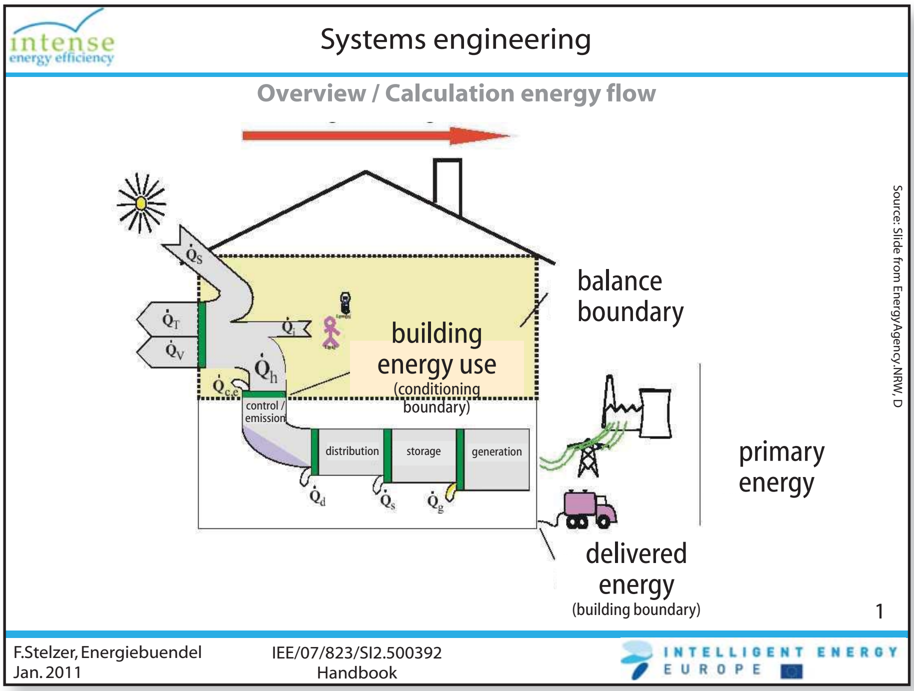


HVACR is Heating, Ventilation, Air Conditioning and Refrigeration, meaning all the building equipment and appliances. Including hot water, which is used mainly in domestic houses but also i.e. in schools an sport facilities.

To calculate the energy demand of passive houses first the balance boundary and its energy balances are defined. Next step (and beginning of this topic) is the efficiency of the ventilation system and the further steps are the therefore necessary energy usage, losses, the delivered energy and finally the primary energy. The comfort of the passive house is affected by the systems as well and designing must consider it!

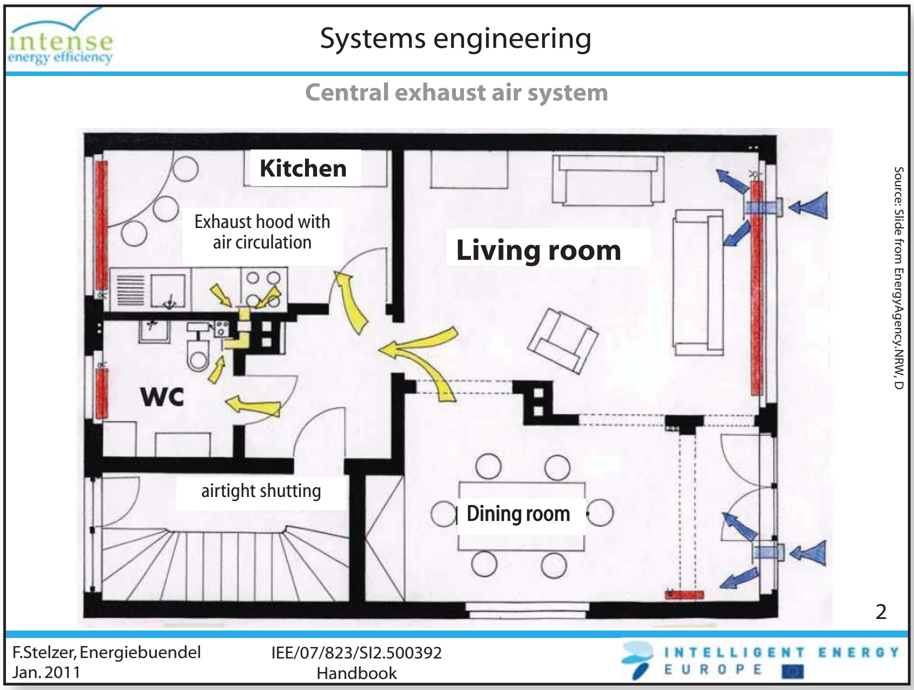
All of the system equipment has a huge influence on the energy efficiency of the building or even settlement. The difference between energy demand and delivered energy is main, but not the only object of this topic. Also there are descriptions of important technologies of minimizing energy demands.

The target of this module is to introduce important technologies that provide energy efficiency and if possible are based on renewable energy resources in all of the appliances. These should be judged with SWOT-Analysis, which is shown in an example.

Therefore the relation of energy demands for the different energy types (Heating, Cooling, Hot Water, Ventilation) as well as the criteria of indoor comfort will be considered. In an holistic view settlement planning and architectural design influences strongly the energy demands and should be kept in mind.

