CASE STUDY – NEW HUNGARIAN TWO-DWELLING HOUSE

1. GENERAL INFORMATION

Building type: two-dwelling house

Net heated floor area: 467,01 m^2

Short description: The case study building is a newly built house for two families with high quality materials. The building has a basement + 3 storeys and flat roof.

2. BUILDING CONSTRUCTIONS AND TECHNICAL SYSTEMS

The building envelope complies with the requirements of nearly zero energy buildings. The main solutions are the following:

- External wall: reinforced concrete (RC) walls with EPS insulation
- Internal slabs: reinforced concrete slab
- Flat roof: reinforced concrete slab, EPS insulation and PVC waterproofing
- Windows: triple glazing, alu-wood frame
- Space heating and domestic hot water is provided by an air-to-water heat pump with floor heating

Three alternative designs have been defined (see the Table). In version 2, only the insulation material on the wall was changed to rock wool. In version 3, reinforced concrete walls were replaced with hollow brick. In version 4, also the reinforced concrete slab was replaced with a semi-monolithic beam and block slab.

	External wall	Internal floors	Flat roof
1- RC-EPS wall, RC slab	20 cm reinforced concrete wall with 20 cm EPS insulation	25 cm reinforced concrete slab, cement screed with acoustic insulation	20 cm reinforced concrete slab, bituminous vapour barrier, EPS insulation, PVC waterproofing
2- RC-rock wool wall, RC slab	20 cm reinforced concrete wall with **15 cm rock wool insulation**	25 cm reinforced concrete slab, cement screed with acoustic insulation	20 cm reinforced concrete slab, bituminous vapour barrier, EPS insulation, PVC waterproofing

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3- Brick-EPS wall, RC slab	**30 cm hollow brick wall** with 15 cm EPS insulation	25 cm reinforced concrete slab, cement screed with acoustic insulation	20 cm reinforced concrete slab, bituminous vapour barrier, EPS insulation, PVC waterproofing
4- Brick-EPS wall, beam and block slab	**30 cm hollow brick wall** with 15 cm EPS insulation	**21 cm semi-monolithic slab with beams and blocks,** cement screed with acoustic insulation	**21 cm semi-monolithic slab with beams and blocks,** bituminous vapour barrier, EPS insulation, PVC waterproofing

3. CALCULATION METHODOLOGY

The heating energy demand was calculated according to the Hungarian regulation for the energy certification of buildings. This methodology takes into account the thermal characteristics of the building envelope, the ventilation losses due to the fresh air need, winter solar gains through the windows and the internal heat gains from people and household appliances. The efficiency and losses of the technical building systems are also considered. Please note that this calculation assumes a 'standard' occupants' behaviour, for example a set temperature of 20 °C in the winter in the whole building. If the occupants choose to set a lower or higher temperature or heat different rooms to different temperatures, this will affect the heating energy demand and the results would change. Also, for the technical systems, default efficiency and losses are considered, so if the efficiency of the chosen system is better than the default, the energy saving would increase. Other electricity use (lighting and appliances) was considered with a typical average value.

The environmental impact was calculated with the method of Life Cycle Assessment (LCA) with the help of the OneClickLCA software, according to the Level(s) life cycle assessment methodology. As the number of materials with an Environmental Product Declaration is limited in Hungary, the most representative international datasets have been selected from the available databases.

The life cycle costs (LCC) or global costs were also calculated with the OneClickLCA software. These costs are the sum of the investment cost and the annual costs for every year (energy costs, maintenance, replacements, etc.), all expressed as Net Present Value referring to the starting year. The calculation period is 50 years both in the LCA and LCC calculations. The investment cost, including the price of material and labour, were taken from Hungarian market prices of actual construction projects of the recent years and do not include the VAT. Other costs related to the scaffolding, excavation, elevator and metal works are reported in the "Construction and construction related costs" category. The costs of the electric systems, plumbing and HVAC systems are not included and neither the cost of the plot, design and organisation. Replacement of some materials is necessary at the end of their expected life time: indoor painting was assumed every 10 years, change of parquet every 30 years, waterproofing every 20 years and windows every 35 years. A discount rate of 3% and an energy inflation rate of 2% were assumed.

