

SQUARE - A Quality Assurance System  
for Improvement of Indoor Environment and Energy  
Performance when Retrofitting Multifamily Houses

## Energy Improvement Measures and their effect on the indoor environment



All fotos and illustrations: © AEE INTEC,  
if not separately marked



Armin Knotzer, Sonja Geier  
AEE - Institute for Sustainable Technologies (AEE INTEC)

# Due to different climates

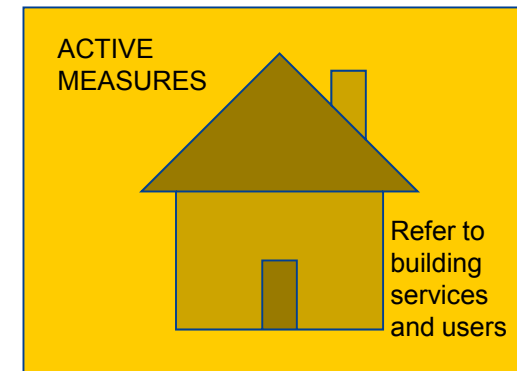
„Energy efficient solutions with respect to varying climates“...

EU			
CLIMATE / CHARACTERISTICS*	W <sub>warm</sub>	T <sub>temperate</sub>	C <sub>cool</sub>
Lowest standard outside temperature during heating period [°C]	0 to -10	-10 to -16	-12 to -25
Outside average temperature during heating period [°C]	+8 to +10	+2 to +4	-10 to +2
Outside average temperature during summer [°C]	+20 to +24	+17 to +22	+10 to +16
Heating degree days <sub>20/12</sub> [K.d]	1.200 – 3.000	3.000 – 4.500	4.500 – 7.000
Solar radiation [kWh/m <sup>2</sup> a]	1.200 – 1.500	1.000 – 1.200	Up to 1.000

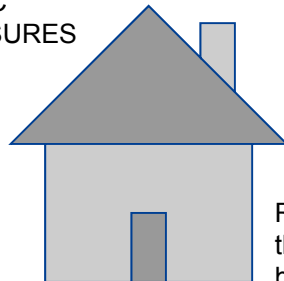
\* Source: AEE INTEC, verified by SQUARE partners; the temperatures may overlap because of differences within each climate

# Ten improvement measures

Optimized heating system  
Use of renewable energy sources  
Optimized heating control system  
Optimized ventilation system  
User's briefings/ behaviour

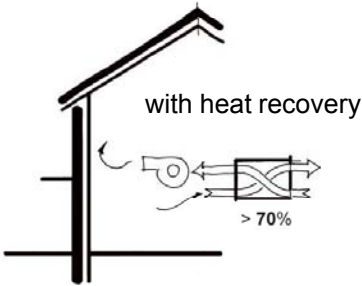
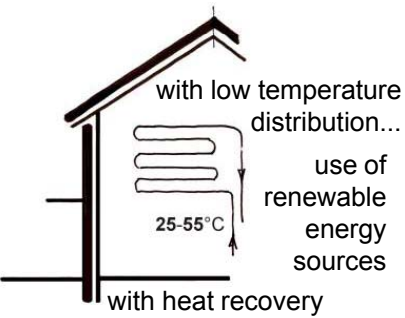
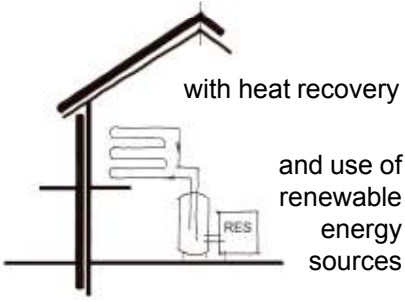
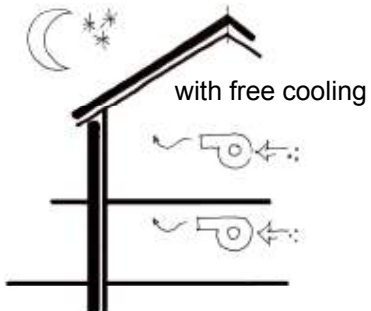
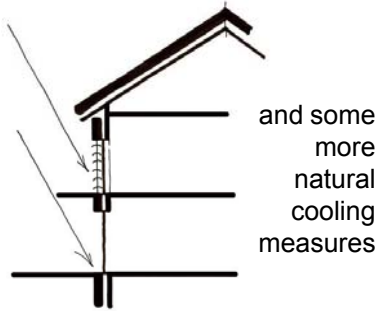
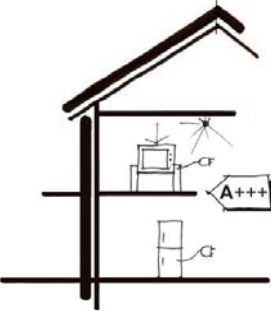


