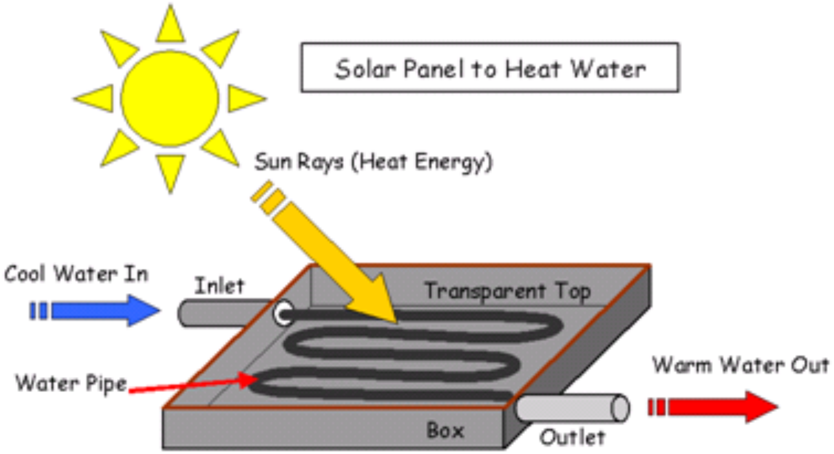
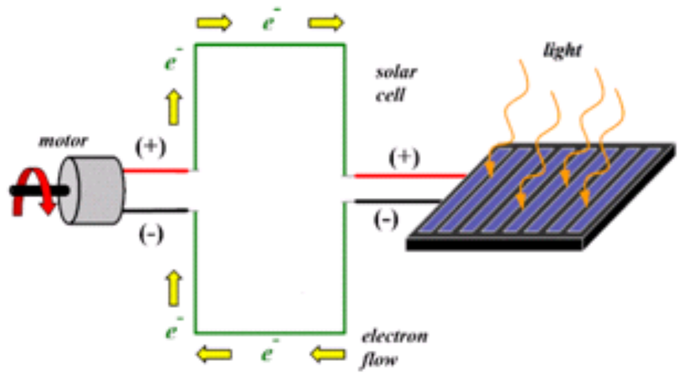
Solar energy and climatology

