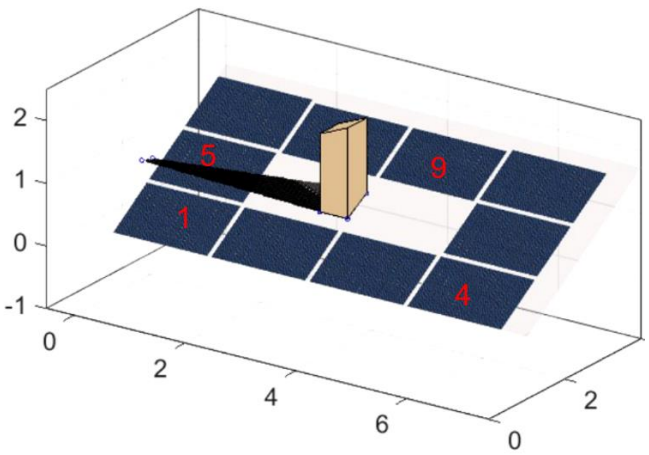


IEA PVPS

Will PV optimizer lead to optimum solar output at light shading conditions?

Franz Baumgartner, ZHAW Winterthur, Switzerland

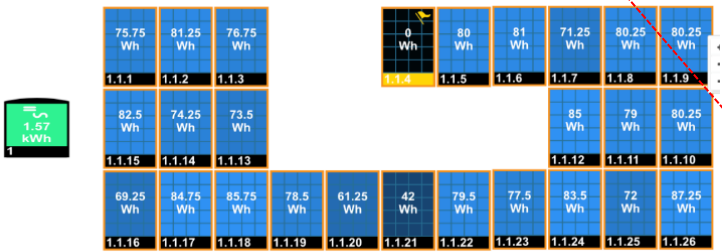
8th World Conf. PV Energy C.; Milano, 26th Sept 2022

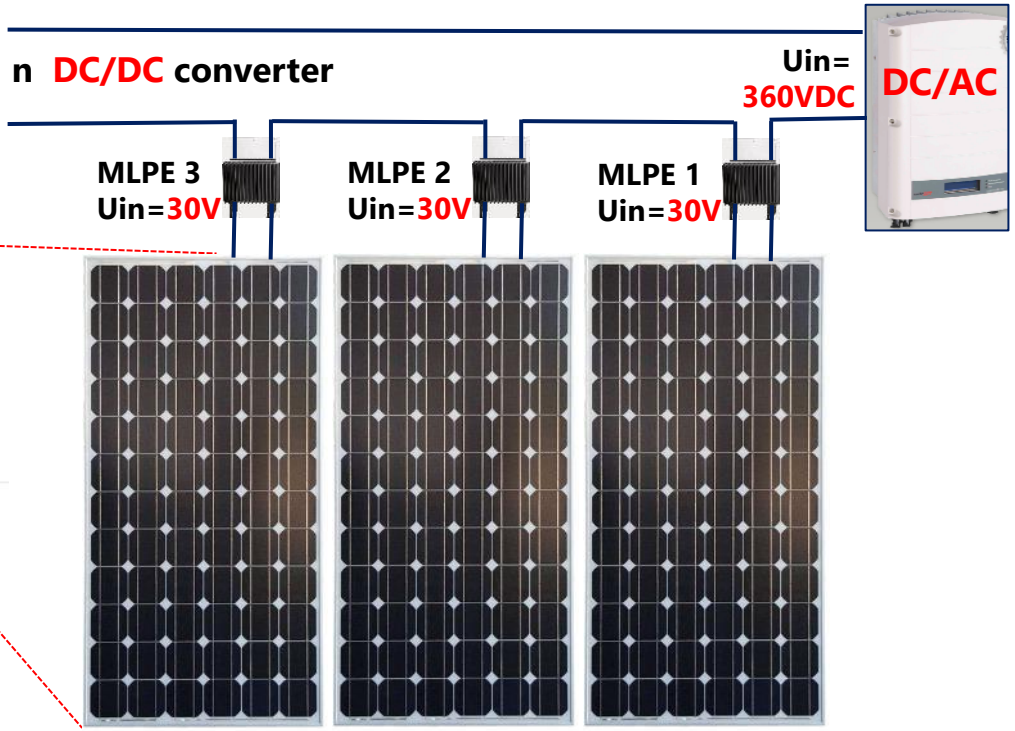
Content

- Goal of T13 ST2.5 Performance at partial shading
- What is the potential benefit of Optimizer (MLPE)
- Method of estimation at light shading conditions
- Outcome – WCPEC-8 Poster – Journal Paper
- Call for typical shading condition
  in different countries

