

MODERN ARCHITECTURE AND THEORIES OF SOLAR ORIENTATION

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1. ABSTRACT

This paper begins from John Perlin's discussion of solar orientation in German modernist housing projects of the 1920s. In *Let it Shine* (2013), Perlin noted that most such projects were oriented with the long axis running north-south, so that the units faced east-west. It was later understood that the optimum for heating and energy savings was to orient row-houses east-west, to maximize south-facing exposure. Perlin asked: "How did these renowned architects err so badly?" and concluded that they did not understand the emerging science of solar geometry.

This paper, a historical study, proceeds from the premise that modernist approaches to orientation can sustain a more nuanced exploration. It examines several seminal projects of European modernism and theories of solar orientation from the 1920s-40s. It finds that the early modernists did not "err" when judged against their own intentions. They thought clearly about orientation and proceeded from rational premises.

2. INTRODUCTION

Beginning in the 1920s, European planners and architects began to explore a radical new idea about organizing people on the land: long and shallow apartment blocks, organized in parallel rows, spaced widely. Housing the masses was seen as an urgent need which could "only be solved by

large-scale planning"[1] and by abandoning the traditional European pattern of filling blocks with deep, narrow buildings and small interior courtyards. In Germany, where the most progressive large-scale housing projects were realized in the 1920s, this pattern was called *Zeilenbau* (row-houses). The contrast between the old and new approaches was neatly captured in sequences of images by both Swedish and German architects (Fig. 1).

The social concerns that motivated these ideas have been widely discussed, but the physical form of the *Zeilenbau* also speaks strongly to modern environmental concerns. The Swedish manifesto *acceptera* (1930) said the "open style of building, with parallel blocks" responded to "the demand that all modern dwellings get direct sunlight." [2] And Walter Gropius said this new model of housing offered "the great advantage that every dwelling receives its proper share of sunlight." [3] Indeed, sunlight took on an importance so great that Catherine Bauer used the label "Heliotropic housing" to describe this work in her seminal book *Modern Housing* (1934). [4] Heliotropic means 'sun-responsive', or perhaps more accurately 'solar-oriented'.

Given that access to the sun was a central concern, the question of orientation with respect to solar geometry logically follows. Which direction should the housing blocks face? The simple answer to this basic question ultimately reveals several deeper and important issues about

the evolution of environmental thinking among architects in the modern period.

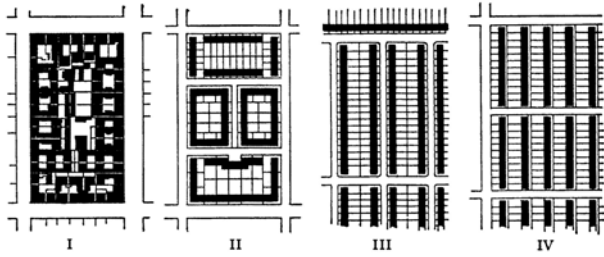


Fig. 1: “Four Stages in German Block-Planning” by Ernst May (1932). The Zeilenbau Plan is Stage IV.

3. ZEILENBAU PLANNING

As is well-known and well-documented, when German cities—particularly Frankfurt and Berlin—embarked on major housing initiatives in the mid-1920s, they generally adopted bold new ideas about architecture and planning. The broader movement was encapsulated by the term *Neues Bauen* (“New Building”). Frankfurt, for example, has been called “one of the most remarkable city planning experiments of the twentieth century.”[5] Between 1924-30 over 1,650,000 housing units were built in the country.

