POTENTIAL ENERGY SAVINGS IN BUILDINGS

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POVZETEK

Stavbe so v celotnem življenjskem ciklusu veliki porabniki energije. V zadnjih letih se zmanjšuje raba energije za ogrevanje. Razviti so različni koncepti energijsko učinkovitih stavb (nizkoenergijske, nič-energijske, samozadostne, plusenergijske, pasivne hiše). Optimalna je pasivna hiša – s sprejemljivim razmerjem med stroški in prihranki energije. Višja energijska učinkovitost sicer zmanjša rabo obratovalne energije, vendar se zaradi večjega deleža gradiv in komponent poveča vgrajena energija. Faza gradnje stavbe postaja potencial prihrankov energije.

ABSTRACT

Buildings are large energy consumers during their entire life cycle. In recent years, the use of energy for heating has been decreasing. Various concepts of energy efficient buildings have been developed (low energy, zero-energy, self-sufficient, plus-energy and passive houses). The optimum type is a passive house with an acceptable balance between energy costs and savings. While energy efficiency does reduce the consumption of operating energy, the larger proportion of materials and components increases the embodied energy. The construction stage has increasing potential for energy savings.

1. INTRODUCTION

The European Union is grappling with increasing energy needs, which presents an economic, social and ecological risk. Currently more than 50% of its energy needs are met with imports, placing the EU at the top globally. If the planned measures are not introduced, this share could rise to 67% by 2030 [2]. Only a small portion of its energy products are domestic, with the majority coming from various countries outside the European area [1]: natural gas from the Russian Federation (34%), then from Algeria (14%), and more than 10% from Qatar, Libya, Nigeria and Egypt. Crude oil comes from OPEC (35%), the Russian Federation (33%) and 9% from Kazakhstan and Azerbaijan. The EU's dependence on energy imports is therefore constantly growing (Fig. 1).

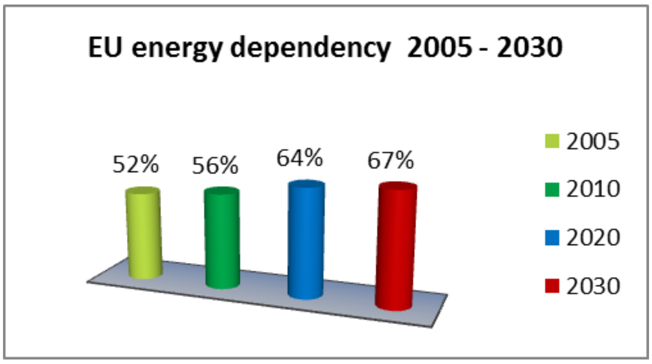

Fig. 1: EU energy dependence on imports 2005 – 2030 [2]

The import dependence of Member States varies (Fig. 2). In 2009, Slovenia’s energy dependence was slightly below the European average, standing at 49% [1].

