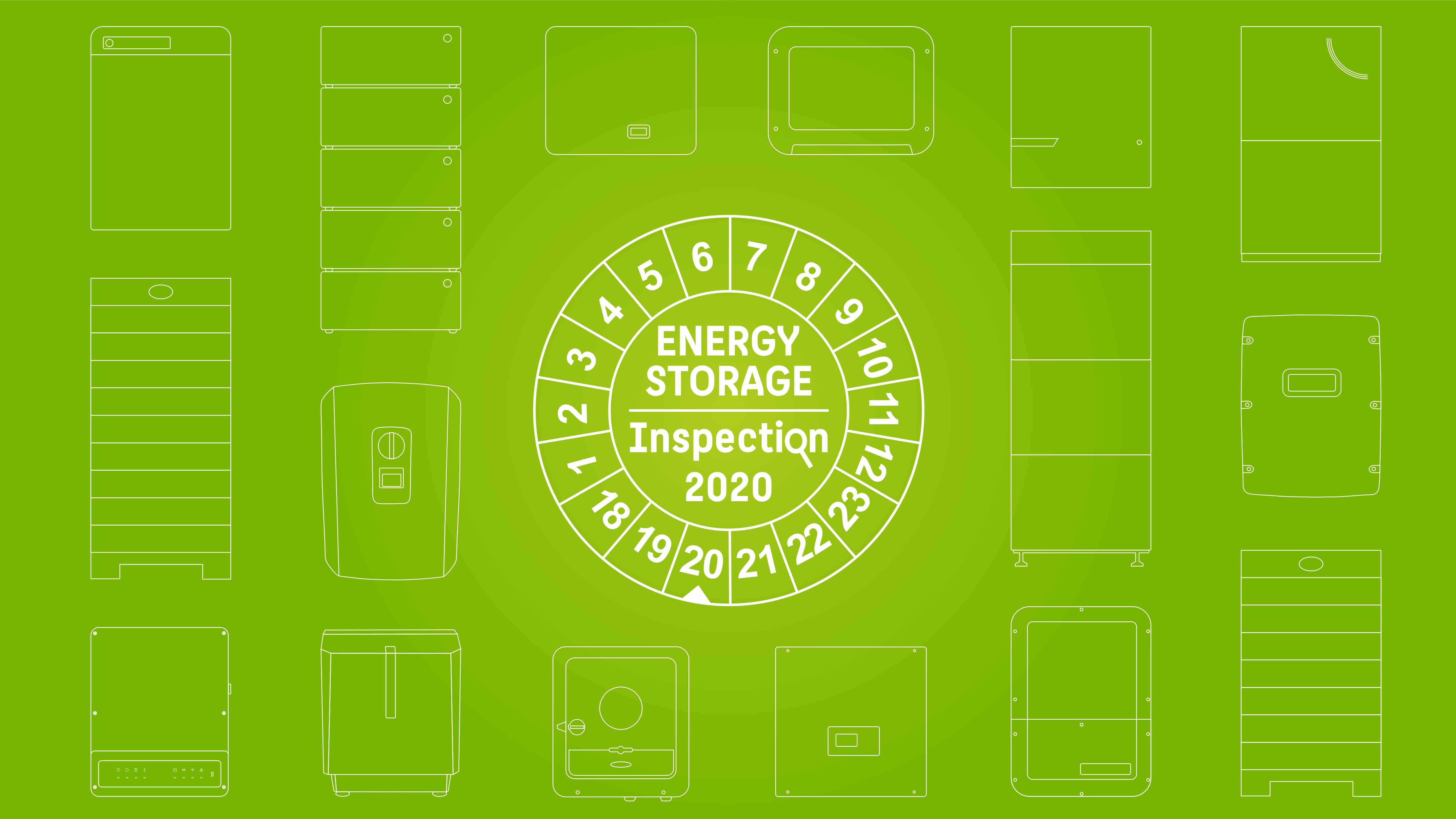
ENERGY STORAGE
Inspection
2020
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ENERGY STORAGE Inspection 2020

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Research study

Energy Storage Inspection 2020

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Release

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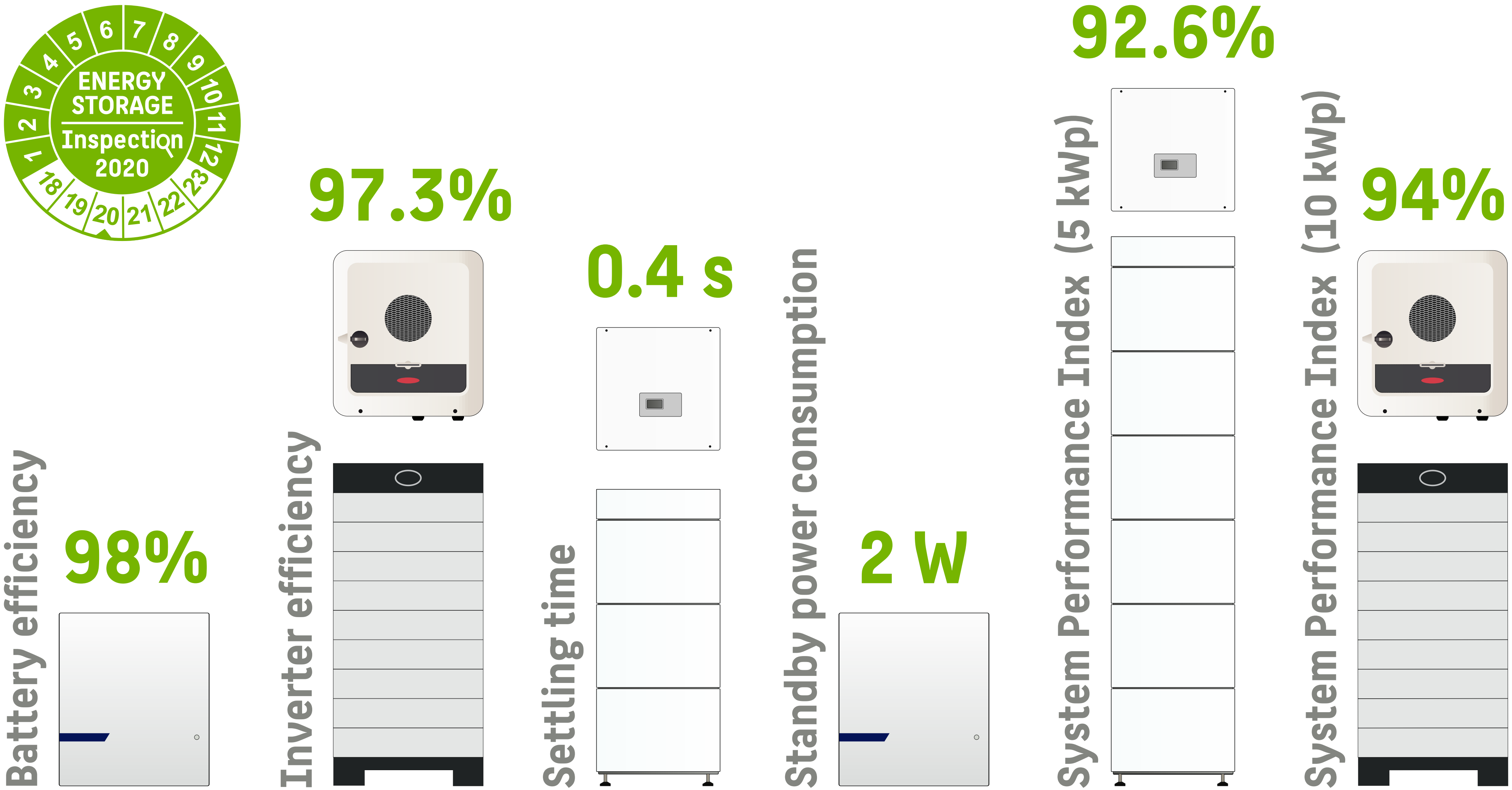
Website

www.stromspeicher-inspektion.de

Funding

This research study is part of the project “EffiBat“ which is funded by the German Federal Environmental Foundation (DBU).

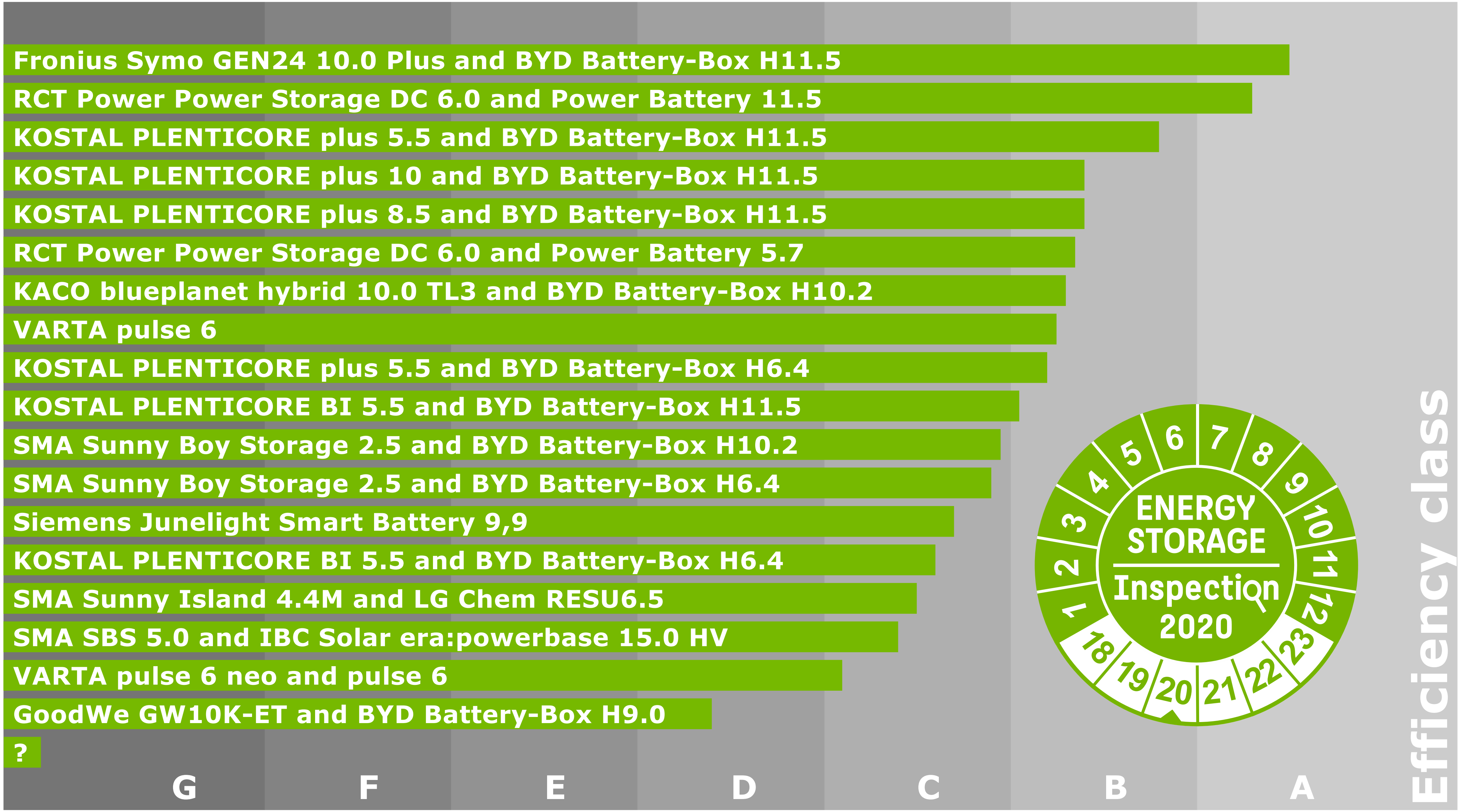
Front runners of the Energy Storage Inspection 2020



Outstanding systems of the Energy Storage Inspection 2020

Inverter efficiency: average efficiency in the discharge mode, Standby power consumption in the discharged state

Results of the Energy Storage Inspection 2020

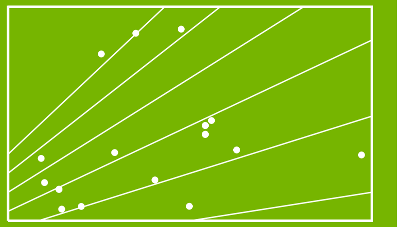


The efficiency classification is based on the System Performance Index SPI (5 kWp) and SPI (10 kWp).

