Performance comparison of a P370 power optimizer system and a string inverter system

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ZHAW IEFE Winterthur, www.zhaw.ch/=bauf

Research objectives

- Yearly performance comparison of a residential decentralized SolarEdge P370 buck-boost power optimizer system and a centralized string inverter (SINV) system under unshaded and partially shaded (chimney and tree) conditions.
- Analysis of voltage conversion performance for a SolarEdge P370 power optimizer.

Methodology

- Indoor laboratory measurements were used to create a system model. The system model was fed into a ZHAW ray tracing simulation tool, allowing yearly performance comparisons of various system configurations at minute time steps (Table 1). Both systems were fitted with the optimum number of modules for the optimizer system.
- Simulation results are presented in the form of a MLPE gain. MLPE gain represents the value of the shading adaption efficiency of the optimizer system when compared to the SINV. The shading adaption efficiency (SAEta) describes the performance of SINV and MLPE systems based on the same reference – the theoretical performance of a lossless system with module-level tracking for a specific shading case [1][2][3] (Figure 1):

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

Table 1: Datasheet values of simulated system configurations

	PV Modules	# PV Modules	String inverter system	MPLE system Inverter	MPLE system Power Optimizer
1 Phase	Pn = 400 W 60 Cells	12	Huawei SUN2000-3.68KTL-L1 Uin,rated = 360V EURO-Eff = 97.3%	Solaredge SE3500H Uin,rated = 380V DC/AC EURO-Eff: 98.8%	Solaredge P370 DC/DC Efficiencies: Wght.-Eff = 98.8% Max.-Eff = 99.5%
3 Phase	3 bypass diodes	14 & 21	Fronius Symo 10kW Uin,rated = 600V EURO-Eff = 97.4%	Solaredge SE10k Uin,rated = 750V DC/AC EURO-Eff: 97.6%	

