Introduction (1 h, about 20 slides)

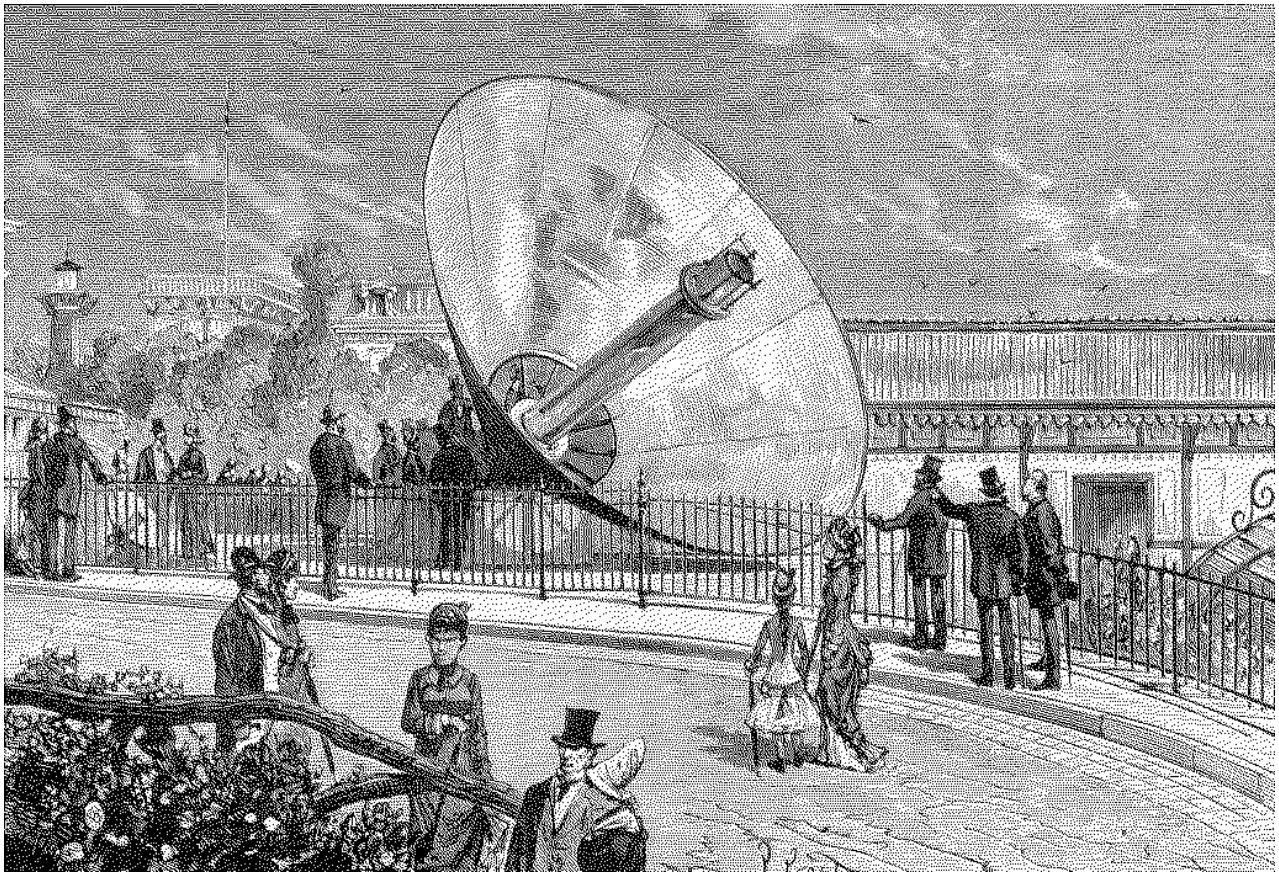
1. Why solar air conditioning?
    a. Existing energy demand for cooling
    b. Perspectives and targets/obligations at national and international level
    c. Peak load issues and energy prices
    d. World and national market for conventional cooling systems (from luxury to necessity)
2. A short review of existing solar cooling applications

1. Why solar air conditioning?

Solar Cooling

- Using solar radiation to drive a cooling process
- Displacing the use of fossil fuel derived electricity that would otherwise be used in a conventional vapour compression air conditioner
  - Solar thermal heat driving a thermal cooling process
  - Solar photovoltaic panels driving a conventional vapour compression cooling process

A New Technology?



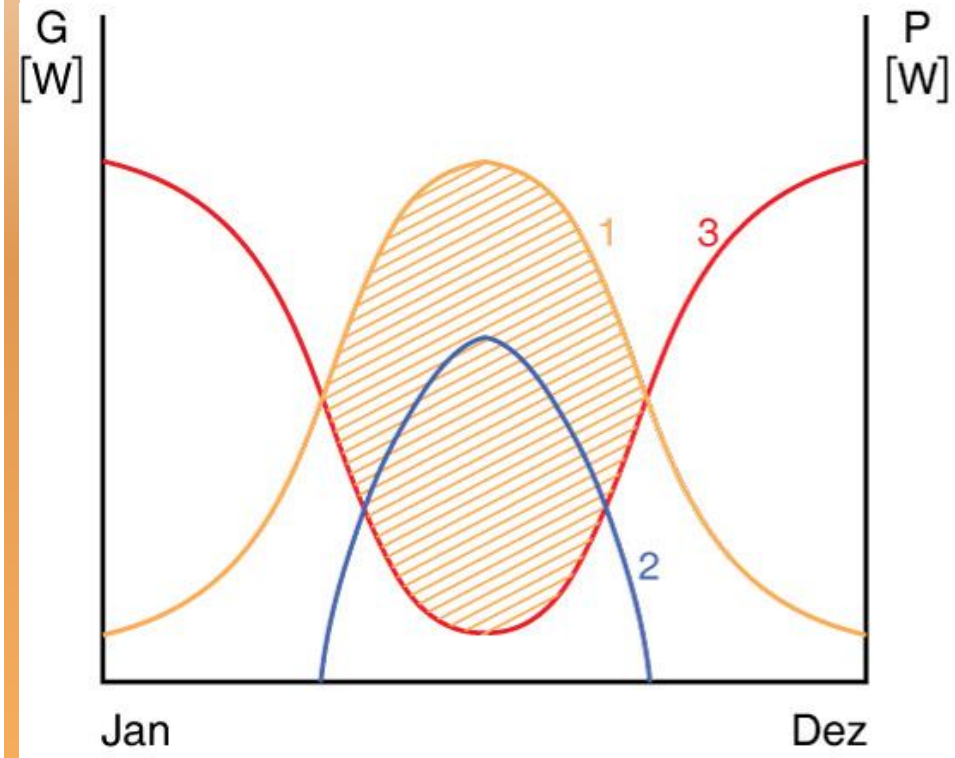
World Exhibition 1878 in Paris - A. Mouchot produced the First Ice Block with Solar Energy

Source: Olynthus Verlag

1. Why use solar energy for air conditioning: the "solar thermal" point of view

- Cooling loads and solar gains are simultaneous: on a seasonal basis - the need for cooling is greater when there is more sun!
- Solar thermal plants: best use of facilities, use of solar energy throughout the year. Faster amortization with the ability to cover larger part of the demand.

