

# Monitoring 30,000 PV systems in Europe: Performance, faults, and state of the art

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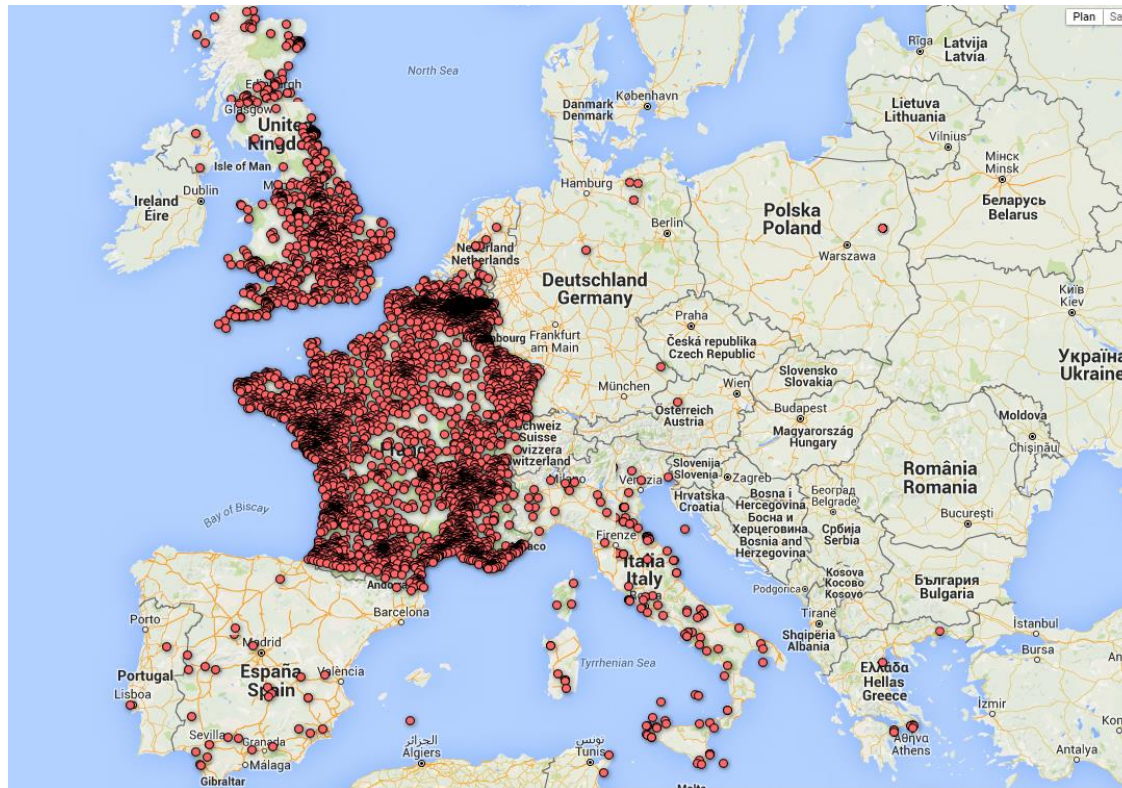


# Objective: ask questions and get answers from the data



- Energy yield?
- Overall performance? Differences? Key factors?
- Best PV cell technologies?
- Improvement in state of the art?
- PV modules/systems degradation?
- Do we observe faults?
- Effects of the policymaker?

# Data from 31000+ PV systems

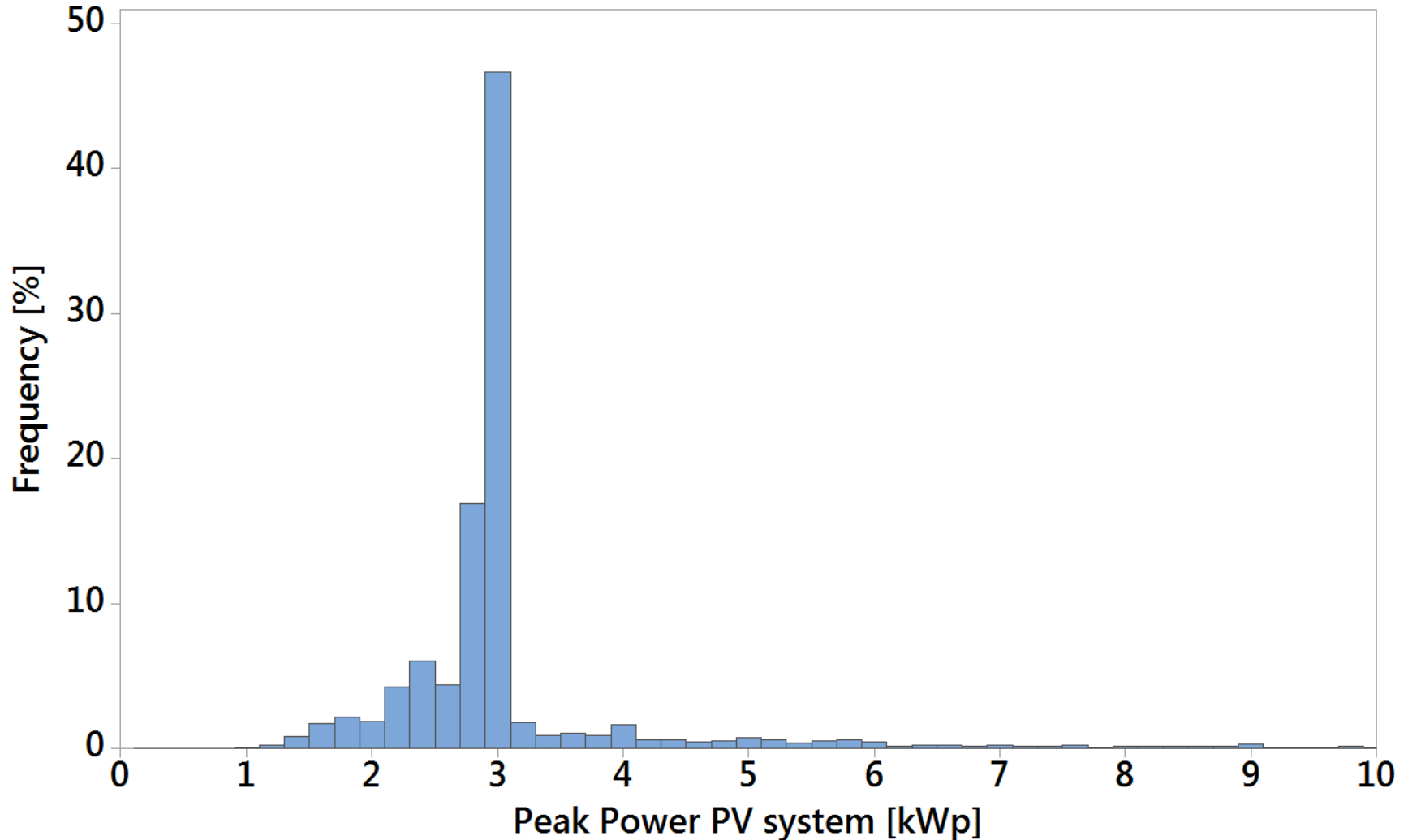


INPUT DATA	
Data	Source
PV systems characteristics	PV system installer or owner
Energy production	Energy meter or inverter
Solar irradiation (GTI)	Synermet

Country	Nb PV systems	Peak power [MWp]	Type
France	17672	65	Rooftop
Belgium	7648	50	Rooftop
UK	5835	23	Rooftop
Spain	29	116	PV plant
Rest of Europe	307	3	Rooftop
<b>TOTAL</b>	<b>31491</b>	<b>255</b>	

