



OPTIMISED ENERGY EFFICIENT DESIGN
PLATFORM FOR REFURBISHMENT
AT DISTRICT LEVEL

A comprehensive ontologies-based framework to support the retrofitting design of energy-efficient districts

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Work programme:

HORIZON 2020-WORK PROGRAMME 2014-2015

5. Leadership in enabling and industrial technologies

Call identifier: H2020-EeB-2014-2015 / H2020-EeB-2015

Topic: EeB-05-2015 Innovative design tools for refurbishment at building and district level

Title of the Proposal:

Optimised Energy Efficient Design Platform for Refurbishment at District Level

List of participants: **13 Partners – 4 RTO, 2 Universities, 2 IND, 3 SME and 2 Cities**

GA no. 680676, Contact: contact@opteemal.eu

4-year project → **We are in the 1st year!**



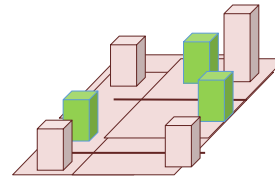
- Project Overview
- District Data Model & DPLs
- Calculation methodologies for the DPLs
- Conclusions

- **Project Overview**
- District Data Model & DPIs
- Calculation methodologies for the DPIs
- Conclusions



Context

- Refurbishment projects at District Level



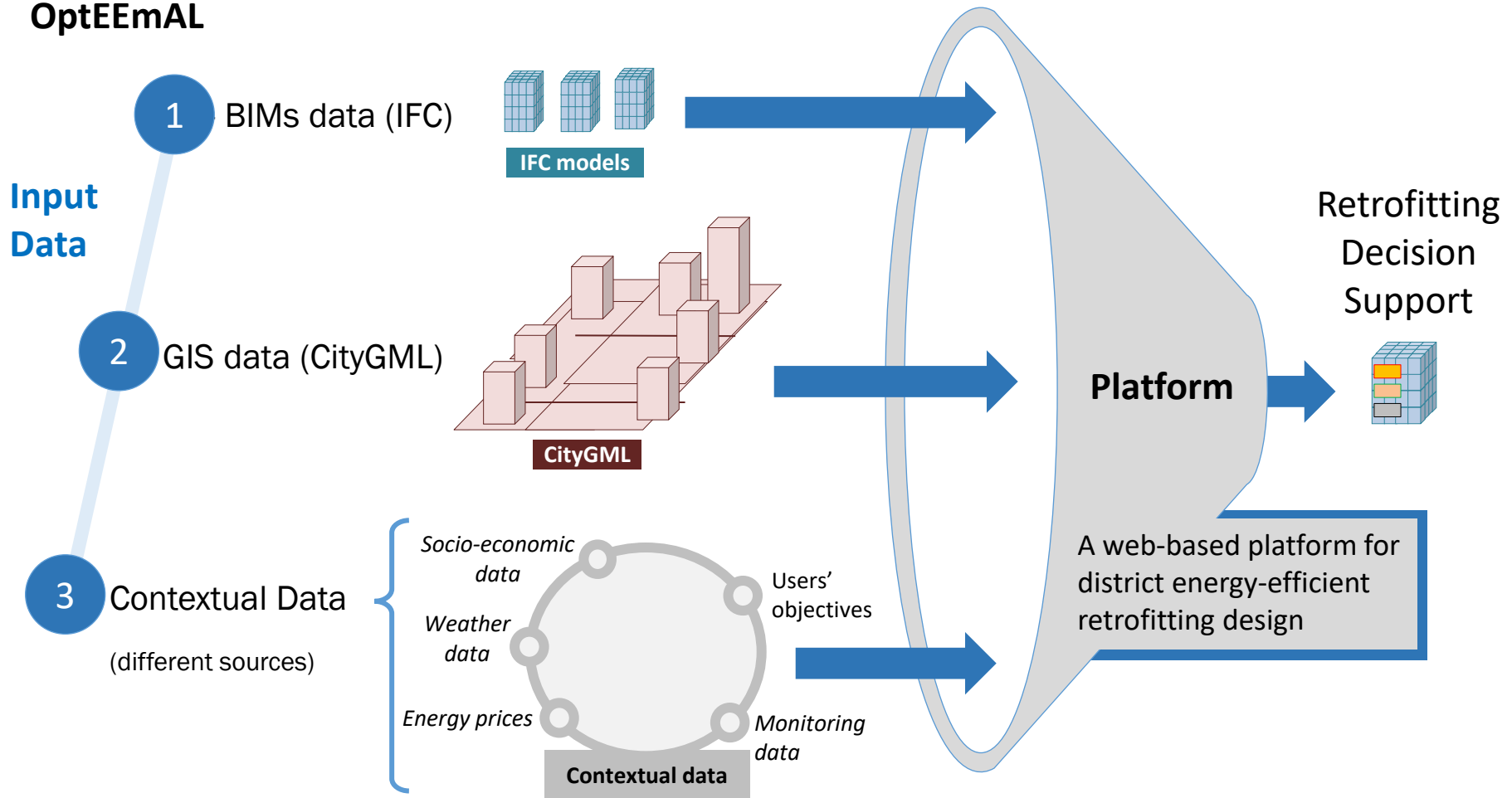
Research topic

- How to provide an **optimized building-district retrofitting design** through a **consistent integration of geometry and semantic representation** of information from:
 - (1) IFC
 - (2) CityGML files (with different levels of detail)
 - (3) other **data sources** (contextual data)

Important components of the platform

- District Data Model (**DDM**)
- Energy Conservation Measures Catalogue (**ECMs**)
- Automated generation of input data for simulation tools

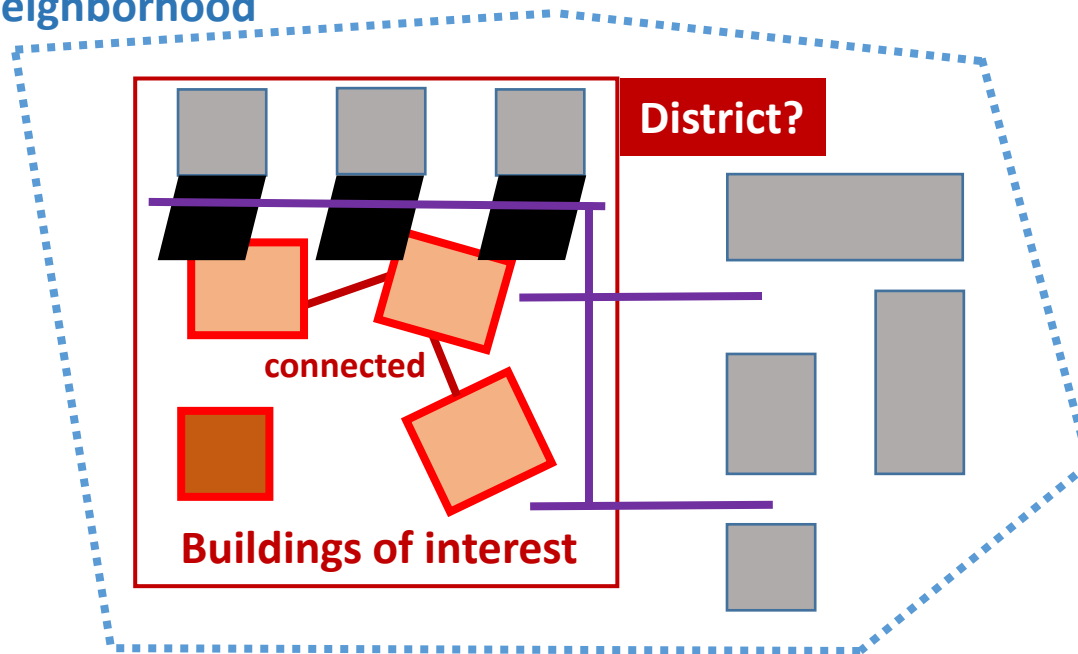
OptEEmAL



Definition of the “problem”

1. Urban district information is provided by users via upload a CityGML file
2. Users select the buildings of interest and define their relation with the environment.

