Interoperability: A data conversion framework to support energy simulation

Luis Paiva - Uninova

This project has received funding from the EU FP7 under grant agreement No 609380

Background

luismpaiva@uninova.pt

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)

SEVENTH FRAMEWORK PROGRAMME
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Interoperability Challenges

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

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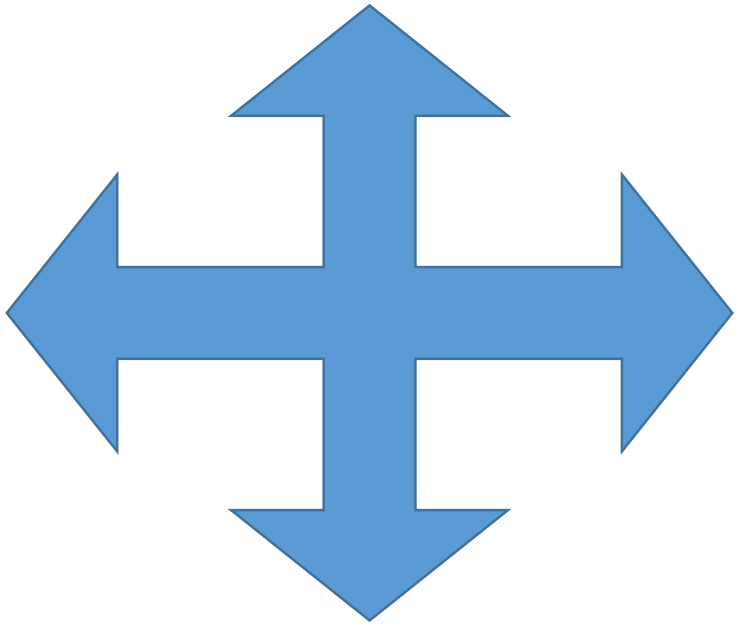
CAD-CAE SOFTWARE



PROPRIETARY SOFTWARE

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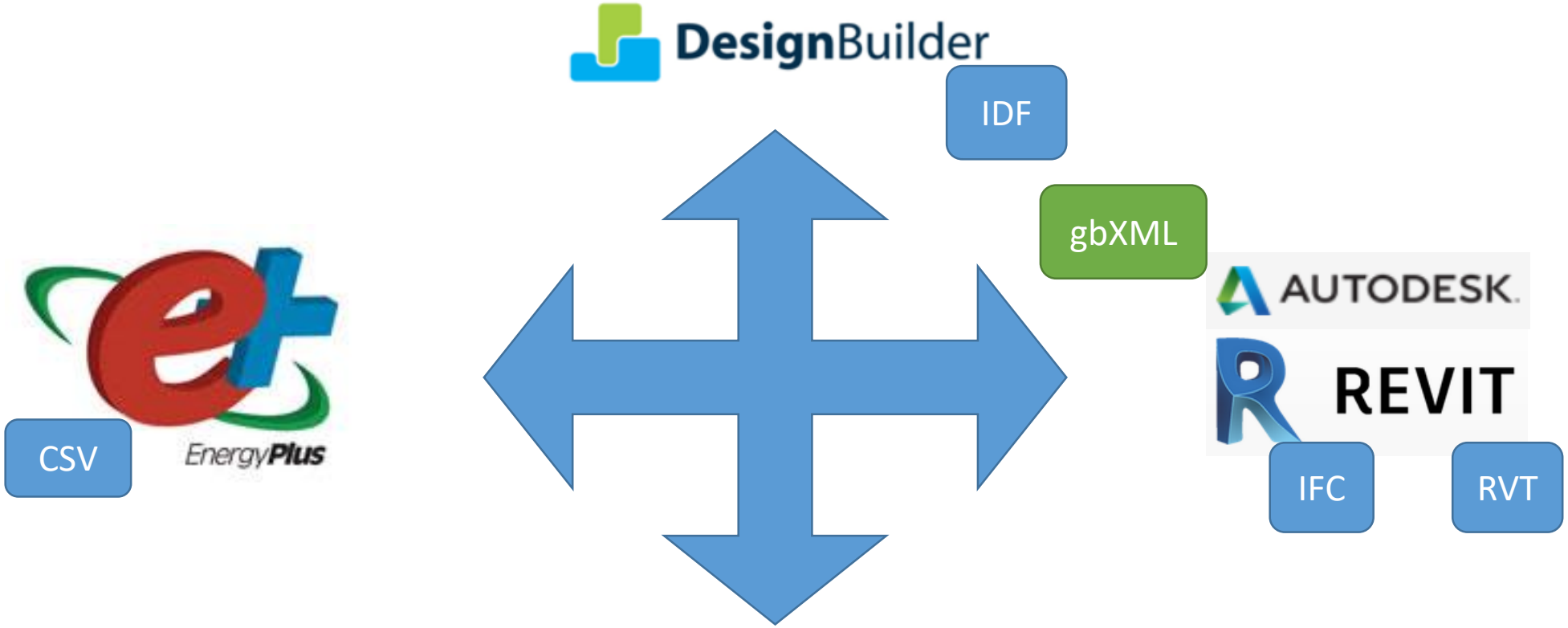
CAD-CAE SOFTWARE



