

REVIEW OF A DOCTORAL DISSERTATION

Dissertation: "The Future of Housing Buildings; Optimizing Natural Ventilation Strategies in Polish Housing: Simulation-Based Design for Thermal Comfort in a Changing Climate"

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1. Basis for the review

This review has been prepared pursuant to the appointment of the Reviewer by the Council of the Discipline of Architecture and Urban Planning at Poznan University of Technology, communicated by letter of the Dean of the Faculty of Architecture of 16 July 2026, and in accordance with Article 187 of the Act of 20 July 2018, Law on Higher Education and Science (consolidated text: Journal of Laws of 2024, item 1571, as amended). The dissertation was submitted as an illustrated volume of 193 numbered pages in A4 format, together with a digital copy.

The Reviewer works in building performance simulation and computational design research, and the assessment below is written principally from that vantage. Where the dissertation is examined critically, the criteria applied are whether the computational model is fit for the questions it is asked to answer, whether a reader can reconstruct what was done, and whether the conclusions remain within the envelope of what was actually computed. The properties of individual turbulence closures are not examined here as a subject in their own right.

Sections 6, 7 and 8 are separated according to what is being asked. Section 6 contains matters the Reviewer would wish to see addressed at the public defence. Section 7 contains corrections that ought to be made before the work is published. Section 8 contains two proposals for carrying the research further. Critical observations also arise at points in Sections 3 to 5 where they bear directly on the assessment being made there. None of these observations affects the positive conclusion recorded in Section 9.

2. Formal characteristics of the dissertation

The work is composed of six chapters, the first three establishing the problem and the state of knowledge, the fourth constructing the method, the fifth presenting the simulation results and the sixth drawing them together. The pagination runs: Overview, pp. 25 to 29; Natural ventilation, pp. 31 to 46; Polish housing, pp. 48 to 62; Methodology, pp. 64 to 89; Results, pp. 91 to 150; Synthesis, pp. 152 to 177. A bibliography of 260 items closes the volume. Conclusions are appended to each chapter individually.

The dissertation is written in English. A Polish abstract is provided on pp. 20 to 21, which satisfies the requirement of Article 187(4) of the Act. A list of abbreviations and a declaration of authorship with associated publications precede Chapter 1.

One observation on the reference apparatus deserves to be recorded at the outset, since it is favourable and easily overlooked. Each of the 260 entries was checked against the body text and each is cited; more than fifty date from the years 2022 to 2025. The bibliography has therefore been worked rather than assembled, which is worth recording.

3. Subject matter, aims and research design

3.1 The problem addressed

Summer overheating in dwellings, and the consequent drift toward mechanical cooling in a climate where it was until recently unnecessary, is the condition to which the dissertation responds. The response proposed is architectural rather than technical: if the geometry of a dwelling, the disposition of its openings and the protection of its facades can be made to do more work, the recourse to cooling equipment may be deferred or avoided.

Two ventilation configurations are examined, cross ventilation and the considerably less studied corner arrangement. The choice of the latter is well judged. Corner dwellings are common in the Polish stock, their diagonal flow path behaves differently from the straight path of a through-ventilated unit, and the literature has given them comparatively little attention. Pairing the two, rather than treating cross ventilation alone, is one of the things that gives the dissertation its distinct position.

Two reservations should be recorded here rather than deferred.

The hypothesis as formulated on p. 25 contains its own conclusion, stating that the analysis will reveal larger windows, properly oriented and shaded, to improve passive cooling. A hypothesis that announces its outcome cannot fail, and it would have been preferable either to separate the expected results from the proposition under test or to cast part of the material as questions rather than as assertions.

The boundaries of the study are also absent from Chapter 1. That the computation is steady state, that a single reference wind speed is used throughout, that every window is fully open in every scenario, that internal gains are not quantified, and that night ventilation, the thermal mass of the fabric and the behaviour of occupants fall outside the model, are all defensible decisions for an exercise comparing variants under a severe condition. A reader of Chapter 1, however, will expect a study of considerably wider reach than the one performed, and will encounter these boundaries only in Chapter 4. They also govern how far the conclusions concerning 2050 may properly be taken, which is a further reason for declaring them early.

