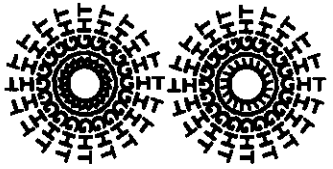

ADELINE - AN ADVANCED COMPUTER TOOL TO DESIGN AND EVALUATE DAY- AND ELECTRIC LIGHTING APPLICATIONS IN BUILDINGS

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ABSTRACT

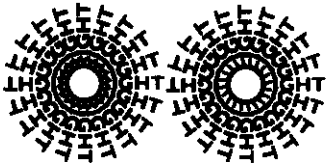
Within the project Task XII "Building Energy Analysis and Design Tools for Solar Applications" in the Solar Heating and Cooling Programme (SHC) of the International Energy Agency (IEA), design tools for energy efficient buildings have been developed resp. the capabilities of existing design tools have been enhanced and integrated. Aim of SHC Task XII is to develop and hand out design tools to designers, architects and engineers for the integrated evaluation of daylighting and heating/cooling concepts in an early stage of the actual design process. Concerning the software for the lighting and daylighting evaluation, the following international validated programmes are used:

- SUPERLITE (Radiosity)
- RADIANCE (Raytracing)
- SUPERLINK (linkage between daylighting and energy analysis).

The thermal and energetic behaviour of buildings can be analysed with the simulation tools

- SUNCODE
- TRNSYS
- tsbi.

The input of the programmes is handled by a common CAD programme and special converters. The software package is produced in international collaboration and will be distributed in 1993.



1. INTRODUCTION

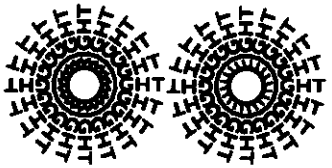
Planning a future building, especially with regard to its energy and daylighting features, is continually becoming more and more complex and demanding due to innovative materials, components and systems on the one hand and their impact on visual comfort and the thermal and energetic performance of a building on the other hand. Apart from the rather insufficient guidelines as provided by the authoritative standards [1], building designers are left without suitable design tools to assist them in their challenging task of designing a building distinguished by the rational use of energy and daylighting. Considering the importance of a comprehensive approach to energy utilization, there is a strong need for a design tool capable of fulfilling several tasks, namely to

- determine the lighting conditions in buildings with artificial lighting
- determine daylighting and temperature conditions in buildings
- evaluate visual and thermal comfort
- determine the impact of daylighting on lighting in general
- determine the effects of different strategies on heating and air conditioning
- evaluate economic and lighting aspects of many diverse daylighting and energy systems.

The International Energy Agency (IEA) is coordinating international research activities in the field of "Building Energy Analysis Tools", namely collaboration concerning the development, enhancement and validation of selected daylighting programmes as well as their connection with detailed dynamic, thermal and energetic building simulation programmes. Involved in the development of design tools have been:

- Fraunhofer Institute of Building Physics, Germany (Task lead)
- Lawrence Berkeley Laboratory, U.S.A.
- Ecole Polytechnique Fédérale de Lausanne, Switzerland
- Swiss Material Testing Institute EMPA, Switzerland
- Danish Building Research Institute, Denmark.

The principal aim of developing such design tools is to address the effects of daylighting on the energy performance of a future building at a very early stage in the design process so as to avoid mistakes in planning, thereby eventually enabling architects, builders and specialist planners to construct energy-efficient buildings.



2. CHARACTERISTIC FEATURES OF THE NEW DESIGN TOOL ADELINE

The ADELINE software package (Advanced Day- and Electric Lighting Integrated New Environment) has been developed within the framework of the research activities coordinated by the International Energy Agency. ADELINE is capable of solving a great variety of design problems associated with daylighting and electrical lighting applications.

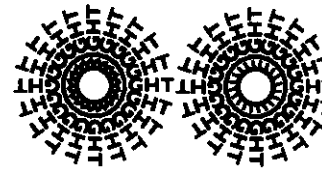
ADELINE is an integrated lighting analysis tool for building design purposes which is intended to assist the architect in all issues associated with daylighting and electric lighting design. This programme system equally applies to simple rooms and complex buildings. **Figure 1** gives a schematic presentation of the ADELINE programme system.

