UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

NEK
Sustainable Energy Concepts

RIO 12
World Climate
& Energy Event

RIO 12 - PV Expert Workshop

Net-Metering & Grid-Parity in Brazil

Rio de Janeiro - 10th of April 2012

www.RIO12.com

PV 3.0

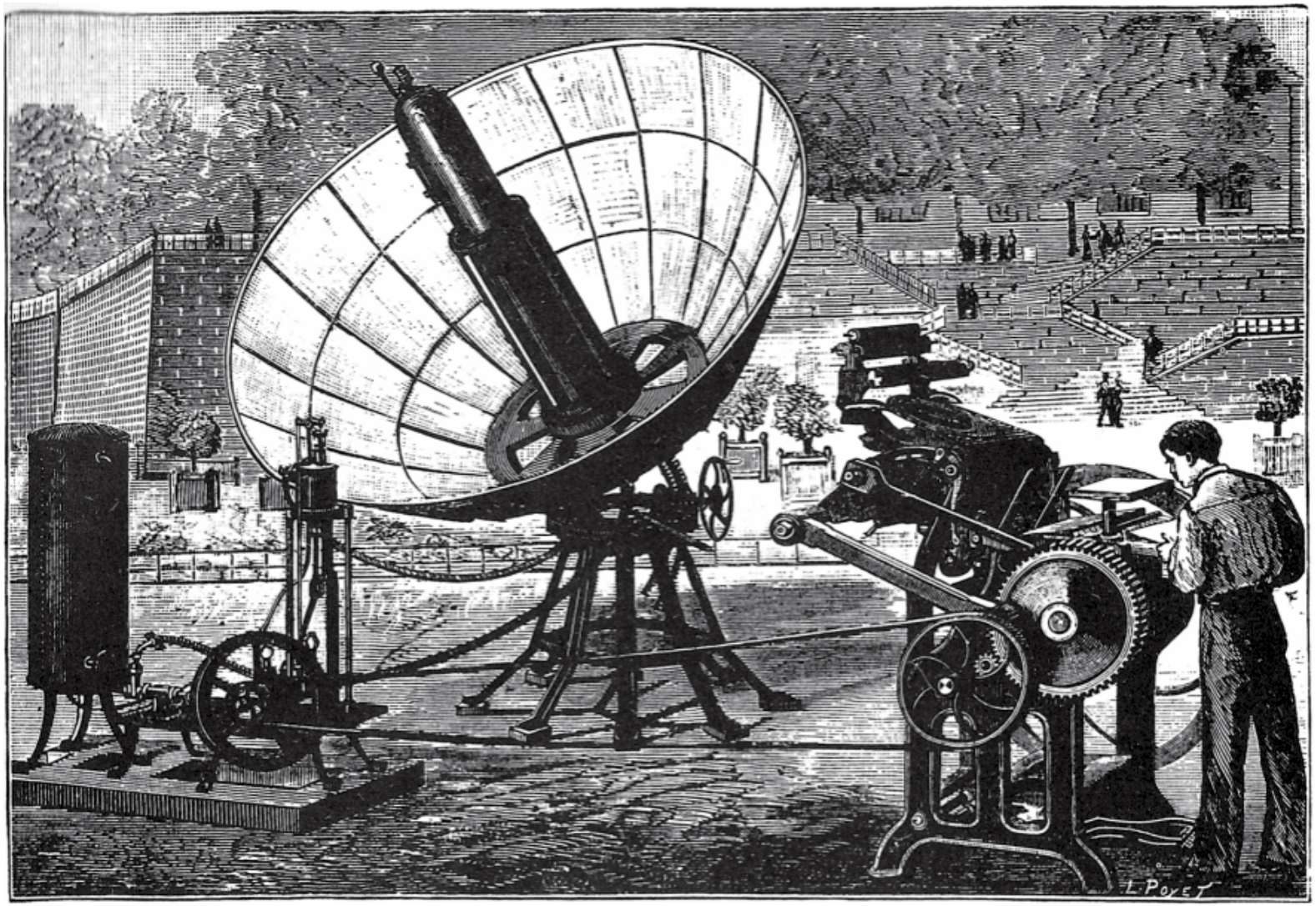
Photovoltaics reaches competitiveness

From indispensible markets to policy-driven markets to natural markets

Prof. Dr. Stefan Krauter

University of Paderborn
Electrical Energy Technology
Sustainable Energy Concepts
www.nek.upb.de

Solar power conversion in 1900



„Four Solaire“ (Southern France, 1970)

“Four Solaire“, Odeillo:

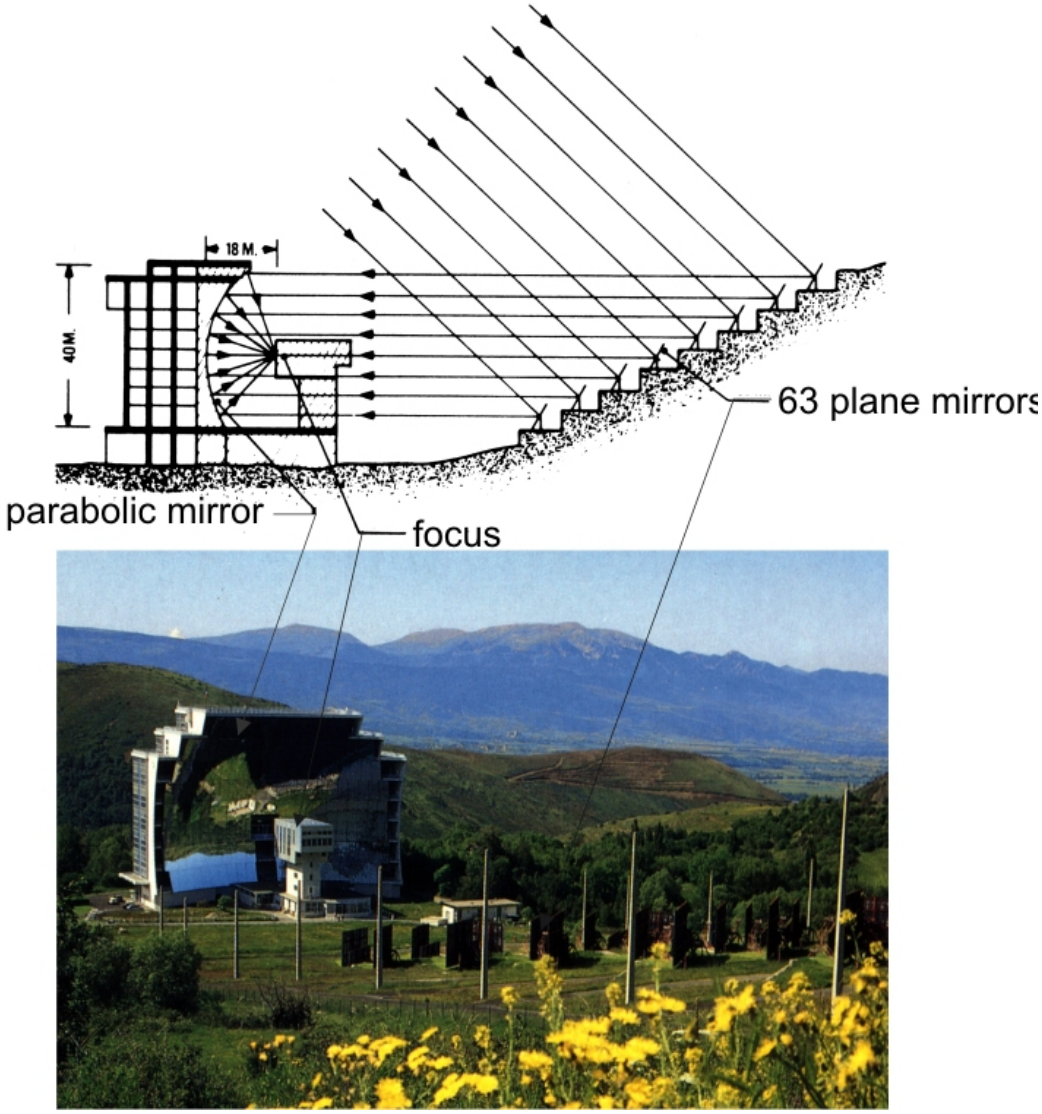
Solarthermal power plant at 16 MW, „double reflection“ scheme, with 63 tracking mirrors and one fixed parabolic mirror

Concentration factor: 16,000

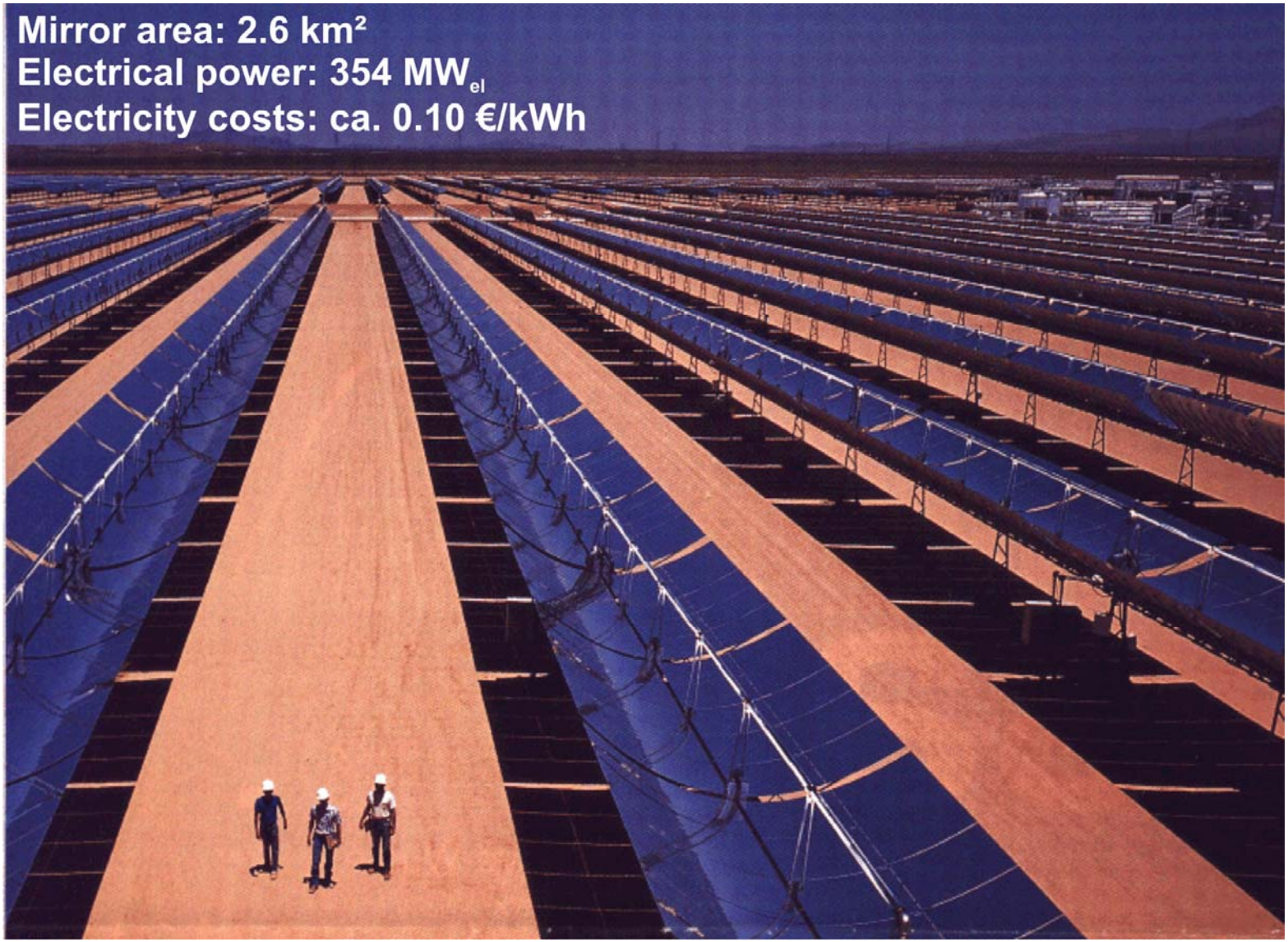
Power density: 1.6 kW/cm²

max. temperature: 3,000°C

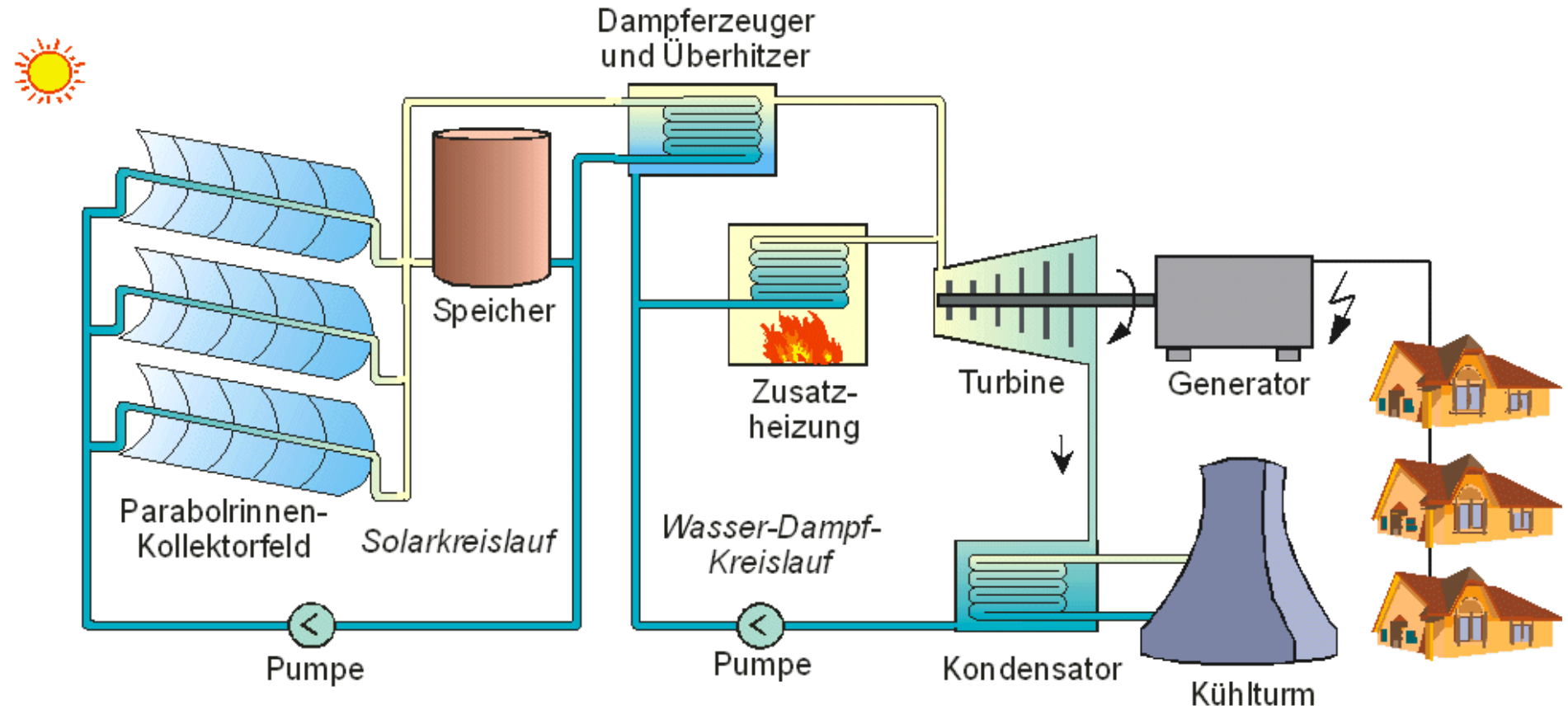
Efficiency: 60%



Solar Thermal Power Plant SEGS (USA, 1990)