PROPRIETARY SOFTWARE

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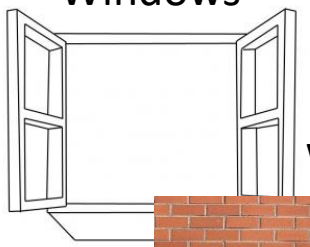
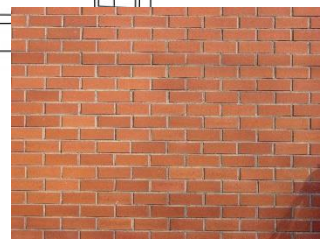
BUILDINGS DATA / ENERGY DATA

Windows



Walls



Neighbourhood

MAKING SENSE OUT OF DATA

KPI

Weather

Devices/Appliances

- Life cycle cost
- Thermal Comfort
- Energy balancing
- Return on Investment (ROI)
- Indoor air quality
- Carbon footprint

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File Contents – Example 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
3	01/01	02:00:00	4.4	11.8408745083225	12.5752340906228
4	01/01	03:00:00	4.4	11.5150107960844	12.2179442626873
5	01/01	04:00:00	4.4	11.2144463622752	11.9048279558348
6	01/01	05:00:00	4.0875	10.9042159480946	11.6021516899488
7	01/01	06:00:00	3.9	10.8200990519393	11.4303823583874
8	01/01	07:00:00	3.525	20.0700718295471	16.3058811107842
9	01/01	08:00:00	3.3	20.0000000000001	16.6062541543148
10	01/01	09:00:00	2.9875	20.0000000000002	16.7710937025845
11	01/01	10:00:00	3.1125	20.0000000000003	16.8983265005484
12	01/01	11:00:00	3.675	20.	17.0021619255326
13	01/01	12:00:00	4.5875	20.	17.0946746338426
14	01/01	13:00:00	5.6875	14.0453025652163	13.9625407744301
15	01/01	14:00:00	6.7875	12.4673943721305	12.9067664231628
16	01/01	15:00:00	7.8875	12.4204531270101	12.7330719818707
17	01/01	16:00:00	8.3	12.2903547583088	12.5484012577633
18	01/01	17:00:00	7.9875	12.0398636126046	12.3075886201086
19	01/01	18:00:00	7.425	11.721328548805	12.0232485435576
20	01/01	19:00:00	6.8875	20.0998352685443	16.4417877718721

	Date/Time	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)	AIM0083:Zone Operative Temperature [C](Hourly)
2	01/01	01:00:00	7.06714140507	6.8213359336046	6.78464423730068
3	01/01	02:00:00	4.8408745083225	2.5752340906228	6.58140046989626
4	01/01	03:00:00	1.5150107960844	2.2179442626873	6.47364191312834
5	01/01	04:00:00	1.2144463622752	1.9048279558348	6.36967227394589
6	01/01	05:00:00	1.0042159480946	1.6021516899488	6.23261623194266
7	01/01	06:00:00	0.8200990519393	1.4303823583874	6.69137833412069
8	01/01	07:00:00	13.0700718295471	8.3058811107842	6.97945927050573
9	01/01	08:00:00	13.0000000000001	8.6062541543148	6.90860507459024
10	01/01	09:00:00	13.0000000000002	8.7710937025845	6.8036411328325
11	01/01	10:00:00	13.0000000000003	8.8983265005484	6.74202305159124
12	01/01	11:00:00	13.	9.0021619255326	6.33683133235794
13	01/01	12:00:00	13.	9.0946746338426	6.3640438191857
14	01/01	13:00:00	13.0453025652163	8.9625407744301	6.50618003210056
15	01/01	14:00:00	12.4673943721305	7.9067664231628	6.67355381220198
16	01/01	15:00:00	12.4204531270101	7.7330719818707	6.86529148686286
17	01/01	16:00:00	12.2903547583088	7.5484012577633	7.02350184591654
18	01/01	17:00:00	12.0398636126046	7.3075886201086	7.1210817370061
19	01/01	18:00:00	11.721328548805	7.0232485435576	7.1904758876762
20	01/01	19:00:00	20.0998352685443	16.4417877718721	7.96725352581885

