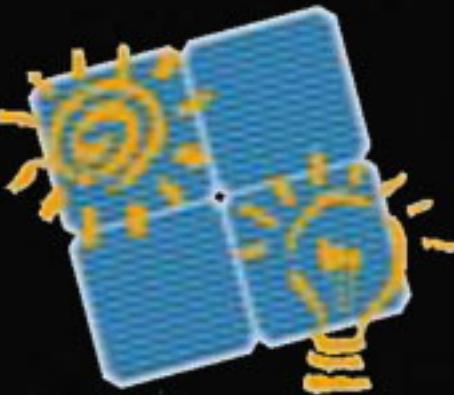


Reliability of Photovoltaic products Yield optimisation and monitoring the output of solar plants over their lifetime,

2nd International Conference
on Solar Photovoltaic Investments by EPIA
Frankfurt, Germany • 19th February 2008

Thomas Nordmann
IEA-PVPS Task 2 • Leader of Subtask 6
CEO TNC Consulting AG
8703 Erlenbach • Switzerland
nordmann@tnc.ch • www.tnc.ch



Overview

- How can you describe and analyse a PV system?
- Why is System performance over lifetime so important for our customer and the PV industry?
- How can you achieve an ø annual Performance Ratio (PR) of 0.80
- What can we learn from Japan and the automobile industry?
- The Evolution of PV systems from 1991 to 2005 Conclusions and Outlook



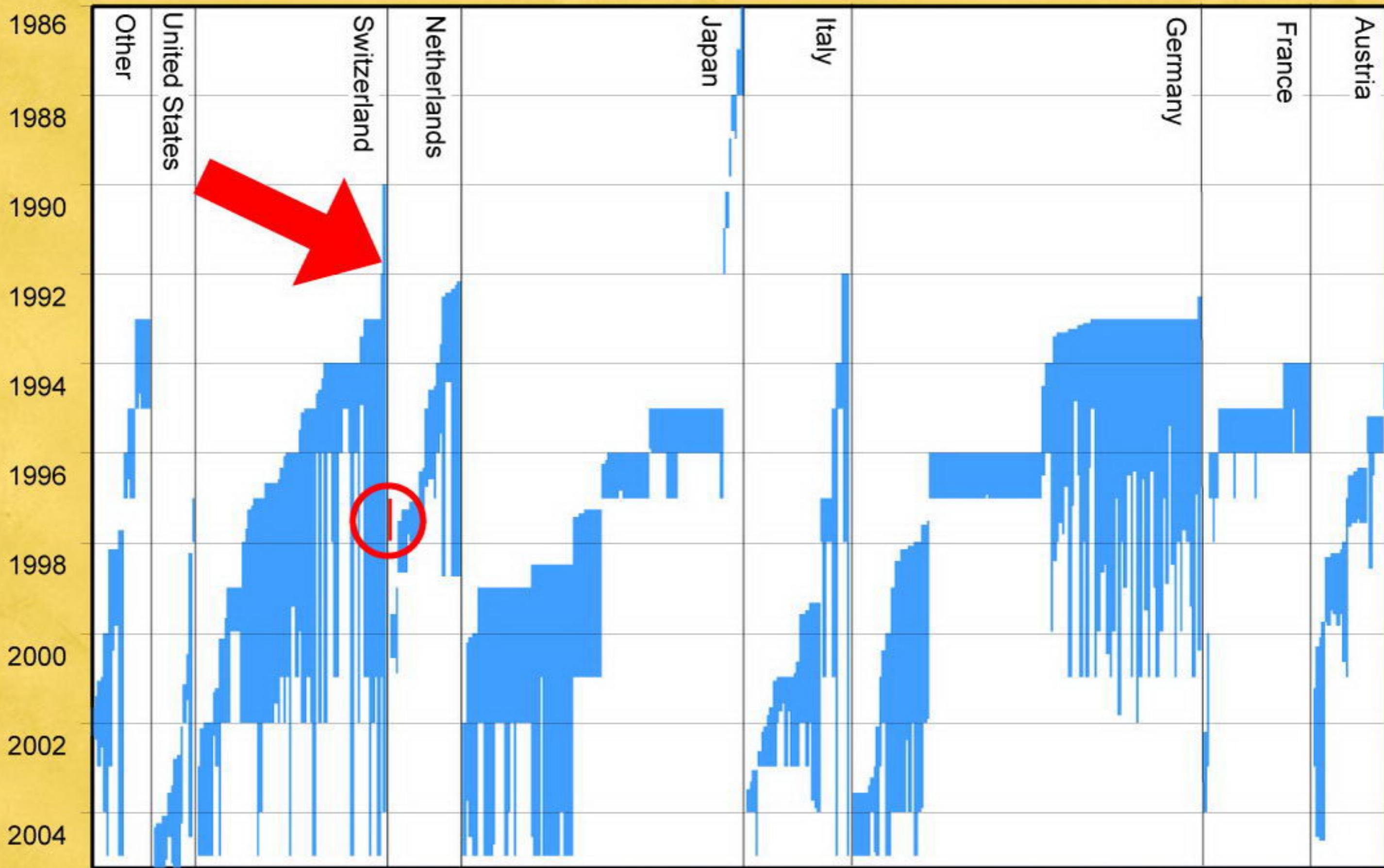
IEA - PVPS TASK 2 Provides...

- Network of 17 experts from 13 countries:
Austria, Canada, European-Commission, EPIA, France,
Germany, Italy, Japan, Poland, Sweden, Switzerland,
United Kingdom and USA
- Free Database including programme
- Reports and publications → www.iea-pvps-task2.org
- National and international workshops
- Technical information on operational performance,
longterm reliability and costs of PV systems



The Footprint of Performance Database

Benchmarking the PV World



The Footprint of Performance Database Benchmarking the PVWorld

IEA-PVPS Task 2 Performance ... Important! Please READ!



Search
In order to have the right webpage visualisation, please press either the corresponding button or the "Back" button more than once.

Browse

Tip! You can browse the plants by clicking the right icons.

DOMAT Switzerland

Plant data **Performance data** **Diagram**

Name:	DOMAT
Country:	Switzerland
Year of installation:	1989
Type of plant:	Grid-connected
Type of mounting:	Sound barrier
Module type:	Kyocera LA 381 J48
Inverter type:	Siemens Simatic 100
Nominal area of PV array:	967.8 m ²
Nominal Power at STC:	103.97 kW _p

100 kW Grid-Connected PV-installation along the N13 Motorway in Switzerland - Plant Monitoring and Evaluation. This 100 kW grid-connected PV plant went into operation in autumn 1989. At the same time, an intensive monitoring programme was launched. After ten years of operation and monitoring, comprehensive data have been collected and analysed. The monitoring system was designed in accordance with the EU-Guidelines for PV System Monitoring. The PV array of this plant consists of 72/2 sub-arrays. Each sub-array comprises twelve strings of 24 Kyocera LA 381 J48 modules in series. The array-voltage at STC is 400 V dc. A sub-string consists of 12 modules in series giving half the array-voltage. The DC current of these 32 sub-strings was monitored from 1990 through 1992. The sub-strings are mounted on top of a sound-barrier along the motorway and the installation extends over a distance of 800 meters. In the first seven years (Dec. '89 to Dec. '96) of operation the plant has produced 7487750 kWh, on average 1057000 kWh/yr with a specific annual yield of 1004 kWh/kWp and a performance of 74 %. The plant performed extremely well with a minimum of maintenance required. In 1995 an educational pavilion on solar energy was officially opened. Monitoring will go on for at least another few years. This project is sponsored by the Swiss Federal Office of Energy.

[1] L. Clevedetacher, Th. Nordmann, Prediction and Effective Yield of a 100 kW Grid-Connected PV-installation, Solar Energy Vol. 51, No. 2, pp 101 - 107, 1993, Pergamon Press, New York. [2] L. Clevedetacher, Th. Nordmann, TNC Consulting AG, Evaluation of Grid-Connected PV-installations, Paper 18-32, 12th European Photovoltaic Energy Conference, Amsterdam, April 1994. [3] L. Clevedetacher, Th. Nordmann, TNC Consulting AG, 100 kW Grid-Connected PV Plant A13 in Switzerland - 10 Years and 10000000 kWh Later, [789] DCS/2, 15th European Photovoltaic Energy Conference, Glasgow, May 2000. [4] TNC Consulting AG, 100 kW PV-Aerovibrationslage A13, Meerkampagne (in German), Annual Reports 1990 ... 2002. [5] IEA-PVPS, TASK 2, CASE STUDIES on Long-term Performance and Reliability of PV Systems, 100 kW Grid-connected PV-plant A13, IEA PVPS, 2003.

Language:
deutsch english français italiano español

Search criteria:
Country: Switzerland
Nominal power:
Type of Plant: Grid-connected

Home **List view** **Print**



Click here to move the image smaller

The Footprint of Performance Database Benchmarking the PV World

IEA-PVPS Task 2 Performance ... Important! Please READ!

