Urban Geography — Participatory Modelling — Informatics

Energy consumption & Urban restructuring **simulation** for **participatory modelling** and decision making, taking into account **social and micro-climate data**

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In an ideal city:

- **Decision makers:** would be confident and knowledgable about what they are voting for. Especially concerning vital issues such as: urban restructuring, social cohesion, climate change, energy consumption and more..
- **Geographers / Civil engineers:** Would be able to provide their city council and general public, with insights regarding these decisions in an inclusive manner of participation.
- **Social Workers:** Would be equipped with the tools and data that they need to predict situations where they should intervene.
- **Computer Scientists:** Would have languages and tools that would facilitate the modeling and simulation of cities, to support all of the above

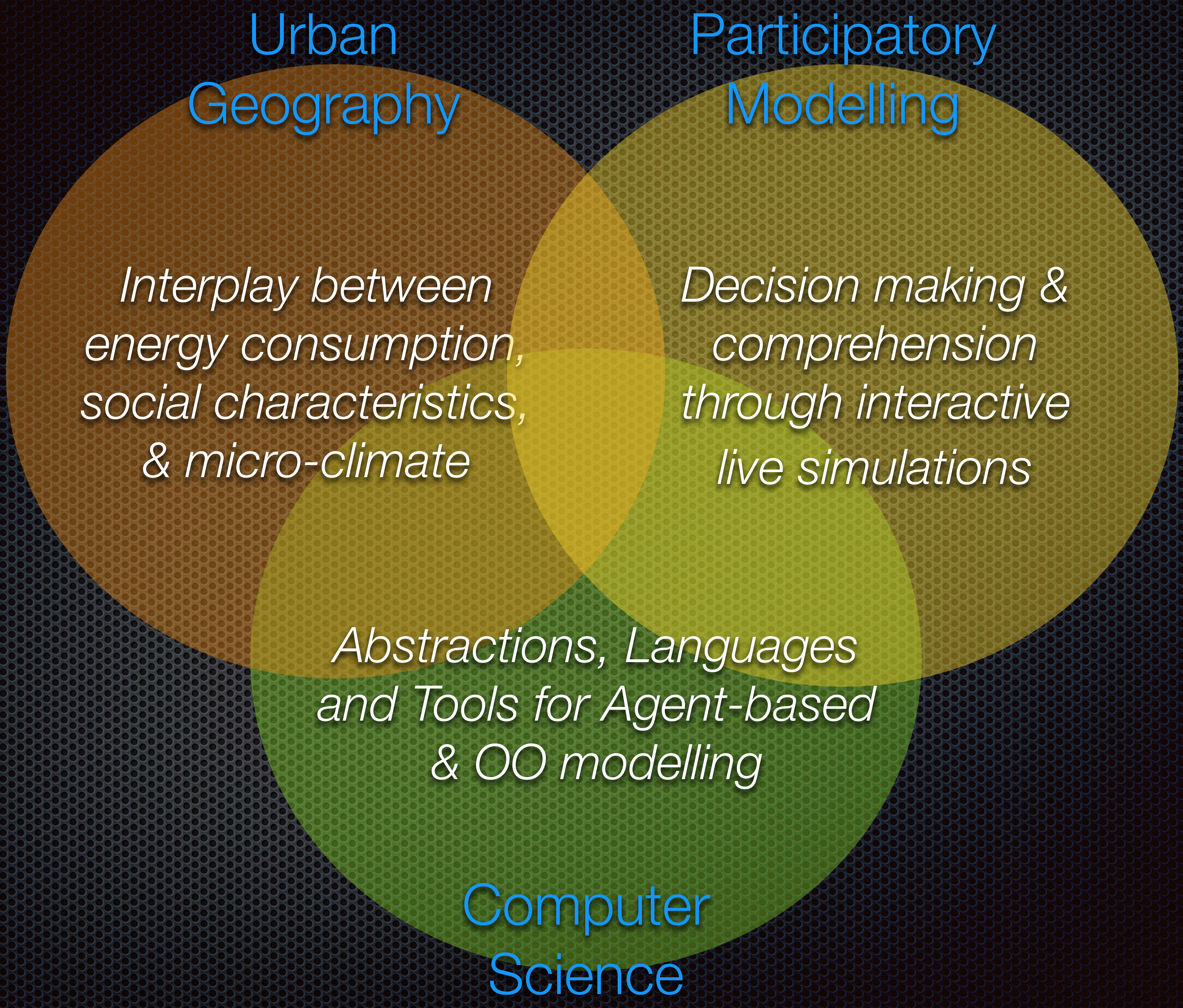
but…:

- **Cities are complex, non-linear, chaotic systems:** That we strive to understand (Suggested reading: *Scale, 2017 by Geoffrey West*)
- **Decision Making:** Can be an ad-hoc multi-facet process, plagued by conflicting interests, with little to no connection to real world data or predictive models.
- **Social Services:** Are striving to help, without all the necessary tools in their disposal (digital or otherwise), while usually being under-staffed and under-paid.
- **Software:** That could help with monitoring, prediction and decisions, is mostly build by large corporations (larger than the population of La Rochelle) that only engage if there is financial interest

Research Project:

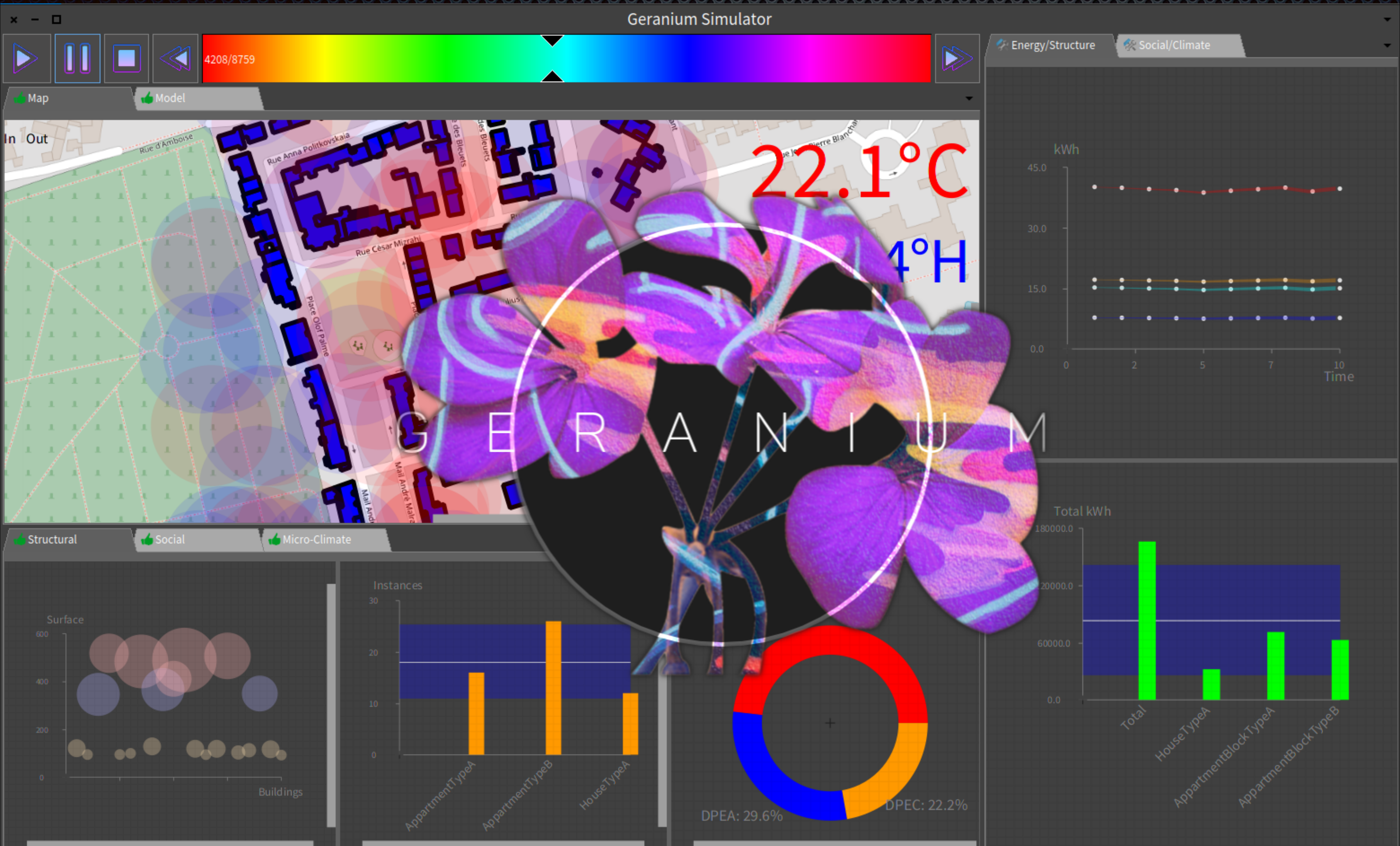
GERANIUM

Energy consumption & Urban restructuring **simulation** for **participatory modelling** and decision making, taking into account **social and micro-climate data**


Urban Geography
Participatory Modelling
Interplay between energy consumption, social characteristics, & micro-climate
Decision making & comprehension through interactive live simulations
Abstractions, Languages and Tools for Agent-based & OO modelling
Computer Science

Mock-up & Environment

Prototype



https://gitlab.com/npapoylias/Geranium

Generated Automatically for each:

```
StatisticalScenario new
   named: #ScenarioA;
   coordinates: (46.16352961038194 @ -1.1302614212036133)
   -> (46.166851083597415 @ -1.1267745494842527);
   totalNumberOfBuildings: #determinedByMap;
   residencePercentages:{
      #AppartmentBlockTypeA.
      #AppartmentBlockTypeB.
      #HouseTypeA
   } % { 0.1 . 0.1 . 0.8 };
   climateProfile: #UrbanClimateA;
   trendsProfile: #FrenchConsumptionTrends;