BASIC MEASURES



Complete exterior insulation  
Thermal optimized windows/doors  
Airtightness  
External shadowing  
Natural cooling

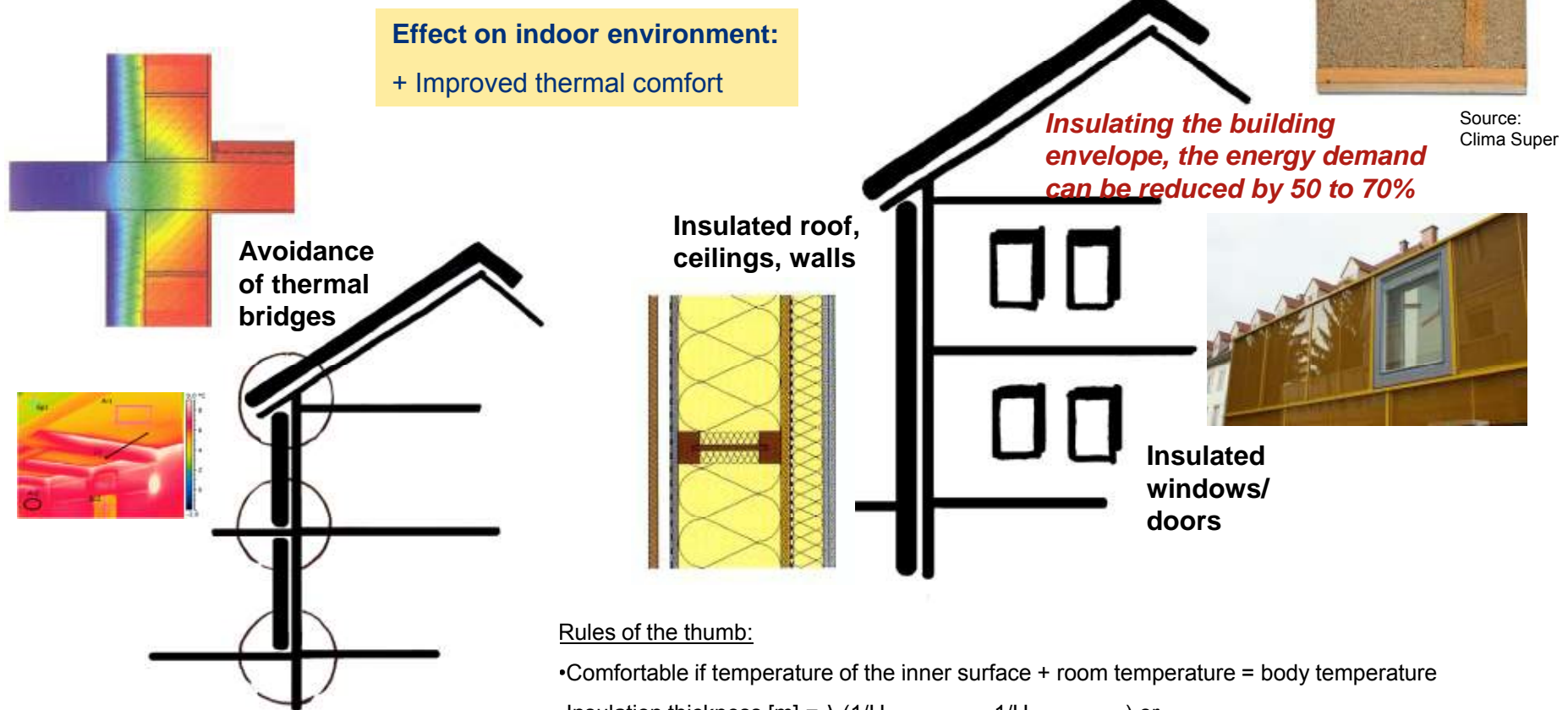
# Most important measures...

