The Climatic Potential

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In 1996, French climatologists Denis Lamarre and Pierre Pagney proposed the notion of "climatic potential" to define the way in which a society, at a given moment, represents the constraints and resources of a climate. This notion encompasses what is possible and impossible to do in a given climate at a given time. The annual thermal amplitude, the sunshine, the violence of the wind or the regime of precipitations participate in the definition of the climatic potential of a region which evolves in time. All these factors are more or less involved in the popular image of certain climates (mild and sunny climate of the south of France, rainy climate of the Atlantic coast, etc.).

By unconsciously or consciously modifying the climate on a local or regional scale, but also by producing instruments to understand the climate it inhabits, a society transforms its perception of the climatic potential. The invention or development of certain techniques also modifies this perception. For example, the introduction of the windmill in Europe in the 12th century profoundly changed the climatic potential of many climates, from the North Sea coast to the Mediterranean. Windy climates, often unpleasant to live in, became economically attractive because they could provide intermittent but directly usable energy for long periods. With this type of technology, the climate becomes a resource .

This notion of "climatic potential" is rarely used today, except in old climatology textbooks. However, its importance seems crucial in the era of climate change. Although it has been known for several decades that human activities cause warming on a global scale, the identification of climatic potential on a regional or local scale remains approximate. At our latitudes (45° N), we know, among other things, that precipitation patterns will be disrupted, that heat waves will increase and that extreme weather events (floods, storms, etc.) are likely to increase. But beyond these obvious constraints with sometimes dramatic consequences for life, is the use of the possibilities of our climates planned on a local scale?

Water and precipitation management on a regional scale is currently at the heart of many debates (retentien, soil sealing, etc.). These debates mobilize numerous hydrogeological and climatic studies on the subject, which present divergent results. Apart from this exception, the study of current and future climatic potential often remains partial or very general. It is generally limited to the analysis of the possibilities of using renewable energies (solar photovoltaic, wind power) and possibly to its evolution

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under the action of climate change. For example, a study published in 2021 highlighted a long-term decrease in wind energy resources of about 15% in Europe in the most pessimistic IPCC scenario (SSP5-8.5), with a high level of uncertainty for France[2].

The case of the "solar deposit"

In the field of solar energy, the exploitation of sunshine for energy purposes is far from being recent. The choice of agricultural plots according to their exposure and the selection of species adapted to the local climate (resistance to frost, drought, etc.) are inseparable from the birth of agriculture. The development of tools for measuring sunshine, from Horace Bénédicte de Saussure's heliothermometer in the 18th century to the most recent pyrheliometers and pyranometers, has made it possible to quantify the intensity of solar radiation on a local scale and then on a national scale at the beginning of the 20th century. It is on the basis of these observations that a geographer like Maximilien Sorre could affirm in 1943 that as far as the direct use of solar energy is concerned, "the subtropical climates of the Mediterranean type (Mediterranean, Chile, California) present the most favorable conditions[3]".

The evaluation of the potential for the use of solar energy developed mainly after the Second World War. In 1950, the American climatologist Paul Siple published one of the first synthetic maps showing the "maximum feasibility", "possible feasibility" and "minimum feasibility" of solar energy use in the United States[4]. After the shortages caused by the war, solar energy is presented as the "golden coal of the future[5]", according to an expression by Felix Trombe. This French engineer experimented with many applications of solar energy between the 1950s and 1970s: he is best known for inventing the "Trombe wall," a system for accumulating and storing solar energy for home heating. At that time, the direct use of solar energy in thermal and photovoltaic form appeared as an alternative to fossil fuels, whose depletion prefigured by shortages was already announced by some engineers.

After the first oil crisis, research on solar potential increased in the United States and Europe. In 1976, the French meteorologist Christian Perrin de Brichambaut published maps showing the distribution of what he called the "solar deposit" in France. They show the unequal distribution of the potential for using solar energy in France. In particular, the average amount of solar energy received daily in January by the same south-facing vertical surface is three times greater in the extreme south of France than in the northeast, while it is almost equal in July. Reading these maps, it appears that the solar deposit in the south of France can provide most of the heating needs of a well-designed and well-oriented building.