Figure 4. Single-family home with residential PV system (modules with 3 bypass diodes) and shading objects of type chimney and ventilation pipe. The 13 kWp PV plant was implemented by PV installer in Switzerland. Reproduced with permission.[30] Copyright 2022, Alsona AG.

Module Level Power Electronics (MLPE)





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Theoretical available Max DC Power

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at 11:05 the string inverter and MLPE find max. power

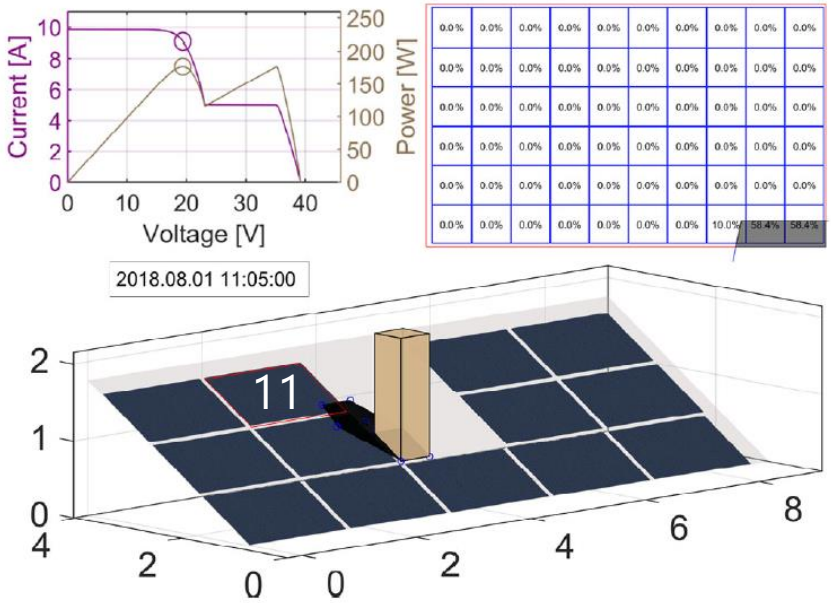

Figure 6. Second time step of the simulated PV system at 11:05 of August 1, 2018 (same shading scenario as described in the caption of Figure 5).

at 11:50 only the MLPE find max. Power

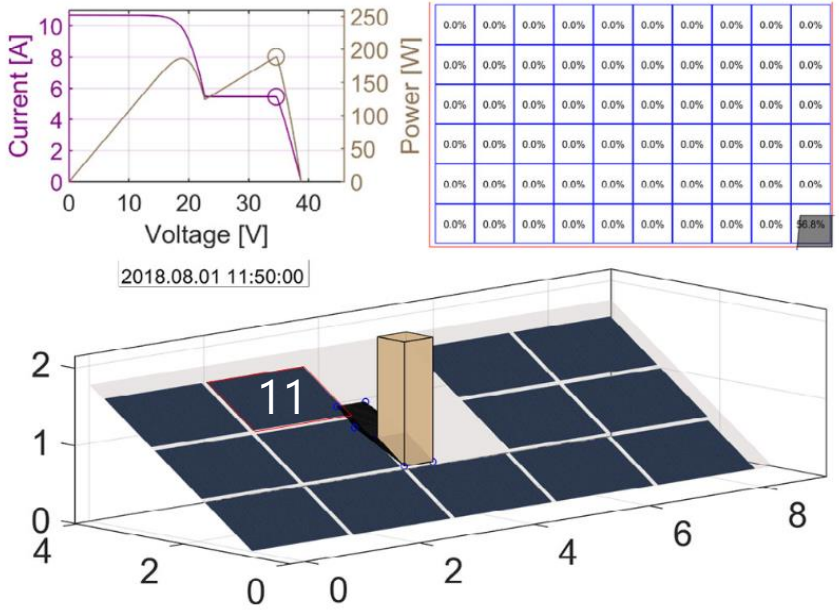

Figure 7. Third time step of the simulated PV system at 11:50 of August 1, 2018 (same shading scenario as described in the caption of Figure 5).