Solar cooling – Solar resource vs. Cooling demand



Resource and demand are in phase

1 **Global radiation**

2 **Cooling demand**

3 **Heat demand**

Excess solar heat in summer

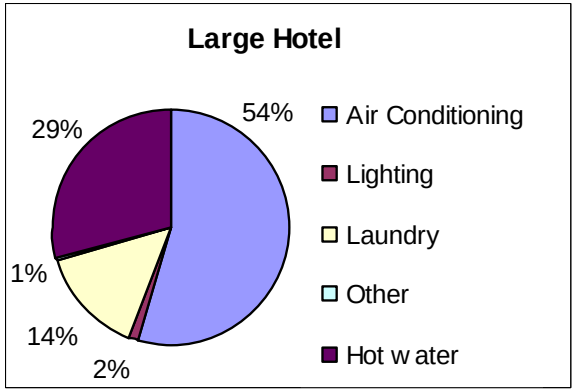
Source: SolarNext

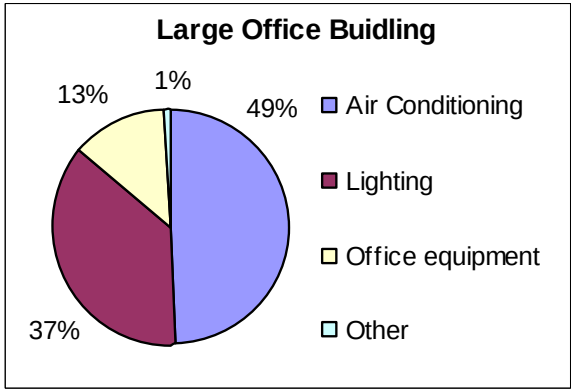
2. Why use solar energy for air conditioning: the policy point of view

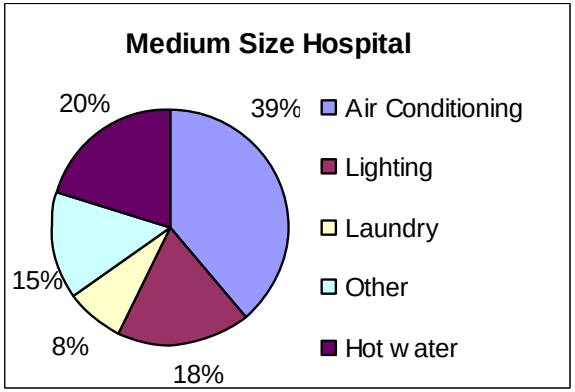
1. Reduce greenhouse gas emissions - The building sector accounts for 42% of global electricity consumption (IEA 2007)