	Date/Time	AIM0086:Zone Mean Air Temperature [C](Hourly)	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)
2	01/01	01:00:00	6.73312725552589	1.44751974512024	1.41266134618421
3	01/01	02:00:00	6.54933280409182	1.43765653181149	1.41119003433948
4	01/01	03:00:00	6.43490646004356	1.43591684277803	1.41054766338509
5	01/01	04:00:00	6.32491316650956	1.43439953904276	1.41002095427086
6	01/01	05:00:00	6.19753802800232	1.43445207311914	1.41092036756064
7	01/01	06:00:00	6.61451856340065	1.43508693416961	1.41428063540872
8	01/01	07:00:00	6.56503700357327	1.48391566162875	1.41772809346673
9	01/01	08:00:00	6.50396784861159	1.48460329054736	1.41836685968391
10	01/01	09:00:00	6.41274852685054	1.48629668573038	1.41944676577808
11	01/01	10:00:00	6.34037748639605	1.48562971487246	1.41849398657274
12	01/01	11:00:00	6.08125124759615	1.48261259132493	1.41356210211648
13	01/01	12:00:00	6.05194556370174	1.47773237666007	1.40904766632494
14	01/01	13:00:00	6.11996523371086	1.44260795867763	1.40478899393992
15	01/01	14:00:00	6.23021165785777	1.42854988839672	1.39962823800402
16	01/01	15:00:00	6.37648010615627	1.42261508236443	1.39499782384385
17	01/01	16:00:00	6.5237114781633	1.41987352987899	1.39373119905001
18	01/01	17:00:00	6.64461281210965	1.42019108674287	1.39575330737862
19	01/01	18:00:00	6.74605794557972	1.42145597079498	1.39890465769241
20	01/01	19:00:00	7.2532122657715	1.466353449272	1.40574676123342

	Date/Time	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)	AIM0083:Zone Operative Temperature [C](Hourly)
2	01/01	01:00:00	1.41266134618421	411.154882557756	434.227829786432
3	01/01	02:00:00	1.41119003433948	406.019791109693	420.950064574816
4	01/01	03:00:00	1.41054766338509	404.116206237947	416.002729607232
5	01/01	04:00:00	1.41002095427086	403.738196674929	415.014660992242
6	01/01	05:00:00	1.41092036756064	403.644355238102	414.764603836748
7	01/01	06:00:00	1.41428063540872	406.921133732508	428.08783662314
8	01/01	07:00:00	1.41772809346673	411.249048650171	444.741261937225
9	01/01	08:00:00	1.41836685968391	413.368359039828	452.608322348329
10	01/01	09:00:00	1.41944676577808	414.250216851066	453.934120798768
11	01/01	10:00:00	1.41849398657274	414.629868223123	454.171778410563
12	01/01	11:00:00	1.41356210211648	413.009880259915	444.848676558409
13	01/01	12:00:00	1.40904766632494	411.215002402312	437.705503467188
14	01/01	13:00:00	1.40478899393992	410.819177767053	439.36821183074
15	01/01	14:00:00	1.39962823800402	410.851714550855	442.735751061487
16	01/01	15:00:00	1.39499782384385	410.900854388073	444.110219207051
17	01/01	16:00:00	1.39373119905001	410.936963192588	444.463103188306
18	01/01	17:00:00	1.39575330737862	410.948920174635	444.526119966655
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20	01/01	19:00:00	1.40574676123342	414.030415612753	456.258833629893