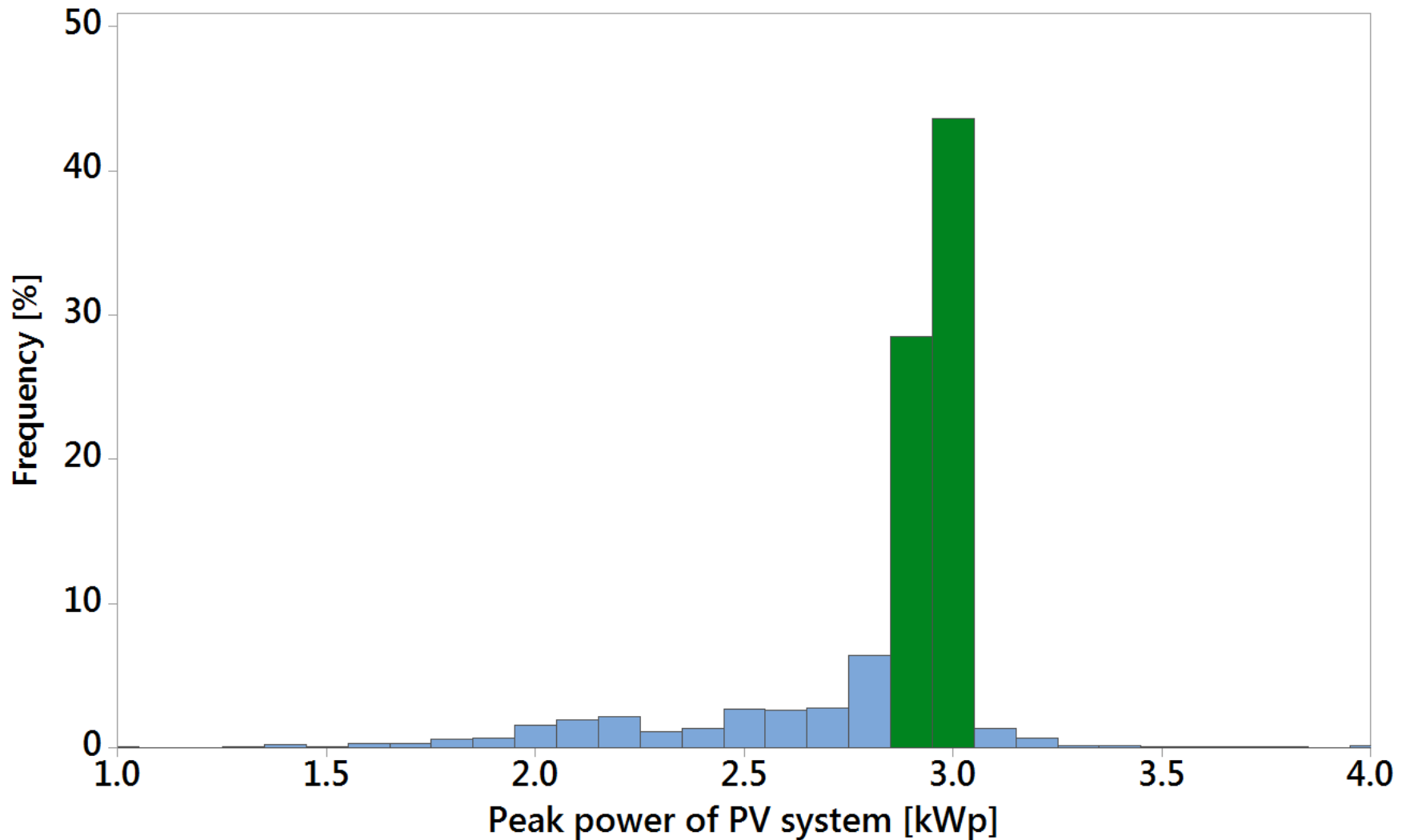
# The peak power of most of the PV systems is < 5 kWp

Peak power of PV systems - Europe



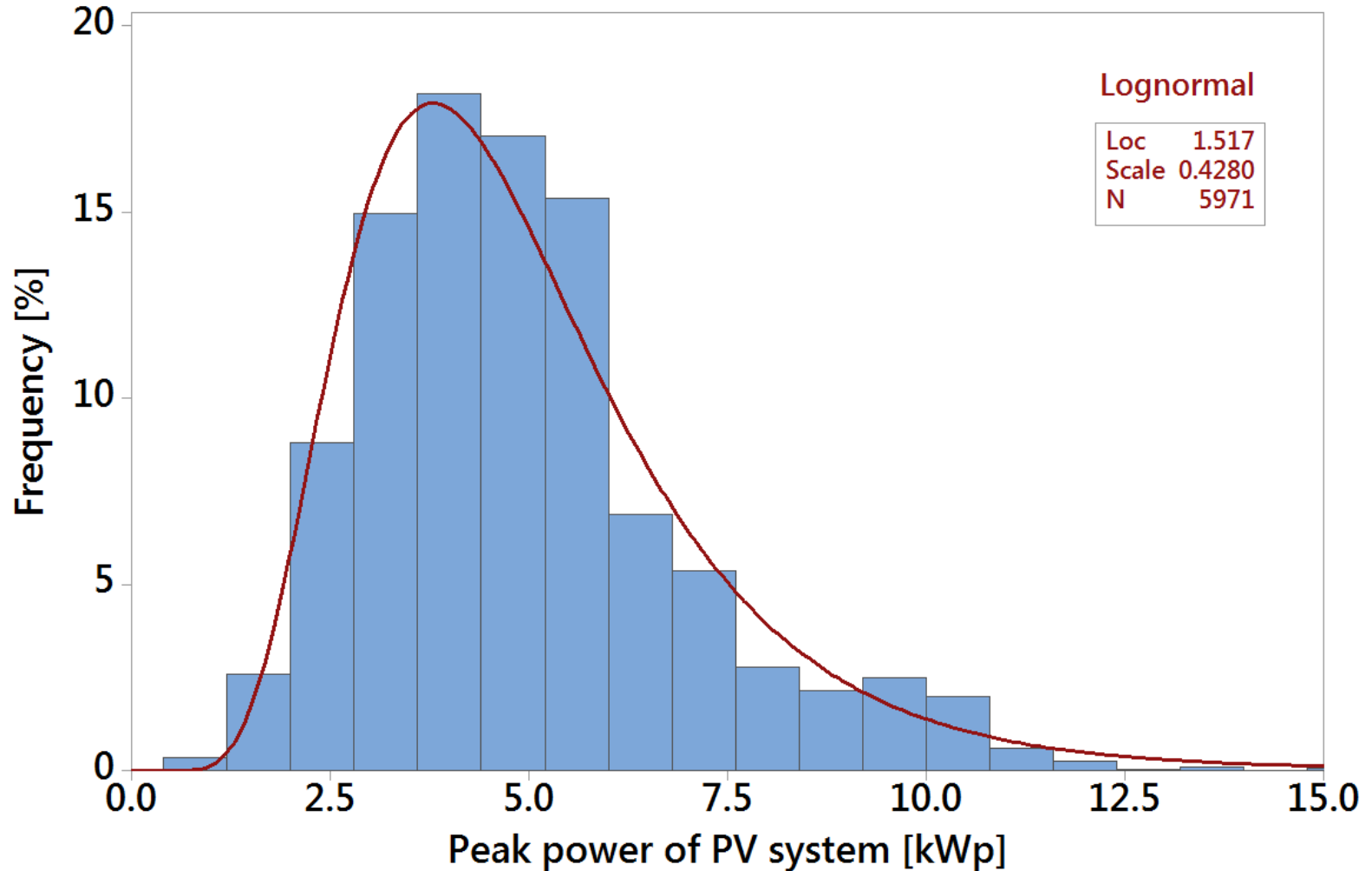
# France: peak power limited to 3 kWp by public incentives

Peak power of PV systems - France



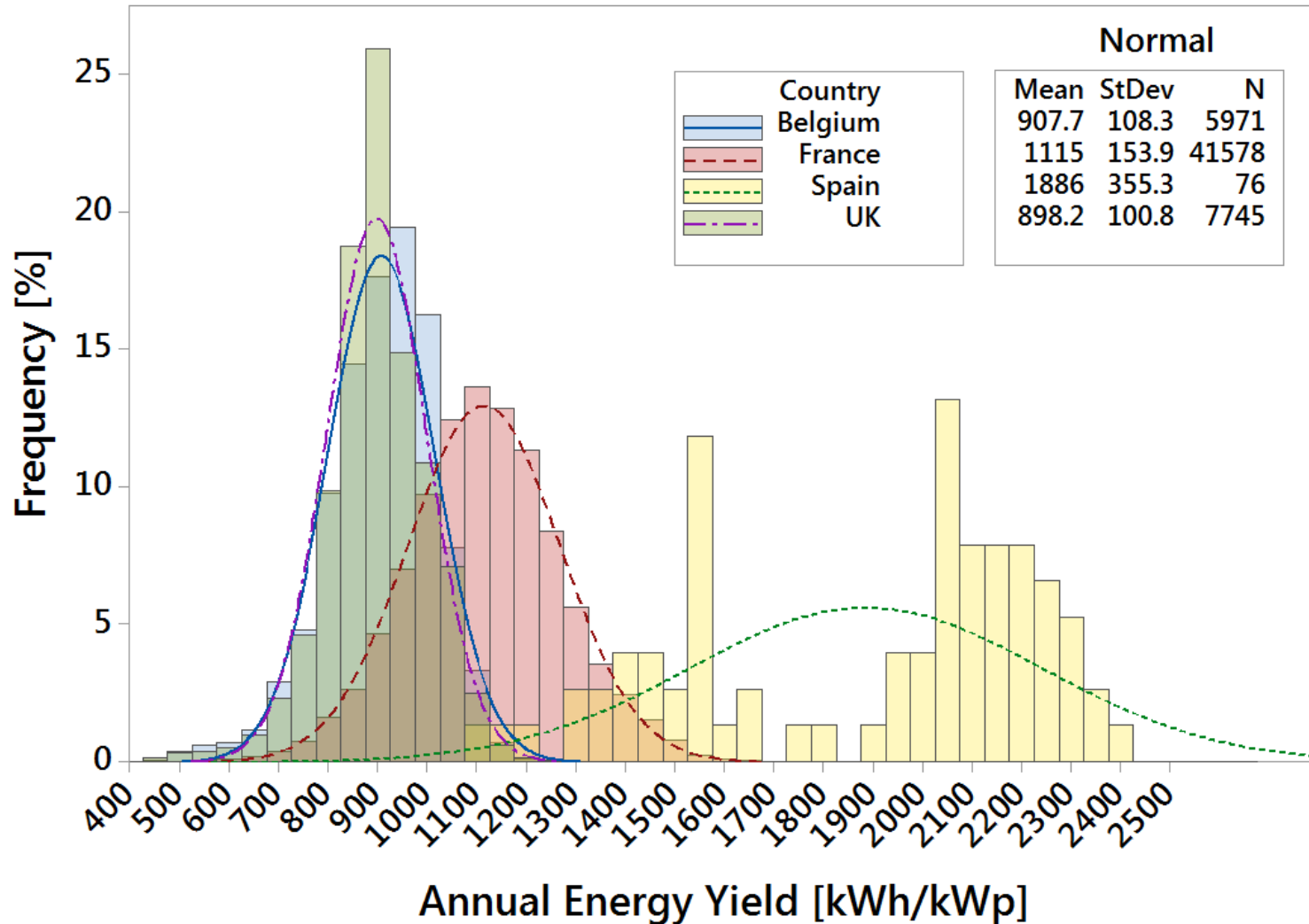
# Belgium: peak power shaped by net-balance incentives