Search
In order to have the right webpage visualization, please press either the corresponding button or the "Back" button more than once.

Browse

DOMAT Switzerland

Plant data **Performance data** **Diagram**

Monthly Yields and Losses 1997

Yield: Reference yield based on the in-plane irradiation: $Y=Y_{in} \cdot L_{in}$
 Li: Array capture losses: $L_i=Y-Y_{in}$
 La: System losses: $L_a=Y_{in}-Y$
 PR: indicates the overall effect of losses on the array's nominal power: $PR = Y_{in} / (Y_{in} + L_i + L_a)$

IEA-PVPS Task 2
Operational performance, maintenance and sizing of photovoltaic power systems and subsystems

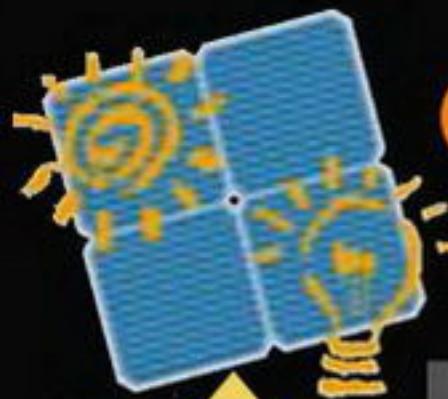
Performance Database
Programme Version 1.10
Database 06/2008

1997 → PR Ø 80

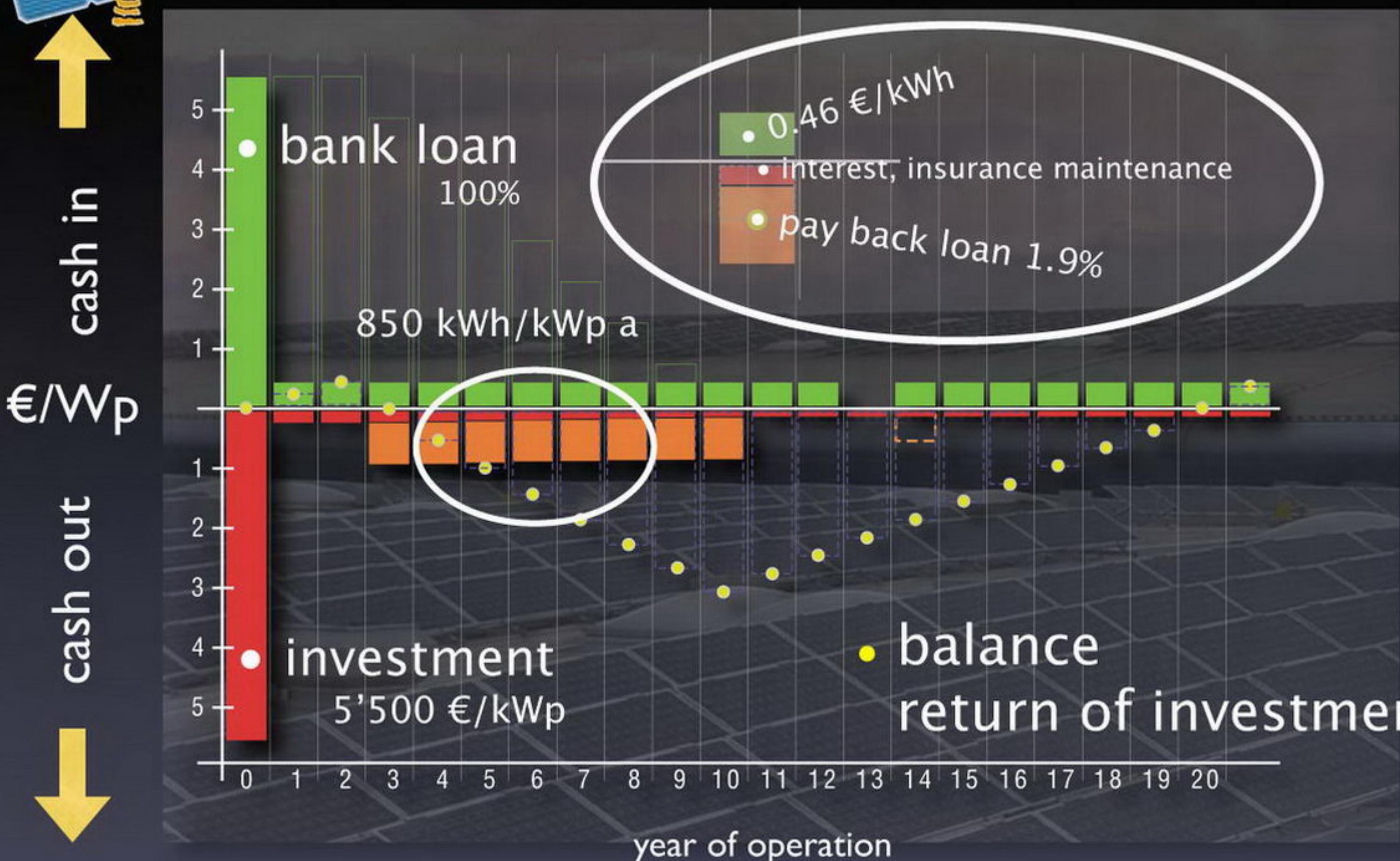
Information on over 505 PV plants in 21 countries worldwide with 13.5 MW

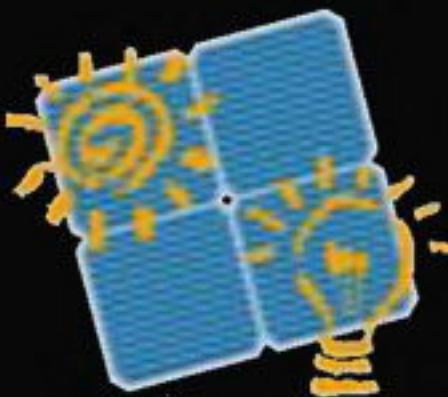
Print

Search criteria:
 Country: Switzerland
 Nominal power: 13.5 MW
 Type of Plant: Grid-connected



Cash Flow Analyses for Rate based Incentive

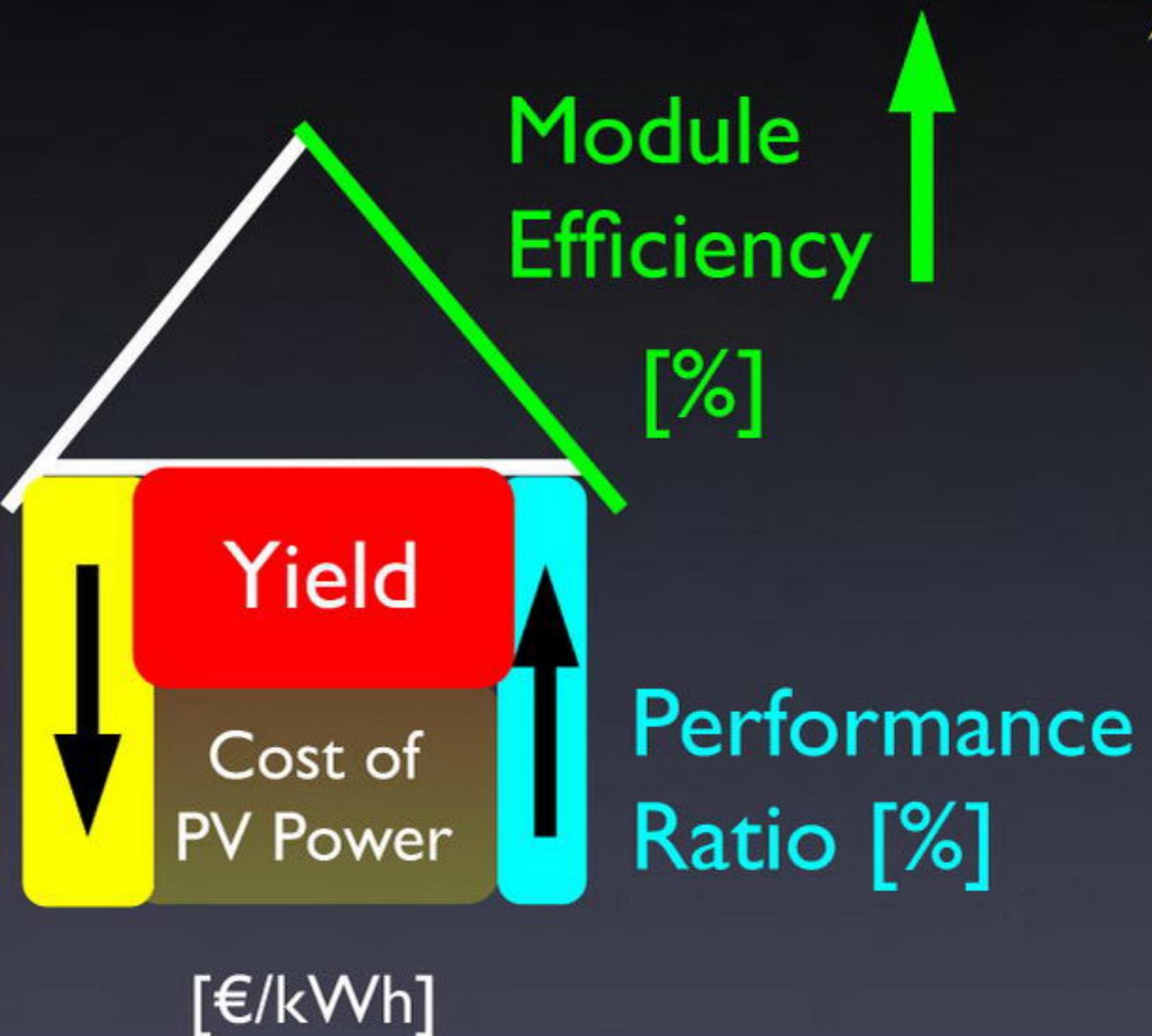




To Describe and Analyse a PV System: you
need several Elements of Data ...



