

Brief analysis of variable renewable energy contribution during loadshedding (Q1-2019)

CSIR Energy Centre

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Key takeaways

A constrained power system meant South Africa had to loadshed again in Q1-2019

- The RSA power system again became constrained in Q1-2019 with Eskom needing to loadshed (Stage 4 at times)
- Causes of loadshedding have been cited as high unplanned plant failures on the thermal coal fleet, the loss of Cahora Bassa import from Mozambique followed by intensive use of diesel (at OCGTs) and water (at pumped storage schemes) which eventually depleted¹
- This has been the most intensive loadshedding experienced in RSA with 595 GWh of load shed just in March 2019 of the total 769 GWh in Q1-2019 (there was 1325 GWh of loadshedding throughout 2015)

The utility-scale VRE fleet notably contributed to limit the extent of loadshedding in Q1-2019

- The utility-scale VRE fleet² contributed 2 975 GWh (5.3%) to the RSA power system in Q1-2019 with monthly contributions ranging from 4.9-6.0%, weekly contributions from 4.1-7.0% and daily contributions from 2.9-7.7%
- During loadshedding periods, the utility-scale VRE fleet contributed 357 GWh of the total 2975 GWh from VRE during Q1-2019 i.e. loadshedding could have increased from 769 GWh to 1126 GWh (a 46% increase)
- Instantaneous contributions from the VRE fleet during loadshedding periods was up to 2.3 GW i.e. without the VRE fleet, loadshedding stage 5 & 6 could have been invoked

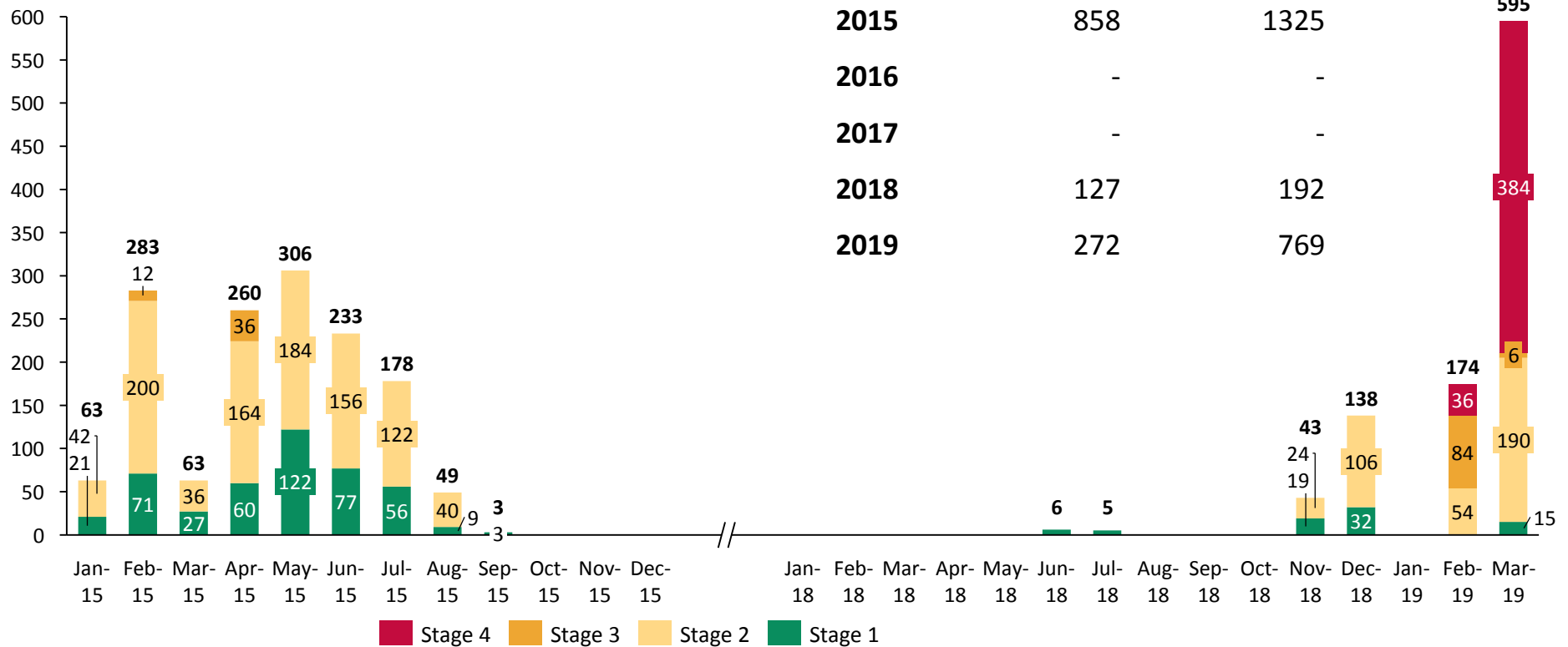
¹ Department of Public Enterprises, UPDATE : ESKOM ELECTRICITY SUPPLY, 03 April 2019;

² 1.5 GW solar PV, 2.0 GW wind and 0.5 GW CSP (CSP is marginally dispatchable considering coupling with thermal storage)

RSA = Republic of South Africa; VRE = variable renewable energy

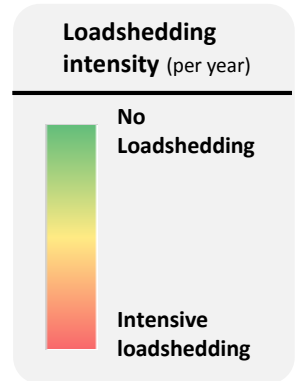
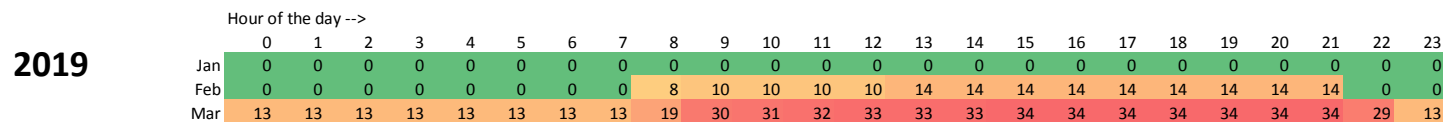
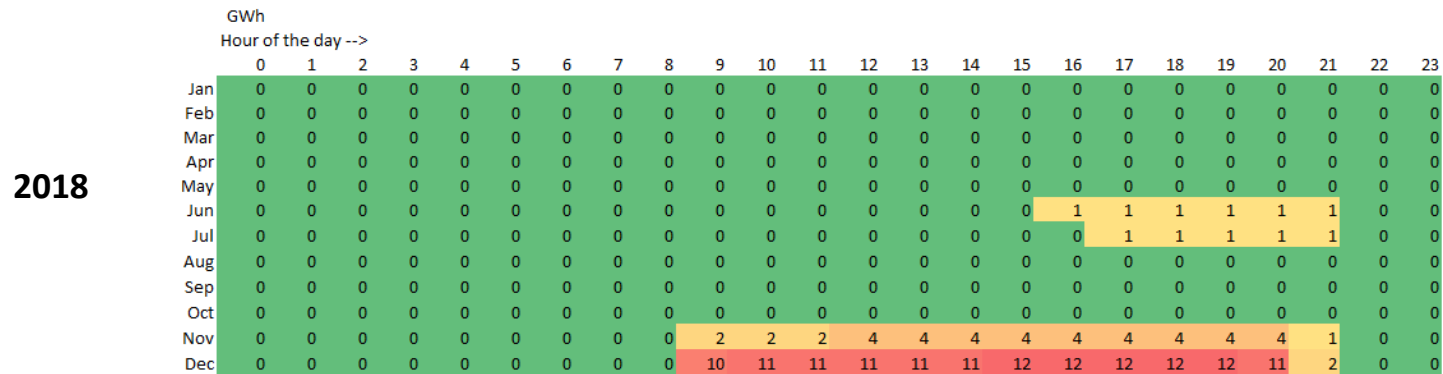
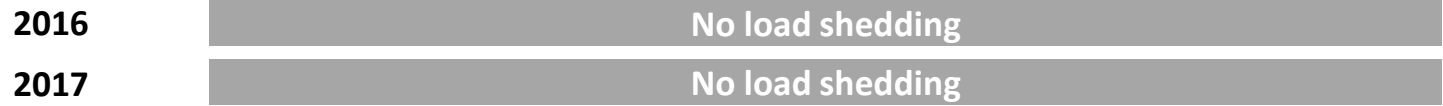
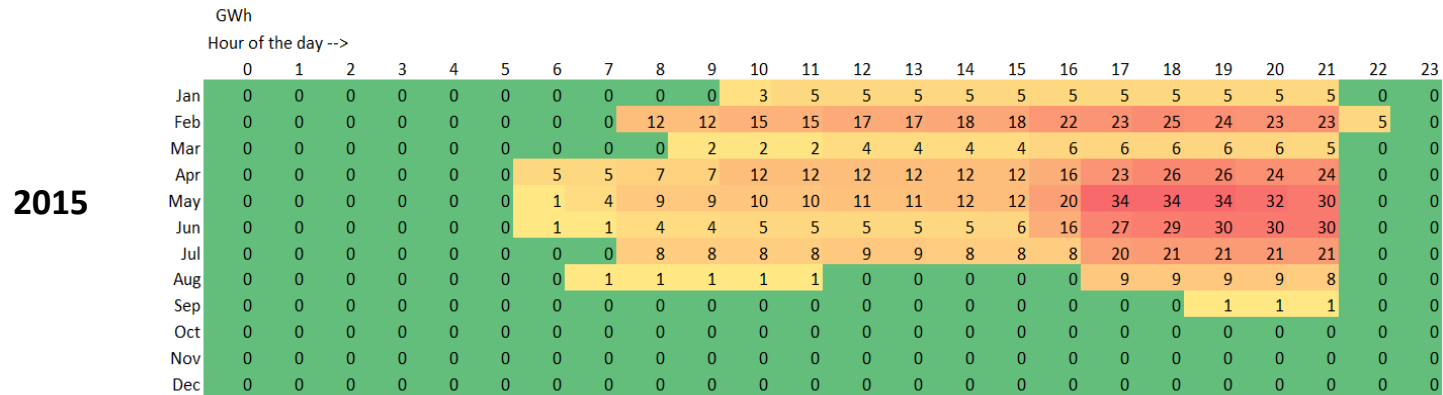
First 3 months of 2019 – most intensive loadshedding in March with 595 GWh of 769 GWh in 2019... 1325 GWh throughout 2015

