# Congreso Internacional de Iluminación
## El alumbrado en el siglo XXI

León
12-21 de Mayo 2005

# CIE Midterm Meeting
## Lighting in the XXI Century
CIE Divisional and Technical Committees Meetings

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Fourth Circular and Final Programme
4

León 05
CIE Midterm Meeting y
Congreso Internacional de Iluminación

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CIE Midterm Meeting y
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Título del trabajo
*Title of paper*

# Artificial radiant energy for fish processing efficiency

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Abstract

The purpose of this study is to examine the possibility of the simulation of terrestrial solar radiation, for application in the food drying, particularly fished, from conventional artificial sources of radiating energy. Some considerations are carried through and some proposals of configurations are presented on the basis of the spectral contents of the primary sources. The solar energy, in exteriors, has been used for the removal of the humidity (drying) of products of fishes. Some times the necessary radiation’s intensity, from this type of natural source, is not available and an alternative artificial source can be used. Considered to exist electricity availability, in the task of selection of artificial source for irradiation, the interaction between the biological system considered and the spectral contents of the radiating energy (no-ionizing), in the bands of the visible and ultraviolet - UV radiation of the optical range, are considered, data that the UV can establish sanitary environment to the processing, having been important and motivation of this article. The use of special light bulb, like solar simulator type (or Sunlamps), in substitution to the solar radiation must be prevented in case that this kind of primary source can be: low efficiency one, raised cost, still the current expenses with electric energy has to remain as low as possible. Different arrangements of light bulbs are projected; being that two of them will be tested in the field (project-pilot), in different modalities of production, one being a continuum and other one to simulate the daily solar variation. The estimate base for the use of energy in the project was gotten from a process of traditional solar drying for ova of fish, being that the calculation for the installation is done, as well as the running cost of the electric energy. The decision of the user for the adoption of the investigated methodology depends basically on the price that could be practiced in the market, being primordial that the product must keep unchanged its traditional flavor.

1. MOTIVATION FOR THE METHODOLOGY PROPOSAL

Fishing is a vital activity, economically considered important because it can make possible improvements in the feeding peoples all over a country, in rural areas, as in the coastal zone mainly. Two methods for the food preservation are popular, the smoking and the drying. The preference of use for one of these methods is conditioned by factors as the type and final flavor of the food, the matrix of energy, the manpower and the market available. As a illustration, in the coastal zone of Ghana (Africa), preference is for the smoking of the fished one was identified, and also a chance of reduction for 50% in the wooden, combustible consumption used, for a change in the technology of the used equipment [1]. The process for which is called drying can be removed part of the water contained in a food. Generally it is made for convenience; someone wants to add value or to have a period of longer storage to the food. The solar energy has been used for production, whose scale is small and in the regions where the climatic conditions allow it. The dry food production, from the solar energy, can be made with not intensive man power, technical knowledge very reduced, initial capital and operational cost low. A plant that is planing to add value to its fish's products, it is imperative to comply within certain standards and thus exportations could also be made for markets with bigger demand or requirement. In some situations it is necessary to make use of another type of energy to the process, like when it will be necessary that the food is dried entirely, or in a short period of time only, as much to complement the natural source or for a complete period without any interruption, whose example is the process of drying intended indoor. In case that the electricity is the type of energy source to be used in closed environment, for defined process of drying, the supply of the radiating energy will have to be searched from primary source capable to provide spectral contents as close as possible to the light from the sun. Under this premise, the hypothesis of this search points out with respect to the use of primary source, a qualified set of artificial electric bulb. This initial direction was presented as a answer to an order received among to the citizen greco-brazilian, Mr. Katopodis, in reply the necessity identified in its plan of project in aqueous environment, which was not evolving, having cited that its takes over on a contract basis outside launched about one year, after to have received reply little satisfactory from a secretary of the local federal government [2].

The presented problem, to select the source most appropriate (perhaps as the illuminant B or C, standard CIE) or a group of simpler sources, is not a new one, where the field of the illuminating engineering meets established, neither it can be classified as the most interesting research to do, however, it allows to exercise accumulated knowledge, and makes possible to be made consideration to a involved ancillary proceeding in the food production in small scale, from availability of bulbs for production of electric light. Therefore, it will be treated to investigate alternative situation, in which electric resistance and fans (or natural convection of air) are not only mounted together or either of the situation where an electric heater could make the required work. Where it is necessary to make consideration also on the flavor of the finished product, and therefore on it final customer. It come from the comment on existing significant difference of flavor between the traditional process, to the sun and that one in greenhouse, having been important reason for the strategy adopted in this work to have been established, which is based on the spectral contents of the energy to be used. As a starting point to the searched solution, the substitution of natural radiating source for the increase of scale in activity in the food sector, it must be fixed that the received request was destined specifically to deal with it the spawn drying of a type of fish, called “Tainha”. The received information indicates that the traditional spawn drying has been carried from solar radiation.