[kWh/kW_P a]
**System, Capital,
Maintenance Cost**
[% of Invest/year]





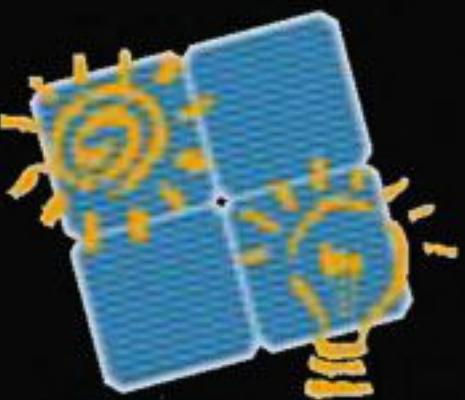
Focused Pe

COST AND PERFORMANCE TRENDS IN
GRID-CONNECTED PHOTOVOLTAIC
SYSTEMS AND CASE STUDIES



PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Report IEA-PVPS T2-06:2007



Survey on www.iea-pvps-task2.org

June 2005 - December 2006

Interface in:

- English
- French
- German
- Italian
- Japanese
- Spanish

IEA-PVPS Task 2 · Subtask 6
PV System Cost Over Time

IEA-PVPS Task 2 · Subtask 6
PV System Cost Over Time

IEA-PVPS Task 2 · Subtask 6
PV System Cost Over Time

あなたのログ
noromann@...
システムの名
A13 PV Schall
ホーム
Translatio
ログアウト
ヘルプ
言語の変更
Japanese

Capacidad nominal
fotovoltaico a condi
de prueba

Área total de los am
Marca de los módul
Si es otro, por favor
Tipo de módulo
Si es otro, por favor
Marca del inversor
Si es otro, por favor
Tipo de inversor:
Si es otro, por favor

システムの定格出力 (全パネル)
パネル面積
パネルのメーカー
選択肢がない場合は記入して下さい:
パネルの種類
選択肢がない場合は記入して下さい:
インバータのメーカー
選択肢がない場合は記入して下さい:
インバータの種類
選択肢がない場合は記入して下さい:

103 kW
1000 m²
Kyocera
IA 321 K 45 S
Siemens
custom built

続ける キャンセル

Number of PV Systems analysed:

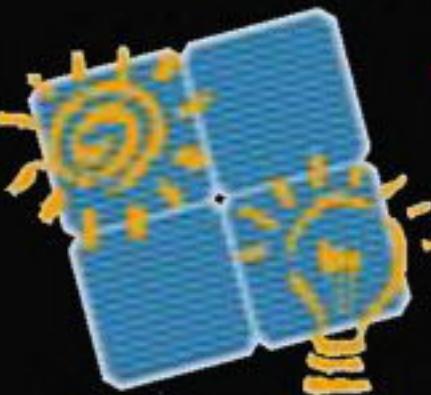
- From the IEA PVPS Performance Database
- From the T2/6 Economic Survey

	Nr. of systems	Built between	Average Operational Years	Total Operational Years	Average Nominal Power [kW]	Total Nominal Power [kW]
Performance Data from 17 Counties	461	1991-2006	3.3	1'544	27.7	12'322
Economic Data from 11 Counties	527	1991-2006	--	--	21.0	11'063



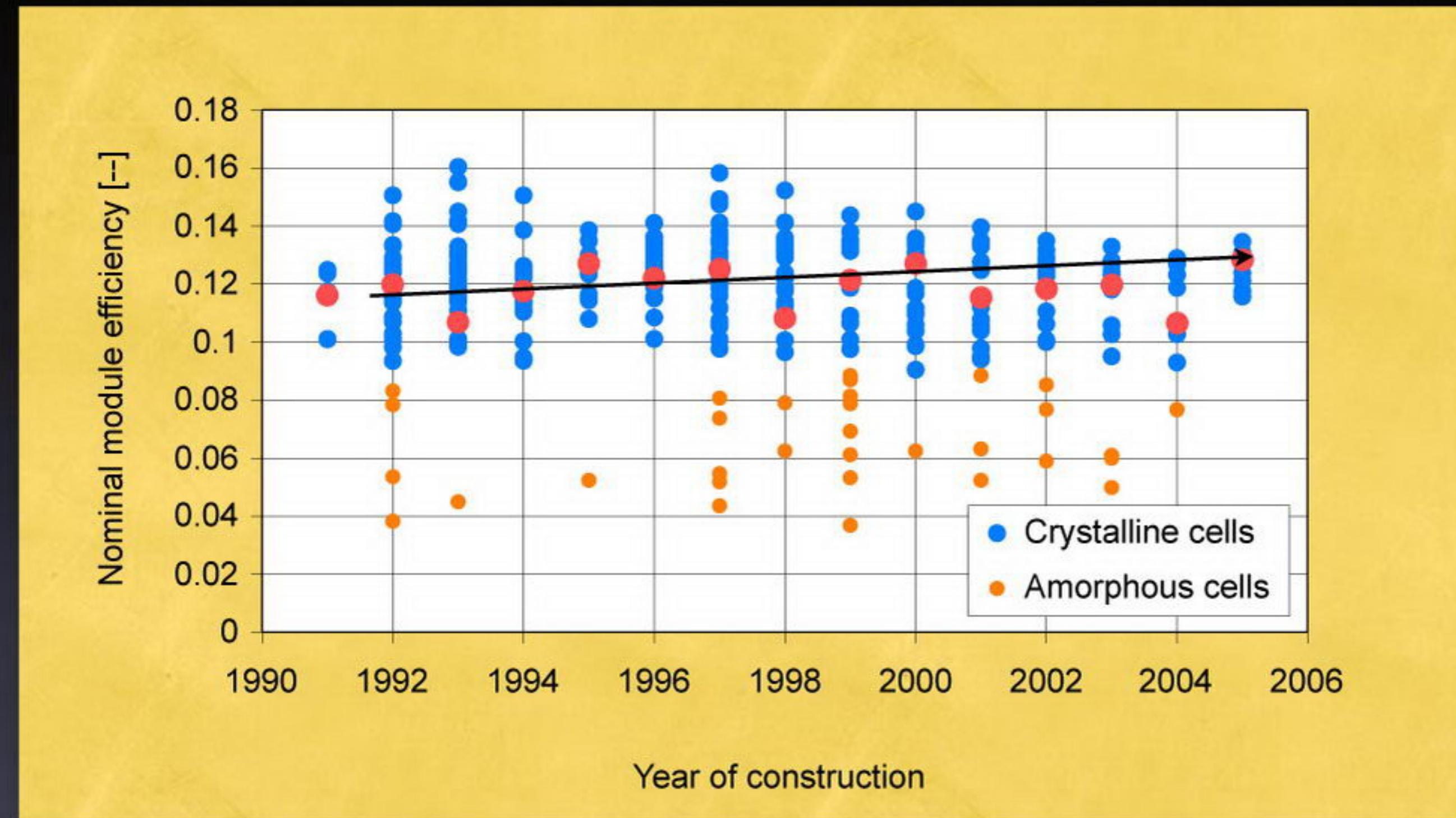
To Describe and Analyse a PV System: you
need several Elements of Data ...