The slides shows the important calculations steps from used to delivered energy:

Control / emission, distribution, storage and generation.



The ventilation system is a central part of an passive house. Normally only systems with heat recovery are used. This is the system with the most influence on comfort, hygiene, heating and cooling. Also building physics is influenced.

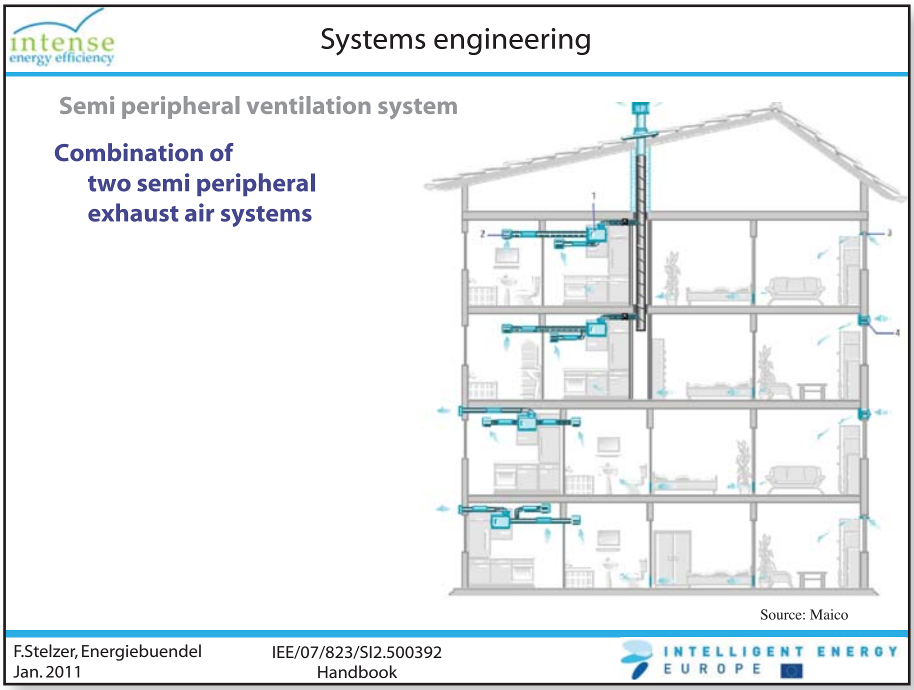
All the elements of a ventilation system are important and there are huge differences between ventilations units for housing buildings and non-residential buildings.

Speaking about ventilation systems in apartment houses, the air is generally used several times, i.e. there are rooms with fresh air supply (living room, dining room, study, children's rooms) with an supply air valve, there are transfer air rooms (hall, corridor, staircase) with slots under, in or above the doors and finally exhaust air rooms (kitchen, bath, toilet) with further valves (see slide).

For municipal buildings this is also a possibility of designing. But usually there are supply **and** extract air valves in each office, classroom, conference hall etc.

The slide shows the basic principle for a very simple system. Good for explaining and understanding. For more complex buildings like central ventilation units in office buildings the principle is the same but the supply air is brought with ducts and valves to the offices and meeting rooms.

The amount of the air change rate depends on design principles variing by the type of usage (Office, class rooms, toilets etc. The most common parameters for the design of the air quality are CO_2, H_2O and VOC content.



The basic design of ventilation systems are

- Peripheric systems are usually installed in walls or windows (good for retrofitting, systems with an high heat recovery ratio for passive houses are available).
- Semi central systems are with some conditionings centralized in the building, other conditionings are local in single housing units or rooms.
- Central ventilation systems are usually for housing units with heat recovery only.
- Central AC units are the most completed systems with all kind of air conditioning.

The slide shows a combination of different semi peripheral systems. It is the same for ventilations system with heat recovery. In one single apartment one own central system is the same like in a single family house. The upper one has some central parts, in the chart just a duct. In systems with heat recovery also the heat exchanger as well as the filters could be central.

The variety of system setups is huge and this slide shows a not very well known system.

Systems engineering

Heat recovery systems

System	separated supply and extract air possible?	Humidity recovery	Moving parts	Heat recovery ratio (without condensation)
Recuperator - cross flow - counter flow	no	no	no	45 - 65% 60 - 90%
Water recirculation system	yes	no	yes	40 - 70%
Heat pipe	no	no	no	35 - 70%
Rotation heat exchanger (without hygroscopic coating)	no	yes (little)	yes	65 - 80%
Rotation heat exchanger (with hygroscopic coating)	no	yes (good)	yes	65 - 80%

Source: Data from Recknagel-Sprenger

4

F.Stelzer, Energiebuendel
Jan. 2011

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Handbook

INTELLIGENT ENERGY EUROPE

There are different types of heat recovery (HR) systems. The classic one is the recuperator, which is mainly used in residential buildings.

