EBC
Energy in Building and
Communities Programme

# IEA EBC Annex 83
# Positive Energy Districts

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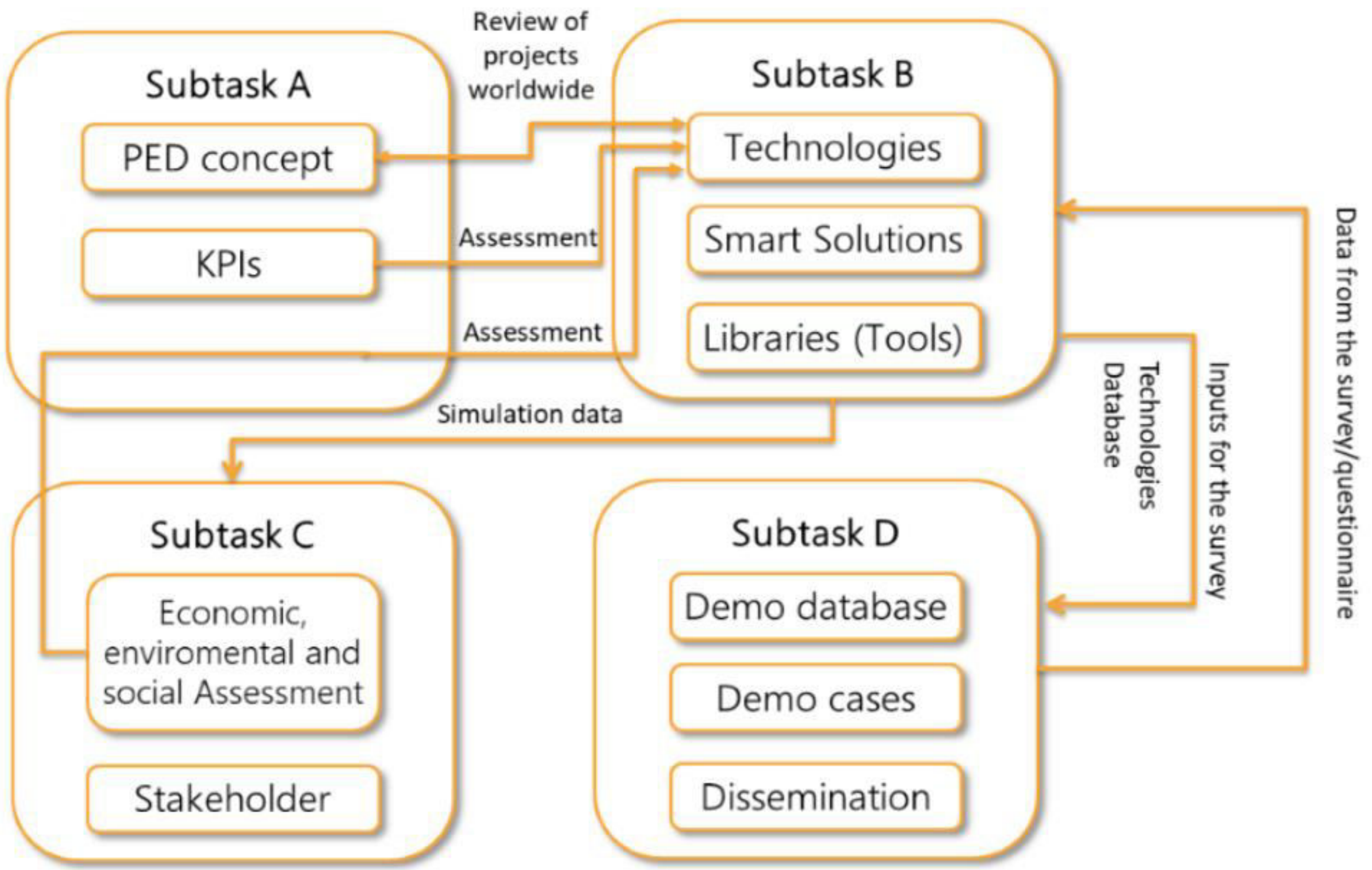
# Main Objectives of Annex 83

- **Objective 1.** Map the relevant city, industry, research, and governmental (local, regional, national) stakeholders to ensure their involvement in the development of relevant definitions and recommendations.
- **Objective 2.** Create a shared in-depth definition of PED by means of multistakeholder governance model. So far international activities have developed generalized definitions that leave many questions open.
- **Objective 3.** Develop the needed information and guidance for implementing the necessary technical solutions (on building, district and infrastructure levels) that can be replicated and gradually scaled up to the city level, giving emphasis to the interaction of flexible assets at the district level and also economic and social issues such as acceptability.
- **Objective 4.** Explore novel technical and service opportunities related to monitoring solutions, big data, data management, smart control and digitalization technologies as enablers of PEDs.
- **Objective 5.** Develop the needed information and guidance for the planning and implementation of PED's including both technical planning and urban planning. This includes economic, social and environmental impact assessment for various alternative development paths.

Image source: clipart-library.com

# IEA EBC Annex 83 subtasks

- **Subtask A:** Definitions and context
- **Subtask B:** Methods, Tools and Technologies for Realizing Positive Energy Districts
- **Subtask C:** Organizing principles and impact assessment
- **Subtask D:** Demos, implementation and dissemination

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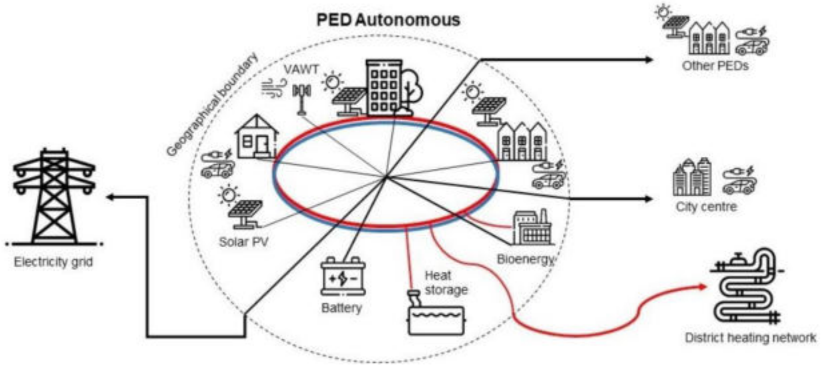
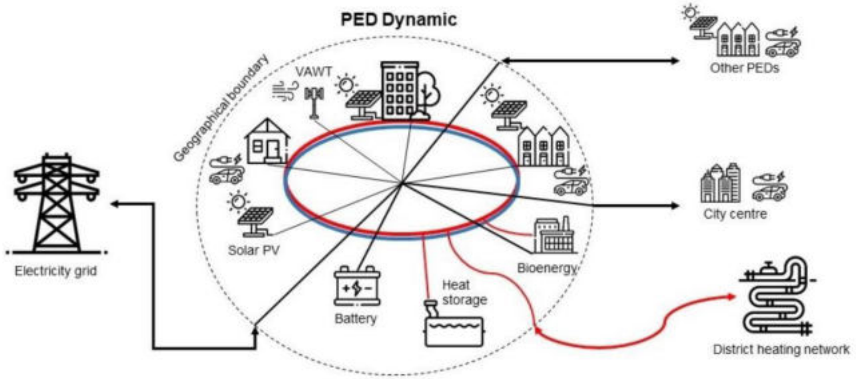
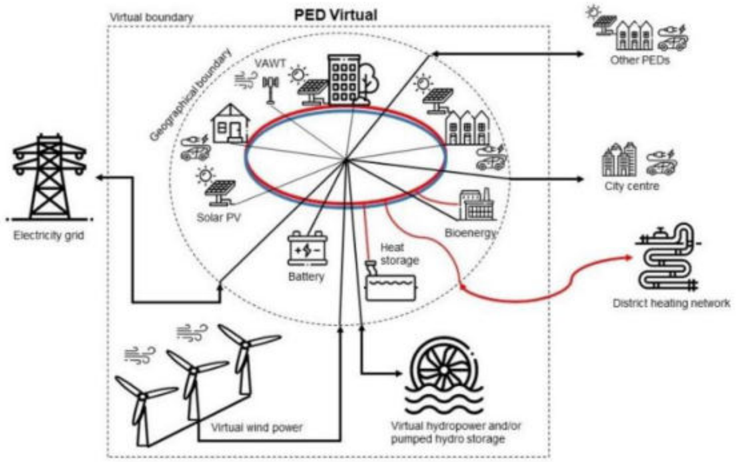
# DEFINITIONS: Positive energy district definitions based on on-site renewable contribution and grid interaction




