# Daylighting in Schools: Technology, Energetical, Economical and Environmental Impact

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## ABSTRACT

The paper describes the transfer of technology appropriated from the social, economical and environmental point of view in schools at the province of Mendoza (South latitude 32º, 53´, West longitude 68º 51´, semi-arid climate) placed at the Southwest region of Argentina. The main aim of the investigation is to develop technologies which allow the maximum autonomy in terms of heating and lighting of the school buildings trough the use of solar energy. The approach of the research work and the connected technological developments is to generate solutions for demands in countries with great inhabitants poverty levels, strong financial shortage and high rates of unsatisfied basic needs of the people living in the rural areas of influence of the schools. Even though the results are also meaningful for urban schools buildings and can be extended to other socio-economical conditions like in developed countries. In this paper are analyzed the environmental – energetically aspects related with lighting.

## INTRODUCTION

In Argentina 78% of the schools buildings are public, the remaining 22% is under private management. While in Mendoza the percentage of public schools is 81% and the yearly costs of energy used for lighting reach 64%. The bright climate of the region is particularly suitable for the use of daylighting in school buildings during the day shift which is the most sustainable way in terms of energy use. This aim can be reached designing the class room windows also as daylight luminaries.

The designed buildings incorporate on the class room walls apertures and solar radiation control systems easy for maintenance and operation by students, teachers or assistant personnel. The buildings final cost is equivalent to the cost of a conventional building based on electric lighting and heating generated by gas energy.

Trough field and laboratory studies has been developed the technology incorporated in 4 school buildings where attend around 1000 children and teenagers during each yearly period of 187 days. The enquiries and users participation during the research work facilitate the introduction of technical innovations in the daylighting systems particularly in the control devices. Nowadays the need of additional energy than solar to lit a class room in a bioclimatic building type during a school period amounts to 292 hours while a traditional building needs 1472 hours of no renewable energy consumption for lighting during the same period.

Applying the approach above described to the whole of school buildings of the Mendoza province, the potential electric energy saving could be up to 80%. The potential reduction of the environmental impact should be of the same magnitude by savings of CO2 associated emissions, reduction of contributions on the global

heating (ton eq. CO2), Acidification (ton eq. SO2), Eutrophication (ton eq. PO4-3) and on photochemical Oxides (ton eq. C2H4). .

## LUMINOUS CLIMATE

Mendoza is placed in the center west of the Republic Argentina, with latitudes that go from the 31 ° 97'S up to the 37 ° 55 ' S and lengths from 66 ° 31 ' West up to the 70 ° 35 ' West and altitudes average 800 msnm. Most of the territory possesses semi-arid climate. The principal urban center has developed on an axis of the north oasis of the province, surrounded by a landscape cultivated in the East and an arid natural area on the west.

