PEP method for assessing 3-Phase UPS sustainability

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Introduction

Introduction

As discussed in White Paper 64, Why Data Centers Must Prioritize Environmental Sustainability: Four Key Drivers, companies are seeking ways of **decreasing their data center's environmental footprint** and of their company in general. These needs apply to all data center sizes, from the largest multi-megawatt purpose-built data center to a single-rack micro data center in a branch office. Most vendors recognize these needs and therefore promote their product's sustainability as a means to help their customers attain their sustainability goals.

As one of the leading companies in demonstrating sustainability[1], Schneider Electric believes that **customers care about three key topics** when it comes to sustainable products:

1. **Compliance with applicable regulations**, particularly those related to hazardous substances. Includes mandatory compliance to hazardous substance regulations such as the European directive for Restriction of Hazardous Substances (RoHS); European Regulation for Registration, Evaluation (REACh); European directive for Waste from Electrical and Electronic Equipment (WEEE); China RoHS; and California Proposition 65.

2. **Sustainability data** that is free and available to all customers and validates product claims, including documentation like environmental product disclosures and product end-of-life treatments.

3. **Performance characteristics that improve a product's sustainability**, including lower impact materials, energy efficiency, durability, repairability, and take-back.

[1] Schneider Electric recognized in Corporate Knights' Global 100 for the 12th year in a row

Environmental declarations

Environmental declarations

An environmental product declaration (EPD) summarizes the environmental life cycle data of a product or service and is normally valid for five years. These documents help specifiers make Uninterruptible Power Supply (UPS) decisions based on environmental impacts like carbon footprint and water use, making it easier to compare UPSs of the same category.

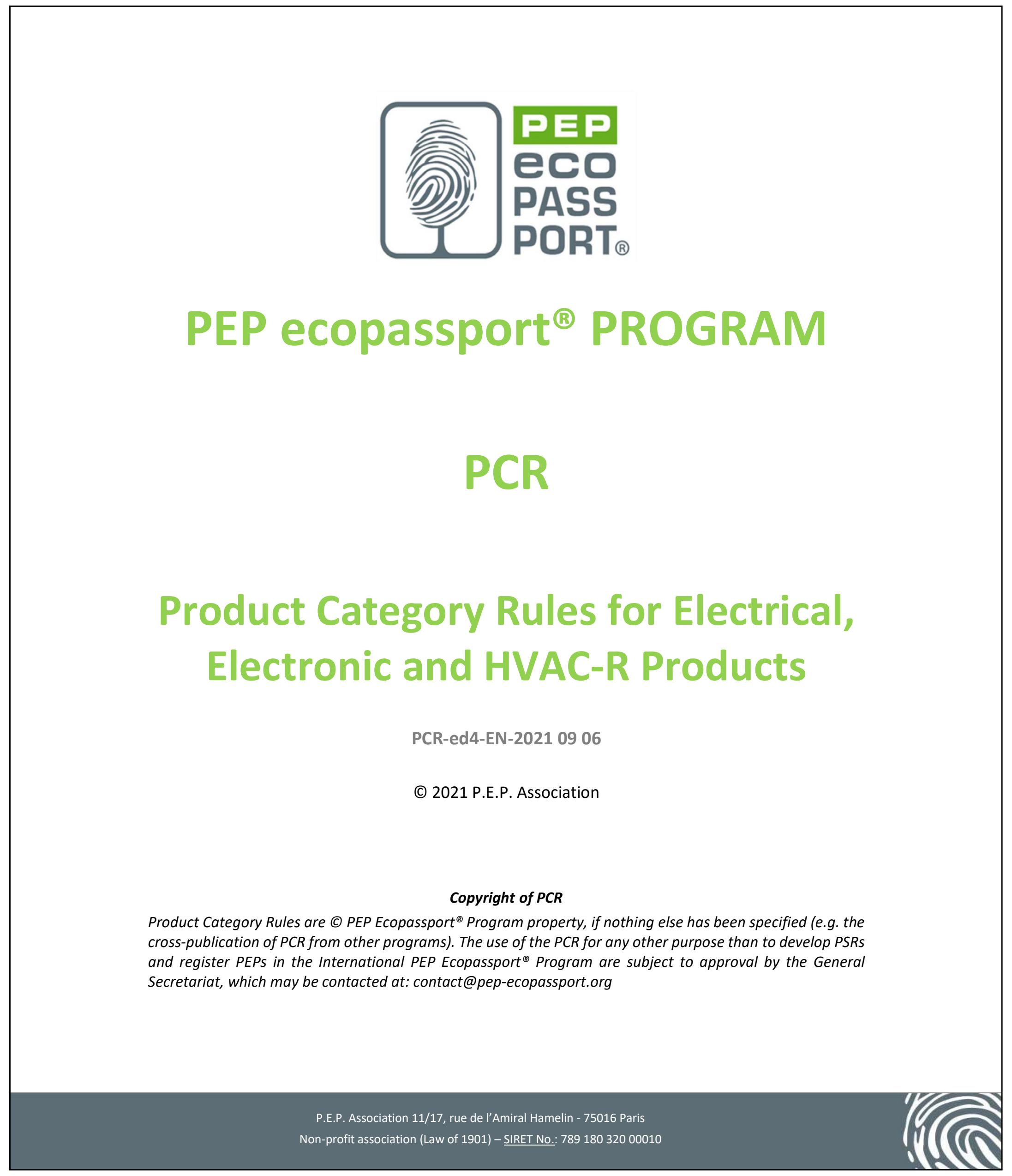
The International Organization for Standardization (ISO) publishes the standards that underly EPDs, in particular ISO 14025. EPDs must be based on life cycle assessment (LCA) data or life cycle inventory analysis (LCI) data, which are governed by the ISO 14040 standard. For more information on ISO standards, see Schneider Electric White Paper 70. Note that ISO 14040 is generic and applies to all types of products and services.

