Environmental assessment of building‘s technical system

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Abstract

The growing trend in building energy use has made energy efficiency strategy the main concern for energy policies which then involve developing new building regulations and certification processes. Technical system of the building plays a key role in energy consumption and CO_2 emissions of houses. The efficiency of a technical system in building can be reliably estimated by means of such indicators as the energy loss coefficient. The paper describes typical modern technical systems of buildings and gives an example of environmental assessment of the building's system quality.

Key words: assessment, technical system, housing.

1. Typical technical systems in buildings

According to the type, age and design of a building, different concepts of a technical system exist. There is a great variety of different technical equipment of buildings. Often because of reconstructions, reequipment and modernization in practice a large number of mixed forms of different systems' components exists. In spite of this only integral systems have to be chosen to give a vision of actual and widely distributed technical systems [1].

Different heat production systems have to be designed taking into account the energy demand of the building. Generally, an improved thermal insulation, for example by newly-built houses, gives a higher flexibility in option of heating and hot water warming systems, and type and arrangement of heating surfaces. The lower is the energy demand the easier it is to integrate in a system renewable energy sources [2]. Solar collectors and heat pumps will be efficient in such buildings. The lower is transmission heat loss (through constructions) of a building the more important role plays the heat loss through ventilation. Installation of mechanical ventilation is often reasonable (depending on the target value of energy demand and thermal insulation level), because by minor ventilation heat losses the heating can be reduced.

Typical technical systems of building are described in table 1.

Tab. 1: Typical technical systems for different type of buildings.

Newly-built building in accordance with current construction norms	▪ Heating system: as a rule low temperature boiler (oil or gas) or condensing boiler; ▪ Installation in a boiler room or inside the dwelling; ▪ Combination with household water warming with hot water storage device; ▪ Heat transfer trough radiators under windows.
Low-energy house	▪ Heating: gas condensing boiler or oil low temperature boiler; ▪ Combination with household water warming with hot water storage device, probable installation of solar collector for household water warming; ▪ Heat transfer through underfloor heating (low temperature level) or radiators; ▪ Installation of mechanical ventilation system.
Passive house	▪ Because of low heating demand, water heating system can be rejected; ▪ Mechanical ventilation with air in- and outtake units with heat recovery; ▪ Air heating (central intake air warming); ▪ Air intake units in living space, air outtake units in kitchen and sanitary arrangements; ▪ Hot water warming by a small heat pump or solar collector.

2. Basic notions

Heating demand – quantity of heat which has to be delivered from heating system to rooms of a building to maintain continuously the required indoor temperature.

The value of heating demand is defined by balancing of heat loss (transmission and ventilation) and heat sources (solar and indoor) and shows (under consideration of the defined conditions of use) the thermal insulation quality of the building.

Heating energy demand. Heating energy demand is the quantity of energy required to heat the building taking into account heating demand and heat losses of the heating system. Heat losses of the heating system appear through heat transfer, heat distribution, heat storage and heat production. These losses are included in the energy loss coefficient of the heating system. A low energy loss coefficient refers to an energy efficient heating system.

Energy demand. Energy demand is the quantity of energy required not only for the building's heating taking into account the heating demand and heat losses of the heating system, but also for household water warming taking into account heat loss of hot water preparation system. The quantity of energy includes also accessory energy required for operation of technical devices (pumps, control devices etc.).

Primary energy demand means the quantity of energy which covers the final energy demand including the additional energy necessary for production, conversion and distribution of a respective fuel material till delivery to the building.

Primary energy demand can serve as an estimating value for ecological criteria, for example CO_2 emissions, as it includes the total energy use for building's heating and household water warming.

3. Energy loss coefficient

To assess or compare different technical systems of buildings the energy loss coefficient of the system e_p can be used. The coefficient describes the ratio between consumption and utility. Through utility (availability of the required quantity of heat in the heating system) arises the consumption which begins at the extraction of raw oil and ends at the transmission of heat to the room. This process is reflected in primary energy factors as it is shown in table 2.

