

Building Integrated Energy Systems in Smart Energy-Efficient Buildings

A State-of-the-art overview within the research
program

Smart Energy-Efficient Buildings

at NTNU and SINTEF

2002-2006

User/Building Types

■ Residential

- Houses
- Apartments
- Cabins/ part-time housing



■ Non-Residential

- Commercial
 - retail, grocery
- Office space
- Institutional
 - schools, healthcare
- Industrial



Energy Needs

- Heating
 - space
 - water
- Cooling
 - space
 - equipment
- Ventilation
 - human
 - process
- Lighting
 - space
- Equipment
 - appliances
 - process/office
 - personal

Building Integrated Energy Systems

Integrated energy systems in the building envelope or structure that utilizes the available on-site energy resources in a way that minimizes the need for purchased energy and maintains a satisfactory indoor environment

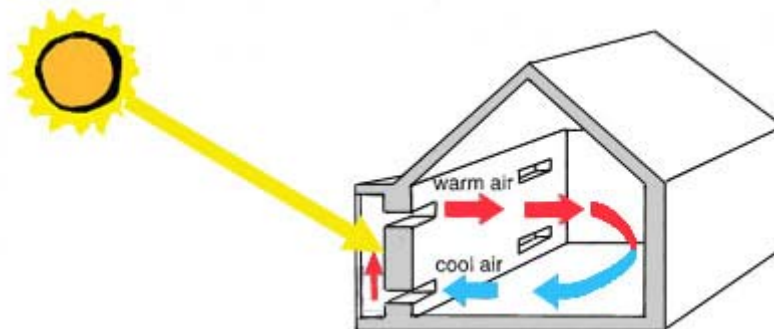
- Enhanced sun protection and cooling load control while improving thermal comfort and maximizing daylighting
- Enhanced air quality and reduced cooling loads using natural ventilation schemes through an active façade
- Reduced operating costs by minimizing lighting, cooling and heating energy use by optimizing the daylighting-thermal tradeoffs
- Improved indoor environments leading to enhanced occupant health, comfort and performance

Available Technologies

- Solar thermal energy systems
 - both active and passive
- Solar photovoltaic systems
 - subtask 2.4: Building Integrated Photovoltaics
- Daylighting systems
 - subtask 2.3: Lighting Systems
- Solar shading/glare control systems
- Natural and hybrid ventilation systems
- Energy storage at envelope - thermal wall

Solar Thermal Energy Systems

- Active systems
 - hot water / air
 - preheat ventilation air
- Passive systems
 - windows
 - sun-space
 - atrium



Solar Photovoltaic Systems

■ Building Integrated

- roof elements
- wall elements
- double façade
- shading devices

■ Subtask 2.4

Integrated Solar PV



Daylighting Systems

■ Daylighting (with shading)