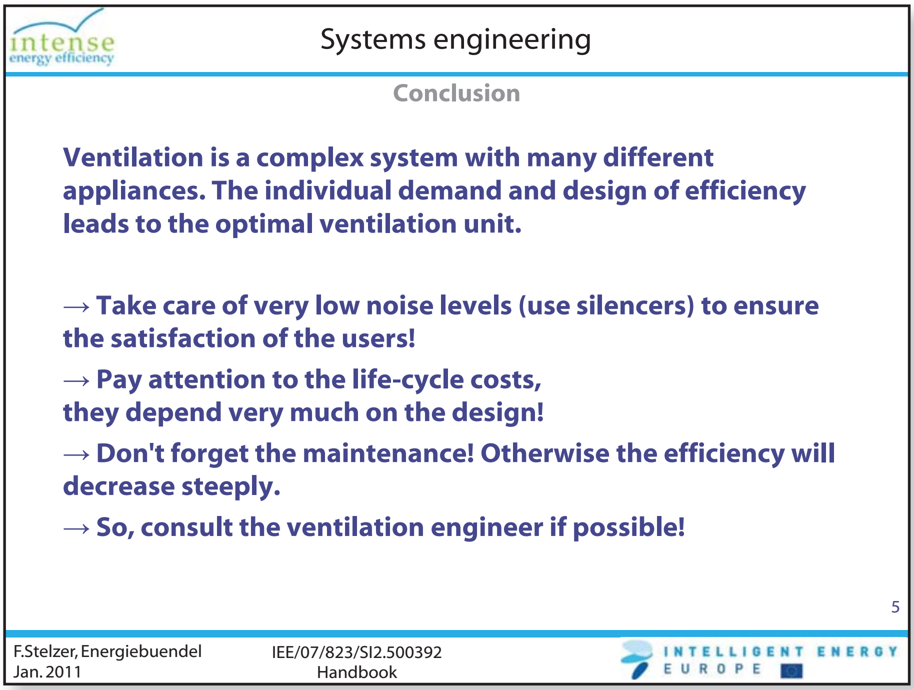
In the big central AC units the counter flow systems are not used, the crossing of the big ducts is not that easy.

In these cases for efficient HR rotation heat exchangers are the best choice but they require more space. Additional to the indicated numbers the HR (enthalpy recovery) ratio is even higher considering the humidity recovery.

The most expensive systems are
- the heat pipe, which has no moving parts and
- the water recirculation system, which is used in case of space reasons.

Beside the ventilation itself, which is necessary, the heat recovery is the central part for saving energy and for the parameters of a passive house!

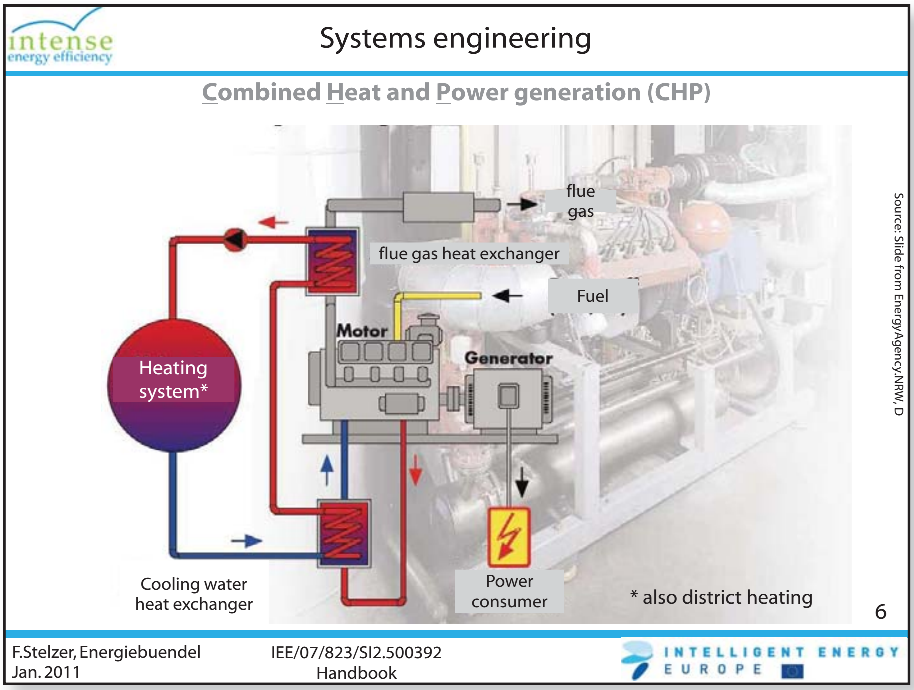
Beside the heat recovery ratio the duct design concerning the pressure drop as well as the fan itself are the main elements for an high efficiency



Beside the power consumption the filter change is an expense factor. And resulting, if cleaning is necessary, too! So take big filters with optimized life time cycles to reduce costs here. Filter selection is beside the energy consumption a maintenance factor.

In the conclusion the point of comfort and acceptance is new and important! The system should be used and accepted, otherwise the base for an efficient operation is missing.

And reducing noise is another part of environmental protection.