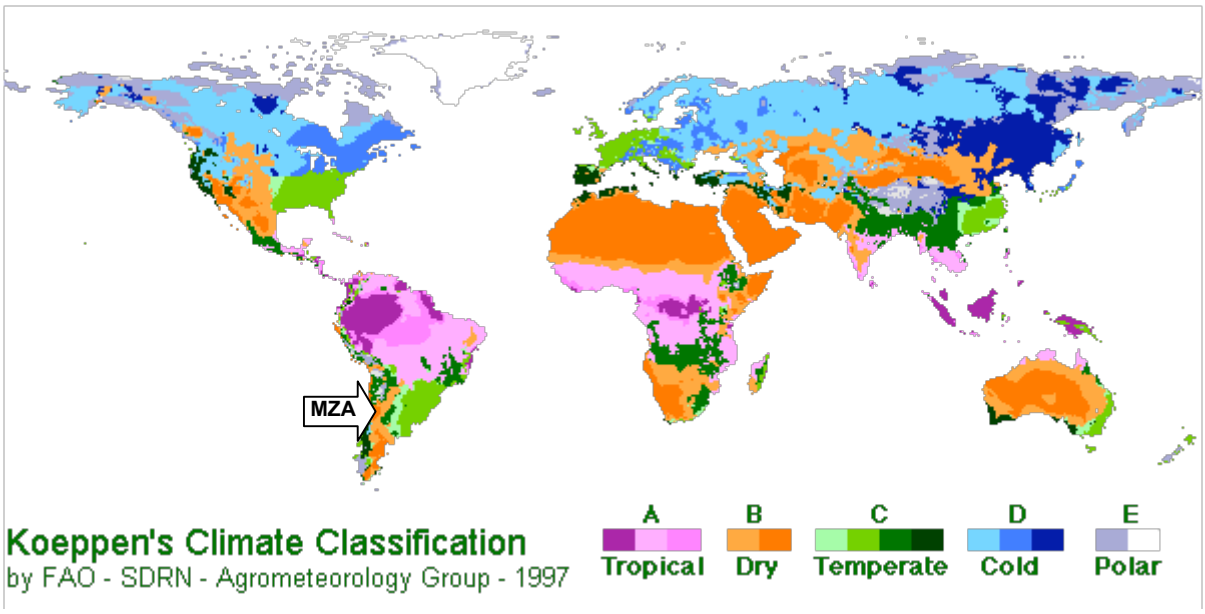



Figure 1-Climate Classification map. Mendoza localization.

In the majority of the provincial territory, the climatic conditions are more critical for winter that for summer, with an average of 200 ° day of need of cooling and of 1500 ° day of need of heating to come to the temperature of comfort. The type of predominant sky is the clear sky with Sun, 83 % of the year the sky meets clear or partially cloudy with sun presence. (SMNA for the period 1981-90). The annual average of hours of the Sun is approximately 2850 hours.

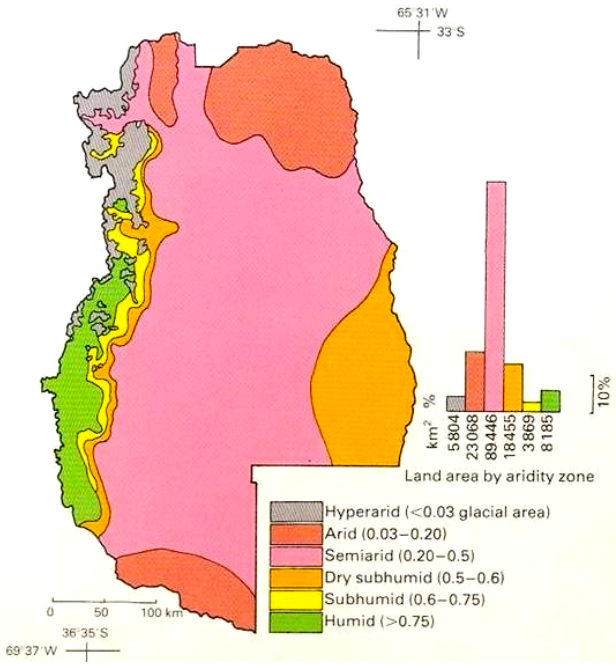



Figure 2- Land area by aridity to Mendoza

The following figure show the isolines (lux) corresponding to the information of Global and Diffuse horizontal illuminance (clear sky) for Mendoza (S32.89, W68.87, 864 msm). The daylight availability is sufficient to be used as principal source of interior lighting in classrooms (diurnal hours of use). Only it would be necessary to complement her with artificial light in the first hours of the morning and last of the evening in the winters months.

