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Nachhaltigkeit im ETH Bereich

Sustainable Real Estate Development and Green Skills
a Swiss-Czech Comparative Perspective
organized by Envi A. o.p.s.

Passive buildings and planning strategies

International Conference 'Together for the Environment'
National Technica Library, Prague
17-18th March 2011

Severin Lenel

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Agenda

- Passive House, MINERGIE and MINERGIE-P
- Planning principles
- Examples
- MINERGIE-ECO

European passive house labels

- Germany: Passivhaus
- Switzerland: MINERGIE-P
- Italy: CasaClima Gold
- Austria: klima:aktiv
- France: la maison passive

What is a passive house?

- A passive house is a building that requires in principle no active heating system.
- The passive house philosophy aims for a heating energy demand of 15 kWh / m2a.
- “Passive” energy sources like solar, geothermal, internal loads (people, lighting, household appliances, consumer electronics, personal computers etc.) are used. Ventilation systems must have a very efficient energy recovery.
- The international passive house standard was established in 1996 by Dr. Wolfgang Feist. The Passive House Institute Darmstadt researches, calculates and certifies passive houses.

MINERGIE

- MINERGIE is a quality label for buildings
- The aim is to support energy efficiency and the use of renewable energies in the construction sector while providing a high living comfort
- The label MINERGIE defines certain demands for buildings and construction components
- Certification of new and renovated buildings of almost all types
- 20‘000 certified buildings in Switzerland since 1998, with a market share of ca. 25% in new buildings – MINERGIE is the most successful building label worldwide.

The most important MINERGIE procedures

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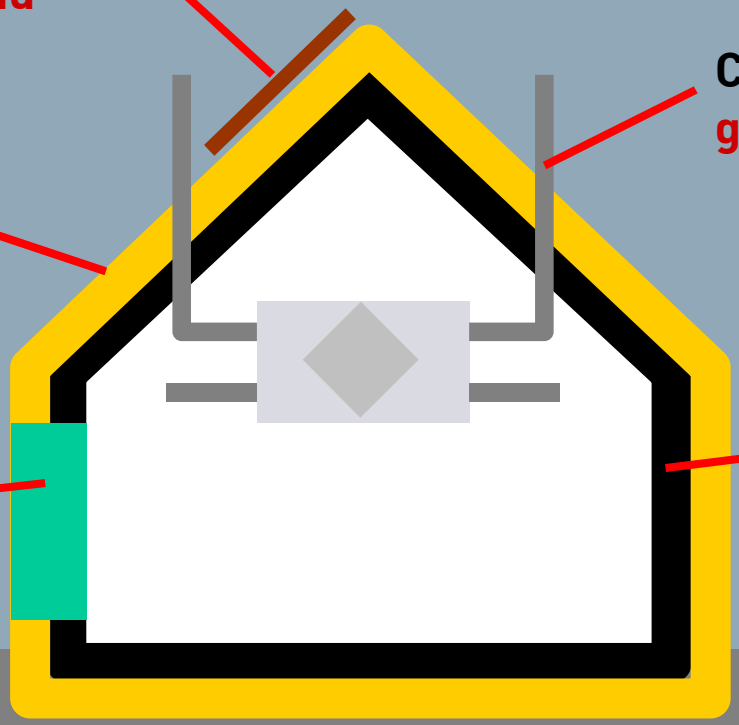
Use of renewable energies
low n.r. energy demand

Good insulation
high surface temperatures, low energy demand

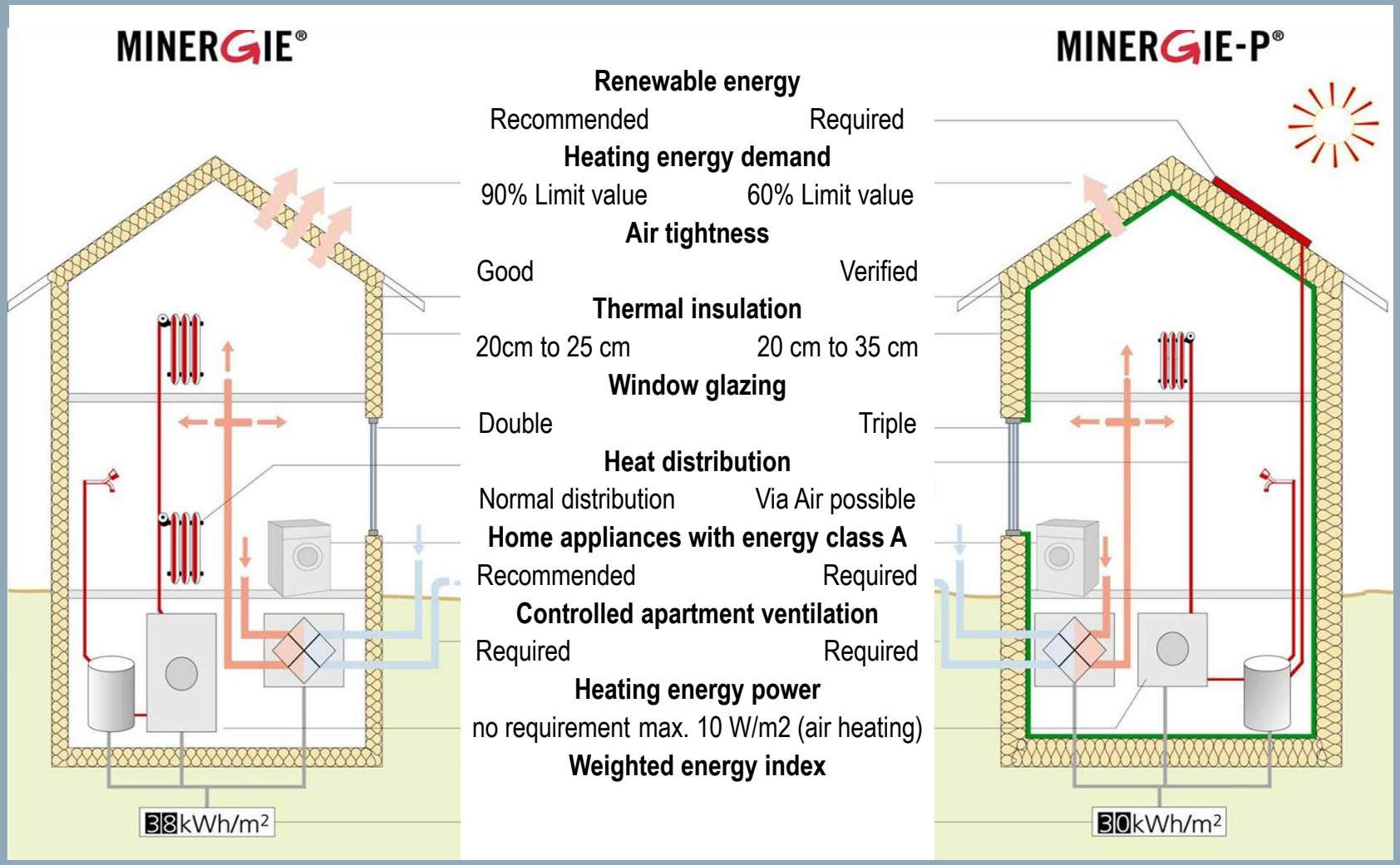
Solar gains
low energy demand



Controlled ventilation
good indoor air quality

Air-tight building envelope
low energy demand

Minergie and Minergie-P



Comparison only valid for new single-family buildings

Requirements of Minergie-P

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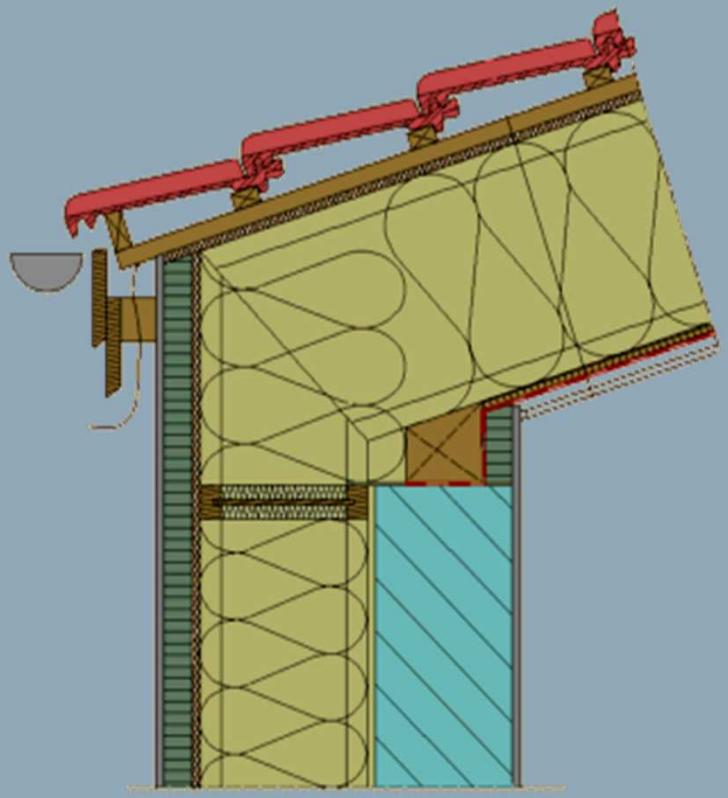
In analogy to Minergie (but in part more strict values):

- Limited heating energy demand (→ building envelope)
- Limited energy demand for heating, cooling, ventilation (weighted energy conversion factors are applied)
- further requirements, e. g. energy demand of lighting

Additional criteria for Minergie-P:

- Air tightness of building envelope
- Limited specific heating demand (only for air heating)
- Energy efficiency of home appliances

Heating energy demand



Calculated according to SIA 380/1:2009 («primary requirements»)

- New buildings:
  - Qh < 60 % Qh,li (target value SIA)
  - Qh < 15 kWh/m2a
- Modernisations:
  - Qh < 80 % Qh,li
  - (related to SIA-New building value!)
  - Qh < 15 kWh/m2a

In most cases the strictest requirement in the implementation of the Minergie-P-standard