I) PED autonomous:
No import, only export, 100% on-site renewables

II) PED dynamic:
Import and export, on-site renewables >= demand




III) PED virtual:
Import and export, on-site and off-site renewables >= demand

Urban density as important criteria

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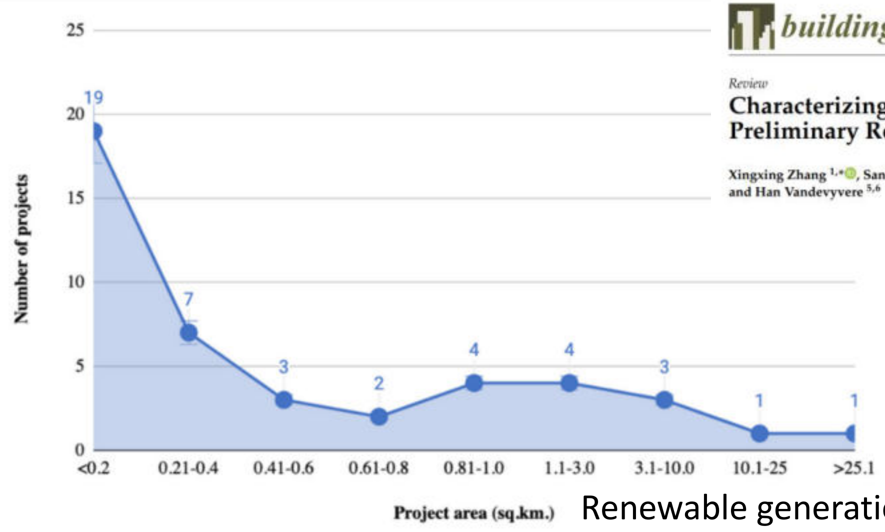
# 60 PED’s in Europe, 37 with heat pumps, rest co-gen



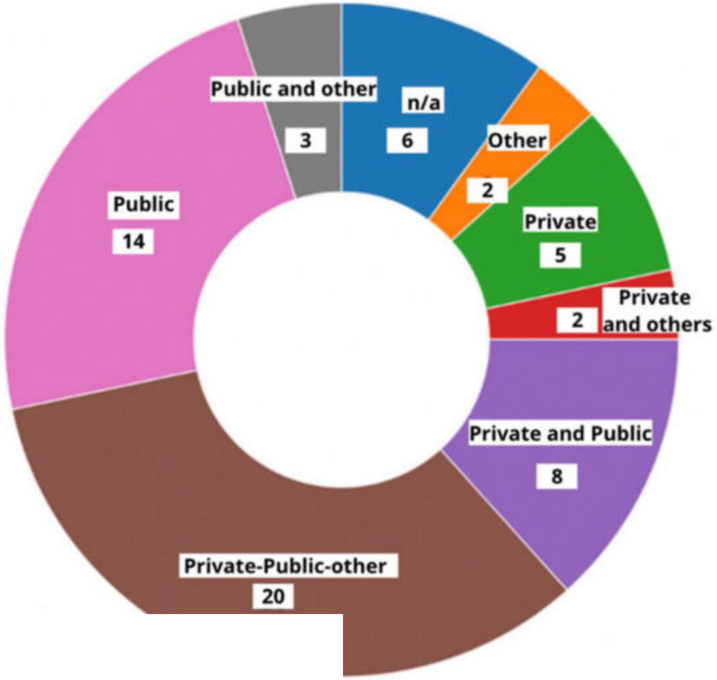

Renewable generation area

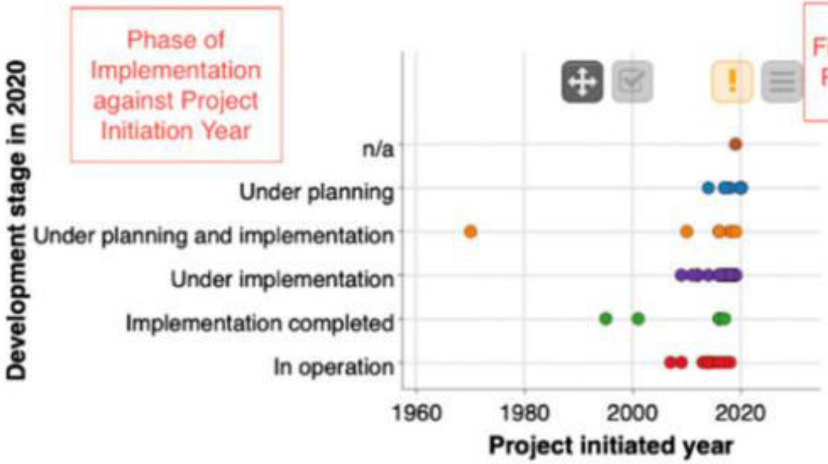
buildings MDPI

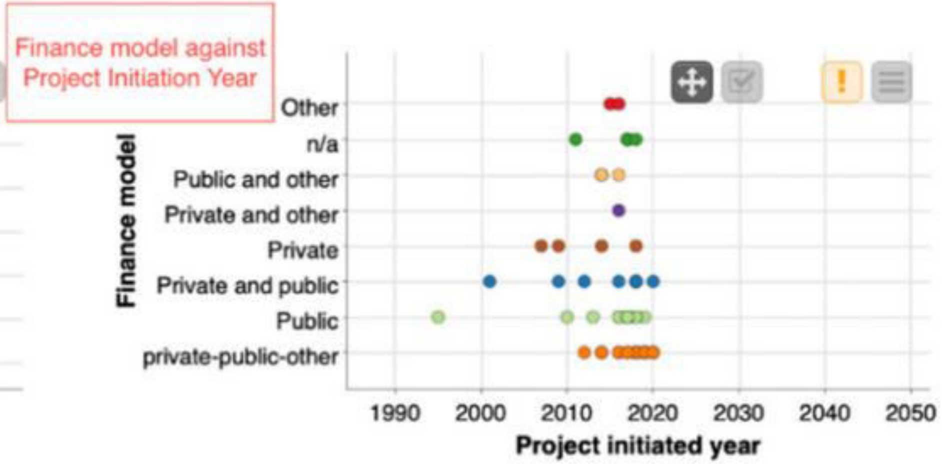
Review

**Characterizing Positive Energy District (PED) through a Preliminary Review of 60 Existing Projects in Europe**

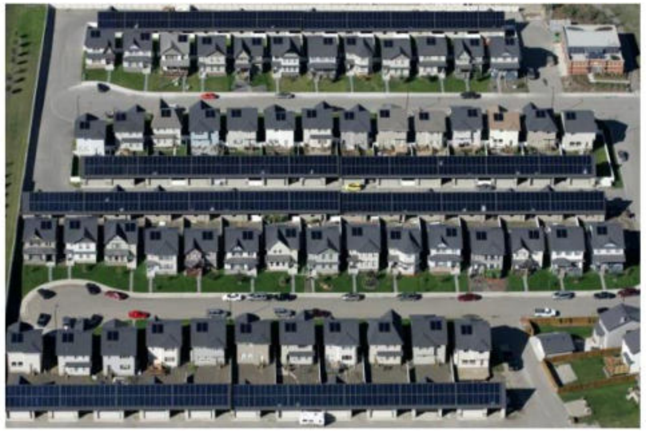

Xingxing Zhang [1,*], Santhan Reddy Penaka [2], Samhita Giriraj [2], Maria Nuria Sánchez [3], Paolo Civiero [4] and Han Vandevyvere [5,6]

