ENERGY AND THE FORM OF URBAN FABRIC: THE EXAMPLE OF PARIS

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Summary

Cities are simultaneously human systems and complex, porous physical surfaces on several scales, combining a high degree of variability and a more or less orderly subjacent structure. They are at once built volumes (solids) and empty spaces. The analysis of the bioclimatic and energy aspects of distinct units composing the solids (that is to say, the buildings) has been strongly developed. Much less work has been devoted to the texture of the city as a whole (size of solids and voids, porosity, density of grid, connectivity of voids, size of breaks). In order to arrive at operational results, the morphological description of the different types of density, both in their impacts on mobility and in their impacts on the microclimate, must be fine-tuned and quantified. Here we analyze the heat energy consumption on the scale of blocks and districts for the Parisian urban fabric.

Keywords: Energy, Buildings, Urban form, Heating

1 Introduction

The heating needs of a building, like those of a block, are characterized by the sum of losses through the walls and through ventilation, minus internal and solar gains. In a first order approximation, the theoretical consumption can thus be calculated based on the following parameters: heat loss through envelope, ventilation losses, internal heat gain and solar heat gains. This method of calculation brings out parameters that would require a more complete definition which is not permitted by the limited length of the present paper.

A thermal equation based on the parameters described here above and on a methodology initially developed by the APUR (APUR, 2007) was used to calculate the heat energy consumption of Parisian blocks. The analysis presented in this paper focus on types of Parisian fabrics and their energy signatures.

2 A typology of Parisian urban fabrics

The form of buildings, blocks and districts in Paris is strongly marked by history, which has in turn played a role in the choice of our typology. For this reason, we are presenting some brief elements of history about the city and its urbanism, which we hope will be helpful for the comprehension of our typology.

The history of the built environment in Paris shows the extent to which urbanism has always been highly influenced by political authorities and strongly reflected the ideologies of the period. In fact, the overarching ideological and political movements are visible in this built environment and can therefore serve as a basis to establish a typology. For this to be significant, historical and strictly architectural considerations were tallied with geometric parameters.

We will examine five paradigmatic examples of Parisian urban fabric.

The first type corresponds to the built environment dating to before 1800. It is characterized by less dense, less compact but more complex and diverse blocks than the later Haussmannian blocks, with courtyards of a variety of sizes and still relatively small buildings standing amid bigger ones. The interior of the blocks is not built up.

The second type corresponds to the Haussmannian period (1850–1915). The Haussmannian blocks are built on a single model with few variations. The buildings are generally 6 floors high, give or take a storey. The lower floors have high ceilings, which decrease as you go up. The floor immediately below the roof is designed as living quarters for the domestics and the ground floor is for stores or stables. The blocks are densely constructed, leaving no spaces, aside from tiny courtyards that double as airshafts. The construction material is a type of cob and river rocks, faced in dressed stone for the wealthier building or in plaster for the others. The buildings extend 12 m deep from the edge of the block. Then come courtyards and a second row of buildings, then more courtyards and so on, with a lovely symmetry in relation to the bisections of the triangle and diamond shapes. The block seems to be generated by an algorithm designed to maximize the built space and passive volume by the creation and arrangement of minimal courtyards. This is, in fact, a good example of maximal bioclimatic density.

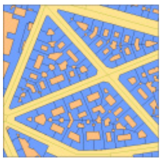
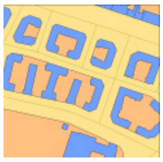
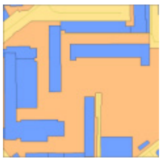
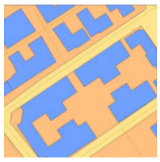
The third type corresponds to the interwar period (1915–1939) and the construction of HBMs (public housing) characterized by open blocks with tree-planted courtyards at the center. The buildings are a little taller than the Haussmannian building but still of moderate height, with brick as the privileged construction material. The construction quality is much better than the HLM (*habitat à loyer modéré*, or low income housing) of the post-war period. Although the density is much lower, the buildings are not very deep, and so they benefit from natural lighting and ventilation.

