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Title: Solar concentrating and redirecting systems for application in an agricultural construction

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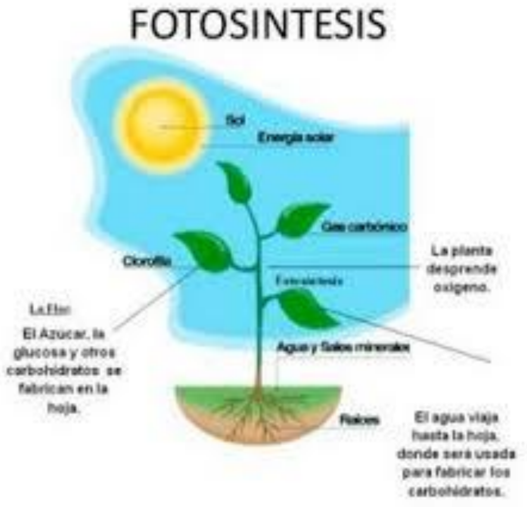
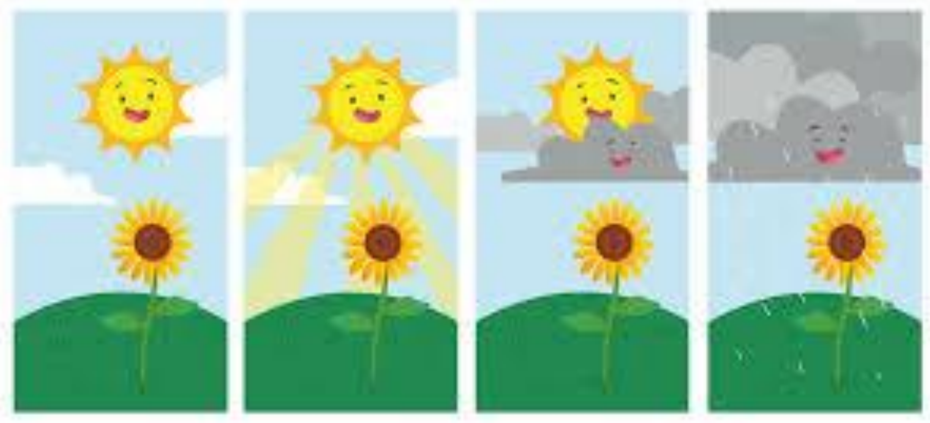
Introduction

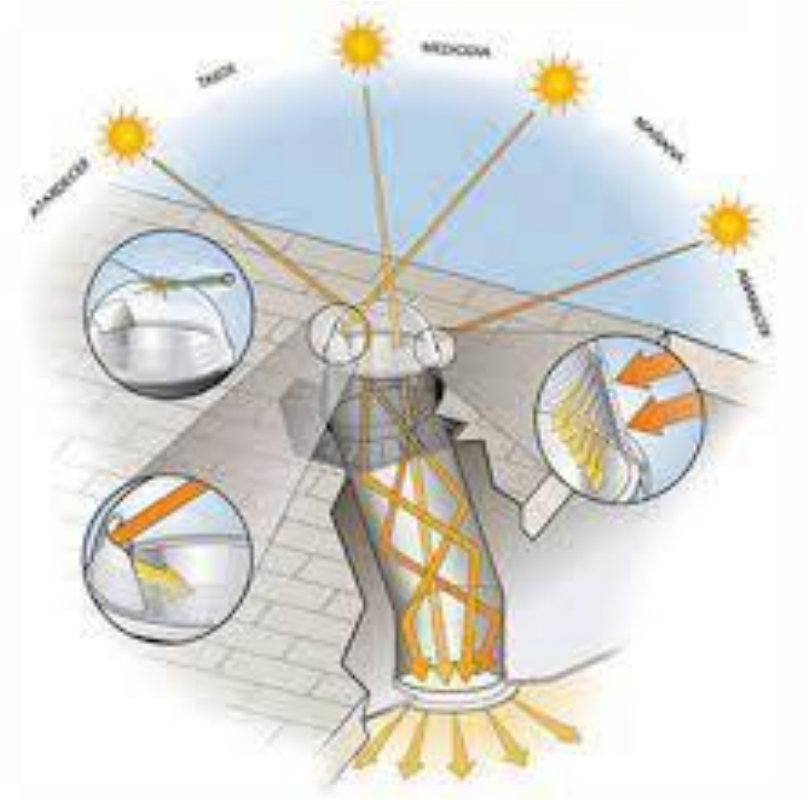
Most human and biological activities on earth are governed and powered by the sun, as the sun has been a source of illumination throughout human history. The development and use of efficient artificial lights has led humans to separate themselves from the healthiest and best source of illumination: natural light.