3.2 The empirical basis and the selection of cases

Before any simulation was undertaken the Author assembled an archive: upwards of 320 dwellings drawn from some thirty estates in seven Polish cities, built between 1940 and 2020, sorted by the ventilation each plan permits, by the number of rooms, and by period and location. Little of this material is visible in the final work, but it is what allows the two dwellings eventually modelled to be described as representative of anything, and it is a considerable quantity of preparatory labour.

From this archive two units were taken: one in the Winnica estate in Warsaw, ventilated through, and one in Cotton House, also in Warsaw, ventilated at the corner. Both date from 1998 to 2000. Each was placed within a model of its surrounding development, so that neighbouring massing contributes both shading and the deformation of the approaching wind.

A consequence of this selection should be recorded. Both dwellings come from a single short period, and nothing built by the prefabricated methods that dominated Polish housing production for two decades after 1970 enters the simulated sample. Those buildings house a great many people and overheat readily, so a study of summer comfort in Polish housing that does not include them should say so. The distinction also matters for how the results travel: the mechanisms the dissertation identifies are portable, whereas the temperatures it reports belong to the geometry that produced them.

3.3 The parametric programme

The programme varies three quantities: window width, at 120 and 150 cm; solar protection, in three arrangements comprising an unprotected baseline, an overhang with side fins, and horizontal louvres; and the direction of the approaching wind, at eight equal intervals. This yields 48 configurations per case study and 96 in total, and it is a clean factorial design that permits each variable to be isolated.

One point of terminology should be raised, although it bears on the title rather than on the work. The dissertation speaks throughout of optimizing natural ventilation. What is

performed is an exhaustive sweep of a small parameter space, without an objective function and without any search procedure. This is an entirely appropriate method for the question asked, and nothing further is requested of the Author computationally. It would nonetheless be better either to adjust the vocabulary or to state expressly that formal optimization lies outside the scope of the work. The Author is plainly aware of the distinction, since he identifies the coupling of simulation with surrogate and optimization methods as the direction the field is taking, and a co-authored paper on surrogate modelling appears among the literature cited on p. 61. How he situates that line of development in relation to the present study would be worth hearing at the defence.

4. Assessment of the computational method and its verification

4.1 Construction of the model

The exterior domain is dimensioned on the customary multiples of building height and is then deliberately extended beyond them, because the geometry is rotated to obtain the eight wind directions and would otherwise approach the lateral boundaries at the oblique angles. This is a consideration that directional studies frequently overlook, and its treatment here is correct. Mesh refinement is applied at four levels around walls and openings.

The interior and exterior are solved together rather than sequentially. The Author sets out the alternative, in which an exterior computation supplies pressures at the openings for a separate interior computation, and rejects it on the authority of studies showing that it misrepresents the bidirectional exchange occurring at large openings. Given the size of the openings under examination this is the right decision, and it is properly argued rather than merely asserted.

The formulation is steady state and incompressible, solved by the Reynolds-averaged equations with the RNG k-epsilon closure. Two matters are left open. The discretisation scheme and the solver formulation employed by the chosen software are stated nowhere in the dissertation, and the selection of the RNG variant in preference to the standard or realizable forms is neither argued nor tested. Neither omission is fatal, but both belong in a methodological chapter.

4.2 Verification

Verification proceeds in three stages, and the design of the sequence is sound.

Grid sensitivity is examined first, across coarse, medium and fine discretisations, with the change in mean interior velocity falling below two percent at the first refinement and below one percent at the second. It should be noted, however, that this exercise was conducted in OpenFOAM through the Butterfly interface, whereas every scenario reported in the dissertation was computed in Autodesk CFD using its own automatic

mesh generator. Grid independence has therefore not been established for the solver that produced the results, and this should be acknowledged in the text.

Comparison against measurement follows. The benchmark selected is the wind tunnel study of Kosutova et al. (2024), which is well chosen: it concerns cross ventilation in a generic building with one wall heated, so that the comparison tests the thermal behaviour of the model and not merely its velocities, and it provides two opening sizes. Acceptance thresholds are fixed before the comparison is made, and the computed CV-RMSE values fall within them for both opening sizes and at all measurement stations. Declaring the criterion in advance, and then reporting the less favourable of the two opening sizes alongside the more favourable, is the correct order of operations and should be recorded as such. A question concerning the derivation of the threshold itself is raised in Section 6.5 below.

A cross-engine comparison closes the sequence, both case studies being recomputed in OpenFOAM for four of the eight directions. The Author reports the discrepancies without selection, including the widest of them.