# Case studies (ST D)



DRAKE LANDING SOLAR COMMUNITY
Alberta, Canada
**Objective:** Achieving High Solar Fraction

West 5, London, Ontario, Canada
**Objective:** Net zero energy

SMART ENERGY ALAND
Aland Islands
**Objective:** Climate neutrality 2035 / Positive energy

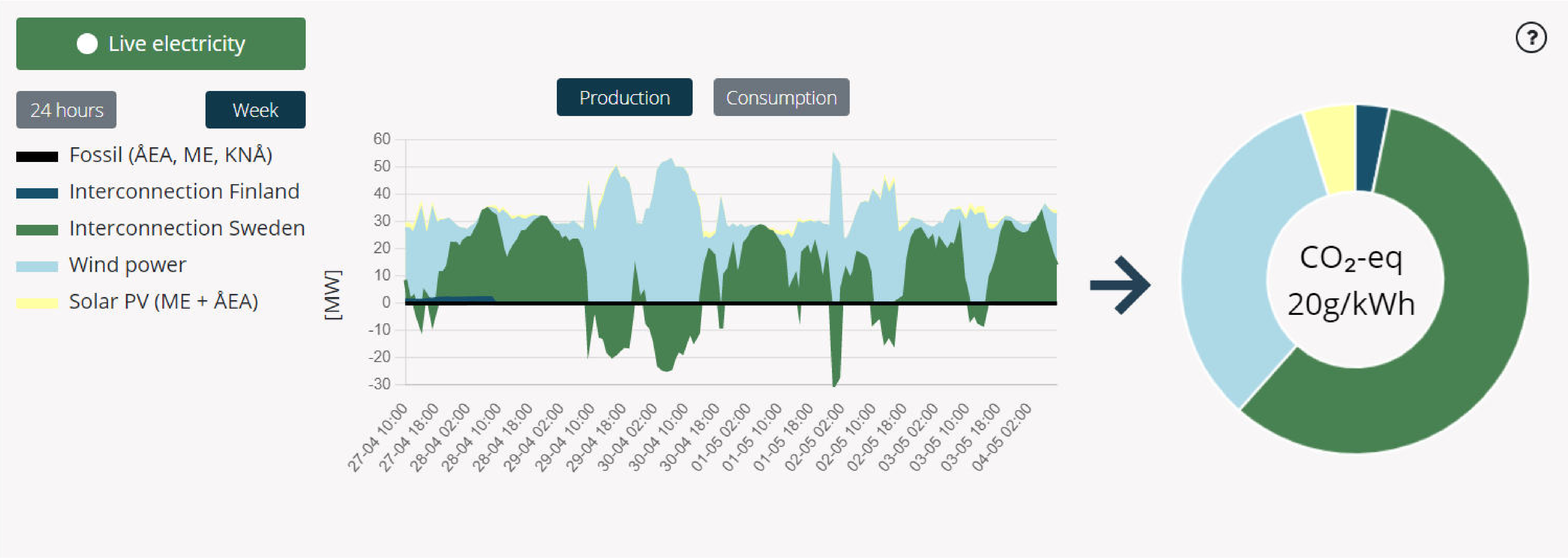
School of Design & Environment 4 (SDE4)
Singapore
**Objective:** Net Zero Energy Building

# Case Aland

## Electricity use on Åland in real time

This interactive graph illustrates the origin of the electricity consumed on Åland. The graph is updated every 15 minutes via Flexen's Energy Portal . For more information, click on the question mark in the graph.

https://smartenergy.ax/live-matare/



# Case studies

| | | DRAKE LANDING | ALAND ISLANDS | SDE4+1+3* |
|---|---|---|---|---|
| **Location:** | | OKOTOKS, CANADA | ALAND ARCHIPIELAGO, FINLAND | UNIVERSITY CAMPUS, SINGAPORE |
| **Objective** | | Achieve the highest solar fraction (>90%) | Climate neutrality 2035 / Positive energy | Net Zero energy building |
| **Objective achieved?** | | Yes, 90% and 93% in some years | Not yet; but in 2020 achieved 26.2% of emissions reductions compared to 2005 | Positive: reducing as much as possible the demand (with efficiency, smart controls, etc.). |
| **Climate (Köppen and Geiger)** | | Dfb | Dfb | Af |
| **Total area [m2]** | | 11,614 $m^2$ | 666,586 $m^2$ | 8,500 $m^2$ |
| **Yearly in-plane irradiation** | | 1263 $kWh/m^2$ | 1021 $kWh/m^2$ | 1290 $kWh/m^2$ |
| **Urban morphology data:** | Density | LOW, terraced houses (2 floors) | LOW, 4132 houses mixed (detached mainly) | Six floors SDE4 |
| | population (in the district) | - | 30k inhabitants | 600 students in SDE4 |
| **Cost data** | Investment cost (€, canadian $, etc.) | CAN$14 million (Houses) + CAN$560,000 (Energy Centre) | Not available | Not available |
| | operational costs | Not available | Not available | Not available |
| **Demand side** | building typologies | RESIDENTIAL | MIX USED | |
| | average building year | ~2007 | Not available | ~ 2014 to 2019 |
| **Energy systems:** | Heating and cooling systems | Solar thermal district heating network. | Woodchips mainly, heat pumps, bio-fuels, oil when freezing | Natural ventilation + Hybrid cooling (adaptative system) |
| | Domestic hot water systems | Solar thermal and gas boiler as backup | Mixed | - |
| | electricity supply systems | Grid supply | Mixed: offshore windfarms, small scale wind, PV and grid from mainland | 428kWp PV & grid |
| | storage | Borehole long-term storage + Short-term storage tanks | Mixed (heat-2-heat, electricity-to-heat, batteries and hydrogen) | - |
| **Monitoring or simulated data** | Actual energy use | 760 MWh/yr heating, 21 MWh/yr electricity | *328.6 GWh/yr electricity* Electricity usage for heating 70.7 kWh/m2 | 470.7 MWh/yr |
| | Energy produced | 706 MWh/yr of solar (93%) | *56.2 GWh/yr Wind, 1 GWh/yr Solar* | 619.3 MWh/yr |
| | Net Energy use | - | - | - 148.6 MWh/yr |
| | EUI | 65.4 $kWh/m^2$ /yr | | 55.4 $kWh/m^2$/yr |

# KPI – Global Costs (ST C)

- EU guideline on cost optimal calculation (2012/C 115/01) as methodological basis
- Cost categories
  - Investment costs
  - Operation and maintenance costs for complete calculation period
  - Energy costs (cost for electricity and gas, revenues from electricity feed-in and demand response services) for complete calculation period
- Global costs are calculated as net present value (NPV)
  - Discounting of all costs
- Calculation period of 30 years
- EBPD recast aims for a new method including CO2 and health costs

