Urban solar energy schemes as sustainable energy solutions for eco-cities

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What is Urban Solar Energy ?
Main characteristics:

- Large scale utilisation of solar energy in built environments to provide a major share of the community's energy through solar power;
- Satisfying different forms of energy needs with solar energy (hot water, space heat, space cooling, electricity) to provide comfort;
- Integration of solar energy technologies into buildings and building elements to provide an aesthetically attractive environment;
- Optimal interfacing of solar with other energy systems to provide maximum benefits and full sustainability.

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Outline of the presentation

- Basic concepts and technologies for urban solar utilization
- Experiences from Ekoviikki ecological suburb in Helsinki
- Preplanning of sustainable whole building energy concepts
- Outline for a urban solar scheme in Tianjin

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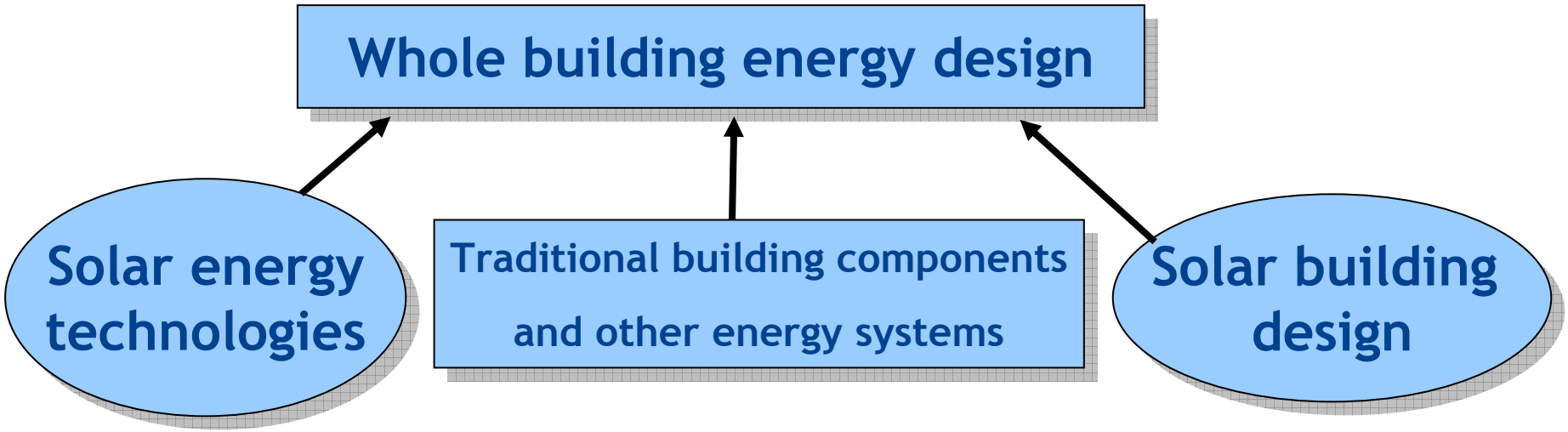
Urban solar energy technologies



- Solar hot water
- Solar space heating
- Solar cooling
- Solar electricity (=photovoltaics)

- Direct solar gains/passive solar
- Daylighting
- Natural ventilation/cooling
- Thermal and visual comfort

