



Vernissage Fachbuch Photovoltaikanlagen | Solothurn, 25. November 2021 | Christof Bucher

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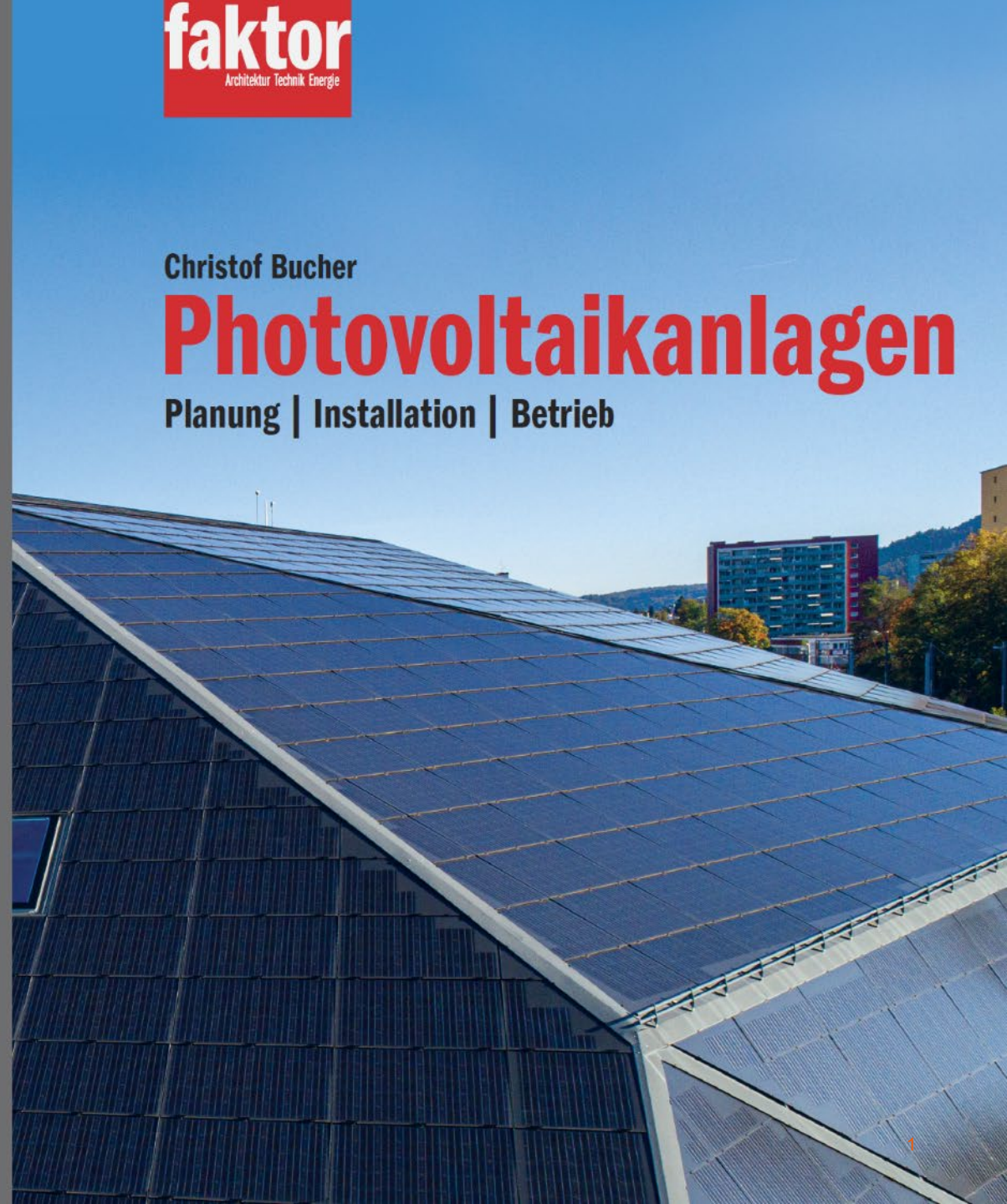
faktor
Architektur Technik Energie

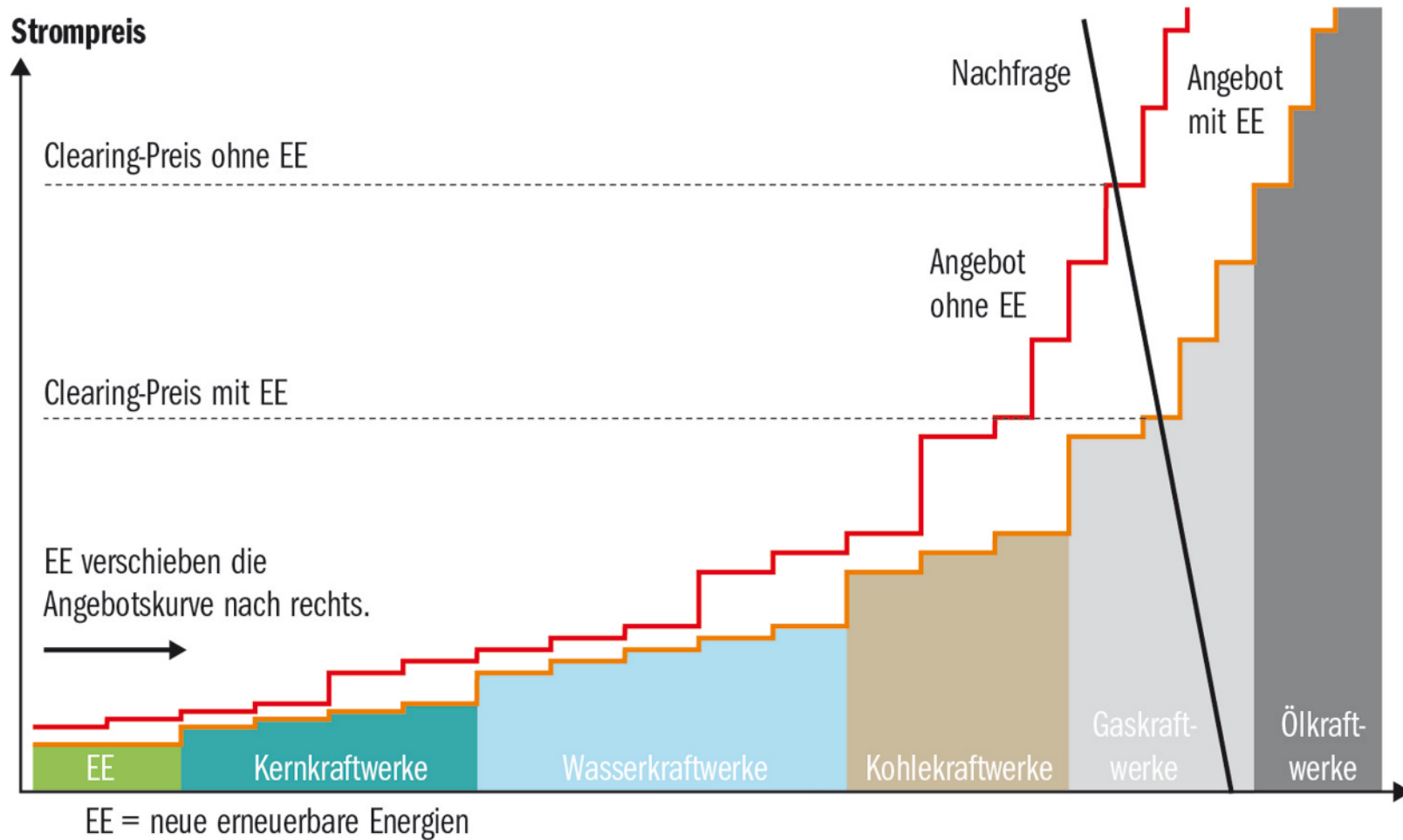
Christof Bucher

Photovoltaikanlagen

Planung | Installation | Betrieb

Christof Bucher ■ Photovoltaikanlagen ■ Planung – Installation – Betrieb





Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Investitionskosten: 1000 Fr./kW, LCOE = 8,1 Rp./kWh

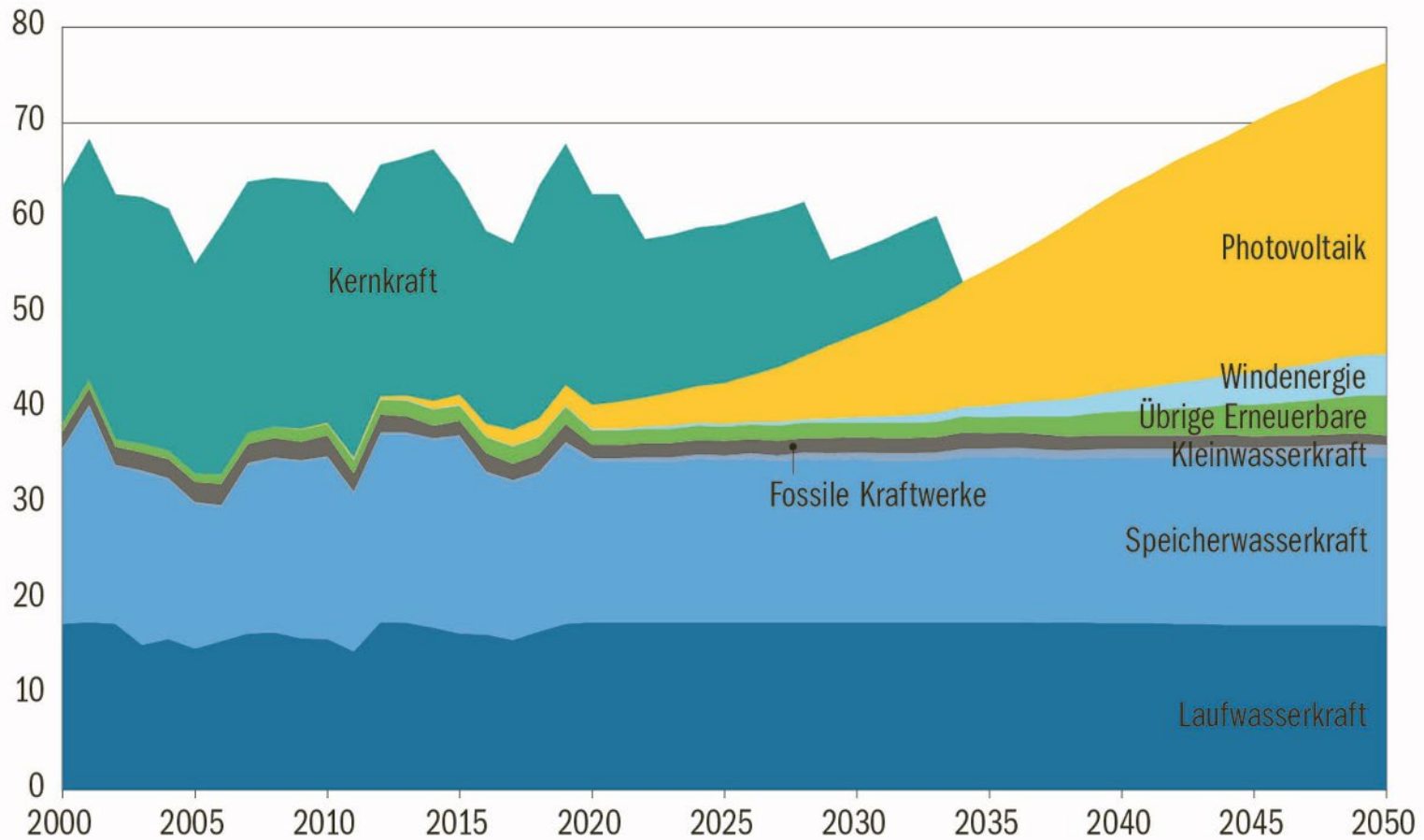
		Strompreis (Rp./kWh)										
		16	17	18	19	20	21	22	23	24	25	26
Einspeisetarif (Rp./kWh)	12	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0
	8	2	1	1	1	1	1	1	1	1	1	1
	7	12	11	10	9	9	8	7	7	7	6	6
	6	21	19	18	16	15	14	13	12	12	11	11
	5	28	26	24	22	21	20	18	17	16	16	15
	4	34	32	29	27	26	24	23	22	21	20	19

Investitionskosten: 2000 Fr./kW, LCOE = 13,2 Rp./kWh

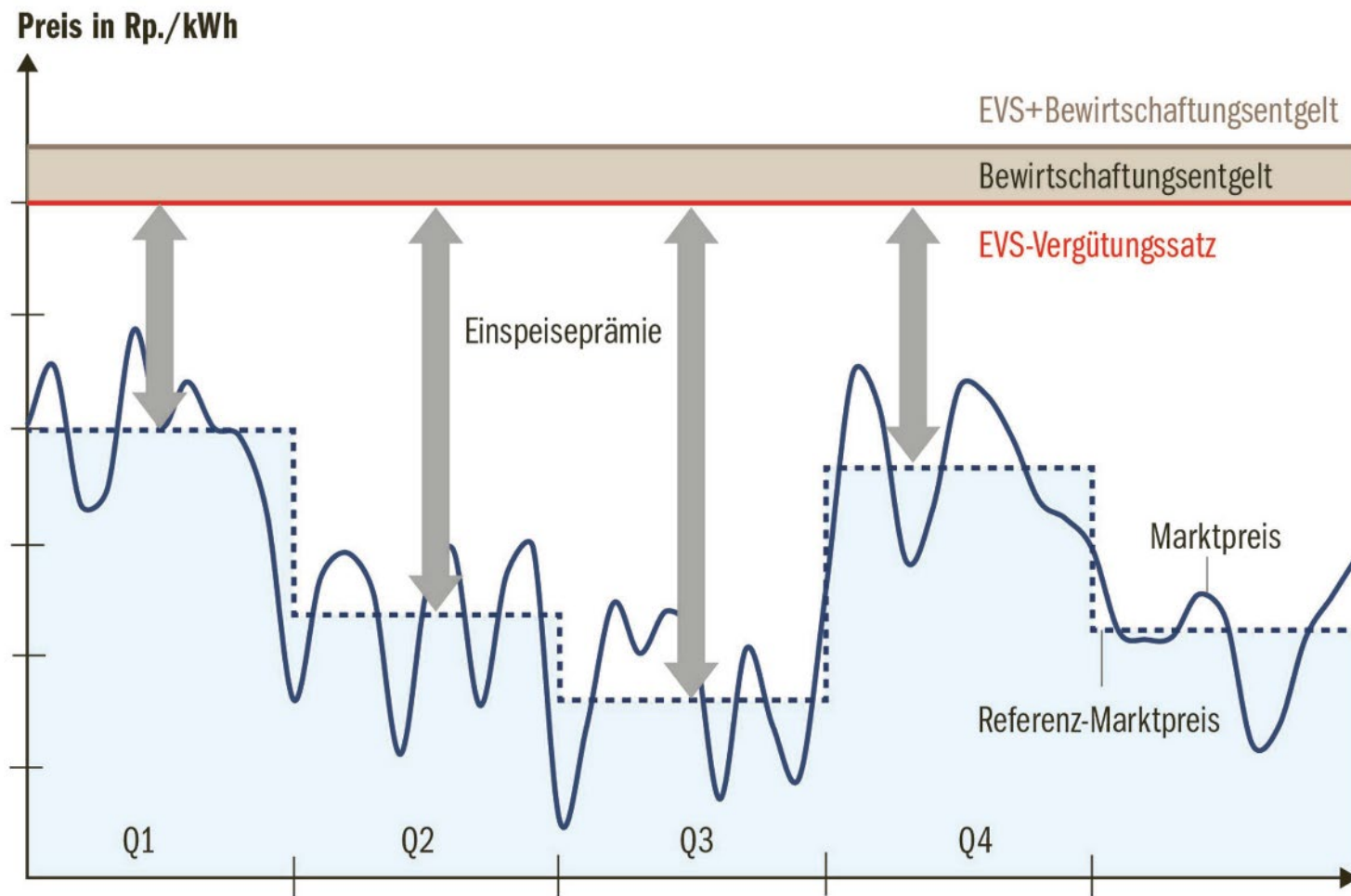
		Strompreis (Rp./kWh)										
		16	17	18	19	20	21	22	23	24	25	26
Einspeisetarif (Rp./kWh)	12	31	25	21	18	16	14	12	11	10	10	9
	11	45	37	32	28	25	22	20	19	17	16	15
	10	54	46	41	36	32	29	27	25	23	22	20
	9	61	53	47	42	39	35	33	30	28	27	25
	8	66	58	52	48	44	40	37	35	33	31	29
	7	69	62	57	52	48	45	42	39	37	35	33
	6	72	66	60	56	52	48	45	43	40	38	36
	5	75	69	63	59	55	52	48	46	43	41	39
	4	77	71	66	62	58	54	51	49	46	44	42

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

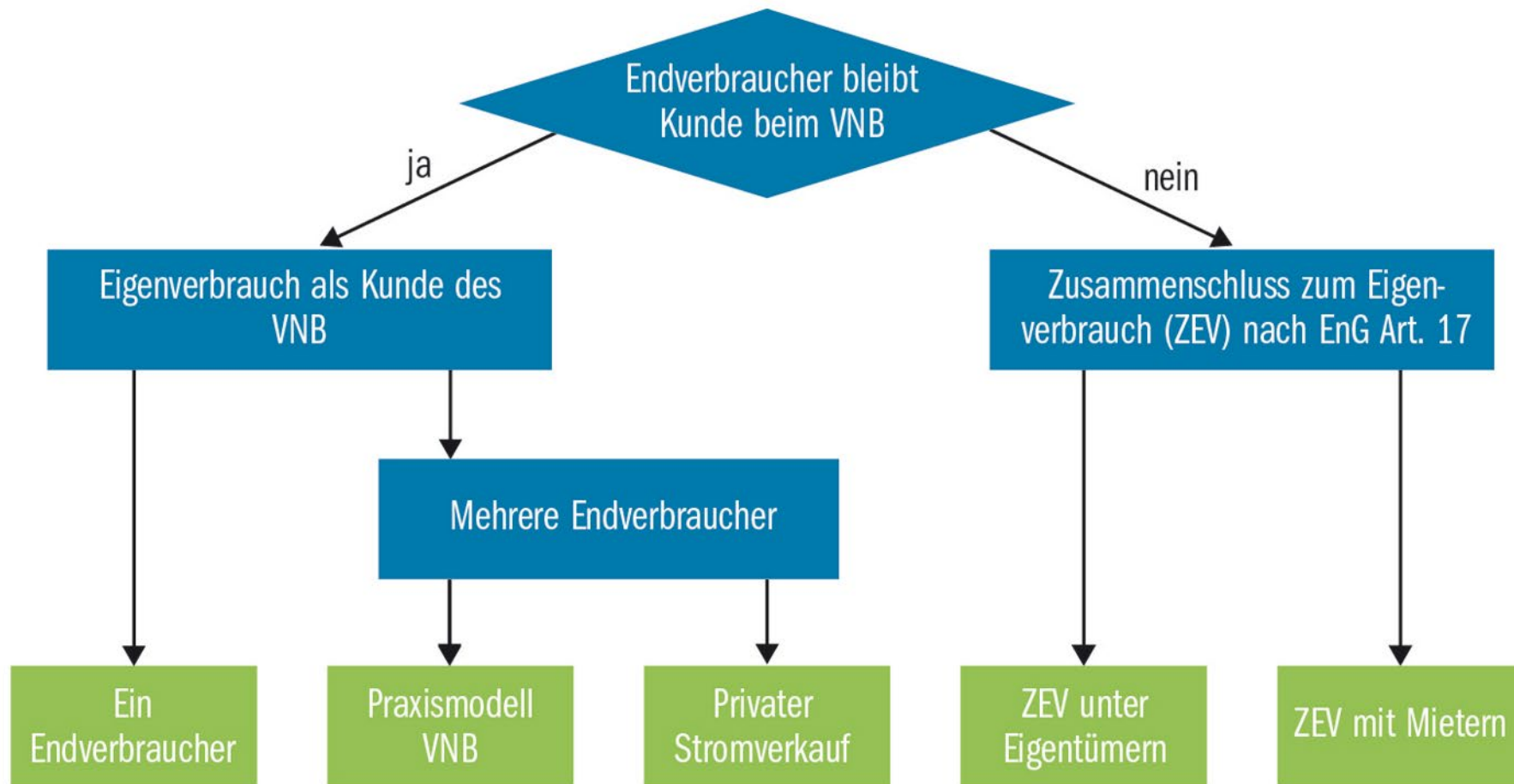
Jahresenergieproduktion in TWh



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



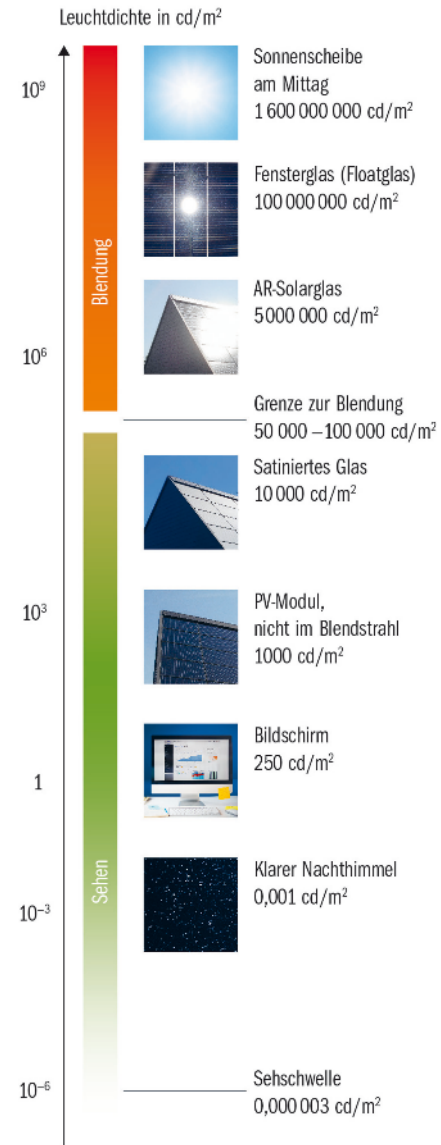
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



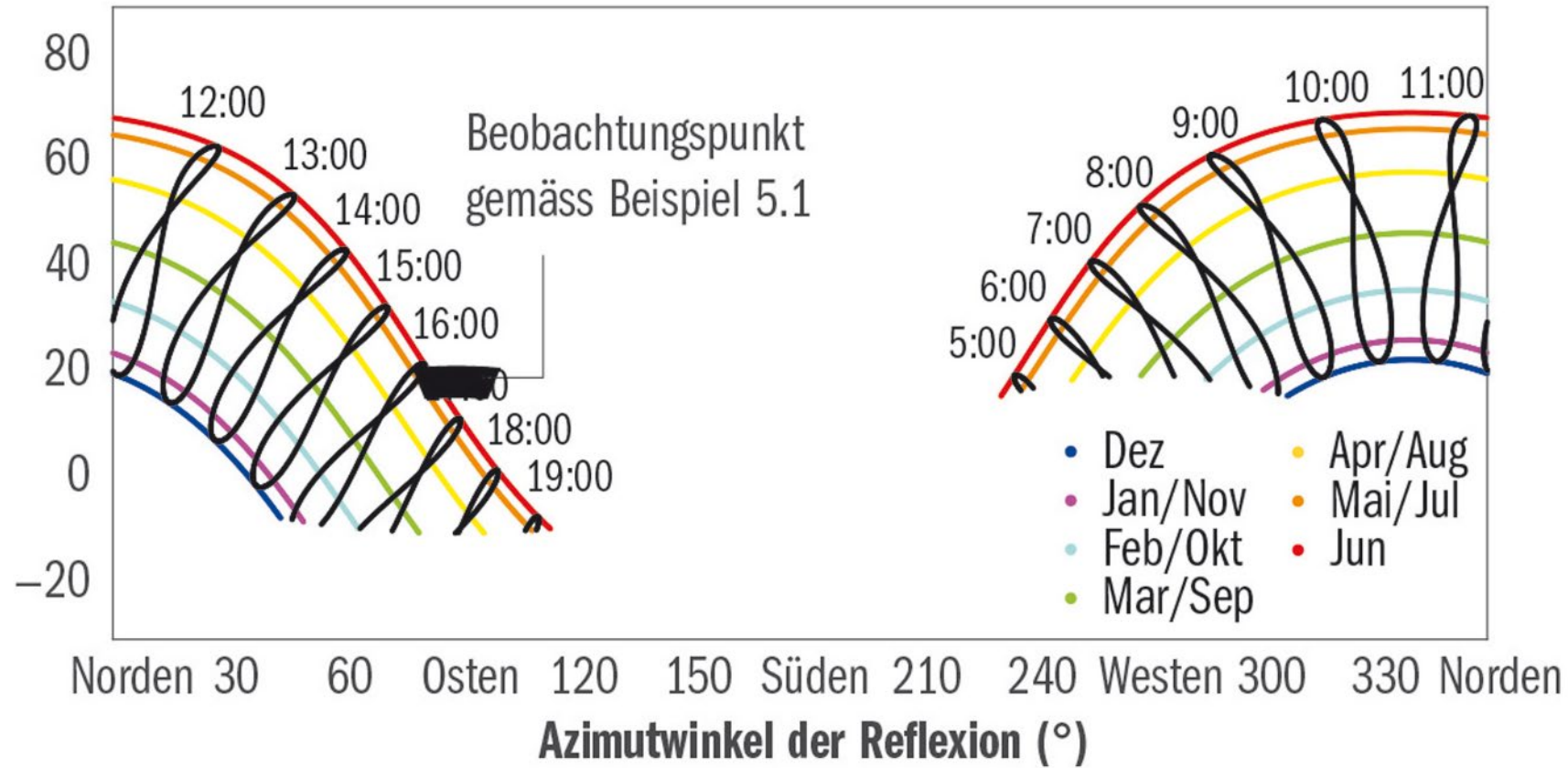
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

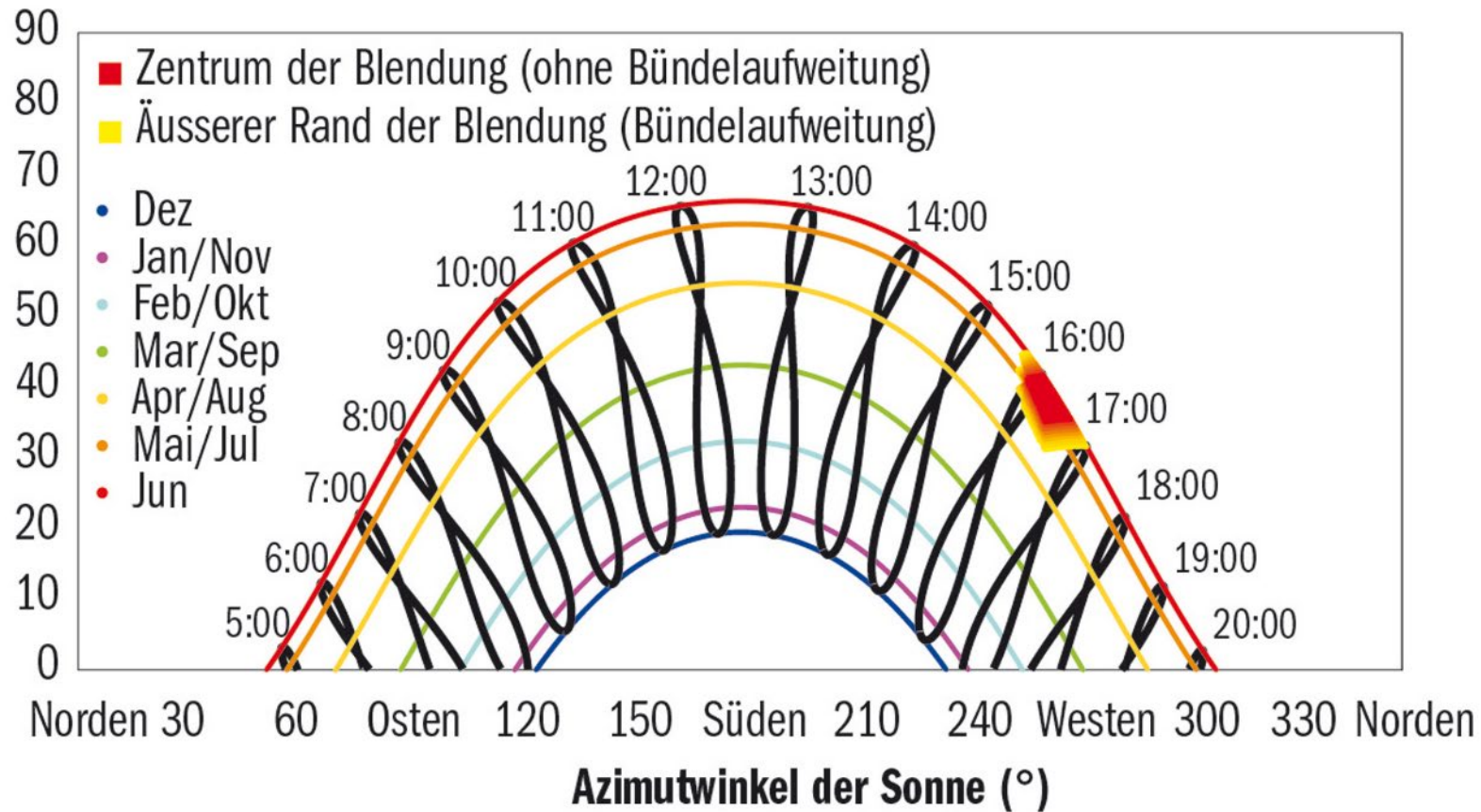


Elevationswinkel der Reflexion (°)



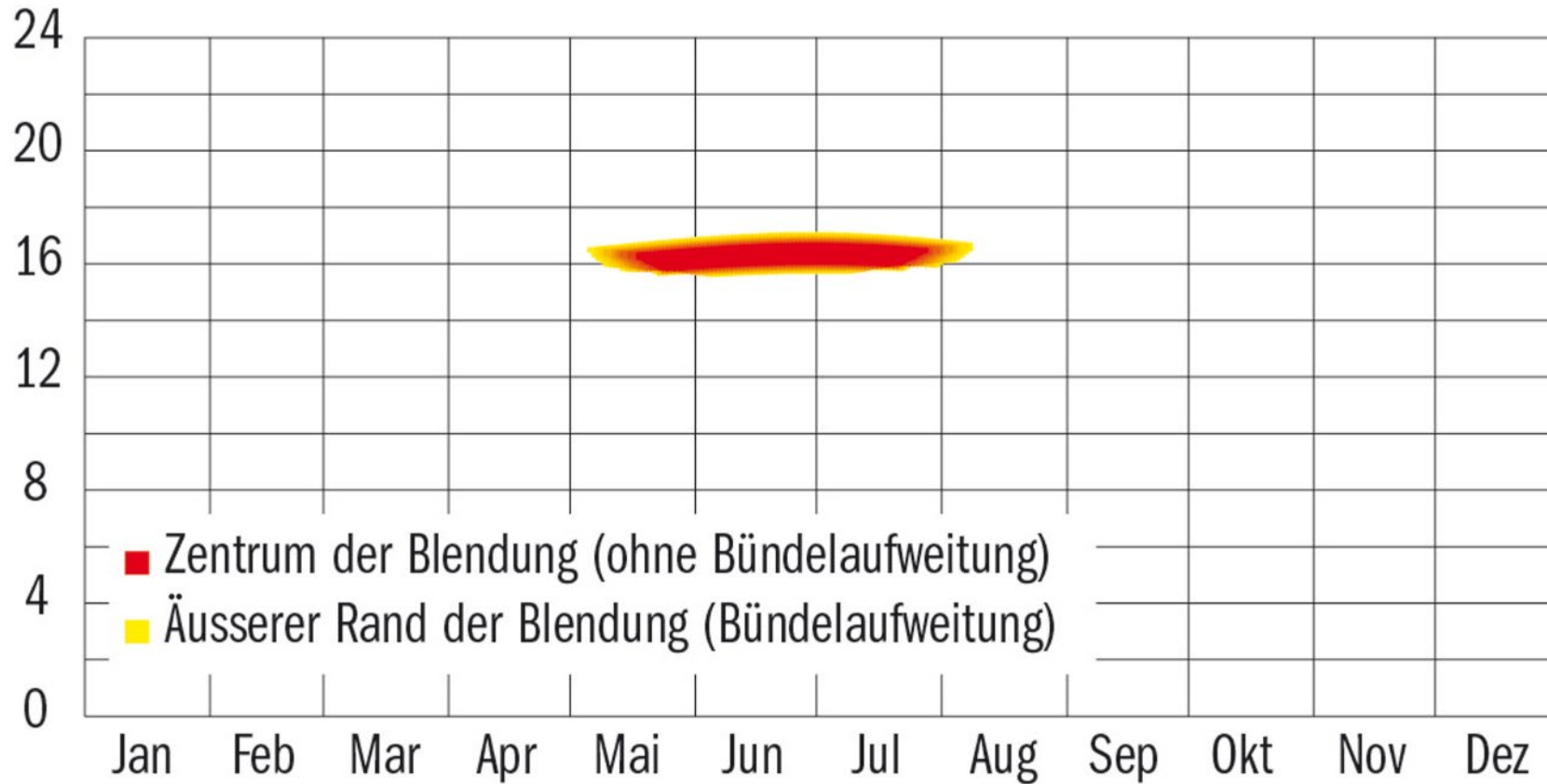
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Elevationswinkel der Sonne (°)

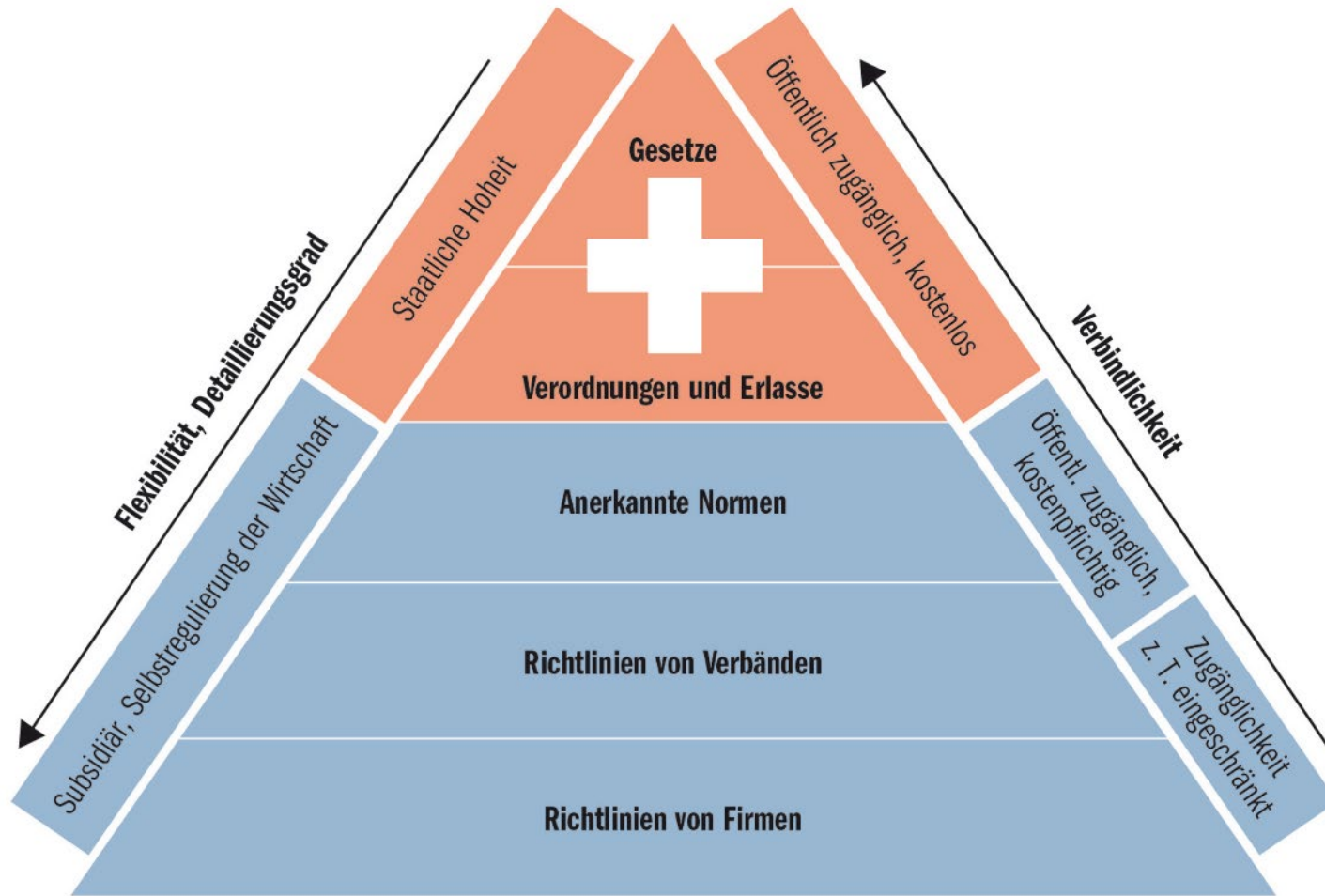


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Tageszeit (Stunde)



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

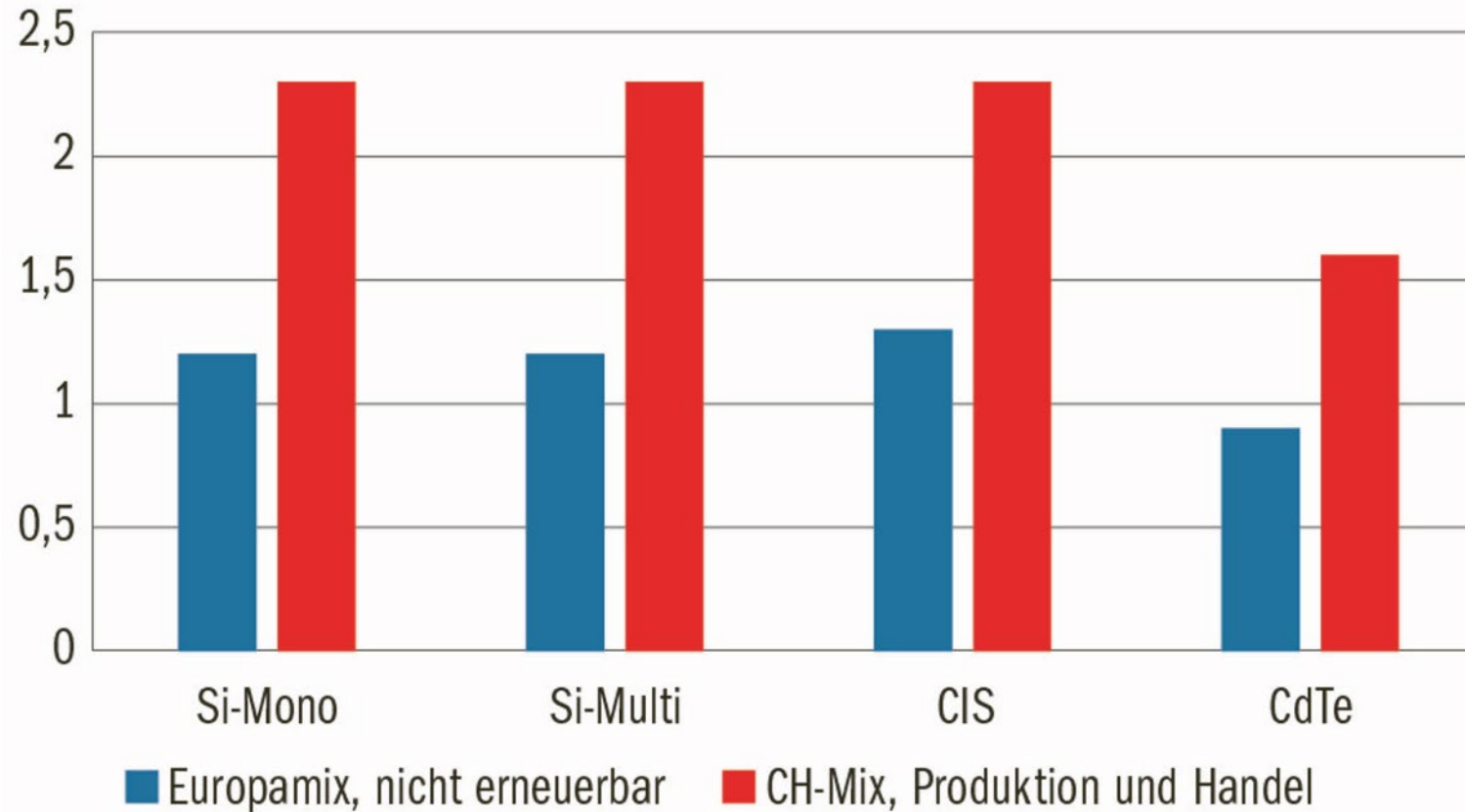


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



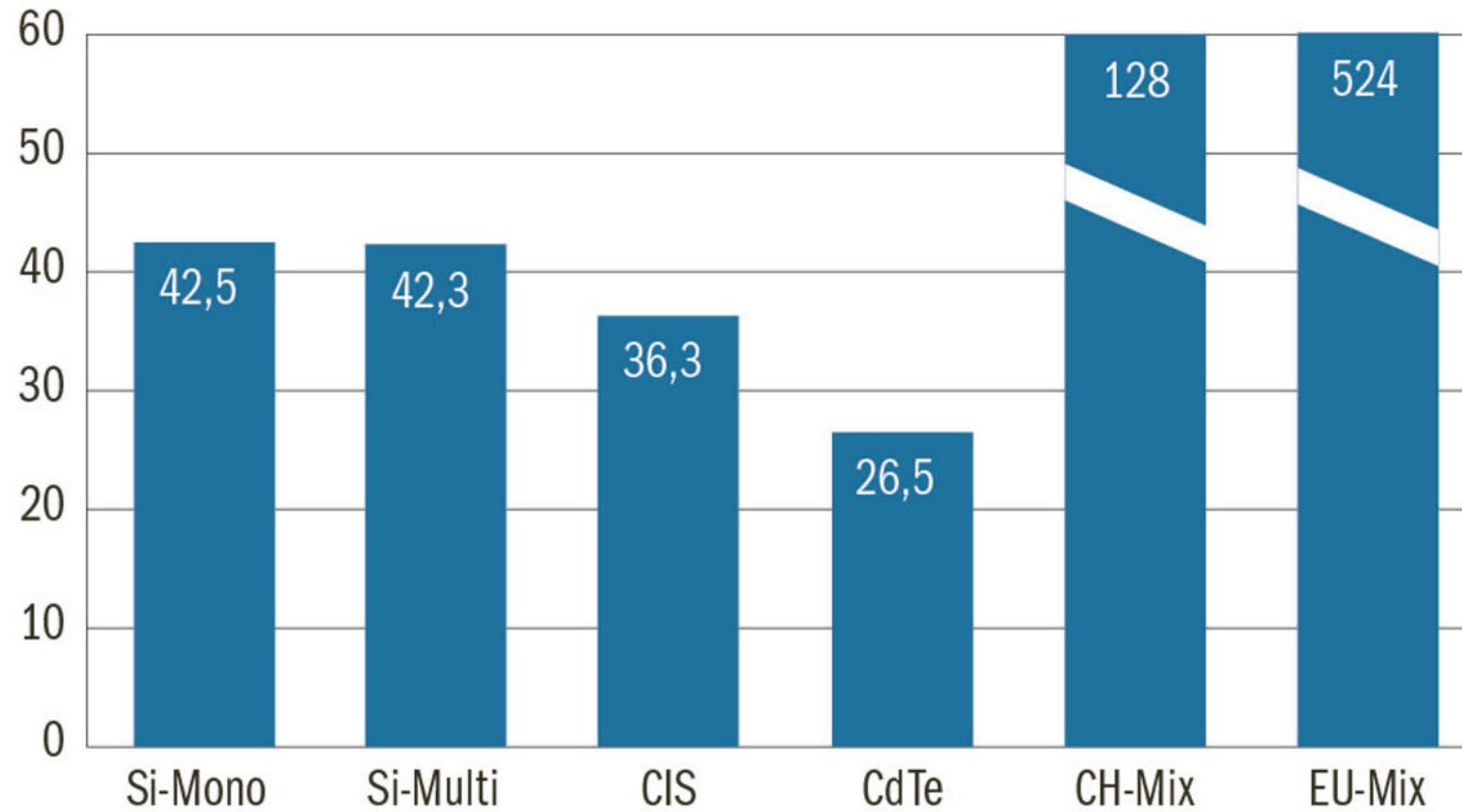
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Energierückzahldauer in Jahren



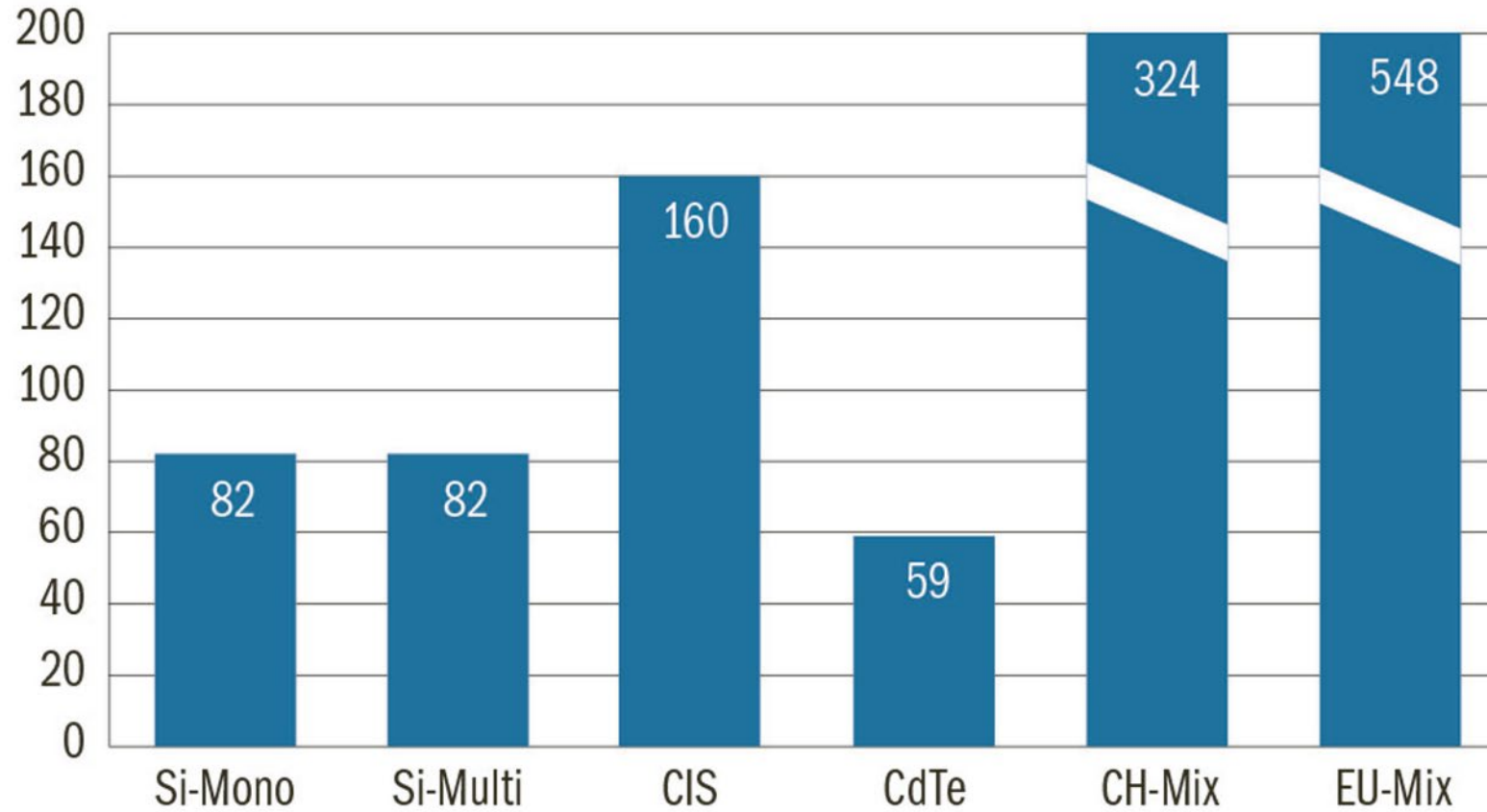
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

CO₂-Äquivalenz in g/kWh Strom

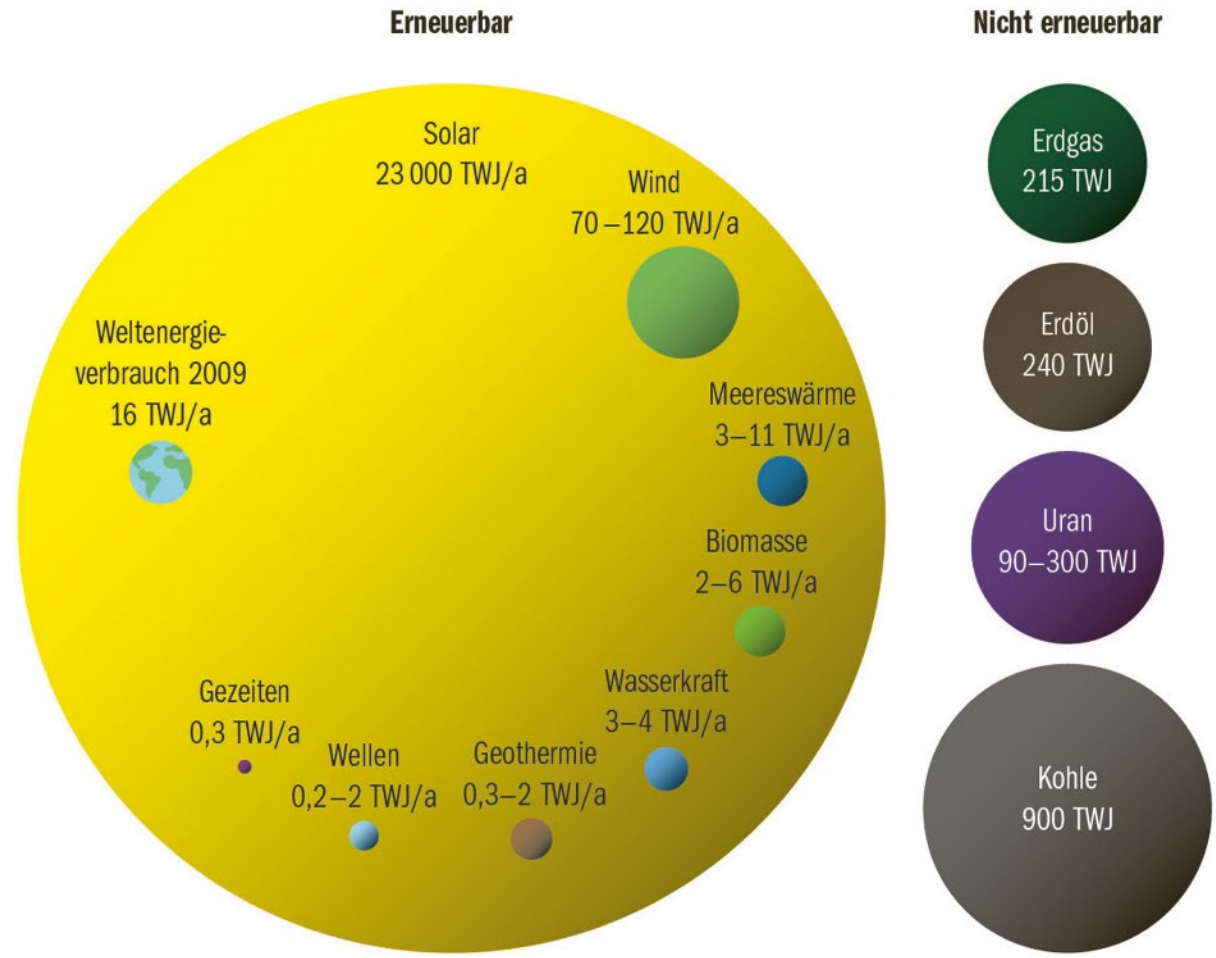


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

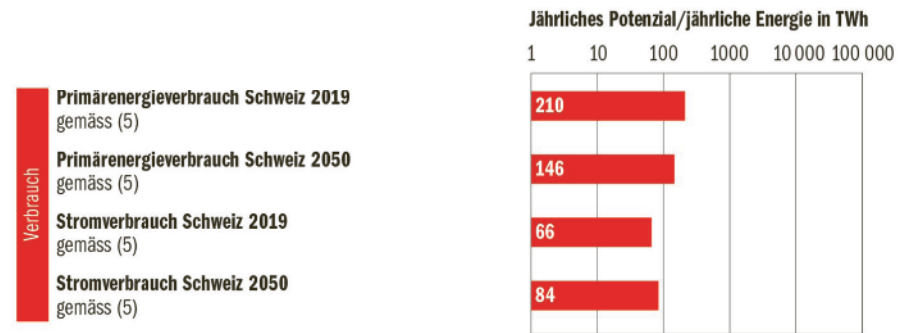
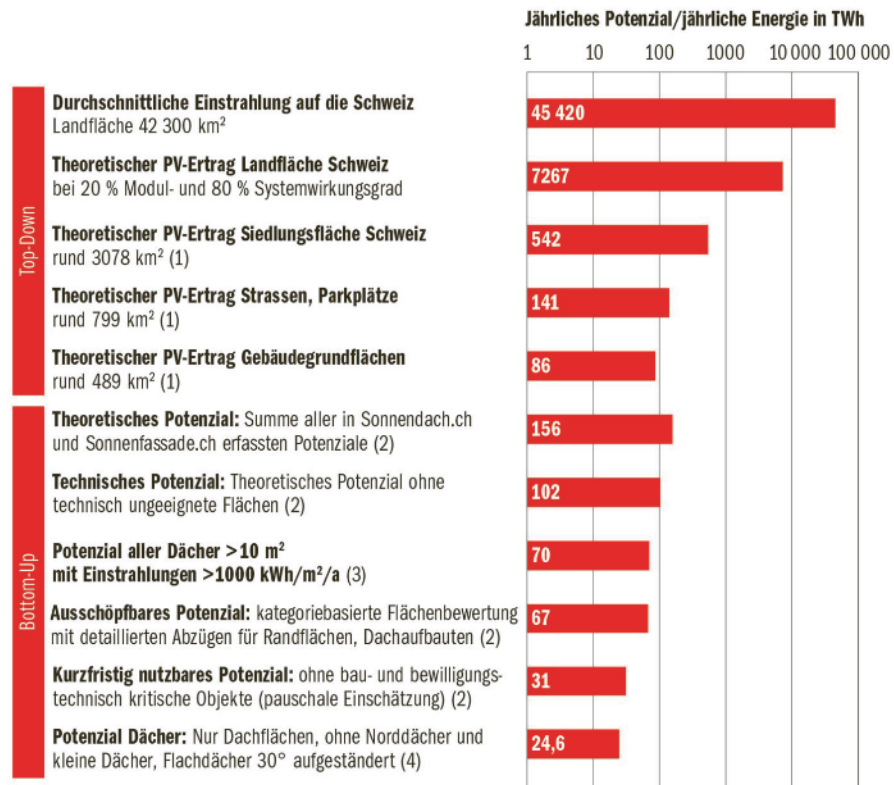
Umweltbelastungspunkte (UBP'13) pro kWh Strom



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

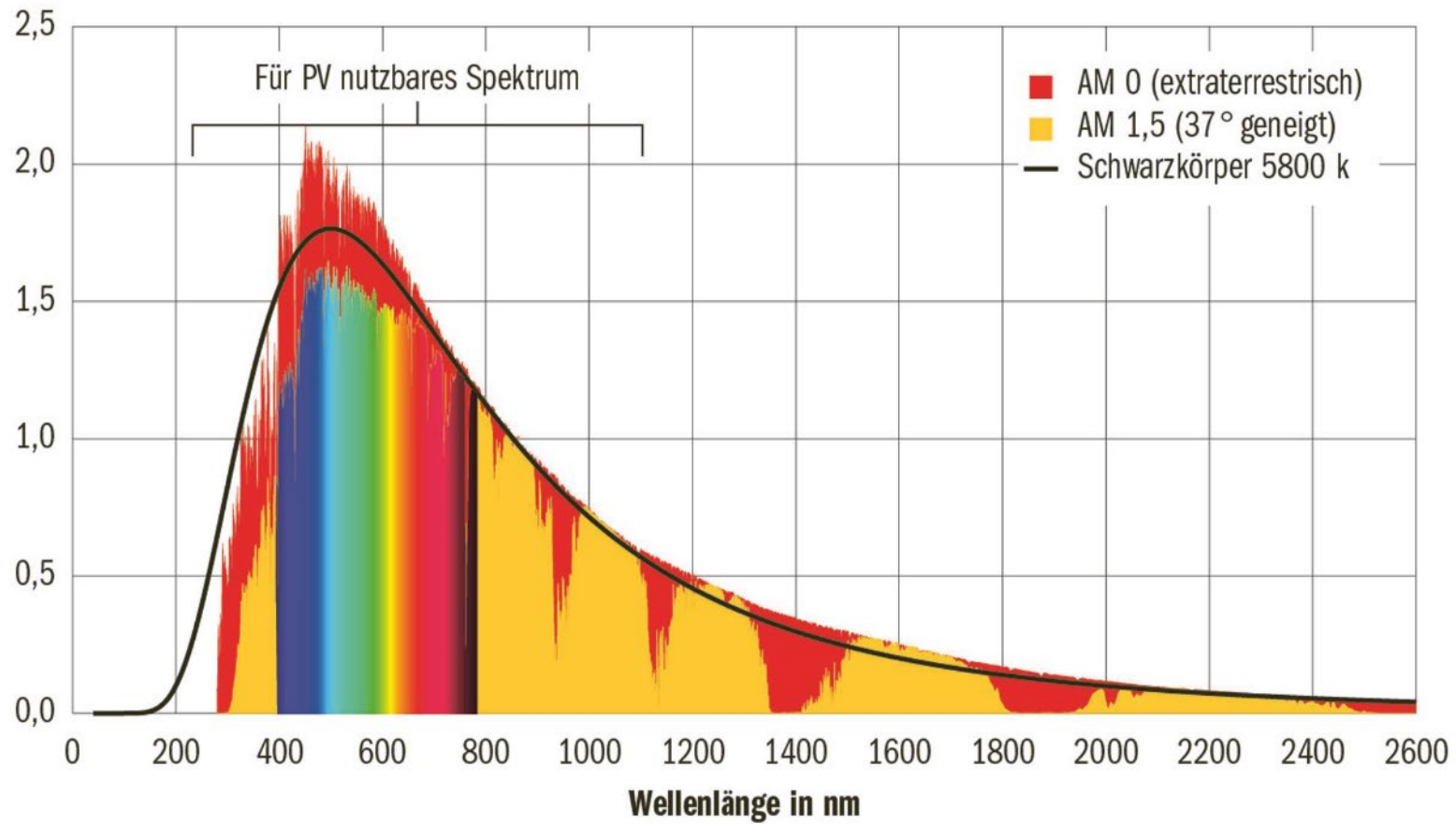


Datenquellen

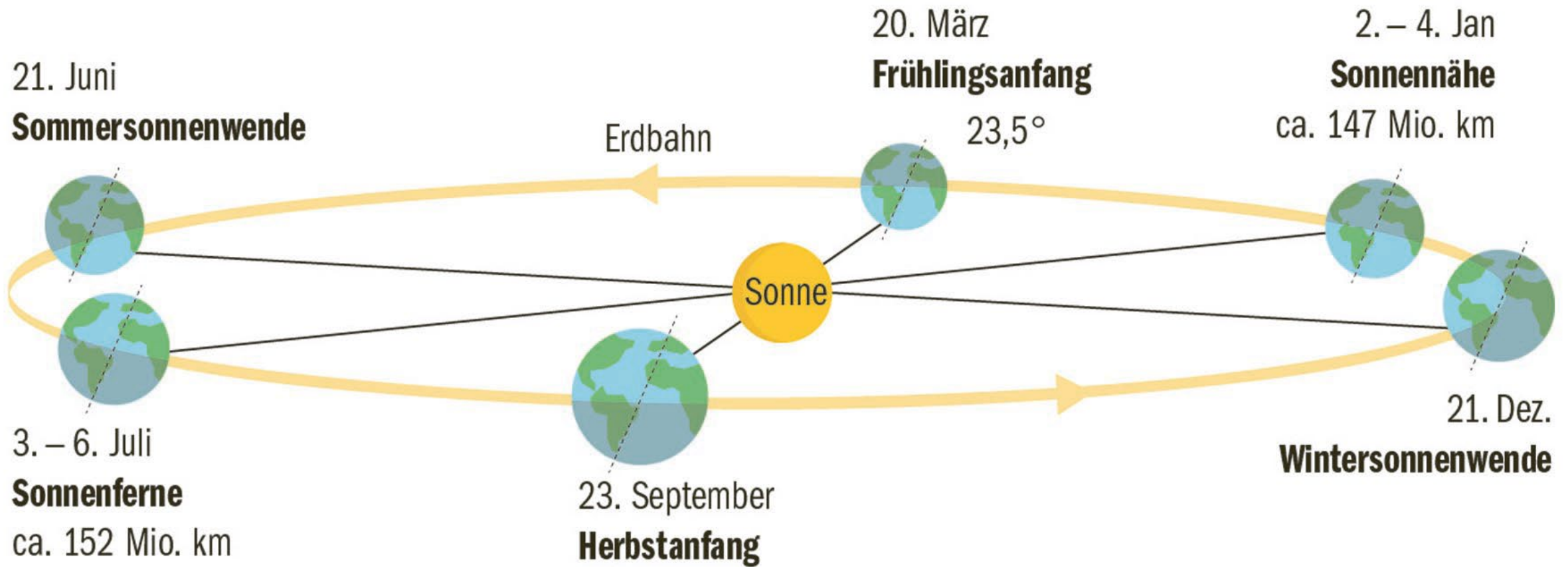
- 1) Quelle für Flächen: Bundesamt für Statistik BFS, Arealstatistik
- 2) Swissolar, Detailanalyse Solarpotenzial auf Dächern und Fassaden, basierend auf Daten von Sonnendach.ch und Sonnenfassade.ch von Meteotest
- 3) Bauer et al., Potenziale, Kosten und Umweltauswirkungen von Stromproduktionsanlagen, PSI, 2019
- 4) Walch et al., Big data mining for the estimation of hourly rooftop photovoltaic potential and its uncertainty, EPFL, 2020
- 5) Energieperspektiven 2050+, Bundesamt für Energie

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

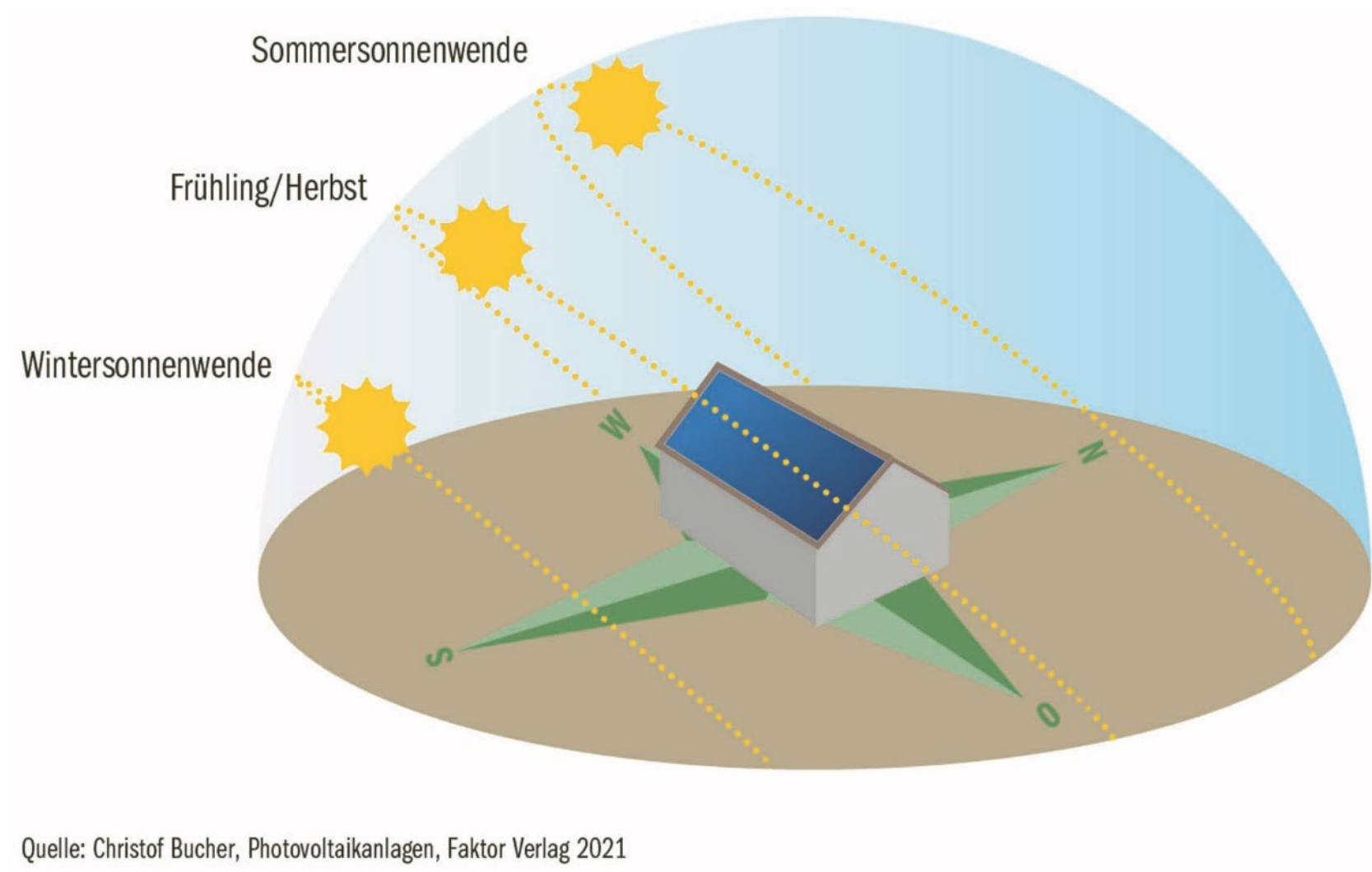
Einstrahlung in $\text{W}/\text{m}^2/\text{nm}$



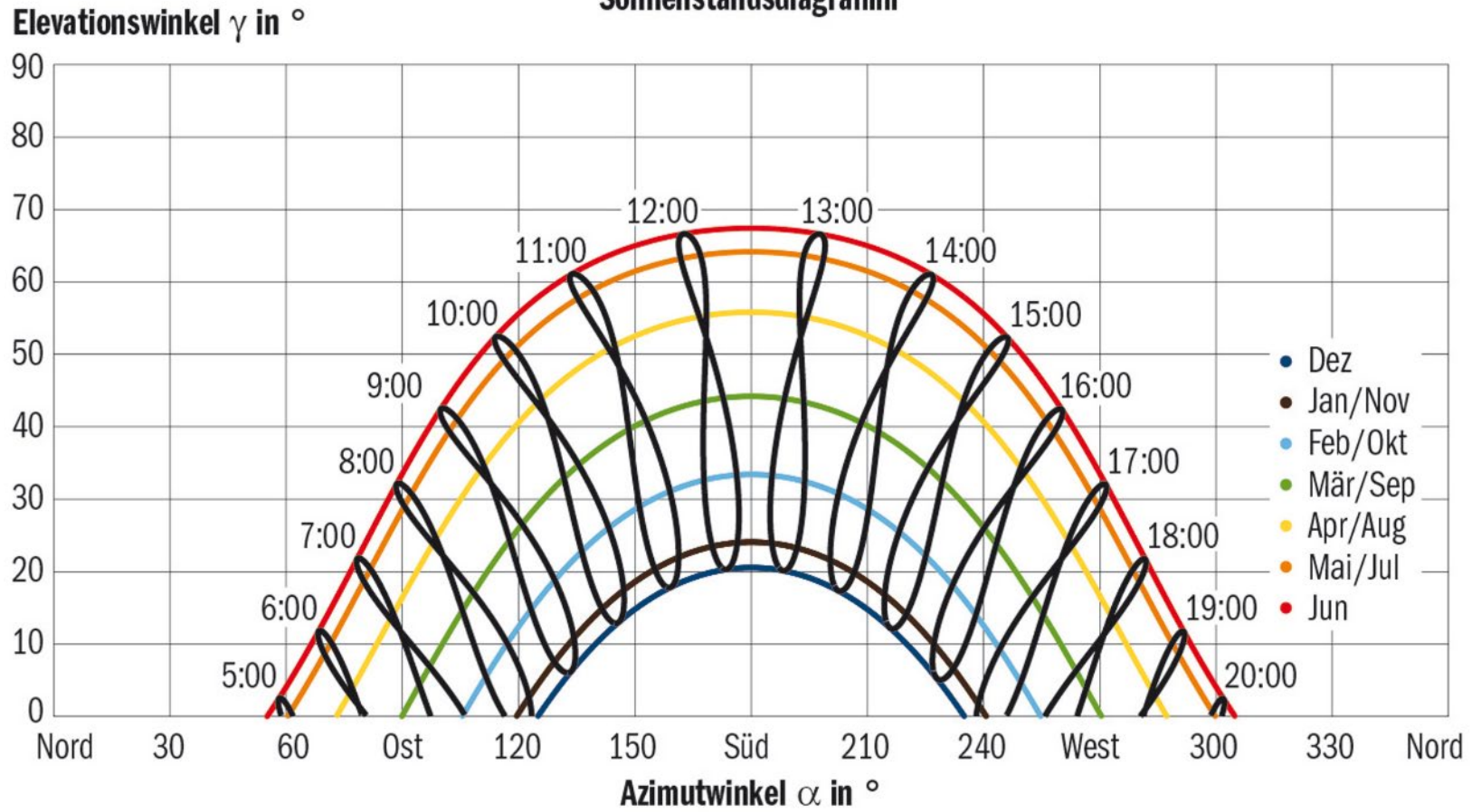
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



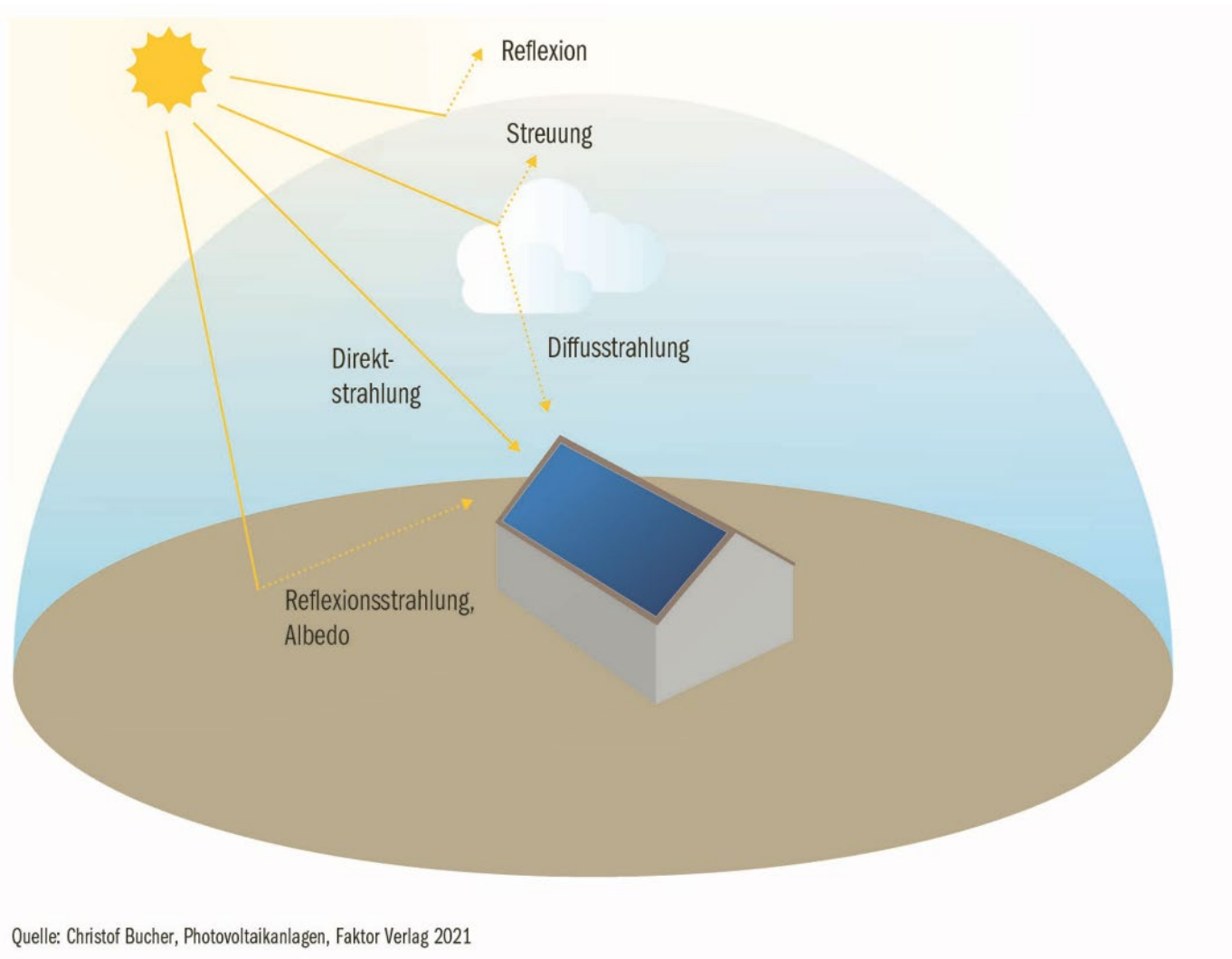
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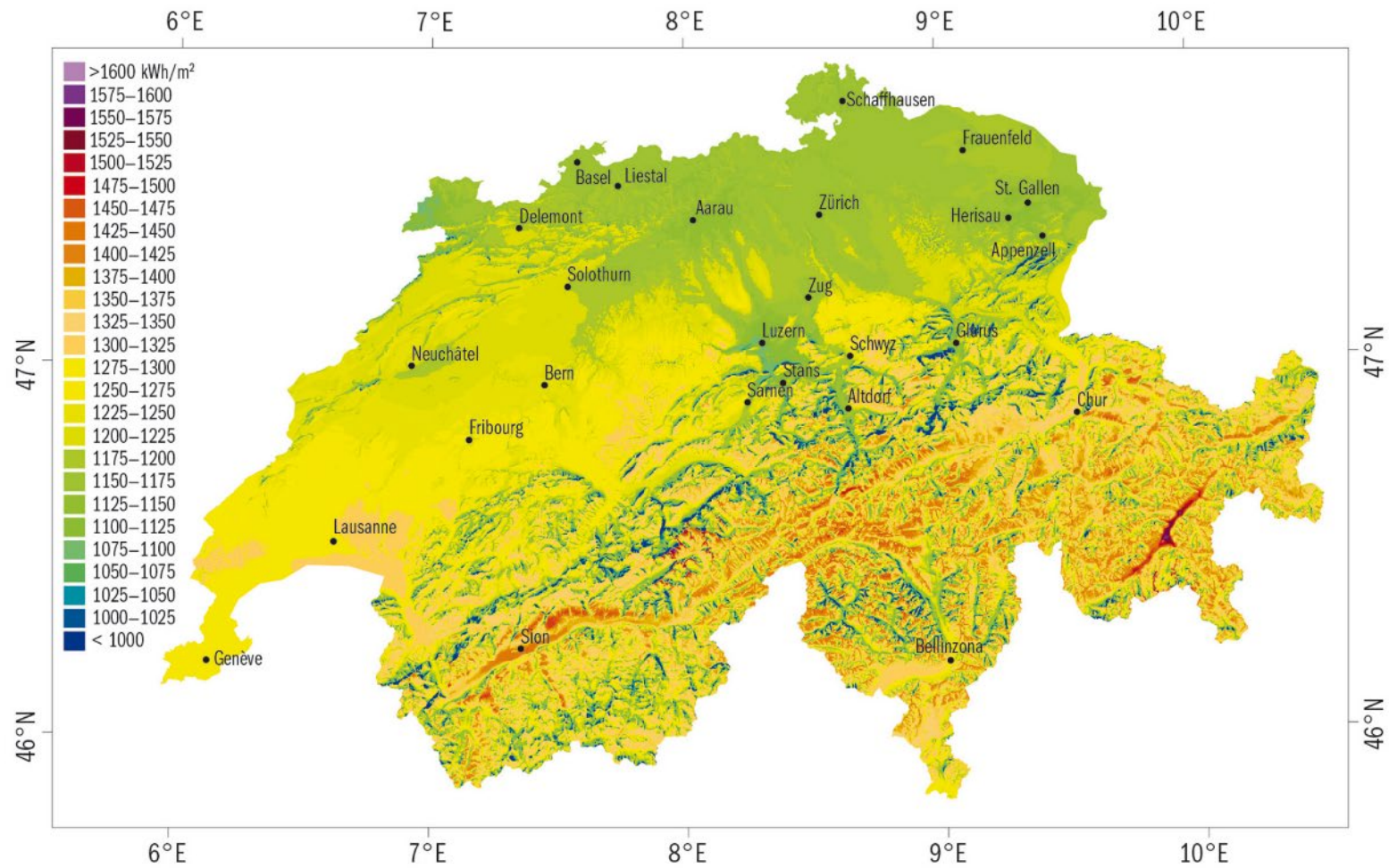
Sonnenstandsdiagramm



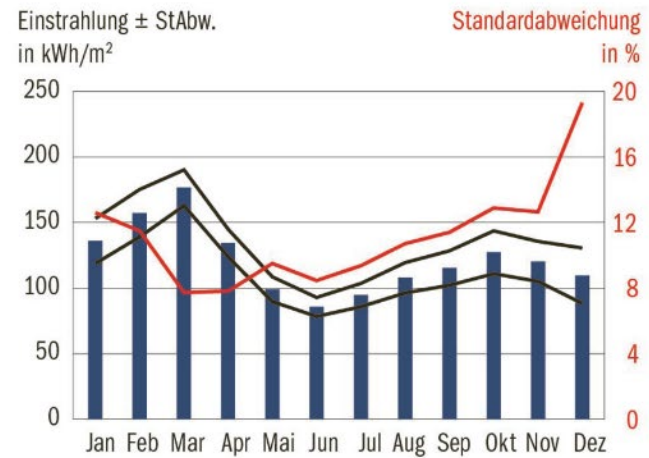
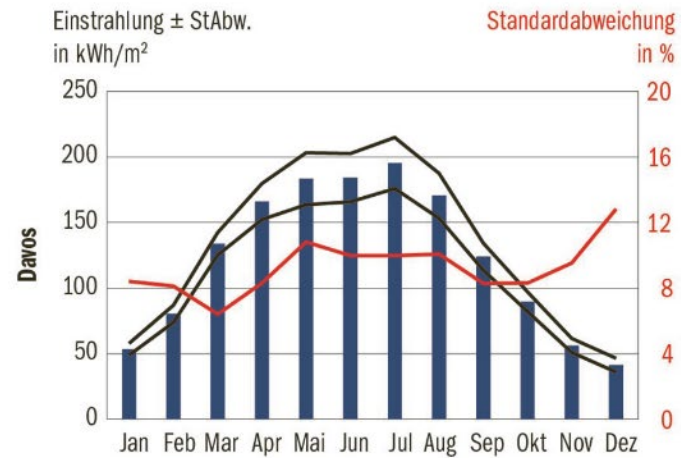
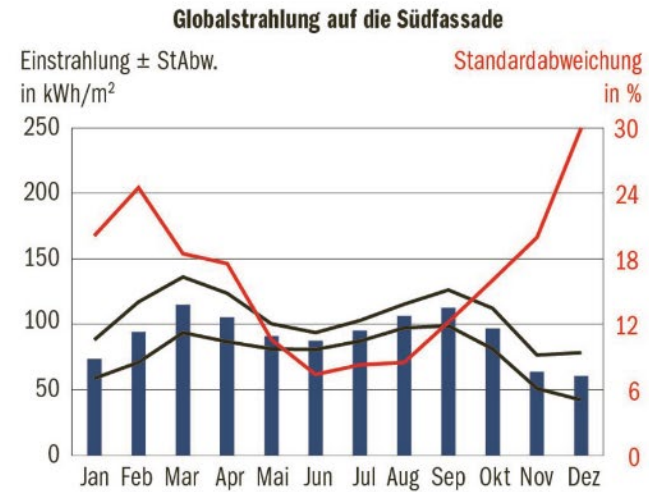
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

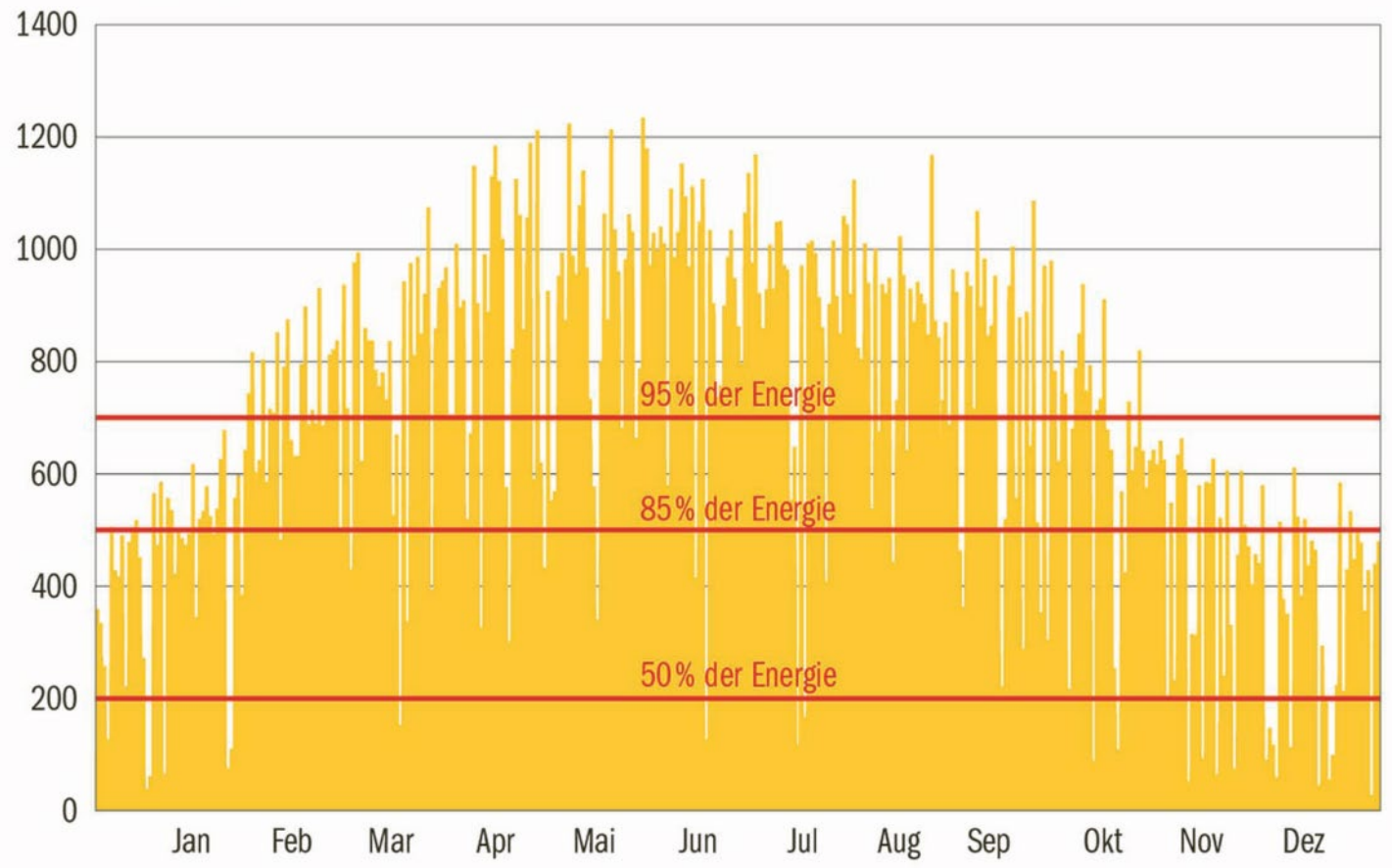


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



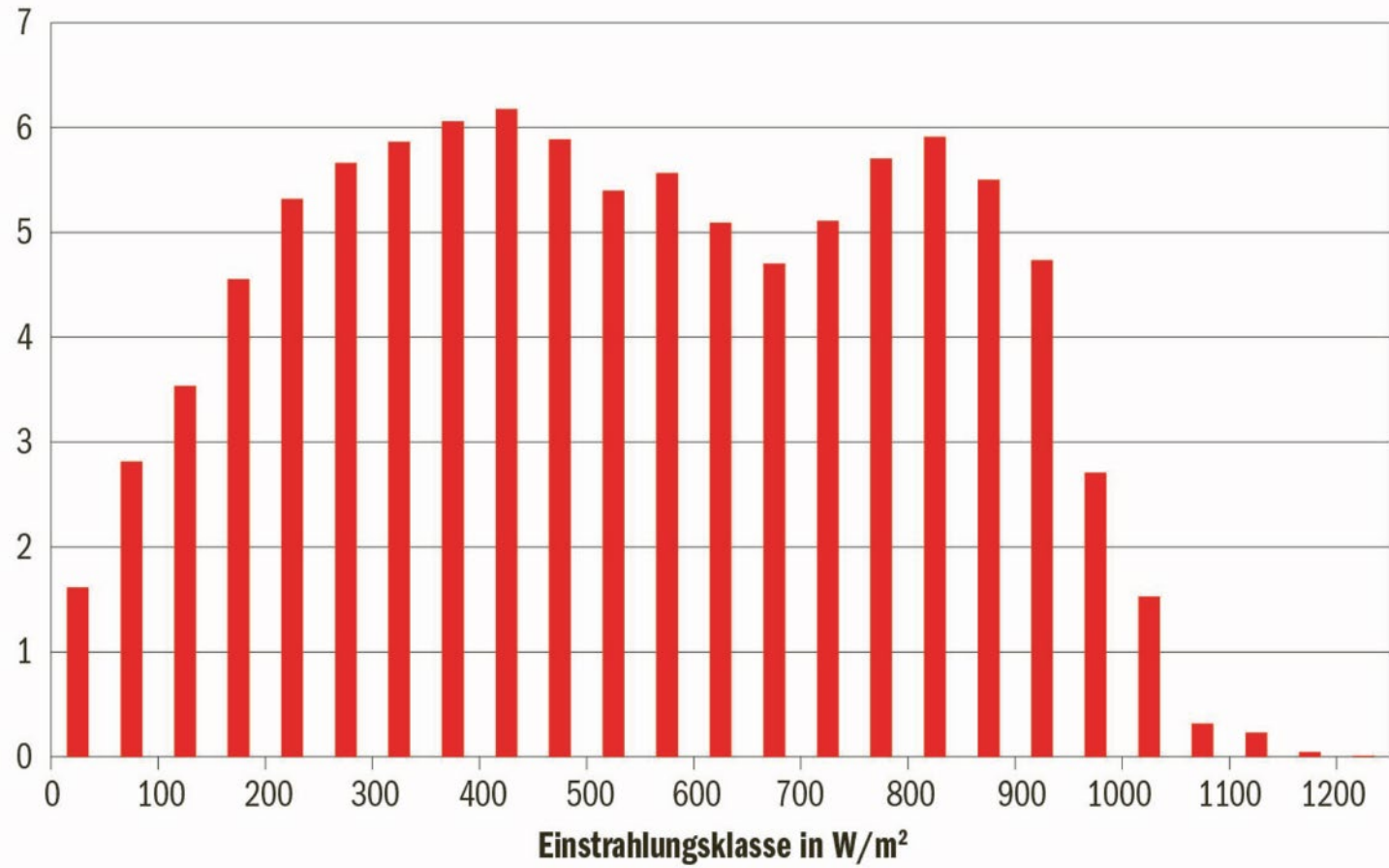
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Einstrahlung in W/m²



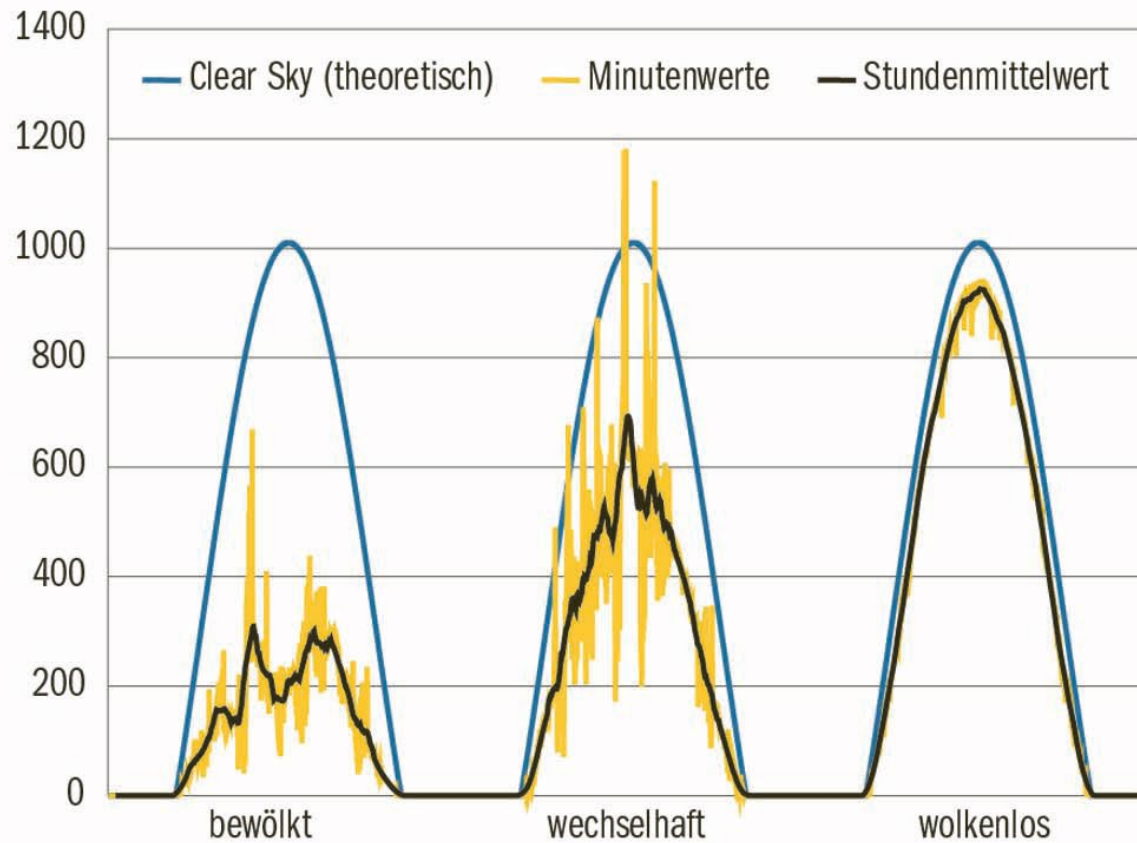
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Anteil an der Jahreseinstrahlung in %



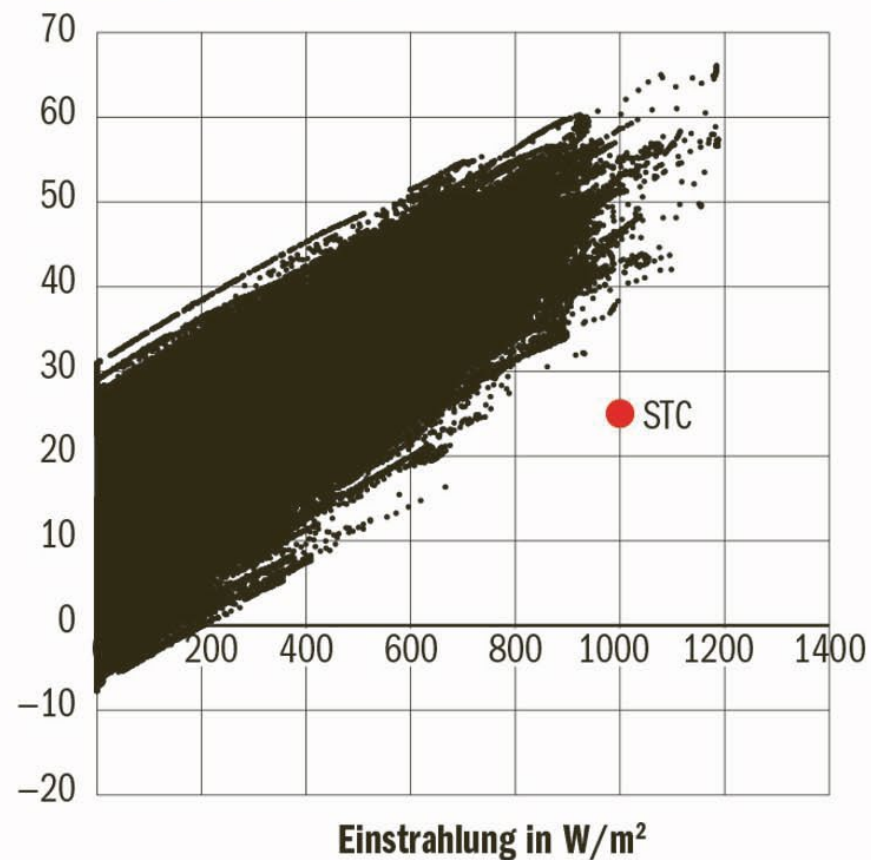
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

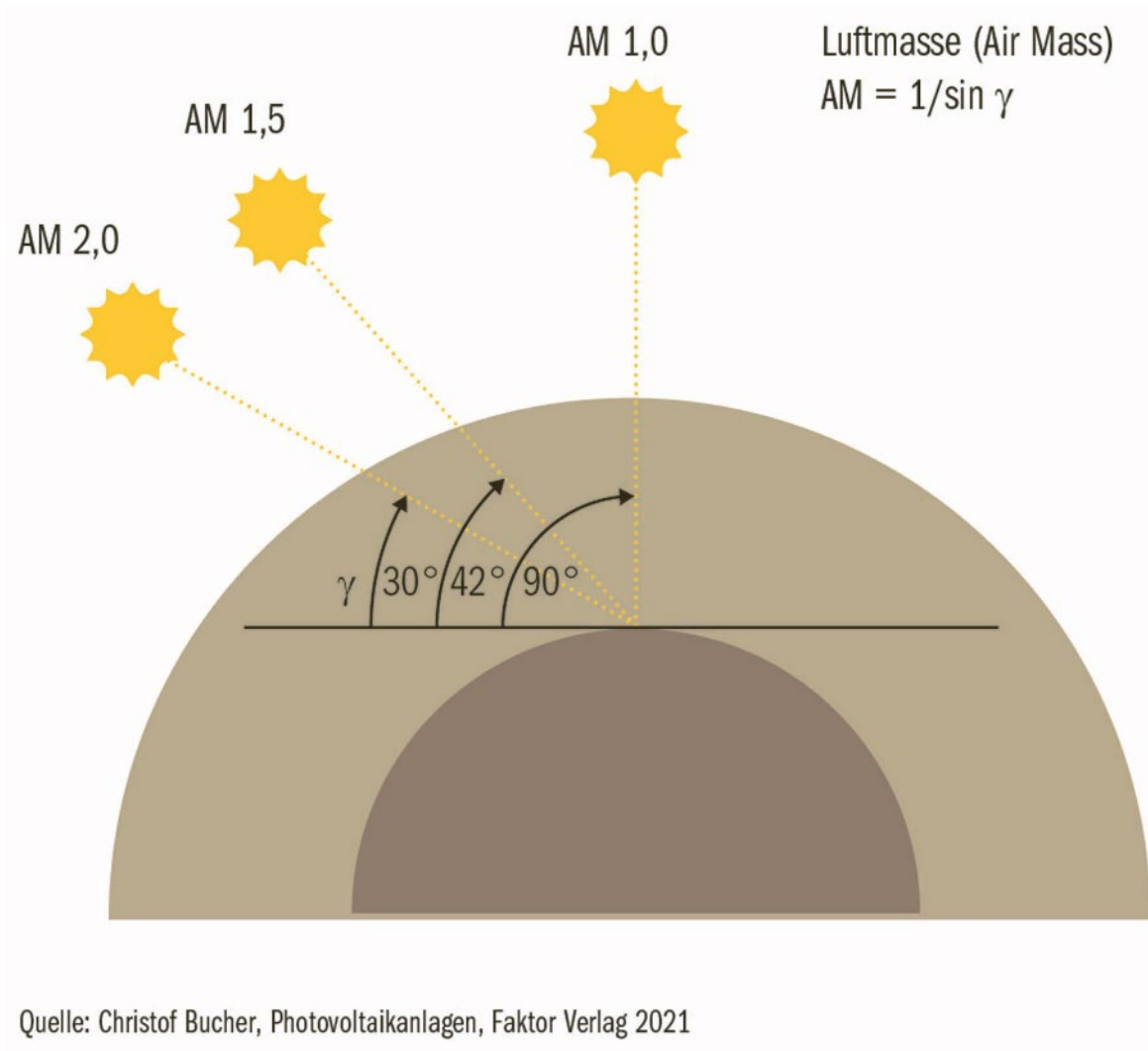
Globalstrahlung Gh in W/m²



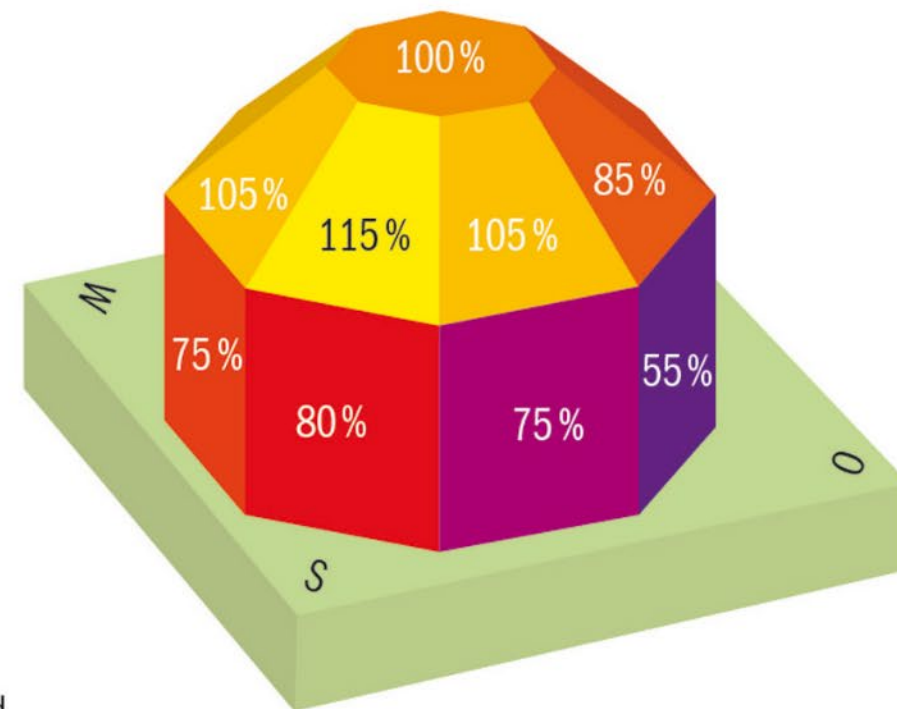
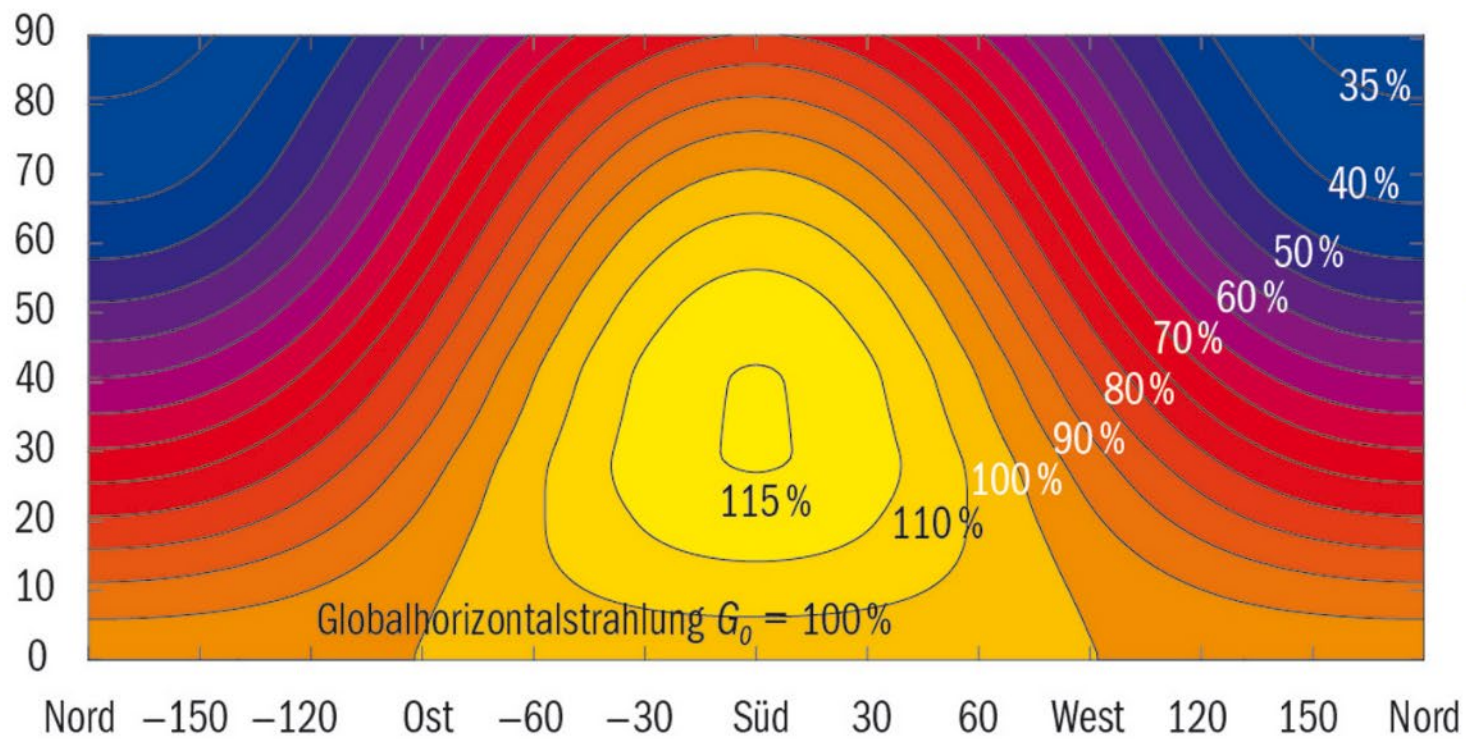
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Zelltemperatur in °C