Within the ADELINE software system, lighting calculations are executed by SUPERLITE [2] and RADIANCE [3], while SUPERLINK [4] is a linkage between daylighting and other energy analysis tools used for predicting the dynamic, thermal and energetic performance of a building. With the exception of RADIANCE, the entire software package operates on a 386 PC with a mathematical coprocessor and a graphical monitor. RADIANCE requires a UNIX workstation.

The input of the programmes is handled by a common CAD programme and special converters. This common CAD programme [5] with a 2D-DXF interface enables the uniform data input of the building geometry under simulation for SUPERLITE, the RADIANCE raytracing technique and the SUPERLINK linkage programme. Moreover, the user is provided with a data base containing the material data of more than 250 different opaque and transparent materials. From closed polygons, the CAD programmme SCRIBE-MODELLER defines surfaces which may be attributed specific properties such as colour, reflectivity, roughness and the like. An interface programme will convert all geometry and material data of the CAD input into the different input formats required for SUPERLITE, RADIANCE and SUPERLINK, respectively. **Figure 2** shows a typical CAD input for the SCRIBE-MODELLER programme.

SUPERLITE 3.0 is an update version of the SUPERLITE 1.0 daylight simulation programme [2] which was developed in the course of the IEA activities. SUPERLITE 3.0 differs from previous SUPERLITE versions by several programme extensions, namely

- multi-zone modelling with radiative transfer
- shading/obstruction simulation
- modelling of daylighting systems
- SI-units used for input and output
- optimized running time
- graphical input and output programmes.



SUPERLITE simulations will provide the user with data on the

- illuminance distribution on the reference plane
- daylight factor profiles

that are to be expected in the designed building.

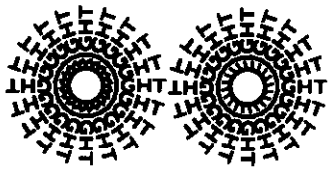
In **Figure 3** the illuminance distribution inside a room as predicted by SUPERLITE is illustrated. The RADIANCE raytracing programme is able to compute a photorealistic visualisation of the input scenario, considering all physical laws of light propagation. For daylighting calculations, the standardized sky according to CIE (Comité International de l'Eclairage) may be taken into account. Correspondingly, the luminous intensity distribution curves of any luminaires may be considered for electric lighting calculations.

Predicted results e.g. for a building will support users with

- physically exact photorealistic views of the building
- both luminance and illuminance distributions on all component surfaces
- visual comfort evaluations.

The SUPERLINK calculation programme allows to determine potential energy savings due to daylighting for a certain building. Besides computing possible savings in electric lighting energy, the impact of daylighting onto the overall energetic behaviour of a building (including heating and cooling) may also be determined by linking dynamic thermal and energetic analysis tools. In this case, the necessary daylighting calculations will be performed by SUPERLITE, considering the sunshine probability at the given location. User results will include

- hourly illuminance distribution on the reference plane under standardized sky models (cloudy skies; clear skies with/without sun) for one day per month
- hourly energy consumption for general lighting needed to ensure the required rated illuminance
- annual relative daylighting hours
- annual switch-on time of electric lighting.



3. SOFTWARE ENHANCEMENT AND CONTACT PERSONS

Responsible institutions for maintenance and enhancement of the ADELINE programme system are the Lawrence Berkeley Laboratory in the U.S., the Ecole Polytechnique Fédérale de Lausanne (Switzerland) and the Fraunhofer Institute of Building Physics (Germany) in Europe. The whole software package of ADELINE is expected to be finalized by mid-1993. Subsequently, ADELINE will be available as a public domain software for practical applications while the source codes will remain with the research centers.