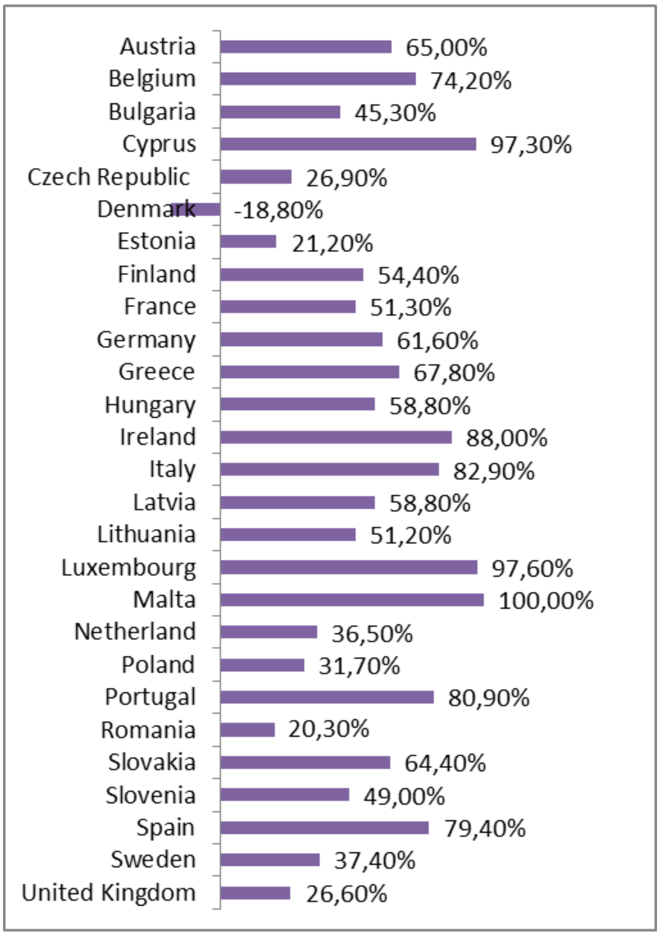

Fig. 2: Energy import dependence of EU Member States in 2009 [1]

In addition to the large quantities of raw material resources that must be secured by a country for energy generation, difficulties are also created by greenhouse gas emissions which cause global warming of the atmosphere. Under the Kyoto Protocol [3], which Slovenia signed in 1998, signatories agreed on CO_2 emission quotas that individual countries are permitted to reach. There are 16 EU Member States that do not exceed the agreed quotas (Fig. 3). Slovenia is one of nine European countries where CO_2 emissions exceed the permitted levels (Fig. 4). In 2008 it was already 14.52% more than the quota permitted for 2012 [1].

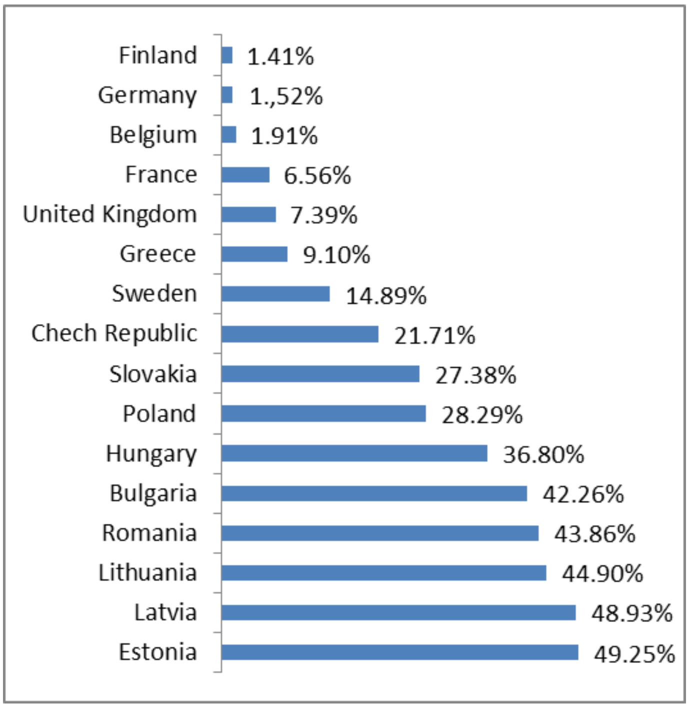

Fig. 3: EU Member States UNDER Kyoto target 2012 (in 2008) [1]

