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# An online collaborative tool for sustainable design.

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# AN ONLINE COLLABORATIVE TOOL FOR SUSTAINABLE DESIGN

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**Abstract.** One of the most important aspects a design team needs to consider fairly early on is that of energy saving, cost, thermal comfort and the effect on the environment in terms of CO<sub>2</sub> emissions. This paper presents an online collaborative tool that allows the design team to collaborate –from distance- on providing a general description of a building which can be used to generate sufficient data to drive a valid analysis using a detailed thermal model at the early sketch stage of the design process. This tool – called CASD - guides the user through the input process using a series of screens giving options for keywords used to describe the building; comprehensive default data built into the software are then attached to these keywords. The resulting data file is a building description that is the best possible interpretation of the design intent. This can then be used to assess options and guide towards a final design.

## 1. Introduction

In the early stages of building design process, architects need to assess various design alternatives and choose the one which best represent their design intent. One of the important aspects that architects need to consider fairly early on is the aspect of energy saving and thermal comfort especially for non-domestic buildings [1], taking into account the bioclimatic issues [2].

In this paper, we report on an online tool called Computer Aided Sustainable Design (CASD) that will guide the user through a series of input screens in order to describe the building and select various environmental and energy saving options. This tool is to be accessed, through the World Wide Web, by members of the same design team in order to collaborate [7, 8, 9], in the early design stages of a building project, at integrating environmental aspects in their design.

A selection of building specifications from a database is used to generate numerical information that will be used by a calculation engine that uses sophisticated thermal models [4].

One of the projects main objectives was to develop a tool that assisted in reducing the number of design cycle iterations (revisions). This fits with government policy to improve the effectiveness of the design process and to make procurement of buildings cheaper and more efficient.

In the past, people have resisted the use of such simulation programs for a number of reasons. The main objections were that

- The input process of the necessary data is time-consuming,
- The interfaces are generally not user-friendly enough, both in terms of input and output. For the latter, it could even be manifested by a lack of trust in the system if the results obtained by that tool are not explained properly.

CASD goes along way in addressing both of these objections:

- it reduces the amount of input required for each building, (i) with the use of extensive, intelligent defaults and (ii) by providing an online collaborative platform allowing the team members to share the load of the input task, whereby each member contributes the inputs corresponding to his expertise required for the design of the building. A by-product of this collaboration is the increase in trust in this system given that each team member will contribute his expertise.
- it offers a user-friendly interface where the input is pictorial based, and where the output is given in terms of figures (bar charts) comparing different specifications of the same building on a number of environmental and energy-saving indicators (e.g., CO<sub>2</sub> emissions).

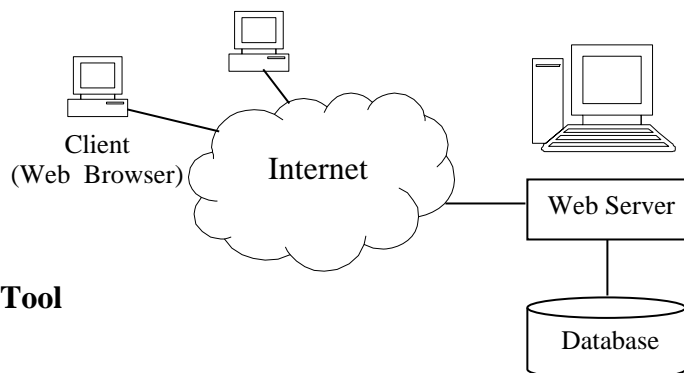
## 2. Design team and distance collaboration

An architectural design project involves many building actors in various areas of expertise, such as architects, mechanical engineers, environmental engineers, surveyors, electrical engineers, financial experts ... etc.

At the sketch design stage, these actors are required to meet very frequently for consultation and debate in order to discuss the design. Each expert is supposed to bring in his knowledge to decide on the building specifications related to his area of expertise. Usually, a rapporteur will then take the outcomes of these meetings and integrate them in the design. This last stage could be error-prone due essentially to the misinterpretation, by the rapporteur, of the meetings' discussions and outcomes. It would also be a time-consuming exercise.

CASD enables the design team to have fewer meetings, to collaborate from distance on the design project, and to enable each expert to input, by himself, the data that corresponds to his area of expertise.

Each expert can contribute to the design project by accessing the Internet and pointing his web browser (see figure 1) to the URL where CASD is located. The data and the processing will be done on the server, a dedicated machine which hosts the CASD tool and the database of building regulations.



## 3. The CASD Tool

**Figure 1:** Collaborative Platform for the Design Team

Although a number of energy systems already exist, such as the ones developed by the Energy Systems Research Unit (ESRU)<sup>1</sup> of the University of Strathclyde, the EnergyPlus<sup>2</sup> system developed by the U.S. department of Energy, or Graphisoft's flagship building services product, Cymap<sup>3</sup>, CASD has the advantage of being online, thus making full advantage of the World Wide Web infrastructure and enabling collaborative design.