Robert Pasicko, UNDP

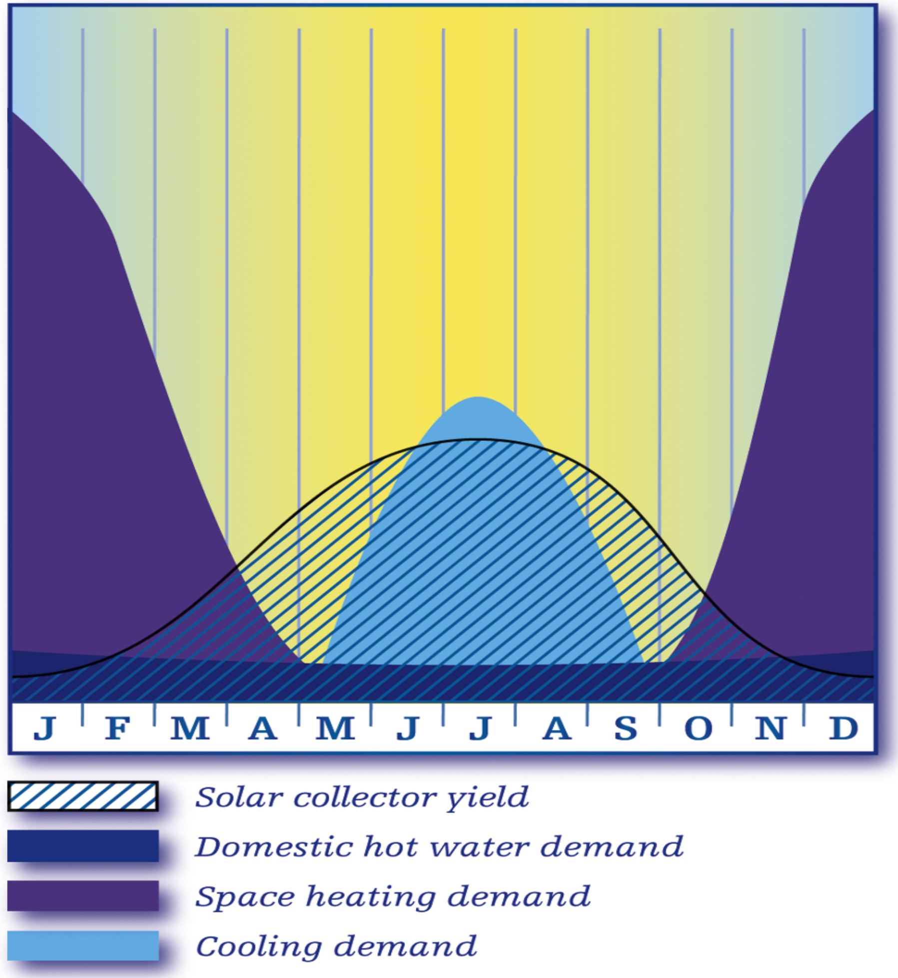


Solar Cell Circuit



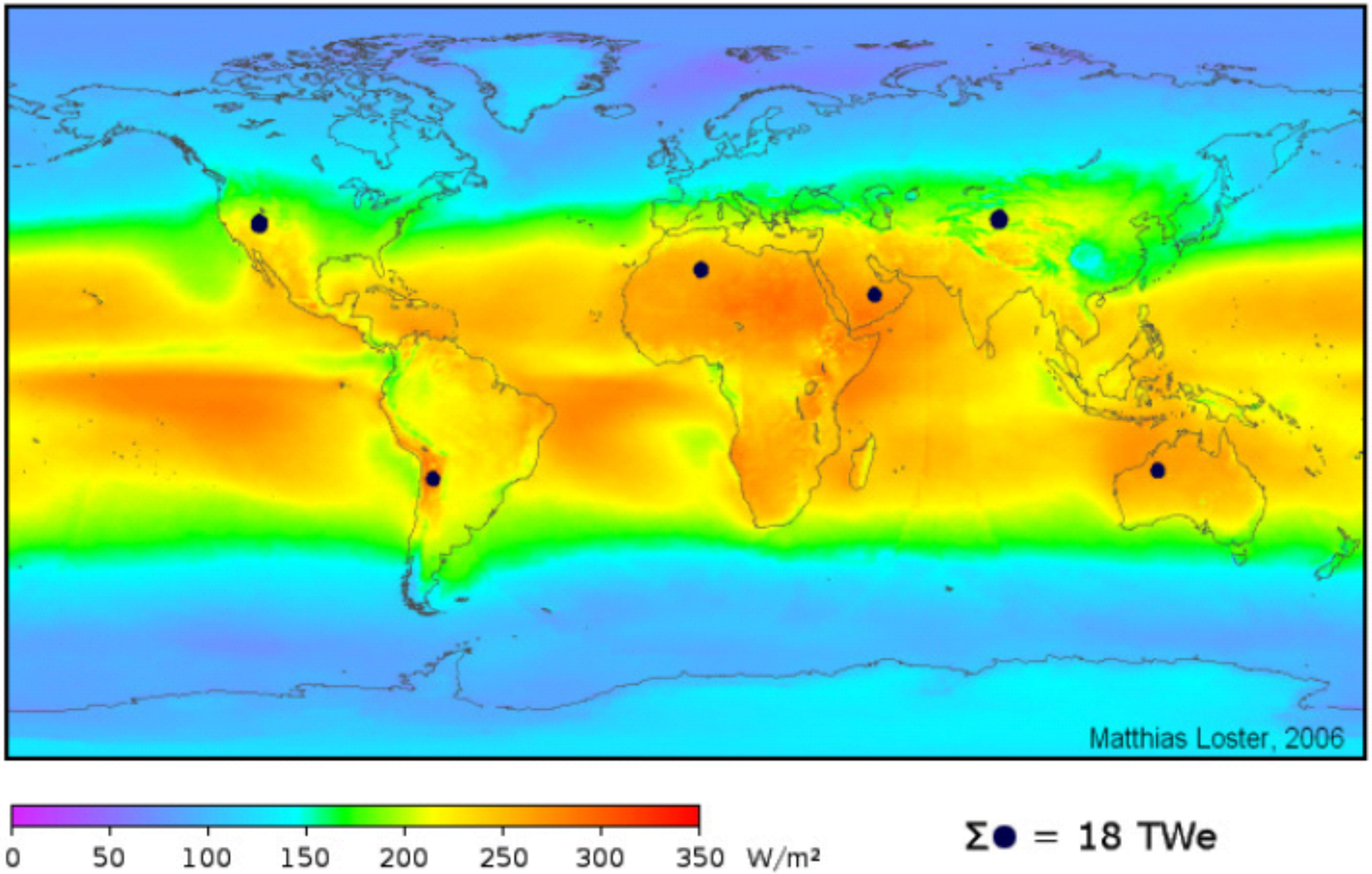
EXAMPLE:
Correlation between hot water demand and irradiated solar energy

Solar cooling & heating system: demand & supply

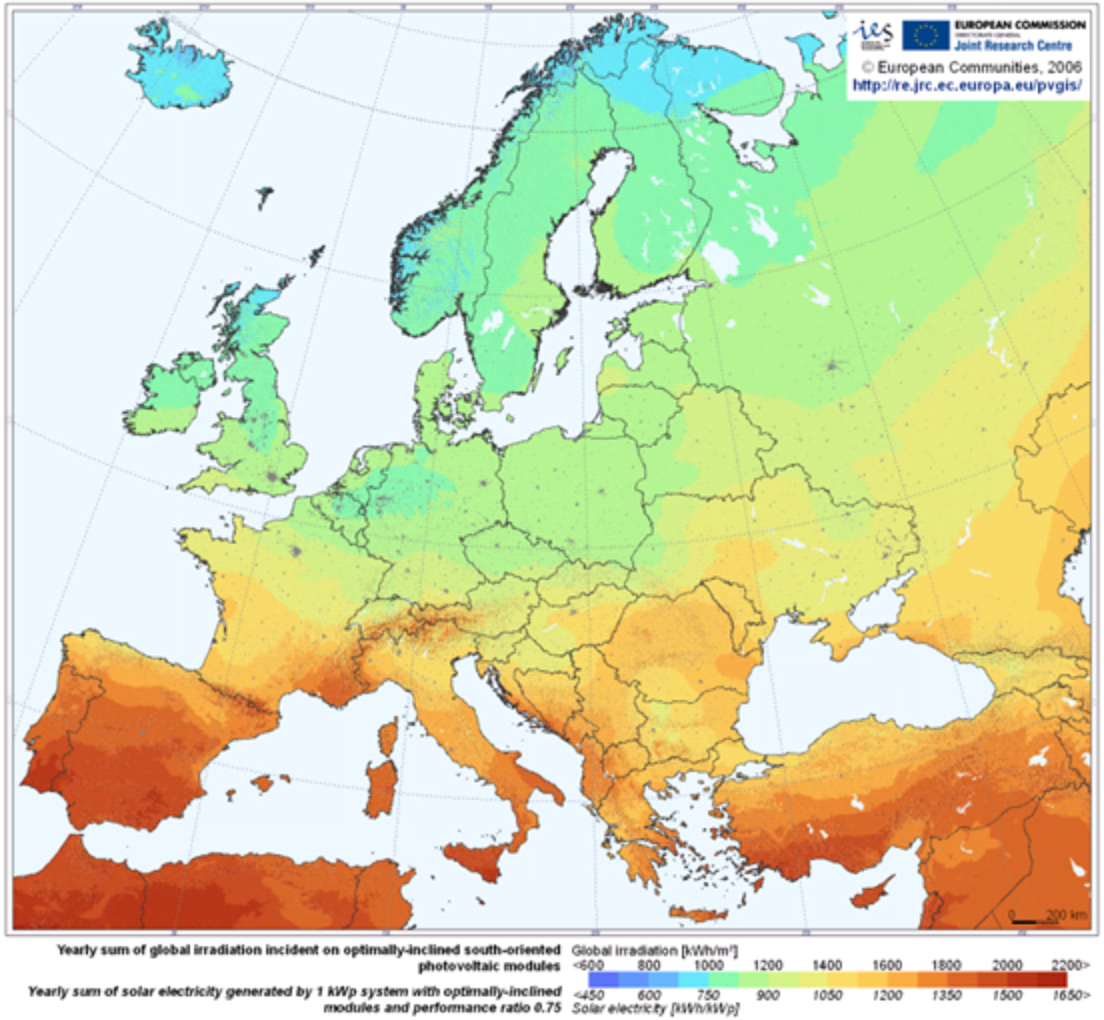


Solar thermal can cover a substantial part of the heating and cooling demand in a typical Central European building.

