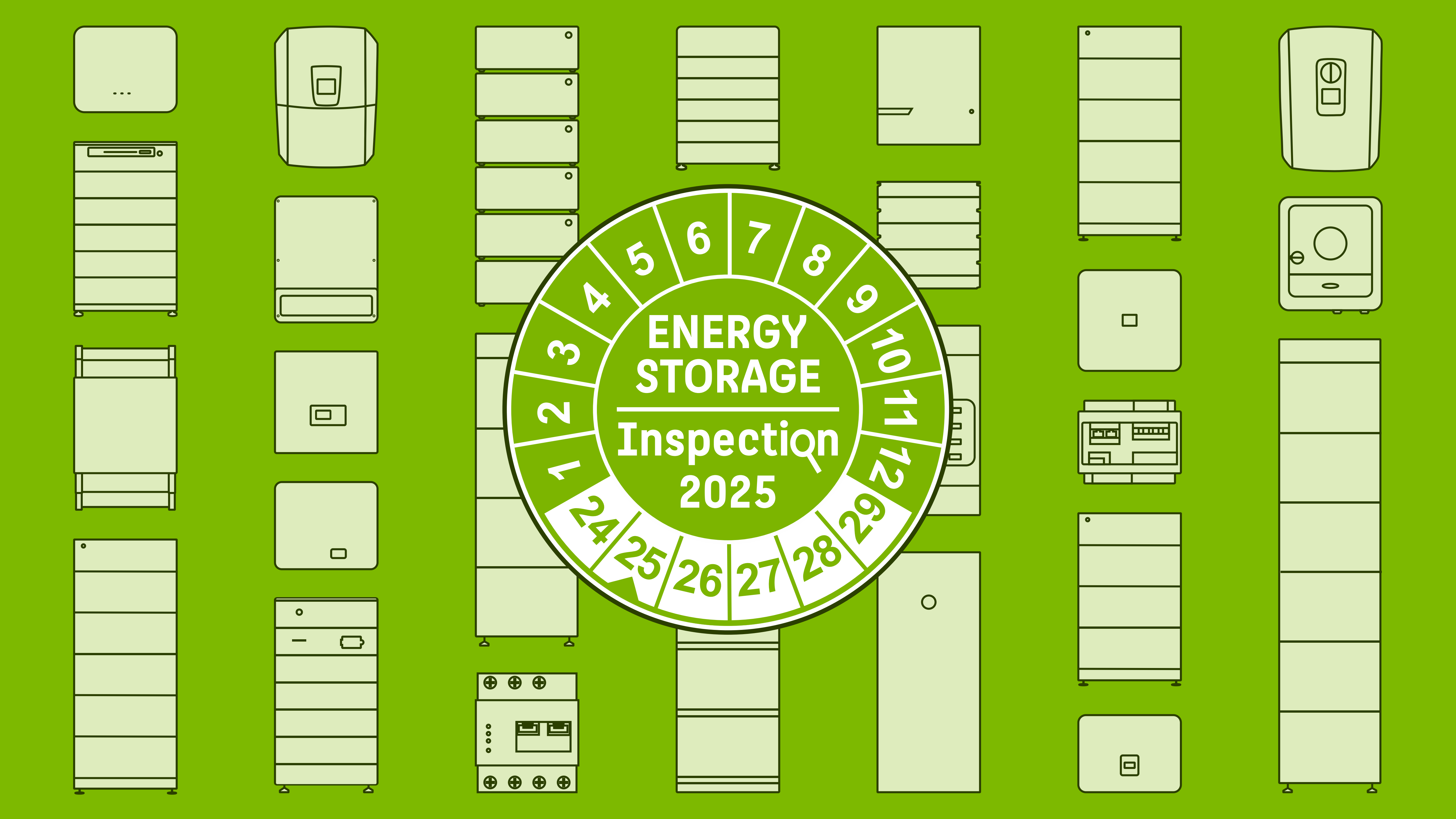

ENERGY STORAGE
Inspection
2025
1 2 3 4 5 6 7 8 9 10 11 12
24 25 26 27 28 29

ENERGY STORAGE Inspection

Hochschule für Technik und Wirtschaft Berlin
University of Applied Sciences

Forschungsgruppe
SOLARSPEICHERSYSTEME

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Research study

Energy Storage Inspection 2025

Authors

Dr.-Ing. Johannes Weniger
Nico Orth
Lucas Meissner

Research Group – Solar Storage Systems
HTW Berlin – University of Applied Sciences

Version

Version 1.0 (February 2025)

Web

solar.htw-berlin.de/inspection

Manufacturers who participated in the Energy Storage Inspection 2025

Energy efficiency benchmarking

BYD
Dyness
energy depot
FOX ESS
Fronius
GOODWE Smart Energy Innovator
KOSTAL
Miba Miba Battery Systems
PYLONTECH
RCT power
SAX SAX Power GmbH
VARTA

and 5 anonymously participating companies

Energy management benchmarking

FENECON
KOSTAL
RCT power
sonnen

and 2 anonymously participating companies

ENERGY STORAGE Inspection 2025

All test results can be found here: solar.htw-berlin.de/inspection

The most efficient PV-battery systems 2025

5 kW class	Rank	10 kW class
RCT POWER Power Storage DC 6.0 and Power Battery 7.6	1	**RCT POWER** Power Storage DC 10.0 and Power Battery 11.5
FRONIUS Primo GEN24 6.0 Plus and **BYD** Battery-Box HVS 7.7	2	**ENERGY DEPOT** Centurio 10 and DOMUS 2.5
KOSTAL PLENTICORE plus G2 5.5 and **BYD** Battery-Box HVS 7.7	3	**FRONIUS** Symo GEN24 10.0 Plus and **BYD** Battery-Box HVS 10.2

Energy Storage Inspection 2025: The efficiency benchmark of 21 PV-battery systems is based on the System Performance Index SPI.
All test results can be found here: solar.htw-berlin.de/inspection

ENERGY STORAGE Inspection 2025

New participants with outstanding efficiency

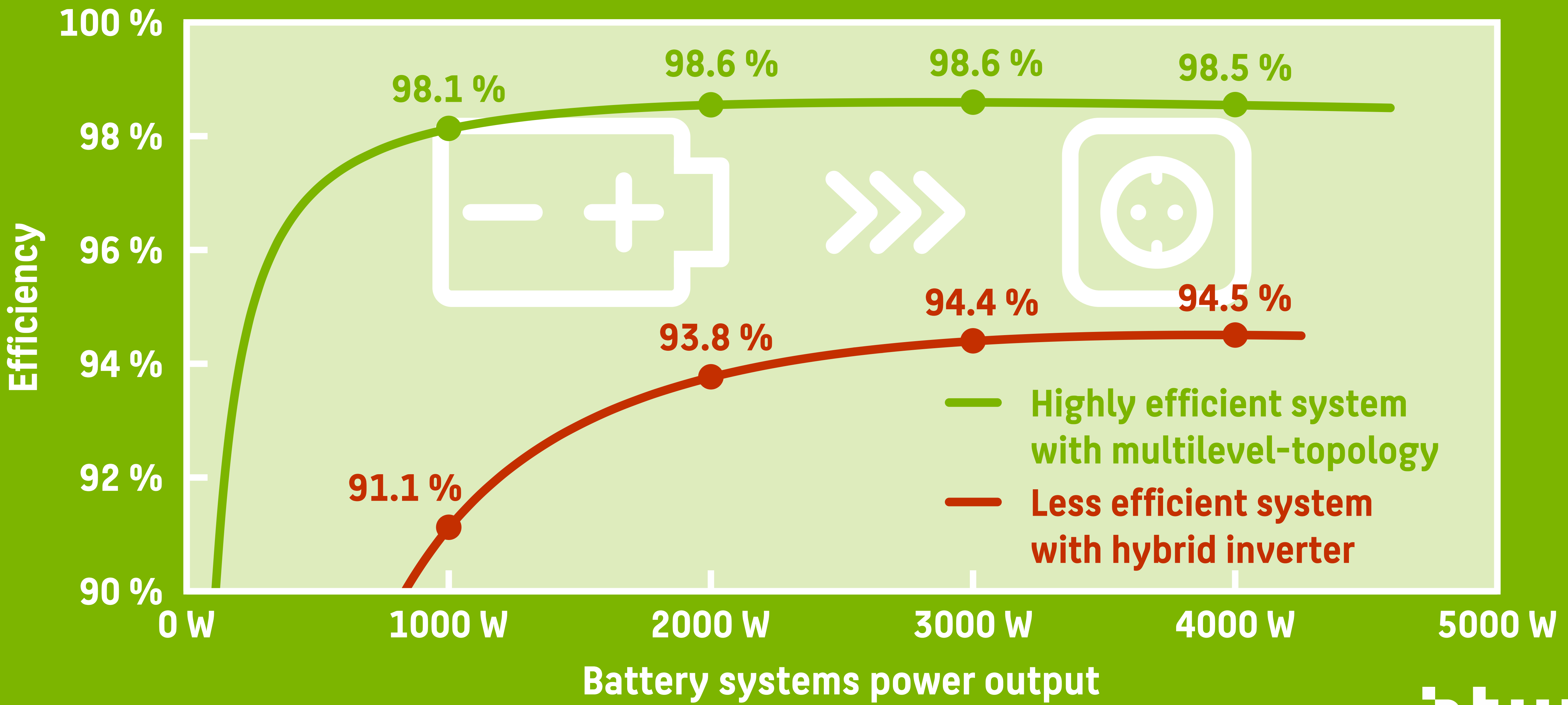
Class	System	SPI (10 kW)
A	**FRONIUS** Symo GEN24 12.0 Plus SC and **BYD** Battery-Box HVS 12.8	95.2 %
A	**KOSTAL** PLENTICORE G3 M 10 and **BYD** Battery-Box HVS 12.8	95.1 %
A	**FOX ESS** H3-10.0-Smart and ECS2900-H6	94.8 %
B	PV-battery system from an anonymously participating manufacturer	94.0 %
B	PV-battery system from an anonymously participating manufacturer	93.7 %

Outstanding: Rating of the energy efficiency with the System Performance Index SPI (10 kW) above 93.5 % (efficiency classes A and B).

All test results can be found here: solar.htw-berlin.de/inspection

htw

Significant differences of the conversion efficiency during discharging



Conversion efficiency of two battery systems in discharge mode. Data: KIT

More information about the Energy Storage Inspection 2025: solar.htw-berlin.de/inspection

Large differences in efficiency between hybrid inverters

How efficient are the inverters if only 100 watts are consumed during the night?

	Battery (DC)	Efficiency (DC/AC)	Output (AC)
RCT POWER Power Storage DC 10.0	116 W	86 %	100 W
FRONIUS Symo GEN24 12.0 Plus SC	132 W	76 %	100 W
KOSTAL PLENTICORE G3 M 10	152 W	66 %	100 W
GOODWE GW10K-ET-20	159 W	63 %	100 W
Less efficient system with hybrid inverterr	186 W	54 %	100 W

Note: The efficiency of hybrid inverters depends on the battery voltage, which varied between 195 V and 520 V depending on the system.

Data: AIT and KIT. All results from HTW Berlin and the Energy Storage Inspection 2025 can be found here: solar.htw-berlin.de/inspection

Home energy management systems of six manufacturers under study

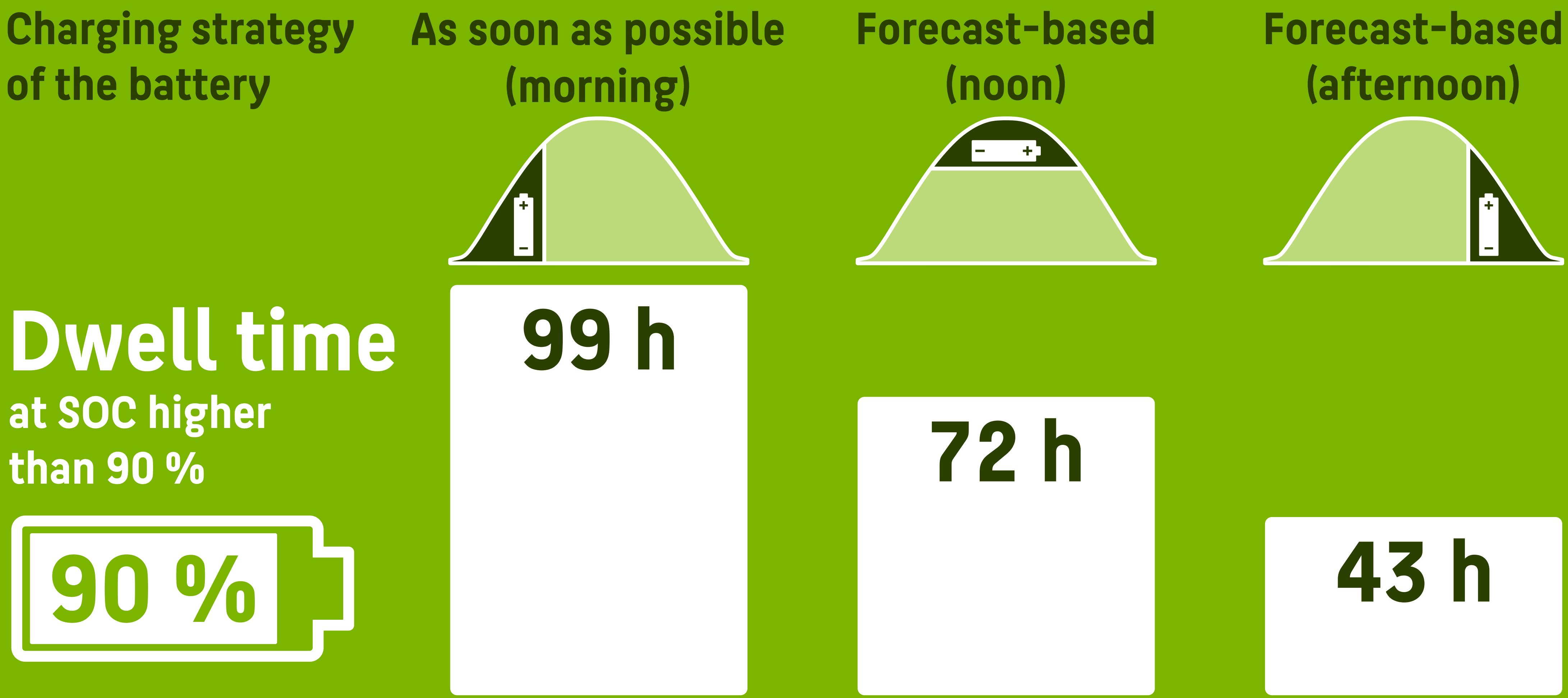
Feature	Anonymous	Anonymous	sonnen	FENECON	KOSTAL	RCT power
Implementation of online weather forecasts	✓	✓	✓			
PV power forecast based on historical data				✓	✓	✓
Individual energy management settings[1)]		✓		✓		
Charging schedule is created locally or on the company server	server	local	server	local	local	local
Updates of the charging schedule	10 min	n/s	1 h	1 s	1 h	30 min
Optimized charging strategy to slow down ageing of the battery		✓		✓		

1) with regard to the forecast-based charging strategy

All results of the energy management test of KIT and HTW Berlin can be found in the Energy Storage Inspection 2025: solar.htw-berlin.de/inspection

htw

Spending less time at a high state of charge extends battery lifetime



If a lithium-ion-battery spends less time fully charged, ageing effects slow down.

Data: Measurement of a 7-kWh-battery over 240 hours with different energy management strategies.
All results of the energy management test of KIT and HTW Berlin can be found in the Energy Storage Inspection 2025: solar.htw-berlin.de/inspection

Features of an outstanding PV-battery system energy management

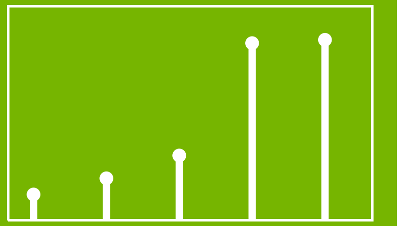
Prosumers with PV systems should have a battery that...

- ☐ delays charging in the morning on sunny days.
- ☐ charges around noon to mitigate solar generation peaks.
- ☐ reaches the fully charged state in the afternoon rather than early in the day.
- ☐ minimizes dwell time spent at a high state of charge to reduce battery ageing.
- ☐ updates its charging schedule regularly.
- ☐ quickly responds to fluctuations in solar generation and residential load.
- ☐ provides an accurate state of charge estimate to the energy management system.

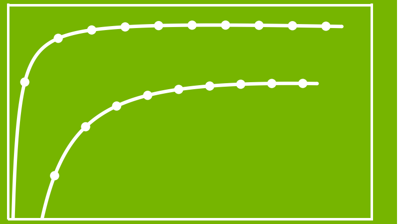
All results of the energy management test of KIT and HTW Berlin can be found in the Energy Storage Inspection 2025: solar.htw-berlin.de/inspection

Main topics of the Energy Storage Inspection 2025

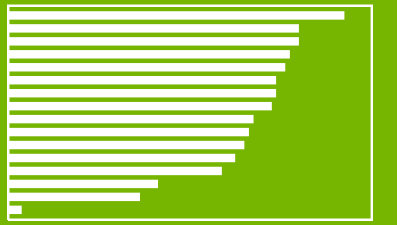
1 Analysis of the German market for residential PV-battery systems



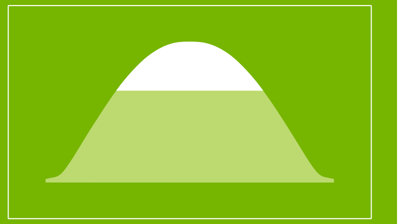
2 Comparison of the system properties based on the test reports according to the Efficiency Guideline



3 Simulation-based assessment of the PV-battery systems with the System Performance Index (SPI)



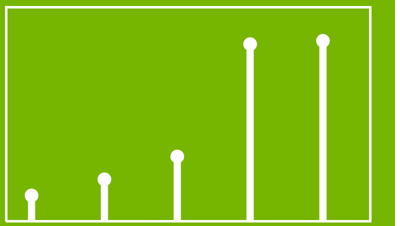
4 Comparison of forecast-based energy management strategies of multiple PV-battery systems



htw

Main topics of the Energy Storage Inspection 2025

1 Analysis of the German market for residential PV-battery systems



2 Comparison of the system properties based on the test reports according to the Efficiency Guideline

3 Simulation-based assessment of the PV-battery systems with the System Performance Index (SPI)

4 Comparison of forecast-based energy management strategies of multiple PV-battery systems

Presence of climate friendly technologies in Germany

January 2025

installed battery systems[1)]

> 1.7 million

registered battery electric vehicles

> 1.8 million

installed heat pumps

> 2.0 million

residential pv systems[2)]

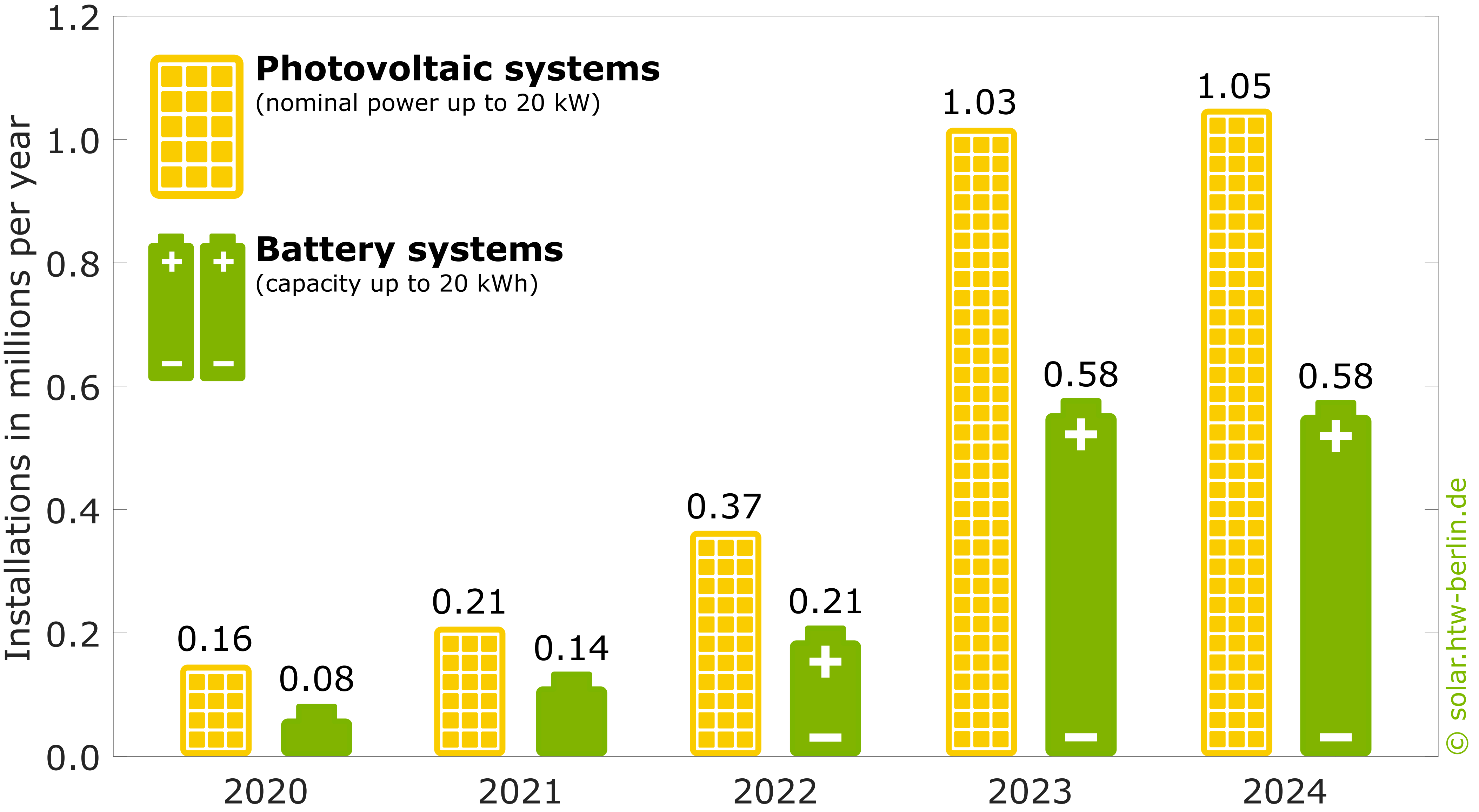
> 3.4 million

residential buildings in Germany

> 16.3 miilion

1) Battery systems with a capacity under 20 kWh. 2) PV systems with a nominal power between 2 kW and 20 kW.
Data: German Federal Network Agency (BNetzA), German Federal Motor Transport Authority (KBA), German Heat Pump Association, Federal Statistical Office