Energy conversion factors and Threshold Values

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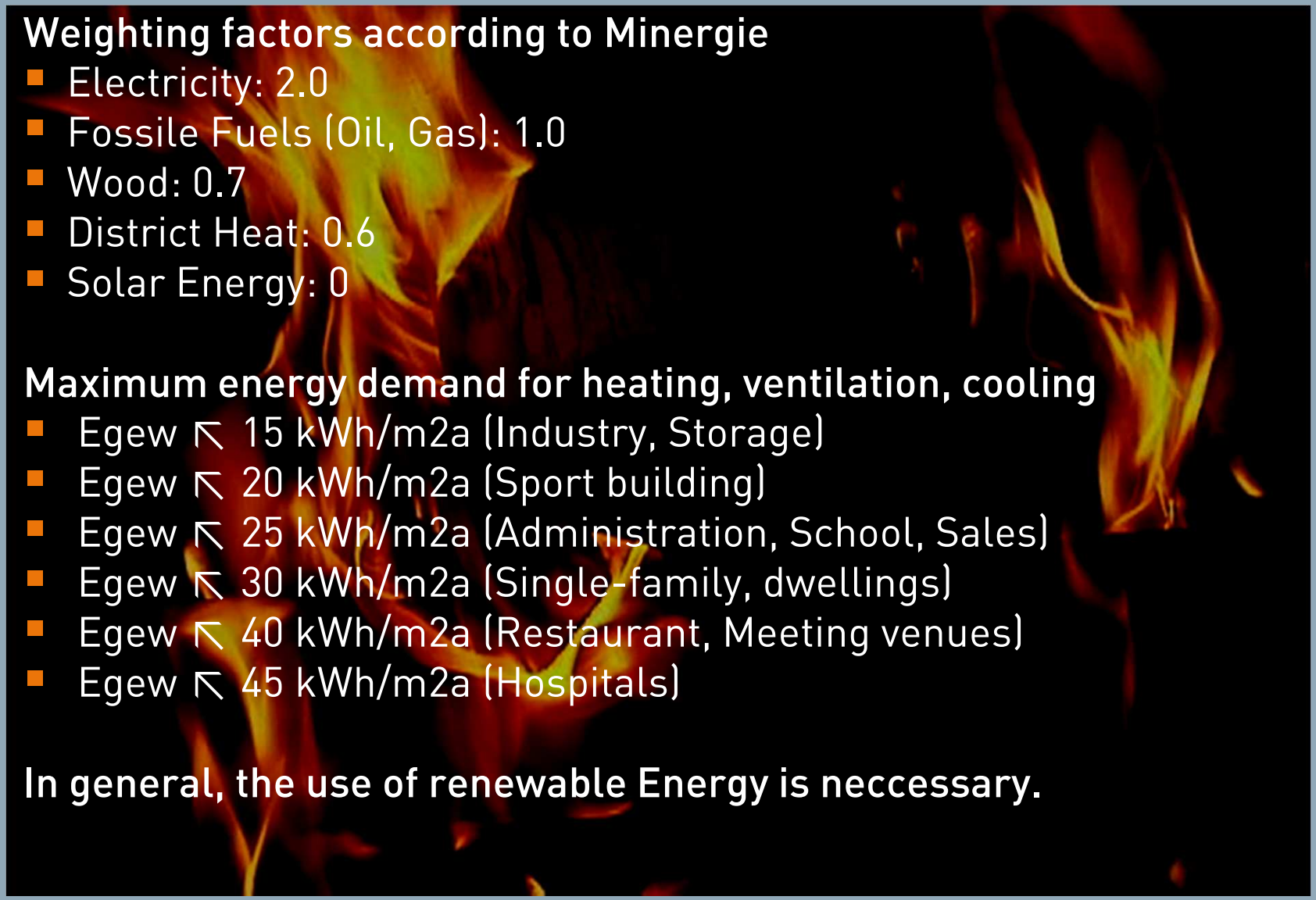


Weighting factors according to Minergie

- Electricity: 2.0
- Fossile Fuels (Oil, Gas): 1.0
- Wood: 0.7
- District Heat: 0.6
- Solar Energy: 0

Maximum energy demand for heating, ventilation, cooling

- Egew ≤ 15 kWh/m2a (Industry, Storage)
- Egew ≤ 20 kWh/m2a (Sport building)
- Egew ≤ 25 kWh/m2a (Administration, School, Sales)
- Egew ≤ 30 kWh/m2a (Single-family, dwellings)
- Egew ≤ 40 kWh/m2a (Restaurant, Meeting venues)
- Egew ≤ 45 kWh/m2a (Hospitals)

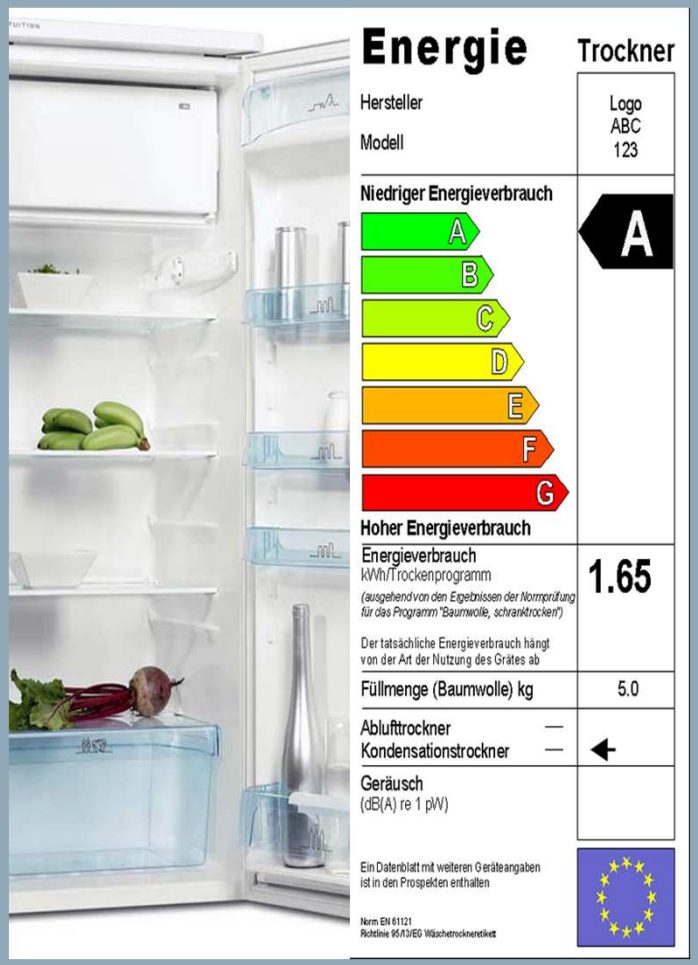
In general, the use of renewable Energy is neccessary.

Air-tight building envelope

Proof with Blower-Door-Test

- Requirements for new buildings:
  n50,st ‹ 0.6 h-1
- Requirements for modernisations:
  n50,st ‹ 1.5 h-1

Electrical energy demand



- Requirements for home appliances (Tumblers, washing machines, cooking stoves, ovens):
  Energy efficiency class A
- Requirements for cooling units (Refrigerators, Freezers):
  Energy efficiency class A+

Extra costs

- Maximal 15%, otherwise not certifiable
- According to experience 5 to 8%
- Correct (early!) planning can lead to lower extra costs, particularly with increasing experience of planners and executors
- Crucial question is always: extra costs compared to what? What does the "typical manufacturing" look like?
- Statistical evidence is still missing, studies are in progress

Minergie-P objects

Multi-family building „Kraftwerk B“ MINERGIE-P-ECO

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Plus-energy-building: 110% energy generation

Next steps: zero and plus energy buildings, MINERGIE-A

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133% energy generation

175% energy generation

Quelle: Gallus Cadonau

Plus energy building, Riehen/BS

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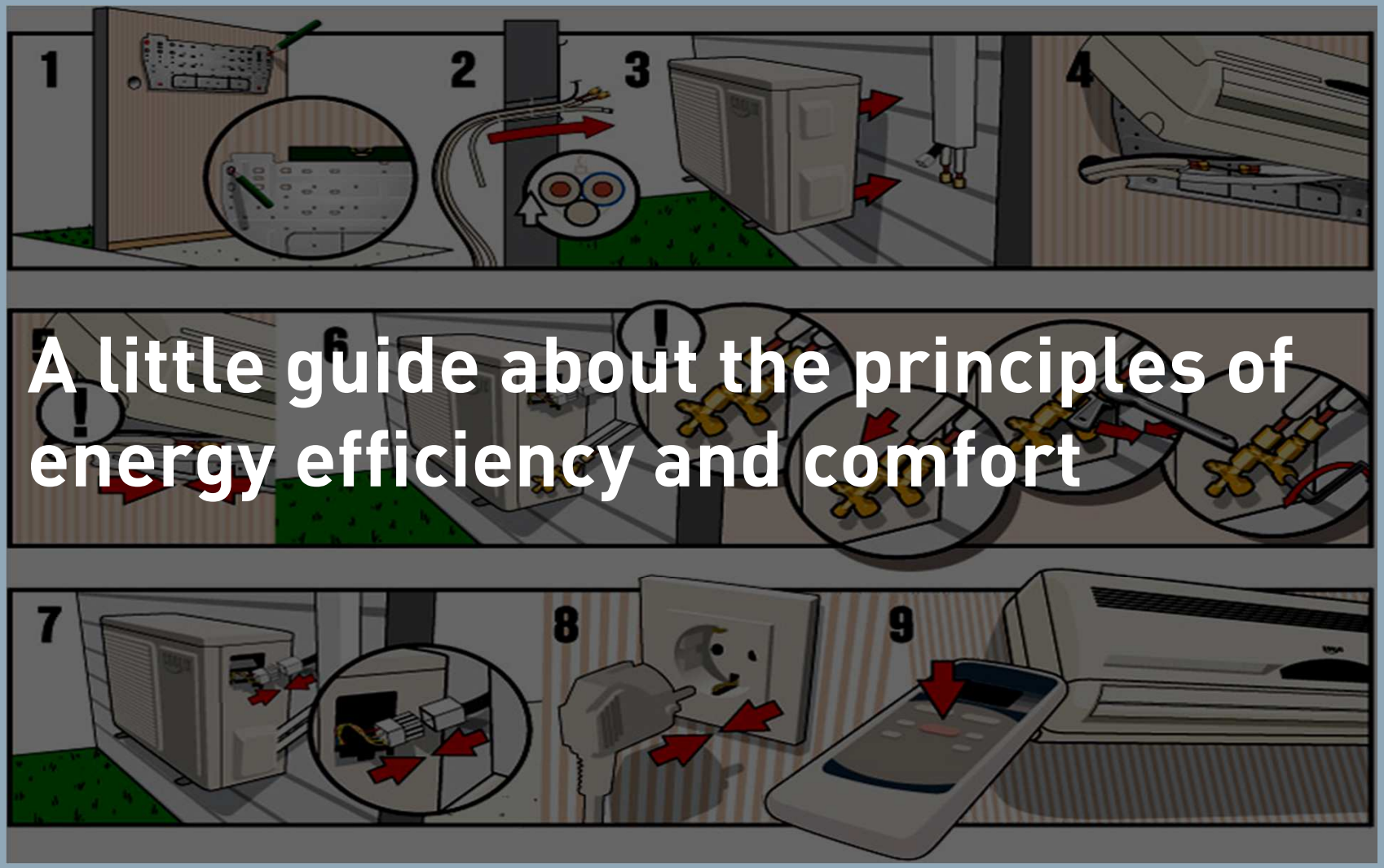
200% energy generation
Reduction of CO_2-Emissions: 17'300 kg/a
Increased initial costs: 12%/180‘000 CHF

Energy efficient building design



Compact building envelope

Very good windows

- Optimization between gains and losses ...
- Good insulation (triple glazing)
- Glass U-value: 0.5 ... 0.7 W/m2K
- Frame U-value: 0.9 ... 1.4 W/m2K
- High energy transmission value (g-value of 0.45 ... 0.50)
- High daylight transmission value

- Additional insulation of frames

- Products: www.topfenster.ch

Very good insulation

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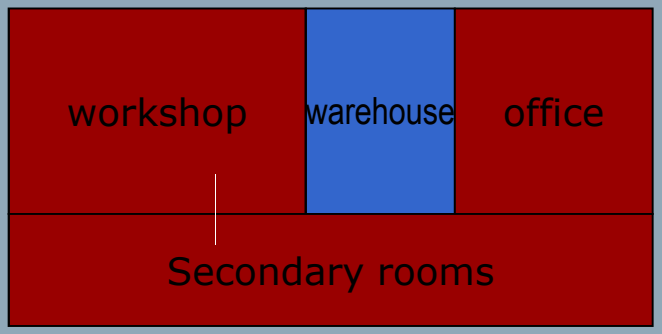
Insulation thickness of 25 to 35 cm

