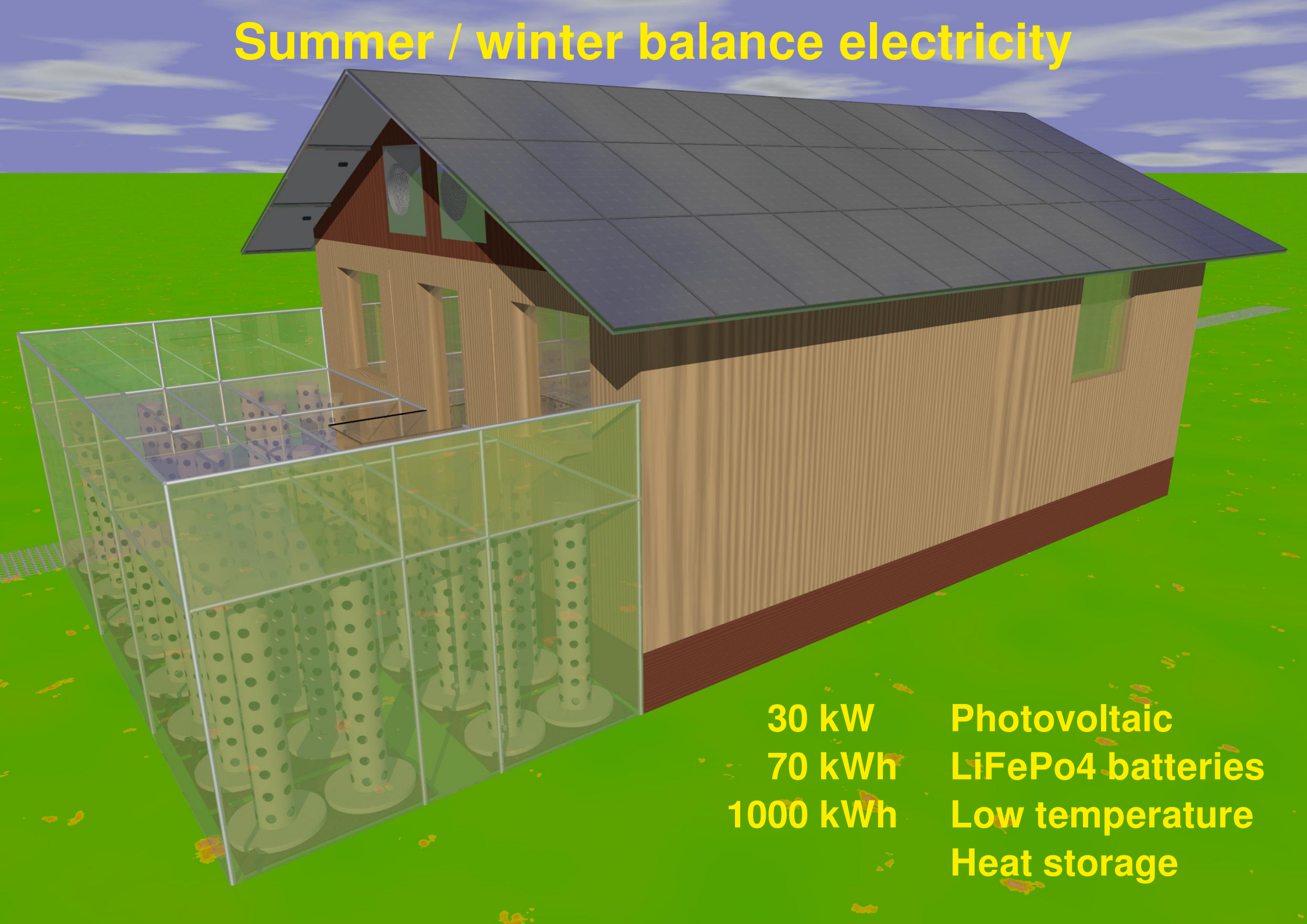
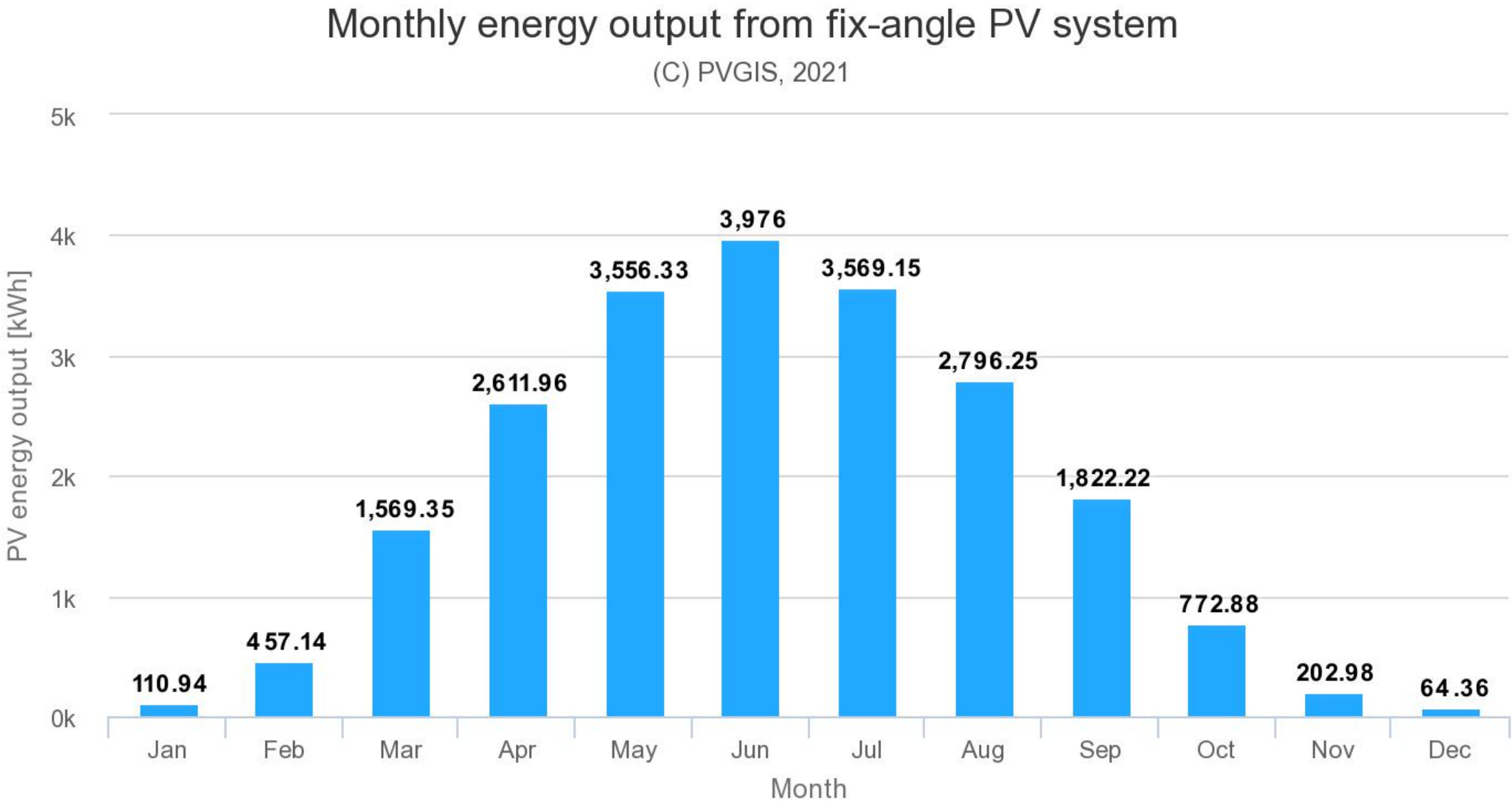
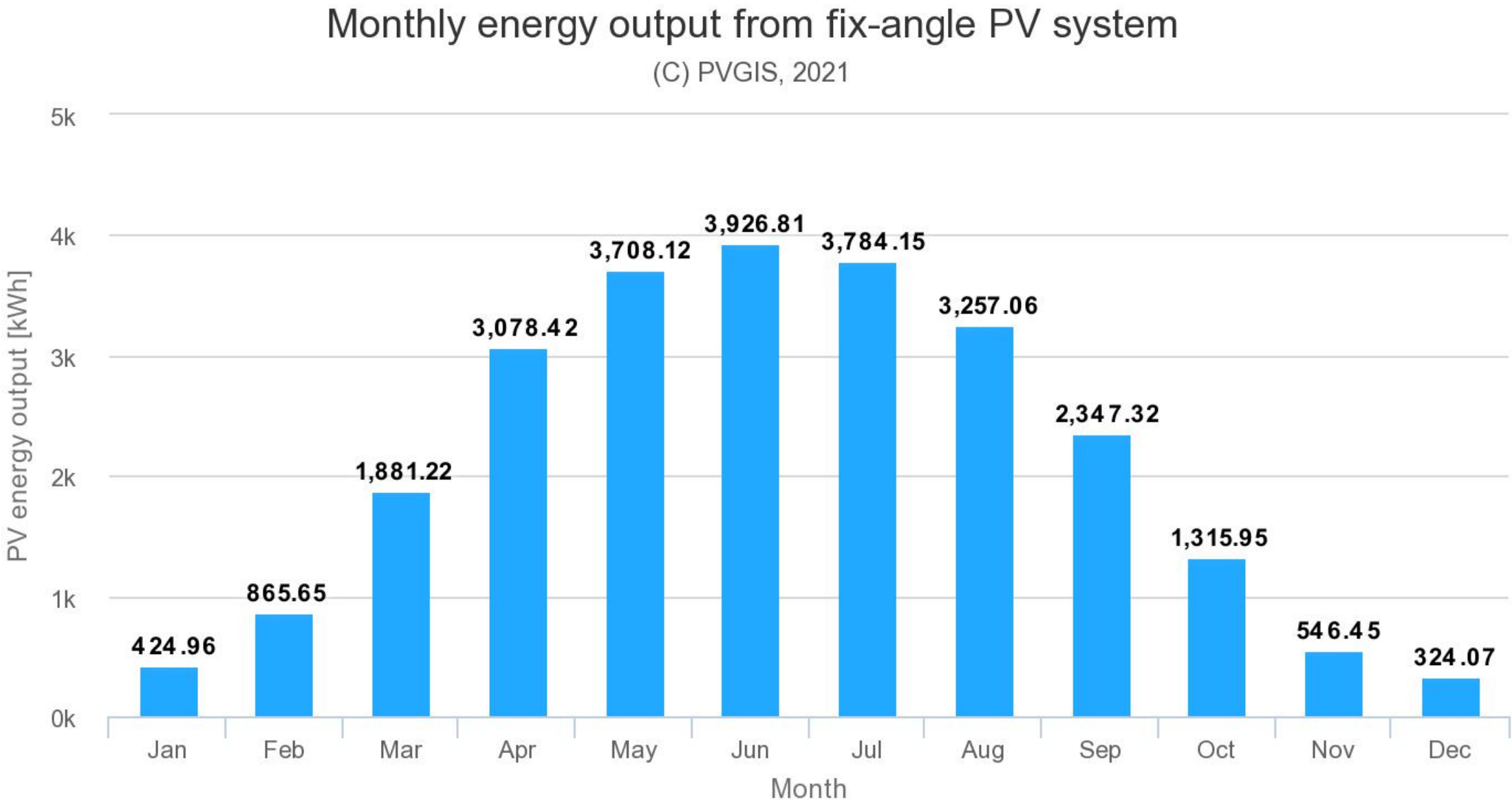
Summer / winter balance electricity