In this case, at the State of Rio de Janeiro, Brazil, during the month of July, and with the duration of 2 to 3 days[1]. The lack of regularity in the periods of sun is the main motivation that took the producer to make contact with the IEE/USP for suggestion to find an alternative way to the use of radiating source (artificial) in substitution to the sun. Only to complement the solar irradiation daily (typical), from artificial sources is an alternative to be investigated; therefore it will be able to increase the productive capacity and to modify the process costs. To reproduce the conditions of the process, as the information received, there are two important functions of the solar, the heat and asepsis[2], which in terms of band (wavelength) of the radiation they are: the region of the ultraviolet radiation - UV and infrared - IR. The definition for the adequate dose of each artificial source to be used, as well as the establishment of continuous irradiation or not (cycling), they are decisions that will be taken only after to have been done field evaluations. The area to be used or intended for the process and the physical distribution of the food are another needed data to the calculations. The available information are limited, possess raised uncertainty, but they can be used for to estimate of the density of artificial radiating energy that will have to be supplied for the case considered here.

## 2. PERTINENT DATA FOR PRIMARY SOURCES

The total irradiance of the sun on the Earth's surface, at noon on a typical sunny day of June, in the north hemisphere, is evaluated around 1 kW/m² and the annual average solar radiation at a latitude of 50°N is around 200 W/m² [5]. These values of available power density, in such a way instantaneous or annual average, they can be derived, for numerical integration of a spectral irradiance curve of the source (for detail to see figure 1) in a specified range of wavelength.

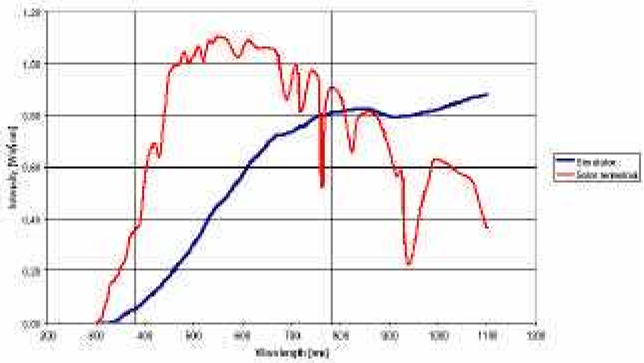

*Figure 1 - Curves of spectral irradiance, band of (300 - 1100) nm, monochromatic, component: solar normal direction, AM1.5 (terrestrial) and for one kind of solar simulator. Source: [6].*

In figure 1, the curve of spectral irradiance that possesses the more raised value of intensity, it is mentioned to normal solar component (AM1.5; terrestrial). In the case of the solar simulator presented by figure 1, whose predominant characteristic is from a incandescent source, it comparison to the solar spectral contents is divergent or precarious in such a way above of 870 nm (region of IV or heat) and below of 340 nm (region of UV).

Notes: [1] For ends of comparative referential, it is cited the equipment development with hybrid technology (solar-biomass), from Philippine, whose initial investment is said to be amortized in two years, and it is capable to dry 50 kg of pineapple, with initial humidity of 92 % to 20 %, in 18 hours [3]. Another data available, on the withdrawal of humidity for drier, in the case of grapes, are a daily drying rate of 21 % [4]; and

[2] Still that another method can be used for asepsis (called the acid way); but the interest in this work is start a study on the radiating possibility exclusively.

In case that this type of source, the solar simulator, could be used (local availability does not exist, neither it cost), it would have necessity of being added filter to attenuate the IV and to aggregate an additional source to supply UV.