GWh of load shedding



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

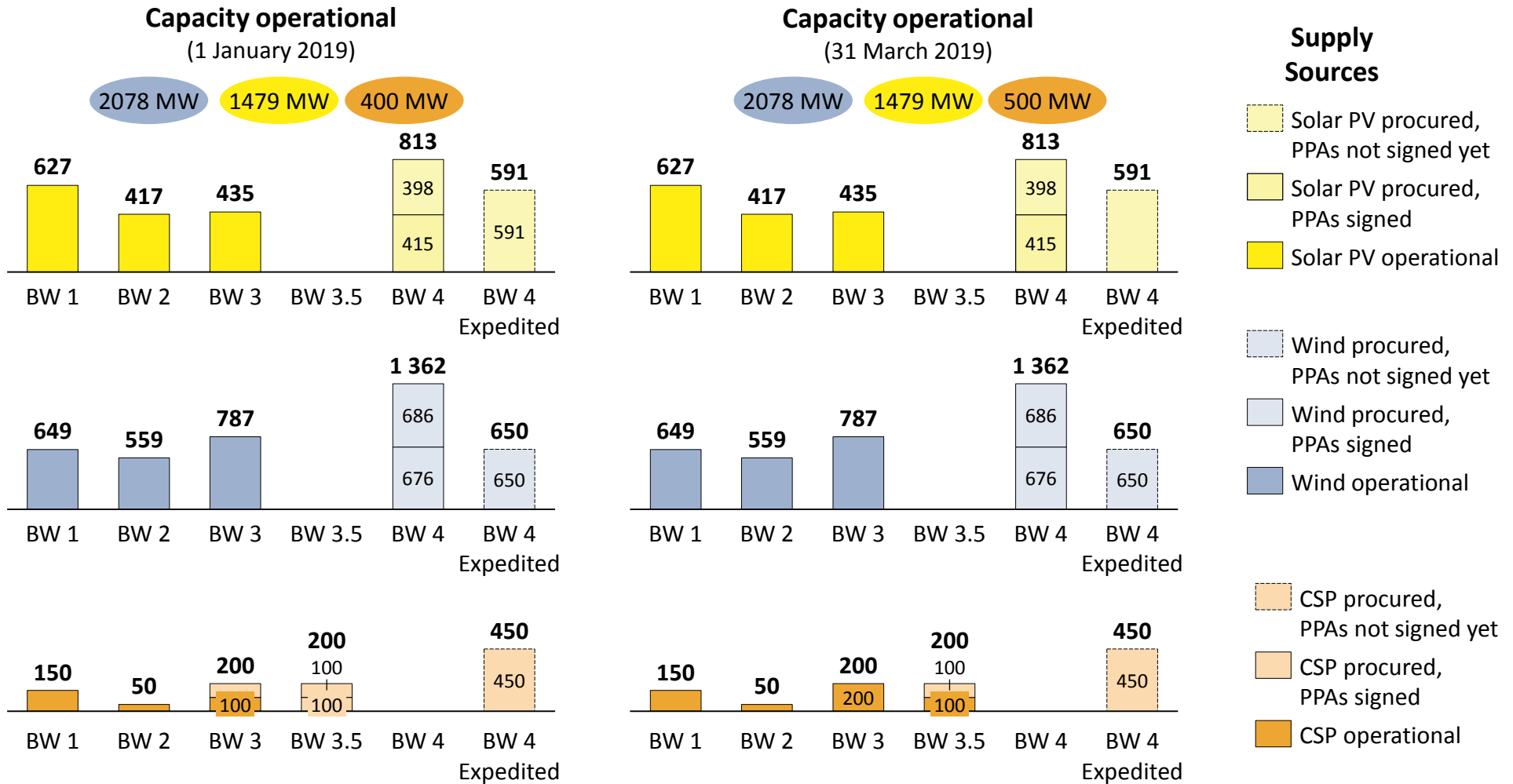
Loadshedding in 2015 predominantly during high demand periods (day and evening peaks)... most recently in 2019 this has been day/night



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

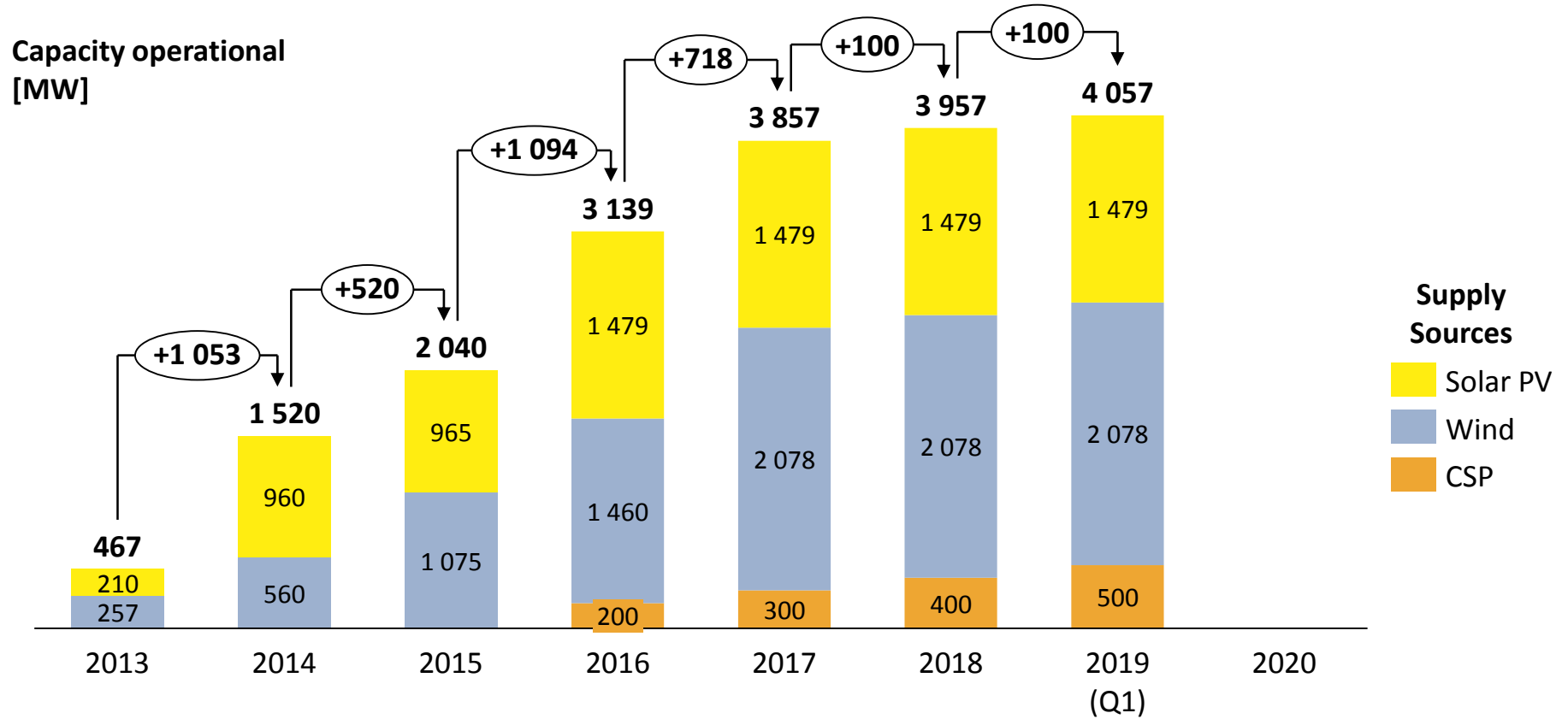
Sources: Eskom Twitter account; Eskom se Push (mobile app); CSIR analysis

Procured and operational capacity under RSA's RE IPP Procurement Programme (REIPPPP) with only 100 MW of CSP added in Q1-2019



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

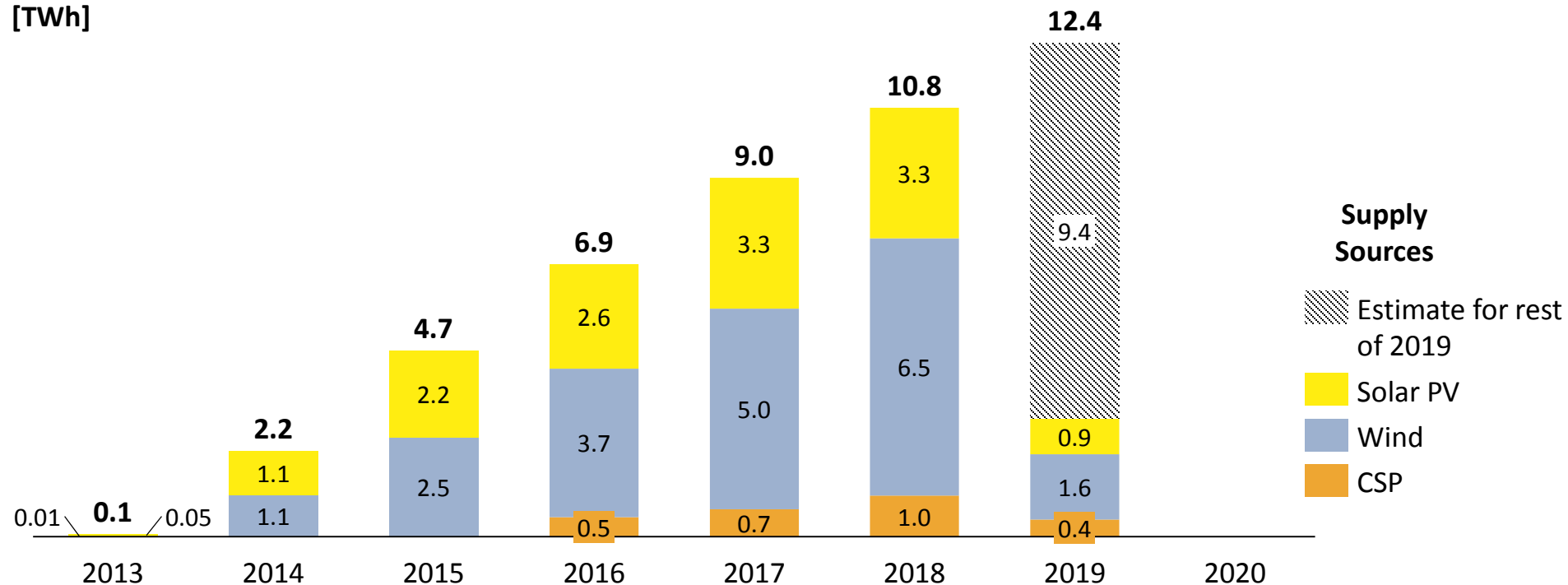
From 1 November 2013 to 31 March 2019, 2 078 MW of wind, 1 479 MW of large-scale solar PV and 500 MW of CSP became operational in RSA



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

In Q1-2019 - 3.0 TWh of wind, solar PV and CSP energy was produced in RSA with estimates of over 12 TWh for 2019 expected

Annual energy produced [TWh]



