Energy Analysis Software Evaluation
BIM Interface and Interoperability

IES <VE> 5.8.1
Ecotect 5.60
eQuest 3-6
IDA ICE 3.0
EnergyPlus v.2.1
RIUSKA 4.4

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1 Introduction

Energy analysis programs are tools to study energy performance and thermal comfort during the building life cycle. Numerous such tools are available and they differ in many ways; in their thermodynamic models, their graphical user interfaces, their purpose of use, their life cycle applicability, and their ability to exchange data with other software applications.

Data exchange, primarily from CAD applications, but also in conjunction with other design tools such as HVAC modeling tools, can provide a user friendly and practical way of integrating these tools in the design process of a building.

In this evaluation, six programs were tested. The focus was on determining the software’s capability to utilize open format building information models (BIM). The tested programs were IES <Virtual Environment>, Ecotect, eQuest, IDA ICE, RIUSKA and EnergyPlus. In the first part of the evaluation the programs’ BIM interface was tested. In the second part, the programs that were able to utilize BIMs were familiarized with and their value to practical design work was evaluated briefly.
2 Program comparison

2.1 Program versions

The tested energy analysis software versions were:

- IES <VE> 5.8.1 trial version
- Ecotect 5.60 trial version
- eQuest 3.6
- IDA ICE 3.0 trial version
- EnergyPlus v.2.1
- RIUSKA v. 4.4

2.2 Tested models

In this evaluation three models were used to test the interoperability and usability (importing) of open standard building information models; in this case IFC and gbXML. It should be noticed that gbXML (the Green Building XML schema) is targeted to exchanging information to engineering analysis, mainly thermal analysis, softwares. IFC (Industry Foundation Classes) has wider scope to support whole building and facility industry through the whole life cycle of a building.

Three types of models were tested, each of them having certain characteristics:

Rodino federal office building (Figure 1):
- The model is exported from Revit by CIFE
- For demonstrating how the tested software would handle a real large scale model

Test model by BuildingSMART/ISG (Figure 2):
- Two-storey test model for space boundaries
- For testing a clean small scale BIM, e.g. in such cases where larger models would fail to be imported

Three-storey model for thermal simulation (Figure 3):
- Three-storey model created by Olof Granlund Oy using MagiCAD Room space modeling tool
- The model is intended for testing the interoperability with simple building elements
The following schemas were tested:

- Rodino Office Building IFC 2x2 and gbXML
- ISG test model IFC 2x3 and gbXML
- Three-storey model IFC 2x2 and gbXML

Figure 1. Model of Rodino Office Building (viewed by Solibri Model Checker).

Figure 2. ISG test model (viewed by Solibri Model Checker).
2.3 BIM import testing

2.3.1 IES <VE>

Integrated Environmental Solutions (IES) <Virtual Environment> does only support gbXML as BIM interface. All attempts to import the gbXML models were successful. The models were otherwise correct, but IES<VE> lost the upper story windows on the two smaller models.

Figure 3. Model of three-storey building (viewed by Solibri Model Checker).

Figure 4. Rodino model, gbXML to IES <VE>
2.3.2 Ecotect

Ecotect has added the support for IFC and gbXML schemas since the release of the newest version 5.6. There seems to be still some problems with exterior wall and roof placement, at least with the IFC. All the BIMs (IFC and gbXML) seemed to import rather well but the Rodino IFC produced a faulty model.

gbXML:
Figure 8. ISG test model, gbXML to Ecotect

Figure 9. Three-storey model, gbXML to Ecotect

IFC:

Figure 10. Rodino model, IFC to Ecotect


2.3.3 eQuest

eQuest does not provide any BIM interface directly. The only way to import 3D-geometry information from a CAD program is indirectly by using a third party program Green Building Studio (GBS) that takes care of the transformation between the gbXML format model and the DOE-2 input file, which is needed for eQuest.

It was found though that the import of the model hinders the actions in the program itself. Provided that the model is imported, eQuest will disable the wizard functions. That means that with imported model usability of the software decreases.

The path to import a model into eQuest was not working in the test. GBS client didn’t produce a single working input file and therefore importing failed.
Figure 13. Data flow in the Green Building Studio (GBS) to DOE-2 input file, which is information source for eQuest.

2.3.4 IDA ICE

IDA Indoor Climate and Energy is a sophisticated tool for calculating single space thermal simulations, but it handles quite poorly large building spatial models.