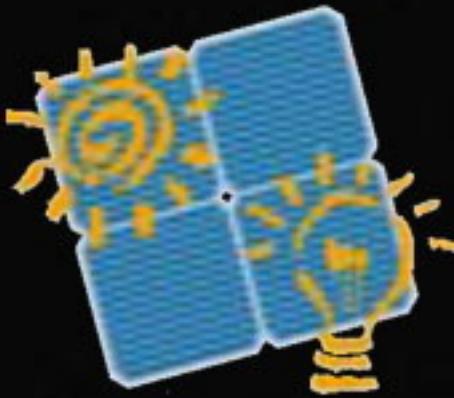


The Evolution of the Module Efficiency

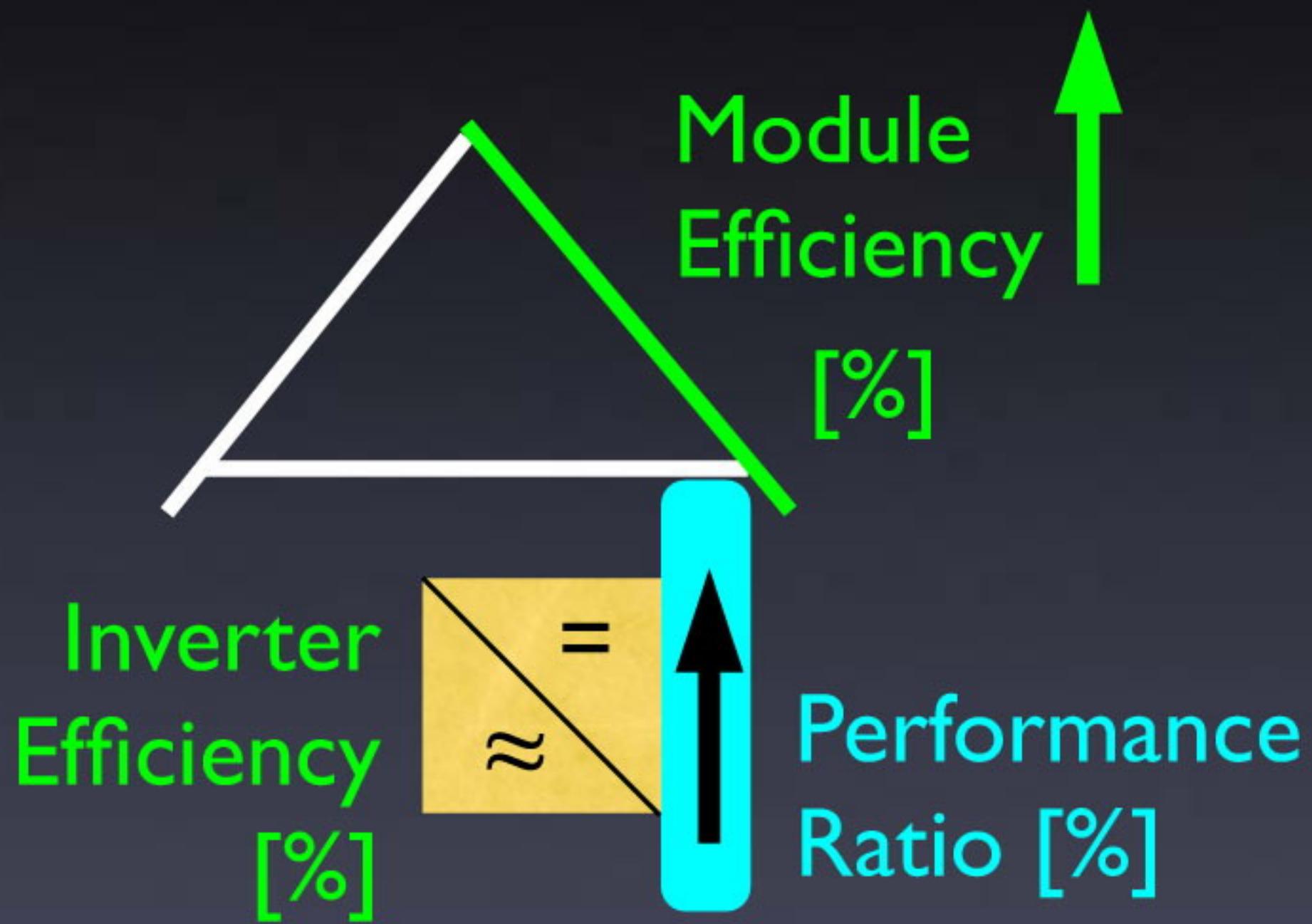
N = 461

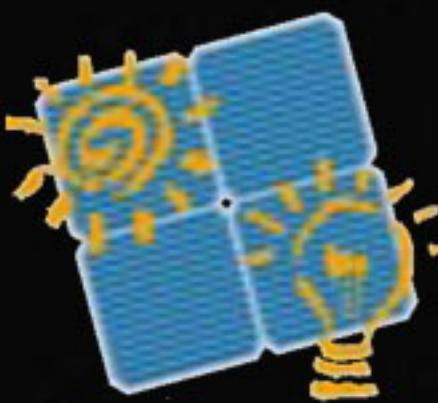


1991 ø η = 11.5% → 2005 ø η = 13%, best case 14%



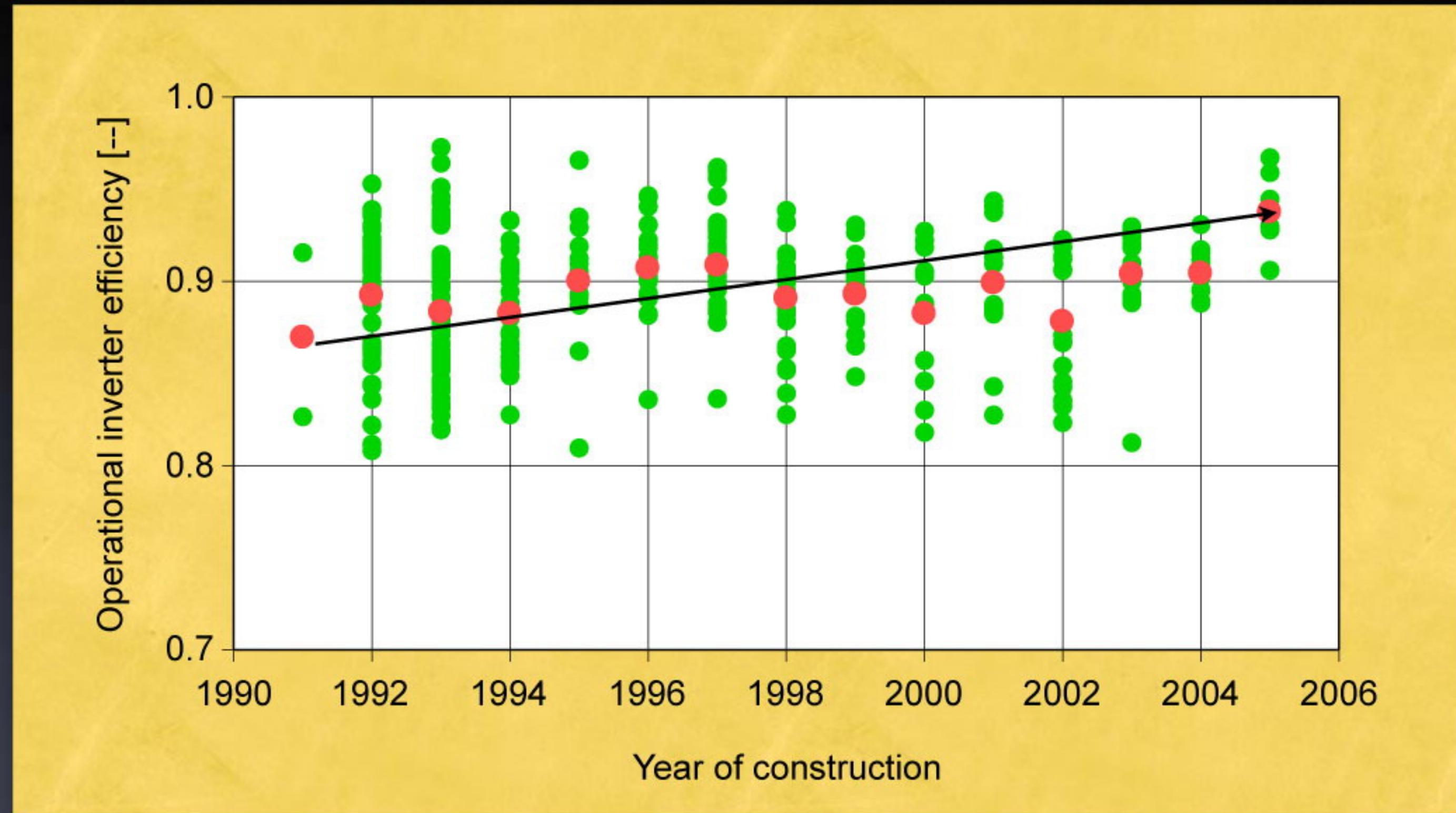
To Describe and Analyse a PV System: you need several Elements of Data ...