...regarding*	W warm	T temperate	C cool
<b>Heating</b>	<p>Insulation, airtightness and optimized ventilation system</p> 	<p>Insulation, airtightness, optimized ventilation and heating system</p> 	<p>Insulation, airtightness, optimized ventilation and heating system</p> 
<b>Cooling</b>	<p>Natural cooling, external shadowing, user's briefing/ behaviour and optimized ventilation</p> 	<p>External shadowing, user's briefing/ behaviour</p> 	<p>User's briefing/ behaviour and external shadowing</p> 

\* Source: AEE INTEC, verified by SQUARE partners

# 1. Complete exterior insulation

**Impact:** Reduces heat transmission losses and avoids thermal bridges



## Rules of the thumb:

- Comfortable if temperature of the inner surface + room temperature = body temperature
- Insulation thickness [m] =  $\lambda (1/U_{\text{after retrofit}} - 1/U_{\text{before retrofit}})$  or
- $U [\text{W/m}^2\text{K}] = 4 / \text{insulation thickness in cm}$

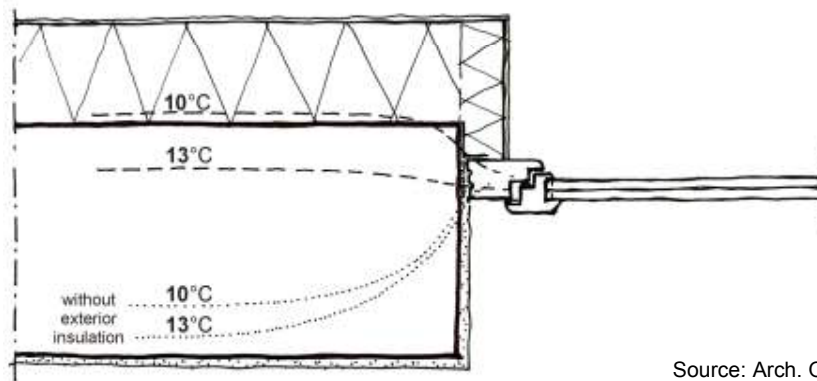


## 2. Thermal optimized windows and doors

**Impact:** Reduce heat transmission losses and gain „passive“ solar energy

**Effects on indoor environment:**

- + Improved thermal comfort
- + Decreased draught and cold surfaces
- + Decreased risk of condensation

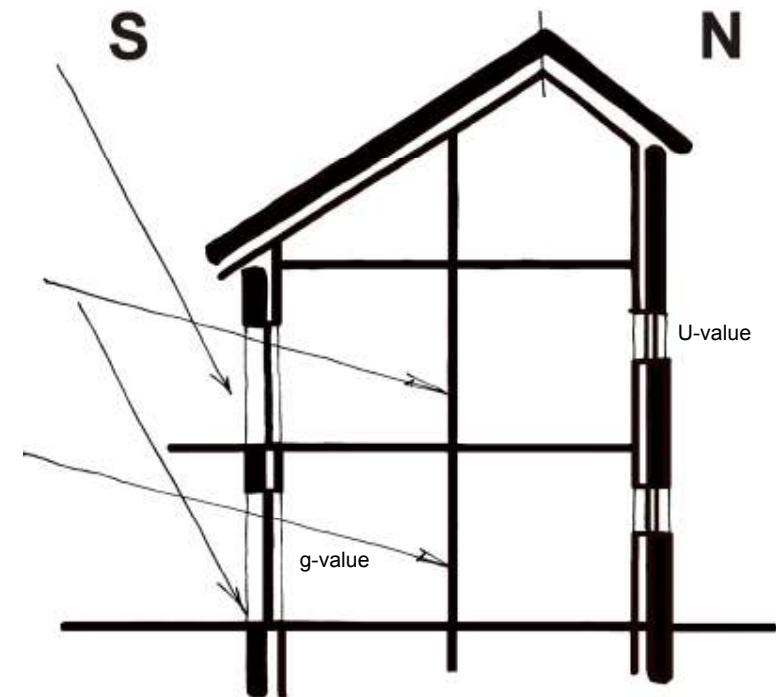


Source: Arch. Obereder



Some „rules“ for temperate climate:

- Not more than 15 to 40 % of the south wall should be window area
- Only windows with  $U < 1,2 \text{ W/m}^2\text{K}$  show a positive energy balance during heating period