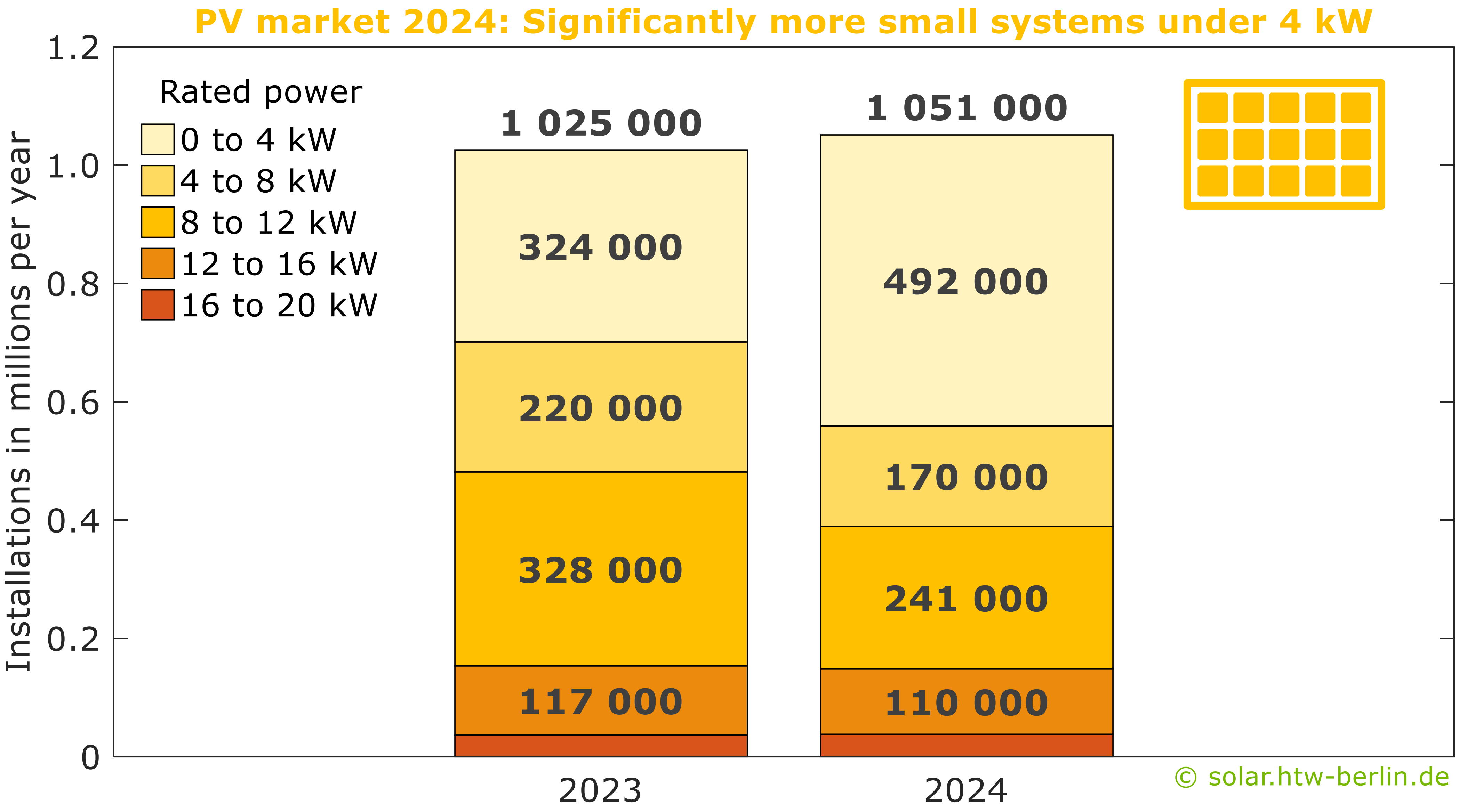
Development of the PV-battery market in Germany



Data: German Federal Network Agency, February 1, 2025

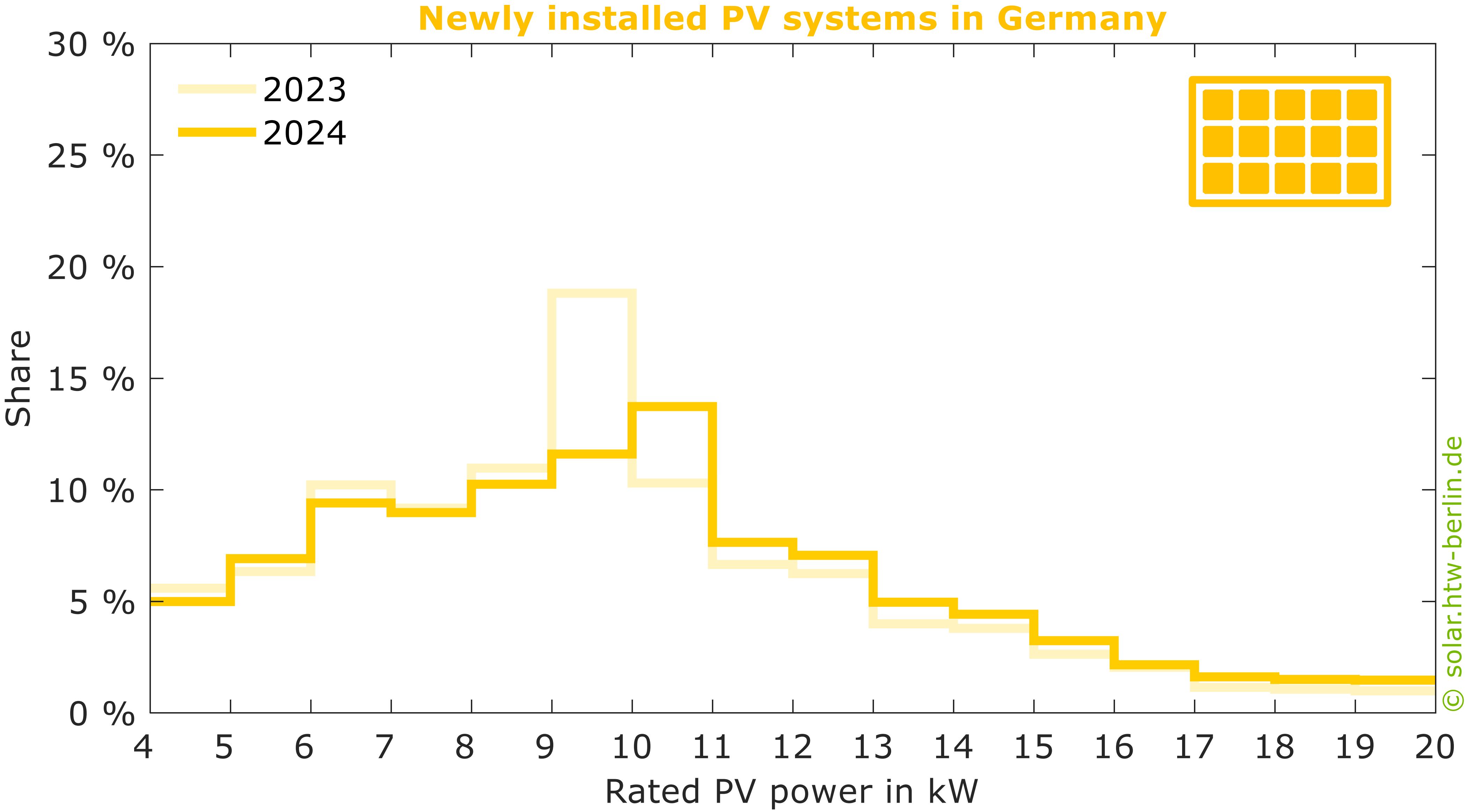
htw

The residential PV market in Germany



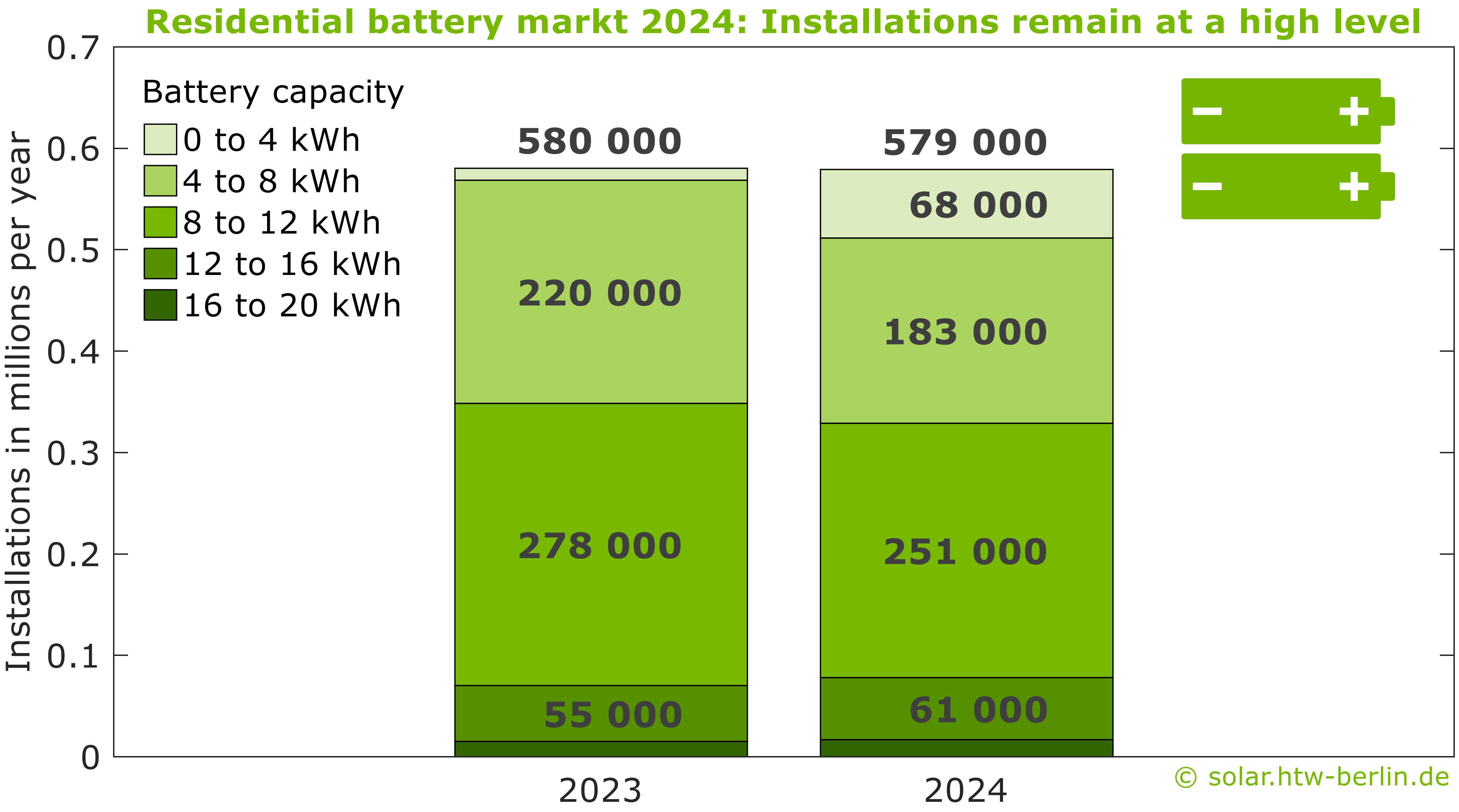
Data: German Federal Network Agency, class width: 4 kW, February 1, 2025

Rated power of the PV-systems between 4 kW and 20 kW



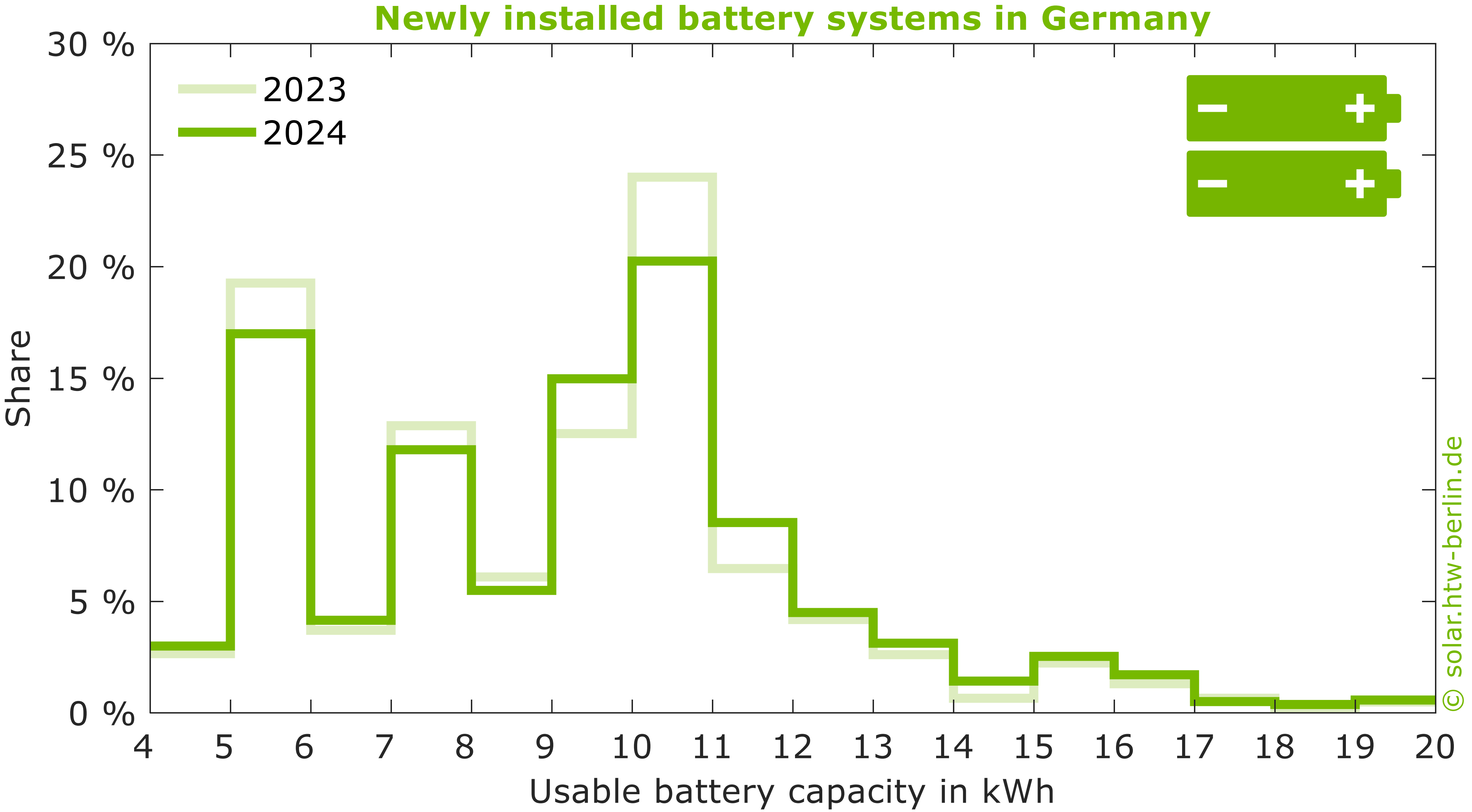
Data: German Federal Network Agency, PV systems between 4 kW and 20 kW, class width: 1 kW, February 1, 2025

The residential battery system market in Germany



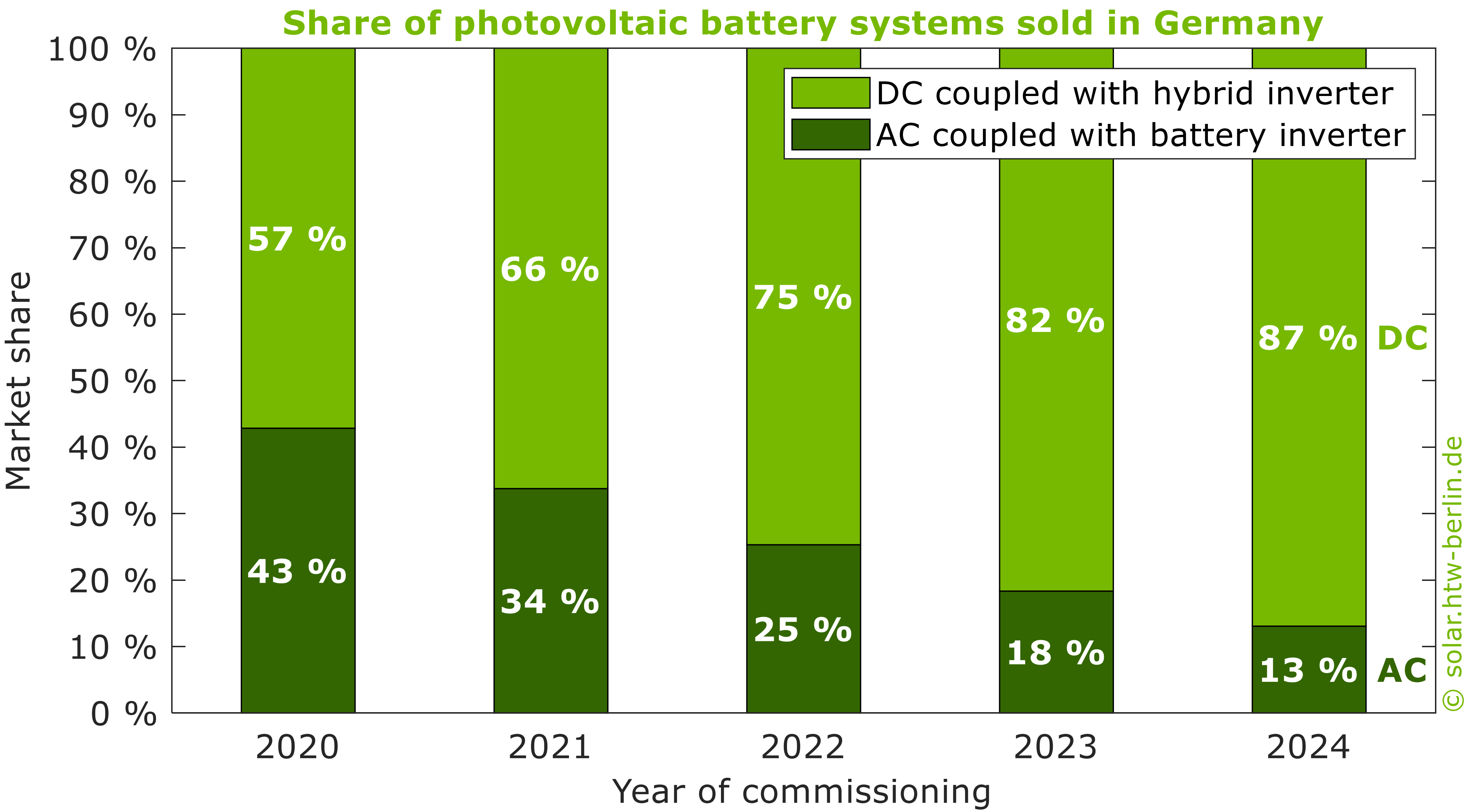
Data: German Federal Network Agency, class width: 4 kWh, February 1, 2025

Usable capacity of the battery systems between 4 kWh and 20 kWh



Data: German Federal Network Agency, battery systems between 4 kWh and 20 kWh, class width: 1 kW, February 1, 2025

System topologies of the PV-battery systems in Germany



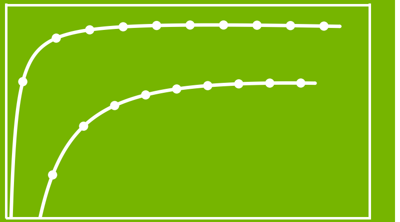
Data: German Federal Network Agency, battery systems between 4 kWh and 20 kWh, February 1, 2025

image: AIT

Main topics of the Energy Storage Inspection 2025

1 Analysis of the German market for residential PV-battery systems

2 Comparison of the system properties based on the test reports according to the Efficiency Guideline



3 Simulation-based assessment of the PV-battery systems with the System Performance Index (SPI)

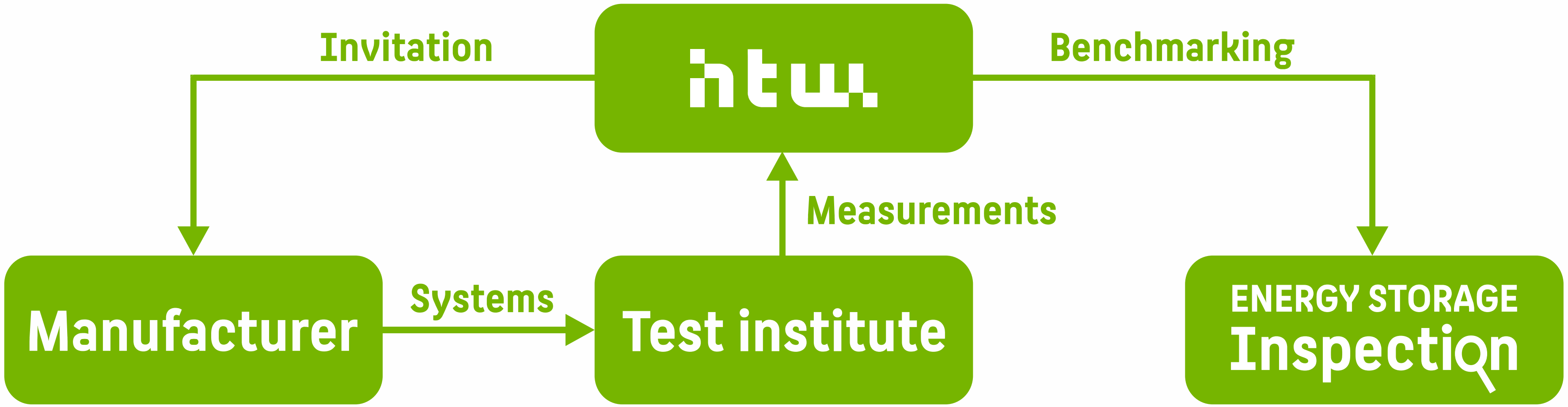
4 Comparison of forecast-based energy management strategies of multiple PV-battery systems

Participants of the Energy Storage Inspection 2025

- For the eighth consecutive year, all manufacturers of systems or components for solar electricity storage in residential buildings were invited to participate in the **Energy Storage Inspection 2025**.
- **17 manufacturers** took part in the Energy Storage Inspection 2025 with laboratory measurements from a total of **22 systems.**
- Two of those systems were purchased **independently**.
- Five manufacturers decided to **participate anonymously**.
- The following 12 manufacturers are contributing to **greater transparency** in the home storage market by participating by name.

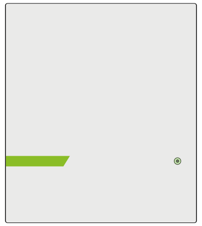
Analysis of system properties according to the Efficiency Guideline

- Laboratory tests were conducted by **independent testing institutes** following the "**Efficiency Guideline for PV Storage Systems**".
- To each analyzed system, a **system abbreviation** (e.g. A1) was assigned.
- The batteries of the **AC-coupled systems** A1 and C1 are equipped with battery inverters. The **DC-coupled systems** C2 to M1 have so-called hybrid inverters. System N1 is just a battery.
- Details about the **methodology** can be found in the Energy Storage Inspections 2018 and 2023.