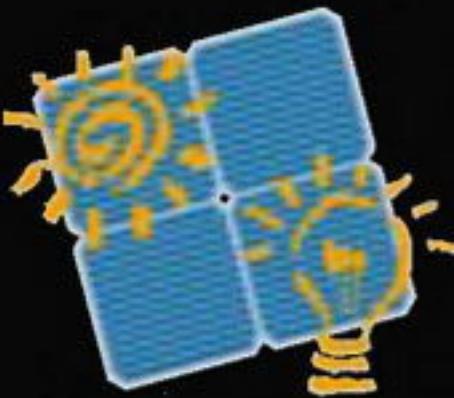


The Evolution of the Inverter Efficiency

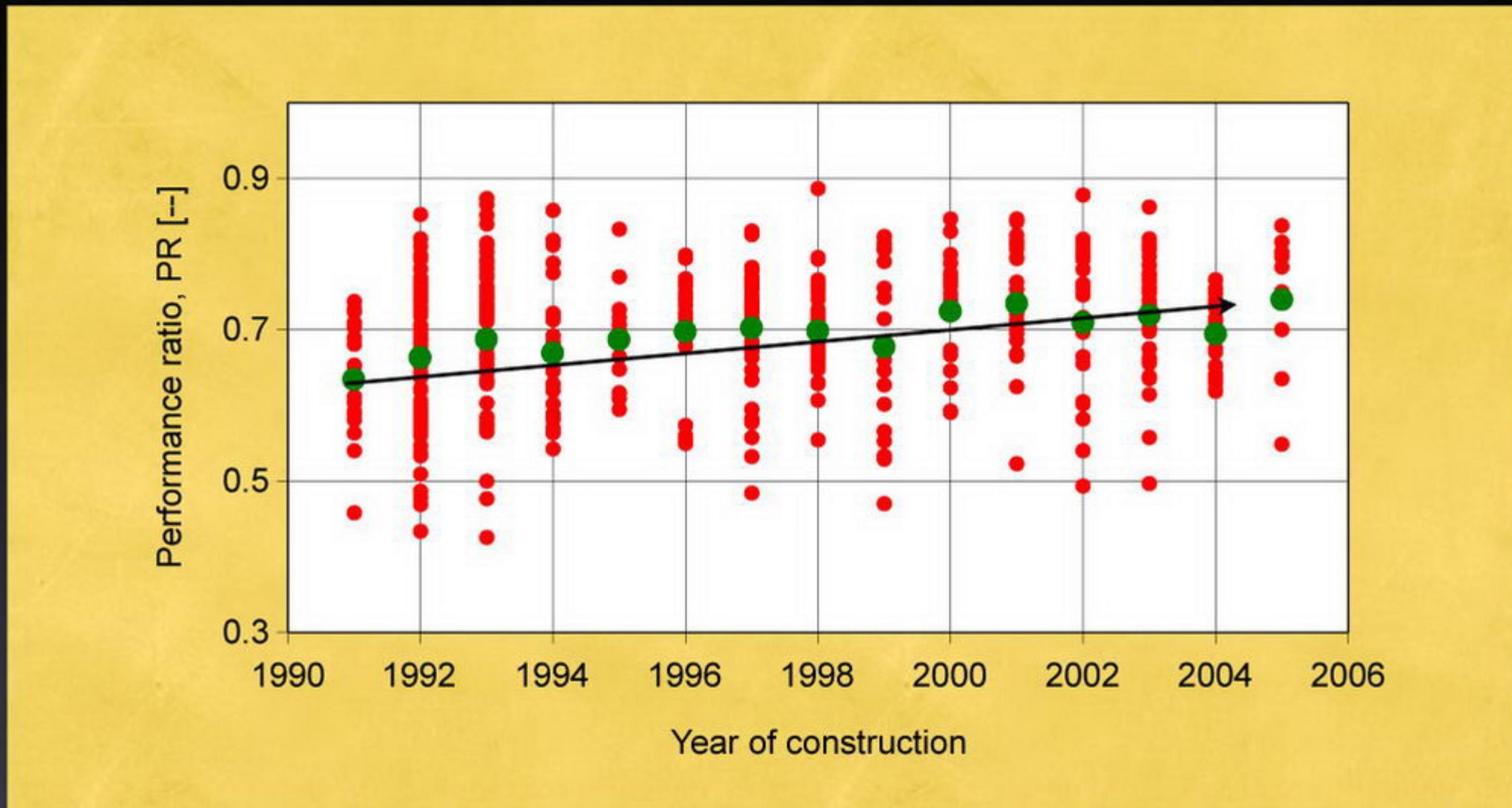
N = 331



1991 Ø PR = 0.89 → 2005 Ø PR = 0.94, Best Case = 0.94



The Evolution of the Performance Ratio N = 461

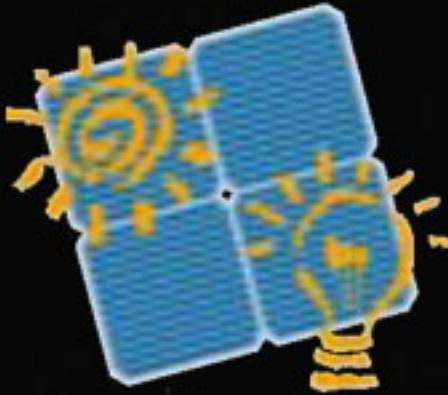


1991 \varnothing PR = 0.64 \rightarrow 2005 \varnothing PR = 0.74, best case 0.84

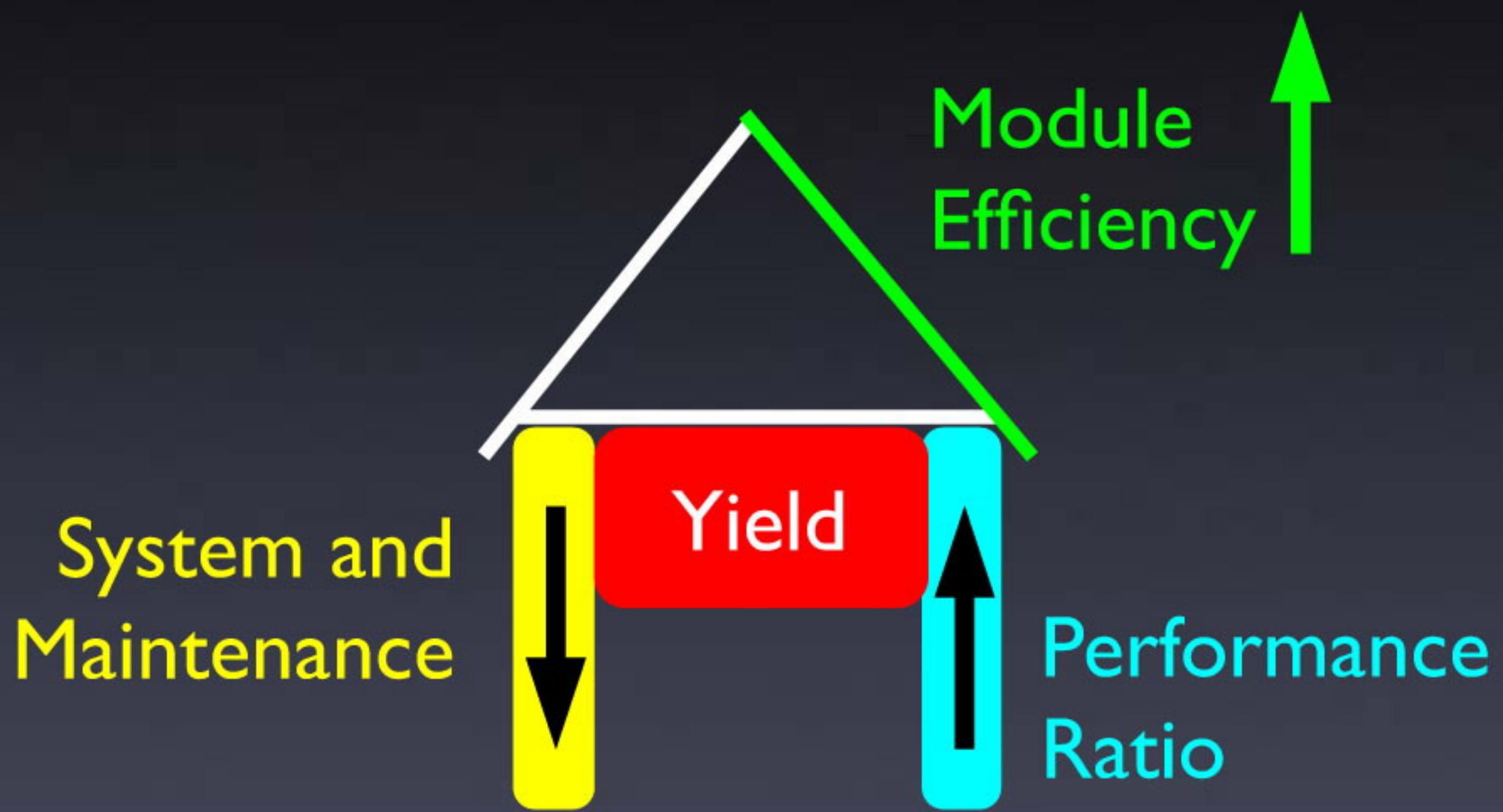


How can you achieve a Performance Ratio (PR) of 0.80 for your PV system?