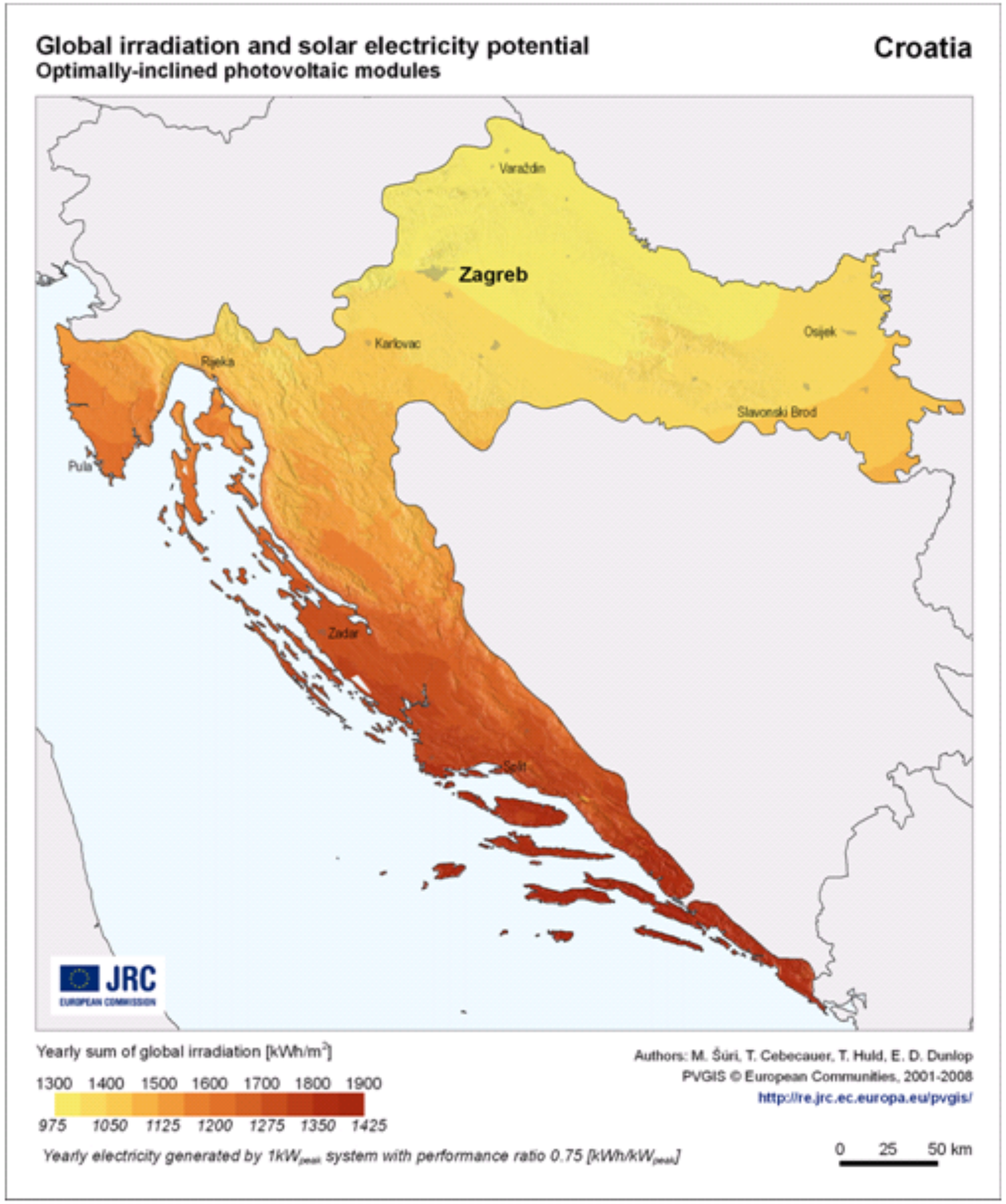
ESTIF
European Solar Thermal Industry Federation


Matthias Loster, 2006
0
50
100
150
200
250
300
350
W/m²
Σ● = 18 TWe

Photovoltaic Solar Electricity Potential in European Countries



Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy, 81, 1295–1305, http://re.jrc.ec.europa.eu/pvgis/.