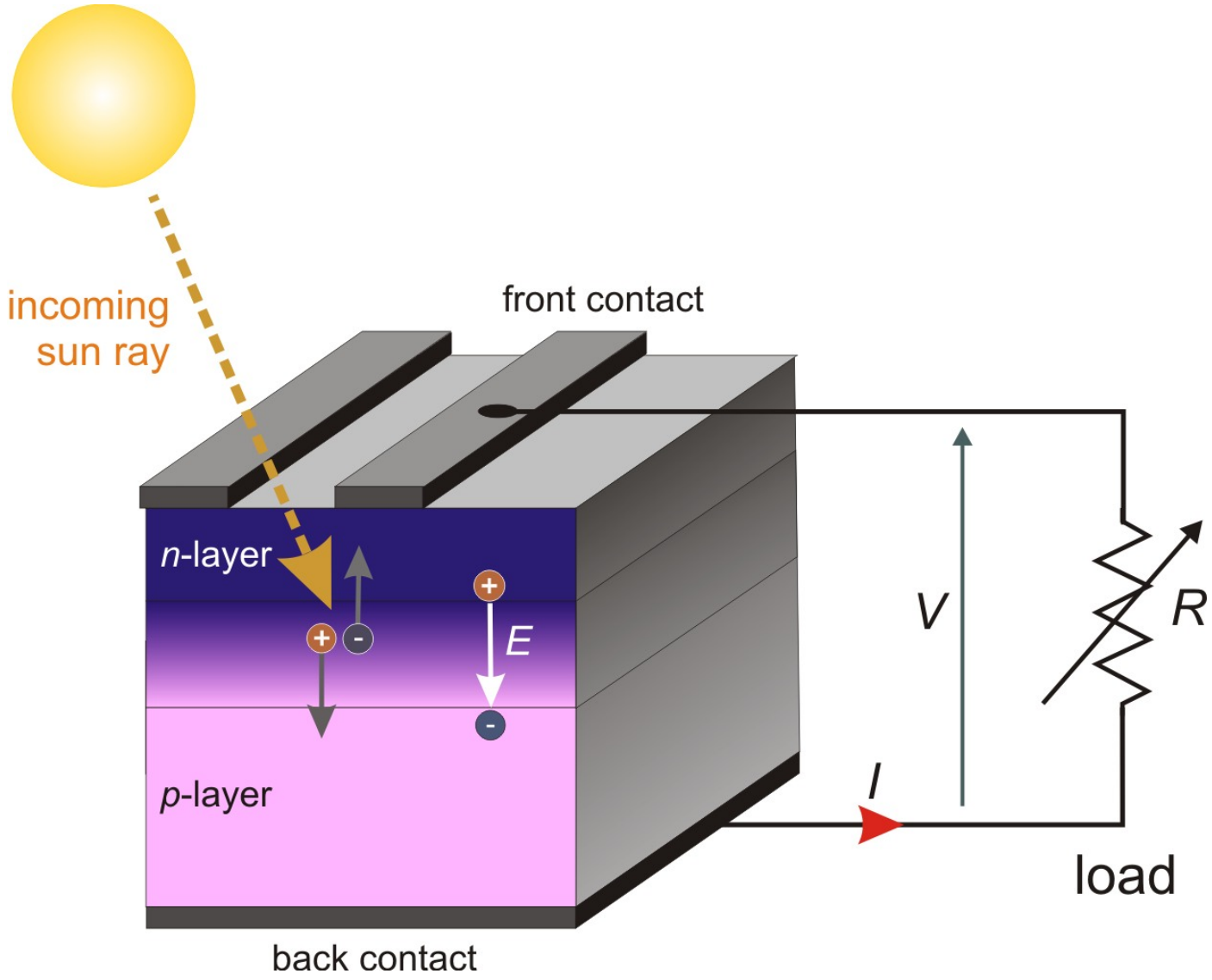


Operating Scheme of SEGS

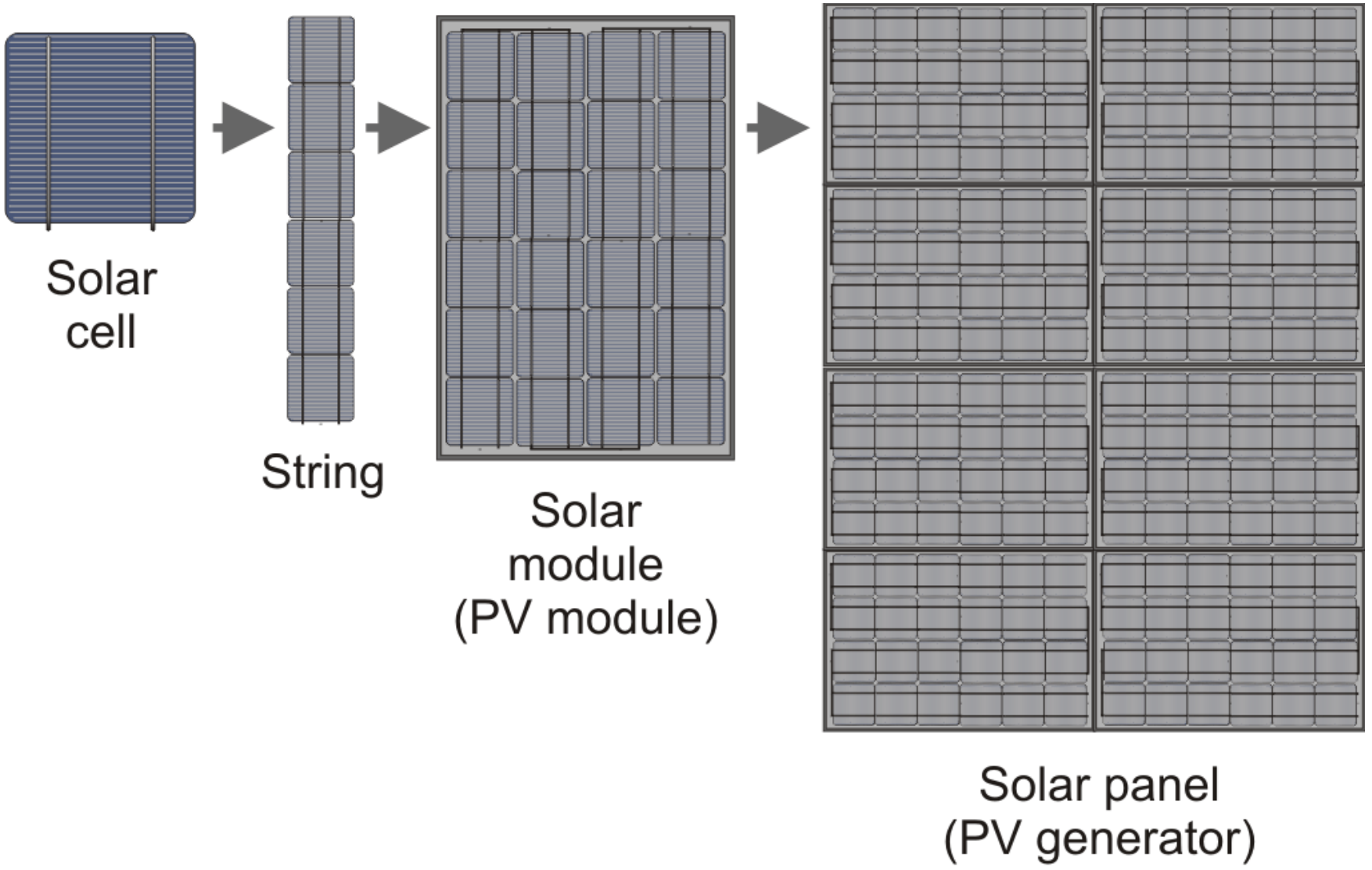


Quelle: Volker Quaschning - Regenerative Energiesysteme

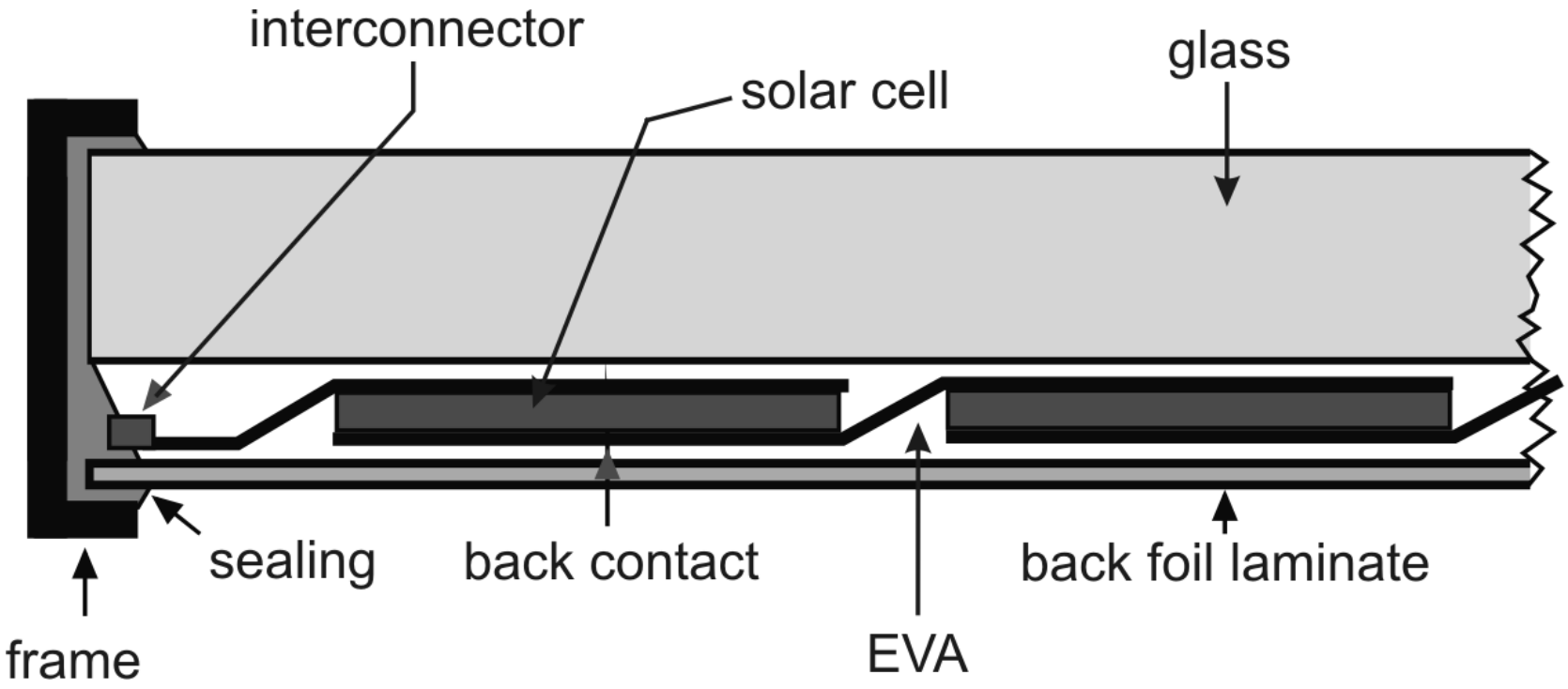
Scheme of photovoltaic solar energy conversion