Analyzed systems in the Energy Storage Inspection 2025

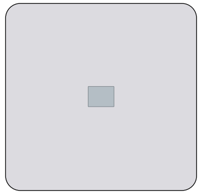
A1 ENERGY STORAGE Inspection 2025



VARTA pulse neo 6

Battery connection	AC
Battery Capacity	5.8 kWh
Discharge power	2.3 kW
PV output power	-
Efficiency class	B

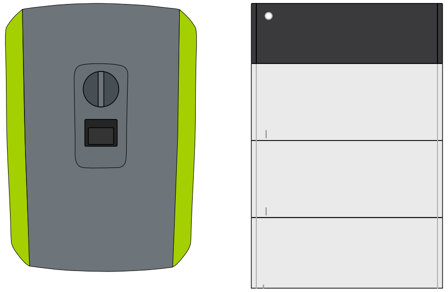
B1 ENERGY STORAGE Inspection 2025



SAX Power Home Plus

Battery connection	AC
Battery Capacity	6.2 kWh
Discharge power	4.6 kW
PV output power	-
Efficiency class	B

C1 ENERGY STORAGE Inspection 2025

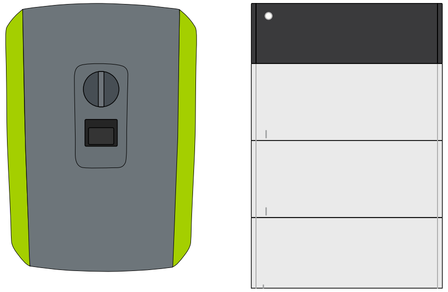


KOSTAL PLENTICORE BI G2 10/26 and BYD Battery-Box Premium HVS 12.8

Battery connection	AC
Battery Capacity	12.0 kWh
Discharge power	10.1 kW
PV output power	-
Efficiency class	B

Analyzed systems in the Energy Storage Inspection 2025

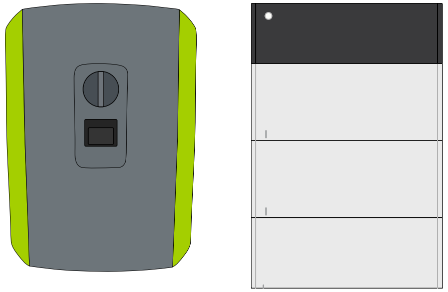
C2 ENERGY STORAGE Inspection 2025



KOSTAL PLENTICORE plus G2 5.5 and BYD Battery-Box Premium HVS 7.7

Battery connection	DC
Battery Capacity	7.1 kWh
Discharge power	3.8 kW
PV output power	5.5 kW
Efficiency class	B

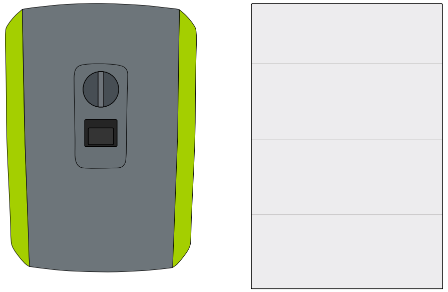
C3 ENERGY STORAGE Inspection 2025



KOSTAL PLENTICORE plus G2 10 and BYD Battery-Box Premium HVS 12.8

Battery connection	DC
Battery Capacity	11.9 kWh
Discharge power	6.3 kW
PV output power	10.0 kW
Efficiency class	A

C4 ENERGY STORAGE Inspection 2025

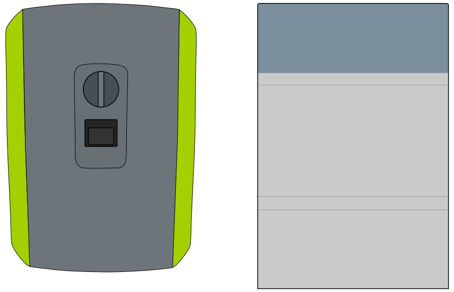


KOSTAL PLENTICORE plus G2 10 and DYNESS Tower T14

Battery connection	DC
Battery Capacity	13.5 kWh
Discharge power	4.8 kW
PV output power	10.0 kW
Efficiency class	B

Analyzed systems in the Energy Storage Inspection 2025

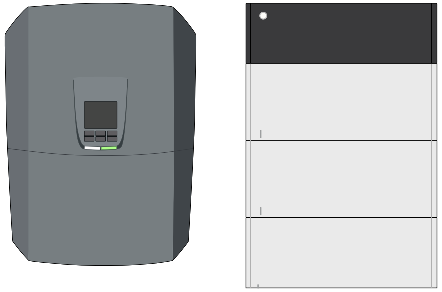
C5 ENERGY STORAGE Inspection 2025



KOSTAL PLENTICORE plus G2 10 and PYLONTECH Force H2

Battery connection	DC
Battery Capacity	13.6 kWh
Discharge power	4.8 kW
PV output power	10.0 kW
Efficiency class	B

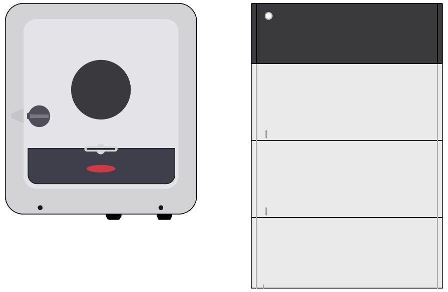
C6 ENERGY STORAGE Inspection 2025



KOSTAL PLENTICORE G3 M 10 and BYD Battery-Box Premium HVS 12.8

Battery connection	DC
Battery Capacity	11.9 kWh
Discharge power	10.1 kW
PV output power	10.0 kW
Efficiency class	A

D1 ENERGY STORAGE Inspection 2025

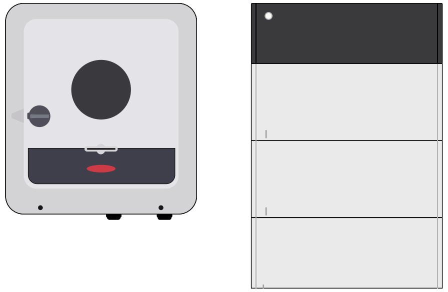


FRONIUS Primo GEN24 6.0 Plus and BYD Battery-Box Premium HVS 7.7

Battery connection	DC
Battery Capacity	7.4 kWh
Discharge power	5.8 kW
PV output power	6.1 kW
Efficiency class	A

Analyzed systems in the Energy Storage Inspection 2025

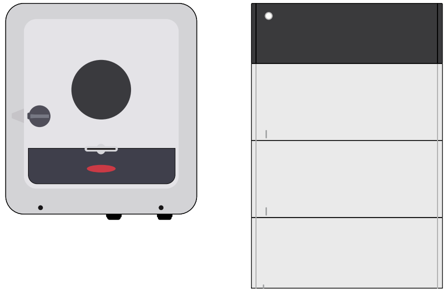
D2 ENERGY STORAGE Inspection 2025



FRONIUS Symo GEN24 10.0 Plus and BYD Battery-Box Premium HVS 10.2

Battery connection	DC
Battery Capacity	9.9 kWh
Discharge power	8.9 kW
PV output power	10.2 kW
Efficiency class	A

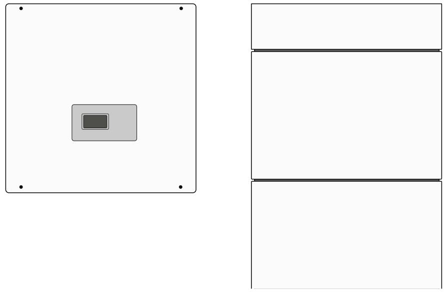
D3 ENERGY STORAGE Inspection 2025



FRONIUS Symo GEN24 12.0 Plus SC and BYD Battery-Box Premium HVS 12.8

Battery connection	DC
Battery Capacity	12.0 kWh
Discharge power	11.1 kW
PV output power	12.1 kW
Efficiency class	A

E1 ENERGY STORAGE Inspection 2025

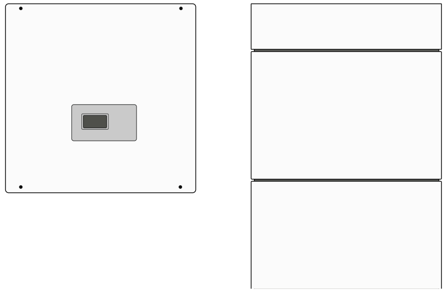


RCT POWER Power Storage DC 6.0 and Power Battery 7.6

Battery connection	DC
Battery Capacity	7.0 kWh
Discharge power	5.9 kW
PV output power	5.9 kW
Efficiency class	A

Analyzed systems in the Energy Storage Inspection 2025

E2 ENERGY STORAGE Inspection 2025



RCT POWER Power Storage DC 10.0 and Power Battery 11.5

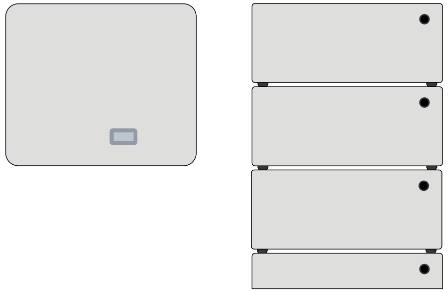
Battery connection	DC
Battery Capacity	10.6 kWh
Discharge power	9.9 kW
PV output power	10.0 kW
Efficiency class	A

F1 ENERGY STORAGE Inspection 2025

GOODWE GW10K-ET-20 and LX F16.0-H-20

Battery connection	DC
Battery Capacity	15.5 kWh
Discharge power	10.0 kW
PV output power	10.0 kW
Efficiency class	A

G1 ENERGY STORAGE Inspection 2025

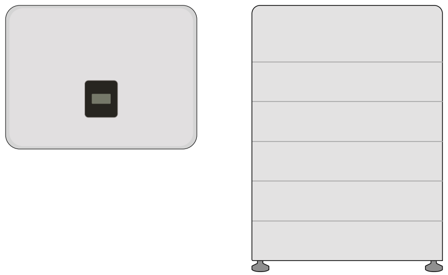


ENERGY DEPOT Centurio 10 and DOMUS 2.5

Battery connection	DC
Battery Capacity	15.1 kWh
Discharge power	7.5 kW
PV output power	10.3 kW
Efficiency class	A

Analyzed systems in the Energy Storage Inspection 2025

H1 ENERGY STORAGE Inspection 2025



FOX ESS H3-10.0-Smart and ECS2900-H6

Battery connection	DC
Battery Capacity	16.0 kWh
Discharge power	9.8 kW
PV output power	9.9 kW
Efficiency class	A

I1 ENERGY STORAGE Inspection 2025

DC-coupled system of an anonymously participating manufacturer

Battery connection	DC
Battery Capacity	13.5 kWh
Discharge power	9.1 kW
PV output power	10.2 kW
Efficiency class	B

J1 ENERGY STORAGE Inspection 2025

DC-coupled system of an anonymously participating manufacturer

Battery connection	DC
Battery Capacity	10.3 kWh
Discharge power	10.0 kW
PV output power	9.9 kW
Efficiency class	B

Analyzed systems in the Energy Storage Inspection 2025

K1 ENERGY STORAGE Inspection 2025

DC-coupled system of an anonymously participating manufacturer

Battery connection	DC
Battery Capacity	14.2 kWh
Discharge power	8.9 kW
PV output power	10.2 kW
Efficiency class	D

L1 ENERGY STORAGE Inspection 2025

DC-coupled system purchased independently

Battery connection	DC
Battery Capacity	8.9 kWh
Discharge power	4.3 kW
PV output power	9.8 kW
Efficiency class	D

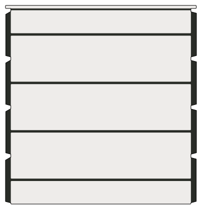
M1 ENERGY STORAGE Inspection 2025

DC-coupled system purchased independently

Battery connection	DC
Battery Capacity	9.8 kWh
Discharge power	4.8 kW
PV output power	10.0 kW
Efficiency class	G

Analyzed systems in the Energy Storage Inspection 2025

N1 ENERGY STORAGE Inspection 2025



MIBA VOLTHOME #03
(Battery storage without an inverter)

Battery connection	-
Battery Capacity	12.0 kWh
Discharge power (DC)	8.9 kW
PV output power	-
Efficiency class	-

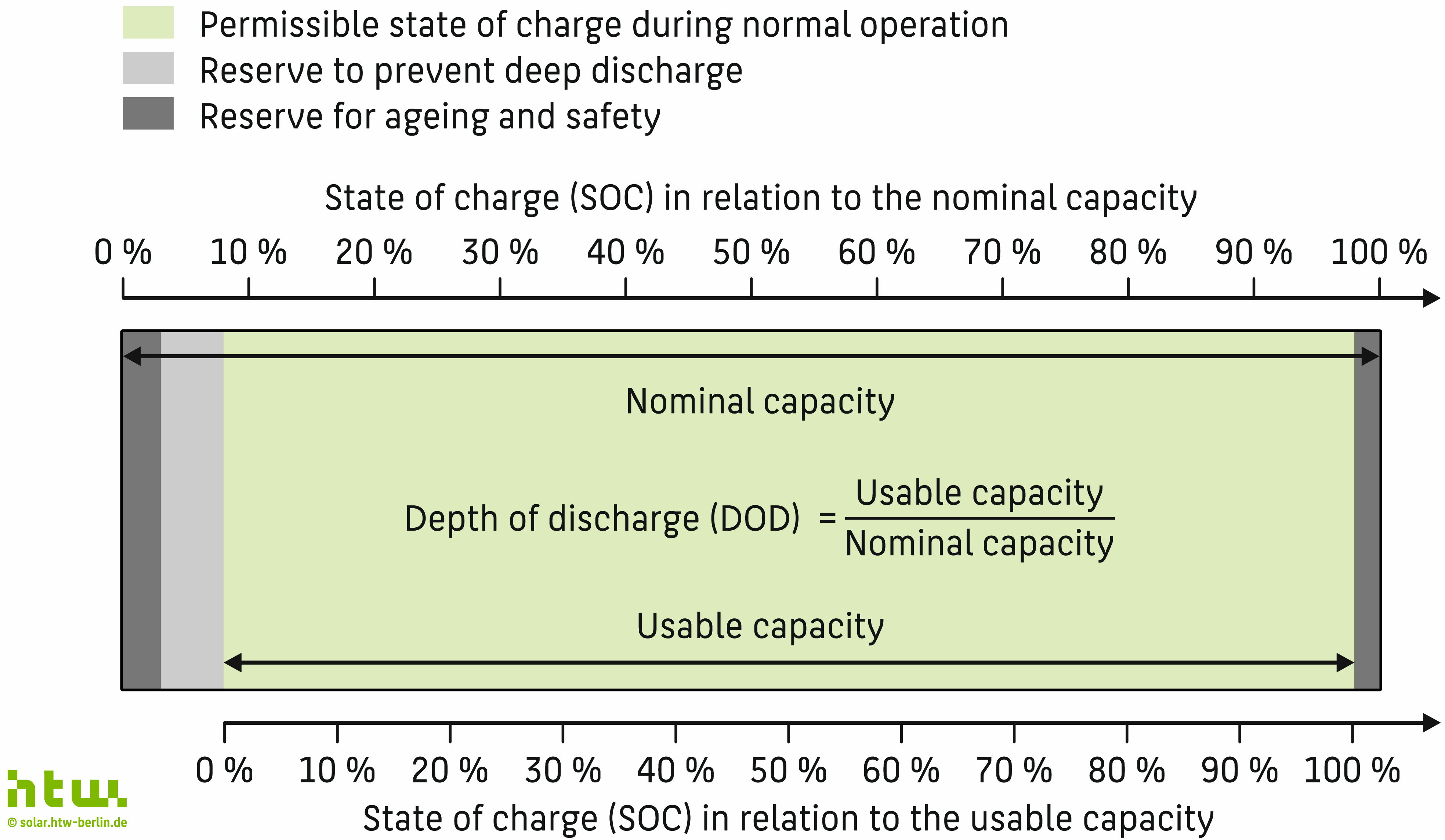
System abbreviations

System	Product name
A1	VARTA pulse neo 6
B1	SAX Power Home Plus
C1	KOSTAL PLENTICORE BI G2 10/26 and BYD Battery-Box Premium HVS 12.8
C2	KOSTAL PLENTICORE plus G2 5.5 and BYD Battery-Box Premium HVS 7.7
C3	KOSTAL PLENTICORE plus G2 10 and BYD Battery-Box Premium HVS 12.8
C4	KOSTAL PLENTICORE plus G2 10 and DYNESS Tower T14
C5	KOSTAL PLENTICORE plus G2 10 and PYLONTECH Force H2
C6	KOSTAL PLENTICORE G3 M 10 and BYD Battery-Box Premium HVS 12.8
D1	FRONIUS Primo GEN24 6.0 Plus and BYD Battery-Box Premium HVS 7.7
D2	FRONIUS Symo GEN24 10.0 Plus and BYD Battery-Box Premium HVS 10.2
D3	FRONIUS Symo GEN24 12.0 Plus SC and BYD Battery-Box Premium HVS 12.8

System abbreviations

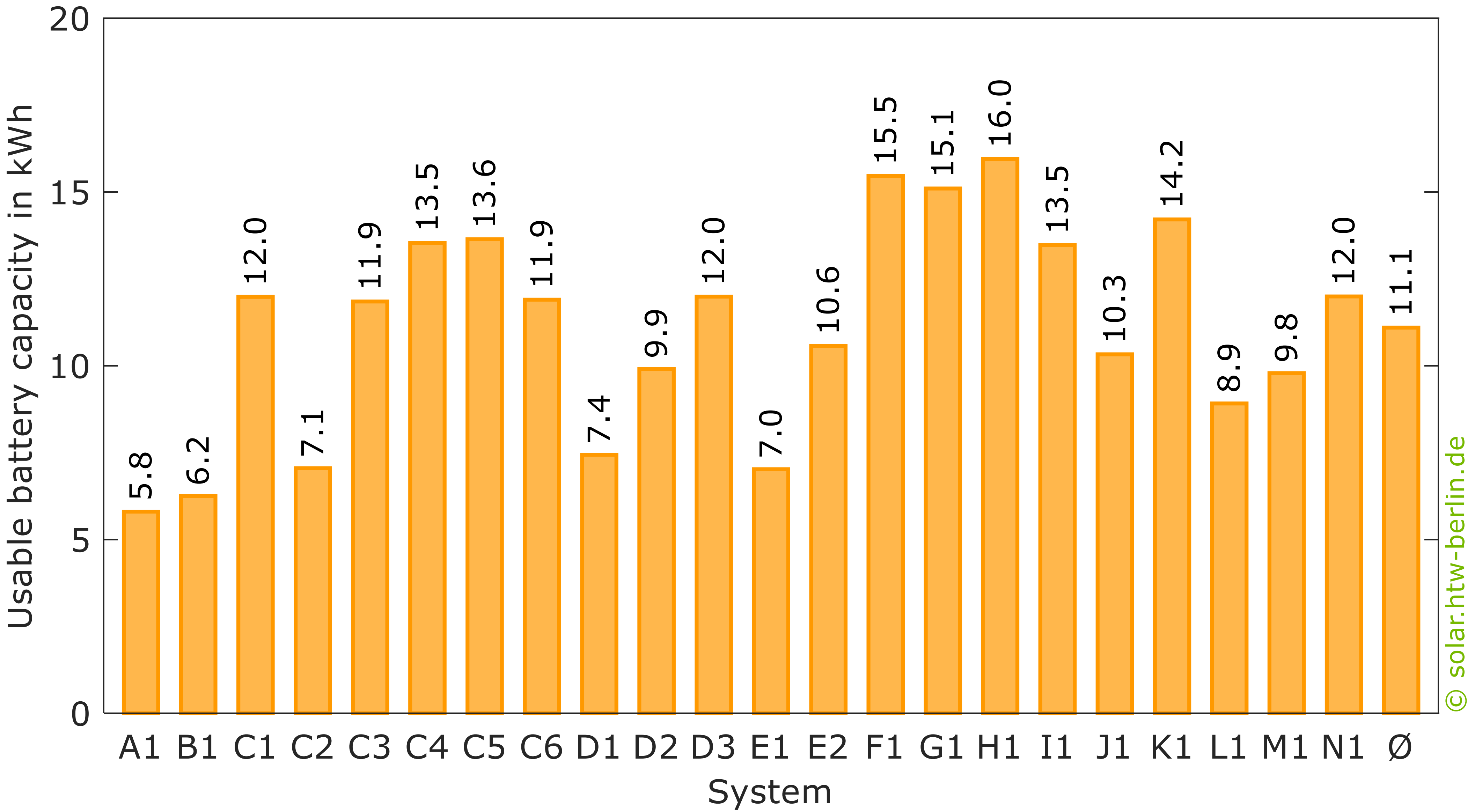
System	Product name
E1	RCT POWER Power Storage DC 6.0 and Power Battery 7.6
E2	RCT POWER Power Storage DC 10.0 and Power Battery 11.5
F1	GOODWE GW10K-ET-20 and LX F16.0-H-20
G1	ENERGY DEPOT Centurio 10 and DOMUS 2.5
H1	FOX ESS H3-10.0-Smart and ECS2900-H6
I1	DC-coupled system of an anonymously participating manufacturer
J1	DC-coupled system of an anonymously participating manufacturer
K1	DC-coupled system of an anonymously participating manufacturer
L1	DC-coupled system purchased independently
M1	DC-coupled system purchased independently
N1	MIBA VOLTHOME #03

Nominal and usable battery capacity in comparison



The permissible state of charge (SOC) range is restricted to prevent deep discharge of the battery and to account for aging and safety reserves. The values shown in the illustration are exemplary.

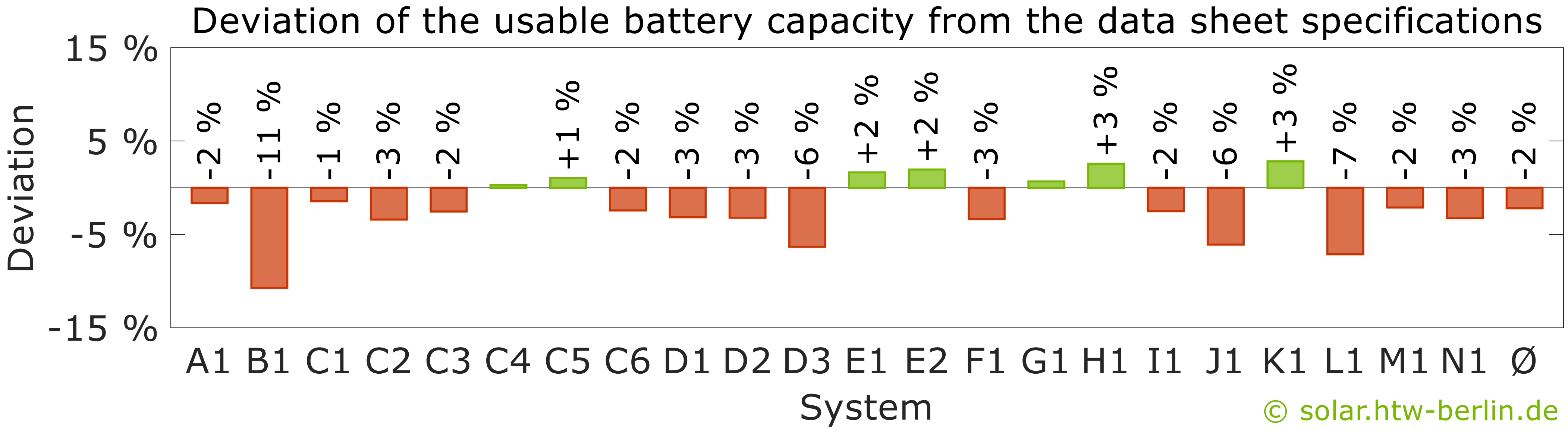
Usable battery capacity of the analyzed systems



Systems E1, E2, I1 and N1: Due to a temperature-induced derating, the test could not be run at 100 % of the nominal power.