The following sections explain how to read an EPD, explain three key concepts of a 3-phase UPS PSR, and describe the typical carbon profile of a 3-phase UPS.

Reporting environmental data for a UPS

Program operators like the P.E.P. Association administer programs in compliance with ISO 14025 so that EPDs report the same type of information. They develop, approve, and publish product category rules (PCR) and product-specific rules (PSR) for Type III environmental declarations. All EPDs must be independently verified by internal[2] or external experts and provide information need to track Scope 1, 2, and 3[3] emissions.

For this e-guide, the PCR related to a UPS covers electrical, electronic, and HVAC-R products and defines how vendors should perform the LCA. When the PCR isn't detailed enough to develop EPDs for specific products, program operators develop PSRs.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PCR

Product Category Rules for Electrical, Electronic and HVAC-R Products

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[2] This applies to business-to-business products only.
[3] See Appendix of White Paper 67, *Guide to Environmental Sustainability Metrics for Data Centers*, for information on Scope 1, 2, and 3.

What is a PEP and how to read it

PEP stands for Product Environmental Profile. The PEP Ecopassport association defines which mandatory information a PEP must provide. While the templates change from vendor to vendor, **the key information needed for a UPS comparison is usually presented in the following order:**

1. **The "reference product" or "representative product"**
2. **The "function" or "functional unit"**
3. **Constituent materials**
4. **Additional environmental information**
5. **Environmental impacts**
6. **Verification information**

PEP contains the CO_2 emissions data of the product

PEP Extract of a 3-phase UPS: Galaxy VX

The 'Contribution to climate change' contains the CO_2 Emissions of the product expressed in kg CO_2 equivalent.

Description of the different Life Stages of the product

Mandatory Indicators			Galaxy VX UPS System - GVX1250K1250NHS				
Impact indicators	Unit	Total	Manufacturing [A1 - A3]	Distribution [A4]	Installation [A5]	Use [B1 - B7]	End of Life [C1 - C4]
Contribution to climate change	kg CO2 eq	1.97E+06	9.41E+04	1.04E+03	2.18E+02	1.87E+06	6.05E+03
Contribution to climate change-fossil	kg CO2 eq	1.97E+06	9.36E+04	1.04E+03	2.89E+02	1.87E+06	5.94E+03
Contribution to climate change-biogenic	kg CO2 eq	2.51E+03	4.94E+02	0*	0*	1.97E+03	1.09E+02

All values in the PEP are expressed in scientific notation using a decimal value with an exponential (E) of 10. In this example:

1.97E06 = 1.97 x 10E6 = 1.97 x 1,000,000 = 1,970,000

Product specific rules (PSR) for 3-phase UPS

The PSRs define rules for specific products within the larger product category. Due to their unique function, such as multiple operating modes, UPSs are one of those products that require their own product specific rules.