Peak power of PV systems - Belgium



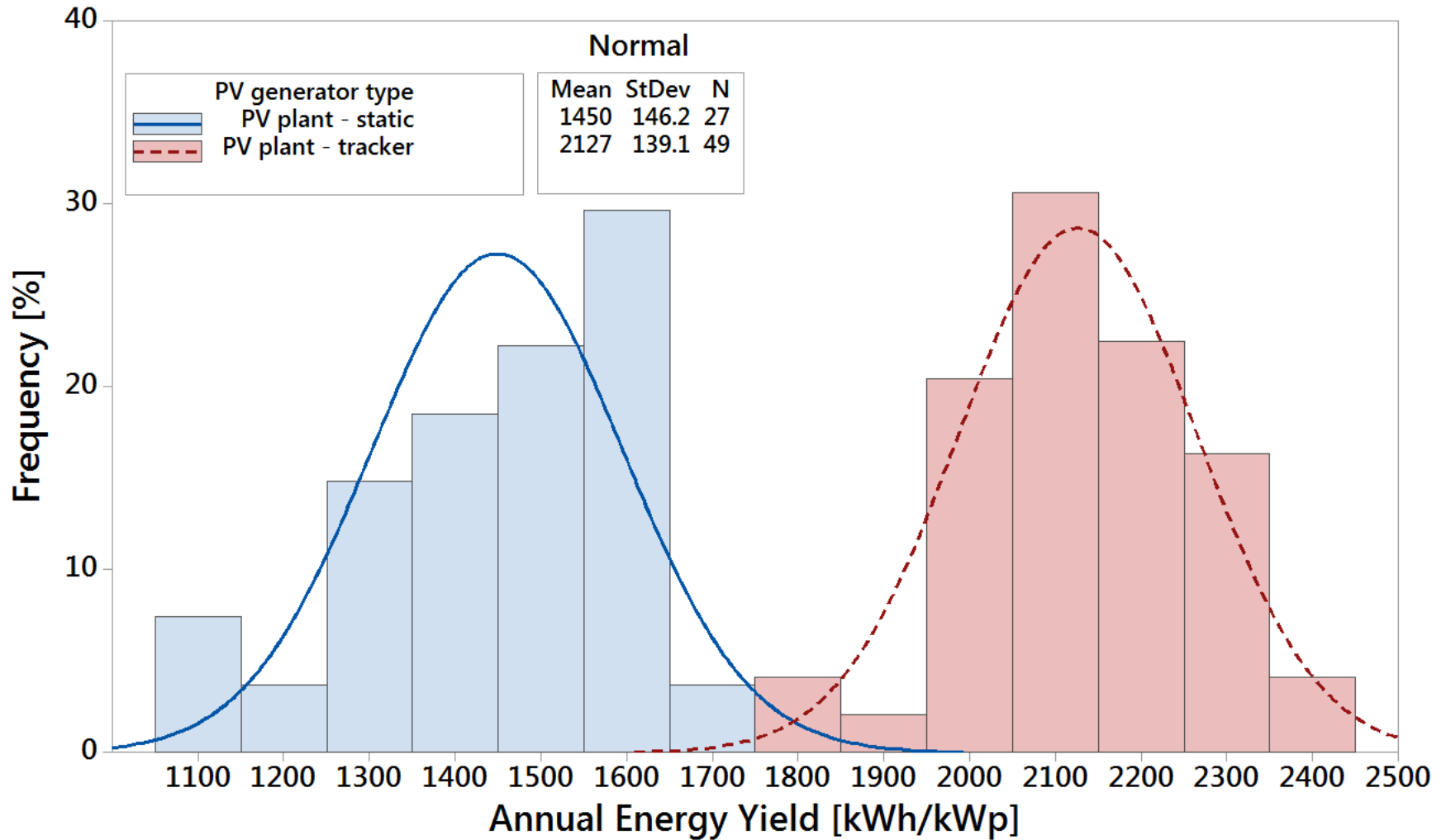
# The annual energy yield greatly varies geographically

## Annual Energy Yield - Belgium, France, Spain, UK



# Annual energy yield of PV plants in Spain and tracking

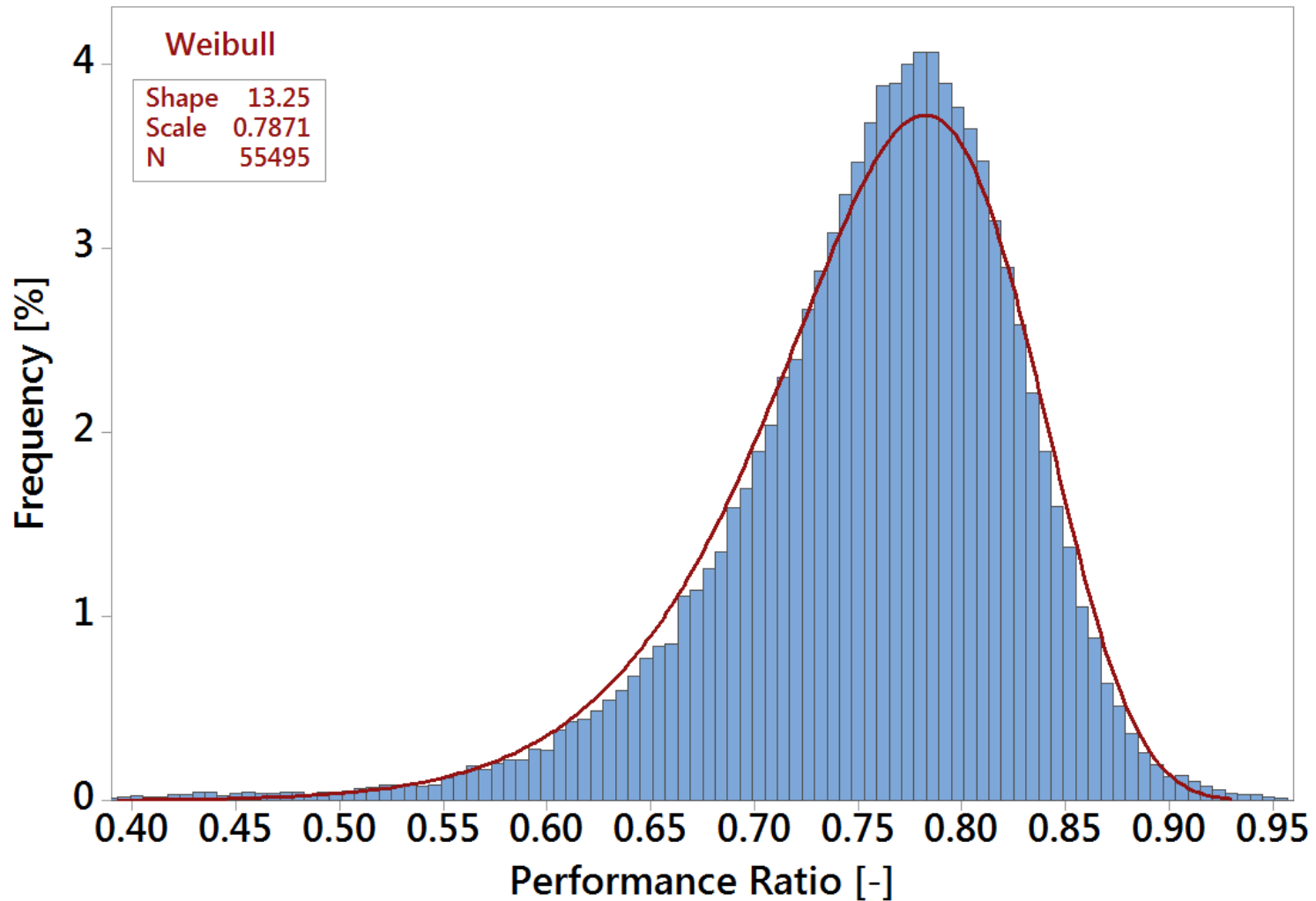
Annual Energy Yield of PV plants in Spain vs static/tracker generator type