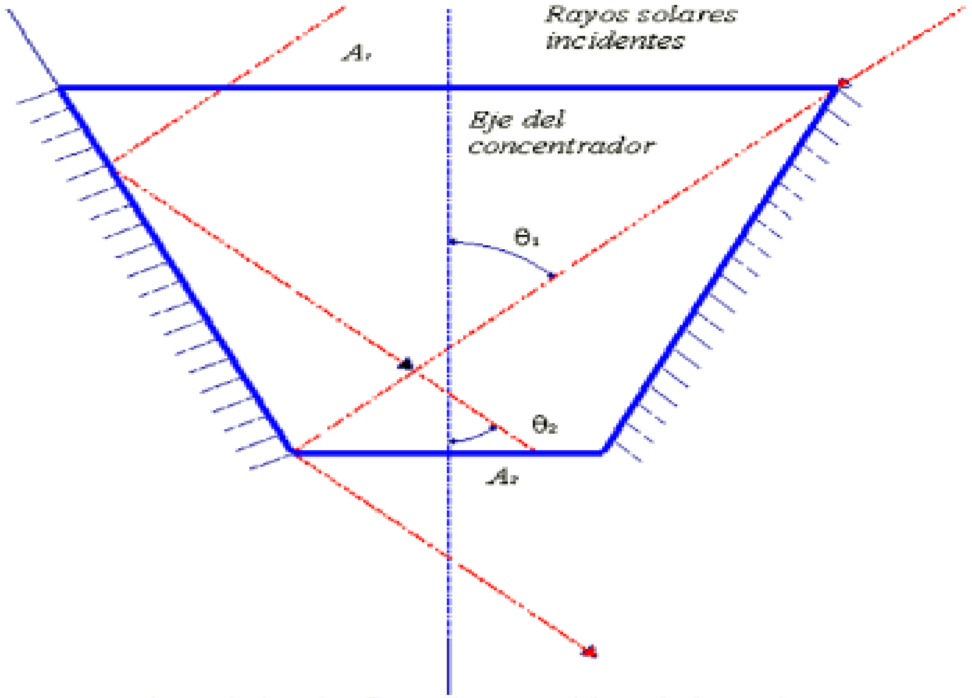




Studies have shown the benefits in health, safety and labor productivity when buildings are naturally illuminated (Roche, 2000). In addition to the quality of natural light, another reason to use it is its compatibility with lighting control systems to achieve a reduction in the use and cost of conventional energy, thus achieving a sustainable system.