MLPE Real Efficiency ZHAW Measurement

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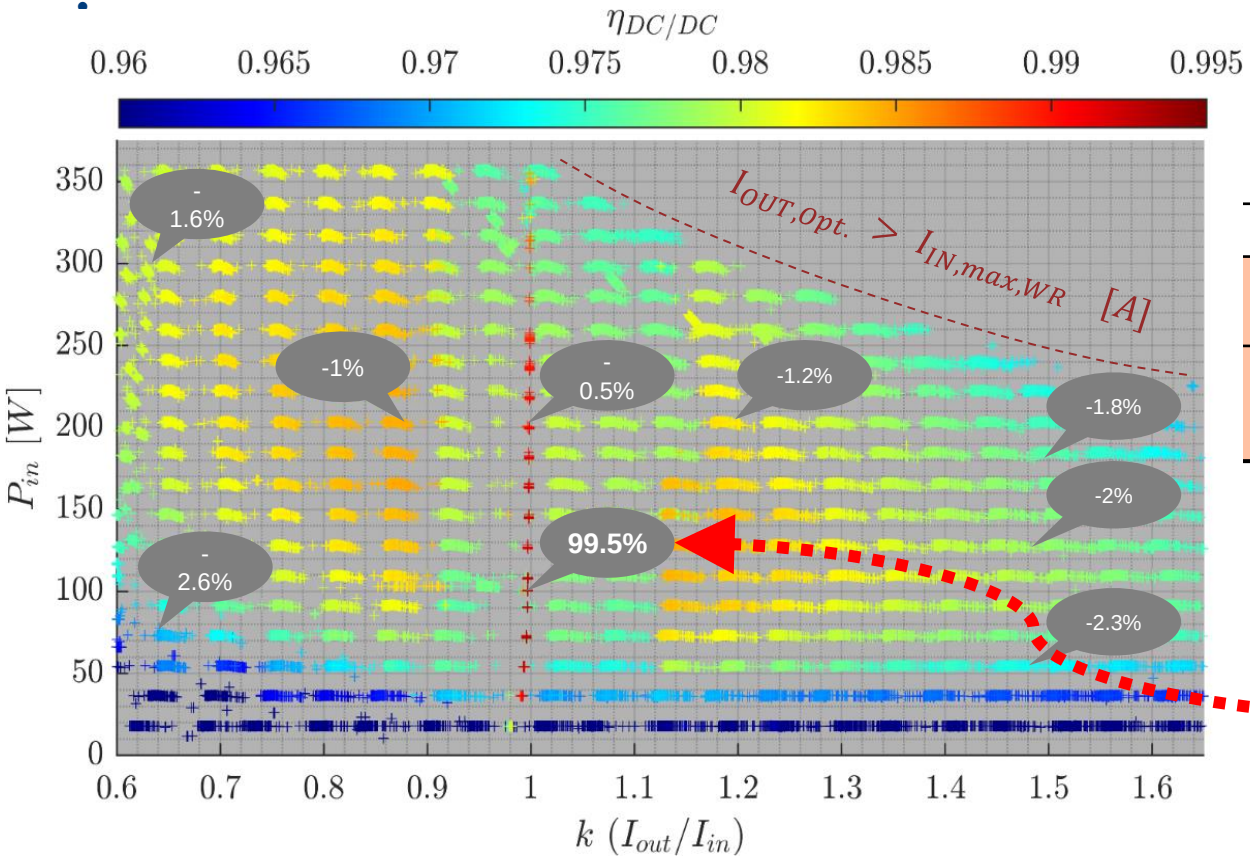


