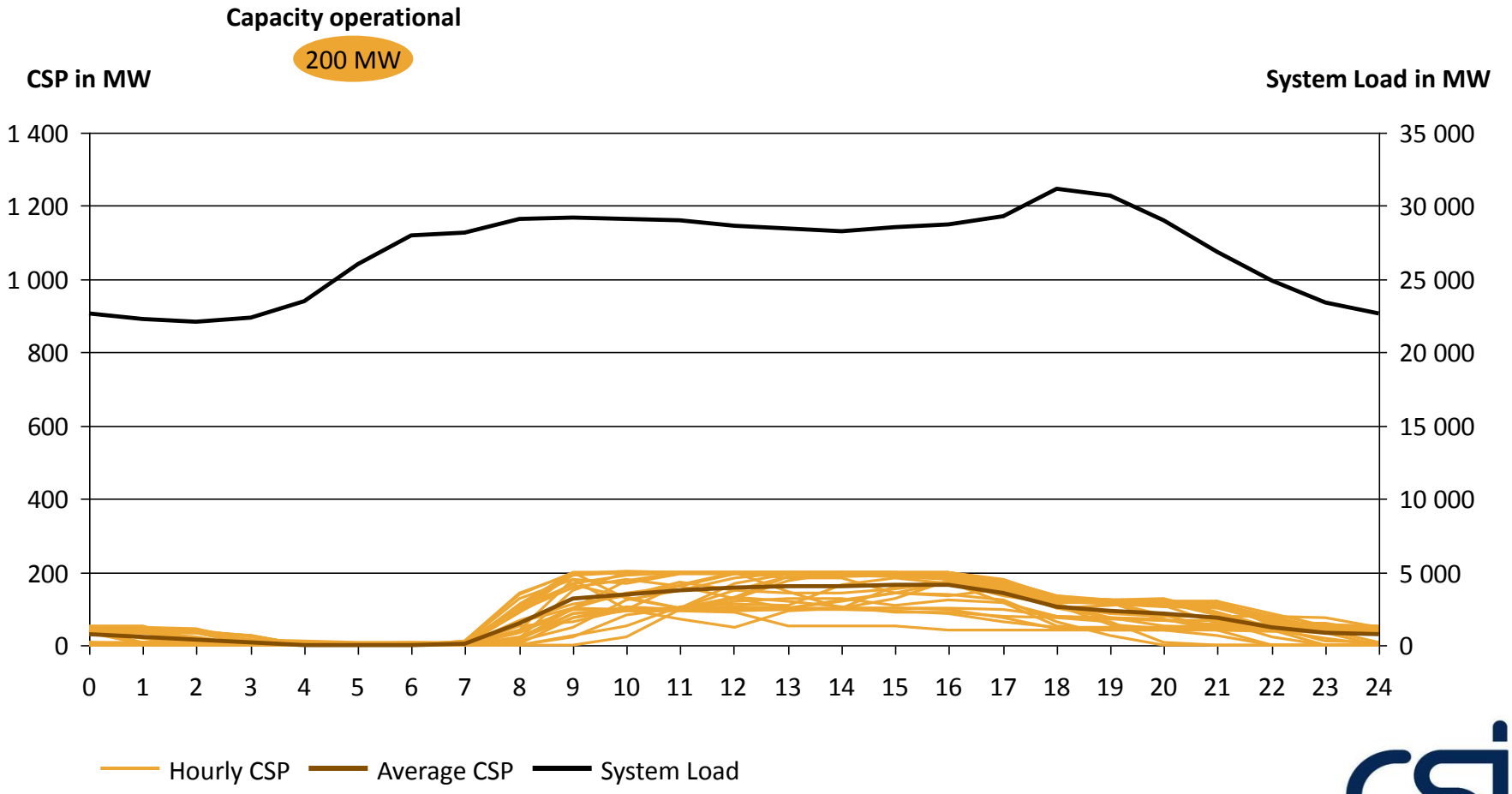
Hourly CSP production for all 31 days of Aug 2016 and average system load diurnal course



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

In Sep 2016, CSP storage used in evenings

Hourly CSP production for all 30 days of Sep 2016 and average system load diurnal course



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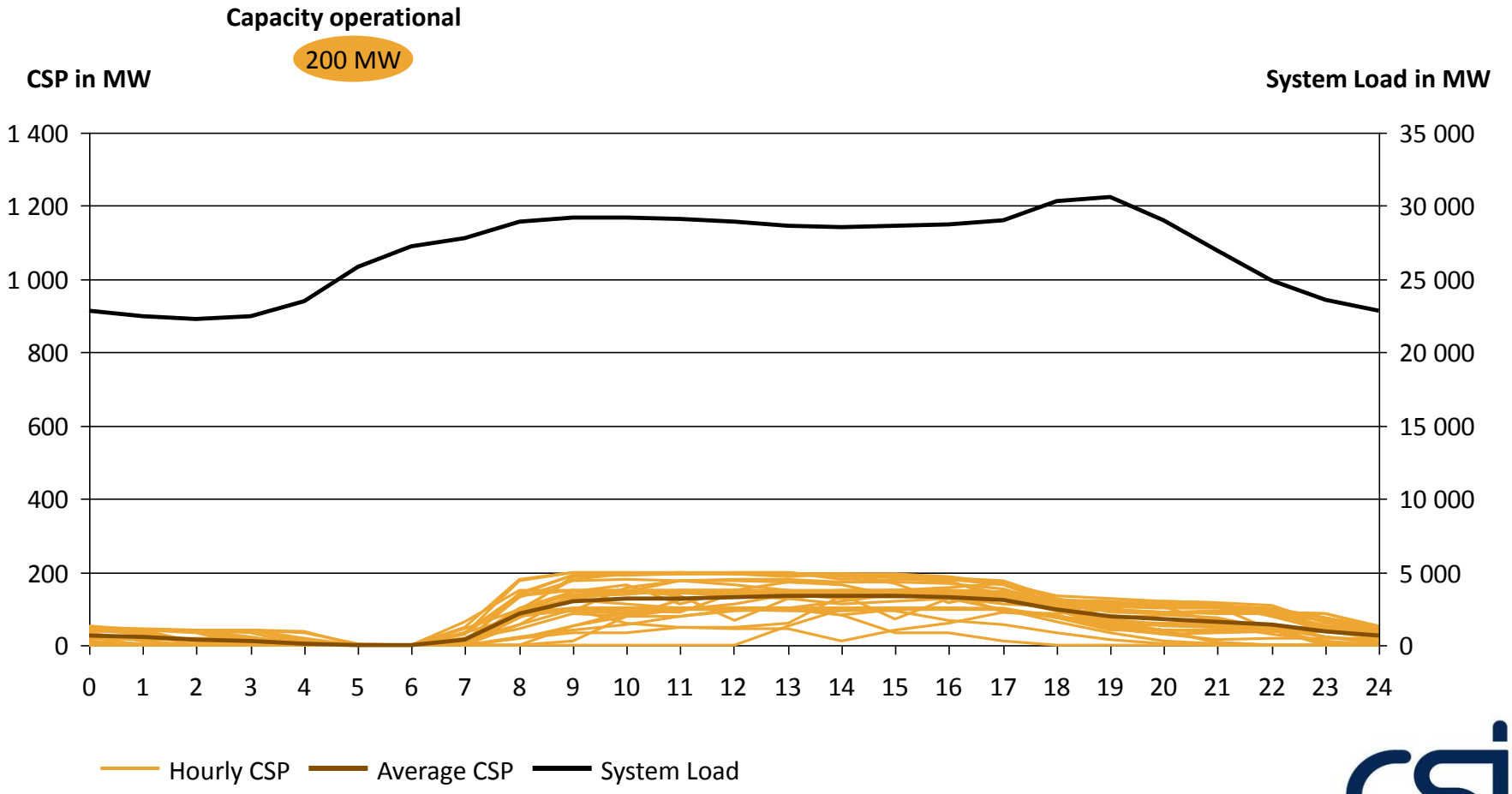
Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Oct 2016, CSP storage used in evenings

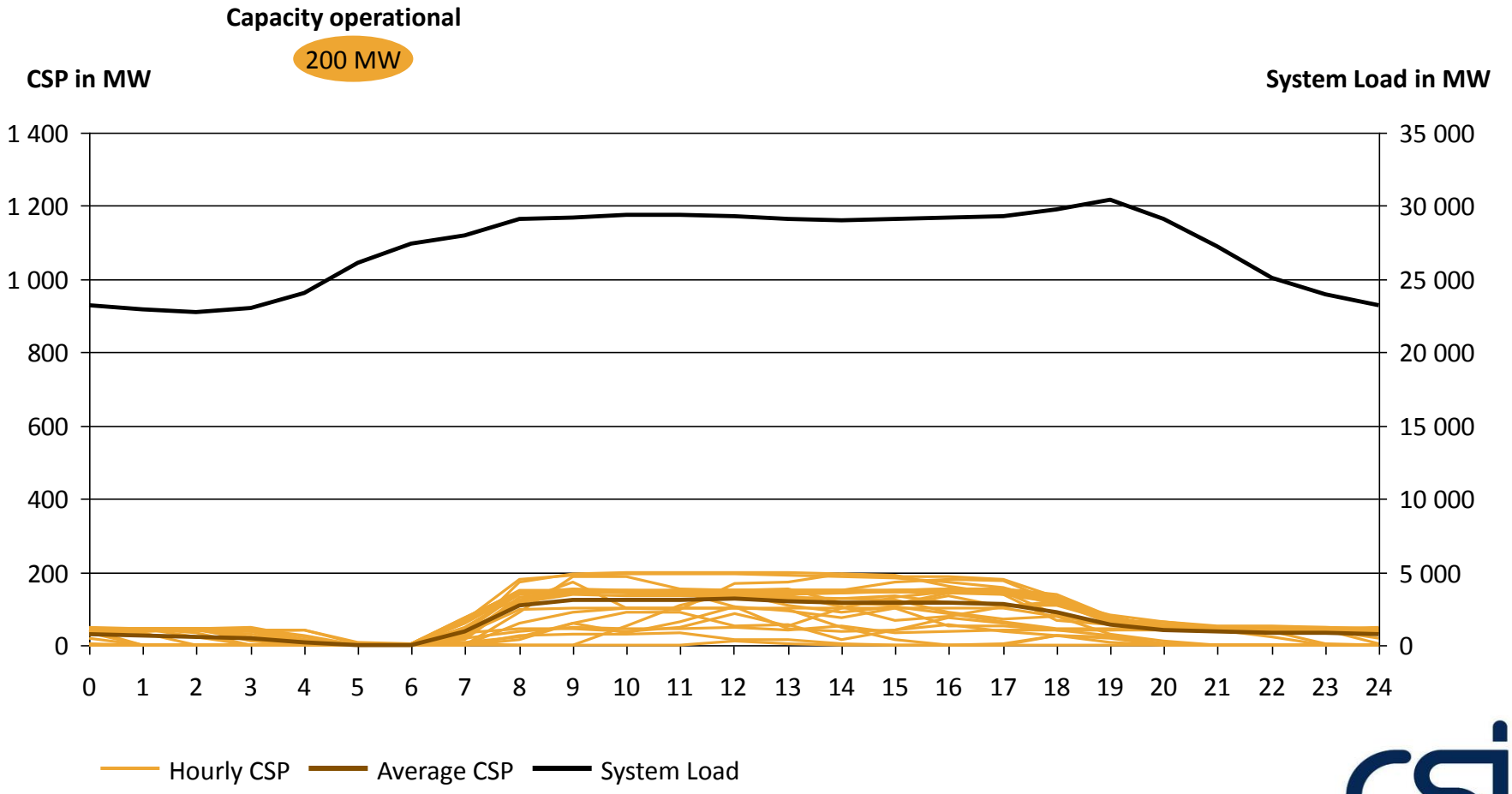
Hourly CSP production for all 31 days of Oct 2016 and average system load diurnal course



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

In Nov 2016, CSP storage used in evenings

Hourly CSP production for all 30 days of Nov 2016 and average system load diurnal course



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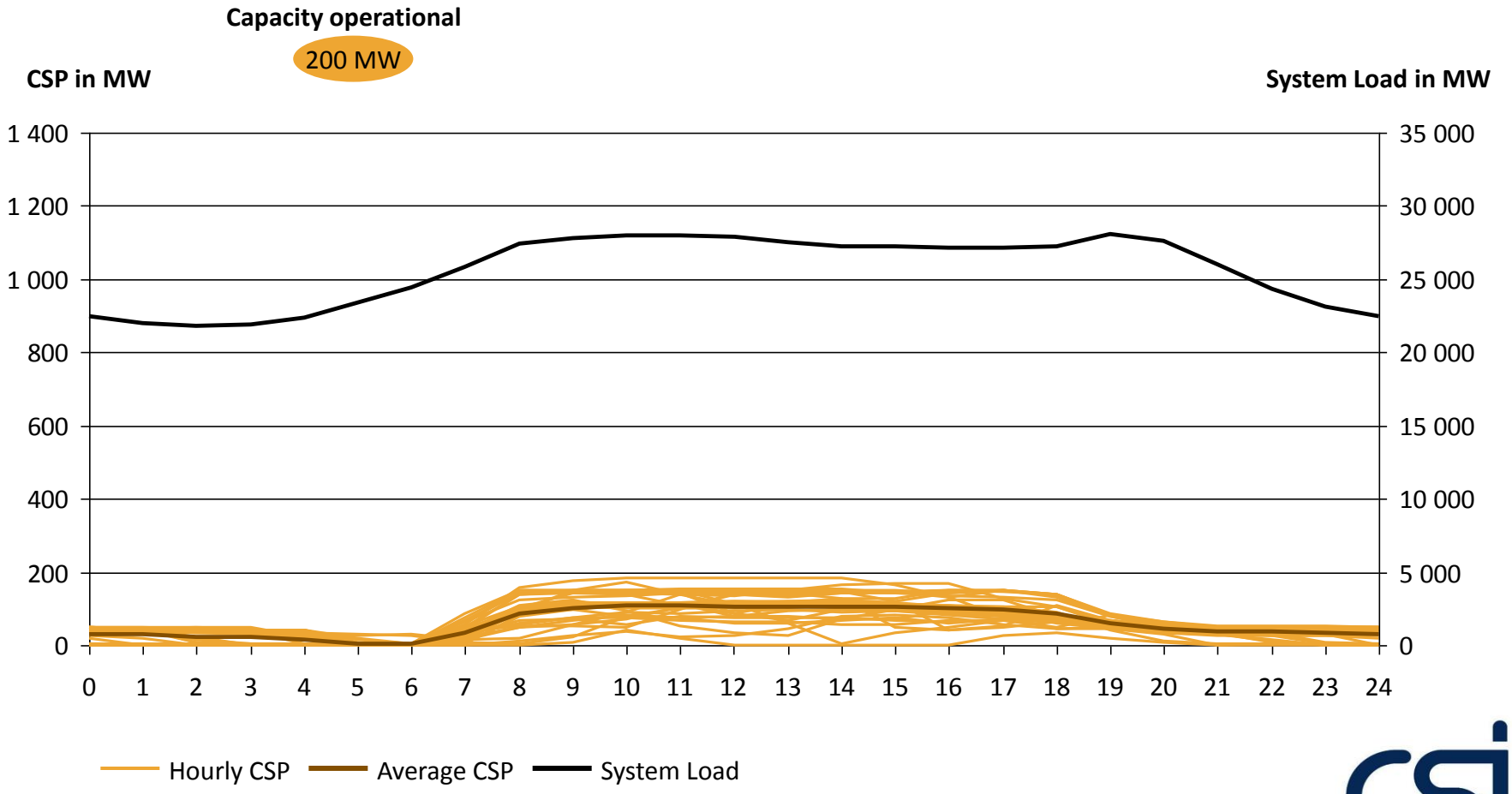
Note: System load excludes hydro pumping load

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

In Dec 2016, CSP storage used in evenings

Hourly CSP production for all 31 days of Dec 2016 and average system load diurnal course



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

Agenda

Overview actual electricity production data for 2016

Monthly electricity production

Weekly electricity production

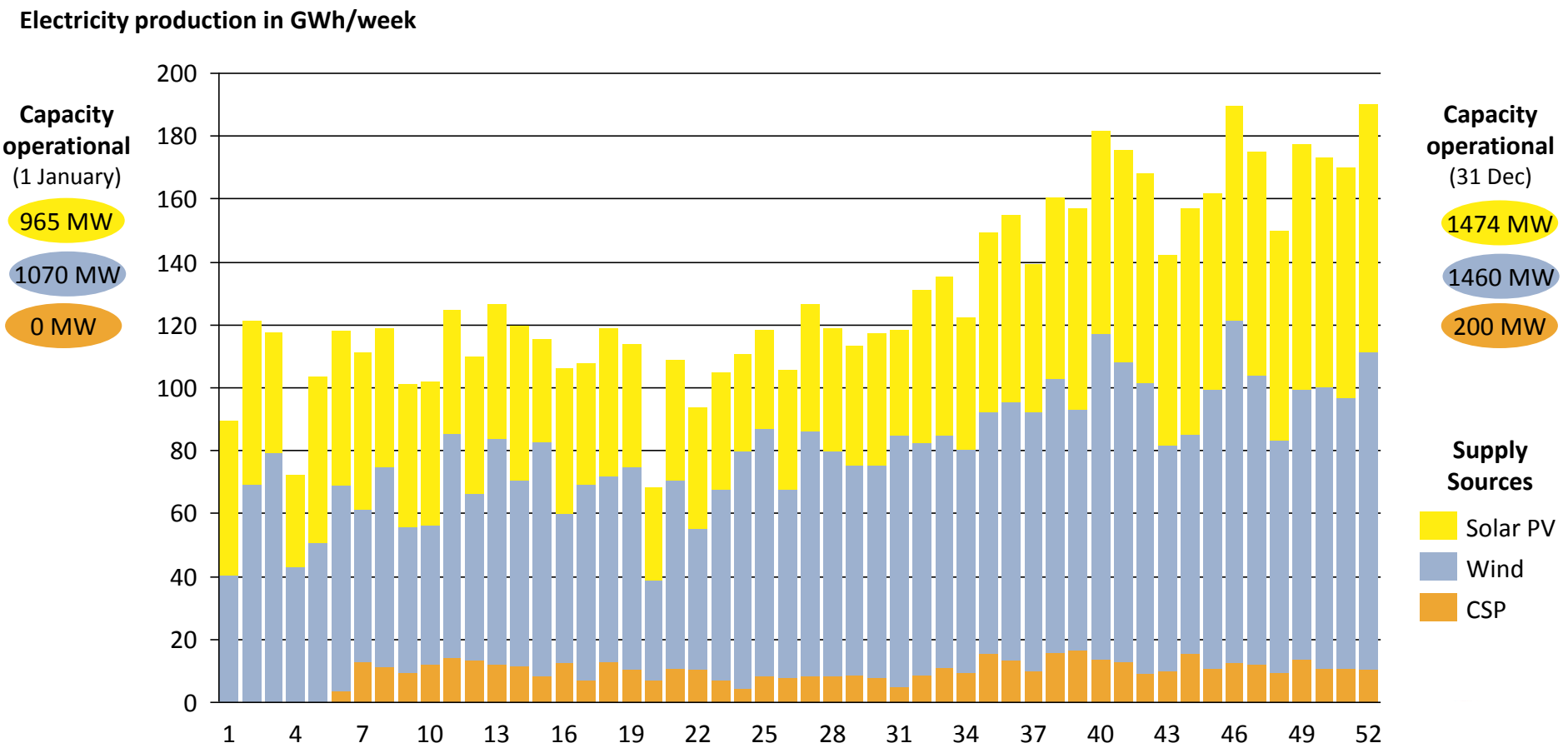
Daily electricity production

Hourly electricity production and gradients

Actual load shedding in 2016

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 2016

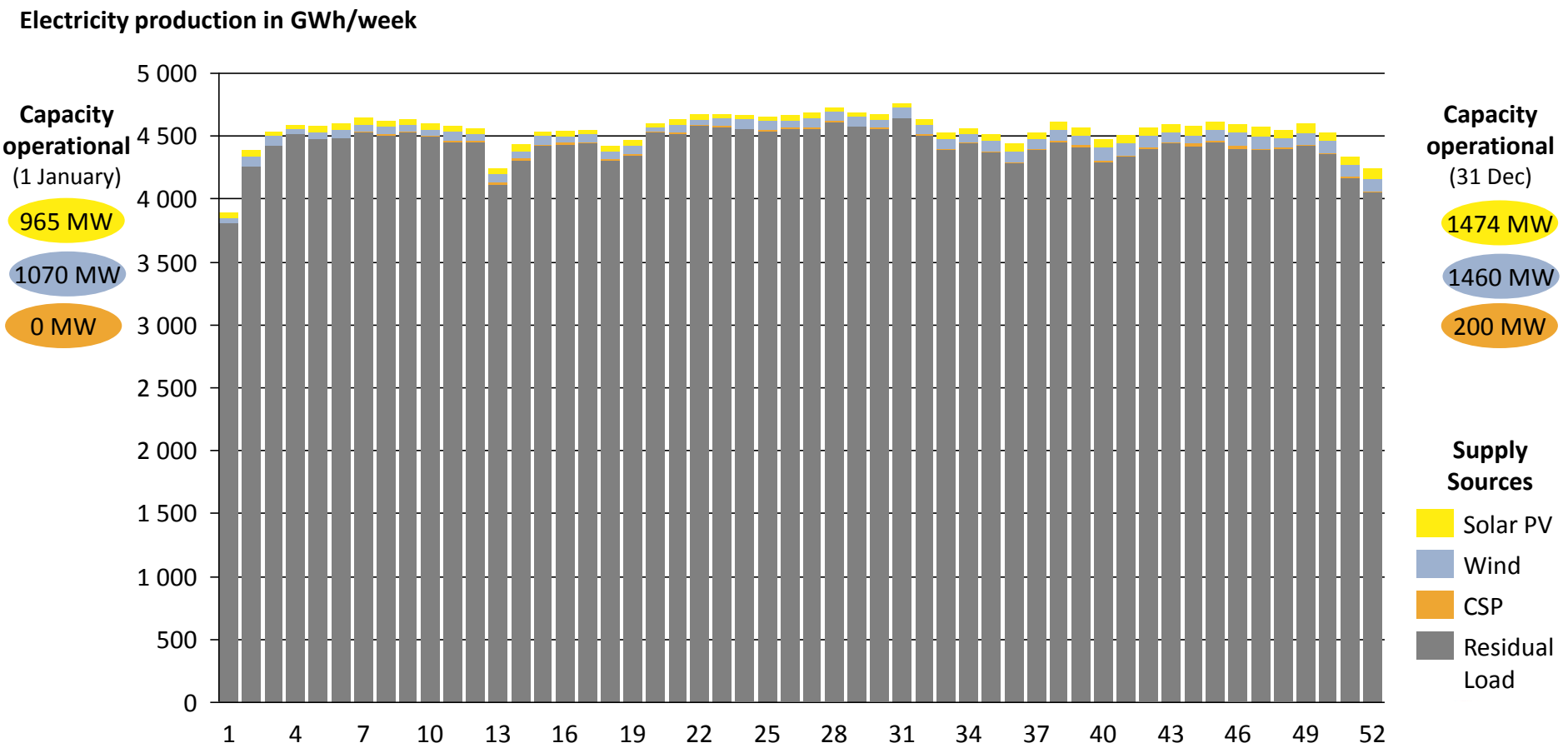


- Maximum wind + solar PV weekly production of 121 GWh in week 2
- Minimum wind + solar PV weekly production of 62 GWh in week 20

Note: Design as per Fraunhofer ISE. Week 1 adjusted/scaled to 7 day week.
Sources: Eskom; DoE IPP Office; 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 2016



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

Agenda

Overview actual electricity production data for 2016

Monthly electricity production

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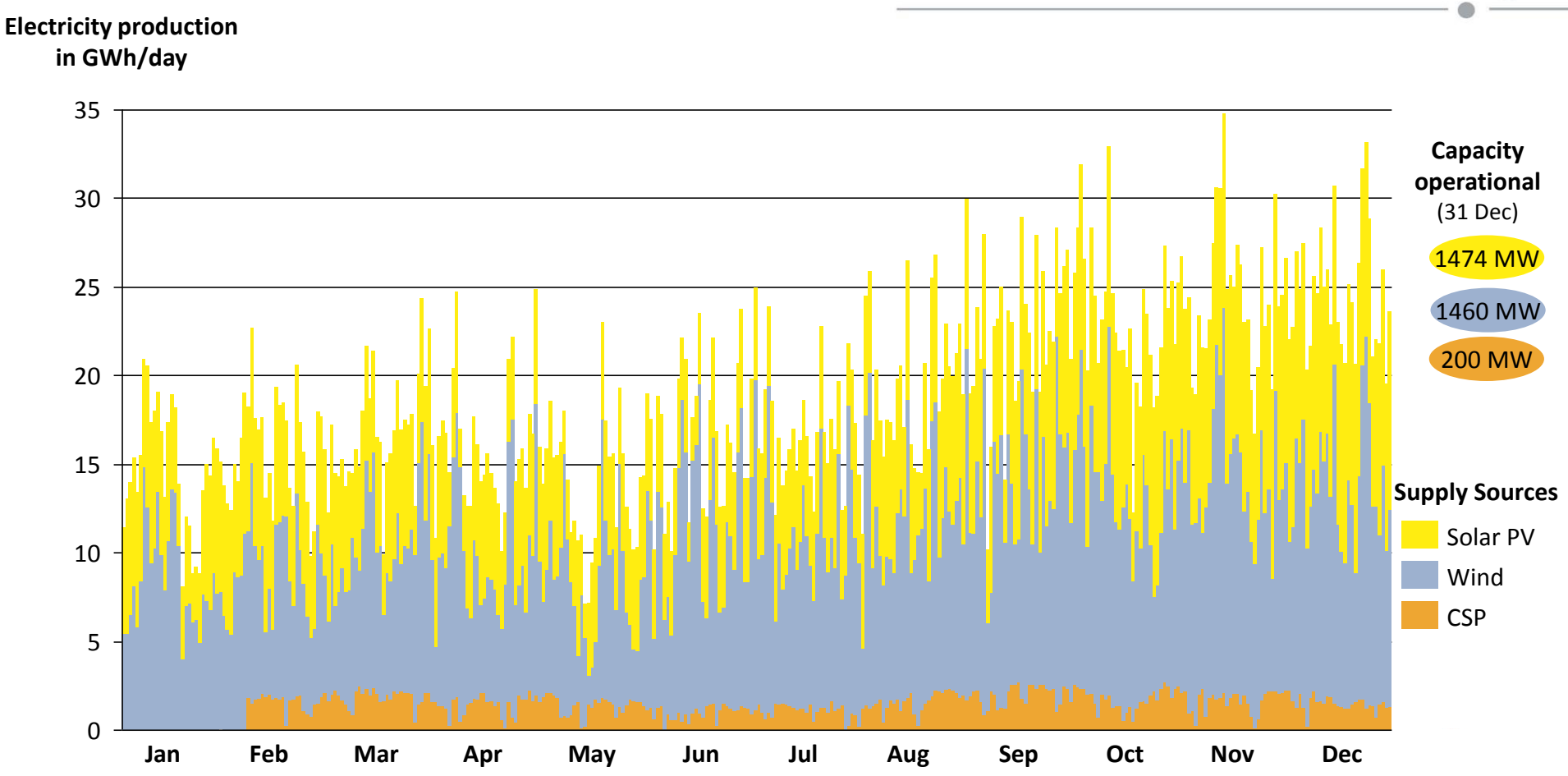
Actual load shedding in 2016

Daily electricity production wind, solar PV & CSP fleet Jan to Dec 2016

Actual daily production from large-scale solar PV, wind and CSP plants under the REIPPPP from Jan-Dec 2016

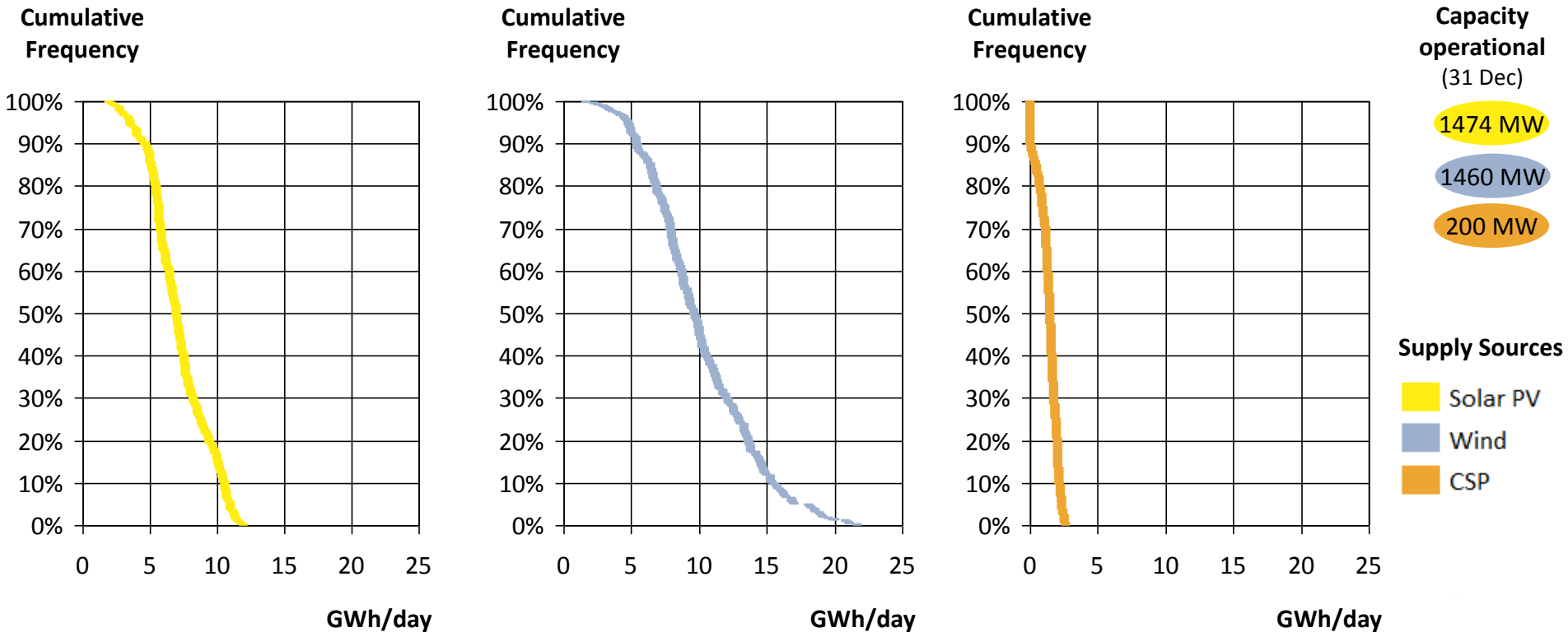


- Maximum daily production of 22.9 GWh on 13 Nov 2016 (Sunday)
- Minimum daily production of 5.7 GWh on 14 May 2016 (Saturday)

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

On 90% of the days from Jan - Dec 2016, solar PV and wind had a daily energy production of 4 GWh or more

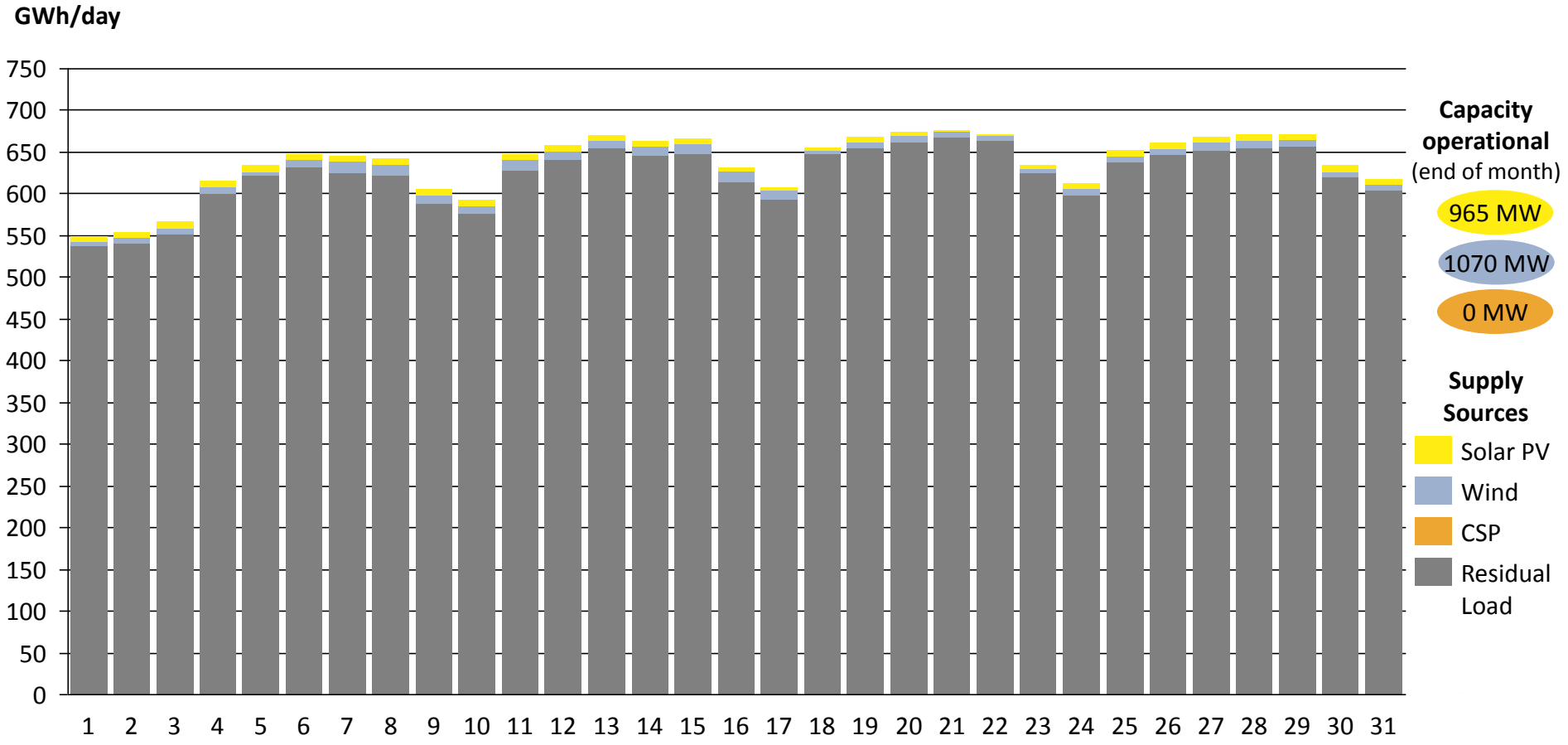
Frequency distribution of daily solar PV, wind and CSP electricity production for January - December 2016



Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily electricity production of between 548-676 GWh in Jan 2016

Actual daily production from all power supply sources in South Africa for January 2016

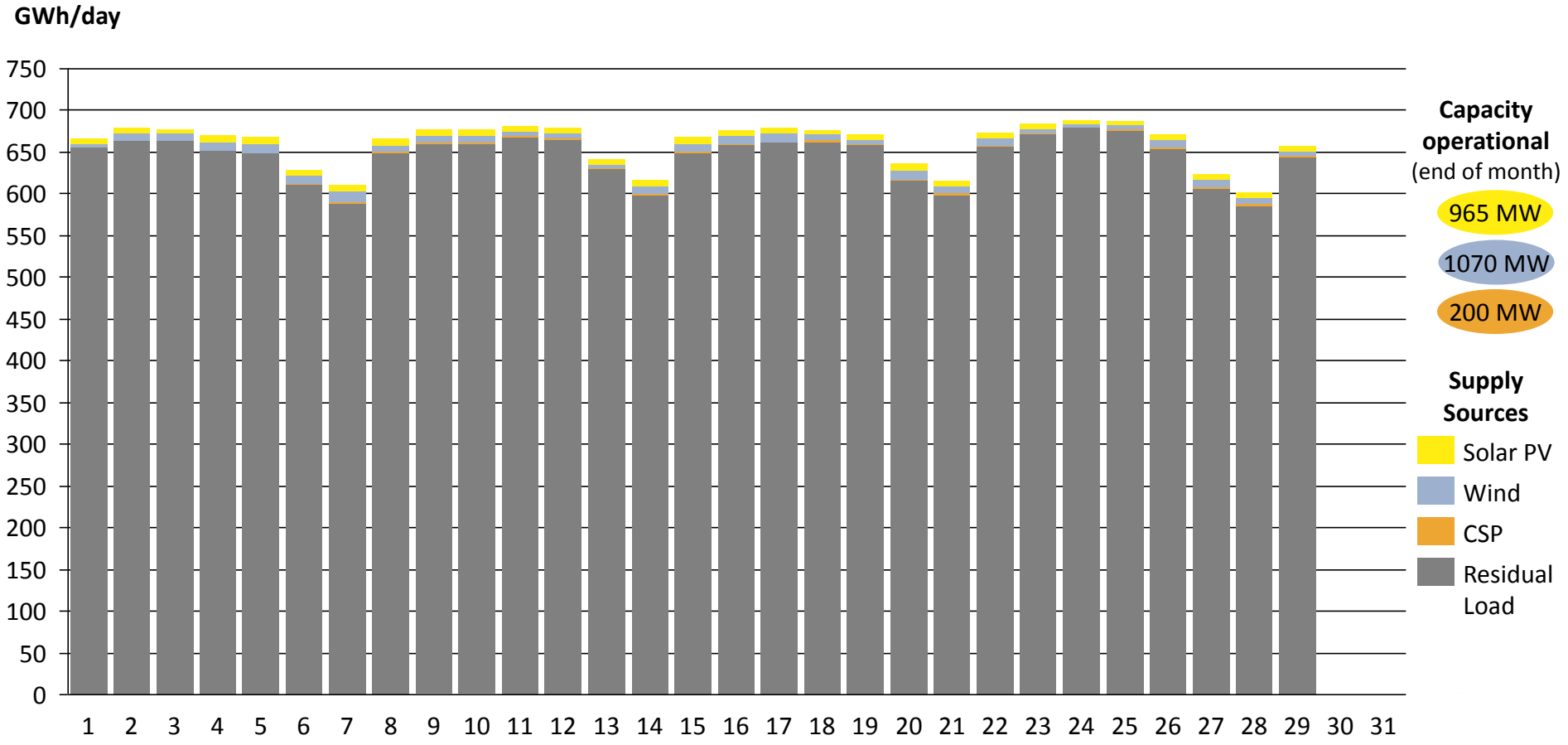


- Maximum daily production of 676 GWh on 21 Jan 2016 (Thursday)
- Minimum daily production of 548 GWh on 1 Jan 2016 (Friday)

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

Daily electricity production of between 601-688 GWh in Feb 2016

Actual daily production from all power supply sources in South Africa for February 2016

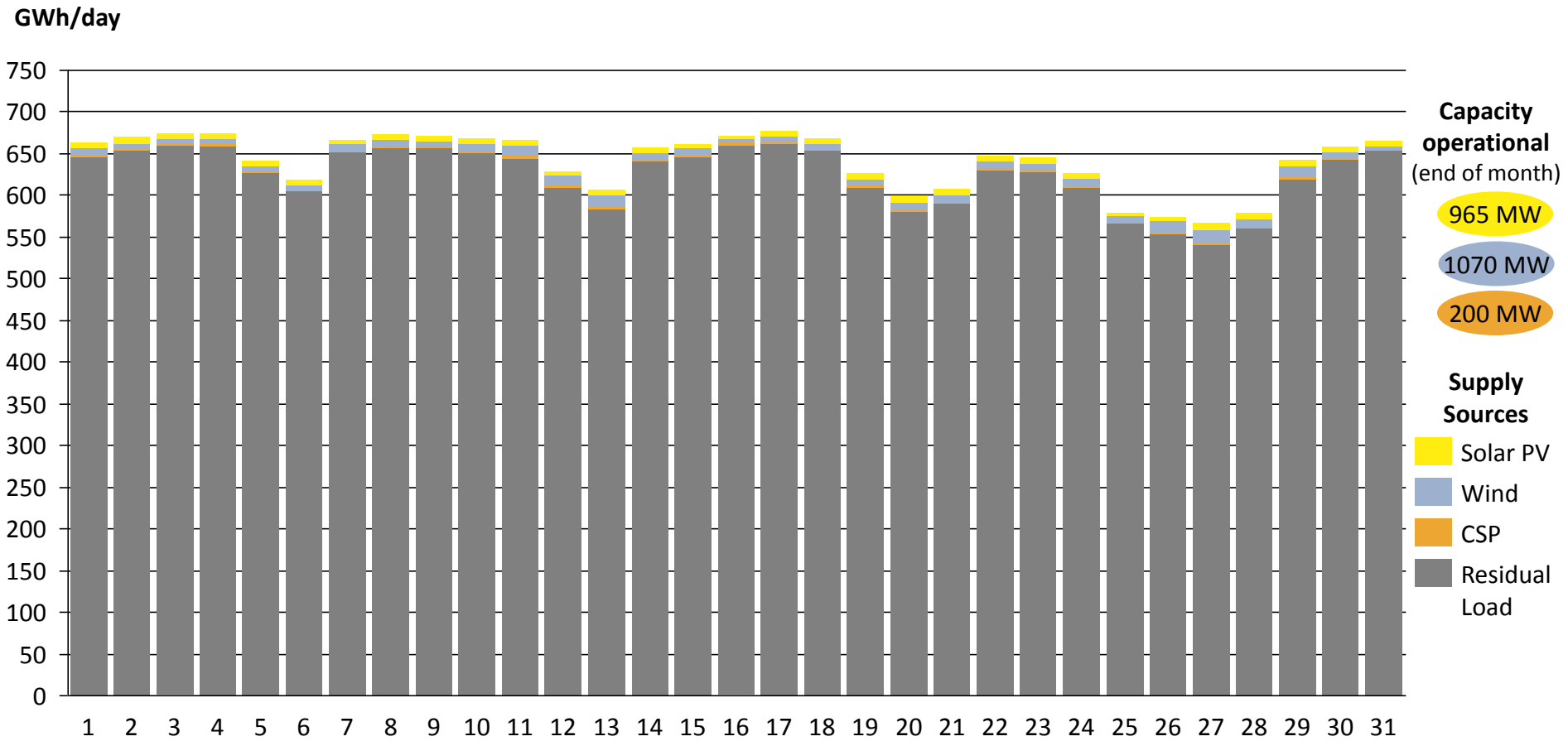


- Maximum daily production of 688 GWh on 24 Feb 2016 (Wednesday)
- Minimum daily production of 601 GWh on 28 Feb 2016 (Sunday)

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

Daily electricity production of between 565-677 GWh in Mar 2016

Actual daily production from all power supply sources in South Africa for March 2016

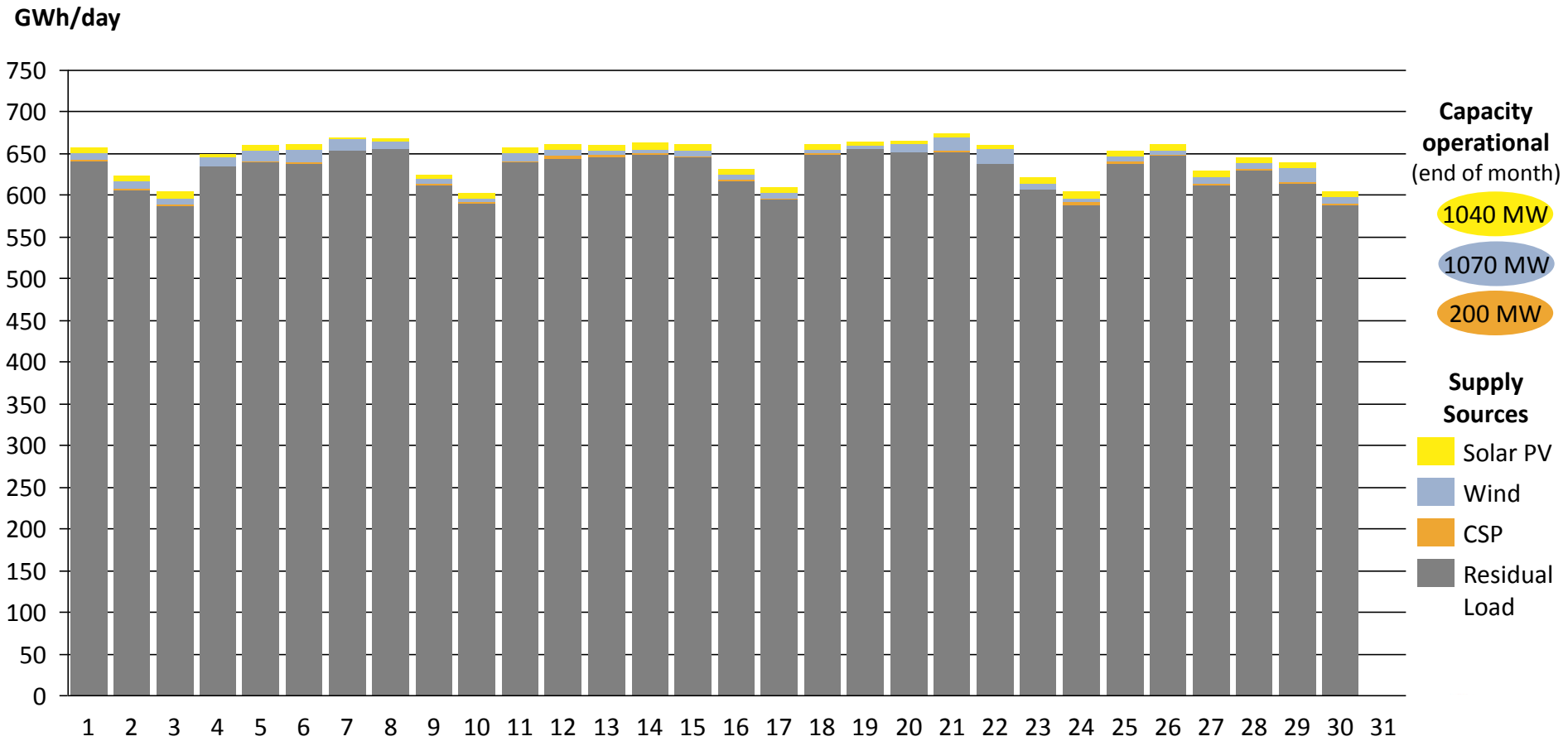


- Maximum daily production of 677 GWh on 17 Mar 2016 (Thursday)
- Minimum daily production of 565 GWh on 27 Mar 2016 (Sunday)

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

Daily electricity production of between 602-673 GWh in Apr 2016

Actual daily production from all power supply sources in South Africa for April 2016

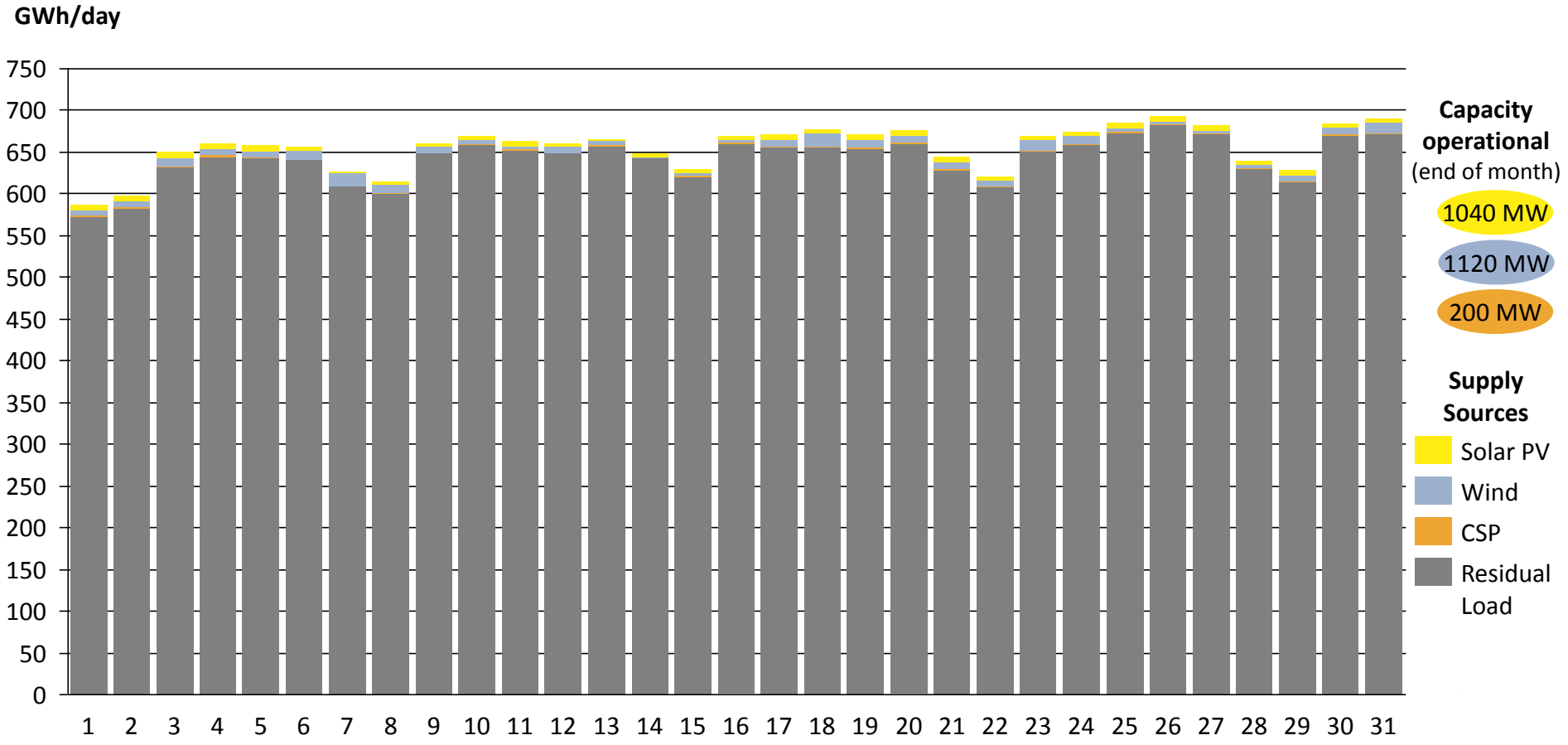


- Maximum daily production of 673 GWh on 21 Apr 2016 (Thursday)
- Minimum daily production of 602 GWh on 10 Apr 2016 (Sunday)

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

Daily electricity production of between 579-684 GWh in May 2016

Actual daily production from all power supply sources in South Africa for May 2016

