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Wind and Solar PV Production in Germany in September 2013

Bernard CHABOT

Consulting and Training on Renewable Energy

BCCONSULT

GARBEJAIRE B107, 06560 VALBONNE - FRANCE

E-mail: bechabot@wanadoo.fr

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□ **Part 1: analysis of wind + PV production from 1 to 9/2013**

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- ⇒ Comparison with 2012 production and productivity
- ⇒ Conclusions

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- ⇒ Hourly Wind power capacity factor and production: Germany compared to France
- ⇒ Detailed analysis of PV production and productivity, average, maximum and minimum production
- ⇒ Hourly Wind, PV, [Wind + PV] production in Germany
- ⇒ Hourly Wind, PV, [Wind + PV] % of [Wind + PV + Conv. > 100 MW] production
- ⇒ Daily Wind and PV production and % of [Wind + PV + Conv. > 100 MW] production
- ⇒ Impact on the common ELIX index of the kWh market price in Germany, Austria, Switzerland

Introduction

☐ Refer to preceding articles on renewables in Germany:

- ⇒ **“Wind and Solar PV Production in Germany in the first 8 months of the year, with a focus on August 2013“**, online and downloadable as pdf on September 9, 2013 at : <http://www.renewablesinternational.net/power-production-data-updated-for-august/150/537/72620/> “
- ⇒ **“Diversity in PV Systems Sizes and Market Deployment Management from Prices: Two Strategic Lessons from the German PV Policies and Measures“**, online September 3, 2013 and downloadable as pdf at: <http://www.renewablesinternational.net/two-strategic-lessons-from-distributed-pv/150/452/72521/>
- ⇒ **“Renewable Electricity In Germany in July 2013“** , online on August 5, 2013 and downloadable as pdf at: <http://www.renewablesinternational.net/german-green-power-2013-catching-up-with-2012/150/537/71732/>
- ⇒ **“ Sunny or Cloudy weather: which impact on electricity from wind and solar?“** , online on June 4, 2013 and downloadable as pdf at: <http://www.renewablesinternational.net/update-on-combined-wind-and-solar-power-production/150/537/63129/>

☐ Production and market prices data from:

- ⇒ Production in Germany: EEX: <http://www.transparency.eex.com/>
- ⇒ Wind production in France: RTE: <http://www.rte-france.com/fr/developpement-durable/eco2mix/telechargement-de-donnees>
- ⇒ ELIX kWh market price: EPEX SPOT SE: http://www.epexspot.com/fr/donnees_de_marche/elix

☐ Analysis for electricity production:

- ⇒ Power, energy, penetration rates, productivity
- ⇒ Comparisons of wind production and capacity factors in Germany and France

☐ Analysis of electricity market price:

- ⇒ ELIX index for Germany, Austria, Switzerland, France

Part 1:

**Analysis of the wind and PV
production from January to
September 2013**

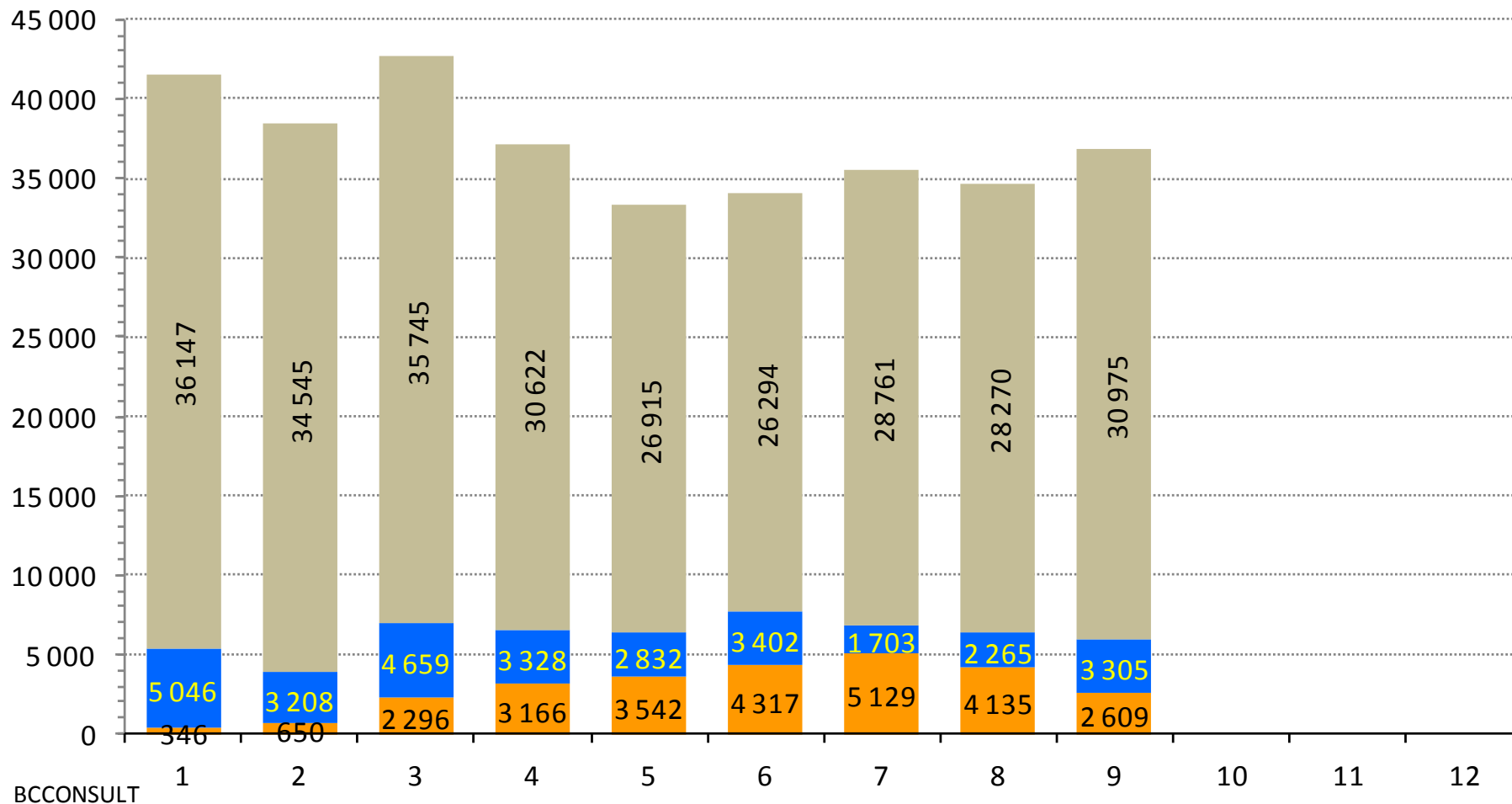
Monthly wind, PV and conventional production in 2013

2013 Production from PV, Wind, Conv. > 100 MW

GWh/month, source of data: EEX

TWh end August: PV: 26.19; Wind: 29.75, Conv. > 100 MW: 278. Total: 334 TWh

PV Wind Conv. > 100 MW



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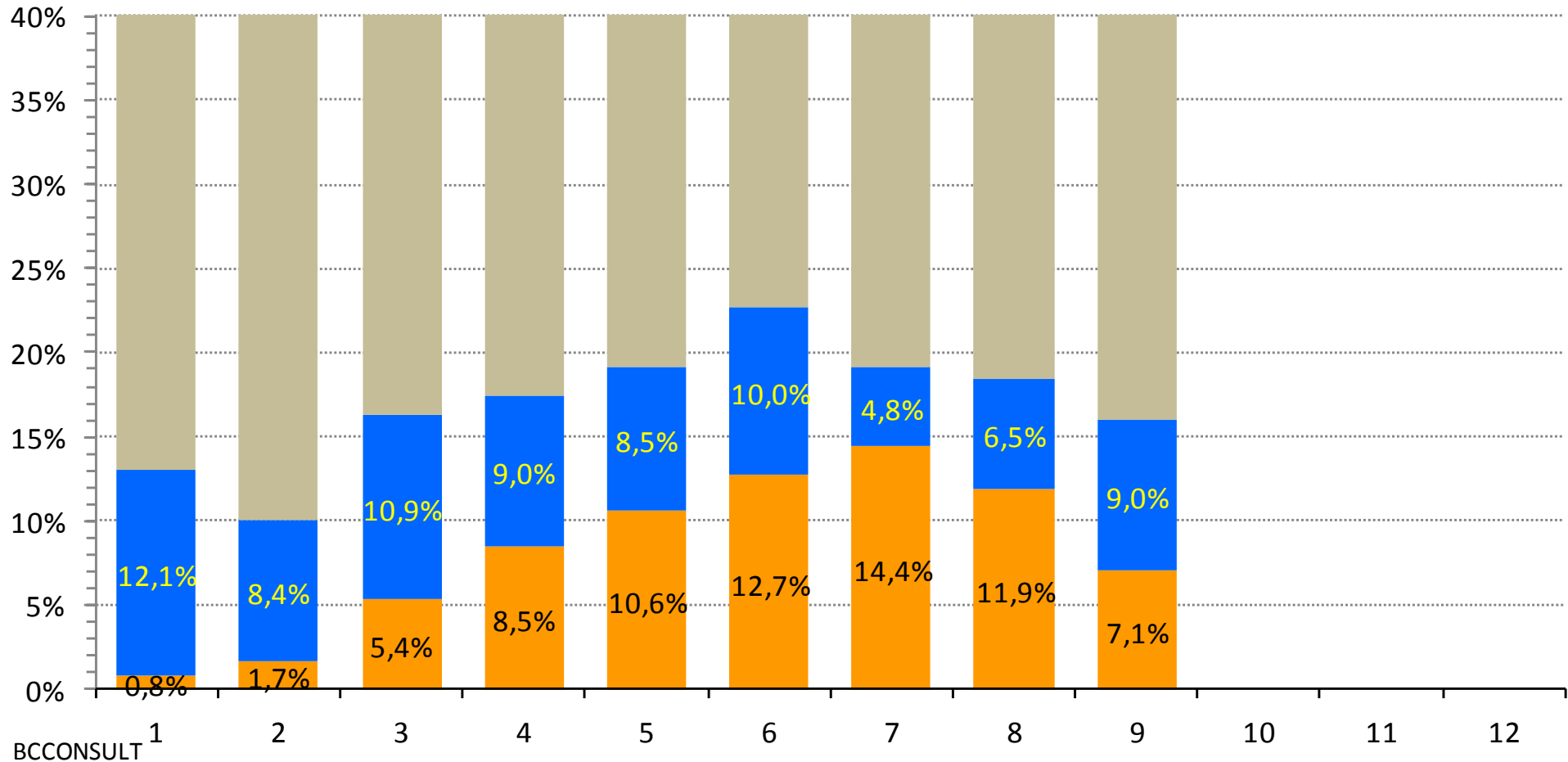
% of monthly wind and PV production in 2013

% of 2013 Production from PV, Wind, Conv. > 100 MW

GWh/month, source of data: EEX

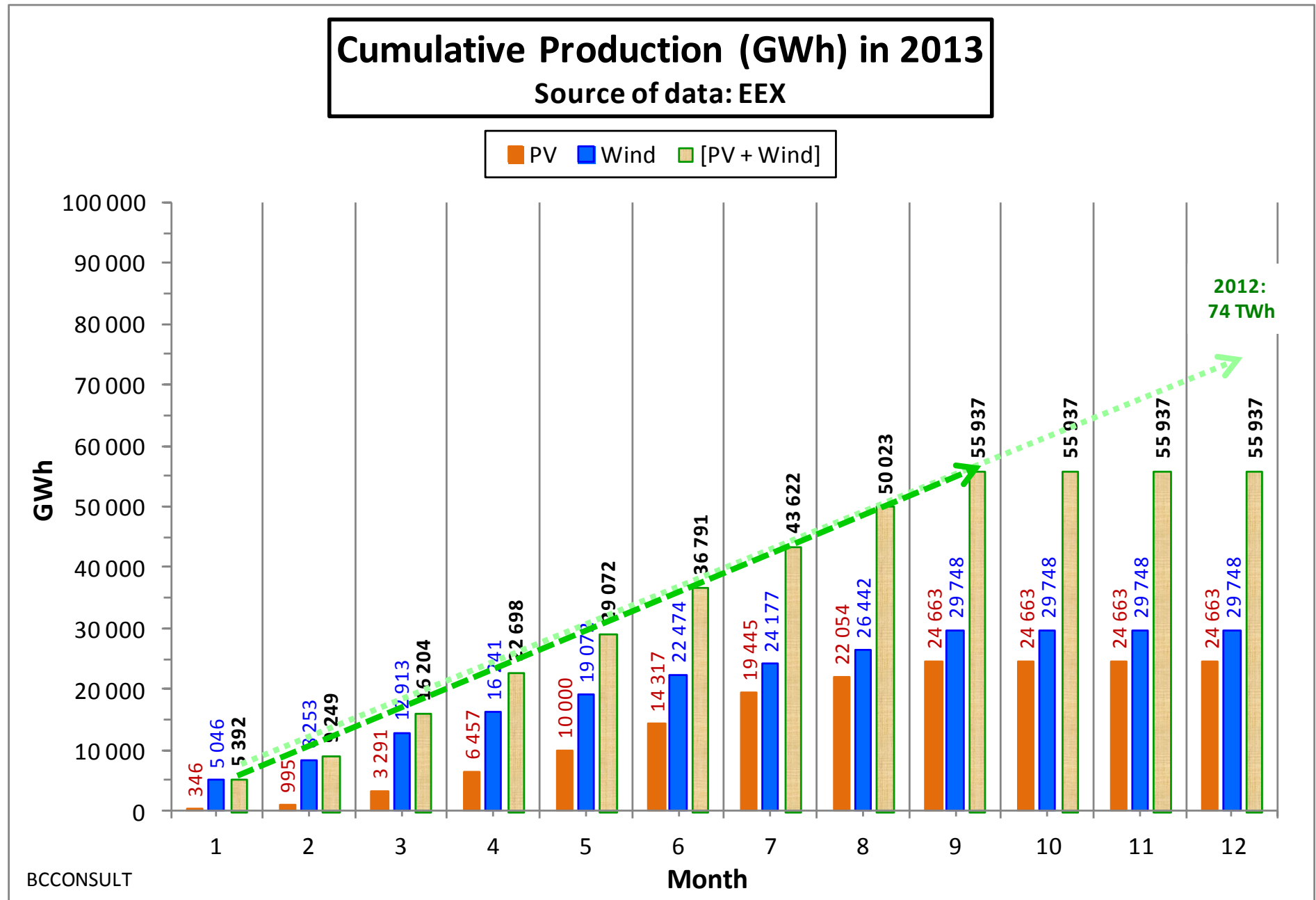
% end August: PV: 7.4 %; Wind: 8.9 %, Conv.> 100 MW: 83.3 %. Total: 334 TWh