25 postaja za Hrvatsku

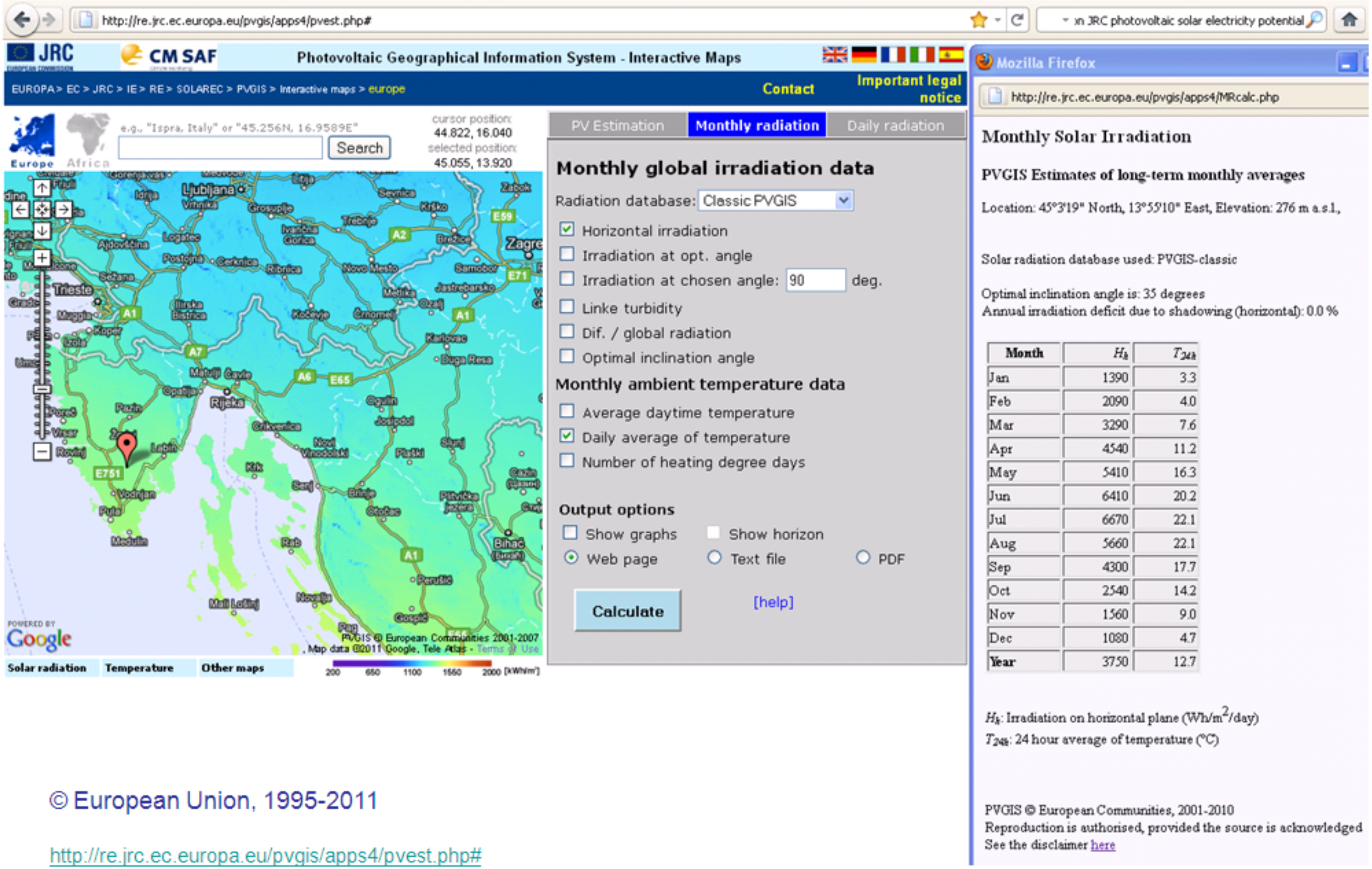
Global irradiation [Whm^{-2}] ,monthly means,1981-1990

Sunshine duration [hours] ,monthly means,1981-1990

Sunshine duration, monthly, 1981-1990

Izvor podataka: European Solar Radiation Atlas (ESRA, 2000, Ecole des Mines de Paris), glavnina podataka za razdoblje 1981–1990. http://re.jrc.ec.europa.eu/pvgis/

Interactive map for identifying solar energy potential



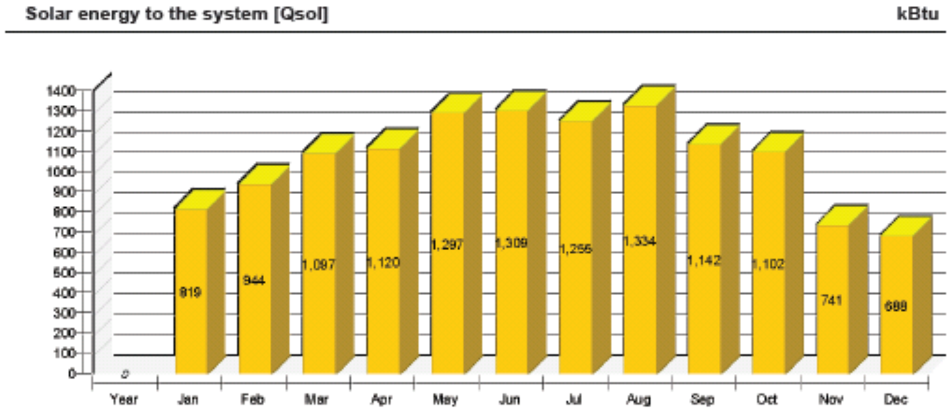
http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#

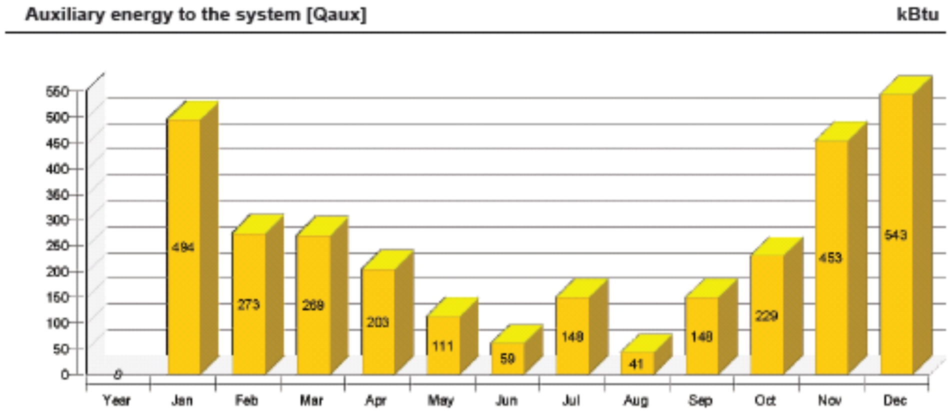
Softwares avaliable for using solar energy potential