	Date/Time	AIM0086:Zone Mean Air Temperature [C](Hourly)	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)
2	01/01	01:00:00	0.0	0.0	0.0
3	01/01	02:00:00	0.0	0.0	0.0
4	01/01	03:00:00	0.0	0.0	0.0
5	01/01	04:00:00	0.0	0.0	0.0
6	01/01	05:00:00	0.0	0.0	0.0
7	01/01	06:00:00	0.0	0.0	0.0
8	01/01	07:00:00	0.0	0.0	0.0
9	01/01	08:00:00	0.0	0.0	0.0
10	01/01	09:00:00	0.0	0.0	0.0
11	01/01	10:00:00	0.0	0.0	0.0
12	01/01	11:00:00	0.0	0.0	0.0
13	01/01	12:00:00	0.0	0.0	0.0
14	01/01	13:00:00	0.0	0.0	0.0
15	01/01	14:00:00	0.0	0.0	0.0
16	01/01	15:00:00	0.0	0.0	0.0
17	01/01	16:00:00	0.0	0.0	0.0
18	01/01	17:00:00	0.0	0.0	0.0
19	01/01	18:00:00	0.0	0.0	0.0
20	01/01	19:00:00	0.0	0.0	0.0

	Date/Time	AIM0086:Zone Mean Air Temperature [C](Hourly)	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)
2	01/01	01:00:00	0.0	0.0	0.0
3	01/01	02:00:00	0.0	0.0	0.0
4	01/01	03:00:00	0.0	0.0	0.0
5	01/01	04:00:00	0.0	0.0	0.0
6	01/01	05:00:00	0.0	0.0	0.0
7	01/01	06:00:00	0.0	0.0	0.0
8	01/01	07:00:00	0.0	0.0	0.0
9	01/01	08:00:00	0.0	0.0	0.0
10	01/01	09:00:00	0.0	0.0	0.0
11	01/01	10:00:00	0.0	0.0	0.0
12	01/01	11:00:00	0.0	0.0	0.0
13	01/01	12:00:00	0.0	0.0	0.0
14	01/01	13:00:00	0.0	0.0	0.0
15	01/01	14:00:00	0.0	0.0	0.0
16	01/01	15:00:00	0.0	0.0	0.0
17	01/01	16:00:00	0.0	0.0	0.0
18	01/01	17:00:00	0.0	0.0	0.0
19	01/01	18:00:00	0.0	0.0	0.0
20	01/01	19:00:00	0.0	0.0	0.0

	Date/Time	AIM0086:Zone Operative Temperature [C](Hourly)	Environment:Site Outdoor Air Drybulb Temperature [C](Hourly)	AIM0083:Zone Mean Air Temperature [C](Hourly)	AIM0083:Zone Operative Temperature [C](Hourly)
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5	01/01	04:00:00	305.3090964	0.0	0.0
6	01/01	05:00:00	305.3090964	0.0	0.0
7	01/01	06:00:00	915.9272892	0.0	0.0
8	01/01	07:00:00	15816.8539522814	5.42346848912226	0.0
9	01/01	08:00:00	15008.3802378674	3.096829459536821E	0.0
10	01/01	09:00:00	14364.0315668783	1.32331479107961	0.0
11	01/01	10:00:00	13788.0866916085	3.81987774744629	0.0
12	01/01	11:00:00	13417.4926883013	3.619788913056254E-010	915.92
13	01/01	12:00:00	12793.8107215808	3.551576810423285E-010	915.92
14	01/01	13:00:00	12793.8107215808	3.551576810423285E-010	915.92
15	01/01	14:00:00	12793.8107215808	3.551576810423285E-010	915.92
16	01/01	15:00:00	12793.8107215808	3.551576810423285E-010	915.92
17	01/01	16:00:00	12793.8107215808	3.551576810423285E-010	915.92
18	01/01	17:00:00	12793.8107215808	3.551576810423285E-010	915.92
19	01/01	18:00:00	12793.8107215808	3.551576810423285E-010	915.92
20	01/01	19:00:00	15365.8875160289	2.083349196861188E	0.0