PV Wind Conv. > 100 MW



Analysis of the wind and PV monthly production changes in 2013 compared to 2012

Cumulative wind and PV production up to August 2013



Production in the first 9 months in 2012 and 2013

First 9 months: production and changes			
GWh	1 to 9, 2013	1 to 9, 2012	2013/2012
Wind	29 748	32 603	-8,8%
PV	26 189	24 967	4,9%
[Wind + PV]	55 936	57 570	-2,8%

Em GWh/month	2013			2012		
	PV	Wind	[Wind+PV]	PV	Wind	[Wind+PV]
September	2 608	3 305	5 913	2 912	3 021	5 933
August	4 135	2 265	6 400	3 885	2 157	6 042
July	5 129	1 703	6 832	3 750	2 644	6 394
June	4 317	3 402	7 719	3 727	2 894	6 621
May	3 542	2 832	6 374	4 127	2 912	7 039
April	3 166	3 328	6 494	2 634	3 354	5 989
March	2 296	4 659	6 955	2 347	4 023	6 370
February	650	3 208	3 857	1 047	4 565	5 612
January	346	5 046	5 392	537	7 034	7 571
January-Sept.	26 189	29 748	55 936	24 967	32 603	57 571

Changes in monthly production Em (GWh)			
2013/2012	PV	Wind	[Wind+PV]
September	-10,5%	9,4%	-0,3%
August	6,4%	5,0%	5,9%
July	36,8%	-35,6%	6,8%
June	15,8%	17,6%	16,6%
May	-14,2%	-2,8%	-9,4%
April	20,2%	-0,8%	8,4%
March	-2,2%	15,8%	9,2%
February	-37,9%	-29,7%	-31,3%
January	-35,6%	-28,3%	-28,8%
January-Sept.	4,9%	-8,8%	-2,8%

Productivity in the first 9 months in 2012 and 2013

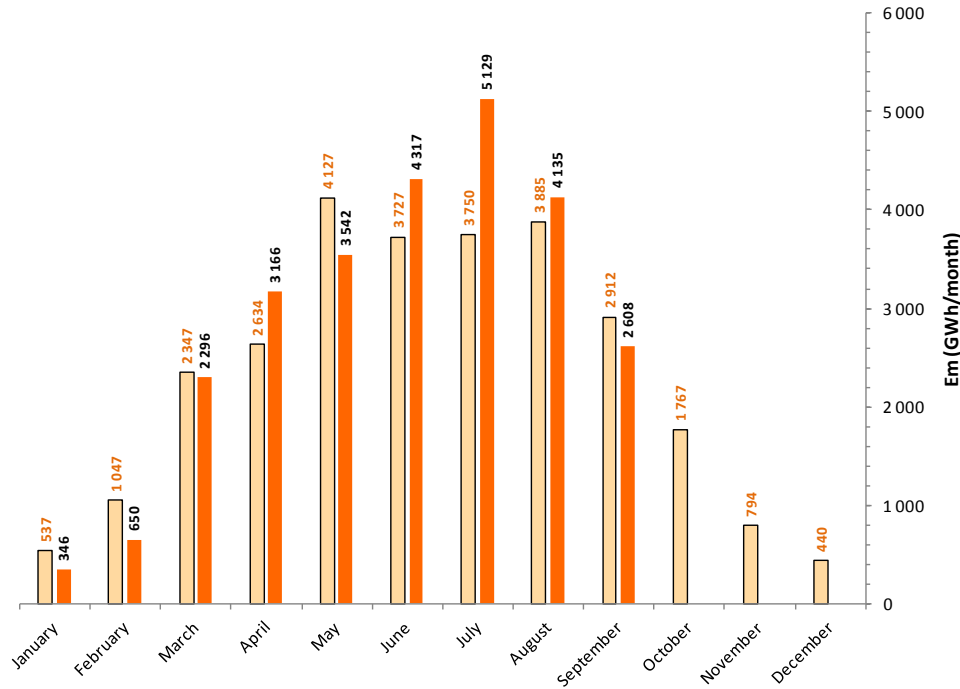
Nh Hour/day	2013			2012		
	PV	Wind	[Wind+PV]	PV	Wind	[Wind+PV]
September	2,50	3,39	2,93	3,23	3,31	3,27
August	3,87	2,24	3,08	4,22	2,30	3,25
July	4,83	1,69	3,31	4,15	2,84	3,49
June	4,24	3,51	3,89	4,54	3,23	3,86
May	3,41	2,85	3,13	4,91	3,16	4,00
April	3,18	3,48	3,33	3,28	3,79	3,55
March	2,25	4,75	3,48	2,97	4,42	3,74
February	0,71	3,64	2,15	1,43	5,39	3,55
January	0,34	5,21	2,73	0,70	7,80	4,53

Changes in mean daily productivity Nh (h/d)			
2013/2012	PV	Wind	[Wind+PV]
September	-22,7%	2,4%	-10,5%
August	-8,4%	-2,9%	-5,3%
July	16,5%	-40,5%	-5,2%
June	-6,6%	8,6%	0,8%
May	-30,6%	-10,0%	-21,6%
April	-3,0%	-8,0%	-6,1%
March	-24,0%	7,5%	-7,1%
February	-50,2%	-32,4%	-39,5%
January	-50,7%	-33,2%	-39,7%

PV Production and productivity in 2012 and 2013

PV in Germany : monthly GWh in 2012 and 2013

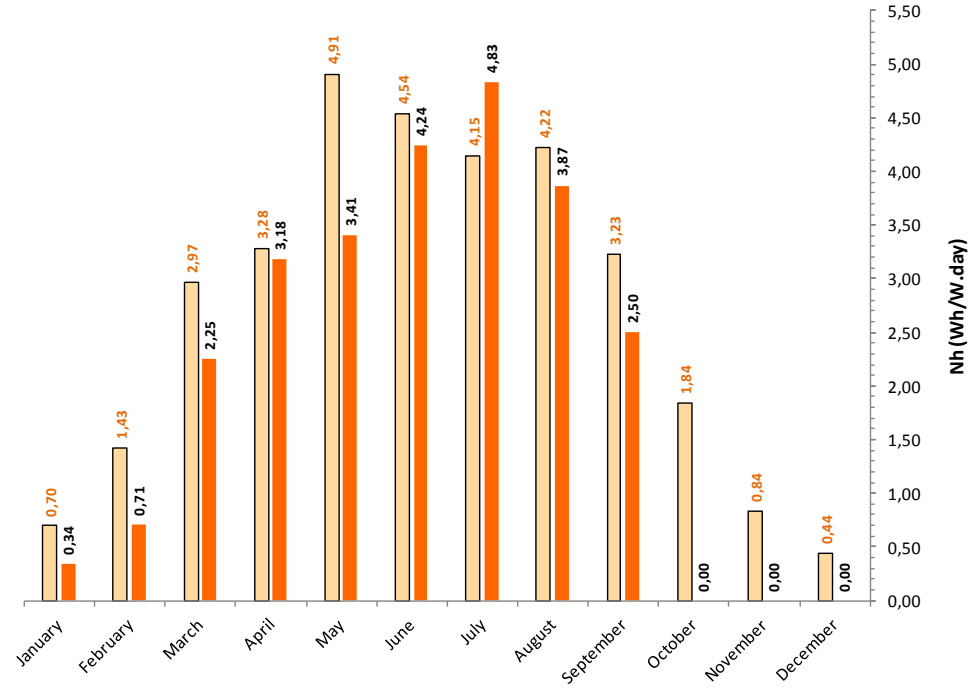
■ 2013 ■ 2012



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PV in Germany : monthly Nh (Wh/W.day) in 2012 and 2013

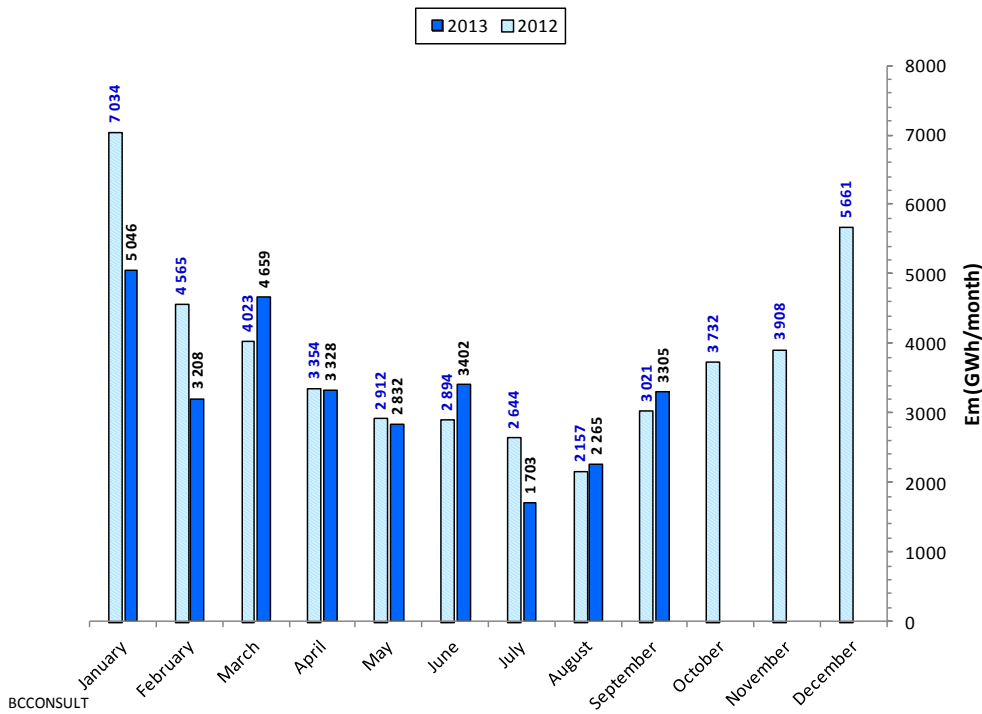
■ 2013 ■ 2012



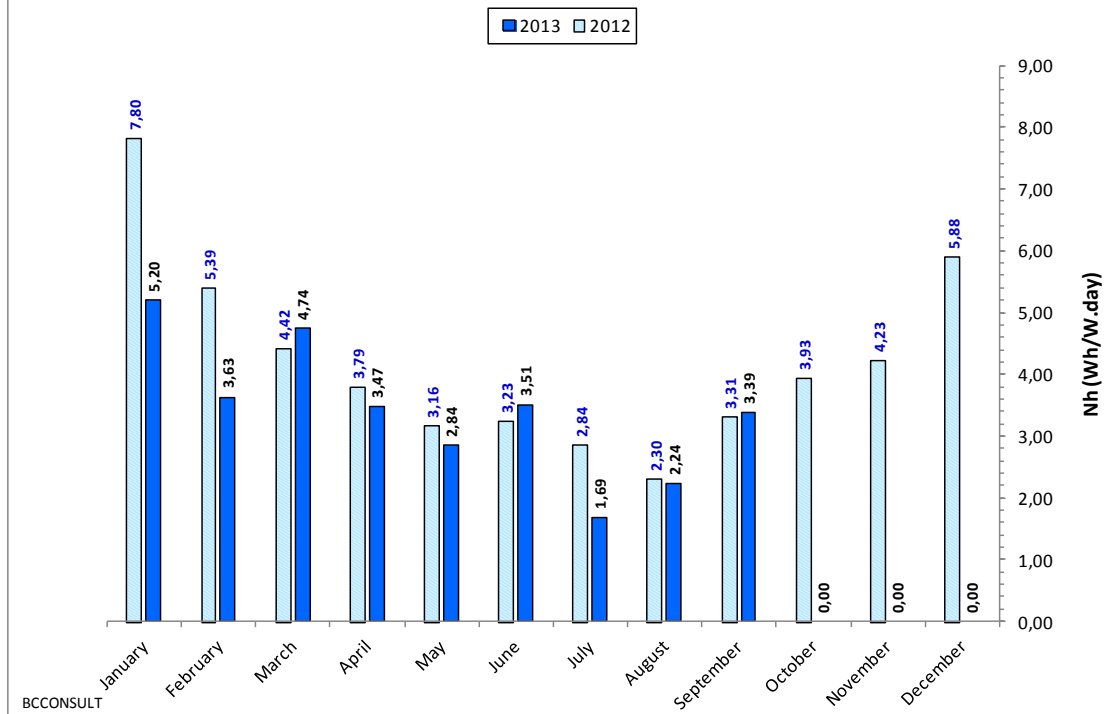
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Wind production and productivity in 2012 and 2013