There are 3 key concepts in the UPS PSR that play a significant role in determining the life cycle carbon footprint of a UPS.

1. Reference Service Life (RSL)

The RSL is the length of time the UPS is expected to remain in service. According to section 3.5.5.1 of the PSR, a 3-phase UPS over 10 kW has a service life of 15 years. This means that the life cycle assessment accounts for 15 years of UPS emissions. For example, if the electricity use emissions for the UPS is 100,000 kg CO_2e per year, its lifetime electricity emissions would be 100,000 kg CO_2e x 15 years or 1,500,000 kg CO_2e.

Output power [W]	Reference service life RSL Units: year
Functional Unit	1
P≤ 1500 W	5
1500 W< P ≤5000 W	8
5000 W< P ≤10000 W	10
P> 10000W	15

Reference Service Life (RSL) of a UPS

2. Typical load profile

A load profile is meant to ensure that all manufacturers use the same assumptions to calculate electricity use. A load profile includes % load, length of time a UPS operates during its lifetime, and UPS operating mode.

For 3-phase UPSs greater than 10 kW, the electricity use is based on operating at:

- 25% load for 25% of the UPS life (3.75 years)
- 50% load for 50% of the UPS life (7.5 years)
- 75% load for 25% of the UPS life (3.75 years)
- 100% load at 0% of the UPS life (0 years)

Output power P [W]	Proportion of Time spent at specified Proportion of Reference Test Load during RSL			
	25%	50%	75%	100%
P ≤ 300 W	0,2	0,2	0,3	0,3
300 W < P ≤ 3500 W	0	0,3	0,4	0,3
3500 W< P ≤10000 W	0	0,3	0,4	0,3
P > 10000W	0,25	0,5	0,25	0

Typical load profile of a UPS

Product specific rules (PSR) for 3-phase UPS (continued)

3. Energy efficiency calculation

The percent load and operating mode are important because they determine the UPS's efficiency at a specific load percentage. If a UPS has two operating modes, it will have two different efficiency values that characterize each mode. However, according to UPS PSR section 3.5.5.3, the electricity use calculation must be based on the UPS's operating mode with the worst case weighted efficiency; which in most cases is double conversion.

The weighted efficiency for a 3-phase UPS (>10 kW) is calculated according to the formula:

Weighted efficiency = 25% x Eff25% + 50% x Eff50% + 25% x Eff75% + 0% x Eff100%

Weighted efficiency in **double conversion**
= 25% x 95.6% + 50% X 96% + 25% x 95.7% + 0% x 95.2% = **95.8%**

	Normal operation			
Voltage (V)	**380**	**400**	**415**	**440 V**
25% load	95.6%	95.6%	95.7%	95.7%
50% load	95.8%	96.0%	96.1%	96.3%
75% load	95.4%	95.7%	95.8%	96.0%
100% load	94.8%	95.2%	95.3%	95.7%

Weighted efficiency in **eConversion**
= 25% x 97.9% + 50% X 98.8% + 25% x 98.9% + 0% x 99% = **98.6%**

