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# Renewable Energies for Climate Protection

## Focus on photovoltaic solar energy conversion

1. Actual energy supply - Climate Change
2. Development, perspectives, potentials
3. Photovoltaics: basics, market, outlook

**Prof. Dr.-Ing. habil. Stefan Krauter**

**Photovoltaik Insitut Berlin AG**
**University of Applied Sciences Biberach**

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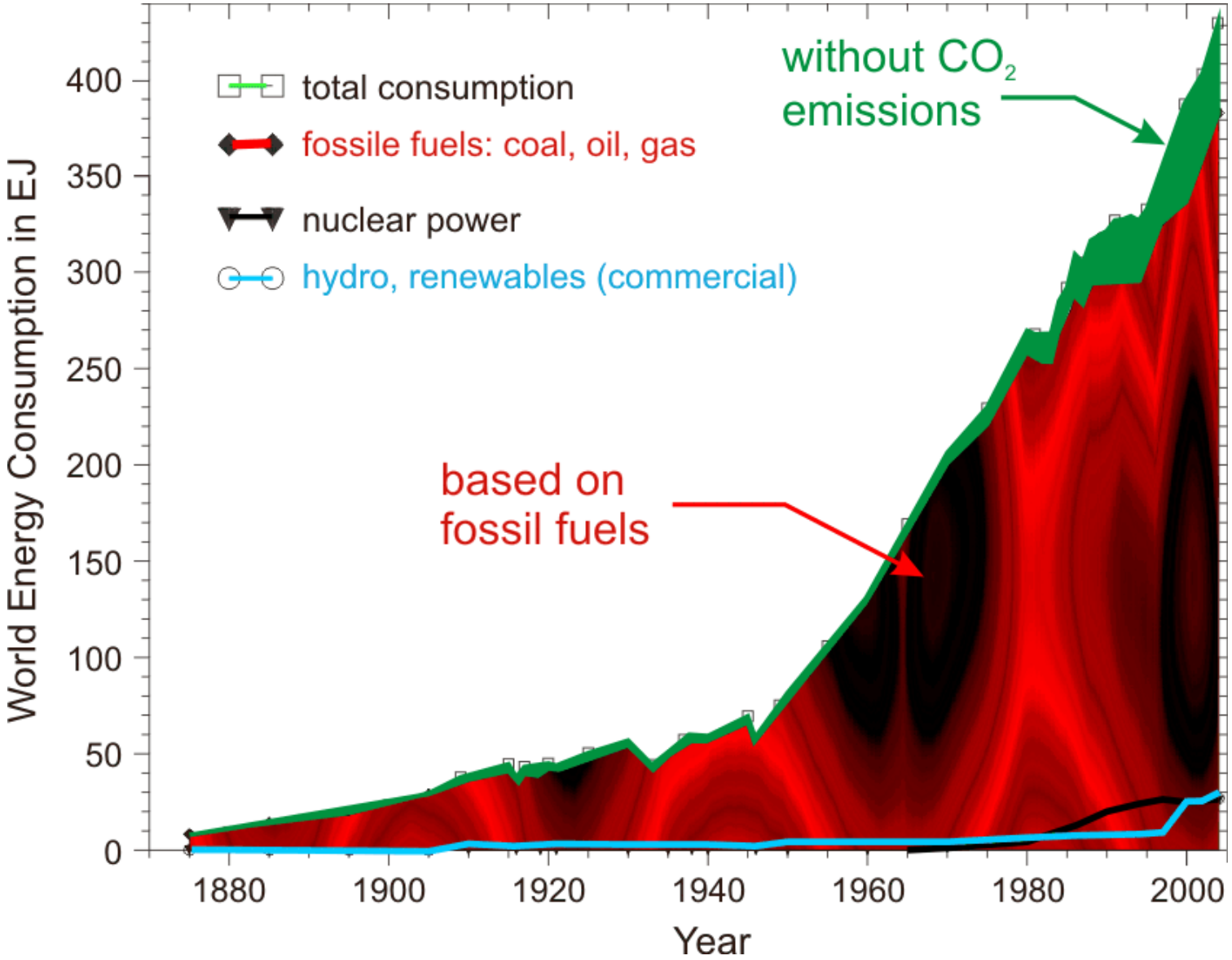
# Development of World's Energy Supply



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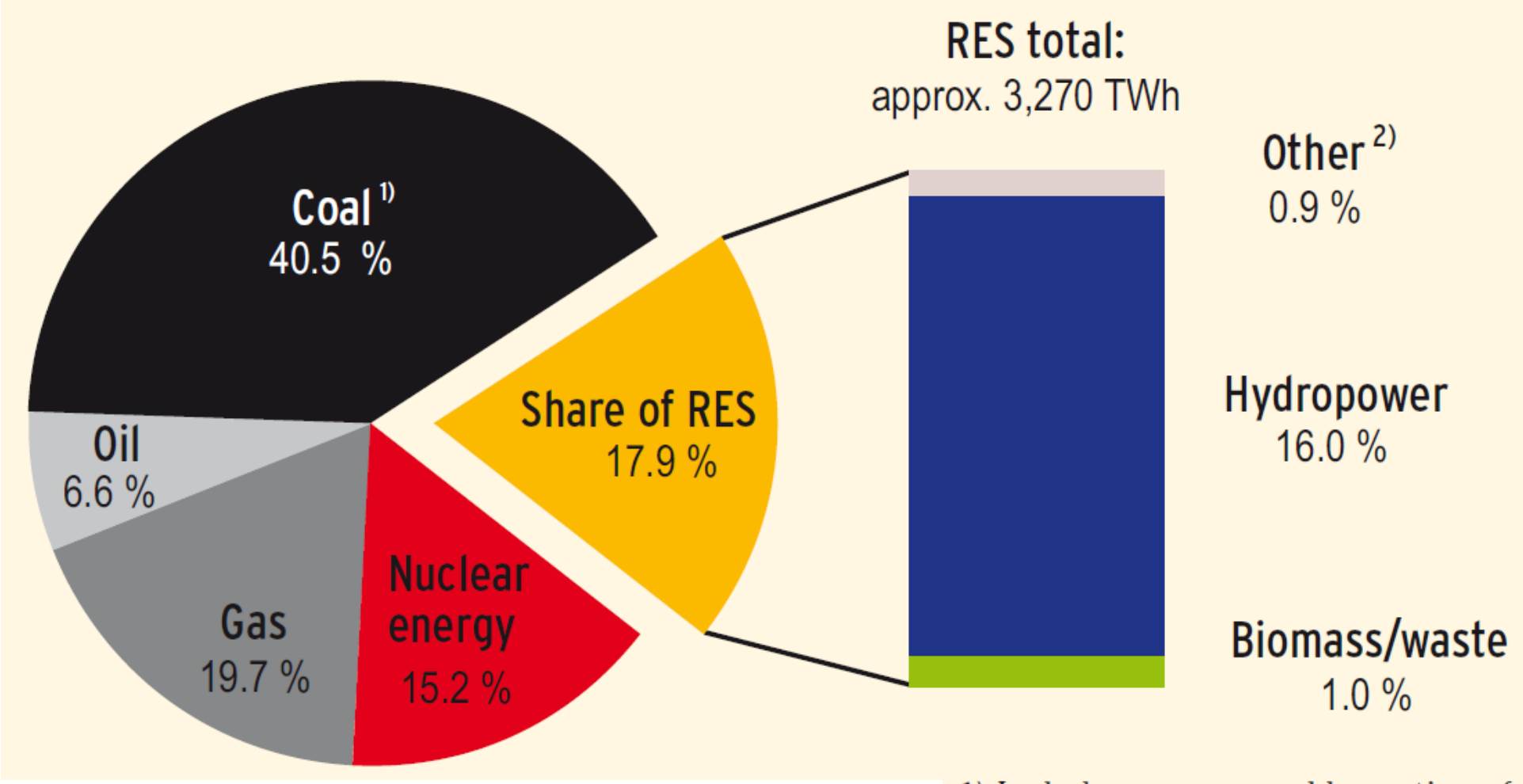
# World‘s electricity supply




Source: BMU publication „Renewable energy sources in figures - national and international development“, Status: June 2008

1) Includes non-renewable portion of waste (0.2 %)
2) Geothermal energy, solar energy, wind energy, marine energy

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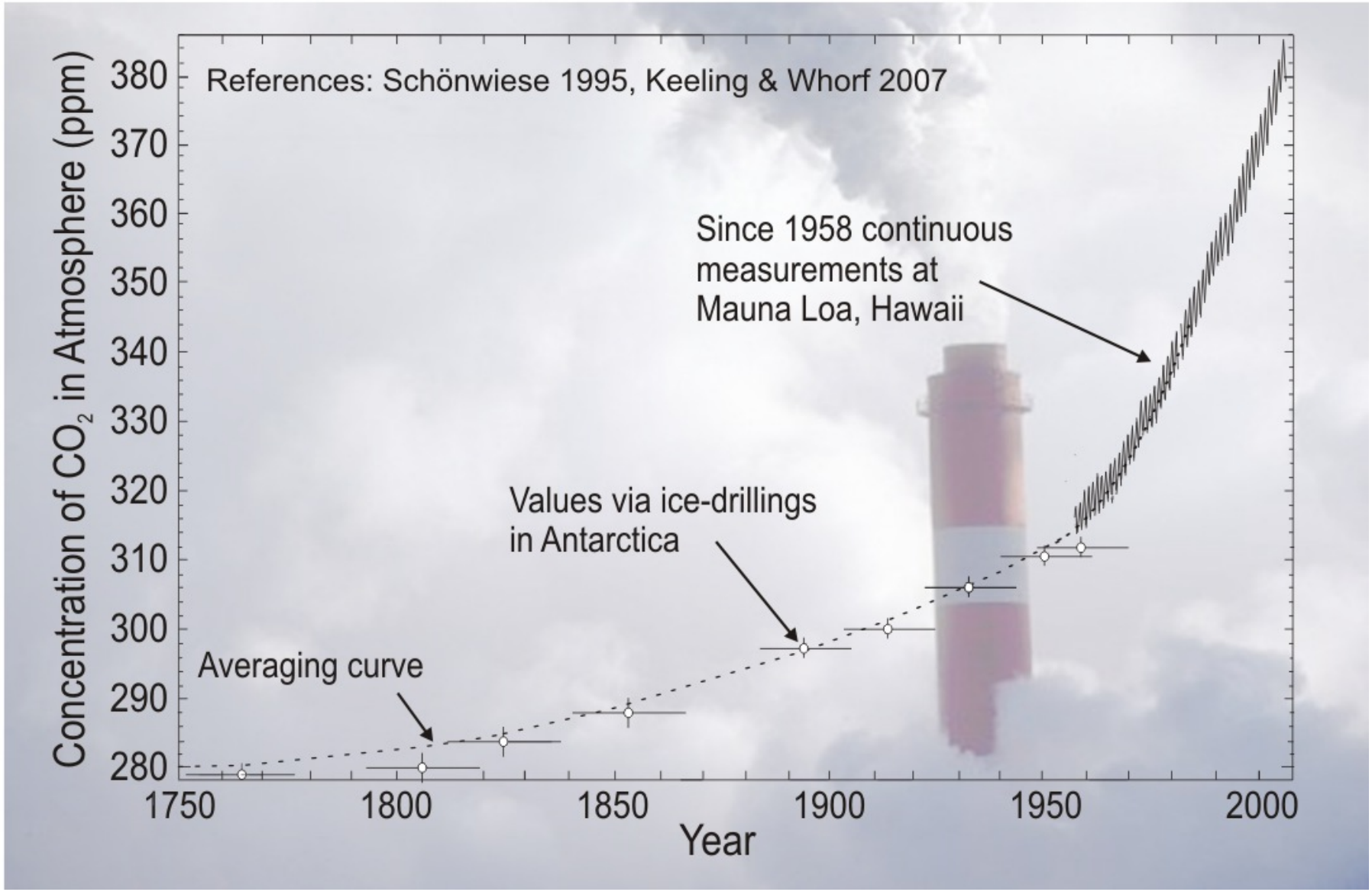
# Development of Earth‘s atmosphere $CO_2$-contents