4.3 The revision of the analytical method

Section 6 of Chapter 5 records that the approach first adopted, in which results were read along a centreline at occupied height, proved insufficient, and describes its replacement by planar extraction across the room with subsequent averaging into functional zones. The reasons given are specific: a single line cannot represent lateral variation, it is interrupted by partitions, and the resulting plots are difficult to read.

That an unsuccessful approach is reported rather than quietly discarded is a mark of scientific candour, and it should survive into any published version of the work. The Reviewer notes in passing that the consequence of this revision is addressed in Section 7.9 below.

5. Assessment of the results and their architectural interpretation

5.1 What the simulations establish

The dissertation's central empirical claim is that the performance of an opening cannot be read from the opening itself. Across the matrix, the same window in the same climate produces materially different interior conditions according to where it sits in the plan, what the sun has done to the facade the air passes over before entering, and which floor the dwelling occupies. The argument against reasoning from an idealized single room, developed on pp. 129 and 145, is thus supported by the Author's own measurements rather than by citation, and it is an argument that belongs to architecture rather than to building physics.

The directional structure identified for the through-ventilated case on p. 128 gives this claim concrete form. Three groups emerge: directions along which the incoming air has

passed over sunlit facades and arrives already heated; directions along which the openings present no useful pressure difference and the air scarcely moves; and directions from which the air arrives over shaded surfaces. The grouping is physically explained and is legible to a designer.

5.2 The shading result

Among the findings the dissertation presents, the one with the most direct bearing on practice concerns solar protection, and its value lies in the fact that it does not generalize. In the through-ventilated case the overhang with side fins performs better than the louvre array. In the corner case the relationship reverses, the louvres exceeding the overhang by some 0.4 °C averaged over all wind directions. The Author accounts for the reversal: a corner dwelling receives sun on two perpendicular facades, and a shallow overhang cannot intercept the low western sun of a summer afternoon, whereas a louvre array distributes its shading across a much wider range of solar altitudes.

The rule is actionable, and it could not have been obtained from a simplified geometry, since the mechanism resides in the corner condition itself. It is, in the Reviewer's opinion, the clearest return the dissertation obtains on the computational effort it required.

5.3 The comfort analysis

The second substantial result concerns how comfort is assessed rather than how a building performs. Comfort calculations customarily take a single wind speed from the weather file and apply it uniformly across the space. The dissertation replaces that scalar with the computed velocity field and shows the difference to reach ± 6 °C in Standard Effective Temperature at individual points within a single dwelling. Stagnant corners that the conventional method cannot see are revealed, and the benefit obtained along a well ventilated path is shown to have been understated.

This has consequences beyond the two dwellings examined, and it is among the more transferable things the dissertation has to offer.

5.4 A limitation of the reported quantities

The assessment rests on two quantities alone, air temperature and air speed. The volumetric and exchange-rate measures conventional in this literature, which the Author himself sets out in Figure 5-1, are not given for any simulated case. Their absence makes it difficult to place these results against the studies surveyed in Chapter 2, and a table of exchange rates would be a small addition with a disproportionate effect on comparability.

6. Matters for clarification at the public defence

6.1 The design guidelines announced in the aims

Page 25 undertakes to deliver design guidelines and a methodology, both scientifically validated. The methodological undertaking is met, or nearly so: the procedural sequence set out in Table 4-7 is transferable and usable, though it carries no attribution and its content plainly did not originate in this work.

The design guidelines are harder to locate. What the dissertation offers is conclusions in prose, distributed through Chapter 6 at sections 4.4 and 4.8 and in the comparative passages on pp. 156 and 161. There is no table, no ordered set of rules, and no closing chapter in which the Author's architectural recommendations are gathered. For a dissertation whose stated purpose is to produce guidance for designers, this is a gap, and it is the more conspicuous because the material to fill it is already present.

Tables 6-1 and 6-2 demonstrate the point. Each sets out, for every wind direction, the best and worst interior temperature with the responsible configuration identified, together with the best velocity. That is precisely the form guidance should take. Both tables, however, stop at the ground floor bedroom, which is one of the four zones analyzed in each case study. Carrying the same format across the living rooms and the upper floor, and adding a column naming the recommended window width and shading arrangement, would produce the artefact the aims promise. For the through-ventilated case this requires no new analysis, the values being available in Chapter 5, though one entry should be checked: Table 6-1 gives the worst temperature at 0° as 37.8 °C for the small louvred configuration, whereas that configuration reaches 37.4 °C in the corresponding row on p. 112, and no configuration in that row reaches 37.8 °C. For the corner case the extension depends first on the question raised in Section 7.1.

