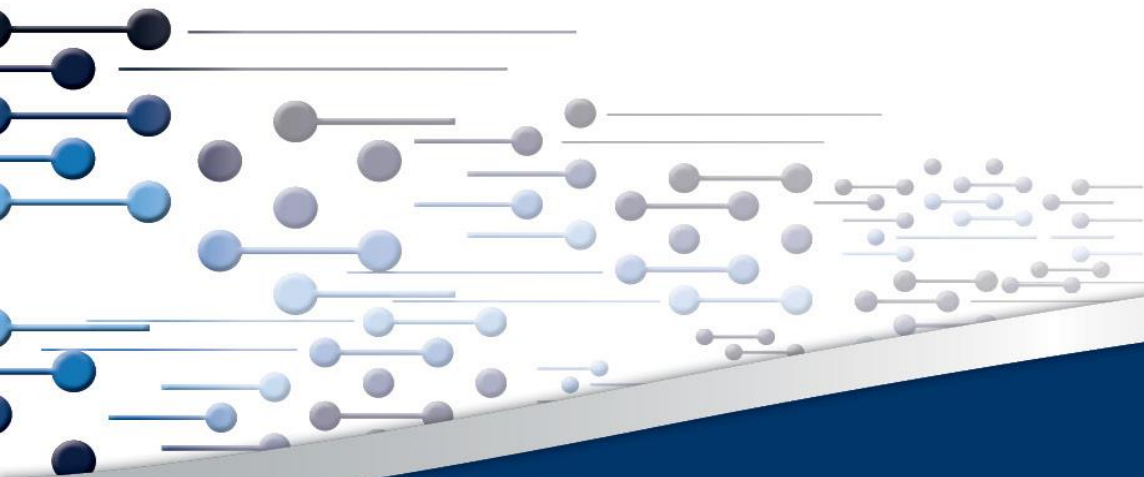


# Statistics of utility-scale solar PV and wind in South Africa in 2014

CSIR Energy Centre

May 2016



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**CSIR**  
*our future through science*

# Summary of 2014:

## 1.0% of system load supplied from wind & solar PV in South Africa

**The South African Department of Energy is procuring new generation capacity and 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, ~560 MW of wind and 960 MW of solar PV were operational and fed energy into the grid end of 2014

**In 2014, total wind and solar PV production was 2.2 TWh, supplying 1.0% of the South African system load**

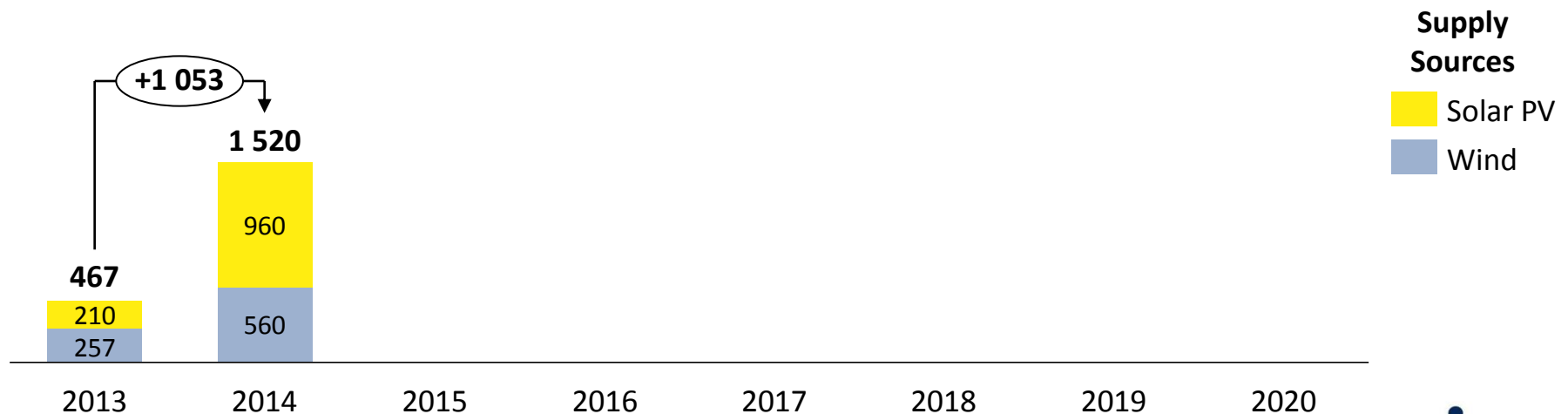
- Maximum daily total energy from solar PV and wind combined was 15.6 GWh (2.4%), which occurred on 15 Nov 2014
- Wind power achieved a maximum peak power production of 498 MW between 18h00-19h00 on 14 Dec 2014
- Solar PV power reached a maximum peak power of 894 MW between 12h00-13h00 on 24 Dec 2014
- Maximum instantaneous power contribution of wind and solar PV was 5.0% on 25 Dec 2014 between 14h00-15h00
- Maximum instantaneous power contribution of wind alone was 2.2% on 25 Dec 2014 between 17h00-18h00
- Maximum instantaneous power contribution of solar PV alone was 3.5% on 26 Dec 2014 between 12h00-13h00

**Total monthly wind and solar PV production from Jan to Dec 2014 varied between 48 GWh and 343 GWh**

- The monthly wind production from Jan to Dec 2014 varied between 26 and 147 GWh
- The monthly solar PV production from Jan to Dec 2014 varied between 23 and 213 GWh

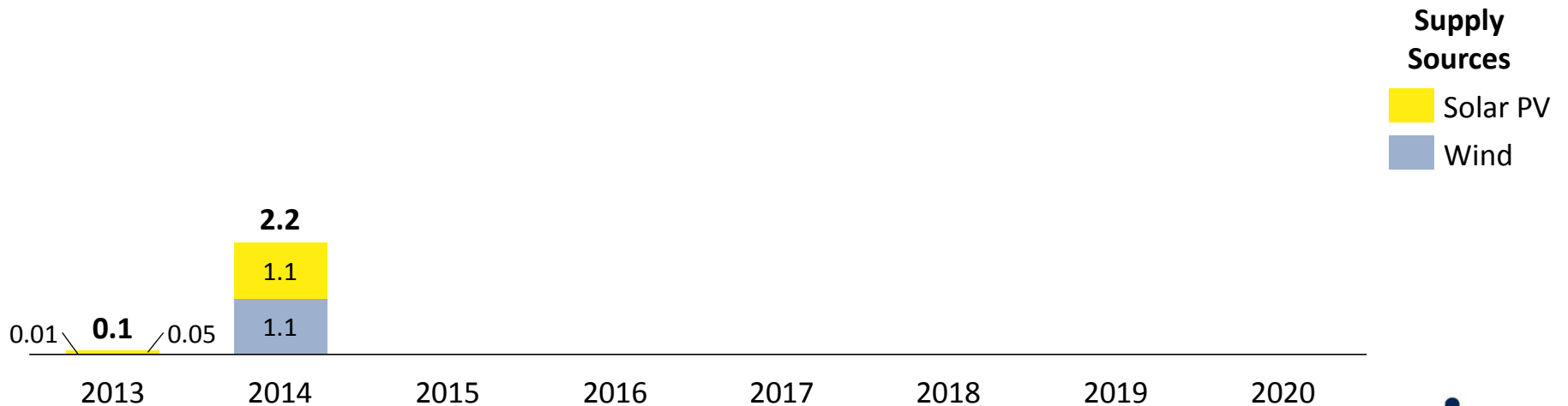
# From 1 November 2013 to 31 December 2014, 560 MW of wind and 960 MW of large-scale solar PV were commissioned in RSA

Capacity  
online in MW  
(end of year)



# In 2014, almost 2.2 TWh of wind and solar PV energy produced in RSA

Annual energy  
produced in TWh



# Agenda

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## Overview actual electricity production data for 2014

Monthly electricity production

Weekly electricity production

Daily electricity production

Hourly electricity production

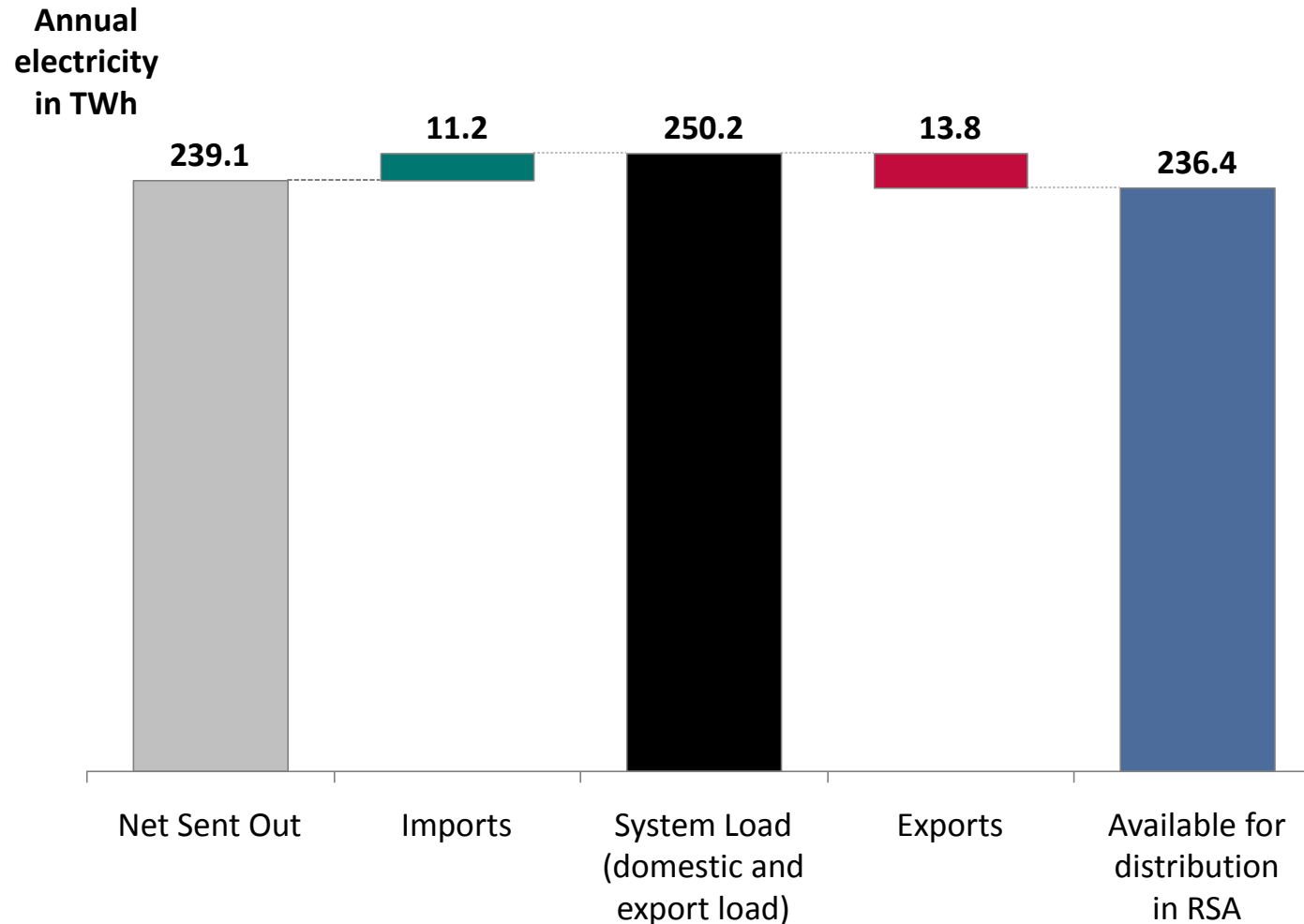
Diurnal courses

Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

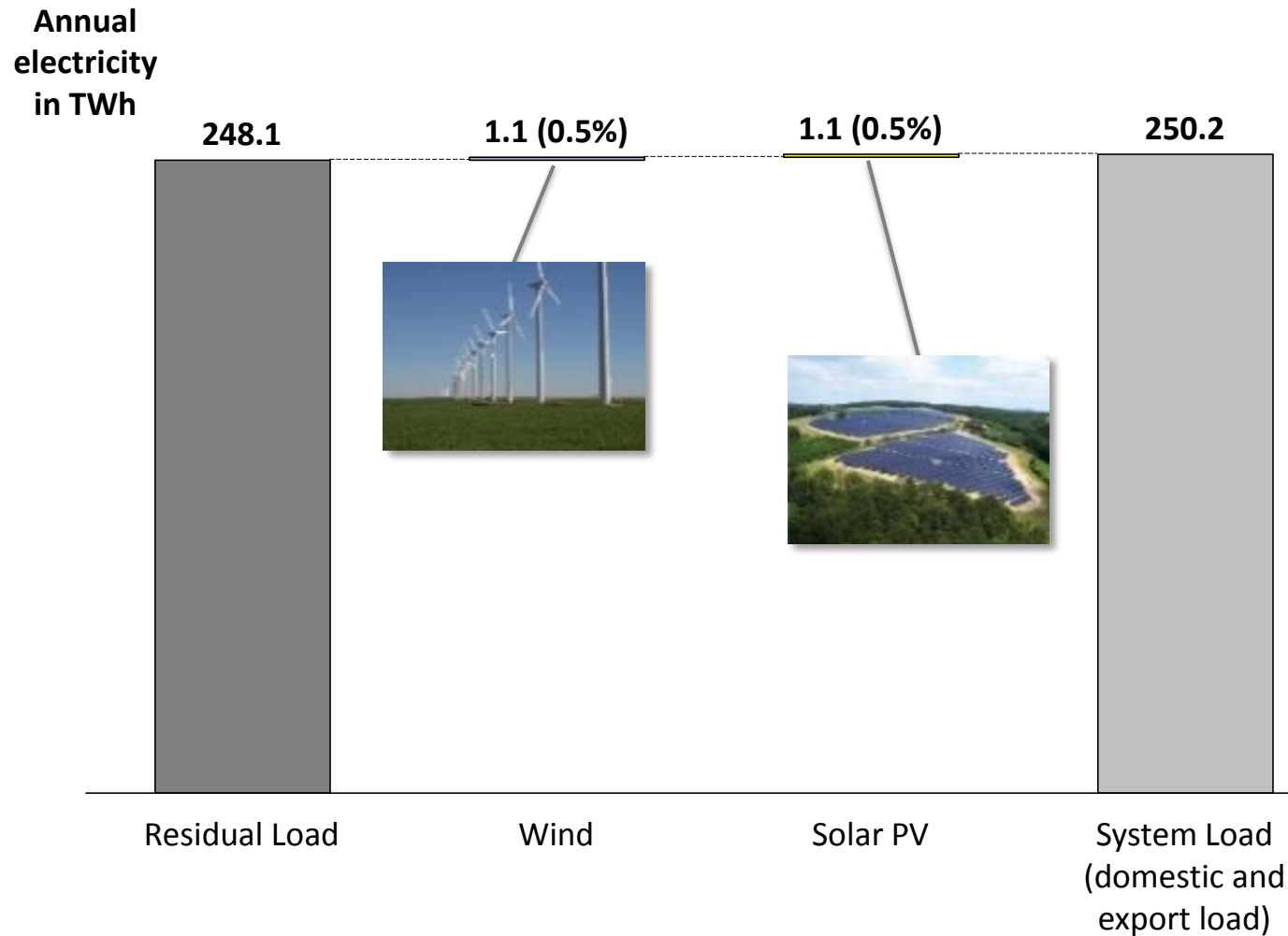
# In 2014, 239 TWh of net electricity were produced in South Africa

Actuals captured in wholesale market for Jan-Dec 2014 (i.e. without self-consumption of embedded plants)



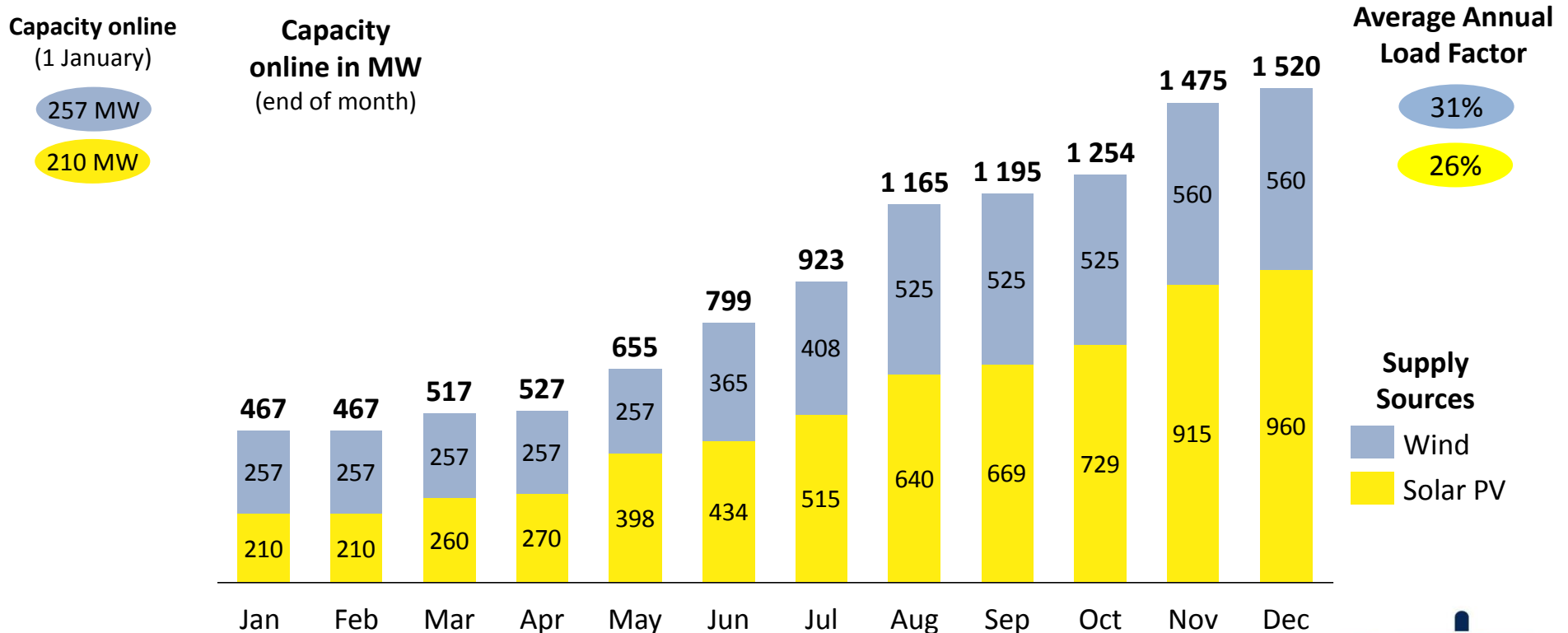
# Wind & solar PV supplied 1% of total South African system load in 2014

Actuals captured in wholesale market for Jan-Dec 2014 (i.e. without self-consumption of embedded plants)



# In 2014, 303 MW of wind & 750 MW of solar PV were added to the grid

Total monthly installed capacity of wind and Solar PV in MW in RSA from Jan-Dec 2014

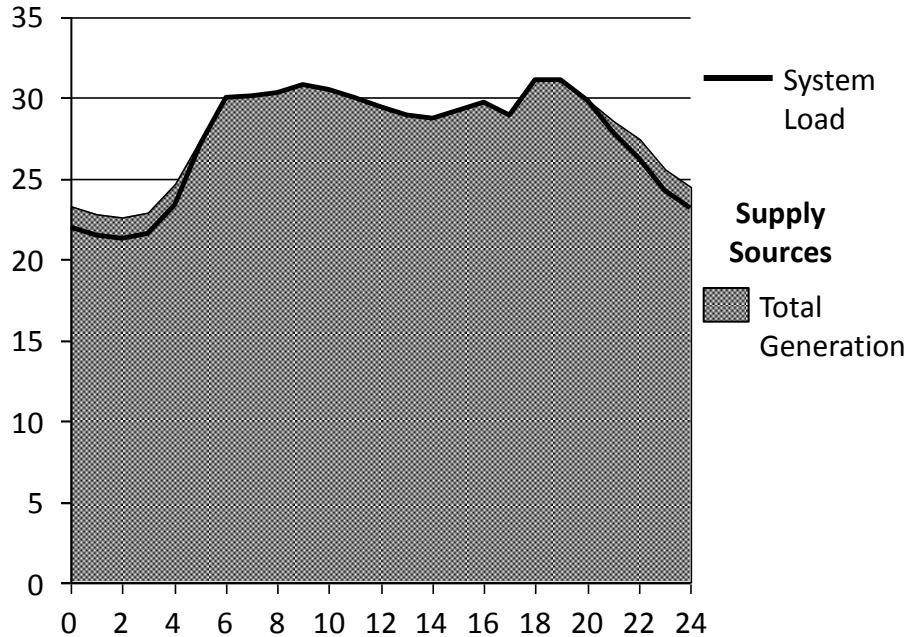




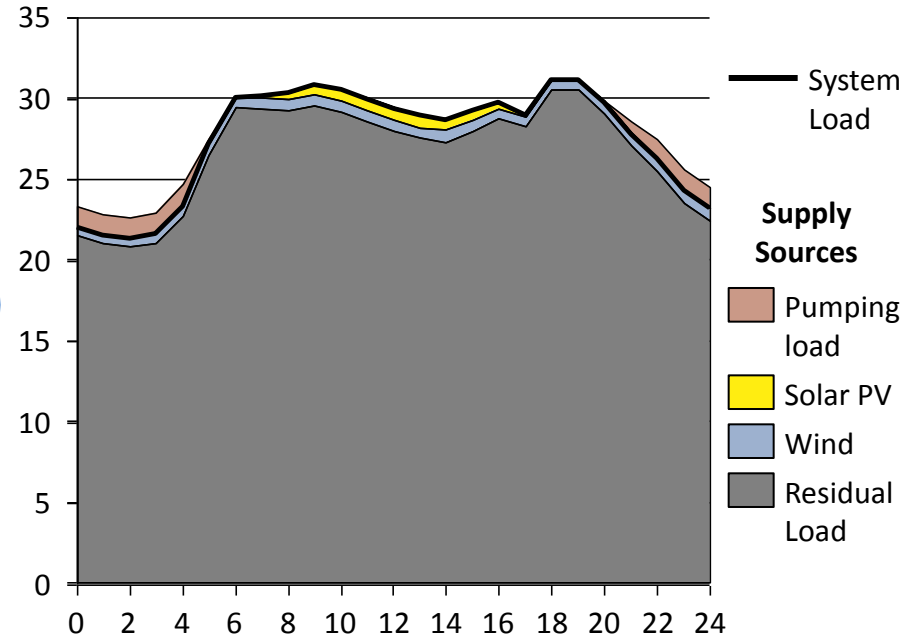
# Illustrative day explaining terminologies used in this presentation

Hourly South African supply structure for a random day

Power in GW



Power in GW



**Total Generation**

= domestic generation (Eskom + IPPs) + imported generation

**System Load**

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

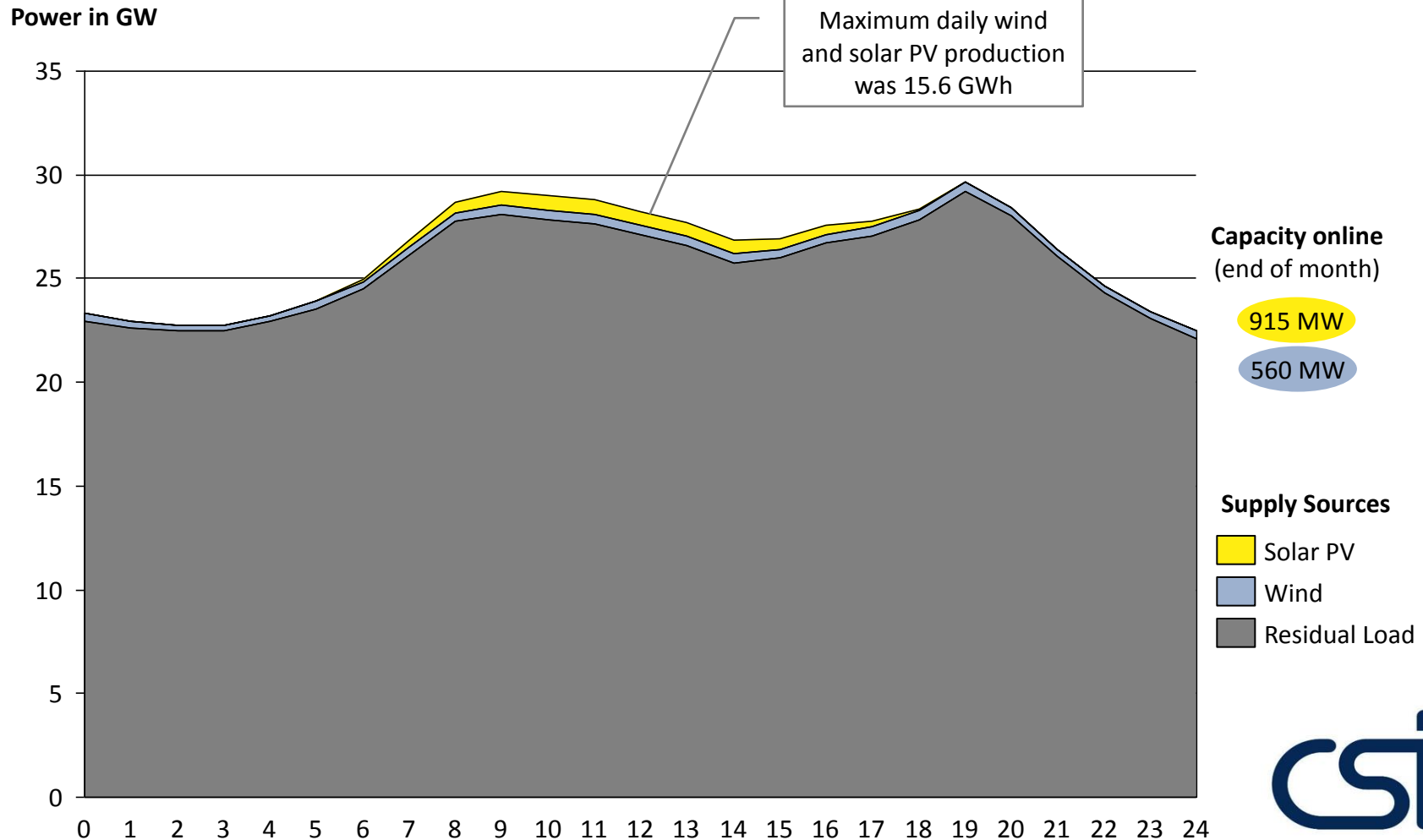
= domestic customer load without pumping load (also referred to as simply "domestic load") + export load

**Residual Load**

= System Load – wind – solar PV

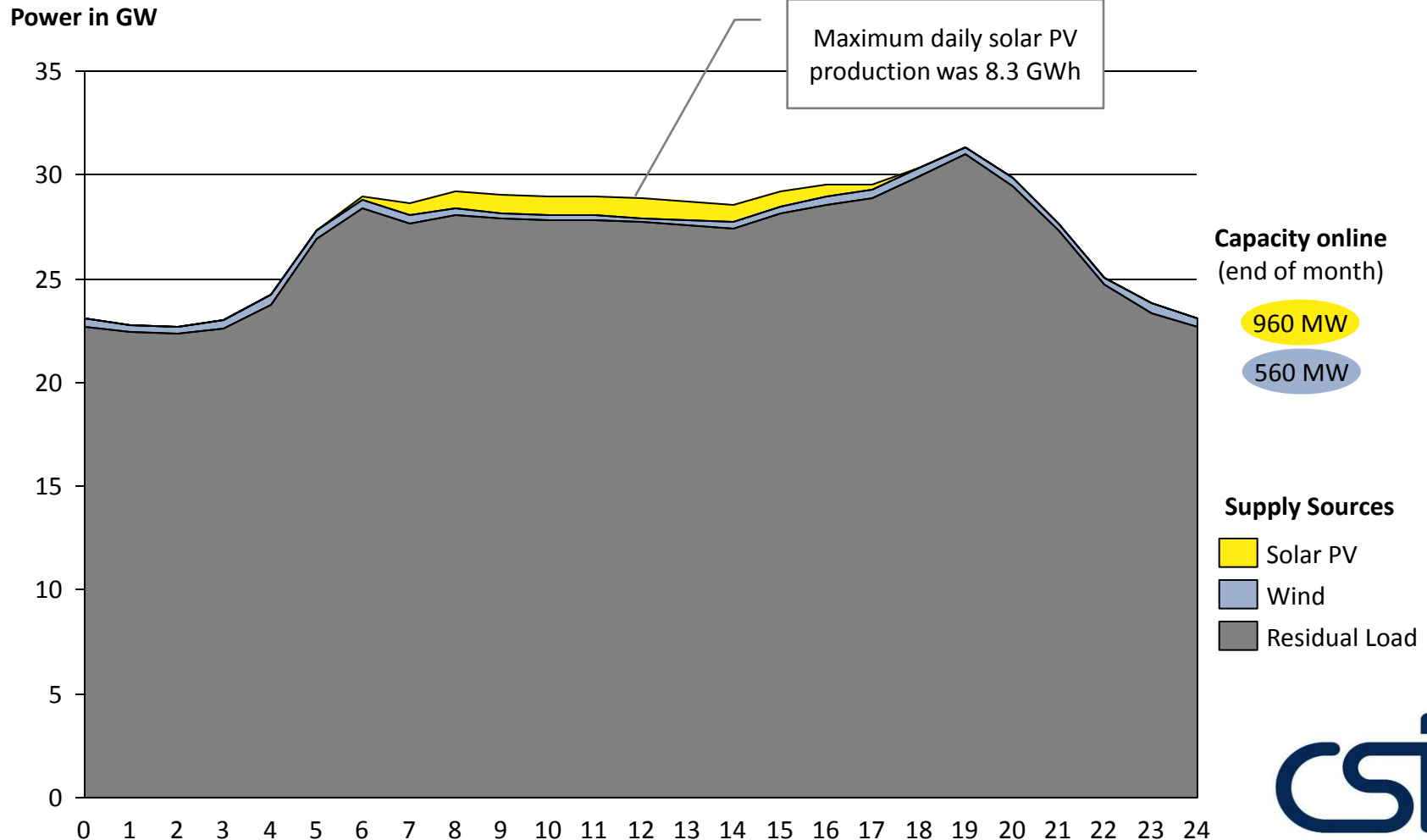
# Maximum daily wind & PV energy of 15.6 GWh occurred on 15 Nov 2014

Actual hourly wind and solar PV energy production in South Africa on 15 November 2014 (Saturday)



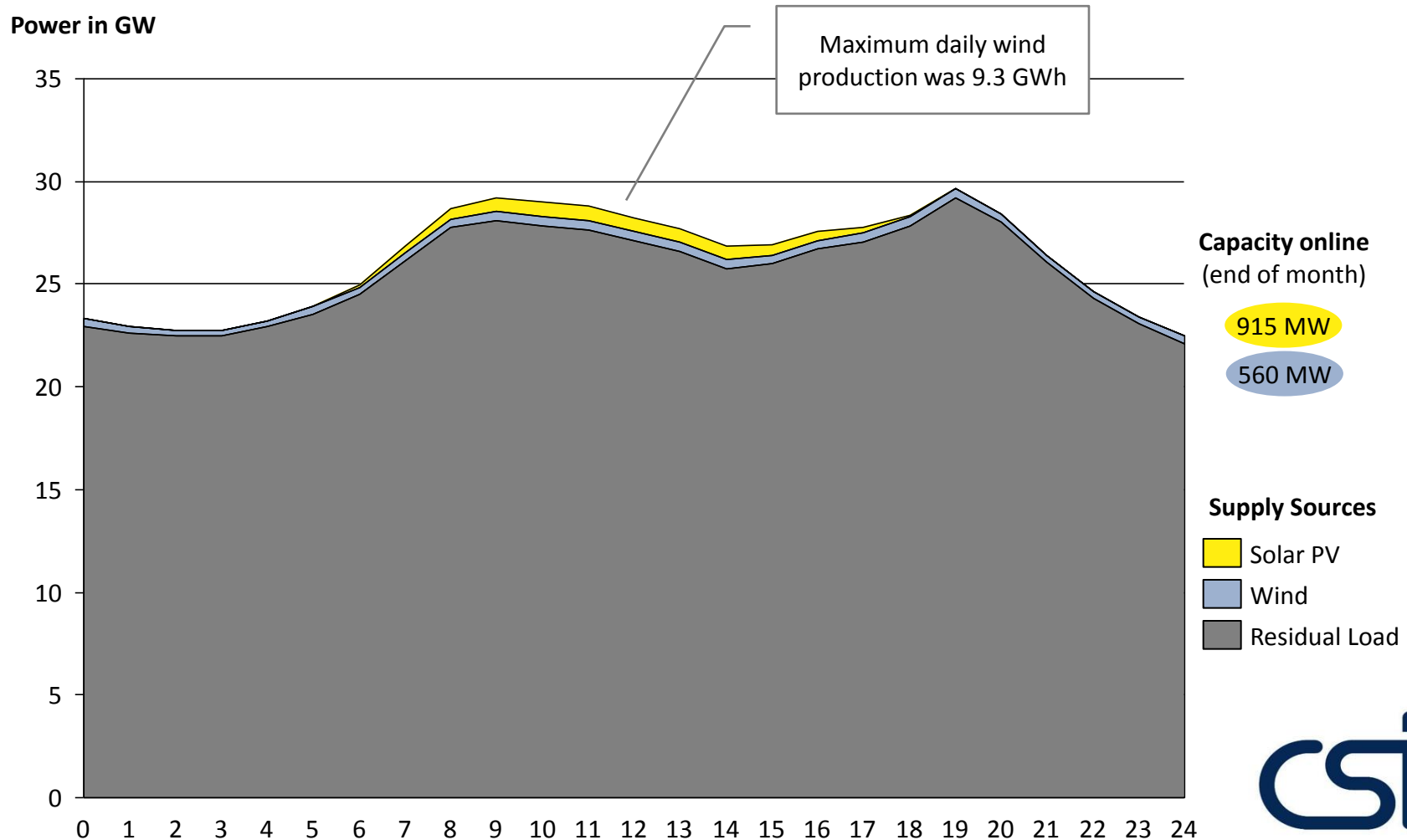
# Maximum daily solar PV energy of 8.3 GWh achieved on 24 Dec 2014

Actual hourly wind and solar PV energy production in South Africa on 24 December 2014 (Wednesday)



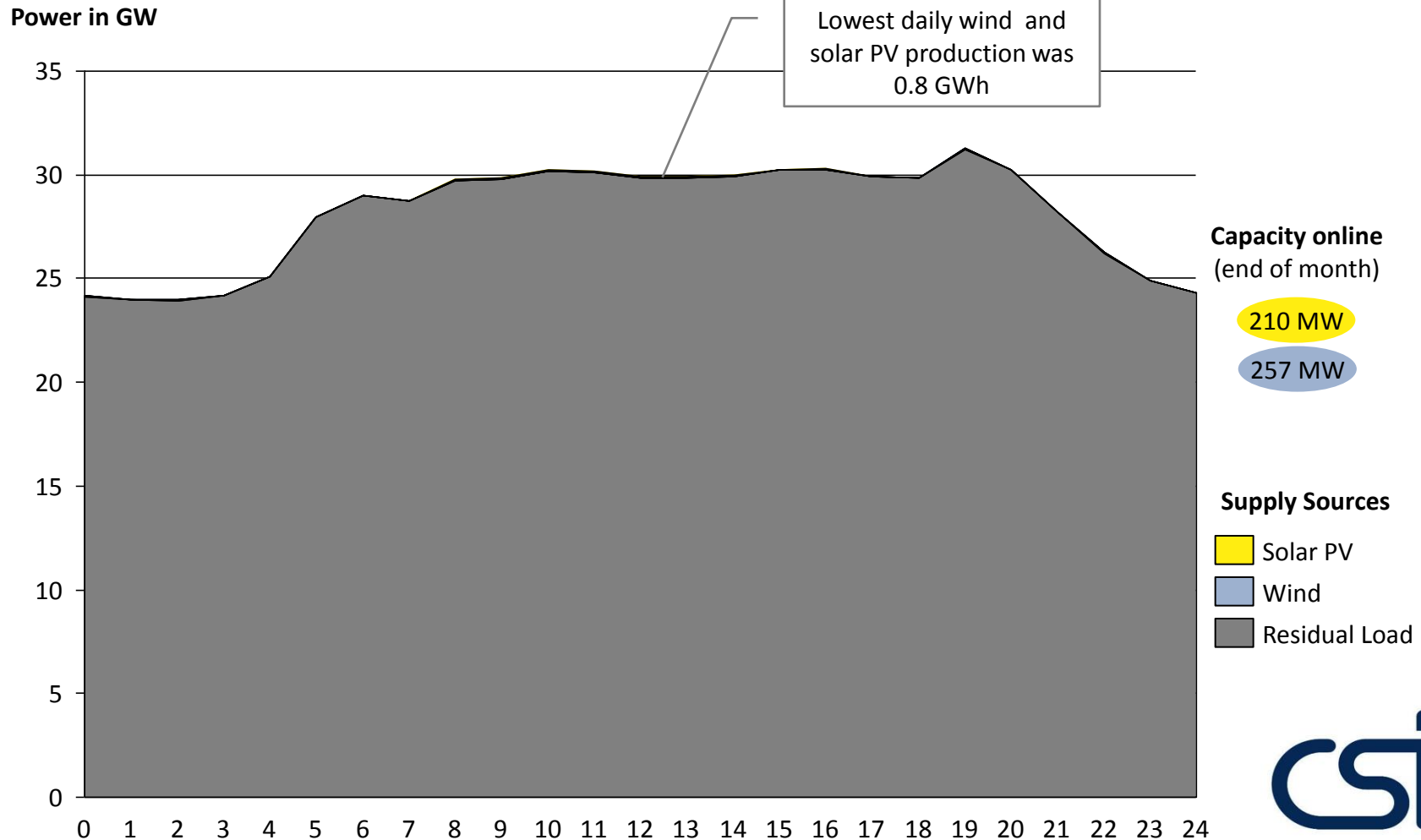
# Maximum daily wind energy of 9.3 GWh achieved on 15 Nov 2014

Actual hourly wind and solar PV energy production in South Africa on 15 November 2014 (Saturday)