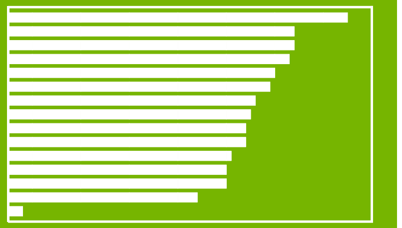
Main topics of the Energy Storage Inspection 2020

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

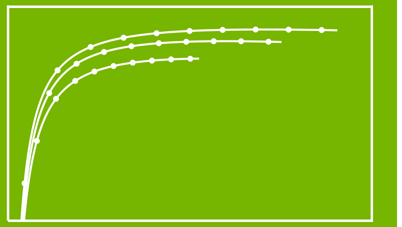
2 Comparison of the system properties based on the test reports according to the Efficiency Guideline



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



4 FAQ: Answers to questions concerning the efficiency of PV-battery systems



Main topics of the Energy Storage Inspection 2020

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

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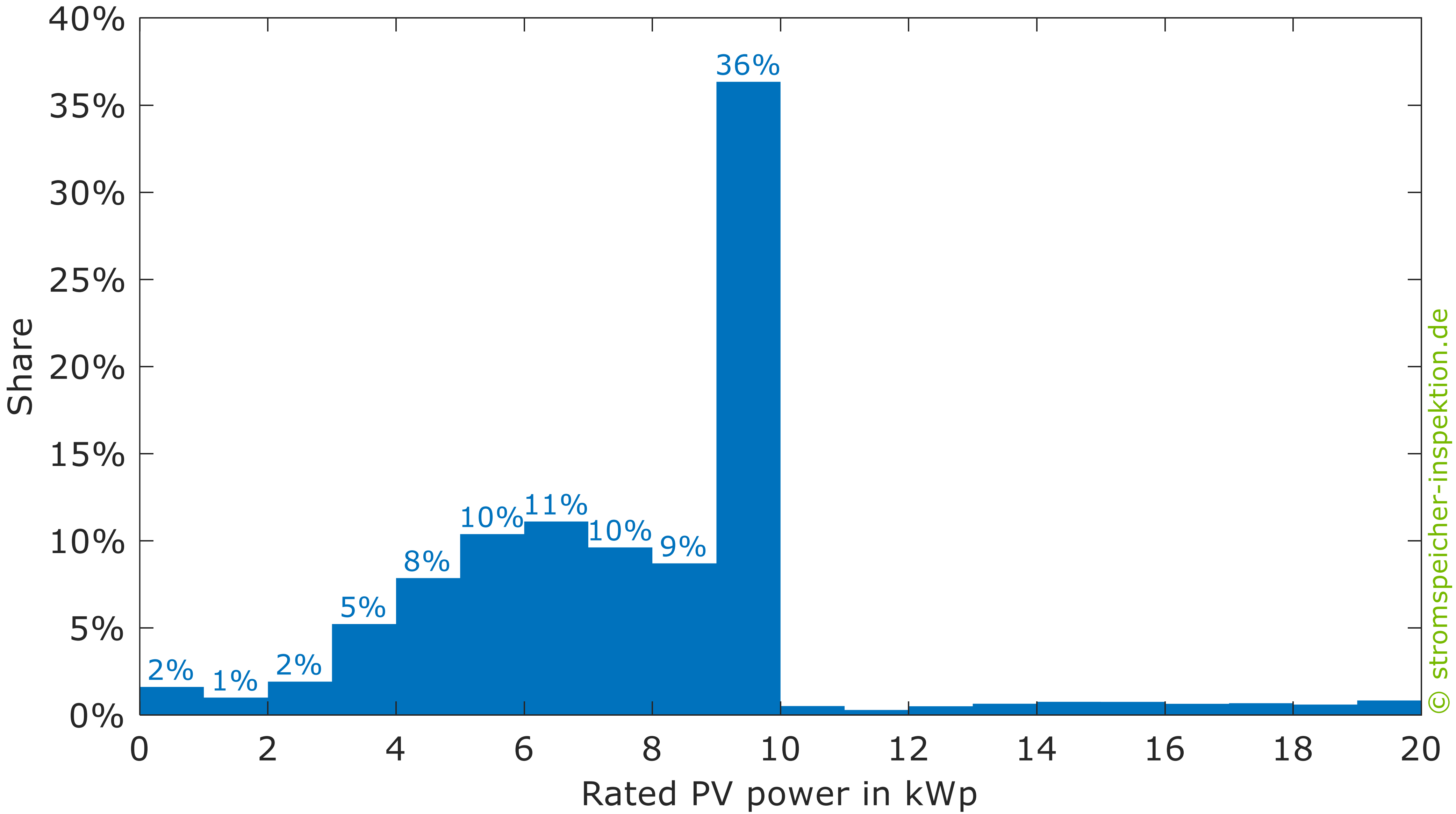
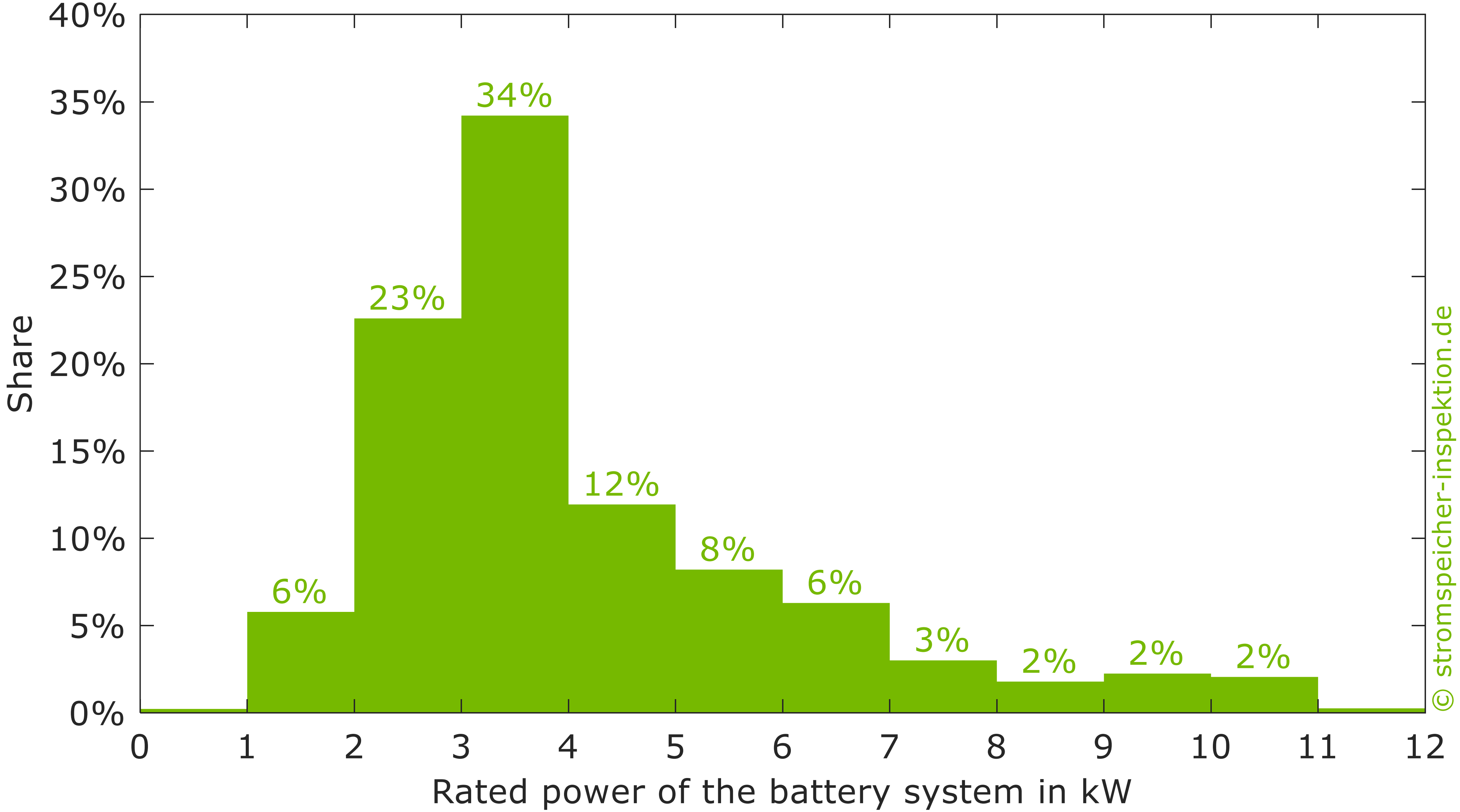
4 FAQ: Answers to questions concerning the efficiency of PV-battery systems

Rated power of the PV systems installed in 2019



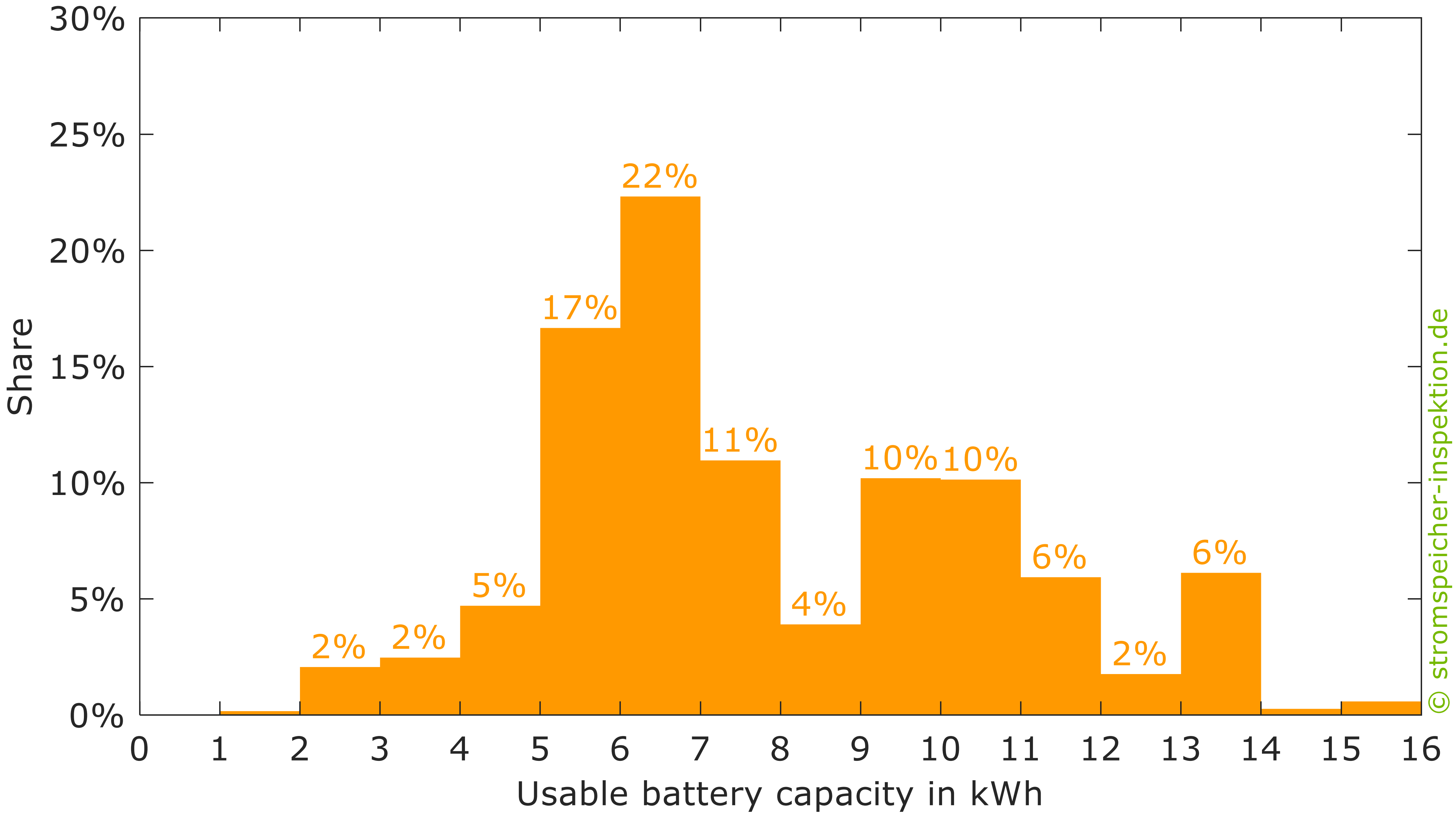
Data: German core energy market data register, number of systems of less than 20 kWp: 87.958

Rated power of the battery systems installed in 2019



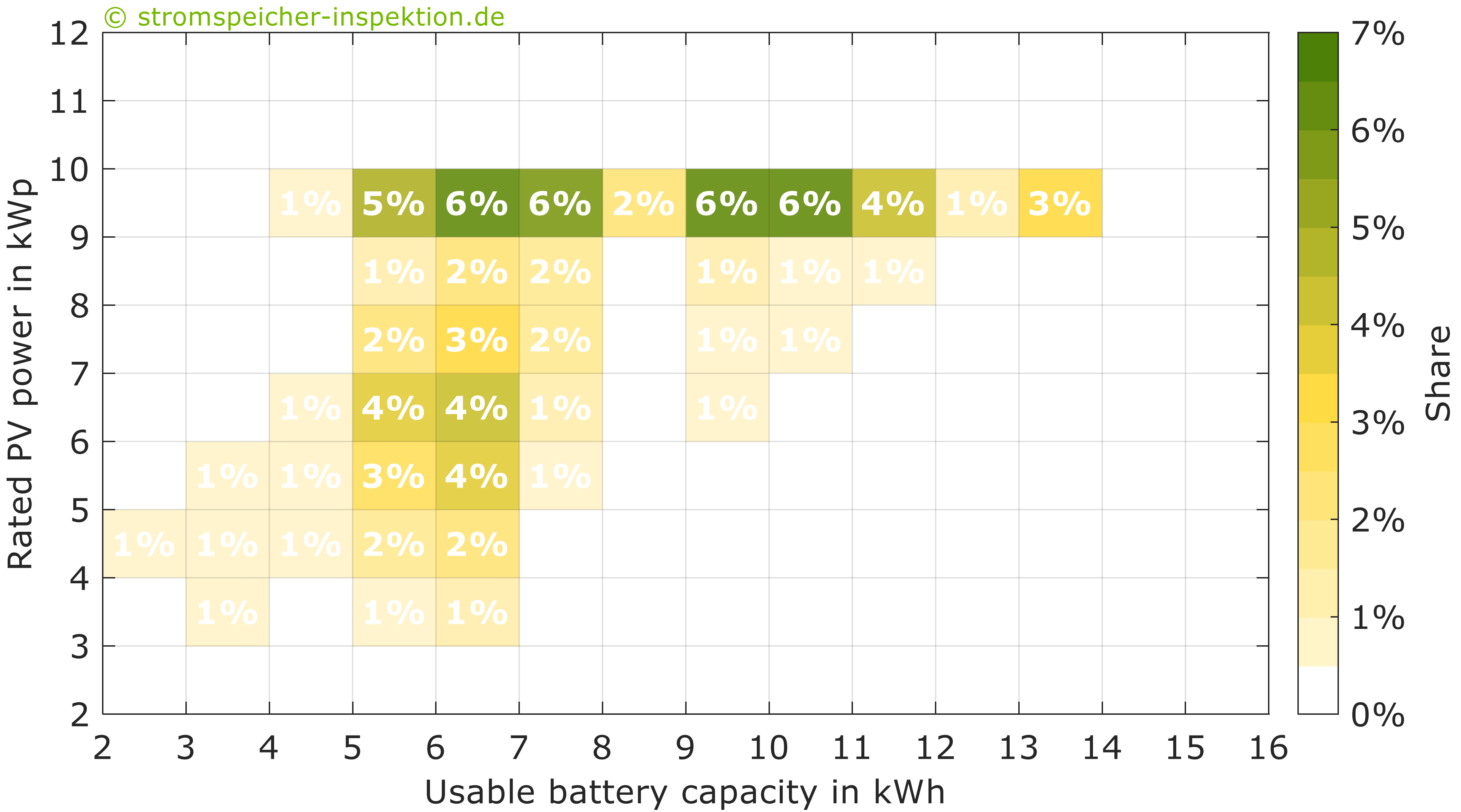
Data: German core energy market data register, number of systems of less than 20 kW and 20 kWh: 36.400

Usable battery capacity of the battery systems installed in 2019



Data: German core energy market data register, number of systems of less than 20 kW and 20 kWh: 36.400

Rated PV power and battery capacity of the PV-battery systems

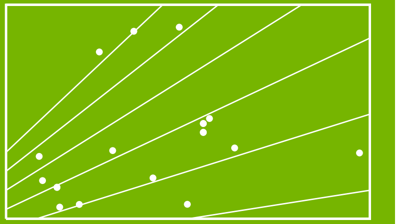


Data: German core energy market data register, number of identified PV-battery systems: 30.459

Main topics of the Energy Storage Inspection 2020

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 FAQ: Answers to questions concerning the efficiency of PV-battery systems

Methodology of the Energy Storage Inspection 2020

- All manufacturers of solar energy storage systems for residential buildings were invited to take part in the **Energy Storage Inspection 2020**.
- **14 manufactures** participated in the comparison of the storage systems with measurement data of **21 systems**.
- Laboratory tests were conducted by **independent testing institutes** in accordance with the "Efficiency Guideline for PV Storage Systems".
- The measurement results were evaluated in line with the specifications of the **second edition of the Efficiency Guideline**.
- Please note that many systems were not measured at the **average number of battery modules** as specified in the Efficiency Guideline.
- Each analyzed system has been assigned to a **system abbreviation** (e.g. A1).
- Further details on the methodology can be found in the **Energy Storage Inspection 2018**.

