NATURAL VENTILATION AND PASSIVE COOLING SIMULATION IS NOT ANY MORE A PRIVILEDGE OF EXPERTS

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ABSTRACT

Natural ventilation and dynamic temperature simulation of buildings was until now a priviledge of highly skilled building physicists. Combined simulation of both is even rarer.

A new software approach guiding the user to construct rapidely, easyly and intuitively step by step a valid thermal model, makes passive cooling design affortable to any building designer, even to a non building physics experts. Dial+ software offers the possibility to sumulate for the same room natural ventilation air flow, dynamic thermal behaviour and natural lighting performance. Behind its intuitive interface, Radiance for natural lighting, Cocroft algorithm for natural ventilation and EN ISO 13791 indoor air dynamic simulation give answers to the designers questions in order to optimise design and meet passive building specifications.

The article presents how the software was employed to optimise two similar office buildings situated one in Geneva and one in Nicosia. Both buildings consume less than 40 kWh/m2 of primary energy. The results show how essential is night cooling in both mediteranian and central Europe climates and quantify the contribution of passive techniques (insulation, glazing performance, solar shading, thermal mass etc) to the high energy performance. Both buildings were constructed and the performances verified in practice.

KEYWORDS
Potential for ventilative cooling strategies - Design approaches for ventilative cooling and case studies - Ventilative cooling in energy performance regulations - Summer comfort and ventilation.

INTRODUCTION
Estia SA in collaboration with the Laboratory of Urban Architecture and Energy Reflexion (LAURE/EPFL) has developed a suite of software tools aiming to simultaneously assess:

- Daylighting: **Dial+Lighting,**
- Natural window ventilation: **DIAL+*Ventilation***,
- Thermal dynamic behaviour for winter or summer conditions: **DIAL+*Cooling***.

The possibility to combine natural and artificial lighting analysis with natural ventilation and dynamic indoor temperature analysis existed in the past, but it was a privilege for researchers, or building physics experts. The corresponding tools did require a high level of expertise, many weeks of training and many working hours to build credible models able to calculate correctly a given reality. Thanks to its intuitive interface, DIAL+ innovates and gives to non-expert users the opportunity to quickly model a complex room and to calculate the following results:

- Dynamic indoor temperature (ISO 13791)
- Number of overheating hours (SIA 382/1, EN 15251)
- Solar gains (taking into account fixe or movable shading and horizon obstacles)
- Stack effect natural ventilation airflow rate (dynamically hour by hour)
- Annual energy demand for heating and cooling (EN 15255, EN 15265)
- Daylight factor values (BREEAM, CERTIVEA)
- Daylighting autonomy (MINERGIE ECO, SMEO, LEED)
- Annual energy consumption due to artificial lighting (SIA 380/4, MINERGIE)

The three software modules are designed with a particular focus on user-friendliness. User data input is simple and straightforward and thus allows planners to correctly model the room and quickly analyse lighting and thermal indoor comfort, even without profound knowledge of building physics.

The software suite DIAL+ therefore represents a simple and efficient professional tool, ideal not only for proving the conformity to various norms and building labels, but also for optimising building design, especially in early planning phases.

Software interface description, methods and more references may be found in [1]. The software possibilities are presented through optimisation in the design process of two similar office buildings, one situated in Geneva and one in Cyprus.

PRESENTATION OF THE TWO BUILDINGS AND SOME INTERFACE WINDOWS OF THE SOFTWARE DIAL+

Figure 1. Picture of the south facade and plan of the second floor of the two buildings. Building Ge is on the left and the building Ni on the right.

Building Ge is situated in Geneva suburbs - Switzerland in an industrial area, while building Ni in Nicosia city centre – Cyprus. Both of them are low energy office buildings, privileging passive strategies and technical sobriety rather than high standard complex technical installations. Both buildings are naturally ventilated and heated / cooled with a standard solution common in the local market. Both buildings rely on a high energy-performance envelope, passive solar gains and passive cooling. Inauguration of building A took place in 2009, and of building B in 2012.