2. Lower energy costs

3. Benefit the electricity system (reduced demand charges)

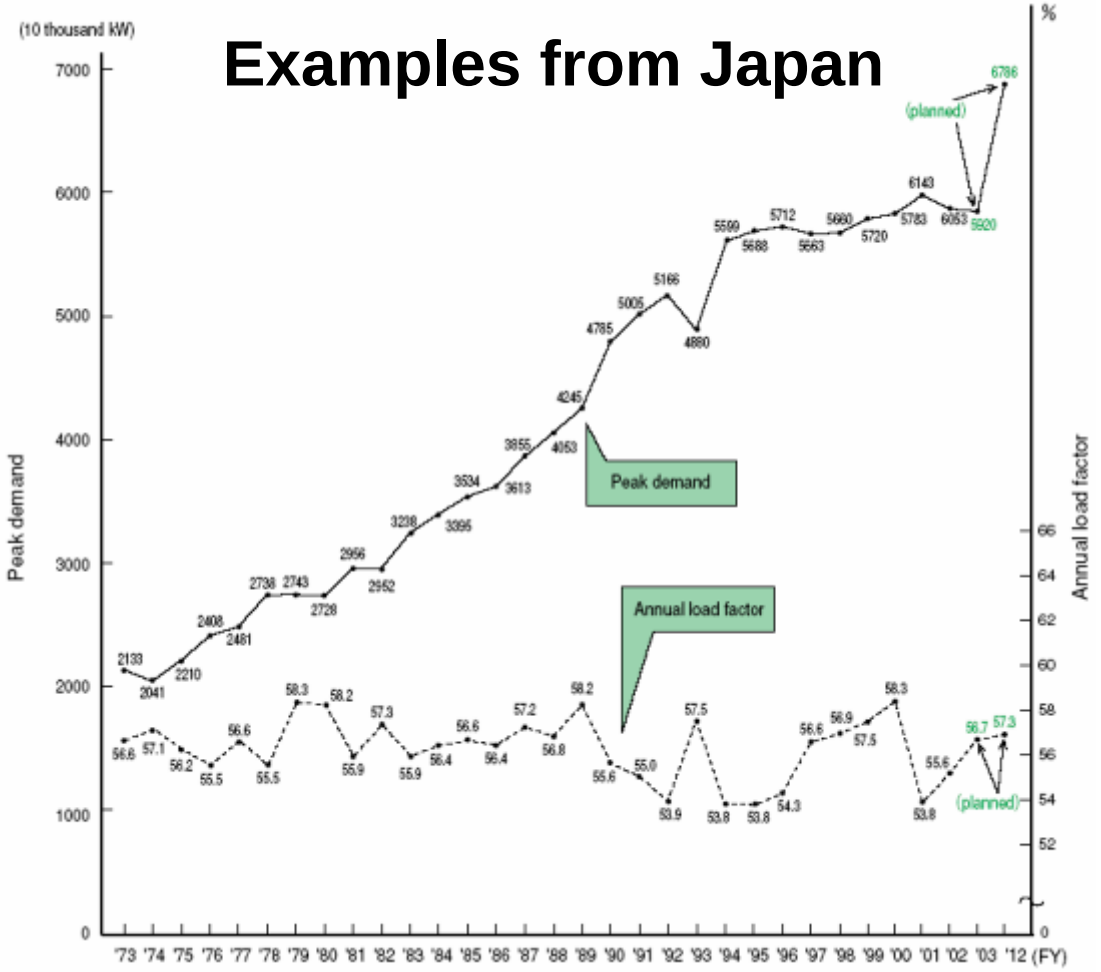






The problem of peak demand

Examples from Japan

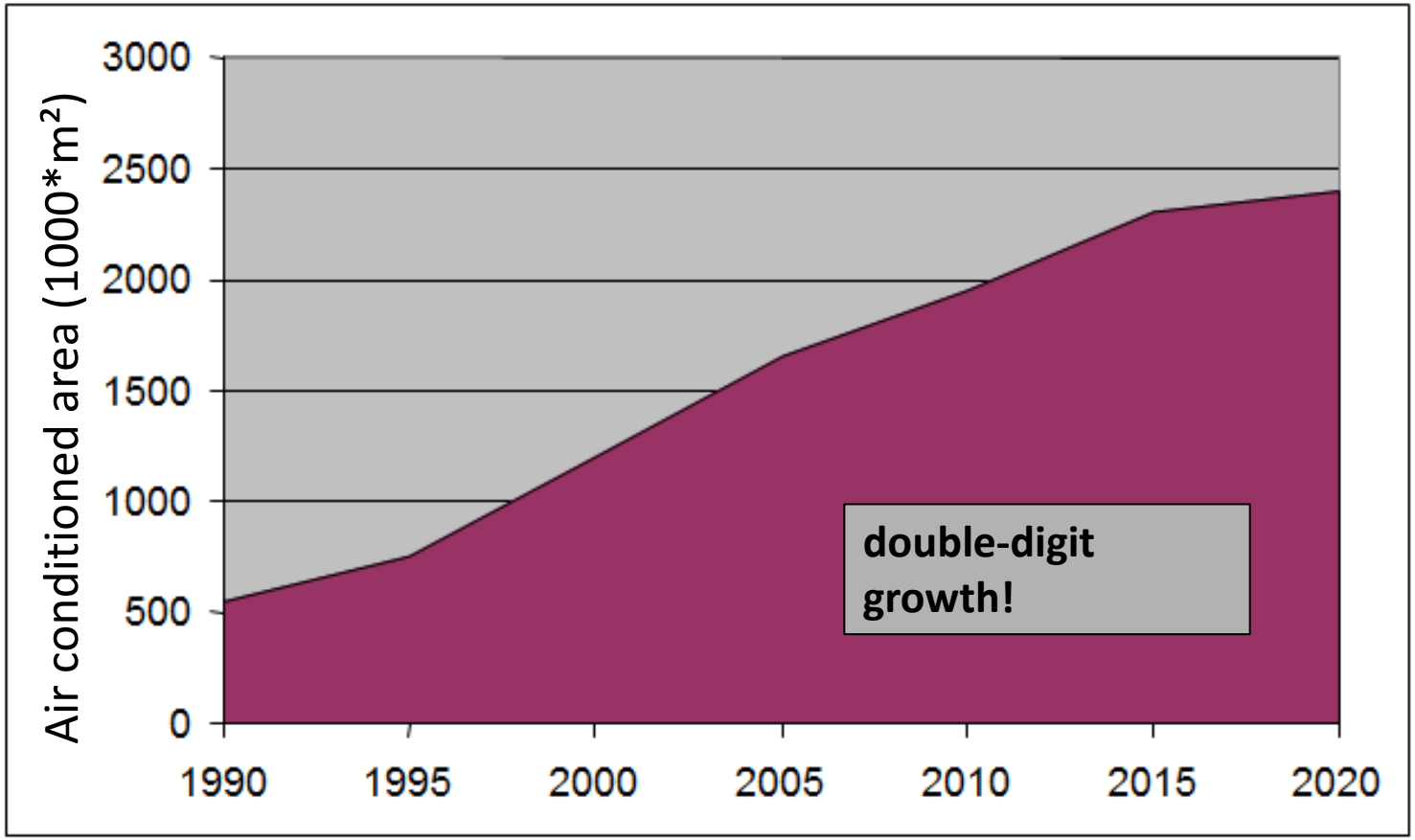