- diffuse
- redirect
- scattering
- transport

- windows
- atrium

■ Subtask 2.3 *Lighting Systems*



Solar Shading / Glare Control Systems

■ Solar Shading

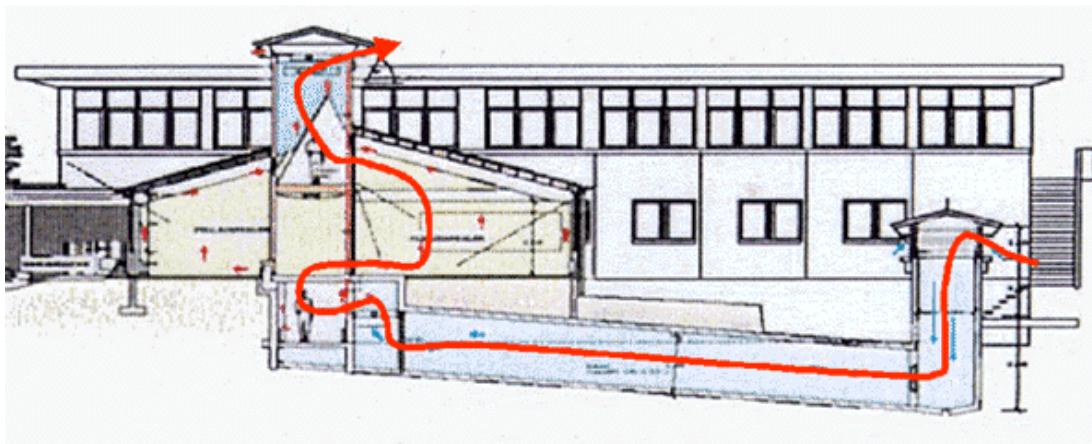
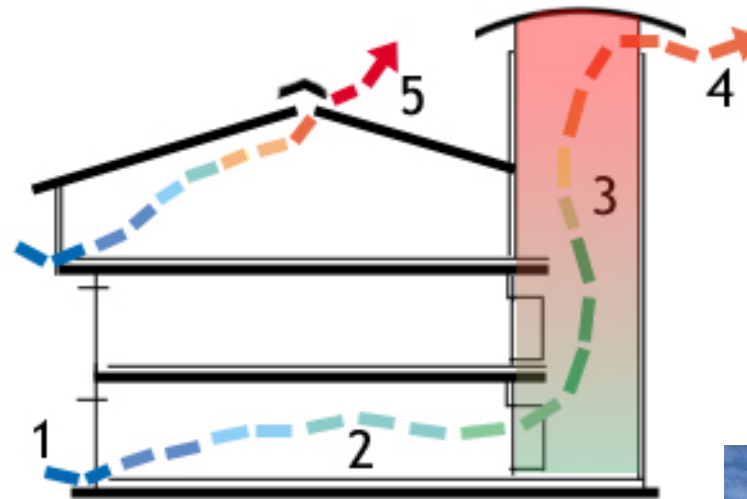
- blinds
- louvers
- overhangs
- window setback
- filters

■ Glare Control



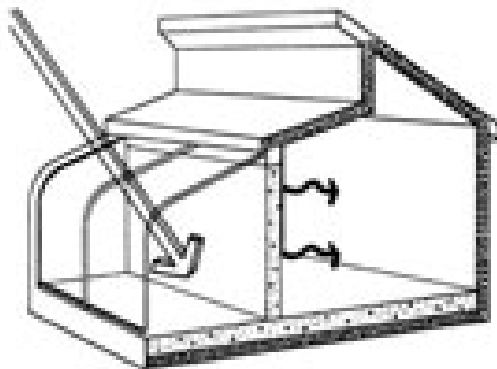
Natural / Hybrid Ventilation Systems

- Natural Ventilation
 - all nature
 - thermal + wind
- Hybrid Ventilation
 - fan assisted
 - low pressure drop



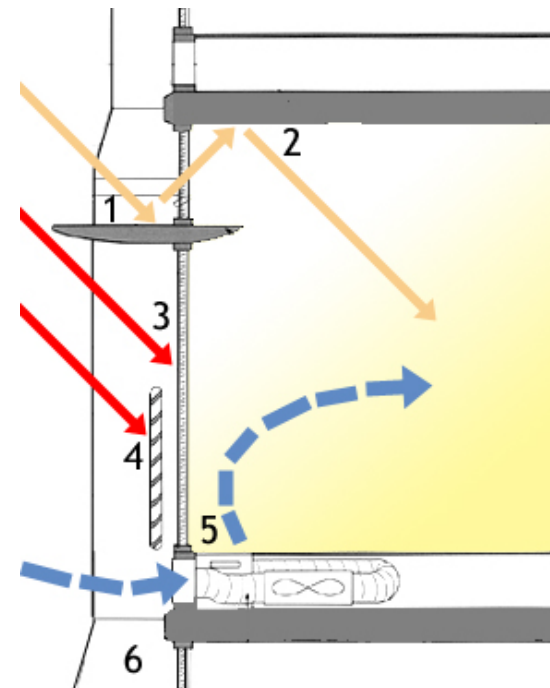
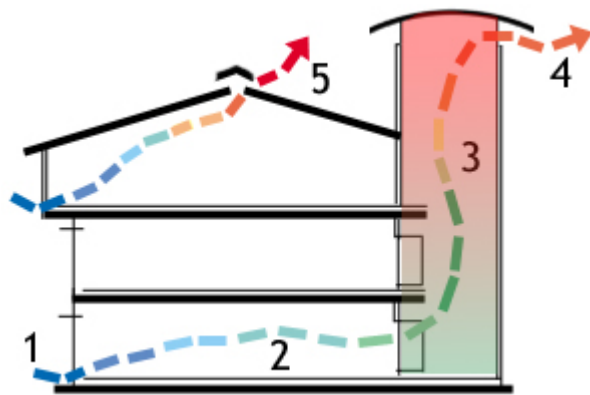
Energy Storage at Envelope