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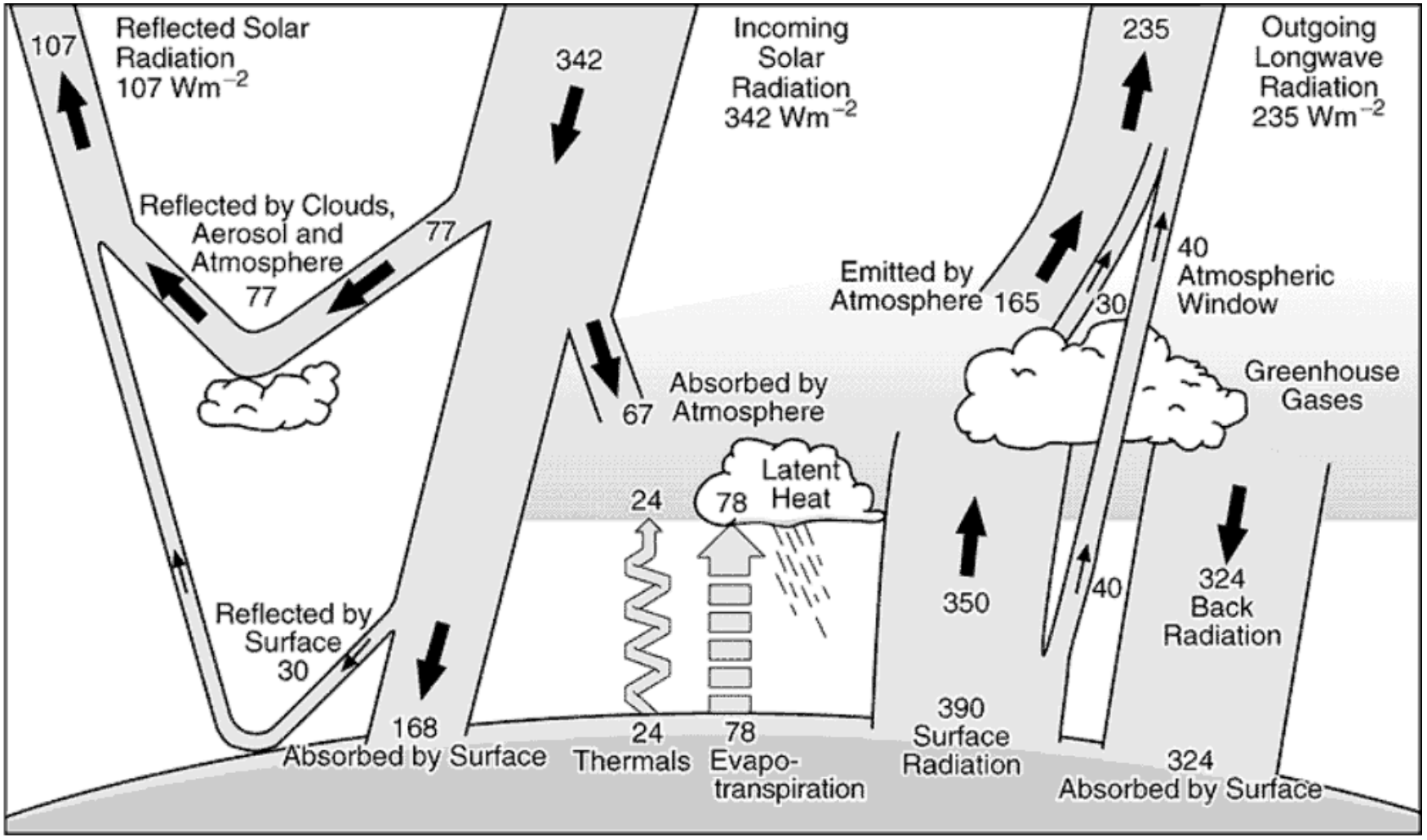
# Earth‘s Radiation Balance




Source: Kiehl and Trenberth, 1997:
Earth’s Annual Global Mean Energy Budget, Bull. Am. Met. Soc. 78, 197-208.

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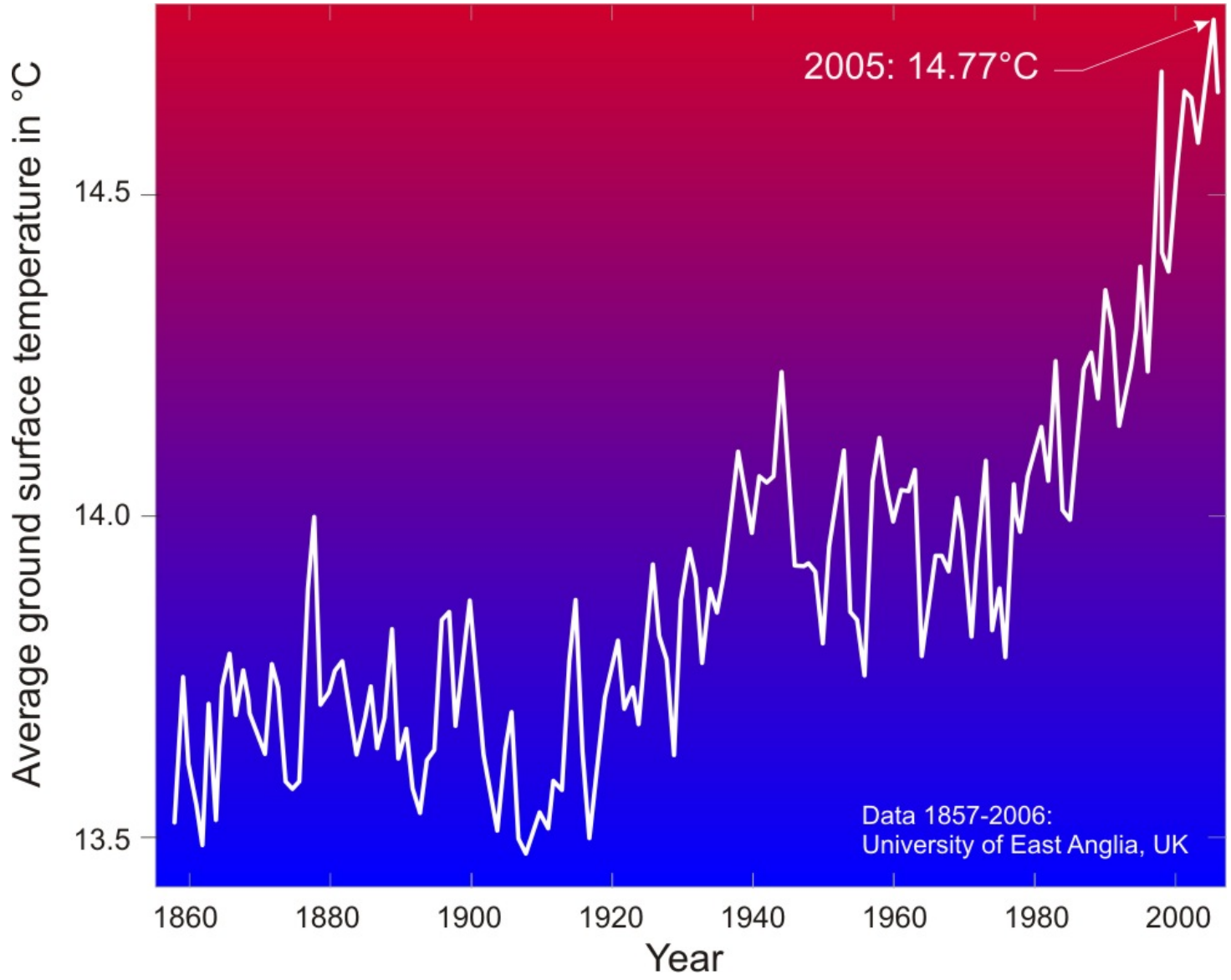
# Development of global ground surface temperature



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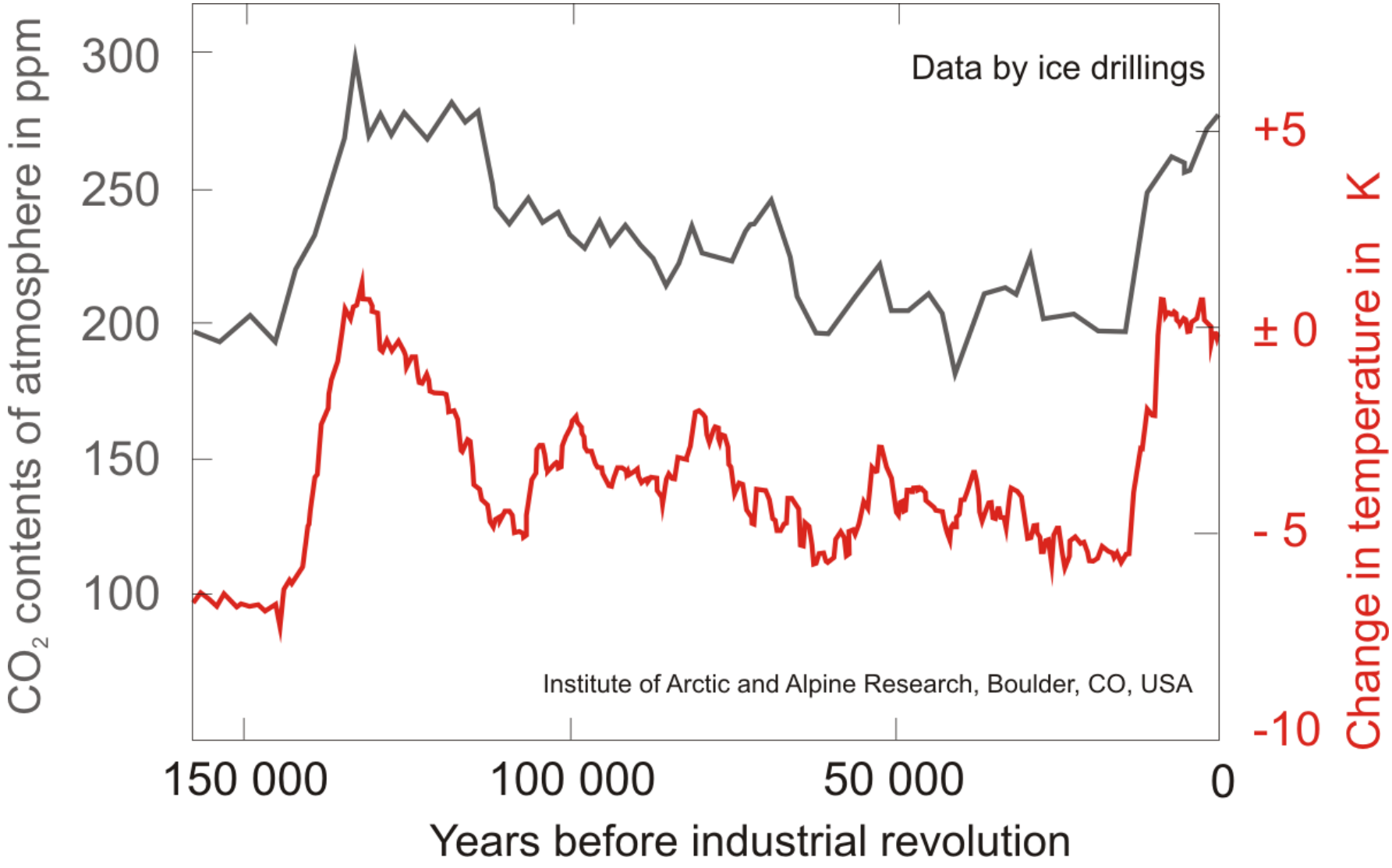
# $CO_2$ contents in Earth's atmosphere and global temperature



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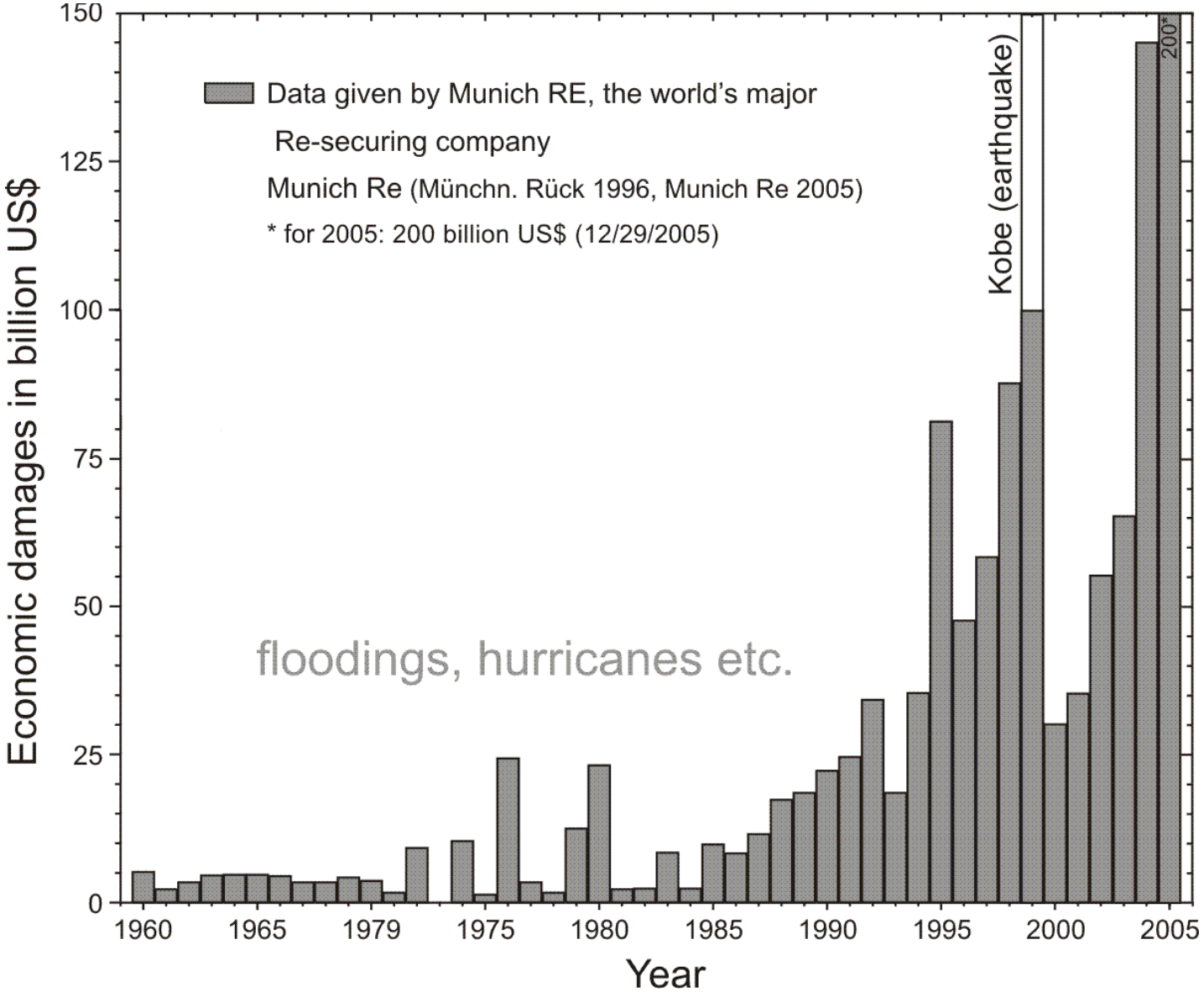
# Economic damages caused by natural catastrophes