Passive houses usually still need a heating after optimizing the energy demand and ventilation. One basic part is the type of radiators, heating surfaces or damper register in the ventilation system. On the other end there is the most popular part of the heat generator itself:

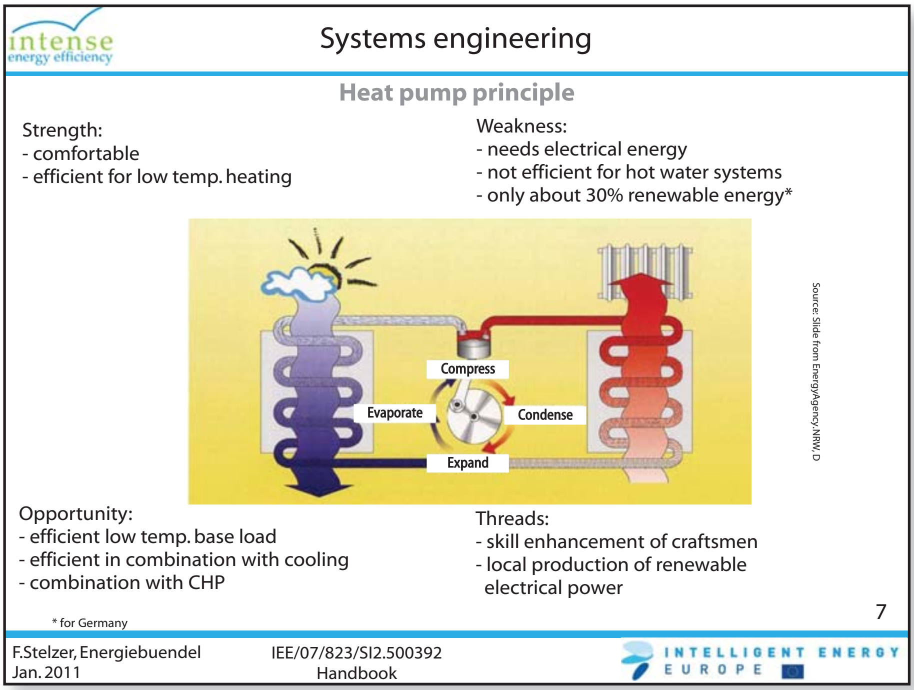
One possibility to deliver the heat in municipal houses is a CHP. Mostly realized just for the base load.

Therefore the electrical power consumption is the main design parameter. Usually the CHP should run 4000 to 6000 h/a.

The motor drives the power generator. The cooling water of the motor heats the heating water in first step and in the second step this is done by the flue gas.

The substitution of the big fossil fuel power plant is only possible with a big number of local, small and very efficient power plants. This is possible by cogeneration of heat and power. In first step most of them still use fossil fuel, in the second step regenerative fuels as biogas or plant oil can be used.

There are two important systems of the configuration:
- independent, usually controlled by local demand of heat
- as virtual power plant controlled centrally according to power demand of the electrical power grid.



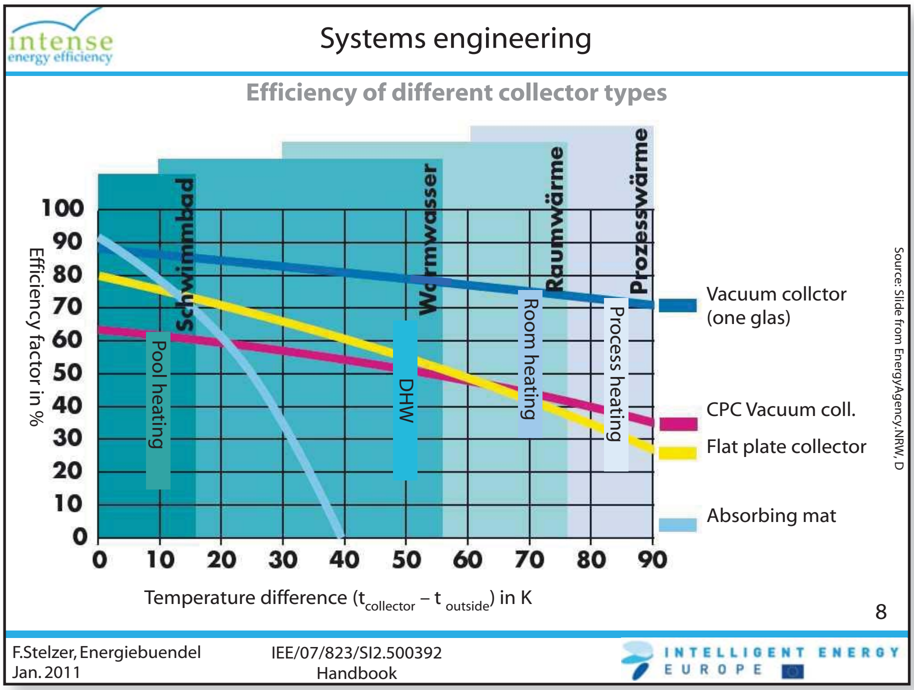
Especially in office buildings as passive houses with no hot water consumption the heat pump can be very efficient. The thermodynamical process of the heat pump is the same as of the classical fridge in each household.

On the left side is the heat source, on the right side the heat consumer.

The relativly high amount of electrical energy is needed by the motor. In a gas heat pump the motor is driven by gas and you can use the additional heat from the exhaust air for heating.

A gas heat pump usually has a nominal capacity of 100 kW or more. Just now there are some new developments of units with less power.

