

# Life Expectancy of PV Inverters and Optimizers in Residential PV Systems

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The average Time To Failure (TTF) of PV inverters and PV optimizers is investigated in this paper. The focus is on residential and small commercial systems. The data used in this paper includes 1195 PV systems consisting of 2121 inverters and 8542 optimizers. After 15 years, 34.3 percent of systems show a first failure. The most important factors influencing the TTF are the installation location of the inverter, the manufacturer and the inverter topology.

## Introduction

PV inverters are typically said to have a life expectancy of 15 years and must therefore be replaced once in the service time of a typical PV system. In a study by the Bern University of Applied Sciences (BFH), the life expectancy of PV inverters is investigated. The study uses the mean time to energy-related failures (TTF) as the relevant parameter.

## Available Data

- Data is gathered from three sources between March and May 2022:
1. By means of an online survey, mainly filled in by private owners / operators of PV systems (343 systems).
  2. Data of the PV system portfolio of a professional PV system operator (83 systems).
  3. Data of the PV system portfolio from professional PV system installers and operators (769 systems).

## Data Correction

- Due to inhomogeneous data sources, several error detection measures are undertaken:
- Deletion of incomplete or unrealistic data sets
  - Creation of a consistent nomenclature
  - Correction of obvious errors

| source of Data  | no of sys. | total power (kVA) | no of inv. | no of inv. per sys | power per sys (kVA) | power per inv. (kVA) |
|-----------------|------------|-------------------|------------|--------------------|---------------------|----------------------|
| priv. owner     | 343        | 6172              | 546        | 1.6                | 18                  | 11.3                 |
| prof. owner     | 83         | 7050              | 314        | 3.8                | 84.9                | 22.5                 |
| prof. installer | 769        | 13443             | 1261       | 1.6                | 17.5                | 10.7                 |