**With thermal insulated windows and doors, the energy demand of the building can be reduced by 20 to 25%**

### 3. Airtightness

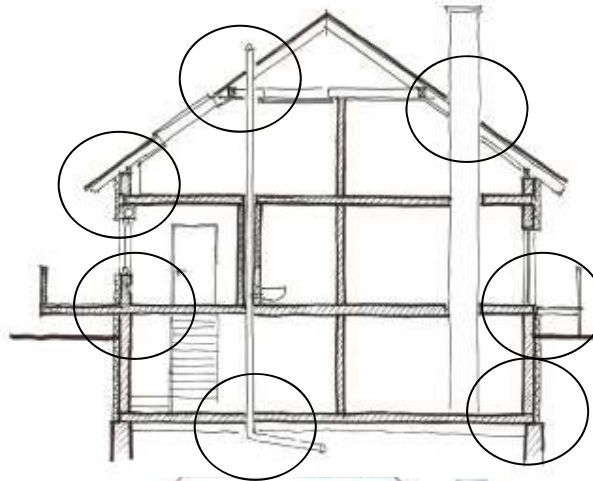
**Impact:** Reduces air infiltration heat losses due to involuntary ventilation

**Effects on indoor environment:**

- + Improved thermal comfort
- + Decreased draught and cold surfaces
- + Decreased risk of condensation

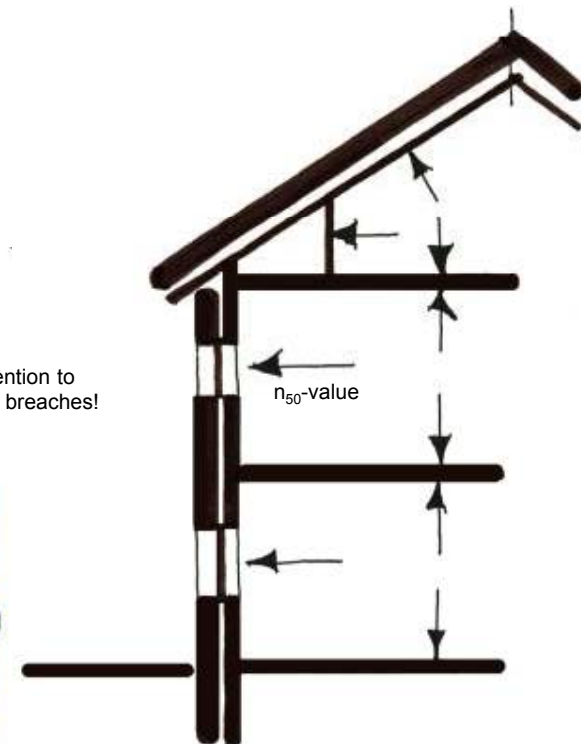


Blower Door Test



Source: Siga

Pay attention to building breaches!



Rule of thumb:

If one sheet of paper can be moved through a closed window it is not tight!