Optimizer P370

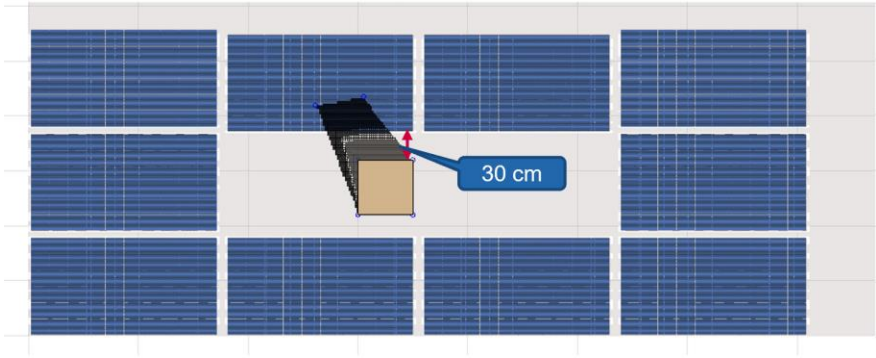
	ZHAW IEFE Measurement results					
P370	0.85	0.95	k = 1	1.05	1.2	1.5
EURO Eff.	97.7 %	97.3 %	98.9 %	97.4 %	97.6 %	96.6 %
No. Optimizer	9	10	11	12	13	17

Manufacturer	
Max	Weighted
99.5%	98.8%

-2%

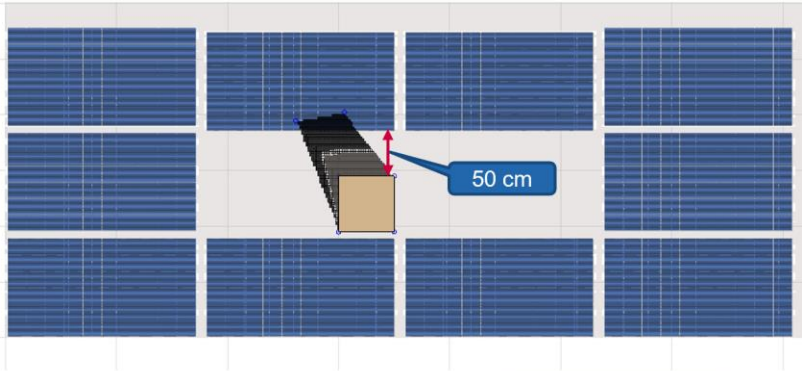
Annual Simulation Results 1 with real Eff.

System A : **MLPE @ Chimney - near**
Optimizer Solaredge SE3500H (HD-wave)+P370



	Chimney «near»
MLPE	100%
SINV	99.5%

System B : **SINV @ Chimney - far**
Stringinverter Huawei SUN2000-3.68KTL-L1



	Chimey «far»
MLPE	102.8%
SINV	103%

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PV Plan Designer will find OPTIMUM

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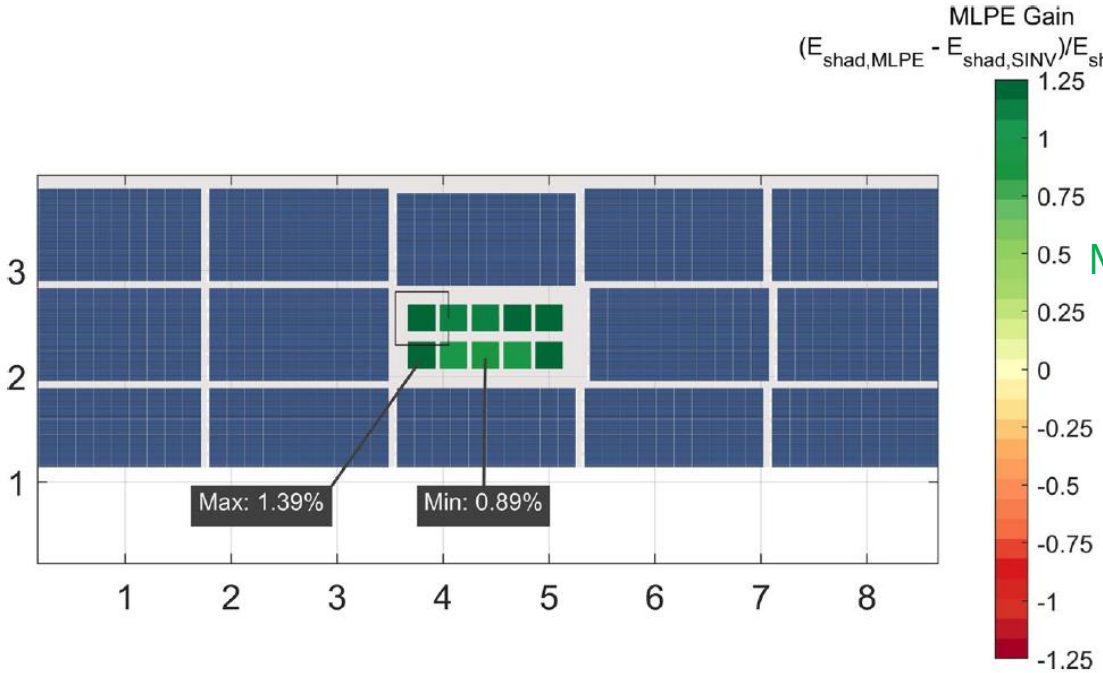
System of 14 PV modules: Percentage Performance Benefit of **MLPE (new DC/AC)** versus **SINV**