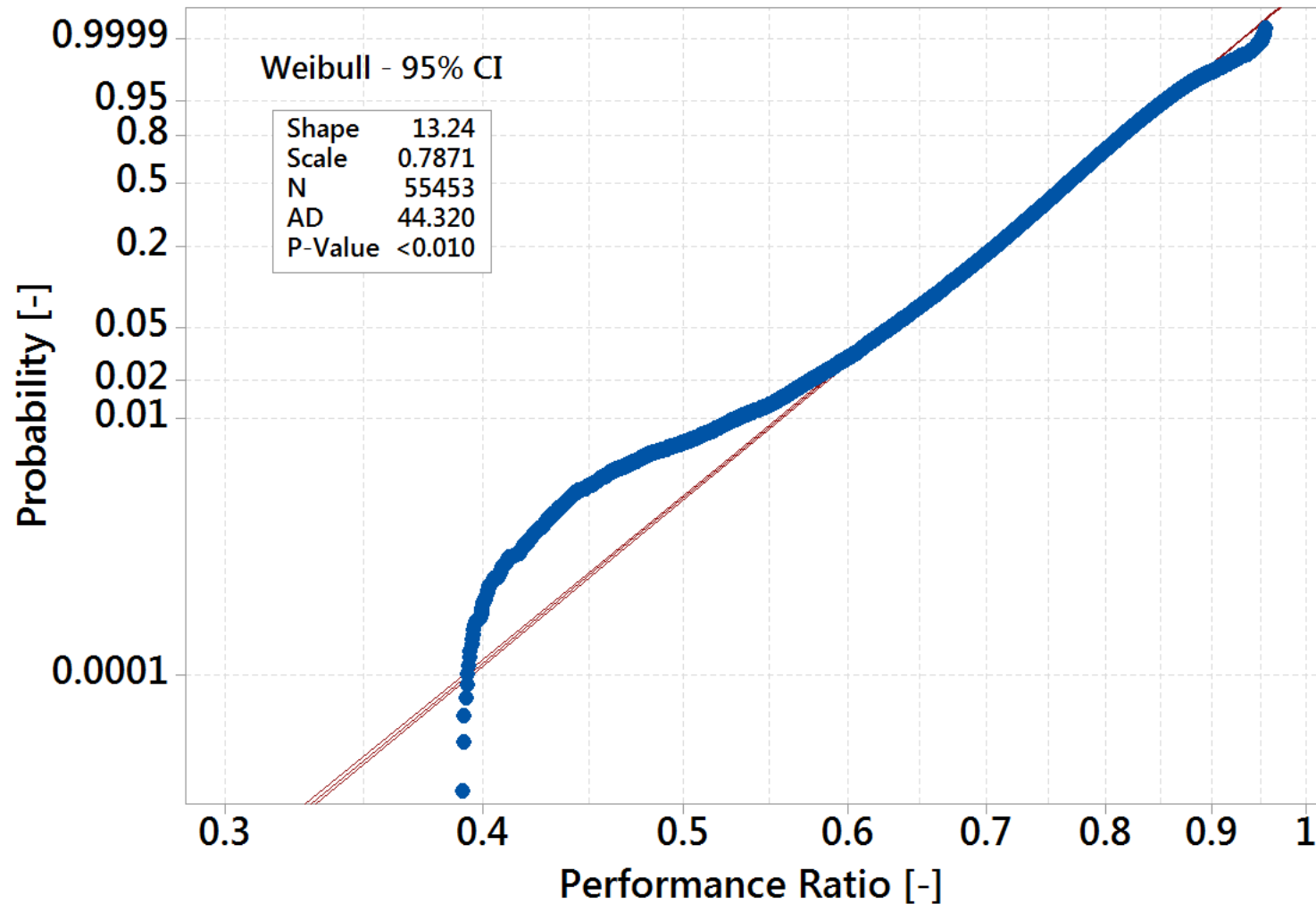
# The yearly PR follows a Weibull distribution

## Yearly integrated Performance Ratio - Europe



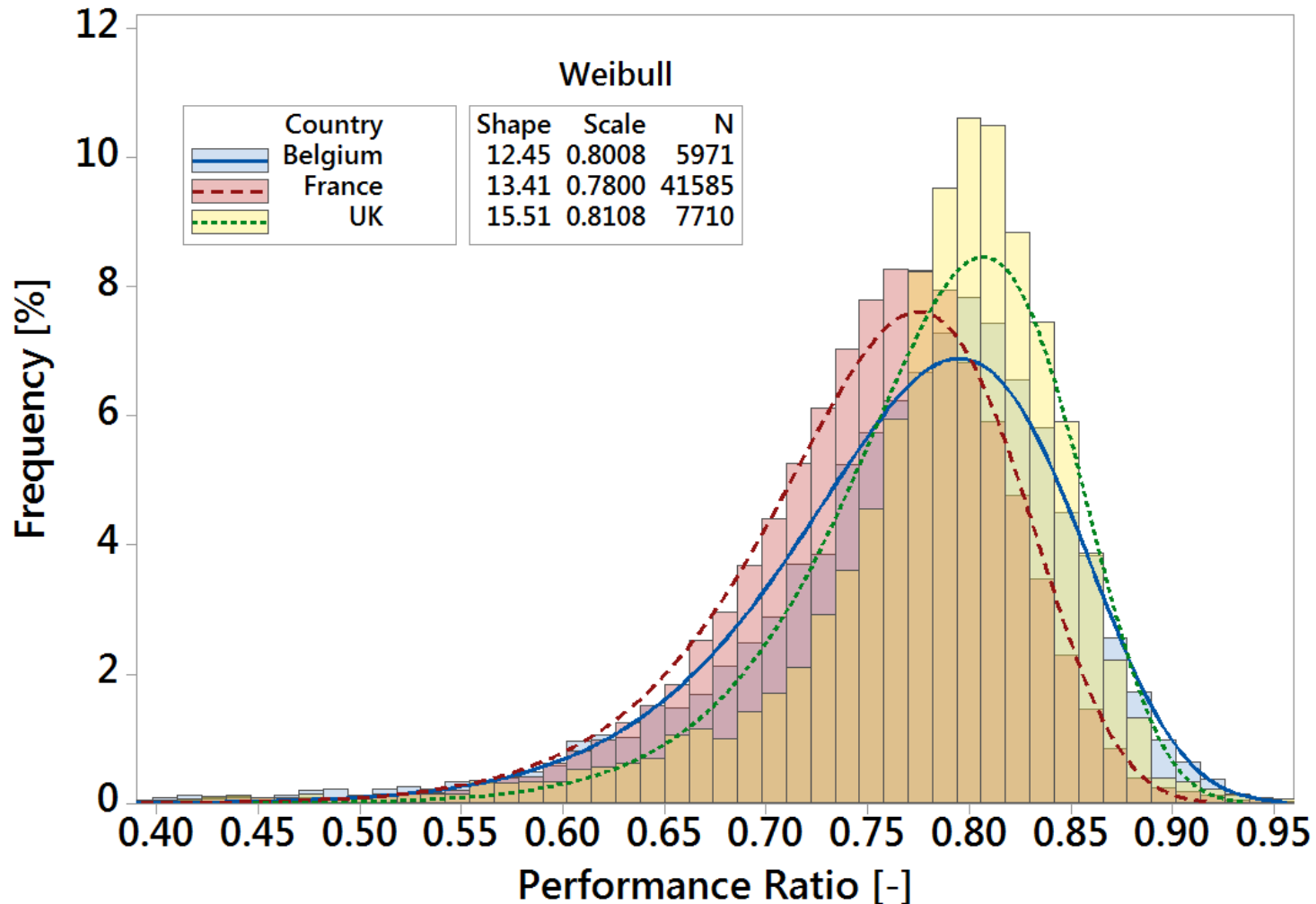
# The data follow a Weibull distribution for $0.6 < PR < 0.9$

Probability plot of Yearly integrated Performance Ratio vs Weibull distribution - Europe