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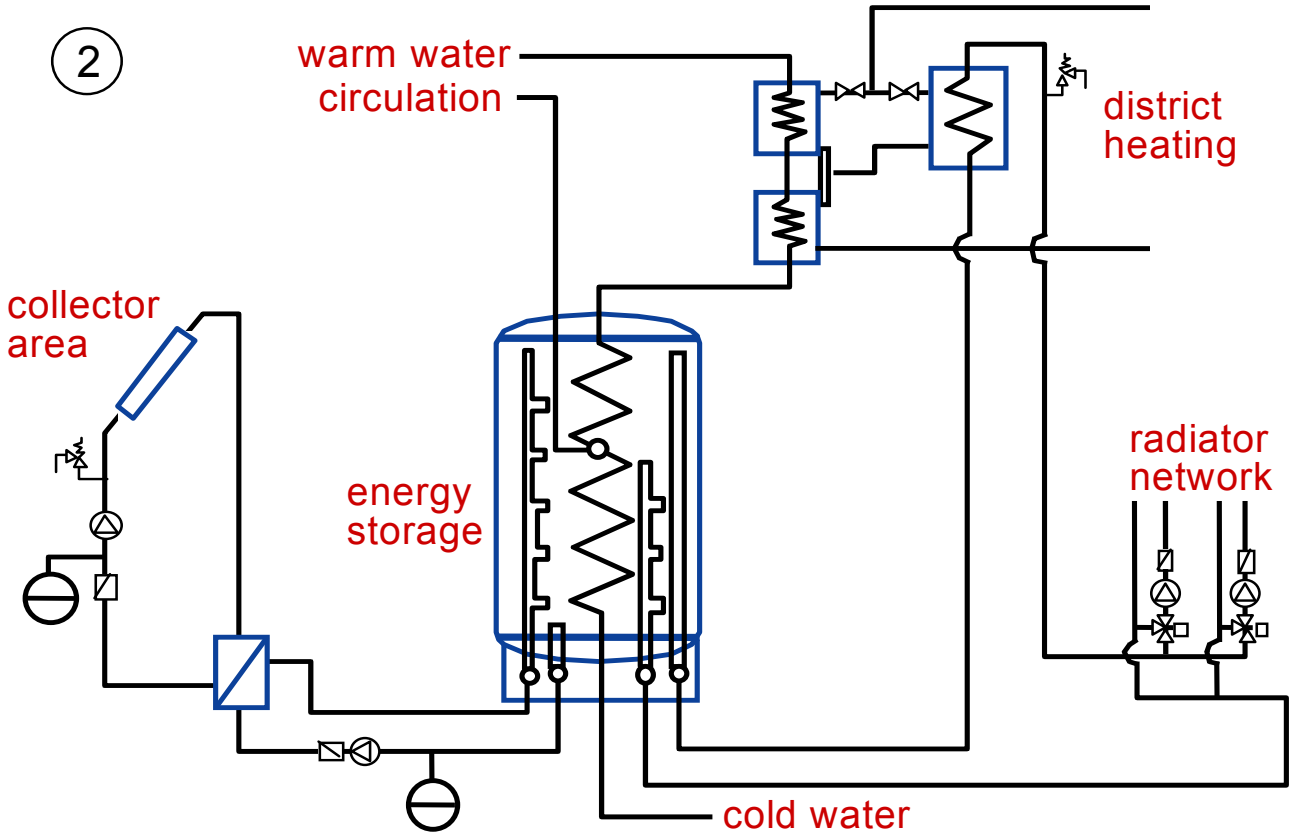
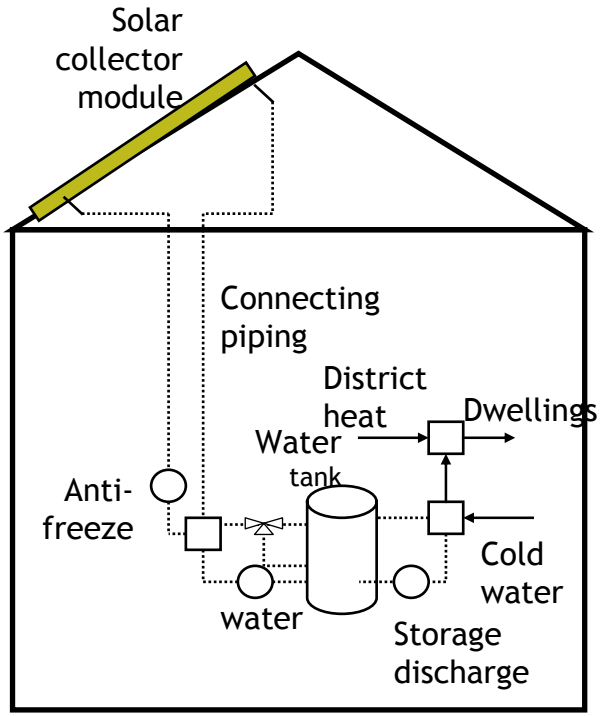
Lay-out of urban solar heating system