One condition should attach to such guidance. It ought to be expressed as rules that carry their own limits rather than as general recommendations, and the dissertation supplies the reason. Negative temperature differences appear at 90° and 270° in the through-ventilated case and at 135° and 315° in the corner case, which is to say that with an inlet at 35 °C a larger opening can admit heat faster than it removes it when the flow is poorly aligned. The Author treats these as anomalies. They are better understood as the boundary of the principal recommendation, and stating them as such would make the guidance more robust, not less.

6.2 Whether the distance between simulation and design practice has in fact been closed

The dissertation undertakes on pp. 75 to 76 to close the distance between simulation as practised in engineering and the working method of architects. The claim is a wide one,

and the Reviewer would welcome hearing it defended, since the text argues it more briefly than its prominence in the aims would suggest.

The argument offered is essentially that the tools have improved: platforms have matured, plug-in environments have brought computational fluid dynamics within reach of design software, and the analysis is consequently practicable early in a project. The difficulties of the method are set out on p. 75, drawn from the literature, but they are not afterwards applied to the Author's own procedure. The case for the particular software chosen, made on p. 76, consists of six advantages taken from one secondary source; it concedes in a single clause that OpenFOAM may be more precise, but the concession comes from that same source rather than from the Author's own comparison.

There is also a tension between the claim and the procedure. The workflow described spans a modelling environment, a visual programming environment, one commercial solver, a second open-source solver reached through a plug-in, and a separate comfort pipeline. That is not a light apparatus for an architectural office.

The question takes its sharpest form as follows. Table 5-2 records iteration counts and elapsed times for the three grid sensitivity runs. For the 96 scenarios that constitute the study itself, no times are given, no hardware is specified, and no cost per case is stated anywhere in the dissertation. A claim about the practicability of this method in architectural practice stands or falls on exactly that evidence, and the Reviewer would be grateful to receive it.

6.3 The origin of the velocity field used in the comfort calculation

Page 162 states that the velocity field imported into the comfort calculation, at 0.5 m resolution, was produced in Butterfly, that is to say in OpenFOAM. The OpenFOAM computations are described on p. 98 as covering four of the eight directions, and the tables that accompany them contain only the unshaded configurations. On the face of it, that exercise was a verification subset rather than the study proper.

Should the comfort maps of Chapter 6 indeed rest on that subset, then the comfort analysis, which is the part of the dissertation closest to design, would rest on four directions and two configurations rather than on the full matrix, which is not what the figure captions imply. The Reviewer expects this to be a fault of wording rather than of method, but it is material enough to require an explicit answer.

6.4 The weight the stagnation findings can bear

Table 5-4 sets out, for the through-ventilated case, the discrepancy between the two solvers at each of the four directions recomputed. Where the dwelling ventilates well the two agree: every entry at 0° and at 180°, on both floors, lies below ten percent, and

several are below five. Where it does not, the agreement deteriorates markedly. At 90° the discrepancies run from 11.3 to 14.4 percent, and at 270° from 14.2 to 22.9 percent.

Those two directions are the ones the dissertation subsequently designates its stagnant group and treats as the critical condition under which passive cooling fails. The finding is not thereby invalidated, and there is a straightforward reason for the pattern: at velocities of a few centimetres per second a small absolute difference produces a large relative one, and no Reynolds-averaged formulation reproduces such fields with the consistency it achieves in a well developed flow. The Reviewer raises the matter because the conclusions concerning stagnation happen to rest on the region of the model where the two codes agree least, and would be interested to hear what weight the Author considers they can bear.

6.5 The derivation of the fifteen percent acceptance threshold

The threshold against which the wind tunnel comparison is judged is fifteen percent, and Section 4.2 above commended its having been fixed in advance. Two incompatible derivations are offered for it. Table 5-3 reproduces tolerances of the kind used when calibrating whole-building energy models against monthly data. The text beside it derives the same fifteen percent from the experimental scatter reported by Kosutova and colleagues. These are different things, and neither is a criterion for point-wise validation of a velocity or temperature profile. The reasoning would be worth setting out.