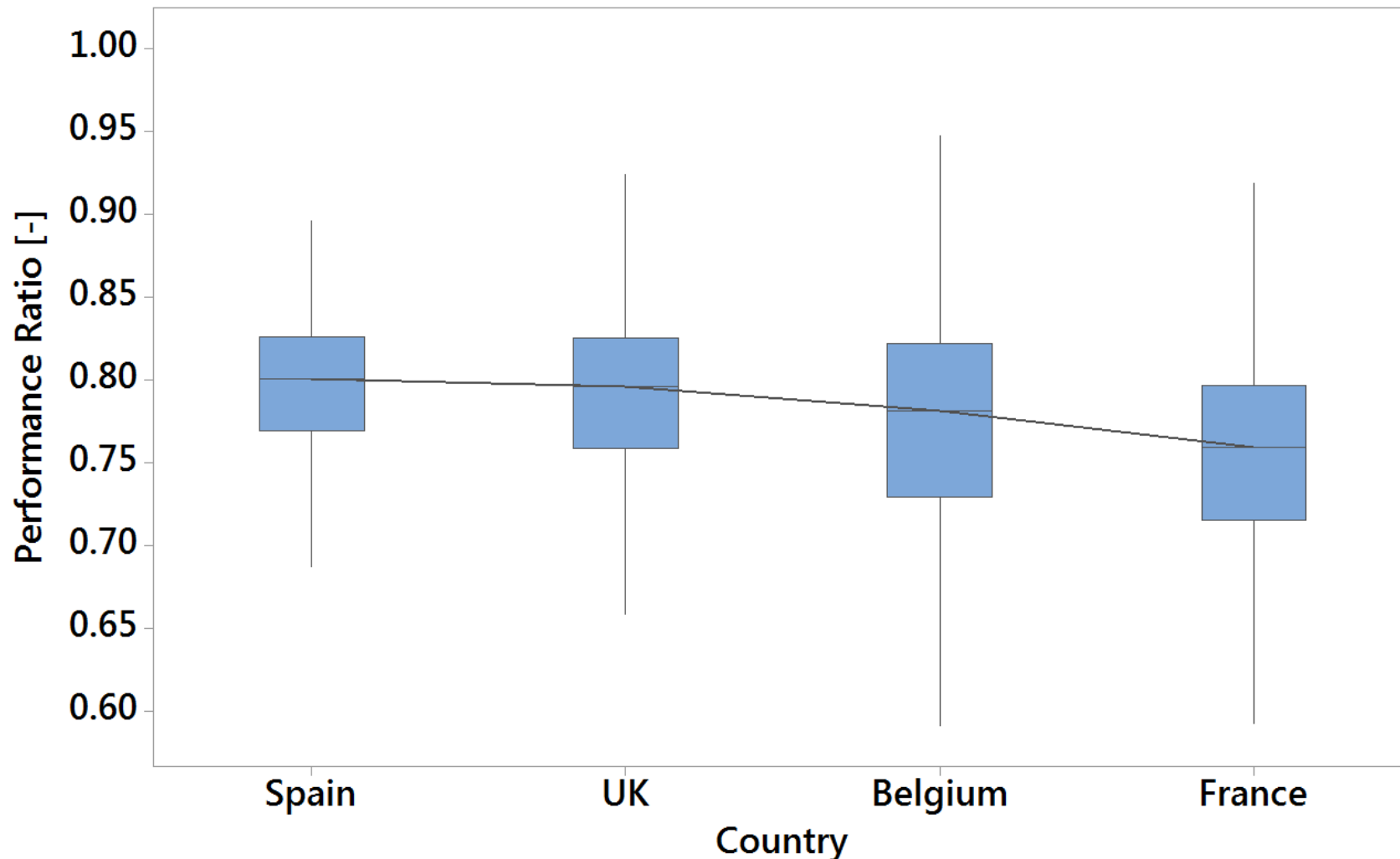
# The mean yearly PR in Europe lies within 0.75 – 0.8

## Yearly integrated Performance Ratio - Belgium, France, UK



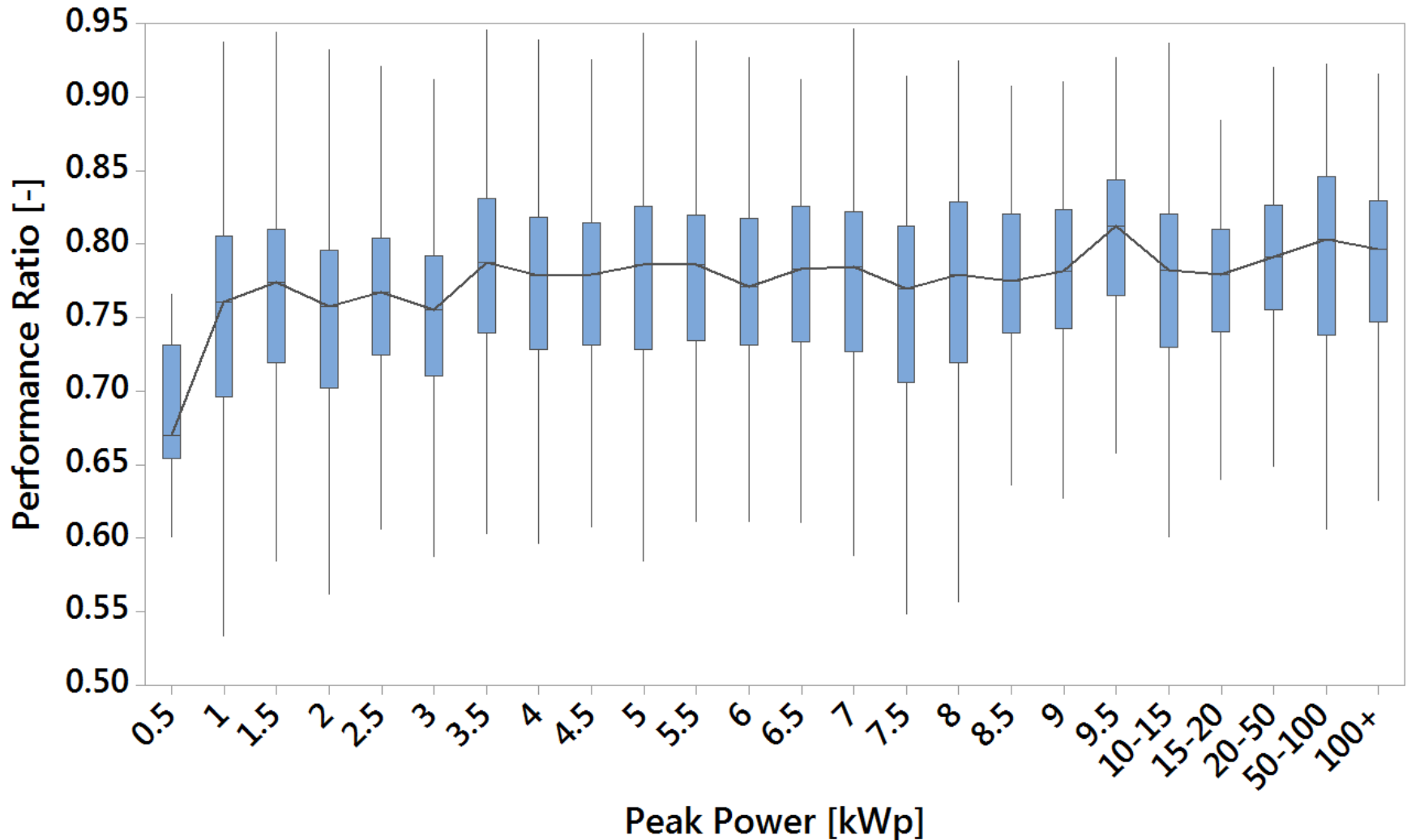
# Mean yearly PR France: 2-3% lower than other countries

