Report 6.7 – Design4Energy Interoperability Suite Optimization

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOI</td>
<td>Area of Interest</td>
</tr>
<tr>
<td>D4E</td>
<td>Design 4 (for) Energy</td>
</tr>
<tr>
<td>Dn</td>
<td>Deliverable number n</td>
</tr>
<tr>
<td>gbXML</td>
<td>Green Building XML</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Development Environment</td>
</tr>
<tr>
<td>IDF</td>
<td>Intermediate Data Format</td>
</tr>
<tr>
<td>IOS</td>
<td>Interoperability Suite</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicators</td>
</tr>
<tr>
<td>LU</td>
<td>Loughborough University</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>WP</td>
<td>Work Package</td>
</tr>
<tr>
<td>DRY</td>
<td>Do not Repeat Yourself</td>
</tr>
<tr>
<td>XML</td>
<td>eXtensible Markup Language</td>
</tr>
</tbody>
</table>
1. EXECUTIVE SUMMARY

Interoperability is a key point in the Design4Energy (D4E) project. As such, two different however complementary approaches to interoperability were taken into consideration in the project. Namely, organizational and process interoperability, as well as technical interoperability.

The document herein is a report, which is part of the work package 6 (WP6). Such package is composed by the following 3 tasks:

- **Task 6.1 Interoperability Specification Design** – This task will focus on the organizational and process interoperability, by applying the IDM process to the Design4Energy interactions, in order to provide a better understanding of the information flow, and the stakeholders of each needed action.

- **Task 6.2 Interoperability Execution Engine** – This task will focus on the scientific approach used to solve the interoperability problem presented.

- **Task 6.3 Design4Energy Interoperability Suite** – This task will focus on the specifics of the Interoperability needs of the Project, and will provide the implementations to ensure that the proper interoperability solutions are achieved.

This report addresses task 6.3, specifically addresses a detailed description regarding the creation of an Interoperability Suite, which integrates the Execution Engine (D6.5) and that provides the mechanism to register Interoperability Specifications. Herein, an insight view regarding the data exchange solution that includes both data translation and simulation services is provided.

This report mainly focuses the following achievements.
- Interoperability Suite dully optimized, tested and validated.
- Tools to aid KPI optimization related to VTT KPI Energy analysis workflow.
- Such tools working and online.

While other partners contributed in early reports, the current document was produced solely by UNINOVA team.
2. GENERAL OVERVIEW

The present document is the last one regarding WP6. It follows Report 6.5 – Design4Energy Execution Engine - Full Release and Report 6.6 – Design4Energy – Interoperability Suite – Full Release. This report relates to optimization of the tools, bug correction, testing and validation. One can also find instructions and guides for the tools discussed in this document.

The picture present below, depicts an overview of the work done in WP6. It implies:

- A Component Catalogue module available through a plugin, which imports the desired model into Revit to provide to the designers the components to be used in their designs.
- A Data Filtering/Transformation module responsible for transforming a BIM model into a data source that can be used by the Collaborative Workspace and/or Simulation Platform. Transformations from: RVT to IFC, IFC to RVT, RVT to gbXML, IFC to gbXML, gbXML to IDF, E+CSV to d4eXML.
- A Simulation Platform Integration architecture following the mediator pattern for supporting multi-discipline simulations on the BIM models provided by the Data Filtering/Transformation module. Implemented Data Simulation Service for energy simulator EnergyPlus.
- WP6’s Plug’n’Interoperate key S&T solution applied and proven to the specific cases that Design4Energy tackles making possible the automatic creation of new simulation services not needing manual changes made to the internal behavior of the model orchestrator, which is a hidden entity from the user point of view.

The cooperation amongst the different tools is done through the orchestrator, which is the central piece of the process, as its responsibility is to mediate the interconnection of all entities.

![WP6 Interoperability Overview](image)

The present report will deal with the features and functionalities of this workpackage. Specifically, in the following Chapter 3, a description of all the tools developed is presented. Reader can find a connection between all of them. These are defined as Interoperability Tools, which includes at the present moment three different tools. The following chapters 4, 5 and 6 will describe all these tools, providing a detailed information.

Chapter 4 relates to Interoperability Suite, it describes some optimizations as well as some testing and validation that proves the workability of the tool. Afterwards, Chapter 5 will be dedicated to the Target Setting and Matching Tool, developed by VTT, which relates a set of indicators and success factors for holistic energy matching. In Chapter 6 the KPI Integrator is
presented, which is a new tool developed for KPI Optimization of an Energy Analysis from a
neighbourhood or buildings.
Finally, Chapter 7 presents some minor conclusions about this document and the achievements
of this work.
3. INTEROPERABILITY TOOLS

Interoperability Tools are a set of tools elaborated for Design4Energy (D4E) project. It includes features that should be used by D4E end users, such as conversion services or energy analysis predictions.