In the beginning of the artificial electric light, the simple carbon arc was used as primary source of optical radiation, it is capable of supply the UV necessity. When a wire, an electric resistor was used to ballast the electric arc, if it becomes warm, this could contribute with infrared radiation, resulting in a complete solar simulator (the solar spectral contents follows decreasing up to 2300 nm, [7]). In the literature, the called sunlamp appears around the year 1935. Generically, its characteristic has similarity to the current self-ballast lamp (mercury vapor light bulbs that also possess associated tungsten filament), however, comparatively, it electric current, at that time was sufficiently high (28.7 A for the so called S-1 type; and 9.1 A for the S-2 type), the voltage was at the order of 12 V and special glass was used (called Corex, with high transmittance in the UV band [7]). Ultra-Vitalux (Osram) is one of the observed commercial brand for light bulb of this type, the arc tube with mercury (80 W) and in the place of the reactor, it uses tungsten filament inside of the same exterior bulb; other brands found to these type of light bulbs are MLU (Philips), and the RS Sunlamp (GE). The popularity of these models had its use for artificial sun-tanning, however system based on fluorescent tubular light bulb, around year 1980, must be the reason that attenuated the availability of this technology. The process of cure of certain plastics by it exposition to radiation UV, certain increase in the demand for tests for the artificial aging of materials (trustworthiness of useful life or service under particular climatic circumstances), changes in the properties of materials, particularly to the tropical environment and other applications have kept some availability of the Ultra-Vitalux type, whose manufacturer [5] informs that a disposal of 16 light bulbs (300 W, 230 V, 1 kh) for one square meter, to a distance of approximately 50 cm, between the bulb (external face) and the radiated object (another gotten data from the literature:12 $W.m^{-2}$ for light bulb [6]) obtains an uniform irradiance to reproduce solar radiation.

## 3. ARRANGEMENTS OF PRIMARY SOURCES

In the previous section, a type of commercial source is identified, it will be able to serve as referential for the experiment intended to be done in the field. Important condition is in knowing that in the solar simulator it is necessary to have ultraviolet radiation from 300 nm, until infrared radiation around 3000 nm, which has been gotten from one mixes of incandescent source (tungsten filament) and electric arc (mercury). Special glass bulb is used too. The primary source, type metal halide - MH plough current alternative, relatively cheap, in relation the use of fluorescent lamp that is used for sun-tanning, if it is necessary the significant increase of the UV fraction. The radiation production, in particular UV, will be carried through initially from the mercury vapor - HPM 80 W light bulb, whose external bulb was removed, and it discharge tube is screened against the human eyes. In begin, the special fluorescent tubular light bulbs (like type EVERSUN [5]) will not be used because its raised local cost (US$ 38), the conventional tubular fluorescent bulbs will be able to assist only in the production of visible radiation, it have low UV capacity. All the light bulbs, which the incandescent conventional (GLS), will be accommodated in the interior of parabolic reflectors, whose narrow torch allows to optimize the task of irradiation with the focus on the food. Air circulation is planned in two independent circuits, natural and forced convection. The movement of the food, by means of a mechanic gear will be part of future project. Still, the incorporation of a clock is foreseen, for timing schedule the irradiation cycles that simulate day and night. This is for an intended study that will search for the possible influence from periods without light, in the process, and it relation to the final result, considered most important, the flavor of the processed food.

In place of GLS source, responsible by the IR parcel it is foreseen to be tested the incandescent halogen light bulb and also its partial substitution with HPS (and fluorescent), that they are option to increase the amount of visible radiation and the search for the maximum reduction of the installed electric to power. It is foreseen six arrangements of primary sources to be tested, they are: 1- (GLS and HPM); 2- (GLS and MH); 3- (Halogen and HPM); 4- (Halogen and MH); 5- (Halogen, VMAP and HPS); 6- (Halogen, MH and HPS); being that the source type sunlamp will be kept as the referential.

The verification of the spectral irradiance, in the reference plane of the food, will be made for each arrangement of source informed It will be carried through in three restricted bands of the spectral irradiance (UV, visible and IR), conditioned to each available sensor spectral sensitivity.

## 4. SOME RESULTS

The data gotten from the daily average solar energy incident on the region considered (the city of Rio de Janeiro, 23 S 43 W, Brazil), in the month of July shows 3.78 kWh/$m^2$ (for hour detail to see figure 2). Assuming that the traditional drying possess duration is 2.5 days, it makes possible to absorb about 70 % of this incident energy and that the typical day has the average duration of 10 hours in July, this leads to an average necessity of 265 W/$m^2$ and it will results in a estimate of energy expense of the order of 6.6 kWh/$m^2$ for the considered process of traditional drying.

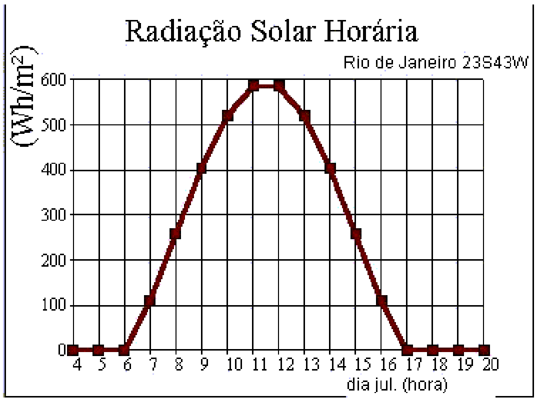


*Figure 2 - Curve of solar irradiance (total) for each hour, in a typical day on the month of July, city: Rio de Janeiro, 23 S 43 W, Brazil. Typical average: 3.78 kWh/$m^2$. Source: [8].*

The primary source to be used in the food drying with ballast in illuminant B or C (CIE standards), does not serve for the intended practical in the field, basically because its construction requires abilities that still are not found with easiness in certain localities of developing countries. Also the use of the popular self-ballast light bulb is not recommended, it have luminous efficiency (photopic) to be relatively low enters the sources the discharge, of order 22 lm/W (250 W), its external bulb is not to be adjusted and so little it could be removed.

