Introduction to solar architecture

- Sustainable future
- Energy conscious design
- Solar buildings
Sustainable Future
Sustainable future

• “In 2005, for the first time in human history, more people will live in urban areas than in rural areas.

• This transformation has already had a huge impact on the planet's resources.

• This generation must be committed to the task of bringing urban areas into balance with the natural environment!”

United Nations Environment publication for World Environment Day 2005

Global impact of buildings

• Buildings consume more energy than any other sector

• Buildings are the largest contributor to climate change

• The health of the global economy is tied to the building sector
Global impact of buildings

Buildings account for 40% of the world's energy use ...

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Figure 12. World Primary Energy Consumption, 1970-2025


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Figure 13. World Energy Consumption by Region, 1970-2025

Global impact of buildings

Industry 22.7% (21.7 QBTu)
Transportation 28.2% (27.0 QBTu)
U.S. Energy Consumption by Sector

Global impact of buildings

Industry 23% (8.96 QBTu)
Building Operations 77% (29.99 QBTu)
Transportation <1% (0.07 QBTu)
U.S. Electricity Consumption by Sector
Global impact of buildings

... cut the planet’s carbon footprint by 77%!

Figure 16. World Installed Nuclear Capacity, 2001-2025

Figure 17. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1970-2025

Energy Crises

- 1970: peaking of oil production in major industrial nations
- 1973: OPEC oil export embargo
- 1979: Iranian Revolution
- 1990: Gulf War
- 2000: Environmental- and Energy crisis

The 2030 Challenge

<table>
<thead>
<tr>
<th>Year</th>
<th>Fossil Fuel Energy Consumption</th>
<th>Renewable Energy</th>
<th>Fossil Fuel Energy Reduction</th>
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</thead>
<tbody>
<tr>
<td>Today</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td></td>
<td>90%</td>
</tr>
<tr>
<td>2030</td>
<td></td>
<td></td>
<td><em>CARBON NEUTRAL</em></td>
</tr>
</tbody>
</table>

* Using no fossil fuel GHG emitting energy to operate
The 2030 Challenge

Reducing fossil fuel energy by 2030 ... would also restore the CO2 content of the atmosphere ...

Potential Coal Energy Reductions by 2030

Source: ©2010 2030 Inc. / Architecture 2030. All Rights Reserved.
Data Source: Adapted from P. Wilbur et al., Options for Near-Term Phasing out of CO2 Emissions from Coal Use in the U.S., 2010.

The 2030 Challenge

Reducing fossil fuel energy by 2030 ... would also restore the CO2 content of the atmosphere ...

Cost of 1q8tu Delivered Energy

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The 2030 Challenge

- Design Strategies
- Solar Systems & Technologies
- Renewable Energy

Sustainable Future

- Global impacts of buildings
- Cut back of building energy consumption
- Solar design strategies
Historic Overview of Energy Conscious Design

Historical Overview

- Traditional architecture
- Modern architecture
- Architecture of the “International Style”
- Energy conscious architecture
Traditional architecture

- Reflects local climate
- Uses local, natural materials
- "Passive solar" design

Continental climate:
- Thick wall structures
- Small openings

Modern architecture

- RC, steel, glass
- Large glazed elevations
- Independent of climate
- Immature constructional details and MEP systems
- Increasing energy demand
- Lack of human comfort requirements

Walter Gropius — Pagus shoe factory, 1911-33
The “International Style”

- RC, steel, glass, plastic
- Large glazed elevations
- Independent of climate
- Improved constructional details and MEP systems
- Air Conditioning
- High energy demand

Energy conscious architecture

- Function + form + energy
- Considers climate, geologies
- Utilizes active and passive solar systems
Energy conscious refurbishment

- Function + form + energy
- Considers climate, geologies
- Utilizes active and passive solar systems
- Energy conscious building restoration
“The refurbishment and renovation sector now represents almost half of the total building work carried out within the United Kingdom. The market is predicted to rise from £43bn last year to £46bn in 2012.”

“By 2050 Germany wants to reduce Energy consumption by 80%, which means that 12 million buildings have to be renovated.”
Energy conscious refurbishment

“Save energy during the construction, usage and refurbishing the buildings!”