30 kW	Photovoltaic
70 kWh	LiFePo4 batteries
1000 kWh	Low temperature
	Heat storage


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
5k
4k
3k
2k
1k
0k
110.94
457.14
1,569.35
2,611.96
3,556.33
3,976
3,569.15
2,796.25
1,822.22
772.88
202.98
64.36
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Oslo


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
5k
4k
3k
2k
1k
0k
424.96
865.65
1,881.22
3,078.42
3,708.12
3,926.81
3,784.15
3,257.06
2,347.32
1,315.95
546.45
324.07
Jan
Feb
Mar
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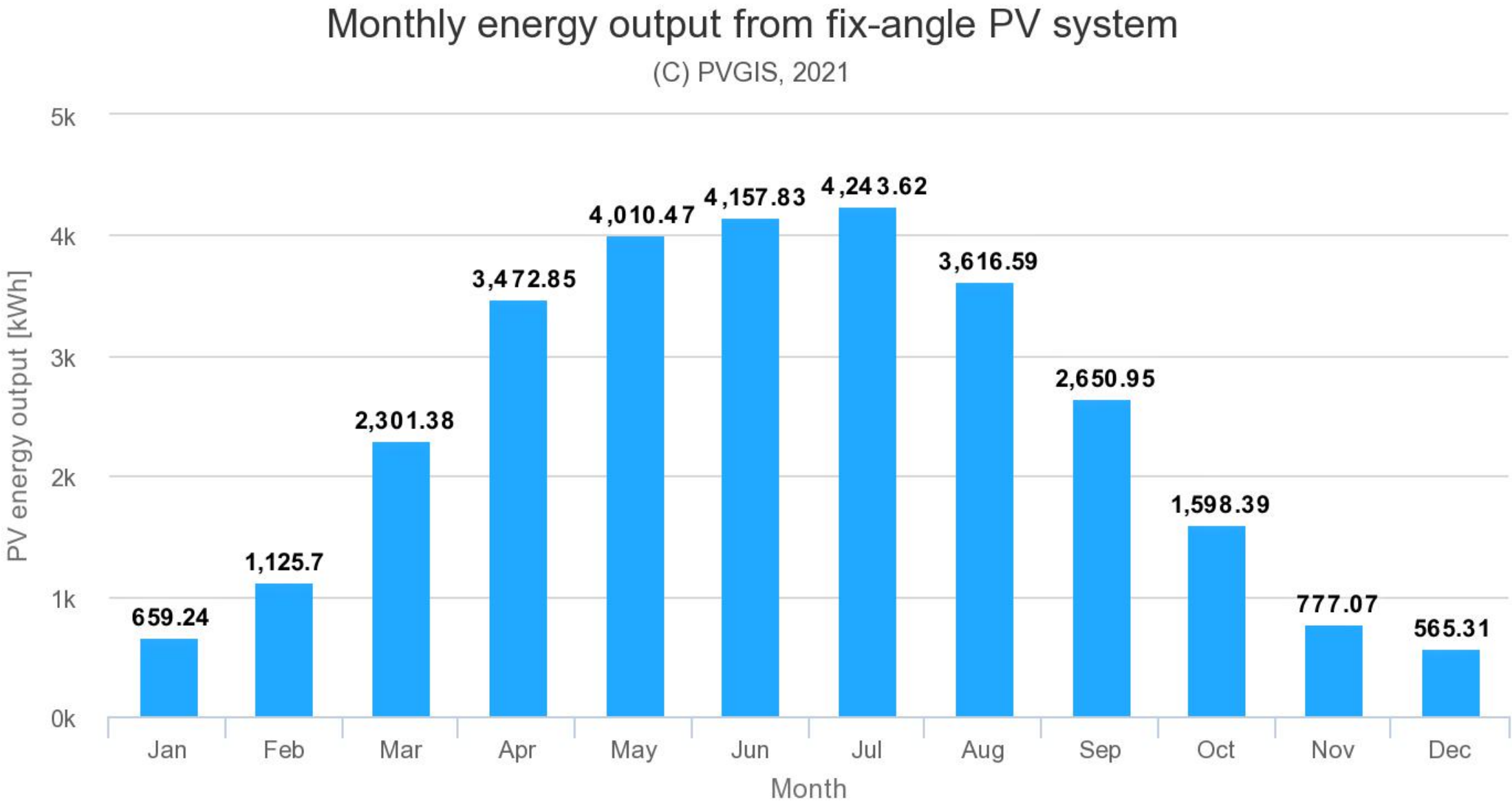
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Berlin