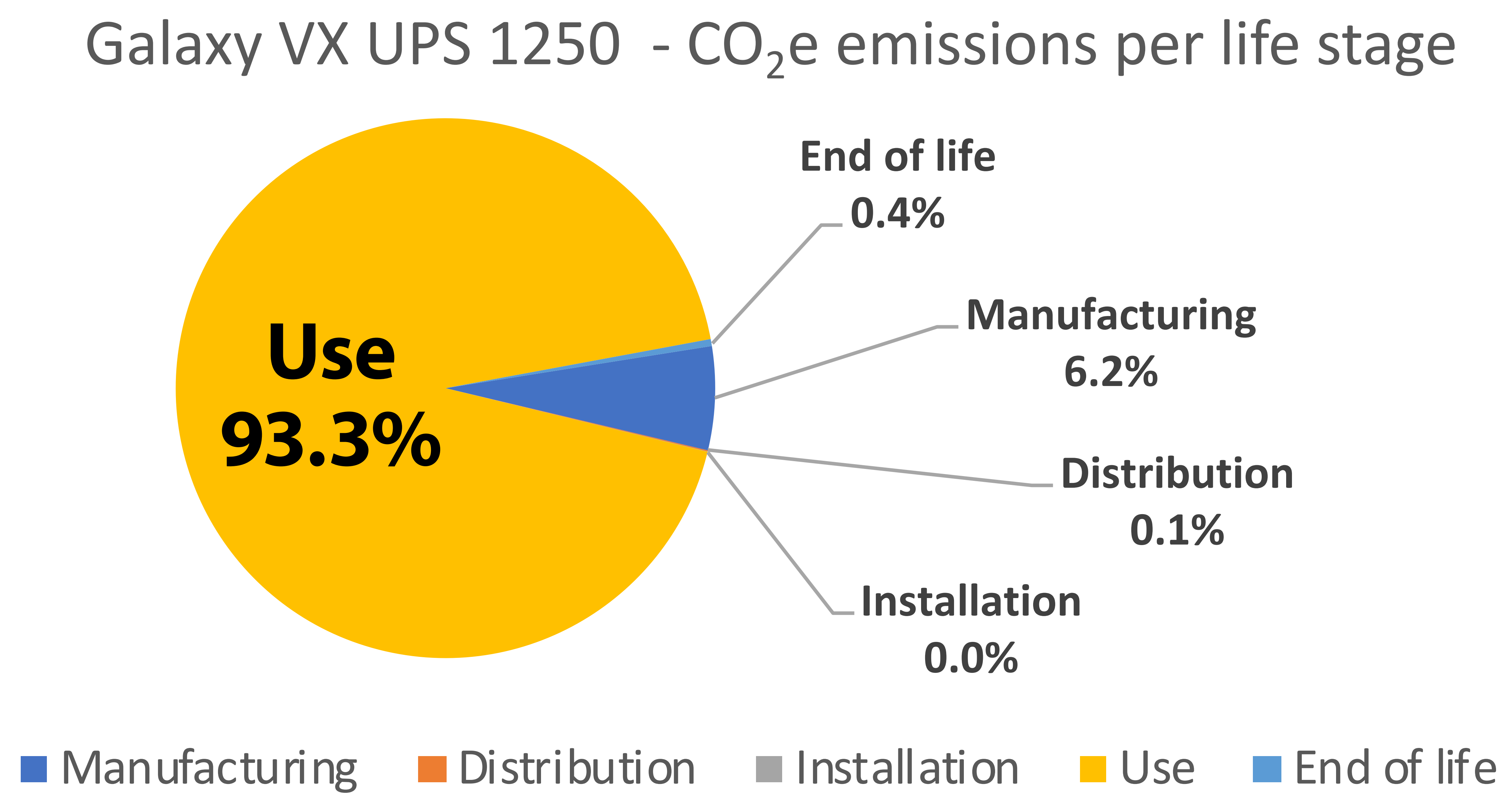
	eConversion			
Voltage (V)	**380**	**400**	**415**	**440 V**
25% load	97.9%	97.9%	98.0%	98.0%
50% load	98.7%	98.8%	98.7%	98.7%
75% load	98.9%	98.9%	98.9%	99.0%
100% load	98.7%	99.0%	99.0%	99.1%

Efficiency figures at different load percentages for two operating modes (example: Galaxy VX 1250 kW)

Carbon profile of a typical 3-phase UPS

Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the "use" stage.

While there are significant differences among UPS models in terms of efficiency and the associated electrical losses, **electricity consumption is by far the largest contributor of CO_2e life cycle emissions**. Here is an example of how each stage of the lifecycle contributes to the CO_2e emissions of a 3-phase UPS taken from the Galaxy VX PEP. The use stage emissions represent about **93% of the UPS's carbon footprint**.



Breakdown of total carbon footprint for a 3-phase UPS (example: Galaxy VX).

UPS carbon footprint comparisons

UPS carbon footprint comparisons

- A sustainability comparison makes sense only after developing a list of UPS models that meet your functional requirements.
- In the case of a UPS, requirements may include kW capacity, physical footprint, efficiency, modularity, etc. Once you have a list of UPSs, then you can quantitatively compare their environmental characteristics.
- The most effective way to do this is to **compare their PEPs**.
- A comprehensive UPS carbon footprint comparison should consider all five of its life cycle stages. This section first explains common errors to avoid when comparing UPSs and then provides step by step guidance on comparing each of the five life cycle stages.
- We use two UPSs to demonstrate the comparison. A key theme in this section is the concept of comparing “apples to apples.”