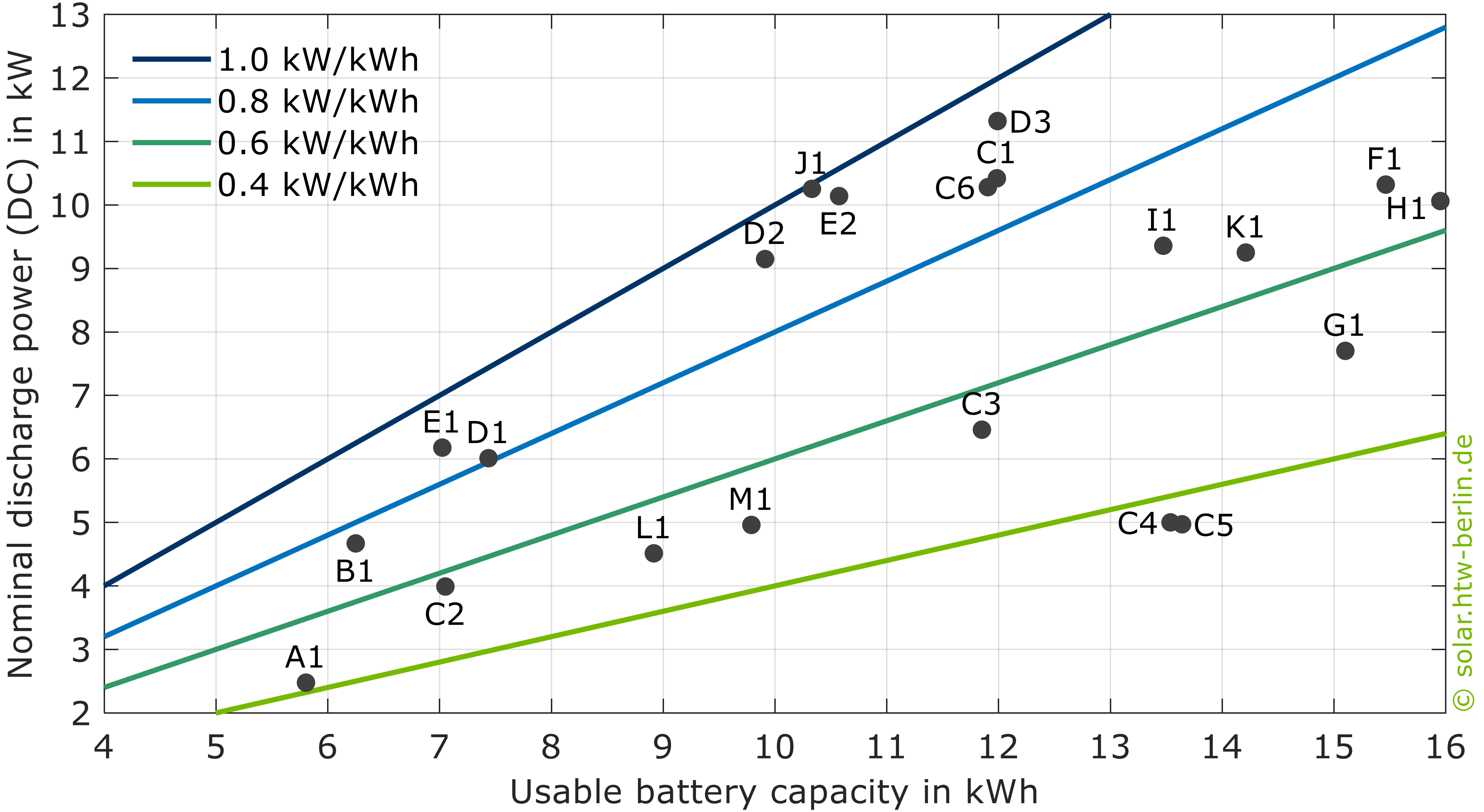
Comparison of data sheet specification and tested value

- For 15 of the 22 systems tested, **lower usable storage capacities** were determined in the laboratory test than those declared on the data sheets.
- A lower **depth of discharge (DOD)**, which protects the battery against deep discharge, is often the reason for the measured values being lower.
- The usable storage capacity of system B1 is **11 percentage points** below the value specified on the data sheet.

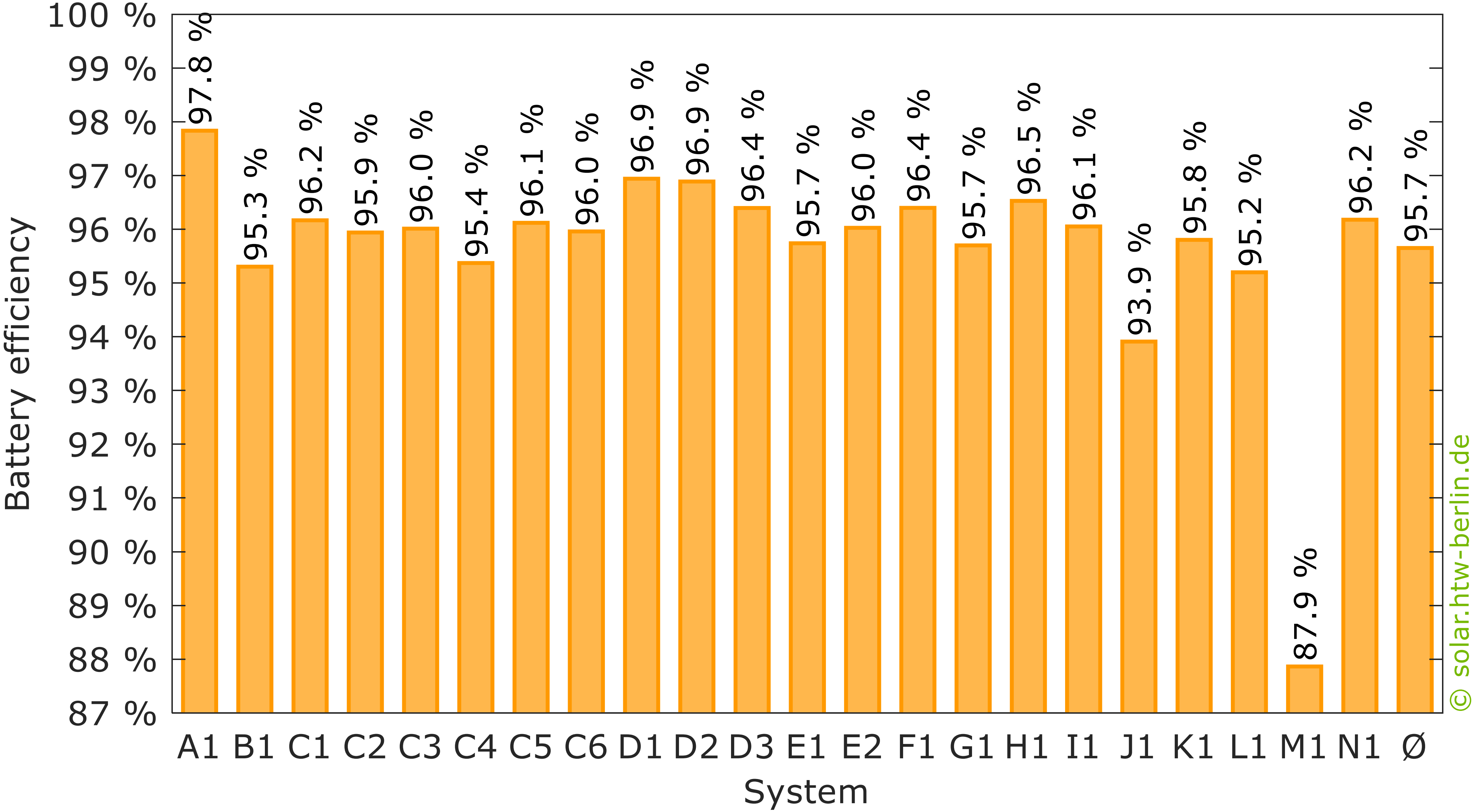


htw

Nominal discharge power of the analyzed systems

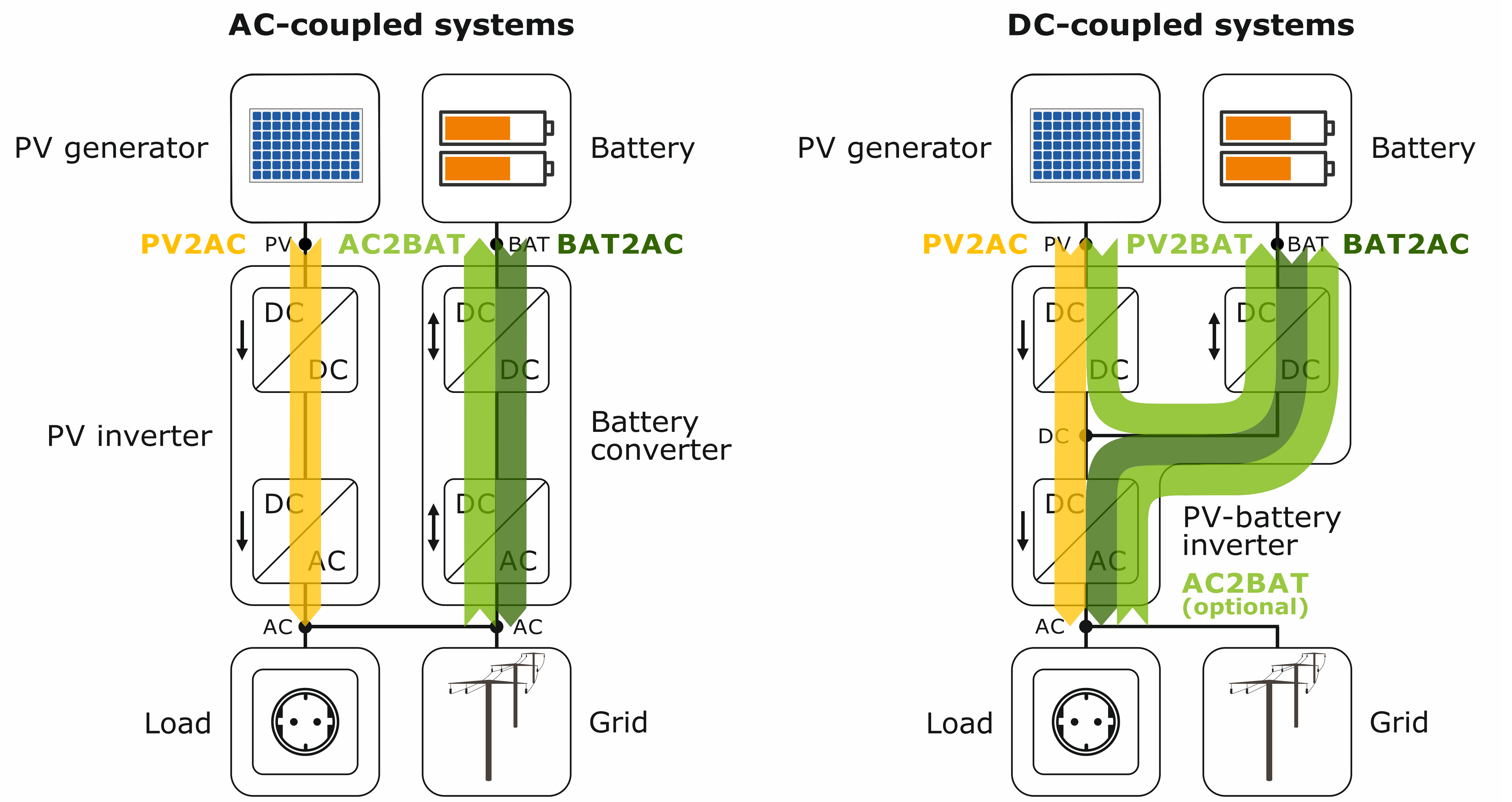


Average battery efficiency

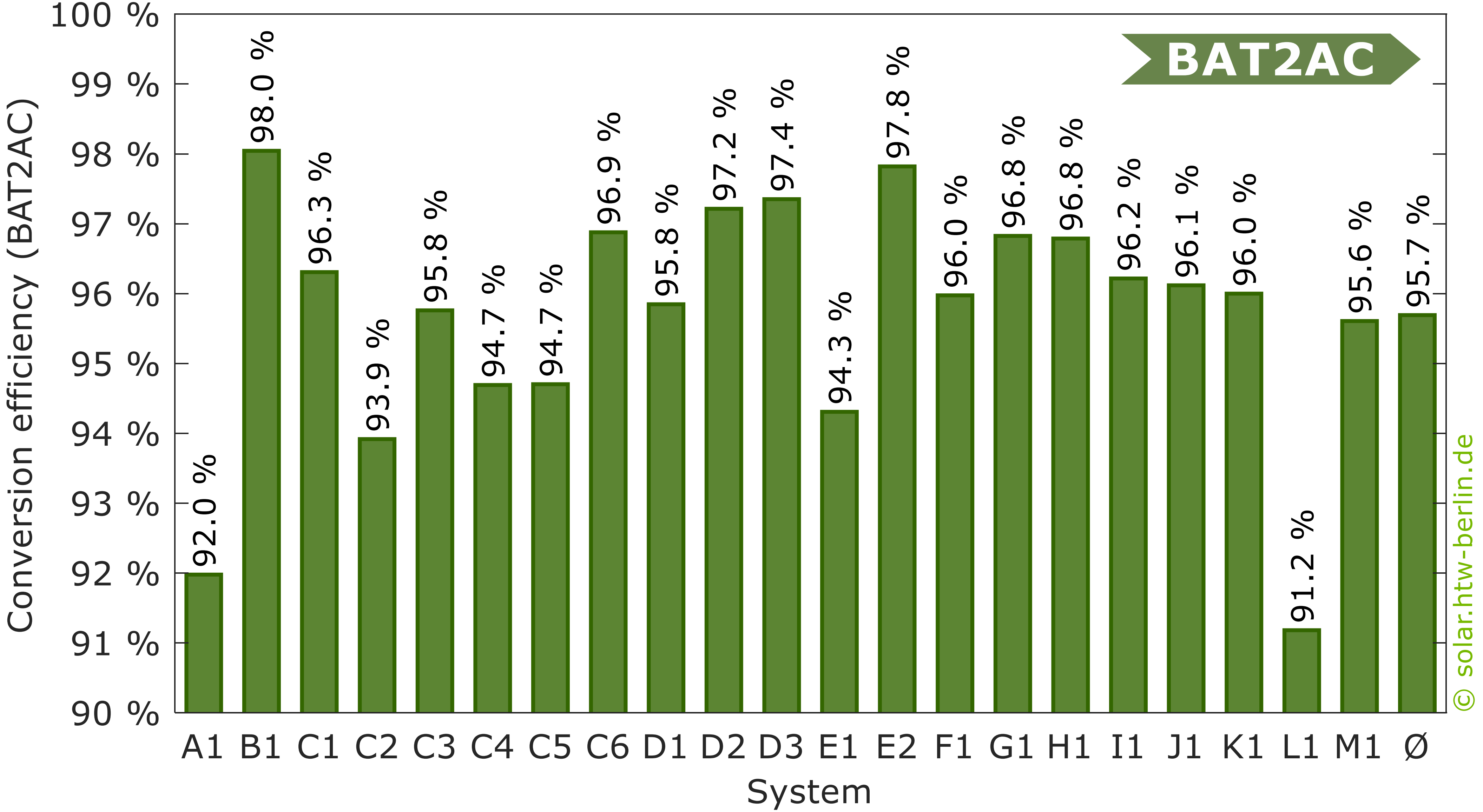


Systems E1, E2, I1 and N1: Due to a temperature-induced derating, the test could not be run at 100 % of the nominal power.

Energy conversion pathways of the different system topologies



Average conversion efficiency of AC battery discharging



Average pathway efficiencies of AC discharging according to the „Efficiency Guideline for PV Storage Systems“ 2.0.

Average efficiency of the energy conversion pathways

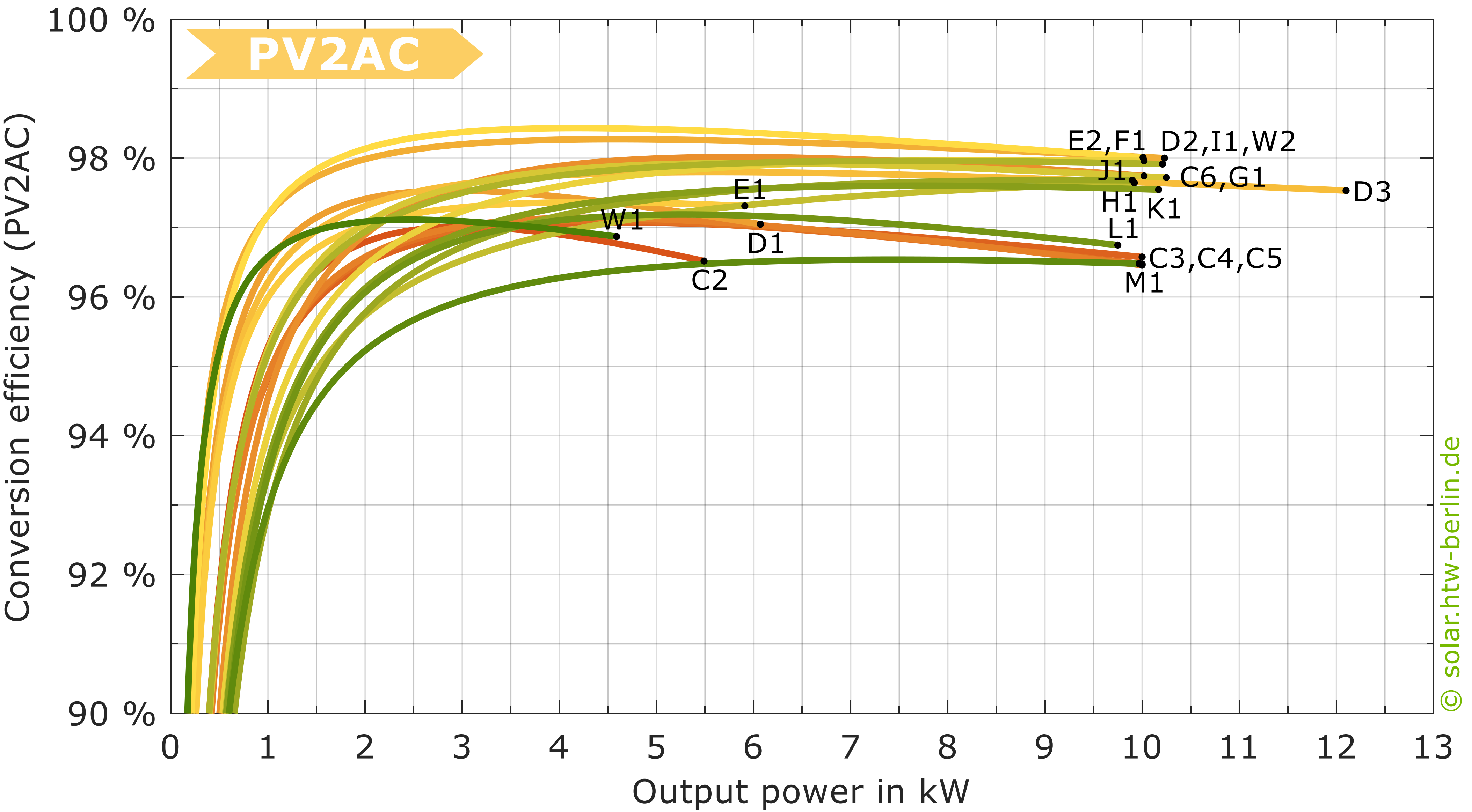
System	PV2AC PV feed-in	PV2BAT PV charging	AC2BAT AC charging	BAT2AC AC discharging
A1			92.1 %	92.0 %
B1			96.0 %	98.0 %
C1			96.1 %	96.3 %
C2	95.5 %	93.9 %		93.9 %
C3	96.3 %	95.8 %		95.8 %
C4	96.3 %	94.6 %		94.7 %
C5	96.3 %	94.6 %		94.7 %
C6	96.9 %	98.2 %		96.9 %
D1	96.6 %	96.8 %	95.6 %	95.8 %
D2	97.9 %	97.9 %	96.5 %	97.2 %
D3	97.4 %	98.0 %		97.4 %
E1	96.4 %	94.7 %	94.0 %	94.3 %
E2	97.9 %	98.1 %	97.7 %	97.8 %
F1	96.7 %	96.4 %		96.0 %
G1	97.1 %	97.4 %	96.9 %	96.8 %
H1	96.1 %	96.9 %	96.3 %	96.8 %
I1	97.1 %	96.2 %		96.2 %
J1	96.1 %	95.6 %		96.1 %
K1	96.3 %	95.8 %		96.0 %
L1	95.9 %	92.0 %		91.2 %
M1	95.4 %	95.0 %		95.6 %
Ø	96.6 %	96.0 %	95.7 %	95.7 %

Conversion pathway

Average conversion efficiency: 90 % – 98 %

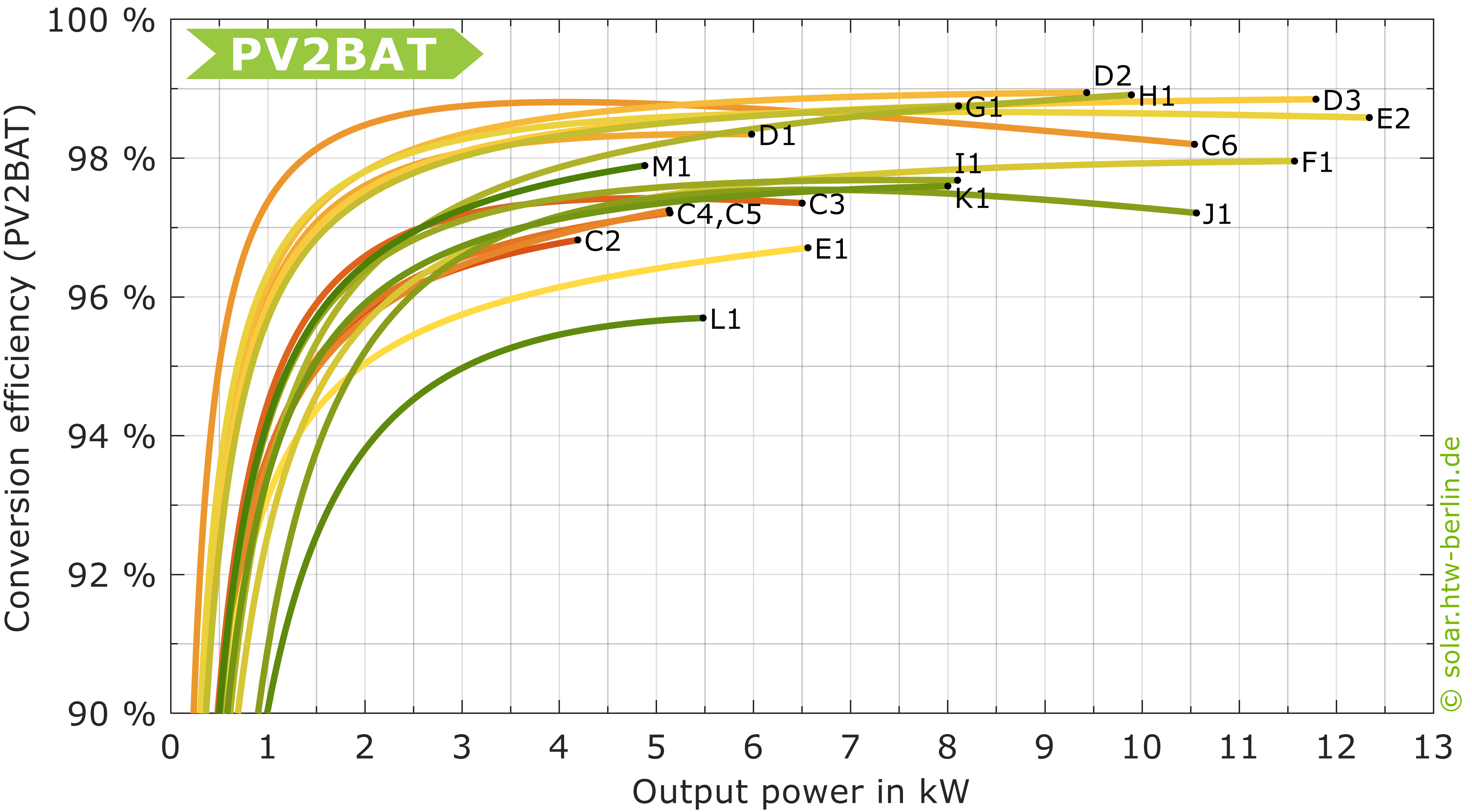
Average pathway efficiencies according to the “Efficiency Guideline for PV Storage Systems” 2.0.