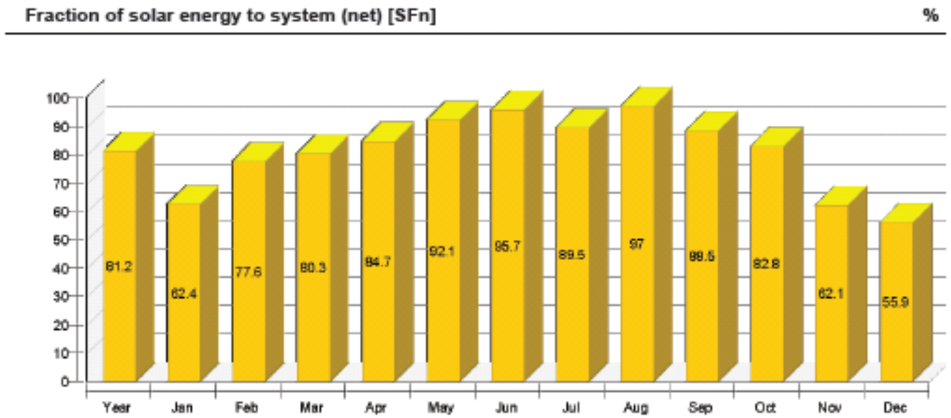
- HOMER
- POLYSUN
- TSOL Pro and PVSOL Pro
- Sunnydesign
- PVSYST
- …

POLYSUN

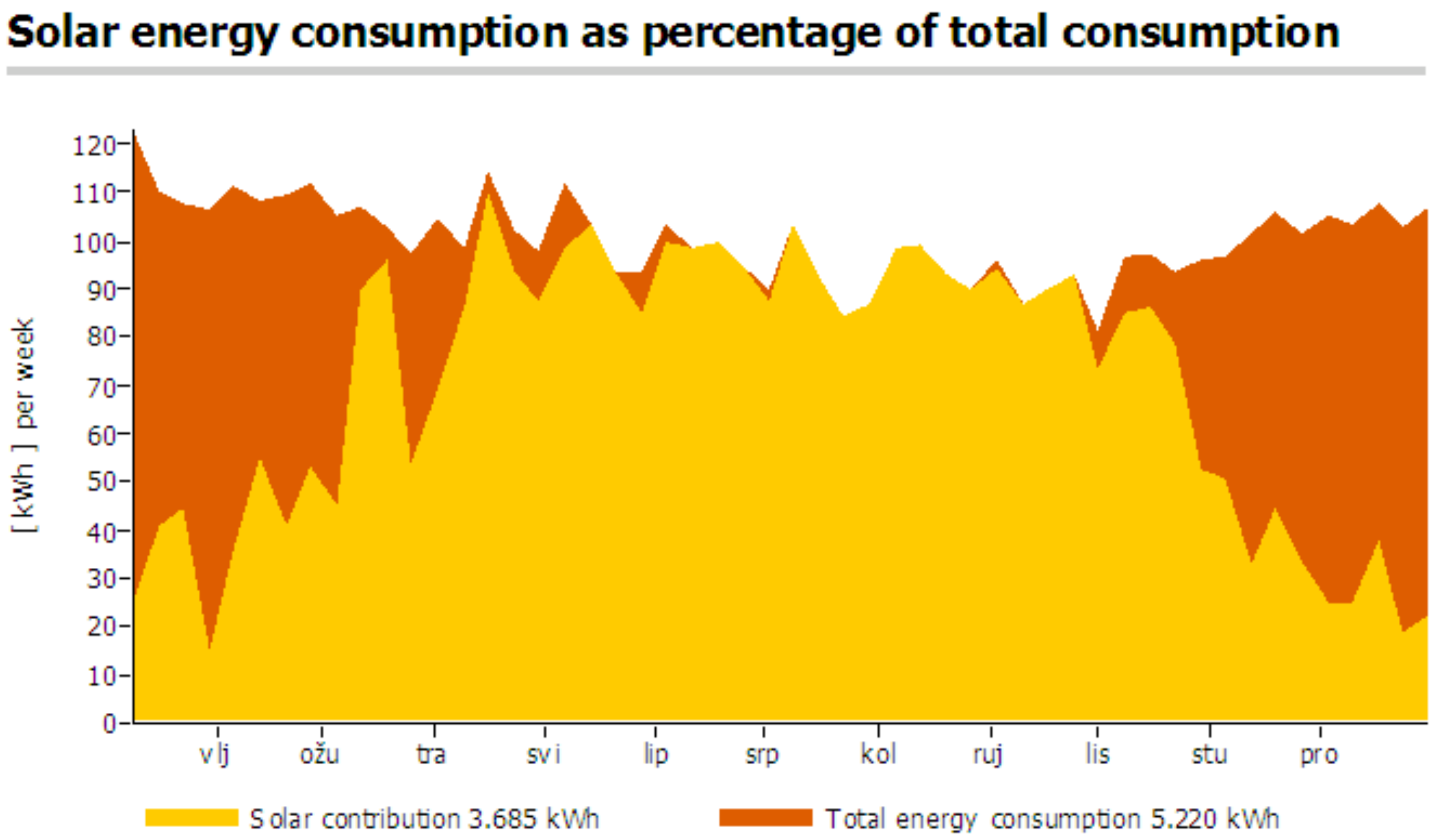
(solar thermal)