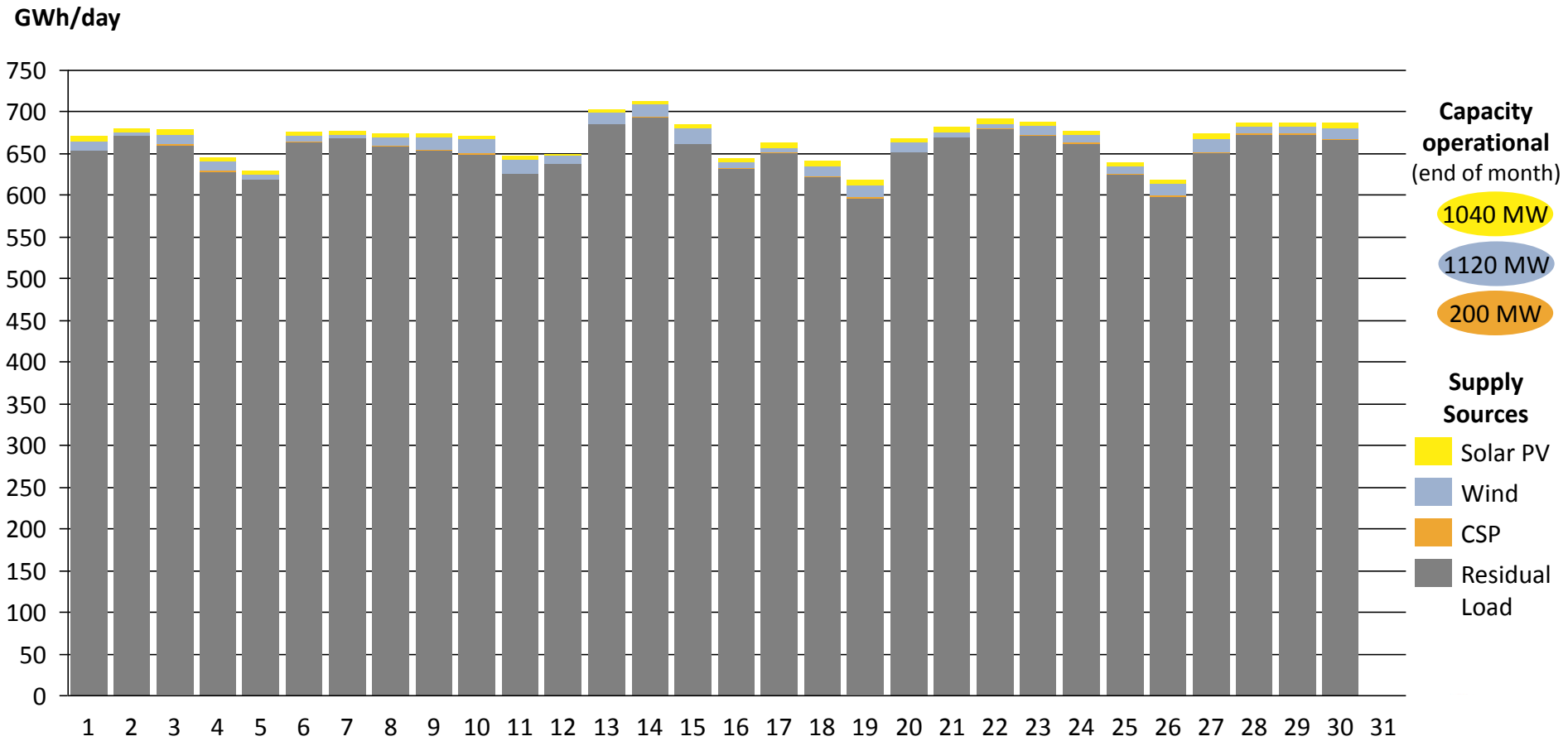


- Maximum daily production of 684 GWh on 26 May 2016 (Thursday)
- Minimum daily production of 579 GWh on 1 May 2016 (Sunday)

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

Daily electricity production of between 618-711 GWh in Jun 2016

Actual daily production from all power supply sources in South Africa for June 2016

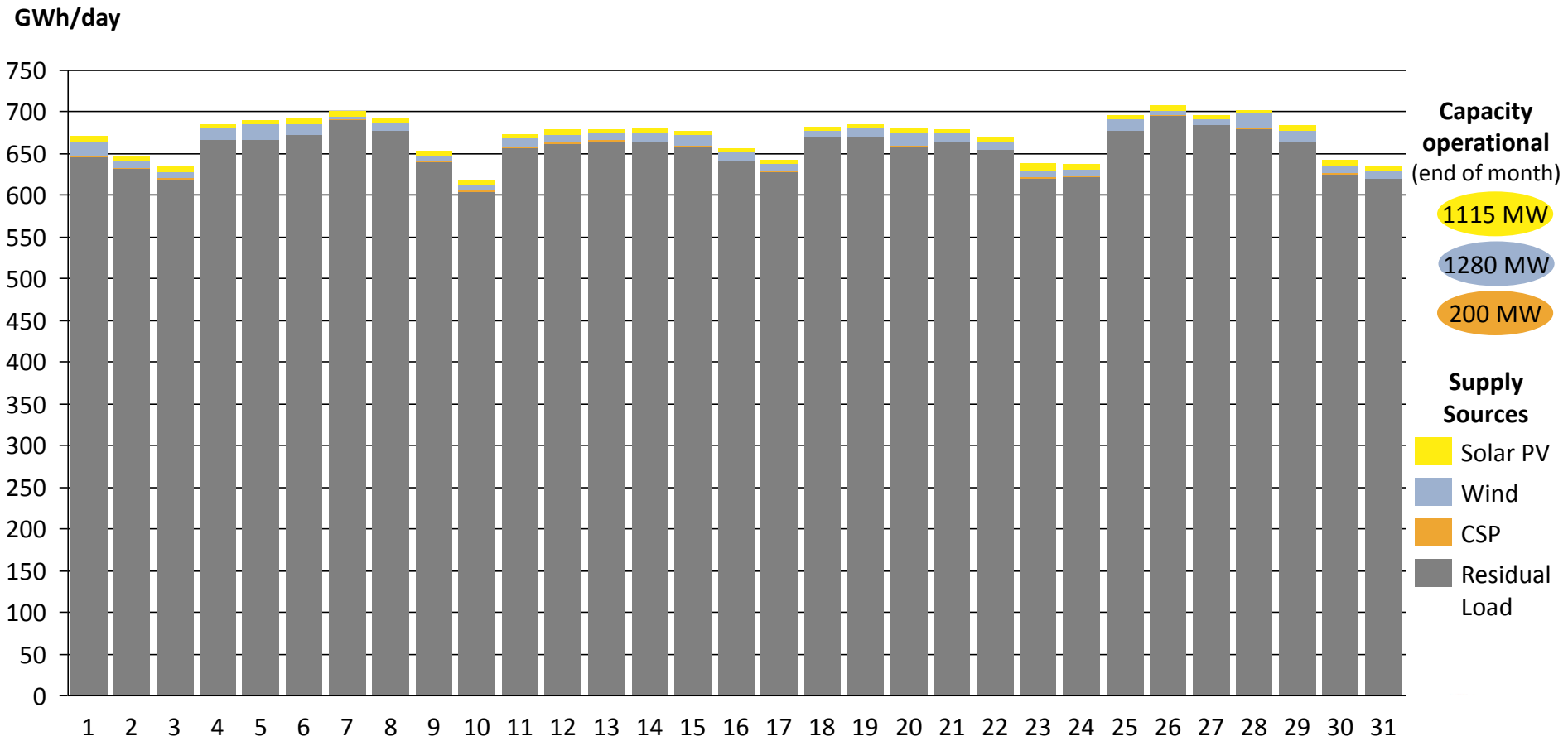


- Maximum daily production of 711 GWh on 14 Jun 2016 (Tuesday)
- Minimum daily production of 618 GWh on 19 Jun 2016 (Sunday)

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

Daily electricity production of between 618-706 GWh in Jul 2016

Actual daily production from all power supply sources in South Africa for July 2016

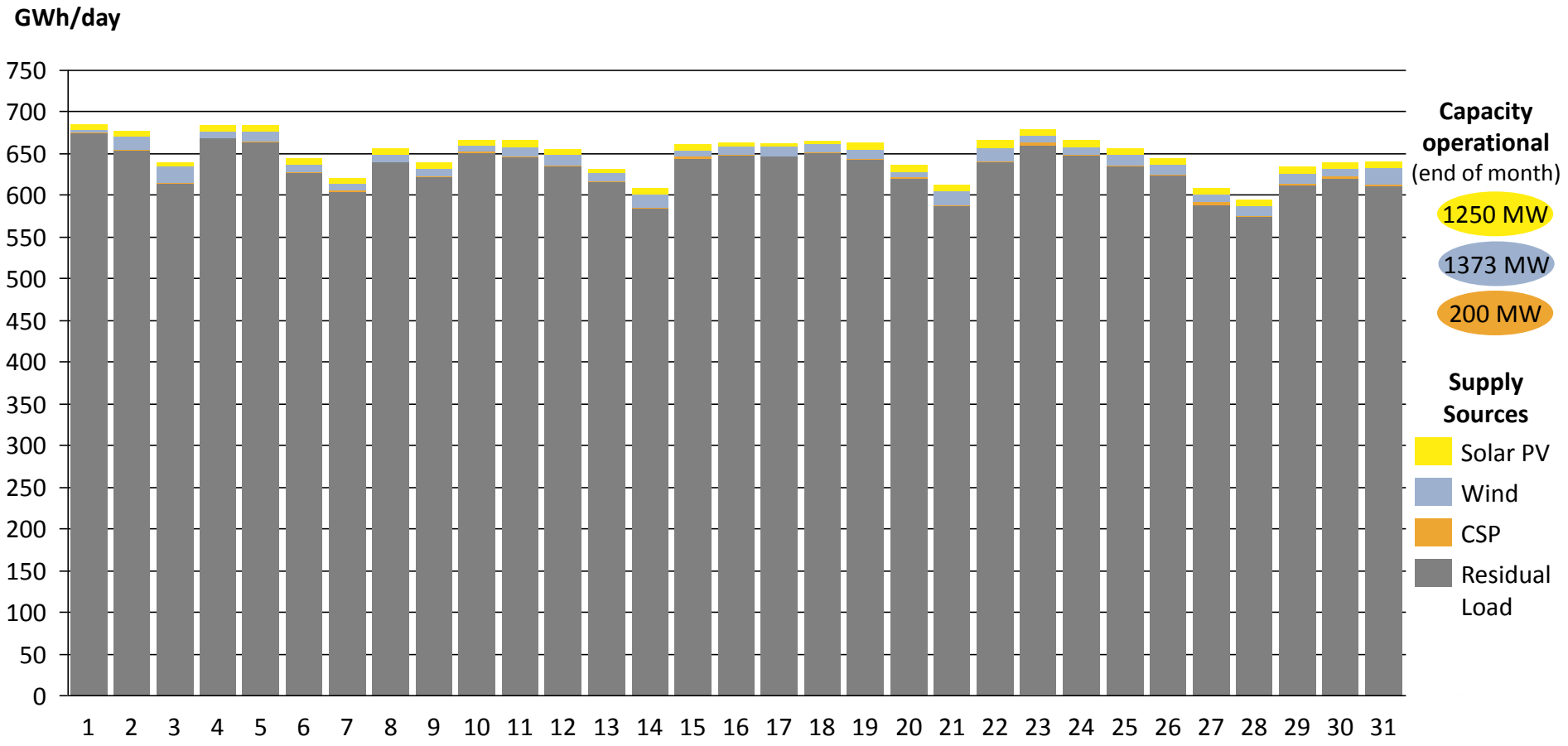


- Maximum daily production of 706 GWh on 26 Jul 2016 (Tuesday)
- Minimum daily production of 618 GWh on 10 Jul 2016 (Sunday)

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

Daily electricity production of between 595-684 GWh in Aug 2016

Actual daily production from all power supply sources in South Africa for August 2016

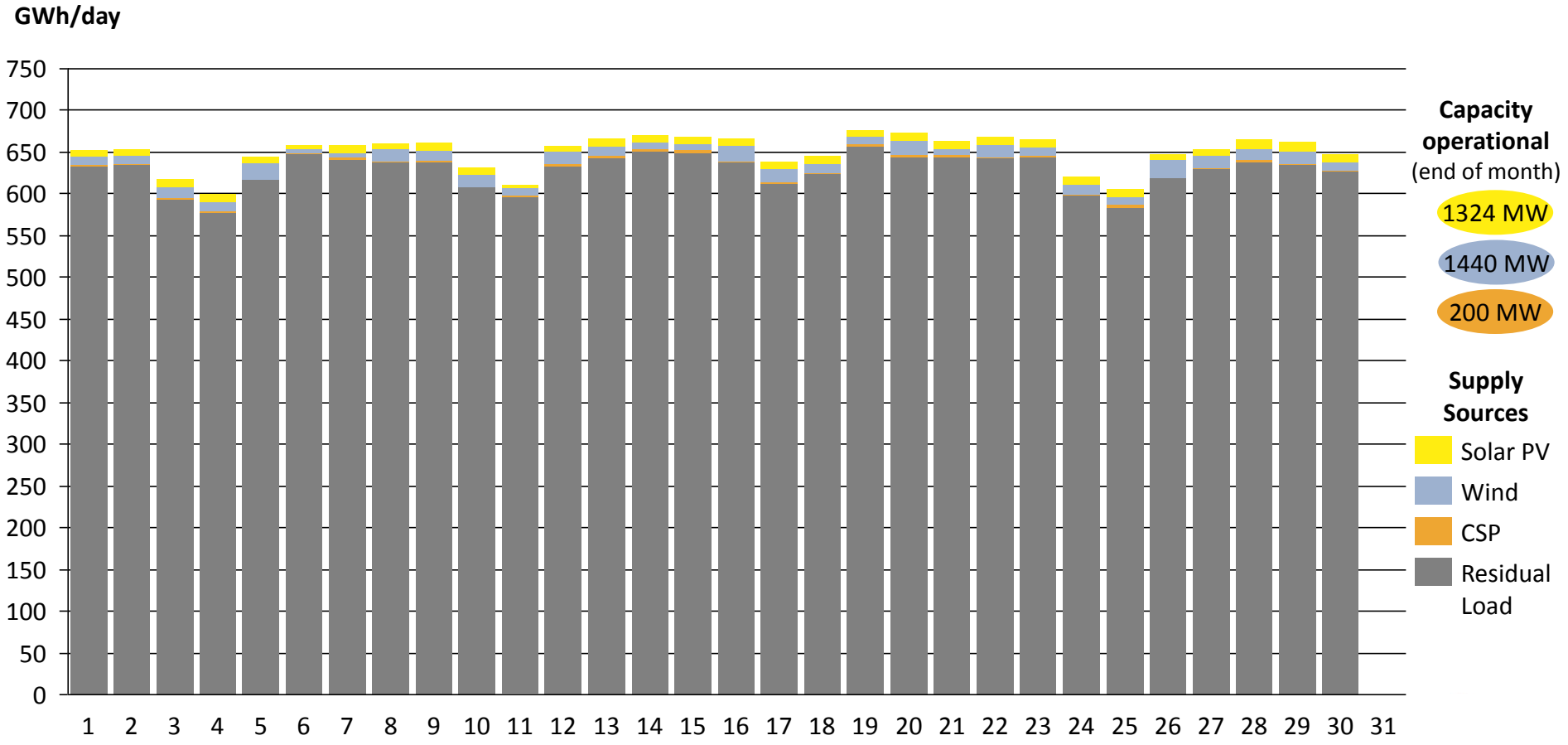


- Maximum daily production of 684 GWh on 1 Aug 2016 (Monday)
- Minimum daily production of 595 GWh on 28 Aug 2016 (Sunday)

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

Daily electricity production of between 598-676 GWh in Sep 2016

Actual daily production from all power supply sources in South Africa for September 2016

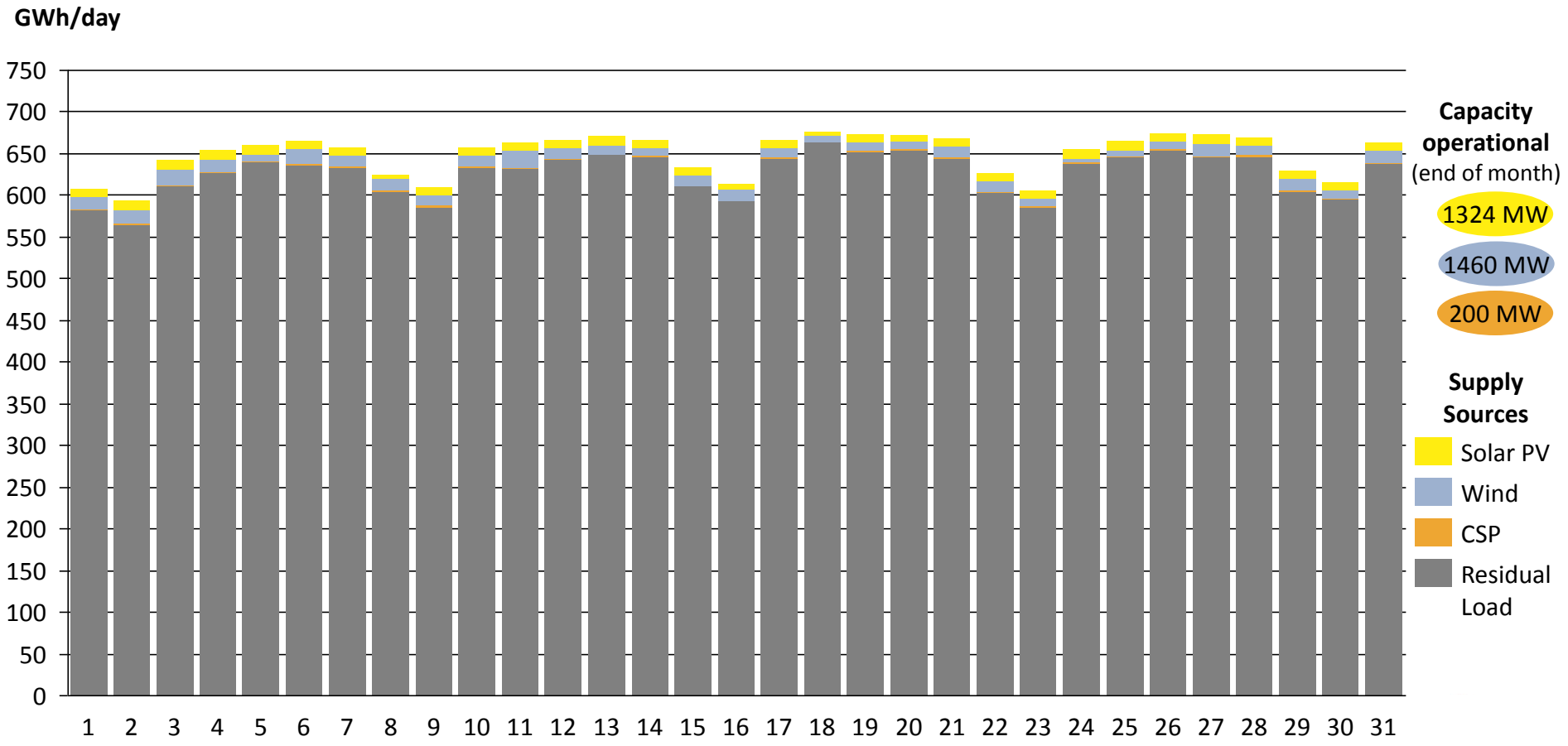


- Maximum daily production of 676 GWh on 19 Sep 2016 (Monday)
- Minimum daily production of 598 GWh on 4 Sep 2016 (Sunday)

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

Daily electricity production of between 598-676 GWh in Oct 2016

Actual daily production from all power supply sources in South Africa for October 2016

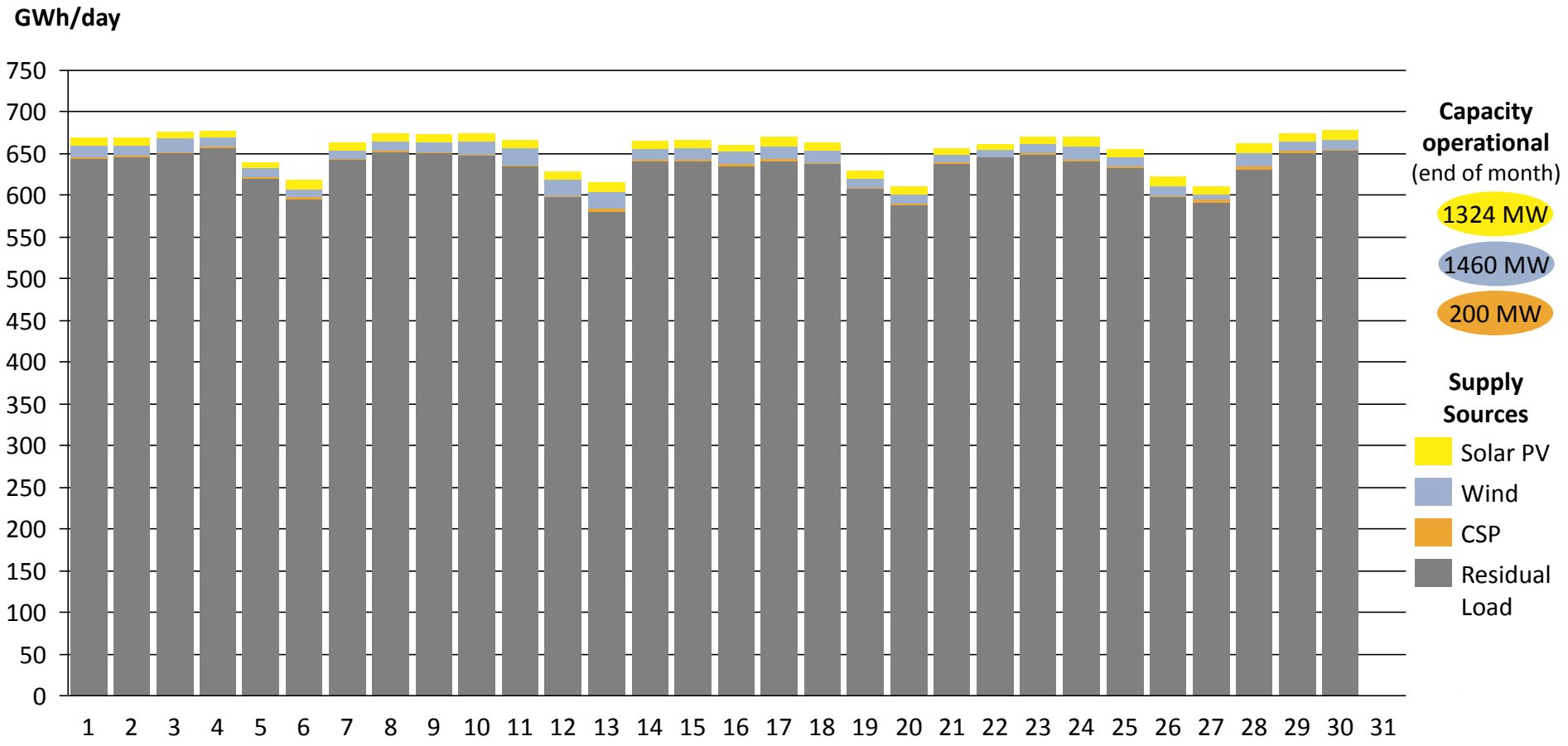


- Maximum daily production of 675 GWh on 18 Oct 2016 (Tuesday)
- Minimum daily production of 592 GWh on 2 Oct 2016 (Sunday)

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

Daily electricity production of between 598-676 GWh in Nov 2016

Actual daily production from all power supply sources in South Africa for November 2016

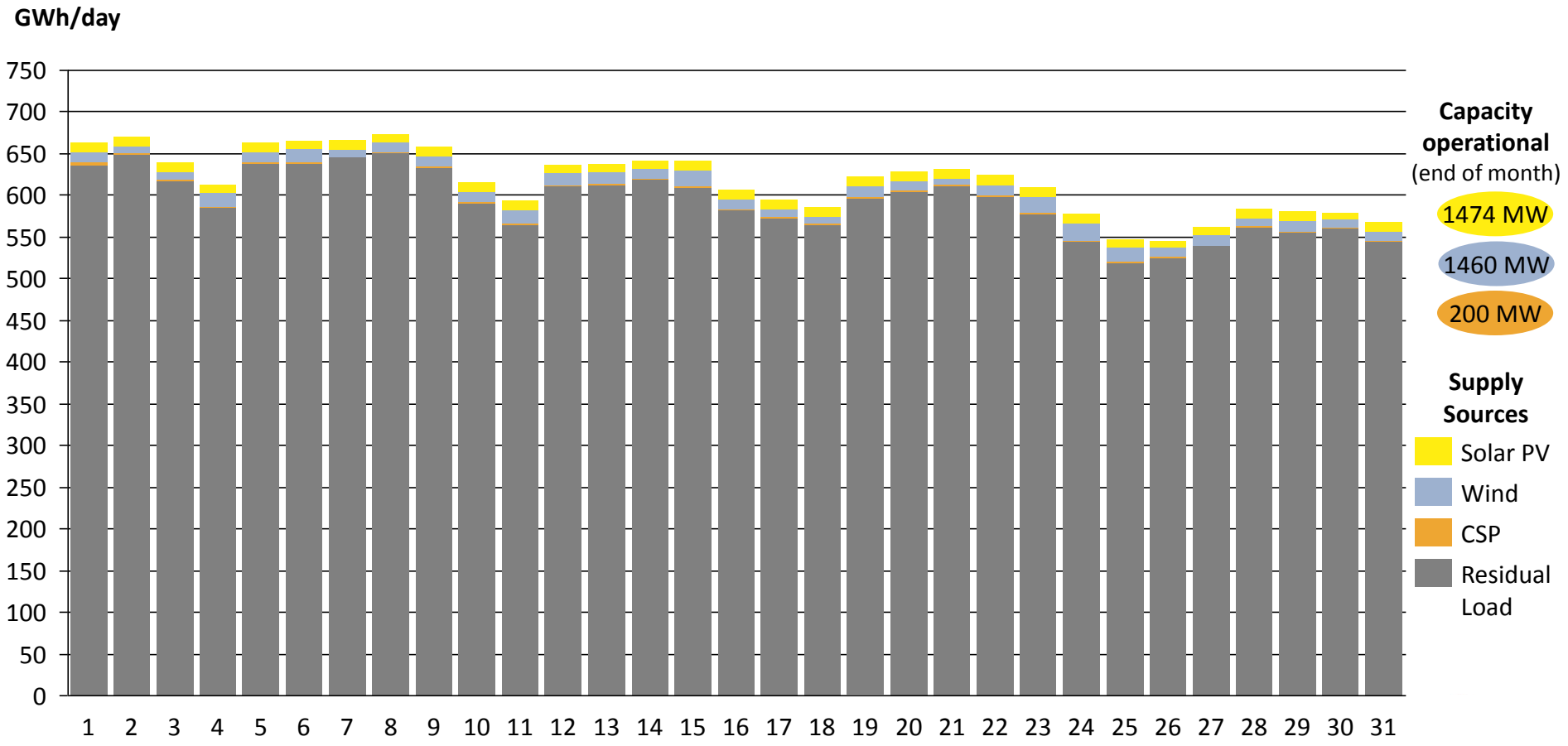


- Maximum daily production of 677 GWh on 30 Nov 2016 (Wednesday)
- Minimum daily production of 610 GWh on 20 Nov 2016 (Sunday)

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

Daily electricity production of between 598-676 GWh in Dec 2016

Actual daily production from all power supply sources in South Africa for December 2016

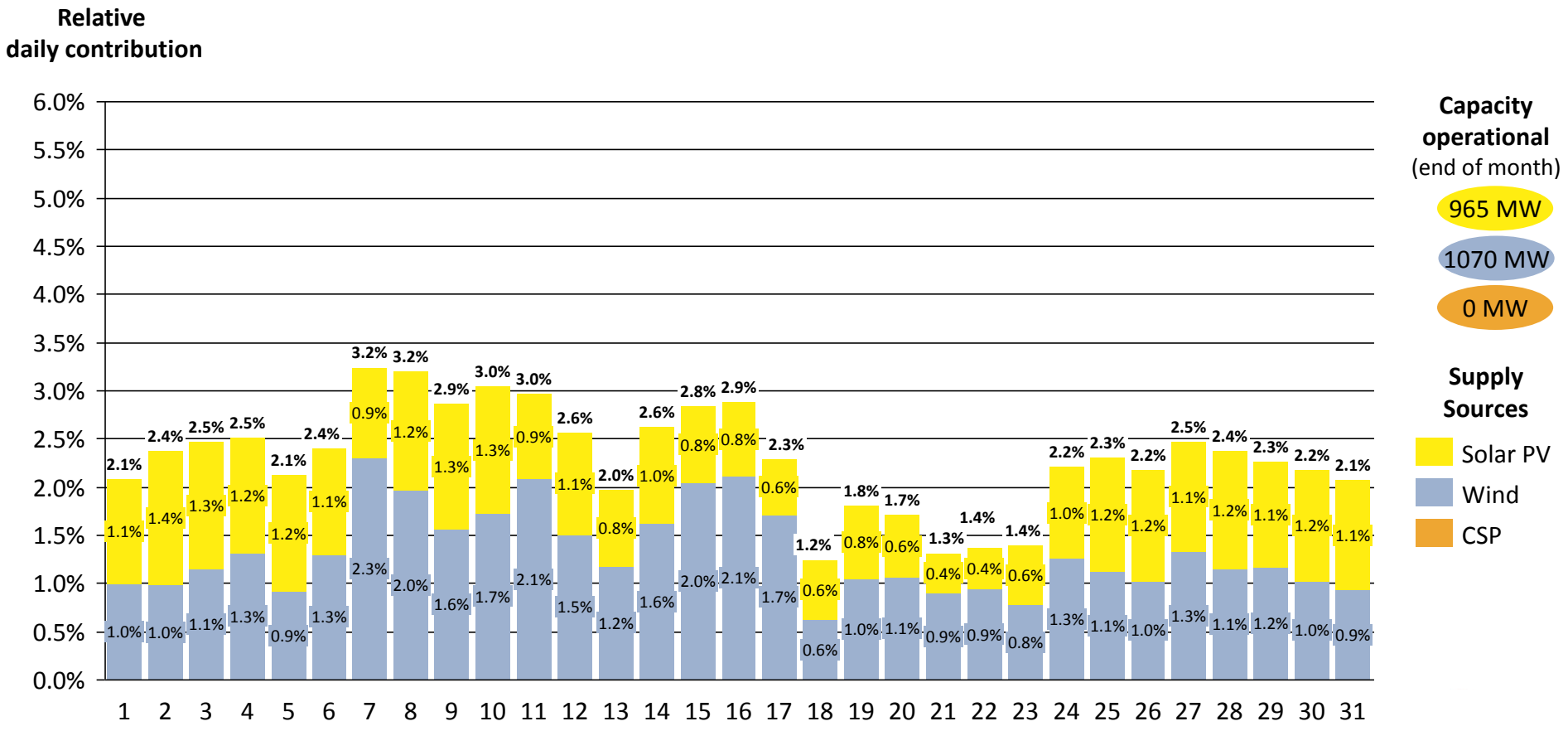


- Maximum daily production of 675 GWh on 18 Oct 2016 (Tuesday)
- Minimum daily production of 592 GWh on 2 Oct 2016 (Sunday)

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

Daily solar PV, wind & CSP contribution of 1.2-3.2% in Jan 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for January 2016

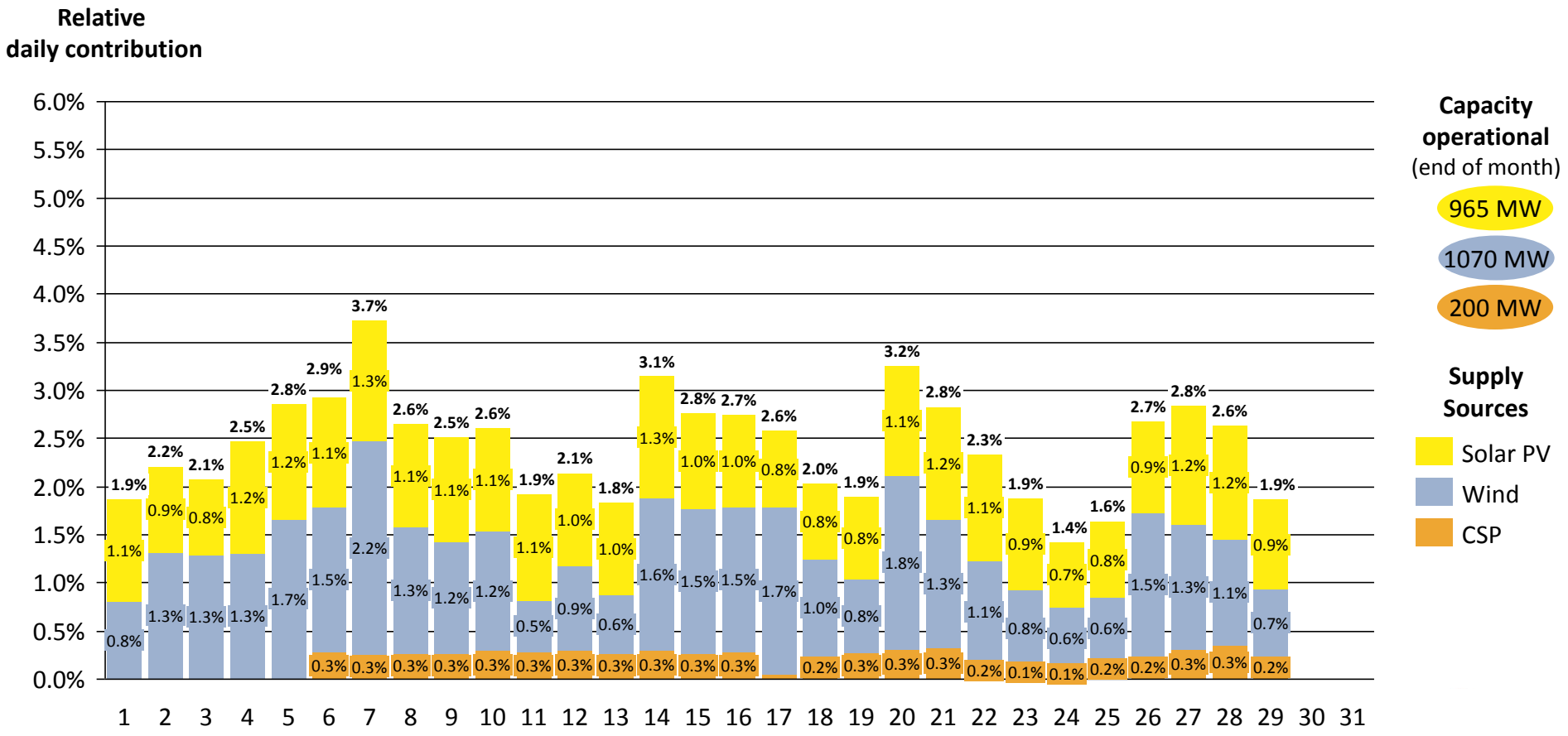


- Maximum daily relative solar PV contribution of 1.4% on 2 Jan 2016 (Saturday)
- Maximum daily relative wind contribution of 2.3% on 7 Jan 2016 (Thursday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.4-3.7% in Feb 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for February 2016

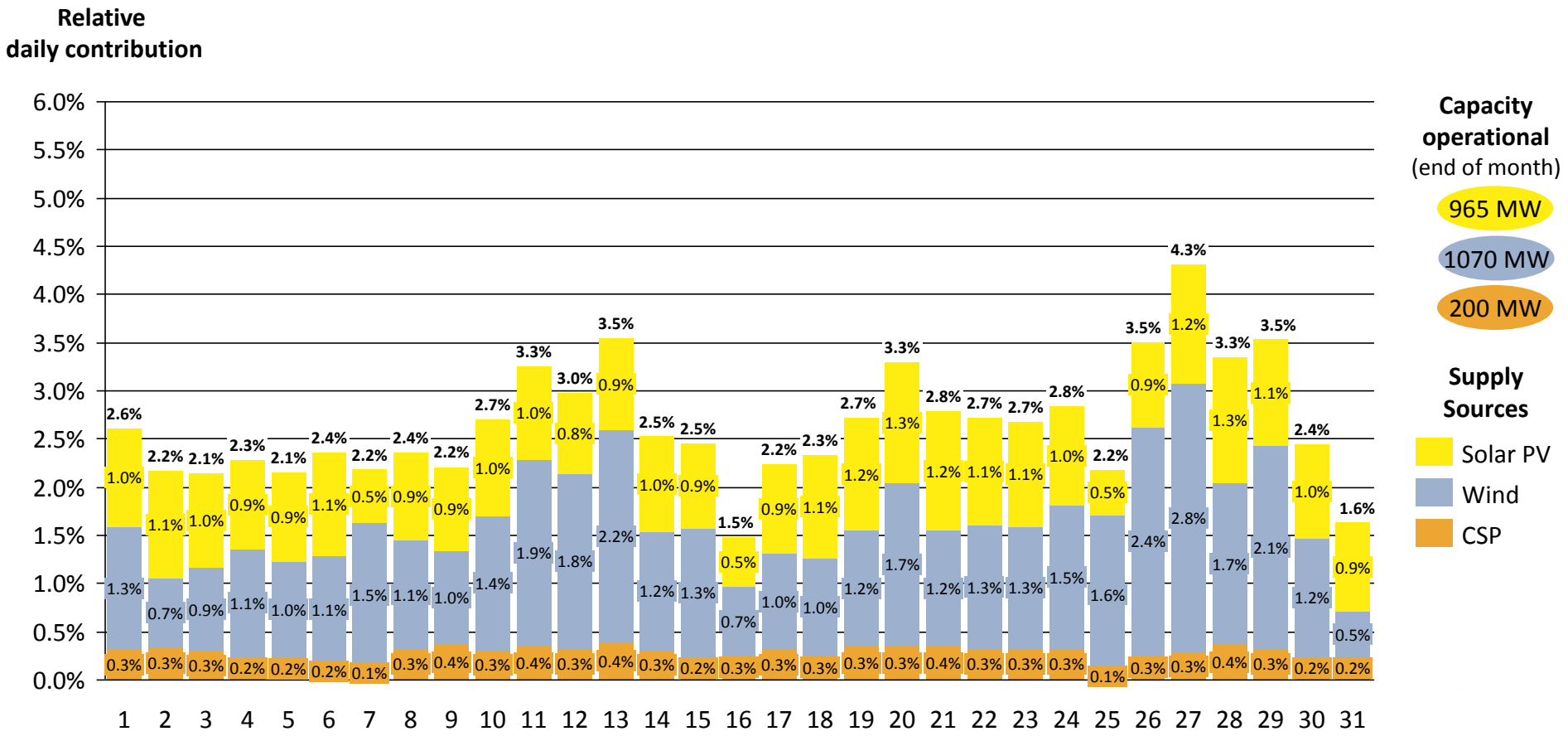


- Maximum daily relative solar PV contribution of 1.3% on 14 Feb 2016 (Sunday)
- Maximum daily relative wind contribution of 2.2% on 7 Feb 2016 (Sunday)
- Maximum daily relative CSP contribution of 0.3% on 28 Feb 2016 (Sunday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.5-4.3% in Mar 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for March 2016

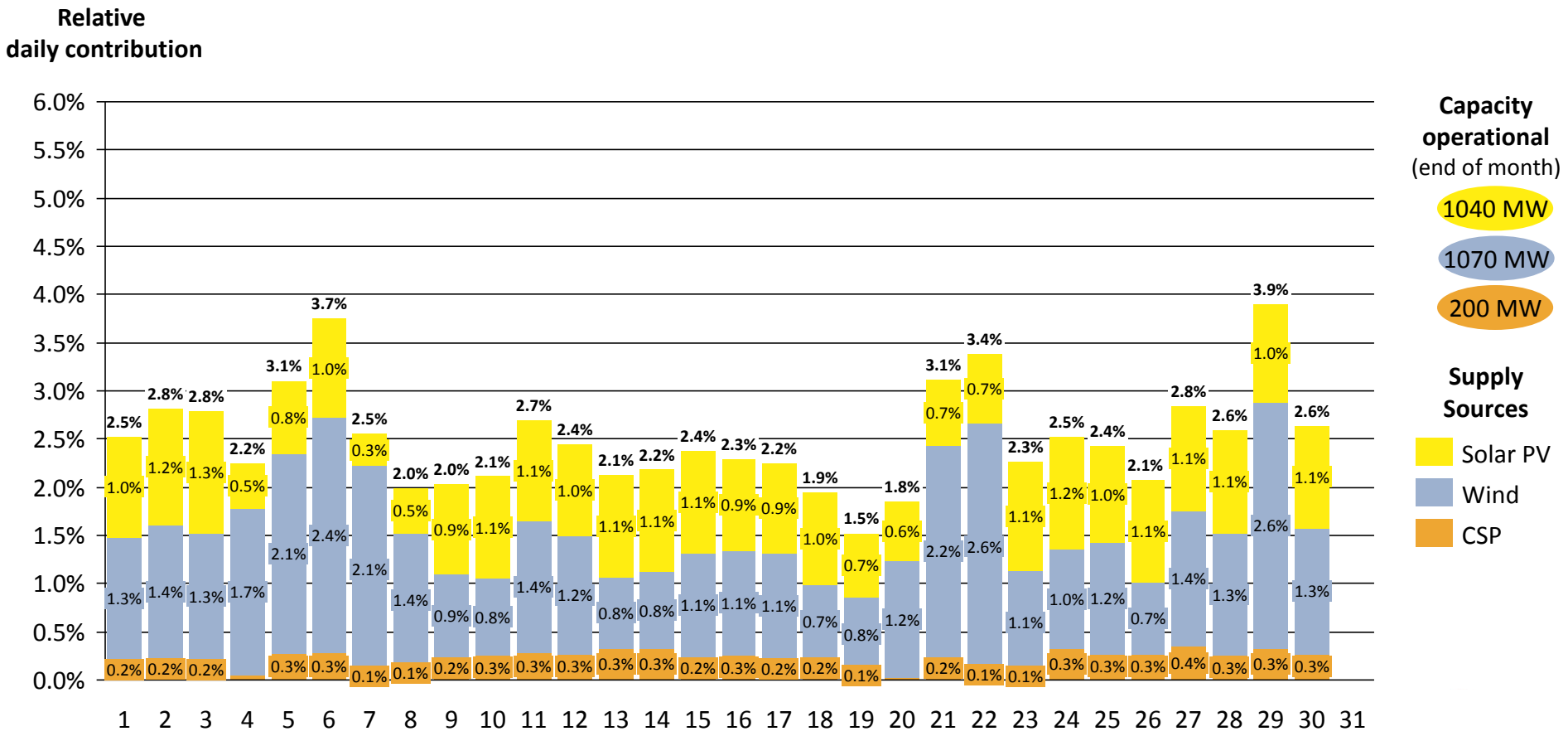


- Maximum daily relative solar PV contribution of 1.3% on 28 Mar 2016 (Monday)
- Maximum daily relative wind contribution of 2.8% on 27 Mar 2016 (Sunday)
- Maximum daily relative CSP contribution of 0.4% on 13 Mar 2016 (Sunday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.5-3.9% in Apr 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for April 2016

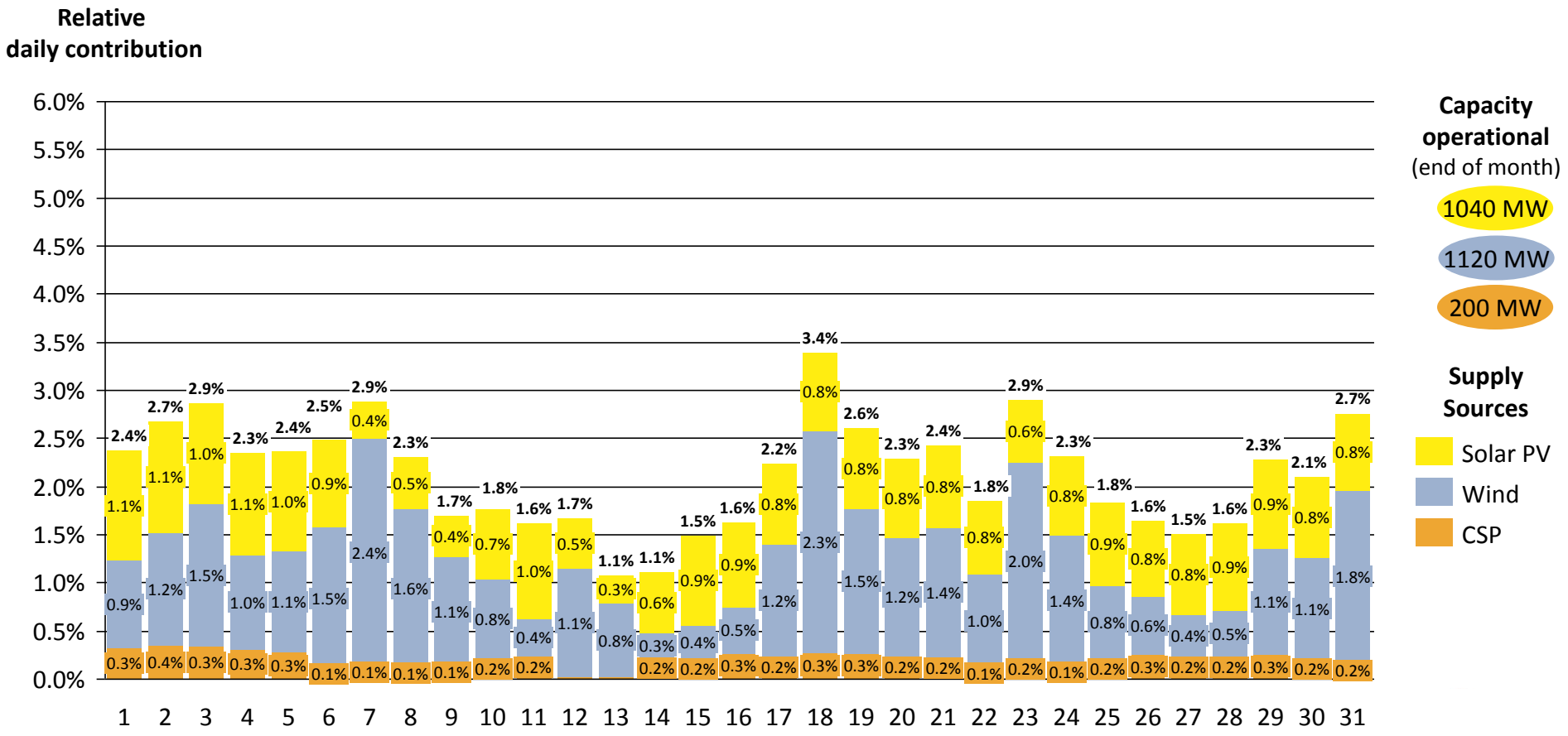


- Maximum daily relative solar PV contribution of 1.3% on 3 Apr 2016 (Sunday)
- Maximum daily relative wind contribution of 2.6% on 29 Apr 2016 (Friday)
- Maximum daily relative CSP contribution of 0.3% on 27 Apr 2016 (Wednesday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.1-3.4% in May 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for May 2016

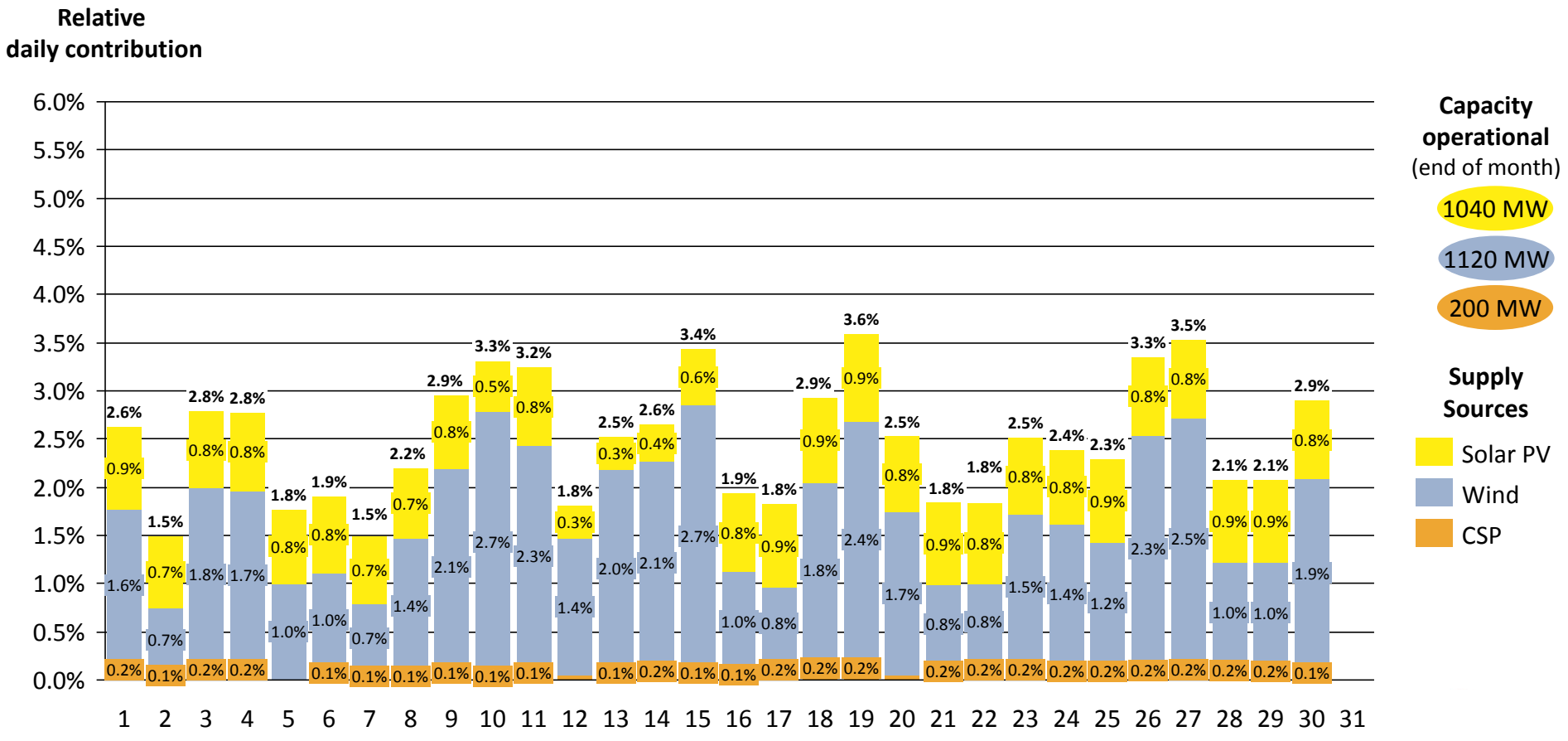


- Maximum daily relative solar PV contribution of 1.1% on 2 May 2016 (Monday)
- Maximum daily relative wind contribution of 2.4% on 7 May 2016 (Saturday)
- Maximum daily relative CSP contribution of 0.3% on 2 May (Monday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.5-3.6% in Jun 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for June 2016

