SOLAR SCHOOL PROGRAM IN REUNION ISLAND

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Summary

Because of its particular geographic situation and relatively high altitude (3069 meters), Reunion Island is composed of a very large amount of micro-climates which have direct impact on buildings' comfort, energy consumptions and renewable energy system efficiency.

In Réunion Island, the industrial engineering laboratory is involved in the regional solar school program. Its aim is to gather some local construction actors (cities technical office, architects, civil engineers, specialized university team research, meteorological services), for a better knowledge transfer, and a better environment understanding. The main objective is to rehabilitate primary school in a bioclimatic and low energy consumption way, taking into account of climatic conditions.

Three primary schools corresponding to three particular micro-climates have been studied, simulated to evaluate main comfort targets (from a thermal, ventilation, humidity, lighting, and acoustic points of view). Architects then worked considering the technical prescriptions for renovation project. An internal and external instrumentation has been installed before and is planned to be reinforced after the renovation to valid these prescriptions.

This program illustrates exactly what has to be done in each building project:

- Meteorological data acquisition (hourly data for simulation software and for renewable energy options analysis and optimizations).
- Thermal comfort simulations taking into account of natural ventilation, heating or cooling needs, condensation or other pathologies risks.
- And finally, instrumentation campaign for all targets evaluation.

Keywords: bioclimatic, comfort, micro-climates, renewable energy.

INTRODUCTION

Reunion Island is situated near the tropic of Capricorn at the latitude of 21° south and a longitude of 55° east. The climate is humid tropical on coast, and rather like temperate climate in high altitude. There is a wet season (November-April), mainly warm and rainy with risks of cyclones and a dry season (May-October), cool and drier, predominated by trade winds. There is a lot of different micro-climates due to the high altitude (3069m), specific relief, and geographic orientation.

In the insular context of fossil energy dependency, the local economy has to supply important needs in accommodations. Following the "Agenda 21", the local energy policy promotes energy reduction needs in buildings and initiates the "Solar school program". This action gathers local construction actors: cities technical office, architects, civil engineers, specialized university team research and meteorological services.

The program consists of rehabilitation of three primary schools (Espérance, Goyaviers and Platanes Sud) following bioclimatic prescriptions. Figure 1. presents steps that will be apply to design prescriptions in buildings construction or renovation according to micro-climates. We illustrate the steps with the case of Platanes' school, altitude 970 meters. Scientific publications already explained similar methodologies [1] [2] [3] [4]. A micro-climatic characterisation and by numeric simulations of buildings behaviours, energy consumption and renewable energy systems production (photovoltaic, solar thermal water, wind turbine) give quantitative solutions and advice for architects and civil engineers. During the rehabilitation works, scientific instrumentation for comfort and energy system evaluation is installed.

MICRO-CLIMATIC ANALYSIS

Reunion Island overseas territory has the densest France's meteorological net. It is composed of more than sixty [Meteo France] points of survey, including one for each primary school of the program. Automatics [Météo

France] stations measure and store each hour: dry air temperature (°C), relative humidity (%), global irradiation (j/m²), wind speed (m/s), wind direction (°) and pluviometry.

Treating large range of climatic data needs computer support like NewRuneole software based on climatic data bases analysis and generation using the typical weather sequences study [5]. It can provide pertinent files for buildings and energy systems simulation software. It is very powerful for climatic characterisation and climatic potentials or constraints evaluation.

NUMERIC SIMULATIONS

NewRuneole creates the implementation file for the building behaviour simulator CODYRUN. CODYRUN is a detailed building thermal simulation software regrouping design and research aspects. This software has already been covered in various publications [6]. Essentially, it involves multiple zone software including natural ventilation, humidity transfer and comfort estimation.

