POLITECNICO DI TORINO

# Honors thesis

COURSE OF

SUSTAINABLE ARCHITECTURE AND DESIGN

*Abstract*

## AN INNOVATIVE PHOTOBIOREACTOR FOR THE PRODUCTION OF MICROALGAE AND BIOMASS USED AS A STATIC SCREEN FOR GLASS SURFACES IN BUILDING


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December 2015

This thesis was developed in the context of the research project: *SOS_TEBE*: *Scenedesmus Obliquus, a Sustainable TEchnology for Built Environment*, developed at the Department DISAT of Politecnico di Torino, Italy[1].

The growing need for environmentally friendly products and processes for architecture led to the development of innovative components with reduced embodied energy, embodied $CO_2$ and consumption of raw materials. SOS_*TEBE* Project, was aimed to design, optimize and realize static shields for glazing surfaces as photo-bioreactors for the production of microalgal biomass. The bio-subtraction of carbon dioxide using microalgae is a promising method for both combat global warming and improve indoor air quality (IAQ). Microalgae are also important source of protein, lipids and carbohydrates for the food, nutraceutical, pharmaceutical and cosmetic industry, as well as for the production of biofuels. The growth of microalgae is influenced by the availability of carbon dioxide, the presence of sunlight, the composition of the culture media and the type and surface area/volume ratio of the photo-bioreactor. The ultimate goals of *SOS_TEBE* project were the large-scale production of biomass and the improvement of indoor quality of confined environments, through $CO_2$ bio-subtraction and increased visual comfort.
In the present work of thesis, some transparent, economic and recyclable plastic bags were designed, and tested as photo-bio-screens (PBSs). The microalgal growth rate was evaluated through optical density measurements by spectrophotometric analysis and biomass production was determined through dry mass weighing. Different simulations have been carried out in order to determine the visual comfort and the annual electric energy demand for lighting of a sample room.

The experimental work of thesis was composed of three phases:

**STEP 1: EXPERIMENTATION** carried out at the Biotechnology Laboratory of the Dep. DISAT of PoliTO, Italy, consisted of:

- the design and realization of several full-scale prototypes of photo-bio-screens (PBSs) to optimize the growth rate of microalgae and the indoor visual comfort of a sample room (Fig. 1);
- the monitoring of the microalgal growth rate inside PBSs hanged to the inner surface of a sample room' glazing;
- the evaluation of the light transmittance of PBSs by mean of photo-sensors connected to a Datalogger.

[1] A novel photo-bioreactor for microalgae production as static screen for windows in buildings. Project Area: Residential Building/Energy Efficiency. Proposal for the Siebel Energy Institute (19 June 2015). Lead Researcher: S.L. Pagliolico (Dep. DISAT, PoliTo, Italy)., Chief Scientist: F. Bosco (Dep. DISAT, PoliTo, Italy). Other Researchers: V.M. Lo Verso (Dep. DENERG - TEBE research Group, PoliTo, Italy), C. Mollea (Dep. DISAT, PoliTo, Italy).

**Fig. 1**: Different types of PBSRs during the tests

**STEP 2: SIMULATIONS**, the lighting simulations were conducted at the TEBE Group, Dep. DENERG of PoliTO, Italy (Fig. 2). Step 2 consisted of:

- the evaluation of the indoor visual comfort of a sample room varying size, orientation and area of the glazing surface covered with PBSs, through Radiance software;
- the simulation of the annual electric energy demand for the lighting of the sample room, using Daysim software.

**Fig. 2**: Representations of the sample room

**STEP 3: RESULTS,**

Disposable plastic bags with circular cubicles gave the best performances as static screens for windows and photo-bioreactors for microalgae cultivation. The daylight availability in the presence of the PBSs was higher than that available in the case of glazing with venetian blinds and the energy demand for lighting resulted lower. Furthermore, the green color of microalgae appears to induce psychological well-being for the occupants.

**FUTURE DEVELOPMENTS** PBSs will be implemented and monitored in a school building as a future step of the still on-going SOS-*TEBE* research: the kindergarten sited in the municipality of Saint Marcel - Aosta, Italy (Fig. 3).

**Fig. 3:** Representation of PBSs hanged to the glazing of kindergarten.

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