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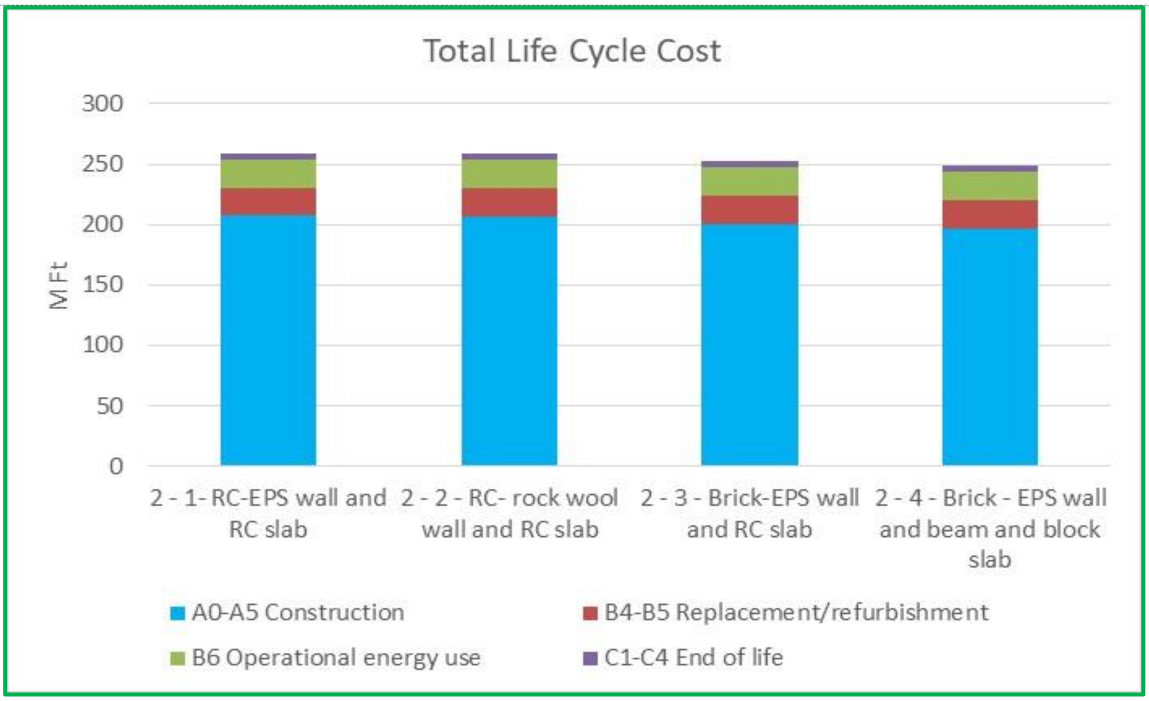
4. RESULTS

4.1. LIFE CYCLE COSTS (DISCOUNTED) (LCC)

The life cycle costs are the total discounted costs for 30 years, including investment, replacement and operation. Regarding the life cycle stages, construction is responsible for the most significant share of about 80% of the life cycle costs in all cases, while replacement for 9% and end-of-life for 2%. The share of operational energy is low, it is only around 9% during 50 years. This can be explained by the high energy efficiency of the building that complies with the new nearly zero energy building standard and also with the relatively low energy prices.

The total costs are about the same in v1 and v2 when only the insulation material is changed. Version 3 with brick walls and v4 with brick walls and beam and block slab has somewhat lower costs, the total cost is 3% and 4% lower than in v1, respectively.



Regarding the share of the building elements, the ratios are similar in every version. The most significant elements are the following (without the other costs): flooring (screed and floor finish) accounts for 16-17%, foundation for 14-15%, external wall structure for 13-16%, floor structure for 12-14%, internal finishes (plaster and paint) for 12%, façade insulation for 7-8%, windows and doors for 6-7%. The share of internal finishes is high because of the need for maintenance. The difference between the alternatives is small.