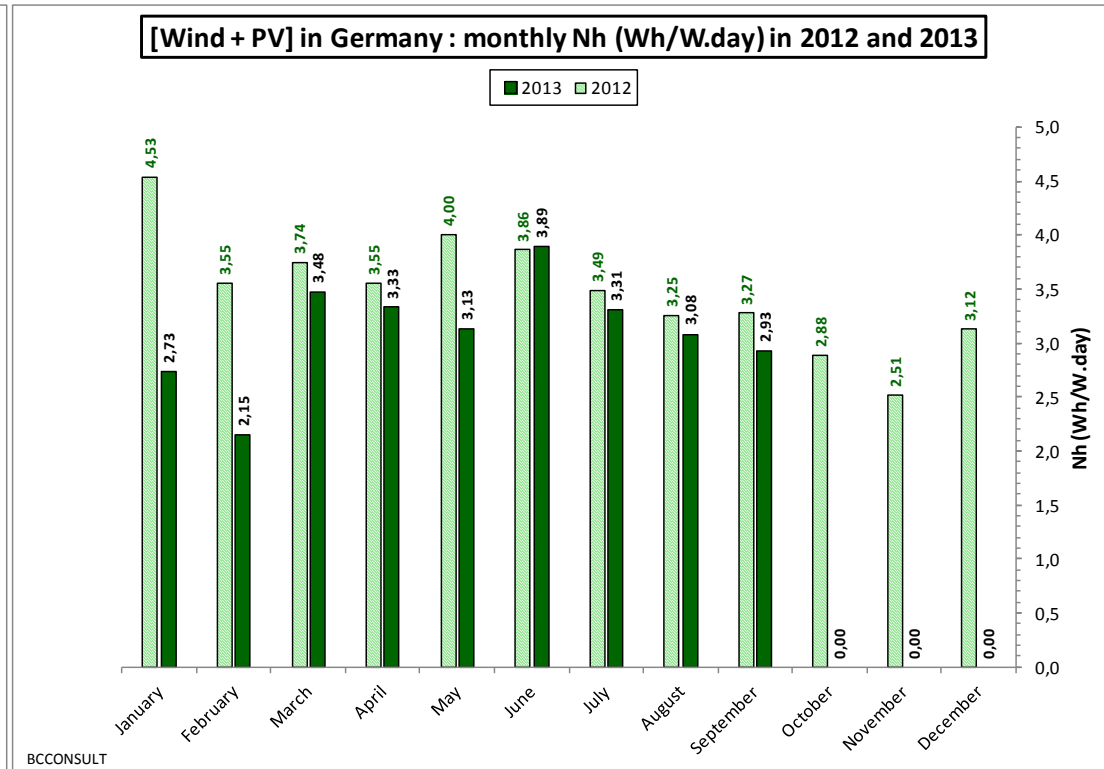
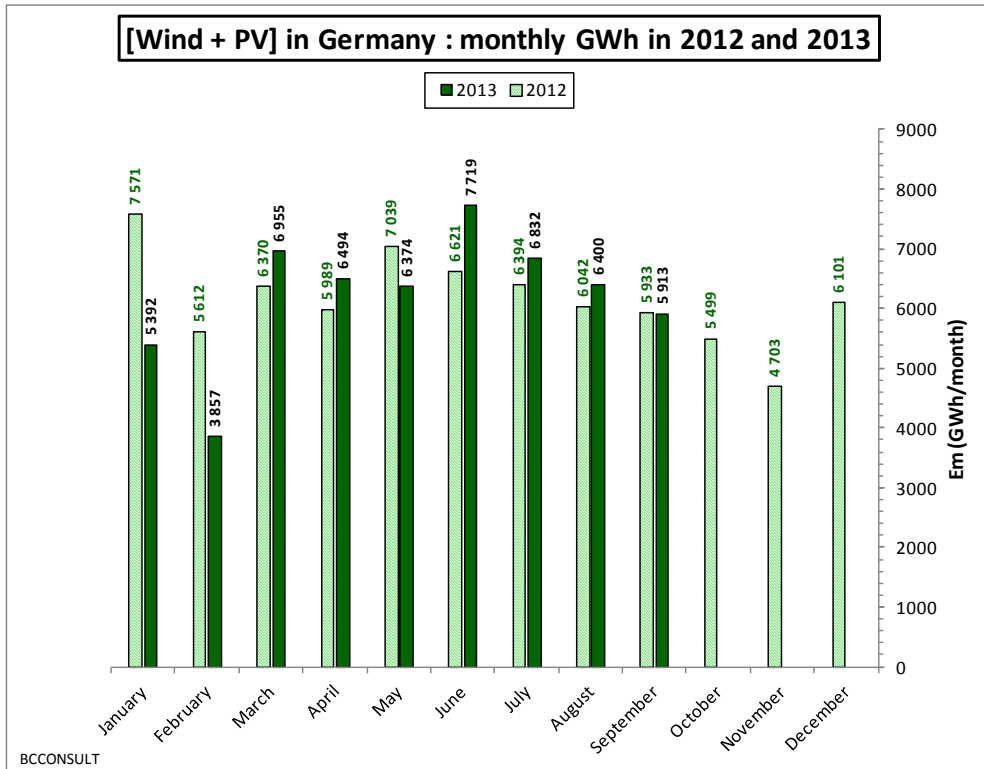
Wind in Germany: monthly GWh in 2012 and 2013



Wind in Germany: monthly Nh (Wh/W.day) in 2012 and 2013



[Wind + PV] production and productivity in 2012 and 2013



Conclusions on Part 1

- ❑ **[Wind + PV] contribution in Germany in the first 9 months was less in 2013 compared to 2012 due to meteorological conditions:**
 - ⇒ 8.8 % less for wind
 - ⇒ 4.9 % more for PV
 - ⇒ 2.8 less for [wind + PV]
 - ⇒ Total [wind + PV] production : 55.936 TWh from 1 to 9/2013 compared to 57.571 in 2012

- ❑ **Decrease in productivity was not fully compensated by increases in wind and PV installed power**

- ❑ **The mix of wind and PV is an advantage for monthly demand following, but future mix should be more optimal:**
 - ⇒ Higher capacity factor for onshore wind from incentives to use new high specific area ($S_u = S/P > 4 \text{ m}^2/\text{kW}$) IEC3 wind turbines for light wind areas
 - ⇒ More total installed wind than PV to increase winter [Wind + PV] production

Part 2:

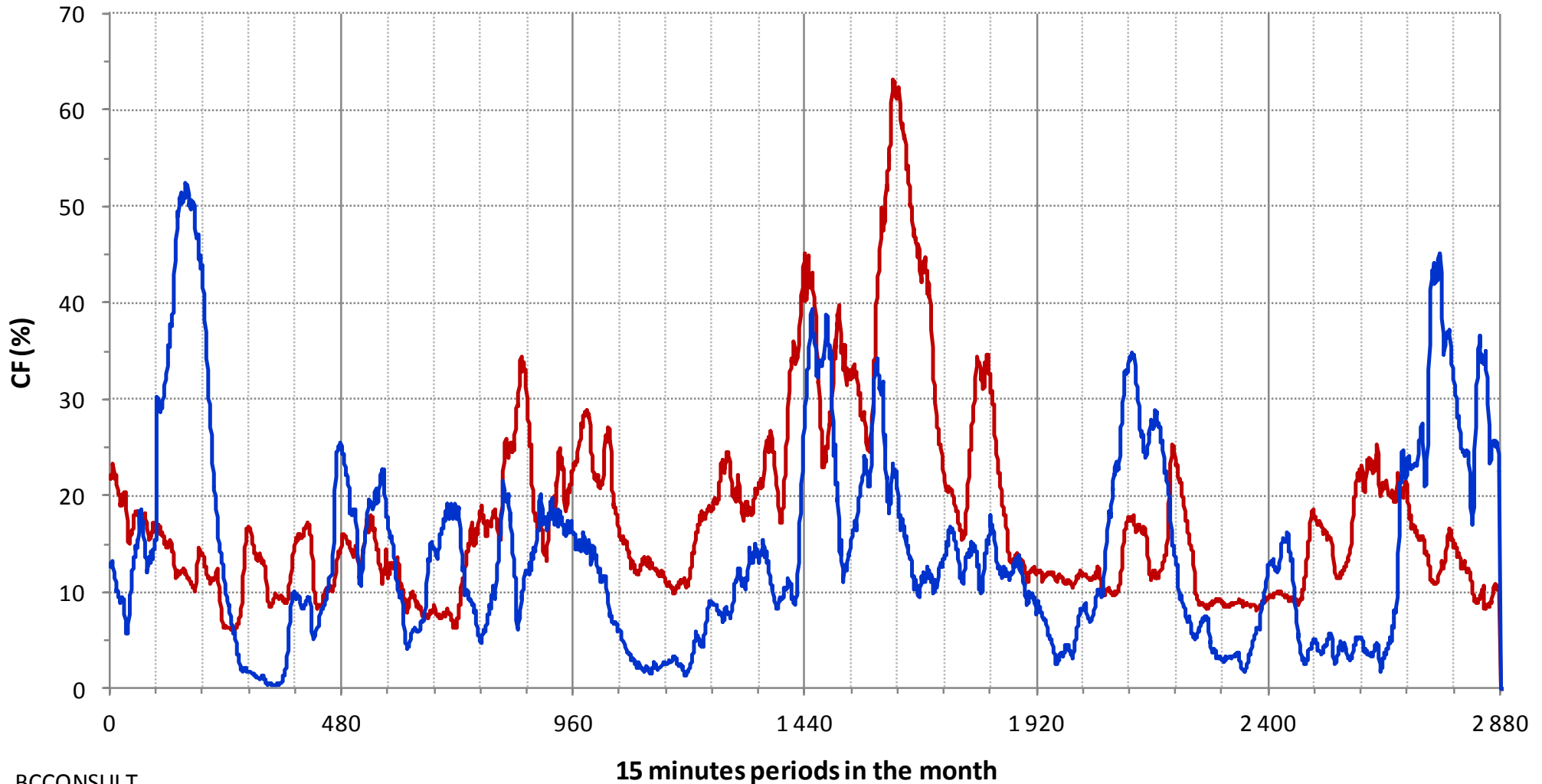
Analysis of monthly production and ELIX market prices in September 2013

Wind power capacity factors in Germany and France in 9/2013

Wind Power Capacity Factor (CF, %) in France and Germany in 9/2013

Average Germany: 13.7 %. France: 17.2 %. Data from: RTE, EEX

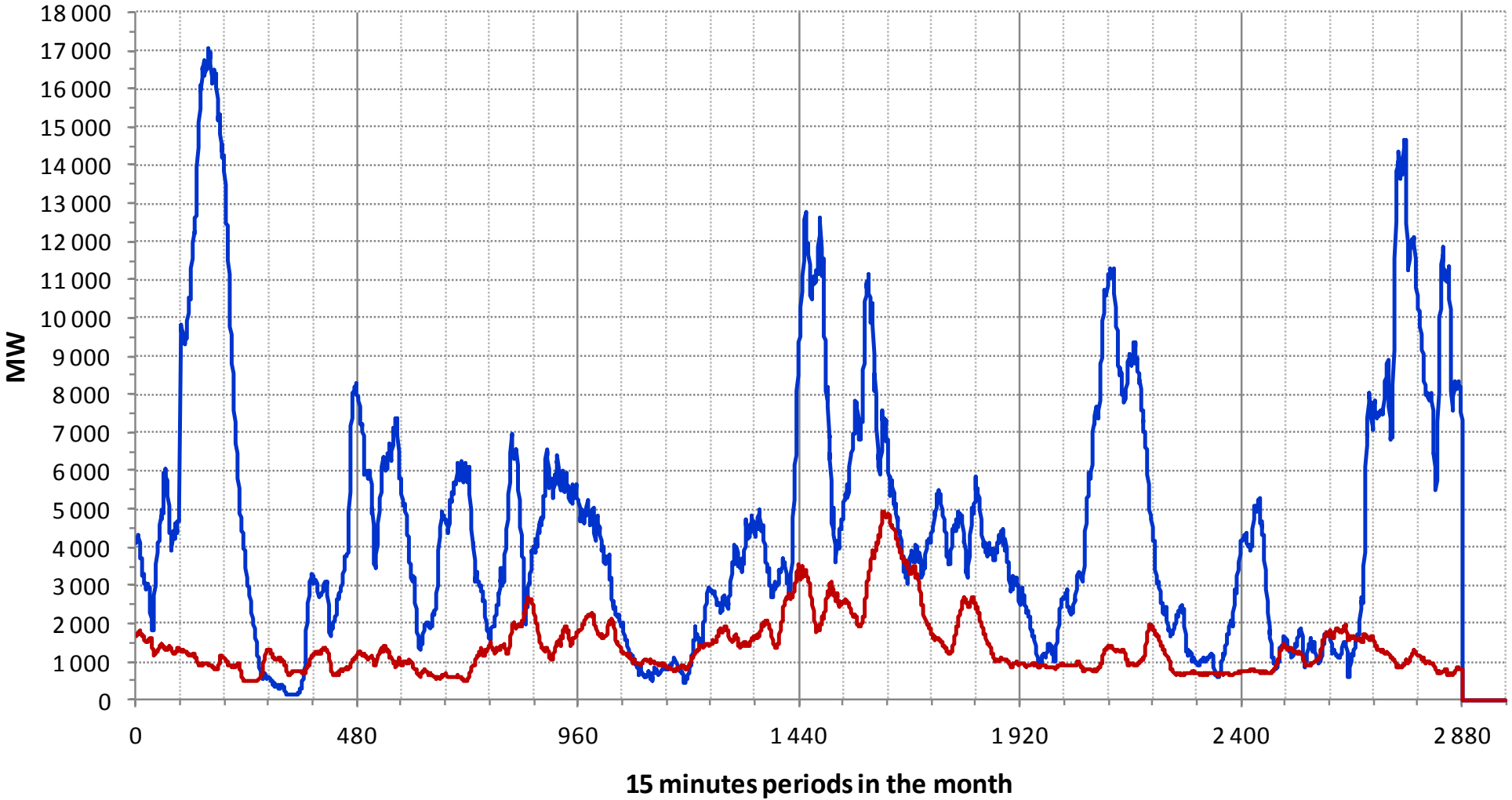
— CF France — CF Germany



Wind power production in Germany and France in 9/2013

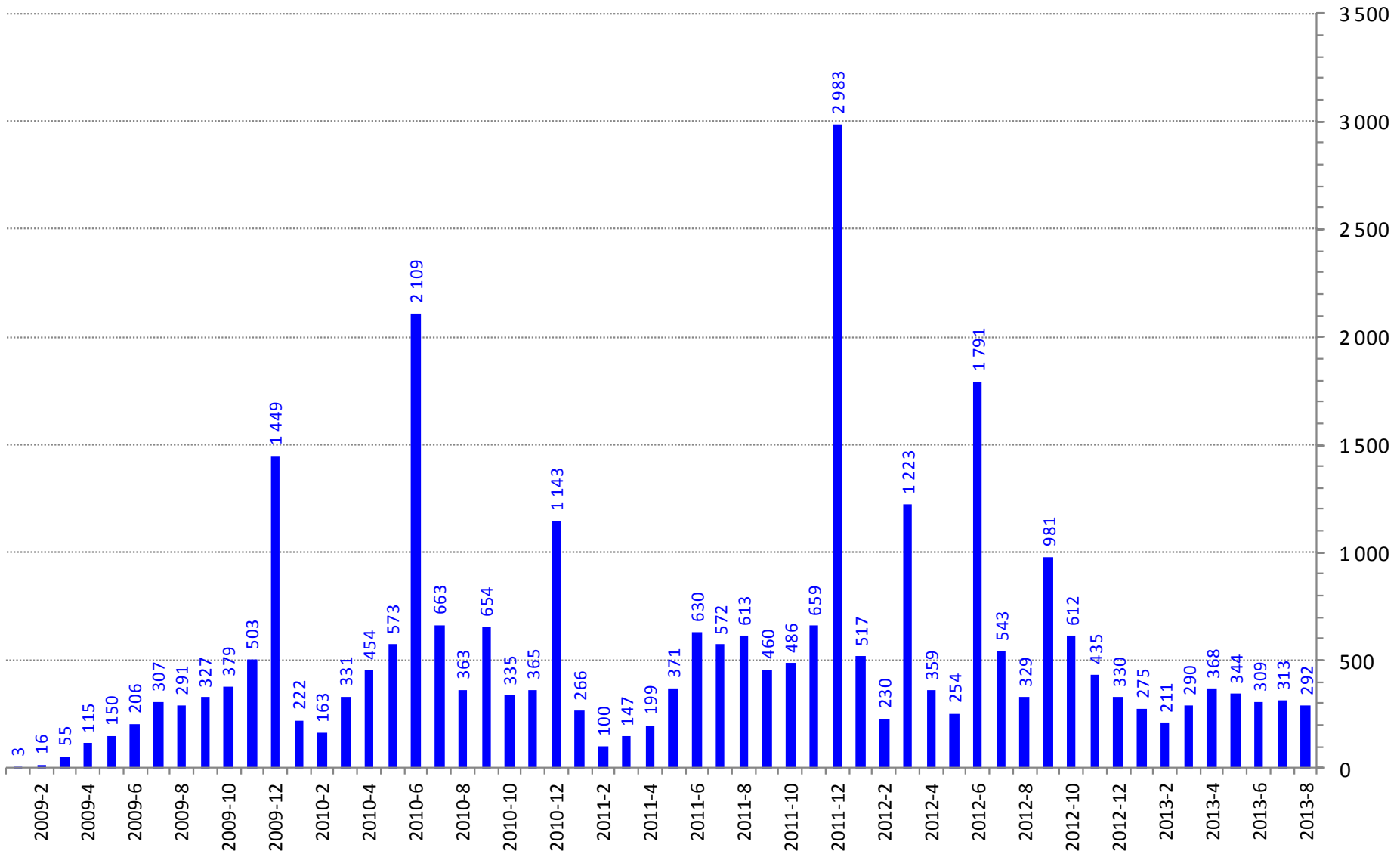
P Wind Power (MW) in France and Germany in September 2013
Average: Germany: 4443 MW. France: 1392 MW. Sources of data: RTE, EEX