PV feed-in pathway efficiency

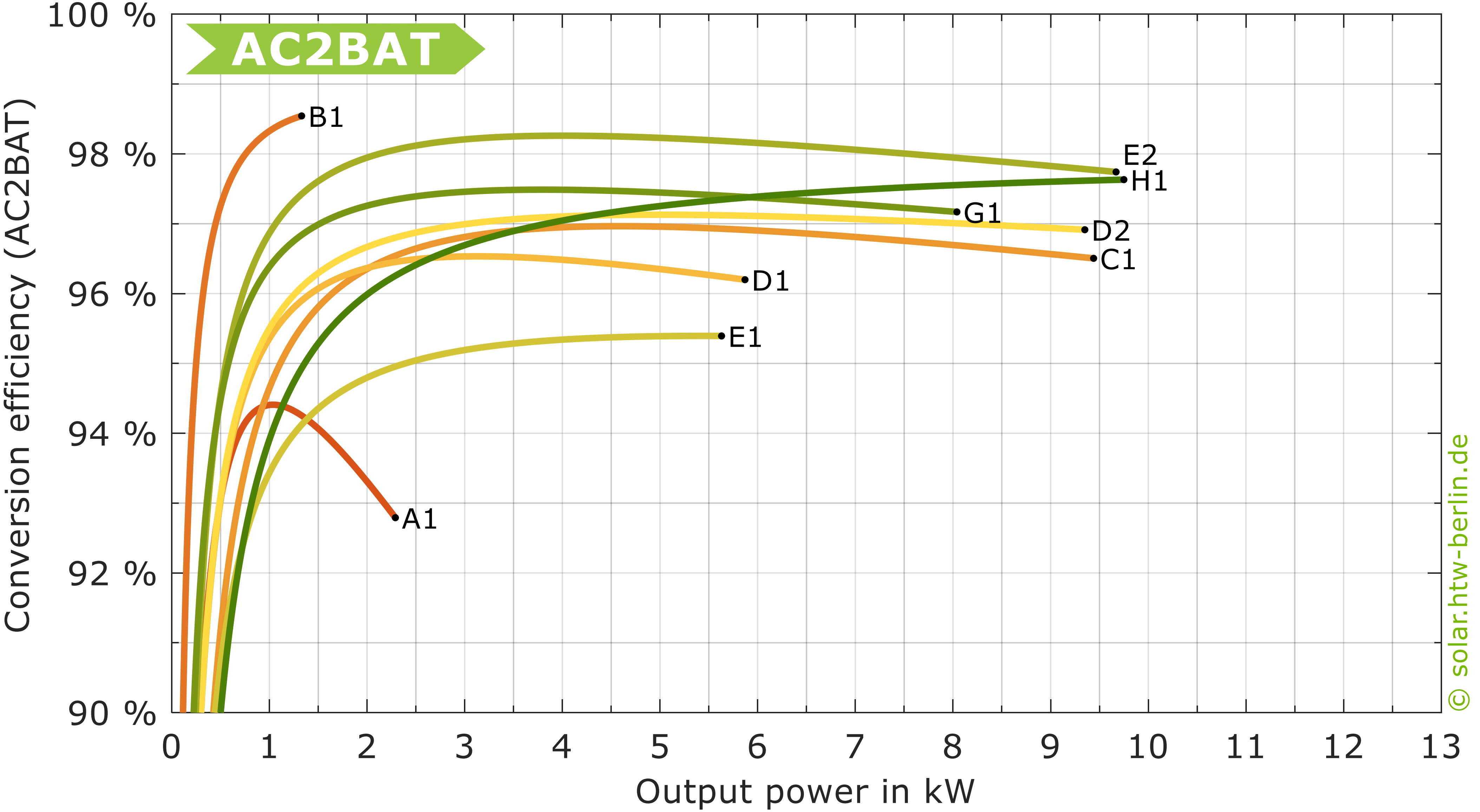


W1 and W2: PV inverter used for assessing the AC-coupled systems with the SPI (5 kW) and SPI (10 kW).

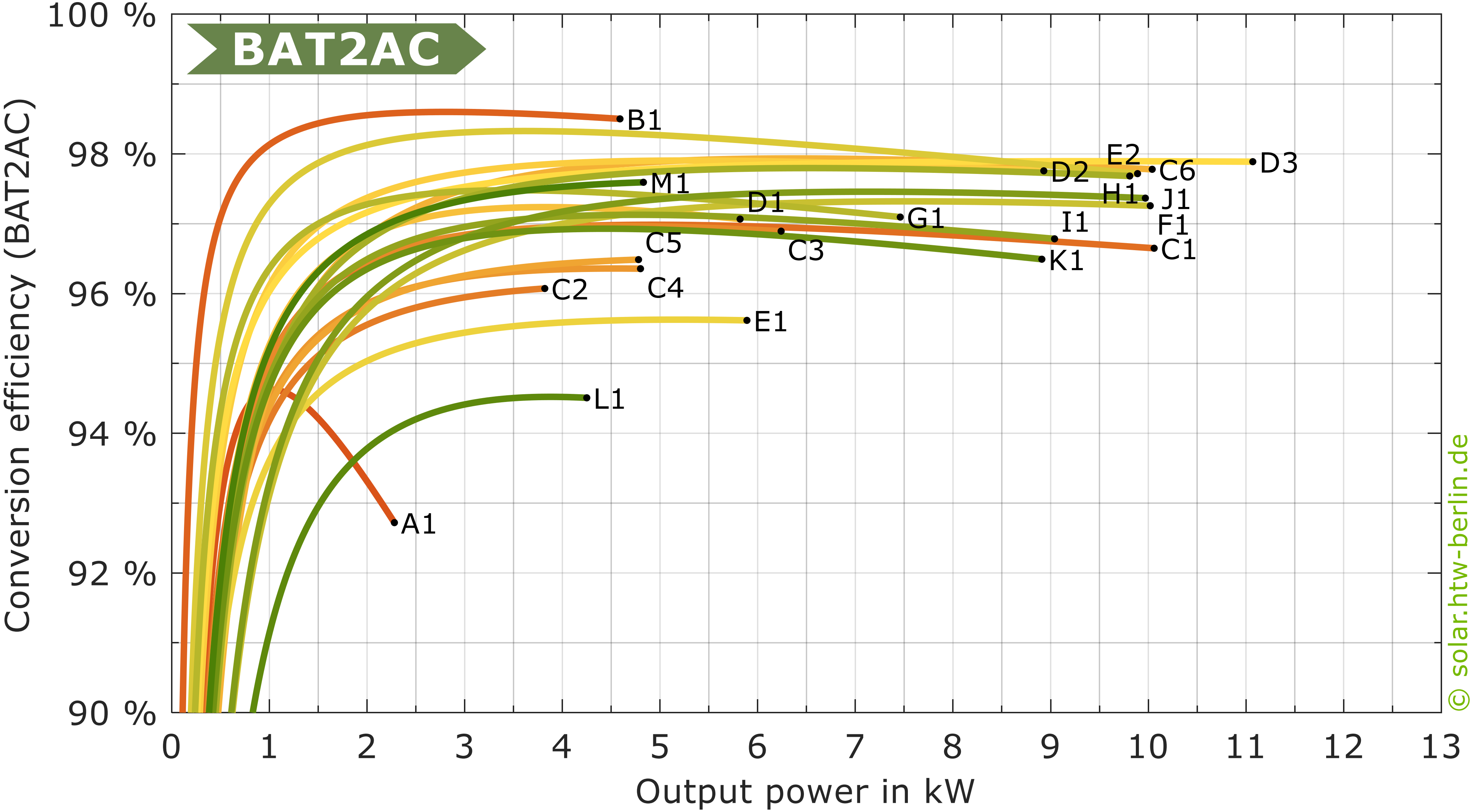
PV battery charging pathway efficiency



AC battery charging pathway efficiency

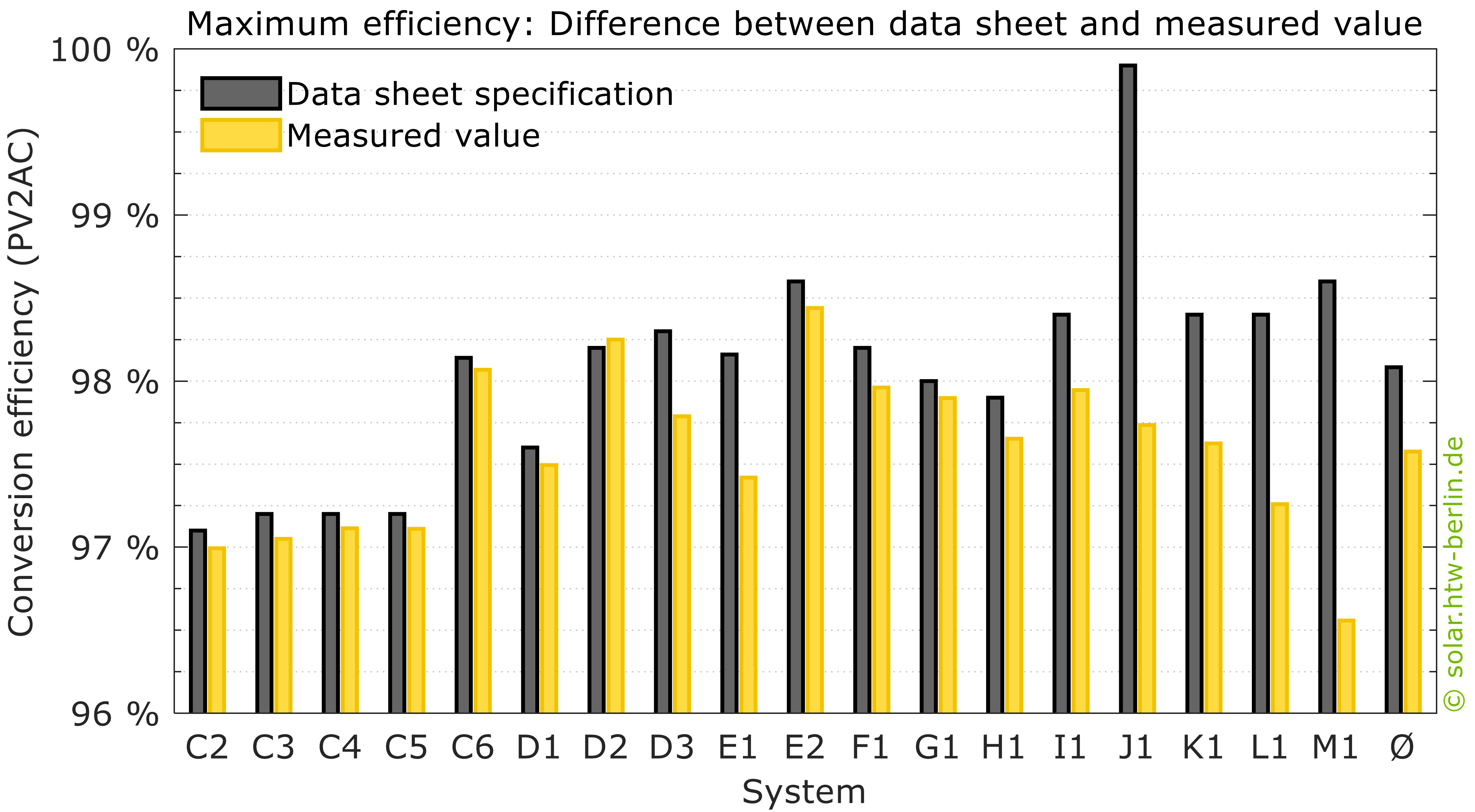


AC battery discharging pathway efficiency

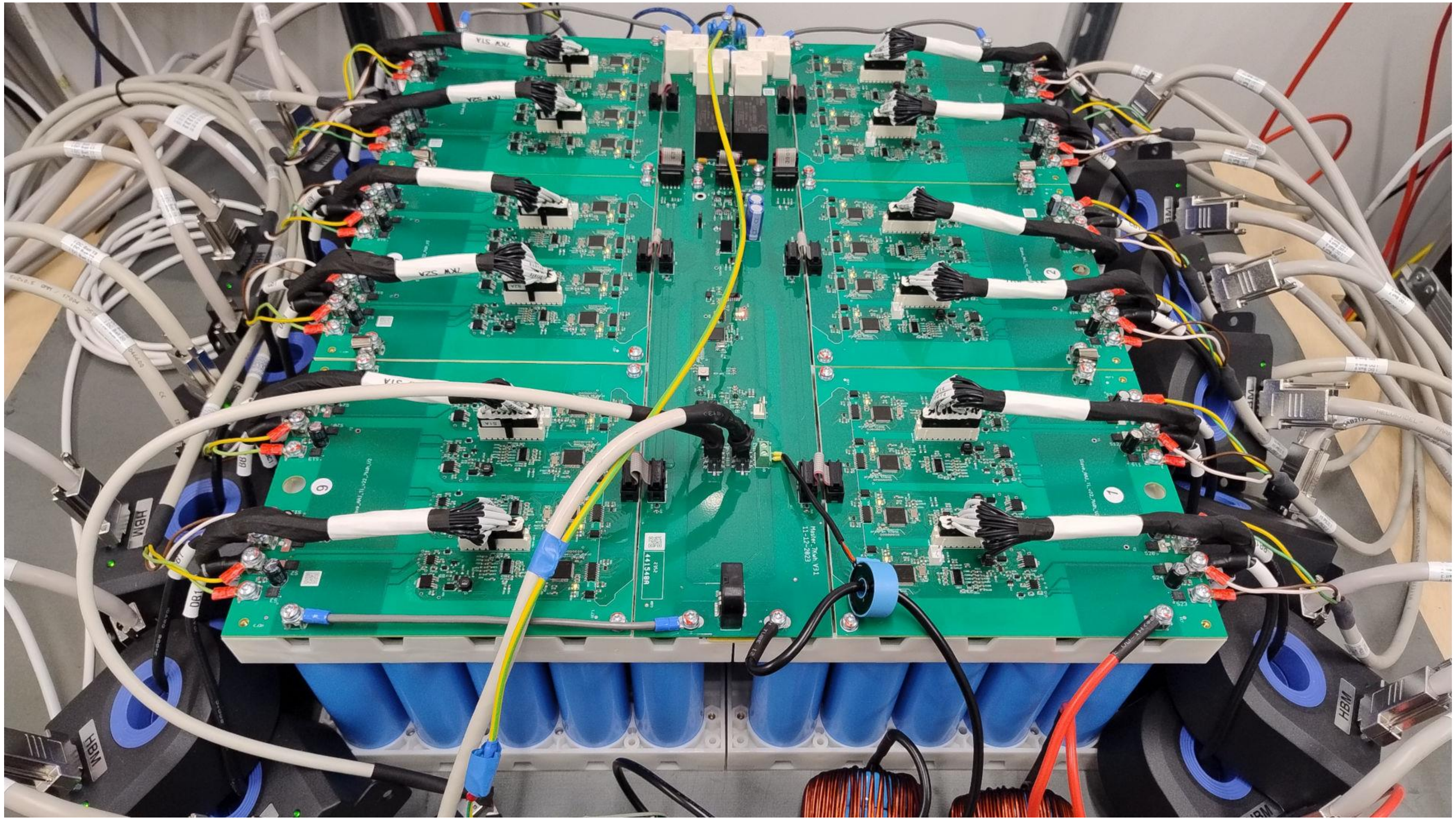


htw.

Comparison of data sheet specification and tested value



Newcomer: battery system with multi-level-technology

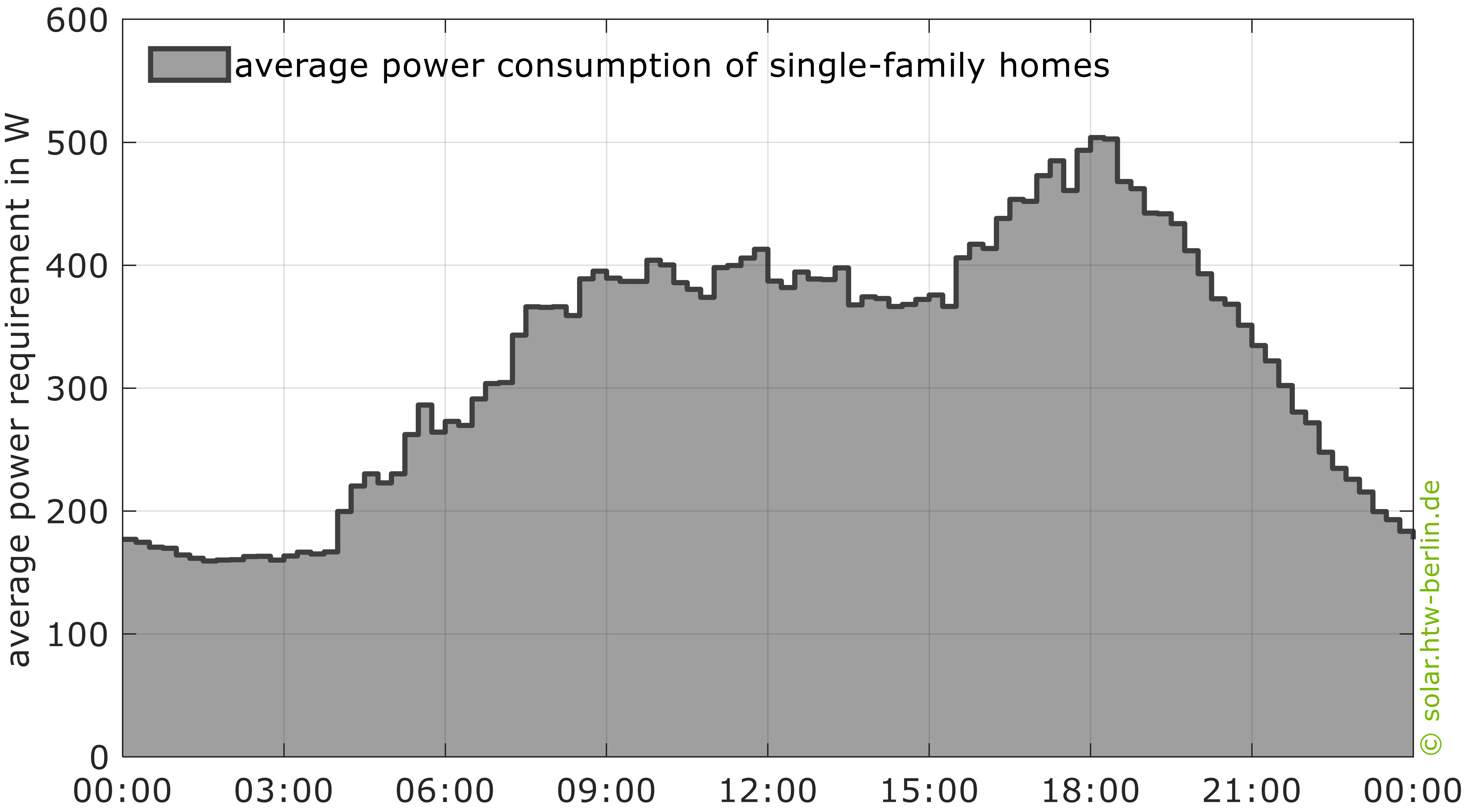


In order to be able to test the SAX Power Home Plus system at all, the KIT had to place a total of 24 DC measuring transformers between the electronics board and the 24 battery cell strings. In each battery cell string, 5 LFP battery cells with a capacity of 20 Ah are connected in series, resulting in a nominal voltage of 16 V per cell string (image: KIT).

Newcomer: battery system with multi-level-technology

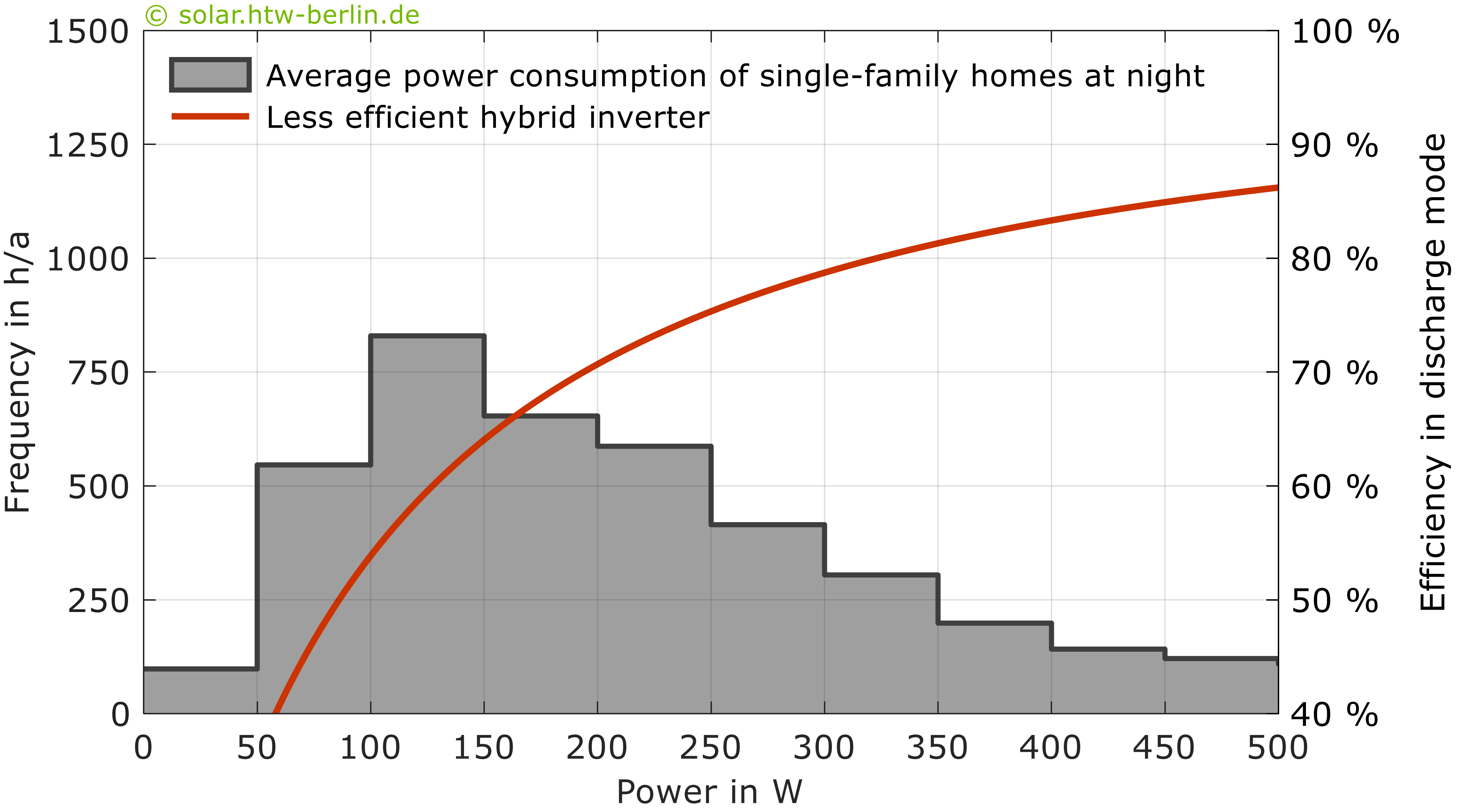
- The system concept of the storage system Power Home Plus from SAX Power differs significantly from the system concepts of other manufacturers. The storage system is based on the so-called **multi-level-technology**.
- Five battery cells are connected in series to form a cell pack with a voltage of 16 V and are connected to a **separate power electronics unit**, which is known as an H-bridge.
- The cell packs are connected in series via the **H-bridge**.
- To achieve the necessary peak voltage of 325 V, **20 of the 24 cell packs** must be charged or discharged via the H-bridges.
- The individual cell packs are activated and deactivated with a time delay. This allows a **staircase-shaped sinusoidal** voltage curve to be generated at the output of the battery system