- U-value roof ≈ 0.10 W/m2K
- U-value floor ≈ 0.15 W/m2K
- U-value wall ≈ 0.12 W/m2K
- Very good control of thermal bridges

Energy efficient floor layout

- Layout of areas based on room temperatures (e.g. heated/ not heated)
- Buffer zones
- Passive solar gains through appropriate building orientation, window arrangement, thermal mass, absorption possibilities

Temperature zoning



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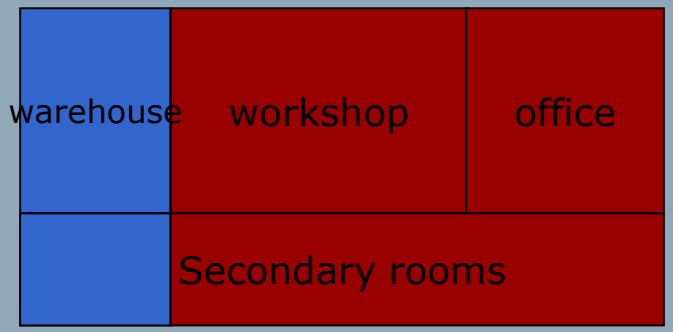

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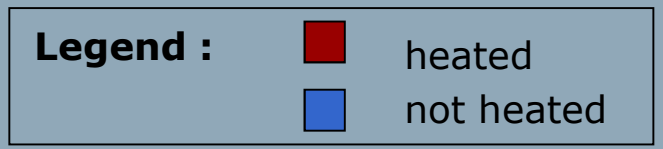
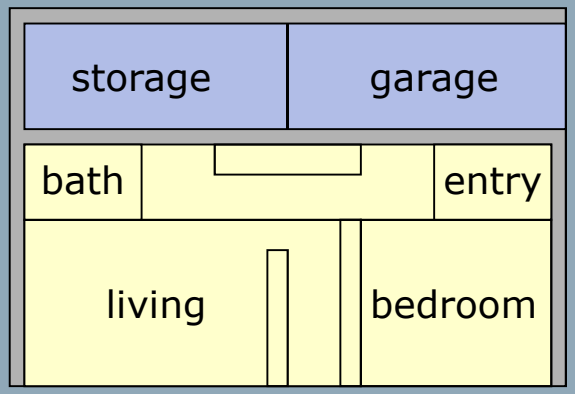
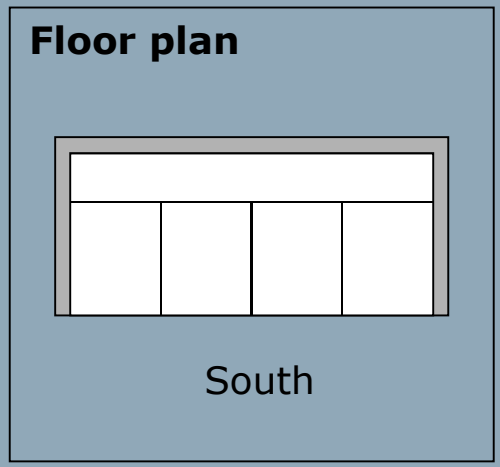


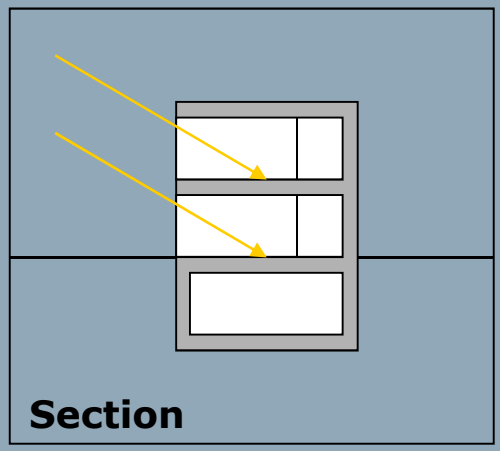


south

Passive solar heat gains (1): Principles in the heating season

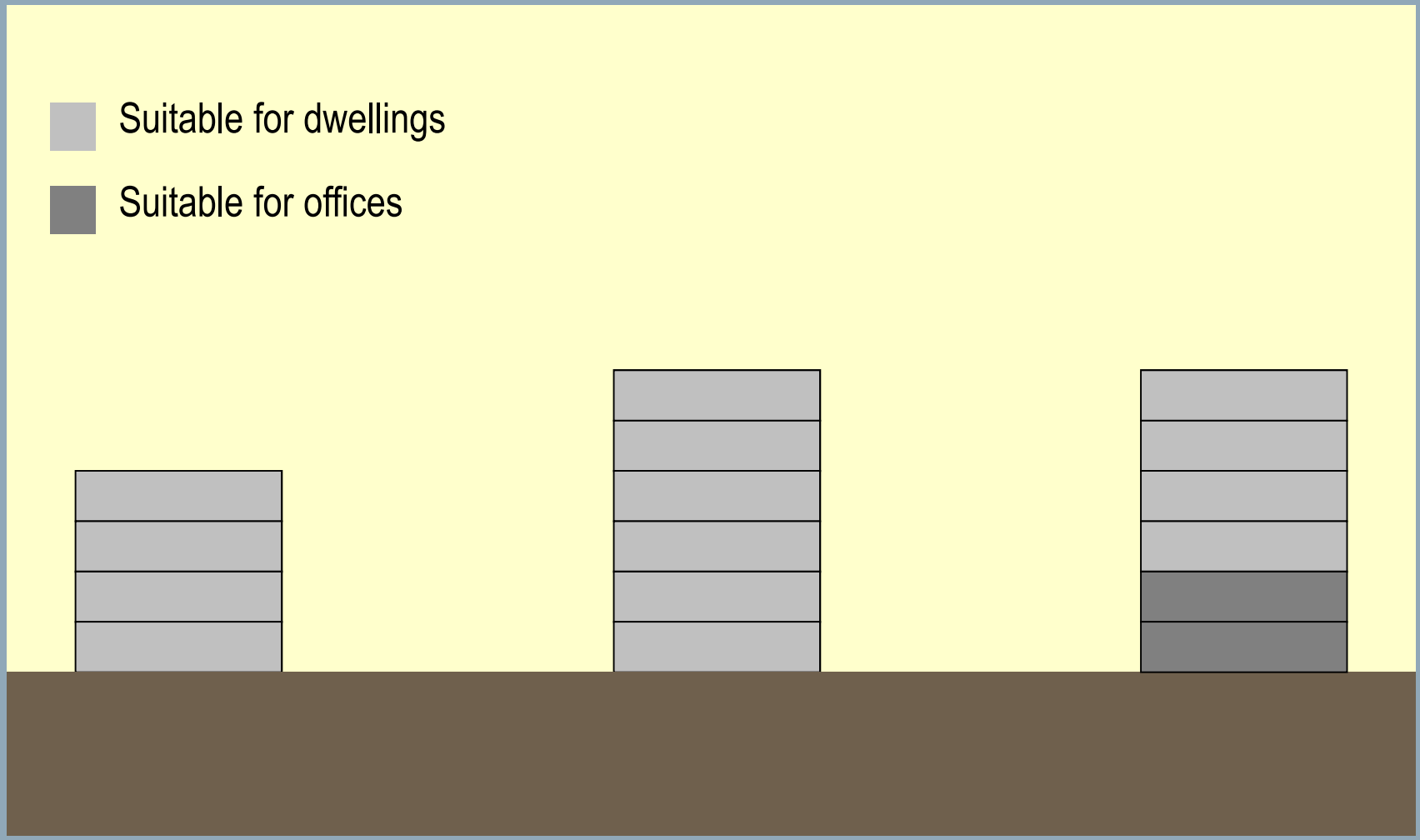
- Capture of energy in the house
  - Building orientation normally towards south (largest energy gains)
  - Large windows facing south, no or small lintel (large sunlit surface)
  - If possible, principal rooms facing south
  - High g-value of the glass (good energy transfer)
- Let escape as little energy as possible
  - Good thermal insulation
  - Small U-value of the glazing





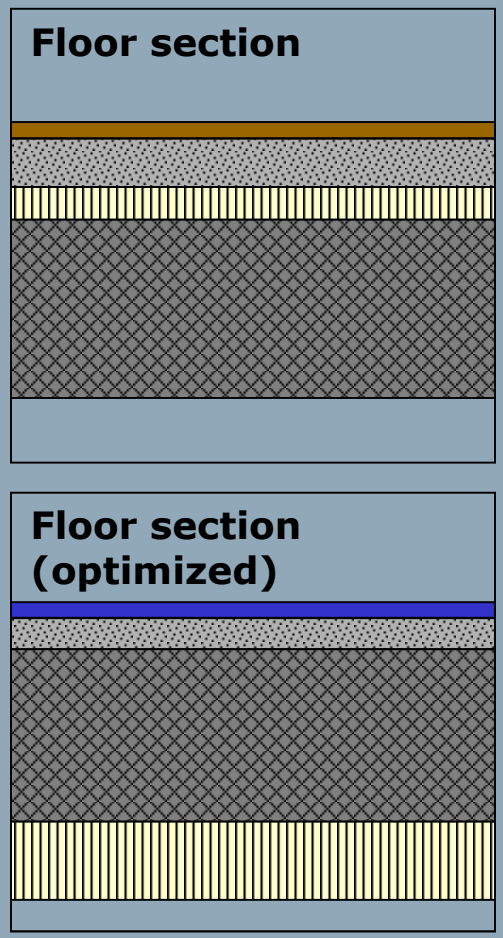
Large south oriented windows

Passive solar heat gains (2)