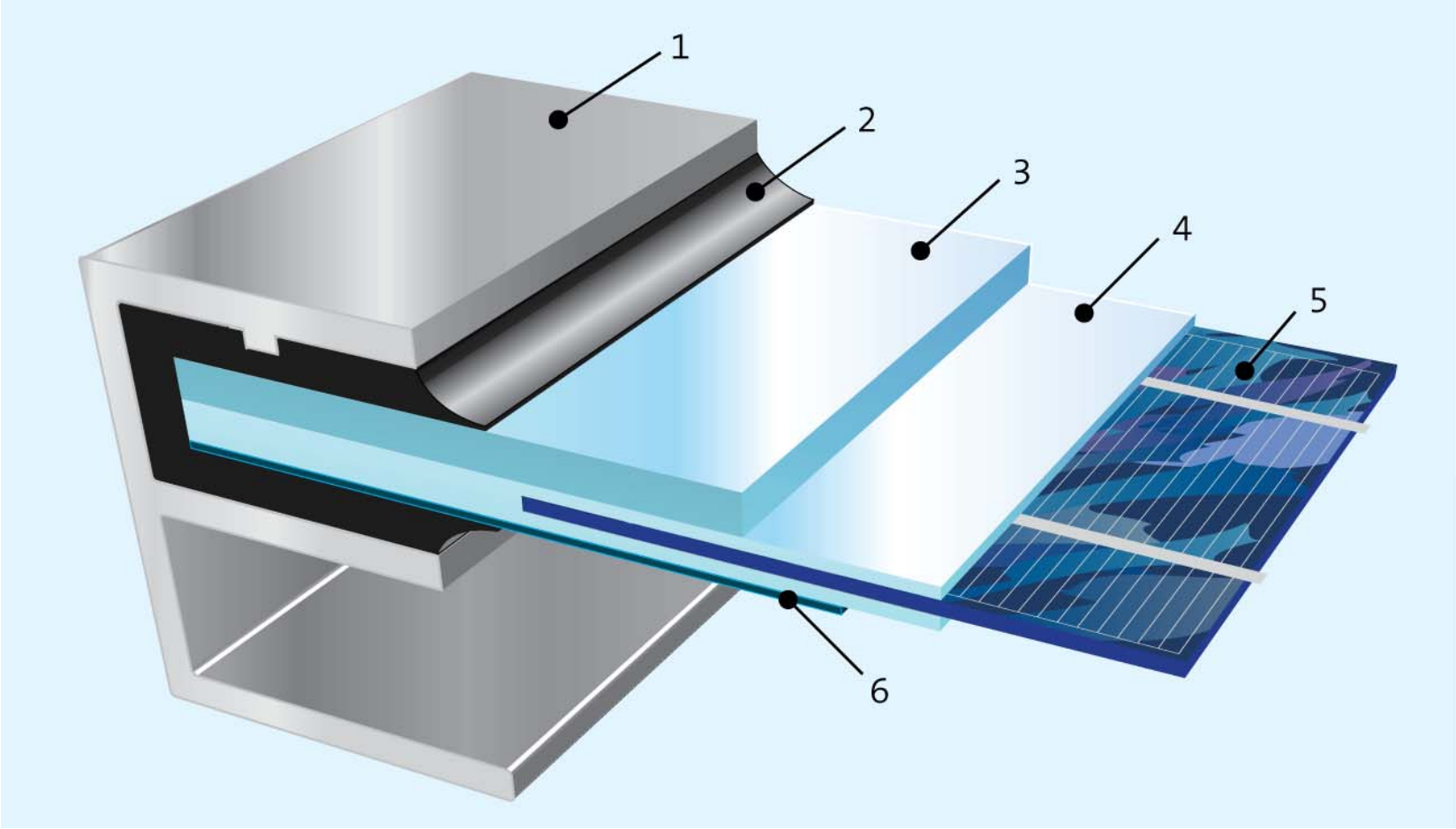
From the solar cell to the PV generator



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

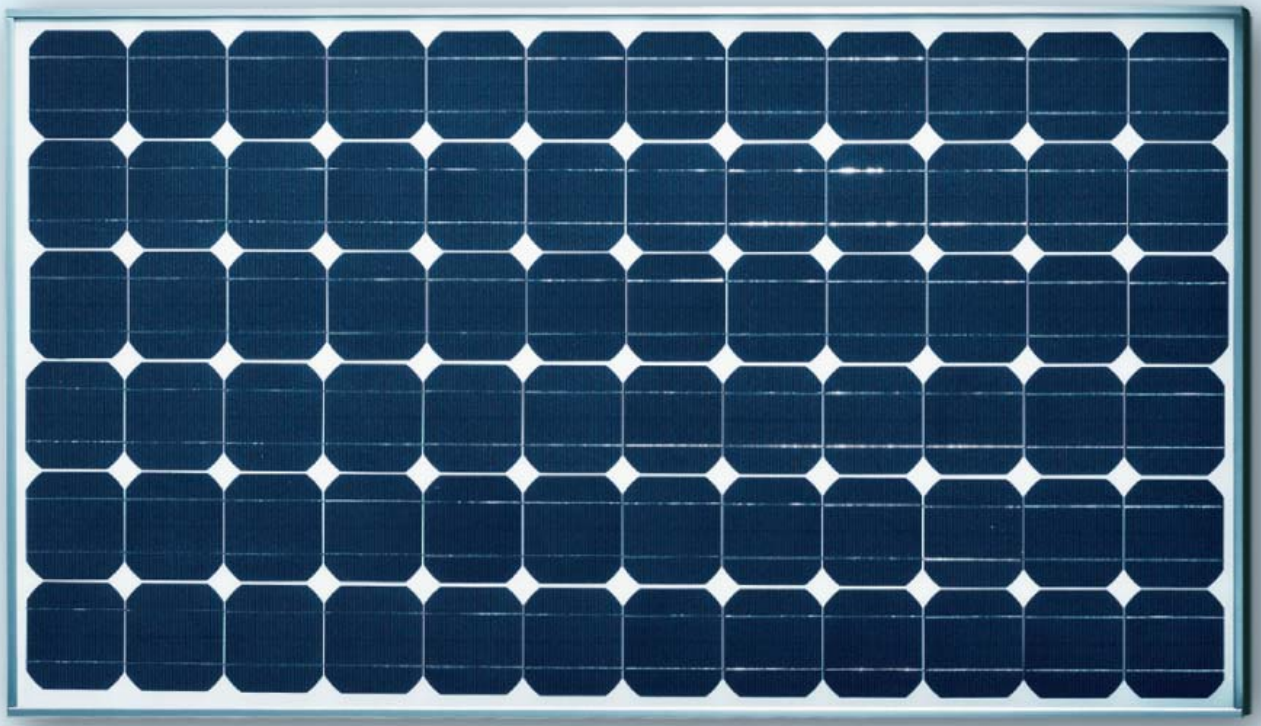


Laminated PV Module for crystalline solar cells with frame



1 Aluminum frame, 2 seal, gasket, 3 Glass, 4 EVA embedding, 5 crystalline solar cell, 6 Tedlar-Polyester-Foil

Single crystalline PV module (sc-Si)



© Vaillant

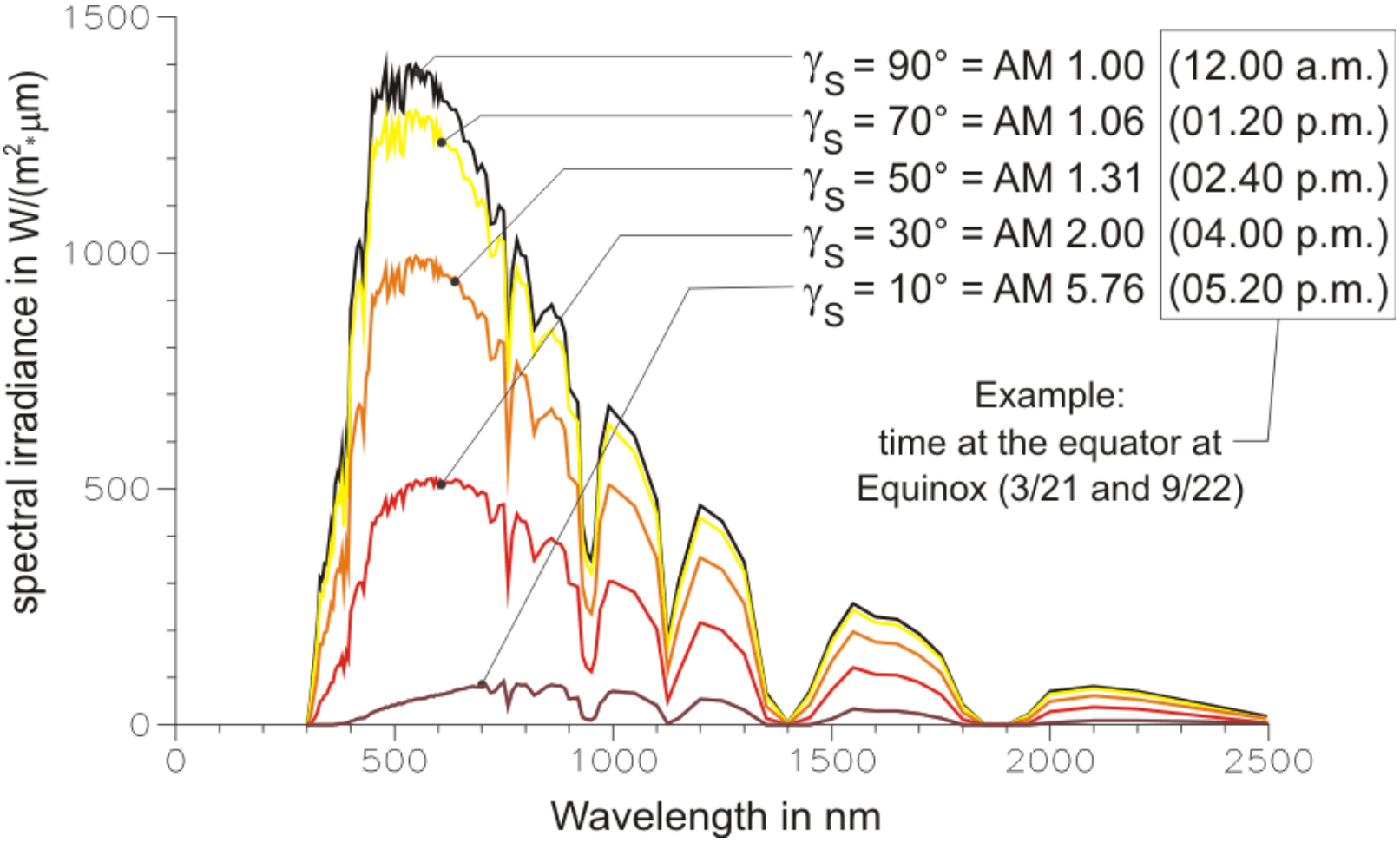
Multi-crystalline PV modules (mc-Si)

© www.solarpraxis.de / Tom Pischell

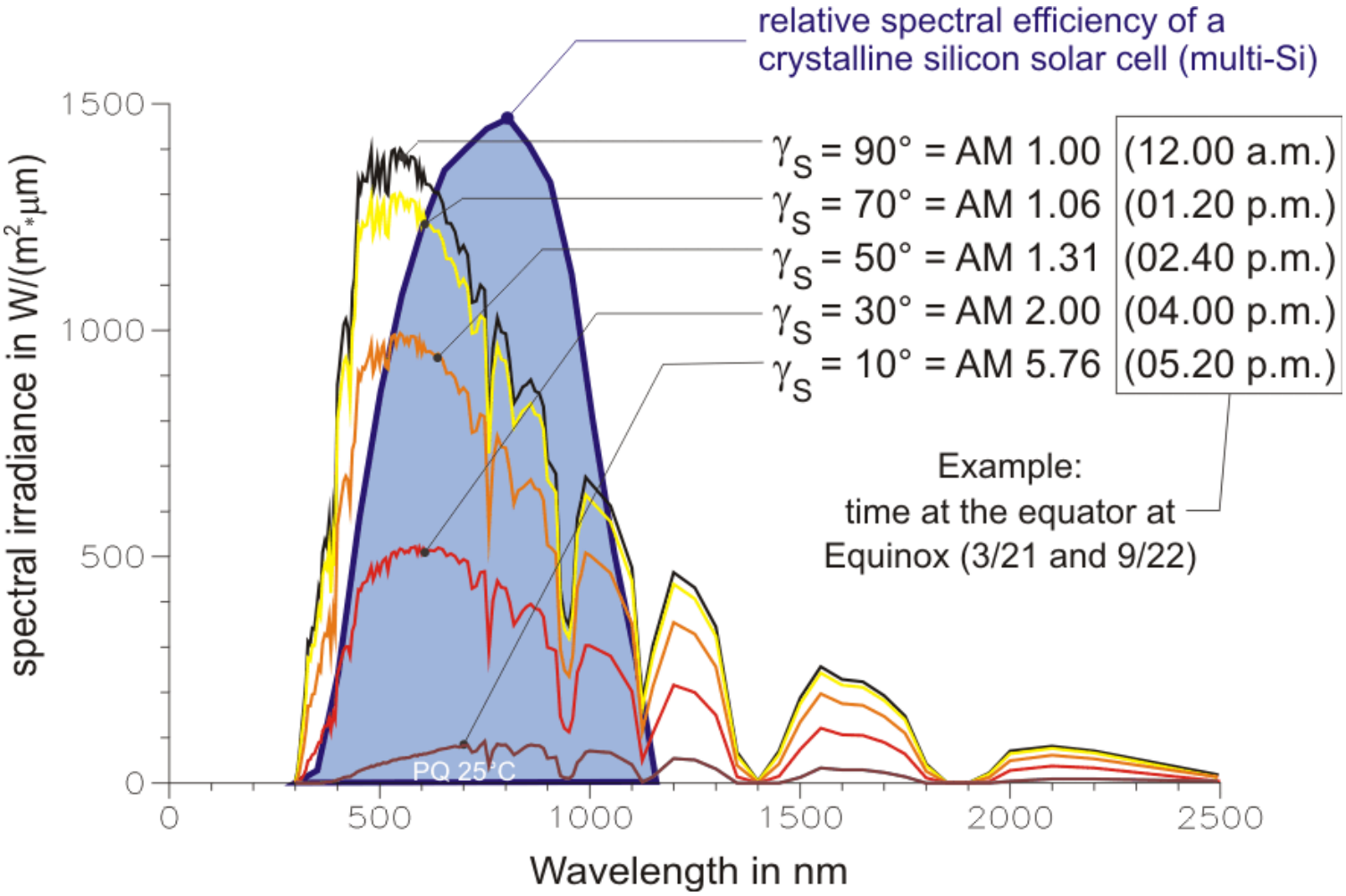
Flexible multi-junction thin film module

