Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. XLVI 2016

THE CARBON FOOTPRINT GENERATED BY TOURIST INFORMATION POINTS LOCATED IN TISMANA AND CHEILE SOHODOLULUI AREA

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Keywords: environmental impact, energy consumption, building envelope, heat demand

ABSTRACT

The paper summarizes the main issues on the carbon footprint generated by two tourist information points throughout the duration of their use. In order to maintain comfort conditions inside the building throughout the year, it requires heating, water and lighting so greenhouse emissions will be generated, mostly CO_2.

The study proposes two types of tourist information points in two different but not far sites, which for was evaluated the equivalent carbon dioxide emissions generated by the building itself and the amount of energy that satisfy the building needs in order to maintain it's proper function.

INTRODUCTION

The paper presents a case study for evaluating environmental impact regarding CO_2 emissions generated by two tourist information points located in Gorj region, one of them being proposed to be located in Tismana area and the other one in CheileSohodolului area.

The building has an octagonal shape with sides of 4 meters and the inner surface is 75 square meters. Clear height of the rooms is 2.75 meters, so the total heated volume is 206.25 m^3.

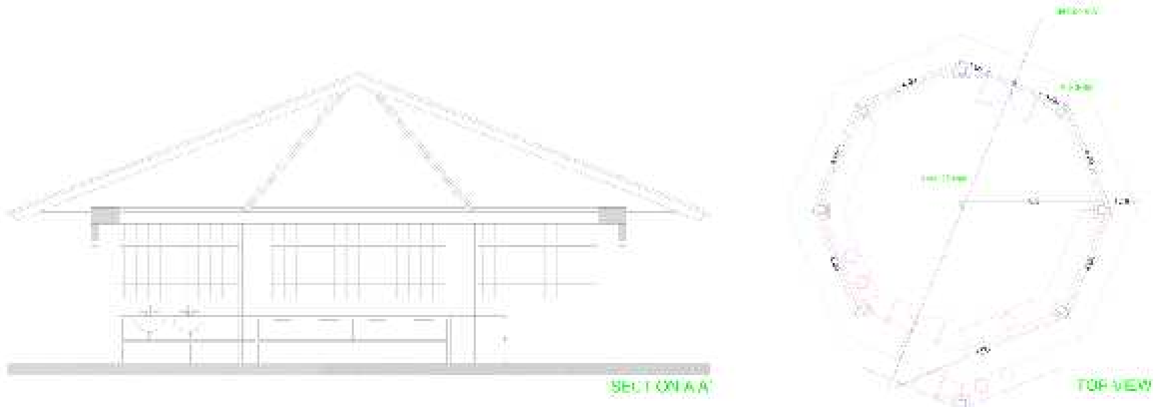

Figure1 Tourist information point building section and top view [15]

The study analyzes three scenarios for the building envelope construction materials and for the primary energy supply fuel.

The construction of the building envelope was considered by wood and expanded polystyrene in the first case, bricks and expanded polystyrene in the second case and precast concrete and expanded polystyrene for the last case.

For all the cases there was considered three options for the primary energy source that would heat up the building, respectively gas, electrical energy and wood.

MATERIALS AND METHODS

An energy performance assessment was performed in order to establish the amount of CO_2 emissions generated by the building use [6] in a year span.

In the first scenario, the exterior wall type A within the building envelope is considered by wood and expanded polystyrene as it is shown in table 1 and there are three options for the primary energy source.

Table 1

Exterior wall type A structure

Layers	Percent %	D [mm]	λ W/(mK)	a [-]	λ' [W/mK]	R m²K/W
Exterior face						
Fireproof expanded polystyrene EPS 15	100.0	150	0.038	1.00	0.04	3.947
Pressed plate 68761-1	100.0	25	0.130	1.00	0.13	0.192
Spruce, Pine, Fir	100.0	100	0.130	1.00	0.13	0.769
Plywood drywall DIN 18180	100.0	20	0.250	1.00	0.25	0.080
Interior face						0.130
		295.0				R = 5.159 m²K/W

Seasonal heat consumption for the building is 11 013[kW/season].

