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Training for Renovated Energy Efficient Social housing

Intelligent Energy -Europe programme, contract n° EIE/05/110/SI2.420021

Intelligent Energy Europe

Section 1 Techniques
1.6 Heating Equipment

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Classifications

Heating installations :

- heat producing systems (heat sources),
- transporting networks
- heat emitters

Heating networks:

- Primary networks (district heating) on urban level
- Secondary networks – on a bulding level:
  - Central heating: supplies heat for numerous rooms produced in a common unit.
  - Flat heating
  - Room heating

Heat-carrying agents:

- warm water
- steam
- warm air

Source of energy:

- Fossile fuels
- Electricity (further classification according to origin)
- Renewables (in heating mainly biomass, geothermal and solar)

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1. HEATING NETWORKS AND SYSTEMS

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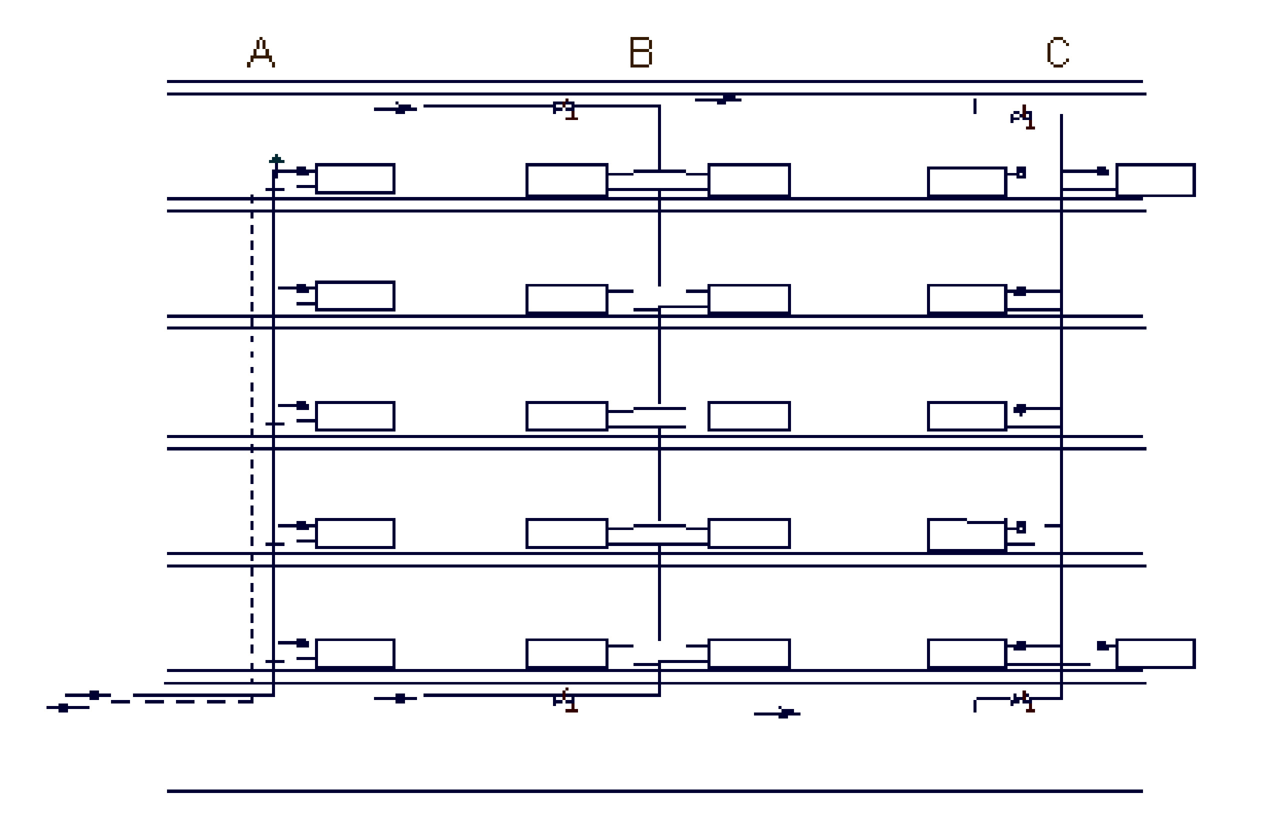
Warm water double-pipe and single-pipe heating systems

- **double-pipe function (A)**
- **single-pipe overflow (B)**
- **by-pass (C) heating systems**



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Air heating 1

Advantages of air heating systems:

- Operational reliability,
- Low thermal persistence,
- Low capital cost,
- They can be used also for room ventilation.