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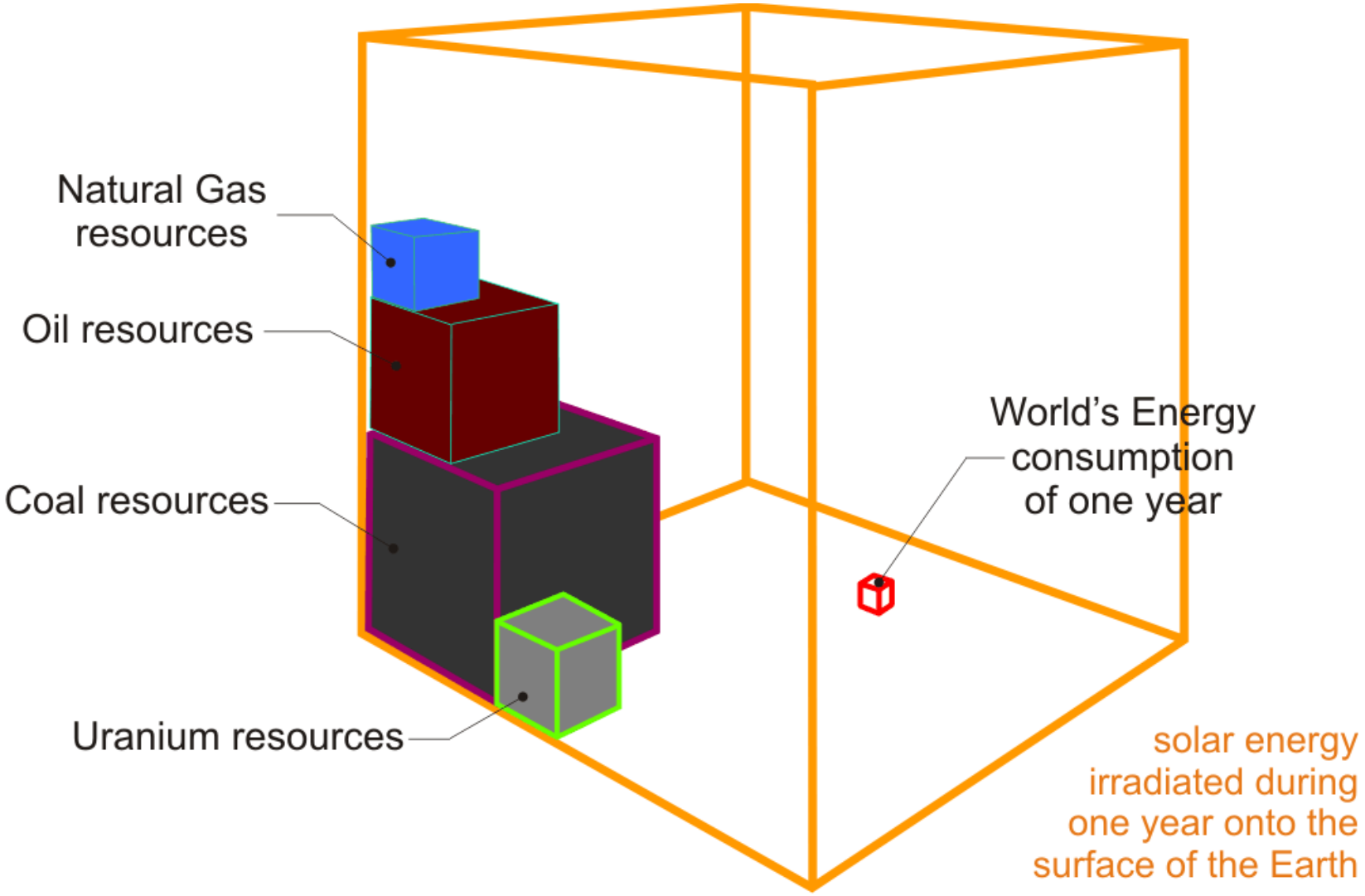
# Consumption, resources and potentials of Energy



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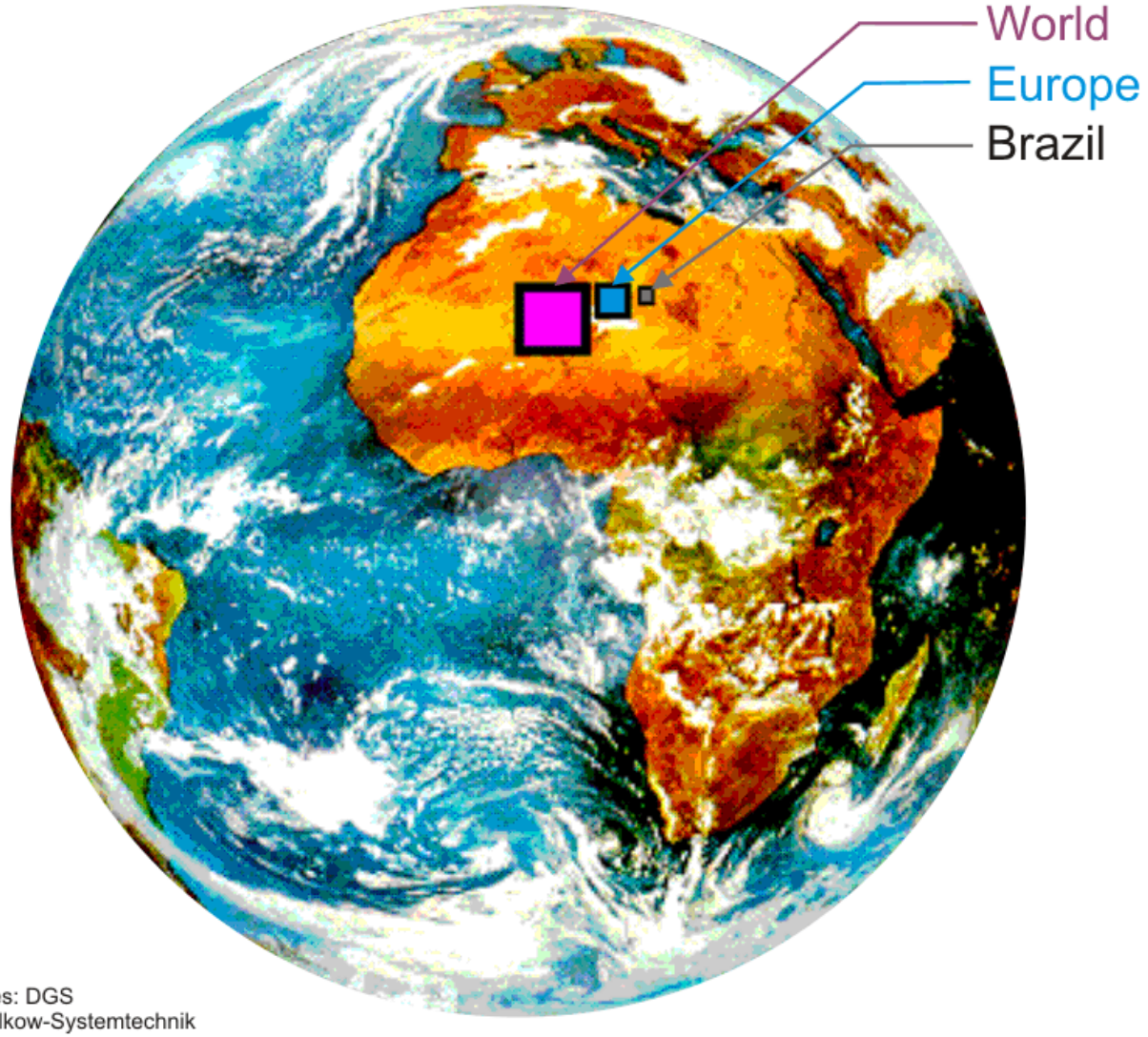
# Area necessary for energy supply via photovoltaics




References: DGS
Lutwig-Bölkow-Systemtechnik

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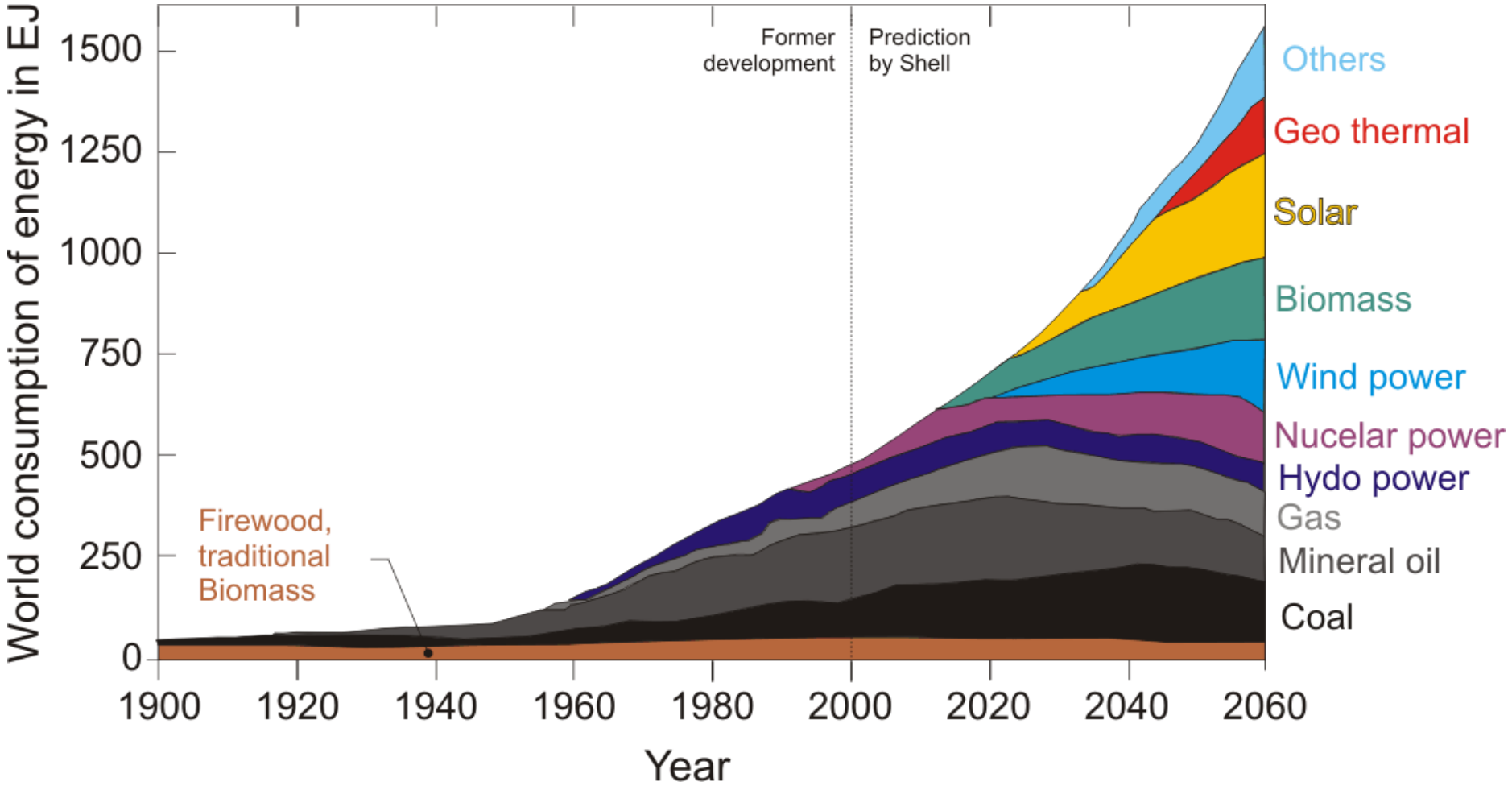
# Energy carriers: Present development and forecast



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# Solar power conversion in 1900