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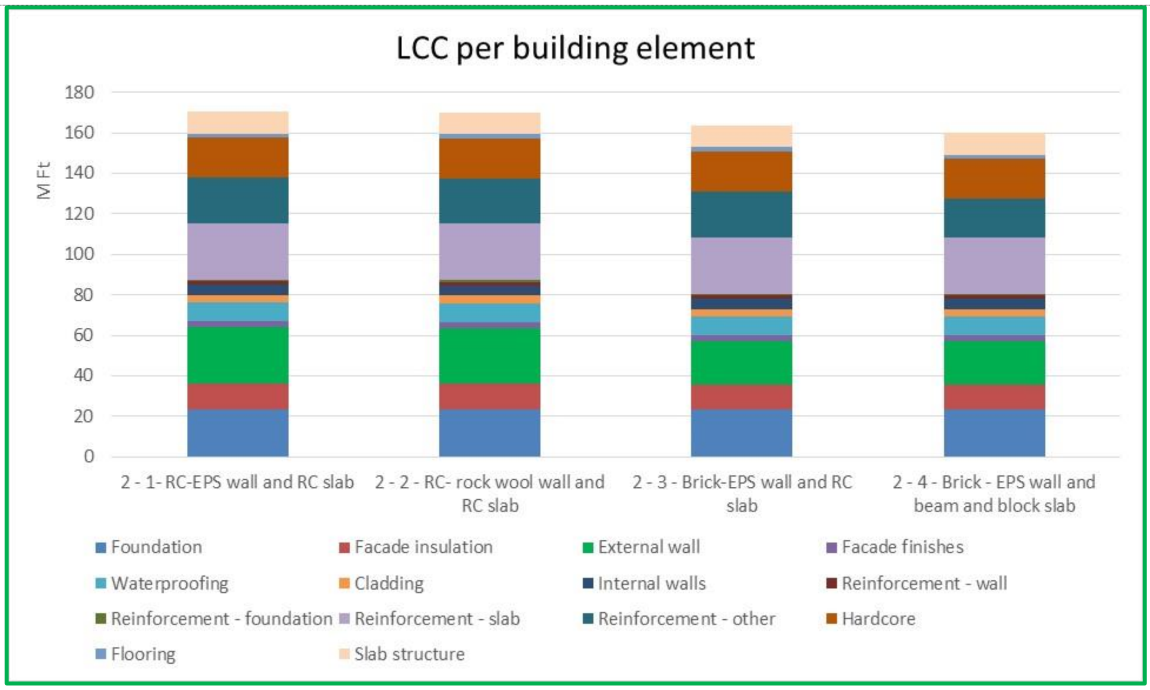

4.2. GLOBAL WARMING POTENTIAL (GWP)

The GWP figures show very different results compared to the LCC figures. In GWP energy use is dominant with a share of 54-59%. Material production accounts for 33-38%, while transport, replacement and end-of-life are less significant. Even though this is a nearly zero energy building with low energy consumption, in a life cycle perspective the environmental impact caused by operation is still significant. Do not forget that we use the current Hungarian energy mix in our calculations (about 40% of all energy is nuclear, a significant portion is fossil and a small portion comes from renewable sources), but a significant decarbonization is foreseen in the 50-year perspective for which we calculate the effects of the construction. So we can rightly hope that in the diagrams below the environmental impact from energy consumption will be significantly lower.

If the total impacts are compared, the difference between v1 and v2 is rather small, while version 3 has 4% and version 4 has 8% lower GWP than v1. Reducing the amount of reinforced concrete leads to a saving in greenhouse gas emissions.

Regarding the share of the building elements, the ratios are similar in every version but differ from the ratio of the costs. The most significant elements are the following: foundation accounts for for 21-26%, floor structure for 10-21%, flooring (screed and floor finish) for 10-12%, external wall structure for 11-17%, other RC structures for 9-11%, windows and doors for 6-8%, and façade insulation for 4-5%, internal finishes (plaster and paint) for 2% of the GWP. Structures with reinforced concrete have a relatively higher impact in GWP than in LCC, while for internal finishes the opposite is true as their relative contribution is lower in GWP than in LCC.