## 4. External Shadowing

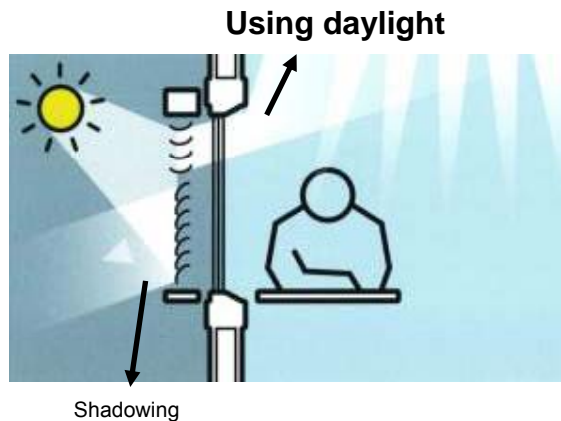
**Impact:** Reduces cooling demand



Shadow from PV

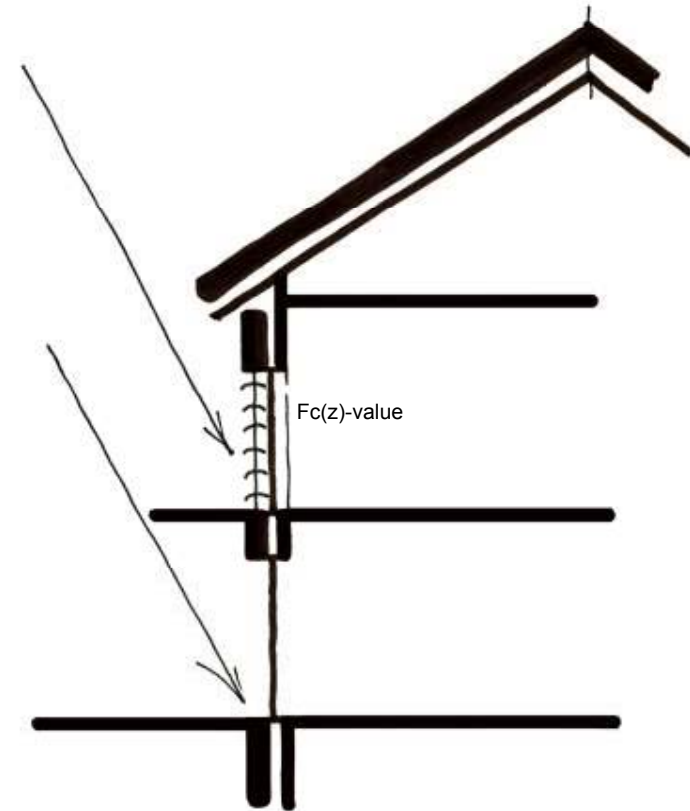
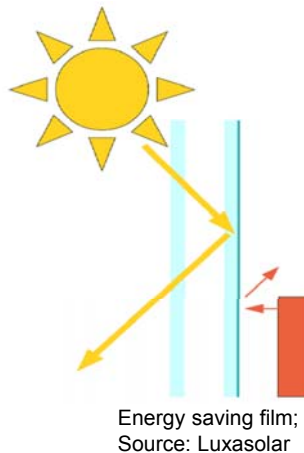


Outside blinds



Rule of thumb:

External shadowing is more than twice as effective as internal shadowing!