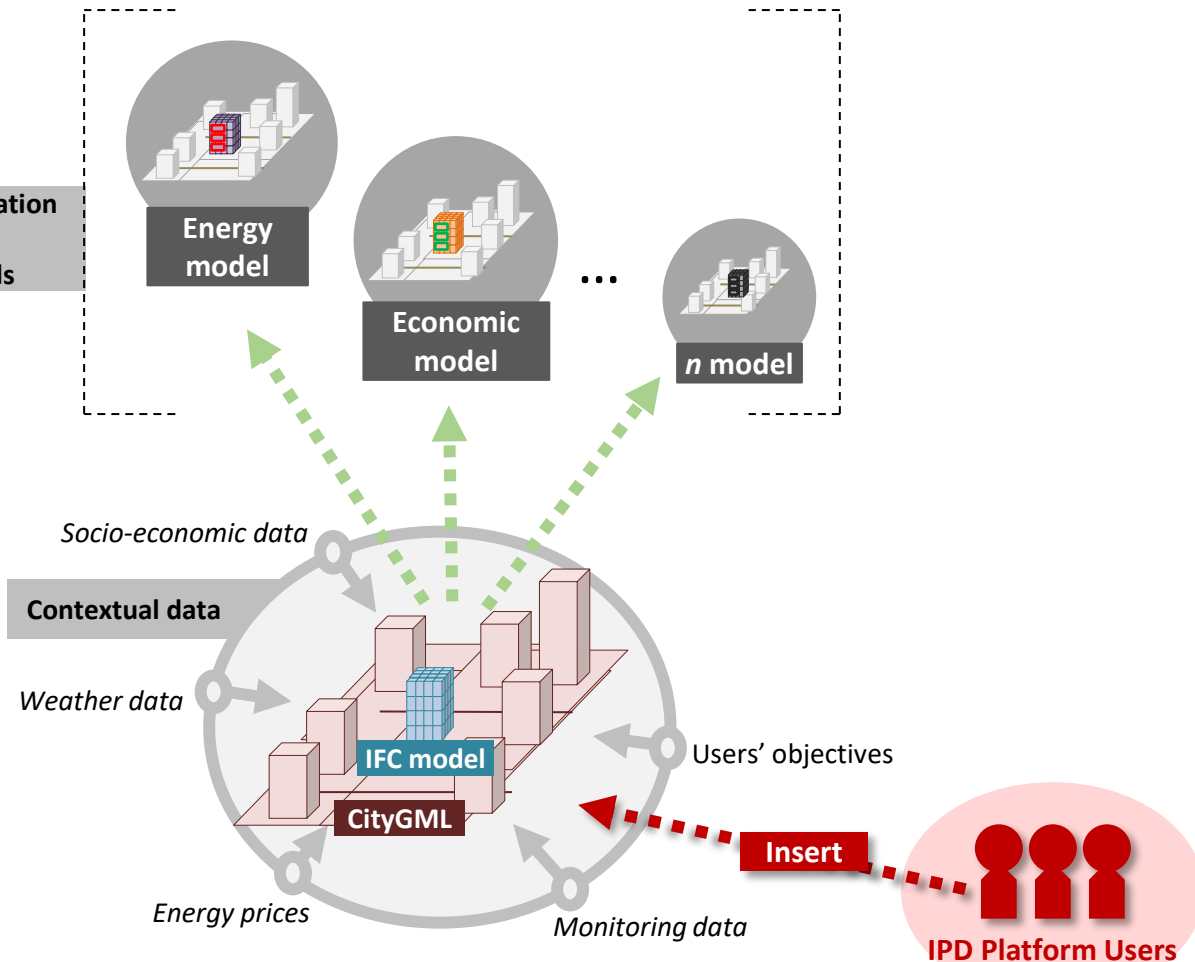
Neighborhood

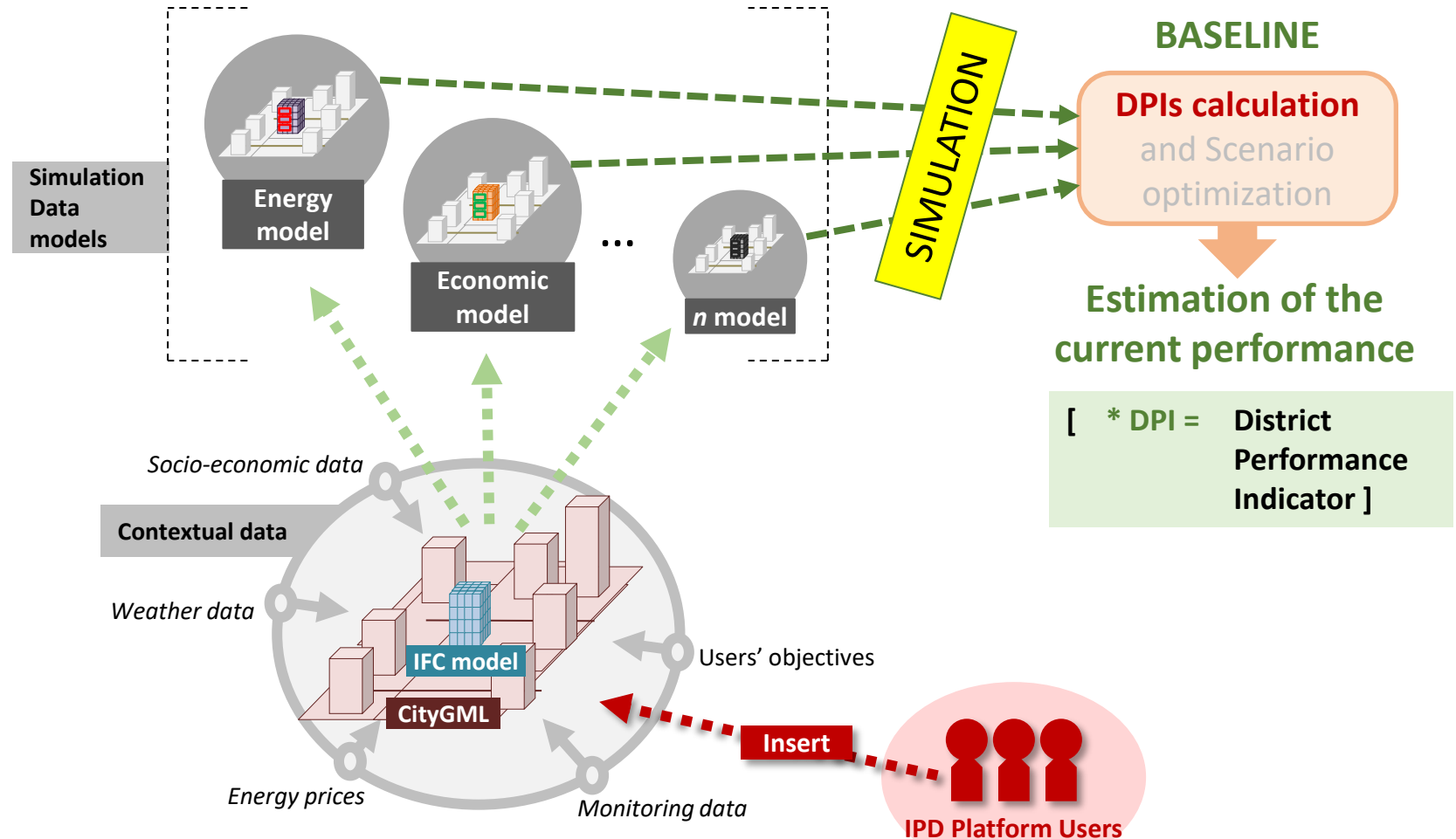


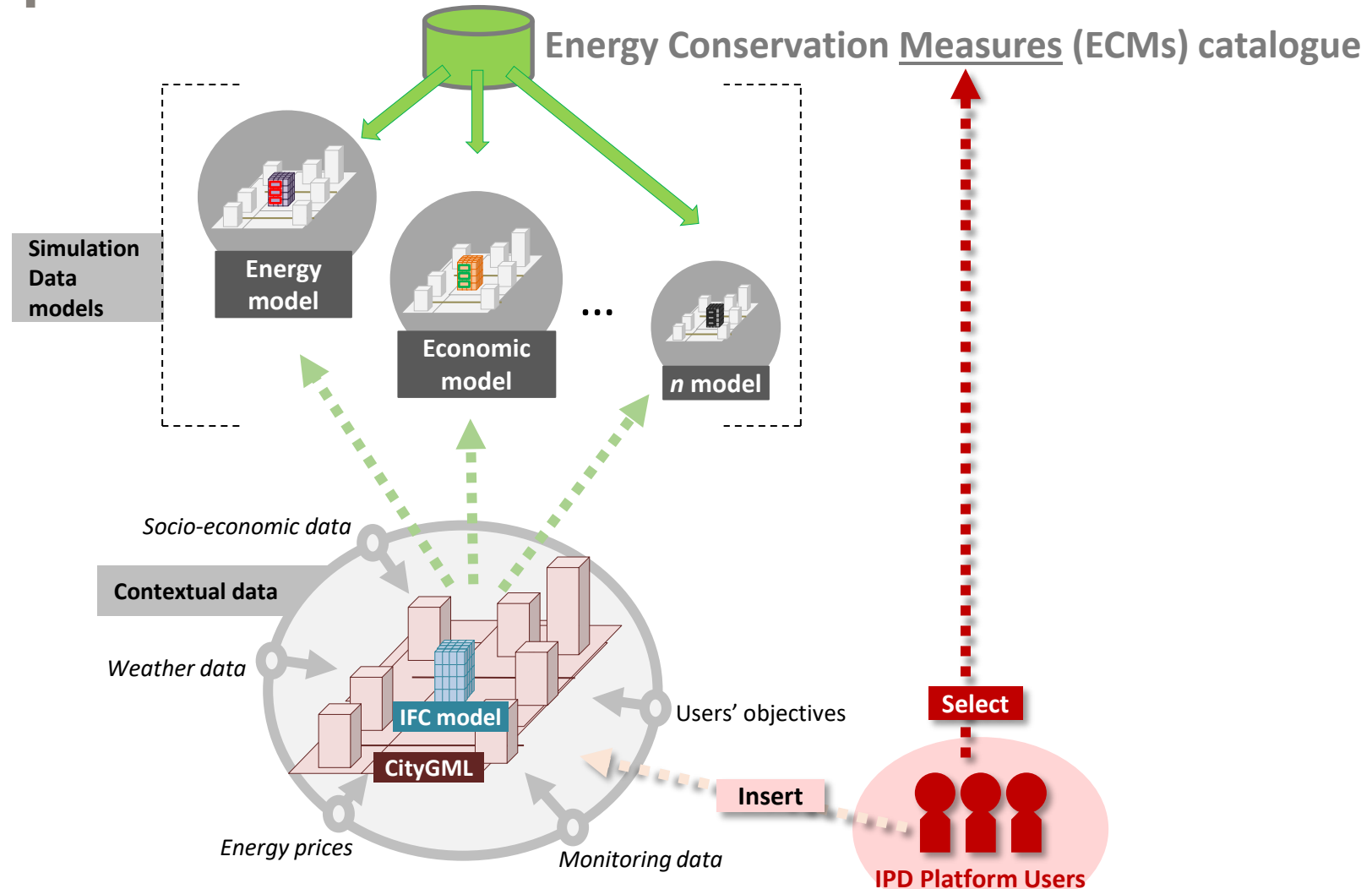
1. District Heating
2. Energy transfers
3. Cast shadows
4. ...