Common errors to avoid when comparing products

While the ISO standards provide the basis for LCAs and PEPs, they don't eliminate vendor mistakes or ensure valid comparisons. Therefore, end users must be vigilant when comparing PEPs for two or more UPSs, especially if they're from different vendors. This section covers the major errors people make when comparing the carbon footprint of two or more UPS.

Error #1 Comparing "use stage" carbon emissions based on different utility grid emission factors

An emission factor is the ratio of greenhouse gas emitted for every kWh of electricity a utility generates. The emission factor is multiplied by the energy (kWh) the UPS uses in its lifetime to arrive at the use stage emissions from electrical losses. Because a UPS operates continuously over its lifetime, the largest contribution to its carbon emissions comes from the use stage. Even a small difference in emission factors has a major impact on a comparison. This is why you can't compare UPSs with different grid emission factors.

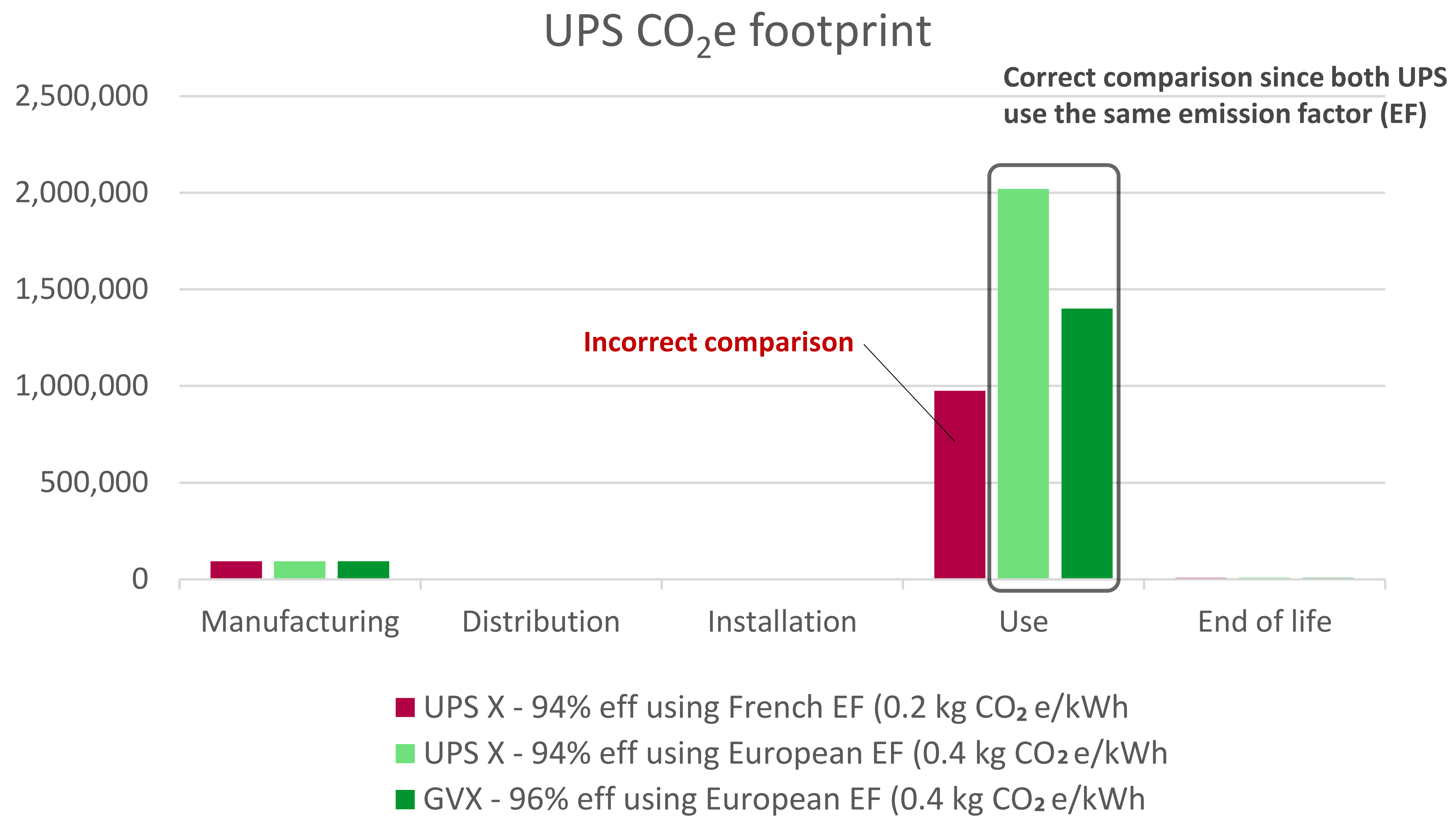
An example of this frequent error is illustrated here. As shown in the table below, it's quite possible for a PEP of an inefficient UPS (e.g., UPS X at 94%) to show lower total emissions than a more efficient UPS (e.g., Galaxy VX at 95.8%) with an (erroneously calculated) 980,000 kg CO_2e vs. 2,000,000 kg CO_2e. In reality, only **the second and the third line can be used for an apples-to-apples comparison**, which shows that UPS X emissions are much higher than Galaxy VX.