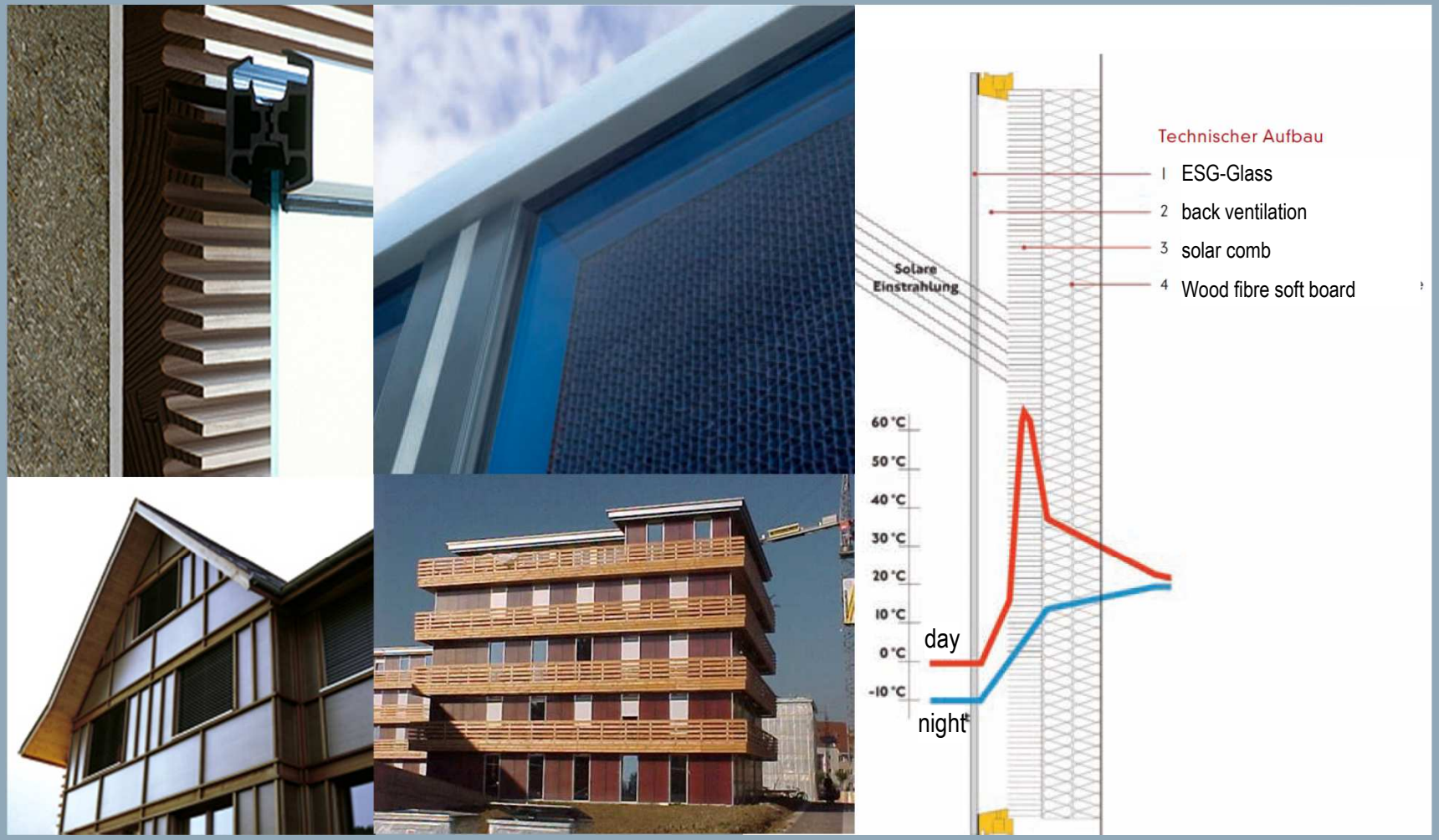


Passive solar heat gains (3)

- Make use of captured energy
  - Heat storage capacity to mitigate the short-term temperature fluctuations (depth of penetration!)
  - Floors with good thermal conductivity
  - Dark surface (energy absorption)
- Strive for high inertia to buffer temperature fluctuations
  - Thermal storage capacity to compensate for long-term temperature fluctuations (by means of mass or Phase Change Materials)
  - Mass coupling to heated rooms

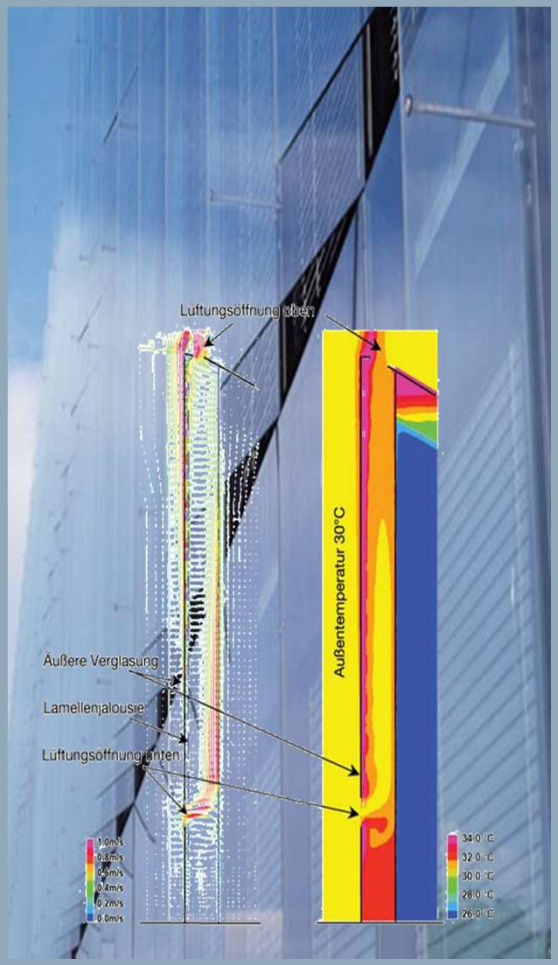


Passive solar heat gains (4)

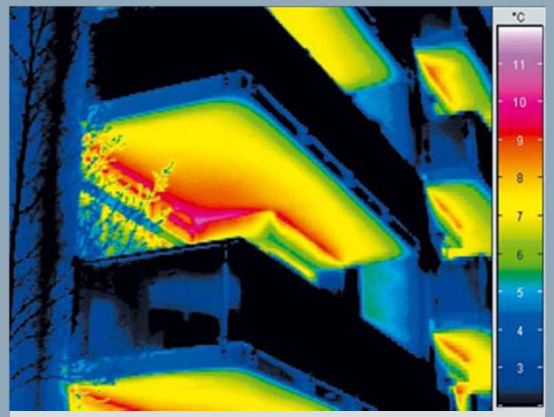


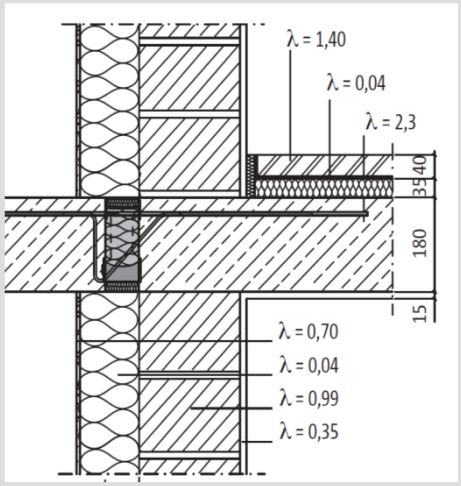
Passive solar heat gains (5): double layer glass facades

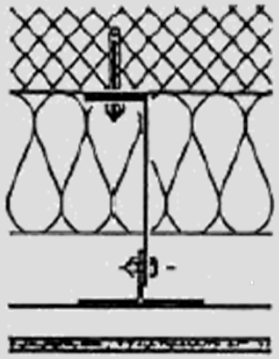
- Double layer glass facades use a second glass layer to optimize heat gains, protect windows and shades and reduce external noise. They allow a natural ventilation, even in skyscrapers.
- Because the space between the two layers can heat up in summer, heat protection has to be planned carefully (i.e. cfd simulations)
- Disadvantages of these facades are
  - very high embodied energy
  - high initial cost
  - reduced daylight transmission, leading to higher cost for lighting.



Thermal bridges (1)







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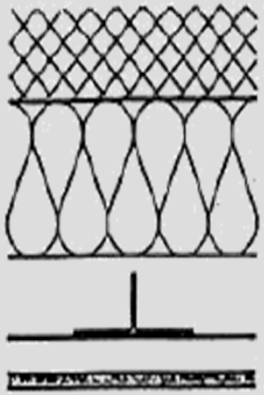

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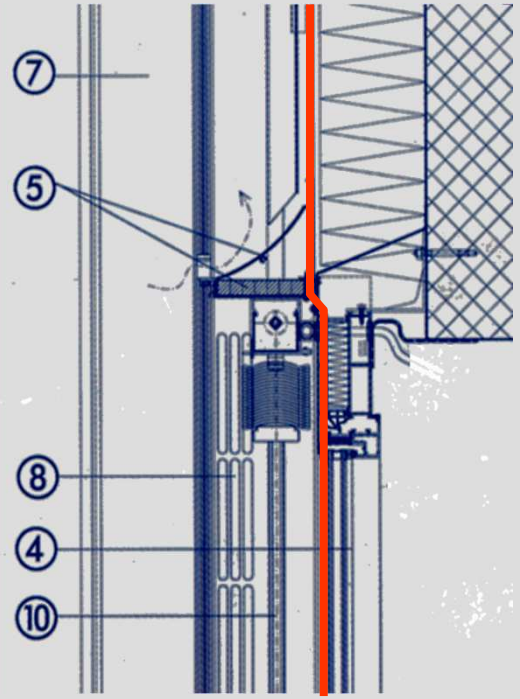
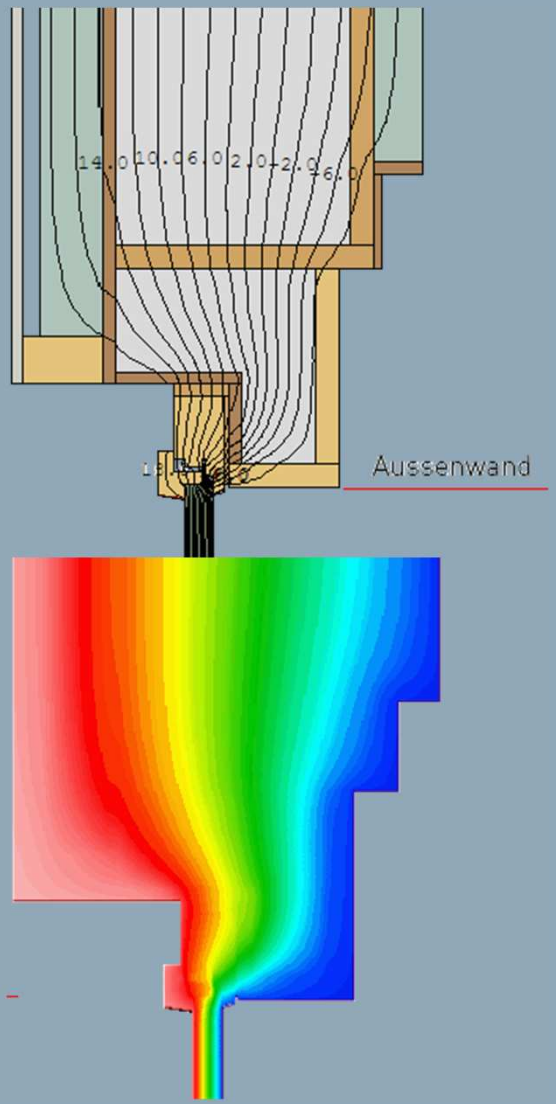
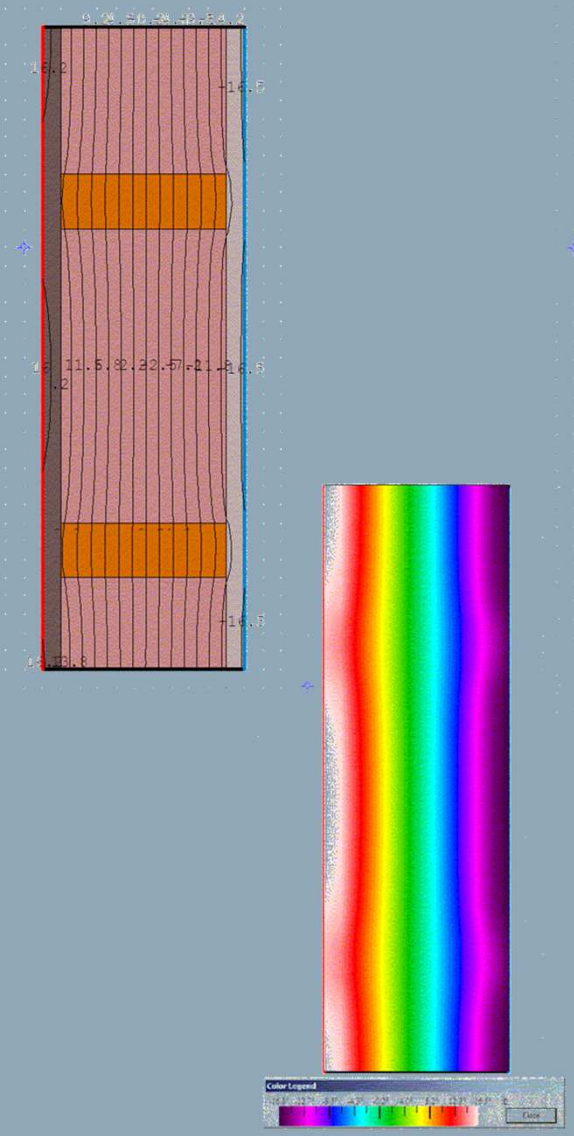