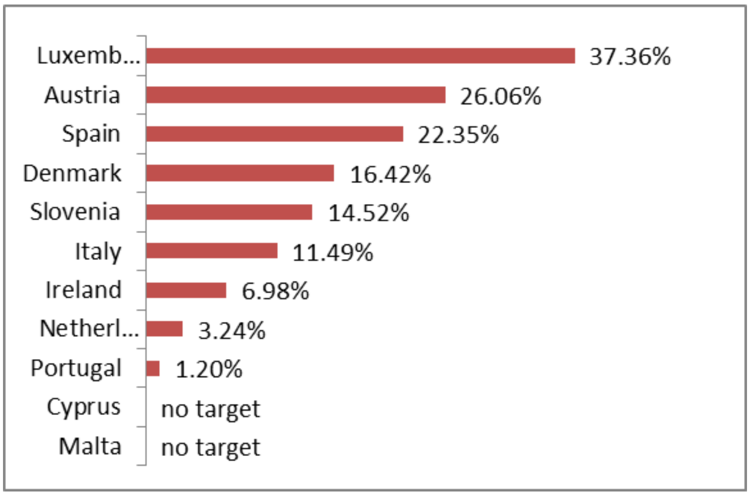

Fig. 4: EU Member States ABOVE Kyoto target 2012 (in 2008) [1]

A large proportion of the energy obtained is used by European households. Total final energy consumption in EU households amounted to 307 Mtoe in 2010, or 26.6% of the total

[4]. Heating accounts for 70% of consumed energy and contributes around 14% of the total emissions of greenhouse gases [5].

In Slovenia, total final energy consumption amounted to 5.1 Mtoe in 2010, of which 1.3 Mtoe was used in households (25.5%). A total of 0.8 Mtoe is used for household heating (61.5%). The share of solar and geothermal energy – which cause no CO_2 emissions – is negligible: heat from geothermal sources amounts to 757 toe (0.9%) and from solar power it is much less, at 212 toe (0.25%) [6].

It is thus evident that European and Slovenian households have great energy potential – with reduced consumption of energy for heating and an increased share of renewable energy sources.

2. LEGISLATION

Energy consumption for heating buildings is limited by EPBD Directive 2002/91/EC [7] and particularly by the updated EPBD Directive 2010/31/EU [8], which further increases certain requirements:

- 20% reduction in greenhouse gas emissions (relative to the base year 1990)
- 20% reduction in primary energy consumption through increased energy efficiency
- 20% share of renewable sources in the primary energy balance

The two directives envisage restrictions on energy consumption at the entire building level, which in addition to the building envelope includes specific technical systems in buildings such as ventilation, heating, air conditioning, cooling, hot water and lighting.

The EPBD Directive 2010/31/EU envisages increases in the energy performance of buildings at the level of the nearly zero-energy house until 2020:

- by 31 December 2020 – all new buildings must be nearly zero-energy,
- by 31 December 2018 – all new publicly owned buildings must be nearly zero-energy, since they must serve as a model for others.

The anticipated results of the updated EPBD Directive 2010/31/EU are a 5% to 6% reduction in the EU's final energy, 160 Mt – 210 Mt a year in CO_2 savings and 280,000 to 450,000 new jobs by 2020 [9].

In 2010, in accordance with directives EPBD 2002/91/EC and EPBD 2010/31/EU, Slovenia adopted national construction legislation – the Rules on efficient use of energy in buildings [10]. The Rules set out the minimal technical requirements and guidelines for constructing low-energy houses today (energy consumption for heating approximately 40 – 50 kWh/(m^2a)) or nearly zero-energy houses in the future.

Directives EPBD 2002/91/EC and EPBD 2010/31/EU set out the introduction of the Energy Performance Certificate, which will show the energy consumption of individual buildings. In Slovenia the Energy Performance Certificate was introduced with the Energy Act [11].Energy Performance Certificates are issued for:

- buildings or building units that are constructed, sold or rented out to new tenants,
- buildings where the total useful area of more than 500 m^2 (from 9 July 2015 more than 250 m^2) is used by public authorities or frequented by the public,
- each multi-apartment building with at least four floor units, which must obtain an Energy Performance Certificate not later than by 2015.