Analyzed systems of the Energy Storage Inspection 2020

A1 SMA Sunny Boy Storage 2.5 and BYD Battery-Box H6.4

A2 SMA Sunny Boy Storage 2.5 and BYD Battery-Box H10.2

A3 SMA Sunny Boy Storage 5.0 and IBC Solar era:powerbase 15.0 HV

A4 SMA Sunny Island 4.4M and LG Chem RESU6.5

B1 Siemens Junelight Smart Battery 9,9

C1 VARTA pulse 6

C2 VARTA pulse 6 neo and VARTA pulse 6

D1 KOSTAL PLENTICORE BI 5.5 and BYD Battery-Box H6.4

D2 KOSTAL PLENTICORE BI 5.5 and BYD Battery-Box H9.0

D3 KOSTAL PLENTICORE BI 5.5 and BYD Battery-Box H11.5

D4 KOSTAL PLENTICORE plus 5.5 and BYD Battery-Box H6.4

D5 KOSTAL PLENTICORE plus 5.5 and BYD Battery-Box H11.5

D6 KOSTAL PLENTICORE plus 8.5 and BYD Battery-Box H11.5

D7 KOSTAL PLENTICORE plus 10 and BYD Battery-Box H11.5

E1 RCT Power Power Storage DC 6.0 and Power Battery 5.7

E2 RCT Power Power Storage DC 6.0 and Power Battery 11.5

F1 KACO blueplanet hybrid 10.0 TL3 and Energy Depot DOMUS 2.5

F2 KACO blueplanet hybrid 10.0 TL3 and BYD Battery-Box H10.2 (FENECON Pro Hybrid 10)

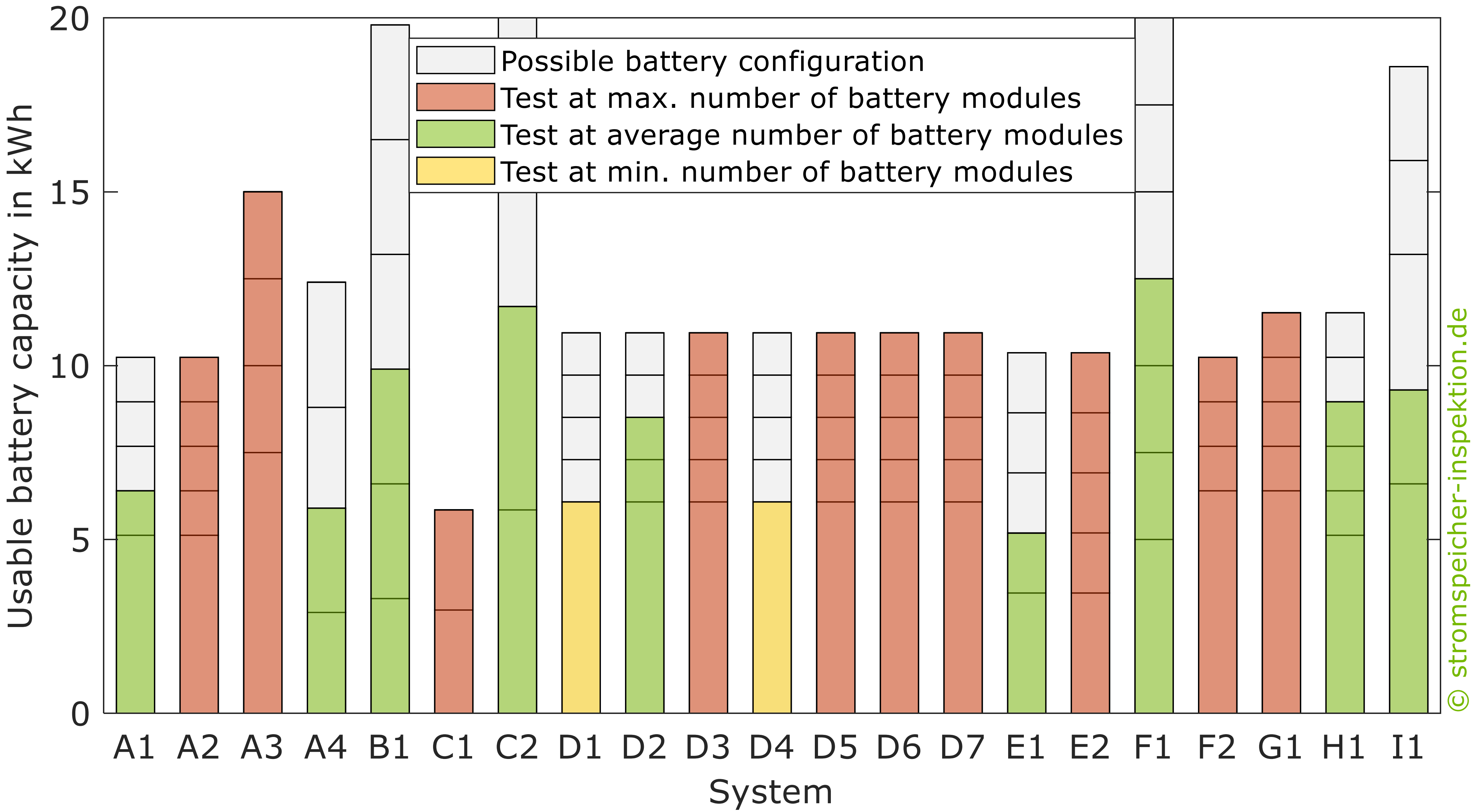
G1 Fronius Symo GEN24 10.0 Plus and BYD Battery-Box H11.5

H1 GoodWe GW10K-ET and BYD Battery-Box H9.0

A1 A2 A3 A4 B1 C1 C2 D1 D2 D3 D4 D5 D6 D7 E1 E2 F1 F2 G1 H1 I1

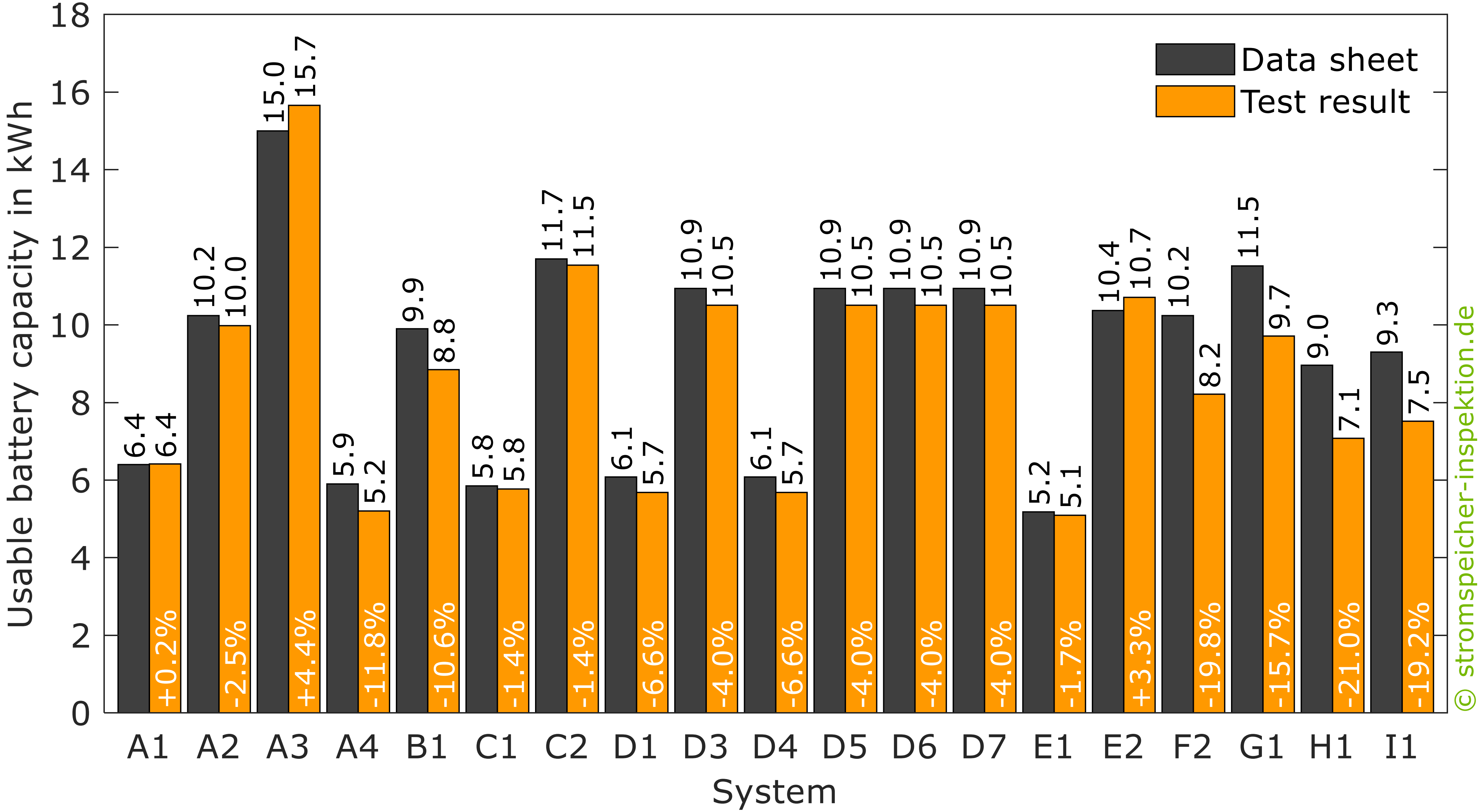
AC-coupled systems | DC-coupled systems

Available battery configurations of the analyzed systems



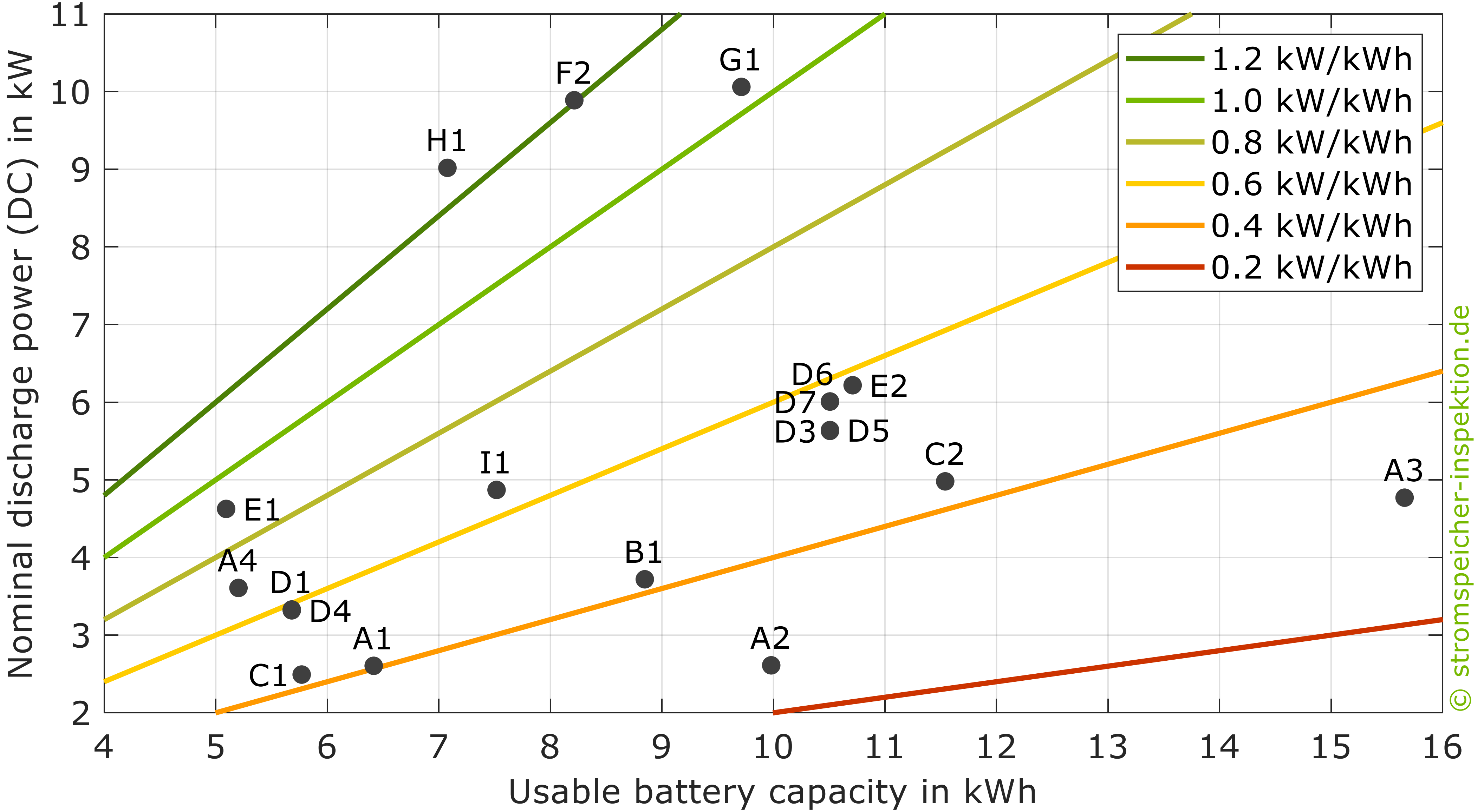
Source: data sheet specifications, systems C1 and C2: the usable battery capacity has been calculated based on the nominal battery capacity and the depth of discharge according to the data sheet