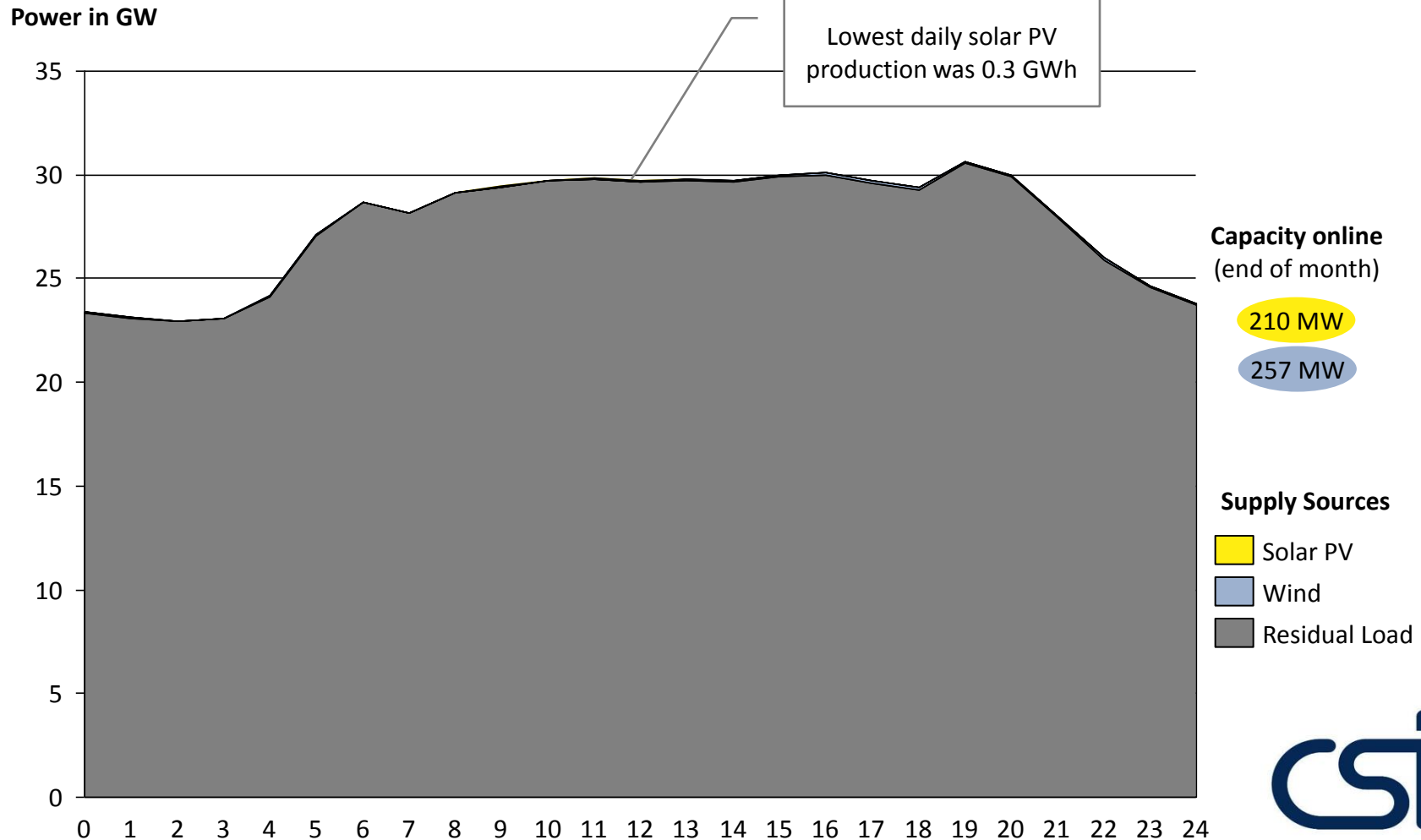
# Lowest combined wind & solar PV energy of 0.8 GWh on 28 Jan 2014

Actual hourly wind and solar PV energy production in South Africa on 28 January 2014 (Tuesday)



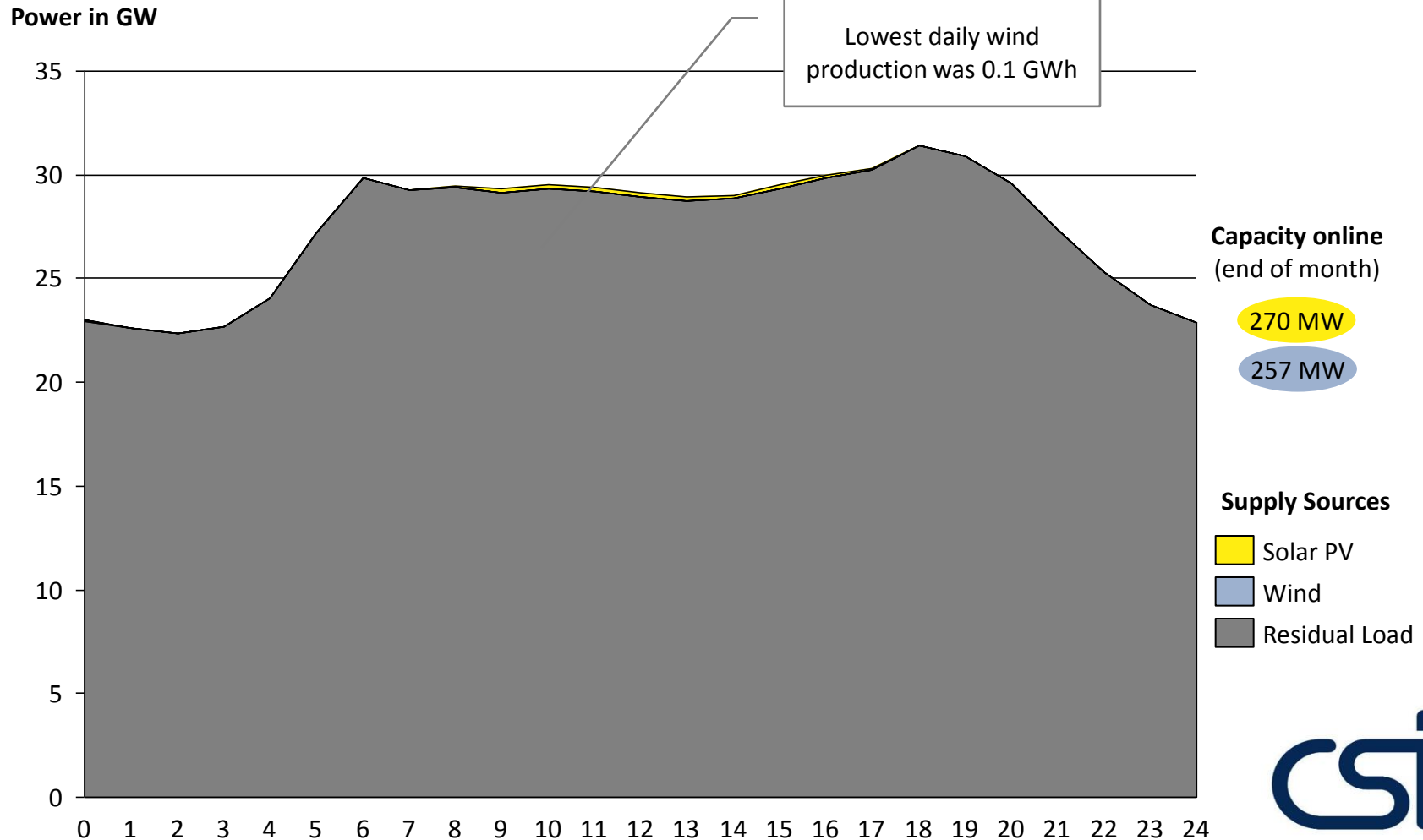
# Lowest solar PV energy production of 0.3 GWh occurred on 4 Feb 2014

Actual hourly wind and solar PV energy production in South Africa on 4 February 2014 (Tuesday)



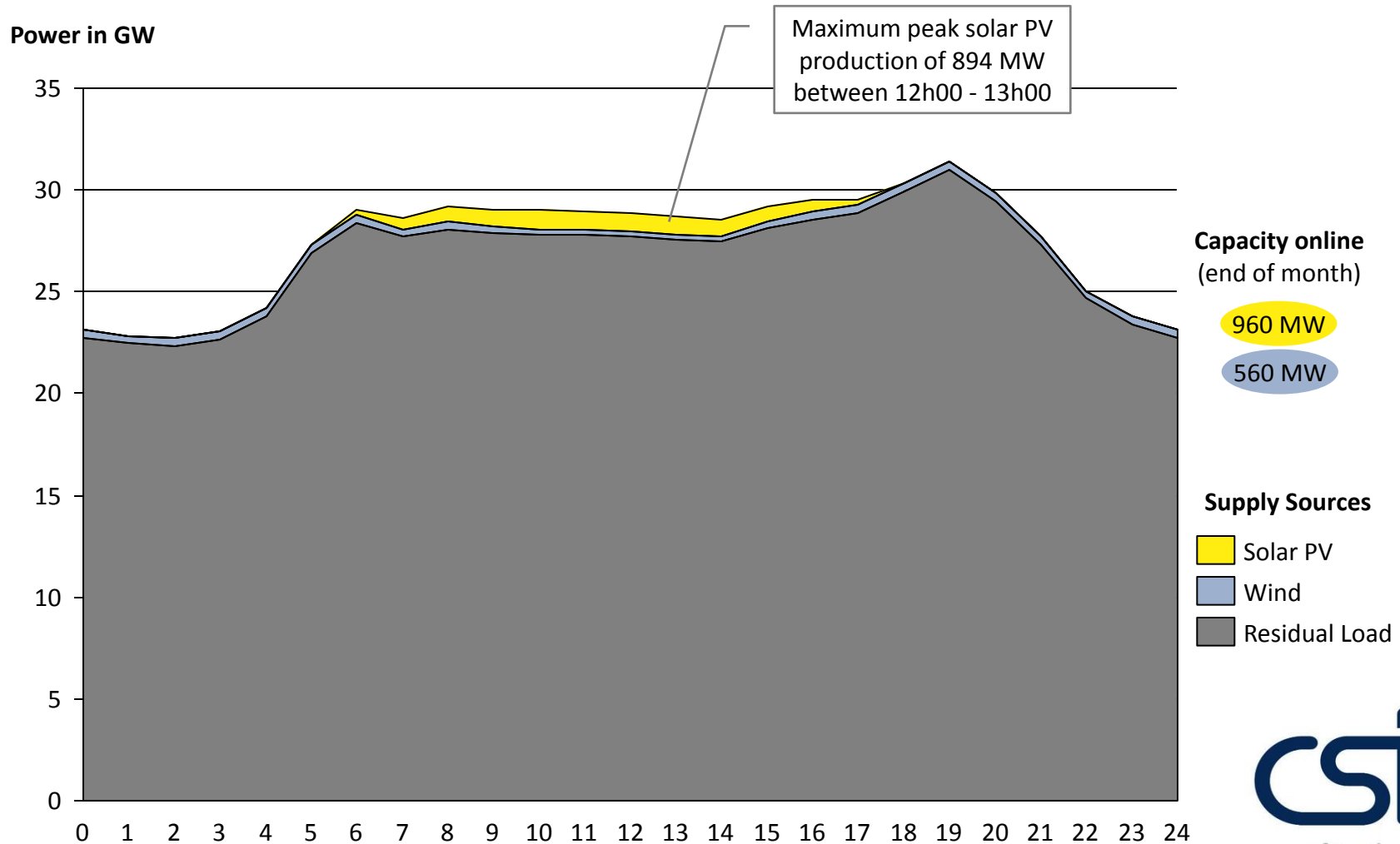
# Lowest wind energy production of 0.1 GWh occurred on 10 Apr 2014

Actual hourly wind and solar PV energy production in South Africa on 10 April 2014 (Thursday)



# Maximum solar PV power output of 894 MW occurred on 24 Dec 2014

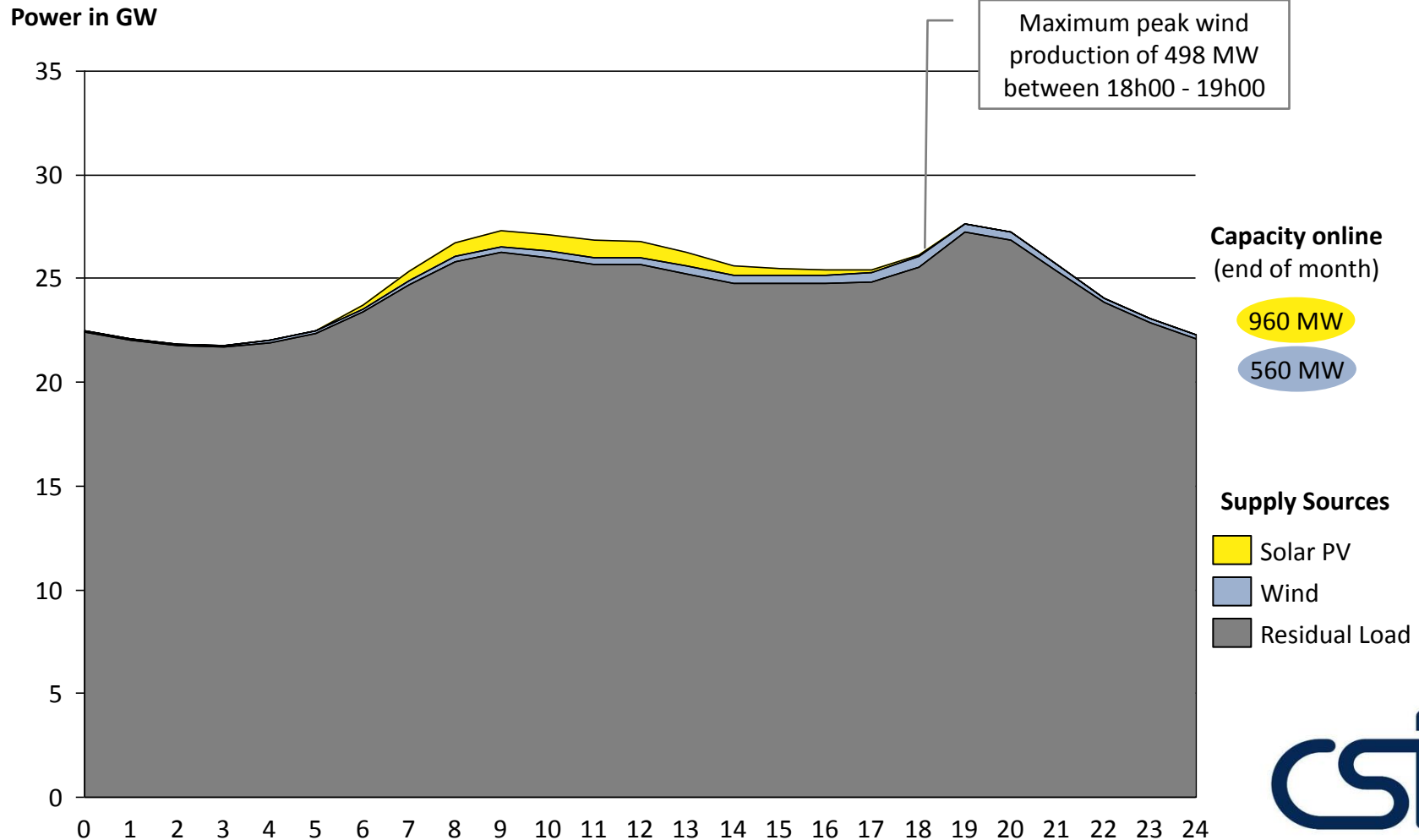
Actual hourly wind and solar PV energy production in South Africa on 24 December 2014 (Wednesday)





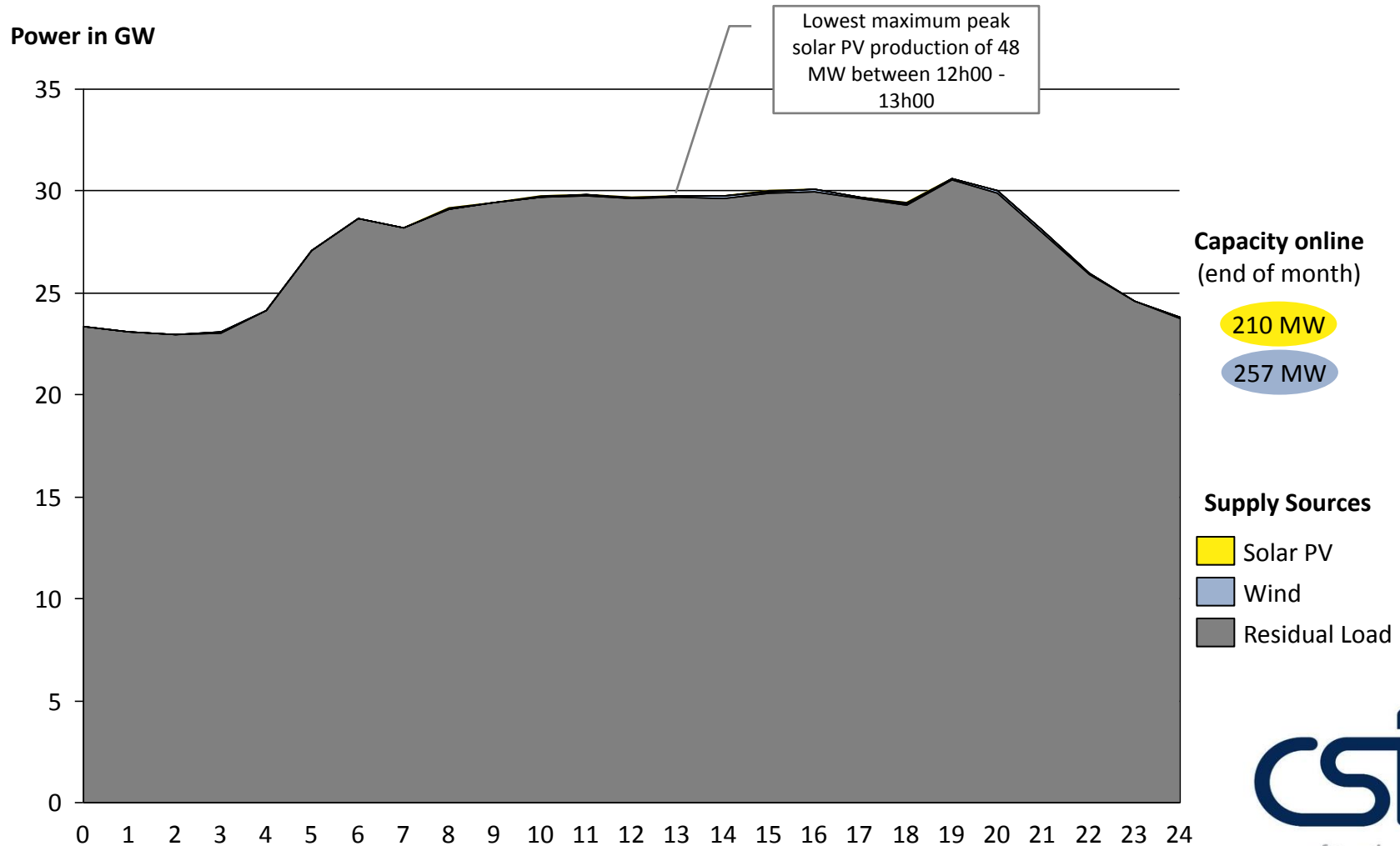
# Maximum wind power output of 498 MW occurred on 14 Dec 2014

Actual hourly wind and solar PV energy production in South Africa on 14 December 2014 (Sunday)



# Lowest daily peak solar PV power output of 48 MW on 4 Feb 2014

Actual hourly wind and solar PV energy production in South Africa on 4 February 2014 (Tuesday)



# Agenda

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Overview actual electricity production data for 2014

**Monthly electricity production**

Weekly electricity production

Daily electricity production

Hourly electricity production

Diurnal courses

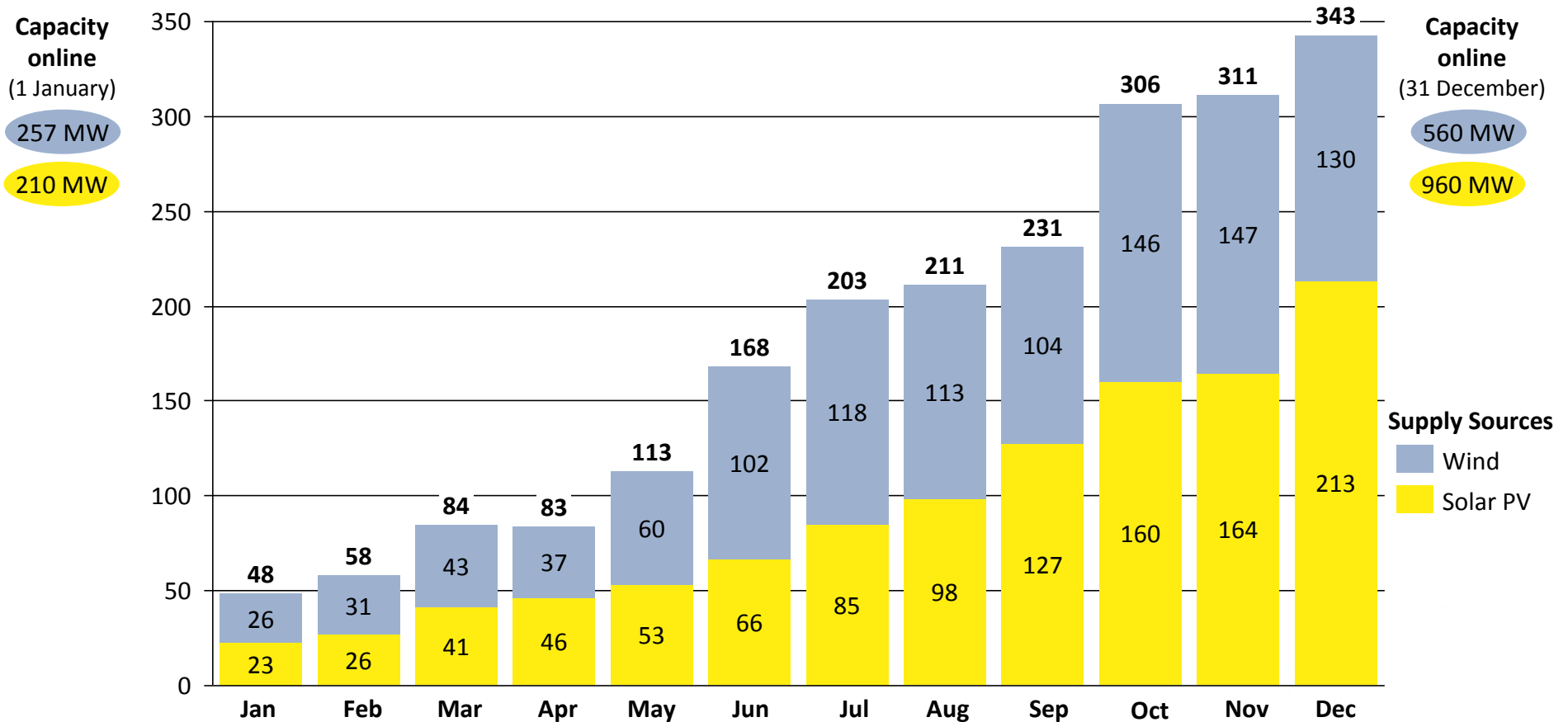
Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

# Monthly electricity production of South African wind and solar PV fleet

Actual monthly production from solar PV and wind plants in South Africa from Jan-Dec 2014

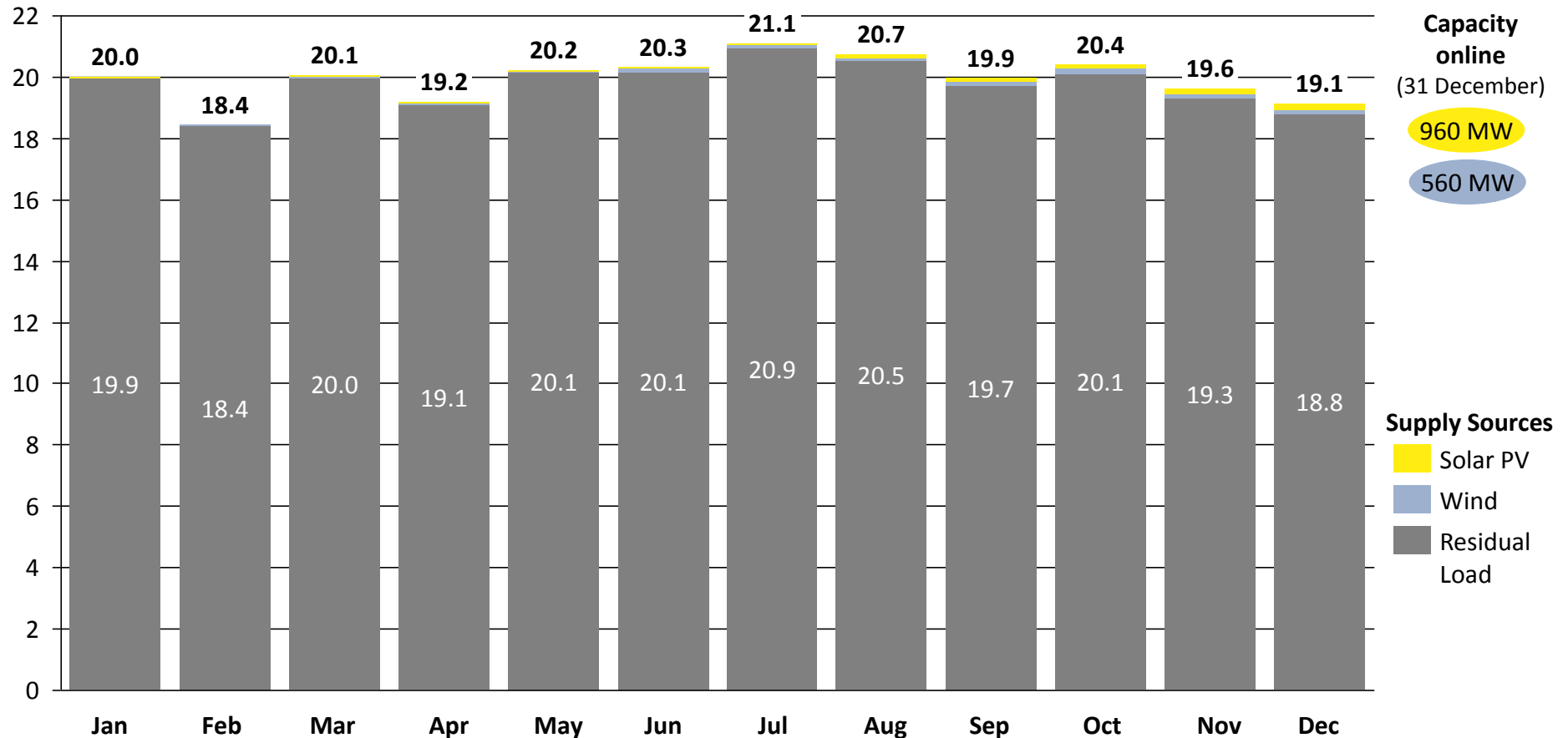
## Electricity production in GWh/month



# Monthly electricity production wind, solar PV and residual load

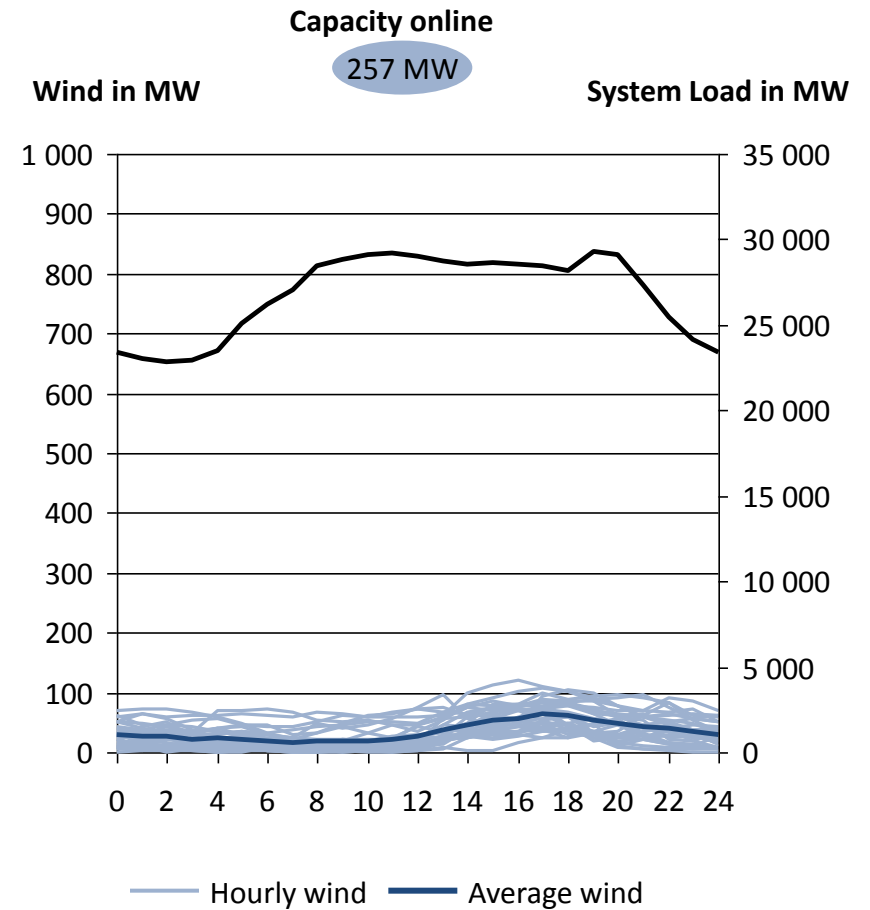
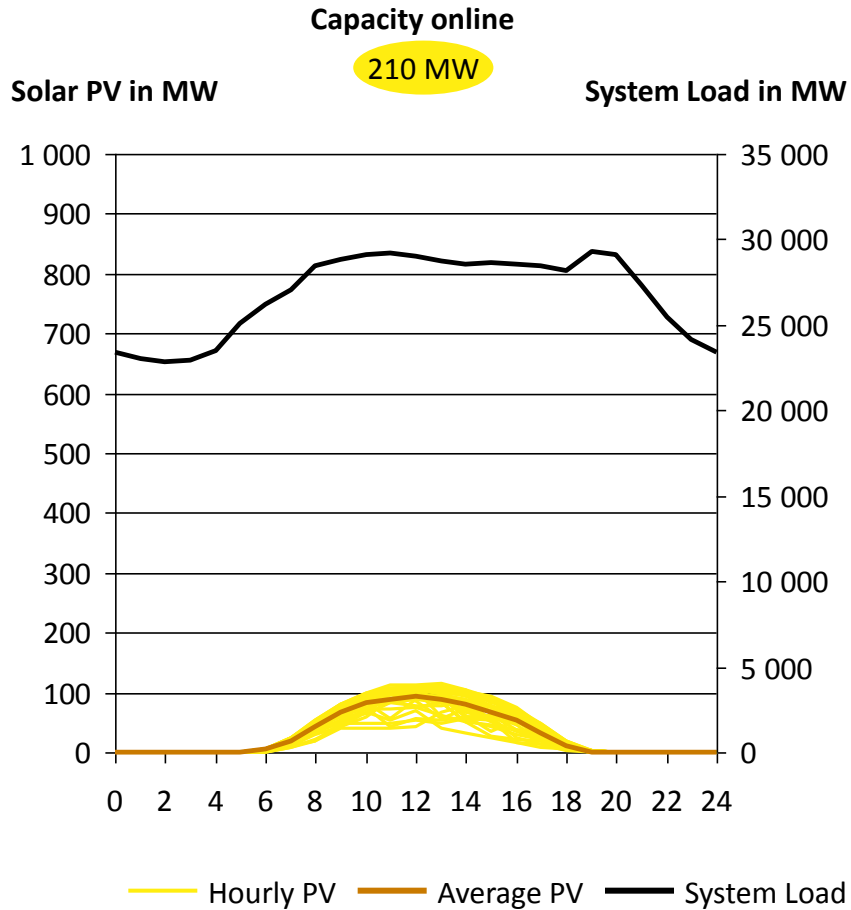
Actual monthly electricity production for Jan-Dec 2014 from the different supply sources in South Africa

Electricity in  
TWh/month



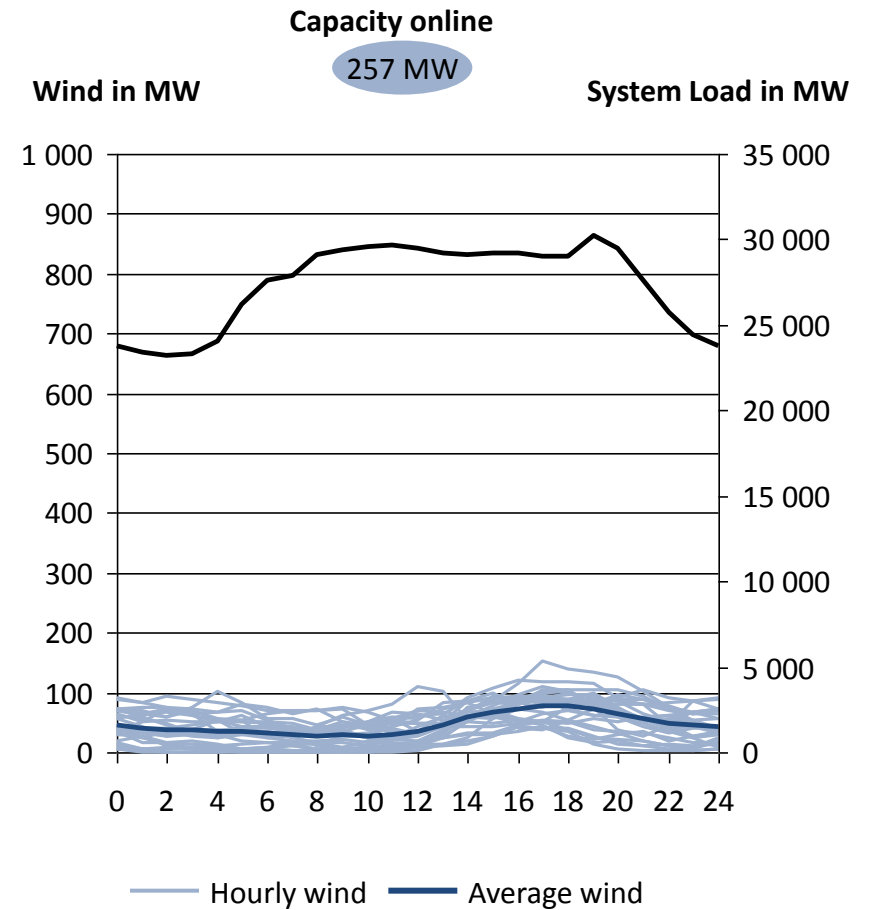
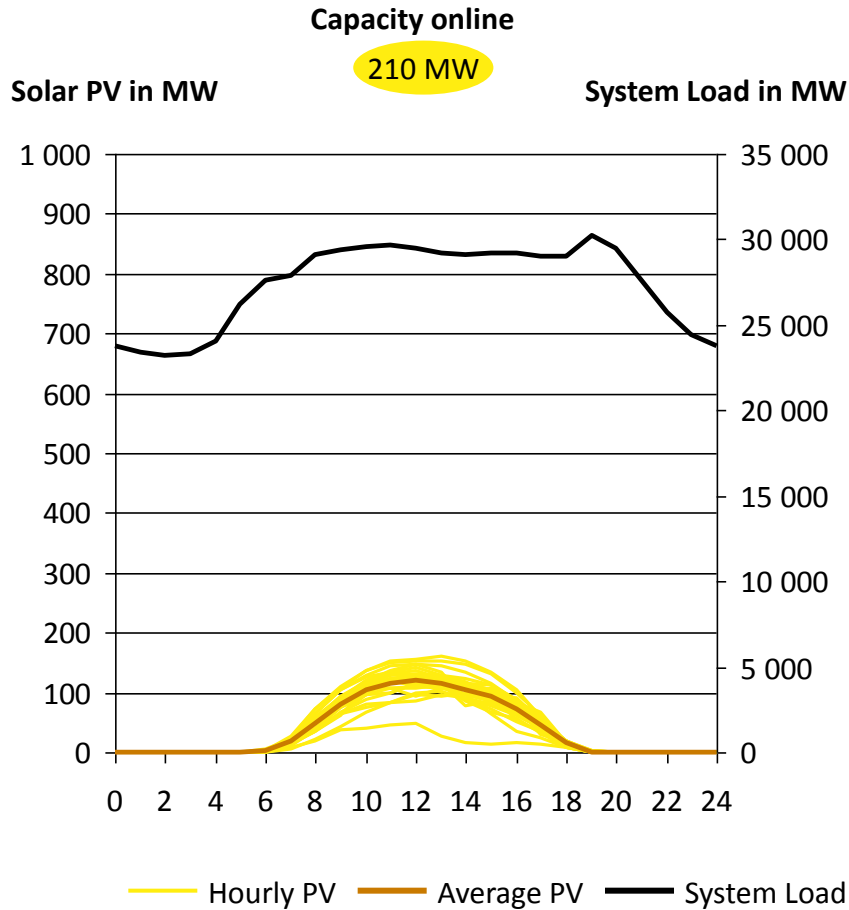
# Solar PV supply in Jan 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 31 days of Jan 2014 and average system load diurnal course



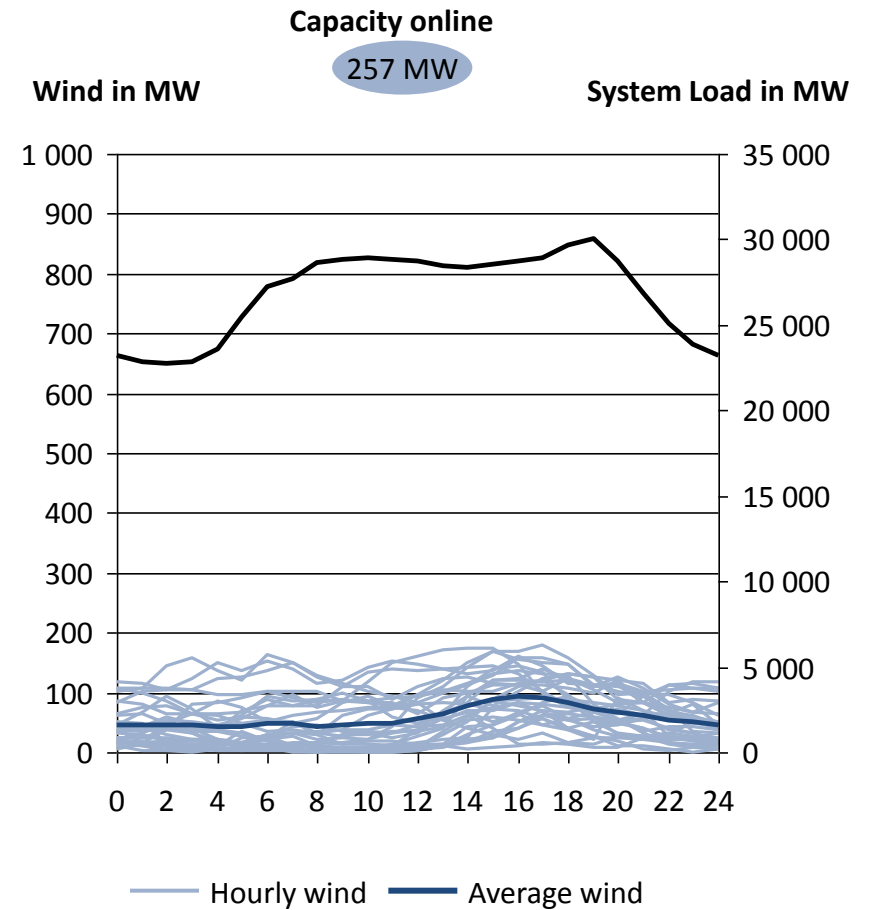
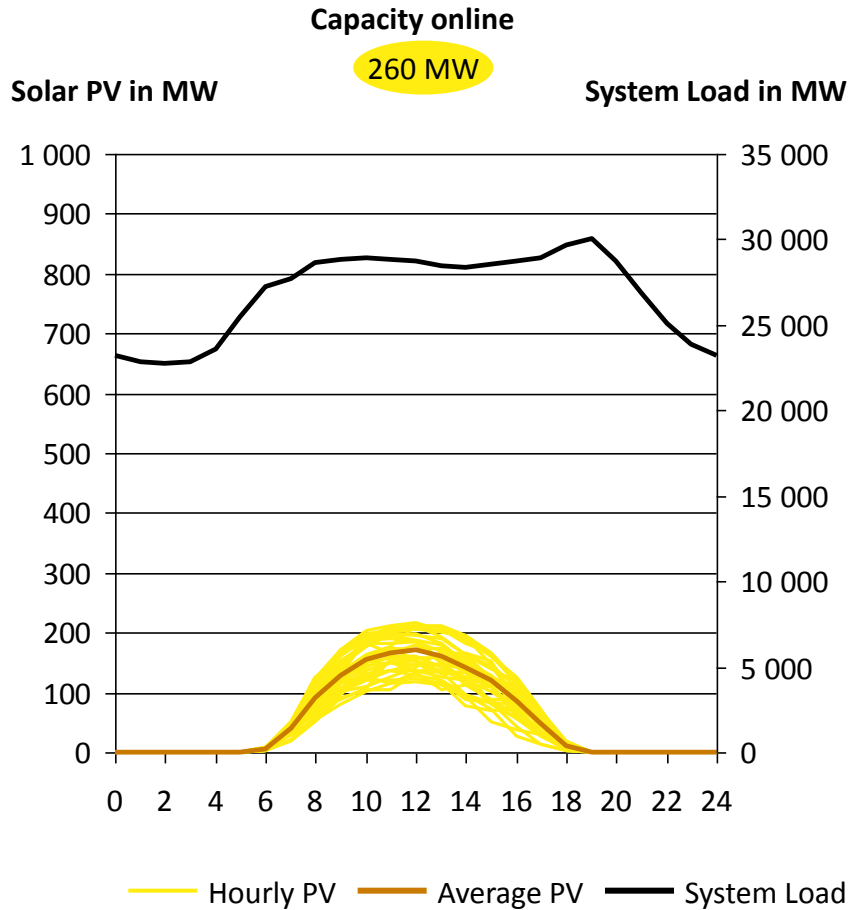
# Solar PV supply in Feb 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 28 days of Feb 2014 and average system load diurnal course