- Realistic, truthful module ratings
- No shading problems
- Better inverter availability and efficiencies
- Higher system availabilities, no long repair times
- Fault detection and monitoring of the systems increase the overall performance



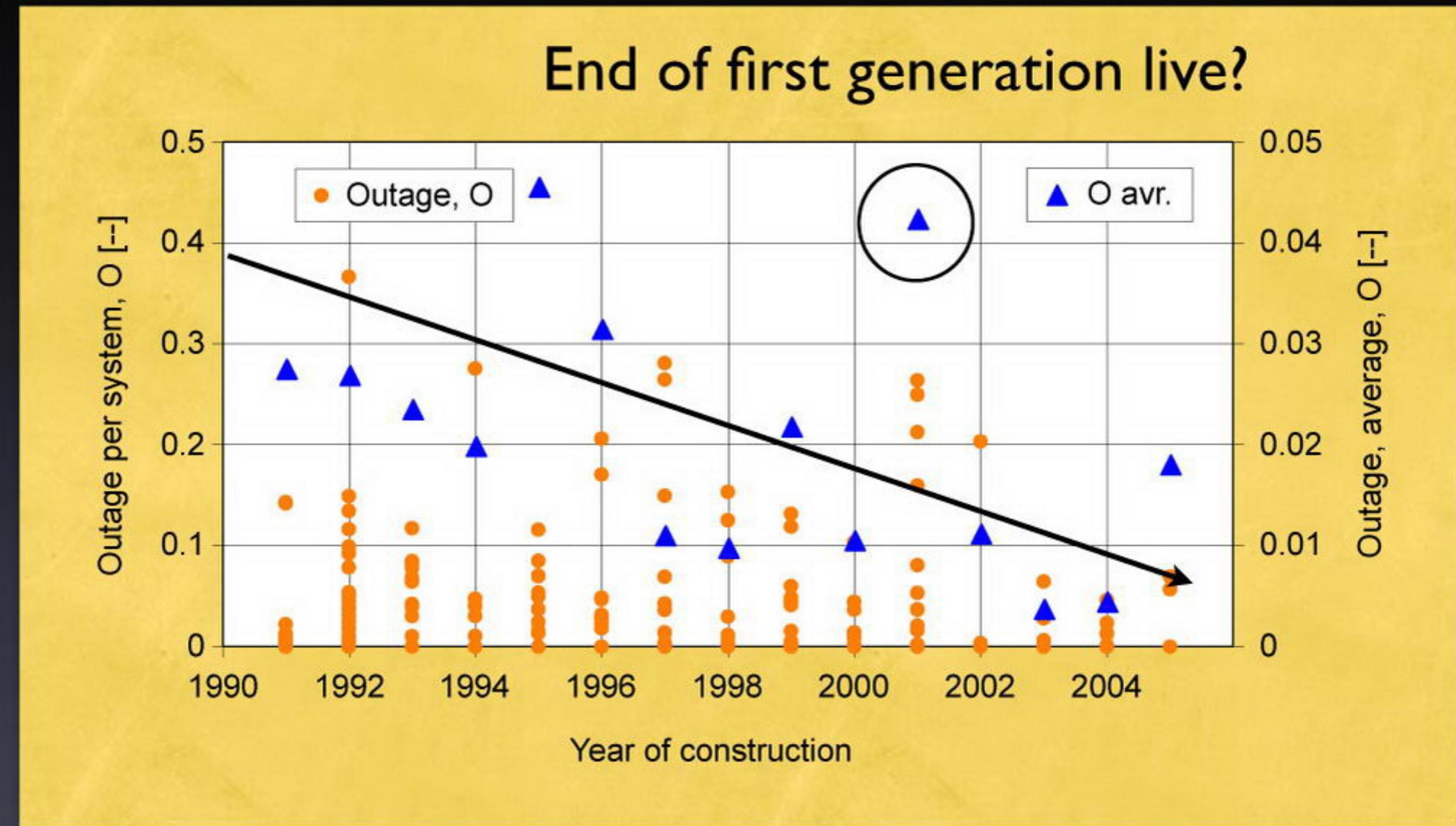
To Describe and Analyse a PV System: you need several Elements of Data ...





The Evolution of the System-Outage

N = 461



1991 ø 0.03 → 2005 ø 0.01, best case 0.00!