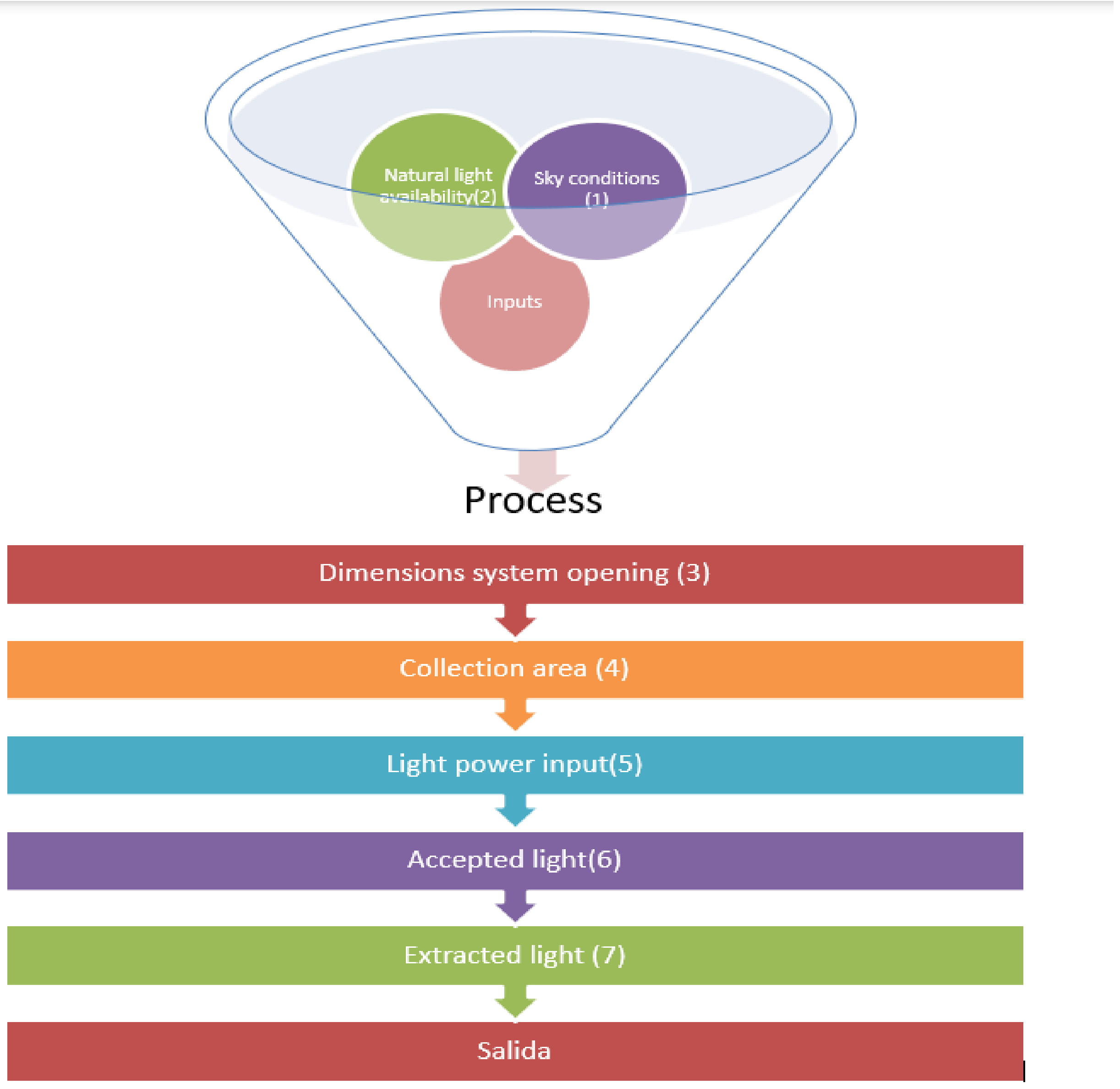
In order to transport natural light from the exterior to the interior of a physical space, lumiducts, which are simple structures that allow the transmission of natural light, are being used; there is currently a considerable increase in the use of this technology, with an estimated three million ducts installed worldwide (CIBSE, 2003). Generally, they consist of a collector (usually a hemispherical polycarbonate dome), the duct itself and an emitter.