The fourth type corresponds to the buildings constructed after the Second World War according to principles of modernism (1968–1975). Blocks are replaced by very big isolated buildings constructed without regard for the roads and with the express purpose of destroying the street. The buildings are long, compact, and very tall. They are made of concrete, have more extensive glass surfaces and are generally quite badly insulated. They were built, by and large, to last 10 years at most.

The fifth type is a district built in the 2000s. Once again the buildings are aligned on the streets but they are deeper and much more compact than the other types. They form open blocks with interior courtyards. The construction material provides better wall and window insulation. The aeration equipment minimizes the thermal bridges at these levels.

3 The energy signature of different types

Tab. 1 *Heating needs for 5 types of Parisian urban fabrics*

					
Period of construction	Pre 1800	Haussmannian	Interwar	Post war	2000s
Heating needs (kWh/m^2/yr)	158	129	150	165	31
Heating needs with standard U-values (kWh/m^2/yr)	56	39	35	46	31

These values presented in the first line of this table present the theoretical heating needs of the different fabric types. They are influenced not only by form but also by the U-values of insulation of the construction materials. We observe that the fabrics offering the lower U-values are those from the 2000s, followed by Haussmannian fabrics, then by the HBMs, the slabs and finally the 18th-century fabric. The calculations were made on different selections, to be sure, but these are representative nonetheless of the same typologies. The results are very close. The biggest difference is for the post-WWII slabs, most probably because this typology presents the greatest variety of forms in Paris and its suburbs. The overall lack of disparity between the results validates our method of calculating heat energy needs prior to consideration of occupant behavior.

To pinpoint the actual impact of the urban form, we redid the calculations as if the construction materials were all equally efficient, hence applying a single U-value to all the fabrics. This is a way of determining which form would be more efficient using today's materials. The results are presented in the second line of the table.

By not taking occupant behavior into account and standardizing the U-value, we have managed to single out the role of urban morphology. The open blocks of the 2000s remain the most efficient form, but the HBMs and the Haussmannian blocks prove to be very close in performance. These are followed by the slabs, and then the 18th-century fabric. The HBMs are actually very similar in form to the modern open blocks, but the buildings are not as deep and the built and human density is much lower; this can work against other important factors, such as density, mixed-used, and a return to the street. Indeed, these forms remain very isolated, and do not lend themselves to a lively street life with a mix of activities. The form of the 19th-century buildings proves to be efficient; benefiting from current technology, this efficiency could be much higher. In addition, mixed-use, density and fractality offer other advantages (Salat, 2011). The 18th-century fabric is less efficient, most probably because of its complexity and the excessively small size of its constituent elements. Finally, the slabs of the post-WWII period suffer from their excessive size and over simplified and dispersed forms. It is worth noting that simply as result of morphology, the towers and slabs require 1.4 times more energy than the contemporary blocks from the 2000s.

4 Conclusions

At a time when towers and slabs are spreading everywhere in emerging countries, diffusing the disasters of modernist urbanism throughout the world, this rapid comparative analysis of the social and energy efficiency of different Parisian fabrics demonstrates the inefficiency of modernist models for sustainable development.

The calculation of the comparative energy needs of the different fabrics allowed us to moderate certain initial hypotheses, such as the preponderant role of compactness, or the impression that a high percentage of ground area occupied was detrimental to daylight access. This study represents a preliminary step in improving our method and serves as a basis for the study of other urban fabrics, with the aim of gaining a better understanding of the phenomena induced by urban morphology in terms of energy consumption. It allows us to discuss the influence of natural elements, studied here in terms of their heat input. The sun can be used for the light and heat it brings, directly through the windows and indirectly by way of photovoltaic panels or other systems. Positive energy buildings and districts strive to use the potentialities of the sun and the possibilities of natural aeration and air-conditioning.

5 References

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