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
5k
4k
3k
2k
1k
0k
659.24
1,125.7
2,301.38
3,472.85
4,010.47
4,157.83
4,243.62
3,616.59
2,650.95
1,598.39
777.07
565.31
Jan
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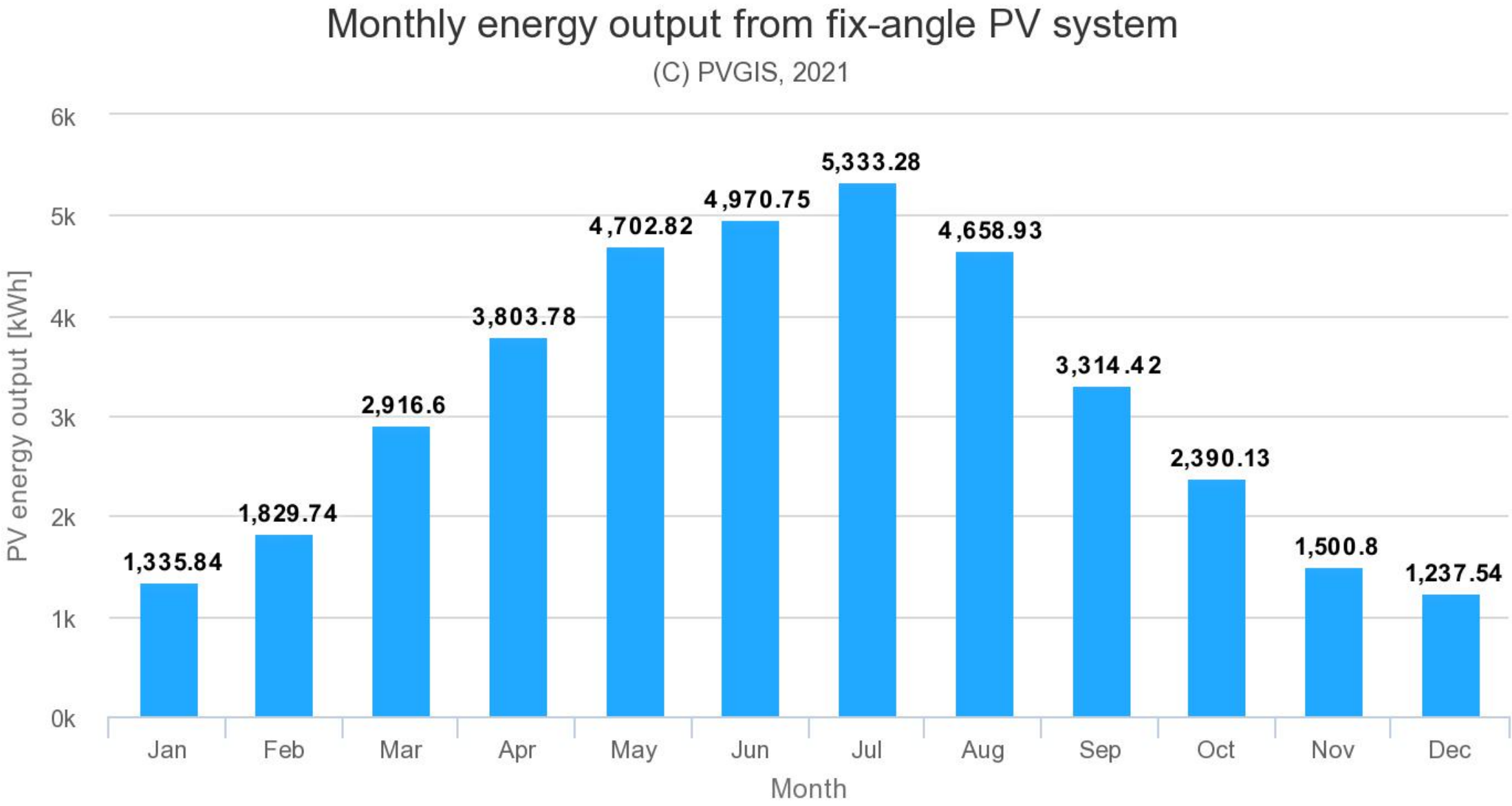
Nov
Dec
Month

Vienna


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
6k
5k
4k
3k
2k
1k
0k
1,335.84
1,829.74
2,916.6
3,803.78
4,702.82
4,970.75
5,333.28
4,658.93
3,314.42
2,390.13
1,500.8
1,237.54
Jan
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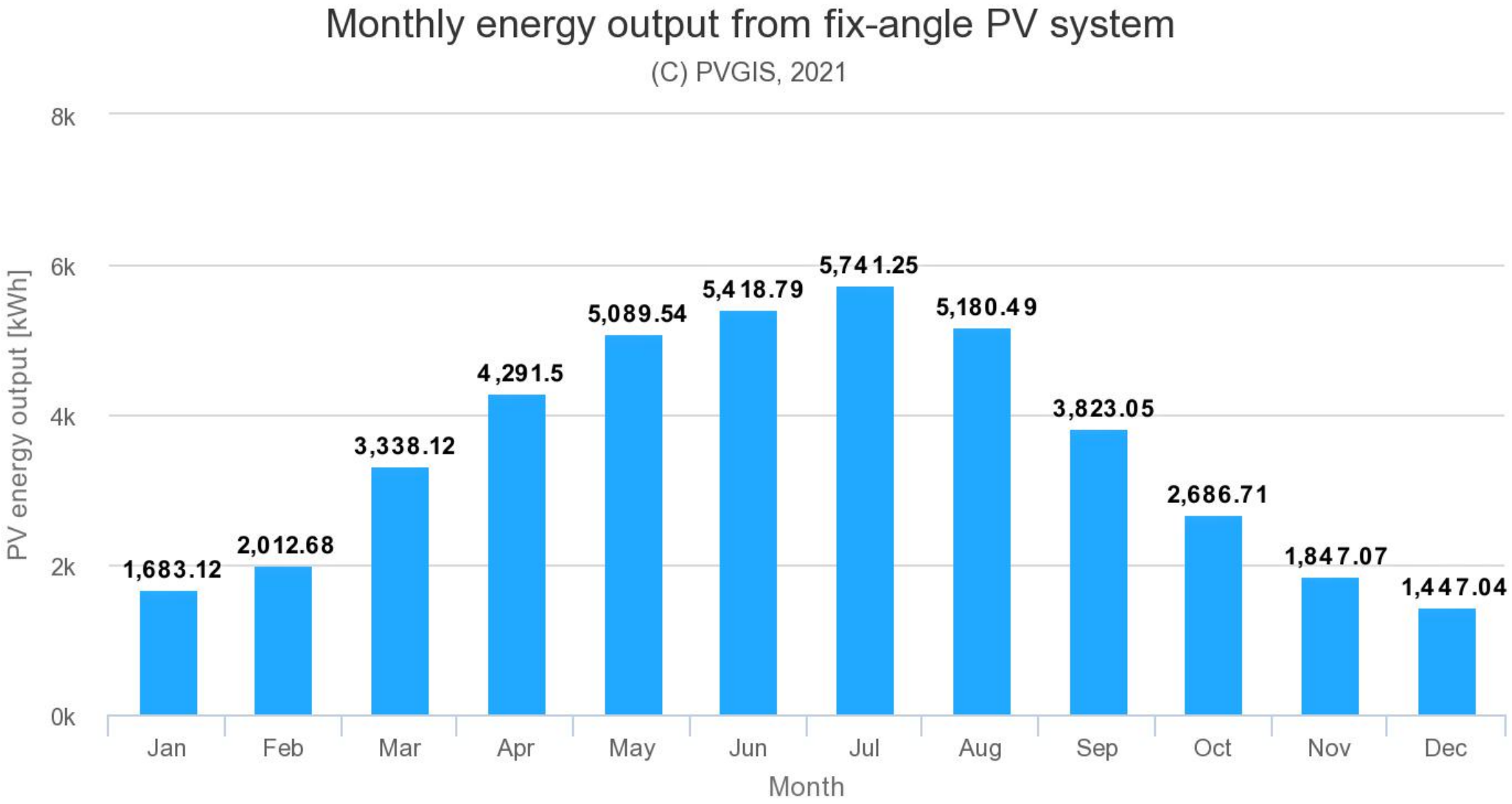
Nov
Dec
Month