Methodology

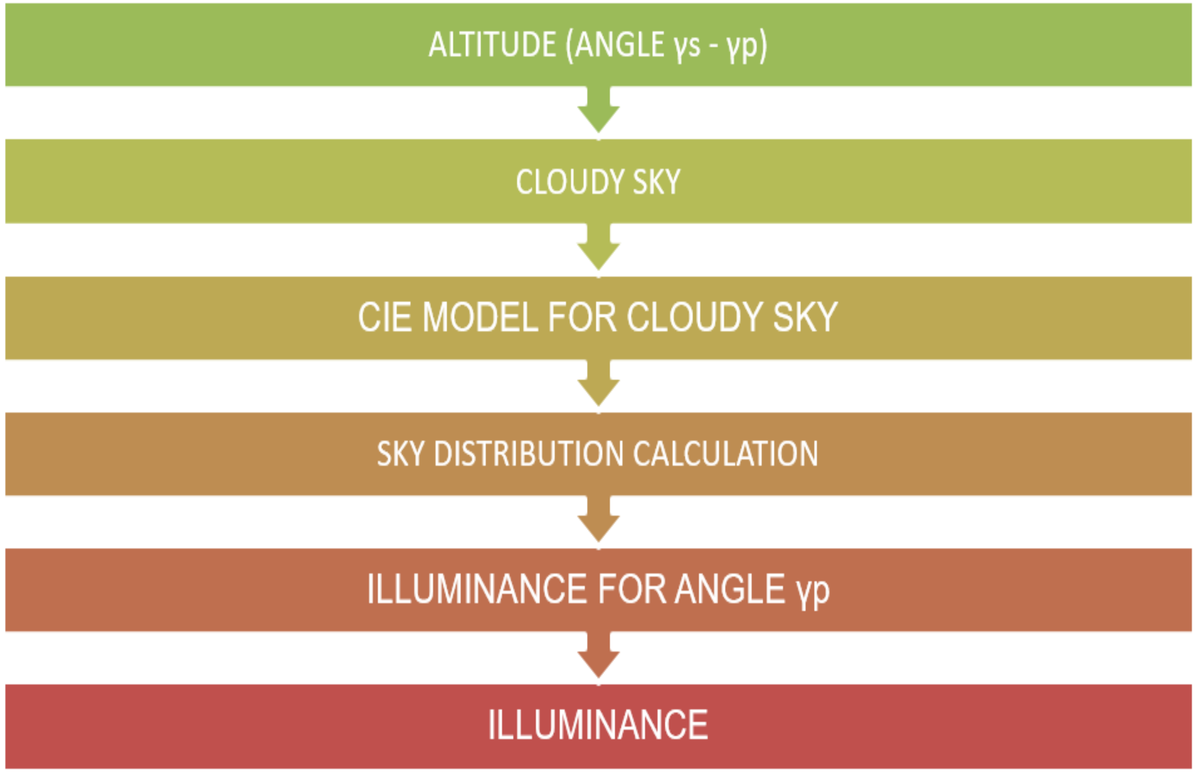
- Calculation of daylight availability (lx),
- Dimensions of the entrance aperture of the system,
- Collection area (solar concentration, depending on the solar elevation angle),
- Incoming light power (available light depending on collection area),
- Light reflected and not reflected by the system),
- Extracted and distributed light (illuminance levels obtained).



Schematic diagram of daylighting model performance calculation. *Source: Own*

Availability of daylight
&
Sky models

Models to estimate the luminance distribution for clear and cloudy sky conditions according to CIE, and the theoretical irradiance values described and determined by Bounger's Law.



Schematic for calculating daylight availability (γ_s solar altitude, γ_p altitude angle path in the sky), for cloudy sky. CIE standard. *Source: Own*