Example: 1250 kW UPS	Efficiency %	Grid Emissions Factor ($kgCO_2$ /kWH)	Grid geography	CO_2 emissions declared in PeP (Use phase) in $kgCO_2$
UPS X	94%	**0,2**	**FR**	**980 000**
	94%	**0,41**	EU-27	2 000 000
Galaxy VX	95,8%	**0,41**	**EU-27**	**1 400 000**

How different grid emission factors impact CO_2e emissions declaration.

When the emission factors are set equal (0.41 kg CO_2e/kWh), the total CO_2e footprint for the low-efficiency UPS is 1.4 times higher than the high-efficiency UPS.

This example was calculated assuming an overall emission factor for the 27 European countries (0.41 kg CO_2e/kWh) compared to that of France (0.2 kg CO_2e/kWh)[6].



Example of CO_2 footprint comparison between UPS with different emission factors.

Because PEPs use codes that can be difficult to understand, an easier way to assess the use stage emissions between two or more UPSs is to compare their efficiencies with the same grid emission factor. The 3-phase UPS Efficiency Comparison Calculator simplifies this task.

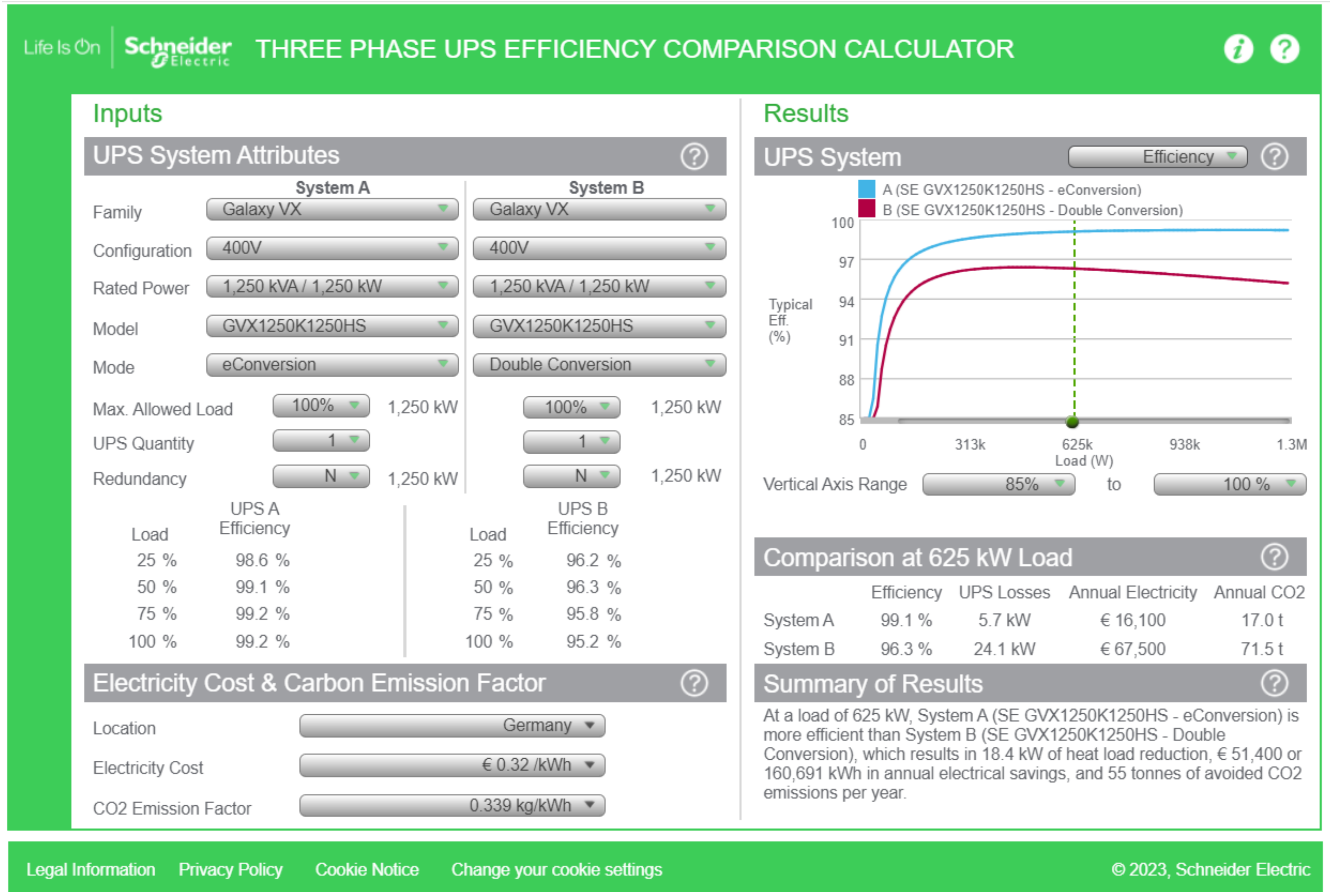
[6] This is an older (and higher) value than today's EU-27 and France values. The program operator, P.E.P. Association, tries to keep this value consistent over the years to avoid publishing PEP documents based on different emission factors.

