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Solar energy: vulnerability to extreme events from climate change

Anthony G. Patt, Stefan Pfenninger & Johan Lilliestam

International Institute for Applied Systems Analysis
Laxenburg
Austria

Strada Costiera 11, 34151 Trieste, Italy - Tel.+39 040 2240 111; Fax +39 040 224 163 - sci_info@ictp.it

Solar energy:
vulnerability to extreme events from climate change

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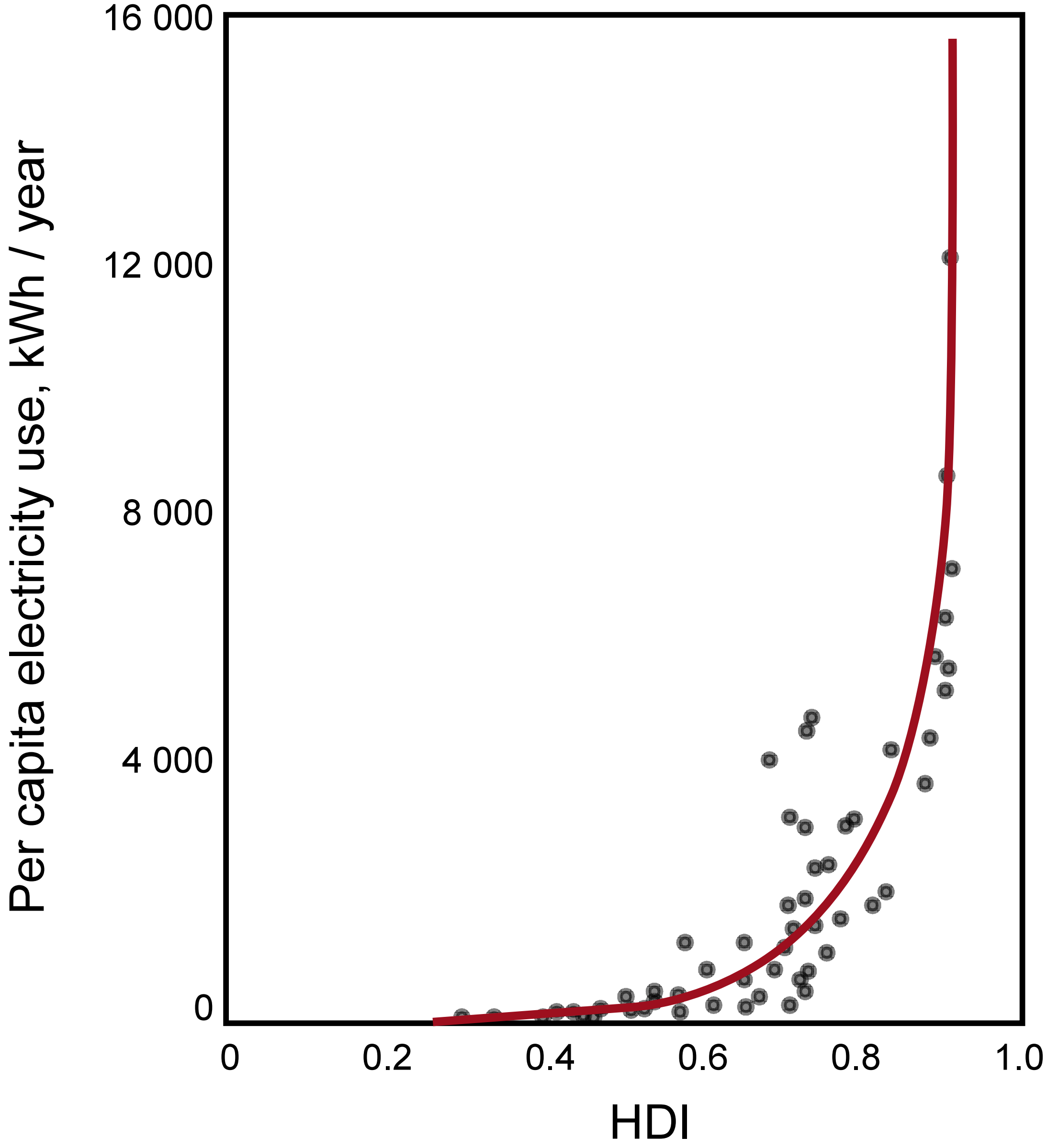
International Centre for Theoretical Physics, Trieste
21 April 2010

Outline

- Why solar energy matters
- Current and future prospects
- Technical aspects leading to vulnerability
- Changes in climate extremes
- Discussion