Disadvantages of air heating systems:

- Dust turbulence owing to the air flow,
- Radiation component of heat exchange missing,
- Uneven temperature distribution, high vertical temperature gradient.

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Air heating 2

- Air heating systems are used for
  - Industrial halls, storage houses, parking houses, sport halls, exhibition halls and similar large rooms with intermittent heating
  - Passive houses and low-energy buildings
- Air heating often combined with conventional heating:
  - in unoccupied periods the air heating can be turned off
  - the conventional heating temperates the room
  - energy saving

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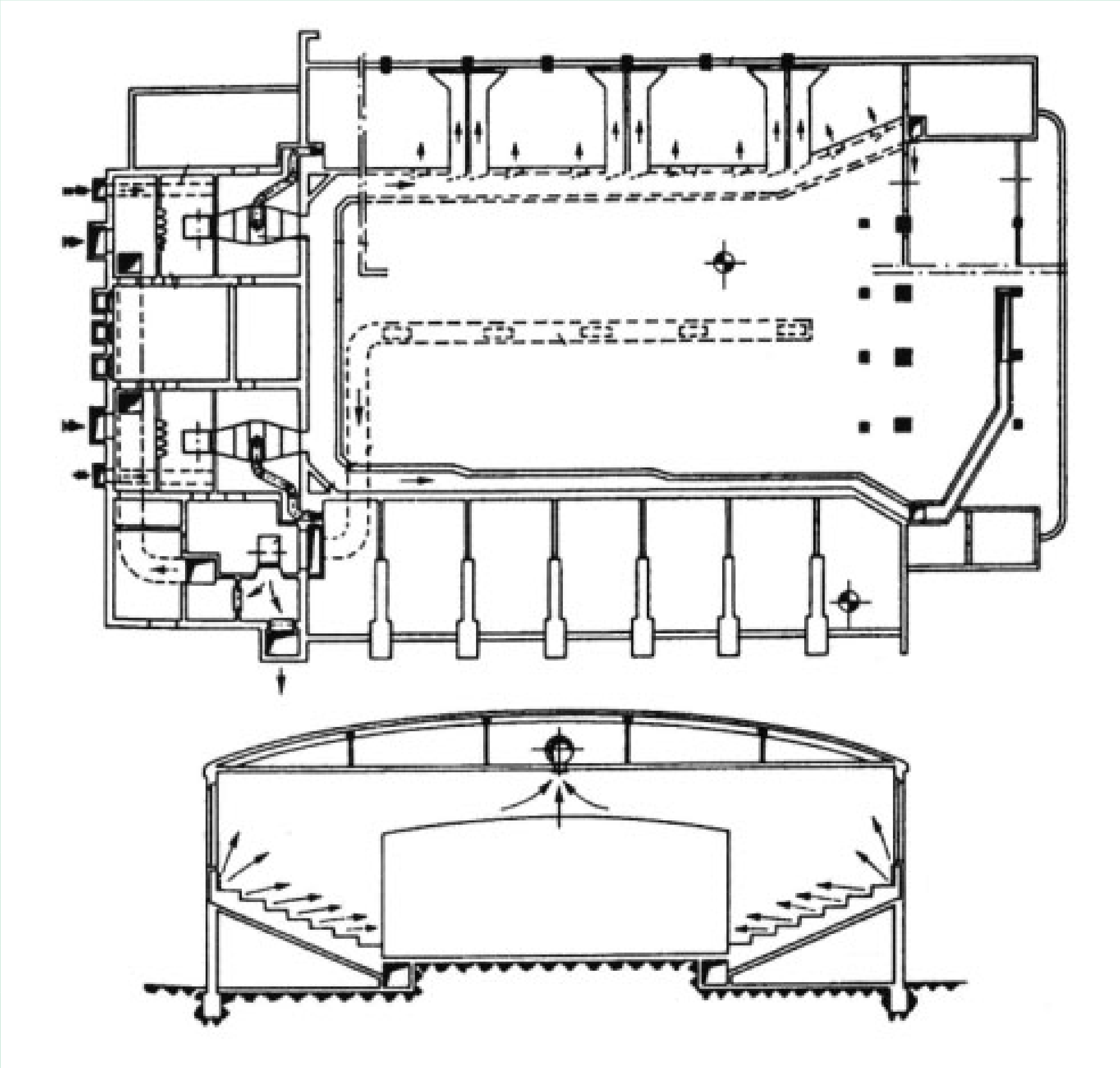
Air heating of large halls