CSV ENERGY PLUS EXPORT

SEVENTH FRAMEWORK PROGRAMME

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File Contents – Example 2

```
<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSpy v2016 rel. 2 (x64) (http://www.altova.com)-->
<D4ESIM>
    <Building simulationTool="Energy+" date="2017-03-02T09:30:47Z" author=""
        version="" modelname="" modelvariation="" area="00.00"
        type="" buildingName="" projectID=""
        TotalCO2="124157" LCCCost="" CO2OverLimit="" TempOverLimit=""
        timestep="hour" thermalZone="">
            <simulationresult>
                <time>0</time>
                <Heating>0.0</Heating>
                <DomesticHotWater>0</DomesticHotWater>
                <HouseholdElectricity>0</HouseholdElectricity>
                <HvacElectricity>0</HvacElectricity>
                <LightingElectricity>0</LightingElectricity>
                <CoolingElectricity>0.0</CoolingElectricity>
                <CO2>422.691</CO2>
                <Temperature>10.275</Temperature>
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                <HouseholdElectricity>0</HouseholdElectricity>
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            </simulationresult>
...
    </Building>
</D4ESIM>
```

D4E XML FILE CONTENTS

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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) AIM0086:Zone Operative Temperature [C](Hourly)	<xs:element name="Temperature" /> (Average of zones)
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) AIM0086:Zone Air CO2 Concentration [ppm](Hourly)	<xs:element name="CO2" /> (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" />

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Objectives

Objectives:

Provide simple UIs aimed at AEC/B&C experts

Build tools to provide interoperability of functionalities

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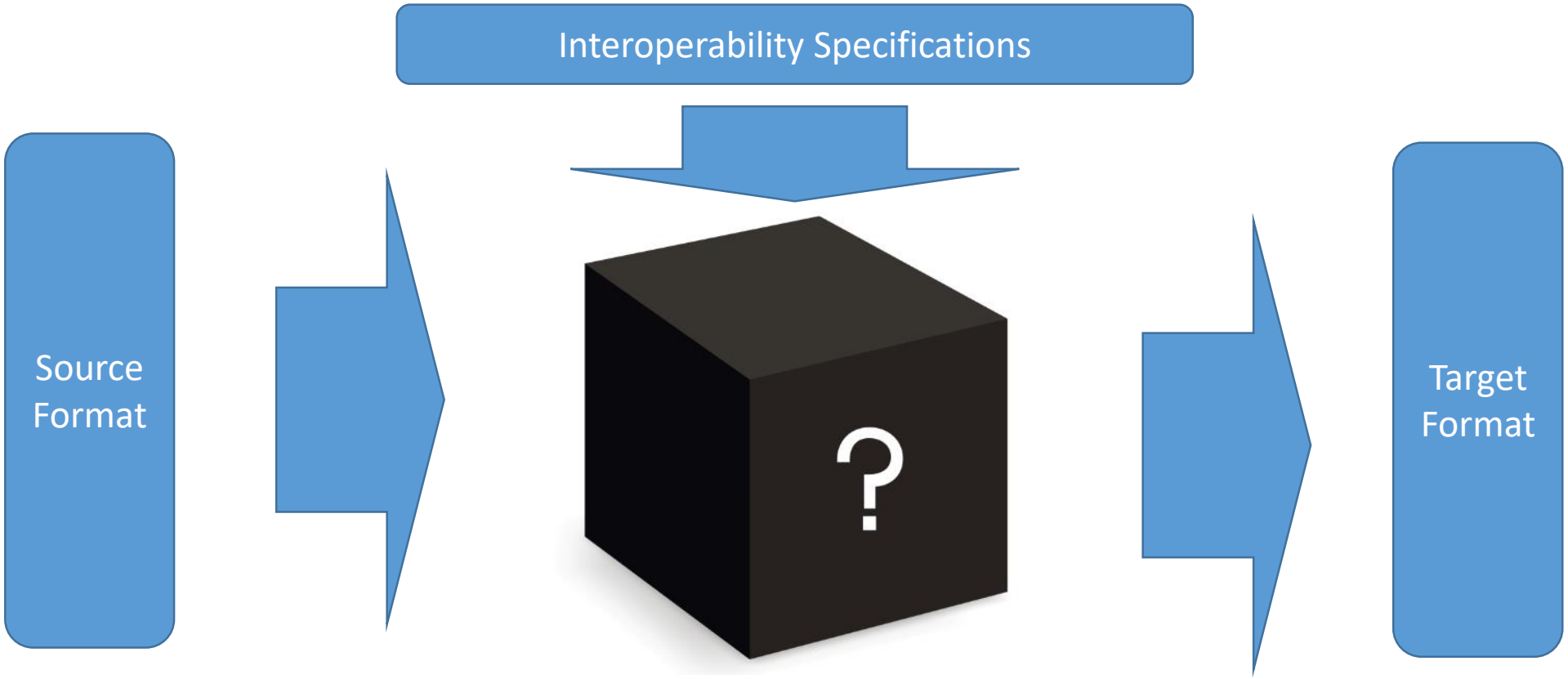
Plug'N'Interoperate (PnI)