**Effect on indoor environment:**

- + Decreased over-temperatures during summer
- + Daylight for living quality

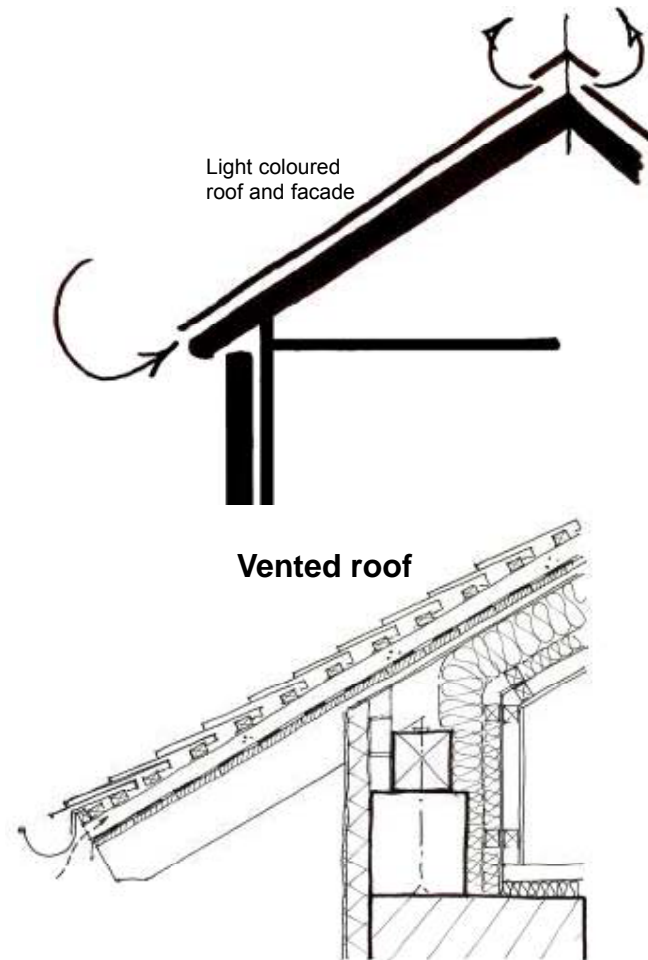
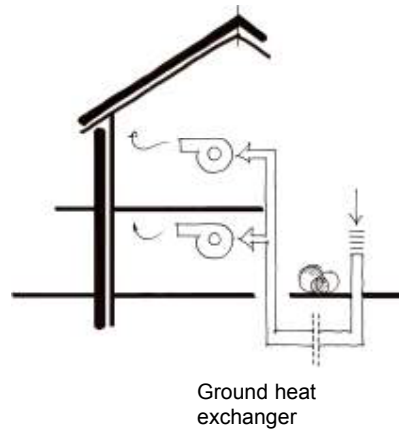
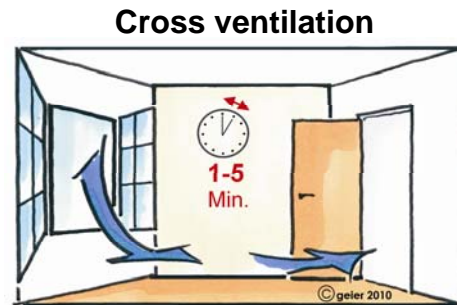
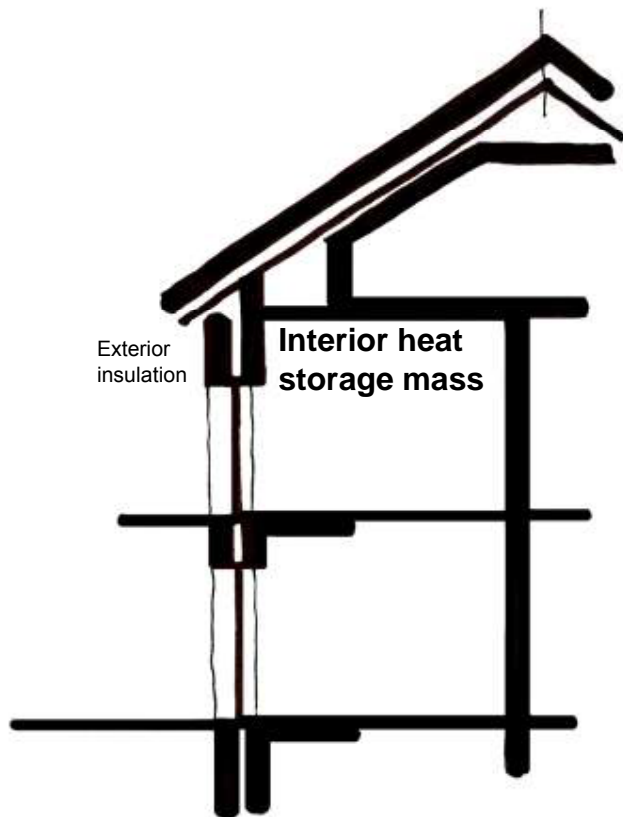