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# Preliminary results from cost data gathering

| | | | Spain | Finland | Austria | Belgium | Source |
|---|---|---|---|---|---|---|---|
| Geothermal heat pump | Installation cost | €/kW | | | | | |
| | Equipment cost | €/kW | | | | | |
| | Total cost | €/kW | | 3000 | | | Kozarcanin et al. 2020 |
| Collector for geothermal heat pump | Installation cost | €/kW | | | | | |
| | Equipment cost | €/kW | | | | | |
| | Total cost | €/kW | | | | | |
| Aerothermal heat pump | Installation cost | €/kW | | | | | |
| | Equipment cost | €/kW | | | | | |
| | Total cost | €/kW | | 2000 | | | Kozarcanin et al. 2020 |
| Photovoltaic | Installation cost | €/kWp | 625 | | | | |
| | Equipment cost | €/kWp | 1125 | | | | |
| | Total cost | €/kWp | 1750 | | | 1500 | |
| Thermal solar hybrid collector (PVT) | Installation cost | €/kWp | 1250 | | | | |
| | Equipment cost | €/kWp | 1750 | | | | |
| | Total cost | €/kWp | 3000 | | | 4090 | |
| Cogeneration unit | Installation cost | €/kW | | | | | |
| | Equipment cost | €/kW | | | | | |
| | Total cost | €/kW | | | | | |

- Scientific literature, technical reports, and interviews are used to collect the cost data of energy system component, building retrofit, and envelope renovation
- The work has been started with Spain, Finland, Austria, and Belgium representing 4 different climates.
- Technical detail for each component like COP, heat source, type of collector, etc. are being collected

# Subtask B: Technologies and Modelling

## Aim:

Assess whether the concept of PEDs or energy communities is feasible for a district

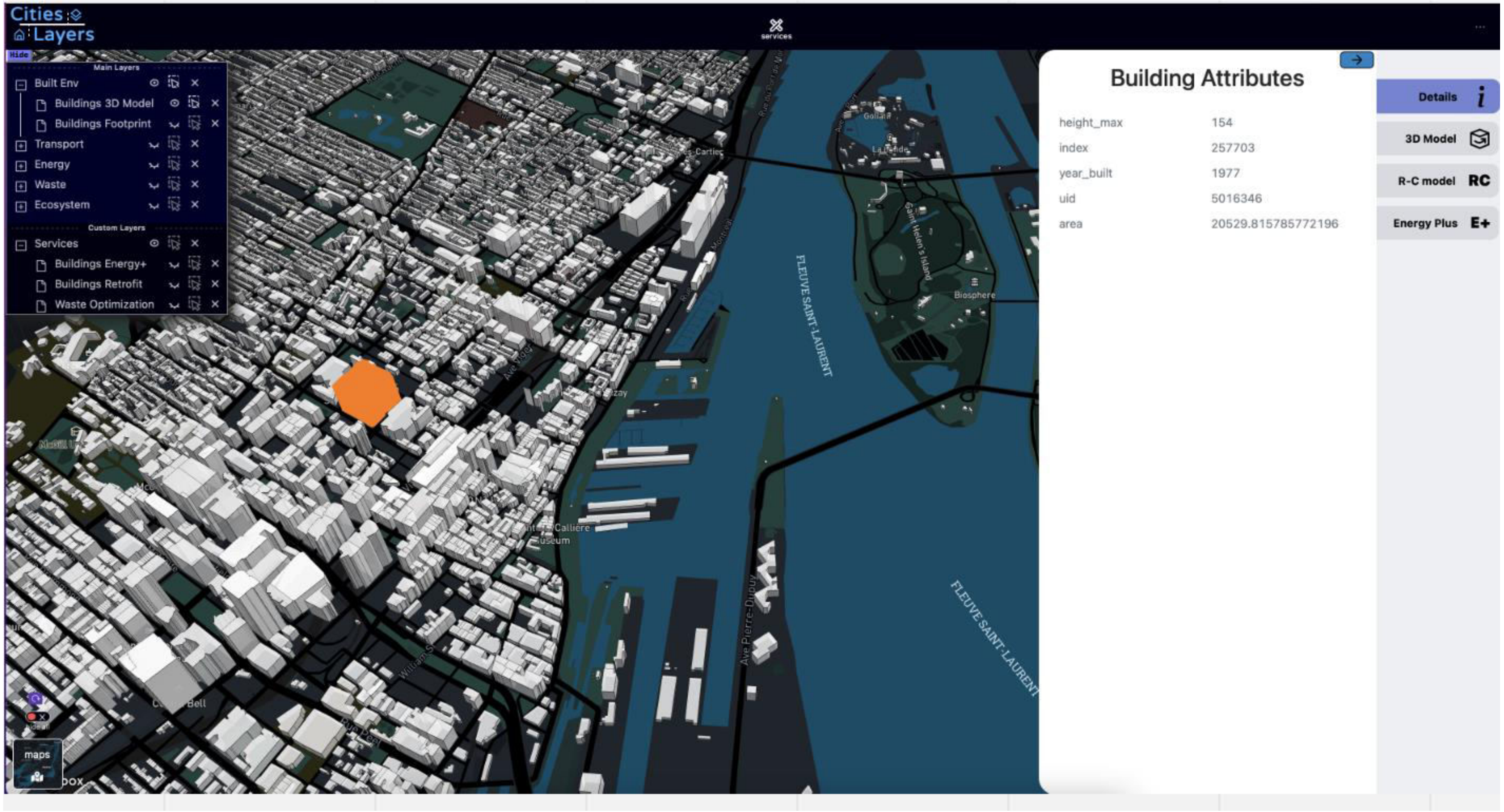
## Challenge:

***How to manage and organize the data for modelling PEDs***

1) ***Cases with monitoring data*** → at different levels (sensor, system, building, district, etc.) → be able to store data in a harmonized way and extract KPIs.
2) ***Cases with simulated or measured demand data*** → assess feasibility of different energy systems scenarios → Using manufacturer catalogues to find the optimal system and the list of manufacturers available in the region
3) ***Cases with no data or limited data*** → with low data input we need to be able to estimate its baseline and the feasibility of different energy systems scenarios