Typical load profile of residential households



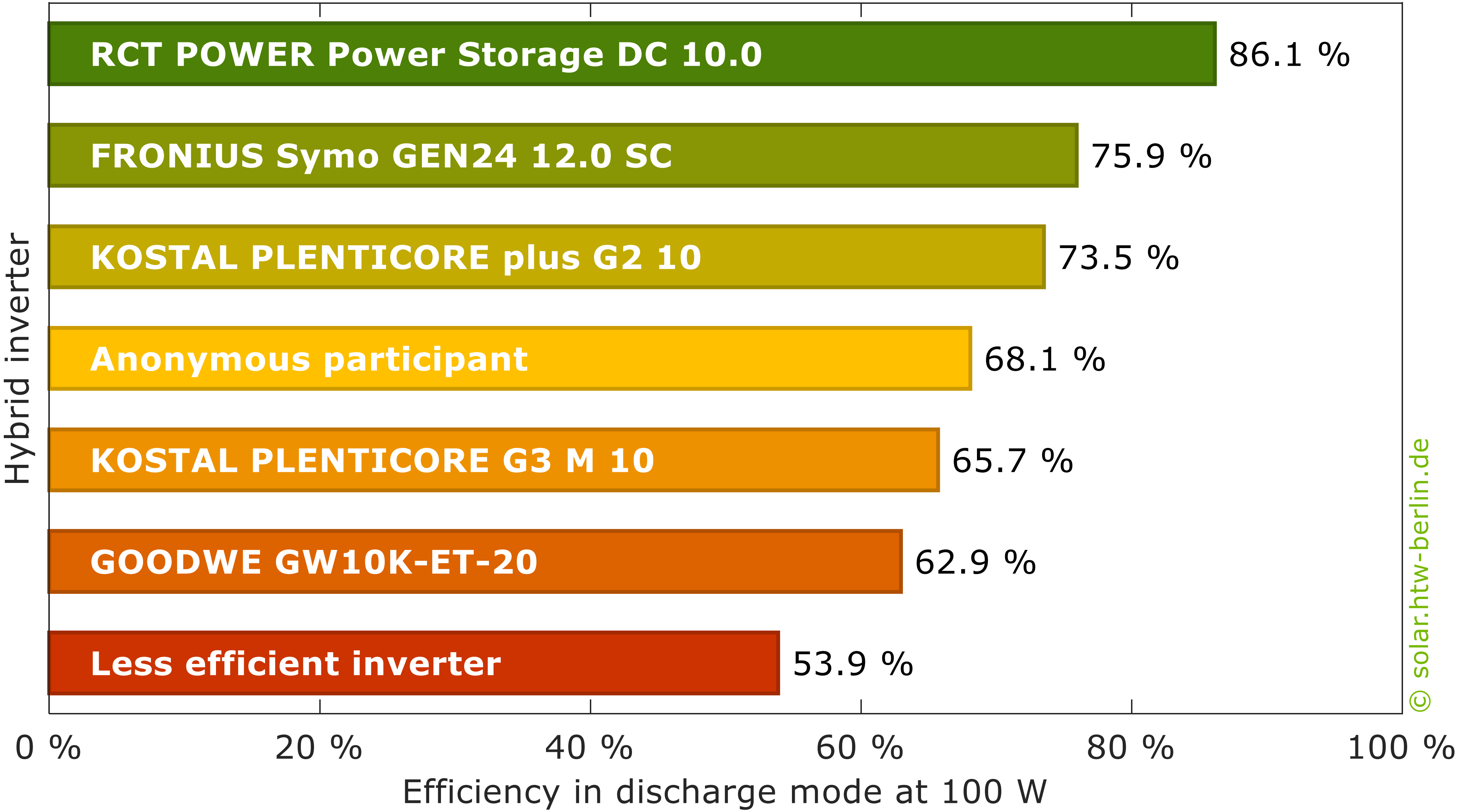
Central value (median) of the daily course of the household load of the 28 single-family houses examined. Time resolution: 15 min.
Daten: Schlemminger et al. - Dataset on electrical single family house and heat pump load profiles in Germany.

Partial load efficiencies of an inefficient hybrid inverter



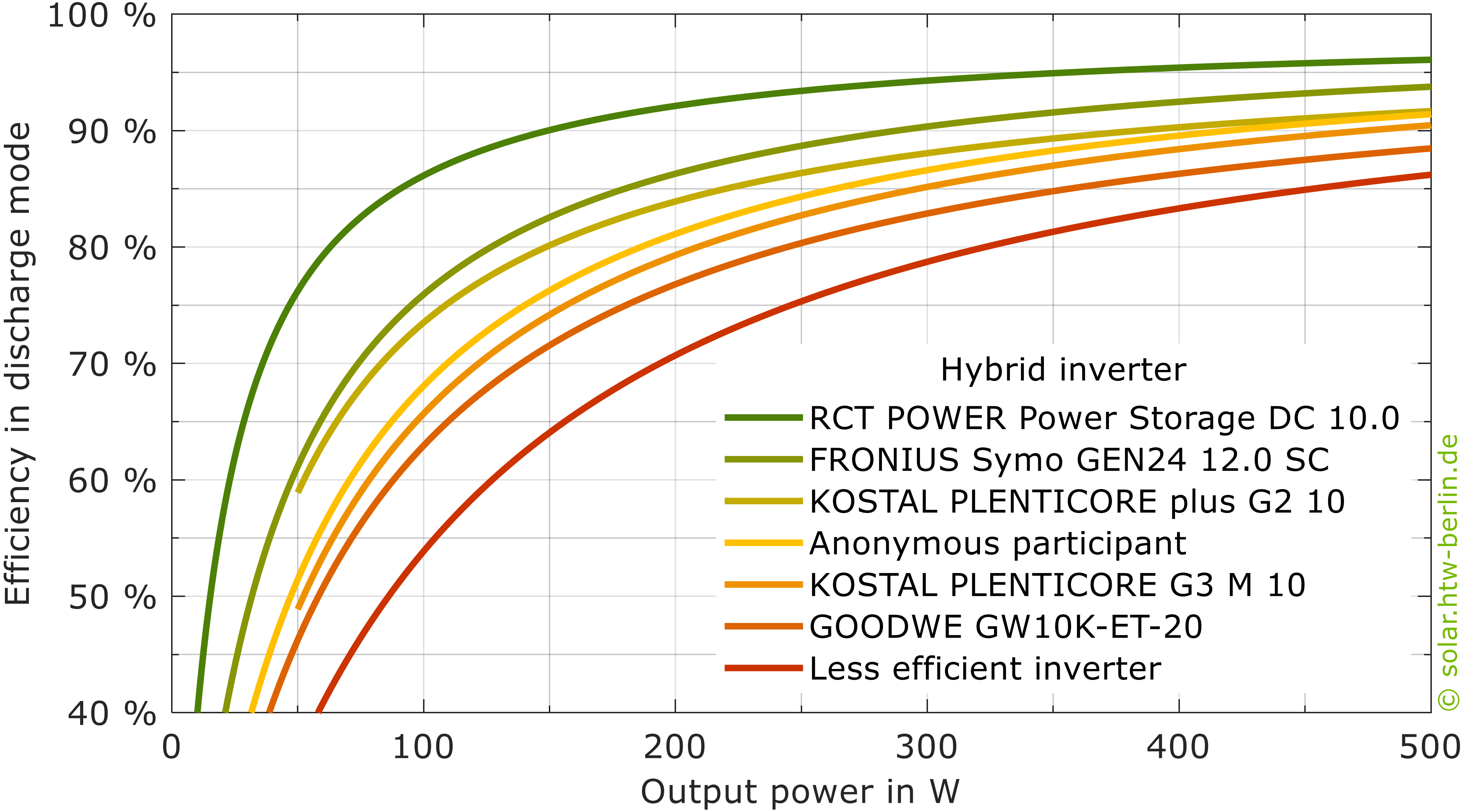
Average frequency distribution of the nighttime electricity consumption of different households based on 10 s measurement data.
Class width: 50 W, data: Schlemminger et al. - Dataset on electrical single-family houses and heat pump load profiles in Germany.

Efficiencies of hybrid inverters at a household load of 100 watts



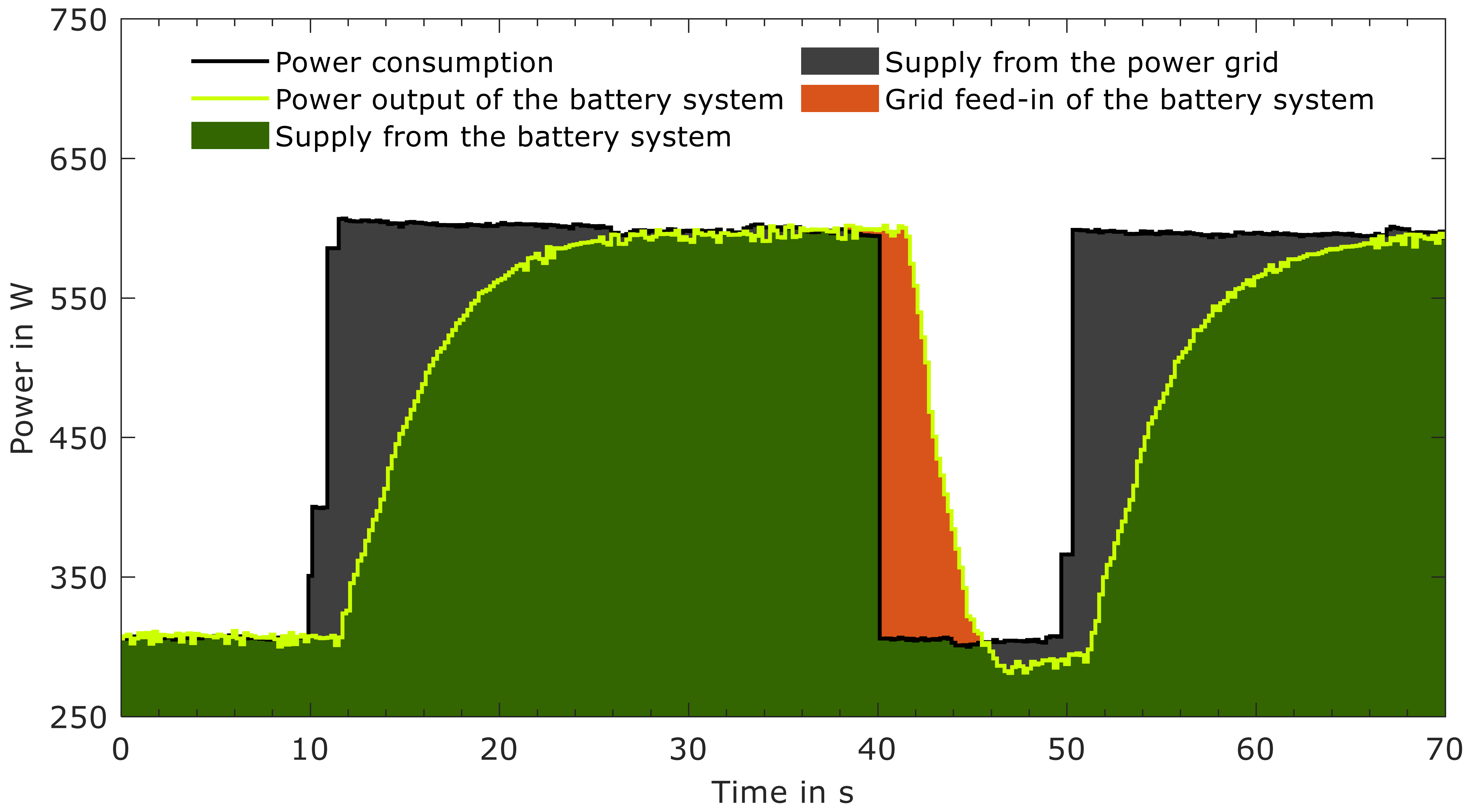
Laboratory measurement data of the hybrid inverters: AIT and KIT, battery voltages between 195 V and 520 V.

Partial load efficiencies of different hybrid inverters



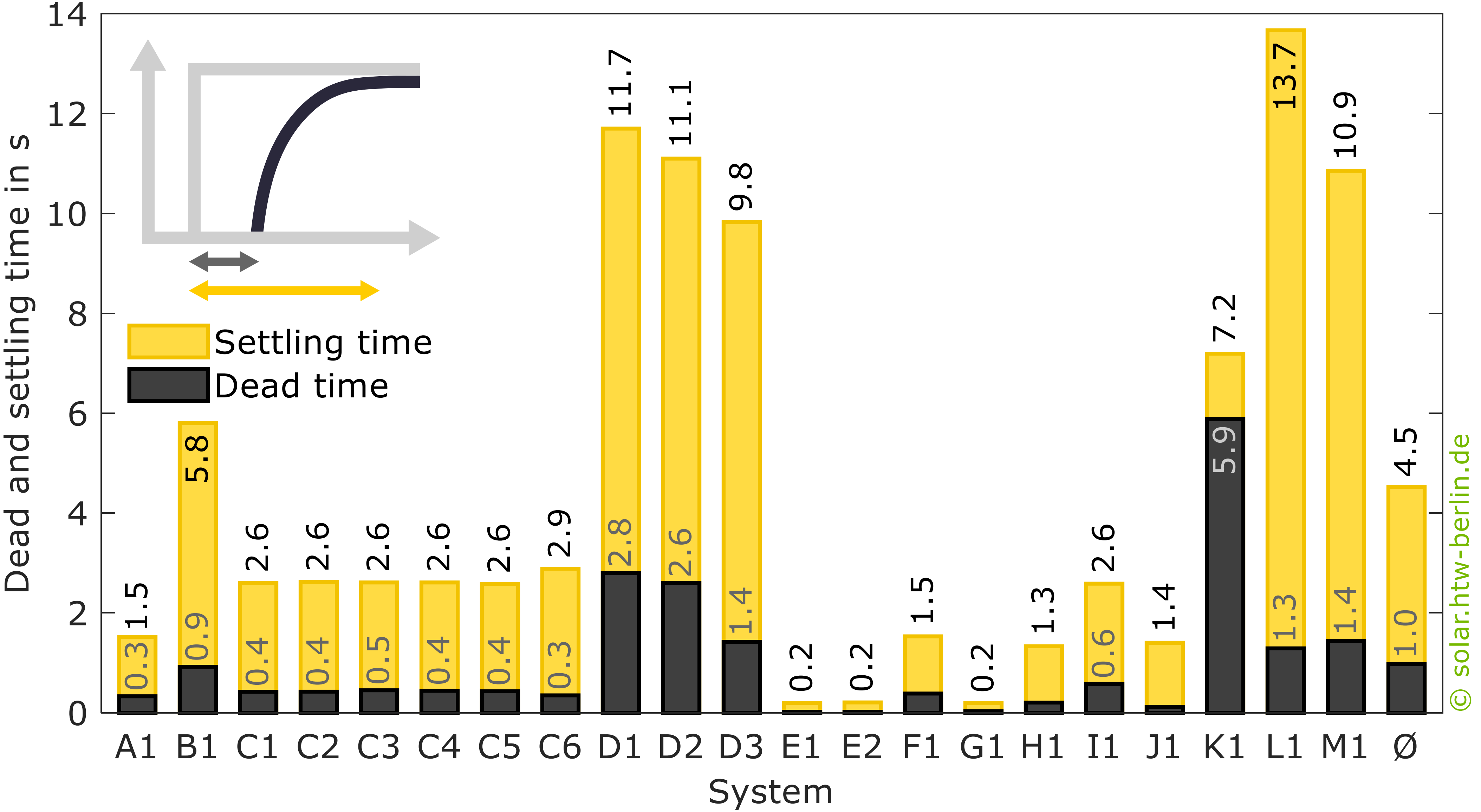
Laboratory measurement data of the hybrid inverters: AIT and KIT, minimum output power of the hybrid inverter from Kostal: 50 W.

Dynamic control deviations of a slow battery system

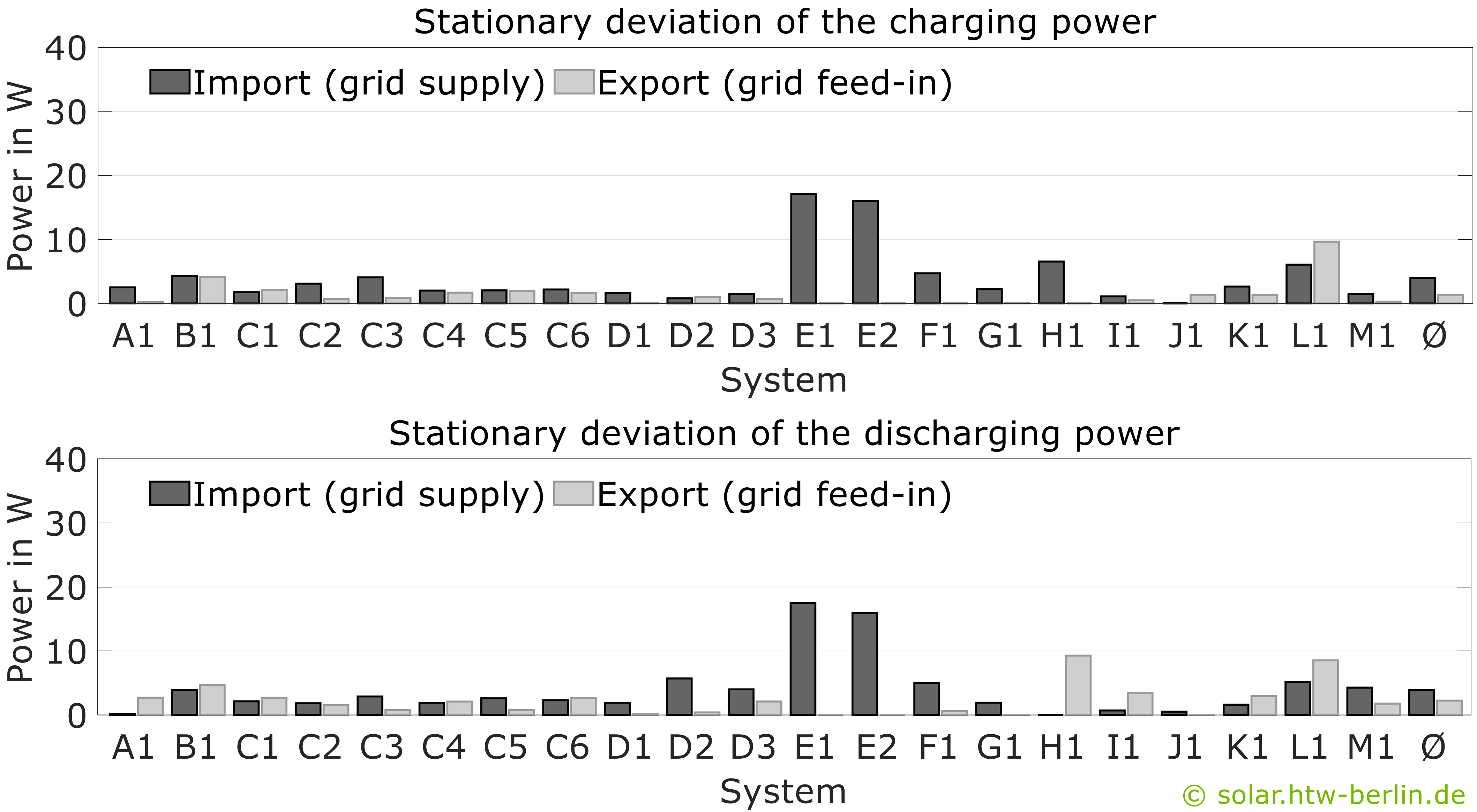


Settling behavior of system M1 with a mean settling time of 10.9 s, Data: KIT

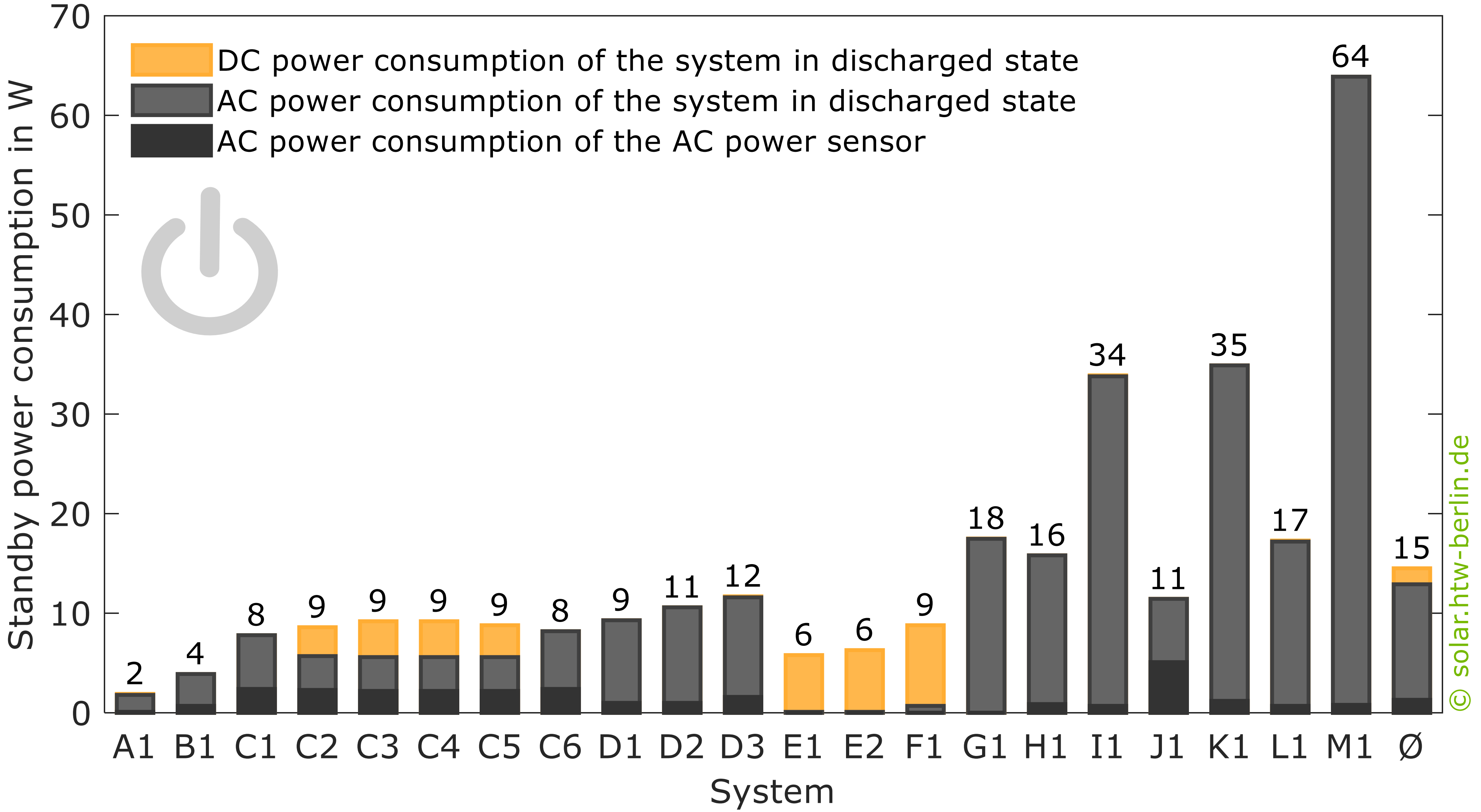
Dynamic control deviations: dead and settling time