## 5. Natural cooling

**Impact:** Reduces cooling demand

**Effect on indoor environment:**

+ Decreased over temperatures during summer



## 6. User's briefing/ behaviour

**Impact:** Decreases final energy use...

**Effect on indoor environment:**

+ More stable indoor climate



...and increases efficiency...



Source: Eric Werner, Tecknaren AB



...by better understanding of technical equipment, services and maintenance

## 7. Optimized heating system

**Impact:** Increases efficiency of the heating system

**Effect on indoor environment:**

+ Improved thermal comfort



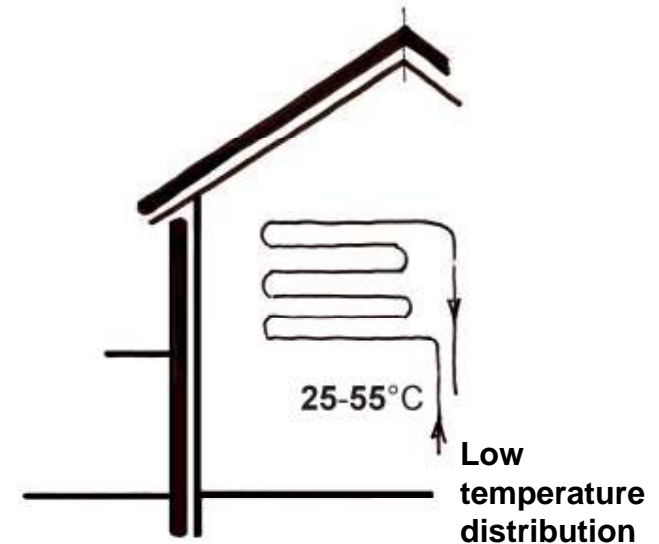
**Insulated pipes**



**Latest boiler technology**



Source: Guntamatic



Source: natürlich bauen GmbH

## 8. Use of renewable energy

**Impact:** Reduces the use of fossil fuels and resources



Photovoltaics, Source: PV Austria

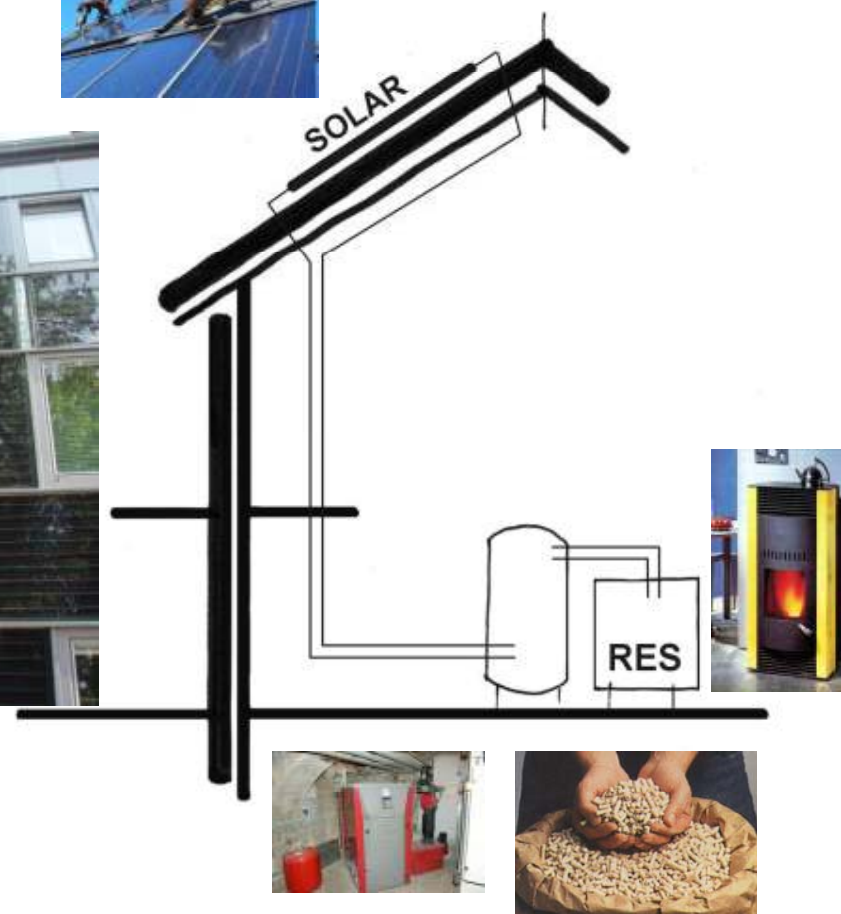
### Power sources:

Wind, water, wave, tidal, deep  
geothermal and solar (e.g. PV) power

### Heat sources:

- Biomass
- Solar thermal
- Geothermal\*

*\*Please note: HEAT PUMPS should only be considered if none of the renewable options are feasible. In order to be considered as a renewable heat source, a HEAT PUMP must run only with renewable power.*



Use of Biomass



## 9. Optimized heating control

**Impact:** Reduces energy use for heating



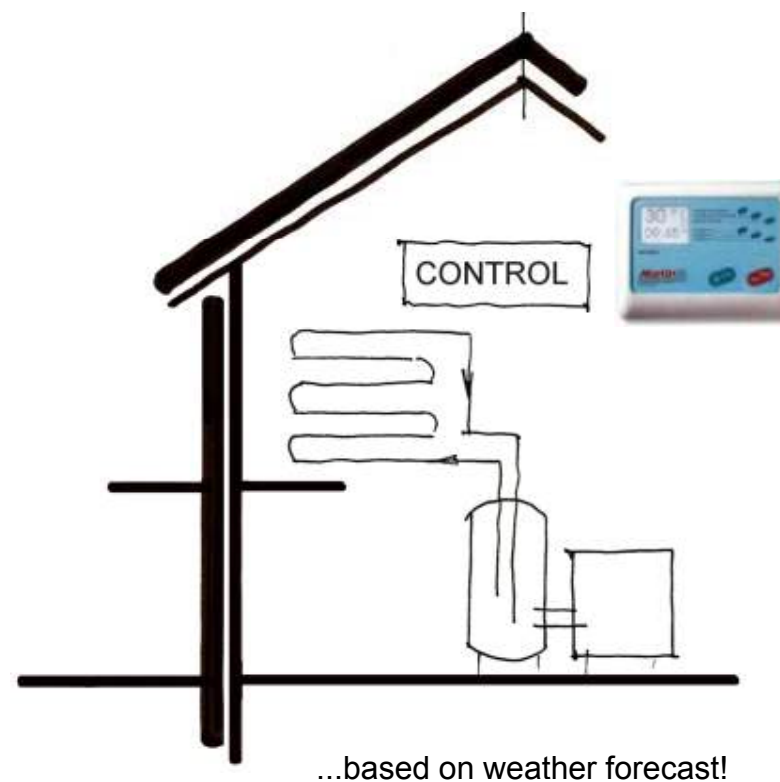
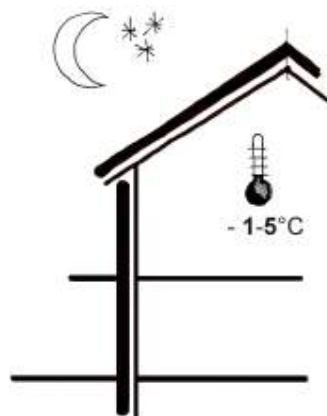
Source: Star