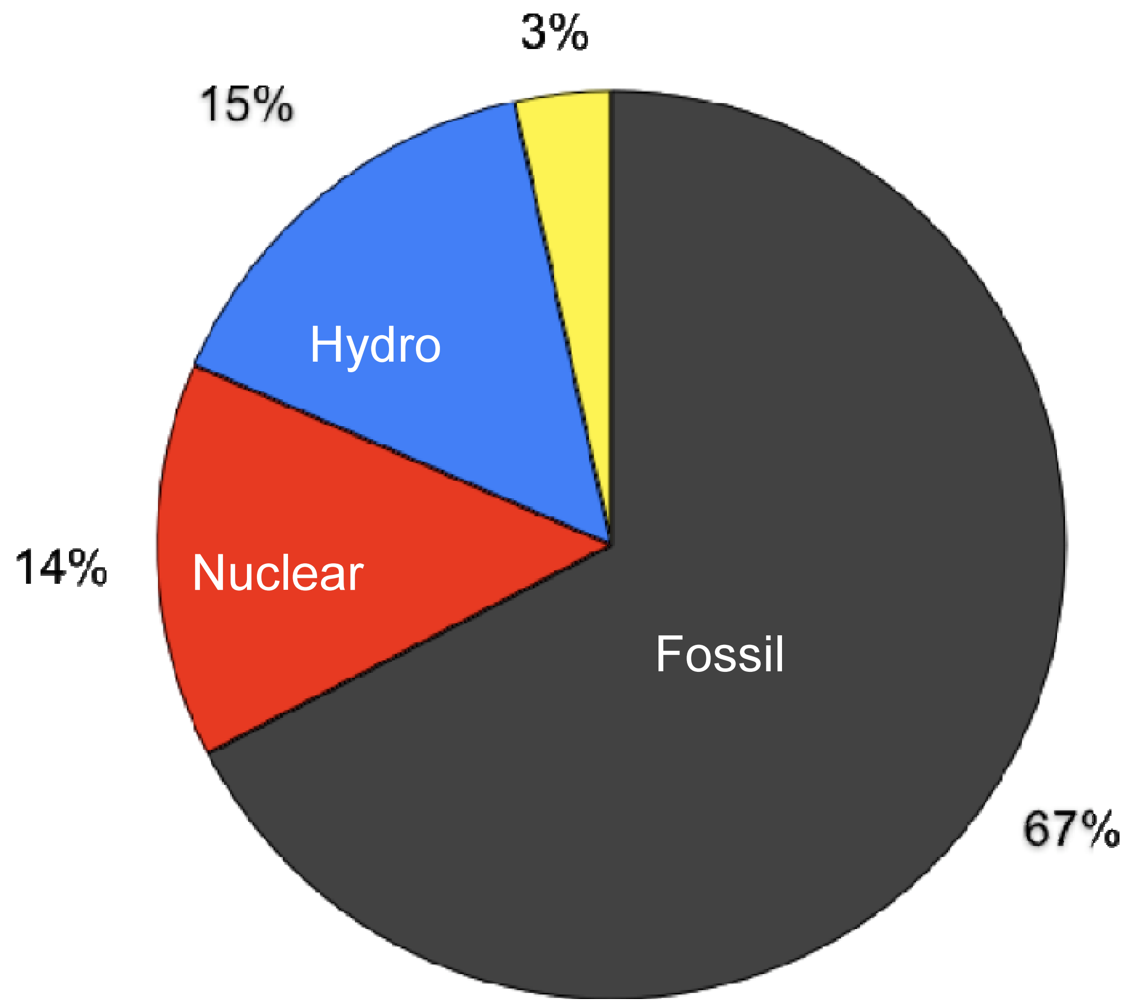
Why solar energy matters



Source: Pasternak et et al, 2000

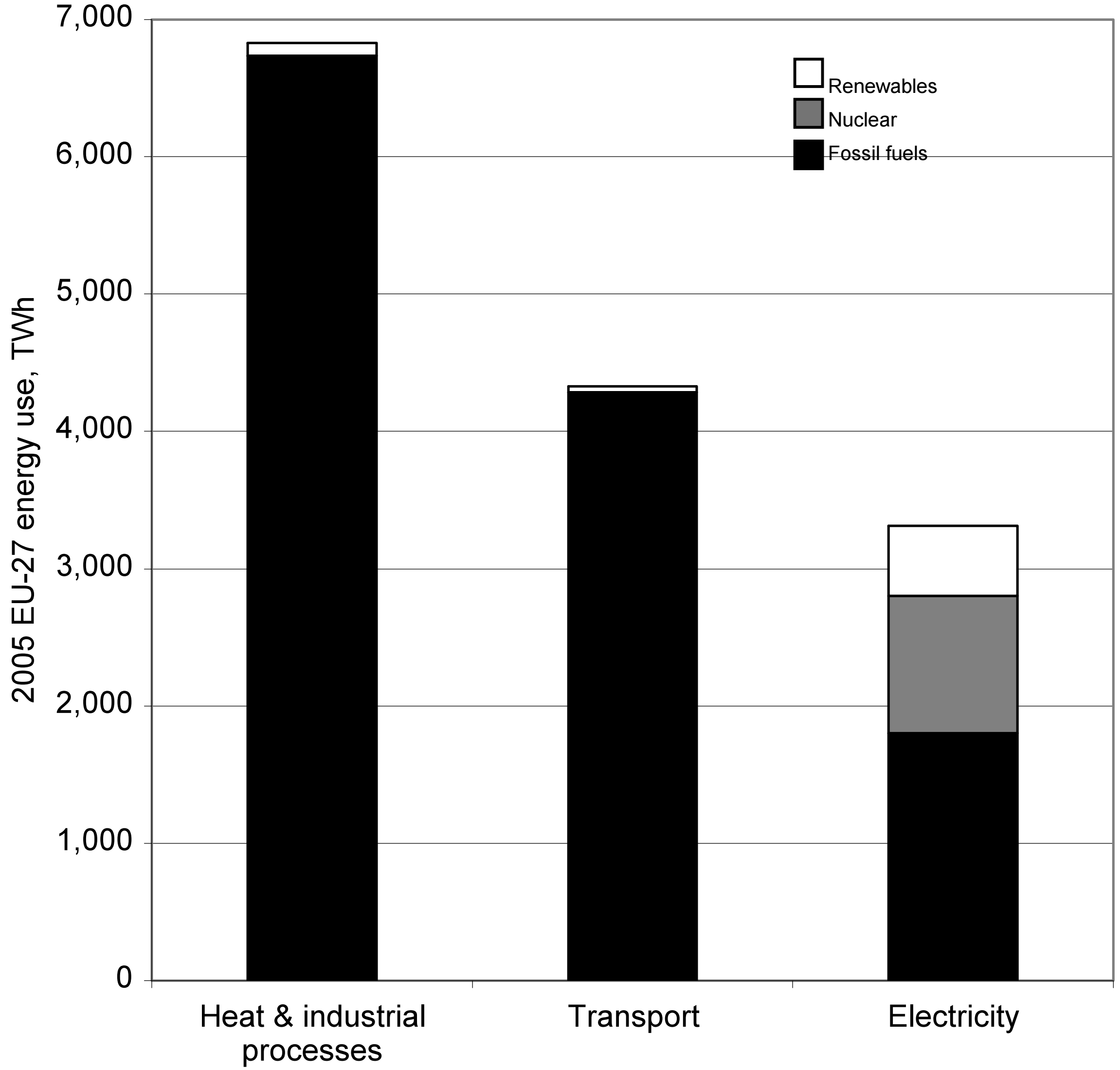
Why solar energy matters

Electricity supply, global, 2005



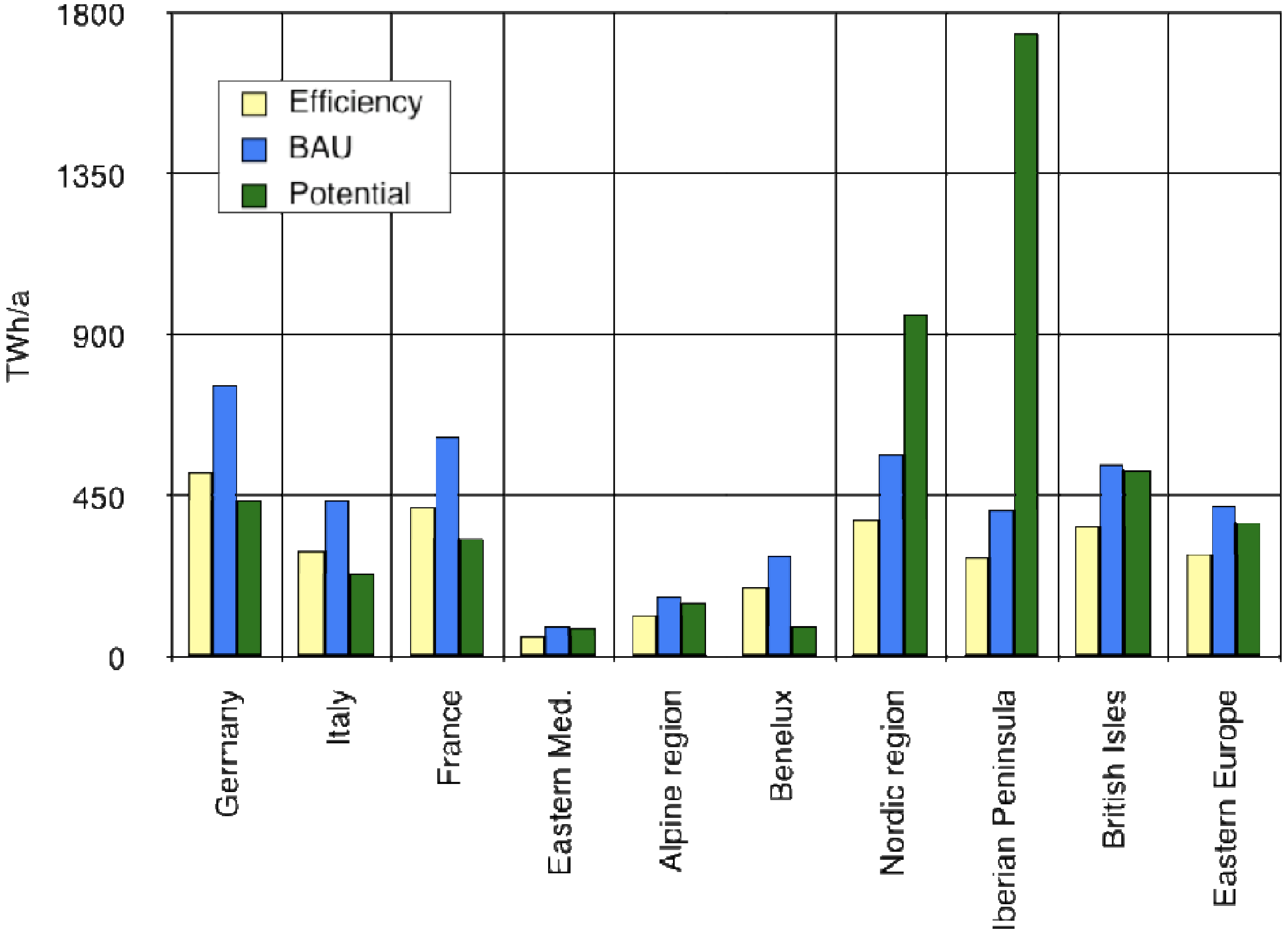
Source: IEA, 2006

Why solar energy matters



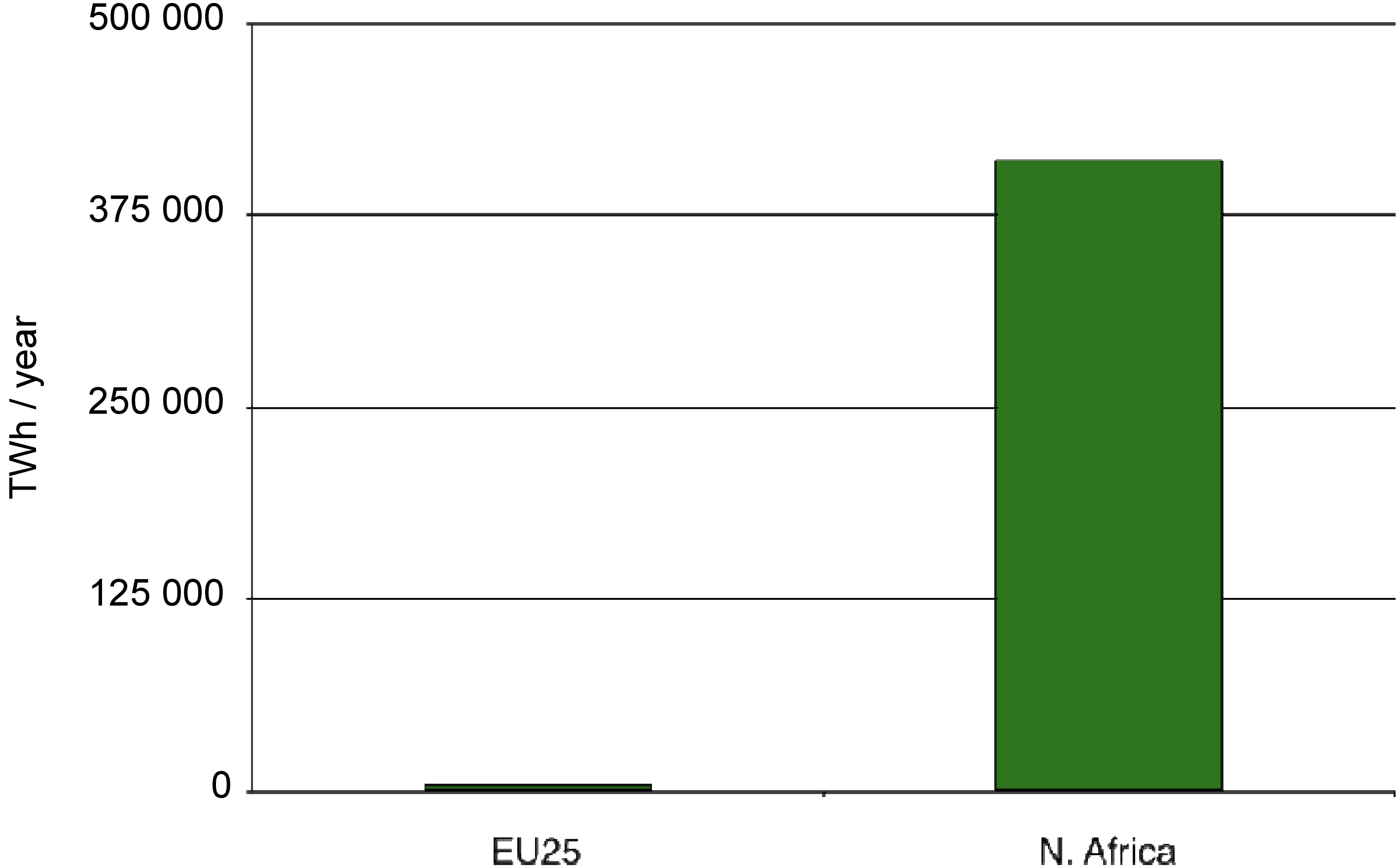