Annual specific energy consumption index for the building is 142.56 [kWh/m^{2}year]

Primary energy consumptionis 15 270 [kWh/year]

CO_2 equivalent emission amount generated by the building with wood as fuel for heating is 498.17 [kg/year]

CO_2 equivalent emission index generated by the building with wood as fuel for heating is 6.45[kgCO_2/m²year]

CO_2 equivalent emission amount generated by the building with gas as fuel for heating is 2428.74 [kg/year]

CO_2 equivalent emission index generated by the building with gas as fuel for heating is 31.44[kgCO_2/m²year]

CO_2 equivalent emission amount generated by the building with electrical energy as fuel for heating is 2645.79 [kg/year]

CO_2 equivalent emission index generated by the building with electrical energy as fuel for heating is 34.25[kgCO_2/m²year]

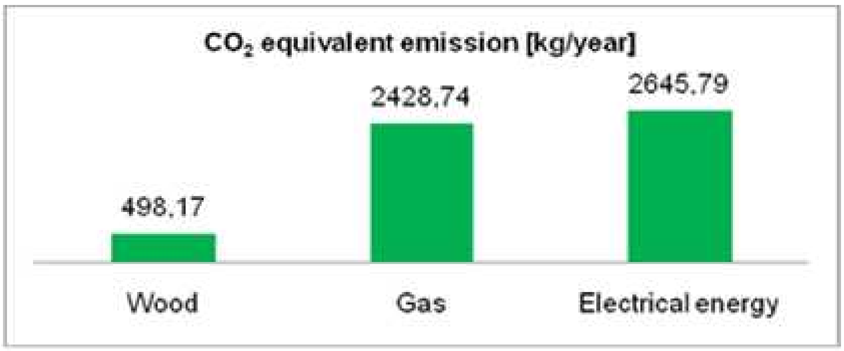

Figure 2 Annual amount of CO_2 emission for case A

In the second scenario, the exterior wall type B within the building envelope is considered by bricks and expanded polystyrene as it is shown in table 2 and there are three options for the primary energy source.

Table 2

Exterior wall type B structure

Layers	Percent %	d [mm]	λ W/(mK)	a [-]	λ' [W/mK]	R m²K/W
Exterior face						
Insulating plaster 060	100.0	10	0.060	1.00	0.06	0.167
Fireproof expanded polystyrene EPS 15	100.0	150	0.038	1.00	0.04	3.947
Vertical hollow bricks	100.0	300	0.680	1.00	0.68	0.441
Lime mortar plaster	100.0	25	0.870	1.00	0.87	0.029
Interior face						
		485.0				R = 4.754 m2K/W

Seasonal heat consumption for the building is 11 034 [kW/season].

Annual specific energy consumption index for the building is 142.84 [kWh/m^{2}year]

Primary energy consumption is 15 270 [kWh/year]

CO_2 equivalent emission amount generated by the building with wood as fuel for heating is 498.93 [kg/year]

CO_2 equivalent emission index generated by the building with wood as fuel for heating is 6.46 [kgCO_2/m^{2}year]

CO_2 equivalent emission amount generated by the building with gas as fuel for heating is 2433.05 [kg/year]

CO_2 equivalent emission index generated by the building with gas as fuel for heating is 31.50[kgCO_2/m^{2}year]

CO_2 equivalent emission amount generated by the building with electrical energy as fuel for heating is 2650.50 [kg/year]

CO_2 equivalent emission index generated by the building with electrical energy as fuel for heating is 34.31[kgCO_2/m^{2}year]

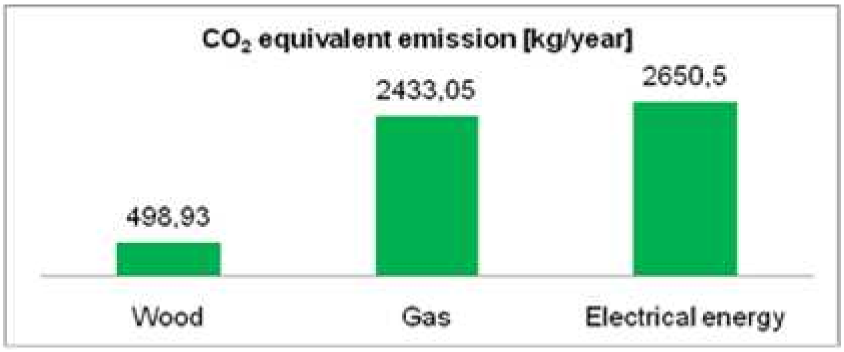

Figure 3 Annual amount of CO_2 emission for case B

The numerical simulations for energy performance were performed according to [8].

The numerical simulations for the heat load of the building were performed according to [9, 10, 11,12].

In the third scenario, the exterior wall type C within the building envelope is considered by precast reinforced concrete and expanded polystyrene as it is shown in table 3 and there are three options for the primary energy source.

