

Interoperability: A data conversion framework to support energy simulation

Background

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MSc in Electrical and Computer Engineering
Developing Software in UNINOVA – Centre of Technology and Systems - Portugal

Research areas:

Artificial Intelligence

Making sense out of Data (Big Data)

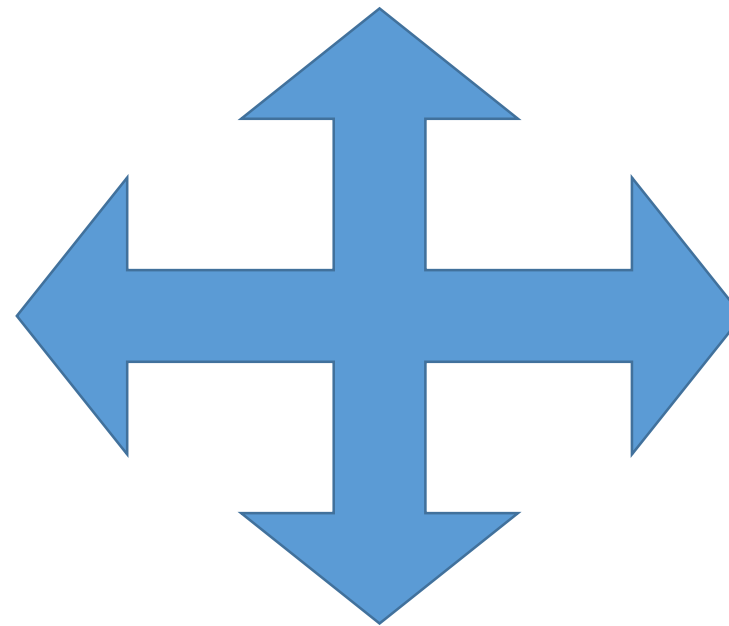
Semantic Technology (Ontologies)

European Projects: CoSpaces, Proasense, Arrowhead, Design4Energy (Sep 2017)

Interoperability Challenges

- Different Vendors
- File Complexity
- Different Models
- File Size
- Existing Tools Complexity
- Different semantics