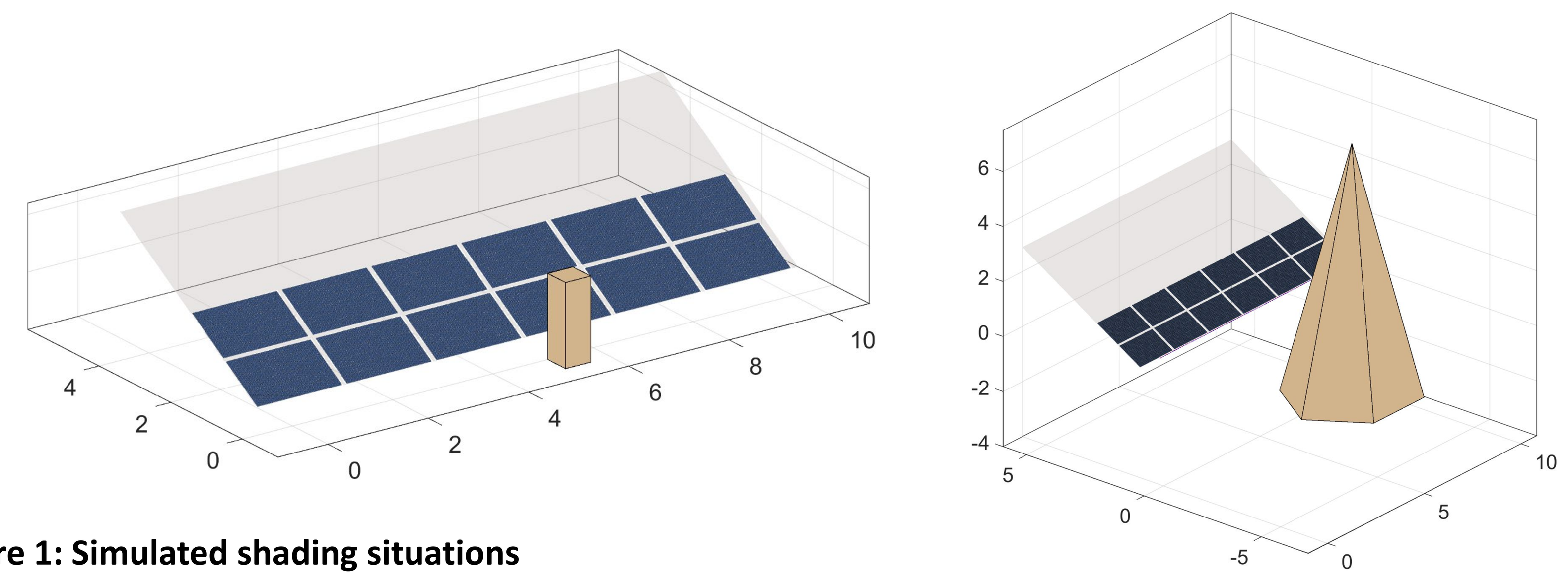

Figure 1: Simulated shading situations

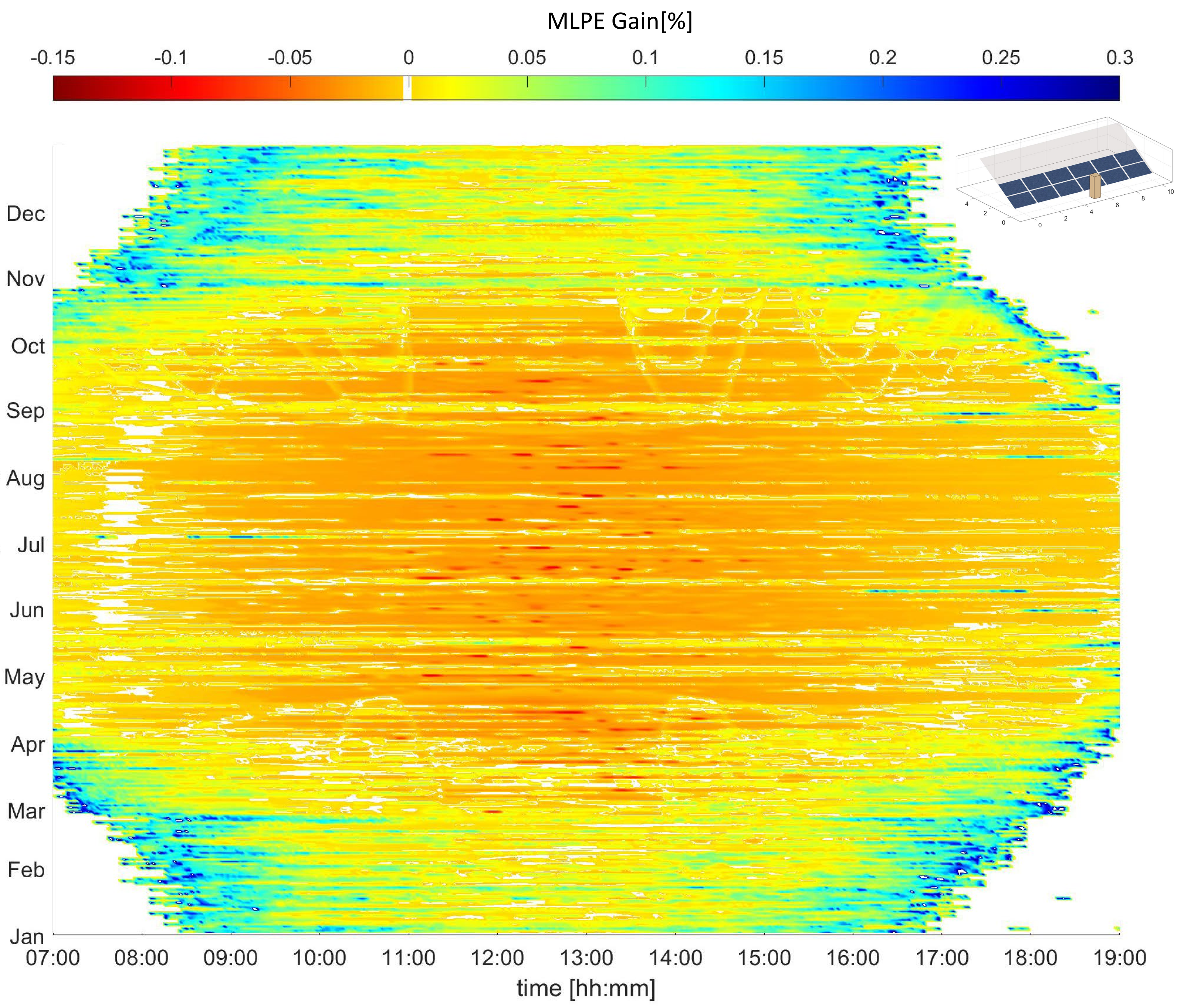

Figure 2: Yearly MLPE gain [%] (combined DC/DC & DC/AC efficiency) for a 3 phase system partially shaded by a chimney, dt=2min, simulation output of the ZHAW MLPE Shade software.