Study model proposed

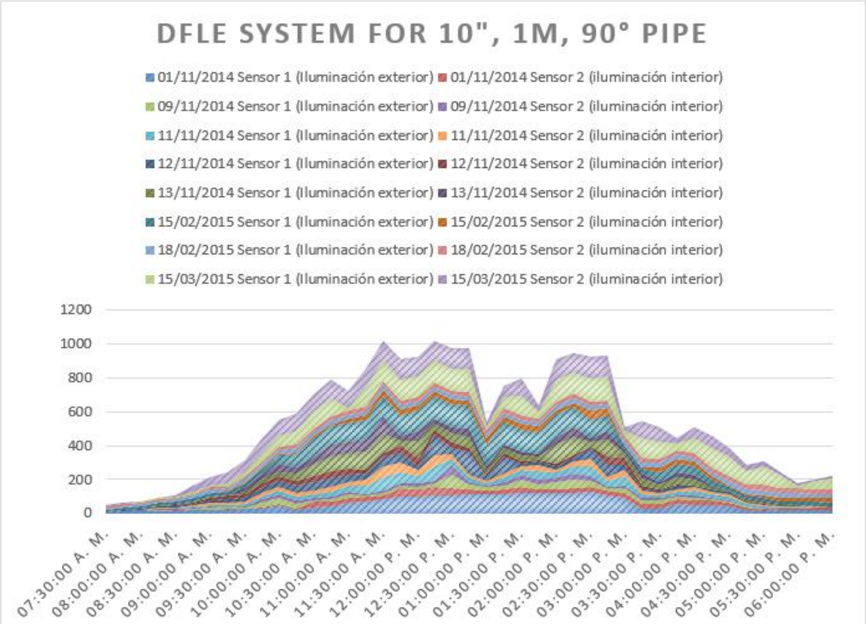
Dome+Fresnel (passive concentration) + Lumiduct + Emitter - DFLE

Table 1. Experimental configurations. *Source: Own*

$\emptyset = inlet\ diameter$,
$L = length\ of\ the\ lumiduct$, and
$angle = angle\ of\ entry\ of\ the\ rays$

Configuration	Parameters
1	$\emptyset = 254\ mm\ (10\ '')$ $L = 1m$ $angle = 90°$
2	$\emptyset = 356\ mm\ (14\ '')$ $L = 1m$ $angle = 90°$
3	$\emptyset = 254\ mm\ (10\ '')$ $L = 2m$ $angle = 90°$
4	$\emptyset = 356\ mm\ (14\ '')$ $L = 2m$ $angle = 90°$
5	$\emptyset = 254\ mm\ (10\ '')$ $L = 1m$ $angle = 45°$
6	$\emptyset = 356\ mm\ (14\ '')$ $L = 1m$ $angle = 45°$
7	$\emptyset = 254mm\ (10\ '')$ $L = 2m$ $angle = 45°$
8	$\emptyset = 356mm\ (14\ '')$ $L = 2m$ $angle = 45°$