Most of those housing projects—dozens of them—were built in the linear Zeilenbau pattern with a north-south row direction (or nearly so). Here are some selected examples:

- Weissenhofseidlung by Ludwig Mies van der Rohe and others (Stuttgart, 1927). Mies’ housing block at Weissenhofseidlung is perhaps the most well-known of the German housing projects, and was promoted as an example. It followed the “typical Zeilenbau alignment,” according to Mark Stankard, which had the advantage of “exposing the living units to a balanced quality of light from the east and the west.”[6]
- Wohnstadt Carl Legien by Bruno Taut and Franz Hillinger (Berlin, 1928-30). Here, the rows ran east-of-north in typical Zeilenbau fashion, but Taut used short terminus blocks to create “common garden courts.”[7]
- Siedlung Westhausen by Ernst May (Frankfurt, 1929-31). Westhausen has been described (in a nod to Catherine Bauer) as “the ultimate in heliotropic housing,” where sunlight and fresh air “became so important that other site design factors became ignored.”[8]

- Großsiedlung Siemenstadt by Martin Wagner, with Hans Scharoun, Walter Gropius, Hugo Häring and others (Berlin, 1929-34). Bauer later identified this project as the prototypical example of a “rigidly geometrical Zeilenbau scheme, solely geared to a narrow system of standardized solar orientation.”[9]
- Siedlung Dammerstock by Walter Gropius and others (Karlsruhe, 1929). Architect Adolf Behne criticized Dammerstock’s north-south orientation (see Part 4 below).

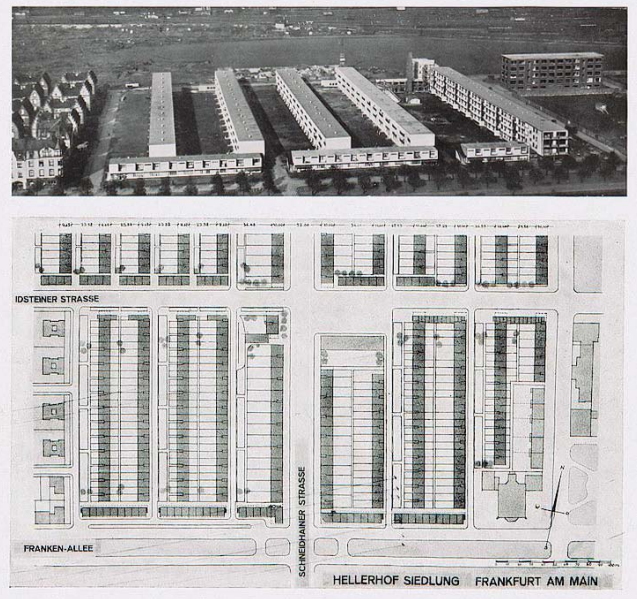


Fig. 2: Hellerhof Seidlung by Mart Stam (Frankfurt, 1929-32), an example of Zeilenbau planning principles.

The general approach, which might be called Zeilenbau orientation, was in fact much more widely adopted. Other examples, selected to illustrate geographical diversity, include:

- Lawn Road Flats, a.k.a Isokon Building, by Wells Coates (London, 1933-34).
- Carl Mackley Homes by Oscar Stonorov and Alfred Kastner (Philadelphia, 1933-34).
- Bergpolderflat by de Tijen, Brinkman, and Van der Vlugt (Rotterdam, 1933-34).
- La Murette by Marcel Lods and Eugène Beaudouin. (Paris, 1932-34).

After the Zeilenbau pattern in had been established in Frankfurt in the mid-1920s, architect Ernst May and his team sought to bring scientific rigor to the question of orientation. Walter Schwagenscheidt, who worked under May beginning in 1928, conducted studies to determine the

“scientific optimum” orientation for the housing blocks. He called them “Comparative Sunlight Studies.”[10] He concluded that the best orientation was to align the building with its long axis $22\frac{1}{2}^\circ$ west of north (see Fig. 3).

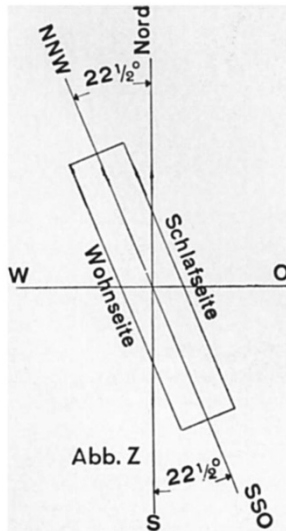


Fig. 3: “Comparative Sunlight Studies” by Walter Schwagenscheidt (1930), showing preferred orientation for Zeilenbau-type projects.