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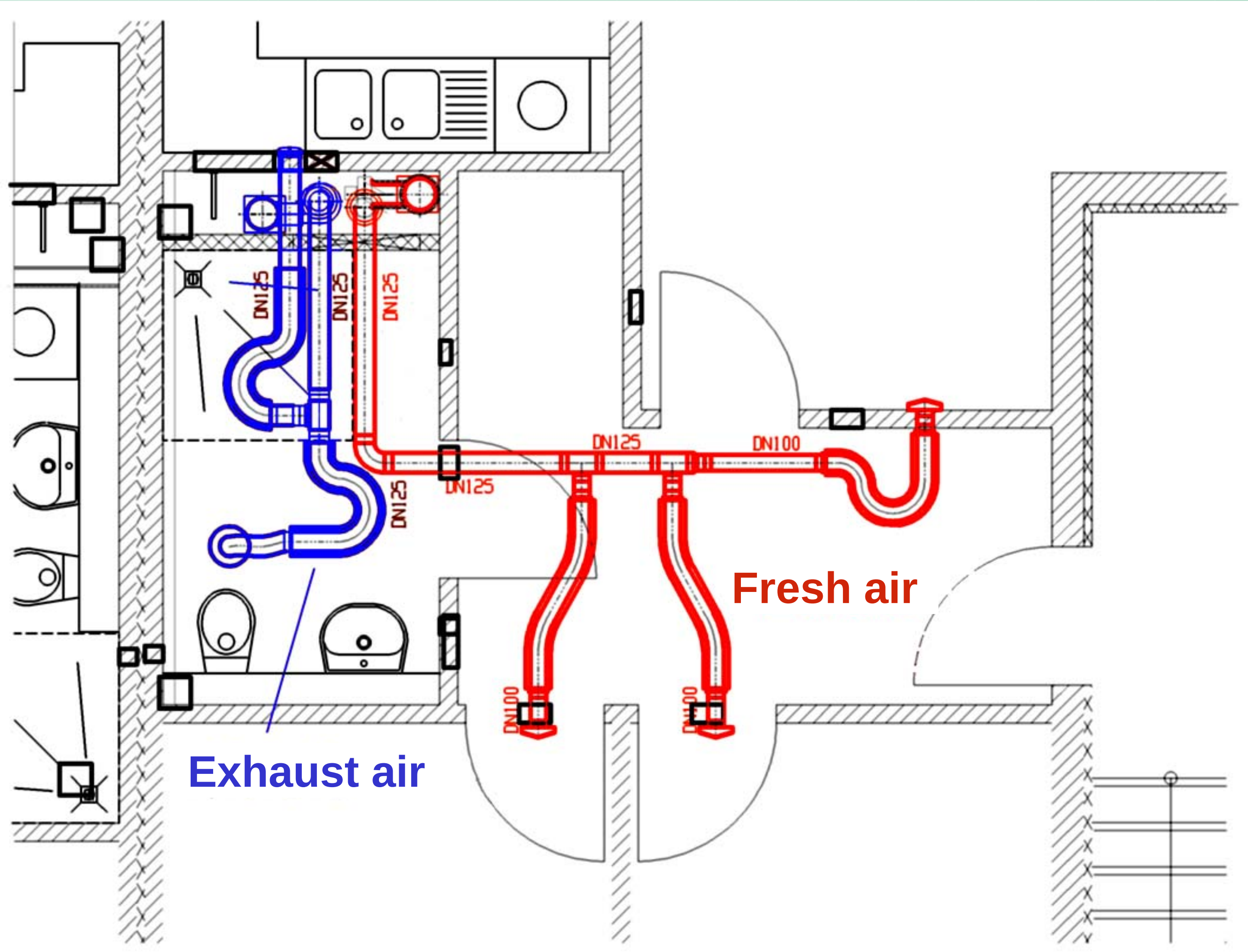
Balanced ventilation without conventional heating in a passive house



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2. HEAT EMITTERS

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Transfer of heat into the heated space

Heat transfer into the heated rooms is performed by:

- Convection,
- Radiation.

Heating emitters using mainly radiation:

- Large panel heating, thermo active heating systems (TABS)
  - Floor heating
  - Ceiling heating
  - Wall heating
- Hanged radiant panels,
- Heating by dark and light infrared irradiators

Heating emitters using mainly convection:

- Convectors
- Heating pipes in floor channels
- Air heating

Conventional radiators use radiation and convection at the same tyme, the proportion depends on the shape of the heat emitter

