ARTHELIO

Intelligent and Energy-optimised Lighting Systems Based on the Combination of Daylight and the Artificial Light of Sulphur Lamps

EnerBuild RTD
Energy Environment & Sustainable Development
Thematic Network on Energy in the Built Environment

Thematic Group 2
Lighting

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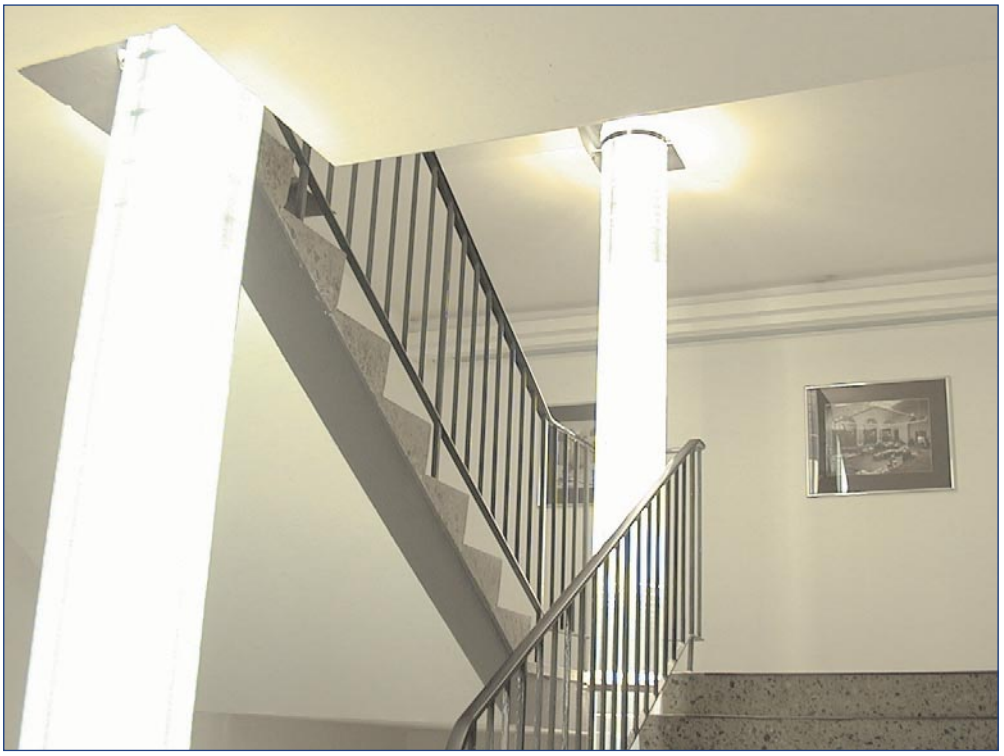
Joule III



Hollow Light Guide System - Berlin Prototype at Semperlux

Project Information

Contract:
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Project Partners:
Ricerca et Progetto, Bologna, Italy
Göteborg University, Sweden
IKL, Stockholm, Sweden
Semperlux AG, Berlin, Germany

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Summary

ARTHELIO aims to improve both the energy performance of buildings and the visual comfort of their interior environments. It is an innovative, energy-saving system based on effective utilisation of both daylight and artificial light that benefits from new lighting technologies and 'smart' electronic components. ARTHELIO is the result of scientific research and development work to optimise different system components and attune one to another.

The ARTHELIO Project

The European-Commission funded research project, ARTHELIO, aims to reduce the energy used for indoor lighting by transporting daylight, when available, into the core areas of deep-plan buildings. Artificial light is introduced when sufficient daylight is unavailable. Thus both energy performance and indoor visual comfort can be improved significantly. Daylight is generally preferred by building occupants to artificial light and can provide measurable health, well-being and productivity benefits while saving energy and reducing the need for cooling. The ARTHELIO lighting system is modular, enabling it to be incorporated easily into many different building types and applications. It consists of the following components:

- An ARTificial light source (a sulphur Lamp) which is dimmable using an electronic ballast.
- A HELIOstat-based daylighting system, which collects, transports and distributes natural light.
- A Coupling System that mixes natural and artificial light according to the available daylight.
- Intelligent Electronic Components that control the operation of the heliostat and the artificial light source as part of a daylight-responsive lighting control system linked to a Building Energy Management System (BEMS).
- A Hollow Light Guide System (HLG) that transports and distributes light for interior illumination.

The objectives of the ARTHELIO project were:

To develop a system for rational use of energy for lighting, heating and cooling:

Intelligent, BEMS-linked control systems are required to achieve optimal use of daylight and artificial light and highly efficient sources of artificial lighting are desirable to minimise energy use.

The light intensity of sulphur lamps can be electronically controlled over a broad range without perceptible changes in the colour temperature of the light.