(It should be noted that the original publication included an English translation, which rendered *besonnung* as “insolation,” though sunlight would be more accurate. The word insolation would later describe solar heat, and is used in that manner today, but Schwagenscheidt did not intend that meaning. Some later writers have continued to use “insolation,” potentially causing confusion.[11] Zeilenbau architects did not think in terms of solar heat, and did not attempt to quantify gains.)

There is some evidence that these patterns were codified, at least to a degree. There is reference in the historical literature to “*Besonnungsdoktrin* (doctrine of orientation of housing towards sunlight),” which mandated “a north-south orientation, i.e., living-sides to the garden east and west.”[12] When some of the Zeilenbau were proposed (successfully) as a UNESCO World Heritage Site, the nomination referred to “the doctrine of orientation towards morning and afternoon sunshine.”[13] No actual rules or doctrines have been located, but it appears that Schwagenscheidt’s conclusion carried some authority.

4. THE QUESTION

From our perspective today, the Zeilenbau orientation seems counterintuitive. We know now the actual ‘scientific optimum’, for energy use and solar control, is an east-west row-direction, so that the long side of the building faces

north and south. In the new book *Let it Shine*, John Perlin asked, of the Zeilenbau practice: “How did these renowned architects err so badly?”[14] He concludes that they simply did not understand the science.

Here Perlin flirts dangerously with the *historian’s fallacy* of applying new knowledge and/or values to judge past actions. To his credit, Perlin notes that Zeilenbau orientation, though ubiquitous, was the subject of some controversy at the time. In 1930, German architect Adolf Behne offered a lengthy critique of Walter Gropius’ Dammerstock housing:

“[Its orientation] would be right if our compass had only east and west, if the sun commuted along the shortest path between east and west without touching north and south ... [the architect] need not orient apartments toward the north. But must he boycott the south?”[15]

Additionally, while praising the “Heliotropic housing” of the Zeilenbau type, Catherine Bauer also admitted in 1934 that “Recent studies by Mr. Henry Wright tend to show that if living-rooms are toward the south, they receive more sun in winter and less in summer than if they face west.”[16] In other words, the status of the “scientific optimum” was in doubt, and the conventional wisdom of today, from which Perlin proceeds, was already on the table.

However, Perlin’s analysis did not fully explore the true intentions of the Zeilenbau architects. And, given the full sophistication of the modernist housing enterprise as a whole, the use of the word “err,” in particular, calls for further examination of Zeilenbau principles.

5. BACKGROUND

Zeilenbau orientation is sometimes misunderstood due to familiarity with a building spacing diagram presented by Gropius to the third congress of CIAM (Congrès International d’Architecture Moderne) in 1930.[17] The drawing (Fig. 4) was meant to determine the best height and spacing of buildings for the best use of land, constrained by solar geometry. Gropius called it an “economic comparison” (*wirtschaftsvergleich*). (The study concluded that high-rise buildings of ten to twelve floors are preferred, although Gropius argued that cities required a mix of low-rise, mid-rise, and high-rise housing. Ernst May disagreed “with great intensity” about the advantages of high-rise housing.”[18])

Because of the presence of solar angles, Gropius’ diagram may be wrongly interpreted as an early demonstration of passive solar heating, because the angle is presumed to be winter noon. Gropius did not have an interest in solar heat at this time, nor did any of the other Zeilenbau architects

(with the possible exception of Hannes Meyer).[19] He used the term *lichteinfallswinkel* (“light incidence angle,” or “illumination angle”).