source: International Energy Agency

Why solar energy matters



Sources: DLR 2005:56; DLR 2006:43; EIE 2006:29ff; Eurostat 2006:16; IEA 2007

Why solar energy matters



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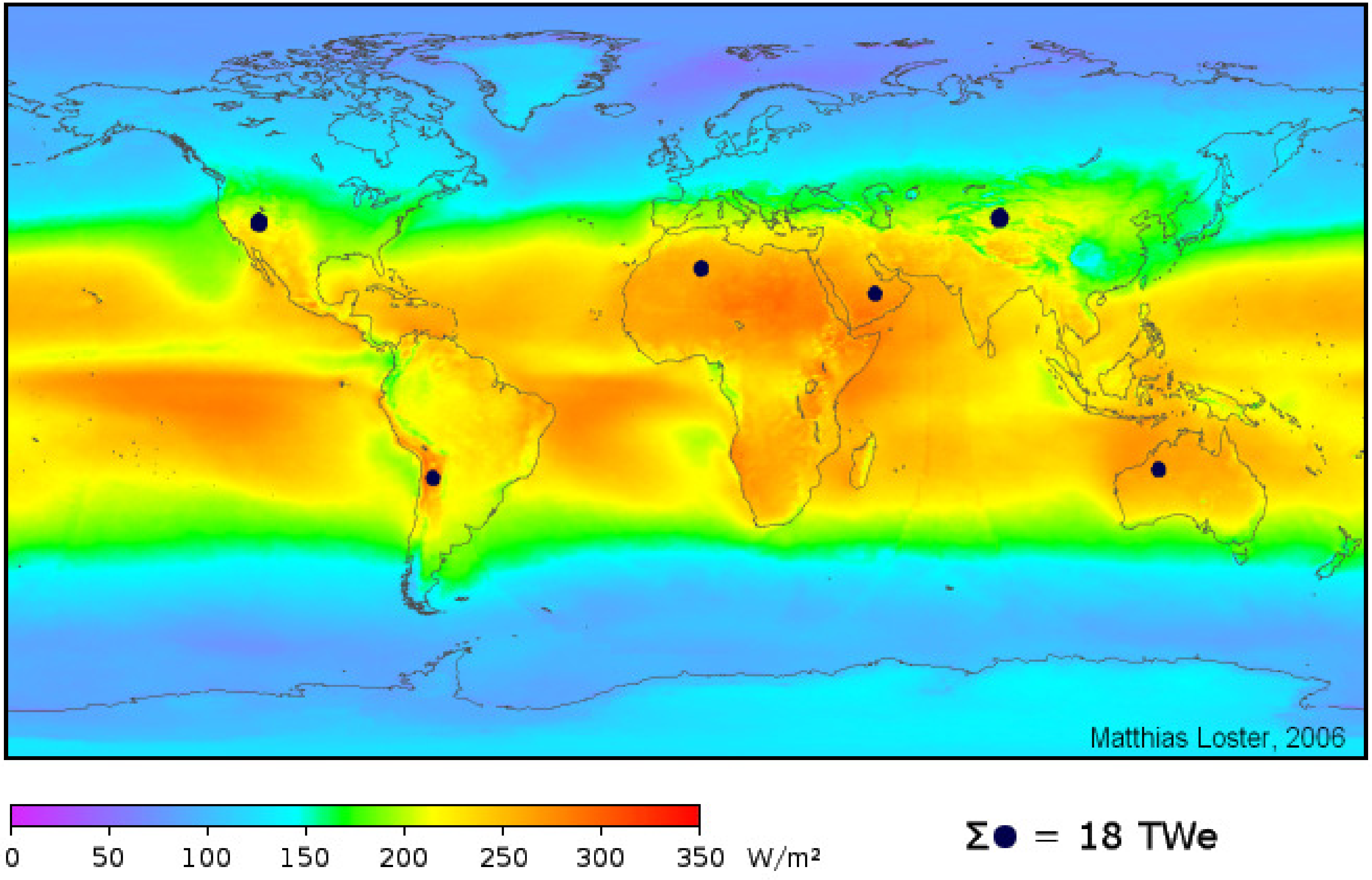
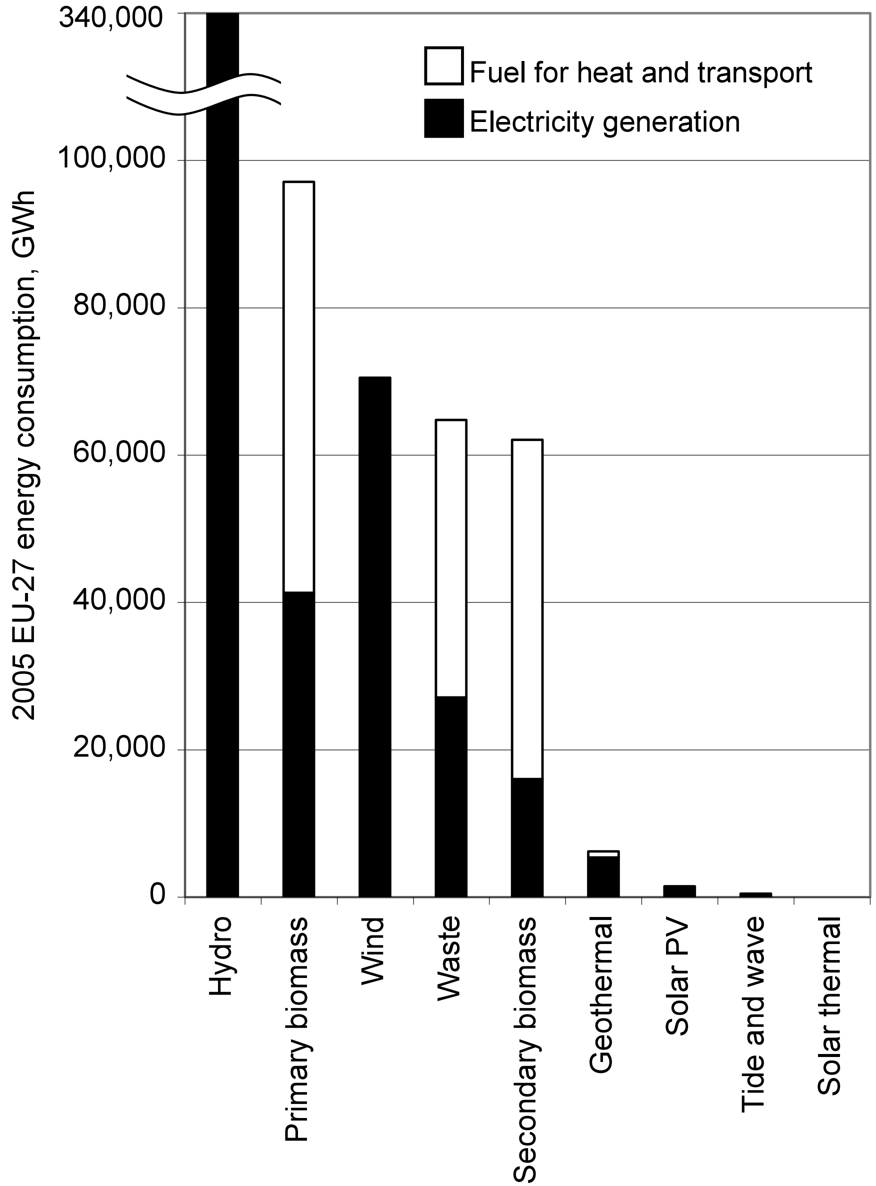
Why solar energy matters