***Different data models with various level of detail are developed to solve the challenges***

# Automated processes for energy system modeling



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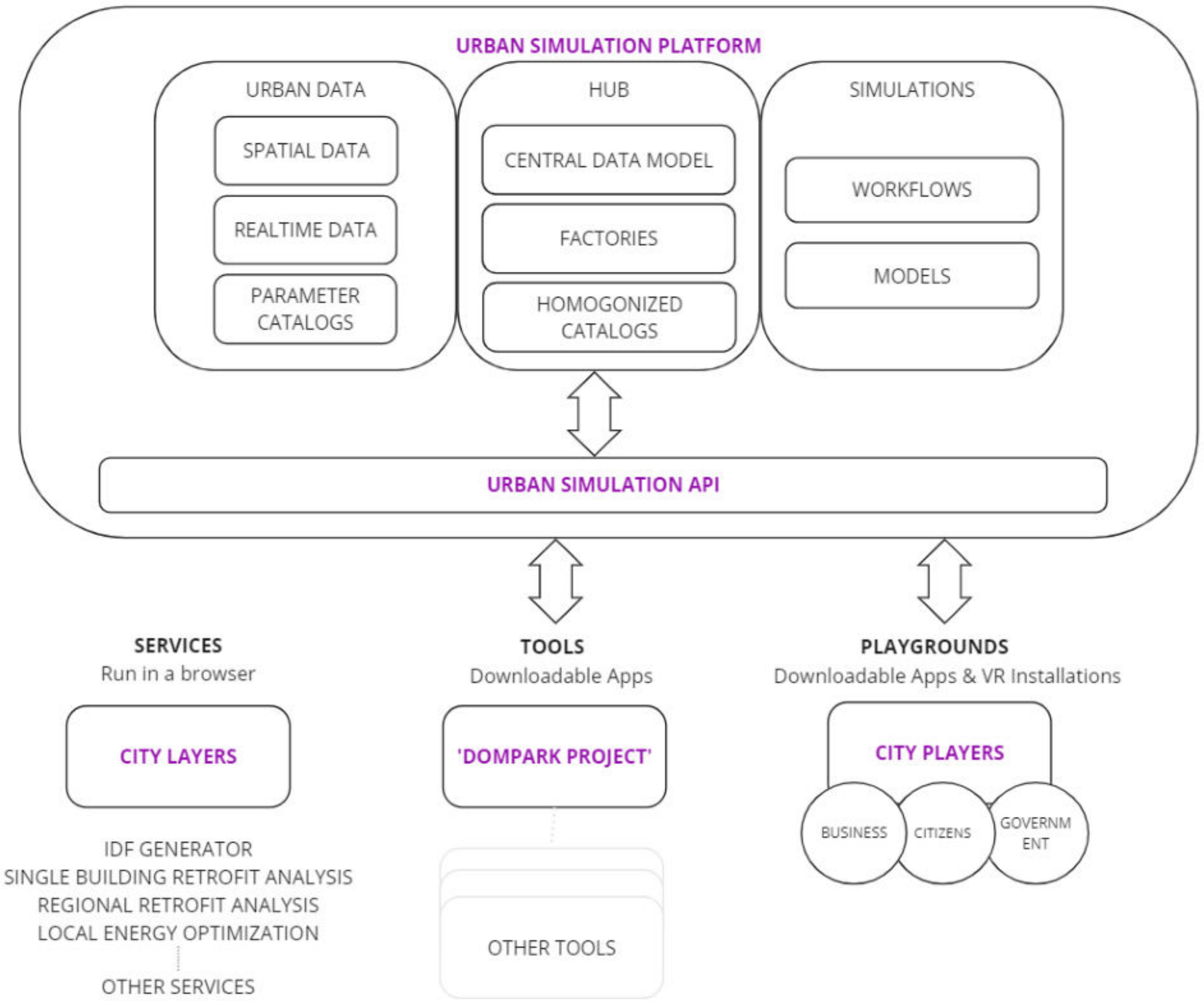
**BACK-END**

Runs on Concordia Server




- Data-driven Scenarios
- City Scale
- Informs high-level strategy
- Multi-domain
- Free to use

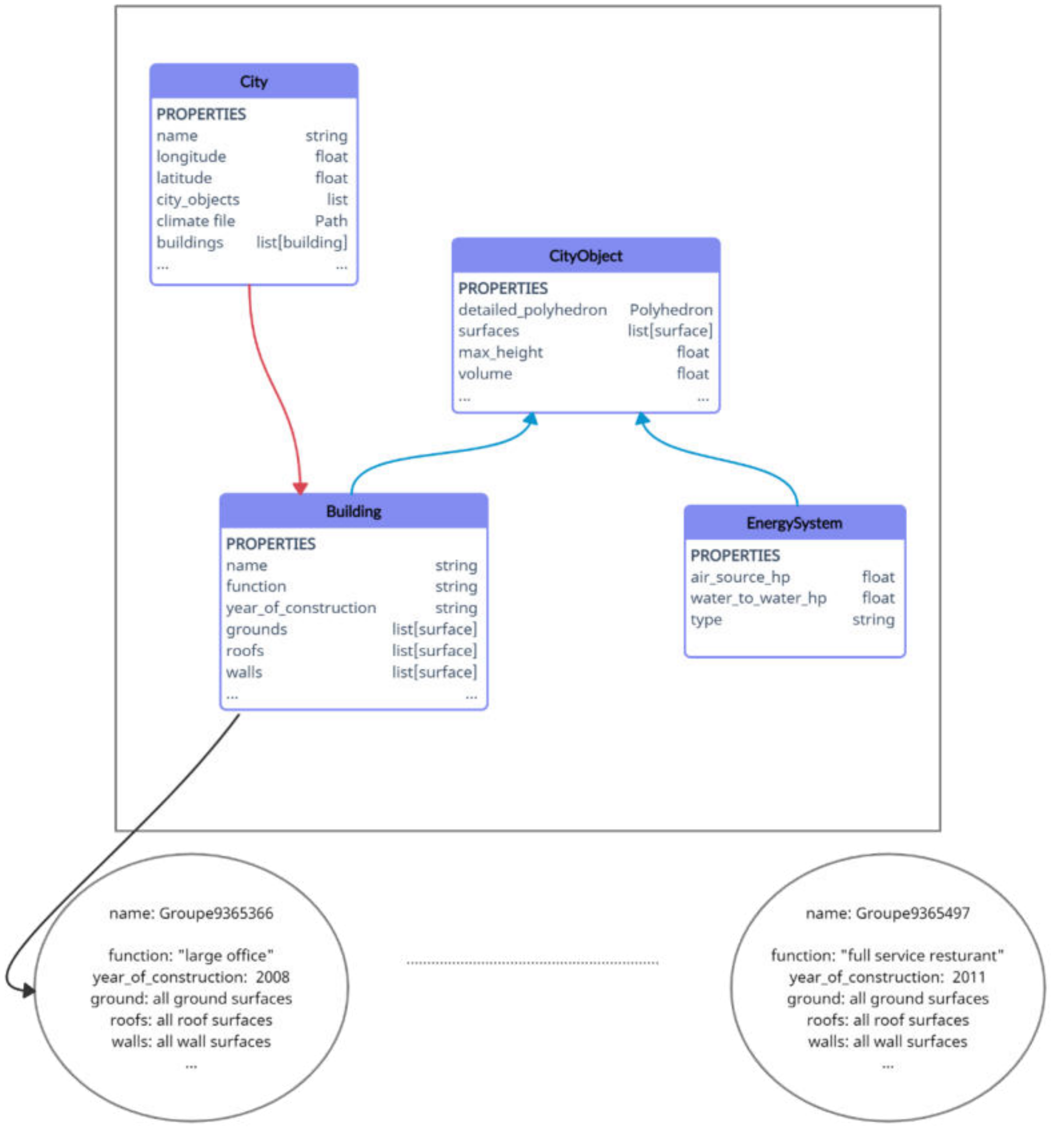
*Limited Gamification*

- Simulation-driven Scenarios
- Building Scale
- Informs detailed decisions
- Single-domain
- Licensable