6.6 The future climate analysis

The 2050 component carries considerable weight in the dissertation and is at the same time the part least well prepared for the reader. Three matters arise.

Its introduction. Chapter 4, which is where the methods of the dissertation are established, says nothing about weather file morphing, about the emissions pathway adopted, or about the tool by which the future file was generated. All of it appears for the first time in Chapter 6, at the moment of use. A subsection in Chapter 4 alongside the treatment of present climate data would remedy this, and the purpose of the exercise should be indicated in the introduction so that the reader knows what to expect of it.

Its scope. As the Reviewer reads the work, no new computation was performed for 2050. The velocity field obtained under present conditions is carried into the comfort calculation beneath the morphed weather file. The wind field is thus held constant, and the interior temperatures derive from computations made with a 35 °C inlet while the 2050 condition is given as 39 to 40 °C.

The Reviewer wishes to be unambiguous on this point: no further simulation is being requested. Reusing the field is a reasonable and economical way to obtain a first indication, and declaring it plainly would strengthen the analysis rather than diminish it.

What is asked is that the limitation be stated, so that the reader understands the exercise to isolate the outdoor signal rather than to recompute the interior, and that the full future-climate simulation be presented as the next stage of the research, which this dissertation has already framed and partly answered. It may be added that the Author's observation that the amplification factor is nearly identical in both case studies, and that the climatic signal is therefore governed by outdoor conditions rather than by the geometry, follows partly from the procedure adopted, since the geometry was not recomputed, and might be expressed more cautiously for that reason.

Its conclusion. The third matter concerns what the analysis concludes. Do the measures the dissertation recommends matter more under the 2050 scenario than they do today?

The work gives three answers and does not choose between them. On p. 167 future climate is said substantially to erode the effectiveness of passive cooling. On p. 166 the benefit of larger openings and solar protection is said to become proportionally more important under the same future climate. On p. 173 passive ventilation of either type is said to be insufficient on the ground floor during peak 2050 afternoons without supplementary cooling. The closing pages are more optimistic again.

The Author's own material appears to support a definite answer, and one that none of the three quite states. The absolute effect of the measures is roughly unchanged; what changes is their marginal worth, because the distribution of outdoor temperature shifts upward against the comfort threshold, so that an intervention of fixed magnitude converts a larger number of hours. The monthly distributions given in section 5 of Chapter 6 contain exactly the data required to demonstrate this. The dissertation performs the calculation once, obtaining some twenty additional hours across July and August, and presents the figure as an estimate without showing how it was reached. Carried out across both distributions at one consistent threshold, it would settle the question, and would in the Reviewer's view repay the effort more than anything else the remaining material could yield. It requires no additional computation.

Two obstacles stand in the way and should be removed first. The magnitude of the benefit is given inconsistently: a reduction of 1.5 to 2.0 °C in Standard Effective Temperature on p. 166, and a cooling effect of 3 to 4 °C on pp. 175 and 177, where it carries the whole argument about the extended operating range. And the comparison between 2,087 hours in the band from 15 to 33 °C and 3,011 hours in the band from 15 to 37 °C changes the climate and the upper bound of the measurement at the same time, so that an unknown share of the additional 924 hours is an artefact of the redefinition. The same passage expresses that difference as a percentage where percentage points are meant.

7. Corrections to be made before publication

7.1 The corner ventilation results tables

Of the corrections listed in this section, the following is the one that most requires attention.

The temperature table printed on p. 132 under the heading of ground floor bedrooms is identical, in all forty eight values, to the first floor table on p. 139, and the p. 132 table is itself captioned as first floor. The velocity table beneath it appears to be genuine ground floor data. The text on p. 133 discusses values that occur in neither table.

The missing dataset can nevertheless be recovered, which suggests it exists. Taking the ground floor bedroom differences for 0° from Table 5-10 and applying them to the figures quoted in the narrative closes the row consistently at 36.8, 36.3 and 36.8 °C for the three small-window configurations and 35.2, 34.5 and 34.9 °C for the three large-window configurations, with the two independent routes to the large unshaded value agreeing. The same procedure does not close against the values printed on p. 132. The correct data therefore appear to have existed and to have been used in the later analysis without ever being printed.