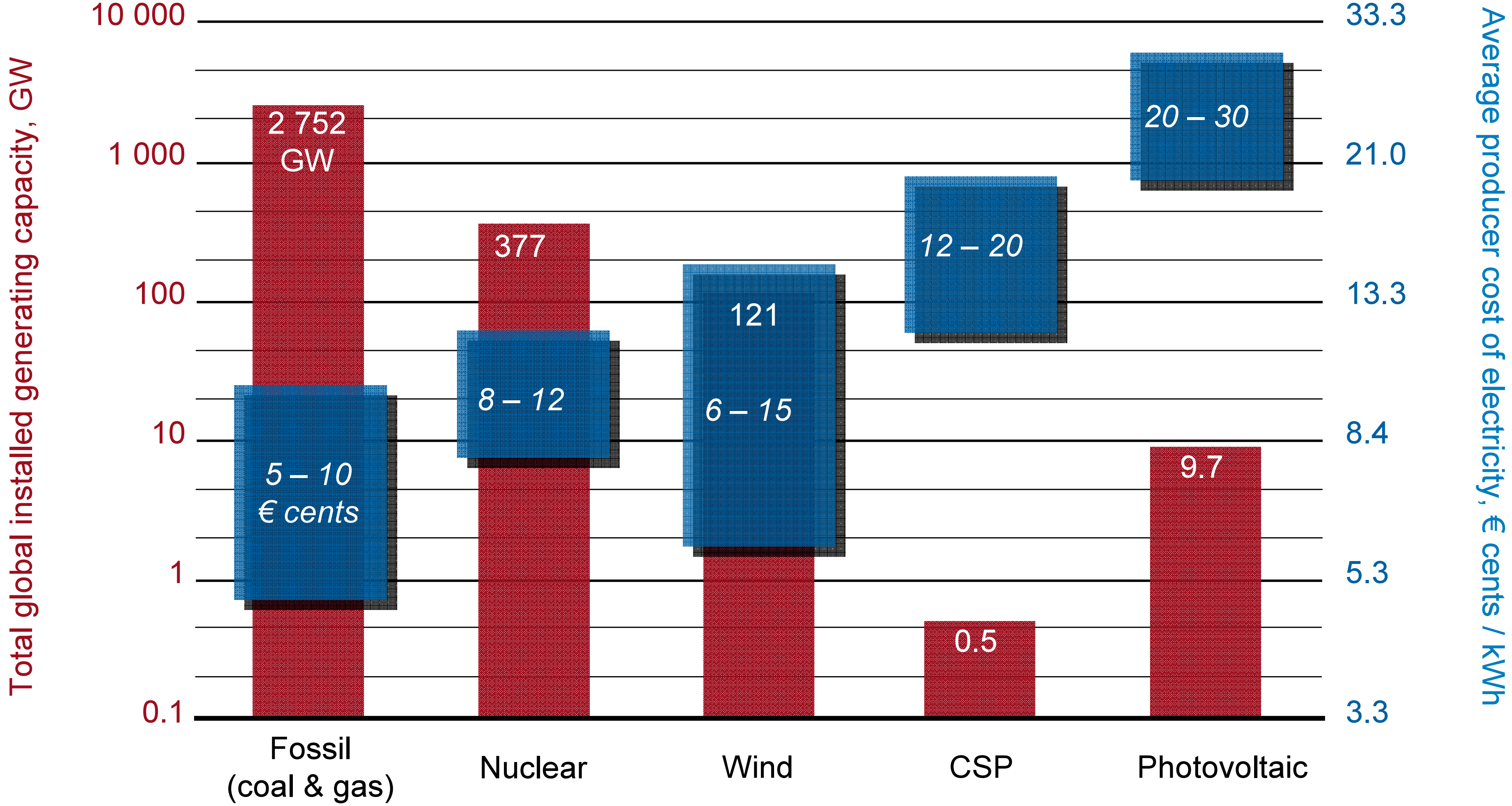


Current and future prospects



source: International Energy Agency

Current and future prospects



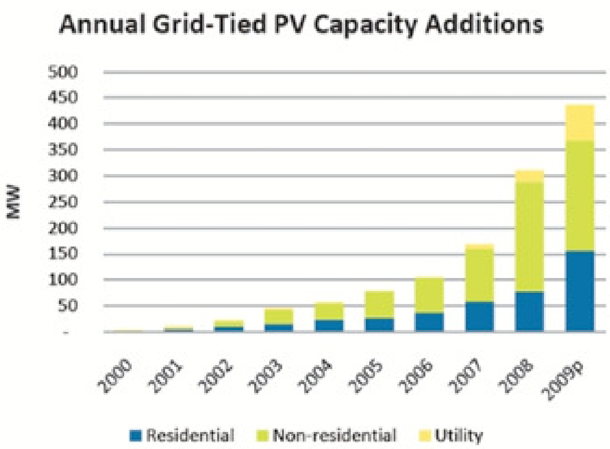
Sources: IEA, EIA, EWEA, NREL, DLR

Current and future prospects

Posted on April 16, 2010 by Graham Jesmer, Staff Writer

US Solar Sees 38% Growth in PV Capacity in 2009

Washington, D.C., United States [RenewableEnergyWorld.com]
The Solar Energy Industries Association (SEIA) this week released the 2009 U.S. Solar Industry Year in Review, finding another year of strong growth despite the economic recession. Overall U.S. solar electric capacity increased by 37 percent (photovoltaic and concentrating solar power combined). This was driven primarily by strong demand in the residential and utility-scale markets, resulting in a 36 percent increase over 2008 in overall revenue.



Grid-tied photovoltaic installations grew by 38 percent. Residential grid-tied PV solar installations doubled from 78 megawatts (MW) to 156 MW while non-residential grid-tied PV solar installations grew 2 percent less than in 2008. The utility market tripled their cumulative grid-tied PV capacity from 22 MW to 66 MW.

Over that same time period, solar water heating shipments grew by 10 percent over 2008 while solar pool heating growth was 10 percent less than 2008 growth, reflecting construction and housing declines.

On a call to discuss the results, Freeman Ford, founder of FAFCO said that while the U.S. solar thermal is seeing much larger growth than in recent years, the market lags behind the rest of the world.

Posted on April 9, 2010 by David Appleyard, Associate Editor

Parabolic Growth

CSP Moves Into the Mainstream

London, UK [Renewable Energy World Magazine]
Some 150 years after the French mathematician Augustin M
solar energy, the father of CSP technology would no doubt b
Mouchot's vision is at last becoming a reality, given the evid

Use of
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reason that CSP has attracted the interest not only of utility companies keen to expand on their renewable portfolios, but also original equipment manufacturers which have traditionally supplied the utility market.

Certainly, one of the clearest signs that the CSP sector is maturing came from the autumn 2009 acquisition of CSP technology company Solel by Germany engineering colossus Siemens.

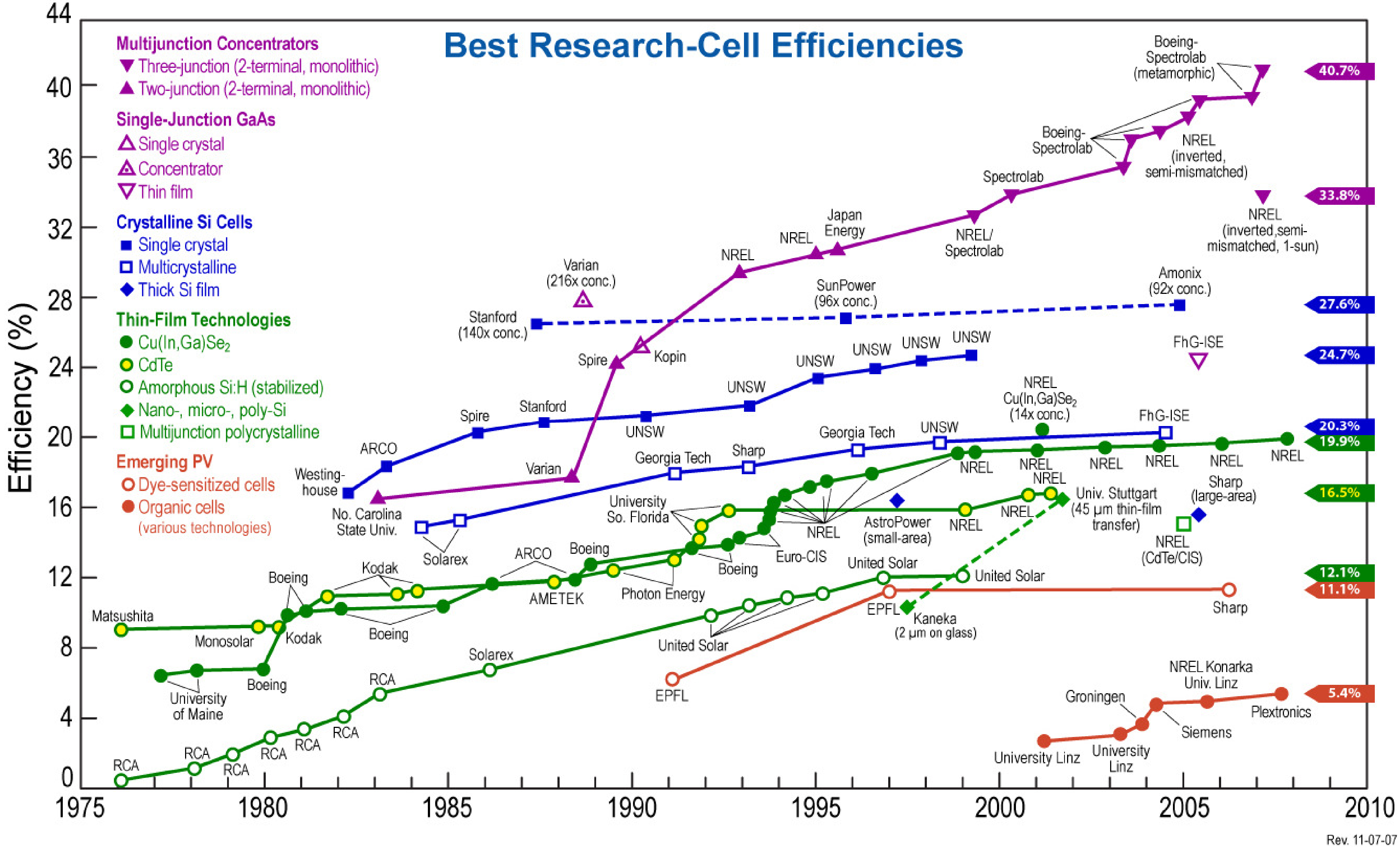
Siemens acquired the remaining 63% stake in Israel-based