   weightsProfile: #UrbanHypothesisA;
   years: 1.


UrbanProfileForAppartmentBlock new
   named: #AppartmentBlockTypeA;
   dimensions: (3 x: 4 x: 5);
   appartmentPercentages: {
      #AppartmentTypeA.
      #AppartmentTypeB.
   } % { 0.2 . 0.8 }.

UrbanProfileForAppartmentBlock new
   named: #AppartmentBlockTypeB;
   dimensions: (5 x: 2 x: 10);
   appartmentPercentages: {
      #AppartmentTypeA.
      #AppartmentTypeB.
   } % { 0.5 . 0.5 }.
```

Scenario described in
an "Urban Setting" Language
that we have developed

Scenarios Embedded DSL (Argot)

```
UrbanProfileForAppartment new
    named: #AppartmentTypeA;
    category: DPEC;
    surface: [50.0 -> 80.0];
    occupantClass: {SingleAdult . Couple . Family} % {0.60 . 0.30. 0.10};
    numberOfChildren: [1 -> 3]; "valid only for family"
    income: (72000.0 ~ 10000) | [36000.0 -> 100000];
    awareness: {ConsumptionAware . ConsumptionUnaware} % {0.40 . 0.60};
    ownership: true % 20.

UrbanProfileForAppartment new
    named: #AppartmentTypeB;
    category: DPEB;
    surface: [80.0 -> 110];
    occupantClass: {Family . Couple} % {0.50 . 0.40};
    numberOfChildren: [1 -> 3]; "valid only for family"
    income: (92000.0 ~ 15000) | [66000.0 -> 180000];
    awareness: {ConsumptionAware . ConsumptionUnaware} % {0.10 . 0.90};
    ownership: true % 10.

UrbanProfileForHouse new
    named: #HouseTypeA;
    category: DPED;
    surface: [90.0 -> 130.0];
    exposure: (5 ~ 1) | [0 -> 5];
    occupantClass: Family;
    numberOfChildren: [1 -> 3]; "valid only for family"
    income: (72000.0 ~ 10000) | [36000.0 -> 80000];
    awareness: {ConsumptionAware . ConsumptionUnaware} % {0.15 . 0.85};
    ownership: true % 60.
```