# Solar PV supply in Mar 2014 very stable, wind fluctuated day-to-day

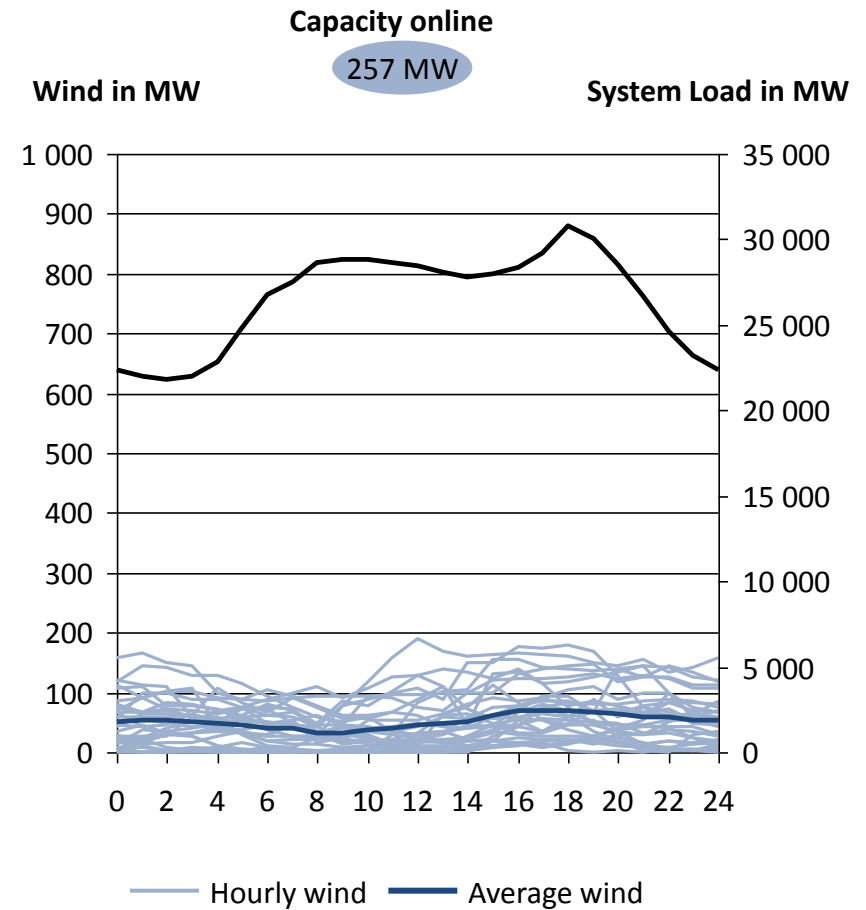
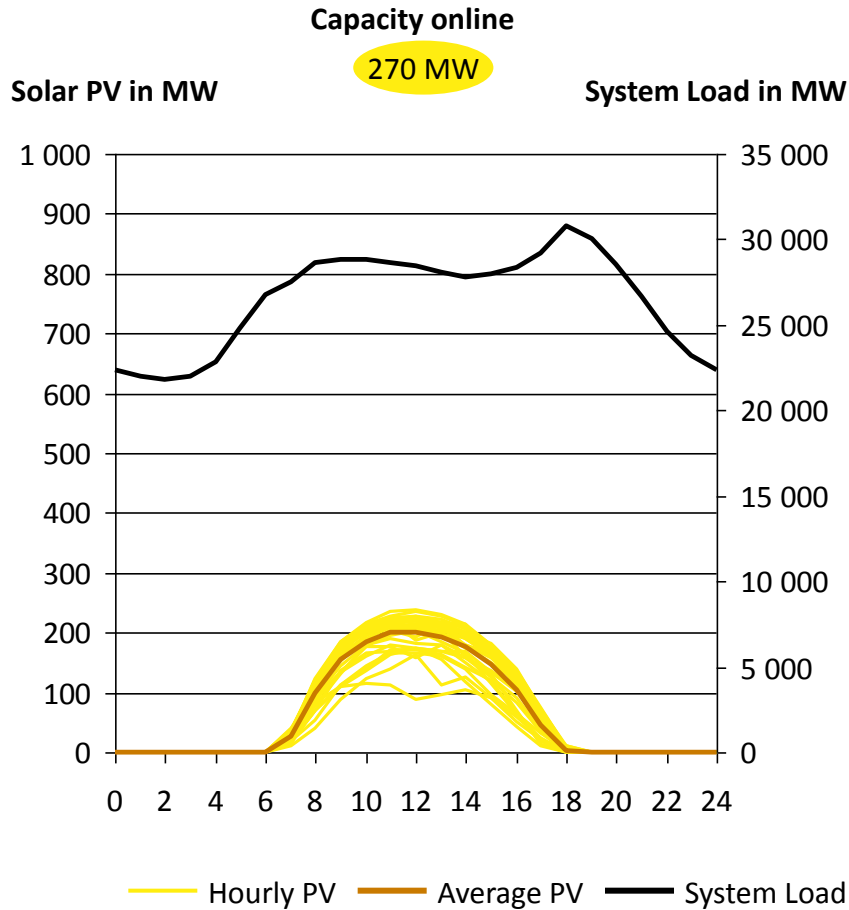
Hourly solar PV and wind production for all 31 days of Mar 2014 and average system load diurnal course





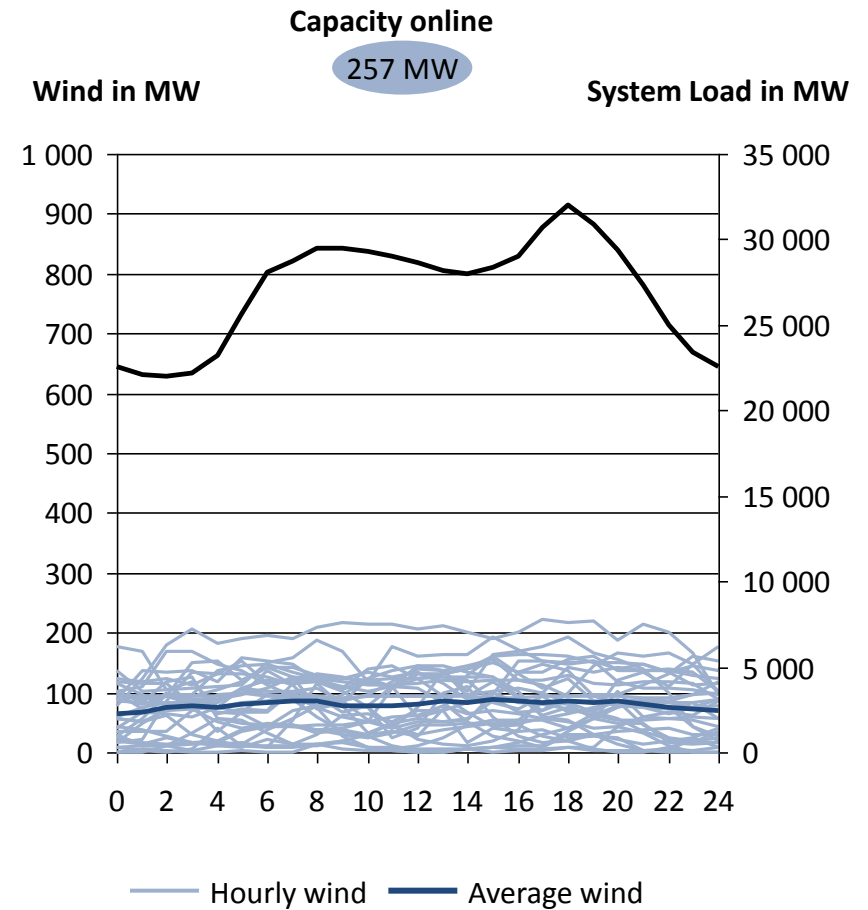
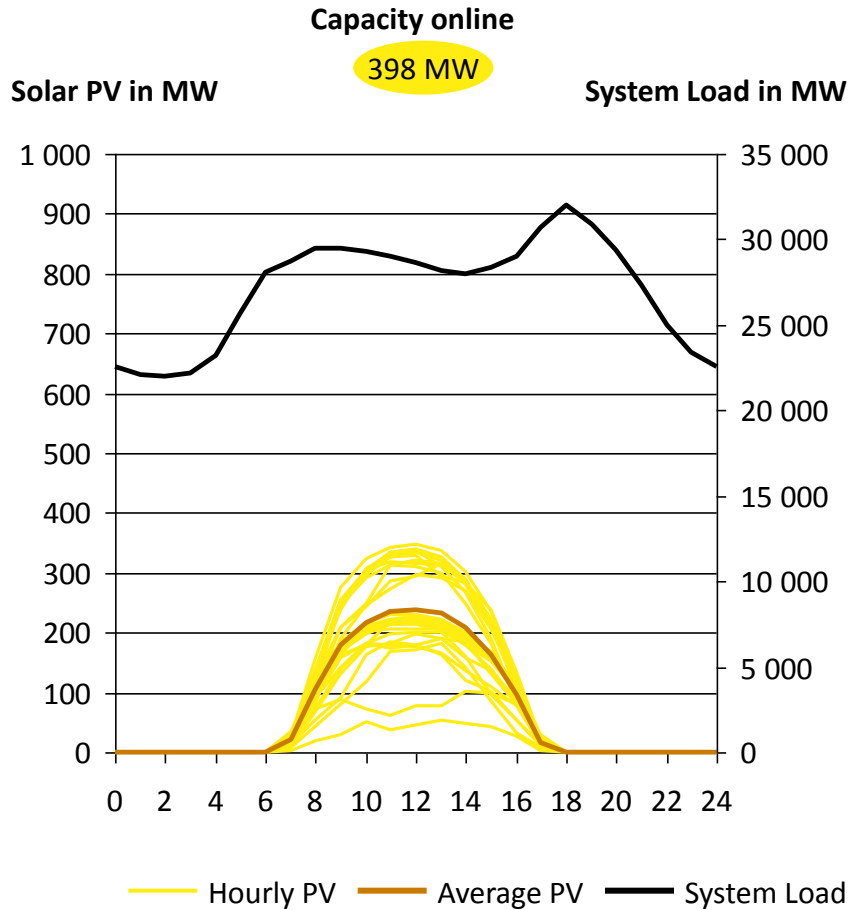
# Solar PV supply in Apr 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 30 days of Apr 2014 and average system load diurnal course



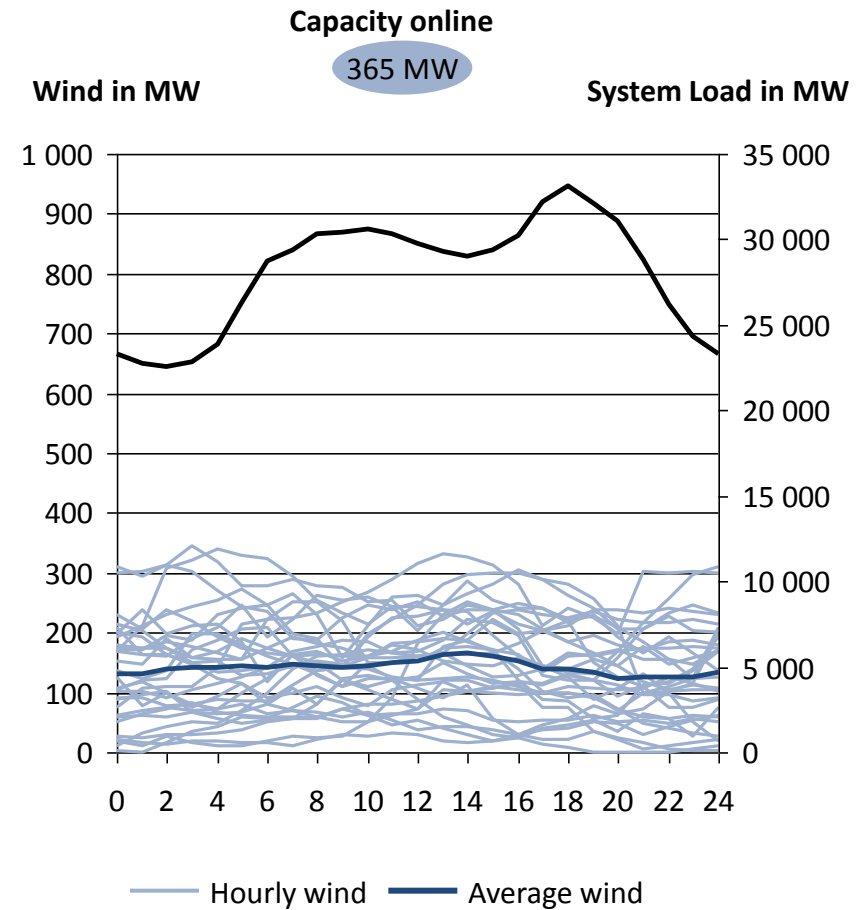
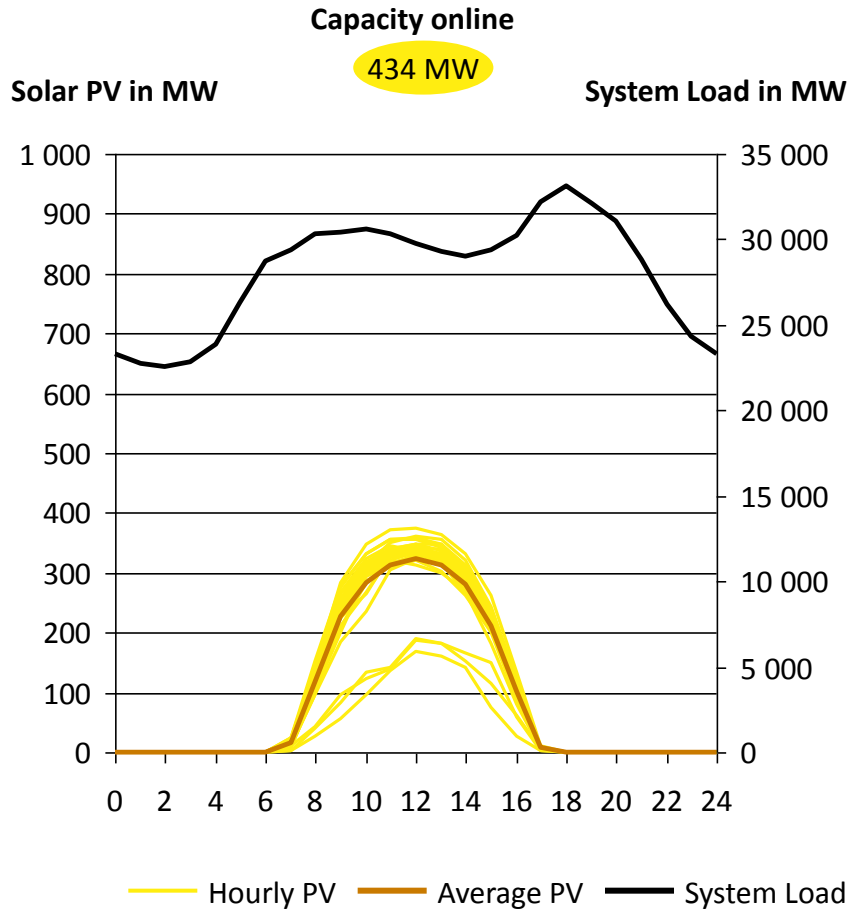
# Solar PV supply in May 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 31 days of May 2014 and average system load diurnal course



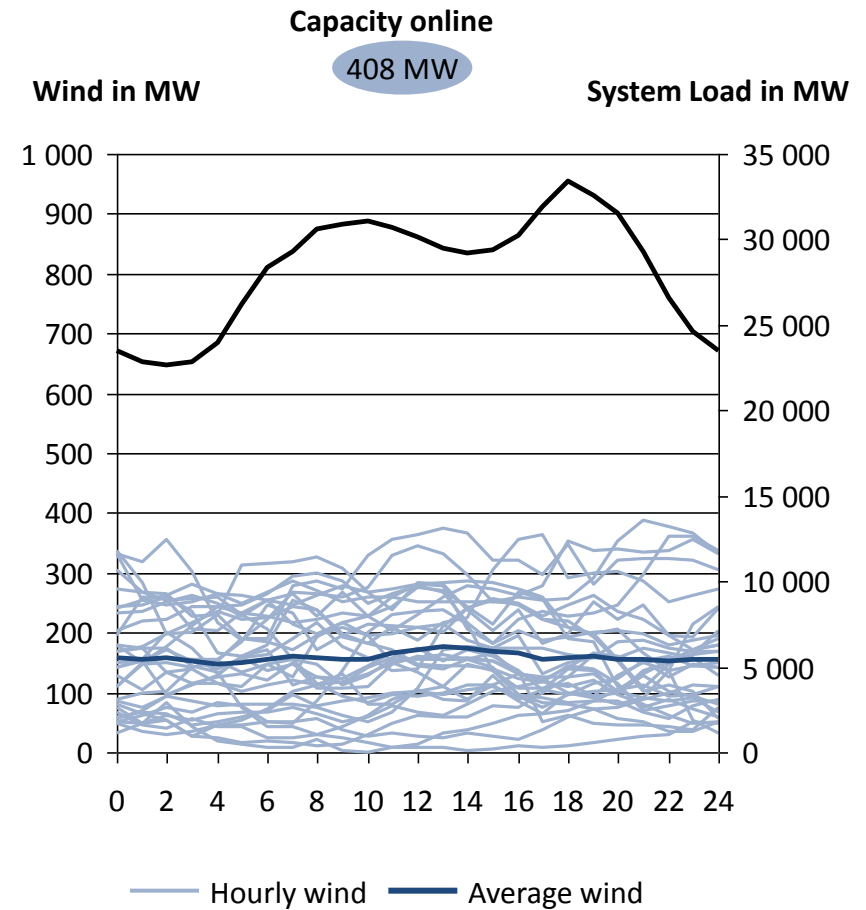
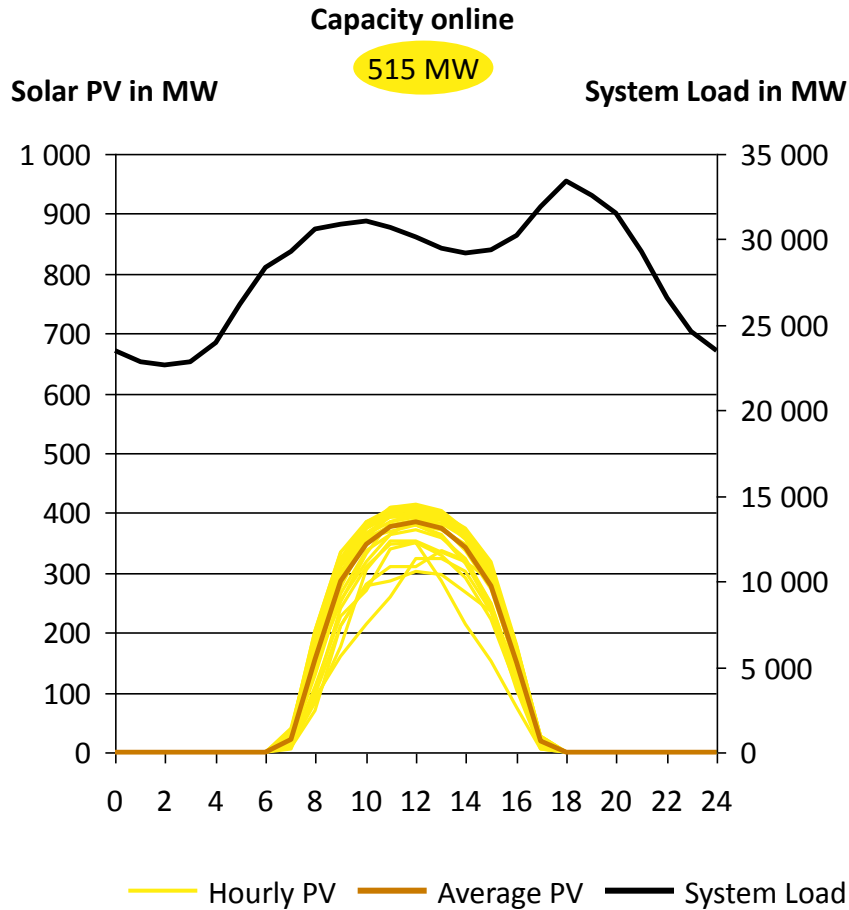
# Solar PV supply in Jun 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 30 days of Jun 2014 and average system load diurnal course



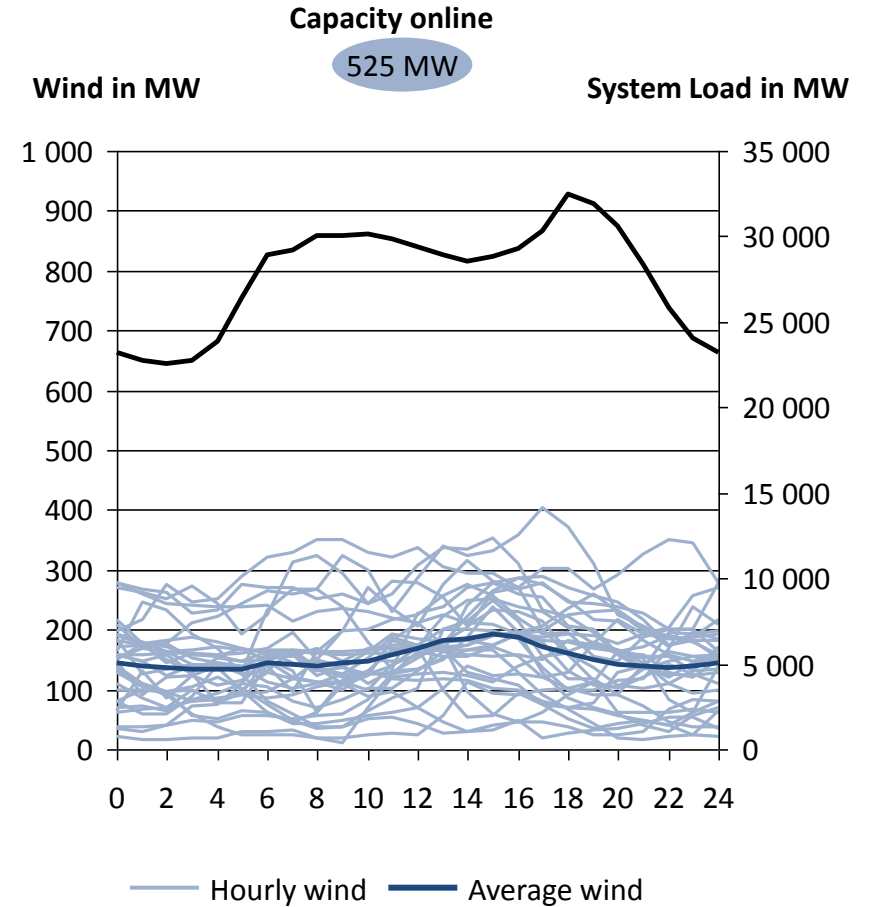
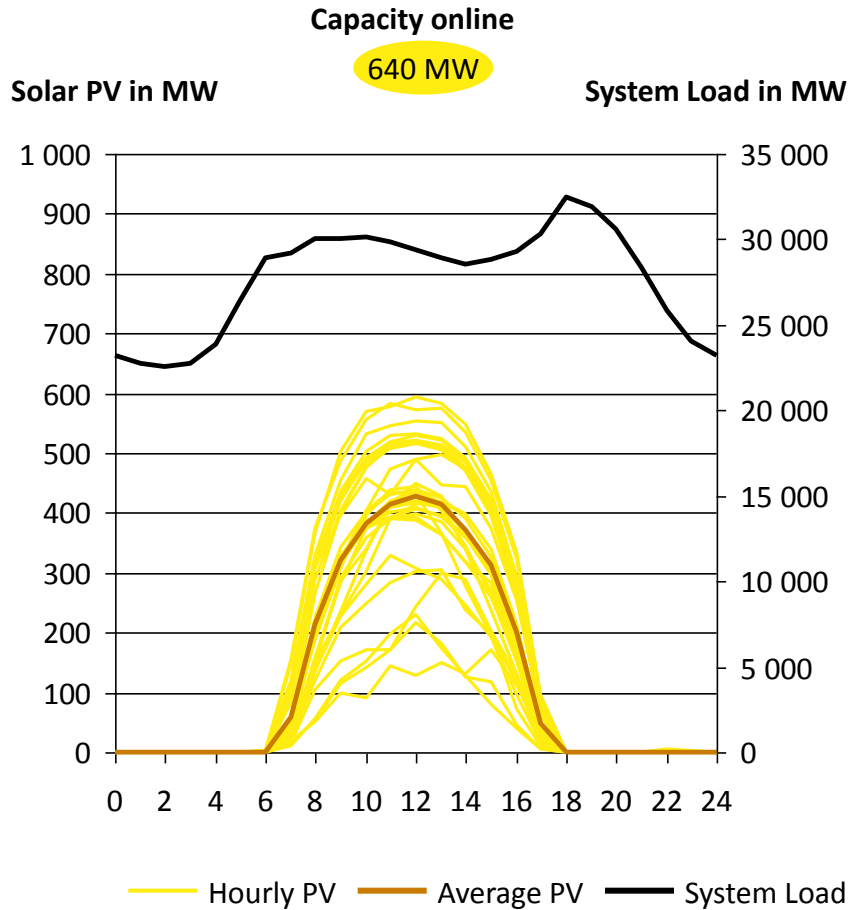
# Solar PV supply in Jul 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 31 days of Jul 2014 and average system load diurnal course



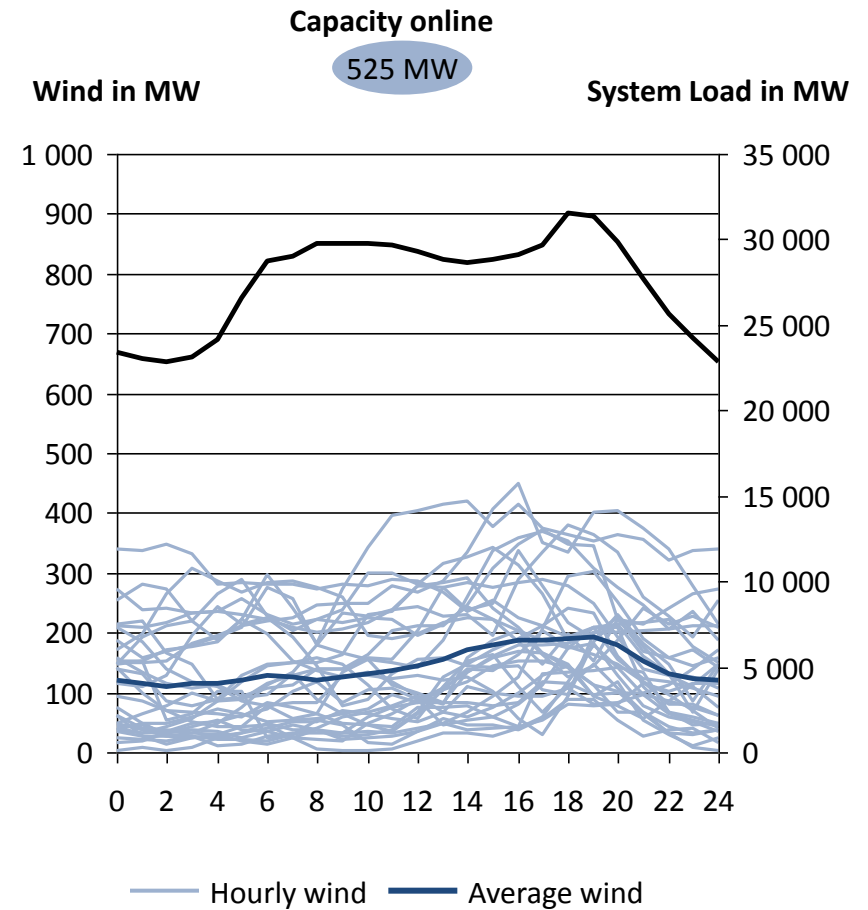
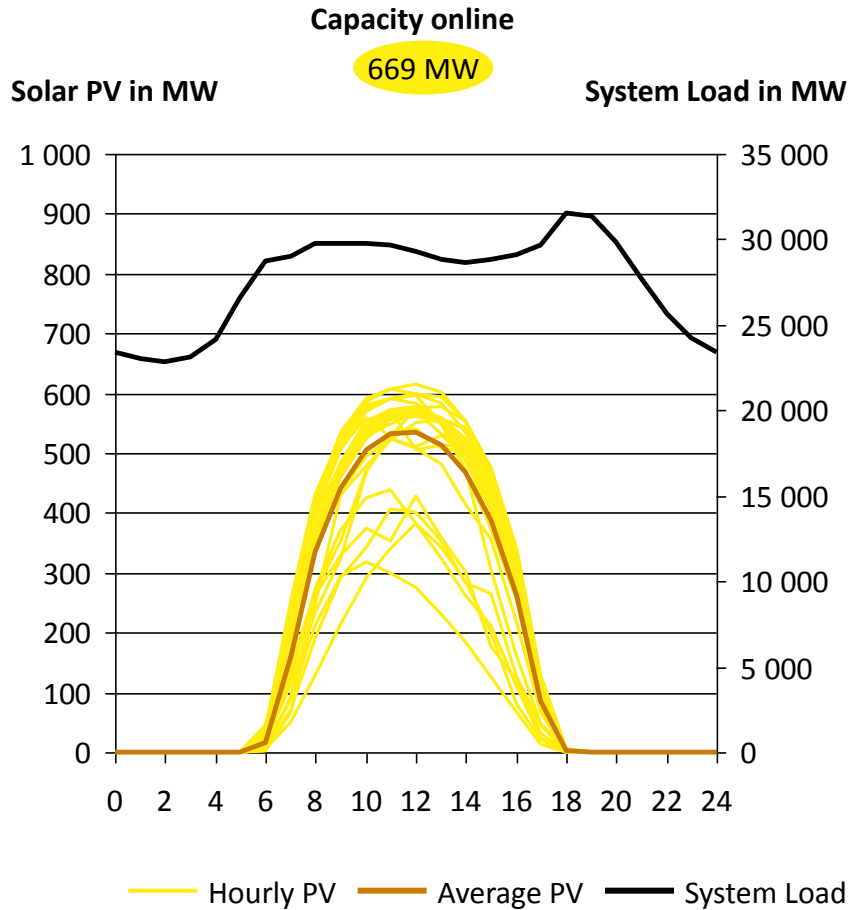
# Solar PV supply in Aug 2014 was stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 31 days of Aug 2014 and average system load diurnal course



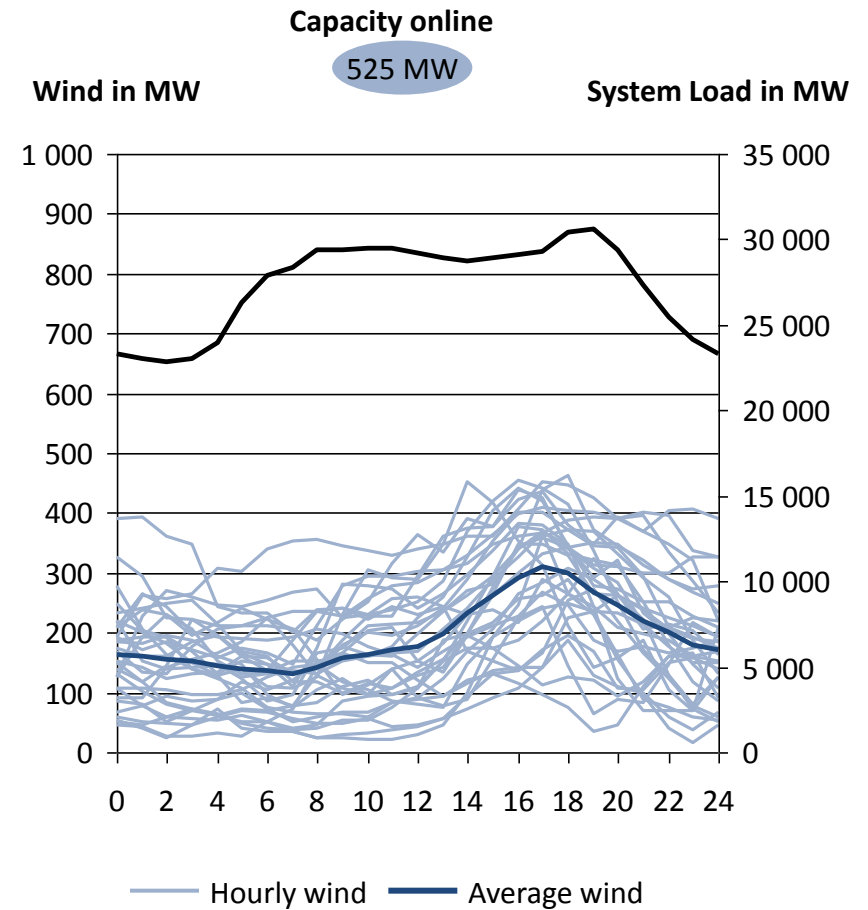
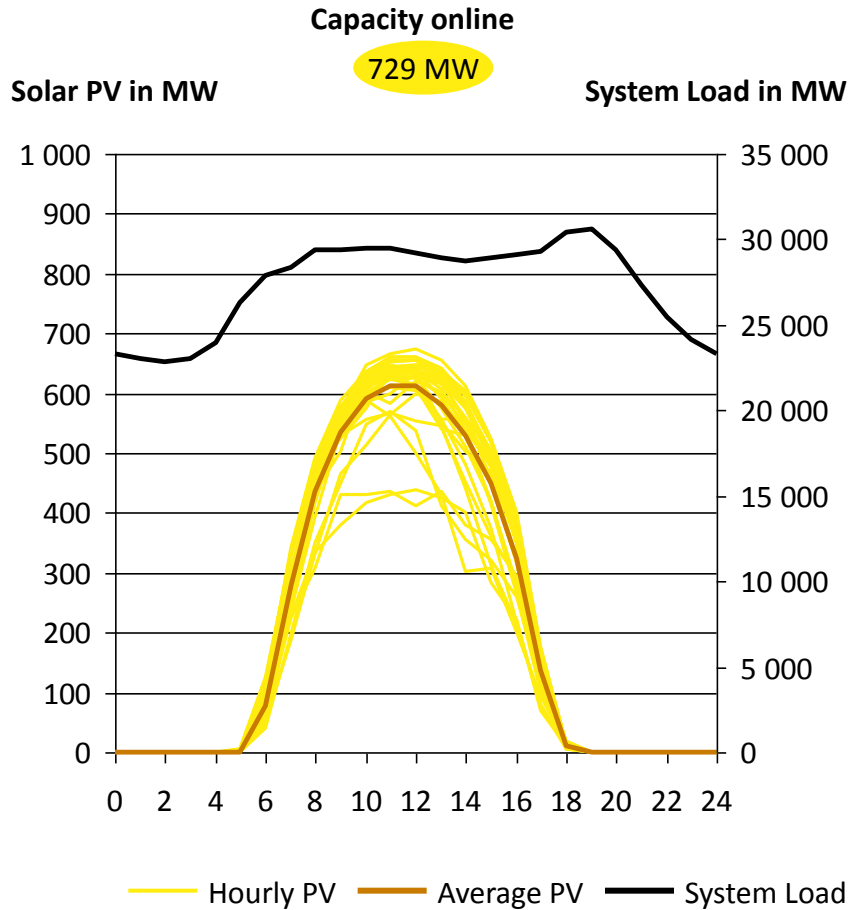
# Solar PV supply in Sep 2014 very stable, wind fluctuated day-to-day

Hourly solar PV and wind production for all 30 days of Sep 2014 and average system load diurnal course