Source: TEPCO

The last **blackouts** due to overloading of the electrical network:

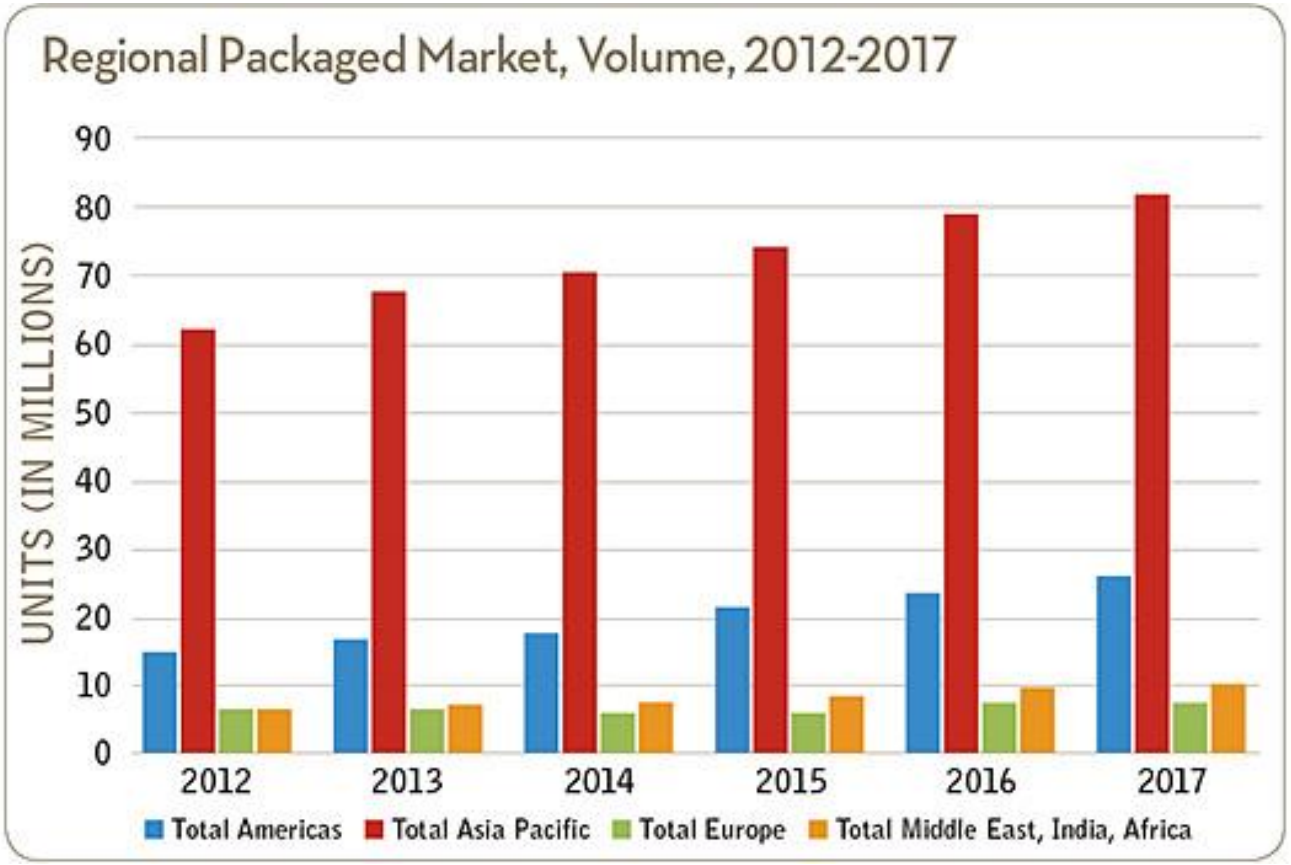
- 14.08.2003: Northeast U.S. / Canada
- 12.07.2004: Athens