This historical detour shows that in terms of the climatic potential of renewable energies, and in particular of solar energy, we are only just beginning to make up for the delay accumulated after the oil crisis of the mid-1980s. This period was marked by an almost generalized abandonment of all research on solar energy conversion in France. Today, some direct uses of solar energy remain unfortunately under-exploited (solar hot water, passive heating, etc.), but much of this research has resumed. The decrease in manufacturing costs of semiconductor elements has considerably democratized the use of

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2 A. Martinez, G. Iglesias, "Wind resource evolution in Europe under different scenarios of climate change characterised by the novel Shared Socioeconomic Pathways", *Energy Conversion and Management*, vol. 234, 2021. https://www.sciencedirect.com/science/article/pii/S0196890421001370 [consulté le 03/04/2023]
3 M. Sorre, *Les Fondements de la géographie humaine : Les Fondements techniques*, Paris : Armand Colin, 1954, p. 289
4 D. A. Barber, *A House in the Sun: Modern Architecture and Solar Energy in the Cold War*, New York : Oxford University Press, 2016, p. 111.
5 F. Trombe, "L’énergie solaire, houille d’or de l’avenir", *L’Astronomie*, vol. 64, 1950, p. 413-421.

photovoltaic systems and the evaluation of the solar potential of a site is now very easy. The online Geographic Information Systems (GIS) developed by the European Union allow to consult sunshine maps and to evaluate the yield of a system.[6].

The climatic potential of natural cooling

However, it would be wrong to think that the climatic potential of a place or region is limited to its solar or wind resources. This notion encompasses all the constraints and resources associated with a climate and is not limited to the possibilities of electrical energy production. Agricultural practices, tourism and urban planning, for example, also depend on a certain local or regional climatic potential. However, it remains largely ignored: in architecture and urban planning, for example, the standardization of needs and techniques on a national or global scale often imposes the same solutions without taking into account local climatic specificities.

This standardizing ideology of modernity is now showing its limits. We cannot treat the climate as a simple component of the environment. Climate change reminds us that a climate determines the conditions of possibility and impossibility of many human activities. In our latitudes, which are often presented as being spared from extreme phenomena, current climate change is creating increasingly strong pressure on some of these activities (agriculture, construction, tourism, etc.).

In this sense, the evaluation of the climatic potential is urgent and includes the implementation of strategies for adaptation to climate change. The climatic potential of a place will depend on all the parameters that characterize its local climate: the thermal amplitude, the hygrometry or the type of cloud cover have a fundamental role. All these factors determine the climatic potential of urban cooling, which has become a major public health issue since the 2003 heat wave in France, which caused about 15,000 deaths.

The possibilities of cooling at night during a heat wave are very unequal in different climates. For example, the difference between the lowest and highest temperature of a day (nycthemeral amplitude) plays a major role. This amplitude varies considerably between a continental and a coastal climate: to a first approximation, it is high for a continental climate and lower for a coastal climate. Thus, for a coastal climate and in the absence of breezes, the night temperatures of the hottest months can remain high and degrade the thermal comfort inside the buildings, and thus the sleep and rest of their inhabitants. It can be deduced that the climatic potential for night-time cooling of buildings is very unequal between these two types of climates, all other things being equal.

In terms of combating heat waves or the urban heat island effect, it is clear that the evaluation of the climate potential to fight against the consequences of these phenomena, which often have dramatic health impacts, is still in its infancy. Large cities are only just beginning to become aware of the repercussions of the heat island phenomenon, which has been known to meteorologists for at least a century, but has remained poorly understood until now. We now know all the factors involved in this phenomenon (impermeability of surfaces, low albedo, etc.), but the strategies put in place to reduce its effects often remain timid.

What is most striking is that the potential of local climates for natural cooling of buildings is generally underestimated. The use of radiative cooling, cooling wells or thermal draught to ventilate with air extracted from the basement is only very rarely evaluated on the scale of a built-up area.