CASD also has the ambition of enabling building actors to share their experiences by using XML [6] as a standard language for describing, sharing and communicating building descriptions and specifications. This is achieved by designing a number of tags (data containers) which will help describe a building's specification. In figure 2, the tags (text enclosed between <>) serve to describe the building's attributes, whereas the space used between the two tags is used to input the value of that attribute:

```
<FloorToFloorHeight> 5 </FloorToFloorHeight>  
<PercentageGlass> 17 </PercentageGlass>  
<LightPowerPerArea> 325 </LightPowerPerArea>
```

**Figure 2:** XML as a description language of buildings' specifications

XML is a cross-platform, software and hardware independent tool for describing and transmitting information across the Web. We use XML to summarise the data input by the users into CASD and to communicate this data to a third-party thermal engine. Results returned by the latter are also described in XML to be then graphically presented to the users in terms of bar charts.

CASD is a tool that allows users to enter a minimum amount of data to produce an energy analysis file. The analysis of this file is performed by a third party analytical program. It is intended to be used to compare the performance of different building's design specifications so that the building actors can choose the best option with regard to a number of environmental and energy-saving indicators.

The originality of this tool is that the inputs and the outputs are generated in a language that can be understood by building actors where it is not necessary for them to have good computer skills.

The interface has been developed using HTML. ASP (Active Server Pages) [5] code was used to link the Web pages to a Microsoft Access Database containing all the data entered by the user, and other default (standard) values related to the building regulations in the U.K. ASP allows you to dynamically edit, change or add any content of a Web page, respond to user queries or data submitted from HTML forms, access any data in the database and return the results to the browser. The images and icons have been manipulated using Adobe Photoshop. The interface has been designed in consultation with an architect who approved its layout and content.

The interface is comprised of a sequence of 12 screens (Web pages) in which the user can freely move forth or back. The user is free to start from any screen after completing the first one which relates to the project description. The user can stop at any stage, save his/her work and resume at some other time. Because of space limitation, we will only show here some of the options available to the user in each of these screens:

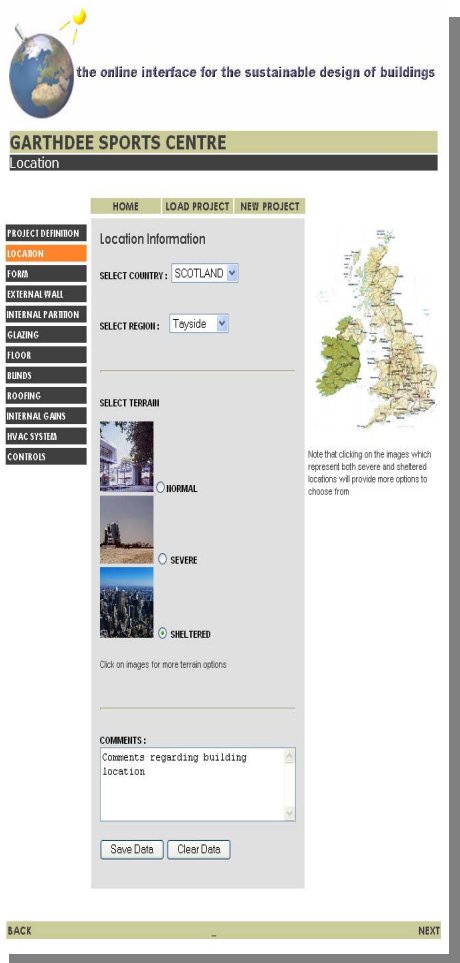
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<sup>1</sup> [www.esru.strath.ac.uk](http://www.esru.strath.ac.uk)

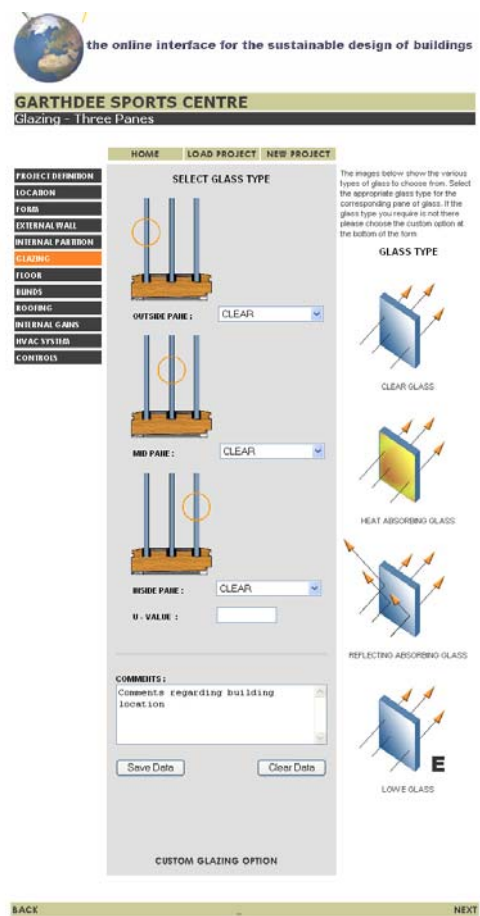
<sup>2</sup> [www.eere.energy.gov/buildings/energyplus](http://www.eere.energy.gov/buildings/energyplus)