Yearly integrated Performance Ratio - Spain, UK, Belgium, France



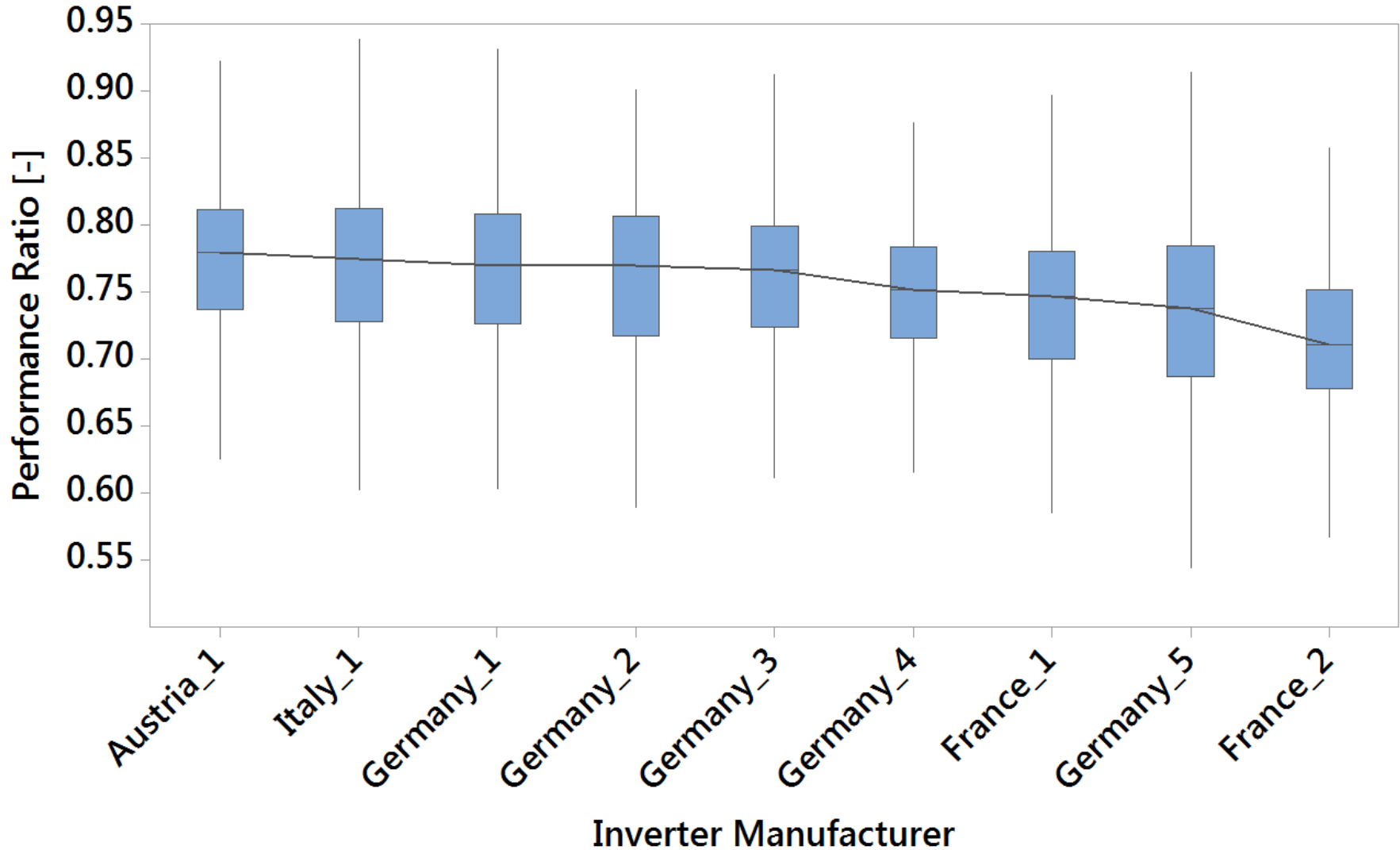
# The small PV systems have a lower PR

Yearly integrated Performance Ratio vs PV system peak power - Europe



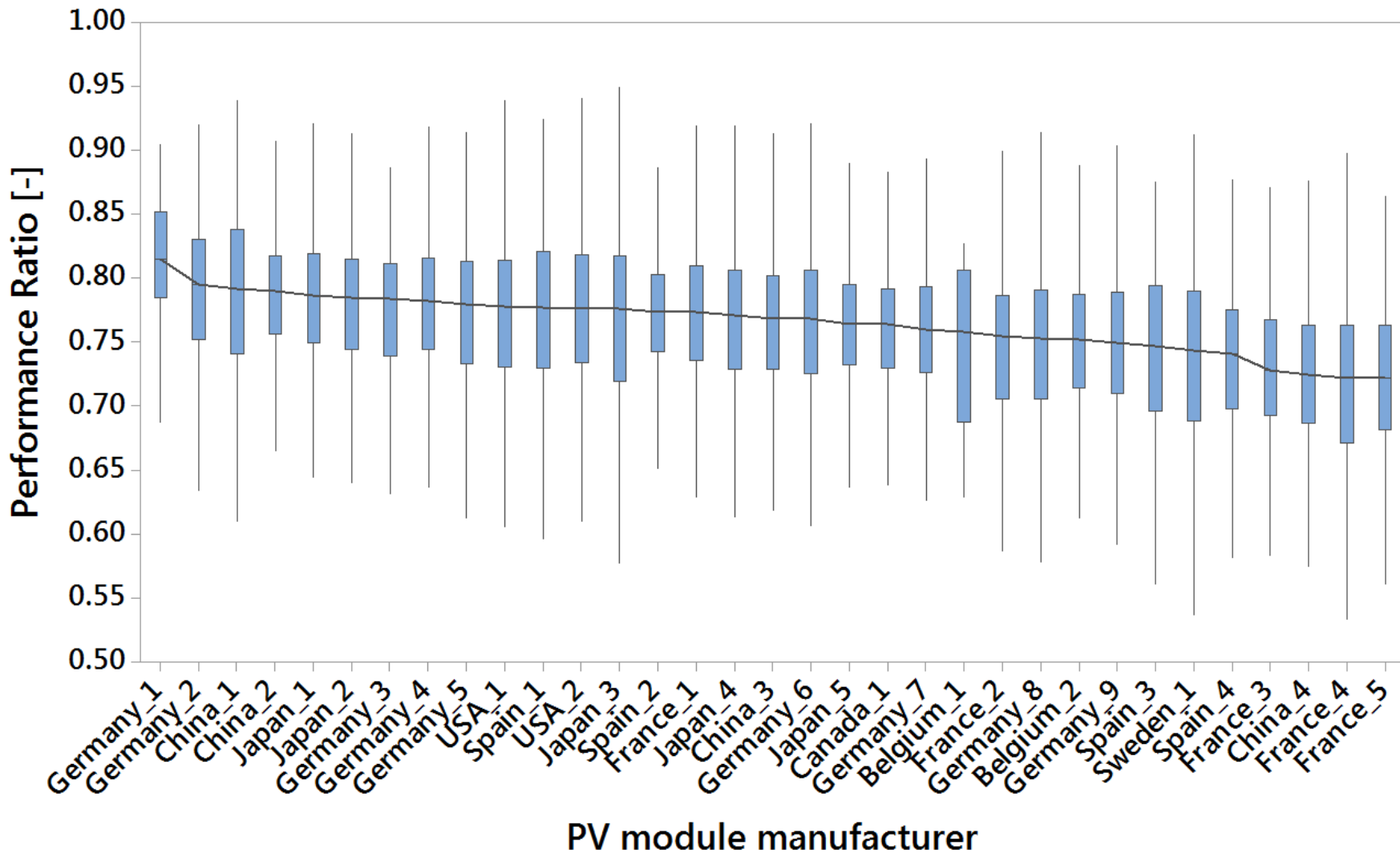
# Difference in PR between inverters: 1-5 %

Yearly integrated Performance Ratio vs Inverter manufacturer - PV systems Europe



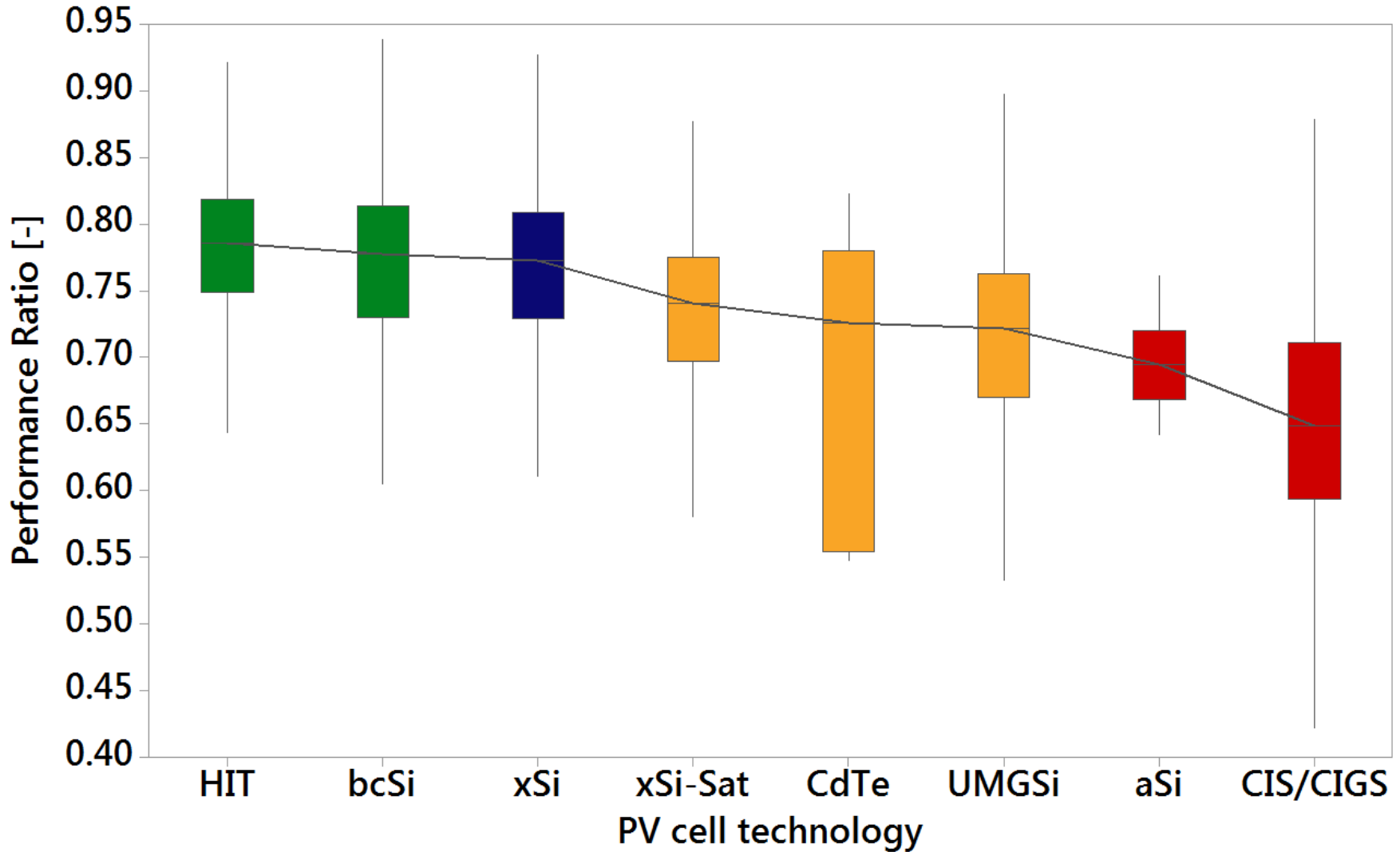
# Difference in PR between modules (no thin-film): 1-6%