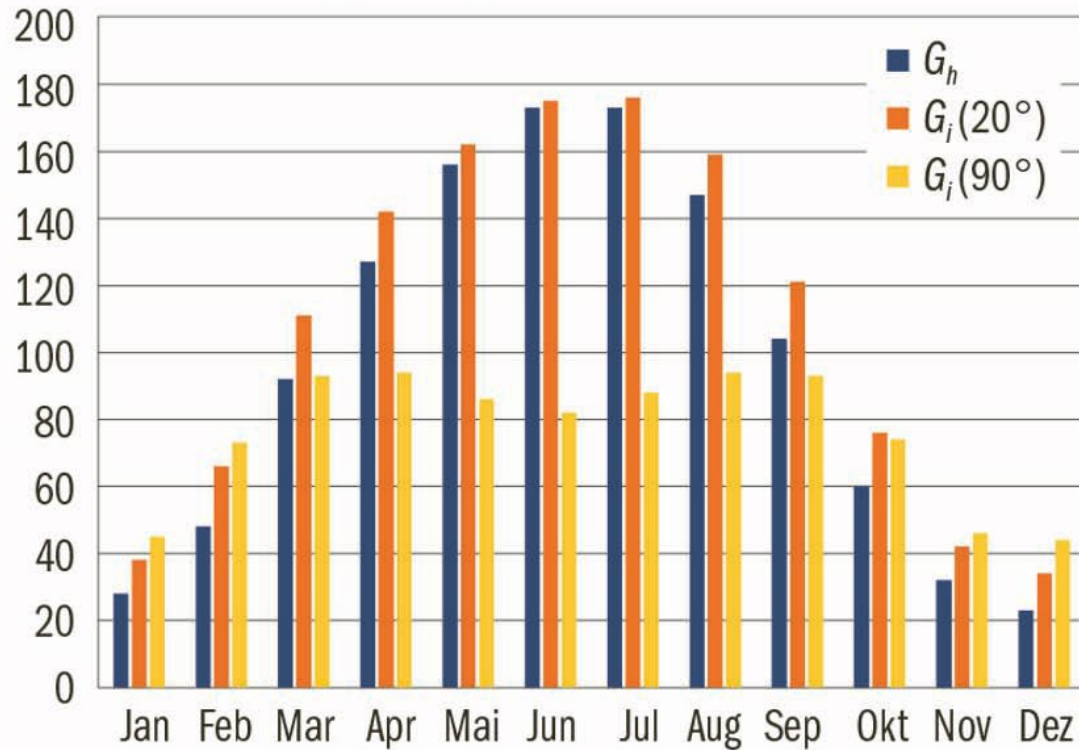


Neigungswinkel in Grad

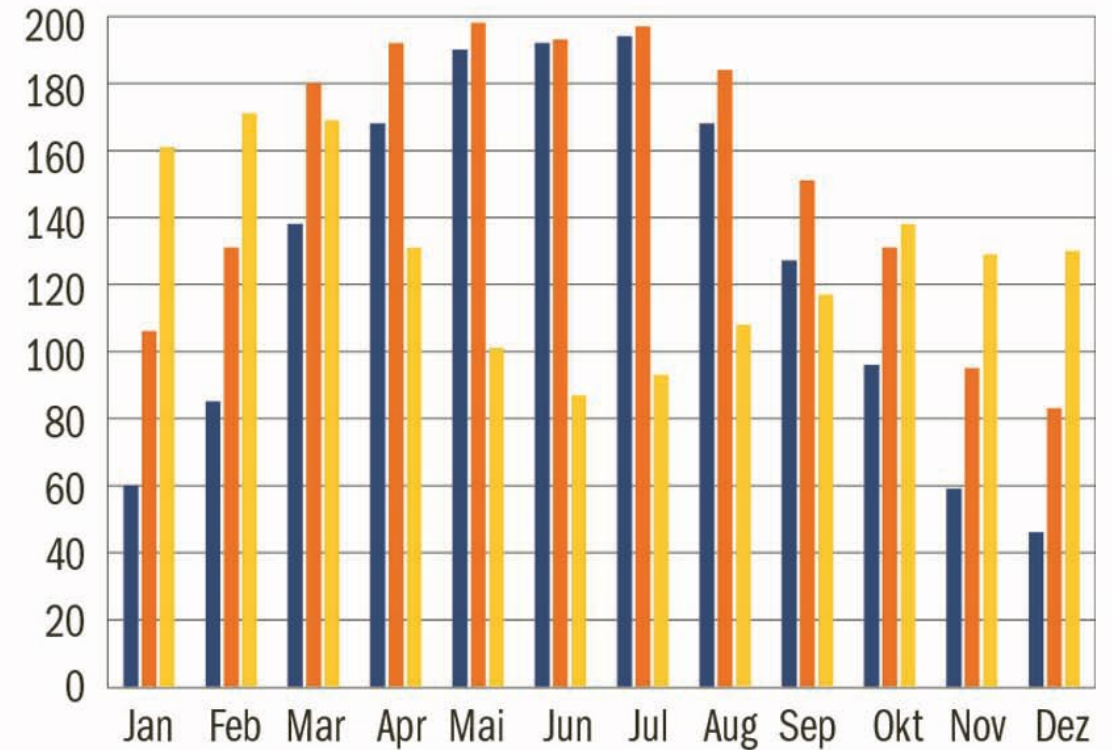


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

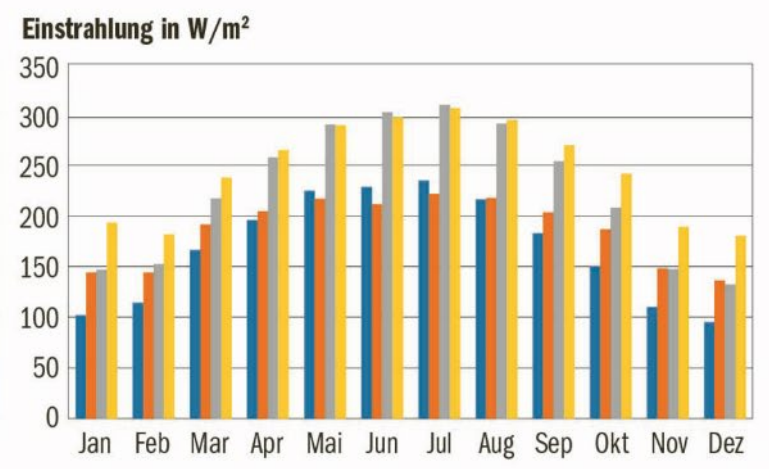
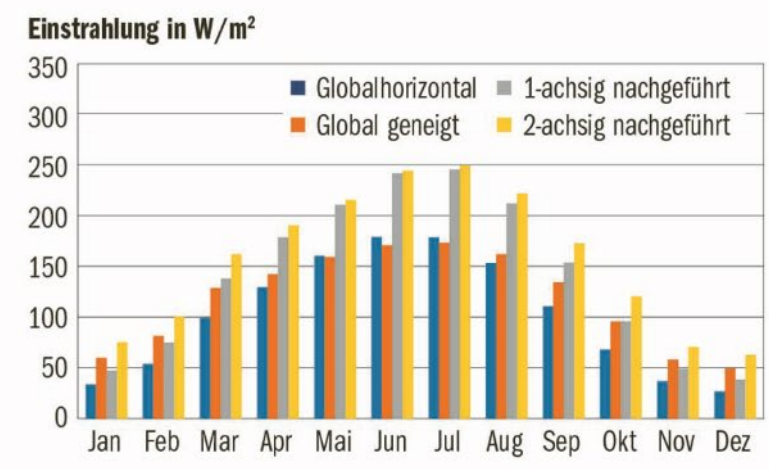
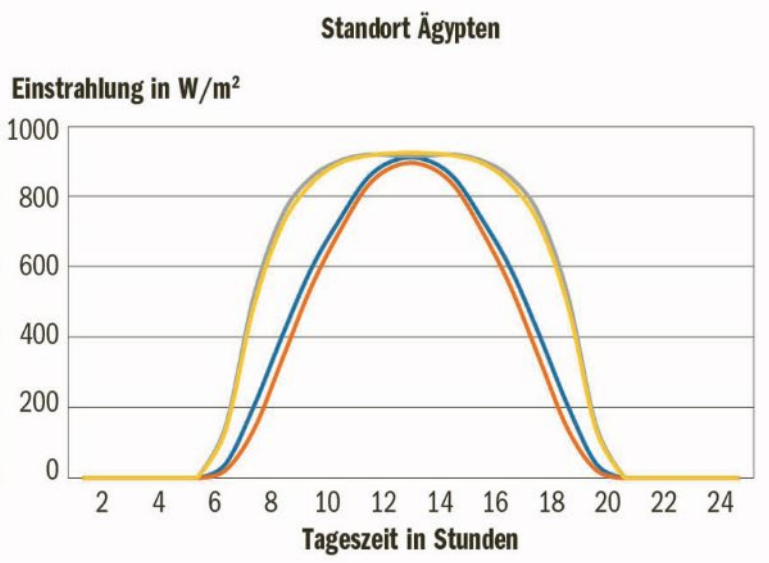
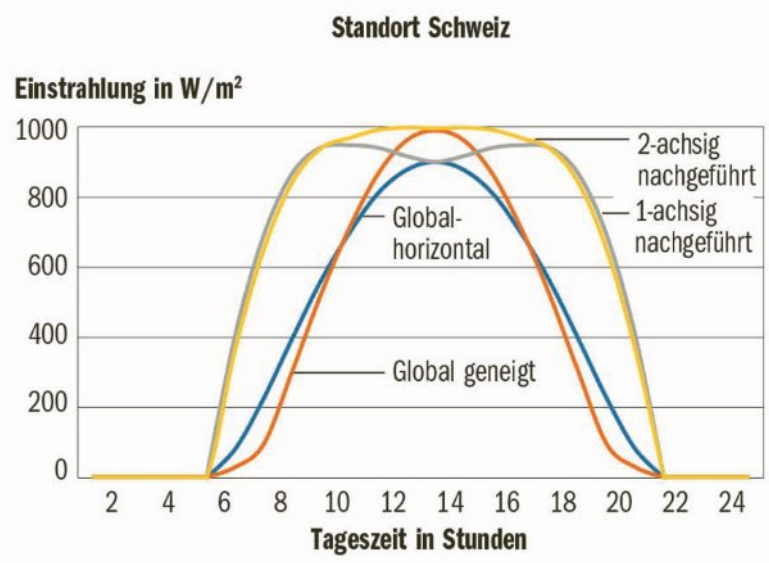
Olten: Globalstrahlung in kWh/m²



Davos: Globalstrahlung in kWh/m²



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

90	Globalstrahlung Ebene um 20° nach Süden geneigt in kWh/m ² nach Himmelssektor (Bern, 1408 kWh/m ² /Jahr)																																					
80	0	0,2	0,4	0,5	0,5	0,6	0,3	0,5	0,5	0,3	0,5	0,5	0,5	0,6	0,6	0,6	0,8	0,5	0,5	0,8	0,6	0,6	0,6	0,5	0,5	0,5	0,3	0,5	0,5	0,3	0,6	0,5	0,5	0,4	0,2	0	17	
70	1,3	0,9	1,1	0,9	1,1	1,1	1,1	1,2	1,1	1,5	1,3	1,8	1,8	3,6	4,9	6,6	6,9	7,3	7,3	6,9	6,6	4,9	3,6	1,8	1,8	1,3	1,5	1,1	1,2	1,1	1,1	1,1	0,9	1,1	0,9	1,3	91	
60	1,3	1,4	1,1	1,2	1,2	1,3	1,3	1,6	2,5	3,9	5,7	7,2	8,1	9,7	10	10	10	10	10	10	10	10	10	9,7	8,1	7,2	5,7	3,9	2,5	1,6	1,3	1,3	1,2	1,2	1,1	1,4	1,3	176
50	1,7	1,4	1,2	1,3	1,3	1,4	1,5	2,6	4,2	6	8,3	10	11	12	13	13	13	13	13	13	13	13	12	11	10	8,3	6	4,2	2,6	1,5	1,4	1,3	1,3	1,2	1,4	1,7	232	
40	0,7	1,1	1,1	1,1	1,1	1,3	2	3,4	5,4	7,5	10	12	13	14	15	15	16	16	16	16	15	15	14	13	12	10	7,5	5,4	3,4	2	1,3	1,1	1,1	1,1	1,1	1,1	0,7	268
30	0,8	0,7	0,8	0,8	0,9	1,2	2,1	3,7	5,7	8	11	12	13	14	14	14	13	13	13	13	14	14	14	13	12	11	8	5,7	3,7	2,1	1,2	0,9	0,8	0,8	0,7	0,8	256	
20	0,2	0,4	0,5	0,5	0,5	0,9	1,8	3,4	5,4	7,4	8,9	9,8	10	10	10	10	10	10	10	10	10	10	10	9,8	8,9	7,4	5,4	3,4	1,8	0,9	0,5	0,5	0,5	0,4	0,2	201		
10	0	0,1	0,1	0,1	0,2	0,3	1,1	3,2	4,7	5,5	5,8	5,8	6,1	7,5	7,5	7,3	6,7	6,6	6,6	6,7	7,3	7,5	7,5	6,1	5,8	5,2	5,5	4,7	3,2	1,1	0,3	0,2	0,1	0,1	0,1	0	136	
0	0	0	0	0	0	0,2	0,3	0,6	0,9	1,4	1,7	2,2	2,2	1,9	1,7	1,2	0,8	0,8	0,8	0,8	1,2	1,7	1,9	2,2	2,2	1,7	1,4	0,9	0,6	0,3	0,2	0	0	0	0	0	32	
von	-180	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170		
bis	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	1408	
	6	6	6	6	7	8	12	20	30	42	52	62	65	74	76	77	77	77	77	77	77	76	74	65	62	52	42	30	20	12	8	7	6	6	6	6	1408	

90	Globalstrahlung Südfassade in kWh/m ² nach Himmelssektor (Bern, 1016 kWh/m ² /Jahr)																																									
80	0	0	0	0	0	0	0	0	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0	0	0	0	0	0	0	0	0	0	0	0	0	4			
70	0	0	0	0	0	0	0	0	0,4	0,5	0,7	0,7	1,8	2,5	3,7	4	4,2	4,2	4	3,7	2,5	1,8	0,7	0,7	0,5	0,4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	
60	0	0	0	0	0	0	0	0	1,6	2,7	3,8	4,4	5,9	6,6	7	7,3	7,4	7,4	7,3	7	6,6	5,9	4,4	3,8	2,7	1,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	
50	0	0	0	0	0	0	0	0	2,5	4	5,6	6,3	8,4	9,4	10	11	11	11	11	10	9,4	8,4	6,3	5,6	4	2,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	135
40	0	0	0	0	0	0	0	0	3,2	5,2	7,1	8,1	11	12	13	14	15	15	14	13	12	11	8,1	7,1	5,2	3,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	178
30	0	0	0	0	0	0	0	0	3,7	6	8,4	9,5	13	14	14	14	14	14	14	14	14	13	9,5	8,4	6	3,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	193
20	0	0	0	0	0	0	0	0	3,7	5,5	7,7	8,6	11	12	12	13	12	12	13	12	12	11	8,6	7,7	5,5	3,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	171
10	0	0	0	0	0	0	0	0	2,6	4,2	6,6	7,5	11	12	11	11	10	10	11	11	12	11	7,5	6,6	4,2	2,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151
0	0	0	0	0	0	0	0	0	1,7	2,7	3,9	4,1	4,2	3,6	3	2	1,8	1,8	2	3	3,6	4,2	4,1	3,9	2,7	1,7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54
von	-180	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170						
bis	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	1016					
	0	0	0	0	0	0	0	0	20	31	44	49	66	72	75	76	76	76	76	75	72	66	49	44	31	20	0	0	0	0	0	0	0	0	0	0	0	0	0	1016		

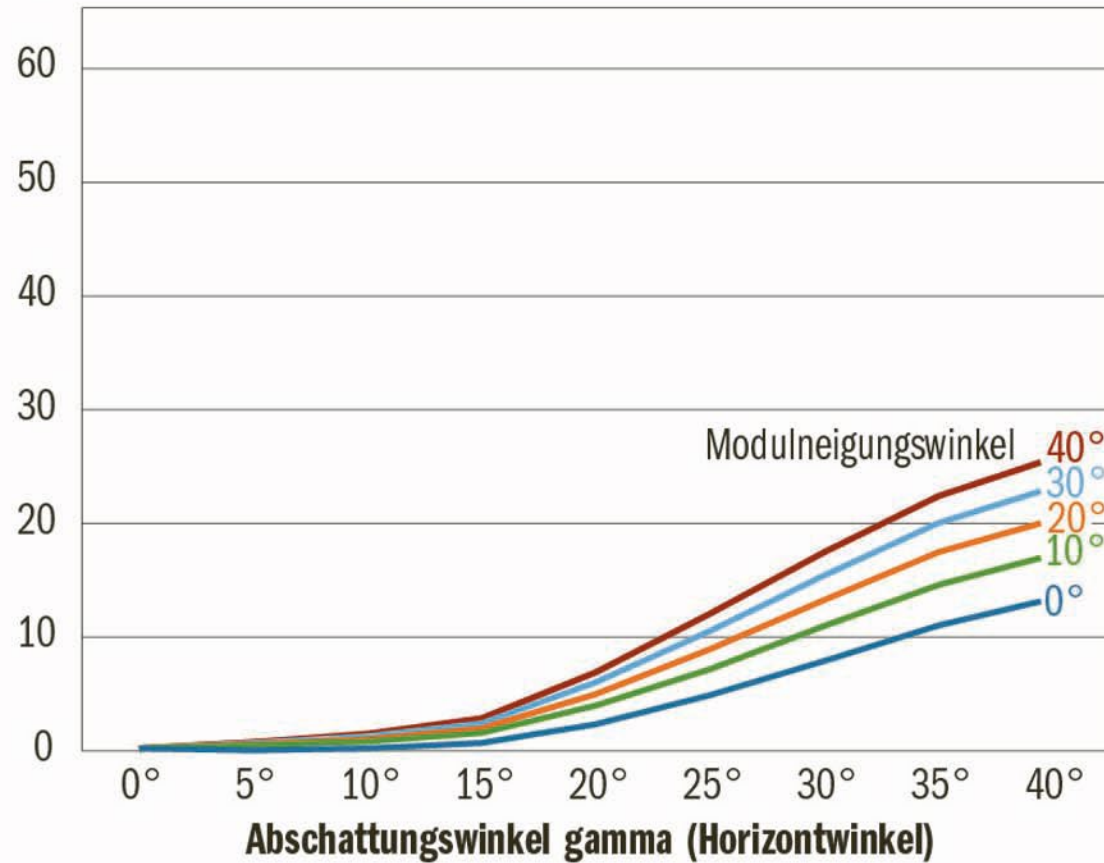
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

90	Globalstrahlung 20° nach Westen geneigt in kWh/m ² nach Himmelssektor (Bem, 1211 kWh/m ² /Jahr)																																				
80	0	0,3	0,3	0,2	0	0,2	0,2	0,2	0,4	0,4	0,4	0,4	0,4	0,2	0,4	0,2	0,4	0,7	0,7	0,7	0,7	0,7	0,4	0,4	0,7	0,7	0,7	0,9	1,1	0,9	0,9	0,7	0,7	0,4	0,3	0	17
70	0	0,4	0,5	0,2	0,2	0,2	0,5	0,5	0,6	0,6	0,9	0,9	1,1	2,1	3,2	4,7	5,4	6	6,1	6,2	6,4	5,1	4,1	2,5	2,2	2	2,2	2,2	2	2,2	2,2	1,7	2,1	2	2,2	83	
60	0,2	0,3	0,4	0,5	0,4	0,5	0,5	0,6	1,2	2,1	3,1	4,3	5,6	6,2	6,7	7,1	7,4	7,7	8,2	8,7	8,9	9,5	9,6	9,5	8,3	7,1	5,3	4,1	3,1	2,7	2,8	2,7	2,7	2,6	3,1	3,7	157
50	0,4	0,6	0,5	0,5	0,5	0,5	0,6	1,1	1,9	3	4,3	5,6	6,7	7,4	8	8,5	9	9,4	10	11	11	12	12	12	12	10	8,1	6,4	4,8	3,2	3,1	3,1	3,1	3	3,4	3,7	201
40	0,7	0,6	0,6	0,6	0,5	0,5	0,8	1,3	2,1	3,3	4,6	5,8	7	7,8	8,5	9,2	9,9	11	12	12	13	14	14	14	14	13	11	8,5	6,3	4,3	3,3	3,1	3	2,9	2,9	3	227
30	0,9	0,8	0,5	0,4	0,4	0,4	0,6	1,1	2	3,1	4,4	5,6	6,4	6,8	7,1	7,2	7,5	8	8,9	10	11	13	14	15	15	14	12	9,8	7,3	5	3,6	2,7	2,4	2,3	2	1,9	212
20	0,7	0,5	0,4	0,3	0,3	0,3	0,4	1	1,8	2,7	3,2	3,8	4	4,1	4,2	4,7	5,2	5,8	6,6	7,4	8,2	9,2	10	11	12	12	11	9,7	7,2	4,9	3,3	2,2	1,8	1,7	1,4	1,5	166
10	0,4	0,2	0,1	0,1	0,1	0,1	0,1	0,5	0,7	0,9	0,7	0,7	0,9	1,2	1,6	2,1	2,5	3,1	3,7	4,6	5,7	6,9	7,9	8	8,1	8,1	10	11	9	4,9	2	1,2	1	1	0,7	0,7	110
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0,2	0,2	0,4	1,1	1,6	2,2	3,1	3,4	3,4	3,6	4,3	3,6	3,1	2,7	1,8	0,7	0,4	0,3	0	36
von	-180	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	
bis	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	1211
	3	4	3	3	2	3	4	6	11	16	22	27	32	36	40	44	48	52	56	61	66	71	74	76	75	71	64	57	44	31	24	20	17	16	16	17	1211

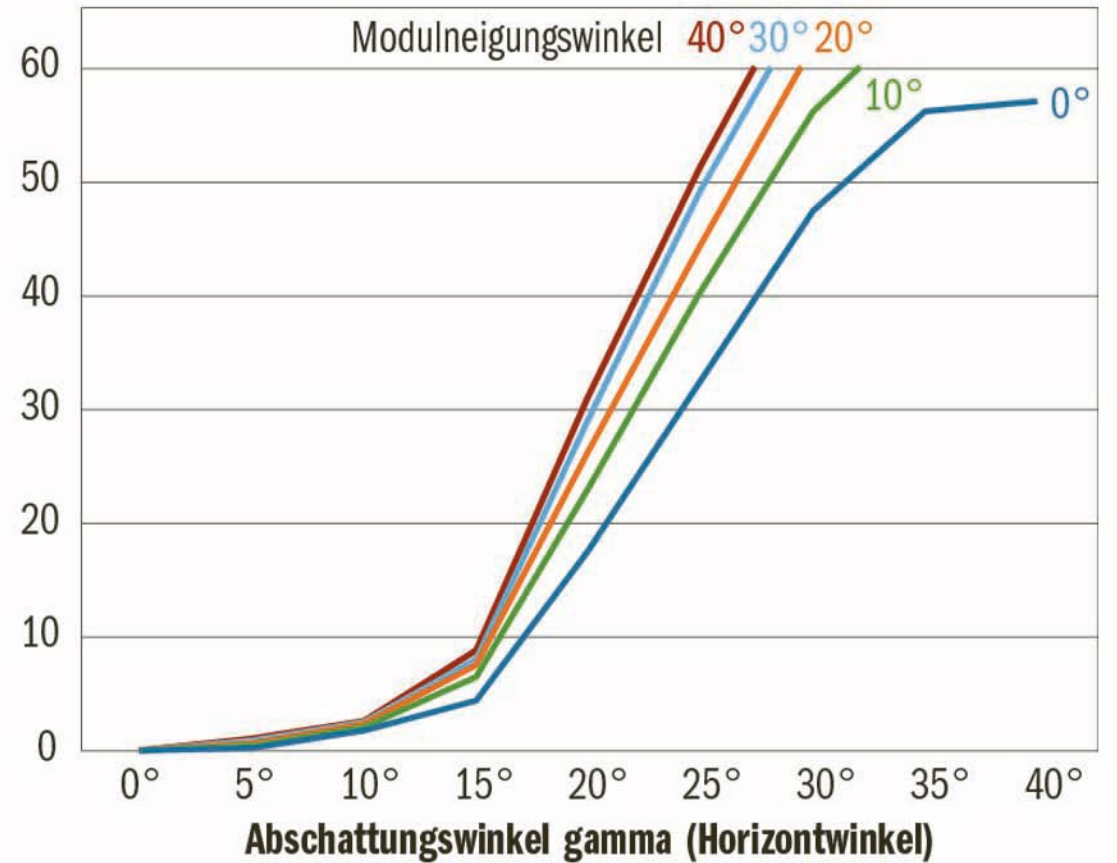
90	Globalstrahlung Westfassade in kWh/m ² nach Himmelssektor (Bern, 805 kWh/m ² /Jahr)																																					
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,2	0,2	0,5	0,5	0,2	0,2	0,2	0	0	0	0,5	0,5	0,5	0,5	0,7	0,2	0,3	0	6		
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,7	0,9	1,6	2,2	2,2	1,9	1,3	1,2	1,1	1,2	1,2	1,2	1,6	1,3	1,3	0,8	0,9	0,8	0,7	24		
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,4	1,9	2,7	3,8	4,9	5,8	6,4	6	5,2	4,4	3,3	2,6	2,3	2,1	1,9	1,8	1,3	1,2	1	60		
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,7	2,6	3,8	5,2	6,8	8	9,2	9,7	9,1	7,7	6,2	4,7	3,1	2,7	2,3	2,1	1,6	1,5	1	89		
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,2	3,4	5	6,7	8,9	10	12	13	13	12	9,5	7,4	5,1	3,2	2,6	2,4	1,8	1,5	1	121		
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3,2	5,2	7,6	10	12	14	16	16	15	13	10	7,1	4,5	2,6	2,3	1,7	1,2	0,7	144		
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,6	2,7	4,5	6,5	8,9	11	13	15	16	16	14	11	7,8	5	3	2	1,4	0,9	0,3	140		
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,8	1,7	3,5	6,1	8,9	11	13	13	14	17	18	16	9,4	4,2	2	1,5	1,3	0,7	0	142		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0,5	1,9	3,6	5,1	6,5	7,5	7,7	7,7	9,7	8,7	7,7	6,3	4,8	1,5	0,7	0,3	0	80		
von	-180	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170		
bis	-170	-160	-150	-140	-130	-120	-110	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	805	
	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	0	0	0	0	0	0	0	0	0	0	0	805

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

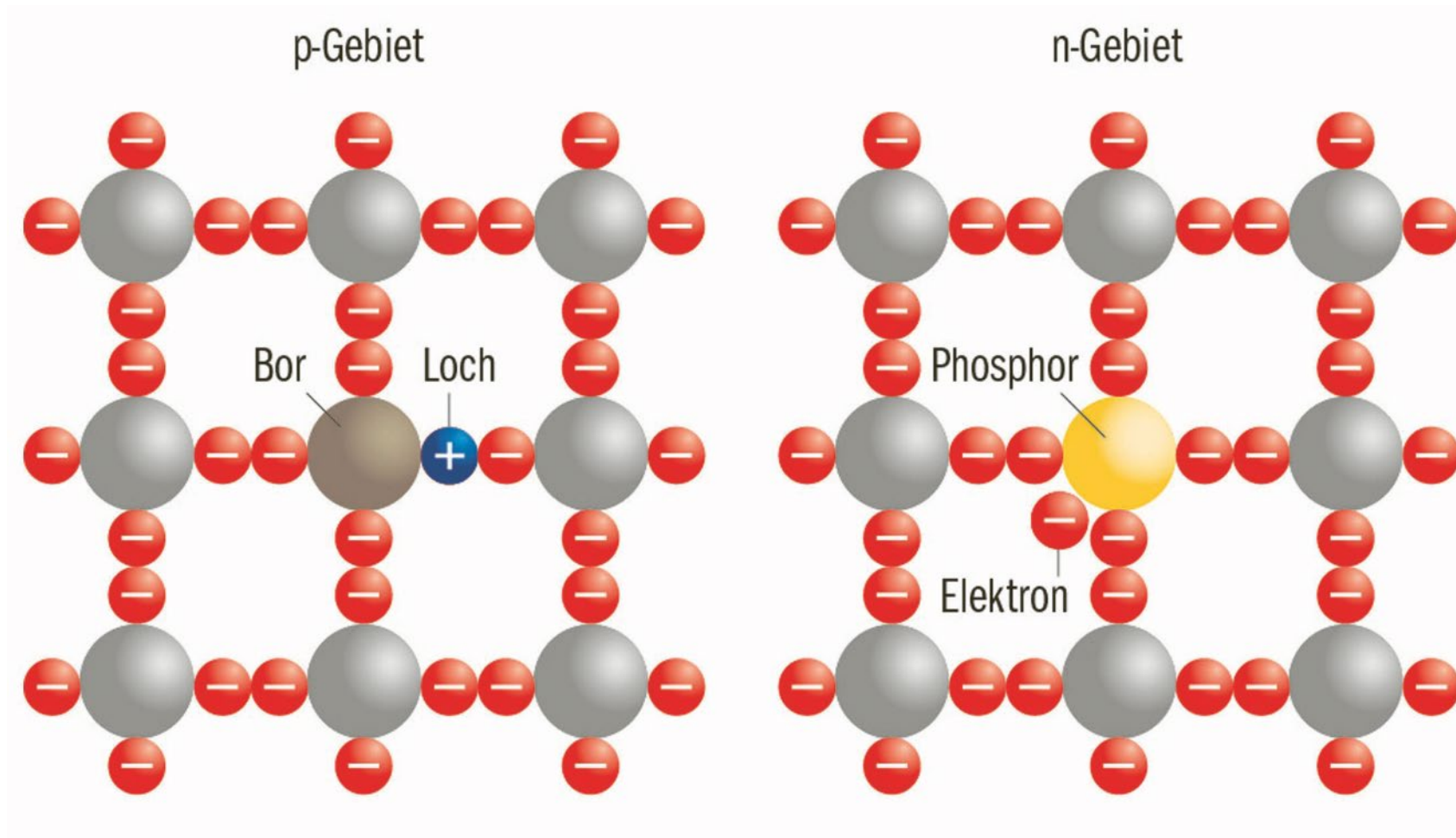
Jahresdurchschnitt: Ertragsverlust in %



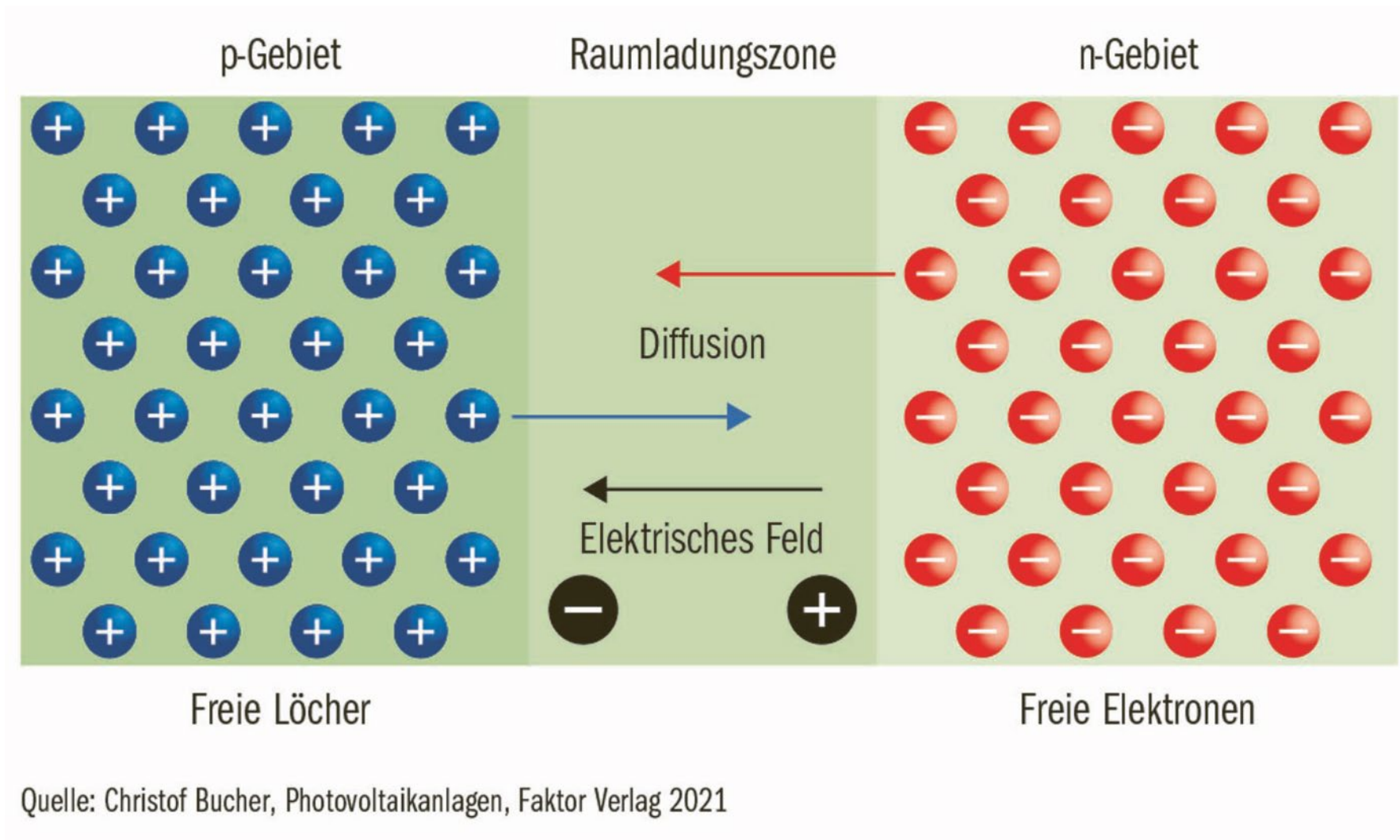
Wintermonate: Ertragsverlust in %

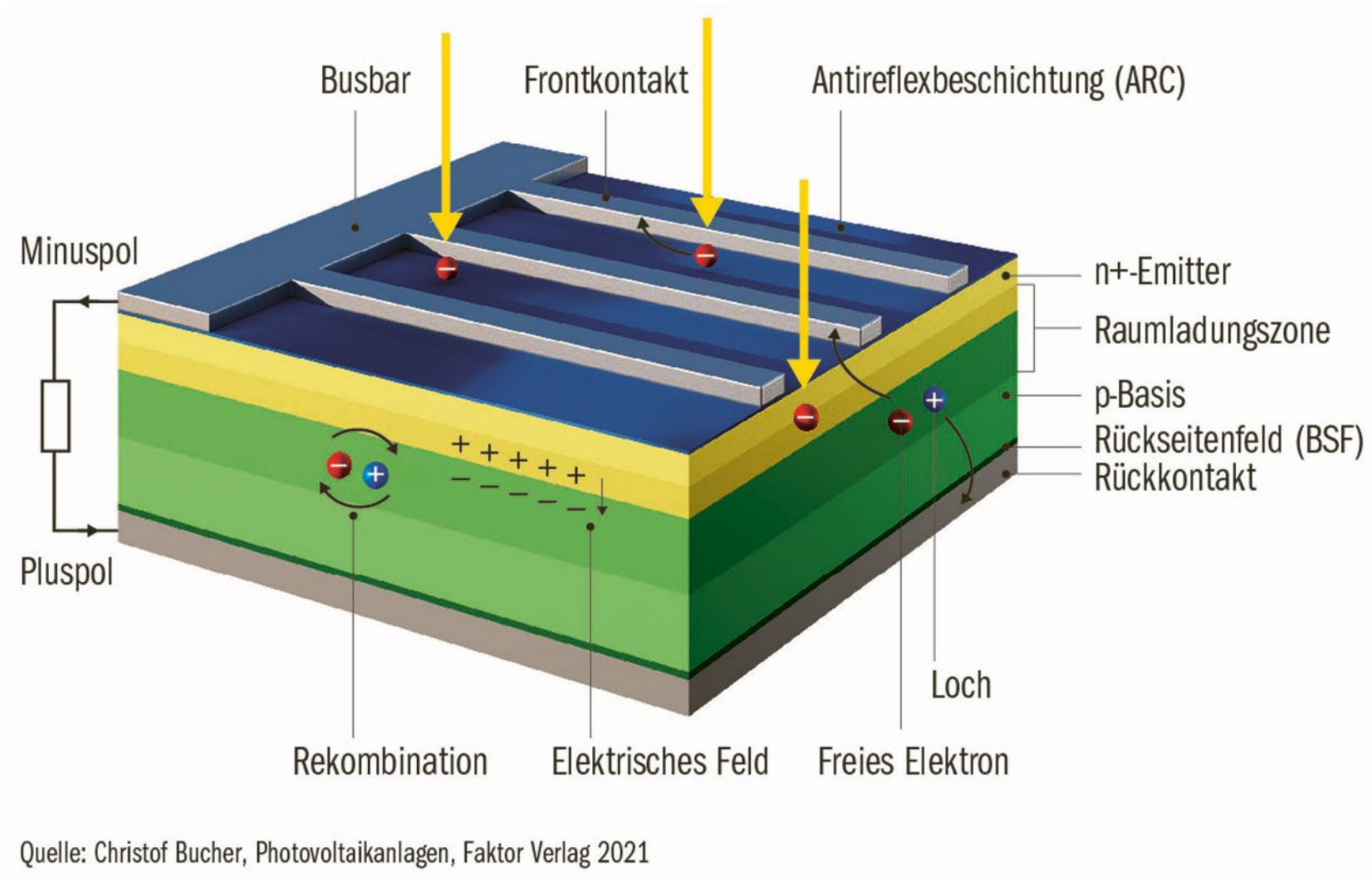


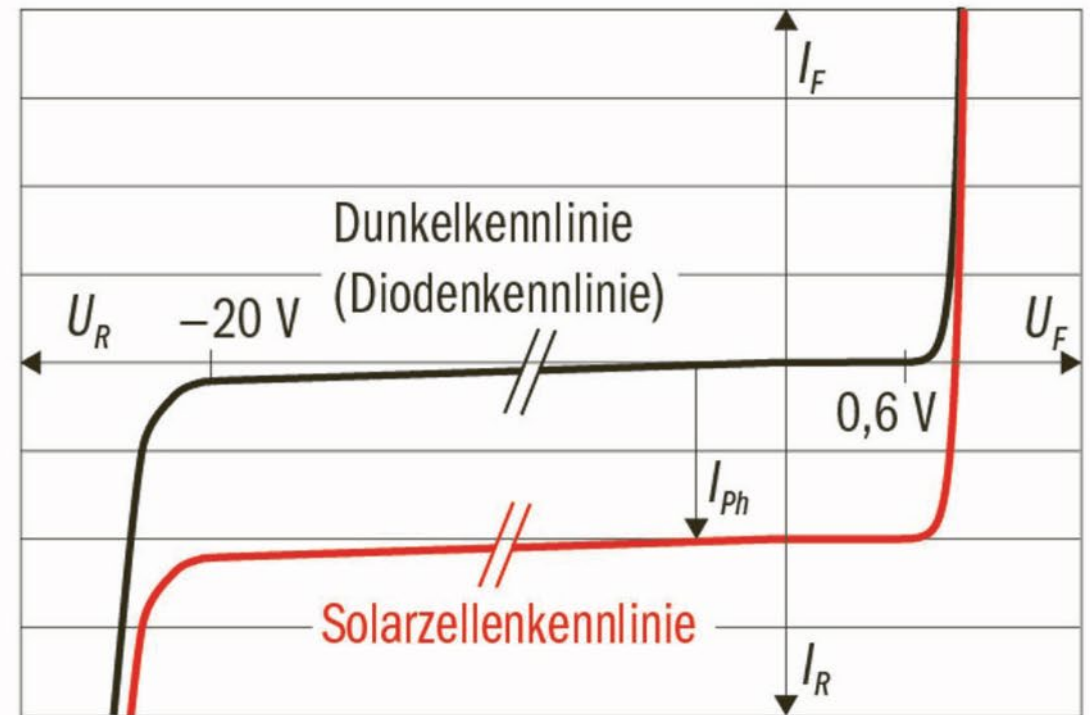
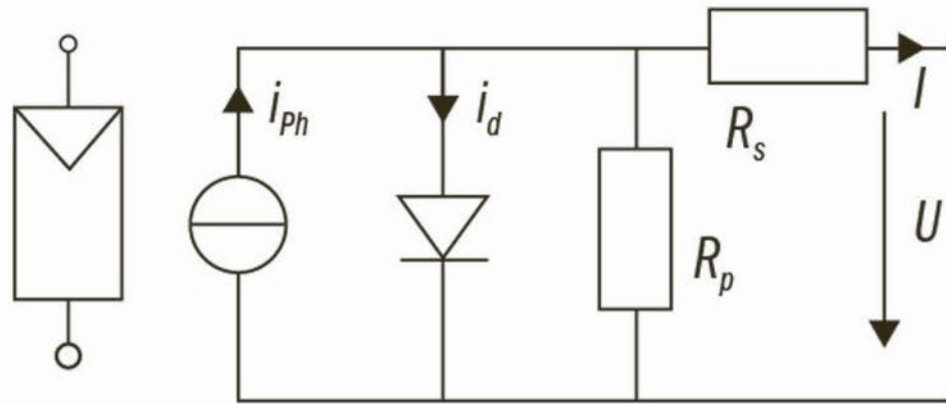
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



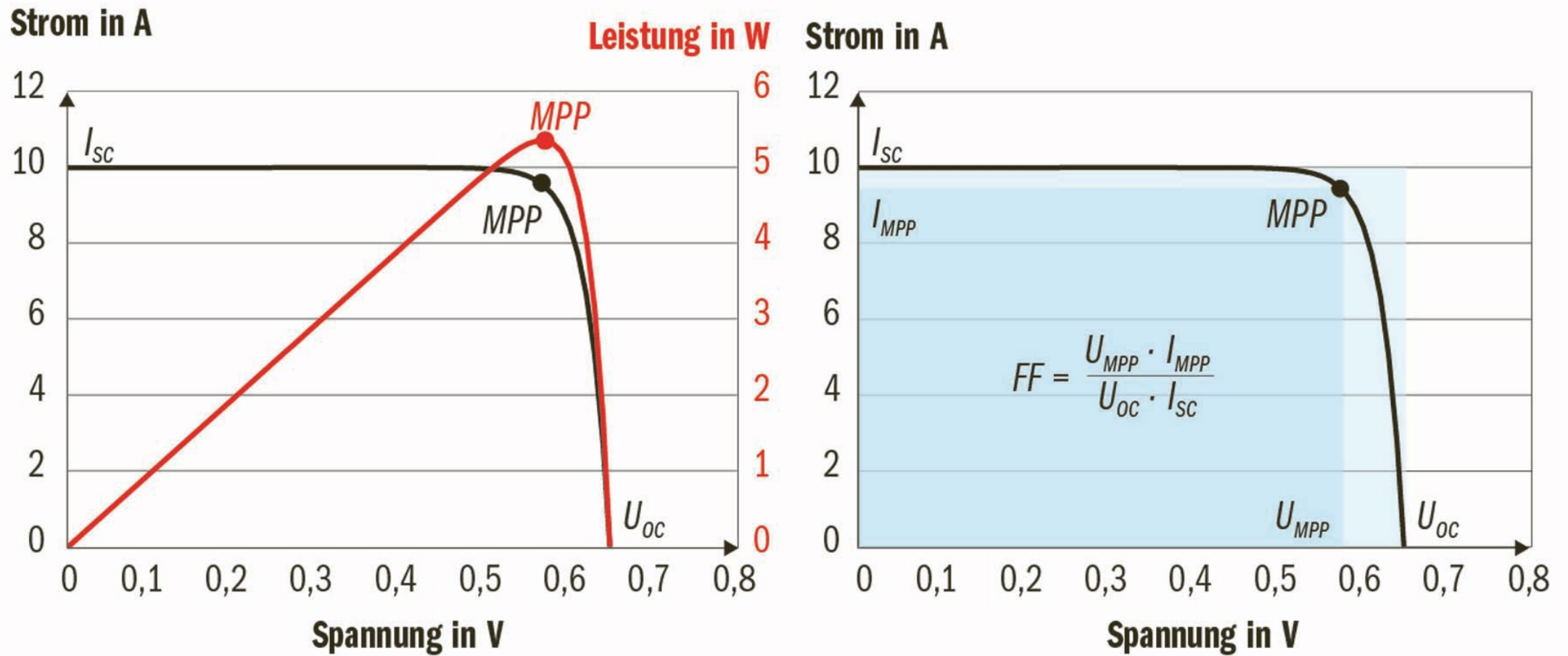
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



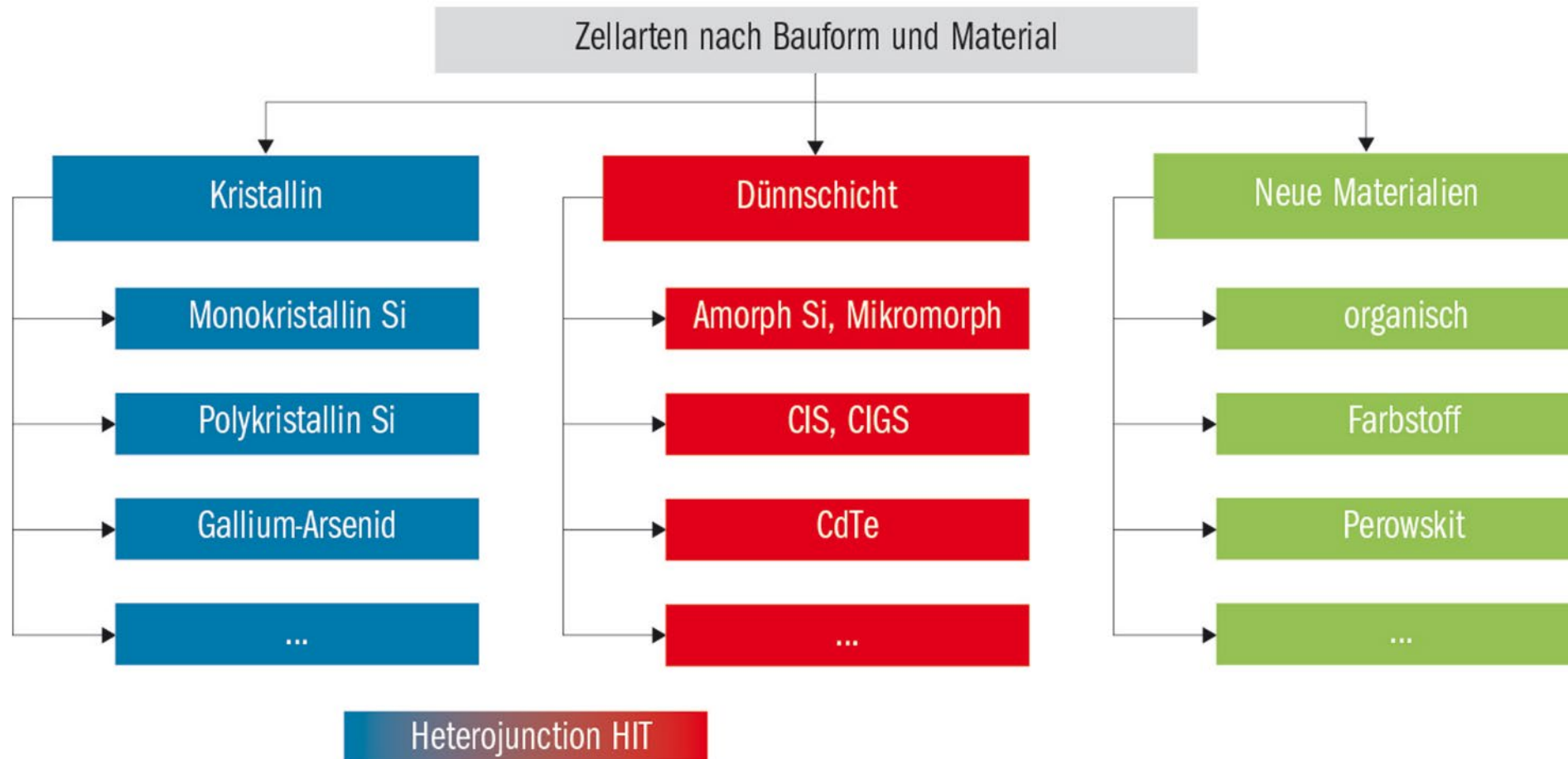




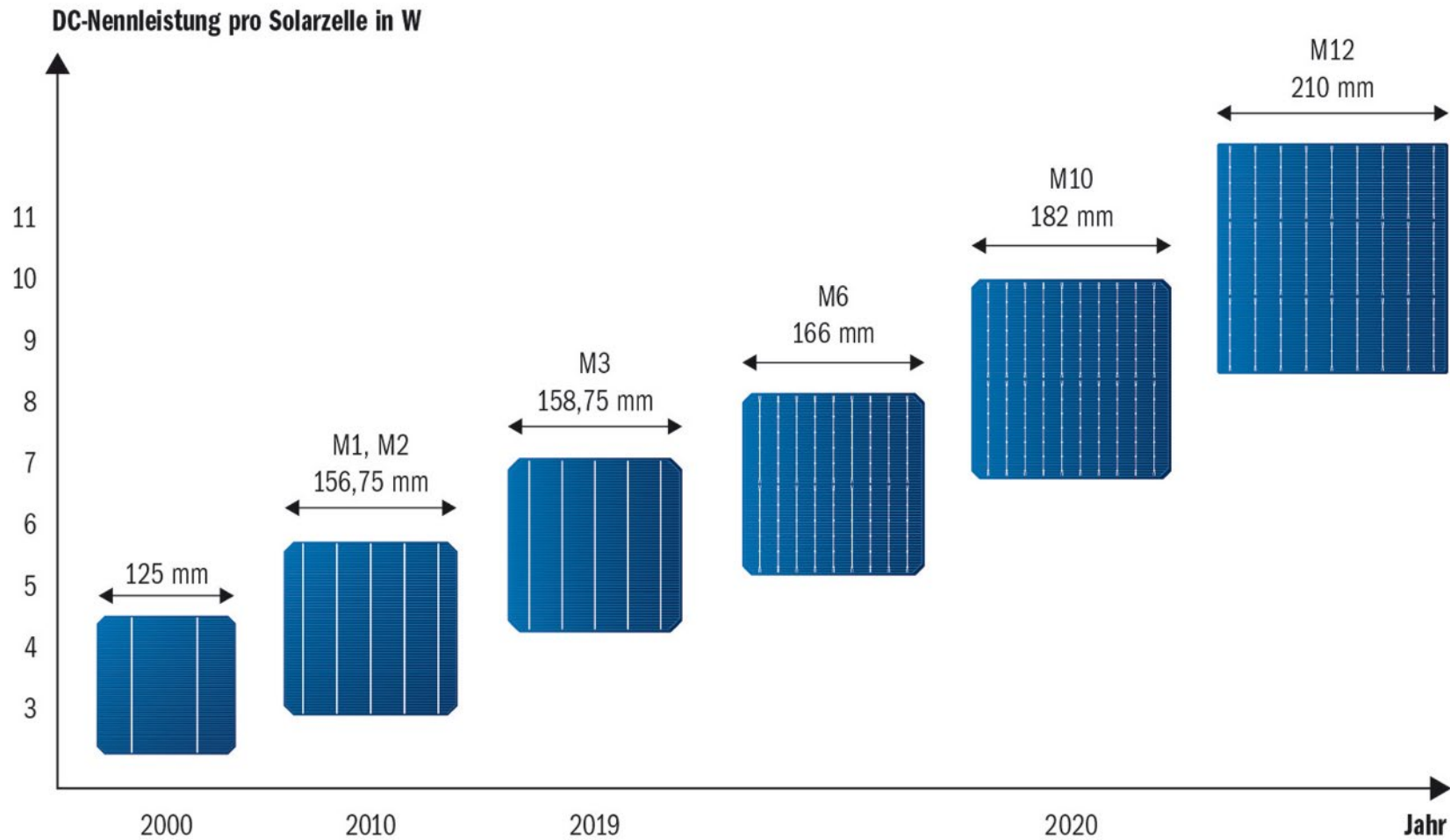
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



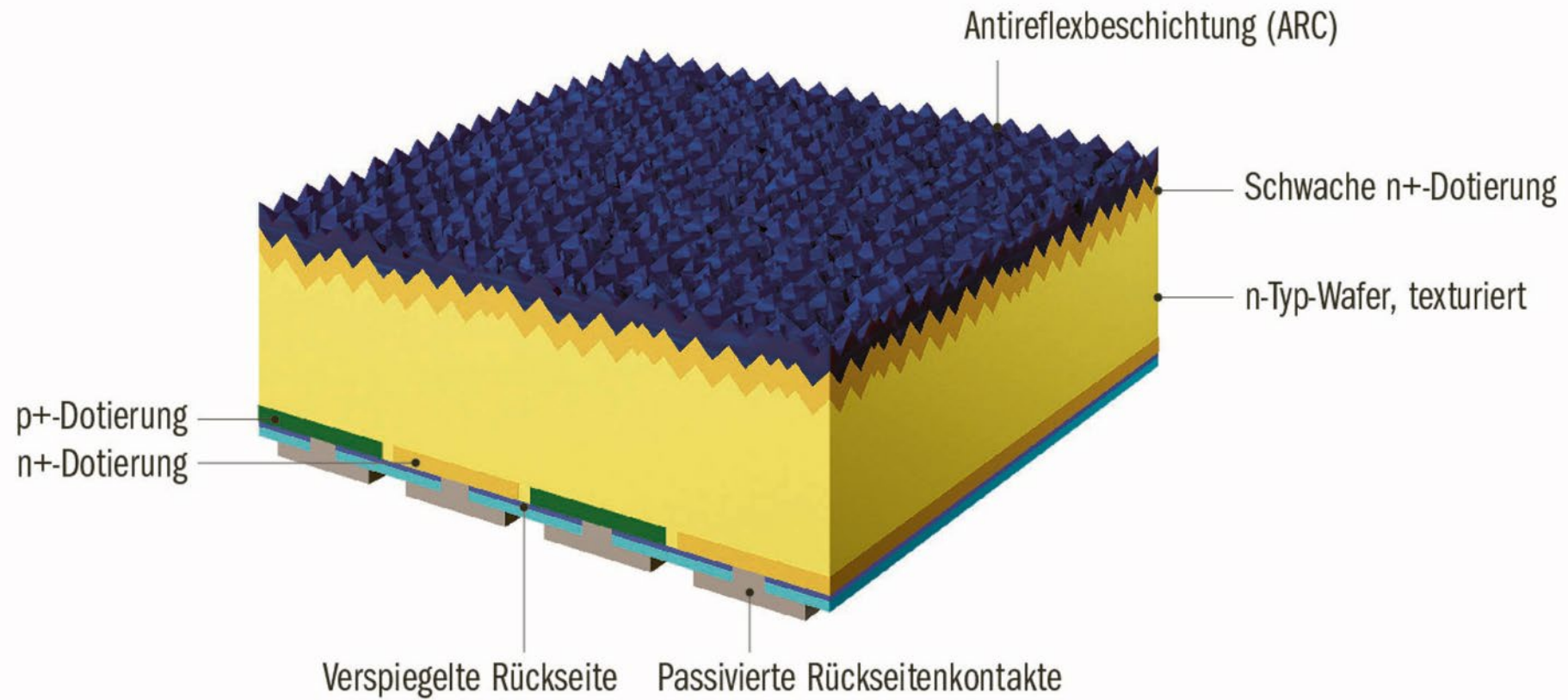
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



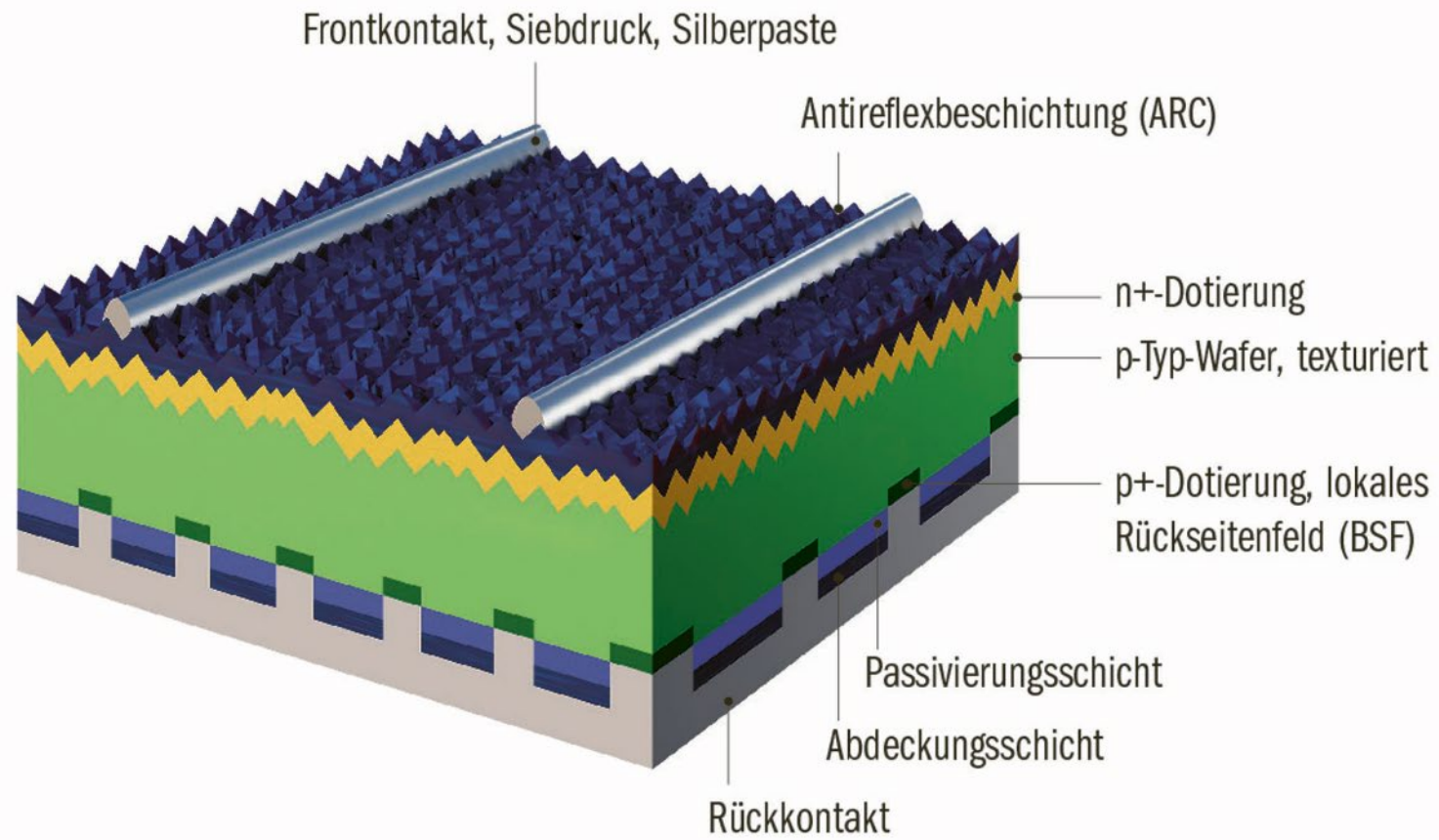
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



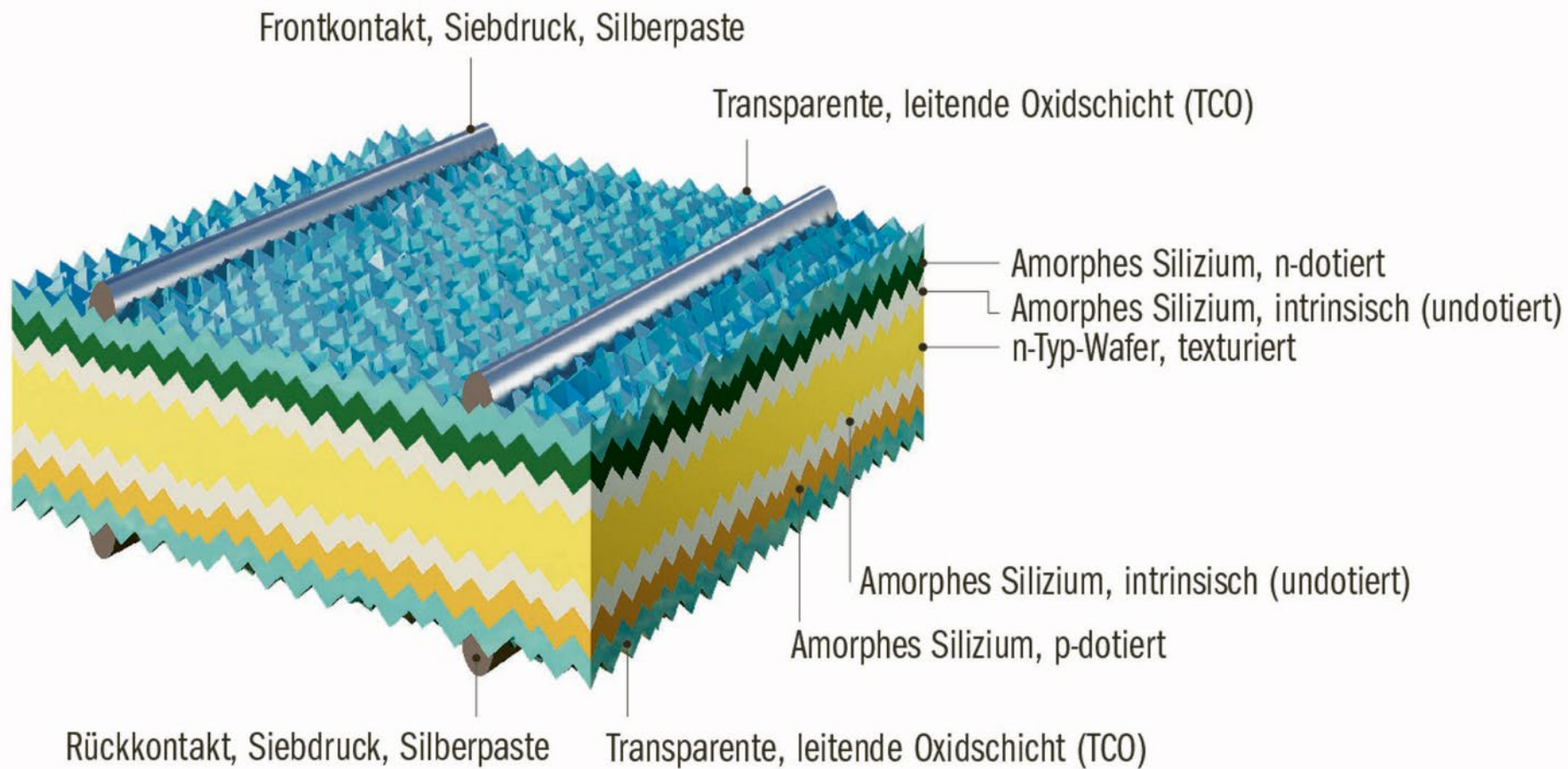
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



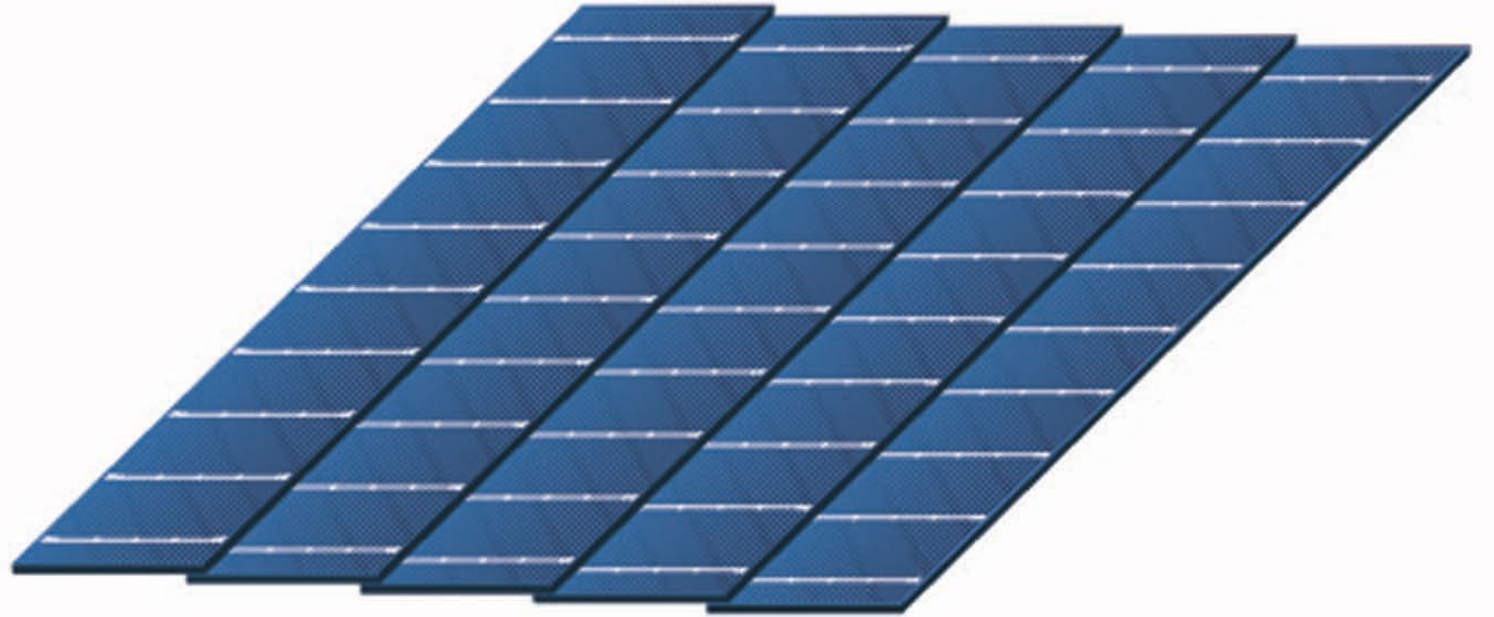
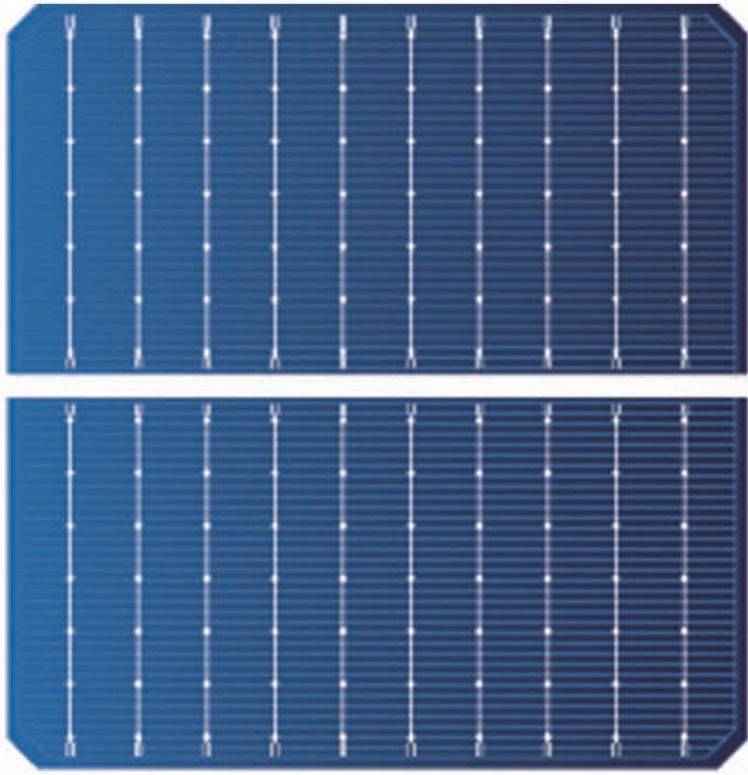
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



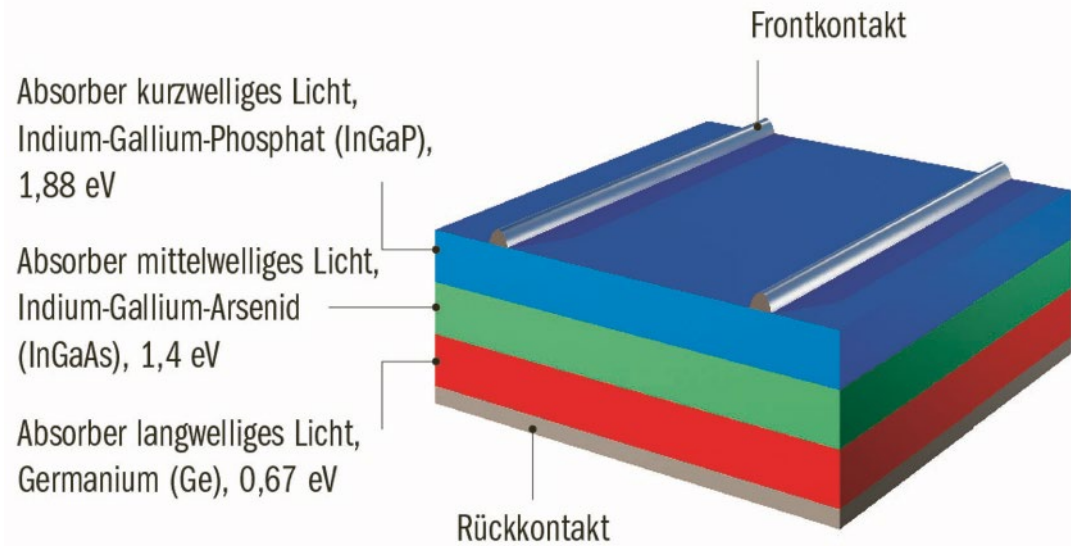
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



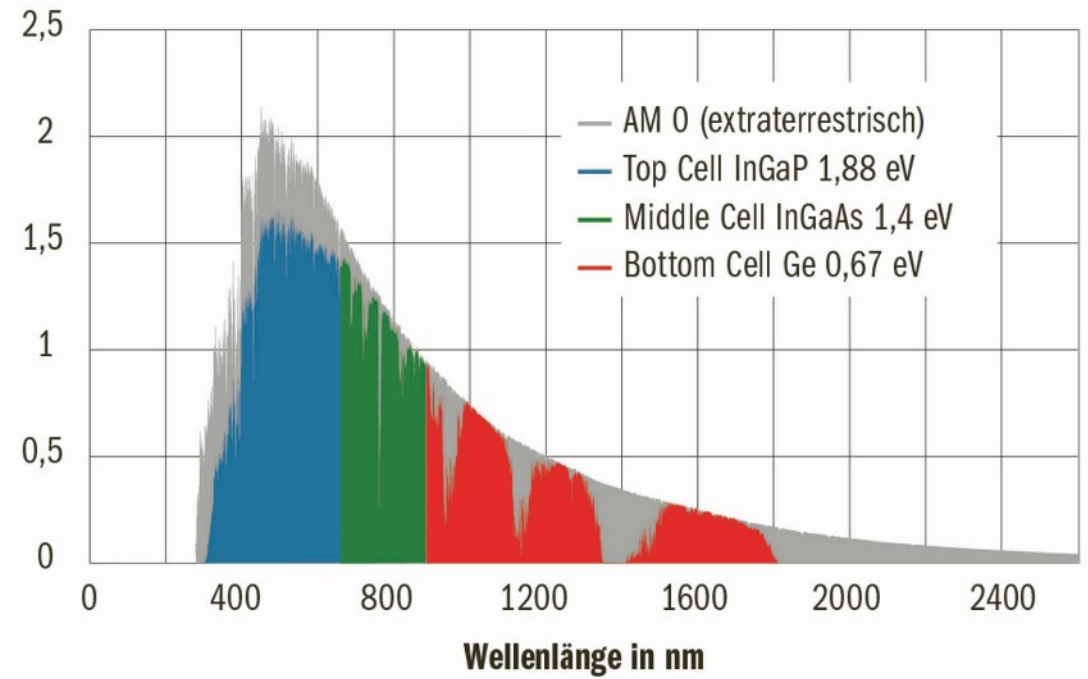
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

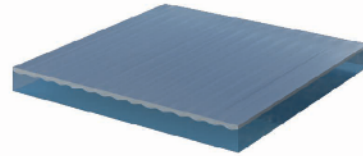


Einstrahlung in W/m²/nm

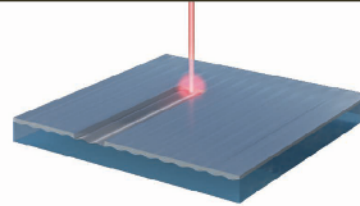


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

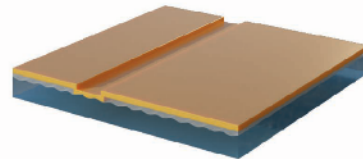
Die Herstellung von Dünnschichtmodulen



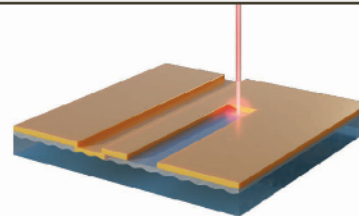
1 Auf ein geätztes Trägerglas wird der transparente, leitende Frontkontakt (TCO) aufgebracht.



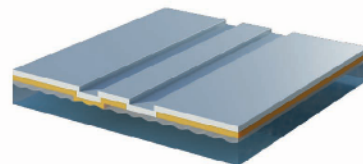
2 Mittels Laser wird das TCO in einzelne Zellen unterteilt.



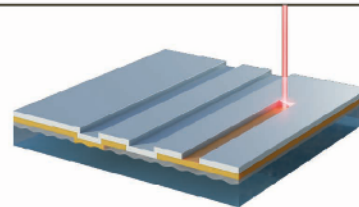
3 Die Zellschichten werden mit dem Verfahren «Plasma-Enhanced Chemical Vapour Deposition» (PECVD) auf das TCO abgeschieden.



4 Wiederum mit Laser werden die Zellschichten strukturiert.

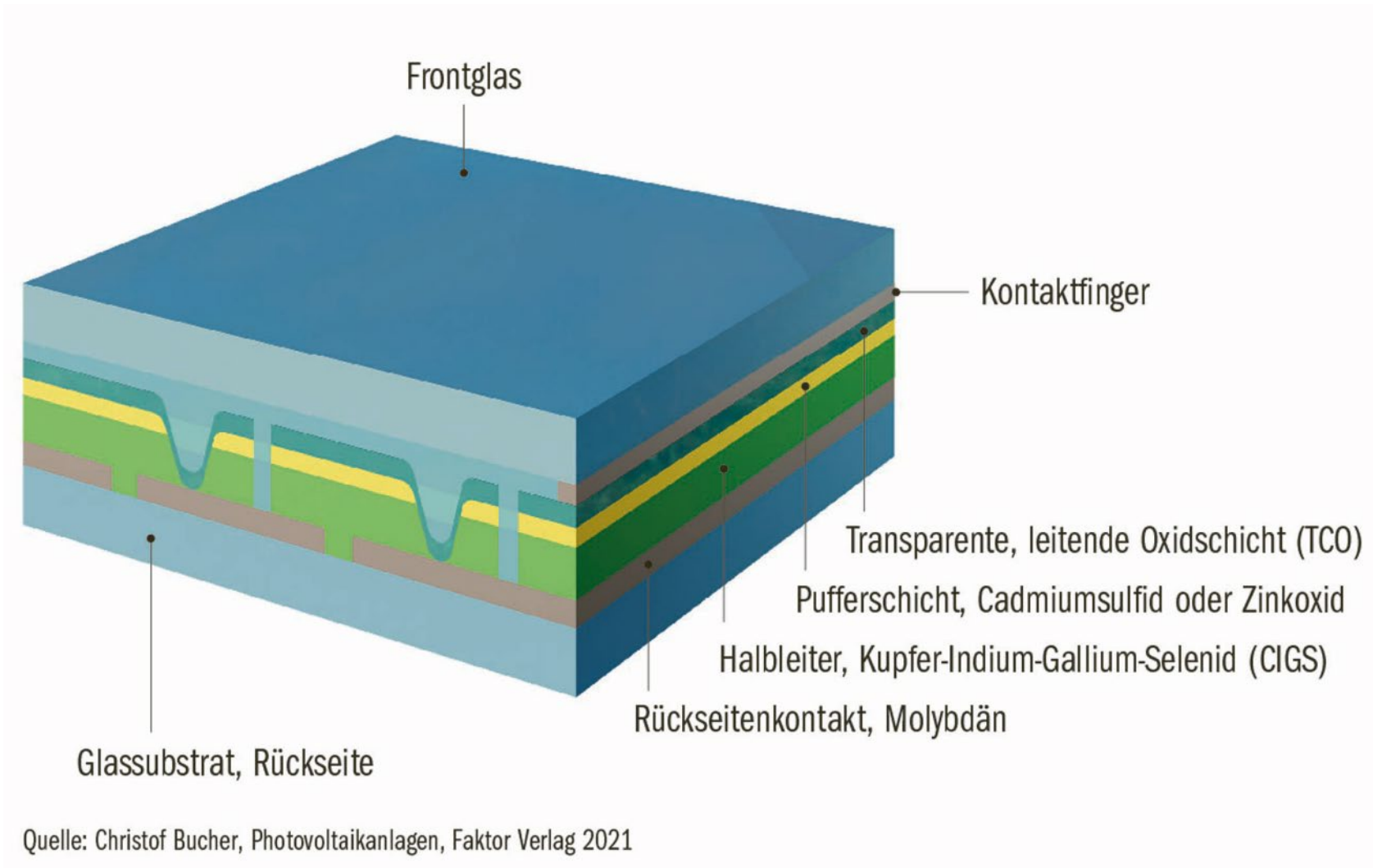


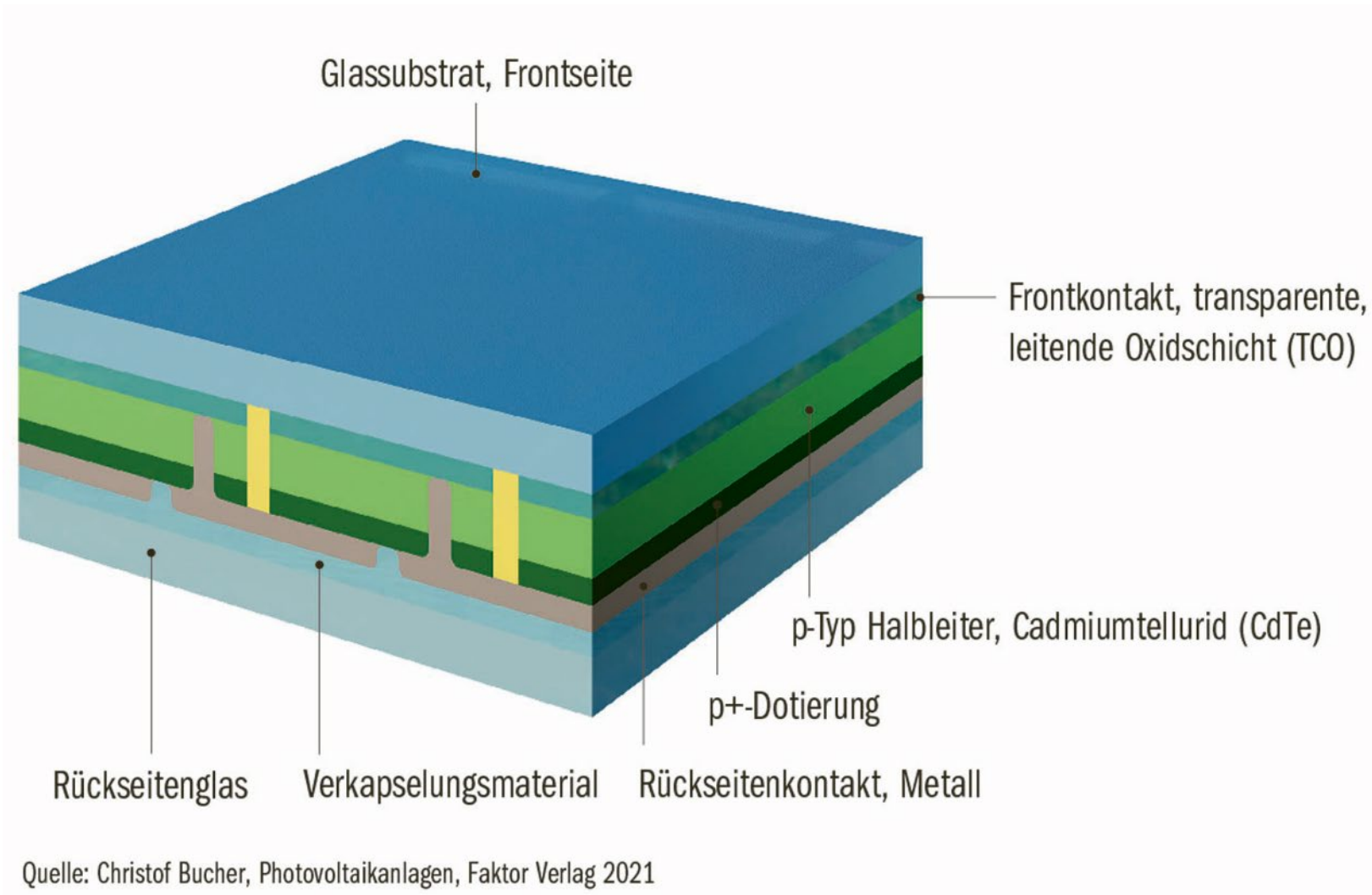
5 Der Rückseitenkontakt wird mit Sputtern aufgetragen.