- Thermal energy storage (TES)
 - passive solar heat gain
 - thermal mass in construction
 - rock or water filled storage
- Phase change materials (PCM)
- Subtask 3.4
Thermal Energy Storage



Natural Ventilation and Daylighting

- Inland Revenue Centre, Nottingham
 - Solar chimney stack-induced cross ventilation
 - Integrated lightshelves - daylighting
 - Shading devices (incl:between-pane adjustable blinds)
 - Occupant controlled fresh air inlet



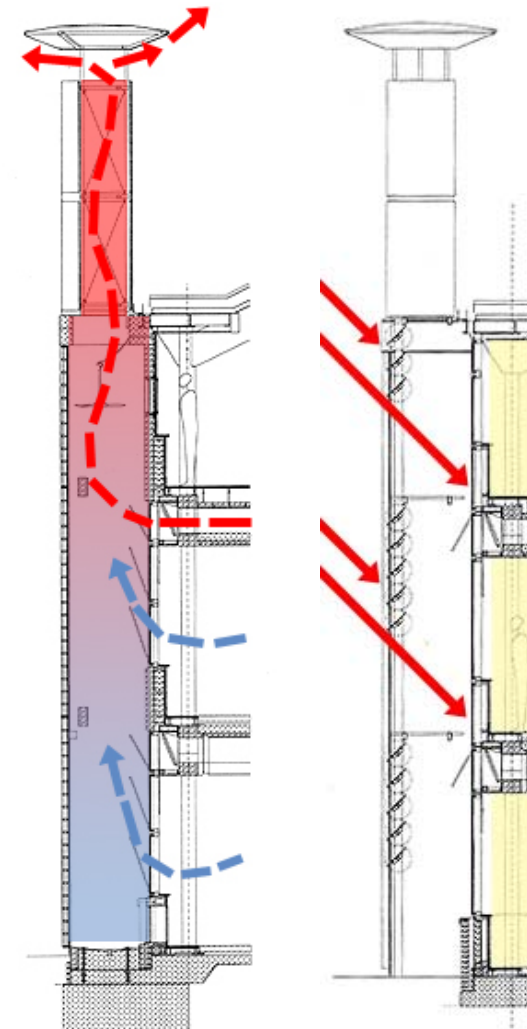
Double Facade

- GSW Headquarters, Berlin
- Double-skin façade
 - cross ventilation
 - thermal buffer in heating season
 - vertical louvers - shading



Ventilation and Shading

- Building Research Establishment, Garston
 - Stack ventilation
 - Highly glazed façade - daylighting
 - Solar shading
 - PV (demonstration



Technology and Market

- Increased focus on energy efficiency
 - Renewed interest in alternative/innovative design
- Still low volume and high cost in most technologies
- Need to interact with conventional systems
 - HVAC, lighting and automation
- Educate all market participants
 - owners, users, architects, engineers, contractors

BIES and *SmartBuild*

- Concentrate on Northern European Climate
- Interact/co-operate with ongoing projects
- Focus on our expertise:
 - building integrated PV
 - daylighting
 - hybrid ventilation
- Interaction with conventional systems
 - HVAC and automation systems
- Evaluate existing buildings / designs / concepts
 - energy
 - indoor environment

R&D Institutions and Projects

- SINTEF/NTNU
 - INTFAS: Energy-efficient intelligent facades
- Norden
 - Norges byggforskningsinstitutt **Norge**
 - Sveriges Provnings- och Forskningsinstitut **Sverige**
 - Statens Byggeforskningsinstitut **Danmark**
 - VTT Building Technology **Finland**
- Europa
 - TNO Building and Construction Research **Nederland**
 - Fraunhofer-Institute for Building Physics **Tyskland**
 - Belgian Building Research Institute **Belgia**
 - Building Research Establishment **Storbritania**
- Nord Amerika
 - National Renewable Laboratory (NREL) **USA**
 - Lawrence Berkeley National Laboratory (LBNL) **USA**
 - CANMET Energy Technology Center **Canada**