At the present moment, Interoperability Tools include three tools. Namely Interoperability Suite, Target Setting Tool and KPI Integrator. Interoperability Suite is a tool aimed at conversion and simulation services. It allows to convert several file types commonly used in energy field. Also, it uses specific software to provide an energy analysis for requested buildings.

The next one, the Target Setting Tool, is aimed at providing an energy analysis based on several Key Performance Indicators (KPI). They provide an energy score based on several factors, such as KPIs, and specific location dependant indicators.

Lastly, the third tool is the KPI Integrator, which is responsible to provide conversion between Energy+ output files, and a proprietary XML (d4eXML), to feed target setting tool. Such tools are described in this document by the following lines.
Such tools can be accessed at address referred in Figure 3.

Figure 3 - Interoperability Tools Address
4. INTEROPERABILITY SUITE

Interoperability Suite (IOS) is a tool that provides file conversions and simulations related to energy consumption regarding the building sector. Specifically, IOS provides conversions of gbXML files into IDF files, Figure 4, simulations of IDF files, and also a composed service that does all tasks.

![Design4Energy Interoperability Suite](image)

**Figure 4 - IOS Layout v.1**

Current address for the IOS tool described in Figure 5 below.

![Web address of the Interoperability Suite tool](image)

**Figure 5 – Web address of the Interoperability Suite tool**

4.1 Last development & Bug correction

4.1.1 Last developments

The UI was developed initially as a standalone tool, however this UI was integrated later in the Interoperability Tools framework. Also, the layout of the UI was updated according to the rest of the other tools included in the Framework. These layout updates included several tasks, such as changing the theme to a green based theme, also changing format of buttons, dropboxes, and all other components. With this, the system achieved a layout adapted to D4E layout. This layout was updated from the one at Figure 4 into the one at Figure 6.
4.1.2 Bug correction

Interoperability Suite was initially developed as a prototype, and later it grew closer to a production solution. In this sense, the system needs updates, and changes that could lead to new code development. These issues normally lead to bugs. Features, if not well developed, can stop working. This means that developer that makes the future developments needs to identify (if possible predict) these issues, and act accordingly. Considering this, some bugs were found that needed attention, and were related to:

- Uploads and download files – several browsers can be found in the market that can be potentially used by end users of IOS. In this sense, all functionalities of IOS system should be developed considering at least the majority of this system. As their engines can be different (i.e. Webkit, Gecko, etc), bugs can arise.
- Typos and text copy paste problems – One of the work principle of a developer should be to make the best use of the work already done, in other words, when a piece of code should make something already made, then the work already done should be used. This helps to deliver a solution faster, as well as improves the work management of the developer. This principle is referred to as DRY principle (Don’t Repeat Yourself). This is true when deadlines are far away, and there is time to develop a solution, as working with this principle can take time, otherwise with time constraints, the development is faster, more prone to errors due to copy and paste issues. Texts and documentation can also suffer from this. In this sense, some bugs were corrected related to typos and lack of the use of DRY.
4.2 Testing

It is important that the solution developed works as expected. As such, testing is the key subject in this matters. In this section, several tests were defined, and executed, to prove the workability of the functionalities developed to the platform as follows:

- Signing in; (Table 1)
- Convert (Table 2)
- Simulate (Table 3)
- Composed Service (Table 4)

Table 1 - Defined test for “Sign in” feature followed by script executed

<table>
<thead>
<tr>
<th>Action</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open platform in browser through address</td>
<td></td>
</tr>
<tr>
<td>Insert username</td>
<td></td>
</tr>
<tr>
<td>Insert password</td>
<td></td>
</tr>
<tr>
<td>Press Log In</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 - Defined test for “Convert one file” feature followed by script executed

<table>
<thead>
<tr>
<th>Action</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log in</td>
<td></td>
</tr>
<tr>
<td>Select Convert</td>
<td></td>
</tr>
<tr>
<td>Choose file to be converted</td>
<td></td>
</tr>
<tr>
<td>Choose converter</td>
<td></td>
</tr>
<tr>
<td>Press Convert</td>
<td></td>
</tr>
<tr>
<td>Download file</td>
<td></td>
</tr>
</tbody>
</table>

2017-09-27
### Table 3 - Defined test for “Simulate one file” feature followed by script executed