Prospective in the EU



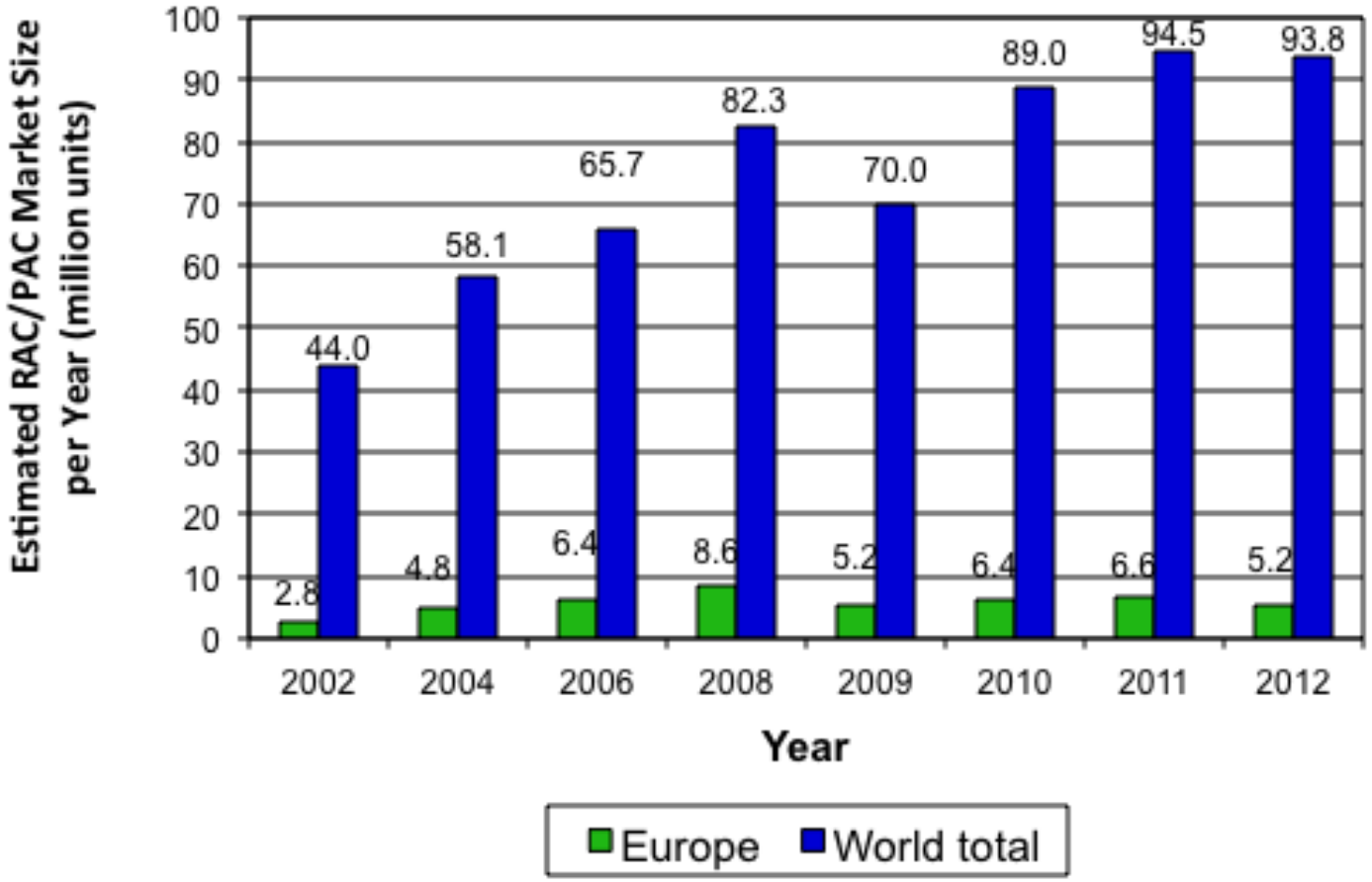
Source: EECCAC report 2003

Prospective in the EU



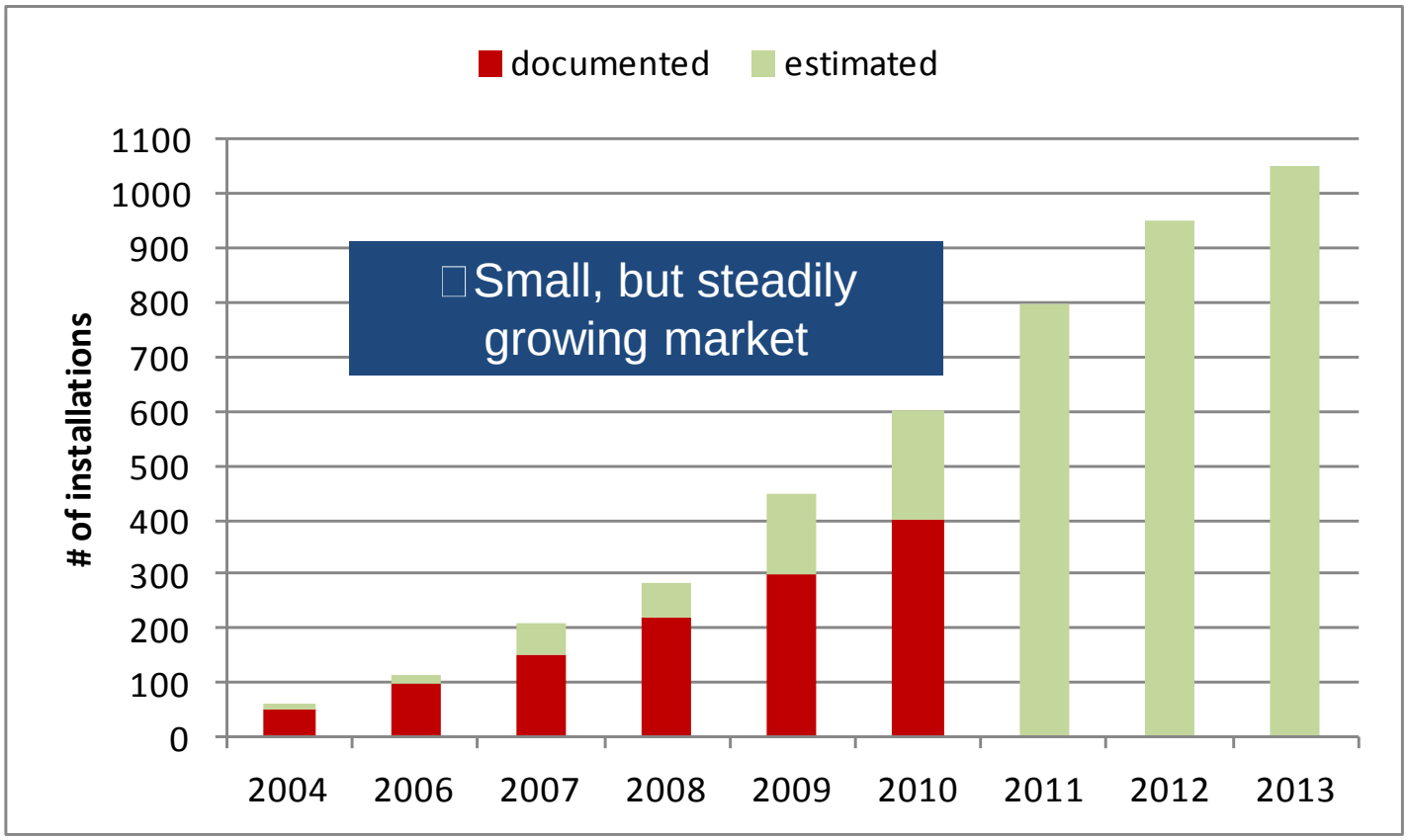
Source: Building Services Research and Information Association (BSRIA).
http://www.achrnews.com/articles/127385-global-ac-market-starting-to-warm-up