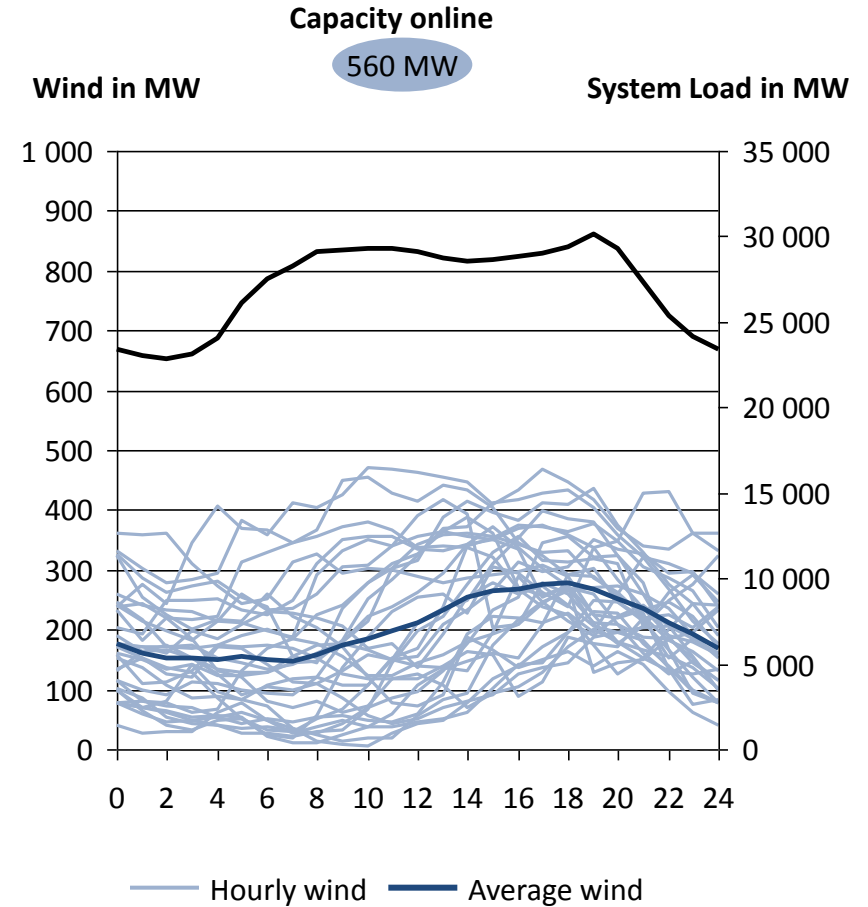
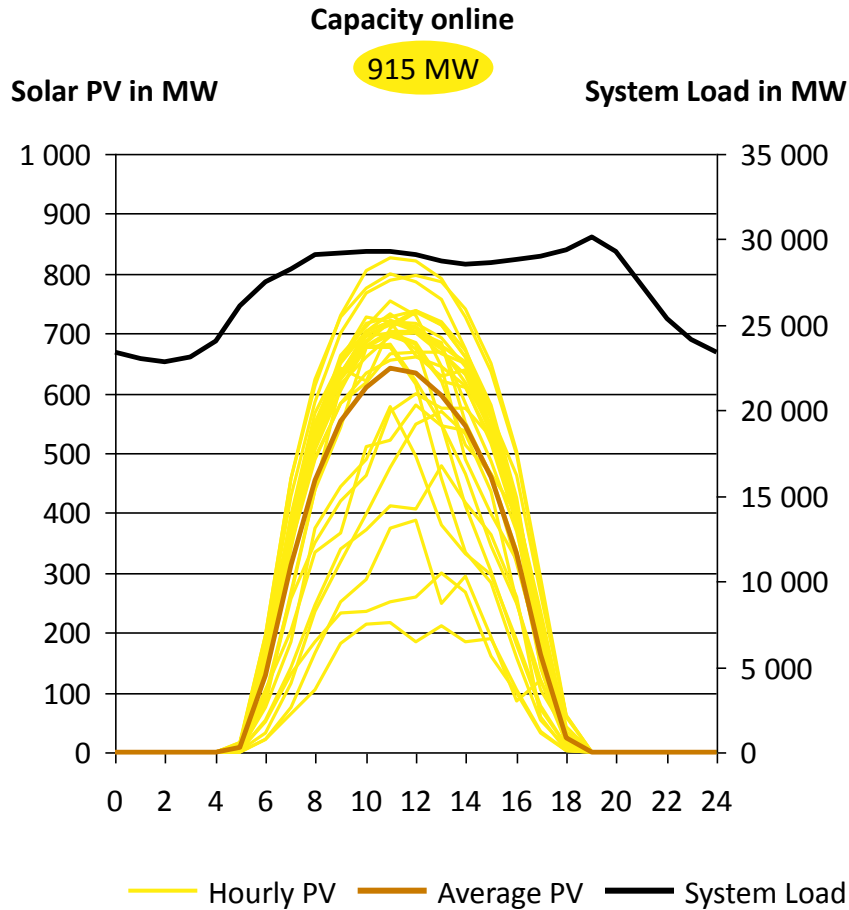
# Solar PV supply in Oct 2014 very stable, wind supplied more evenings

Hourly solar PV and wind production for all 31 days of Oct 2014 and average system load diurnal course



# Solar PV supply in Nov 2014 very stable, wind supplied more evenings

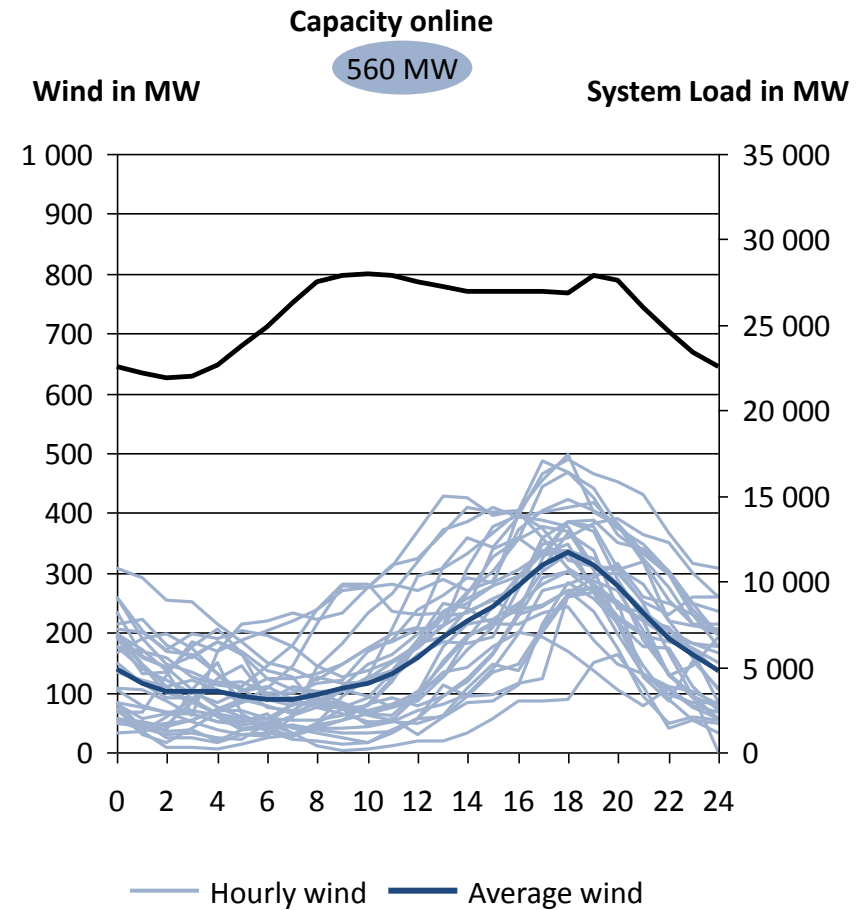
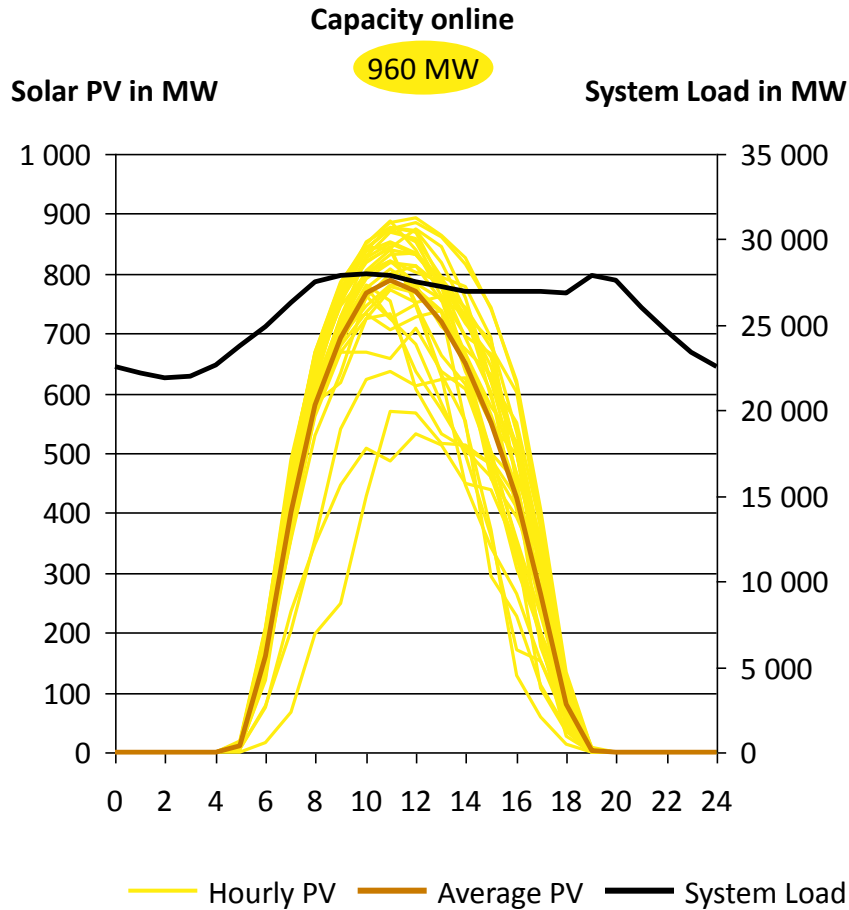
Hourly solar PV and wind production for all 30 days of Nov 2014 and average system load diurnal course





# Solar PV supply in Dec 2014 very stable, wind supplied more evenings

Hourly solar PV and wind production for all 31 days of Dec 2014 and average system load diurnal course



# Agenda

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Overview actual electricity production data for 2014

Monthly electricity production

**Weekly electricity production**

Daily electricity production

Hourly electricity production

Diurnal courses

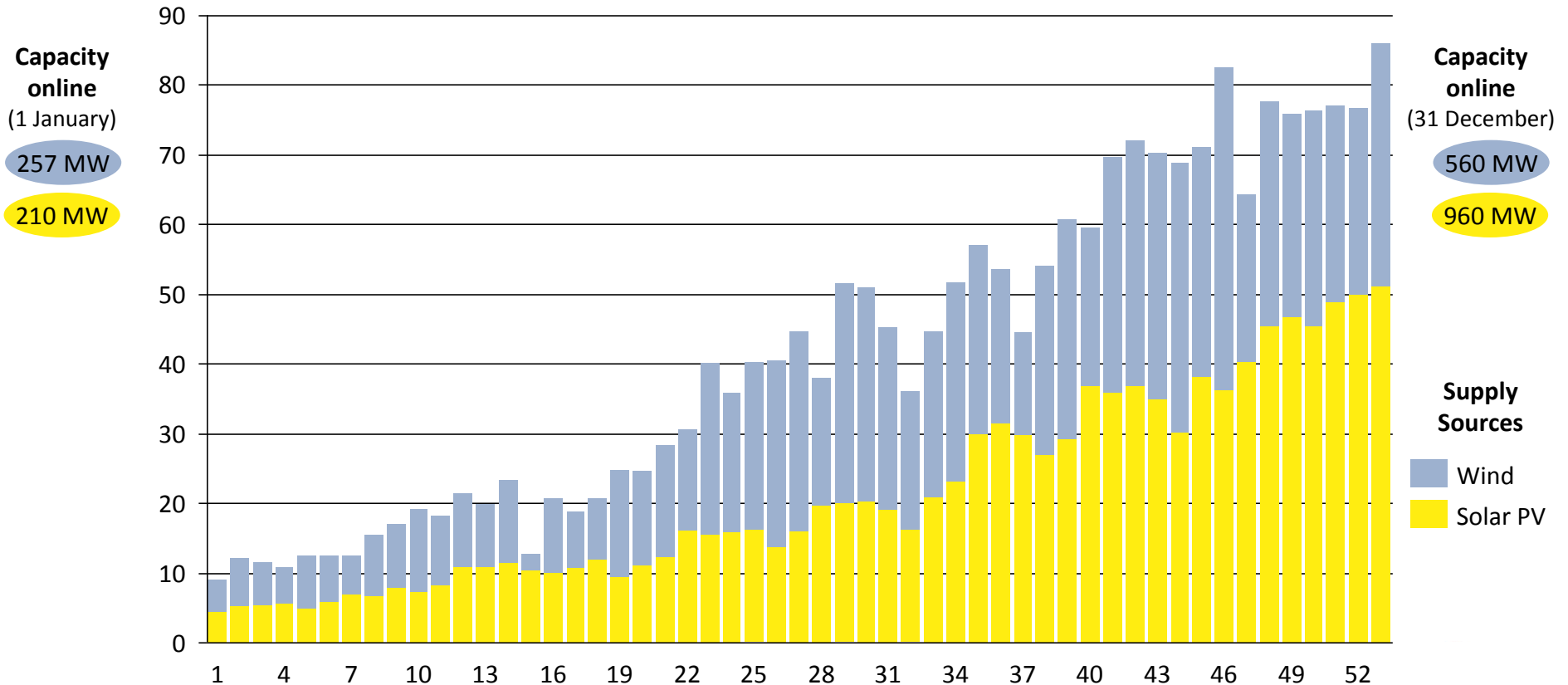
Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

# Weekly electricity production of South African wind & solar PV fleet

Actual weekly production from large-scale solar PV and wind plants under the REIPPPP from Jan-Dec 2014

Electricity production in GWh/week



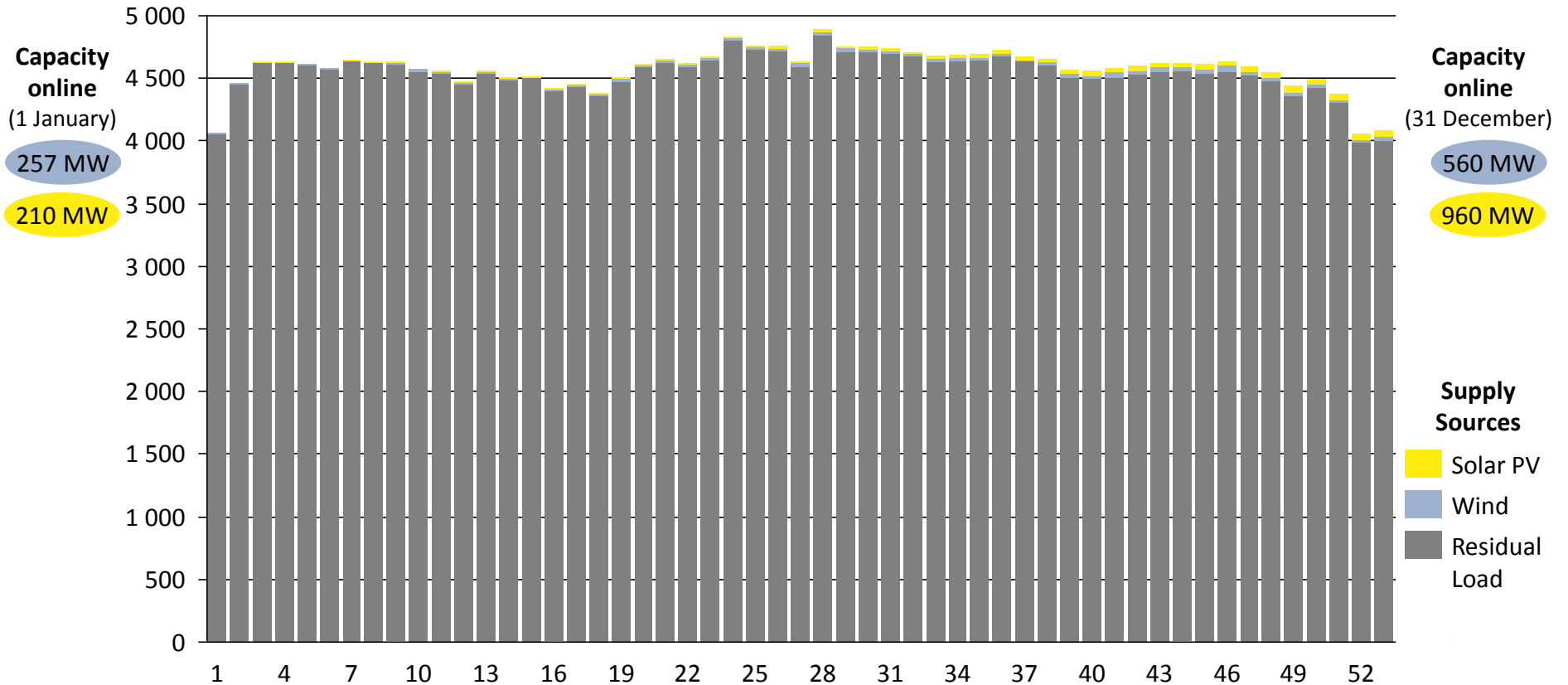
- Maximum wind + solar PV weekly production of 83 GWh in week 46\*
- Minimum wind + solar PV weekly production of 11 GWh in week 4

Note: Design as per Fraunhofer ISE. Week 1 and week 53 adjusted/scaled to 7 day week. \*Week 1 and 53 excluded from minimum and maximum production calculation.  
 Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Weekly electricity production wind, solar PV and residual load

Actual weekly production: conventional fleet, wind & solar PV plants under REIPPPP from Jan-Dec 2014

Electricity production in GWh/week



# Agenda

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Overview actual electricity production data for 2014

Monthly electricity production

Weekly electricity production

**Daily electricity production**

Hourly electricity production

Diurnal courses

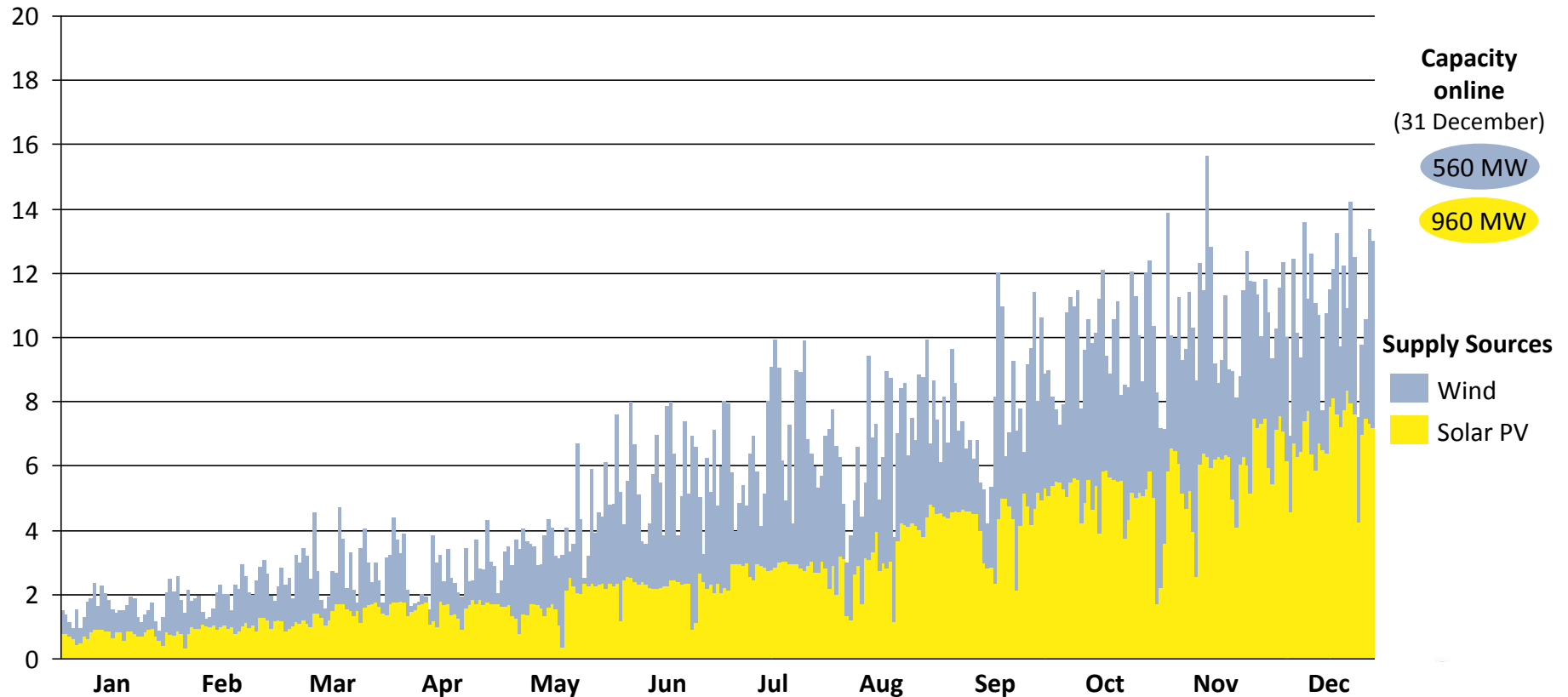
Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

# Daily electricity production wind and solar PV fleet Jan to Dec 2014

Actual daily production from large-scale solar PV and wind plants under the REIPPPP from Jan-Dec 2014

Electricity production  
in GWh/day

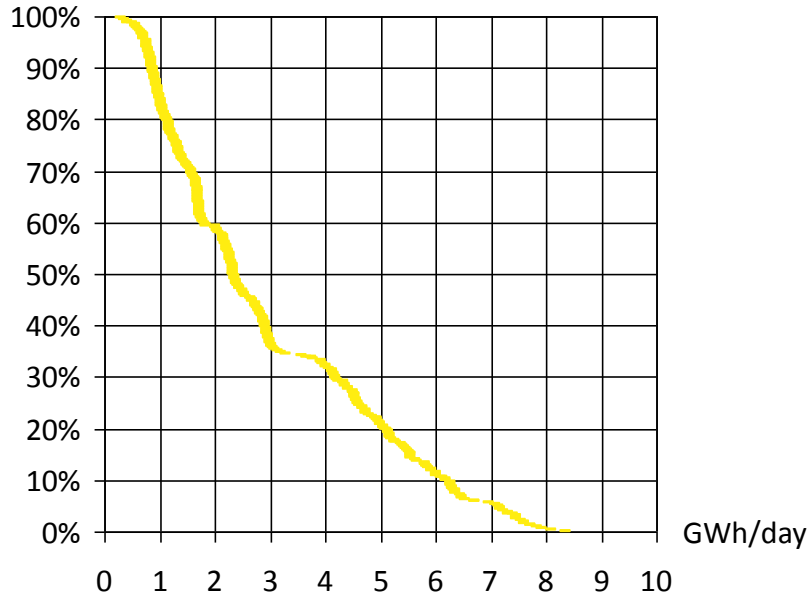


- Maximum daily production of 15.6 GWh on 16 Nov 2014.
- Minimum daily production of 0.8 GWh on 28 Jan 2014.

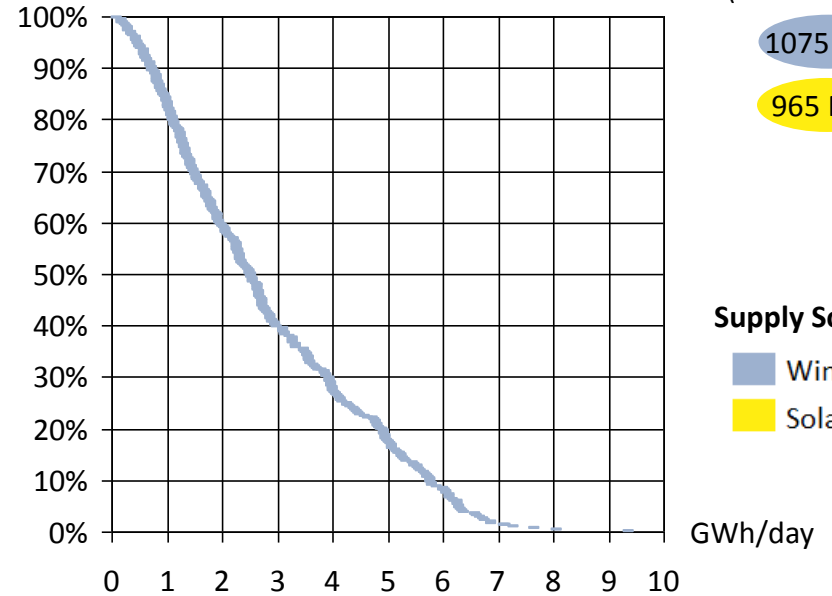
# On 80% of the days in 2014, solar PV and wind had a daily energy production of 1 GWh or more

Frequency distribution of daily solar PV and wind electricity production in 2014

Cummulative Frequency



Cummulative Frequency



**Capacity online**  
(31 December)

1075 MW  
965 MW

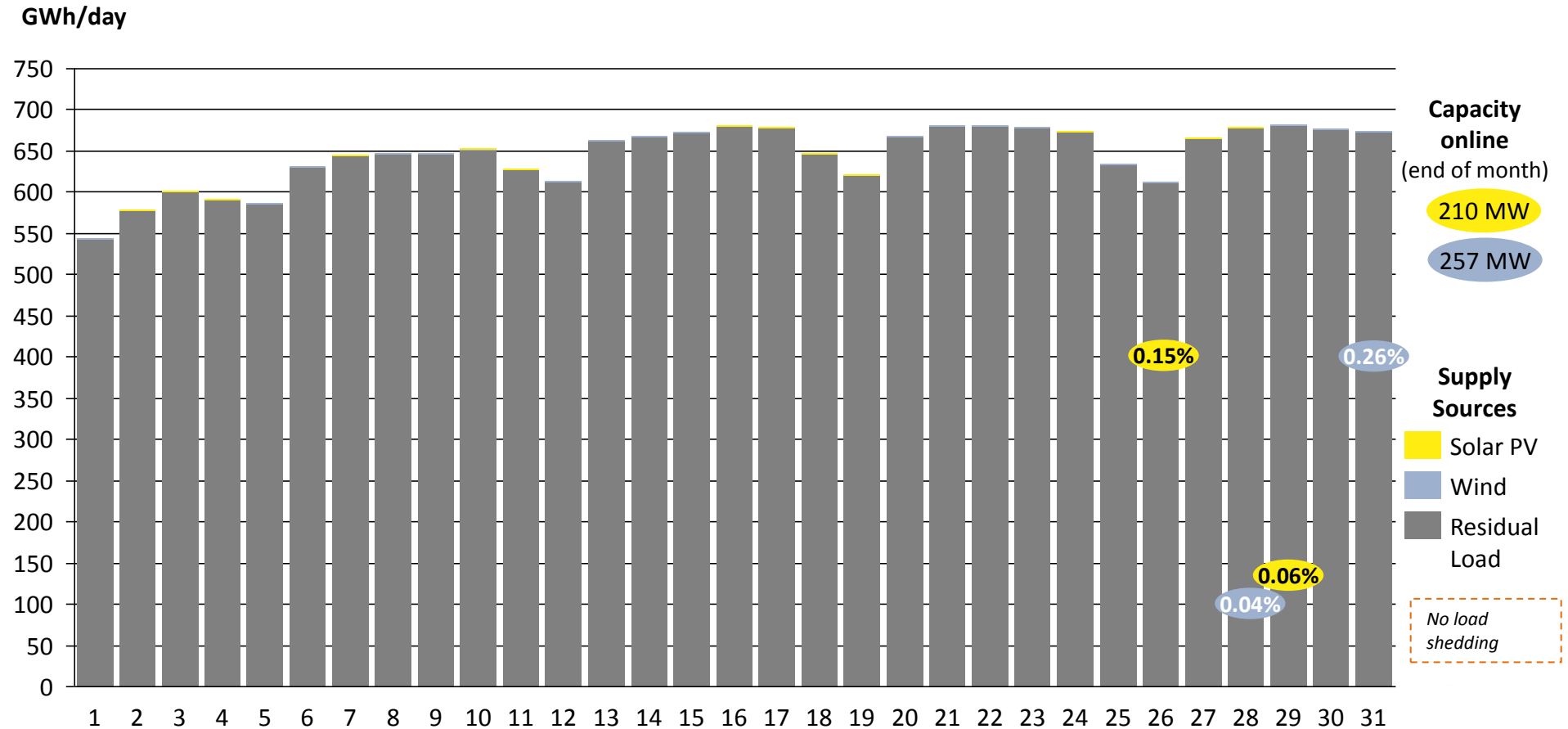
**Supply Sources**

Wind  
Solar PV



# Daily electricity production of between 544-682 GWh in Jan 2014

Actual daily production from all power supply sources in South Africa for January 2014



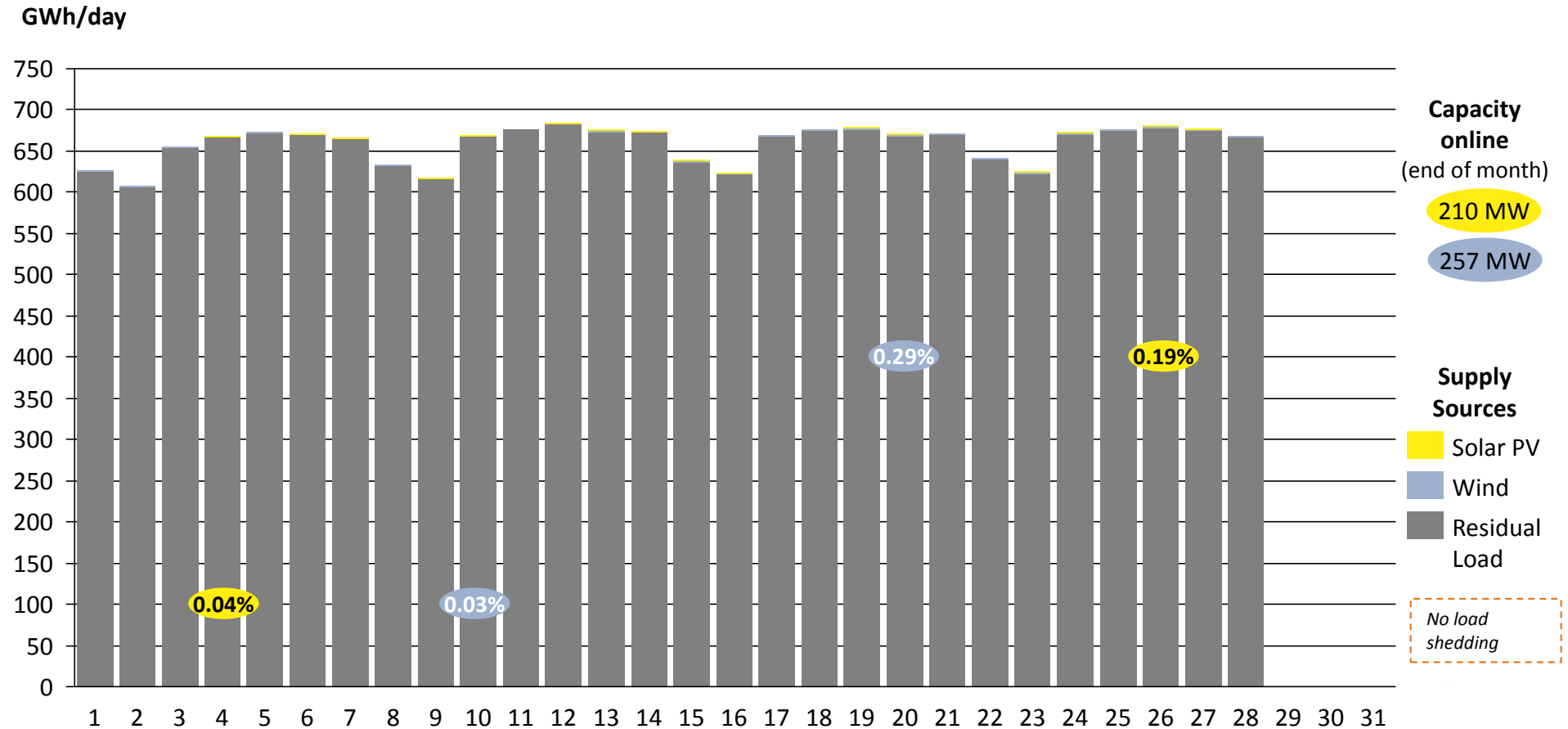
- Maximum daily production of 682 GWh on 29 Jan 2014 (Wednesday)
- Minimum daily production of 544 GWh on 1 Jan 2014 (Wednesday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis



# Daily electricity production of between 608-682 GWh in Feb 2014

Actual daily production from all power supply sources in South Africa for February 2014

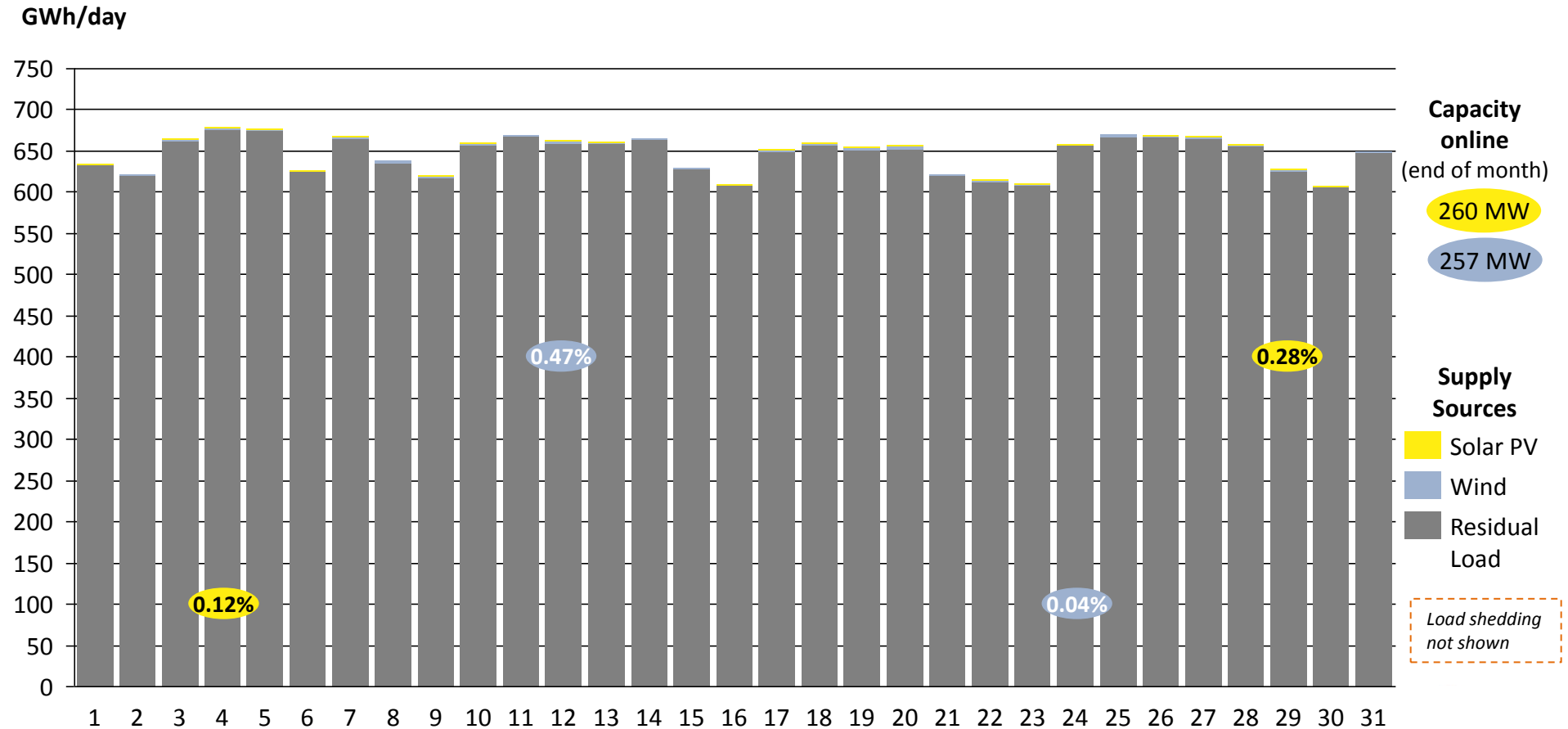


- Maximum daily production of 682 GWh on 12 Feb 2014 (Wednesday)
- Minimum daily production of 608 GWh on 2 Feb 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
 Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 607-678 GWh in Mar 2014

Actual daily production from all power supply sources in South Africa for March 2014

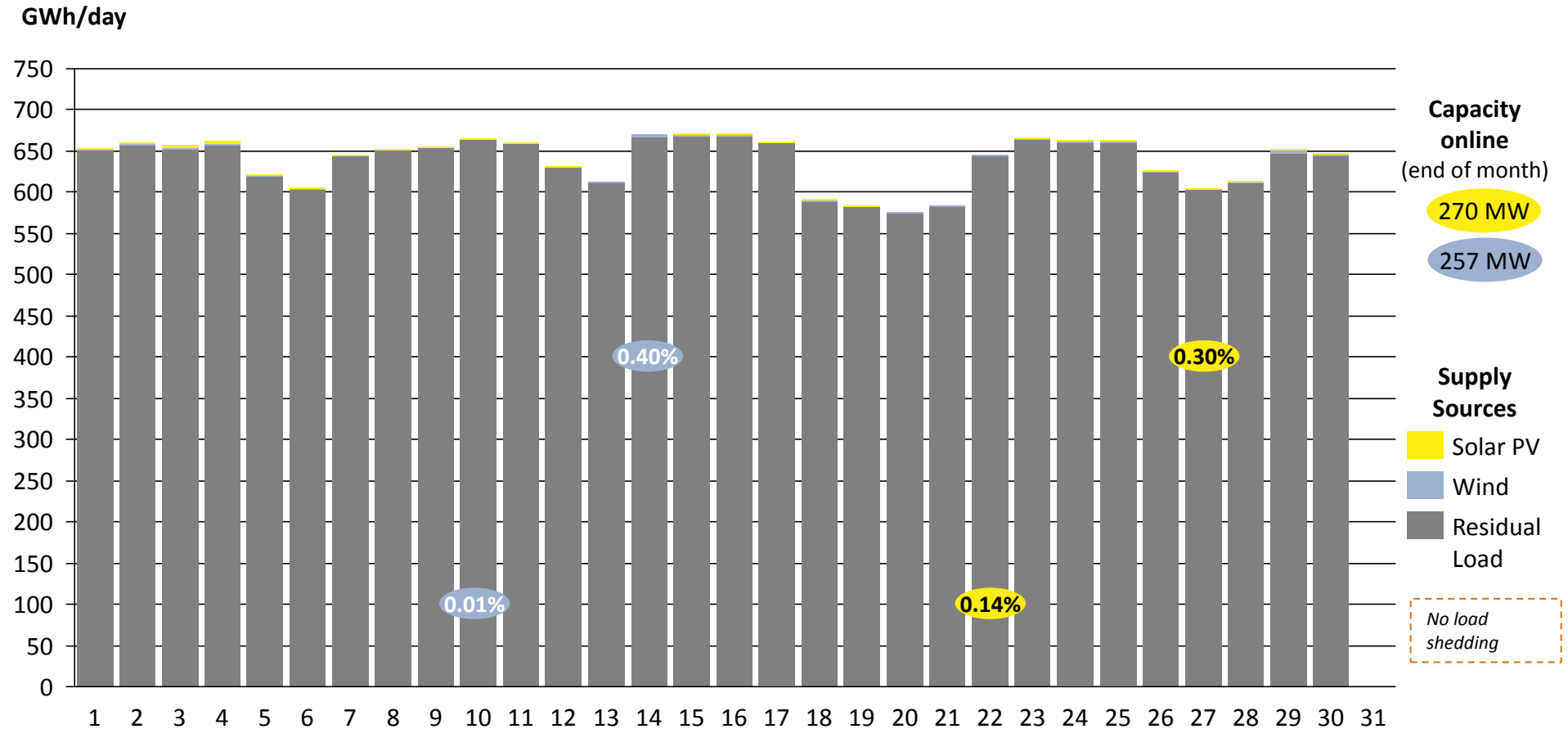


- Maximum daily production of 678 GWh on 4 Mar 2014 (Tuesday)
- Minimum daily production of 607 GWh on 30 Mar 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 576-671 GWh in Apr 2014

Actual daily production from all power supply sources in South Africa for April 2014