Rome


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
8k
6k
4k
2k
0k
1,683.12
2,012.68
3,338.12
4,291.5
5,089.54
5,418.79
5,741.25
5,180.49
3,823.05
2,686.71
1,847.07
1,447.04
Jan
Feb
Mar
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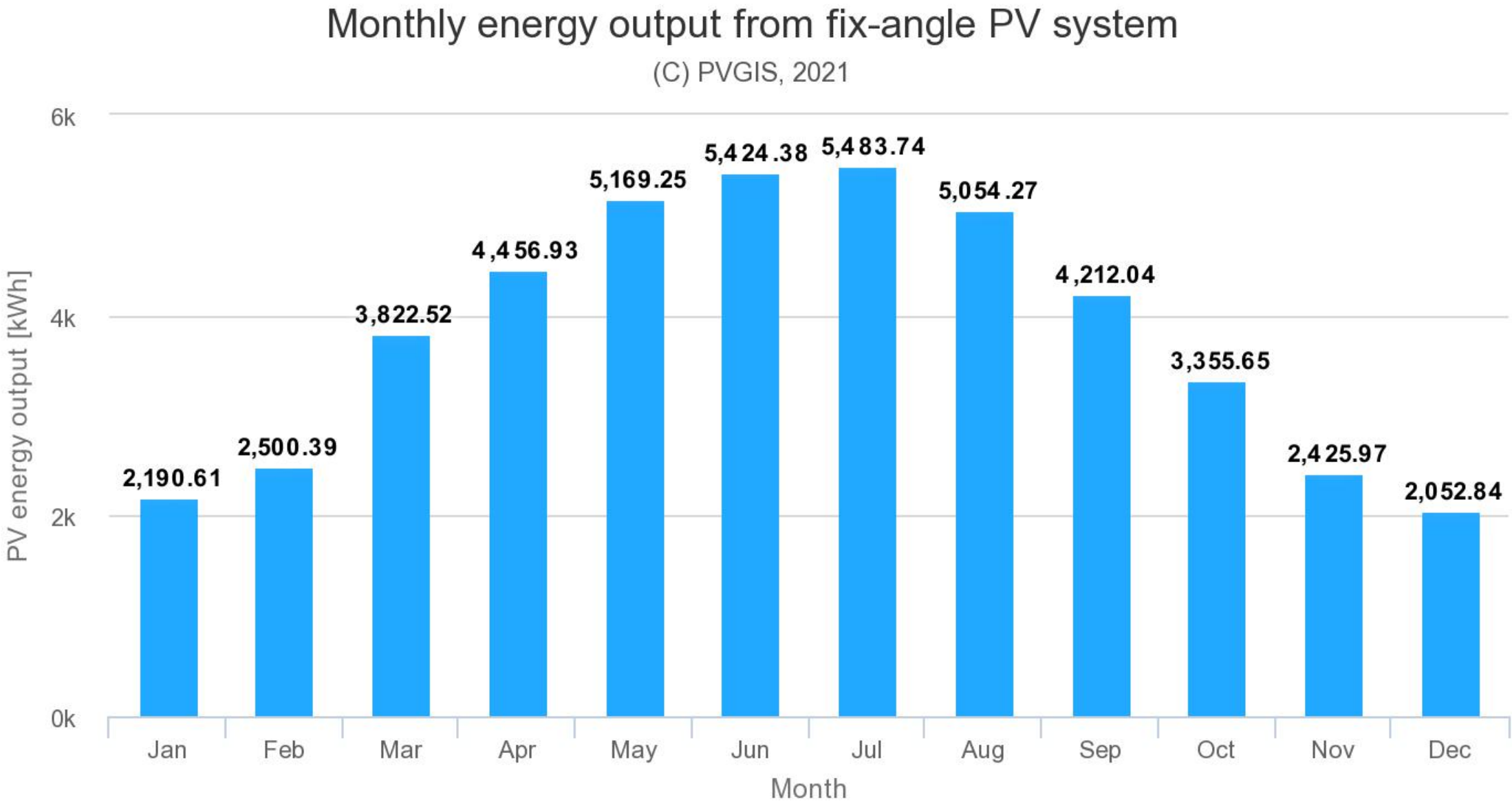
Nov
Dec
Month

Athens


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
6k
4k
2k
0k
2,190.61
2,500.39
3,822.52
4,456.93
5,169.25
5,424.38
5,483.74
5,054.27
4,212.04
3,355.65
2,425.97
2,052.84
Jan
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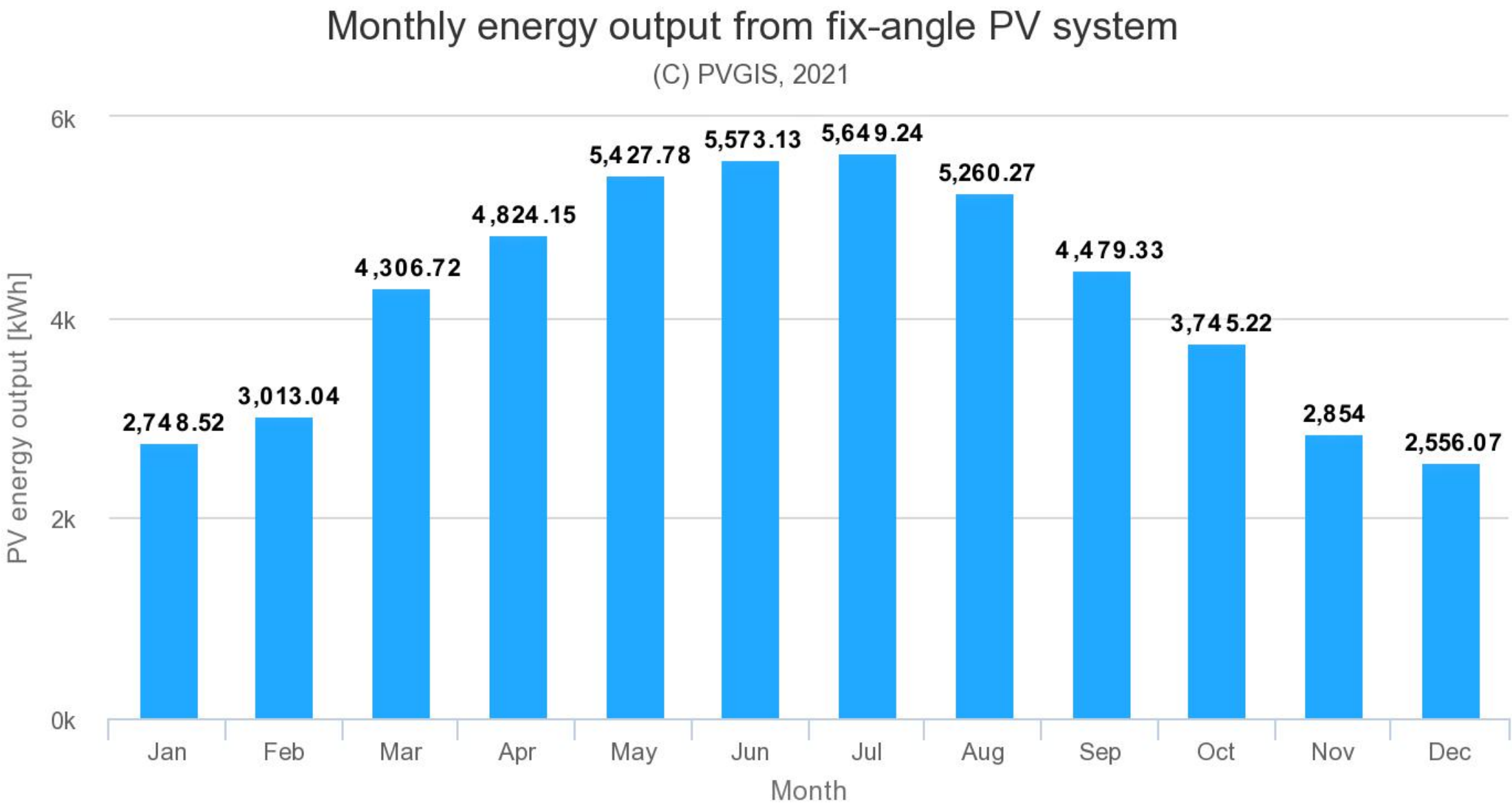
Nov
Dec
Month

Tel Aviv


Monthly energy output from fix-angle PV system
(C) PVGIS, 2021
PV energy output [kWh]
6k
4k
2k
0k
2,748.52
3,013.04
4,306.72
4,824.15
5,427.78
5,573.13
5,649.24
5,260.27
4,479.33
3,745.22
2,854
2,556.07
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Cairo

Solar yield for 30 kW peak	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	111	457	1,569	2,612	3,556	3,976	3,569	2,796	1,822	773	203	64	21,510
Berlin	425	866	1,881	3,078	3,708	3,927	3,784	3,257	2,347	1,316	546	324	25,460
Vienna	659	1,126	2,301	3,473	4,010	4,158	4,243	3,617	2,651	1,598	777	565	29,178
Rome	1,336	1,830	2,917	3,804	4,703	4,971	5,333	4,659	3,314	2,390	1,501	1,238	37,995
Athens	1,683	2,013	3,338	4,292	5,090	5,419	5,741	5,180	3,823	2,687	1,847	1,447	42,559
Tel Aviv	2,191	2,500	3,823	4,457	5,169	5,424	5,484	5,054	4,212	3,356	2,426	2,053	46,149
Cairo	2,749	3,013	4,307	4,824	5,428	5,573	5,649	5,260	4,479	3,745	2,854	2,556	50,437