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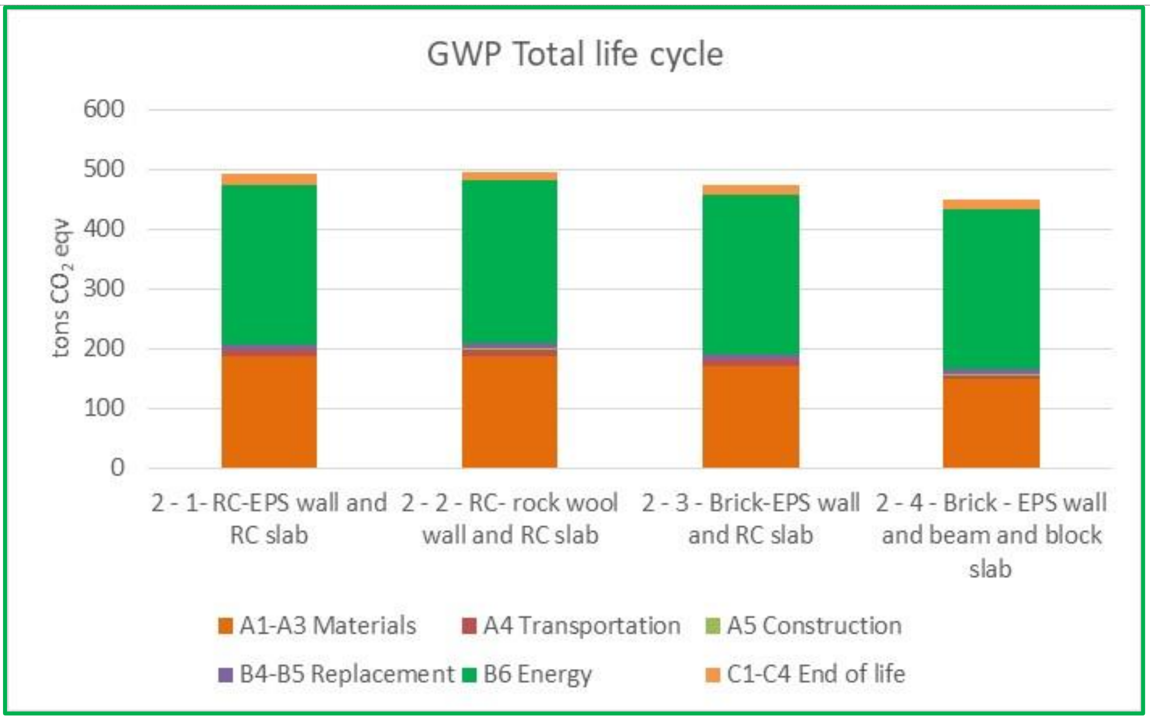