- solar heating provides hot water or hot water and space heat (combi systems)
- easy to integrate with district heating or any other heating system





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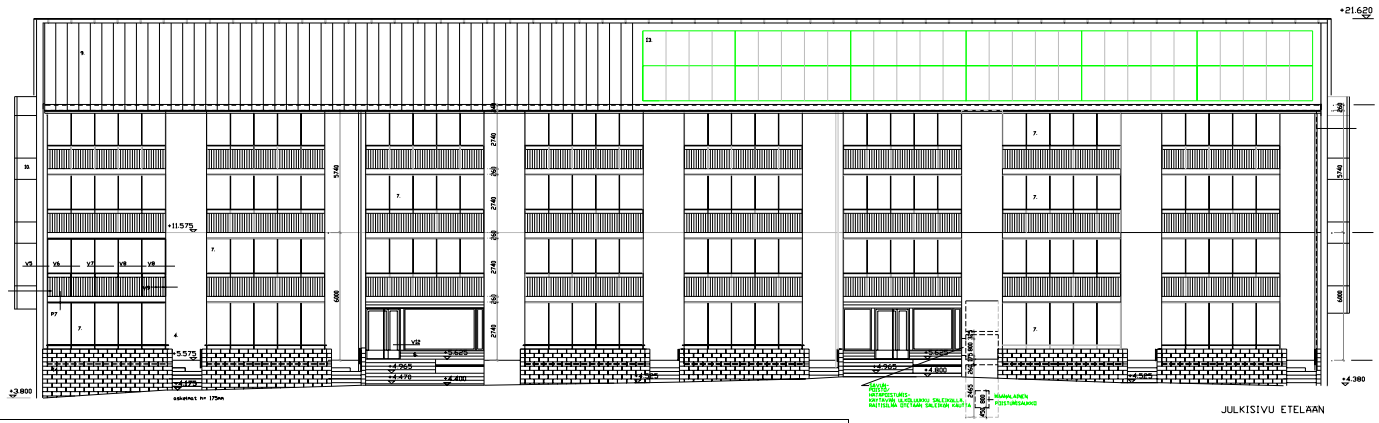
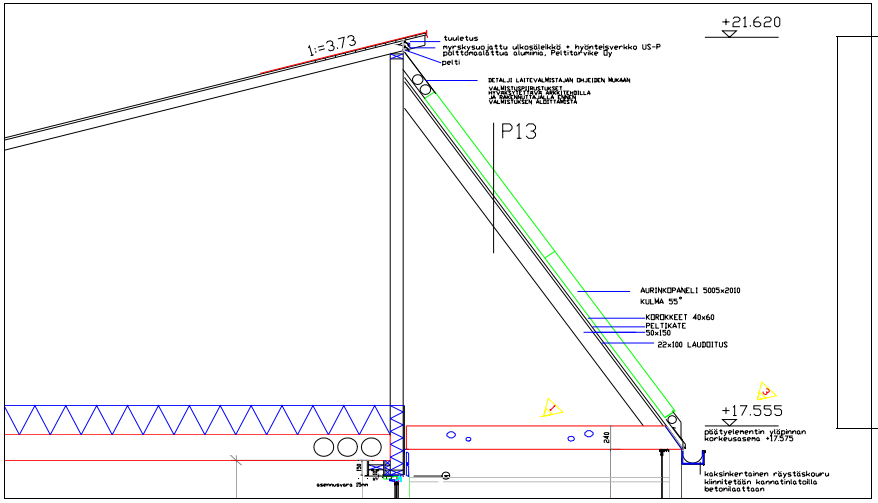
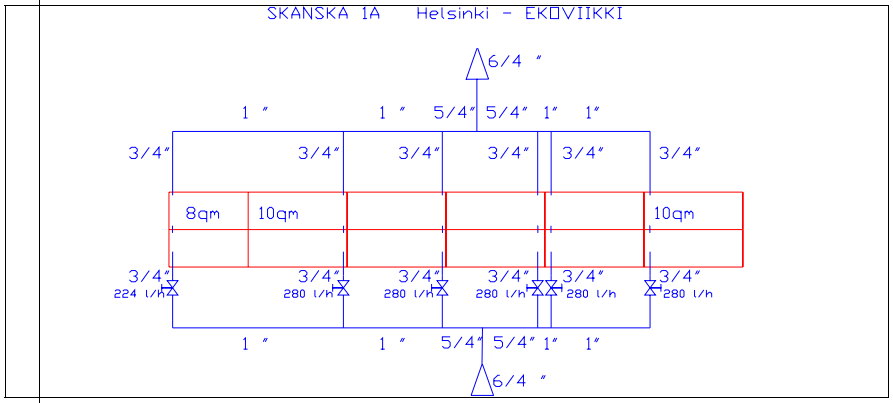
Roof integration of large-area solar collectors