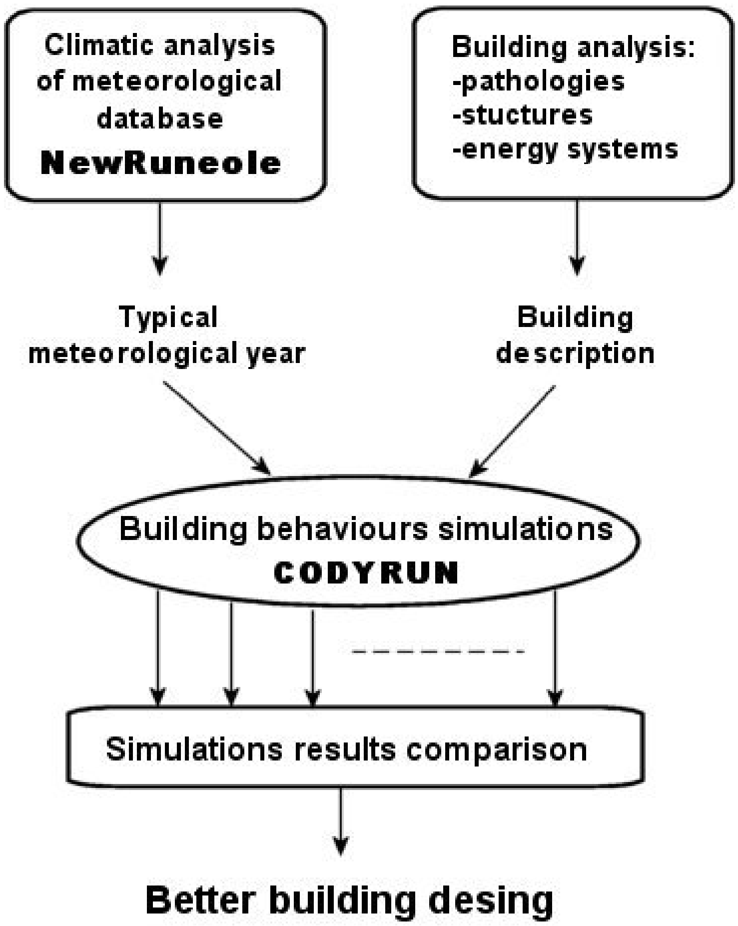

Figure 1. Applied methodology to support architects design

First step: in situ observations permit a first approach to evaluate buildings pathology and configuration (table 1. and figure 6.). At the same time we collect climatic data, we lead a measurement campaign about indoor comfort variables with “white boxes”. This small thermo-hygrometer datalogger stores hourly data during 40 days. Numeric simulations of the buildings before rehabilitation lead to comparison with in situ surveys during two sequences in dry and wet season.

	Description			Pathologies	
Classrooms 1 to 4	Orientation of principal faces		North and south	Thermic	Heat sensation in wet season with uncomfortable ventilation
	Dimensions		7.87m long, 7.43m large and 3.5m high		Sensation of discomfort in dry season (due to low temperatures or high humidity rates)
	Structure		Reinforced concrete beams		Heating : 2 electric convectors
	Walls and roof		20cm concrete	Humidity	Infiltartions by ceiling
	Windows	North face	2 sliding window 183x138cm		Decollement of painting
		South face	3 french windows 176*138cm		Molds
			8 Nacos 70x80cm	Acoustic	None
	Doors	Extern	1 door 210*108cm	Lighting	use of artificial lighting
		Intern	1 door 210*108cm		Insufficient in natural lighting

Table 1. Platanes' school description and pathologies

In the figure 2., The "initial building" curve is the thermal numeric simulation during dry season of the building actual configuration without using the electrics convectors. "Measured data" curve corresponds of the in situ survey during the same days. The impossibility to model how users usually turn on the electric convectors explains the differences between the curves. The figure 3. corresponds to simulated condensation risks, they are anormally high because of humidity sensor overestimation. Rather than absolute observations, we will look relative differences between simulations. Figures 2. and 3. are temperature and condensation risk means for each hours of the considered period (July 23 to September 2 - 2002).