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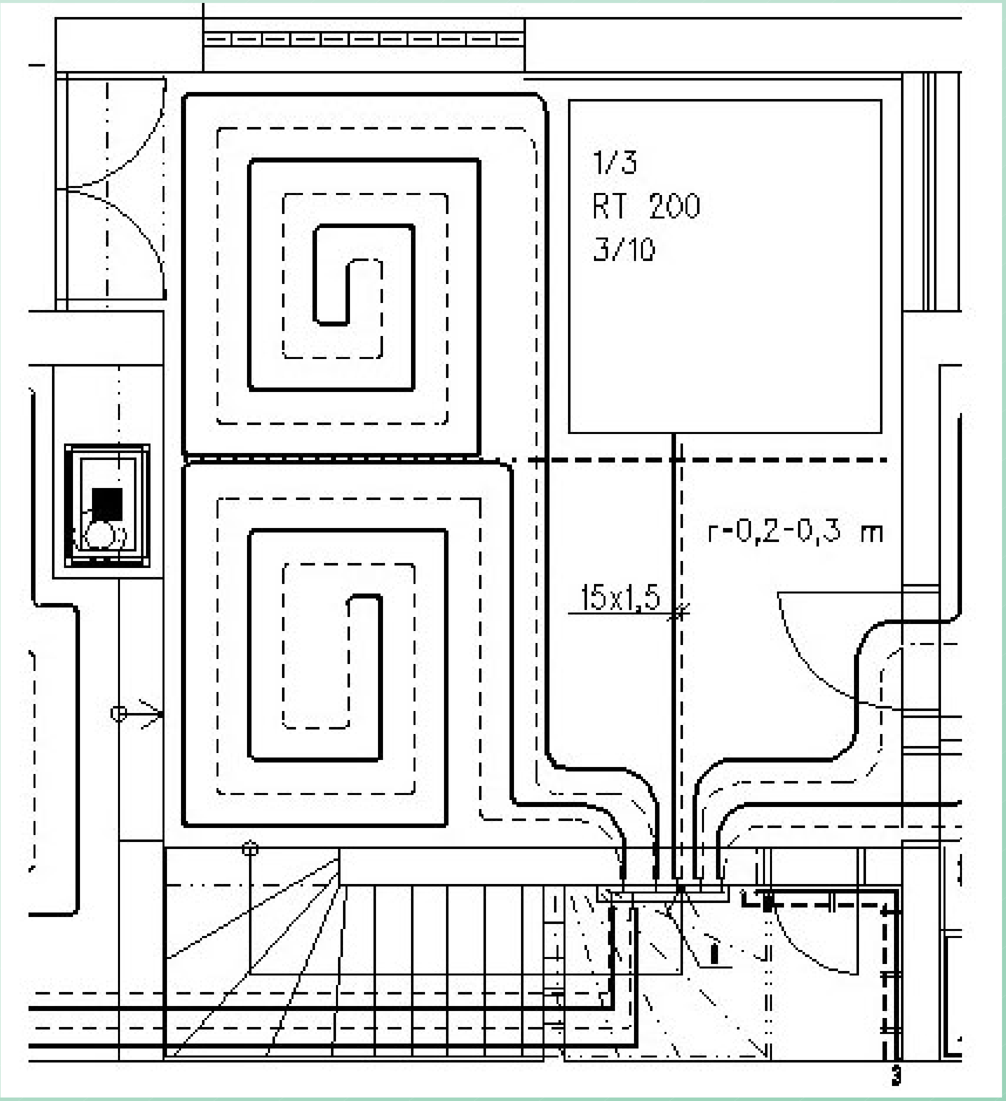
Example of a large-surface floor panel heating



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3. HEAT PRODUCTION

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Conventional boilers

Classification of the boiler rooms according to the used fuel:

- **Solid fuel,**
- **Gas fuel,**
- **Liquid fuel.**

Gas fuel boilers are the most common for heating and hot water heating

- **high efficiency,**
- **good adjustability and**
- **relative low environmental impacts**

In gas boiler rooms appliances must fulfill requirements of technical standards, codes and notices.

The requirements of the location, geometry and the the safety equipment of boiler rooms depend on the size and the regulations of the country.

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Basic parameters of fossile fuels

Fuel Characteristics	Natural Gas	Propane Butane	Heating Oil EP	Coke	Black Coal	Brown Coal
Density/specific gravity (kg/m^3,)	0,72	2,02	860	650	850	600
Specific thermal capacity-c_p (J/kg.K)	2497	1584		1100	1260	980
Calorific value **(MJ/m^3, MJ/kg*)	35,8	92,0	42,01*	27,0*	28,1*	16,0*
Required combustion air (m^3/m^3), (m^3/kg)*	9,53	28,3	10,5	13,0*	12,1*	14,0*

* EP – low sulphur oil

** Informative calorific values

Informative values of CO_{2max} for different fuels:

Fuel Characteristics	Natural gas	Propane Butane	Heating Oil EP	Coke	Black Coal	Brown Coal
CO_{2max}	12,0-12,5	13,8-14,1	15,5-15,9	20,0-20,3	18,5-19,5	18,5-20,5

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Classification of gas boilers

Flue temperatures of gas boiler different types:

- Classical gas boilers: > 200 °C

- Advanced gas boilers: 160 – 180 °C

- Low-temperature boilers: 110 – 130 °C

- Condensing boilers: < 60 °C

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Condensing boilers 1

In traditional appliances, vapour departs together with flue gas

Problems with the presence of vapour :

- vapour transfers latent heat energy out of the system;
- flue gas cools down in the chimney → condensation in the chimney → vapour reacts with carbon dioxide and sulphur dioxide → acid → chimney corrosion;
- in order to avoid the flue gas has to leave the chimney at a high temperature, carrying out sensible heat.

Solution af all these problems: **condensing boiler**

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Condensing boilers 2

PRINCIPLE:

- Cools down the combustion gases below the dew point temperature.
- Further sensible, and the latent heat can be utilised.

RESULT:

- Higher boiler efficiency (using formal equation over 100%)
- Lower pollution content of the flue gas → less harmful to the environment

SPECIAL REQUIREMENTS:

- Material of the boiler and the chimney must be corrosion free
- Not enough temperature difference between the air and the combustion gas → chimney drought is very small →air supply must be provided by a fan.

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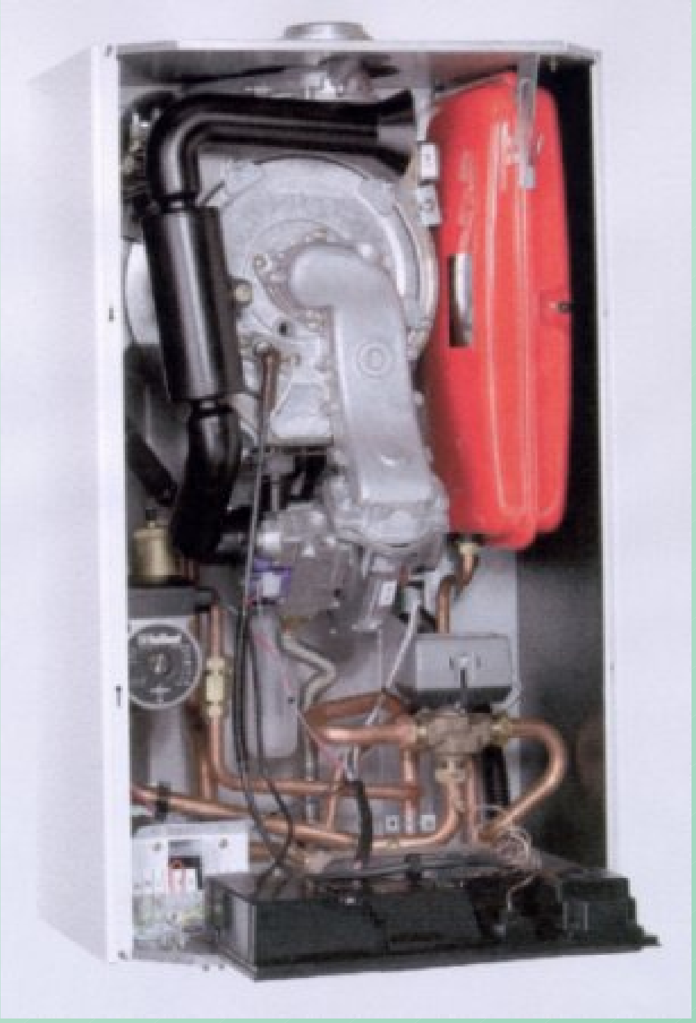
Condensing boilers 3