© United Solar Ovonic

Sun’s spectra for different times of a day



Matching of spectral efficiency with sun's spectra



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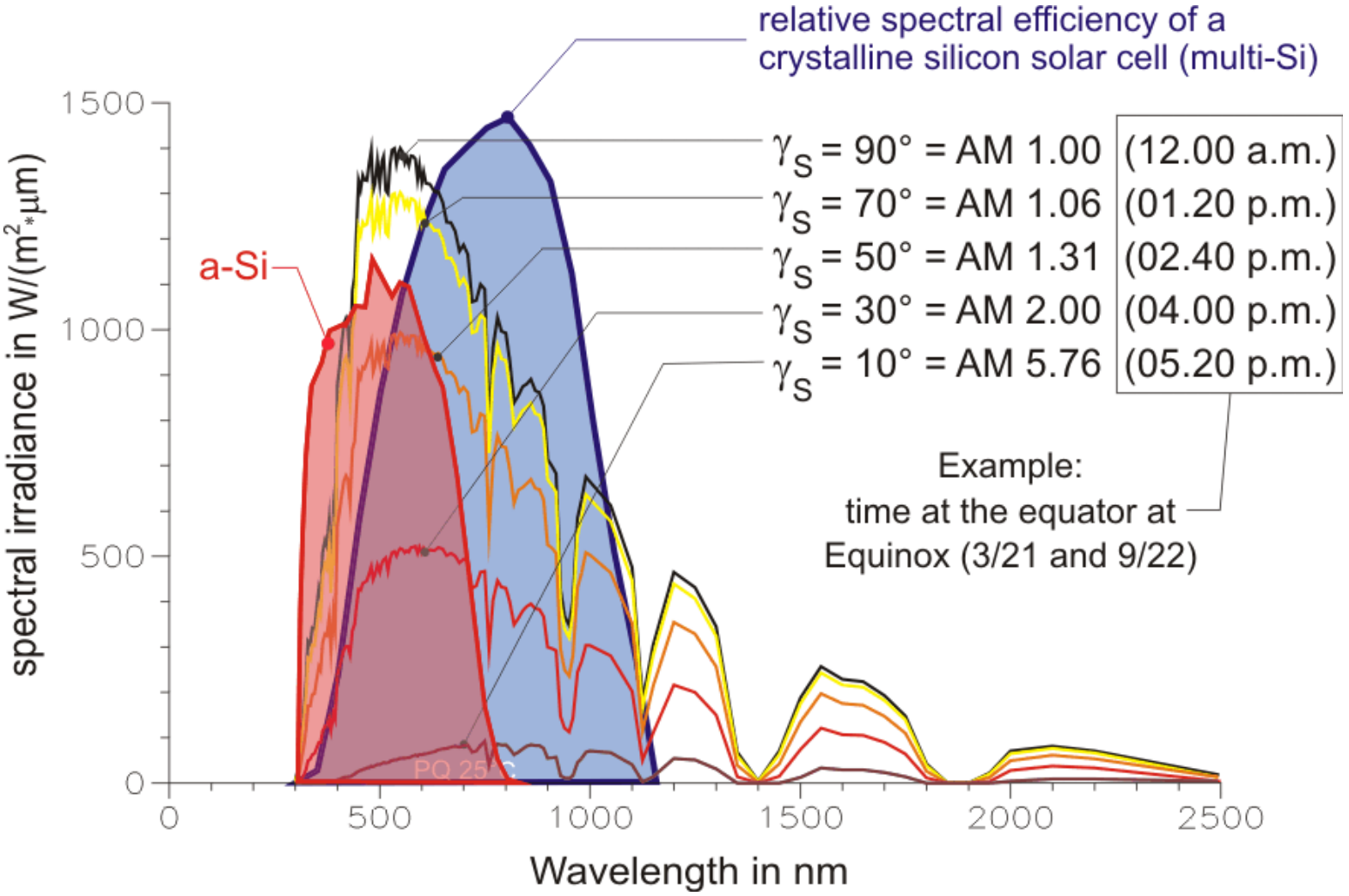
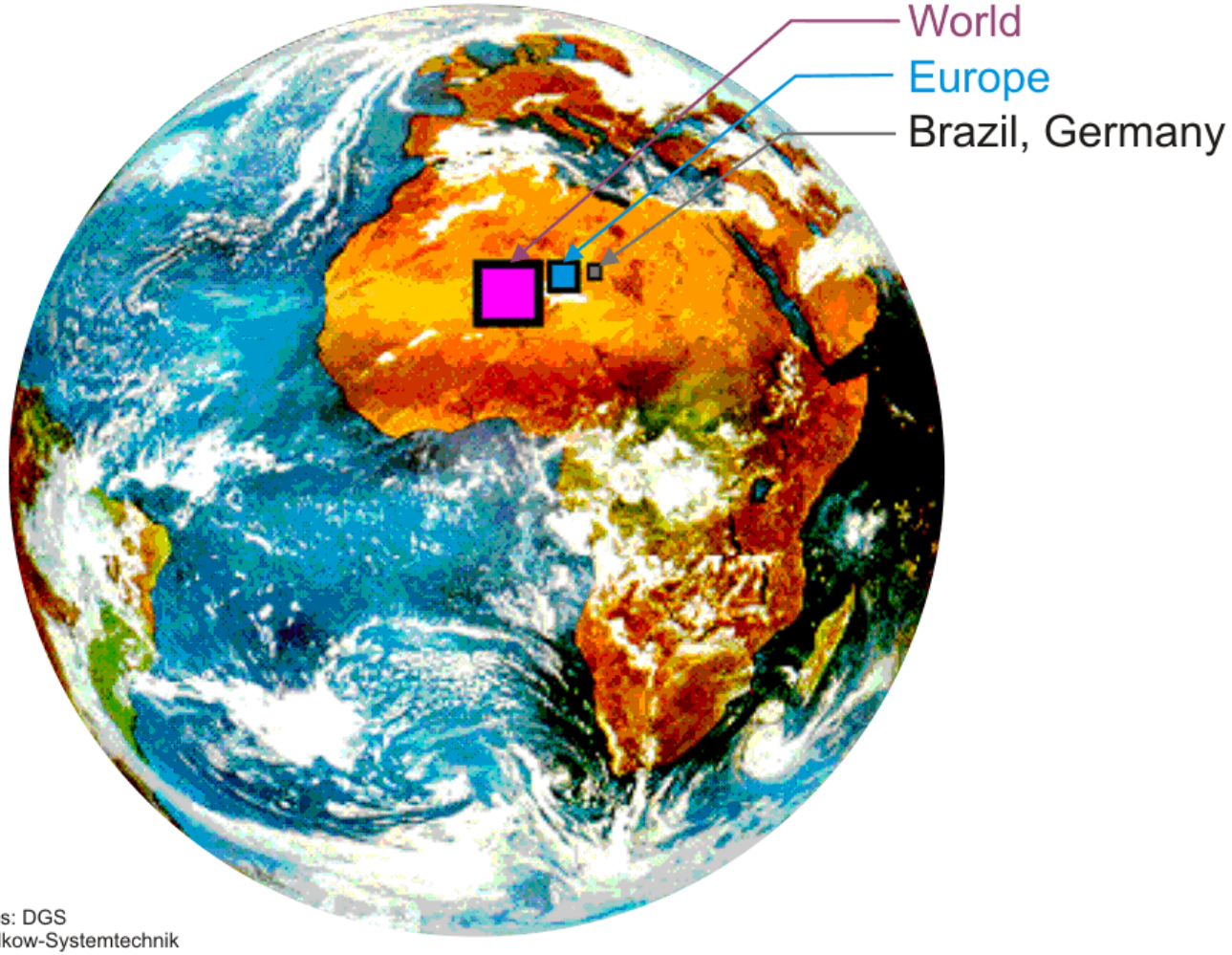


Area necessary for the energy supply via photovoltaics



References: DGS
Lutwig-Bölkow-Systemtechnik

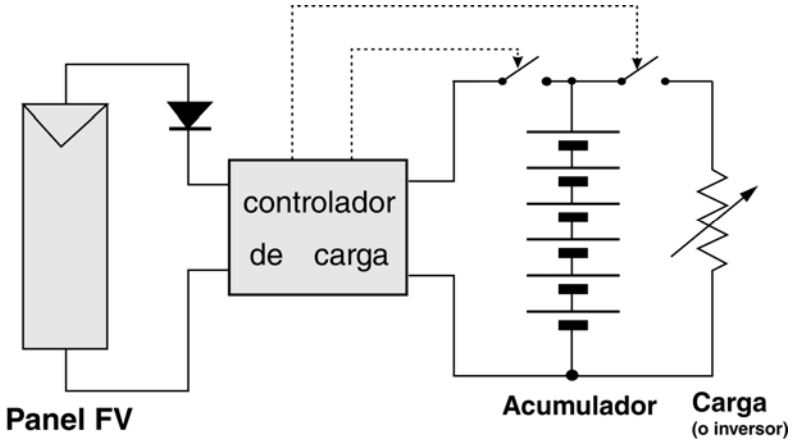
Photovoltaics 1.0

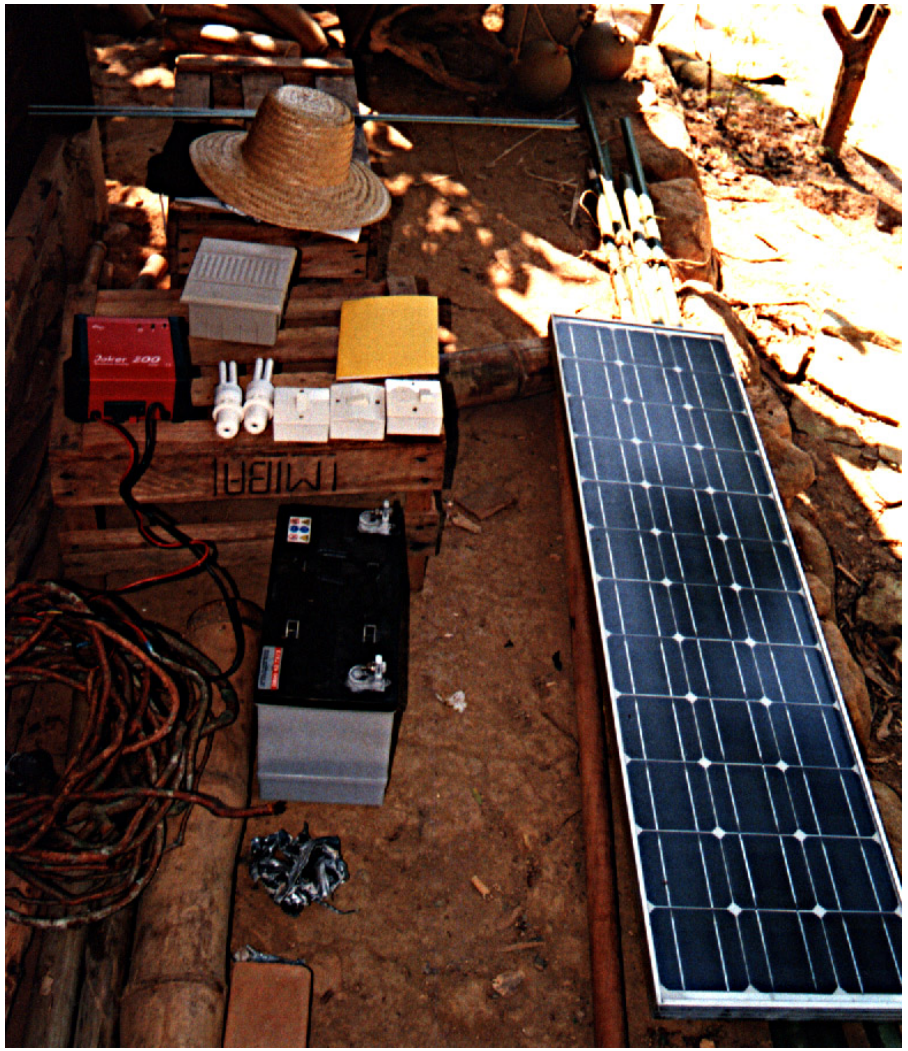
The first stage of PV use has been in space (since 1960) and for remote power supply (since 1980). System size has been in the kW-range and system prices (terrestrial) at 5 to 10 €/W_p.