— MW Wind Germany — MW Wind France



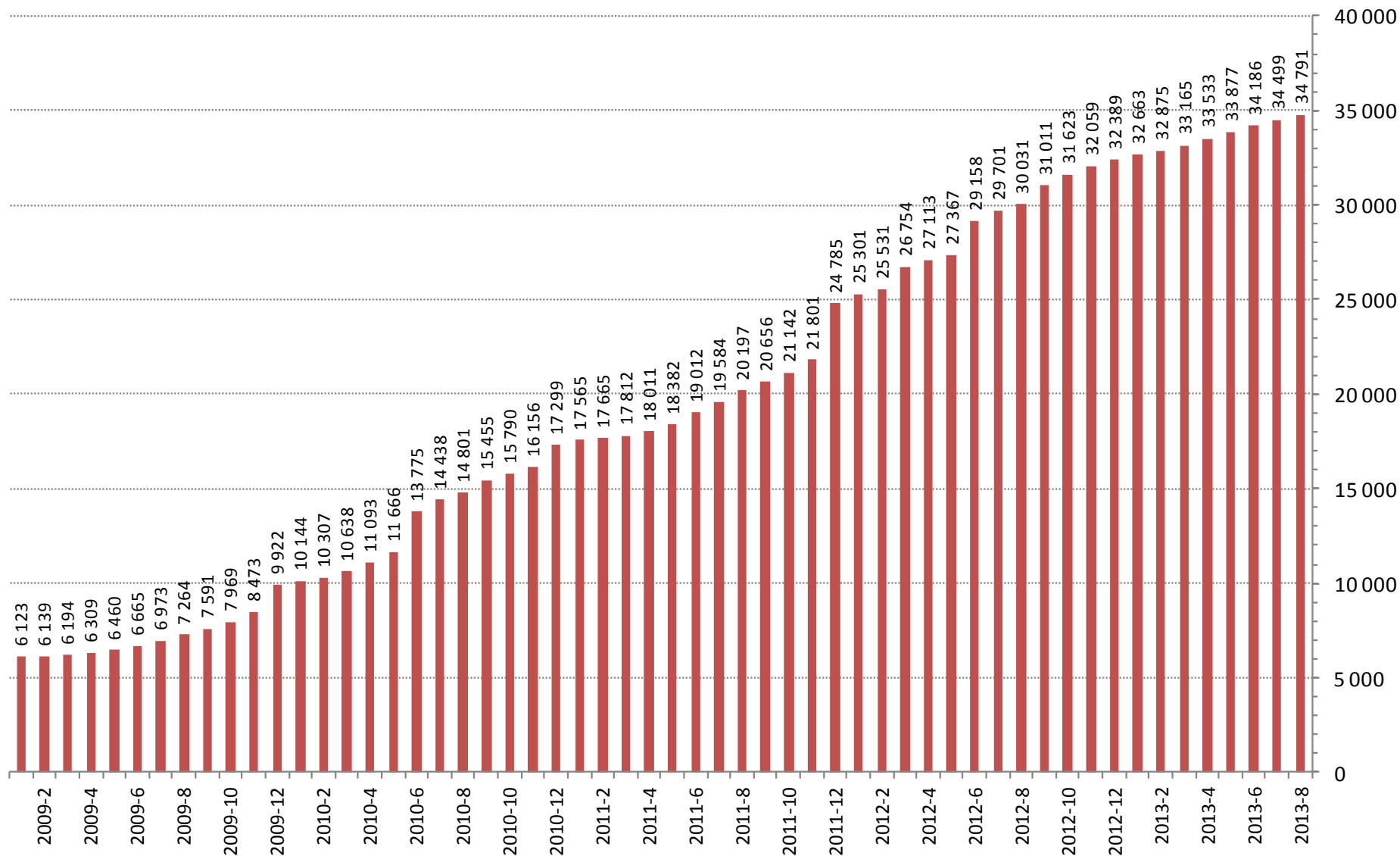
Monthly Solar PV in Germany 1/2009 to 9/2013

PV development in Germany 2009-2013
MW/month registered under EEG. Source of data: BNETZA



Total Solar PV in Germany 1/2009 to 9/2013

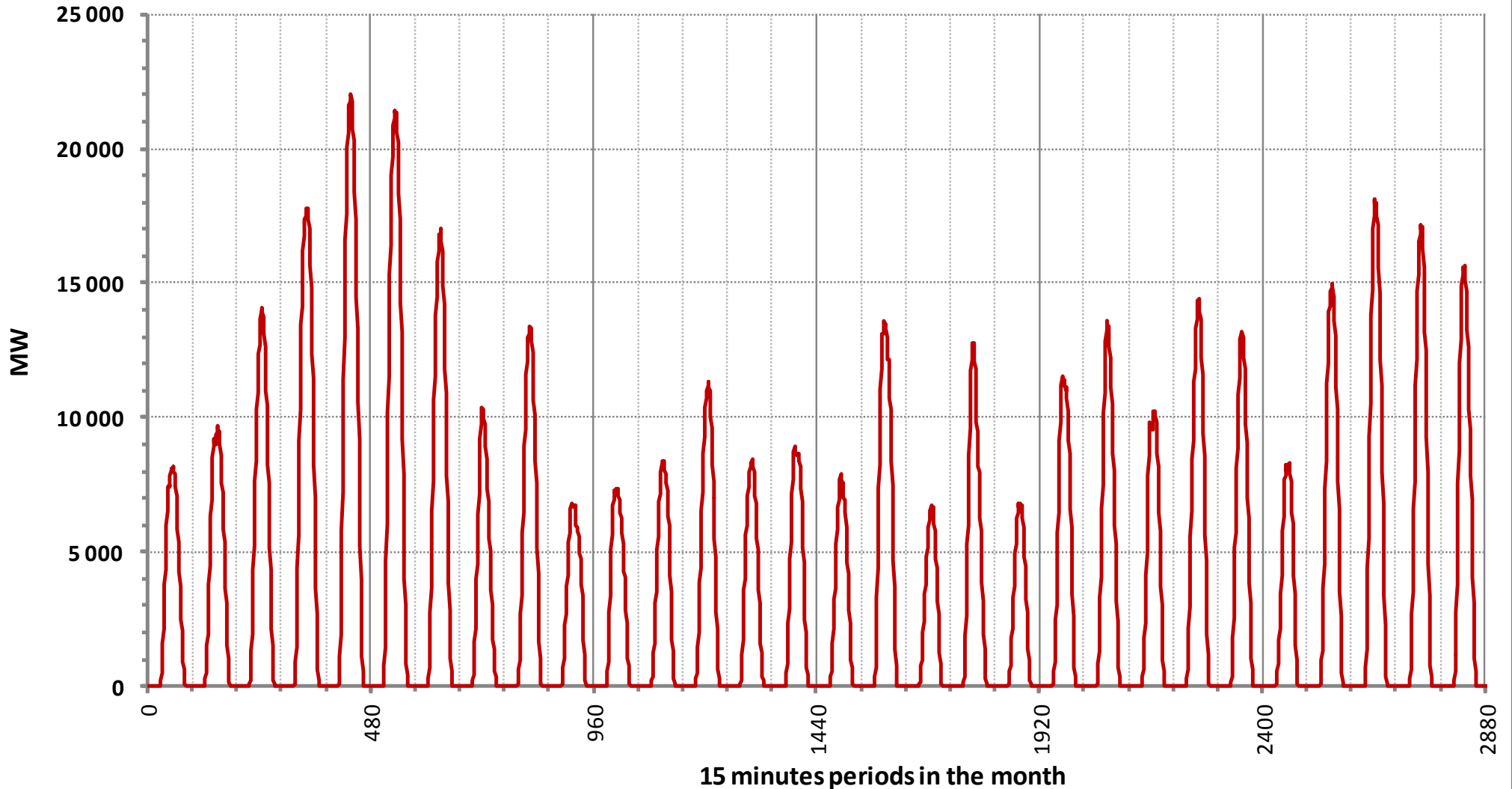
PV development in Germany 2009-2012
MW end of month registered under EEG. Source of data: BNETZA



Solar PV in Germany in 9/2013

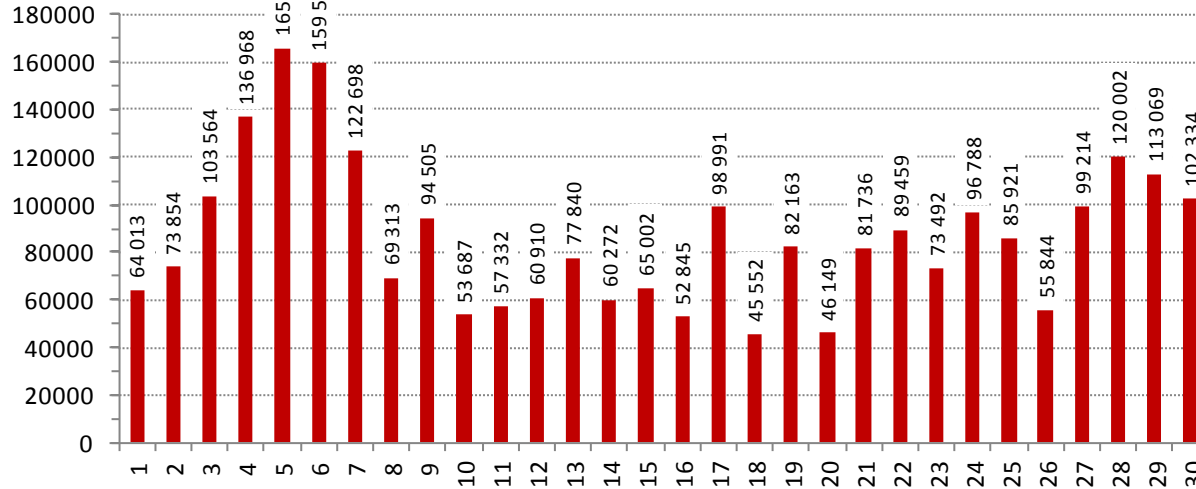
PV in Germany in September 2013 (MW)

Average: 3,623 MW. Max: 21,998 MW. Total production: 2,608 GWh (87 GWh/day)