Technical aspects leading to vulnerability: PV

Thin film

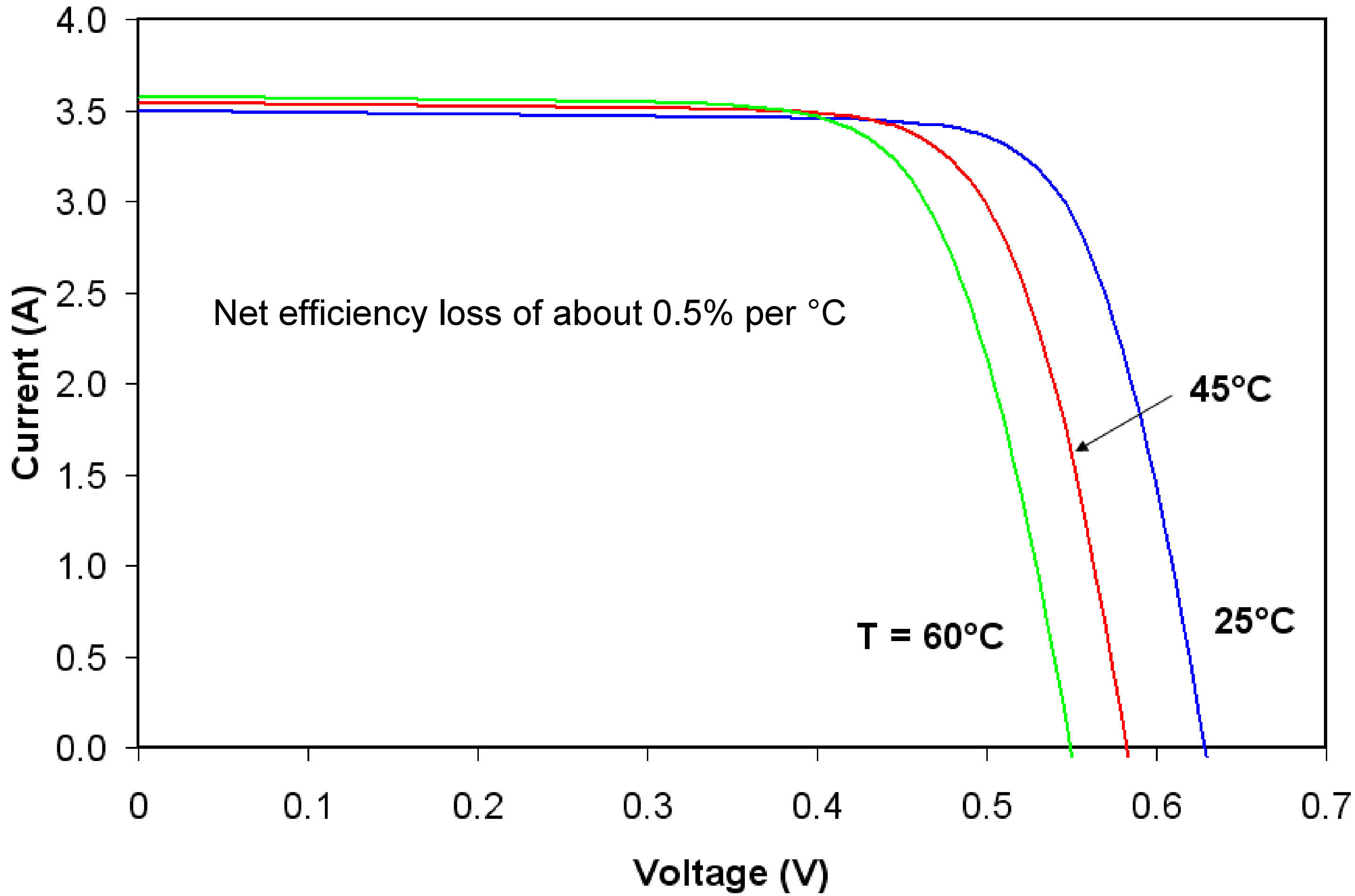
Crystalline silicone

Technical aspects leading to vulnerability: PV



Source: US DoE 2007

Technical aspects leading to vulnerability: PV



Source: SQM 2008

Technical aspects leading to vulnerability: PV

Current standard:
withstand 11 impacts
of 25 mm hailstones

Changes in climate extremes

TORRO Scale

Level	Intensity category	Typical hail diameter (mm)[a]	Typical damage impacts
H0	True (hard) hail	5–**9** (pea)	No noticeable damage
H1	Potentially damaging	10–**15** (large pea, mothball)	Slight general damage to plants, crops
H2	Significant, damaging	16–**20** (marble, grape)	Significant damage to fruit, crops, vegetation
H3	Severe	21–**30** (large marble, walnut)	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	"	31–**40** (pigeon's egg, squash ball)	Widespread glass damage, vehicle bodywork damage
H5	Destructive	41–**50** (golf ball, pullet's egg)	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	"	51–**60** (hen's egg)	Bodywork of grounded aircraft dented, brick walls pitted
H7	"	61–**75** (tennis ball>cricket ball)	Severe roof damage, risk of serious injuries
H8	"	76–**90** (large orange>small soft ball)	(Severest recorded in the British Isles) Severe damage to aircraft bodywork
H9	Super hailstorms	91–**110** (soft ball, grapefruit)	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	"	>**110** (melon)	"

Source: Webb et a., 2009

Technical aspects leading to vulnerability: thermal

Flat plate

Evacuated tube

Technical aspects leading to vulnerability: thermal

Flat plate	Hailstorm vulnerability low (up to 35mm) Up to 50% loss of efficiency at very low temperatures
Evacuated tube	Hailstorm vulnerability higher (25mm destroys one third) 20% loss of efficiency at very low temperatures

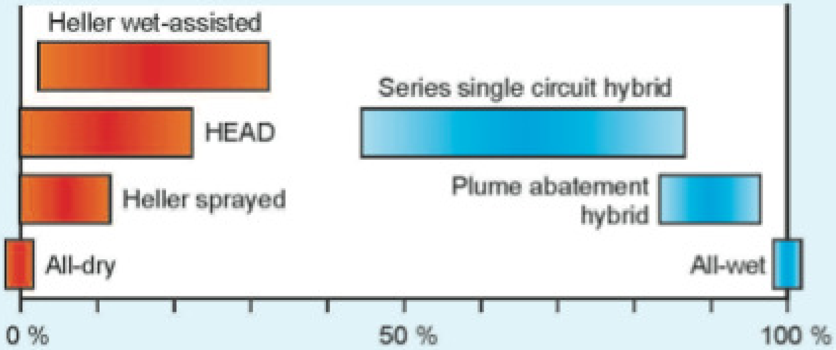
Technical aspects leading to vulnerability: CSP