## Yearly integrated Performance Ratio vs PV module manufacturer - PV systems Europe



# PV modules technology greatly affects performance

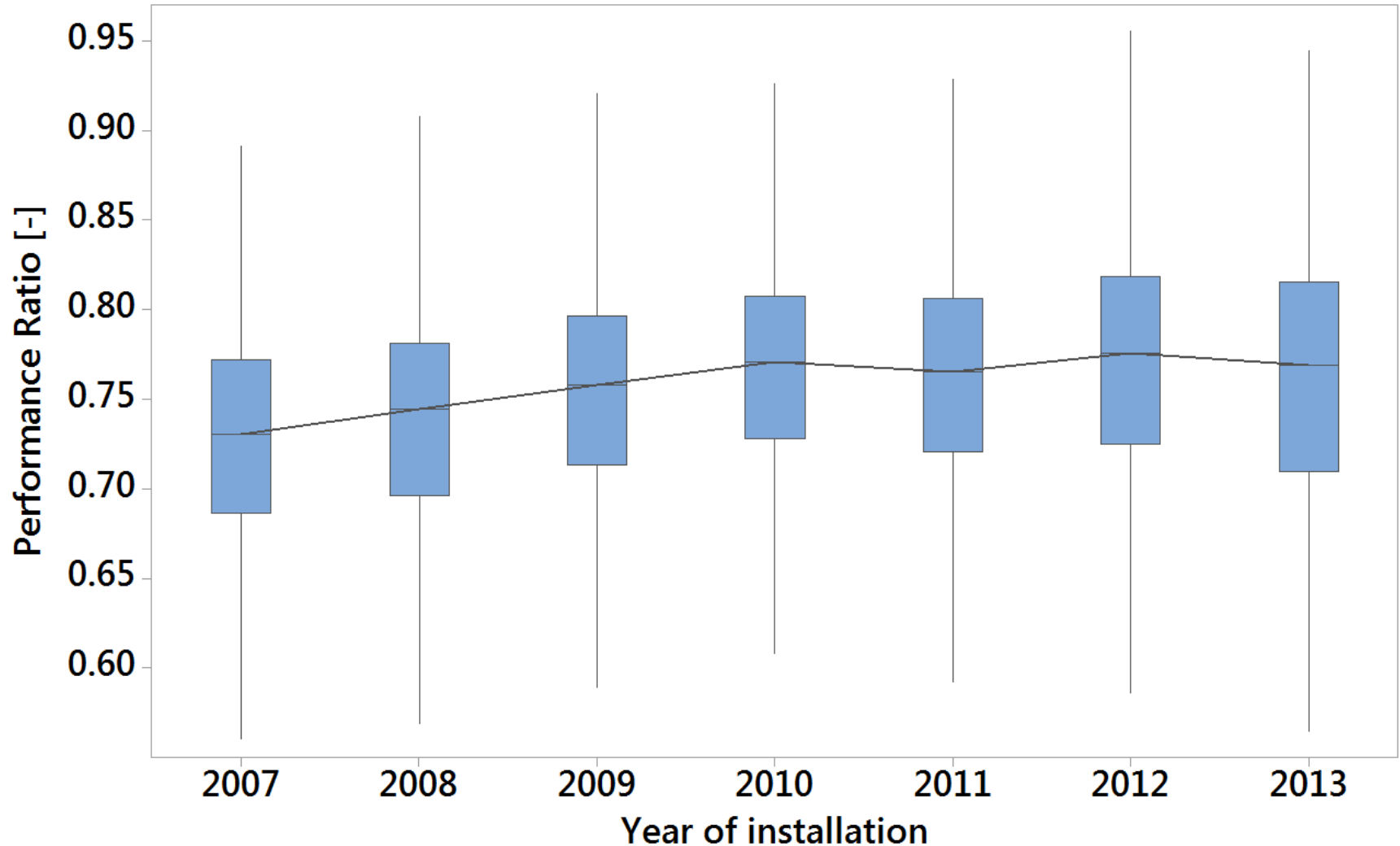
Yearly integrated Performance Ratio vs PV cell technology - PV systems Europe





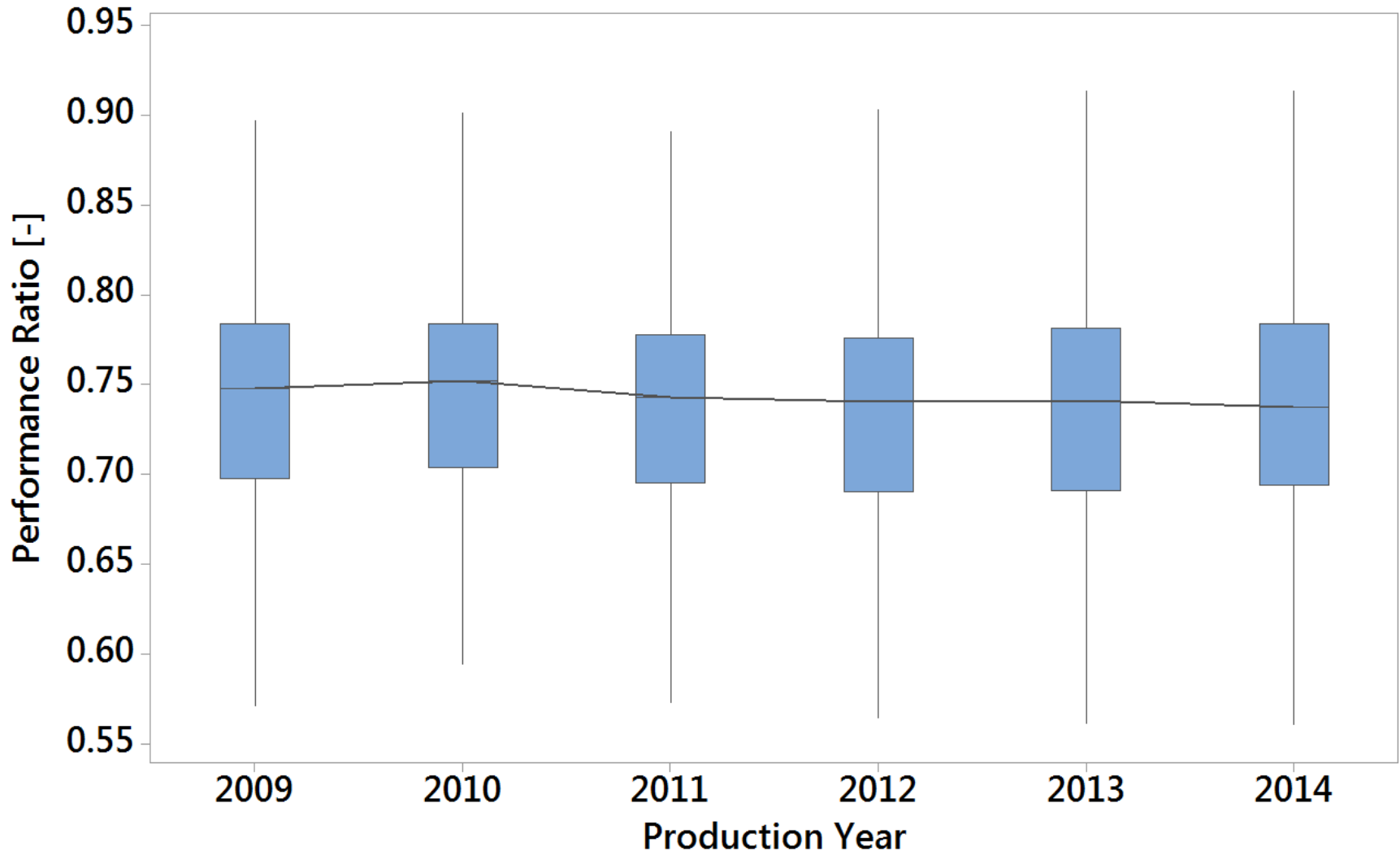
# PV systems performance has improved over time

