Abstract – This Danish-German-France project co-operation RENARCH I+II aims to develop and disseminate information about renewable energy and sustainable architecture in the three countries. It is based on the idea, that environmental issues have to be integrated from the beginning of the design process. To this purpose, the project partners develop special teaching materials: fundamentals, architecture themes and elements, design-guidelines, a database of architecture examples and a simulation tool which are applied in the professional education of architecture students and in life-long learning courses for architecture professionals.

1. INTRODUCTION

The RENARCH I project was a Danish-German co-operation project supported by the EU-ALTENER programme under DG XVII, the Directorate-General for Energy. National support in the two respective countries was given by Deutsche Bundesstiftung Umwelt, the German Environment Agency and Energistyrelsen, the Danish Energy Agency. RENARCH II has received support also from the EU-ALTENER programme to a continued development, refinement and translation of the teachware.

The purpose of the project RENARCH I+II is to develop ‘teachware’ and disseminate information about renewable energy and sustainable architecture to both architecture students and practising architects in the two countries (Mørck & Tuschinski 1996). One of the initiating factors was the fact, that both Denmark and Germany introduced revised building regulations in 1995, with the goal of reducing the energy consumption to heat buildings, and provided simple calculation tools for heating loads.

Pedagogic principles has been used to develop teaching packages that address sustainability with an architectural language based on form, space, structure, materials, etc. In this way the issues of sustainable architecture can be integrated into the architectural design process from the beginning. The RENARCH I project has been completed (1996-1999) and the following activities undertaken:

• A comparative study of the energy related building regulations in Germany and Denmark
• Two courses for renewable energy and sustainable architecture:
  • one as workshop for students in Denmark and
  • one as Internet-based Online-workshop for architects in Germany, including a database of inspirational built examples of sustainable architecture.

• A simple-to-use and highly graphic interactive heat load calculation tool based on the CEN standard methodology, RENSIM.

RENARCH II (planned for 1999-2001) is designed to continue the activities of RENARCH I. In RENARCH II France is included as a participating country. The comparative study of the energy related building regulations will be continued looking at the newest legal changes in the three countries, and the new RENARCH – Information system will gather all the information and materials produced and publish it on the Internet. Besides the existing material will be improved and translated. The expected results encompass: A course for students, an energy calculation tool for architecture students, a course for architects - integrated with RENARCH-online, a comparative study of the German and Danish and French building regulations and an Information System on the Internet called RENARCH-Online. Through RE-NARCH II the knowledge regarding renewable energy and sustainable architecture for both students and practising professionals will be disseminated in Germany, Denmark and France and internationally through the Internet. The didactic materials and the computer tools developed within RENARCH could be further utilised in regular training courses in universities for architecture students and in life-long training courses for architecture professionals.

2. COMPARISON OF DANISH AND GERMAN BUILDING REGULATIONS

One of the starting points of the project RENARCH was, that both Germany and Denmark had recently introduced new building regulations related to the reduction of heating loads: Germany starting 1 January 1995 and Denmark starting 1 April 1995: Both regulations consider the thermal impact of the renewable energy of solar radiation falling through transparent building elements - windows and sunspaces - as passive heat gain in buildings.
Both Danish and German building regulations also bring in a new approach - the limitation of the heating load of buildings by considering all design aspects and elements that make up architecture: building orientation, form and zoning, transparency of the building shell, thermal inertia of building mass, modes of using the building in terms of heating: setpoints, hours of use, and ventilation: natural, mechanical, or mechanical ventilation with heat recovery. In the calculation methods for the buildings’ heating loads provided by the regulations of the two countries, these aspects are considered in relatively similar ways, with several differences, like the accuracy of weather data.

As one of the RENARCH project-tasks, the two revised building regulations of Germany and Denmark have been compared in terms of backgrounds, goals, approaches, points of view, calculation methods, consequences and future perspectives. A special attention has been given to the consideration of the impact of solar radiation - as renewable energy to be used in buildings.

For a better comparison of the impact of the two regulations for the design process of architecture, two low-energy residential buildings have been used as examples for heating load calculations and for the comparison of the consequences of the two building regulations. The calculations have been effectuated using the software running under the MsWindows-platform as follows: BV’95 - conform to the Danish regulation and WPASS - conform to the German regulation.

Based on the different calculation results for the two buildings and the corresponding climatic data of both countries, ample conclusions were drawn. As a further step, for one building there have been carried through energy simulation calculations using the software SunCode.PC and the dynamic weather data for Copenhagen and Würzburg. The conclusions were drawn in relevance to the goals of the RENARCH-project and will be a part of the Internet-based Design Guidelines.

3. THE RENARCH-TEACHING MATERIAL

The teaching material developed within RENARCH for Danish students is based on a tree-structure similar to the Institute for Building Science’s previous publication ‘Teknik og arkitektur’ published 1995. The teaching material comprises the two following components:

- **Fundamentals**: Teachware for architecture students in Denmark. This describes the framework that sustainable architecture operates within; Politics & economy, Global environmental problems, External climate conditions, Internal climate conditions.

