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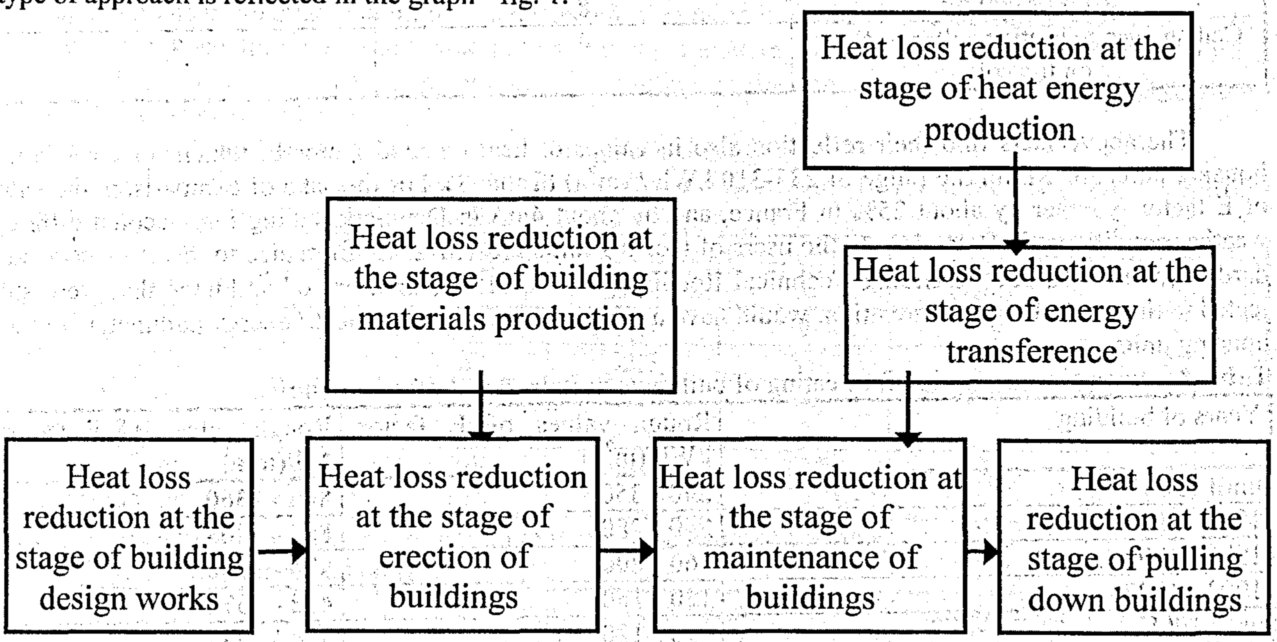
# ENERGY CONSUMPTION IN POLISH BUILDING SECTOR

The building industry is the Polish economy's most energy-consuming branch. Erection and maintenance of buildings absorbs almost 50% of the state's energy demand. High energy consumption levels result, inter alia, in rapid depletion of energy raw materials deposits, and increasing emissions of many hazardous compounds, including $CO_2$ and $SO_2$ [1]. Irrational energy management threatens with the emergence of energy raw materials barriers (i.e. conditions in which energy raw materials acquisition becomes impossible or economically ineffective, whereas the production of additional volumes of energy is impractical for technical reasons). The scope of the latter phenomenon may be confirmed by the following data: forecast total world energy consumption in the year 200 at the level of 400 EJ will result in the emission of 6.6 $10^9$ MT of $CO_2$, and 135.0 $10^6$ MT of $SO_2$.

Therefore, extensive research is now run in Poland, aimed at discovery of various reduction opportunities of the building industry's energy consumption levels. In order, however, to achieve expected results in this respect, the issue of heat loss reduction should be considered as a whole, and in complex manners. This type of approach is reflected in the graph - fig. 1.




**Figyre 1** – The main sources of heat loss reduction in the Polish building industry [5]

As indicated in the graph, the most important sources of energy saving occurs at the following stages:

– Production and transference of heat energy;
– Designing, erection, maintenance, and liquidation of buildings, including building materials production.

In Poland, energy needed to heat about 60% of housing units is produced centrally. The remaining 40% of housing units possess their own boiler rooms. Heating ovens usually have low efficiencies. Hard coal is the basic type of fuel. Therefore, the following activities should be conductive to reduce heat loss in this domain: further decentralization of energy production sources (avoiding in this way any serious losses at the stage of its transference to various customers); substitution of out-dated heat ovens and facilities with state-of-the-art ones of high efficiencies, replacement of coal with hydrocarbonic fuels (as an example, their share in Germany's fuel structure amounts to about 90%) (Table 1).