Results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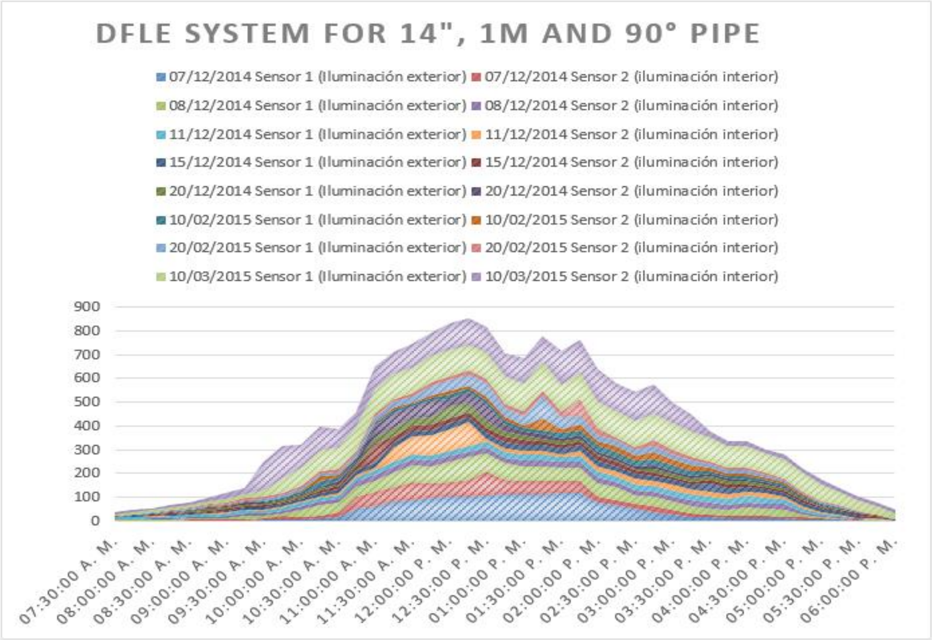
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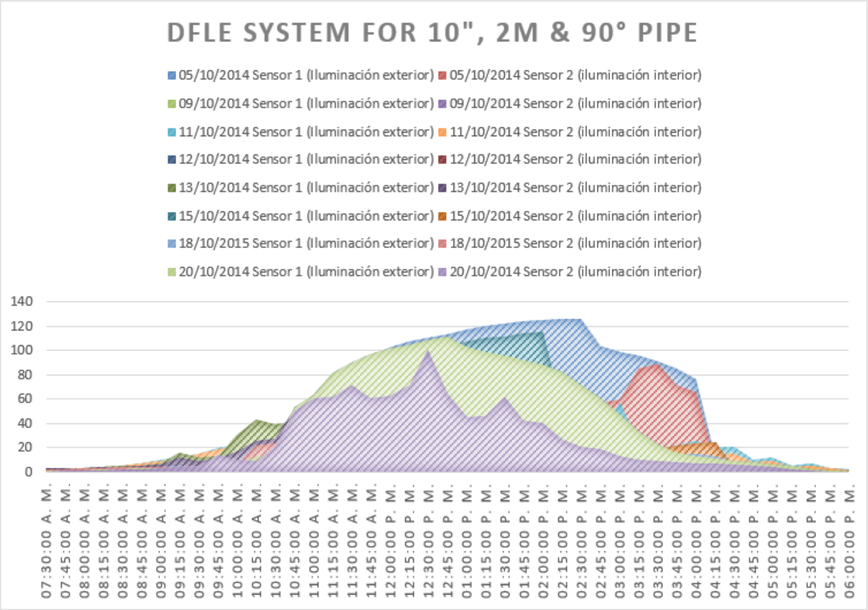
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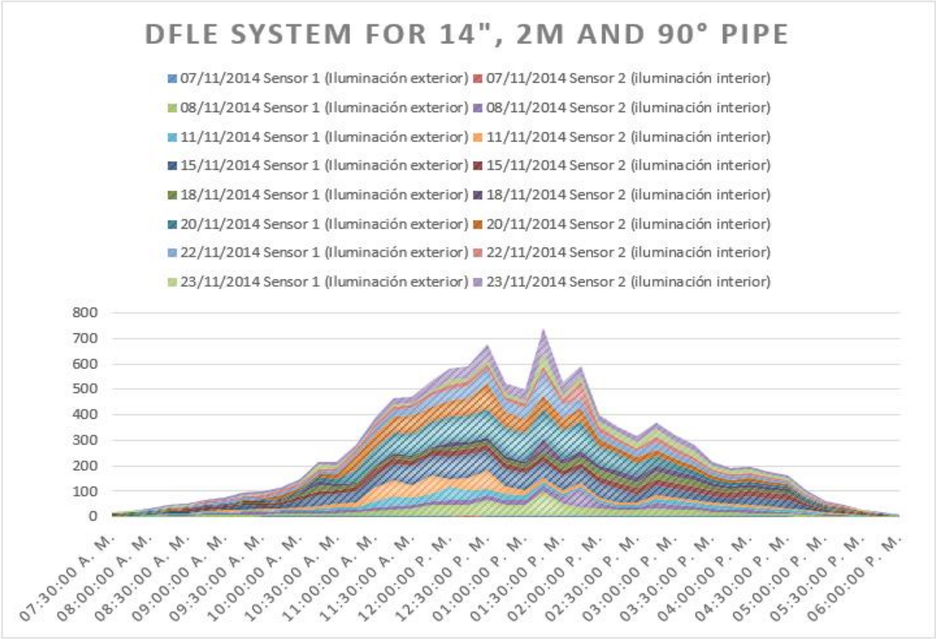
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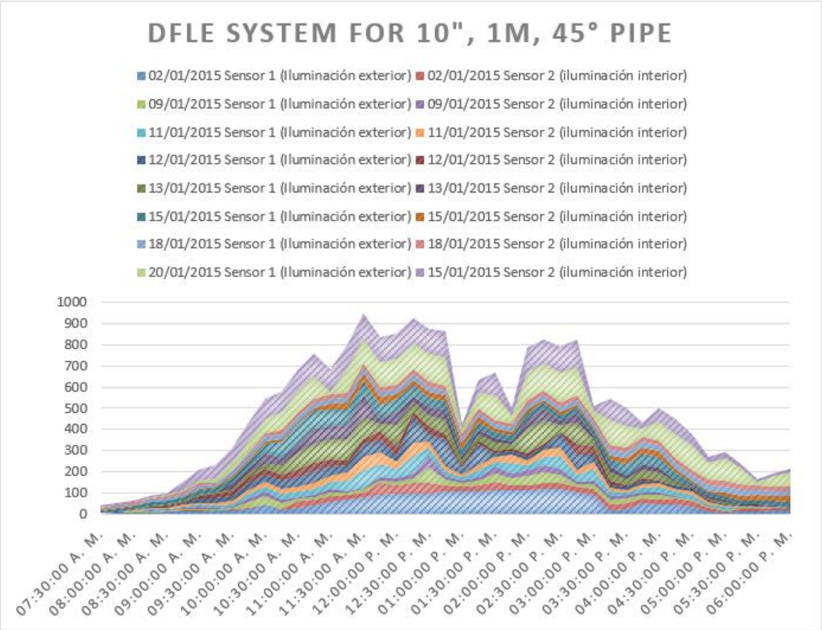

