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

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

Air conditioned area (1000* m²)

- 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
Market development of solar cooling

Small, but steadily growing market

Source: Solem Consulting / TECSOL
IEA Technology Roadmap – Market potential by 2050

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

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)

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 $f_{\text{grid}}$ (annual value):
    - standard deviation of grid exchange fluctuations (normalised to average of grid load)
  - The less $f_{\text{grid}}$, the smaller the ‘stress’ on the grid

Calculation base

\[ f_{\text{grid}} = \sigma \left[ \frac{P_{\text{Grid},i}}{\langle |P_{\text{Grid},i}| \rangle} \right] \]

** normalisation different than in NZEB approach

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

Single or double effect absorption

Stirling 1-50 kW, 50-75°C

Cogeneration Motor heat 70-95°C

Micro gas turbine 270-680°C from 20 kW

60-100°C

150-200°C
Quality Assurance & Support Measures for Solar Cooling Systems

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

Specific costs of solar cooling kits [EUR/kW cold]

- 50%

Year:
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012

Capacity:
- Small capacity up to 10 kW
- Medium capacity up to 50 kW
- Large capacity above 50 kW

Source: Solem Consulting / Green Chiller