Solar yield for 30 kW peak	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	111	457	1,569	2,612	3,556	3,976	3,569	2,796	1,822	773	203	64	21,510
Berlin	425	866	1,881	3,078	3,708	3,927	3,784	3,257	2,347	1,316	546	324	25,460
Vienna	659	1,126	2,301	3,473	4,010	4,158	4,243	3,617	2,651	1,598	777	565	29,178
Rome	1,336	1,830	2,917	3,804	4,703	4,971	5,333	4,659	3,314	2,390	1,501	1,238	37,995
Athens	1,683	2,013	3,338	4,292	5,090	5,419	5,741	5,180	3,823	2,687	1,847	1,447	42,559
Tel Aviv	2,191	2,500	3,823	4,457	5,169	5,424	5,484	5,054	4,212	3,356	2,426	2,053	46,149
Cairo	2,749	3,013	4,307	4,824	5,428	5,573	5,649	5,260	4,479	3,745	2,854	2,556	50,437

1 : 1.4

Oslo : Cairo

in June

Solar yield for 30 kW peak	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	111	457	1,569	2,612	3,556	3,976	3,569	2,796	1,822	773	203	64	21,510
Berlin	425	866	1,881	3,078	3,708	3,927	3,784	3,257	2,347	1,316	546	324	25,460
Vienna	659	1,126	2,301	3,473	4,010	4,158	4,243	3,617	2,651	1,598	777	565	29,178
Rome	1,336	1,830	2,917	3,804	4,703	4,971	5,333	4,659	3,314	2,390	1,501	1,238	37,995
Athens	1,683	2,013	3,338	4,292	5,090	5,419	5,741	5,180	3,823	2,687	1,847	1,447	42,559
Tel Aviv	2,191	2,500	3,823	4,457	5,169	5,424	5,484	5,054	4,212	3,356	2,426	2,053	46,149
Cairo	2,749	3,013	4,307	4,824	5,428	5,573	5,649	5,260	4,479	3,745	2,854	2,556	50,437

1 : 40
Oslo : Cairo
in December

62 : 1
June : December
in Oslo

Solar yield for 30 kW peak	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	111	457	1,569	2,612	3,556	3,976	3,569	2,796	1,822	773	203	64	21,510
Berlin	425	866	1,881	3,078	3,708	3,927	3,784	3,257	2,347	1,316	546	324	25,460
Vienna	659	1,126	2,301	3,473	4,010	4,158	4,243	3,617	2,651	1,598	777	565	29,178
Rome	1,336	1,830	2,917	3,804	4,703	4,971	5,333	4,659	3,314	2,390	1,501	1,238	37,995
Athens	1,683	2,013	3,338	4,292	5,090	5,419	5,741	5,180	3,823	2,687	1,847	1,447	42,559
Tel Aviv	2,191	2,500	3,823	4,457	5,169	5,424	5,484	5,054	4,212	3,356	2,426	2,053	46,149
Cairo	2,749	3,013	4,307	4,824	5,428	5,573	5,649	5,260	4,479	3,745	2,854	2,556	50,437

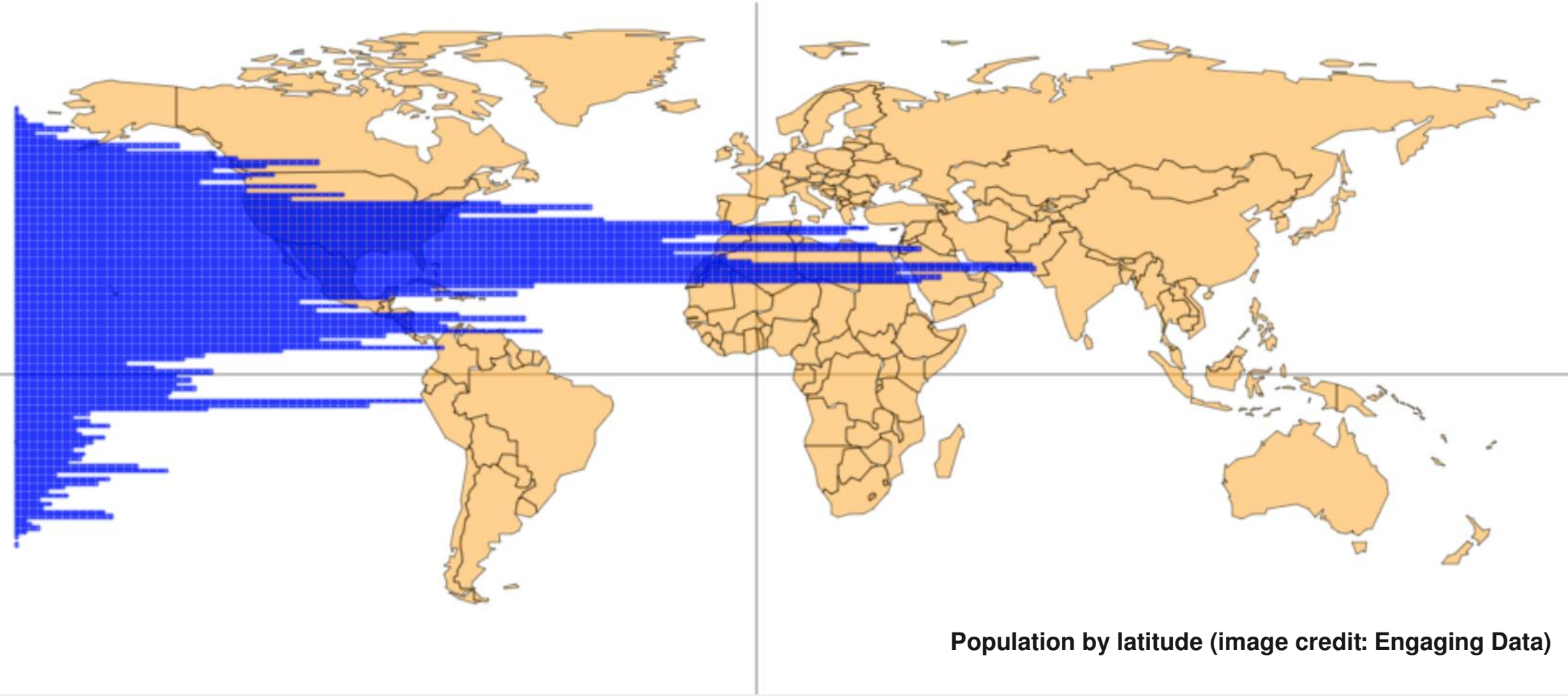
2,2 : 1
July : December
in Cairo

600 kWh per month for household, hot water and electric cars additional demand for space heating and cooling:

General monthly consumption kWh	600												
Extra usage for heating and cooling	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	500	300	100							100	300	500	1,800
Berlin	400	200									200	400	1,200
Vienna	400	200				50	50				200	400	1,300
Rome	150	100			100	200	200	100			100	150	1,100
Athens	150	100			100	200	200	100			100	150	1,100
Tel Aviv	100	100	150	200	200	200	200	200	200	150	100	100	1,900
Cairo	50	100	150	200	250	250	250	250	200	150	100	50	2,000
Electricity balance	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	-989	-443	869	2,012	2,956	3,376	2,969	2,196	1,222	73	-697	-1,036	12,510
Berlin	-575	66	1,281	2,478	3,108	3,327	3,184	2,657	1,747	716	-254	-676	17,060
Vienna	-341	326	1,701	2,873	3,410	3,508	3,593	3,017	2,051	998	-23	-435	20,678
Rome	586	1,130	2,317	3,204	4,003	4,171	4,533	3,959	2,714	1,790	801	488	29,695
Athens	933	1,313	2,738	3,692	4,390	4,619	4,941	4,480	3,223	2,087	1,147	697	34,259
Tel Aviv	1,491	1,800	3,073	3,657	4,369	4,624	4,684	4,254	3,412	2,606	1,726	1,353	37,049
Cairo	2,099	2,313	3,557	4,024	4,578	4,723	4,799	4,410	3,679	2,995	2,154	1,906	41,237