**Table 1** – Municipal household sector's fuel consumption for heat production structure

| Country | Hard coal and coke | Hydrocarbon fuel |
|---|---|---|
| Polska | 80 % | 20 % (usually gas) |
| Niemcy | 10 % | 90 % (usually oil) |
| Czechy | 68 % | 32 % |
| Wêgry | 40 % | 60 % |

In case of decentralized energy production, energy is subject to distribution to customers. Heat losses due to transference may reach as much as even 20% [2], and may grow in case of heat network emergency occurrences. These losses may be limited through bringing to a minimum the length of energy transference routes, and through isolation of heat pipelines with state-of-the-art materials (of cellular structure, e.g. Aeroflex).

Besides heat energy production and transference, huge saving opportunities exist at the stages of design works, erection, and maintenance of buildings. Construction / technological design works play a crucial role in the indicated triangle; as it is the designer who creates definite material, construction, and technological solutions, which, when made reality in the form of a building, or earlier building materials production, exert a decisive impact upon energy consumption levels both at erection and maintenance stages. Since the share of particular multi-family building elements in heat losses presented in Table 2.

**Table 2** – Average heat losses in multi-family building

| Heat losses | Participation in heat losses by external surface, % | Participation in building heat losses , % |
|---|---|---|
| External walls | 47 | 34 |
| Windows and doors | 41 | 30 |
| Ventilation | – | 27 |
| Roof or ceiling | 8 | 6 |
| Ceiling over no heating cellar or floor on the soil | 4 | 3 |

The above facts find their reflection also in values of heat demand factor E, which for most Polish housing units are within the range of 235-310 kWh / ($m^2$a) (Table 3). For the sake of comparison, the value of E factor is lower by about 25% in France, and by about 46% in Denmark, taking into account different weather conditions. In Poland, only the users of housing units erected in conformance to the 1991 heat standard requirements, and "Building Technical Requirements" of 1995, or users of buildings that were subjected to thorough thermal renovation, would have a chance to reach similar heat / energy parameters of their housing units.

**Table 3** – Energy consumption for heating of buildings in Poland and others countries

| Years of building | Rough values of E factor, kWh/($m^2$a) | Rough values of E factor, MJ/($m^2$a) |
|---|---|---|
| until 1966 | 240 - 350 | 864 - 1360 |
| 1966 - 1985 | 240 - 280 | 864 - 1008 |
| 1986 - 1992 | 160 - 200 | 576 - 720 |
| 1993 - 1997 | 120 - 160 | 432 - 576 |
| until 1998 | 90 - 120 | 324 - 432 |
| current standards in Germany | 40 - 80 | 144 - 288 |
| current standards in Sweden | 30 - 60 | 108 - 216 |

Modern isolation and construction materials with low heat permeability factors make it possible to significantly improve thermal isolation parameters of walls and windows. Heat loss reduction through ventilation conduits may be achieved if ventilation conduits' necessary volumes and quantities, as specified in standards, are not exceeded.

Except for construction elements, it is important to create appropriate designs of interior heating installations, including, but not limited to, equipment of heat junctions in hot water in-take automatic adjustment facilities, usage of high efficiency radiators, radiator screens, and thermostatic valves. As an example, heat junctions equipped in hot water in-take automatic adjustment facilities may reduce energy consumption by about 12%, whereas usage of radiator screens by about 4% [3].

Energy savings should be also sought at the stage of construction. Energy levels used to erect a building usually does not exceed 10% of those within the maintenance period. The essence of saving at this stage of investment consists in energy consumption rationalization at the successive stages of basic and auxiliary production, aided by unification and industrialization of building processes.

Energy consumption levels of buildings erection are significantly influenced by energy consumption levels of building materials production. Variance in energy consumption levels at the production of this type of materials may be quite substantial; e.g.: in order to manufacture 1 $m^3$ of reinforced concrete elements 11.5

GJ of energy is needed, the manufacture of 1 $m^3$ of calcium-silicate bricks requires as little as 1.6 GJ [7]. Energy consumption levels of building materials production presented in Table 4.

**Table 4** – Coefficients of accumulated energy consumption in production of some building materials in the following countries: Canada, USA, Switzerland, Finland and in Poland [Our own data based on [8]]

| Materials | Canada | USA | Switzerland | Finland | Poland |
|---|---|---|---|---|---|
| Aluminium | 236,3 | 192,0 | 261,7 | — | 224,5 |
| Steel | 25,7 | 39,0 | 27,7 | — | 54,7 |
| Window glass | 10,2 | 19,8 | 21,6 | 16,5 | 30,5 |
| Plaster | 7,4 | 7,2 | 1,4 | — | 7,2 |
| Brick | 4,9 | 5,8 | 3,1 | 2,8 | 9,1 |
| Mineral wool | 22,3 | 14,0 | 18,0 | 23,4 | 20,8 |
| Cement | 5,9 | 9,4 | 4,9 | 4,9 | 8,2 |
| Concrete | 1,2 | 1,3 | 0,9 | — | — |
| Mortal | 2,2 | — | 1,4 | — | — |

At the building industry consumes very high quantities of materials, energy consumption levels of building materials production should not be neglected. Desirable in this area is considered searching for materials of thermal isolation but at the same time strength parameters, that demand little energy expenditure at the stage of production, as well as making use, in building production processes, of materials that require little energy to be manufactured.