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Plug'N'Interoperate (PnI)

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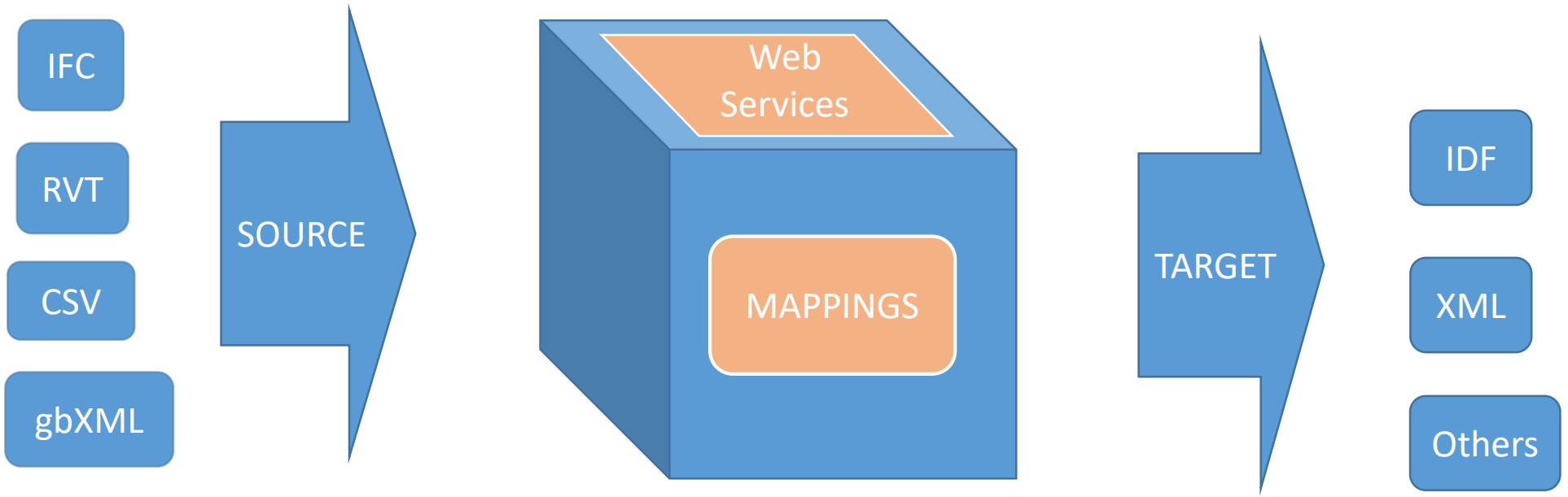
Plug'N'Interoperate (PnI)