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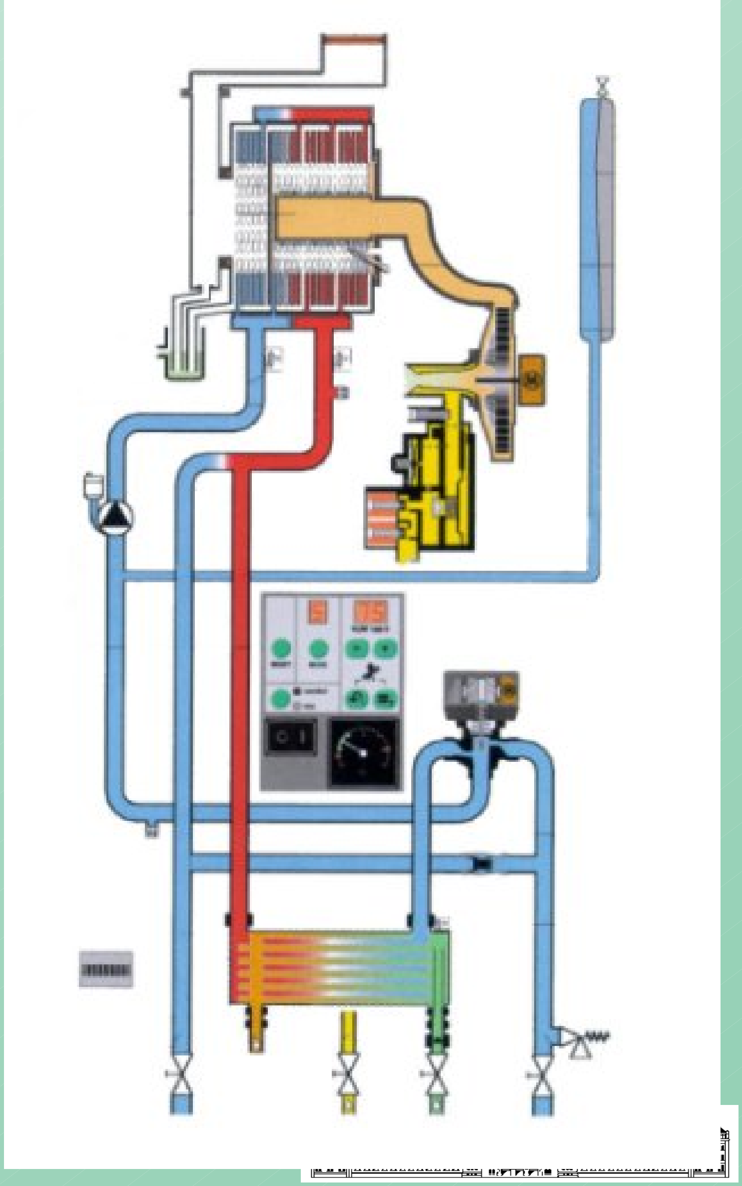
Scheme of a condensing boiler

Elements:

- heat exchanger (below),
- pump,
- control unit,
- fan,
- combustion chamber
- flue in closed system (marked with yellow),
- closed expansion tank (up, to the right, in blue and grey).



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BIOMASS 1: Heating with biomass, wooden-chip boilers

Arguements for biomass/wood fired boilers:

- new generation of wood-combustion boilers can achieve perfect burning → high energy efficiency → low pollution emission
- wood/biomass is renewable energy source, because the CO_2 emission is equal to the quantity of CO_2 decomposed during the lifetime of the plant
- Modern biomass boilers are applied in different sizes: from small units used in single family houses to large industrial boilers used in power plants.

From the point of view of heating biomass can be divided into three subgroups:

- firewood,
- pellets, wooden chips,
- grain and agricultural by-products.

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BIOMASS 2: Firewood

- Heating with firewood is a traditional way of heating, in rural areas it is still in use in ordinary stoves.
- traditional stoves don't meet the present technical and environmental requirements,
  - the origin of most of the firewood is questionable
  - the efficiency of the stoves is usually poor
- In order to fulfil the requirement of sustainability firewood has to be harvested from a forest managed in a sustainable way.
- Wood has to be burned under 25% moisture content → must be dried before burning
  - soft wood for at least one year,
  - hard wood for two years
- In domestic boilers: length of fire logs < 15 cm → proper surface-to-volume ratio → shorter burning process, less pollution emission

BIOMASS 3: Gasification process

- Biomass contains volatile oil
- At 250-300 ^{o}C the volatile oils are released
- Modern biomass boilers contain two burning chambers:
  - First chamber: gasification process (primary burning)
  - Second chamber (afterburner): the released gases are burned (secondary burning). The most difficultly flammable components are burned at 1100 ^{o}C.
- Complete burning of all components, high efficiency and low pollution emission.
- Remaining by-product: fine ashes, usable in agriculture for fertilizing purposes

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BIOMASS 4: Control of boilers with wood firing

In modern wood gasifying boilers the control can be established in two ways:

- **by control of the air volume entering into the burning chamber,**
- **by application of buffer tanks (safety water cooling loop required!).**

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BIOMASS 5: Pellets and bio-briquettes 1

- Can be produced from any combustible wastes suitable for firing (wastes from the wood processing industry, agriculture, sewage)
- Sawdust or the wastes are mixed with a combustible binding material then compressed at a high pressure
- Bio-briquette: diameter > 50 mm
- Pellets: diameter 5-25 mm, higher density (1-1,3 g/cm^3) production at higher pressure (above 800 bars)