Heliostat-based lighting system

To incorporate high efficiency sulphur lamps:

Sulphur lamps use electrical energy very efficiently (typically 100 lm/W). For photopic light levels, i.e. relatively high levels of light, the only lamp that can match the sulphur lamp in efficiency is the high-pressure sodium lamp which has, however, an unpleasant spectrum with a very poor colour rendering capability. At lower, mesopic light levels, the sulphur lamp is much more efficient than any other high-pressure discharge lamp known today. Furthermore, the sulphur lamp is the only dimmable lamp available for these purposes.

To offer reduced maintenance costs:

Hollow light guide systems accumulate less dirt than most conventional luminaires because of their sealed, aerodynamic design. Low maintenance costs result from the very long life of the sulphur lamp (typically 45,000 hours) and the magnetron (typically 15,000 hours) which is inexpensive and quite easy to replace. Therefore, maintenance intervals are longer than with other lighting systems.

To offer high level of visual comfort:

Medical research has shown the desirability of natural light for visual comfort and well being in spaces that are occupied for several hours of the day. This is especially important the core areas of deep-plan buildings and in underground floors. The reasons for this relate to the natural light spectrum and its variability, the perception of outdoor conditions and the passage of time, views to the exterior and other psychological and physiological influences. Integration of natural and artificial light helps to assure higher levels of visual comfort that cannot be achieved by the use of artificial light alone.

Higher visual comfort levels are achieved as a result of the excellent quality of daylight and the continuous spectrum of light from the sulphur lamp (Tcp = 6000 K, Ra = 78). Hollow light guides can provide uniform illumination with minimal glare.

The ARTHELIO system can take optimal advantage of available daylight and supplement this when necessary by light of an acceptable quality from intelligently controlled sulphur lamps to improve the visual comfort and well being of occupants while minimising energy use.

To offer improved safety features:

There are reduced risks of electrical shock, explosion and fire due to the low temperatures and absence of electrical currents in the channels of the guides. The lamp, ballast, electrical connections and any other sources of heat can be easily located outside hazardous or sensitive areas.

To use environmentally friendly technologies (the sulphur lamp):

The sulphur lamp, unlike most other comparable lamps, contains no heavy metals or other materials that could be harmful to the individual or the environment. Its light spectrum is continuous and resembles that of daylight, but with very low infra-red and negligible ultra-violet radiation. By comparison with fluorescent tubes and other discharge lamps, light flicker is minimal.

A new goniophotometer has been designed and built within the ARTHELIO project at the Technical University of Berlin. This is the only device available that is capable of measuring the luminous flux and luminous intensity distribution of hollow light guides.

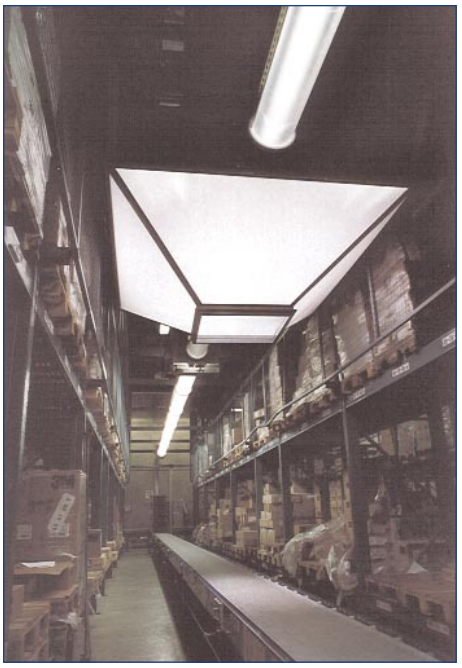
Once the necessary photometric data was acquired, the design of a lighting system using hollow light guides became possible.

The Technical University of Berlin has continued to measure hollow light guides from many manufacturers and also assists in the design of lighting systems using these luminaires.

Two demonstration prototypes were built, one in Carpiano, Italy and the other at the Semperlux building in Berlin. Both show, that the ARTHELIO system can be incorporated easily in different building types, and measurements show that demanding lighting system performance requirements can be achieved.

Heliostat System

For example, measurements on a sunny day in February using the Berlin prototype show an energy saving of more than 50%.



Hollow Light Guide System - Milan Prototype at 3M

Market potential

No other comparable technologies are currently available. Therefore, the world-wide market potential for the application of the ARTHELIO system to provide good quality, economical, easily installed, energy-efficient lighting in deep plan building interiors, underground stations, shopping malls, tunnels, and areas of buildings that hitherto could only be lit artificially is enormous.

The ARTHELIO system and the data acquired during its development are likely to be of particular interest to manufacturers of hollow light guide / light pipe daylighting systems but will also be of interest to organisations developing instrumentation and light delivery systems generally, including those involved in luminaire technology, photometry, goniophotometry, and other quantitative and qualitative light measurement activities).