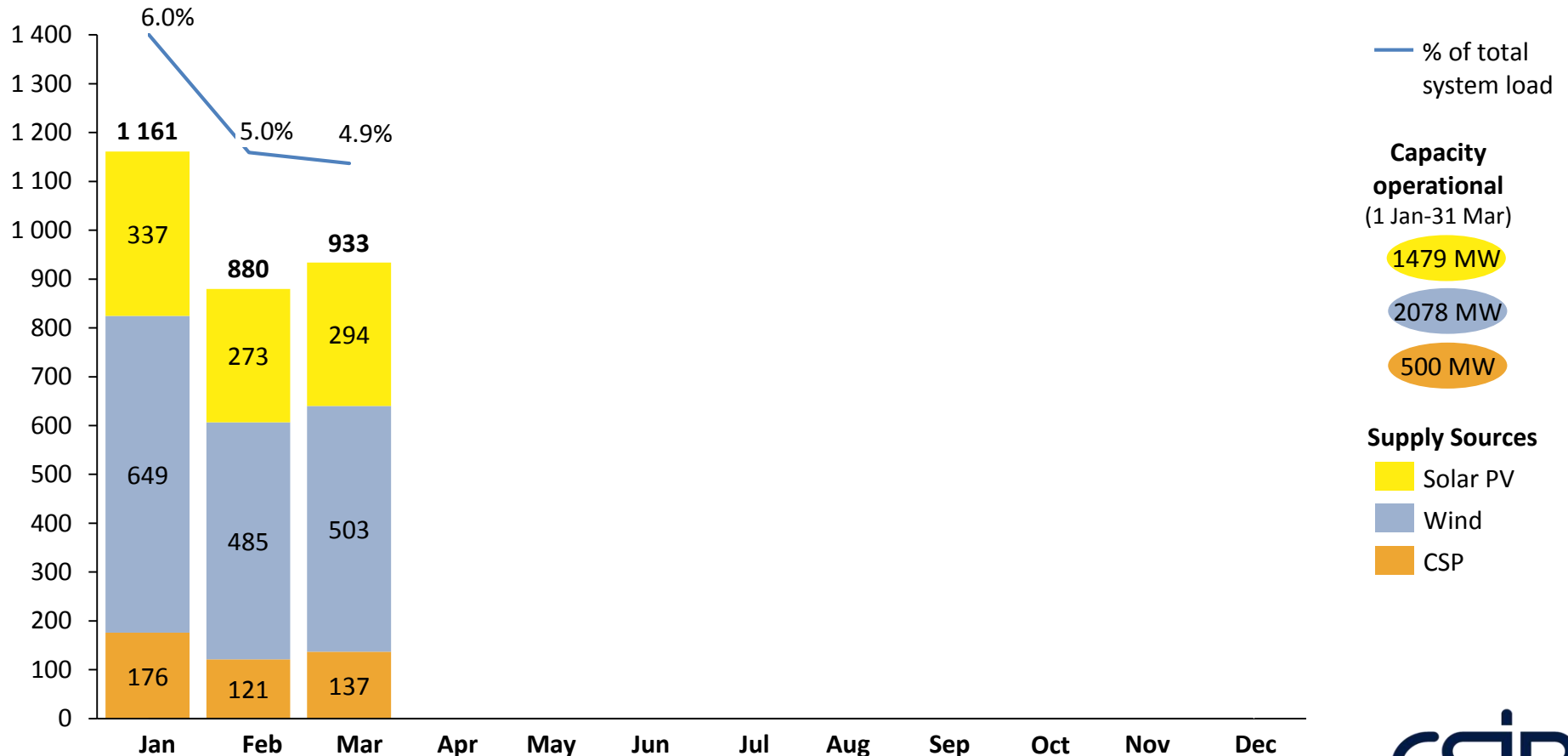
Notes: Wind includes Eskom's Sere wind farm (100 MW). CSP energy measured from date when more than two CSP plant were commissioned.

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

Sources: Eskom; DoE IPP Office

Monthly electricity production of SA's wind, solar PV and CSP fleet ranging from 4.9-6.0% (similar to previous year)

Monthly electricity production in GWh



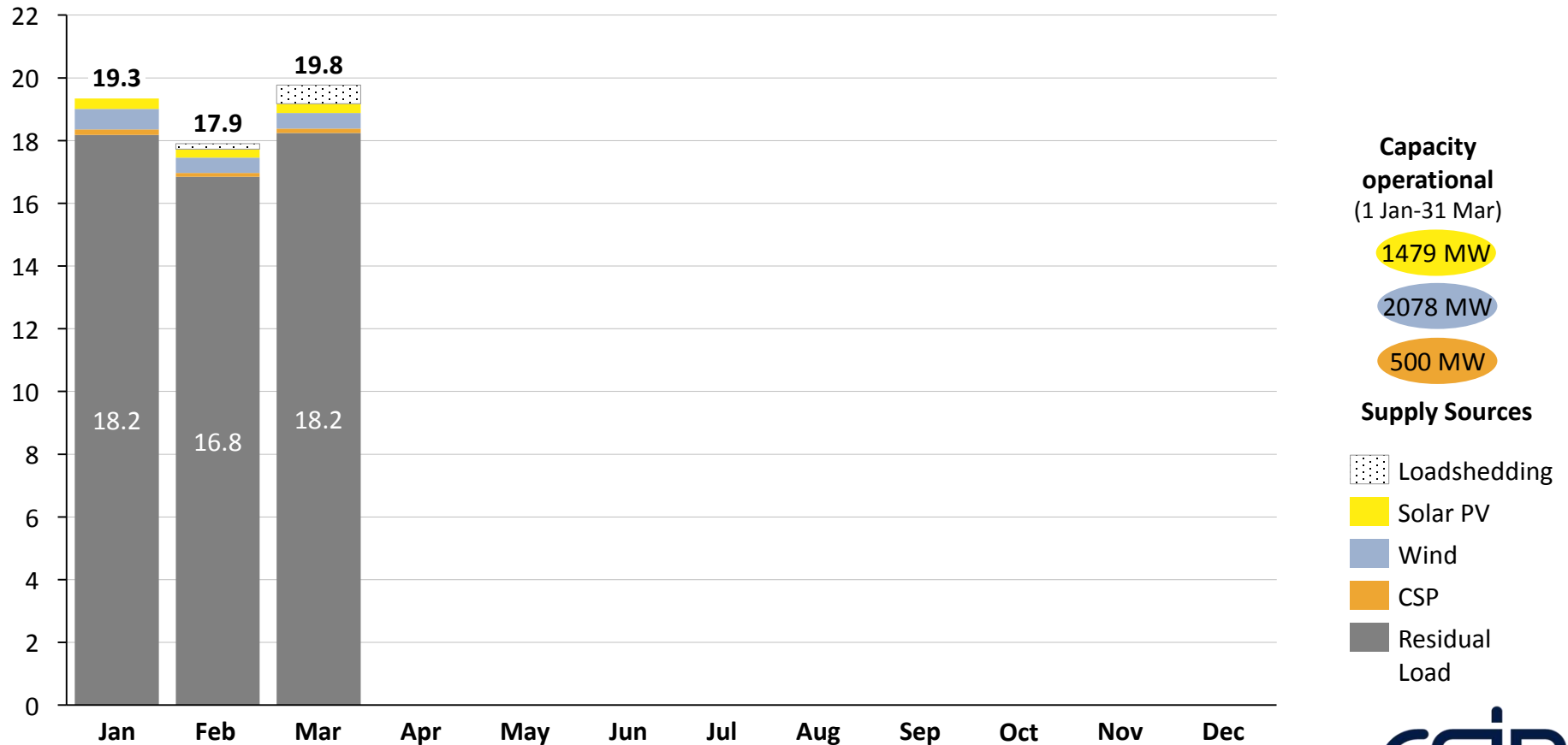
Note: Wind generation includes Eskom's 100 MW Sere wind farm. CSP energy only measured from date when more than two CSP plant were commissioned.

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

Sources: Eskom; CSIR Energy Centre analysis

Monthly electricity production from wind, solar PV, CSP, residual load and loadshedding impact in Q1-2019

Monthly electricity production in TWh

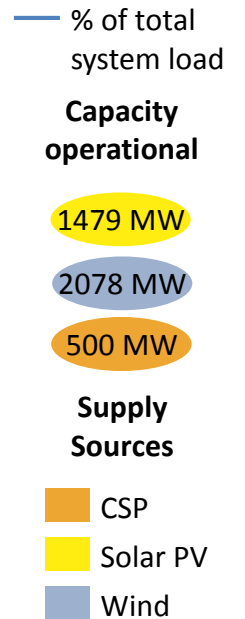
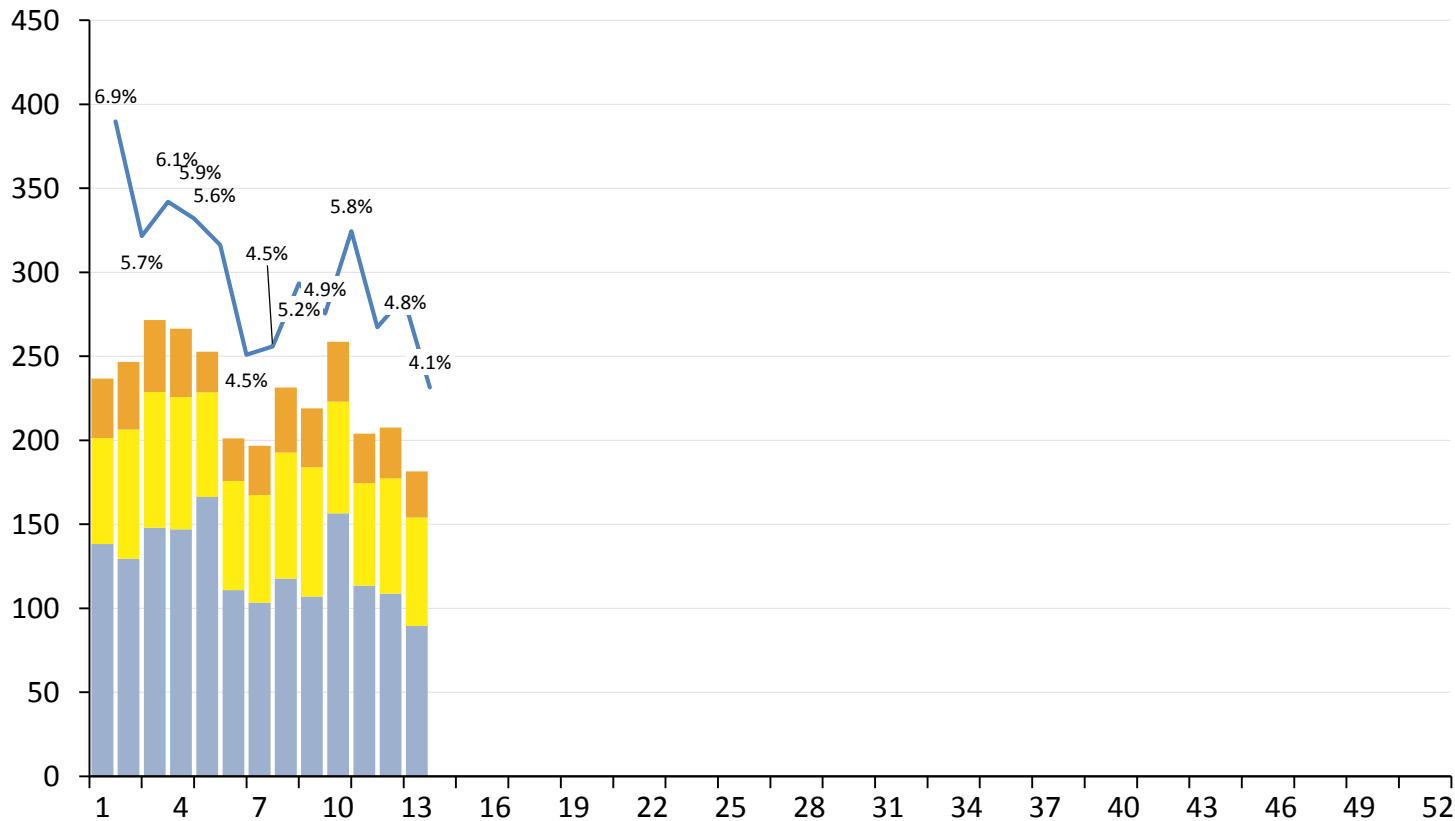


Notes: Pumping load excluded. Wind generation includes Eskom's 100 MW Sere wind farm.