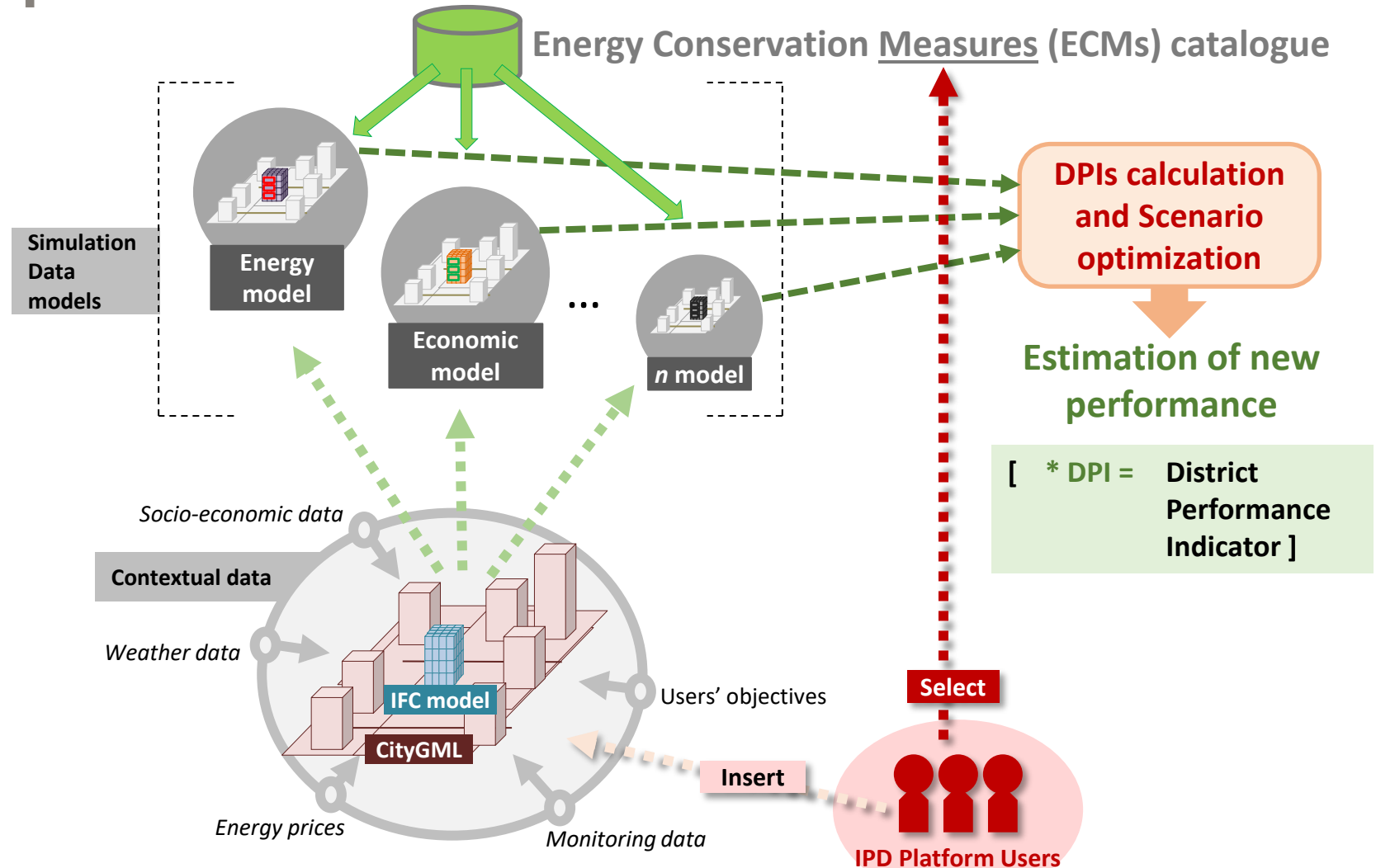
- Project Overview
- **District Data Model & DPIs**
- Calculation methodologies for the DPIs
- Conclusions











DPIs – District Performance Indicators

ENERGY DPI's

ENE01 - Energy demand
 ENE02 - "Final Energy Consumption" or "Operational Energy Use"
 ENE03 - Peakload and profile of electricity demand
 ENE04 - Peakload and profile of thermal energy demand
 ENE05 - Degree of energetic self-supply
 ENE06 - Net fossil energy consumed
 ENE07 - Total energy use per capita
 ENE08 - Total residential electrical energy use per capita
 ENE09 - Energy demand covered by renewable sources (%)
 ENE10 - Total residential natural gas energy use per capita
 ENE11 - Total residential butane gas energy demand
 ENE12 - Energy consumption of public buildings per year
 ENE13 - Energy use from District Heating
 ENE14 - Energy use from Biomass
 ENE15 - Energy use from PV
 ENE16 - Energy use from Solar Thermal
 ENE17 - Energy use from Hydraulic
 ENE18 - Energy use from Mini-Eolica
 ENE19 - Energy use from Geothermal

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COMFORT DPI's

COM01 - Local thermal comfort
 COM02 - Percentage outside range
 COM04 - Indoor Air Quality

3

ENVIRONMENTAL DPI's

ENV01 - Global Warming Potential
 ENV02 - GWP Investment
 ENV03 - GWP reduction
 ENV04 - Primary energy consumption
 ENV05 - Embodied energy of refurbishment scenarios
 ENV06 - Energy payback time

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ECONOMIC DPI's

ECO01 - Operational energy cost
 ECO02 - Investments
 ECO03 - Grants
 ECO04 - Life cycle cost
 ECO05 - Internal rate of return
 ECO06 - Internal rate of investment
 ECO07 - Total energy cost

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SOCIAL DPI's

SOC01 - Energy poverty measure
Incomes used to pay energy bills

1

URBAN DPI's

URB01 - Percentage of buildings compliant with EPBD standard
 URB04 - Percentage of buildings compliant with nZEB standard
 URB02 - Percentage of building with PassivHaus standard
 URB03 - Percentage of building with EnerPHit standard

3

GLOBAL DPI's

ENE01 - Energy demand

1

SIMULATION TOOLS

EnergyPlus Requirements

Simulation Parameters
 Building Geometry Description
 Building Materials
 Weather Data
 Schedules
 Internal Gains
 Energy Systems
 Exterior Energy Use Equipment
 Renewable Energy Systems
 CitySim Requirements
 Simulation Parameters
 Building Geometry Description
 Building Materials
 Weather Data
 Schedules
 Internal Gains
 Energy Systems
 Renewable Energy Systems

CitySim Requirements

Simulation Parameters
 Building Geometry Description
 Building Materials
 Weather Data
 Schedules
 Internal Gains
 Energy Systems
 Renewable Energy Systems