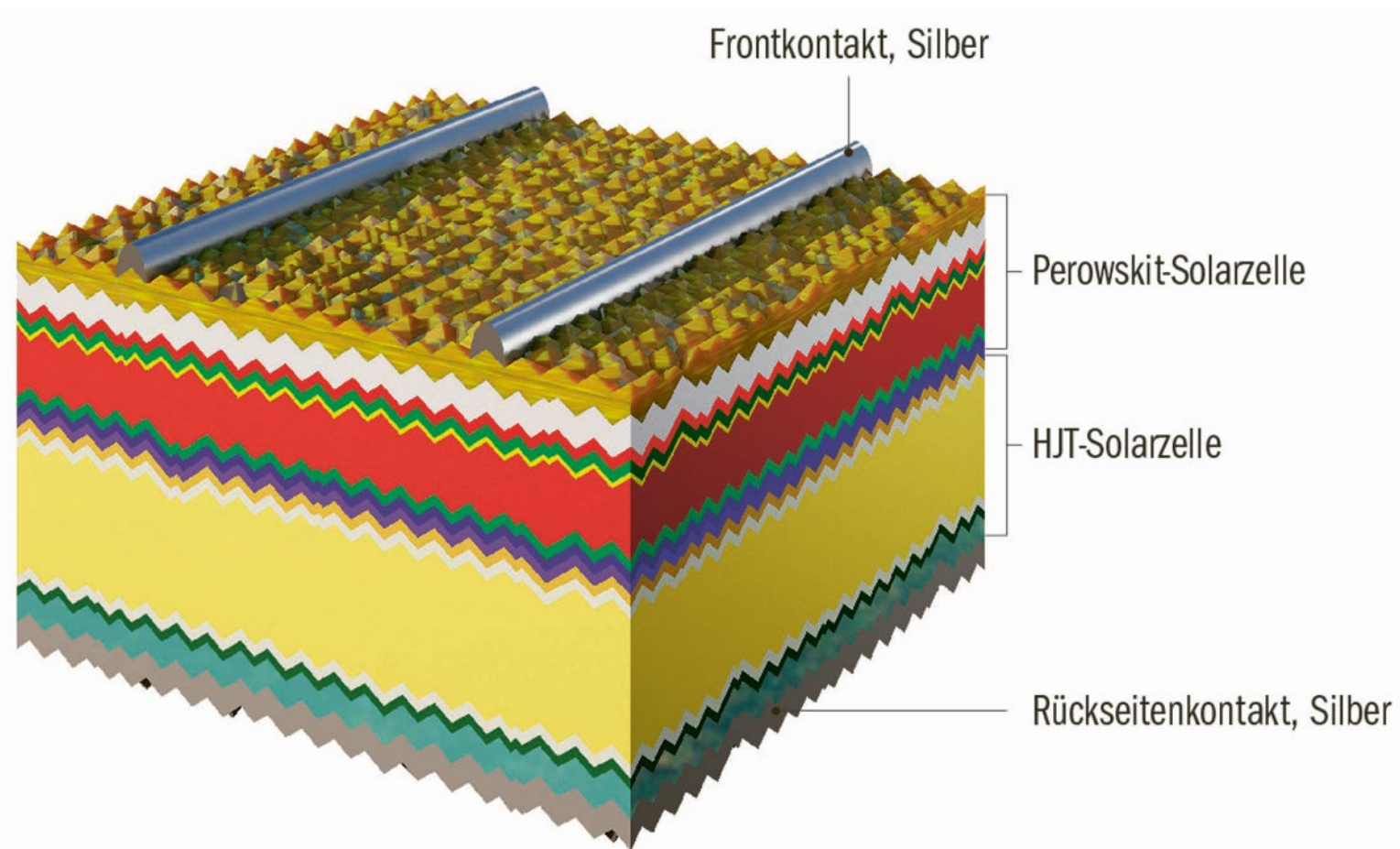


6 Die Rückkontakte werden zu Zellen gelasert.

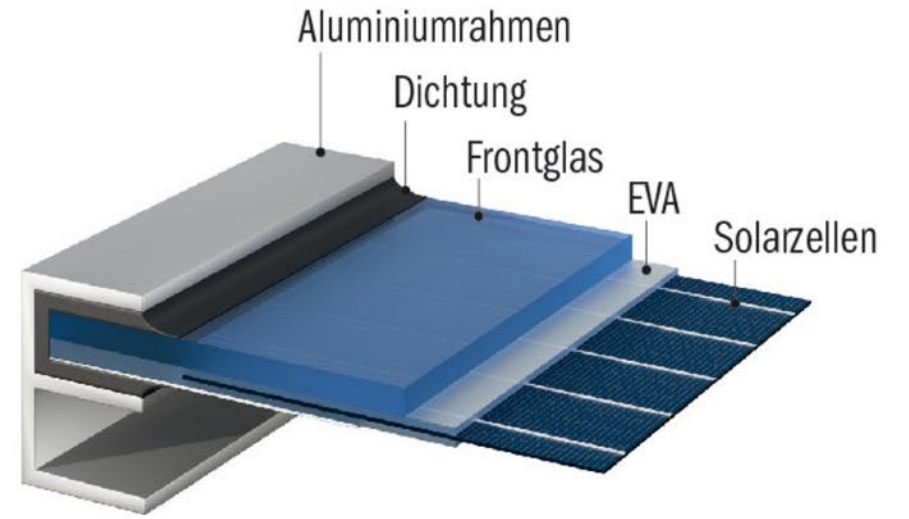
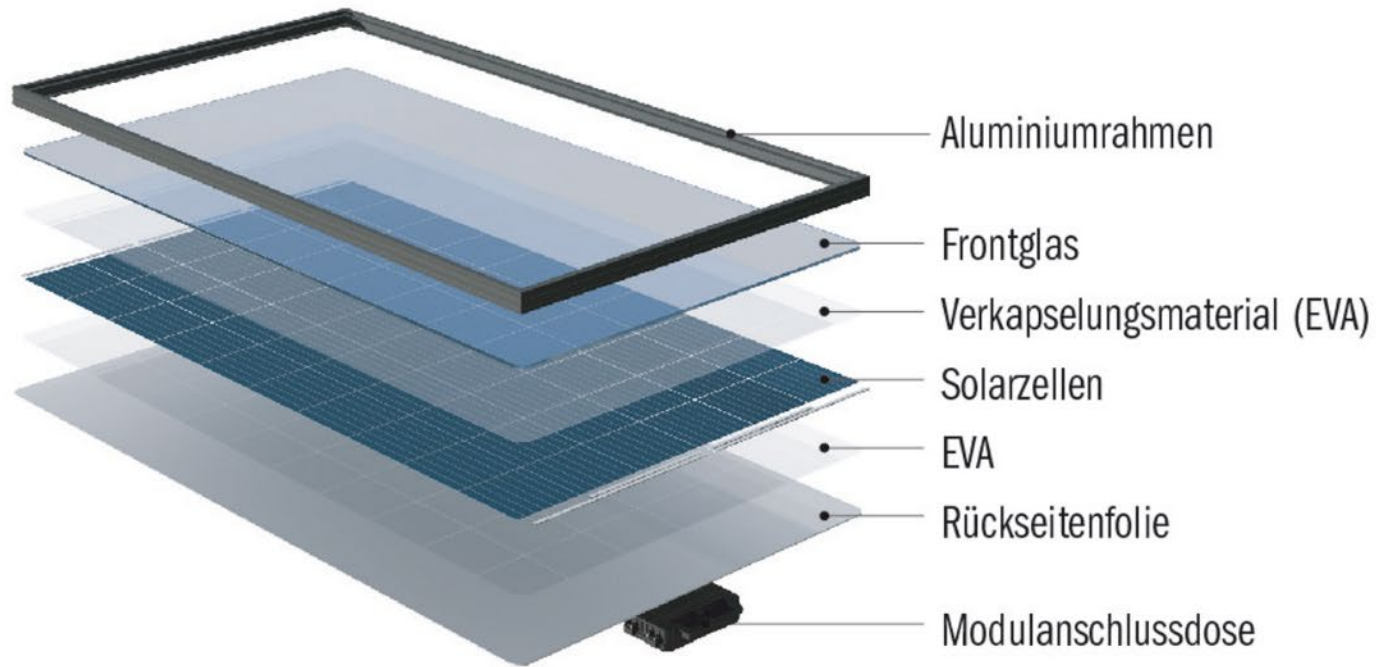
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



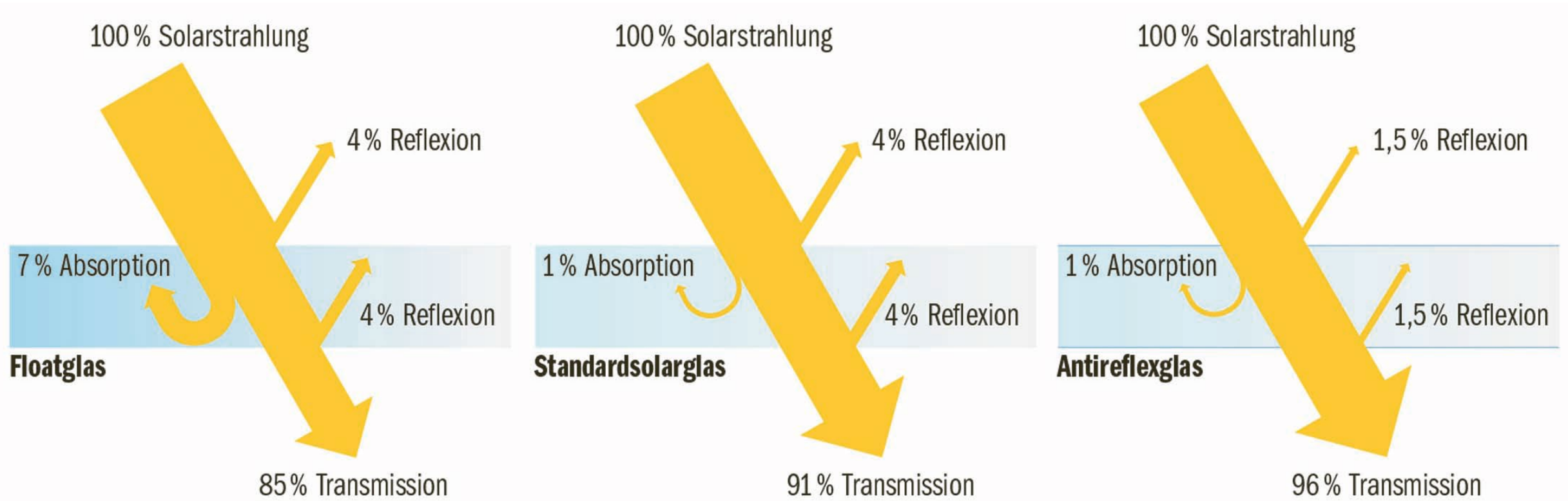




Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

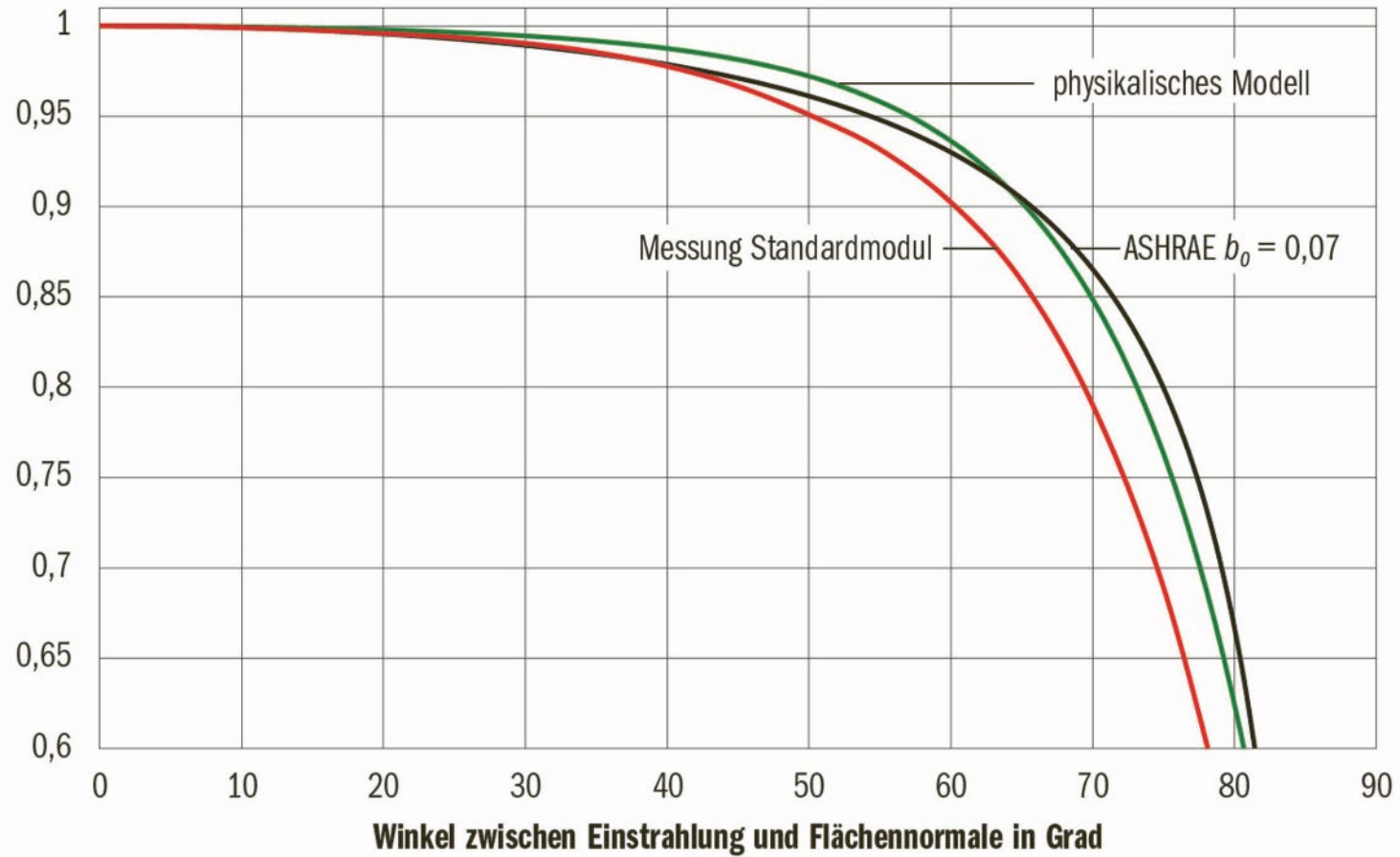


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

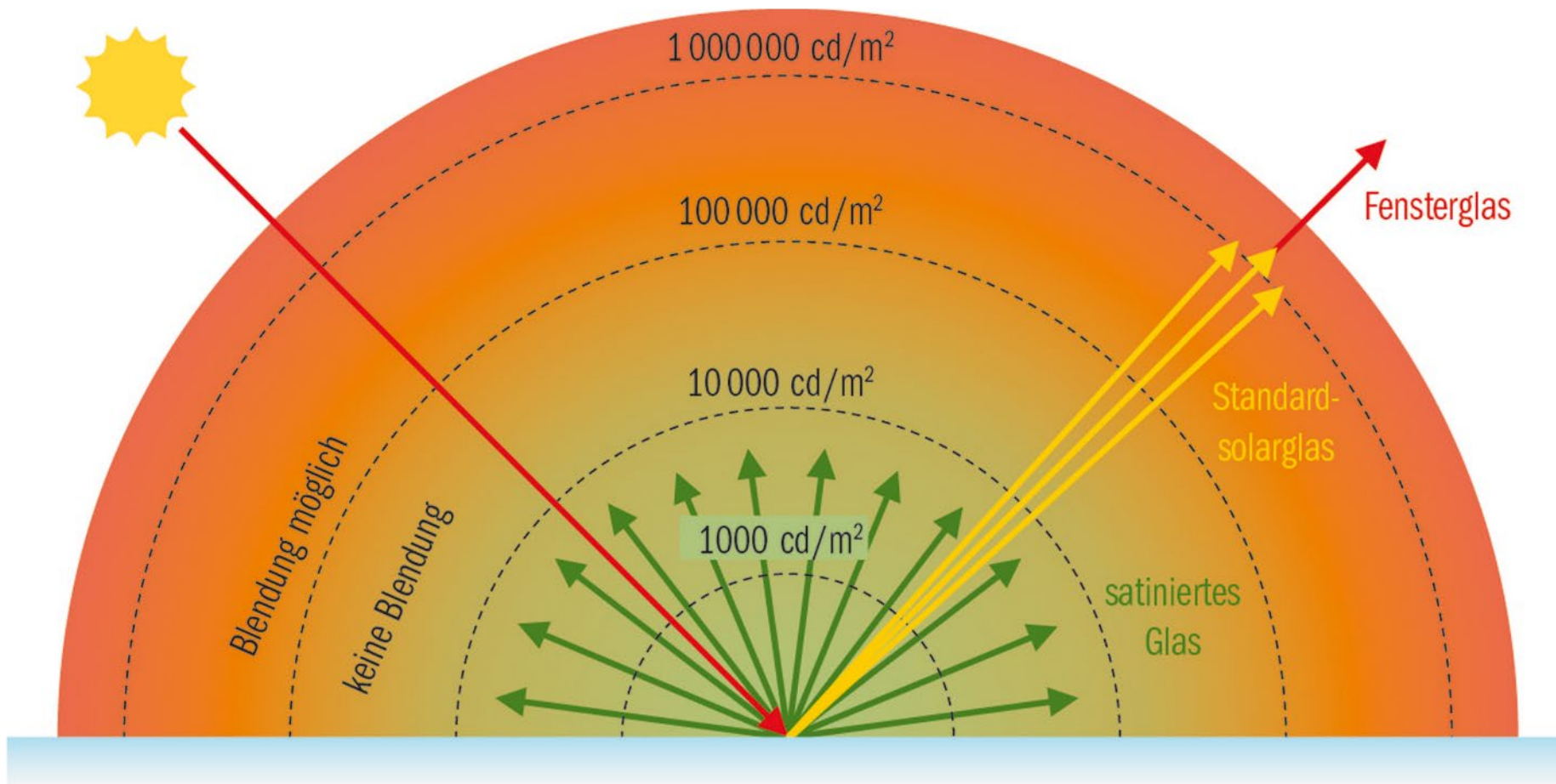


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

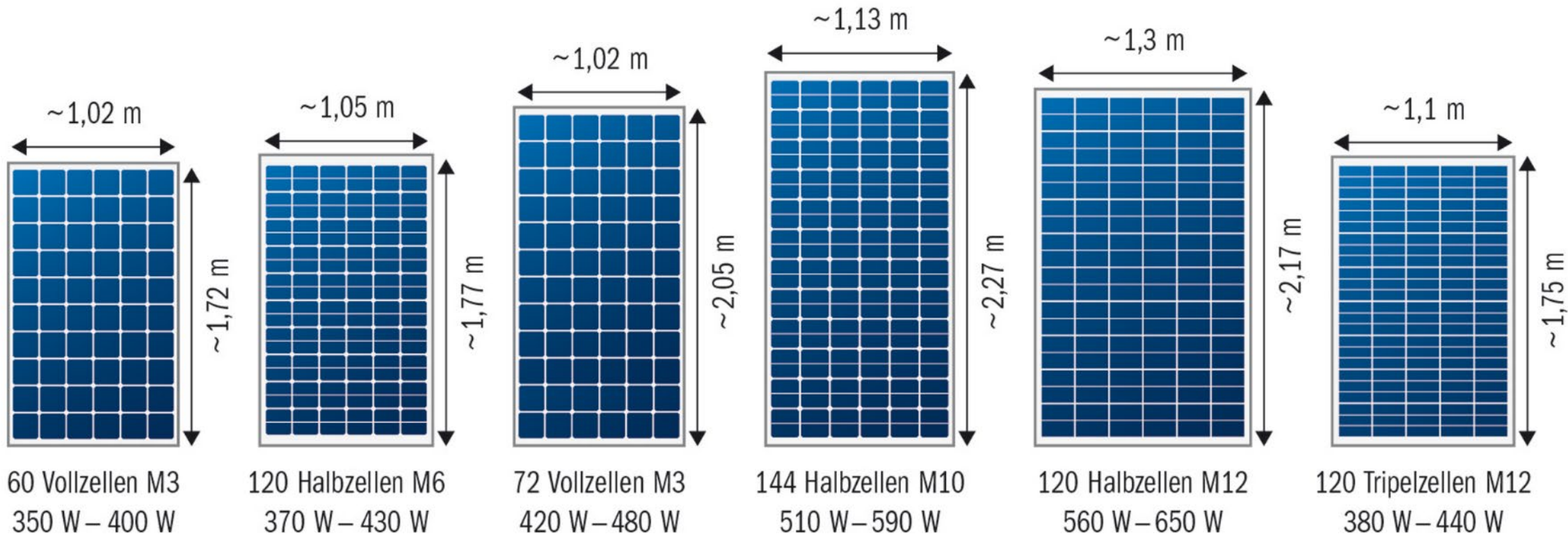
Incident Angle Modifier



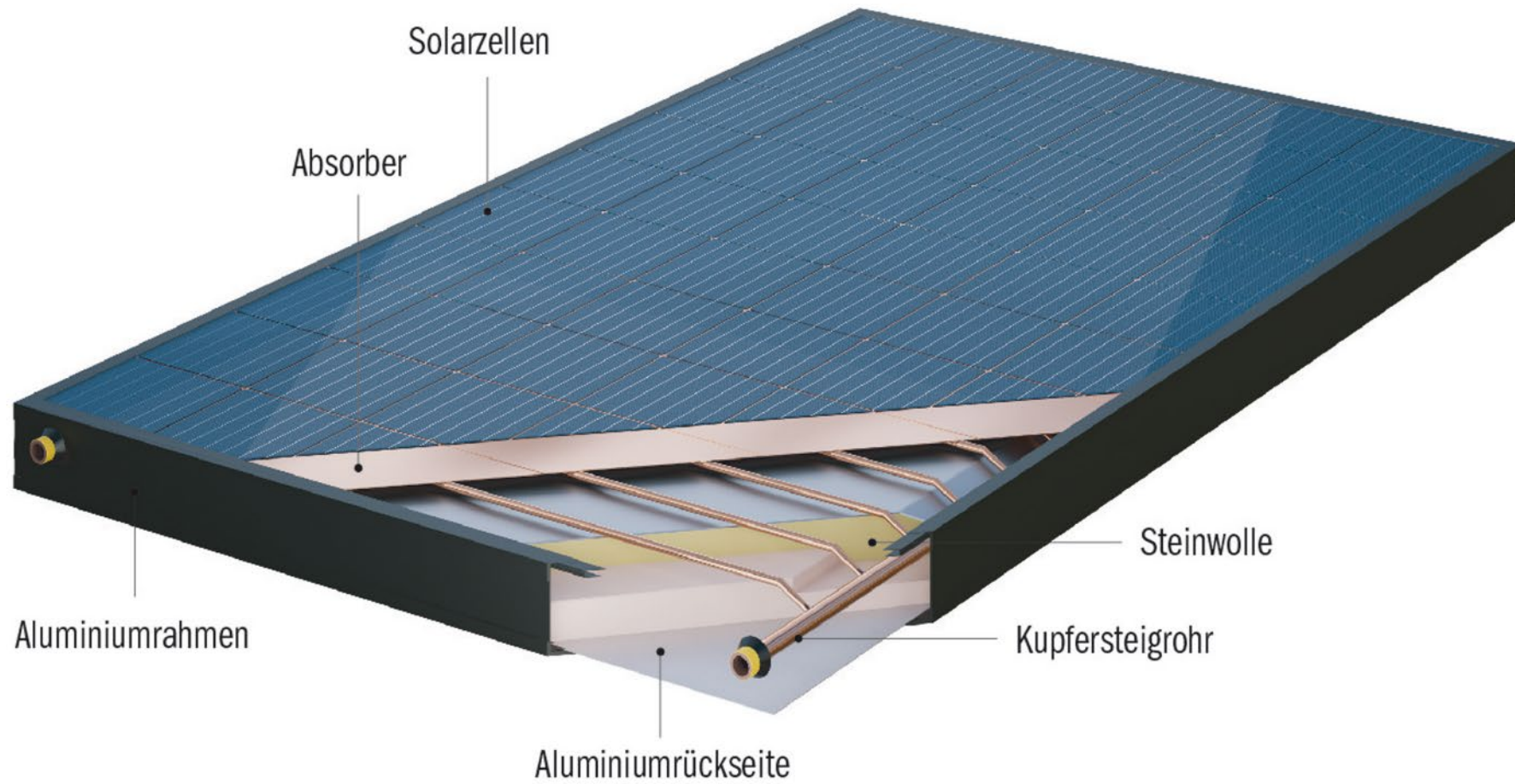
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



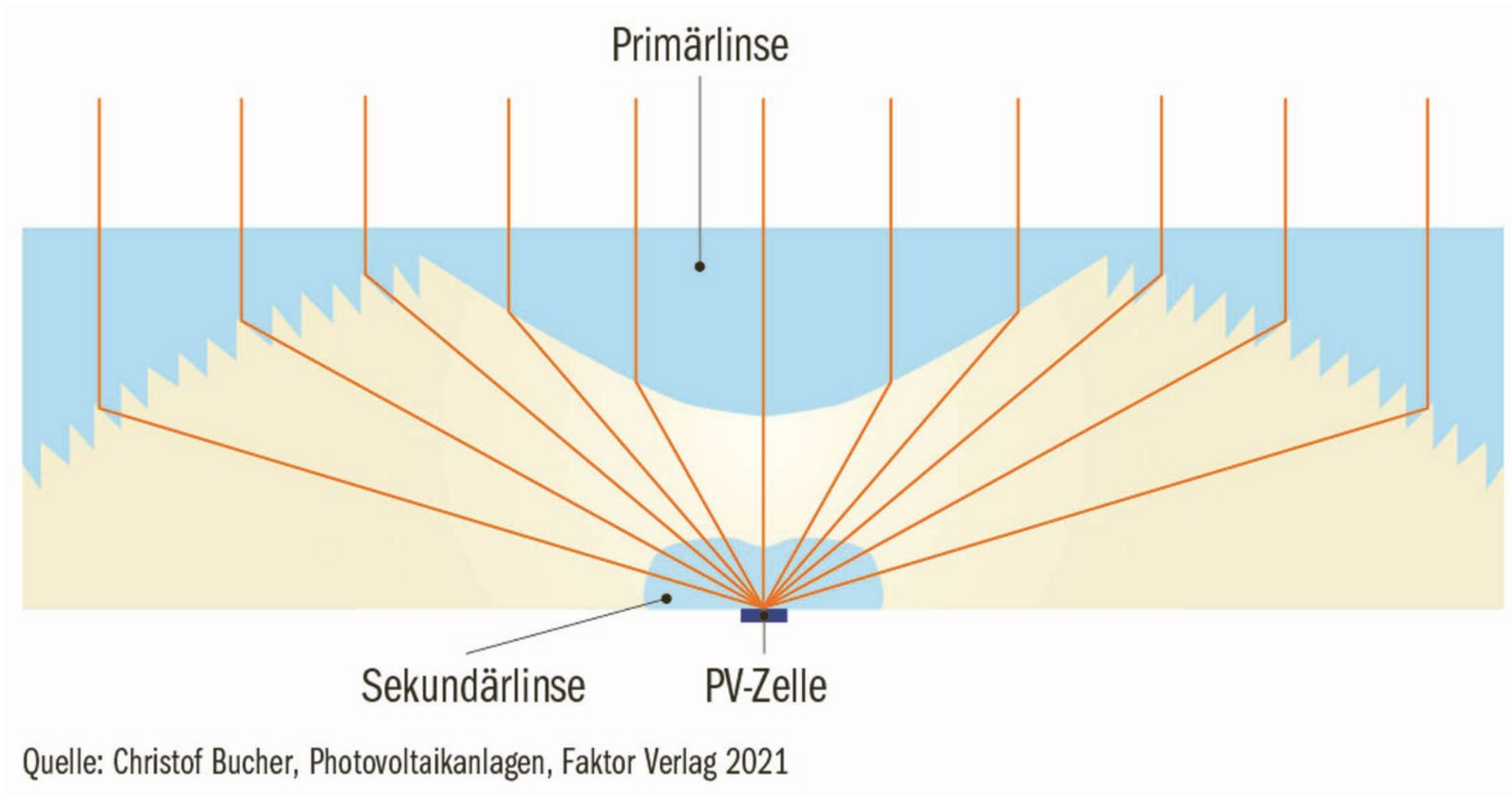
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

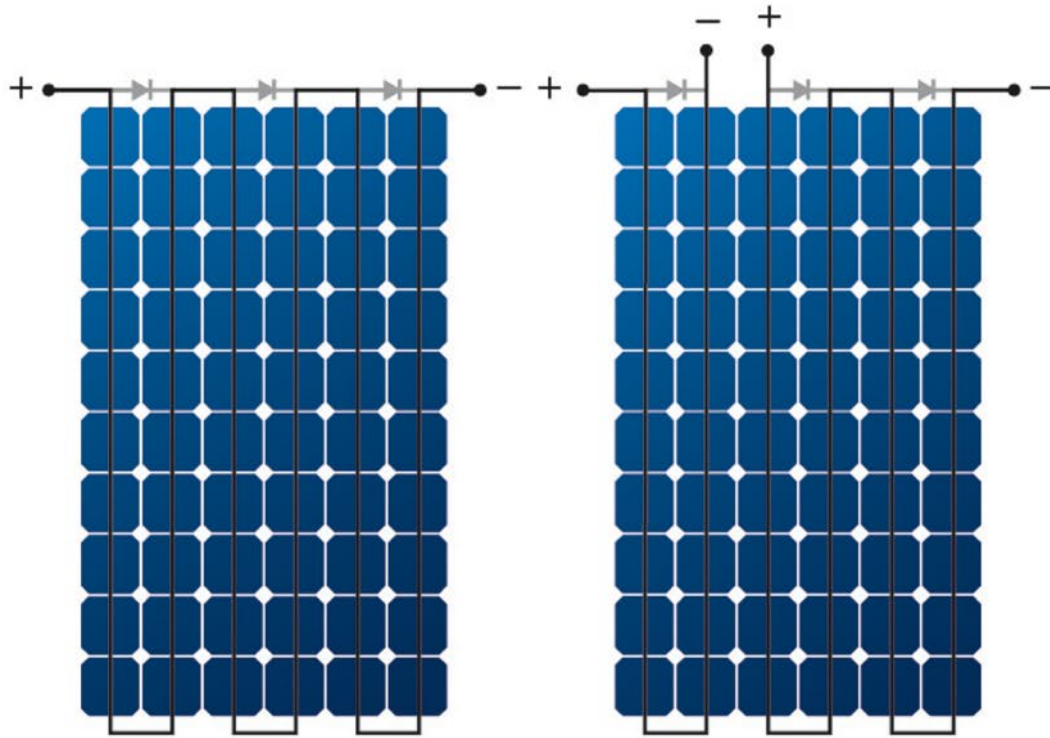


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

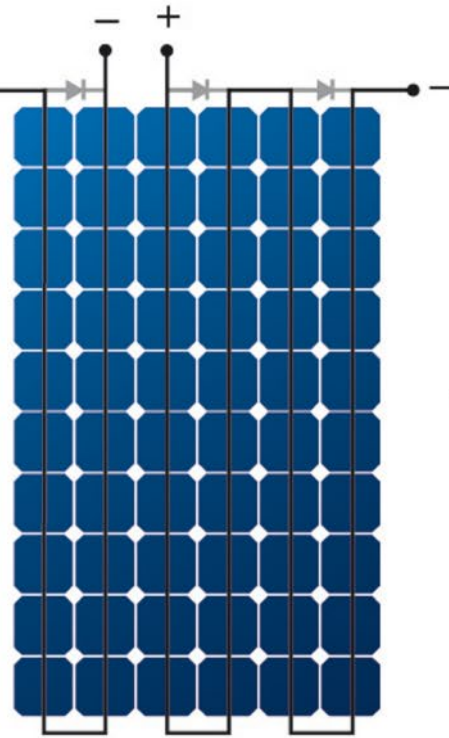


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

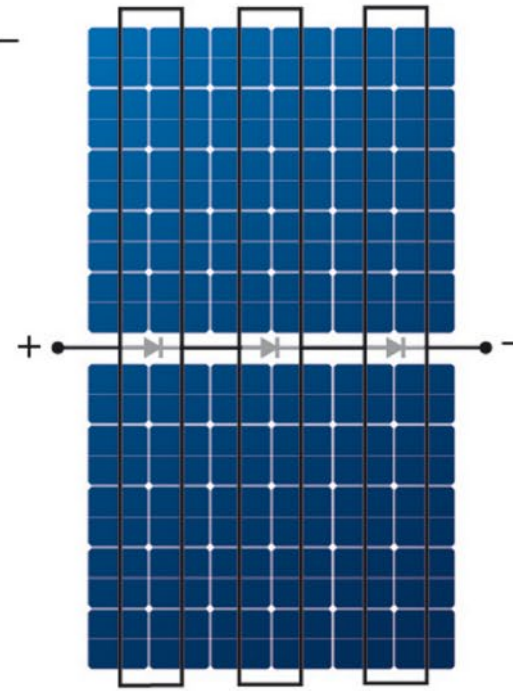




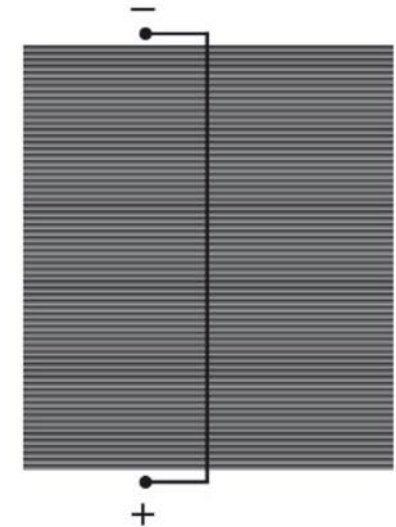
60-Zellen-Standardmodul mit
schlangenförmiger Serienschaltung



Projektspezifisches
Sondermodul

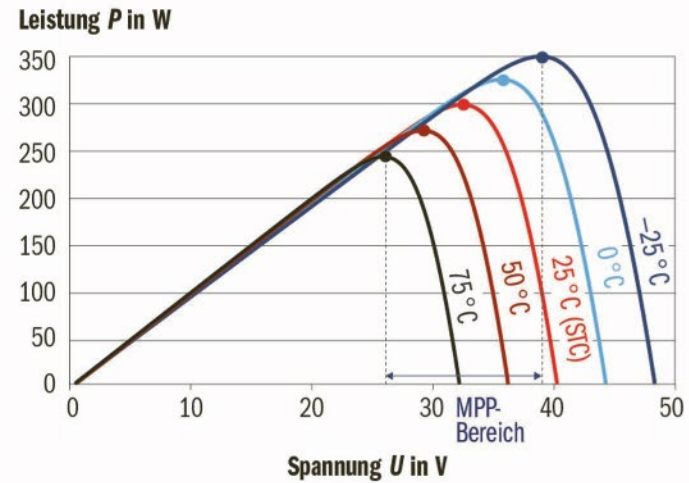
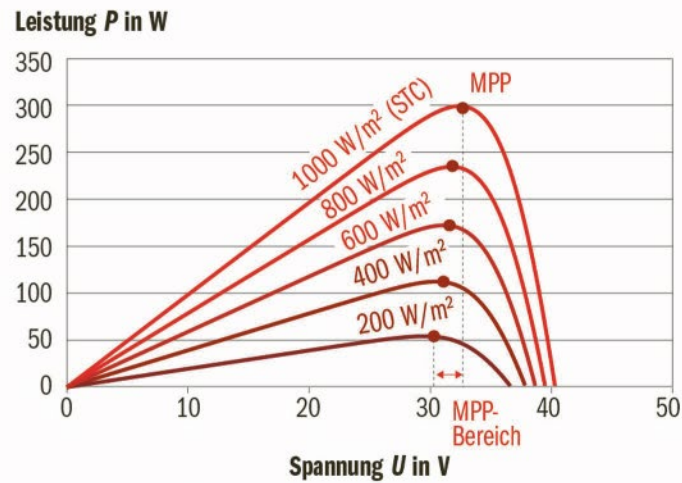
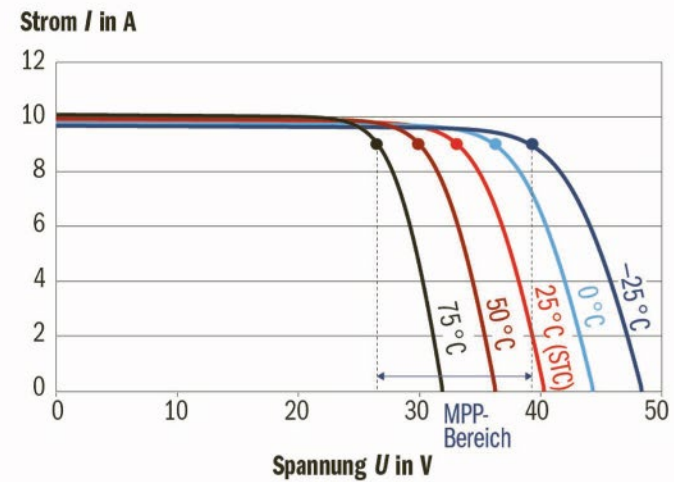
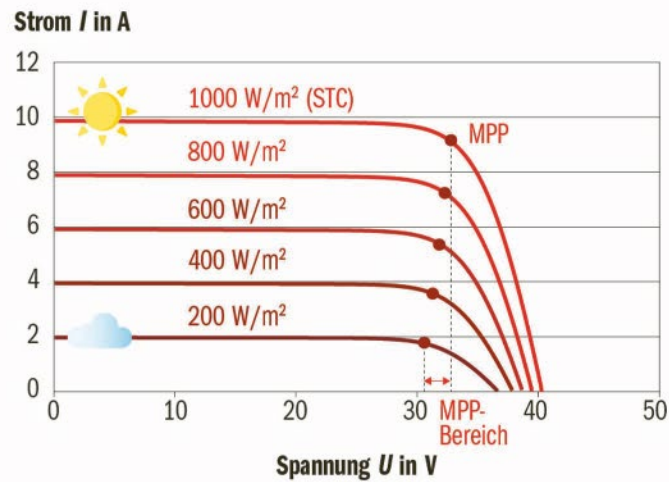


Halbzellenmodul mit Modul-
anschlussdose in der Modulmitte



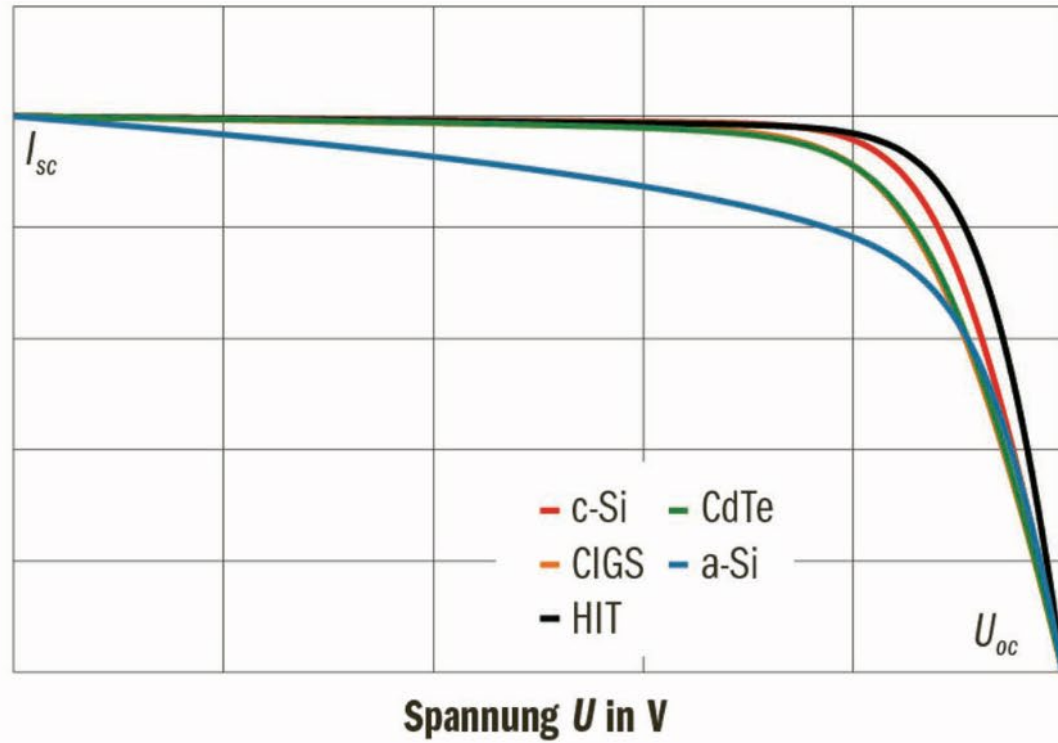
Dünnschichtmodul

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

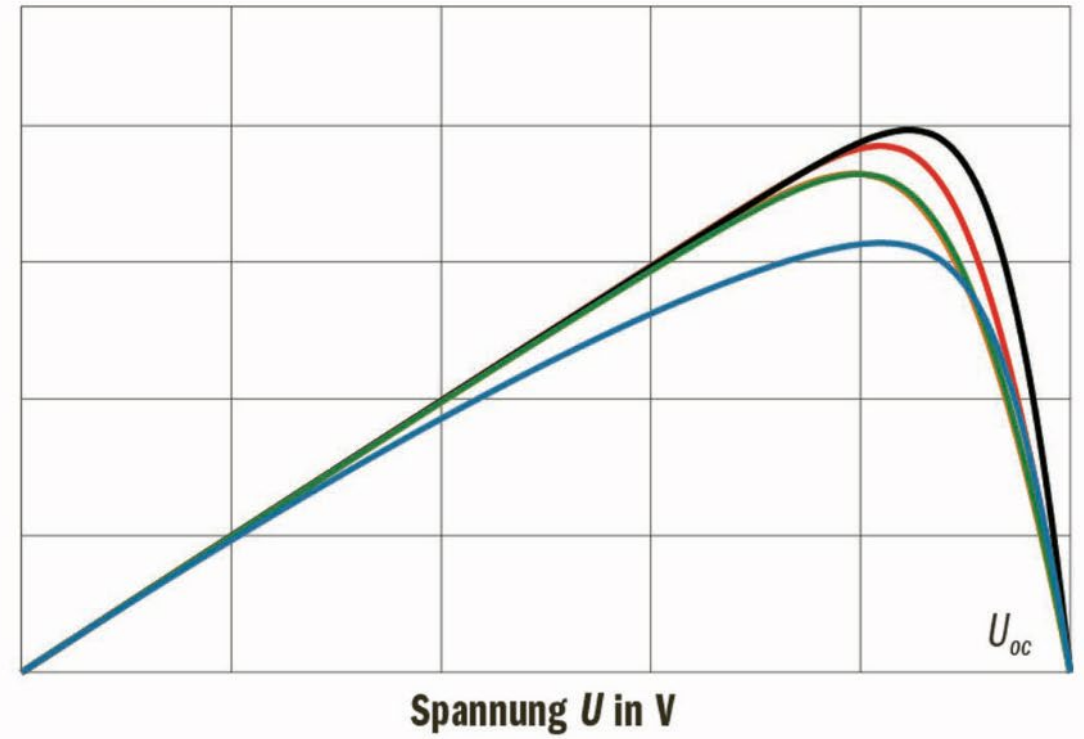


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

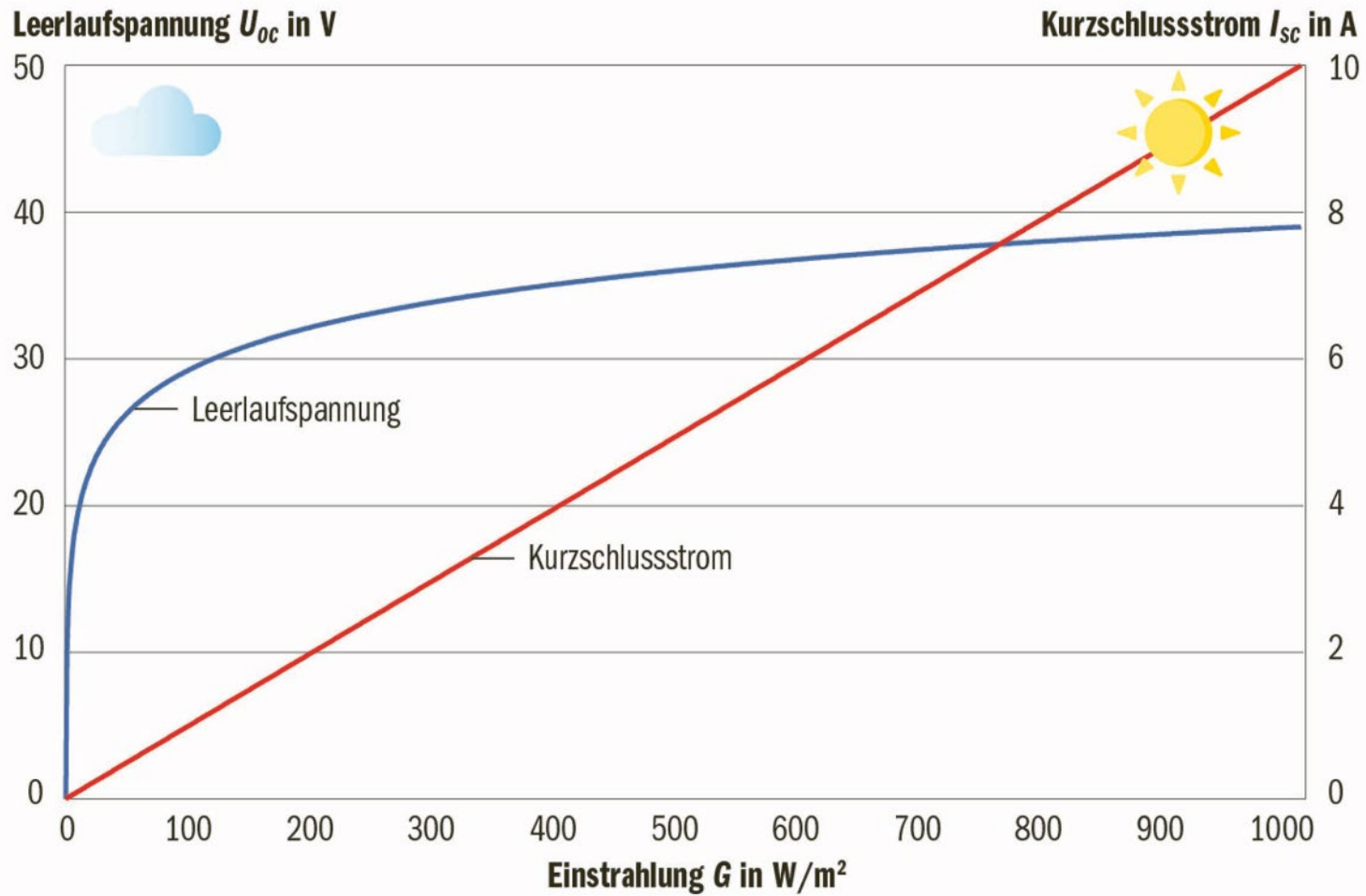
Strom I in A



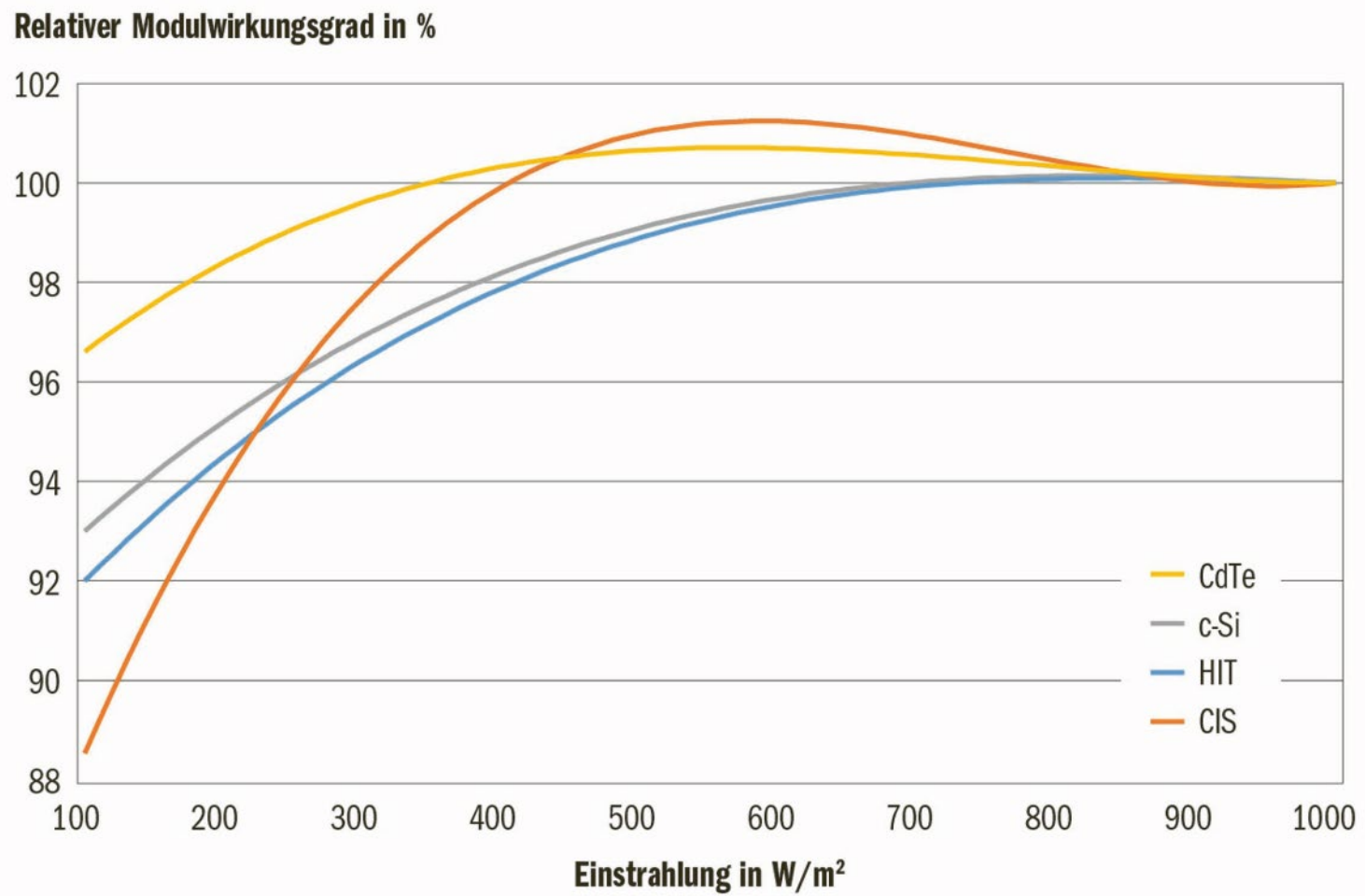
Leistung P in W



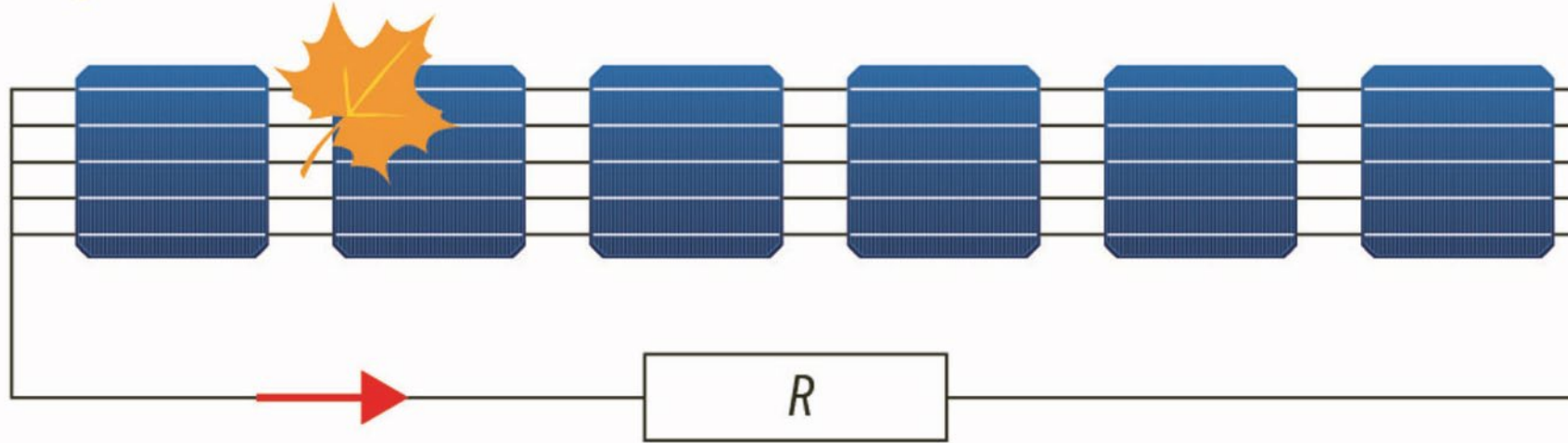
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



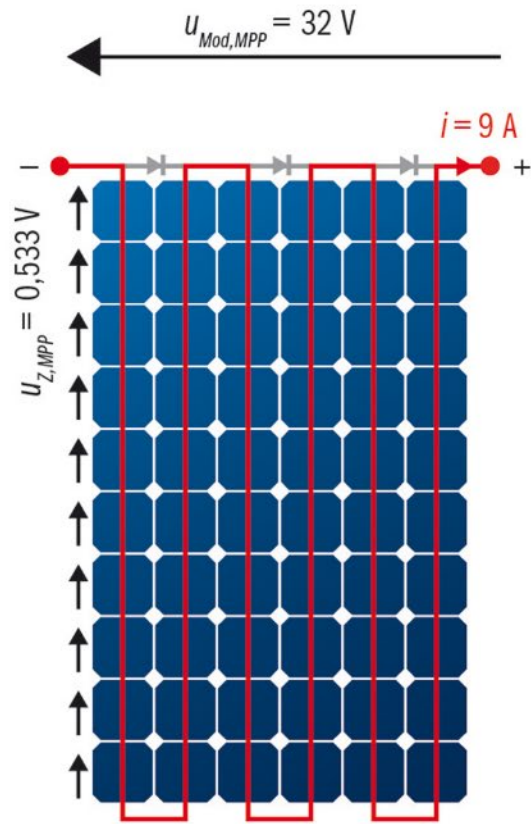
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



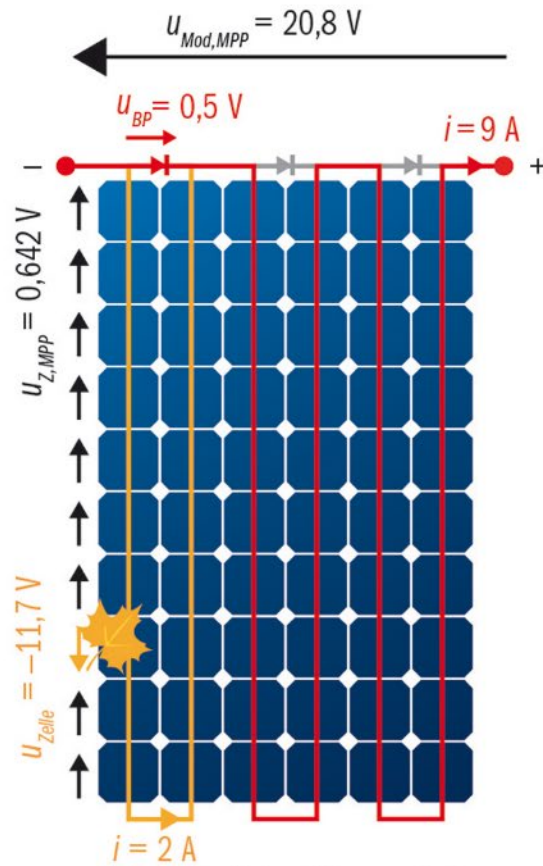
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



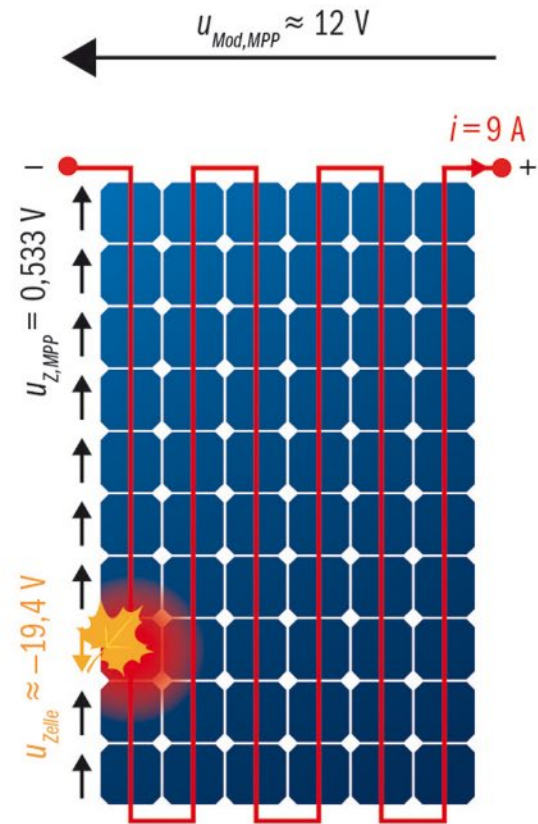
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Unverschattet
 $P = 288 \text{ W}$



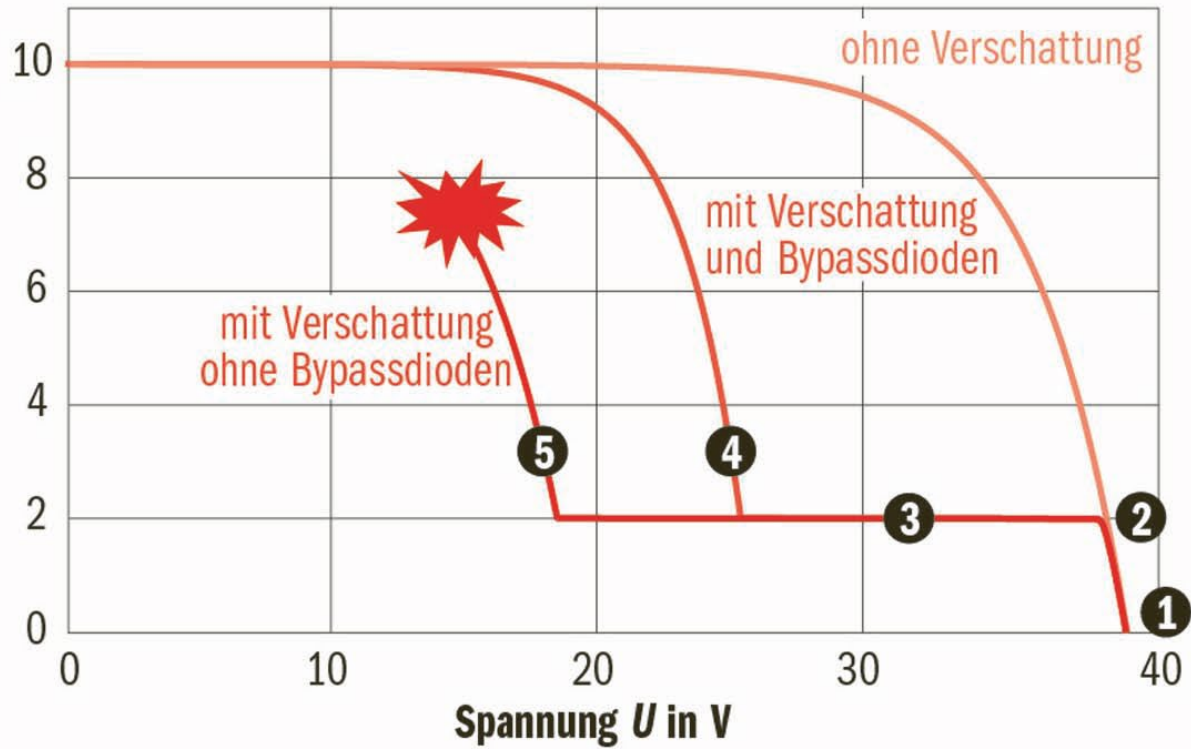
Teilverschattet mit Bypassdiode
 $P = 185 \text{ W}$



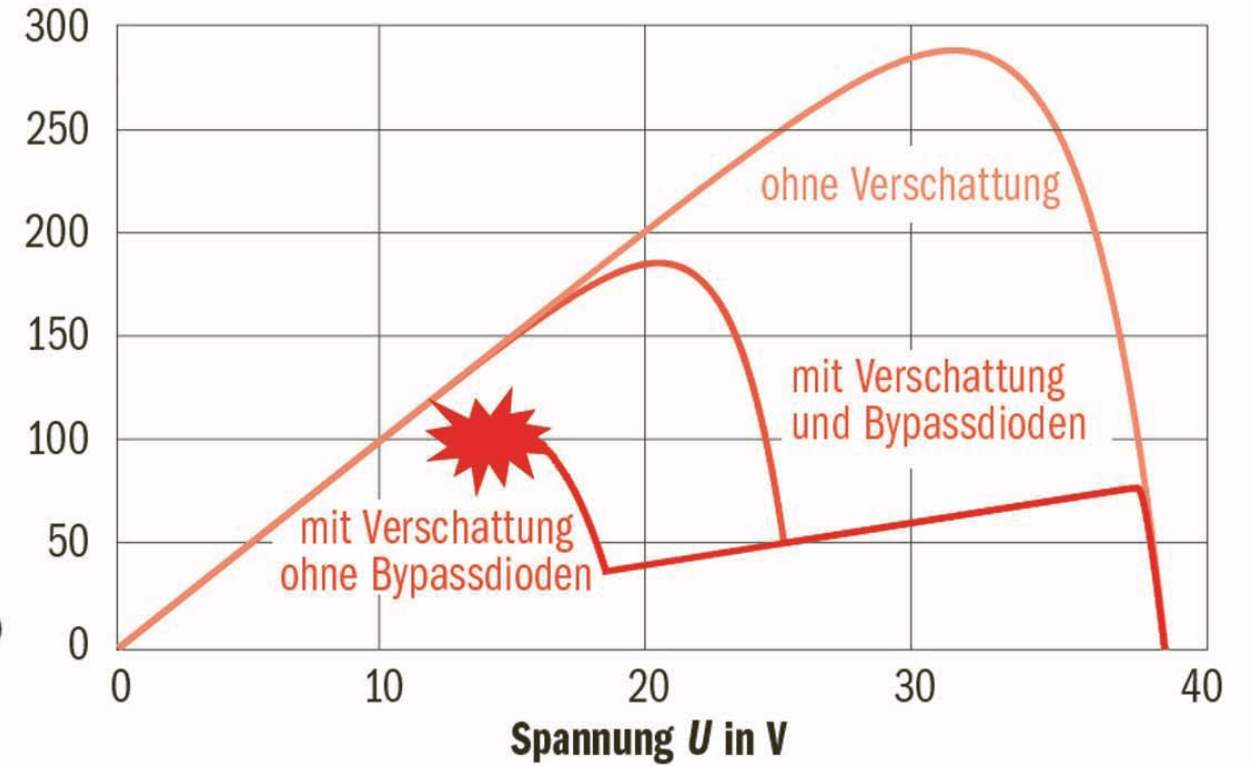
Teilverschattet ohne Bypassdiode
 $P = 108 \text{ W}$ (Hotspot-Gefahr!)

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Strom I in A

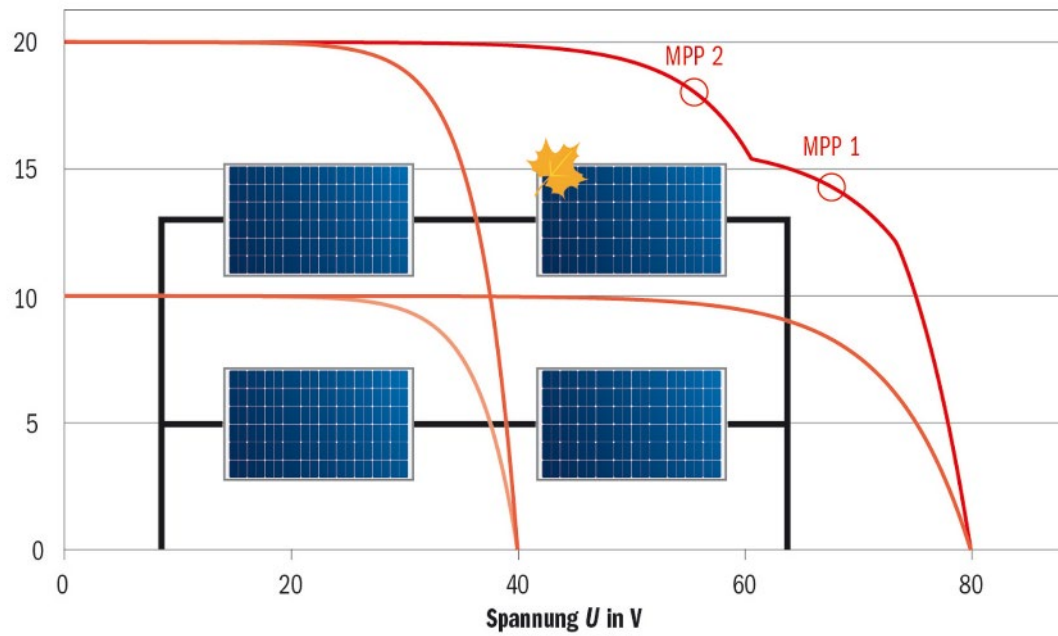


Leistung P in W

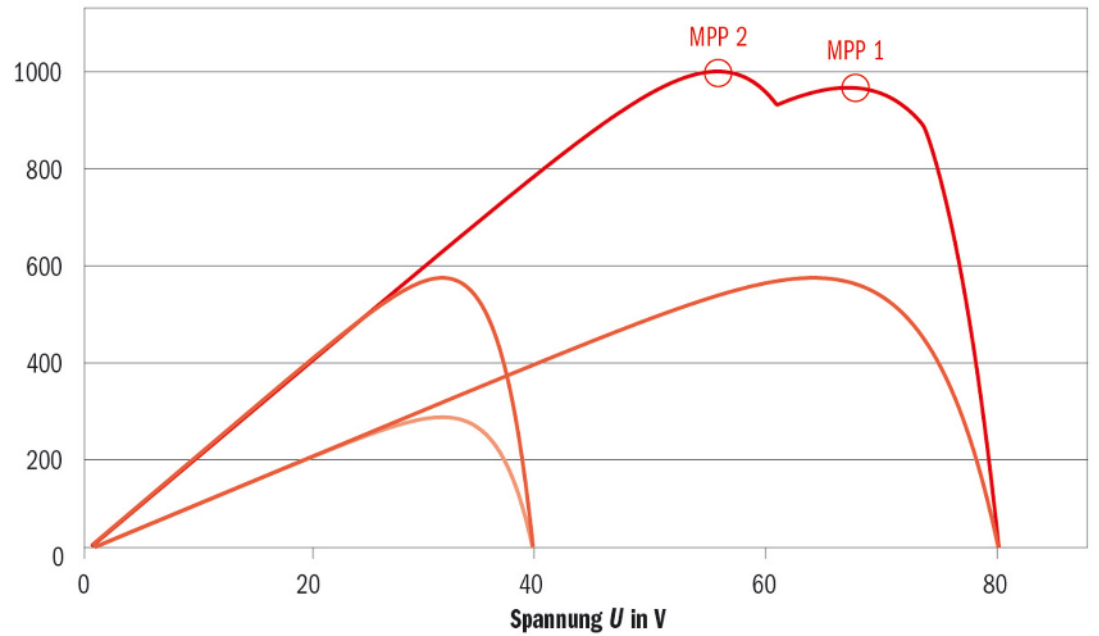


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

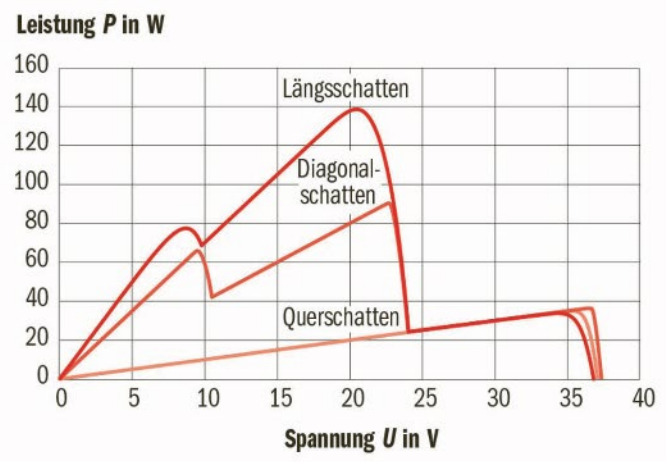
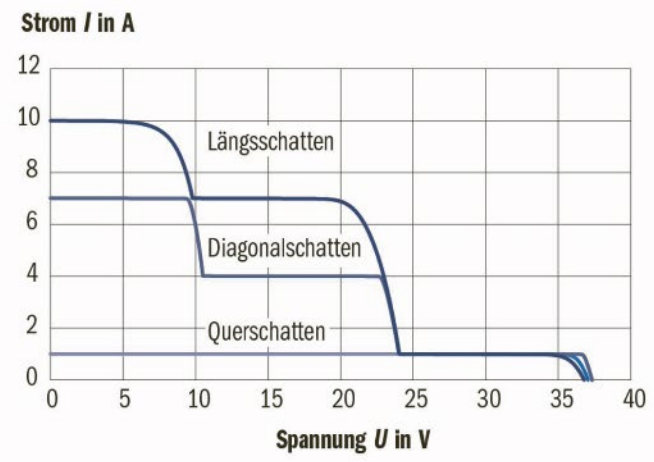
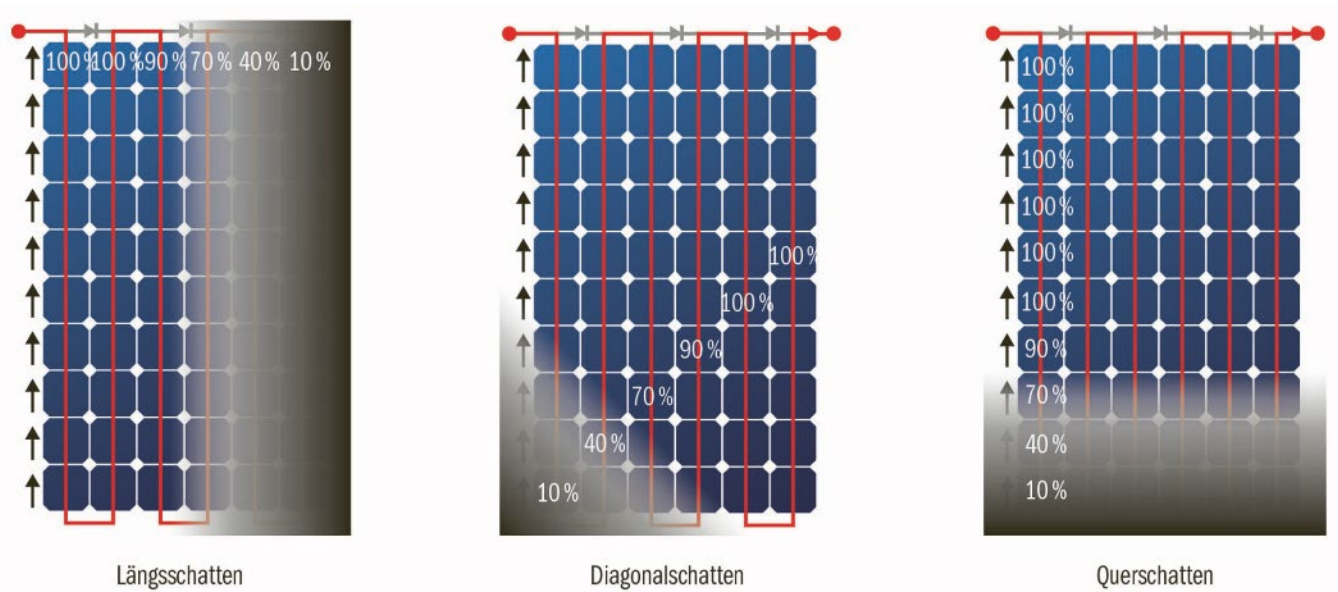
Strom I in A



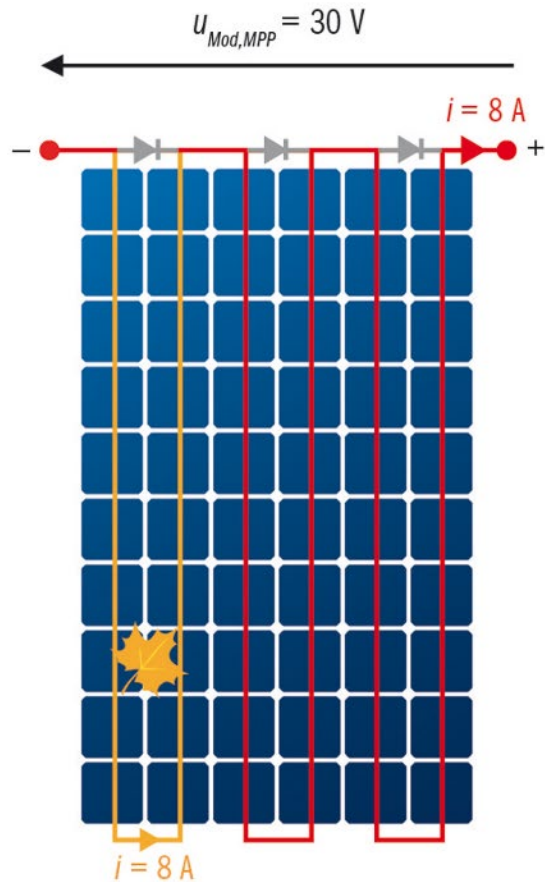
Leistung P in W



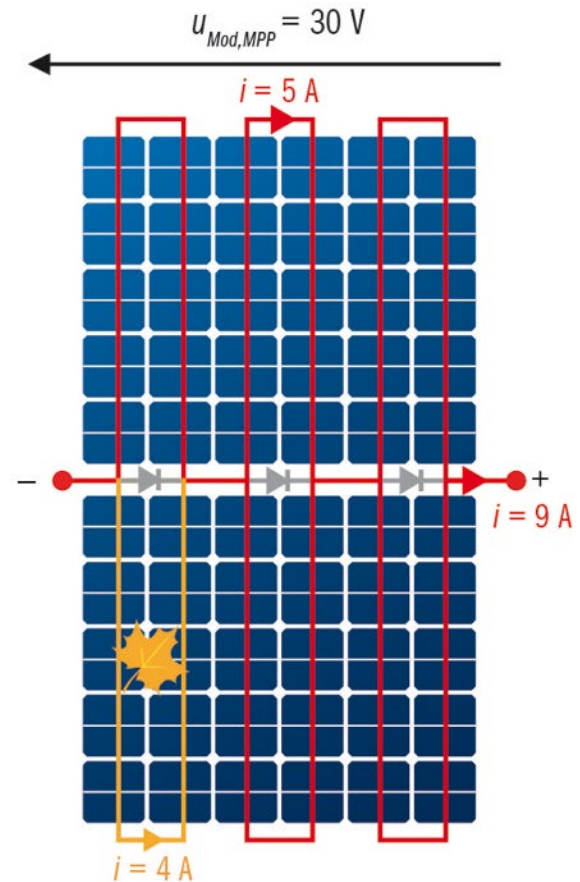
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

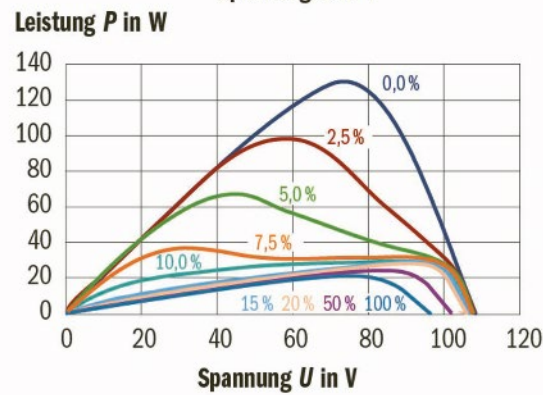
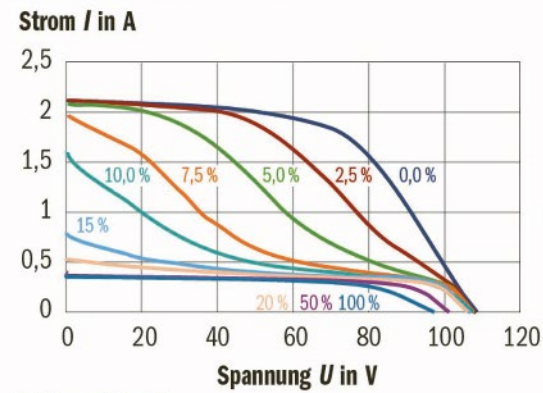
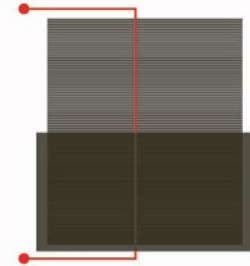
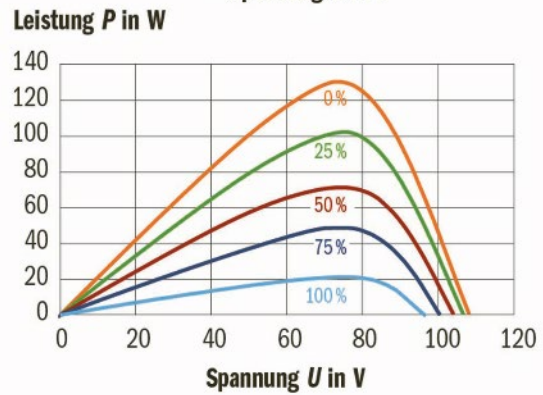
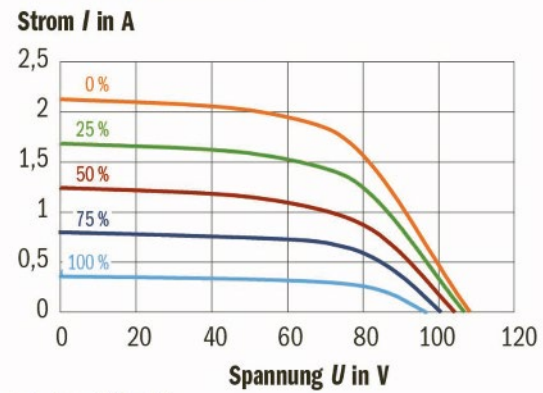
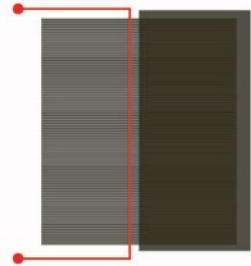


Leicht teilverschattet
 $P = 240 \text{ W}$



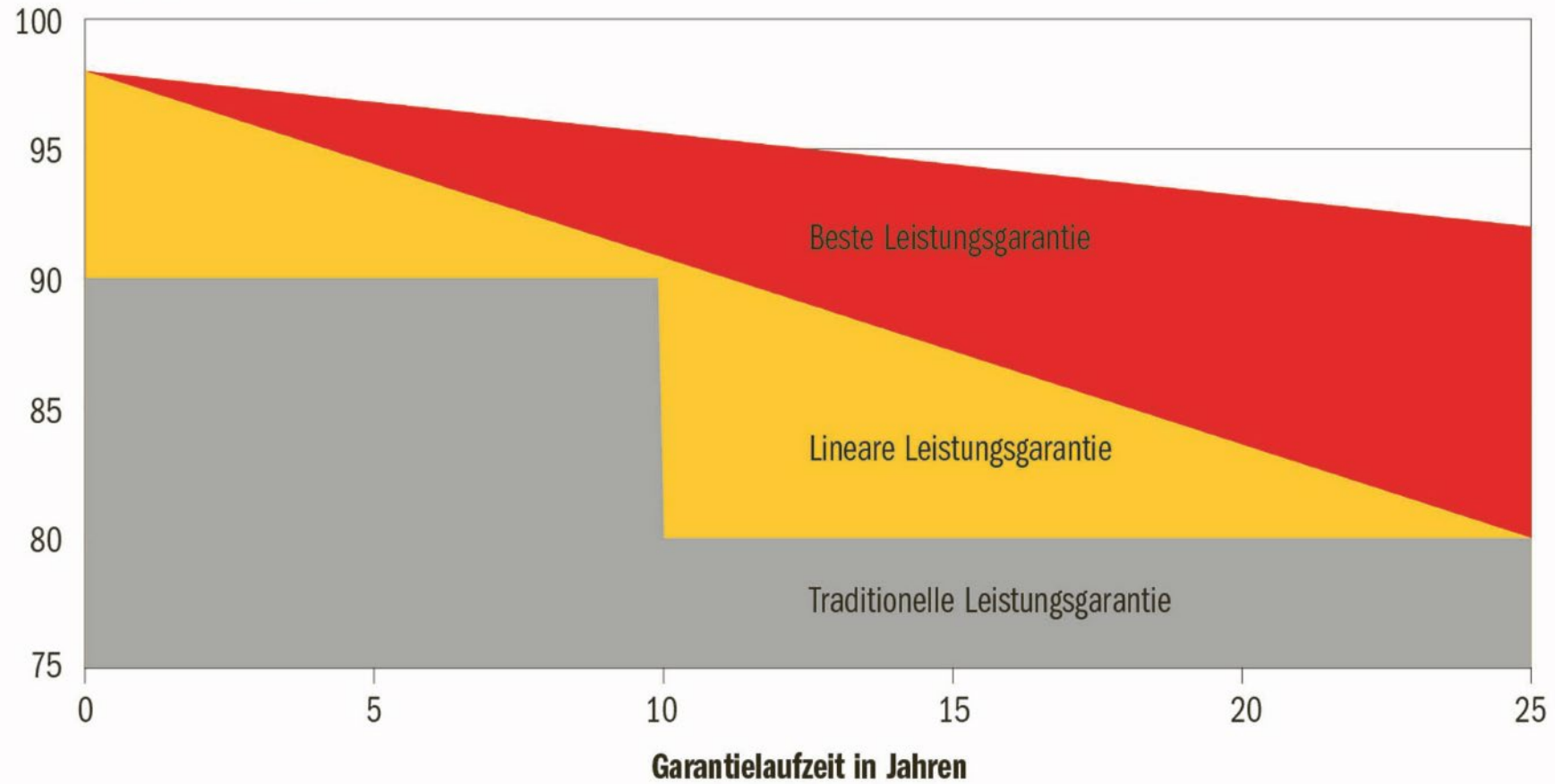
Leicht teilverschattet, Halbzellenmodul
 $P = 270 \text{ W}$

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

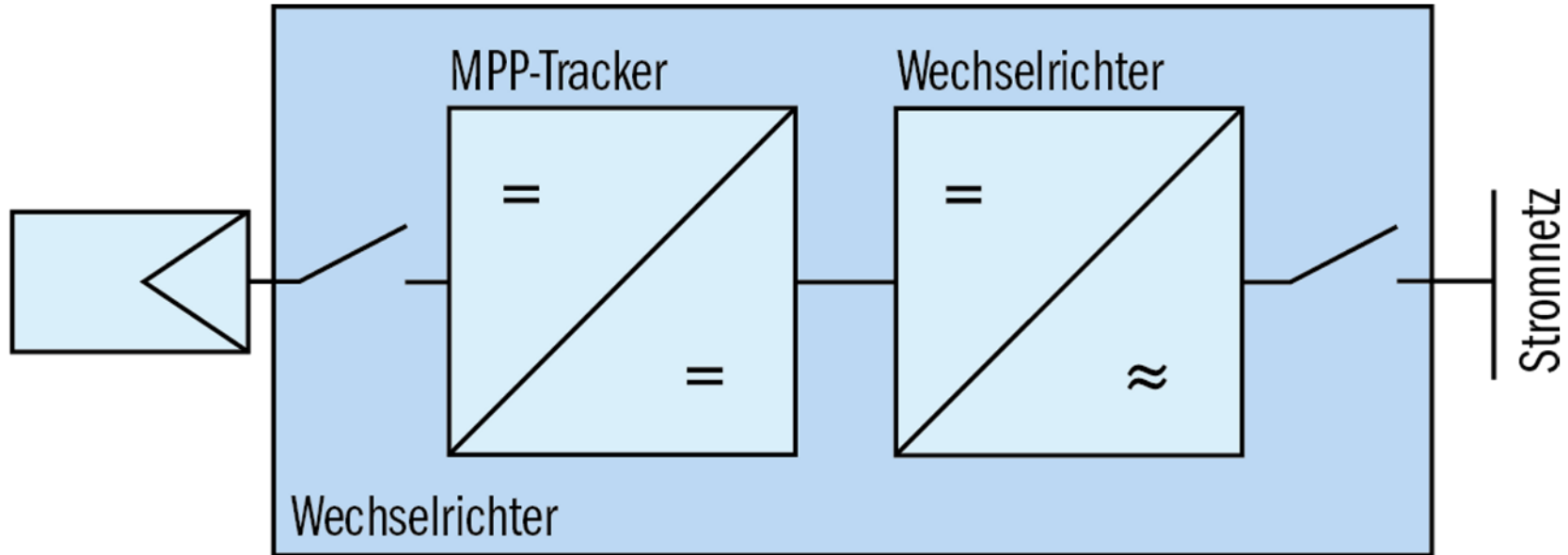


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Garantierte Mindestleistung in %

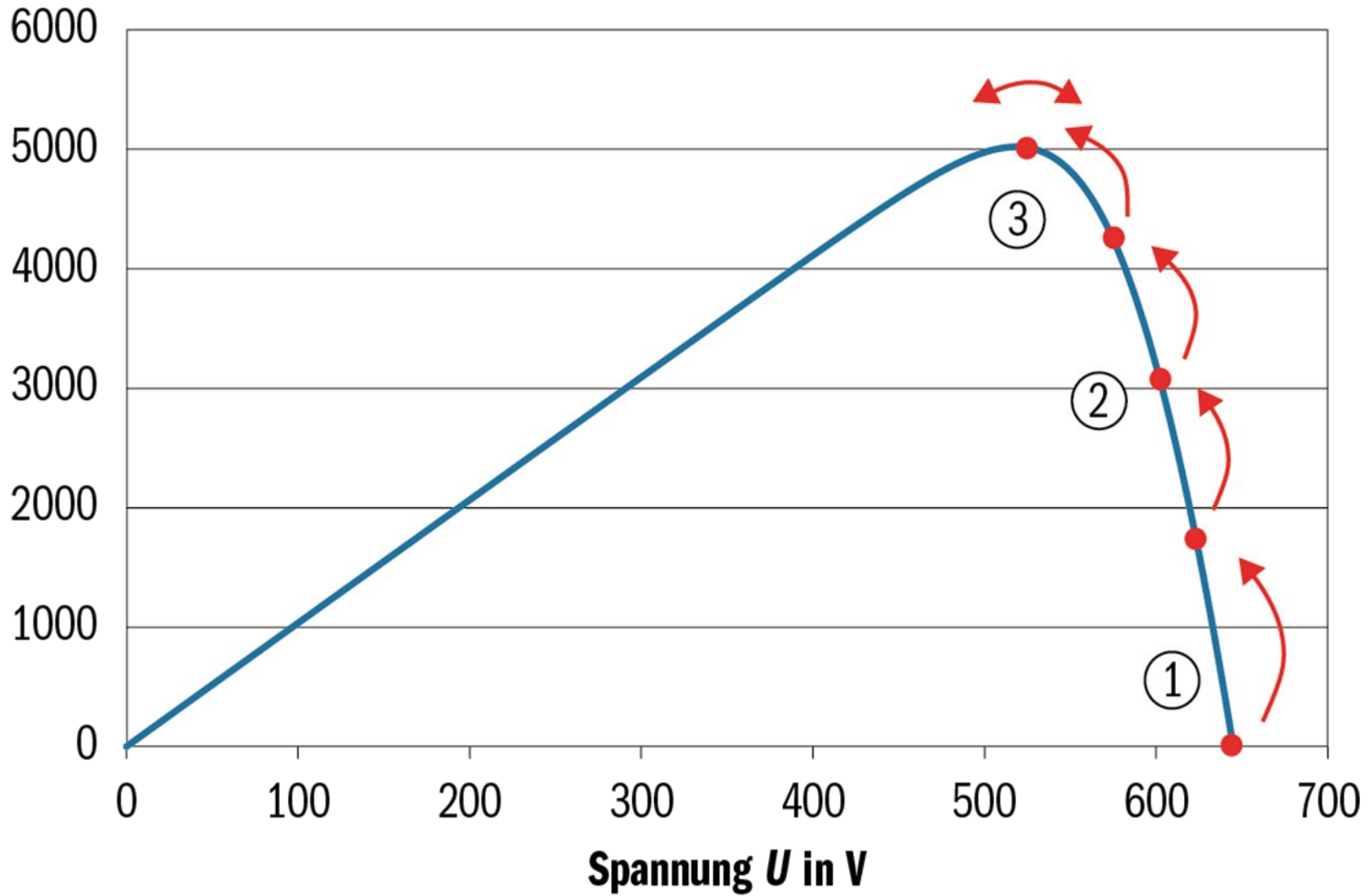


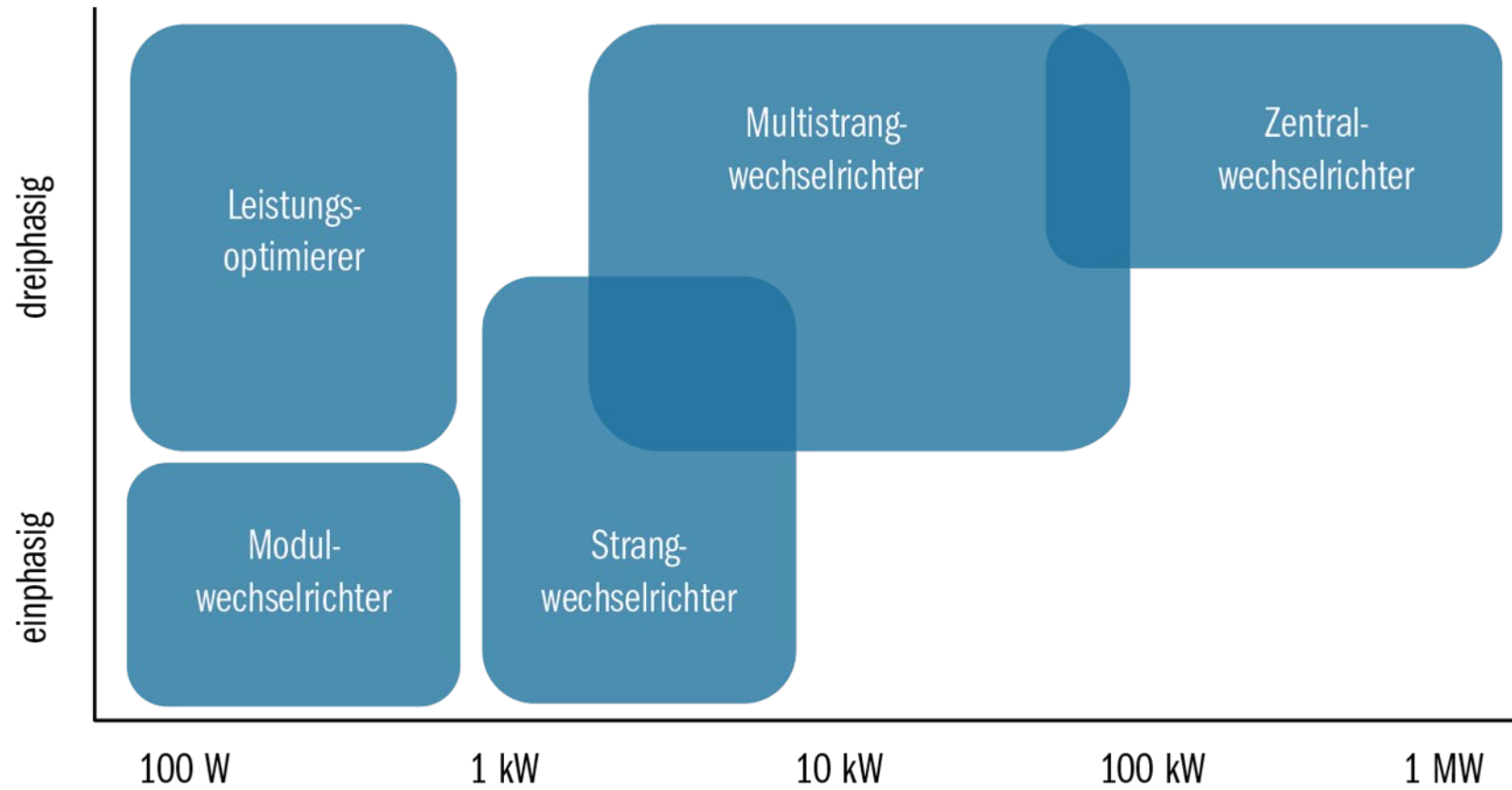
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



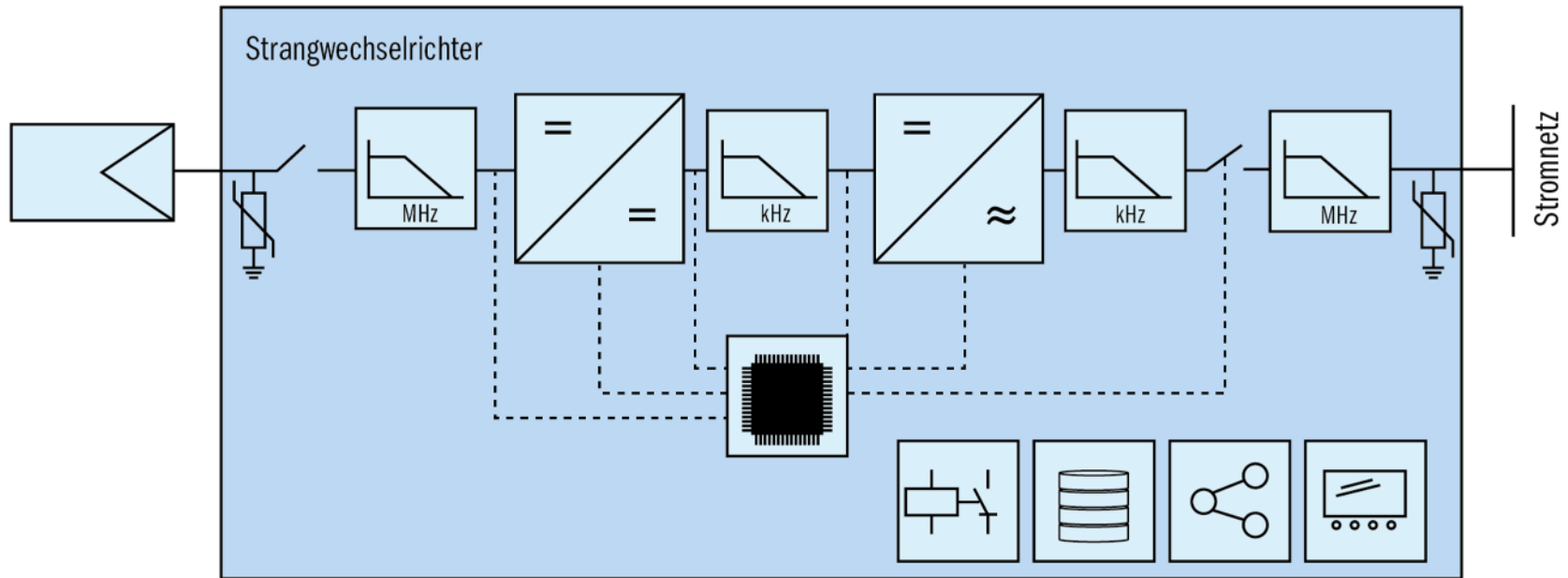
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Leistung P in W

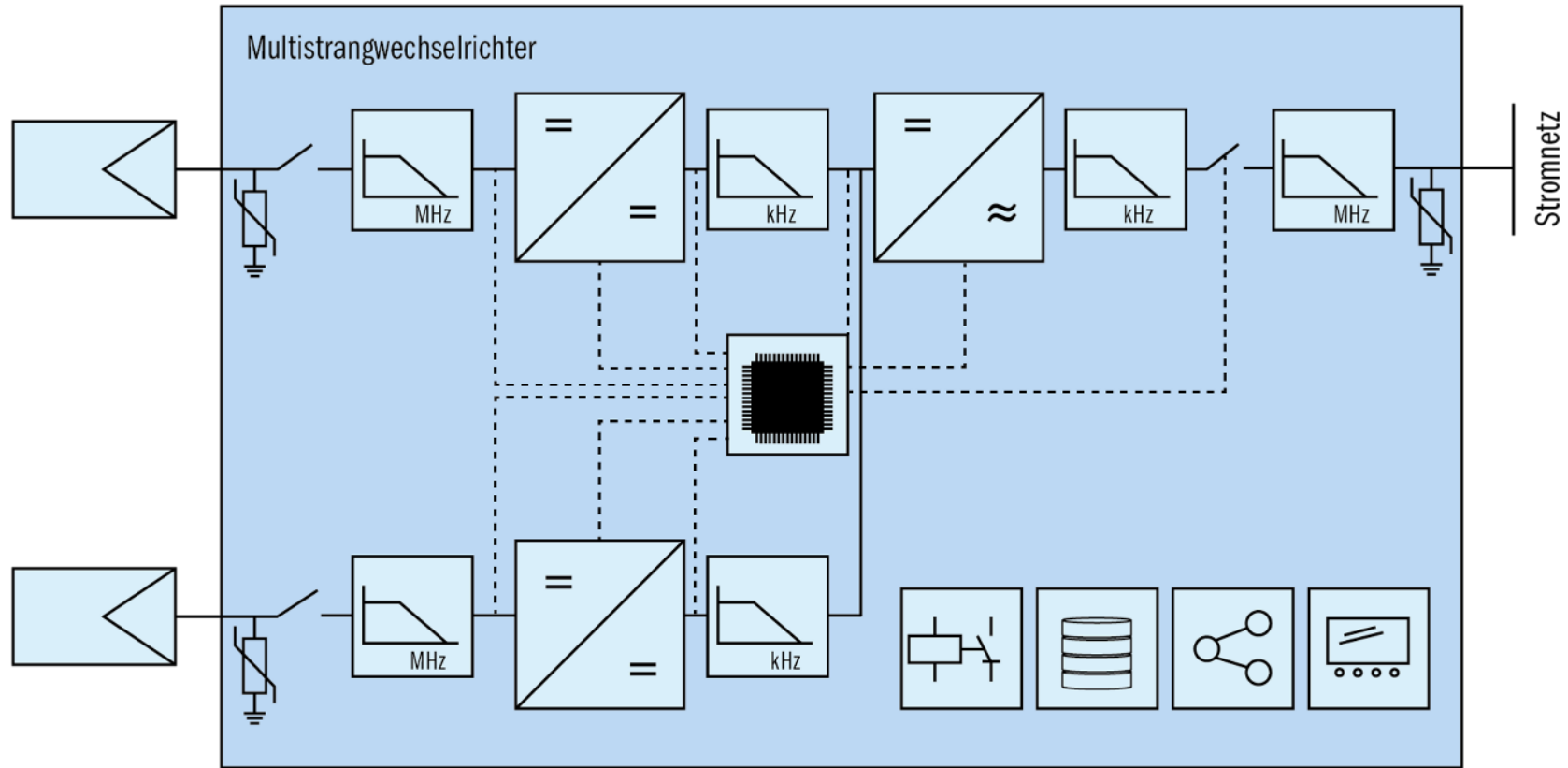




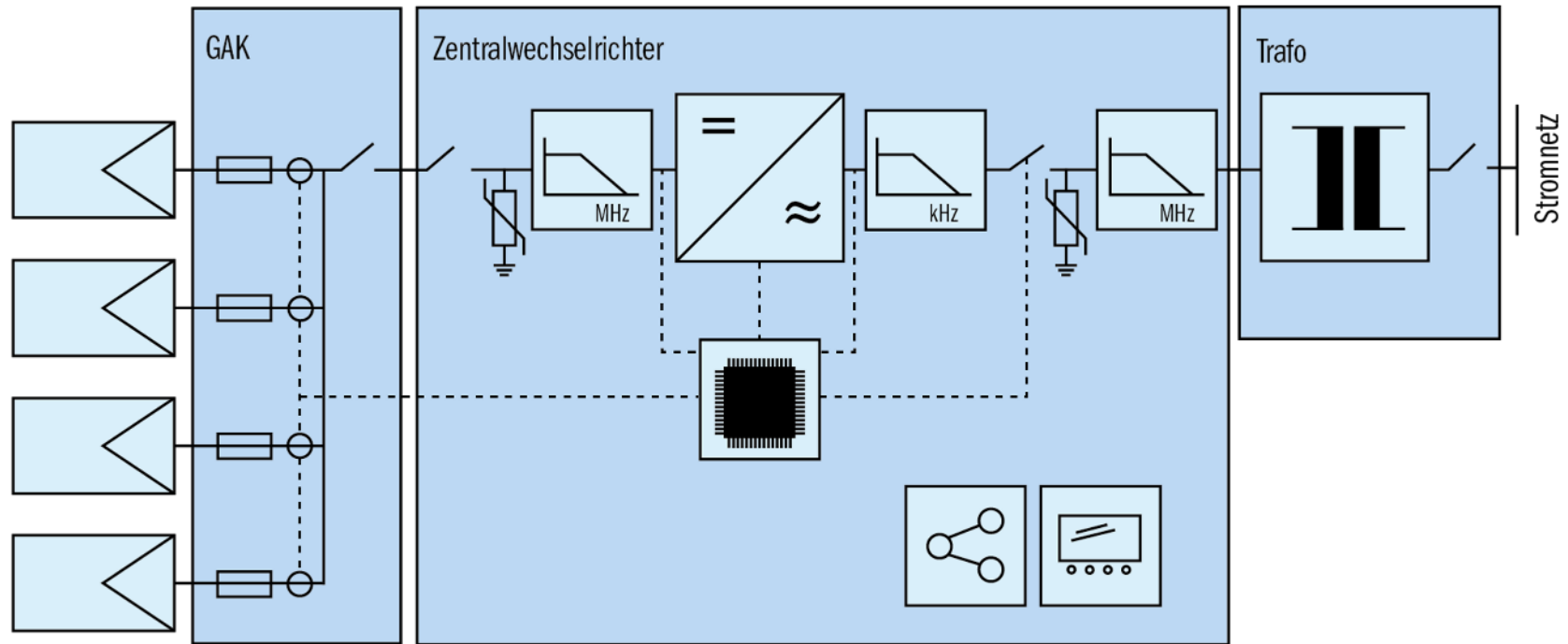
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



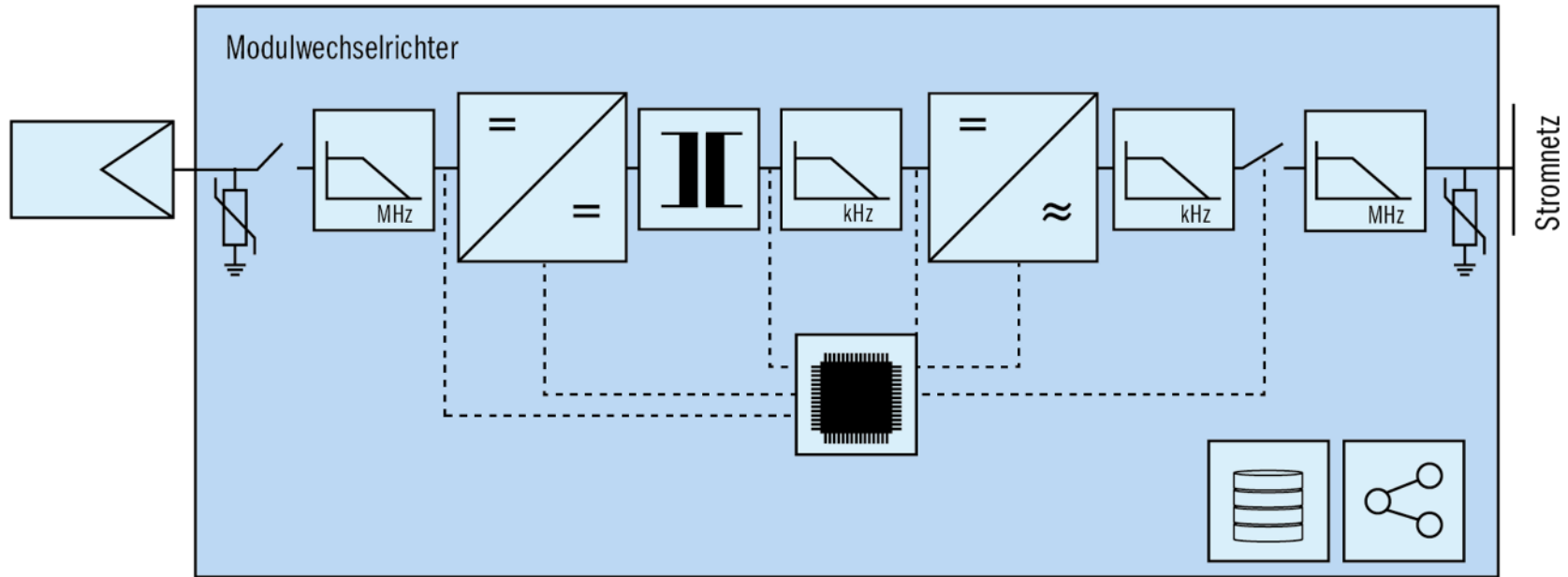
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



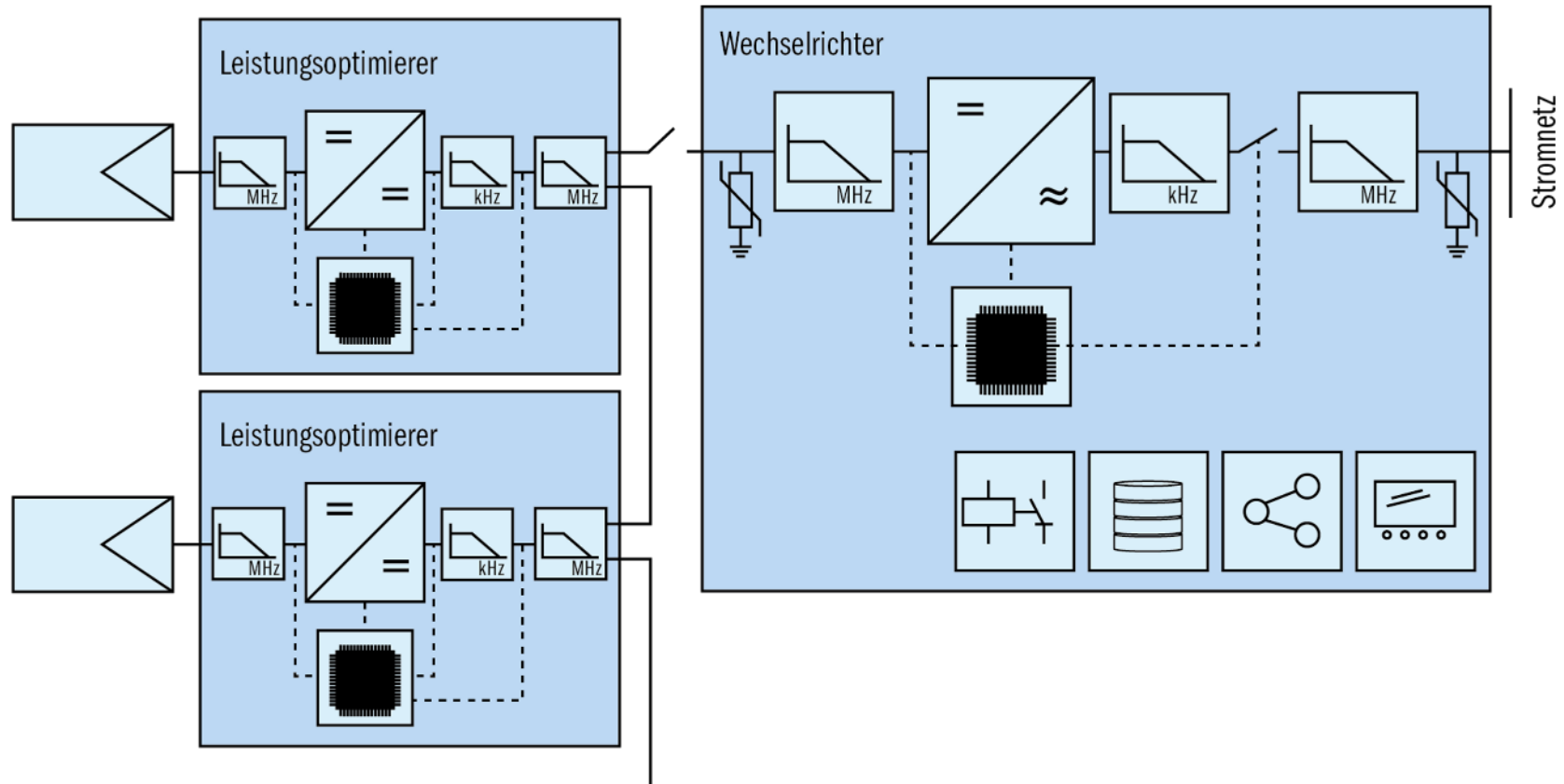
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