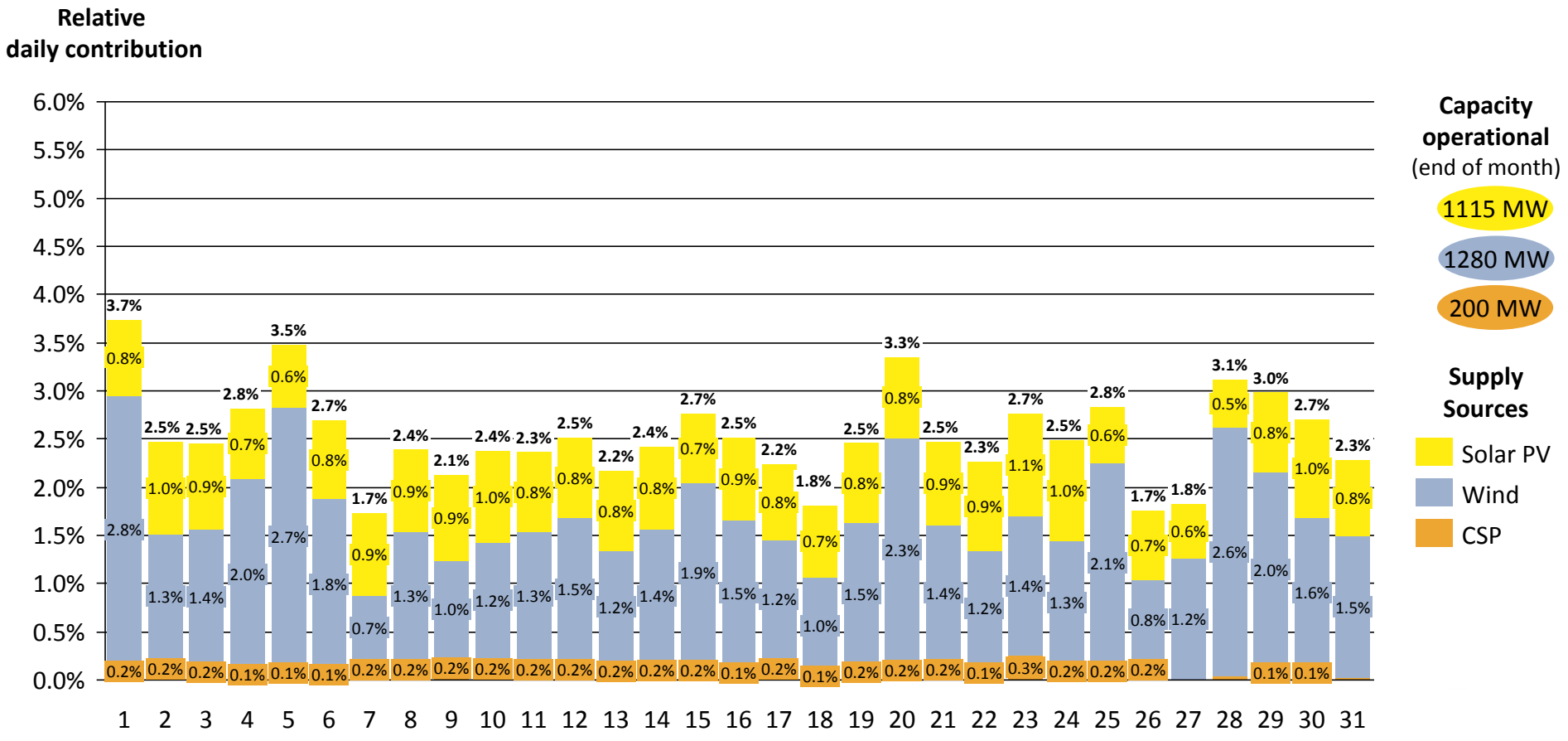


- Maximum daily relative solar PV contribution of 0.9% on 19 Jun 2016 (Sunday)
- Maximum daily relative wind contribution of 2.7% on 15 Jun 2016 (Wednesday)
- Maximum daily relative CSP contribution of 0.2% on 19 Jun 2016 (Sunday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.5-3.6% in Jul 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for July 2016

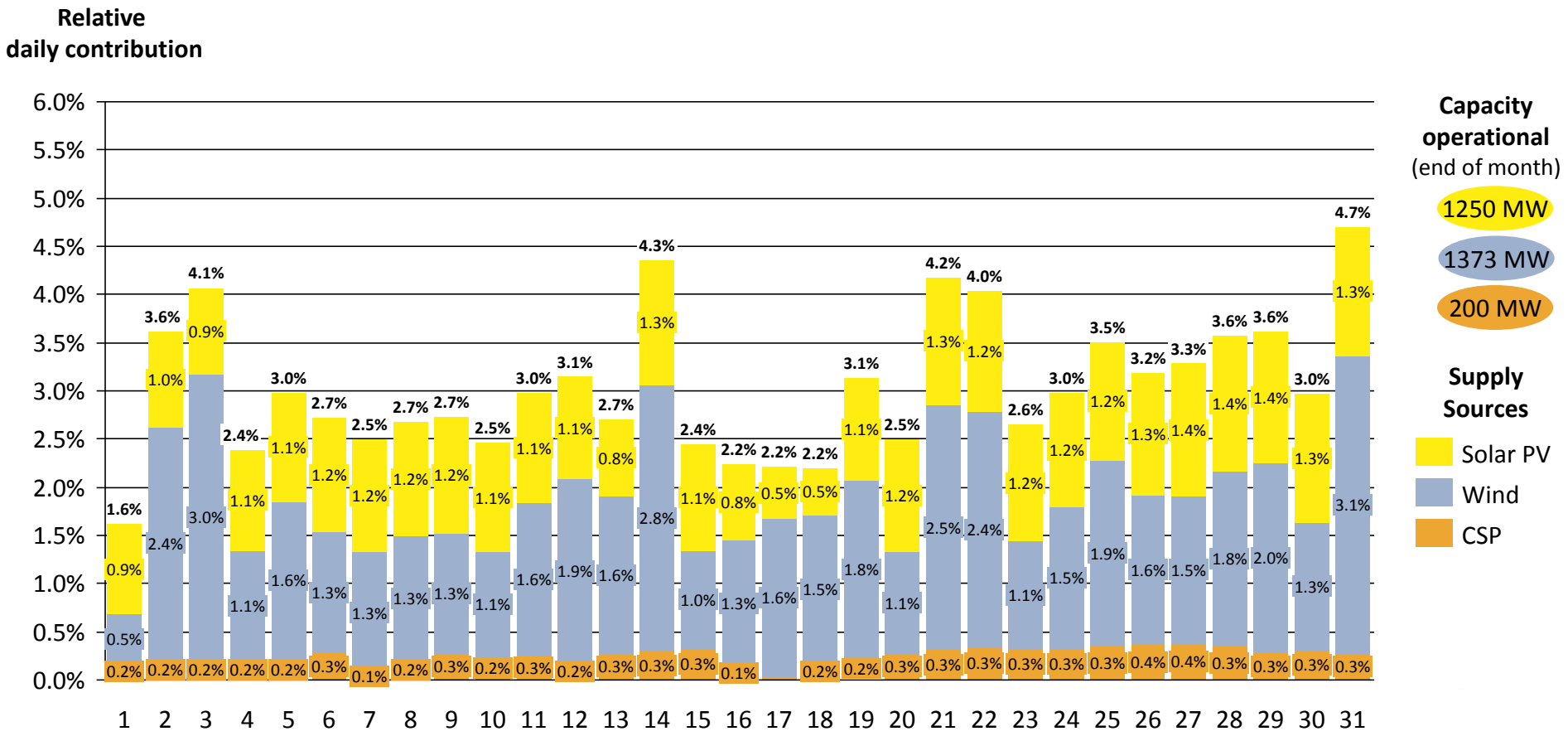


- Maximum daily relative solar PV contribution of 1.1% on 23 Jul 2016 (Saturday)
- Maximum daily relative wind contribution of 2.8% on 1 Jul 2016 (Friday)
- Maximum daily relative CSP contribution of 0.3% on 23 Jul 2016 (Saturday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.6-4.7% in Aug 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for August 2016

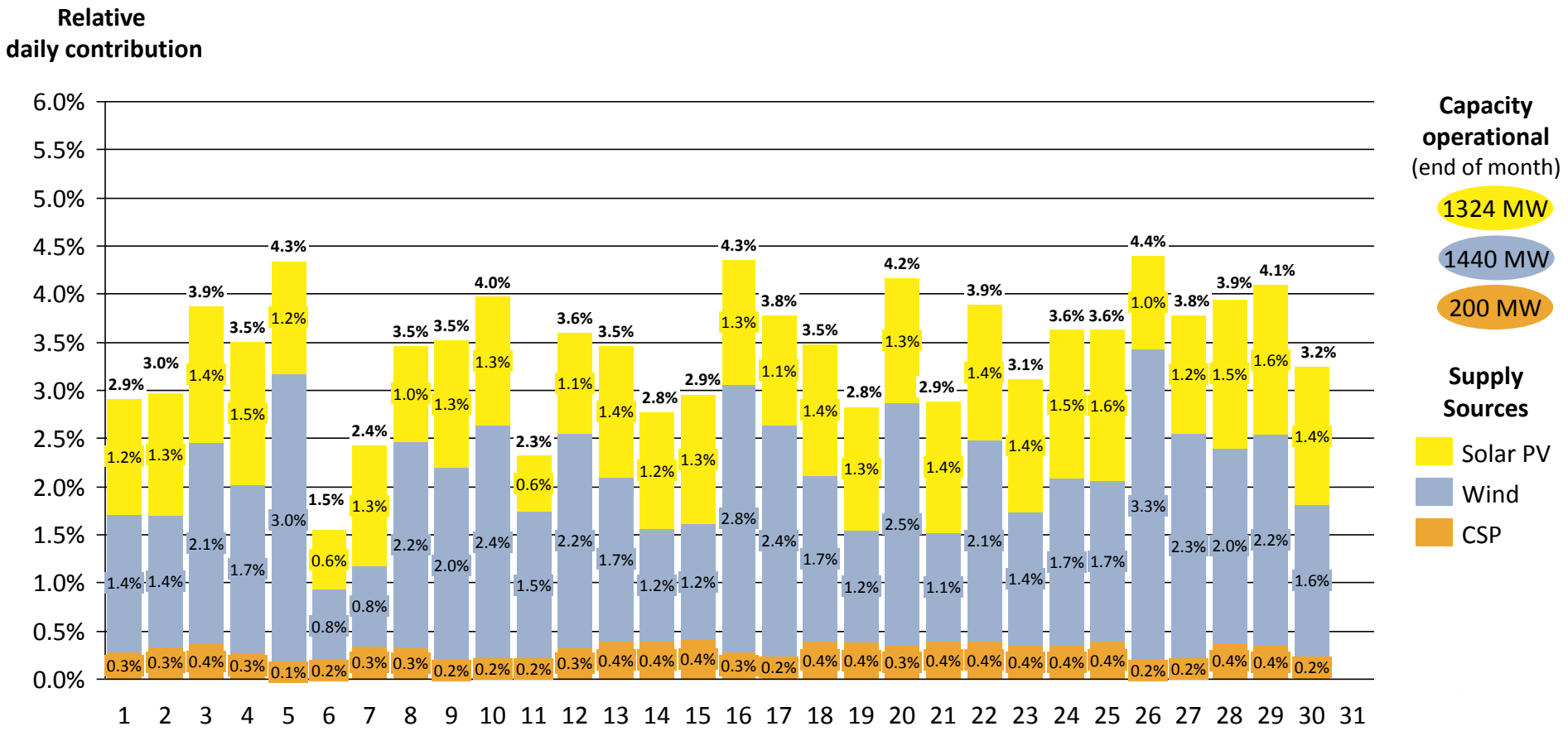


- Maximum daily relative solar PV contribution of 1.4% on 28 Aug 2016 (Sunday)
- Maximum daily relative wind contribution of 3.1% on 31 Aug 2016 (Wednesday)
- Maximum daily relative CSP contribution of 0.4% on 27 Aug 2016 (Saturday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.5-4.4% in Sep 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for September 2016

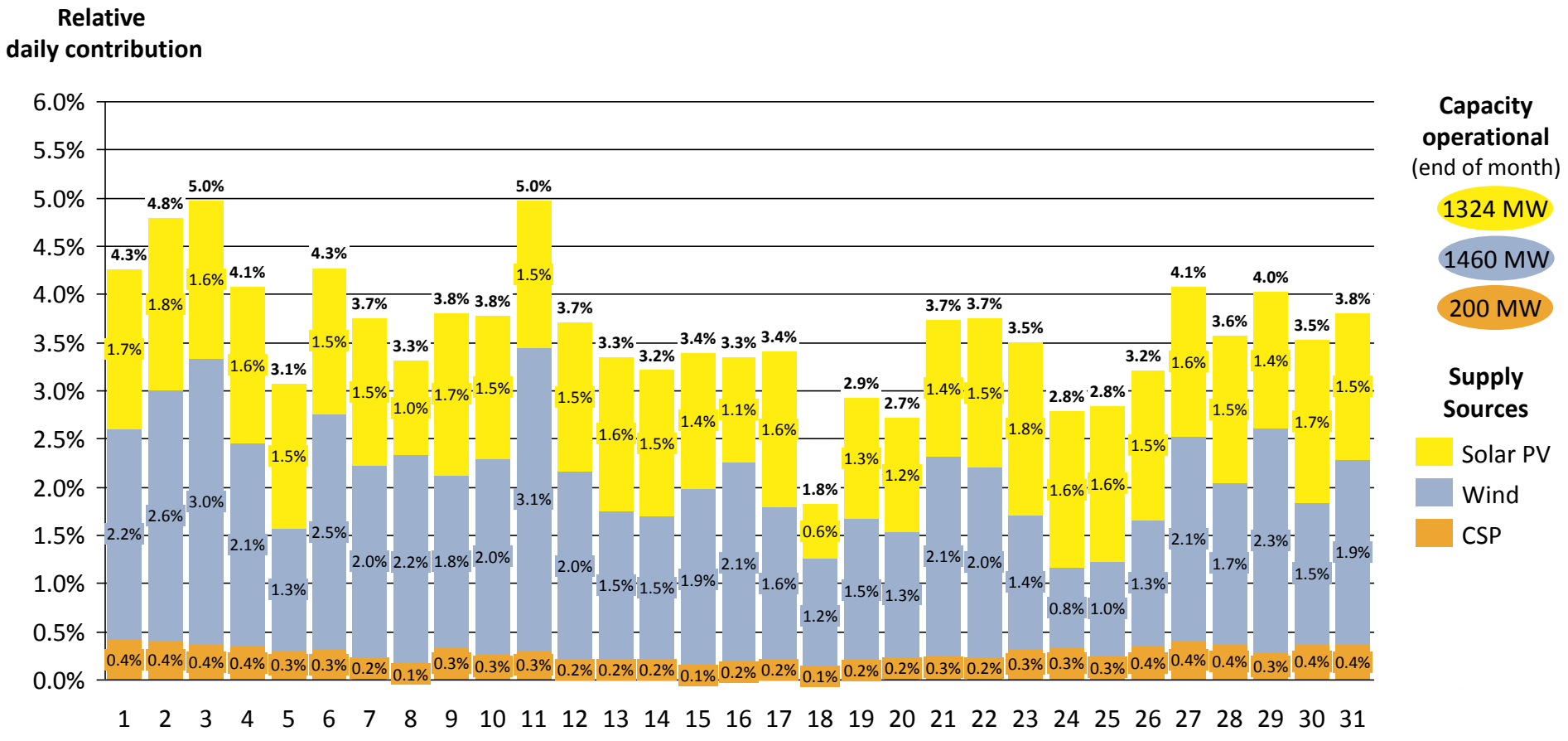


- Maximum daily relative solar PV contribution of 1.6% on 25 Sep 2016 (Sunday)
- Maximum daily relative wind contribution of 3.3% on 26 Sep 2016 (Monday)
- Maximum daily relative CSP contribution of 0.4% on 15 Sep 2016 (Thursday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 1.8-5.0% in Oct 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for October 2016

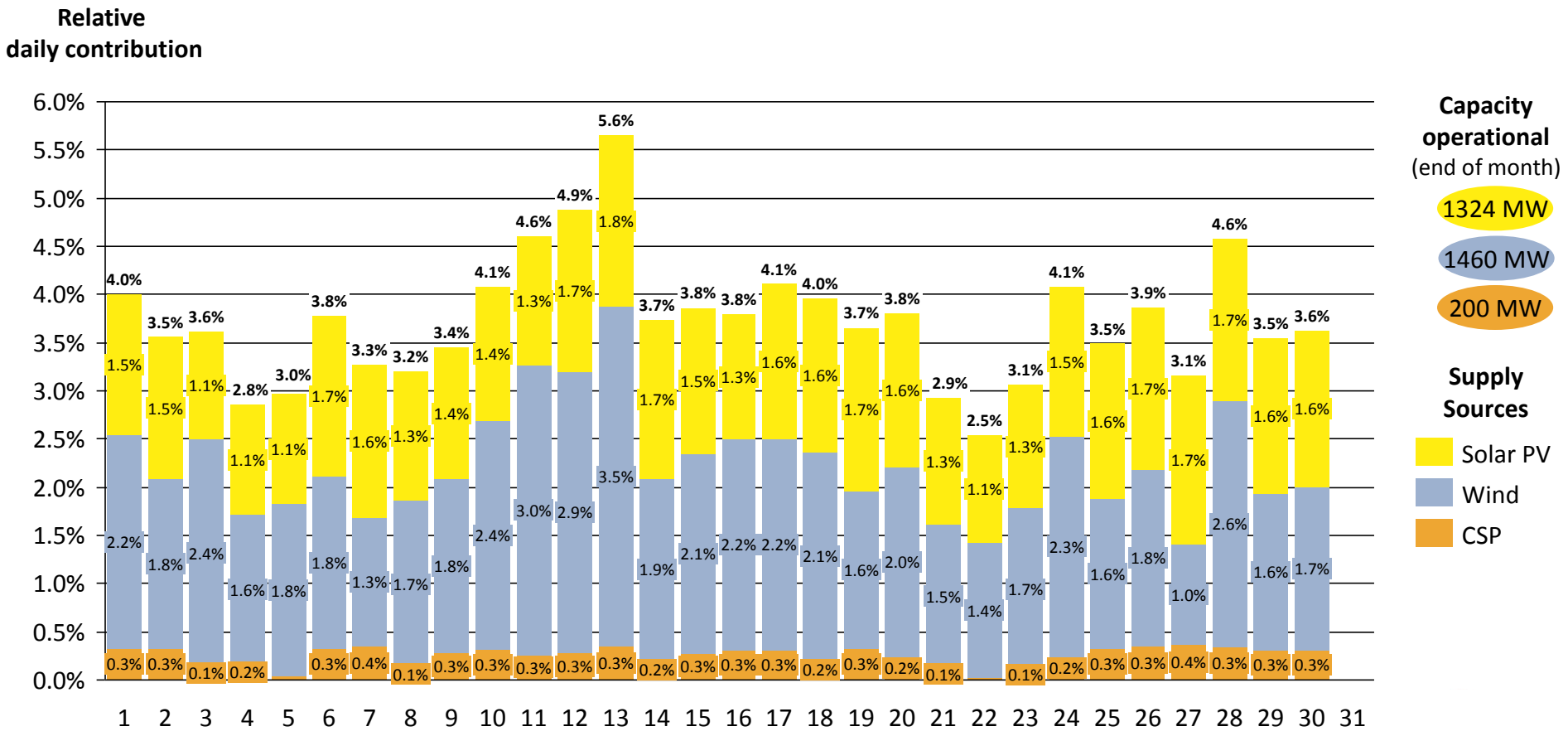


- Maximum daily relative solar PV contribution of 1.8% on 2 Oct 2016 (Sunday)
- Maximum daily relative wind contribution of 3.1% on 11 Oct 2016 (Tuesday)
- Maximum daily relative CSP contribution of 0.4% on 1 Oct 2016 (Saturday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 2.5-5.6% in Nov 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for November 2016

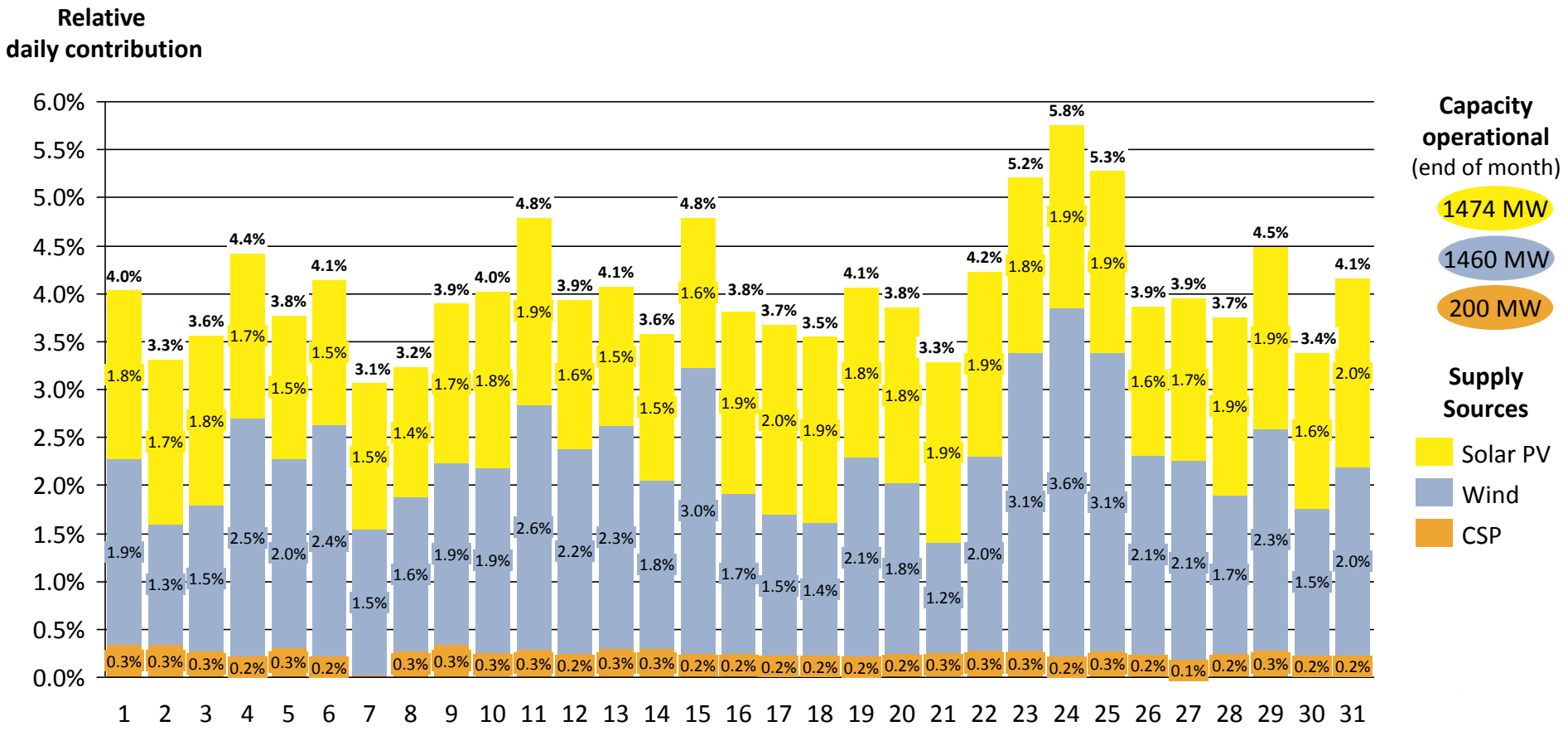


- Maximum daily relative solar PV contribution of 1.8% on 13 Nov 2016 (Sunday)
- Maximum daily relative wind contribution of 3.5% on 13 Nov 2016 (Sunday)
- Maximum daily relative CSP contribution of 0.4% on 27 Nov 2016 (Sunday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Daily solar PV, wind & CSP contribution of 3.1-5.8% in Dec 2016

Actual daily relative solar PV/wind/CSP contribution as % of total supply in RSA for December 2016



- Maximum daily relative solar PV contribution of 2.0% on 31 Dec 2016 (Saturday)
- Maximum daily relative wind contribution of 3.6% on 24 Dec 2016 (Saturday)
- Maximum daily relative CSP contribution of 0.3% on 9 Dec 2016 (Friday)

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Agenda

Overview actual electricity production data for 2016

Monthly electricity production

Weekly electricity production

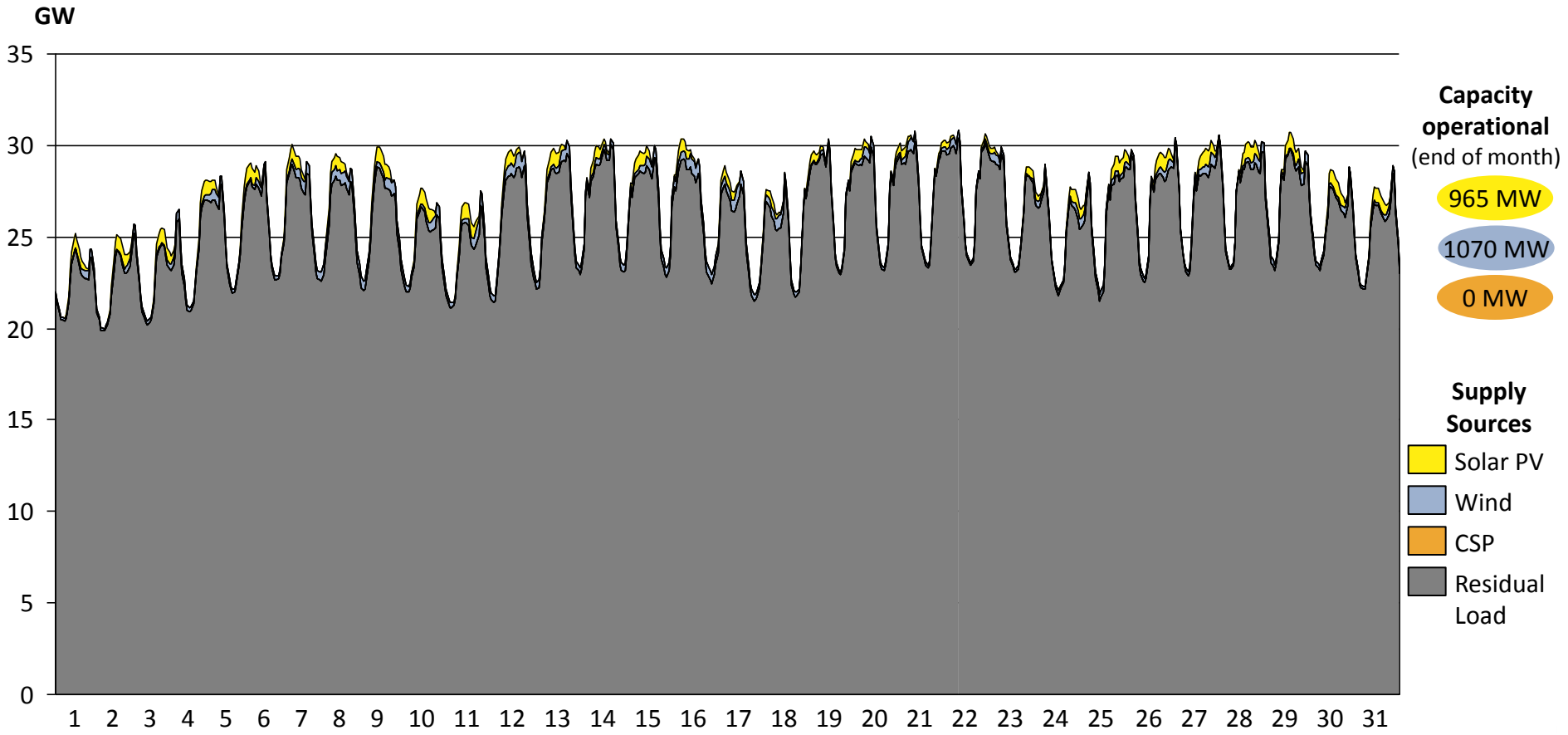
Daily electricity production

Hourly electricity production and gradients

Actual load shedding in 2016

Hourly electricity production in Jan 2016

Actual hourly production from all power supply sources in RSA for January 2016

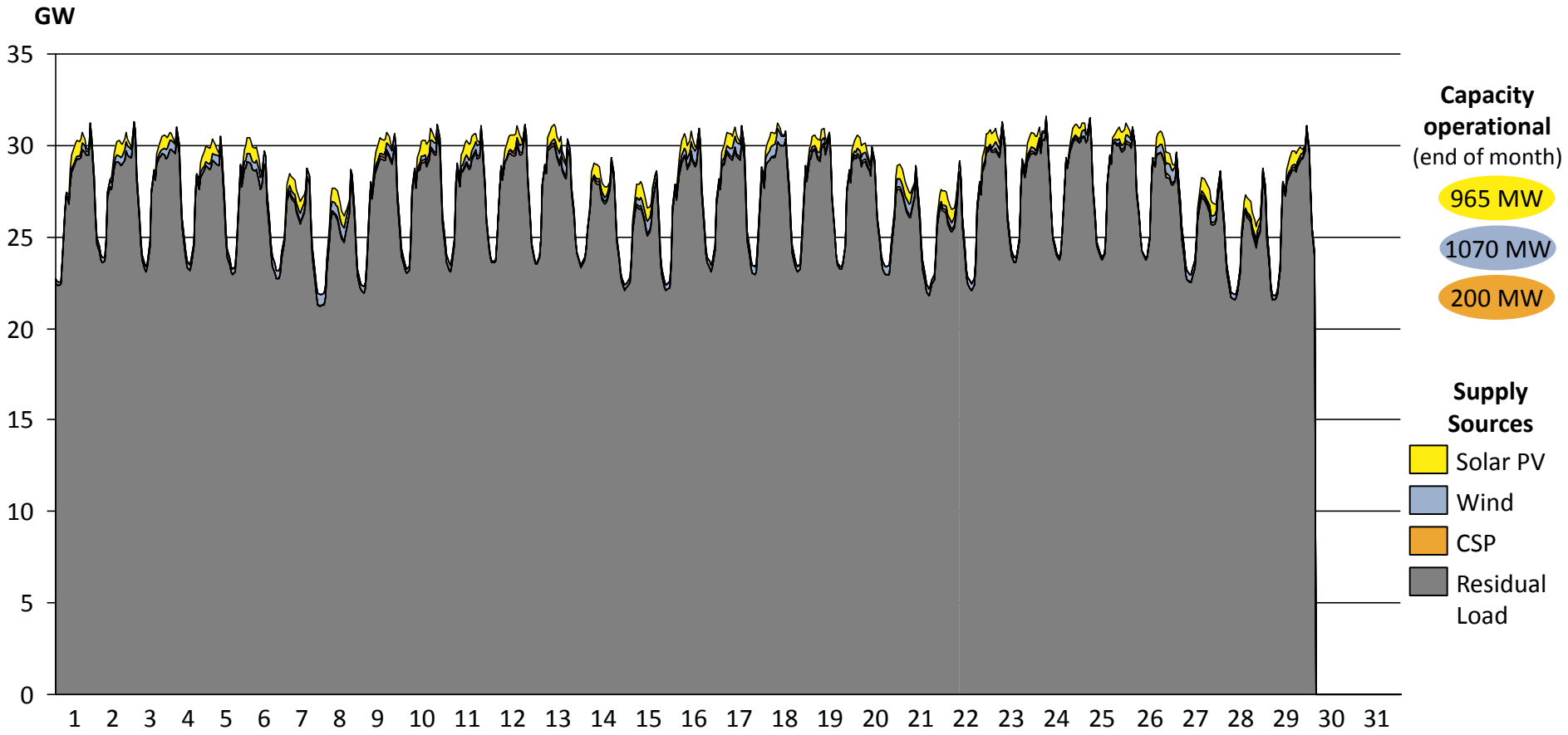


- Maximum power of 31 GW between 19h00 and 20h00 on 21 Jan 2016
- Minimum power of 20 GWh between 03h00 and 04h00 on 2 Jan 2016

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

Hourly electricity production in Feb 2016

Actual hourly production from all power supply sources in RSA for February 2016

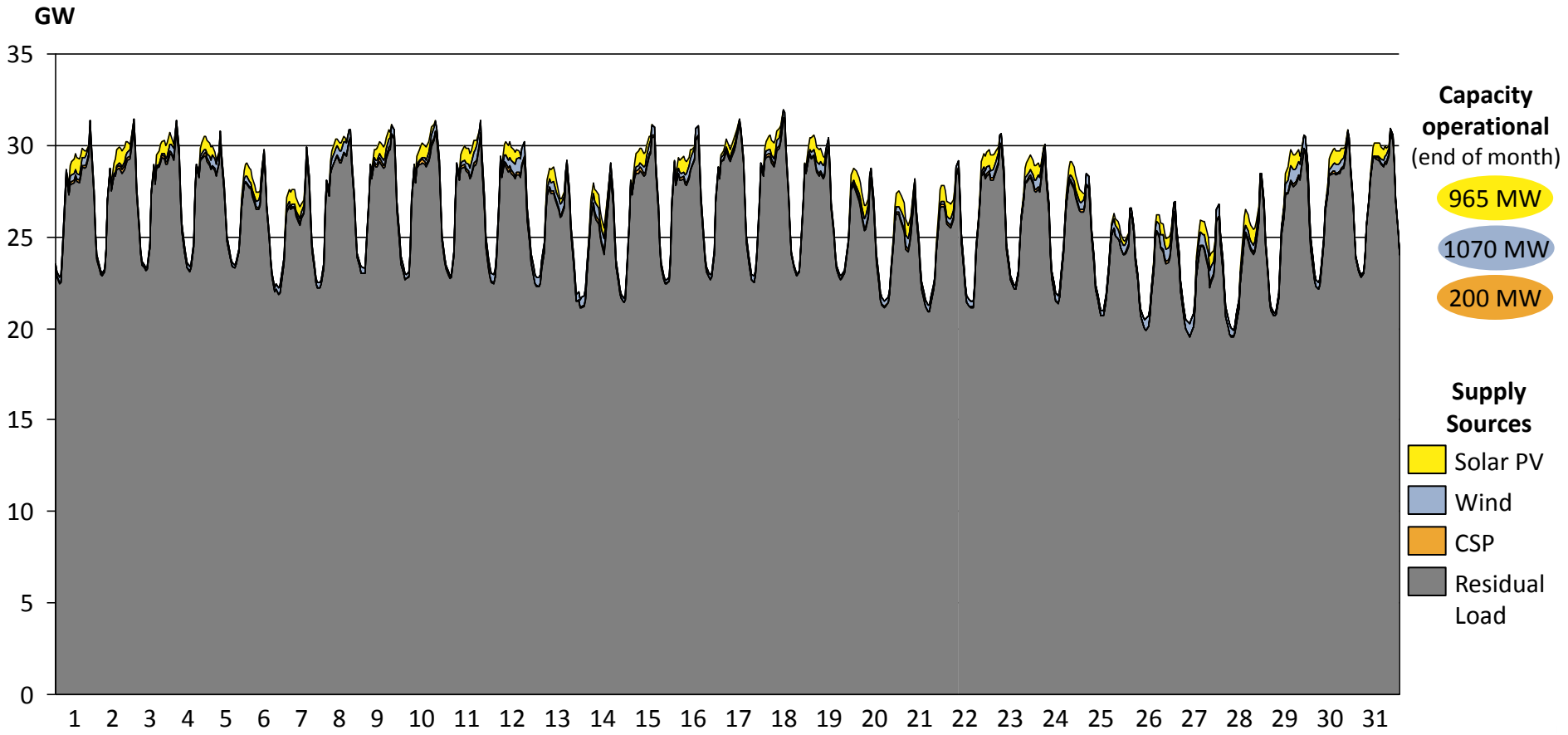


- Maximum power of 32 GW between 19h00 and 20h00 on 23 Feb 2016
- Minimum power of 22 GWh between 03h00 and 04h00 on 28 Feb 2016

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

Hourly electricity production in Mar 2016

Actual hourly production from all power supply sources in RSA for March 2016

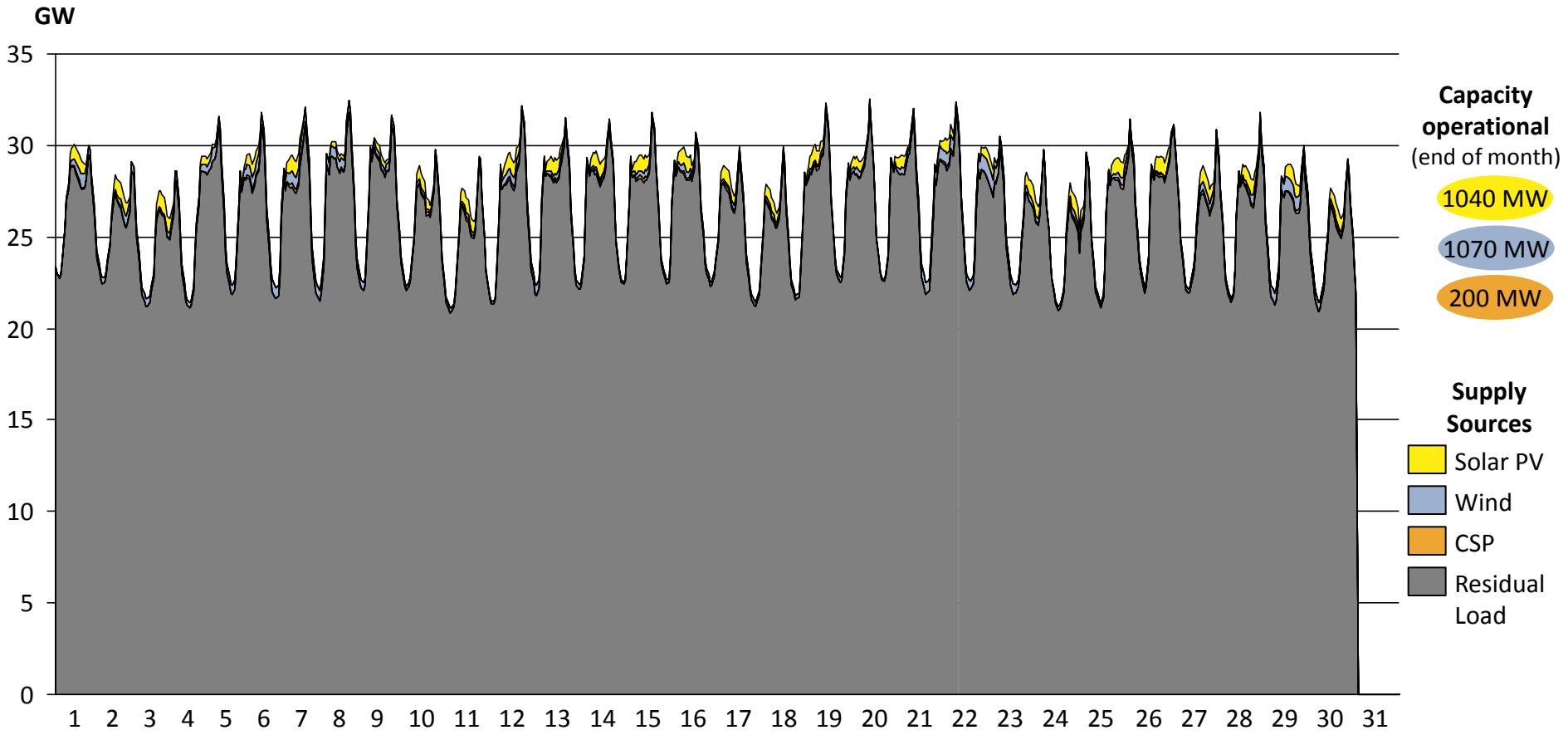


- Maximum power of 32 GW between 18h00 and 19h00 on 17 Mar 2016
- Minimum power of 20 GWh between 03h00 and 04h00 on 28 Mar 2016

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

Hourly electricity production in Apr 2016

Actual hourly production from all power supply sources in RSA for April 2016

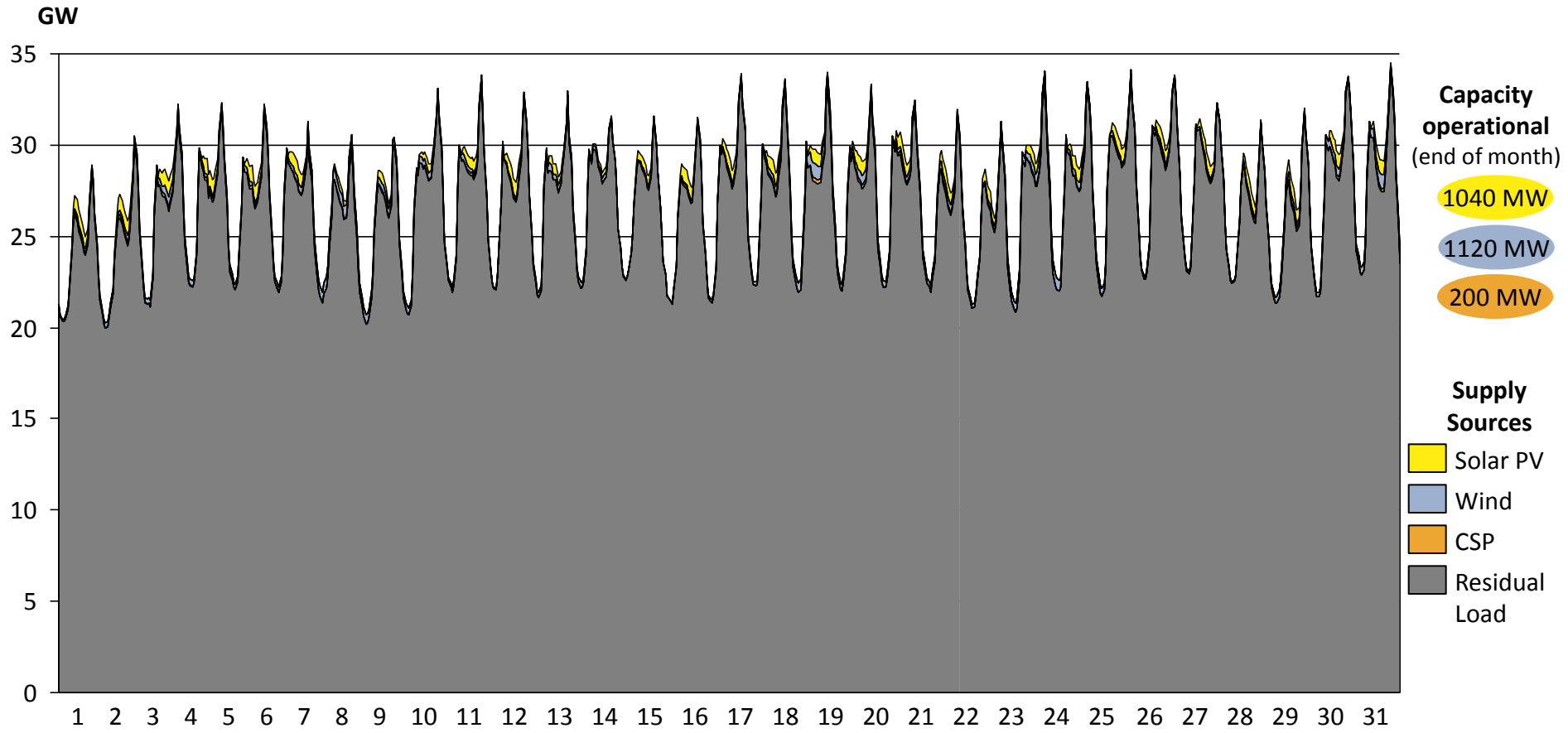


- Maximum power of 33 GW between 18h00 and 19h00 on 19 Apr 2016
- Minimum power of 21 GWh between 02h00 and 03h00 on 10 Apr 2016

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

Hourly electricity production in May 2016

Actual hourly production from all power supply sources in RSA for May 2016

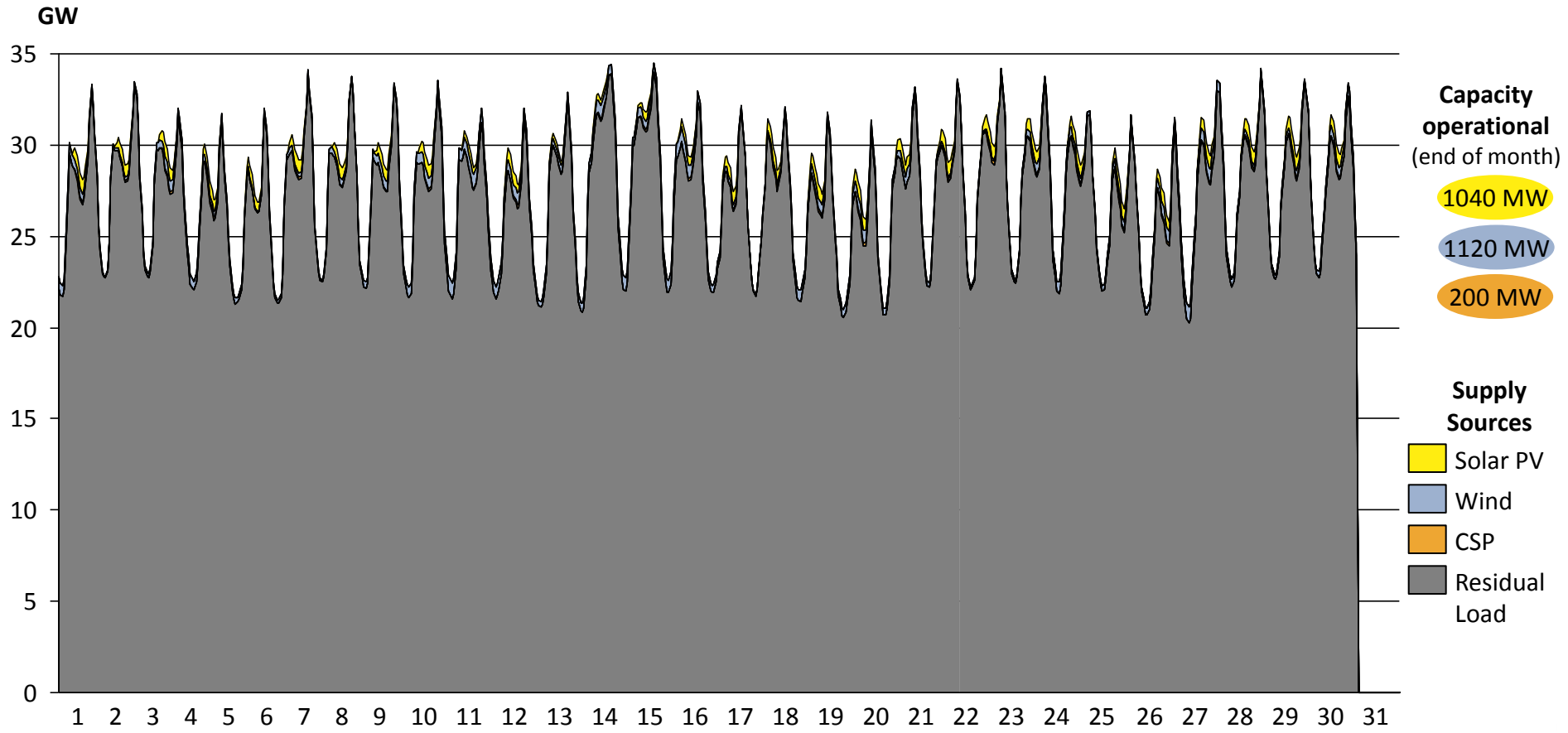


- Maximum power of 34 GW between 18h00 and 19h00 on 31 May 2016
- Minimum power of 20 GWh between 02h00 and 03h00 on 2 May 2016

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

Hourly electricity production in Jun 2016

Actual hourly production from all power supply sources in RSA for June 2016

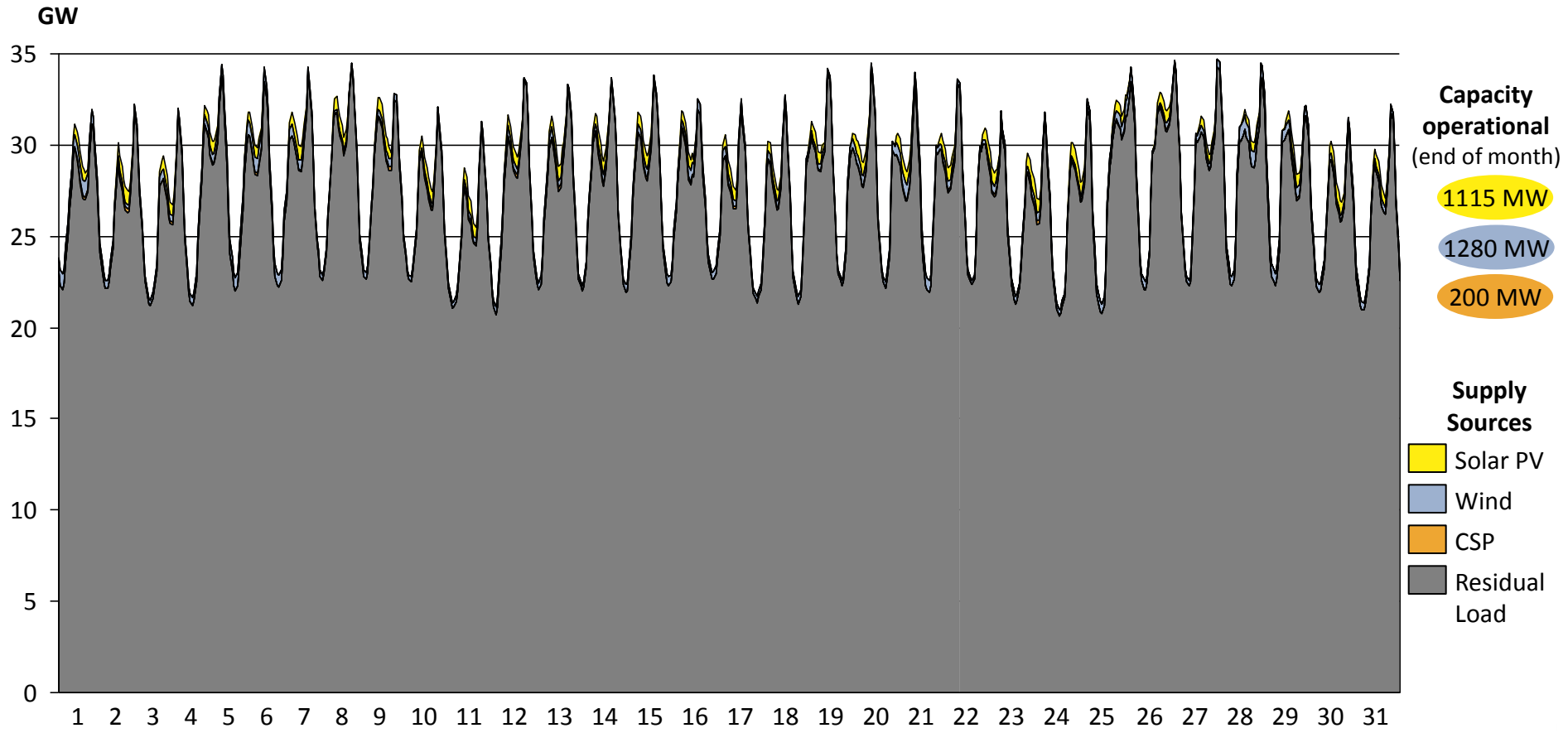


- Maximum power of 34 GW between 18h00 and 19h00 on 13 Jun 2016
- Minimum power of 21 GWh between 02h00 and 03h00 on 19 Jun 2016