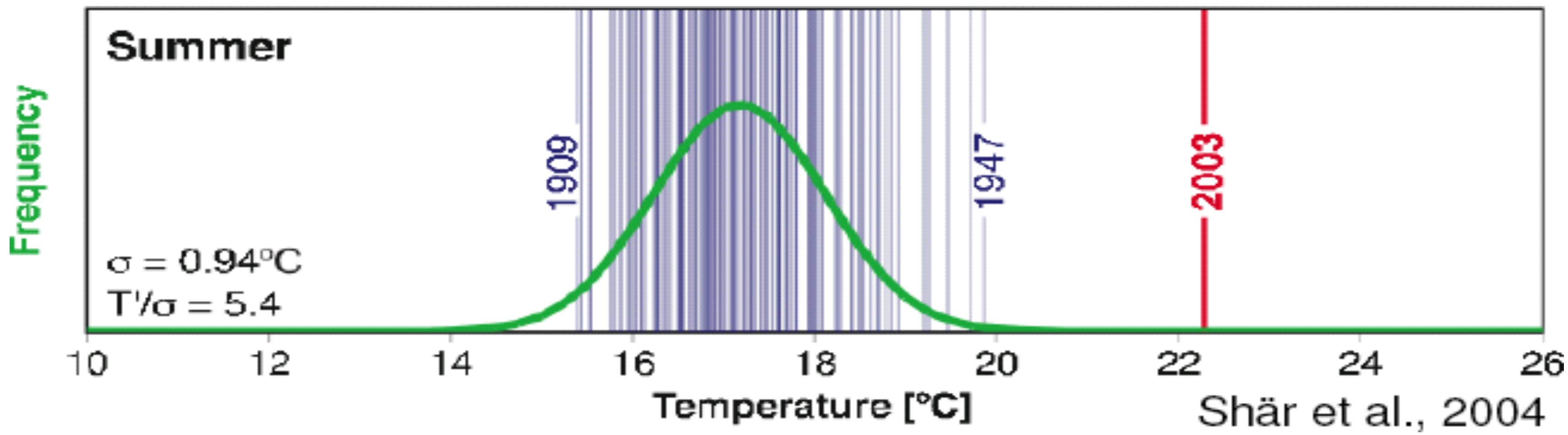


TSOL Pro and PVSOL Pro (using METEOSyn)



Photovoltaics – impact from CC

- Temperature
- Number of days under snow cover
- Annual irradiated energy
- Extreme events



GHI - Global Horizontal Irradiance

Global Horizontal Irradiance

- A sum of Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DIF)
- Mostly influenced by cloudiness

- **Less precipitation** (rain and snow) generally leads to lower cloudiness and more direct irradiation

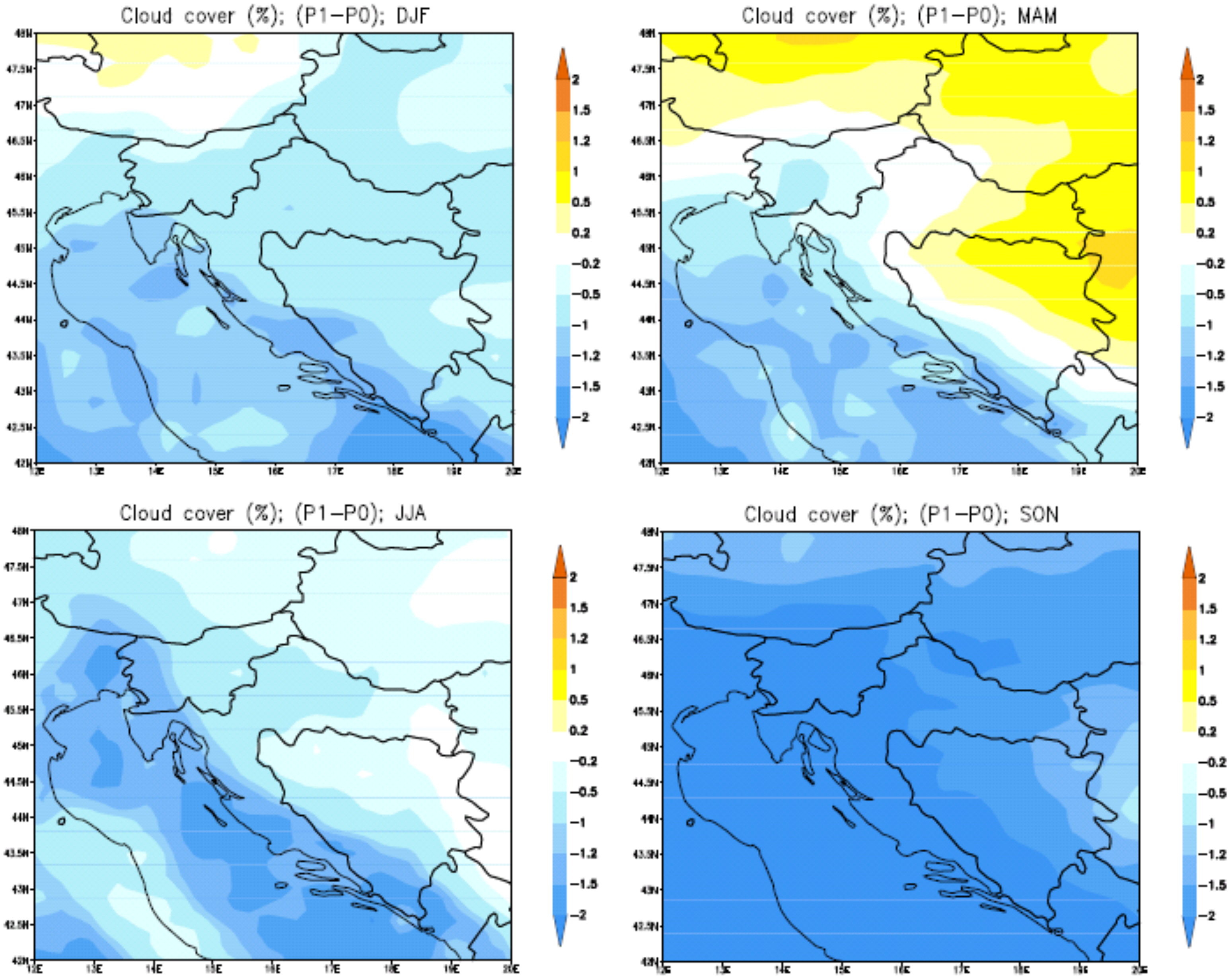


Fig. 1. Cloud-cover change (in %) due to climate change in the period between 2011 and 2040 (P1) when compared to 1961–1990 (P0), for different seasons (DJF: December–February, MAM: March–- May, etc), with A2 IPCC scenario.