This also explains why Table 6-2 cannot be traced to Chapter 5, and the difficulty there extends to velocity as well as temperature: the ground floor figures of 0.23, 0.31 and 0.08 m/s at 0°, 90° and 315° correspond to neither floor as printed.

Until the printed tables are reconciled with the dataset actually used, the ground floor results for this case, and everything in Chapter 6 that depends on them, cannot be independently checked. The Author should therefore establish which figures are the operative ones and reprint them, noting whether anything in the comparisons between floors or configurations changes as a result.

7.2 Column headings in Tables 5-10 and 5-11

The headings of the two corner ventilation temperature difference tables have been corrupted in typesetting. Where the equivalent tables for the through-ventilated case correctly distinguish three window-size contrasts followed by four shading contrasts, the headings in Tables 5-10 and 5-11 collapse into an alternation of two labels repeated across all fourteen columns.

The values beneath were checked against their sources and are correct and in the expected order, so nothing in the analysis is affected. The corresponding velocity tables are sound.

7.3 Sign conventions in the difference tables

The window-size columns reverse their subtraction between the temperature and velocity tables, while the shading columns retain the same order in both. The

consequence is that a positive shading entry in the velocity tables indicates the unshaded case to be the faster, which is the opposite of how the surrounding text reads them. A single sentence of explanation beneath each pair would settle it.

7.4 The counts on p. 153

Page 153 reports seven negative temperature differences among 48 combinations and a positive outcome in 88 percent of scenarios, or 42 of 48; the second figure recurs in conclusion (2) on p. 167. Counting the window-size temperature differences in Tables 5-6 and 5-7 yields eight negative values among 96 cells, or 91.7 percent positive. Taking the ground floor alone gives a denominator of 48 but only five negatives. Neither reading reproduces the figures as printed, and they should be recomputed.

7.5 Boundary conditions and the climate data

Several discrepancies in the stated boundary conditions appear to originate in a single passage, the climate description on p. 83, and identifying that origin should make them straightforward to resolve.

The outdoor temperature of 37 °C to which Chapter 6 refers as the present condition is the value given on p. 83 for Poznan. Both case studies are in Warsaw, for which 35 °C is given and which is the value Chapter 4 adopts. The same passage reports a minimum wind speed of 3 to 4 m/s, after which 4 m/s is used, the upper bound of that range; this appears to be where the 3 m/s in the caption to Table 6-3 comes from, notwithstanding the statement on p. 152 that Chapter 6 works throughout with the conditions of Chapter 4. Relative humidity is 60 to 70 percent on p. 83 and 50 percent in Table 4-6. The future outdoor temperature is 39 to 40 °C on p. 166 and 39.5 to 40.0 °C on p. 171.

Two further items belong here. The supplementary climate analysis promised on p. 83, which was to identify the band from 28 to 32 °C within which natural ventilation is most effective and was expressly deferred to the final chapter, does not appear there. And the upper limit of adaptive comfort is given three values within four pages: approximately 33.8 °C on the authority of the source cited, 33 °C as the figure adopted, and 32 to 33 °C in the closing passage.

7.6 Spatial resolution

Three figures are given for what appears to be one quantity. Page 88 states a result grid of 0.5 m and then describes the resulting spacing as under 20 cm; p. 111 describes extraction at 20 cm; Chapter 6 refers throughout to a field at 0.5 m. A single figure should be established and carried consistently, since the spacing at which the field was sampled bears on how the spatial claims in Chapter 6 are to be read.

7.7 Documentation of the computational campaign

The cleaning step described on p. 111 discards erroneous temperature values without stating what made a value erroneous. One sentence would close this.

More substantially, the dissertation asserts on pp. 88 and 101 that convergence was obtained in every case, but offers nothing in support: no per-case iteration counts, no record of runs that diverged, no meshes that failed, no geometry that required repair, no case excluded or repeated. Across ninety six coupled computations involving rotated geometry and small openings, some trouble is to be expected, and a paragraph substantiating the assertion would cost half a page and would materially strengthen confidence in the matrix.

7.8 Directional conclusions stated without their conditions

A reader who consults Chapter 5 and Chapter 6 for advice on orientation will find the same direction commended in one place and warned against in the other. Sections 9.4 and 9.5, two pages apart on pp. 125 and 126, place the south-easterly and south-westerly directions among the worst for overheating and among the best for ventilation respectively. Conclusion (1) on p. 166 commends the southerly direction for cooling, whereas p. 128 groups it with those that deliver heated air.