Tower

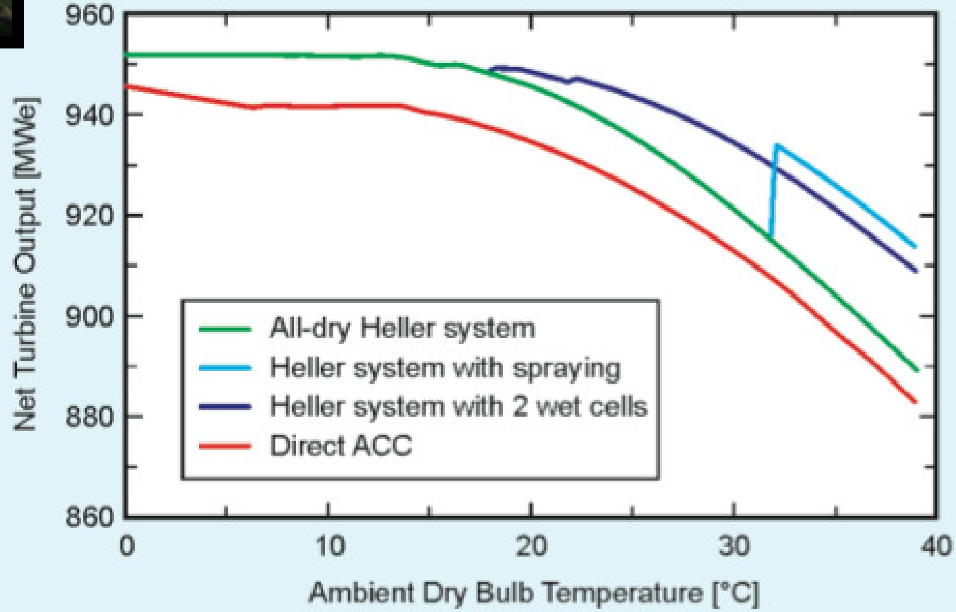
Parabolic trough

Technical aspects leading to vulnerability: CSP

Water requirements



Temperature and power output



Source: PPC 2009

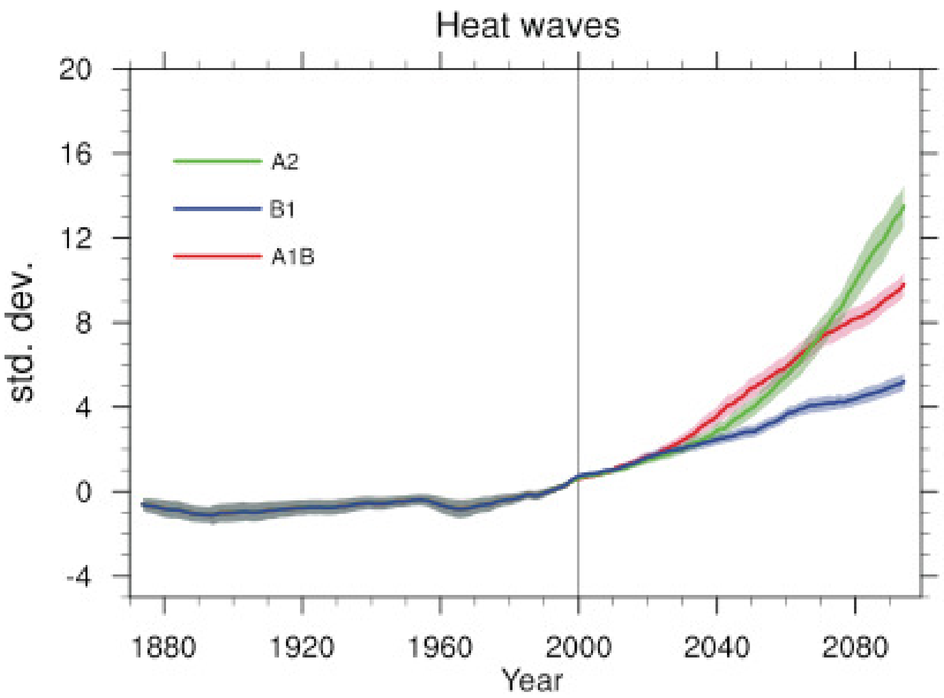
Technical aspects leading to vulnerability: CSP

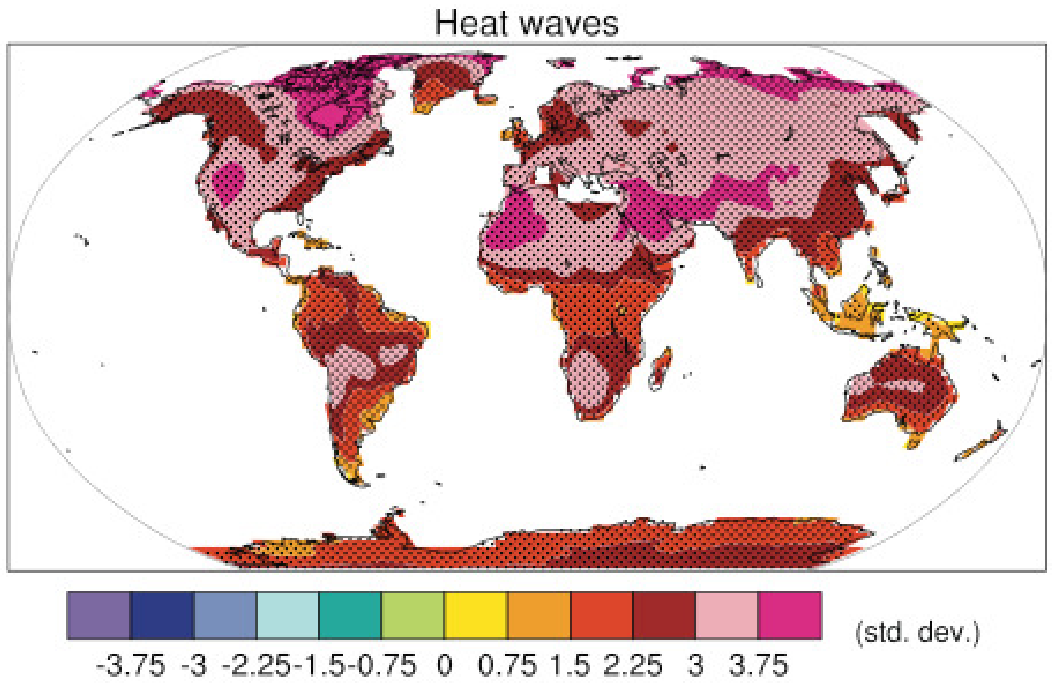
Changes in climate extremes

	1951 – 2003	1979 – 2003
Cold nights	– 1.17 +/– 0.20	– 1.24 +/– 0.44
Warm nights	1.43 +/– 0.42	2.60 +/– 0.81
Cold days	– 0.63 +/– 0.16	– 0.91 +/– 0.48
Warm days	0.71 +/– 0.35	1.74 +/– 0.72