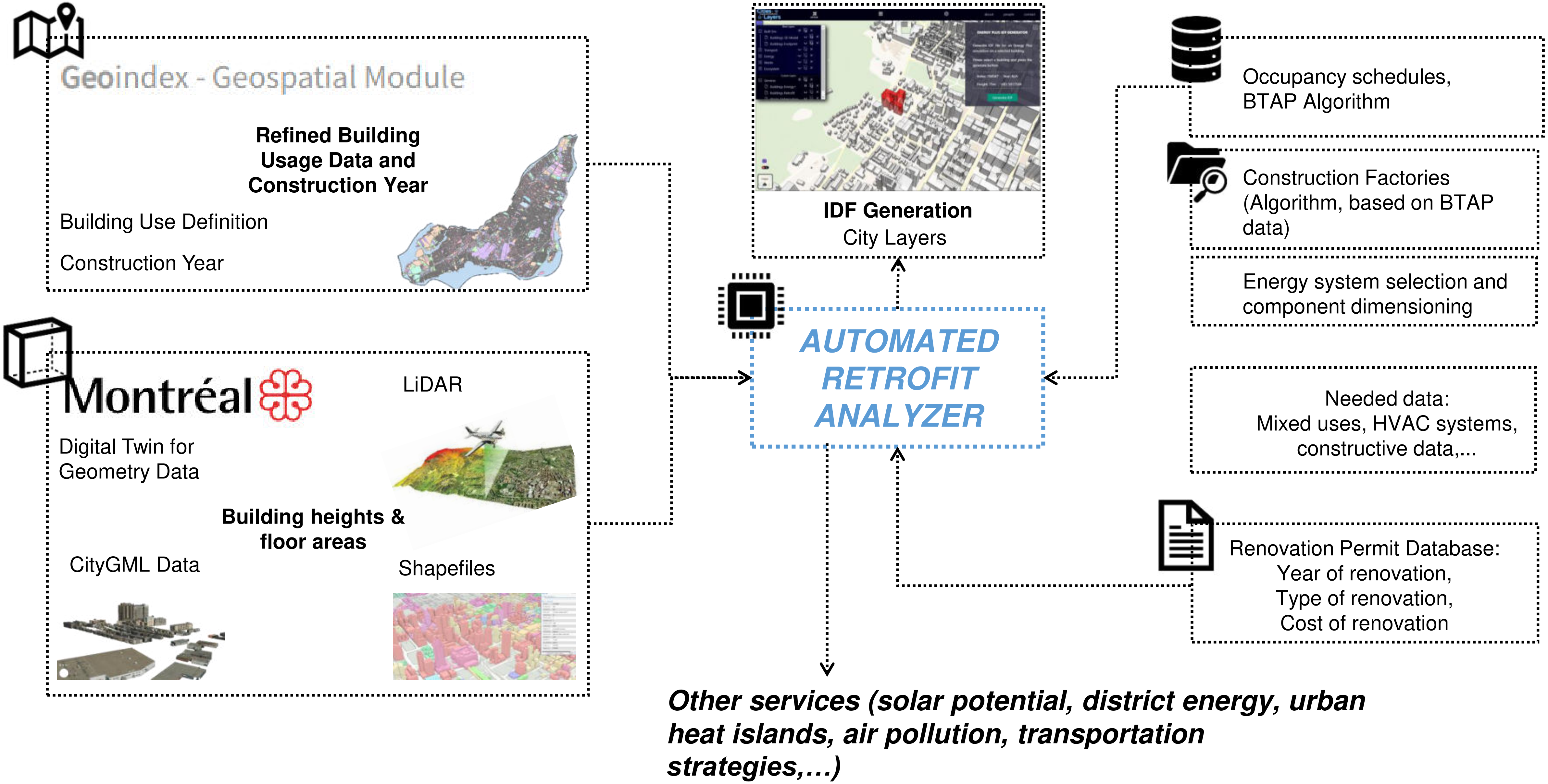
*Gamification*

- Experiential Scenarios
- Neighborhood Scale
- Informs holistic decisions
- Mutli-domain
- Free & Licensable

*Serious Gaming*

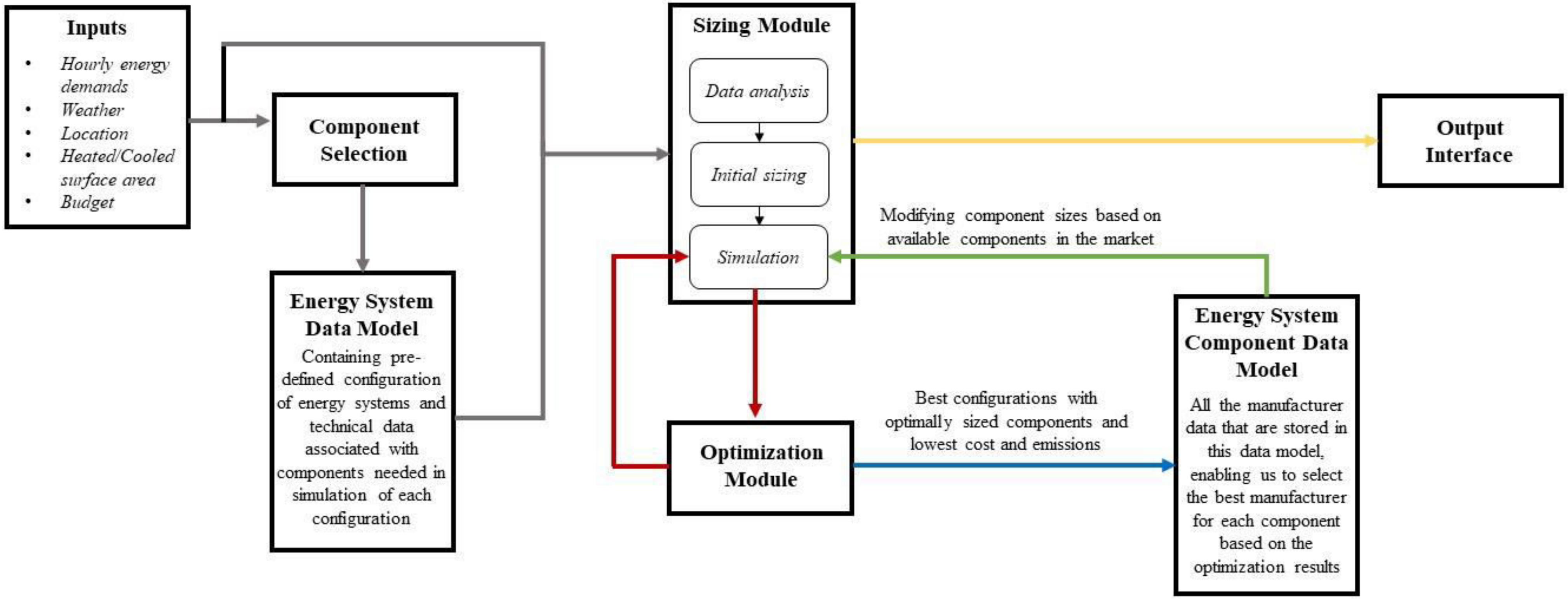


# Workflow for building retrofit analysis



# Automated heat pump sizing based on hourly demand

A framework for automatic sizing of energy systems with minimum cost and emissions. The output will be a list of system configurations with optimally sized components and their manufacturers