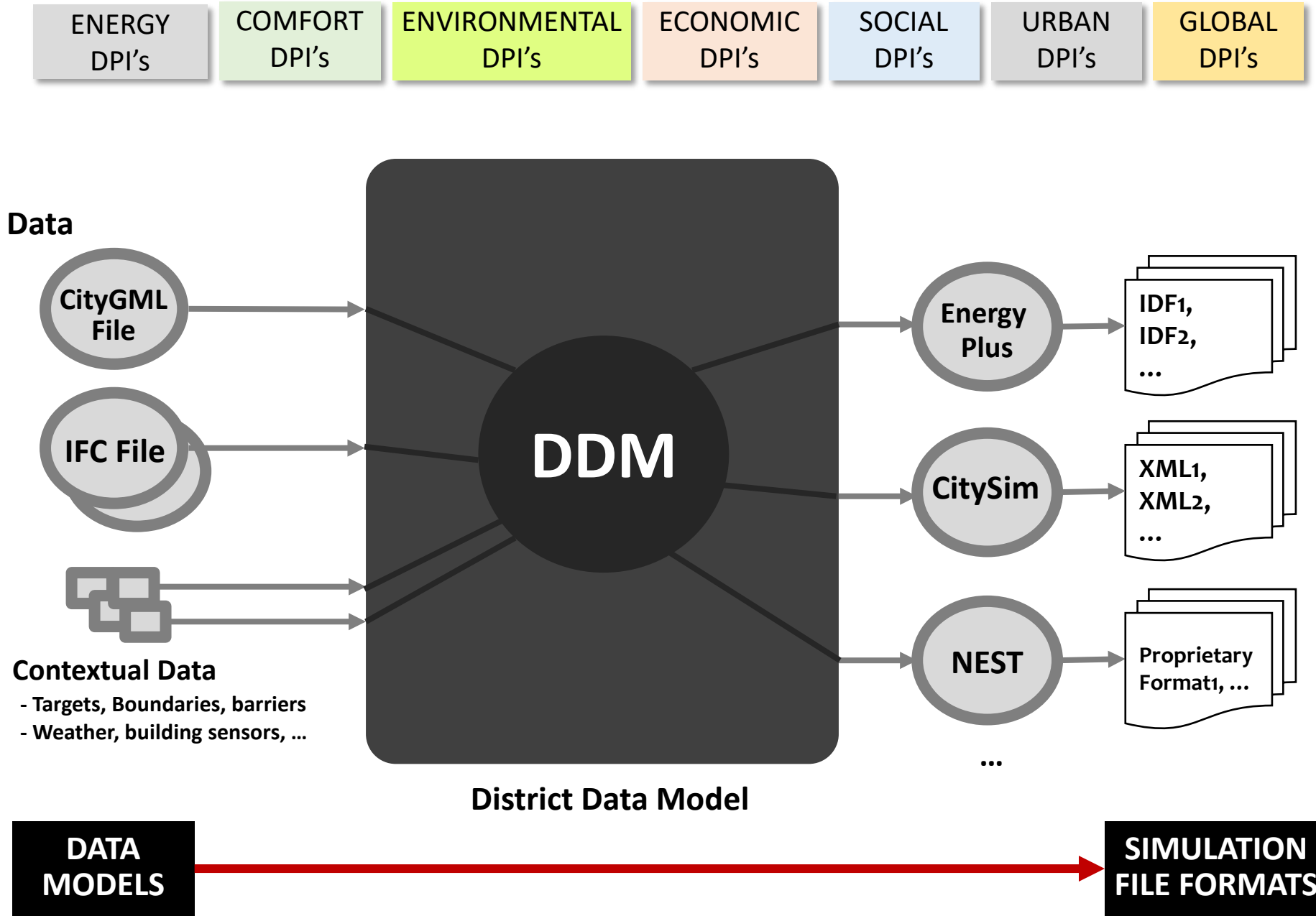
NEST Requirements

Building Description
 ECM Catalogue
 List of DPI
 Conversion Factors

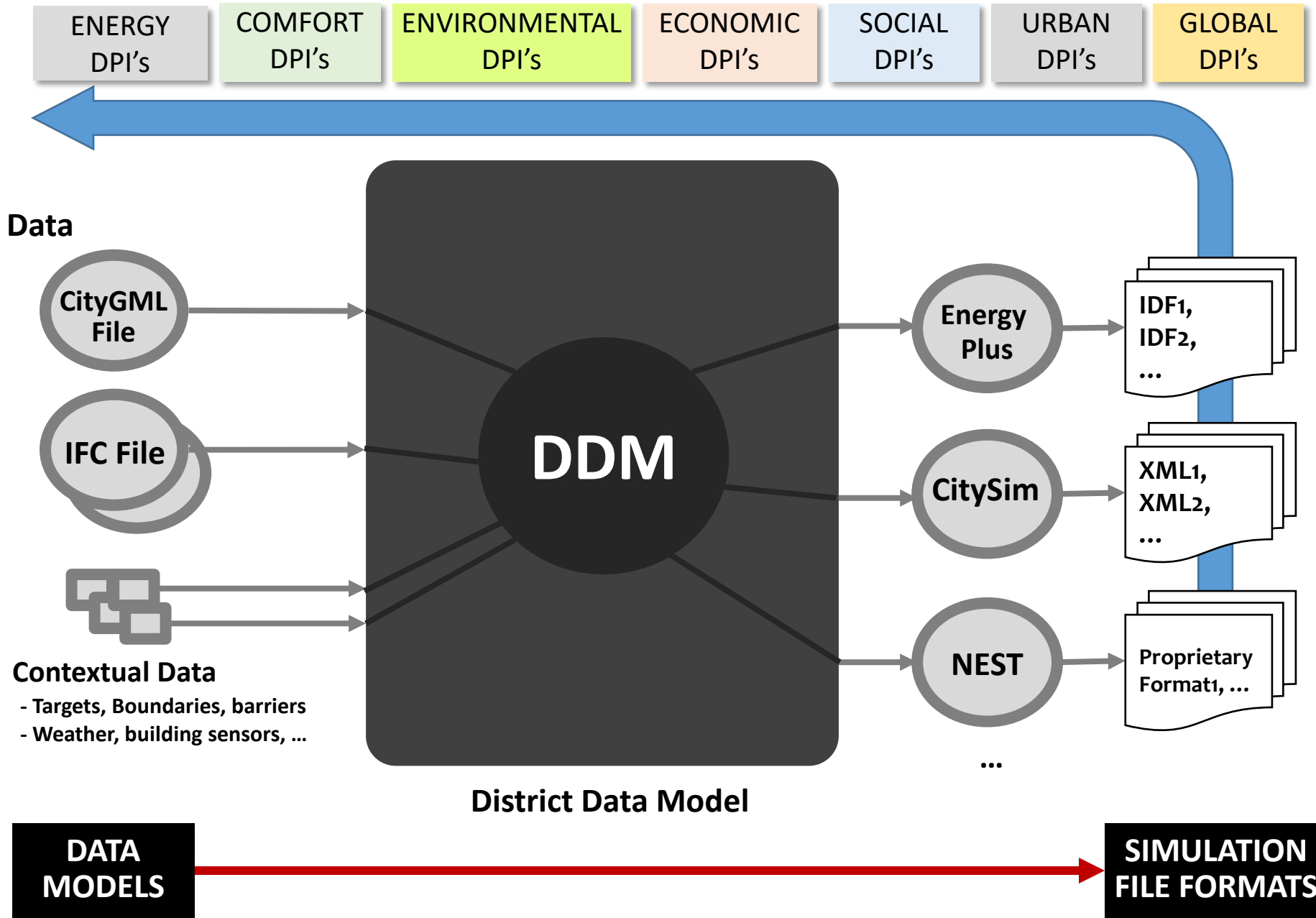
OPTEEMAL Tools for DPI calculation Requirements

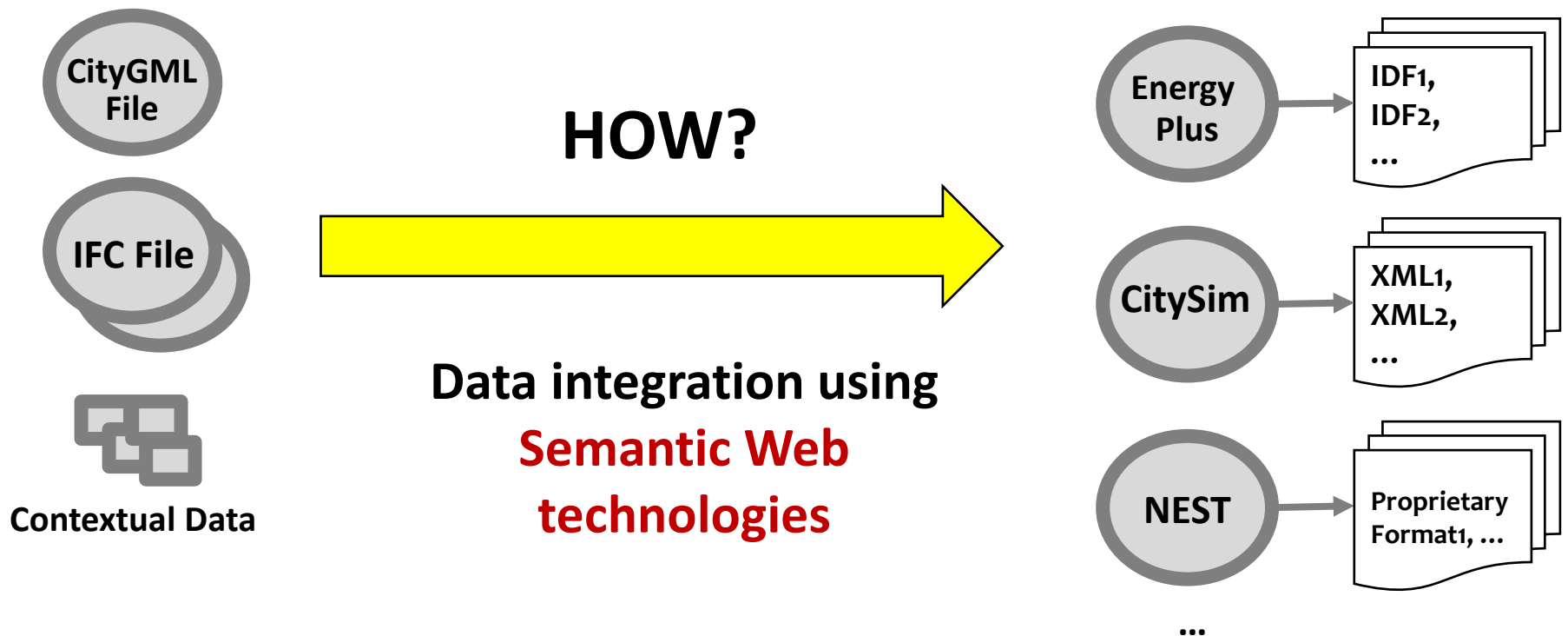
List of DPIs
 Conversion Factors
 Contextual Data (energy production costs, number of Inhabitants, mean income level, city population, etc.)