PV 1.0: Space application: PV for 100 EUR/W

Sistema fotovoltaico de 300 W_p para uma escola indígena

Micro-Kit para instalación fotovoltaica



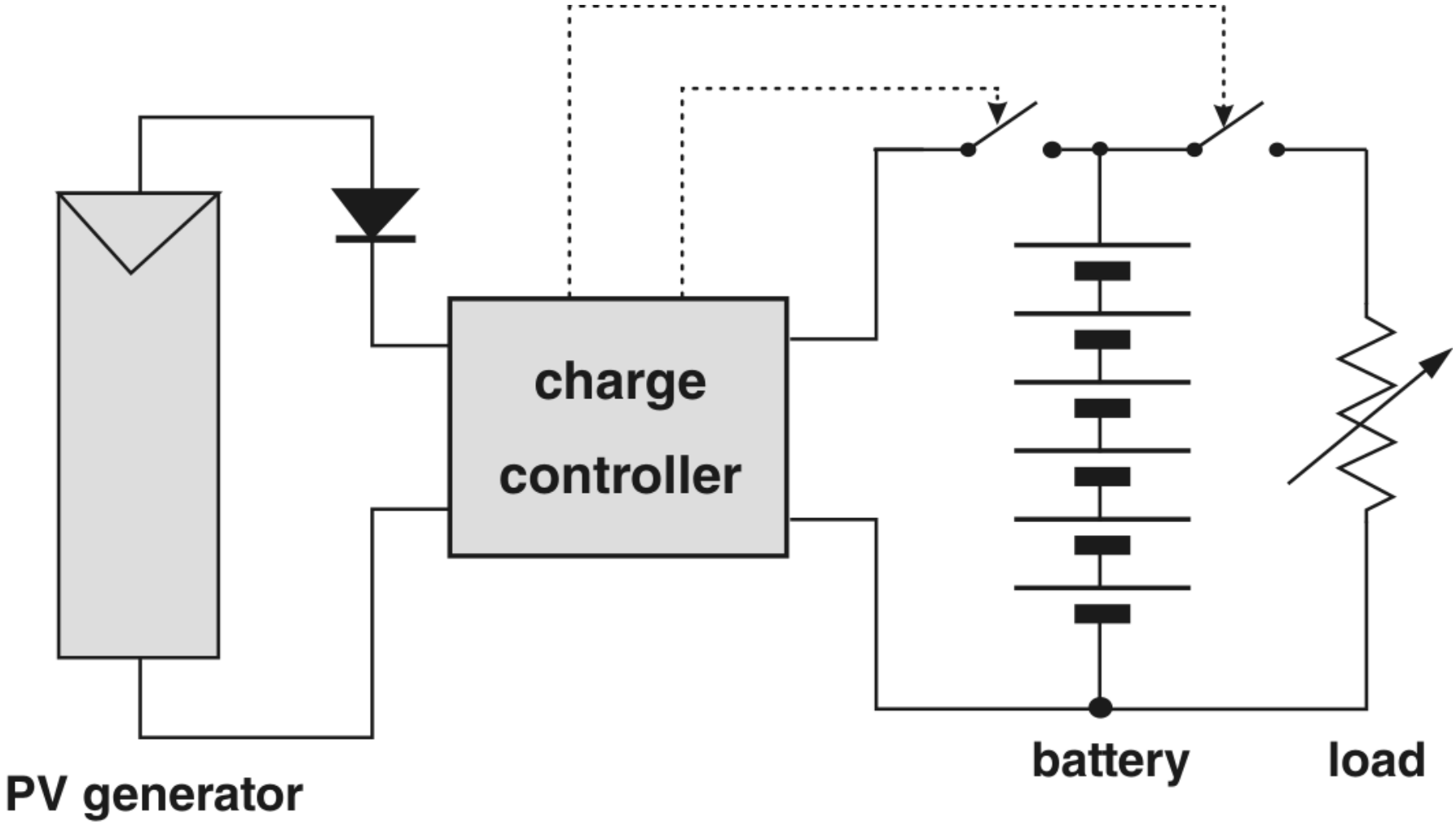


Inverter for off-grid systems and charge controller

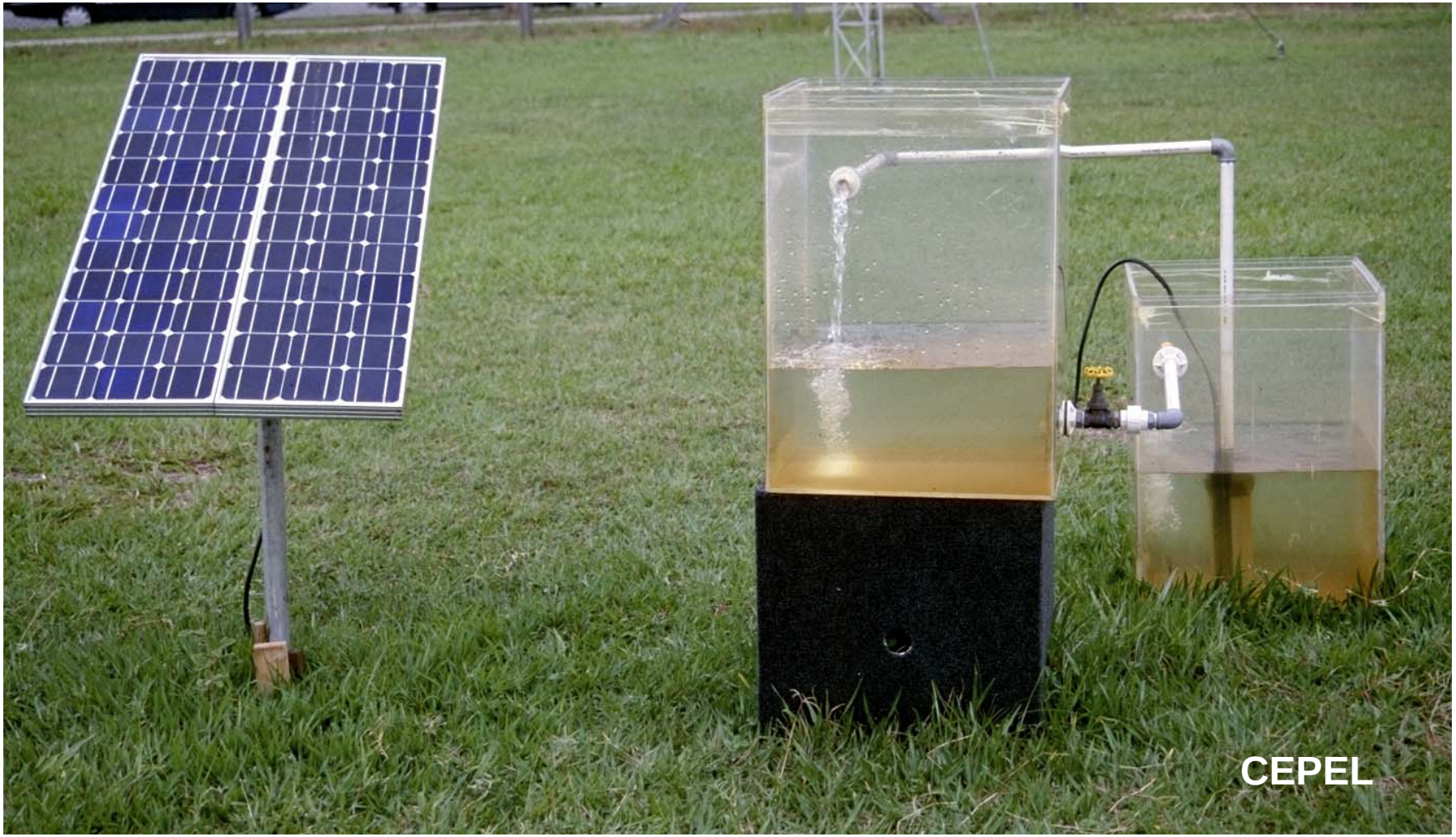
© Steca

© SMA

Scheme of PV off-grid system



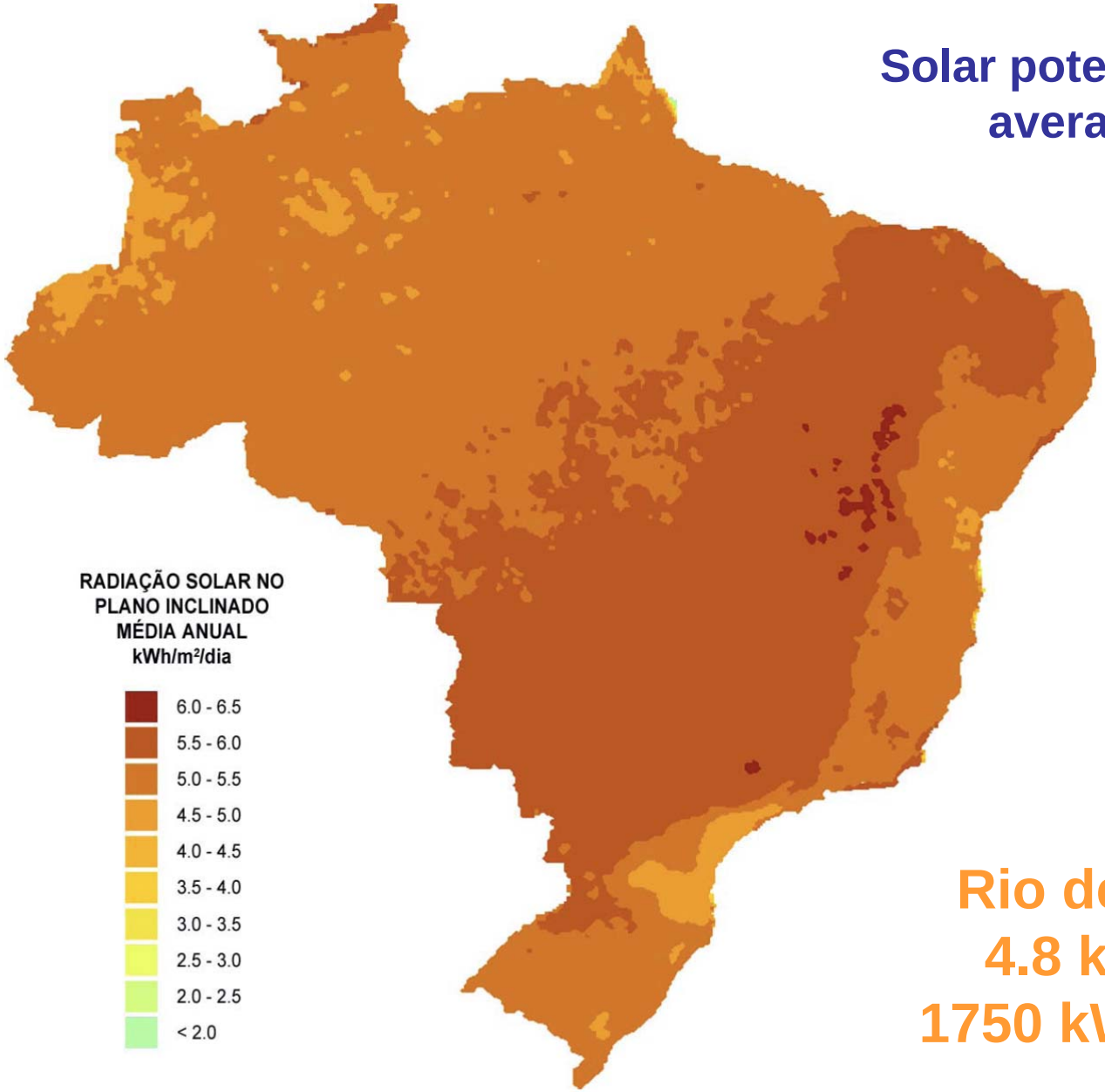
Sistema fotovoltaico para bombeamento d’água



Off-grid middle class 400 W_p PV-system in Brazil

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

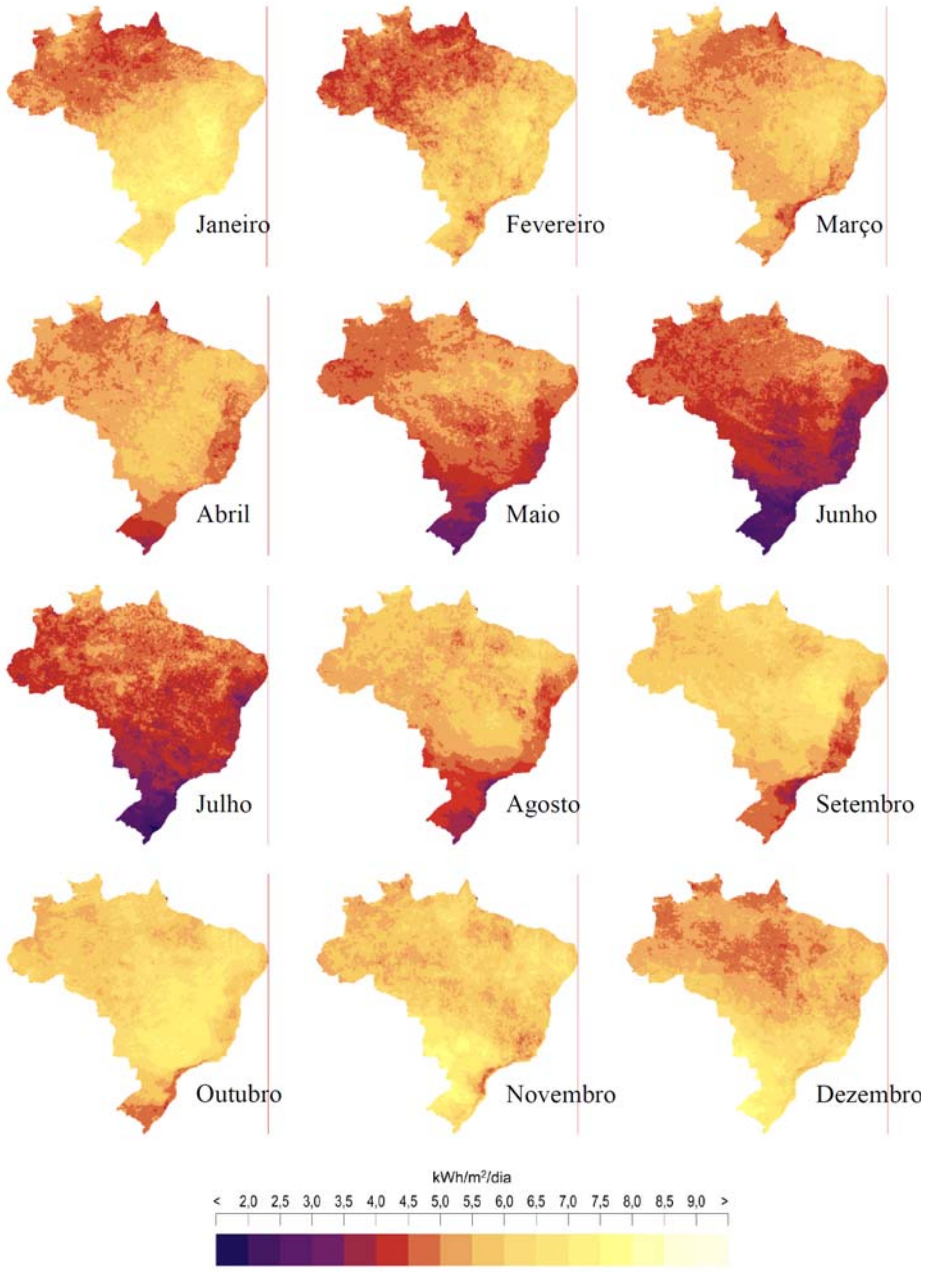
Solar potential of Brazil average irradiance (INPE 2005)