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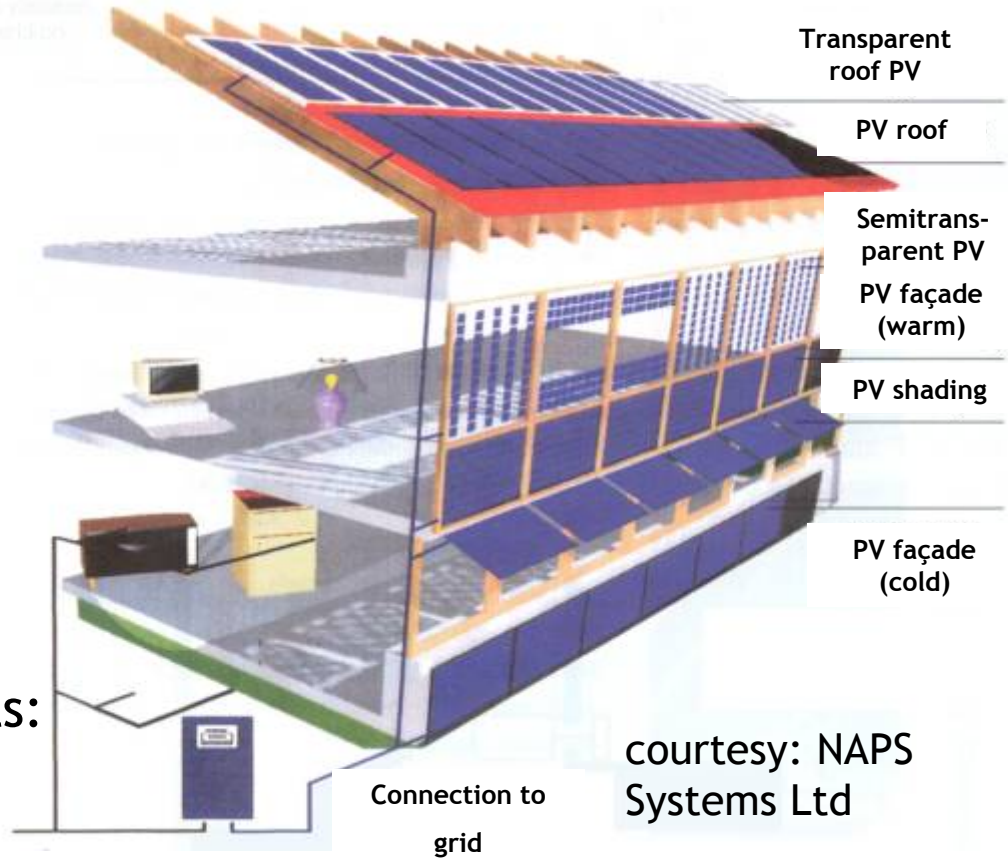
Building integrated photovoltaics (=BIPV)