The Evolution of the Failure Rates

Case study by Japan

N = 725

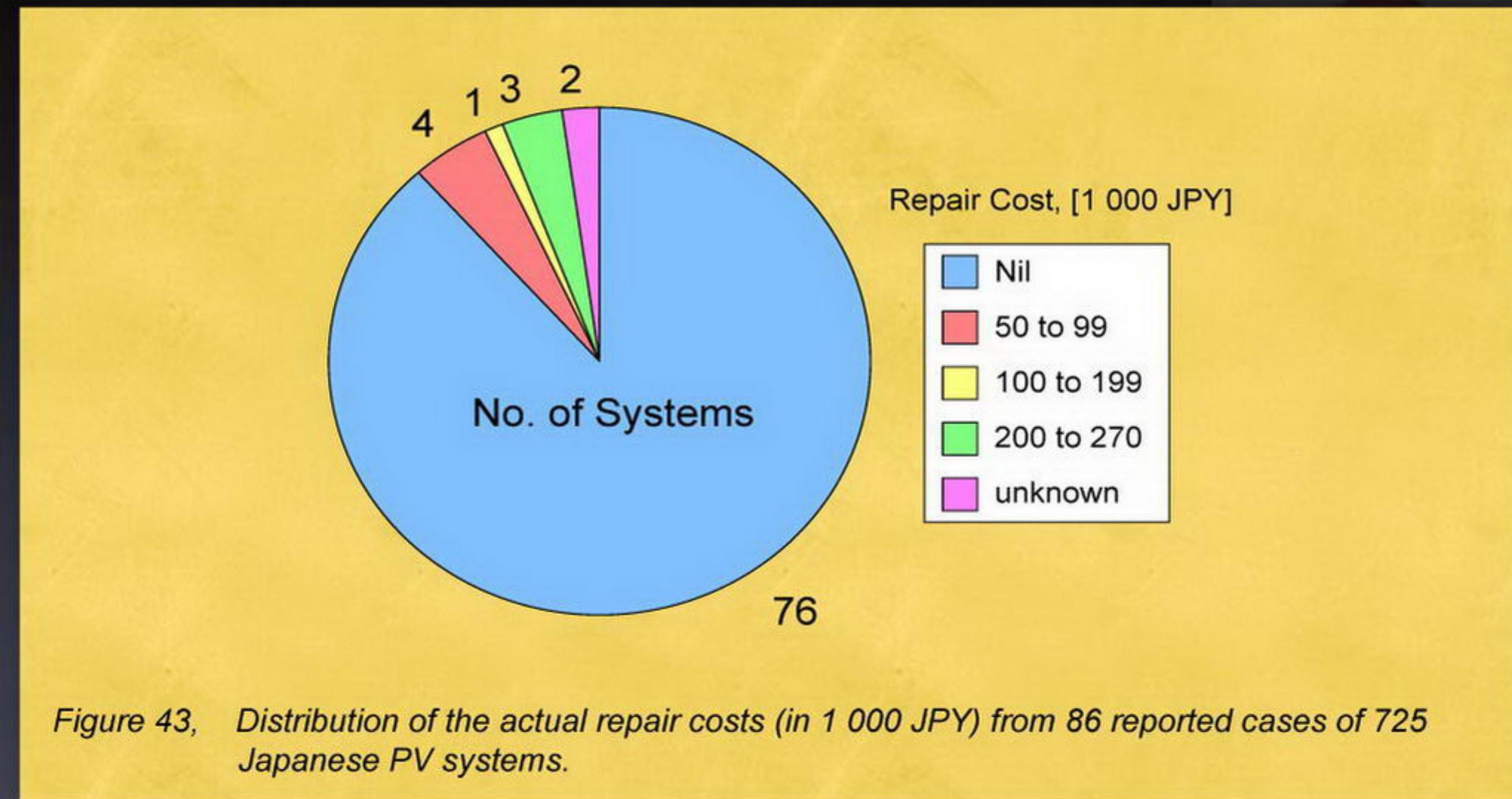




The Evolution of the Failure Rates

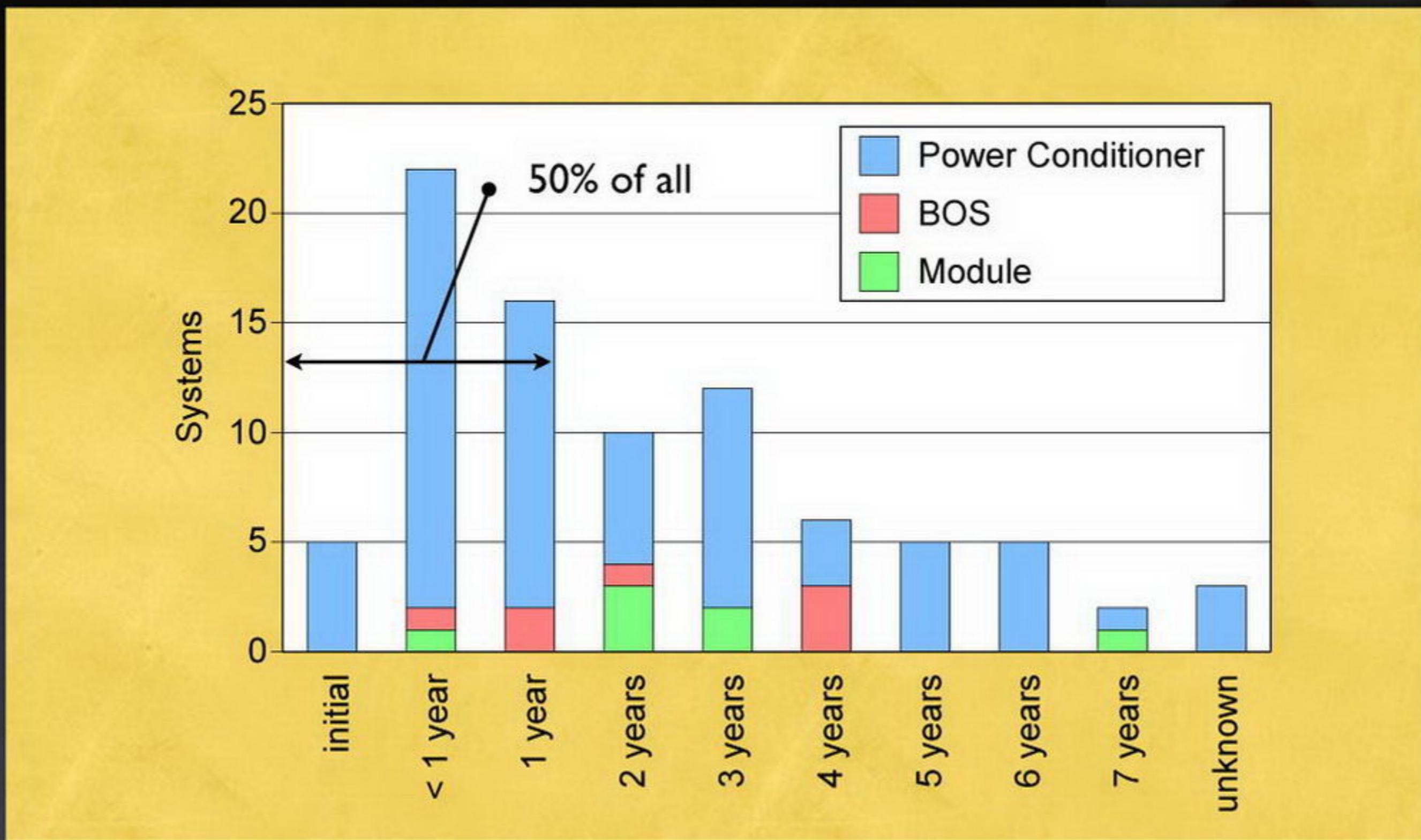
Case study by Japan

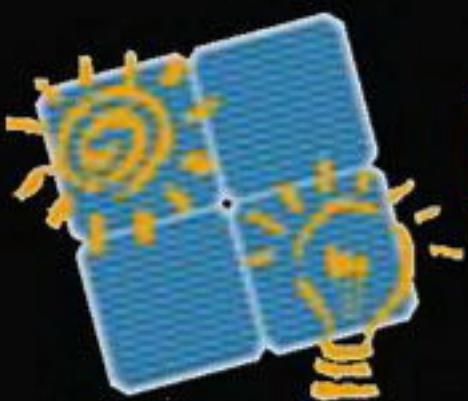
N = 725





The Evolution of the Failure Rates





How is a mature industry treating its recall?

Battery Recall

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3.2.2006 14:17 Uhr

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CBD	6.965	+1.7%	Nas	1.855	+0.8%	ESX	3.810
TDax	825	+4.5%	NasF	1.661	+1.6%	S&P	1.140
EUR	1.4804	-0.3%	Ot	91.97	-0.9%	Gold	905.0

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Klickzeilen

Dienstag, 2. Januar 2007

Rückruf bei Mercedes

A-, B-, und C-Klasse betroffen

Mercedes holt in Deutschland tausende Fahrzeuge wegen möglicher Fehler am Scheibenwischer in die Werkstätten.

Bei den betroffenen Fahrzeugen der A- und B-Klasse sowie des Kombimodells der C-Klasse werde ein Schalter wegen möglicherweise mangelhafter Isolierung vorsorglich ausgetauscht, sagte ein Sprecher der zum Stuttgarter DaimlerChrysler-Konzern gehörenden Autobauers Mercedes am Dienstag.

Betroffen seien die Baujahre zwischen Mai 2005 und Mai 2006. Bei diesen Modellen könne der Heckscheibenwischer ausfallen.



Made in Japan

REV - AOO

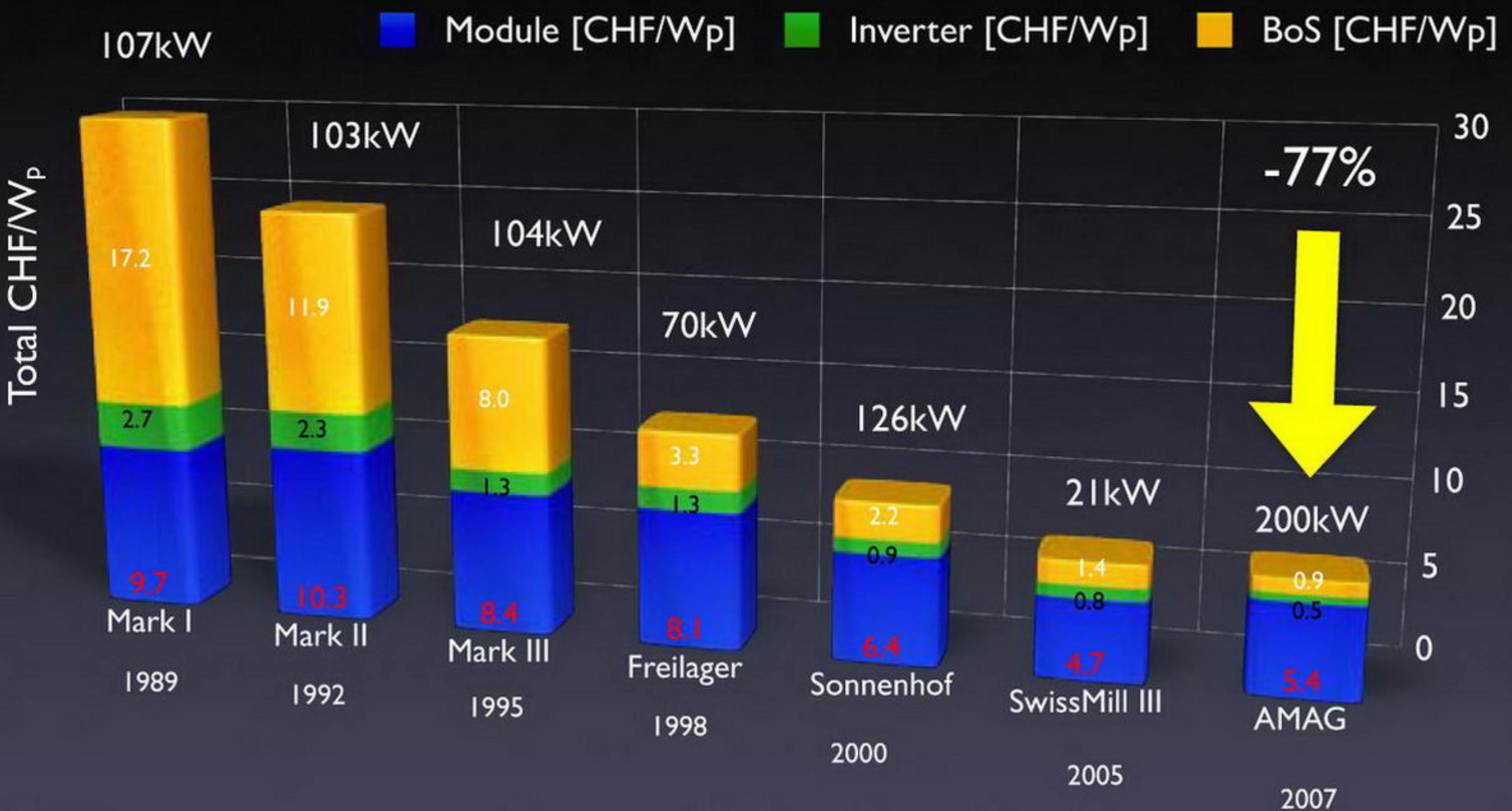
Modelle



N 6er- und BMW 7er-Baureihe liegen einer fehlerhaften Säge durch einen Lieferanten aus Japan. Es habe die Schäden in Autos aus dem April 2006.