Simulations to calculate the DPIs

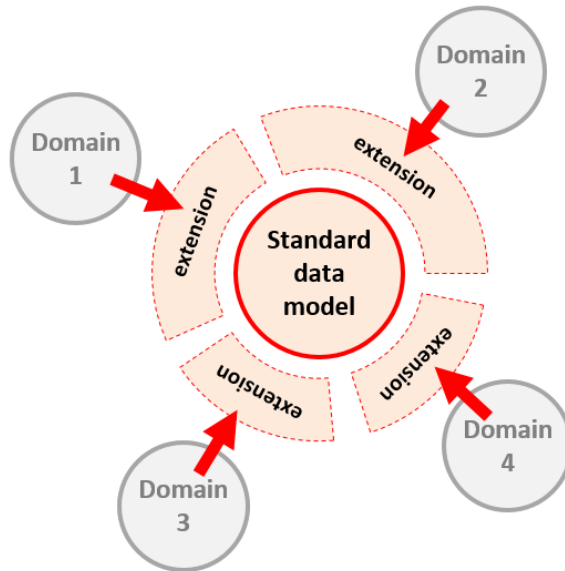


Simulations to calculate the DPIs



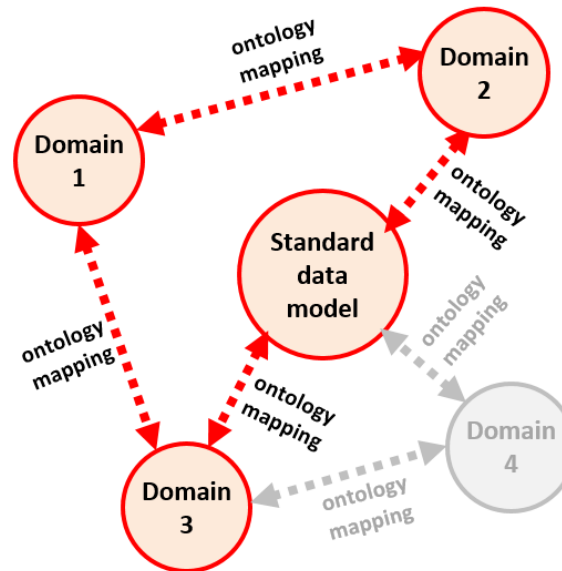


"Centralized" approach



Centralized standard data models
(e.g. CityGML, IFC)

"Decentralized" approach



Decentralized and ad hoc solutions to
interoperability

RÉPENER 2009-2012 - Control and improvement of energy efficiency in buildings through the use of repositories - <http://www.seis-system.org/>
 SEMANCO 2011-2014 7th Framework Programme - Semantic Tools for Carbon Reduction in Urban Planning - <http://www.semanco-project.eu/>
 OPTIMUS 2013-2016 7th Framework Programme - Optimising the energy use in cities with smart decision support system - <http://optimus-smartcity.eu/>

Proposed ontologies

ifcOWL - <http://www.buildingsmart-tech.org/future/linked-data/ifcowl>

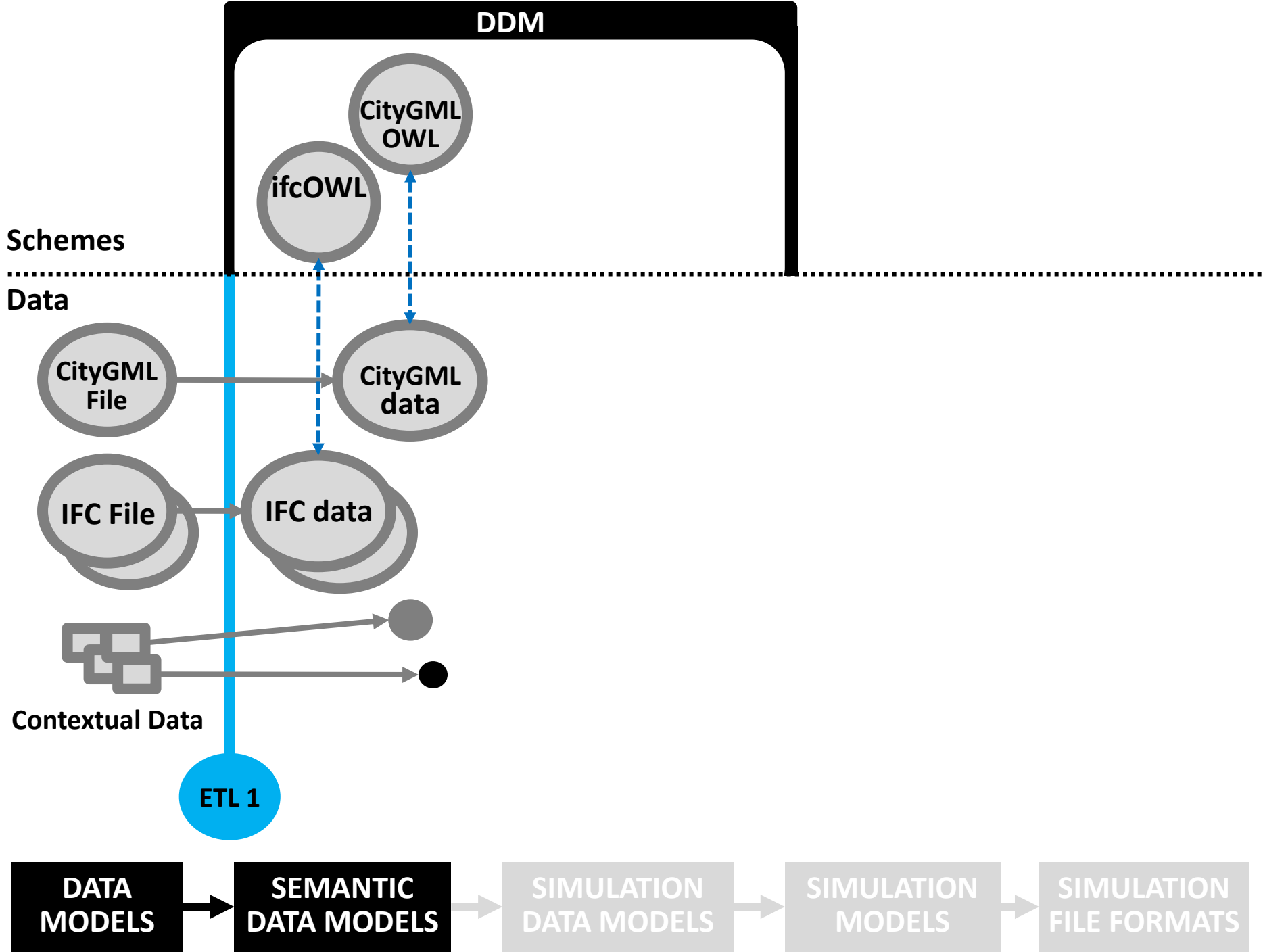
- Pauwels & Terkaj 2015, Beetz 2009, and others.
- Is an ontology for IFC supported by BuildingSMART.
- Exploit the benefits of semantic web technologies in terms of data distribution, **extensibility of the data model, querying, and reasoning**,

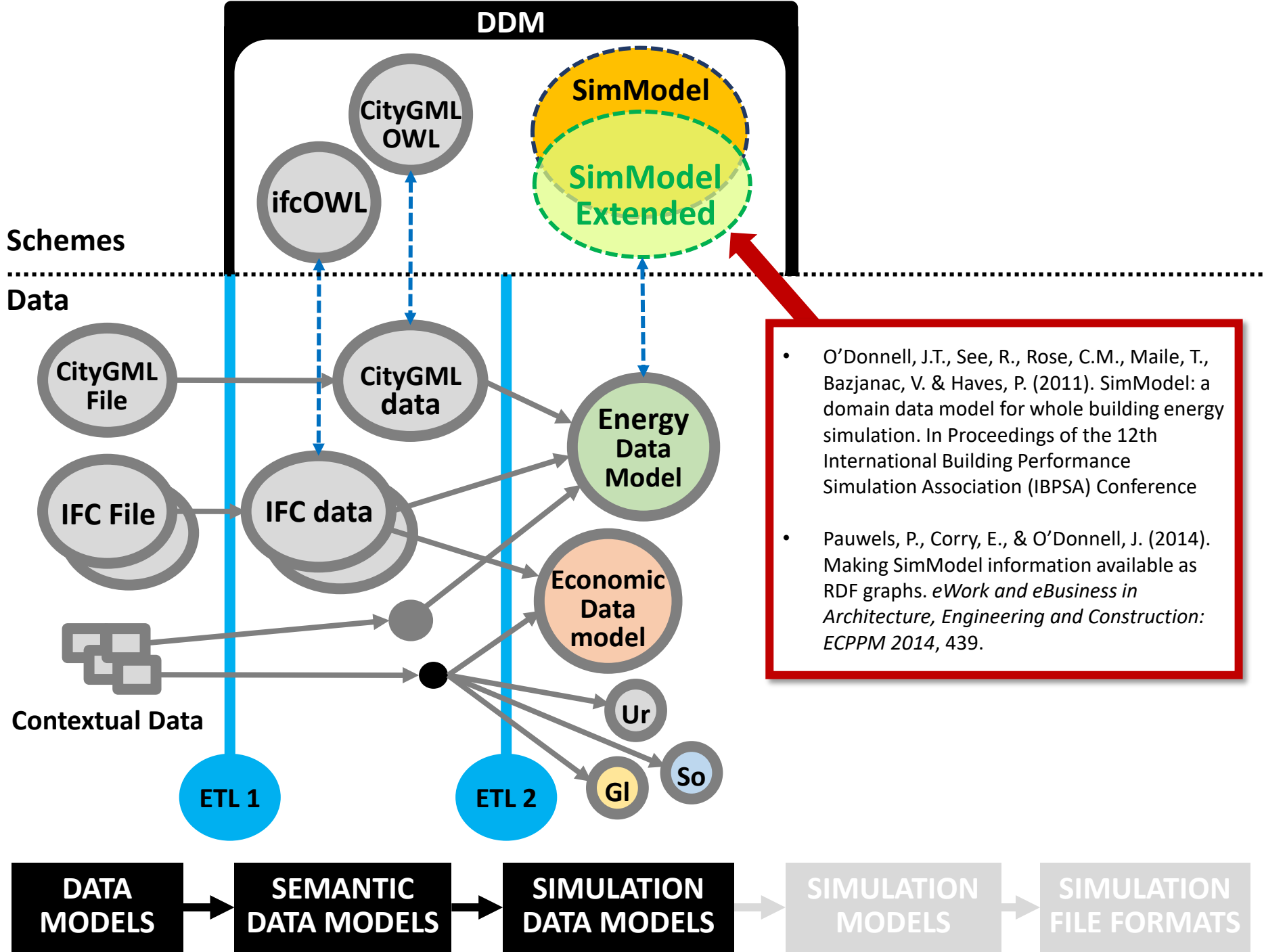
CityGML Owl - <http://cui.unige.ch/isi/icle-wiki/ontologies>