Table 3

Exterior wall type C structure

Layers	Percent %	d [mm]	λ W/(mK)	a [-]	λ' [W/mK]	R m²K/W
Exterior face						
Cement	100.0	30	0.930	1.00	0.93	0.032
Cellular polystyrene	100.0	150	0.044	1.00	0.04	3.409
Reinforced concrete in 2500	100.0	60	1.740	1.00	1.74	0.034
Test - Insulation BCA	100.0	120	0.300	1.00	0.30	0.400
Reinforced concrete in 2500	100.0	120	1.740	1.00	1.74	0.069
Plain concrete with natural aggregates 1800	100.0	20	0.930	1.00	0.93	0.022
Interior face						
		500.0				R = 4.136 m2K/W

Seasonal heat consumption for the building is 11 074 [kW/season].

Annual specific energy consumption index for the building is 143.36 [kWh/m^{2}year]

Primary energy consumption is 15 337 [kWh/year]

CO_2 equivalent emission amount generated by the building with wood as fuel for heating is 500.37 [kg/year]

CO_2 equivalent emission index generated by the building with wood as fuel for heating is 6.48[kgCO_2/m^{2}year]

CO_2 equivalent emission amount generated by the building with gas as fuel for heating is 2441.26 [kg/year]

CO_2 equivalent emission index generated by the building with gas as fuel for heating is 31.60 [kgCO_2/m^{2}year]

CO_2 equivalent emission amount generated by the building with electrical energy as fuel for heating is 2659.47 [kg/year]

CO_2 equivalent emission index generated by the building with electrical energy as fuel for heating is 34.43[kgCO_2/m^{2}year]

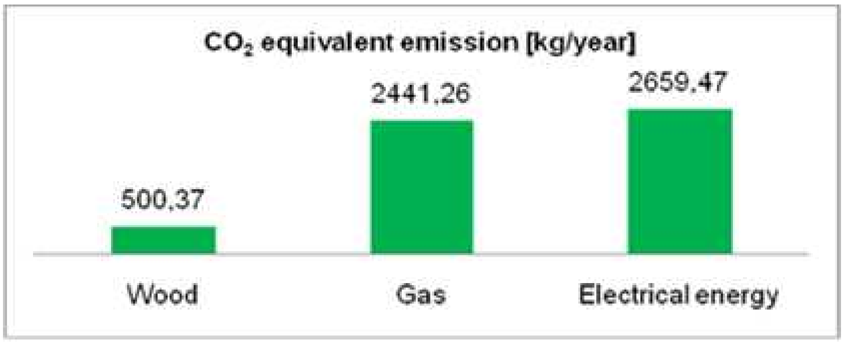

Figure 4 Annual amount of CO_2 emission for case C

RESEARCH RESULTS

In terms of the impact on local biodiversity, this territory investigated is part of the protected area ,,ROSCI0129 – NordulGorjului de Vest”.

In this area we found these types Natura 2000 habitats:

A. Forest habitats represented byfollowing types: habitat**9110 –** *Luzulo-Fagetum*beech forests; CLAS. PAL.41.11; RO habitat type code: R4102, R4105-4107, R4110; habitat **9130-***Asperulo-Fagetum* beech forests; CLAS. PAL.: 41.13; RO habitat type code: R4118, R4119, R4120;habitat **91V0 -** Dacian beech forests (*Symphyto-Fagion*); CLAS. PAL.: 41.1D2; RO habitat type code R4101, R4103, R4104, R4108, R4109, R4116; habitat **9410 -** Acidophilus spruce forests (*Picea*) of the montane to the alpine levels (*Vaccinio-Piceetea*);CLAS. PAL.: 42.21 to 42.23, 42.25-Eastern Carpathian arolla forests; EUNIS cod - G3.1B62 -Eastern Carpathian subalpine spruce forest; RO habitat type code: R4203, R4205, R4206, R4207, R4208, R4209; habitat 91M0 -Pannonian-Balkanic turkey oak sessile oak forests; CLAS. PAL.: 41.76; RO habitat type code**:** R4132, R4133, R4134, R4136, R4137, R4140, R4142, R4149, R4150,R4151, R4152, R4153, R4154, R4155; habitat **91Y0** - Dacian oak-hornbeam forests; CLAS. PAL.: 41.2C; RO habitat type code: R4124, R4125, R4126, R4143, R4147;Habitat **9150** - Medio-European limestone beech forests of the *Cephalanthero-Fagion* CLAS. PAL.: 41.16; RO habitat type code: R4111; habitat **9170** - *Galio-Carpinetum*oakhornbeam forests; CLAS. PAL.: 41.261, 41.262; RO habitat type code: R4123, R4128; habitat **9180*-***Tilio-Acerion* forests of slopes, screes and ravines CLAS. PAL.: 41.4; RO habitat type code: R4117; habitat**91E0***-Alluvial forests with *Alnusglutinosa*and *Fraxinusexcelsior* (*Alno-Padion, Alnionincanae, Salicionalbae*; CLAS. PAL.: 44.3, 44.2 and 44.13 RO habitat type code: R4401, R4402, R4405, R4407, R4408; habitat **91L0 -** Illyrian oakhornbeam forests (*Erythronio-Carpinion*; CLAS. PAL.: 41.2A; RO habitat type code: R412;habitat **9260** - *Castanea sativa* woods; CLAS. PAL.: 41.9; RO habitat type code:R4141; (Gafta and Mountford., coord., 2008)