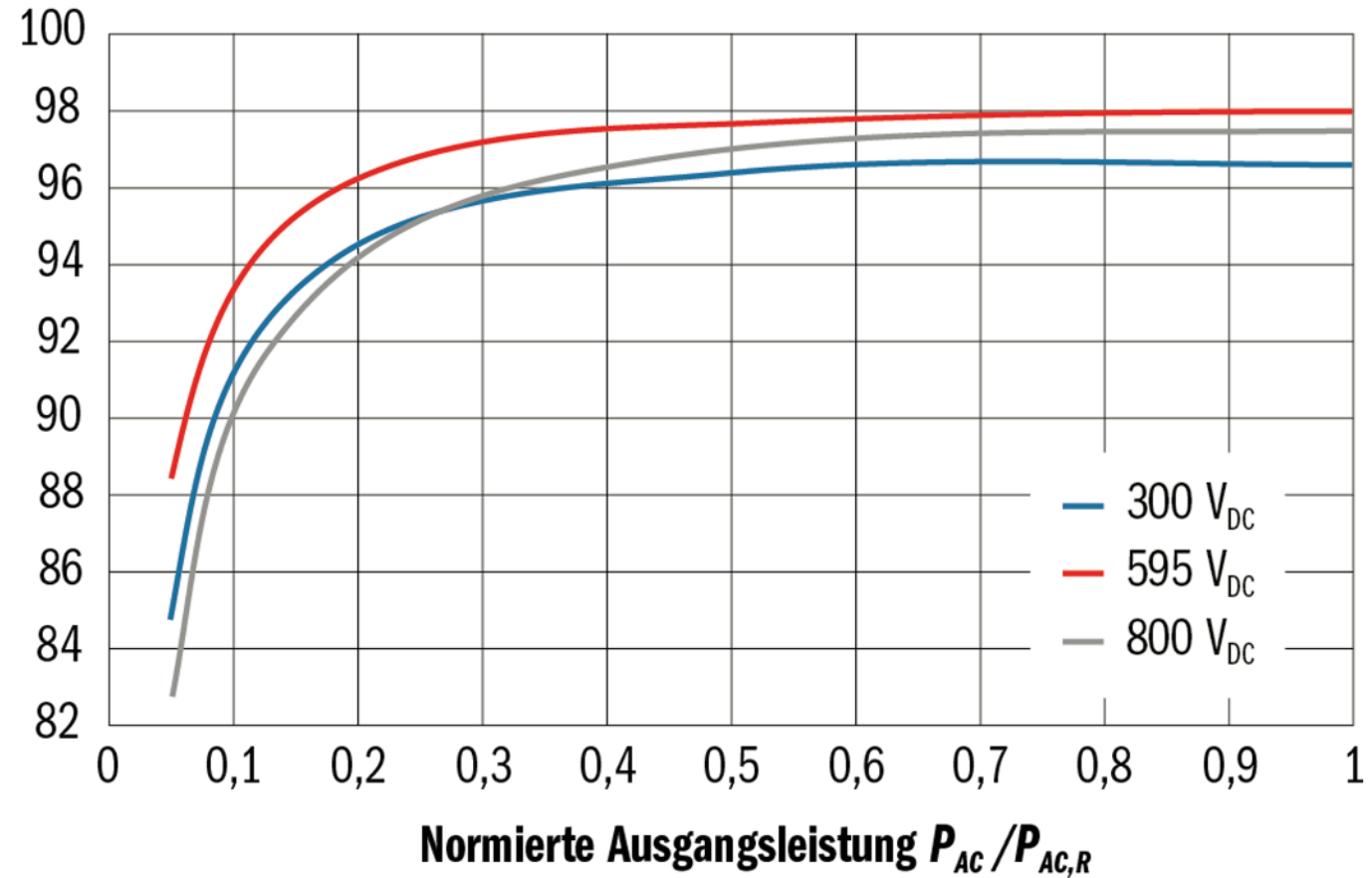


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

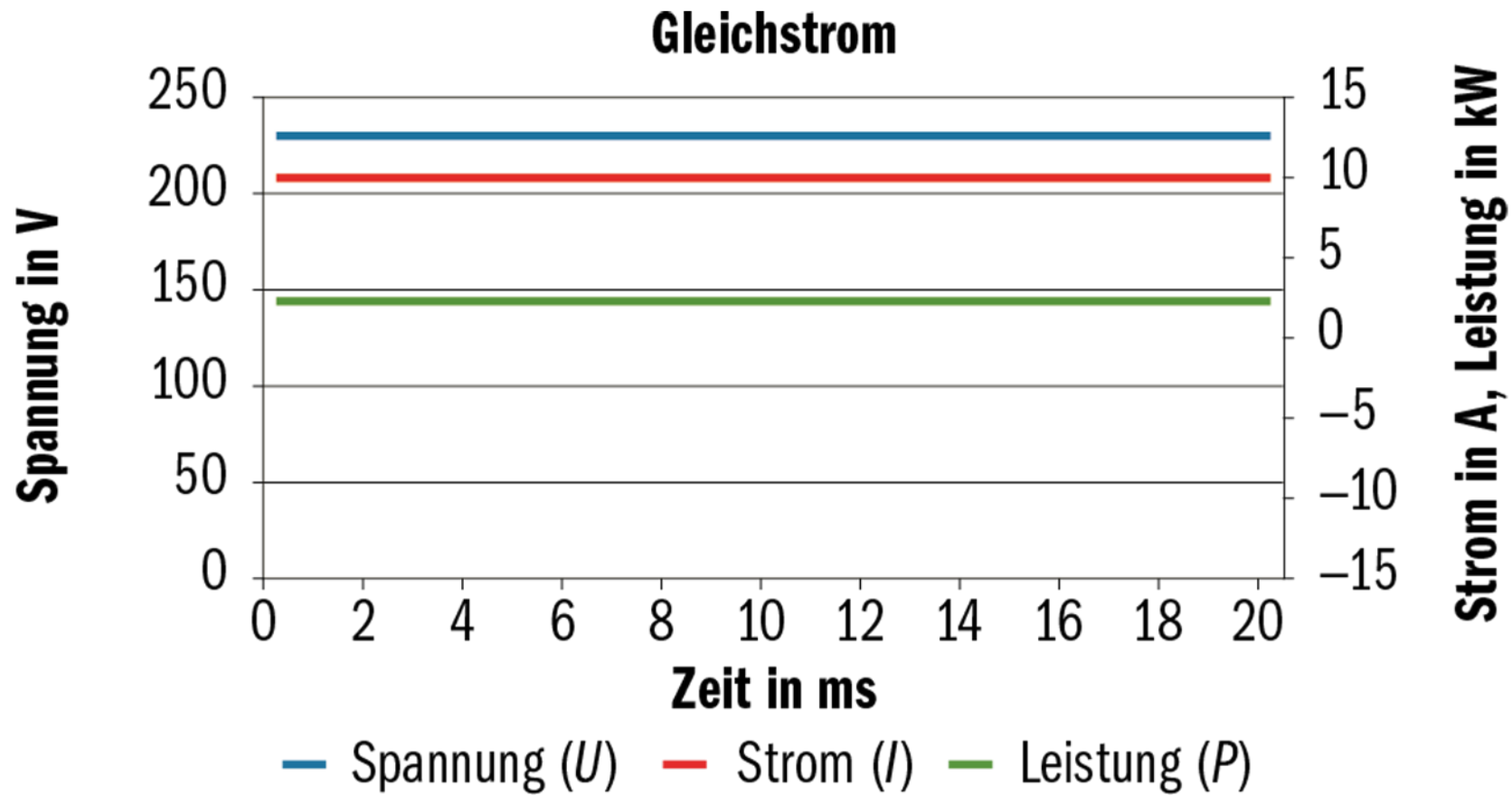


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

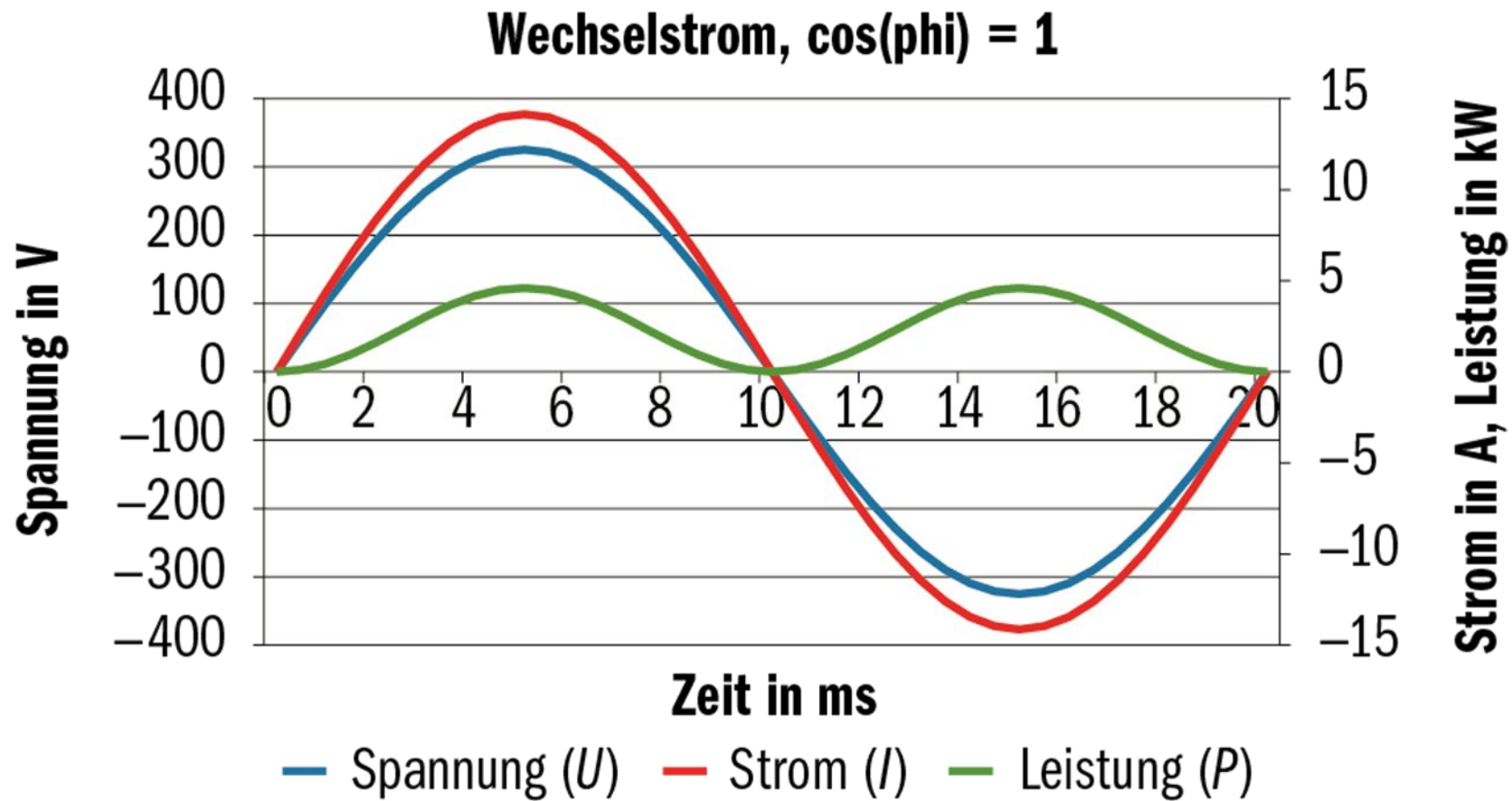
Wirkungsgrad in %



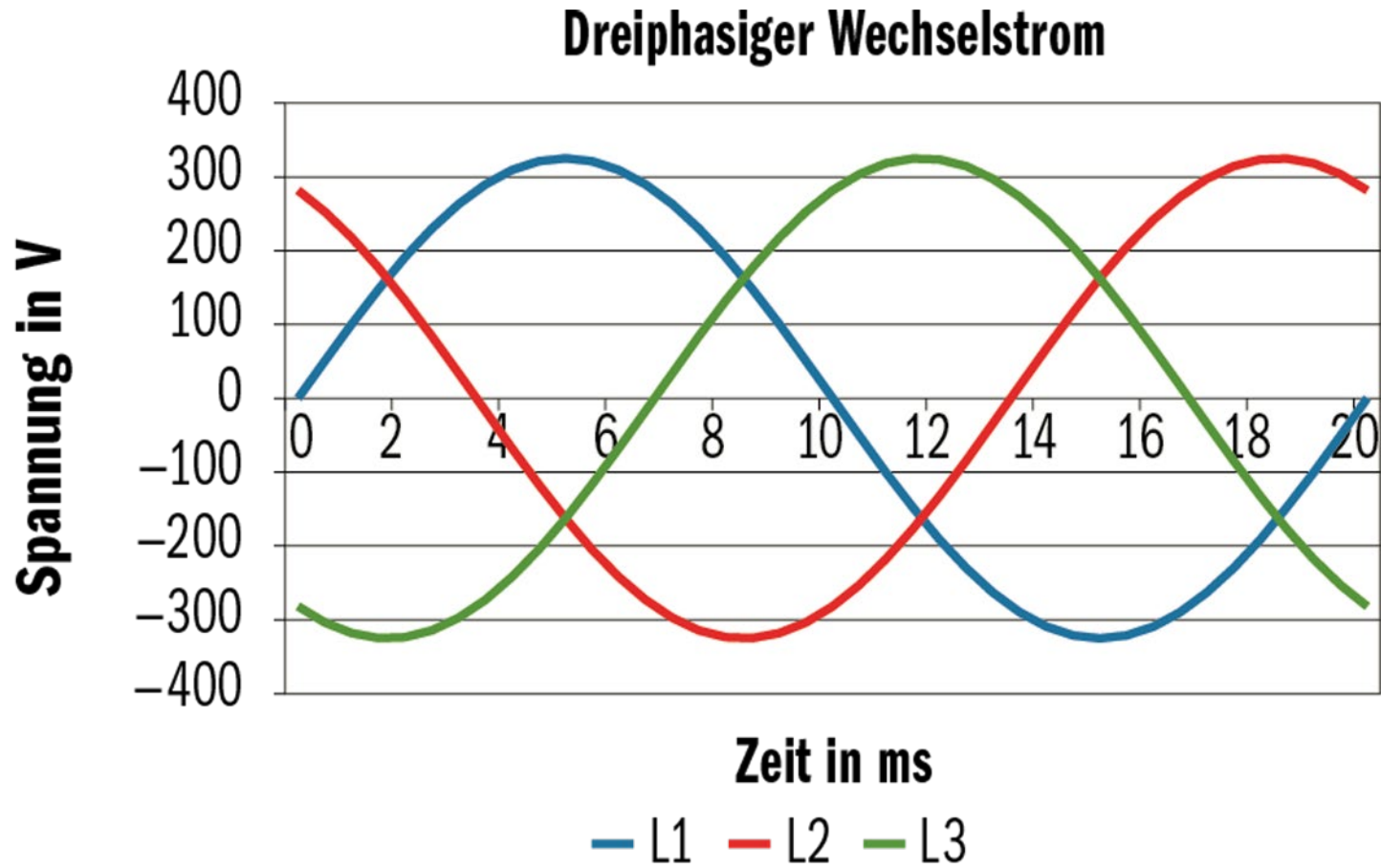
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



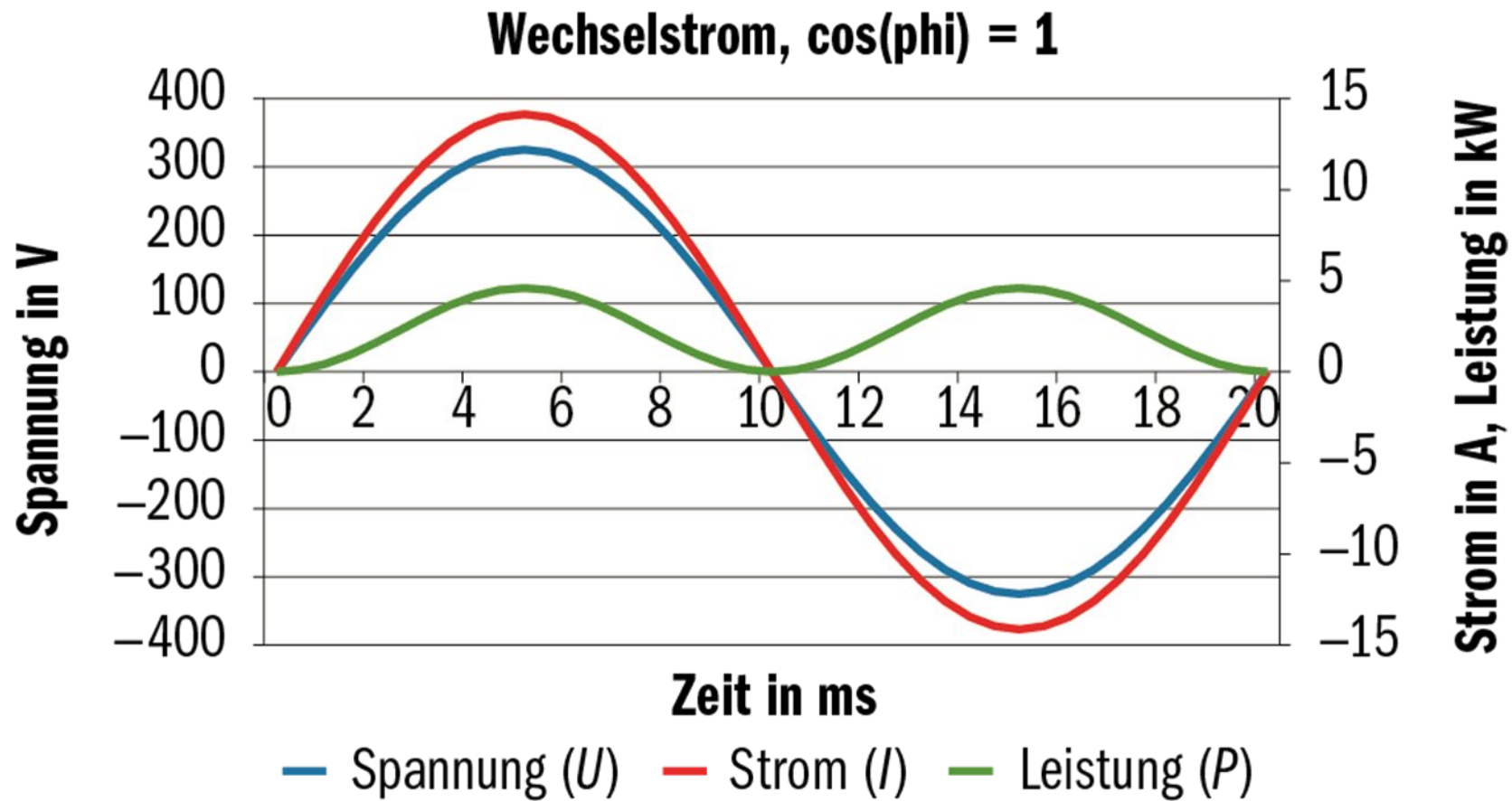
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



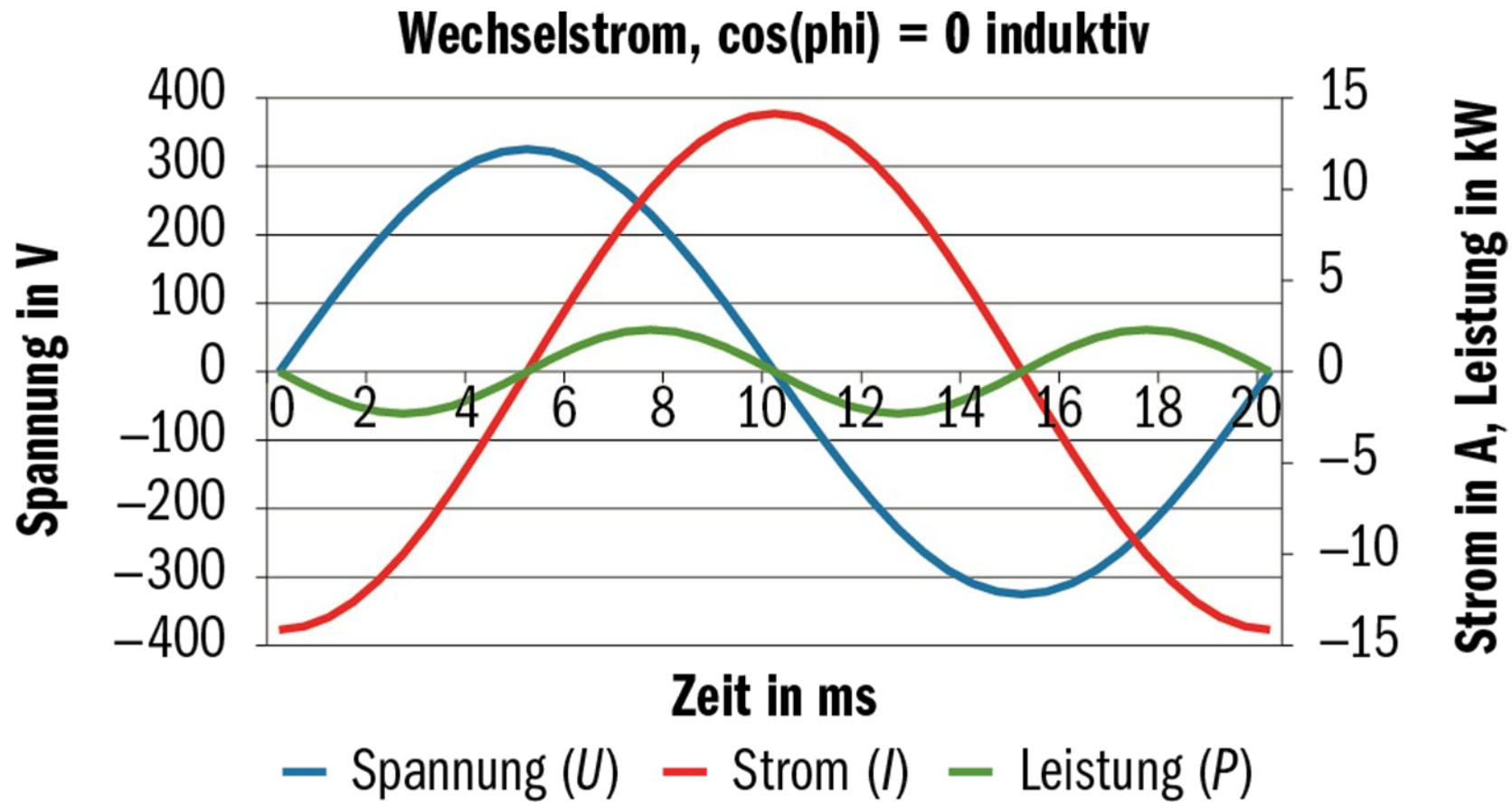
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



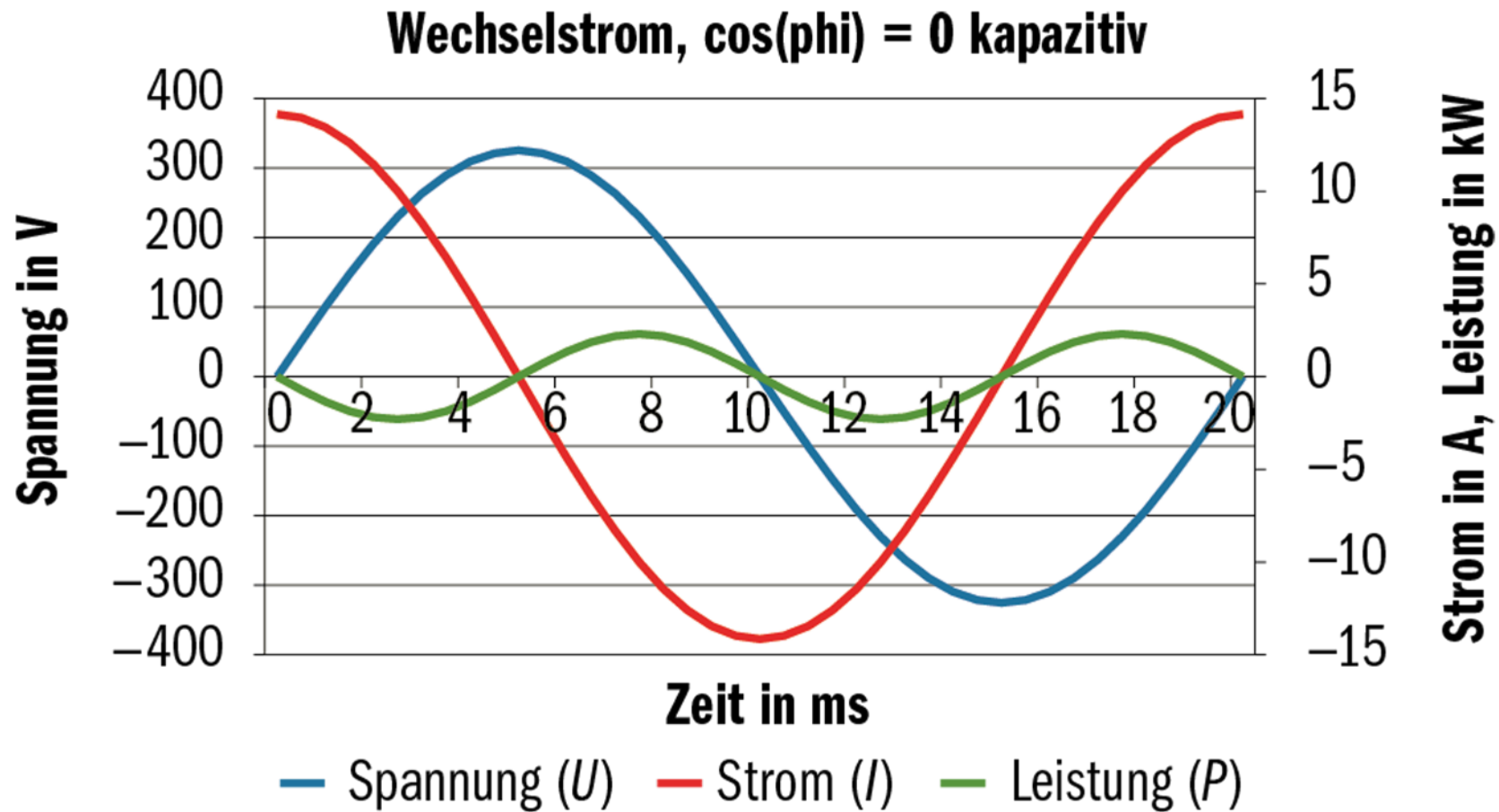
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

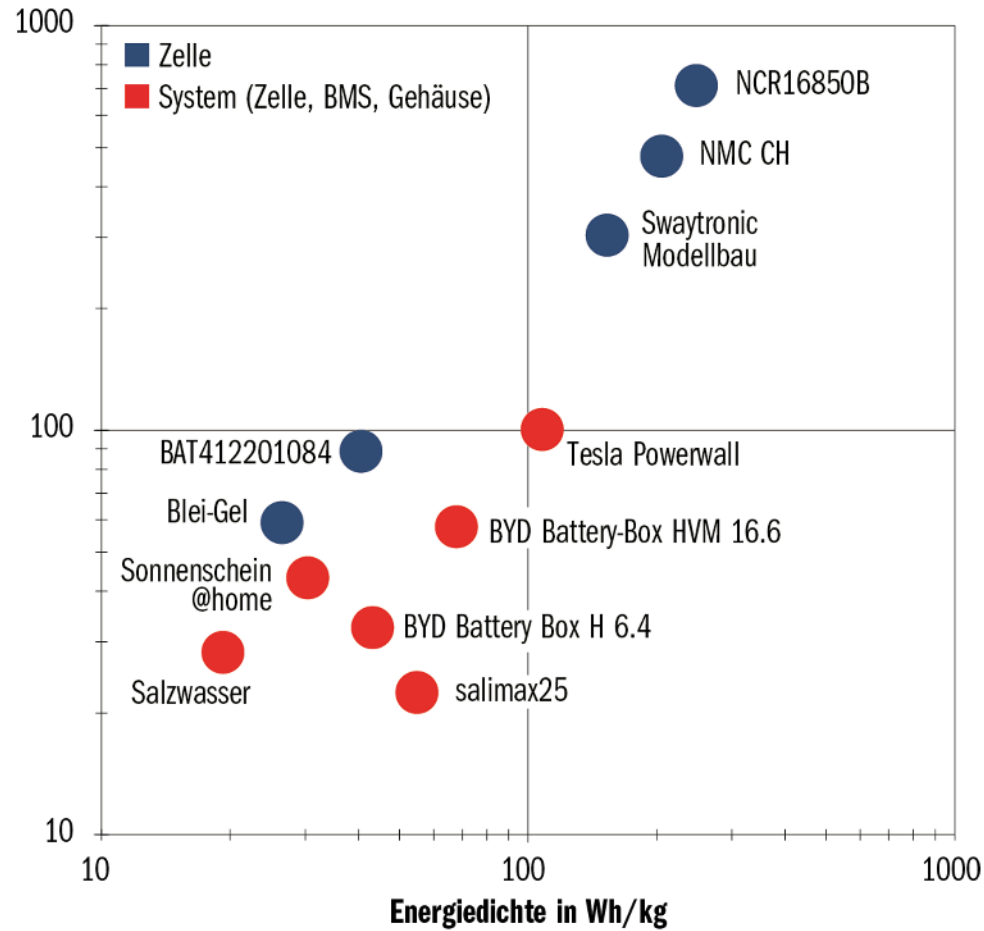


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

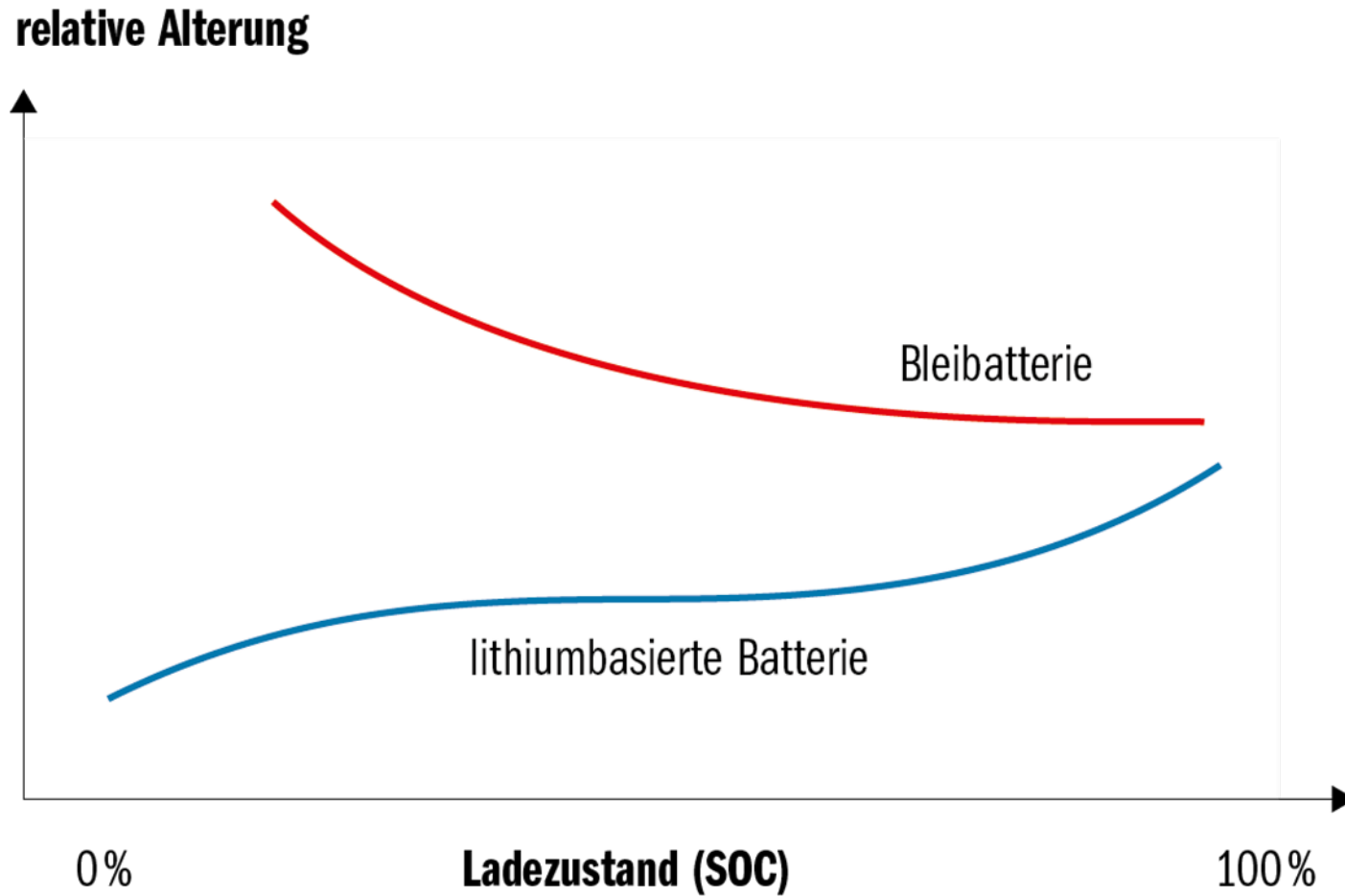


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

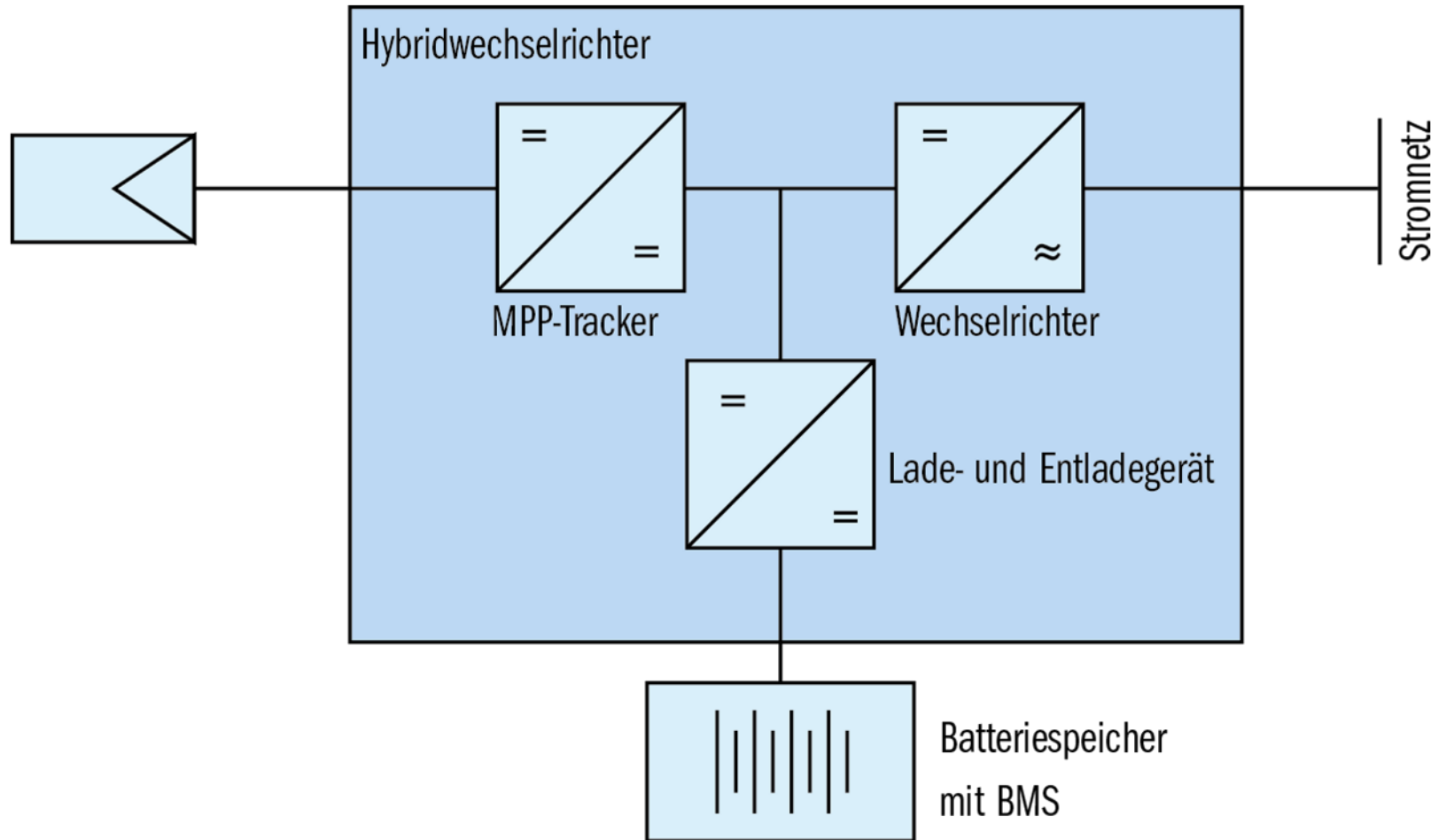
Energiedichte in Wh/dm³



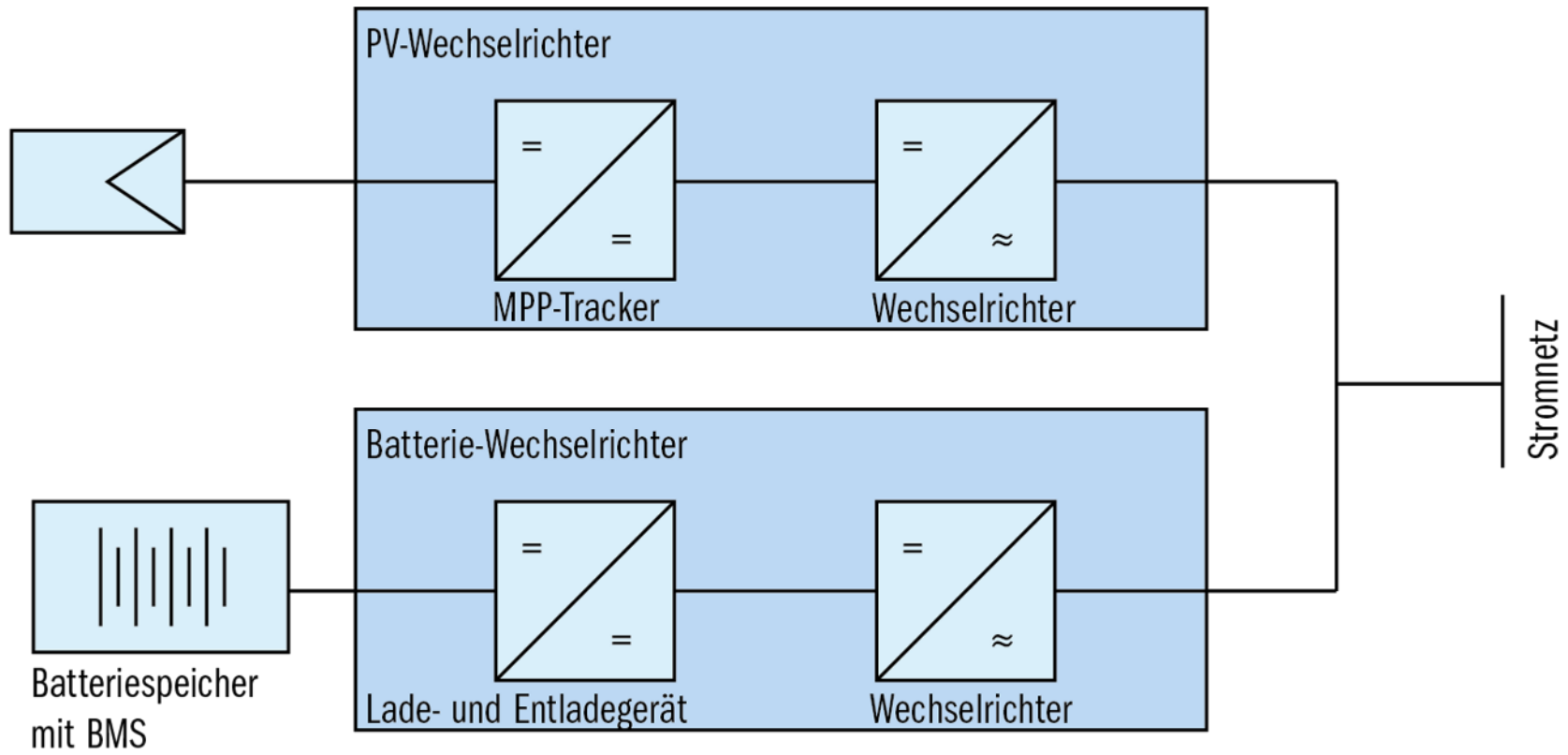
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



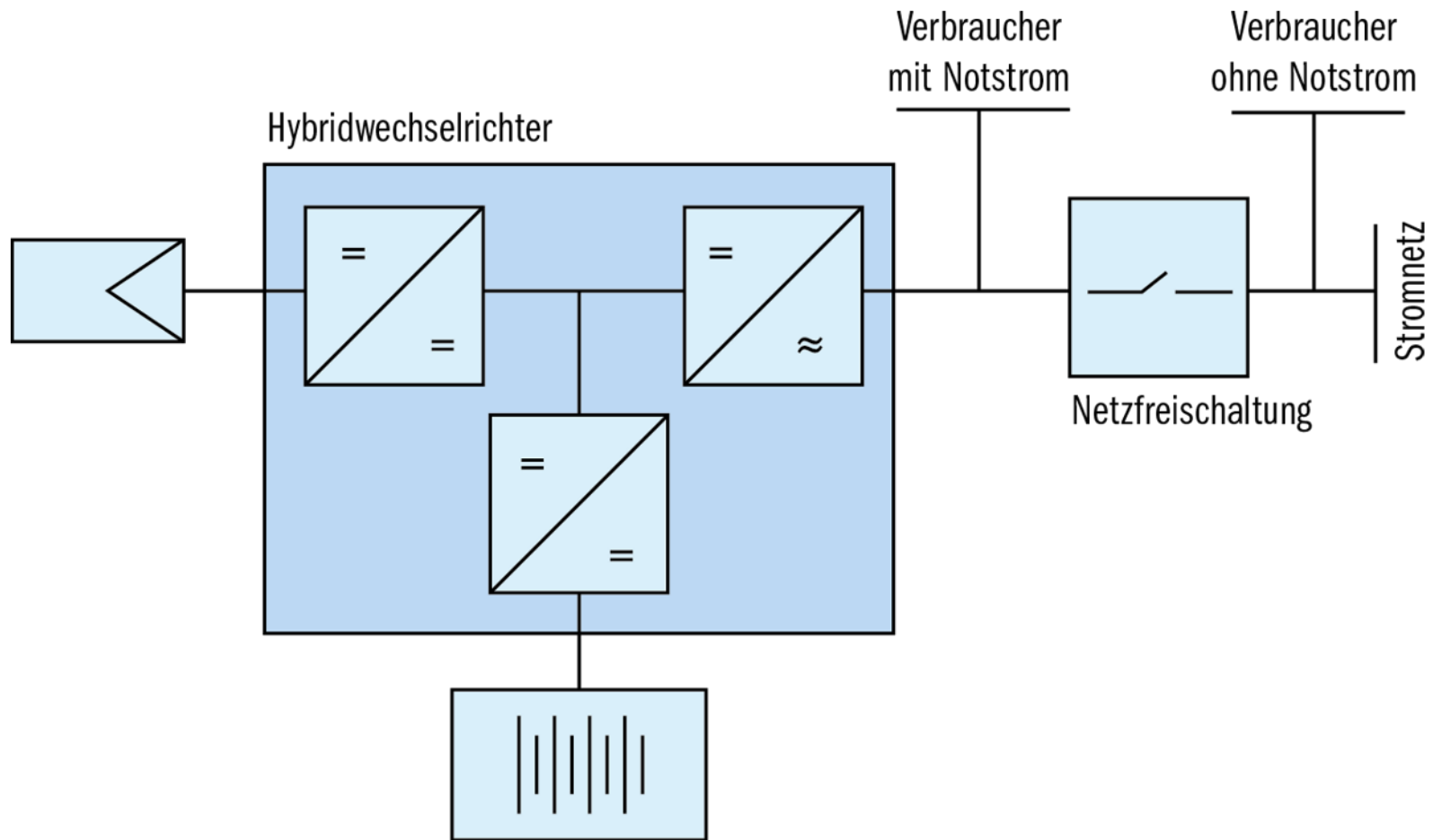
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



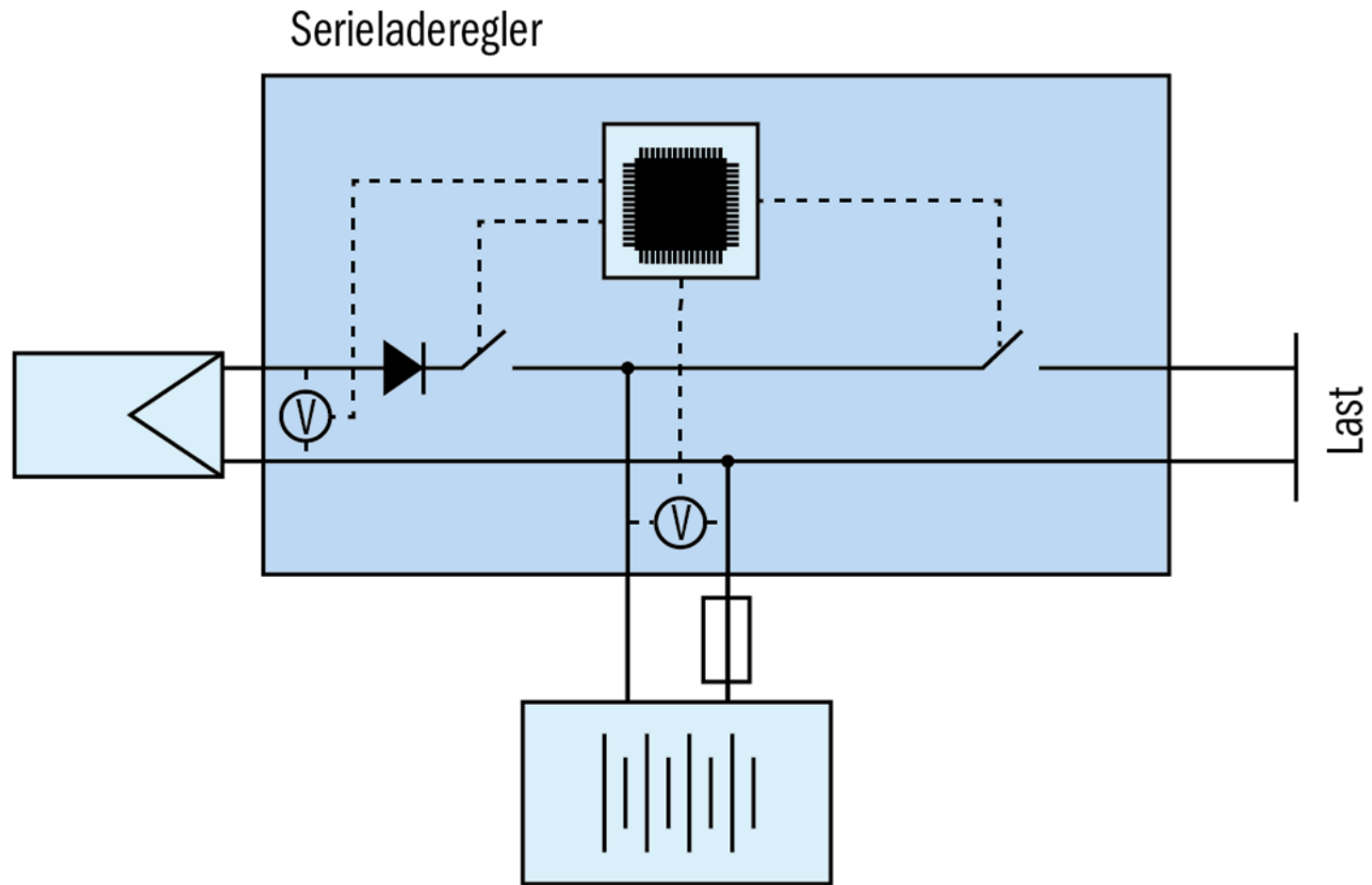
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



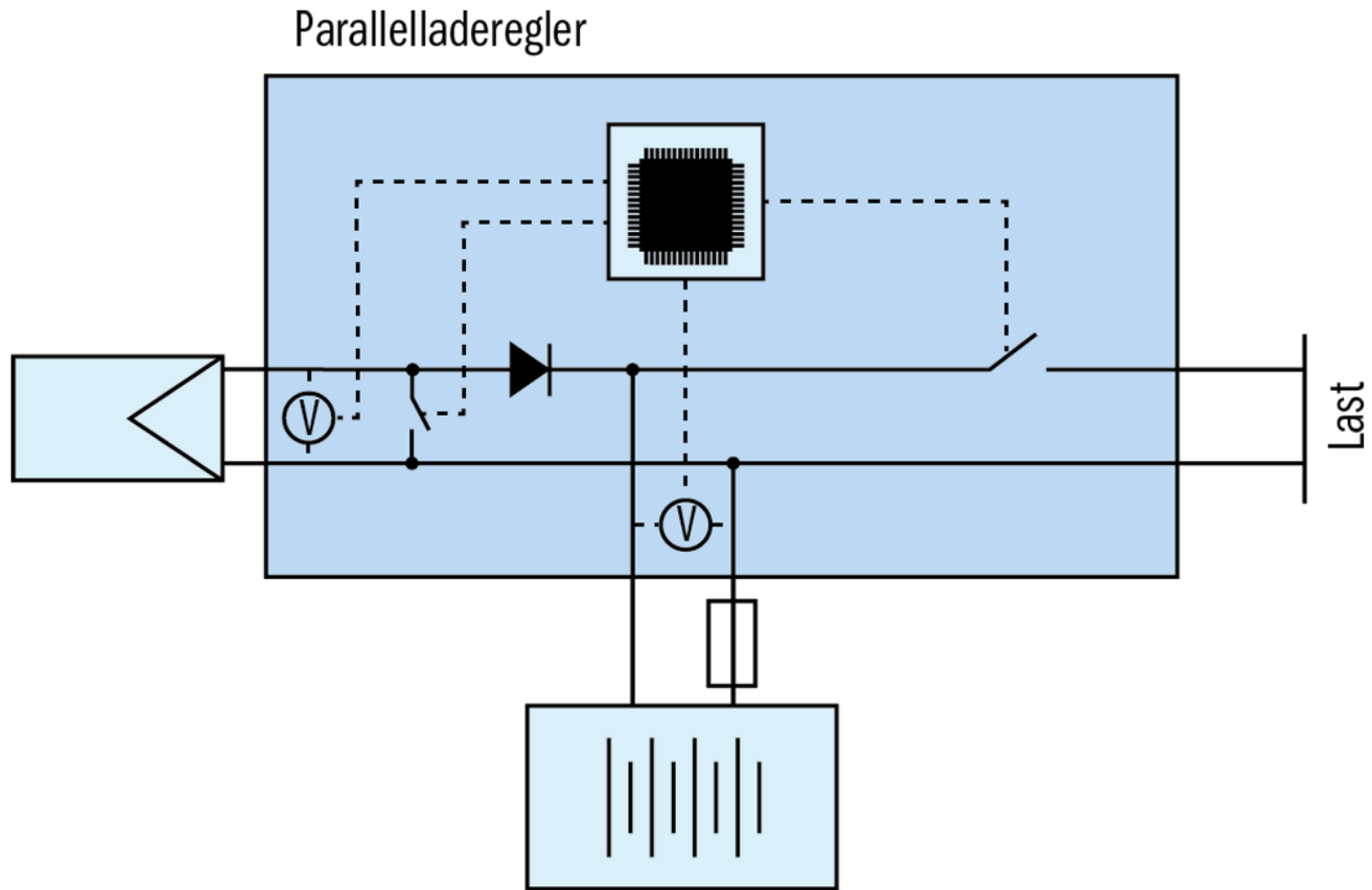
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

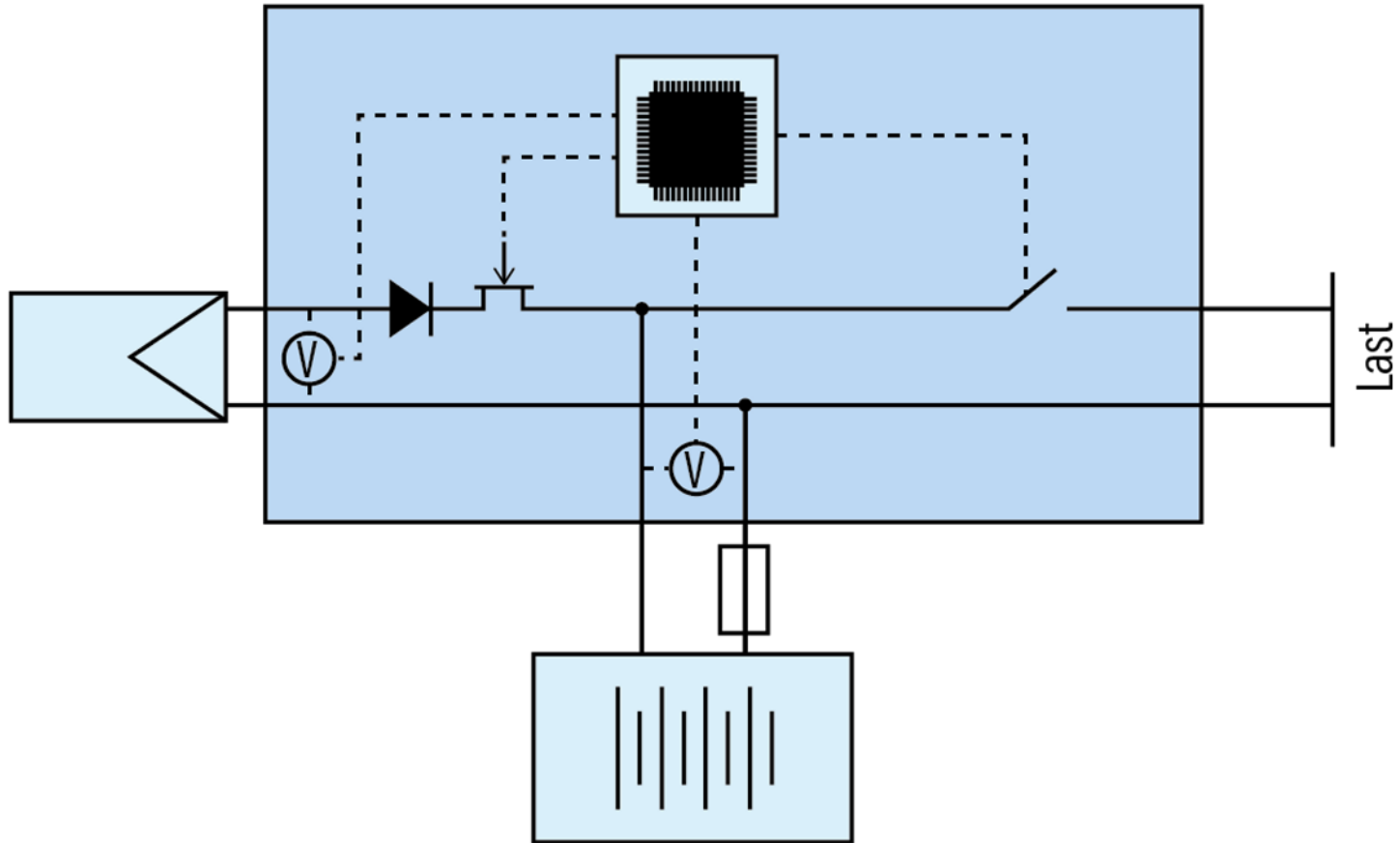


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

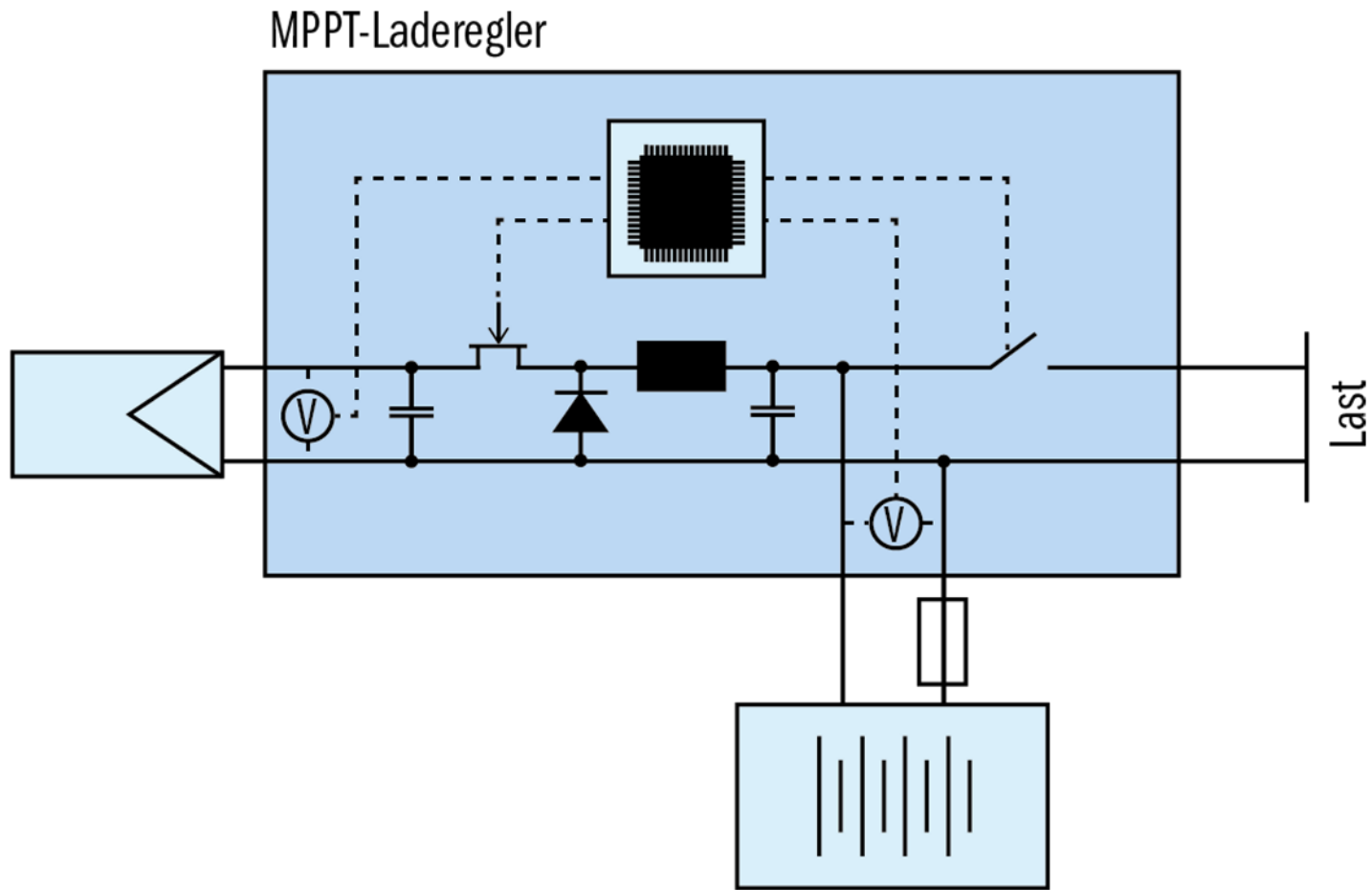


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

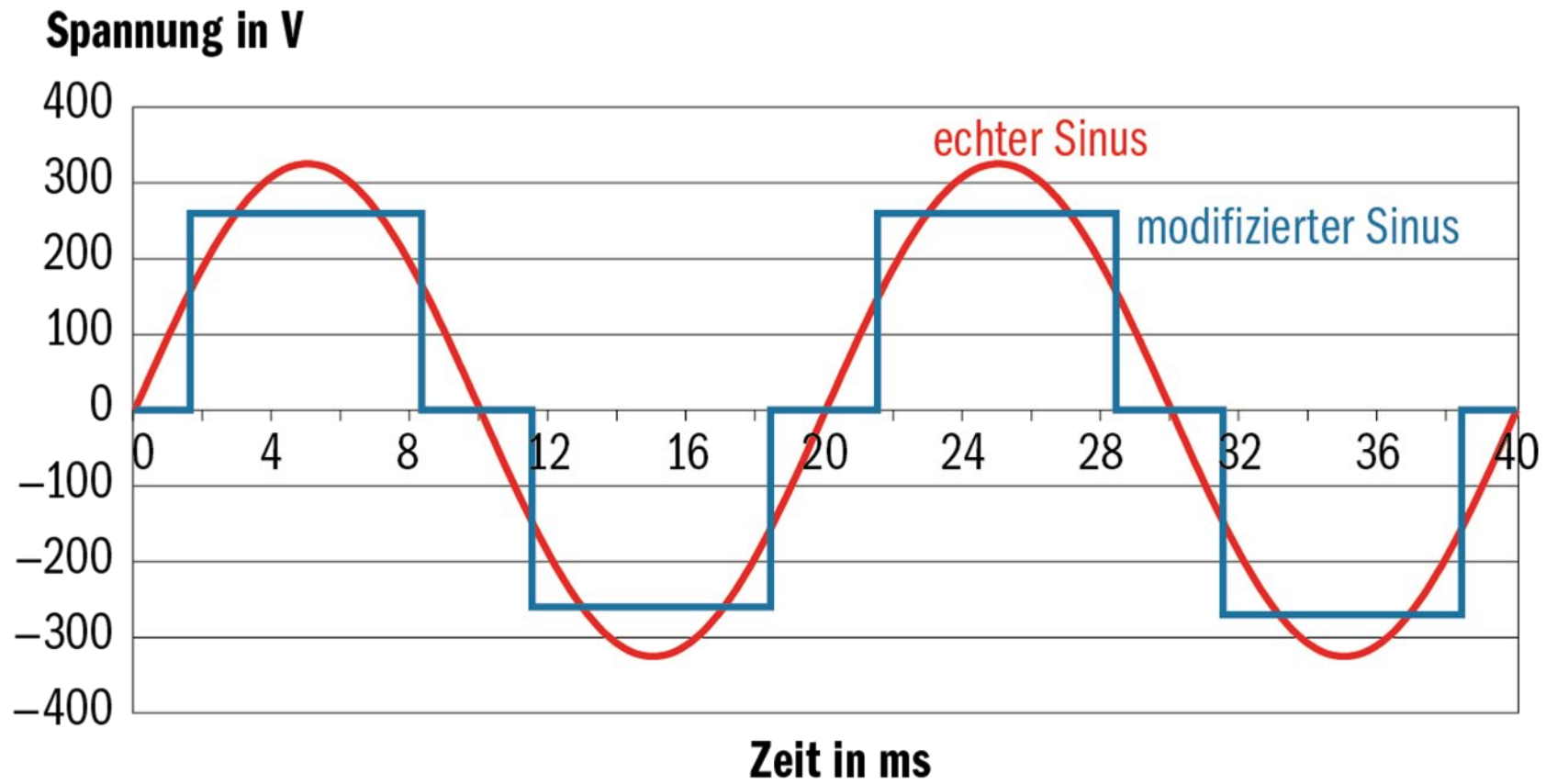
PWM-Laderegler (Serie)



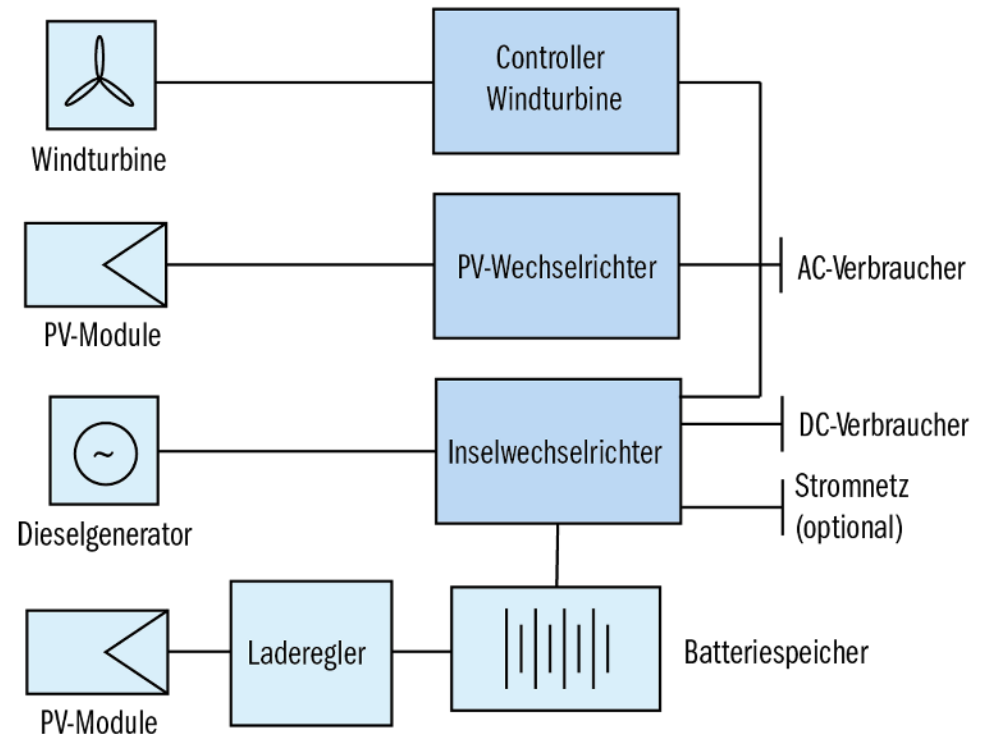
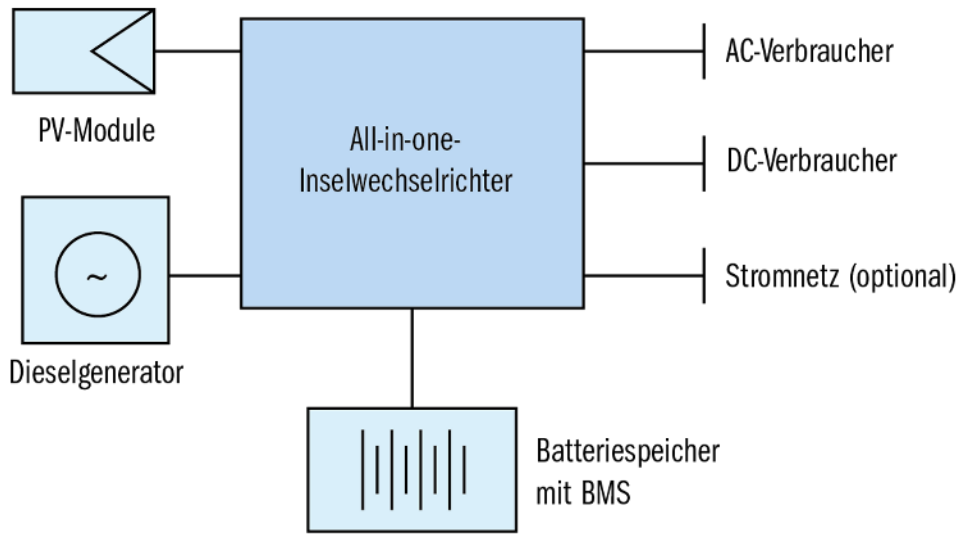
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



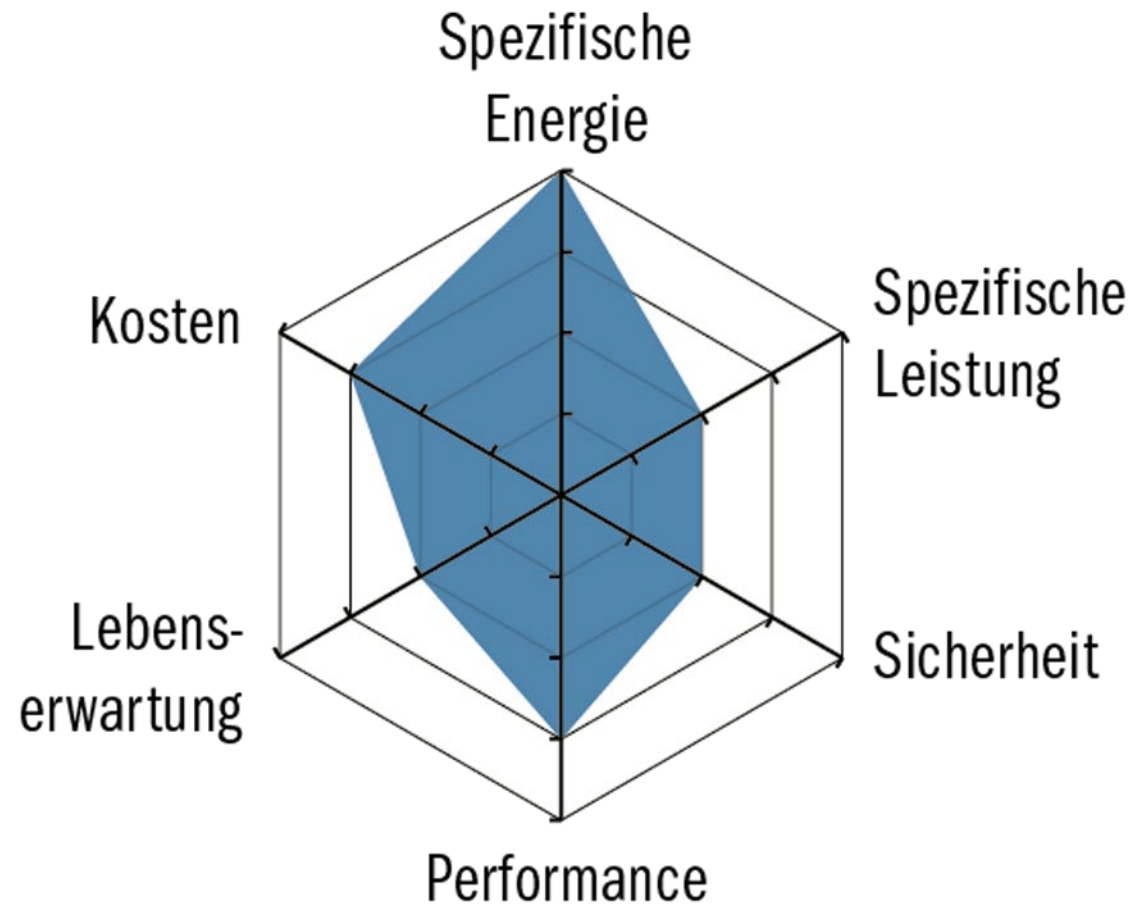
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



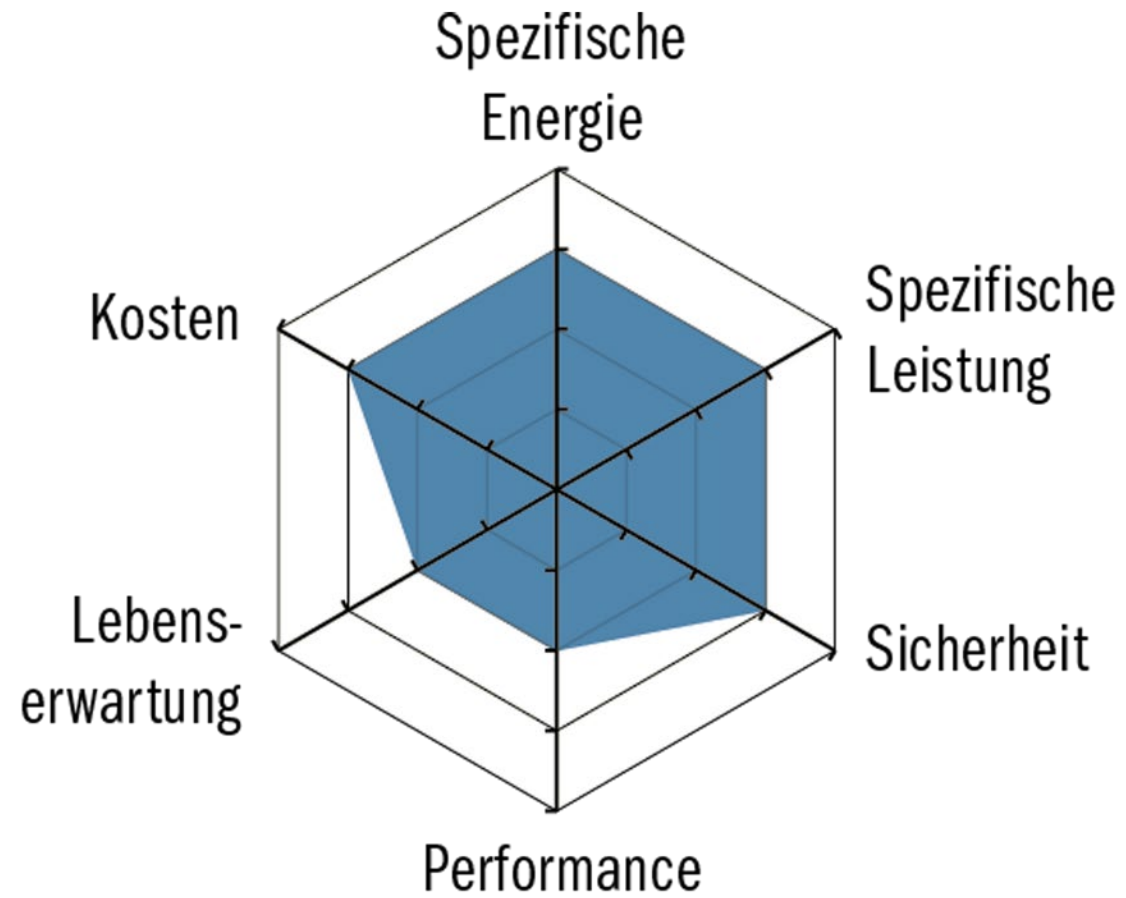
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



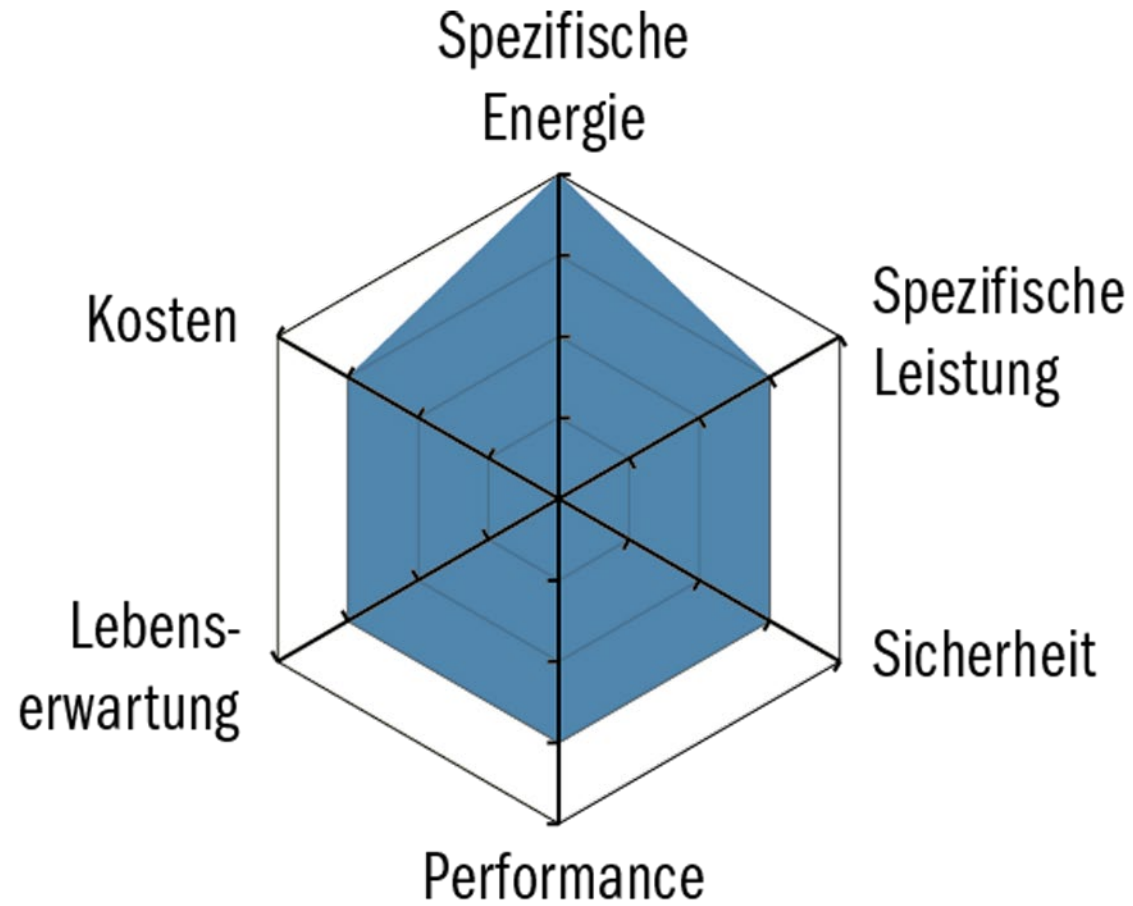
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



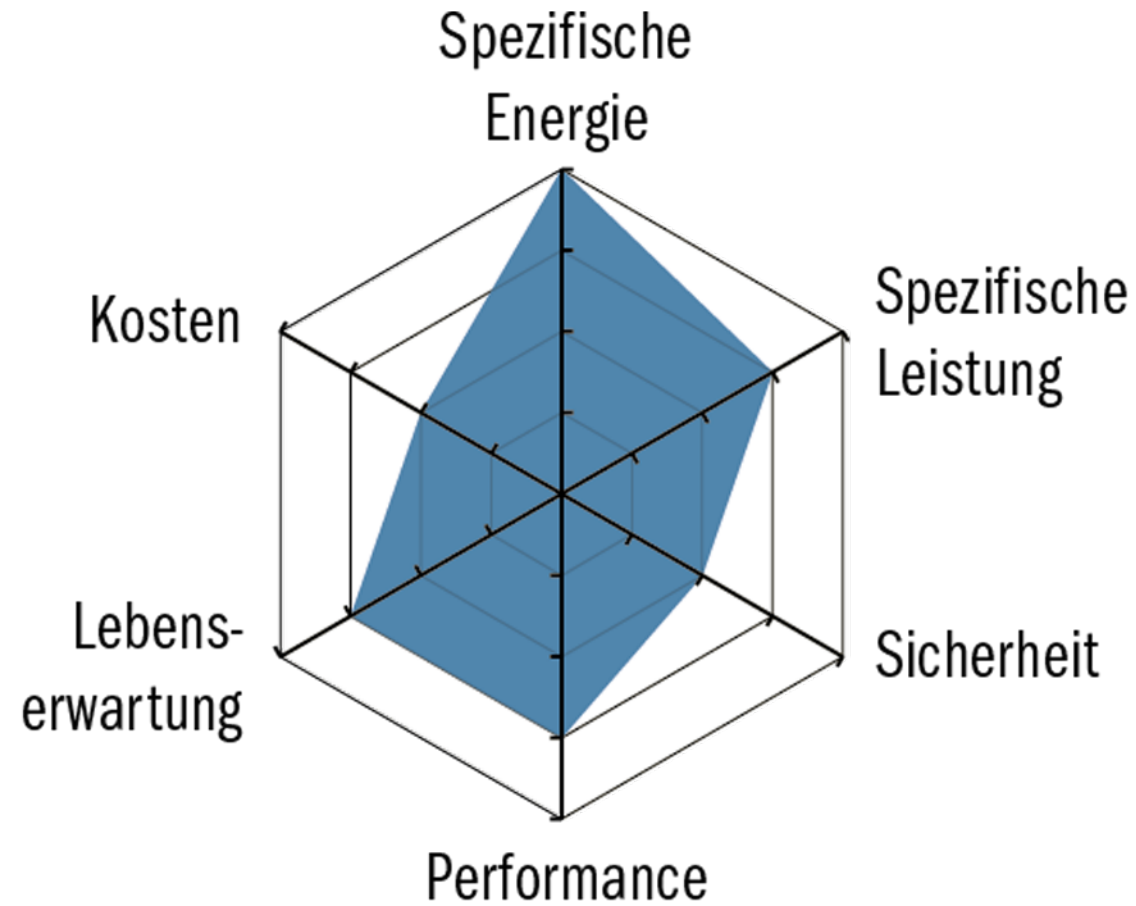
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



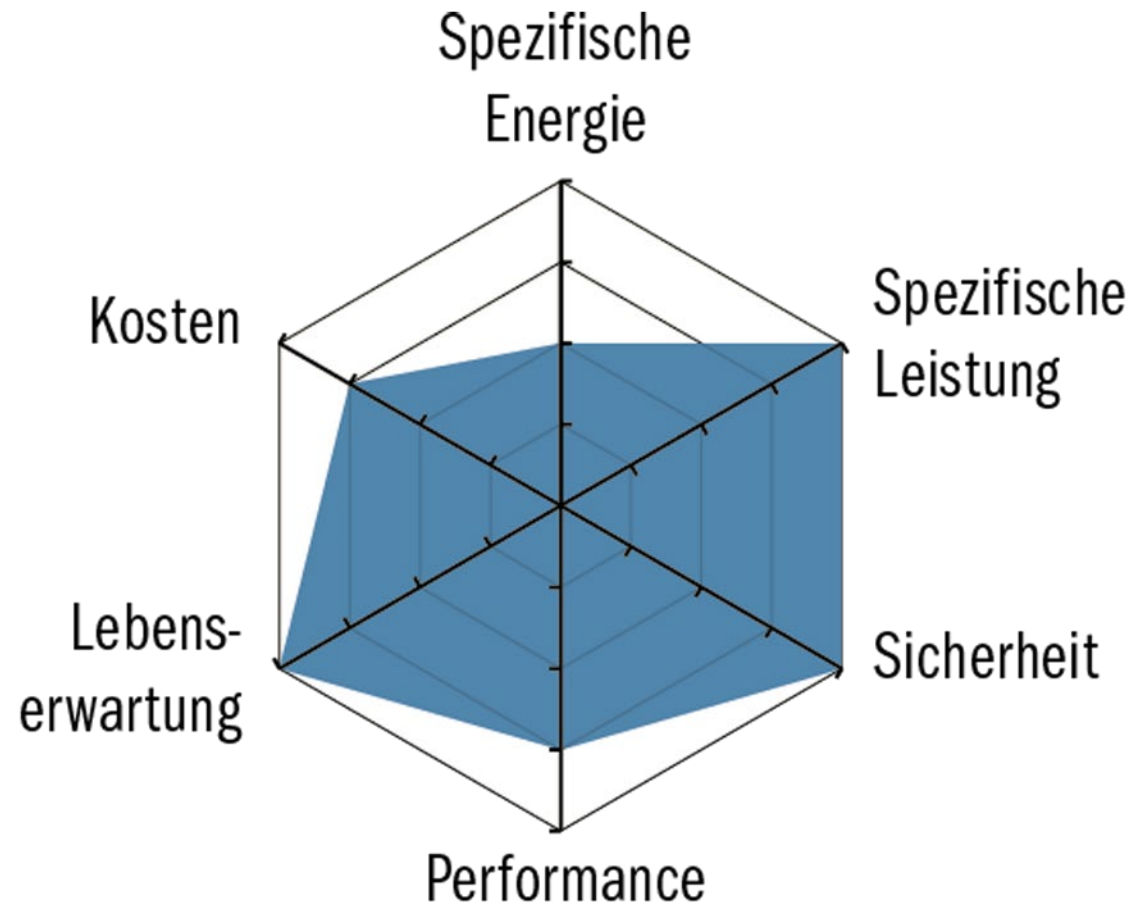
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



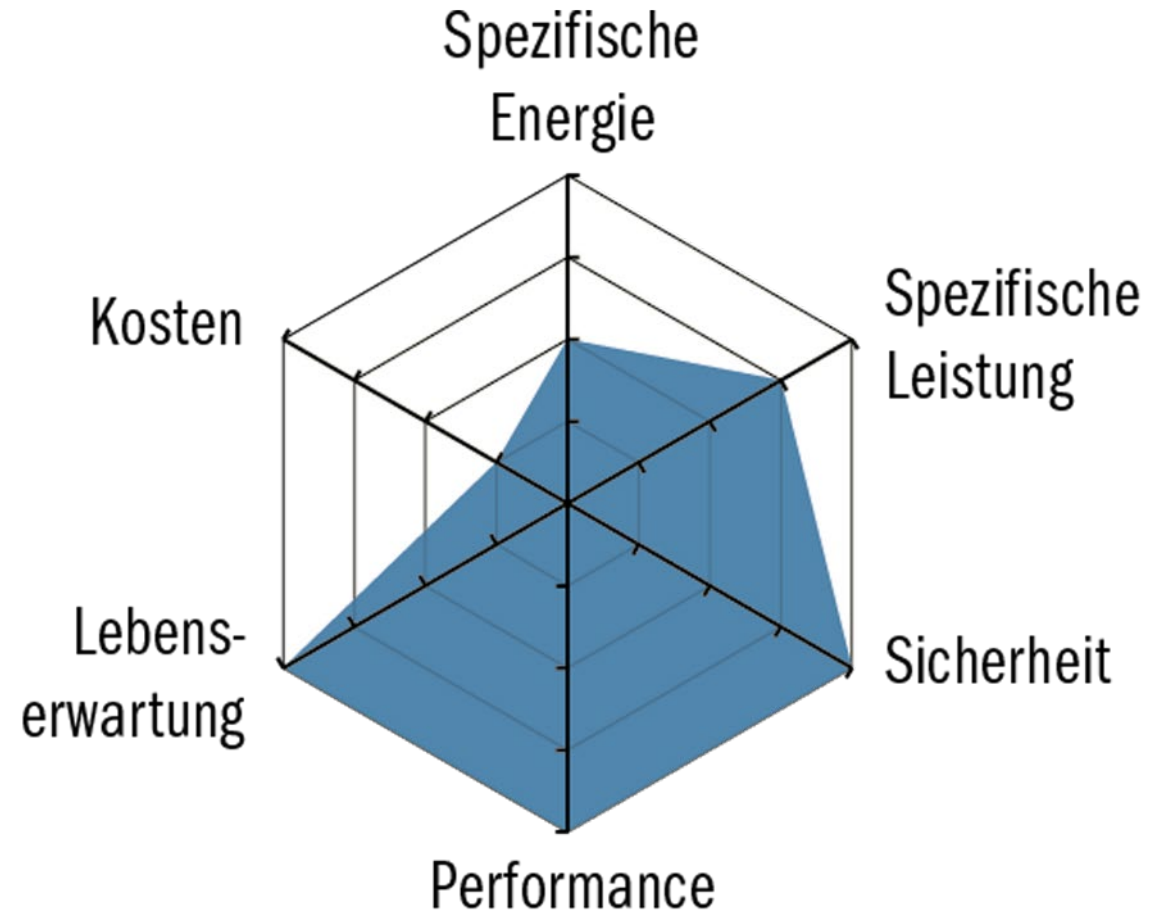
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



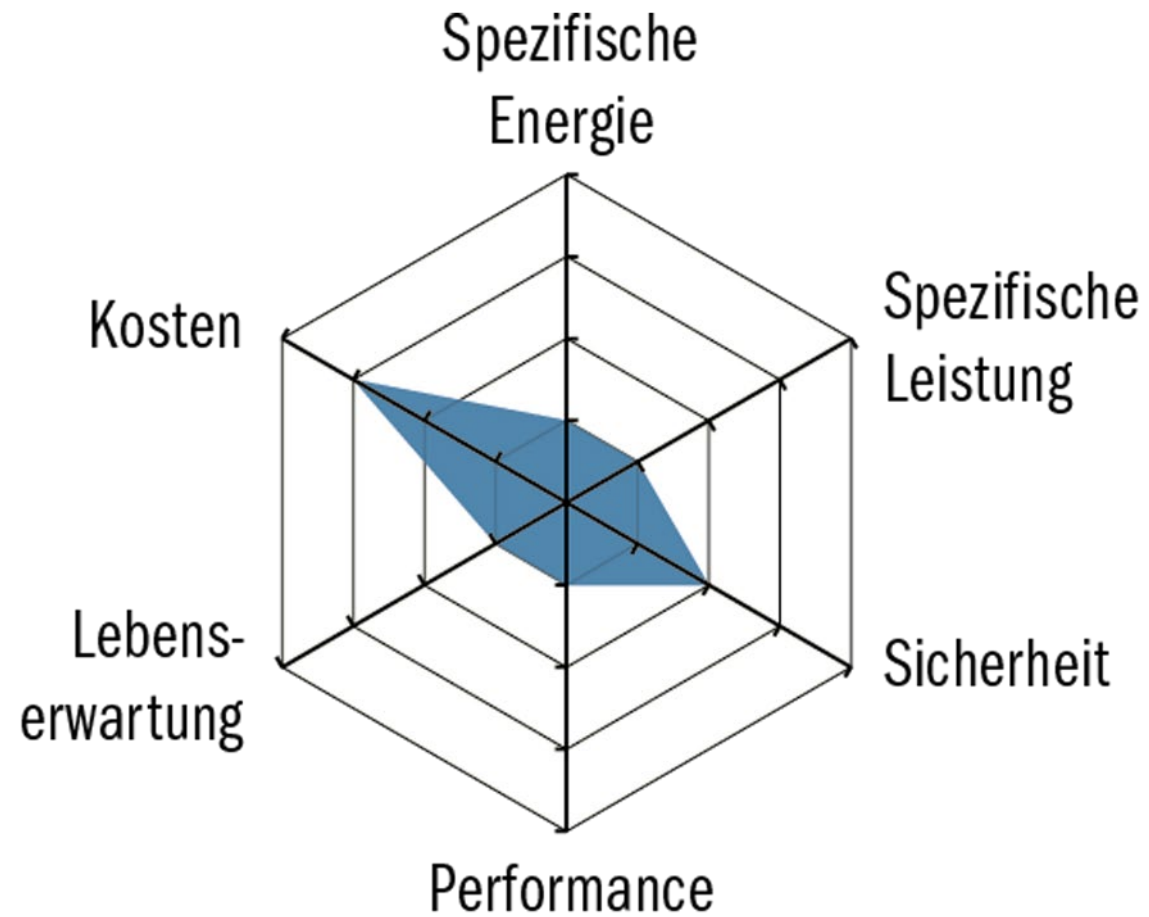
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



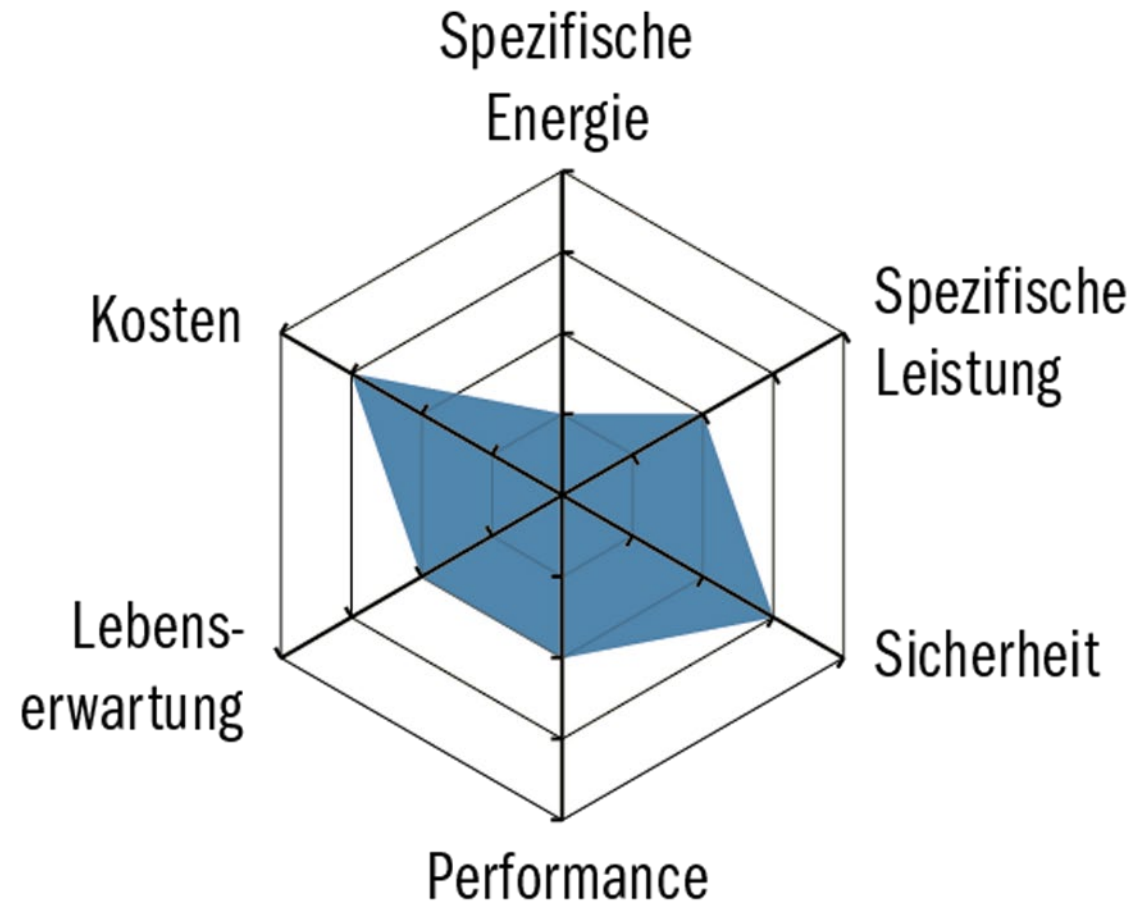
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



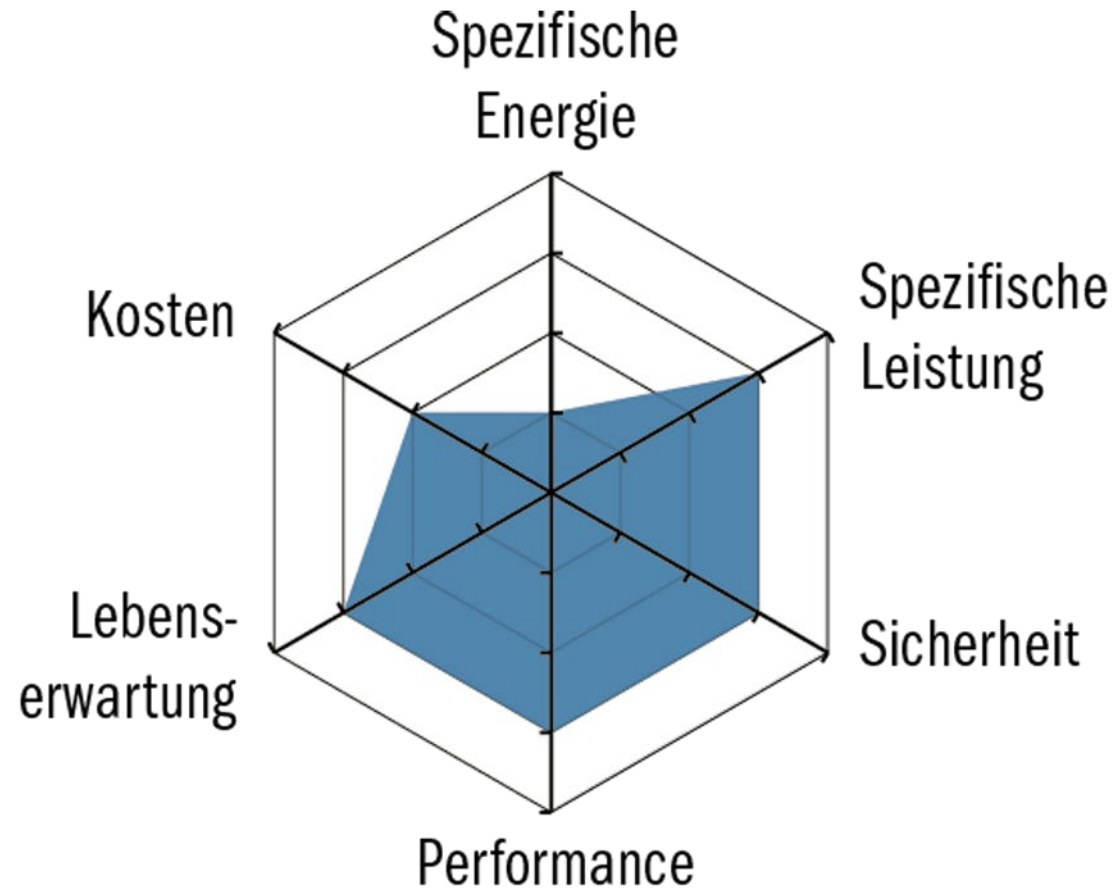
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