Stationary control deviations

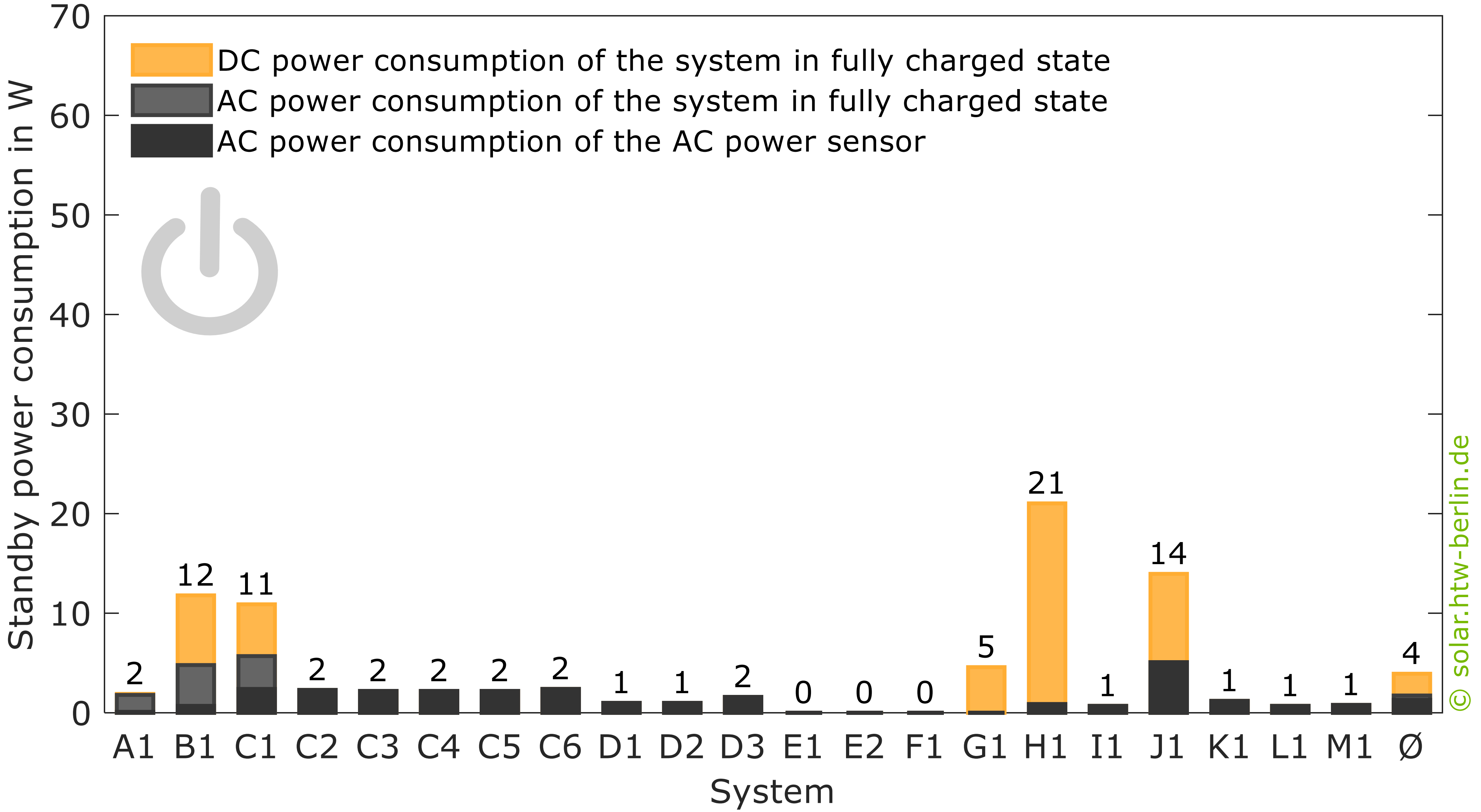


Standby power consumption with discharged battery



The standby power consumption of the battery management system (BMS) is not included in the values listed.

Standby power consumption with fully charged battery



The standby power consumption of the battery management system (BMS) is not included in the values listed.

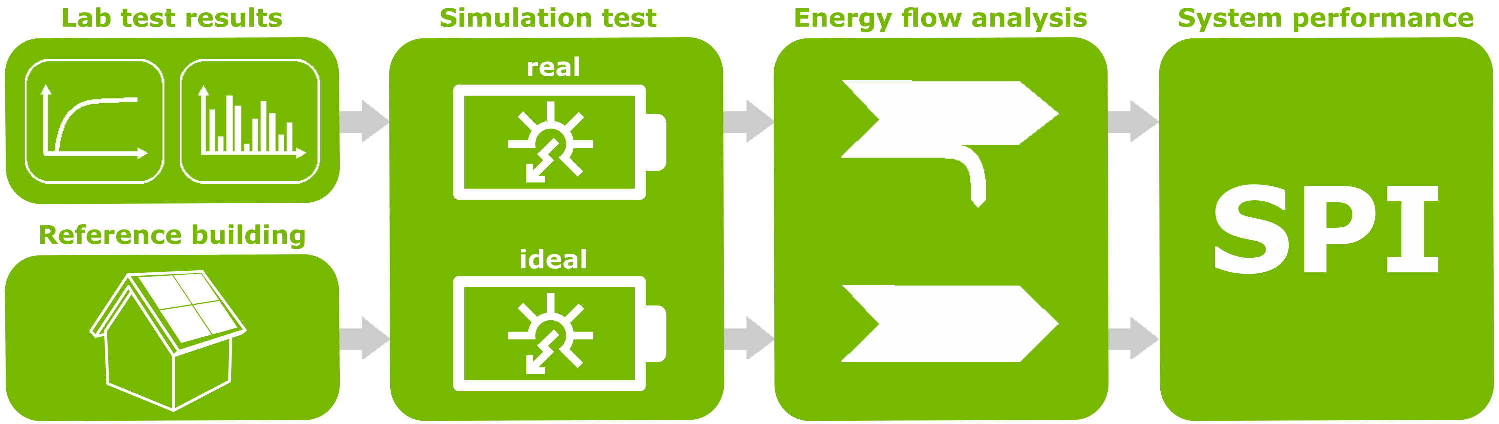

SPI

Main topics of the Energy Storage Inspection 2025

1. Analysis of the German market for residential PV-battery systems
2. Comparison of the system properties based on the test reports according to the Efficiency Guideline
3. **Simulation-based assessment of the PV-battery systems with the System Performance Index (SPI)**
4. Comparison of forecast-based energy management strategies of multiple PV-battery systems

Methodology of the simulation-based system evaluation

- **Simulation of the behavior** of the tested PV-battery systems over a year.
- The **System Performance Index (SPI)** is used to evaluate the systems based on the energy flows at the grid connection point. It considers the different economic values of the energy fed into the grid at 0.08 €/kWh and the energy supplied by the grid at 0.4 €/kWh.
- Parameterization of the simulation model **„PerMod“** (version 2.2) based on the laboratory measurement results determined following the efficiency guideline.
- Including the sizing, conversion, control, and standby losses measured by the institutes.



System Performance Index SPI (5 kW) and SPI (10 kW)

1st reference case for the System Performance Index SPI (5 kW)

PV system (5 kW) + Appliances (5010 kWh/a)

2nd reference case for the System Performance Index SPI (10 kW)

PV system (10 kW) + Appliances (5010 kWh/a) + Heat pump (2664 kWh/a) + Electric vehicle (1690 kWh/a)

Please note: SPI (5 kW) and SPI (10 kW) are not comparable due to the different characteristics of the two reference cases.

Assignment of the systems to the reference cases

- Depending on the size of the **power electronics** and **battery storage**, the efficiency rating is conducted with the **SPI (5 kW)** or **SPI (10 kW)**.
- Only systems with a usable capacity below 8.0 kWh were rated with the **SPI (5 kW)**.
- For a rating with the **SPI (10 kW)**, a usable capacity below 16.0 kWh was required.
- The classification was based on the usable storage capacity determined in the **laboratory test**.
- 5 systems were rated with the SPI (5 kW), and 16 systems were assessed with the SPI (10 kW).

Systems rated with the System Performance Index (SPI)

A1 VARTA pulse neo 6

B1 SAX Power Home Plus

C1 KOSTAL PLENTICORE BI G2 10/26 and BYD Battery-Box HVS 12.8

C2 KOSTAL PLENTICORE plus G2 5.5 and BYD Battery-Box HVS 7.7

C3 KOSTAL PLENTICORE plus G2 10 and BYD Battery-Box HVS 12.8

C4 KOSTAL PLENTICORE plus G2 10 and DYNESS Tower T14

C5 KOSTAL PLENTICORE plus G2 10 and PYLONTECH Force H2

C6 KOSTAL PLENTICORE G3 M 10 and BYD Battery-Box HVS 12.8

D1 FRONIUS Primo GEN24 6.0 Plus and BYD Battery-Box HVS 7.7

D2 FRONIUS Symo GEN24 10.0 Plus and BYD Battery-Box HVS 10.2

D3 FRONIUS Symo GEN24 12.0 Plus SC and BYD Battery-Box HVS 12.8

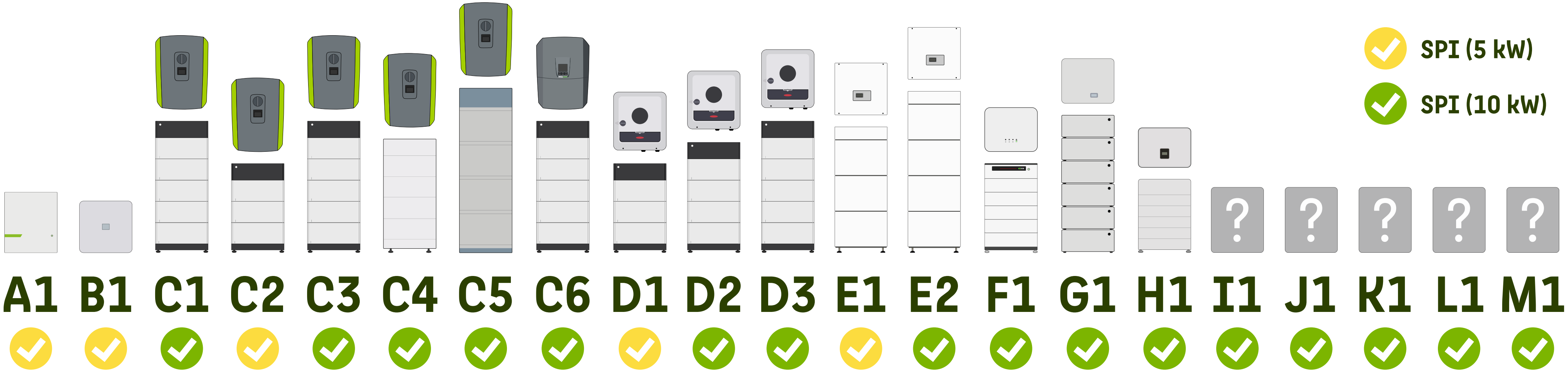
E1 RCT POWER Power Storage DC 6.0 and Power Battery 7.6

E2 RCT POWER Power Storage DC 10.0 and Power Battery 11.5

F1 GOODWE GW10K-ET-20 and LX F16.0-H-20

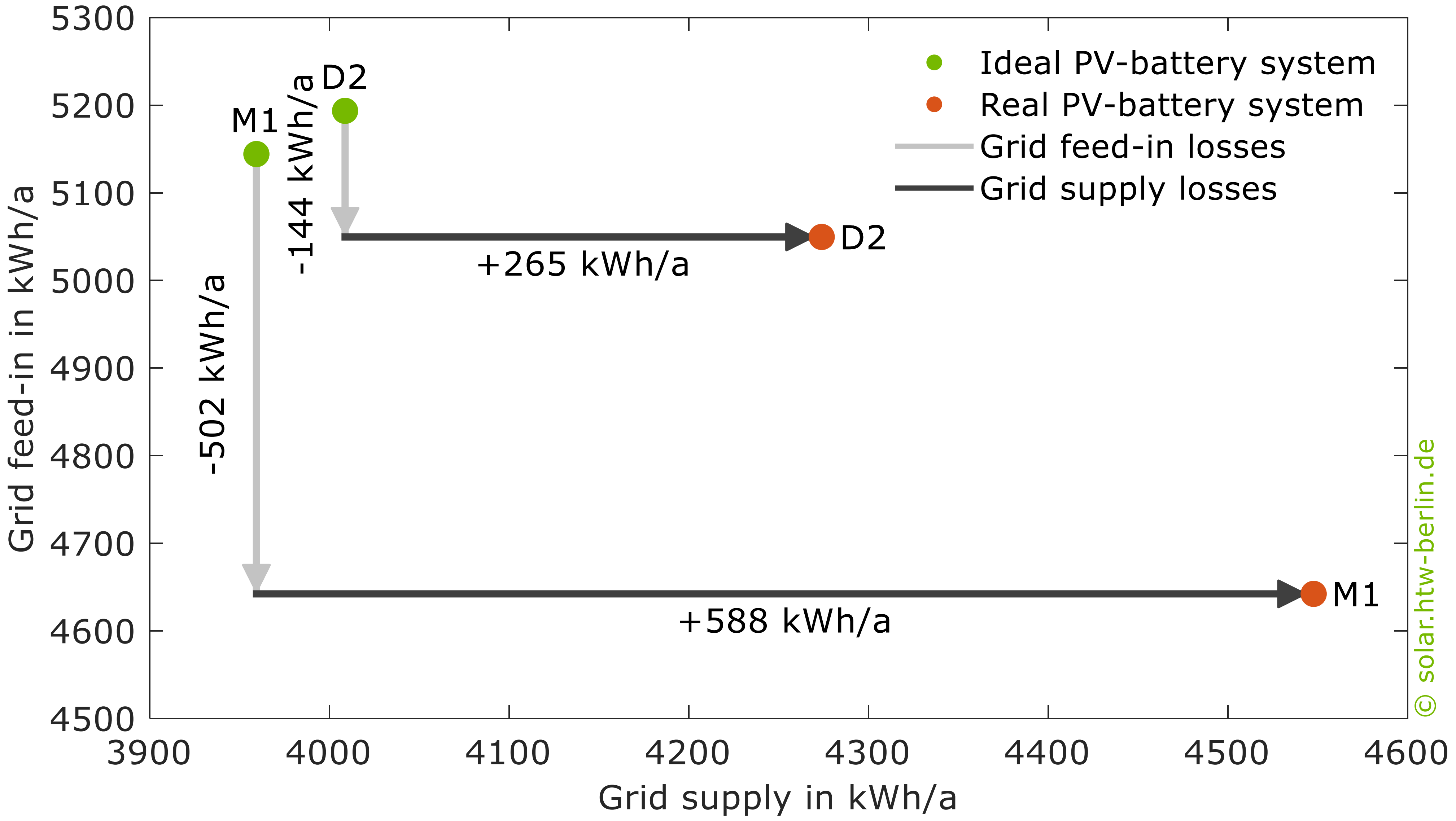
G1 ENERGY DEPOT Centurio 10 and DOMUS 2.5

H1 FOX ESS H3-10.0-Smart and ECS2900-H6



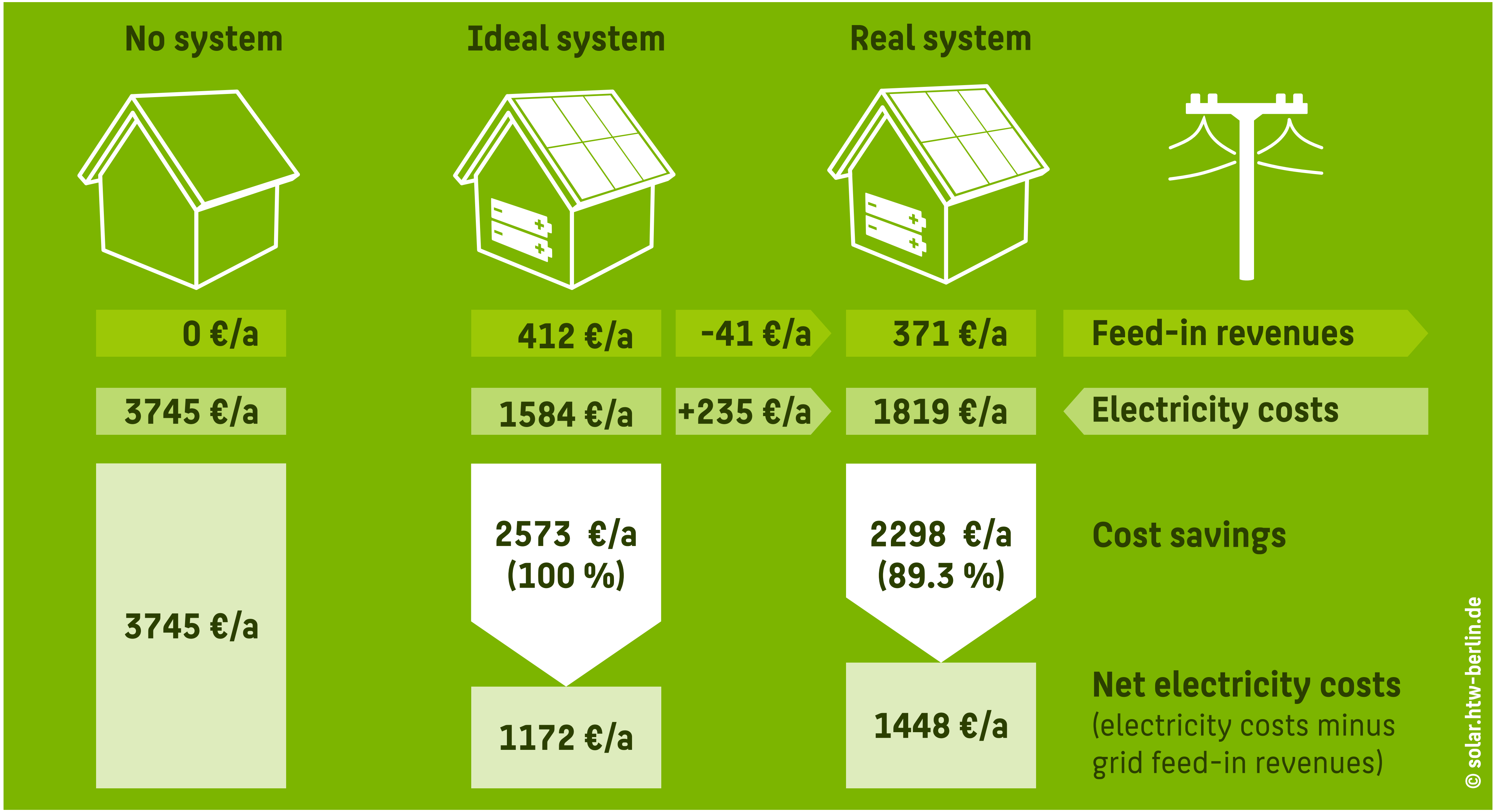
AC coupled | **DC coupled with hybrid inverter**

Low efficiency reduces energy fed in and increases grid consumption



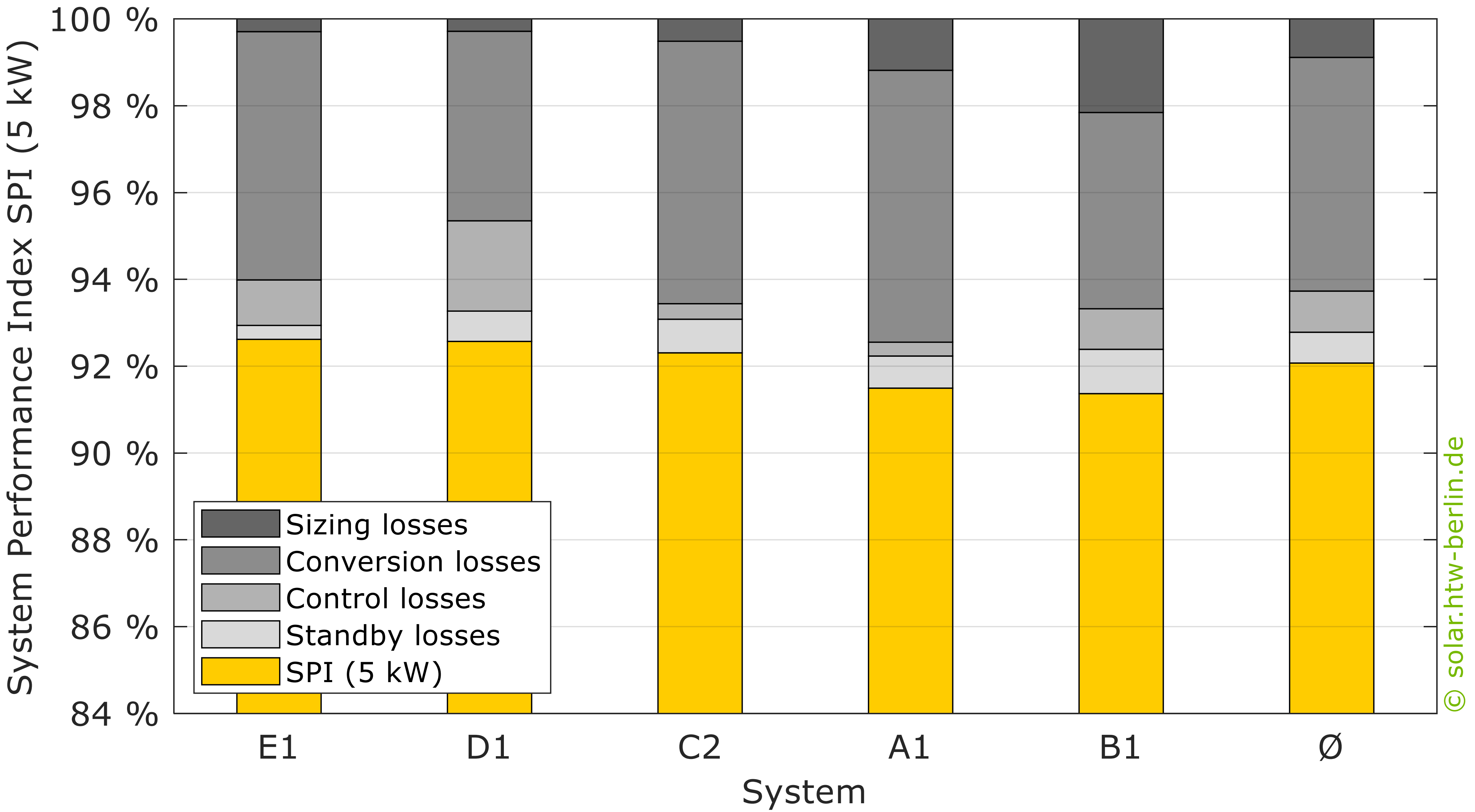
System D2 (highly efficient) and system M1 (less efficient), 2. reference case, demand 9363 kWh/a

Example for determining the System Performance Index (SPI)