B. Rock and screes habitats. The most important debris habitat in this area is the habitat **8120** – Calcareous and calcashist screes of the montane to alpine levels (*Thlaspietearotundifolii*);CLAS. PAL.61.2;RO habitat type code: R6106, R6107, R6108, R6109, R6110, R6111, R6112, R6113. This habitat is found on the calcareous screes and it is poorly spread in general and this habitat is highly significant for the investigated territory as it presents an essential role in early fallowing and application of mobile calcareous screes. In general, the characteristic and dominant species in this habitat are specific and adapted to fixed, semi-fixed or mobile screes, with soilification process or not. Also the habitat **8210** is found in this territory - Calcareous rocky slopes with chasmophytic vegetation; CLAS. PAL.: 62.1;RO habitat type code:R6202, R6204, R6206, R6207, 6208, R6209, R6211 p.p., R6212,R6213, R6214, R6216, R6217, R6218, R6222, R6223**;** (Gafta and Mountford., coord., 2008). This habitat is characteristic to rocky, steep and shady walls, calcareous rocks, growing on superficial rendzinic soils.

Out of the vegetal communities characteristic to the habitat in this area the most frequently found are the following: *Asplenio- Cystopteridetum fragilis*Oberd. (1936) 1949; *Thymo pulcherrimi-Poëtum rehmanii*Coldea (1986) 1990; *Asplenietum trichomano-rutae-murariae*Kuhn 1937, Tx. 1937 (Syn: *Tortulo-Asplenietum*Tx. 1937); *Asplenioquadrivalenti Poëtum nemoralis*Sooex Gergelyet al. 1966.

C. Grassland habitats. The most important grassland habitat is **6170 -** Alpine and subalpine calcareous grasslands; CLAS. PAL.: 36.12, 36.41 până la 36.43, 36.37, 36.38;RO habitat type code:R3601, R3605-3607, R3611, R3612, R3613, R3616, R3618, R3619 (Gafta and Mountford.,coord., 2008). The most important vegetal community in this habitat is: *Seslerio haynaldianae-Caricetum sempervirentis*Puşcaru*et al.*1956 (syn.: *Seslerietum haynaldianae sempervirentis* Puşcaru*et al.* (1950) 1956, *Seslerietum rigidae retezaticum* Csűrös*et al*. 1956 p.p., *Seslerietum rigidae biharicum* Csűrös 1963) and is highly significant for Lespezi Quarry as regards the ecological rehabilitation at the level of the higher bench of the quarry where the exploitation operations ended. Also, the habita**6520** - Mountain hay meadows; CLAS. PAL.: 38.31; RO habitat type code:R3801, R3803, R3804 R3801, R3803, R3804.

D. Tall-herb habitats. From this types we found the habitat**6430 -** Hydrophilous tall-herb fringe communities of plains and of the montane to alpine levels; CLAS. PAL.: 37.7 şi 37.8; RO habitat type code:R3701, 3702, 3703, 3706, 3707, 3708, R3714 (Gafta and Mountford.,coord., 2008).Hydrophilous weeds in this habitat grow in shady places with high humidity of the montane level on colluvium alluvial soils.

E. Heath habitats This category includes,the following two types of habitats: habitat **4060** - Alpine and Boreal heathsCLAS. PAL.31.4;RO habitat type code:R3101, R3104, R3107-3109, R3111, R3115, R3617. It includes dwarf, sometimes crawling heaths, characteristic to the higher montane levels, mainly dominated by *Ericaceae s*pecies; habitat **4070*** Bushes with *Pinusmugo*and *Rhododendron hirsutum*(*Mugo-Rhododendretumhirsuti*); CLAS. PAL.31.5; RO habitat type code:R3105. This habitat includes mountain pine formations(*Pinusmugo*) (Gafta and Mountford.,coord., 2008).