<table>
<thead>
<tr>
<th>Simulate one file (Simulate)</th>
<th>Log in</th>
<th>Select Simulate</th>
<th>Choose file to be simulated</th>
<th>Choose weather file</th>
<th>Press Simulate</th>
<th>Download file</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Command</strong></td>
<td><strong>Target</strong></td>
<td><strong>Value</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>open</td>
<td><a href="http://gris-groupware.uninova.pt/IOS/">http://gris-groupware.uninova.pt/IOS/</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=email</td>
<td><a href="mailto:user@mailbox.com">user@mailbox.com</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=pass</td>
<td>12345678</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Log In']</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assertNotVisible</td>
<td>id=ui-id-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Convert']</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=fileToBeSimulated</td>
<td>C:Users\ArrowHeadProto\Desktop\test2D8EB9E7ADA1DEB2\gbXMLToIdfConversionTool\gbXML_input\REVITExport.xml</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=weather_file</td>
<td>C:Users\ArrowHeadProto\Desktop\test2D8EB9E7ADA1DEB2\weather_files\GBR_London.Gatwick.037760_IWEC.epw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>select</td>
<td>//select[@id='convert-list']</td>
<td>index=1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Simulate']</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Info**

<table>
<thead>
<tr>
<th><strong>Command</strong></th>
<th><strong>Target</strong></th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>open</td>
<td><a href="http://gris-groupware.uninova.pt/IOS/">http://gris-groupware.uninova.pt/IOS/</a></td>
<td></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=email</td>
<td><a href="mailto:user@mailbox.com">user@mailbox.com</a></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=pass</td>
<td>12345678</td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Log In']</td>
<td></td>
</tr>
<tr>
<td>assertNotVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Convert']</td>
<td></td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=fileToBeSimulated</td>
<td>C:Users\ArrowHeadProto\Desktop\test2D8EB9E7ADA1DEB2\gbXMLToIdfConversionTool\gbXML_input\REVITExport.xml</td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=weather_file</td>
<td>C:Users\ArrowHeadProto\Desktop\test2D8EB9E7ADA1DEB2\weather_files\GBR_London.Gatwick.037760_IWEC.epw</td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Simulate']</td>
<td></td>
</tr>
</tbody>
</table>
Table 4 - Defined test for “Composed Service” feature followed by script executed

<table>
<thead>
<tr>
<th>Command</th>
<th>Target</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>open</td>
<td><a href="http://gris-groupware.uninova.pt/IOS/">http://gris-groupware.uninova.pt/IOS/</a></td>
<td></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=email</td>
<td><a href="mailto:user@mailbox.com">user@mailbox.com</a></td>
</tr>
<tr>
<td>assertVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='log in']</td>
<td></td>
</tr>
<tr>
<td>assertNotVisible</td>
<td>id=ui-id-1</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>name=comp_fileToBeSimulated</td>
<td>C:\Users\ArrowHeadProto\Desktop\test\2D8EB9E7ADA1DEB2\gbXMLToIdfConversionTool\gbXML_input\REVITExport.xml</td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>//input[@name='comp_weather_file']</td>
<td>C:\Users\ArrowHeadProto\Desktop\test\2D8EB9E7ADA1DEB2\weather_files\GBR_London.Gatwick.037760_IWEC.epw</td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>select</td>
<td>//select[@id='comp_convert-list']</td>
<td>index=1</td>
</tr>
<tr>
<td>pause</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>select</td>
<td>//select[@id='comp_simulate-list']</td>
<td>index=1</td>
</tr>
<tr>
<td>click</td>
<td>//input[@value='Start']</td>
<td></td>
</tr>
</tbody>
</table>

```javascript
[info] Playing test case Composed Service
[info] Executing: |assertVisible | id=ui-id-1
[info] Executing: |type | name=email | user@mailbox.com
[info] Executing: |assertVisible | id=ui-id-1
[info] Executing: |type | name=pass | 12345678
[info] Executing: |assertNotVisible | id=ui-id-1
[info] Executing: |click | //input[@value='Log in']
[info] Executing: |assertNotVisible | id=ui-id-1
[info] Executing: |click | //a[@onclick="openTab(event, 'composed-tab')"]
[info] Executing: |type | name=comp_fileToBeSimulated | C:\Users\ArrowHeadProto\Desktop\test\2D8EB9E7ADA1DEB2\gbXMLToIdfConversionTool\gbXML_input\REVITExport.xml
[info] Executing: |pause | 3000
[info] Executing: |type | //input[@name='comp_weather_file']
[info] Executing: |pause | 3000
[info] Executing: |select | //select[@id='comp_convert-list'] | index=1
[info] Executing: |pause | 3000
[info] Executing: |select | //select[@id='comp_simulate-list'] | index=1
[info] Executing: |click | //input[@value='Simulate']

Test case passed
```
4.3 Validation

Validation refers to the workability of the developed solution against its goals. In other words, if the tool works as expected. In this section, the tests defined in chapter 4.2 are validated. The tool to use is Selenium IDE, an automated software, who runs previously defined scripts, based in the defined tests aimed at validating the solution. The tests will be made in the top used browsers (cross-browser testing), specifically Mozilla Firefox (v.55.0.3), Google Chrome (v.60.0.3163.79), Microsoft Edge (v.38.14393.1066.0), Microsoft Internet Explorer (v.11.1593.14393.0) and Opera (v.47.0.2631.71). As a conclusion, all the tested browsers except Microsoft Edge proved to be valid choices to operate the solution.