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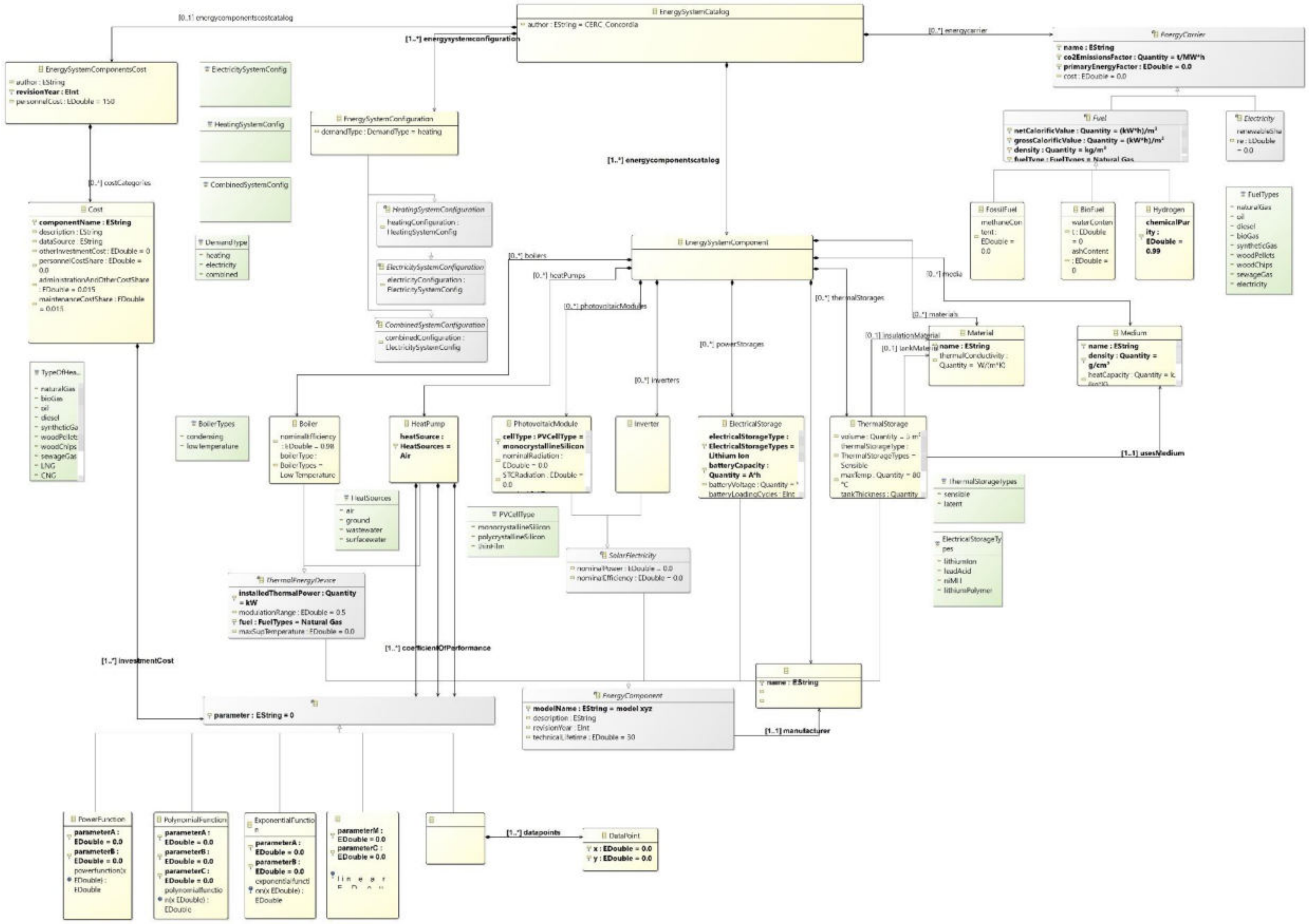
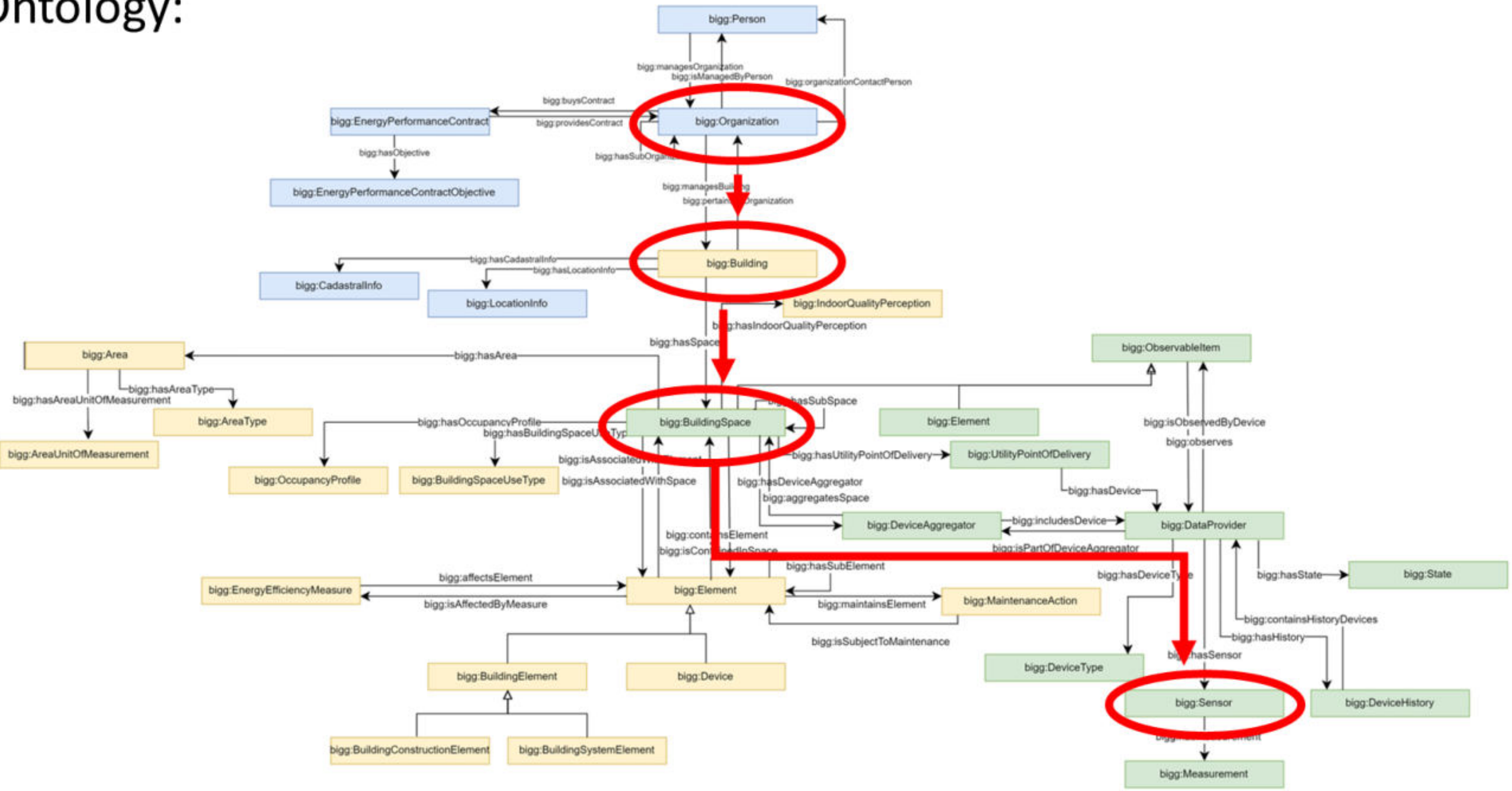
# Harmonized energy systems and components data models



## Ontology for static and dynamic building data storage
## High level of detail

Storing static and dynamic building data in a systematic and organized way is challenging

Ontology:




CIMNE Spain

# Early design tool data model with low level of detail

### *User Input*

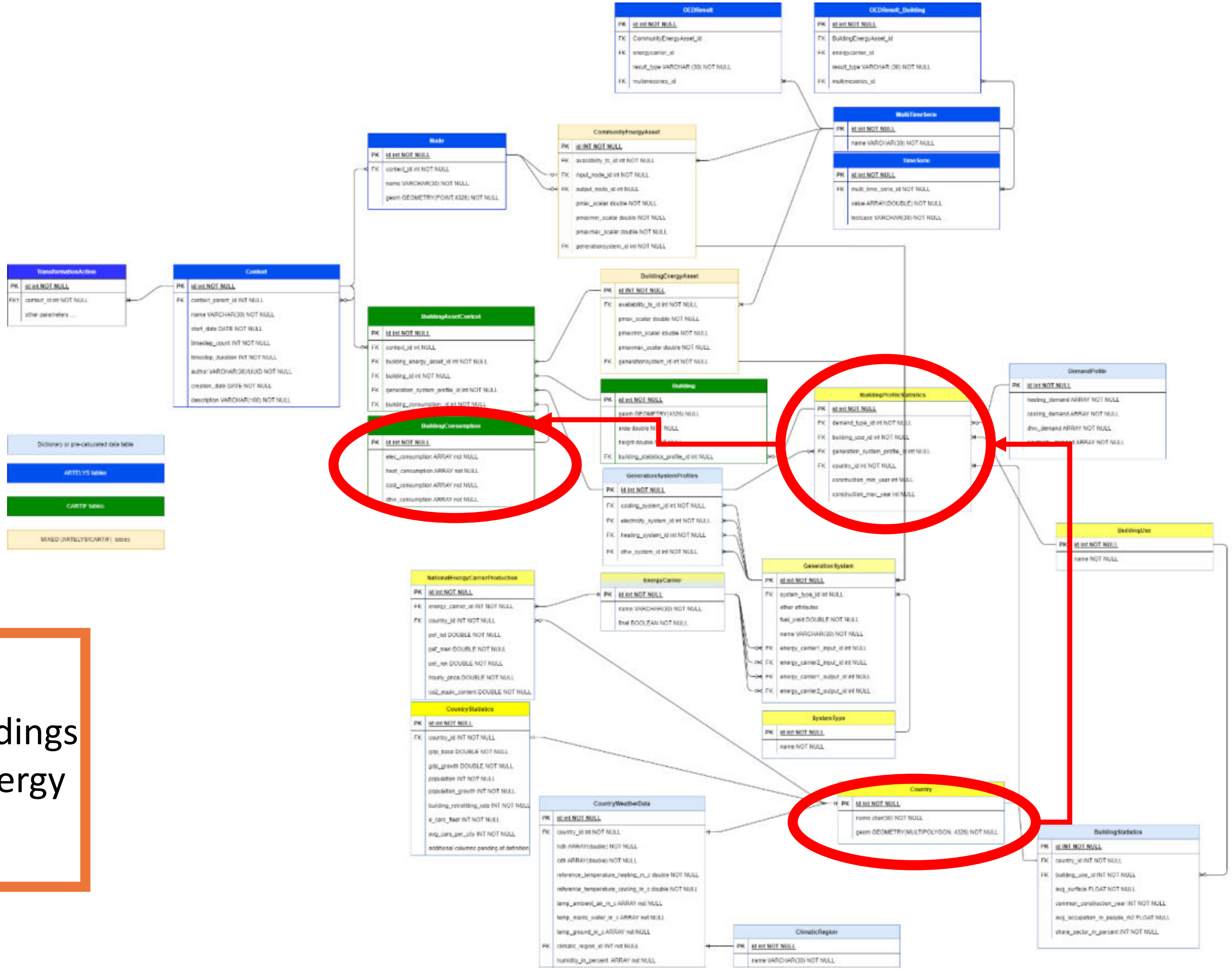
- Building usage
- Year of Construction
- Location of each building

*GIS weather data*

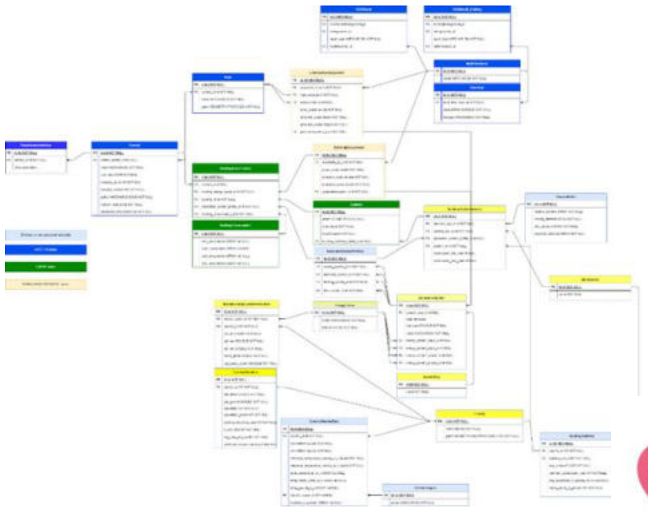
*Country data and statistics*

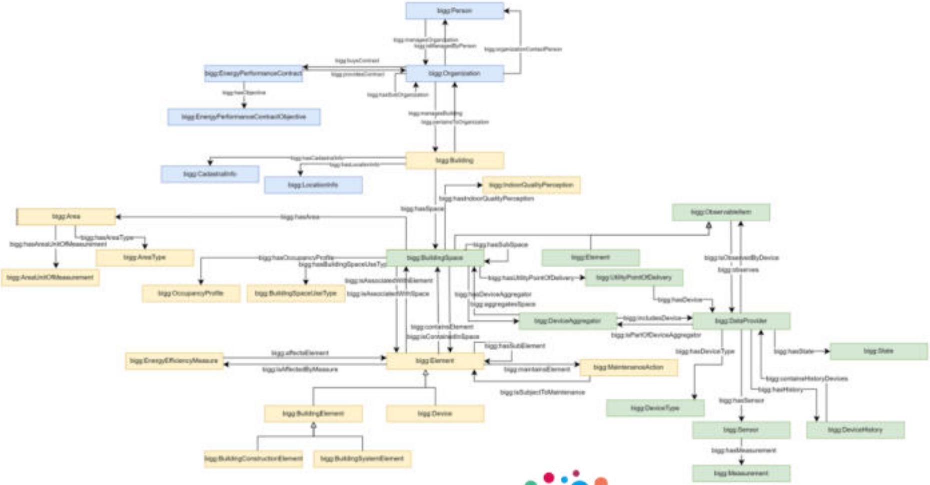
### *Output*

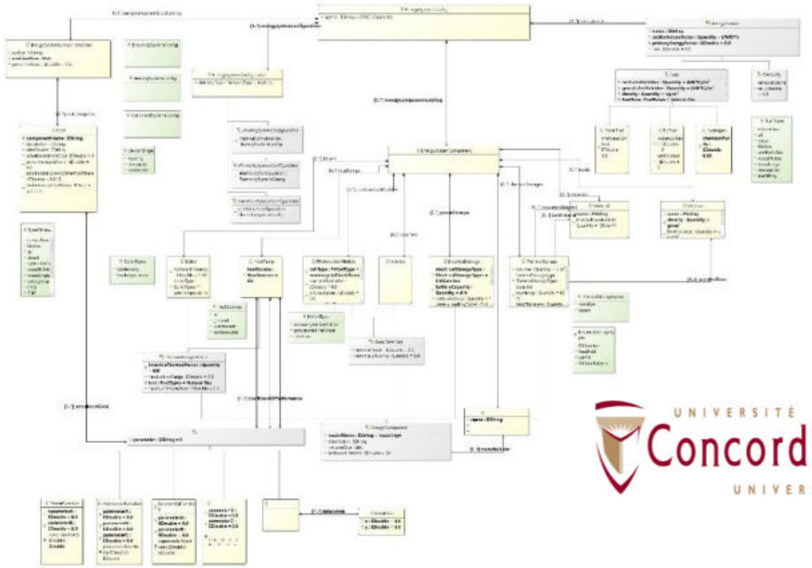
- Energy profile of buildings
- Designed building energy system



# Interoperability of data depending on level of detail required







# Conclusions and next steps

- PEDs are still small and limited in number, degree of local autonomy depends on density
- Solar PV and heat pumps dominate local generation concepts, followed by cogeneration and district heating
- Detailed performance data, especially cost, are still rare
- Data needs to be harmonized and made easily available; need to define a consistent ontology and set of metadata elements depending on level of detail required (from early planning to implementation and monitoring/optimization)
- An urban platform is developed at Concordia, using a data catalogue for energy systems and automated workflows for district modeling, to be able to run different technology scenarios using data from technology providers
- Case study data will be used/tested in the current ontologies and data models to refine them
- An ontology for PEDs will be created to be able to model district scale cases to evaluate KPIs and analyze transition scenarios for urban areas