MLPE higher Performance

Figure 12. Comparison of the SINV: SUN2000-3.68KTL-L1 and MLPE: SE3500H with P370 power optimizer for a 14-module residential PV plant. Annual MLPE yield gain for 10 chimney positions visualized as boxes and their magnitude indicated by color bar. Minimum 0.9% and maximum MLPE yield gain 1.4% are denoted by gray text boxes

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PV Plan Designer will find OPTIMUM

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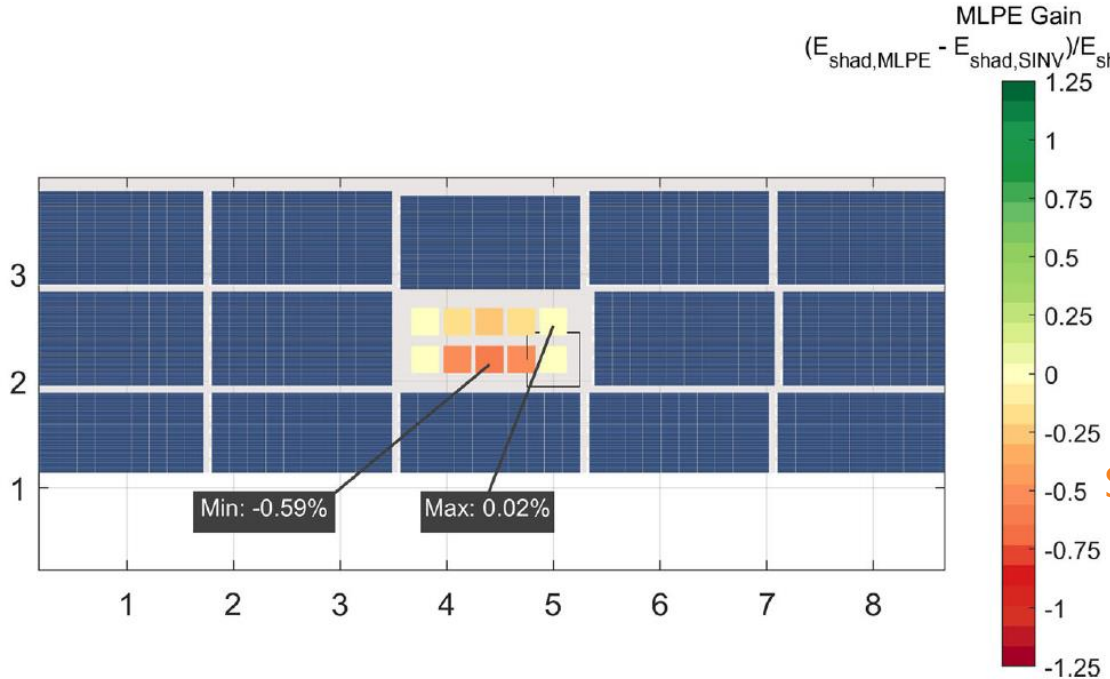
System of 14 PV modules: Percentage Performance Benefit of **MLPE (old DC/AC)** versus **SINV**



SINV higher Performance

Figure 13. Comparison of the SINV: SB3.6-1AV-41 and MLPE: SE3500 (**non-HD-wave**) with P370 power optimizer for a 14-module residential PV plant. Annual MLPE yield gain for 10 chimney positions visualized as boxes and their magnitude indicated by color bar. Minimum 0.6% and maximum MLPE yield gain 0.02% are denoted by gray text boxes

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Annual Simulation Results 2 with real Eff.