<table>
<thead>
<tr>
<th>Sign in to the platform (Signing in)</th>
<th>Mozilla Firefox</th>
<th>Google Chrome</th>
<th>Microsoft Edge</th>
<th>Microsoft Internet Explorer</th>
<th>Opera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open platform in browser through address:</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Insert username</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Insert password</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Press Log In</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Convert one file (Convert)</th>
<th>Mozilla Firefox</th>
<th>Google Chrome</th>
<th>Microsoft Edge</th>
<th>Microsoft Internet Explorer</th>
<th>Opera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log in</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Select Convert</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose file to be converted</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose converter</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Press Convert</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Download file</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Simulate one file (Simulate)</th>
<th>Mozilla Firefox</th>
<th>Google Chrome</th>
<th>Microsoft Edge</th>
<th>Microsoft Internet Explorer</th>
<th>Opera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log in</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Select Simulate</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose file to be simulated</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose weather file</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose simulator</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Press Simulate</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Download file</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Convert and Simulate one file (Composed Service)</th>
<th>Mozilla Firefox</th>
<th>Google Chrome</th>
<th>Microsoft Edge</th>
<th>Microsoft Internet Explorer</th>
<th>Opera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log in</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Select Composed Service</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose file to use</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose weather file</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose converter</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Choose simulator</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Press Simulate</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Download file</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>
4.4 Instructions / Training

4.4.1 Lessons

In order to use the tool with full knowledge of all functionalities, it is important to be acquainted to it and to know how it works. Specifically, it is important to know what it does and how can one use the UI to get the tasks done successfully. In the present section, some small lessons are defined to provide users with some basic knowledge of the tool and its UI.

Lesson 1 – Sign in into platform

Open your preferred internet browser (e.g. Firefox, Chrome, …) at the page address of the tool (Figure 5). When the page loads, you will be presented with a sign in registration form. (Figure 7). You will need to provide your user in email format, as well as your password. When the latter is done, press “Sign in” button, and you will access all functionality of the tool.

![Design4Energy Interoperability Suite](image)

*Figure 7 – IOS Sign-in registration form*

It is worth noting that Lesson 1 will be required for each of the first time the following lessons will be read and executed. In other words, the credentials need to be provided in order before accessing any of the functionalities.

Lesson 2 – Convert a gbXML file into an IDF file

This functionality allows anyone to convert BIM files, specifically, gbXML files into another file type, *i.e.* IDF files. The lines below provide some instructions on its functionality. During the advance of each step for the execution to this functionality, the system provides to the user some indications of what is going on.
One can see a status box, that will tick “✓” indicating that step is completed successfully. Please refer to Figure 8, that displays two moments of the status box, one before the user press the “Convert” button (a)), and other providing information at the moment the file is well converted and ready to download. This way, one can be better aware of their use of the tool.

Figure 8 - Convert functionality - Status boxes: a) before conversion; b) after conversion.

The first time one wants to convert a file, one needs to complete Lesson 1 - Sign in into platform first. After a successful login, the first step is to choose the conversion functionality. Press the “Convert” link to open its page (Refer to Figure 9).

Figure 9 - Convert gbXML to IDF functionality UI

When the page loads, a screen appears with the steps to execute a conversion. First step is to press button in “Choose a file to be converted” (refer to from Figure 10) Please note, that you need to choose an XML file type, with a gbXML file content inside. The converter is not ready for other file types. After selecting a file to perform the conversion, choose the converter to execute. At the moment of writing this document, there are two available converters. Namely, a converter developed by Loughborough University, i.e. “LU gbXML-IDF converter” and a converter developed by DesignBuilder Software Ltd, i.e. “DesignBuilder gbXML-IDF Converter”. Choose either of both. (Figure 11)
Figure 11 - Convert functionality - Choose converter step

The third step is the execution order of this functionality. Press “Convert” button to order the server for the conversion.

Figure 12 – Convert functionality - Download box for converted IDF file

The last step, is a waiting phase, the user will wait for the conversion to be executed. The user knows when the conversion is ready, when a download window appears (Figure 12) with the converted IDF file inside. Proceed with the download, save the file in the disk, for later use.

Lesson 3 – Simulate an IDF file

At the end of Lesson 3, user will be able to simulate an IDF file against some weather conditions file using one of the simulators available.