Thermal bridges (2)





Ventilation heat losses (1)

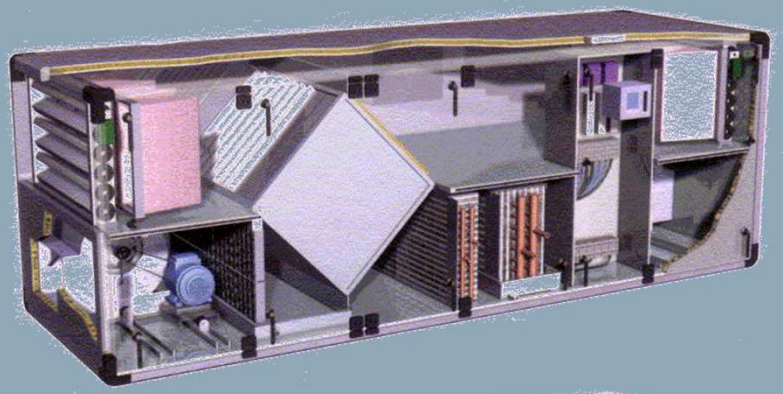
- The ventilation heat losses can amount to up to half of the total heating energy demand of a building.
- Ventilation heat losses within building components are greatly influenced by the following factors:
  - Permeability of joints (for windows and doors)
  - Air permeability (at component joints and ends, also through permeable components)
  - Air temperature and humidity, outdoor temperature
- The air tightness of the building envelope can be proven through a so-called Blower-Door-Test.

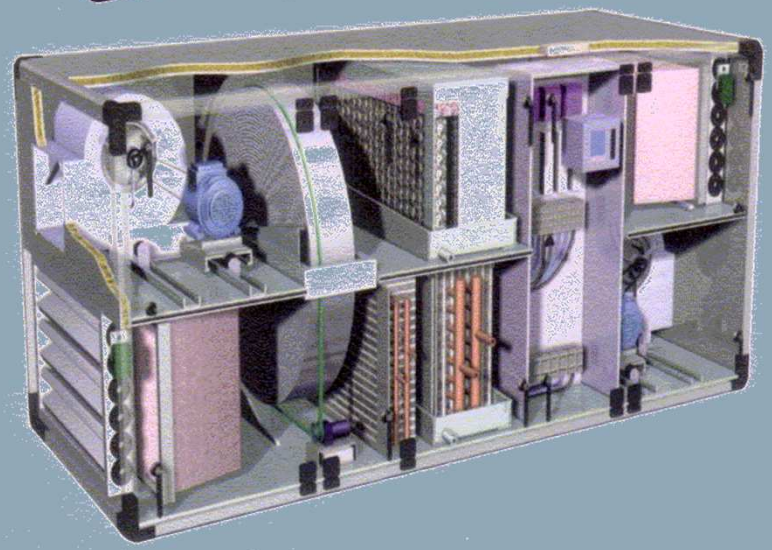
Ventilation heat losses (2)

Ventilation heat losses (3)

- In mechanically ventilated buildings, usually the ventilation system ensures the largest part of the air exchange. Ventilation heat losses in mechanically ventilated buildings are essentially driven by
  - Air volume
  - Efficiency of the heat exchanger
    (Attention: heat exchanger efficiency [air resistance] can have an impact on ventilator energy consumption!)
  - Humidity, outside air and exhaust air temperature

Ventilation heat losses (4)





Thermal comfort: Summer heat protection

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Summer heat protection: Measures (1)

- The thermal comfort must be equally ensured in summer, especially because global warming will lead to even higher summer temperatures in the future.
- The main elements are a combination of
  - External shading and eventually heat protection glazing to limit solar gains
  - Sufficient thermally active materials inside the building to buffer thermal peaks
  - Measures for directing energy out of the building (passive cooling)

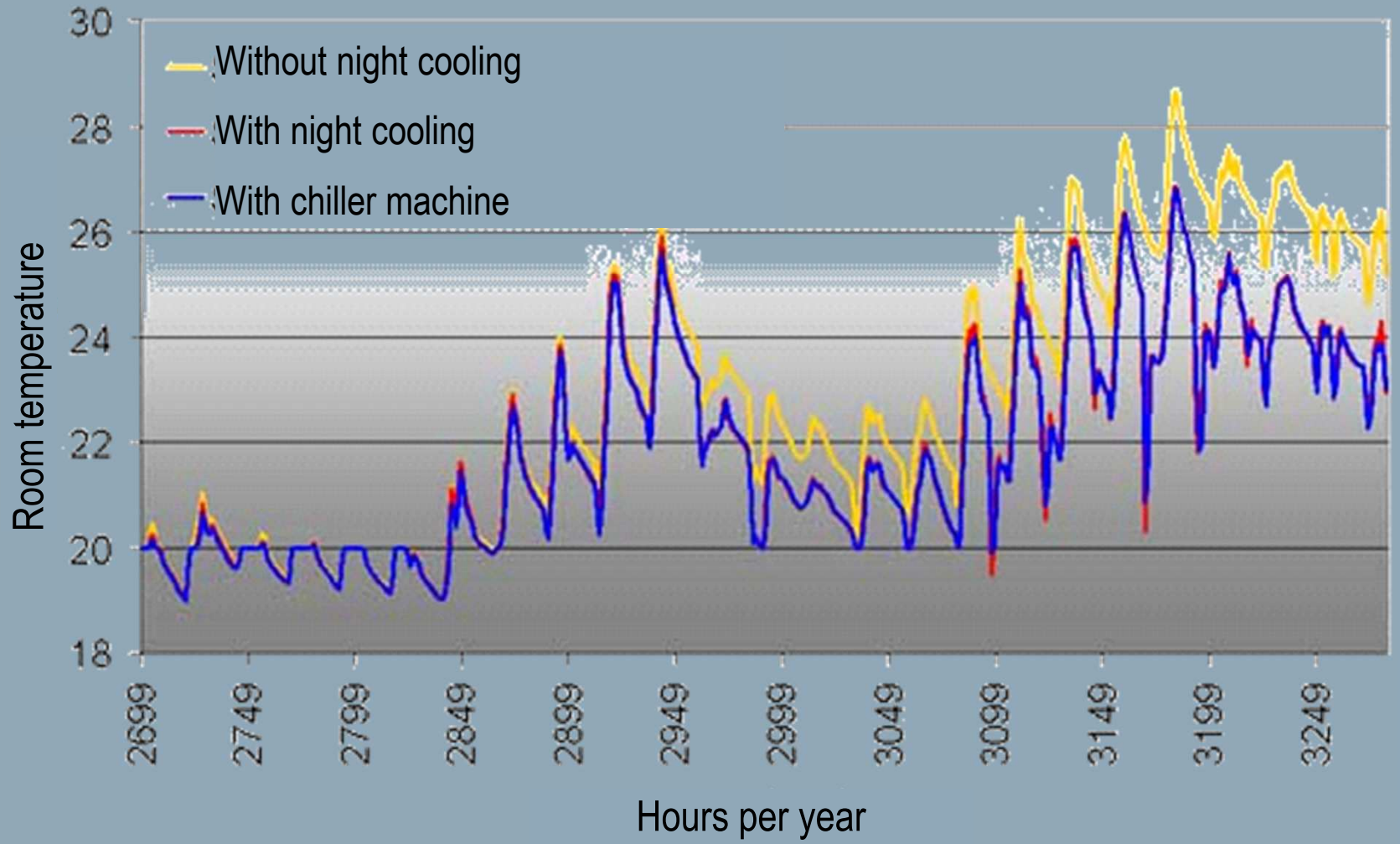
Summer heat protection: Measures (2)

- An active cooling with chillers **must be avoided.** Possibilities of passive cooling are to be used:
  - Night cooling through openings, which can be left open over night (consider intrusion protection!)
  - Earth air register
  - Adiabatic cooling (evaporation of water in the exhaust air stream in ventilation equipment)
  - Passive cooling circuit with geothermal probes, ground water or surface water

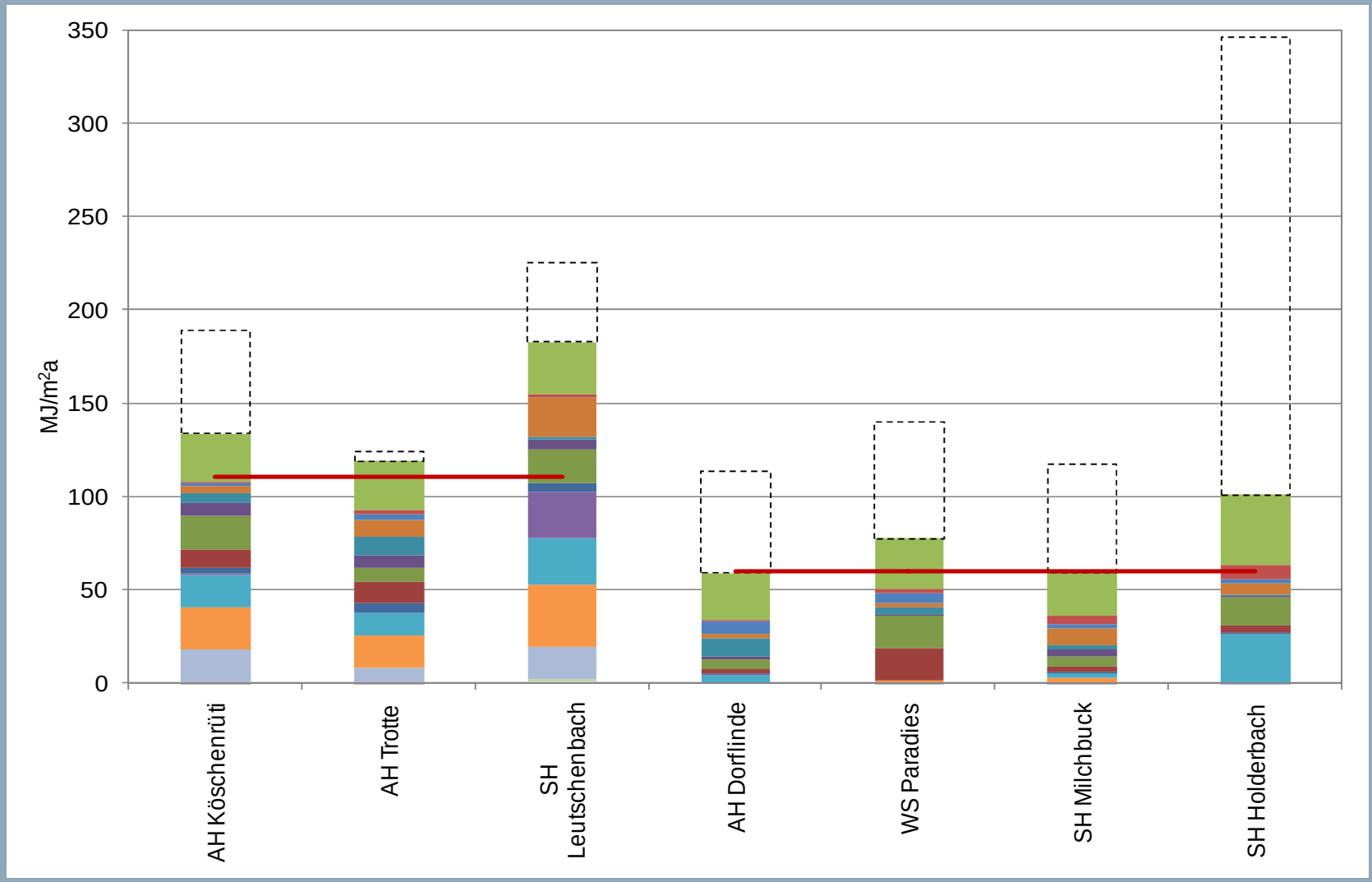
Effective solar protection (shading)