Table 1: Data sources

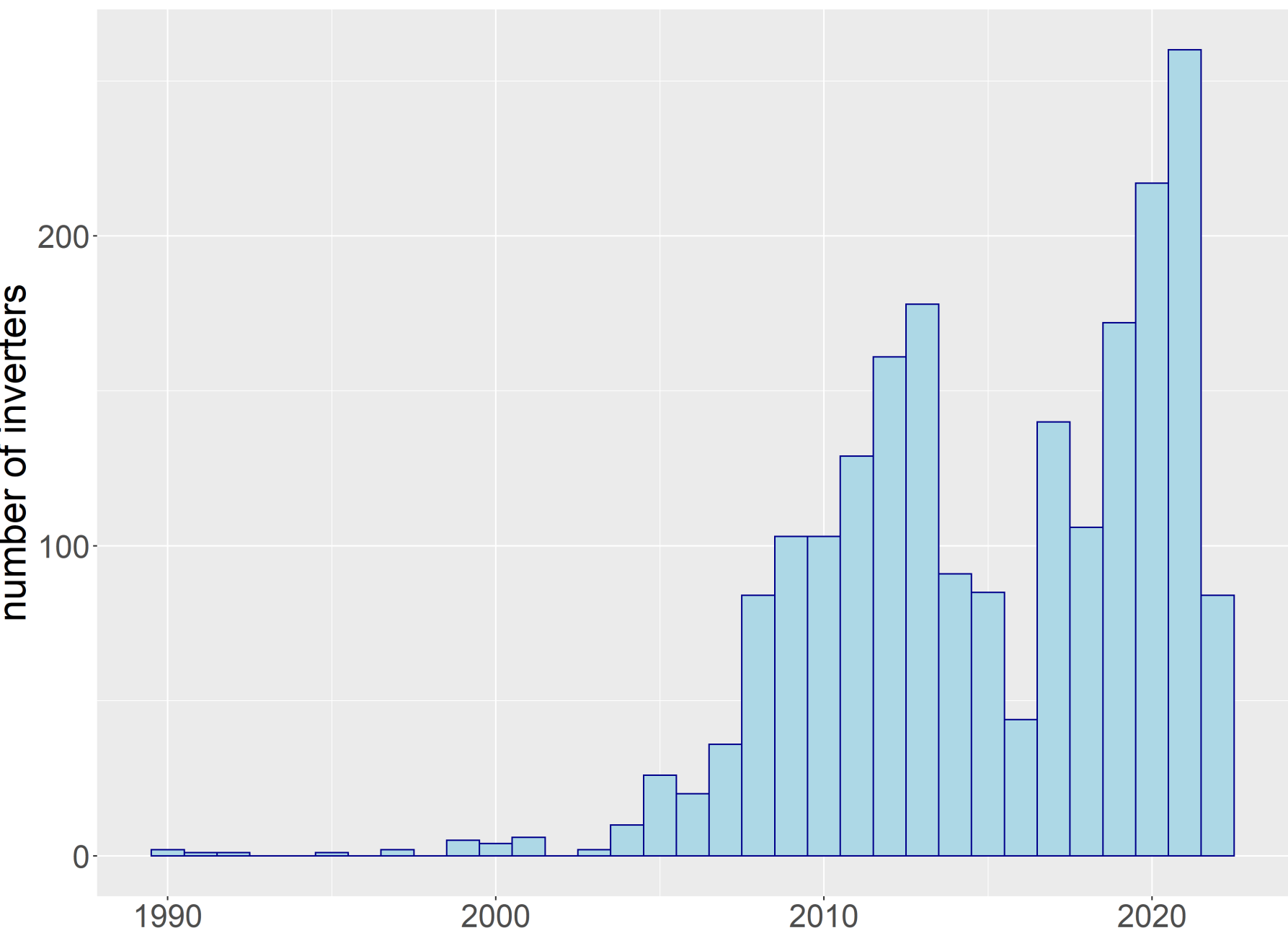


Figure 1: Number of inverters by commissioning year.

## Survival Curves

In order to assess the reliability of the inverters, the duration until the first energy-relevant fault occurs is considered. This duration is defined as Time to Failure (TTF). The TTF is calculated and plotted using the concept of the Kaplan-Meier estimator (Kaplan-Meier survival curve). The survival curve shows what percentage of the population is still alive after how many years.

In order to eliminate the influence of dependent variables, data is filtered for several properties before survival curves are computed. Homogeneous distributions of variables are assumed. This means that all variables are weighted equally when considering the differences between the survival curves of different variables.