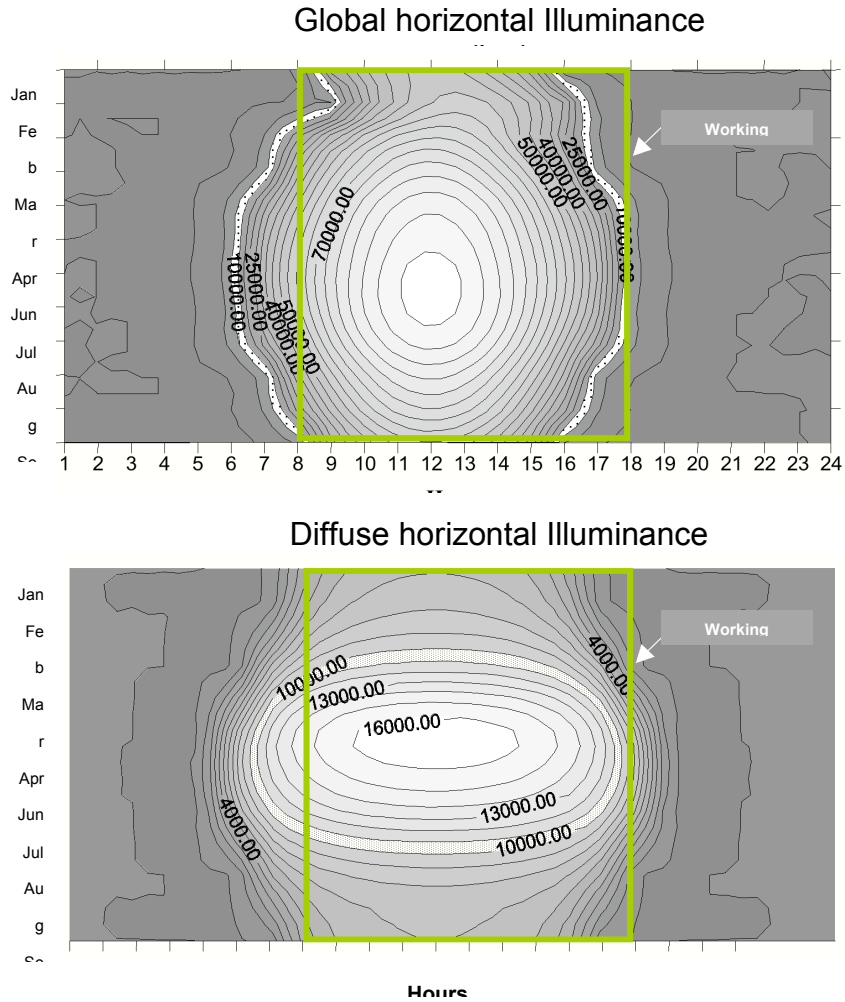



Figure 3- Isolines of Global and Diffuse exterior illuminance to Mendoza, Argentina

The representation of the figure 4 show the probability to exceed a given illuminance level (Klux) for Global and Diffuse Horizontal Illuminance to Mendoza, between 8:00hs to 18:00hs (scholar time)

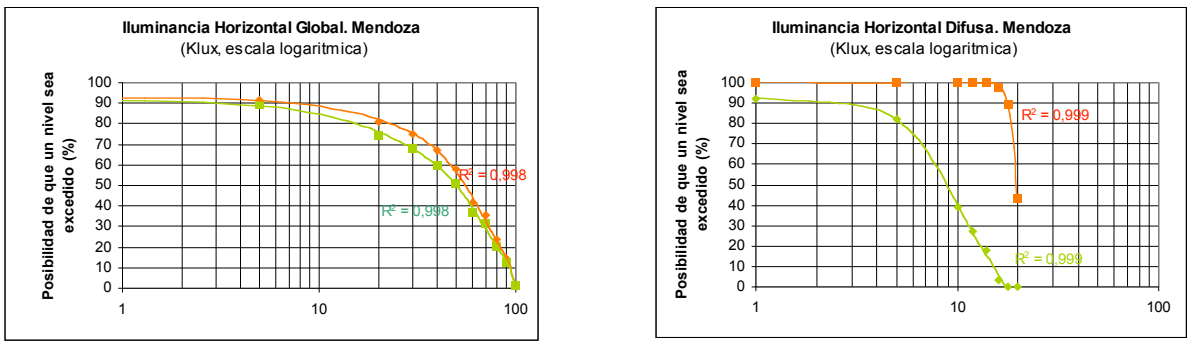



Figure 4 – Probability to exceed a given illuminance level (Klux) Mendoza.

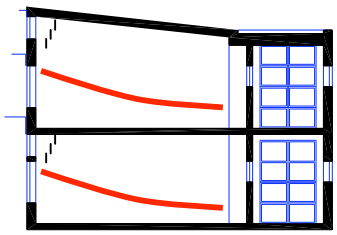
## SCHOOLS THAT USE NATURAL LIGHT TO ILLUMINATE CLASSROOMS

The concept of design of bioclimatic school buildings as a particularity the design and calculation of the utilization of passive solar conditioning for light and thermal comfort. The school buildings where designed in the Laboratory of Human Environment and Housing - CRICYT - CONICET, and transferred to the Government of the province of Mendoza (constructed with the official original budget for traditional schools). (www.cricyt.edu.ar/lahv).