<sup>3</sup> [www.cymap.com](http://www.cymap.com)

- **Project Screen:** enables the user to load an existing project (from the database) or create a new one. For newly created projects, the user can specify a project's name, description and the air conditioning function (standard or prestige).
- **Location Screen:** enables the user to select the country in which the building will exist (at the moment restricted to the U.K.), then select an area within that country (see figure 3), given that in many cases building regulations differ from place to place. And finally, the user can enter the terrain in which the building is to be built, i.e., normal, severe or sheltered. If one of the two last options is selected, the user will be asked to specify whether the terrain is "rough open", "farmland", "urban" or "sub-urban".
- **Form Screen:** enables the user to describe the building's size (length, width, floor to floor height, floor to ceiling height, number of floors...), orientation (using a diagram that the user can rotate) and to describe the façades (in particular, the percentage of façade area that is glazed).
- **External Walls Screen:** enables the user to describe the building's external walls. The user has three different ways of completing this section: Standard, Custom or load other walls. We describe here the first method, which is to simply choose from the standard specification shown for thermal response time and insulation standard. There are three possible values for the thermal response time. For example, slow corresponds to a lightweight external cladding with insulation in the centre and a solid internal wall. Then the user can decide on the insulation standard by either choosing the standard UK building regulations value or a better value.
- **Internal Partitions Screen:** enables the user to describe the building's internal partitions and layout. The description includes the type of internal partition (high mass, medium mass or low mass internal wall) and the type of cell structure (mostly open plan or mostly cellular) for each of the sides of the buildings.
- **Glazing Screen:** enables the user to describe the building's glazing (see figure 4). The user is offered two options: standard or custom specification. The standard option prompts the user for the number of panes of glass (two or three), the type of glass (clear, heat absorbing, reflecting or low E). If the user opts for the custom option, he/she needs to provide the U-Value of the glass, the short and long wave shading coefficients and the light transmission.
- **Floor Screen:** enables the user to describe the building's floors. Again, three options are offered: standard, custom or load other floors. The standard option, for example, prompts the user to select the weight of the internal floor (light or heavy), the type of the internal floor and the type of the ground floor (solid or suspended).
- **Blinds Screen:** The user can describe the building's blinds and shading devices (overhangs, loggia...). The type of blinds includes external blinds, internal blinds and mid-pane.



**Figure 3: Location Screen**



**Figure 4: Glazing Screen**

- **Roofing Screen:** It enables the user to describe the roofing specifications of the building. Again, three options are on offer, namely standard, custom and load other roofs. The standard option, for example, requires the selection of the type of the roof (solid, solid with suspended ceiling and lightweight with suspended ceiling) and its insulation (the default option is set to comply with the building regulations, and if needed the user can select a better U-value).
- **Internal Gain Screen:** This screen enables the user to input data which determine the internal gain of the building [3]. There are two sections in this screen, occupancy and loads. For occupancy, the user must input the schedule showing when the building is occupied (this determines the heating or the cooling schedule and its intensity). The user selects an entry from a list of five choices: Very high occupancy (24hrs, 7 days/week), High (12hrs, 7 days/week) ... etc. The density of the building should be given in terms of the number of people per square meter: Very high density (5m<sup>2</sup> per person), High (7m<sup>2</sup> per person) ... etc. The loads section of the screen describes the power used in the building, and the power used to run the machines inside the building. Again, the user can select from a range of “very high” to “very low”.
- **HVAC System Screen:** It enables the user to input data which determines the type of heating, ventilation and air conditioning system to be used within the building. For

example, the user selects the type of frost coil, the type of heat recovery system, the type of cooling coil and the type of humidifier.

- Controls Screen: Here the user can describe controls related to elements within the building including blinds, lighting, temperature, boiler, perimeter heating and electrical equipment such as computers. Talking about the blinds for example, the user selects how the blinds are operated (profiled, automatic or manual).

## 5. Conclusion

In this paper, we have presented CASD an online collaborative tool that allows different members of a design team to collaborate, using the World Wide Web, on a building project during the early design stages. It has been designed to suit the iterative nature of the 'real-world' design process as well as the language used by the actors involved. One of the most significant contributions of CASD is that it will enable users to share and communicate building descriptions and specifications through the Web. This is achieved by using the XML standard language.

CASD allows a team of professionals to bring in their expertise in order to consider various design scenarios and compare their performances in term of thermal efficiency. This is achieved by producing an output profile, which represents the building's performance according to different criteria.

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