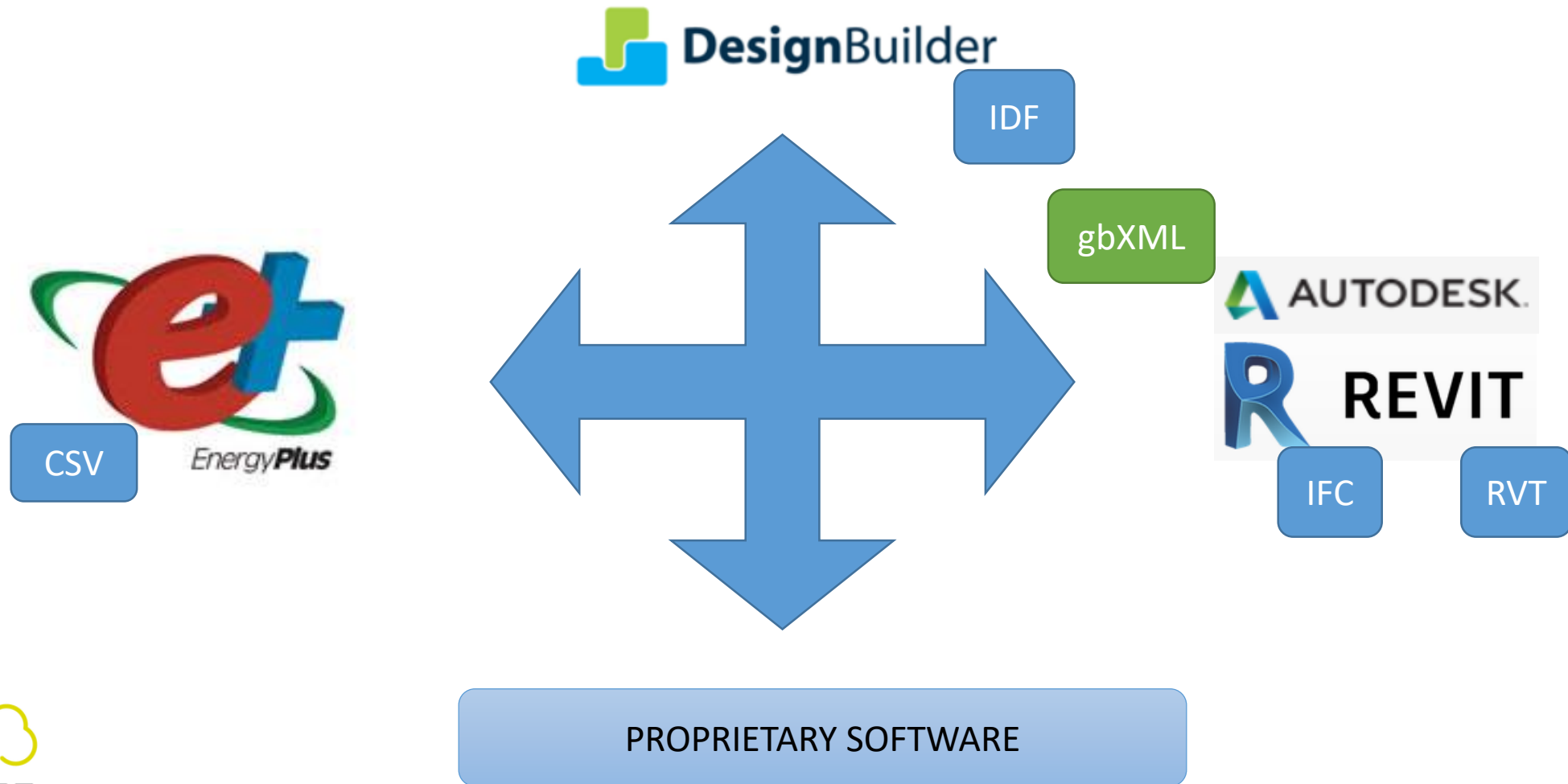
CAD-CAE SOFTWARE



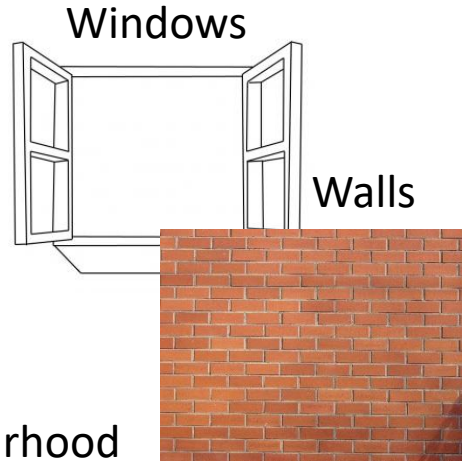
PROPRIETARY SOFTWARE

Luis Paiva - Uninova

CAD-CAE SOFTWARE



BUILDINGS DATA / ENERGY DATA



Neighbourhood

Weather



Devices/Appliances

MAKING SENSE OUT OF DATA

KPI

Life cycle cost

Thermal Comfort

Energy
balancing

Return on
Investment (ROI)