Sources: Eskom; CSIR Energy Centre analysis

Weekly contribution from utility-scale RE in first 3 months of 2019 ranges from 4.1-6.9% of total system demand

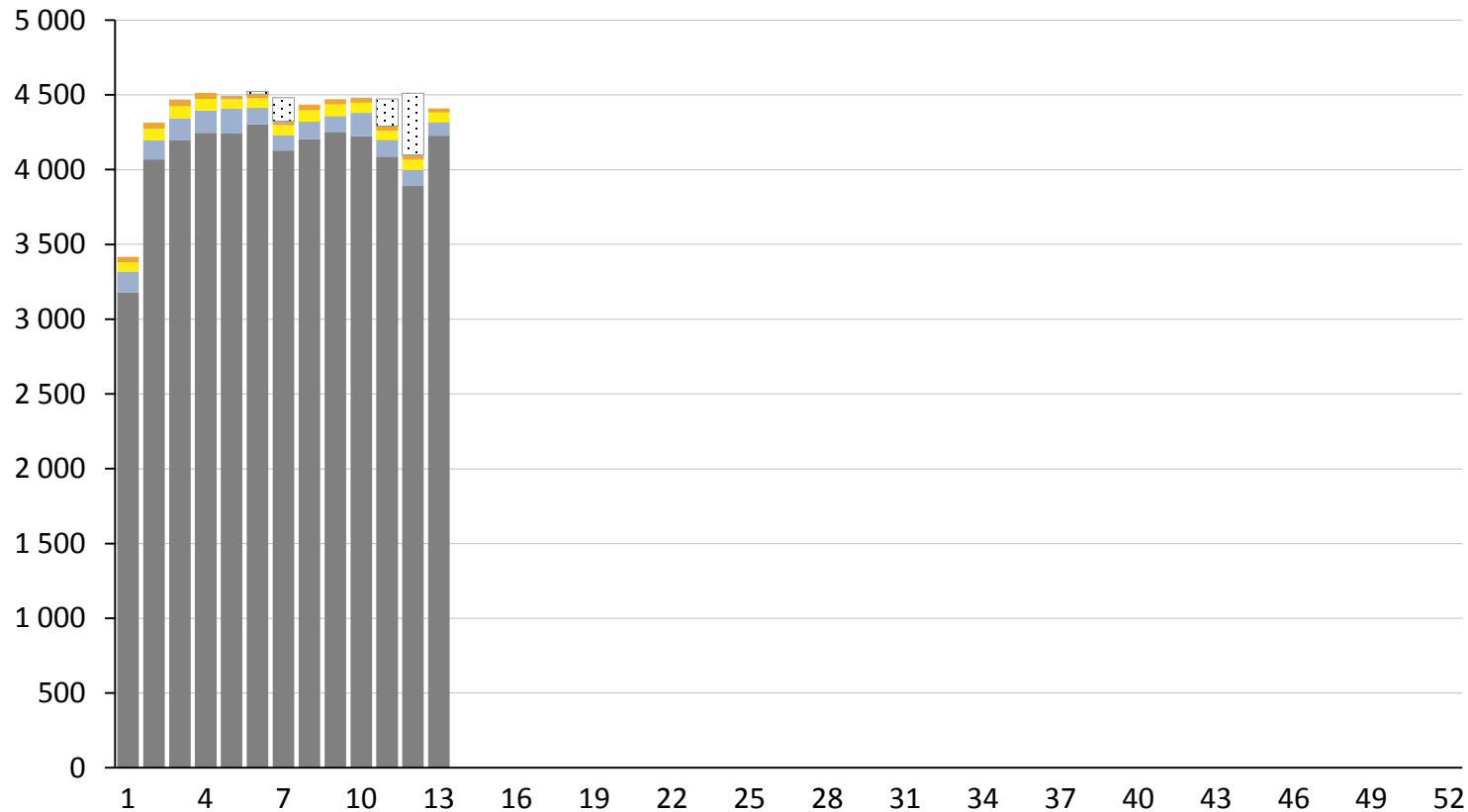
Electricity production in GWh/week



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

Weekly electricity production wind, solar PV, CSP, residual load and loadshedding in Q1-2019

Electricity production
in GWh/week



Capacity
operational

1479 MW

2078 MW

500 MW

Supply
Sources

Loadshedding

CSP

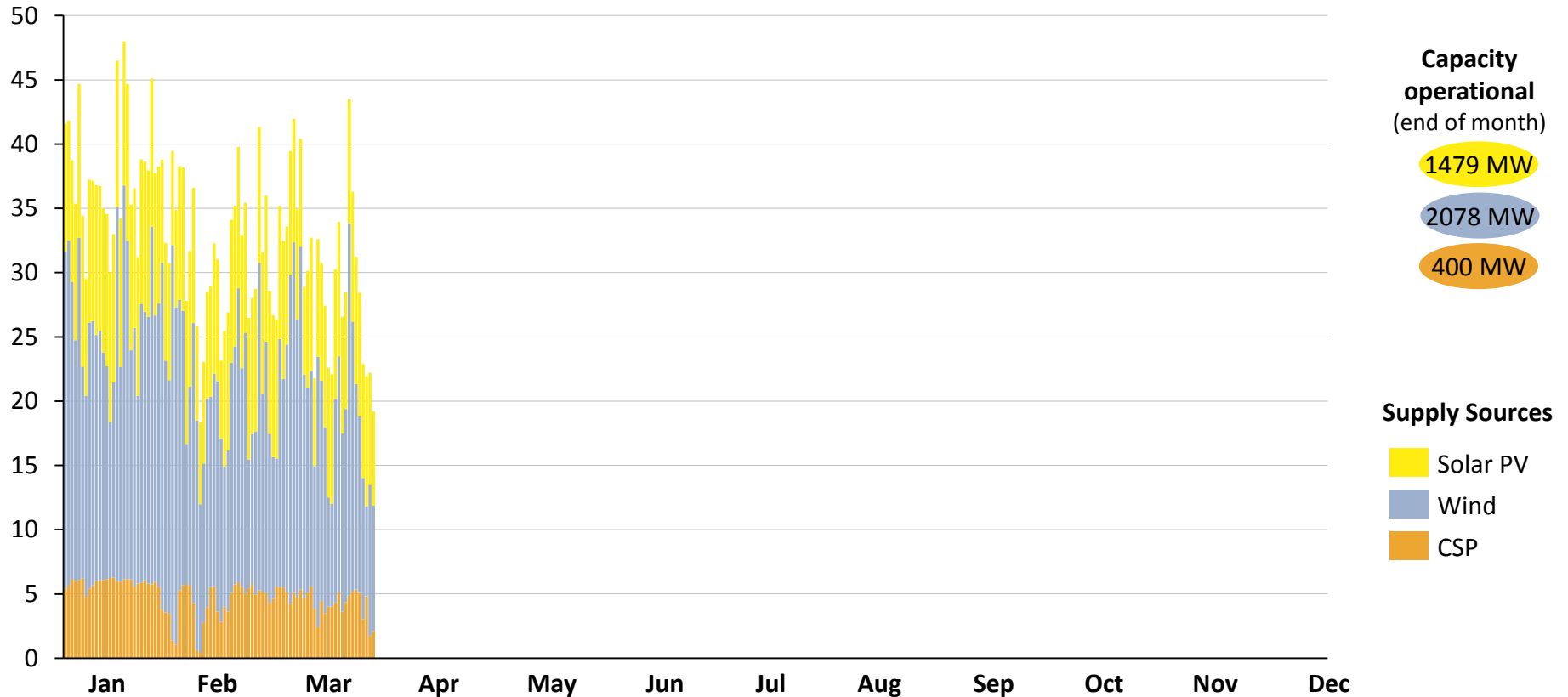
Solar PV

Wind

Residual
Load

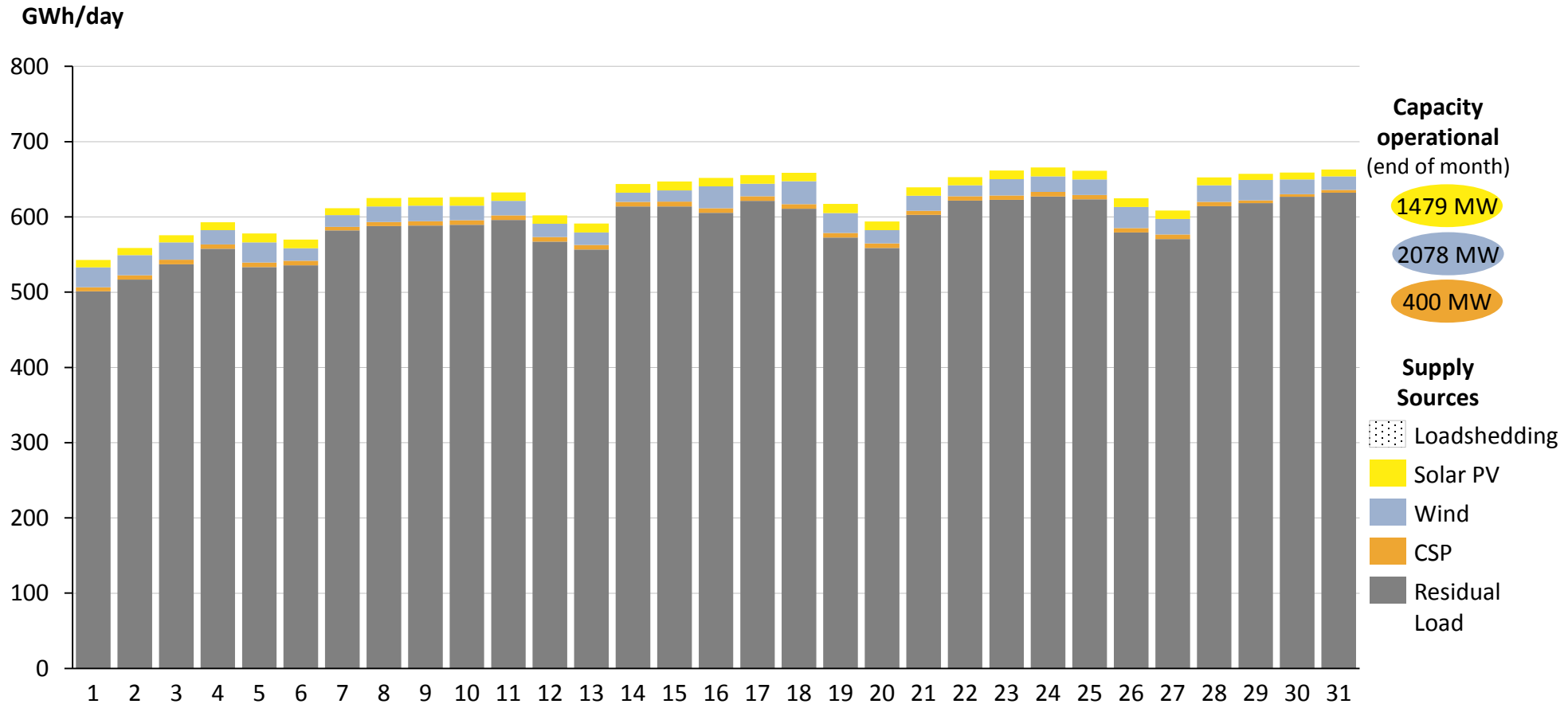
For Jan-Mar 2019, electricity production from wind, solar PV and CSP was above 25 GWh/d 90% of the time with maximum of 48 GWh/d