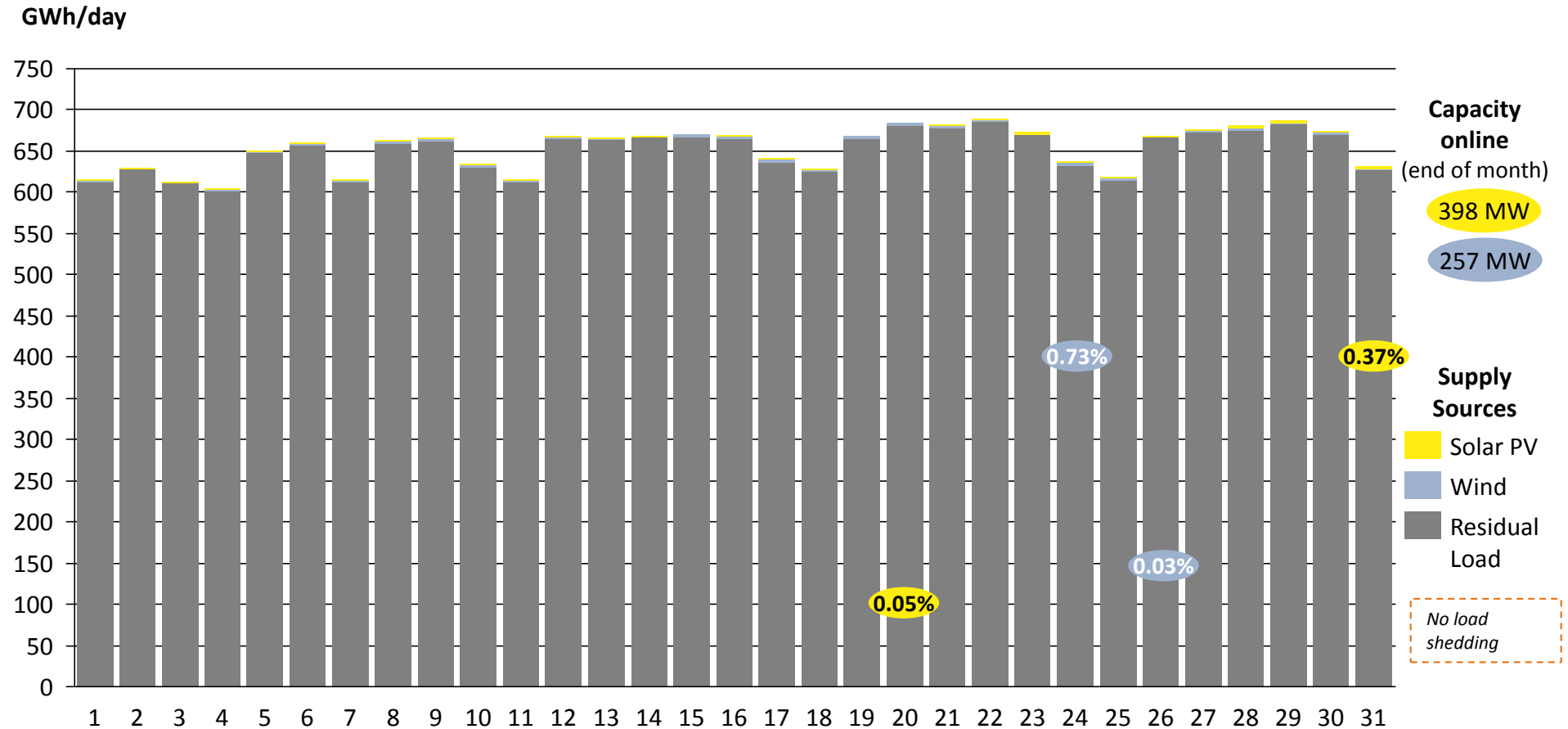


- Maximum daily production of 671 GWh on 16 Apr 2014 (Wednesday)
- Minimum daily production of 576 GWh on 20 Apr 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
 Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 604-688 GWh in May 2014

Actual daily production from all power supply sources in South Africa for May 2014

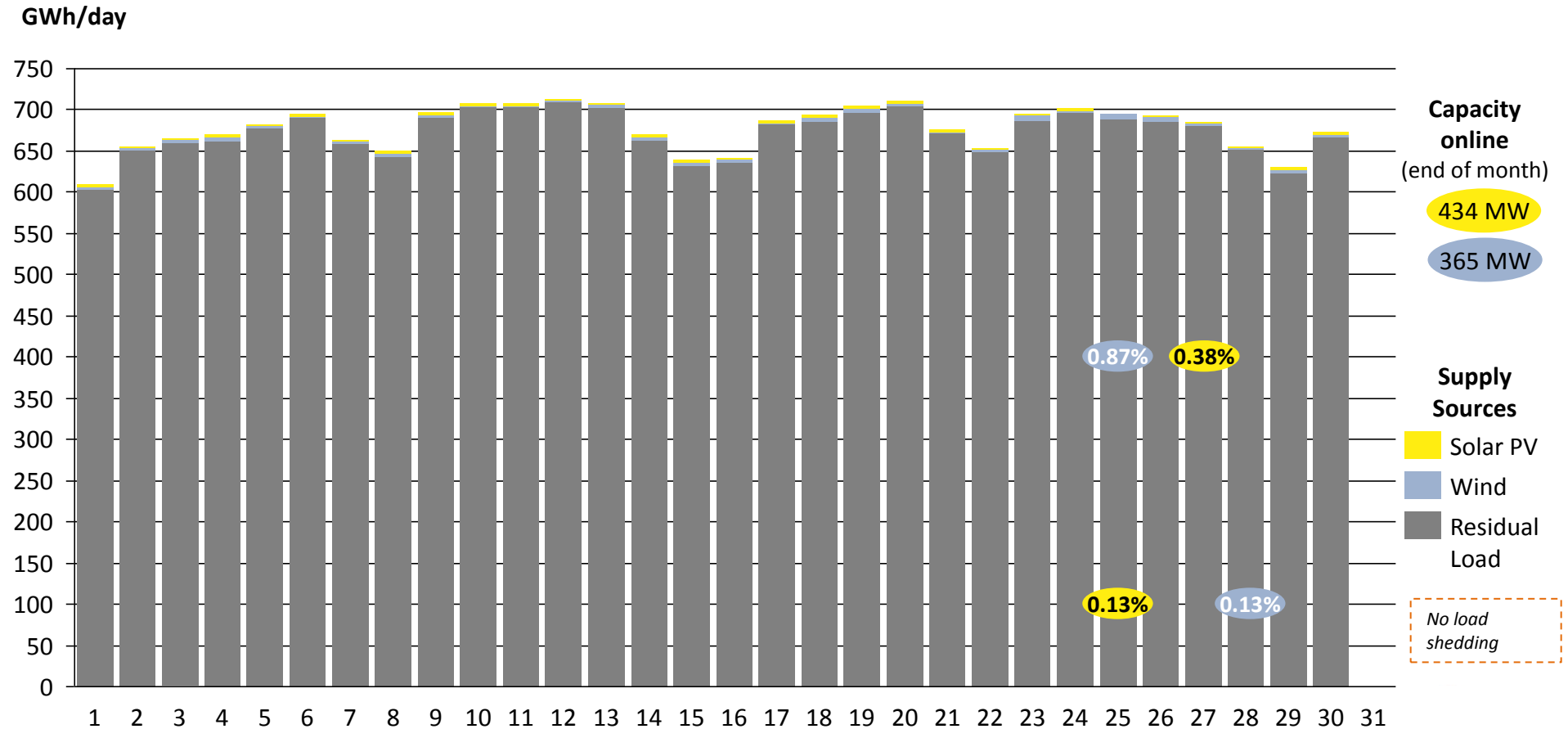


- Maximum daily production of 688 GWh on 22 May 2014 (Thursday)
- Minimum daily production of 604 GWh on 4 May 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
 Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 608-712 GWh in Jun 2014

Actual daily production from all power supply sources in South Africa for June 2014

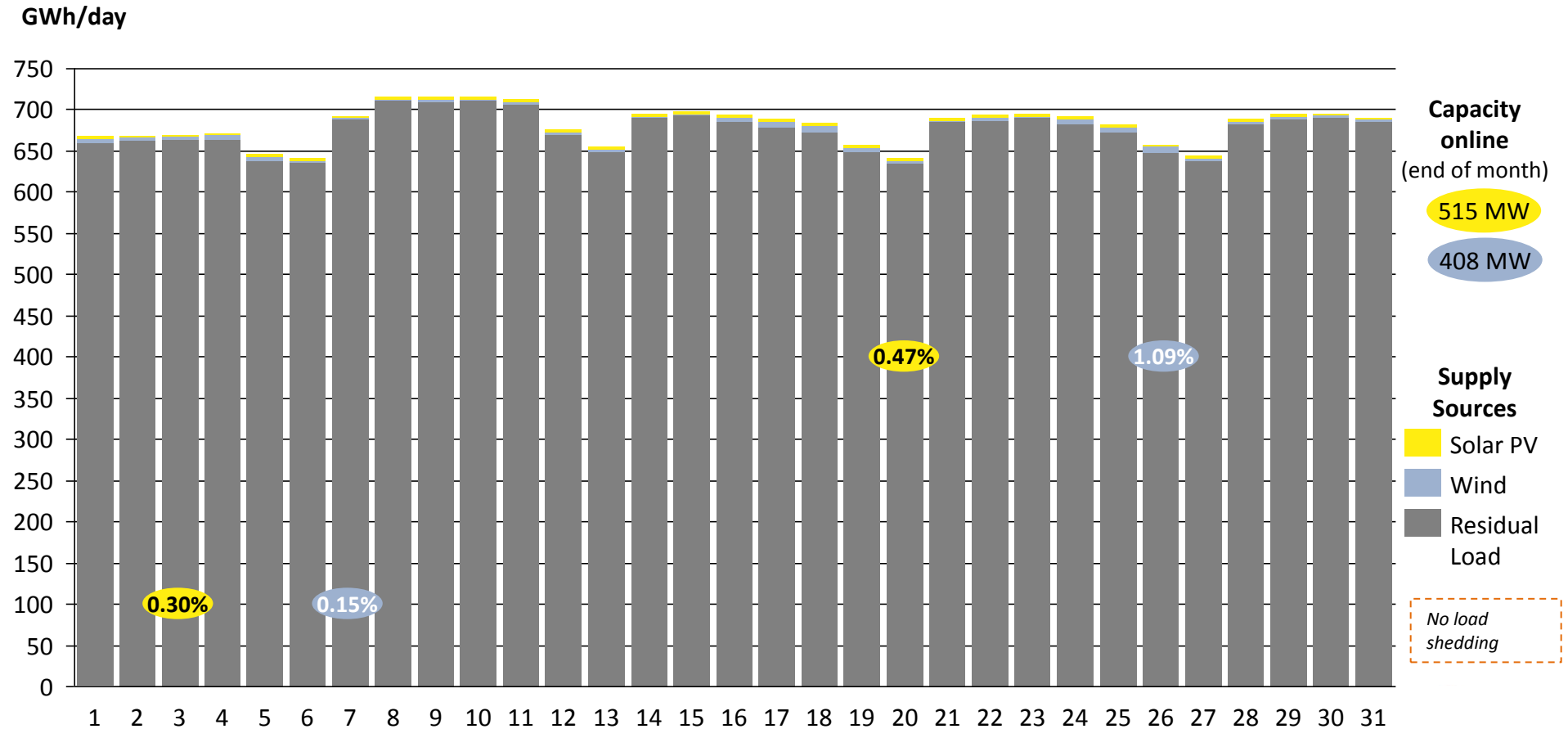


- Maximum daily production of 712 GWh on 12 Jun 2014 (Thursday)
- Minimum daily production of 608 GWh on 1 Jun 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 640-716 GWh in Jul 2014

Actual daily production from all power supply sources in South Africa for July 2014

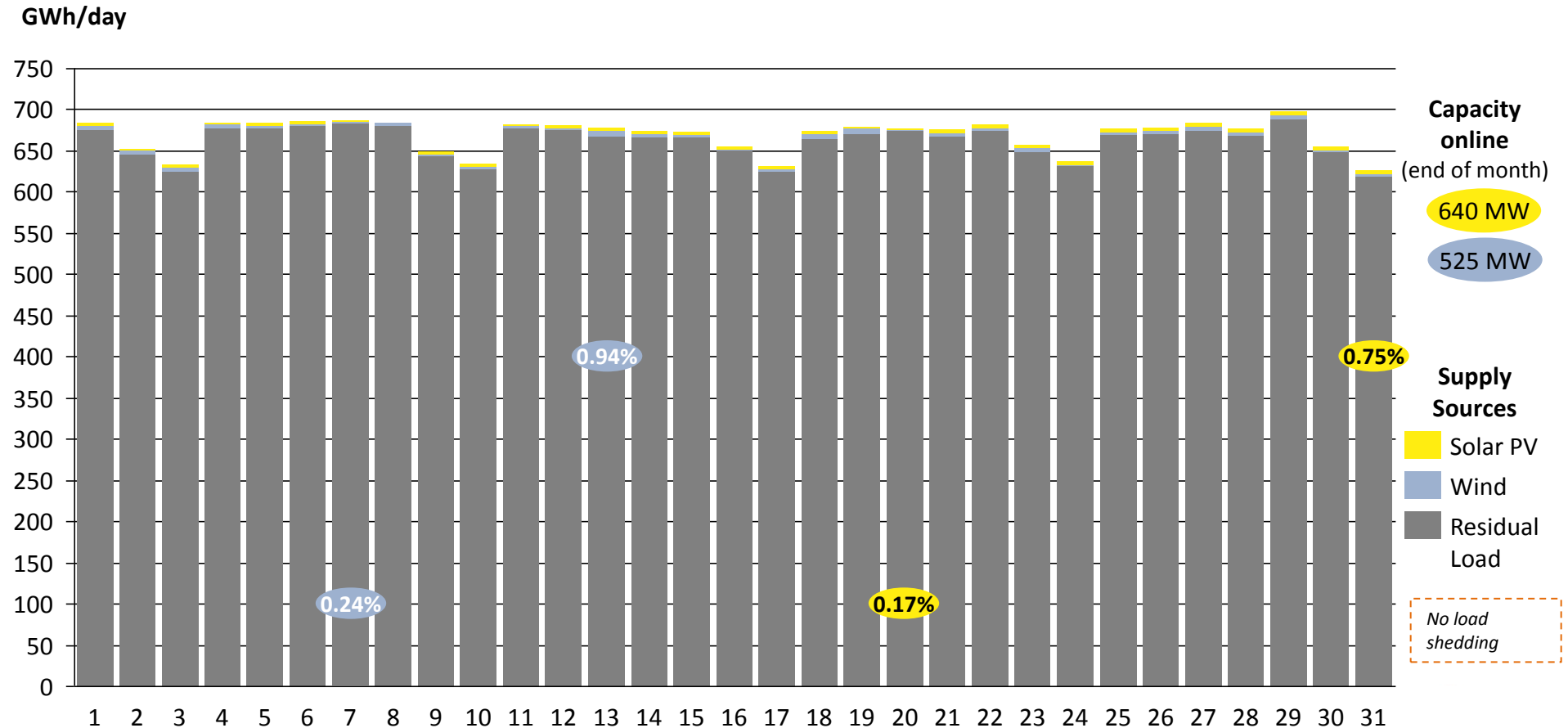


- Maximum daily production of 716 GWh on 10 Jul 2014 (Thursday)
- Minimum daily production of 640 GWh on 20 Jul 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 627-698 GWh in Aug 2014

Actual daily production from all power supply sources in South Africa for August 2014

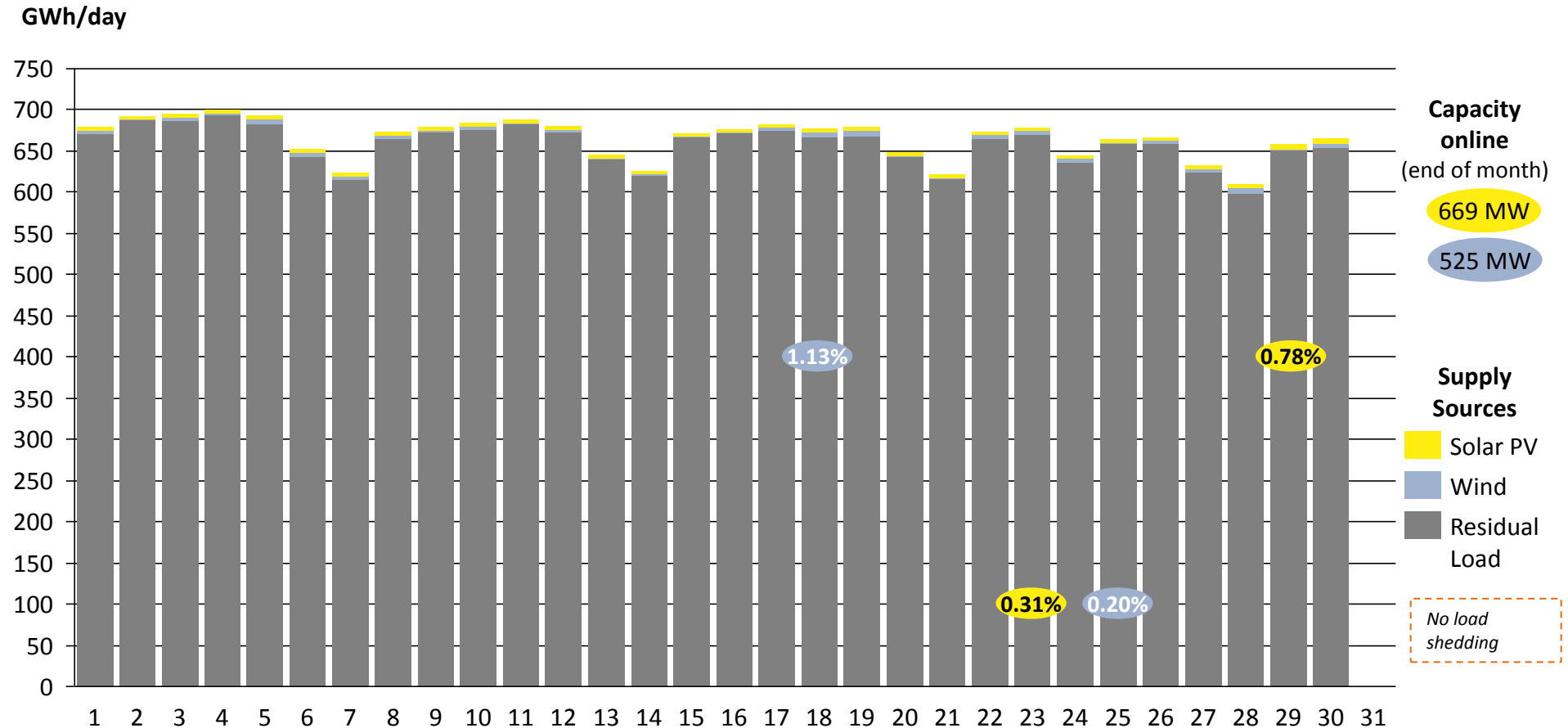


- Maximum daily production of 698 GWh on 29 Aug 2014 (Friday)
- Minimum daily production of 627 GWh on 31 Aug 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 608-700 GWh in Sep 2014

Actual daily production from all power supply sources in South Africa for September 2014



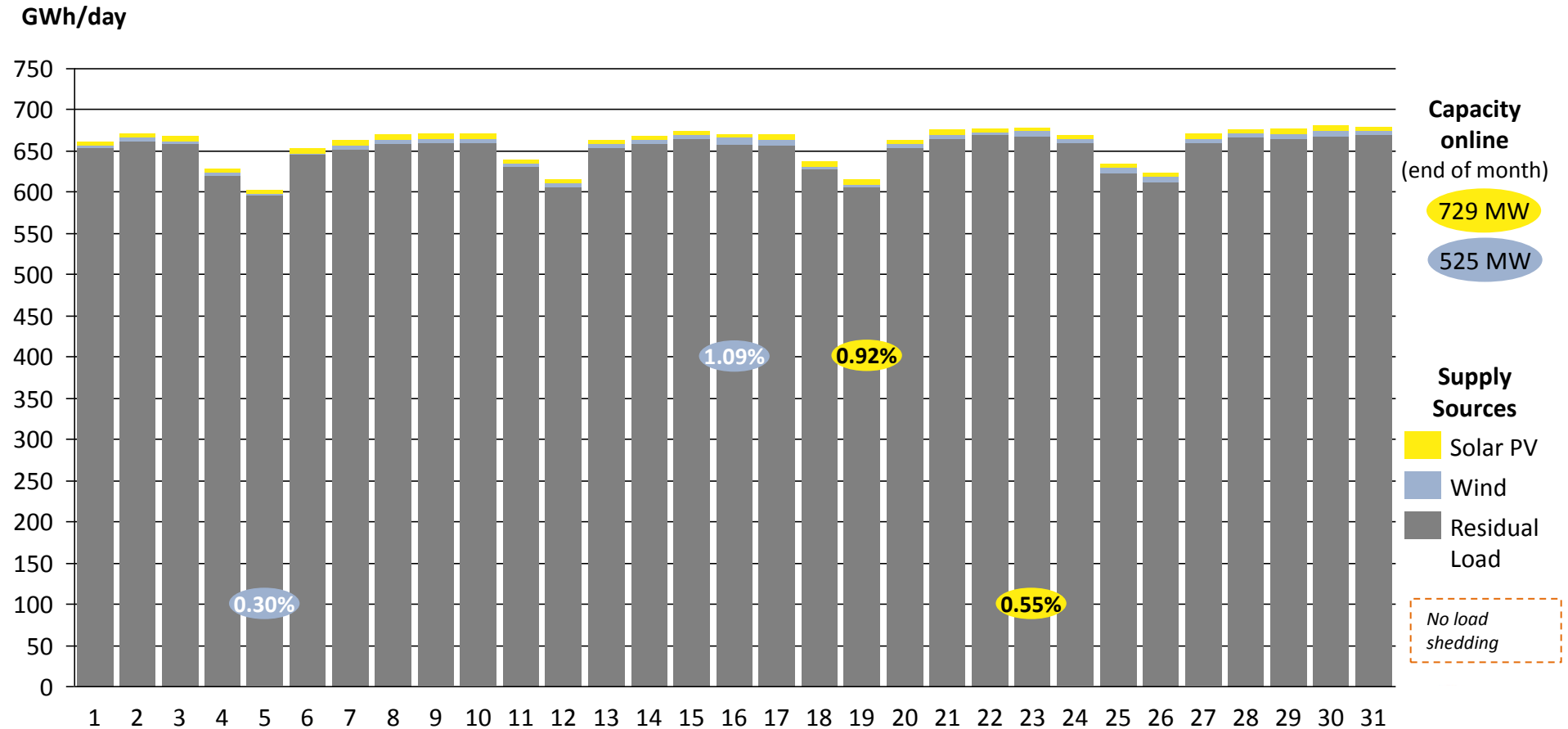
- Maximum daily production of 700 GWh on 4 Sep 2014 (Thursday)
- Minimum daily production of 608 GWh on 28 Sep 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis



# Daily electricity production of between 603-680 GWh in Oct 2014

Actual daily production from all power supply sources in South Africa for October 2014

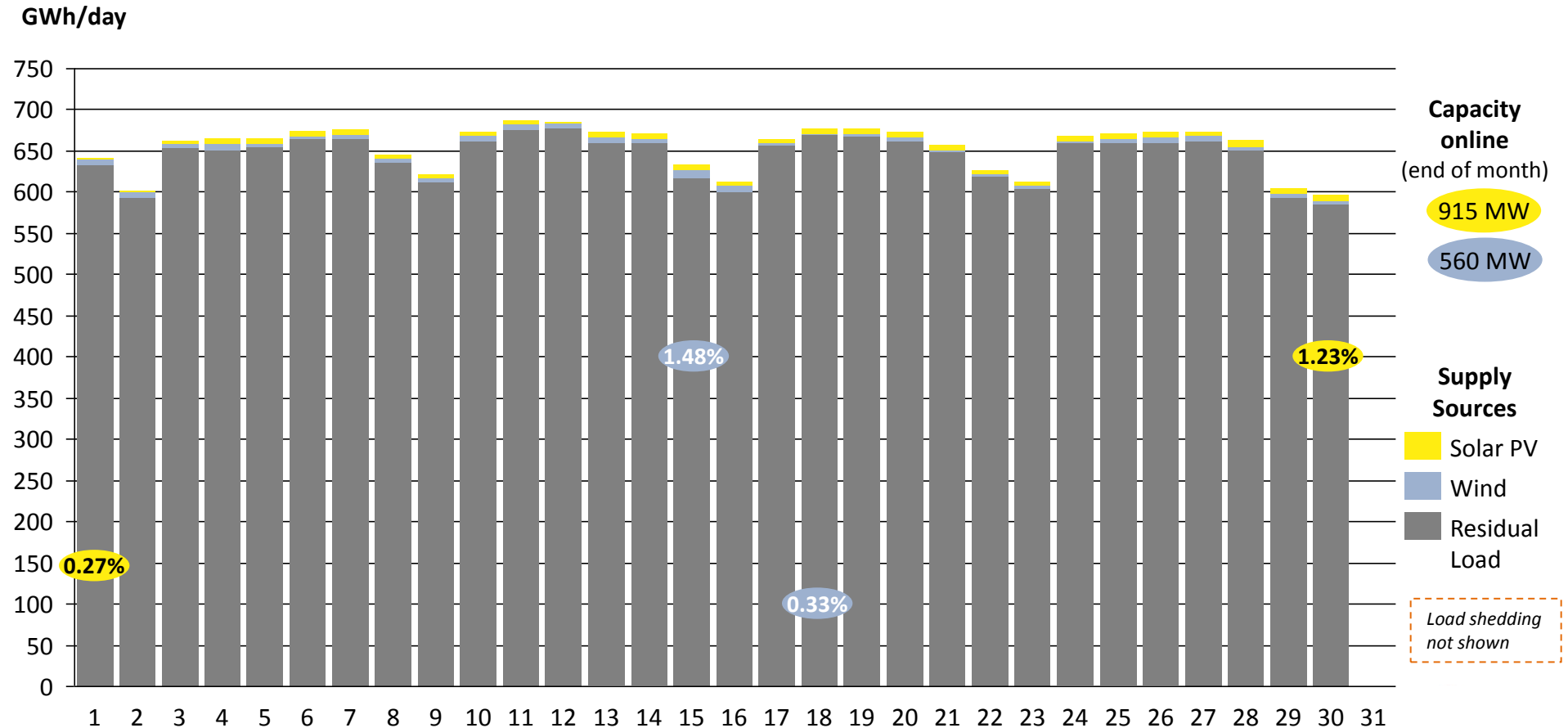


- Maximum daily production of 680 GWh on 30 Oct 2014 (Thursday)
- Minimum daily production of 603 GWh on 5 Oct 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 595-686 GWh in Nov 2014

Actual daily production from all power supply sources in South Africa for November 2014

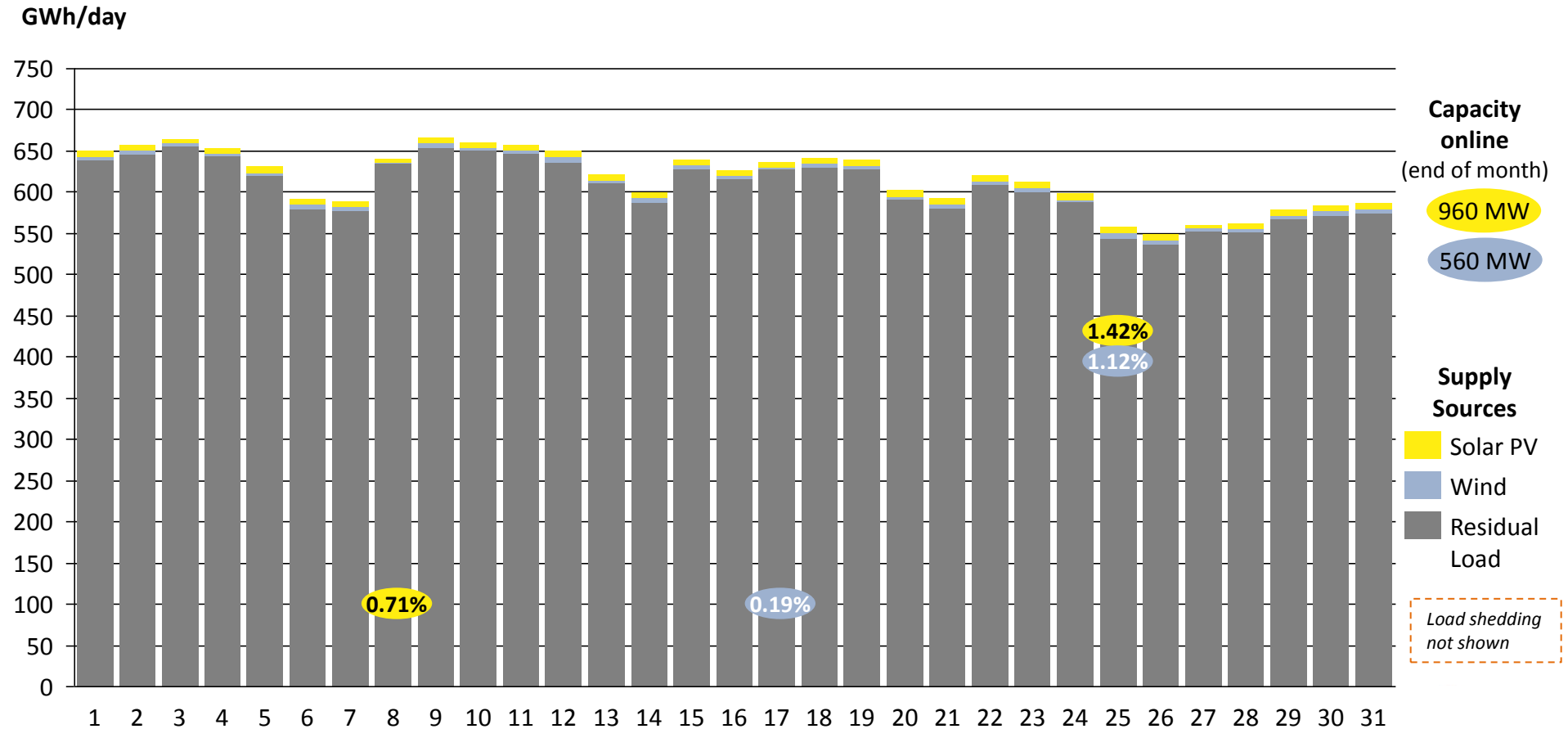


- Maximum daily production of 686 GWh on 11 Nov 2014 (Tuesday)
- Minimum daily production of 595 GWh on 30 Nov 2014 (Sunday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
 Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Daily electricity production of between 548-664 GWh in Dec 2014

Actual daily production from all power supply sources in South Africa for December 2014



- Maximum daily production of 664 GWh on 3 Dec 2014 (Wednesday)
- Minimum daily production of 548 GWh on 26 Dec 2014 (Friday)

Note: Design as per Fraunhofer ISE. Total daily production excludes pumping load. Days with highest/lowest relative solar PV/wind contribution highlighted (as % of total supply on that day)  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis

# Agenda

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Overview actual electricity production data for 2014

Monthly electricity production

Weekly electricity production

Daily electricity production

**Hourly electricity production**

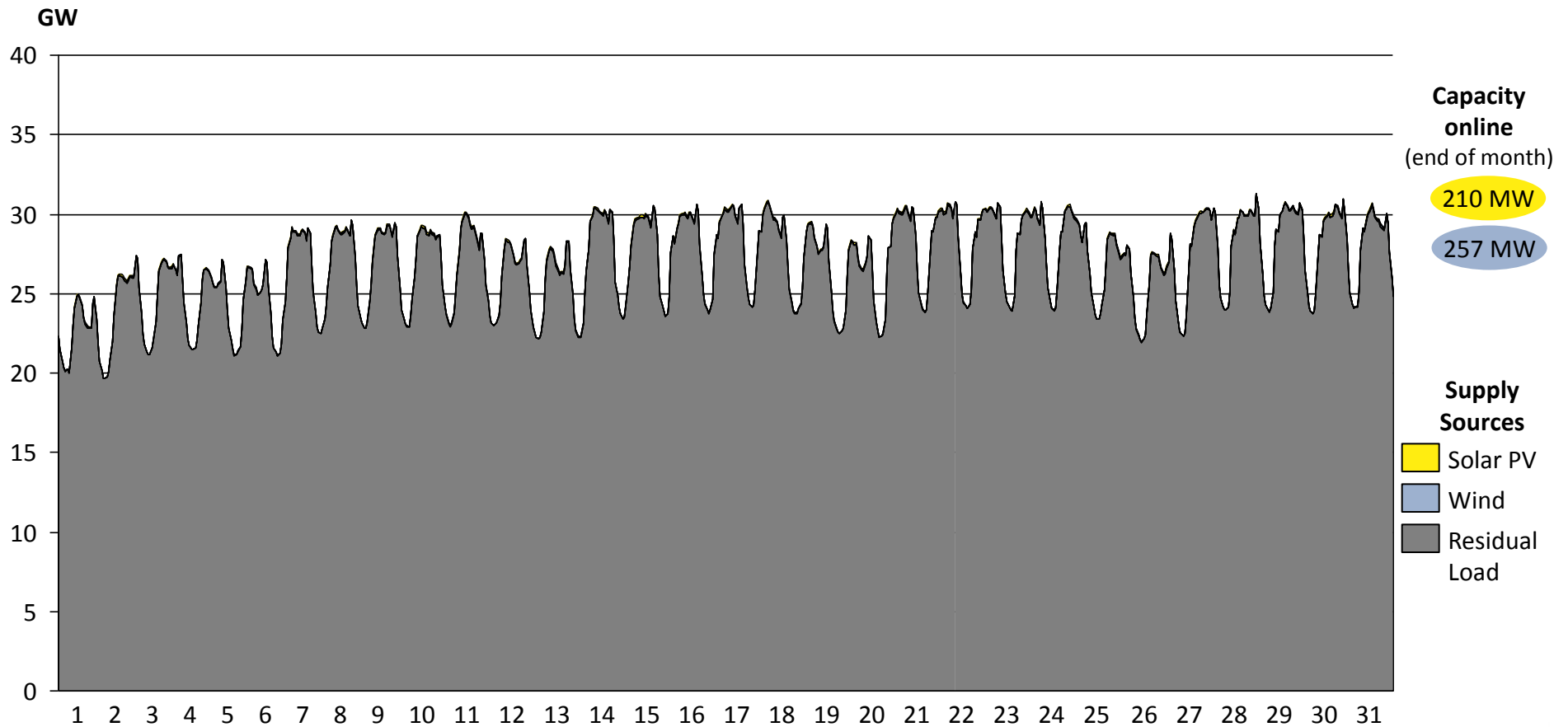
Diurnal courses

Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

# Hourly electricity production in Jan 2014

Actual hourly production from all power supply sources in RSA for January 2014

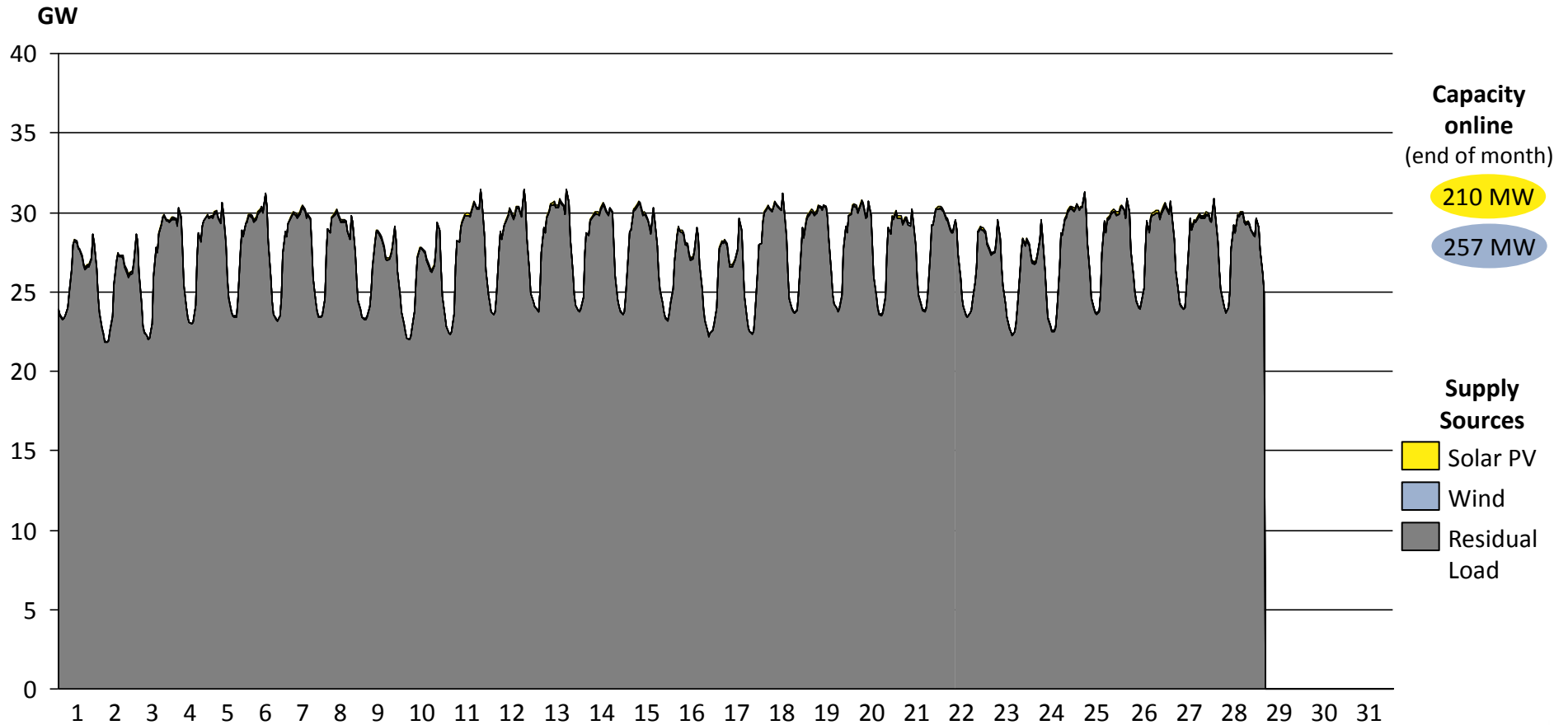


- Maximum power of 31 GW between 19h00 and 20h00 on 28 Jan 2014
- Minimum power of 20 GWh between 02h00 and 03h00 on 2 Jan 2014