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System A : **MLPE**
Optimizer Solaredge SE3500H (HD-wave)+P370

System B : **SINV**
Stringinverter Huawei SUN2000-3.68KTL-L1

	MLPE – new–	MLPE – old–	SINV -new-
Chimney «near»	**96.2%**	94.4%	95.7%
Chimney «far»	96.2%	94.4%	96.6%
Manufacturer	$98.8\% \cdot 98.8\% = 97.6\%$	$98.8\% \cdot 97.5\% = 96.3\%$	97.3%

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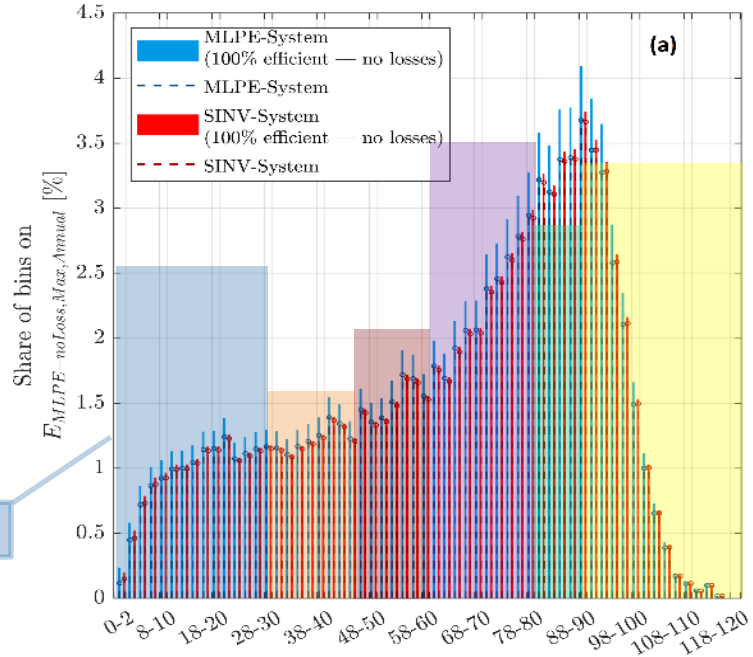
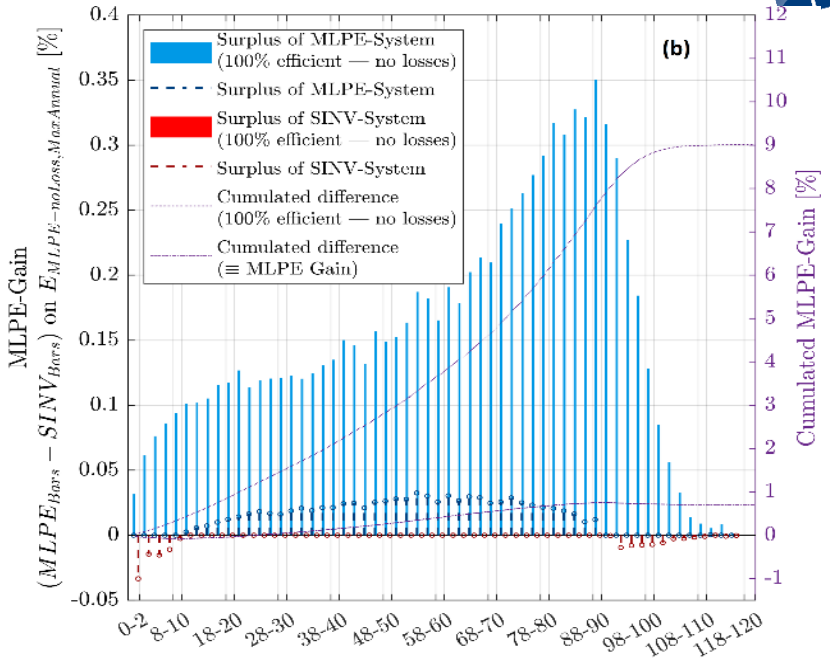
Histogram of Power at Shading Cond.