- Main parts of a building integrated photovoltaic system: 1) photovoltaic (=PV) module, 2) inverter for grid-connection
- Different possibilities to integrate photovoltaic modules into the building
- Applications range from single-family houses to high-rise or office buildings
- Large PV modules as building elements:
  - roofing, balcony glazing, façade
  - on-roof or in-roof



courtesy: NAPS Systems Ltd

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Examples of Building Integrated PV (=BIPV)

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Ekoviikki sustainable suburb in Helsinki, Finland

Helsinki is capital of Republic of Finland

Viikki is a new suburb combining Science and Ecology

courtesy: Helsinki City

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Ekoviikki – overview of urban solar projects

- Helsinki Viikki new suburb 1995-2010
  - Ekoviikki largest ecological building site in Finland (Helsinki City and Ministry of Environment)
  - leading ideas: create “pleasant and sustainable” urban environment
  - ca 10,000 inhabitants by 2010
- Ekoviikki solar energy projects 1999-2004
  - 8 solar heating and 1 BIPV systems, 1 PV pergola
  - realized within the European Union energy programmes

Planning criteria of Ekoviikki in Helsinki

Amount of Pollution

Use of Natural Resources

Effects on Human Health

Effects on Biodiversity

Local Food

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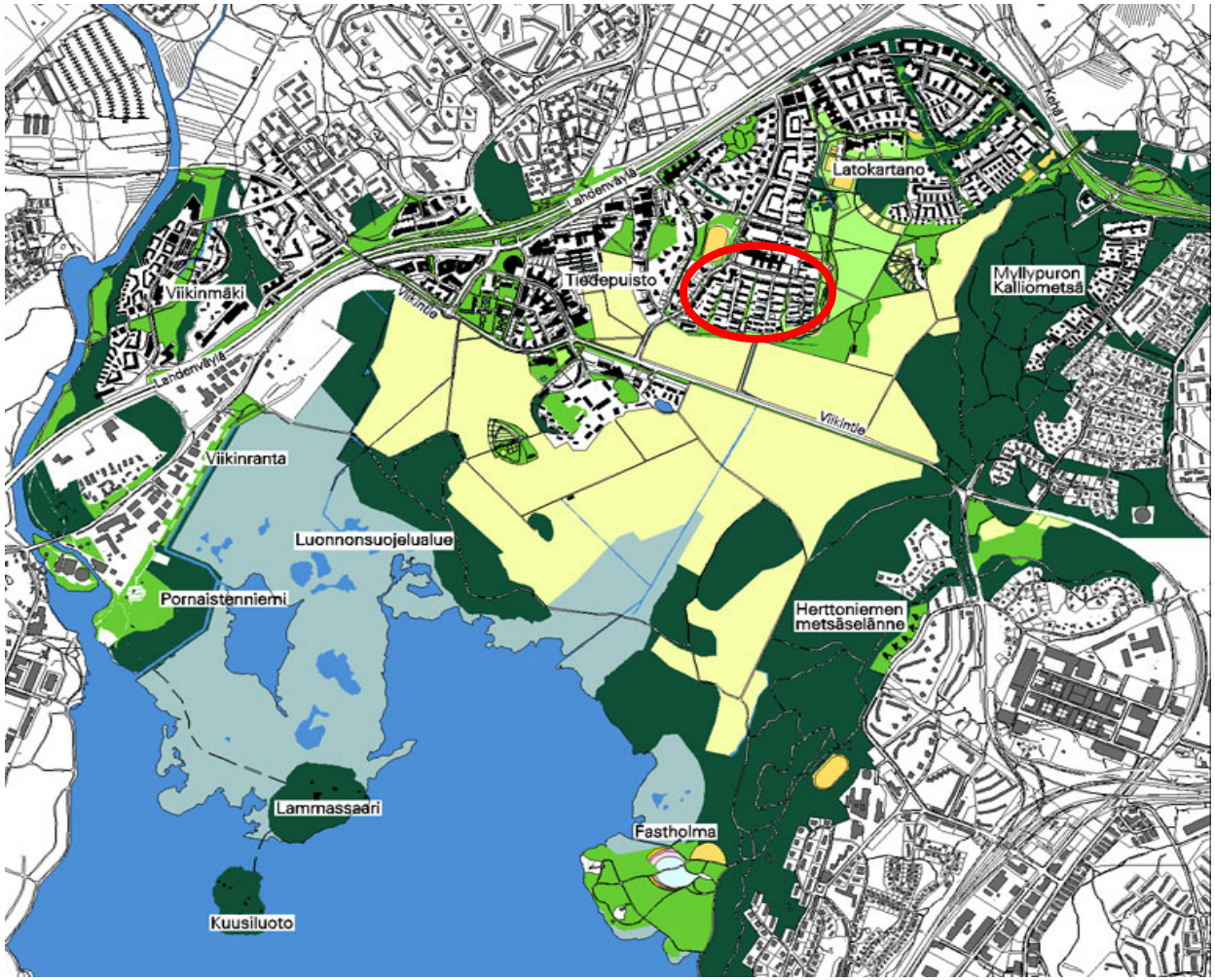
Ekoviikki location – strong ecology in urban area