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

# Hourly electricity production in Feb 2014

Actual hourly production from all power supply sources in RSA for February 2014

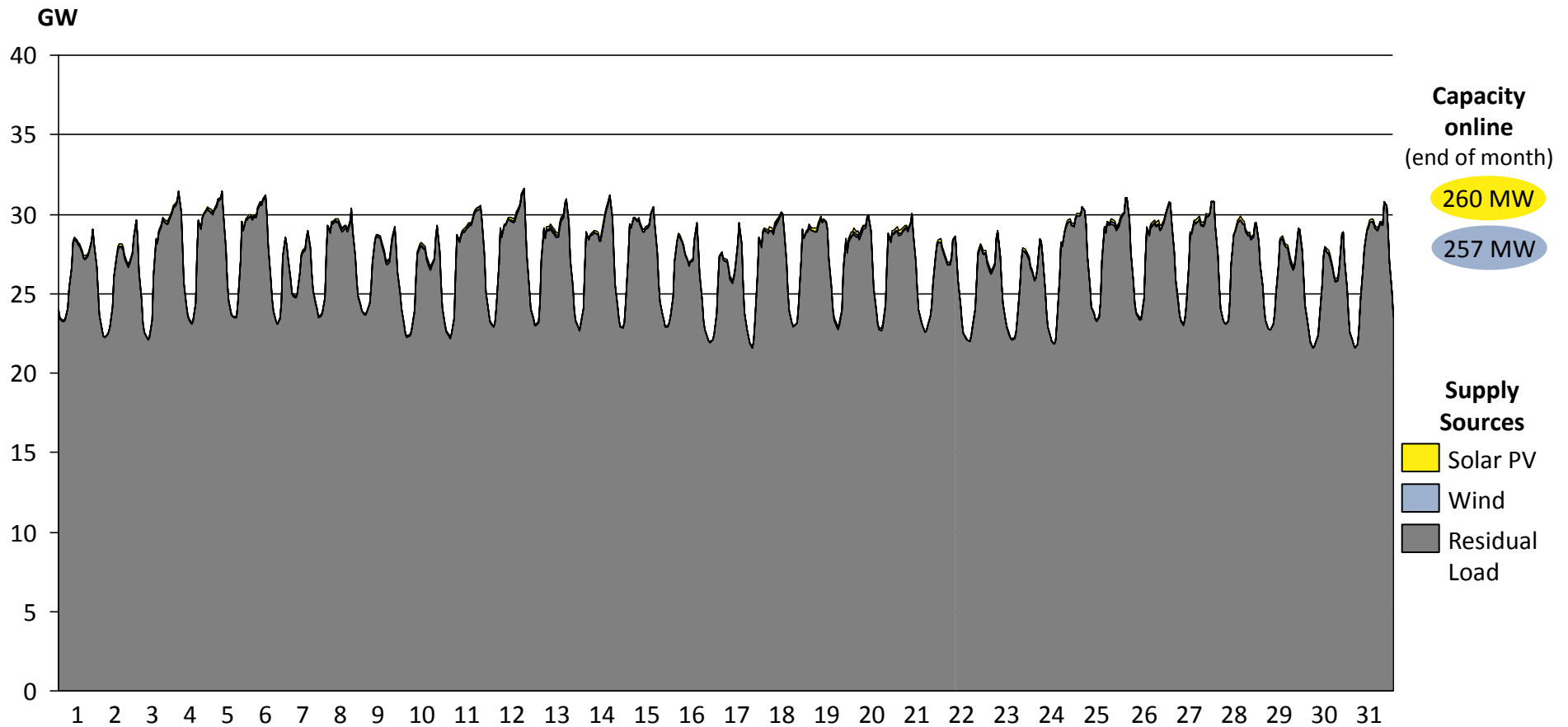


- Maximum power of 31 GW between 19h00 and 20h00 on 11 Feb 2014
- Minimum power of 22 GWh between 03h00 and 04h00 on 2 Feb 2014

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

# Hourly electricity production in Mar 2014

Actual hourly production from all power supply sources in RSA for March 2014

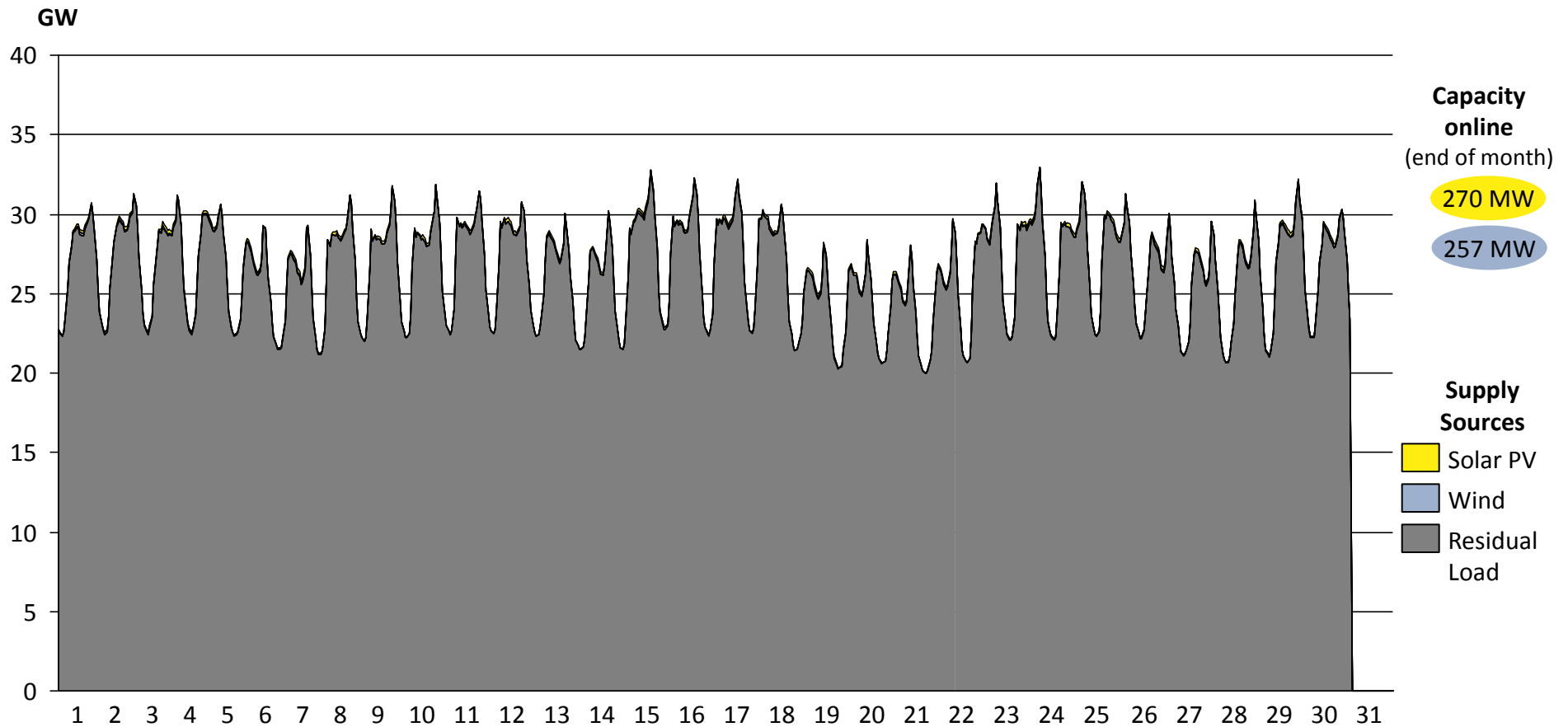


- Maximum power of 32 GW between 19h00 and 20h00 on 11 Mar 2014
- Minimum power of 22 GWh between 02h00 and 03h00 on 17 Mar 2014

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

# Hourly electricity production in Apr 2014

Actual hourly production from all power supply sources in RSA for April 2014



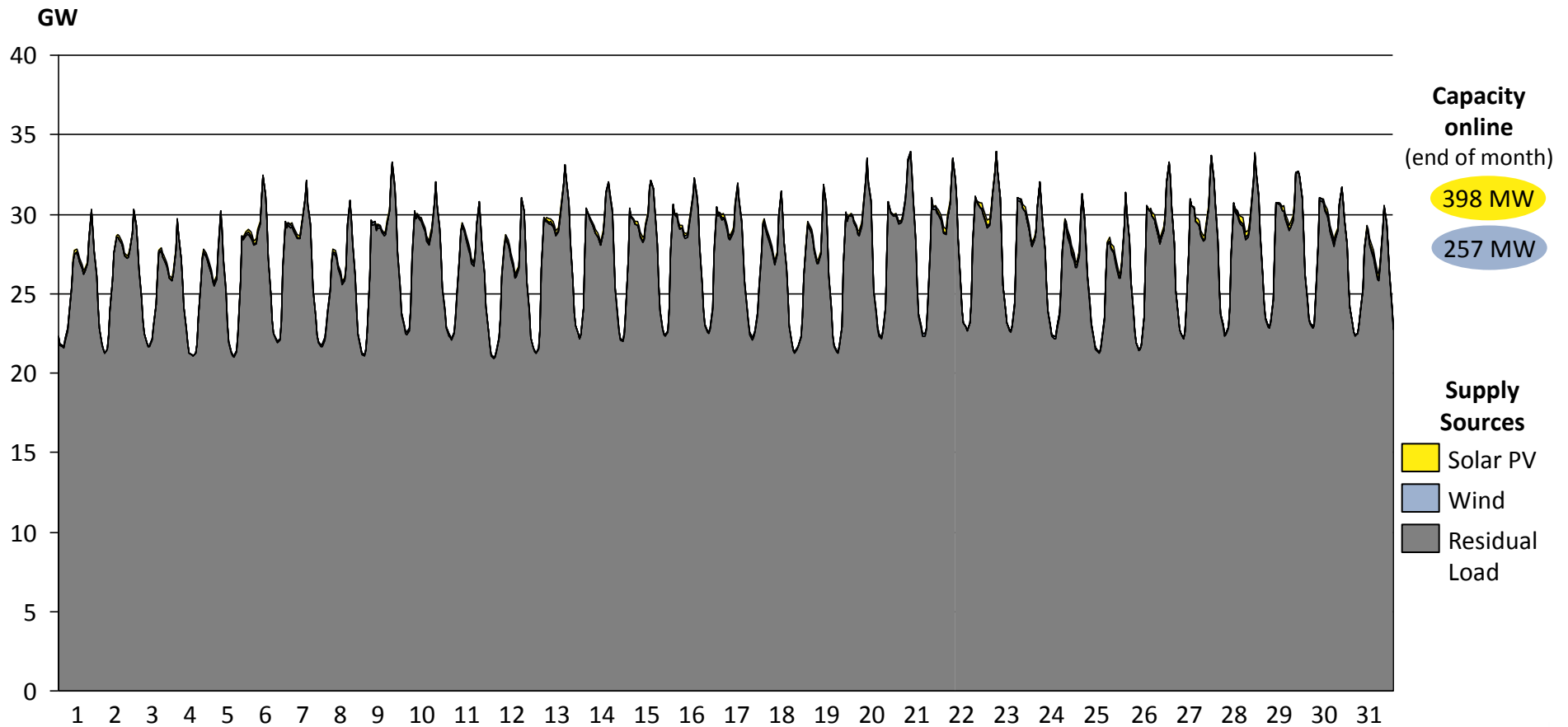
- Maximum power of 33 GW between 18h00 and 19h00 on 23 Apr 2014
- Minimum power of 20 GWh between 03h00 and 04h00 on 21 Apr 2014

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



# Hourly electricity production in May 2014

Actual hourly production from all power supply sources in RSA for May 2014

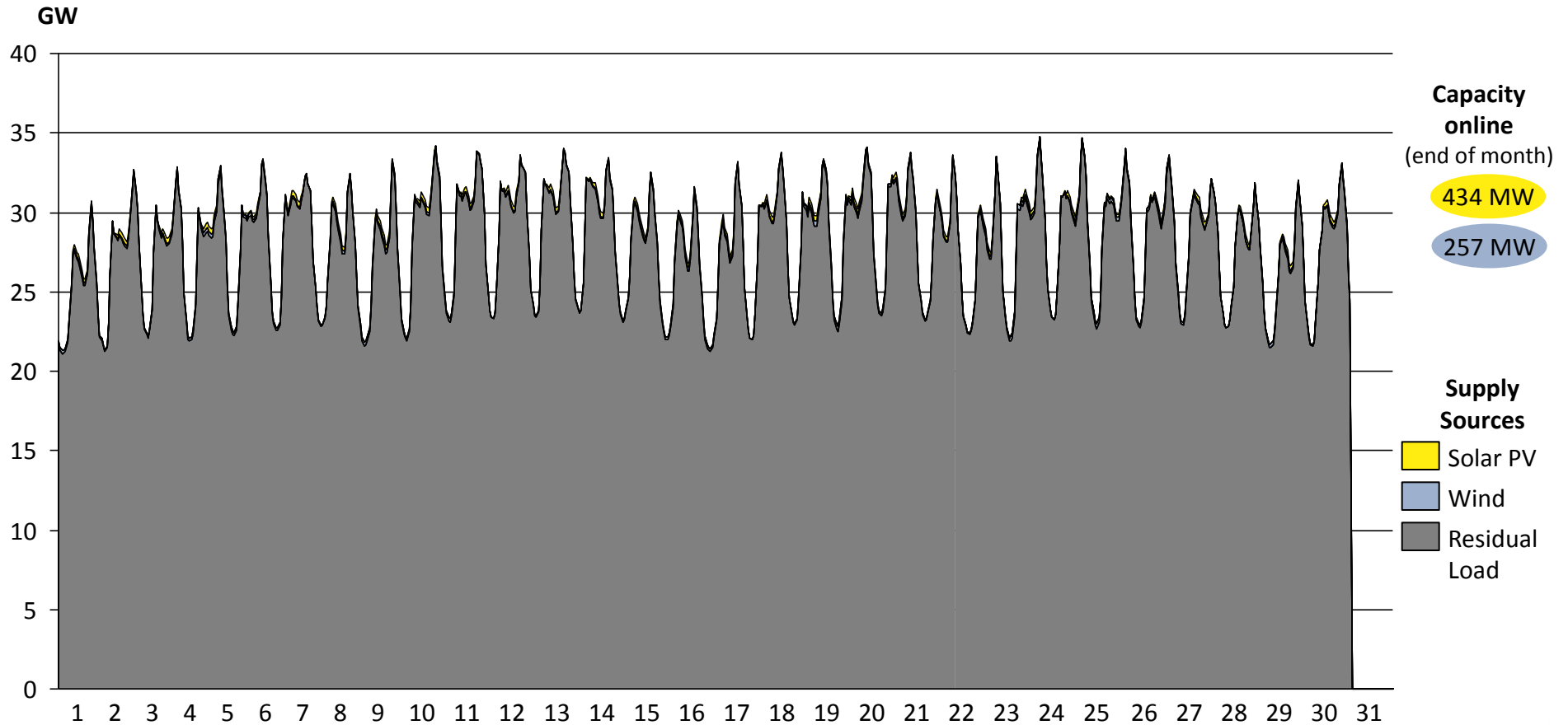


- Maximum power of 34 GW between 18h00 and 19h00 on 22 May 2014
- Minimum power of 21 GWh between 02h00 and 03h00 on 11 May 2014

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

# Hourly electricity production in Jun 2014

Actual hourly production from all power supply sources in RSA for June 2014

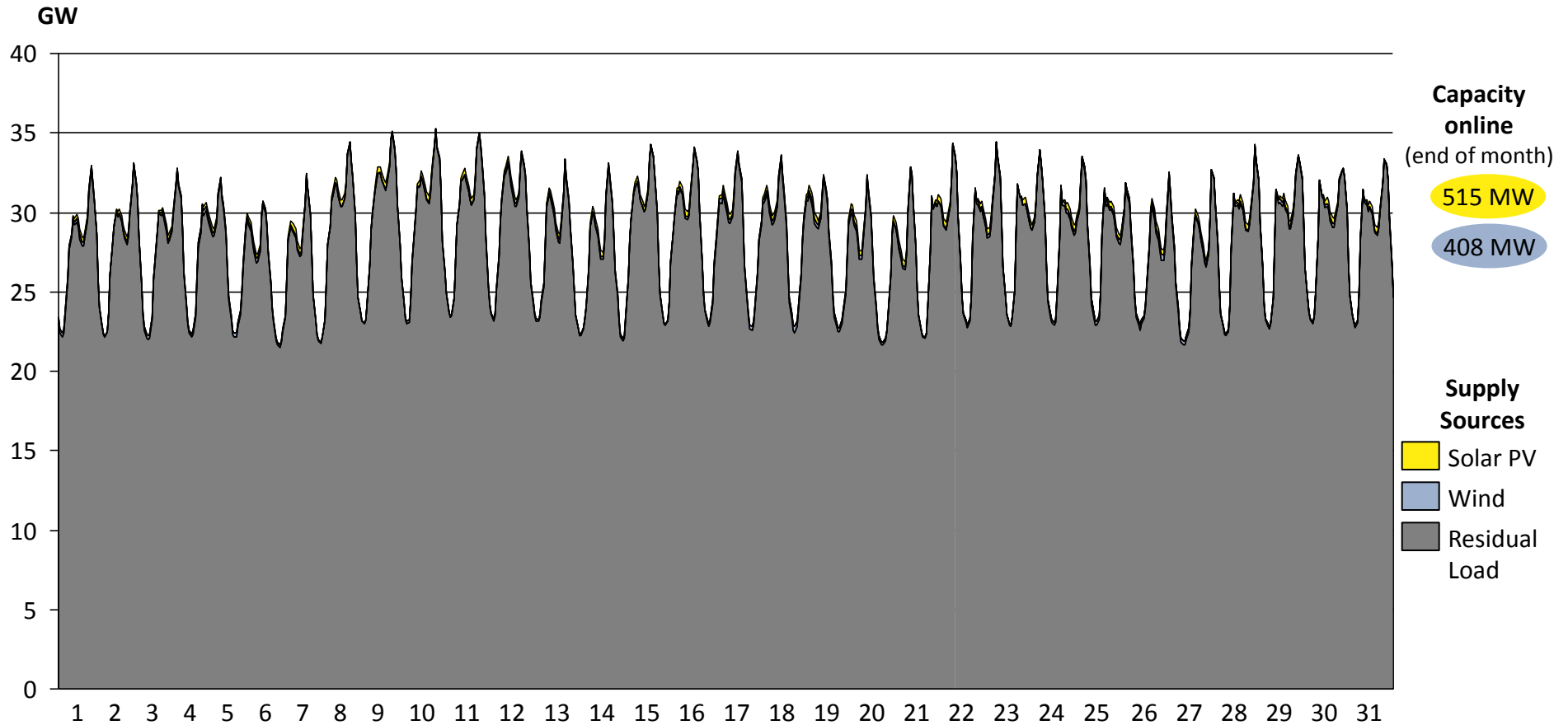


- Maximum power of 35 GW between 18h00 and 19h00 on 23 Jun 2014
- Minimum power of 21 GWh between 02h00 and 03h00 on 1 Jun 2014

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

# Hourly electricity production in Jul 2014

Actual hourly production from all power supply sources in RSA for July 2014

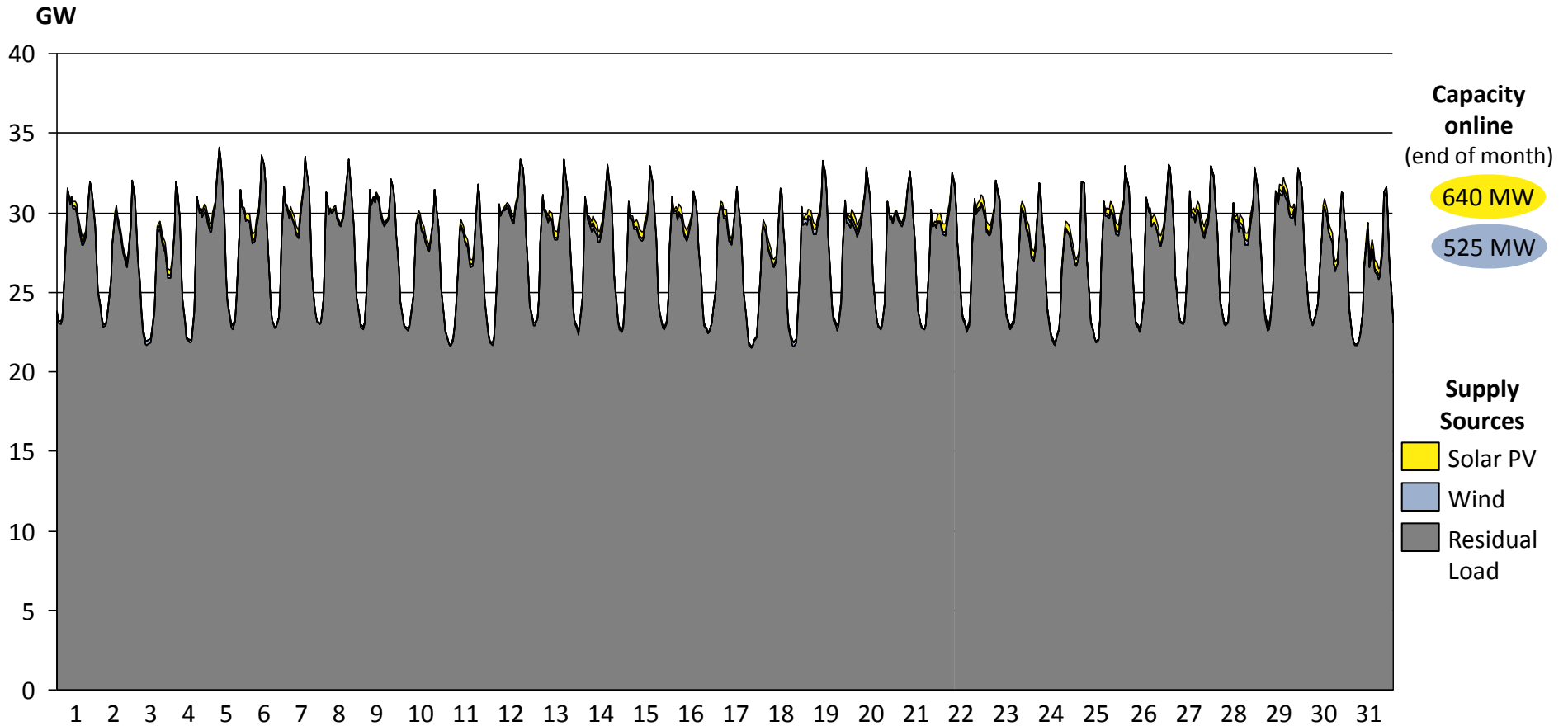


- Maximum power of 35 GW between 18h00 and 19h00 on 9 Jul 2014
- Minimum power of 22 GWh between 03h00 and 04h00 on 6 Jul 2014

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

# Hourly electricity production in Aug 2014

Actual hourly production from all power supply sources in RSA for August 2014

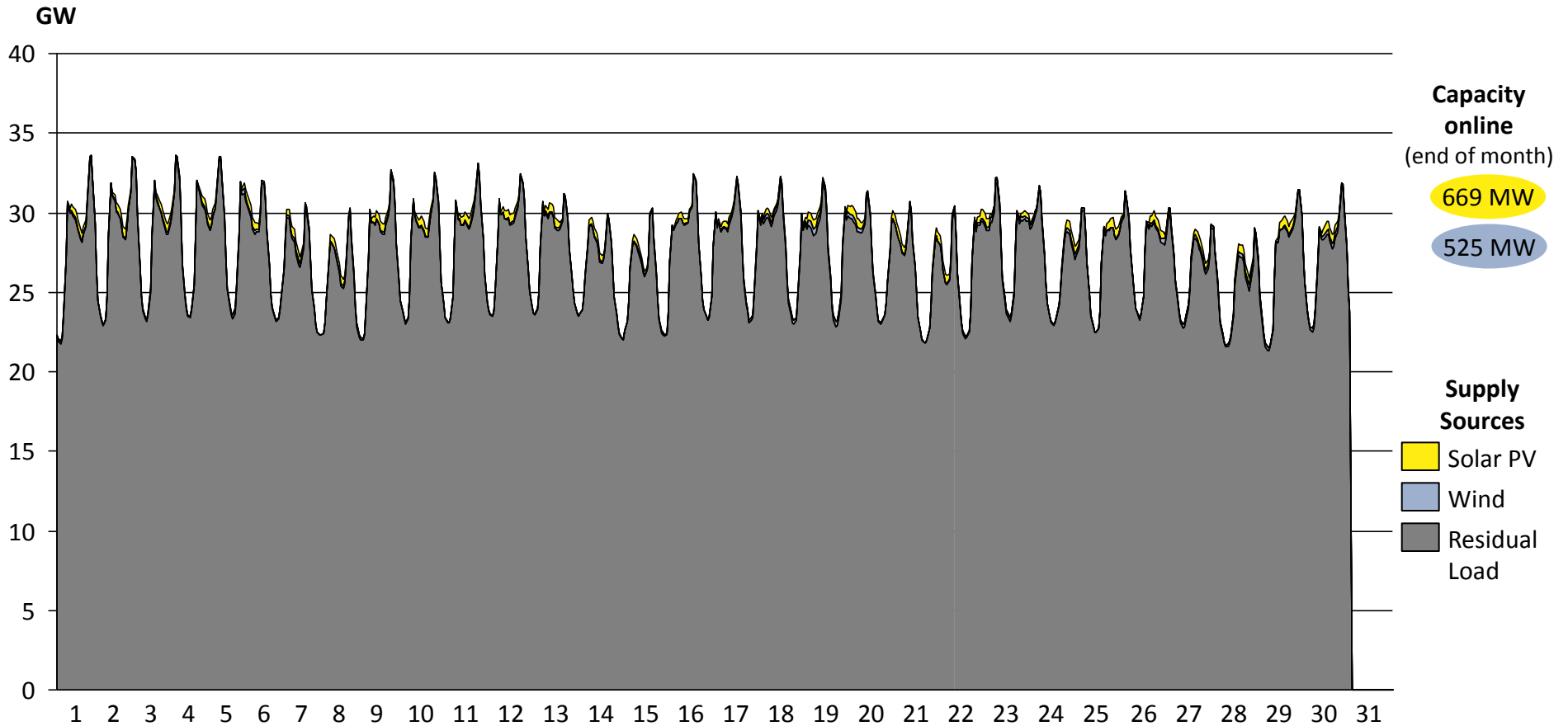


- Maximum power of 34 GW between 18h00 and 19h00 on 4 Aug 2014
- Minimum power of 22 GWh between 02h00 and 03h00 on 17 Aug 2014

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

# Hourly electricity production in Sep 2014

Actual hourly production from all power supply sources in RSA for September 2014

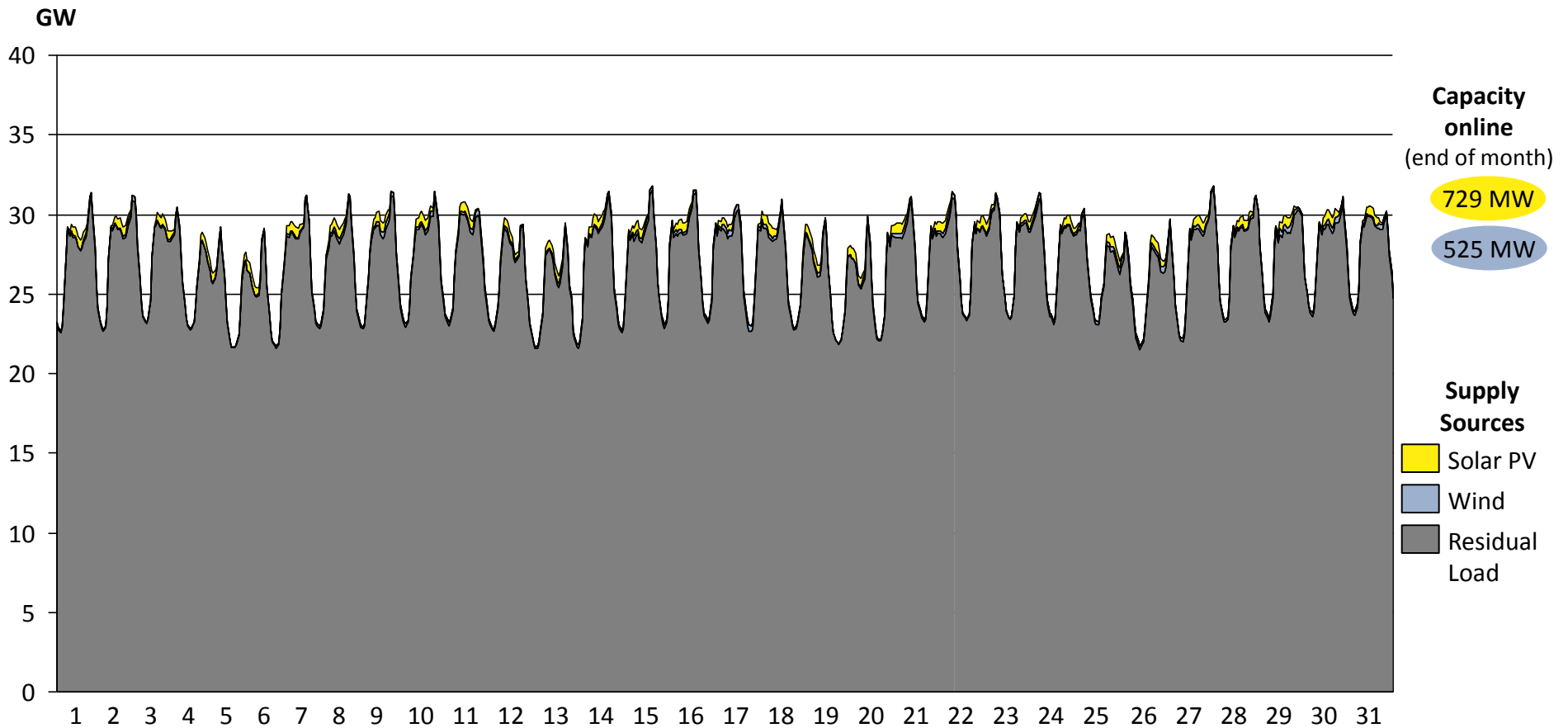


- Maximum power of 34 GW between 19h00 and 20h00 on 1 Sep 2014
- Minimum power of 22 GWh between 02h00 and 03h00 on 29 Sep 2014

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

# Hourly electricity production in Oct 2014

Actual hourly production from all power supply sources in RSA for October 2014

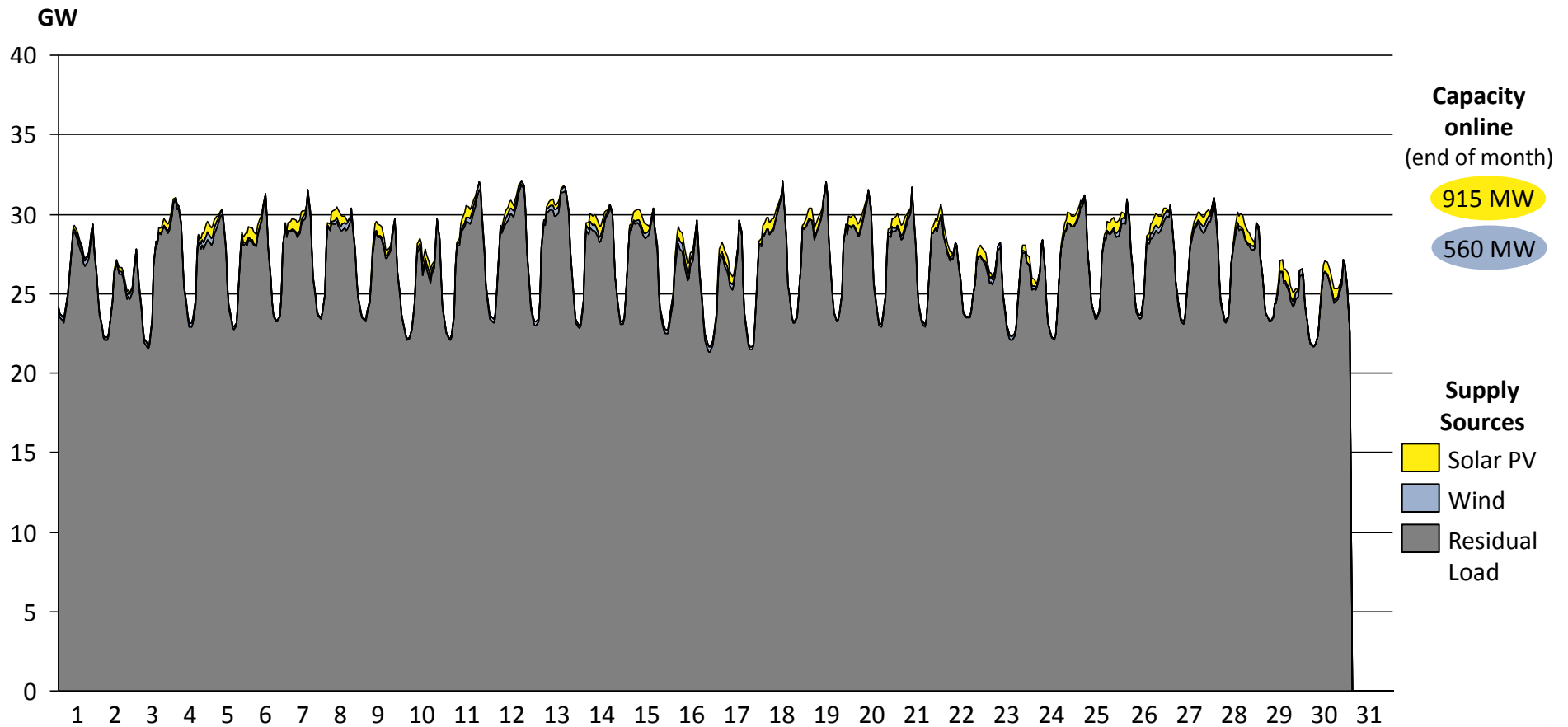


- Maximum power of 32 GW between 19h00 and 20h00 on 27 Oct 2014
- Minimum power of 22 GWh between 03h00 and 04h00 on 5 Oct 2014

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

# Hourly electricity production in Nov 2014

Actual hourly production from all power supply sources in RSA for November 2014

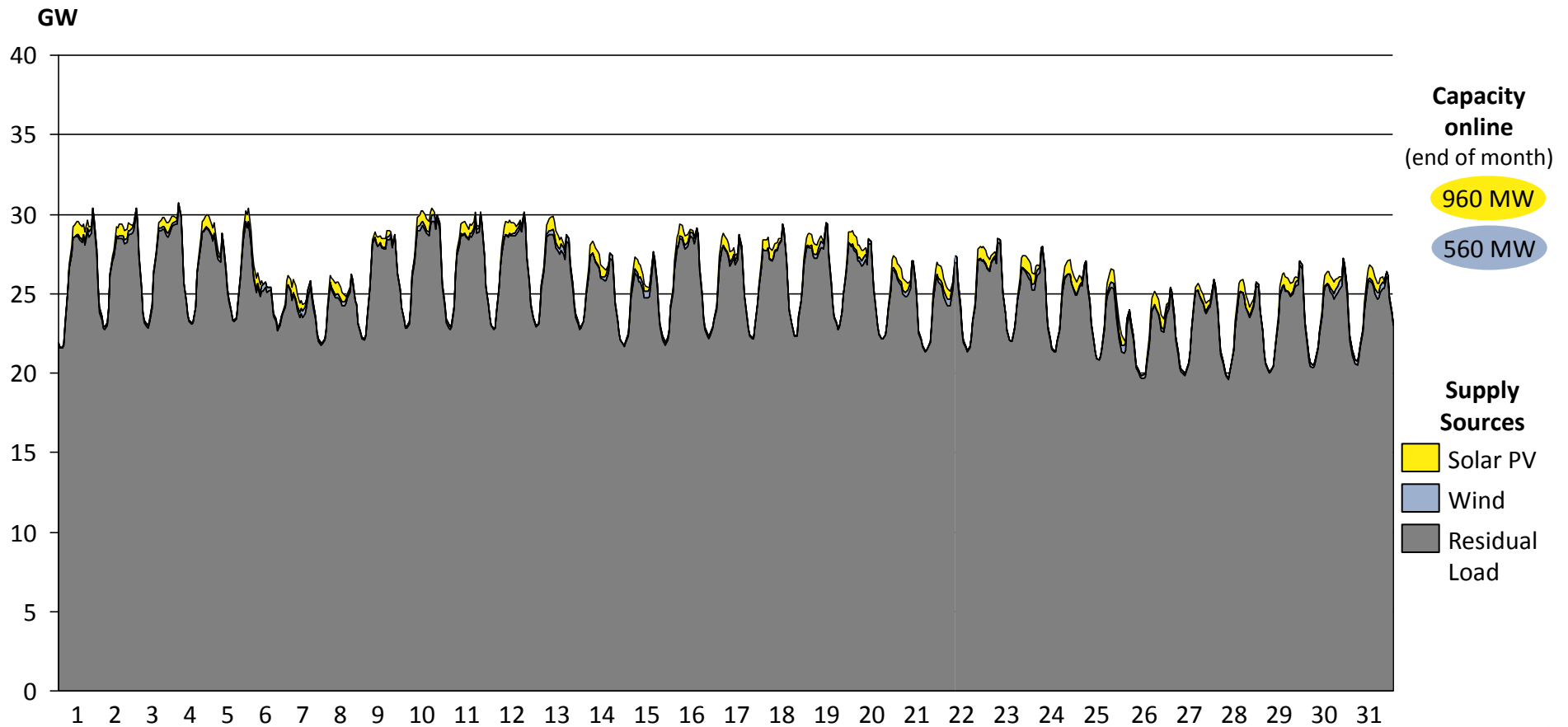


- Maximum power of 32 GW between 19h00 and 20h00 on 17 Nov 2014
- Minimum power of 22 GWh between 02h00 and 03h00 on 17 Nov 2014

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

# Hourly electricity production in Dec 2014

Actual hourly production from all power supply sources in RSA for December 2014

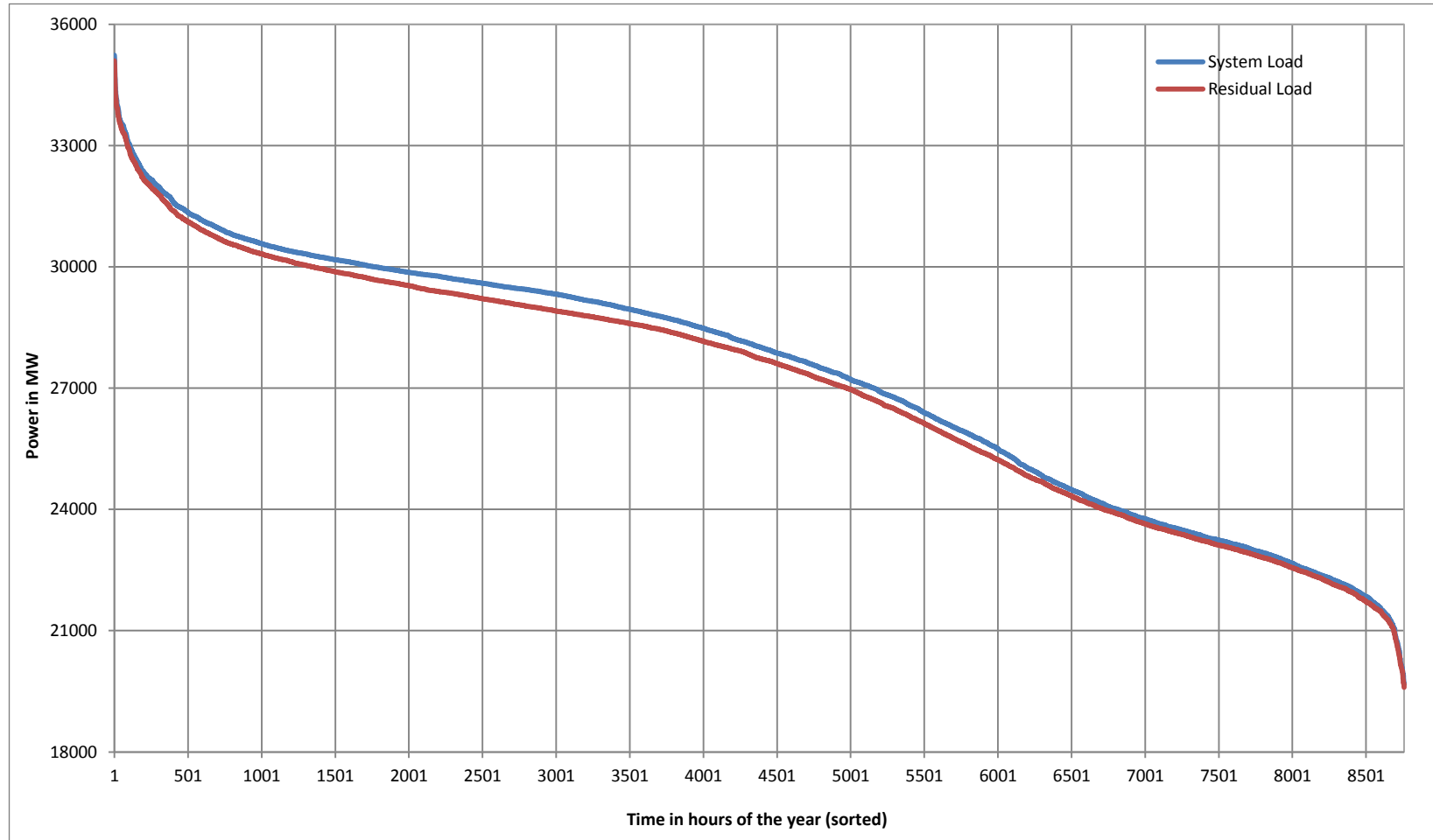


- Maximum power of 31 GW between 19h00 and 20h00 on 3 Dec 2014
- Minimum power of 20 GWh between 03h00 and 04h00 on 28 Dec 2014