- Total energy transmittance of glass and solar protection ‹0.15, for buildings with high glass content (› 50% of glass in facade) ‹0.1
- Available at up to 45 km / h wind speed
- Minimize possible effects on daylight and views

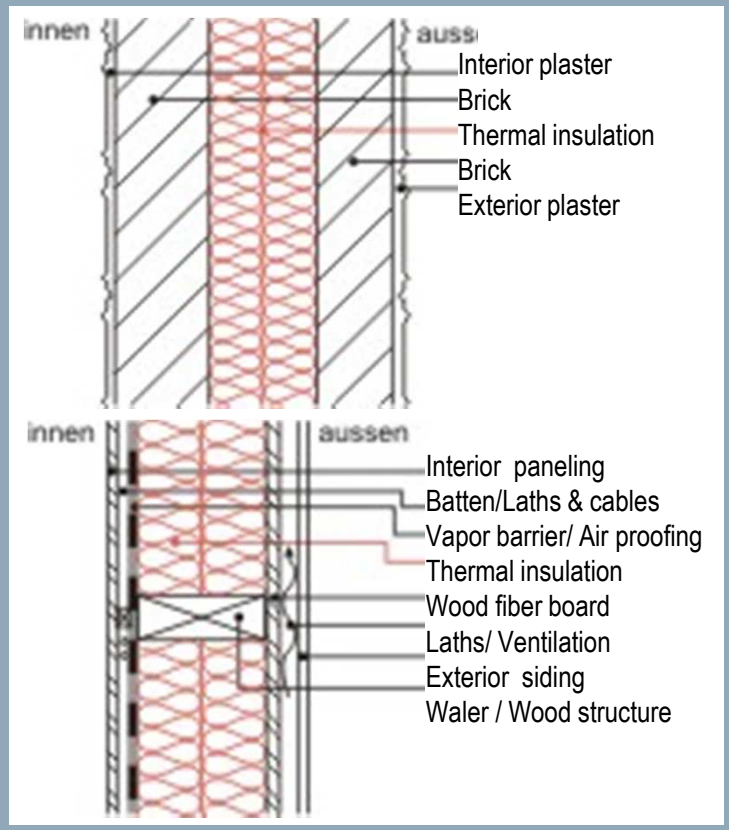
Summer heat protection: night cooling



Embodied energy vs. operation energy



Embodied energy of building components



Sustainability: Recommendation SIA 112/1

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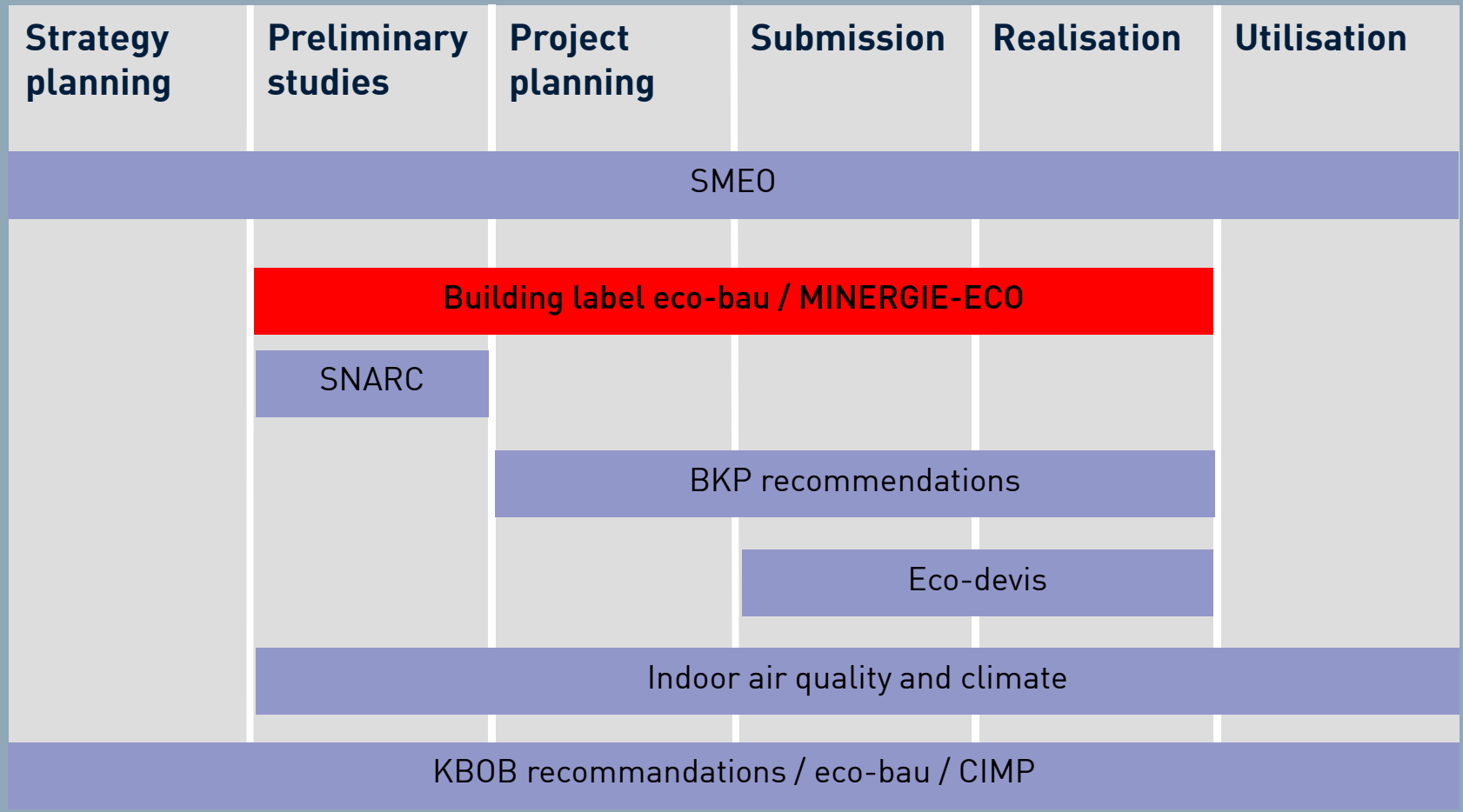
- SIA: Swiss society of engineers and architects
- Lists all relevant criteria of sustainable building
- Detailed specification of the following topics (excerpt):

Society	Economy	Ecology
Building design	Operation and maintenance costs	Resources
Well-being	Building substance	Energy consumption
Health	External costs	Soil, landscape
...	...	...

Building ecology: important tools



Sustainability Label MINERGIE-ECO

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Label for buildings with

- High energy-efficiency and comfort
- Ecological design and materials
- High indoor air quality

Today: more than 300 certified buildings in Switzerland

MINERGIE-ECO®

Mehr Lebensqualität, geringe Umweltbelastung
Meilleure qualité de vie, respect de l'environnement

More than 300 certified buildings

Criteria of MINERGIE-ECO

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MINERGIE-ECO

	MINERGIE	ECO	
High quality of life	**Comfort** •High thermal well-being •Estival heat protection •Comfort ventilation	**Health** •Optimised daylight conditions •Low noise immissions •Low indoor air contaminant loads (VOC, Radon etc)	**Daylight** **Noise** **Indoor air quality**
Low environmental impact	**Energy efficiency** •Total energy consumption must be at least 25% and •fossil energy consumption at least 50% below the average state of the art	**Building ecology** •Well available ressources •Low environmental impact at fabrication •Dismantling, recycling, disposal with low environ-mental impact	**Building concept** **Materials & processes** **Embodied energy**

Software MINERGIE-ECO: Questionnaire and evaluation

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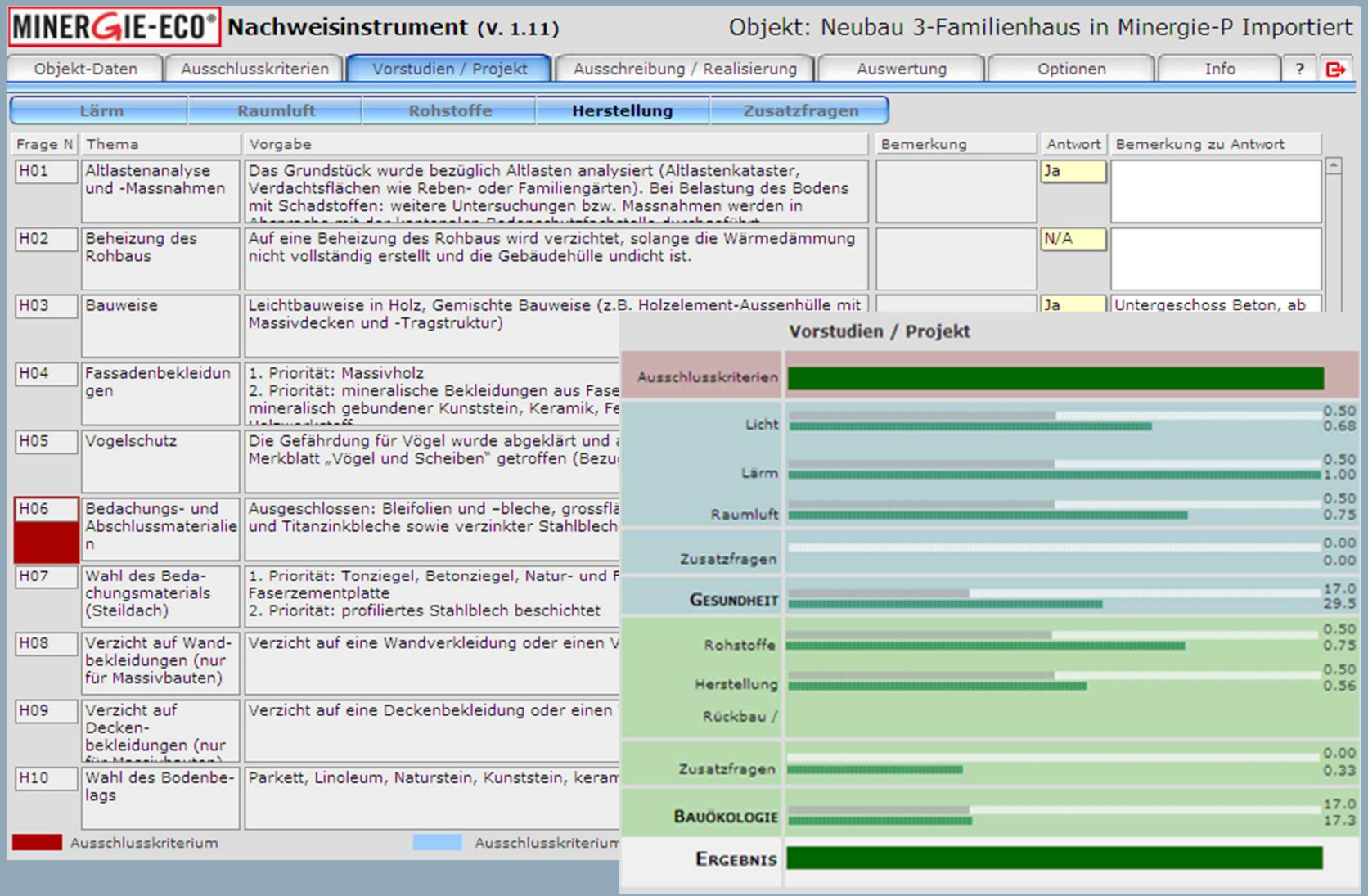