IDA supports IFC file format, but apparently doesn’t understand the IFC 2x3 schema:
- Rodino model failed to import probably due to its size (even though it was IFC 2x2)
- ISG test model failed to import due to schema (IFC 2x3)
- Three-storey model was imported successfully (IFC 2x2)

![Diagram showing data flow from CAD Tool, to CAD Model in gbXML format, to GBS Web Service, to DOE-2 or EnergyPlus Input File.]

Figure 14. Three-storey model, IFC to IDA ICE
There is a new version coming out in the near future that will support also IFC 2x3.

2.3.5 RIUSKA

RIUSKA is a comfort and energy simulation software that utilizes the DOE-2.1E as simulation engine. RIUSKA is based on the import of building geometry through IFC, and has an IFC interface through the BSPro COM-Server middleware tool. gbXML is not supported by RIUSKA. RIUSKA can also export main spatial thermal parameters to IFC to be used in other applications, such as building services system modeling or requirements management tools.

All of the tested IFC models were imported successfully.

IFC:

Figure 15. Rodino model, IFC to RIUSKA

Figure 16. ISG test model, IFC to RIUSKA
2.3.6 EnergyPlus

BIM support for EnergyPlus has been under development in the following fields:

- IFC to IDF, a LBNL-developed client software module based on the BSPro COM-Server was available for EnergyPlus version 1.0 through 1.3. Due to missing space boundaries the EnergyPlus utility (IFCtoIDF) is not currently available.

- gbXML to GBS to IDF, an indirect path from Autodesk Revit, Architectural Desktop, Building Systems, and Graphisoft ArchiCAD to EnergyPlus IDF.

- IFC to Google Sketchup to EnergyPlus, an indirect path where IFC2SKP plugin would produce a GoogleSketchup model from the IFC and Energy Design Plugin would export the Sketchup model to the EnergyPlus.

When the first option, IFC to IDF, is not currently available and the GBS was not working in the test (see eQuest results), the test was concentrated on the IFC to Google Sketchup to EnergyPlus option:

- IFC2SKP Beta version: from IFC to GoogleSketchUp

- Energy Design Plugin 0.9 beta: GoogleSketchUp to Energyplus

In the test the IFC2SKP plugin worked quite well and successfully produced Sketchup models from the two small test models, but the Rodino model import did not work. However the whole path was not successful, because the Energy Design Plugin was not able to transform Sketchup models into EnergyPlus, but is only able to handle or refine already existing EnergyPlus input files.
EnergyPlus test summary:

- GoogleSketchUp does read IFC models and shows them correctly (didn’t read heavy models though; like Rodino)
- The Energy Design plugin enables only opening of existing EnergyPlus input files into SketchUp and modifying them
- It doesn’t allow imported IFC (SketchUp .skp) to be exported to EnergyPlus via the interface and cannot be used to import IFCs to EnergyPlus.

2.4 Program features that support practical design work

The following is a description of useful program features that were identified during the evaluation. eQuest and EnergyPlus were not included in this part, because in those cases the BIM import was not successful.

2.4.1 IES <VE>

The IES Virtual Environment is an integrated system that operates all of its building simulations from a central building model. Once the BIM object has been imported into the IES, there is no tedious repetition of data input or multiple imports into various simulation tools. IES is considered the industry standard in the UK for energy efficient building design, partly because of its capability to simulate advanced HVAC systems and passive building effects.

2.4.2 Ecotect

Ecotect has the ability to display and animate complex shadows and reflections, generate interactive sun-path diagrams for instant overshadowing analysis, calculate the incident solar radiation on any surface. It can also calculate monthly heat loads and hourly temperature graphs for any zone.

Exterior wall and roof placement tend to be the most problematic elements. Ecotect can export to wide range of other programs and CAD formats.

2.4.3 IDA ICE

IDA Indoor Climate and Energy is a simulation application for accurate study of thermal indoor climate of individual zones ( thermal zones) within a building as well as energy consumption for the entire building. The user interface has been designed to make it easy to build up and simulate simple cases, but also to offer the advanced user the full flexibility of IDA, to facilitate the simulation of complex or unusual cases.
The system to be simulated consists of a building with one or more zones (rooms) and a primary system (the subsystem containing chiller and boiler) and one or more air handling systems. For many studies nothing needs to be altered in these HVAC systems. IDA is suited to making sophisticated thermal simulations of a single (or a few) space(s). However IDA can't handle complicated and large buildings with possibly hundreds of spaces.