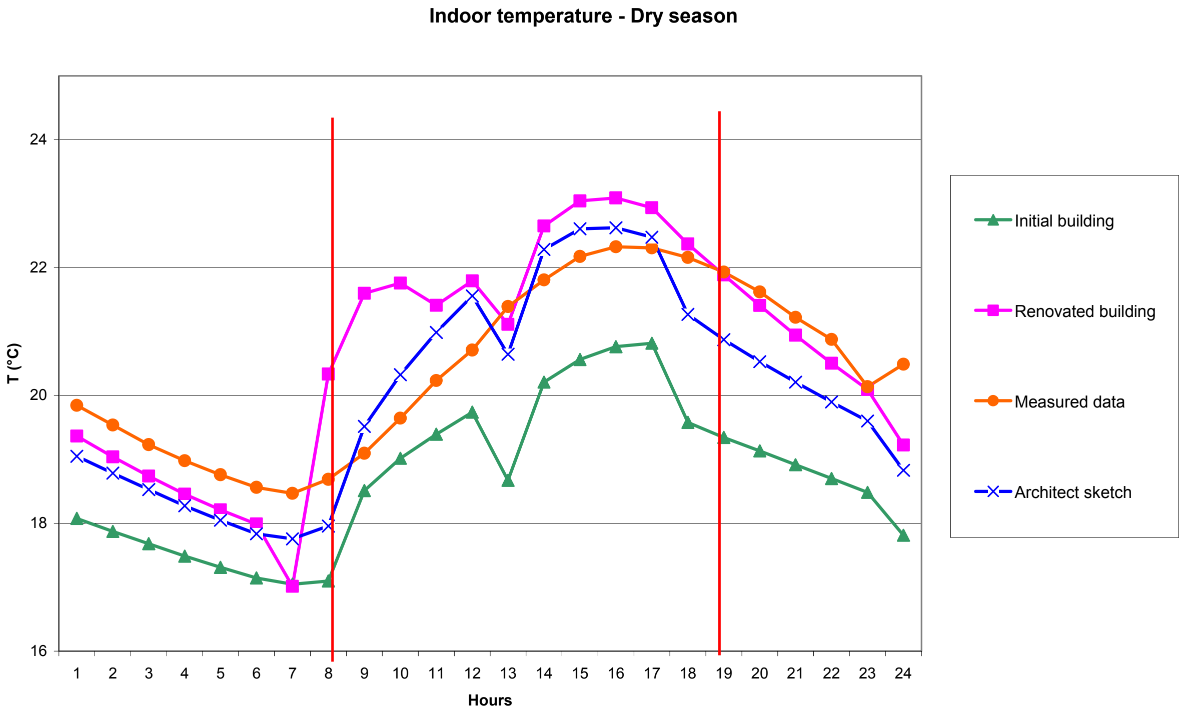

Figure 2. Comparison of measured and simulated mean day indoor air temperatures during dry season