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

Hourly electricity production in Jul 2016

Actual hourly production from all power supply sources in RSA for July 2016

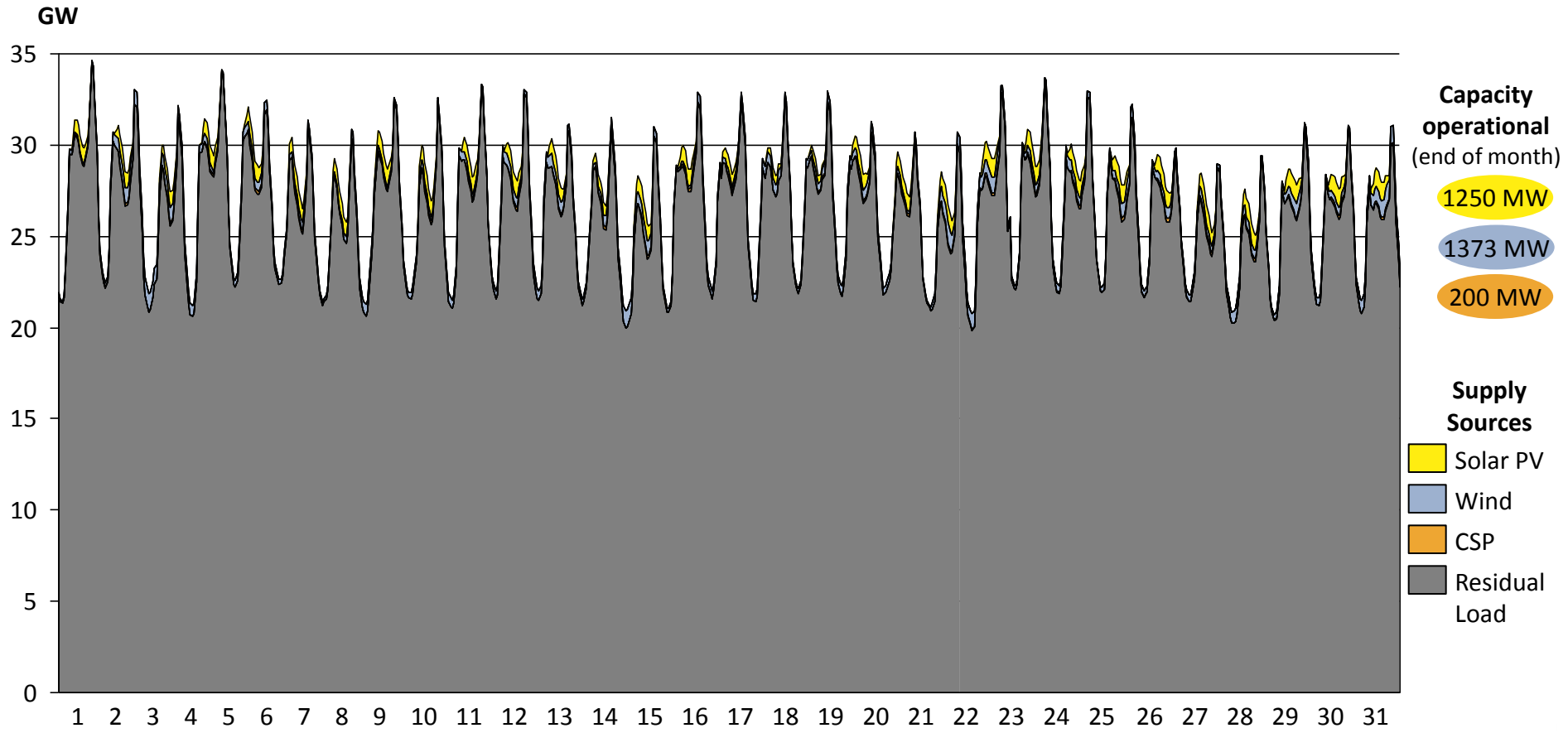


- Maximum power of 35 GW between 18h00 and 19h00 on 27 Jul 2016
- Minimum power of 21 GWh between 02h00 and 03h00 on 24 Jul 2016

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

Hourly electricity production in Aug 2016

Actual hourly production from all power supply sources in RSA for August 2016

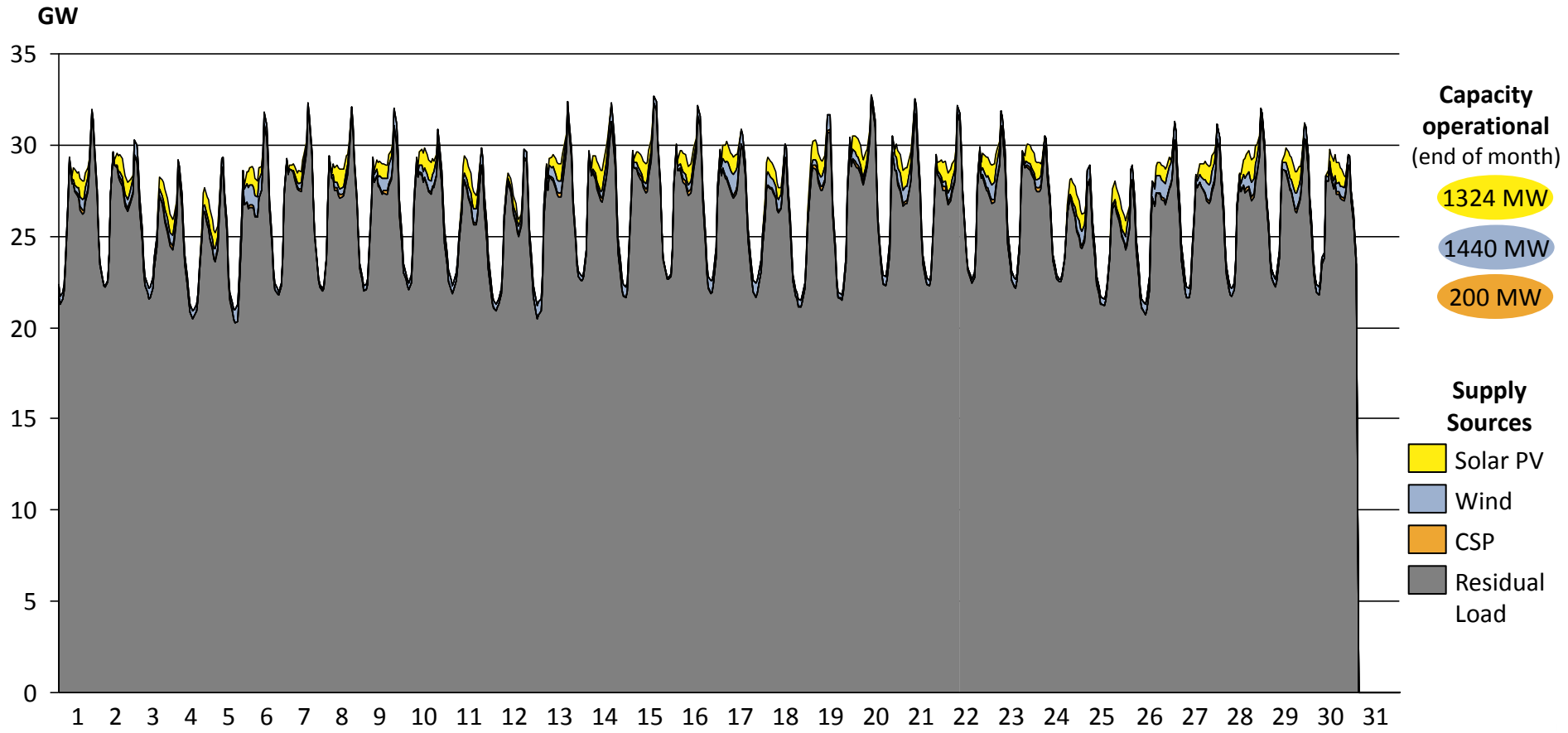


- Maximum power of 35 GW between 18h00 and 19h00 on 1 Aug 2016
- Minimum power of 21 GWh between 01h00 and 02h00 on 29 Aug 2016

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

Hourly electricity production in Sep 2016

Actual hourly production from all power supply sources in RSA for September 2016

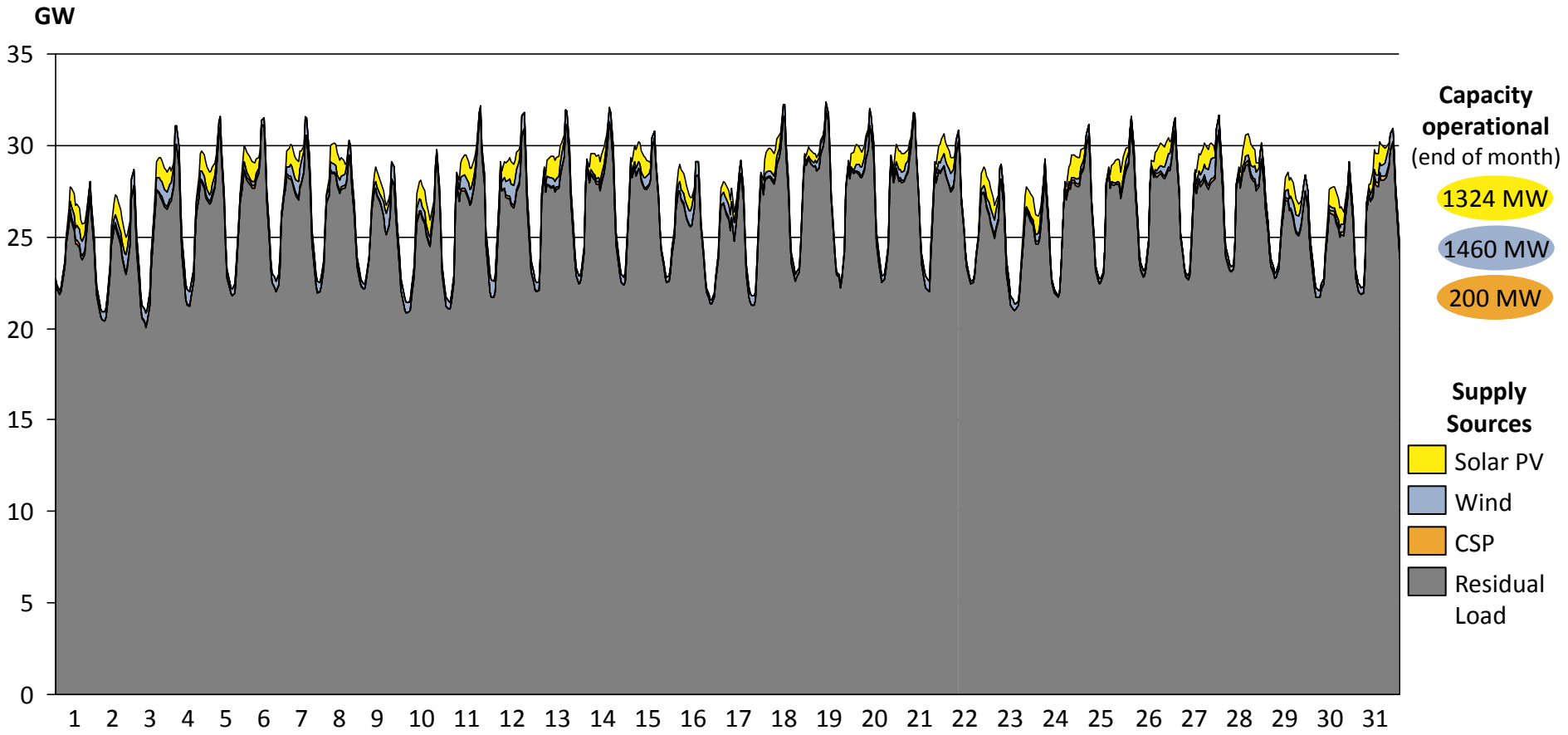


- Maximum power of 33 GW between 18h00 and 19h00 on 19 Sep 2016
- Minimum power of 21 GWh between 02h00 and 03h00 on 4 Sep 2016

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

Hourly electricity production in Oct 2016

Actual hourly production from all power supply sources in RSA for October 2016

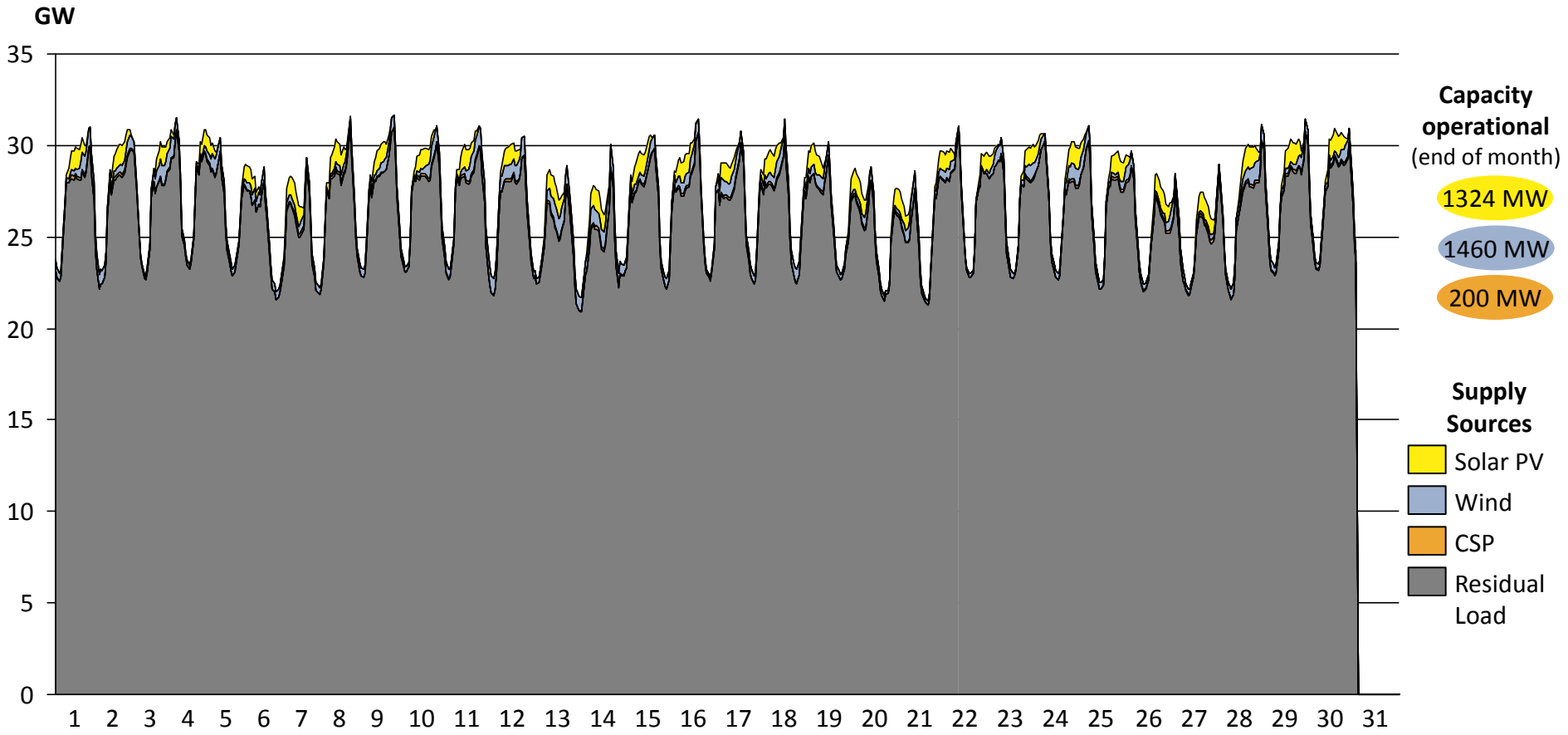


- Maximum power of 32 GW between 18h00 and 19h00 on 18 Oct 2016
- Minimum power of 21 GWh between 02h00 and 03h00 on 3 Oct 2016

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

Hourly electricity production in Nov 2016

Actual hourly production from all power supply sources in RSA for November 2016

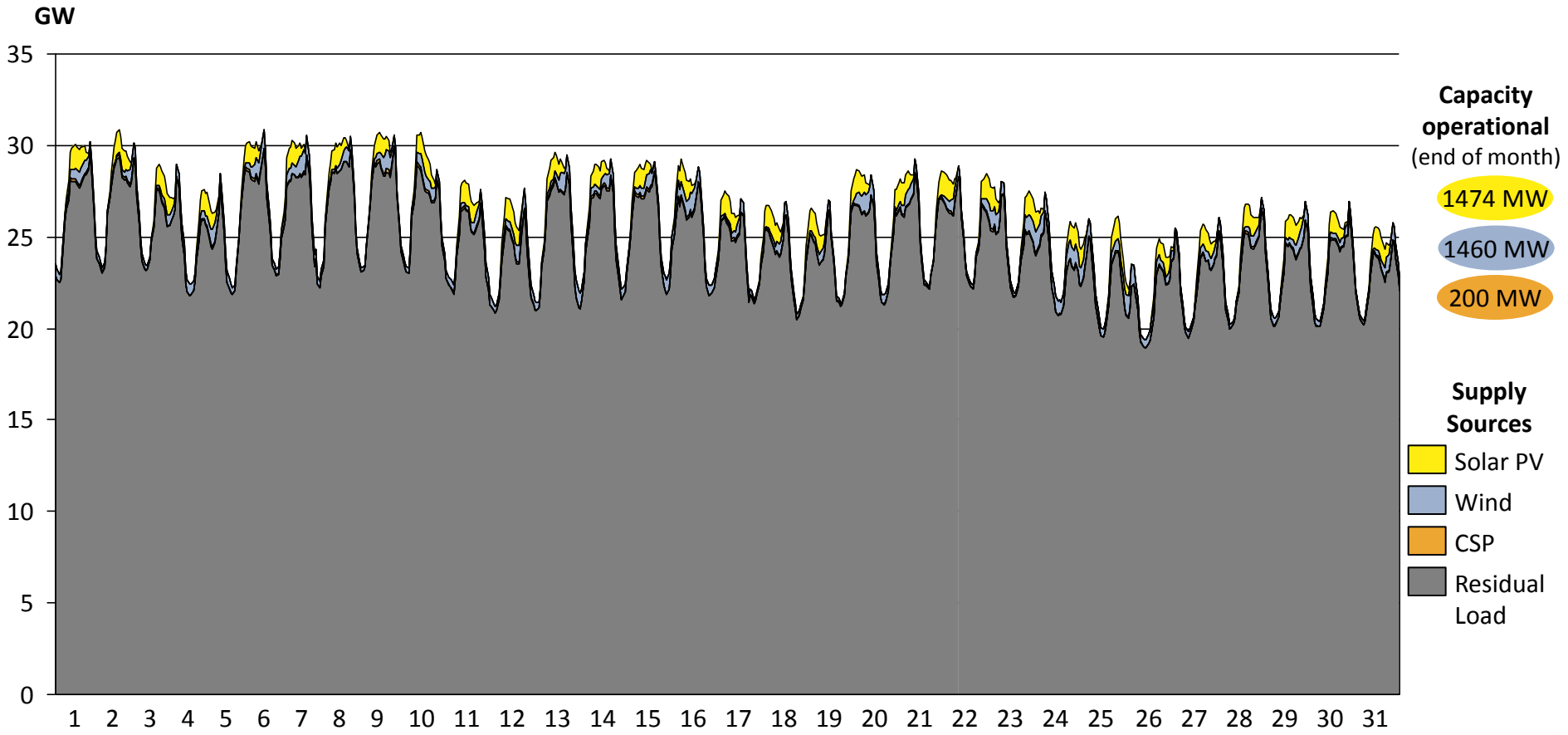


- Maximum power of 32 GW between 19h00 and 20h00 on 8 Nov 2016
- Minimum power of 22 GWh between 02h00 and 03h00 on 21 Nov 2016

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

Hourly electricity production in Dec 2016

Actual hourly production from all power supply sources in RSA for December 2016

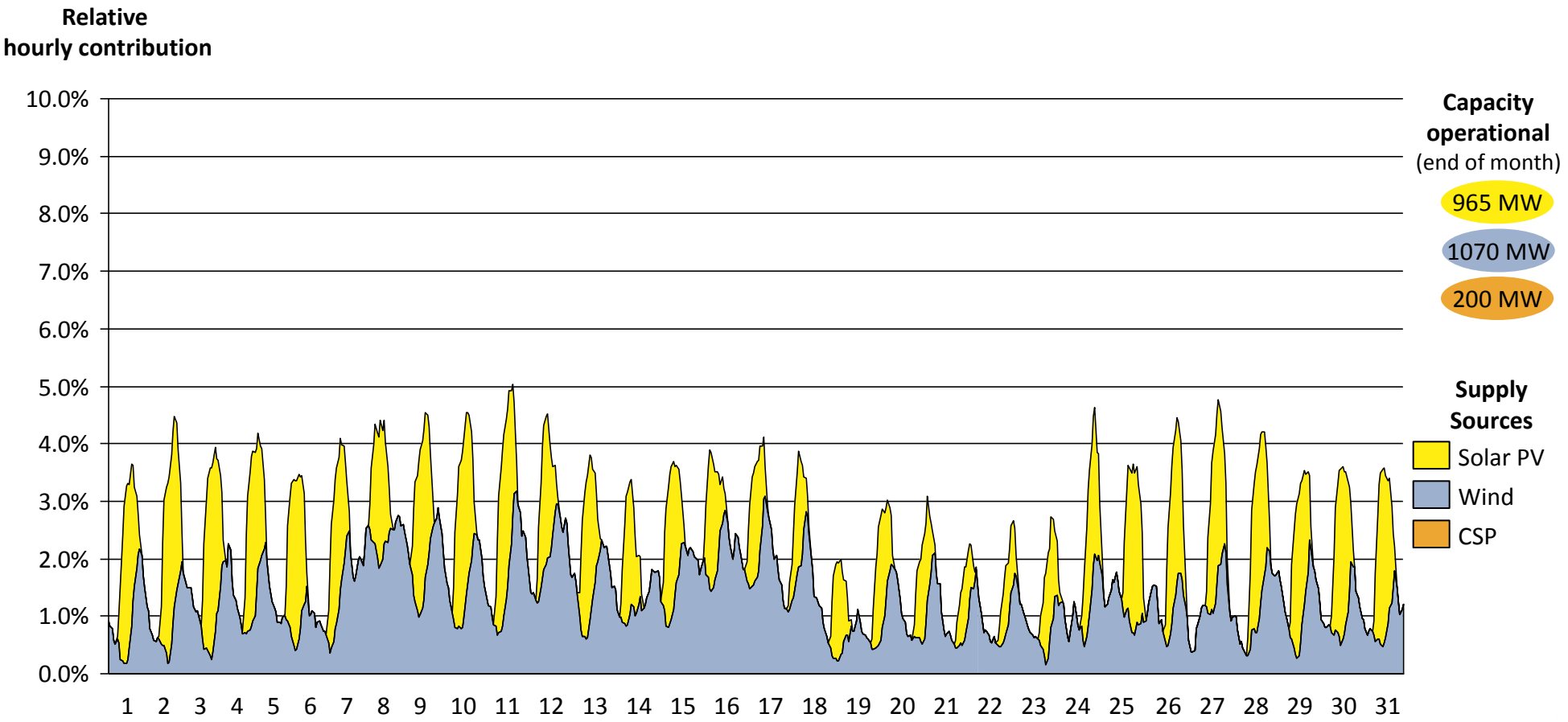


- Maximum power of 32 GW between 19h00 and 20h00 on 5 Dec 2016
- Minimum power of 19 GWh between 02h00 and 03h00 on 26 Dec 2016

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

Hourly solar PV, wind & CSP contribution of 0.3-5.0% in Jan 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for January 2016

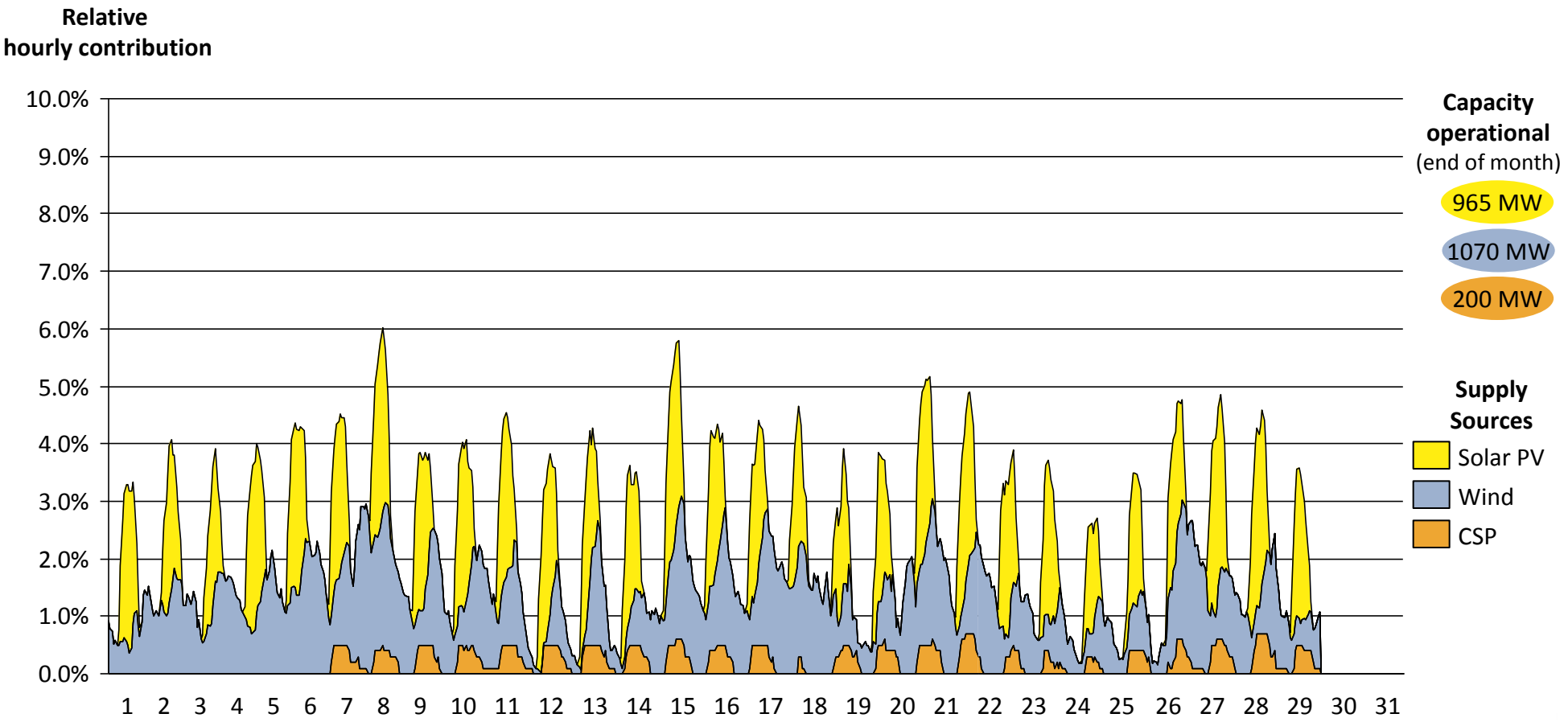


- Maximum solar PV relative contribution of 3.3% between 13h00 and 14h00 on 2 Jan 2016
- Maximum wind relative contribution of 3.2% between 18h00 and 19h00 on 10 Jan 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-6.0% in Feb 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for February 2016

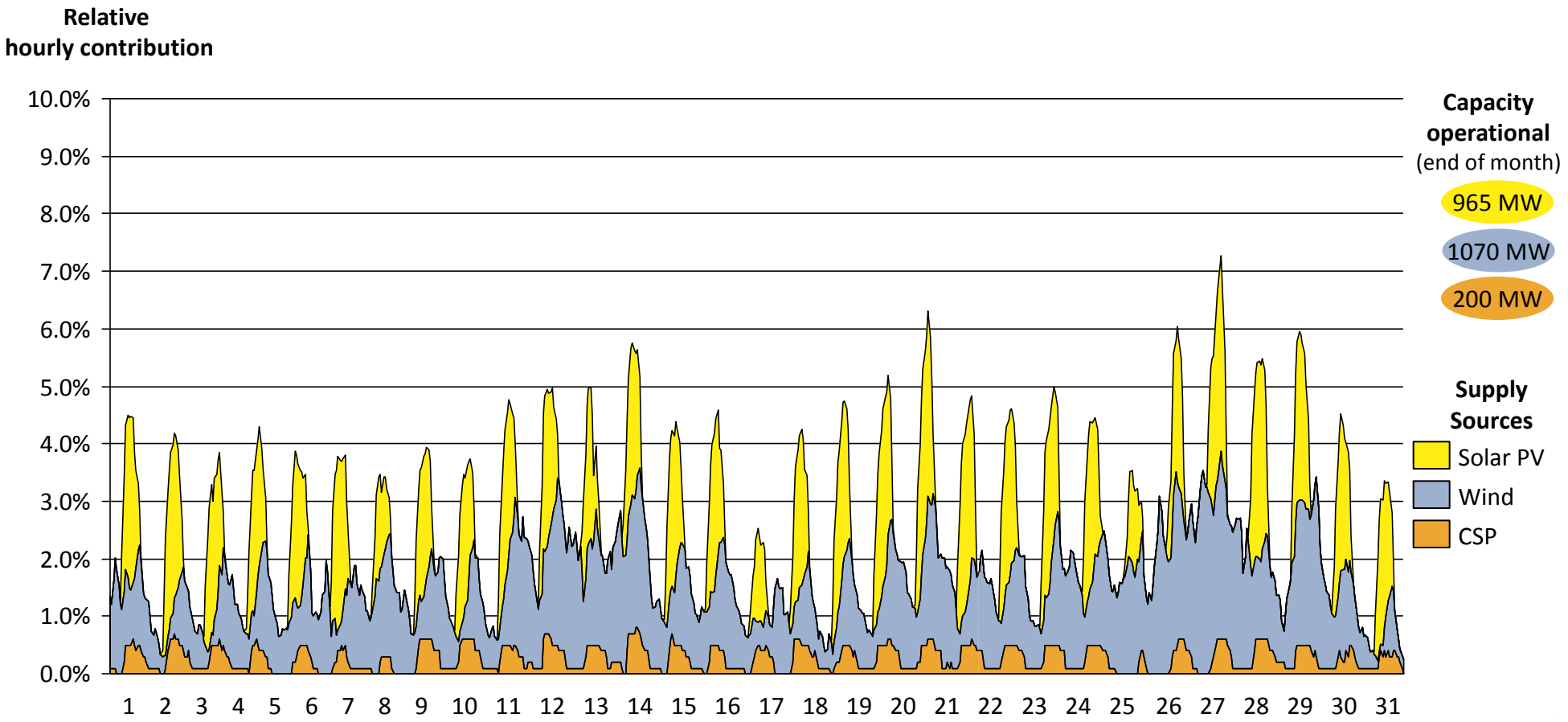


- Maximum solar PV relative contribution of 3.2% between 13h00 and 14h00 on 14 Feb 2016
- Maximum wind relative contribution of 2.8% between 04h00 and 05h00 on 7 Feb 2016
- Maximum CSP relative contribution of 0.7% between 15h00 and 16h00 on 28 Feb 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.2-7.3% in Mar 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for March 2016

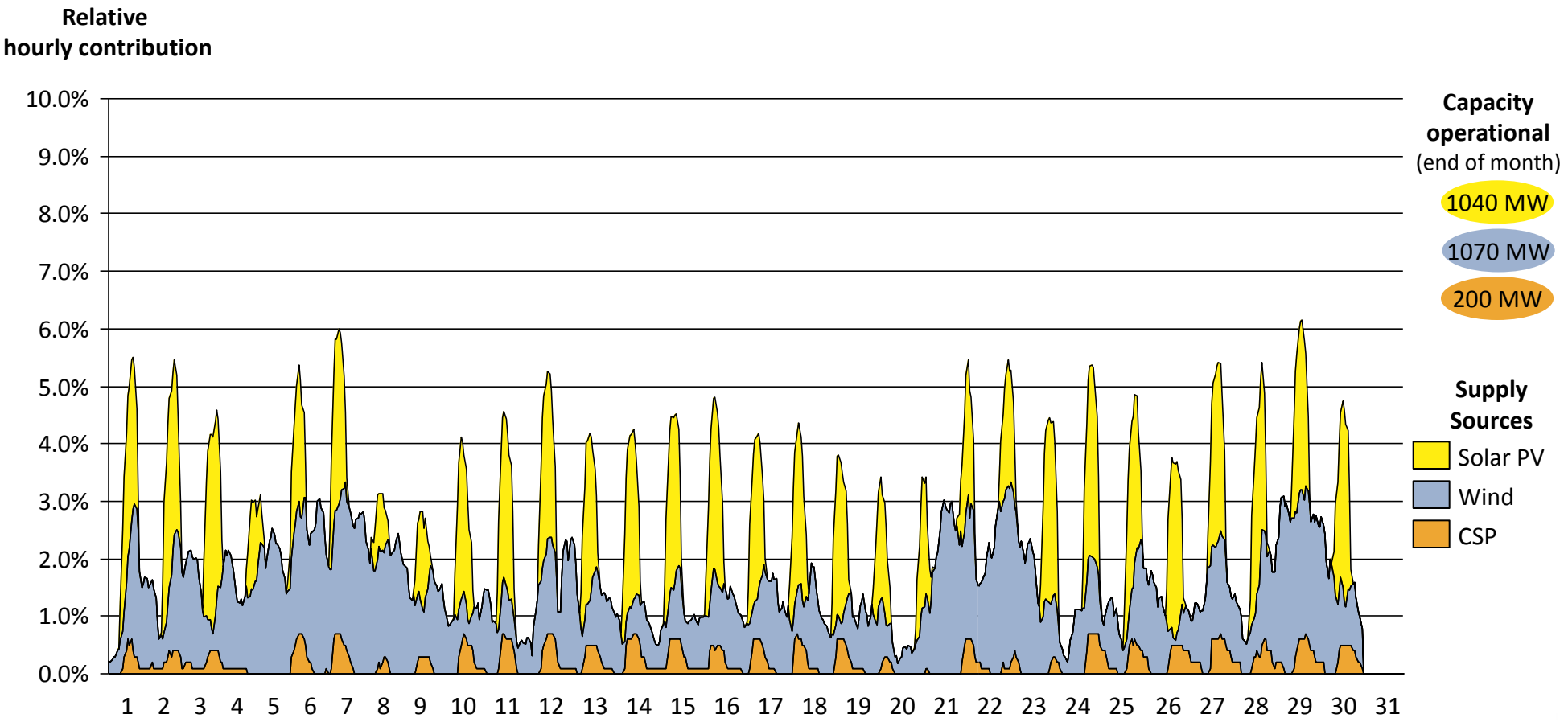


- Maximum solar PV relative contribution of 3.4% between 12h00 and 13h00 on 28 Mar 2016
- Maximum wind relative contribution of 3.5% between 04h00 and 05h00 on 27 Mar 2016
- Maximum CSP relative contribution of 0.8% between 15h00 and 16h00 on 13 Mar 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.2-6.2% in Apr 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for April 2016

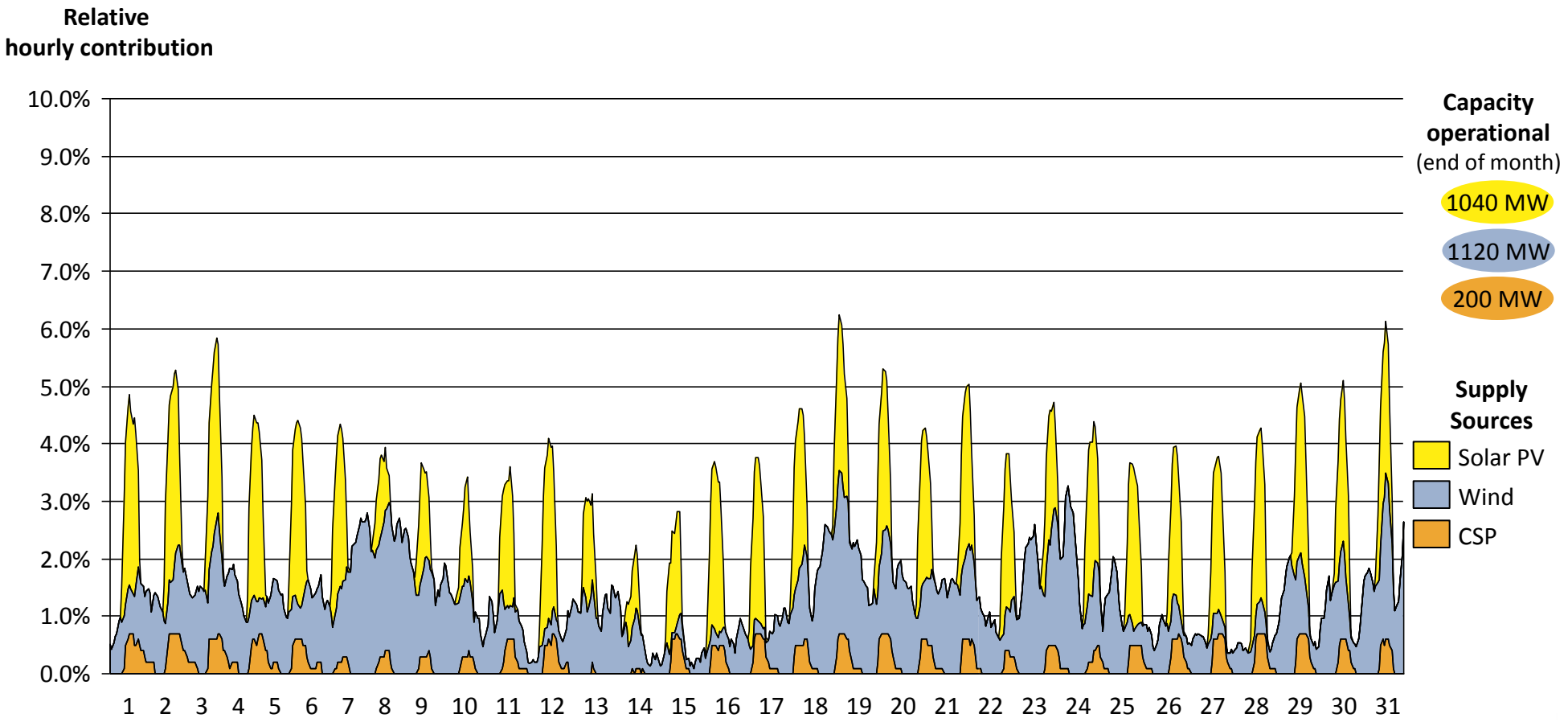


- Maximum solar PV relative contribution of 3.4% between 12h00 and 13h00 on 3 Apr 2016
- Maximum wind relative contribution of 3.2% between 12h00 and 13h00 on 22 Apr 2016
- Maximum CSP relative contribution of 0.7% between 14h00 and 15h00 on 24 Apr 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-6.1% in May 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for May 2016

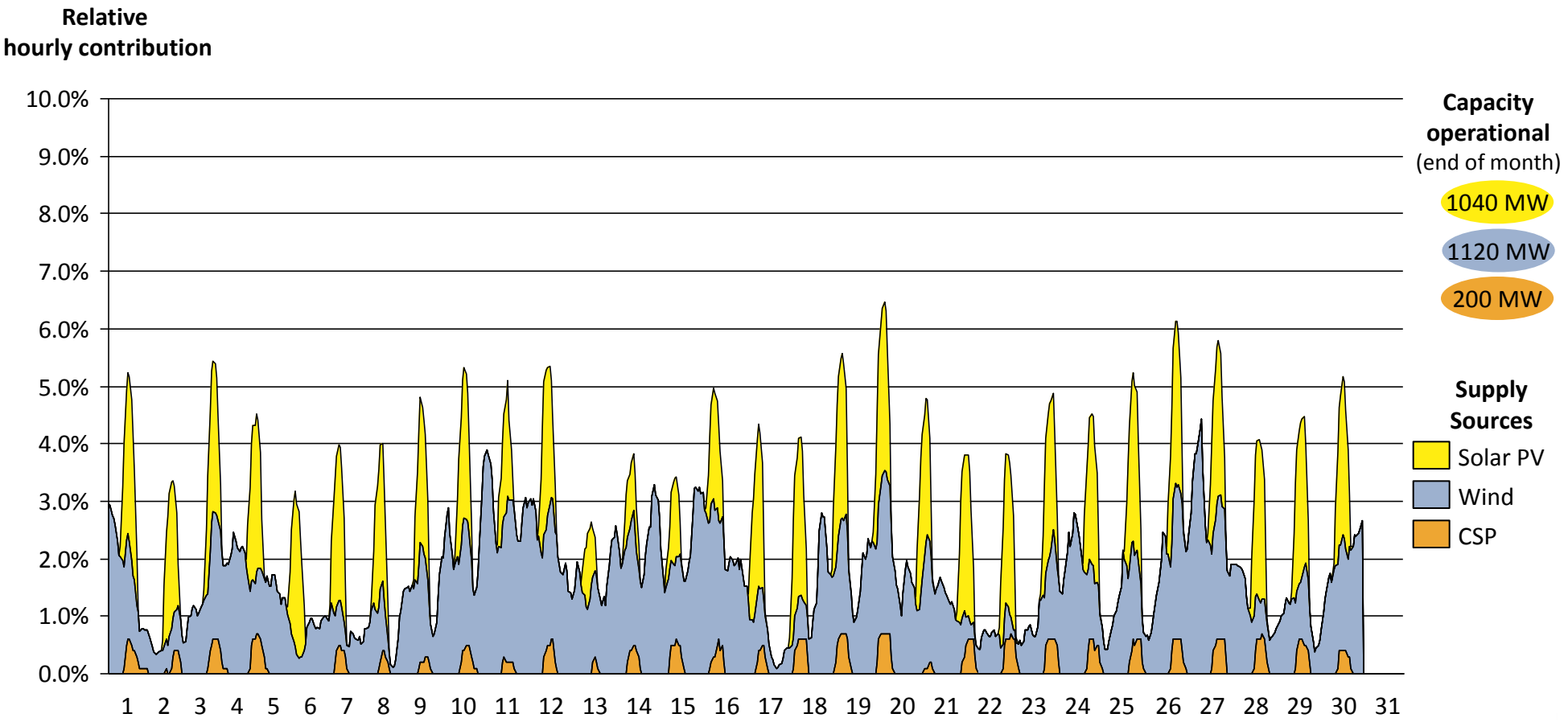


- Maximum solar PV relative contribution of 3.4% between 12h00 and 13h00 on 2 May 2016
- Maximum wind relative contribution of 3.2% between 22h00 and 23h00 on 23 May 2016
- Maximum CSP relative contribution of 0.7% between 14h00 and 15h00 on 29 May 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-5.9% in Jun 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for June 2016

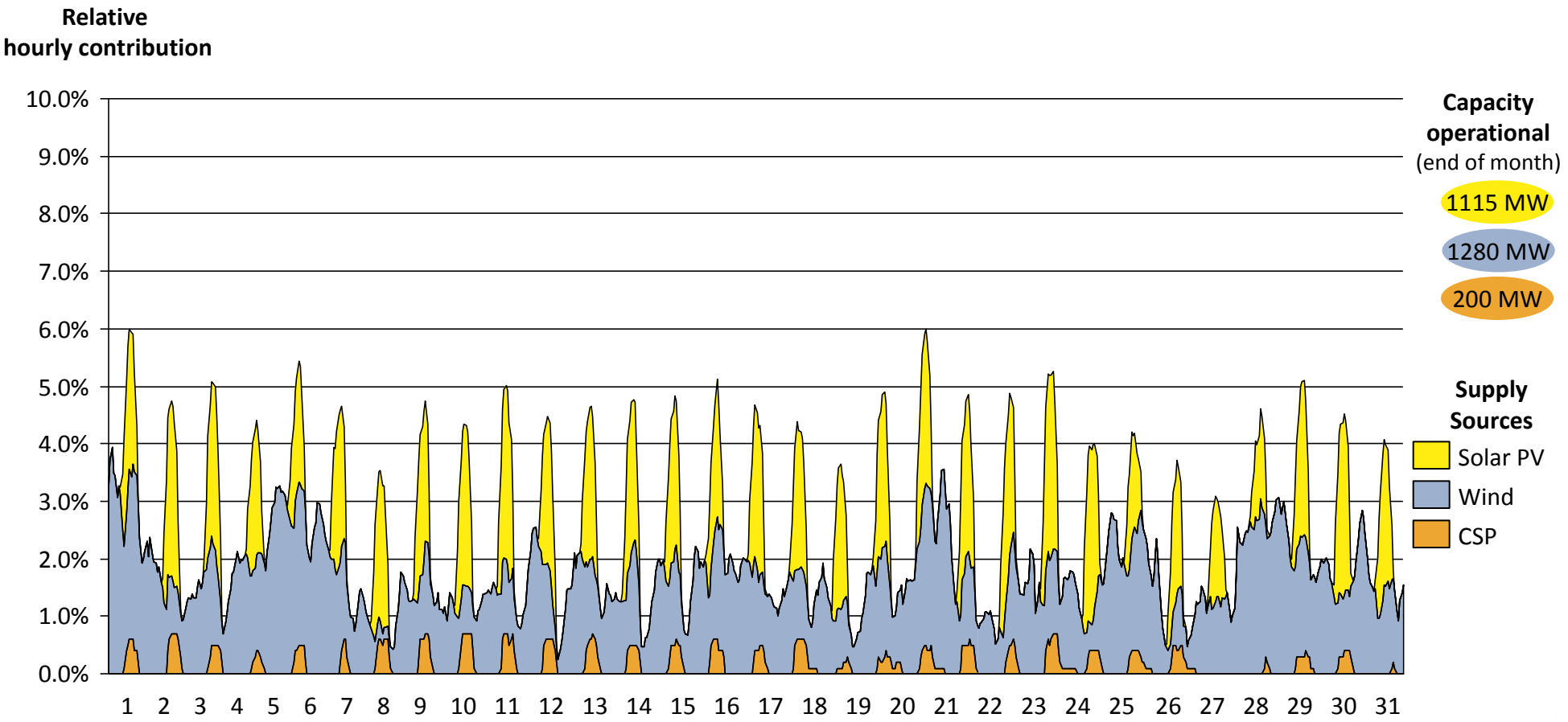


- Maximum solar PV relative contribution of 3.0% between 13h00 and 14h00 on 25 Jun 2016
- Maximum wind relative contribution of 4.4% between 03h00 and 04h00 on 27 Jun 2016
- Maximum CSP relative contribution of 0.7% between 14h00 and 15h00 on 19 Jun 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-6.0% in Jul 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for July 2016

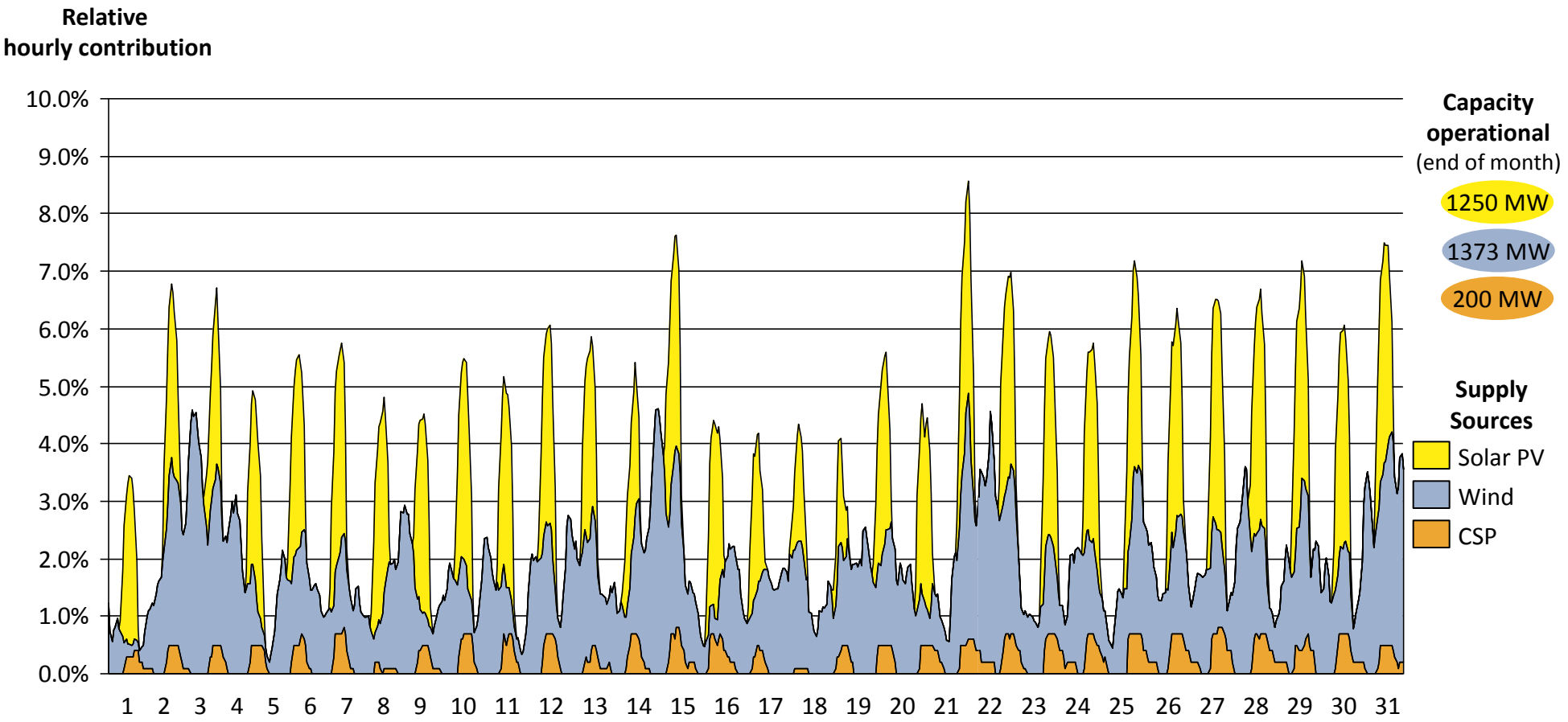


- Maximum solar PV relative contribution of 3.2% between 12h00 and 13h00 on 23 Jul 2016
- Maximum wind relative contribution of 3.9% between 02h00 and 03h00 on 1 Jul 2016
- Maximum CSP relative contribution of 0.7% between 15h00 and 16h00 on 23 Jul 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-8.5% in Aug 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for August 2016