Usable battery capacity of the analyzed systems



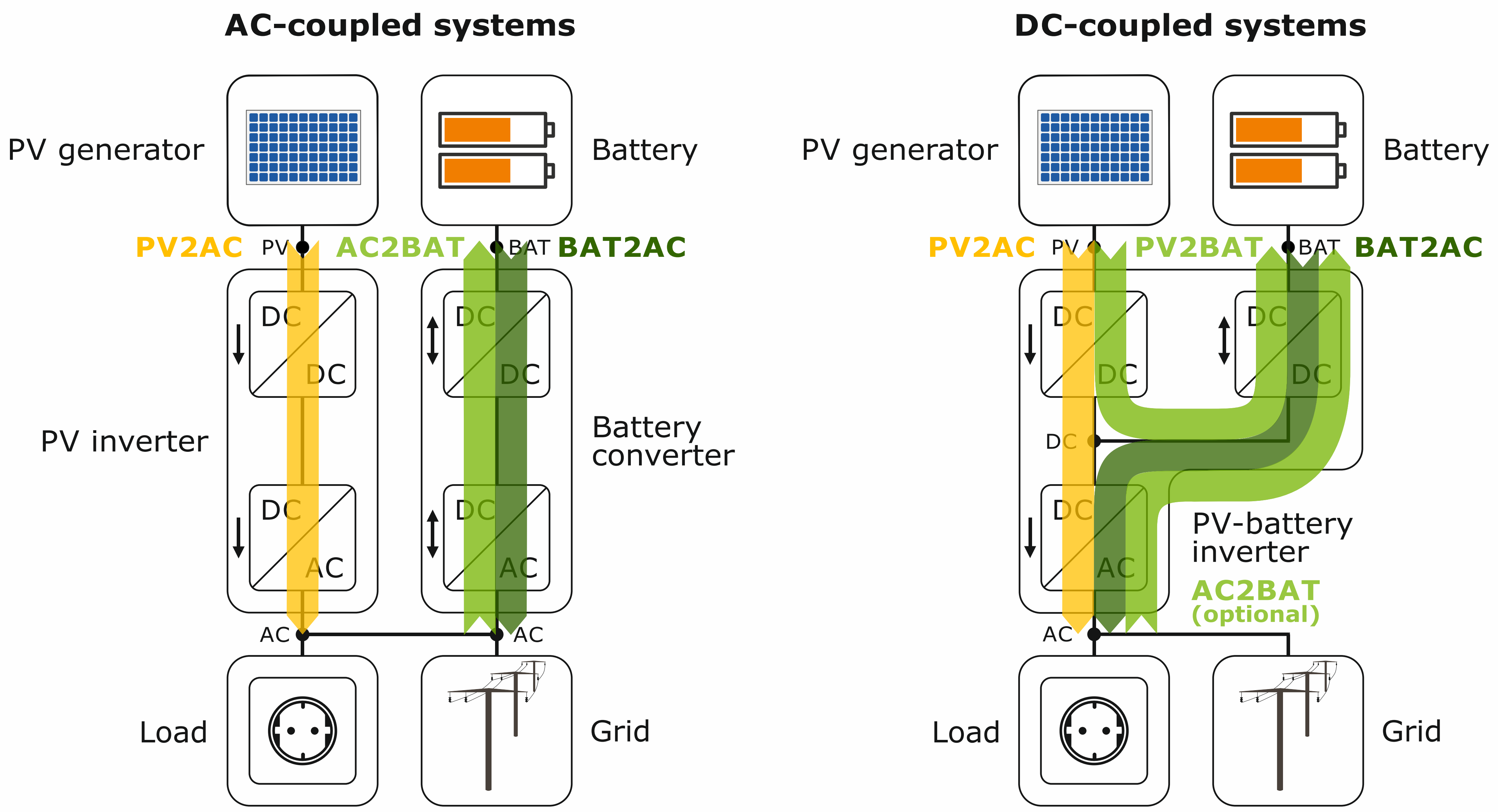
Systems C1 and C2: usable battery capacity was calculated according to the data sheet specifications, D2: measured data of the battery are not available, F1: no reliable battery measurements provided due to cell balancing issues

Nominal discharge power of the analyzed systems

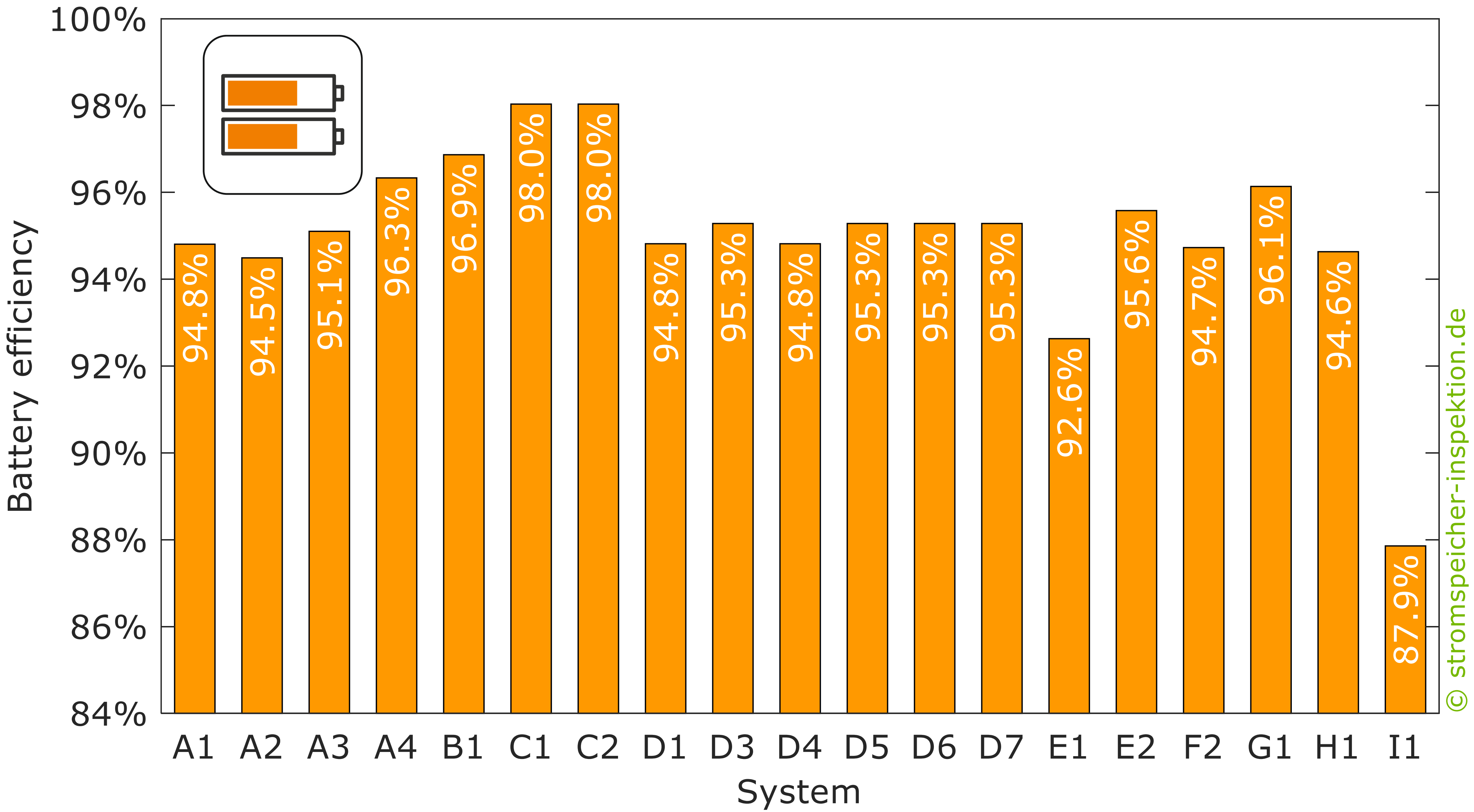


System D2: measured data of the battery are not available, F1: no reliable battery measurements provided due to cell balancing issues