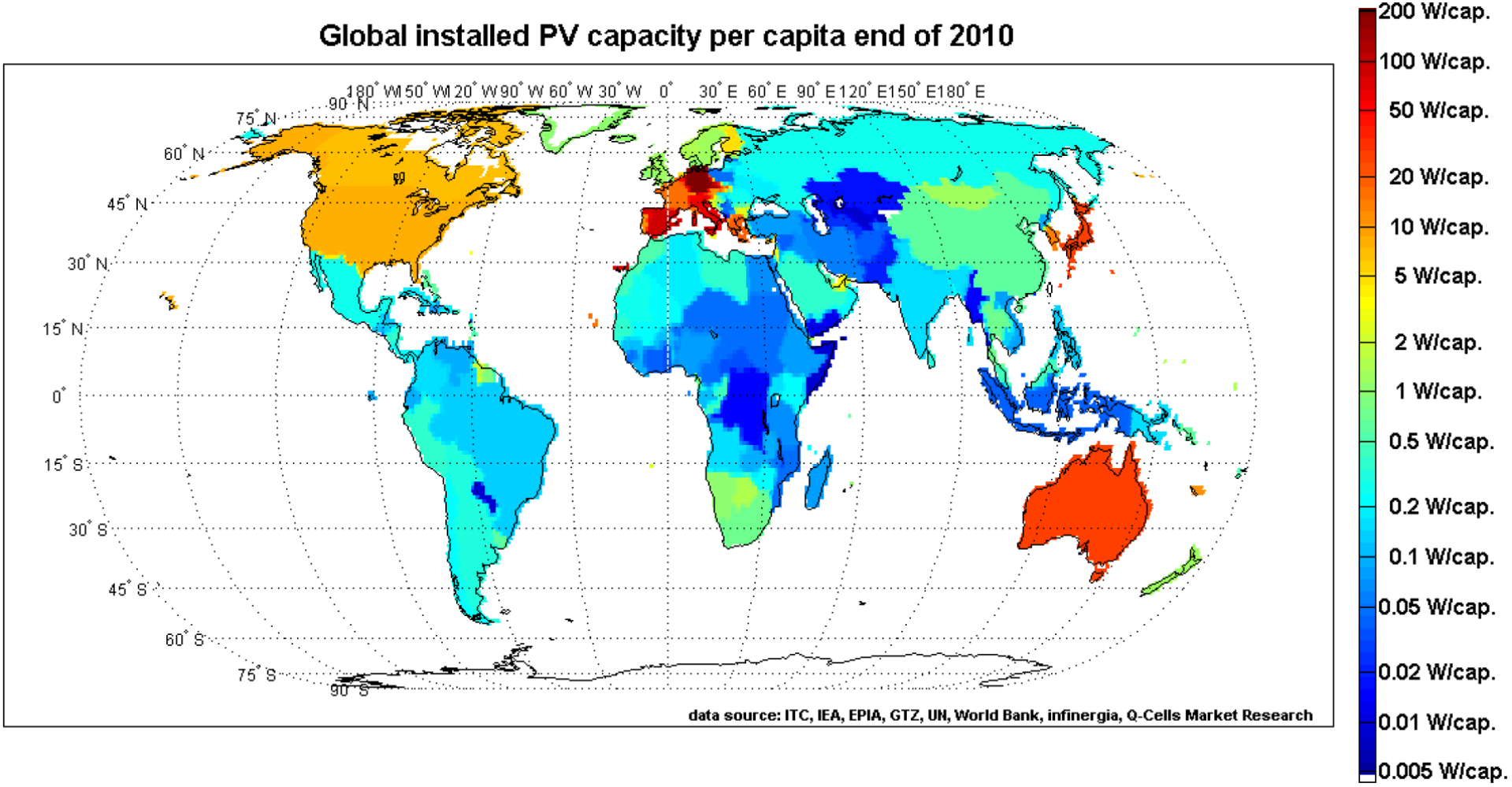
Rio de Janeiro:
4.8 kWh/m²dia
1750 kWh/m²ano

For off-grid PV-systems:

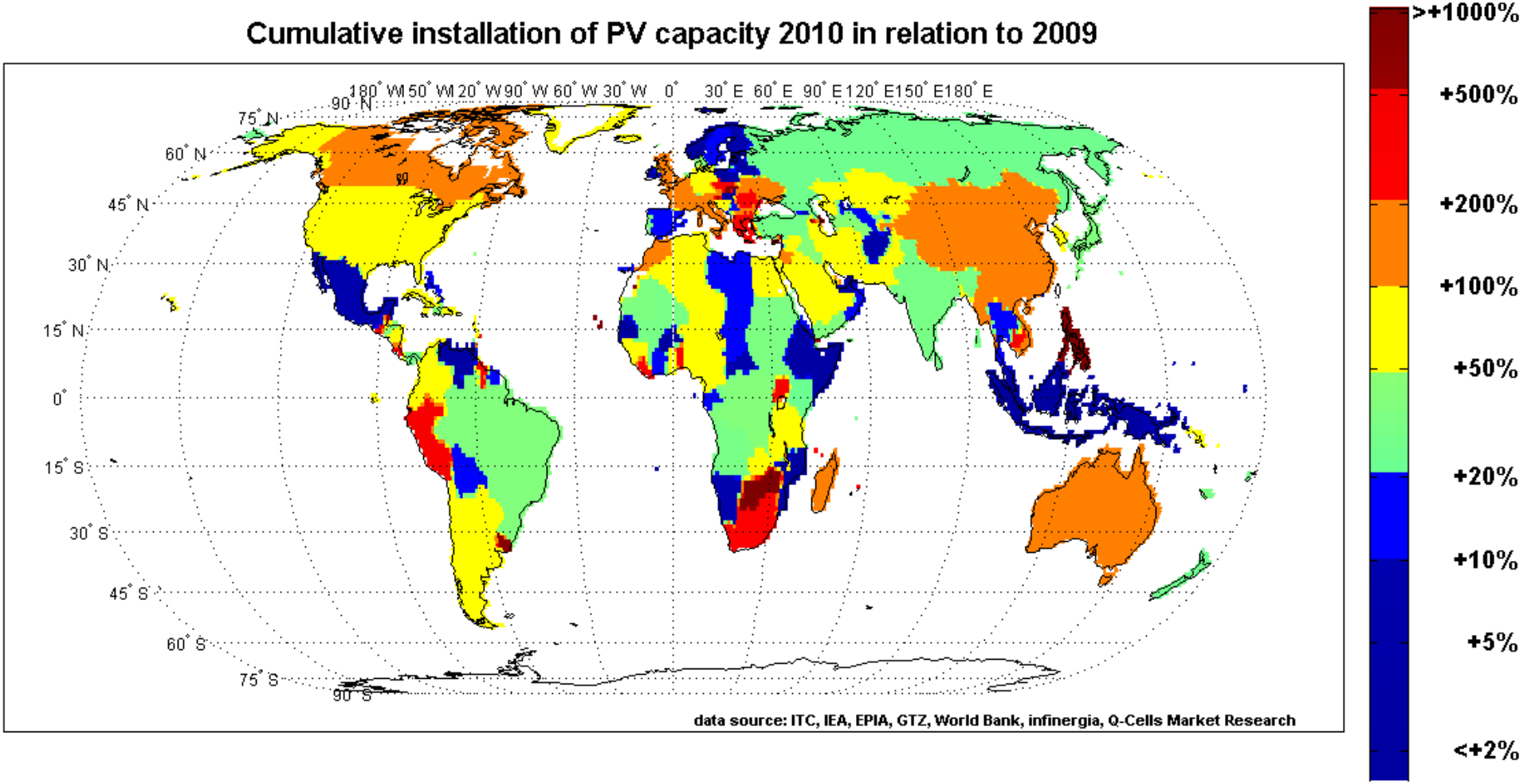
The layout of the PV-system has to be made for a typical day of the worst day of the Year (in Rio de Janeiro: June at 4 kWh/m²day)



Installed PV per capita worldwide



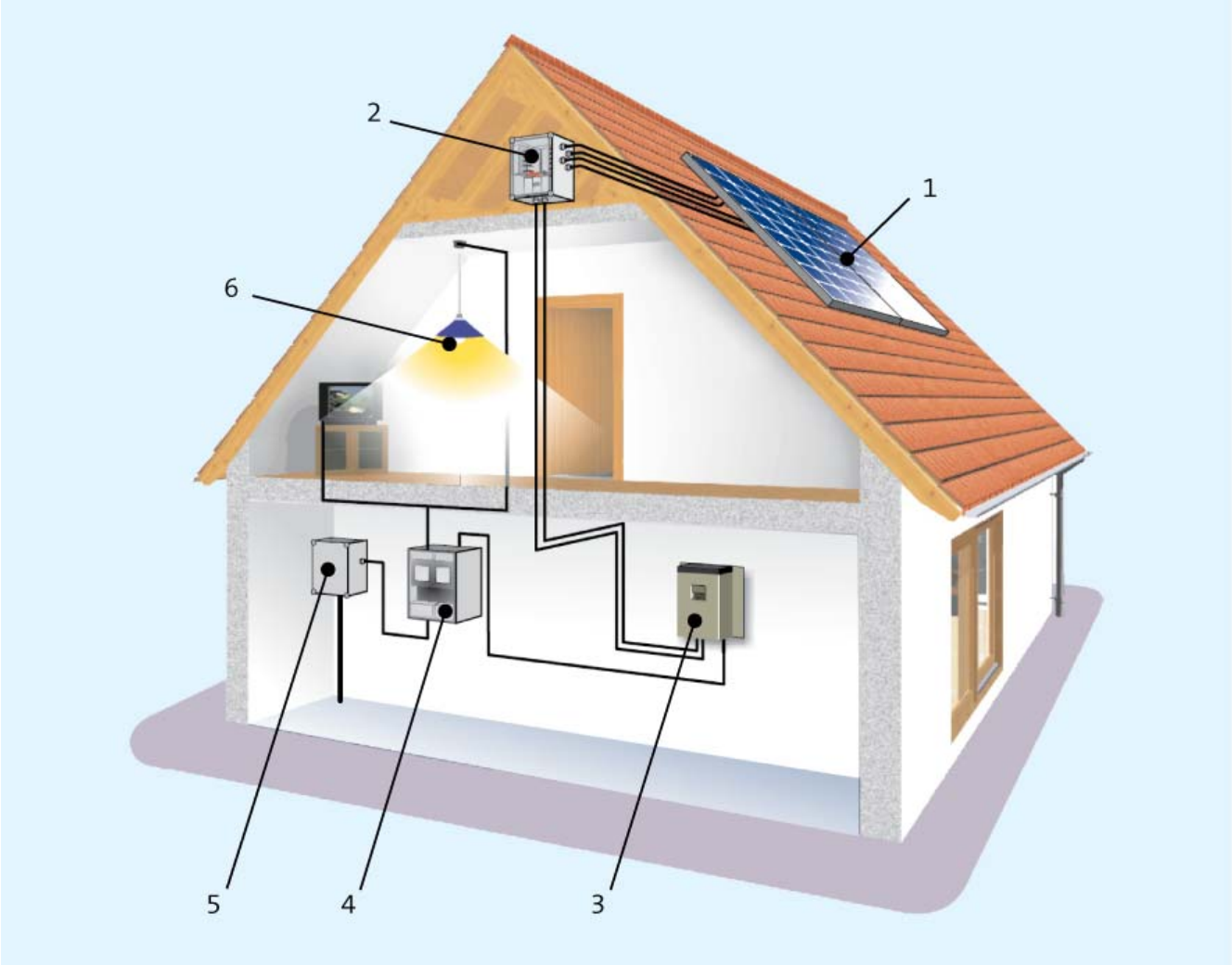
Increase of PV installations



Photovoltaics 2.0

Due to adapted grid-feed tariffs (FIT) in some countries PV boomed during the last decade (2000-2010), production capacities increased and prices went down. System size has been in the MW-range and system prices at 2 to 4 €/W_p.

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



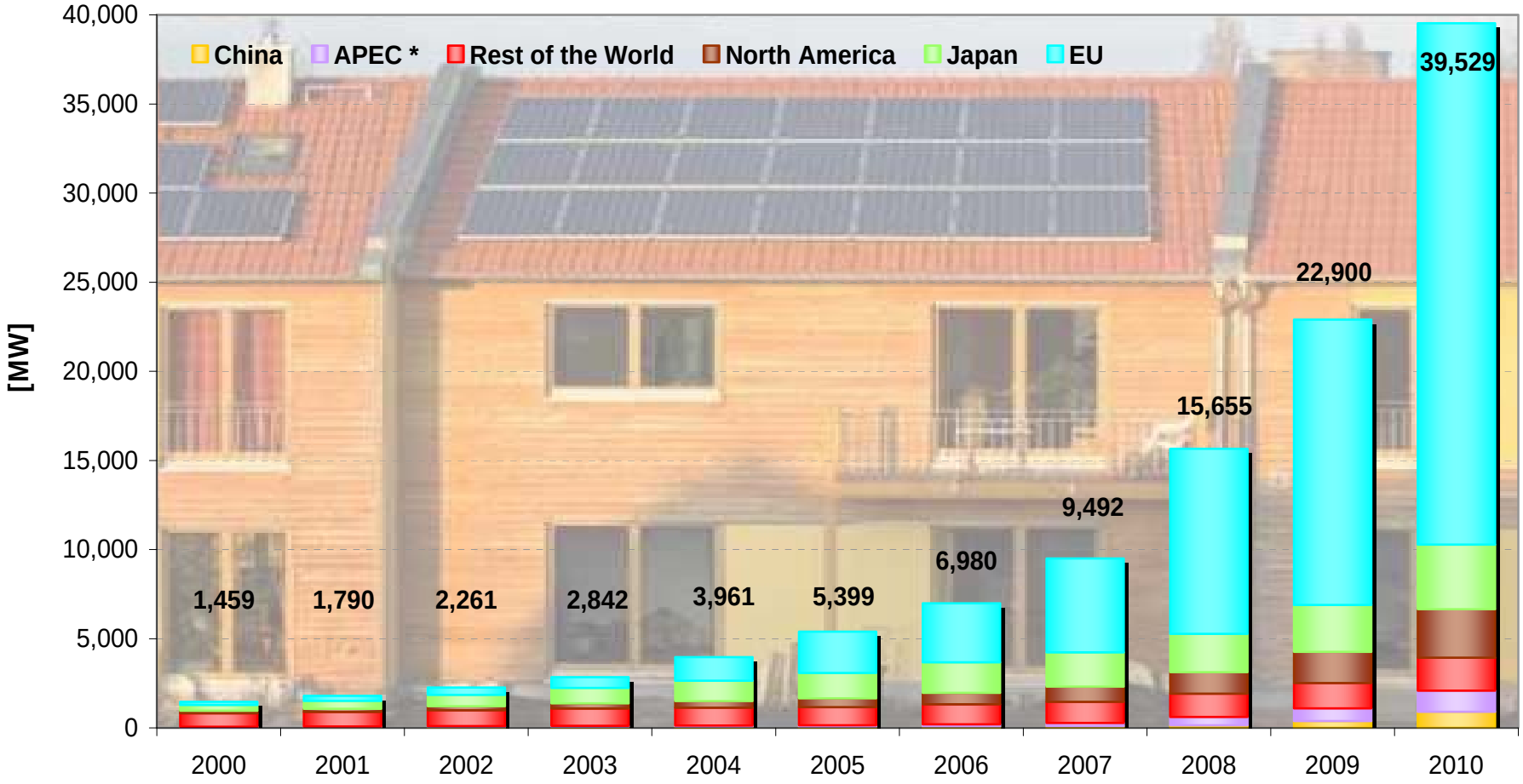
1 PV generator, 2 junction box, 3 Inverter, 4 kWh counter for electricity consumption and PV injection, 5 grid connection, 6 loads