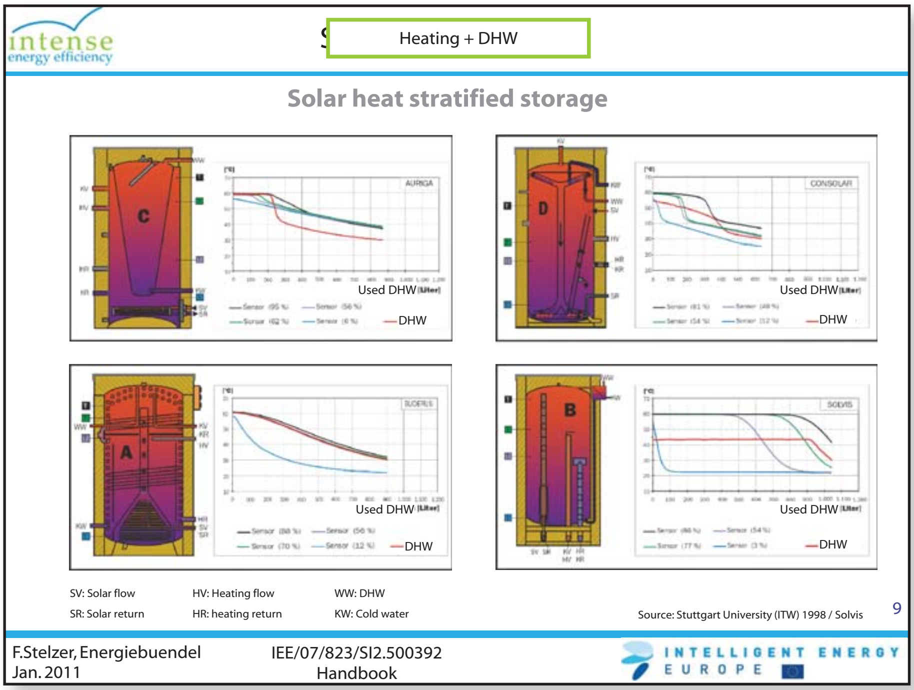
This slide is an example for a SWOT-analysis. SWOT stands for Strength, Weakness, Opportunity and Threads. Such a slide you can add for every system. Of course, the arguments may vary from country to country.



Beside using heat pumps there are other possibilities to use renewable energies: Thermal solar collectors and wood boilers mainly based on pellets as a standardized fuel as well as many other possibilities

The efficiency of different solar collector types shows clearly, which collector should be used for which usage.

The selection of the appropriate system depends on the building parameters and the necessary temperature levels. How much area is available, what orientations and inclinations are possible? In what system the heat is used?

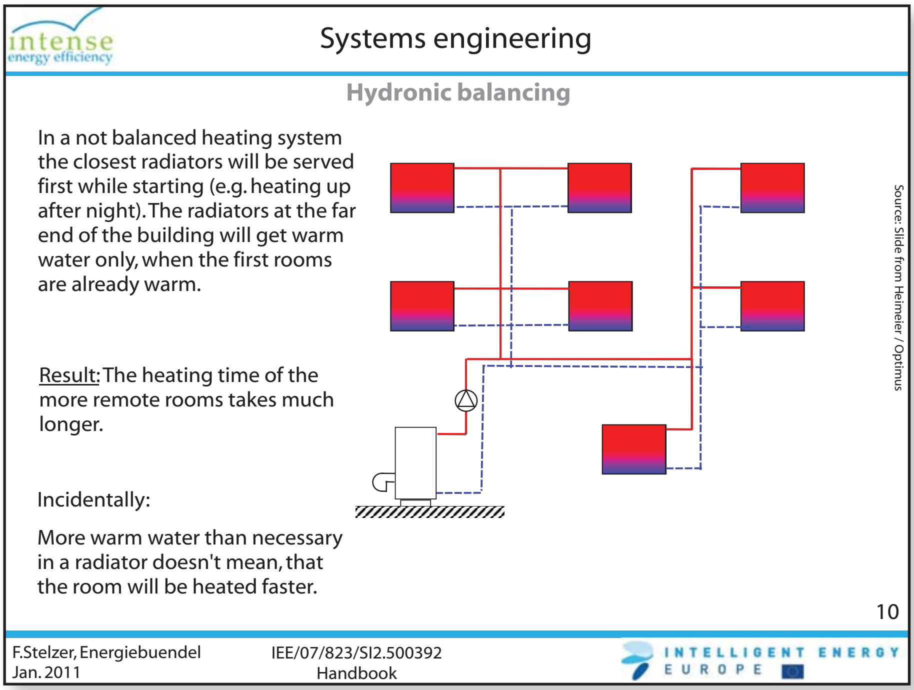


Efficient heat generation is one important part of a heating (or DHW, cooling) system but also the storage, distribution and control and emission are important to get a completly efficient system.

As a conclusion of the generation part are the two points:
- the selection of an individual applicable combination of renewable energy resources and possibly fossil boilers is the big challenge. There is no general reciepe to decide, which system is the best.
- for the selection of the best system examine the conditions at the site: shading, possible heat sources etc.
- consider at least the demands of energy:
  At what temperature levels are they?
  How is the relation between the different demands?
  How will the demands develop in future?

In many cases the discussion of efficient heating is reduced on the selection of the heat generator. But this is by far not enough. All other components as storage, distribution and control and emission have an important influence on the efficiency as well!

As example the slide shows differences of efficient hot water storages as stratified storages. The red line in these graphs indicates the temperature at which hot water can be used. It shows that the different storage types do have different properties!