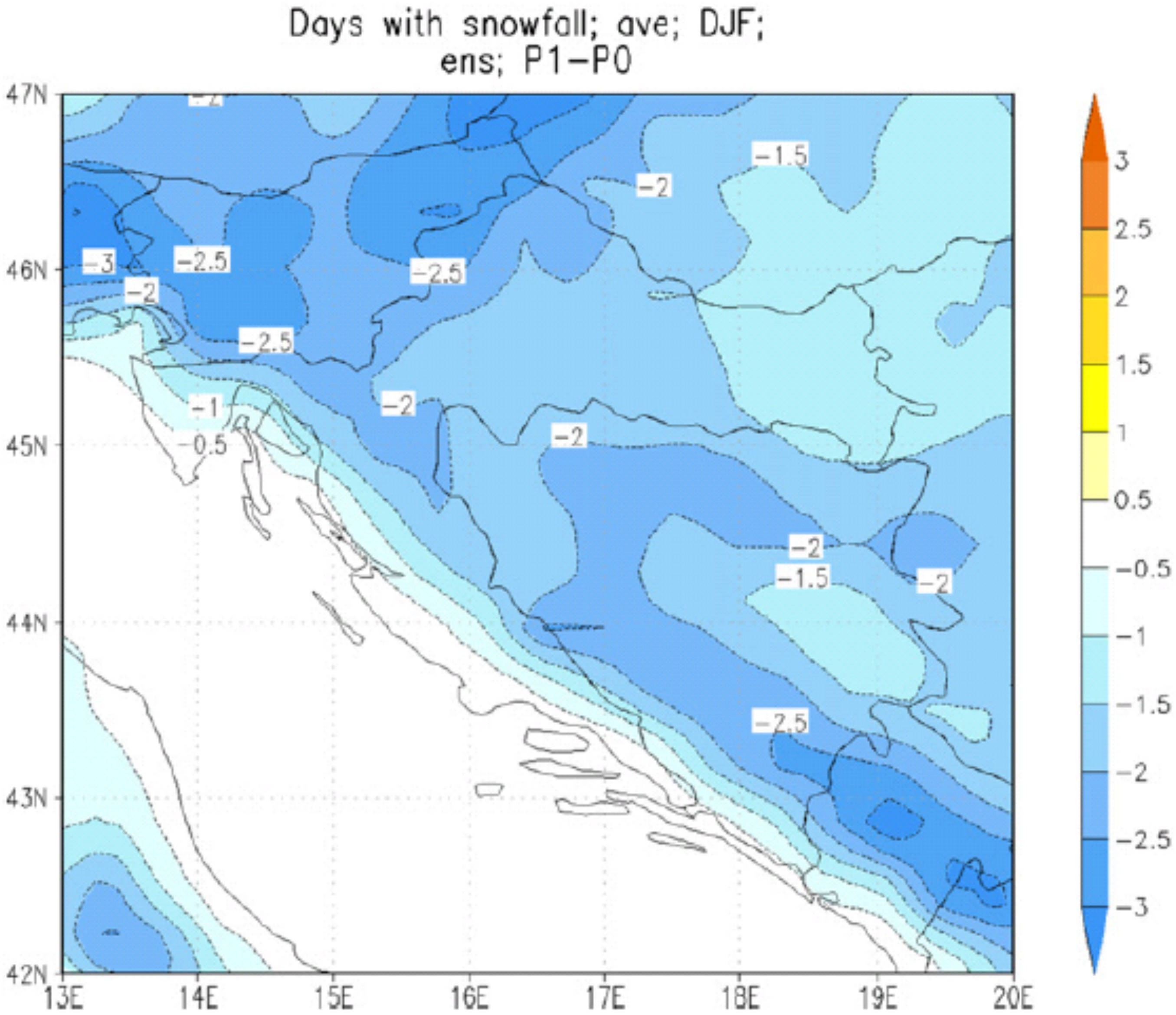
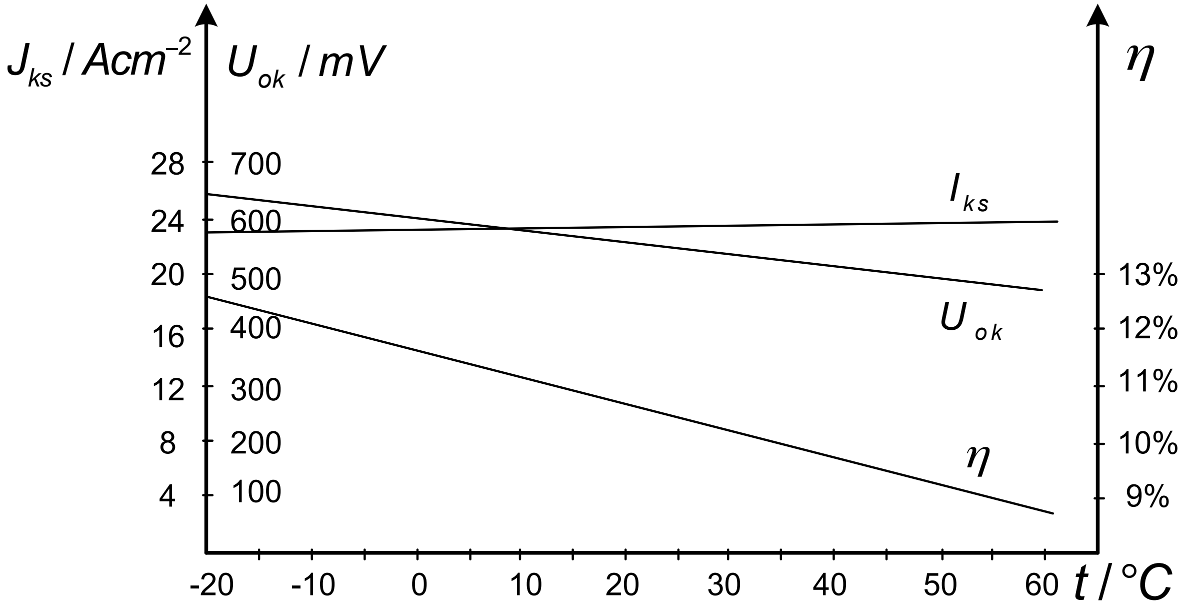


Fig. 4. Change in number of days with snowfall due to climate change in the period between 2011 and 2040 (P1) when compared to 1961–1990 (P0), for December–February (DJF), with A2 IPCC scenario [8].