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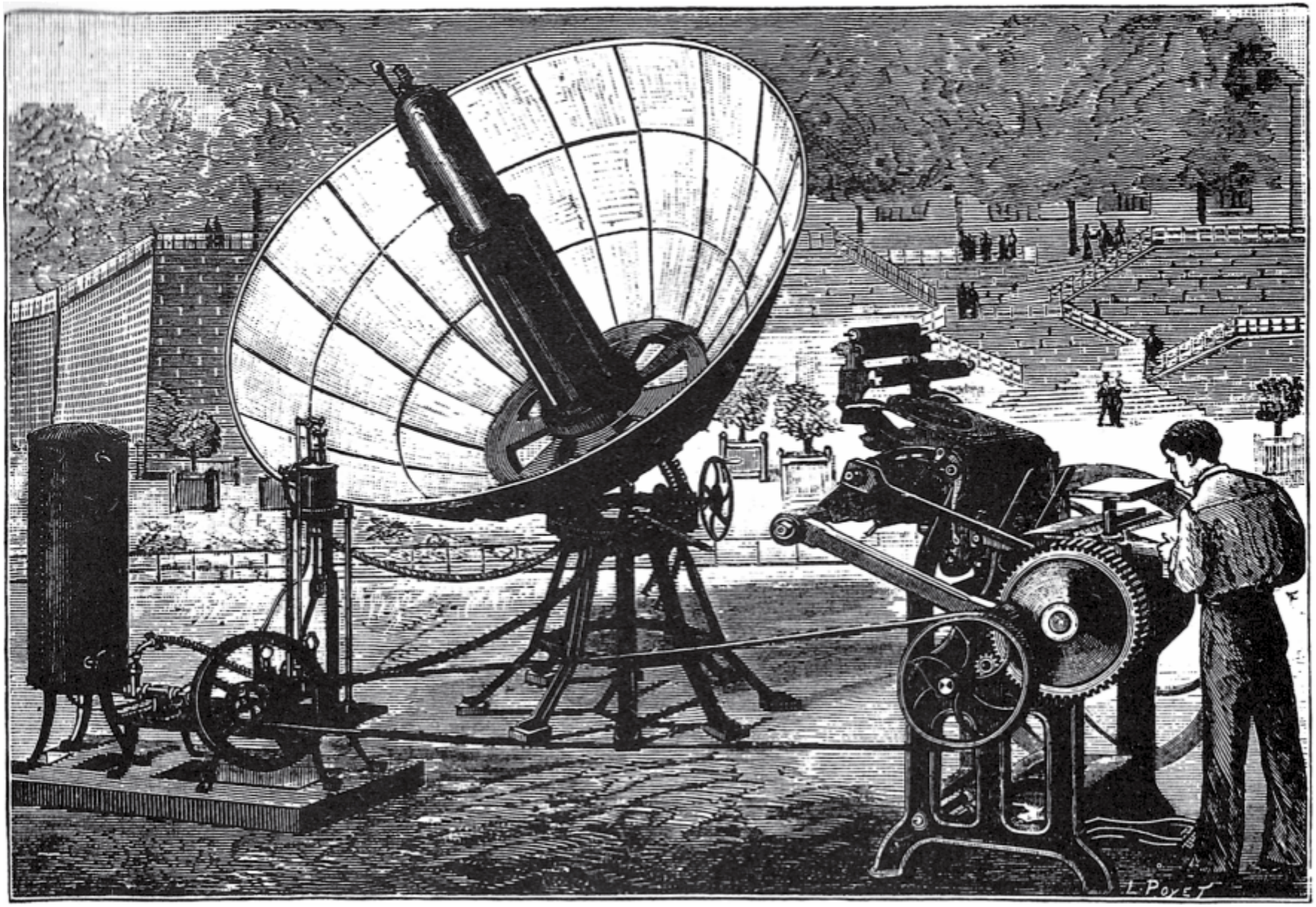

# 2 $MW_p$ PV generator integrated in the airport of Munich 2000

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# PV panels of a solar village in Japan

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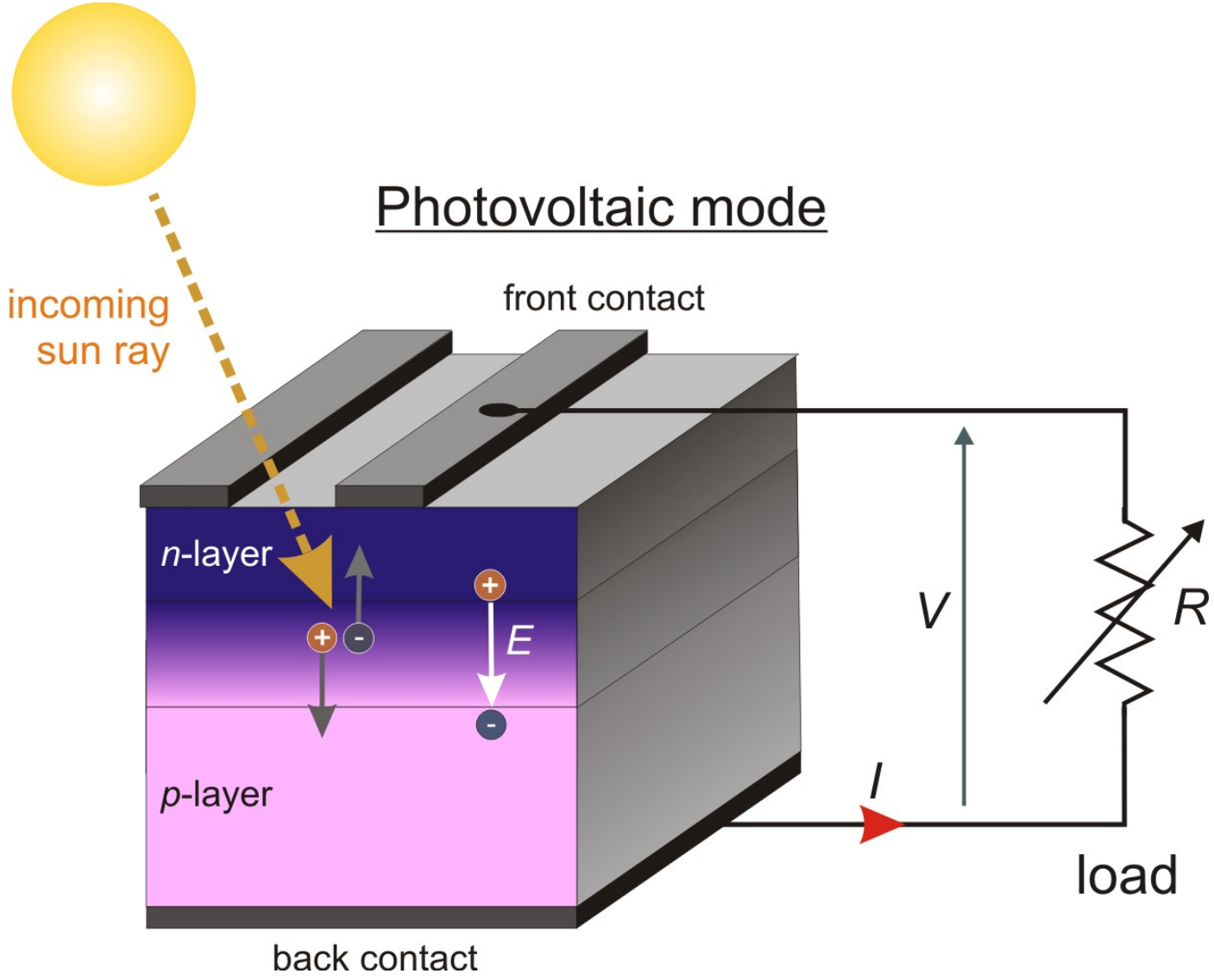
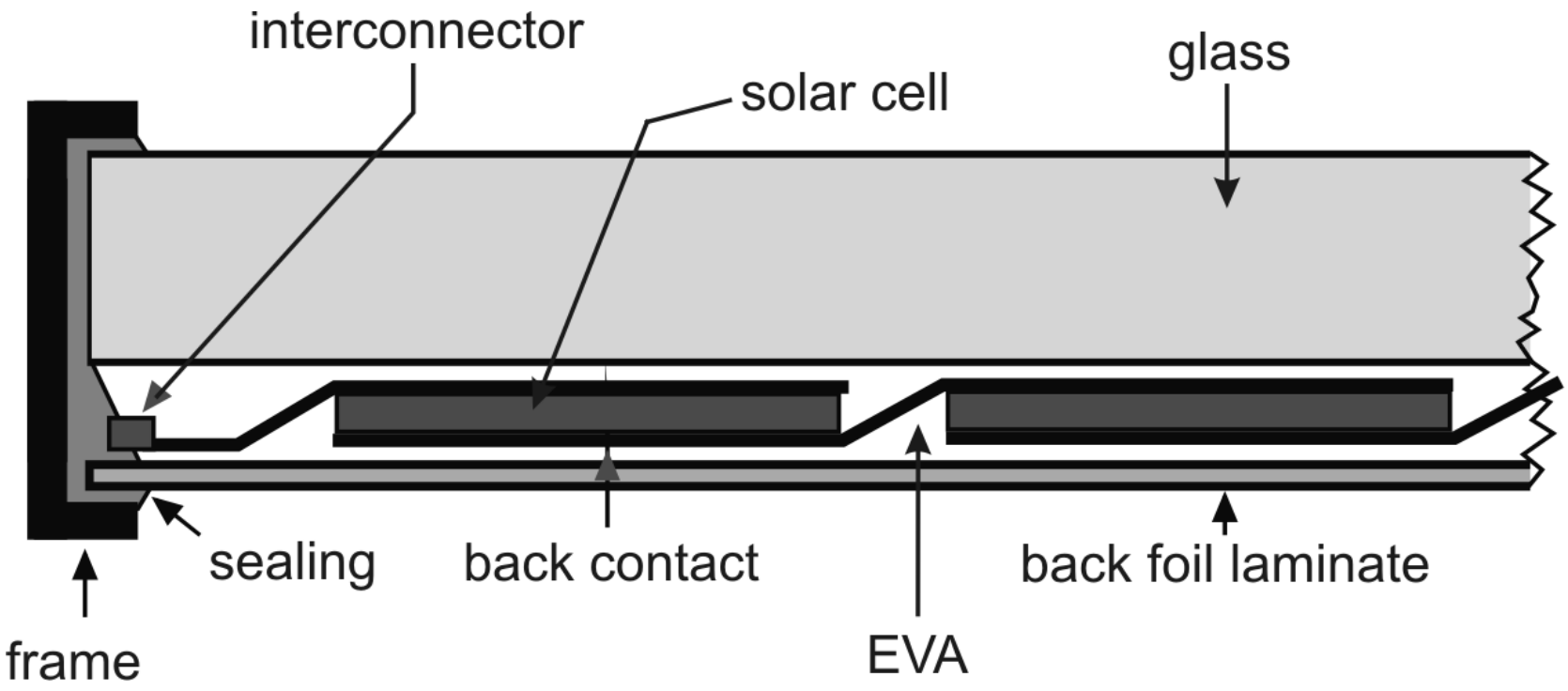
© Hakushin Corporation