Electricity production
in GWh/day



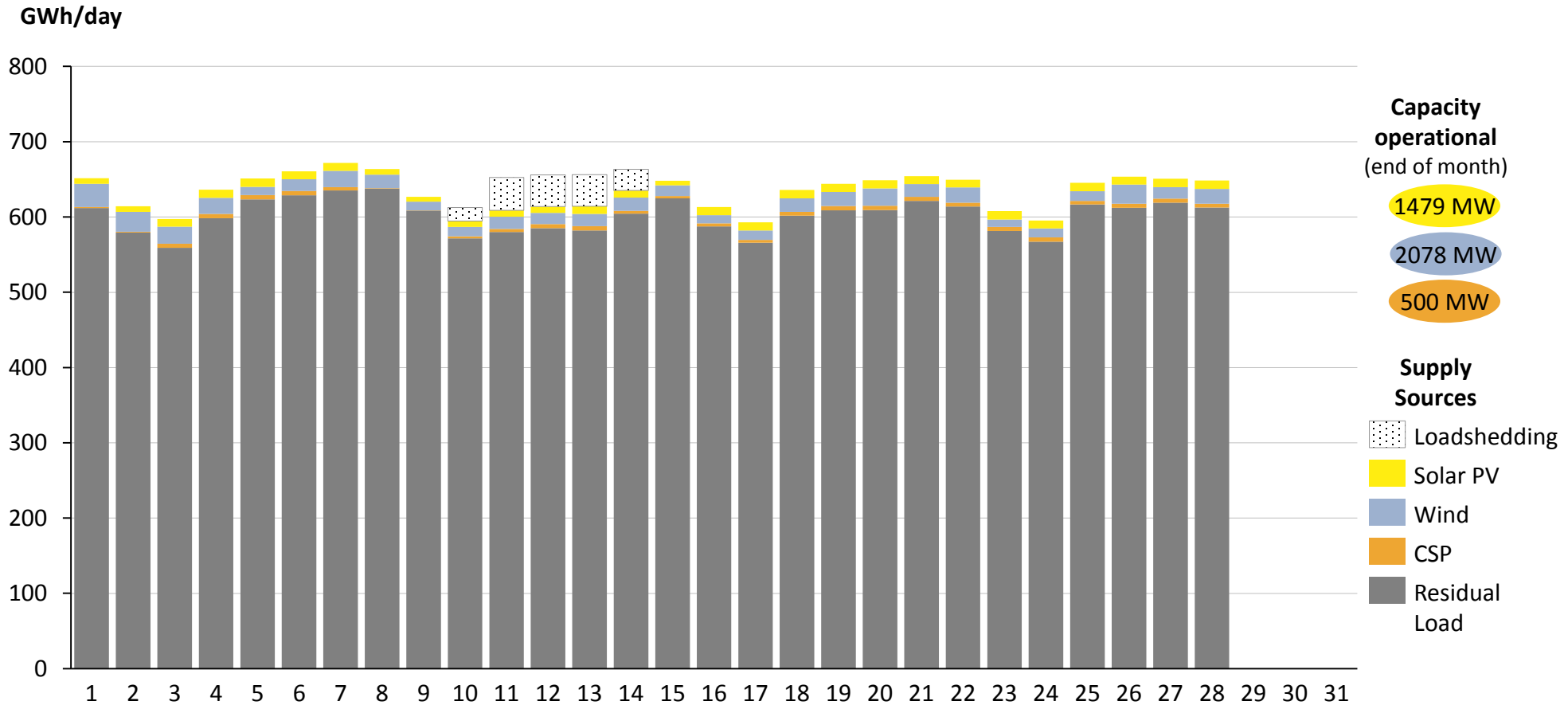
Note: Design as per Fraunhofer ISE. Wind includes Eskom's Sere wind plant.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 543-666 GWh in Jan 2019 with VRE contributing 5-8%



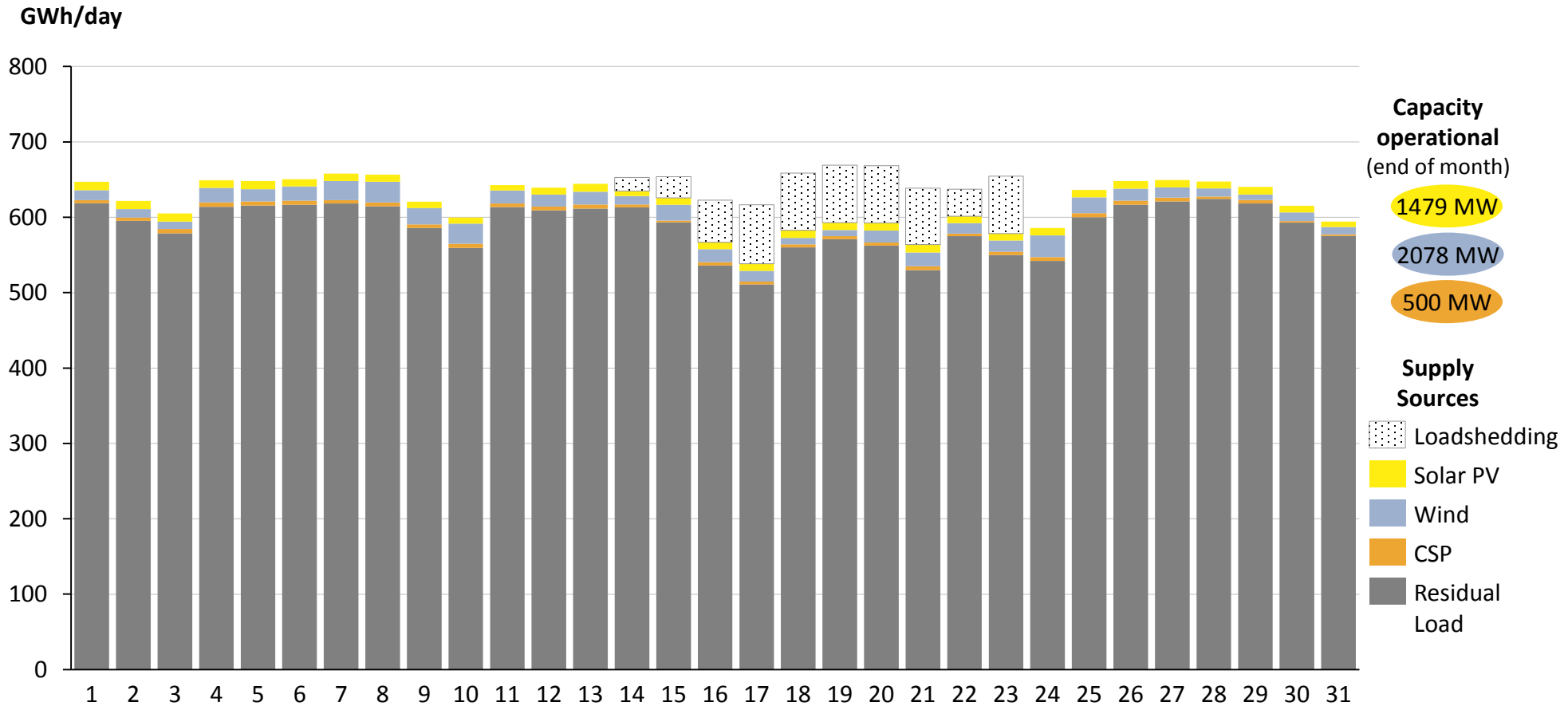
Note: Design as per Fraunhofer ISE. Daily production excludes pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of between 593-672 GWh/d in Feb 2019, VRE supplied 3-6% of system demand and up to 7% of load was shed



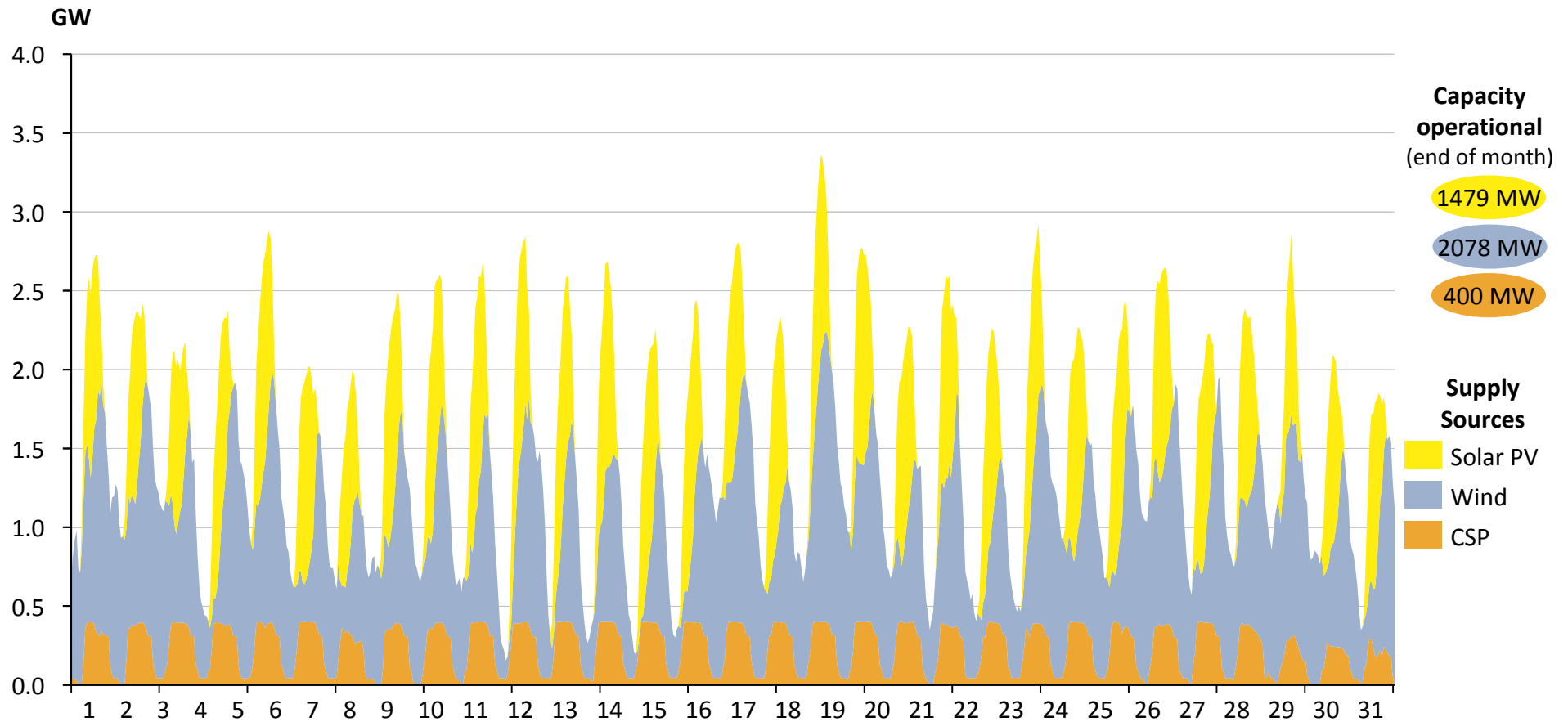
Note: Design as per Fraunhofer ISE. Daily production excludes pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Daily electricity production of 538-658 GWh/d in Mar 2019, VRE contributed 3-7% everyday and up to 14% of load was shed