	Building Ge	Building Ni
Thermal insulation position	external	external
Wall thermal insulation thickness	16 cm	10 cm
Roof thermal insulation thickness	20 cm	10 cm
South glazing g value	0.6	0.4
North glazing g value	0.4	0.4
Window U value	1.3 W/m^{2}K	1.3 W/m^{2}K
Glazing light transmittance	O,7	0.7
Ventilation opening dimensions	55X170	40/60X300
South glazing dimensions	340 X 170	140X300
North glazing dimensions	340 X 200	2 X 140X300
Static solar shading south	100 cm top	60 cm top, 60 cm sides
Static solar shading north	-	Vertical fin 60 cm
South movable solar shading	G shading 0.2	-

Table 1. technical characteristics of the two buildings.

To compare the behaviour of the buildings we isolate a section of the building of 3.6 m large

Some windows from the software interface to enter the space characteristics

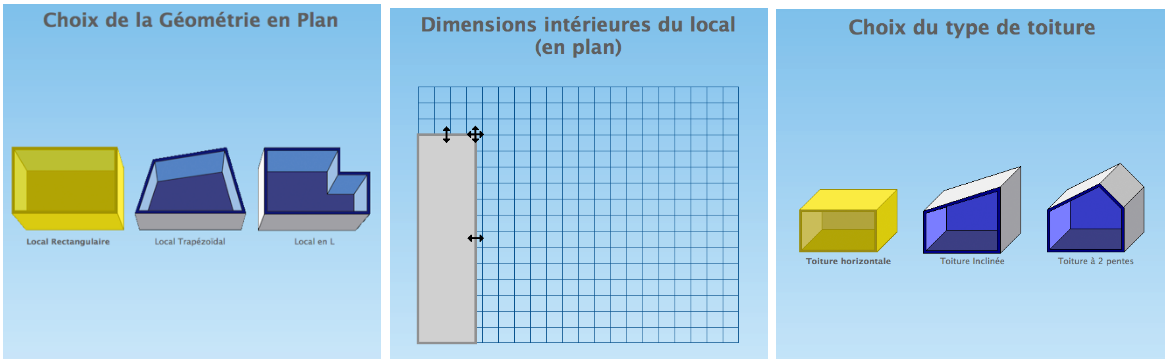


Figure 2. Intuitive interface makes it easy to enter the building dimensional characteristics.

Figure 3. Some window characteristics.

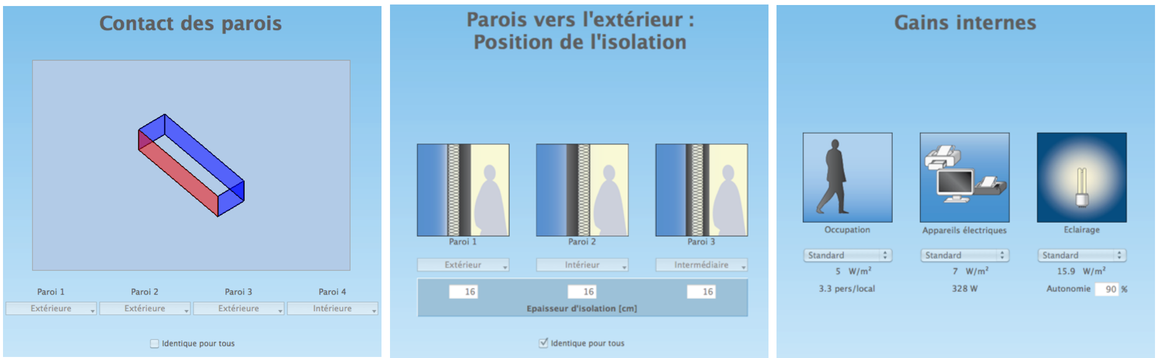


Figure 4. Some thermal characteristics of the building elements and some schedules of conditions of use.

These are some of the interface windows showing the intuitive spirit of the software. For every quantitative value, a qualitative description or a picture help the users to introduce a correct model corresponding to reality, even when if they are not specialists.