- Additional space for fuel and ash storage needed

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BIOMASS 6: Pellets and bio-briquettes 2

Main advantages:

- automatized fuel loading
- pressurization process decreases the moisture content below 10-12% → no drying period needed
- higher calorific value
- perfect burning → quantity of ashes negligible → easy to handle → rich is mineral salts → can be utilised in agriculture for fertilising purposes

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BIOMASS 7: Main parameters of bio-briquette

Raw material	Density of briquette g/cm^3	Moisture content %	Calorific value MJ/kg	Ashes content %
Straw of wheat	1,13-1,37	6,3	15,42	8
Straw of soya	1,31-1,35	8,7	14,87	6,5
Corn-stalk	1,29-1,31	6,2	15,49	6
Sunflower-seed skin	1,01-1,3	7,1	17,22	3,6
Waste wood, sawdust	0,92-1,11	6,1	16,84	1,4

Compare calorific values and density:

Fuel Characteristics	Natural Gas	Propane Butane	Heating Oil EP	Coke	Black Coal	Brown Coal
Density/specific gravity (g/cm^3,)	0,0007	0,002	0,86	0,65	0,85	0,6
Calorific value (MJ/m^3, MJ/kg)	35,8	92,0	42,01	27,0	28,1	16,0

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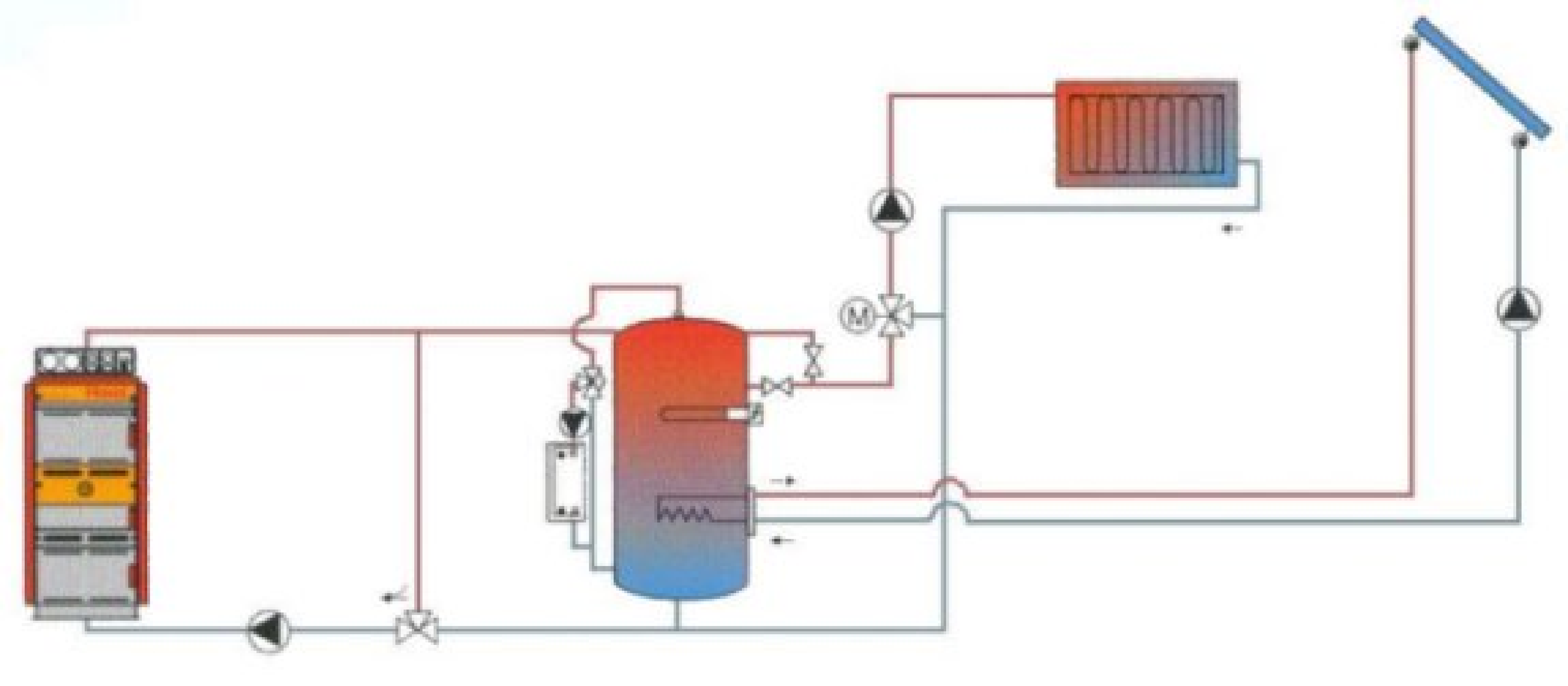
BIOMASS 8: Wooden-chip boilers and other renewables

Wooden chip boilers and even traditional ovens or fireplaces can be taken into account as an auxiliary or boost heating to a heat pump or a solar system.