After entering the page following Lesson 1, one should press the “Simulate” folder to access the simulator page. When this is done, one can see a page with UI similar to other functionalities (Figure 13). Specifically, this page shows the following components: a step list describing the steps necessary on the top; two file input sections for uploading the IDF source file (for simulation) and a weather file; a dropdown box for simulator selection; a simulation button to execute the process; and lastly a status box on the right, to provide information about the status of the whole process (Figure 14).
At this point, if the user has been following the lessons from the beginning, he/she should be already familiar with the UI, as the layout is much similar between the several functionalities.

The first step is the selection of a source file to be simulated. This should be an IDF file converted by this system (Figure 15).

The second step is the selection of the weather conditions for the place where the simulation occurs (Figure 16).

One can choose a simulator in the following step. There are two available at the time this document is written, EnergyPlus v8.4 and EnergyPlus v8.5.
Figure 17 - Simulate functionality - Choose simulator step

For the third step, one needs to execute this functionality in order to simulate the scenario intended and get results. To do the former, press “Simulate” button to order the server for the conversion. Lastly, now one needs to wait some moments for the server to process the request. When the server ends, it sends the file to download for the user, as shown in Figure 18.

Such download terminates Lesson 3. The next lesson will provide instructions on how to use a service to do both Convert and Simulate functionalities.

Figure 18 - Download window for simulation results

Lesson 4 – Composed service – Convert and Simulate a gbXML into an IDF file

When there is the need to make both Conversion (Refer to Lesson 2 – Convert a gbXML file into an IDF file) and Simulation (Lesson 3 – Simulate an IDF file), users can use a functionality, provided by IOS platform, designated by “Composed Service”. Lesson 4 – Composed service – Convert and Simulate a gbXML into an IDF file drives the user through this functionality. This lesson starts by signing the user in into the platform (refer to Lesson 1 – Sign in into platform) and when done, by pressing “Composed service” users can open the page for this functionality.
After loading page, it shows similar areas of interest (AOI) as the other functionalities explained above. The development of the UI was aimed at a simple, intuitive and recognizable layout. As such, one can find an UI similar to the Convert and Simulate functionalities, which also presents three AOI: an instruction area; a functionality area; and a status area.

The instructions area, as already described, presents a box defining the main steps to execute the operation. It is located at the top left of the page. The user can find 4 small intuitive steps. Specifically, to execute the Composed Service, the user should proceed as follows:

It first needs to choose a file for conversion and simulation, a gbXML file, by pressing the “Browse” button at the first green box (Figure 20). After this, one can find the name of the chosen file in it.

The second step relates to choosing a weather file from the location to simulate. One needs to press the correspondent “Browse” button and select it (Figure 21). Its name will appear also in the green box.

After selecting the files, one needs to choose the converter that will execute the gbXML to IDF conversion, aimed at the simulation from two available ones: “LU gbXML-IDF Converter” and
“DesignBuilder gbXML-IDF Converter” (Figure 22). Choose the one it suits best. For this example, choose the first.

![Choose converter](image)

*Figure 22 – Composed Service functionality – Choose converter step*

Fourth step relates to choosing the simulator that will be used. There are two at the present moment, namely Energy+ (v8.5) and Energy+ (v8.4). Please choose the first.

![Choose simulator](image)

*Figure 23 – Composed Service functionality – Choose simulator step*

Lastly, press the last button, to execute the composed service and wait for a window with the simulation files to pop up.

It is worth noting that the third AOI is the status box at the right of the screen, and relates to providing information at several moments of the process.
5. VTT TARGET SETTING

Target setting is a system developed by VTT, following the diagram of Figure 24 below. It includes three main tools KPI tool, Matching tool and Simulation tool. (Please refer to Report D2.3 from VTT for more information on this.)

![Diagram of VTT Target Setting Tools Flow](image)

Two of these tools were included into the Interoperability Tools System with a dedicated UI, specifically Matching tool and KPI Tool.

5.1 KPI Tool UI & Matching Tool UI

The tools are provided with an UI. These UI operate on top of a server. This server includes two excel engines and a converter. The engines are two excel workbooks that provide the calculations necessary for each tool. The converter uses the KPI Integrator webservices (Refer webservices at chapter 6.4 below). Such tools are available on the website referred in Figure 25.

![Target Setting Tool UI Address](image)

Figure 26 below presents the UI of these tools. One can see four panels. Specifically: General Info, Energy KPIs, Design Value Score and Matching KPIs.

General info relates to the general information related to the project which is using these tool, and some location data that could influence energy analysis values. This is the Country, Region and the type of the building being evaluated.