Interoperability Engine



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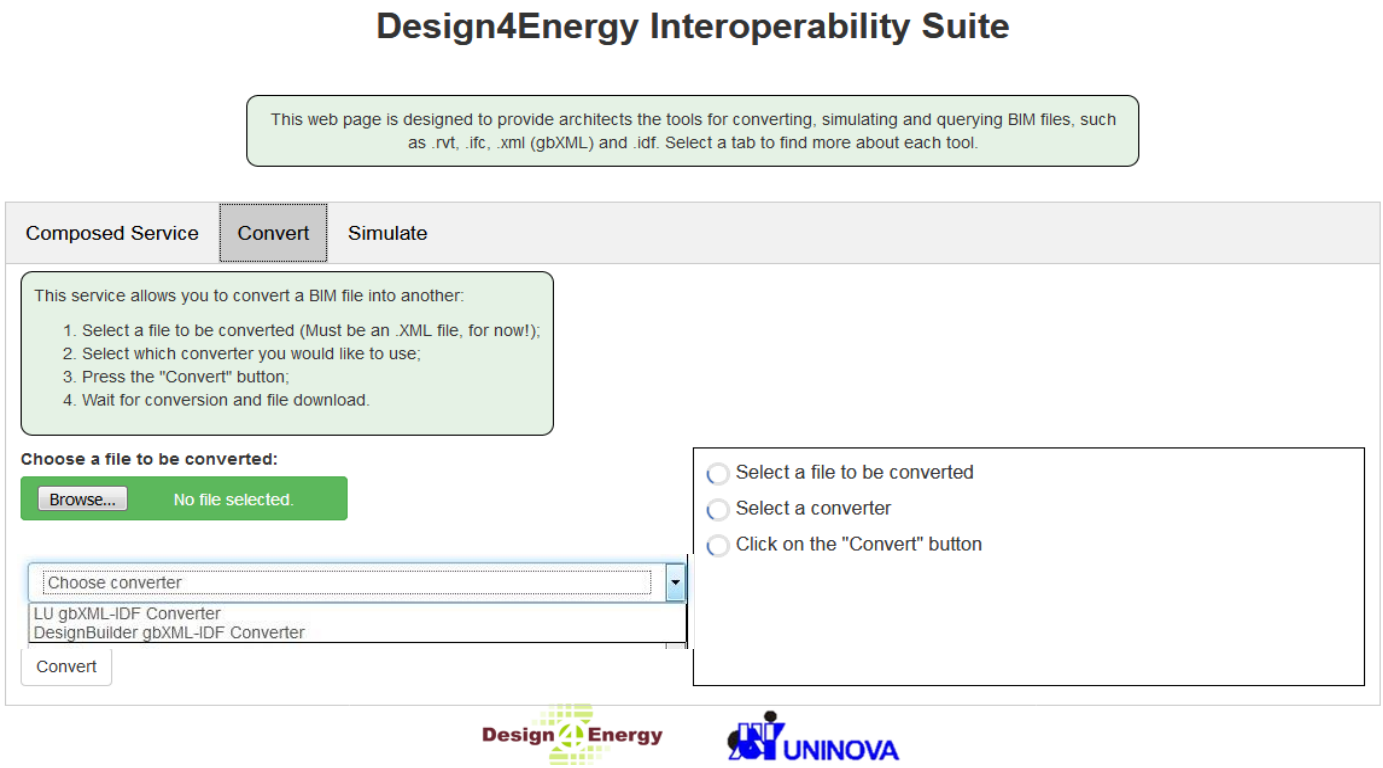
Tool 1 - Interoperability Suite



gbXML -> IDF

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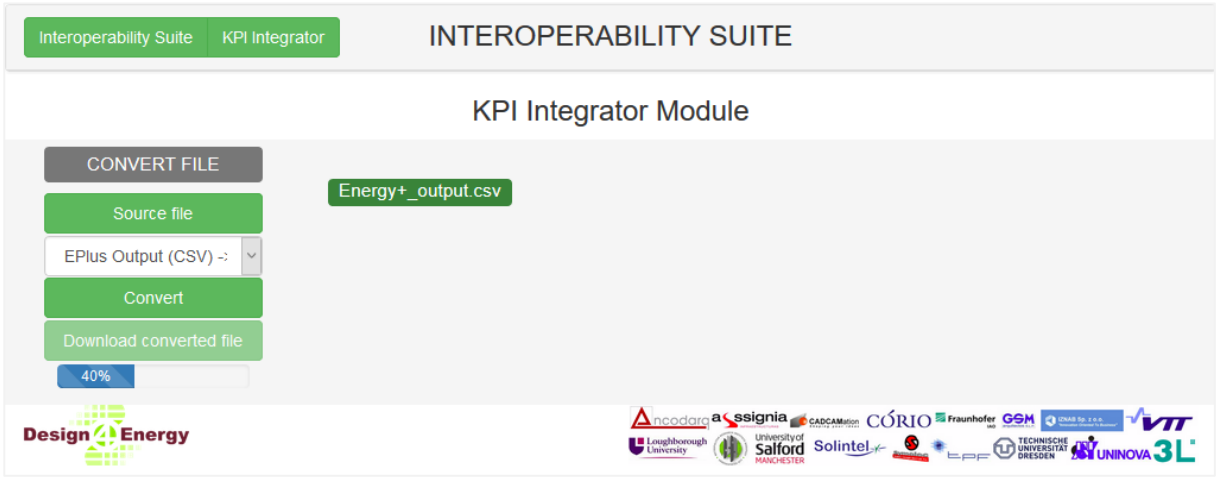
Tool 2 – KPI Integrator