Energy conversion pathways of the different system topologies

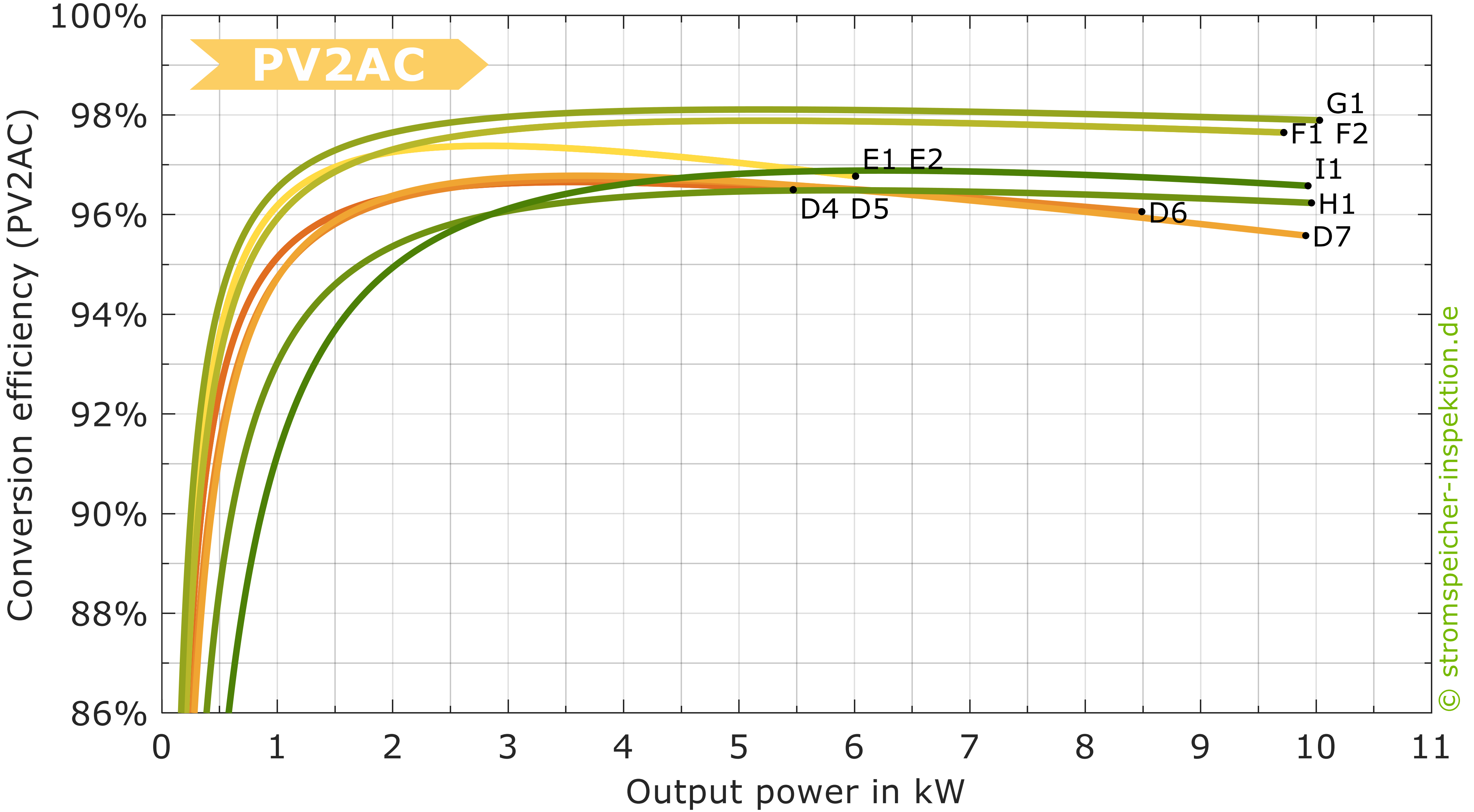


Average battery efficiency

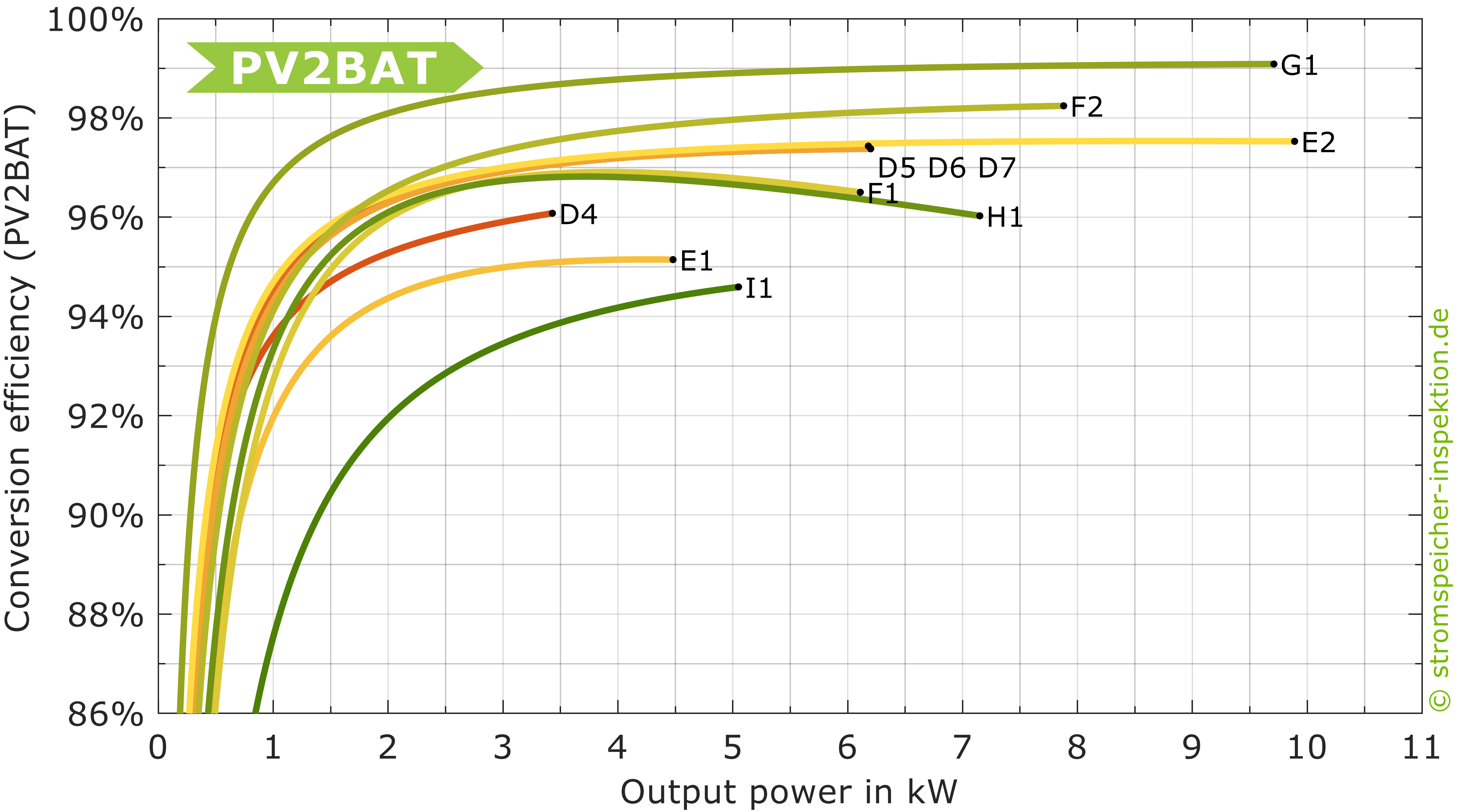


System D2: measured data of the battery are not available, F1: no reliable battery measurements provided due to cell balancing issues

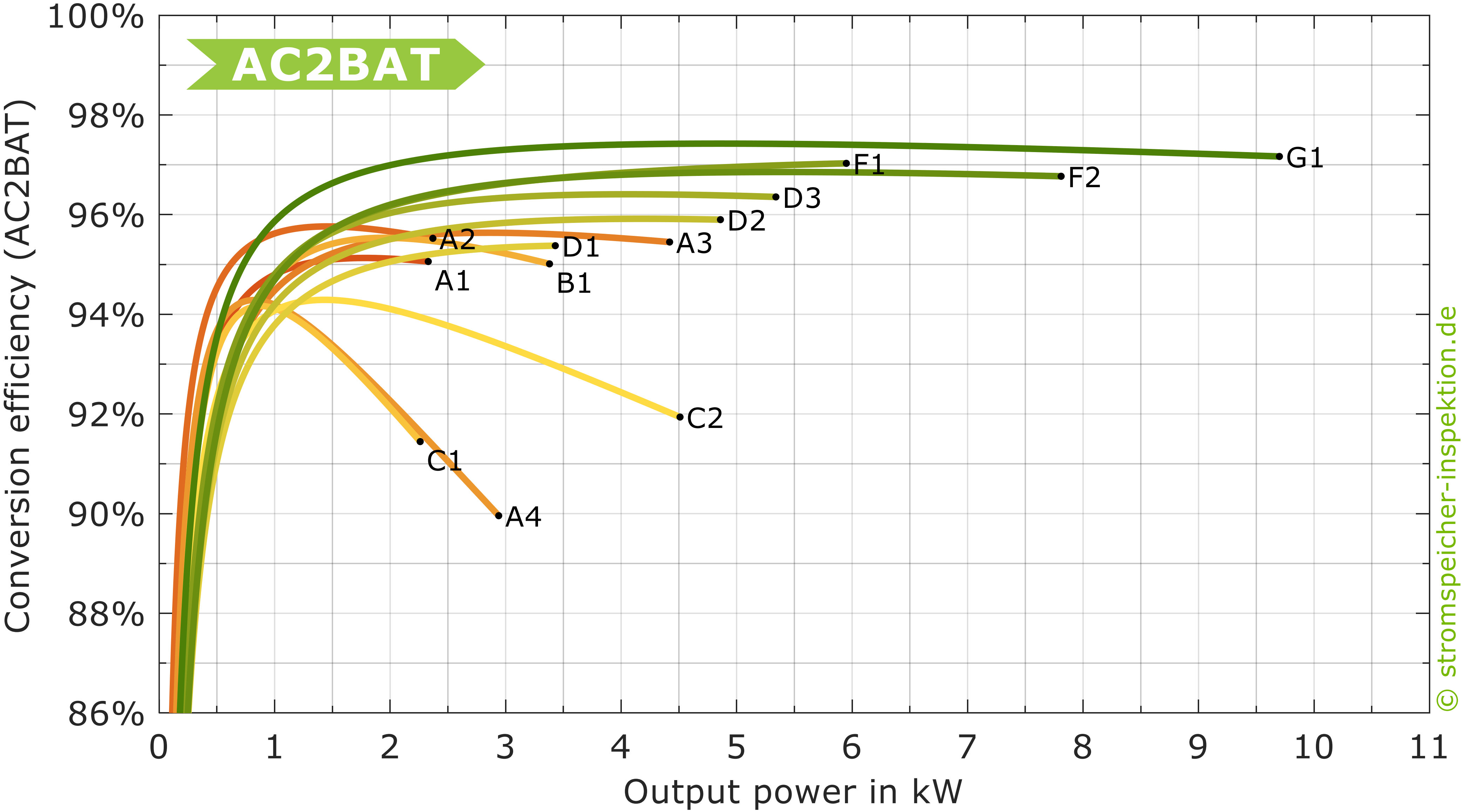
PV feed-in pathway efficiency



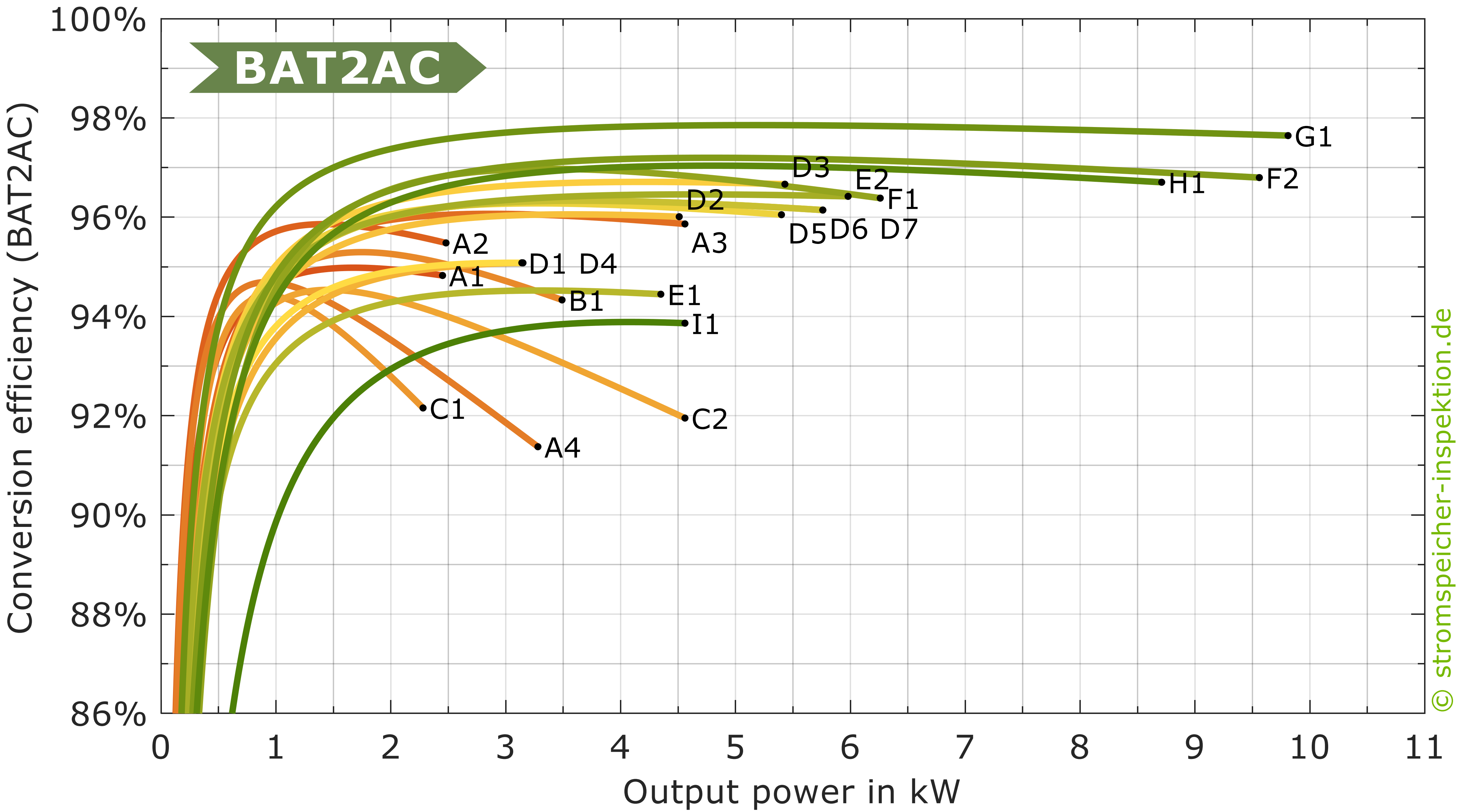
PV battery charging pathway efficiency



AC battery charging pathway efficiency



AC battery discharging pathway efficiency



Average efficiency of the different energy conversion pathways

System	PV2AC PV feed-in	PV2BAT PV battery charging	AC2BAT AC battery charging	BAT2AC AC battery discharging
A1			93.5%	93.4%
A2			94.5%	94.4%
A3			94.3%	94.8%
A4			92.0%	92.9%
B1			93.5%	93.3%
C1			91.7%	92.0%
C2			92.8%	92.9%
D1			93.1%	92.6%
D2			94.4%	94.5%
D3			95.1%	95.4%
D4	95.5%	93.2%		92.9%
D5	95.5%	95.7%		95.1%
D6	95.8%	95.5%		95.1%
D7	95.8%	95.5%		95.1%
E1	96.3%	92.2%		92.9%
E2	96.3%	96.6%		95.4%
F1	97.2%	94.3%	95.7%	95.3%
F2	97.2%	96.4%	95.9%	96.3%
G1	97.6%	98.2%	96.9%	97.3%
H1	95.4%	94.9%		96.0%
I1	95.1%	89.6%		90.3%