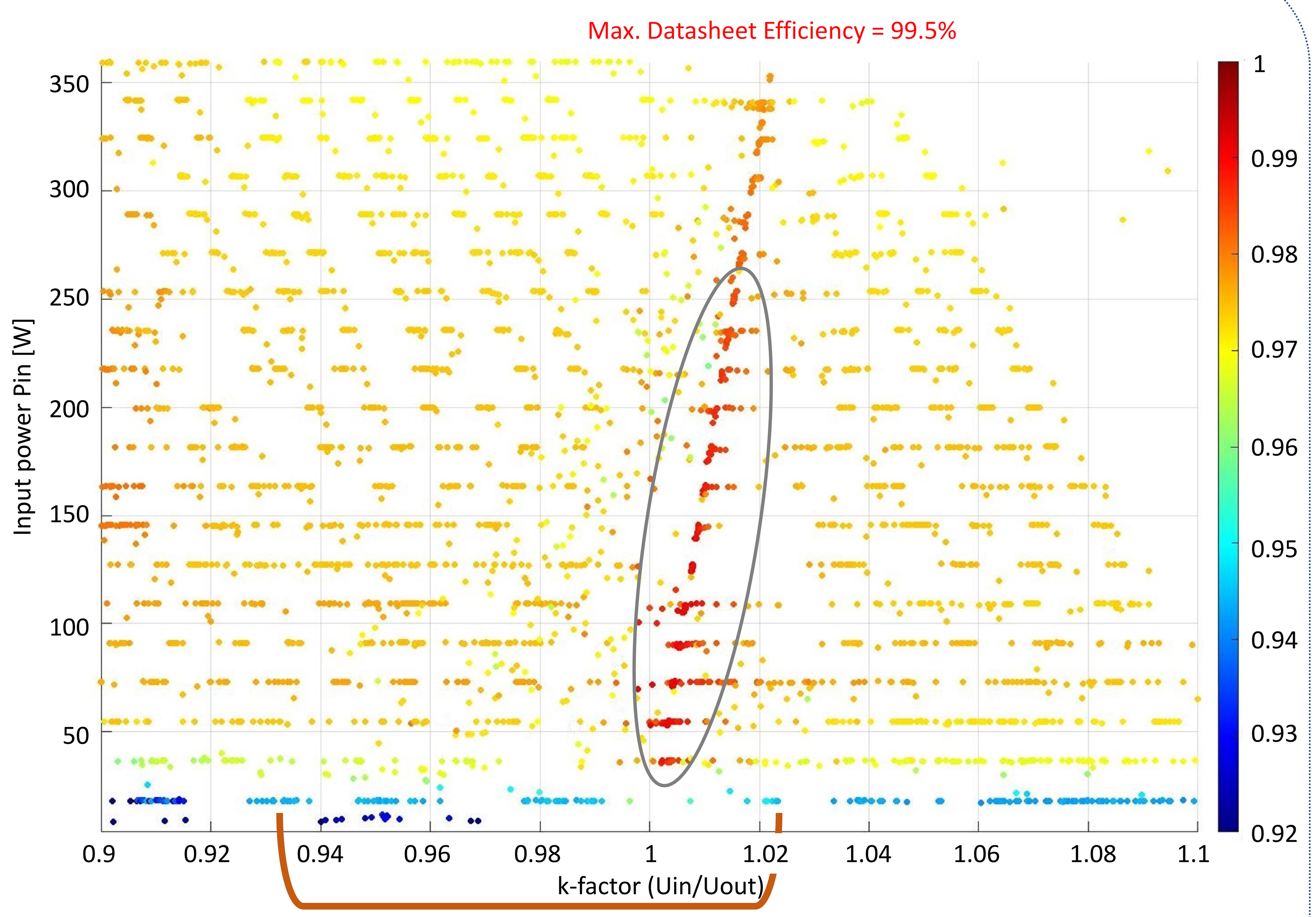

Figure 3: Static efficiencies of a SolarEdge power optimizer P370 as a function of voltage conversion ratios (measured in the laboratory)

Table 3: Yearly shading adaption efficiency (SAEta) for a 1-phase (dt = 1 min) and a 3-phase (dt = 2 min) system

Shading situation	System	1-phase system SAEta (12 modules)	3-phase system SAEta (21 modules)	3-phase system SAEta (14 modules)
Unshaded	SINV	97.7%	96.9%	96.7%
	Optimizer	96.5%	95.4%	93.0%
Chimney	SINV	96.7%	96.3%	95.7%
	Optimizer	96.5%	95.4%	94.5%
Tree	SINV	95.1%	94.9%	94.0%
	Optimizer	96.4%	95.3%	94.4%

Results

- Shading adaption efficiency comparison revealed that for the single-phase system, the optimizer system performs worse in cases without shading obstacles, achieving a SAEta 1.2% lower than the SINV. When partial shading was present, the optimizer system's efficiency was 0.2% lower (chimney) and 1.3% higher (tree) compared to the SINV.
- Results for the unshaded SAEta 1-phase simulation of the SINV (97.7%) are very close to the SINV's stated Euro efficiency (97.3%). In the MLPE System's case, the unshaded 1-phase simulation SAEta of 96.5% is considerably below the expected weighted efficiency of the system of 97.6% (98.8% Inverter x 98.8% Optimizer = 97.6% Total System).
- The three-phase system performed similarly to the 1-phase system, achieving a lower SAEta for the MLPE system of 1.5% (unshaded) and 0.9% (chimney) and a 0.4% SAEta gain when partially shaded by the tree (measurement uncertainty ±0.3%, k=1).