3. ENERGY PERFORMANCE OF BUILDINGS

In Europe, the term energy performance has been in use since the first energy crisis in the 1970s. However, buildings that needed insignificant amounts of energy had been constructed even before that [12]:

- Traditional passive houses in Iceland – as early as in the 18th and 19th century, due to a lack of wood (and coal) buildings were additionally insulated, making them almost self-sufficient.

Fig. 5: Traditional passive houses in Iceland [12]

- The polar exploration ship Fram (author: Fridtjof Nansen) sailed the cold northern seas at the end of the 19th century (built 1883) with no additional heating system. The ship's walls were 40 cm thick and constructed of fir, tarred felt and linoleum which provided air tightness. Windows with triple glazing were used and ventilation was provided by a fan.

Fig. 6: The polar exploration ship Fram [12]

– Zero-energy house, Copenhagen, 1974 (authors: Vagn Korsgaard and Torben Esbensen) had movable thermal insulation in front of the windows, heat recovery, a solar heating system and a 30 m^3 hot water storage tank.

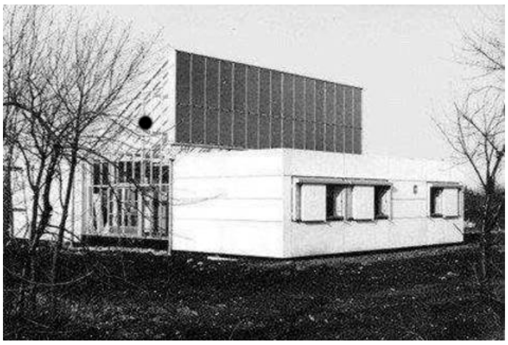

Fig. 7: Zero-energy house, Copenhagen [12]

– The Philips experimental house, Aachen, 1974, required 20 – 30 kWh/(m^2a) for heating. It had a remarkable thermal insulation envelope (U = 0.14 W/(m^2K)) and windows and a controlled ventilation system.

Fig. 8: Philips experimental house, Aachen [12]

– The Rocky Mountains Institute (author: Amory Lovins), Colorado, 1984, altitude of 2164 m – the first extremely insulated solar passive house in the USA. Tropical vegetation flourished in the winter garden and the stove was seldom used. These experiences gave passive house research the assurance and confidence that physics works in practice, too.

Fig. 9: The Rocky Mountains Institute, Colorado [12]

– The first passive apartment house, Kranichstein-Darmstadt, 1991. It was created as part of the CEPHEUS project (author: Dr. Wolfgang Feist). In 1996, the passive house standard was formulated on the basis of the results and experience provided by this building, which caused a surge in the development and construction of energy efficient buildings. By 2000, 322 passive houses had been built in Europe. Their number started to rise dramatically. There were 28,278 by 2010 and 39,390 at the end of 2011. By 2015, Europe is expected to have 143,500 passive houses [13]. There are currently 250 passive houses in Slovenia.

Fig. 10: The first modern passive house, Kranichstein-Darmstadt [12]

4. A NEARLY ZERO-ENERGY HOUSE IS A PASSIVE HOUSE

European as well as Slovenian legislation anticipate the introduction of nearly zero-energy houses in a few years as a standard both for new construction and renovations [8]. At the moment, there is no exact definition of energy use for heating in nearly zero-energy houses, but it will most probably not be very different from the passive house standard that has been known for two decades. The passive house standard is optimal among energy efficient buildings. The cost of building a passive house is between 5 and 10% higher than that for a house built under the currently applicable regulations [14]. The energy consumed for heating is significantly lower and the living comfort is appreciably higher. There are planners and contractors with the relevant know-how. There is also an extensive range of passive house components available on the market at acceptable prices which have been falling in recent years (mostly for window frames and ventilation equipment with heat recuperation from waste air). Fuel costs are rising and interest rates are extremely low. Dr. Feist, who developed the modern passive house, says [15] that those who have the chance to build a new home and don’t seize this opportunity should not complain about the high costs of heating.