courtesy: Helsinki City

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Ekoviikki large-scale solar heating installations

- Total residential floor area 64,000 m^2
- From 80 to 250 m^2 per house; altogether 1,400 m^2 of solar collectors
- Collectors produce 300-450 kWh/m^2 per year
- One roof full of solar collectors produces 30-50% of all heat demand

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Ekoviikki BIPV installation

- 24 kW PV system (south and west façade)
- PV modules used as balcony elements
- PV is connected to the electric network of the building
- Information technology is used extensively for monitoring and diagnostics of the PV system
  - wireless local area network to provide real-time PV performance on-line over the internet
  - digital energy meter

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SOLPROS house in Ekoviikki – example of integration

- Total energy solution:
  - Passive solar heating
  - Winter garden (glazed space)
  - Daylight & natural light utilization
  - Energy efficiency (appliances, heat recovery, thermal insulation)
  - Photovoltaics
  - Monitoring of energy use
- “External PV power plant”
  - 1 kW solar pergola (8 m^2)
  - Connected to house network
  - Cold appliances and ventilation
- Total energy use of the building is 50 kWh/m^2 per year

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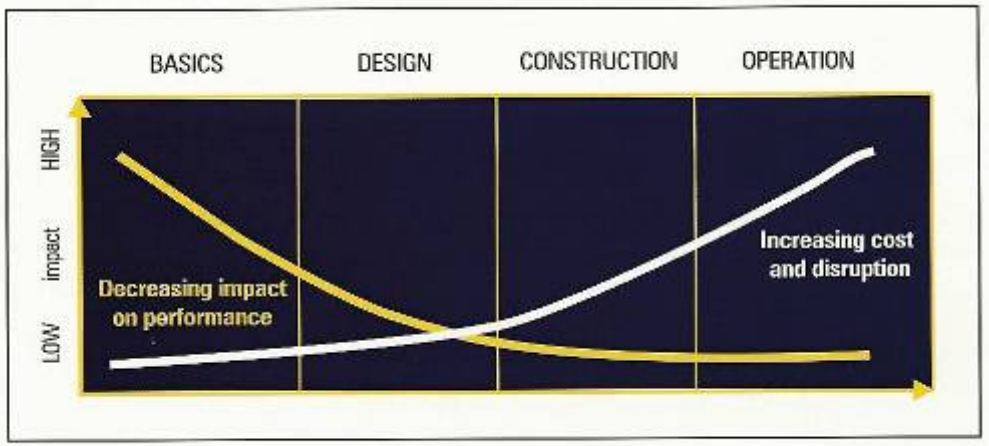
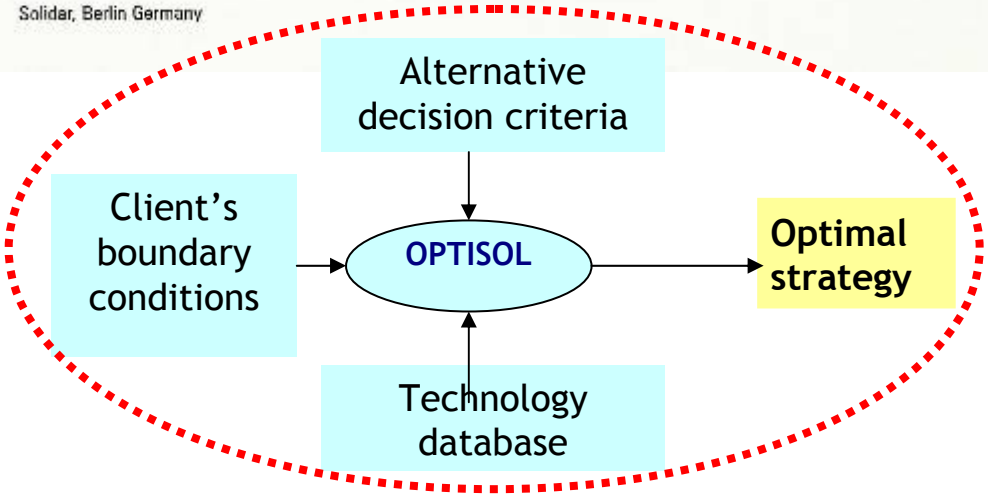
Importance of the pre-design phase of an Ecocity