Indoor air
quality

Carbon footprint

File Contents – Example 1

```
1 Date/Time,Environment:Site Outdoor Air Drybulb Temperature [C](Hourly),AIM0083:Zone Mean Air Temperature [C](Hourly),AIM0083:Zone Operative Temperature [C](Hourly),AIM0086:Zone Mean Air Temper
2 01/01 01:00:00,4.4,13.706714140507,13.8213359336046,6.78464423730068,6.73312725552589,1.44751974512024,1.41266134618421,411.154882557756,434.227829786432,0.0,0.0,305.3090964,0.0,305.3090964,
3 01/01 02:00:00,4.4,11.8408745083225,12.5752340906228,6.58140046989626,6.54933280409182,1.43765653181149,1.41119003433948,406.019791109693,420.950064574816,0.0,0.0,305.3090964,0.0,305.3090964,
4 01/01 03:00:00,4.4,11.5150107960844,12.2179442626873,6.47364191312834,6.43490646004356,1.43591684277803,1.41054766338509,404.116206237947,416.002729607232,0.0,0.0,305.3090964,0.0,305.3090964,
5 01/01 04:00:00,4.4,11.2144463622752,11.9048279558348,6.36967227394589,6.32491316650956,1.43439953904276,1.41002095427086,403.738196674929,415.014660992242,0.0,0.0,305.3090964,0.0,305.3090964,
6 01/01 05:00:00,4.0875,10.9042159480946,11.6021516899488,6.23261623194266,6.19753802800232,1.43445207311914,1.41092036756064,403.644355238102,414.764603836748,0.0,0.0,305.3090964,0.0,305.3090964,
7 01/01 06:00:00,3.9,10.8200990519393,11.4303823583874,6.69137833412069,6.41451856340065,1.43508693416961,1.41428063540872,406.921133732508,428.08783662314,0.0,0.0,915.9272892,0.0,915.9272892,
8 01/01 07:00:00,3.525,20.0700718295471,16.3058811107842,6.97945927050573,6.56503700357327,1.48391566162875,1.41772809346673,411.249048650171,444.741261937225,15816.8539522814,5.42346848912226,
9 01/01 08:00:00,3.3,20.0000000000001,16.6062541543148,6.90860507459024,6.50396784861159,1.48460329054736,1.41836685968391,413.368359039828,452.608322348329,15008.3802378674,3.096829459536821E-
10 01/01 09:00:00,2.9875,20.0000000000002,16.7710937025845,6.8036411328325,6.41274852685054,1.48629668573038,1.41944676577808,414.250216851066,453.934120798768,14364.0315668783,1.32331479107961,
11 01/01 10:00:00,3.1125,20.0000000000003,16.8983265005484,6.74202305159124,6.34037748639605,1.48562971487246,1.41849398657274,414.629868223123,454.171778410563,13788.0866916085,3.8198777474462E-
12 01/01 11:00:00,3.675,20.0000000000004,17.0021619255326,6.33683133235794,6.08125124759615,1.48261259132493,1.41356210211648,413.009880259915,444.848676558409,13417.4926883013,3.619788913056254E-010,915.9272892,
13 01/01 12:00:00,4.5875,20.0000000000005,17.0946746338426,6.3640438191857,6.05194556370174,1.47773237666007,1.40904766632494,411.215002402312,437.705503467188,12793.8107215808,3.551576810423285E-010,915.9272892,
14 01/01 13:00:00,5.6875,14.0453025652163,13.9625407744301,6.50618003210056,6.11996523371086,1.44260795867763,1.40478899393992,410.819177767053,439.36821183074,0.0,0.0,915.9272892,0.0,915.9272892,
15 01/01 14:00:00,6.7875,12.4673943721305,12.9067664231628,6.67355381220198,6.23021165785777,1.42854988839672,1.39962823800402,410.851714550855,442.735751061487,0.0,0.0,915.9272892,0.0,915.9272892,
16 01/01 15:00:00,7.8875,12.4204531270101,12.7330719818707,6.86529148686286,6.37648010615627,1.42261508236443,1.39499782384385,410.900854388073,444.110219207051,0.0,0.0,915.9272892,0.0,915.9272892,
17 01/01 16:00:00,8.3,12.2903547583088,12.5484012577633,7.02350184591654,6.5237114781633,1.41987352987899,1.39373119905001,410.936963192588,444.463103188306,0.0,0.0,915.9272892,0.0,915.9272892,
18 01/01 17:00:00,7.9875,12.0398636126046,12.3075886201086,7.1210817370061,6.64461281210965,1.42019108674287,1.39575330737862,410.948920174635,444.526119966655,0.0,0.0,915.9272892,0.0,915.9272892,
19 01/01 18:00:00,7.425,11.721328548805,12.0232485435576,7.1904758876762,6.74605794557972,1.42145597079498,1.39890465769241,410.94552623491,444.471121683078,0.0,0.0,915.9272892,0.0,915.9272892,
20 01/01 19:00:00,6.8875,20.0998352685443,16.441787718721,7.96725352581885,7.2532122657715,1.466353449272,1.40574676123342,414.030415612753,456.258833629893,15365.8875160289,2.083349196861188E-
```