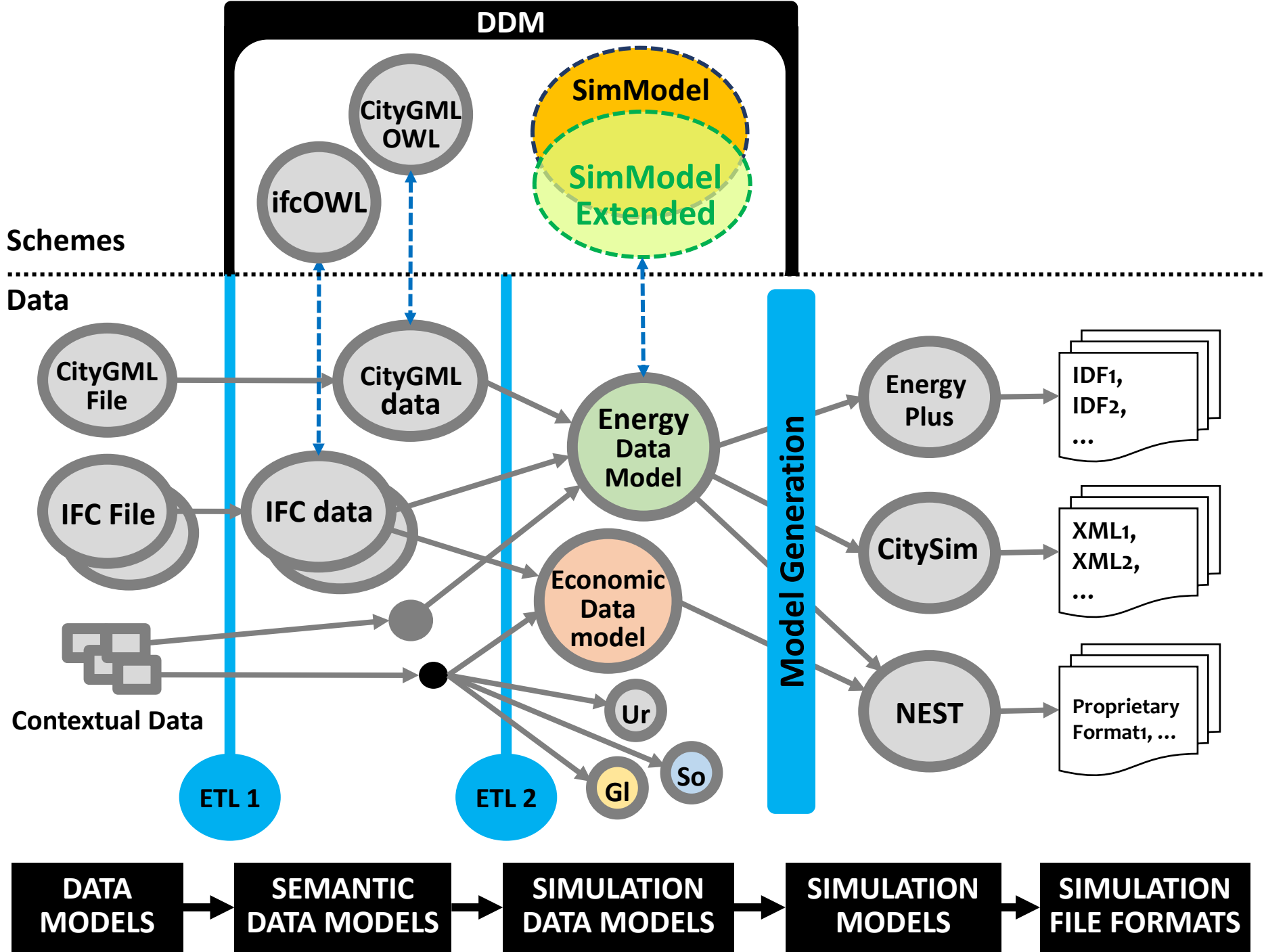
- Knowledge Engineering @ ISS UoG
- Is the only ontology found for CityGML.

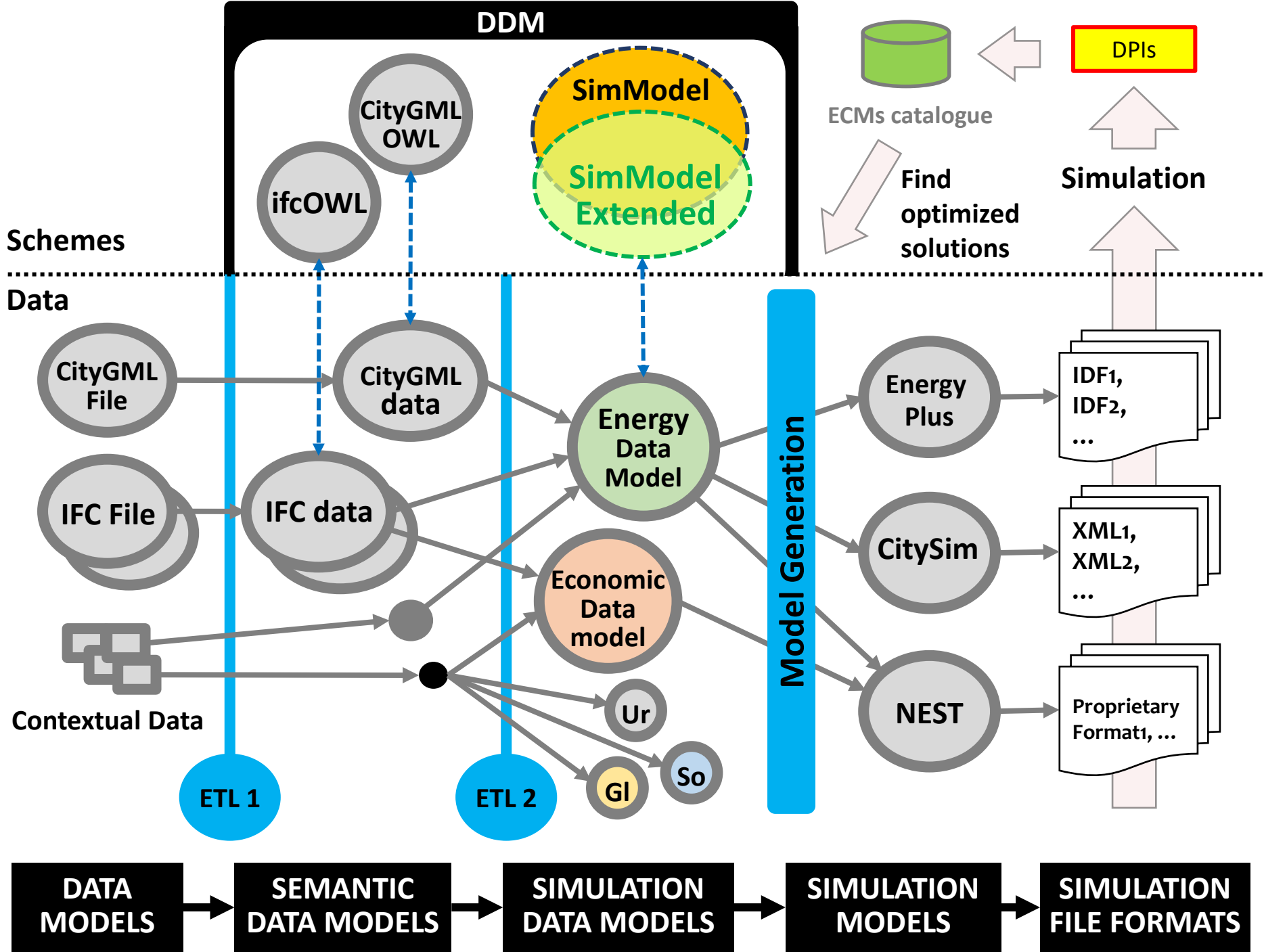
SimModel OWL - <http://www.lbl.gov/namespaces/Sim/>

- Pauwels, Corry & O'Donnell, 2014
- It is a data model with a domain that **covers the domain of energy simulation** of the entire building.
- This is implemented as a data model (.XSD) that is **interoperable through XML**.
- Is “**geometrically compatible**” with IFC among other formats.