# Scheme of photovoltaic solar energy conversion



# Cross section of a laminated PV module based on crystalline cells



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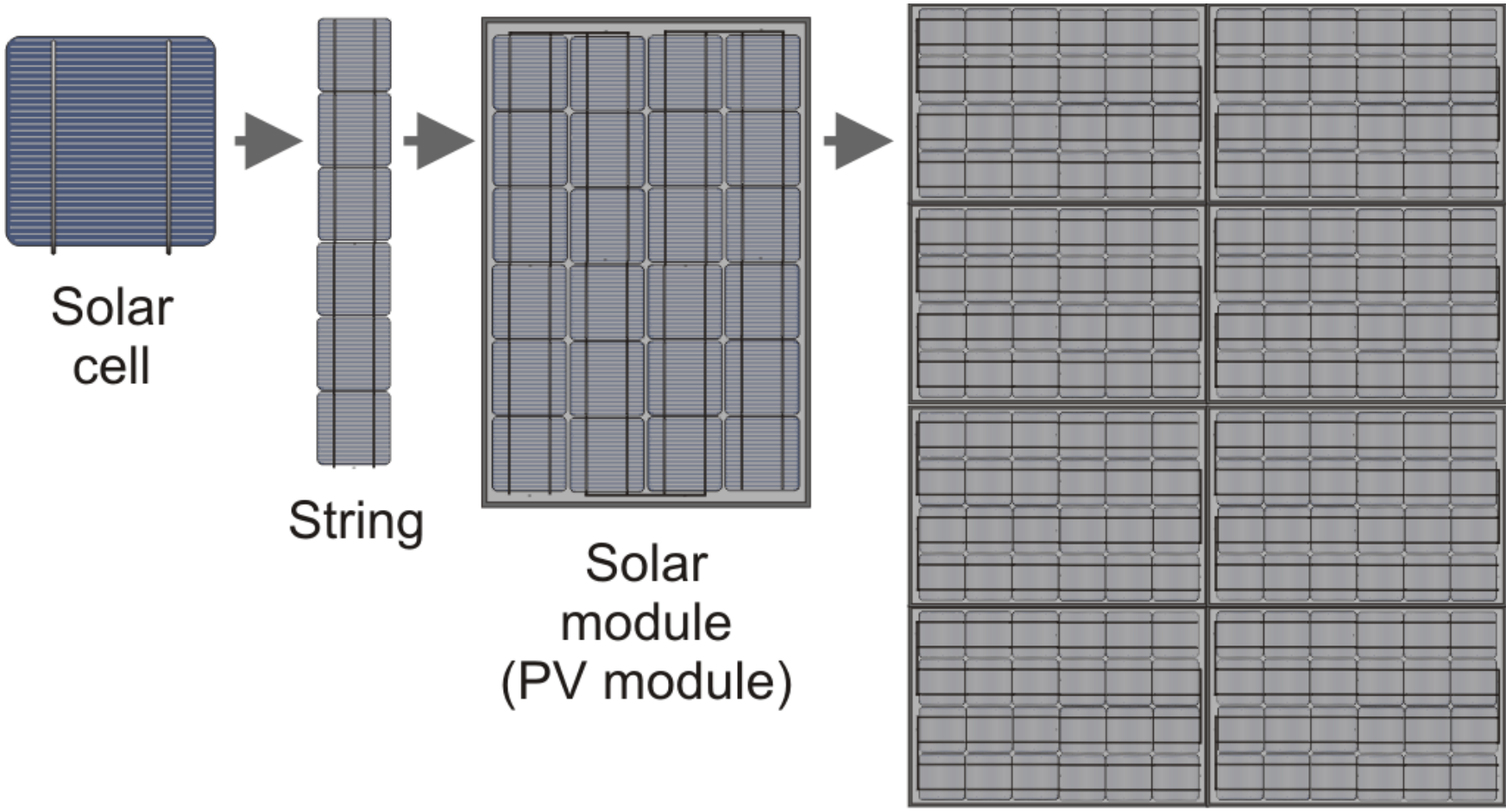
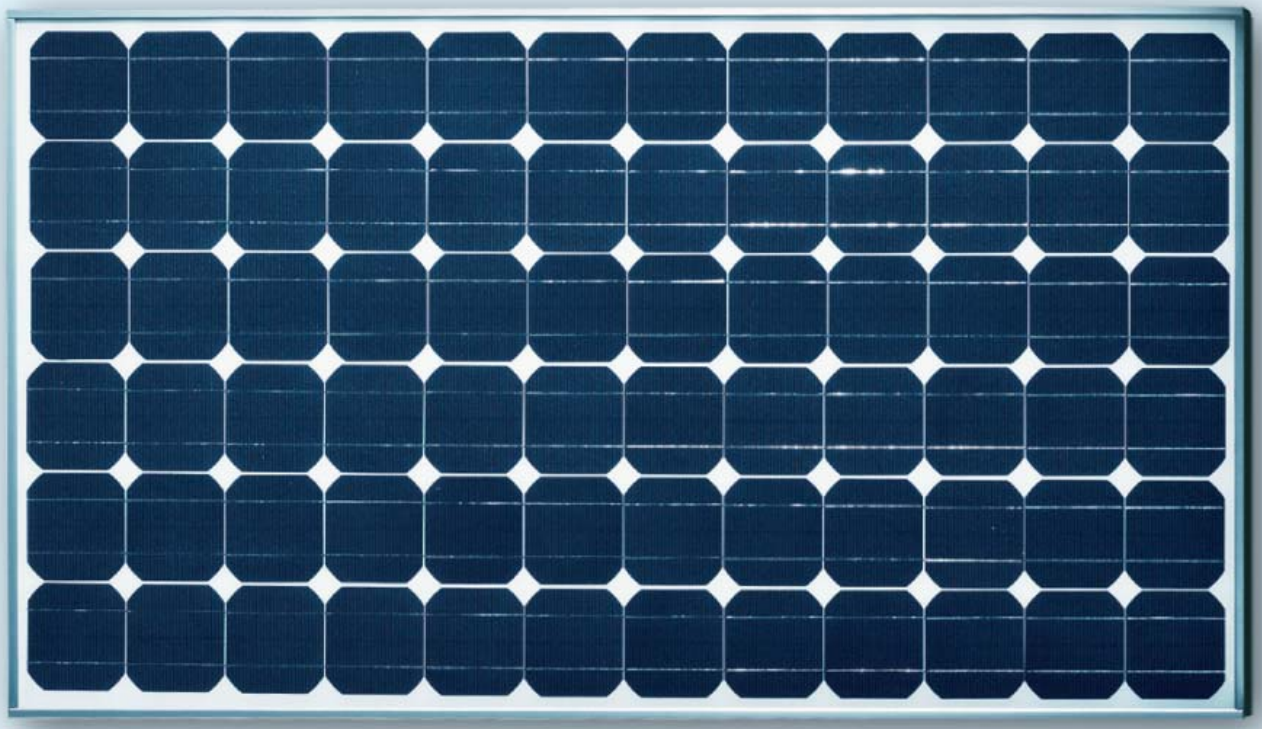
# From solar cell to PV generator



# Single crystalline PV module (sc-Si)



# Multi-crystalline PV modules (mc-Si)

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# Flexible multi-junction thin film module

© United Solar Ovonic

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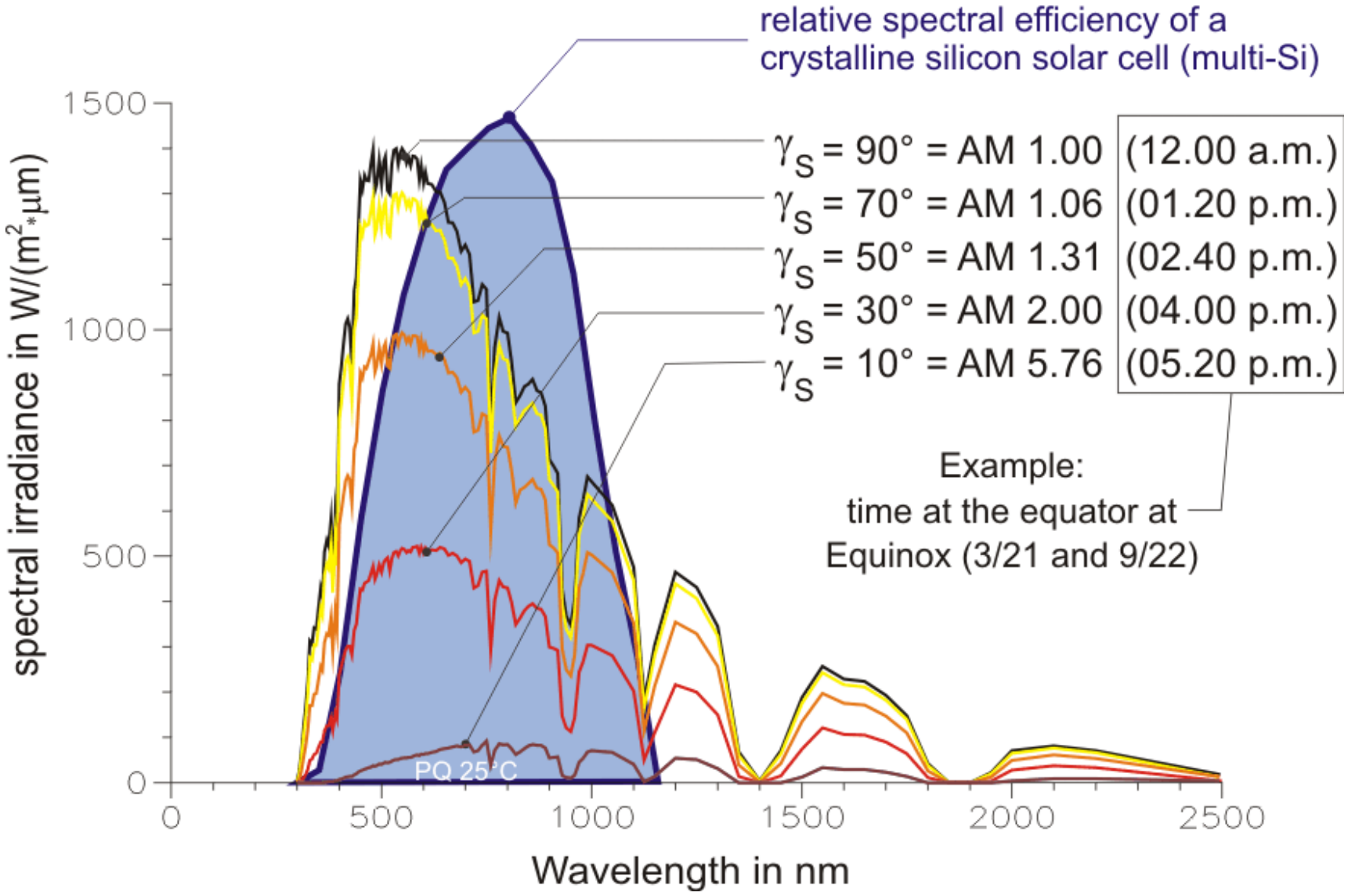
# Matching of spectral conversion efficiency with sun's spectra



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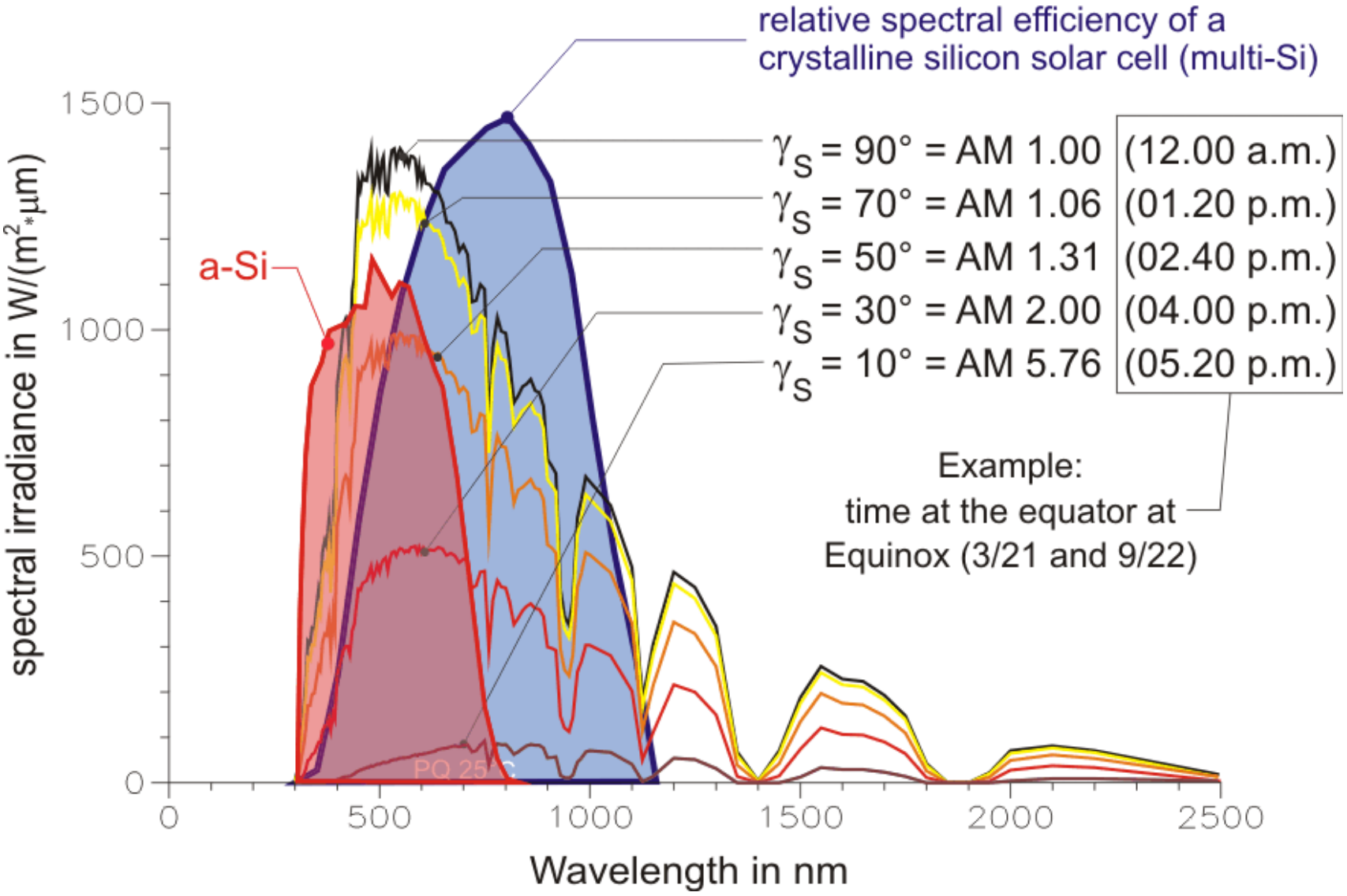
# Matching of spectral conversion efficiency with sun's spectra