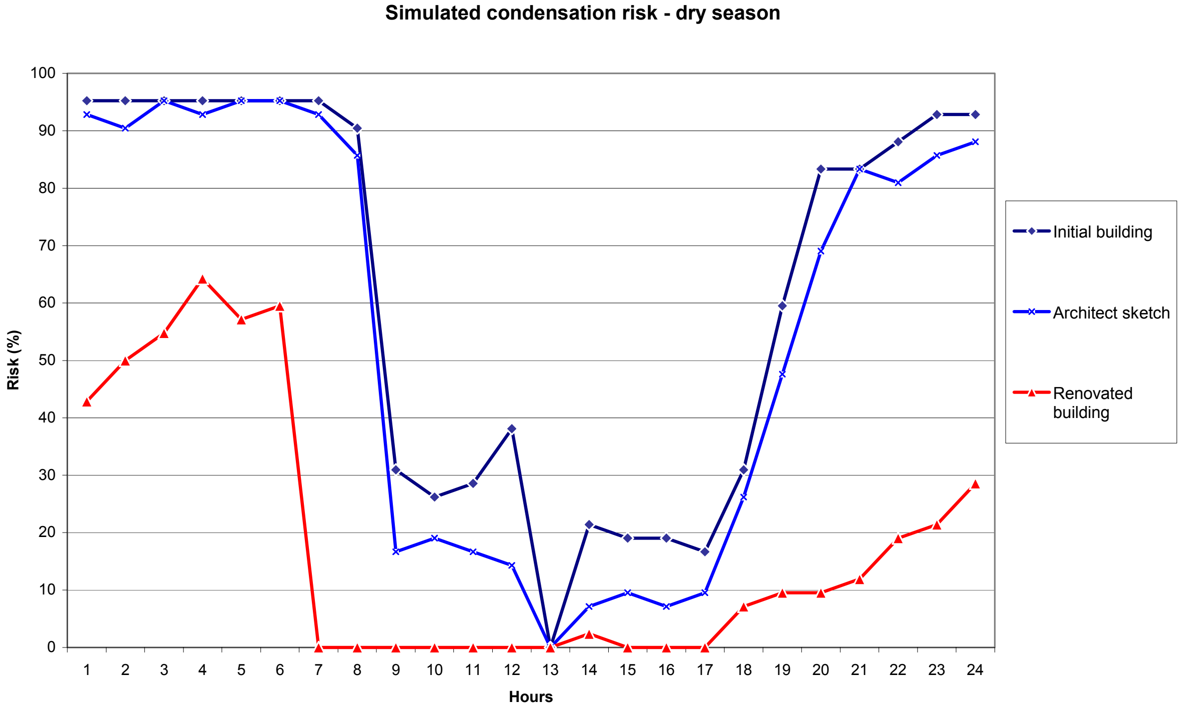

Figure 3. Comparison of simulated mean day condensation risk during dry season

Second step: simulation of architect sketch and test of different building configurations without significant architectural changes.

We virtually put on basic architectural solutions and systems suitable for micro-climate. In the warmer part (littoral), use of well dimensioned solar protections and large open surfaces facing thermal winds (generally perpendicular to trade winds direction on coastal area) give well building behaviours [4]. In the colder part (high altitude), to limit heating needs during dry season systems that collect solar energy in the morning are good solutions [2]. The most problematic zone is situated between the two last parts of the island. Up to 400 meters and under 800 meters, where the mean annual temperature is up to 21°C, high humidity rate produce discomfort feeling and fast building damages. Numeric simulations are useful to reach the best compromise between solar collection and protection including good ventilation for both season.

In Platanes' school case, two main problems have to be solved, hot temperature in wet season due to bad natural ventilation. In dry season sensation of cold is intensified by high humidity rate during first hours of morning (figure 2., "initila buildings" and "measured data") and there is problems of condensation (figure 3., "initial building"). The way to lower both building pathologies is a good concordance between sun protections and ventilation.

In sketch, architect put on 7 m² of windows opening in the top of the north face. Translucent panels including an 80cm solar protection dark panel on the wall side substituate the concrete veranda (Figure 6.). In this building configuration, the new openings give good natural lighting in class, good natural ventilation in wet season and higher temperature in dry season but persists the problem of discomfort during the first hours (figure 2., "architect sketch") and condensation risk (figure 3., "architect sketch").

Simulation shows that mechanic ventilation is necessary to limit condensation risk in dry season. To have good inside air temperature during first hours, two ways have been considered: try to keep good level of inside air temperature with insulation or to heat the classroom early in the morning.