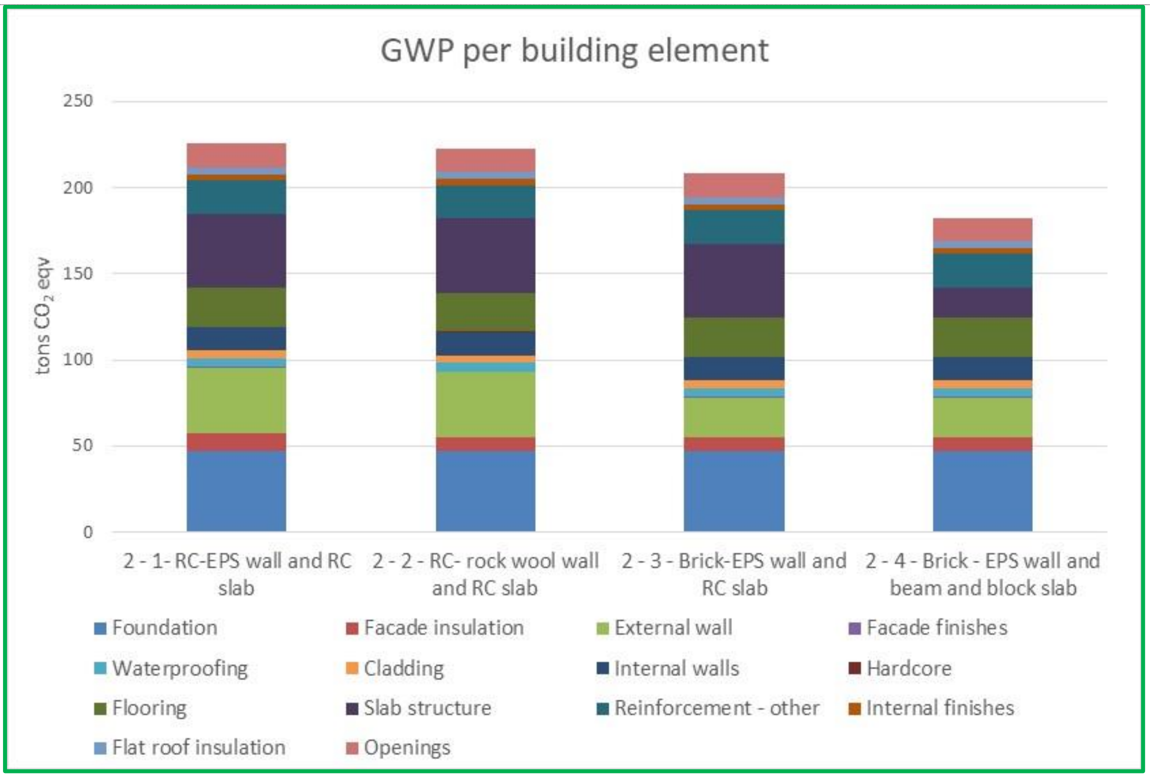

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