Towards modern options of energy conservation in buildings

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Abstract

Looking at modern options of energy conservation in buildings it is necessary to assure energy efficiency first. When the energy load of a building is highly decreased, then innovative options of energy conservation can be introduced. The background and development of the main modern methods for the reduction of energy needs, final and primary energy consumption are analyzed. Differentiation between options for existing and newly constructed buildings is pointed out. Modern options of energy conservation in buildings are focused on innovative architecture, shape, structure, materials of a building and of course systems utilizing renewable energy. A very simple way of reducing building energy needs is the utilization of solar energy in a passive, but planned way. A specific shape of solar buffer space should be created in the building. In high latitude countries the buffer space should be of a specific design containing two cuboid sub-spaces with specific internal overhang and a well-planned extension of the south glazed facade. The paper presents modern renewable energy technologies as technologies with roots in past ideas of using the environment in an effective way. It underlines that future innovative and efficient building technologies will use building integrated renewable, mainly solar technologies.

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1. Introduction

High energy consumption in the building sector leads to high energy intensity of the whole economy of a country. It is typical, that in most developed countries the building sector is responsible for about 40% of the final energy consumption. It is obvious that reduction of energy use in buildings is essential to make the economy of a country less energy intensive and more environmentally friendly. Nowadays, energy conservation has become one of the main aims of energy policy in many countries.

It is necessary to underline that in order to reduce the energy consumption of a country the following general fundamental rule must be obeyed - energy efficiency first then innovative options of energy supply, including utilization of renewable energy.

In the case of the building sector this firstly requires introduction of traditional options of reduction of energy use in buildings, i.e. to improve thermal quality of a building itself and modernize existing energy systems or replace them by more efficient ones. When the energy load of a building is highly decreased, then implementation of modern options of energy supply, including utilization of renewable energy, is a reasonable and effective solution.

Energy conservation in buildings is the subject of much consideration and many research studies. As a result recently many papers have been published in scientific international journals. They deal with this topic in a general and holistic way (e.g. Refs. [1–4]), or are focused on selected types of buildings (e.g. Refs. [5,6]) or just on specific building elements, usually the energy intensive ones (e.g. Refs. [7,8]). The importance of energy conservation in buildings can be seen at the national energy policy level and through fostering research and demonstration programs developed in many countries.

2. Traditional options of energy conservation in buildings

2.1. Reduction of the energy needs of a building

To reduce energy intensity in buildings it is first necessary to reduce energy needs. In the case of an existing building it means improving the thermal quality of the building envelope and its structure through refurbishment and thermal modernization. Thermal modernization is usually done through the introduction of a new building cladding and adding thermal insulation to external walls or making the existing insulation thicker. The thermal quality of a ground floor, ceiling at the top floor and roof can be also improved through increasing their thermal insulation properties. Very often windows are changed from single glazed to the double...
or even triple glazed with noble gas filling and low emissivity coatings on glass panes. External blinds on windows can also be applied. Ventilation system can be made more effective through upgrading ventilation channels, and introduction of passive heating or cooling solutions. Sometimes it is good to increase the thermal capacity of a building by adding some thermal mass elements.

Reduction of electrical energy needs is usually assured through improvement of daylight use and redesign of light sources, their location and operation.

In new buildings it seems easier to assure low energy consumption of a building. The architecture of a building and its civil engineering solutions are the first step and they are crucial for the energy needs of a building. The energy needs of a building result from the architecture of the building, including shape, structure, materials used, location and size of windows (glazed surfaces) and the location of the building itself. The surroundings or vicinity of a building are important (e.g. open space, trees, other buildings, etc.) and environment, e.g. urban or rural. The architectural design and construction of a building must be done in accordance with existing regulations, standards and building codes, which are focused on assuring low energy loads. Nowadays most European countries (but not only) require the energy demand of newly erected buildings to be confirmed by energy characteristics certificates [9].

It should be underlined that all measures for the reduction of the energy requirements of a building may be introduced in a quick and effective way, if end-users are aware of the necessity of reduction the energy use. It is easier when they are also aware of energy efficiency methods recommended for application in buildings.