- The building energy concepts will be fixed in the design phase
- Intelligent pre-design brings 30-50% improvement in sustainability and energy performance with low costs
- Multi-criteria decision making for energy/sustainability
  - OPTISOL tool for energy and environmental building analysis
  - Applicable for feasibility studies, comparing alternative choices, conceptual design, business models





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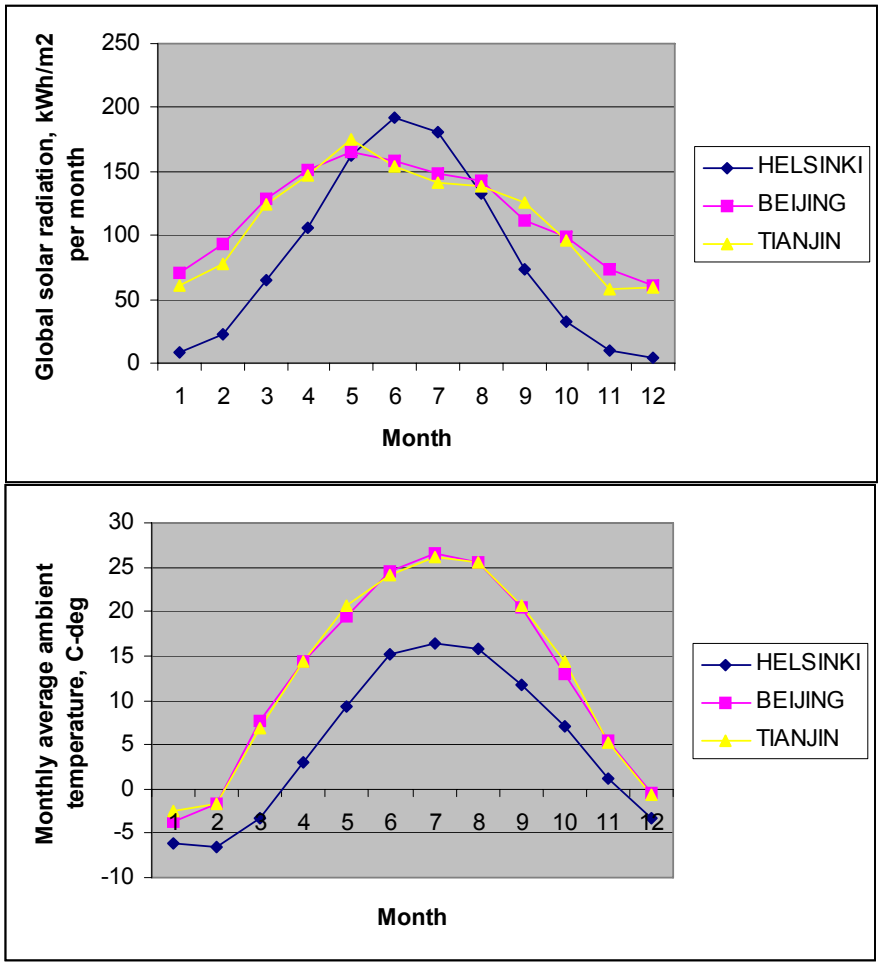
Design example of a sustainable building in Tianjin