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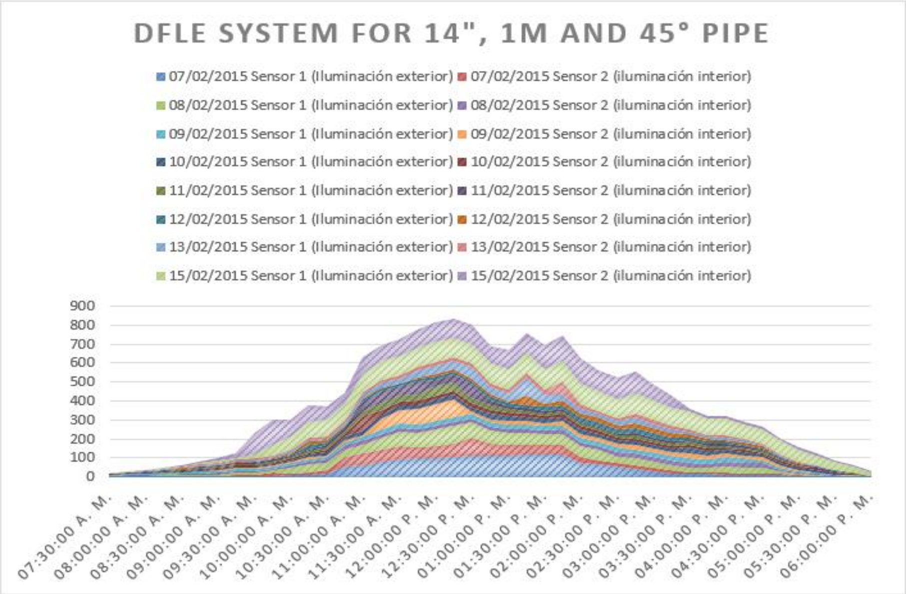