Common errors to avoid when comparing products

Error #2 Comparing “use stage” carbon emissions with different operating modes

If a UPS has two operating modes, it will have two efficiency curves characterizing each mode. An example of this is illustrated using the [Three Phase UPS Efficiency Comparison Calculator].

Example of UPS efficiency curves for two different operating modes.



- UPS with two operating modes will have two efficiency curves
- Generally cannot compare values from different operating modes
- If operator uses high-efficiency for one UPS but double conversion with another, values cannot be compared

Common errors to avoid when comparing products

Error #3 — Comparing UPSs with different capacities

Error #4 — Comparing UPS PEPs with different PSR and PCR versions

Error #5 — Assuming a PEP includes expected components

Error #6 — Granting recycling credit without evidence of recycling program

Error #7 — Declaring a winning attribute that is within the margin of error

Four steps for accurate UPS comparisons

This section describes the steps required to accurately compare two or more UPSs.

Step 1: Calculate the weighted efficiency.

Calculate the weighted UPS efficiency for the operating mode that will actually be used (e.g., double conversion or high-efficiency mode). The typical operating mode is double conversion. Do this for each UPS you're comparing using the formula provided below:

Weighted efficiency = 25% X Eff25% + 50% X Eff50% + 25% X Eff75% + 0% X Eff100%

Step 2: Calculate UPS electricity consumption.

This step requires the following for each UPS you're comparing:

- The efficiencies from Step 1
- The grid emission factor (kg CO_2e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS.
- The rated capacity of the UPS (kW)
- The UPS reference service life (RSL) (15 years)

Step 3: Calculate UPS electricity CO_2 emissions.

This step requires:

- The total energy consumption (kWh) – sum of all reference test loads from Step 2
- The grid emission factor (kg CO_2e/kWh) – Ideally, the emission factor is the same as that of the electric grid supplying the UPS.

UPS life cycle electricity emissions (kg CO_2e) = Total energy consumption kWh X Emission factor (kg CO_2e/kWh)

Step 4: Add CO_2 emissions from the other life stages.

This final step sums the emissions from all five life cycle stages (i.e., manufacturing, distribution, installation, use, and end of life) using the UPS PEP document. If the UPSs have different rated capacities, then you should compare the total carbon footprint using the 'K- factor' described above, or use the data from the nearest UPS rating provided in the PEP. This will allow you to see which UPS has the lowest total carbon footprint.