ACKNOWLEDGEMENTS

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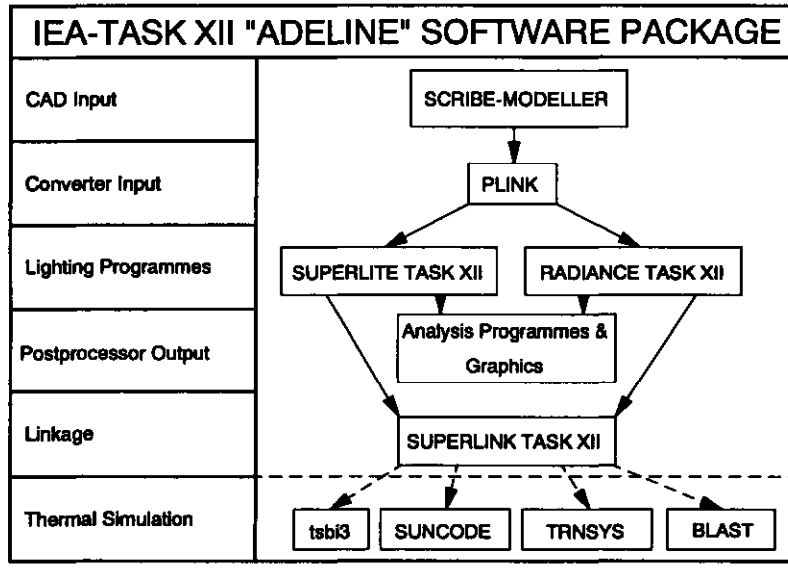

Figure 1 Structure of ADELINE lighting design tool

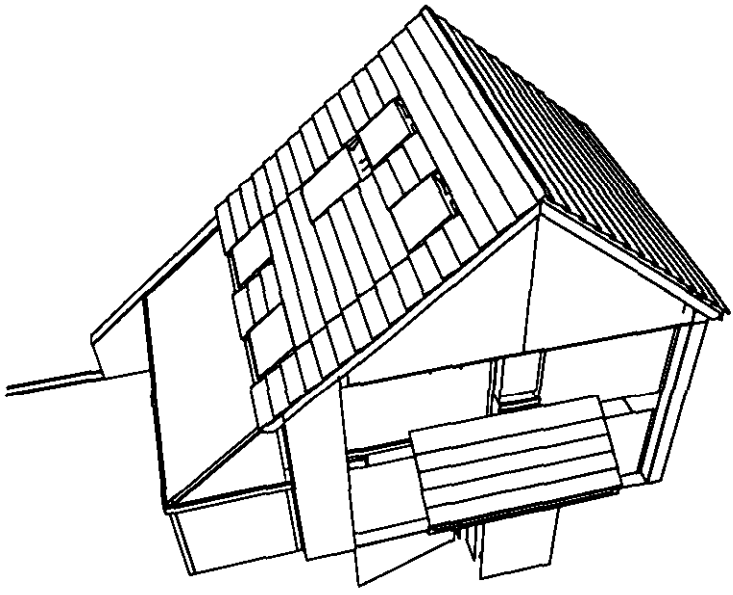

Figure 2 Exemplary building data input using the CAD software SCRIBE MODELLER within ADELINE. CAD input may be linked with a material data base and be converted into SUPERLITE, RADIANCE and SUPERLINK input formats through PLINK.

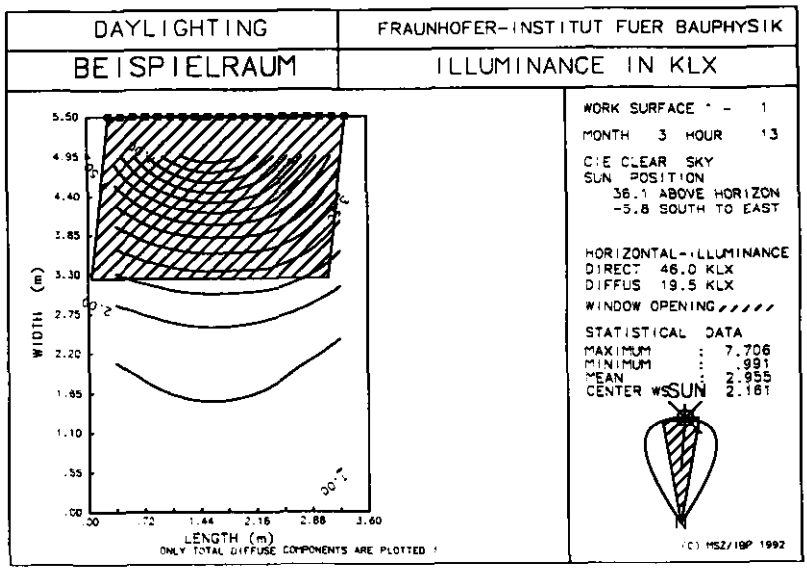

Figure 3 Predicted illuminance distribution inside a space (left) and input data (right) in an examplary plot of a SUPERLITE calculation.