CSV ENERGY PLUS EXPORT

File Contents – Example 2

```

1  <?xml version="1.0" encoding="UTF-8"?>
2  <!--Sample XML file generated by XMLSpy v2016 rel. 2 (x64) (http://www.altova.com)-->
3  <D4ESIM>
4    <Building simulationTool="Energy+" date="2017-03-02T09:30:47Z" author=""
5      version="" modelName="" modelvariation="" area="00.00"
6      type="" buildingName="" projectID=""
7      TotalCO2="124157" LCCCost="" CO2OverLimit="" TempOverLimit=""
8      timestep="hour" thermalZone="">
9      <simulationresult>
10         <time>0</time>
11         <Heating>0.0</Heating>
12         <DomesticHotWater>0</DomesticHotWater>
13         <HouseholdElectricity>0</HouseholdElectricity>
14         <HvacElectricity>0</HvacElectricity>
15         <LightingElectricity>0</LightingElectricity>
16         <CoolingElectricity>0.0</CoolingElectricity>
17         <CO2>422.691</CO2>
18         <Temperature>10.275</Temperature>
19       </simulationresult>
20       <simulationresult>
21         <time>1</time>
22         <Heating>0.0</Heating>
23         <DomesticHotWater>0</DomesticHotWater>
24         <HouseholdElectricity>0</HouseholdElectricity>
25         <HvacElectricity>0</HvacElectricity>
26         <LightingElectricity>0</LightingElectricity>
27         <CoolingElectricity>0.0</CoolingElectricity>
28         <CO2>413.485</CO2>
29         <Temperature>12.208</Temperature>
30       </simulationresult>
31       <simulationresult>
32         <time>2</time>
33         <Heating>0.0</Heating>
34         <DomesticHotWater>0</DomesticHotWater>
35         <HouseholdElectricity>0</HouseholdElectricity>
36         <HvacElectricity>0</HvacElectricity>
37         <LightingElectricity>0</LightingElectricity>
38         <CoolingElectricity>0.0</CoolingElectricity>
39         <CO2>410.060</CO2>
40         <Temperature>9.326</Temperature>
41       </simulationresult>
42       ...
43     </Building>
44   </D4ESIM>

```

D4E XML FILE CONTENTS

Concept Mapping - Example

Energy+ CSV output Concepts	VTT XML input Concepts
Date/Time	<xs:element name="time" />
Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	N/A
AIM0086:Zone Mean Air Temperature [C](Hourly)	N/A
AIM0083:Zone Operative Temperature [C](Hourly)	<xs:element name="Temperature" /> (Average of zones)
AIM0086:Zone Operative Temperature [C](Hourly)	
AIM0083:Zone Infiltration Air Change Rate [ach](Hourly)	N/A
AIM0086:Zone Infiltration Air Change Rate [ach](Hourly)	N/A
AIM0083:Zone Air CO2 Concentration [ppm](Hourly)	<xs:element name="CO2" />
AIM0086:Zone Air CO2 Concentration [ppm](Hourly)	(Average of zones)
AIM0083 IDEAL LOADS AIR SYSTEM:Zone Ideal Loads Zone Total Heating Rate [W](Hourly)	<xs:element name="Heating" />
AIM0083 IDEAL LOADS AIR SYSTEM:Zone Ideal Loads Zone Total Cooling Rate [W](Hourly)	<xs:element name="CoolingElectricity" />
Whole Building:Facility Total Building Electric Demand Power [W](Hourly)	N/A
Site:Environmental Impact Total CO2 Emissions Carbon Equivalent Mass [kg](Hourly)	<xs:attribute name="TotalCO2" />