The panel for Energy KPIs is aimed at regulating them in order to have the desired energy KPI values. There are 7 KPIs which are divided into 4 colour groups. Users can select each KPI value by choosing its weight (from 0 to 100) through a slider bar, and its value (A to E) through...
a dropbox. Each of the colour groups has total weight of 100. When ready, there is an UPDATE button that allows the values to be send to the engine, for energy calculation.

The third panel is the Design Value Score, which is the place where the Design Value Score will appear after it has been calculated in the target setting tool excel engine.

Lastly, Matching KPIS is the panel responsible to provide information about matching energy simulation values into the expected energy values, aimed at fine tuning through Target Setting tool. It uses a different engine, namely Matching Tool Excel Engine.

Figure 26 - Target Setting Tool UI
6. **KPI Integration Tool**

The KPI Integration Tool is a tool aimed at using Energy Plus information in a KPI evaluator. Such evaluator aims at providing some indicators to improve energy analysis in specific areas. The following integration tool aims at providing integration services to execute conversion of files from different systems, Figure 27. It is composed by three modules, specifically KPI converter engine, Webservices and a UI (such UI can be replaced as the services are available and can be consumed by any system requiring it).

![Figure 27 - KPI Integration Tool components](image)

The following lines will present an overview of the Tool, describing each of the components from Figure 27.

### 6.1 Key Performance Indicators

The goal of Key Performance Indicators (KPIs) is to set objectives for the design of a construction project in six dimensions. This sub-chapter will describe what are the KPIs needed to be considered. These KPIs were defined at Reports D2.1 and D5.3, from VTT and LU partners.

<table>
<thead>
<tr>
<th>KPIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return on Investment</td>
</tr>
<tr>
<td>Life cycle cost</td>
</tr>
<tr>
<td>Indoor air quality</td>
</tr>
<tr>
<td>Thermal comfort</td>
</tr>
<tr>
<td>Carbon footprint</td>
</tr>
<tr>
<td>Non renewable primary energy</td>
</tr>
<tr>
<td>Energy balancing</td>
</tr>
</tbody>
</table>

### 6.2 KPI Converter

The KPI converter is composed by four modules, being the most important the webservices module, and the conversion engine module. This importance is rooted from the attribute that relates to the feature that every system can consume the services this system provides.

![Figure 28 - KPI Converter Diagram](image)
6.3 KPI Conversion Engine

The KPI Conversion Engine is the module responsible for the execution of the conversion. In other words, for mapping the output of energy plus into a specific KPI input files. Figure 29 presents the diagram for the state machine responsible for the operation of the engine. One can see that it is a simple machine with only 3 states. State 0, is the starting point where the engine is waiting for a source file aimed for conversion. It stays in this state while the source file is not received successfully. When the source file is well received, it advances for State 1. State 1 is responsible for converting the file. It is the state that commands the start of the conversion process, meaning that all outputs from energy plus will be mapped (and calculated if necessary) into KPI specific outputs. Whenever the conversion terminates and is ready, this state advances to the last state. State 2 is the last state of this process. When the engine arrives into this state, the file is already well converted and mapped, and is ready to download. When the download occurs, and the target file is well sent to the user/system, the engine returns to State 0, waiting for a new conversion.

![KPI Conversion Engine State Machine](image)

6.3.1 Energy Plus CSV output file

Energy+ can provide the energy simulation results in the form of a CSV file. This file needs to be converted to XML as it is the used file in Target Setting tools. As such, the concepts of each file should be mapped. The following Table 5 is presenting energy plus output concepts aimed at the conversion, represented in Figure 30.

<table>
<thead>
<tr>
<th>Table 5 - Energy+ Output Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy+ Output Variables</strong></td>
</tr>
<tr>
<td><strong>Date/Time</strong></td>
</tr>
<tr>
<td>Environment:Site Outdoor Air Drybulb Temperature <a href="Hourly">°C</a></td>
</tr>
<tr>
<td>AIM0083:Zone Mean Air Temperature <a href="Hourly">°C</a></td>
</tr>
<tr>
<td>AIM0083:Zone Operative Temperature <a href="Hourly">°C</a></td>
</tr>
<tr>
<td>AIM0086:Zone Mean Air Temperature <a href="Hourly">°C</a></td>
</tr>
<tr>
<td>AIM0086:Zone Operative Temperature <a href="Hourly">°C</a></td>
</tr>
<tr>
<td>AIM0083:Zone Infiltration Air Change Rate <a href="Hourly">ach</a></td>
</tr>
<tr>
<td>AIM0086:Zone Infiltration Air Change Rate <a href="Hourly">ach</a></td>
</tr>
<tr>
<td>AIM0083:Zone Air CO2 Concentration <a href="Hourly">ppm</a></td>
</tr>
</tbody>
</table>
6.3.2 VTT KPI XMLs input files

The aimed XML file is the input for matching tool, and it is automatized in the KPI Integrator. VTT Target Setting flow provided by VTT presents three XML files. The first one is the output of the energy simulator software, e.g. Energy+, which is going to feed the Matching Tool Engine (Figure 31). It contains the simulation values for the building/neighbourhood being analysed. The second XML file is exported from Matching Tool Engine and is aimed at importing it to Target Setting tool Engine (Figure 32). This file contains the values which are expected and the ones from the simulation matched. Target Setting Tool includes the KPIs to “fine tune” values. The third XML is the output from Target Setting Tool, where the expected values were “fine tuned” by its KPIs (Figure 33). These will be fed into the simulation software for new simulation.