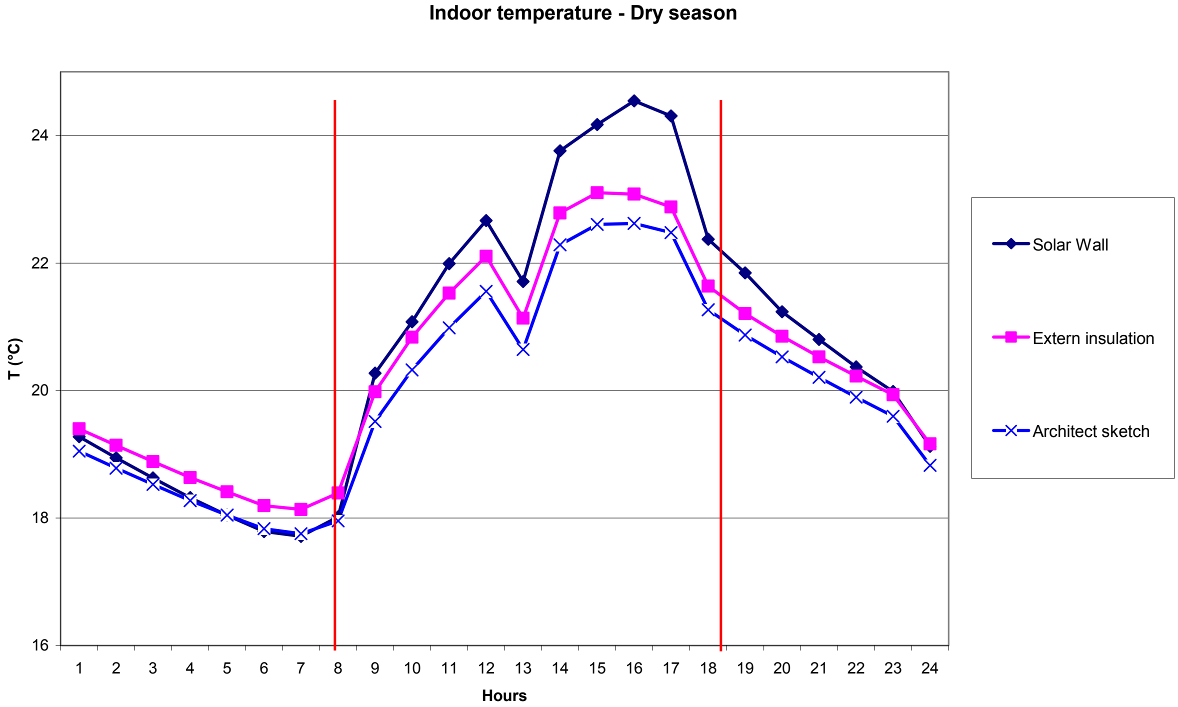

Figure 4. Comparison of measured and simulated mean day indoor air temperatures during dry season

Passive insulation solution, for intern or extern faces of the walls, is not sufficient to keep good level of temperature during night (figure 4., “extern insulation”). To heat the classrooms, we tried solar walls [7] [8] on north face of the building. Figure 4., “solar wall” curve shows that solar walls don’t give enough heat supply during first hours. Taking in account solar walls and building thermal inertias, the effect on class rooms heating begin after 11 hour in the morning. Passive solutions are not sufficients to carry morning temperature at good level. So we test basic active solution, an heating electric resistor inside mechanic ventilation system. This last solution seems to be the best. Turn on the resistance and ventilation system from 6 to 9 hour in the morning it is possible to reach comfort feeling from first hour of school (figure 2., “renovated building”) and minimize condensation risk (figure 3., “renovated buiding”). The comfort index PMV [11] was calculating for each simulation (figure 5.).