Shading moments n:	1	2	3	4	5	6
Power ratio [%] $P_{MLPE-noLoss,Max}/P_{PV,rated}$:	0 - 30	31 - 44	45 - 60	61 - 78	79 - 88	89 - 120
Weighting factors $w_{shad,a,n}$:	0.16	0.10	0.13	0.22	0.18	0.21
Date + Time of shading moments n:	July 3rd, 10:55	April 3rd, 08:55	Aug. 13th, 10:00	Sept. 4th, 14:50	June 9th, 14:35	April 17th, 12:20

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Weighting Factors applied to Lab. Meas.

Shading moments n:	1	2	3	4	5	6
Date + Time of shading moments n:	July 3rd, 10:55	April 3rd, 08:55	Aug. 13th, 10:00	Sept. 4th, 14:50	June 9th, 14:35	April 17th, 12:20

	1		2		3	
	I_{MPP} [A]	V_{MPP} [V]	I_{MPP} [A]	V_{MPP} [V]	I_{MPP} [A]	V_{MPP} [V]
Module 1 - 6, 8 - 10 and 12 - 13	2.06	35.37	4.19	35.37	5.70	35.37
Module 7	2.06	35.30	1.55	38.81	4.59	34.61
Module 11	2.06	35.37	4.18	23.40	5.07	34.74

	4		5		6	
	I_{MPP} [A]	V_{MPP} [V]	I_{MPP} [A]	V_{MPP} [V]	I_{MPP} [A]	V_{MPP} [V]
Module 1 - 13, (all PV-modules)	7.90	31.71	9.26	30.44	10.81	30.26

$$\eta_{shad,a,n} = \frac{P_{ac}}{\sum_{i=1}^{k} P_{mod,i,k}} \quad (1)$$

$$\eta_{shad,a} = \sum_{n=1}^{N} w_{shad,a,n} \cdot \eta_{shad,a,n} \quad (2)$$

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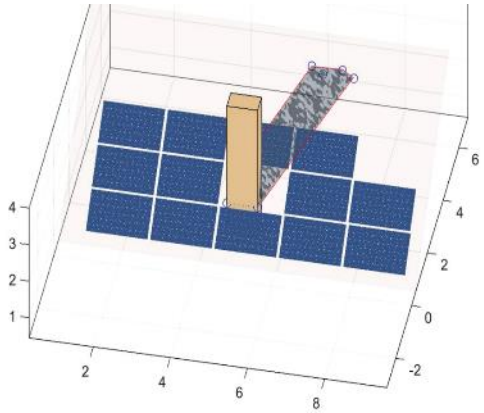
PV Output Estimation with Partial Shading

- Shading by obstacles in Switzerland
- Estimation by simulation with 3D PV-modell

SFH 13kWp by PV installer,
«Alsona AG» - Webpage: https://www.alsona.ch/



ZHAW SOE ShadingTool

Various rooftops in Zurich City, by Juliet Haller (AfS),
Office for Urban Development – City of Zurich, «Leitfaden Dachlandschaften»

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Definition of relevant shading objects

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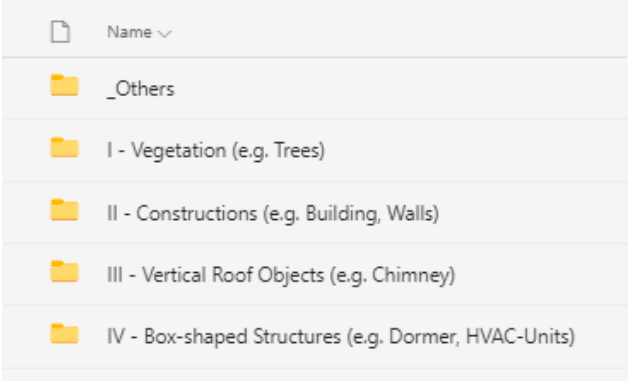
How and where to gather the pictures of shading objects:

Link: *MS Teams Subfolder: >Shading Situations*

ST2_Performance and Durability of PV Systems > ST2.5_Module Power Electronics Efficiency and Shading > 03_Data > 2_simulation verification > **Shading Situations**



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I – Vegetation (e.g. Trees)

Pictures by Bouygues E&S InTec Schweiz AG, Geschäftseinheit Helion

Franz Baumgartner, PVPS T13 ST2.5

bauf@zhaw.ch www.zhaw.ch/=bauf

Poster 3DV.1.40

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