Scenarios Embedded DSL (Argot)

```
ClimateProfile new
    named: #UrbanClimateA;
    medianTemperature: (20.0 ~ 1.5) | [0 -> 32];
    seasonalTemperatureVariation: 3;
    medianHumidity: [ 40.0 ~> 100.0 ];
    seasonalHumidityVariation: 2.

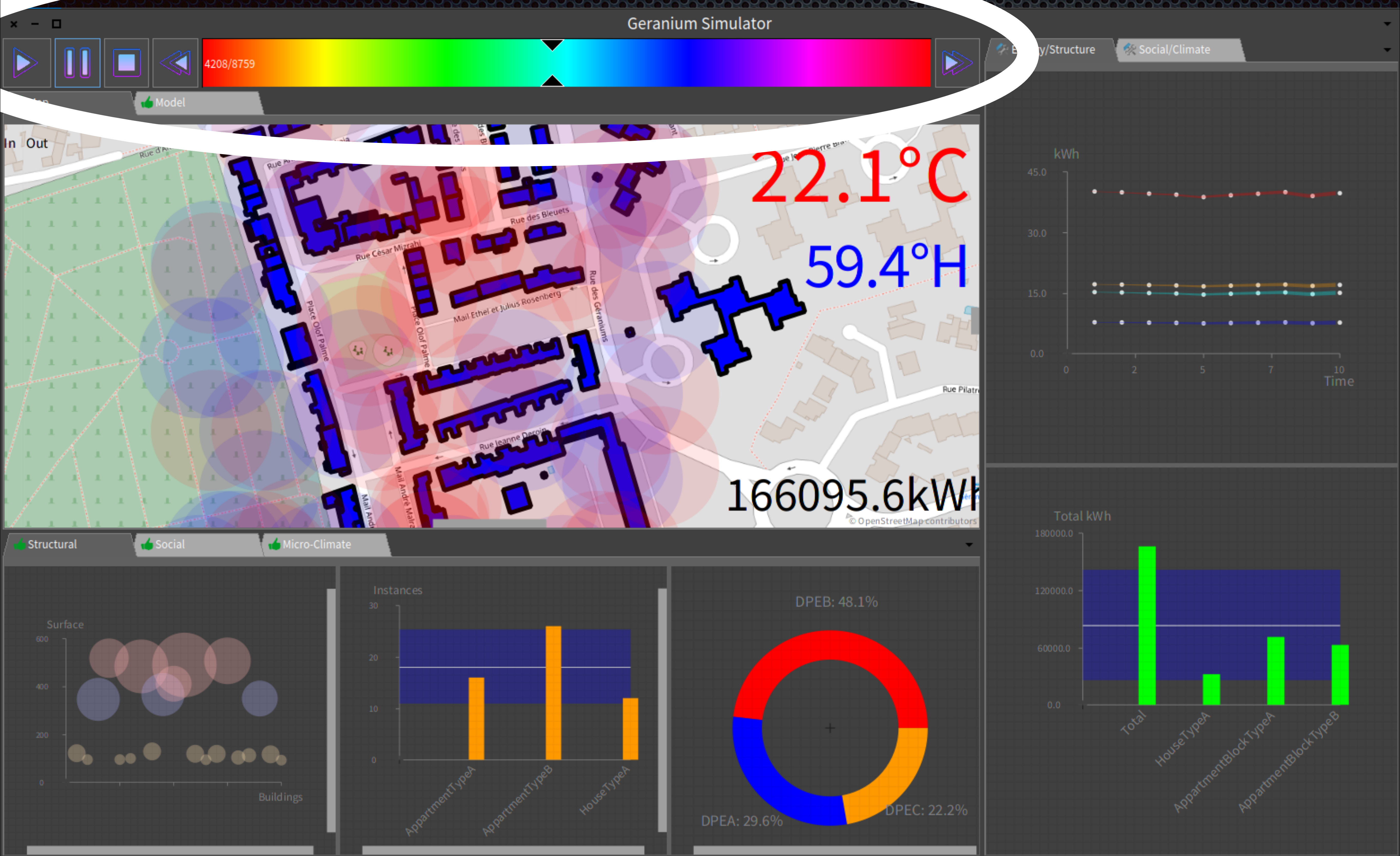
TrendsProfile new
    named: #FrenchConsumptionTrends;
    seasonal: {
        #Winter -> 1.
        #Spring -> -0.2.
        #Fall -> -0.1.
        #Summer -> 1
    }; daily: {
        #Monday -> 0.8.
        #Tuesday -> 0.8.
        #Wednesday -> 0.8.
        #Thursday -> 0.8.
        #Friday -> 0.9.