PV Roof in Freiburg, Germany

2 MW_p PV generator integrated in the airport of Munich 2000

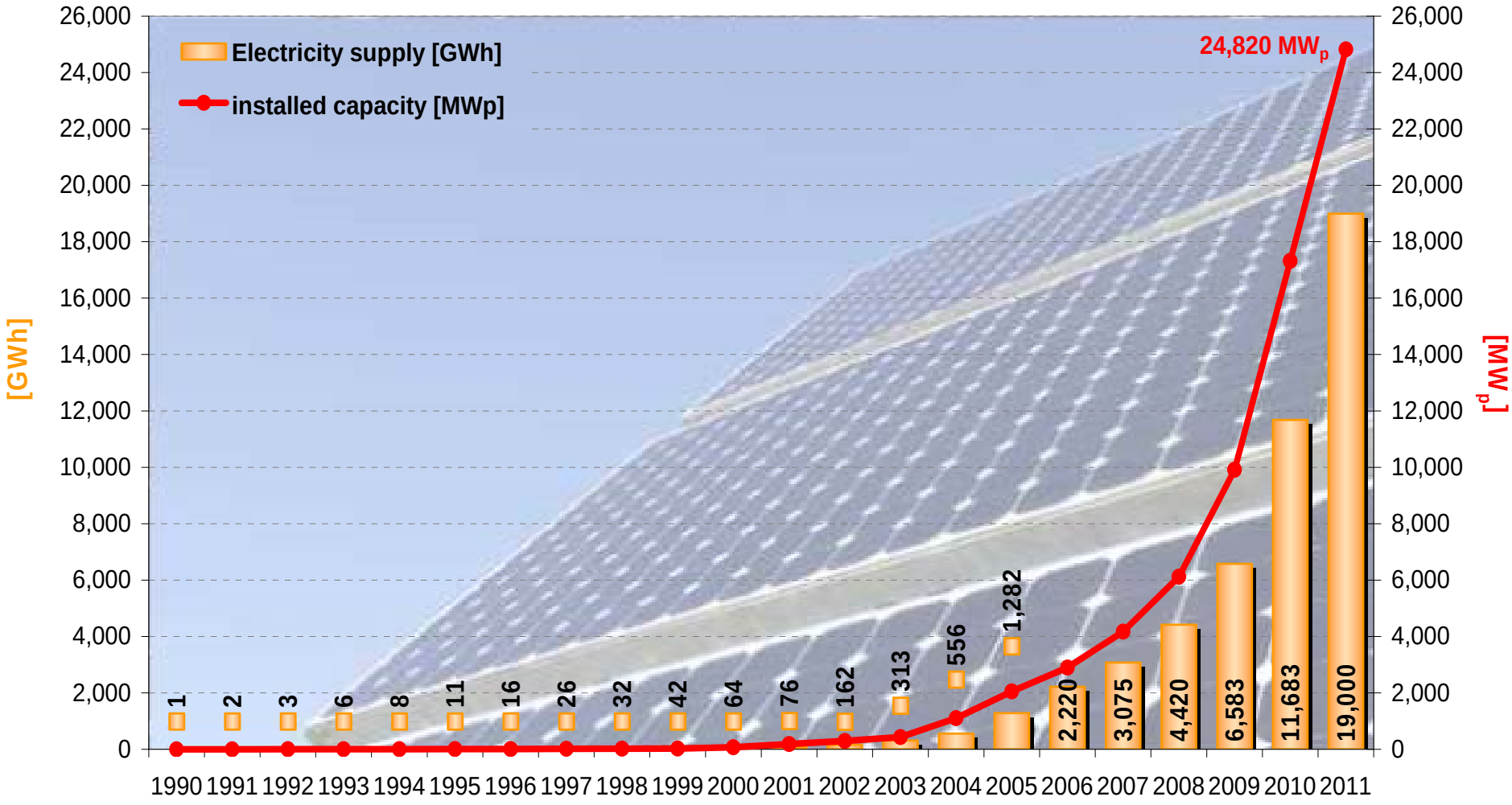
11 MW PV power plant in Cerpa, Portugal

World market Photovoltaics 2000–2010
cumulated installed capacity



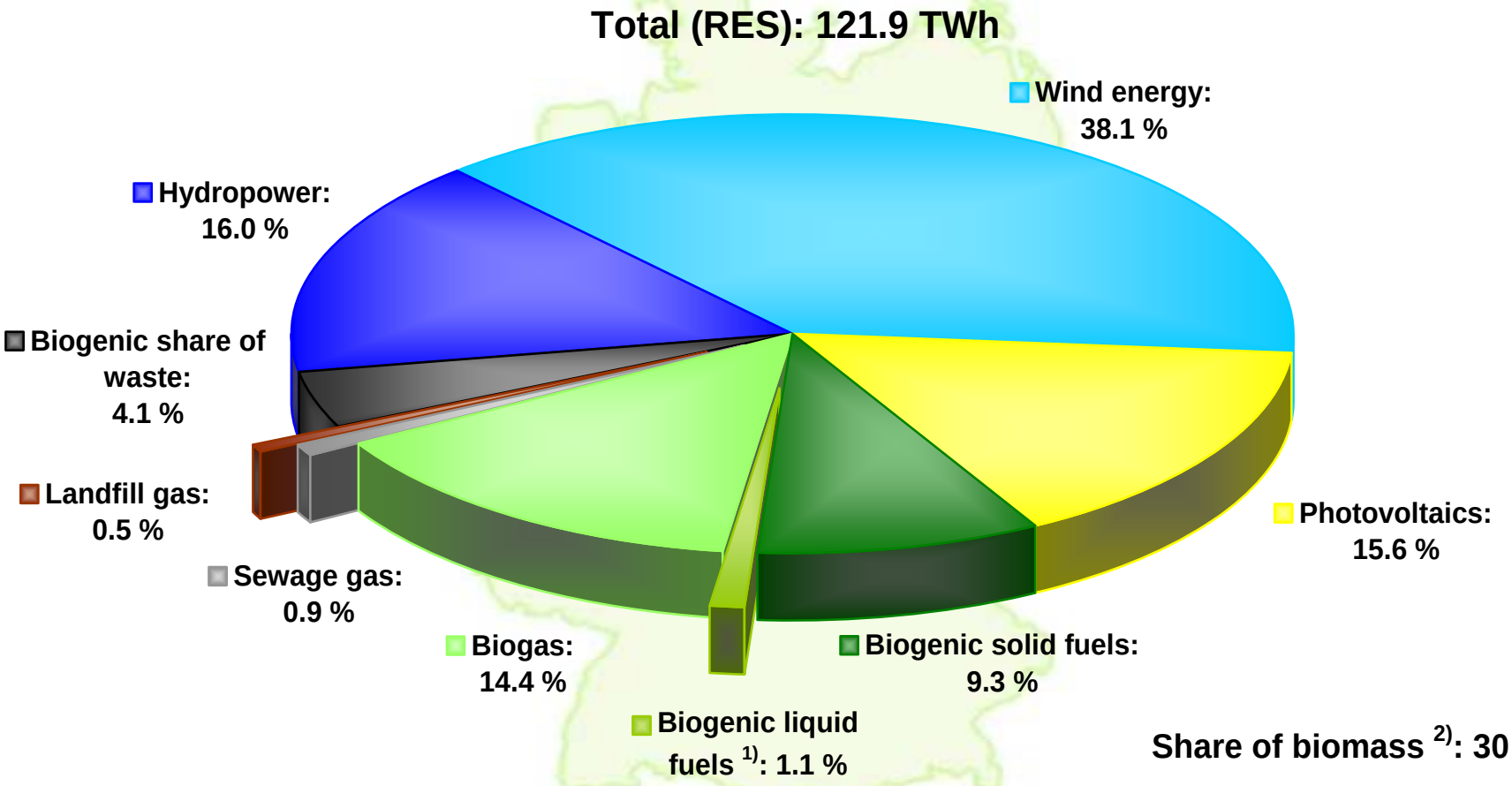
Members of Asia-Pacific Economic Cooperation (APEC) are: Australia, Brunei, Canada, Indonesia, South Korea, Malaysia, New Zealand, The Philippines, Singapore, Thailand, USA, Panama, Taiwan, Hongkong, Mexico, Papua New Guinea, Chile, Peru, Russia, Vietnam plus China and Japan, visualised separatly.
Source: European Photovoltaik Industry Association (EPIA): "Global Market Outlook for Photovoltaics until 2015"; Image: BMU / Brigitte Hiss; as at: May 2011; all figures provisional

Installed capacity and energy supply from photovoltaic installations in Germany



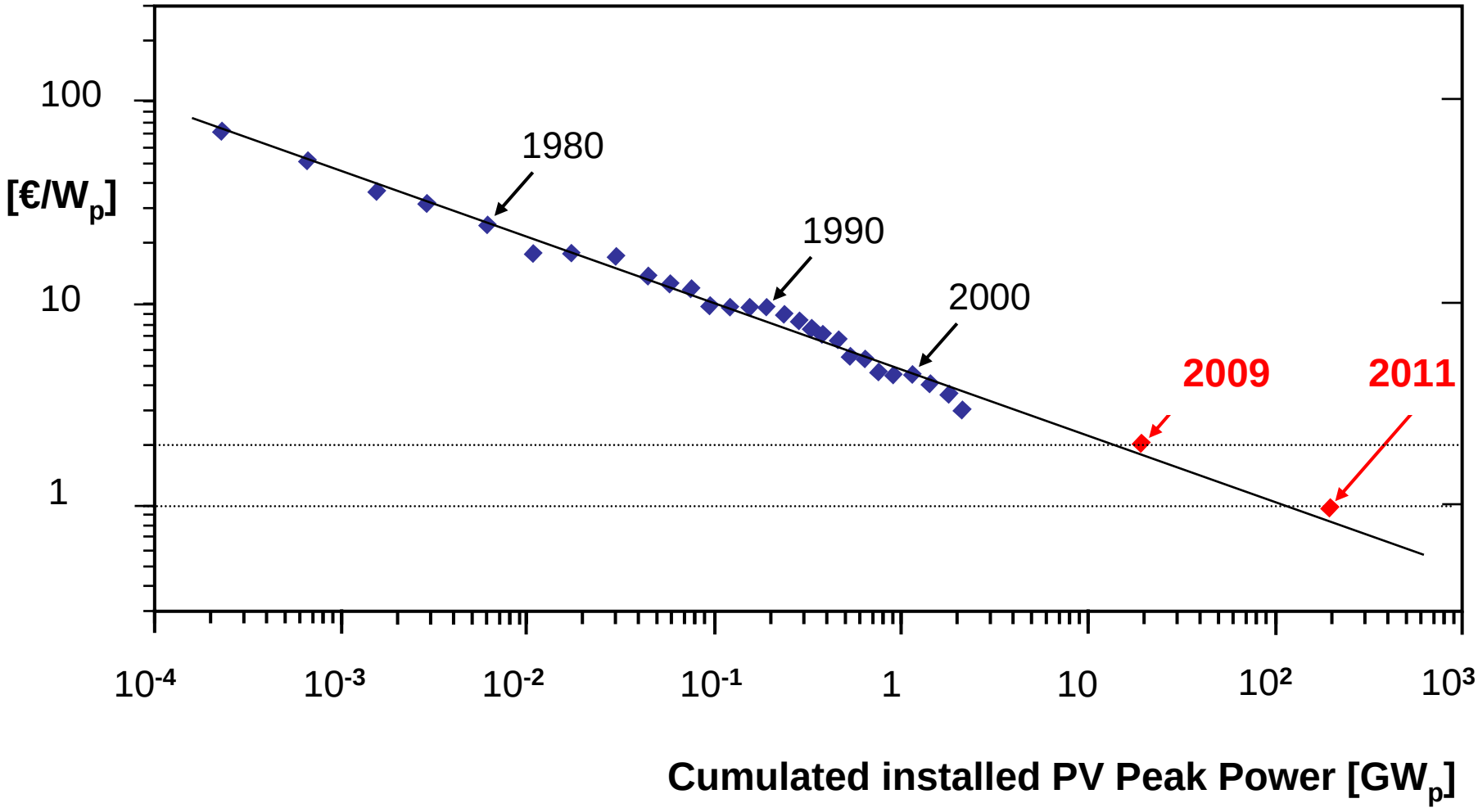
Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat);
1 GWh = 1 Mill. kWh; 1 MW = 1 Mill. Watt; image: BMU / Bernd Müller; as at: March 2012; all figures provisional