The global market. Annual installed capacity for RAC



Source: JARN

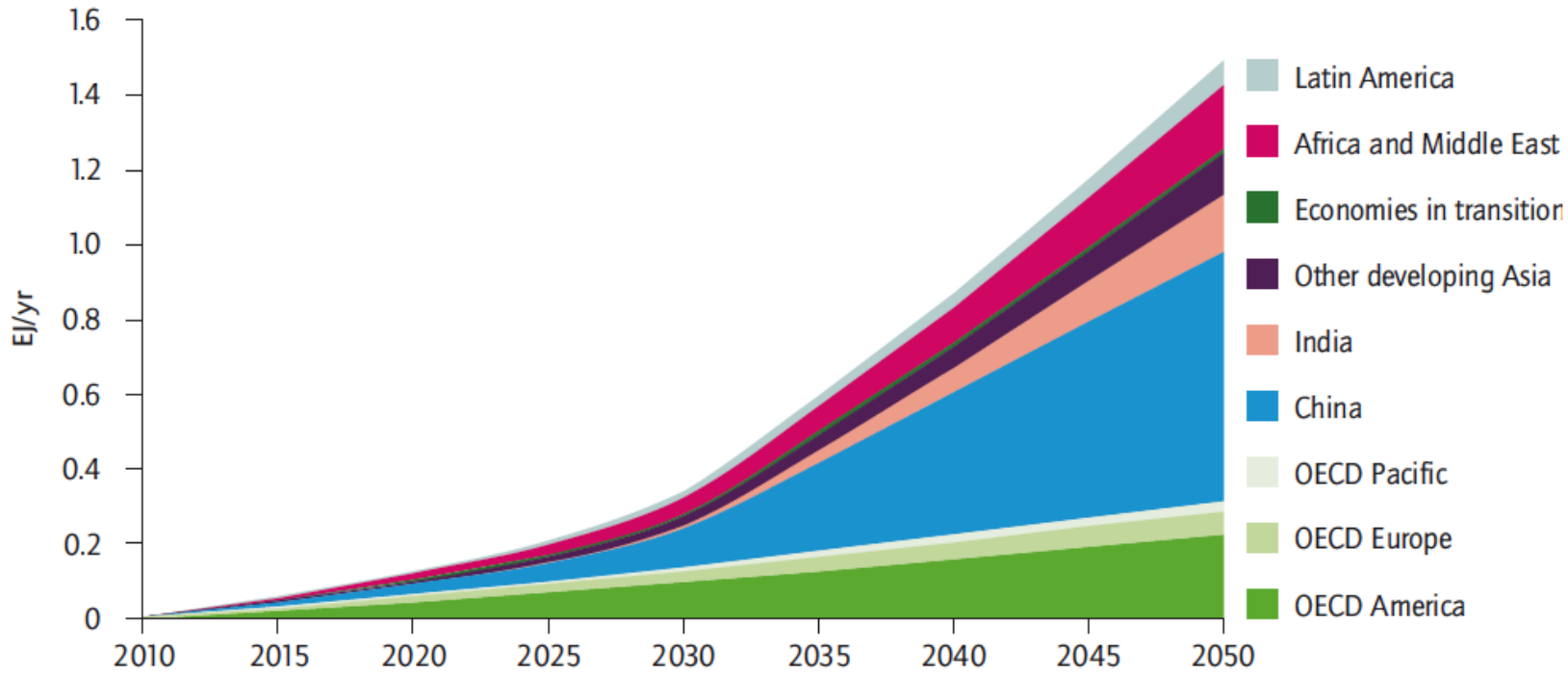
Market development of solar cooling



Source: Solem Consulting / TECSOL

IEA Technology Roadmap – Market potential by 2050

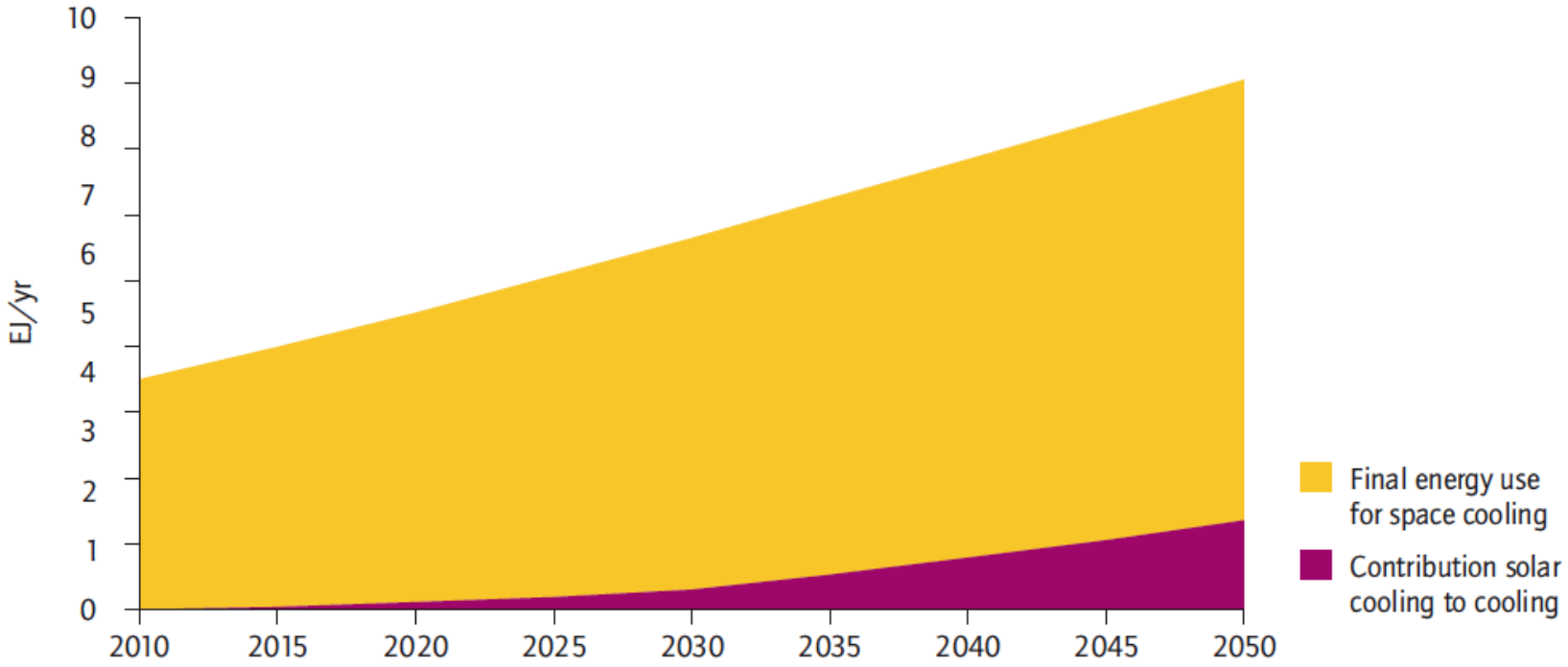
Figure 16: Roadmap vision for solar cooling (Exajoule/yr)



Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

IEA Technology Roadmap – Share of solar cooling by 2050

Figure 17: Roadmap vision for solar cooling in relation to total final energy use for cooling (Exajoule/yr)



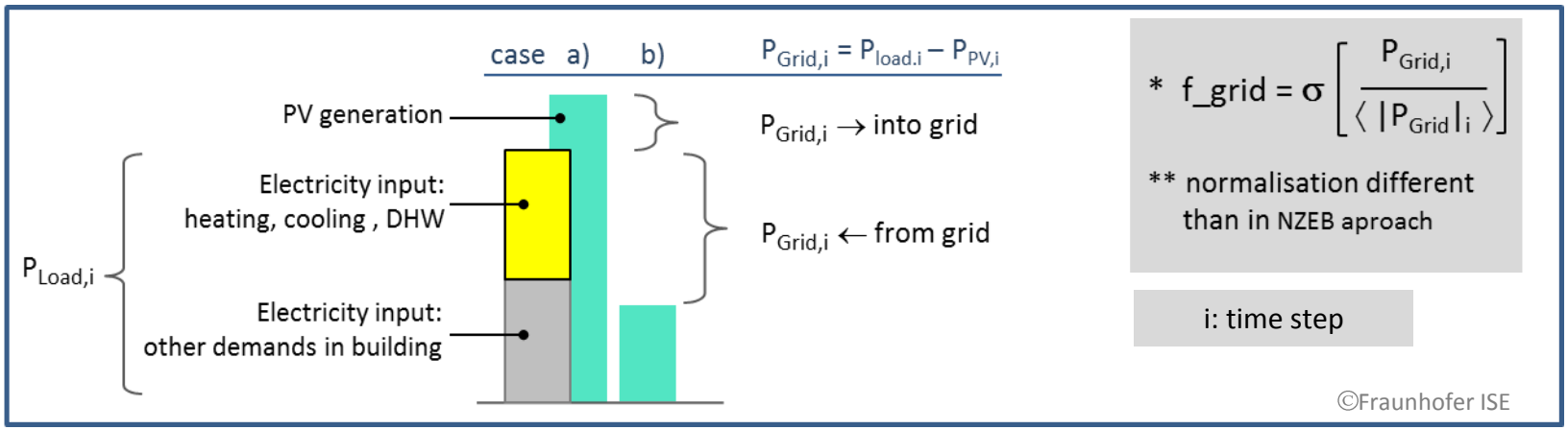
Source: IEA Technology Roadmap Solar Heating and Cooling, 2012