In the upper part of Fig. 4, Gropius used a 30° angle for all types. The significance of this number is not explained. (From November to January in Berlin, the sun never reaches 20°, even at noon.) In the lower drawing, the angle varies, and high-rise construction permits a solar angle of 17°50’. “Without any economic loss,” Gropius wrote, “one gets the advantage of better sun ... between the stripe blocks.”[20]

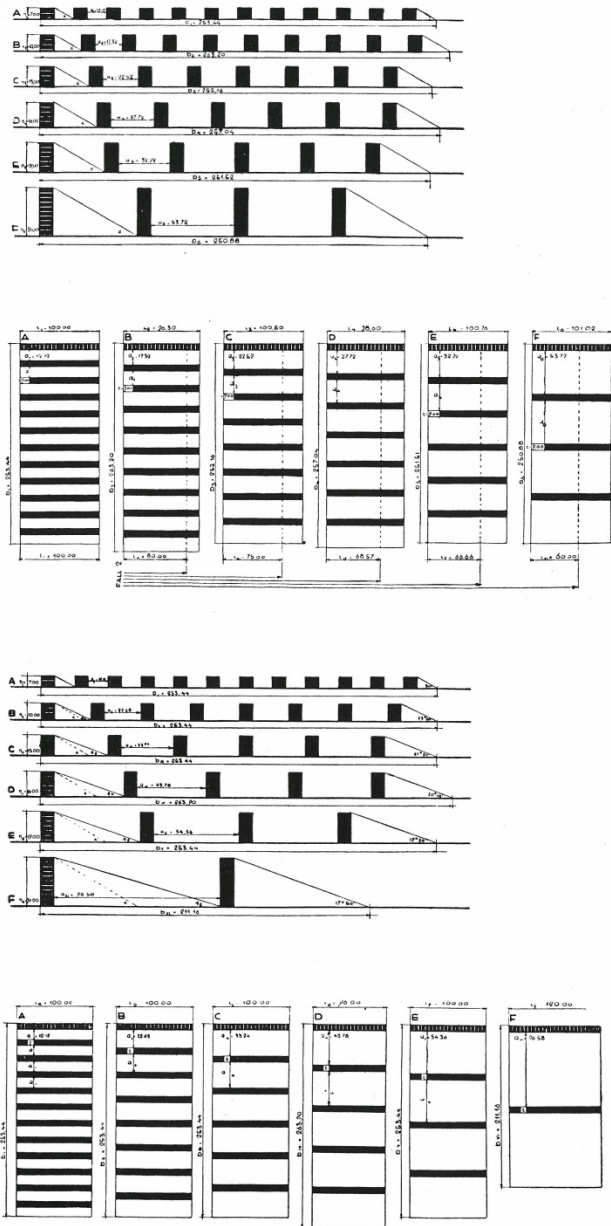


Fig. 4: “Economic comparison” of low-rise, mid-rise and high-rise housing by Walter Gropius (1929-30).

The diagram points clearly to an overarching theme of the architecture of the 1930s: using scientific methods to shape architecture in relation to access to the sun. The larger effort to give sun-responsive architecture a basis in scientific rationality is illustrated by several research projects in the United States and England. Publications included:

- Howard T. Fisher, “A Rapid Method for Determining Sunlight on Buildings,” (1931)
- H.E. Beckett, “Orientation of Buildings,” (1933)
- P.J. Waldram, “Universal Diagrams” (1933)
- Henry N. Wright, “Site Planning and Sunlight,” (1936)[21]

The sun-responsive nature of the Zeilenbau and other housing projects of the 1920s and 30s followed on a short tradition which may be known as *heliotherapeutic architecture*, buildings which accommodated sunlight for reasons of health and hygiene (heliotherapy).

Heliotherapeutic architecture first emerged with the sanatorium movement, prompted by the idea that sunlight, fresh air, and rest were the most effective treatment for tuberculosis. A direct line can be drawn from Les Frênes (Leysin, Switzerland, 1911), probably the first large purpose-built heliotherapy clinic to be constructed, to major works of modern architecture such as the Zonnestraal Tuberculosis Sanatorium by Johannes Duiker and Bernard Bijvoet (Hilversum, The Netherlands, 1925-31), and Alvar Aalto’s tuberculosis sanatorium at Paimio, Finland (1929-33). These structures created architectural meaning from a need to provide sunlight, fresh air, and cleanliness for the patients’ recuperation.[22] The fact that tuberculosis was “still rampant in Berlin at the time” of the Zeilenbau underscores the deep affinities between modern housing and sanatorium architecture.[23]