- Comparison of climatic conditions
  - Tianjin, Beijing, Helsinki
- Case building for Tianjin
  - 1500 m^2 of floor area (20-30 flats)
  - Full use of solar energy strategies
    - 55 kW PV, 150 m^2 solar thermal
    - PV grid-connected, heat storage
  - Good energy efficiency included
    - U_{window}=1.2, U_{wall}=0.15 W/m^2K
- Comfort standards as in EU/Finland
  - full heating and air-conditioning
  - indoor temperature 19-27 °C
  - appliances & hot water as in Finland



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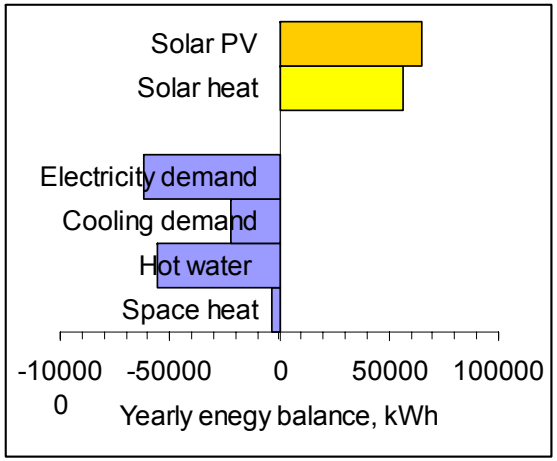
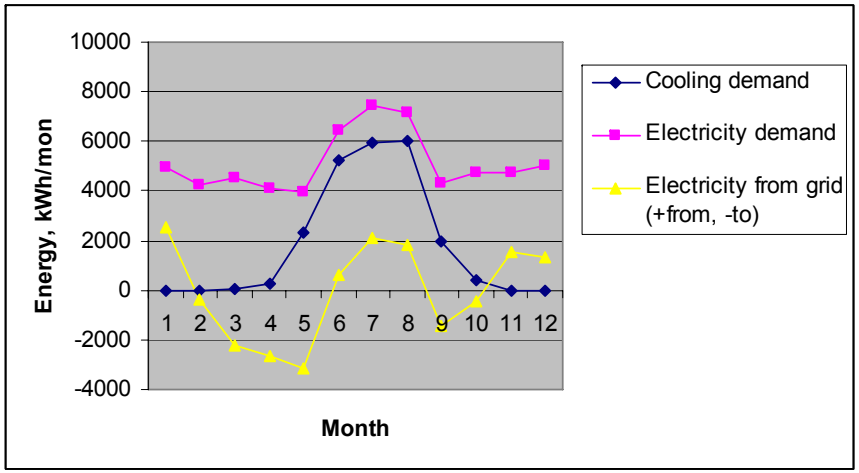
Main results for Tianjin sustainable house

- All energy of the building can be supplied by solar energy on a yearly basis
- No carbon nor sulphur dioxide emissions
- Good thermal and visual comfort
- 100-120$/m^2 upfront investment needed, but 5% savings on a life-cycle basis
- 100% of electricity supplied by photovoltaics; 1/2 of the solar electricity circulated through the grid





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Summary

- Several solar energy options available for urban areas
- Large-scale solar energy was successfully demonstrated in Helsinki
- Up to 100% energy savings and no emissions achievable in Tianjin
- Intelligent building design combines solar energy and energy efficiency
- Good solar design = high comfort and sustainability with low costs

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