        #Saturday -> 1.
        #Sunday -> 1.
    }; hourly: {
        #Midnight -> { -1 . -1 . -1 . -1 . -1 . -1 . -0.5 }.
        #Morning -> { 1 . 1 . 1 . 0.5 . 0.5 . 1 }.
        #Afternoon -> { 0.5 . 0.5 . 0.5 . 0.5 . 0.5 }.
        #Night -> { 1 . 1 . 1 . 1 . 1 . 1 }
    }.
```

```
WeightsProfile new
    named: #UrbanHypothesisA;
    season: [ -0.1 -> 0.1 ];
    day: [ -0.01 -> 0.01 ];
    hour: [ -0.1 -> 0.1 ];
    exposure: [ -0.1 -> 0.1 ];
    occupants: [ 0 -> 0.05 ];
    income: [ -0.05 -> 0.05  ];
    ownership: [ -0.05 -> 0.05 ];
    awareness: [ -0.1 -> 0.1 ];
    temperature: [ -0.4 -> 0.4 ];
    humidity: [ -0.09 ->  0.04 ].
```

```
StatisticalScenario new
    named: #ScenarioB extending: #ScenarioA;
    totalNumberOfBuildings: [10 -> 100];
    residencePercentages: {
        #AppartmentBlockTypeA.
        #AppartmentBlockTypeB.
        #HouseTypeA
    } % { 0.2 . 0.2 . 0.6 };
    weightsProfile: #UrbanHypothesisB;
    years: [ 1 -> 3 ].

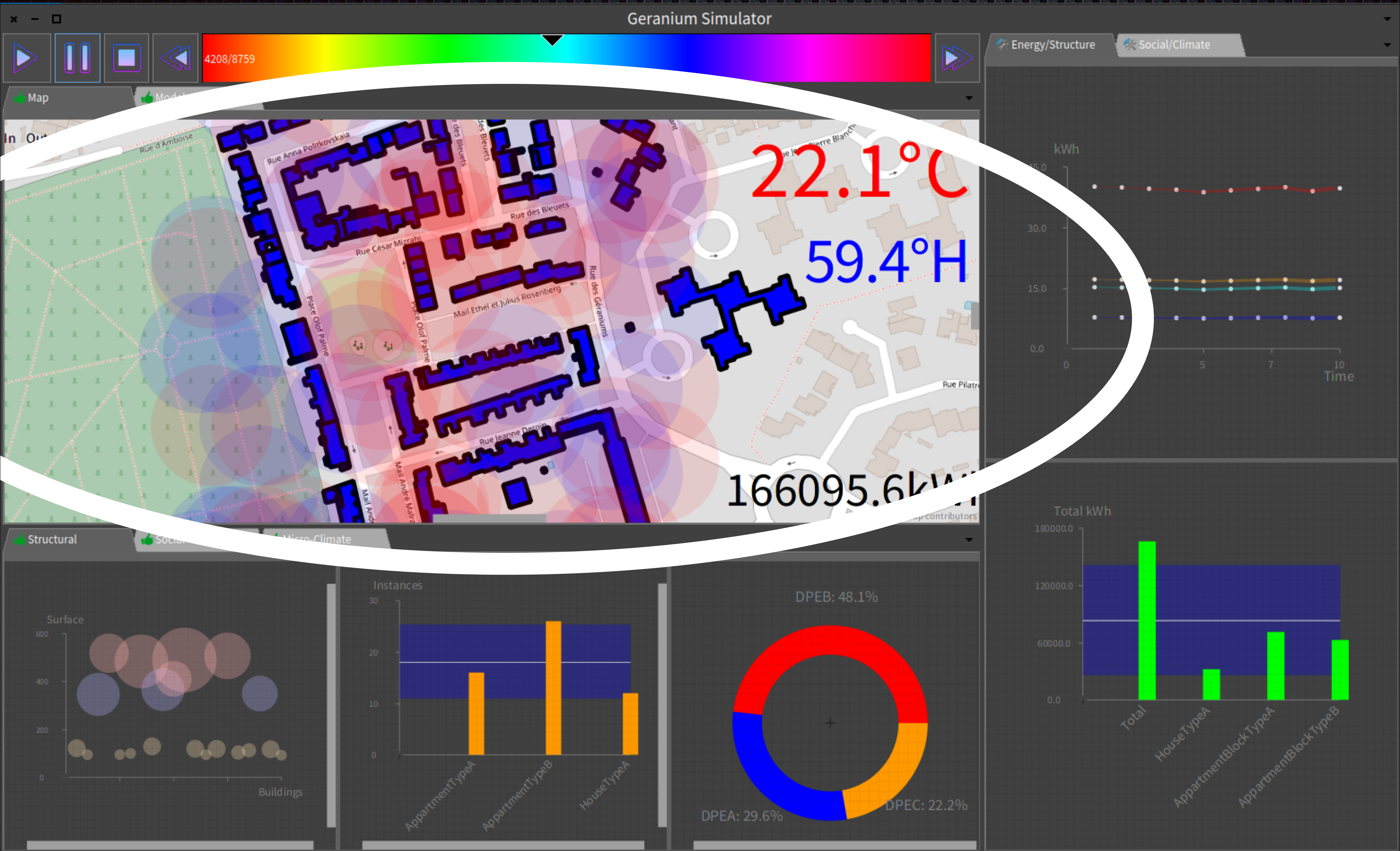
WeightsProfile new
    named: #UrbanHypothesisB extending:#UrbanHypothesisA;
    income: [ -0.2 -> 0.2  ];
    ownership: [ -0.1 -> 0.1 ].
```