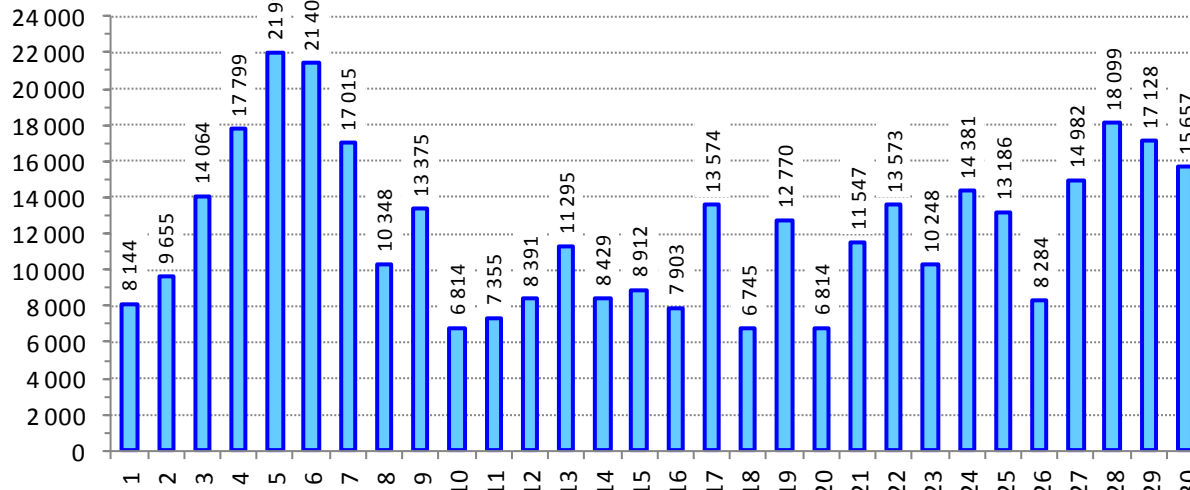


PV in 9/2013: daily production (GWh) and maximum MW

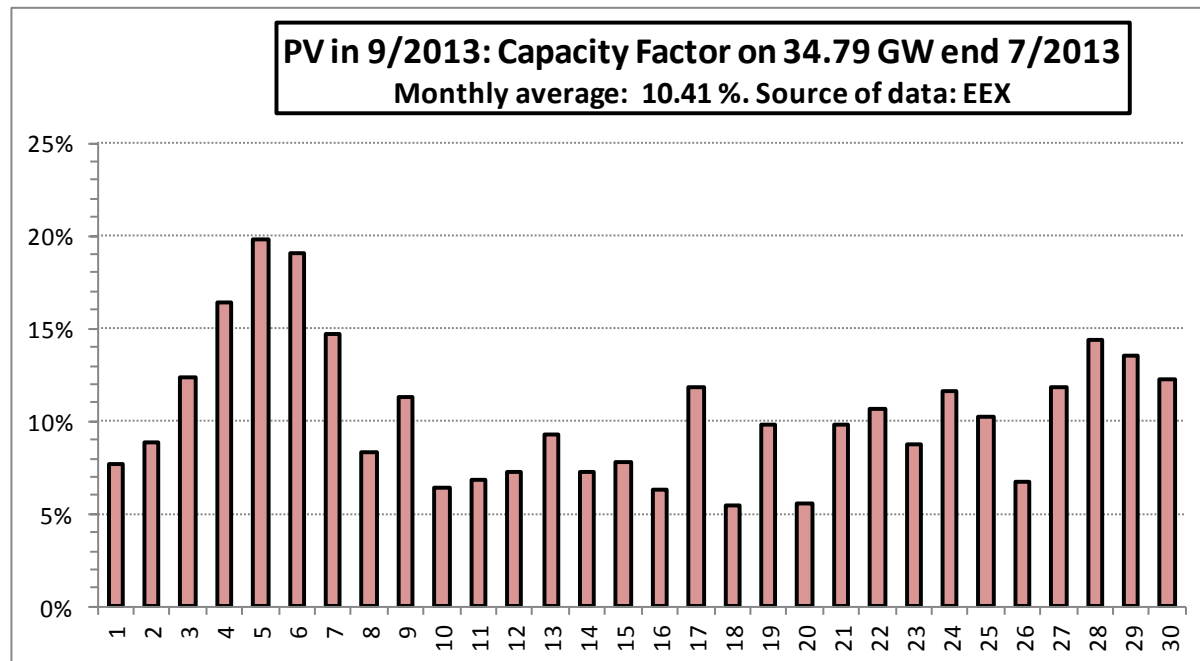
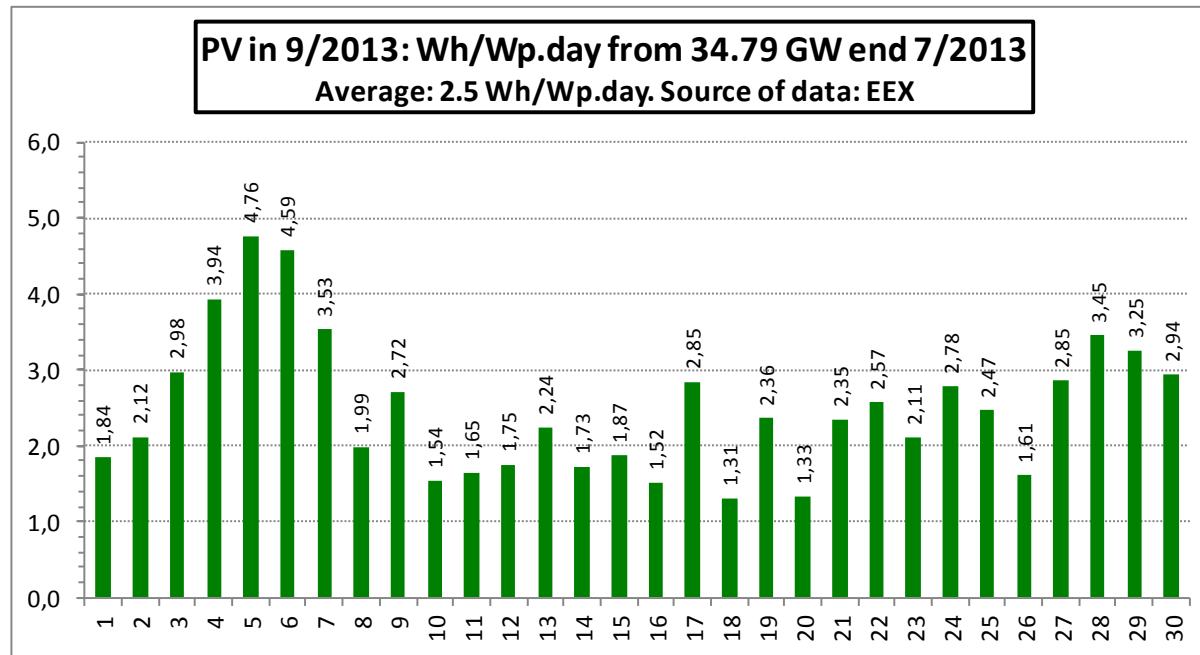
PV in 9/2013: MWh/day (from 34.79 GW end 8/2013)
 Total: 2608 GWh (87 GWh/day). Source of data: EEX



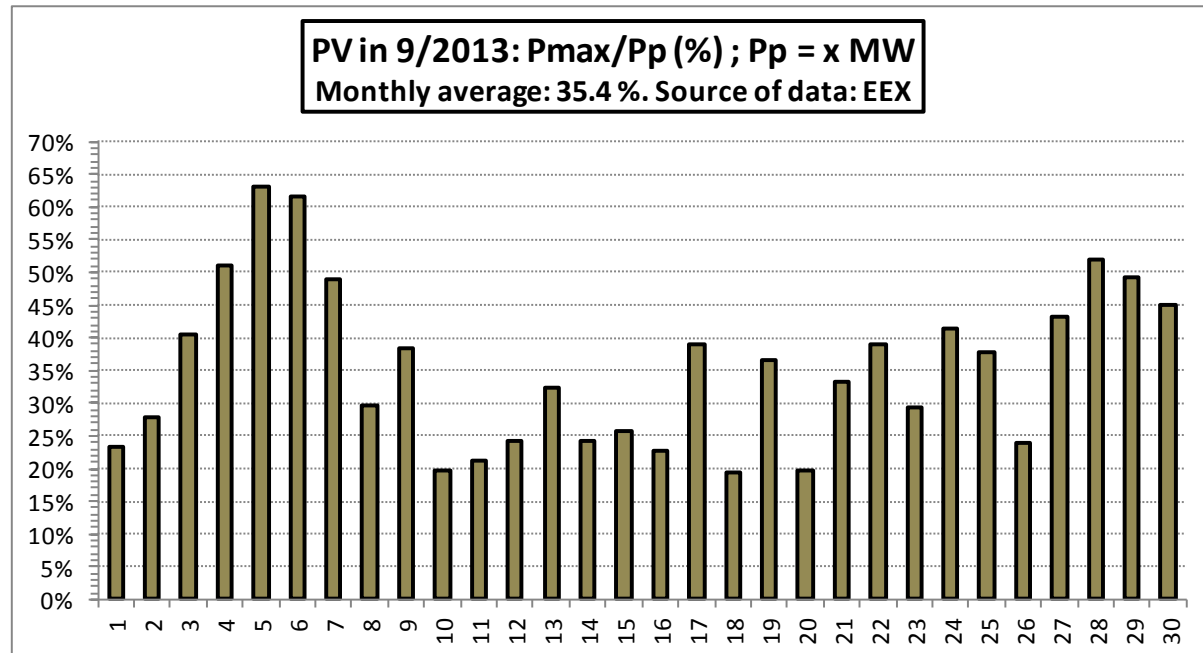
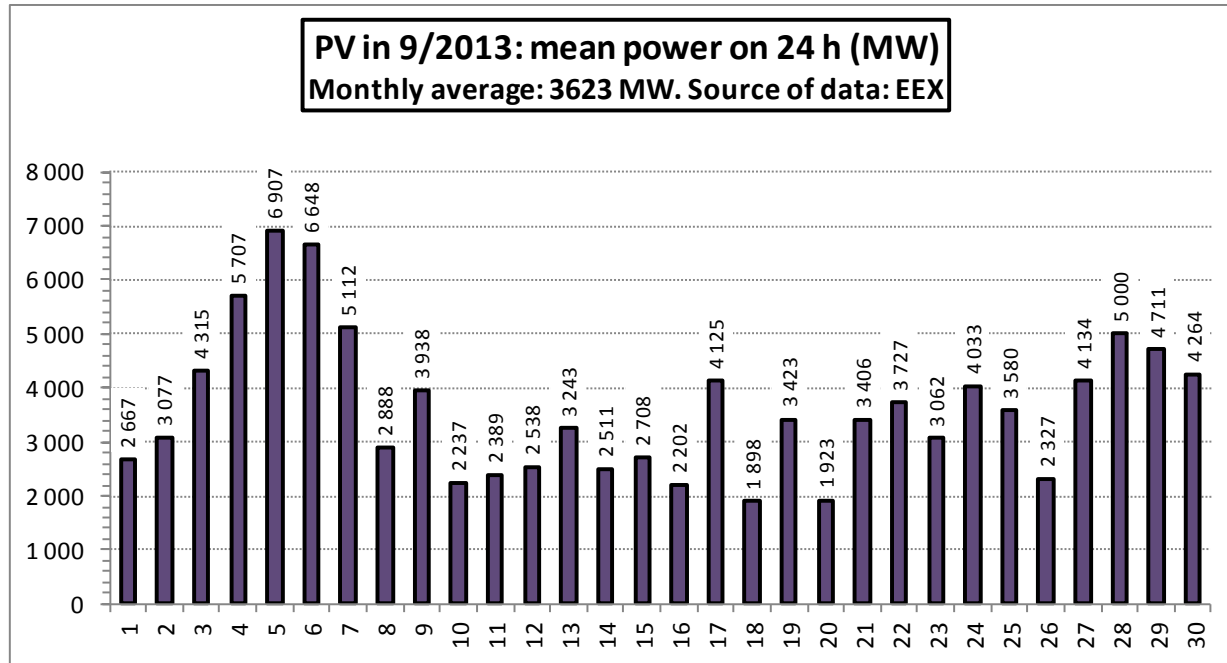
PV in 9/2013: maxi MW (from 34.79 GW end 7/2013)
 Source of data: EEX



PV in 9/2013: daily productivity (Wh/W.day, Capacity Factor in %)