Source: IPCC

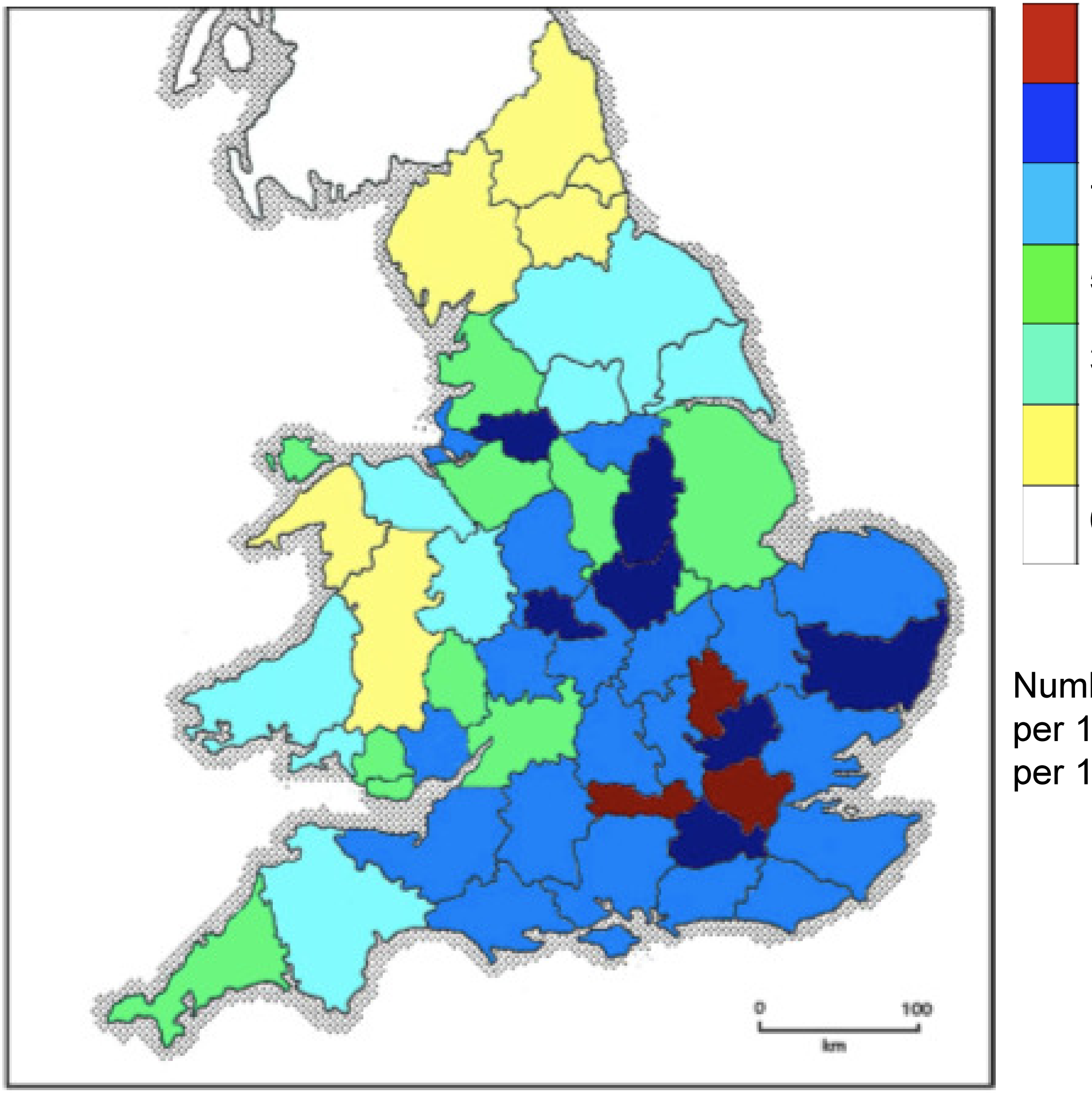
Changes in climate extremes





Source: IPCC

Changes in climate extremes



Number of storms H2 or more, per 1000km^2 per 100 years

Source: Webb et a., 2009

Changes in climate extremes

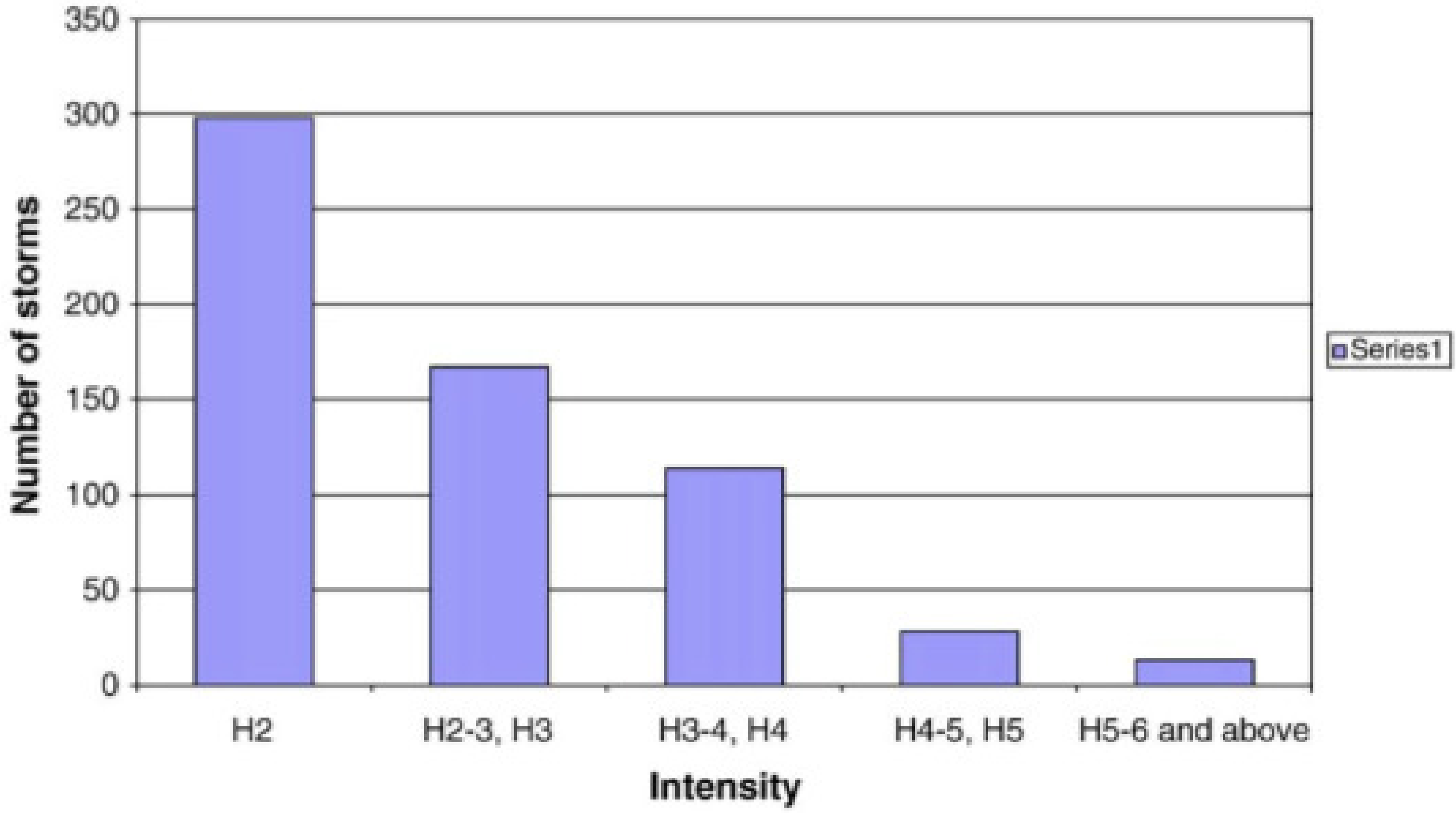
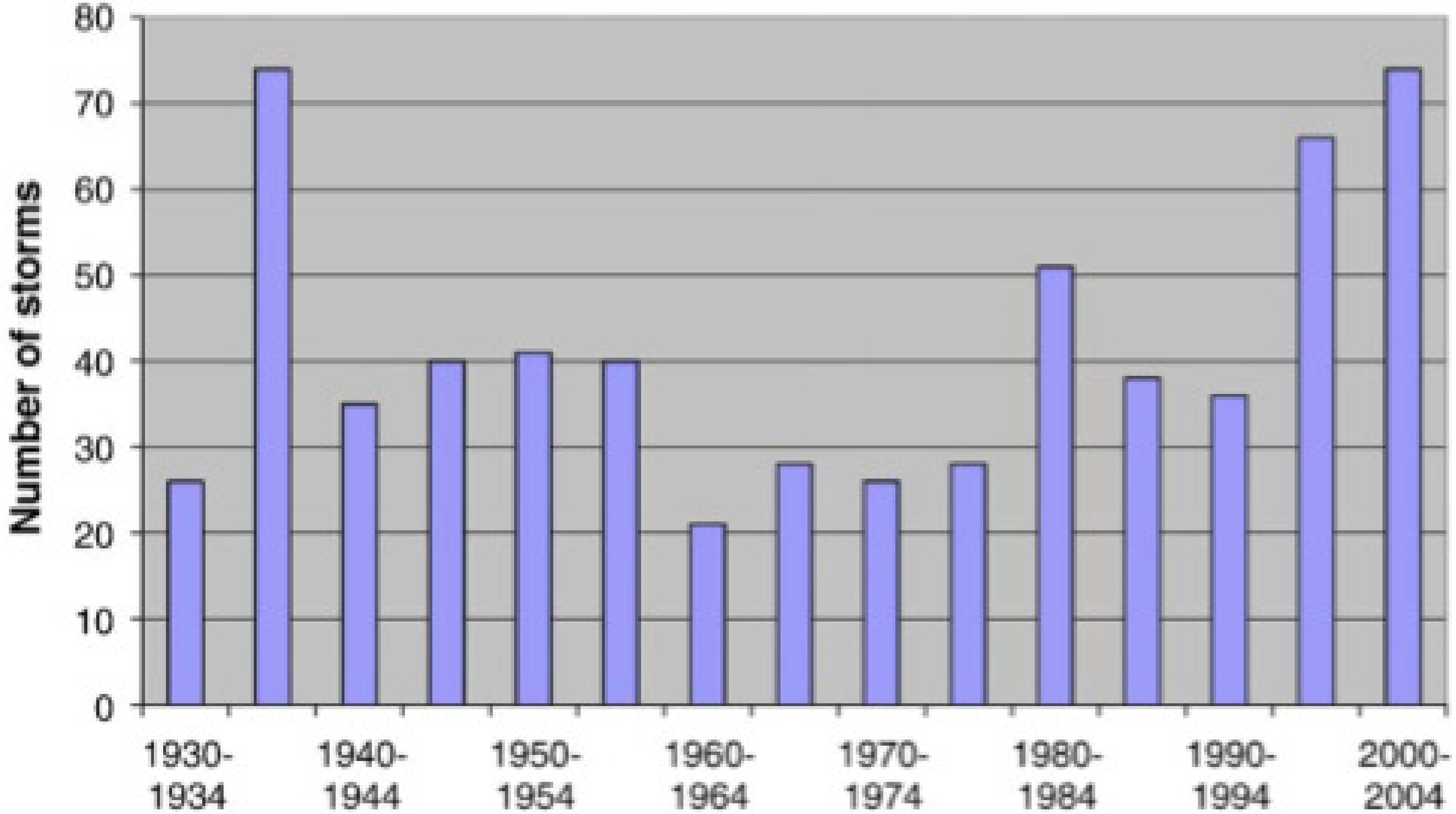


Fig. 3. Number of significant hailstorms above various H scale thresholds, Great Britain 1930–2004.