The classrooms spaces with windows orientated to the South, with design of infiltration improved and thermal insulate glazing to optimize the gain of the solar radiation during the whole day from the dawn up to the late afternoon. By means of exterior fixed overheating the same ones are shaded during the central summer months. Hereby it permit the solar direct radiation for the windows only in the winter period to provide of solar heating, these height openings send natural light to the most deeper of the rooms (figure 5). To avoid glare in the winter period there is realized a diffusion and redirection of the radiation by interior screens designed from the knowledge of the solar geometry (altitude and azimuth of the region).

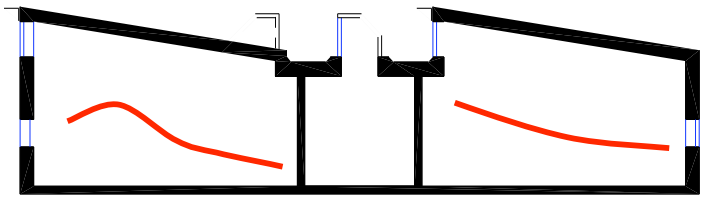
Exterior classrooms
School N° 4110

inner classroom

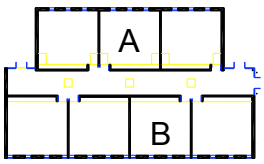


classrooms section-daylight distribution

Exterior view
School N° 4140



Classrooms and circulation section-daylight distribution




Plan classrooms

inner classroom A

inner classroom B

Figure 5- Daylighting in classrooms. Solar schools.

## RESULTS. POTENTIAL ENERGETIC AND ENVIRONMENTAL SAVINGS.

The values of natural interior lighting in the spaces destined to classrooms, verified with campaigns of measurements on horizontal plane at working level height, reached values annual averages between 800 and 1500 lux (considering the central hours of diurnal occupation).

The measured lower values than 500 lux (minimum recommended for visual tasks in classrooms) corresponded in the first and last hour of class, for the winter period.

The theoretical calculations of potential of saving electric power due to the use of the natural light to illuminate the classrooms were effected considering these results and comparing them with campaigns of measurements in classrooms of the schools of typologies more repeated in the province of Mendoza.

If the school provincial park use natural light as principal light source in classrooms the annual saving could reach to a save of approximately 7.905.898 kWh. (Table I). As a direct consequence the environmental impact decrease about 4.313 times measured in tons CO2 equivalents (global warming) almost to less generation and use of electrical energy.

| Energy saving | Annual demand of electric power for lighting classroom of school buildings | Cost of the demand of electric power for lighting (annual) ($ 0,10 x kWh) |
|---|---|---|
| 1- Tradicional buildings | 9.858.867,2 kWh | $ 985.886,72 |
| 2- Bioclimatic buildings with daylighting strategies. | 1.952.969,2 kWh | $ 195.296,92 |
| Potential saving of electric power for lighting | 7.905.898 kWh | **$ 790.589,8/año** |

*Table I. Theoretical analysis of the potential of saving electric power due to the use of natural light to illuminate classrooms in Mendoza, Argentina.*

## CONCLUSION

The way more sustainable of using the natural light is to use it "to "illuminate" the interior spaces.
The energetic - environmental consequences of the changes of technological paradigms of the age post industrial have led us to thinking at present about the rediscovery of technologies incorporated in the technological predominant logic before the years ' 70; being one of them the strategies of natural lighting, which were forming a part of the good practice of building design.

The technologies of lighting and automation of environmental conditioning added to the world availability of energy made us retire in many these good practical decades.

The suitable knowledge of the luminous regional climate and the development of endogenous technologies of natural lighting strategies permit to develop windows and adjacent elements as light artifact adequate to local environment. This specific daylighting system, designed and produced with regional technologies, could function similar to the electric lighting artifact. They allow to illuminate and to distribute adequately the light to inner space. The difference is the energy source, in the first one is the sky and sun instead in the second is electrical light (incandescent or fluorescent lamps).

It is important to mention that the proposed technology must be always accompanied with a campaign of education in energetic environmental issues. Some cultural behavior, like turn on the light when people coming room during days hours, must changed by permitting to the adequate entrance of natural light.

The passive solar school buildings are enough for energetic savings. Moreover they could also consider as an example to introduce environmental good practices to the community.

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