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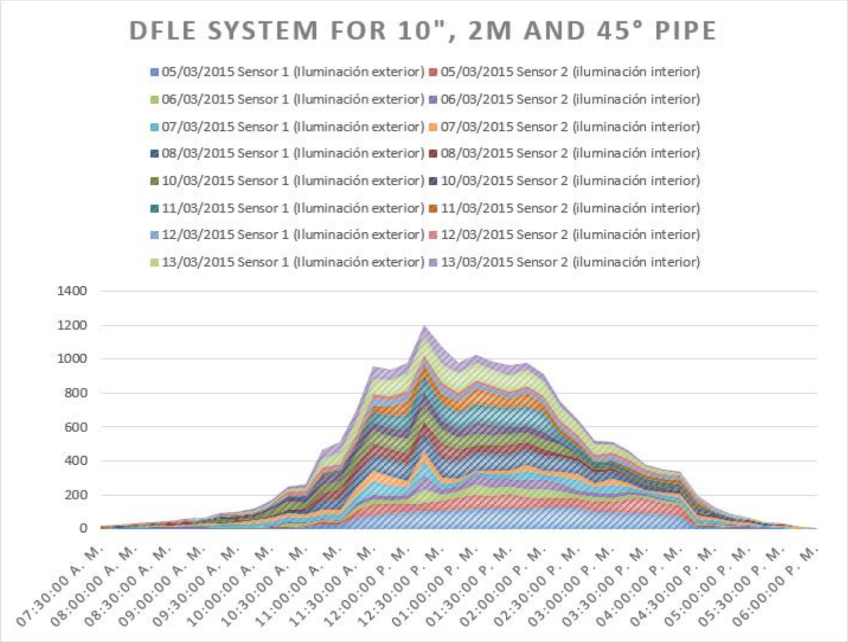

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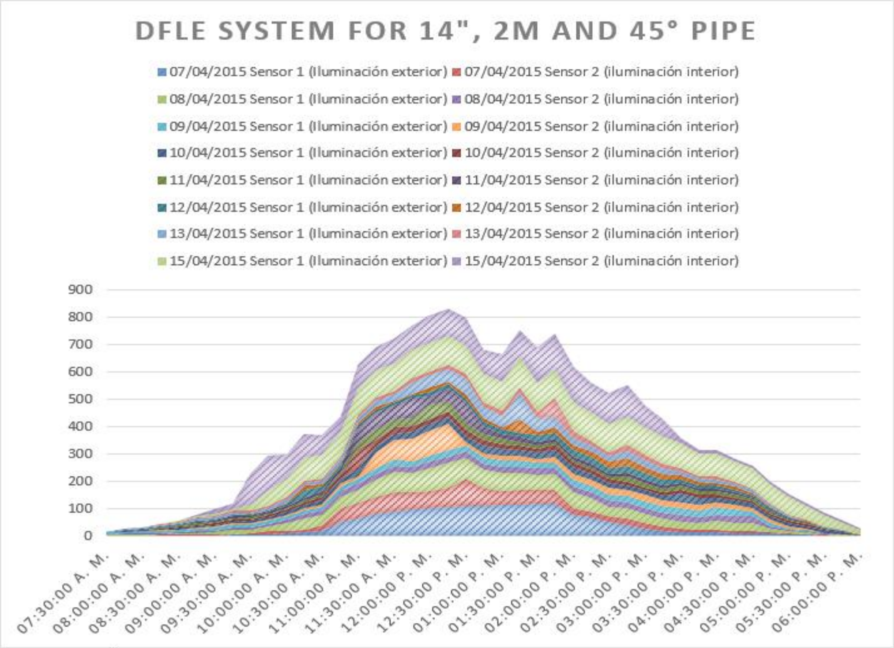

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Conclusions

The concentrator obtained concentration factors between 1.7 and 3.6. The critical aspects that determined the concentration of natural light were the angle of acceptance (45.68º), the direction (45º and 90º) and the reflectance of the material used (95%).

In addition, it was possible to reduce the space taken up by these systems, conserving the illuminance.

It was proved that this system increased the illumination of the interior space where the light did not reach in a natural way, improving the illuminance levels (300-500 lx), according to CIE (Commission Internationale l'Eclarige).

It was demonstrated that the system represents a viable and adaptable solution to illuminate constructions naturally.

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