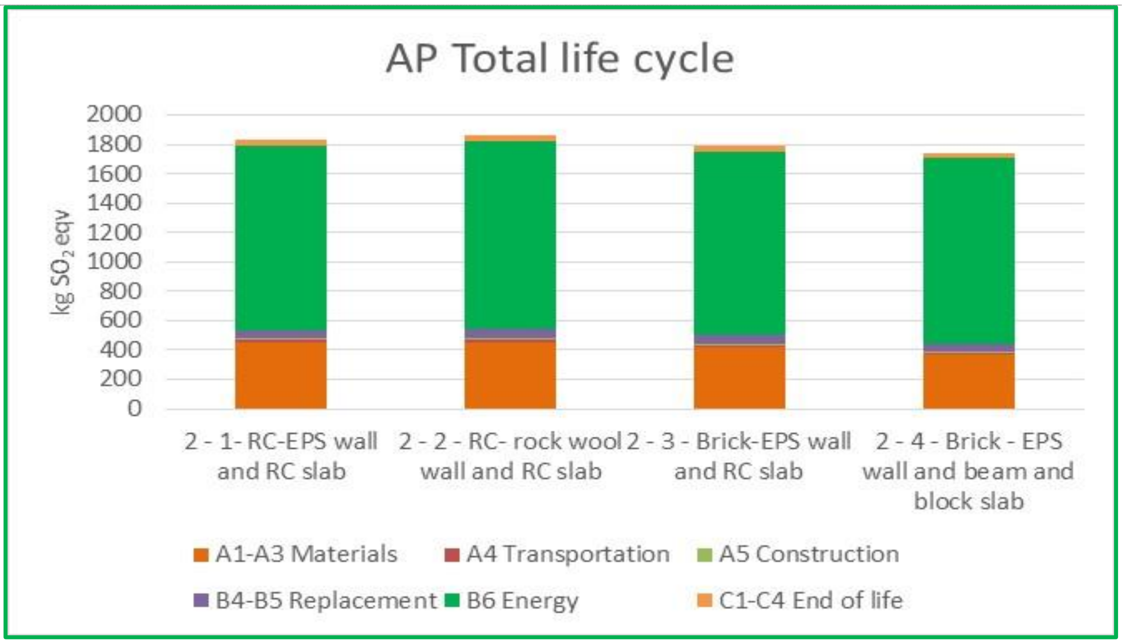
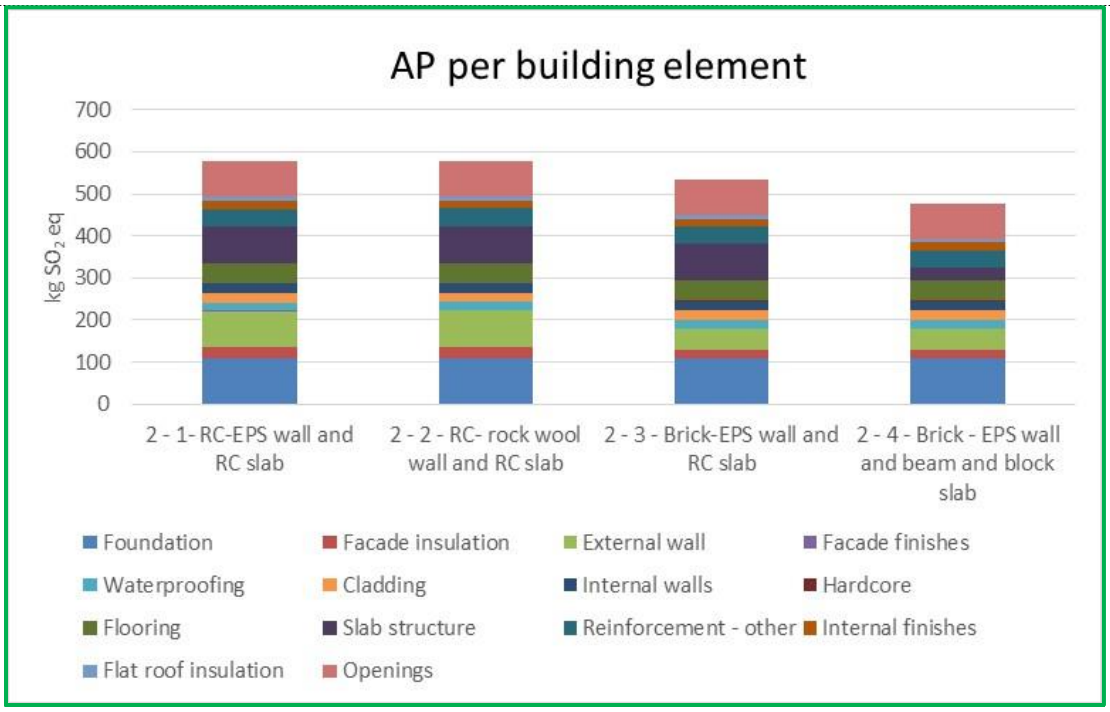
4.3. ACIDIFICATION POTENTIAL (AP)