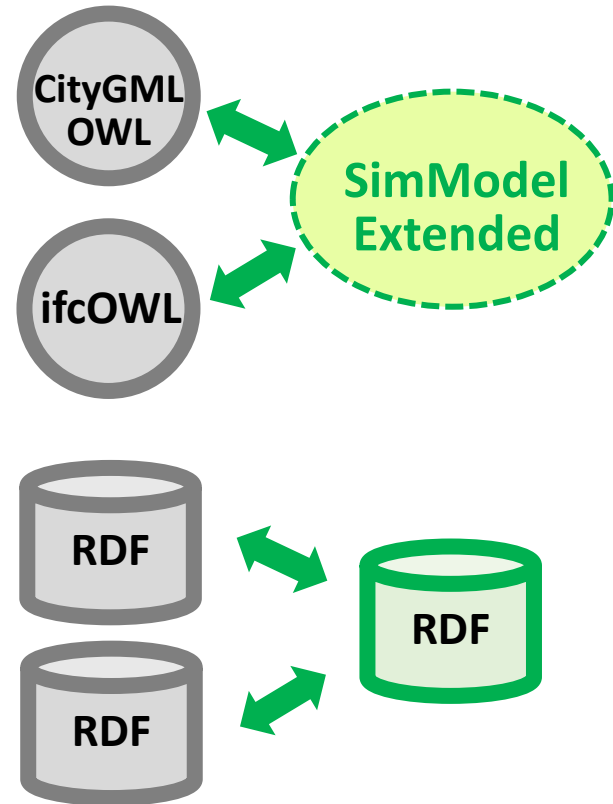
1st Scenario: General approach

1. Finding relations (alignments) between ontologies:

- Ontology matching:
LogMap, AML...

2. Transforming RDF data according to the ontologies and their alignments:

- RDF-To-RDF via SPARQL constructs:
Alignment API, R2R, ...



Scheme
.....
Data

CityG
Fil

IFC

Contextual Data

ETL 1

ETL 2

GI

So

Format1, ...

DATA
MODELS

SEMANTIC
DATA MODELS

SIMULATION
DATA MODELS

SIMULATION
MODELS

SIMULATION
FILE FORMATS

```

...
<Cell>
  <entity1 rdf:resource="http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#IfcCurtainWallTypeEnum"/>
  <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simblgdg#SimCurtainWallType"/>
  <measure rdf:datatype="xsd:float">0.34</measure>
  <relation>=</relation>
</Cell>
</map>
<map>
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    <entity1 rdf:resource="http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#IfcBuildingElementType"/>
    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simblgdg#SimBuildingType"/>
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    <relation>=</relation>
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    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simblgdg#SimColumnType"/>
    <measure rdf:datatype="xsd:float">0.28</measure>
    <relation>=</relation>
  </Cell>
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  <Cell>
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    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simblgdg#materials_List"/>
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    <relation>=</relation>
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<map>
  <Cell>
    <entity1 rdf:resource="http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#IfcMember"/>
    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simblgdg#SimMember"/>
    <measure rdf:datatype="xsd:float">0.32</measure>
    <relation>=</relation>
  </Cell>
</map>
...

```

FIRST APPROACH



MAPPINGS (RELATIONS)

Between

ifcOWL and SimModel

(tool: LogMap)

LogMap


```

...
<Cell>
  <entity1 rdf:resource="http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#IfcCurtainWallTypeEnum"/>
  <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simbldg#SimCurtainWallType"/>
  <measure rdf:datatype="xsd:float">0.34</measure>
  <relation>=</relation>
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    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simbldg#SimBuildingType"/>
    <measure rdf:datatype="xsd:float">0.31</measure>
    <relation>=</relation>
  </Cell>
</map>
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    <entity1 rdf:resource="http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#IfcColumnTypeEnum"/>
    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simbldg#SimColumnType"/>
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    <entity2 rdf:resource="http://users.salleurl.edu/~gcosta/simmodel/simbldg#SimMember"/>
    <measure rdf:datatype="xsd:float">0.32</measure>
    <relation>=</relation>
  </Cell>
</map>
...

```

FIRST APPROACH



MAPPINGS (RELATIONS)

Between
IFC and SimModel

(tool: LogMap)

Correspondences between ifcOWL and SimmodelOWL

	Mappings	SimModelOWL	ifcOWL	
Class:	178	4311	1231	4%
Obj. Prop :	33	3645	1686	1%
DTy. Prop :	0	3709	5	0%

LogMap

Table 3. Experimental results for compliance measures when CityGML is aligned with different ontologies (columns) using different techniques (rows)

				IFC				GbXML				DBPedia				LinkedGeoData			
Technique				Thr.	Prec.	Rec.	F-m.	Thr.	Prec.	Rec.	F-m.	Thr.	Prec.	Rec.	F-m.	Thres.	Prec.	Rec.	F-m.
String techniques	Hamming	0.8	1.000	0.057	0.108	0.7	0.750	0.100	0.176	0.6	0.375	0.115	0.176	0.8	0.500	0.217	0.303		
	SMoa	0.8	0.181	0.228	0.202	0.8	0.238	0.533	0.330	0.9	0.375	0.115	0.176	1.0	0.800	0.174	0.285		
	Levenshtein	0.5	0.141	0.371	0.204	0.5	0.277	0.666	0.392	0.6	0.277	0.192	0.227	0.8	0.500	0.217	0.303		
	Subdistance	0.7	0.625	0.142	0.232	0.5	0.500	0.267	0.347	0.7	0.363	0.153	0.216	0.9	0.714	0.210	0.333		
	Jaro-Winkler	0.6	1.000	0.571	0.108	0.5	0.384	0.167	0.232	0.5	0.200	0.077	0.111	0.6	0.800	0.173	0.285		
	N-grams	0.5	0.142	0.228	0.175	0.7	0.510	0.267	0.372	0.6	0.333	0.192	0.244	1.0	0.600	0.130	0.214		
WordNet techniques	Synonym	0.7	0.416	0.142	0.212	0.6	0.234	0.367	0.285	0.7	0.364	0.153	0.216	0.9	0.400	0.173	0.242		
	Synonym Sim.	1.0	1.000	0.028	0.055	0.6	0.234	0.366	0.285	1.0	0.333	0.038	0.068	1.0	0.375	0.130	0.193		
	Cosynonym	0.0	0.000	0.000	0.000	1.0	1.000	0.033	0.064	1.0	0.500	0.038	0.071	1.0	0.800	0.173	0.285		
	Wu-Palmer	1.0	1.000	0.028	0.055	1.0	0.500	0.033	0.063	1.0	0.333	0.384	0.068	1.0	0.375	0.130	0.193		
	Gloss	1.0	1.000	0.057	0.108	1.0	1.000	0.066	0.125	1.0	0.500	0.038	0.071	1.0	0.018	0.130	0.032		
Matching Systems	S-Match	1.0	0.002	0.028	0.003	1.0	0.007	0.233	0.015	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000		
	SPSM	1.0	0.035	0.028	0.031	1.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000		
	AROMA	0.9	0.400	0.057	0.010	0.4	0.222	0.066	0.102	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000		
	MAPP50	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000		

- Delgado, F., Martínez-González, evaluation of ontology matching ontologies. International Journal

- Delgado, F., Martínez-González, M. M., & Finat, J. (2013). An evaluation of ontology matching techniques on geospatial ontologies. International Journal of Geographical Information Science, 27(12), 2279-2301.

SPARQL Constructs

(tool: Alignment API)



```
PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimFaceBound .
}
WHERE {
  ?s rdf:type ns1:IcfFaceBound .
}

PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimShapeRepresentation .
}
WHERE {
  ?s rdf:type ns1:IcfShapeRepresentation .
}

PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimGeomCsgPrimitive3D .
}
WHERE {
  ?s rdf:type ns1:IcfCsgPrimitive3D .
}
...
```

Alignment API

n2	http://linkedbuildingdata.net/ifc/resources20160520_155948/
rdf	http://www.w3.org/1999/02/22-rdf-syntax-ns#
n3	http://users.salleurl.edu/~gcosta/simmodel/simgeom#
xsdh	http://www.w3.org/2001/XMLSchema#

n2:IcfShapeRepresentation_10394	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_11543	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1161	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1203	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1241	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1272	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1317	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1356	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1404	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1422	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1457	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1526	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1527	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1630	rdf:type	n3:SimShapeRepresentation
n2:IcfShapeRepresentation_1633	rdf:type	n3:SimShapeRepresentation