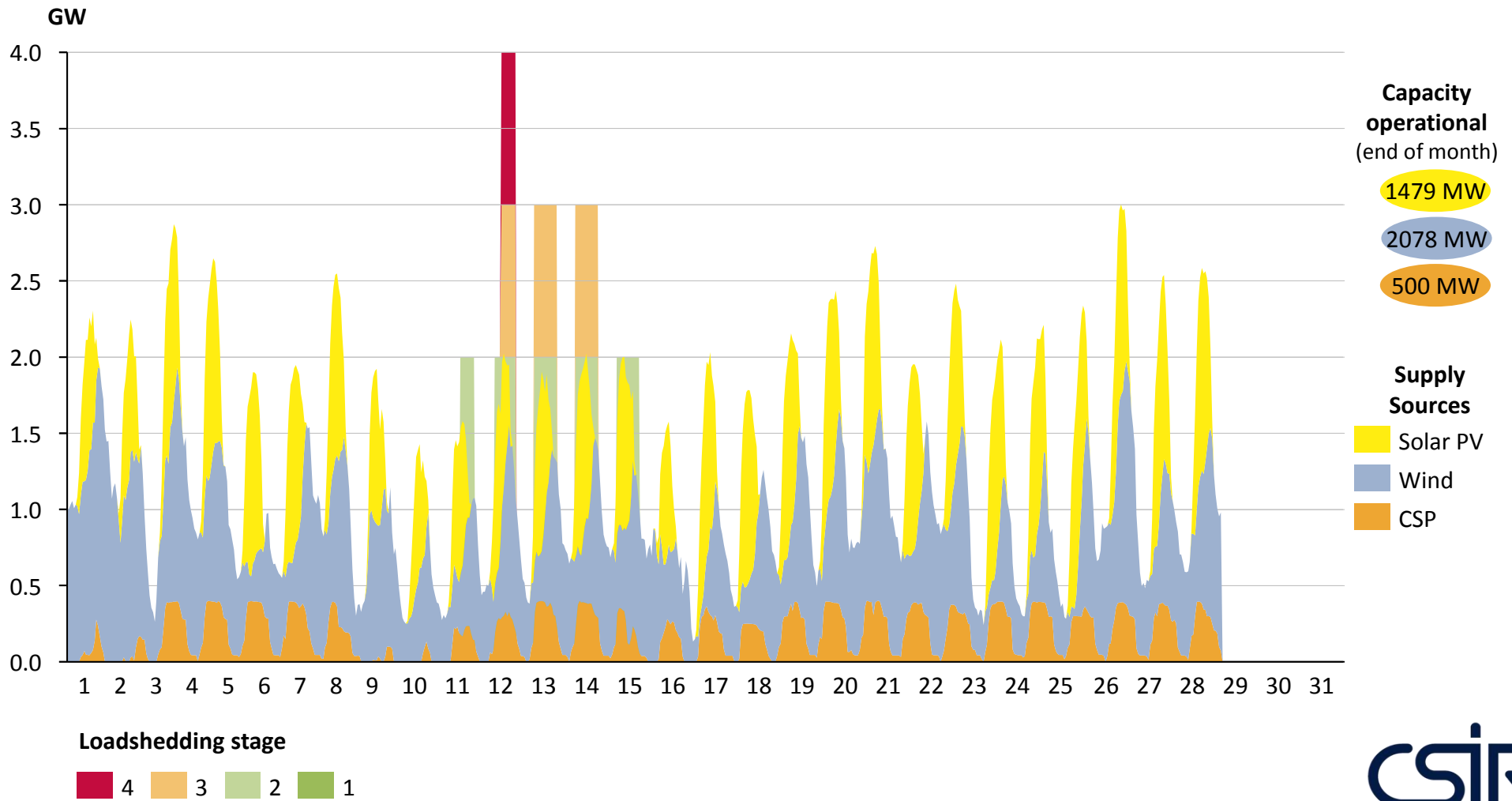
Note: Design as per Fraunhofer ISE. Daily production excludes pumping load. Wind includes Sere.
Sources: Eskom; CSIR Energy Centre analysis

Hourly VRE production in Jan 2019 shows periodic solar PV and CSP; wind varies but contributes notably during evening peaks



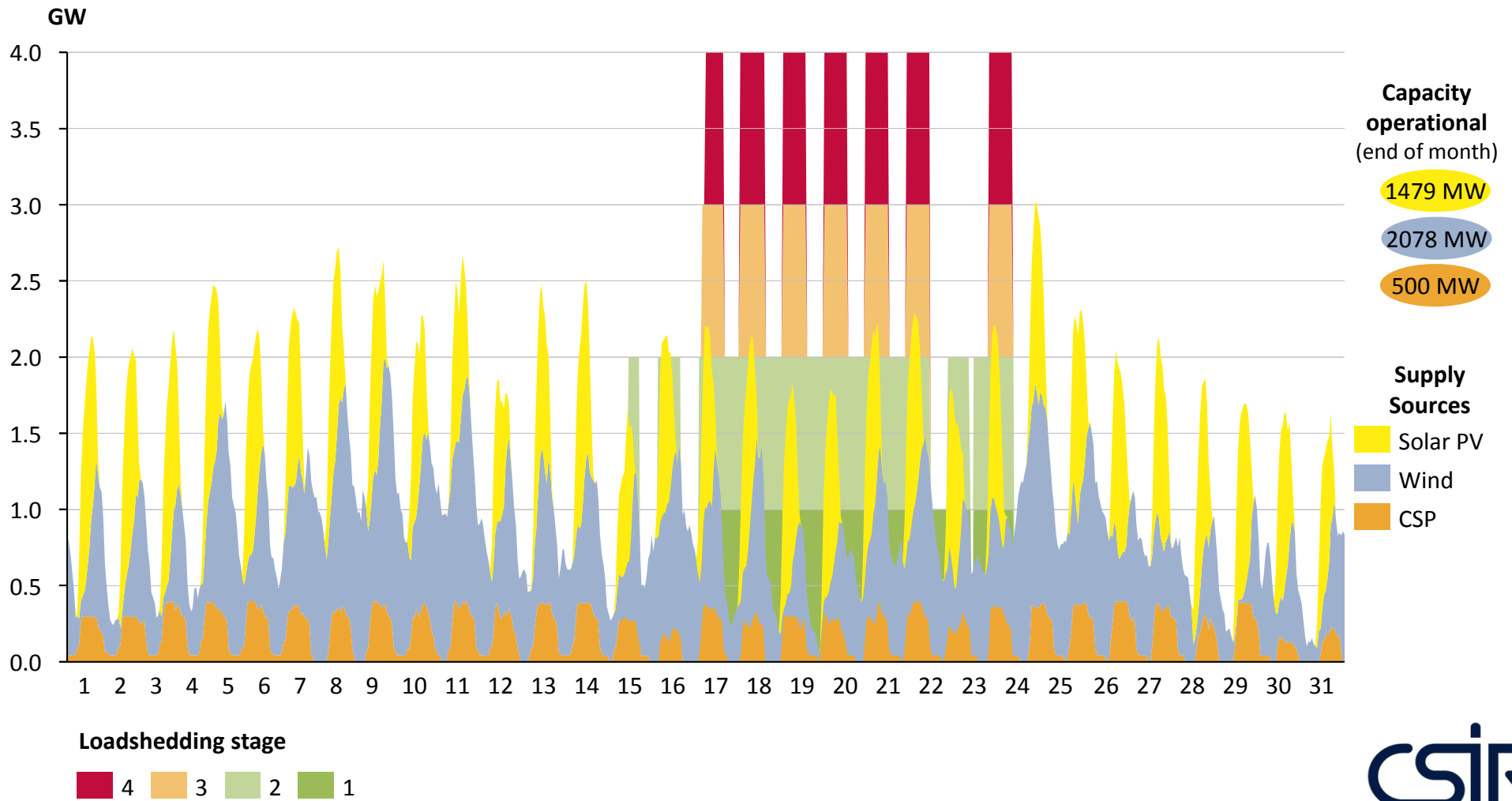
Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

Hourly VRE electricity production in Feb 2019 shows how loadshedding could have increased to Stage 5-6 without VRE