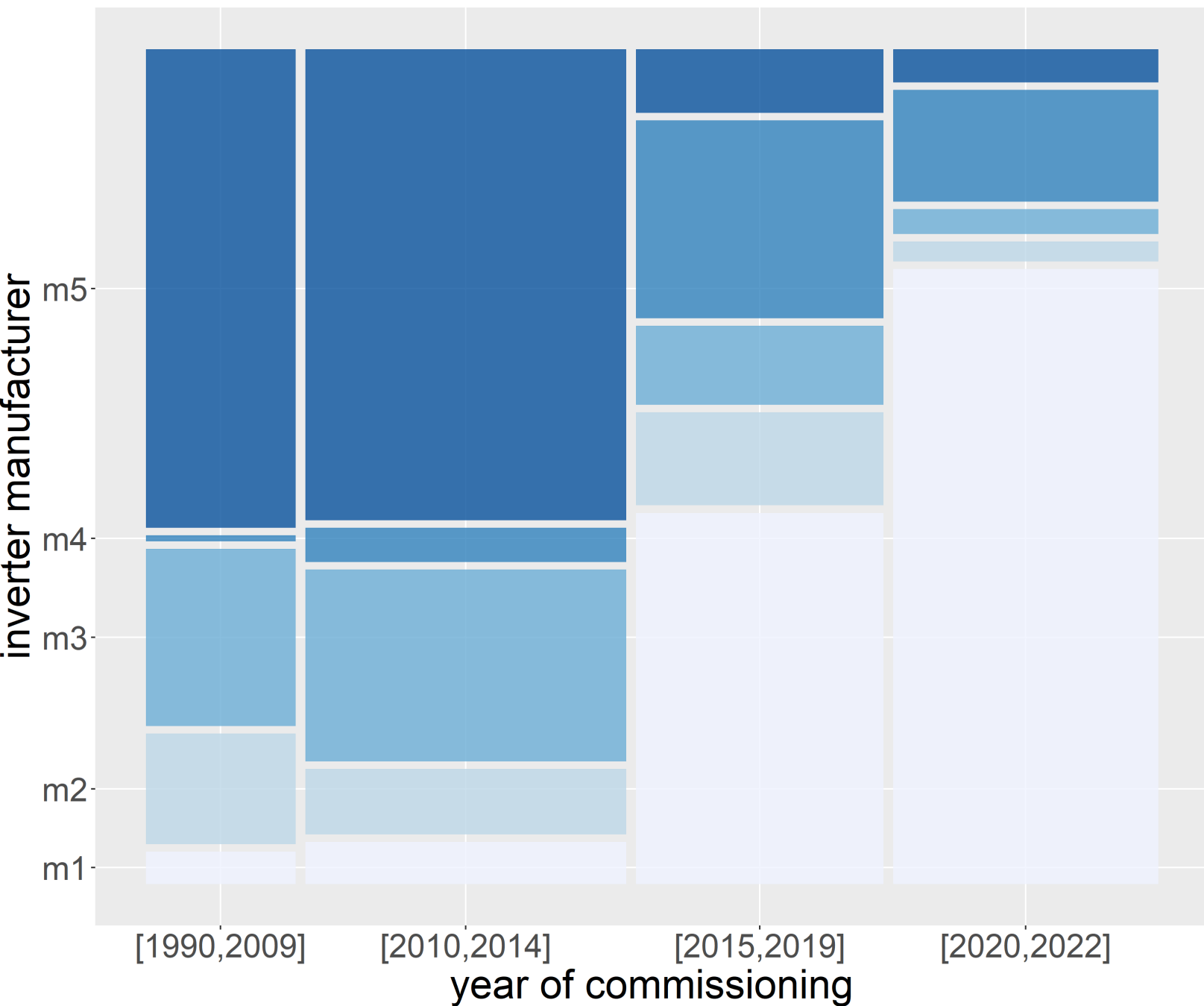


Figure 2: Mosaic showing inverter manufacturer, place of installation and inverter power.