F.Waters flowing. In this area from this type habitats we found : habitat **3220** – Alpine rivers and the herbaceous vegetation along their banks; CLAS. PAL.: 24.221 şi 24.222; RO habitat type code: R5416, R5418, R5420, R5423;habitat **3230** -Alpine rivers and their ligneous vegetation with *Myricariagermanica*; CLAS. PAL.: 24.223 x 44.111; RO habitat type code: R4415; **3240** -Alpine rivers and their ligneous vegetation with *Salix elaeagnos*; CLAS. PAL.: 24.224 x 44.112;RO habitat type code:R4417

Human impact, current pressure and future threats

In the investigated area this habitats is characterized by the following data on the conservation status and human impact.

Conservation status: from favorable up to unfavorably-inappropriate;

Development trend of habitat: from stable up to decreasing;

Human impact and current pressures: G05.07-missing or wrongly directed conservation measures; D.06- Other forms of transportation and communication;H05.01- garbage and solid waste; F04.02.02- hand collection;E03.01- disposal of household/recreational facility waste; A.06.01.02- non- intensive annual crops for food production; D.06- Other forms of transportation and communication; H05.01- garbage and solid waste; A04.01- intensive grazing; H01.09- diffuse pollution to surface waters due to other sources not listed; B01 - forest planting on open ground; E01.01- continuous urbanization;D01.02-roads, motorways;E01-Urbanized areas, human habitation;E02-Industrial or commercial areas; H04 - Air pollution, air-borne pollutants; H05 - Soil pollution and solid waste (excluding discharges).

Future threats: E03.01- disposal of household / recreational facility waste;E01.01-continuous urbanization;D.06- Other forms of transportation and communication; F.03.02.09 - other forms of taking animals; H05.01- garbage and solid waste; H01.09-diffuse pollution to surface waters due to other sources not listed; B01-forest planting on open ground; D01.02-roads, motorways;E01-Urbanized areas, human habitation;E02-Industrial or commercial areas.

In terms of energy performance,the building is classified as B according to [7]. Specific energy consumption for the building is 161 [kWh/m²year], respectively 143 [kWh/m²year] for heat demand, 5 [kWh/m²year] for hot water demand and 13 [kWh/m²year] for lighting systems.

Seasonal heat load for the building is 8298 [kWh/season] and the amount of CO_2 emission generated by the building use can range between 498.17 [kg/year] and 2659.47 [kg/year] depending on primary energy source.

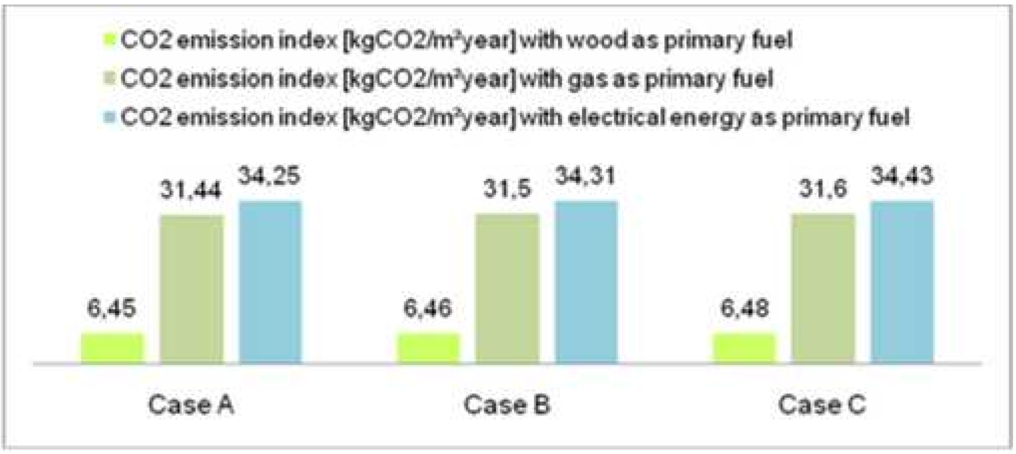

Figure 5 CO_2 emission index for case A, B and C

The study results reveal that the CO_2emissions generated by the building use are mainly influenced by the primary fuel used for the heat demand. Regarding the building envelope structure, there are no significant differences between the three cases in relation with CO_2 emission index.

CONCLUSIONS

The carbon footprint generated by use of the building may be reduced if energy strategy is approached as a whole. The fuel required for maintaining comfort conditions inside having thus a significant environmental impact.

In terms of construction materials the tourist information points could be built with any variants presented above, differences between the three outer envelope construction systems being relatively close in terms of carbon footprint released by the building.

Regarding carbon emissions, the building recorded best results for case A with exterior wall type A and wood as primary energy source for heating the interior spaceand for hot water preparation, CO_2 emission index being 6.45 [kgCO_2/m²year] totalizing 498.17 [kg/year].

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