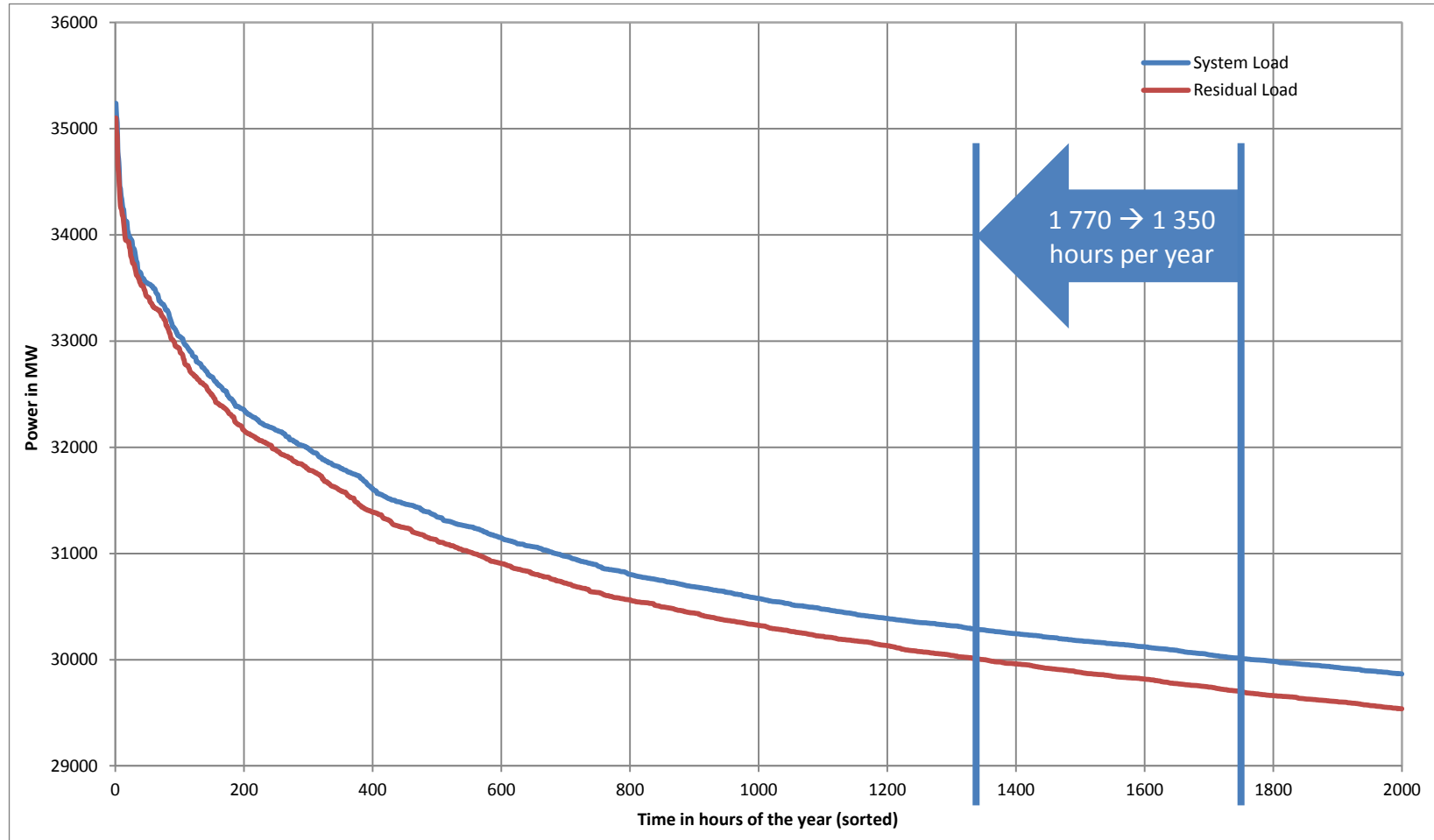
Note: Design as per Fraunhofer ISE. Pumping load excluded.  
Sources: Eskom; DoE IPP Office; CSIR Energy Centre analysis



# 2014 system and residual load duration curves



In 2014, wind and solar PV reduced the number of hours with more than 30 000 MW total load from 1770 to 1350 (420 hours less)



# Agenda

Overview actual electricity production data for 2014

Monthly electricity production

Monthly average wind and photovoltaic electricity production

Weekly electricity production

Daily electricity production

Hourly electricity production

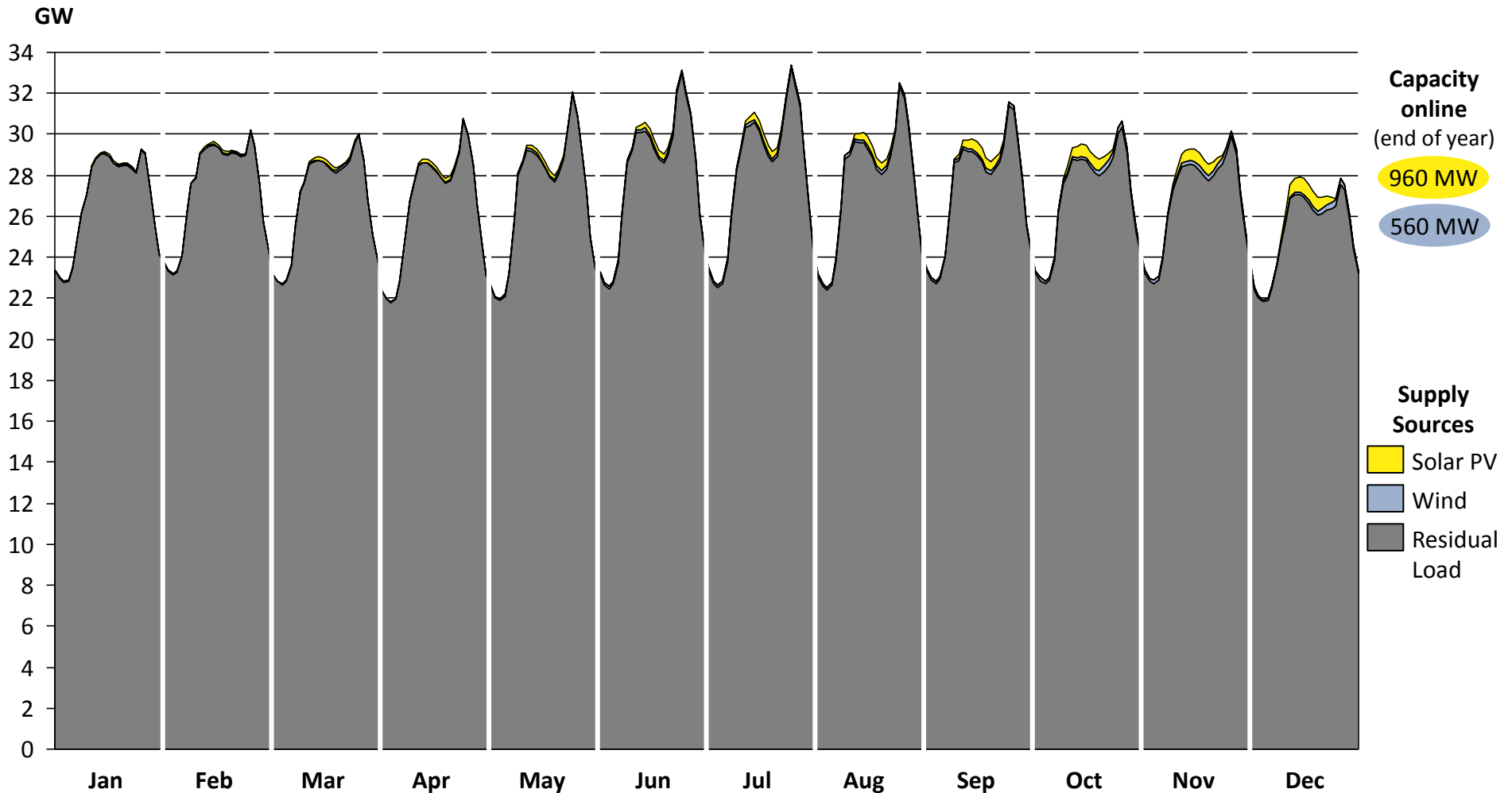
**Diurnal courses**

Hourly gradients of wind and photovoltaics

Actual load shedding for Jan-Dec 2014

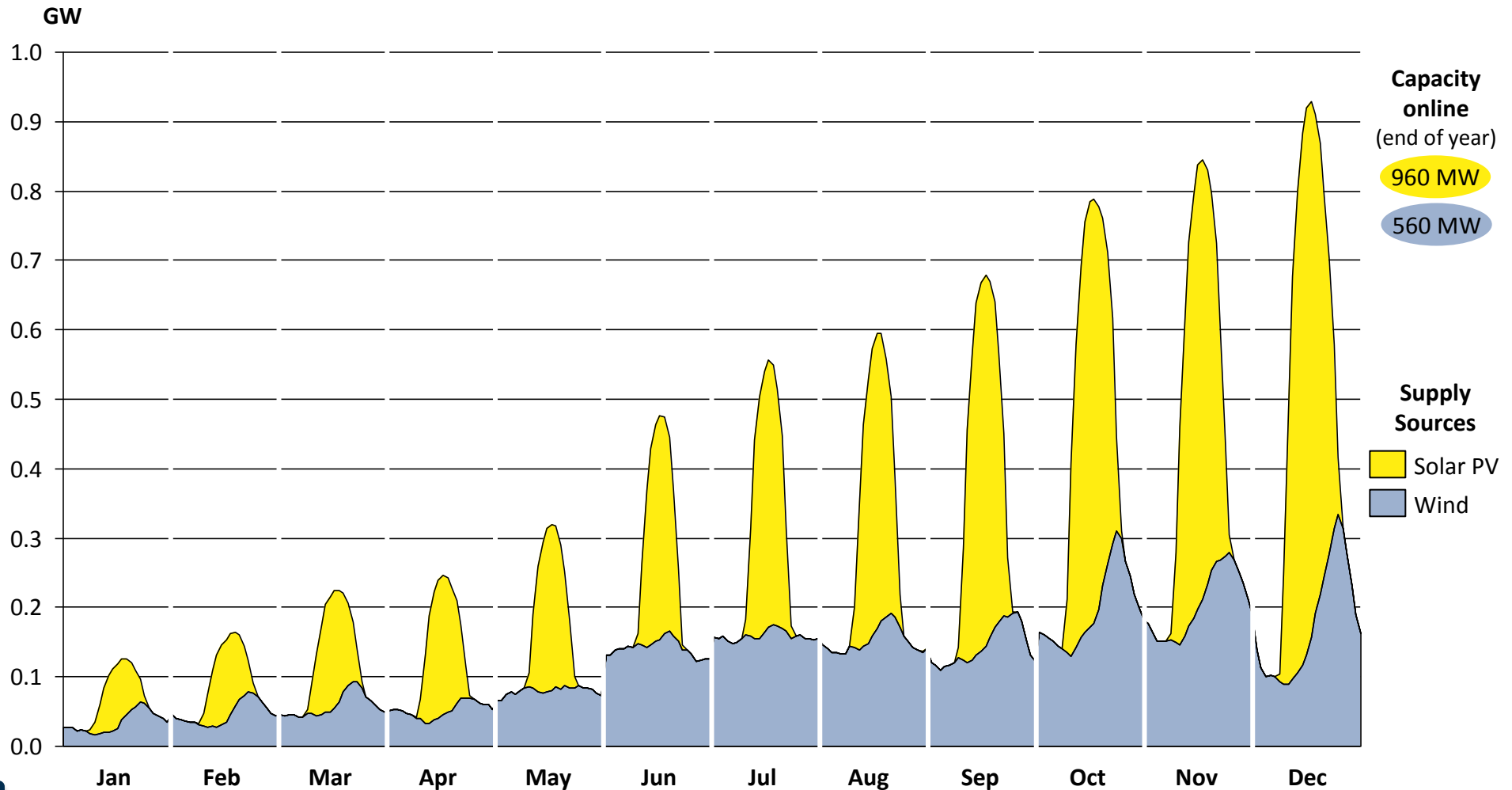
# Diurnal Courses

Actual monthly average diurnal courses of the total power supply in RSA for the months from Jan-Dec 2014



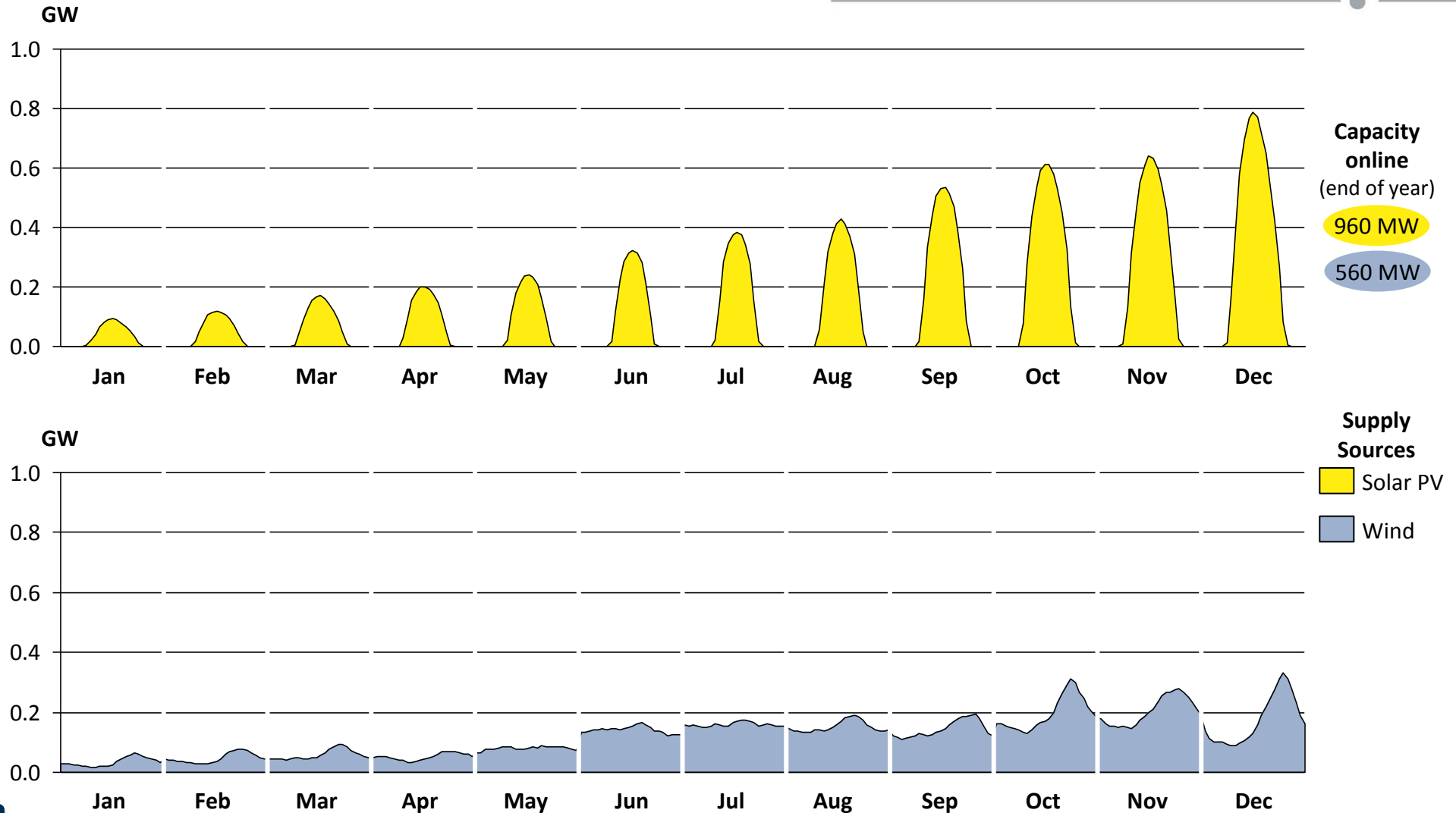
# Diurnal Courses

Actual monthly average diurnal courses of wind and solar PV in RSA for the months from Jan-Dec 2014



# Diurnal Courses

Actual monthly average diurnal courses of wind and solar PV in RSA for the months from Jan-Dec 2014



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

# Agenda

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Overview actual electricity production data for 2014

Monthly electricity production

Weekly electricity production

Daily electricity production

Hourly electricity production

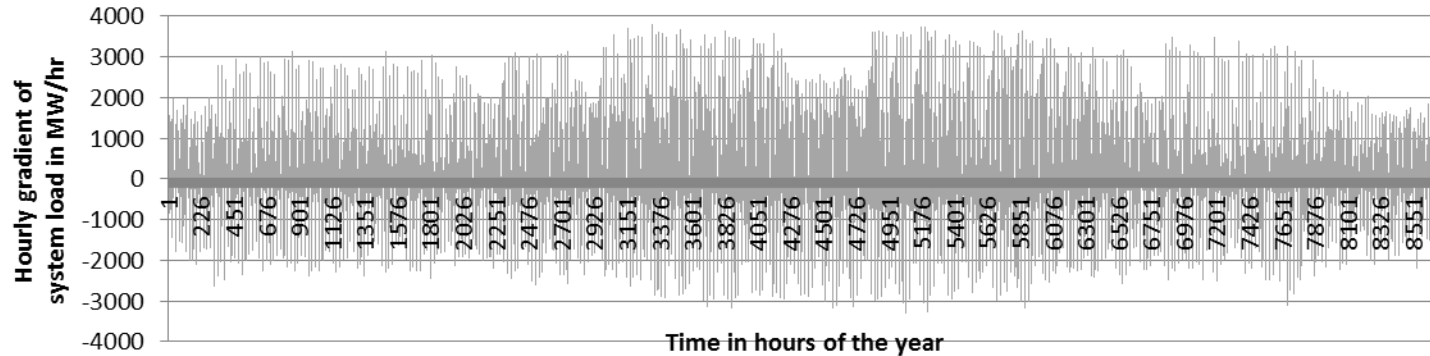
Diurnal courses

**Hourly gradients of wind and photovoltaics**

Actual load shedding for Jan-Dec 2014

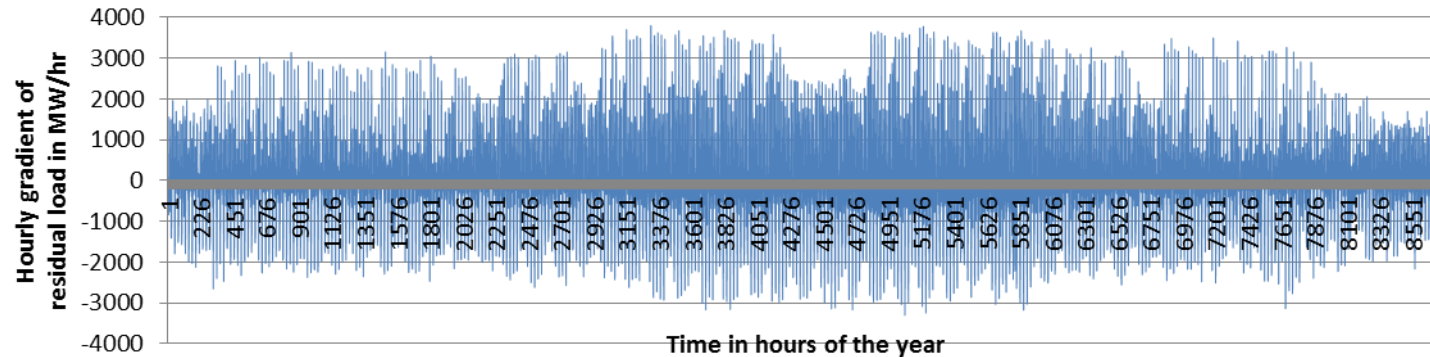
# Maximum 1-hour gradient was not affected by 1.5 GW wind & solar PV

## System Load 1-hour-gradients in 2014



- Max gradient of 3 821 MW on 19 May 2014 between 05h00 and 06h00
- Min gradient of -3 315 MW on 30 July 2014 between 22h00 and 23h00

## Residual Load 1-hour-gradients in 2014



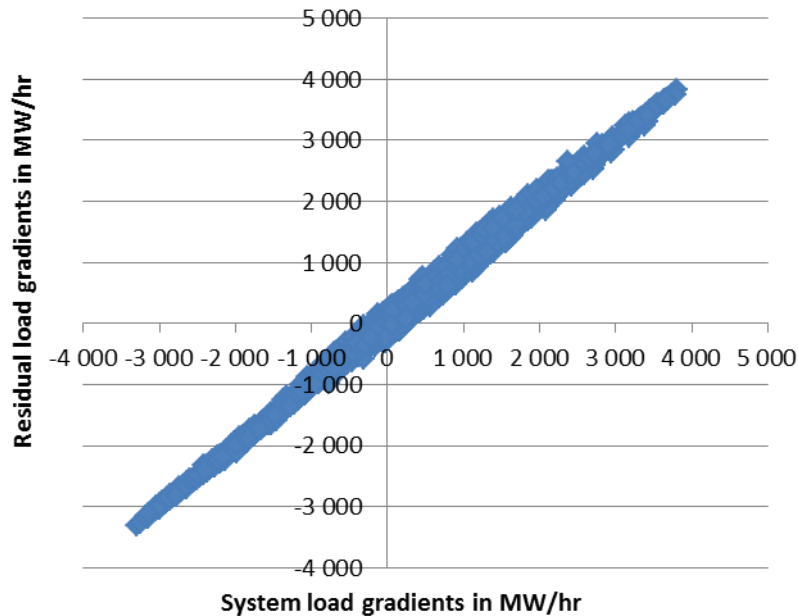
- Maximum gradient of 3 808 MW on 19 May 2014 between 05h00 and 06h00
- Minimum gradient of -3 303 MW on 30 July 2014 between 22h00 and 23h00

- Residual load = System load – Solar PV – Wind

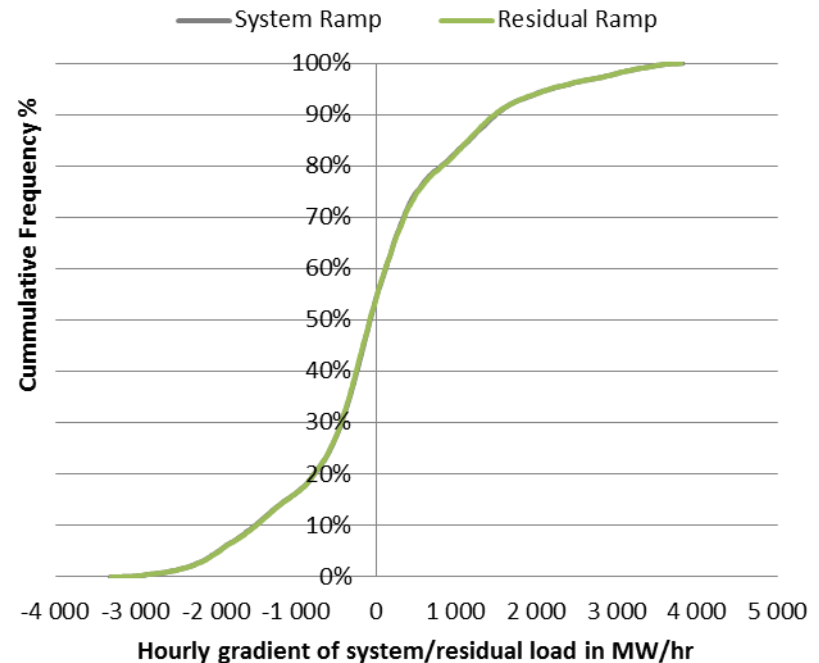


# 1-hour gradients did not increase due to 1.5 GW of wind and solar PV

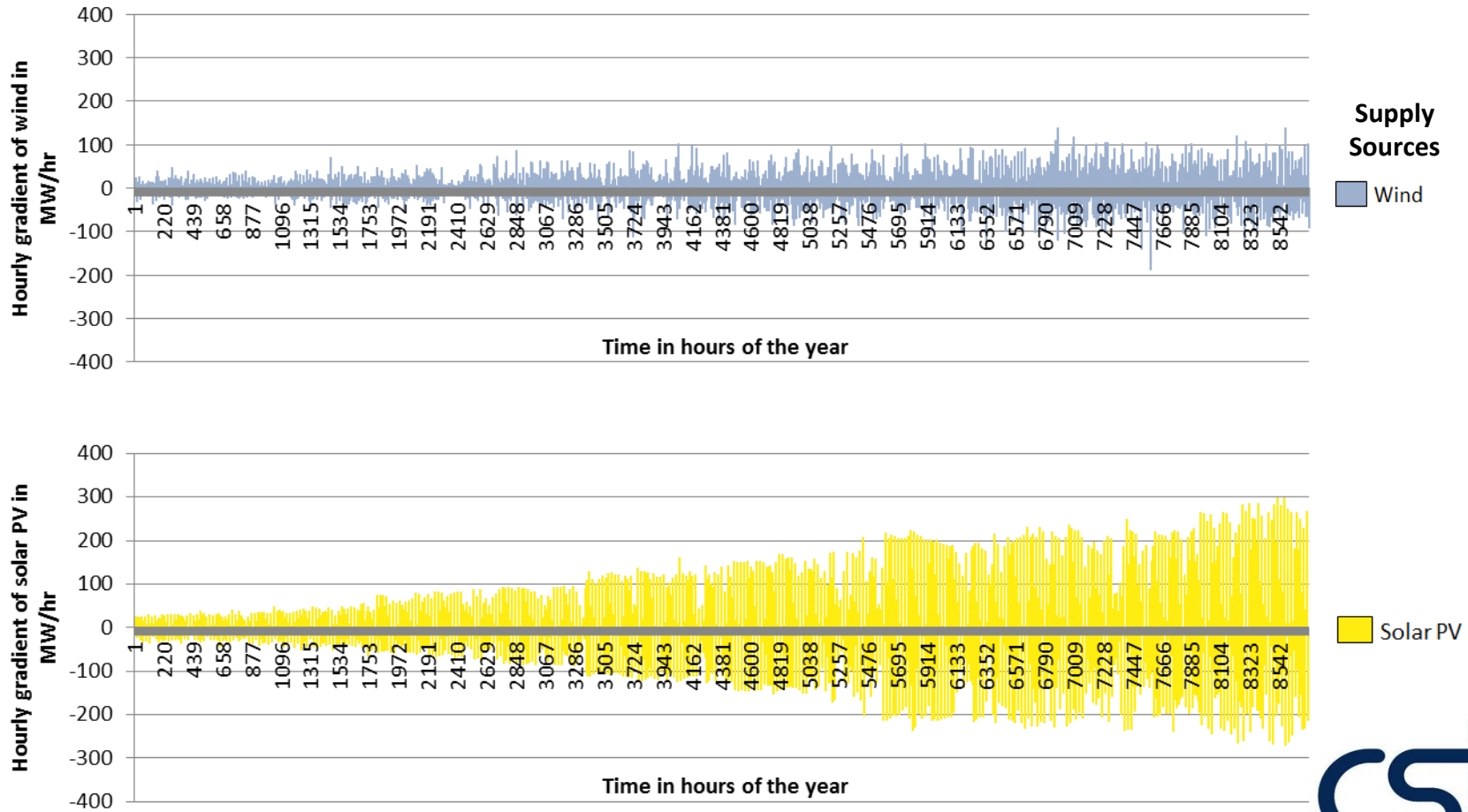
System load 1-hour gradients vs. residual load 1-hour gradients for all hours from Jan – Dec 2014



Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2014

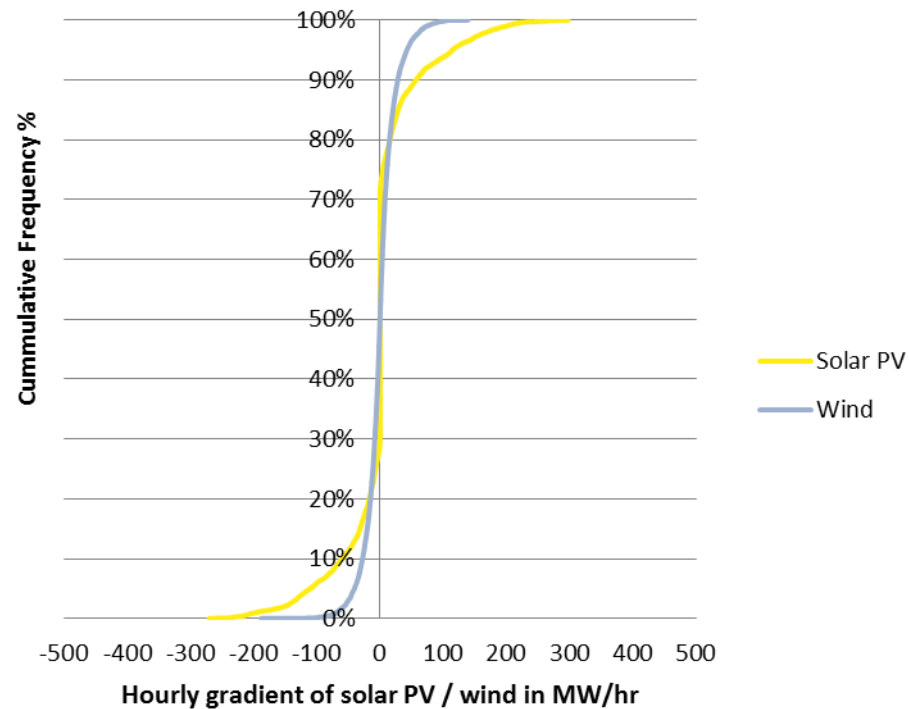


# 2014 1-hour gradients of wind and solar PV supply



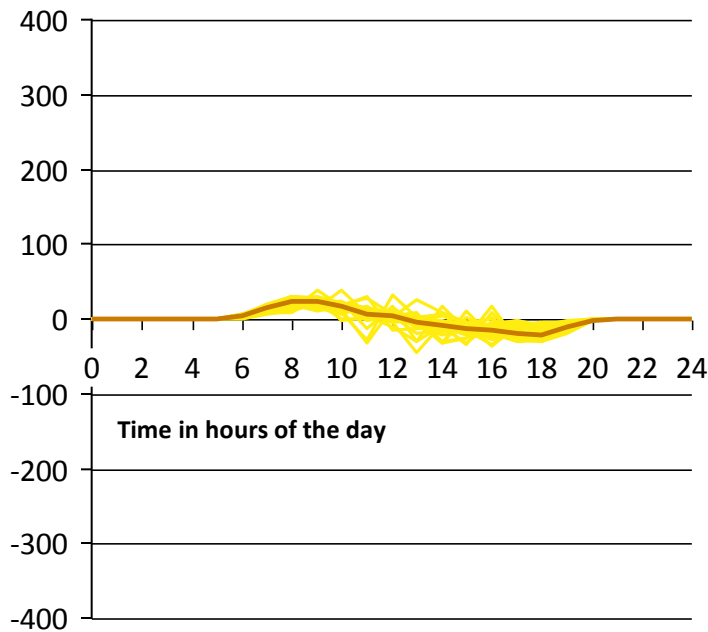
# 2014 wind and solar PV frequency distribution of 1-hour gradients

- Cumulative frequency distribution of 1-hour gradients for all hours from Jan – Dec 2014



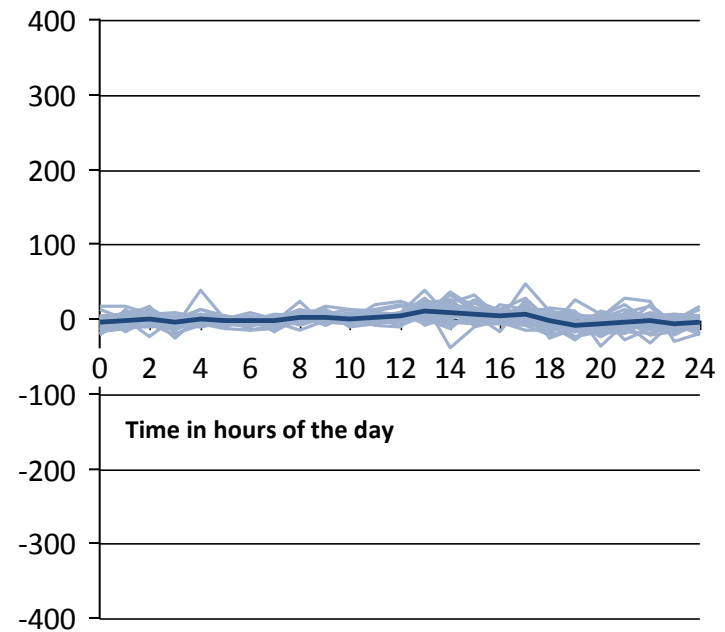
# Solar PV and wind 1-hour gradients in January 2014

Solar PV hourly gradients in MW/hr



— Solar PV hourly gradients in MW/hr  
— Average hourly solar PV gradients in MW/hr

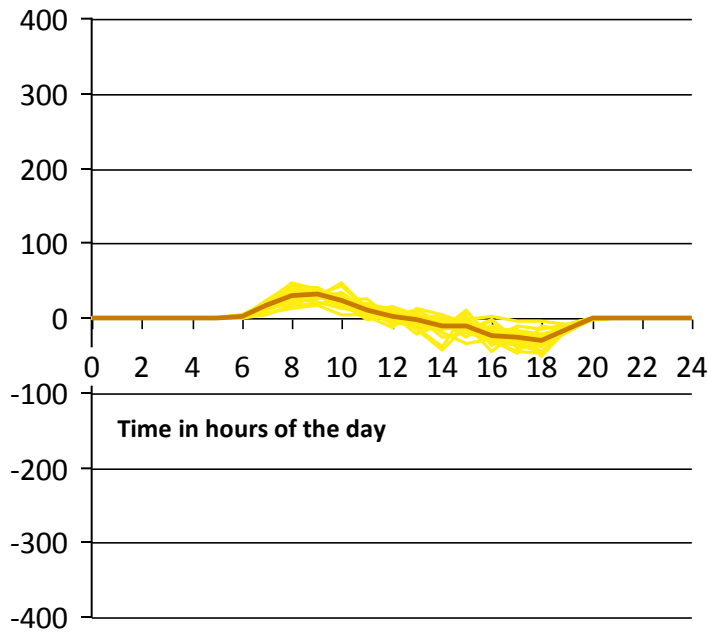
Wind hourly gradients in MW/hr



— Wind hourly gradients in MW/hr  
— Average hourly wind gradients in MW/hr

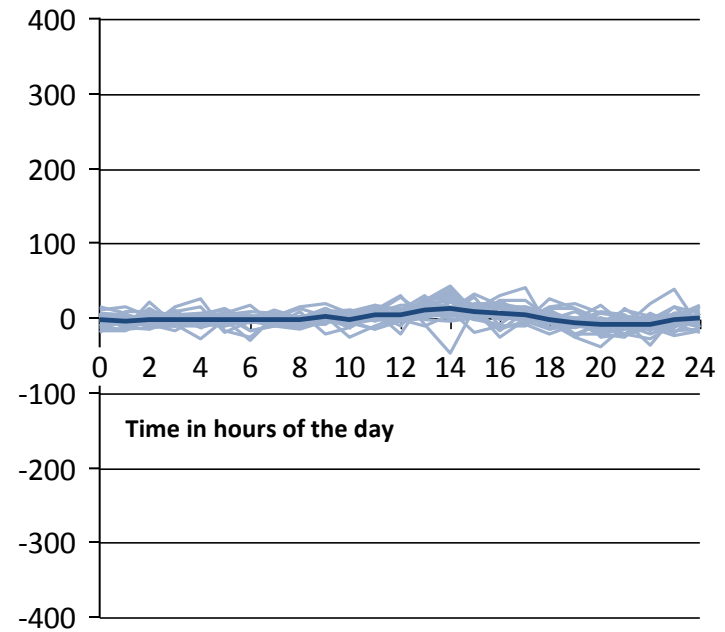
# Solar PV and wind 1-hour gradients in February 2014

Solar PV hourly gradients in MW/hr



— Solar PV hourly gradients in MW/hr  
— Average hourly solar PV gradients in MW/hr