Yearly integrated Performance Ratio in 2013 vs year of installation of PV system - Europe



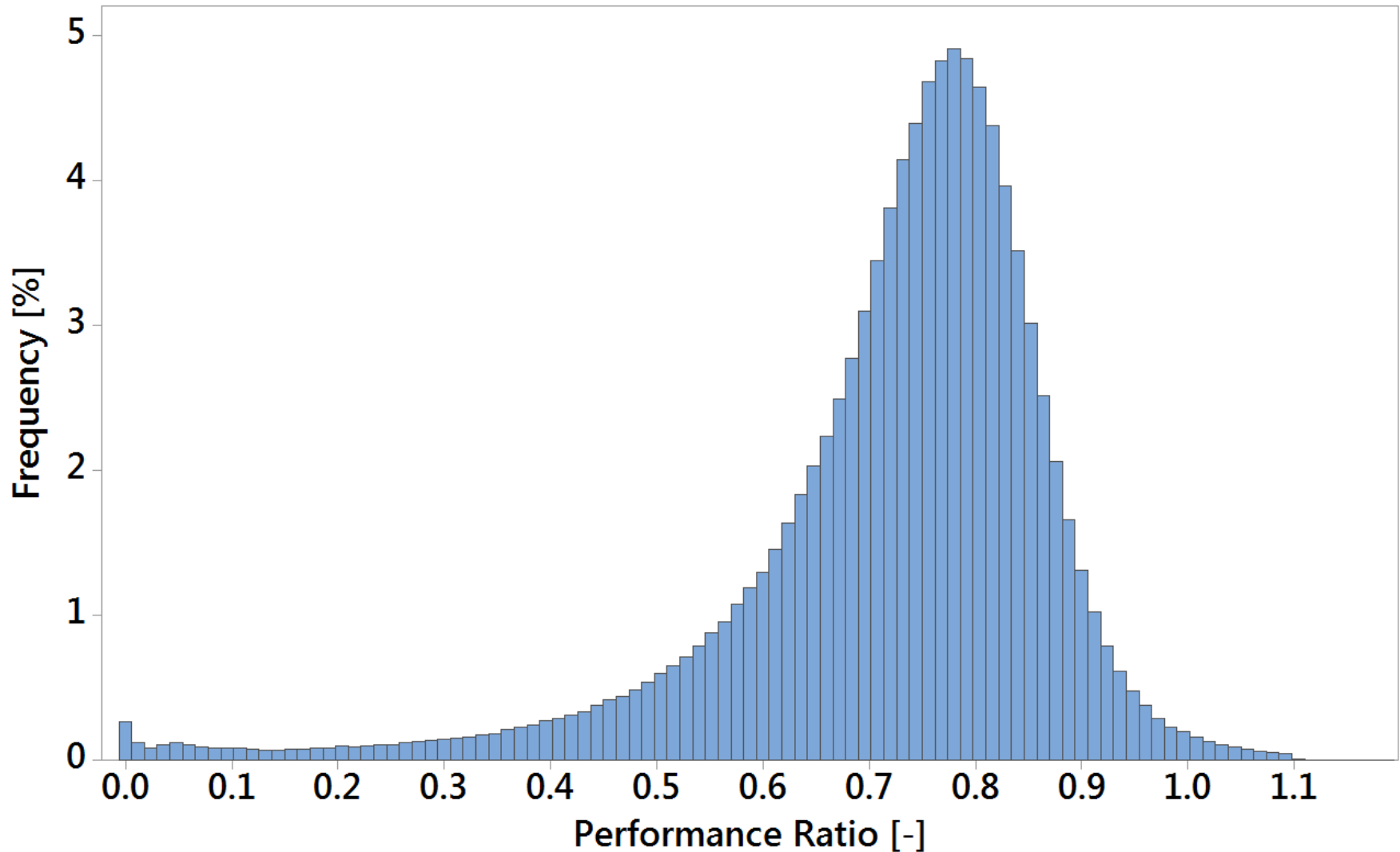
# PV systems performance degradation over time is low

Yearly integrated Performance Ratio for PV systems installed in 2008 vs production year



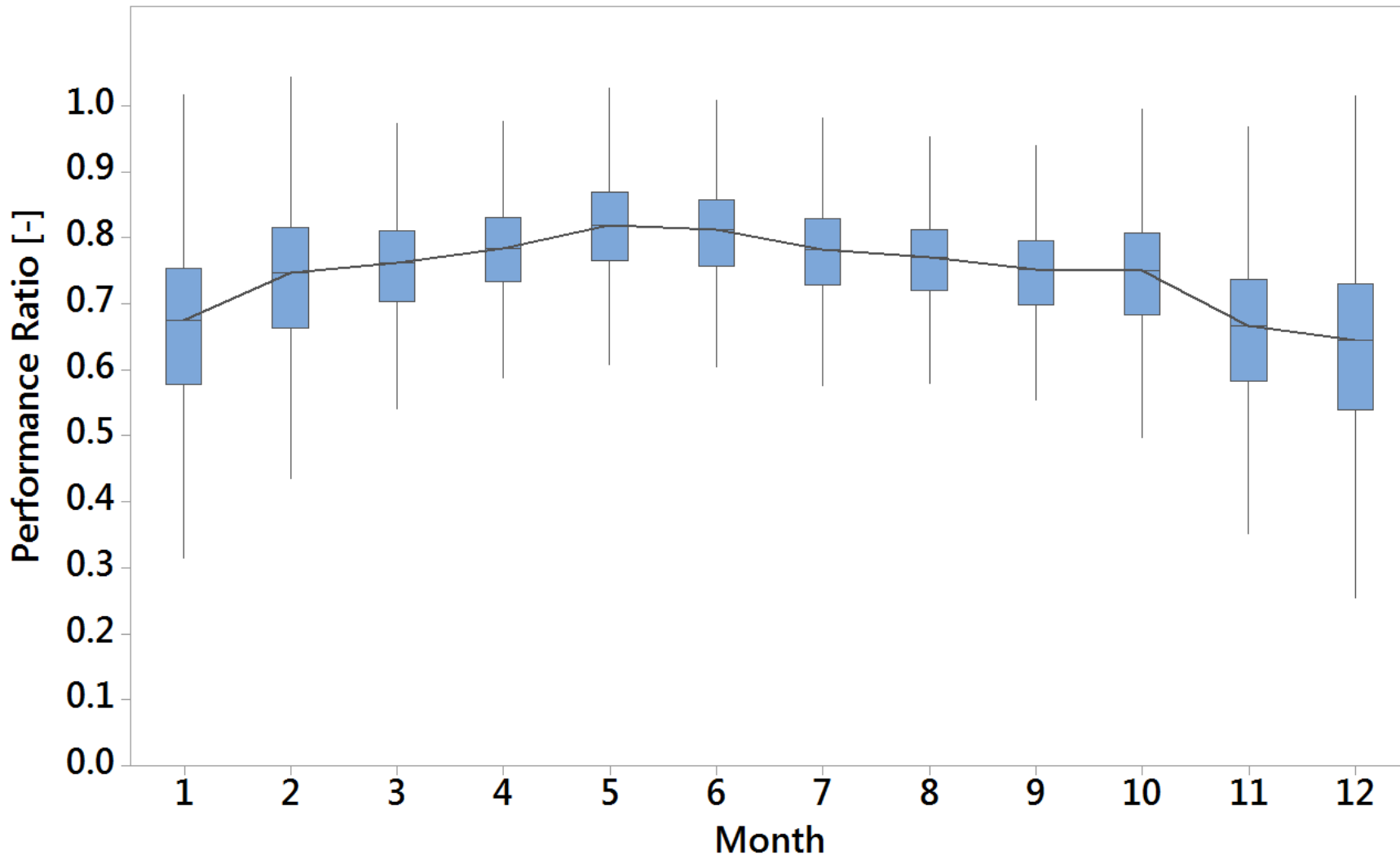
# Some PV systems are clearly subject to faults

Monthly integrated Performance Ratio - All 12 months of the year - Europe



# The monthly PR is influenced by several parameters

## Monthly integrated Performance Ratio - Europe



# Contact



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