6 https://re.jrc.ec.europa.eu/pvg_tools/fr/

Research on the subject, although very developed in the second half of the 20th century[7], is struggling to find applications today. More generally, the natural ventilation of buildings, which was recently highlighted during an exhibition of the main French projects, is only very rarely evaluated on an urban scale.

Some climatic potentials are completely ignored today. This is particularly the case for radiative cooling, which is only studied in certain specialized research laboratories. This technique consists in cooling the horizontal roof of a building covered with a suitable material by radiating long waves towards the sky. This phenomenon, naturally at work in many desert or high altitude climates, is exploited in the vernacular architecture of several countries (Greece, Israel, etc.) and has even been used to make ice in desert areas (ice walls in Iran or Iraq). A team of researchers from the University of Lleida in Spain showed in a study published in 2021 that the climatic potential for using this phenomenon for cooling buildings was significant in southern Europe, especially in the Mediterranean basin[8] (Spain, Greece, etc.). In this type of climate, marked by very high summer temperatures, it is theoretically possible to naturally cool a well insulated single-storey building by radiative cooling. Despite its numerous past uses, this fundamental climatic potential remains locally unknown and largely unused.

Designing for climate potential today

The evaluation of the climatic potential to respond to the cooling problems of cities seems urgent. The knowledge of winds and breezes in hot periods for natural ventilation, the evaluation of the radiative cooling potential or the study of water availability for plant evapotranspiration are all elements to be characterized to define the climatic potential at the scale of a city, in order to implement cooling strategies. In France, only a few engineering firms are capable of evaluating urban climates and they cannot cover all the parameters characterizing the climatic potential of a city because they require multidisciplinary expertise (thermal, phytobiology, ecology, hydrology, etc.). Another difficulty consists in deducing from their diagnoses concrete architectural and urban recommendations.

Of course, urban planning is not the only discipline concerned by the assessment of climatic potential. This assessment is also of interest to agriculture, which is directly impacted by current climate change. There is even a discipline, agroclimatology, whose purpose is precisely to study the potential of climates for agricultural applications. Today, the analysis of soil dryness under the effect of increased atmospheric dryness and evapotranspiration of plants mobilizes all the skills of agroclimatologists. Tourism is also concerned by the evaluation of climatic potential: the future of ski resorts is seriously threatened in the short or medium term. The climatic possibilities of mountain regions are changing and the tourist activities set up in the 20th century no longer correspond to them today.

Beyond the applications discussed here, the study of climatic potential seems to be a good way to overcome the stifling effect of current global climate change. According to the point of view adopted in this article, there can only be a modification of the climate potential, i.e. a redistribution of the constraints and resources of a climate at the local or regional scale. It is not a question of denying the seriousness of the climate change underway or of pretending that our industrial societies will always be able to adapt. The notion of adaptation remains vague and must be criticized[9]. Developing the study of

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7 C. Gaillard, *Moduler le climat. Genèse, développements et significations de la conception bioclimatique en architecture*, thèse de Doctorat en Urbanisme, Paris : Université Paris 1 Panthéon-Sorbonne, 2022, 689 p.
8 R. Vilà, M. Medrano, A. Castell, "Mapping Nighttime and All-Day Radiative Cooling Potential in Europe and the Influence of Solar Reflectivity", *Atmosphere*, vol. 12, n°9, 2021.
9 B. Stiegler, *« Il faut s'adapter ». Sur un nouvel impératif politique*, Paris : Gallimard, 2019, 336 p.

climate potential consists in regaining awareness of the importance of climatic phenomena on a local and regional scale, in order to put in place appropriate strategies as soon as possible.

All this is very pragmatic: there are techniques, systems and devices already implemented in urban planning or vernacular urban planning in some countries located at lower latitudes that could be directly transposed to our latitudes. In terms of urban planning, we have a lot of room for improvement and there are a multitude of relatively simple solutions to implement to improve our cities and our lives. It is up to us to explore the current and future climatic possibilities, in order to set up lifestyles more in line with the climates in which we live.