UPS carbon calculation tool

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UPS carbon footprint comparison tool

This section describes the excel worksheet that facilitates UPS carbon footprint comparisons using the four steps described in the previous section. We describe each input that the worksheet uses to calculate the total life cycle carbon footprint for the UPS models you're comparing. All input cells are highlighted in yellow.

Main input cells:

Three-phase UPS life cycle carbon footprint comparison worksheet for UPS >10 kW

Input cells
Output cells

Emission factor (kg CO2e/kWh)	0,400
Rated UPS capacity (kW)	500
UPS reference lifetime (years)	15

In **Step 1**, the set of inputs describe the efficiency of the UPSs you're comparing. The UPS model and operating mode inputs are used only to label the efficiency data. The efficiency data should have at least one decimal of precision. Note, you must choose the operating mode that will actually be used at the site (typically double conversion). With the data provided by the Three Phase UPS Efficiency Comparison Calculator, you can enter the efficiencies in the yellow cells for most Schneider Electric UPSs.

Table used to calculate weighted UPS efficiency:

Step 1 - calculate weighted UPS efficiency for each UPS using selected operating mode

By default operating mode should be double conversion, except if the customer plans to use high-efficiency mode

Click here to get efficiencies from Schneider Electric 3-phase UPS efficiency tool

	UPS 1	UPS 2	UPS 3
UPS model	XYZ	XYZ	XYZ
UPS operating mode	dbl conv	dbl conv	dbl conv
Efficiency at 25% load	96,40%	93,00%	96,00%
Efficiency at 50% load	97,10%	93,00%	97,00%
Efficiency at 75% load	97,20%	93,00%	98,00%
Efficiency at 100% load	97,10%	93,00%	99,00%
Weighted UPS efficiency	**96,95%**	**93,00%**	**97,00%**

In **Step 2 & 3**, with the data entered thus far, the tool calculates the electricity consumption (kWh) and electricity-based emissions (kg CO_2e) in the green rows.

Table used to calculate the electricity consumption (kWh) and electricity-based emissions (kg CO_2e):

Step 2 & 3 - calculate UPS energy consumption and electricity emissions

	UPS 1	UPS 2	UPS 3
Total lifetime loss energy (kWh)	**969 075**	**2 299 500**	**903 375**
Total lifetime loss energy (kWh/kW rated cap.)	1 938	4 599	1 807

	UPS 1	UPS 2	UPS 3
Total lifetime electricity emissions (kg CO2e)	**387 630**	**919 800**	**361 350**
Total lifetime elec emissions (kg CO2e/kW rated cap.)	775	1 840	723

Per **Step 4**, the last part of the worksheet sums the emissions from the remaining life cycle stages (i.e., manufacturing, distribution, installation, and end of life) using the values in the UPS PEP document. The worksheet also calculates the emissions per unit kW of rated UPS capacity in case the UPSs have different rated capacities.

Table used to calculate the total UPS life cycle carbon emissions (kg CO_2e):

Step 4 - using PEP document, enter life cycle carbon data from remaining stages

	UPS 1	UPS 2	UPS 3
UPS model	XYZ	XYZ	XYZ
Manufacturing (kg CO2e)			
Distribution (kg CO2e)			
Installation (kg CO2e)			
Use* (kg CO2e)	387 630	919 800	361 350
End of Life (kg CO2e)			
Total kg CO2e footprint	**387 630**	**919 800**	**361 350**
Total Lifecycle CO2e footprint (kg CO2e/kW)	775	1 840	723

Conclusion

Conclusion

As more companies and consumers seek to reduce their environmental footprint, vendors are responding with claims of environmentally sustainable UPSs. Assessing the environmental sustainability of a UPS is complex and claims are difficult to ascertain without knowing the underlying assumptions and standards upon which they are made. By understanding the calculations behind the sustainability claims of the UPS you are considering, you can confidently choose a UPS that is better for your operations and the planet.

This e-guide defined and covered five life cycle stages that encompass a UPS's environmental sustainability performance. We provided explanations for how to calculate the electricity-based UPS emissions. Finally, we offered guidance for how to accurately assess the sustainability of similar UPSs and a tool to help with UPS comparisons.

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To learn more about addressing your **UPS's environmental sustainability**, visit:

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