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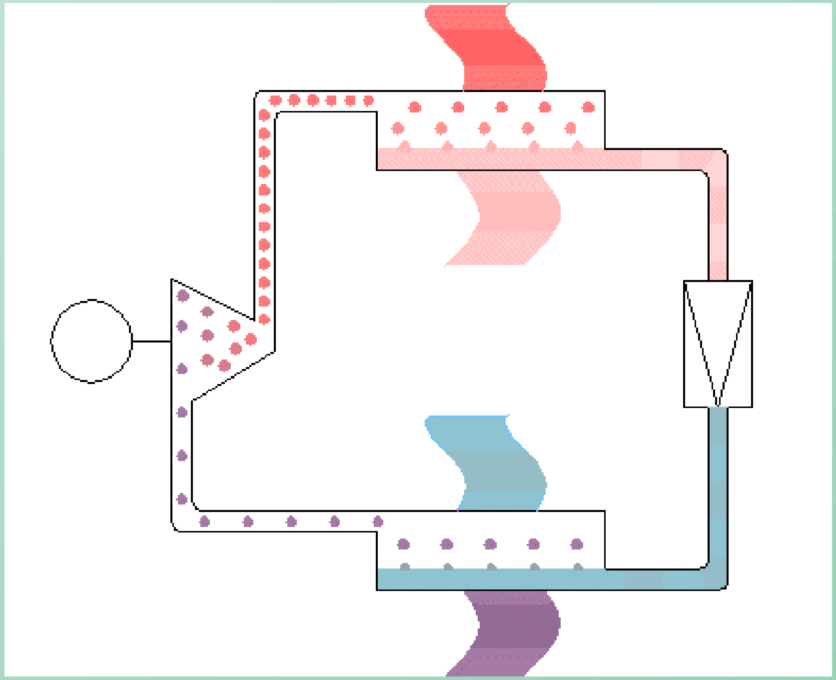
HEAT PUMPS 1: Principle

1. First heat exchanger (evaporator): the medium evaporates at a lower temperature, absorbing heat from its environment. Pressure is low.
2. Compressor: Vapour medium is compressed. Energy input required!
3. Second heat exchanger (condenser): pressurised medium condenses at a higher temperature, releasing heat to its environment.
4. Pressure release (choke) valve: The pressure of the medium decreases



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HEAT PUMPS 2: Application

- Refrigerators : the source is the food and drink inside of it, while the condenser on the backside releases heat into the room.
- Heating:
  - evaporator source is in the environment: external air, soil, water
  - condenser is a heat emitter: radiator, coil, floor heating.
- Cooling:
  - evaporator is in the room
  - condenser is in the environment.
- Only for low temperature heating systems:
  - floor heating,
  - wall heating
  - any thermo active building elements
  - conventional radiators must be designed for low forward temperature
  - not applicable for air heating

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HEAT PUMPS 3: Efficiency

- **A heat pump uses**
  - renewable (geothermal)
  - usually electric energy
- **A heat pump can produce 4 kW heating performance**
- **Uses only 1 kW for driving the compressor. This 1 kW is used for removing heat. 1 kW electric energy is produced in a power station and distributed, efficiency of 25 - 30 %**

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HEAT PUMPS 4: Heat source

- **Heat source:**
  - A big natural water reservoir: sea, lake, river with a relatively stable and high temperature.
  - Soil
  - External air
- **External air as source:**
  - Evaporator: "energy roof" or "energy wall" (roof or wall serve as heat exchanger).
  - If they are irradiated by the Sun, the source temperature is higher.
  - Source temperature not stable. Colder outdoor temperature → higher demand, → lower coefficient of performance (due to the low external air (source) temperature)
  - Frost protection needed in evaporator if the air temperature is lower than + 5 °C.

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HEAT PUMPS 5: Soil as heat source

- 30 W/m^2 peak load and 30-60 kWh/m^2,a consumption
- Capacity of the dry soil is lower,
- Capacity of soils with high moisture content or with filtrating underground water is higher
- Depths of buried coil : 2 - 6 m
- Risk of freezing of a upper thick layer of the soil
- The terrain surface over the buried coil cannot be planted without limitation

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Thank you for your attention!

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