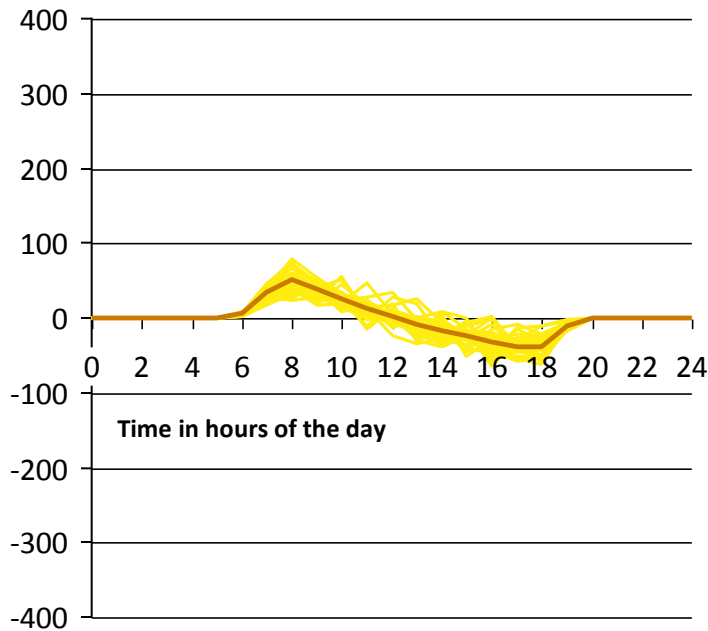
Wind hourly gradients in MW/hr



— Wind hourly gradients in MW/hr  
— Average hourly wind gradients in MW/hr

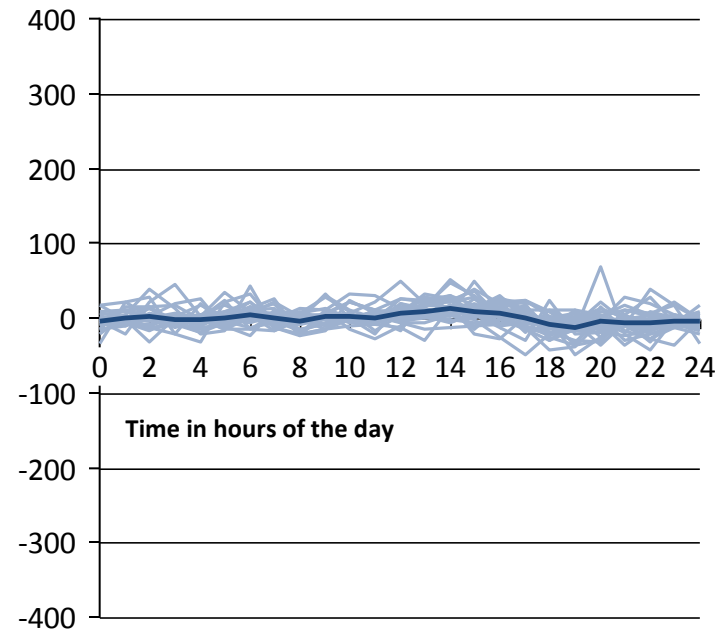
# Solar PV and wind 1-hour gradients in March 2014

Solar PV hourly gradients in MW/hr



— Solar PV hourly gradients in MW/hr  
— Average hourly solar PV gradients in MW/hr

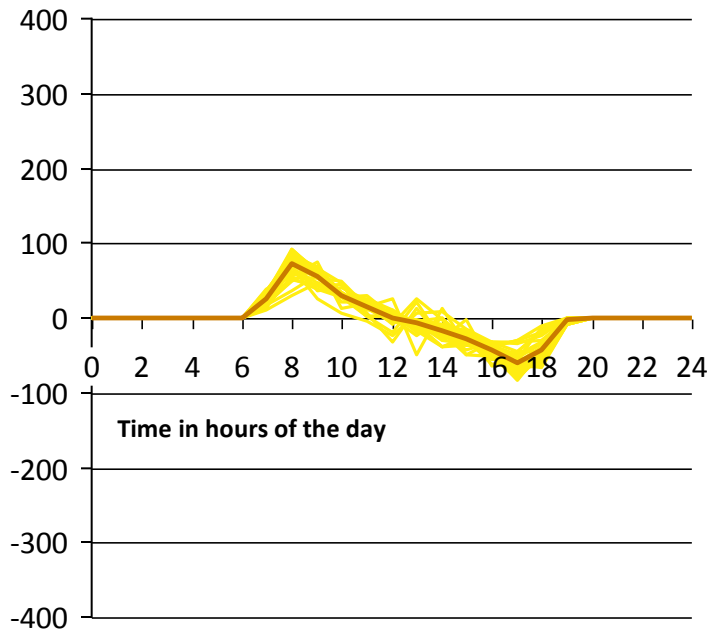
Wind hourly gradients in MW/hr



— Wind hourly gradients in MW/hr  
— Average hourly wind gradients in MW/hr

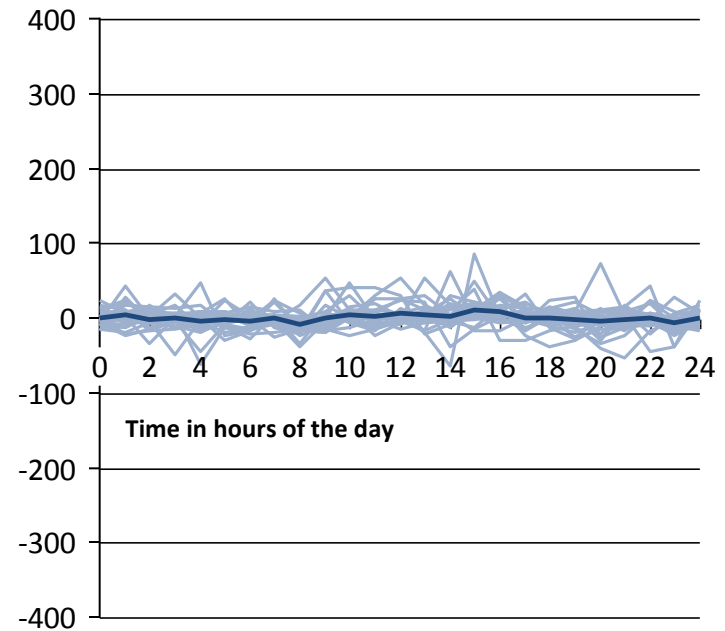
# Solar PV and wind 1-hour gradients in April 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

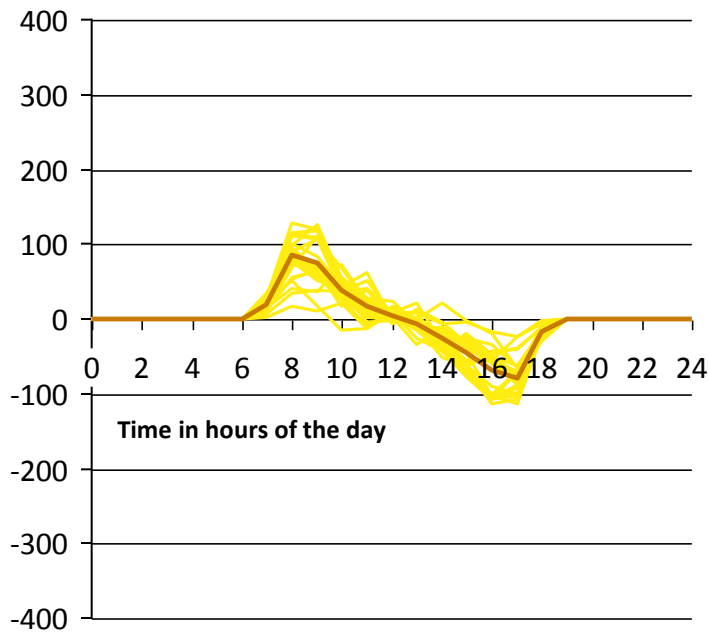
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

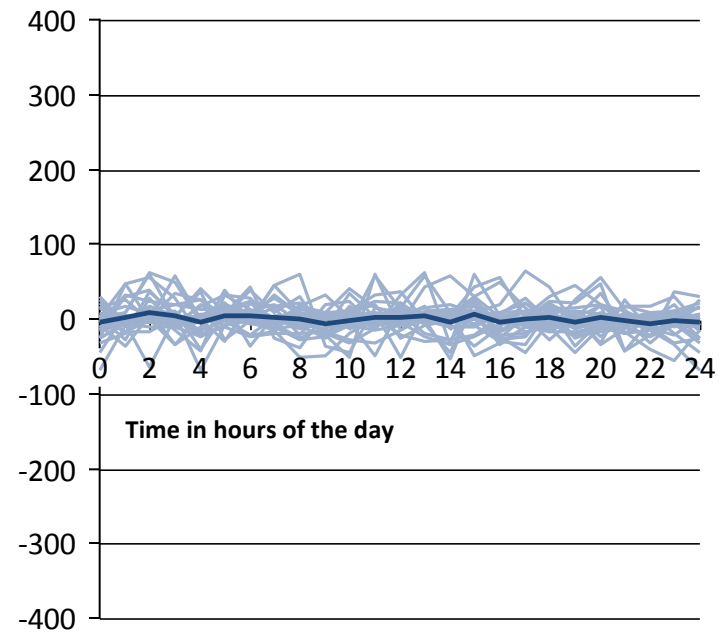
# Solar PV and wind 1-hour gradients in May 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

Wind hourly gradients in MW/hr

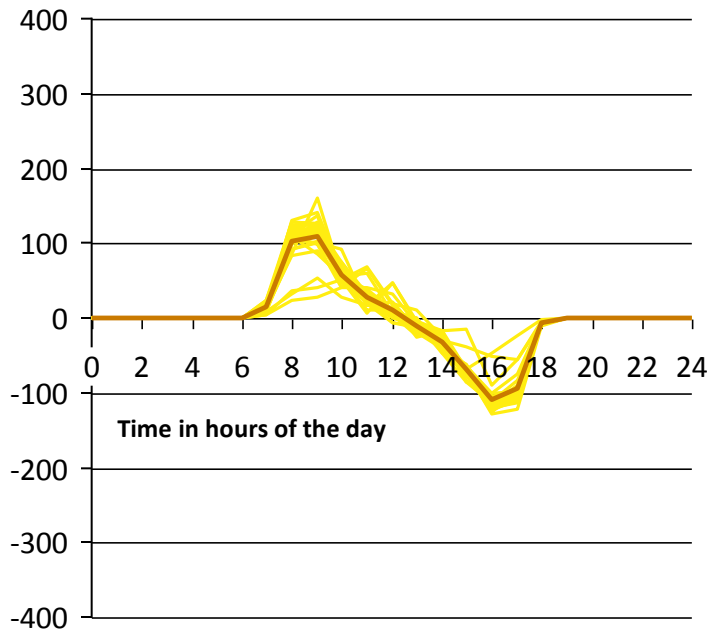


- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr



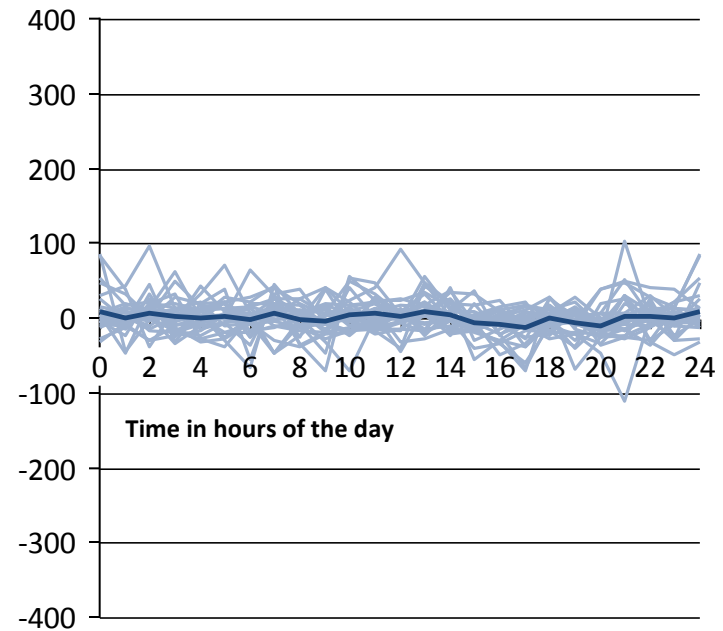
# Solar PV and wind 1-hour gradients in June 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

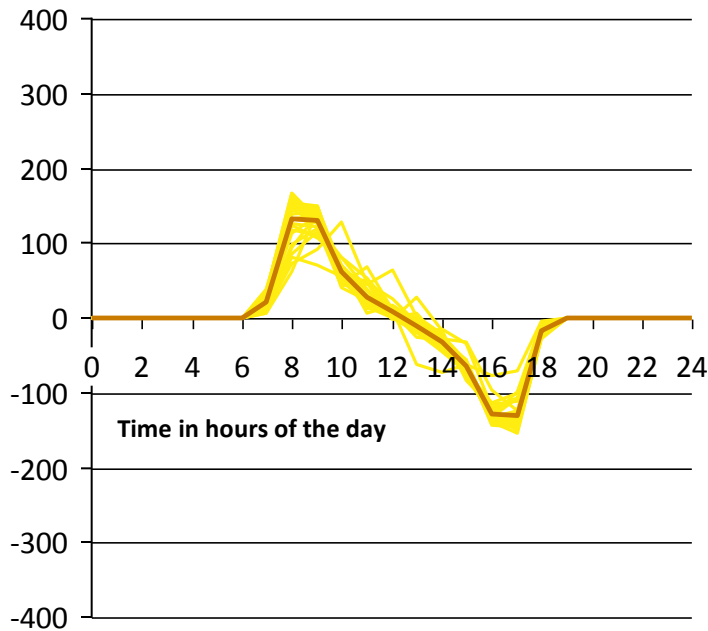
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

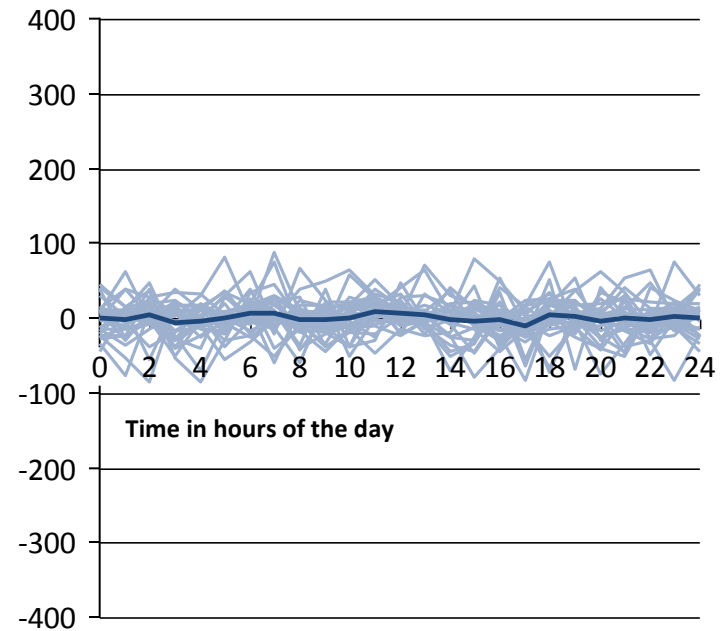
# Solar PV and wind 1-hour gradients in July 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

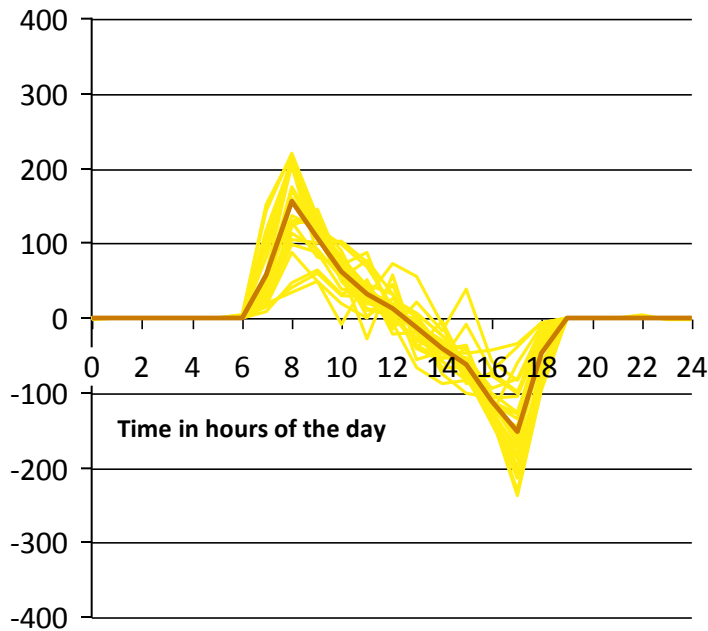
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

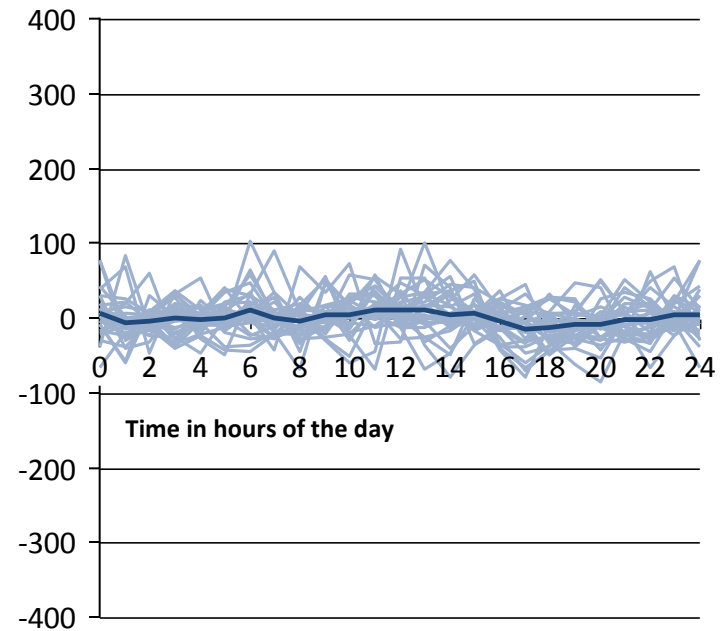
# Solar PV and wind 1-hour gradients in August 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

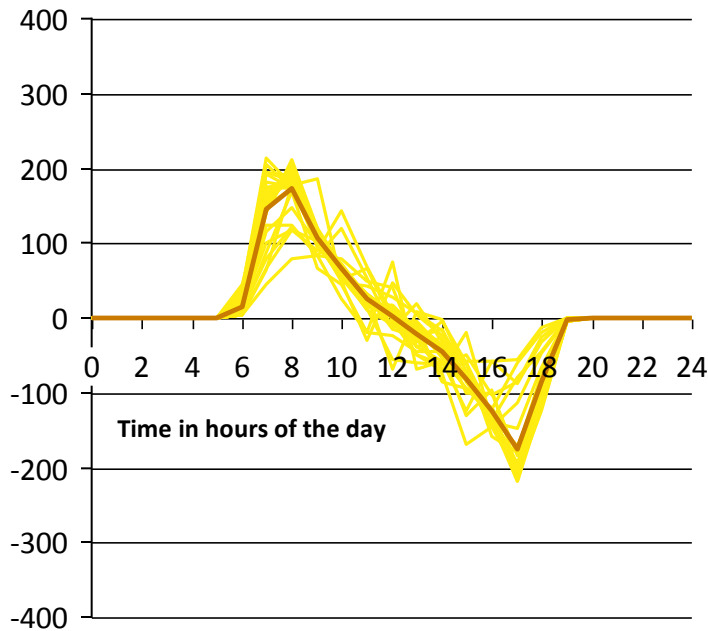
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

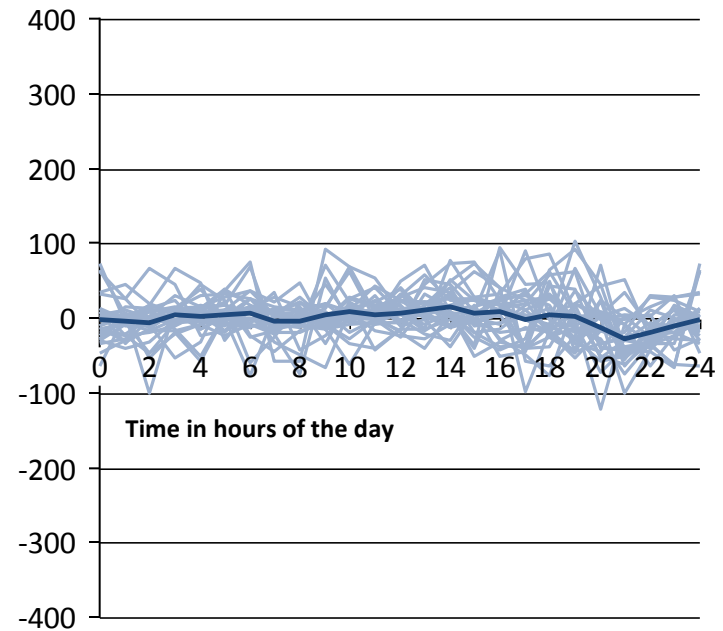
# Solar PV and wind 1-hour gradients in September 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

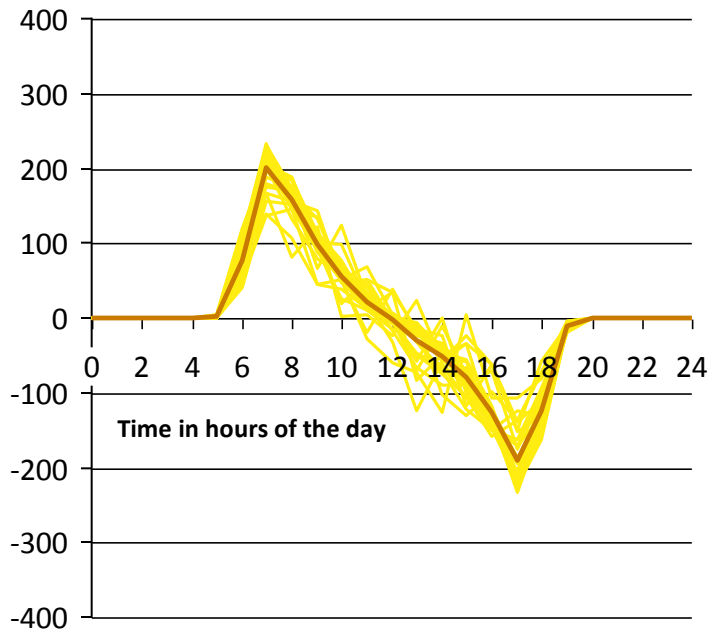
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

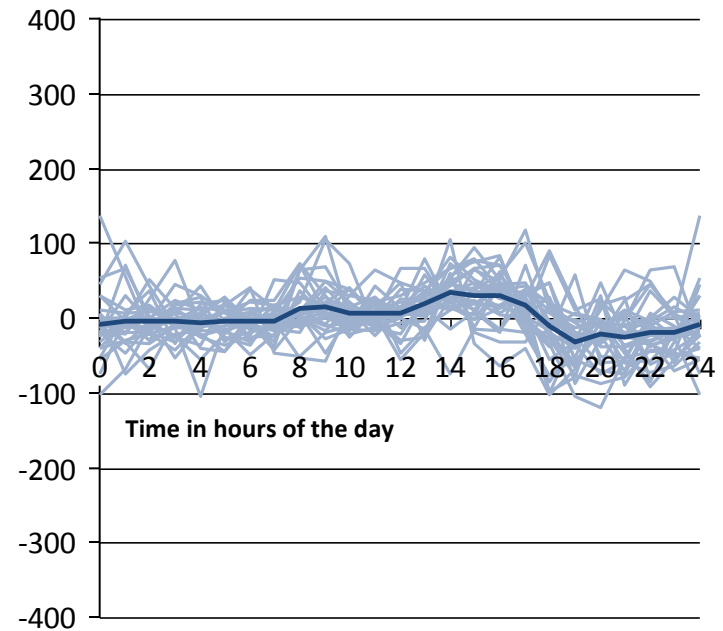
# Solar PV and wind 1-hour gradients in October 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

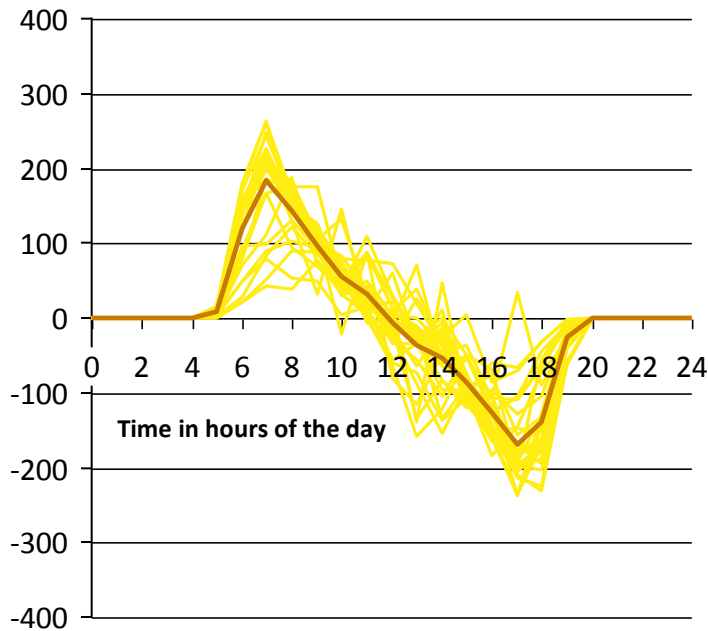
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

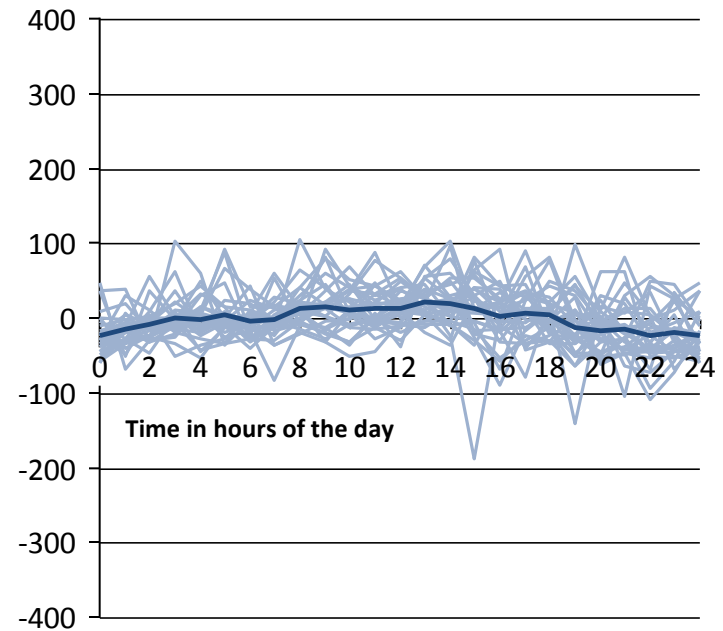
# Solar PV and wind 1-hour gradients in November 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

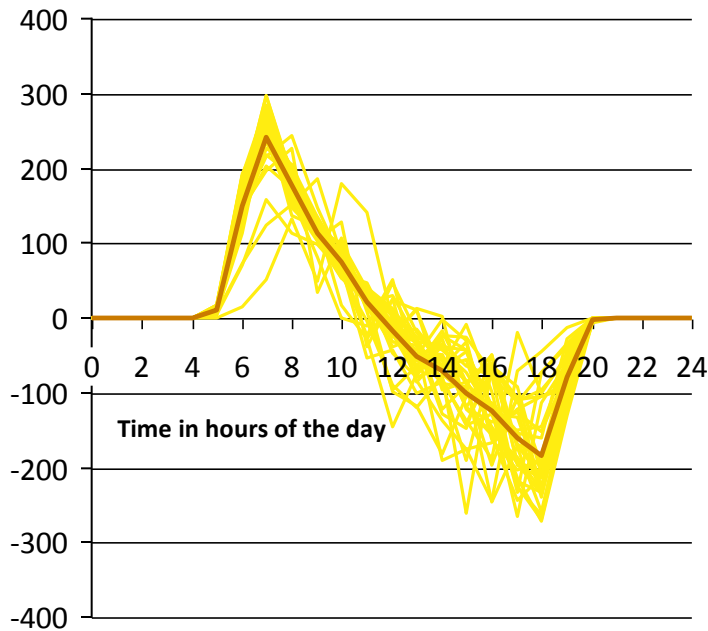
Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

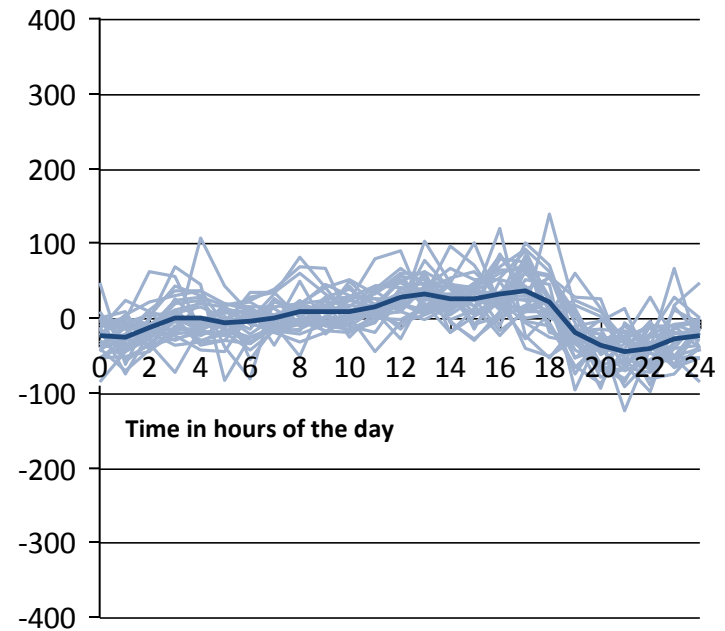
# Solar PV and wind 1-hour gradients in December 2014

Solar PV hourly gradients in MW/hr



- Solar PV hourly gradients in MW/hr
- Average hourly solar PV gradients in MW/hr

Wind hourly gradients in MW/hr



- Wind hourly gradients in MW/hr
- Average wind hourly gradients in MW/hr

# Agenda

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Overview actual electricity production data for 2014

Monthly electricity production

Weekly electricity production

Daily electricity production

Hourly electricity production

Diurnal courses

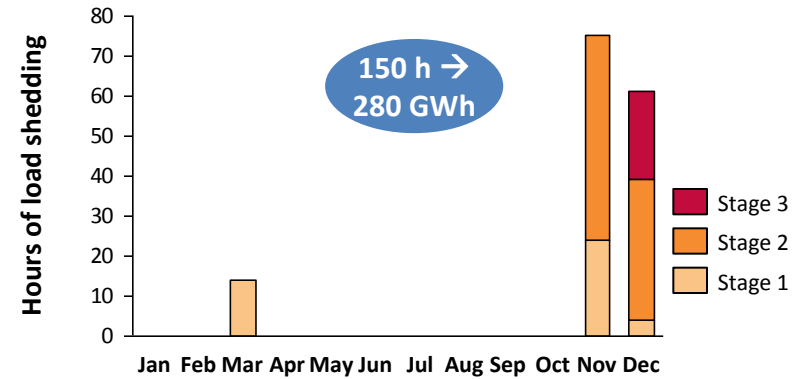
Hourly gradients of wind and photovoltaics

**Actual load shedding for Jan-Dec 2014**



# Actual load shedding occurred on 12 of the 365 days from Jan-Dec 2014

**12 days, 150 hours of load shedding**  
**Approx. 280 GWh of unserved energy**

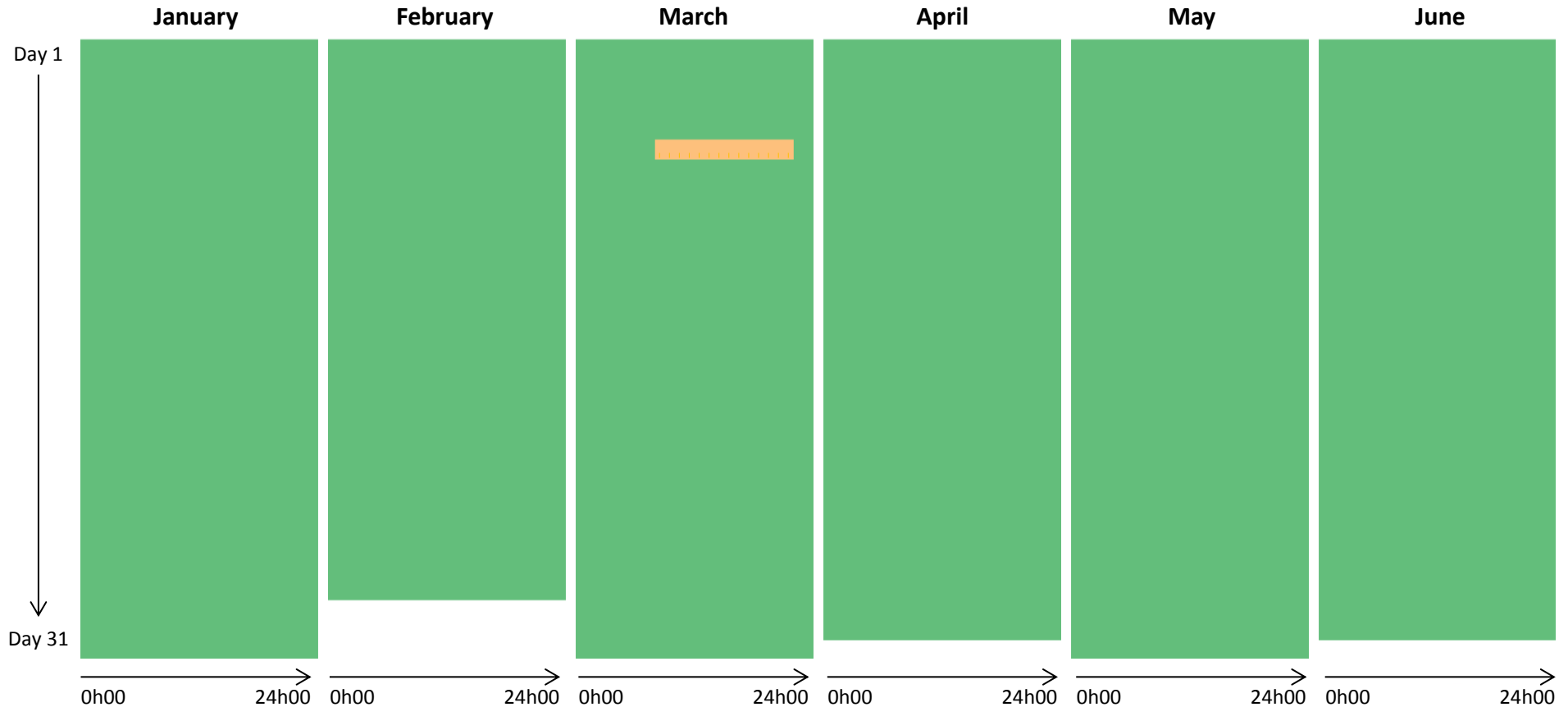


Total unserved energy due to load shedding for all hours per month Jan-Dec 2014 in GWh

	GWh																								Total	
	Hour of the day -->																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	14
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	2	2	5	8	8	8	9	10	10	10	10	10	10	10	9	5	0	0	0	126
Dec	0	0	0	0	0	0	2	2	6	6	6	8	10	10	10	10	12	12	12	12	11	11	0	0	0	140
Total	0	0	0	0	0	0	4	4	12	15	15	17	20	21	21	21	23	23	23	23	21	17	0	0	0	280

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented, in reality 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  
 Sources: Eskom Twitter account; CSIR Energy Centre analysis

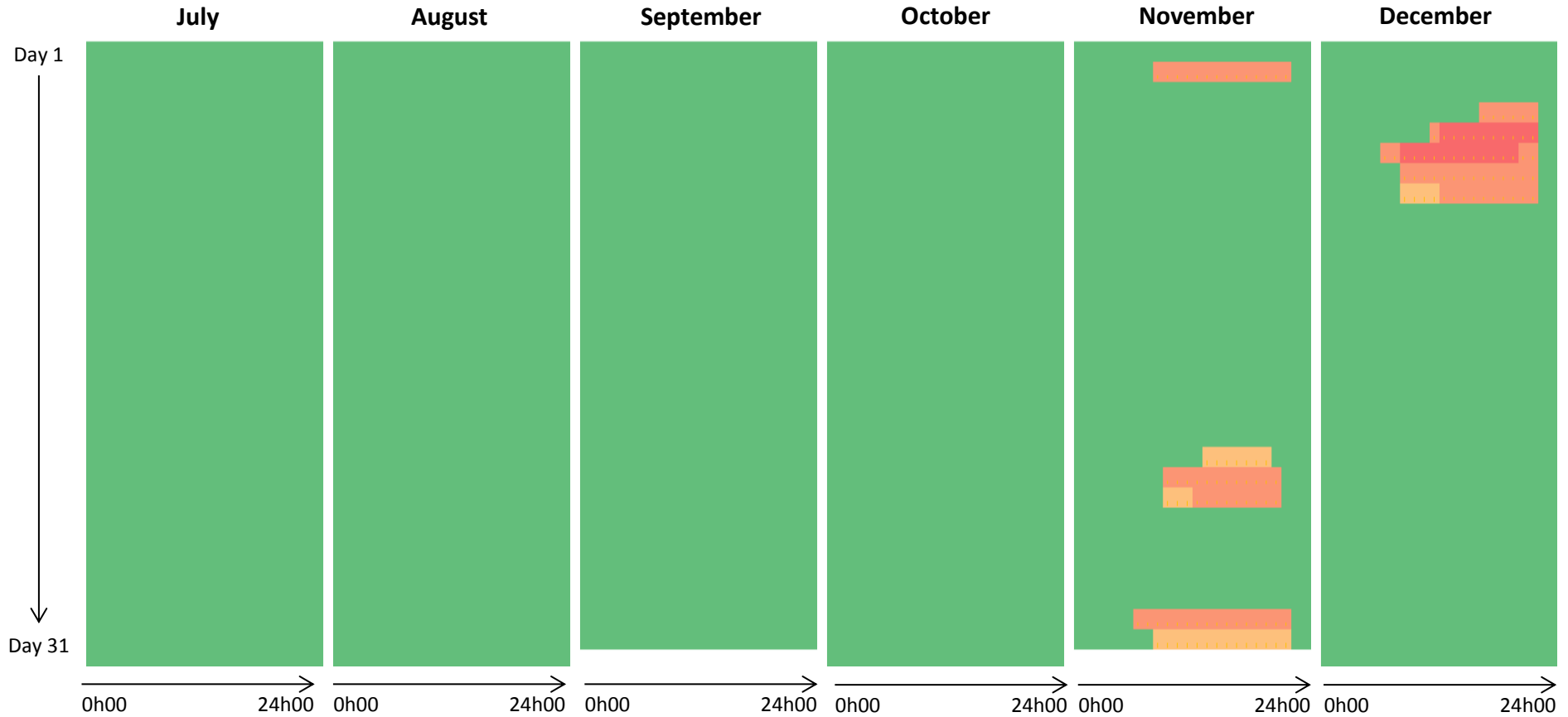
# Hourly distribution of actual load shedding January to June 2014



■ No load shedding    
 ■ Stage 1 load shedding    
 ■ Stage 2 load shedding    
 ■ Stage 3 load shedding

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented, in reality 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  
 Sources: Eskom Twitter account; Eskom Integrated Results for year ended 31 March 2015; CSIR Energy Centre analysis

# Hourly distribution of actual load shedding July to December 2014



■ No load shedding    
 ■ Stage 1 load shedding    
 ■ Stage 2 load shedding    
 ■ Stage 3 load shedding

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented, in reality 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

Sources: Eskom Twitter account; Eskom Integrated Results for year ended 31 March 2015; 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 2014 on aggregated level for all installed wind and solar PV  
Total hourly system energy for the calendar year 2014, minus hydro pumping load

## Total wind and solar PV capacity online

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

## Actual load shedding data

- Data source: Tracking of Eskom Hld SOC Ltd Twitter page ([https://twitter.com/eskom\\_sa](https://twitter.com/eskom_sa) and [https://twitter.com/eskom\\_mediadesk](https://twitter.com/eskom_mediadesk)) load shedding announcements

**Ha Khensa**

**Re a leboha**

**Siyathokoza**

**Enkosi**

**Thank you!**

**Re a leboga**

**Ro livhuha**

**Siyabonga**

**Dankie**