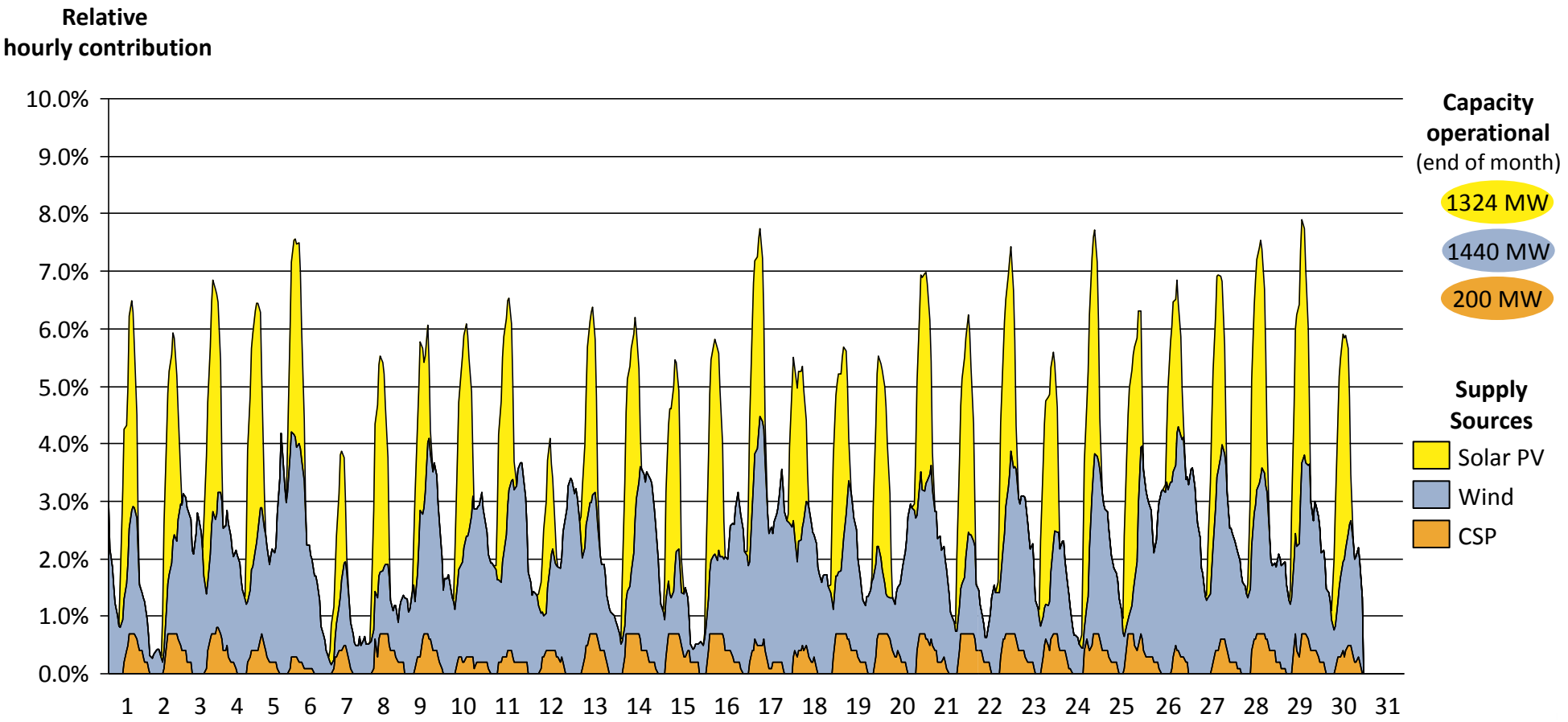


- Maximum solar PV relative contribution of 4.0% between 12h00 and 13h00 on 27 Aug 2016
- Maximum wind relative contribution of 4.6% between 03h00 and 04h00 on 14 Aug 2016
- Maximum CSP relative contribution of 0.8% between 15h00 and 16h00 on 27 Aug 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.3-7.9% in Sep 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for September 2016

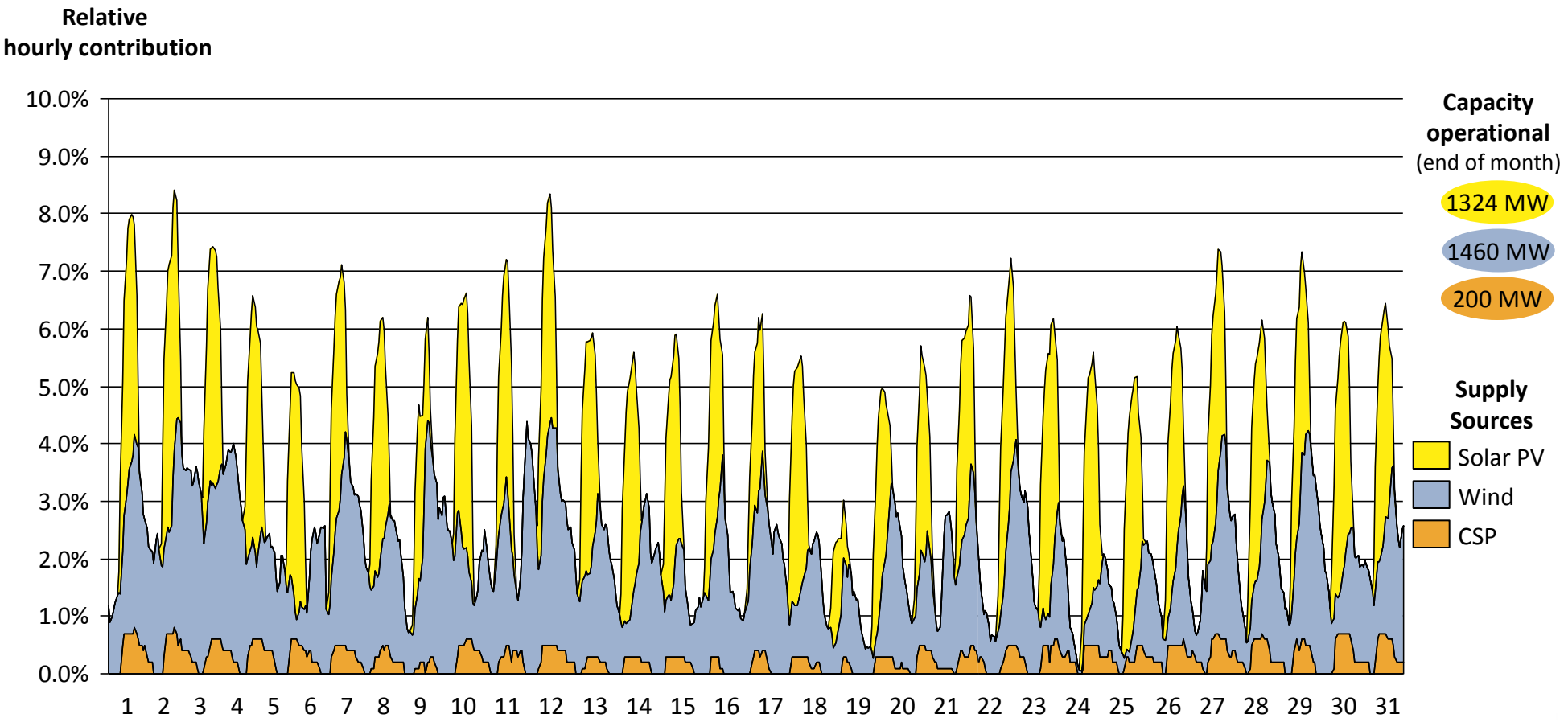


- Maximum solar PV relative contribution of 4.3% between 12h00 and 13h00 on 29 Sep 2016
- Maximum wind relative contribution of 4.2% between 03h00 and 04h00 on 5 Sep 2016
- Maximum CSP relative contribution of 0.8% between 15h00 and 16h00 on 3 Sep 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-8.4% in Oct 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for October 2016

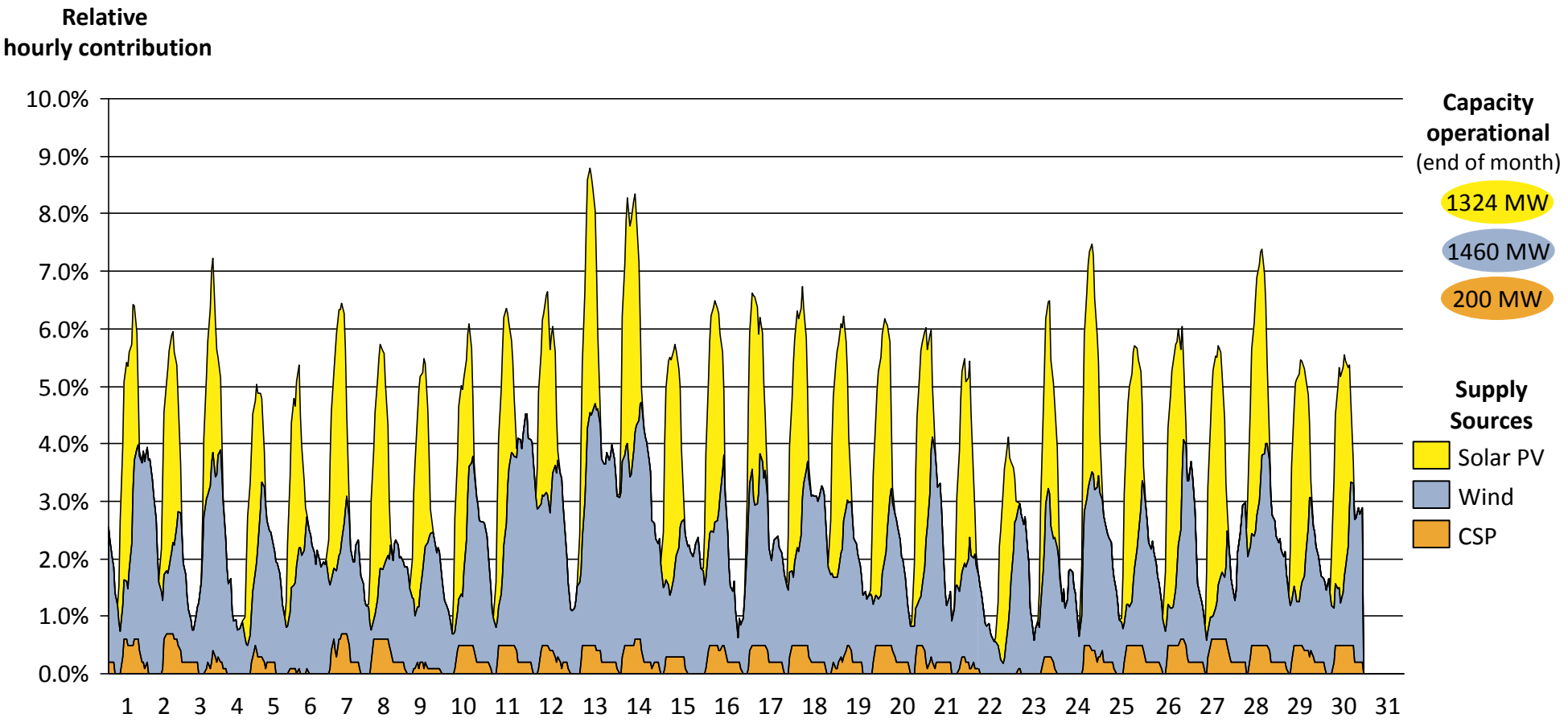


- Maximum solar PV relative contribution of 4.7% between 13h00 and 14h00 on 2 Oct 2016
- Maximum wind relative contribution of 4.4% between 00h00 and 01h00 on 11 Oct 2016
- Maximum CSP relative contribution of 0.8% between 14h00 and 15h00 on 2 Oct 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.6-8.8% in Nov 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for November 2016

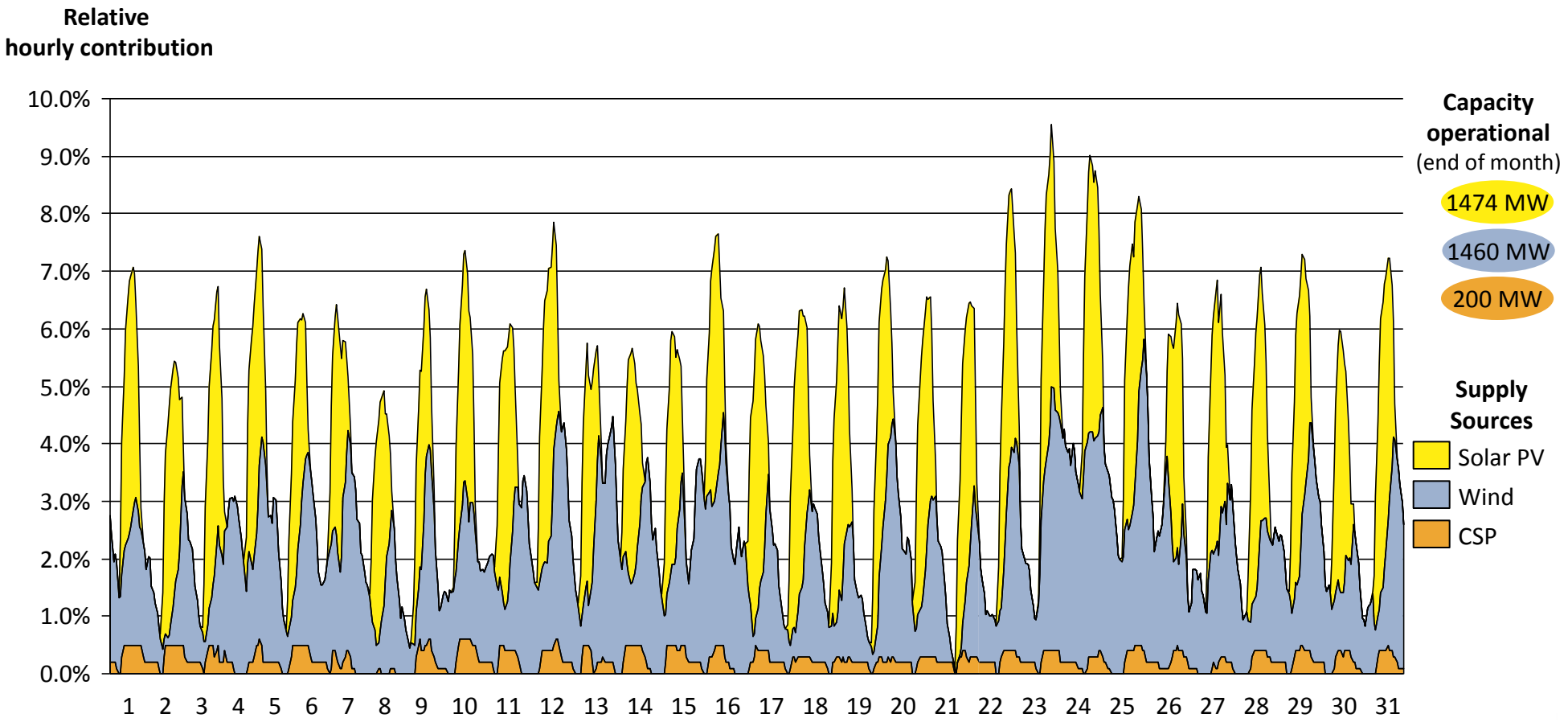


- Maximum solar PV relative contribution of 4.4% between 12h00 and 13h00 on 13 Nov 2016
- Maximum wind relative contribution of 4.3% between 18h00 and 19h00 on 13 Nov 2016
- Maximum CSP relative contribution of 0.7% between 14h00 and 15h00 on 6 Nov 2016

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Hourly solar PV, wind & CSP contribution of 0.1-9.6% in Dec 2016

Actual hourly relative solar PV/wind/CSP contribution as a % of total supply in RSA for December 2016

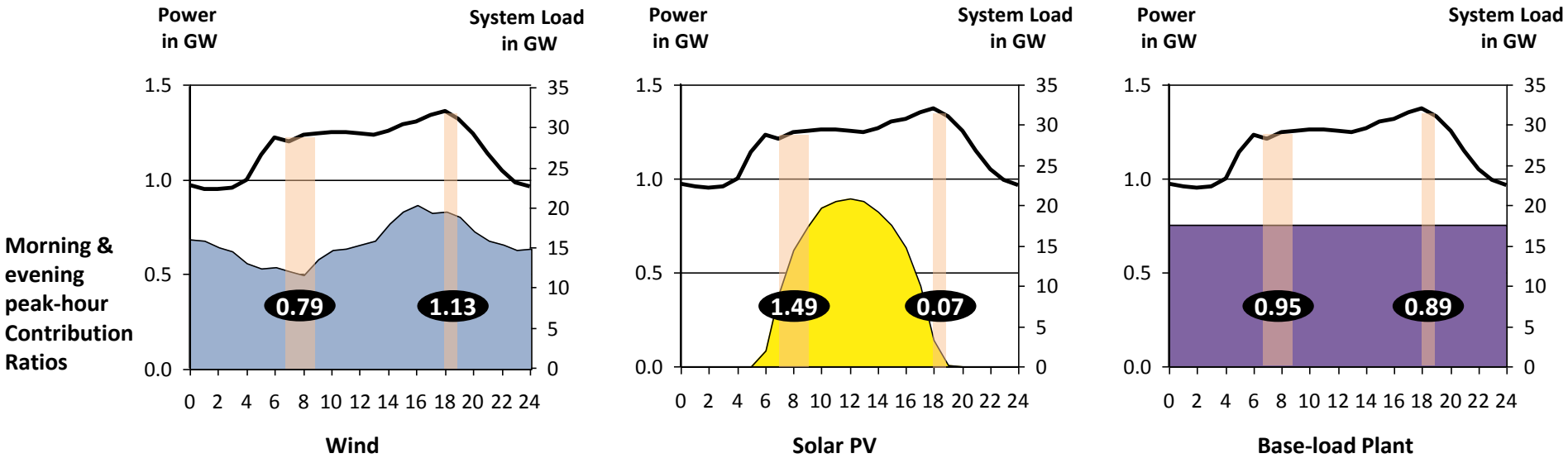


- Maximum solar PV relative contribution of 5.0% between 11h00 and 12h00 on 31 Dec 2016
- Maximum wind relative contribution of 5.4% between 18h00 and 19h00 on 25 Dec 2016
- Maximum CSP relative contribution of 0.6% between 14h00 and 15h00 on 9 Dec 2016

Sources: Eskom; DoE IPP Office; 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 2016) show that:

- Wind contributes 13% more energy during the evening peaks than it does during the other hours of the day
- Solar PV contributes 49% more energy in the morning peaks than it does during the other hours of the day

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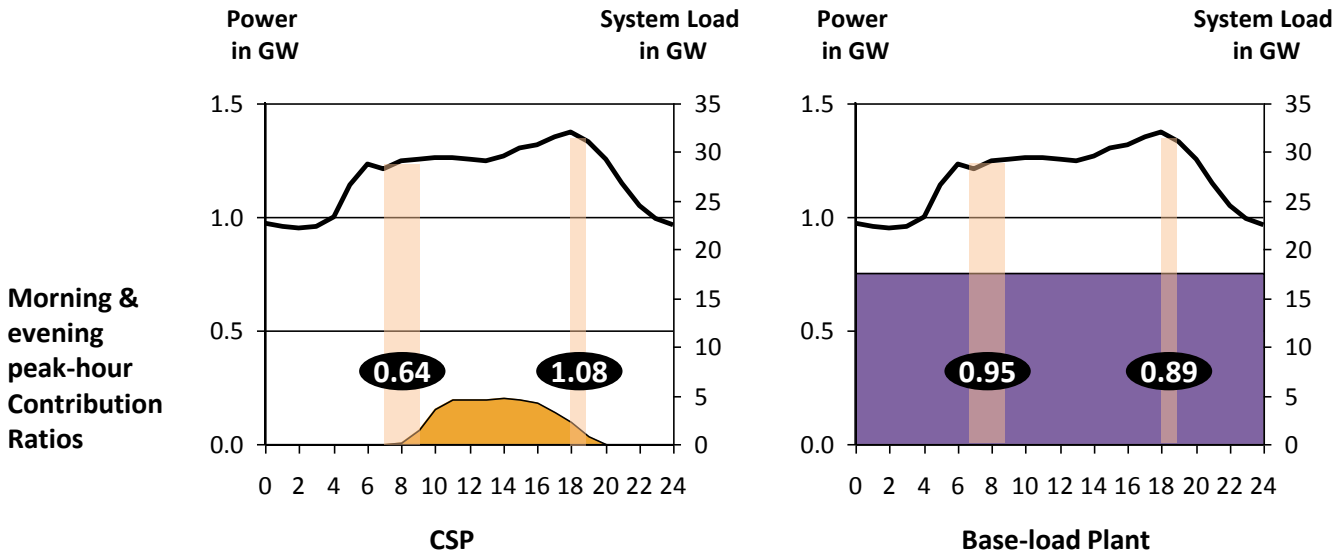
Notes: Morning and evening peak hours classified as per Eskom's 2016 Time of Use Tariff's
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

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



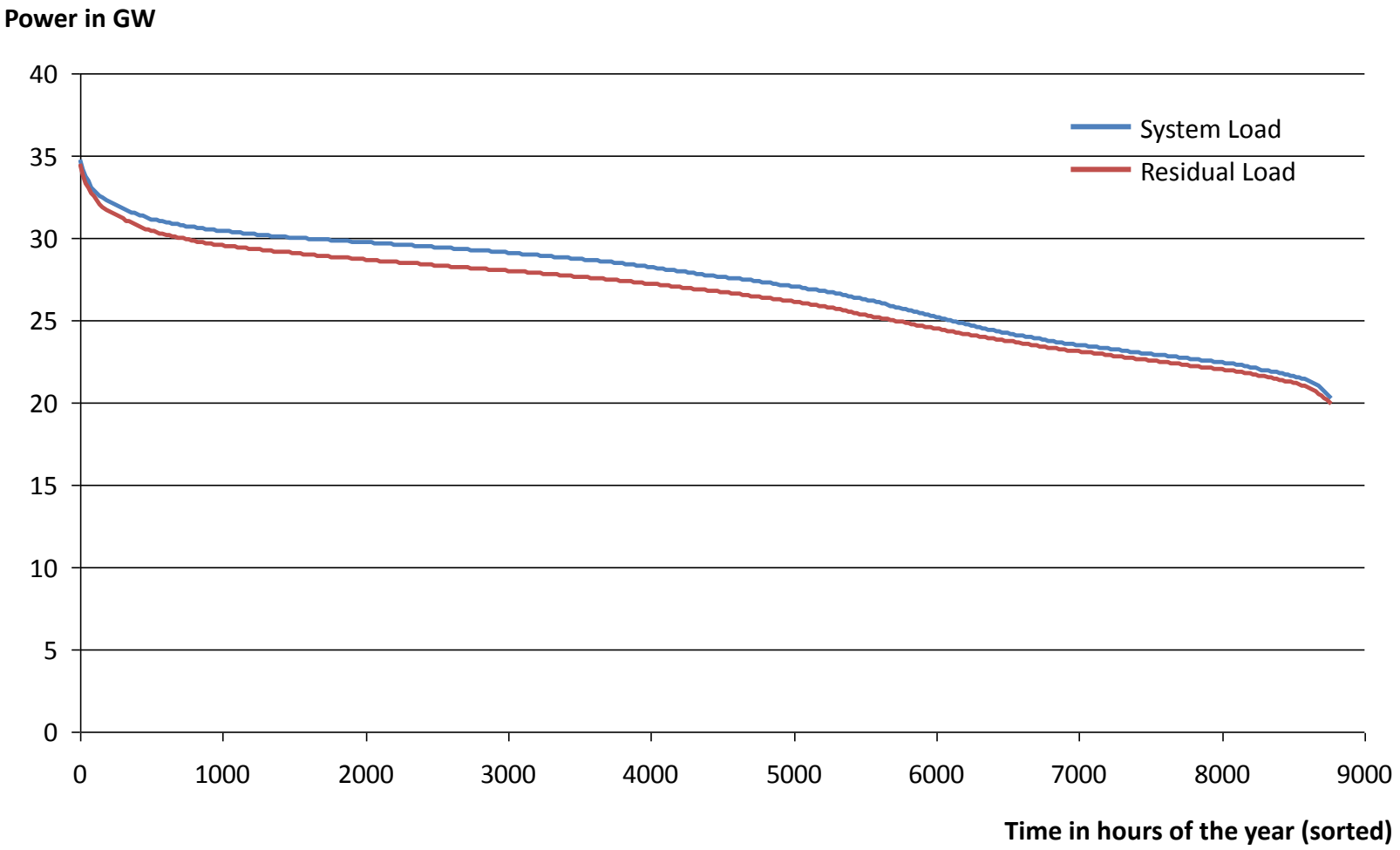
Peak-hour contribution ratio = relative energy contribution during peak / relative total energy contribution

CSP morning and evening peak-hour contribution ratios (for all hours from Jan-Dec 2016) show that:

- CSP contributes 8% more energy during the evening peaks than it does during the other hours of the day

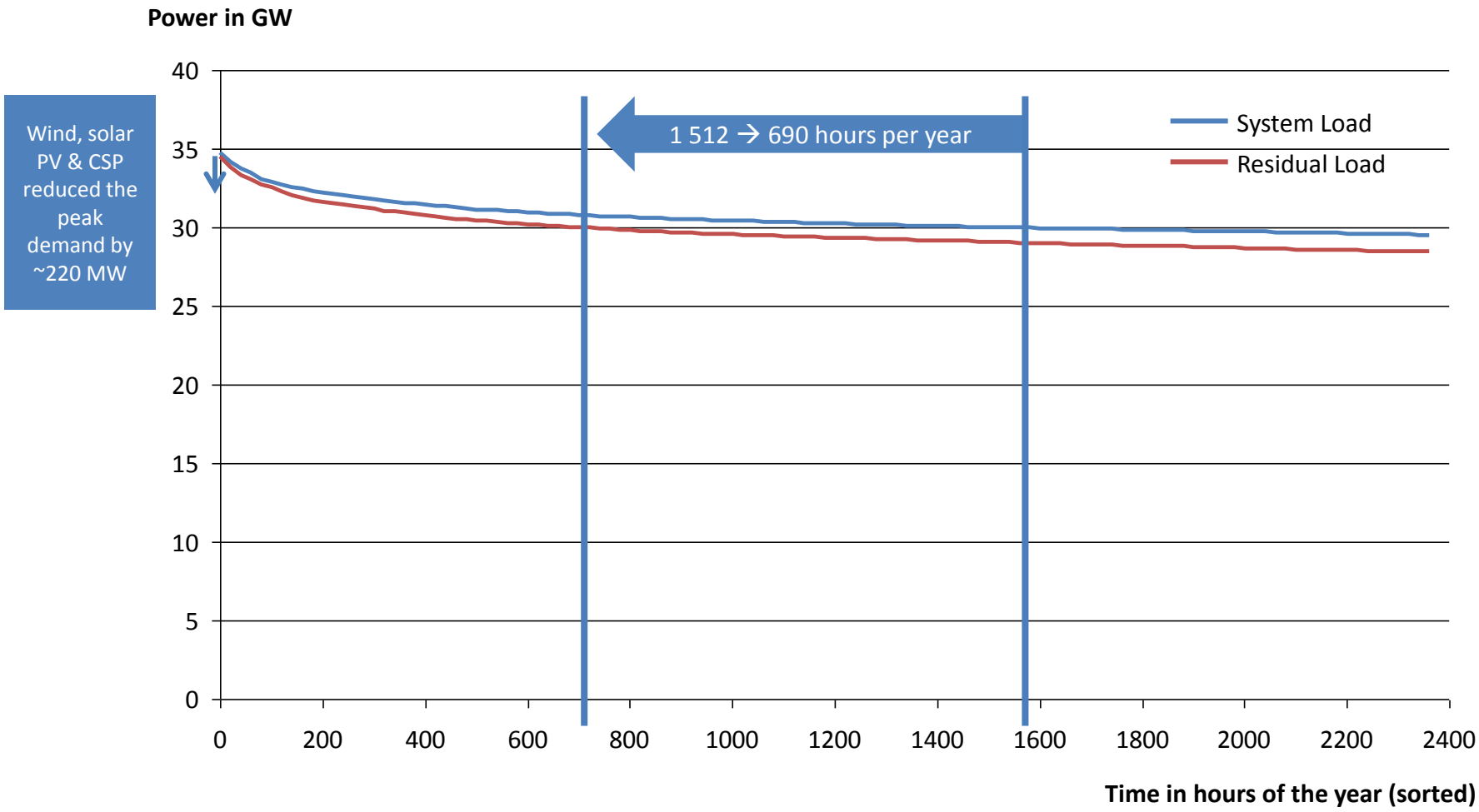
Notes: Morning and evening peak hours classified as per Eskom's 2016 Time of Use Tariff's
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Jan - Dec 2016 system and residual load duration curves



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

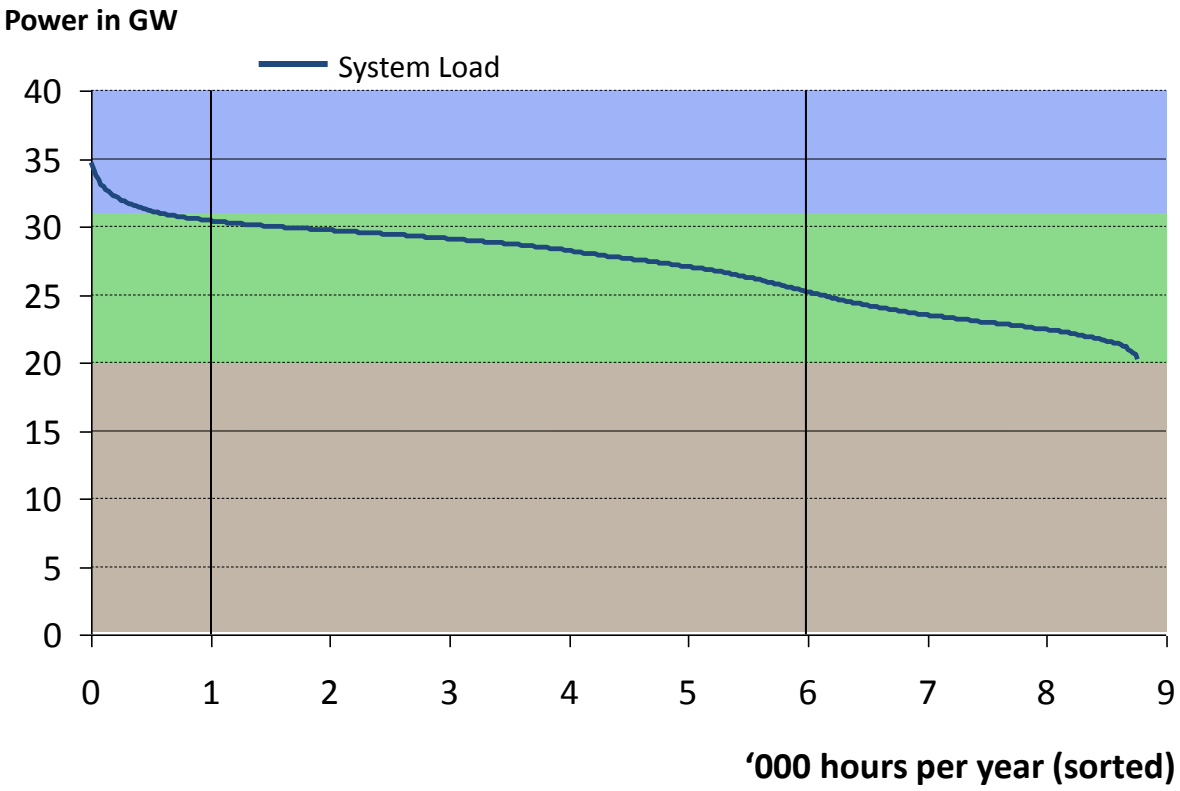
From Jan-Dec 2016, wind & solar PV reduced the number of hours with more than 30 000 MW total load from 1 512 to 690 (~820 hours less)



Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

The system load from Jan to Dec 2016 had a peak demand of 4.3 GW, mid-merit of 5.2 GW, and base-load demand of 25.2 GW

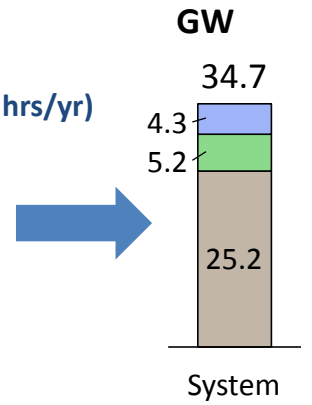
Load Duration Curve for Jan to Dec 2016 as per actual data



Peak-load
(< 1 000 hrs/yr)

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

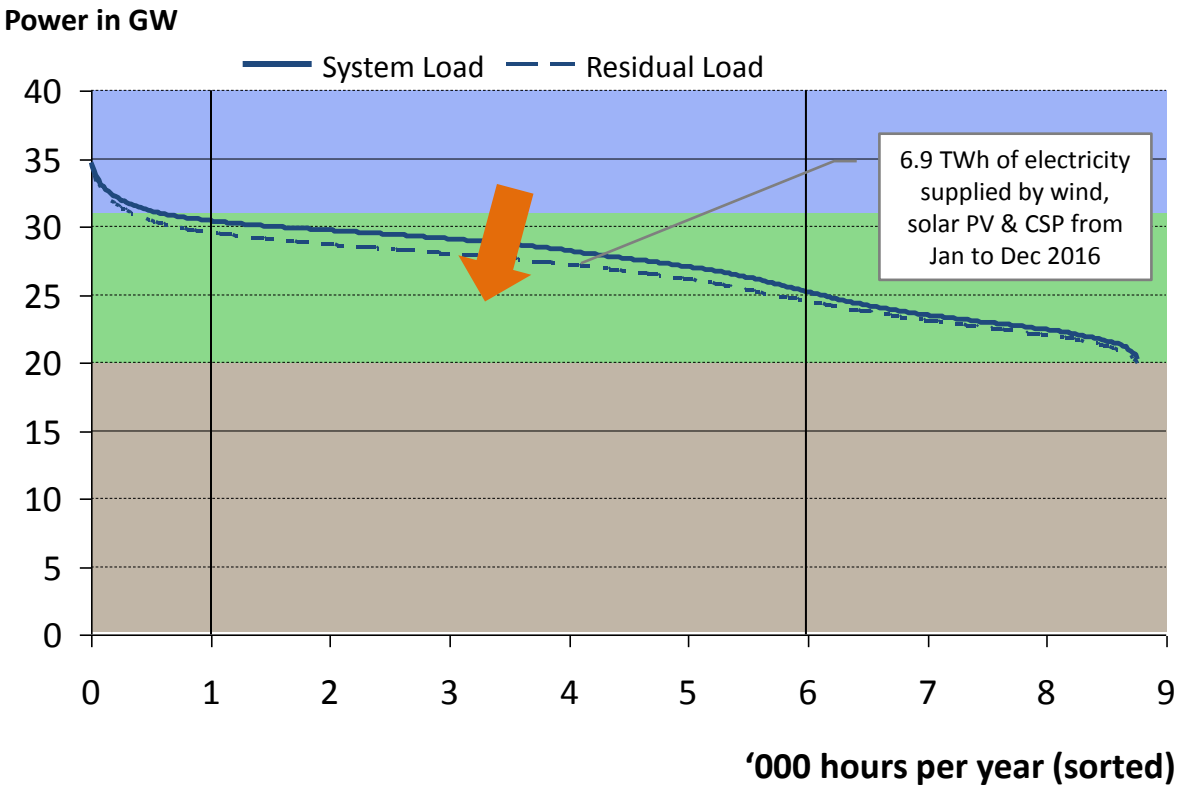
Base-load
(> 6 000 hrs/yr)



Sources: CSIR Energy Centre analysis

Wind/PV/CSP changed shape of residual load: new peak-demand goes up to 5.0 GW, mid-merit & base-load demand go down to 5.1/24.5 GW

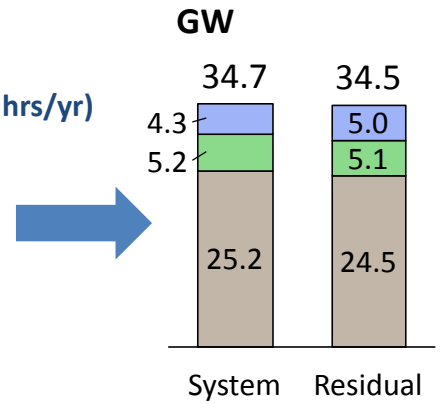
Load Duration Curve for Jan to Dec 2016 as per actual data



Peak-load
(< 1 000 hrs/yr)

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

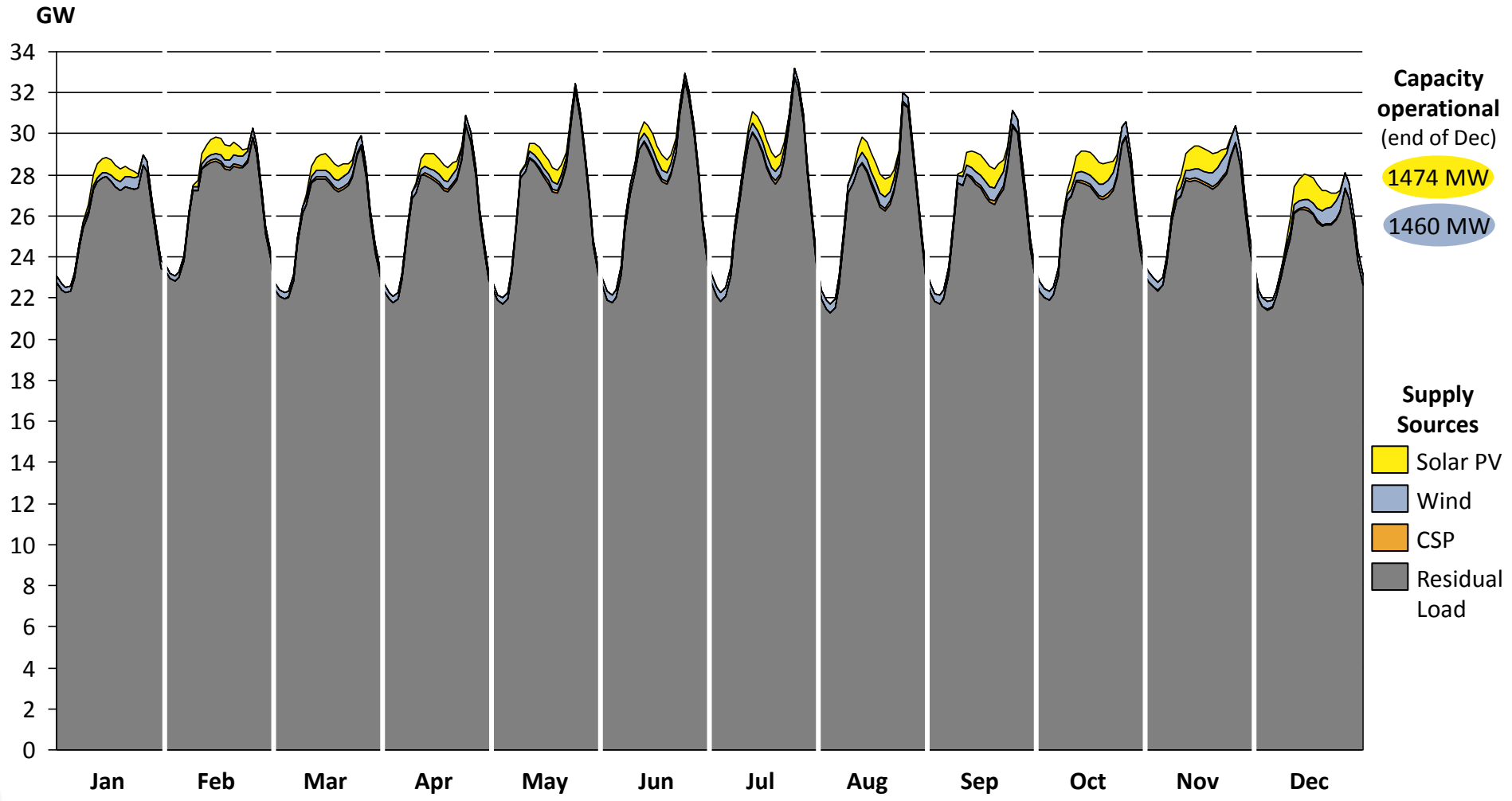
Base-load
(> 6 000 hrs/yr)



Sources: CSIR Energy Centre analysis

Diurnal Courses

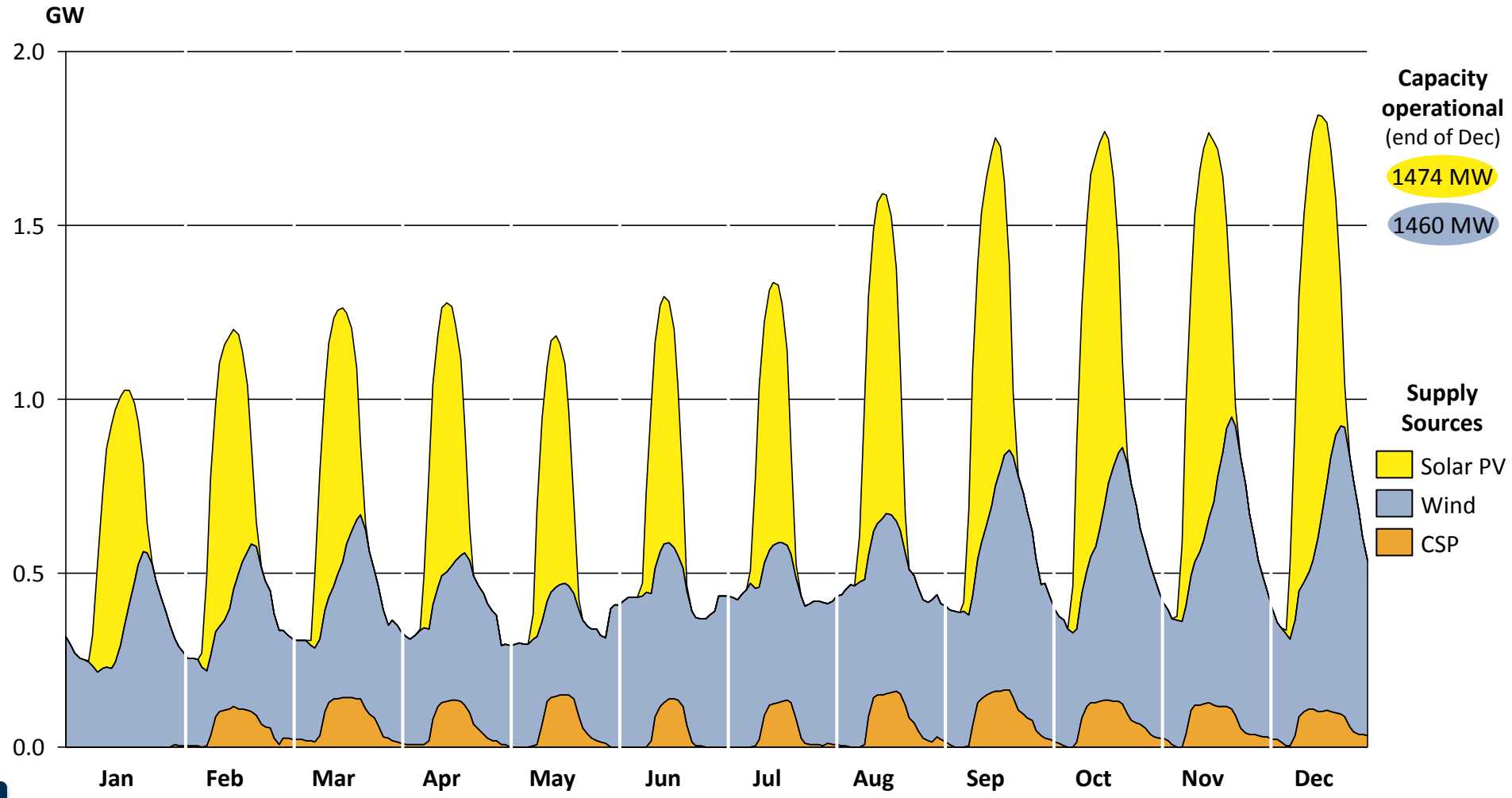
Actual monthly average diurnal courses of the total power supply in RSA for the months from Jan-Dec 2016



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

Diurnal Courses

Actual monthly average diurnal courses of wind and solar PV in RSA for the months from Jan-Dec 2016

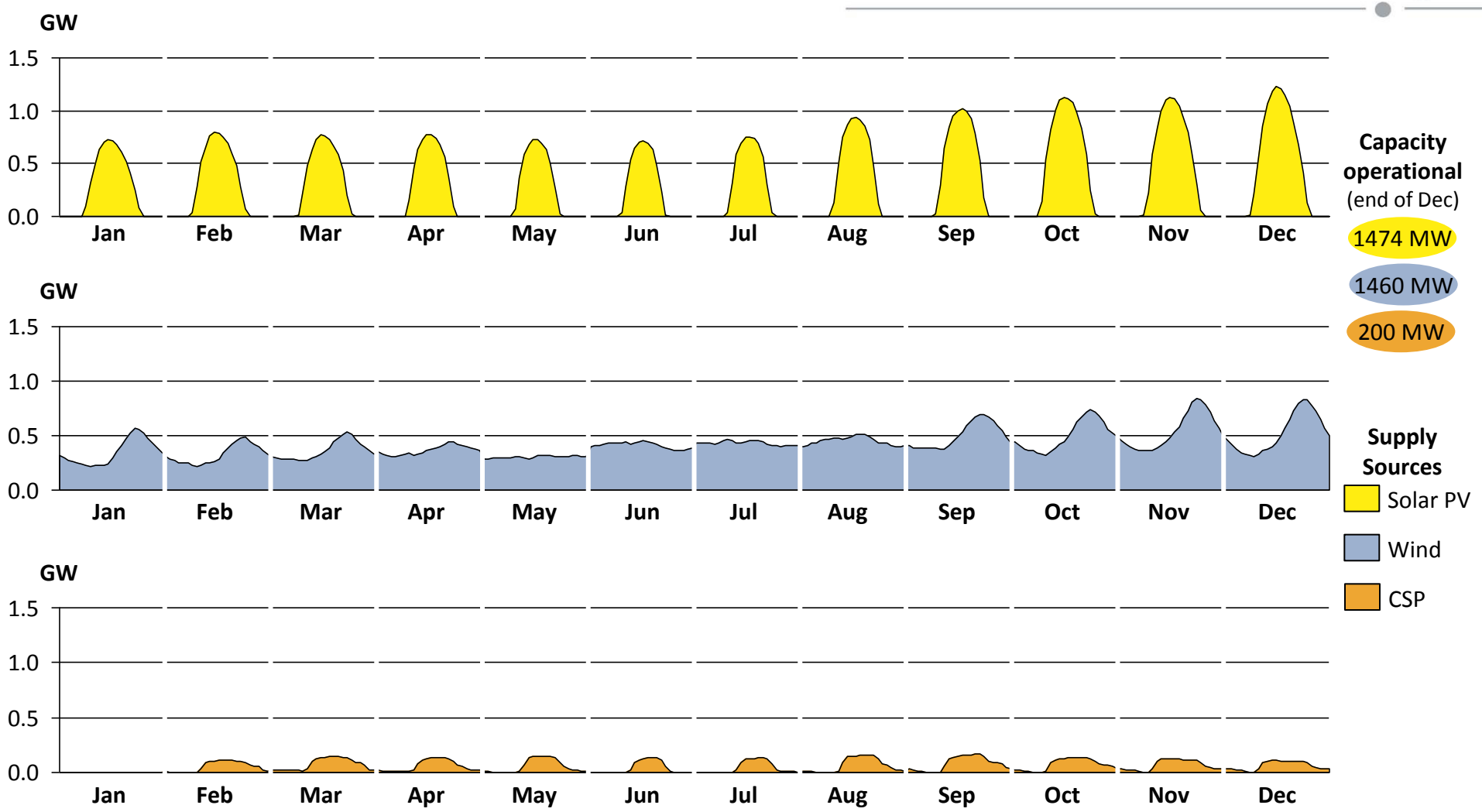


Note: Design as per Fraunhofer ISE

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

Diurnal Courses

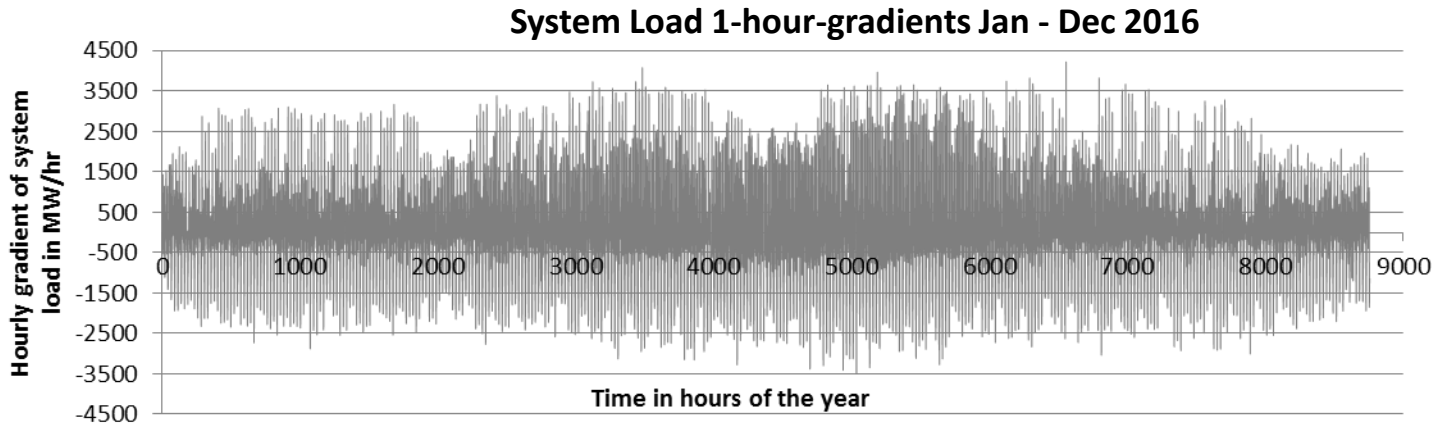
Actual monthly average diurnal courses of wind and solar PV in RSA for the months from Jan-Dec 2016



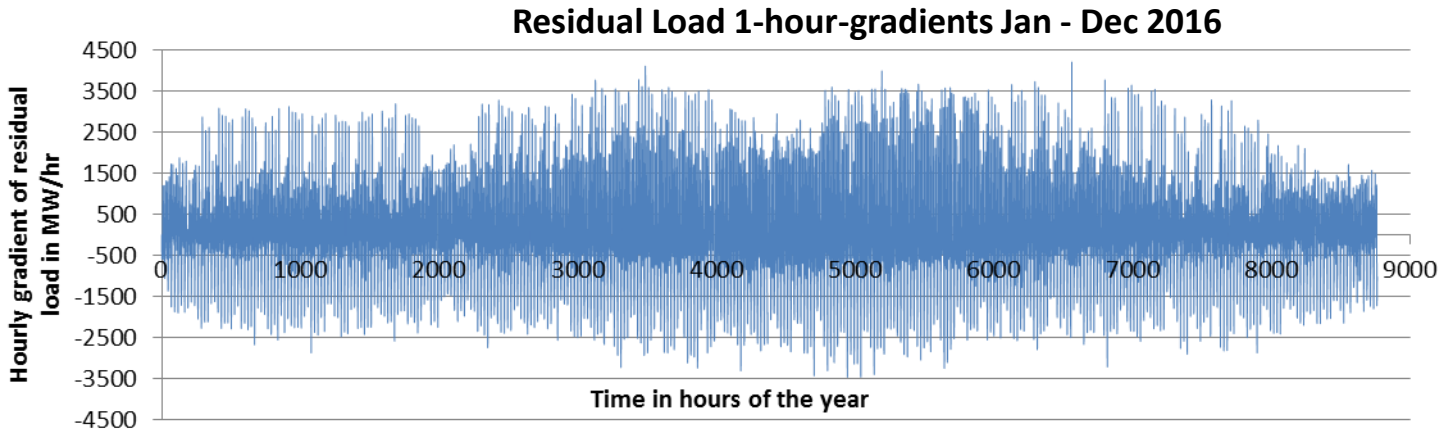
Note: Design as per Fraunhofer ISE

Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

1-hour gradients minimally affected by 3.1 GW of wind, solar PV & CSP



- Max gradient of 4 215 MW on 30 September 2016 between 05h00 and 06h00
- Min gradient of -3 487 MW on 28 July 2016 between 21h00 and 22h00