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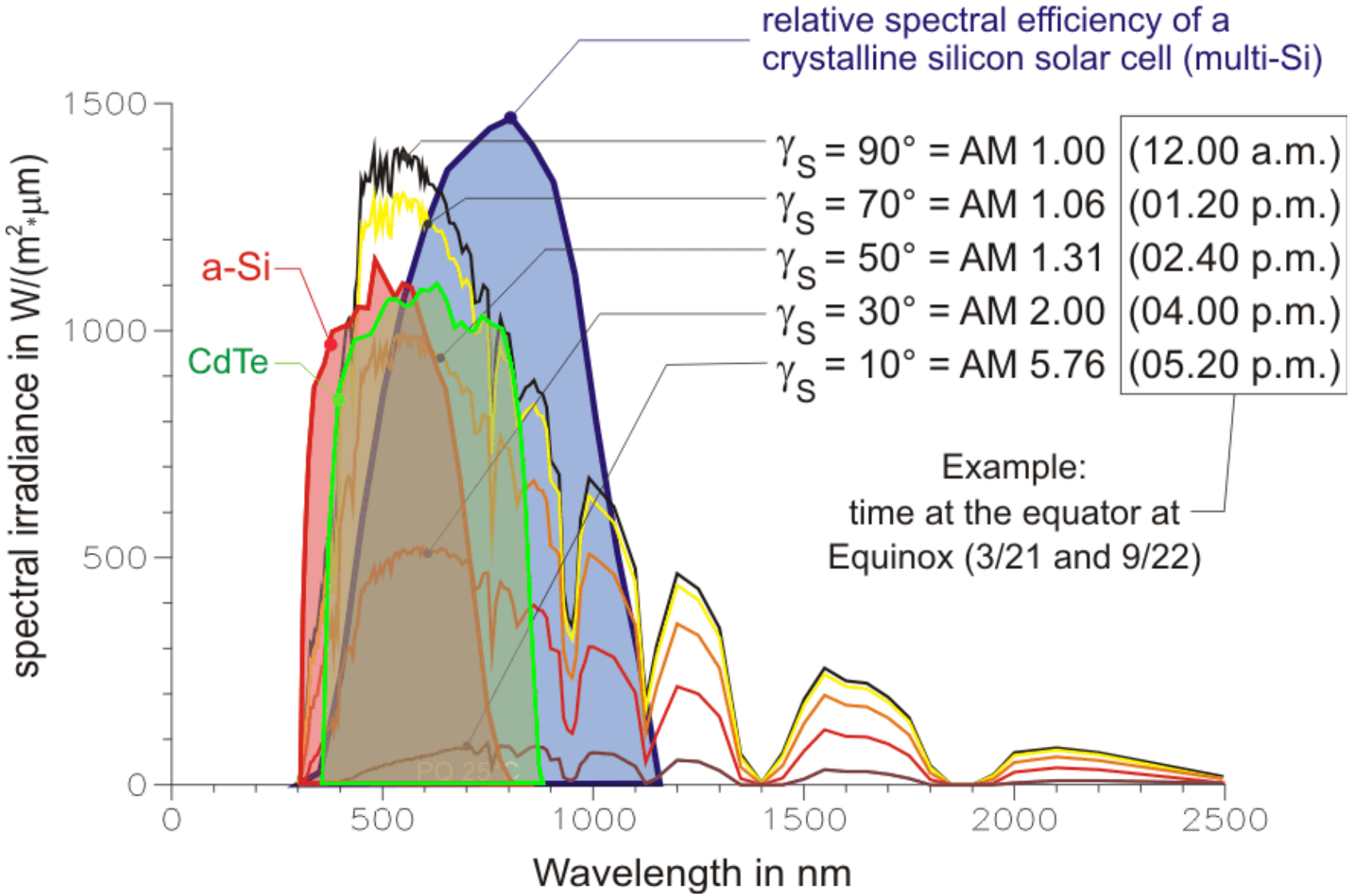
# Matching of spectral conversion efficiency with sun's spectra



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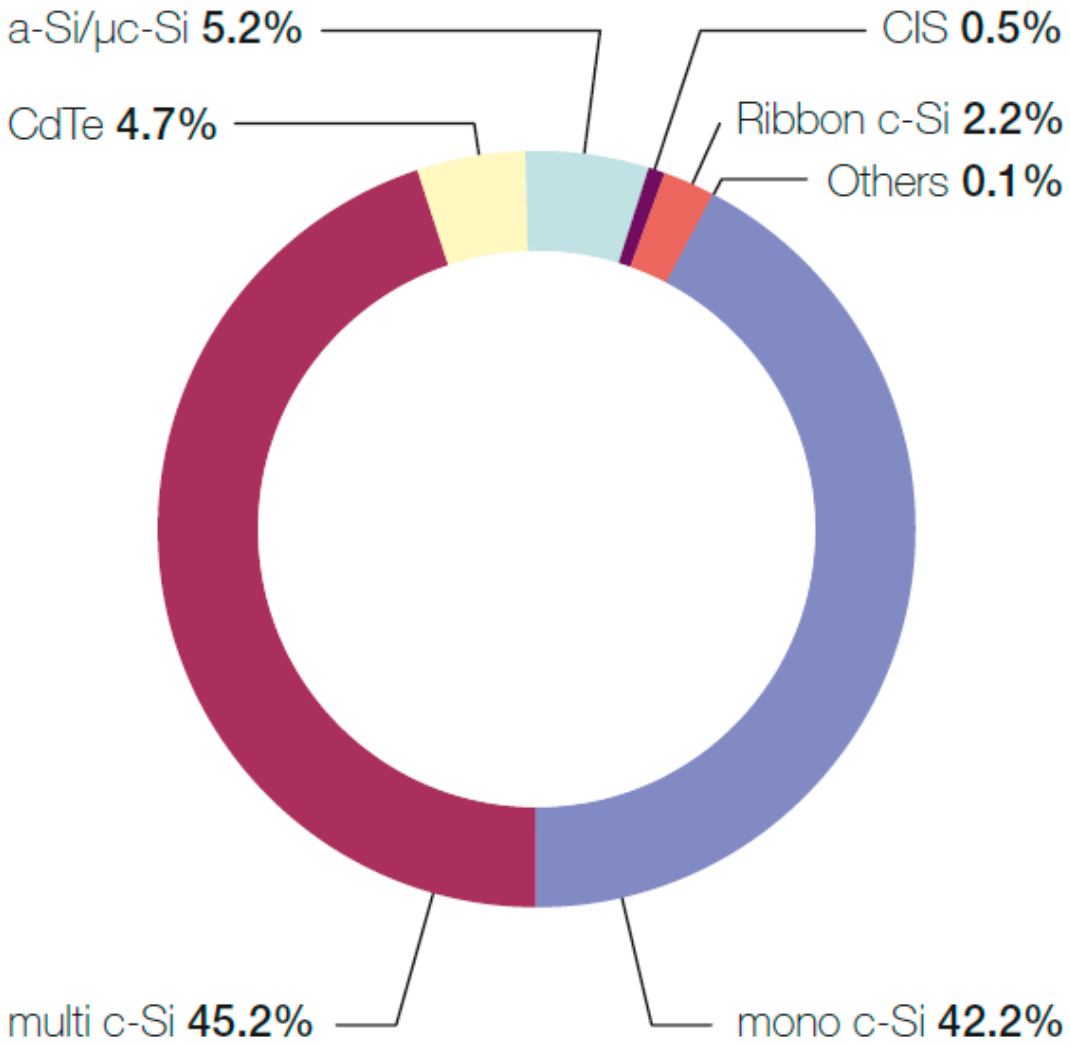
# PV technology share worldwide




Source: Photon International, March 2008

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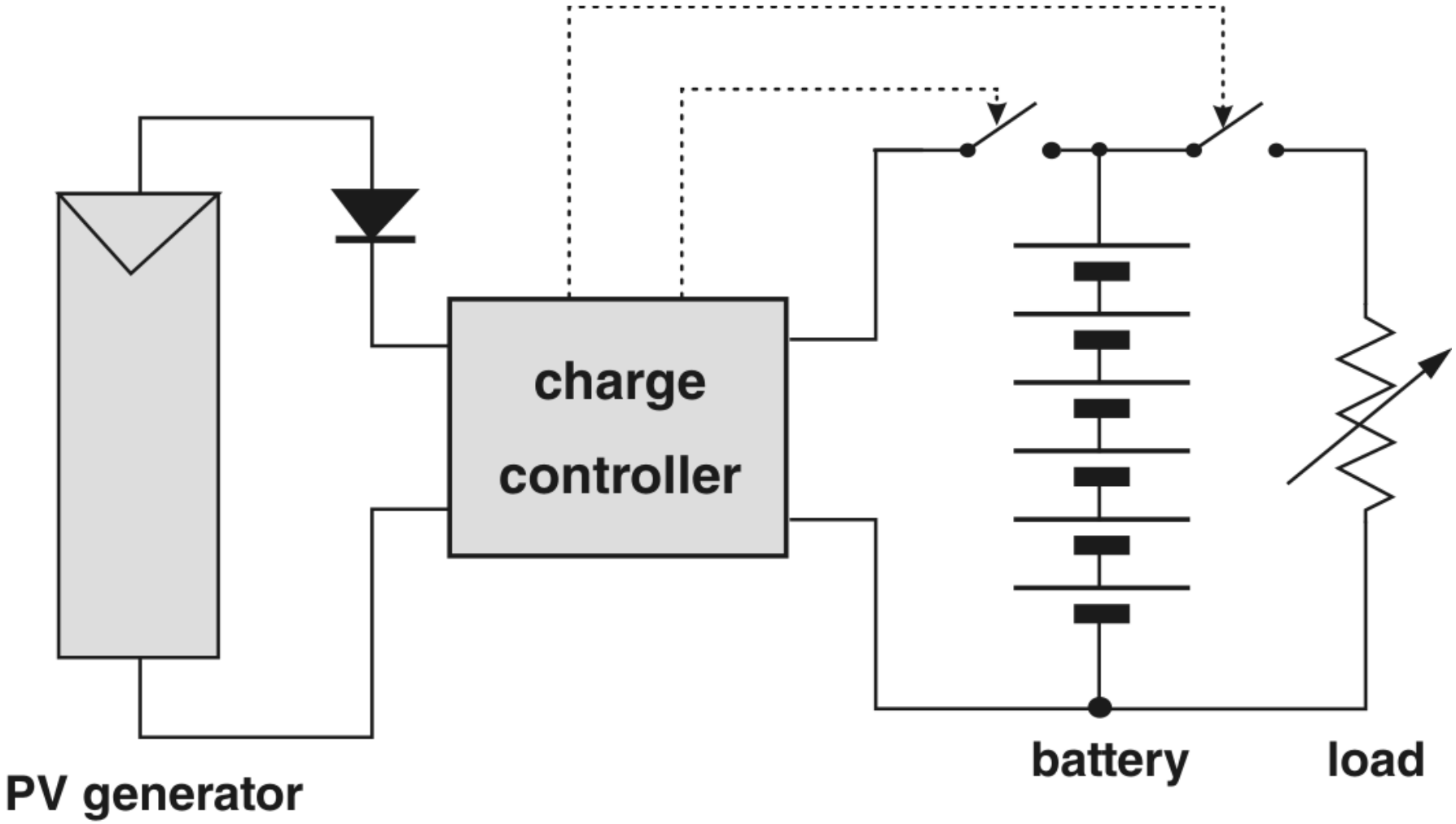
# Scheme of a typical PV off-grid system



2 x 2,5 kW FV, Baleia, Ceará

| | | |
|---|---|---|
| Stefan Krauter | Sistema fotovoltaico autônomo para uma fábrica de gelo | WCRE UECE |