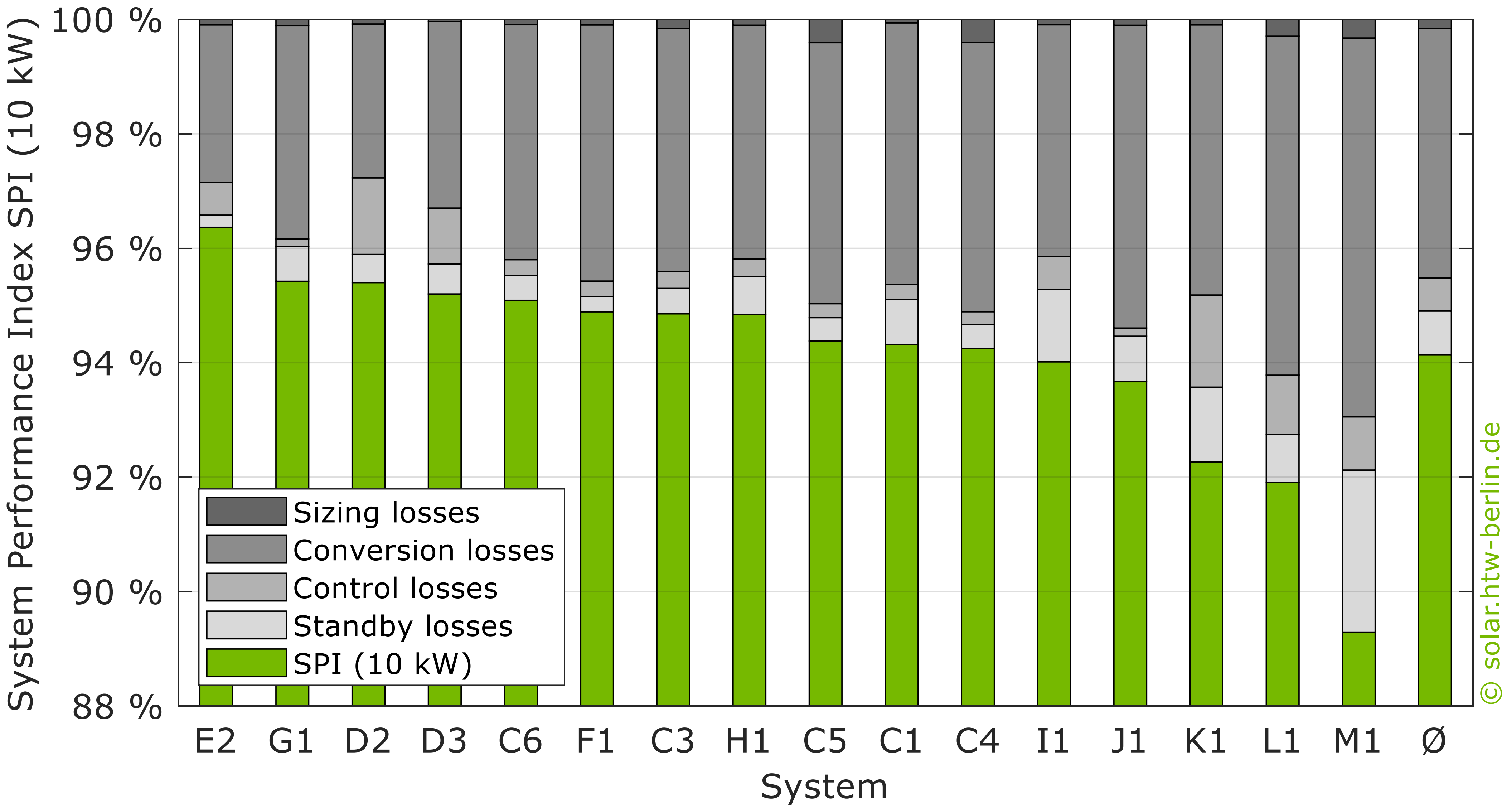


Grid feed-in revenues and grid purchase costs as well as cost savings achieved when using the ideal (loss-free) and real example system K1 (feed-in tariff 0.08 €/kWh, grid purchase price 0.4 €/kWh). Framework conditions according to the 2nd reference case.

Loss analysis of the systems assessed with the SPI (5 kW)



Loss analysis of the systems assessed with the SPI (10 kW)

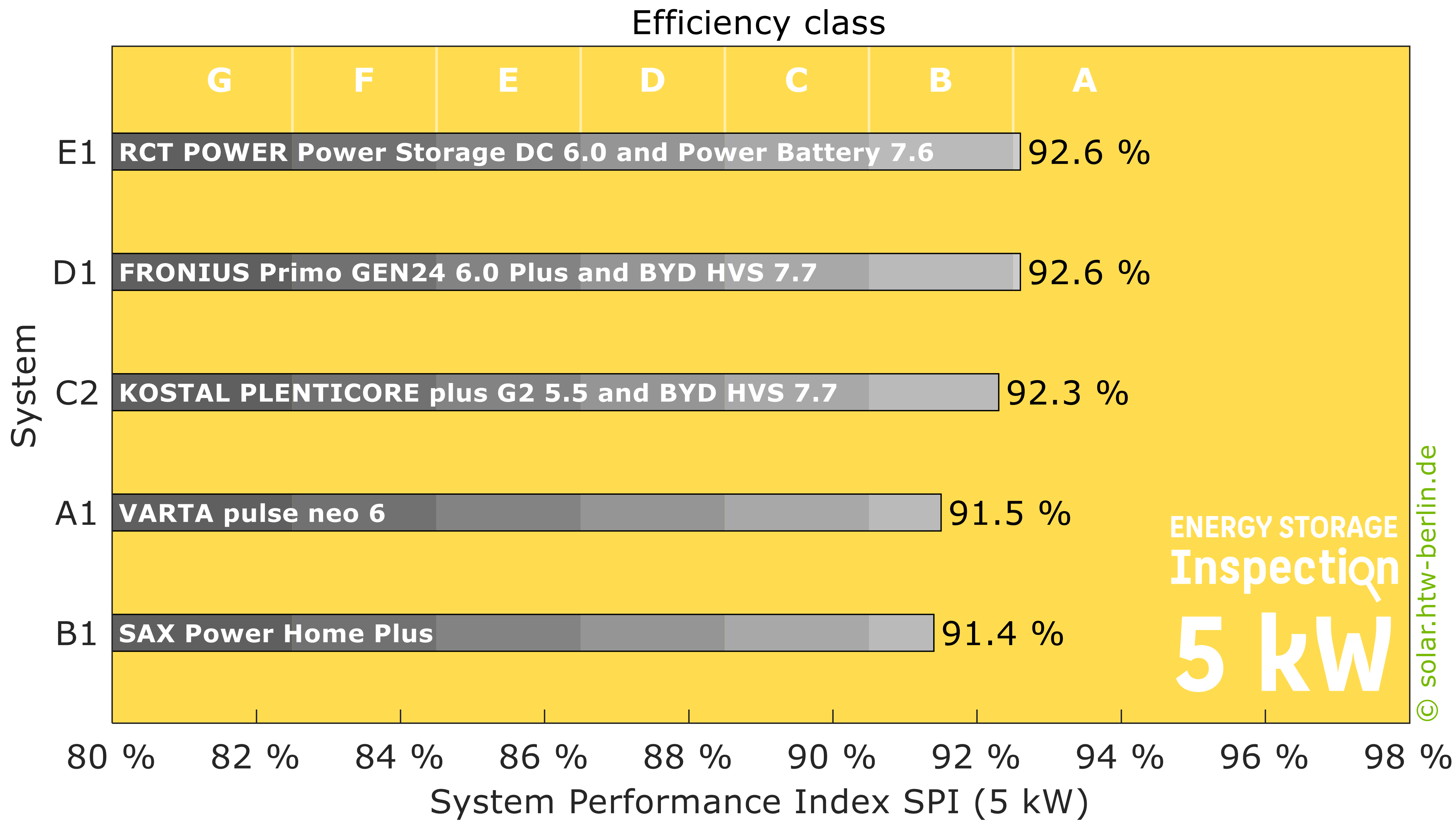


Definition of the efficiency classes for PV-battery systems

- Due to the different SPI values, the threshold values for reaching the individual **efficiency classes** vary.

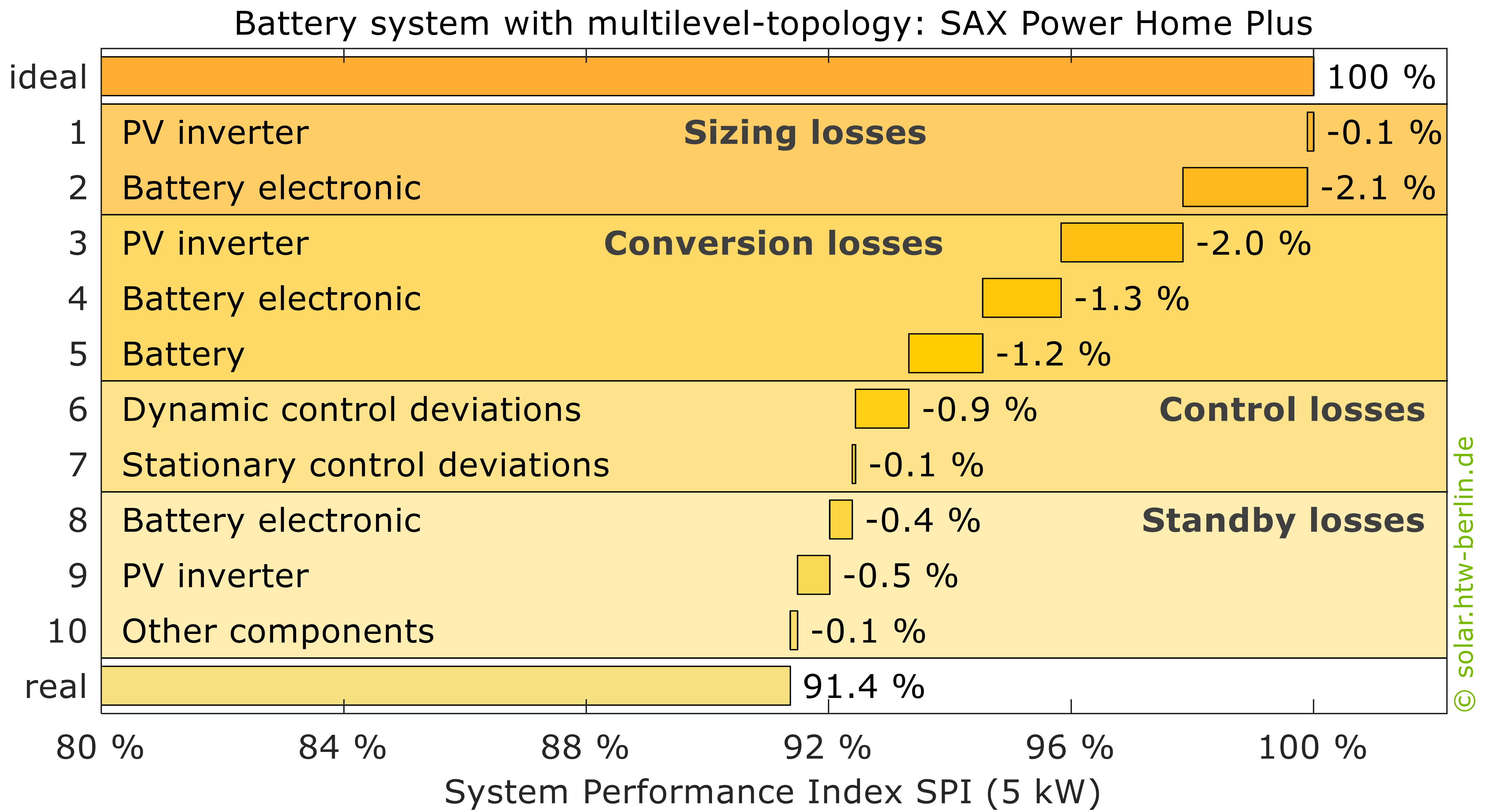
Class	Rating	SPI (5 kW)	SPI (10 kW)
A	very good	≥ 92.5 %	≥ 94.5 %
B	very good	≥ 90.5 %	≥ 93.5 %
C	good	≥ 88.5 %	≥ 92.5 %
D	good	≥ 86.5 %	≥ 91.5 %
E	in need of improvement	≥ 84.5 %	≥ 90.5 %
F	in need of improvement	≥ 82.5 %	≥ 89.5 %
G	inadequate	< 82.5 %	< 89.5 %

SPI (5 kW) and efficiency classes of the analyzed systems



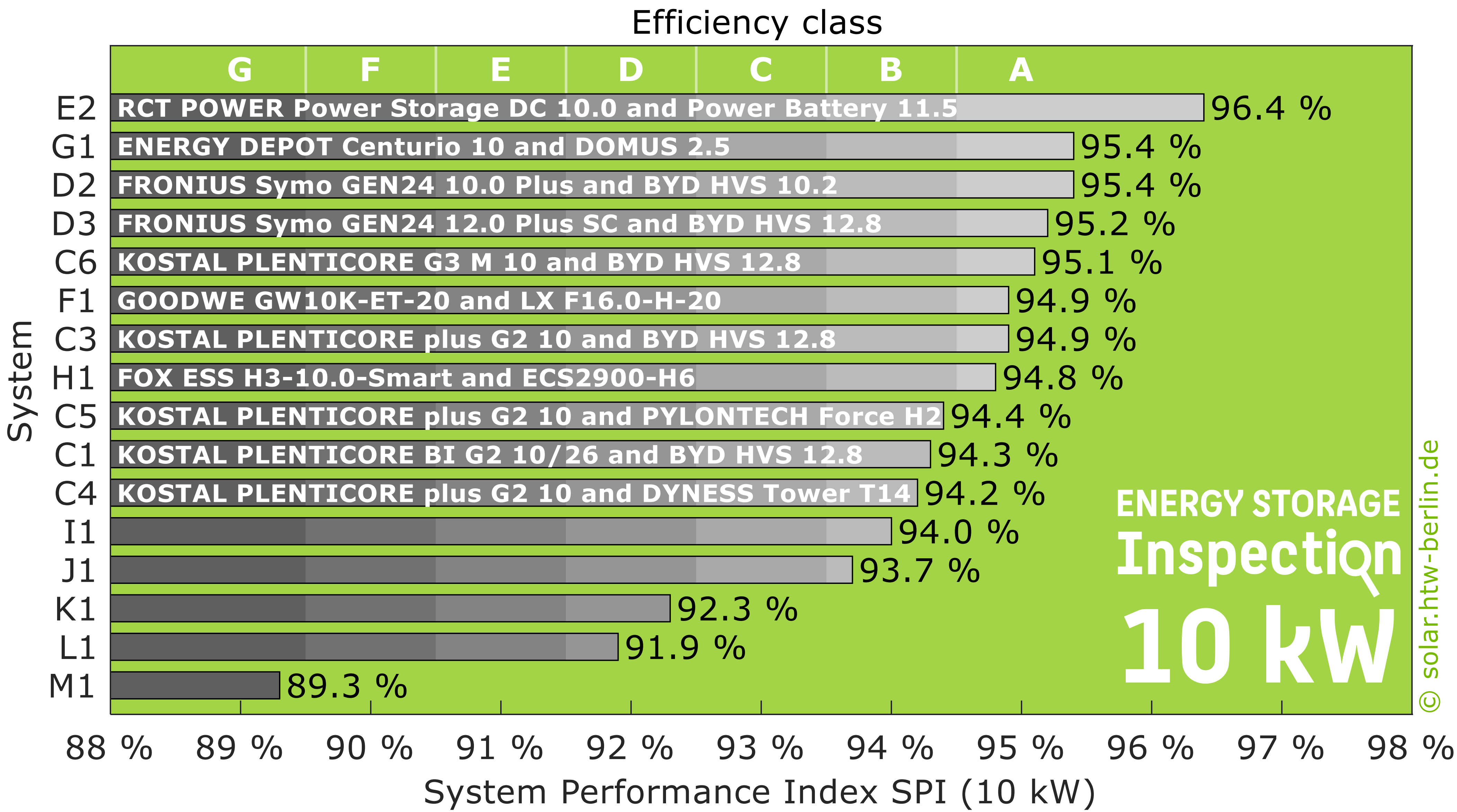
The AC-coupled systems A1 and B1 were assessed in combination with the PV inverter SMA Sunny Boy 5.0.

Influence of different losses on the SPI (5 kW)



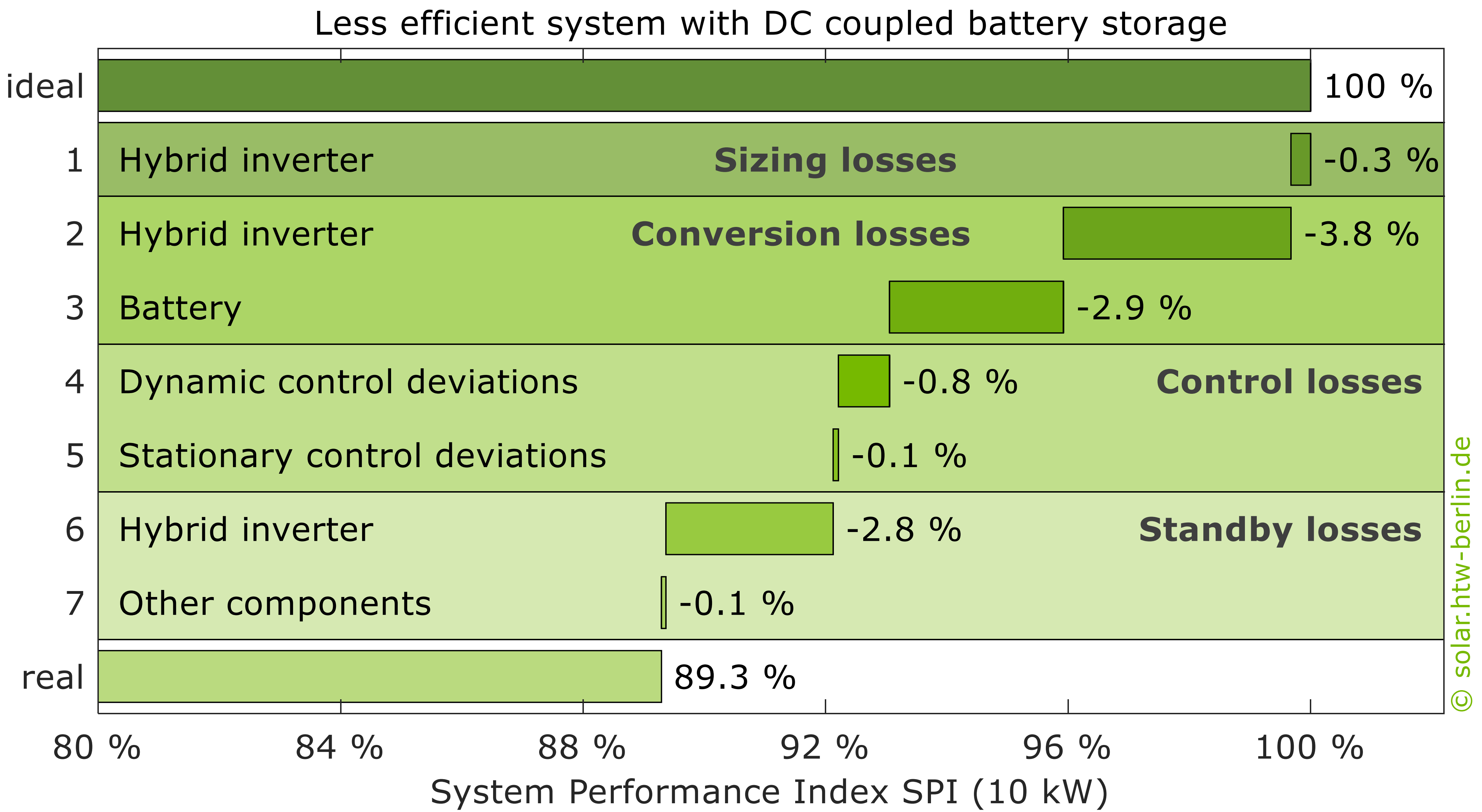
The AC-coupled system B1 was assessed in combination with the PV inverter SMA Sunny Boy 5.0.

SPI (10 kW) and efficiency classes of the analyzed systems



The AC-coupled System C1 was assessed in combination with the PV inverter SMA Sunny Tripower 10.0.

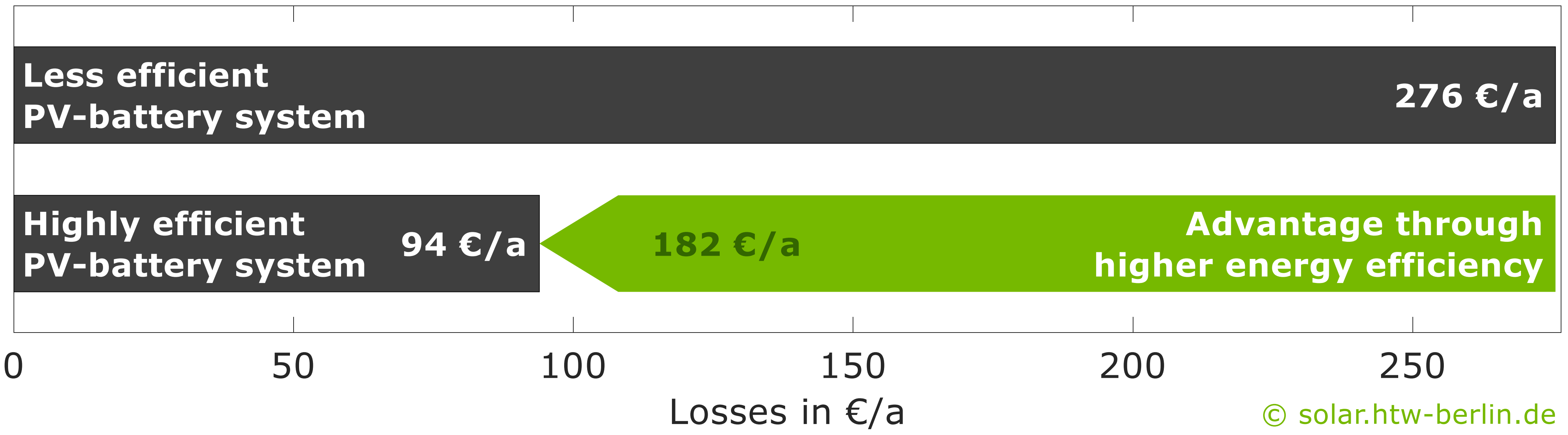
Influence of different losses on the SPI (10 kW)



System: M1

Why is a high system efficiency important?

- Efficiency losses reduce the **potential savings** of a PV-battery system. The economic losses for the systems evaluated with the SPI (10 kW) lay between 94 €/a and 276 €/a.
- Households that choose a highly efficient PV-battery system can save up to an additional **1820 € within the first ten years** of operation compared to a less efficient system.



Highly efficient system: E2, less efficient system: M1, framework conditions of the 2nd reference case.

Summary of the results of the system evaluation

- The Energy Storage Inspection 2025 analyzed and compared the energy efficiency of **21 battery systems**.
- In the reference case up to 5 kW, a DC-coupled system from RCT Power came out on top with an **SPI (5 kW) of 92.6 %.**
- It was closely followed by the hybrid inverters FRONIUS Primo GEN24 6.0 Plus and KOSTAL PLENTICORE plus G2 5.5, both of which competed in combination with the BYD Battery-Box Premium HVS 7.7.
- The system Power Storage DC 10.0 and Power Battery 11.5 from RCT Power achieved the highest **SPI (10 kW)** with a value of **96.4 %**.
- 18 of the 21 systems tested scored with a **very good system efficiency** and achieved either the efficiency classes A or B.
- However, the range of system efficiency is still very wide – the least efficient system only achieved the **efficiency class G**.

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

solar.htw-berlin.de/inspection