Richard Hobday has recently speculated that Zeilenbau orientation derived from an earlier tradition in hospital design, the ‘Nightingale ward’. This facility, a standardized type in the 19th century, was usually oriented with its long axis running north-south, with beds placed in rows perpendicular to the east- and west-facing window walls. Hobday wrote that the Nightingale ward was “one of the earliest examples of solar design for health,” but poor in terms of solar heating and control.[24]

We know today that east-west orientation is the ‘scientific optimum’ for heating and energy savings (with proper shading), and passive solar pioneers such as Henry N. Wright and Fred Keck began to argue for all south-facing rooms in the mid-1930s. In my book *The Solar House: Pioneering Sustainable Design*, I argue that the 20th-century solar house, defined by experimental attention to

space heating and energy savings, occupies a different historical space than *heliotherapeutic architecture* as defined above.[25]

European modern architects of the 1920s, conditioned by the sanatorium tradition, were generally concerned with sunlight, not solar energy. German architects used the words *licht*, *sonne*, and *besonnung*, but phrases which would indicate solar heating (*sonnenenergie*, *solarwärme*, *solarheizung*) do not appear in the German architectural discourse at this time. For architects like May and Gropius, heliotherapeutic considerations—health and hygiene—were primary concerns. The conscious effort to use solar energy in order to reduce energy use in the occurred in the late 1930s in the United States, and there is no evidence that May or Gropius wanted to face the sun for space heating and energy savings.

6. ZEILENBAU PHILOSOPHY

Zeilenbau orientation was predicated upon the logic of one-unit-deep planning, and either single-loaded exterior corridors or central stairwells. According to Bauer, it was considered a “rule” in European housing that “every dwelling must face in two opposite directions.”[26] Therefore, the double-loaded corridor was not used in the Zeilenbau-type housing blocks.

With individual apartments thus having a ‘double-orientation’, they were two rooms deep. As Catherine Bauer noted: “The living-rooms and kitchens are then put on the west side and the bedrooms and bathrooms, in so far as possible, on the east.”[27] In addition to achieving morning sun on the east and afternoon sun on the west, each unit would also have the crucial quality of cross-ventilation. Walter Gropius emphasized this: “As against the old block plan row-house have the great advantage that every dwelling receives its proper share of sunlight, that the free current of air along the rows is not obstructed by cross blocks and that corner apartments without cross ventilation disappear altogether.”[28] In Gropius’ 1930 presentation to CIAM, he said the Zeilenbau plan offered *Licht, Luft und Auslaufmöglichkeiten* (Light, Air, and Free Movement).

In the same period in Sweden, a group of modern architects gave further depth to these issues in a manifesto entitled *acceptera (tiden)*, meaning “accept the times.” The Swedish approach is perfectly clear in its logic:

“...the demand that all modern dwellings get direct sunlight has endowed modern housing areas with a completely new character. It has necessitated an open style of building, with parallel blocks whose orientation is determined with reference to the sun, [long axis] east-west if there are through-apartments, otherwise north-south. The first

building type is preferred as it permits cross-ventilation and provides a side that is genuinely sunny. But it requires through-apartments which, reducing the depth of the building, lead to longer facades as well as fewer apartments on each stairwell, such that this system is economically inferior to blocks that run from north to south.”[29]

Zeilenbau orientation can also be interpreted in terms of early 20th century industrial logic. As Mark Swenarton has argued that Schwagenscheidt’s orientation studies can be seen as “analogous to the pre-production research of the Ford company: since everyone was going to have the same orientation, it had to be established which orientation was the best. The resultant ‘standard form’ would be based on the objective findings of scientific research.” And furthermore, the belief in rational planning was strongly connected to the socialist ideal that “not just a few, but all, would enjoy this optimal product.”[30]

Finally, it should be considered that (what were later called) passive solar heating techniques did not make sense in Germany with 1920s building technology, especially in Berlin, because such techniques would have created more losses than gains. (Double-pane insulated glass units were not generally available until the late 1930s.) But there certainly was some threat of summer overheating. It is possible that architects found the narrow south face to be an ancillary advantage of Zeilenbau orientation for this reason. Bauer alluded to this possibility in her summary of Schwagenscheidt’s studies: “The purpose was to find the orientation of the rows which would provide the maximum of sunlight within all the rooms in *winter and spring* (sun being no great desideratum in the summer).”[31] Because buildings of this time had very little insulation, south-facing walls would transmit a large amount solar heat. It stands to reason that architects of this time would have been more concerned with solar control than solar heating, since mechanical heating was standard but mechanical cooling was not.