- In addition to testing both systems with an optimal number of modules, SAEta for a suboptimal number of modules (14) was also calculated. The MLPE system performed worse than the SINV in the unshaded and chimney cases (3.7% and 1.2% lower SAEta respectively) and slightly better when partially shaded by the tree (0.4% SAEta increase).
- Figure 3 reveals how all measured SolarEdge P370 optimizer efficiencies at 99% or above (maximum datasheet efficiency = 99.5%) occurred at voltage conversion factors when the power optimizer was not in pulse-width modulation (PWM) mode, but rather just conducting.

[1] C. Allenspach, F. Baumgartner, V. Gonzalez de Echavarri Castro, S. Richter, C. Meier, and C. Carigiet, "MODULE-LEVEL POWER ELECTRONICS UNDER INDOOR PERFORMANCE TESTS," 37th European Photovoltaic Solar Energy Conference and Exhibition (EUPVSEC).

[2] F. Baumgartner, R. Vogt, C. A. Allenspach, and F. Carigiet, "Performance analysis of shaded PV module power electronic systems," presented at the 38th European Photovoltaic Solar Energy Conference and Exhibition (EUPVSEC), Sep. 2021. doi: 10.21256/zhaw-23261.

[3] M. Littwin, F. Baumgartner, Mi. Green, and W. van Sark, "Performance of New Photovoltaic System Designs," *Int. Energy Agency - Photovolt. Power Syst. Programme*, p. 89, Apr. 2021.

[4] F. Baumgartner, "Effizienzvergleich PV-String-Inverter versus dezentrale PV-Modulelektronik ", *presentation at 18th Swiss National PV Conference*, Lausanne, Mar. 2020, (presentation available online: https://youtu.be/yKz-zbxijFU) see also bulletin.ch p. 62, 5 / 2021.

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