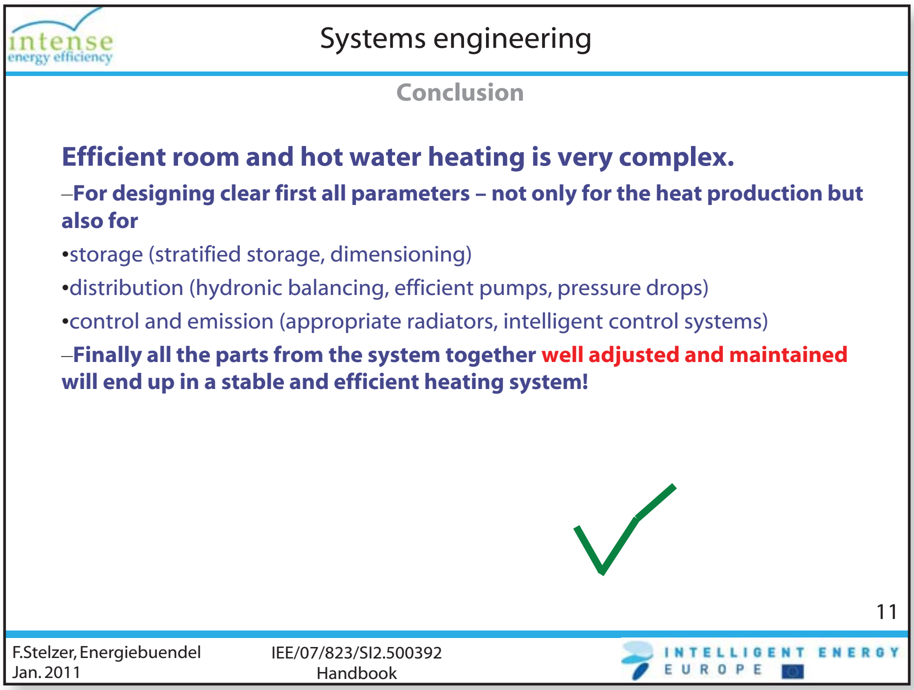
The hydronic system of the heating circuits and storages (stratified storages!) are very complex and especially in passive houses very important for the efficiency of all systems (heating, cooling, hot water and ventilation as well, concerning the pneumatical design.)

The hydronic balancing of the heating (or cooling) system is based on the piping design. In each line the maximum pressure drop (most remote radiator) is determined and all other radiators are adjusted to the same pressure drop with the adjustable thermostatic valves.

This secures that the return flow temperature will have the designed value.

In new heating systems with condensing boilers the difference may be 30% of the energy delivered!

A LARGER AMOUNT OF warm water than necessary DOES NOT AUTOMATICALLY mean that the room will be heated faster.



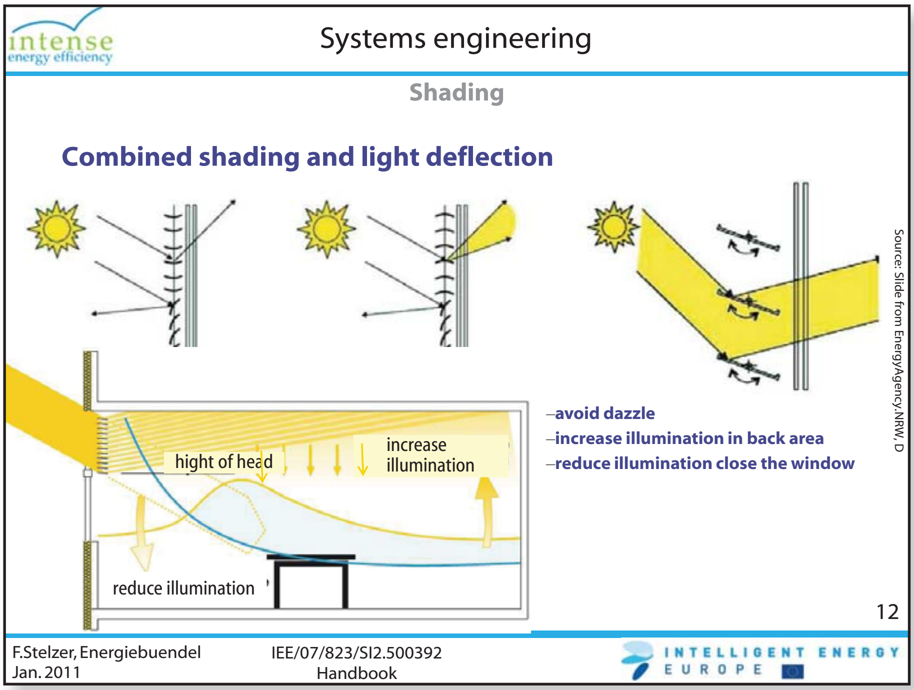
All parts of the system are important and should be considered. The technological improvements are amazing and is guiding the focus of designing in other directions than heat generation only.

How to choose a system, how to make decisions?

Basis of all is the architectural draft. When this is optimized for low energy consumption (calculated, not estimated!), the mechanical systems for heating and DHW are planned. Depending on the building you first choose the way, the heat comes to the rooms incl. control systems, then you design distribution and production/storage. The selection is made according to what is suitable. That is the way an efficient system can be designed.