Source: Webb et a., 2009

Changes in climate extremes

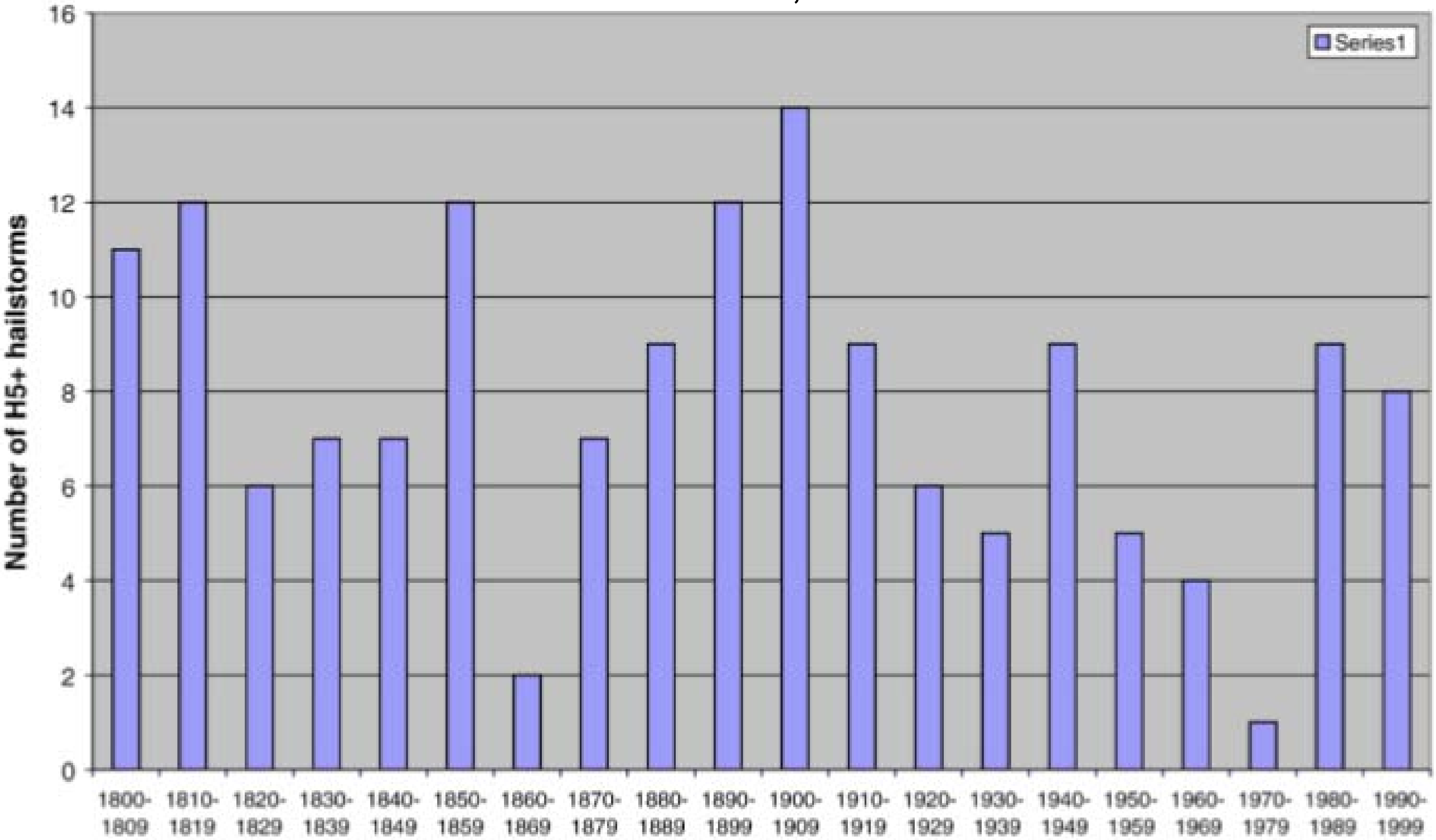
Number of storms over Great Britain, H2+



Source: Webb et a., 2009

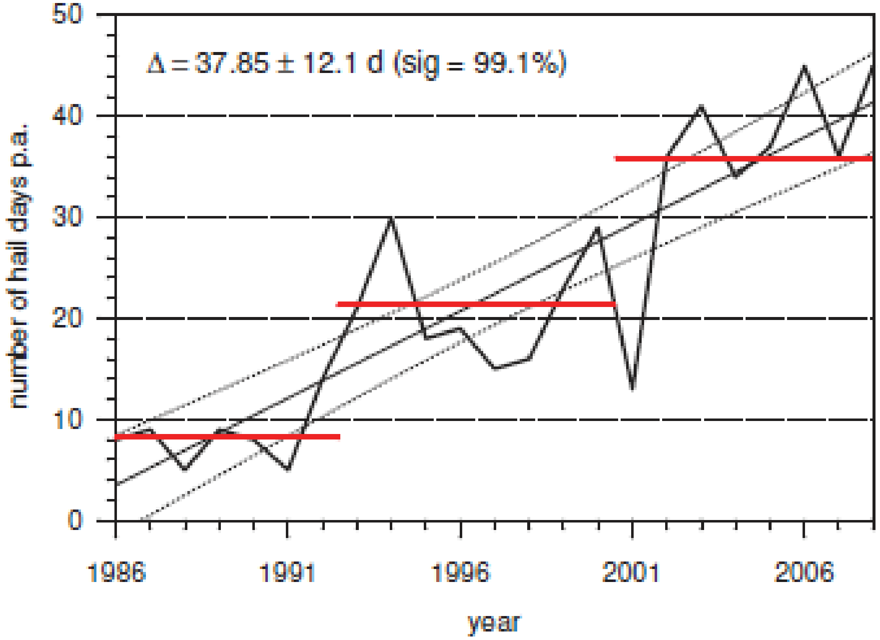
Changes in climate extremes

Number of storms over Great Britain, H5+



Source: Webb et a., 2009

Changes in climate extremes



Data from southwest Germany
Kuntz & Mohr, 2009

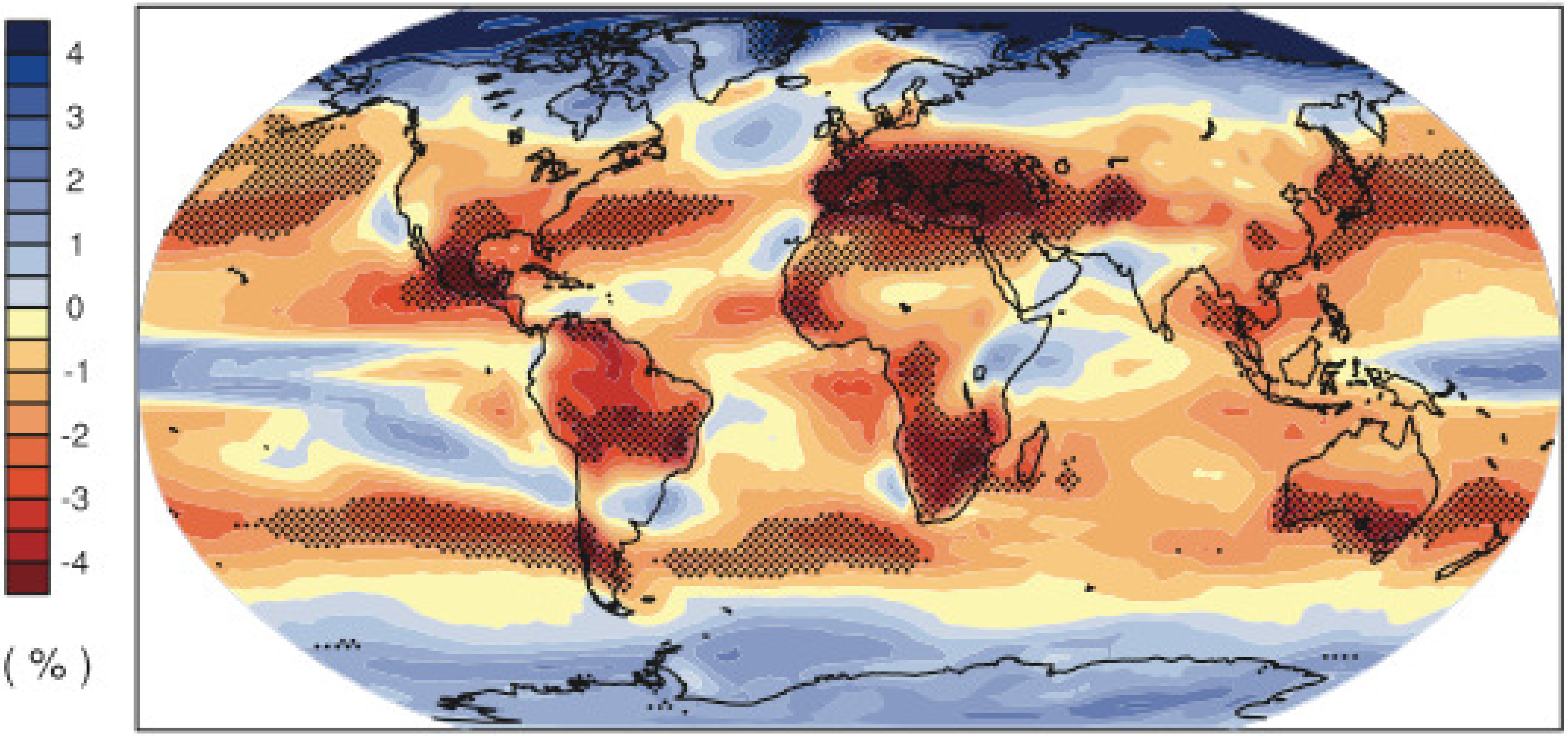
- 26 - 46% increase in hailstorm damage in the Netherlands associated with a 2°C temperature increase (Botzen et al., 2009)
- No significant change in hailstorm risk for Australia (Niall & Walsh, 2005)

Changes in climate extremes

- Increase in the intensity of tropical cyclones
- Increase in the proportion of rainfall occurring during high rainfall events
- Mixed findings on the increase of wind speed of extra-tropical storms

Changes in climate extremes

Changes in cloud cover by 2100



Source: IPCC

Discussion

	Thermal heating	*PV*	*CSP*	*Future trend*
Heat waves		Reduced output and potential material damage	Reduced output due to cooling problems	Increase
Cold waves	Reduced output			Decrease
Hail	Potential material damage	Potential material damage		No clear trend
Strong wind	Material damage from debris, and need for cleaning	Material damage from debris, and need for cleaning	Reduced output, material damage, and need for cleaning	Potential increase, but regionally variable
Prolonged cloudiness	Reduced output	Reduced output	Reduced or eliminated output	Increase at high latitudes, decrease at low latitudes