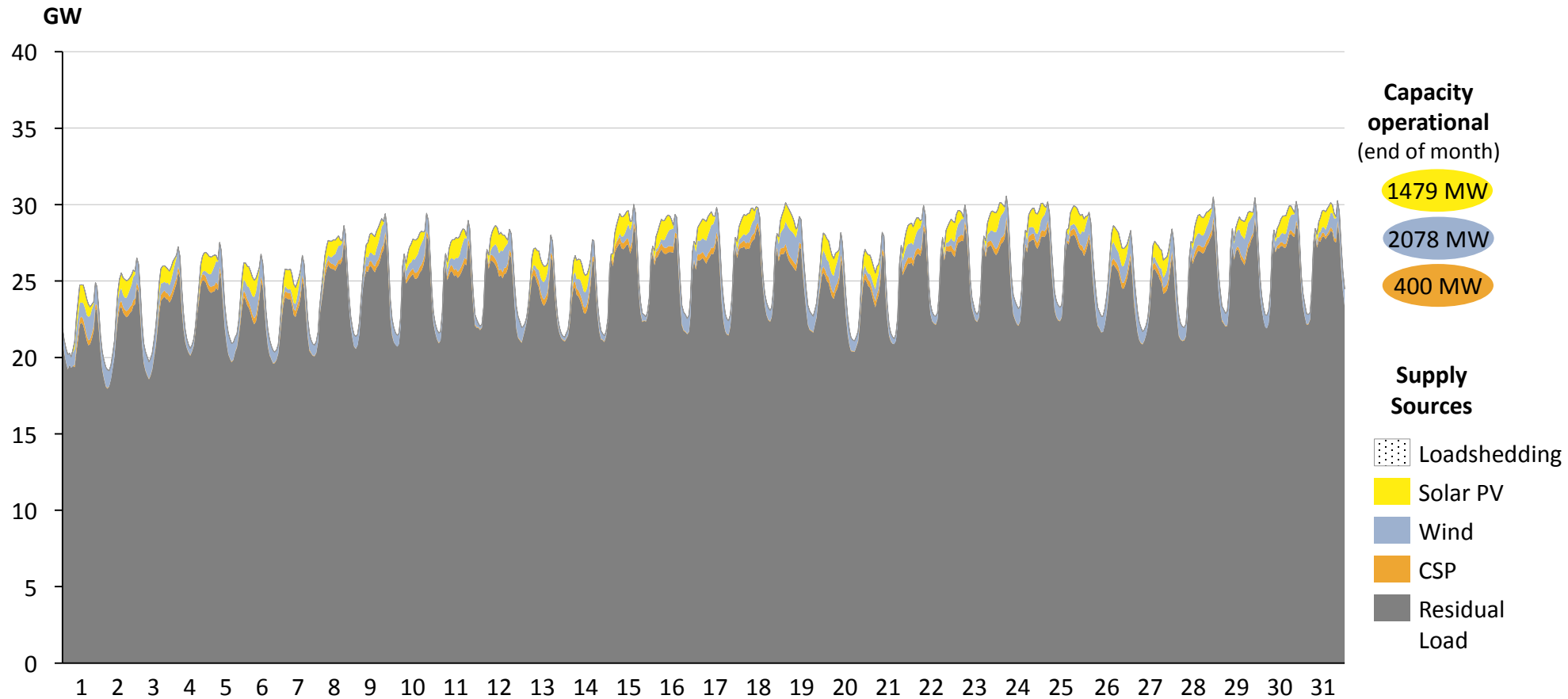
Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

Hourly VRE electricity production in Mar 2019 shows again how loadshedding could have increased to Stage 5-6 without VRE



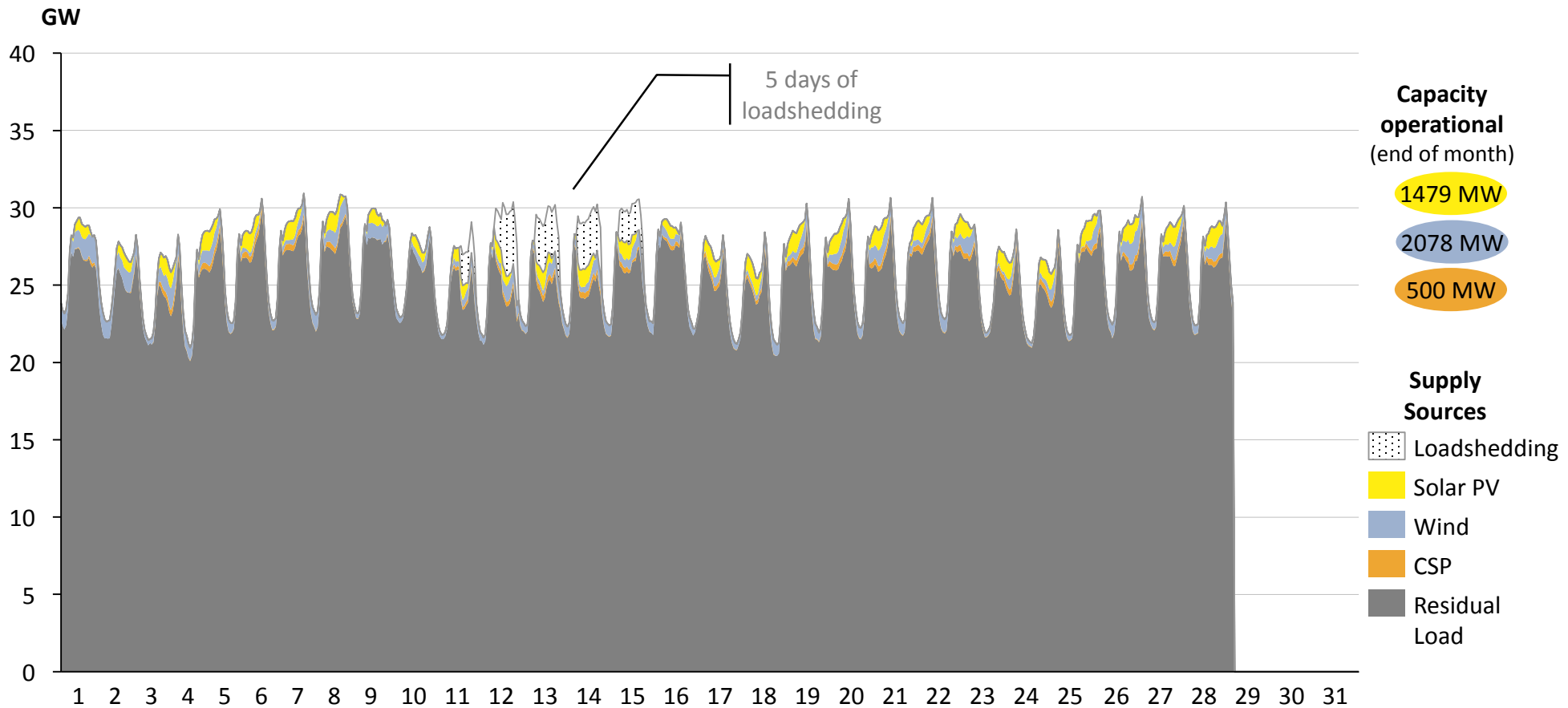
Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