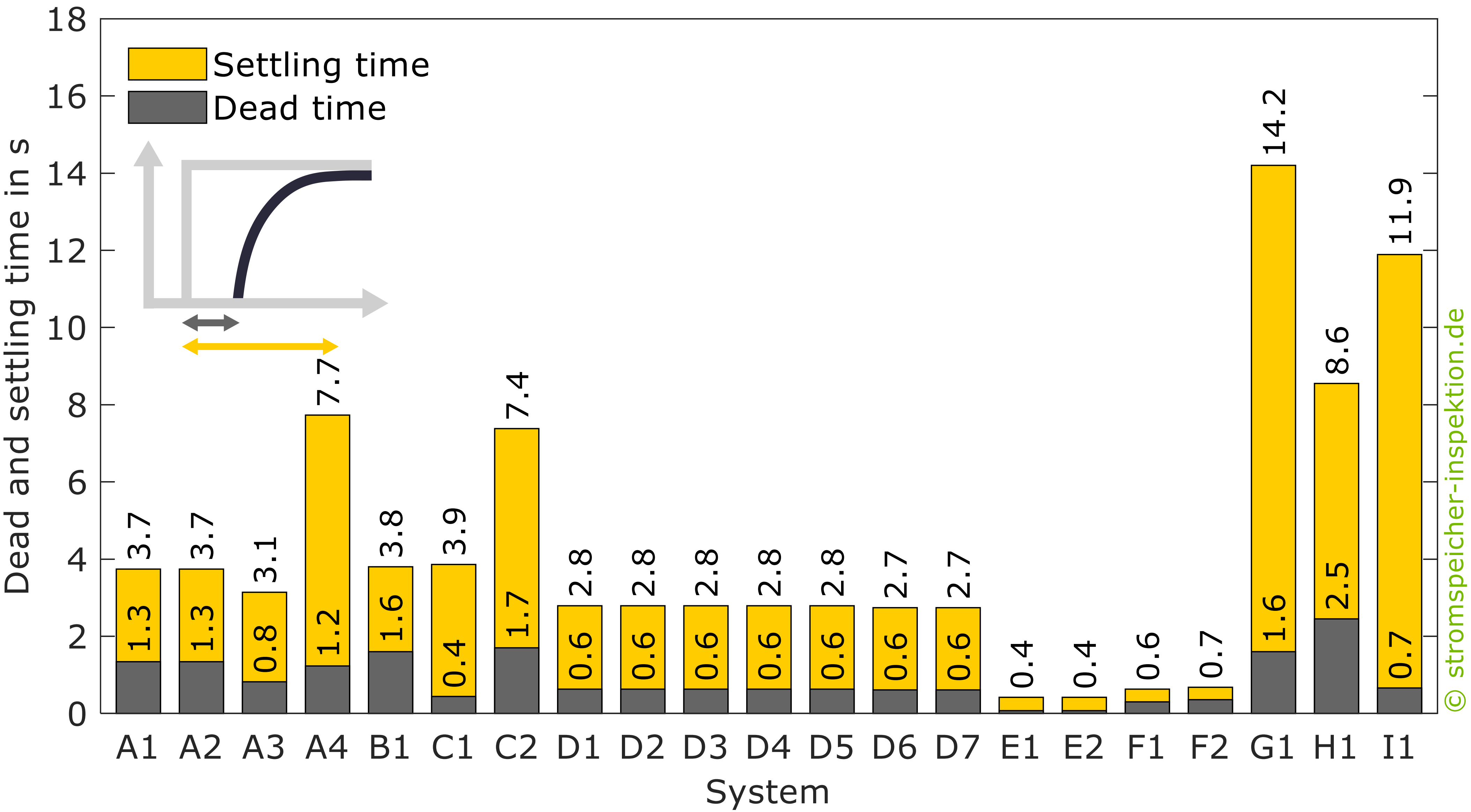
AC-coupled
System
DC-coupled

Average conversion efficiency: 98% 96% 94% 92% 90% 88% 86%

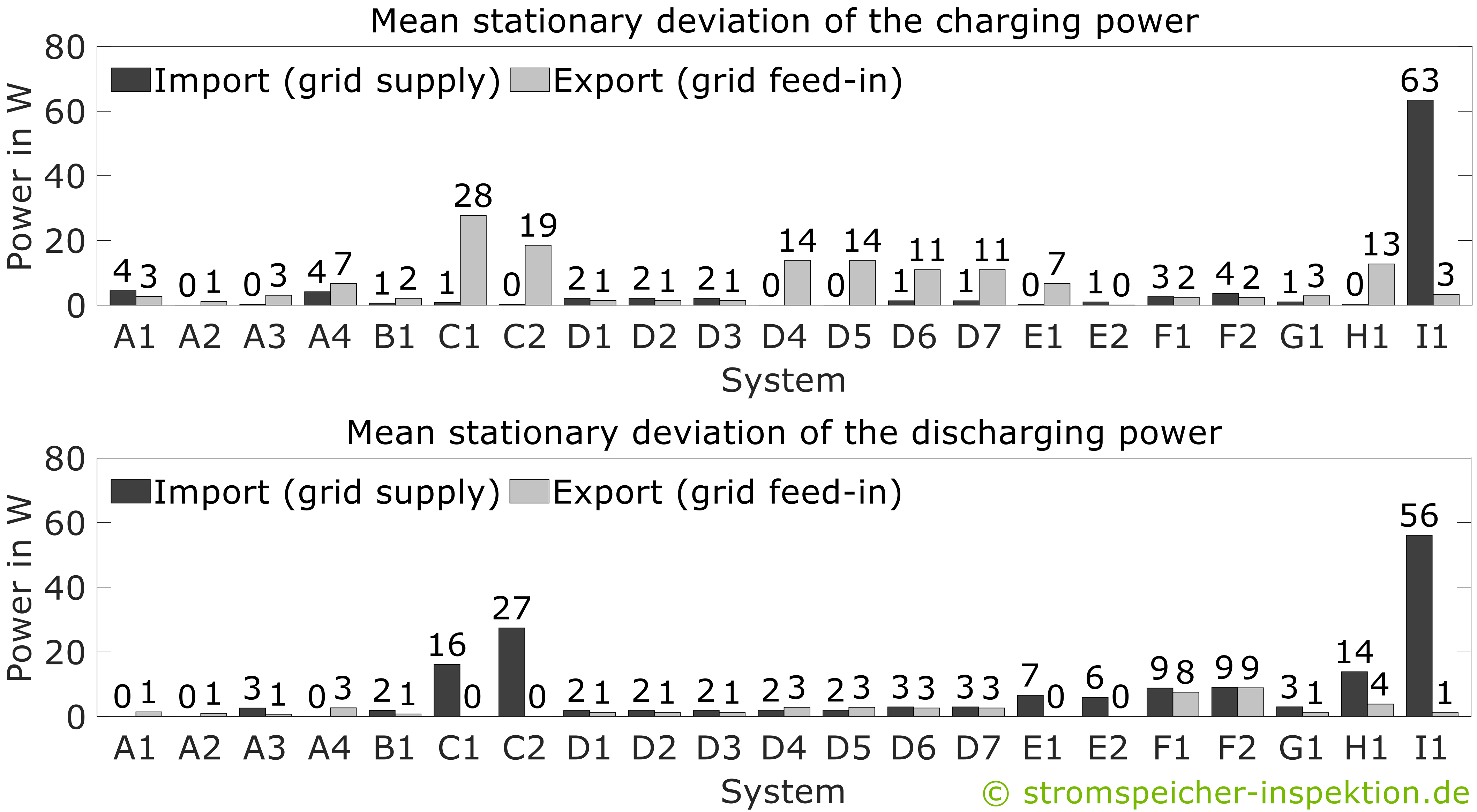
Conversion pathway

Average pathway efficiencies according to the second edition of the Efficiency Guideline for PV Storage Systems

Dynamic control deviations



Stationary control deviations



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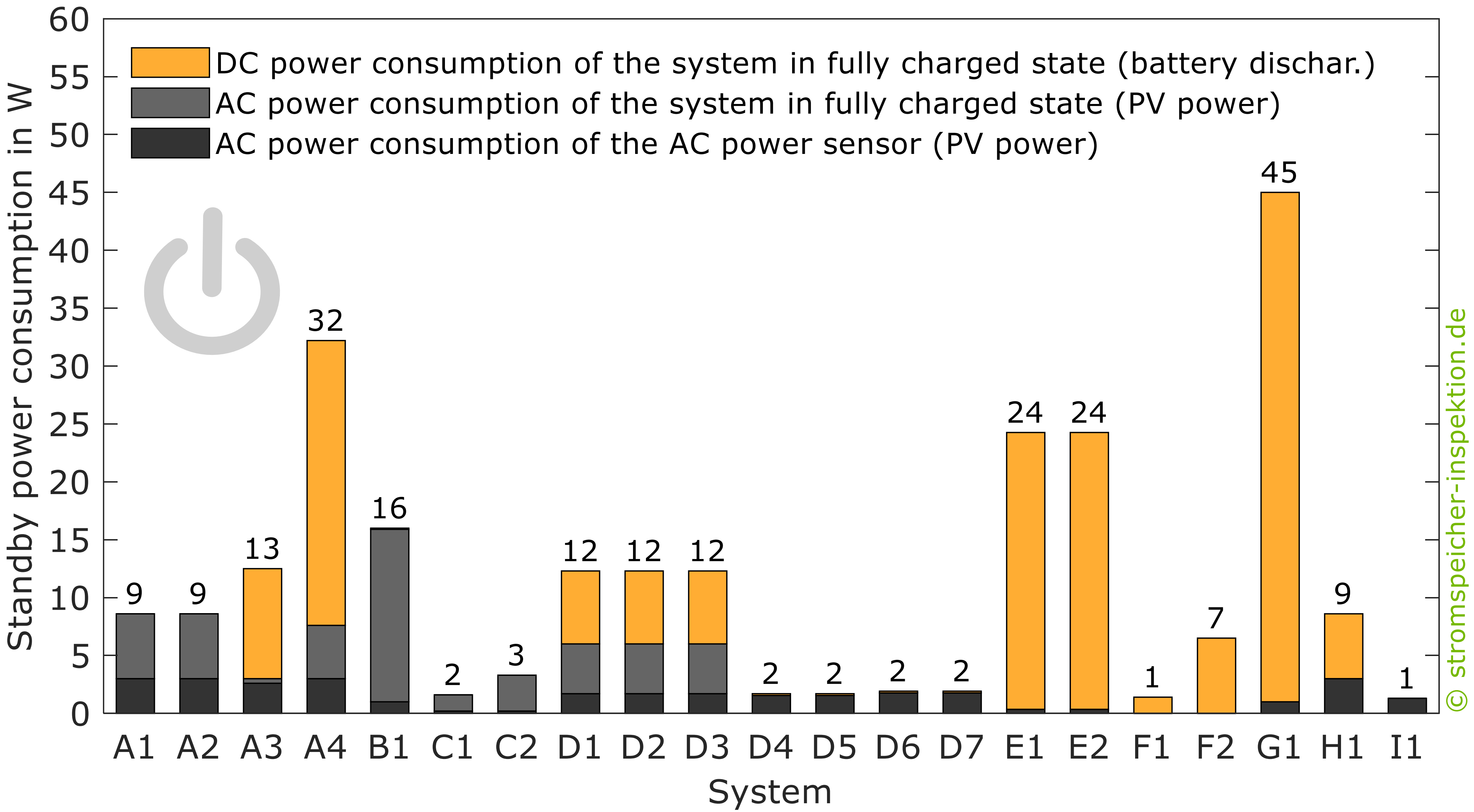
Standby power consumption of the systems in fully charged state



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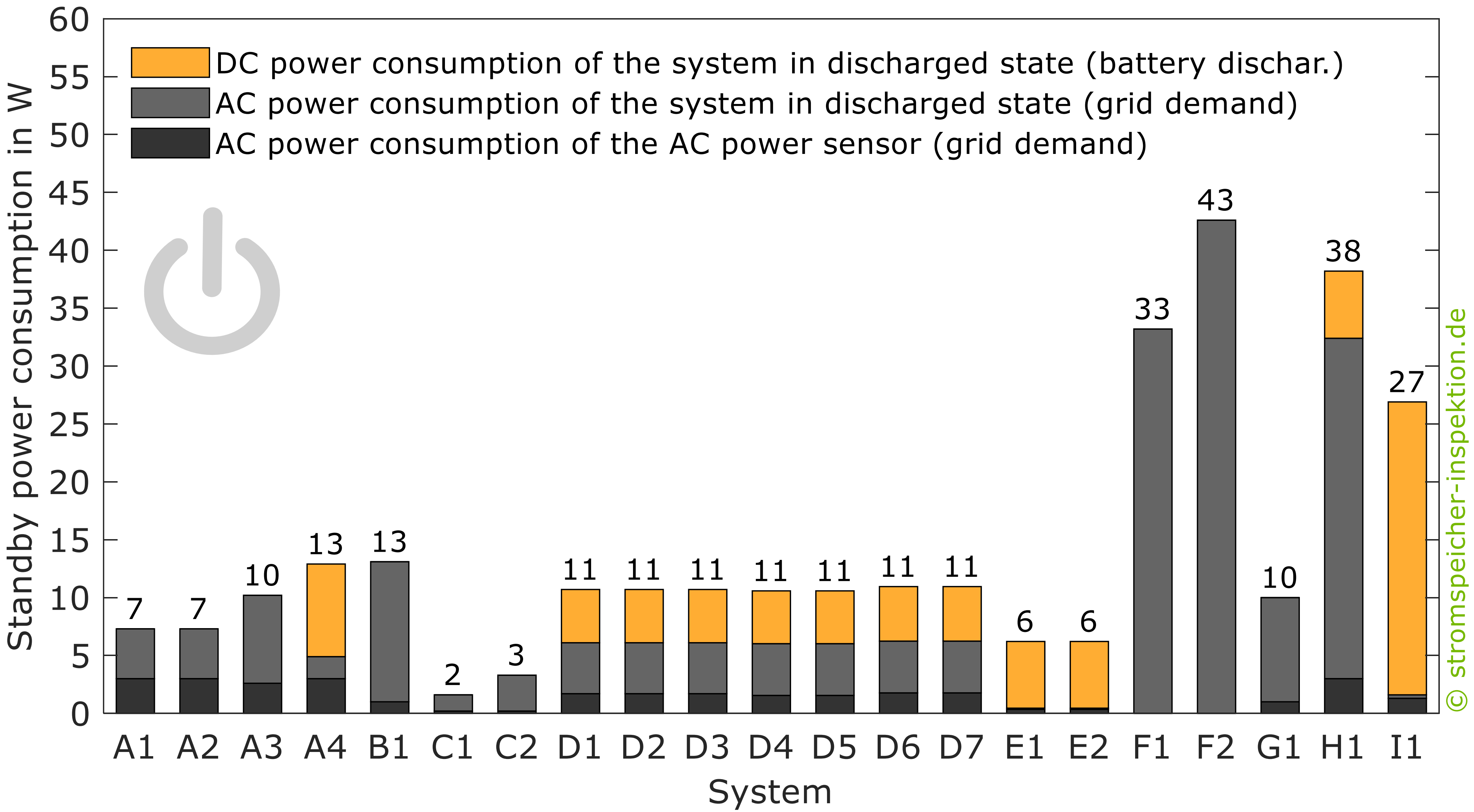
Standby power consumption of the systems in discharged state



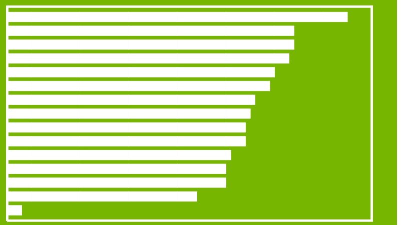
Systems F1 and F2: a power flow from the inverter to the battery was measured

Main topics of the Energy Storage Inspection 2020

1. Analysis of the German market for photovoltaic battery systems

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

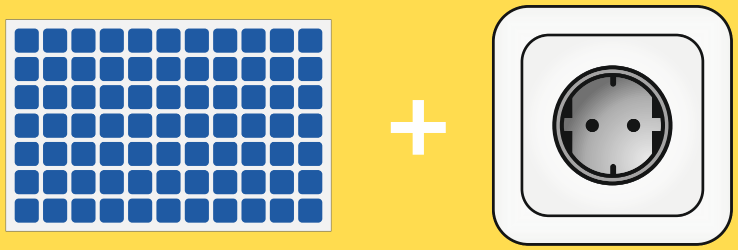
3. **Simulation-based assessment of the PV-battery systems with the System Performance Index (SPI)**