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2000-Watt-society in the building sector

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Agenda

- Methods for the 2000-Watt-society
- Planning principles
- Examples

2000-Watt-Society

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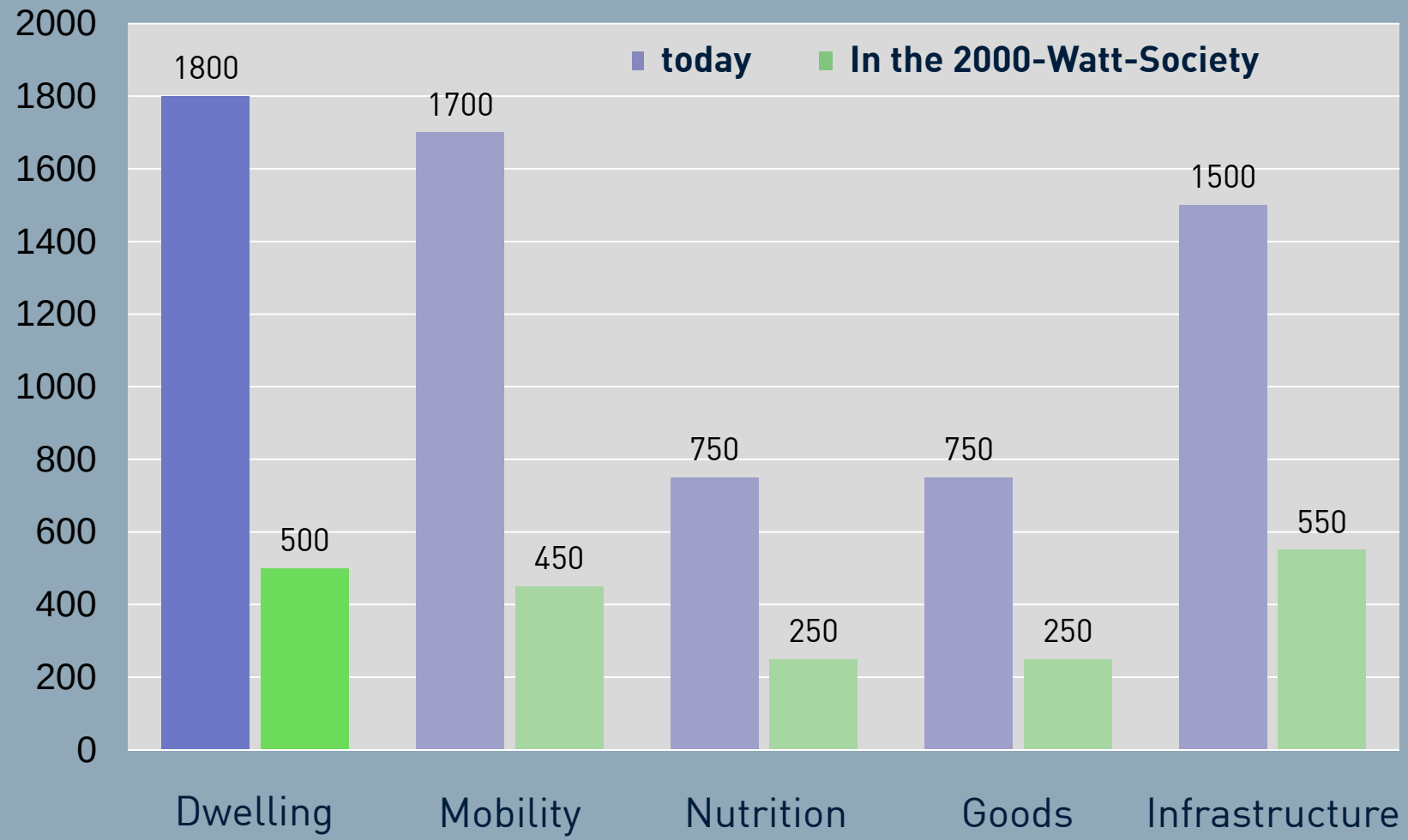
Energy budgets of 2000-Watt-Society



The technical solutions exist already

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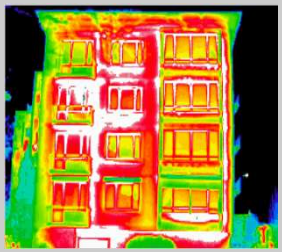
Dwelling	Mobility	Nutrition	Goods	Infrastructure
Existing bldgs 15 L. Oil/m^2	**Cars average** 8 L/100km	**Meat, exotic**	**1-Way-Products** 350 kg waste/a*P	**Fossil energy** **Oil, gas, coal**
				
				
MINERGIE-P 3 L.Oil/m2	**Light, drive syst.** 3 L/100km	**Regional Prod., vegetarian**	**Reusable** 100 kg waste/a*P	**Renewable energy**

2000-W-Society – different tools for different scales

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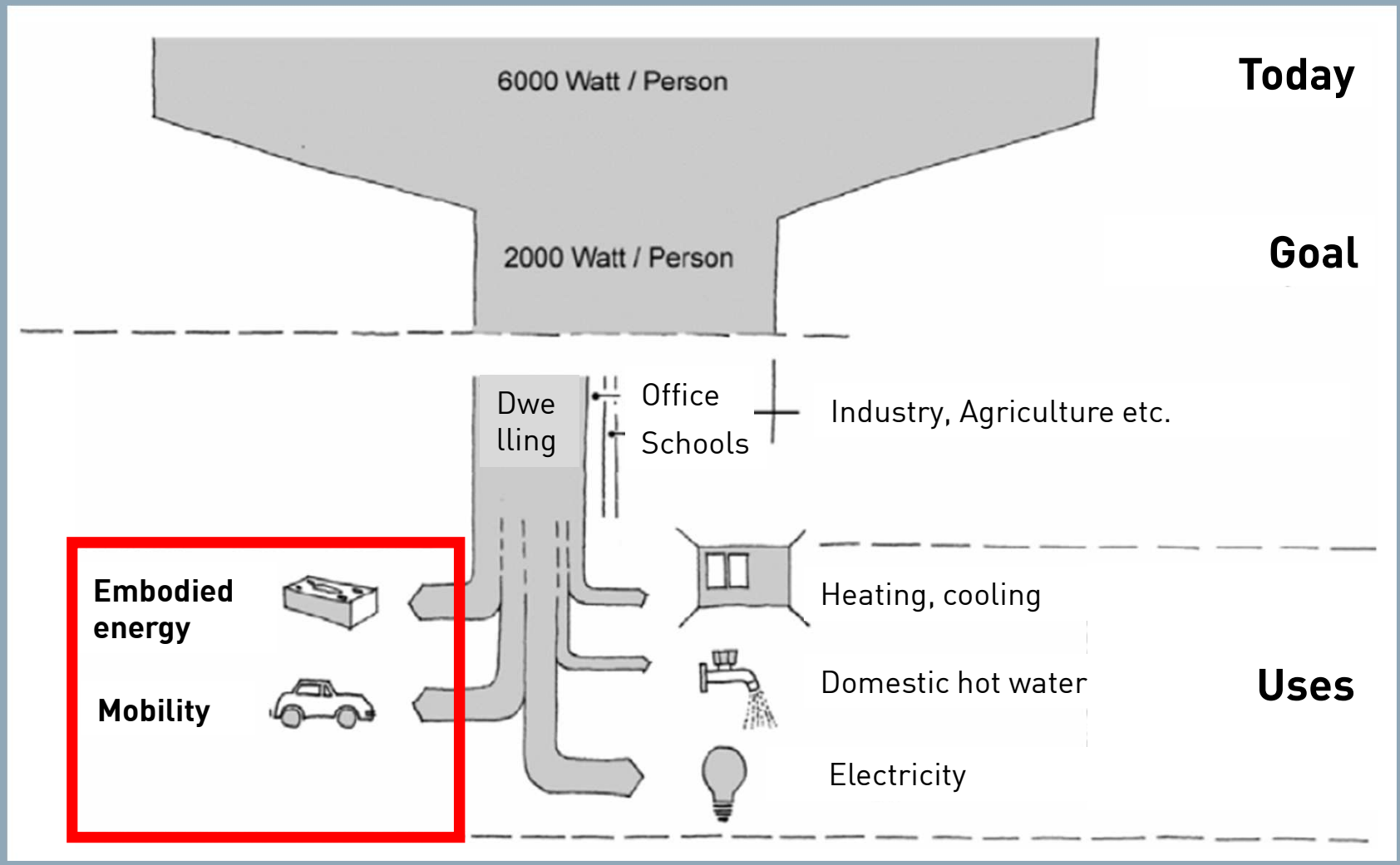
Nation	County	District	Building
			
2000-Watt-Society Strategy sustainable development Statistics	EnergieSchweiz / Energiestadt EcoRegion	Method 2000-Watt-Districts	SIA Leaflet 2040 Energy efficiency path

Literature
Operation energy: SIA Leaflet 2031
Embodied energy: SIA Leaflet 2032
Mobility: SIA Leaflet 2039

SIA energy efficiency path (Leaflet 2040)



SIA leaflet 2031: Operational energy

- Based on Energy Performance Building Directive EPBD
- Takes into account all energy uses (heating, cooling, electrical energy)
- Describes how to calculate a specific primary energy value, related to energy reference area

Tools

- Some energy calculation software have integrated all of the methodology (e.g. LESOSAI 7.1)

SIA leaflet 2032: Embodied energy

- Takes into account all of the building and all building elements, including building equipment and parts of fit-out
- Defines a lifespan of 60 years for new buildings and different lifespans for building components
- Describes how to calculate a specific primary energy value, related either to energy reference area or gross floor area

Tools:

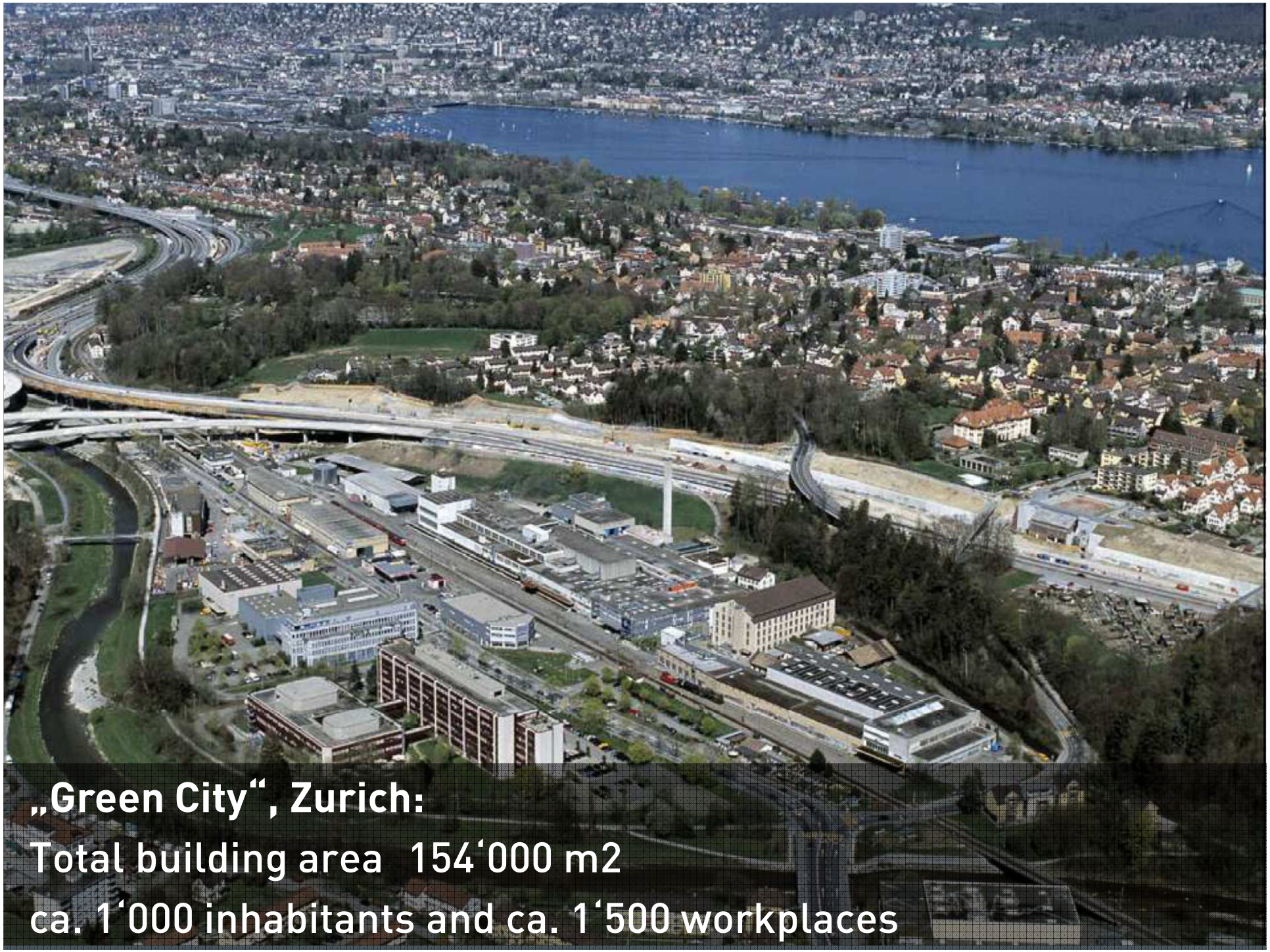
- A simple but not very flexible excel-sheet is available from the site www.energycodes.ch
- On the internet, there's an electronic building component catalogue which has free basic functions
- Tools: Some energy calculation software have integrated all of the methodology (e.g. LESOSAI 7.1)

SIA leaflet 2039: Mobility

- Describes how to calculate energy demand for mobility
- Takes into account all building related forms of mobility
- Results vary greatly in dependence of availability of local public transport

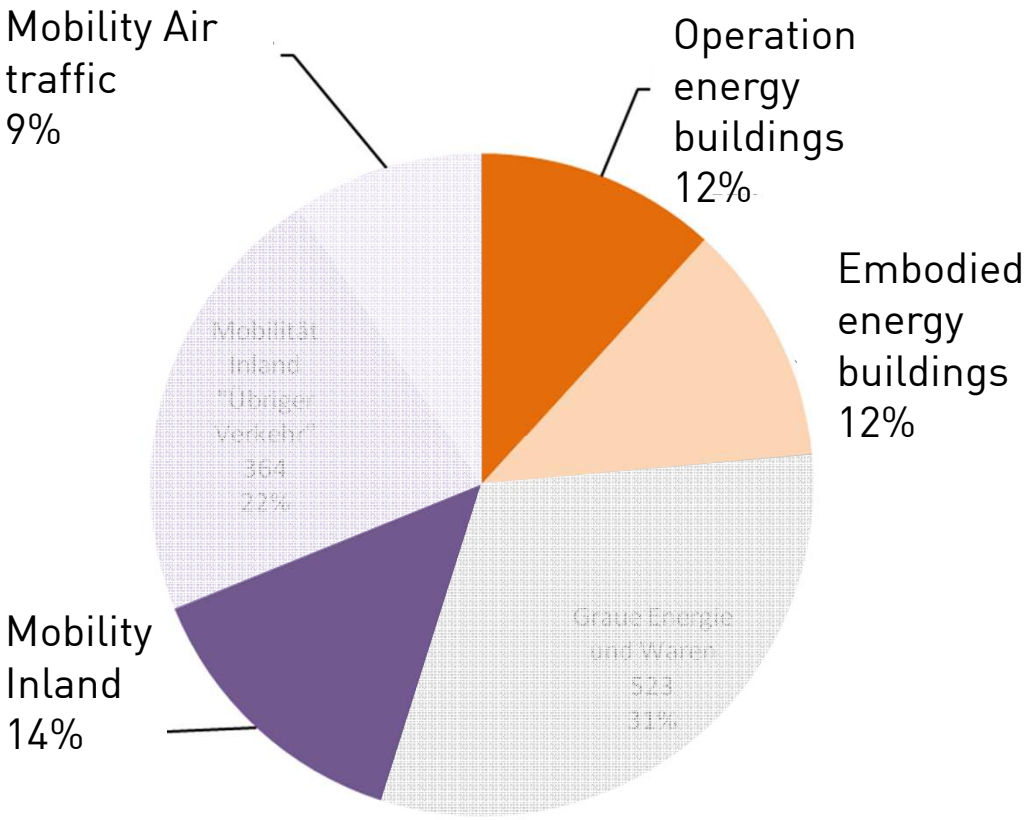
Tools:

- A simple excel-sheet can be downloaded from www.energycodes.ch



„Green City“, Zurich:
Total building area 154‘000 m2
ca. 1‘000 inhabitants and ca. 1‘500 workplaces

Results of simulations: non renewable primary energy



Primary energy per 2050: 1700 Watt per Person

Target value for non renewable primary energy is met.

Results of simulations: Greenhouse gas emissions 2010 - 2050

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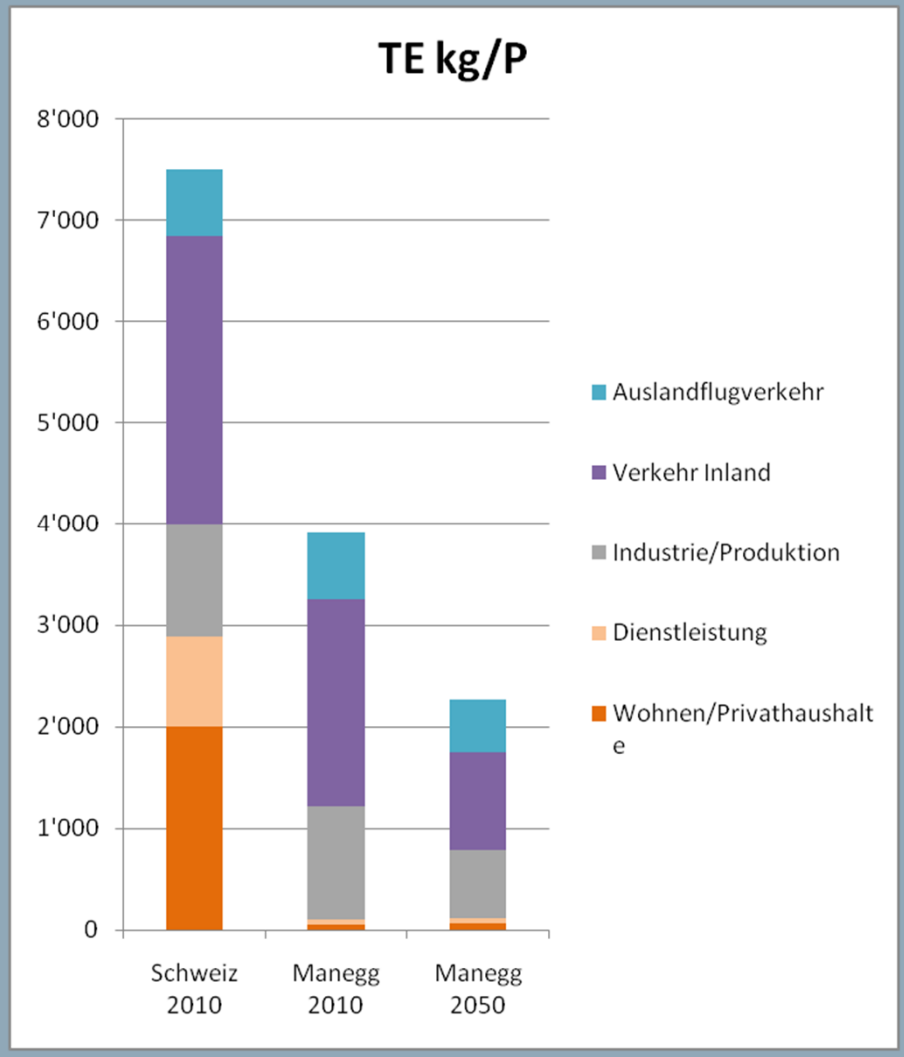
- Sihl-Manegg inhabitants will emit only 55% of greenhouse gases in comparison to a swiss average person.
- CO2-free energy supply contributes to this.
- Strong reduction until 2050 for mobility and goods expected.



Zurich Art Museum Addition

Planning strategies: Building

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Building envelope:

- MINERGIE, MINERGIE-P or Passivhaus level
- Very effective sunshades
- Well positioned and oriented windows

Building fit-out:

- Large thermal capacity of inner materials
- Large moisture storage capacity of materials
- Bright colours to reduce the need for lighting

Planning strategies: embodied energy

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Embodied energy:

- Use of wood constructions, where the requirements for fire or noise protection allow
- Reduce mass of construction where not necessary (e.g. hollow concrete slabs)
- Use of concrete with low CO2-emissions (reduced content of portland clinker, e.g. CEM II/B or CEM III)
- Very limited use of metals (e.g. aluminum)
- Limited window portion in facade
- Keep building equipment simple

Planning strategies: Equipment

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Building equipment:

- Reasonable boundary values for HVAC systems (e.g. temperature, moisture)
- Use of renewable energy is crucial
- Only the most efficient equipment will do
- Every detail counts, e.g.
  - Efficiency of elevators
  - Efficiency of Building Management Systems
  - Efficiency of security systems
  - CO2-controlled ventilation system

Planning strategies: Mobility

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Mobility:

- Locate buildings near train or bus stops or install new public transport means
- Provide shops for the daily demand in walking distance
- Reduce number of parking lots strictly
- Charge for the use of parking lots
- Link building site to road and path network
- Install reasonable amont of bicycle stands and showers
- Reward users of public transport (e.g. subsidized travel cards)

Dwellings „Sihlbogen“, Zurich

It is not because things are difficult
that we do not dare,
it is because we do not dare
that things are difficult.

Thanks for your attention.

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