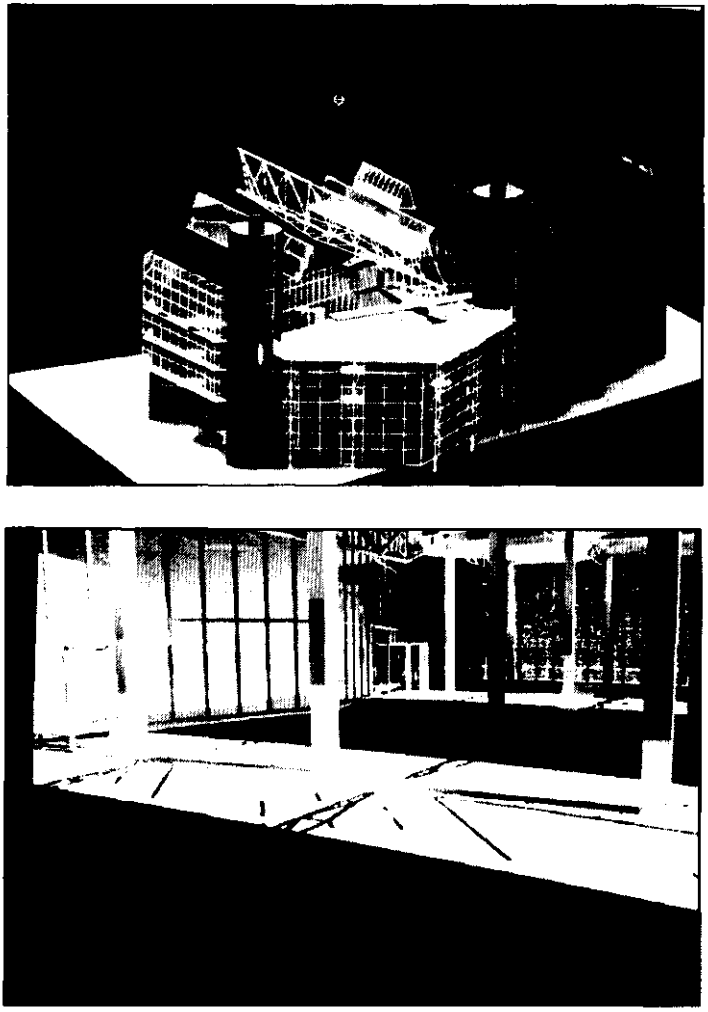

Figure 4 Photorealistic visualisation of predicted values determined under RADIANCE for the planned Berlin Museum of Traffic and Technology (Top: Calculated view of museum; Bottom: View of upper storey).

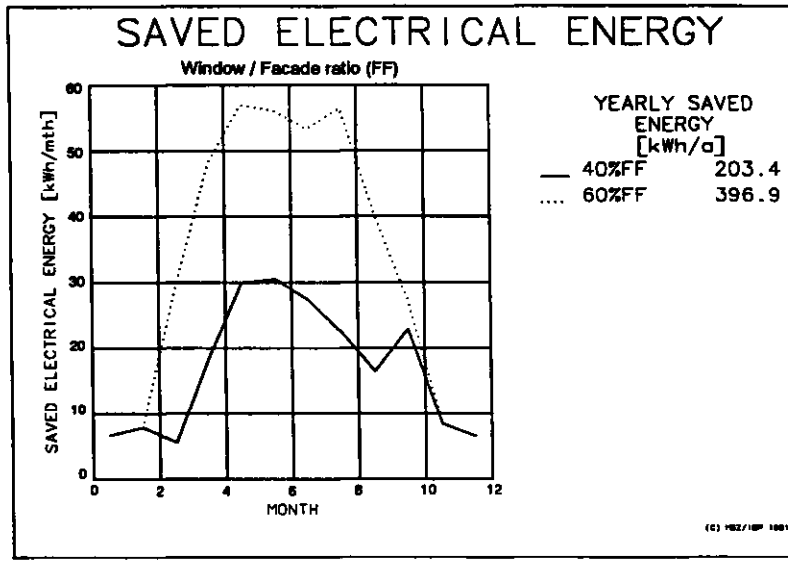

Figure 5 Typical results of a SUPERLINK prediction for a demonstration space with a window/facade ratio of 40 resp. 60 % and a rated illuminance of 500 lux. Saved electrical energy per month using daylighting is plotted vs. continuous electric lighting during occupation time.