4. FAQ: Answers to questions concerning the efficiency of photovoltaic battery systems

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

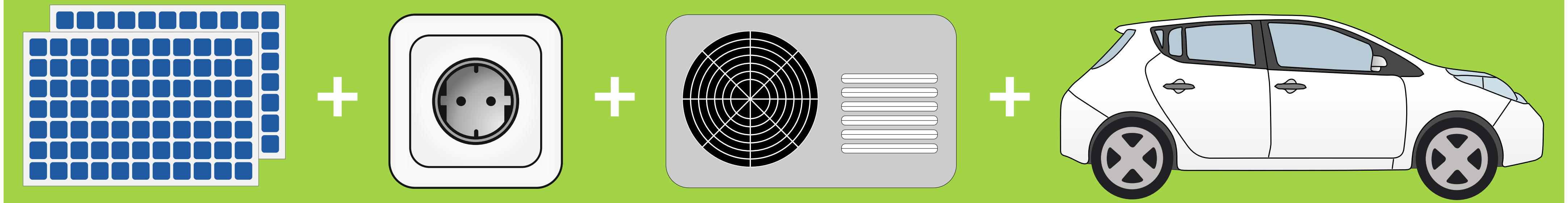
1st reference case for the System Performance Index SPI (5 kWp)



PV system
(5 kWp)

Appliances
(5010 kWh/a)

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



PV system
(10 kWp)

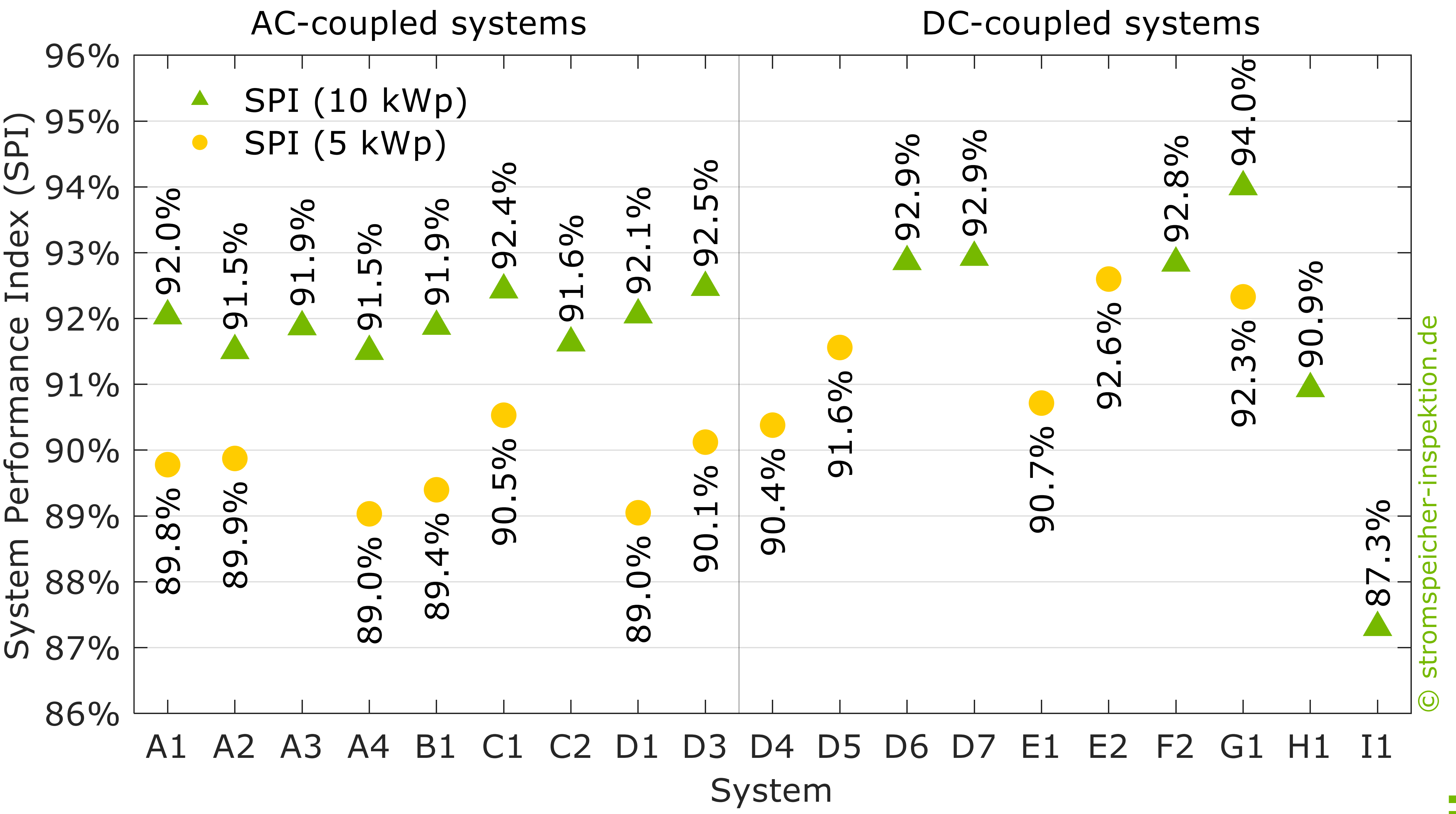
Appliances
(5010 kWh/a)

Heat pump
(2664 kWh/a)

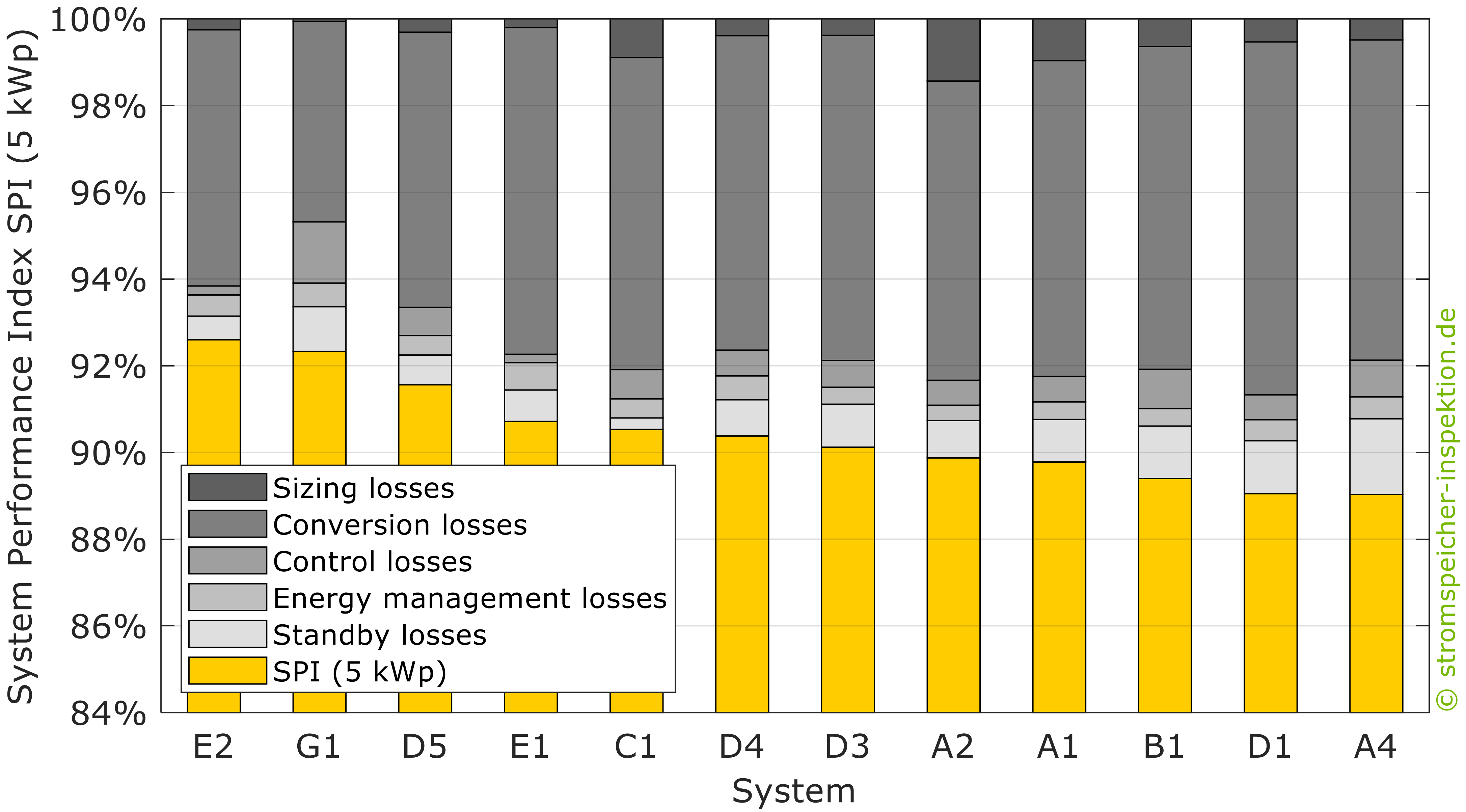
Electric vehicle
(1690 kWh/a)

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

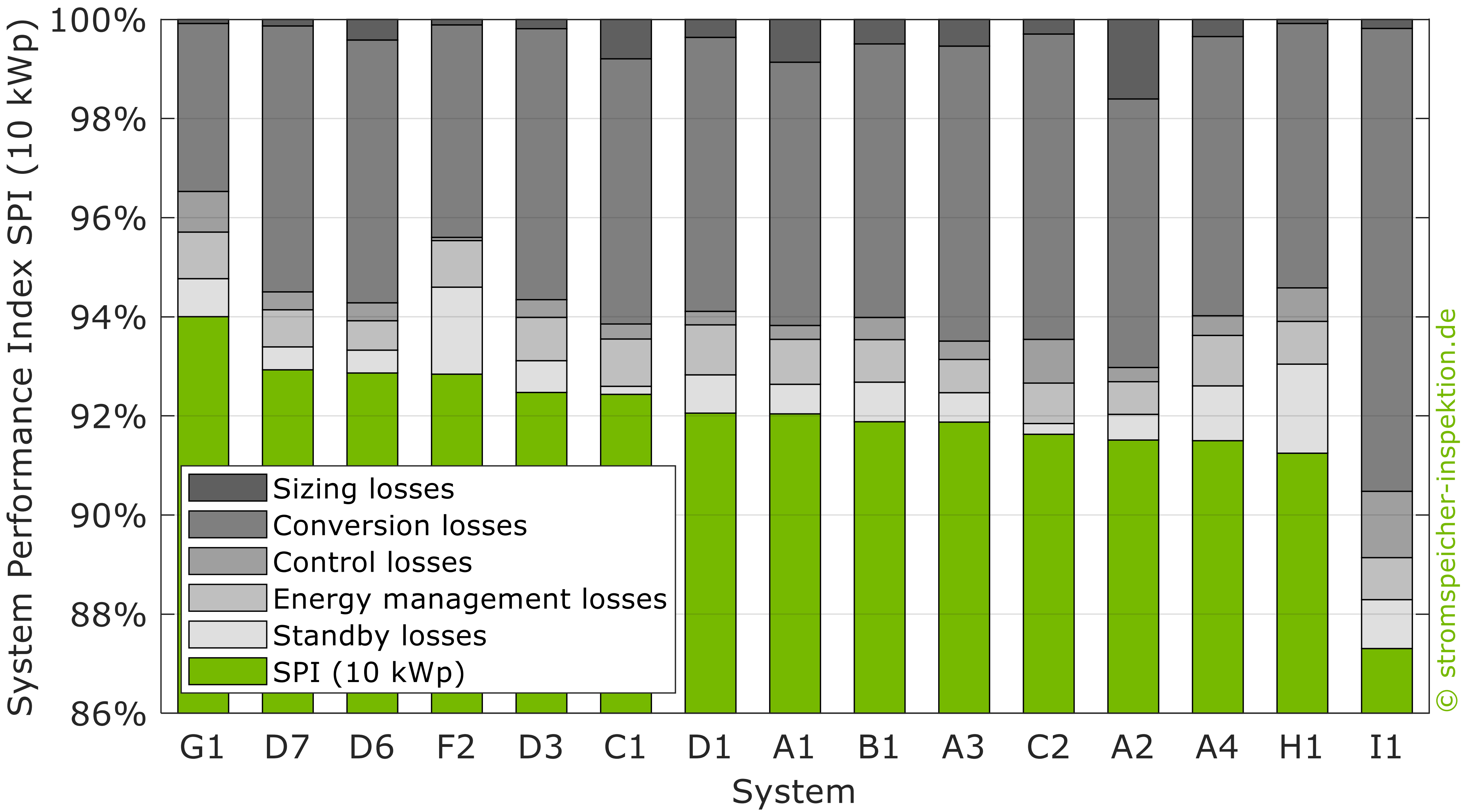
Results of the assessment with the SPI (5 kWp) and SPI (10 kWp)