SPARQL Constructs

(tool: Alignment API)



```
PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimFaceBound .
}
WHERE {
  ?s rdf:type ns1:IcfFaceBound .
}

PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimShapeRepresentation .
}
WHERE {
  ?s rdf:type ns1:IcfShapeRepresentation .
}

PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimShapeRepresentation .
}
WHERE {
  ?s rdf:type ns1:IcfCsgPrimitive3D .
}
...
```

```
n2      http://linkedbuildingdata.net/ifc/resources20160520_155948/
rdf      http://www.w3.org/1999/02/22-rdf-syntax-ns#
n3      http://users.salleurl.edu/~gcosta/simmodel/simgeom#
xsdh     http://www.w3.org/2001/XMLSchema#
```

n2:IcfShapeRepresentation_10394 **rdf:type** **n3:SimShapeRepresentation**

n2:IcfShapeRepresentation_115 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_116 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_126 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_127 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_128 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_129 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_130 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_131 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_132 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_133 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_134 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_135 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_136 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_137 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_138 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_139 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_140 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_141 rdf:type n3:SimShapeRepresentation

n2:IcfShapeRepresentation_142 rdf:type n3:SimShapeRepresentation

Alignment API

```
PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimFaceBound .
}
WHERE {
  ?s rdf:type ns1:IcfFaceBound .
}

PREFIX ns1:<http://users.salleurl.edu/~gcosta/ifc/IFC4_ADD1#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>
PREFIX ns0:<http://users.salleurl.edu/~gcosta/simmodel/simgeom#>
CONSTRUCT {
  ?s rdf:type ns0:SimShapeRepresentation .
}
```

OPTION 2 → R2R Framework

<http://wifo5-03.informatik.uni-mannheim.de/bizer/r2r/>

- Designed to translating RDF data to a target vocabulary.
- R2R generates SPARQL construct from mappings.
- The problem is in the difficulty to generate these mappings.

mp:DBpediaToFoafPersonMapping

```
a r2r:ClassMapping ;
r2r:prefixDefinitions "foaf: <http://xmlns.com/foaf/0.1/> . dbpedia: <http://dbpedia.org/ontology/>" ;
r2r:sourcePattern "?SUBJ a dbpedia:Person" ;
r2r:targetPattern "?SUBJ a foaf:Person" .
```

mp:labelToNameMapping

```
a r2r:PropertyMapping ;
r2r:sourcePattern "?SUBJ rdfs:label ?o . FILTER(lang(?o)='en')";
r2r:classMappingRef mp:DBpediaToFoafPersonMapping ; # This is necessary and means that this mapping makes only sense in a "Person context"
r2r:prefixDefinitions "foaf: <http://xmlns.com/foaf/0.1/>" ;
r2r:targetPattern "?SUBJ foaf:name ?o" ;
r2r:targetPattern "?SUBJ <http://www.w3.org/2006/vcard/ns#n> ?o" .
```

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Example of DPI → **Energy Demand**
(currently, 19 DPIs are proposed for the case of Energy Simulations)

Tool 1: EnergyPlus

Tool 2: CitySim

DPI ENE01: Energy demand		DPI Evaluation Scenarios																							
Calculation Methodology		EP1	EP2	EP3	EP4	EP5	EP6	EP7	EP8	EP9	EP10	EP11	EP12	EP13	EP14	EP15	EP16	EP17	EP18	EP19	EP20	CS1	CS2	CS3	CS4
Data Type	BEPS - Data Req.																								
	Initial Parameters	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Simulation Parameters	Selected Algorithms	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	CityGML LoD1	x	x	x	x																				
Building Geometry Description	CityGML LoD2					x	x	x	x																
	CityGML LoD3									x	x	x	x												
Building Materials	CityGML LoD4													x	x	x	x								
	IFC4 (Design Transfer View)																	x	x	x	x				
Weather Data	Equivalent single layer/ Opaque	x		x		x		x		x		x		x		x		x		x					
	Total thermal resistance	x		x		x		x		x		x		x		x		x		x					
Schedules	Total thermal capacitance	x		x		x		x		x		x		x		x		x		x					
	Thermal conductivity		x		x		x		x		x		x		x		x		x		x				
Internal Gains	Density		x		x		x		x		x		x		x		x		x		x				
	Specific Heat		x		x		x		x		x		x		x		x		x		x				
Energy Sysyems	Thermal Absorptance		x		x		x		x		x		x		x		x		x		x				
	U-factor									x	x	x	x	x	x	x	x	x	x	x	x				
Exterior Energy Use Equipment	SHGC									x	x	x	x	x	x	x	x	x	x	x	x				
	Green Roof Materials									x	x	x	x	x	x	x	x	x	x	x	x				
Renewable Energy Systems	Phase Change Materials									x	x	x	x	x	x	x	x	x	x	x	x				
	Hourly	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Level of Accuracy	Reference Data	x	x			x	x			x	x			x	x			x	x						
	Measurements			x	x			x	x			x	x			x	x								
Exterior Energy Use Equipment	Ideal Load System	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	Heating Setpoint Temperature	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Renewable Energy Systems	Cooling Setpoint Temperature	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	Systems' Templates																								
Exterior Energy Use Equipment	Detailed Description																								
	Exterior Lights																								
Renewable Energy Systems	Exterior Fuel Equipment																								
	Exterior Water Equipment																								
Level of Accuracy	Photovoltaic Systems																								
	Wind Turbine																								
Level of Accuracy	Combined Heat and Power																								
	Geothermal Heat Pump																								
Level of Accuracy		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4

X: Mandatory, O: Optional

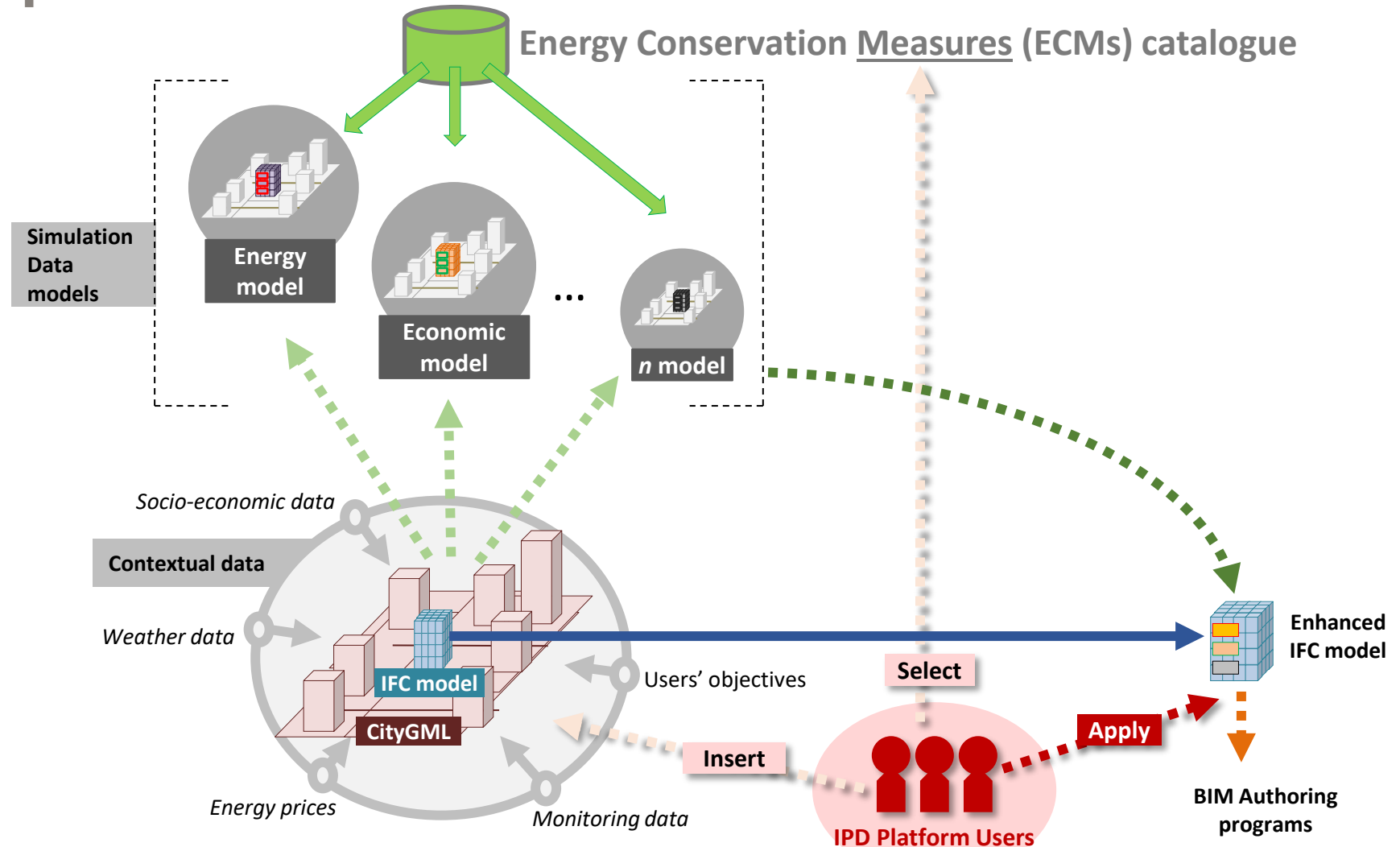
- accuracy

+ accuracy

- +

Energy data
model

Calculation methodologies for the DPLs



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- The use/reuse of standardized ontologies is presented as the **best approach** to provide **interoperability** between input **data required for the simulations** and **simulation tools**.
- In the case of the energy domain, **SimModel** is a simulation data model which is tailored towards the energy-related data required by most popular energy simulation tools. In other domains, such as the ‘**economic**’ one, it is **still not clear that there is such representative model**.
- Even with greater flexibility to generate the simulation models from the data models to perform simulations for each tools, **ad-hoc adapters still need to be developed to provide this interoperability**.
- **Next steps:** find better **methods** and **tools** to facilitate the ‘**data mapping**’ between input data sources and simulation data models.

THANK YOU FOR YOUR ATTENTION!

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