Summer / winter compensation only required from Vienna to Oslo

Fortunately, most people live at latitudes where the difference between summer and winter is small:



Population by latitude (image credit: Engaging Data)

Proposal 1: twice as much photovoltaics:

Electricity balance with twice the PV	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
Oslo	-878	14	2,439	4,624	6,513	7,352	6,538	4,993	3,044	846	-494	-971	34,019
Berlin	-150	931	3,162	5,557	6,816	7,254	6,968	5,914	4,095	2,032	293	-352	42,520
Vienna	318	1,451	4,003	6,346	7,421	7,666	7,835	6,633	4,702	2,597	754	131	49,857
Rome	1,922	2,959	5,233	7,008	8,706	9,142	9,867	8,618	6,029	4,180	2,302	1,725	67,689
Athens	2,616	3,325	6,076	7,983	9,479	10,038	10,683	9,661	7,046	4,773	2,994	2,144	76,819
Tel Aviv	3,681	4,301	6,895	8,114	9,539	10,049	10,167	9,309	7,624	5,961	4,152	3,406	83,197
Cairo	4,847	5,326	7,863	8,848	10,006	10,296	10,448	9,671	8,159	6,740	5,008	4,462	91,675

Works for Vienna,

but where to put so much photovoltaics?

For Oslo, on the other hand:

Twice almost nothing is still almost nothing.

Proposal 2: much more batteries:

		Battery price € per kWh											
Additional kWh batteries	kWh bat.	40	50	60	70	80	100	120	140	160	180	200	250
Oslo	3,956	158,229	197,786	237,344	276,901	316,458	395,573	474,687	553,802	632,916	712,031	791,145	988,931
Berlin	1,881	75,226	94,033	112,839	131,646	150,452	188,065	225,678	263,291	300,904	338,517	376,130	470,163
Vienna	998	39,919	49,899	59,879	69,858	79,838	99,798	119,757	139,717	159,676	179,636	199,595	249,494
Rome													
Athens													
Tel Aviv													
Cairo													

Money has to work, a battery has to work.
If the battery works 300 times a year,
then it is very economical.
If the battery works only 1 time a year
then it is very unaffordable.

Proposal 3: Hydrogen:

Home > Gase kaufen > Schneid- und Schweißgase > Wasserstoff > Wasserstoff 3.0 LIPAC®duo

Wasserstoff 3.0 LIPAC®duo

12 x 50l mit 200 und 300 bar-Anschluss für mehr Flexibilität

Mehr Informationen

Flascheninhalt: 12x50l [300 bar]

Menge: 1

Material-Nr. **31805253**

1.616,00 €

pro Bündel

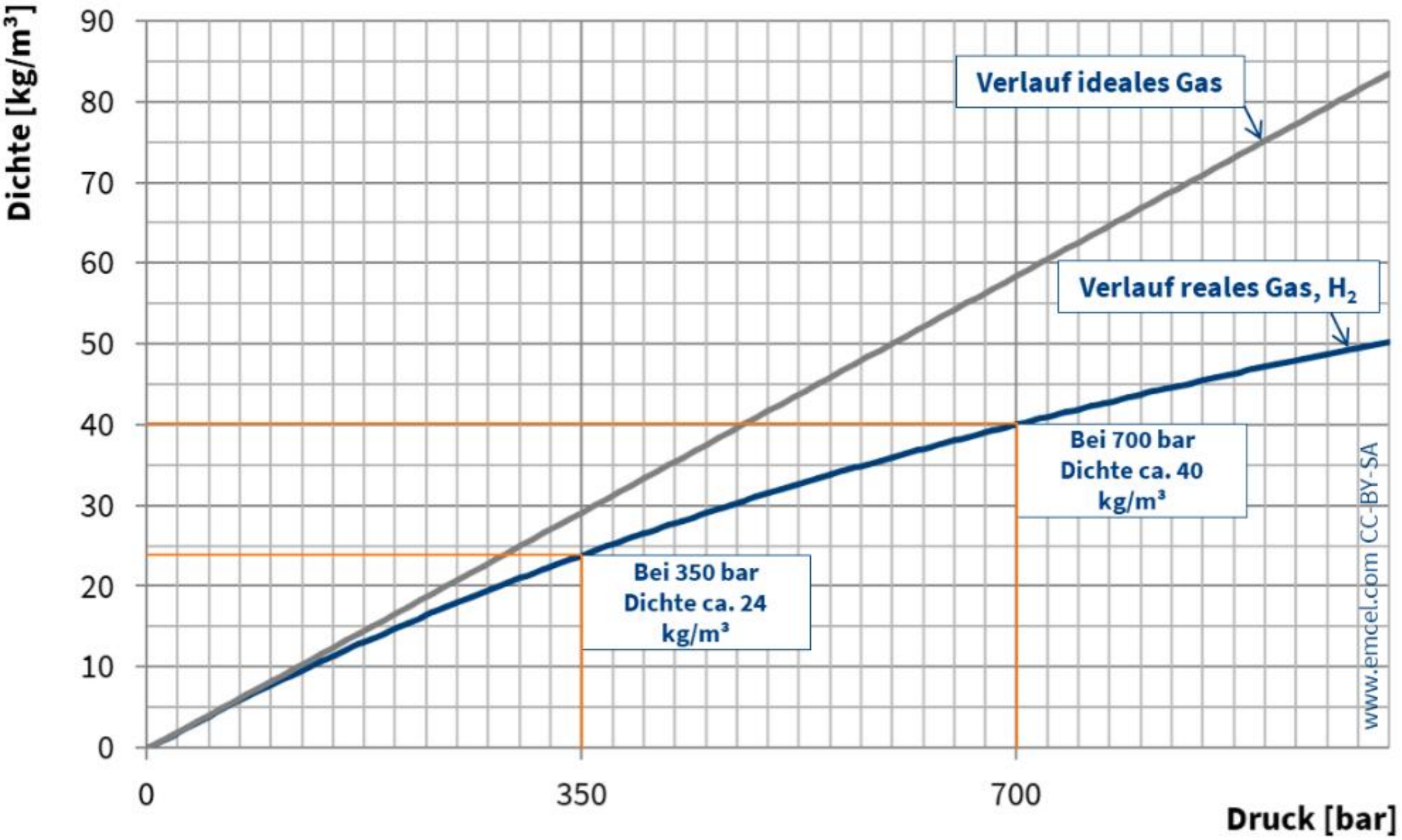
In den Warenkorb

exkl. MwSt. / *Preis zzgl. Miete, Transportkosten und Zuschläge*

LIPAC® duo

Rauminhalt, [Liter]	Füllmenge, ca. [m³]	Fülldruck, ca. [bar]	Anzahl Flaschen im Bündel	Gesamtgewicht, mit Füllung ca. [kg]	Maße ca. (H x L x B)[mm]
600	151	300	12	1460	1900 x 1000 x 770

Warum fasst ein Wasserstofftank bei 700 bar nicht doppelt so viel wie bei 350 bar?



0.6 m^3 * 21 kg/m^3 = 12.6 kg H2

calculated with ideal gas it would be 0.6 m^3 * 300 bar * 0.09 kg/m^3 = 16.2 kg

Fuel cell efficiency according to

https://www.oeamtc.at/thema/tests/test-hyundai-ix35-fcev-40132118

Efficiency of the vehicle

According to measurements by the Vienna University of Technology, the overall efficiency of the Hyundai iX35 FCEV is between 30 % and 39 %, depending on the temperature.

The highest efficiency can be assumed here in domestic operation.

33.33 kWh chemical * 39 % = 13 kWh electricity

12.6 kg H2 * 13 kWh/kg = 163.8 kWh

You could calculate wrong twice: ideal gas and 60 % efficiency:

16.2 kg H2 * 33.33 kWh chemical * 60 % = 324 kWh.

This gas bottle storage weighs more than current LiFePo4 batteries

to store 163.8 kWh

Efficient battery vs cheap hydrogen:

Let's try the hydrogen theory	Storage	One €	All €	Ele. kW	per kW	all kW	FC kW	per kW	all kW	Total €
Oslo	20	2,000	40,000	4	2000	8,000	2	3,000	6,000	54,000
Berlin	10	2,000	20,000	2	2000	4,000	2	3,000	6,000	30,000
Vienna	5	2,000	10,000	1	2000	2,000	1	3,000	3,000	15,000
Rome										
Athens										
Tel Aviv										
Cairo										

Efficient vs cheap
Battery vs hydrogen
In the day/night balance
the efficient battery wins.
In summer/winter balance
the cheap hydrogen wins.