Energy consumption in building presented in Tables 5,6,7,8.

**Table 5** – Accumulated energy consumption in Life Cycle Assessment (LCA) of building, which construction erected with various building materials [4]

| Energy consumption | Wooden construction | | Steel construction | | Concrete construction | |
|---|---|---|---|---|---|---|
| | GJ/$m^2$ | % | GJ/$m^2$ | % | GJ/$m^2$ | % |
| Building erection | 4,4 | 7 | 5,5 | 9 | 4,9 | 8 |
| Use of building | 52,5 | 83 | 52,5 | 81 | 52,5 | 82 |
| Technical exploitation | 6,6 | 10 | 6,7 | 10 | 6,5 | 10 |
| Total energy consumption | 63,5 | 100 | 64,5 | 100 | 63,9 | 100 |

**Table 6** – Accumulated energy consumption in various elements of building [Our own data based on [8]]

| Energy consumption | Exploitation: 50 years | | Exploitation: 100 years | |
|---|---|---|---|---|
| | GJ/$m^2$ | % | GJ/$m^2$ | % |
| Developing of bulding site | 357 | 1,2 | 992 | 1,4 |
| Construction | 0 | 0,0 | 0 | 0,0 |
| External surface | 8943 | 29,5 | 20060 | 29,0 |
| Completing | 9339 | 30,8 | 21046 | 30,5 |
| Installation | 9920 | 32,8 | 23093 | 33,4 |
| Building erection | 1714 | 5,7 | 3911 | 5,7 |
| Sum | 30273 | 100,0 | 69102 | 100,0 |
| Energy consumption index, GJ/$m^2$ | 6,55 | — | 14,96 | — |

Last but not least out of the areas indicated in the graph, i.e. reduction of heat loss at liquidation of buildings, is supplementary in nature. Energy consumption levels when pulling down buildings may be varied, and chiefly dependable upon pulling down technologies and methods of liquidation of their remaining.

Due to limited space of this paper, only the most important guidelines to reduce heat losses in the Polish building industry have been sketched in it. The issues raised here appear to a larger or smaller degree in most post-communist countries, whose scientific and executive personnel keep on trying to find the best methods to solve them. The author of this paper is of the opinion that common, integrated activities run by scientists from these countries could lead to more rational and more global solutions, receivable in shorter periods of time.

Table 7 – Accumulated energy consumption in various elements of building
[Our own data based on [8]]

| Energy consumption | Exploitation: 25 years, % | Exploitation: 50 years, % | Exploitation: 100 years, % |
|---|---|---|---|
| Developing of building site | 0,5 | 1,2 | 1,4 |
| Construction | 0,0 | 0,0 | 0,0 |
| External surface | 32,7 | 29,5 | 29,0 |
| Completing | 32,7 | 30,8 | 30,5 |
| Installation | 28,4 | 32,8 | 33,4 |
| Building erection | 5,7 | 5,7 | 5,7 |
| Sum | 100,0 | 100,0 | 100,0 |

Table 8 – Rough accumulated energy consumption in erecting phase of building in GJ/m$^2$
[Our own data based on [6]]

| Construction | Light | Meddle | Heavy |
|---|---|---|---|
| Easy | 4,0 | 5,0 | 6,0 |
| Traditional / typical | 5,5 | 6,5 | 7,5 |
| Complicated | 7,0 | 8,0 | |

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# ДЕНЕЖНЫЙ ЭКВИВАЛЕНТ ОБЩЕСТВЕННО ОПРАВДАННЫХ ЗАТРАТ НА СНИЖЕНИЕ ДОЗЫ РАДИАЦИОННОГО ОБЛУЧЕНИЯ НАСЕЛЕНИЯ И ПРОБЛЕМЫ ЕГО ОЦЕНКИ

Радиационный фон в помещениях, в частности – жилых [2], формируется, преимущественно, излучением естественных радионуклидов (ЕРН), входящих в состав практически всех природных строительных материалов. Уже хотя бы поэтому полная защита строящихся и обновляемых зданий от ионизирующего излучения невозможна, а предпринимаемая - вынуждена ограничиваться разумными границами.

Важной характеристикой, придающей количественный характер обоснованиям рациональности проектируемых защитных мероприятий, является значение максимально оправданных затрат, требующихся для снижения коллективной дозы облучения населения на 1 чел.-Зиверт (чел.-Зв), измеряемое в денежных единицах, приходящихся на 1 человека.

По оценкам международной комиссии по радиологической защите (МКРЗ), выполненным в 80-х годах прошлого века, такие затраты составляют от 1000 до 100000 тысяч долларов, США [5, с 166]. К сожалению, принципы и факторы, учитывавшиеся при этом, нам неизвестны.