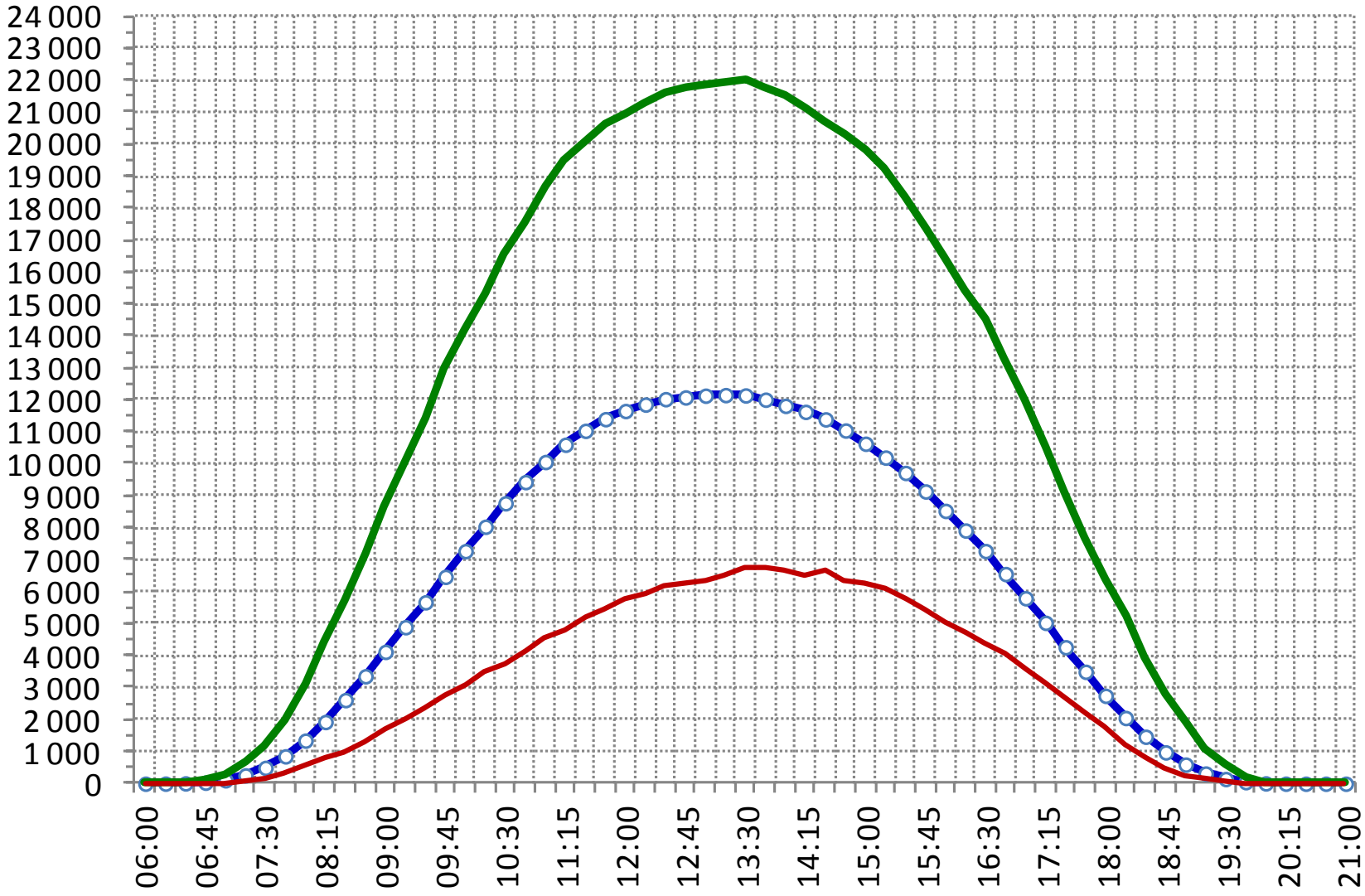


PV in 9/2013: mean daily power (MW) and ratio Pmax/P



PV in 9/2013: averaged, maximum and minimum production days

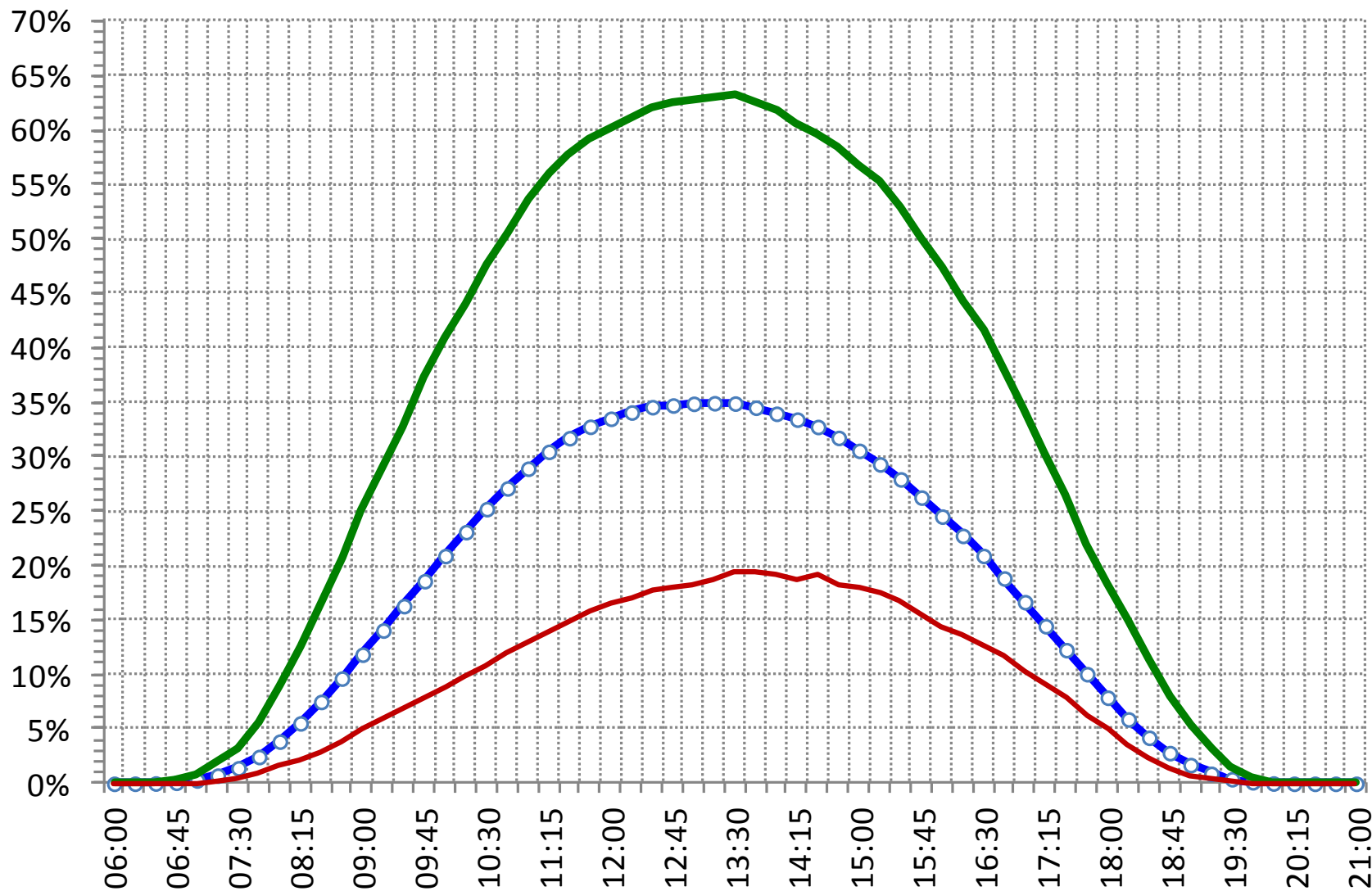
MW PV in September 2013: mean, maxi, mini days
Mini: 18/9/13; Maxi: 5/9/13. Average: 3623 MW, 87 GWh/day



PV in 9/2013: averaged, maximum and minimum P/Pp ratios

Pp = installed peak power = 34791 MW end of August 2013

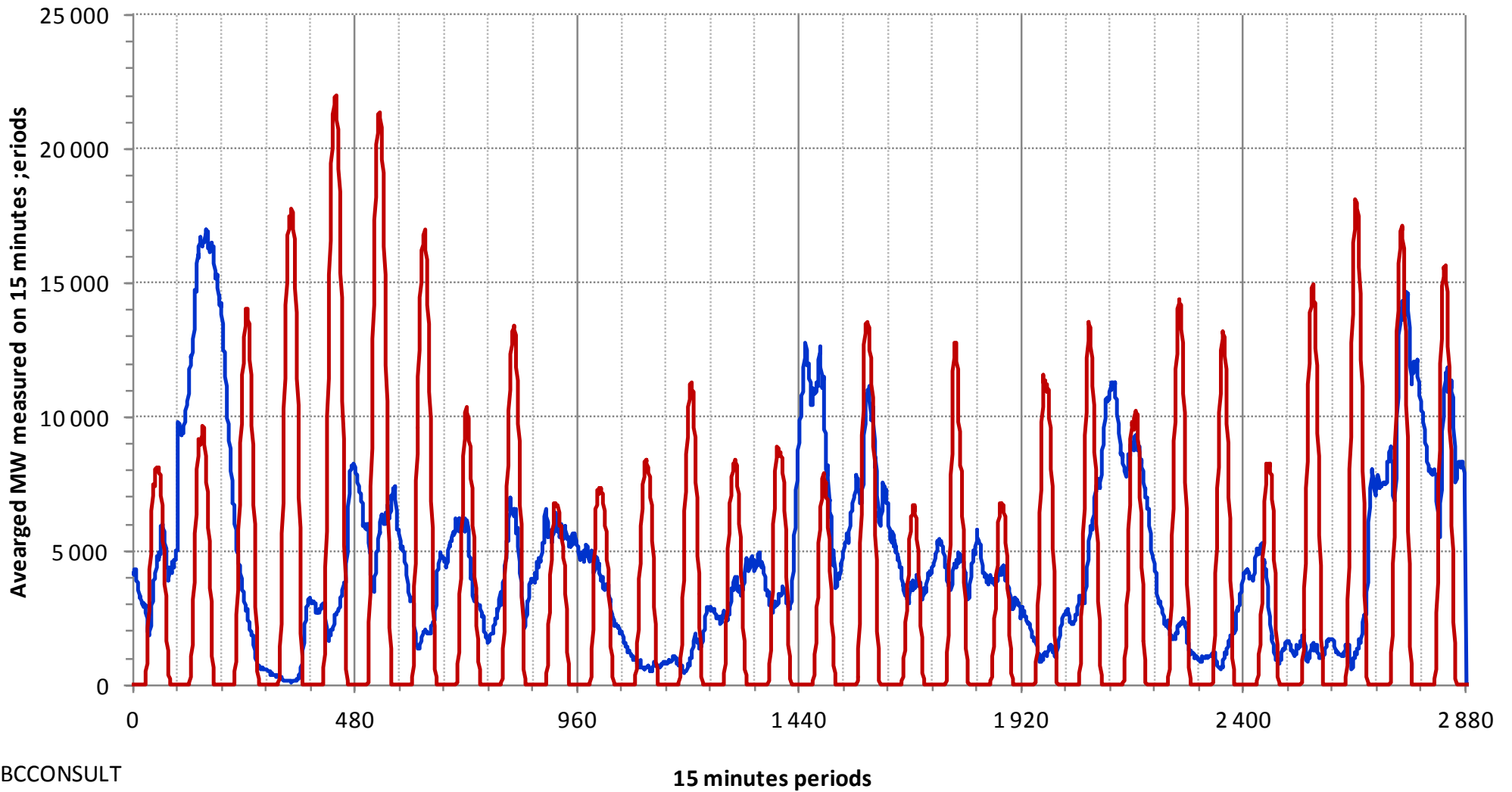
% P/Pp PV on mean, maxi, mini days in 9/2013
Mini: 18/9/13; Maxi: 5/9/13. Average 35 % Source of data: EEX



Wind and PV production in Germany in 9/2013

P (MW) Wind and PV in September 2013
Average: wind: 4443 MW. PV: 3623 MW. Sources of data: EEX