The energy estimate, by hour and unit of area, the active electric power to be installed, by square meter, leads to the necessity of 22 sunlamp light bulbs type, considered without radiant (luminous) depreciation and having unitary or corrected power factor. Still, in case that this configuration of one primary source is used, the calculated running cost, as the tariff of electric energy and the volume of food that can simultaneously be processed, as something in the order of USS 30-40 for square meter. In case that it is evidenced, indoors, not to have necessity of interruption of the irradiation (like to simulate nocturnal period), the productive capacity will be able to fold in relation to the traditional process at the open sky. Due to necessity of importation and high cost (19 Euro) a static assembly of only sunlamp source capable becomes prohibitive to reproduce the solar variation presented at figure 2 and to simulate that maximum value would be necessary about 50 bulbs and 15 kW of installed active power. An imagined alternative will be the use of a mechanical system that allows varying the distance between the source and the food. Still, if one will use only sunlamp care must be taken to the existence of reduced radiating effectiveness. Considered emission of 12 W.m$^{-2}$ for this type of light bulb [6] and 300 W, it absorbed electric power (assuming unitary power factor), the radiating effectiveness or of conversion of energy is 4 %.

The configuration of the sources to simulate the solar radiation for the food processing, from an arrangement of two or more primary sources is an important solution, basically because the cost and mainly for being available in the local market. The incandescent light bulb complies with requirements, or two bands of optical radiation, in the visible and IV, being indicated the best solution for the IR band. The mix of the sources, whose the best composition will have to emerge from tests, are recommended due to luminous efficiency (photopic) relatively to be raised in relation to the incandescent source, and allowing possible reduction in the installed power or maximizing the irradiance. The sunlamp source is kept only as referential to the carried through development and that it searches to make possible the reproduction of the distribution of the solar radiation in interior for productive process, reduced scale, the food sector. It constitutes proposal alternative, to the transfer the activities developed in the conventional process of drying of foods to interiors, and objective to keep the flavor of the food without significant alteration, which if not respected can depreciate it market value.

## 5. CONCLUSION

This work was leaded to study alternative of primary source to be used in place of the solar radiation and it has objective to optimize the process of drying certain type food. The standard sources (CIE illuminant B and C) are not appropriate for practical use in the field, because its construction requires knowledge and specialties that are still not found with easiness in certain places of development countries.

Through the literature a certain type of source, called sunlamp, was located, it have spectral characteristic of emission that complies with applications where artificial the solar radiation is required. However, due to it constructive similarities, in relation to the current self-ballast lamp, that possess luminous efficiency (photopic) relatively low, in the family of sources with electric discharge in gases and raised cost. It was opted to uses it only as referential to the proposal presented of solar simulator with primary source. For artificial reproduction of the typical solar radiation of 600 W.m$^{-2}$ (winter in coastal region in Brazil), from only one source type, sunlamp, should be necessary to use 15 kW of installed active power. Still, the convenience for the use of only source can be hiding radiating effectiveness reduced, esteem in 4 %, in regards to conversion of electric energy to simulated solar optic radiation.

The settled goal is getting a solar simulator from a more than one commercial source, minimizing the consumption of electric energy and to maximize the interest of the consumer on the flavor and aspect of the end food product. The practical confirmation on the launched possibility, the use of primary sources whose little cost is raised and that they are available in the local market will fix an very important solution for countries like Brazil. The conventional incandescent light bulb (GLS) complies with the requirement of being an efficient source of infrared radiation, while it possesses very low initial cost. Also, for the production of UV radiation, as settled methodology, it is a practice that has already been carried through by the author. The optimization of the solar simulator, as indicated, must be a search for the best combination in relation to the availability of those primary source (specified HID) in the local market.

For the traditional process of drying fish spawn was calculated energy necessity in the order of 6.6 kWh/m$^2$.

## ACKNOWLEDGEMENTS

The author is thankful to Mr. Constantin C. Katopodis (and its son Andre) for the aid with preliminary information on the processing of fish products and to the IEE, agency of the University of São Paulo - USP for the support in research.

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