Tab. 2: Primary energy coefficients.

Energy carrier		**Primary energy factor**
Fuel	Fuel oil	1.1
	Gas	1.1
	Liquefied gas	1.1
	Black coal	1.1
	Brown coal	1.2
Central heating from CHP (cogeneration plant)	Fossil fuel	0.7
	Renewable fuel	0
Central heating from heat and power plant	Fossil fuel	1.3
	Renewable fuel	0.1
Electrical energy	Electricity	3.0

Source: [3].

Primary energy factor equal to 1.1 for fuel oil, for example, means that for preparation of one liter of fuel oil through processing of raw oil and transportation to the building ten percent more energy is consumed before the fuel oil can be used in a heat boiler.

Energy loss coefficient shows the energy efficiency of the whole energy supply chain including all the losses in the energy balance. By fuel combustion the exhaust loss arises, besides there is an energy production loss of a boiler. In a storage device arise, depending on thermal insulation and device placement, further heat losses. Heat distribution also leads to energy loss. At the end of the chain there is an energy loss through heat transfer to the rooms of the building.

Energy loss coefficient e_p equals to

$$e_P = e_a \cdot f_p \tag{1}$$

where f_p is primary energy factor, e_a is energy consumption of heating device, see [4].

4. Environmental assessment of building's technical system

A large number of typical used in practice technical systems in buildings is included in construction norms in the form of diagrams and tables [5]. Using the following systematization the optimal system can be chosen/ classified:

- Heat production and energy carrier of the heating system:
  - gas/oil low temperature boiler,
  - gas/oil condensing boiler,
  - electric heat pump,
  - electric heating,
  - distant or local heat.
- Heat production and energy carrier of household water warming system:
  - central,
  - decentralized.
- Solar collector:
  - solar support of household water warming,
  - solar support of heating and warm water preparation.
- Ventilation:
  - air outtake device with/ without heat pump,
  - air in/outtake device with heat recovery,
  - air in/outtake device with heat pump and heat recovery.
- Heat transfer to the rooms:
  - heat surface (for example radiators),
  - integrated heat surface (underfloor heating),
  - electric heating,
  - air heating.
- Placement of technical system components:
  - inside thermally insulated area,
  - outside thermally insulated area.

For example, renovation measure consisting in replacement of an old oil boiler (energy loss coefficient e_p =1.85) with a low temperature oil boiler (energy loss coefficient e_p =1.16) can be assessed in the following way. Because the heating demand of the building is not known, a comparable typical building can be considered. For a dwelling house standing separate from another buildings and built in 1949–57 a rough value of 253 kWh/(m^2a) can be used for a calculation [6]. For the assessment of the technical system with combined household water warming the value of energy demand for the hot water preparation will be included – 12.5kWh/(m^2a). The usable floor area of the building is 130 m^2.

The energy demand of the current building equals to:

$$Q_{E,IS} = (Q_h + Q_w) \cdot e_p \tag{2}$$

where Q_h is annual energy demand for heating,

Q_w – energy demand for household water warming,

e_p – energy loss coefficient.

$Q_{E,IS}$ in our example is (263+12.5)·130·1.85=63,853 kWh/a. After the boiler replacement $Q_{E,NEW}$ equals to (263+12.5)·130·1.16=40,037 kWh/a. The measure leads to the annual energy saving of 23,800 kWh/a. The costs of the measure including installment are approximately 6000– 7000 EUR.

Conclusion

The growing trend in building energy use has made energy efficiency strategy the main concern for energy policies which then involve developing new building regulations and certification processes. Technical system of the building plays a key role in energy consumption and CO_2 emissions of houses. By means of such indicators as energy loss coefficient, the efficiency of a technical system in building can be reliably estimated. Environmental assessment of building's technical system can be essential to reach visible improvements in the energy efficiency of buildings.

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