Objectives

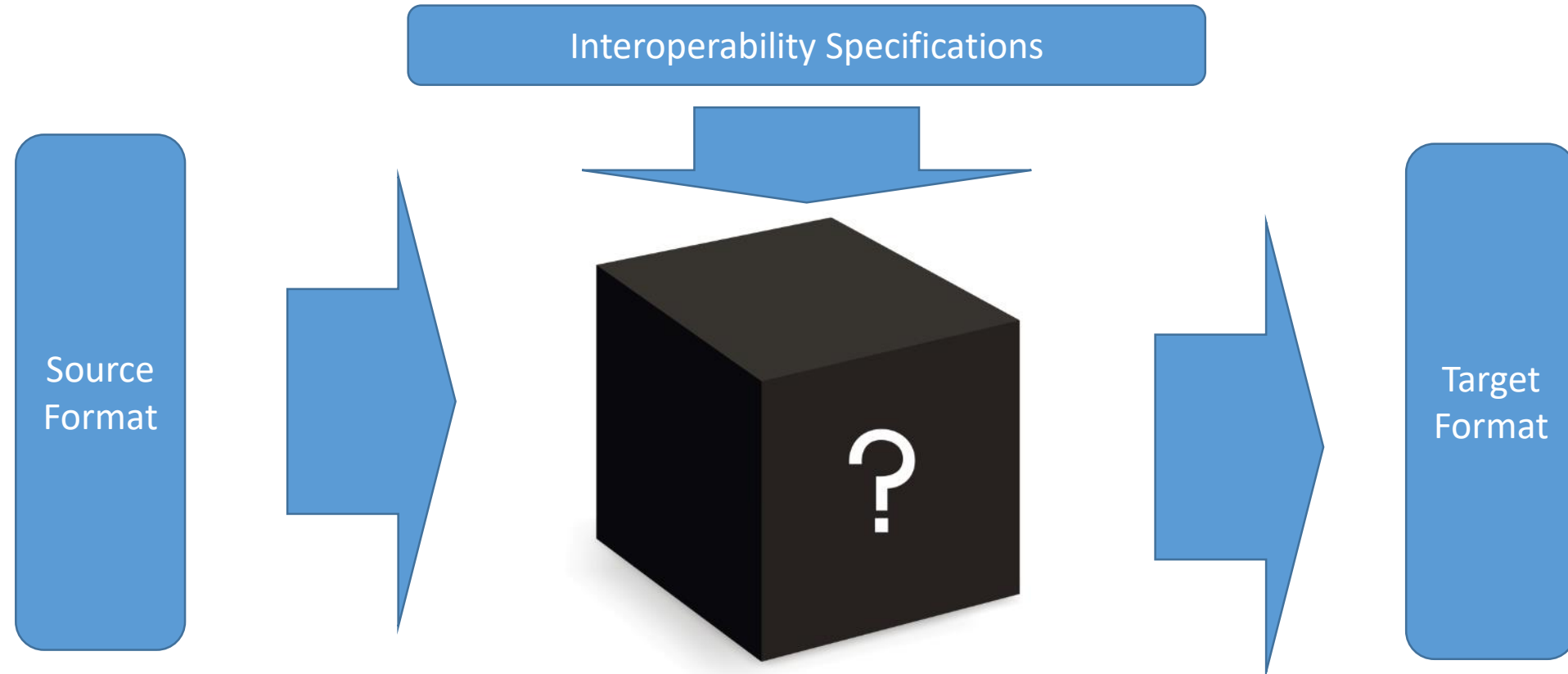
Objectives:

Provide simple UIs aimed at AEC/B&C experts

Build tools to provide interoperability of functionalities



Plug'N'Interoperate (PnI)

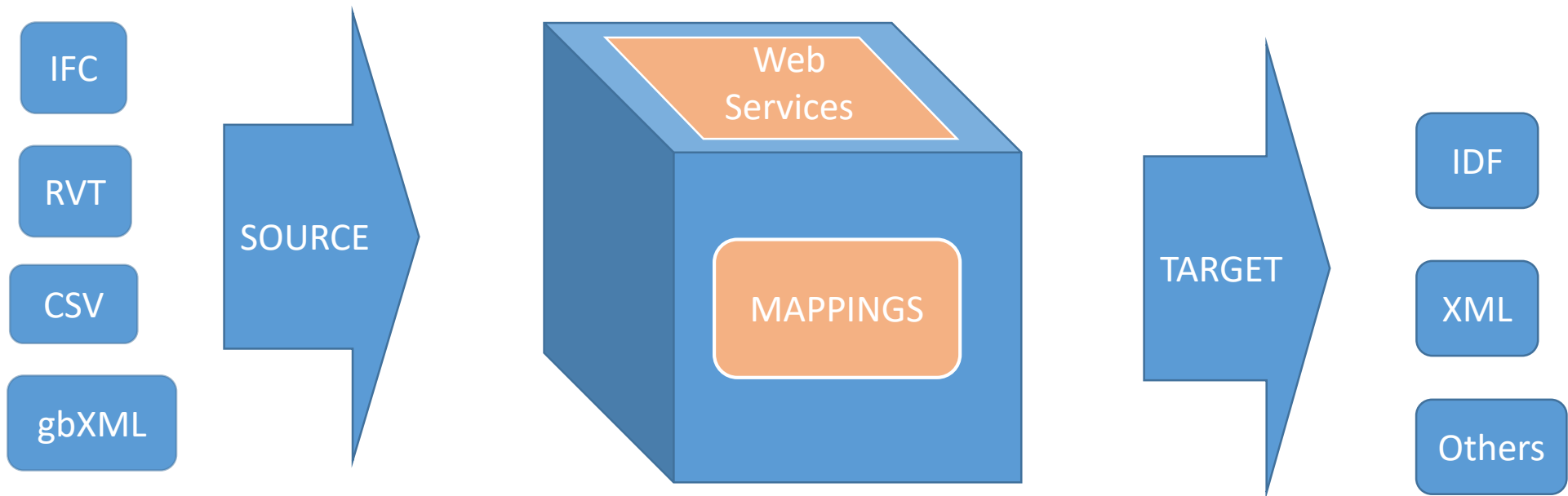


Plug'N'Interoperate (PnI)