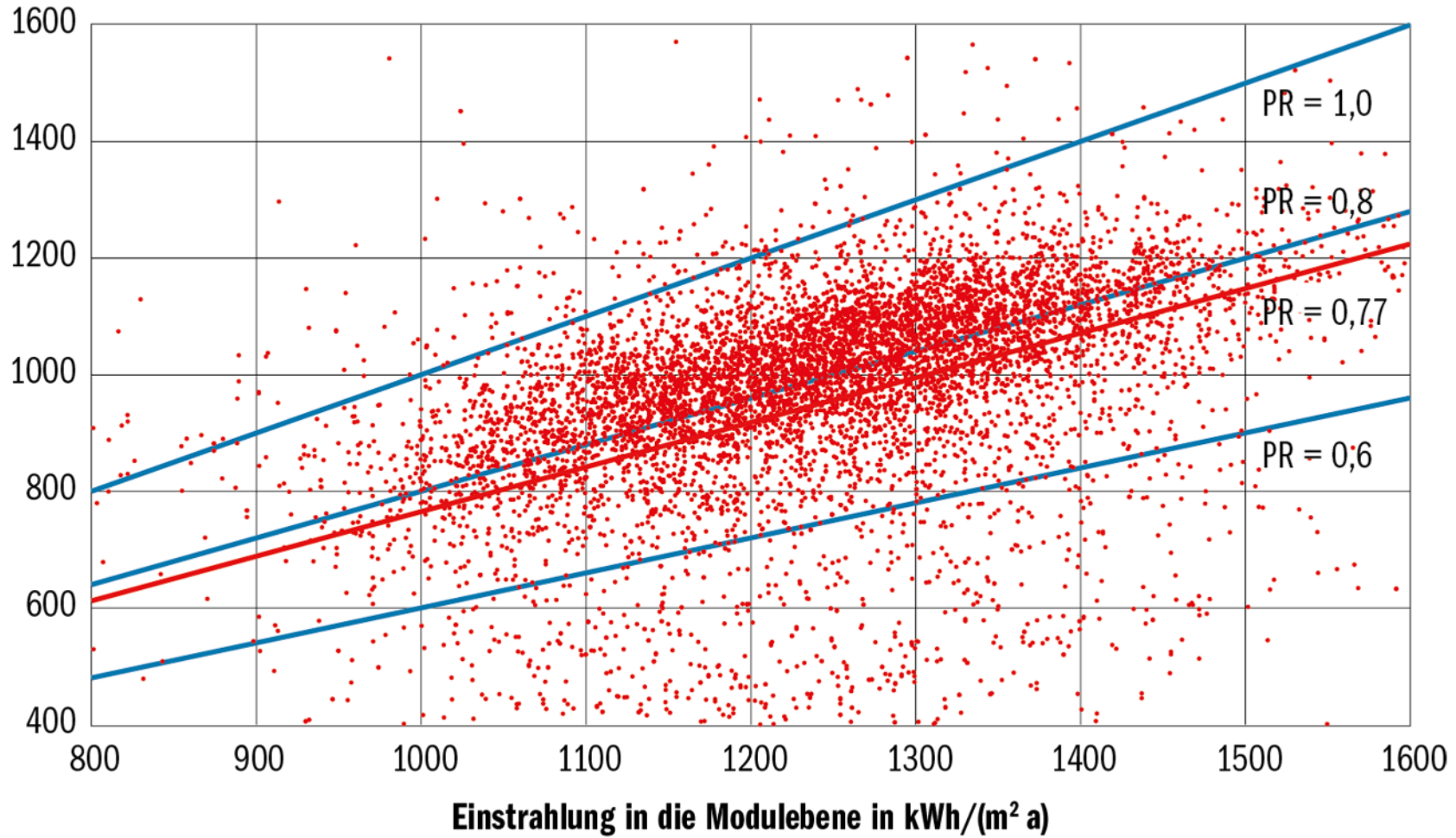
Preis

Genauigkeit

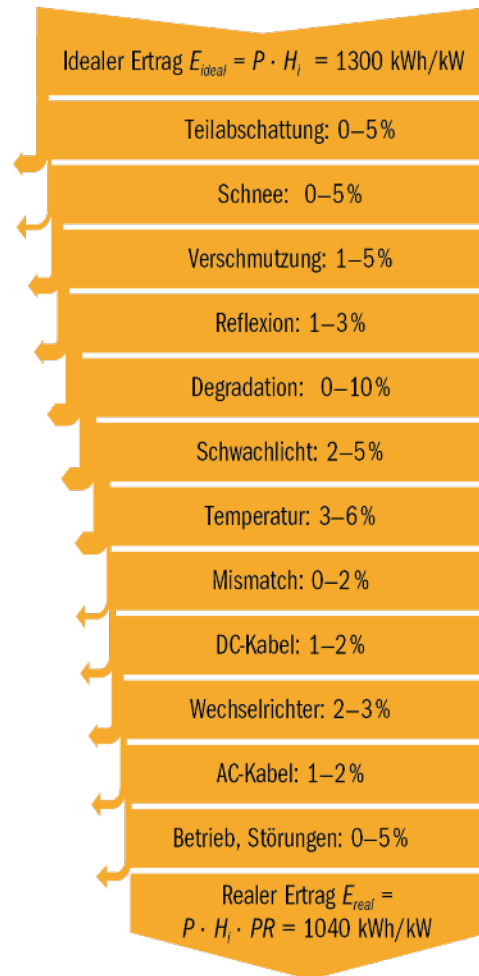


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

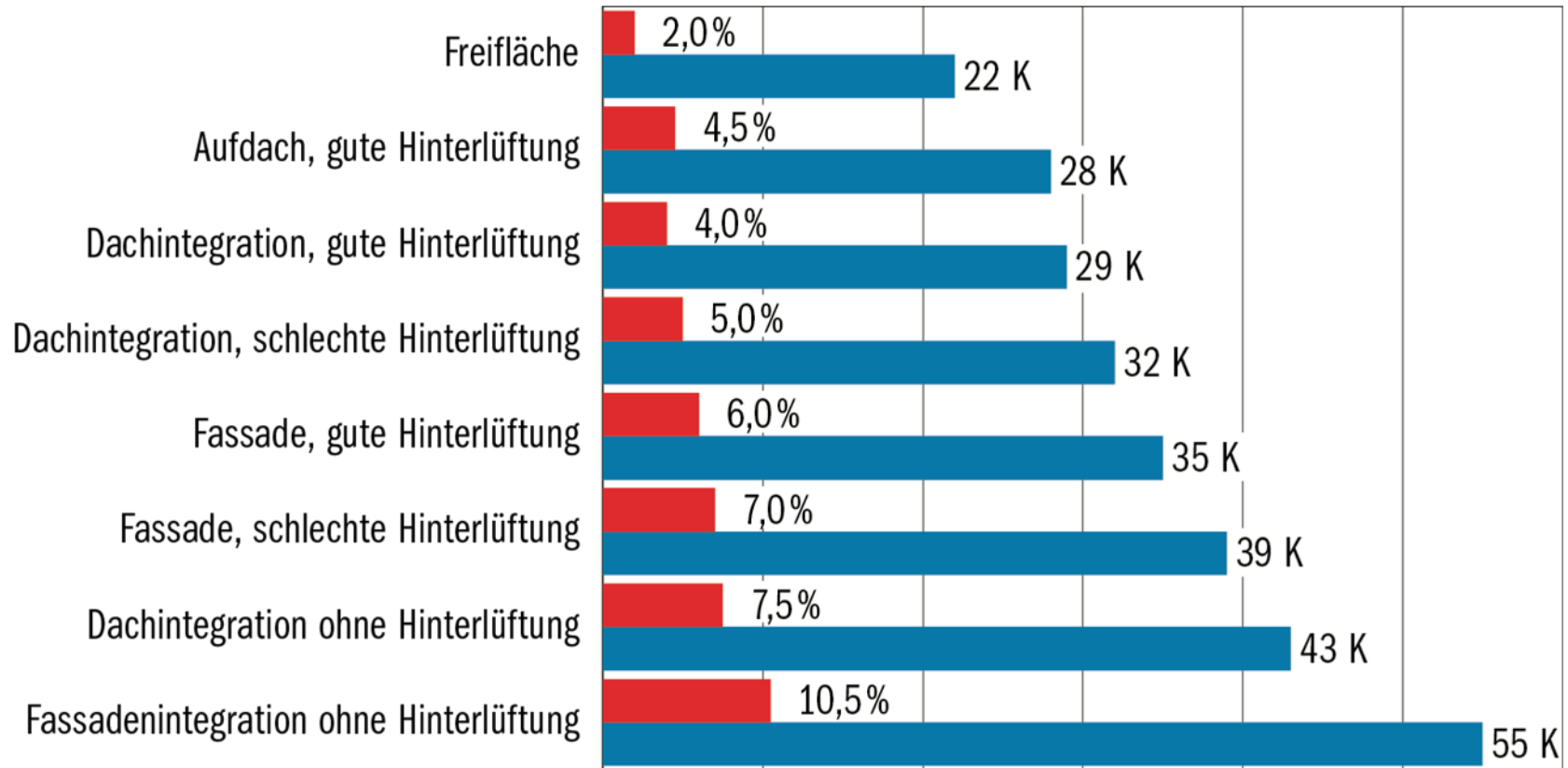
Spezifischer Energieertrag in kWh/kW



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

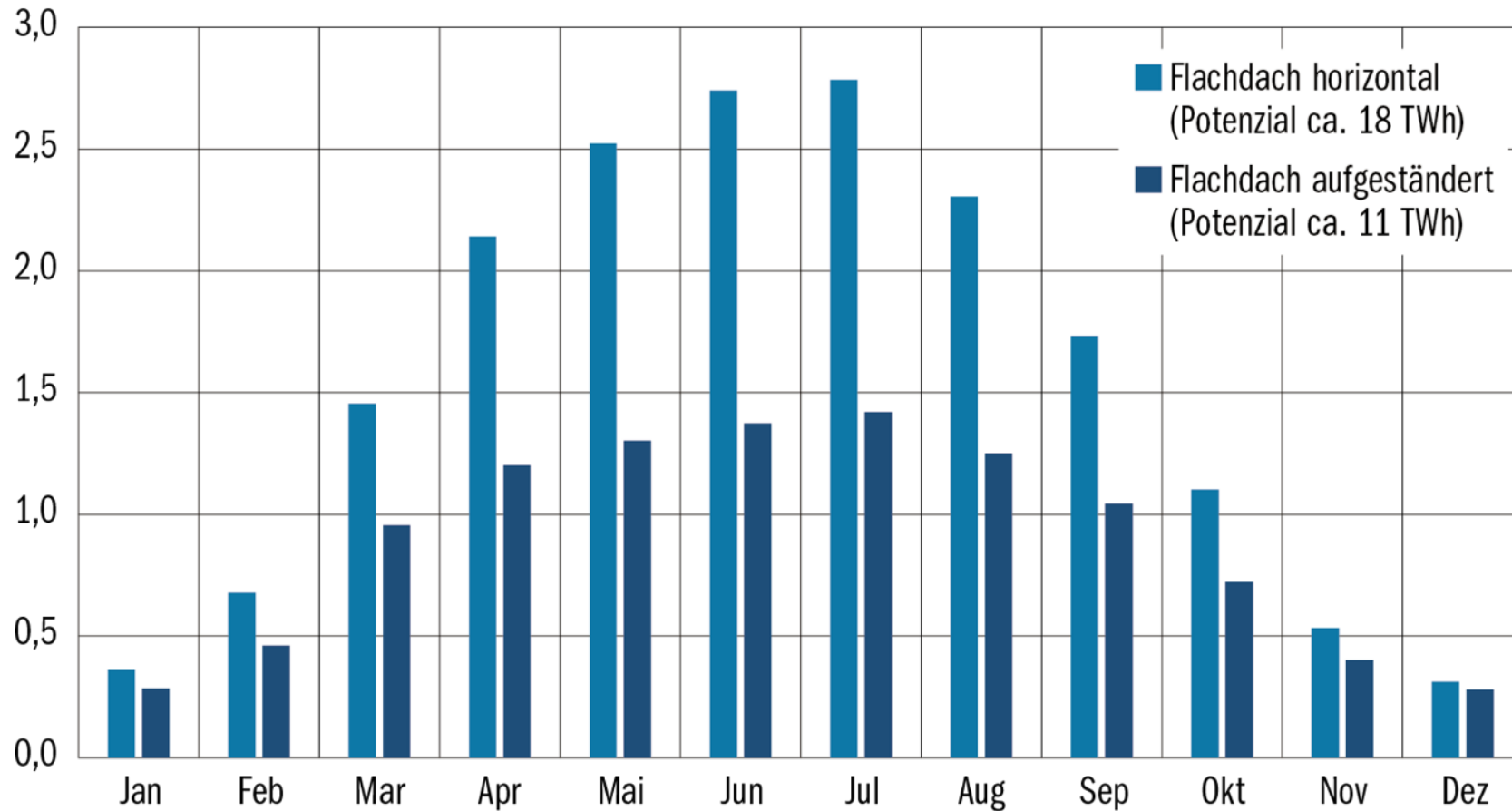


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



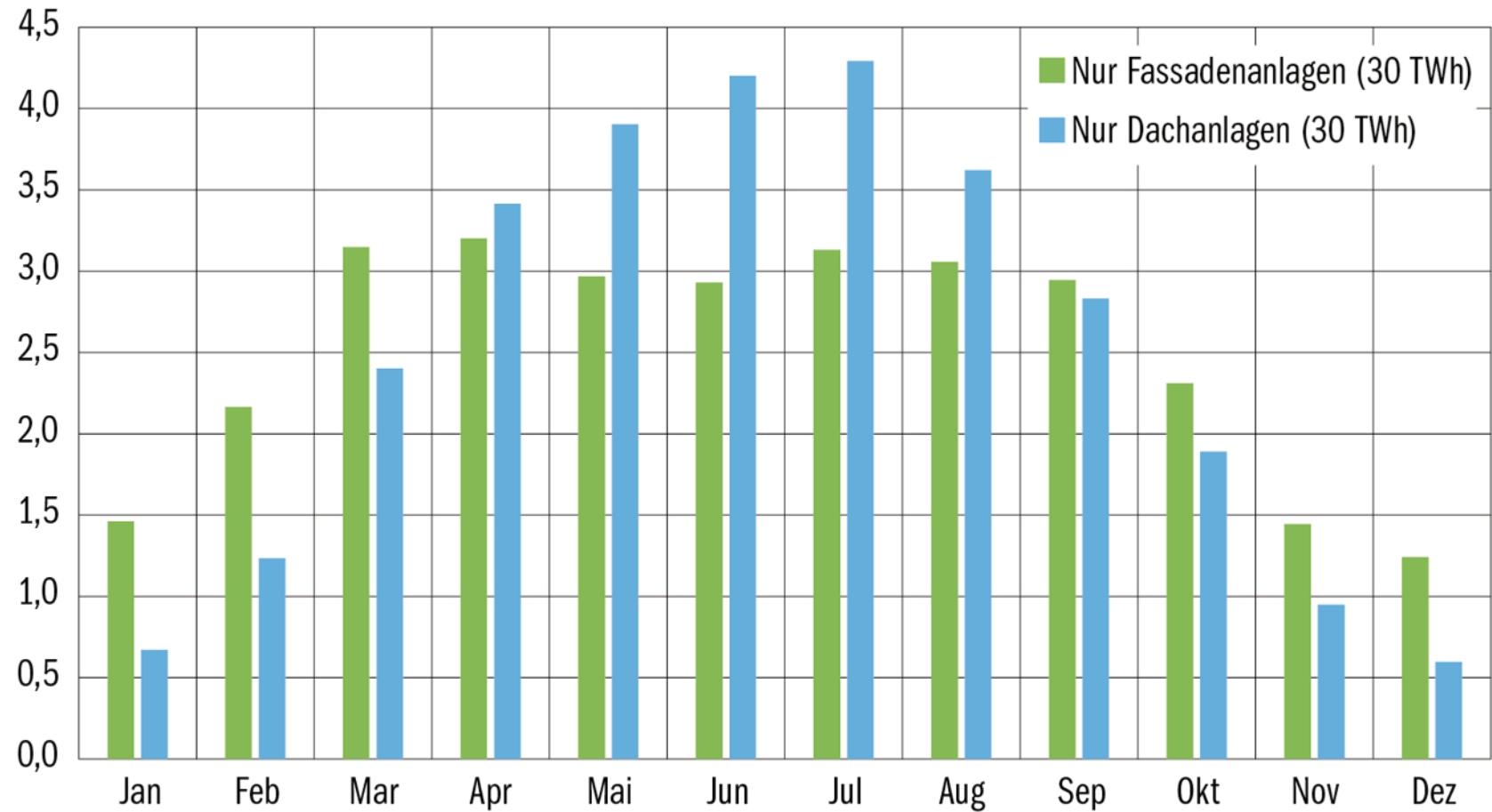
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Monatsertrag in TWh



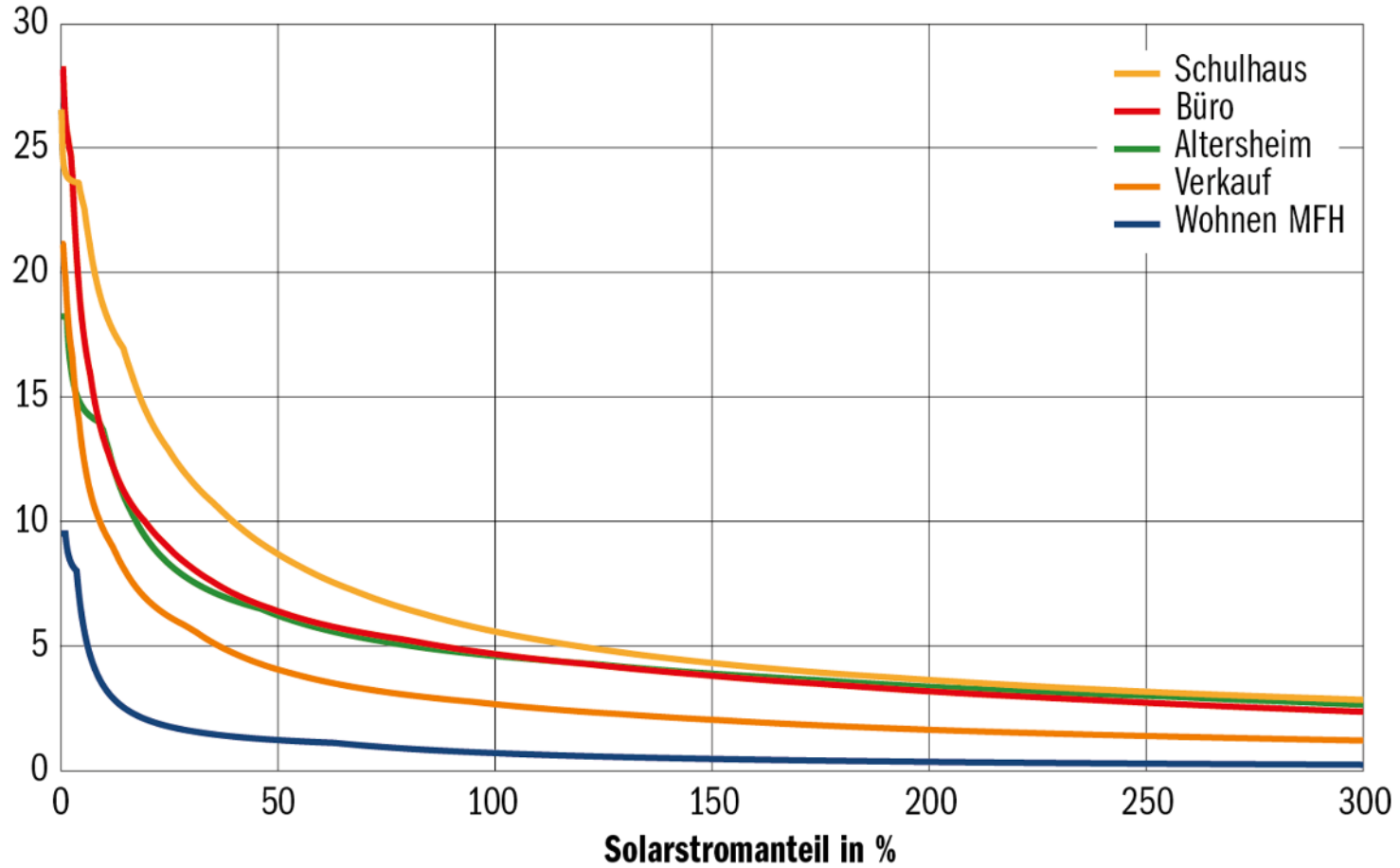
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Monatsertrag in TWh

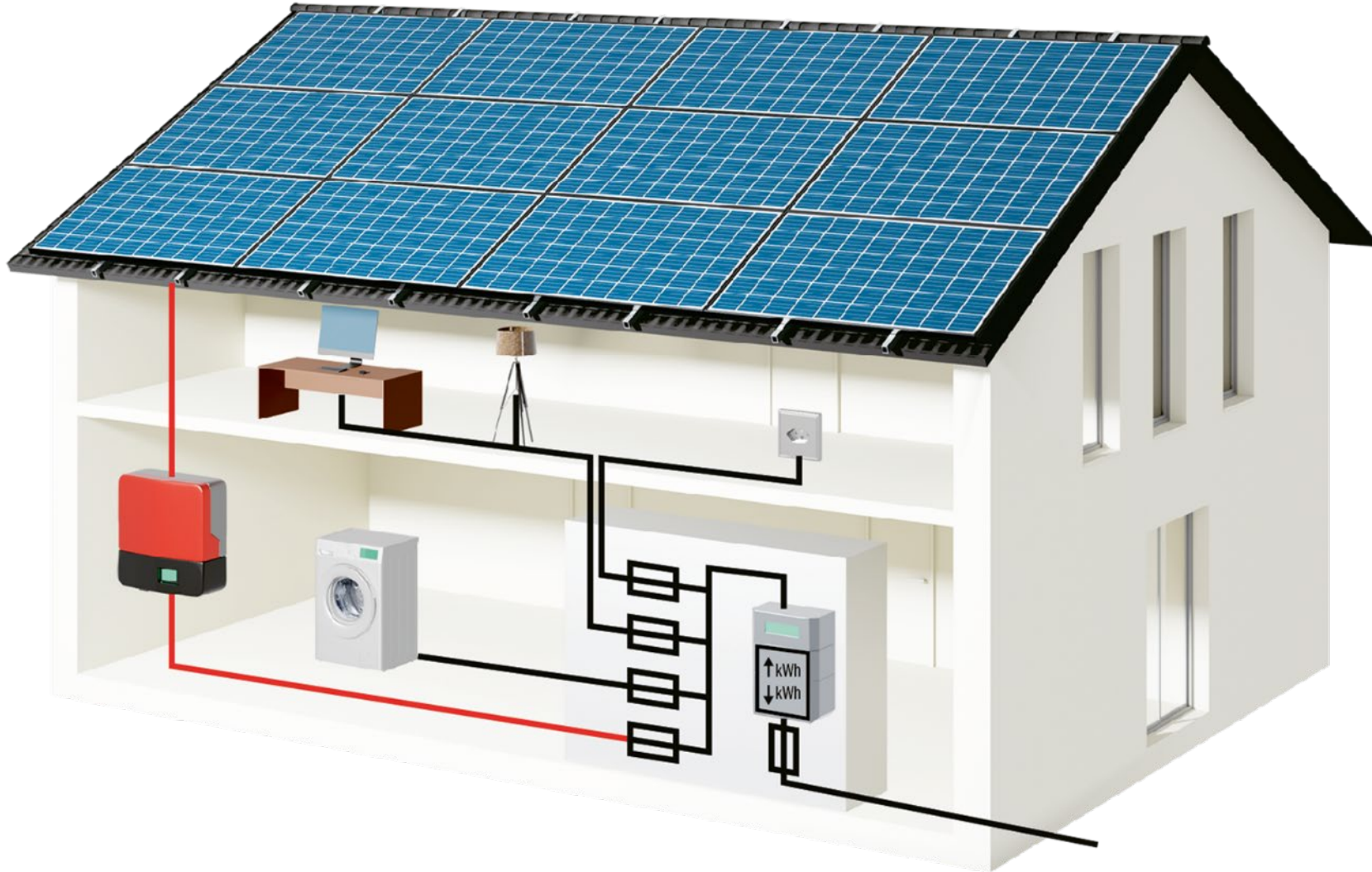


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

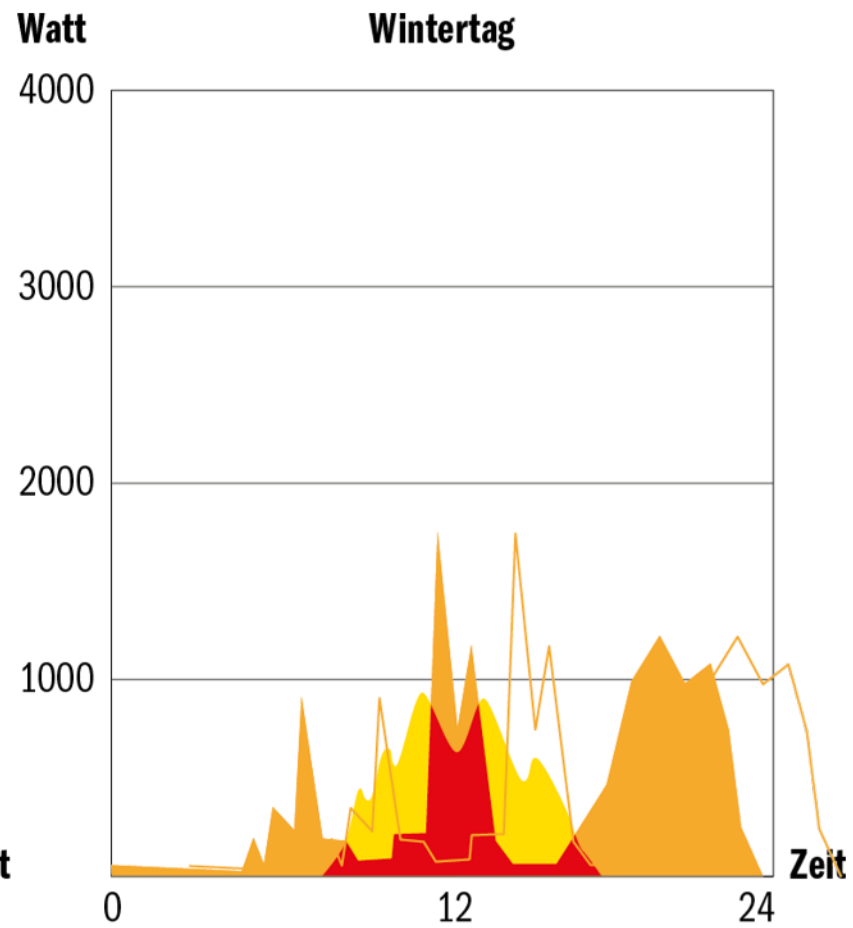
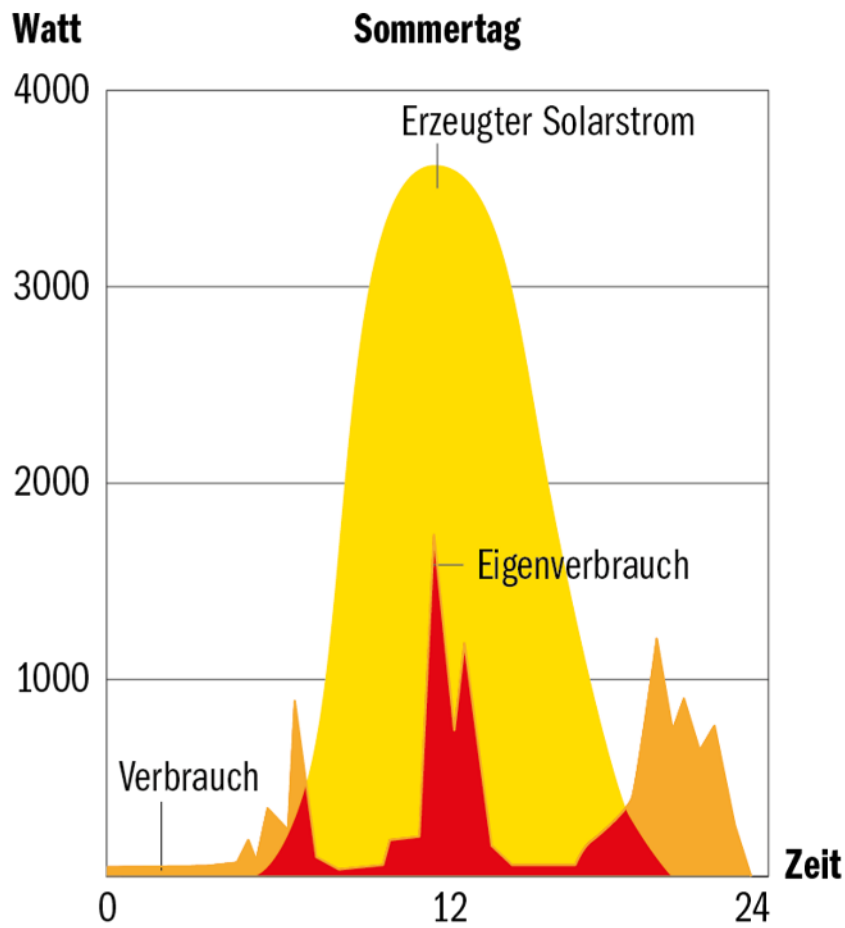
Reduktion monatliche Lastspitze in % der PV-Leistung



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

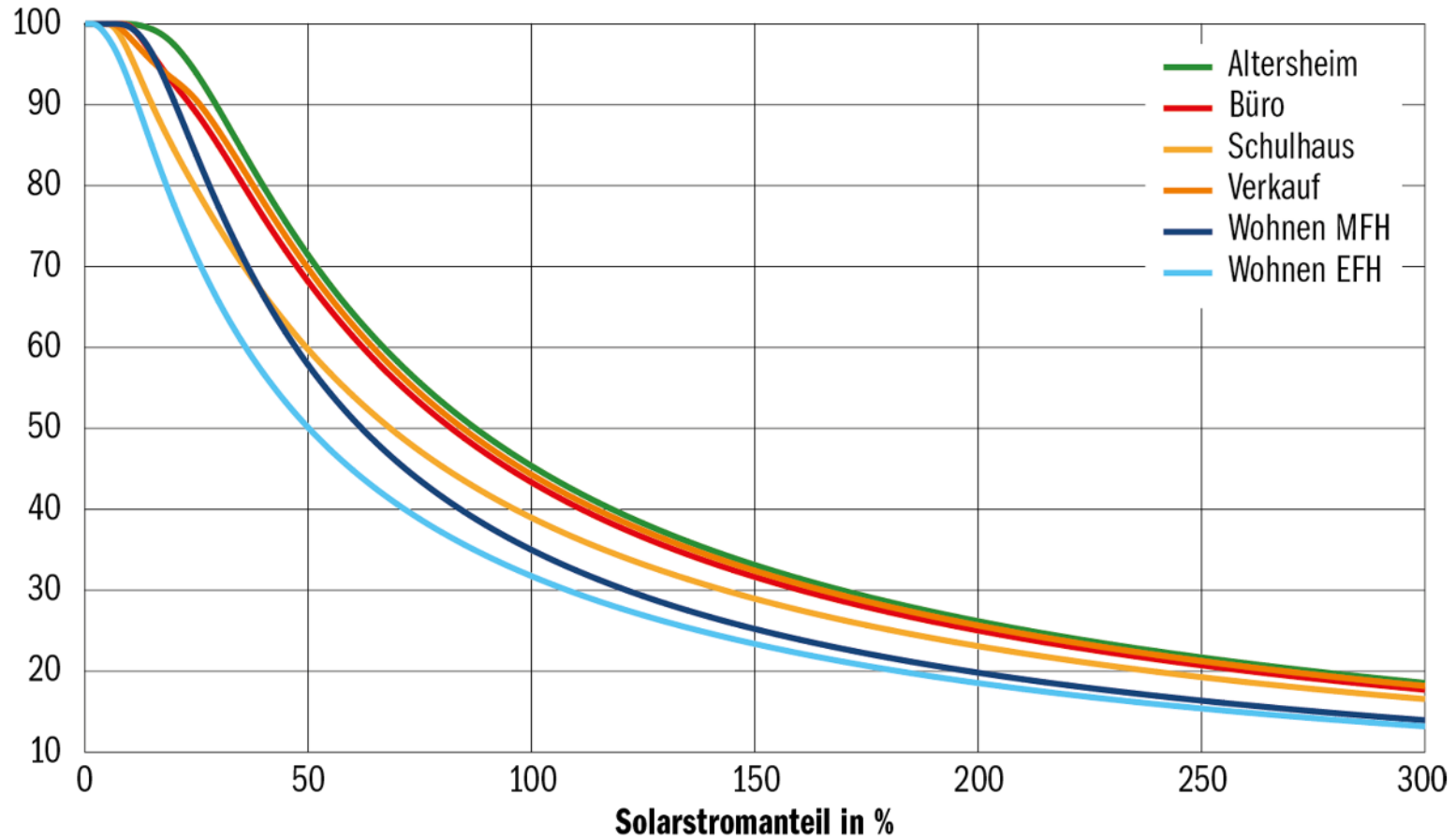


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



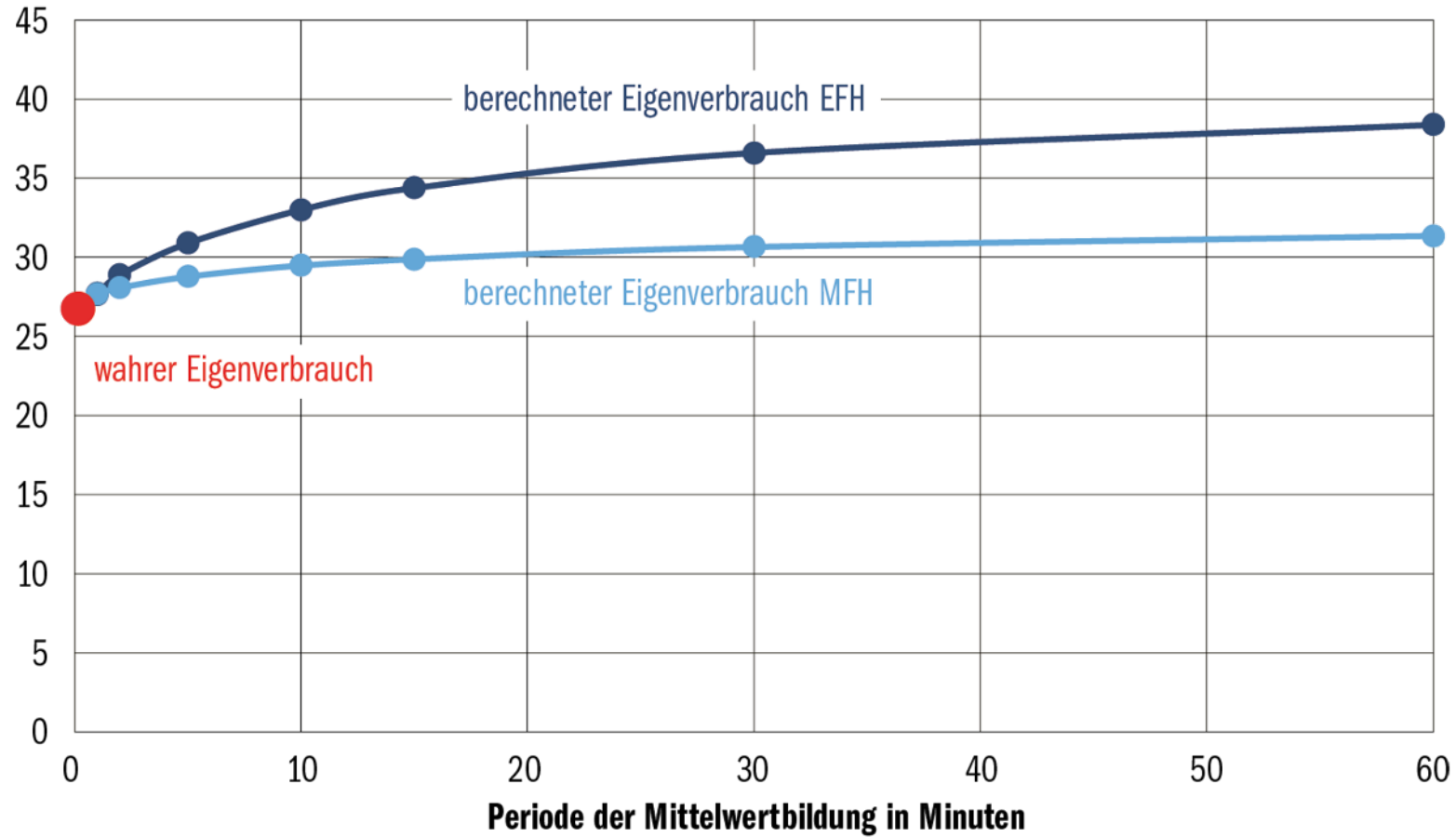
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Eigenverbrauchsanteil in %



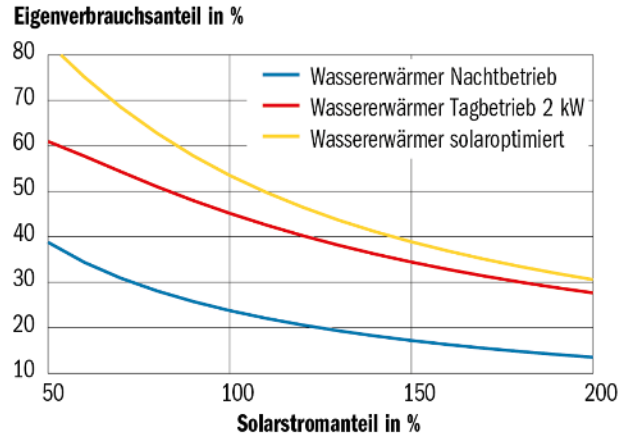
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Eigenverbrauchsanteil in %

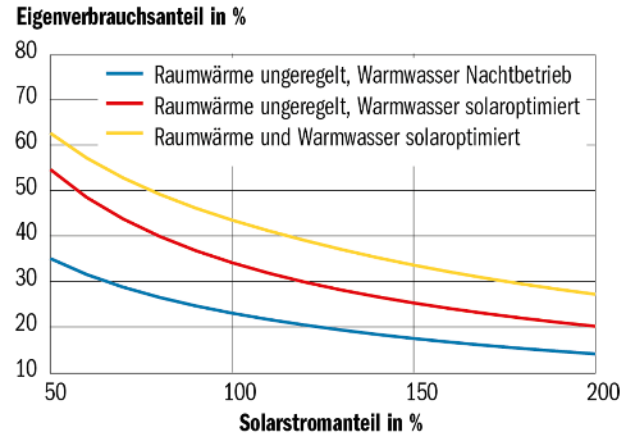


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

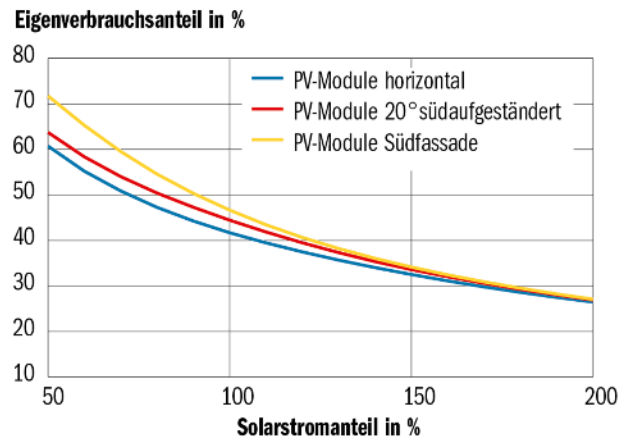
Eigenverbrauch Haushalt 3000 kWh + Wassererwärmer 2000 kWh



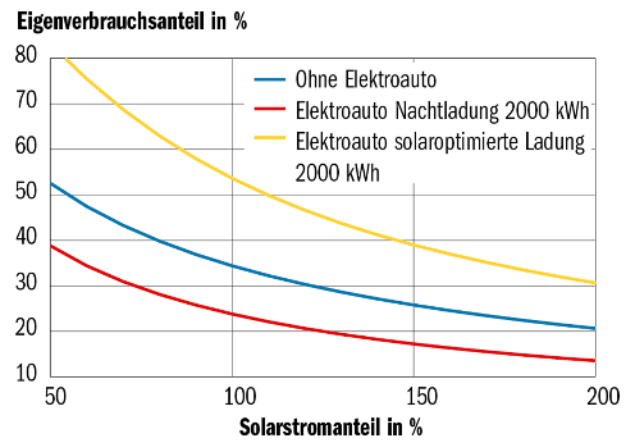
Eigenverbrauch Haushalt 3000 kWh + Wärmepumpe 3000 kWh (Raumwärme) + 1000 kWh (Warmwasser)



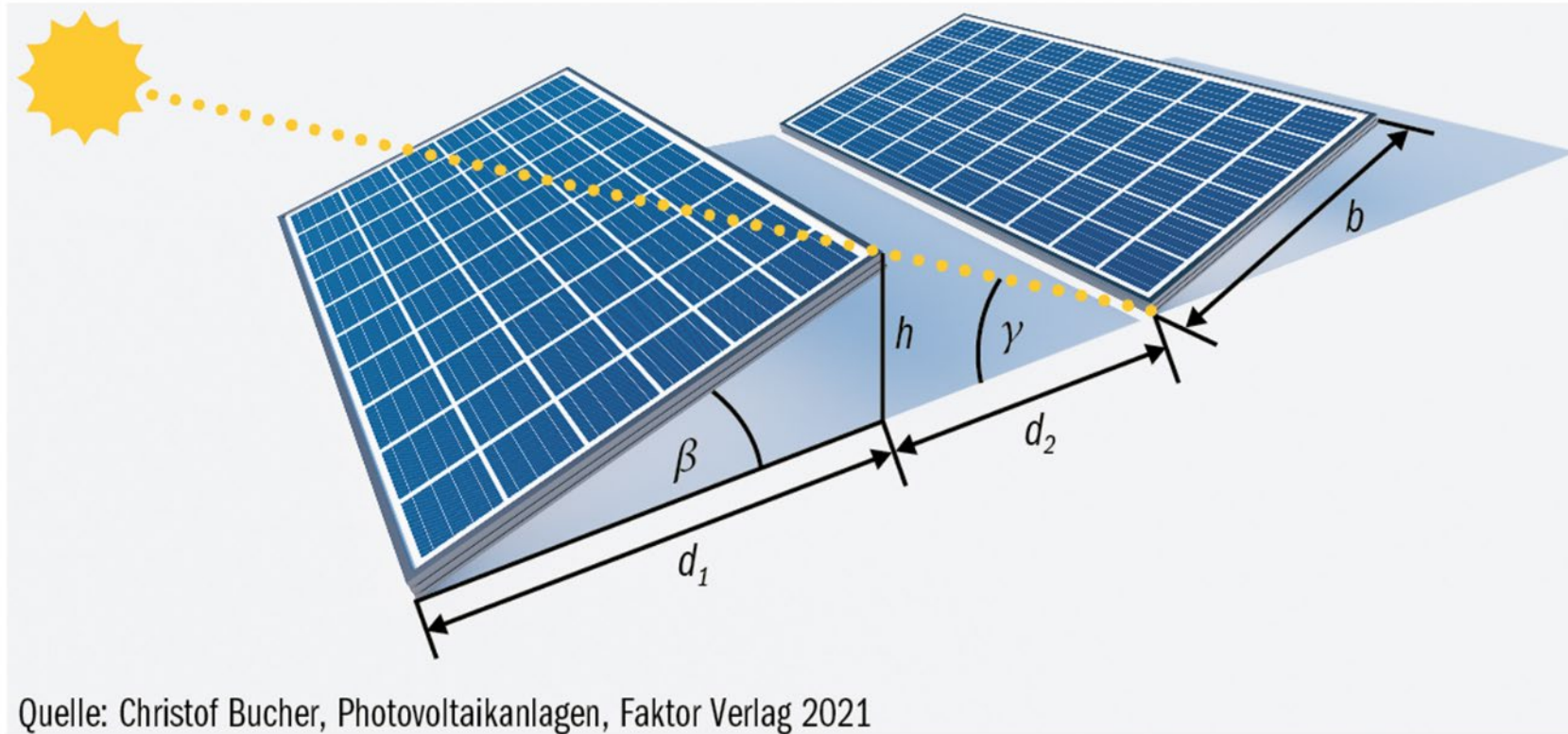
Eigenverbrauch verschiedene Modulausrichtungen (Haushalt 3000 kWh + WP 3000 kWh + 1000 kWh)

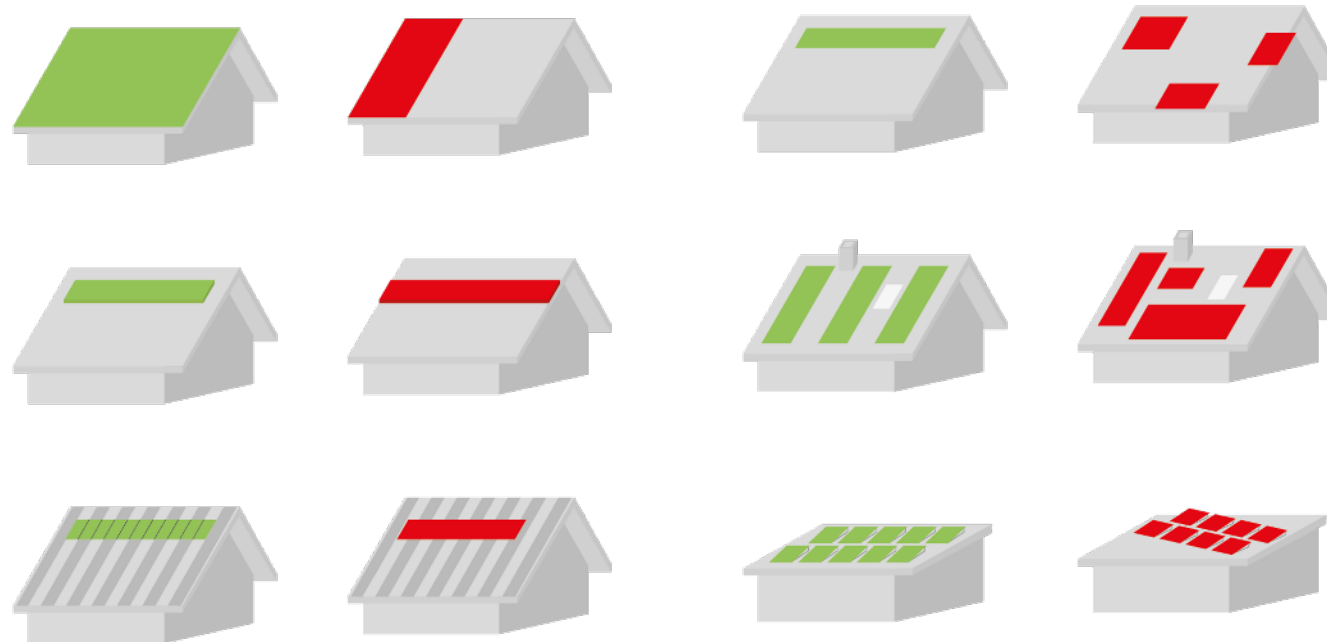


Eigenverbrauch Haushalt 3000 kWh + Elektrofahrzeug 2000 kWh



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

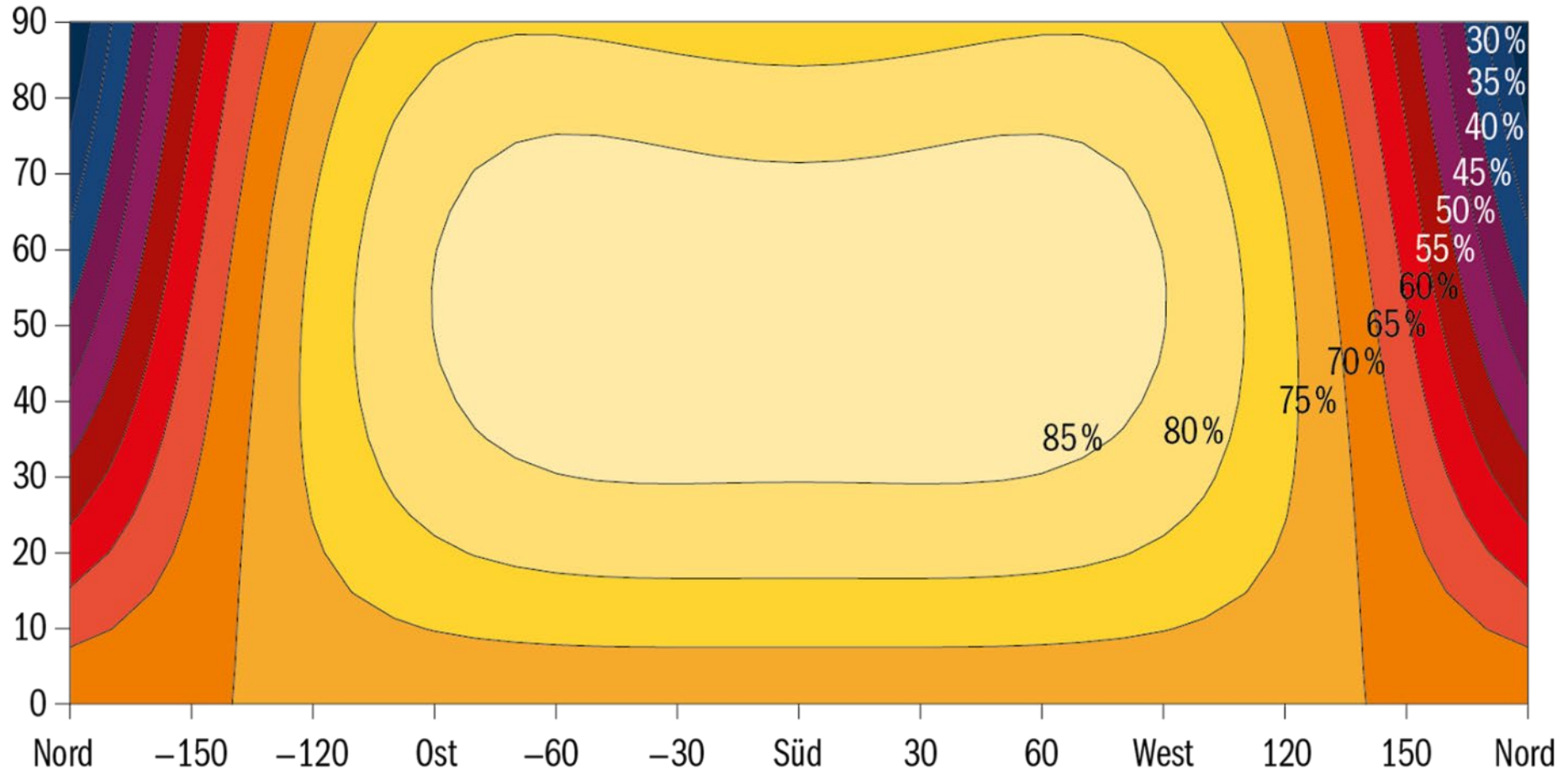




Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

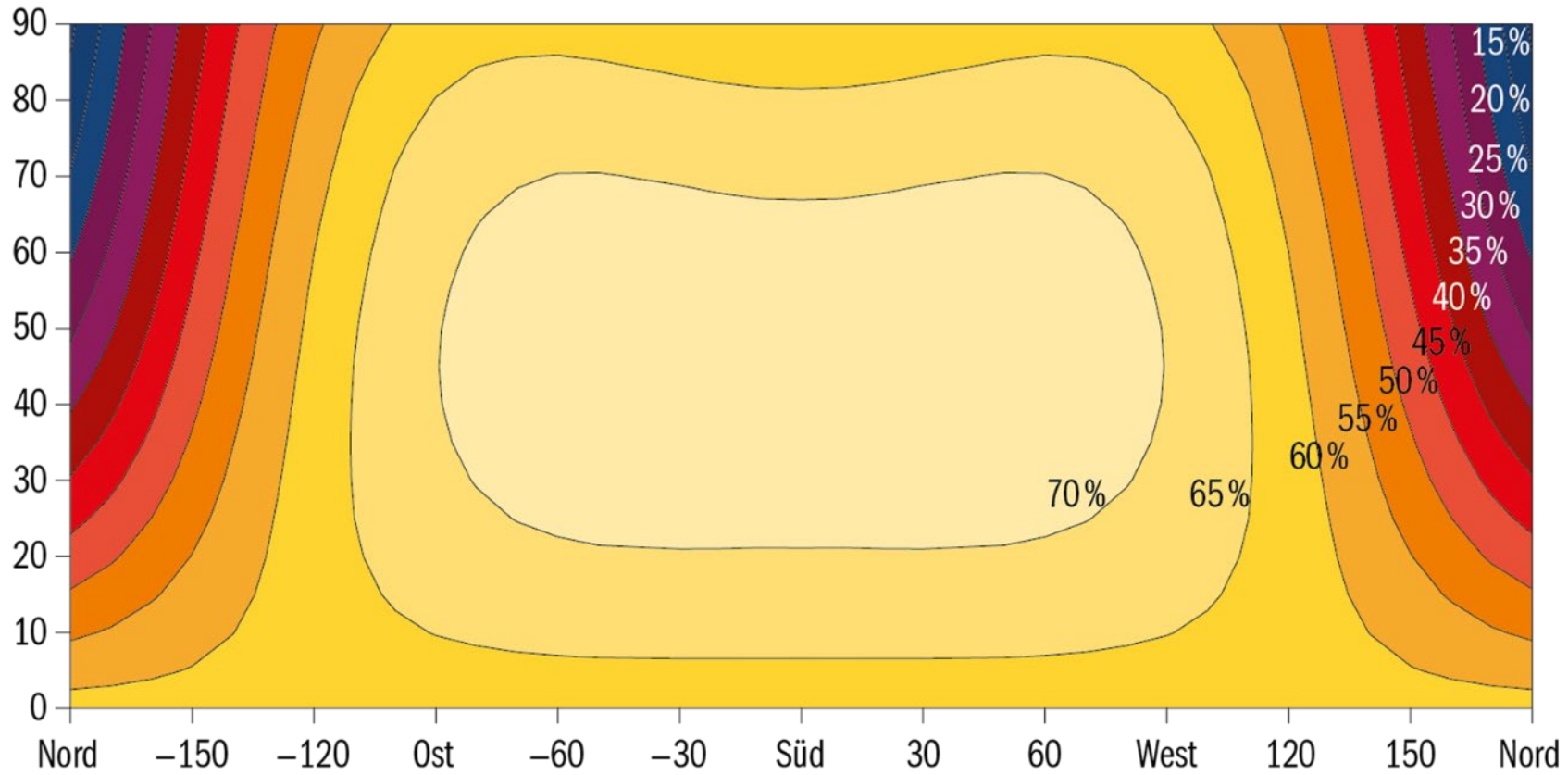
Neigungswinkel in Grad

Nennleistungsverhältnis für 1% Ertragsverlust



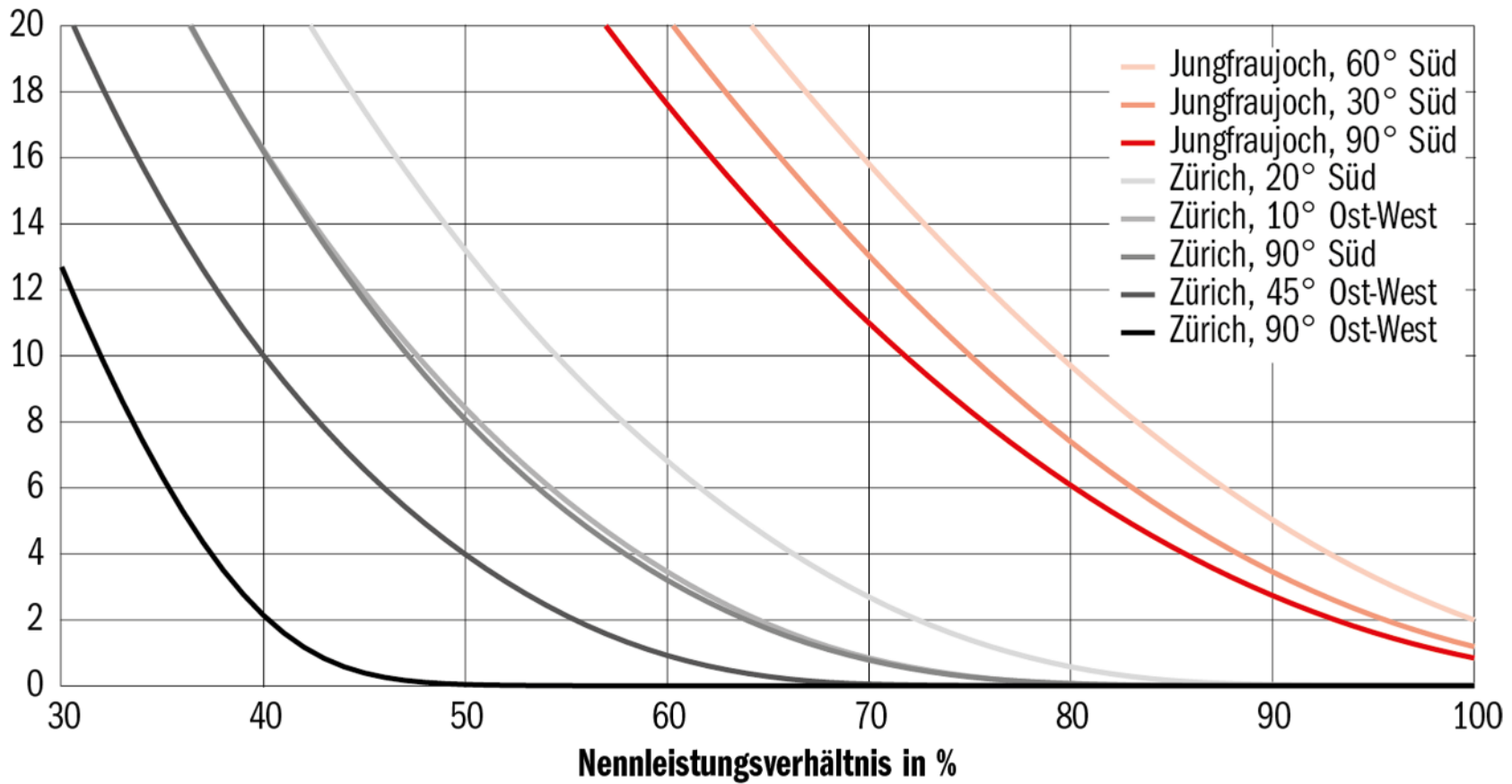
Neigungswinkel in Grad

Nennleistungsverhältnis für 3% Ertragsverlust

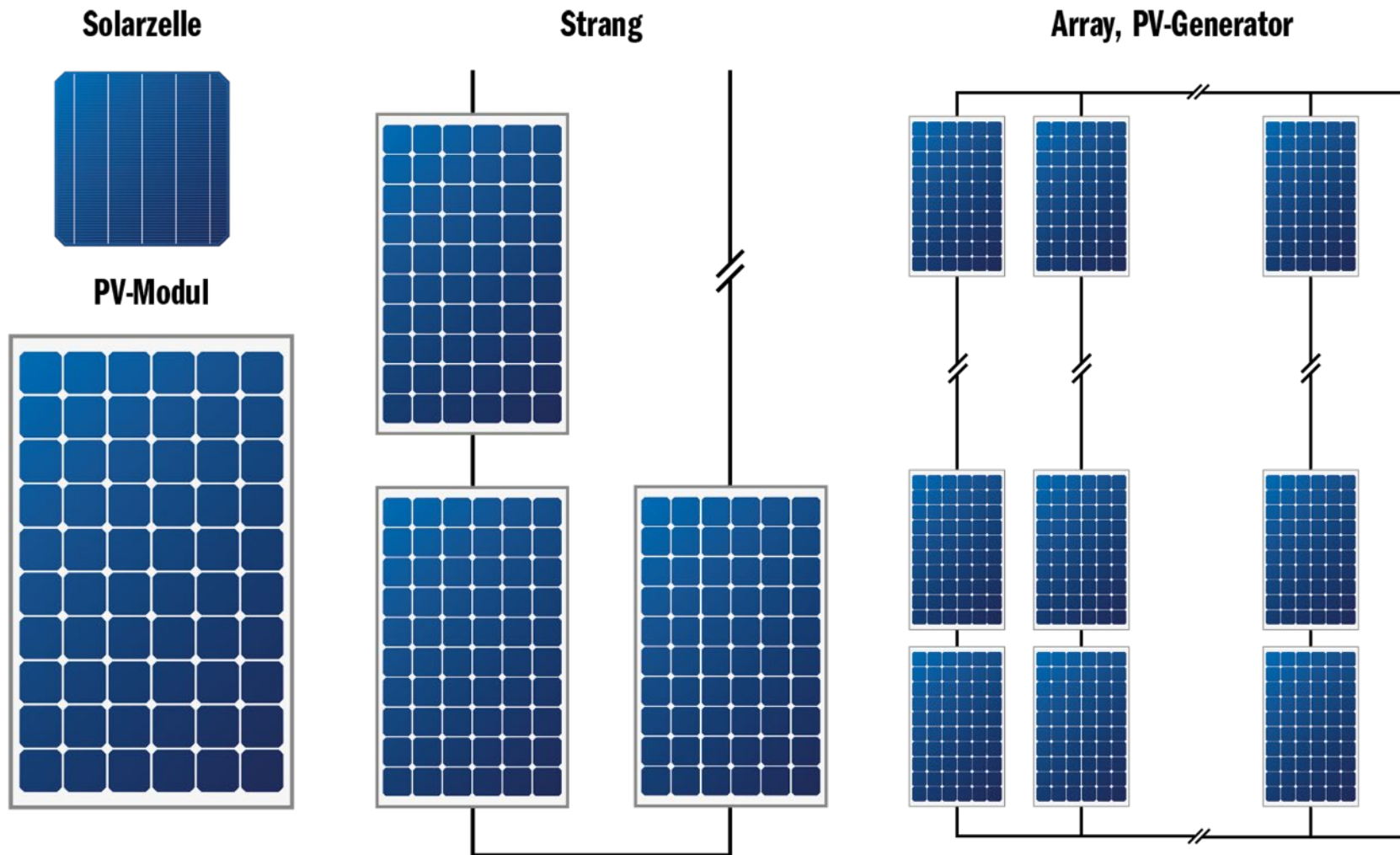


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

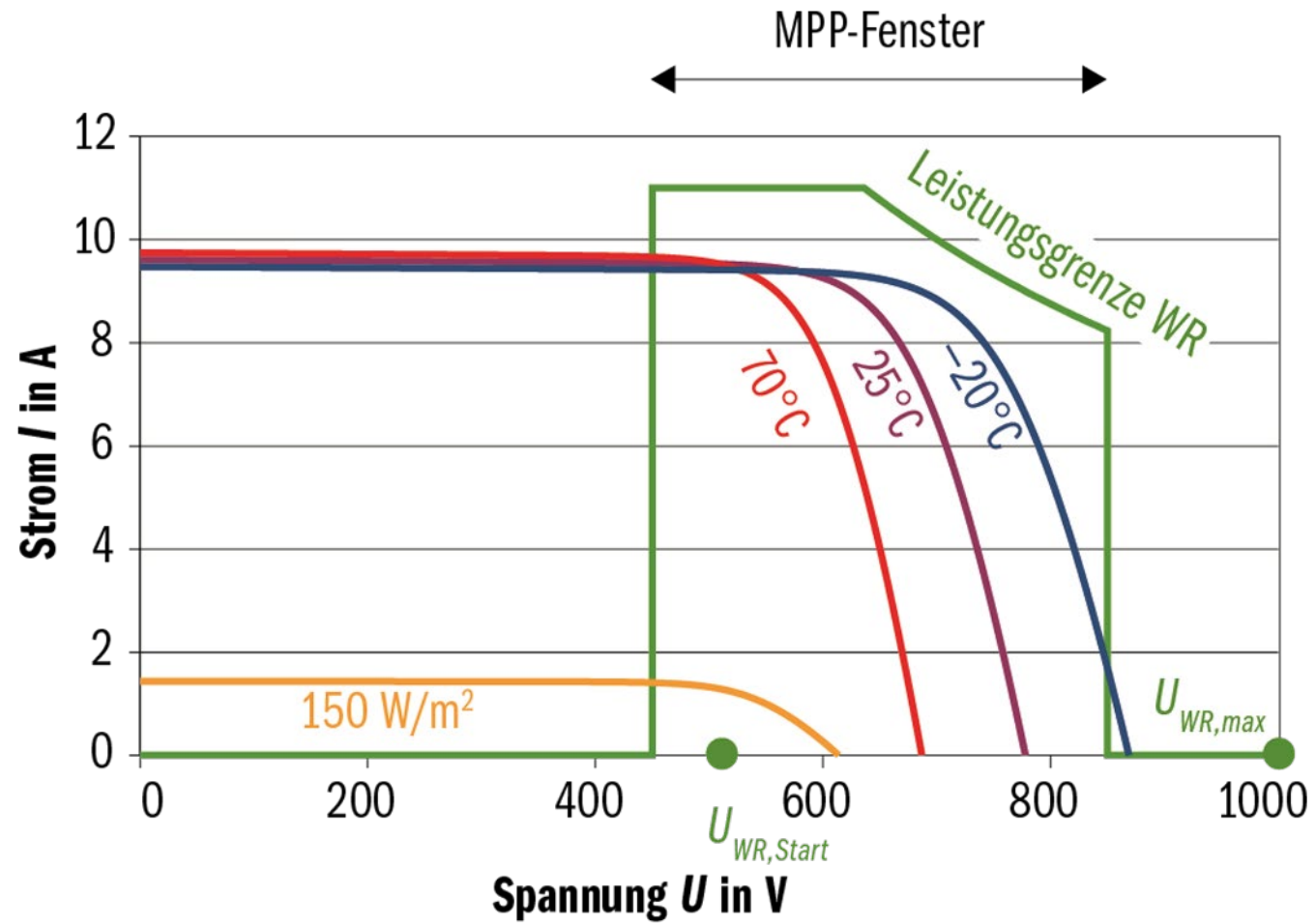
Ertragsverlust in %



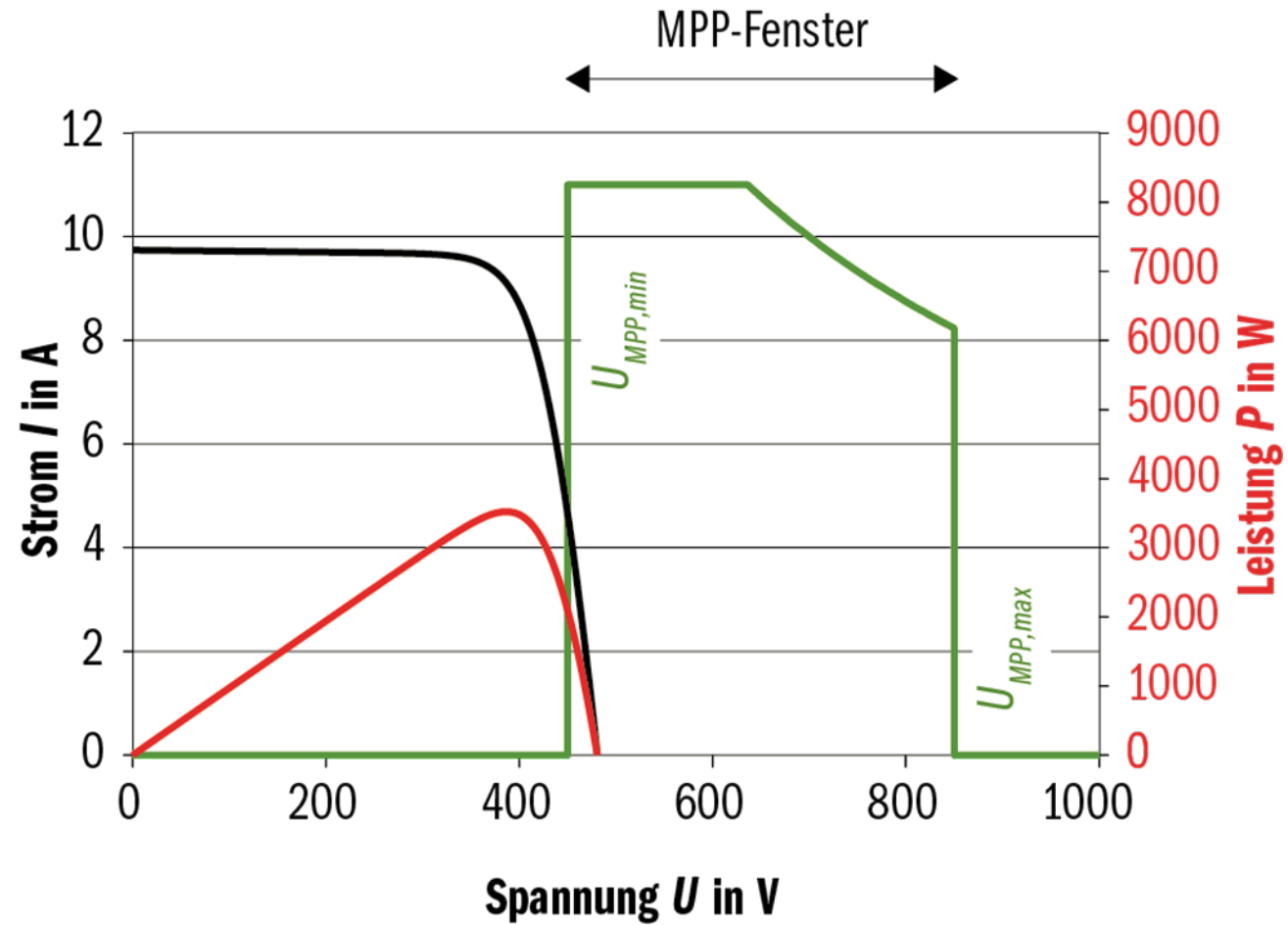
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



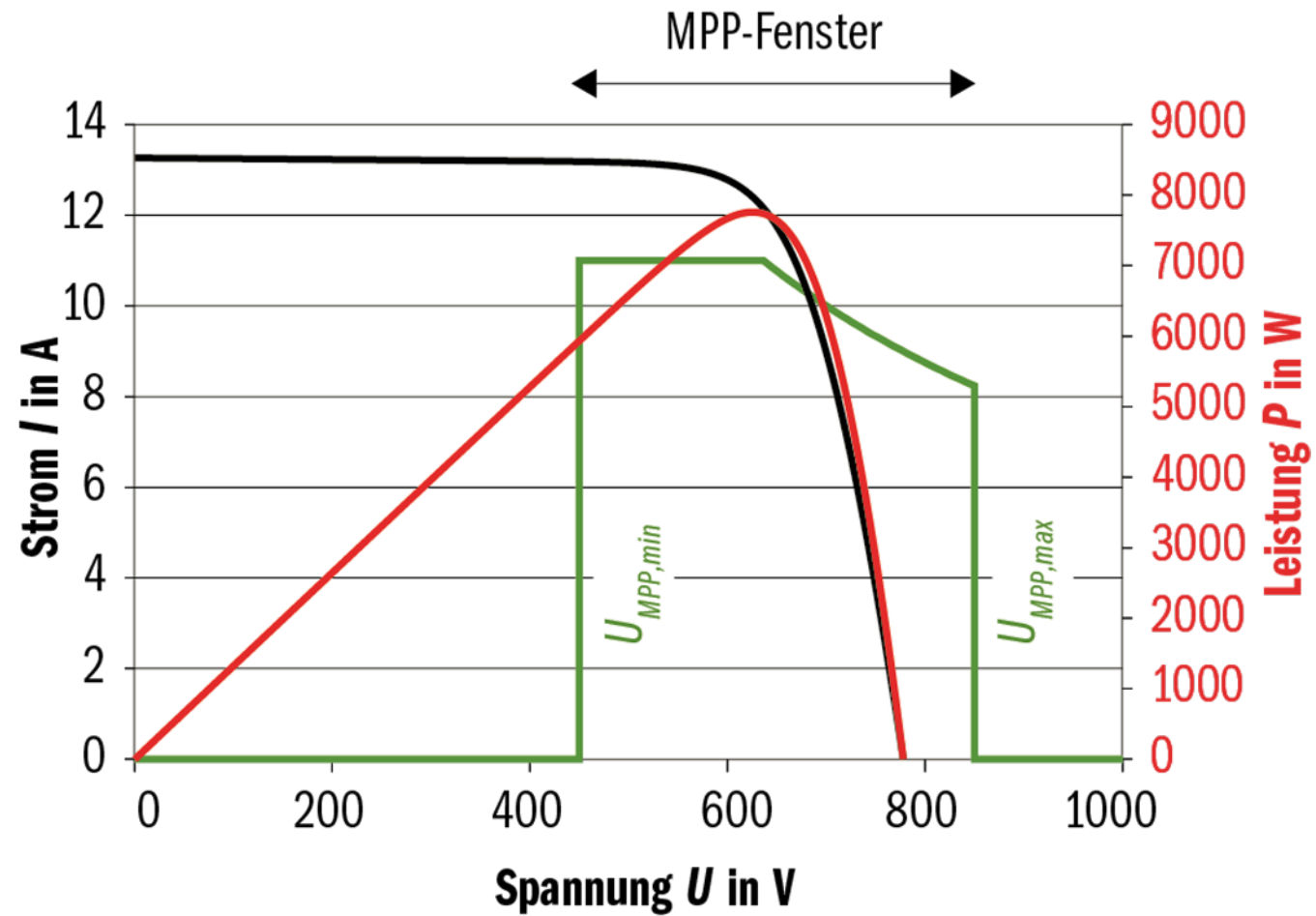
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



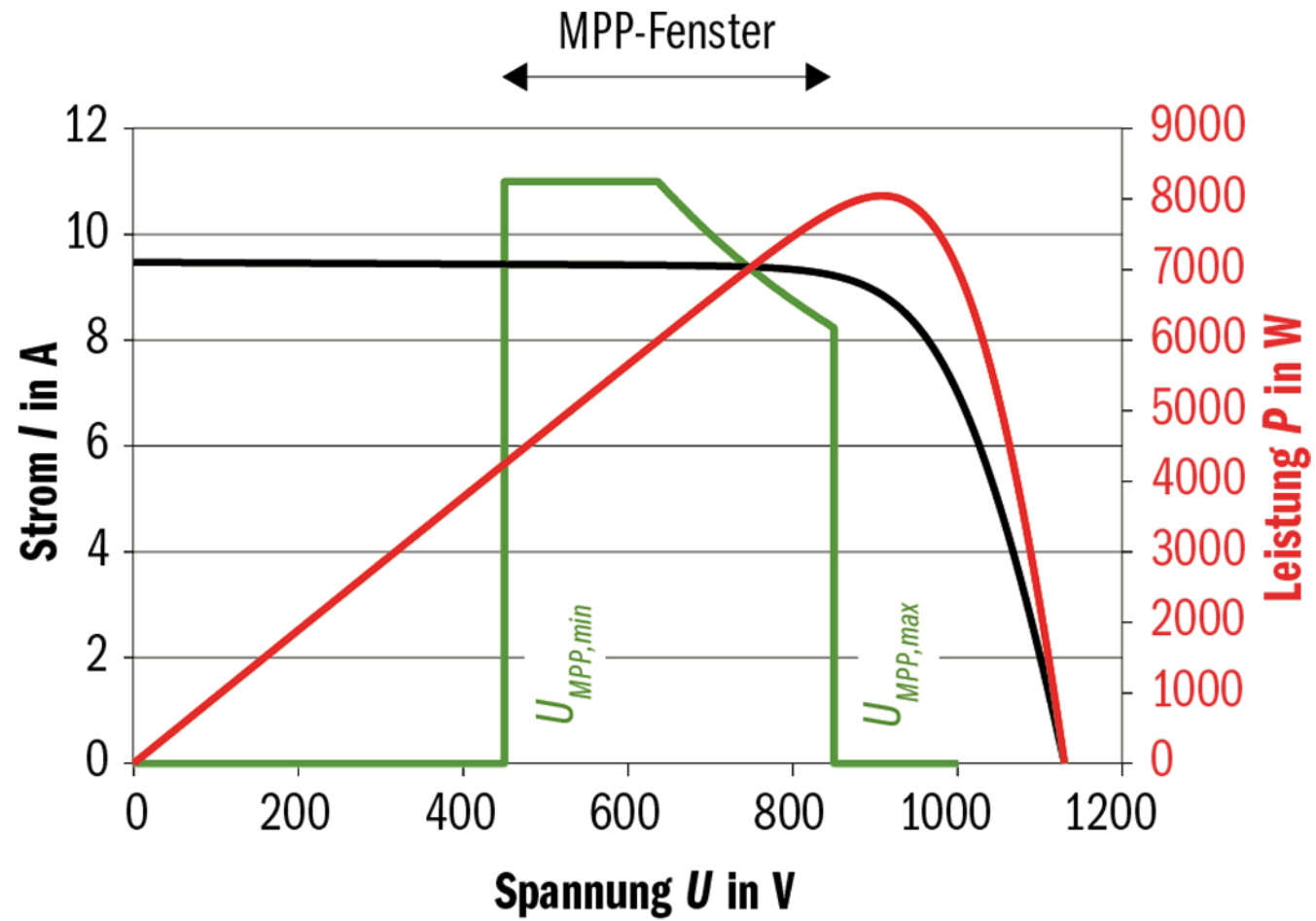
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



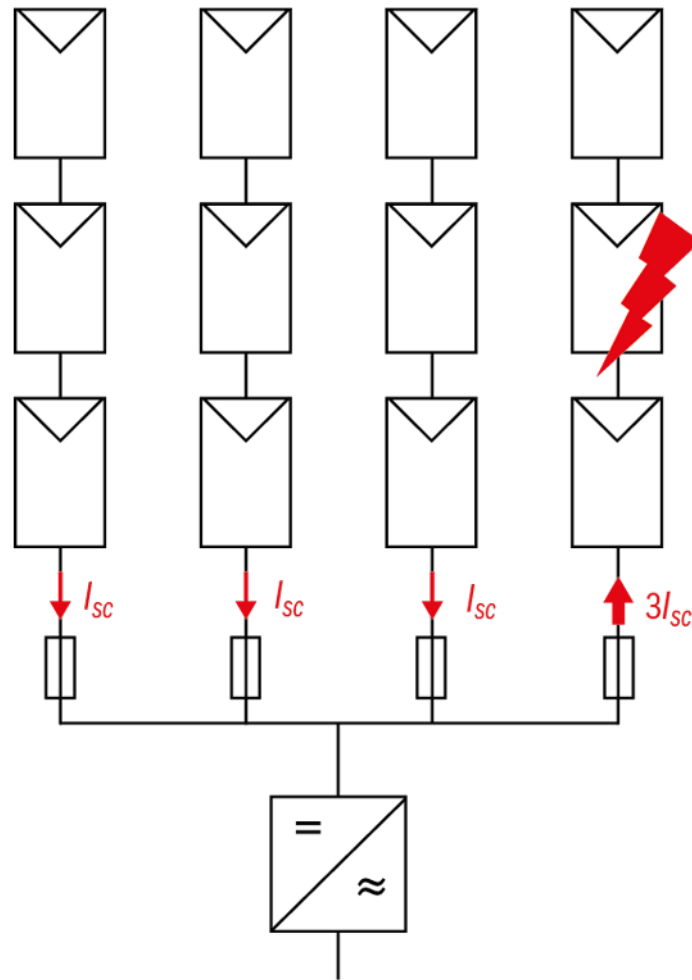
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



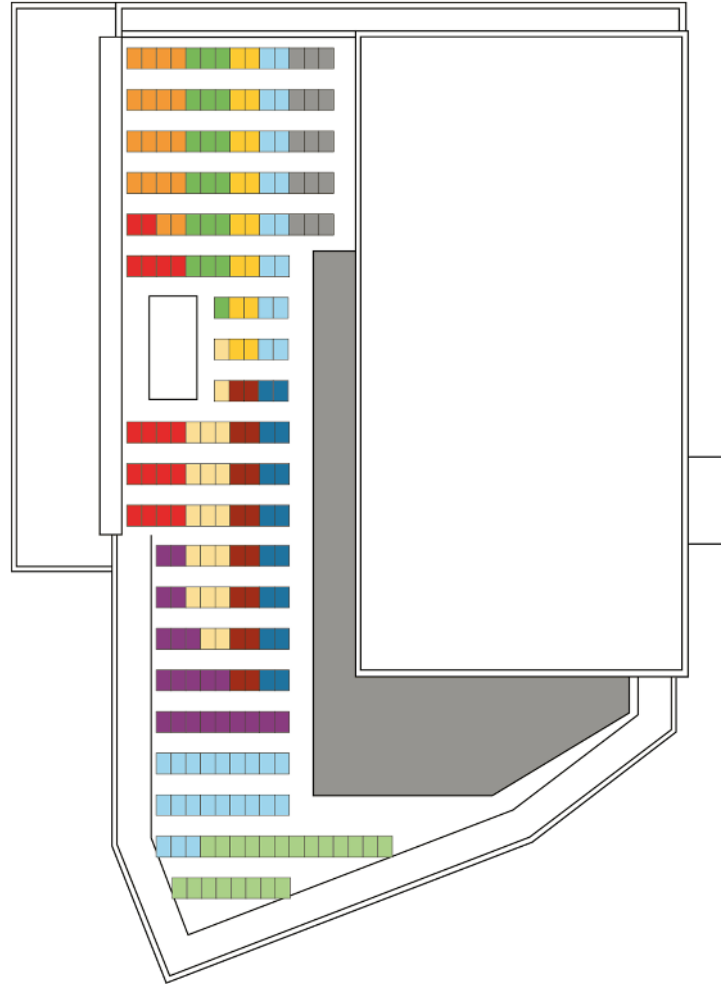
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



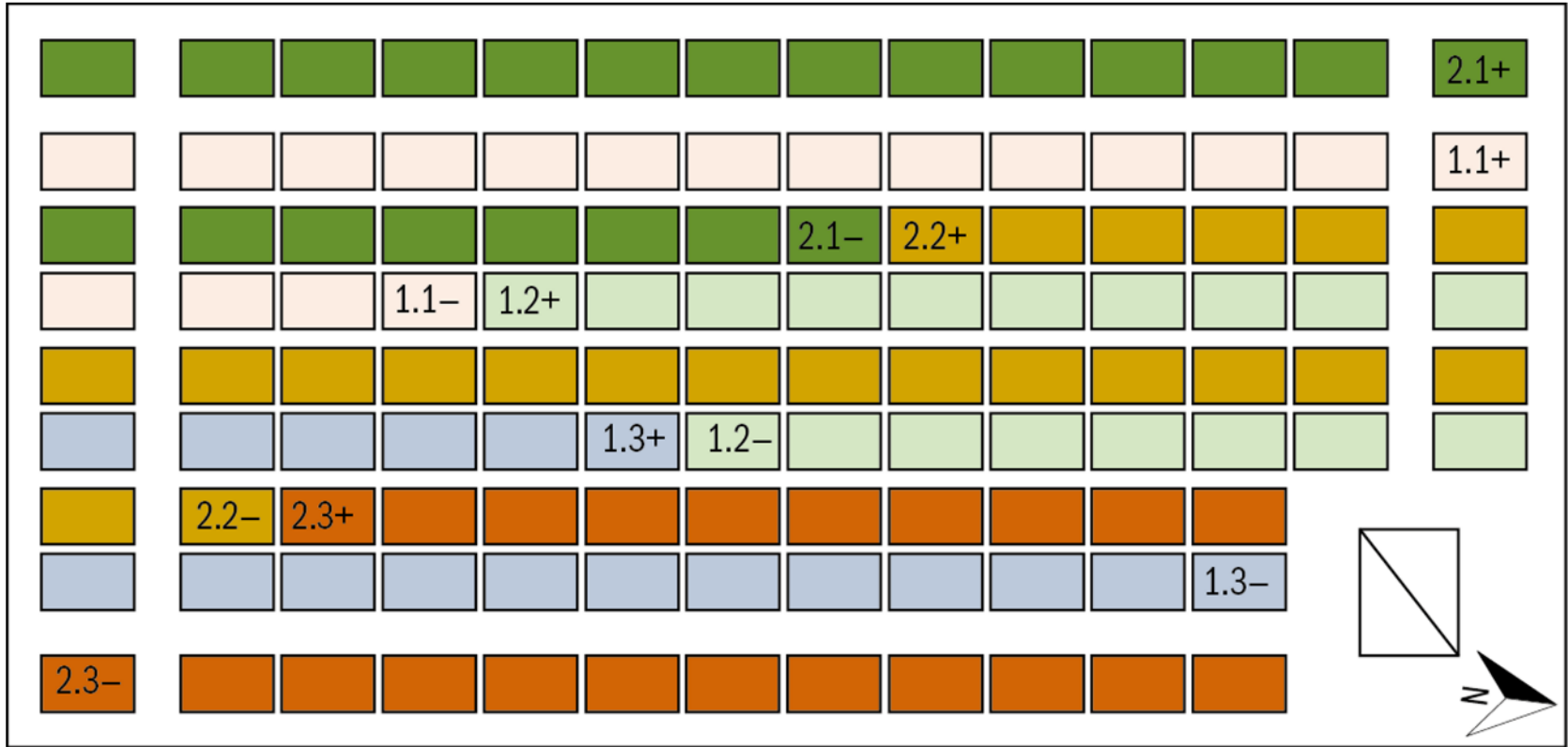
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



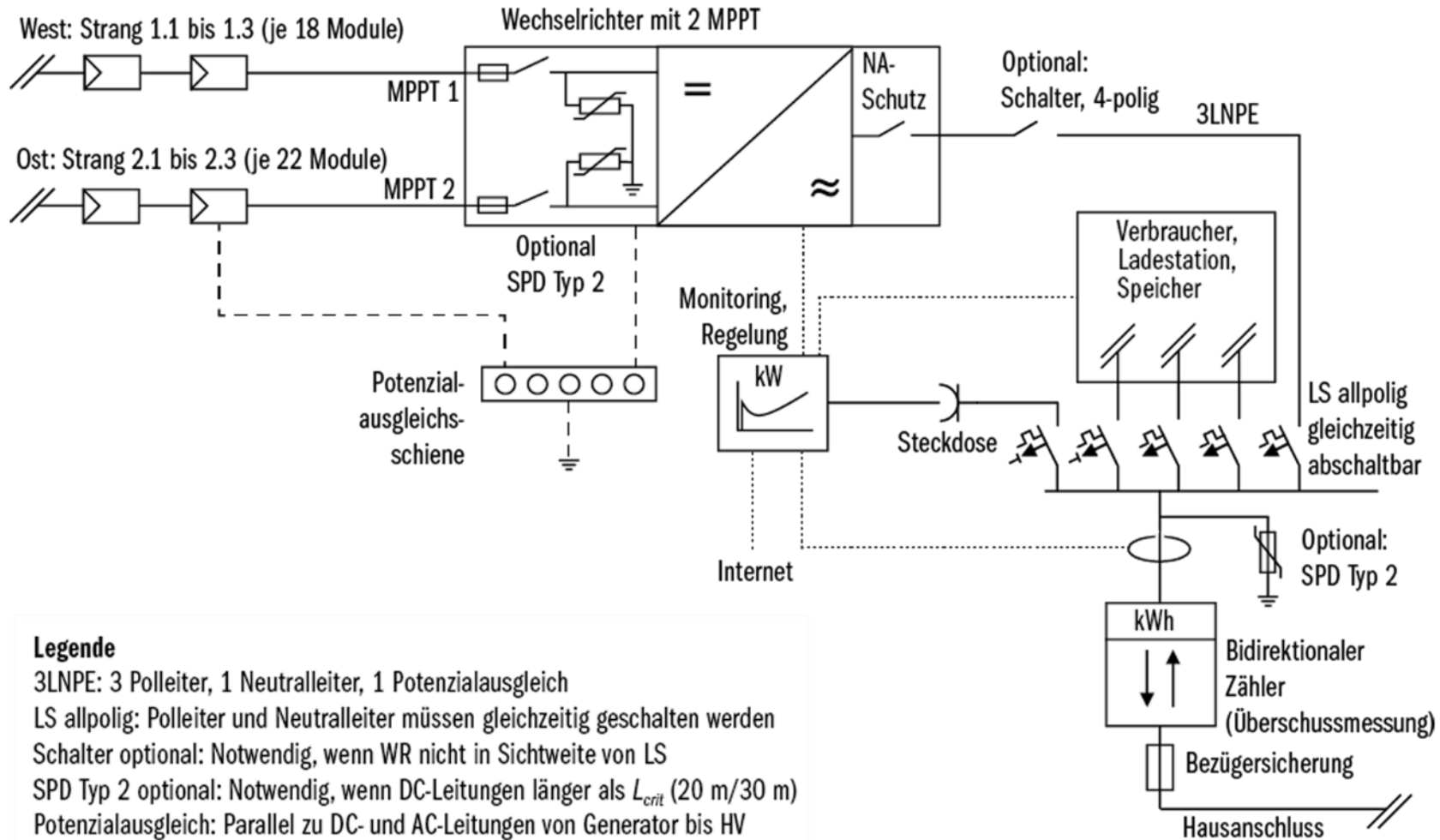
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Legende

3LNPE: 3 Polleiter, 1 Neutralleiter, 1 Potenzialausgleich

LS allpolig: Polleiter und Neutralleiter müssen gleichzeitig geschaltet werden

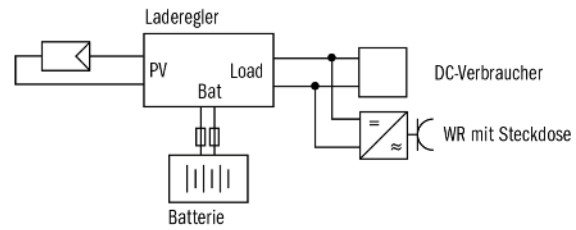
Schalter optional: Notwendig, wenn WR nicht in Sichtweite von LS

SPD Typ 2 optional: Notwendig, wenn DC-Leitungen länger als L_{crit} (20 m/30 m)

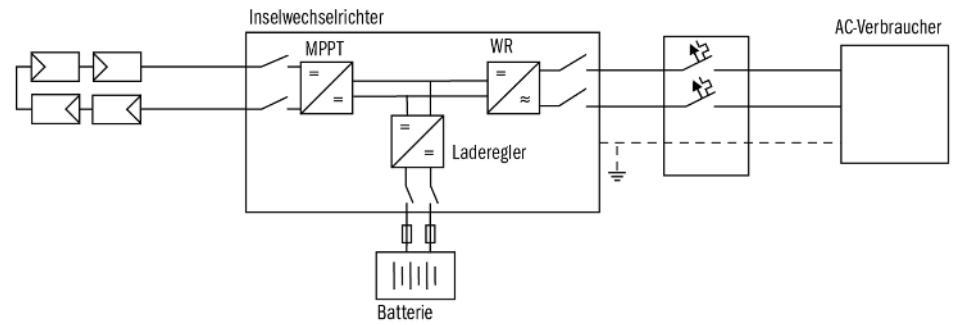
Potenzialausgleich: Parallel zu DC- und AC-Leitungen von Generator bis HV

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

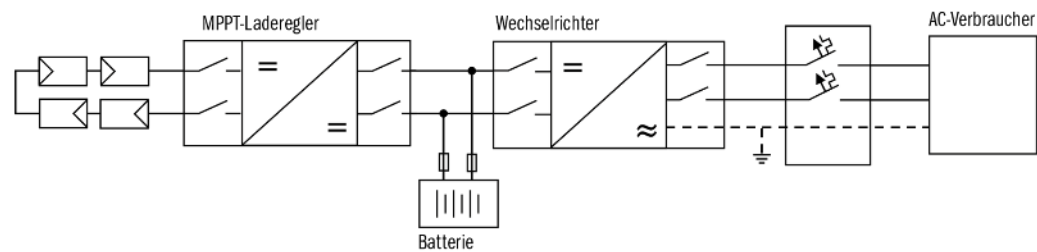
12-V- oder 24-V-DC-Inselanlage mit einem einfachen Laderegler und einem Wechselrichter mit Steckdose



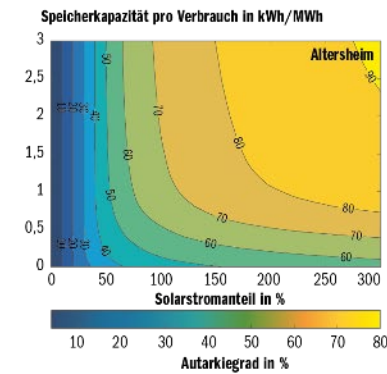
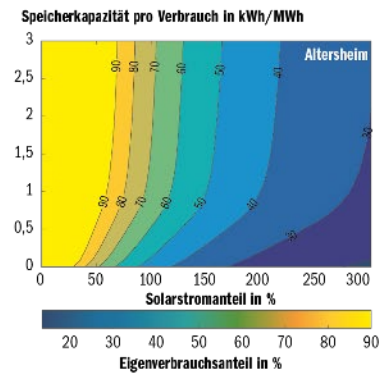
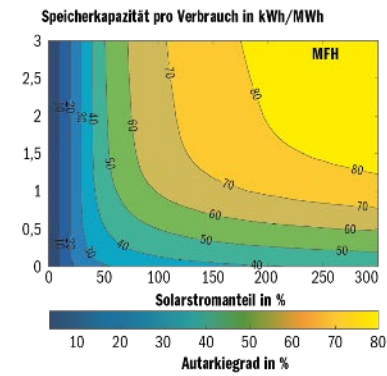
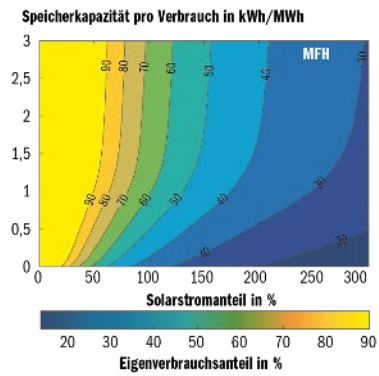
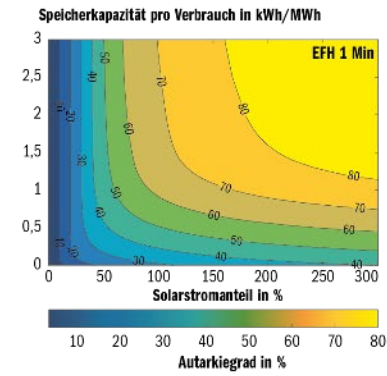
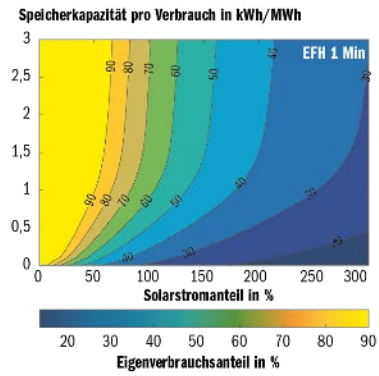
230-V-AC-Inselanlage mit einem PV-Inselschneider

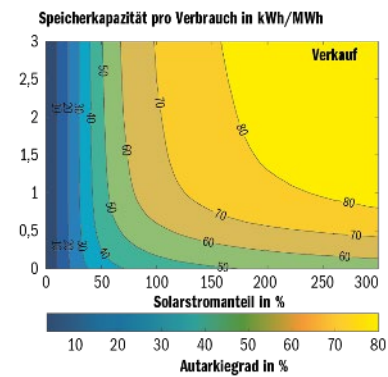
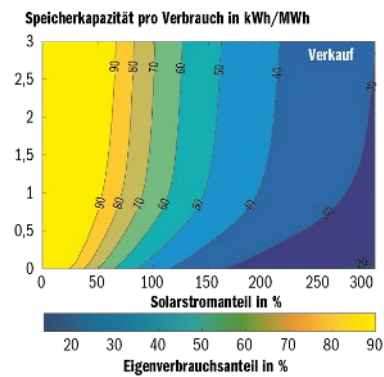
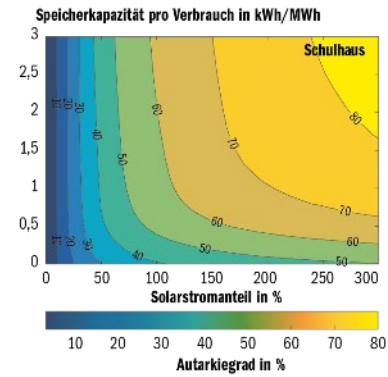
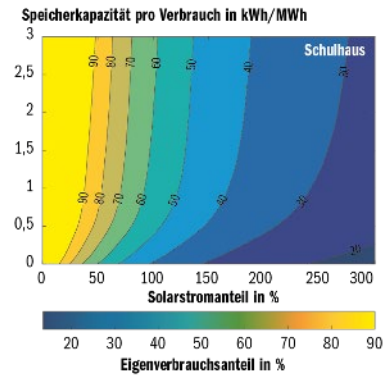
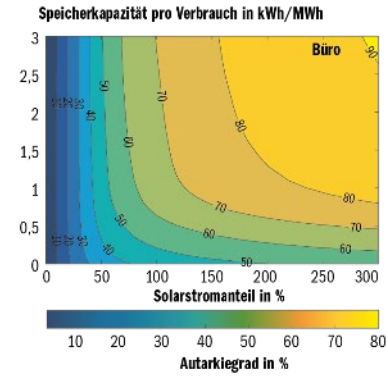
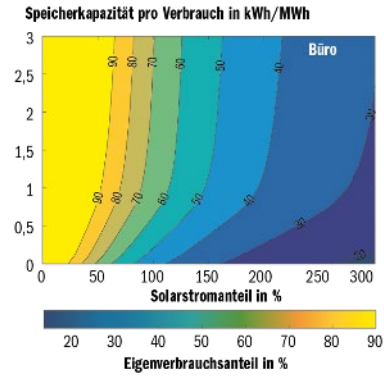


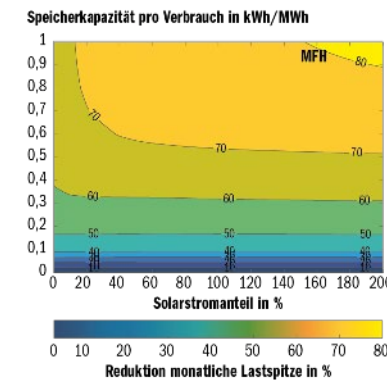
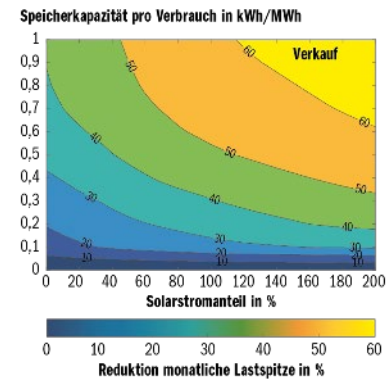
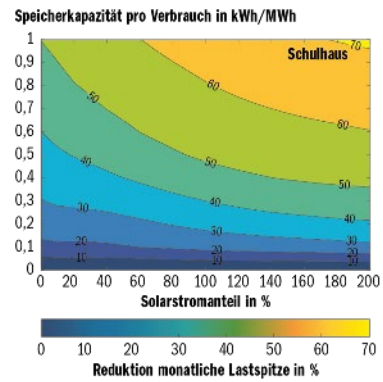
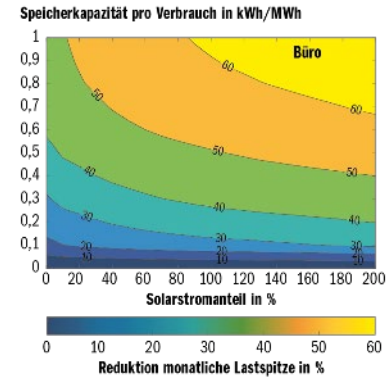
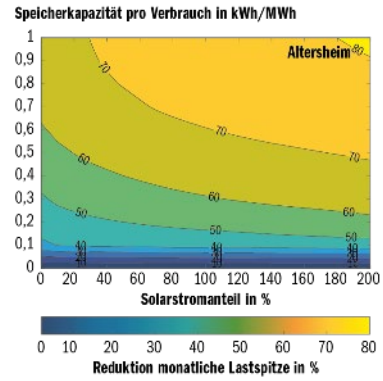
Modulare Inselanlage mit MPPT-Laderegler und separatem Sinuswechselrichter