- Max gradient of 4 208 MW on 30 September 2016 between 05h00 and 06h00
- Min gradient of -3 453 MW on 24 July 2016 between 20h00 and 21h00

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

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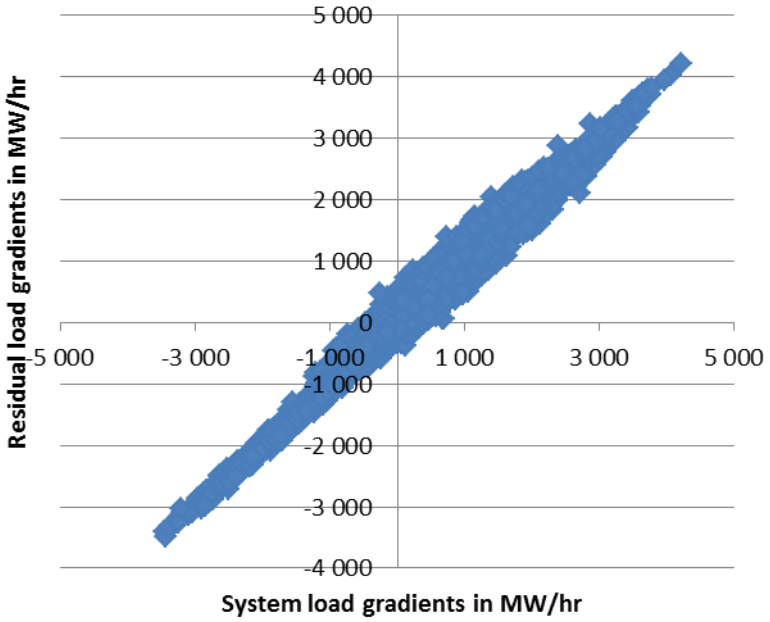
Notes: System and Residual load excludes pumping load for all data points throughout the year. $Load\ gradient_t = load_t - load_{t-1}$

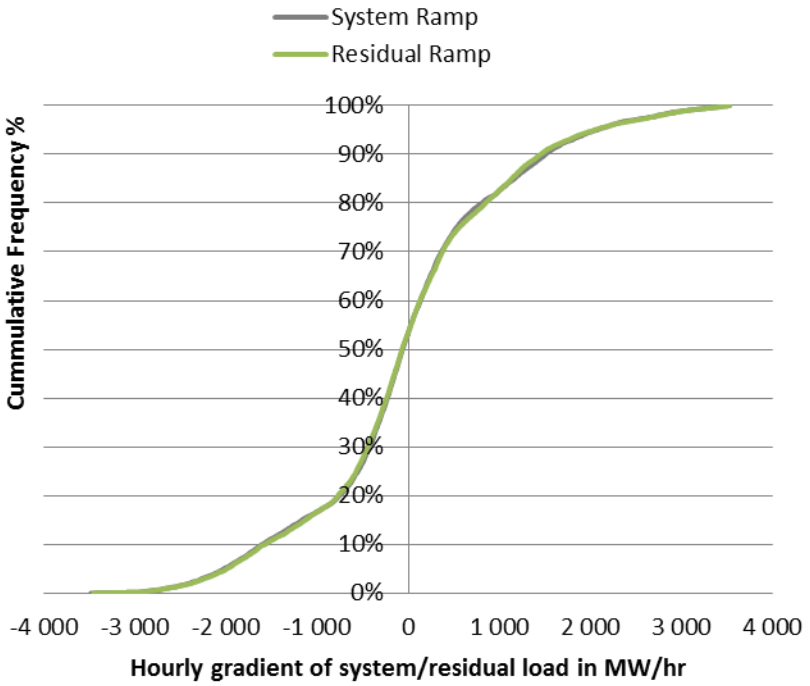
Sources: Eskom; CSIR Energy Centre analysis

1-hour gradients did not increase due to 3.1 GW of wind, solar PV & CSP

System load 1-hour gradients vs. residual load 1-hour gradients for all hours from Jan – Dec 2016

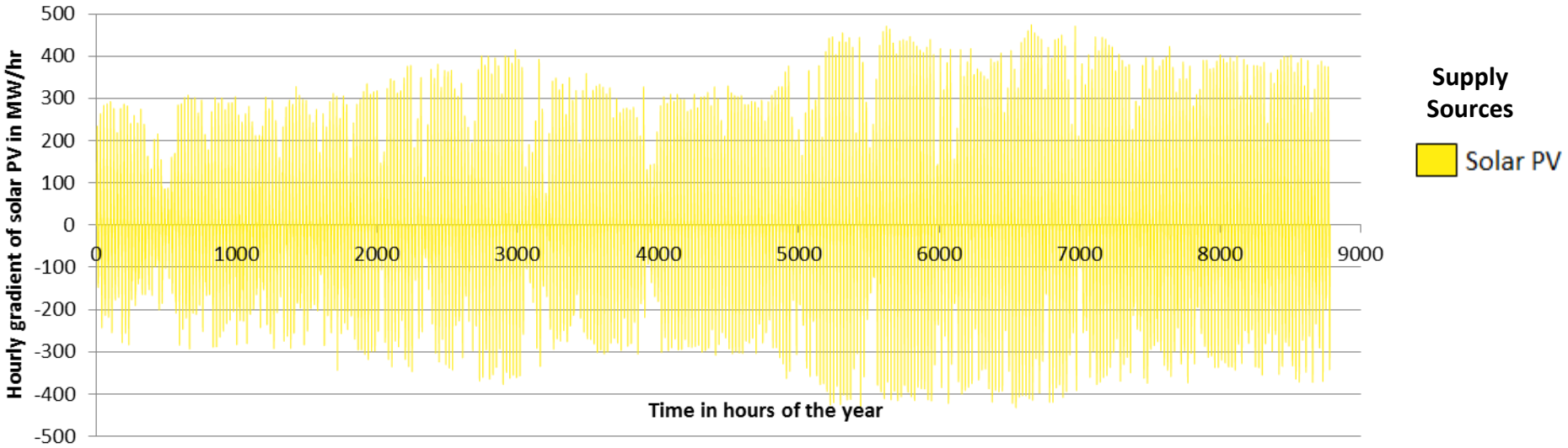


Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2016



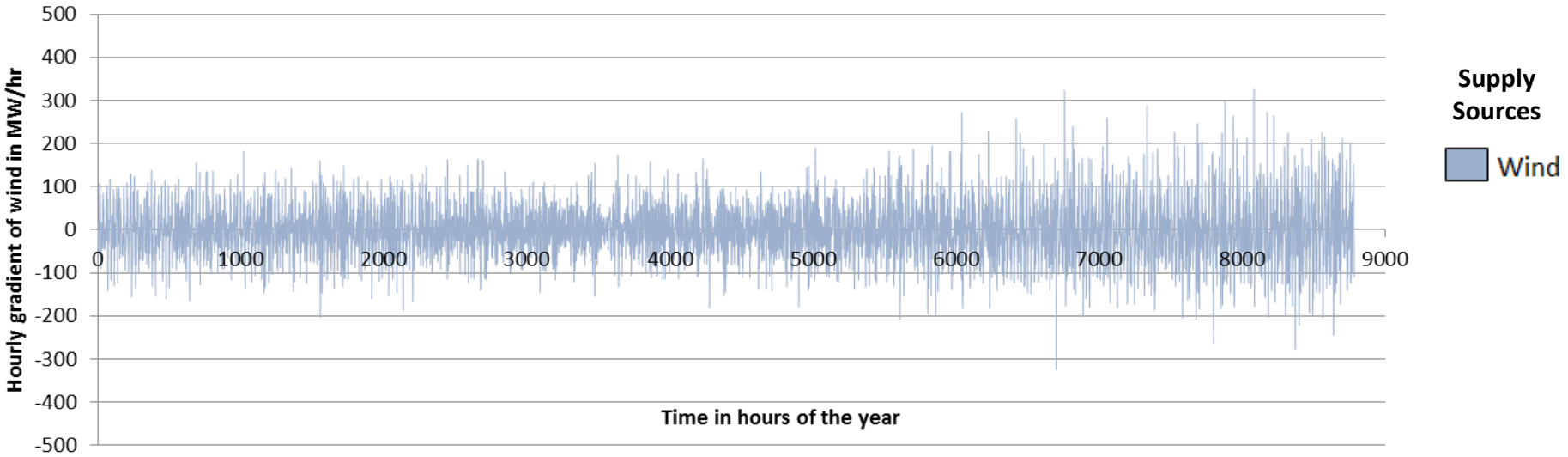
Notes: System and Residual load excludes pumping load for all data points throughout the year
Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2016 1-hour gradients of solar PV supply



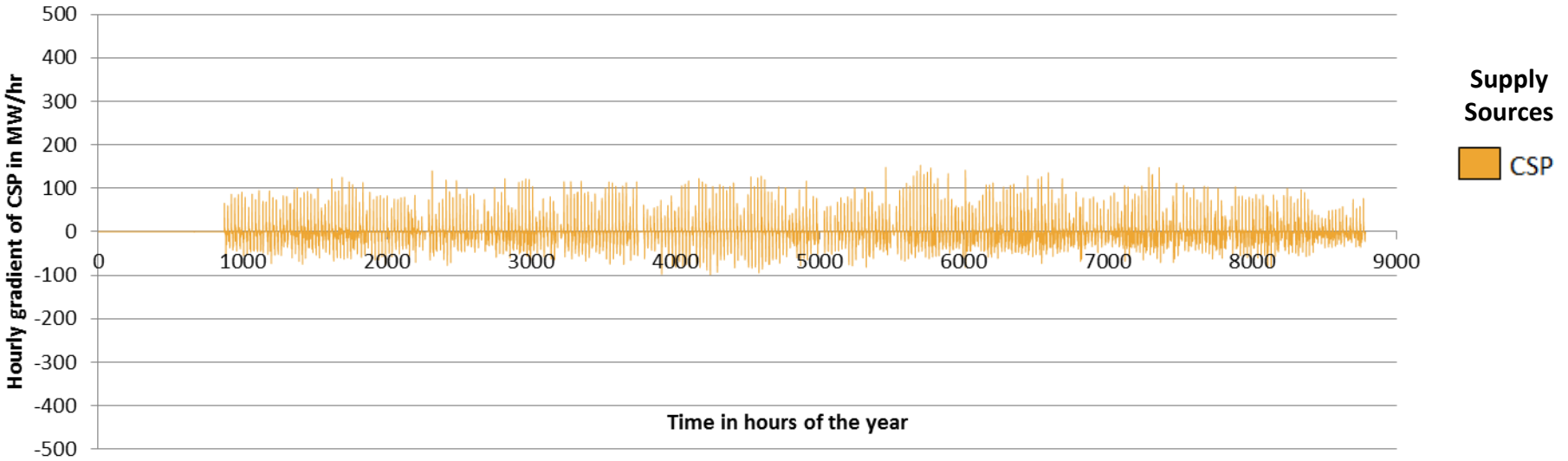
Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2016 1-hour gradients of wind supply



Sources: Eskom; CSIR Energy Centre analysis

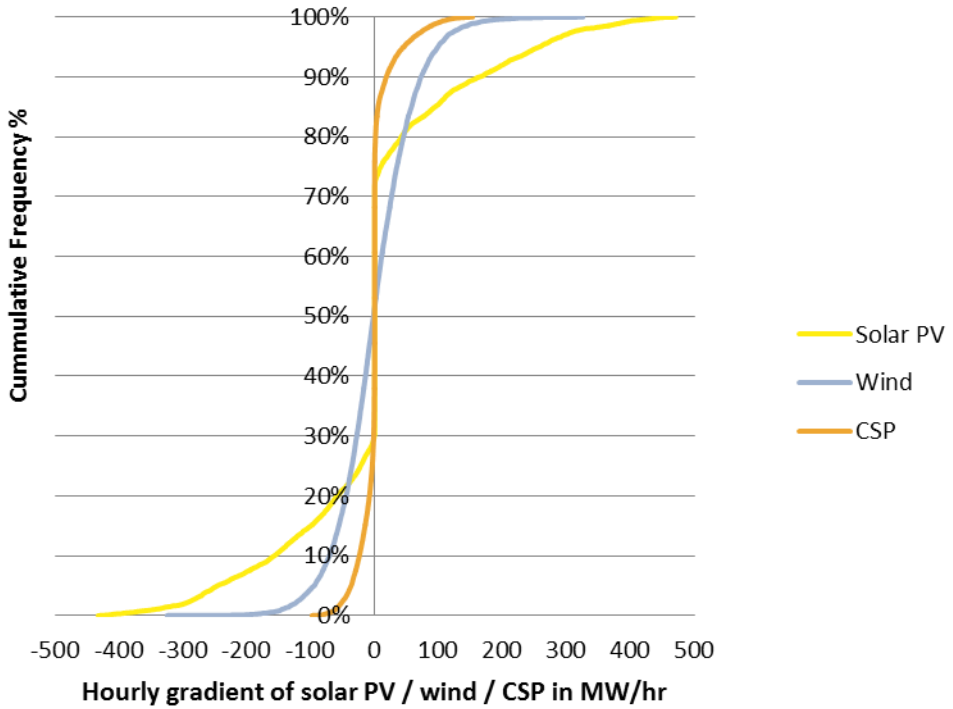
Jan - Dec 2016 1-hour gradients of CSP supply



Sources: Eskom; CSIR Energy Centre analysis

Jan - Dec 2016 wind, solar PV and CSP frequency distribution of 1-hour gradients

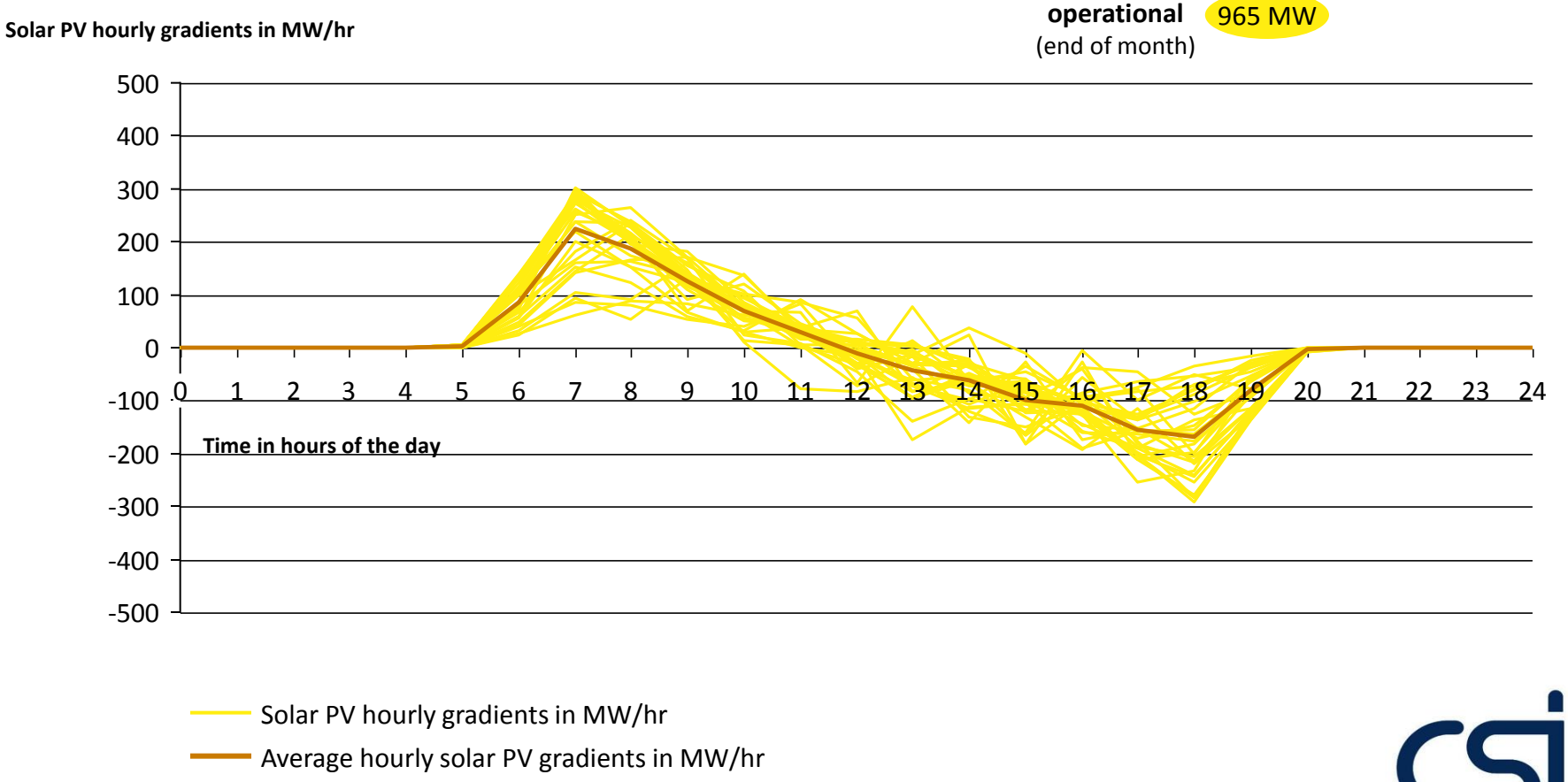
- Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2016



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in January 2016

Capacity operational (end of month) 965 MW



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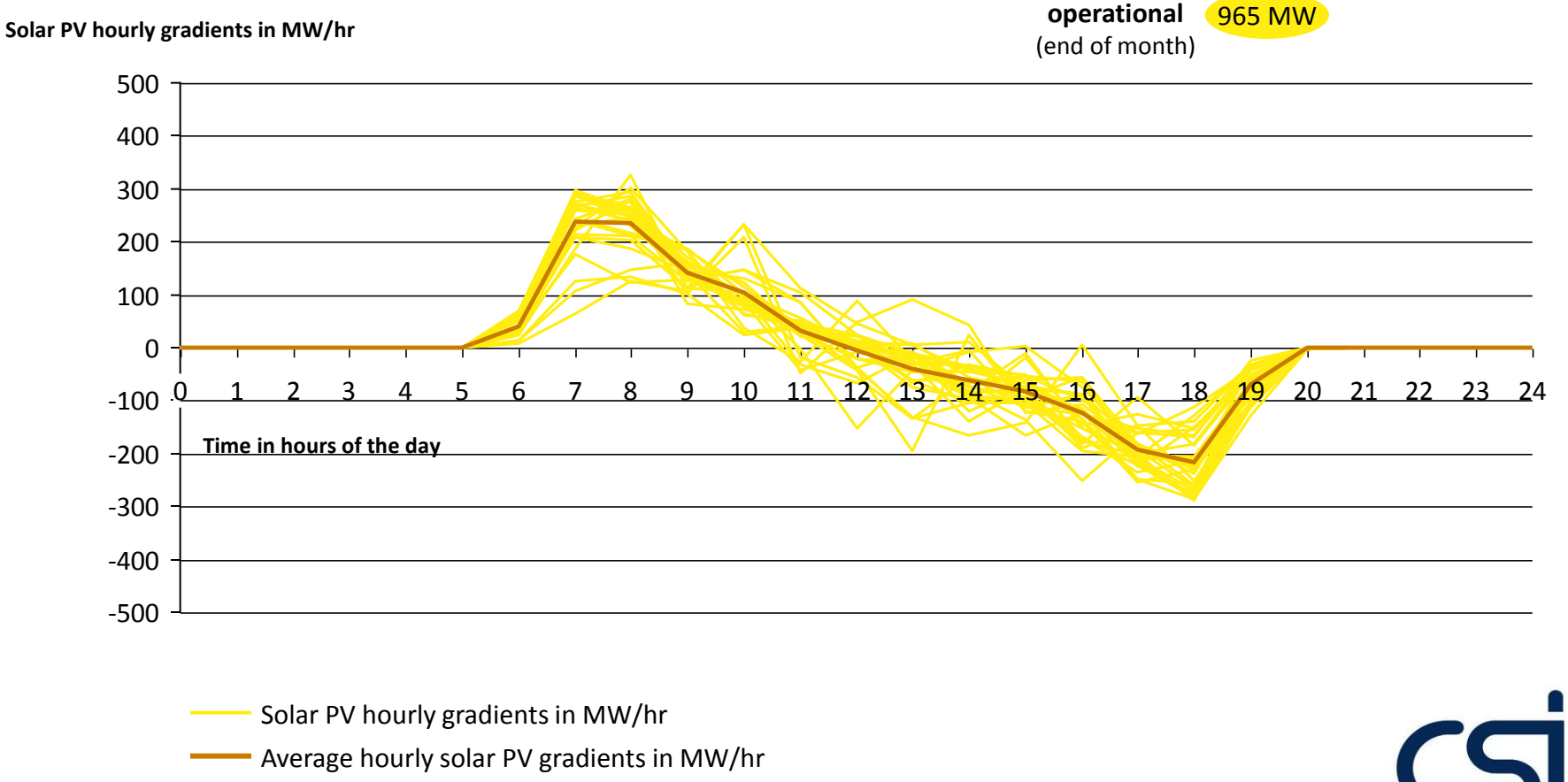
Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in February 2016

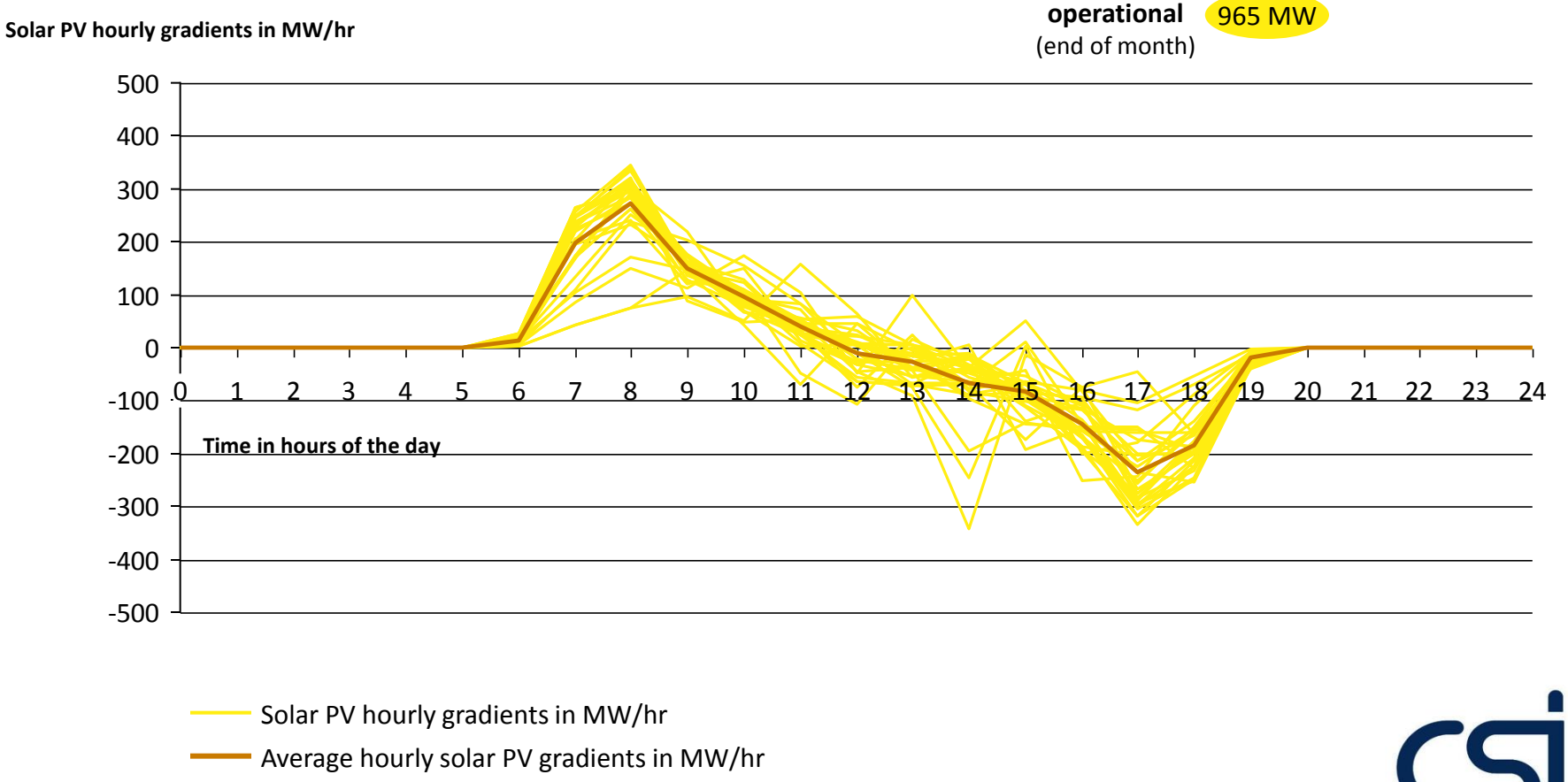
Capacity operational (end of month) 965 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in March 2016

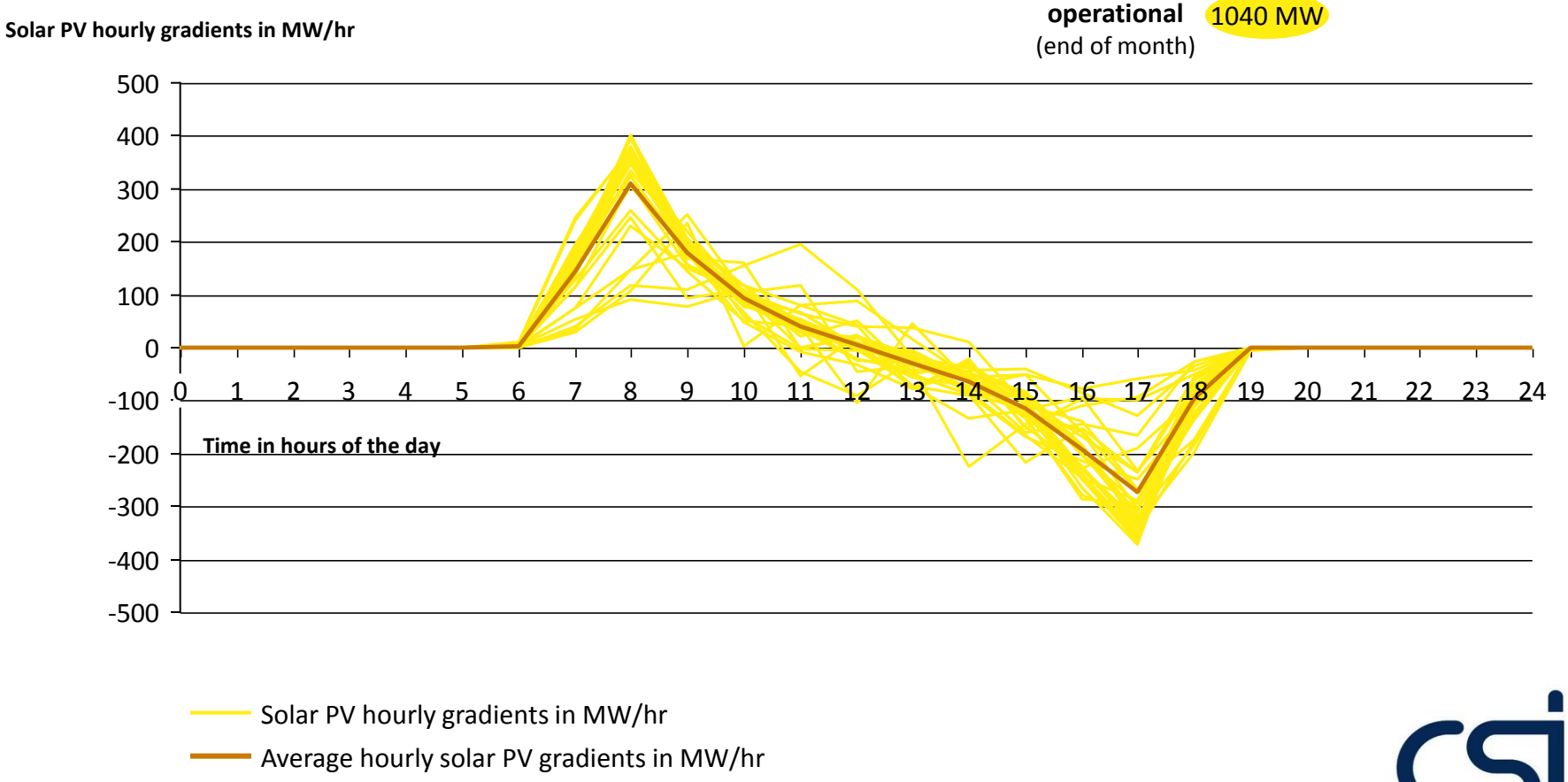
Capacity operational (end of month) 965 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in April 2016

Capacity operational (end of month) 1040 MW



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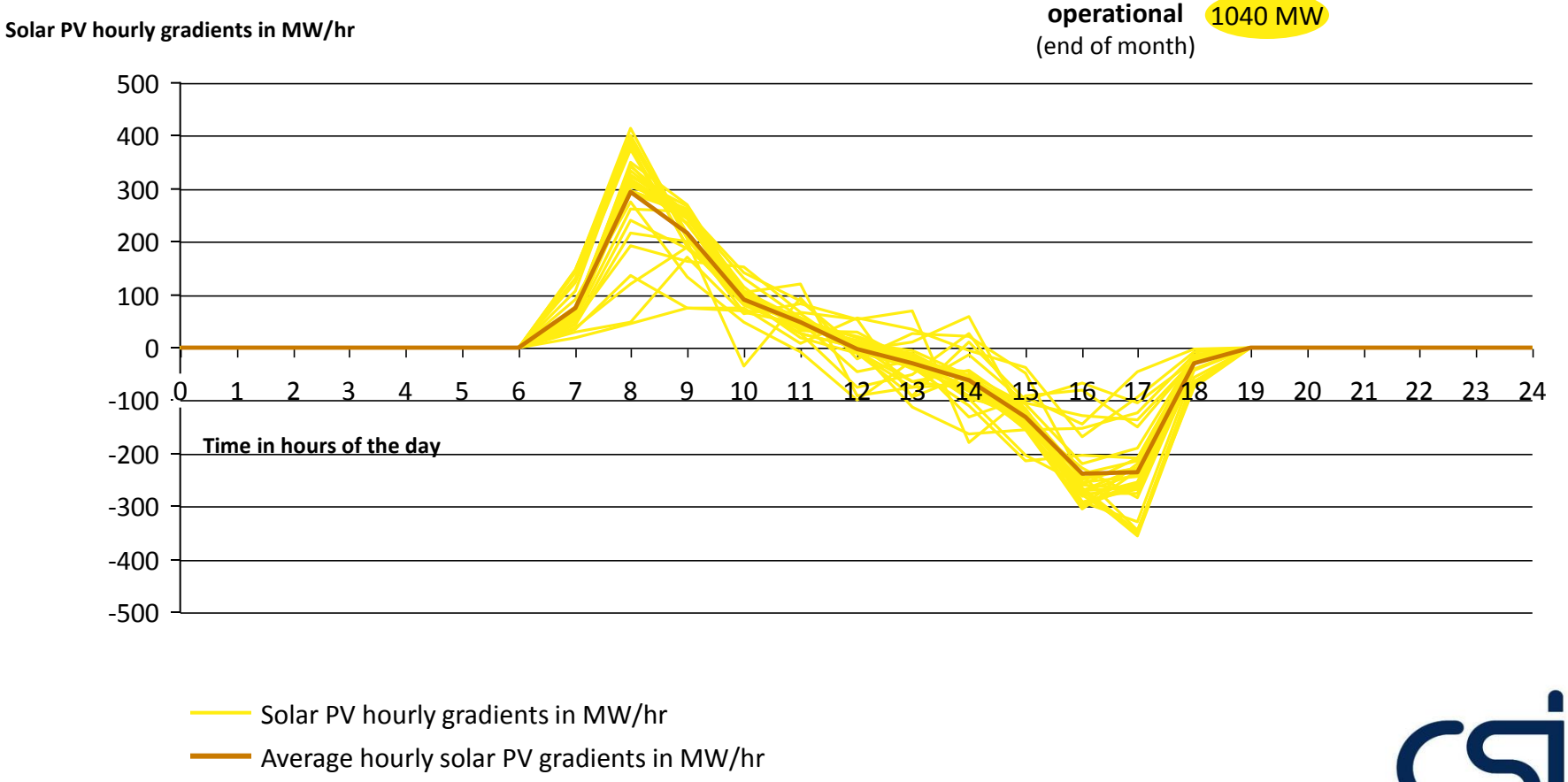
Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in May 2016

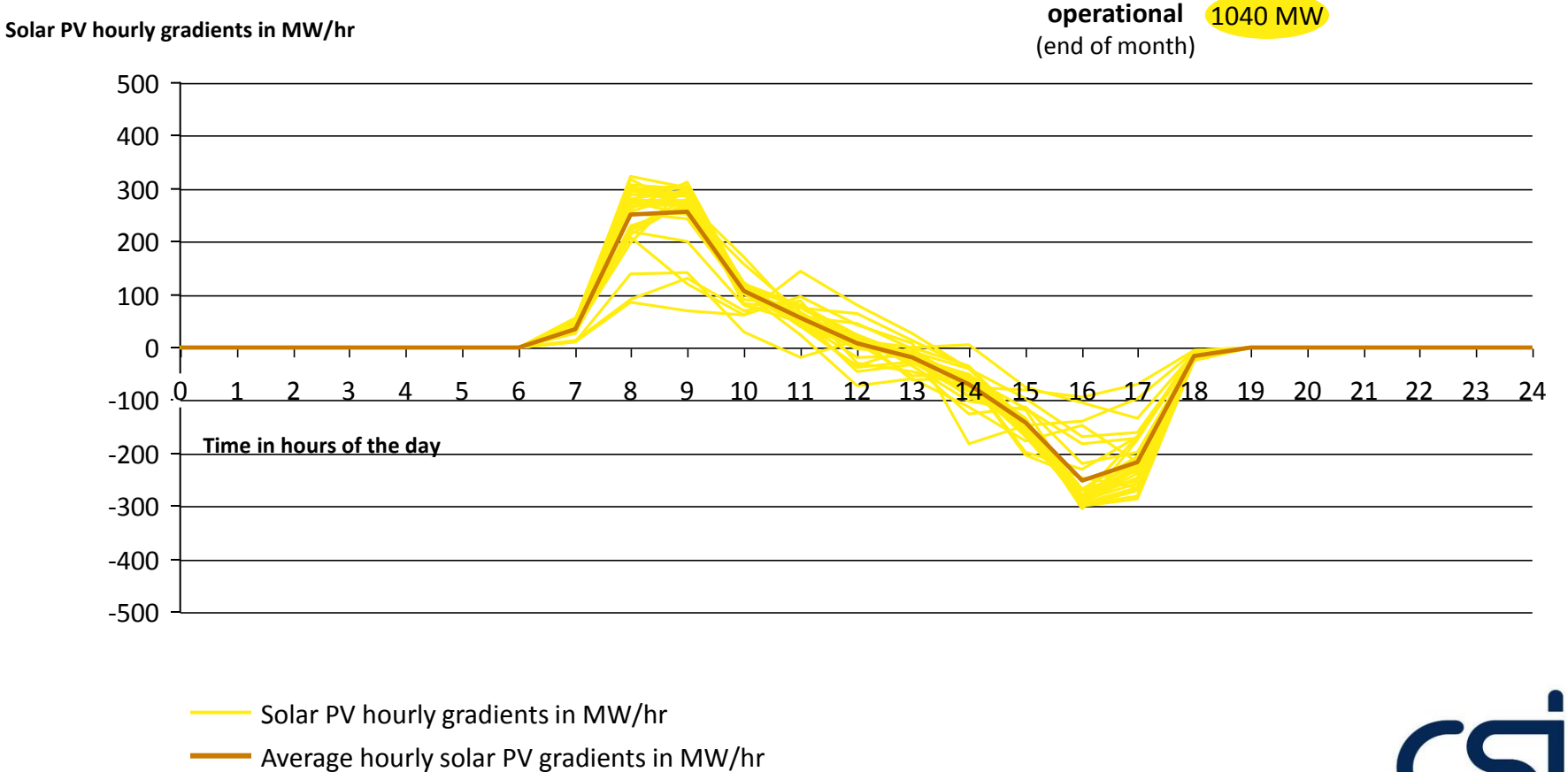
Capacity operational (end of month) 1040 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in June 2016

Capacity operational (end of month) 1040 MW



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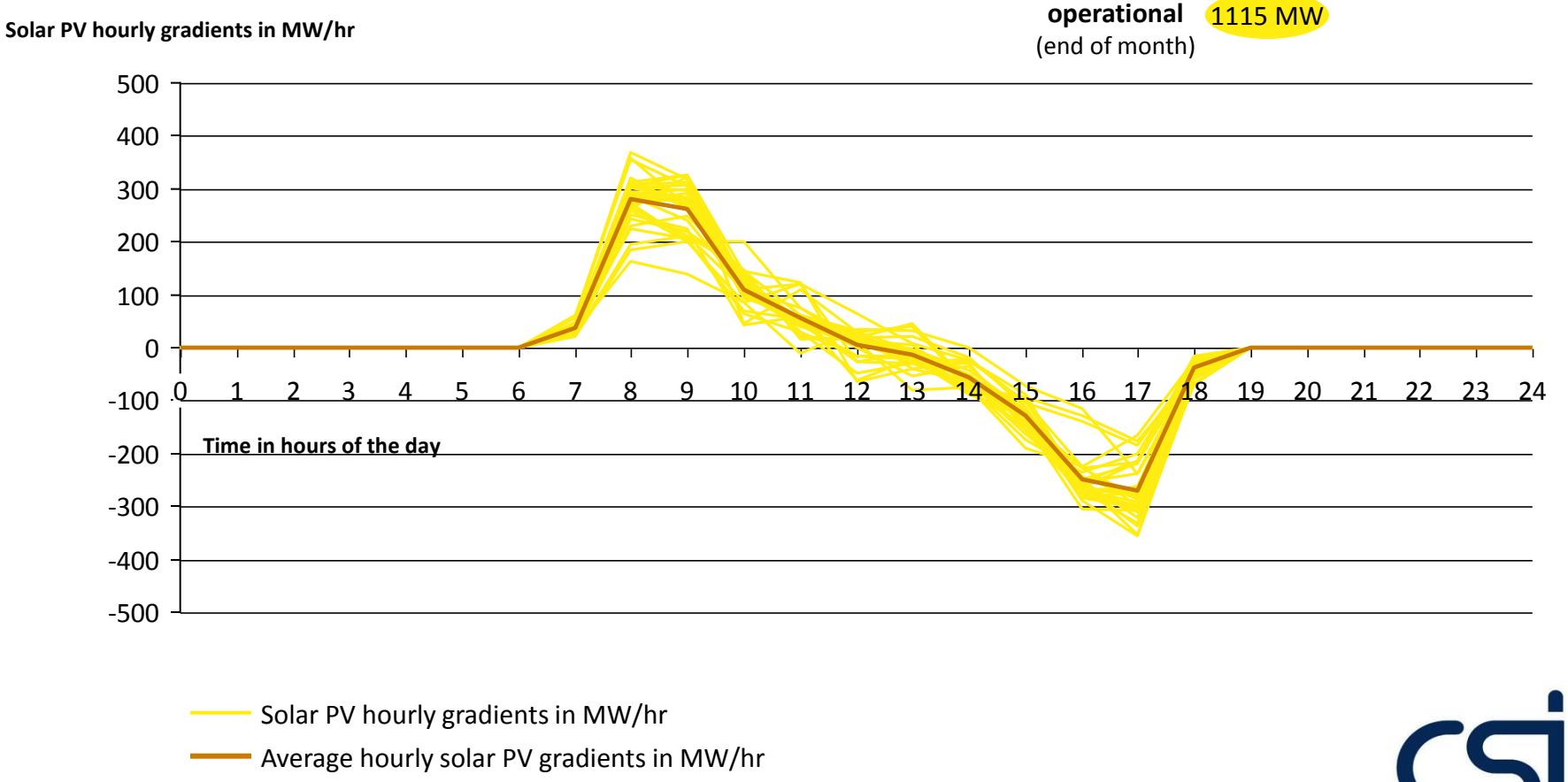
Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in July 2016

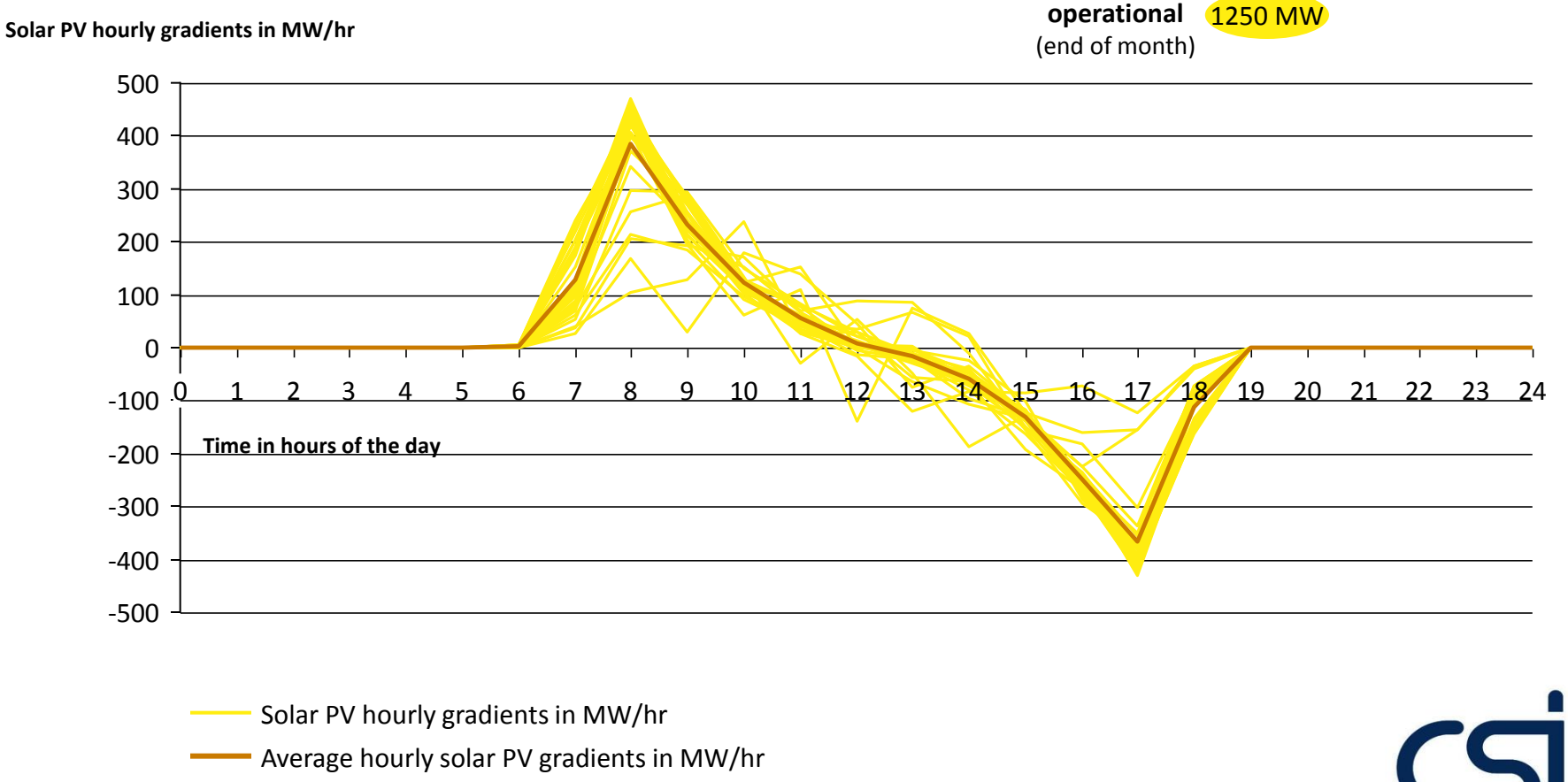
Capacity operational (end of month) 1115 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in August 2016

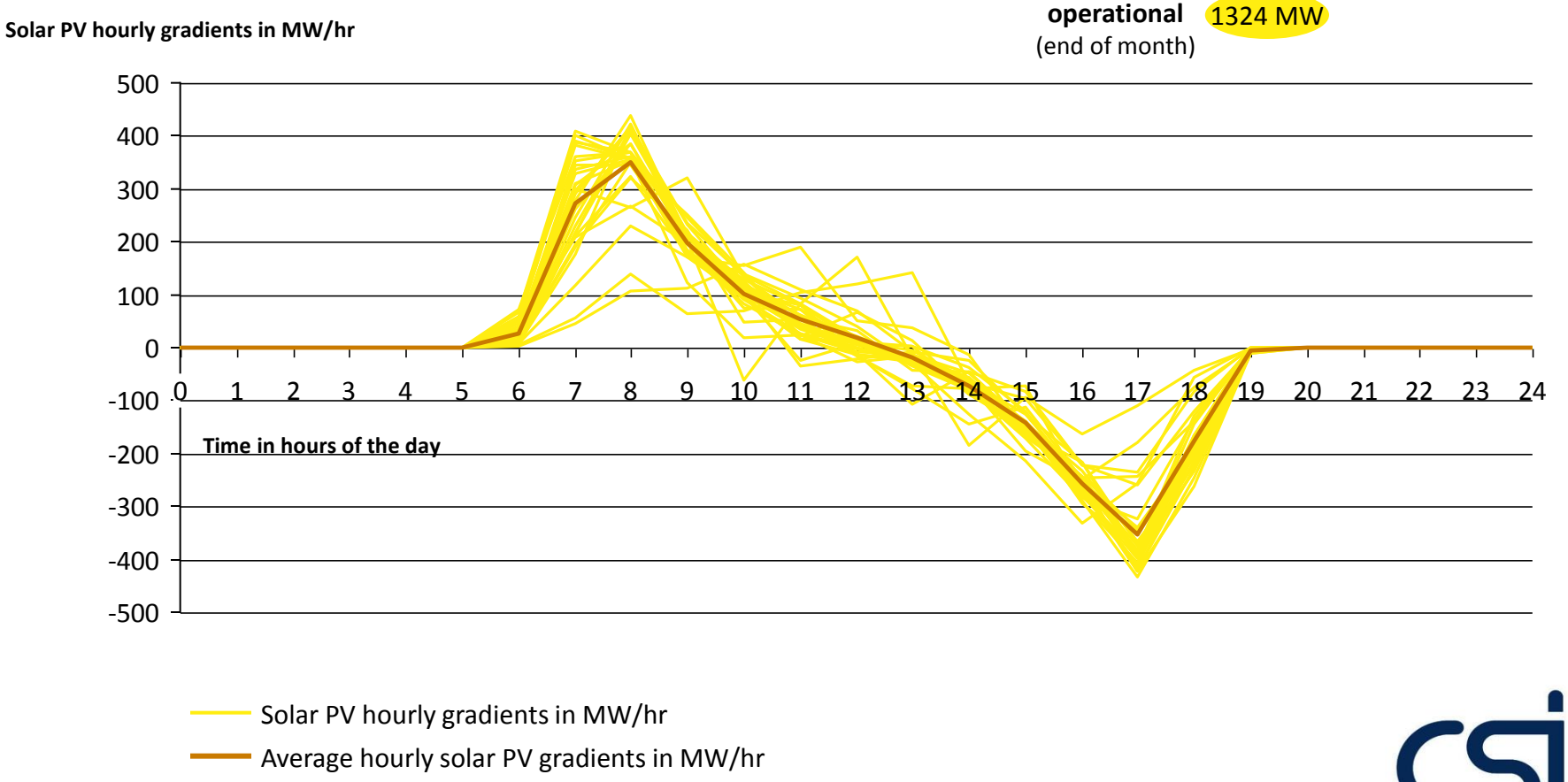
Capacity operational (end of month) 1250 MW



Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in September 2016

Capacity operational (end of month) 1324 MW



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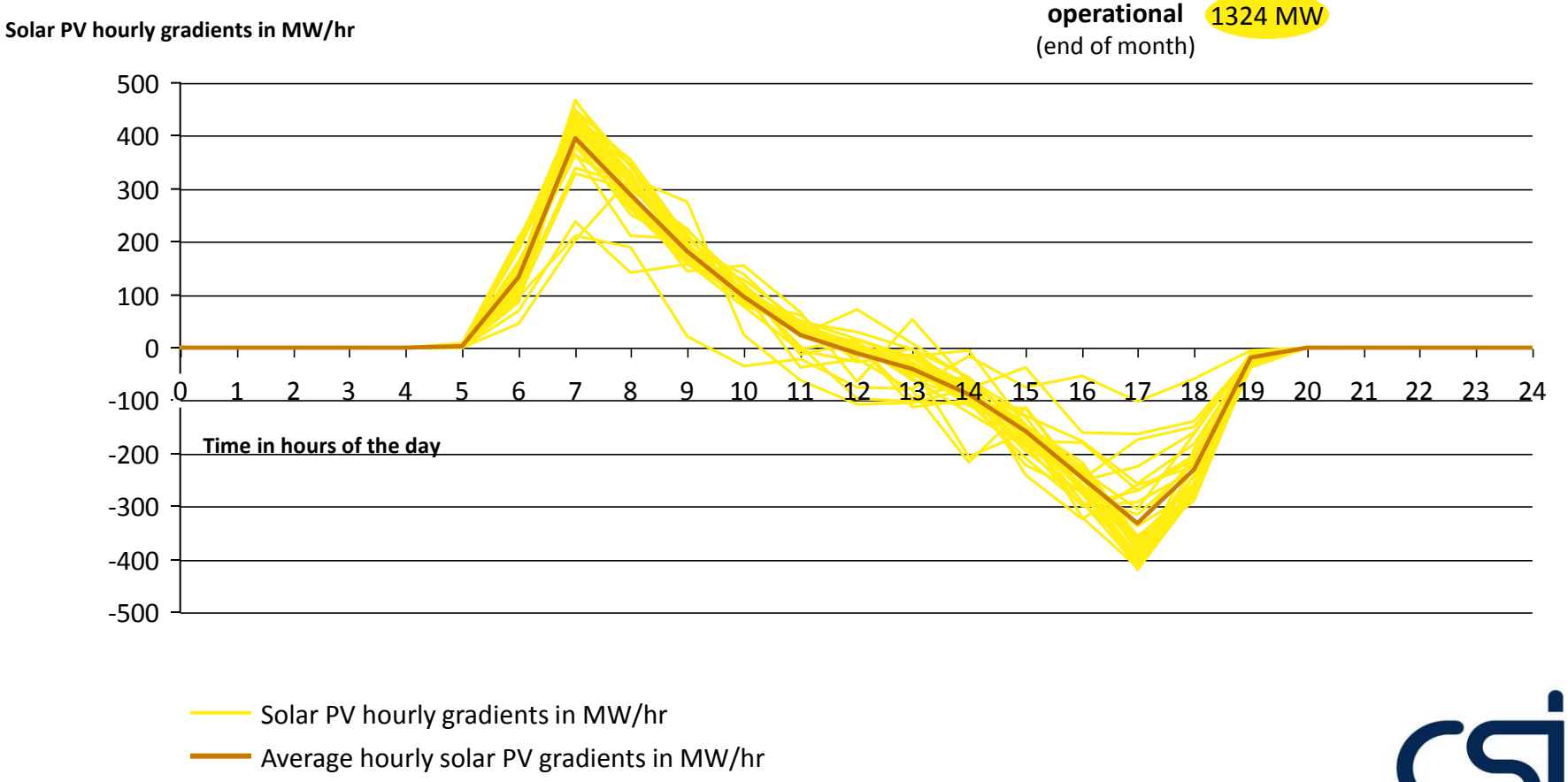
Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in October 2016