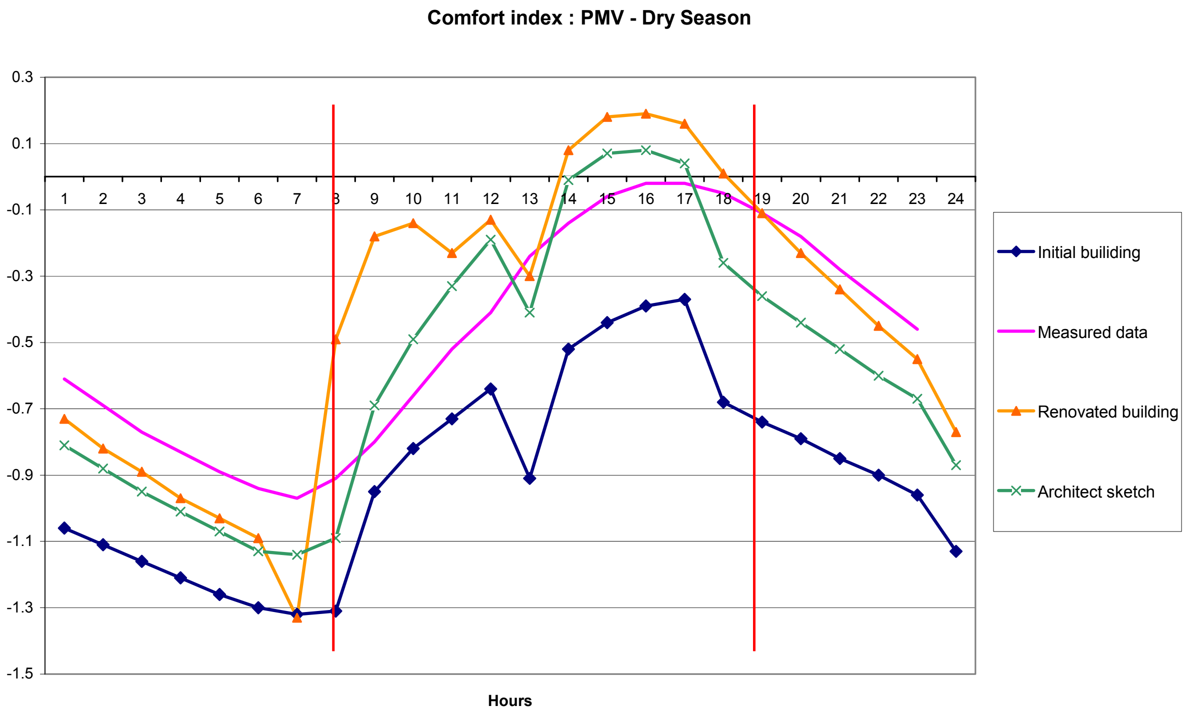

Figure 5. Comparison of measured and simulated mean day PMV during dry season

To know which renewable energy system is pertinent to use [9], we evaluated the climatic resources (daily radiation, wind, rainwater) of each micro-climate. Everywhere in Reunion Island there is a good solar potential. The daily mean radiation is up to 5kWh/m²/day for the coast and around 4.5kWh/m²/day for the rest (table 2.). Long term simulations show that photovoltaic panels, with normal sate subvention and electrical net connexion, takes less than 10 years to obtain return on investments. Likewise solar thermal water is really efficient. Wind turbines start to have good efficiency for a wind speed up to 4m/s. So, to evaluate the wind potential, it is useful to know the wind speed statistical distribution (table 2.). The wind potential is probably the less known for the island, and the cyclonic risk can reduce the useful life of the wind turbines. In the Solar School Program, we only forecast low power wind turbines with fold down possibility. It reduces the risk of noise perturbation and cyclonic destruction for schools and neighbours.

In Platanes' school case, only 10 percents of the time blow winds faster than 4m/s (table 2.), so it is not pertinent to forecast the installation of a wind turbine. But like everywhere in Réunion Island, solar potential can be fully used. So all hot water needs will be supplied by solar thermal water system. Near 60m² of photovoltaic cells will be installed on roofs.

	Platanes (670m)
Mean air temperature	21.5 °C
Mean hygrometry	%
Daily mean radiation	4576 Wh/m²/day
Wind speed < 2 m/s	77.5 %
Wind speed > 4 m/s	10 %
Annual pluviometry	1800 mm

Table 2. Climatic data for energy potentials evaluation

The final step of the numeric simulation campaign is the knowledge transfer to architects and civil engineers. They can take into account all comfort and energy factors to design the better rehabilitation without forget social, financial and architectural constrains (figure 6.).