The estimations on grid stress

- Physical effects on grid frequency and voltage in local supply node: not investigated
- Approach similar as in the Net Zero Energy Buildings (NZEB) programme:
  - Grid interaction index f_{grid} (annual value)* :

    standard deviation of grid exchange fluctuations (normalised to average of grid load)**
  - The less f_{grid}, the smaller the 'stress' on the grid

Calculation base



Source: Fraunhofer ISE

3. Why use solar energy for air conditioning: the end user's point of view

1. Steadily increasing electricity price

2. Achieve higher building star rating
   - Access to green tenants
   - Eligibility for tax incentives
   - Point of sale disclosure

3. Compliance with minimum renewable energy targets (planning permission/ satisfy aspirational targets)

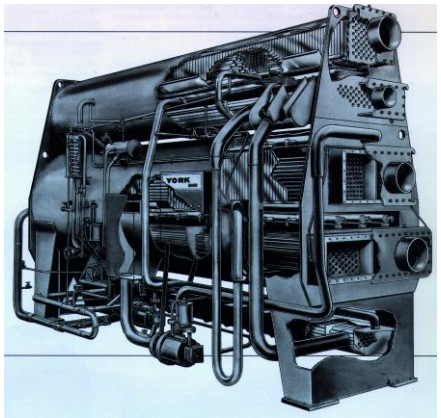
2. A short review of existing solar cooling applications