Capacity operational (end of month) 1324 MW



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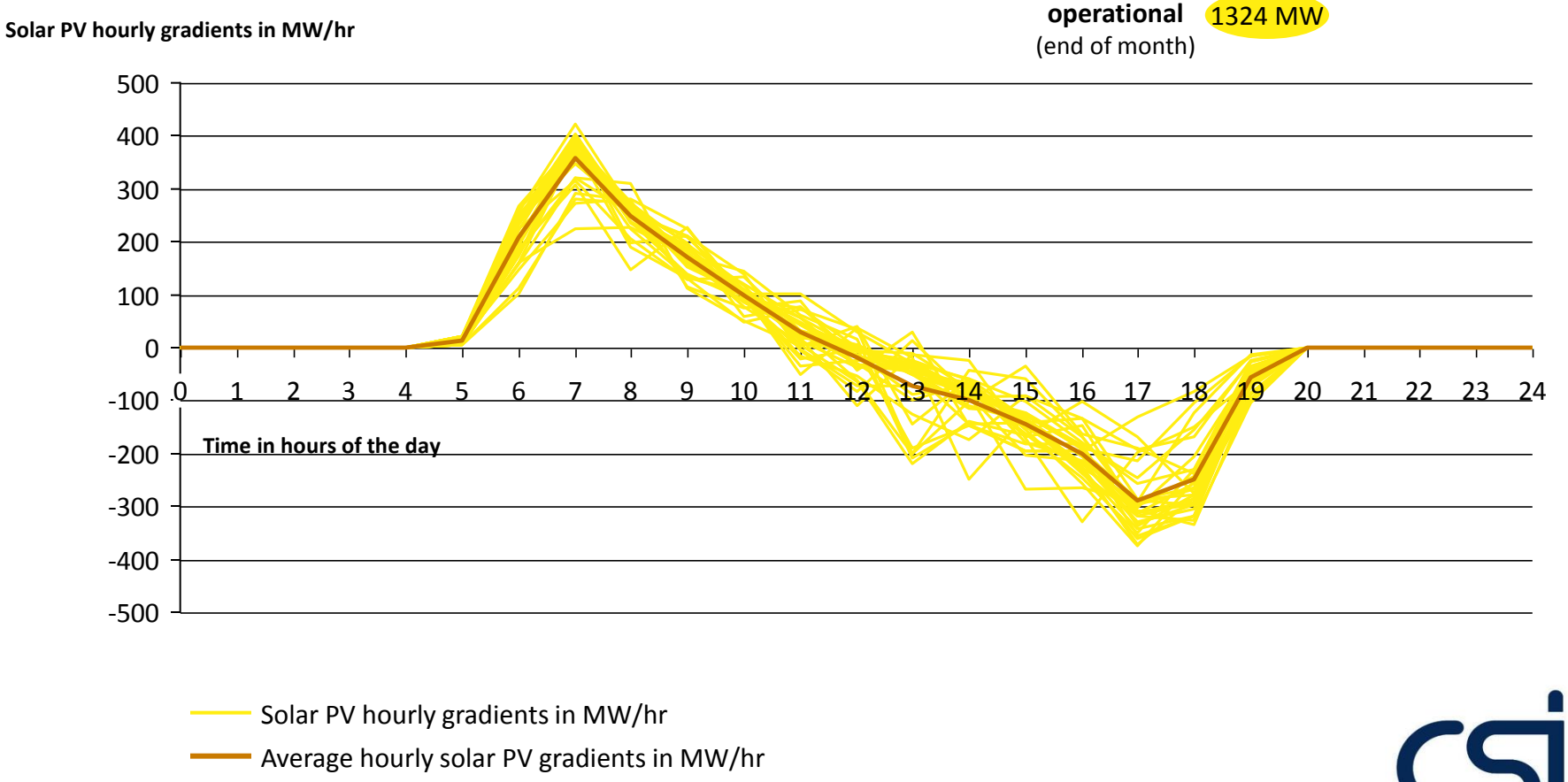
Sources: Eskom; CSIR Energy Centre analysis

Solar PV 1-hour gradients in November 2016

Capacity operational (end of month) 1324 MW



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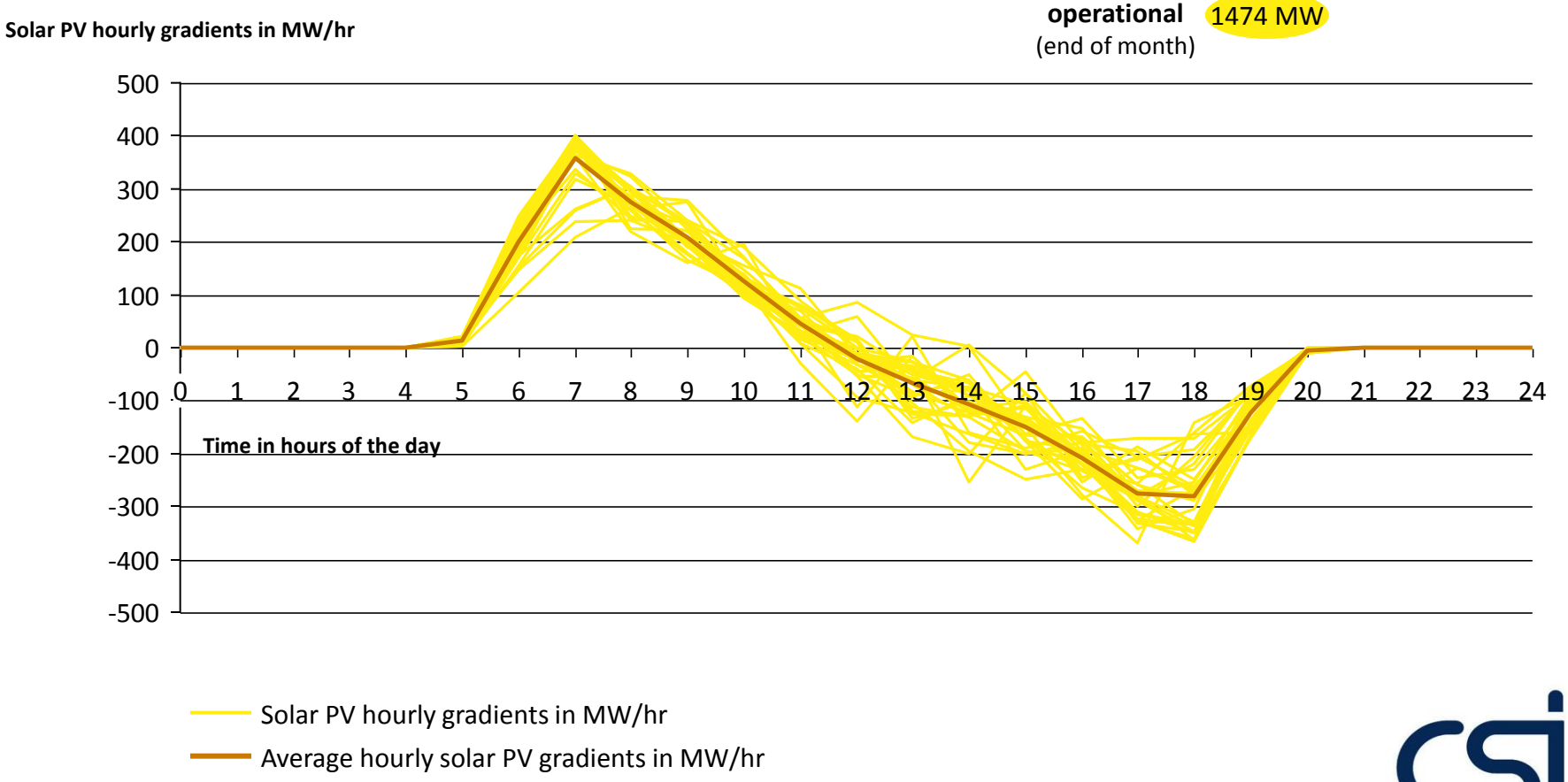
Sources: Eskom; CSIR Energy Centre analysis

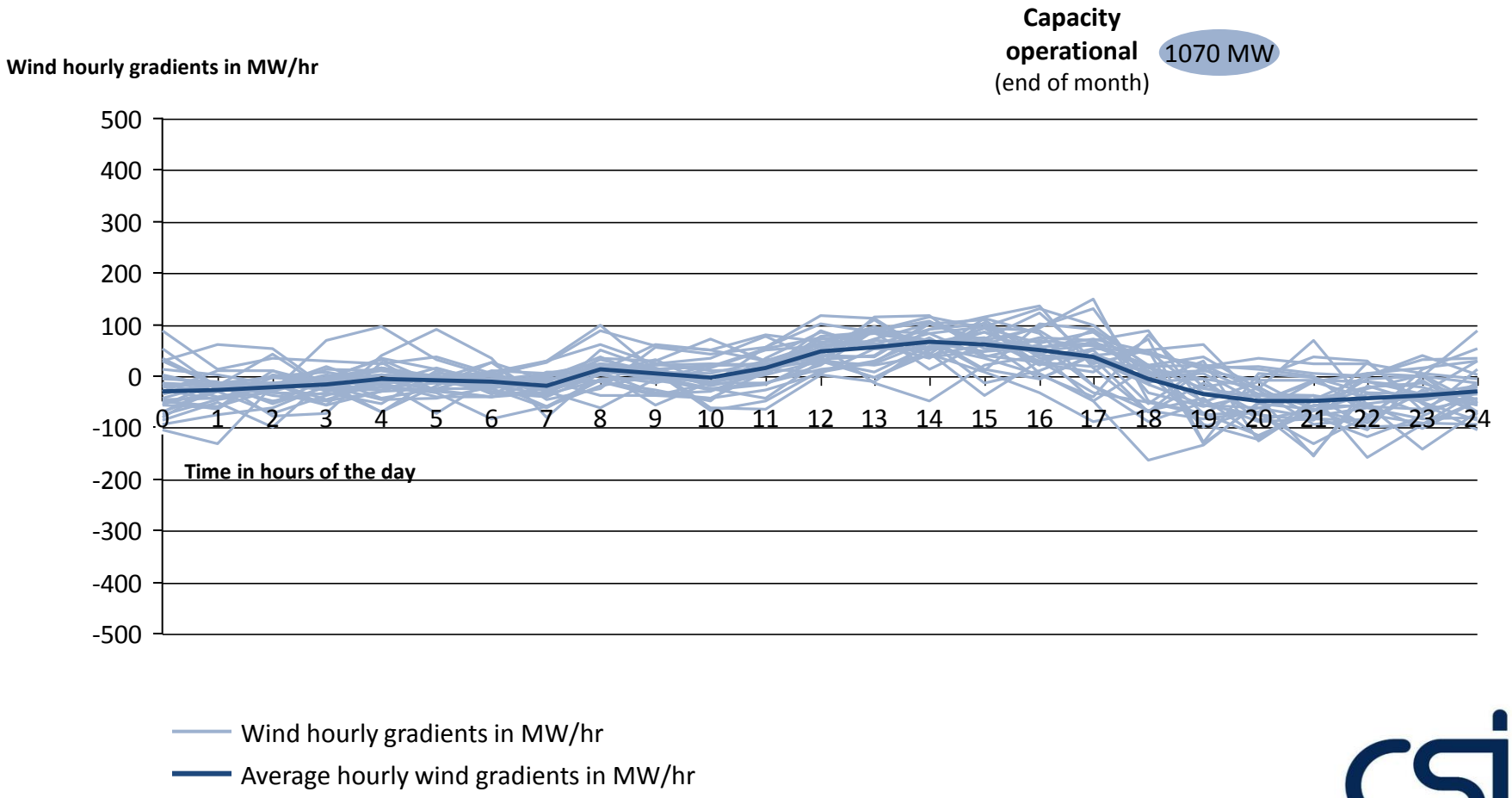
Solar PV 1-hour gradients in December 2016

Capacity operational (end of month) 1474 MW



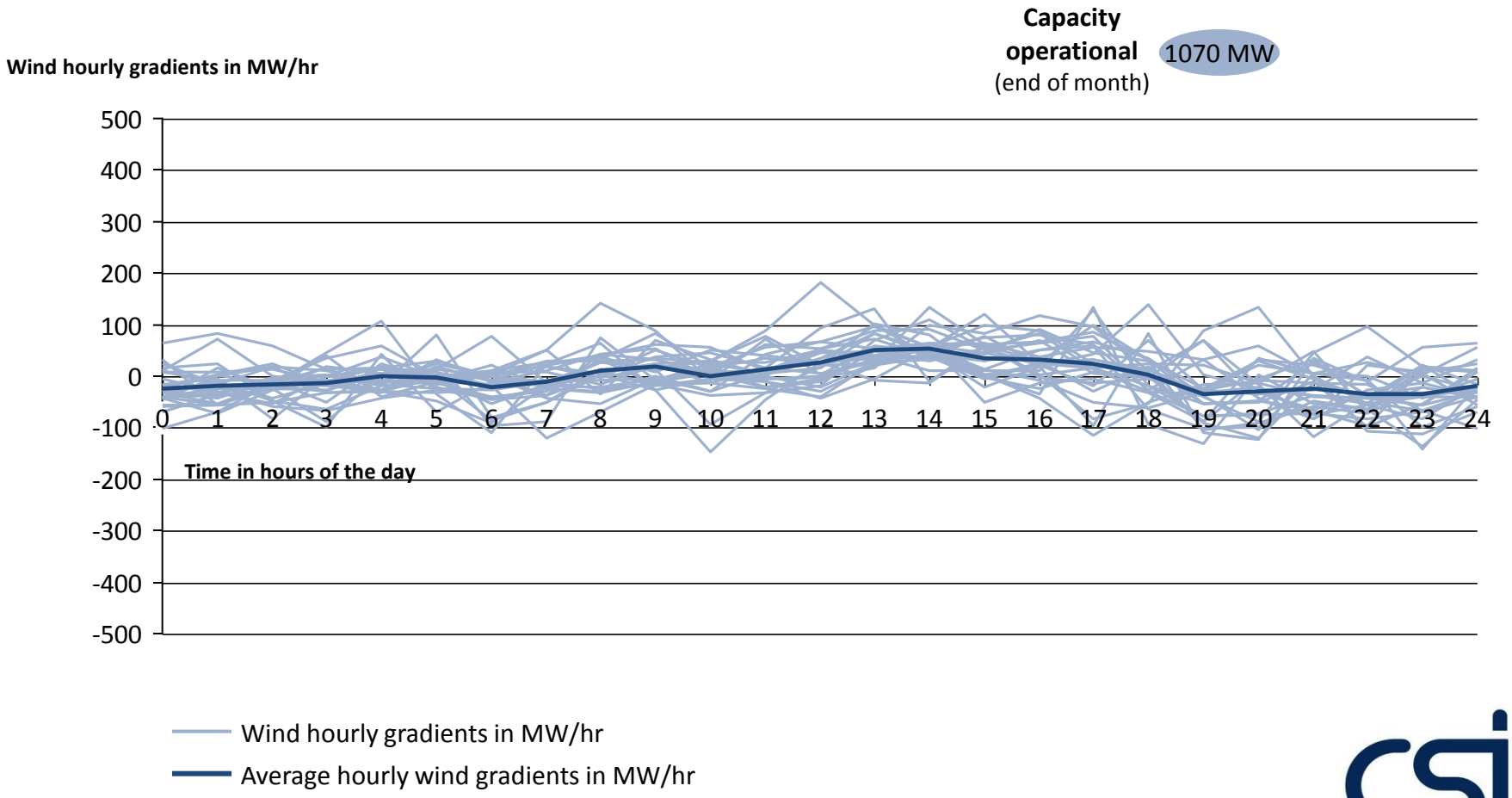
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in January 2016



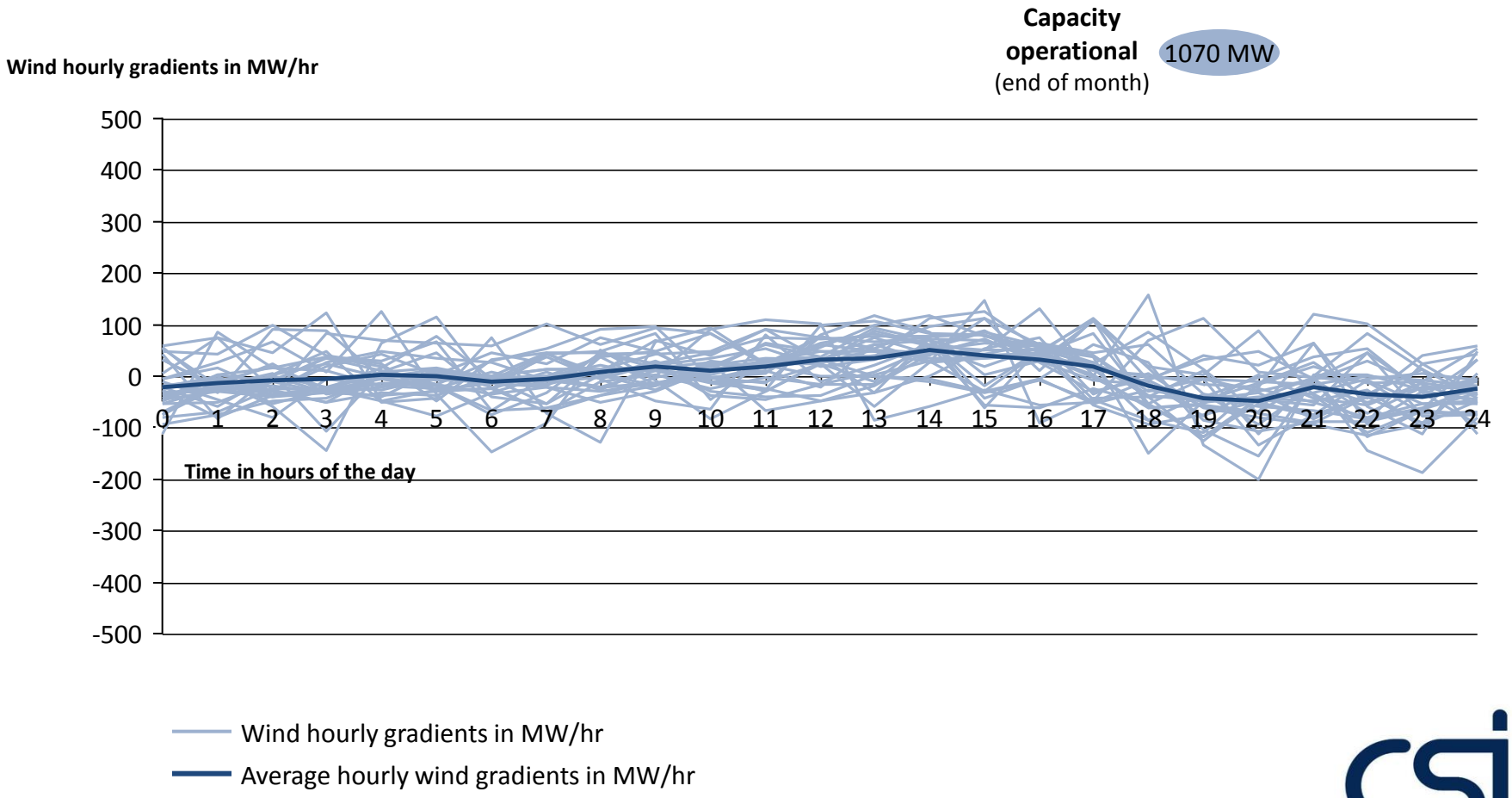
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in February 2016



Sources: Eskom; CSIR Energy Centre analysis

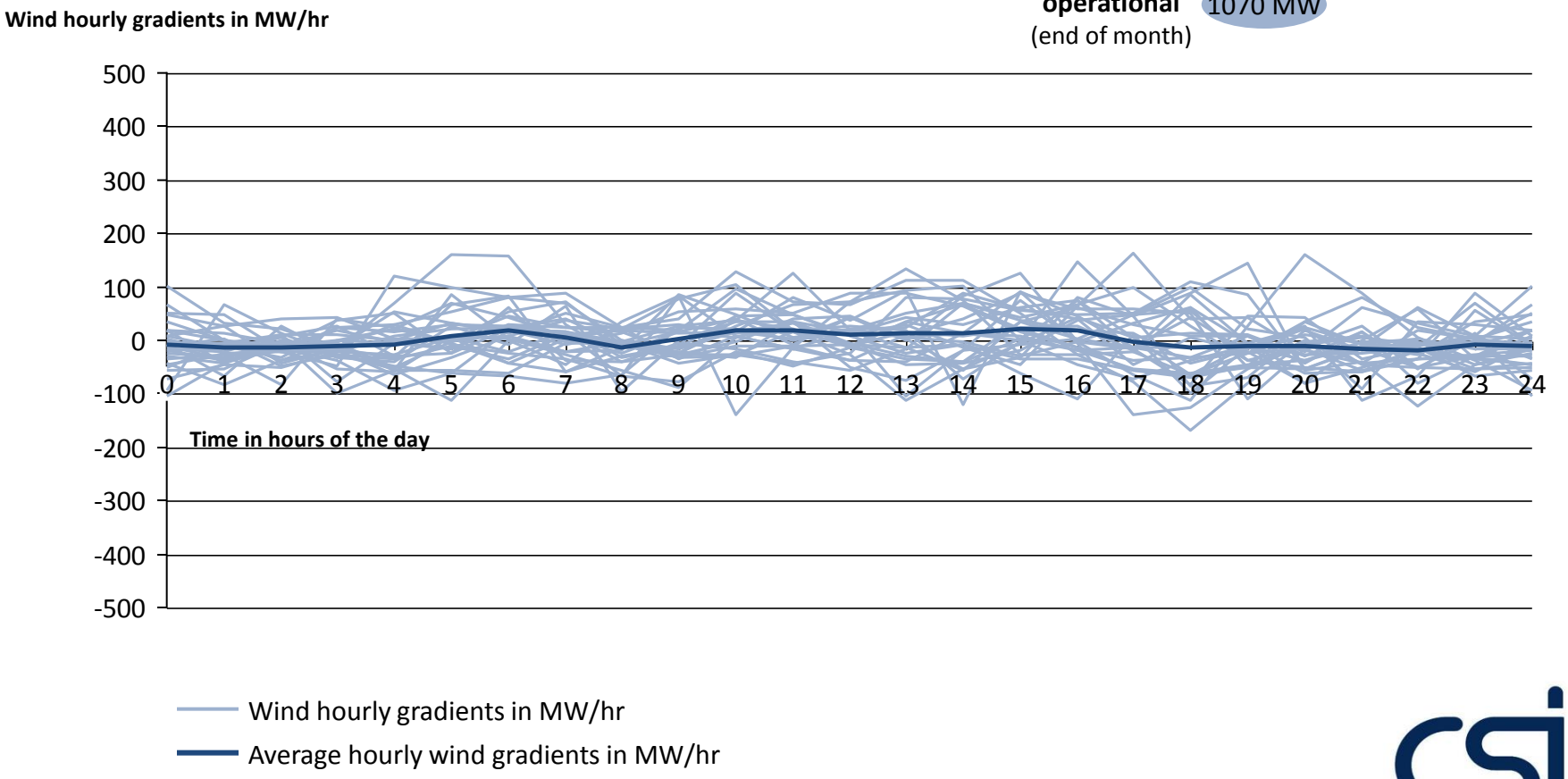
Wind 1-hour gradients in March 2016



Sources: Eskom; CSIR Energy Centre analysis

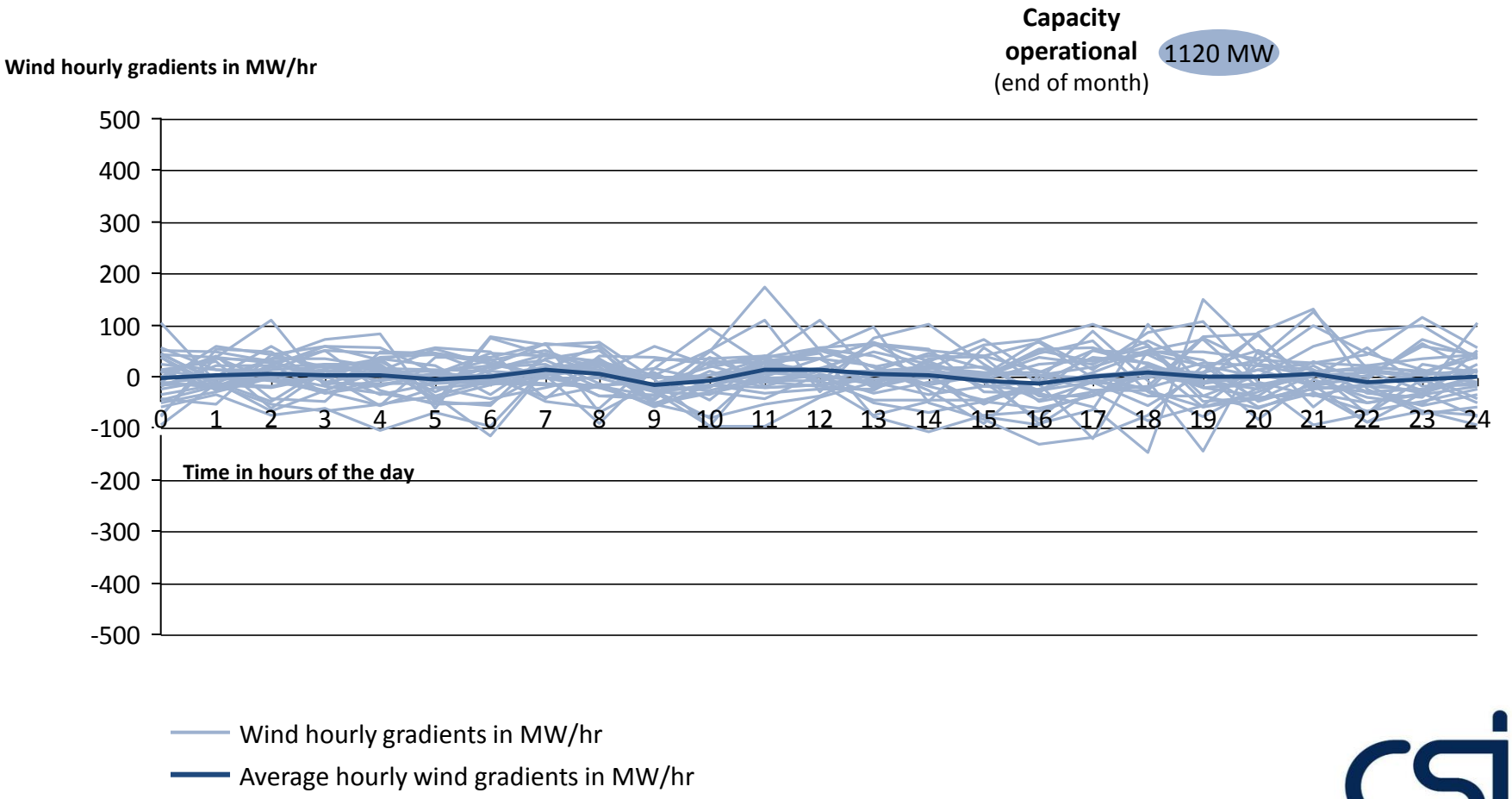
Wind 1-hour gradients in April 2016

Capacity operational (end of month) 1070 MW



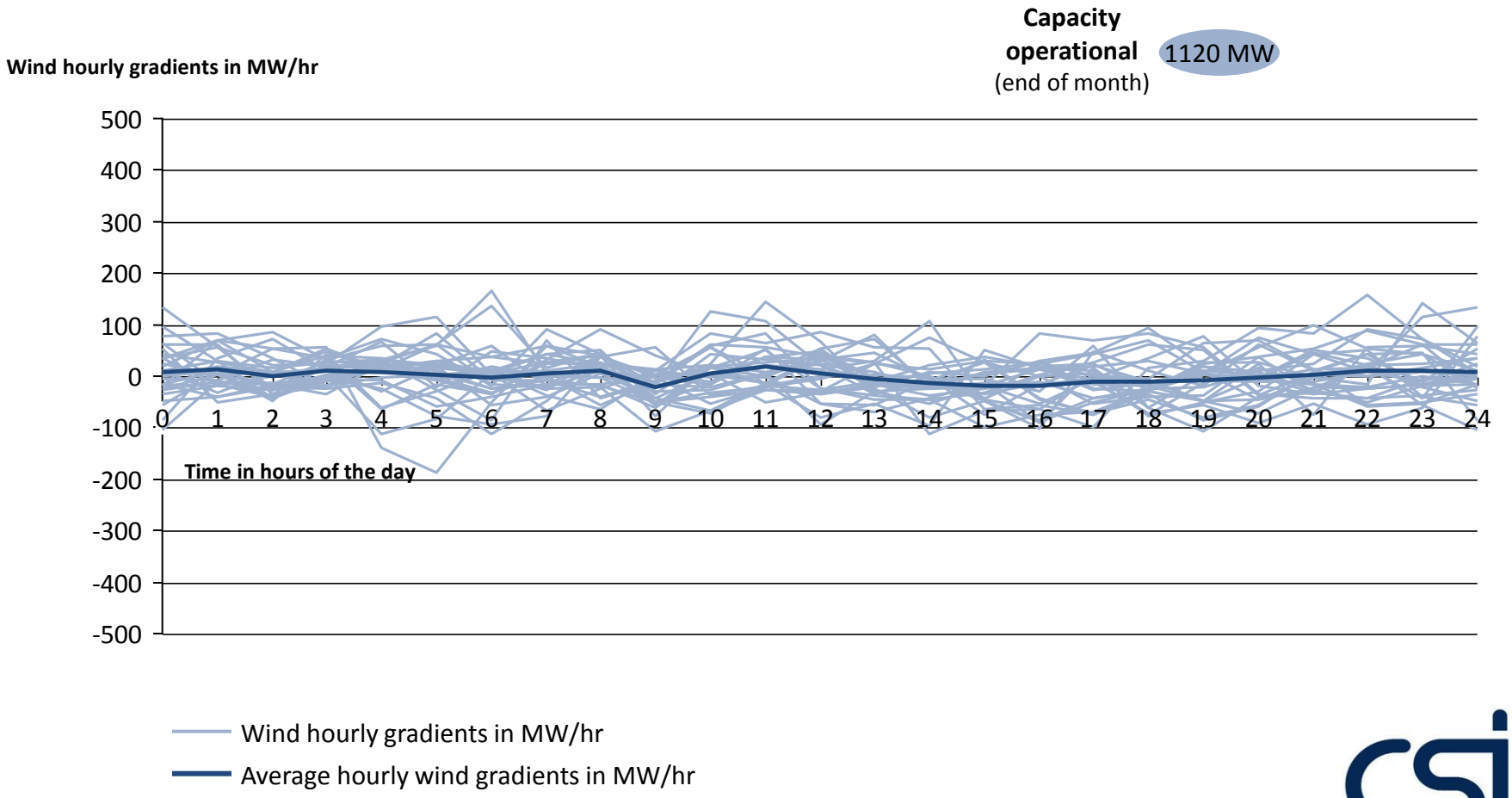
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in May 2016



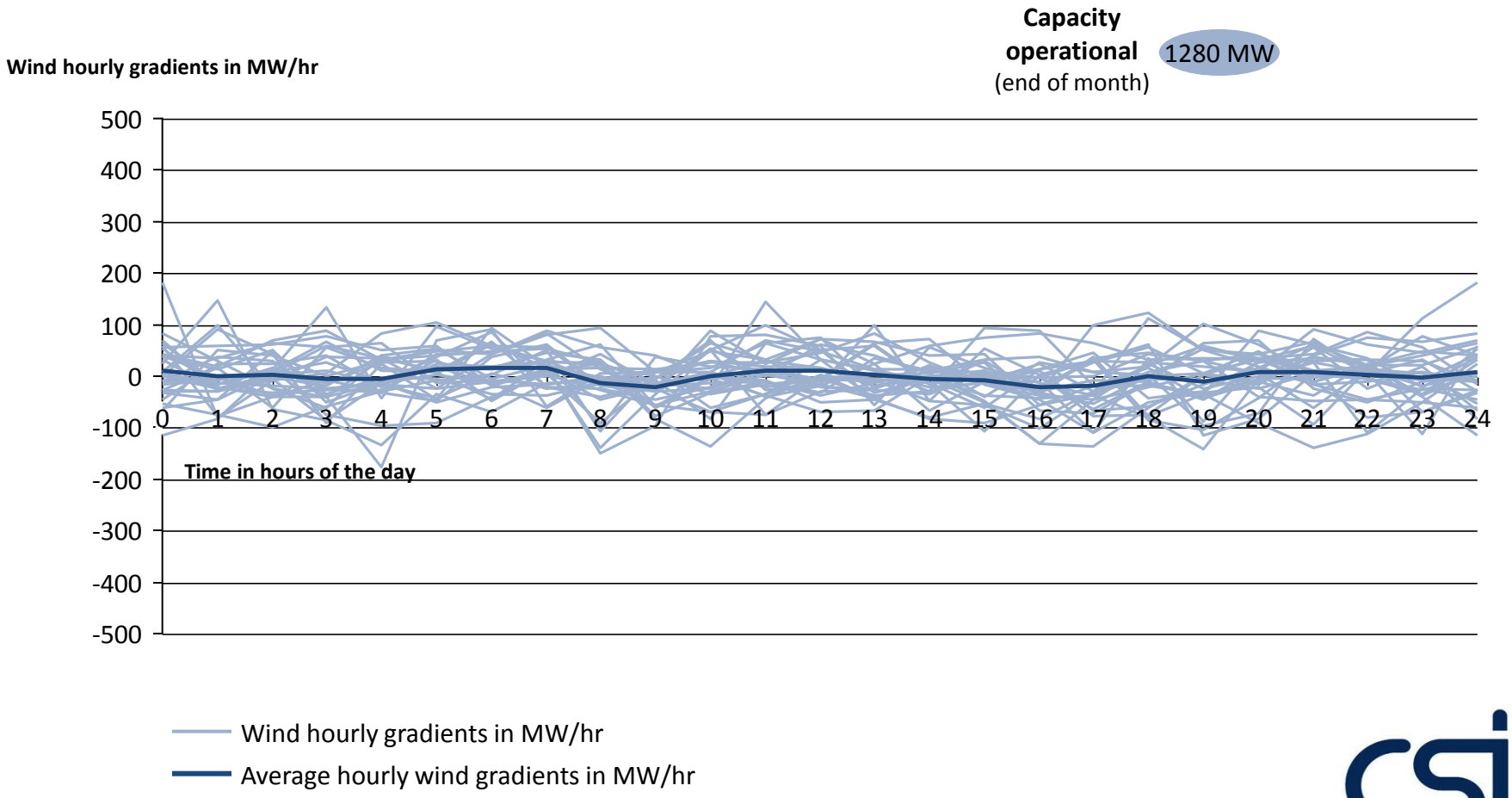
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in June 2016



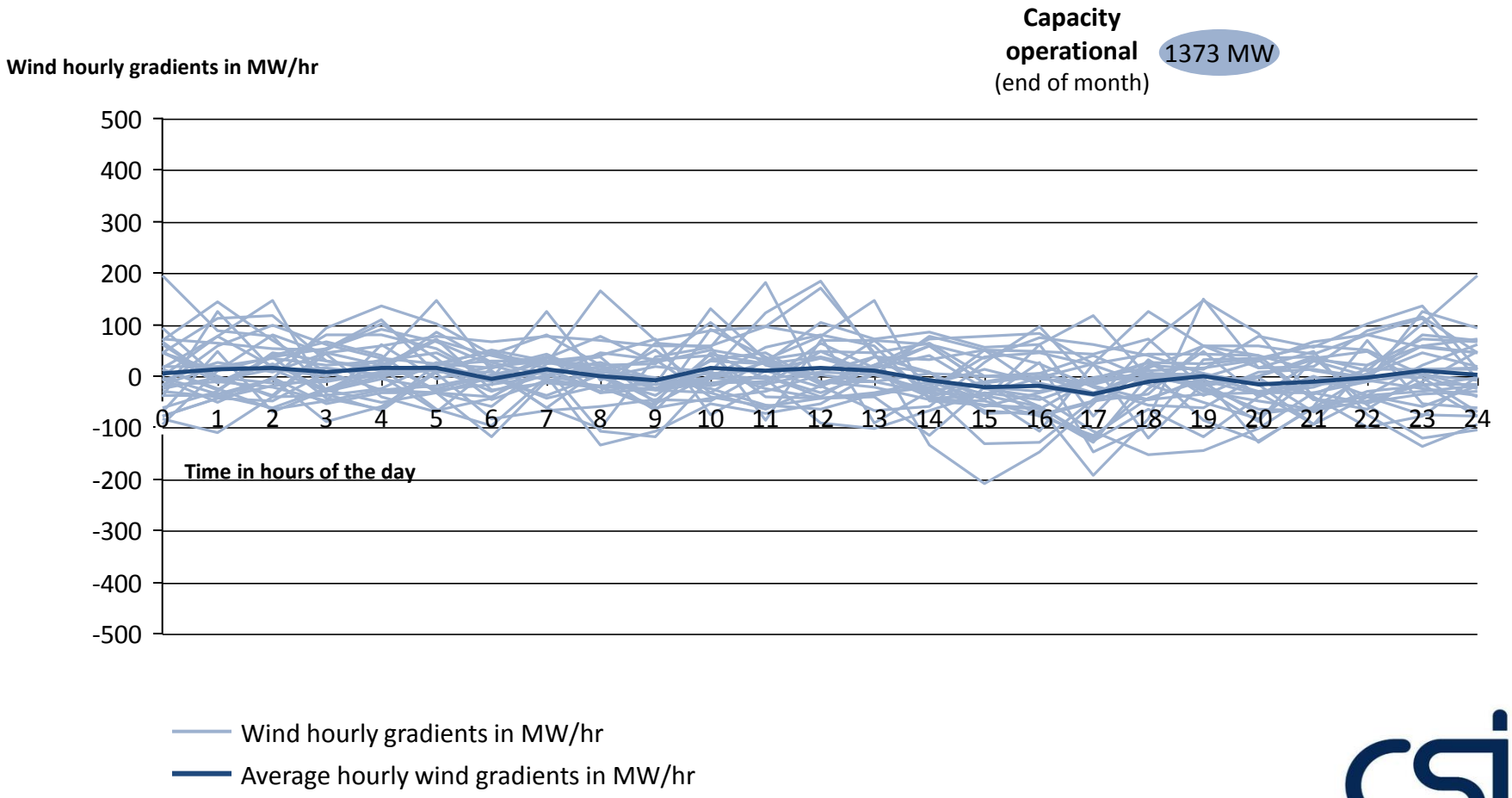
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in July 2016



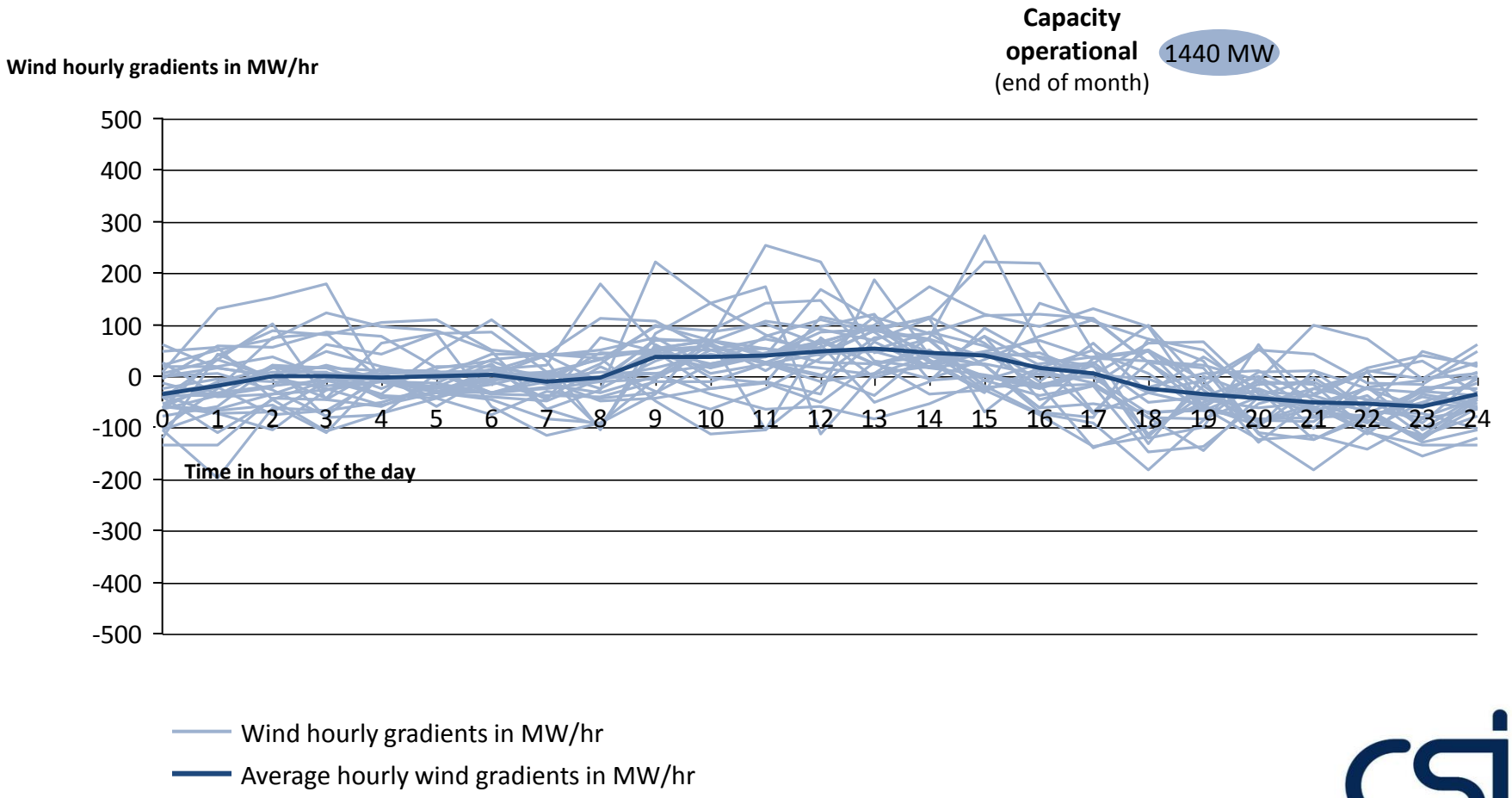
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in August 2016



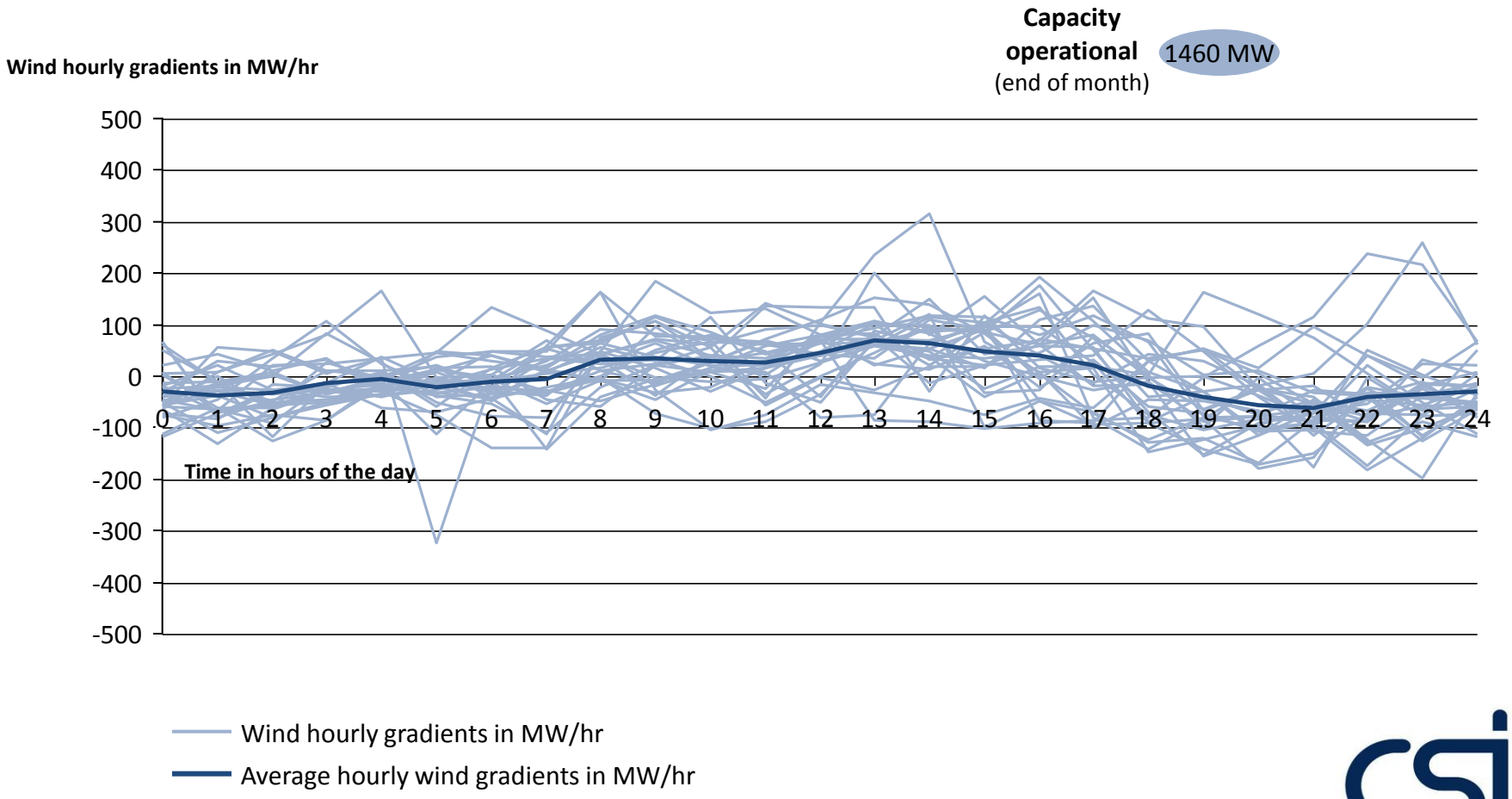
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in September 2016



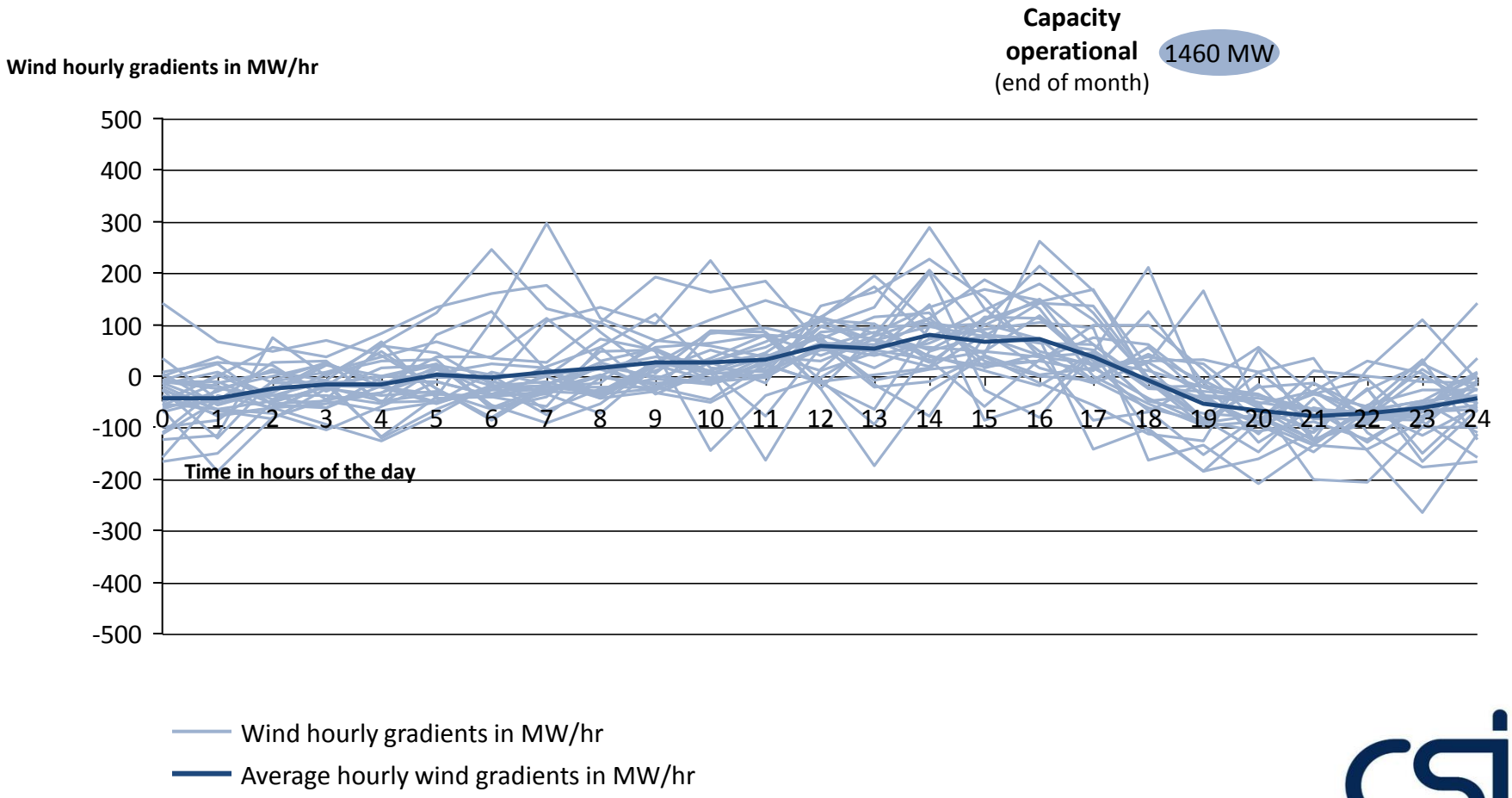
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in October 2016