7. LE CORBUSIER

One architect, Le Corbusier, must be discussed separately due to his singular, independent approach.[32] Le Corbusier certainly participated, beginning in the mid-1920s, in the wider movement of heliotherapeutic architecture. He too was attentive to the sanatorium tradition and shaped his buildings to admit sunlight for health and hygiene. But additionally, his sun-responsive architecture took on powerful poetic dimensions. For instance, the Villa Savoye (Poissy, 1929) is designed around a promenade through the house whose destination is the solarium. It has been called “a temple to sunbathing.”[33]

Le Corbusier's attitudes about orientation changed over time in ways that are difficult to interpret. In 1930 he attended the CIAM congress (discussed above) and that experience seems to have changed his thinking about the sun. At that meeting he presented the Ville Radieuse, an ideal city populated in part by all-glass cruciform skyscrapers. According to Kenneth Frampton, the meeting prompted him to realize the "heliothermic limitations" of that plan.[34]

Then, in 1930-31, he completed the Pavillion Suisse (Paris), a dormitory with a repetitive linear plan. It was oriented, however, with the long-axis east-west, each room facing south. A single-loaded interior corridor occupied the north side. The south-facing glass curtain wall included motorized exterior roller-shades to provide control against overheating. Clearly, this violated Zeilenbau principles and did not provide cross-ventilation, but it would have been effective in reducing energy use, had that been the goal.

By 1933, he introduced a new "sun-inflected high-rise form," where most of the spaces could face south. He said the new plan was "a form dictated by sunlight.... There are no longer any offices facing north. And this new form is infinitely more full of life." [35] When Le Corbusier formulated the Athens Charter for CIAM between 1933 and 1941, he encoded heliotherapeutic principles in the larger agenda of modern architecture and planning. Here is article 26 of the Charter in full:

"Science, in its studies of solar radiations, has disclosed those that are indispensable to human health and also those that, in certain cases, could be harmful to it. The sun is the master of life. Medicine has shown that tuberculosis established itself wherever the sun fails to penetrate; it demands that the individual be returned, as much as possible, to 'the conditions of nature'. The sun must penetrate every dwelling several hours a day even during the season when sunlight is most scarce. Society will no longer tolerate a situation where entire families are cut off from the sun and thus doomed to declining health. Any housing design in which even a single dwelling is exclusively oriented to the north, or is deprived of the sun because it is cast in shadow, will be harshly condemned. Builders must be required to submit a diagram showing that the sun will penetrate each dwelling for a minimum of two hours on the day of the winter solstice, failing which, the building permit will be denied. To introduce the sun is the new and most imperative duty of the architect." [36]

But also in 1933 he had a decidedly negative experience with a south-facing solar orientation. In his Cité de Refuge for the Salvation Army (Paris, 1933), he placed an inoperable glass curtain wall, with no shading, looking south. The project "proved disastrous in summer due to thermal gain." He was forced to retrofit the building with

operable windows. After this, he "reluctantly accepted" the necessity of shading devices (*brises-soleil*). [37] (Le Corbusier's experience was remarkably similar in substance, and uncannily parallel in time, to George Fred Keck's 'discovery' of solar heat at his all-glass House of Tomorrow (Chicago, 1993). [38] Although Keck turned his negative experience for good in designing solar-heated houses, Le Corbusier did not pursue solar heating.)