Navigation

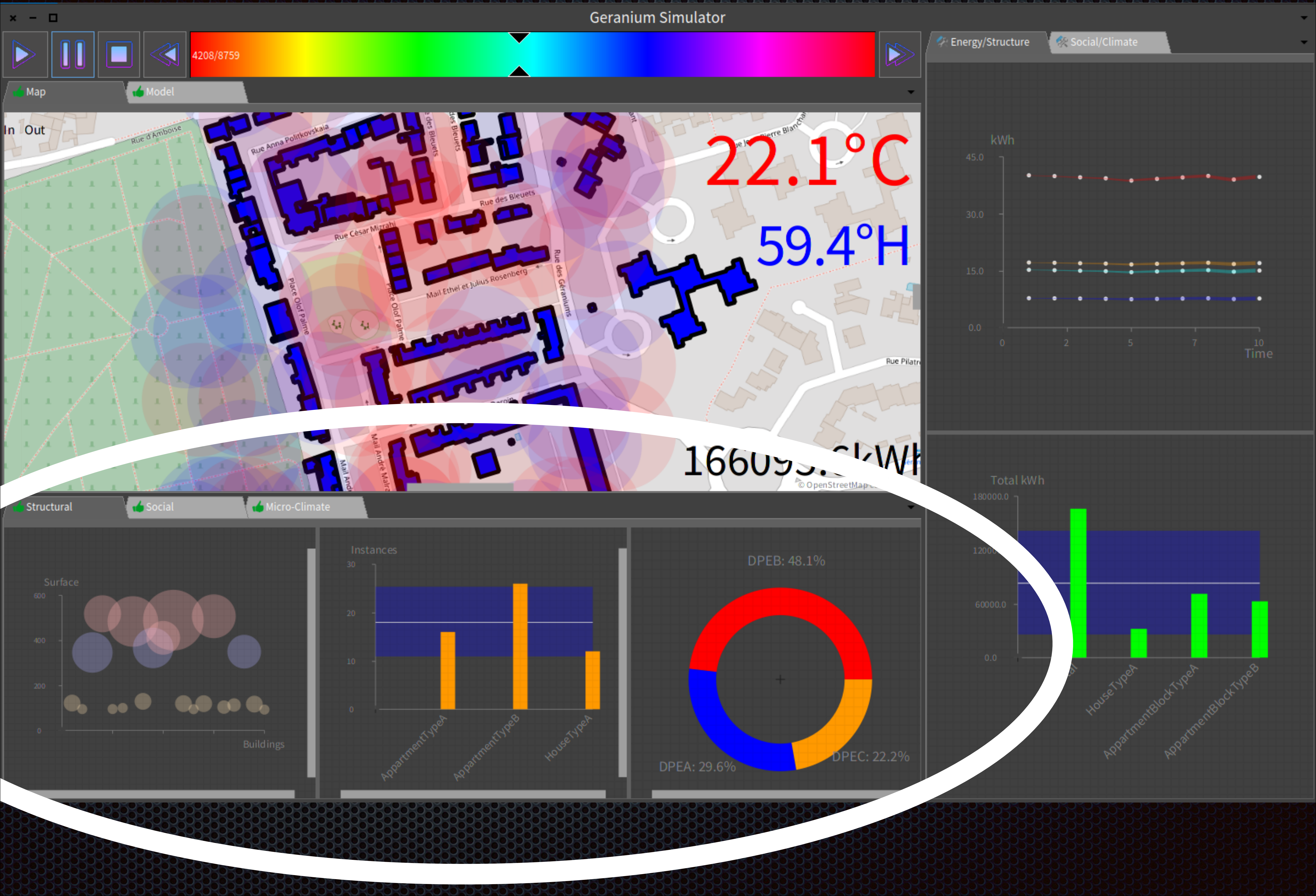


Geranium Simulator
4208/8759
Model
In Out
22.1°C
59.4°H
166095.6kWh
© OpenStreetMap contributors
Social/Climate
kWh
45.0
30.0
15.0
0.0
Time
Total kWh
180000.0
120000.0
60000.0
Total
HouseTypeA
AppartmentBlockTypeA
AppartmentBlockTypeB
Structural
Social
Micro-Climate
Surface
Buildings
Instances
AppartmentTypeA
AppartmentTypeB
HouseTypeA
DPEB: 48.1%
DPEA: 29.6%
DPEC: 22.2%