In Werkstätten. Dort werden die Wagen von ihren

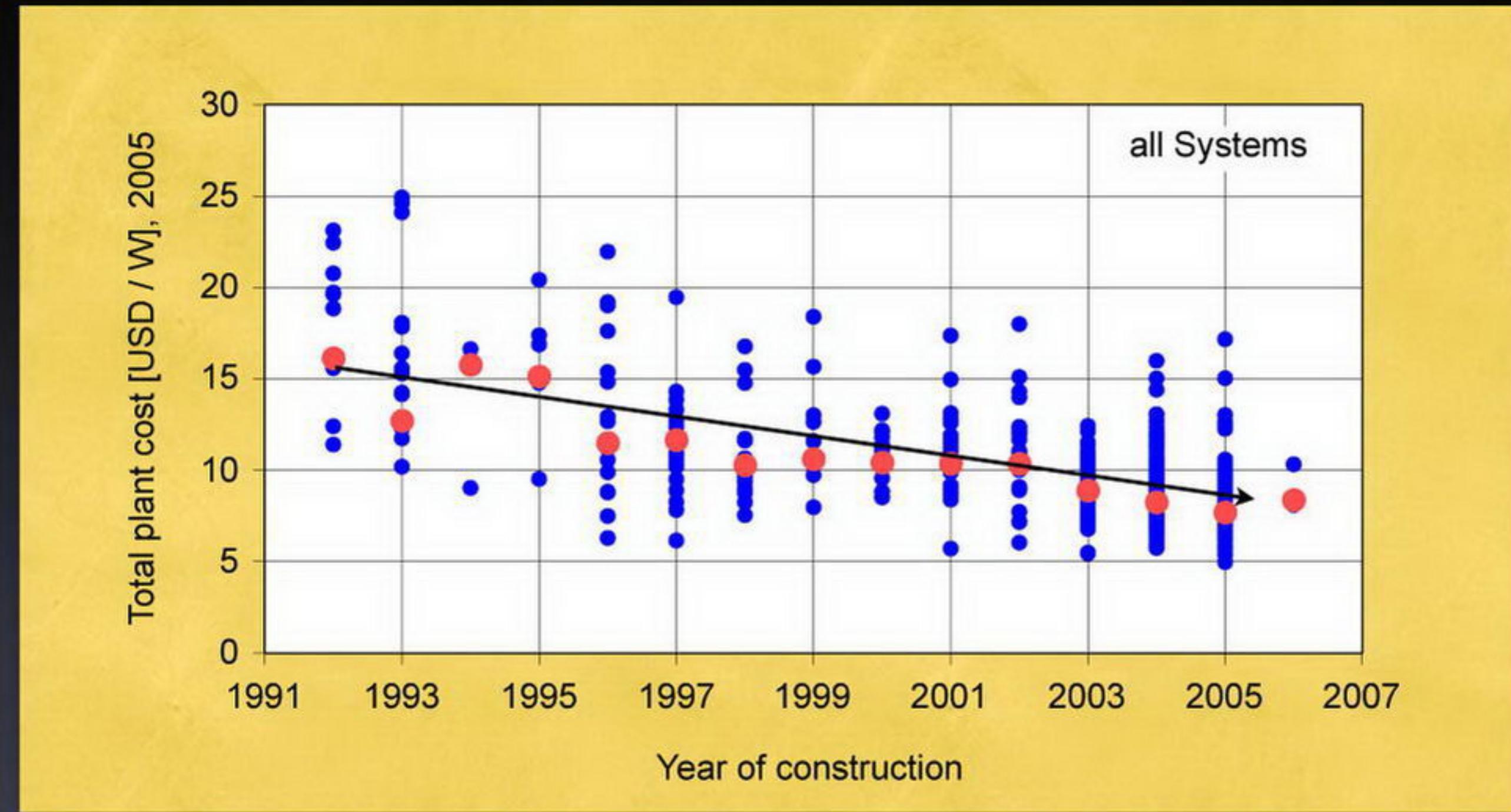
TNC PV systems learning-curve: 1989 - 2007



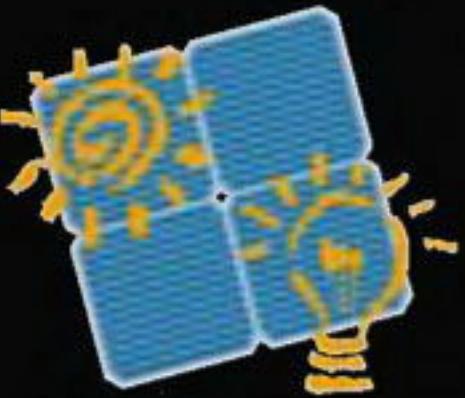


The Evolution of the System cost

N = 527



1992 ø 16 US\$/W → 2006 ø 8 US\$/W -50%,
Best case 6 US\$ - 63%!



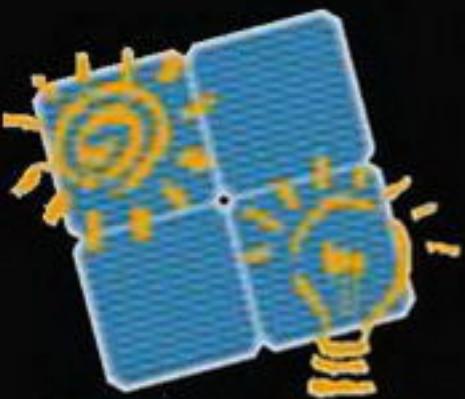
Annual yield – three main groups

Systems

461 grid-connected PV systems 1991 - 2005 from 17 countries.
Mainly domestic roof-top systems smaller than 10 kW.

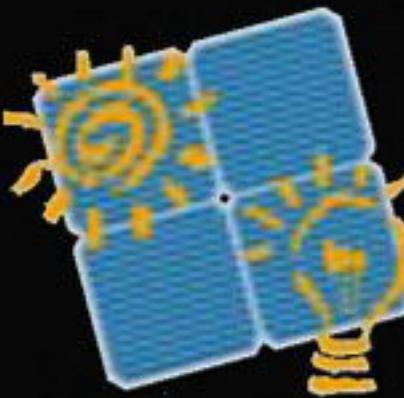
Annual yield – three main groups

- Israel and southern Japan $Y_f = 1'400 \text{ kWh/kWp}$
- Florida, USA, $Y_f = 1'000 \text{ kWh/kWp}$
- Central Europe $Y_f = 900 \text{ kWh/kWp}$



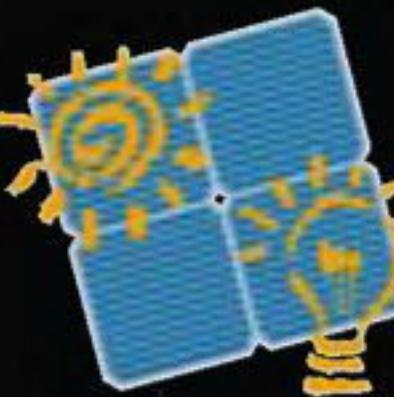
A typical gridconnected PV system ø 1991 and ø 2005 and best case 2005.

Typical system tech. econom.	1991	2005	2005 best case	unit
Nominal module efficiency [η_{A0}]	11.6	12.9	14	%
Operational inverter efficiency [η_I]	89	94	94	%
Outage (O)	0.03	0.01	0	/a
Performance ratio (PR)	0.64	0.74	0.84	PR/a
Overall PV plant efficiency [η_{tot}]	7.4	9.5	11.8	%
Improvement	100	129	158	%
Cost	16	8	6	US\$/W



The evolution of PV 1991 - 2005

- Monday
The increase of the ø module efficiency in the survey is surprisingly low 11.5% - 13% (without thin-film modules!)
- Tuesday
The ø plant performance annual PR increases 0.64 to 0.74.
- Wednesday
The ø inverter efficiency is improved from 89% to 94%.
- Thursday
The reporting on outages and the type of failure is minimal.
The PV industry should learn from the automobile industry.
Zero Recall can not be achieved!



The evolution of PV 1991 - 2005

- **Friday**

Significant finding is a clear trend towards lower system cost over time from 1991 to 2005 - 50% (best case -63%)!

- **Saturday**

Performance, reliability and cost data of PV systems are most important for a broad PV implementation and dissemination strategy in future.

- **Sunday**

Our products have a reliable and sustainable reputation.

We have to ensure the quality of the components and the systems even in a fast growing PV environment!

Quality and education is the key.

A photograph of a sunflower field. The sunflowers are tall with large, bright yellow petals and dark brown centers. They are growing in rows under a clear blue sky.

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now
Q & A

thank you
for your interest