MW Wind Germany Ppv G

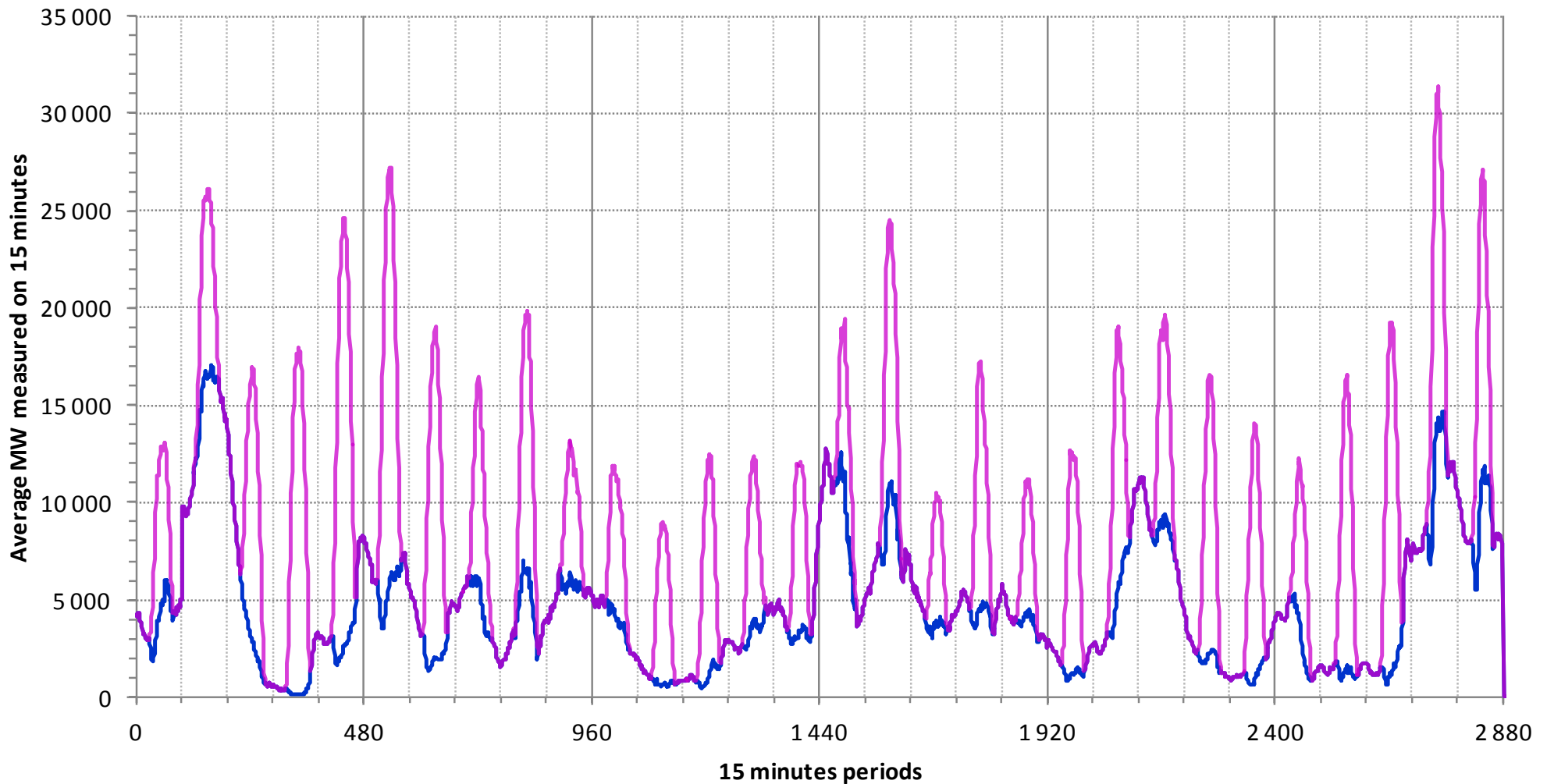


[Wind + PV] production in Germany in 9/2013

P (MW) [Wind + PV] in September 2013

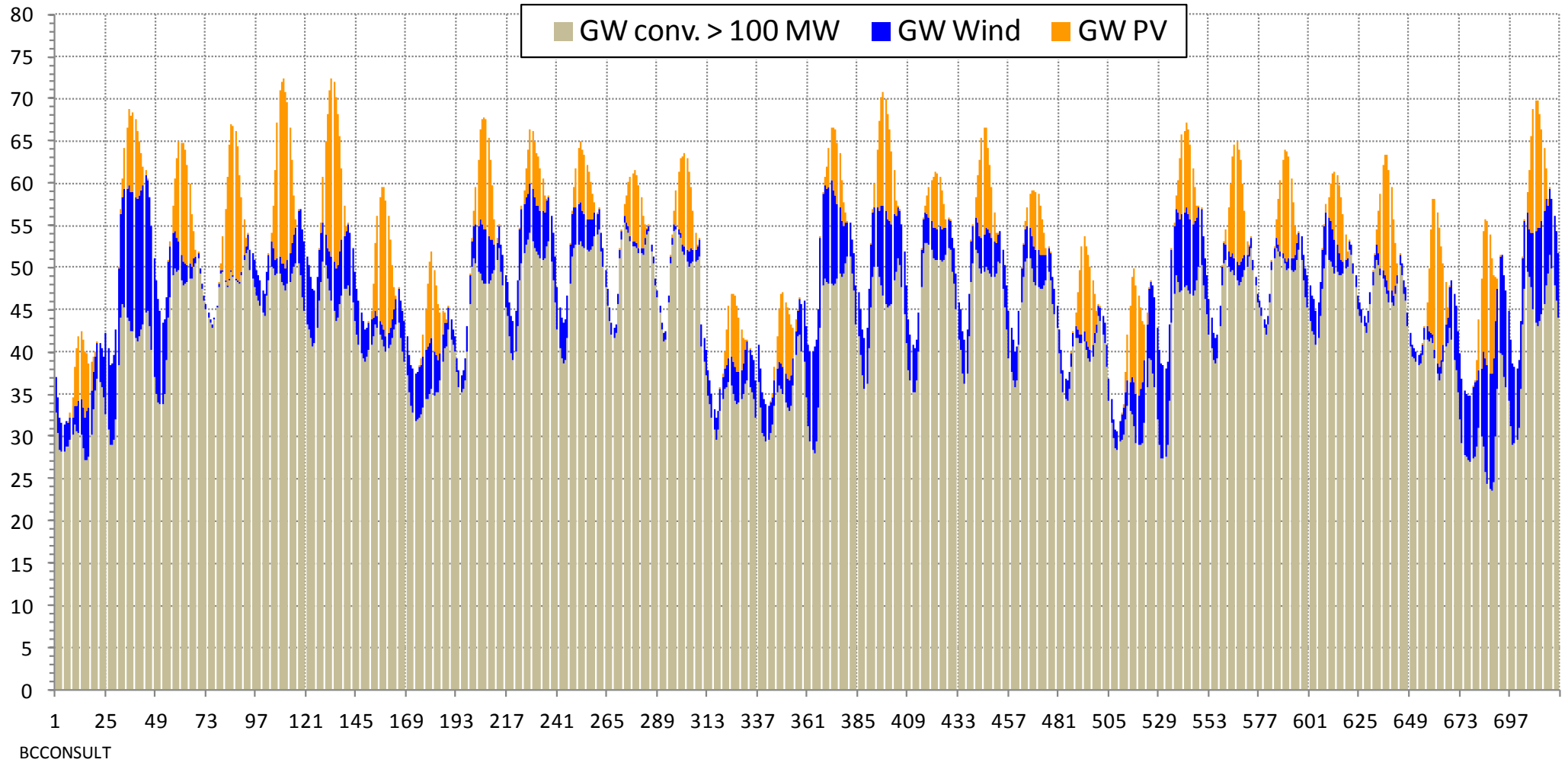
Sources of data: EEX

— MW Wind Germany — PwindI+PV Germany



[Wind + PV + Conv. > 100 MW] production in Germany in 9/2013

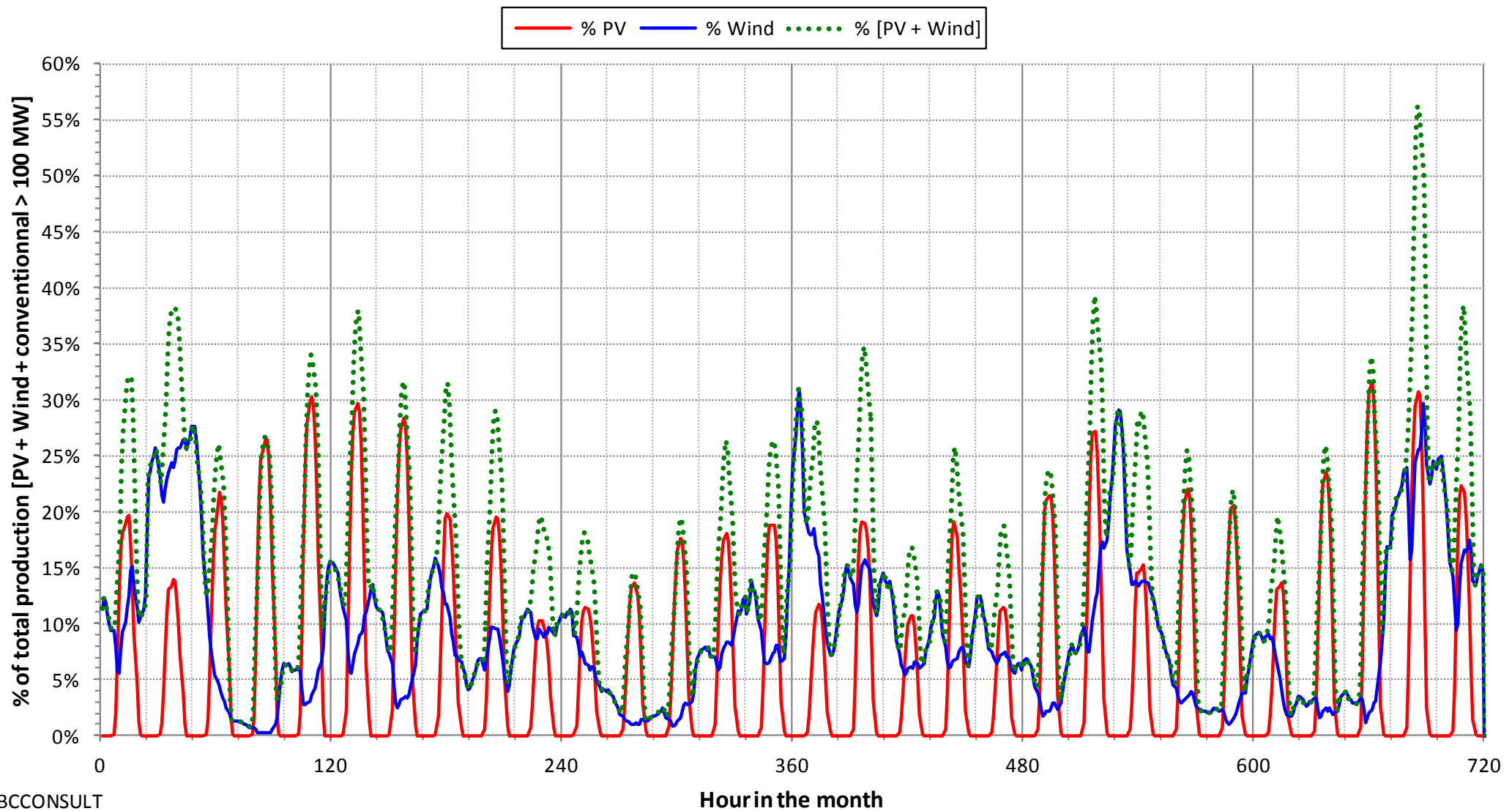
Hourly Production in 9/2013 (Average GW on 1 hour)
Source of data: EEX



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% of wind, PV, [Wind + PV] in 9/2013

September 2013: % production PV, Wind, [PV + Wind]. Source of data: EEX



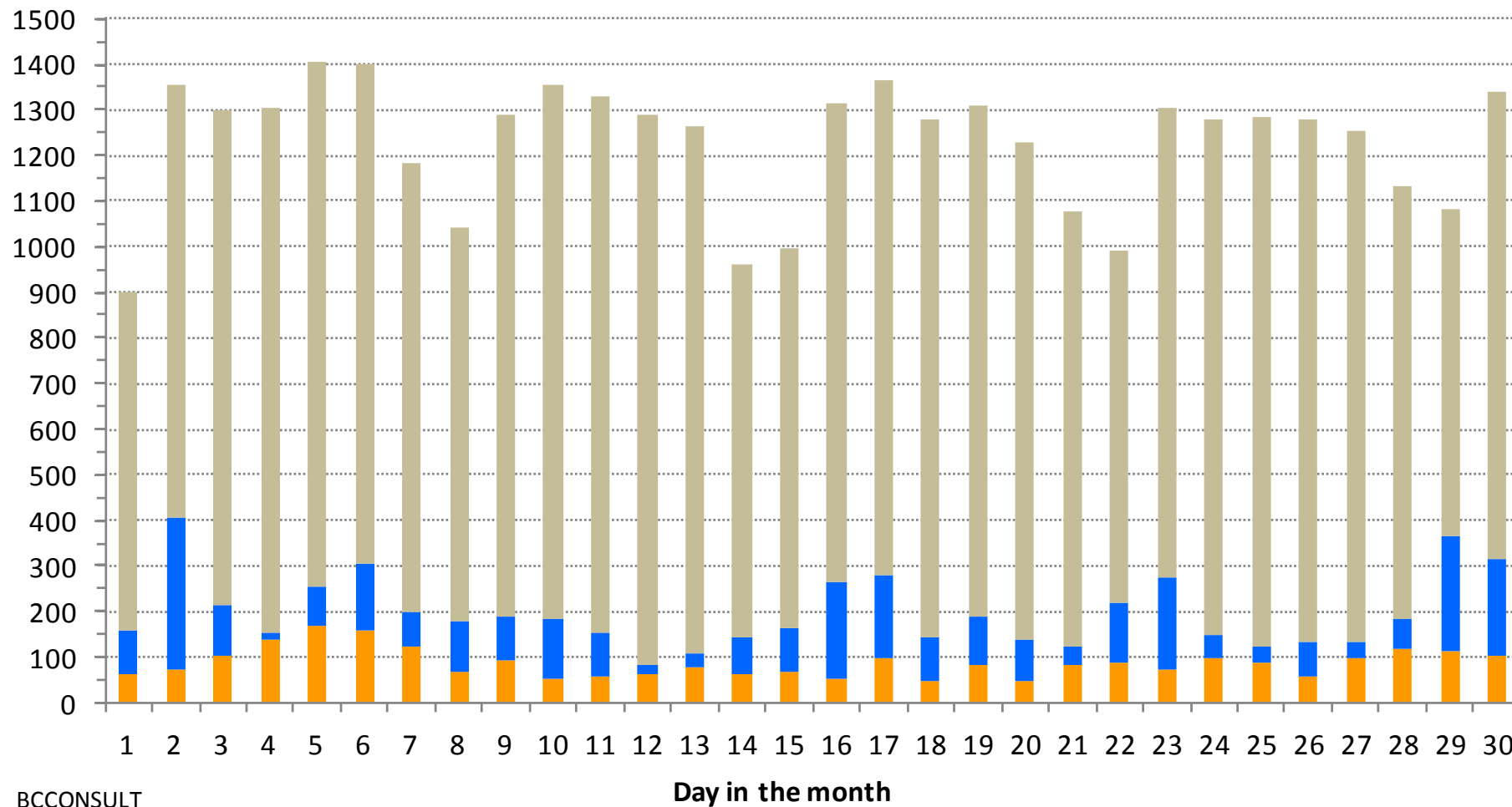
Wind, PV and conv. > 100 MW daily production in 9/2013

Electricity Production in September 2013

(GWh/day, source of data: EEX)

Total PV: 2.61 TWh; Wind: 3.3; Conv. > 100 MW: 31. Total: 36.91 TWh

■ GWh PV ■ GWh Wind ■ GWh Conv. > 100 MW



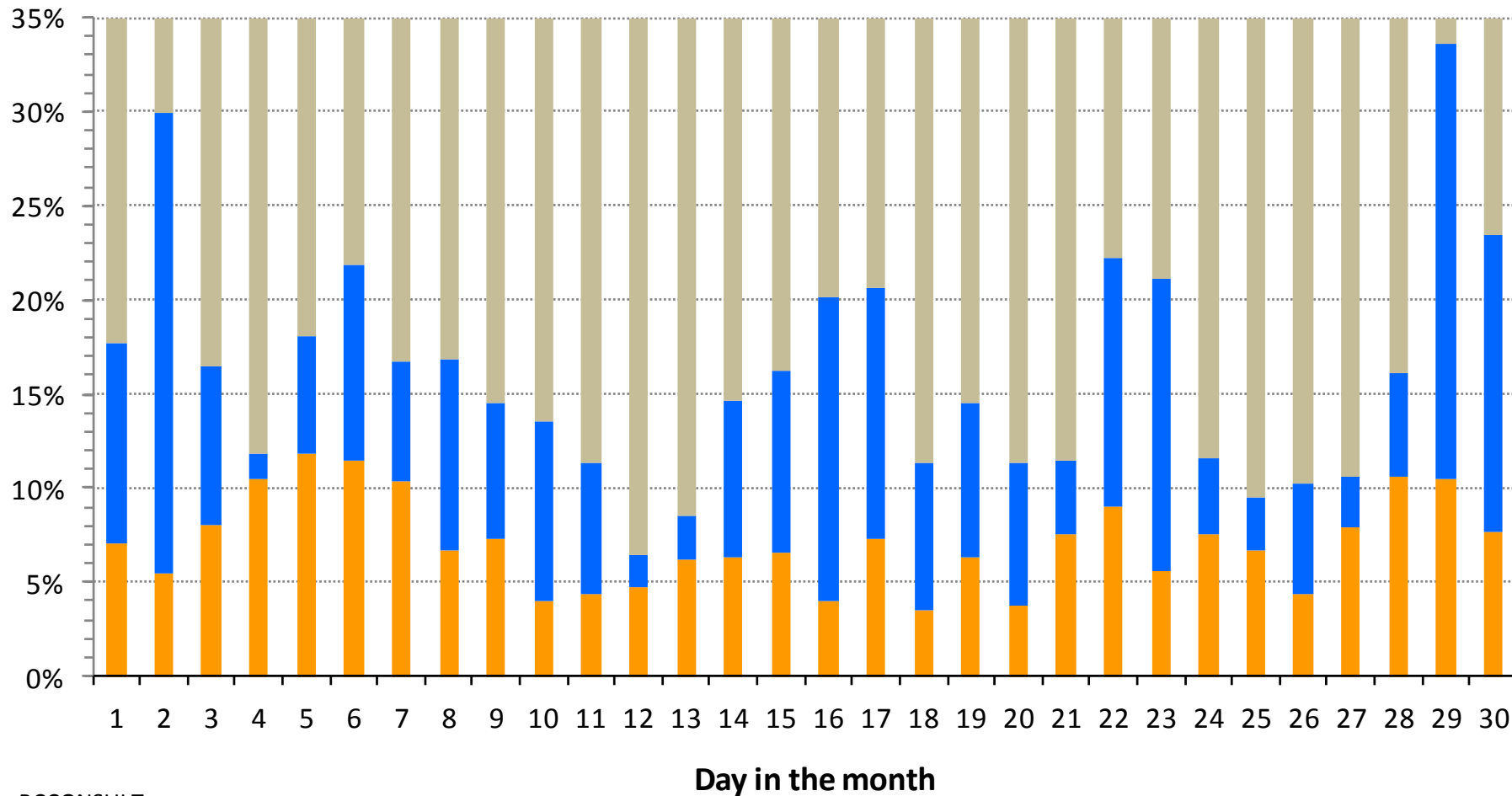
% of wind and PV in daily [Wind+PV+Convent.] production in 9/2013