The awareness for the adjustment and maintenance is still low because of the cheap oil prices in the past. Now this should change rapidly because the investments are low and the rise of efficiency is high.

The slide is applicable for cooling/chilling, too. There are the same problems.



Cooling has especially in the southern countries the highest energy demands. Therefore cooling systems are an important part of building efficiency.

The lesson should show passive possibilities how to reduce heating demand. Try not no refrigiate!

Then the possibilities of calculating the cooling demand should be shown. In case you have national standards explain them, too.

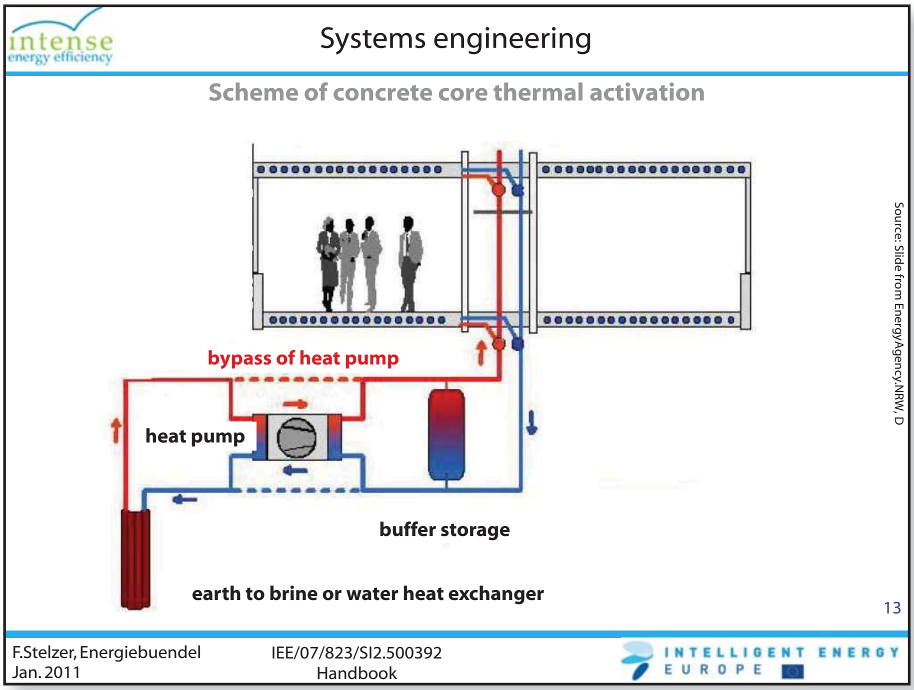
Then the intelligent production of cold water with delivery (control and emission) and distribution are part of the lesson. For all of these systems there are modern and efficient technologies available, which minimize the energy demand and they should be discussed.

To reduce solar gains jalousies are a common application. These are also available with light deflecting parts in the upper area of the windows. This reduces additionally the heat impact of electrical lighting. The higher this area is, the more the room gets illuminated.

Especially in office buildings on sunny days the jalousies are closed and the light is switched on. This is not efficient at all. Especially in passive houses the impact of electrical energy of the building should be reduced.

As well the usage of efficient office applications (computing, printing, telecommunication, copying …) decreases the cooling load and saves therefore twice!

An other possibility of reducing cooling load is high ventilation rates during colder night times.



Control /emission:

Concrete core thermal activation mostly can use free cooling. The water supply temperature (15°C) is higher than the average earth temperature (10°C). Potentially a heat pump could be added.

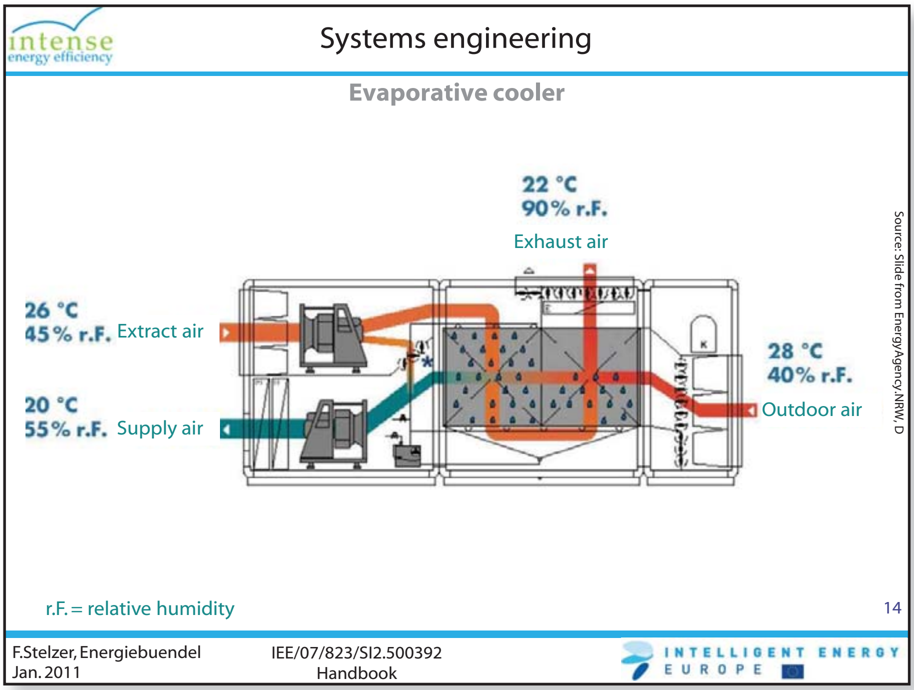
Especially in office buildings with low hot water demand and relatively high internal loads this could be a very efficient system. Combined with heating – and in some times heating and cooling alternate quickly (morning, afternoon, night) – the EER of the heat pump can reach about 5!