Hourly electricity production in Jan 2019 highlighting role of VRE fleet

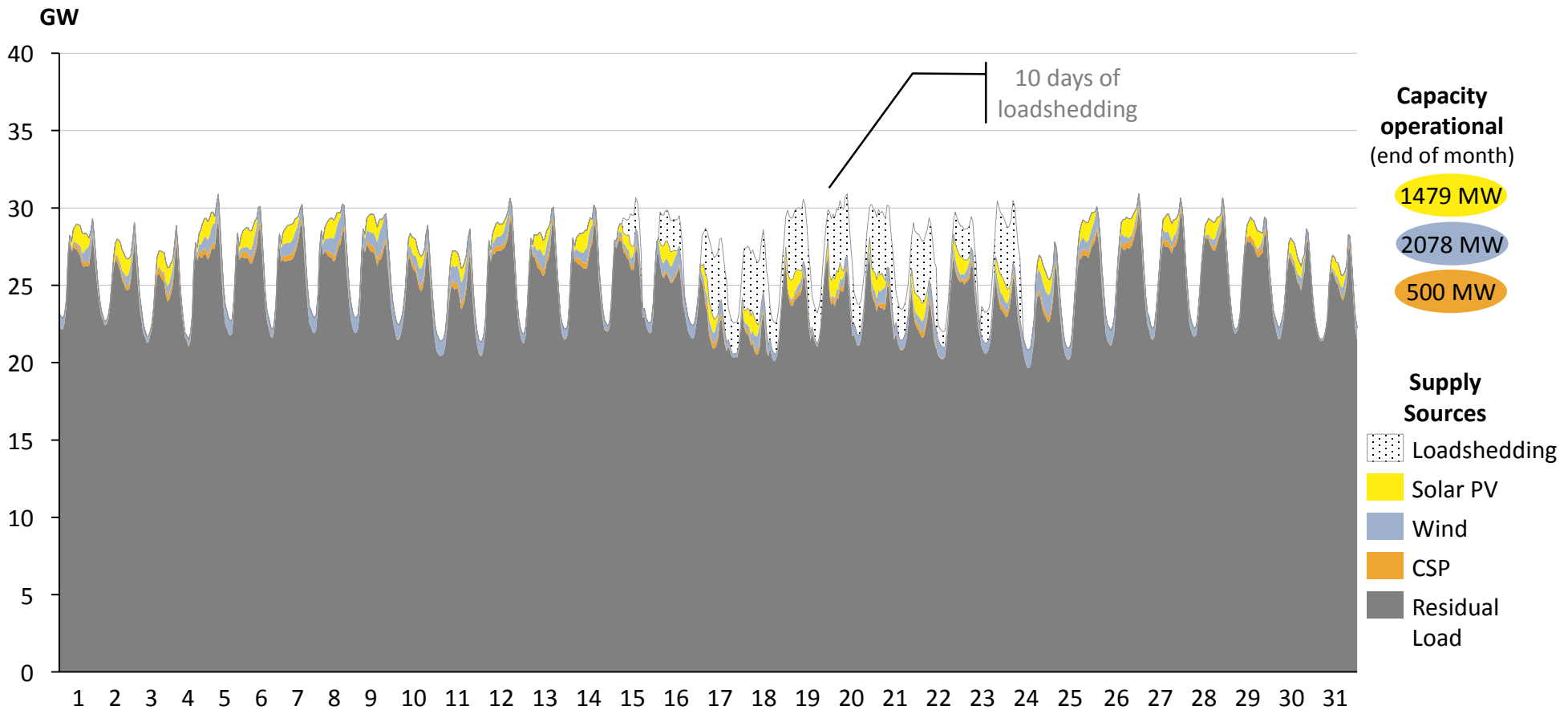


Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

Hourly electricity production in Feb 2019 with 5 days of loadshedding



Hourly electricity production in Mar 2019 with 10 days of loadshedding

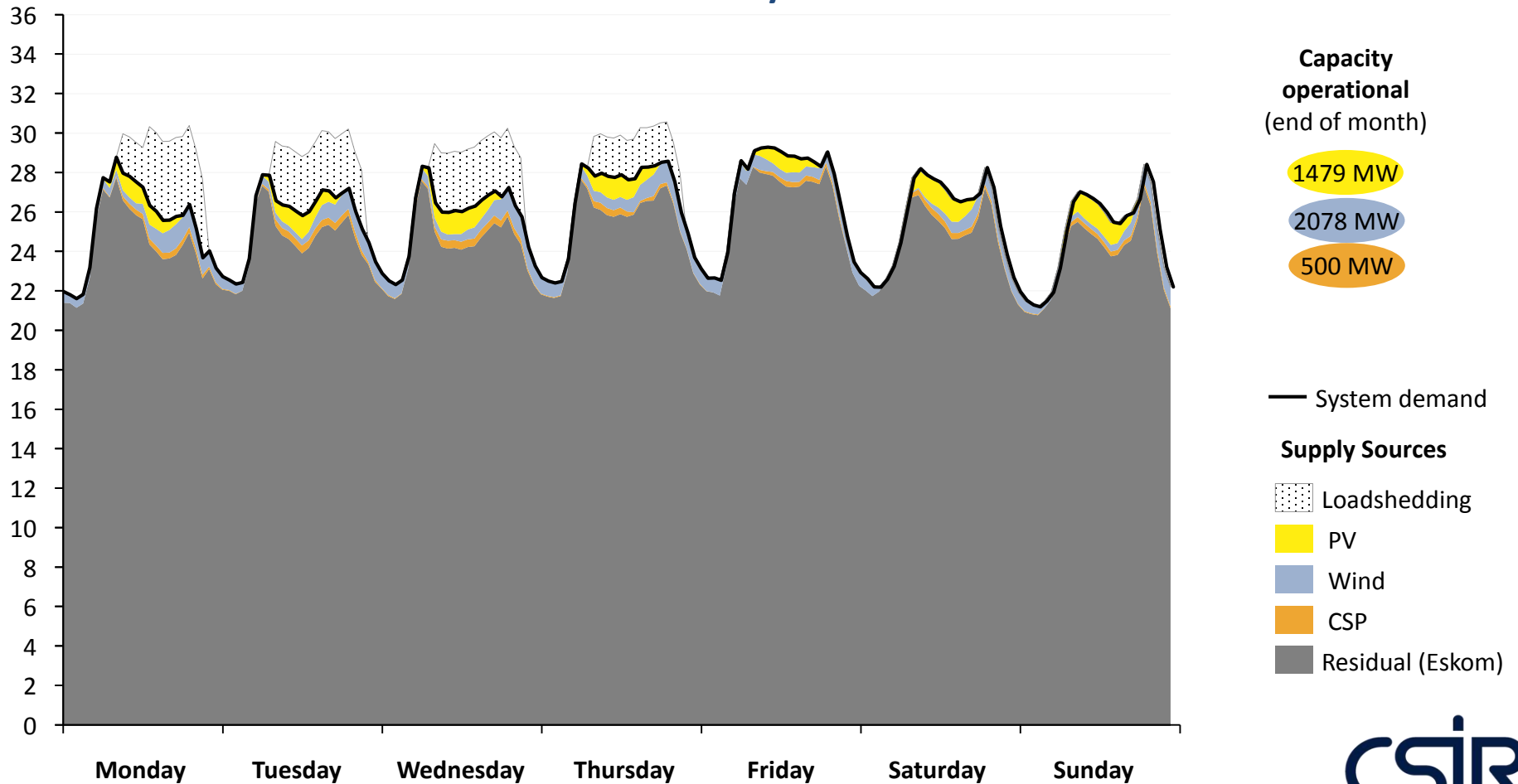


Note: Design as per Fraunhofer ISE. Pumping load excluded.
Sources: Eskom; CSIR Energy Centre analysis

Significant contribution from VRE during loadshedding in Feb 2019 – 103 GWh and a maximum inst. contribution of 2.0 GW

Power in GW

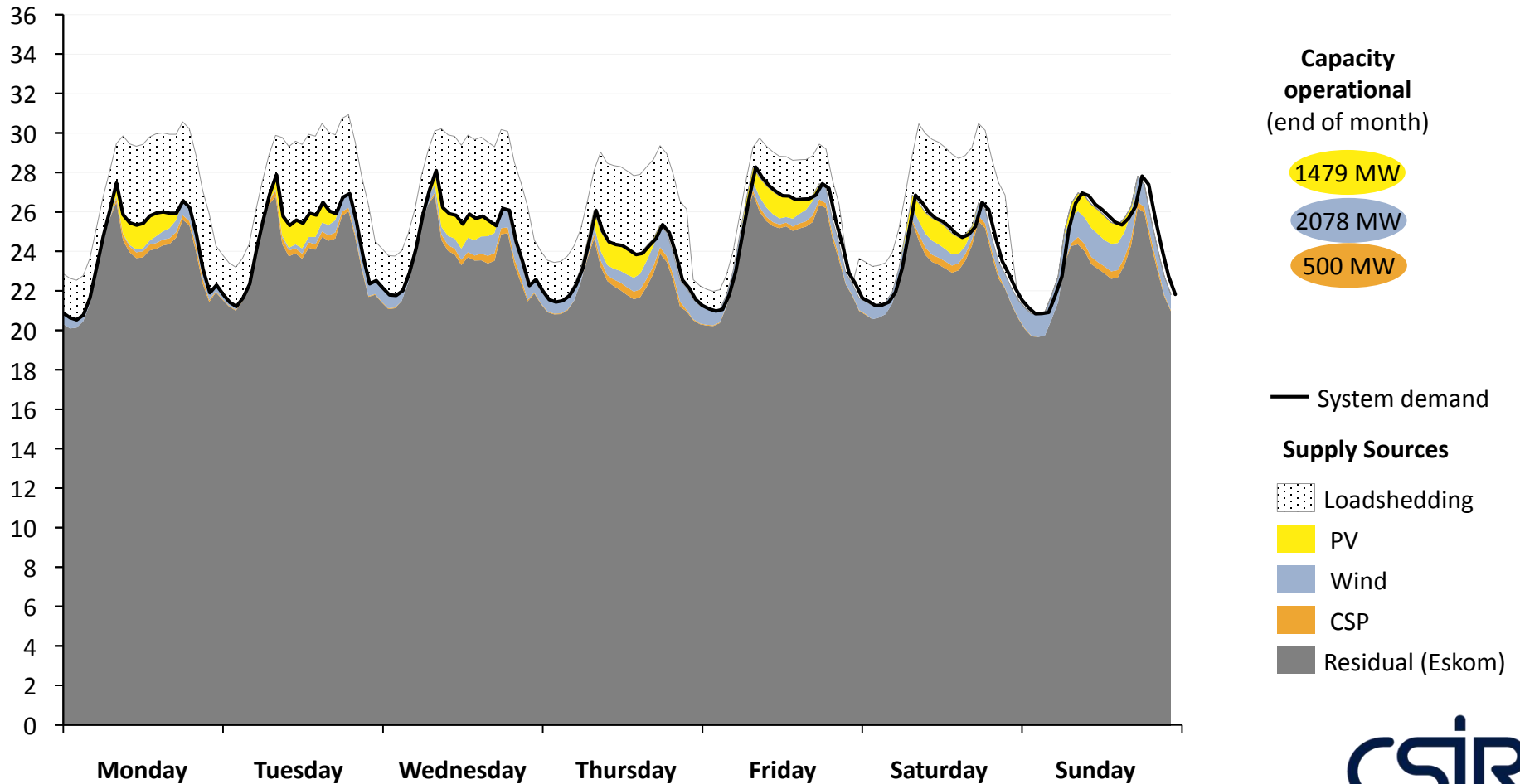
Week of 11-17 February 2019



Similarly, VRE provided valuable capacity during loadshedding in March 2019 – 254 GWh and a maximum inst. contribution of 2.3 GW

Power in GW

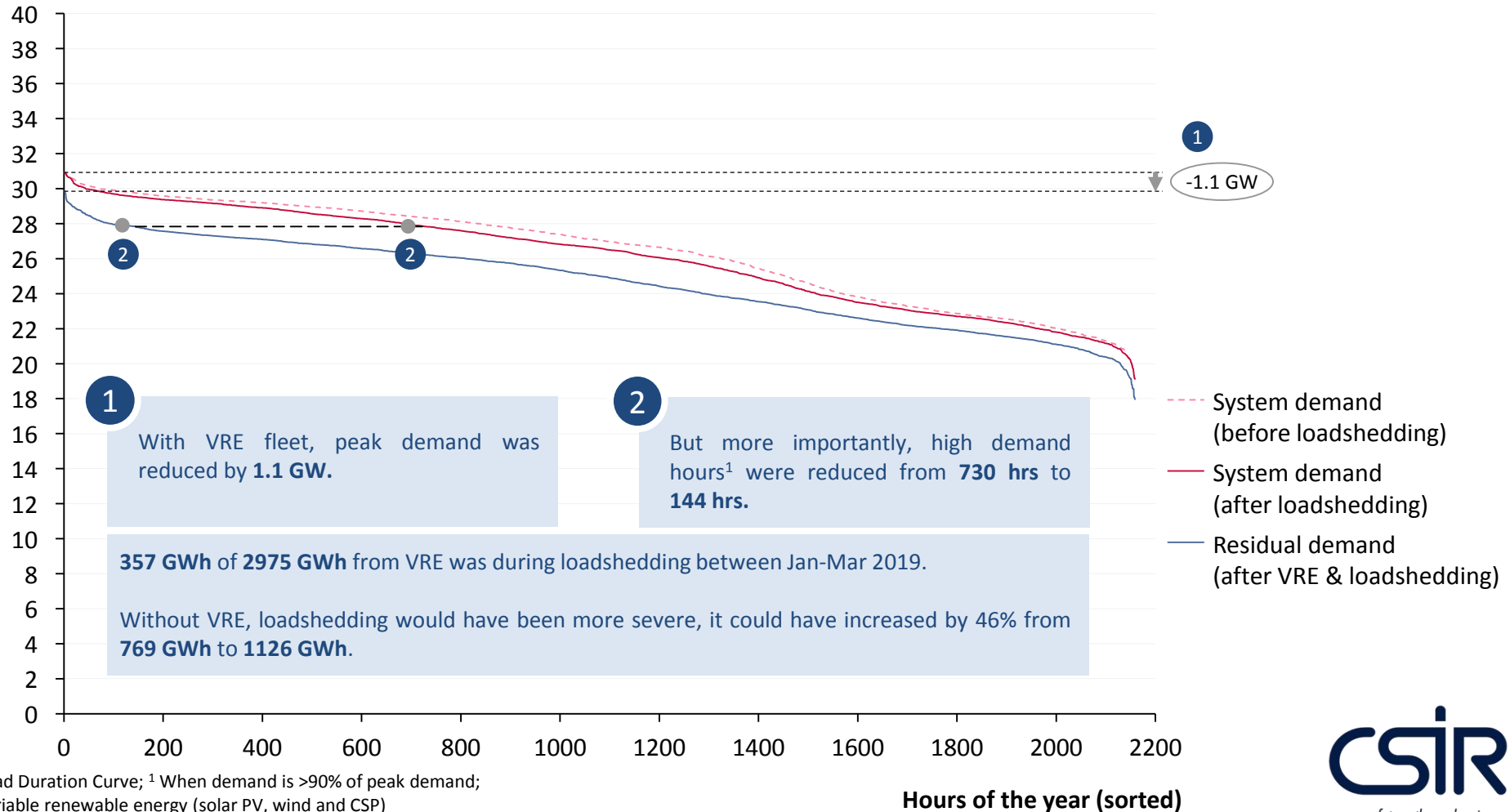
Week of 18-24 March 2019



VRE reduced peak by 1.1 GW & high demand hours notably; loadshedding could have increased by as much as 46% without VRE

Power in GW

LDC (1 Jan – 31 Mar 2019)



LDC = Load Duration Curve; ¹ When demand is >90% of peak demand;
VRE = variable renewable energy (solar PV, wind and CSP)

Sources: Eskom; CSIR Energy Centre analysis

Thank you