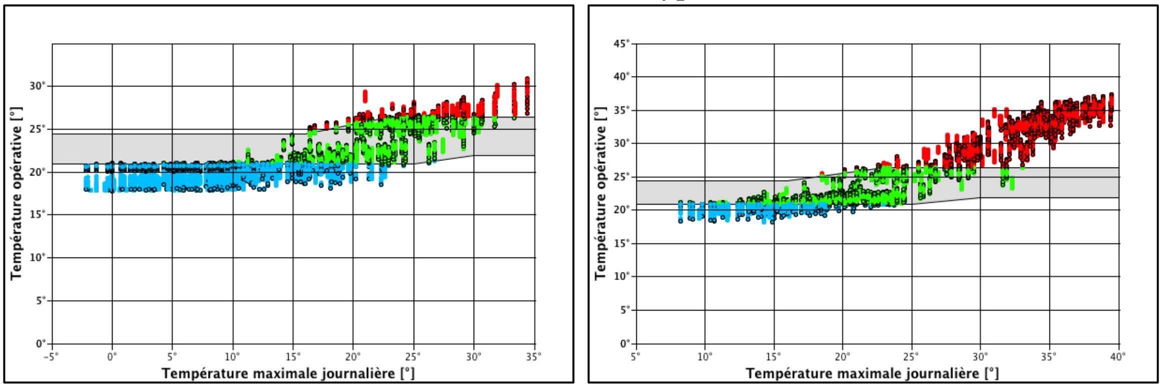
THERMAL BEHAVIOUR OF THE BUILDINGS SIMULATED BY DIAL+

Both buildings are simulated in the Swiss climate and in the Cyprus climate. Simulations consider no special free cooling strategy except of opening the windows when it is too hot.

Overheating hours

Overheating hours are calculated whithout and mechanical cooling.

In Swiss climate | In Cyprus climate



Ge: 240 overheating hours
Ni: 191 overheating hours

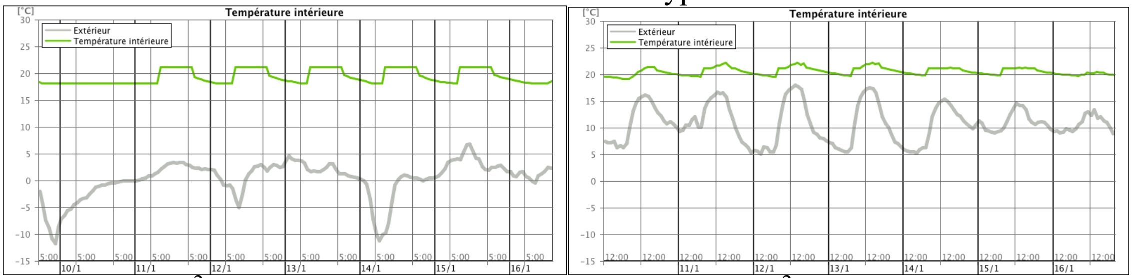
Ge: 1251 overheating hours
Ni: 1262 overheating hours

Figure 5. Temperature distribution of the buildings in Geneva and in Nicosia.

The behaviour of the two buildings is similar for both climates. The Ni building presents less overheating hours than the Ge building because the glazed part is less in the south façade. Although the Ge bulding has external solar protection, the Ni building is better protected by the sun.

Heating demand
Heating demand depends on thermal insulation and on solar gains.