Structure of renewables-based electricity supply in Germany 2011

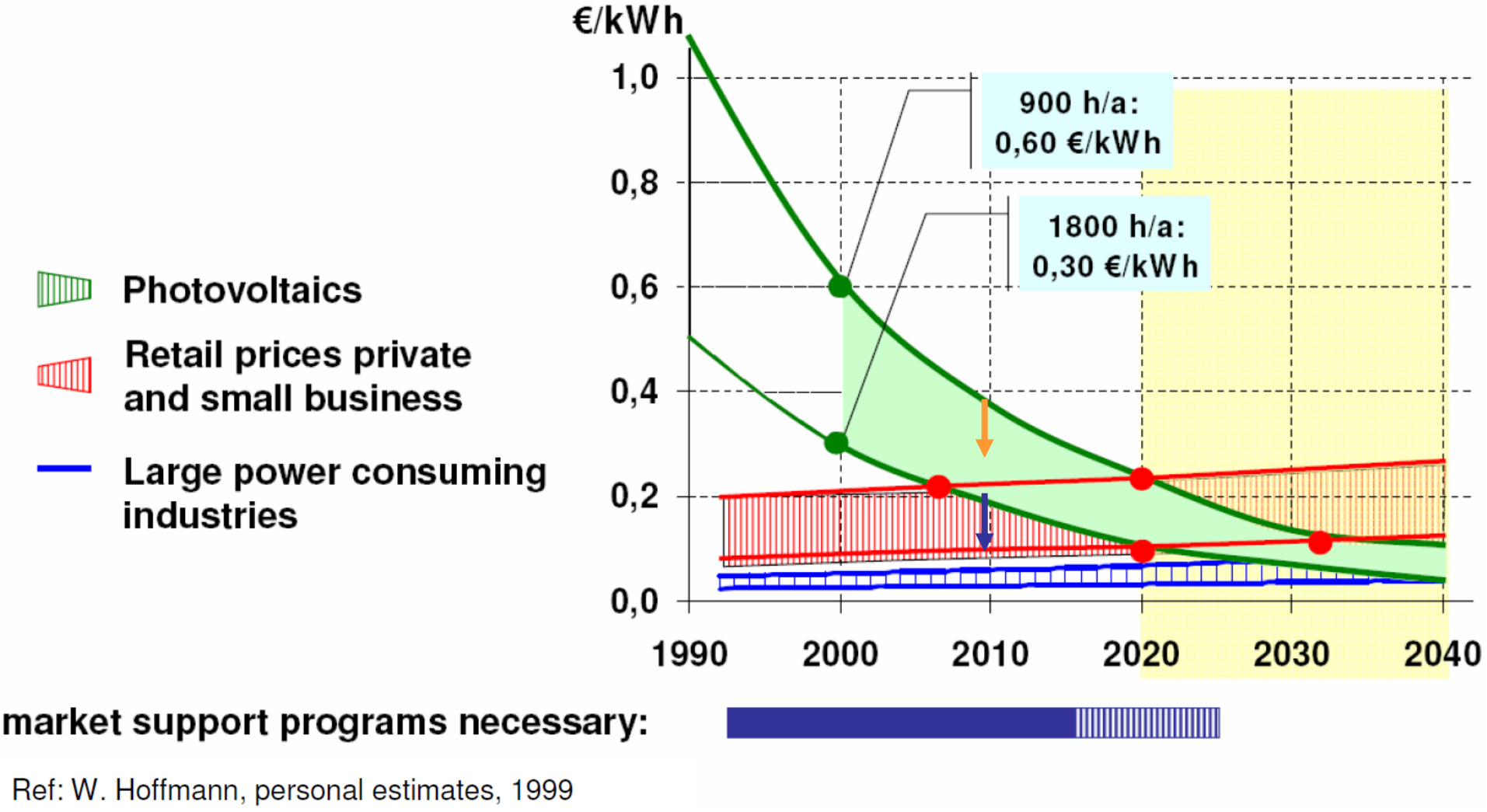


1) Vegetable oil included; 2) solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; electricity from geothermal energy not presented due to negligible quantities produced; deviations in the totals due to rounding; RES: Renewable Energy Sources; 1 TWh = 1 Bill. kWh;
source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); as at: March 2012; all figures provisional

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



Roadmap to „grid parity“ of PV

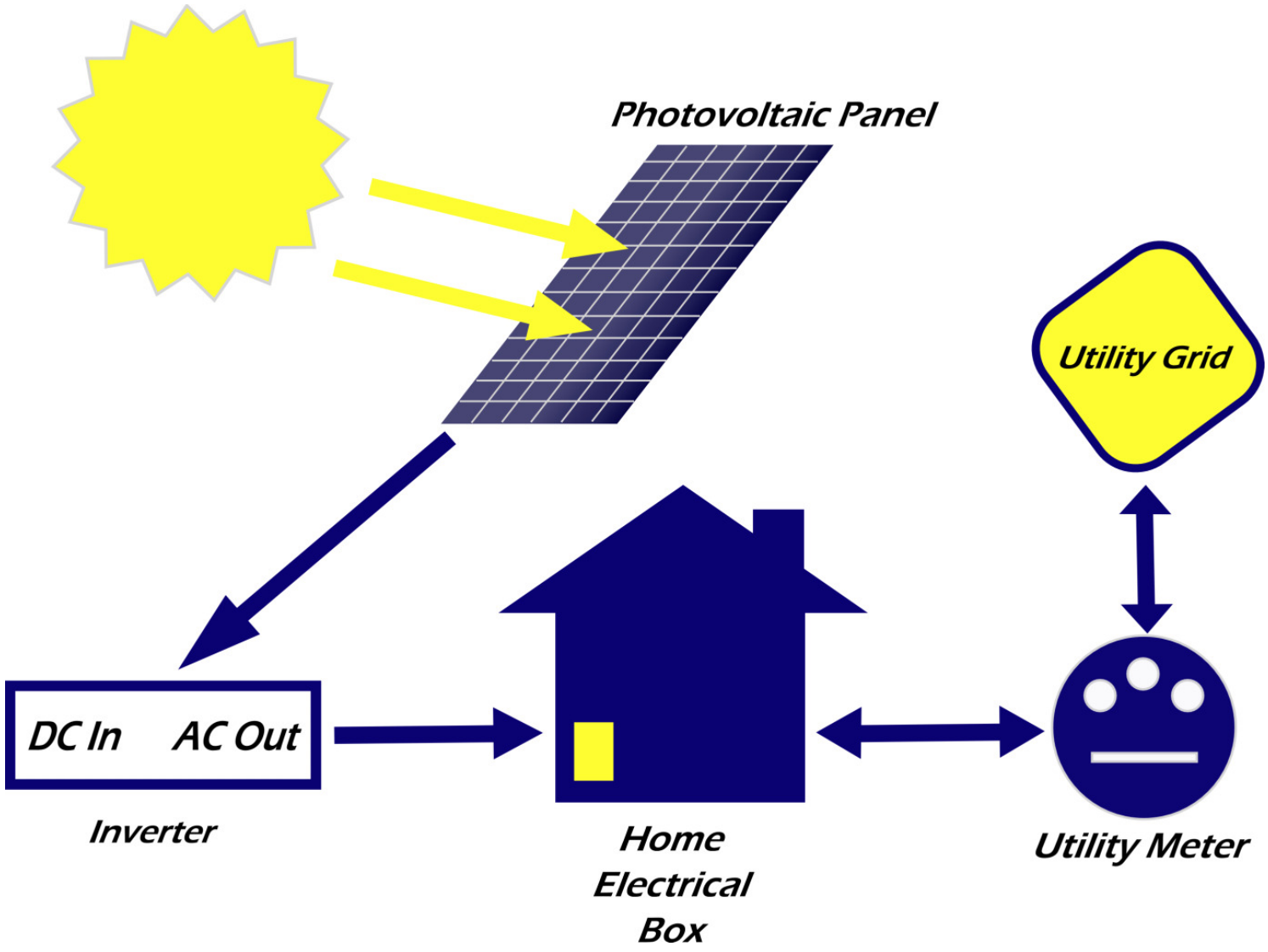


Ref: W. Hoffmann, personal estimates, 1999

Photovoltaics 3.0

Now (since 2012), PV is able to compete with consumer prices for conventional electricity, thus opening abundant markets in many countries with elevated electricity prices and sufficient irradiance. Now, system size may reach the GW-range and system prices are at 1 to 1.5 €/W_p.

Focus RIO 12 PV-Workshop: Net-Metering



Cost of a PV power plant in Brazil

Base costs from factory of a 10 MW PV power plant:

• PV modules	1.00 €/W_p
• Inverters & power electronics:	0.22 €/W_p
• Mounting structure	0.21 €/W_p
• Cables & distribution	0.14 €/W_p
• **Hardware costs:**	**15.7 mio €**
• Planning, set-up, product testing & selection	1.15 mio €
• Transport & Import	0.85 mio €
• Land preparation, foundations	1.10 mio €
• Installation	1.15 mio €,
• Grid connection	0.15 mio €
• Maintenance	0.25 mio €
• **System costs**	**20.35 mio €**

Cost of PV electricity in Brazil

- Yield:
- Performance-Ratio von 0.77, module efficiency 10%, irradiance 1750 kWh/m²a, energy generation: 154 kWh/m²a, for a 10 MW System: 13.48 GWh/a. For 20 years of lifetime and power degradation of 10% (after 10 years) **total electricity yield: 256 GWh.** Land area: 0.3 km²
- **PV electricity generation costs:**

  0.079 €/kWh = 0.18 R$/kWh (0% interest rate, zero land costs).

Data by Prof. Stefan Krauter & Riosolar

Light

LIGHT SERVIÇOS DE ELETRICIDADE SA
AV. MAL. FLORIANO 168 RIO DE JANEIRO RJ CEP 20080-002
CNPJ 60.444.437/0001-46
INSC. ESTADUAL 81380.023 INSC MUNICIPAL 00794678

Ref: Mês / Ano
NOV/2011

TENSÃO NOMINAL EM VOLTS
Disponível: 380
Limites mínimo: 348 Limites máximo: 396

Nº DO MEDIDOR	ENERGIA ATIVA								ENERGIA REATIVA EXCEDENTE			
	Medição Atual		Medição Anterior		Const	Consumo			Medição Acumulada		Const	Consumo
	Data	Leitura	Data	Leitura	Medidor	kWh			Atual	Anterior	Medidor	kWh
2312488	09/11/2011	6.548	10/10/2011	6.513	1	35		30				

Data da Emissão: 09/11/2011
Data de Apresentação: 14/11/2011

Unidade de Leitura: B04 500 11 0791

CÓDIGO DO CLIENTE | CÓDIGO DA INSTALAÇÃO

INDICADORES DE QUALIDADE
Mês de referência: Setembro/2011
Conjunto: COPACABANA

Indicadores	Apurado Mensal	Meta Mensal	Meta Trimestral	Meta Anual
DIC	0,00	4,00	8,00	16,00
FIC	0,00	2,80	5,60	11,20
DMIC	0,00	2,09	---	---

DIC - Duração de interrupção individual
FIC - Frequência de interrupção individual
DMIC - Duração máxima de interrupção contínua

VALOR DO ENCARGO DE USO DO SISTEMA DE DISTRIBUIÇÃO:
R$ 22,22

O cliente tem o direito de solicitar a qualquer tempo a apuração dos indicadores DIC, FIC e DMIC e também receber uma compensação, caso sejam violadas as metas de continuidade individuais – mensal, trimestral e anual – relativos à unidade consumidora de sua responsabilidade.

DATA PREVISTA DA PRÓXIMA LEITURA
09/12/2011

DESCRIÇÃO	CFOP	UNIDADE	QUANT.	PREÇO UNIT R$	VALOR R$
CUSTO DISPONIBILIDADE SISTEMA	5.258	kWh	100	0,41756	41,75
Subtotal Faturamento (Veja abaixo)					41,75
Subtotal Outros					0,00

Após o vencimento haverá multa de 2%, juros e atualização de IGP-M, cobrados em conta posterior (Res. ANEEL nº 414 de 09/09/10 e Lei 10.762 de 11/11/2003)

Valor da Energia	Valor da Transmissão	Valor da Distribuição	Encargos Setoriais	Tributos	Total
14,48	2,23	10,85	4,44	9,75	41,75

Tarifas em R$/kWh sem impostos: 0,32023
PIS/COFINS R$ 2,21

	ICMS R$	Total da Nota Fiscal R$	VENCIMENTO	TOTAL A PAGAR R$
Base de Cálculo	41,75			
Alíquota	18%			
Valor (já incluído no preço)	7,52	*********41,75	23/11/2011	********41,75

41,75 R$ / 35 kWh =

1,19 R$/kWh

DESCRIÇÃO	CFOP	UNIDADE	QUANT.	PREÇO UNIT R$	VALOR R$
CUSTO DISPONIBILIDADE SISTEMA	5.258	kWh	100	0,41756	41,75
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R$ 22,22

O cliente tem o
indicadores DIC, FIC
violadas as metas
relativos à unidade

DATA PREVIST

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VENCIMENTO	TOTAL A PAGAR R$
23/11/2011	*********41,75

CONSUMO MÉDIO

kWh

COMUNICADO AO CLIENTE: REAJUSTE TARIFÁRIO

A Agência Reguladora – ANEEL, através da Resolução Homologatória Nº 1232, de 01/11/2011, autorizou o reajuste de 7,98% nas tarifas de fornecimento de energia elétrica para os consumidores de Baixa Tensão da Light, com vigência a partir de 07/11/2011.

1/2011

RIO 12 - workshop

PV in Brazil is unavoidable!

How does the legal framework work?

How we can set up business models?

What technical issues have to be considered?

Program of *RIO 12* – Expert Workshop on grid-connected PV

- **9.00** *Opening*
- **9.15** Prof. Dr. Stefan Krauter, Photovoltaik Institut Berlin, University of Paderborn, Germany: *PV 3.0 – History of PV: From indispensible markets to policy-driven markets to natural markets.*
- **9.45** Fabio Stacke, Superintendência de Pesquisa e Desenvolvimento e Eficiência Energética – ANEEL, Brasilia : *Arranjos Técnicos e Comerciais para Inserção da Geração Solar Fotovoltaica na Matriz Energética Brasileira* e a nova Resolução de Mini e Microgeração.
- **10.15** Coffee break
- **10.45** Prof. Dr. Ingo Stadler, University of Applied Sciences Cologne, Germany: *German technical minimum requirements for the connection of power generators to the low voltage distribution network*
- **11.15** Dr. Klaus Preiser, Badenova, Freiburg, Germany: *Integration of PV-Systems in the low voltage grid – experience of the German Utility Badenova*
- **11.45** Miguel Ornlelas, Grupp Asunim, Faro, Portugal: *Garantia da Qualidade e Rastreabilidade para Painéis Fotovoltaicos*

Program of *RIO 12* – Expert Workshop on grid-connected PV

- **12.30** Lunch
- **14.00** Round Table and Discussion (max. 10 minutes presentation each, 2 hours of discussion in total)
- **Challenges for the PV market in Brazil**
- Moderation: Stefan Krauter, University of Paderborn
  - Production: Adão Linhares Muniz, Energo, Brazil.
  - Regulation: Fabio Stacke, Especialista em Regulação, ANEEL, Brasilia
  - Market development: Leónidas Andrade, ABINEE, Brazil

- **17.30** Final Remarks
- 19.30 Light Dinner: Rio Szenarium

Let's improve conditions for investments here !

The organization team wishes you a fruitful RIO 12 – workshop !

Thanks to our sponsors:
Arinna Solar, GIZ, Uni Paderborn

Obrigado e bom sucesso !

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Die Universität der Informationsgesellschaft

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