- **Themes & Elements**: An architecturally thematic approach is used to present the issues surrounding sustainable architecture: Building Organisation (Form - volume, zoning, orientation & Structure - materials, construction process, flexibility), Envelope (Openings - daylight, regulation, passive and active solar & Shelter - homogenous, layered, double), Installations (Elements - energy, water, lighting, waste & Organisation - heating, cooling, ventilation, drainage), Materials (Process - lifespan, weathering, recycling & Production - environmental, impact, manufacturing, transportation). This part of the teaching material also contains a database of successfully completed buildings in Europe.

![Figure 1: Example from Architectural Themes & Elements: energy efficient housing project in Copenhagen.](image)
4. DATABASE OF CASE STUDIES OF EUROPEAN ARCHITECTURE

One of the central parts of the RENARCH teaching material is the new database RENARCH with European buildings and projects (from Denmark and Germany in RENARCH I and including France in RENARCH II) that can serve as inspirational examples for the use of renewable energy in architecture. Both the Architectural Themes and Elements, as well as the Design Guidelines and the Calculation Tool use the database of case studies as examples. The architectural case studies have been structured as follows:

Project Fundamentals:
- Building name, type, location, owner, architect, year of completion
- Backgrounds: demonstration project, special funding, etc.
- Site conditions: climate, air temperature, shading, solar radiation, etc.
- Information sources: literature, internet-references, etc.

Energy Concept:
- General approach: climatic scenario (winter, summer, spring)
- Special solutions: passive heating, natural venting and cooling, etc.

Building organisation:
- Form: volume, zoning, orientation
- Structure: materials, construction process, flexibility

Envelope - Climatic Shell:
- Openings: windows, sunspaces
- Solar Components: transparent insulation, solar collectors, PV, etc.
- Shelter: homogeneous, layered, double

Installations:
- Elements: heating, warm water, lighting
- Organisation: heating, venting, cooling, drainage

Materials and building components:
- Production: environmental impact, manufacturing, transportation
- Process: life span, weathering, recycling

The teaching material developed by the project partners within RENARCH I was illustrated by the architecture examples of the new database of case studies. The types of buildings to be looked at in the RENARCH project focus on new-build buildings, especially on housing projects in the two countries: single housing and multiple housing, respective terraced housing / apartment buildings, also smaller educational buildings like kindergartens and elementary schools.

5. SIMULATION TOOL REN-SIM

A new computer-based calculation tool has been developed. The calculation method that lies behind the interface is based on the CEN Euro-standard “Thermal performance of buildings - Calculation of energy use for heating - Residential buildings EN 832:1994”. Rather than inputting the physical dimensions of a building, a choice is made from selecting between a series of pre-designed simple forms based on some standard module sizes, representing a "unit of living accommodation" (e.g., an apartment or terraced house). Variations on these modules are given to represent horizontal forms (terraces) and vertical forms (apartments). A single unit is a detached house. To each form there has been connected a mathematical description of the volume and surface areas so that heat losses can be calculated. Glazing are selected by choosing a proportion of each facade that is glazed. The orientation can be easily changed.

REN-SIM is meant to be used at the beginning of the design process to experiment with ideas and concepts or at a more developed design phase in order to test form that most resembles the design. An analysis / improvement of its performance could then be carried out by the user. The programme was developed as incentive for architecture students as it is easy to use with a good graphical interface and requires the input of large amounts of information, in contrast to other Building
Regulations calculation programmes. It contain three components:

- Knowledge and data to describe buildings, their utilisation and environment and to describe technical systems available for a special building.
- Methods to generate a specific building taking into account user description, to calculate the energy requirement for heating in accordance with EN 832, to derive a list of possible heating systems which are able to provide the energy in a sustainable way and to evaluate the alternatives in accordance with criteria provided by the user.
- A graphical user interface able to input the user decisions and to activate the methods available.

6. TRAINING FOR STUDENTS AND ARCHITECTS

For the Danish architecture students there are small workshops (for 15-25 students) that can be offered to the various architectural design departments at the Royal Danish Academy School of Architecture in Copenhagen. The project partners have developed a co-operation with the Department of Building Sciences at the Aarhus School of Architecture, in Aarhus, Denmark to use the developed training material in the School’s teaching programme. This means that RENARCH’s target audience of architecture students in Denmark will be doubled.

The life-long learning courses within RENARCH for architects in Germany will be carried through as on-line information system and experimental Internet-based course. A virtual discussion forum will give the architects a chance to discuss among them and directly with the architects - the authors of the design projects used as illustration for the Design Guidelines.

As the project proceeds, the training will be evaluated and improvements will be made. These will then be implemented when the training material is used in other institutions in the same countries. In a future extension of the project, all the teaching material might be translated.

7. CONCLUSIONS

RENARCH I was completed in 1999 and is to continued in RENARCH II (planned for 1999-2001). The comparative study of the energy related building regulations will be repeated looking at the newest legal changes in the three countries, and the new RENARCH – Information system will gather all the information and materials produced and publish it on the Internet. Besides existing material will be improved and translated into all three languages. Through RENARCH II the knowledge regarding renewable energy and sustainable architecture for both students and practising professionals will be disseminated in Germany, Denmark and France and internationally through the Internet. The didactic materials and the computer tools developed within RENARCH I+II can be further utilised in regular training courses in universities for architecture students and in life-long training courses for architecture professionals.

REFERENCES

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