Acidification is caused by sulfur and nitrogen oxides released into the air during various technological processes. Sulfur is released into the atmosphere primarily from the burning of fuels or naturally from volcanic eruptions. The source of nitrogen can be topsoil, high temperature combustion, exhaust gas or lightning. The energy consumption of our house also comes with emissions that cause acid deposition. It's no coincidence that the chart is very similar in nature to the GWP chart, but here energy use is even more significant with a share of 69-73%, while material production accounts for 21-25%. The order of the versions is the same as for GWP, version 3 has 3% and v4 5% lower AP than v1.





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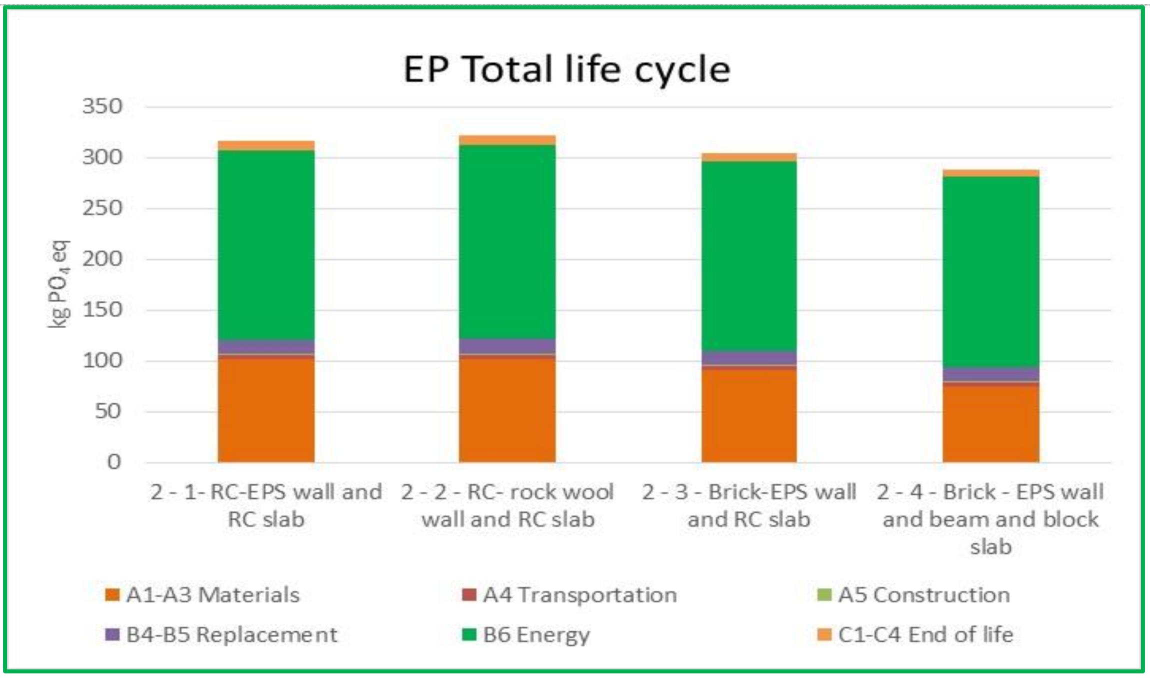
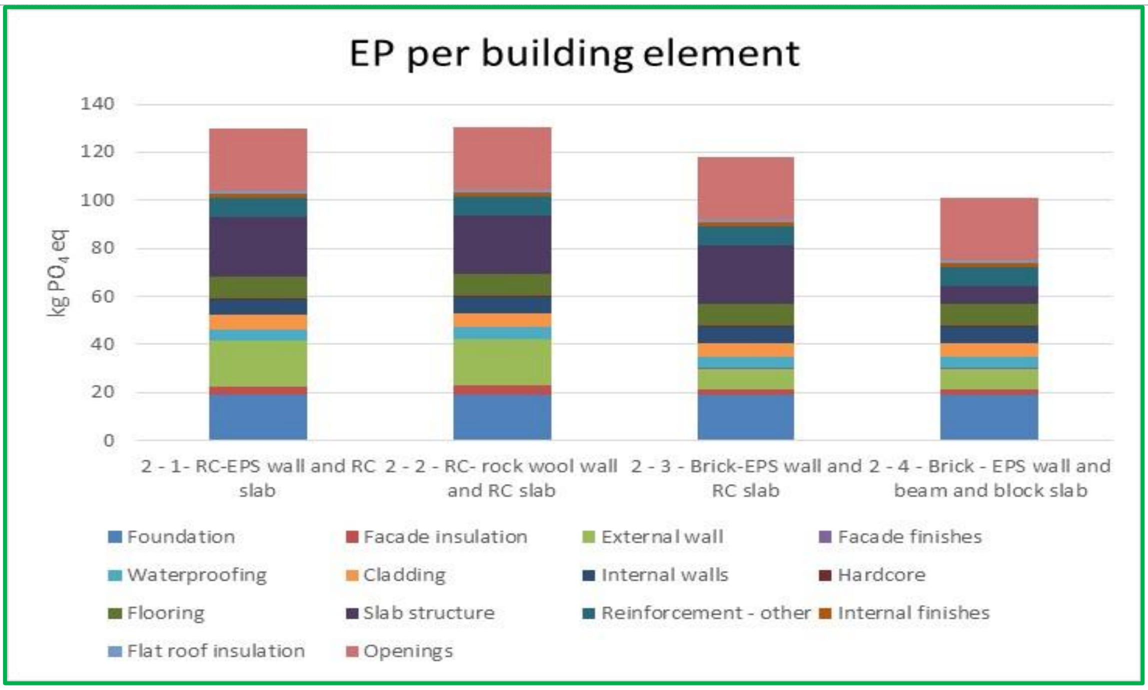
4.4. EUTROPHICATION POTENTIAL (EP)

The phenomenon results from the overfeeding of natural waters, caused by phosphate and nitrate compounds entering the soil and groundwater. As we can see, energy consumption plays a dominant role here as well, so nitrogen oxides formed during energy production also cause this environmental load, phosphate compounds hardly occur here.

Regarding the materials, besides reinforced concrete, the contribution of windows and doors is significant due to the use of aluminium and wood.