PV – temperature impacts



- “Cell temperature coefficients" differ according to technology and producer (efficiency, power, current, voltage)
- For silicon based cells, for each °C temperature rise - efficiency lowers for 0,5%
- For thin film technology, this factor is 0,3%

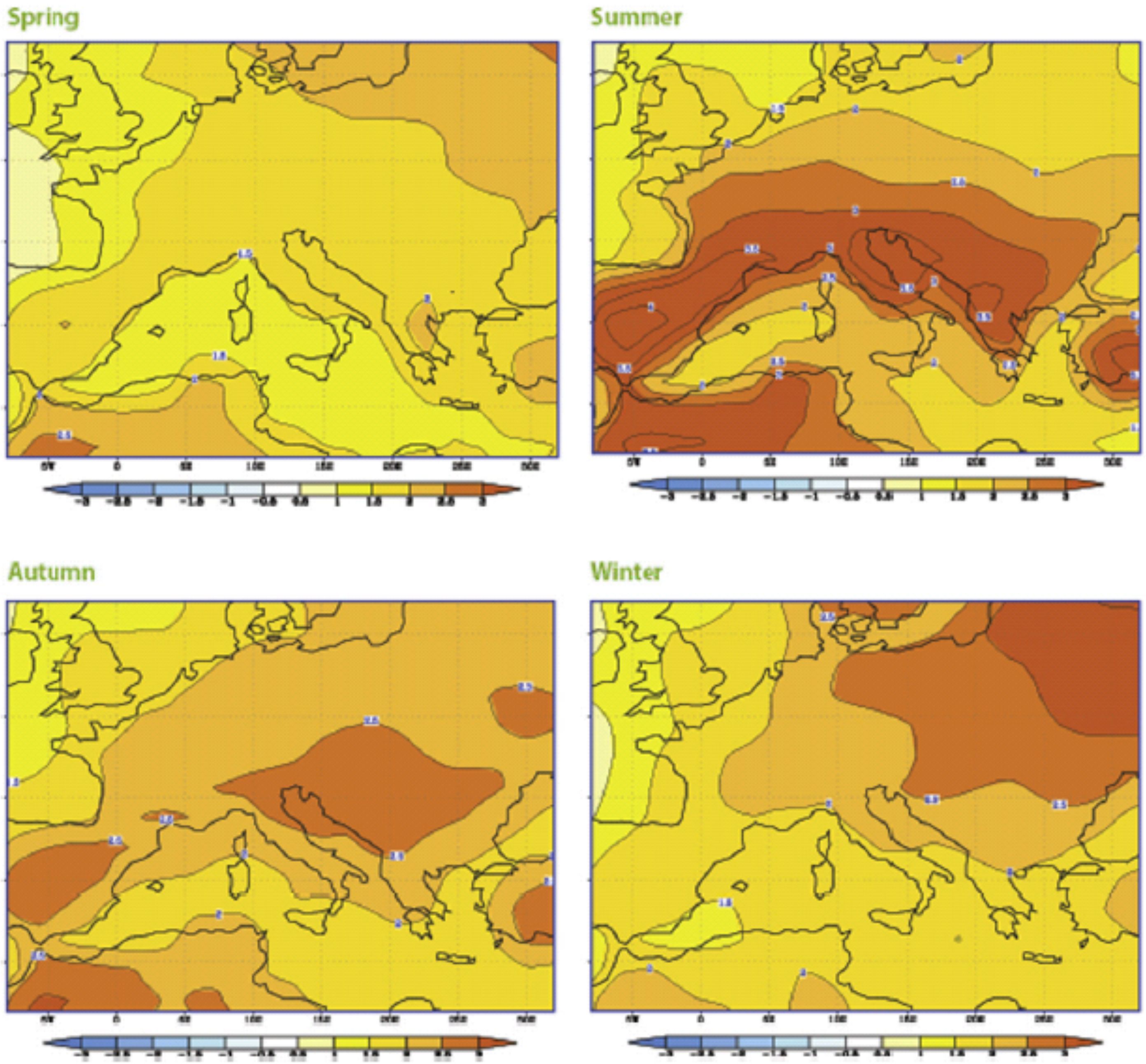
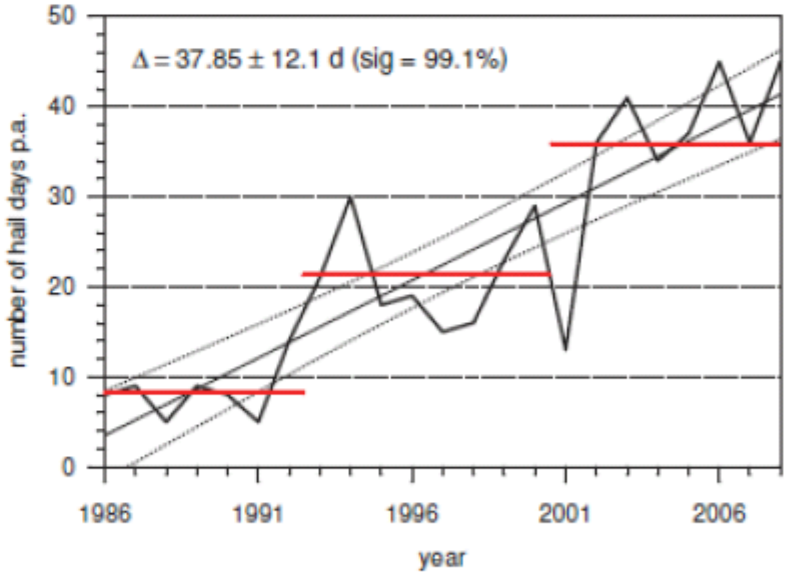


Fig. 2. Comparison of the changes in an average temperature between the period 1961–1990 and period 2041–2070 [5].

PV – other impacts

Current standard: withstand 11 impacts of 25 mm hailstones

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)

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

conclusions

Temperature

For an increase in average temperature of 6°C, the efficiency and production of energy would decrease 3 to 5 %

Global horizontal irradiance

Electricity generation increase by 3% during the summer and 1-2% during spring and winter months in the period to 2040.

Days under snow cover

An increase in electricity generation due to less snow on the panels.

Extreme weather events

A cautious choice of locations due to strong winds and forest fires.

Hailstorms

Large-size hail stones can damage some types of PVs