Plug'N'Interoperate (PnI)

Interoperability Engine



Tool 1 - Interoperability Suite

Design4Energy Interoperability Suite

This web page is designed to provide architects the tools for converting, simulating and querying BIM files, such as .rvt, .ifc, .xml (gbXML) and .idf. Select a tab to find more about each tool.

Composed Service

Convert

Simulate

This service allows you to convert a BIM file into another:

1. Select a file to be converted (Must be an .XML file, for now!);
2. Select which converter you would like to use;
3. Press the "Convert" button;
4. Wait for conversion and file download.

Choose a file to be converted:

Browse...

No file selected.

Choose converter

LU gbXML-IDF Converter

DesignBuilder gbXML-IDF Converter

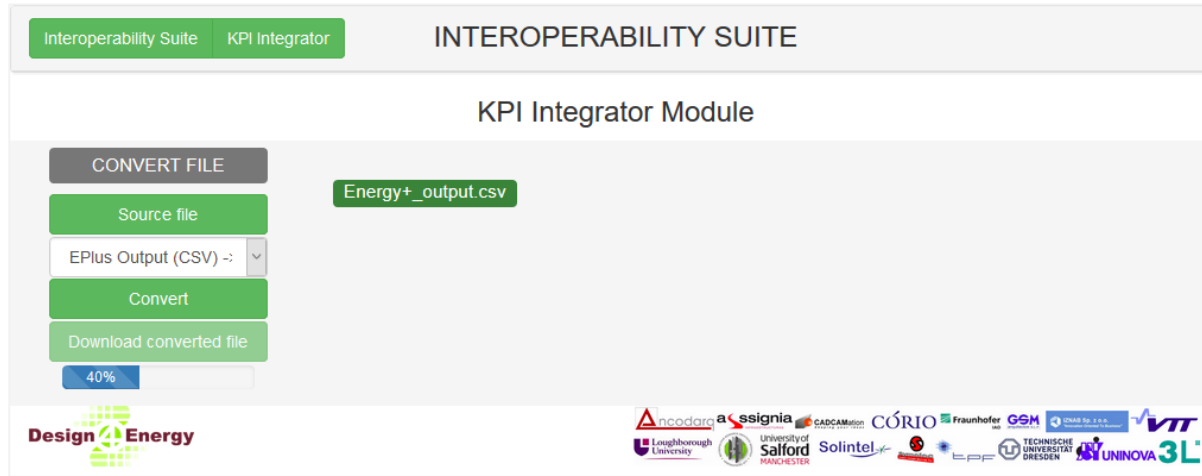
Convert

☐ Select a file to be converted

☐ Select a converter

☐ Click on the "Convert" button

Tool 2 – KPI Integrator



The screenshot shows the 'INTEROPERABILITY SUITE' interface with the 'KPI Integrator' tab selected. The main area is titled 'KPI Integrator Module'. On the left, there is a 'CONVERT FILE' section with a 'Source file' input field containing 'Energy+_output.csv', a dropdown menu set to 'EPlus Output (CSV) ->', and buttons for 'Convert' and 'Download converted file'. A progress bar at the bottom of this section shows '40%'. The bottom of the interface features a row of partner logos including Design Energy, neodara, assignia, CADAMATION, C  RIO, Fraunhofer, GSM, UNINOVA, and others.

CSV -> D4eXML

Tool 3 - Target Setting

GENERAL INFO

Project Id: N/A

Finland town detached

Country Region Building type

VALUE SCORE

A 92.8

ENERGY KPIS

	NOW	
Return on Investment	A (40)	A
Life cycle cost	A (60)	A
Indoor air quality	A (30)	A
Thermal comfort	B (70)	B
Carbon footprint	A (90)	A
Non renewable primary energy	A (10)	A
Energy balancing	B (100)	B

UPDATE

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Thank you