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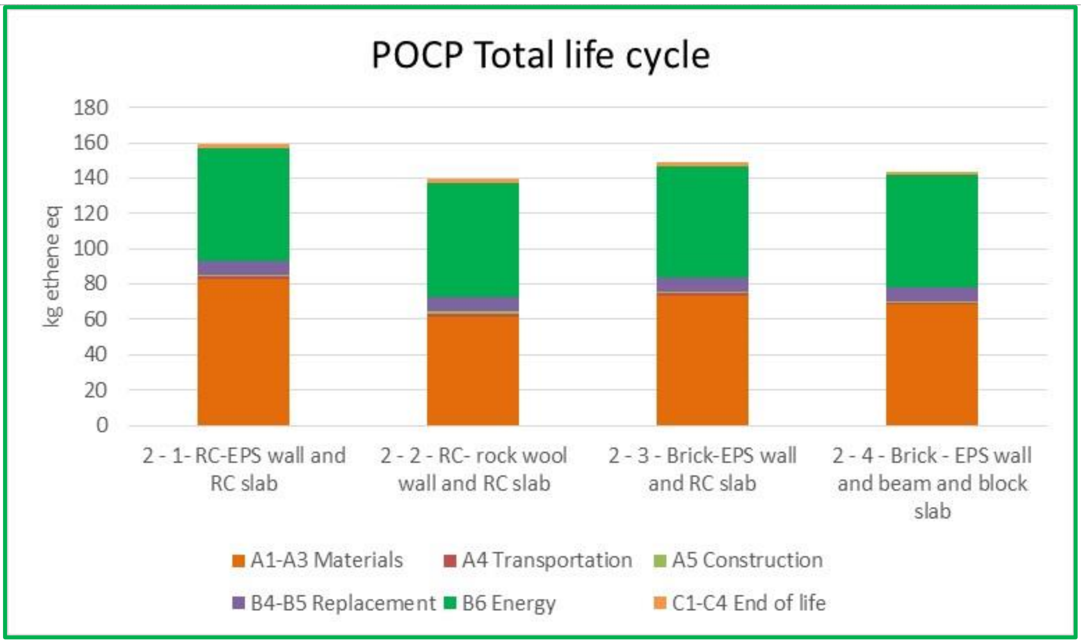
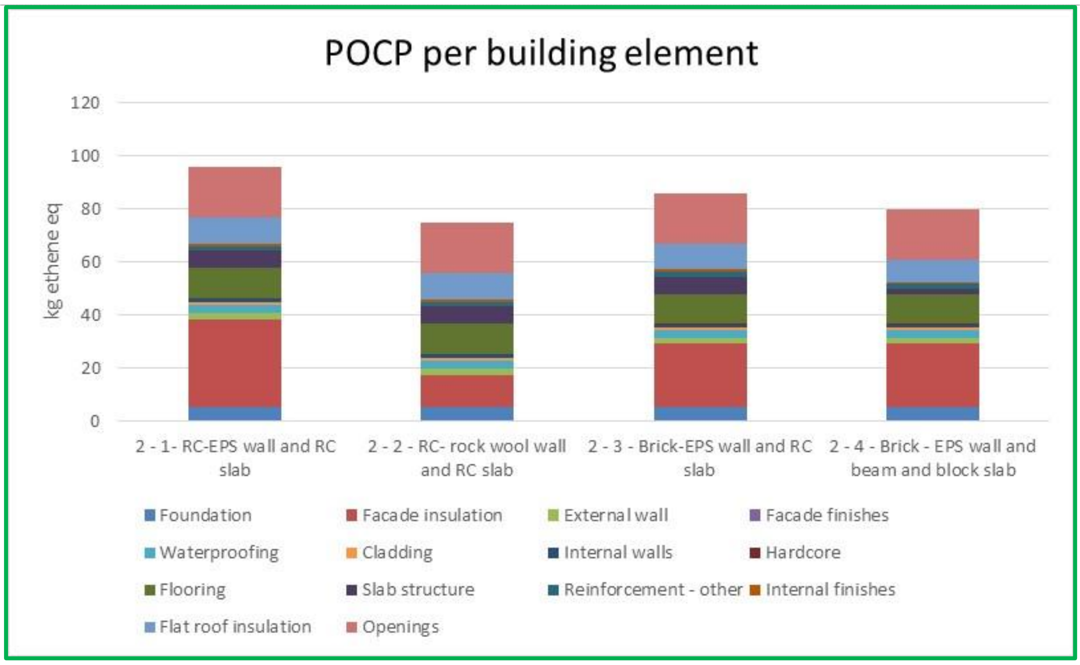
4.5. PHOTOCHEMICAL OZONE CREATION POTENTIAL, (POCP)

Ozone, which is harmful to health, is formed in complex photochemical reactions near the earth. The condition is the combined presence of summer solar radiation, volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Typically, loads from urban traffic, but these materials can also come from imperfect combustion. In this category, materials play a higher role than energy consumption: 44-52% of the impacts are related to material production while 40-46% to energy. EPS insulation has a significant impact as volatile organic compounds are released into the air during the production and foaming of the insulation material, hence the versions with EPS insulation have higher values.





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