In his most significant multi-family housing project, the Unité d'Habitation (Marseille, 1947-52), Le Corbusier oriented the building according to the earlier Zeilenbau tradition. The project is well-known for its organization of space, where each unit spanned the depth of the building and included a double-height space, a single-height-space, and an internal stair. This allowed a double-loaded central corridor on every third level to serve all of the units, an extremely efficient design. Plus, each unit therefore had a 'double-orientation', allowing cross ventilation (Fig. 5).

He could have placed the long axis east-west, in the manner of the Pavillion Suisse, while avoiding the classic problem of the double-loaded corridor arrangement: to banish half the residents to a 'thermal ghetto' on the north. [39] By the late 1940s, the advantages of this orientation, both in terms of passive heating and solar control, were well-understood. But he placed the long axis running north-south, with the units facing east-west. Did he fall back on his memory of the German 'scientific optimum' of the 1920s? Did he remain cautious about a south-facing building due to his experience at the Cité de Refuge? One claim is that, in Marseilles, the north wind known as the *mistral* prompted him to orient the building with a small blank wall facing north. [40] But this does not explain the fact that Le Corbusier built four other Unité d'Habitation projects in different locations—Nantes-Rezé, Berlin, Briey, and Firminy—all oriented as Zeilenbau.



Fig. 5: Unité d'Habitation, cross-section showing units with 'double orientation' and *brises-soleil* on the east and west.

He enshrined this condition of the short side facing south in *Le Poeme de l'Angle Droit* (1947-53), where he painted a tall, narrow building (clearly the Unité d'Habitation) overlaid with the tall parabolic path of the summer sun and the lower curve of winter (Fig. 6). Clearly this suggests that

the orientation was an architectural preference rather than a contingency of the wind in Marseilles.

In *Le Poeme de l'Angle Droit*, the verse corresponding to this image reads, in part:

L'horloge et le calendrier solaires ont apportés à l'architecture le "brise-soleil" installé devant les vitrages des édifices modernes.

Une symphonie architecturale s'apprête sous ce titre: "La Maison Fille de Soleil"

The clock and the solar calendar brought to architecture the "brise-soleil" to be installed in front of the windows of modern buildings.

An architectural symphony is prepared under the title: "The House, Daughter of the Sun." [41]



Fig. 6: Unité d'Habitation, from *Le Poeme de l'Angle Droit*.

In the Unité d'Habitation projects, Le Corbusier did, of course, include *brises-soleil* on the east and west. In their design, Le Corbusier paid attention his own requirement of permitting at least two hours of sun penetration in the winter. Nevertheless, the west-facing apartments, as a consequence, receive a too much direct sun when it is least wanted, late in summer afternoons. David Jenkins has argued: "one is forced to conclude that they have more to do with art than science." [42]

8. DISCUSSION

Clearly the preponderance of evidence shows that Zeilenbau architects did not "err" when judged against their own

intentions. They thought clearly about orientation and proceeded from rational premises. The extent to which their behavior does not conform to our expectations is merely a measure of differing values, and that they had limited information available. These architects wanted to admit sunlight for heliotherapy—a different kind of 'solar energy' and certainly no better or worse than the passive solar heating for energy savings which was pioneered in the 1930s.

It is well within the bounds of the imagination to conjure a future scenario in which passive solar heating is unneeded while heliotherapy gains higher value. In that scenario, Zeilenbau orientation could be seen, again, as correct. If this scenario seems unlikely, consider that architects like May and Gropius must have considered it similarly unlikely that their values and the logic of their decisions would have been usurped by historical change.

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- [39] The excellent concept 'thermal ghetto' is a recent one. See David Gissen, "Thermopolis: Conceptualizing Environmental Technologies in the Urban Sphere," *Journal of Architectural Education* 60:1 (2006), 43-53.
- [40] David Jenkins, *Unite D'Habitation: Le Corbusier* (London: Phaidon), 1993, n.p.
- [41] Le Corbusier, *Le Poeme de l'Angle Droit* (1955), available at Fondation Le Corbusier <<http://www.fondationlecorbusier.fr/corbuweb/morpheus.aspx?sysId=13&IrisObjectId=6474&sysLanguage=fr-fr>>
- [42] Jenkins, *Unite D'Habitation*, n.p.