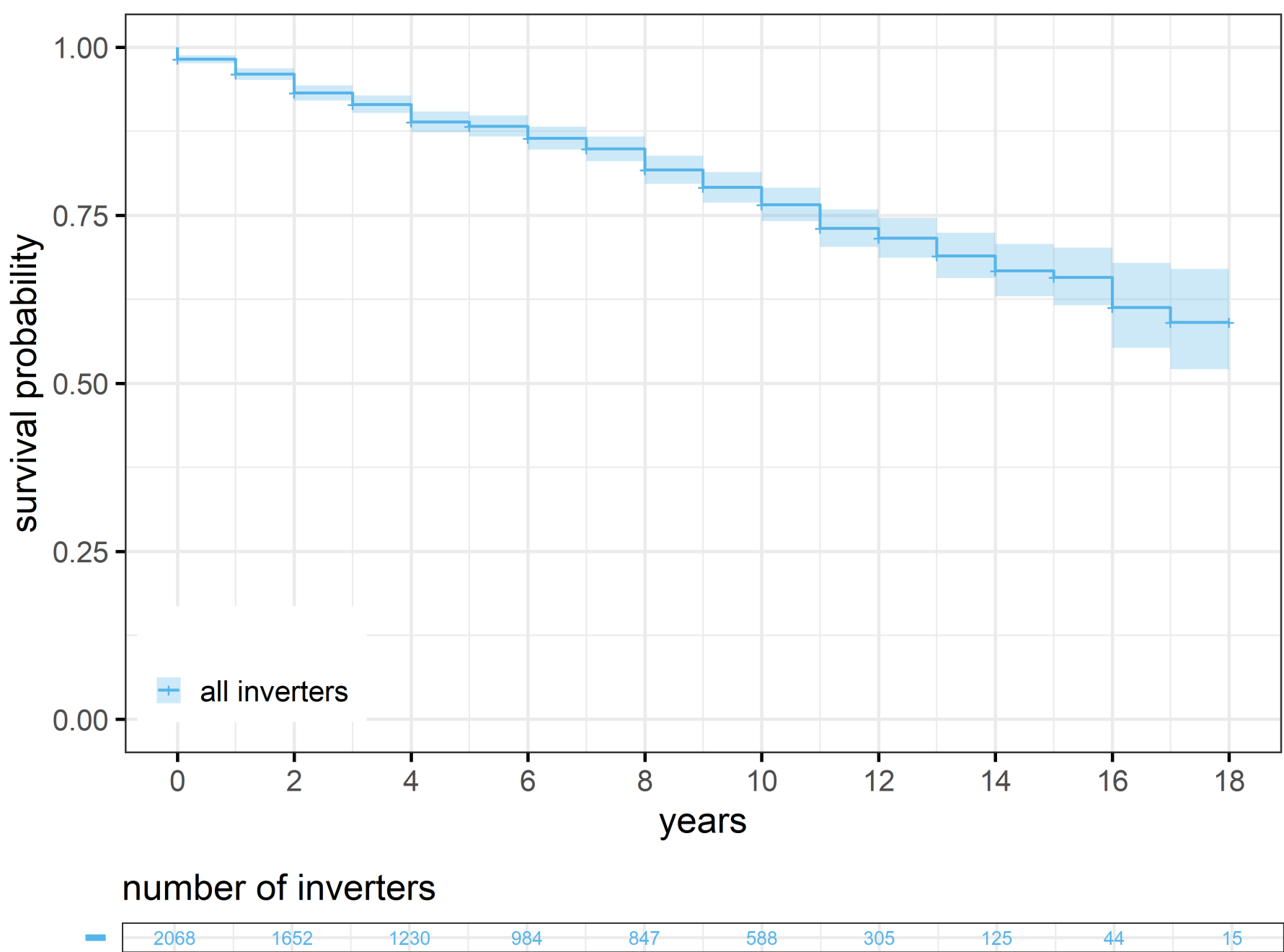


Figure 3: Survival curve of all inverters including inverters with optimizers

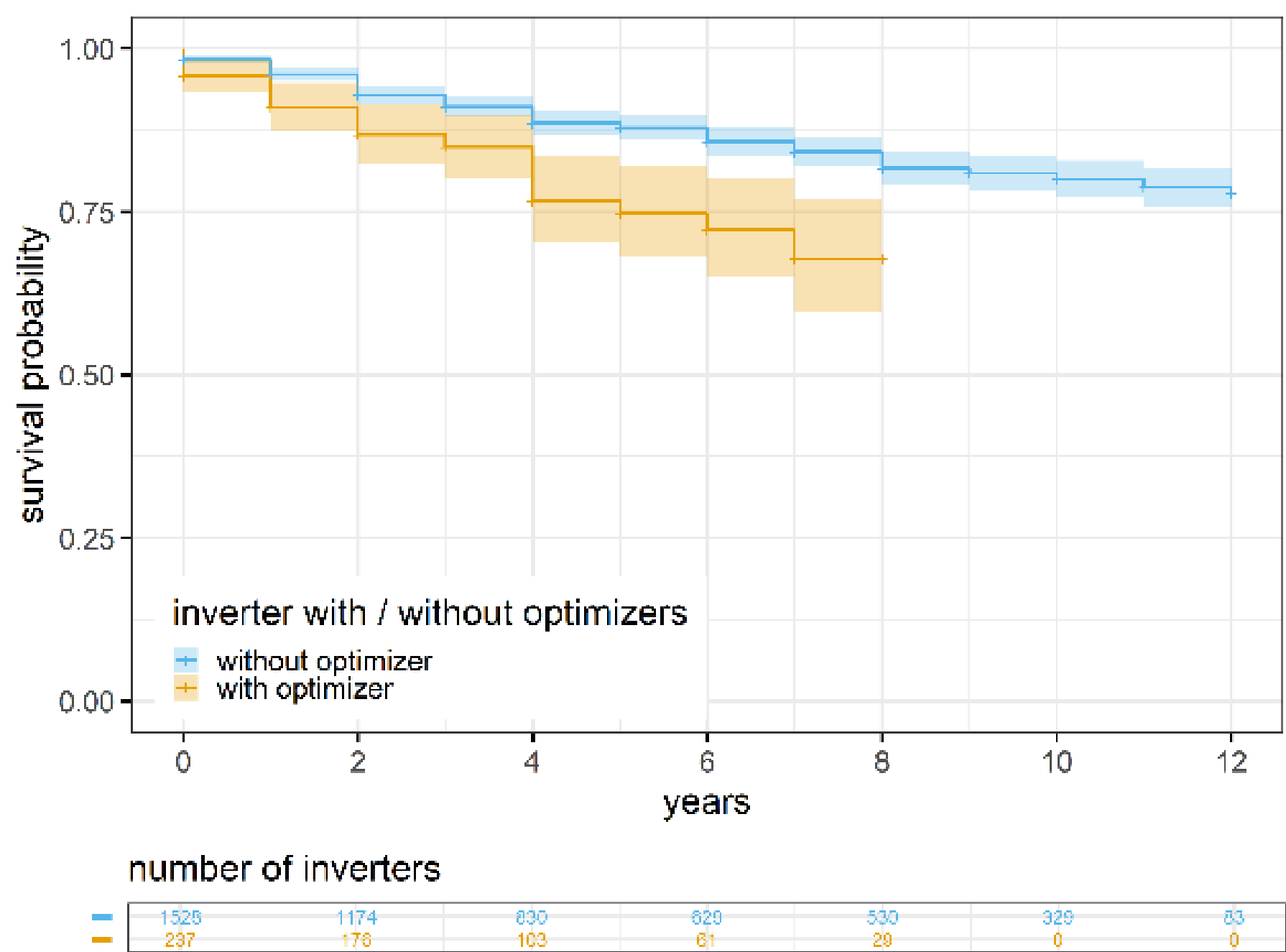


Figure 4: Survival curve for inverters with and without optimizers

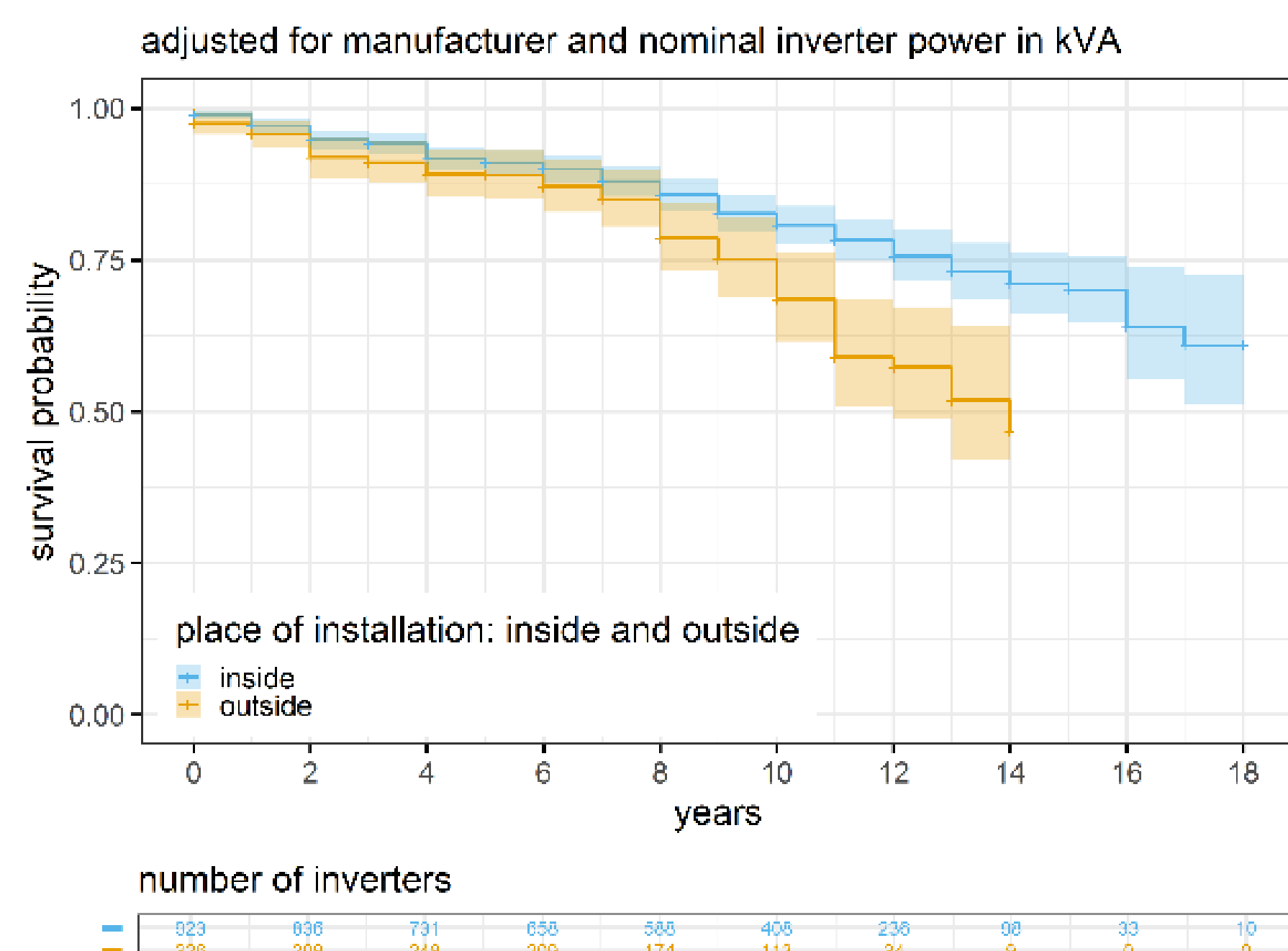


Figure 5: Survival curve for inverters installed inside and outside, adjusted for manufacturer an nominal inverter power.

## Results and Conclusion

The results across all inverters and power optimizers examined show that over 65 percent of inverters do not have a yield-relevant fault by their 15th year of operation.

Furthermore, the investigation shows that the TTF is dependent on various factors, in particular:

- Manufacturer: Different manufacturers have different TTF.
- Power: More powerful inverters have shorter TTFs; individually considered power optimizers have the largest TTFs. However, the overall reliability of a PV system increases significantly with the reduction in the number of power electronic components.
- Installation location: Outdoor power electronics have a shorter TTF than indoor power electronics.
- Topology: In PV systems with inverters with power optimizers, the first fault occurs earlier than in PV systems that do not have power optimizers.