In Swiss climate | In Cyprus climate



Ge: 56 kWh/m^{2}y of heating demand
Ni: 65 kWh/m^{2}y of heating demand

Ge: 7 kWh/m^{2}y of heating demand
Ni: 8 kWh/m^{2}y of heating demand

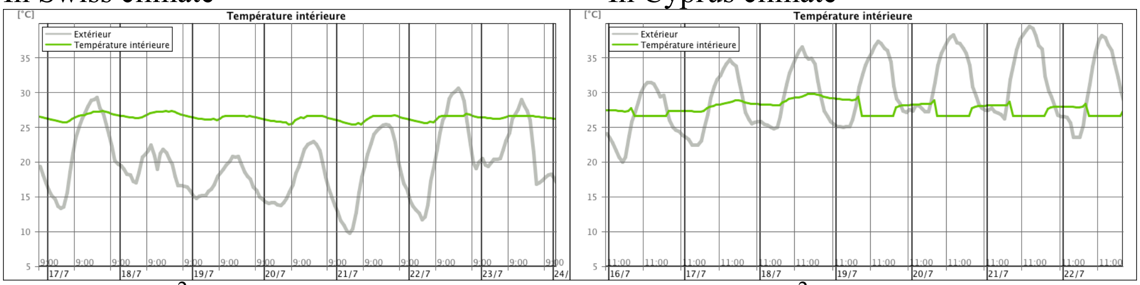
Figure 6. Heating demand of the buildings in Geneva and in Nicosia.

The Swiss building with 16 and 20 cm of thermal insulation saves only 1 kWh/m2 in the Cyprus climatic conditions. This means that over the passive standards of 10 cm of insulation more insulation has very little effectiveness. The Ni building with 10 cm of insulation would consume 16% more than the Ge building. This means that additional insulation in the Swiss climate makes sens.

Cooling demand

Cooling demand is calculated with a conventional air conditioning functioning during working hours to bring temperature down to 26.5°C.

In Swiss climate | In Cyprus climate



Ge: 3 kWh/m^{2}y for cooling demand
Ni: 3 kWh/m^{2}y for cooling demand

Ge: 65 kWh/m^{2}y for cooling demand
Ni: 35 kWh/m^{2}y for cooling demand

Figure 7. Cooling demand of the buildings in Geneva and in Nicosia.

These results show as for the calculation of the overheating hours that the Ni building is better adapted to the hot climate because of its smaller glazing at the south façade.

OPTIMISATION STRATEGIES

Night cooling in Switzerland
Opening the window during working hours when it is too hot for Ge building is not a sufficient strategy. Although opening the windows reduces the overheating hours from 491 to 240 compared with a scenario with the windows closed, poor comfort is still present. The solution is a mechanical cooling, consuming 3 kWh/m^{2}y of a free natural cooling by night

ventilation. Night ventilation reduces to 5 the overheating hours, offering satisfactory comfort conditions.

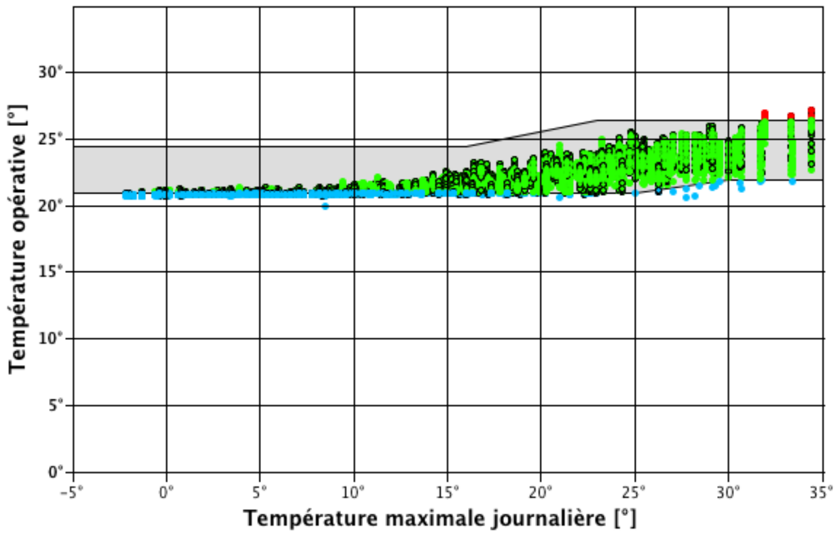


Figure 8. Overheating hours for Ge building with night ventilation strategy for cooling. Overheating hours are reduced to 5.

Night cooling in Cyprus

Night ventilation without air conditioning reduces overheating hours from 1262 to 707. It is a considerable reduce but still uncomfortable. However, with the use of air conditioning, night ventilation reduces the cooling demand to 16.5 kWh/m^2y instead of 36.5. Cooling power of night ventilation goes up to 1500W or 32 W/m^2.