Energy conscious refurbishment

• Save energy during usage
  (full life-cycle analyses)
Energy conscious refurbishment

- Reduce carbon footprint

Energy conscious refurbishment

- Reduce construction waste
Energy conscious refurbishment

- Upgrade your property

The 2030 Challenge
35% of our built environment till 2030 will be refurbished building
Renovation Challenges

- Support local documentation conventions
- Visualize and document by phases

Building Energy Standards
Building energy regulations

EU energy directives till 2020:
- Reduce GHG (greenhouse gas) emission by 20%
- Reduce building energy consumption by 20%

US energy directive:
- All new governmental building in the US must have at least LEED silver certificate

Building energy regulations

- National and international organizations and certifications
- Calculations methods to fulfill local, national standards
- Constantly improving regulations
Certifications, standards

- LEED (US) & BREEAM (UK) certification
- EN-13790, ‘Passive House’ standard
- ANSI / ASHRAE 90.1, 189.1 standard
- DIN V 18599, EnEV 2009 (dynamic) standard

Certifications

The architects’ responsibilities
- Provide correct information about energy performance
- Consider optimal combination of improvements
- Use renewable and district energy sources

Directive 2010/31/EU
LEED certification

LEED: Leadership in Energy and Environmental Design

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environment
- Innovation in design
- Regional priority

Energy consumption of buildings

1. Energy usage of contemporary buildings: 180-280 kWh/m², year
2. 1982 German standard: 150 kWh/m², year
3. 1995 German standard: 100 kWh/m², year
4. EnEV 2002 standard: 60 kWh/m², year
5. Low-Energy building: 50 kWh/m², year
6. Ultra Low-Energy building: 30 kWh/m², year
7. Passive building: 15 kWh/m², year
8. Zero heating energy building: 0 kWh/m², year
9. Autonom building: 0 kWh/m², year
Low energy building

- Less than 30 kWh/m² annual energy consumption
- Approx. 50% less energy consumption compared to "standard" buildings

House in Scotland, Thomas Robinson Architects, Blanefield

Passive energy building

- Less than 15 kWh/m² annual energy consumption (hair drier)

Hadlow College, Tonbridge, Kent, UK, Architect: James Anwyl
Passive energy building

House in Ajkarendek
First eco-passive house in Hungary

Zero „heating” energy building

• 0 kWh/m² annual energy used for heating

Samsung building „for green tomorrow”, Korea, Samoo Architects
Zero „heating” energy building

- 0 kWh/m² annual energy used for heating

Beddington Zero Energy Development (BedZED), Architect: Bill Dunster
Zero „heating” energy building

- 0 kWh/m² annual energy used for heating

Beddington Zero Energy Development (BedZED), Architect: Bill Dunster

Autonom building

- 0 kWh/m² annual energy used for heating, no CO2 emission, independent from public utilities („only water goes in and comes out“).

E-autark building, Freiburg, Architect: Diesch R.
Passive
Solar Systems

Thermal comfort
"Comfort state of mind"
Thermal comfort

- **Room**: temperature and radiation of surfaces
- **People**: clothes, activity, duration
- **Air**: temperature, humidity, airflow speed

Visual comfort

- “Comfort state of mind”
- Information about the surroundings
- Connection with the exterior
Visual comfort

- **Room**: light-transmission or reflection of surfaces
- **People**: activity
- **Light**: quantity and quality

Passive solar systems

“Passive” utilization of renewable energy using:

- solar **radiation**,  
- thermal **mass**,  
- natural **ventilation**,  
- **glazing**,  
- thermal **insulation** and  
- **smart conceptual design**!
80% of the energy-related **architectural design** decisions are made at the early design stages!
Thermal mass

The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

CO$_2$ and other gases in the atmosphere trap heat, keeping the earth warm.
Thermal mass
Transparent insulation

Sunspace
Sunspace

Sunspace + Trombe wall
Green-roofs, green-elevations

Passive solar systems
Passive solar systems

Active Solar Systems
Active solar systems

“Active” utilization of renewable energy with the help of MEP (Mechanical, Electric, Plumbing) systems:

- PV panels (electricity)
- Solar collectors (hot water)
- Wind turbines (electricity)
- Heat pumps (thermal energy)

PV panels
PV panels

Electron Flow

"Hole" Flow

Load

Sunlight

n-type silicon

p-type silicon

Junction

Solar Panel Diagram

Photons

© Ron Carter & Merlina.com
PV panels

Typical PV System

Solar collectors