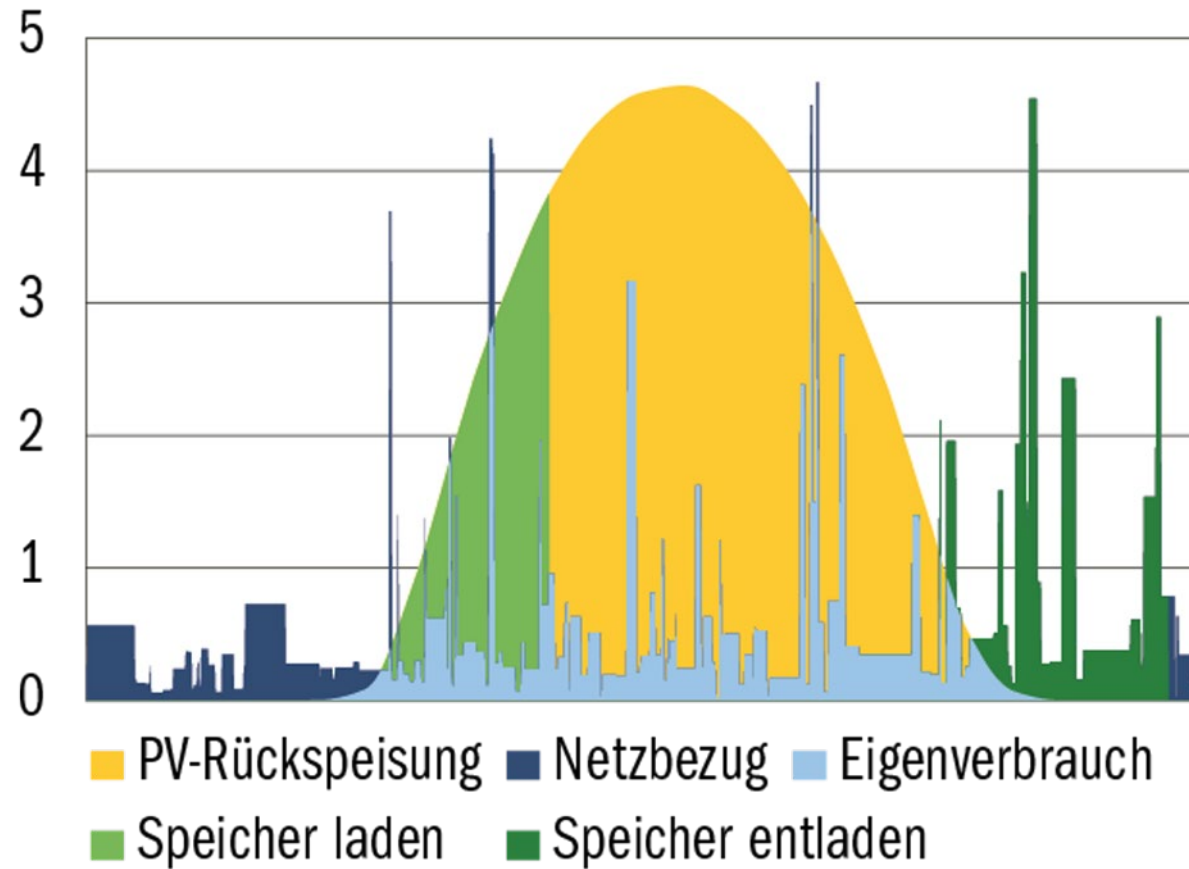
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021





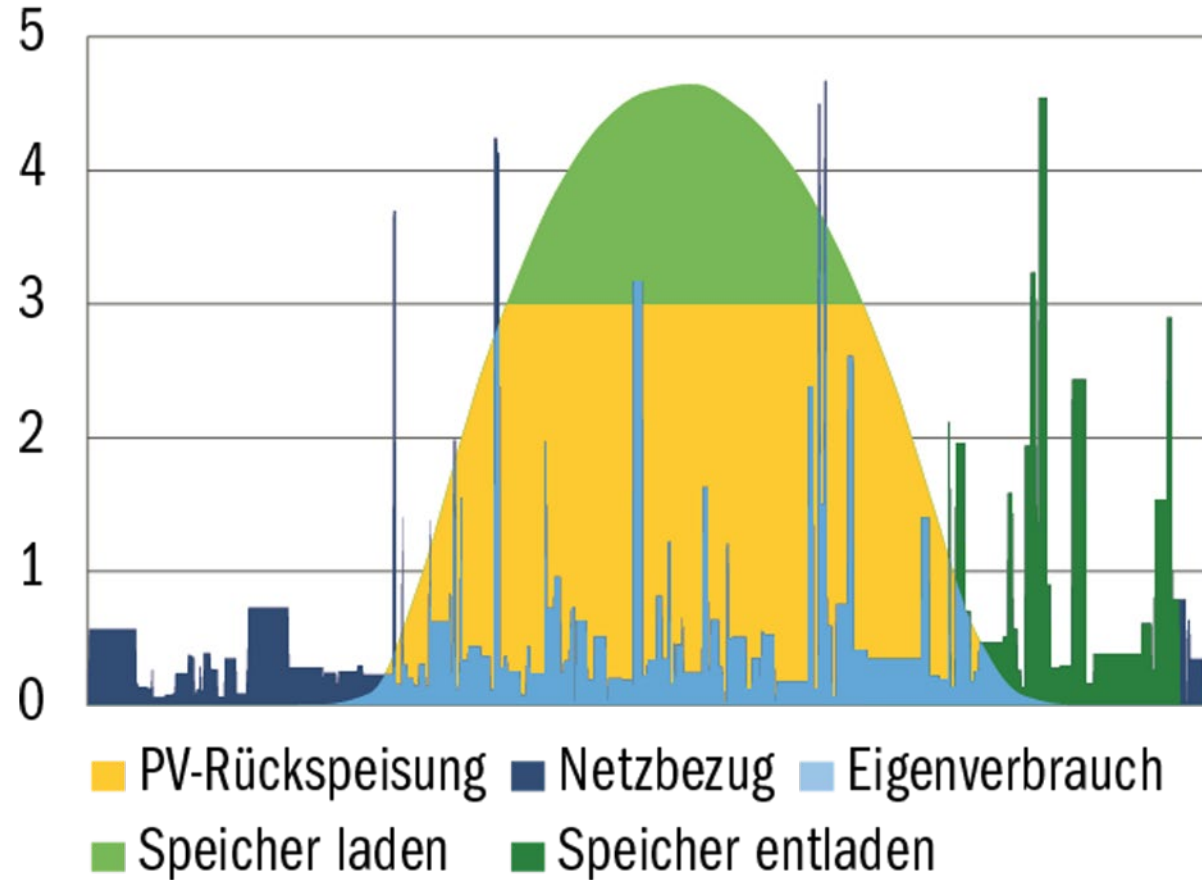


Leistung in kW



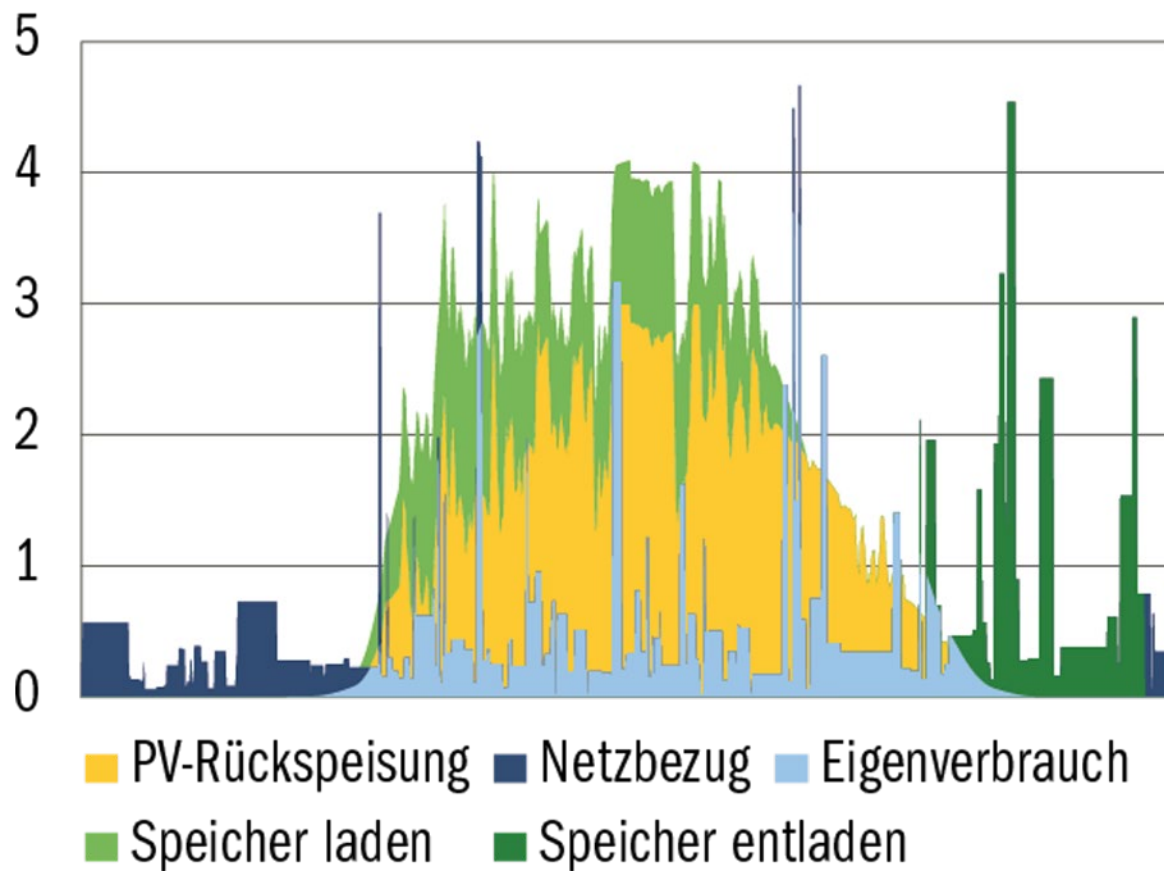
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Leistung in kW

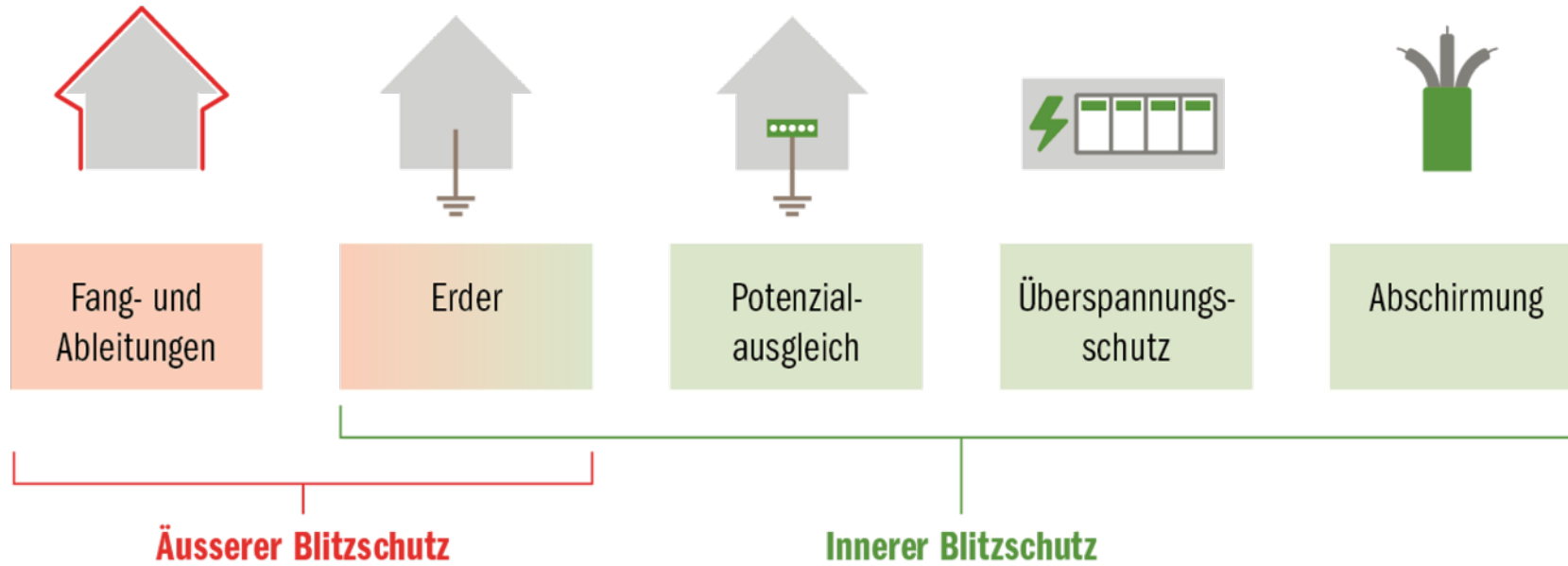


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

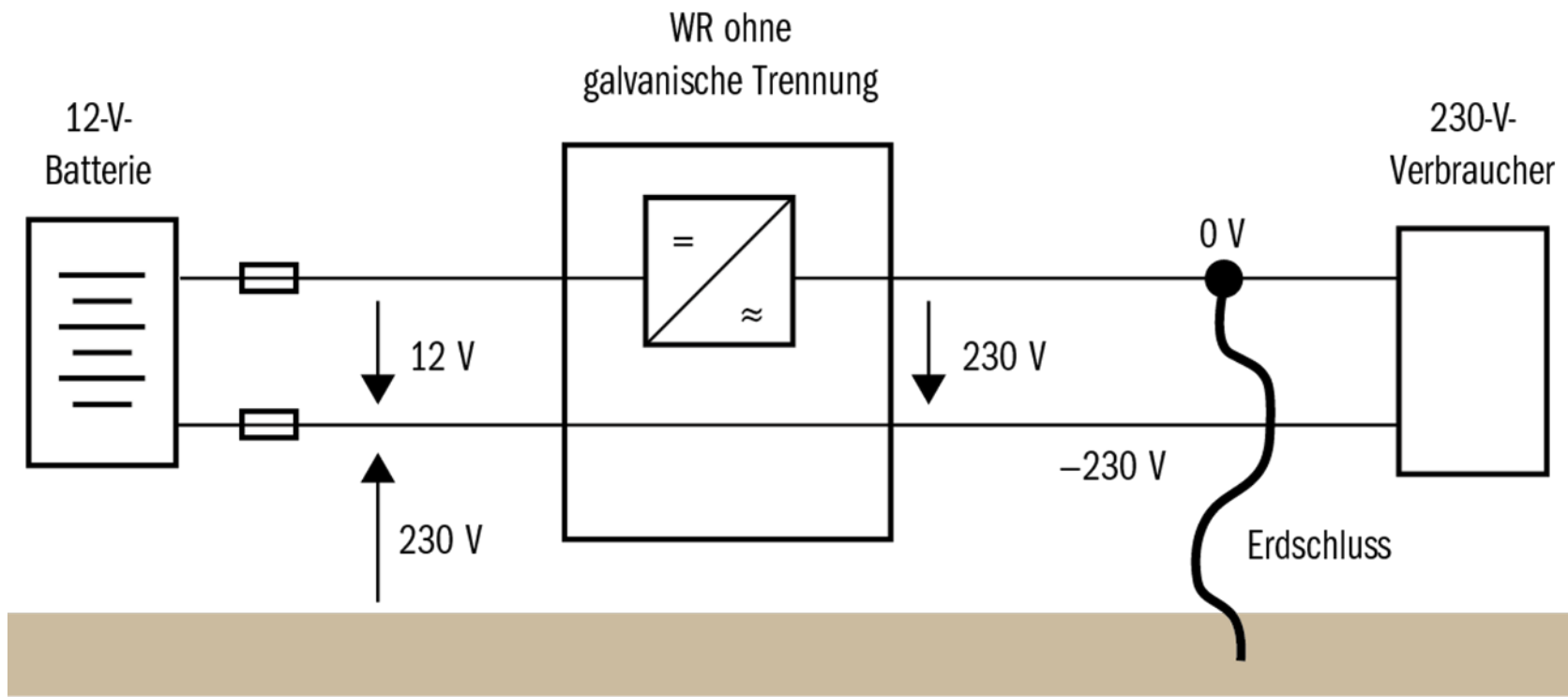
Leistung in kW



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

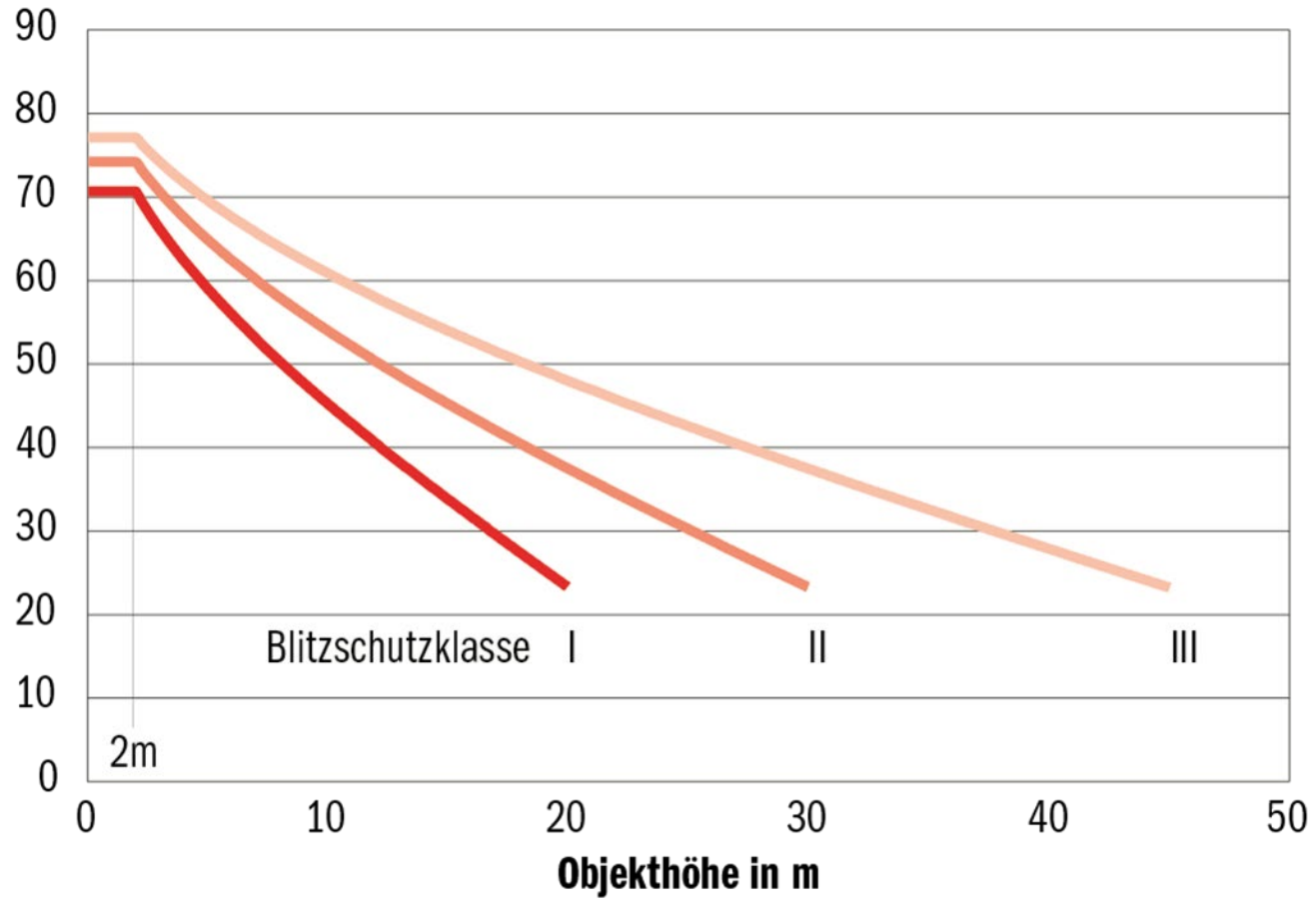


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

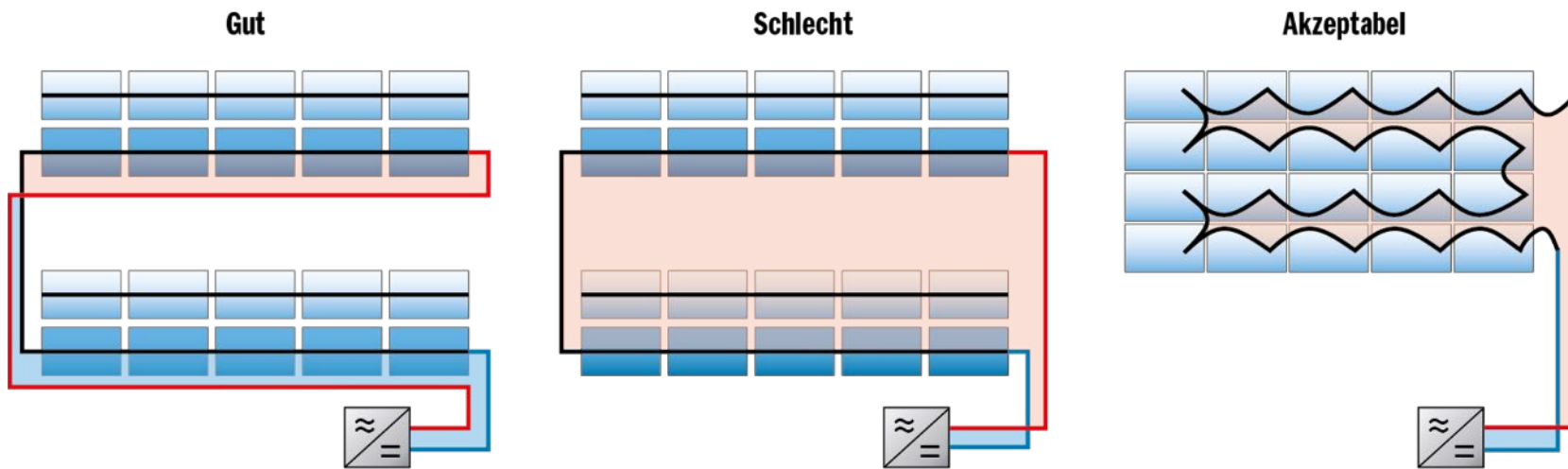


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

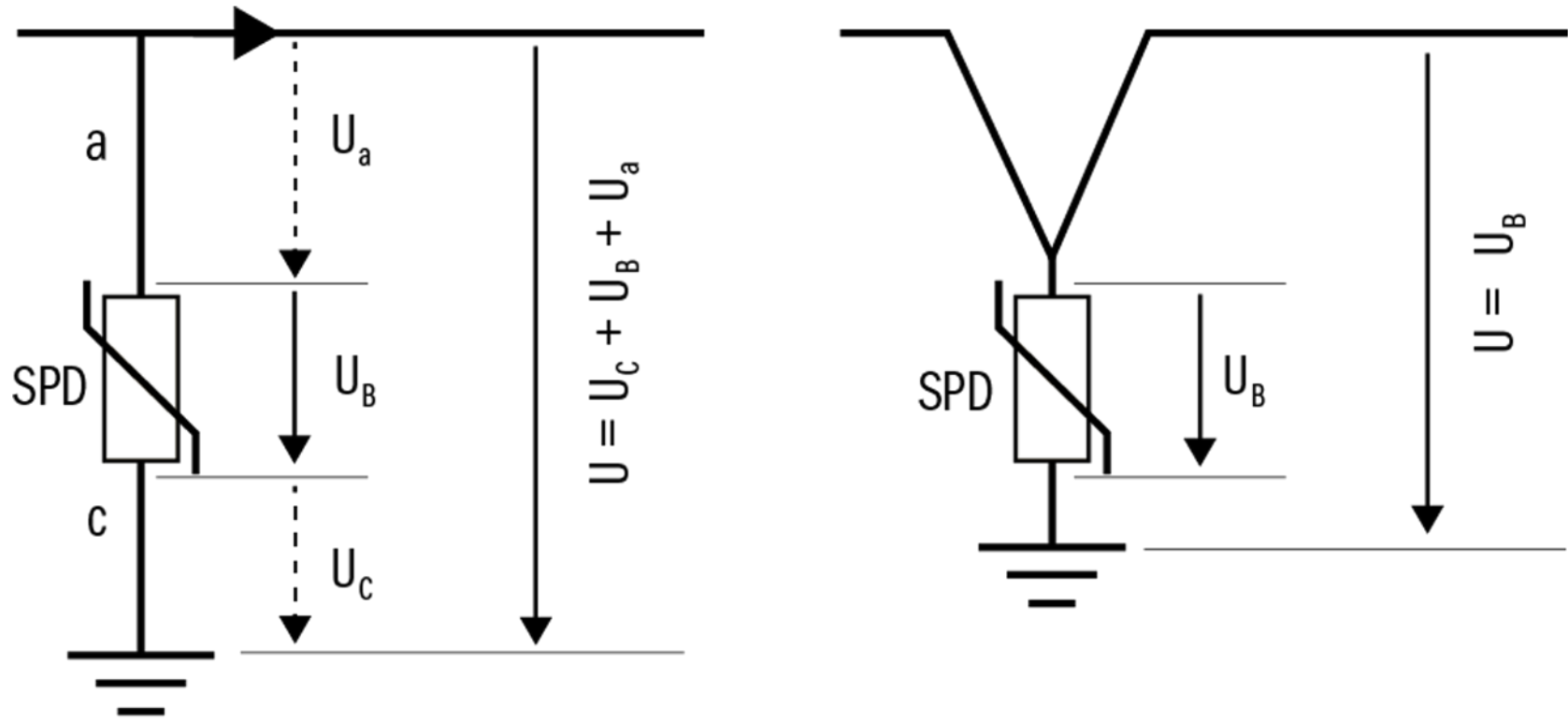
Schutzwinkel α in Grad



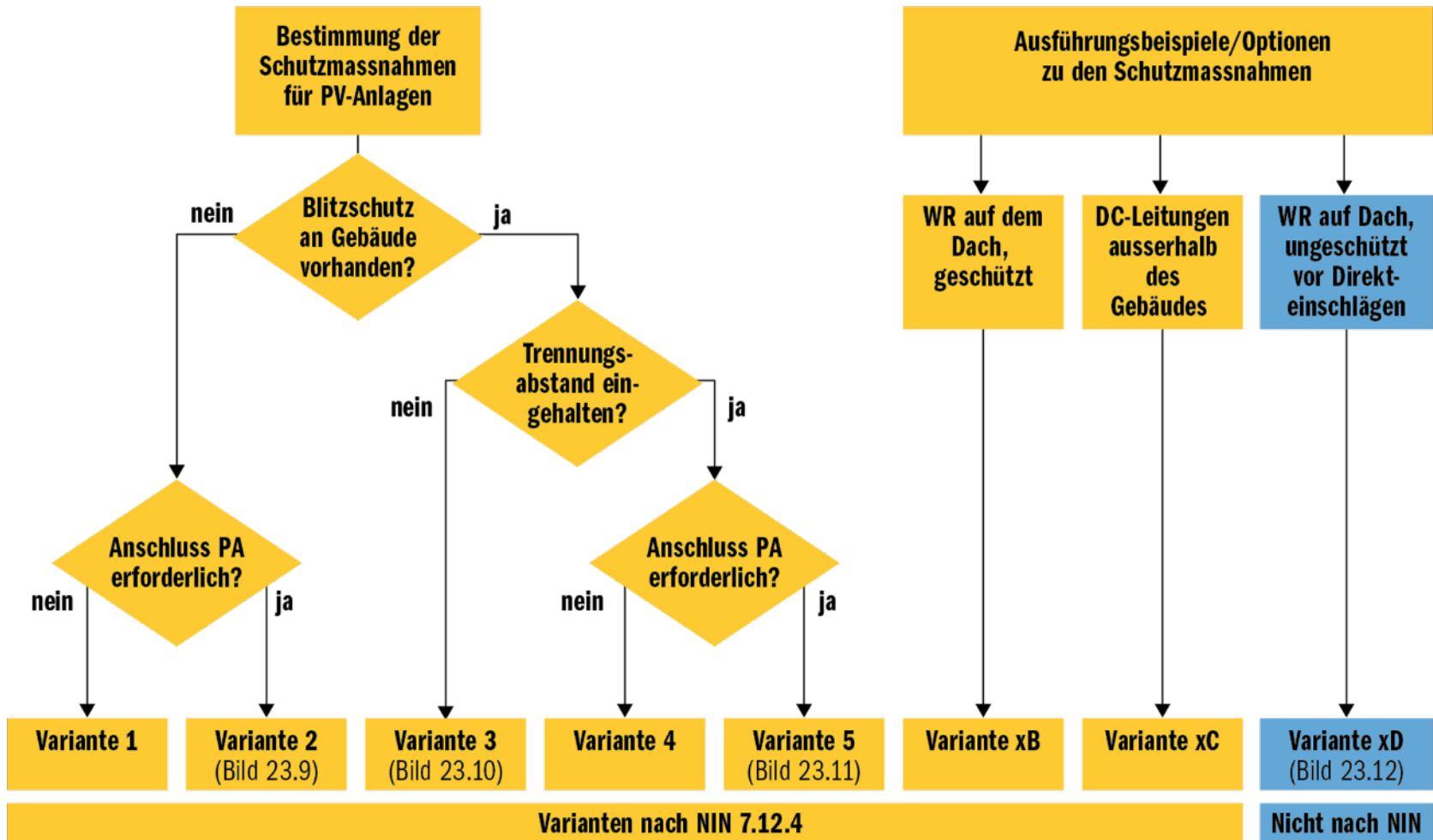
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



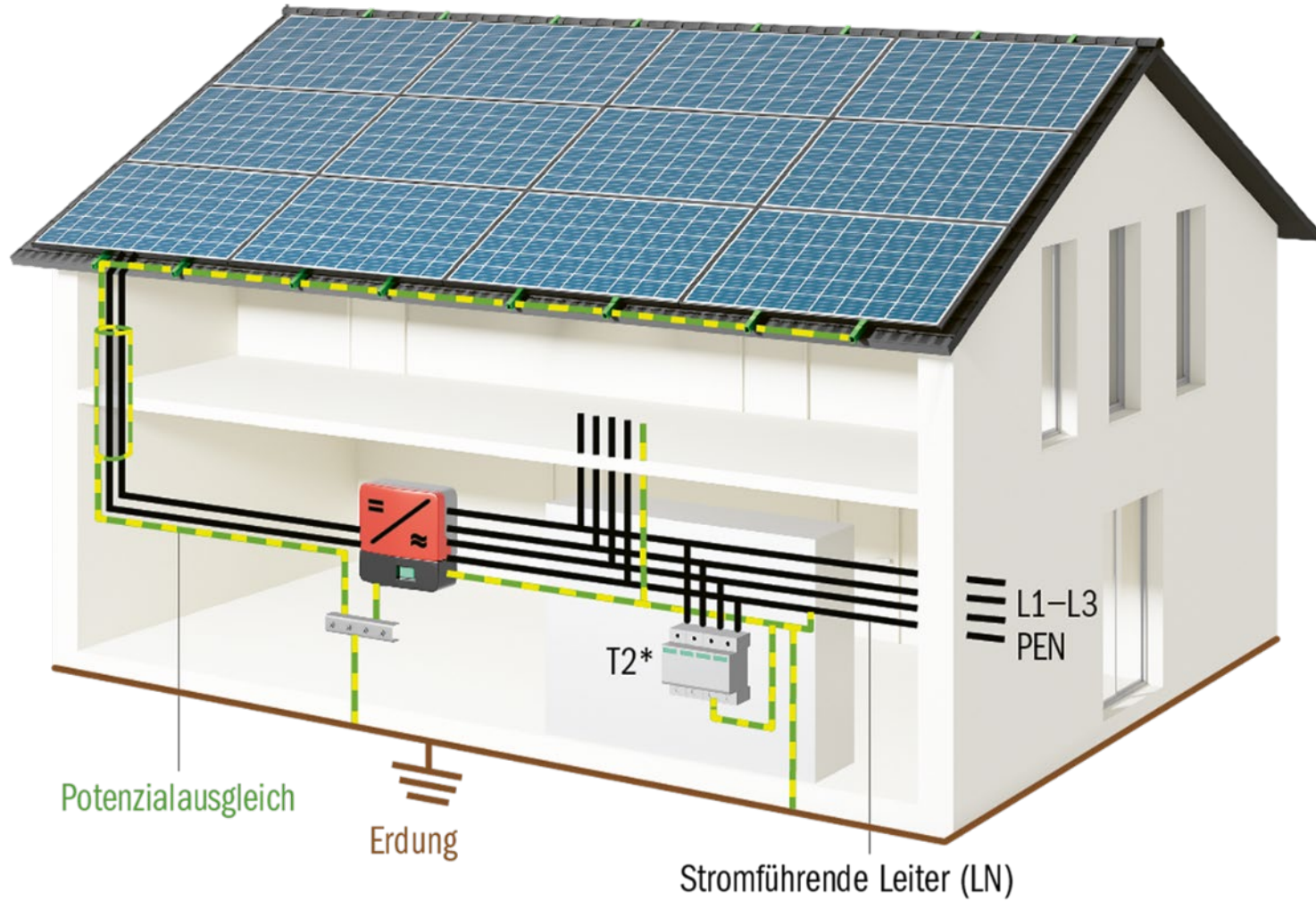
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



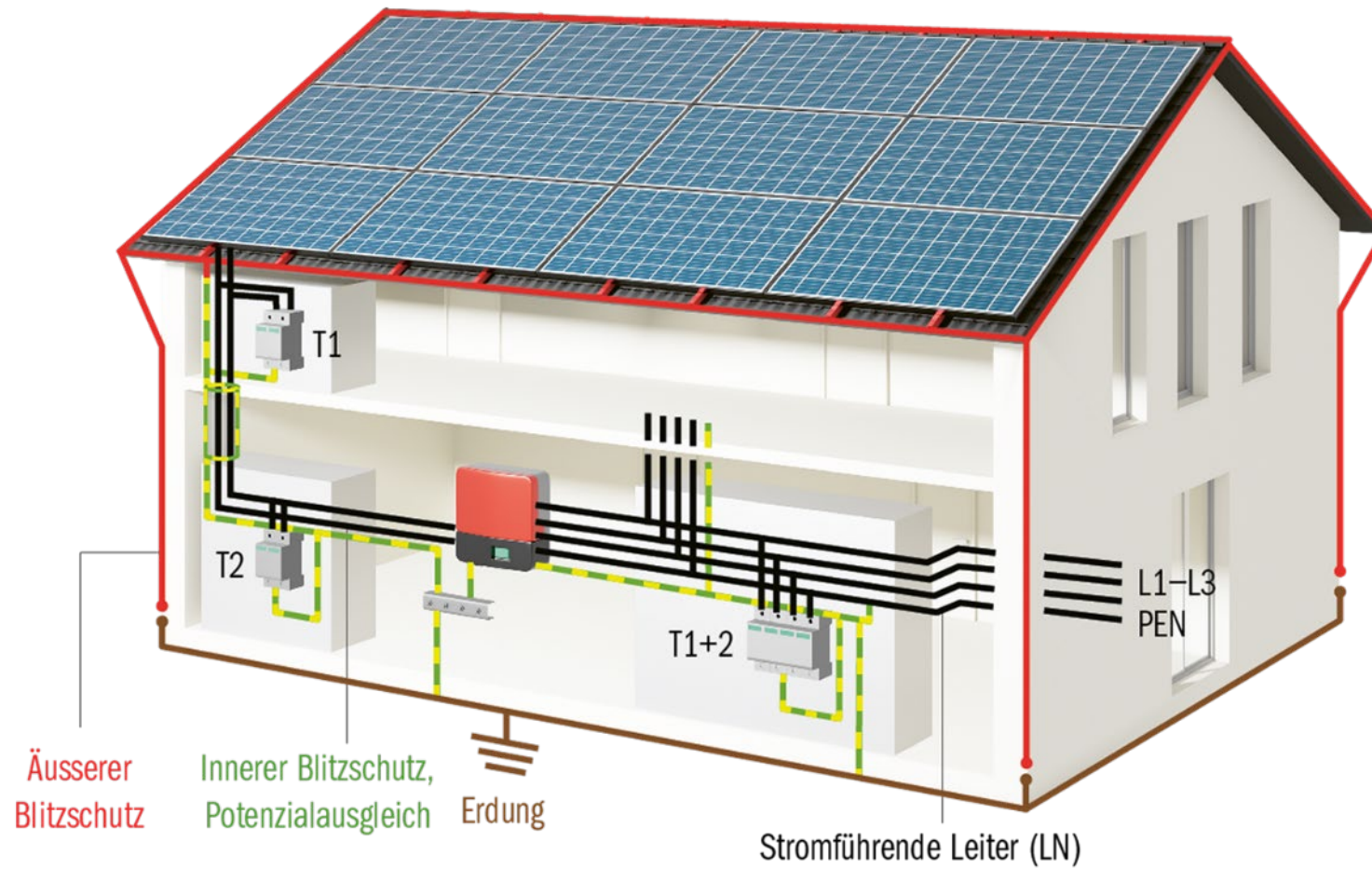
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



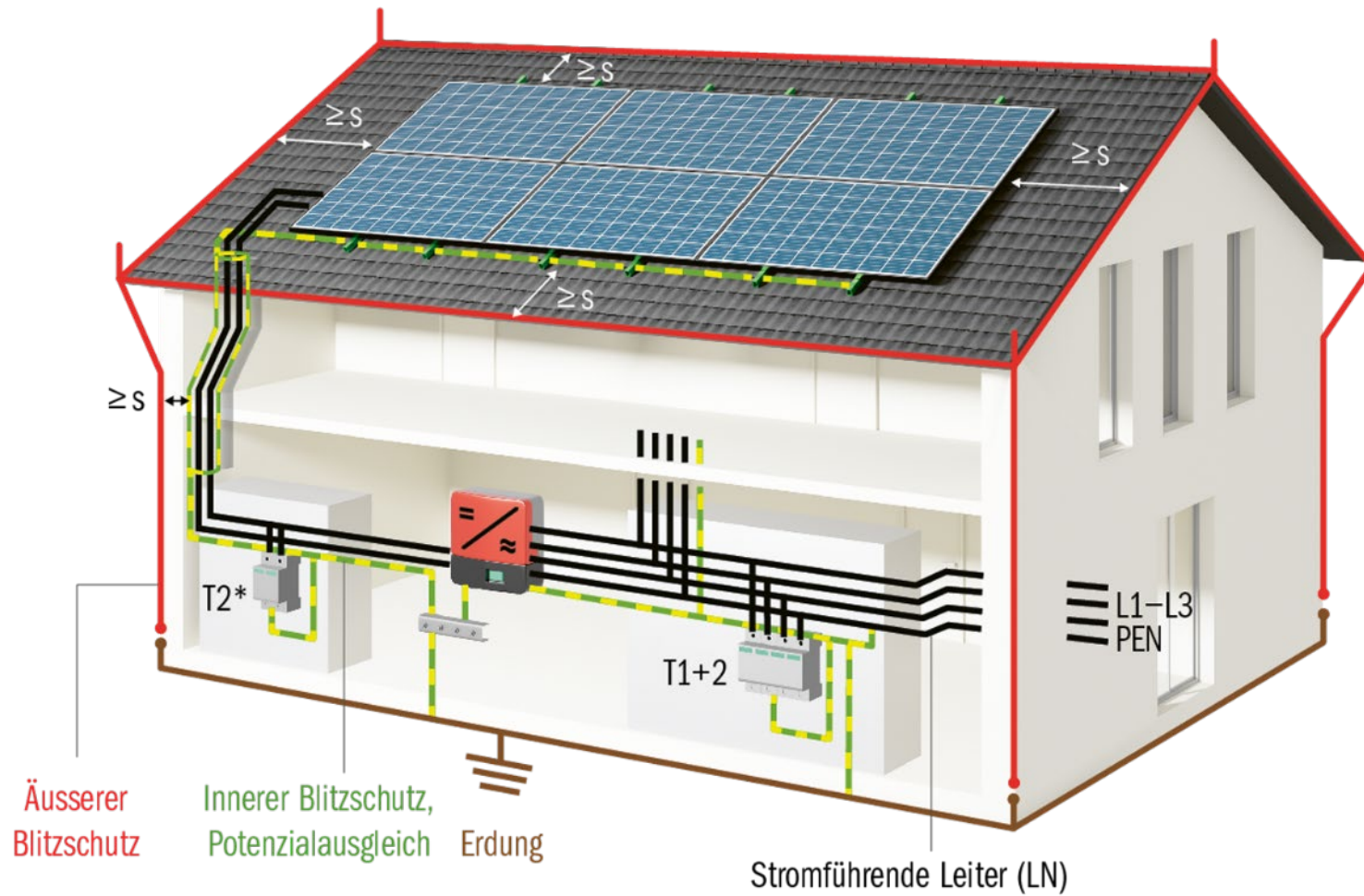
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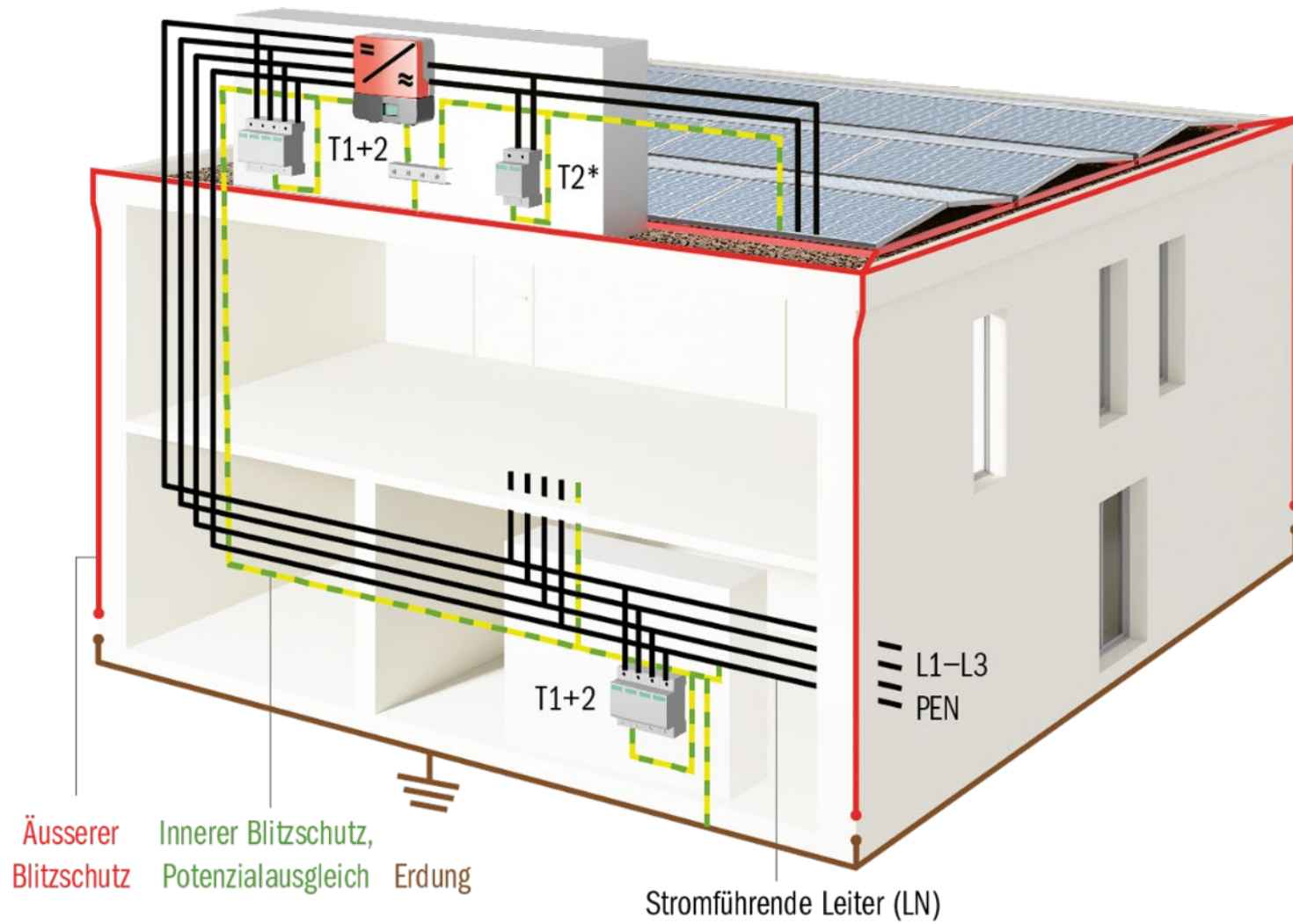
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



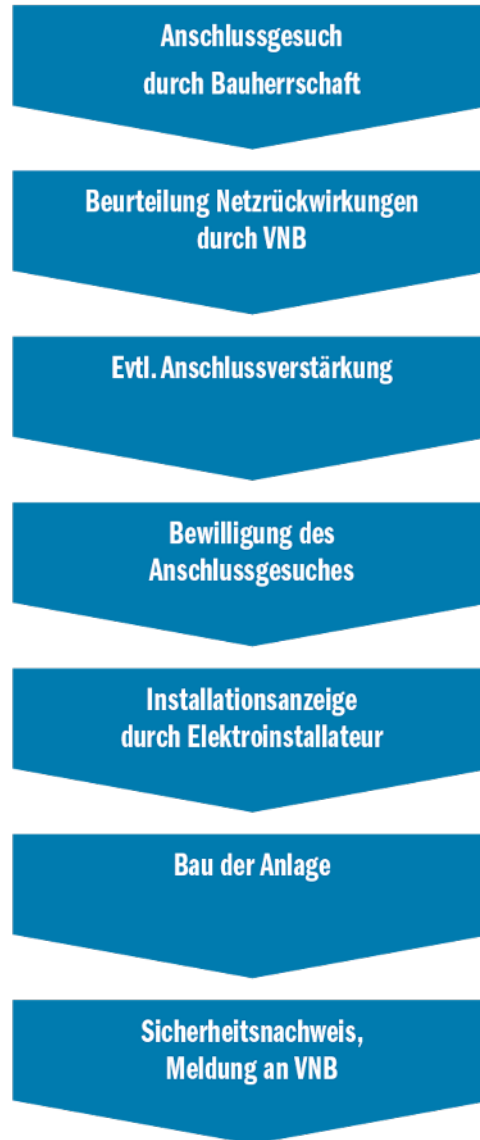
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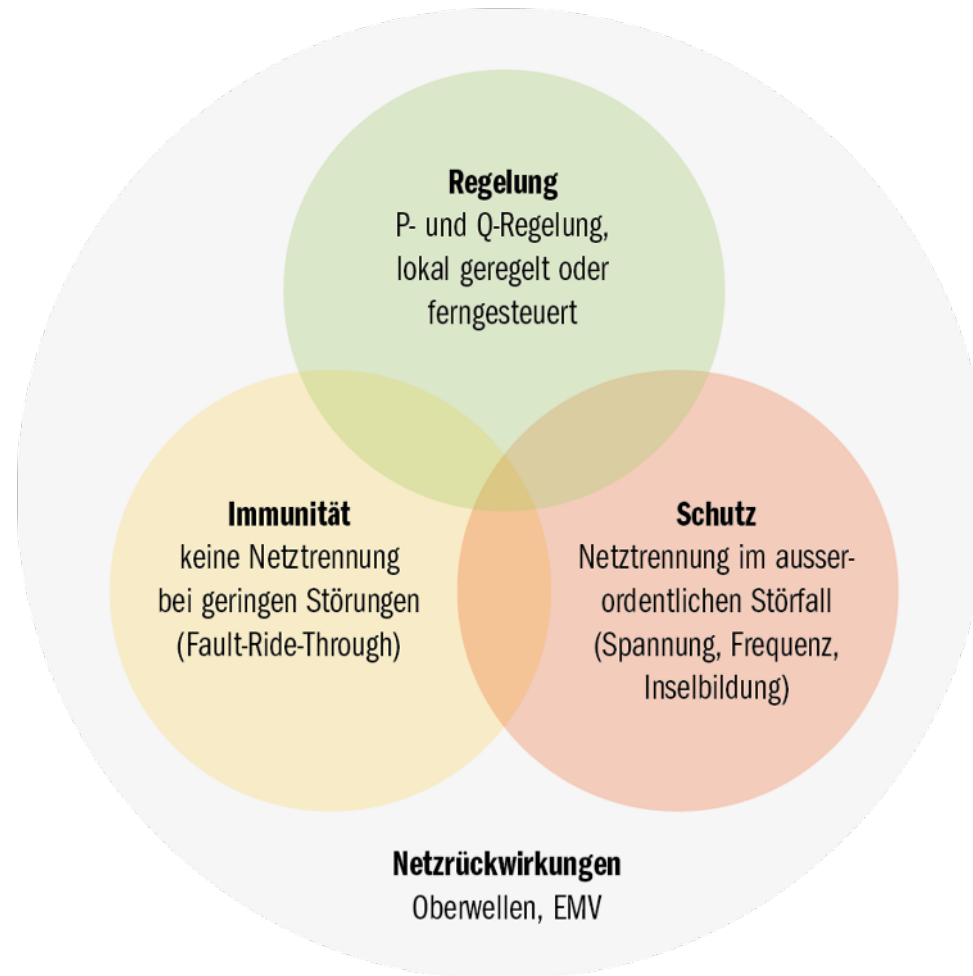


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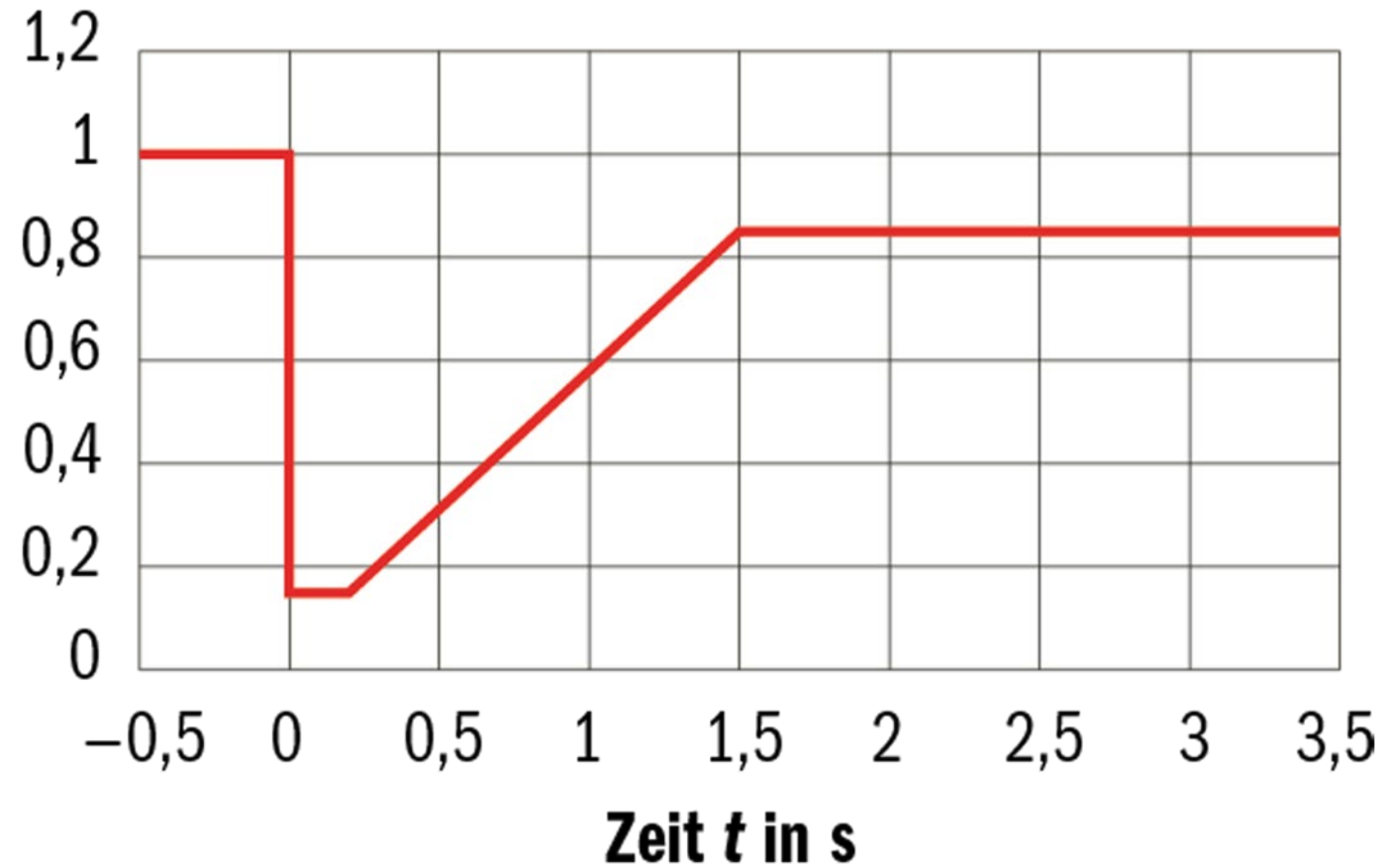
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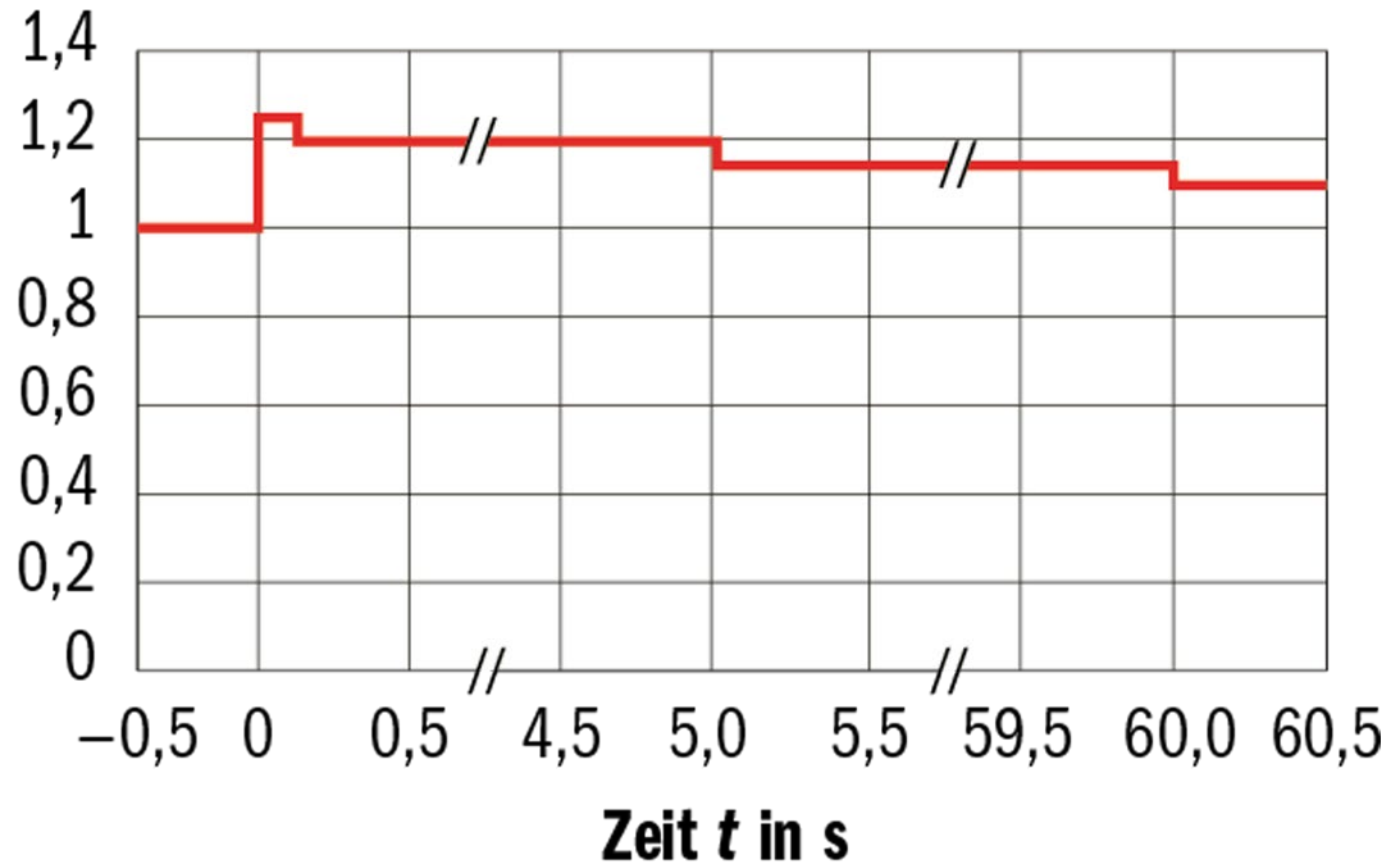
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Spannung U in V



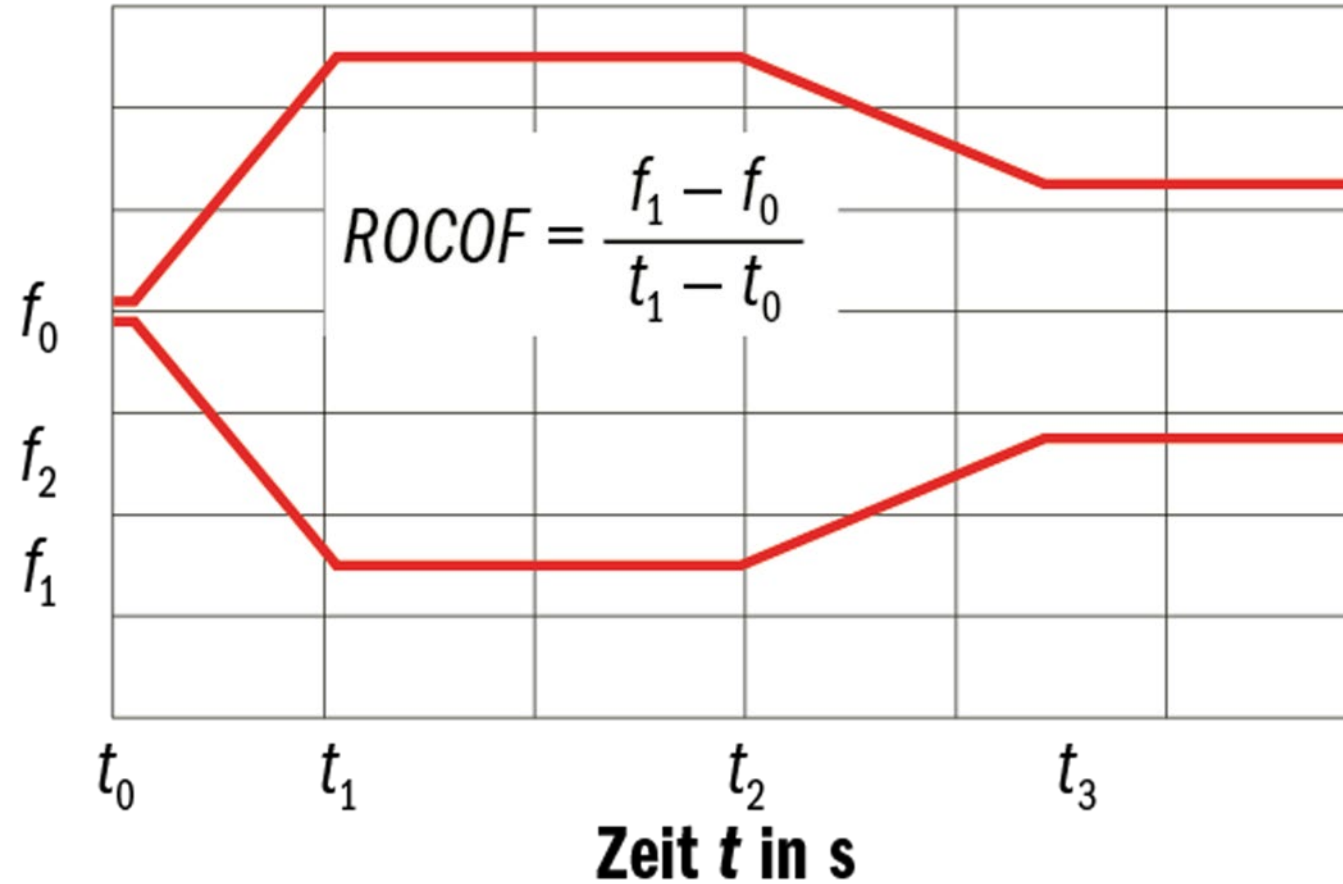
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Spannung U in V



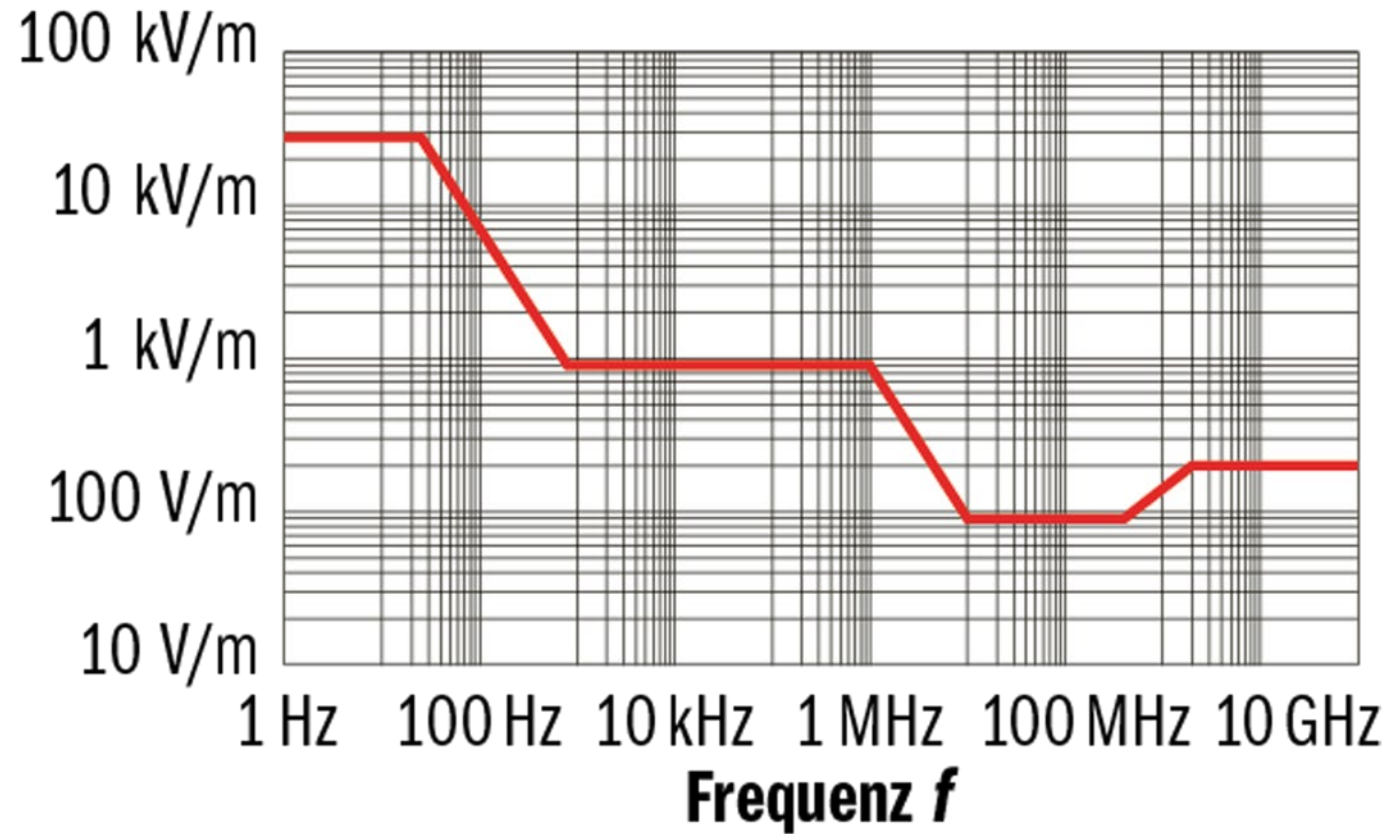
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Frequenz f in Hz



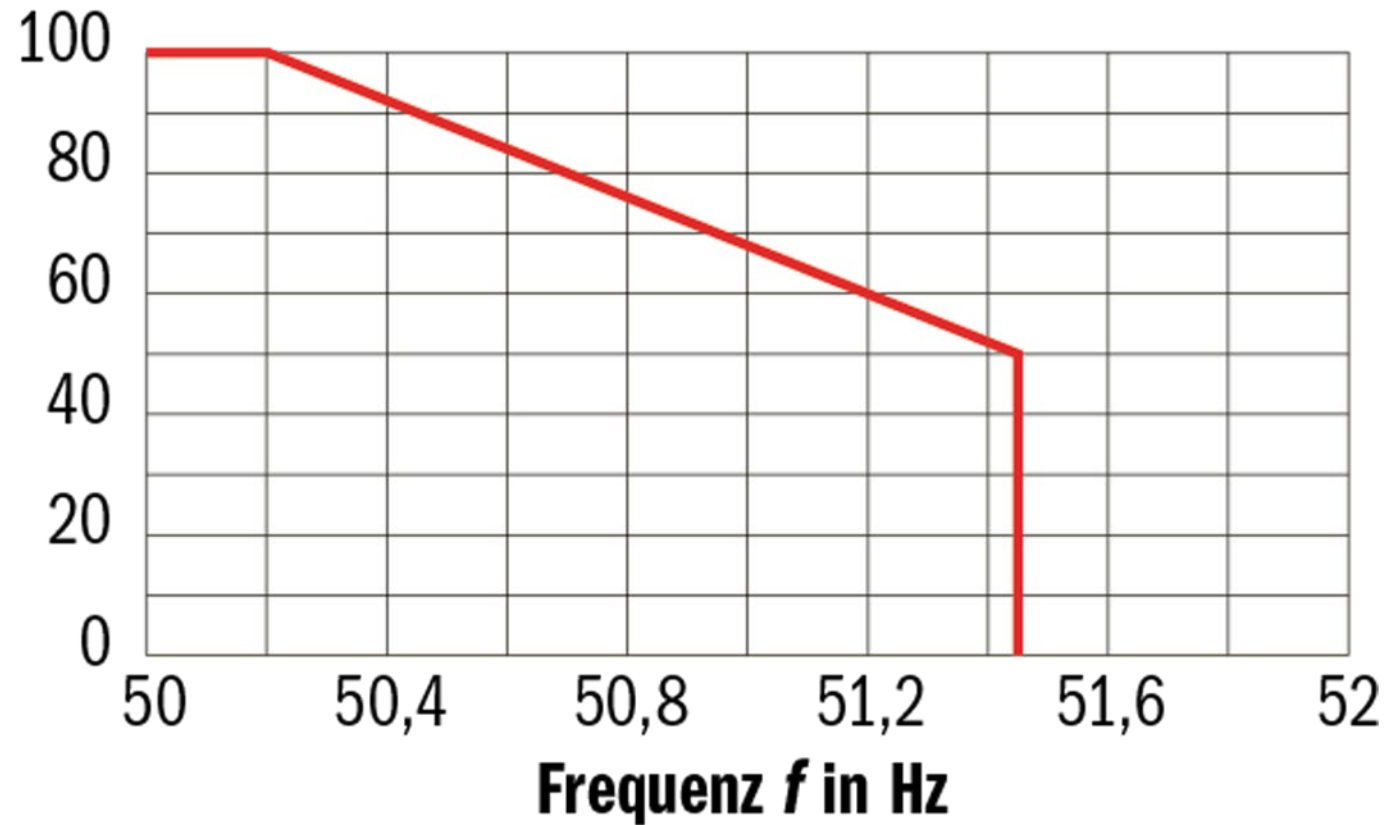
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Elektrisches Feld

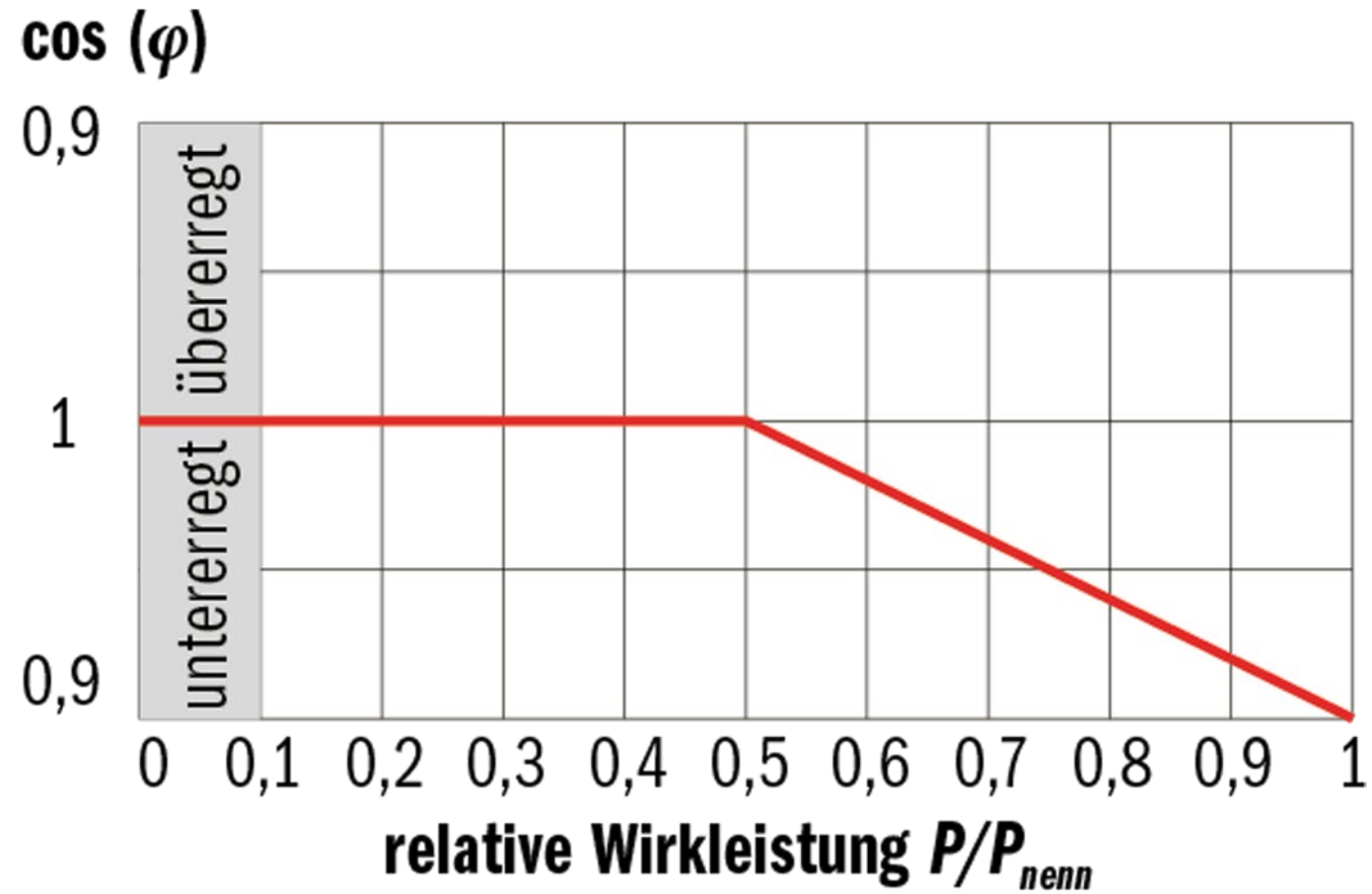


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Relative Wirkleistung P in %

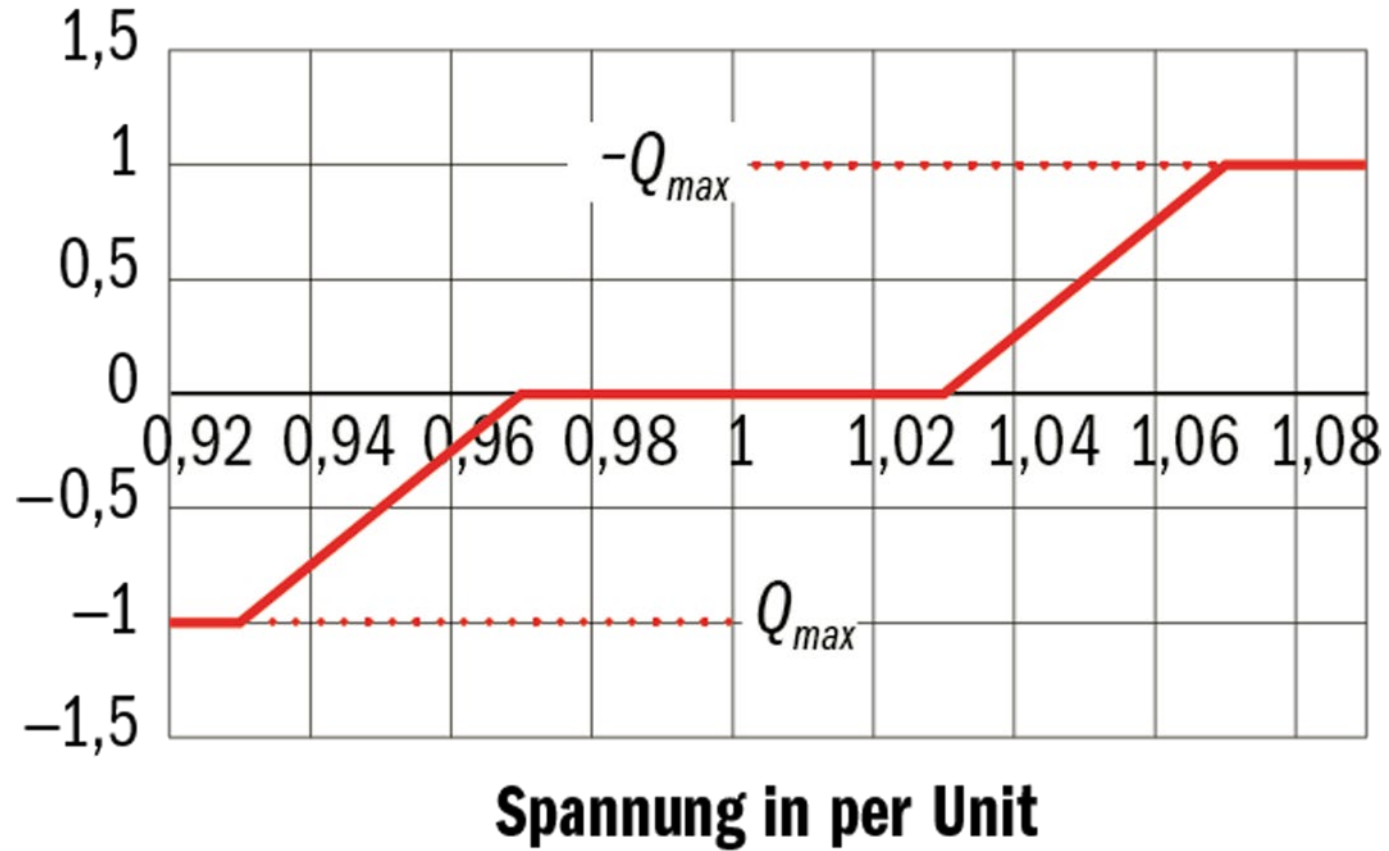


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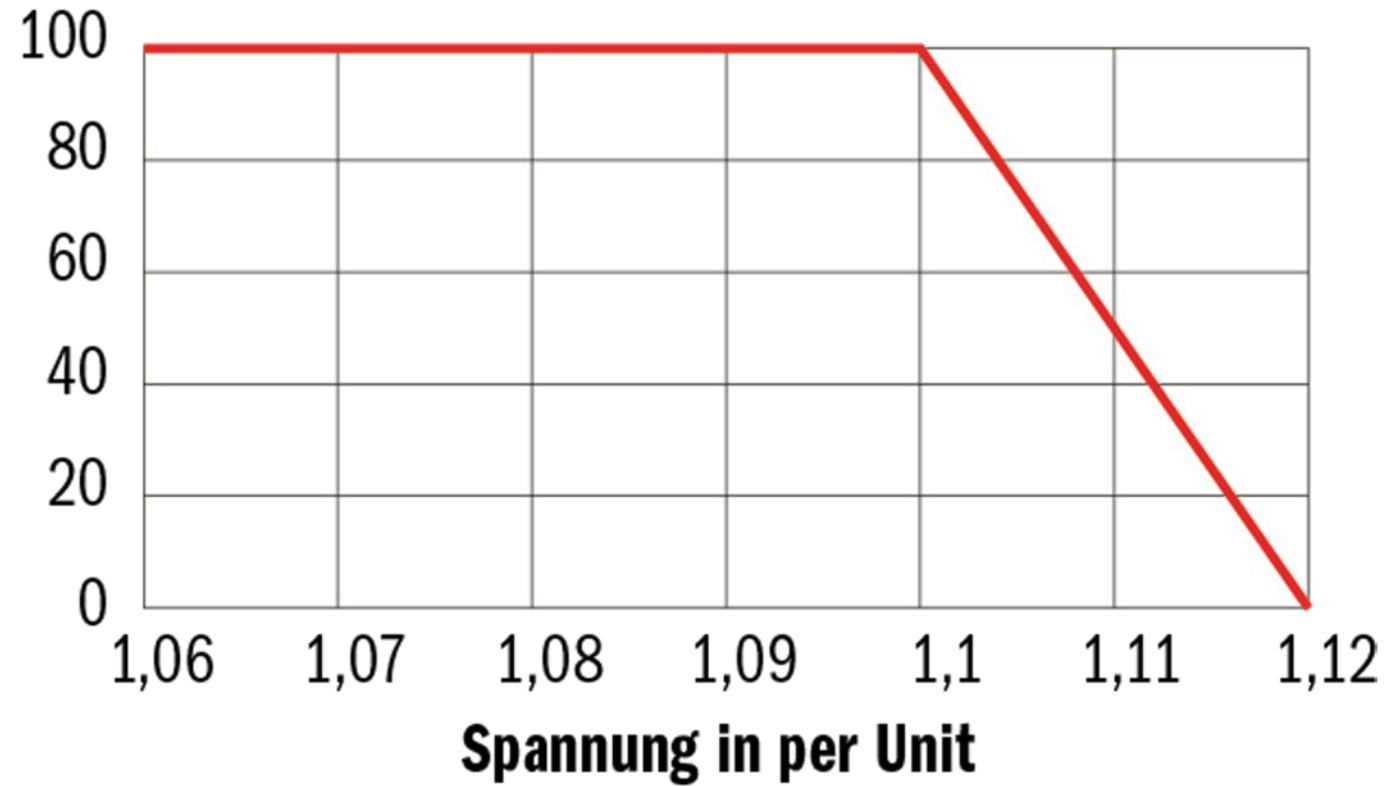
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Blindleistung Q in kVar



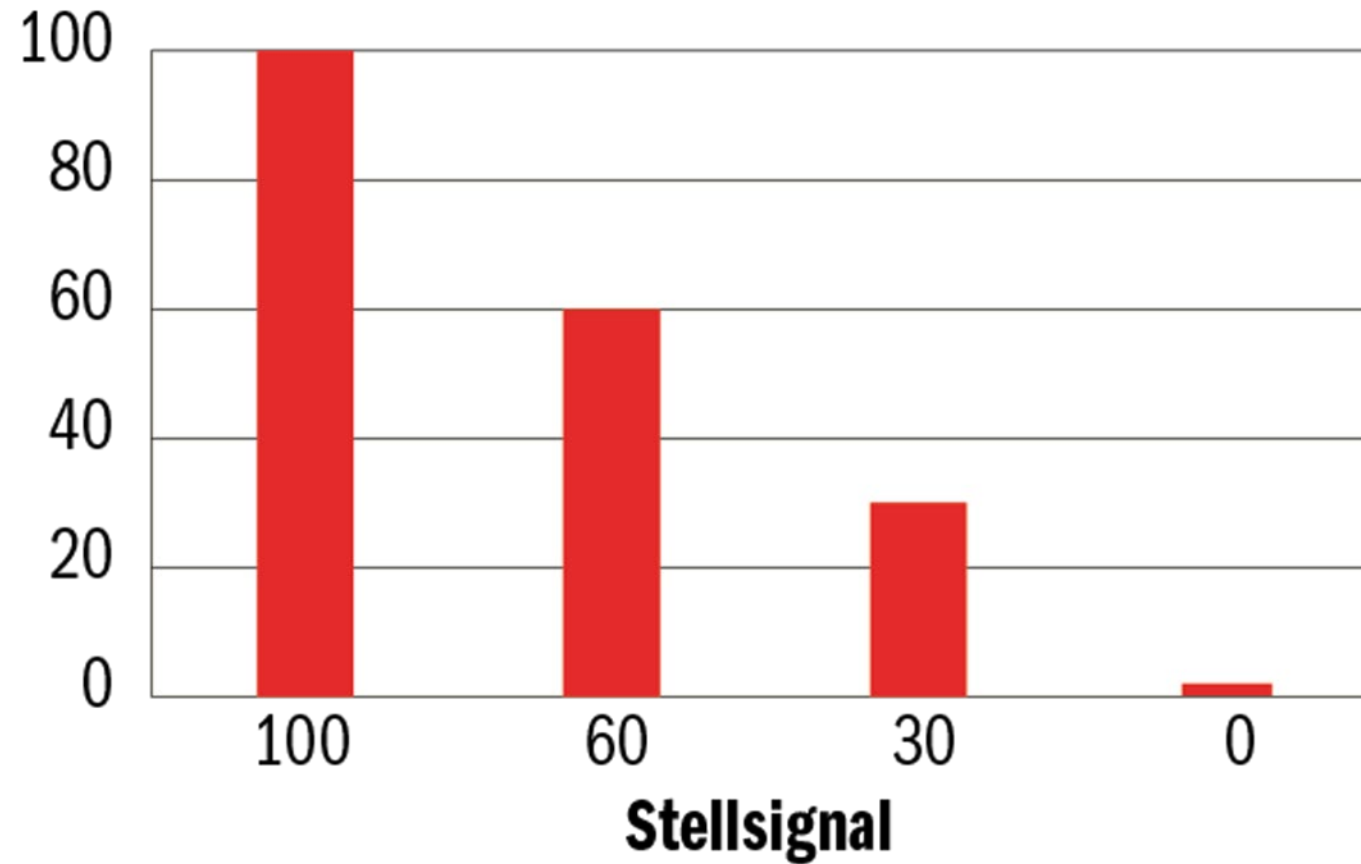
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Relative Wirkleistung P in %

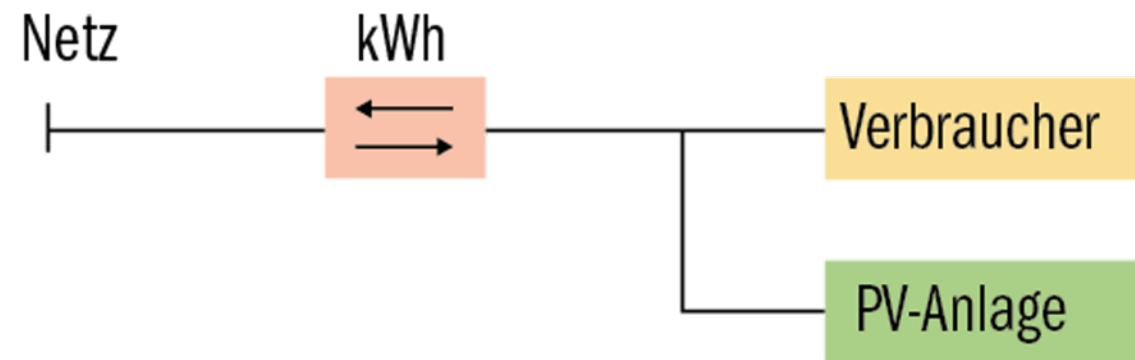


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

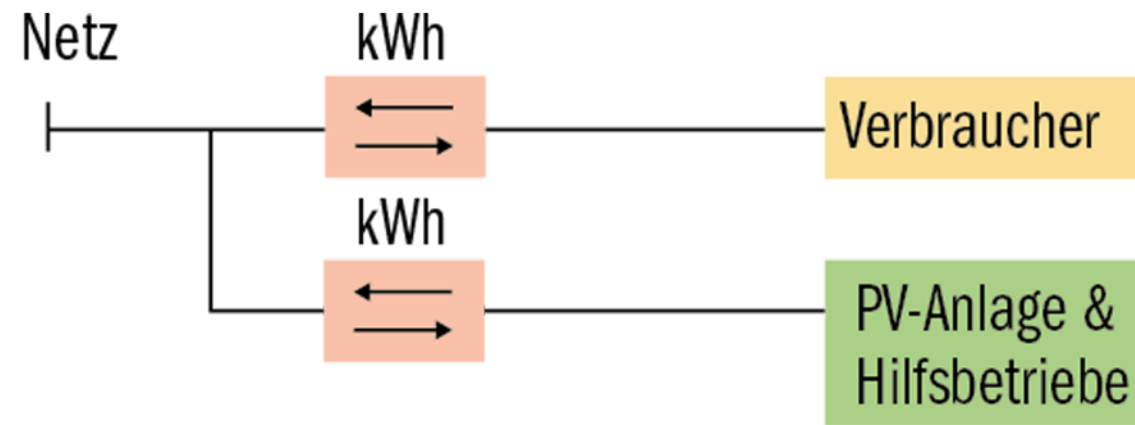
Relative Wirkleistung P in %



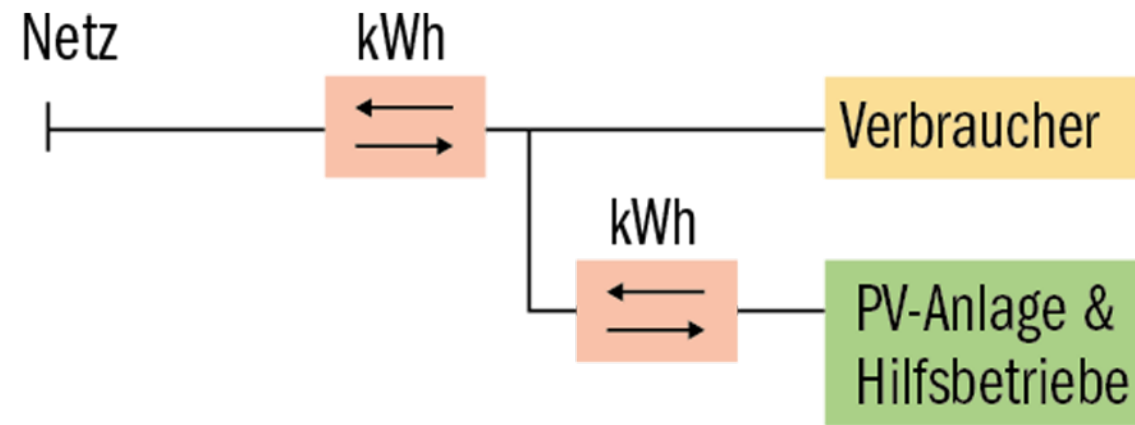
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



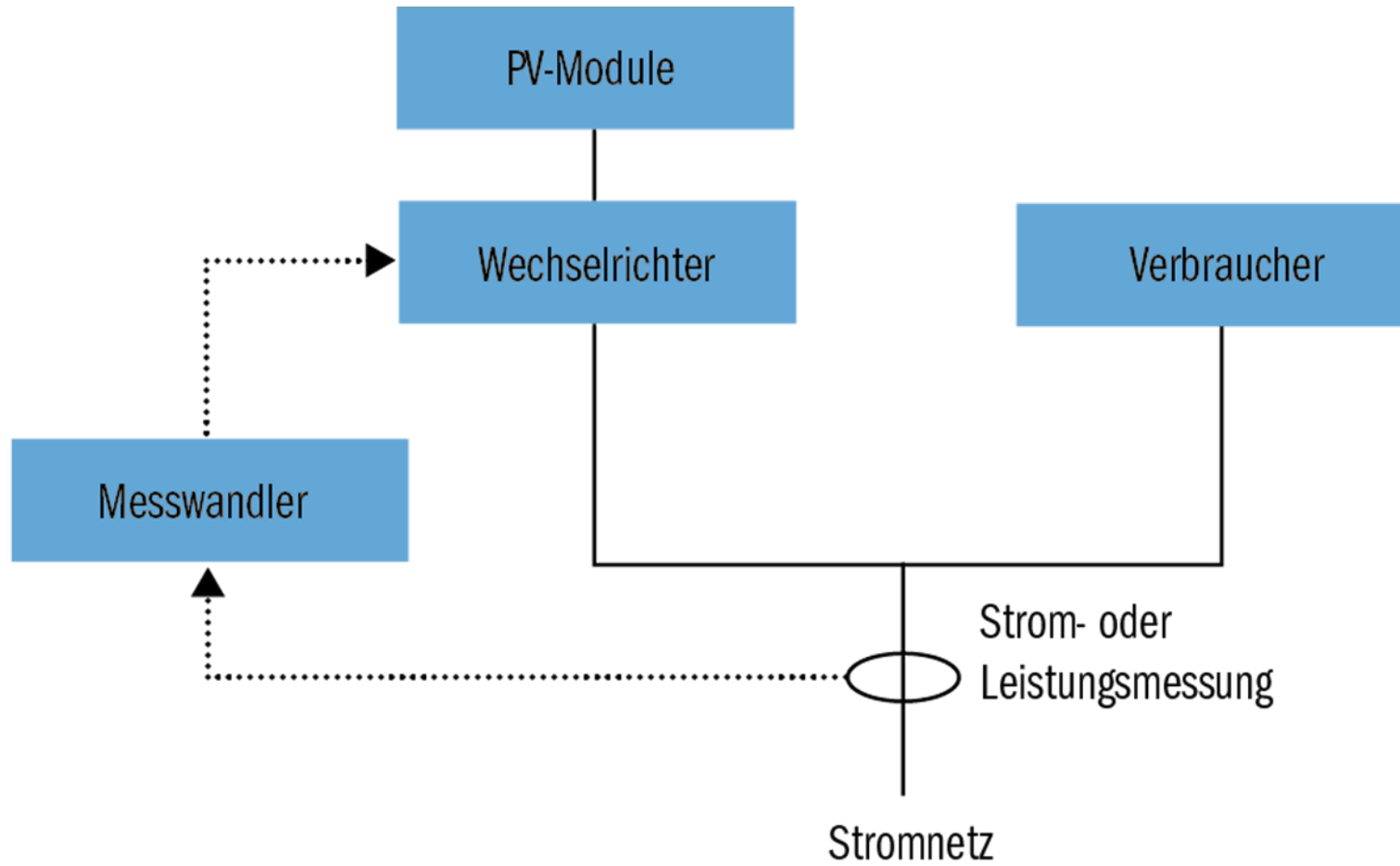
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



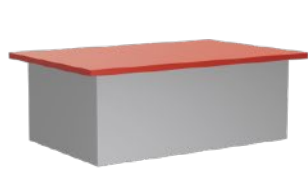
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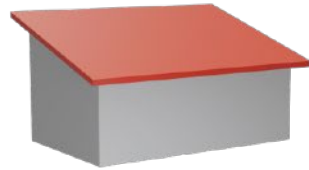
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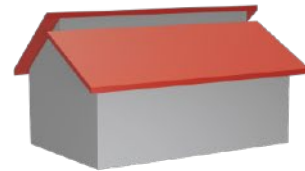
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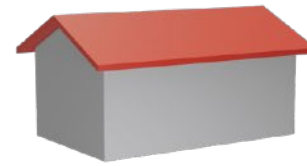
Flachdach



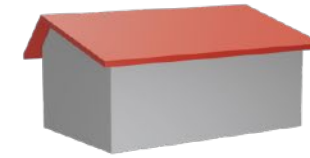
Pulldach



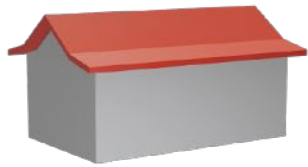
Versetztes Pulldach



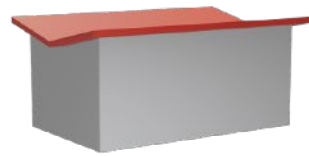
Satteldach



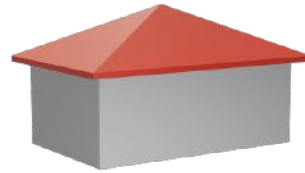
Frackdach



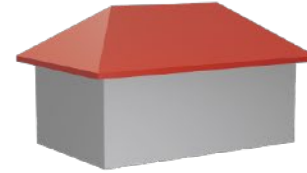
Knickdach



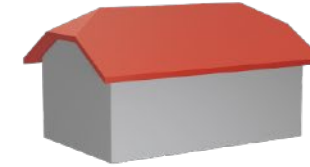
Schmetterlingsdach



Zeltdach



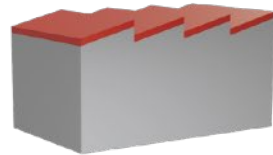
Walmdach



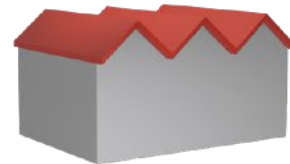
Krüppelwalmdach



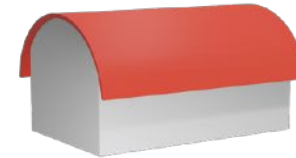
Mansardengiebel



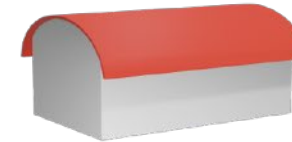
Sheddach



Paralleldach

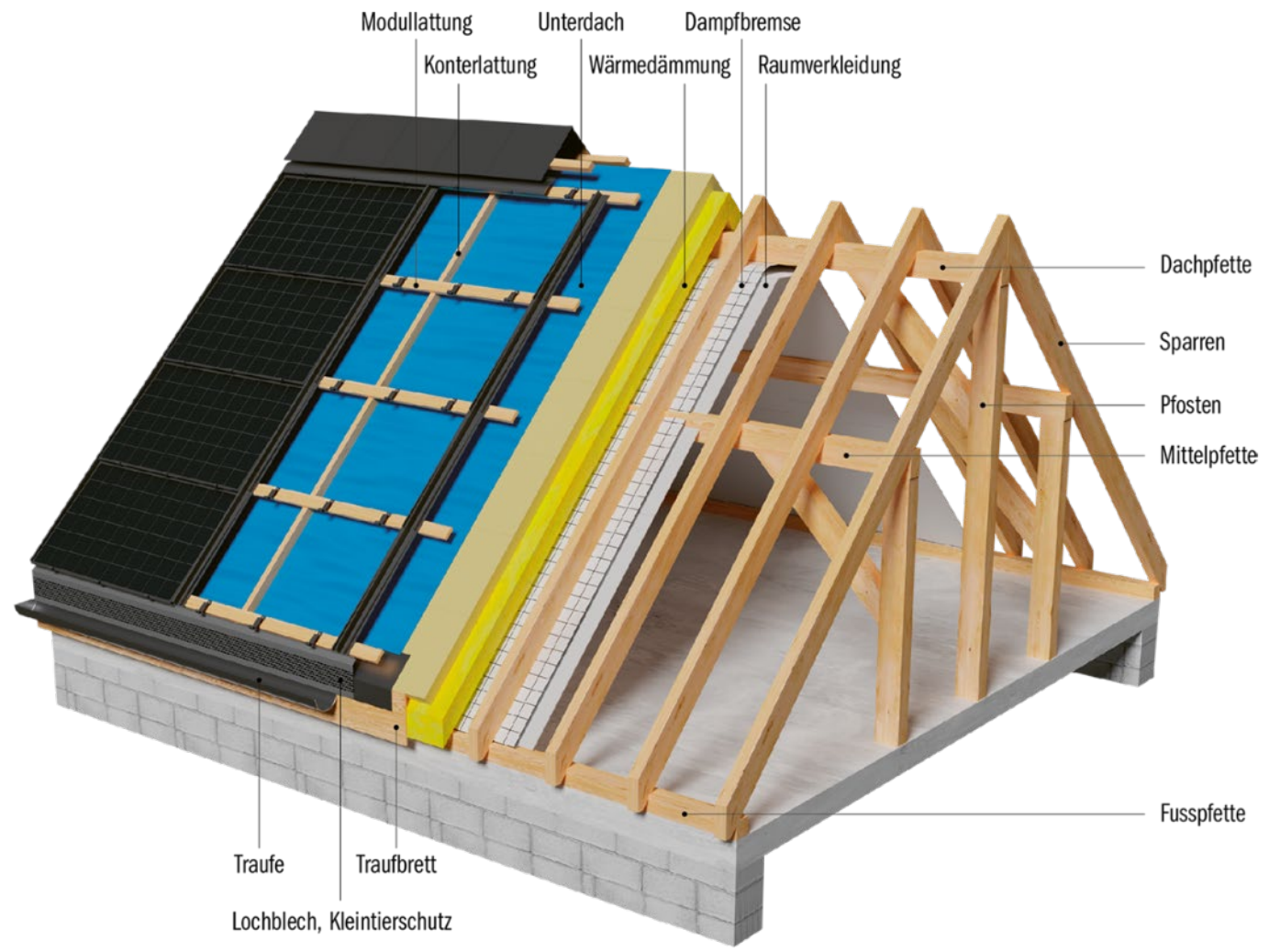


Tonnendach



Bogendach

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Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



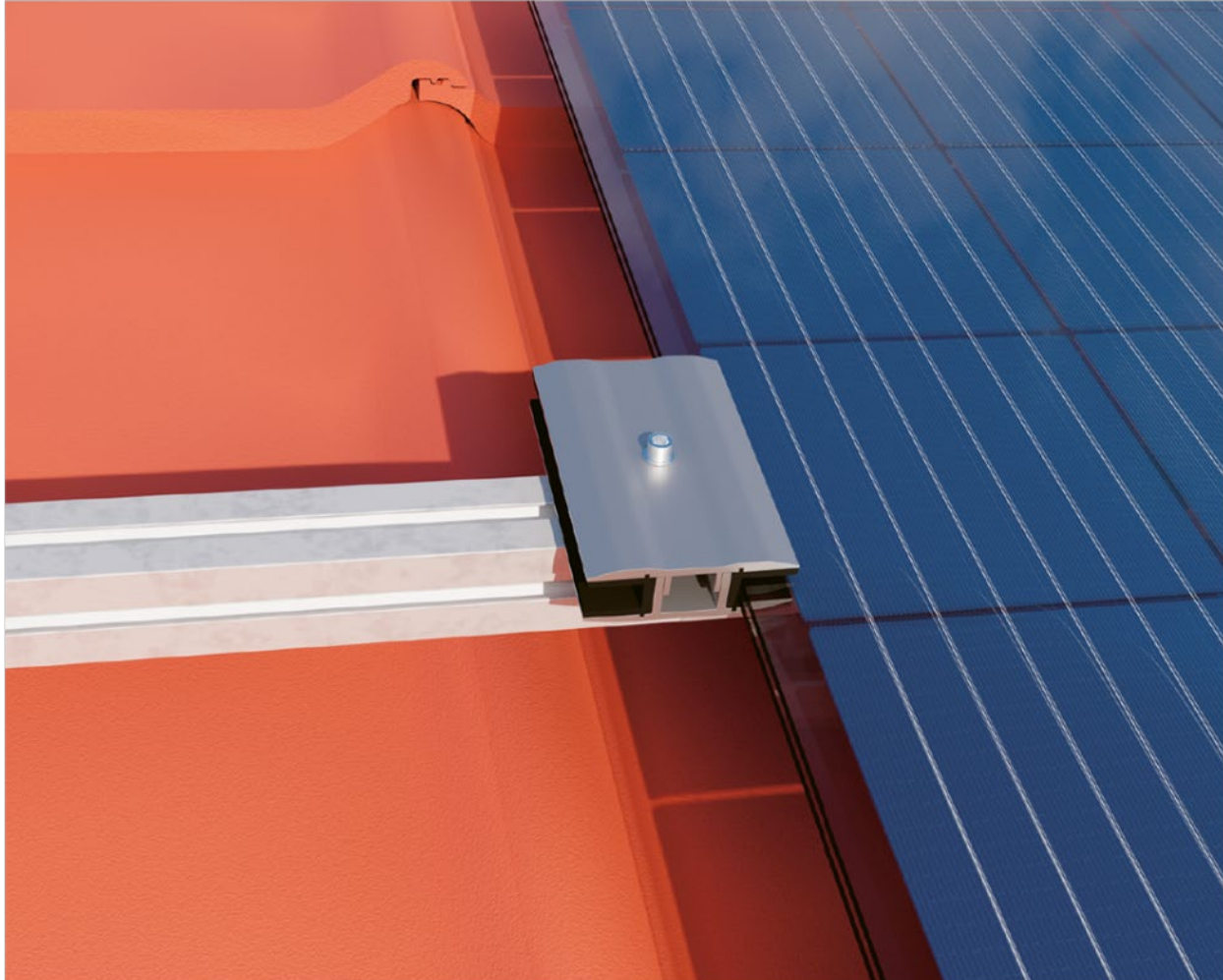
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