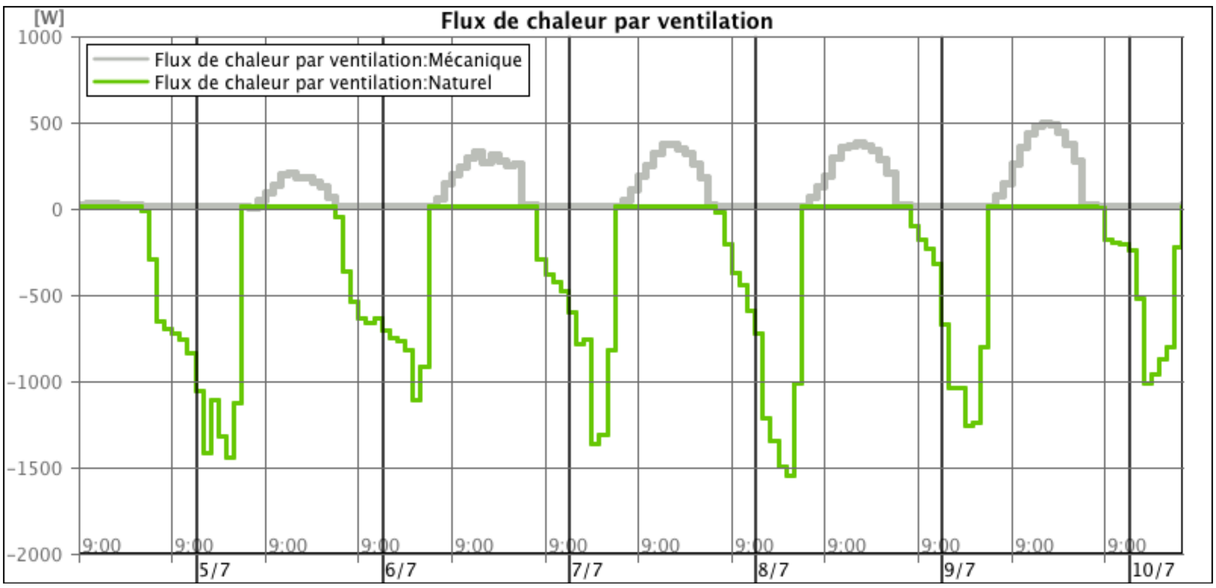


Figure 9. Free cooling power of night ventilation.

The presence of a ceiling fan, rising the tolerated highest temperature to 28.5 °C, before switching on air conditioning, reduces cooling demand even more at 6 kWh/m^2y instead of 16.5 kWh/m^2y with set temperature 26.5°C.

Heat recovery in Switzerland and in Cyprus

In Cyprus a heat recovery system of 80% efficiency reduces heating demand to 4.5 and cooling demand to 33 kWh/m^{2}y instead of 8 and 35 kWh/m^{2}y respectively. The total reduction is 5.5 kWh/m^{2}y or 13%. However, this increases energy consumption to run the fans. The total balance of primary energy is not positive.

In Switzerland, the same system reduces heating demand to 35 kWh/m^{2}y instead of 56. Cooling demand change is not significant. The reduction of 21 kWh/m^{2}y or 37.5% is significant and may pay the primary energy necessary to run the fans, especially when the recovered energy if of high primary energy content.

CONCLUSION

In order to illustrate the use of DIAL+ software we compared the dynamic thermal behaviour of tow similar office buildings in Cyprus and in Switzerland. This comparison shows the potential of the software, but it also shows that passive technics pay differently in a hot and in a cold climates. For hot climates, instead of airtightness and heat recovery, common in north and central Europe countries, natural ventilation and night cooling are much more efficient. Without night cooling strategy it is difficult to meat passive house standards.

REFERENCES

[1] Bernard Paul et al, 2012. *DIAL+Suite : a new suite of tools to optimize the global energy performance of room design*, Status Seminar, Zurich.

More references about DIAL+ methods are found in reference 1.