It is well known that for heating the wall heating is much more comfortable than the ceiling heating. Vice versa for cooling it is much more comfortable and efficient (like floor heating) the ceiling cooling. Thus concrete core cooling or ceiling radiant cooling panels are the best choice.

Therefore in regions with a relevant cooling demand compared with the heating demand, this system is very comfortable as well.

It must be admit, however, the system is slow.

For passive houses the concrete core thermal activation is a modern system. Based on very low temperature differences heating and cooling can be very efficient and alternating quickly. If there is a heat load in the morning and cooling loads in the afternoon systems like this might be the best choice. In particular in combination with adequate storage, e.g. earth storage served with heat pumps, the cooling part don't need more energy than the circulation pump of the heat transfer medium.



Cooling without chiller:

An evaporative cooler is cooling by vaporisation of water thus the efficiency is depending strongly on the indoor air humidity!

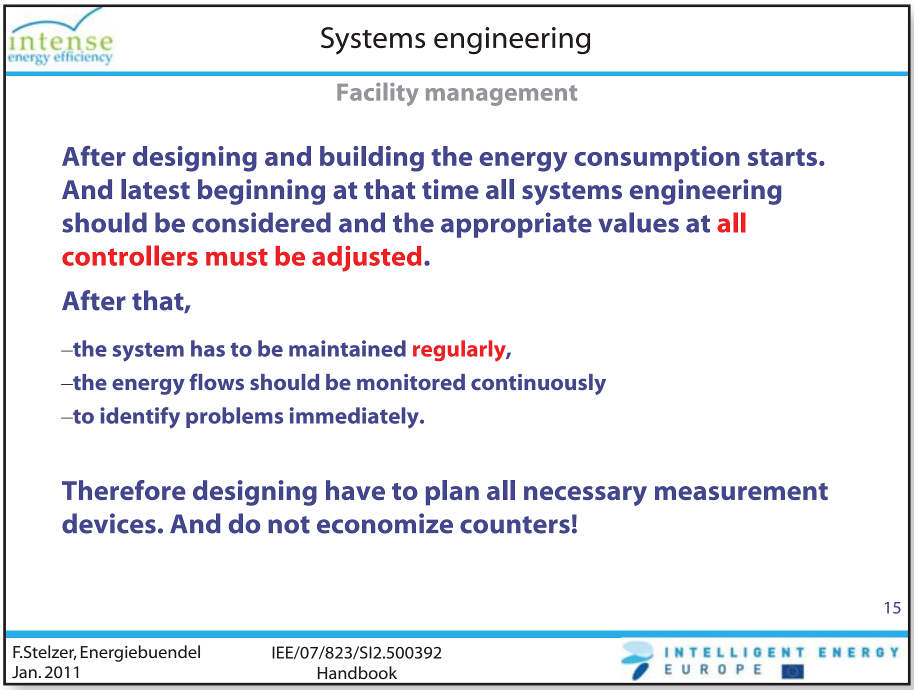
It is not energy but water, which cools the air. The water should be pure otherwise the demand of water increases. Rule of thumb for the cooling temperature: ambient temperature minus one third of the difference between the ambient temperature and the dew point. Add 3-5 K.

An other possibility of efficient cooling is a solar absorption chiller. It is a perfect choice if the cooling load correlates with solar radiation. Especially in southern countries this is the solution for the future. The systems are on the marked but the development has not finished.

The normal thermodynamic process of a heat pump remains the same and only the pump of the refrigerant is substituted by the absorption cycle:

In the absorber water is absorbed by the other fluid (ammonia or more common lithium bromide). This mixture is pumped (no pressure boost), heated by the heat exchanger and with the high (solar) temperature the water is desorbed as steam, pressure increases. The other fluid is pumped back through the heat exchanger for cooling, the steam is condensed by cooling water, throttled and then vaporised by the chilled water.

COP = Q_c/Q_{th} achieves around 0,65 - 0,75 and depends on the desorption temperature.



Even more than for heating and similar to ventilation the perfect adjustment of the controllers of the system and a regularly maintenance is very important for a stable efficient process. In passive houses the energy demand may vary enormously if the systems are not maintained properly.

The maintenance is a requirement written down in the EPBD.

The requirements of the facility management should be considered while designing the buildings with their mechanical systems.

Conclusion Cooling and Chillers

1.) In efficient and well designed buildings no cooling is necessary or you have the choice of several very efficient cooling systems.
2.) Even if cooling is needed, there are some better cooling systems than the "normal" split systems for room cooling.
3.) Especially in modern office buildings with glass façades heating and cooling are at the same time possible or at least quickly alternating. For this there are some efficient systems with heat recovery available (names vary by each manufacturer):
   – VRF variable refrigerant flow
   – 3-pipe system
   – 2 step heating and cooling (20°C main circulation)
4.) Don't forget to design a perfect storage, distribution and control and emission as well!