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



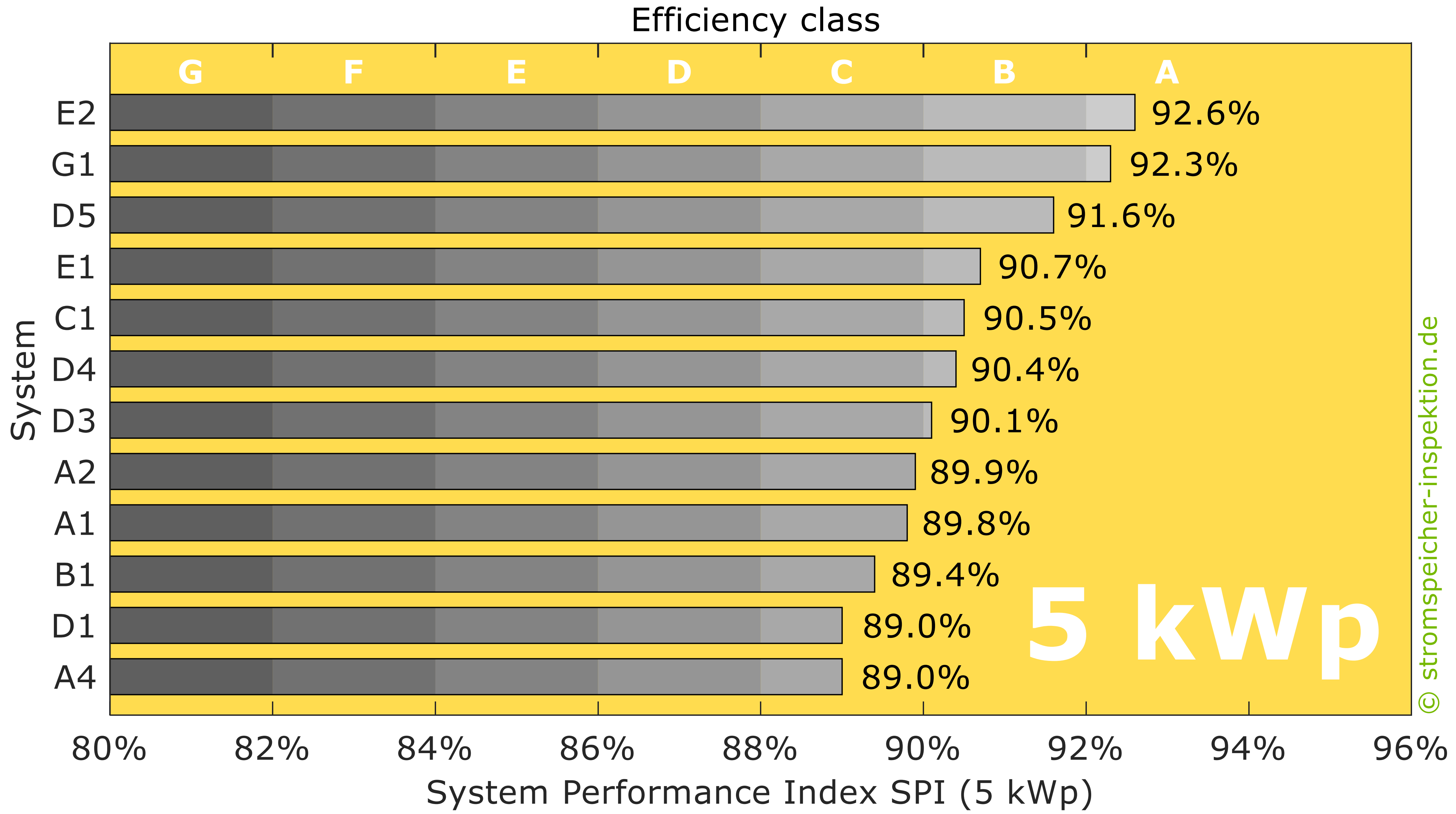
Loss analysis of the systems assessed with the SPI (10 kWp)



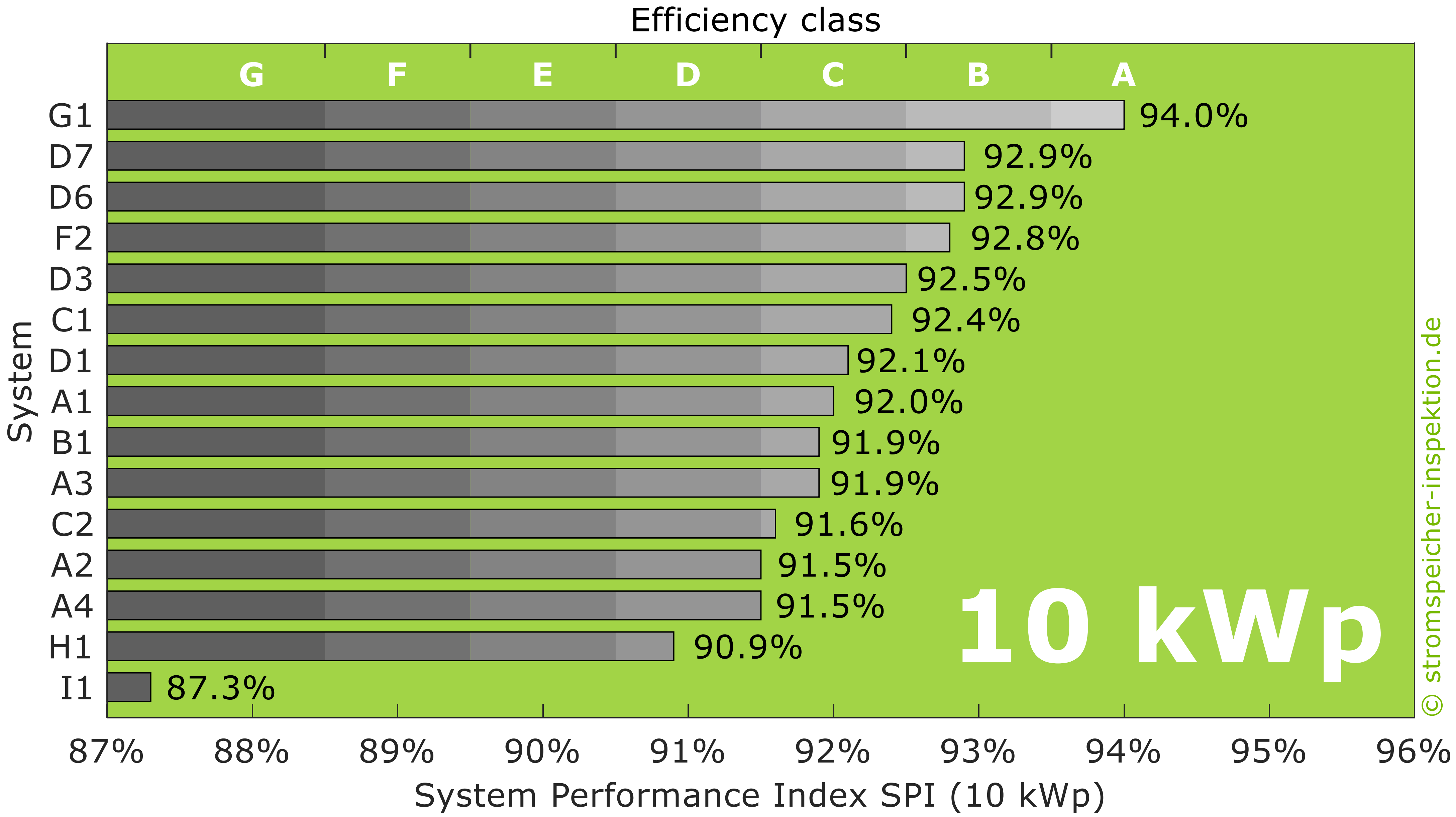
Definition of efficiency classes for PV-battery systems

Class	SPI (5 kWp)	SPI (10 kWp)
A	≥ 92%	≥ 93.5%
B	≥ 90%	≥ 92.5%
C	≥ 88%	≥ 91.5%
D	≥ 86%	≥ 90.5%
E	≥ 84%	≥ 89.5%
F	≥ 82%	≥ 88.5%
G	< 82%	< 88.5%

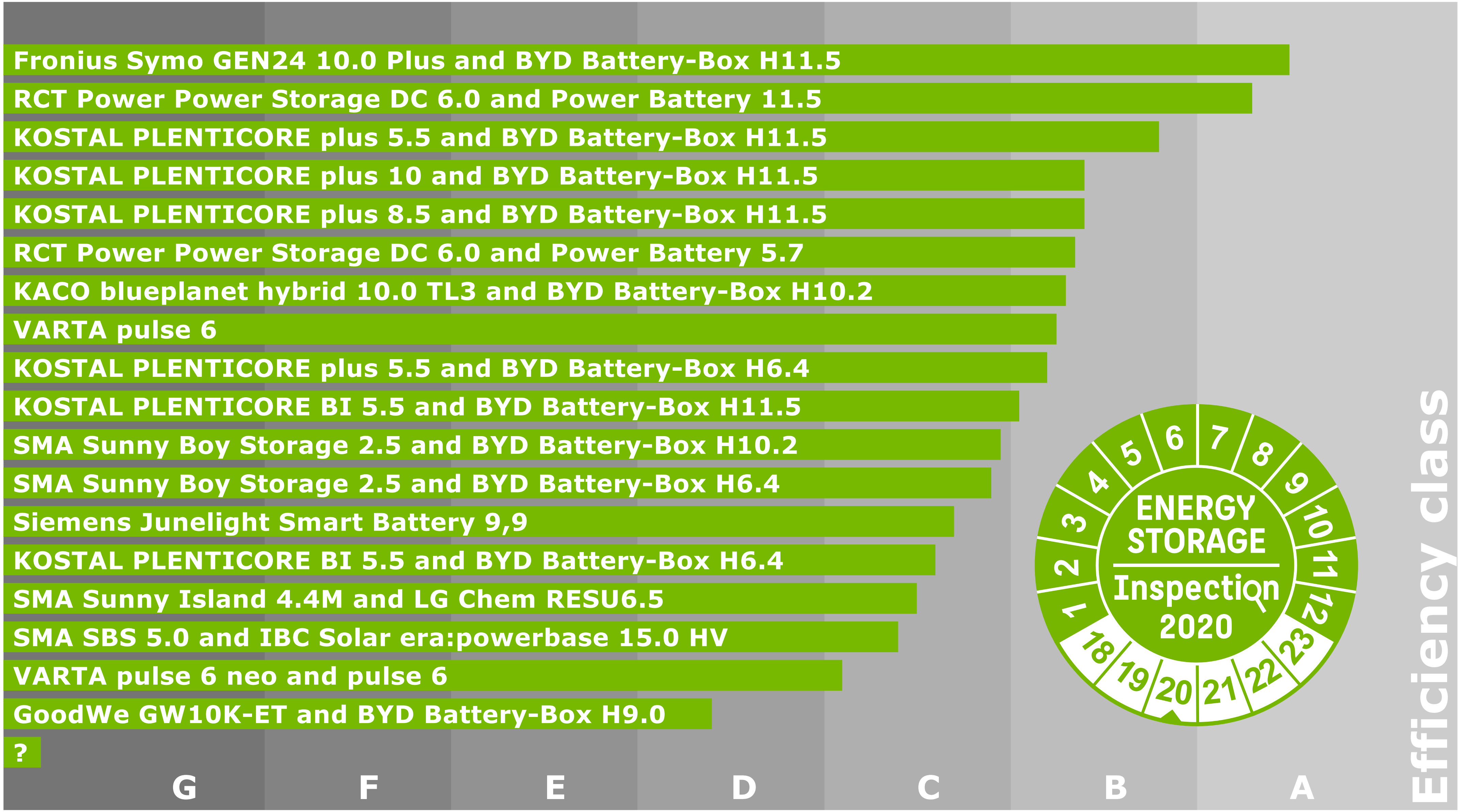
SPI (5 kWp) and efficiency classes of the analyzed systems



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

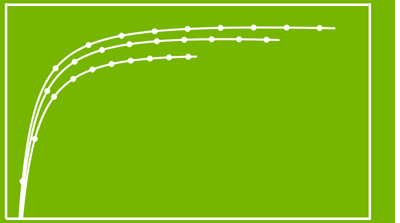


Results of the Energy Storage Inspection 2020



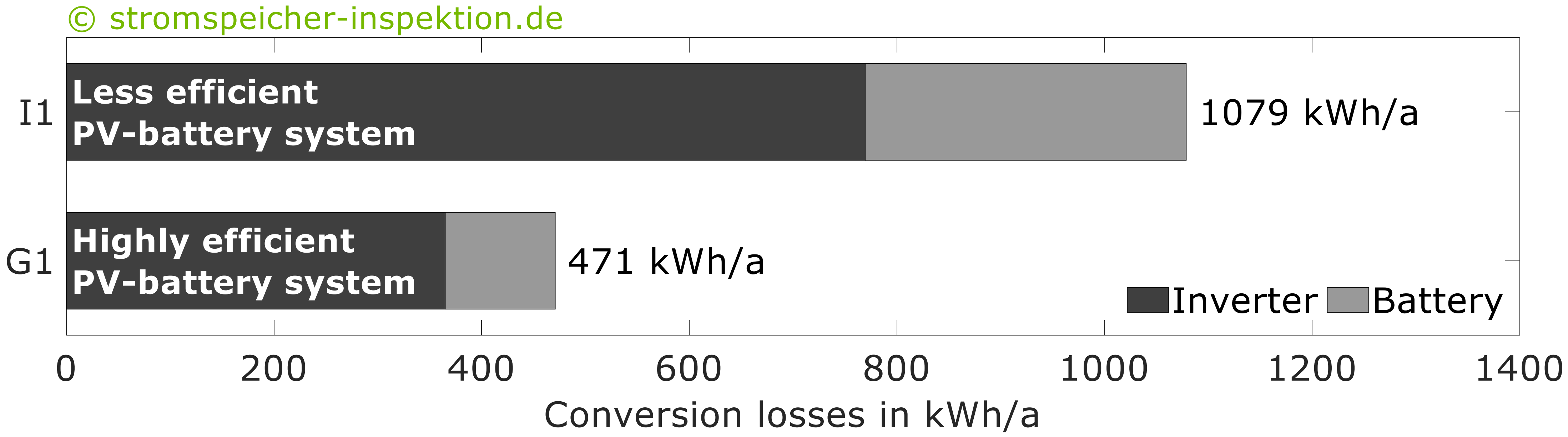
The efficiency classification is based on the System Performance Index SPI (5 kWp) and SPI (10 kWp).
Systems that have been assessed with both figures are ranked on the basis of the better value.

Main topics of the Energy Storage Inspection 2020

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	FAQ: Answers to questions concerning the efficiency of PV-battery systems 

Why is a high conversion efficiency important?

- The **inverter efficiency** as well as the **battery efficiency** of the PV-battery systems are the main sources of loss.
- The simulation results show that the **conversion losses** of the less efficient system I1 exceed those of system G1 by 608 kWh/a.



- Further **questions** and **answers** can be found in the Energy Storage Inspection 2020: **www.stromspeicher-inspektion.de**

Summary of the Energy Storage Inspection 2020

- **New records** were scored in several efficiency related categories within the framework of the Energy Storage Inspection 2020.
- Several 10 kW inverters achieved **outstanding conversion efficiencies** under partial load.
- The majority of the 21 PV-battery systems under study reached a **very high system efficiency**.
- The **System Performance Index SPI (10 kWp)** was introduced in addition to the established **SPI (5 kWp)** to make larger systems comparable.
- A novel **efficiency classification** based on these indicators was developed to further ensure the comparability of the systems.
- By focusing on high partial load efficiencies and low standby consumption, several manufactures improved the **system efficiency** of their products.

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