Figure 31 - Simulation output XML file screenshot
Figure 32 - Matching tool output XML file screenshot

Figure 33 - Target Setting tool output XML file screenshot
6.3.3 Concept Mappings

In Table 6, the mapping that was made by the VTT team and UNINOVA team, for an Energy+ output file, is offered. Such mapping connects each relevant output concept of Energy+ to each input concept of an VTT XML defined file.

<table>
<thead>
<tr>
<th>Energy+ CSV output Concepts</th>
<th>VTT XML input Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date/Time</td>
<td>&lt;xs:element name=&quot;time&quot;/&gt;</td>
</tr>
<tr>
<td>Environment:Site Outdoor Air Drybulb Temperature <a href="Hourly">C</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083:Zone Mean Air Temperature <a href="Hourly">C</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0086:Zone Mean Air Temperature <a href="Hourly">C</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083:Zone Operative Temperature <a href="Hourly">C</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0086:Zone Operative Temperature <a href="Hourly">C</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083:Zone Infiltration Air Change Rate <a href="Hourly">ach</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0086:Zone Infiltration Air Change Rate <a href="Hourly">ach</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083:Zone Air CO2 Concentration <a href="Hourly">ppm</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0086:Zone Air CO2 Concentration <a href="Hourly">ppm</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083 IDEAL LOADS AIR SYSTEM:Zone Ideal Loads Zone Total Heating Rate <a href="Hourly">W</a></td>
<td>N/A</td>
</tr>
<tr>
<td>AIM0083 IDEAL LOADS AIR SYSTEM:Zone Ideal Loads Zone Total Cooling Rate <a href="Hourly">W</a></td>
<td>N/A</td>
</tr>
<tr>
<td>Whole Building:Facility Total Purchased Electric Power <a href="Hourly">W</a></td>
<td>N/A</td>
</tr>
<tr>
<td>Whole Building:Facility Total Surplus Electric Energy <a href="Hourly">J</a></td>
<td>N/A</td>
</tr>
<tr>
<td>Site:Environmental Impact Total CO2 Emissions Carbon Equivalent Mass <a href="Hourly">kg</a></td>
<td>&lt;xs:attribute name=&quot;TotalCO2&quot;/&gt; (Sum of all values)</td>
</tr>
</tbody>
</table>

6.3.4 Result/Final File

This section presents an example of the converted file through the KPI Integrator, shown in Figure 34. The structure of this should be similar to the structure of the Simulation output example provided in 6.3.2 - VTT KPI XMLs input files.
6.4 Web Services

Several web services were developed aiming at making the services technology independent. They were developed in C# language, and are available for public at the following site, Figure 35:

```
Figure 34 - Output from KPI Integrator for Matching Tool

Figure 35 - Webservices Address

Figure 36 - GetFile webservice method - C# code
```

The web services available are: GetFile (Figure 36), PutFile (Figure 37), ConvertFileToName (Figure 38) and GetLocalPath (Figure 39).

```
Figure 37 - PutFile webservice method - C# code
```
Figure 37 - PutFile webservice method - C# code

```csharp
public bool PutFile(string filename, byte[] buffer)
{
    string userHostAddress = this.Context.Request.UserHostAddress;
    string userAgent = this.Context.Request.UserAgent;
    _logmsg = S"[" + userAddress + "] + userAgent + "] + this.GetType().Name + "] + MethodBase.GetCurrentMethod().Name + "]");
    _logmsg += "filename:" + filename;
    _receivedFileName = filename;
    _filenameReceivedFlag = true;

    Console.WriteLine(_logmsg);
    String path = Server.MapPath(filename);
    var x = File.Exists(path);
    _logmsg = "Path: ", path);
    _logmsg = new BinaryWriter(File.Open(filename, FileMode.Create, FileAccess.Write));
    _ intimately.Close();
    _ intimately.Write(buffer);
    _ intimately.Close();
    return true;
}
```