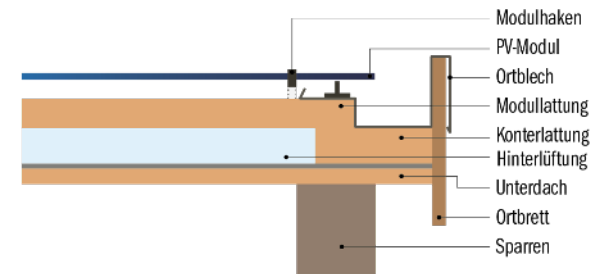
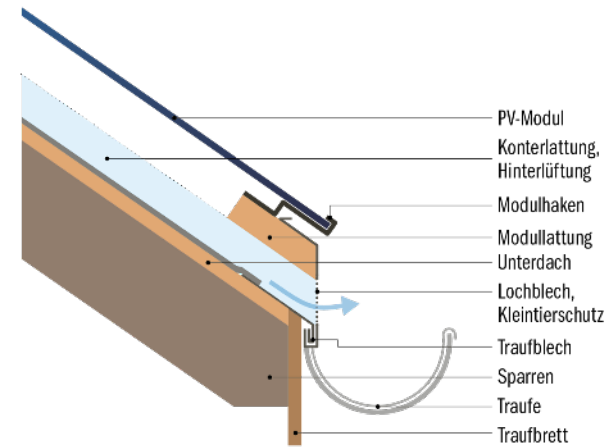
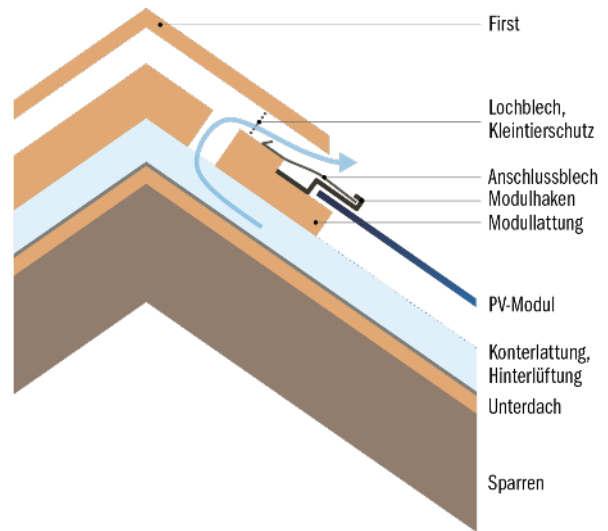
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



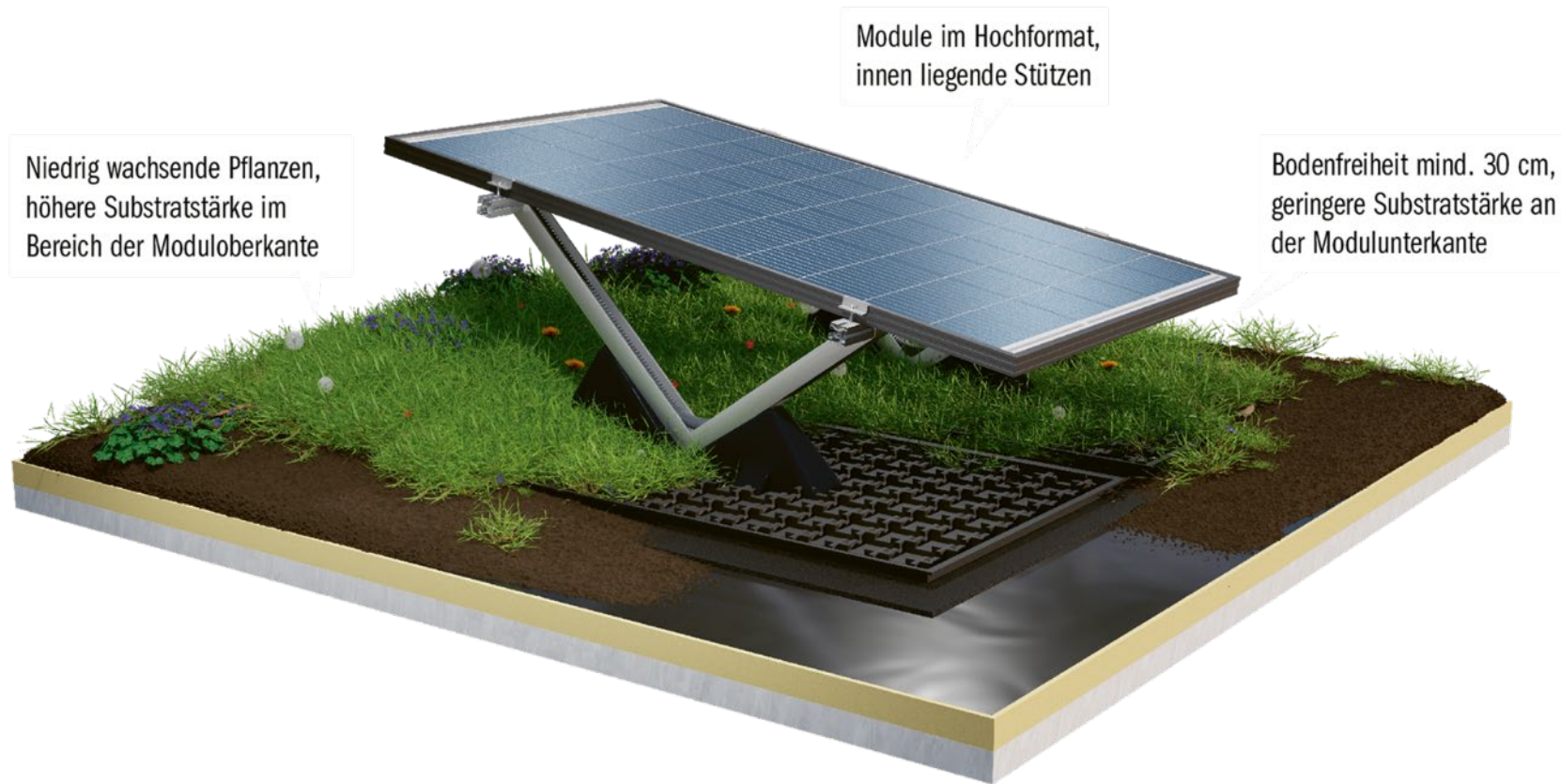
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Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



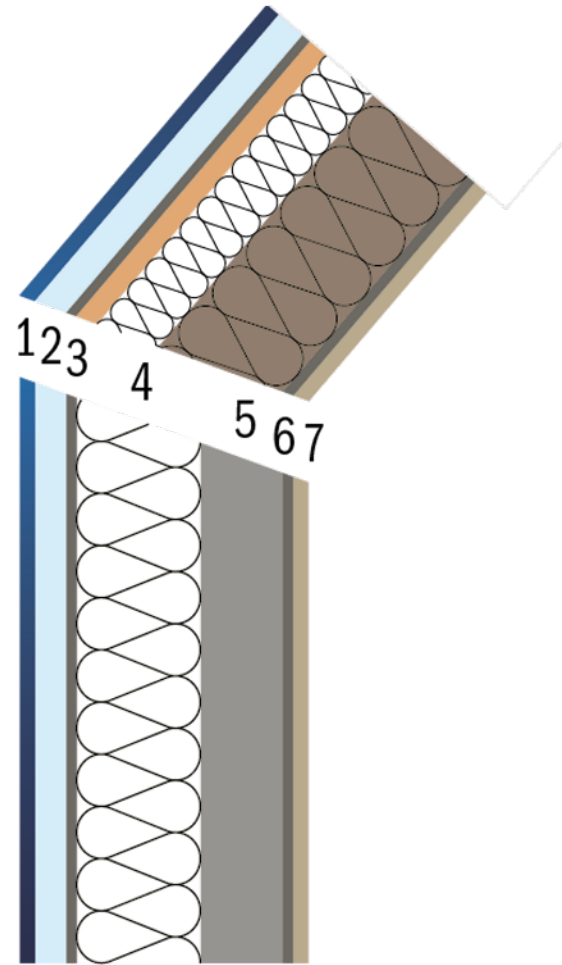
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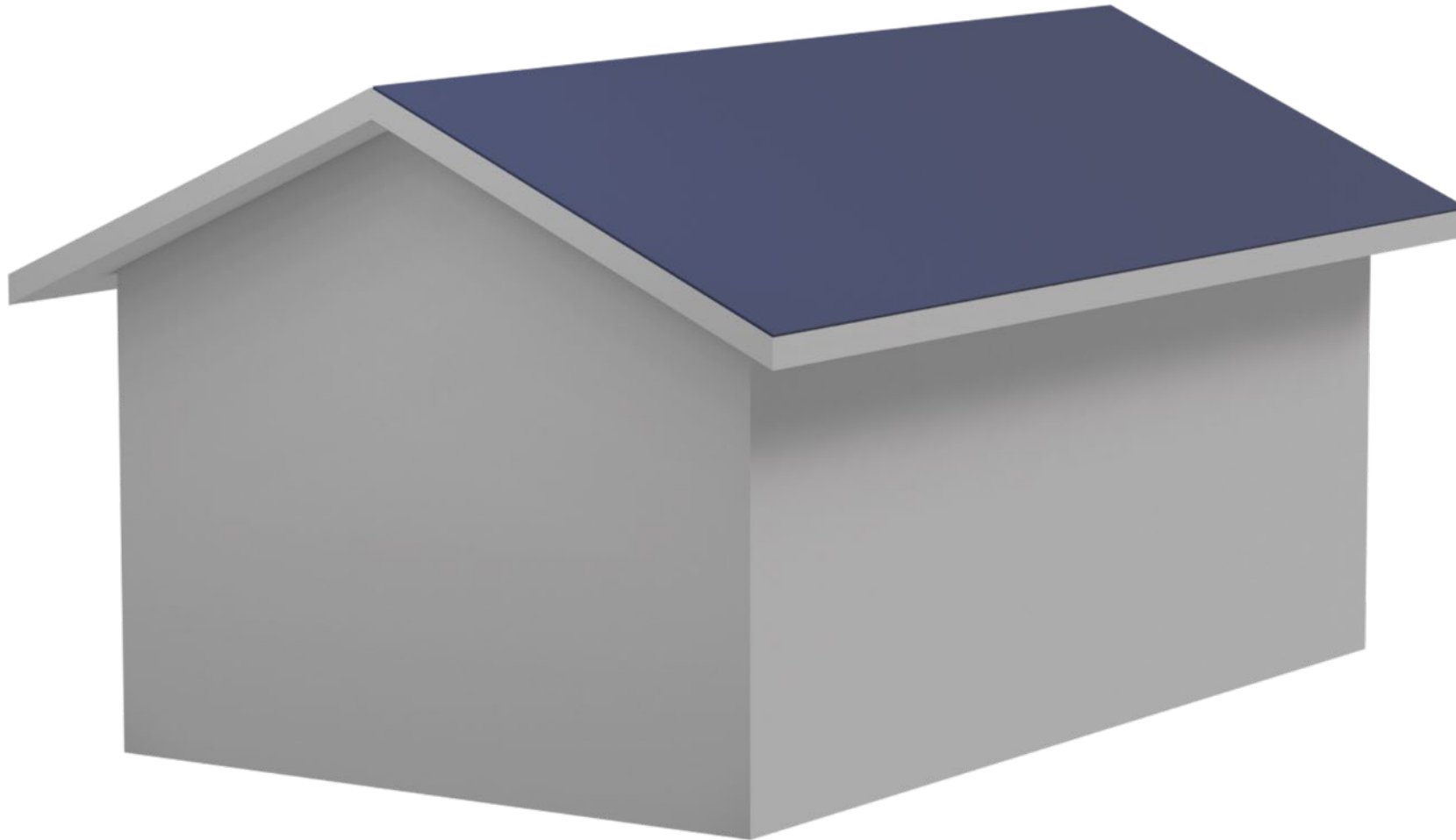
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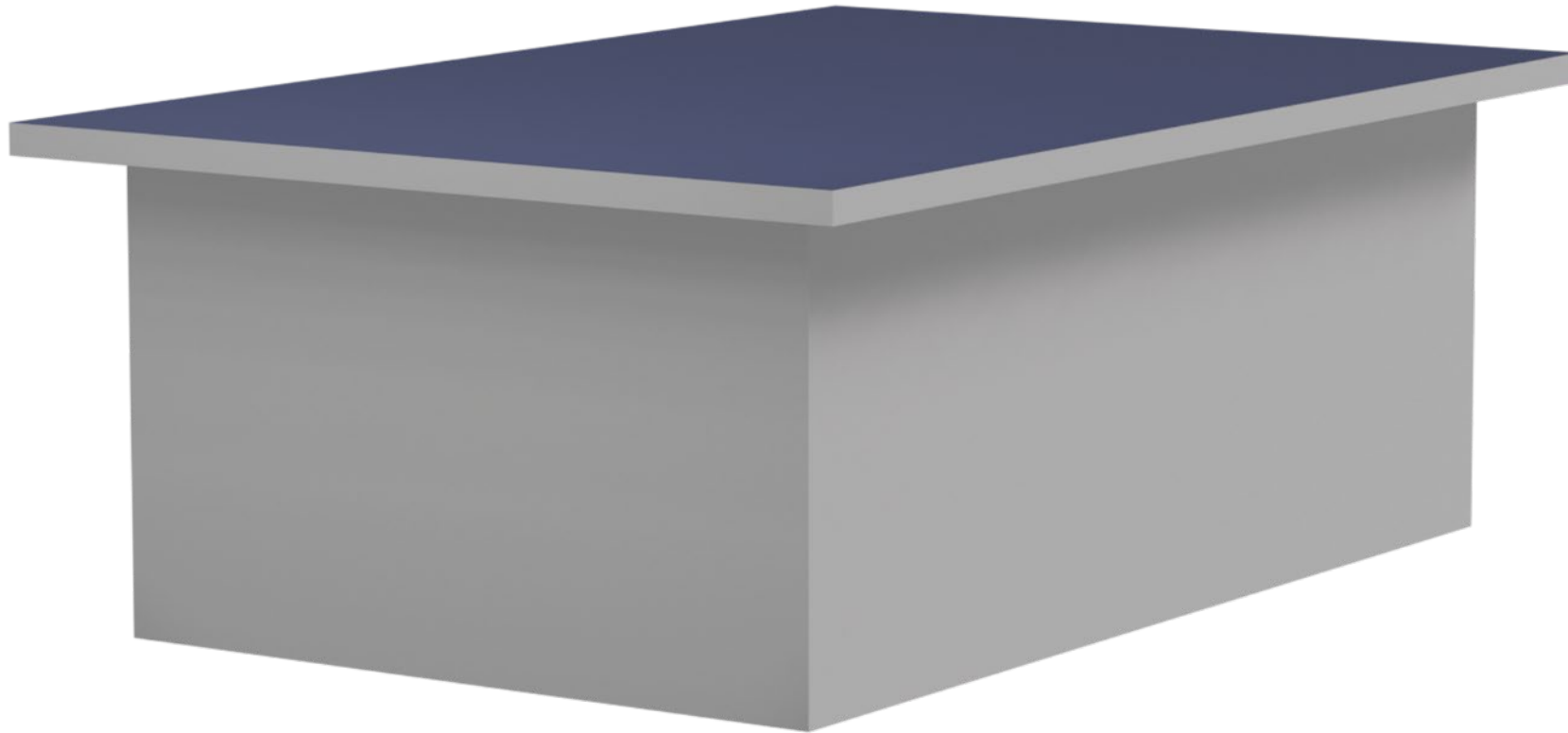
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



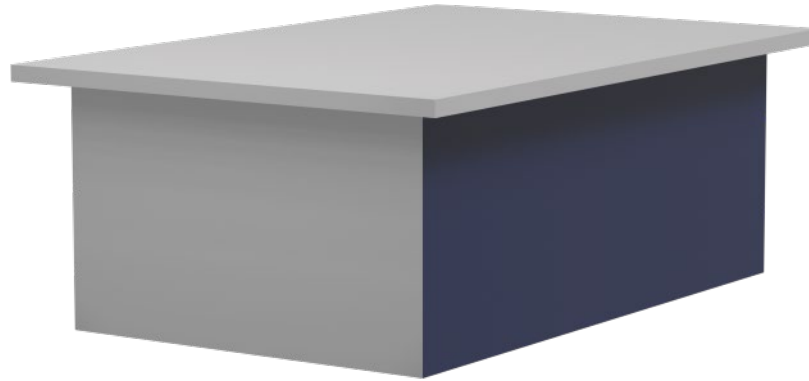
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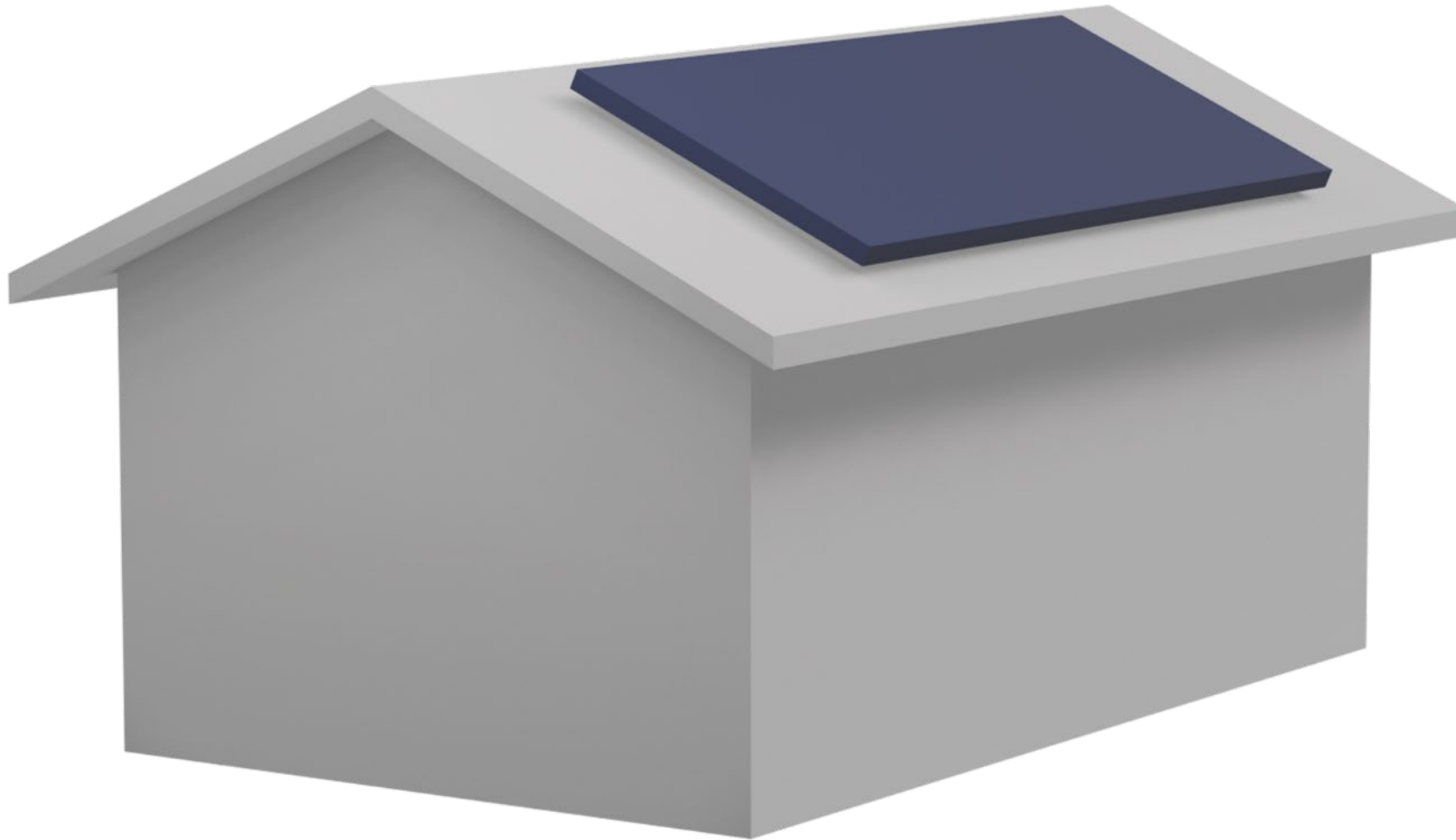
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Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



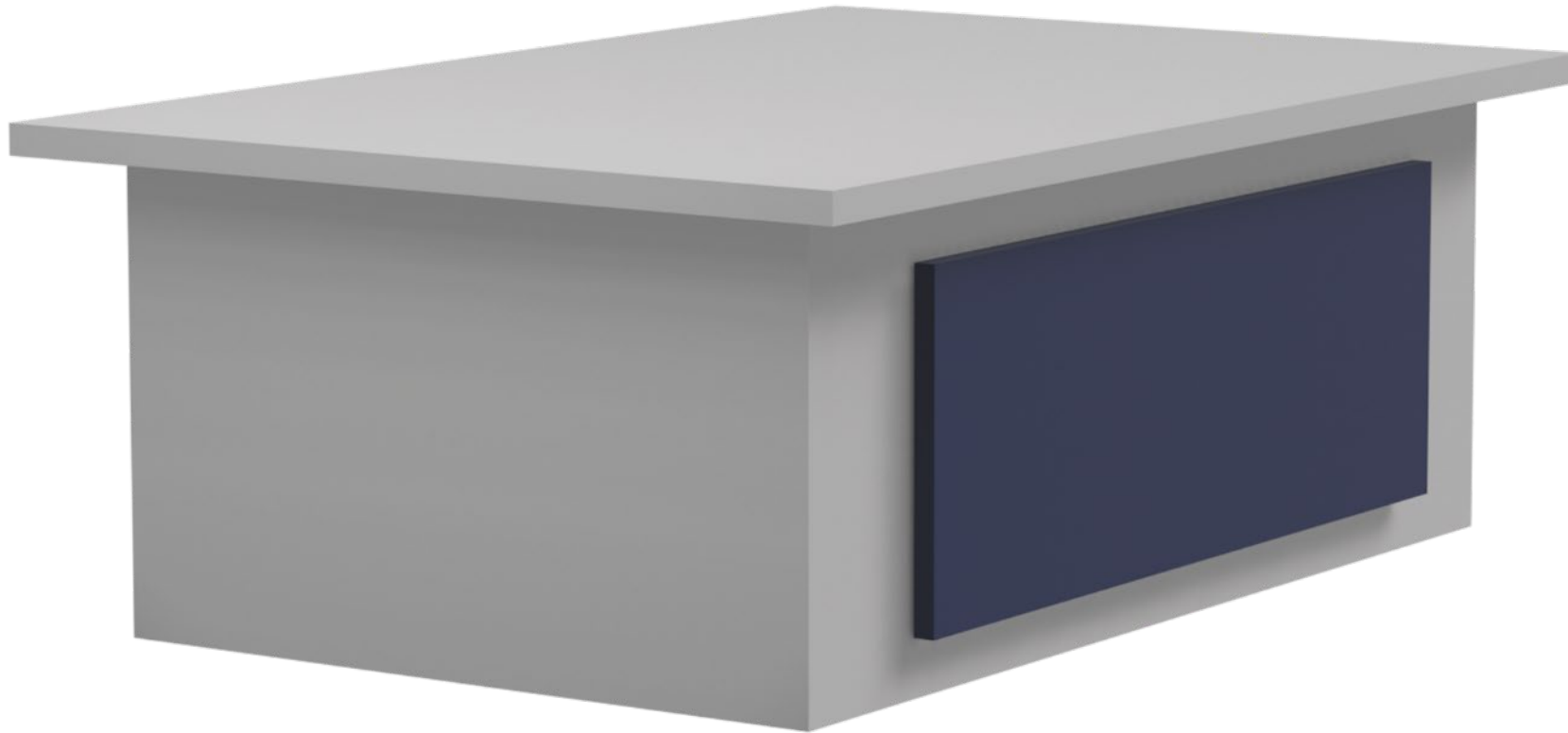
Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



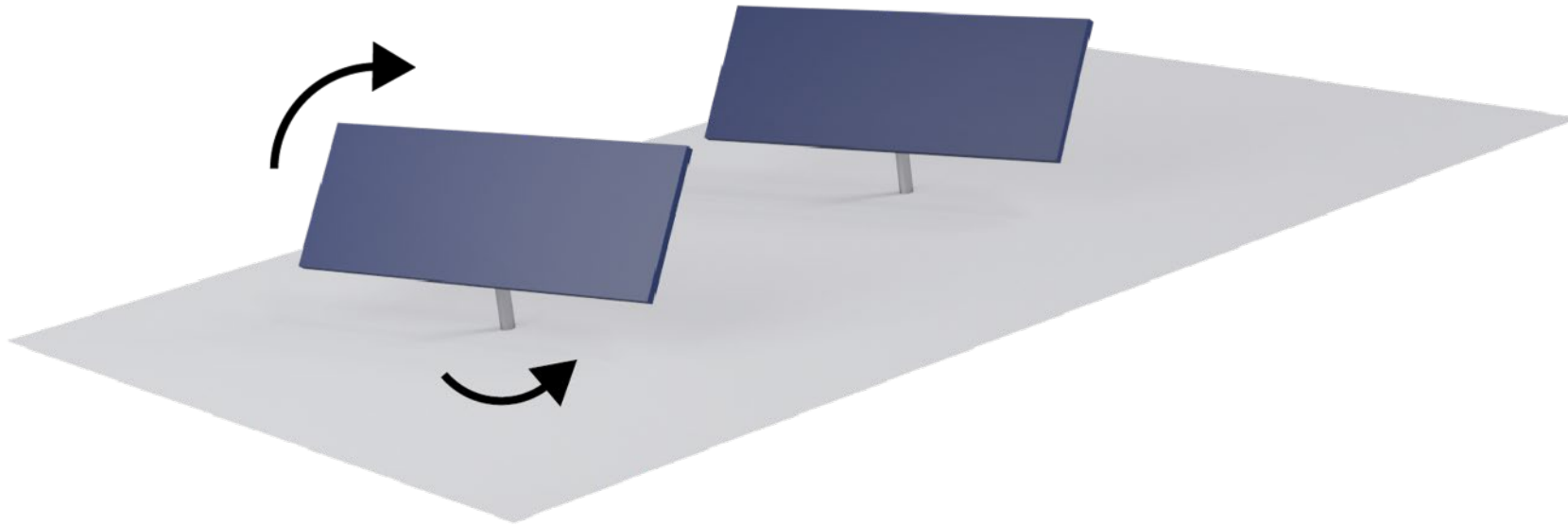
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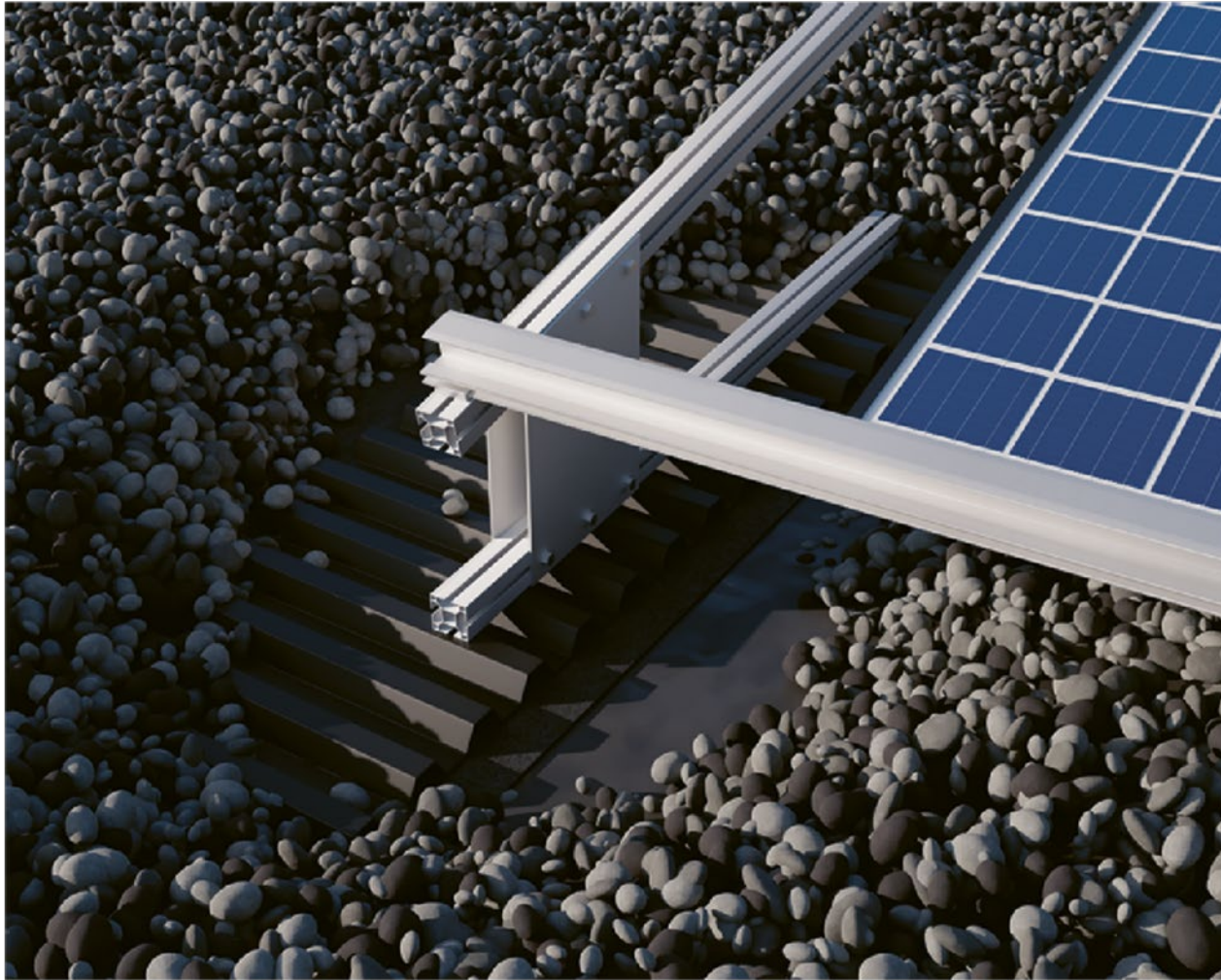
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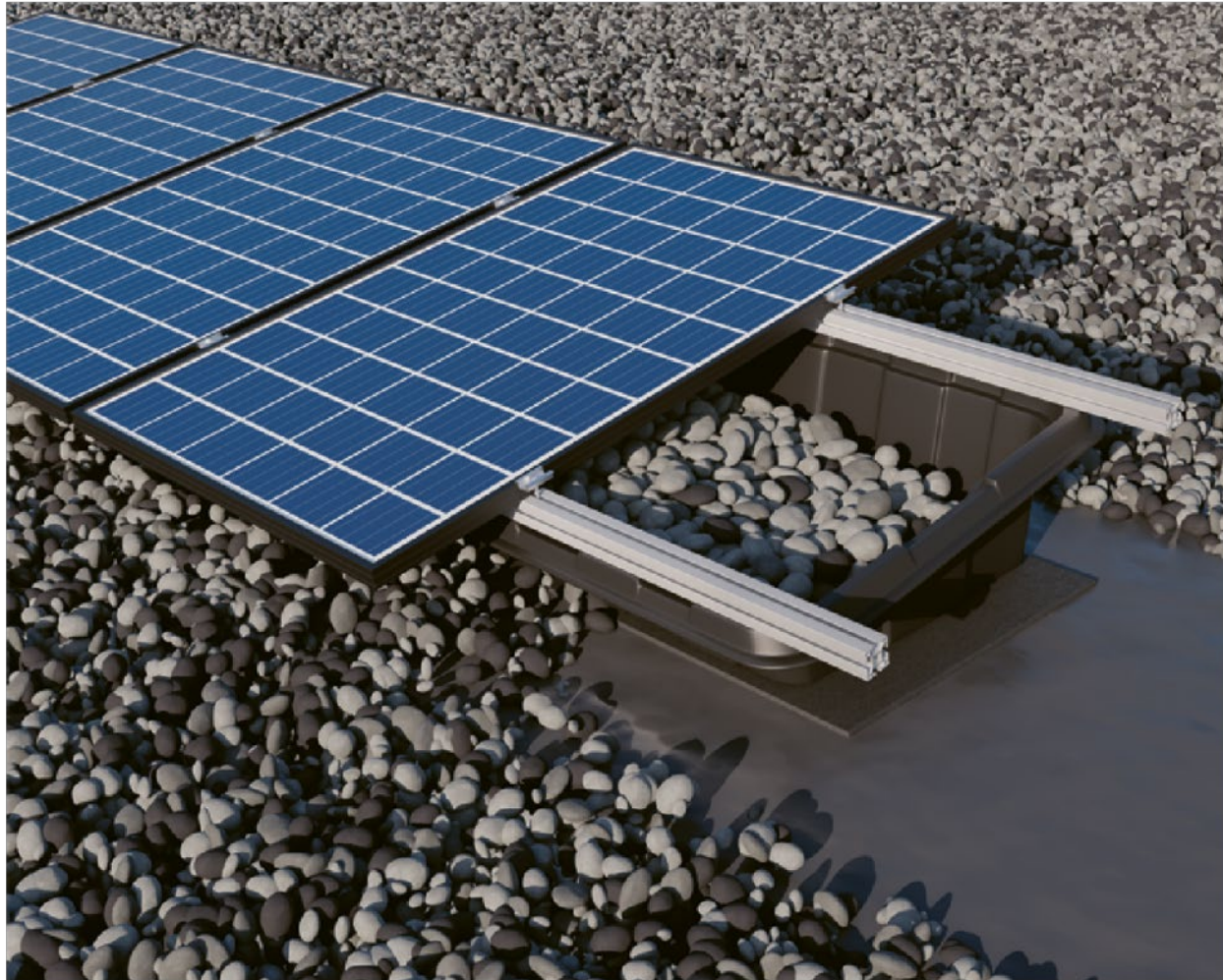
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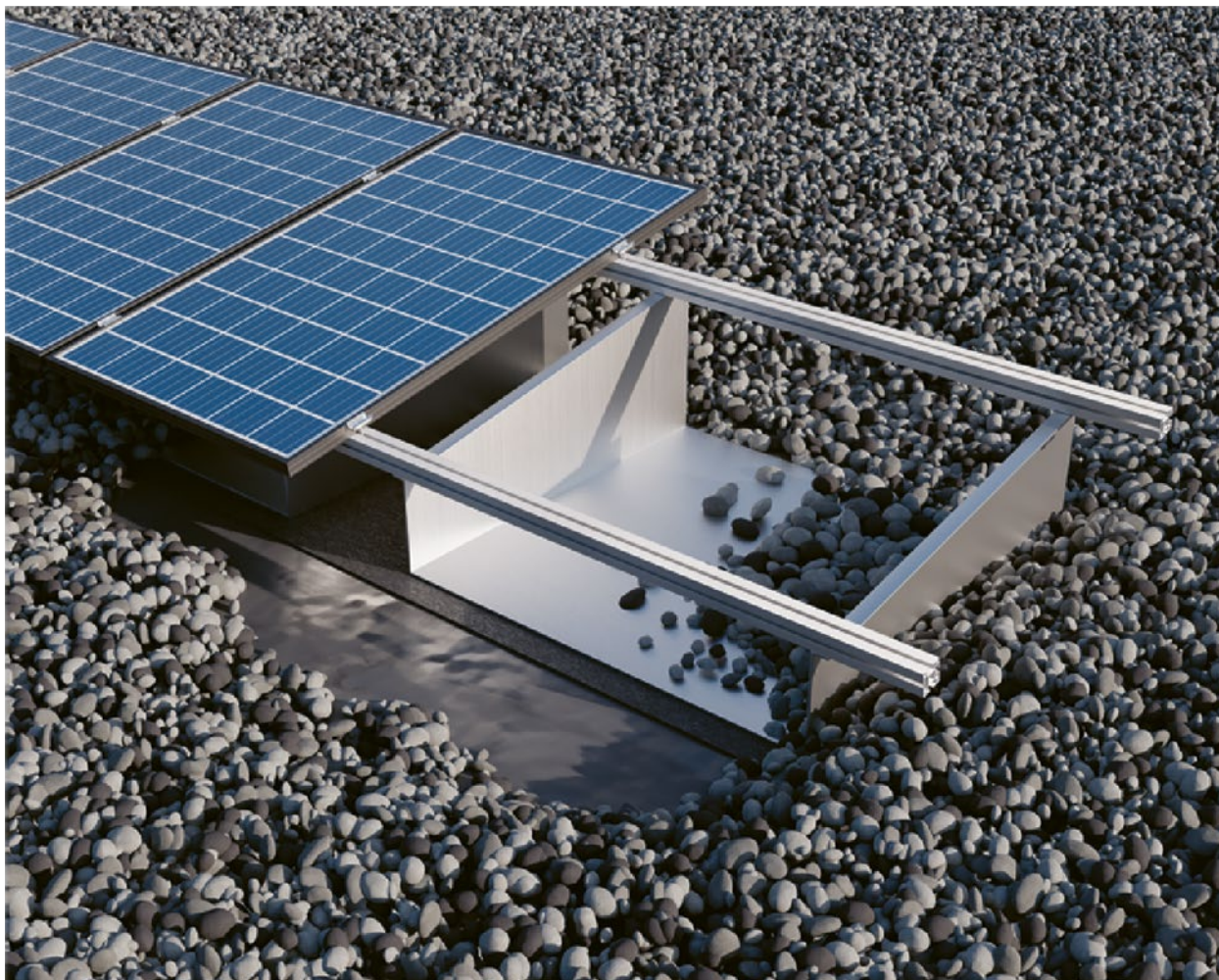
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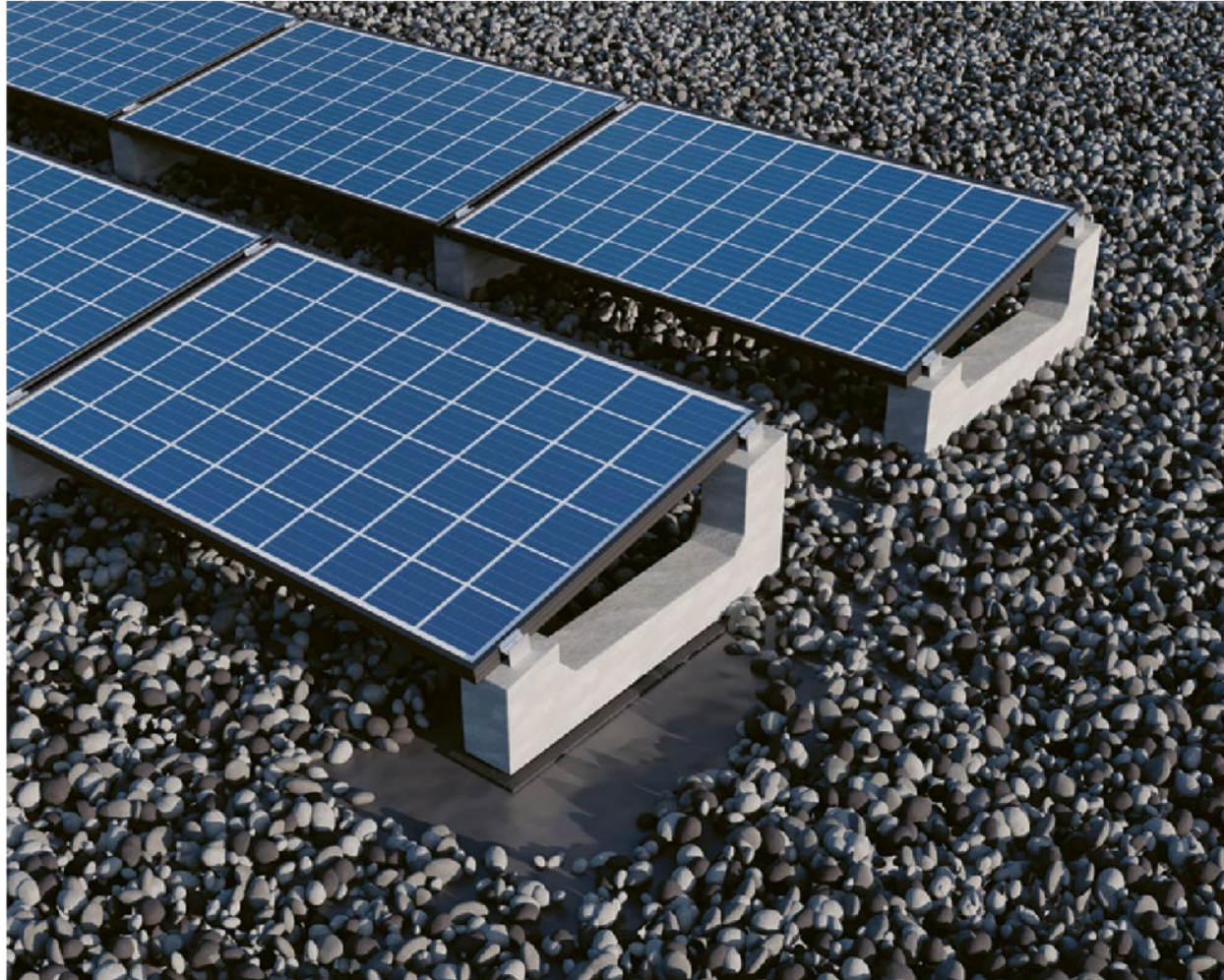
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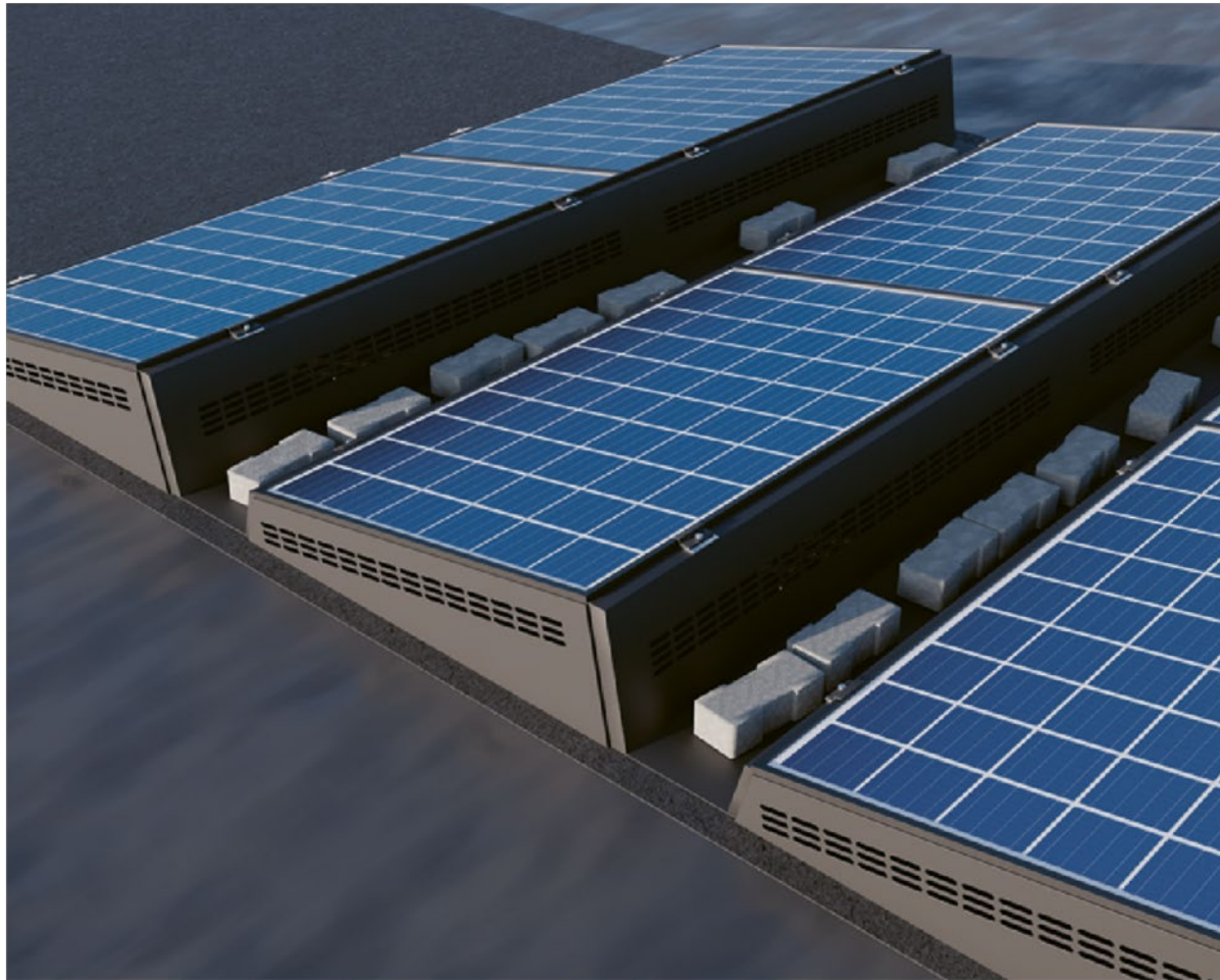
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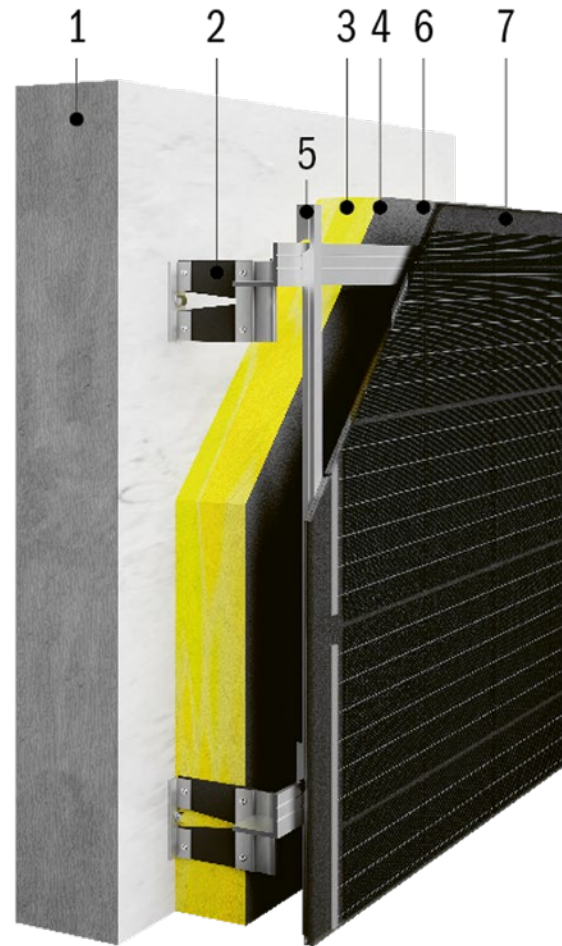
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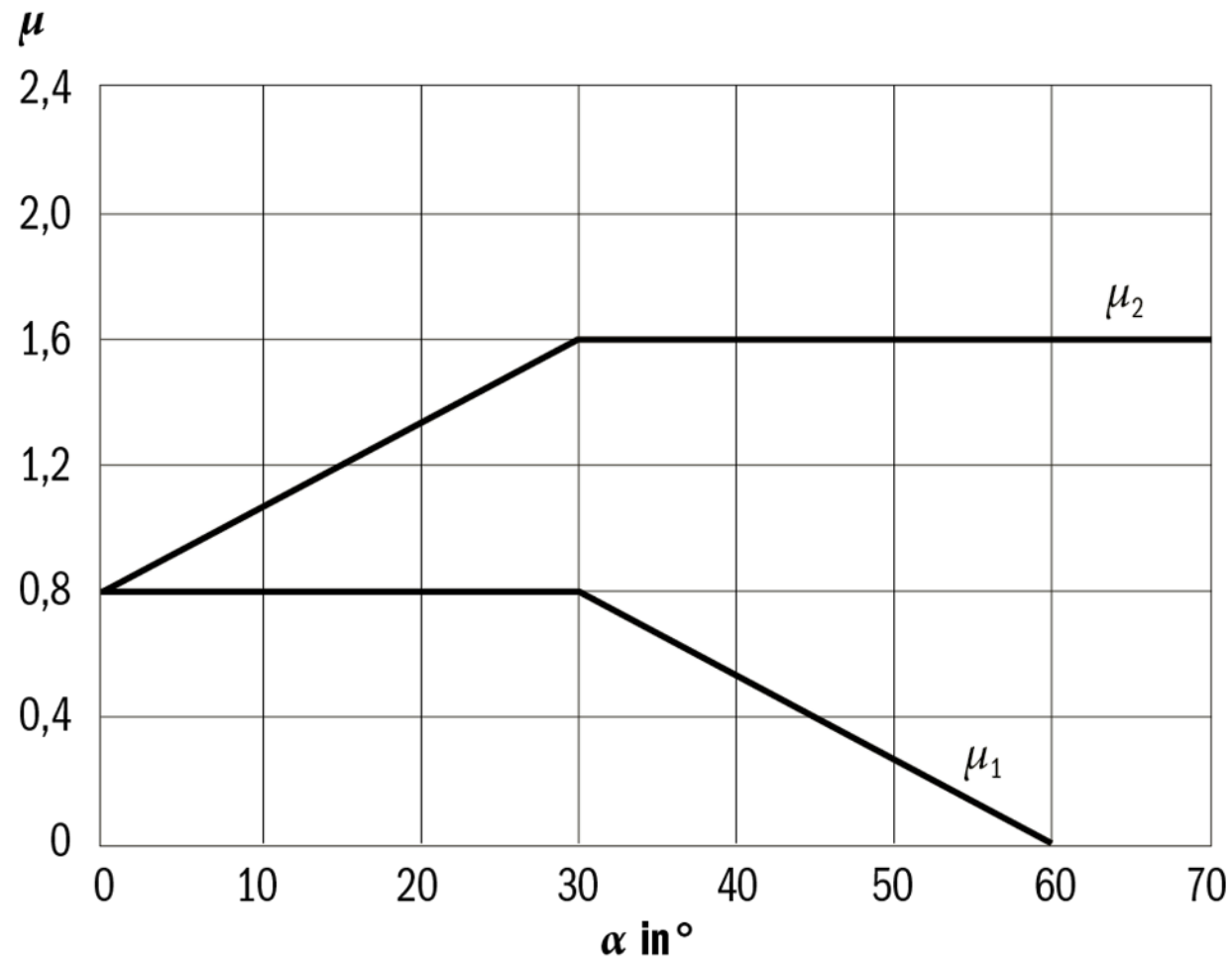
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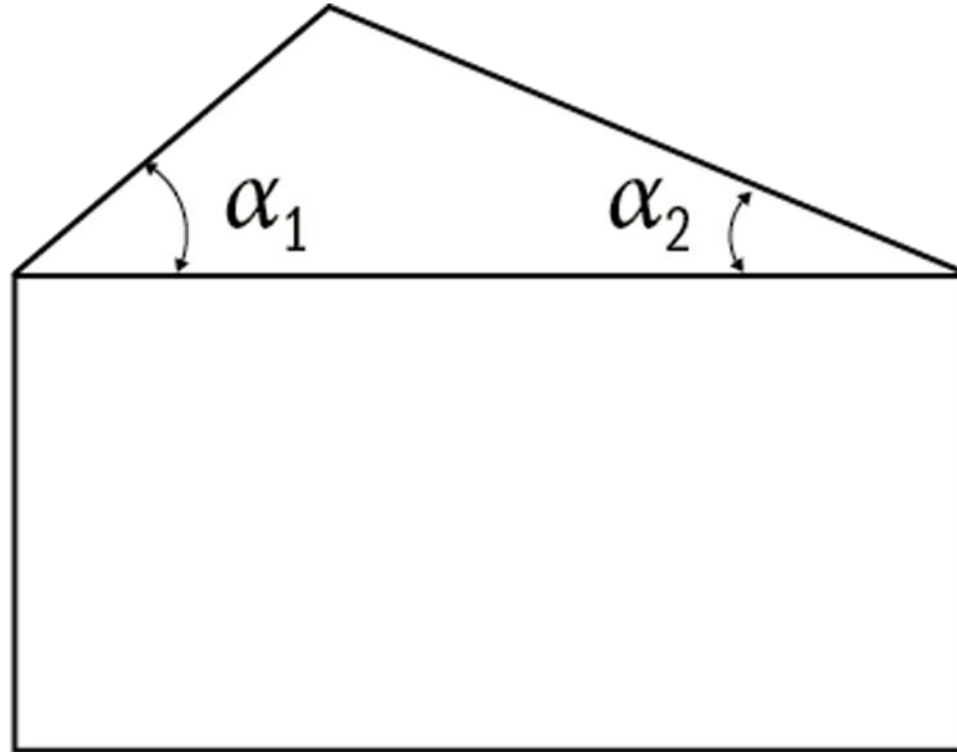
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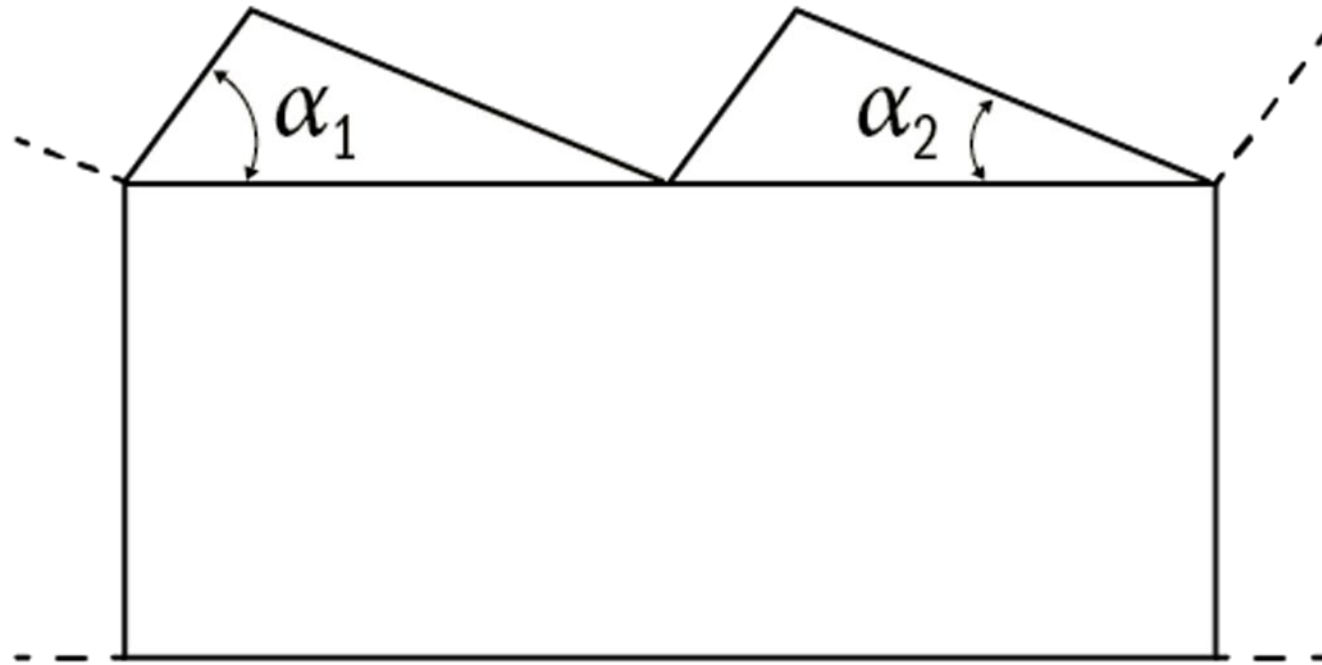
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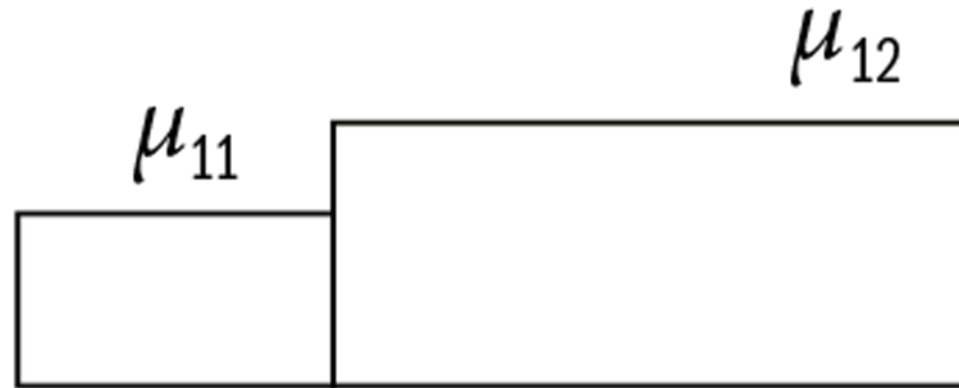
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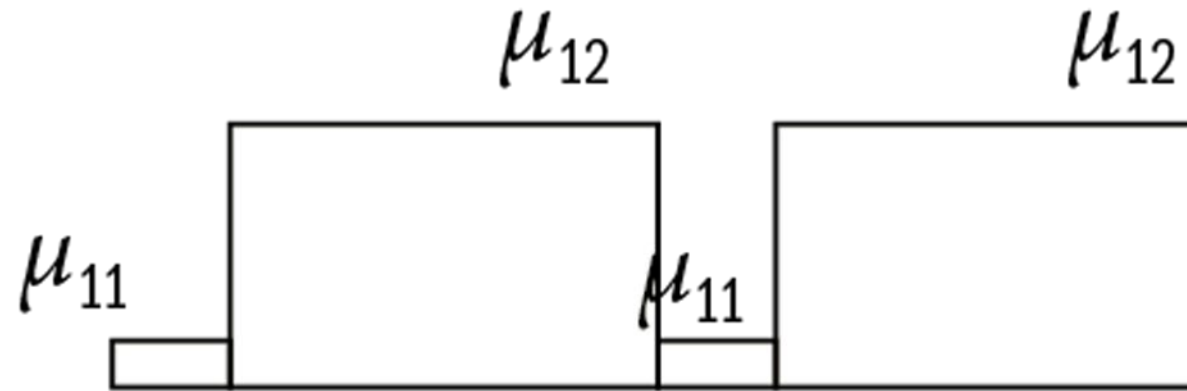
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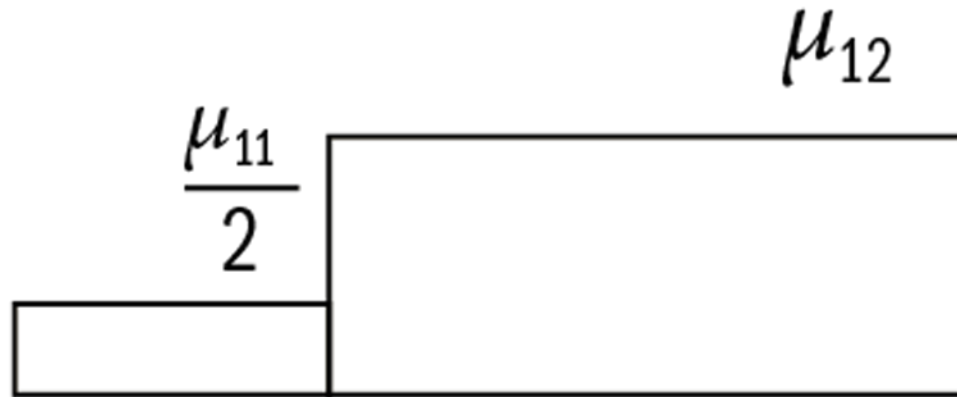
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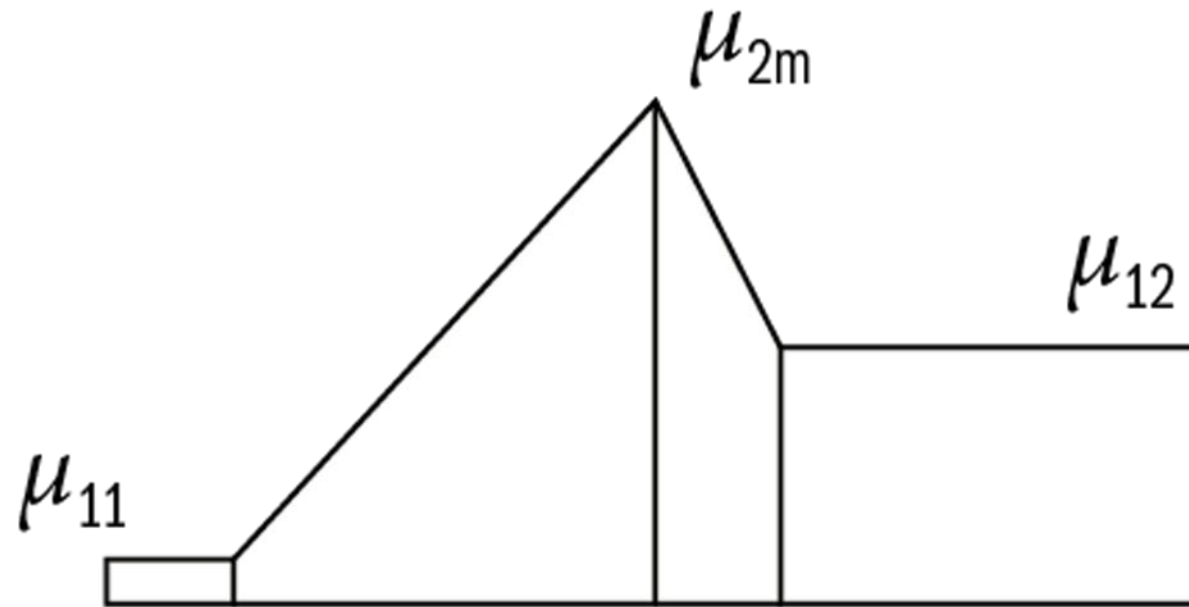
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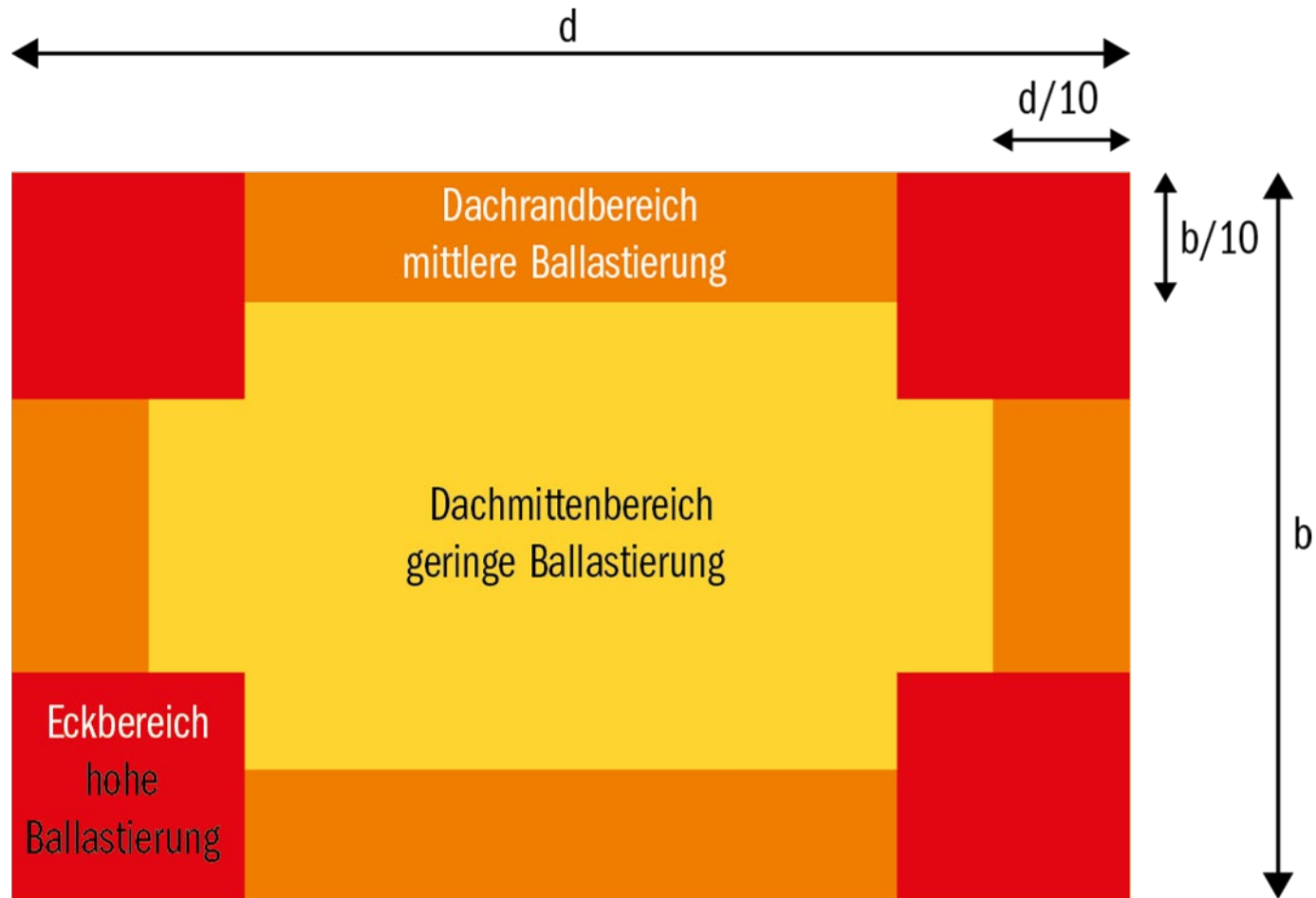
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$$\mu_{11} = \mu_1(\alpha_1) \quad \mu_{12} = \mu_1(\alpha_2)$$

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

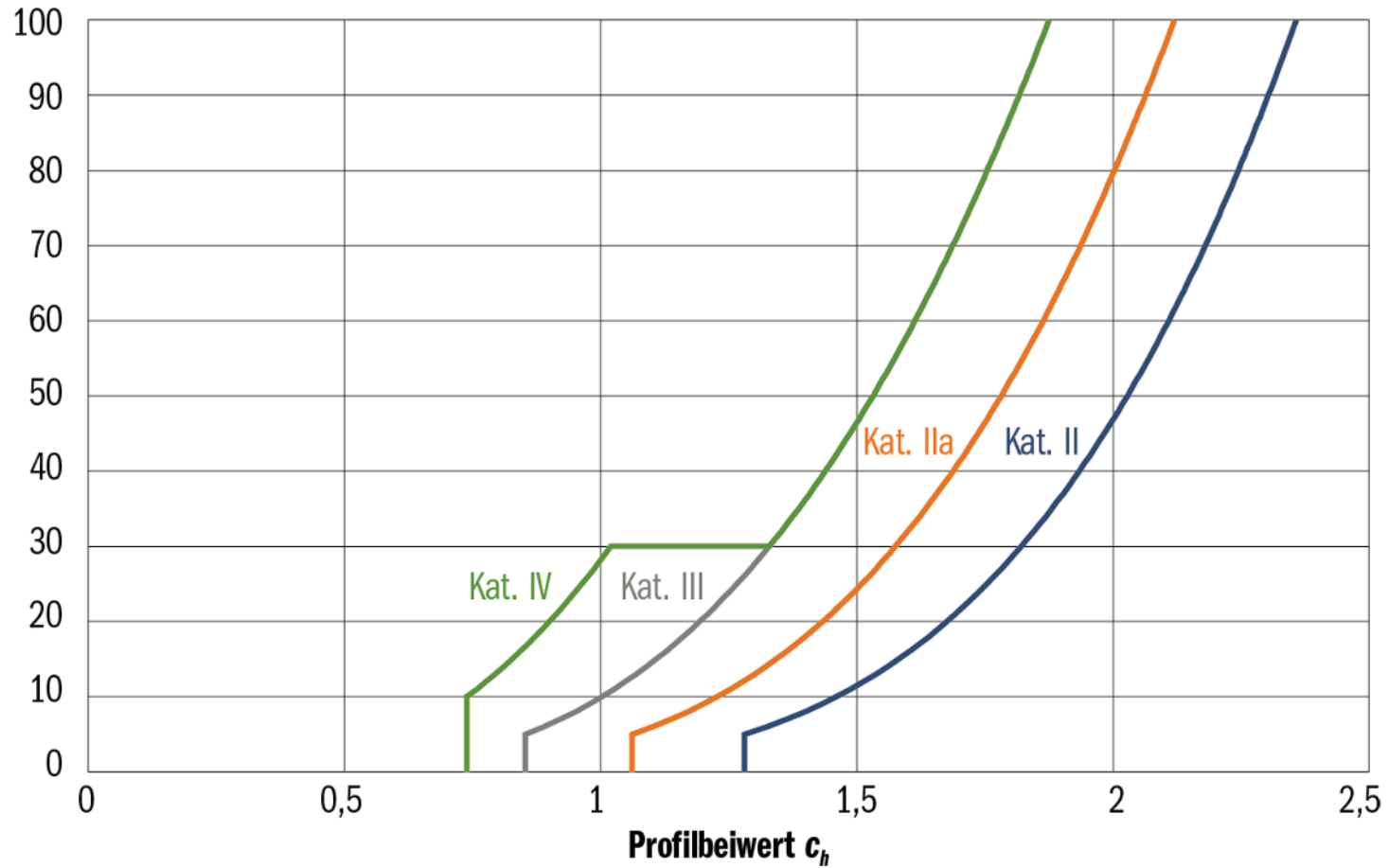
$$\mu_{2m} = \mu_2 \cdot \left(\frac{\alpha_1 + \alpha_2}{2} \right)$$

Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

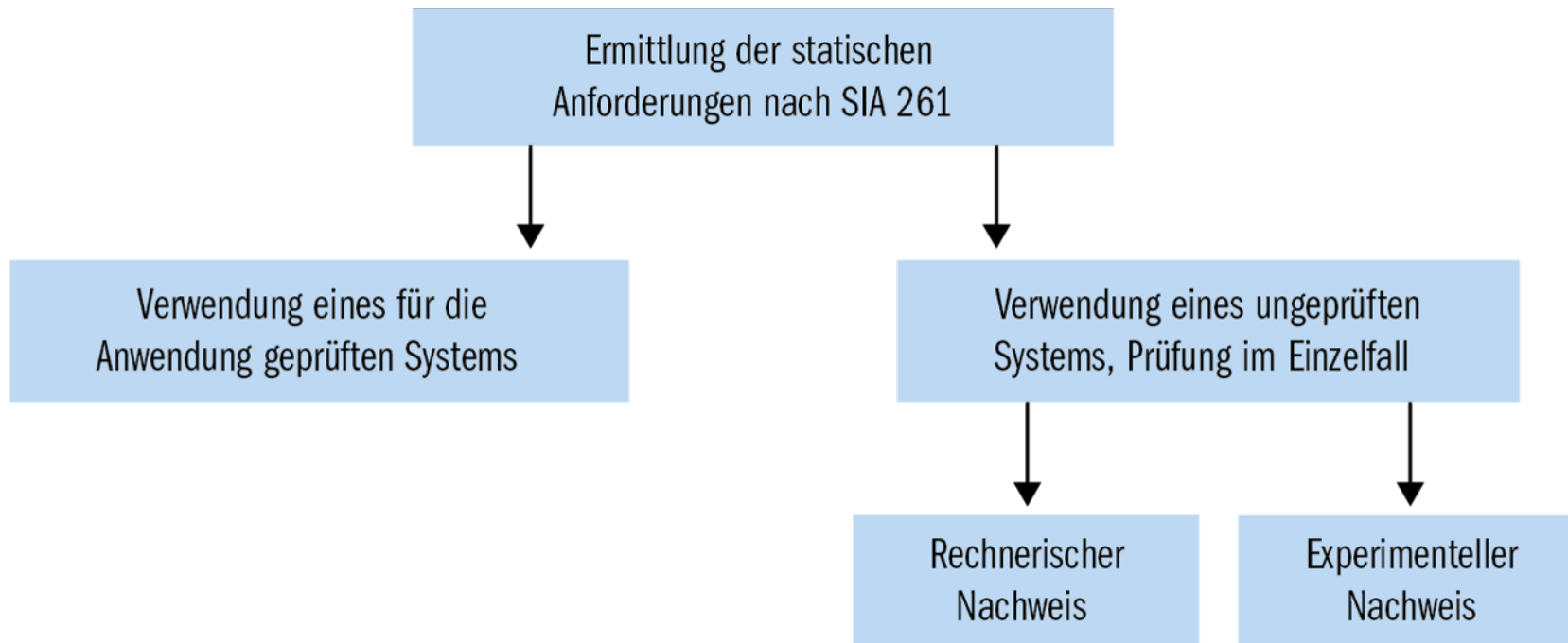


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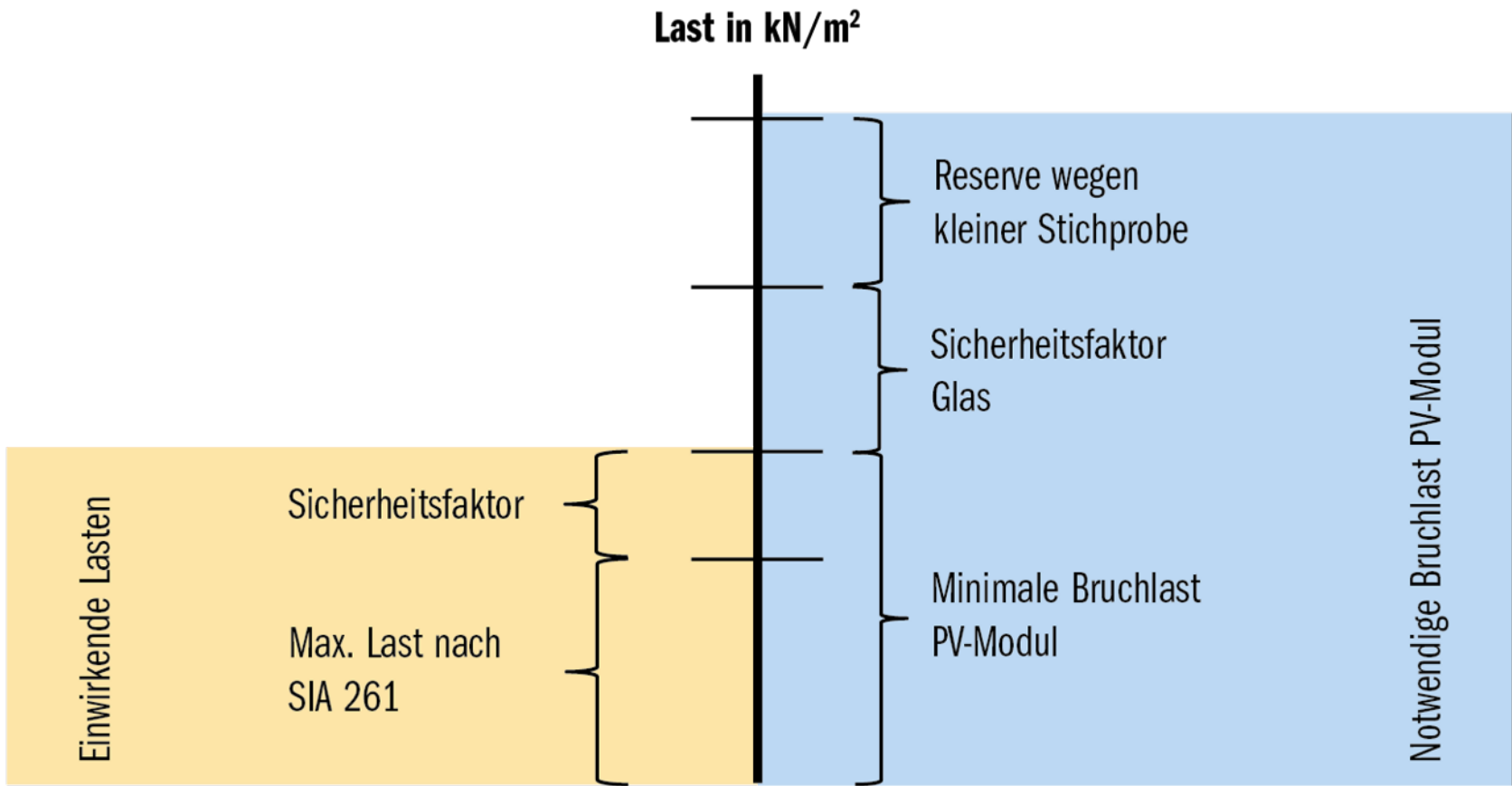
Gebäudehöhe z in m



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



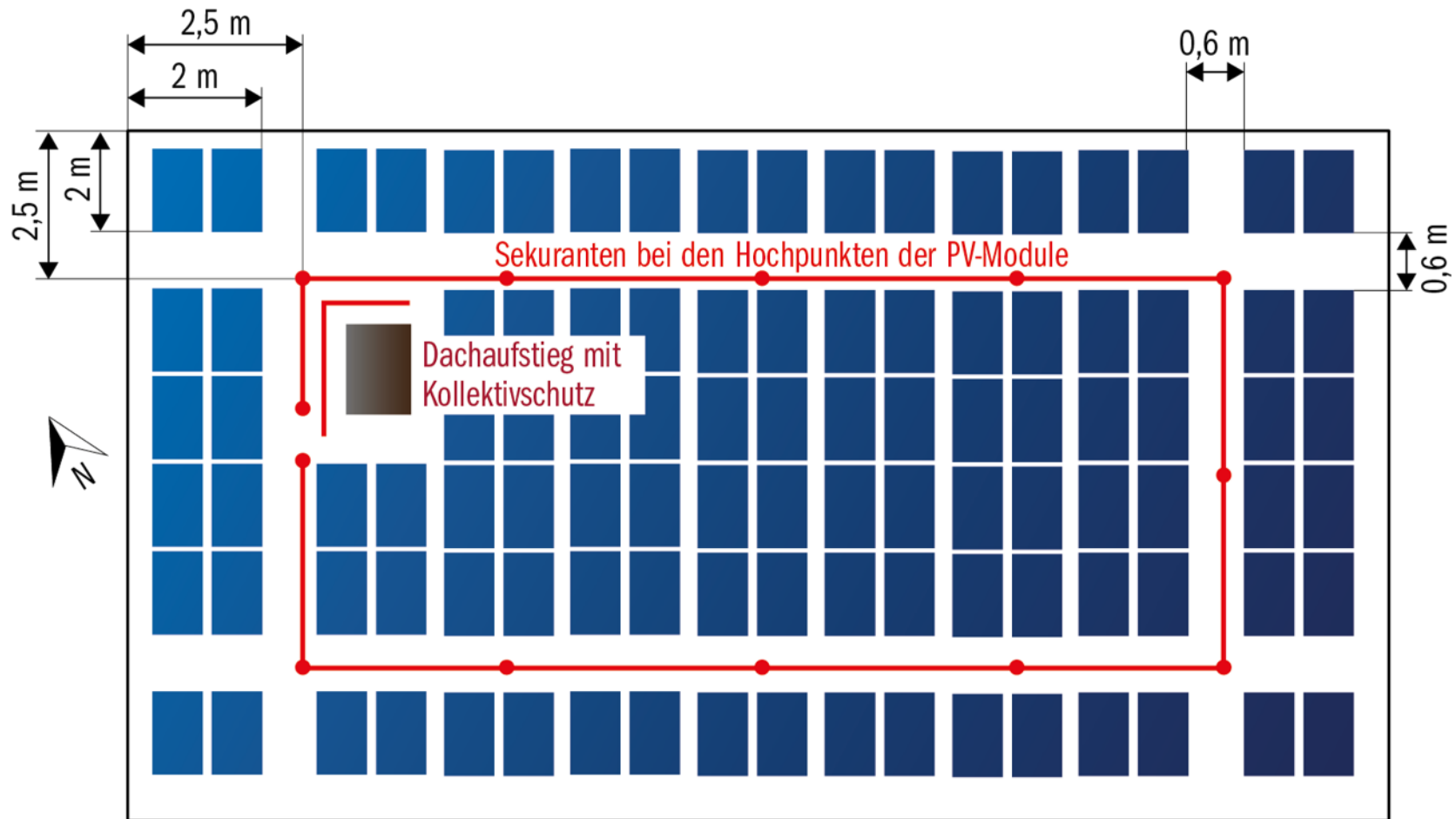
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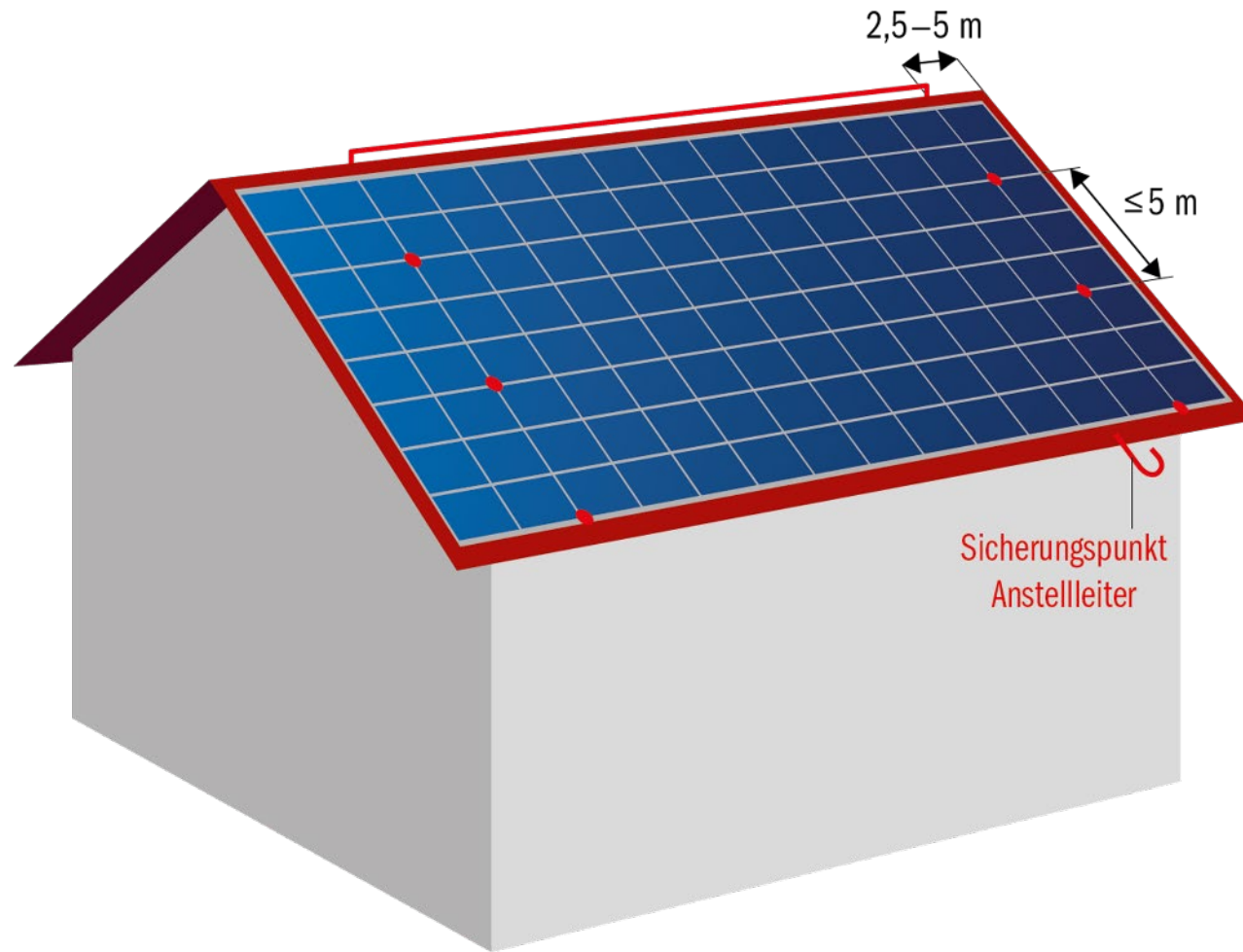
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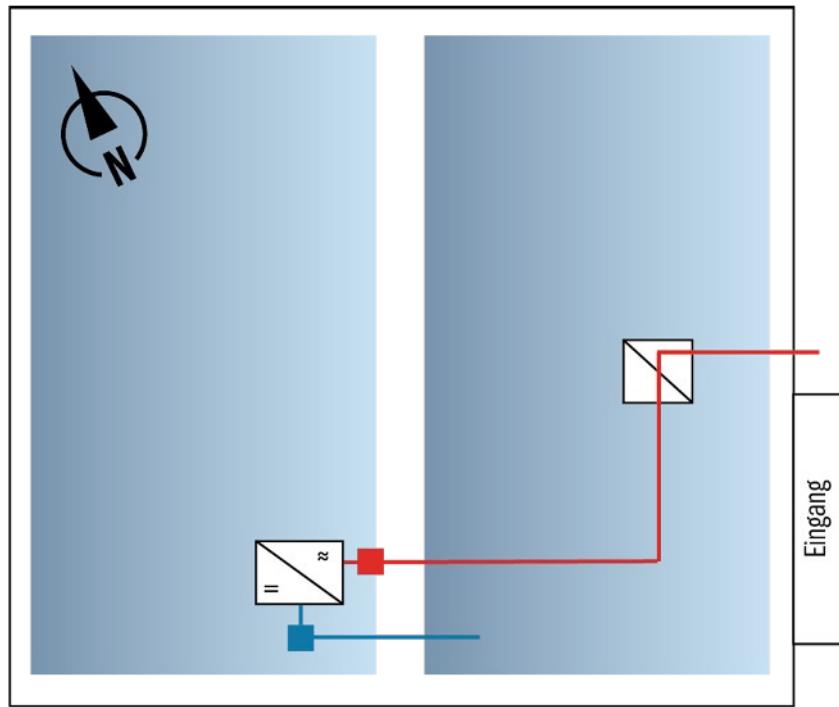
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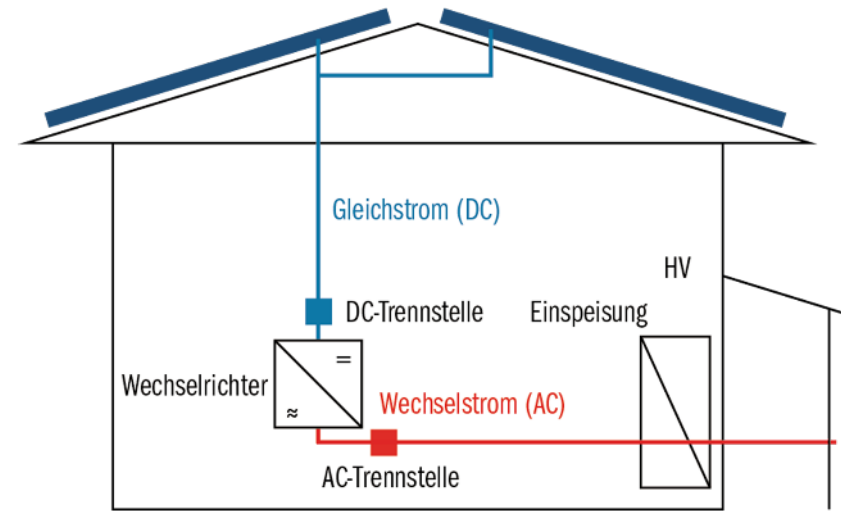
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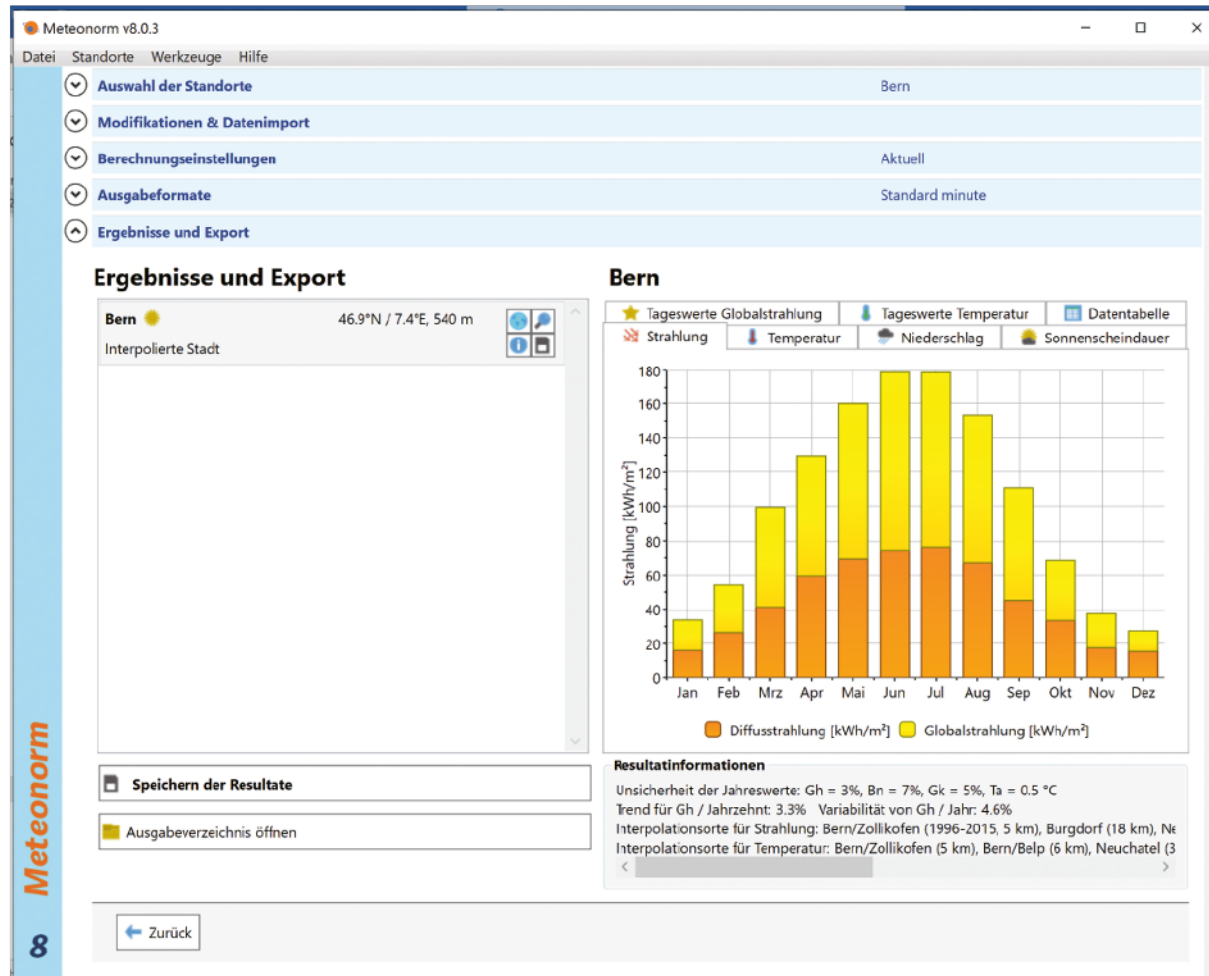


Grundriss



Ansicht Süd

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PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM

European Commission

European Commission > EU Science Hub > PVGIS > Interactive tools

Home Tools Downloads Documentation Contact us

Cursor:
Selected: 46.952, 7.386
Elevation (m): 560

Use terrain shadows:
 Calculated horizon
 Upload horizon file

Download buttons: [csv](#) [json](#)
 Search: Keine Datei ausgewählt.