Increasing the energy performance of a building is an important step towards decreasing the amount of the operating energy required [8]. Many types of energy efficient buildings have been developed with various concepts, such as very good low-energy houses, passive houses, zero-energy houses, self-sufficient houses, etc. Analyses made by the authors prove that the currently optimal type of energy efficient house is the passive house [16].

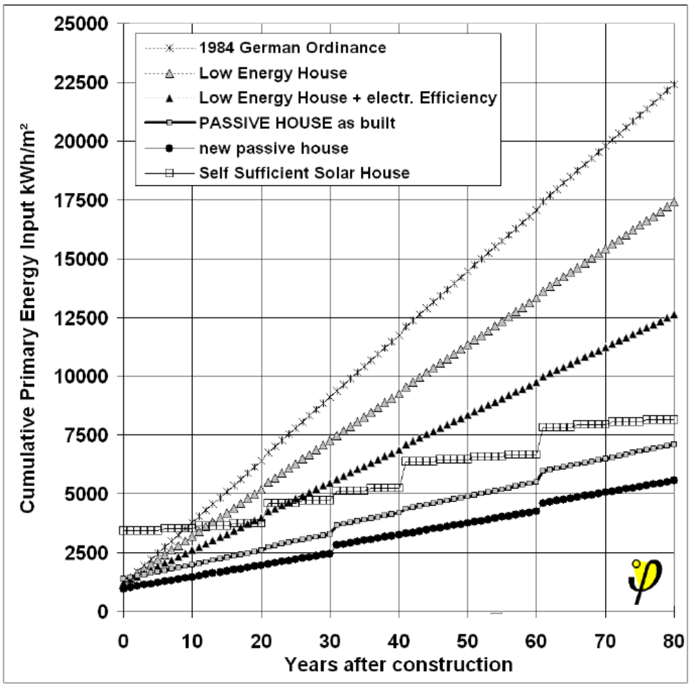

Fig. 11: Life-cycle energy balances compared: low-energy house, passive house, self-sufficient house [*16*].

The passive house uses a maximum of 15 kWh/(m^2a) for heating [17]. It has an extremely efficient thermal envelope (heat transfer coefficient of the walls and roof: U ≤ 0.1–0.15 W/(m^2K), heat transfer coefficient of the installed windows and doors: U ≤ 0.85 W/(m^2K)), which is achieved without heat bridges (ψ ≤ 0.01 W/(mK) and is air tight (air tightness n_{50} ≤ 0.6 h^{-1}). A system of controlled ventilation with heat recovery from waste air is required. Because of these measures the specific heat losses (transmission and ventilation heat losses) in a passive house are lower than 10 W/m^2. As a result, the heat requirements of such a building are so low that conventional heating systems are no longer needed. Passive houses rely on what is known as hot air heating. The air supplied to the living spaces with a ventilation device is additionally heated during cold days, most often with a heat pump. Studies on a large sample of users [18] indicate that living in passive houses brings great satisfaction. Not only due to the low heating costs but particularly because of the thermal and living comfort. Air in passive houses is always warm and fresh.

5. CONCLUSION

In recent decades, energy savings have centred on reducing the consumption of final energy in the operating phase. In buildings with the best energy performance, the energy needs for heating have decreased considerably. However, the energy required in other stages of the building's life cycle tends to be neglected [19]. It is a fact that the measures taken to reduce the required operating energy lead to increased use of energy at the material and components manufacturing stage. For this reason greater attention should be paid to the embodied energy in the future. Research has shown that due to the larger share of embodied energy the total energy consumption in low energy buildings may even be higher than in buildings with higher operating energy [16]. Measures to reduce the energy used to operate a building therefore do not necessarily also reduce the primary energy over its entire life cycle [20]. In buildings with high energy performance the choice of materials and components is becoming increasingly important [21]. The key potential for energy savings in buildings is thus shifting towards strategies for reducing the primary energy consumed to manufacture materials and components.

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