Figure 38 - ConvertFileToName webservice method - C# code

```csharp
public bool ConvertFileToName(string filetype = "xml", string filename = ")
{
    string userHostAddress = this.Context.Request.UserHostAddress;
    string userAgent = this.Context.Request.UserAgent;
    _logmsg = S"[" + userAddress + "] + userAgent + "] + this.GetType().Name + "] + MethodBase.GetCurrentMethod().Name + "]");
    _logmsg += "filetype:" + filetype;
    _logmsg = new StringBuilder(_logmsg);
    string fullSourceFilename = GetLocalPath() + Path.DirectorySeparatorChar + filename;
    string fullTargetFilename = GetLocalPath() + Path.DirectorySeparatorChar + sourceExtensionFromFilename + extensionSeparator + filetype;
    _logmsg = S"[" + userAddress + "] + userAgent + "] + this.GetType().Name + "] + MethodBase.GetCurrentMethod().Name + "],
    _logmsg = new StringBuilder(_logmsg);
    string fullTargetFilename = fullTargetFilename + extensionSeparator + filetype;
    string fullSourceFilename = fullSourceFilename + extensionSeparator + filetype;
    if (fullTargetFilename.Length() != 0) {
        _logmsg = fullSourceFilename + extensionSeparator + fullTargetFilename + extensionSeparator + filetype;
    }
    _logmsg = fullSourceFilename + extensionSeparator + fullTargetFilename;
}
```

Figure 39 - GetLocalPath webservice method - C# code
6.5 Tool UI

The KPI Integrator UI was developed aimed at providing users a place to make the conversions in a more user-friendly place. The developed user interface is depicted in Figure 40.

![Figure 40 - KPI Integrator Tool UI](image)

This tool can be accessed directly by Interoperability Tools’ address, or specifically at the address referred by Figure 41 below.

![Figure 41 - KPI Integrator UI Address](image)

**Development methodology**

The methodology adopted for the development of the UI of KPI converter is based on a waterfall methodology principle. And its design was planned according to the next lines:

1 – Information Gathering

- Discuss with VTT about problem.
  - Receive En+/Vtt files to evaluate.
  - Received documentation to support
  - Discuss tool requirements

- Discuss requirements.

Note: Consulted LU about similar process. LU solution was too specific to consider using it.

2 – Problem Thinking

- Discuss concept mapping.
  - Map each En+ output concept into valuable VTT XML concepts. (Refer to Table 6)
  - Discuss XML final structure

3 – Solution Development

- Develop discussed ideas/solution:
  - Conversion webservice
  - Web UI
  - Background tasks (ex: Processing [Reading CSV and creating XML], transferring & converting files)
Technologies used
As a normal standard, all web tools were developed in PHP/JavaScript language as a client/server-based platform.

The conversion engine was developed in CSharp, as well as the webservice in MS Visual Studio 2013.

For the calls between modules AJAX was used over HTTP with POST messages.

6.6 Instructions for the UI of KPI integrator module

The following lines will provide the necessary guidance for the use of the UI.

Step 1 – Select source file
Press “Source file” button to open a windows file dialog to choose the source file to convert. Such file needs to be per the converter chosen. Now, only conversion of Energy plus output as CSV files is available. Wait for drop down box be active.

Step 2 – Select converter
For the moment, the only available converter is “Eplus Output (CSV) into VTT KPI (XML)

Step 3 – Press convert button
Press convert button to execute the conversion, and wait until the last button becomes ready.

Step 4 – Download converted file
When this button becomes ready, it will provide the opportunity to the user to download the target file, aimed at import to KPI evaluator system.

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Step 1 – Press “SOURCE FILE”. Choose Energy+ CSV output. Wait for drop down box be active.

Step 2 – Choose converter “EPlus Output (CSV) -> VTT KPI Input (XML)”. Wait for “Convert” button be active.

Step 3 – Press “Convert” button to execute conversion. Wait for “Download converted file” button be active.

Step 4 – Press “Download converted file” button to download the converted xml file.

Step 5 – For a new conversion, press “KPI Integrator” button on top, or reload the page.
7. CONCLUSIONS

As a report for the prototype developed, this document presented the validation and testing process of the tools developed in WP6 and provided some guides for their use. Specifically, it presented the Interoperability Tools Framework and provided some information and validation of the tools, namely Interoperability Suite, Target Setting tool UI and KPI Integrator.

With this document, we were able to describe the proposed achievements. Namely, we expected to optimize, test and validate Interoperability Suite, which is described in Chapter 4.

We also developed tools to aid the optimization of energy analysis KPIs. In other words, two tools were developed for this goal, VTT Target Setting and Matching Tool UI as well as KPI Integrator, discussed in Chapter 5 and 6 respectively.

These tools were deployed and made available online, integrated in Interoperability Tools Framework, working properly according to its specifications. Chapter 3 describes this achievement with more in depth.