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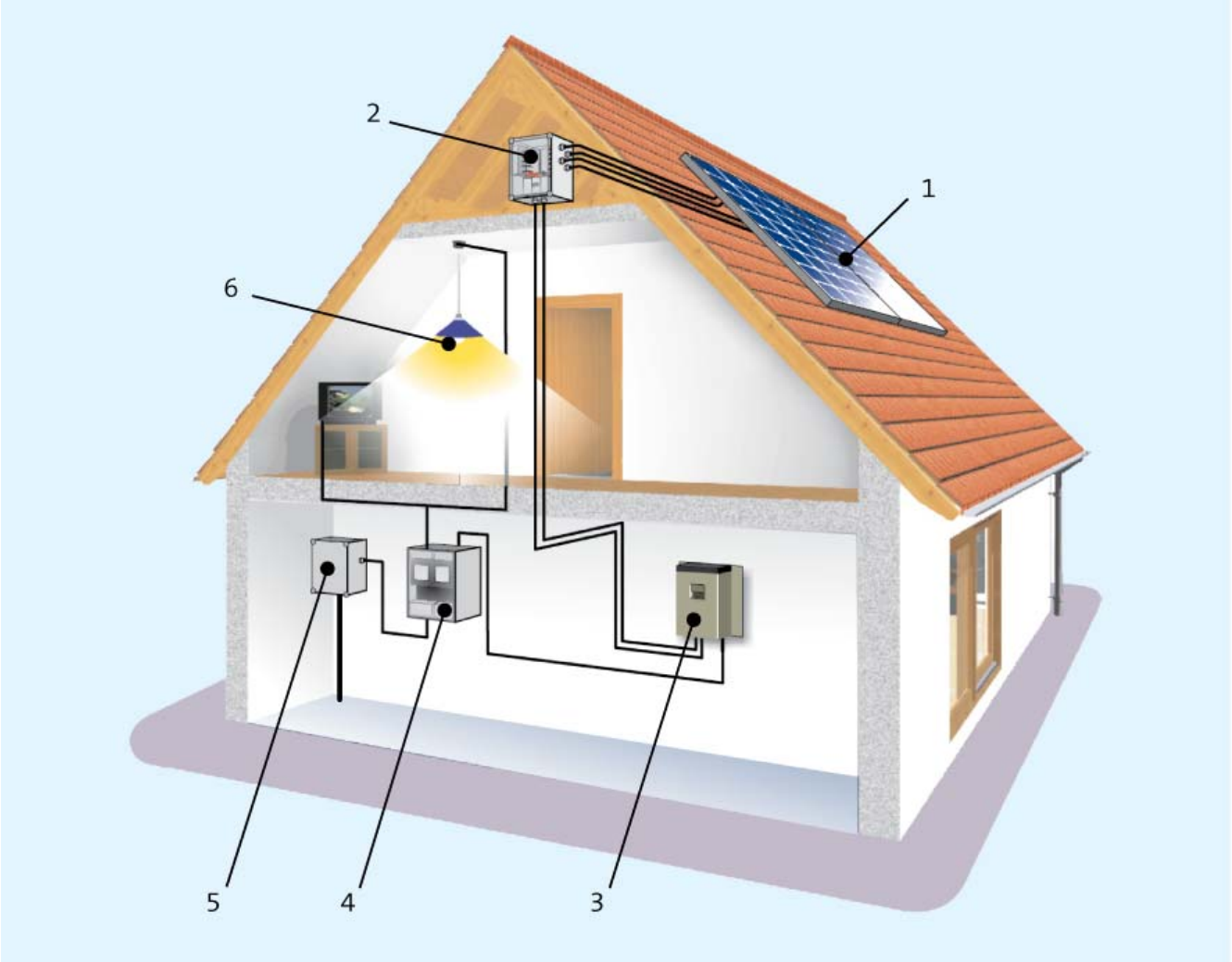
# Off-grid systems: Inverter and charge controller

© SMA

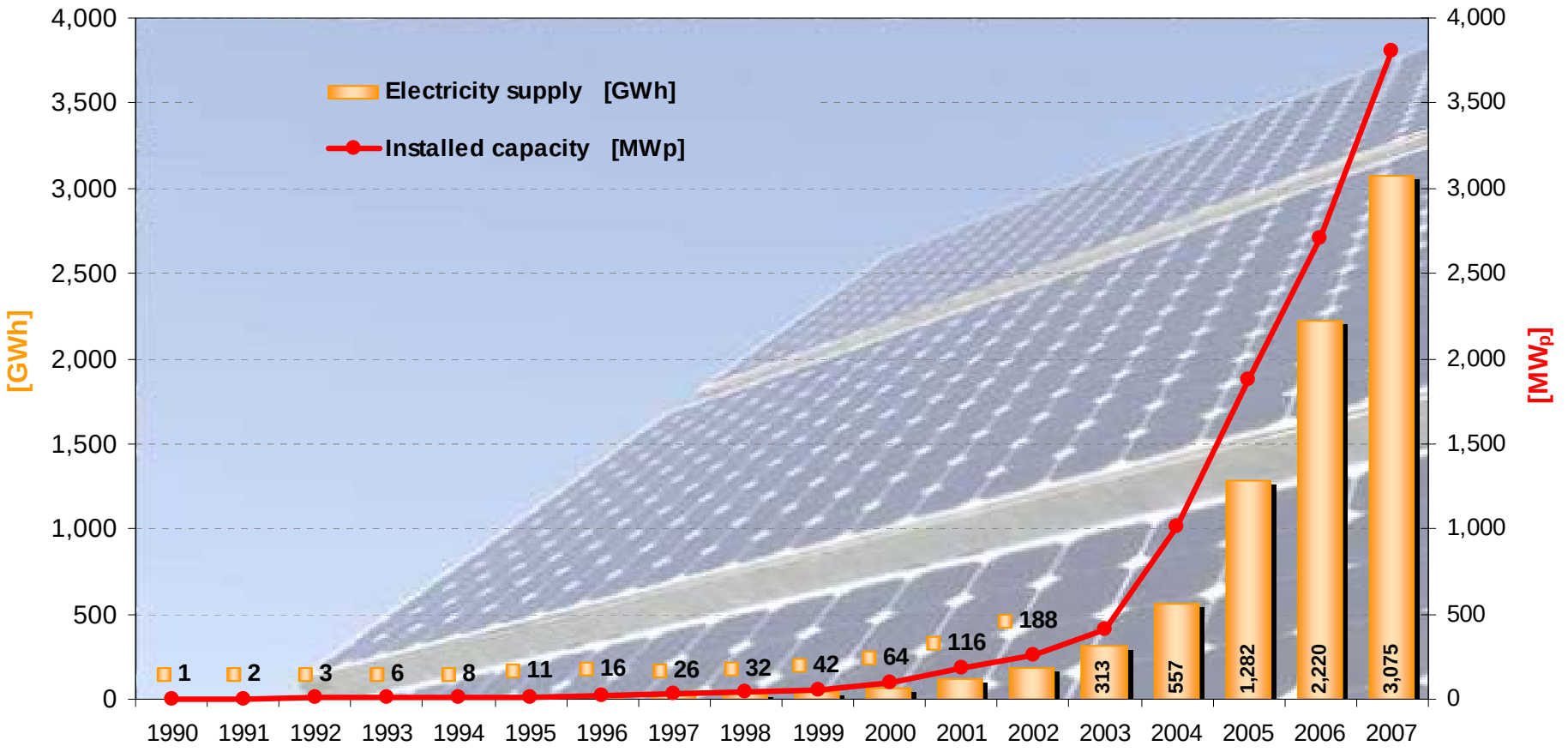

© Steca

# Grid-connected PV system („PV grid injection“)




**1 PV generator, 2 junction box, 3 Inverter, 4 kWh counter for electricity consumption and PV injection, 5 grid connection, 6 loads**

# Development of PV in Germany




Source: BMU-Brochure: "Renew able energy sources in figures – national and international development", Internet Update, KI III 1; Version: 15.12.2008; provisional figures

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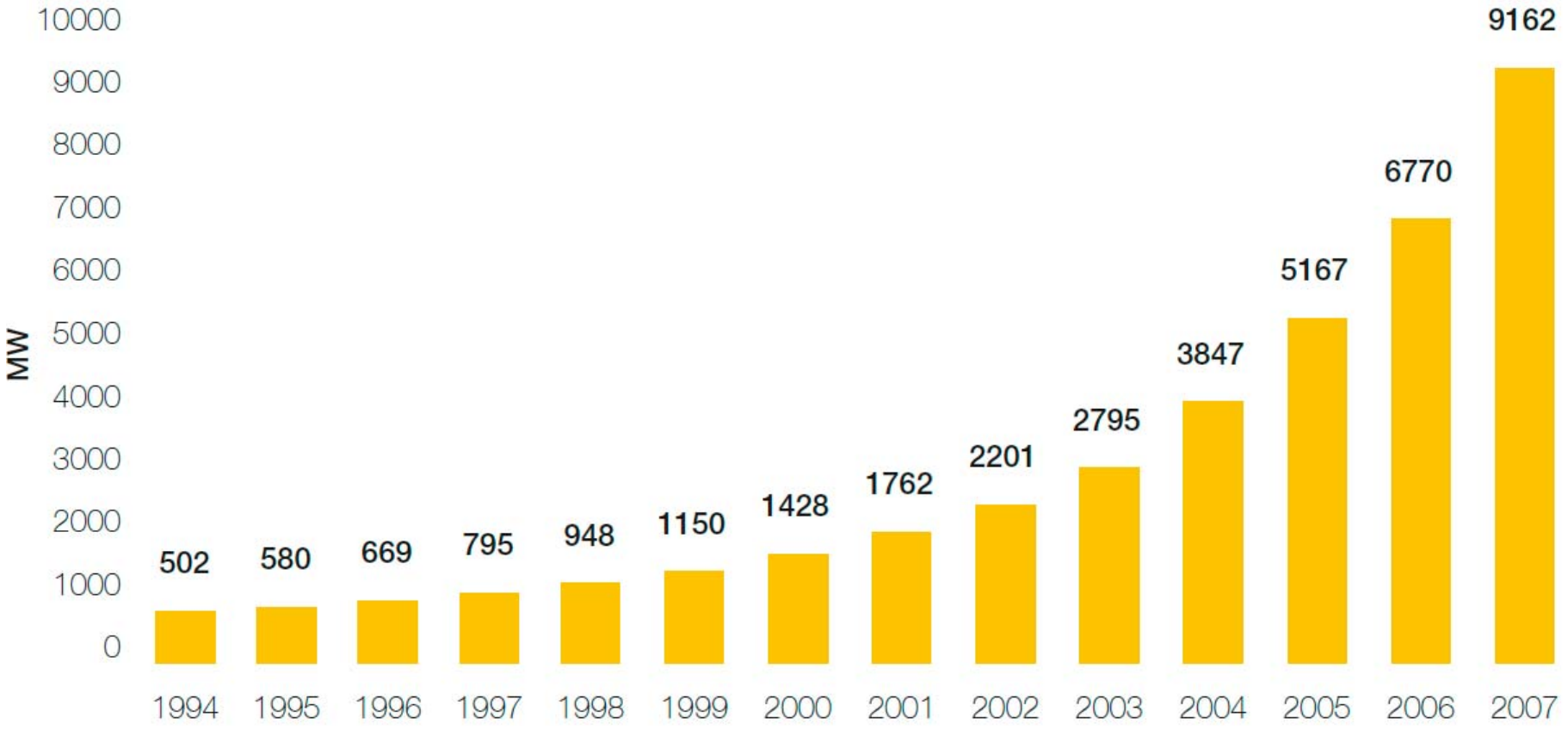
# Cumulative PV installation in MW worldwide