CSV -> D4eXML

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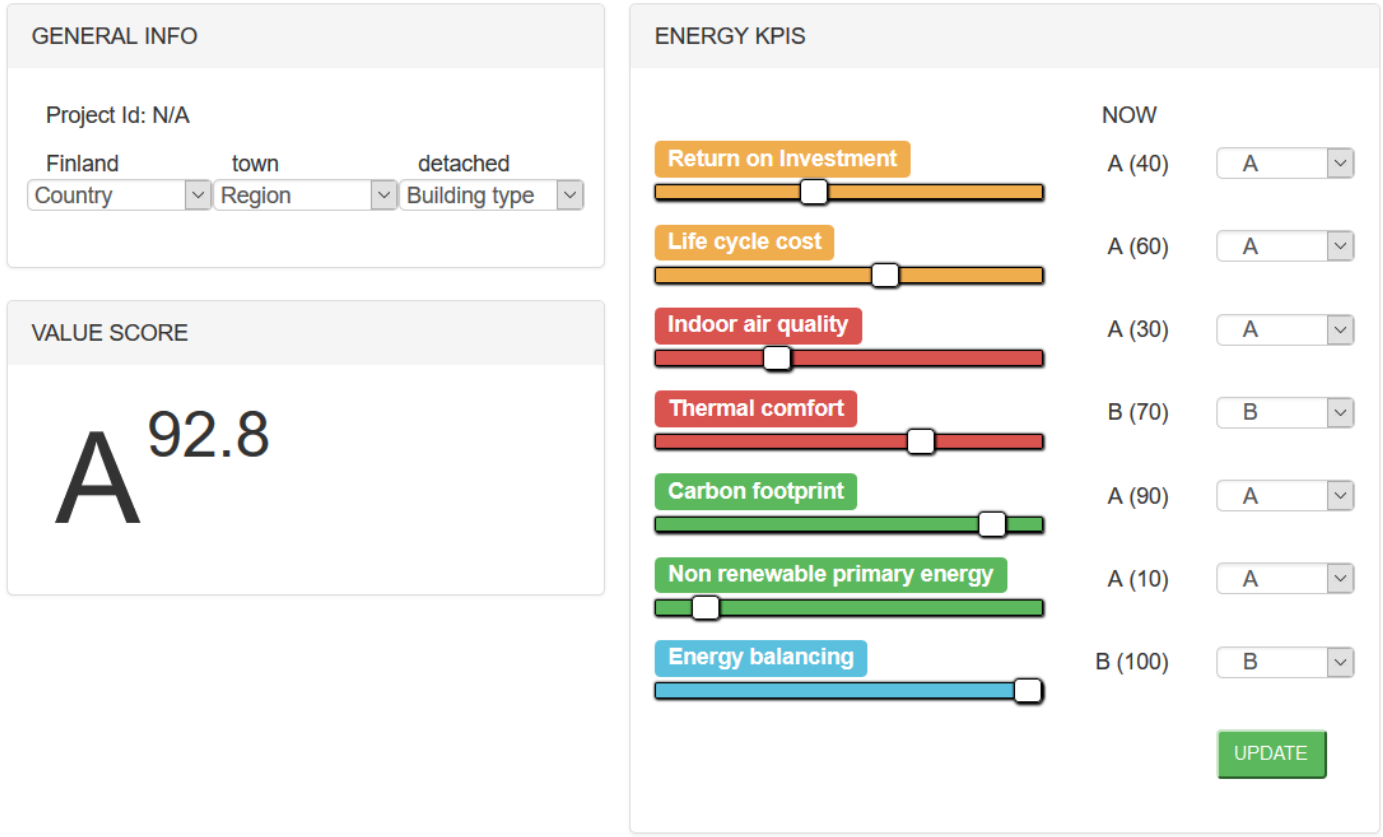
Tool 3 - Target Setting



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VTT - Technical Research Centre of Finland

Vanda Dimitriou, Tarek Hassan
Loughborough University (UK)

Thank you

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