Neither pairing is an error. A strong flow of hot air is both a strong flow and hot air, and a southerly wind arrives at a windward living room and a leeward bedroom under quite different conditions. What is missing in each case is the qualifier, and its absence converts correct observations into contradictory advice. Every such statement should carry the zone and the configuration to which it applies.

A comparable ambiguity attends the shading result. Pages 154 and 167 give the overhang as superior in the through-ventilated case, while a parenthetical comparison on p. 158 implies the louvre to be superior there as well. As this is among the strongest findings in the dissertation, it should be stated once and unambiguously.

7.9 The superseded analysis in Chapter 5

Sections 5.1 to 5.8 of Chapter 5, some ten pages, analyze the results by the centreline method that section 6 then sets aside. The note at the close of section 5.8 indicates that this material derives from the Author's own publication of 2023. Compressing these sections, or relocating them to an appendix as the preliminary analysis, and moving the attribution to the beginning where the reader will meet it first, would shorten the dissertation and remove the impression of two competing analyses of one set of computations.

7.10 The balcony study

Within Chapter 6, the treatment of orientation, window size and shading proceeds from the parametric matrix. The balcony study that follows does not: it rests on one wind direction, on planes extracted for the purpose, and on an estimated rather than

computed reduction in mean radiant temperature. It nonetheless issues specific recommendations as to balcony depth and parapet height. Either it should be set apart from the parametric sequence, or its conclusions should be marked as indicative.

7.11 The treatment of symmetry

Directions above 180° are passed over on the ground that their results resemble those already presented, and the corresponding figures are not given. The difficulty this creates is one of verification: a reader who wishes to check the resemblance has nothing to check it against, and the same applies to the second corner dwelling, which is described as behaving much like the first without its data being shown. Two measures would resolve this at little cost, namely a statement of how much difference was accepted as resemblance, and the tabulation of the omitted values in an appendix. The dissertation shows elsewhere that a facade in afternoon sun does not behave as its shaded counterpart does, which is why the western dwelling was selected for detailed treatment in the corner case; the omitted directions are therefore exactly where the reader would most wish to look.

7.12 Regulatory sources

The account of the Polish regulatory framework is substantively accurate and draws on suitable secondary literature, including Polish-language sources. Not one primary legal or normative instrument, however, is cited anywhere in the dissertation. The technical conditions, the national ventilation standard from which the quoted air flow requirements of 70, 50 and 30 m³/h derive, the European indoor environment standard and the Energy Performance of Buildings Directive are all discussed without being referenced. Where the dissertation asserts what a regulation does or does not contain, and the assertion that overheating goes unaddressed is central to its motivation, that assertion should rest on the instrument itself rather than on a paper describing it. A citation in author-date form on p. 58 is moreover attached to a numbered reference to an unrelated document.

A narrower observation belongs here. The chapter rests on very few sources, and all seven of its figures derive from one report. For a chapter whose function is to establish the national context this basis is thin.

7.13 Bibliography and editorial matters

Two entries are duplicated and should be merged: one report on the financing of energy performance improvement appears twice, as does one review of computational fluid dynamics plug-ins, the latter under two different years. The second of these is the sole authority for the choice of simulation software.

The dissertation would benefit from a language and editorial revision. Numbering subsections afresh in each chapter makes precise citation awkward, and over

considerable stretches of text the figures and tables are not referred to by number, so that the correspondence between illustration and argument is left to be worked out.

8. Proposals for the further development of the research

Neither of the following is a requirement. They indicate where, in the Reviewer's opinion, this work could be taken with the greatest benefit.

8.1 Press the regulatory argument, and ground it in health

The dissertation identifies correctly that Polish regulation is built around energy demand and has little to say about summer comfort or overheating risk. Section 9.7 of Chapter 3 already proposes that comfort and indoor air quality requirements be introduced, together with minimum provisions for solar protection. That recommendation is right, and the Author should make far more of it than he does.