MONTHLY IRRADIATION DATA

Solar radiation database:

Start year: End year:

Irradiation:
 Global horizontal irradiation
 Direct Normal Irradiation
 Global irradiation optimum angle
 Global irradiation at angle:

Ratio:
 Diffuse/global ratio

Temperature:
 Average temperature

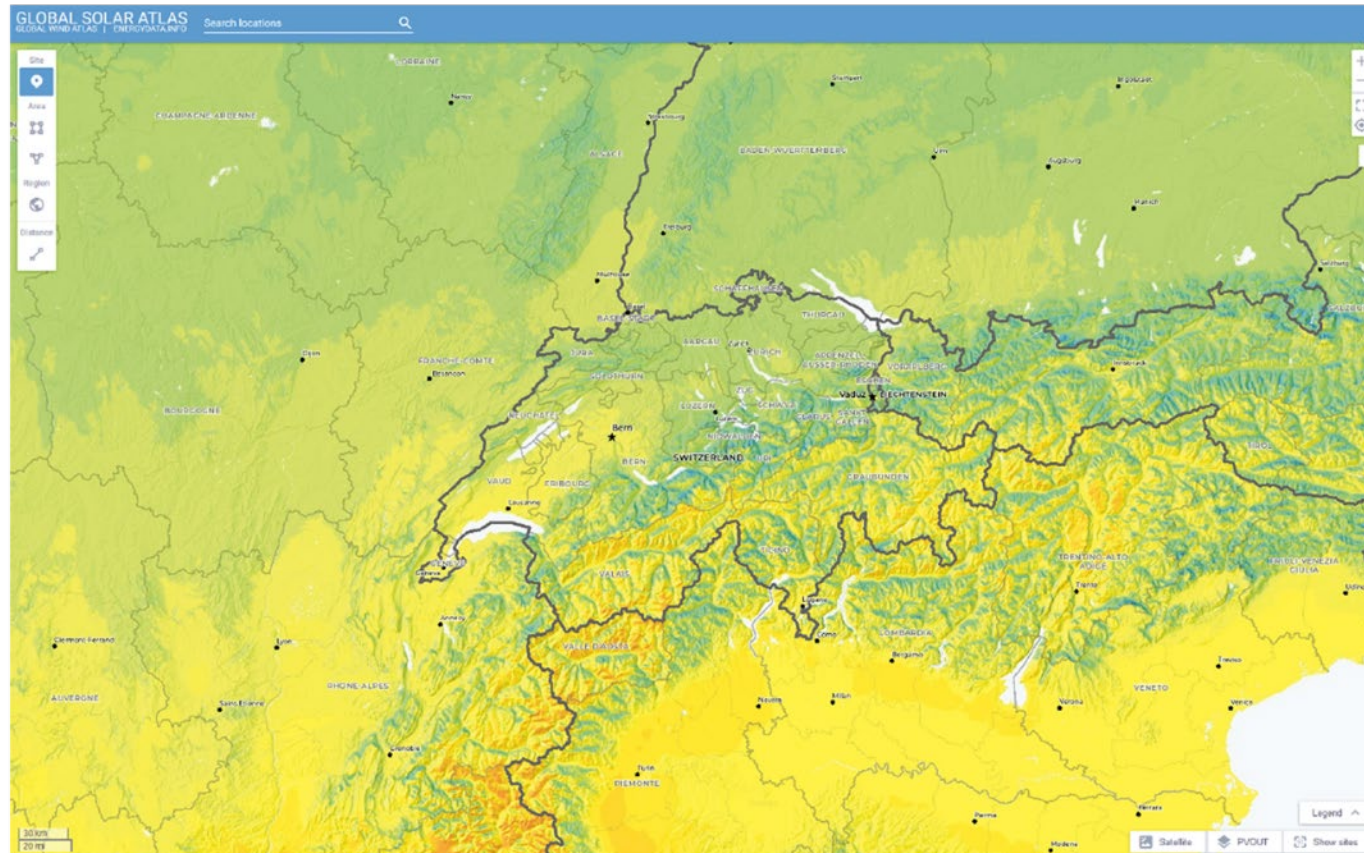
Buttons: [Visualize results](#) [csv](#) [json](#)

Address: [Go!](#) Lat/Lon: [Go!](#)

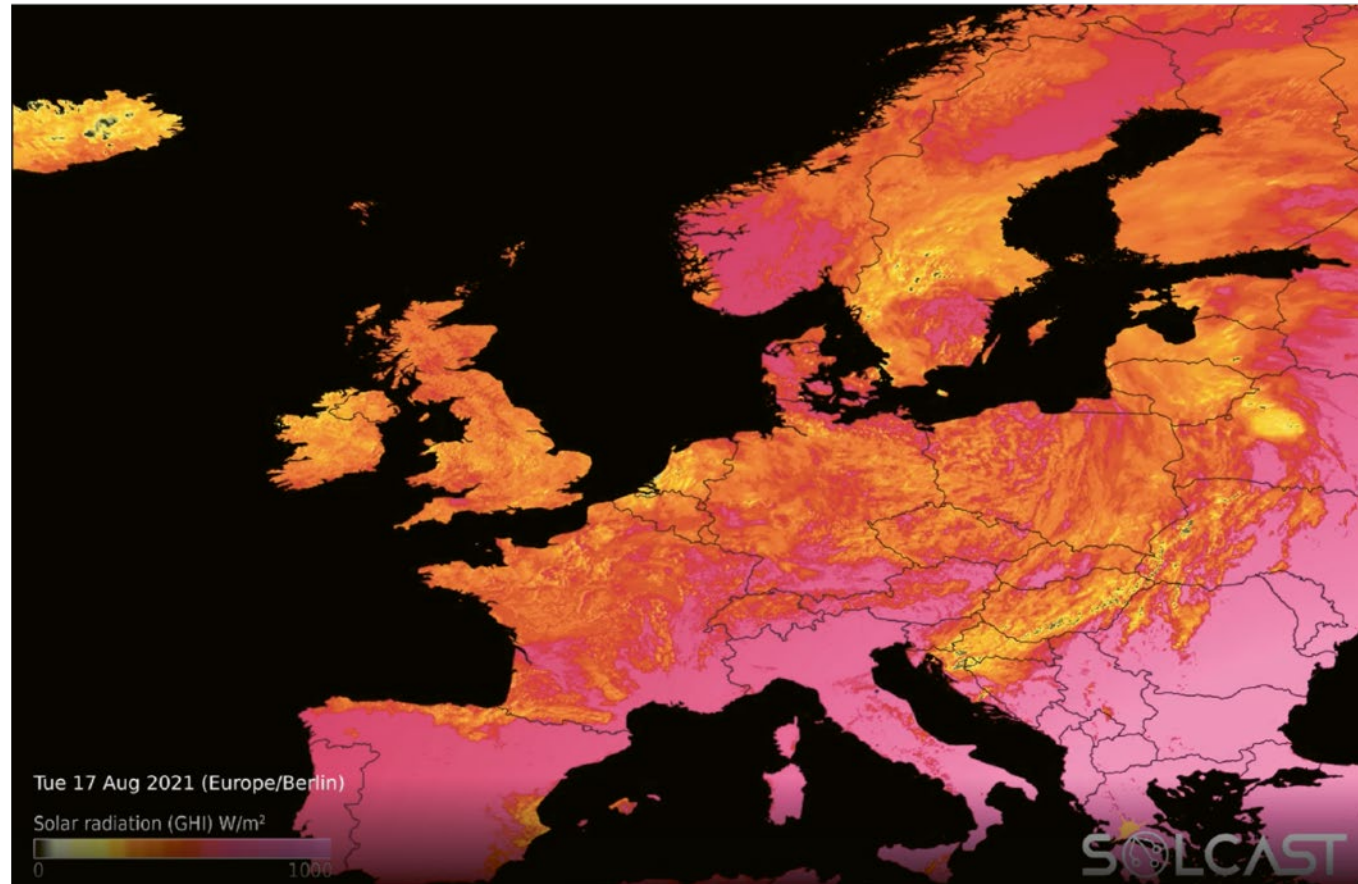
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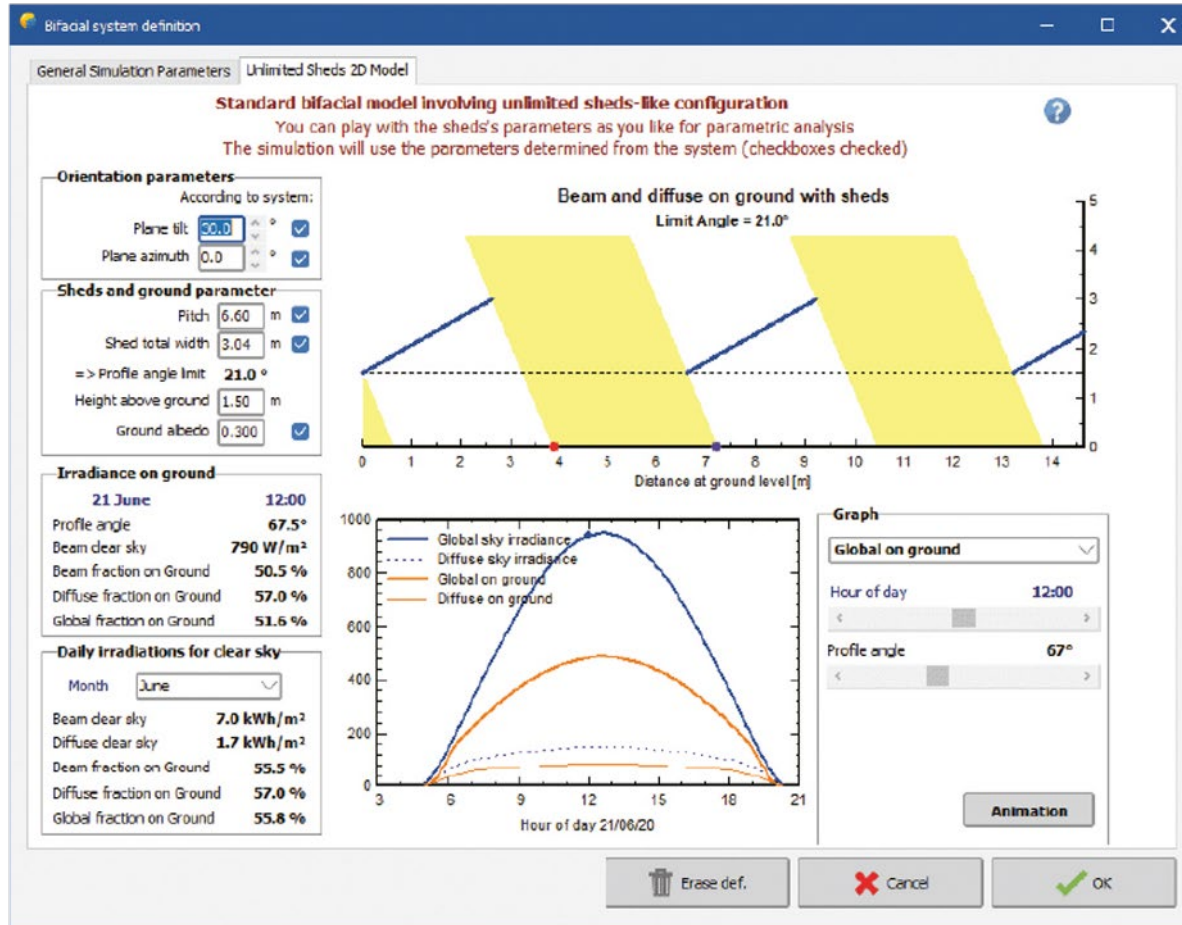
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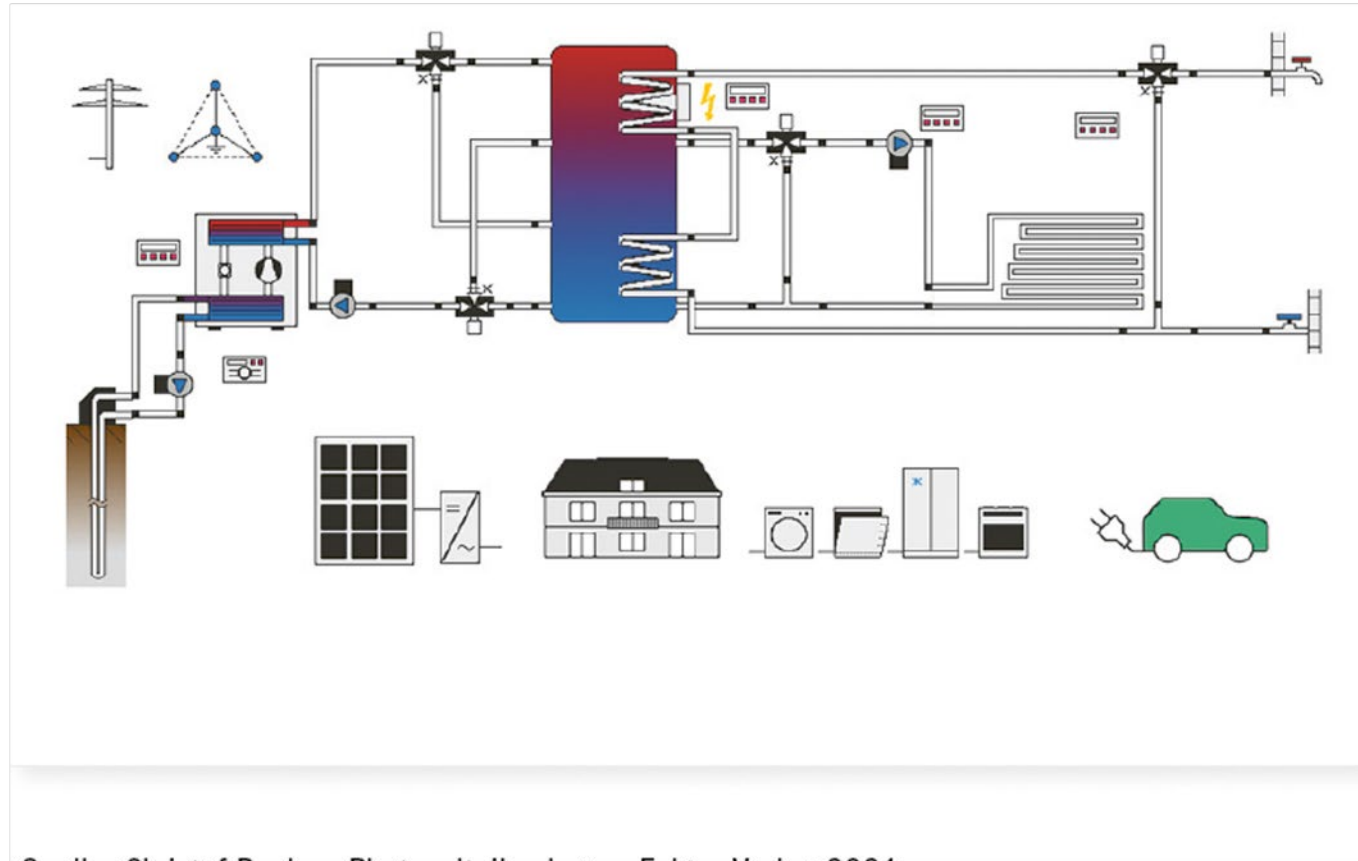
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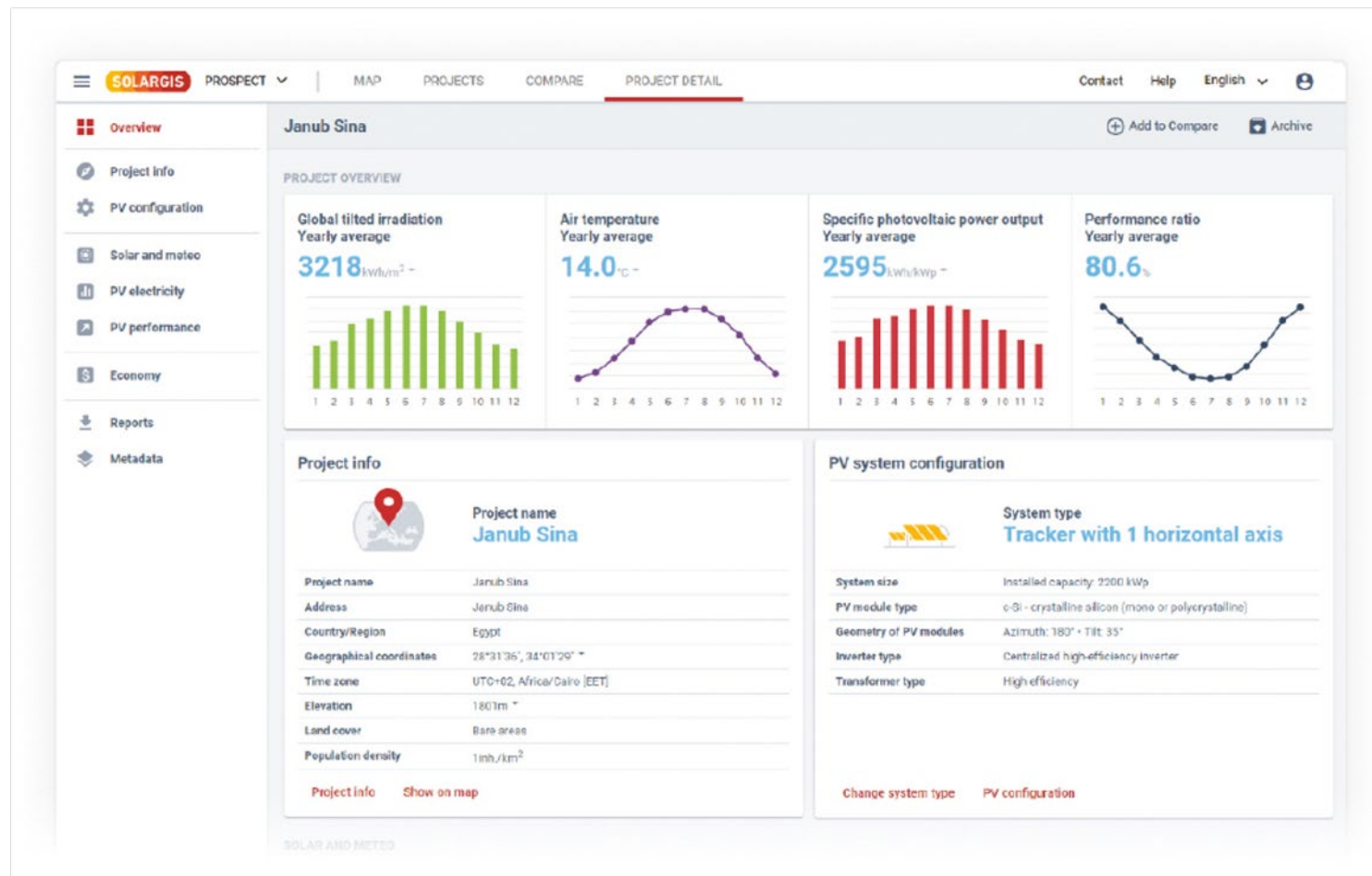
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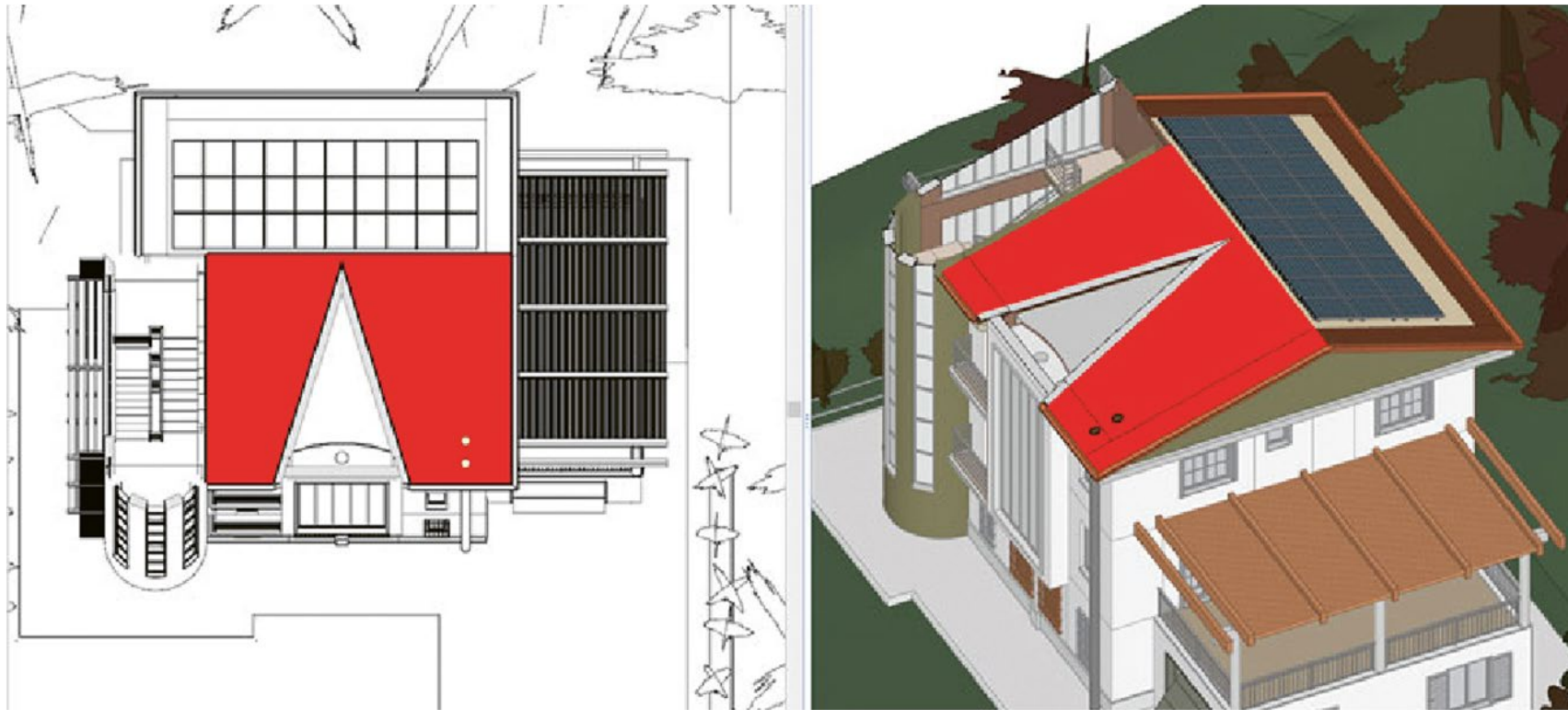
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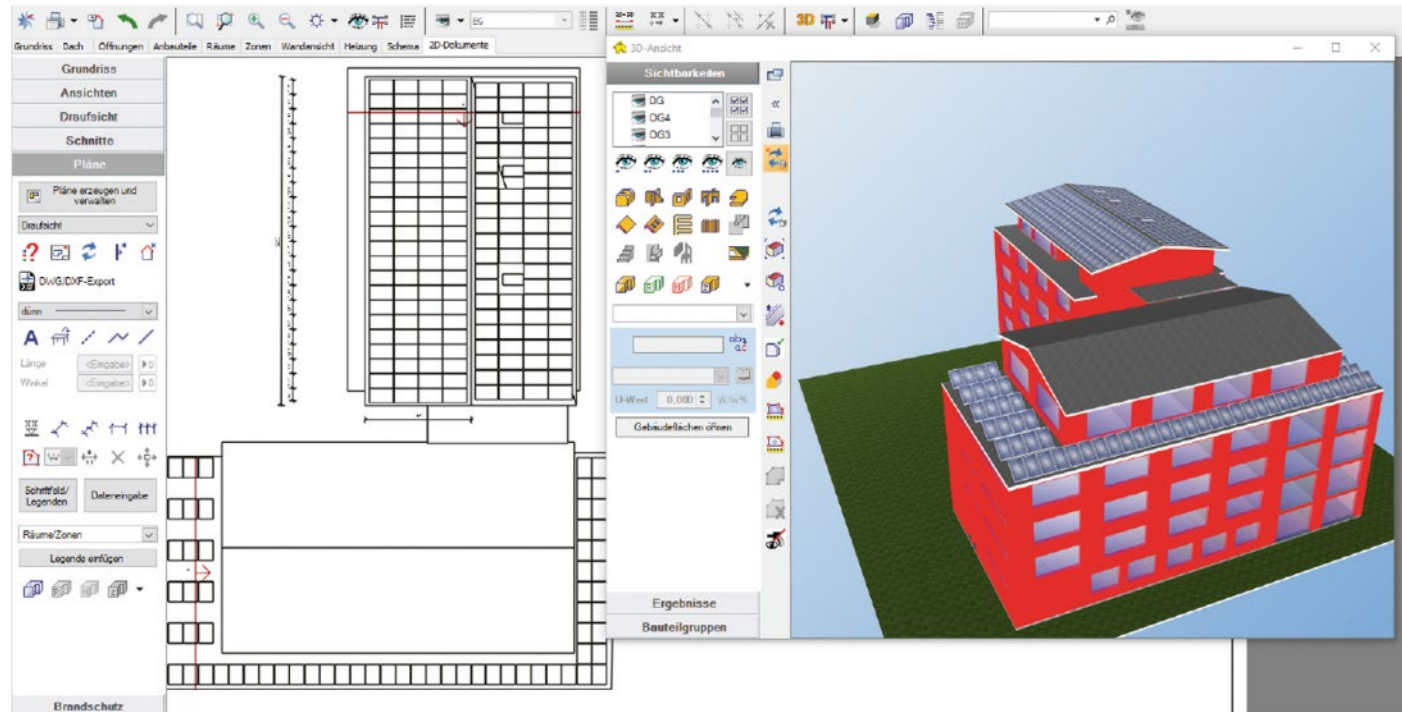
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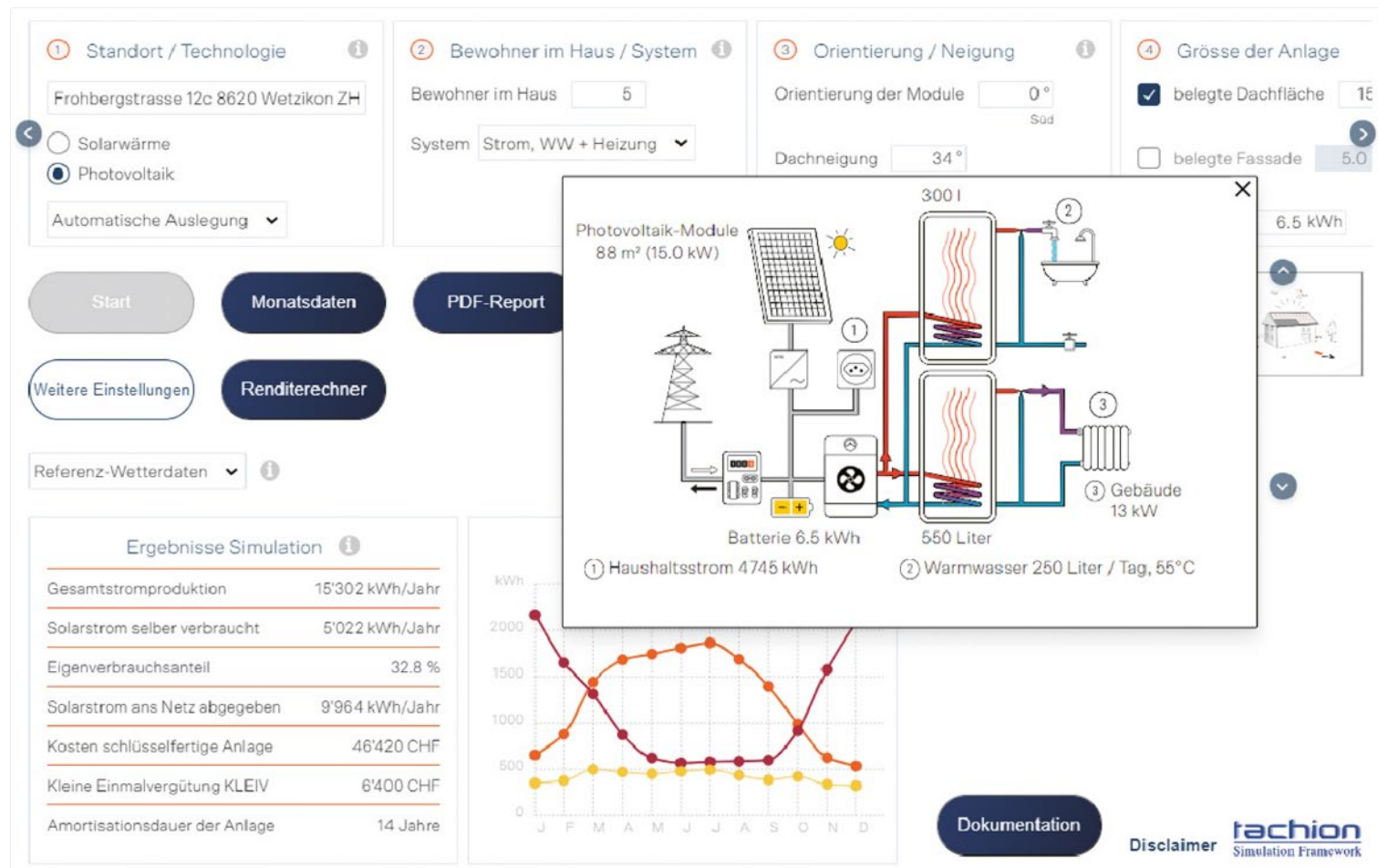
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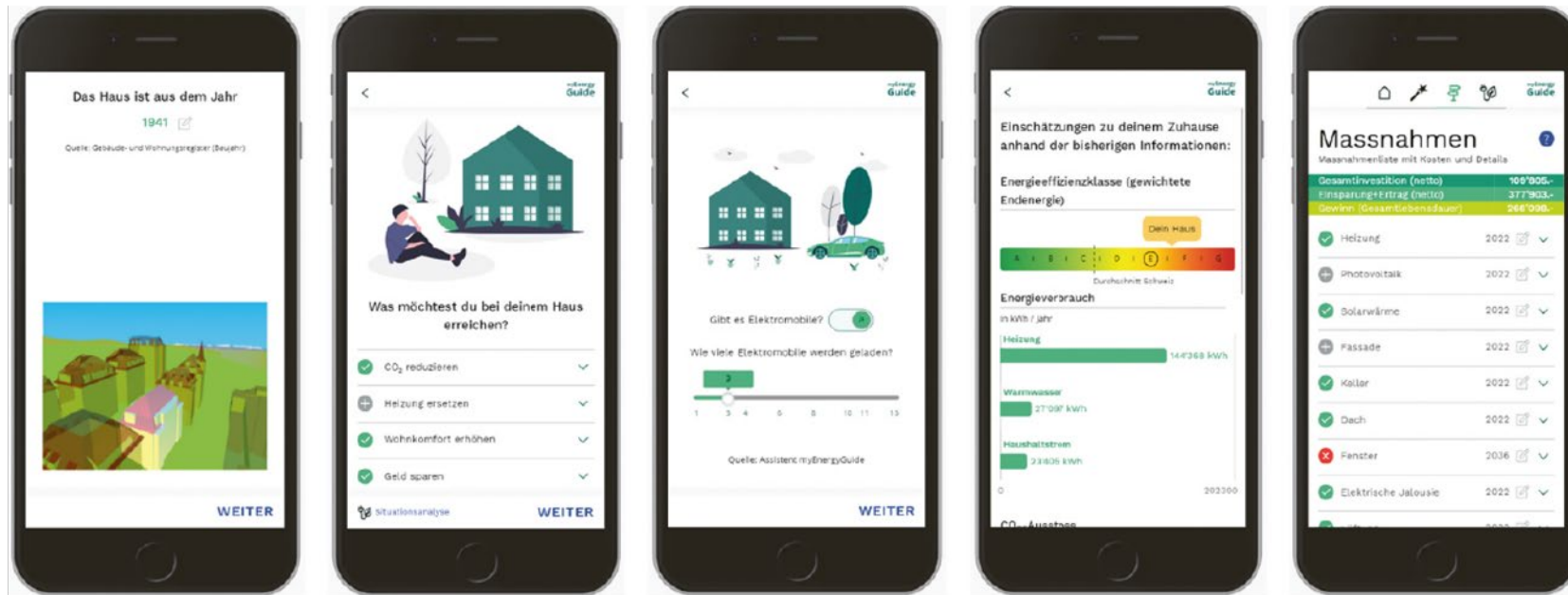
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Gebäudetechnik Rechner

https://stag.btc.suissetec.ch/de/form/1

WIR, DIE GEBÄUDETECHNIKER Deutsch

Gebäudetechnik Rechner

Reset 1 2 3 4 5 6 7 8 9

Auswahl PV PV & Solarthermie PV mit Wärmepumpe

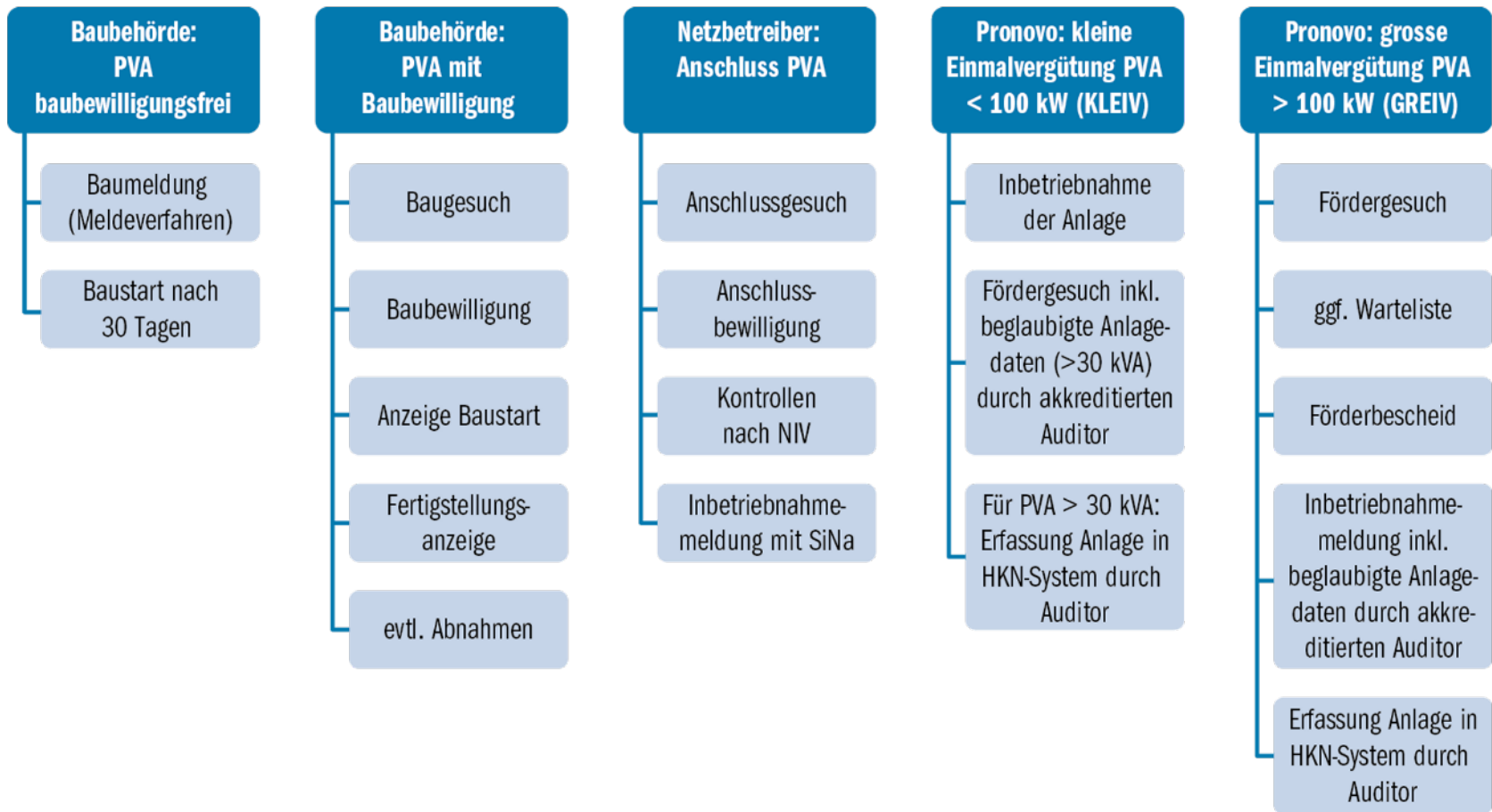
Variantendefinition

- Warmwasser (WW)
- Gebäudetechnik/Heizung (GT)
- Sanierung der Gebäudehülle (GH)
- Photovoltaik (PV)
- Solarthermie (ST)
- Planer Modus aktivieren

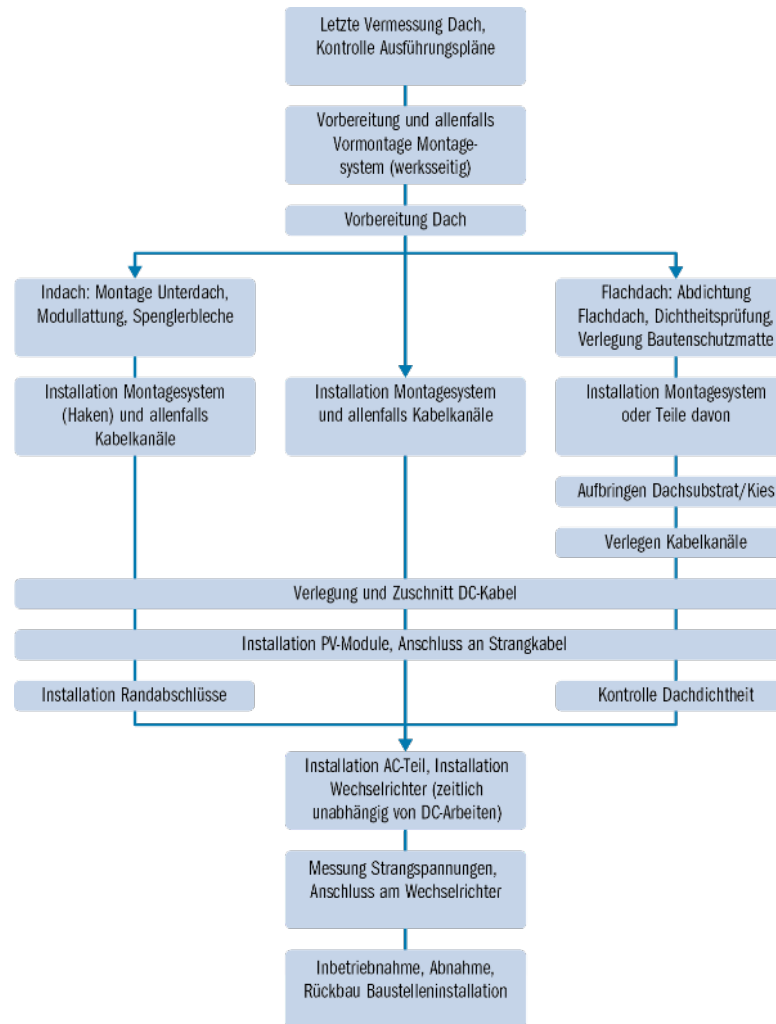
Jahr	Jan	Feb	März	Apr.	Mai	Juni	Juli	Aug.	Sep.	Okt.	Nov.	Dez.
kWh	150	200	320	340	340	350	350	340	300	220	140	110

Schweizerisch-Liechtensteiner Gebäudetechnikverband (suissetec) suissetec

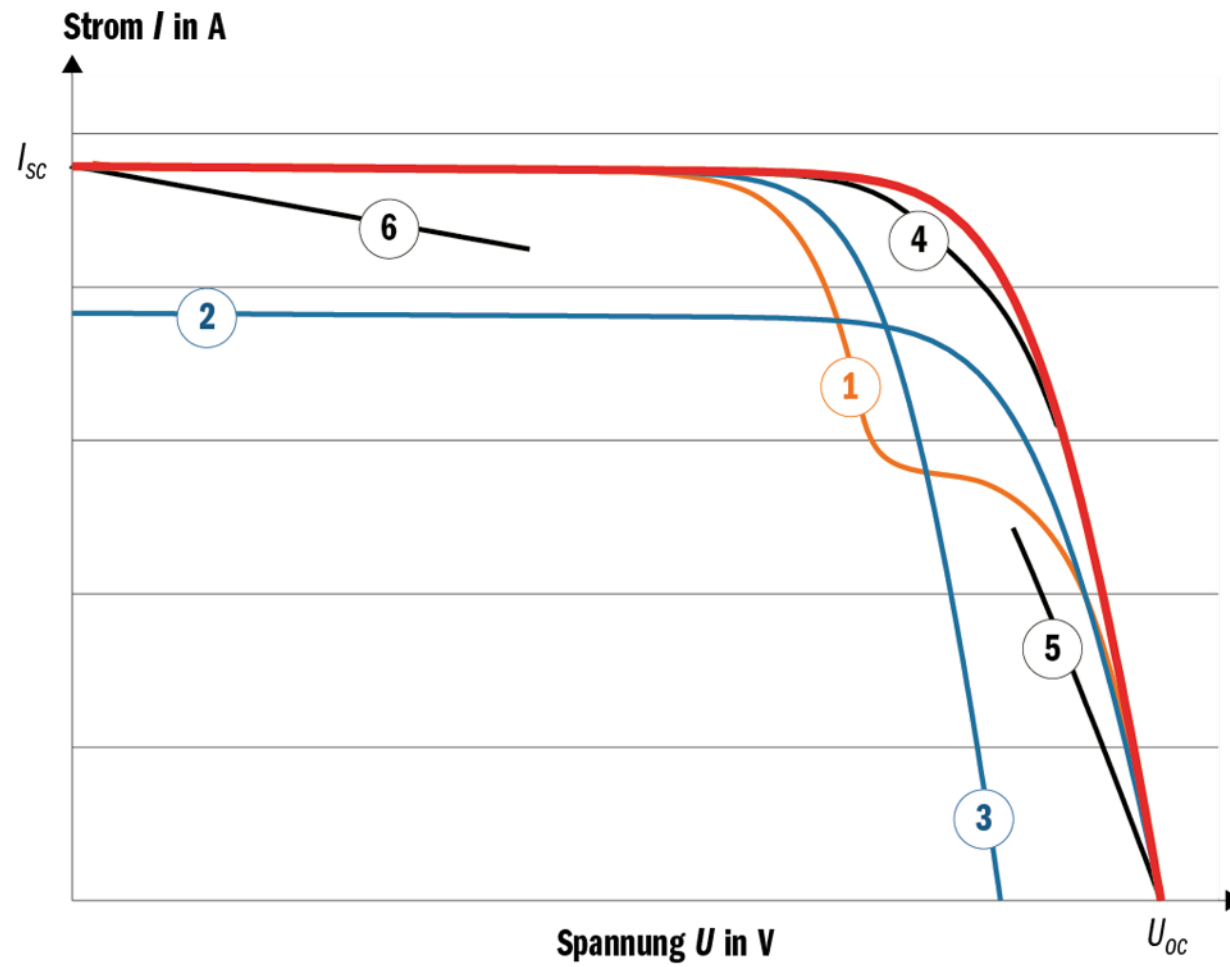
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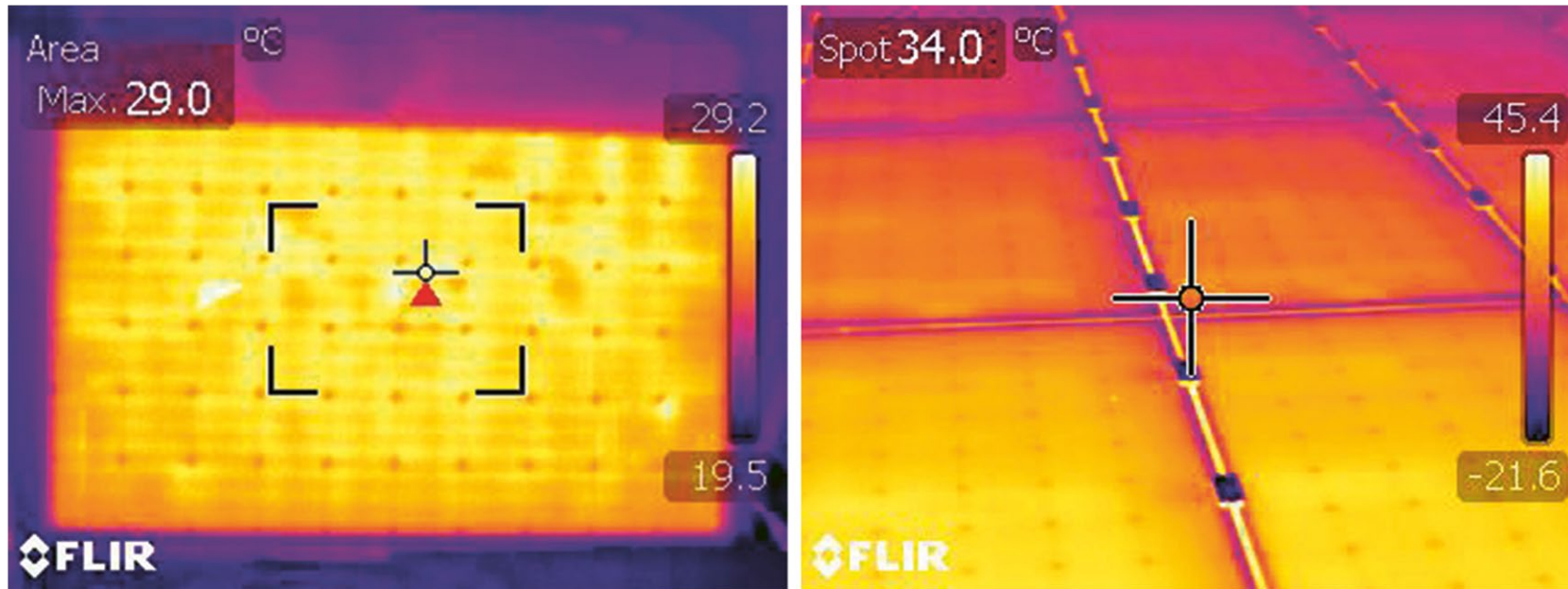
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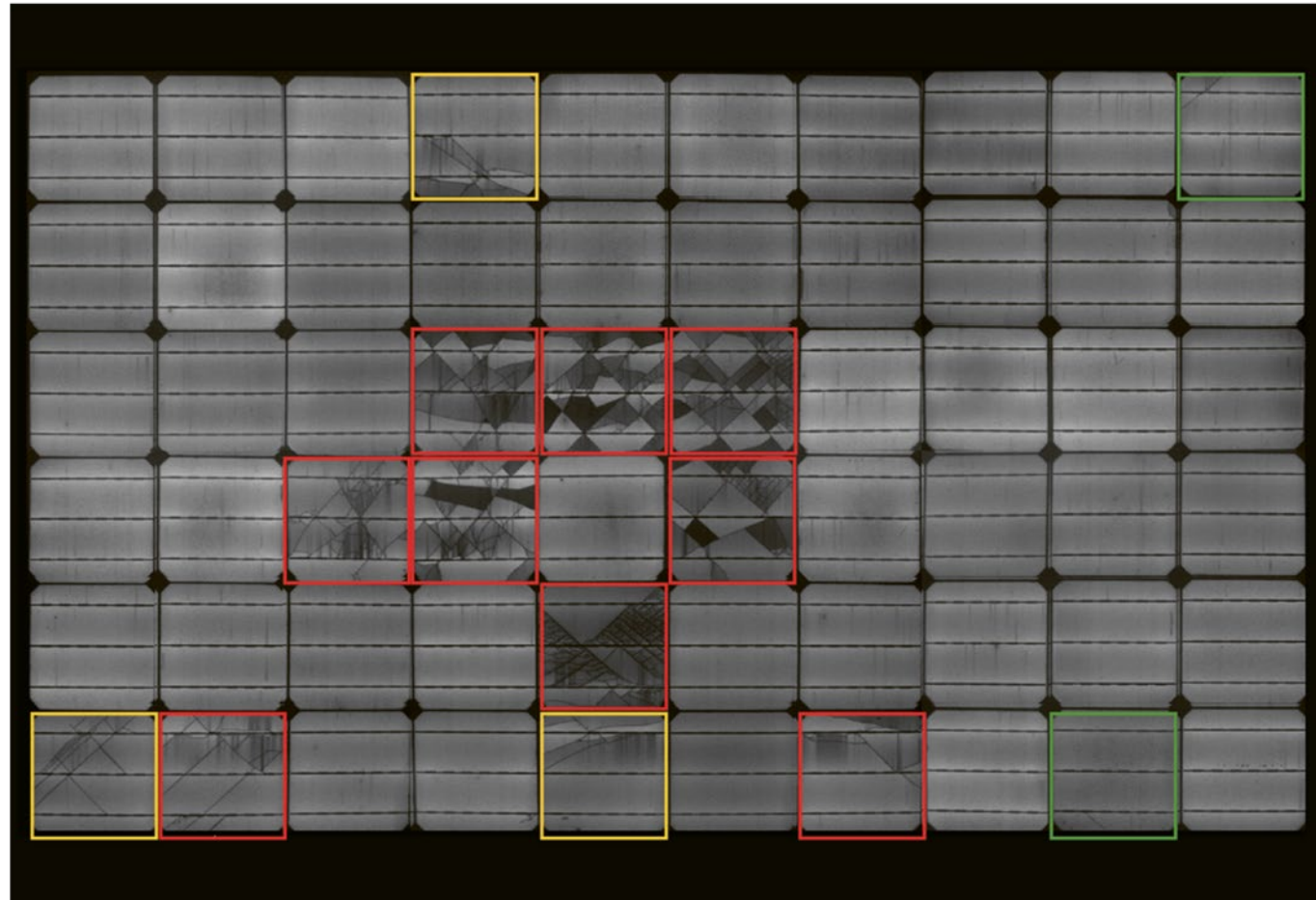
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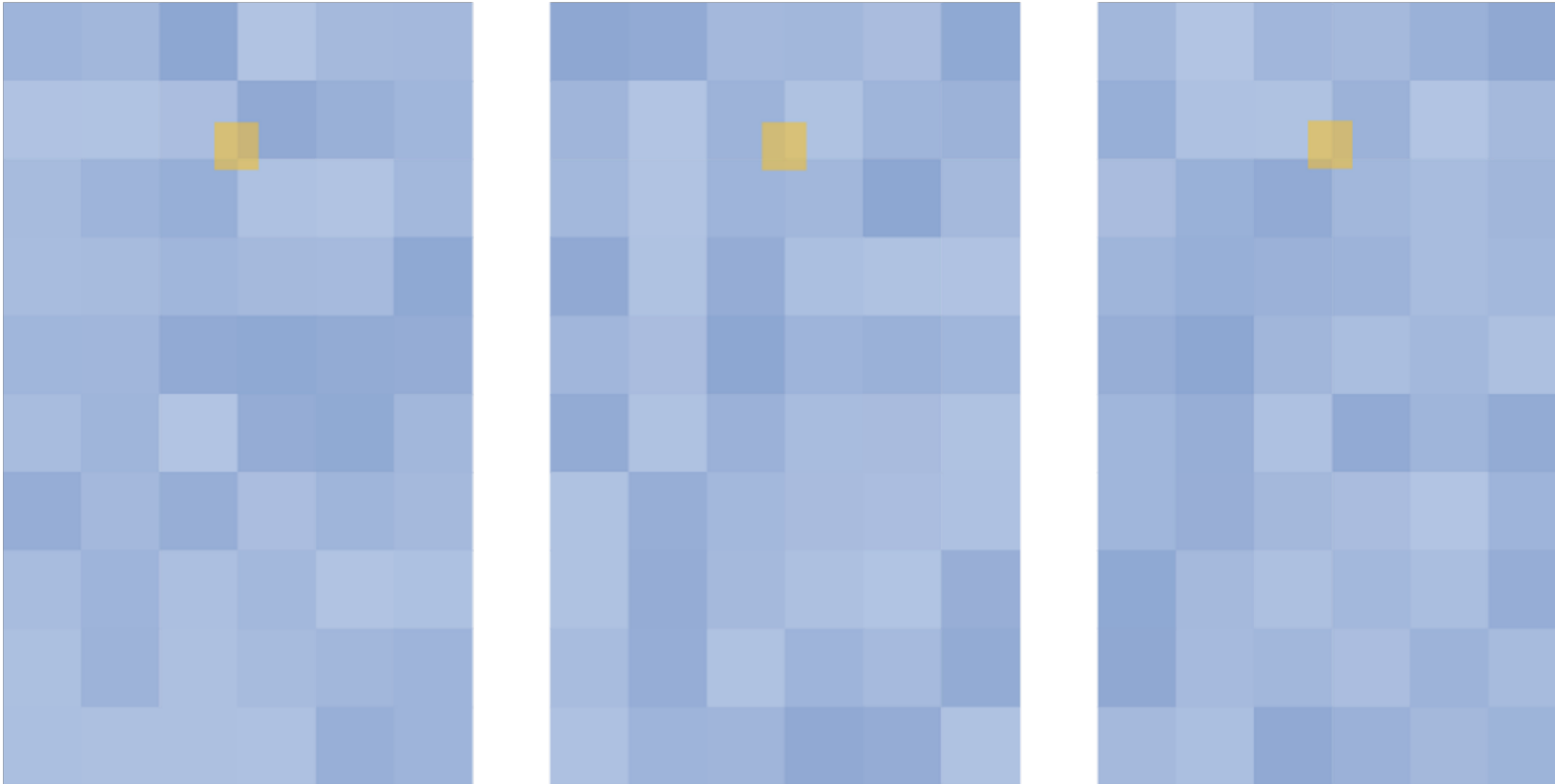
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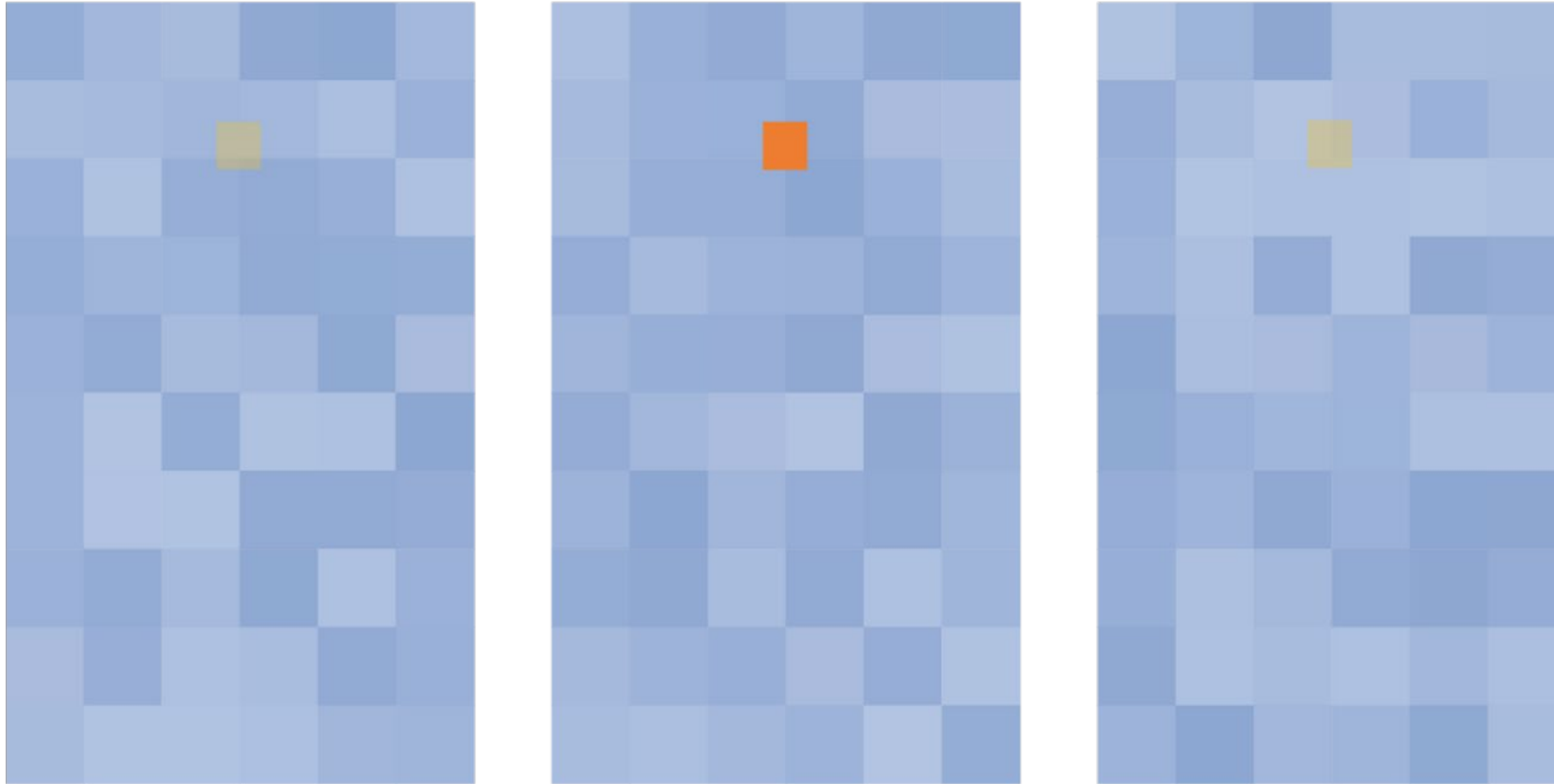
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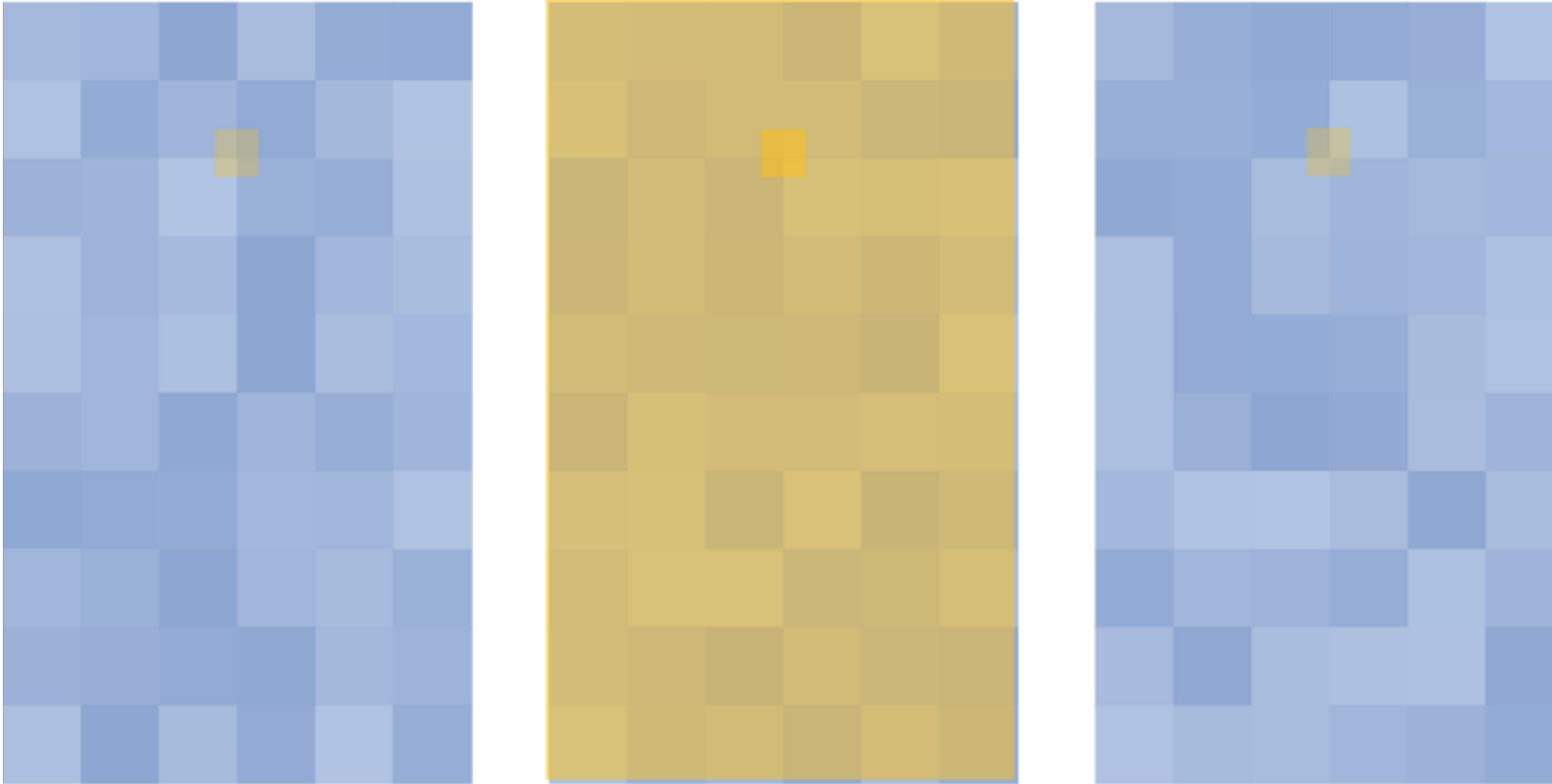
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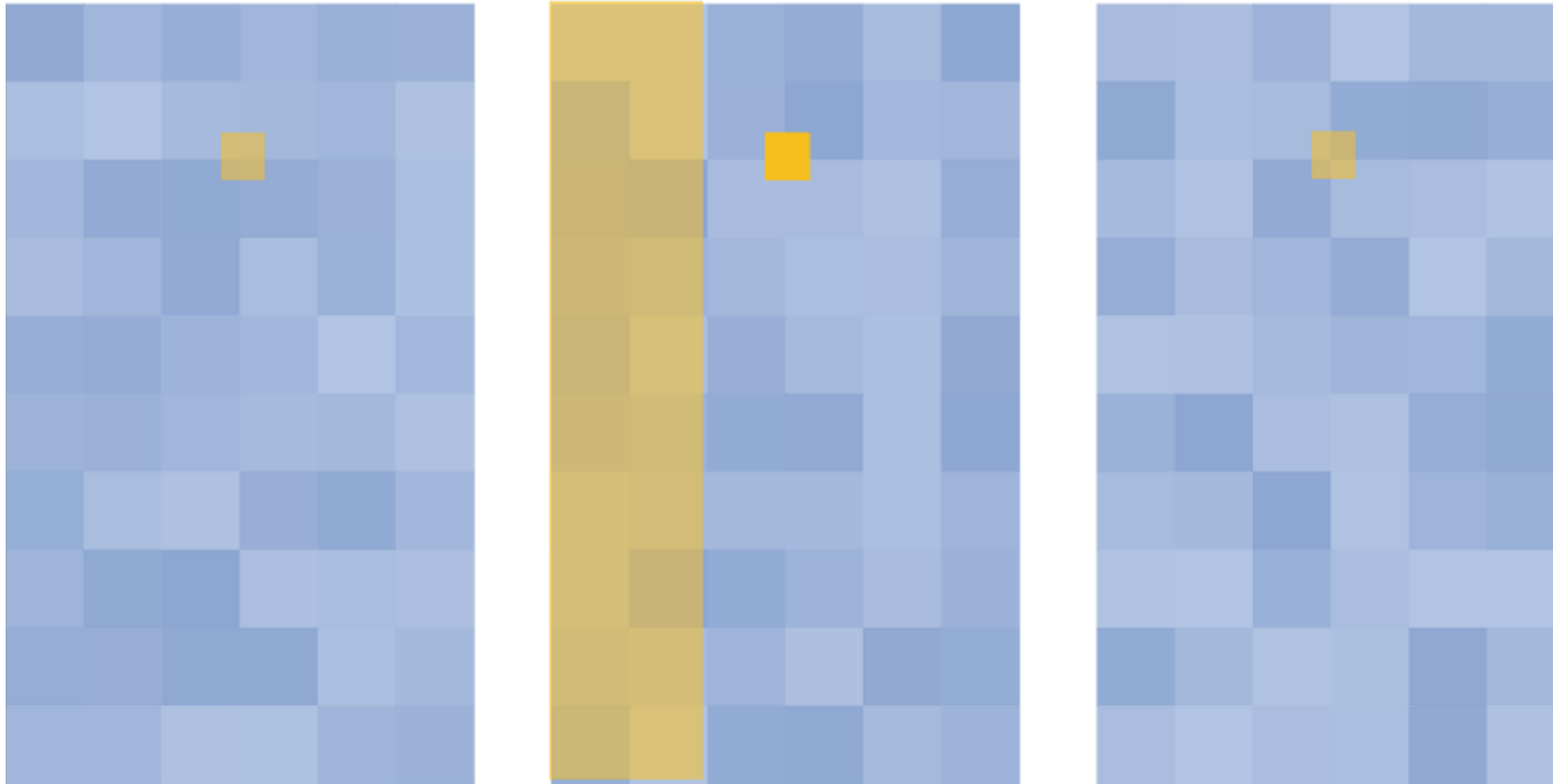
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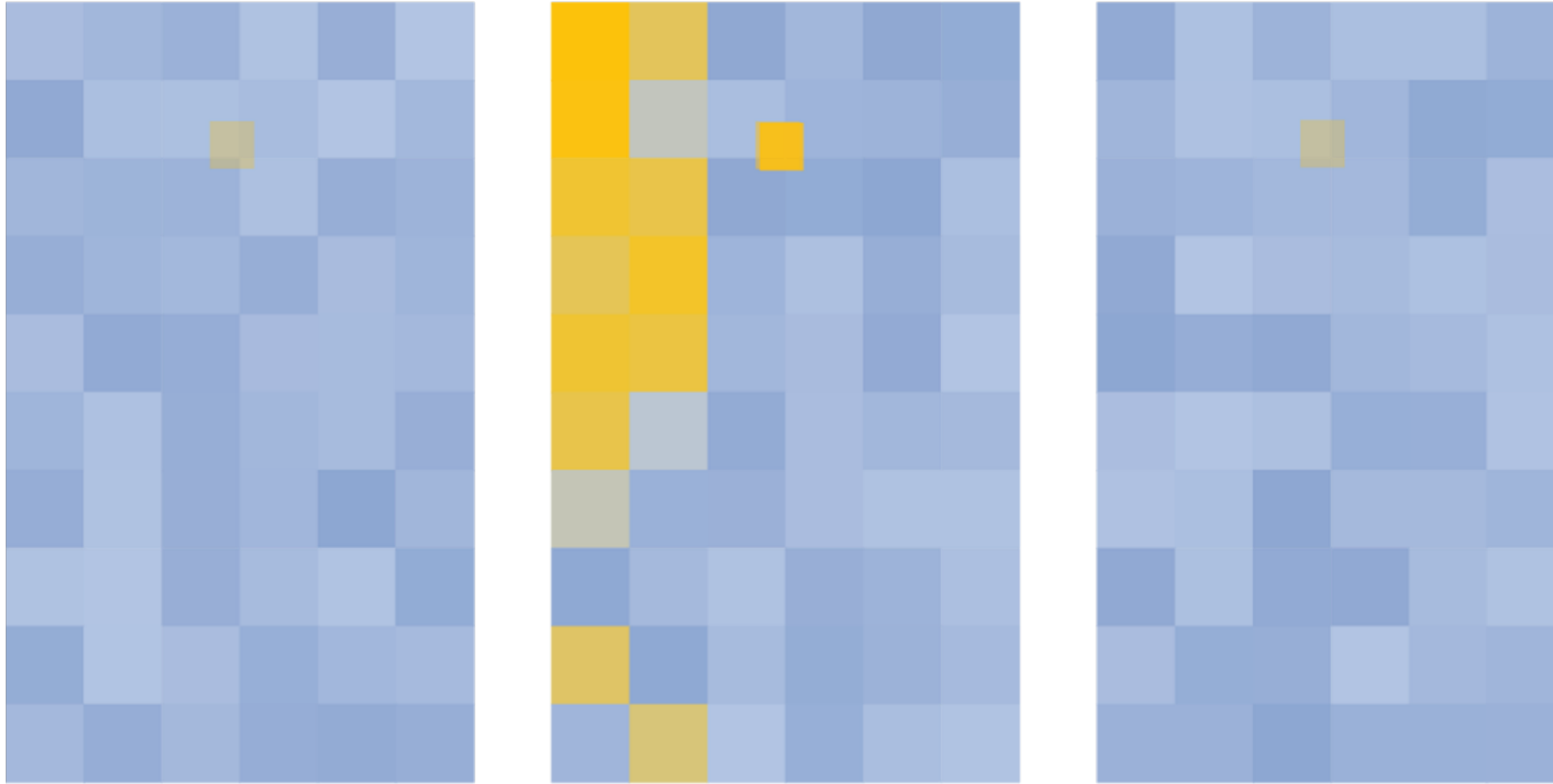
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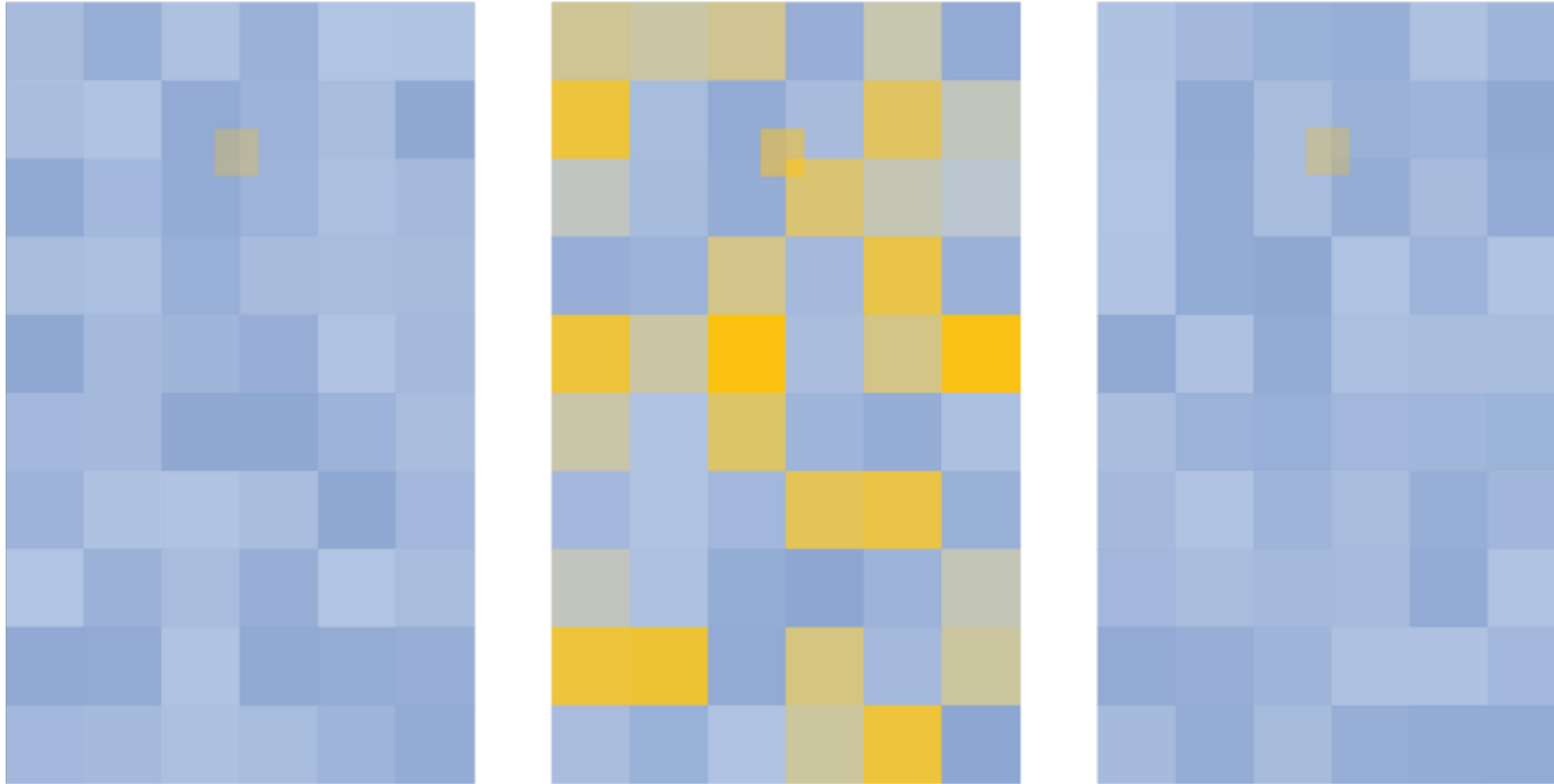
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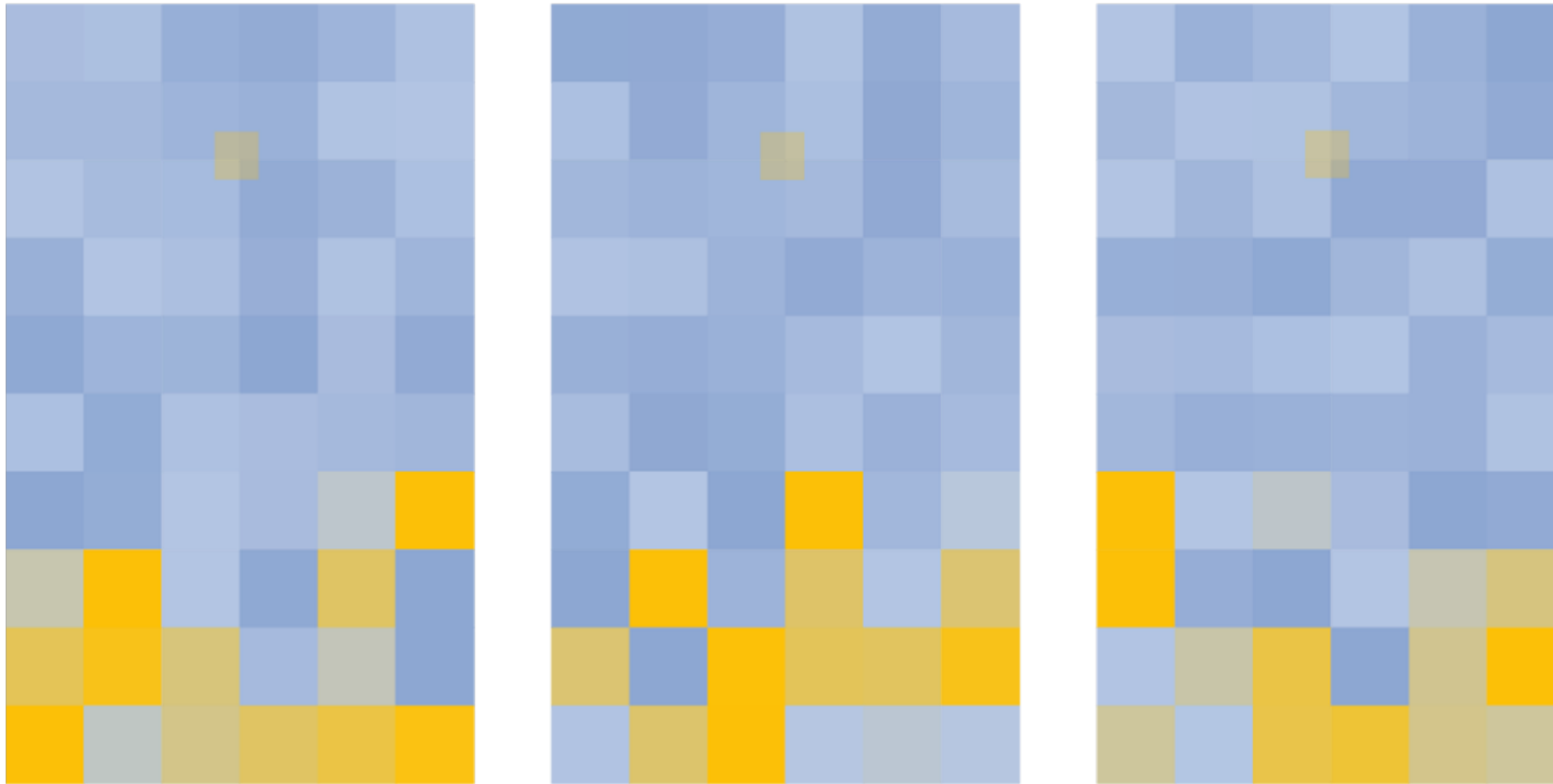
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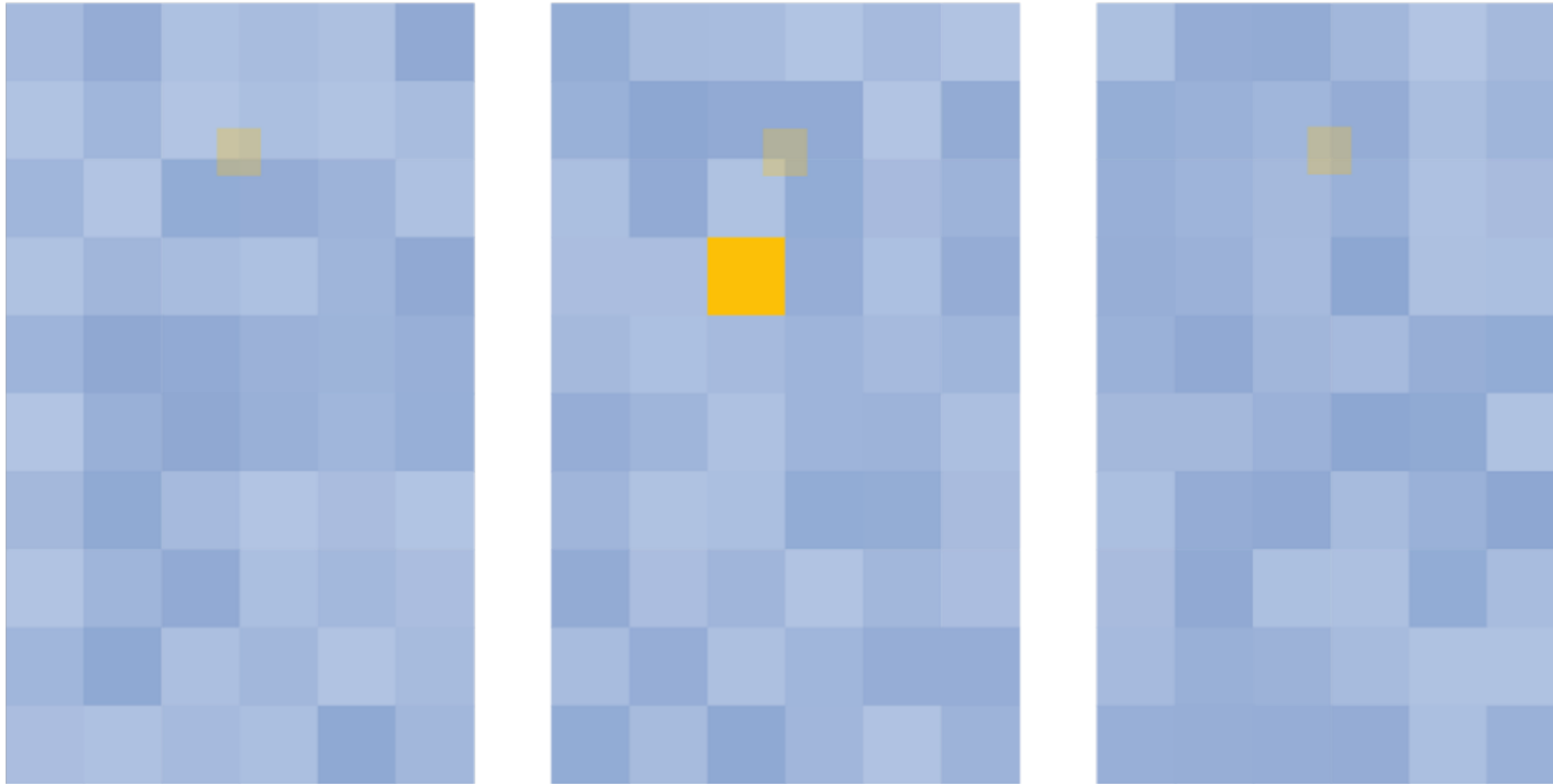
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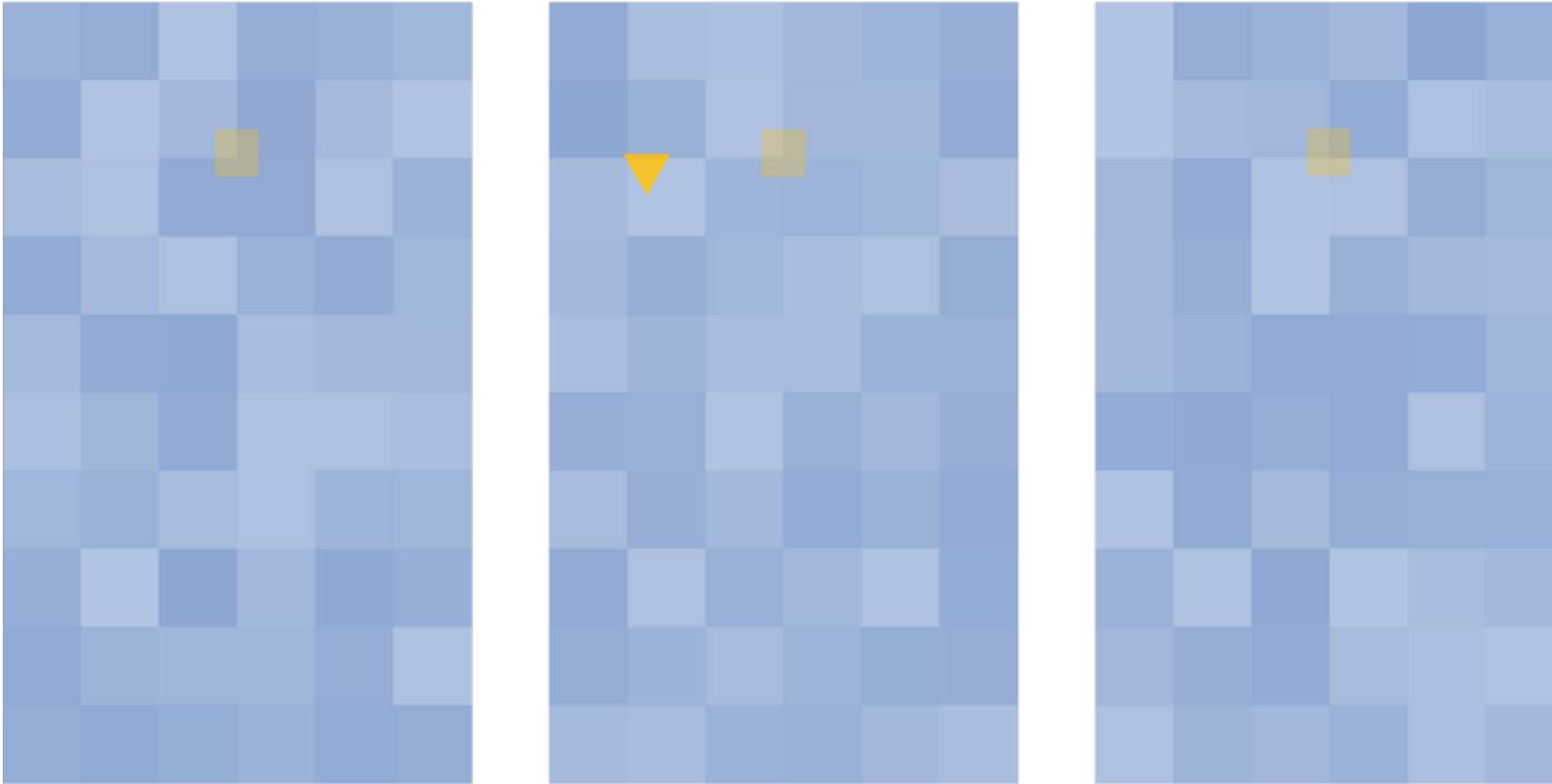
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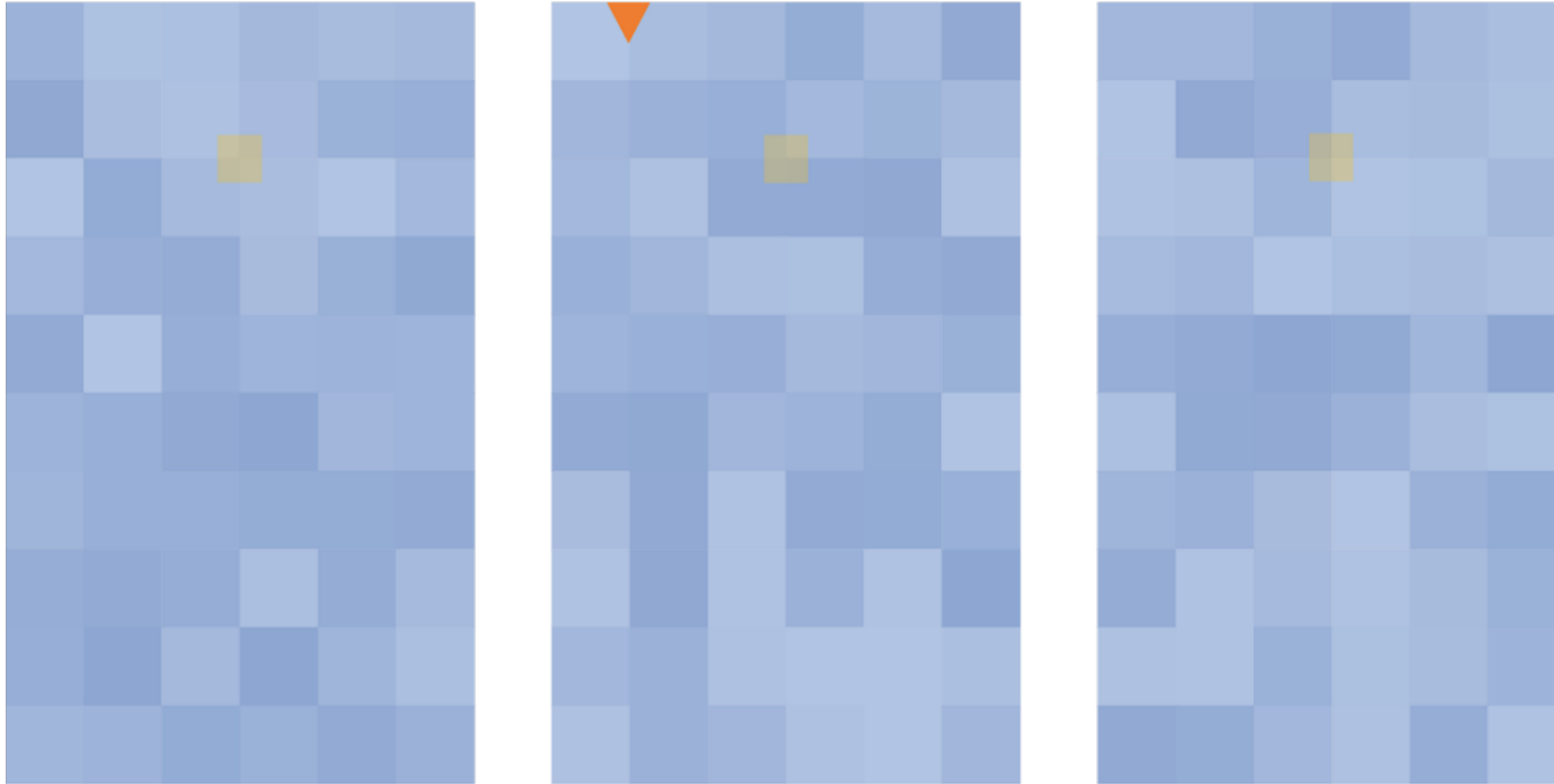
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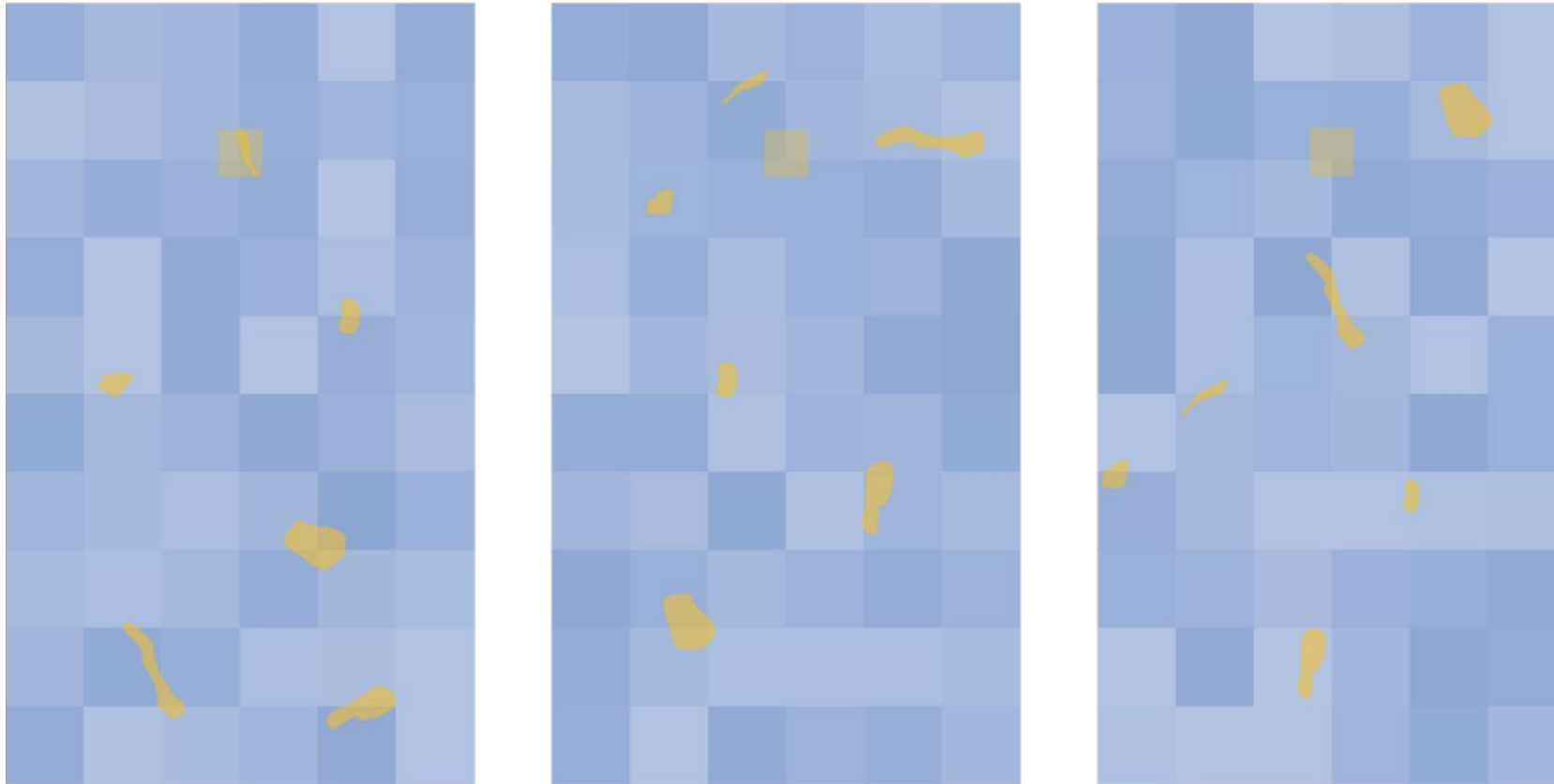
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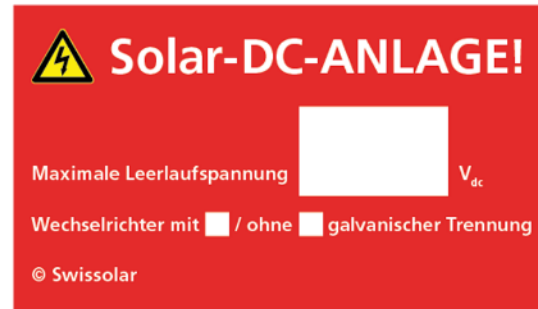
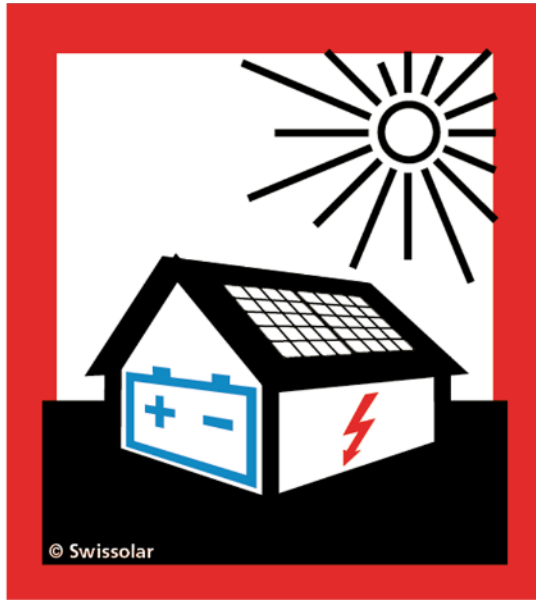
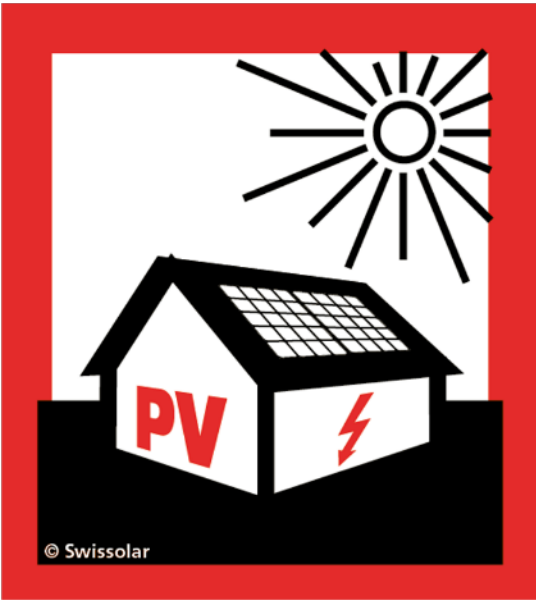
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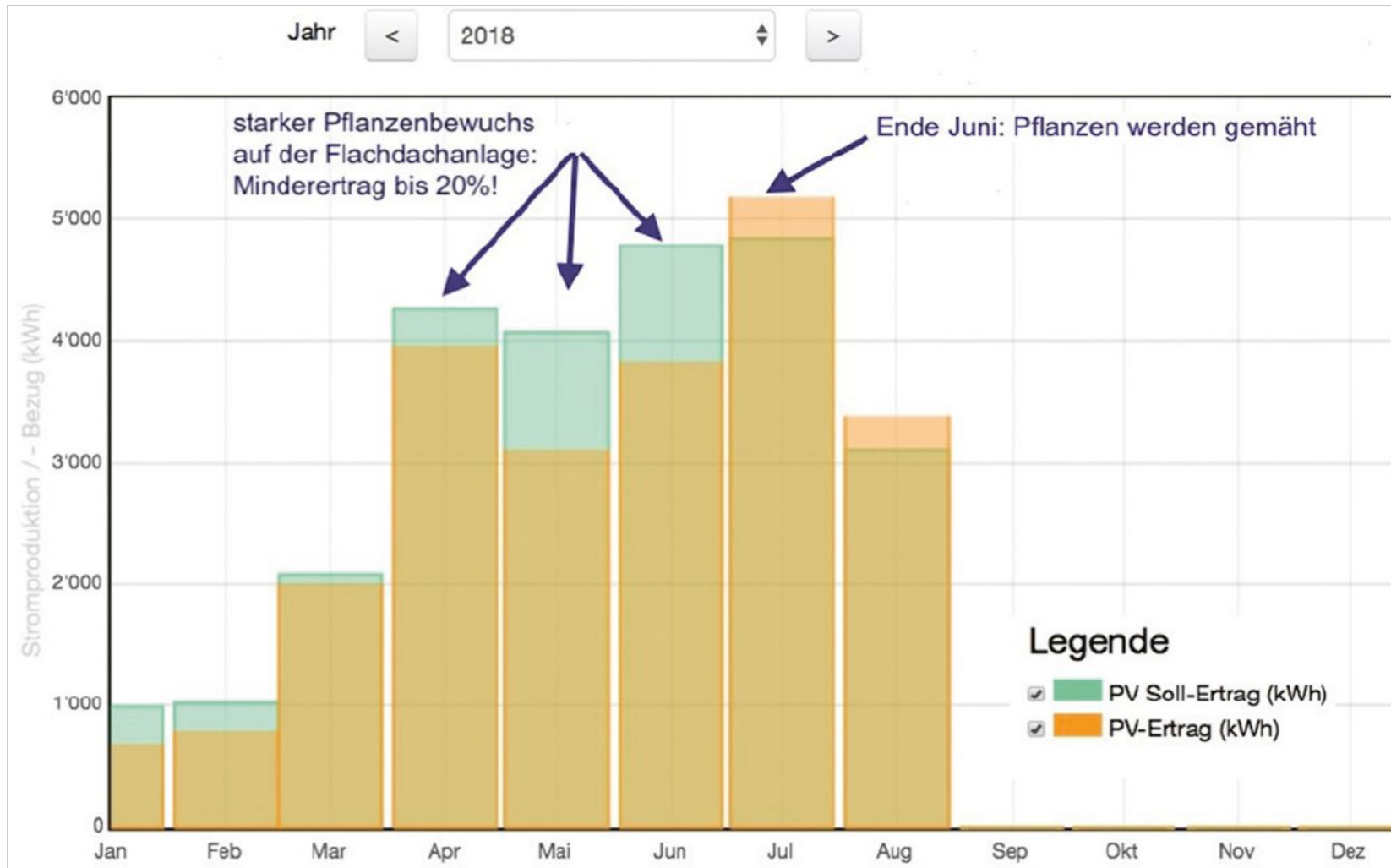
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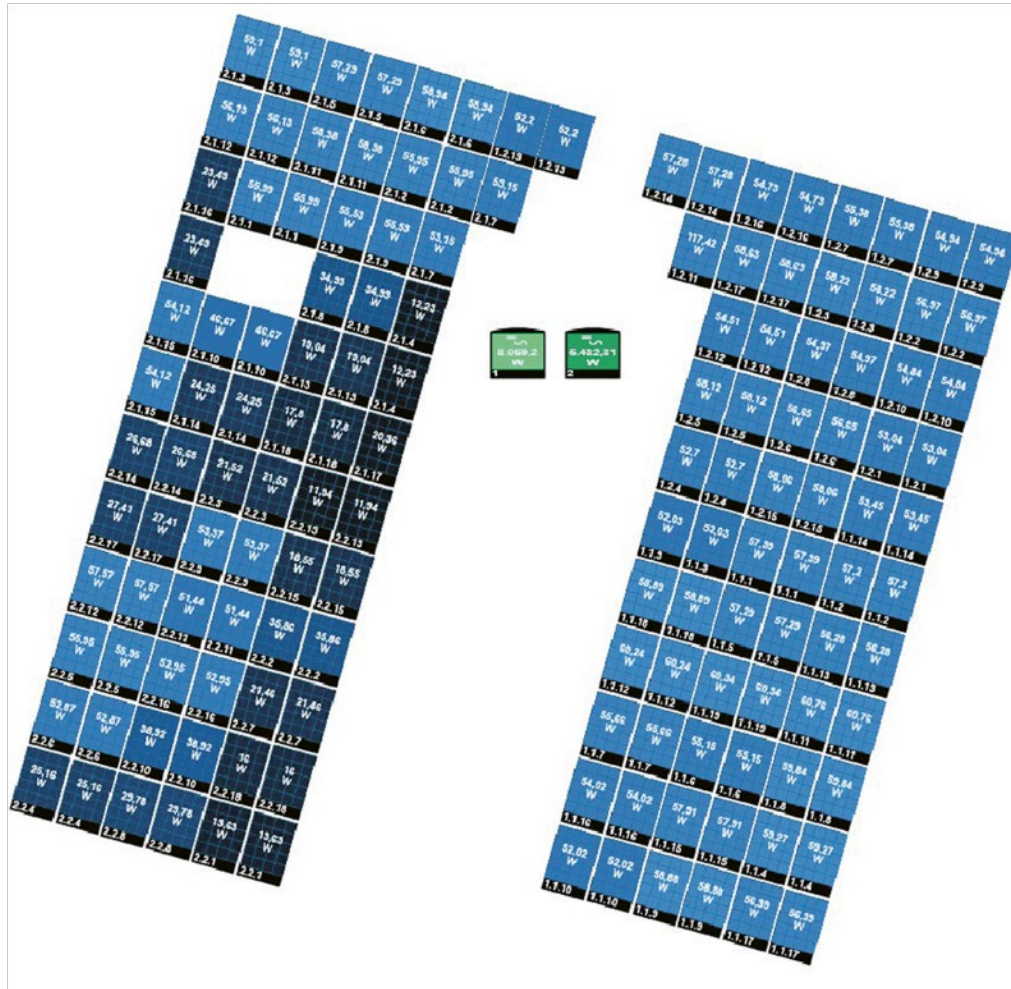
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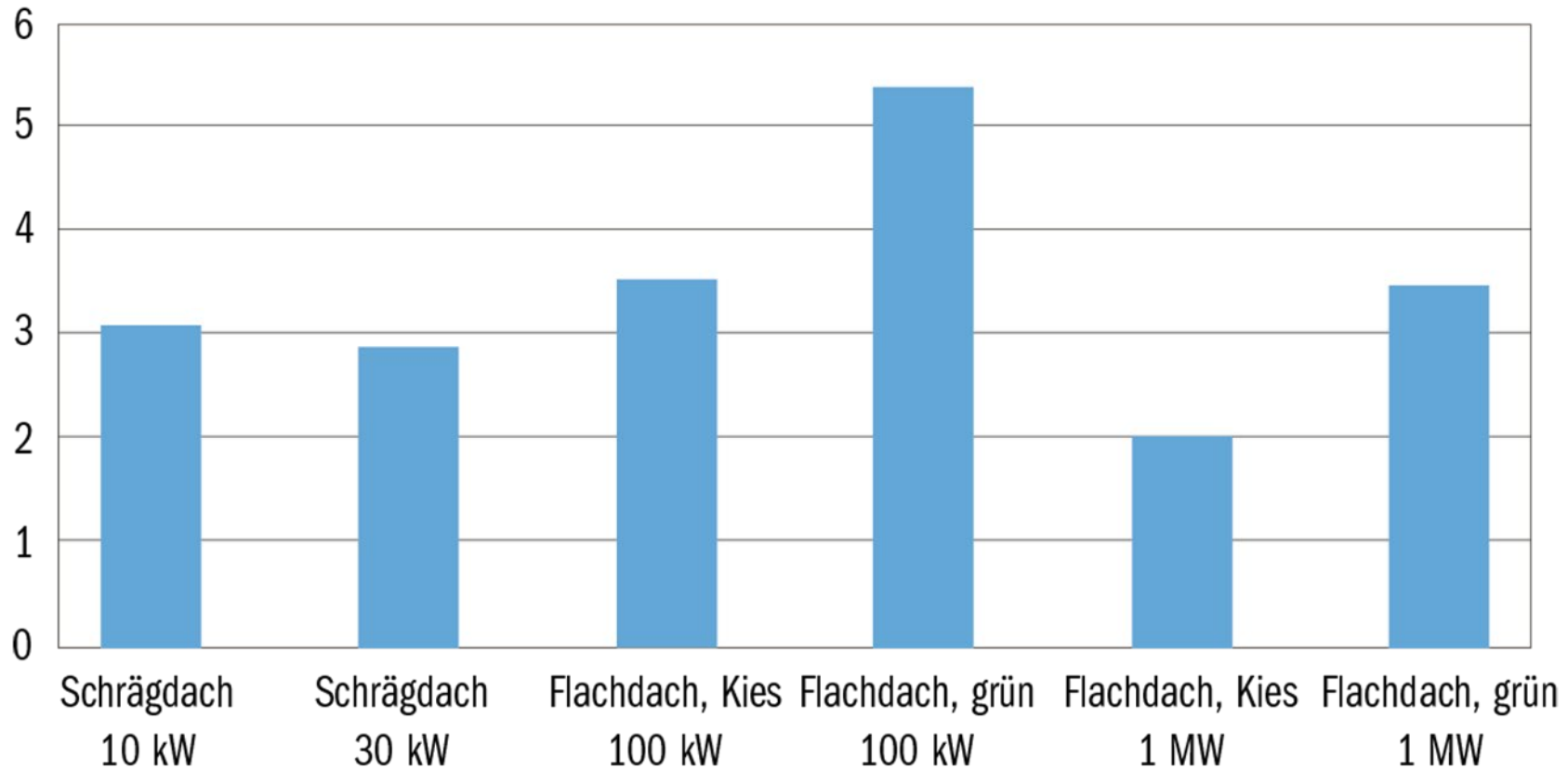


Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021

Erwartete Betriebs- und Unterhaltskosten in Rp./kWh



Quelle: Christof Bucher, Photovoltaikanlagen, Faktor Verlag 2021