### 2.4.4 RIUSKA

RIUSKA is a spatial thermal simulation tool and parameters such as operating schedules (yearly, weekly, daily, hourly), occupancy/lighting/equipment gains, HVAC systems can be defined for each space individually. The user is allowed to specify varying conditions in separate spaces in any number of special configurations, which is a significant advantage over zone-based energy programs.

RIUSKA gives an opportunity to specify temperature set points and design heating and cooling target temperatures for each space. That ensures less over sizing of air conditioning requirements than in a system, where set point and target temperatures are equal.

RIUSKA does provide only simulations of DOE-2's LOADS and SYSTEMS modules and is also limited to four different air conditioning systems. It doesn't utilize the PLANT and ECONOMICS modules nor does it simulate any water loops serving the air loops.

Nevertheless RIUSKA is very efficient and powerful tool for energy analysis in practical design projects.

Tables 1 and 2 summaries some of the main features of the tested programs.
Table 1. Summary of energy analysis software tool features 1/2

<table>
<thead>
<tr>
<th>User interface</th>
<th>IES 5.8.1</th>
<th>Ecotect 5.6</th>
<th>E-Quest 3-6</th>
<th>EnergyPlus v2.1</th>
<th>IDA ICE 3.0</th>
<th>RIUSKA 4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIM based import (other formats)</td>
<td>comfortable</td>
<td>adequate, manual needed</td>
<td>a bit illogical, has wizards though</td>
<td>Doesn't have any</td>
<td>requires understanding</td>
<td>easy to use</td>
</tr>
<tr>
<td>BIM based export (other formats)</td>
<td>gbXML (DXF; GEM; MIT)</td>
<td>IFC, gbXML (+lots more)</td>
<td>gbXML, only indirectly by GBS (didn't work properly)</td>
<td>(IFC), gbXML, only indirectly (IDF; IMF)</td>
<td>IFC (IDM; IDA; IDS; DWG; DXF)</td>
<td>IFC</td>
</tr>
<tr>
<td>3D geometry modelling</td>
<td>via CAD</td>
<td>via CAD</td>
<td>simple, restricted</td>
<td>no, only external</td>
<td>via CAD or in the program</td>
<td>via CAD</td>
</tr>
<tr>
<td>Input parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature gradient</td>
<td>-</td>
<td>-</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>leakage air rate</td>
<td>-</td>
<td>X</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>space type</td>
<td>X</td>
<td>-</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>cooling/heating set point</td>
<td>X</td>
<td>-</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>air flow rate min/max (l/s,m2)</td>
<td>X</td>
<td>-</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>HVAC equipment heating/cooling profile</td>
<td>X</td>
<td>Yes, but all HVAC profiles must be the same</td>
<td>not tested</td>
<td>not tested</td>
<td>X</td>
<td>limited to four types</td>
</tr>
</tbody>
</table>
Table 2. Summary of energy analysis software tool features 2/2

<table>
<thead>
<tr>
<th>Possibility to make a comparison case</th>
<th>IES 5.8.1</th>
<th>Ecotect</th>
<th>E-Quest 3-6</th>
<th>EnergyPlus v2.1</th>
<th>IDA ICE 3.0</th>
<th>RIUSKA 4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Benefits</td>
<td>Lots of additional simulation possibilities</td>
<td>comprehensive solar and lighting simulation</td>
<td>HVAC systems definable</td>
<td>advanced engine</td>
<td>very sophisticated single space simulation program</td>
<td>Suitable for large office buildings and large projects, practical in use</td>
</tr>
<tr>
<td>Limitations</td>
<td>-</td>
<td>IFC and gbXML import is a new function since last beta, reliability is an issue</td>
<td>BIM import didn't work as it was supposed to work</td>
<td>no GUI at all, BIM importing troublesome or impossible</td>
<td>Can't handle large buildings, IFC2x3 is not yet supported</td>
<td>limited to four types of HVAC systems</td>
</tr>
<tr>
<td>manuals</td>
<td>Quite comprehensive, but a bit shallow</td>
<td>Good</td>
<td>Very limited</td>
<td>Limited</td>
<td>Extensive</td>
<td>User manual available</td>
</tr>
</tbody>
</table>