2.2. Reduction of the final energy demand of a building

When energy needs are reduced thanks to good architecture and construction, the next step in the energy conservation process can be undertaken to reduce final energy consumption. Final energy consumption results from the type, construction and mode of operation of energy systems, installations and devices applied in a building. Reduction of final energy consumption in existing buildings can be done through improvement of the operation of heating/cooling systems, ventilation (air conditioning) systems and electrical systems. Particular or all elements of the space heating, cooling, ventilation, DHW systems and electrical system – lighting and electrical appliances, can be upgraded or exchanged for new ones. Operation of those systems is strictly connected to the type of installation and its mode of operation. For example a standard heating system with radiators can be exchanged for an underfloor water heating system. Operation can be more efficient if an automatic control system or energy management system is applied. The heating system does not have to operate continuously. The time of operation of a system depends on the way of life of the inhabitants (users) and their individual demands for thermal comfort. Upgrading a heating system could also be, for example, exchange of the existing heating/cooling source for a more efficient one, e.g. traditional gas boiler to condensing gas boiler, traditional fireplace to fireplace with closed combustion chamber and air ducts supplying heat (heated air) to specific rooms.

The energy efficiency of HVAC (heating, ventilation, air conditioning) system and its devices, and electrical appliances also crucially affect the final energy consumption in new buildings. However, it is much easier to design a completely new system as an efficient one than to upgrade an existing one, especially when modern efficient technologies are available.

To select the energy efficient system and its components, end-users must be aware of availability of such systems on the market and their methods of operation, especially in the energy saving mode. It is very important for end – users to have ability to measure and control the energy use in a building. They can switch off some devices and not use stand-by mode very often. They can change some parameters of the system operation, e.g. reduce temperature of the heating medium in a space heating system, when it is required (e.g. when there is nobody at home). They can decide to replace some domestic equipment, like washing machines, fridges, TV, radio and etc., if they know how much energy (and water, if it is the case) they consume. Metering of energy use in a building is really necessary to evaluate the possibilities for reduction of final energy demand. Nowadays, people are interested in the reduction of final energy consumption, because it means reduction of their expenses for electricity and heating/cooling energy.

When buying a new private house or a new building by a company or public utility, it should be easier to influence the final energy consumption. Of course if the buyer is at the same time also the energy consumer they are aware of energy efficient solutions in the energy systems.

When a building is supplied by a central district heating/cooling system then the end – user cannot directly influence the efficiency of the energy distribution system. This is the duty of energy distribution company: to reduce energy losses during distribution of energy from a generation plant to end-users. It requires modernization of heating/cooling distribution centers, networks, heat-exchange centers and so on. In the case of electricity it also requires upgrading the power grids and transformers centers.

2.3. Reduction of the primary energy demand of a building

When final energy demand is reduced, the next step is to reduce primary energy consumption. When energy efficient systems and devices are applied then the focus is put on primary energy (energy sources, fuels) that is used to provide final energy demand. The type, quality and quantity of a fuel or energy source and methods of its conversion into final energy determine primary energy consumption. To reduce the primary energy consumption of buildings, it is necessary to improve the energetic quality of a fuel or to exchange it to a new one: less energy intensive in the process of its extraction and transportation, and as a result more environmentally friendly. Then it is required to increase the energy efficiency of the processes of energy production, i.e. of heating and cooling energy, and electricity. It requires improving the efficiency of energy conversion processes from fuel to final energy product (heat, cool, electricity) with a reduction of waste energy and waste materials that are created during these processes. It could be done through upgrading and modernization of power/thermal plants or other energy sources (systems), or through construction of completely new plants, switching to clean, efficient fuels. The most effective way of producing energy is using cogeneration, i.e. production of heat and electricity at the same time in the same plant, also called CHP (Combined Heat and Power). Electricity is recognized as energy of a higher exergetic class than heat. In traditional energy plants fired by fossil fuels to produce electricity high temperature and enthalpy steam must be produced to drive turbines to produce electricity. According to thermodynamic laws this process results in the creation of lower temperature heat. This heat should not become waste heat, it should be used for heating purposes, and cogeneration can be achieved.

New buildings can be supplied by their own new energy sources. They can be located directly in every building, or can be one heat source – a new energy plant supplying heat from a central location to every building. Distributed energy systems are becoming popular nowadays. When a new district of a city is planned and constructed, usually it is more effective to build a new energy plant at this site than connect all new buildings to the
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