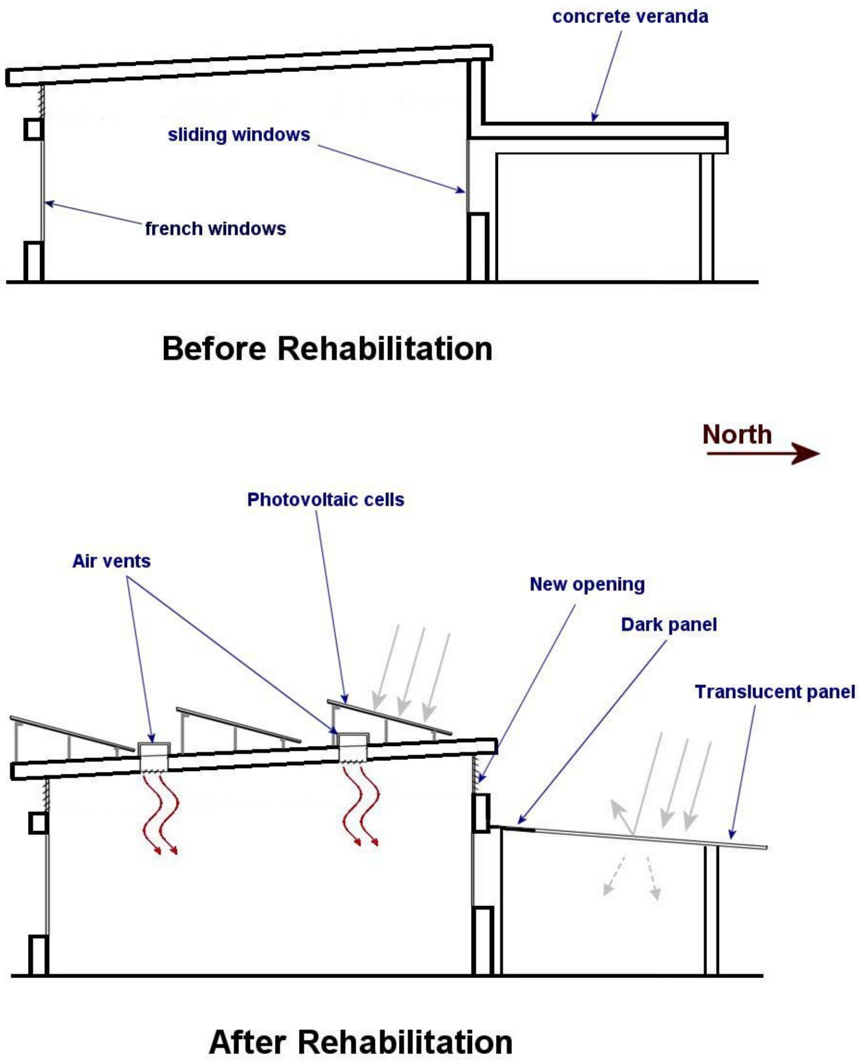

Figure 6. Platanes' primary school, before and after renovation works

RENOVATION AND SCIENTIFIC MONITORING

Rehabilitation forecast schedule: beginning of the work end of the year 2004 for a duration of 10 month.

The building rehabilitation will include a scientific internal instrumentation. One classroom per school will get a complete comfort acquisition chain. In humid tropical climate, human comfort in buildings depends on temperature, humidity, and inside wind velocity [10]. Last one is important for warm and wet weather, the first meter per second of wind speed reduce of 4 degrees thermal skin sensation. This acquisition chain is made up of 4 comfort sensor modules with homogeneous space repartition, air quality and air renewal sensors (Fig 7.). Thermo-hygrometer, indoor air flow probe and long wave radiation sensor compose the 4 comfort sensor modules. The measurement campaign comes with questionnaires about users feeling. Finally the energy consumption and production will be measured and stored with electricity meter (one for each energy source).

All these data acquisitions will be gathered on same computer inside the school. They will serve for educational purpose and could be transfered in our laboratory by internet to create a database about comfort and energy in primary school, generally in tertiary sector.

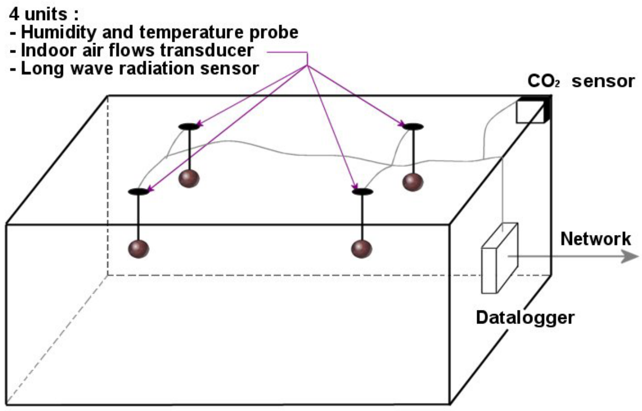

Figure 7. Internal comfort monitoring

This database will permit multiple validations:

- validation of comfort index for insular tropical damp climate taking in account of the micro-climates differences,
- validation of architectural prescriptions for energy saving,
- validation of models of renewable energy systems under humid tropical climate.

CONCLUSION

Our approach to study and realize comfortable and low energy consumption schools use experimental steps of simulation, measurement and validation. It permit to devellop (NewRuneole) and validate (CODYRUN) tools inside a global methodology. The "champ d'action" of these reasearch softwares could be extend to other sector of buildings design.

This analysis showed a multi approach of buildings. It tries to estimate the impact on building comfort and energy benaviour of all possible technical solutions that can be applied on architects design base. Because of its too important time simulation cost, this methodology is not applicable on all renovation or construction projects. So like in the "ECODOM label" elaboration [4], a knowledge database is created with the large number of simulation we have done. The same analysis of different typical buildings for each micro-climatic zone will complete it.

In Reunion Island, this knowledge database will be the base of how to build good comfortable and low energy consumption buildings taking in account the micro-climate. The methodology and tools we showed during this paper will be fully applied in the thermic reglementation of overseas french territories elaboration.

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