Solar Thermal Cooling Technologies

Adsorption: open or closed

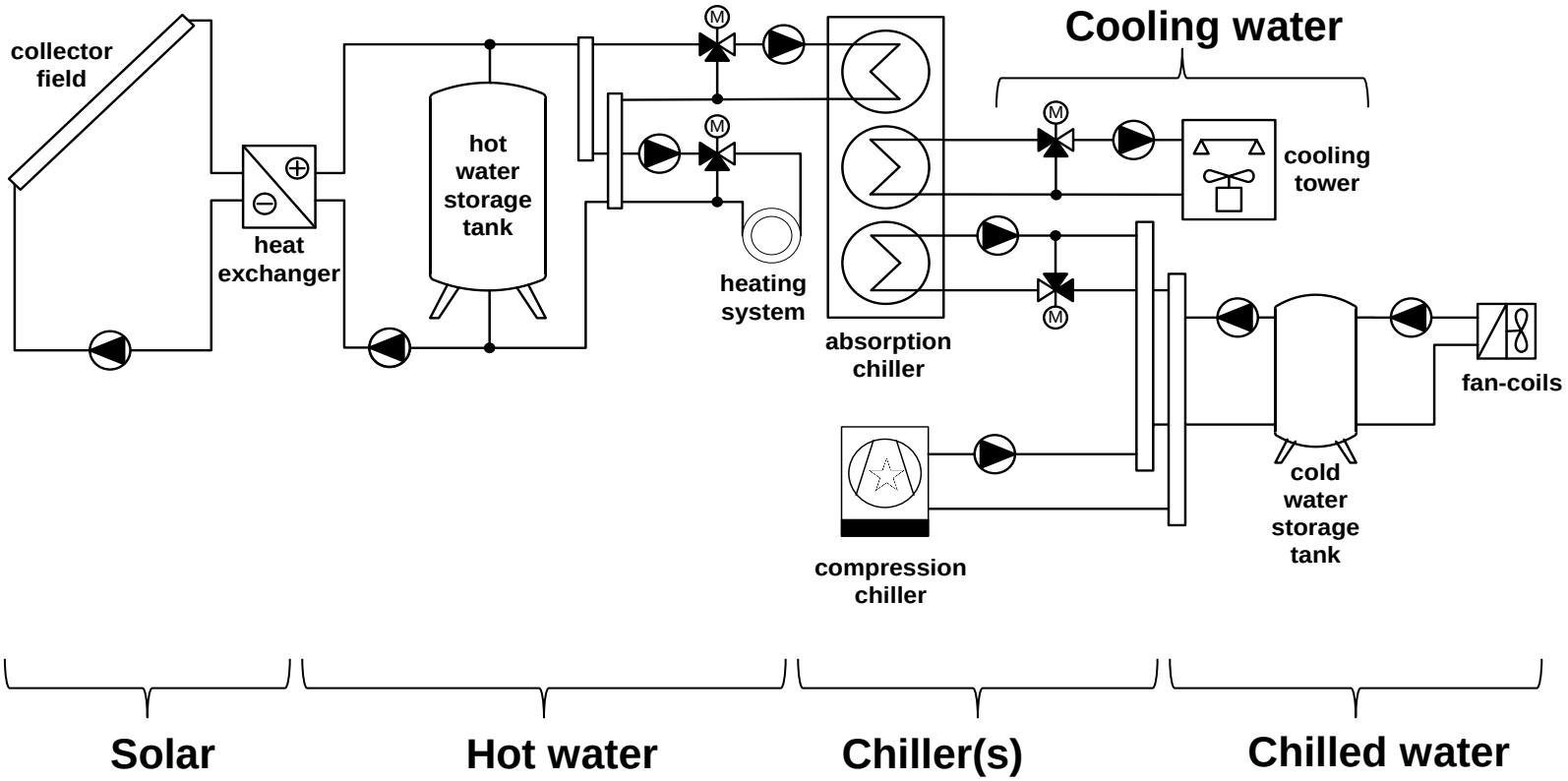
50-80°C

Single or double effect absorption



60-100°C
150-200°C

General solar cooling scheme

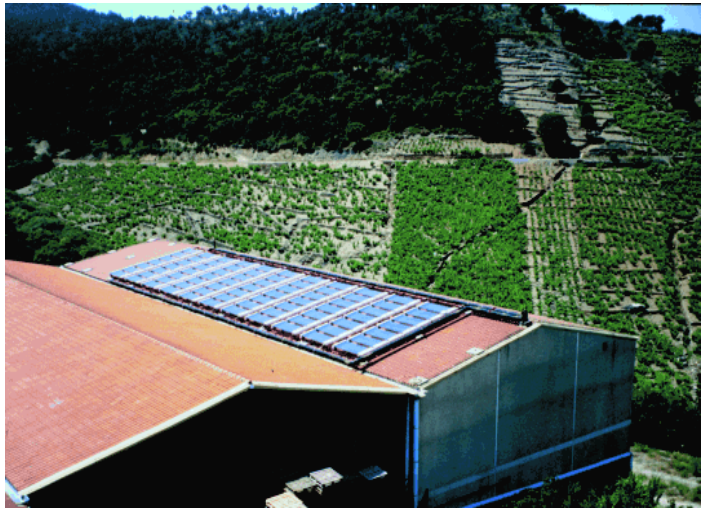


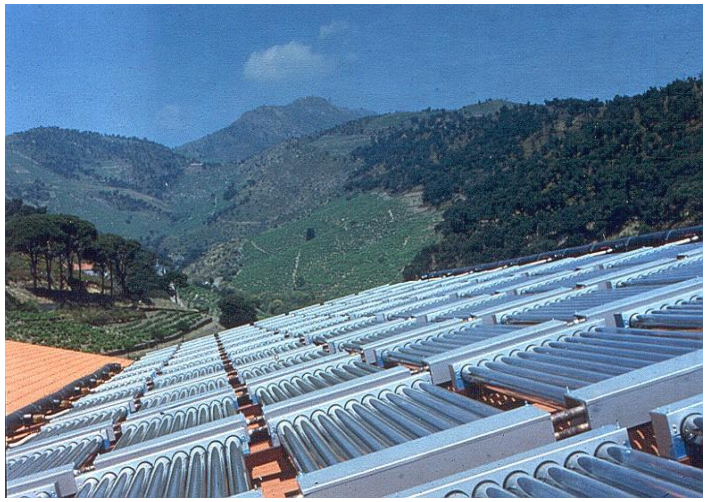
Source: Solem Consulting

Air conditioning for cosmetics industry (Greece)

Air conditioning of university clinic in Freiburg (Germany)

Cooling of cellar, Banylus (France)





Air conditioning of seminar rooms, Freiburg (Germany)

Air conditioning office building – Pristina (Kosovo)

Source: SOLID

Air conditioning in a hotel in Dalaman (Turkey)

Source: Solitem

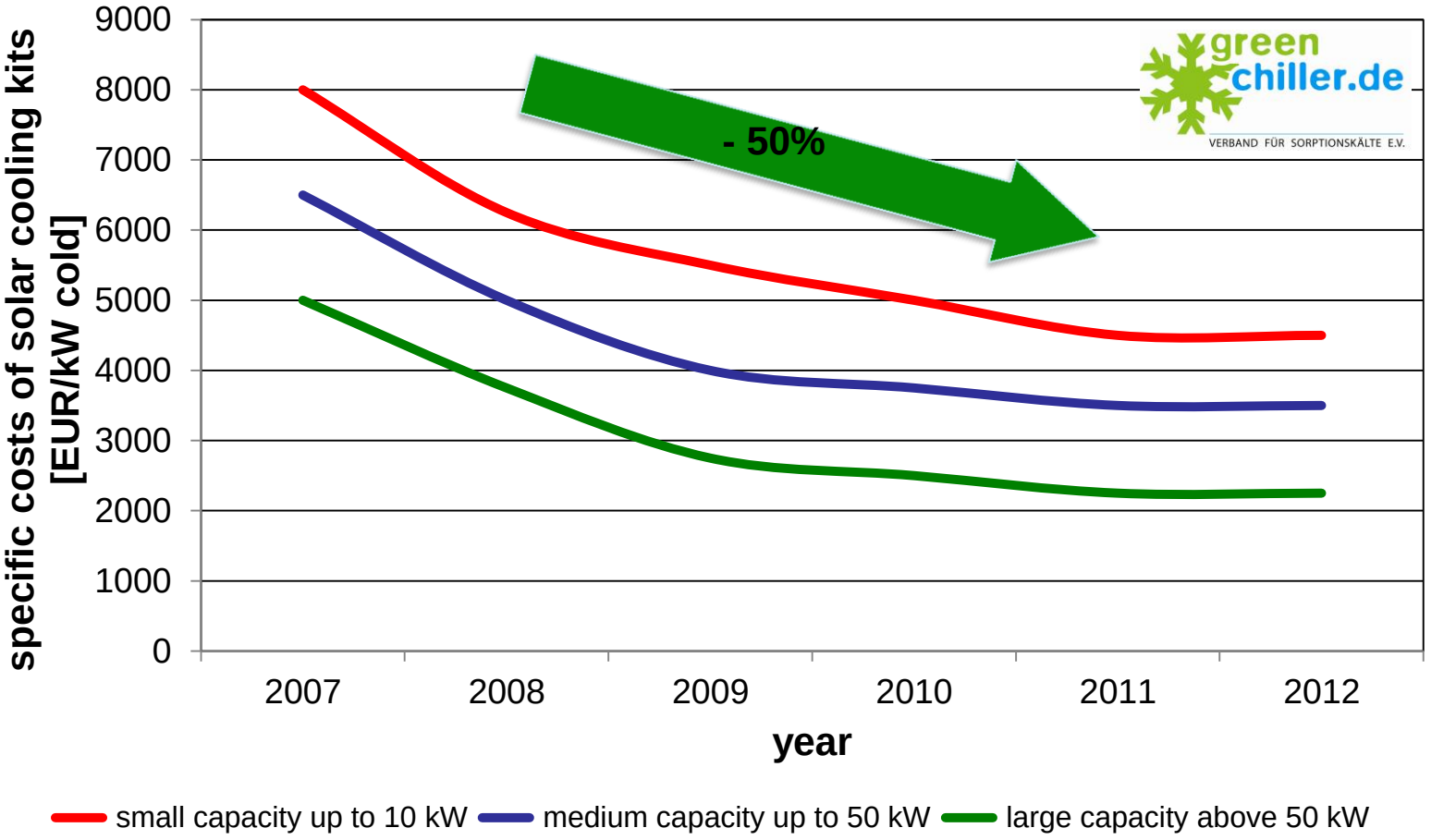
Solar cooling and heating system in Germany

System Components:

15 kW	EAW absorption cooling machine
37 m²	CS-100F flat plate collectors
34 m²	TH SLU1500/16 solar vacuum tube collectors
2 m³	Two 1 m³ hot water storage tanks
1 m³	Cold water storage tank
35 kW	EWK open wet cooling tower

Source: SolarNext

Cost development of solar cooling Kits



Source: Solem Consulting / Green Chiller