% of electricity Production in September 2013

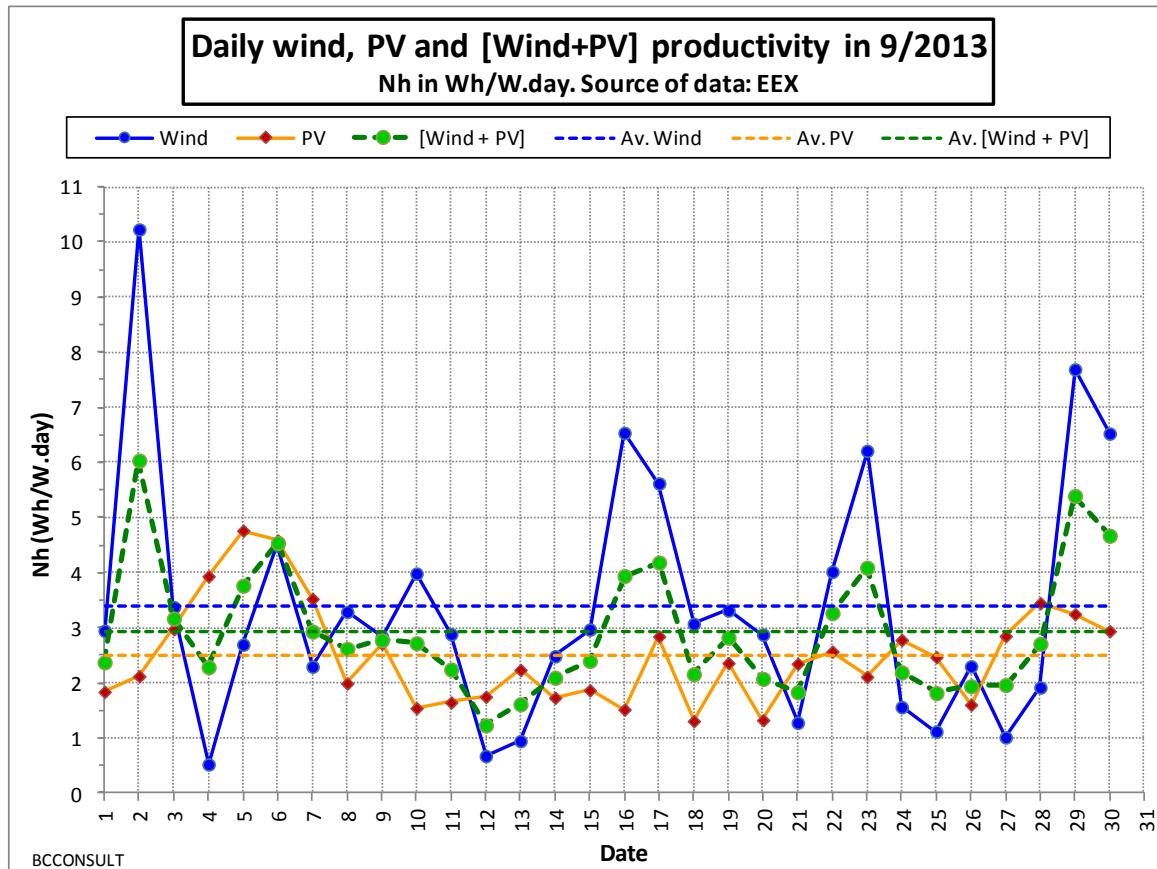
Source of data: EEX

Monthly average: PV: 7.1 %; Wind: 9 %; Conv. > 100 MW: 84 %

■ GWh PV ■ GWh Wind ■ GWh Conv. > 100 MW



Wind, PV and [Wind + PV] Productivity in 9/2013

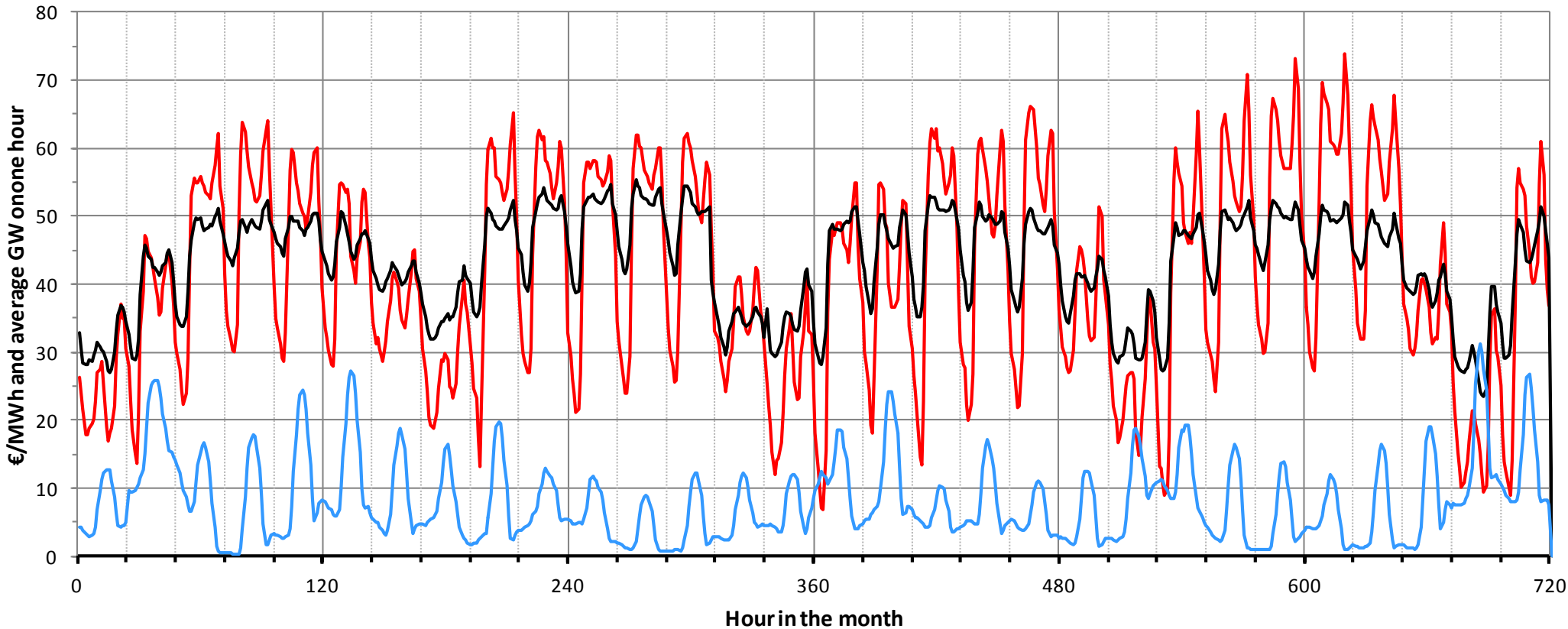


September 2013	Daily Productivity (Wh/W.day)		
Germany	Wind	PV	[Wind + PV]
Maximum	10,23	4,76	6,04
Average	3,391	2,500	2,930
Minimum	0,52	1,31	1,23
Median	2,92	2,36	2,66
Stand. Dev.	2,22	0,98	1,15
Rel. Stand. Dev.	65%	39%	39%

Impact on the market electricity price index ELIX in 9/2013

Index ELIX and GW conv. plants > 100 MW in September 2013 (€/MWh, GW, source EPEXSPOT)

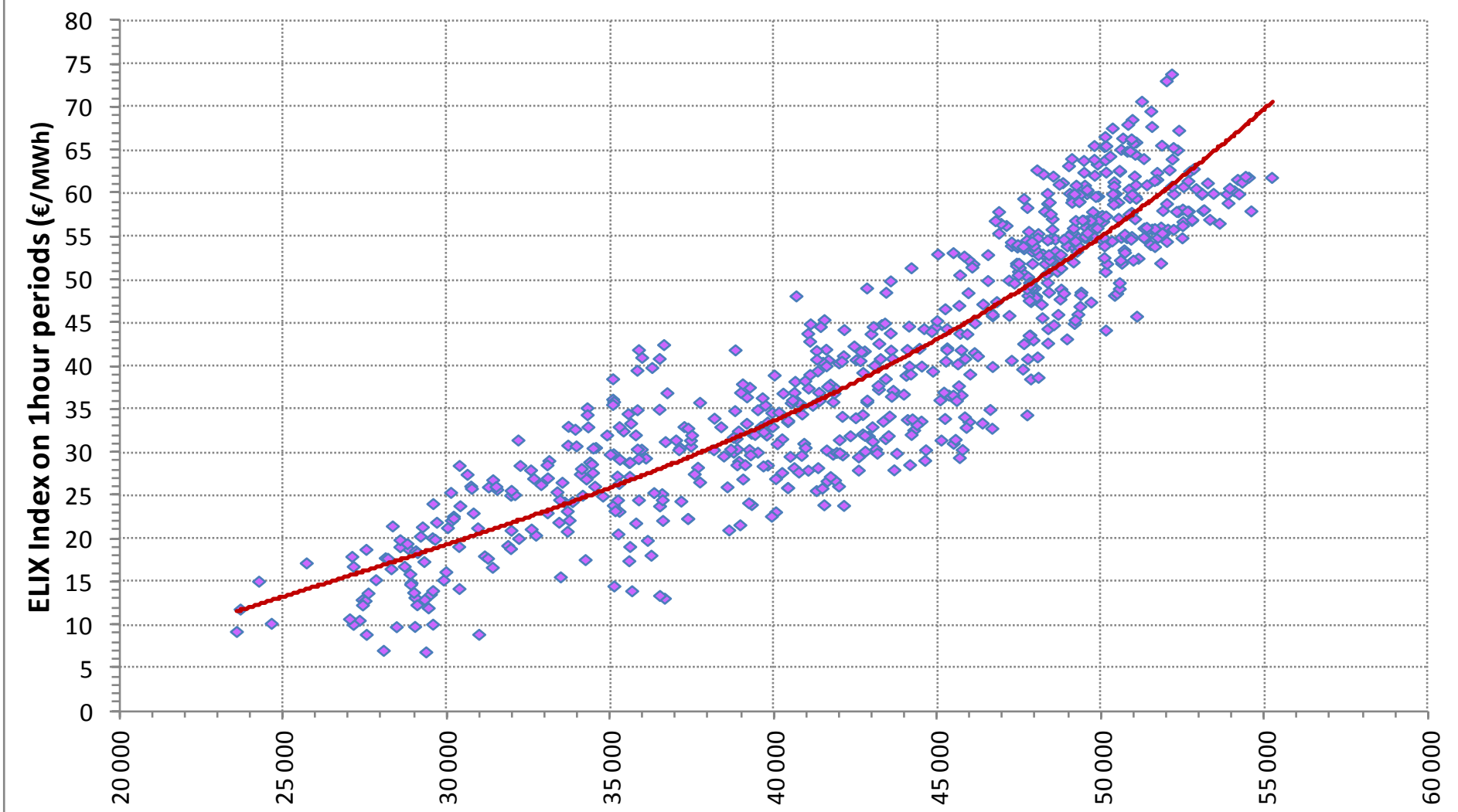
— €/MWh — GW conv. > 100 MW — GW Eol+PV



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Impact on the market electricity price index ELIX in 9/2013

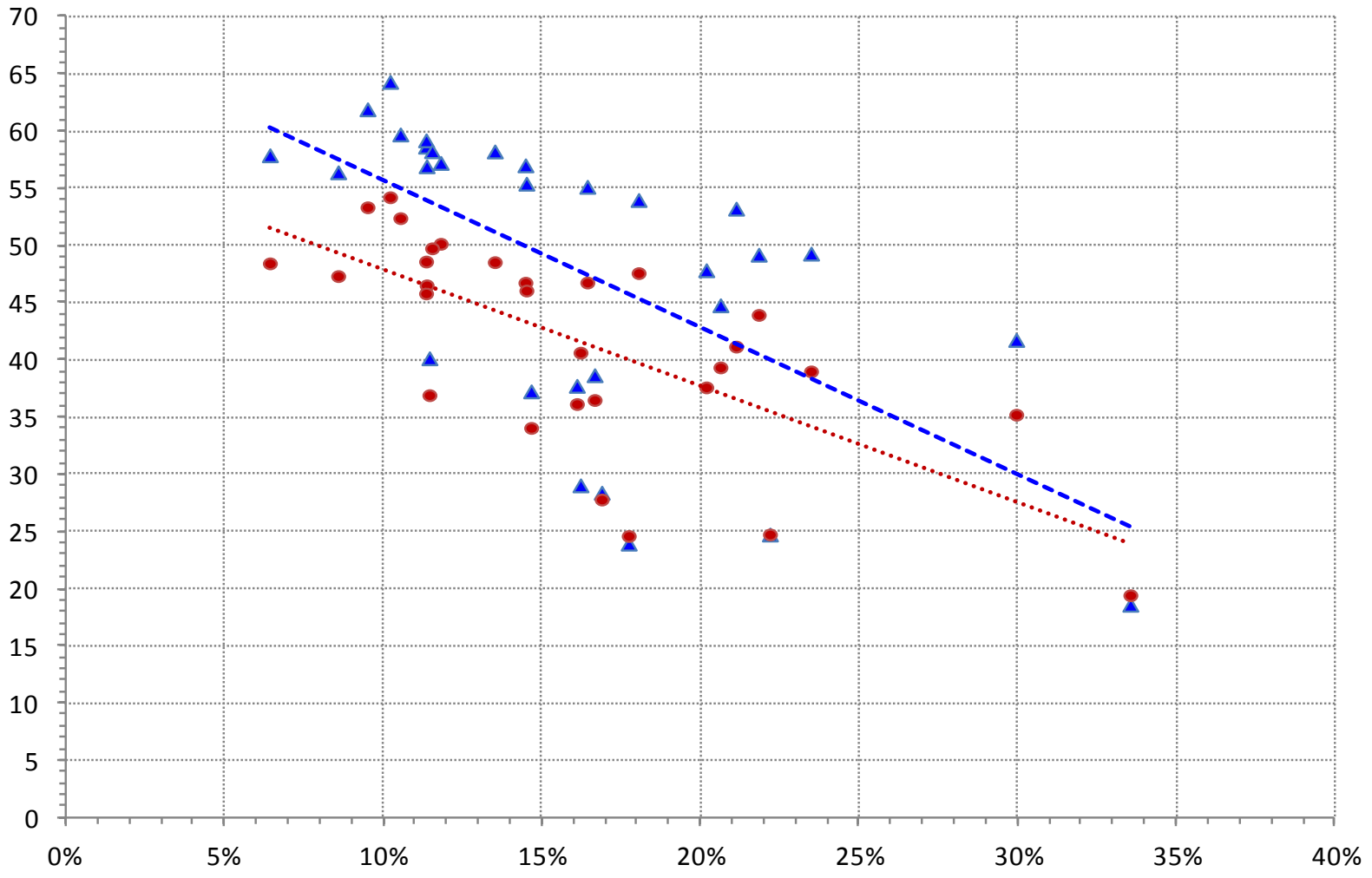
€/MWh ELIX versus MW of conv. > 100 MW Power Plants in 9/2013
Source of data: EEX, EPEXSPOT SE



Impact on the market electricity price index ELIX in 9/2013

€/MWh ELIX Peak Price and Base Price = f(%d [PV+Wind]) in 9/13
Peak ELIX: 8 h to 20 h. Source of data: EEX and EPEXSPOT SE

▲ Peak Price ● Base Price - - - Linéaire (Peak Price) Linéaire (Base Price)



Impact on the market electricity price index ELIX in 9/2013

Ratio (Peak Price/Base Price)ELIX = f(%d [PV+Wind]) in 9/13
Peak ELIX: 8 h to 20 h. Sources of data: EEX and EPEXSPOT SE