At present it appears in a literature chapter, ahead of any of the evidence, and never returns. Yet the evidence that would carry it is produced later in the same volume. Interior temperatures approach 46 °C in the least favourable configurations. More pointedly, the analysis of the corner case reports that the share of the stagnant zone exceeding a Standard Effective Temperature of 38 °C, which the Author identifies as a threshold of cardiovascular stress, rises from roughly 28 percent today to roughly 62 percent by 2050. He describes this as the most alarming result of the future-climate analysis. It then appears in neither the abstract, nor the chapter conclusions, nor the closing.

That result should be brought forward, and the regulatory recommendation restated at the end of the work and supported by it. The argument should also be widened from thermal comfort to indoor air quality and health, because the causal chain is available and is, in the Reviewer's view, the strongest claim on policy the dissertation is in a position to make: a framework that optimizes one variable produces overheating and impaired air quality as by-products of the sealed, heavily insulated envelope it rewards. Anchored to a threshold of physiological risk rather than to a ceiling of adaptive acceptability, the argument would also answer the objection that 33 °C is not a defensible limit where vulnerable occupants or regulatory application are concerned.

8.2 Finish the design matrix, and weight it by wind frequency

As set out in Section 6.1, extending Tables 6-1 and 6-2 across all four analyzed zones, with the recommended window width and shading arrangement named for each orientation, would convert the dissertation's most usable material into guidance. Stated as conditional rules, with the circumstances under which each reverses given alongside it, this would be the artefact the aims promise, and the greater part of the work is already done.

One addition would increase its value considerably. The eight directions are weighted equally throughout the dissertation, and no frequency distribution is presented, although Figure 4-21 does contain hourly directional data for four cities. For a study of natural ventilation the operative question is how often the required combination of temperature, wind speed and direction actually occurs. A frequency-weighted summary would distinguish the recommendations that matter most of the time from those that matter rarely, and the data needed is already in the Author's hands.

9. Originality of the solution and conclusion

In the Reviewer's assessment the dissertation presents an original solution to a scientific problem within the meaning of Article 187(2) of the Act.

The originality is not in the use of computational fluid dynamics, which is by now unremarkable, but in what was done with its output. Three things stand out.

The first is the demonstration, by measurement rather than by argument, of how far an opening's performance depends on its situation: on its place in the plan, on the solar condition of the surface the air crosses before it enters, and on the level at which the dwelling sits. That is a quantitative case against designing from an idealized room, and the dissertation makes it with its own numbers.

The second is a design rule of immediate applicability that does not appear to have been previously stated in these terms, namely that the solar protection appropriate to a through-ventilated dwelling is the wrong choice for a corner one, together with the physical reason why.

The third is the demonstration of how much of the spatial pattern of comfort a single weather-file wind speed conceals, and a workable method for recovering it.

Taken with the treatment of corner ventilation, which the literature has neglected relative to its share of the stock, these constitute a genuine addition to knowledge in the discipline. That the results were carried back into the language of plans, openings and orientations is a harder achievement than the computation itself, and it is the step most studies of this kind omit.

On the evidence of this work the Author is able to conduct scientific research independently. He located a question the literature had left open, assembled the empirical basis for answering it before choosing his instrument, and reported the places where his own verification came off worst. What the dissertation does less well is documentation, and the drawing of boundaries around its own conclusions. Those are matters of presentation, and the material needed to put them right is already in hand.

The Reviewer therefore states that the doctoral dissertation submitted by mgr inż. arch. Mohammad Mahdi Mohammadi, entitled "The Future of Housing Buildings; Optimizing Natural Ventilation Strategies in Polish Housing: Simulation-Based Design for Thermal

Comfort in a Changing Climate", meets the requirements set for doctoral dissertations in Article 187 of the Act of 20 July 2018, Law on Higher Education and Science. It demonstrates the Author's general theoretical knowledge in the discipline of architecture and urban planning, confirms his ability to conduct independent scientific research, and presents an original solution to a scientific problem.

The Reviewer assesses the dissertation positively and requests that the Council of the Discipline of Architecture and Urban Planning at Poznan University of Technology accept it and admit the Candidate to the public defence.

Given the originality of the research design, the attention paid to corner ventilation as a subject in its own right, and the openness with which the limits of the verification are reported, the Reviewer further proposes that the Council consider awarding a distinction.

Statement on the use of AI tools

Generative AI tools were used in preparing this review, as an aid in checking page references and tabulated values against the text and in editing language. The dissertation was read by the Reviewer, and every judgement, question and proposal set out above is his own, for which he accepts responsibility.



Angelos Chronis