Proposal 4: external service provider:

The external service	buy Cent	sell low	sell aver	buy kWh	sell low	sell av.	buy €	sell l €	sell av. €	Total €	vs H2	years
Oslo	40	4	10	3,165	12,658	3,016	1,266	506	302	-458	54,000	71
Berlin	30	3	8	1,505	6,018	12,547	451	181	1,004	733	30,000	111
Vienna	30	3	6	798	8,000	13,477	240	240	809	809	15,000	104
Rome	30	2	5	0	12,000	17,695	0	240	885	1,125		
Athens	30	2	4	0	16,000	18,259	0	320	730	1,050		
Tel Aviv	30	2	3	0	18,000	19,049	0	360	571	931		
Cairo	30	2	3	0	20,000	21,237	0	400	637	1,037		

The external service provider is much cheaper:

Cheap underground storage vs expensive gas cylinders.

Cheap efficient CCPP power plants vs expensive moderately efficient fuel cells.

> 10 € / m³

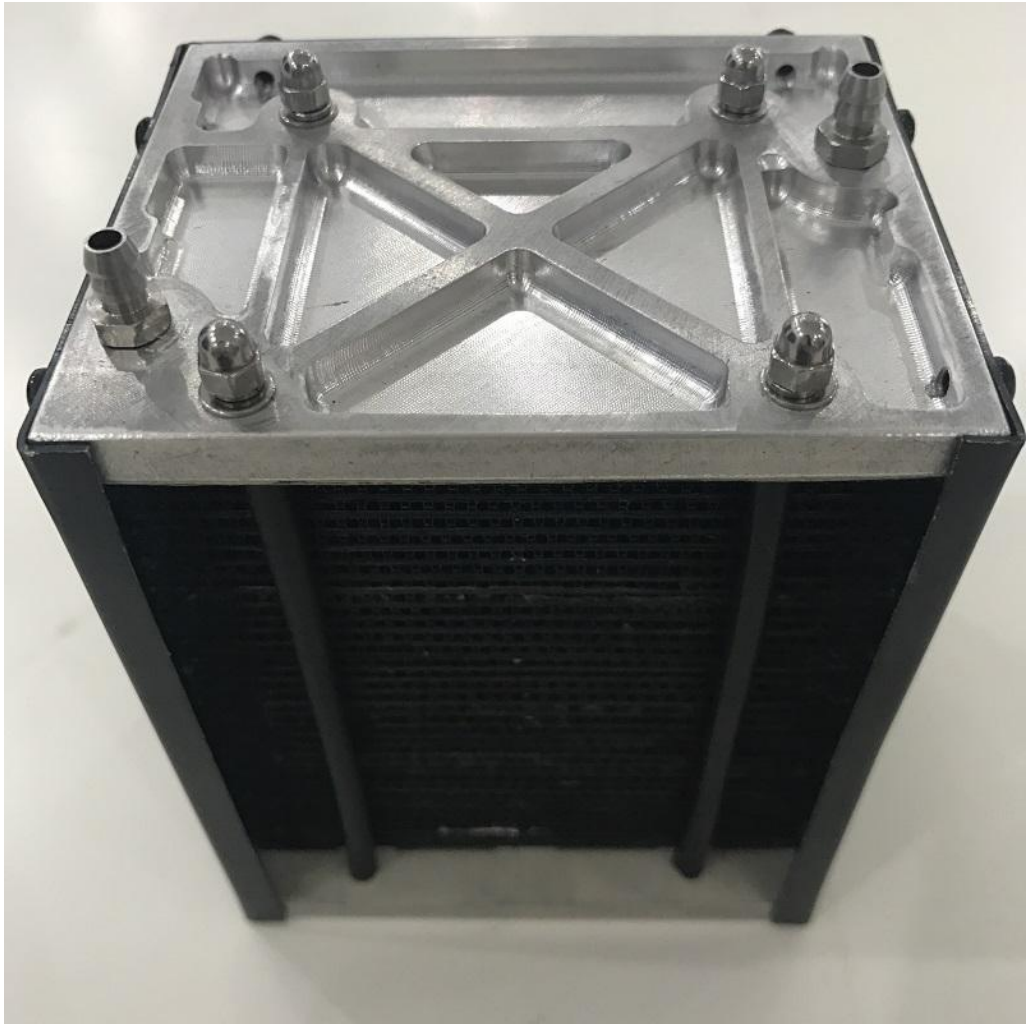
1 m³ hydrogen = 3 kWh

Underground Gas Storage:

< 1 € / m³

1 m³ methane = 9.97 kWh

see study linked PDF



© InfraServ Knapsack

CCPP - Combined Cycle Power Plant

3.000 € / kW

39 % efficiency

1.000 € / kW

60 % efficiency

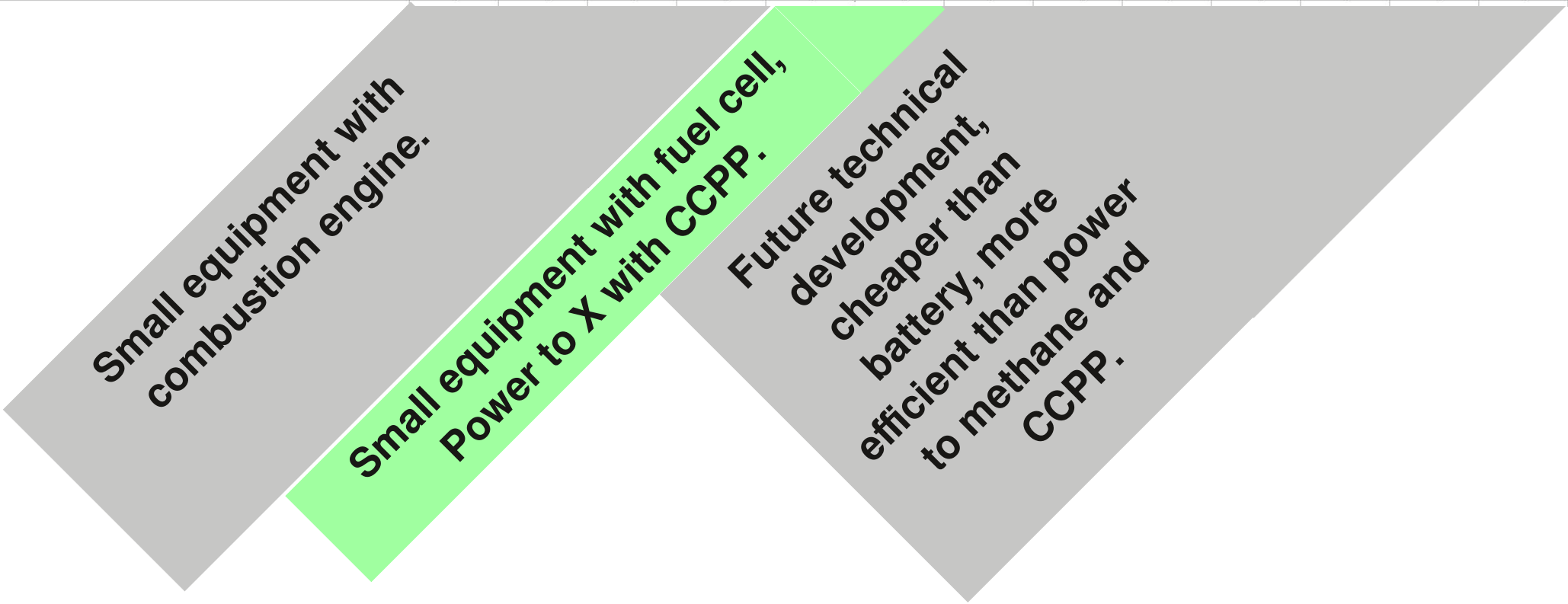
see study linked PDF

Efficiency in summer/winter balance:

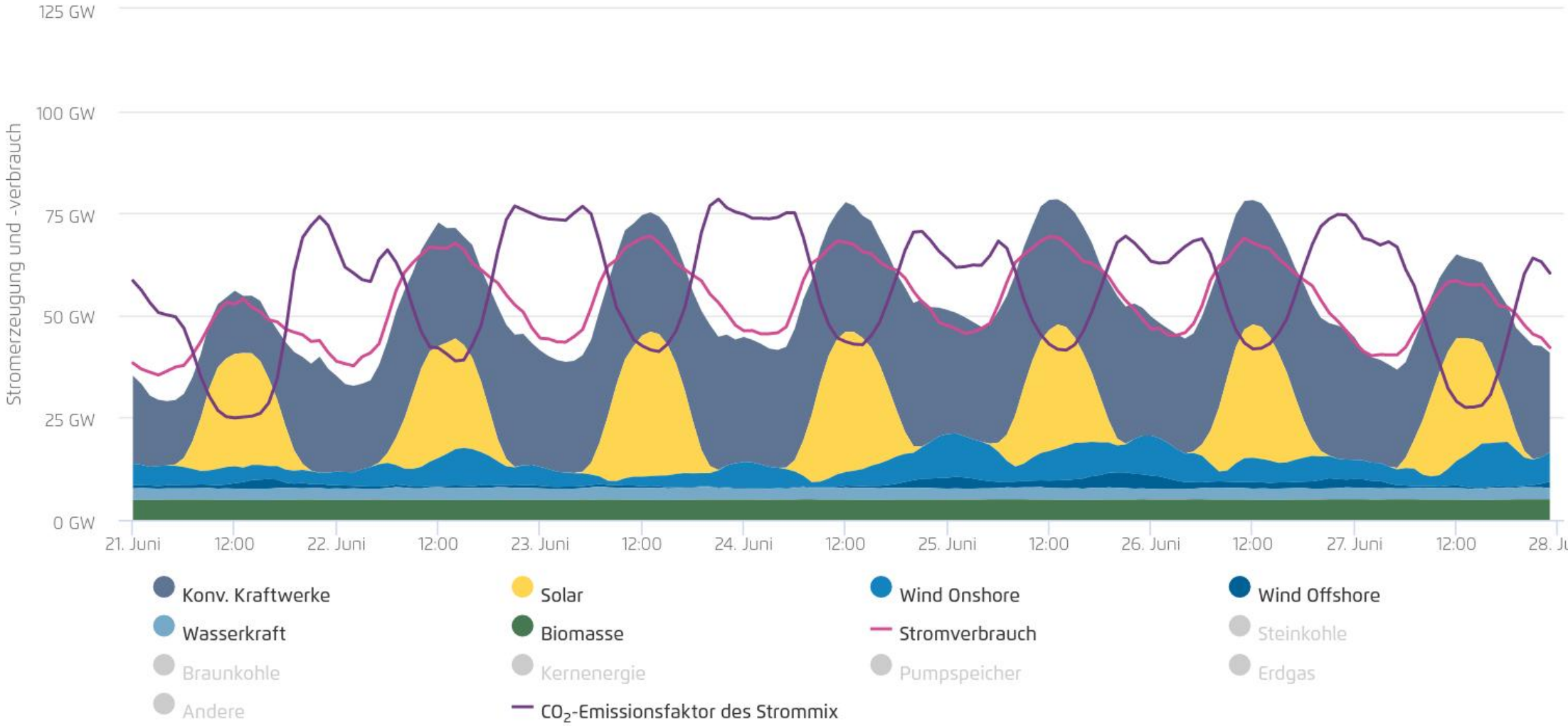
Efficiency of Summer winter balancing in percent	14	16	18	20	25	30	35	40	50	60	70	80	90
Yearly energy balance after summer/winter balancing													
Oslo	-6,930	-4,104	-1,907	-149	3,016	5,126	6,632	7,763	9,345	10,400	11,153	11,718	12,158
Berlin	7,818	9,161	10,206	11,042	12,547	13,550	14,266	14,803	15,556	16,057	16,415	16,684	16,893
Vienna	15,774	16,487	17,041	17,485	18,283	18,816	19,196	19,481	19,880	20,146	20,336	20,479	20,590
Rome	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695
Athens	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259
Tel Aviv	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049
Cairo	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237

Efficiency in summer/winter balance:

Efficiency of Summer winter balancing in percent	14	16	18	20	25	30	35	40	50	60	70	80	90
Yearly energy balance after summer/winter balancing													
Oslo	-6,930	-4,104	-1,907	-149	3,016	5,126	6,632	7,763	9,345	10,400	11,153	11,718	12,158
Berlin	7,818	9,161	10,206	11,042	12,547	13,550	14,266	14,803	15,556	16,057	16,415	16,684	16,893
Vienna	15,774	16,487	17,041	17,485	18,283	18,816	19,196	19,481	19,880	20,146	20,336	20,479	20,590
Rome	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695	29,695
Athens	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259	34,259
Tel Aviv	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049	37,049
Cairo	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237	41,237



But before the seasonal balance becomes topical:



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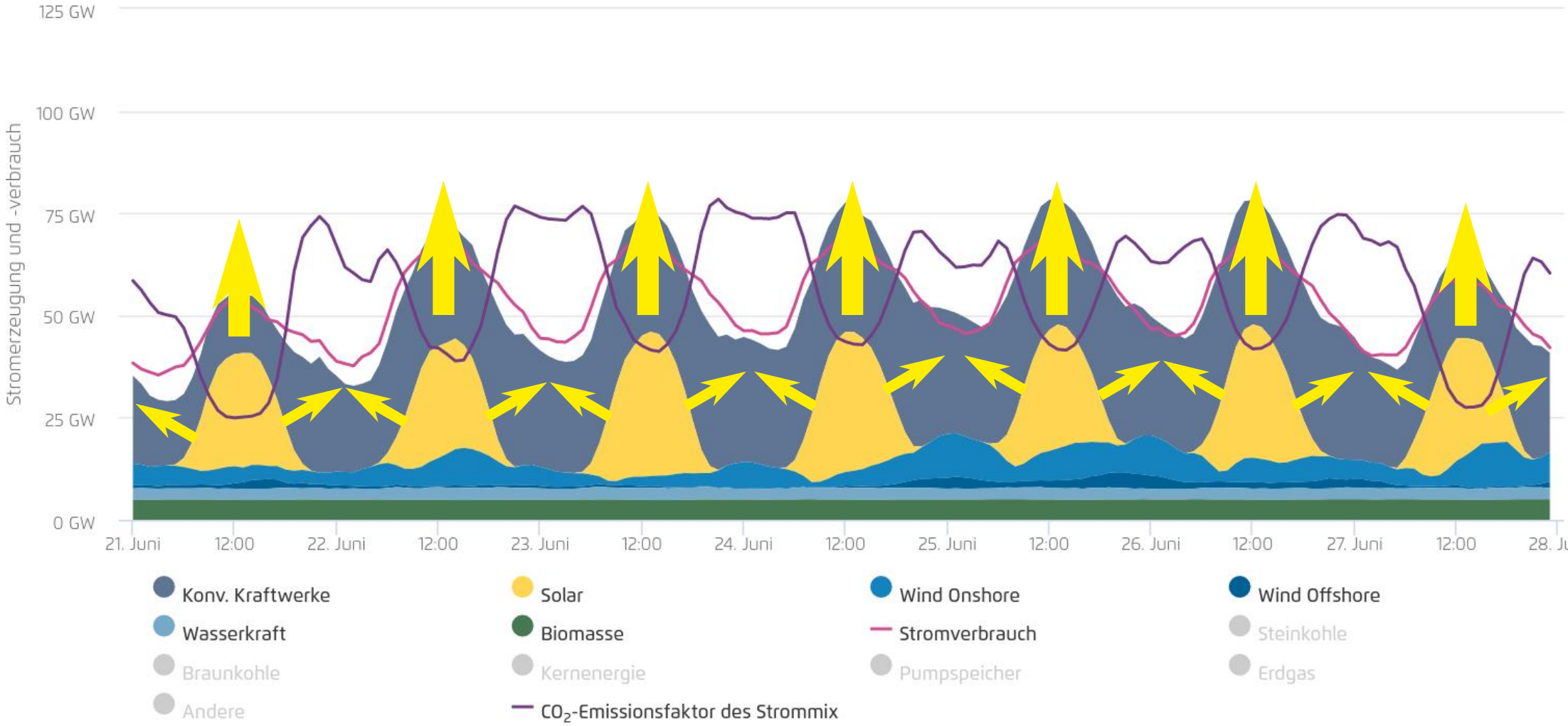

Are in Germany 300 GW of photovoltaics and 750 GWh of batteries required

Summer / winter balancing solar power

PLANETARY ENGINEERING GROUP PEGE