### Effect on indoor environment:

+ Improved thermal comfort

#### Rule of thumb:

Decrease by 1 degree of room temperature reduces 6% of energy use for heating!



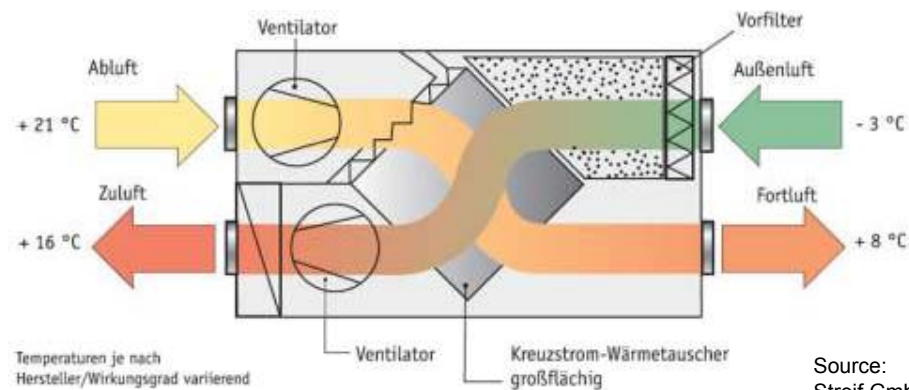


## 10. Optimized ventilation system

**Impact:** Reduces ventilation heat losses if combined with heat recovery



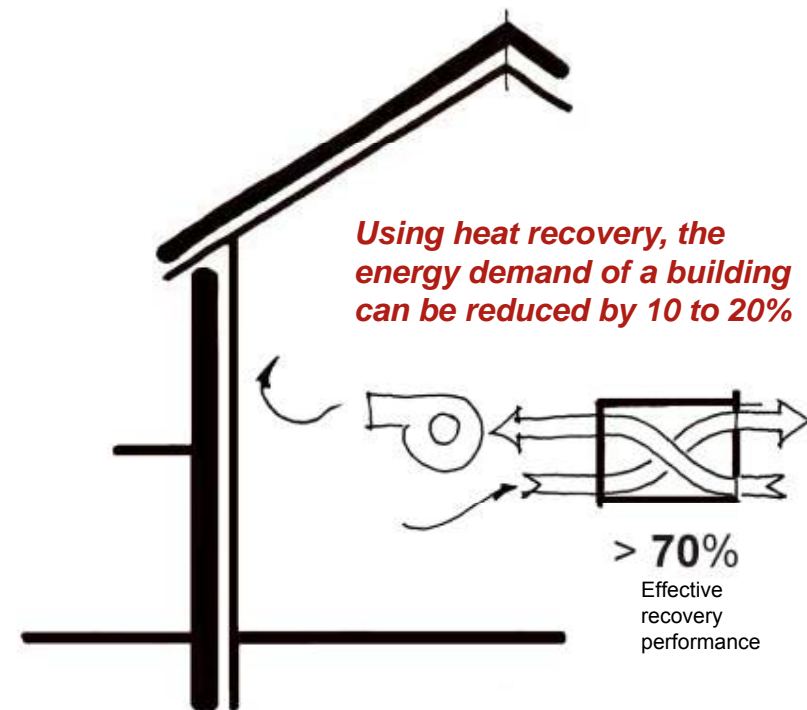
Source: AIT



Source:  
Streif GmbH

### Effects on indoor environment:

- + Decreased risk of condensation
- Risk of odour if rotating heat exchanger



**Thank you**  
for your attention!