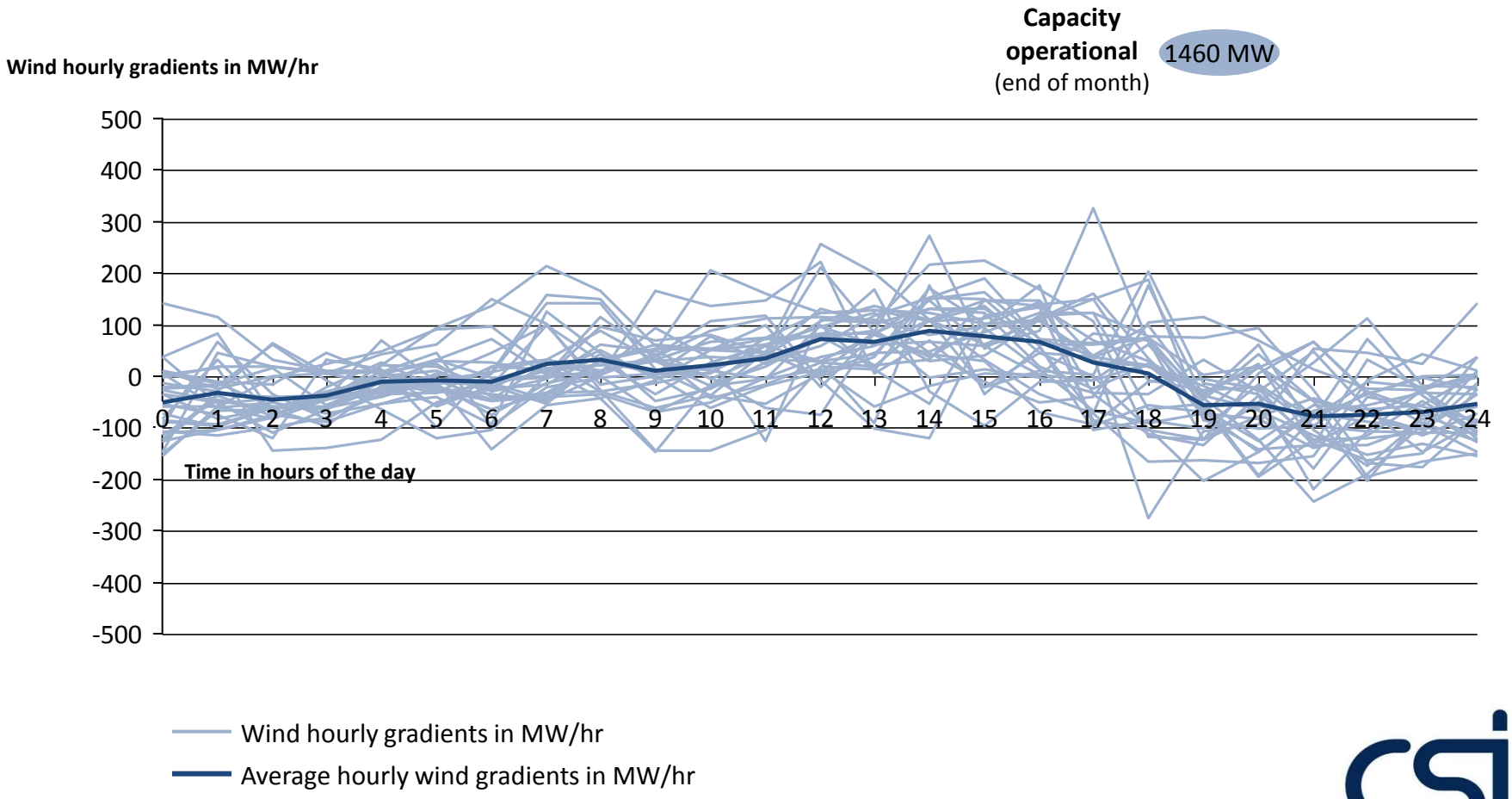
Sources: Eskom; CSIR Energy Centre analysis

Wind 1-hour gradients in November 2016



Sources: Eskom; CSIR Energy Centre analysis

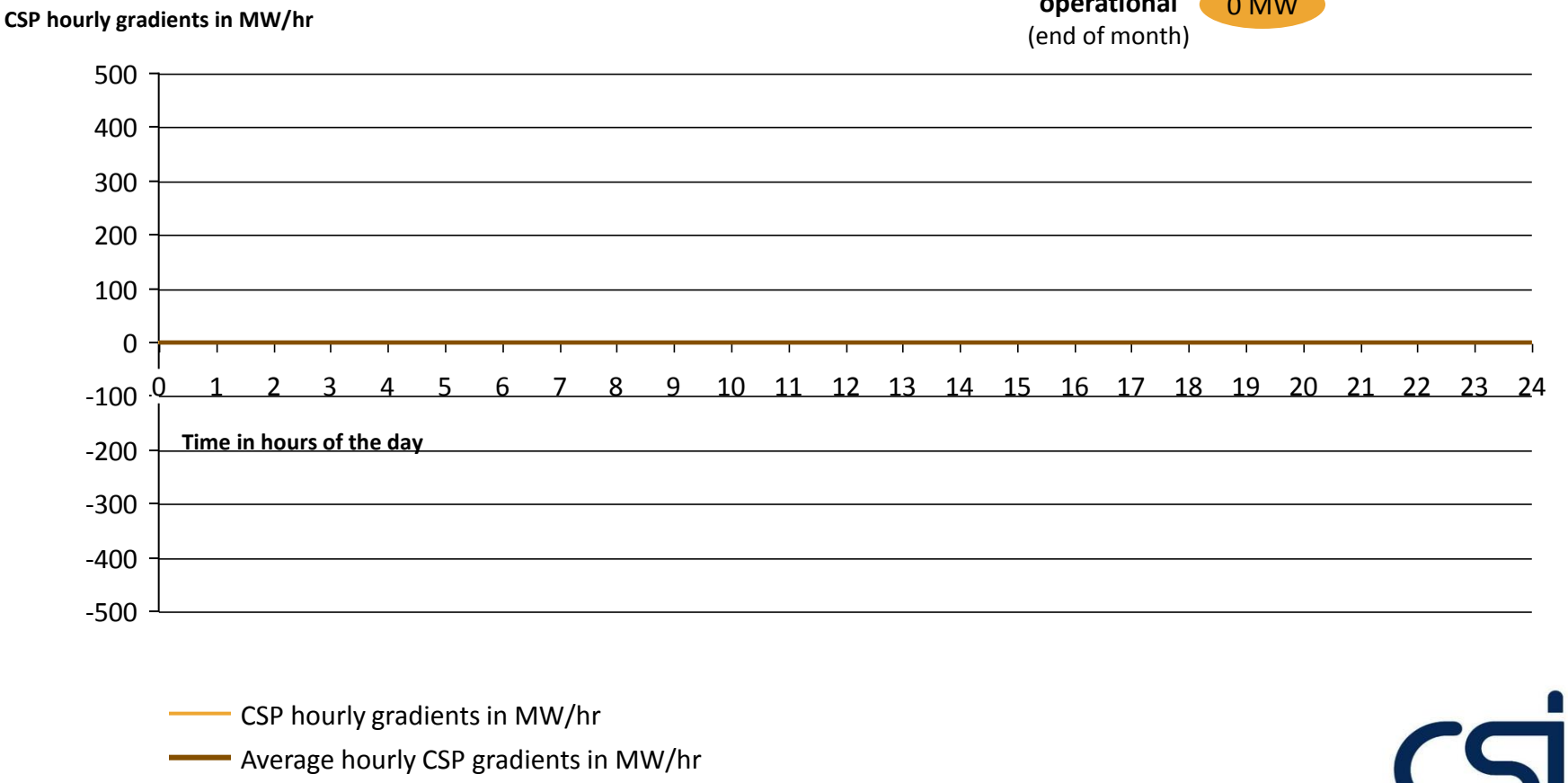
Wind 1-hour gradients in December 2016



Sources: Eskom; CSIR Energy Centre analysis

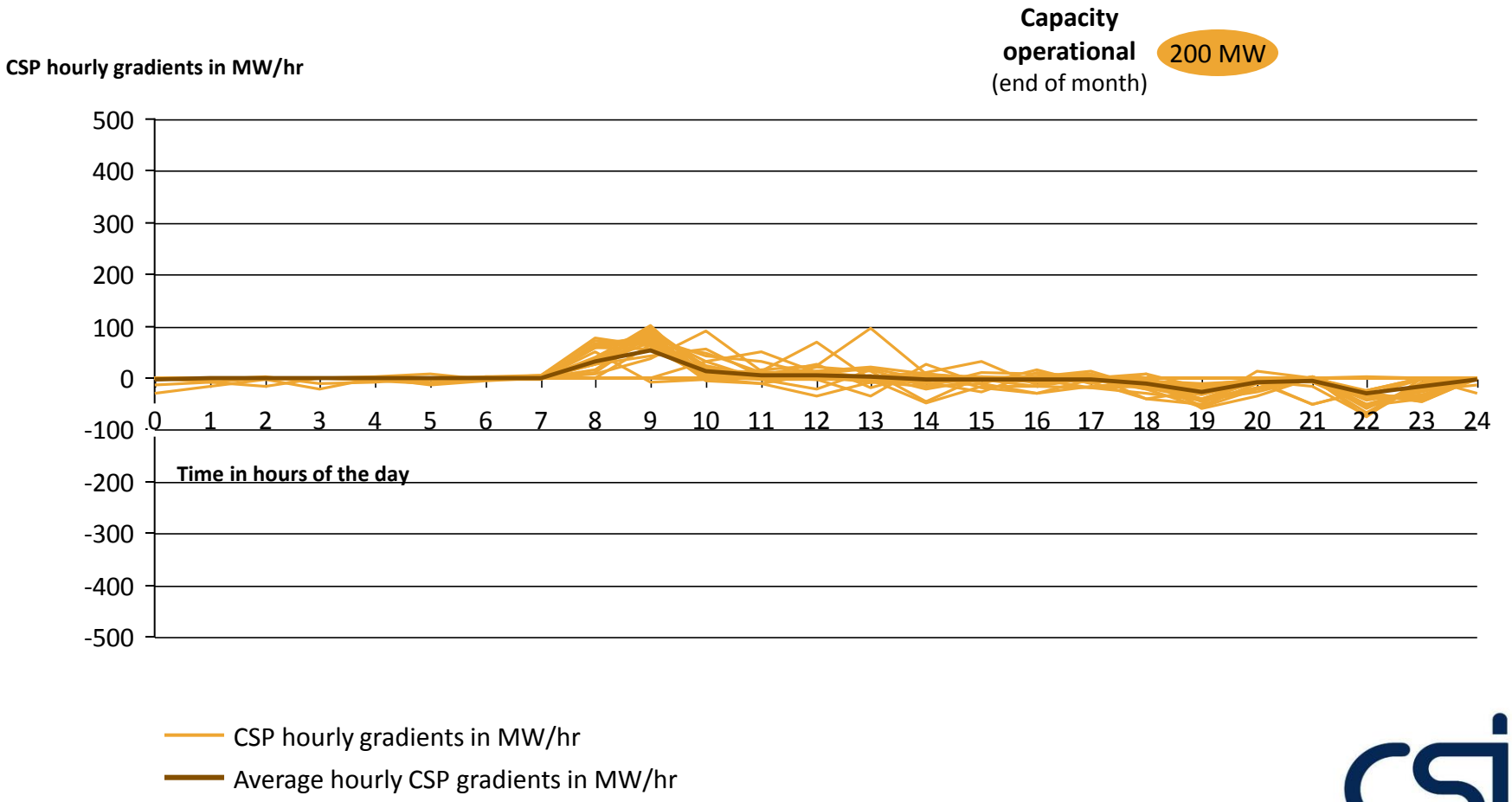
CSP 1-hour gradients in January 2016

Capacity operational (end of month) 0 MW



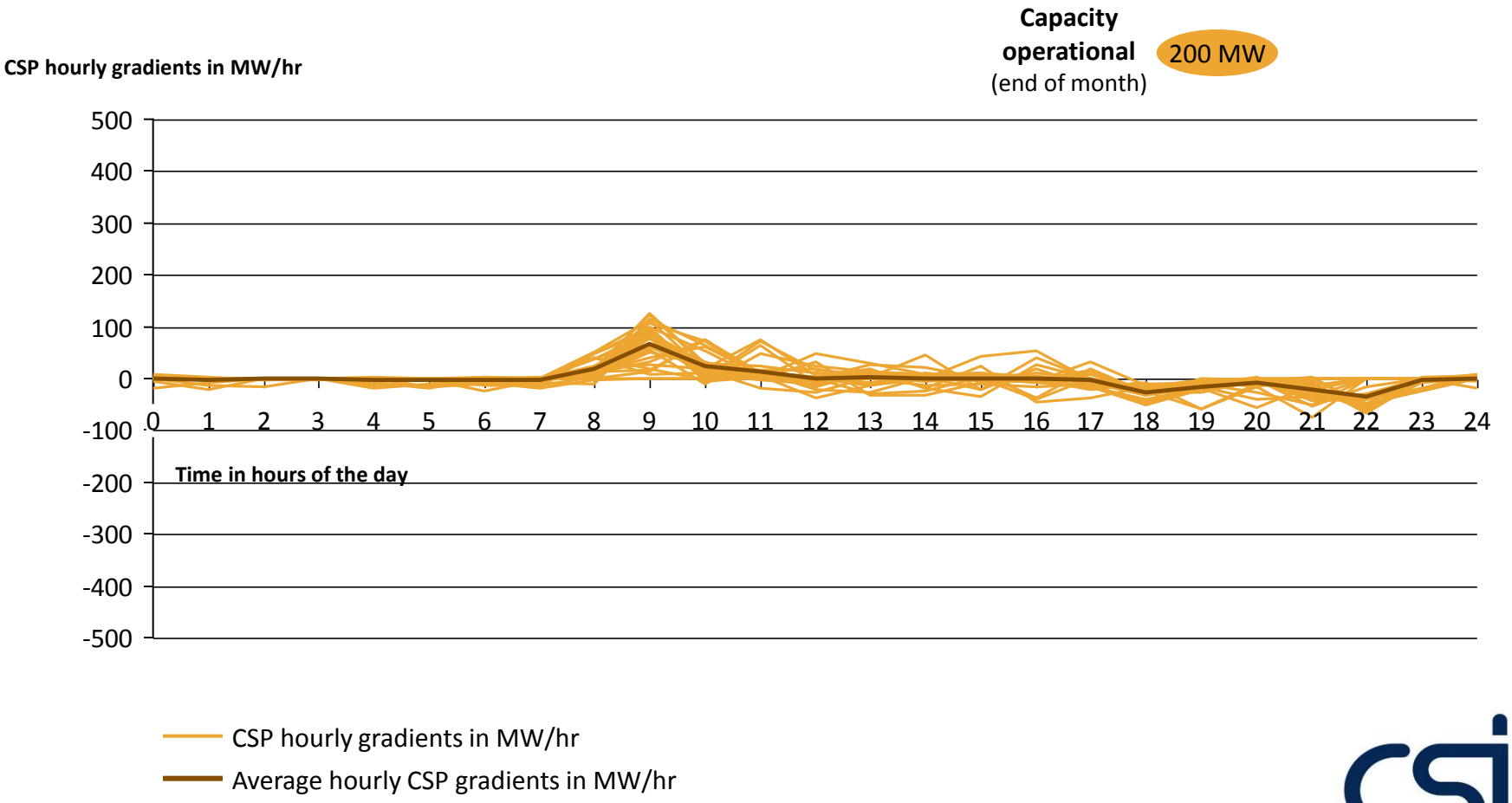
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in February 2016



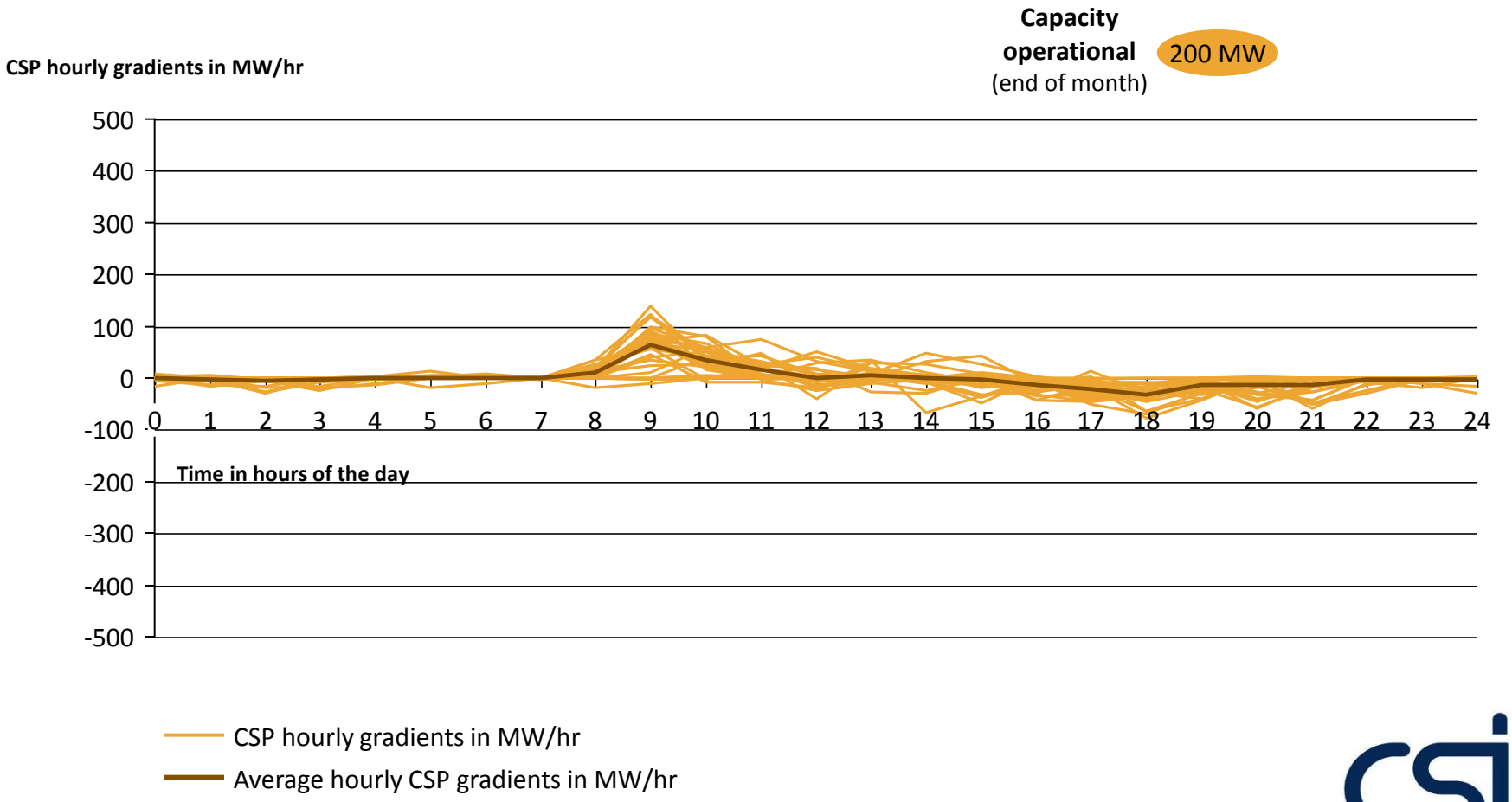
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in March 2016



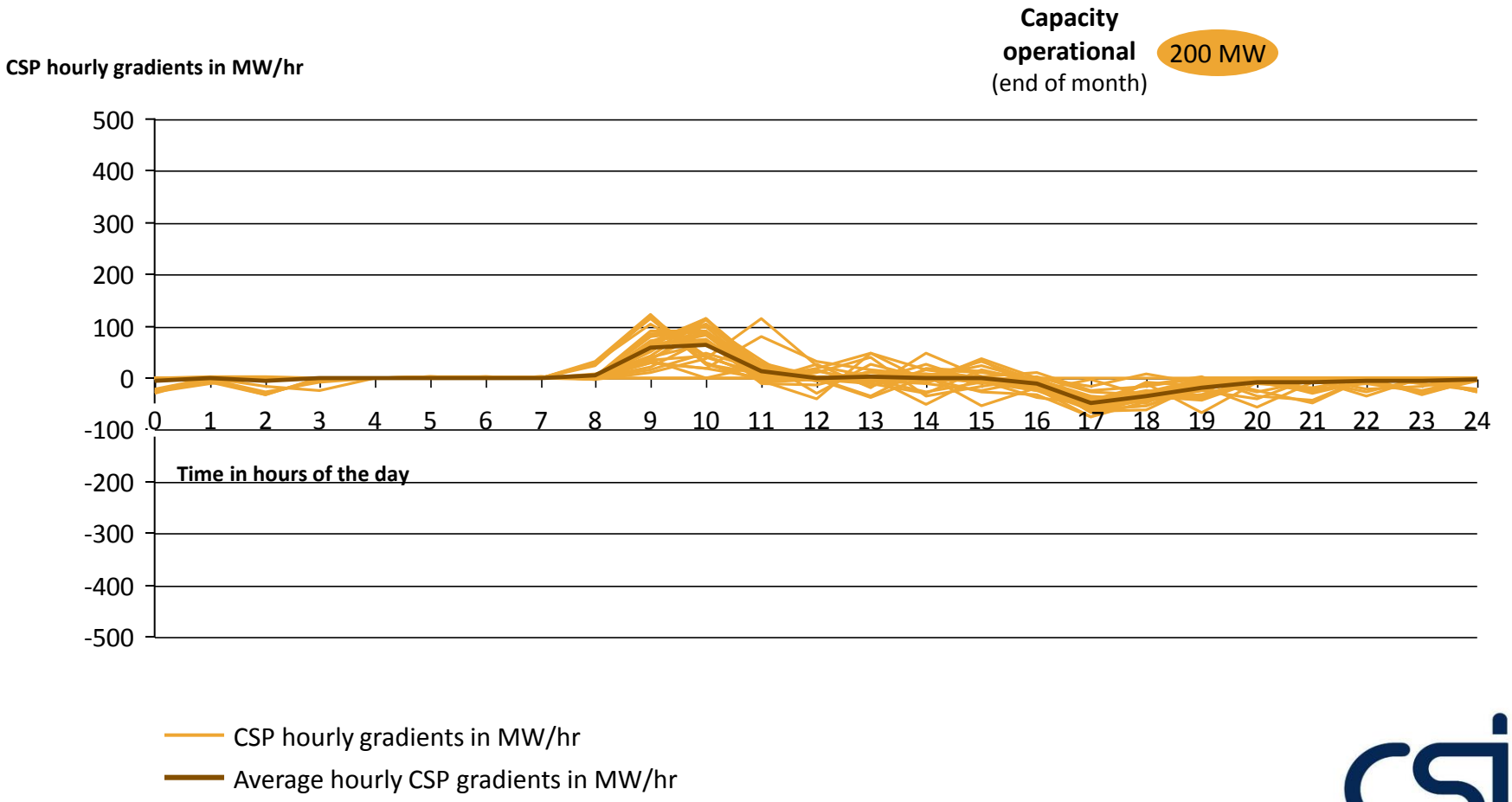
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in April 2016



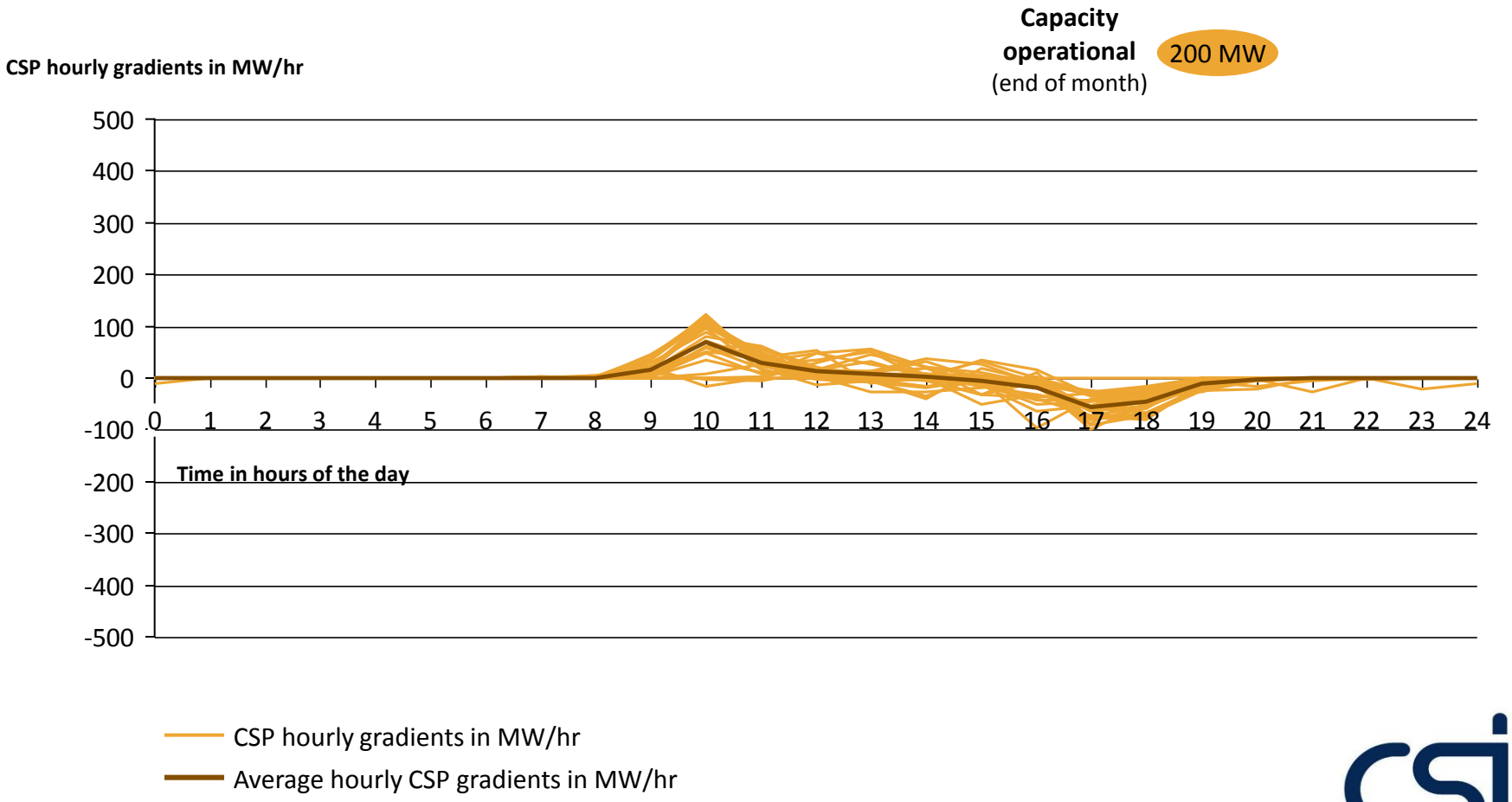
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in May 2016



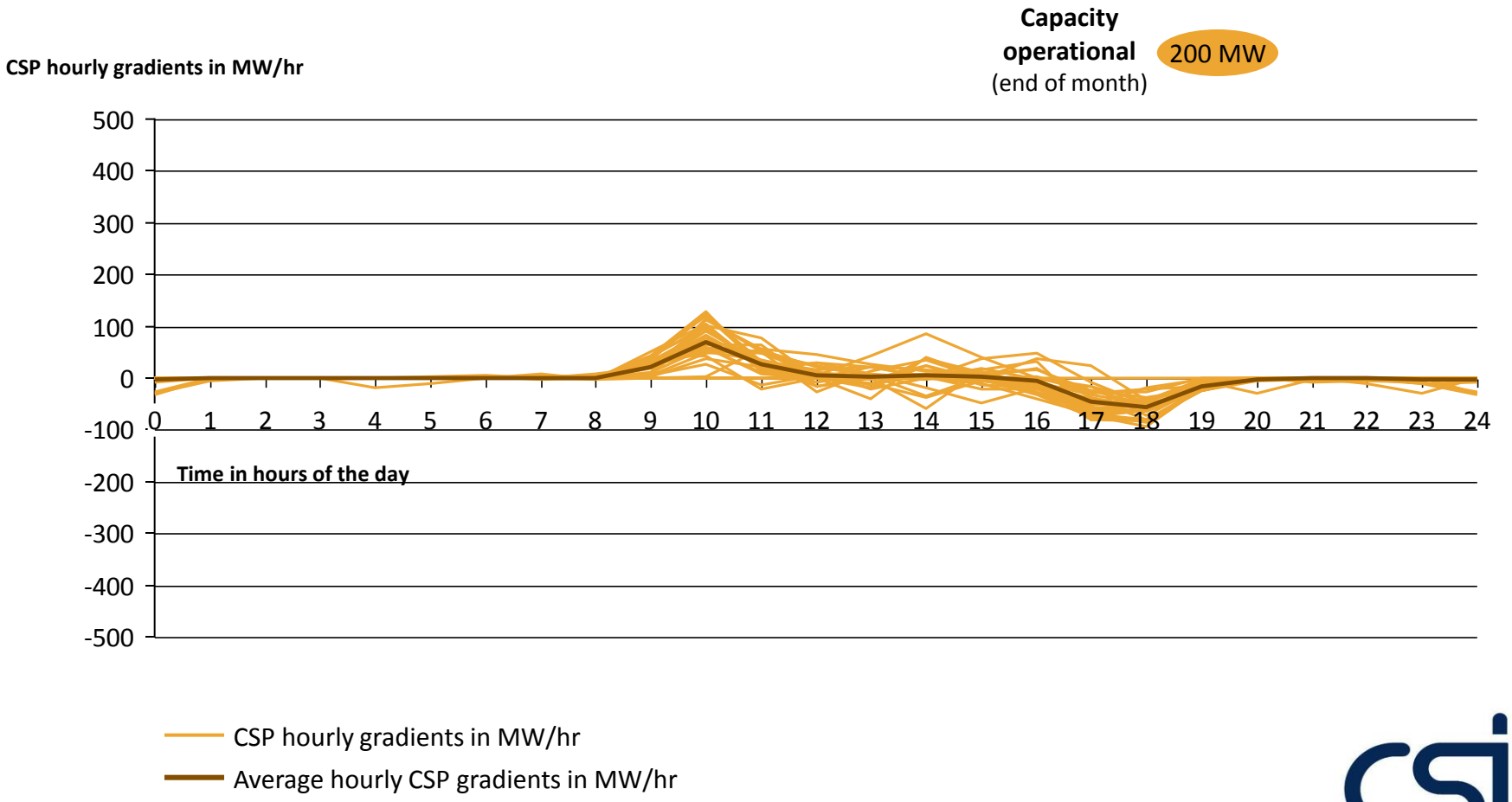
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in June 2016



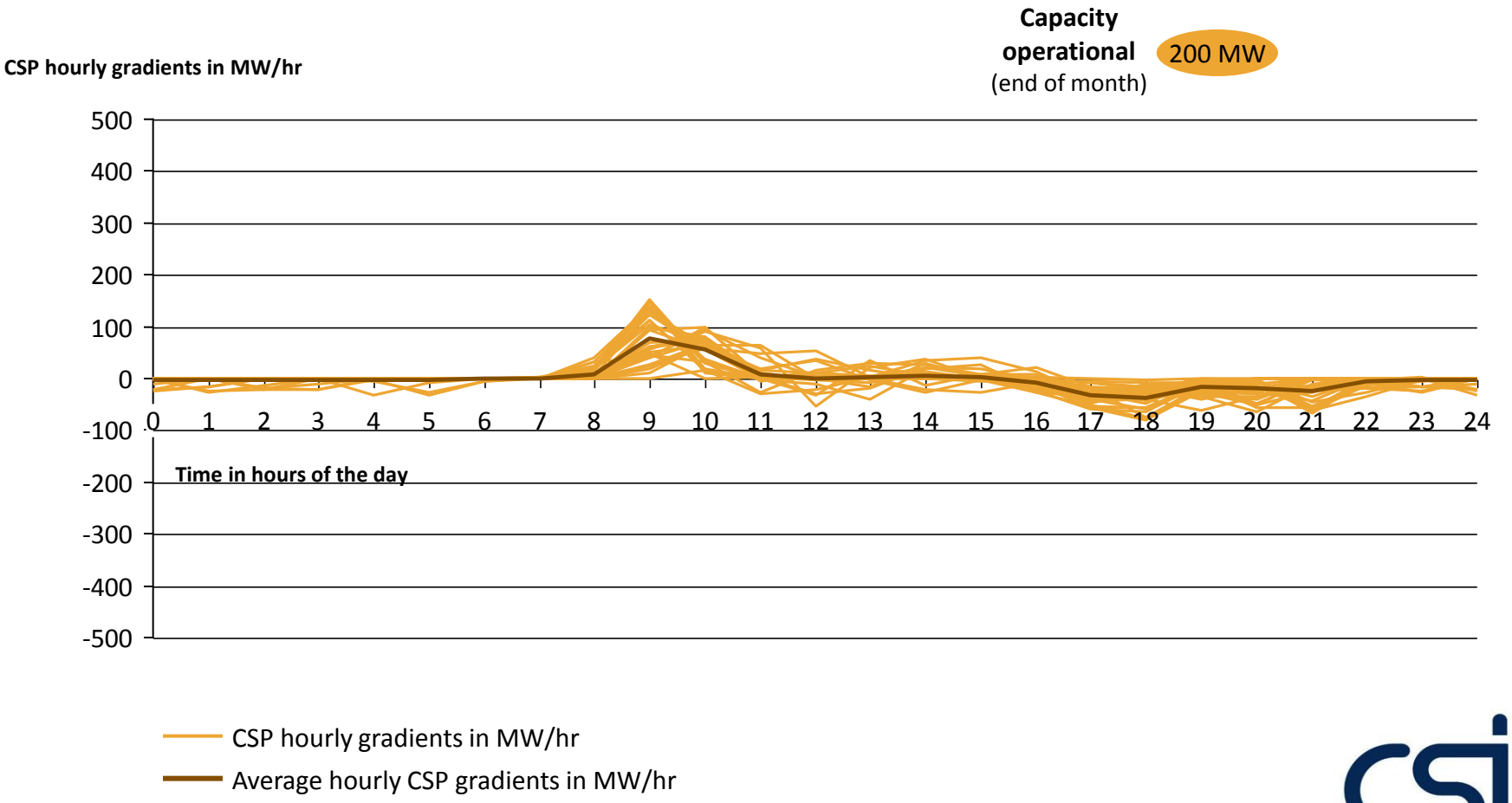
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in July 2016



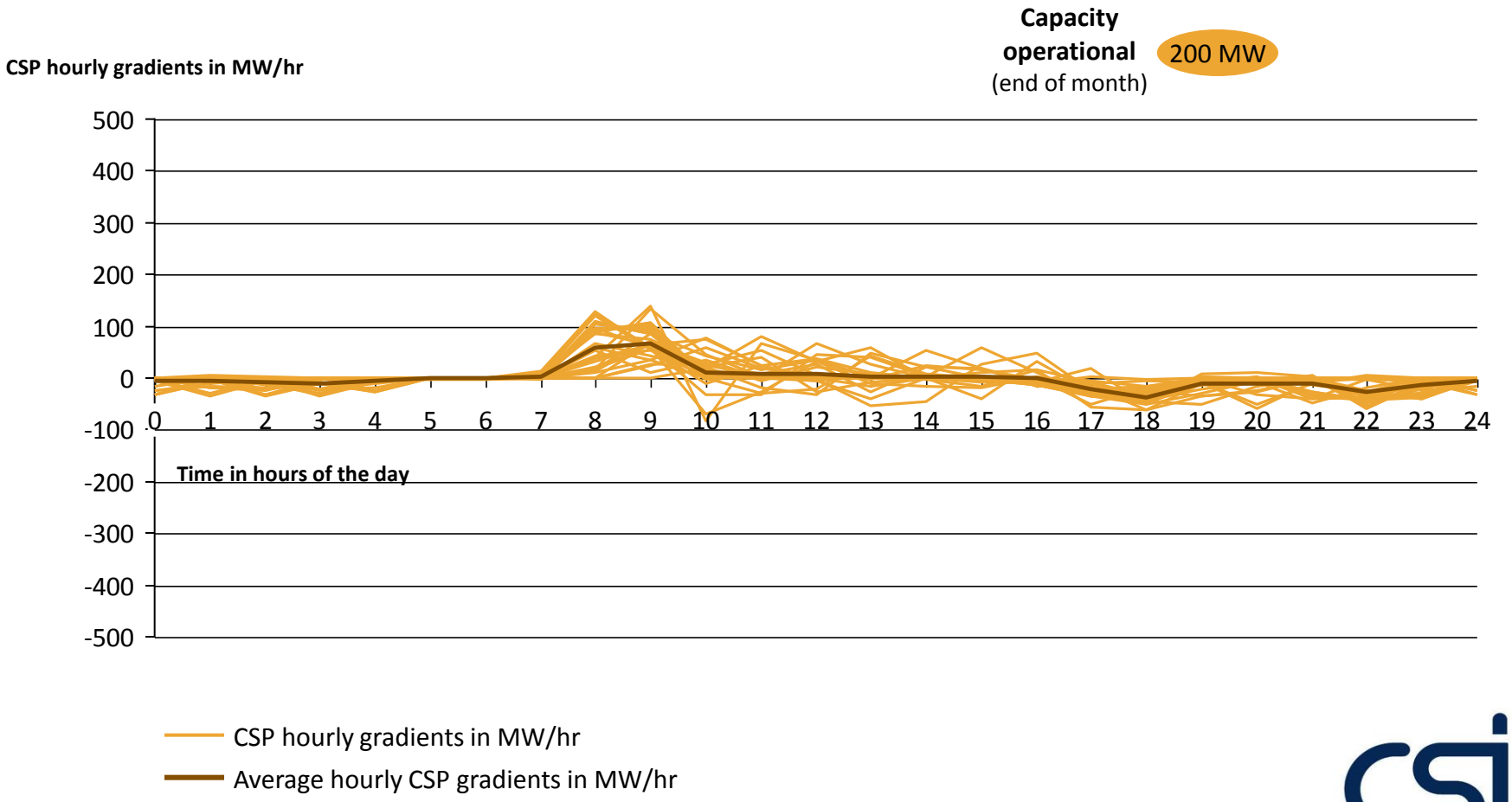
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in August 2016



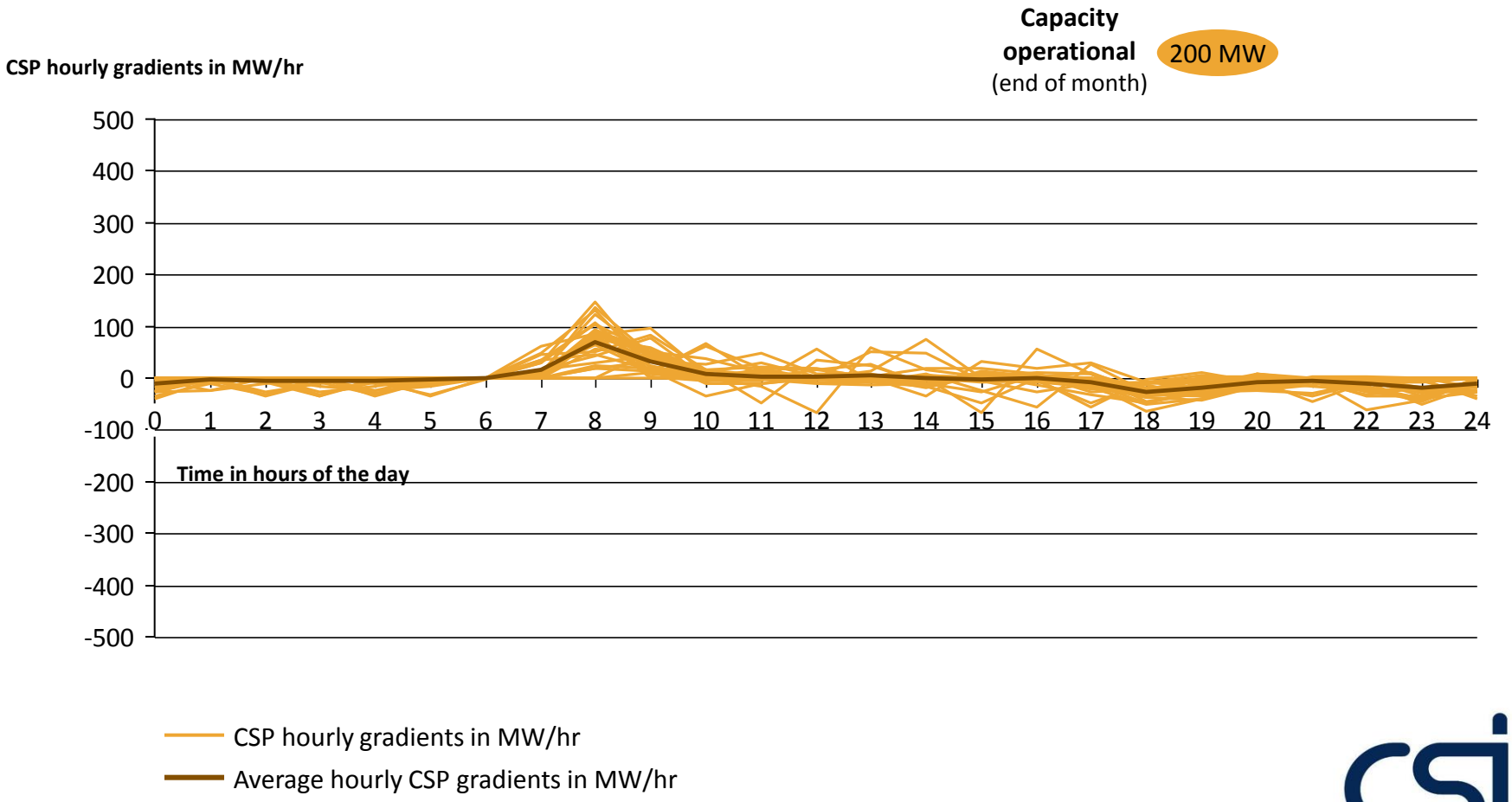
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in September 2016



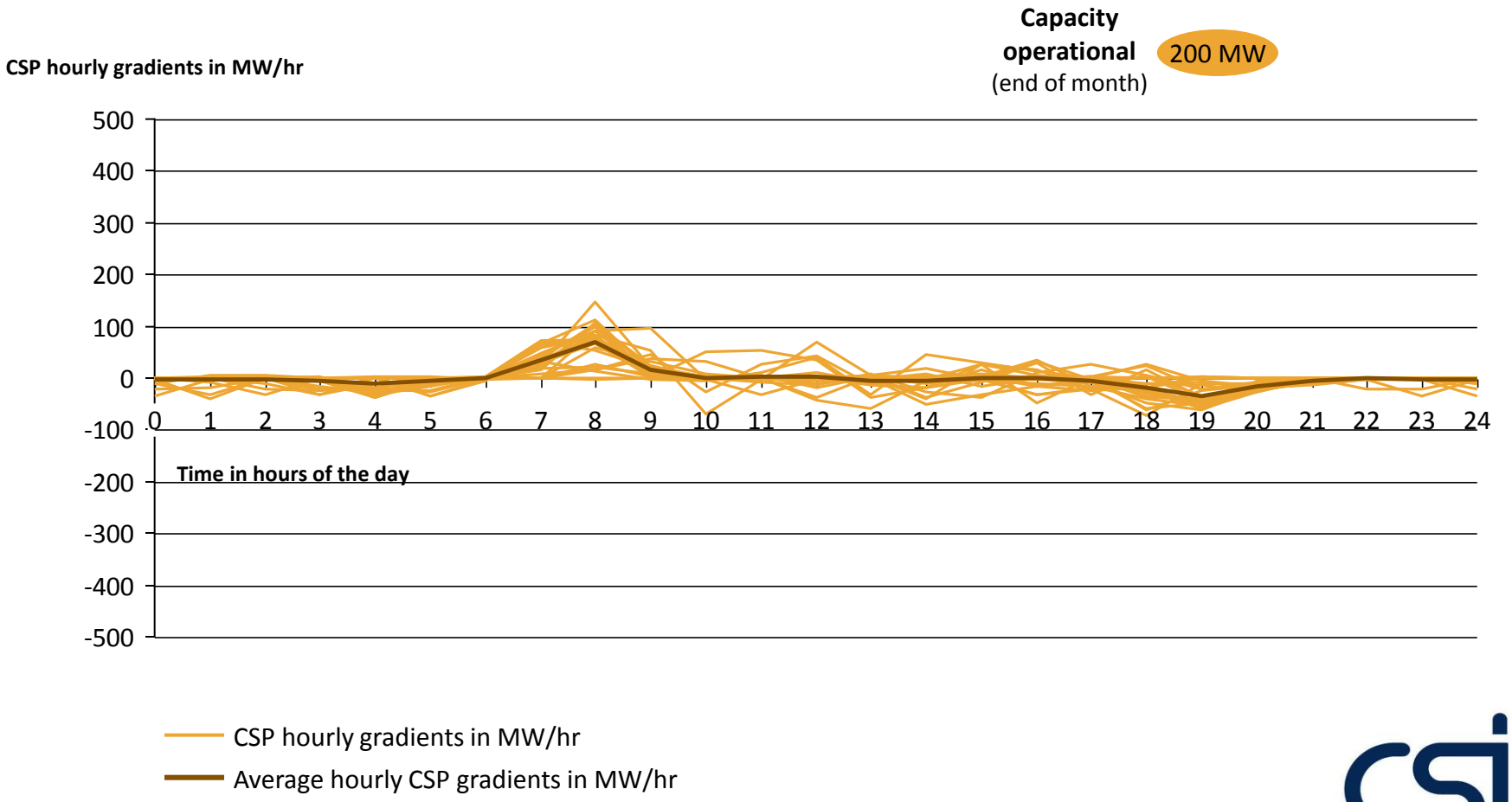
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in October 2016



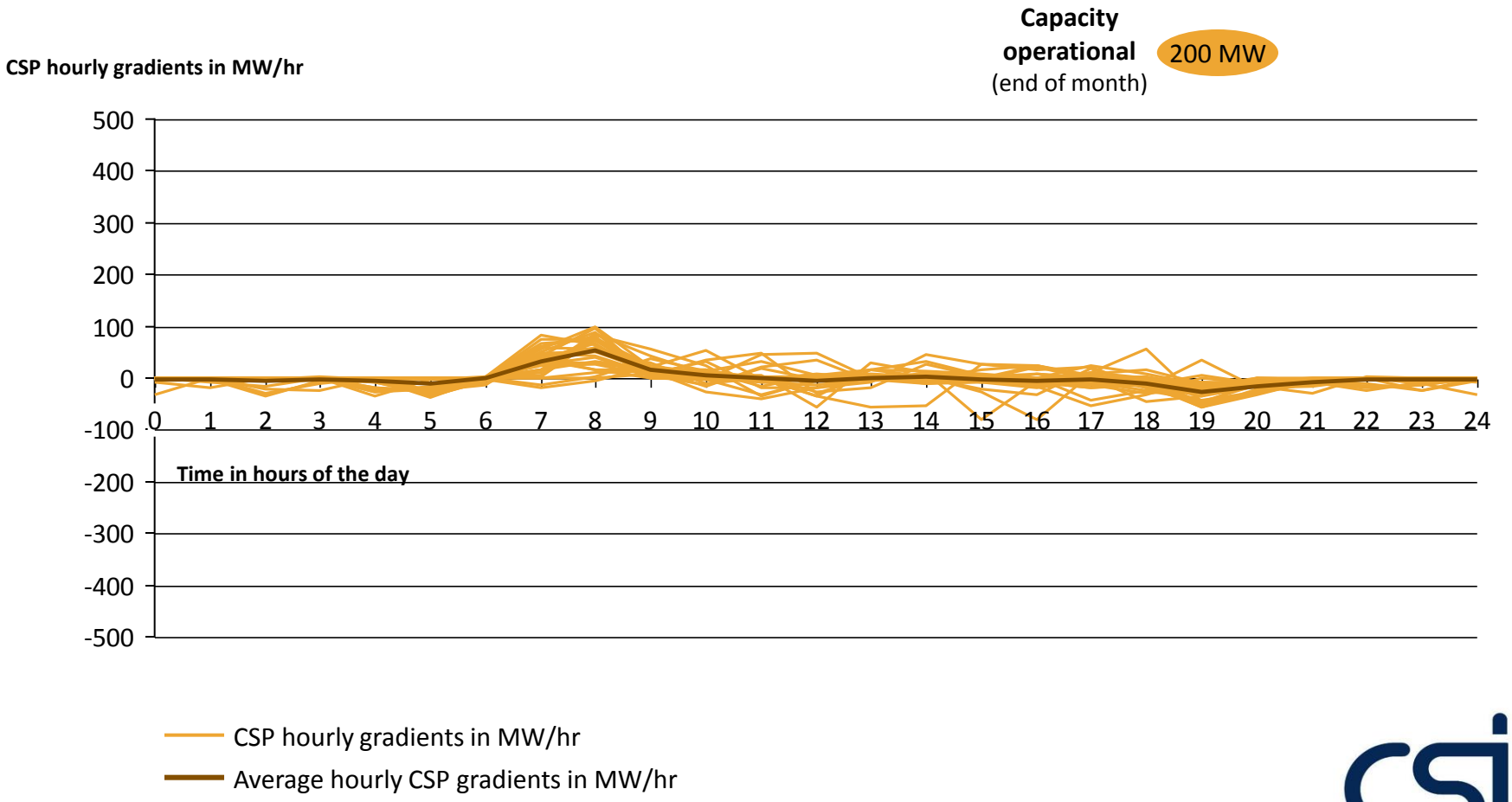
Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in November 2016



Sources: Eskom; CSIR Energy Centre analysis

CSP 1-hour gradients in December 2016



Sources: Eskom; CSIR Energy Centre analysis

Agenda

Overview actual electricity production data for first half of 2016

Monthly electricity production

Weekly electricity production

Daily electricity production

Hourly electricity production and gradients

Actual load shedding in 2016

There has been no load shedding in 2016

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 the calendar year 2016 on aggregated level for all installed wind and solar PV
  Total hourly system energy for the calendar year 2016, minus hydro pumping load

Total wind and solar PV capacity operational

- Data source: Department of Energy (DoE) IPP Office
- Type of data: Monthly total wind and solar PV IPPs operational

Actual load shedding data

- Data source: Tracking of Eskom Hld SOC Ltd Twitter page (https://twitter.com/eskom_sa) load shedding announcements

Re a leboha

Ha Khensa

Enkosi

Siyathokoza

Thank you!

Re a leboga

Ro livhuha

Dankie

Siyabonga