

## Environmental Evaluation of Flexible Housing

Dr. Jaume Avellaneda, Susana Dorantes, Dr. Josep Maria González, Katarina Mrkonjic

Technical University of Catalonia (UPC)

Barcelona, Spain

Contact: katarina.mrkonjic@upc.edu

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### Introduction

Flexibility in use of dwellings can be an important factor for reducing the negative environmental impact, and indicators that reflect this fact should be looked for and used



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### 3 case studies

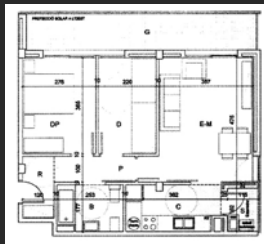
Unit A – “60 dwellings in La Roca del Vallès”, Spain, by Naxal Arquitectura S.L.  
**Particions of perforated bricks** (apr. 40m2 excl. bathroom+kitchen)

Unit B – “60 dwellings in La Roca del Vallès”, Spain, by Naxal Arquitectura S.L.  
**Particions of demountable wooden frames + cladding** (apr. 40m2 excl. bathroom+kitchen)

Unit C – “Optibo”. Göteborg, Sweden, by White Design  
**Transformable floors** (apr. 20m2 excl. bathroom)

Unit A and B

Unit C



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### Material characteristics



#### Unit A - fixed

perforated brick blocks (1cm mortar + 7 cm brick + 1 cm mortar)



#### Unit B - demountable

wooden frames + wooden cladding (wooden board 1,9cm + profiles 5cm x 5 cm + wooden board 1,9cm)



#### Unit C - flexible

double floor with integrated furniture: 60cm high, wooden ribs (15cm x 5cm) at distance of 1m + columns (15cm x 5cm x 40cm) each 2 meters. Wooden floor of 5cm thick boards

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## Environmental impact of used materials: basic values

	Weight (kg/m <sup>3</sup> )	Energy consumption in production (MJ/kg)	CO <sub>2</sub> (g/kg)	SO <sub>2</sub> (g/kg)	NO <sub>x</sub> (g/kg)	Water consumption (liter/kg)	Waste in production (g/kg)
Brick	1200	3	1900	2	17	520	87
Mortar	1900	1	98	0,8	11	170	17
Wood	550	3	116	1	1	330	25
Steel	7500	25	2230	10	840	3400	601

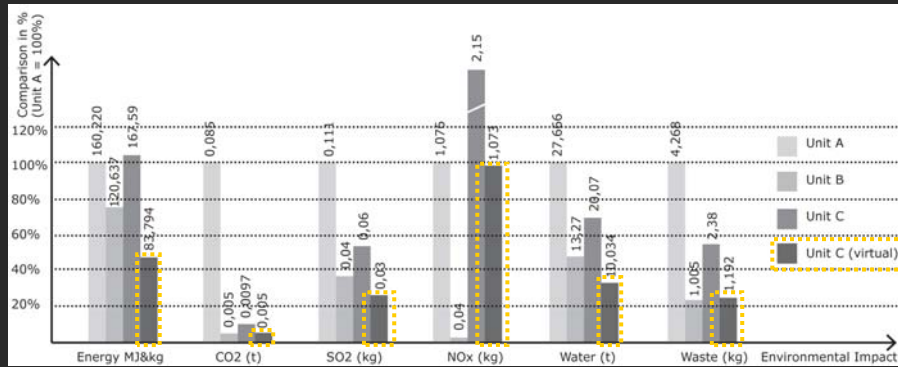
Source:  
Bjorn Berge. *Ecology of Building Materials*. Architectural Press, 2001

## Results

	kg	Energy consumption in production (MJ/kg)	CO <sub>2</sub> (t)	SO <sub>2</sub> (kg)	NO <sub>x</sub> (kg)	Water consumption (t)	Waste in production (kg)
<b>TYPE A</b>							
Brick	1.779	5337,00	3,38	3,56	30,24	925,08	154,77
Mortar	1.307	1307,34	0,13	1,05	14,38	222,25	22,22
total		6644,34	3,51	4,60	44,62	1147,33	177,00
total/m <sup>2</sup>		160,220	0,085	0,111	1,076	27,666	4,288
%		100,00	100,00	100,00	100,00	100,00	100,00
<b>TYPE B</b>							
Wood	1.668	5002,80	0,19	1,67	1,67	550,31	41,69
total/m <sup>2</sup>		120,637	0,005	0,040	0,040	13,270	1,005
%		75,294	5,514	36,222	3,737	47,964	23,554
<b>TYPE C</b>							
Steel	50	1256,25	0,11	0,50	42,21	170,85	30,20
Wood	699	2095,50	0,08	0,70	0,70	230,51	17,46
total		3351,75	0,19	1,20	42,91	401,36	47,66
total/m <sup>2</sup> real		167,59	0,0097	0,06	2,15	20,07	2,38
%		104,598	11,412	54,091	199,380	72,535	55,836
total/m <sup>2</sup> virtual		83,794	0,005	0,030	1,073	10,034	1,192
%		52,299	5,706	27,045	99,690	36,267	27,918

## Results

- Results given per square meter, show that the Unit C, was the one with the highest impact in 2 parameters, while in the others was lower than the brick walls but higher than the wooden ones
- Virtual Unit C = Unit C x 2 = 20m<sup>2</sup> x 2 = 40m<sup>2</sup>
- Virtual Unit C's impact was lower (except for NO<sub>x</sub>) than the one of Unit A and B



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## Conclusions

- **calculating the virtual surface that takes into account the flexibility helps us to get a more realistic picture of benefits of flexible dwelling from an environmental point of view**

Small, but flexible and transformable dwellings :

- **are** justified from the environmental point of view, even though in absolute numbers, per square meter, their impact can be higher than in some types of conventional dwellings
- may imply less need for heating/cooling energy, reduced use of construction materials
- imply higher housing density which leads to minimization of need for transportation, infrastructure etc.

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Thank you for your attention