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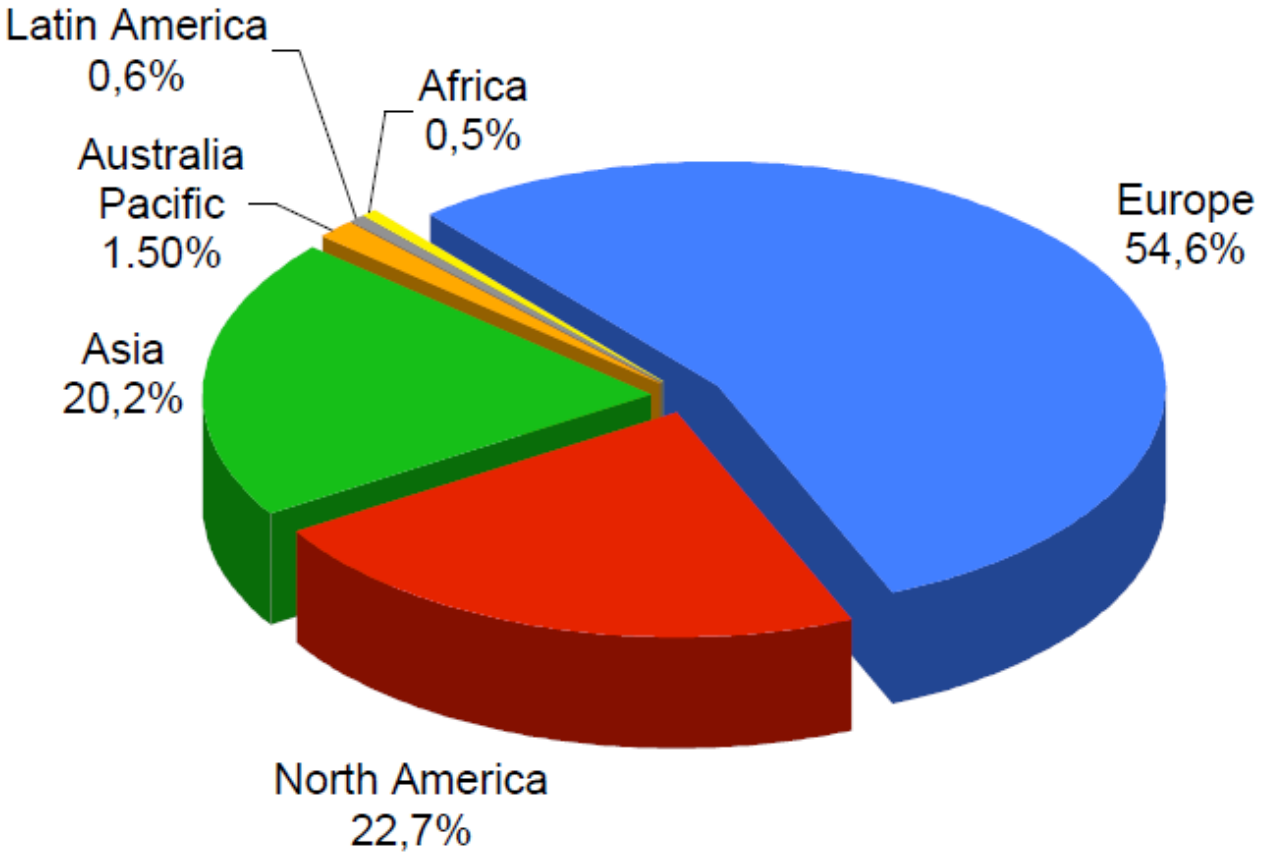
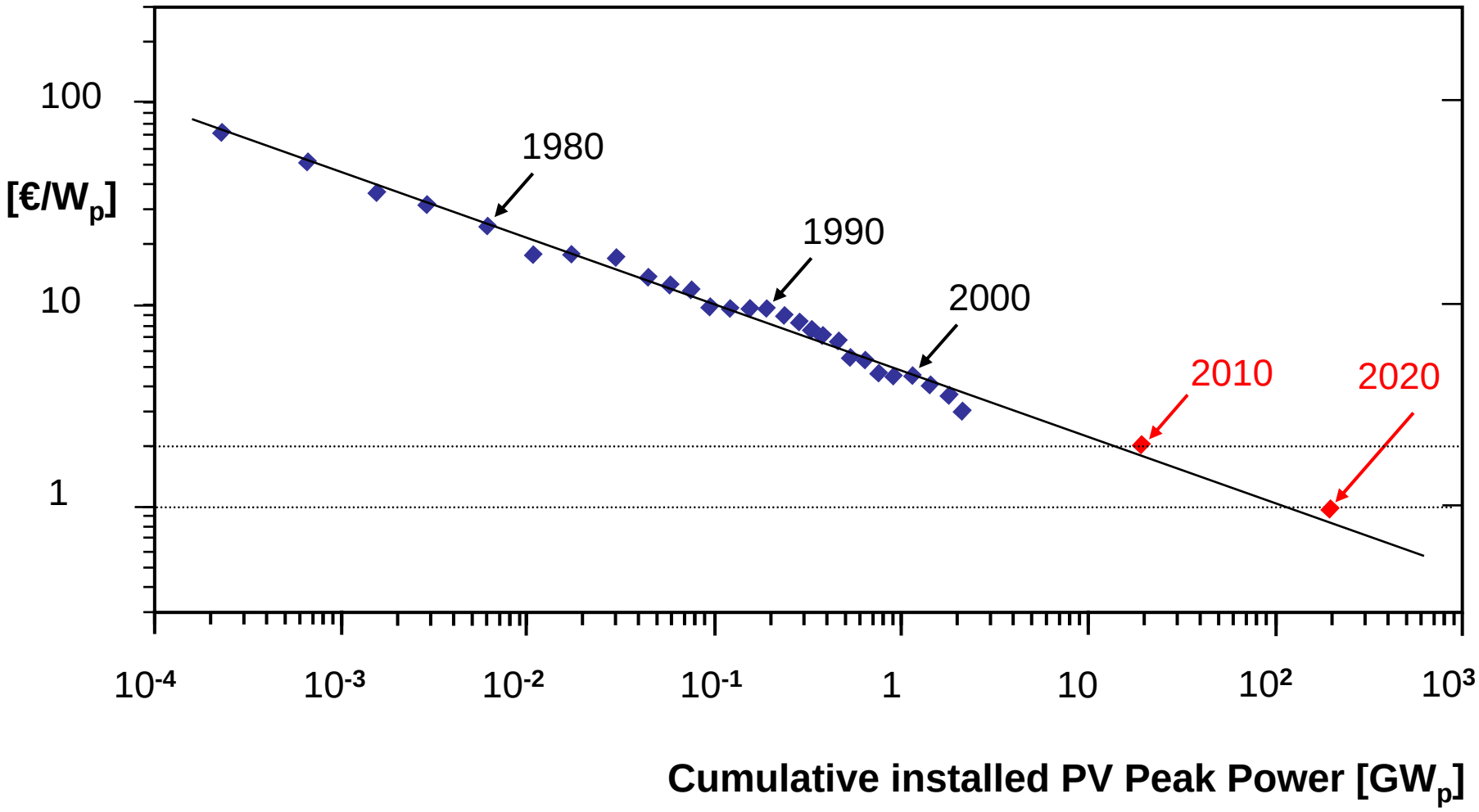
## Continental Shares of Total Installed Capacity 2008

# For comparison: Wind Power




World Wind Energy Association WWEA
Date of publication: February 2009

# „Learning curve“ of PV (for crystalline Si-wafer based PV)



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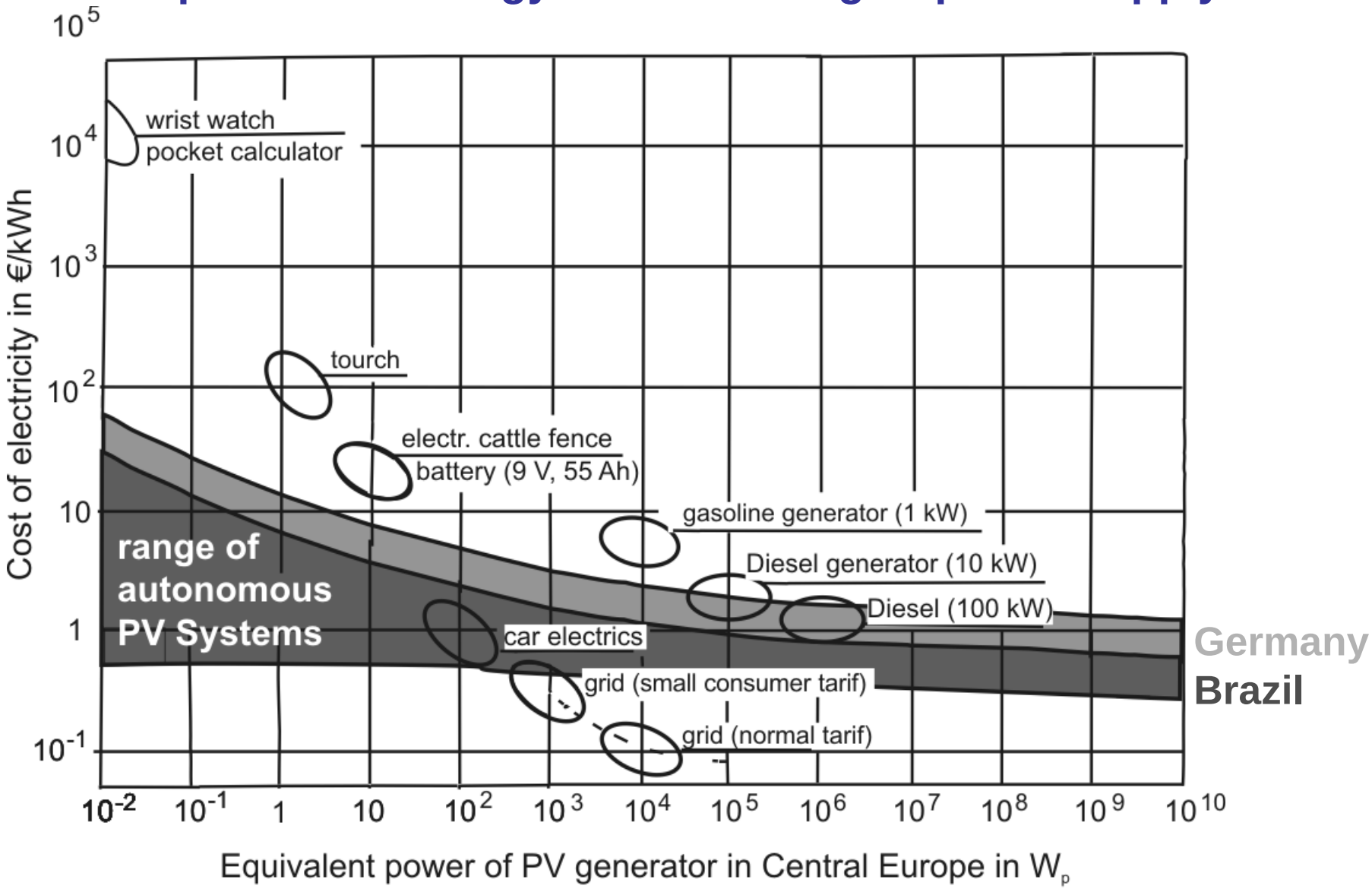
# Comparison of energy costs for off-grid power supply




Germany
Brazil

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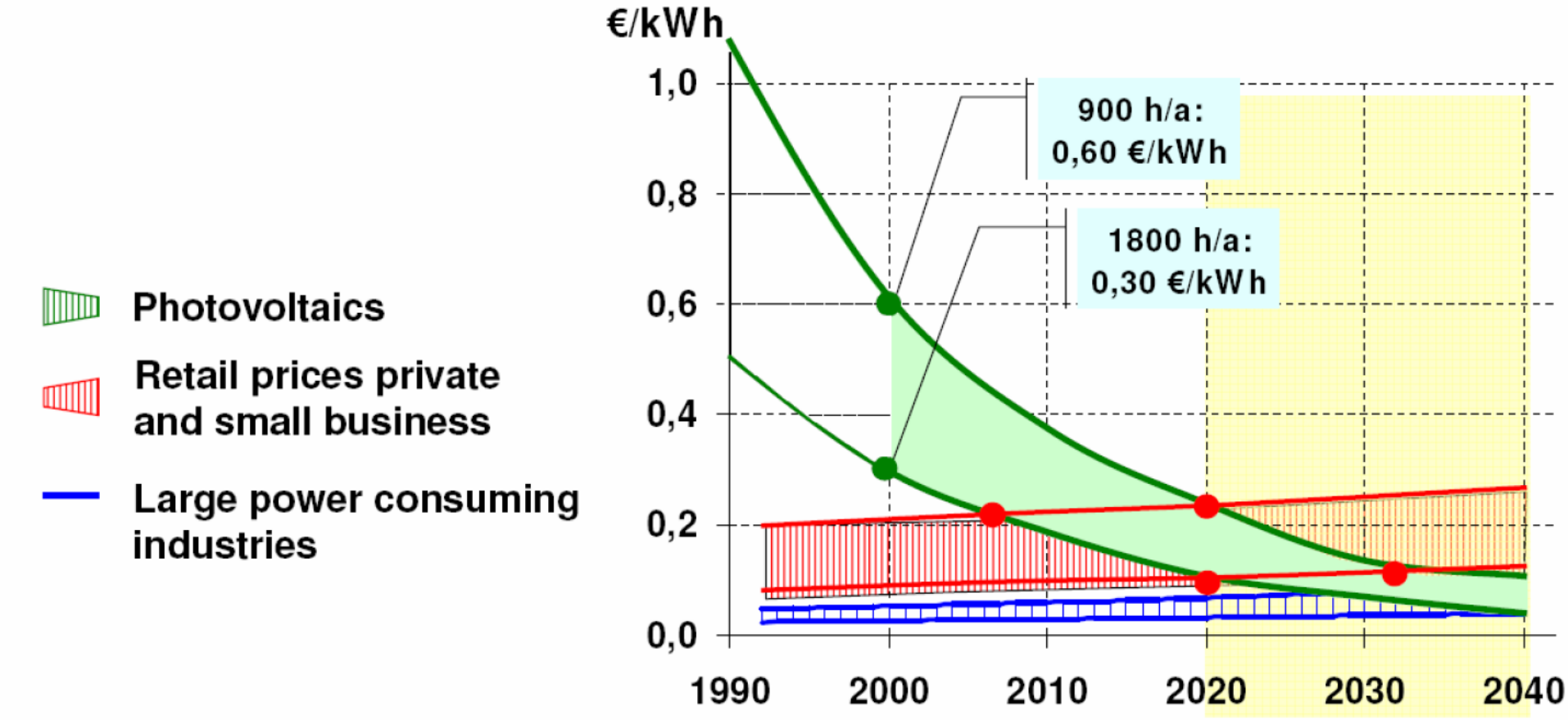
# Roadmap to „grid parity“ of PV




Ref: W. Hoffmann, personal estimates, 1999

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# Initiatives at *RIO 9 - LAREF* 2009

## in Rio de Janeiro 17-19 of March 2009

- PV installation: 1.5 GW/a in Germany vs. 1.5 MW/a in Brazil (even India that has 50 times more than Brazil) – Why ? - How to overcome ?
- PV for the “Maracana” stadium at the football world cup in 2014
- Realization of an example for PV grid parity in Brazil (electricity from PV has the same cost as from conventional electricity supplier)

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# RIO 9 - LAREF 2009

**in Rio de Janeiro 17-19 of March 2009**

- **Big thanks to our sponsors: GTZ, Heinrich Böll Foundation, the German Consulate and Rio Solar Ltd**
- **Great thanks to our team: Elena Kempf, Fabio de Souza, Norma Blandon, Franziska & Johannes**
- **Many thanks to all our exhibitors, scientific contributors and presenters**

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**Have a very nice Event !**

**Muito obrigado !**

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