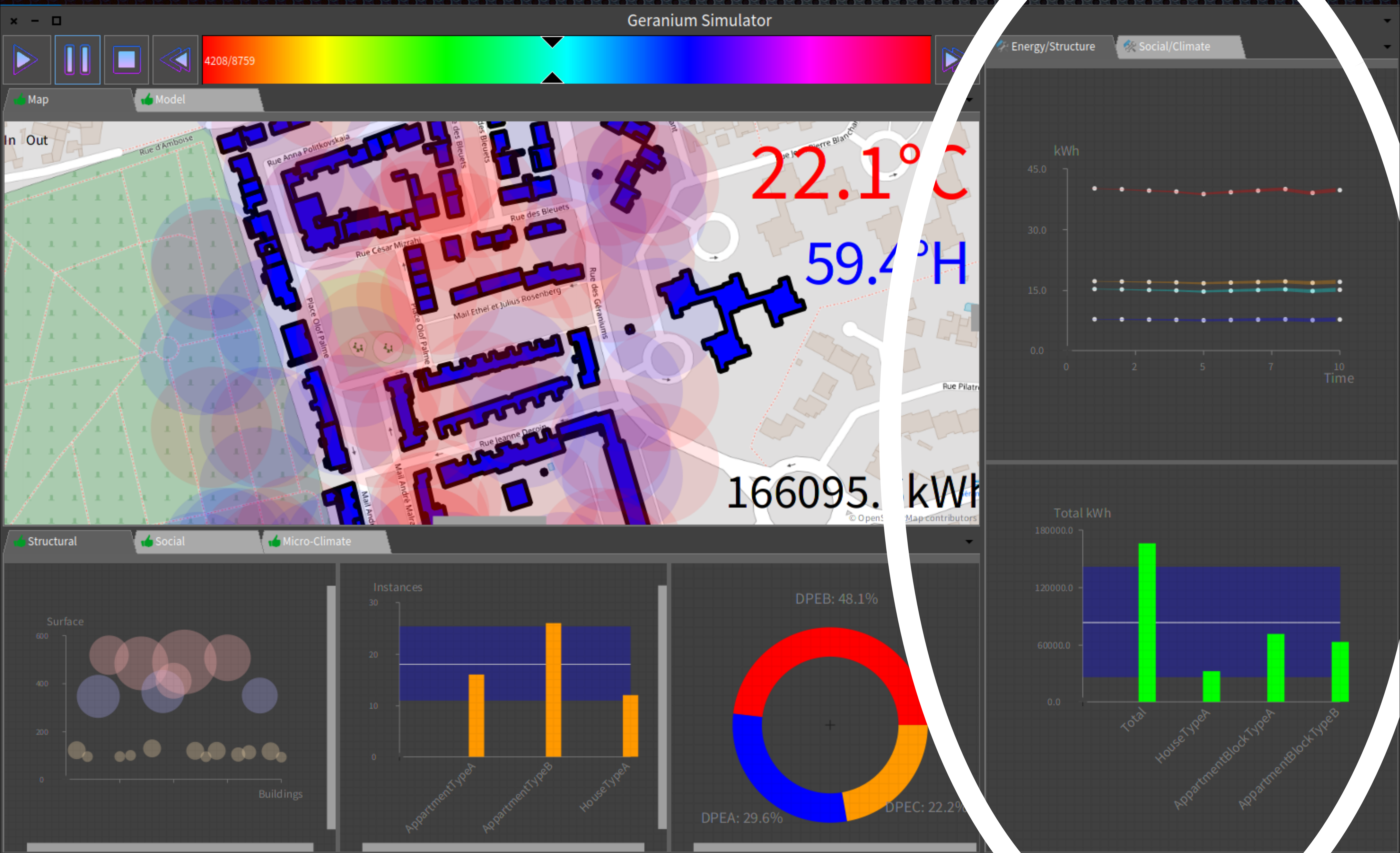
Mapping / Climate / Consumption Indicators



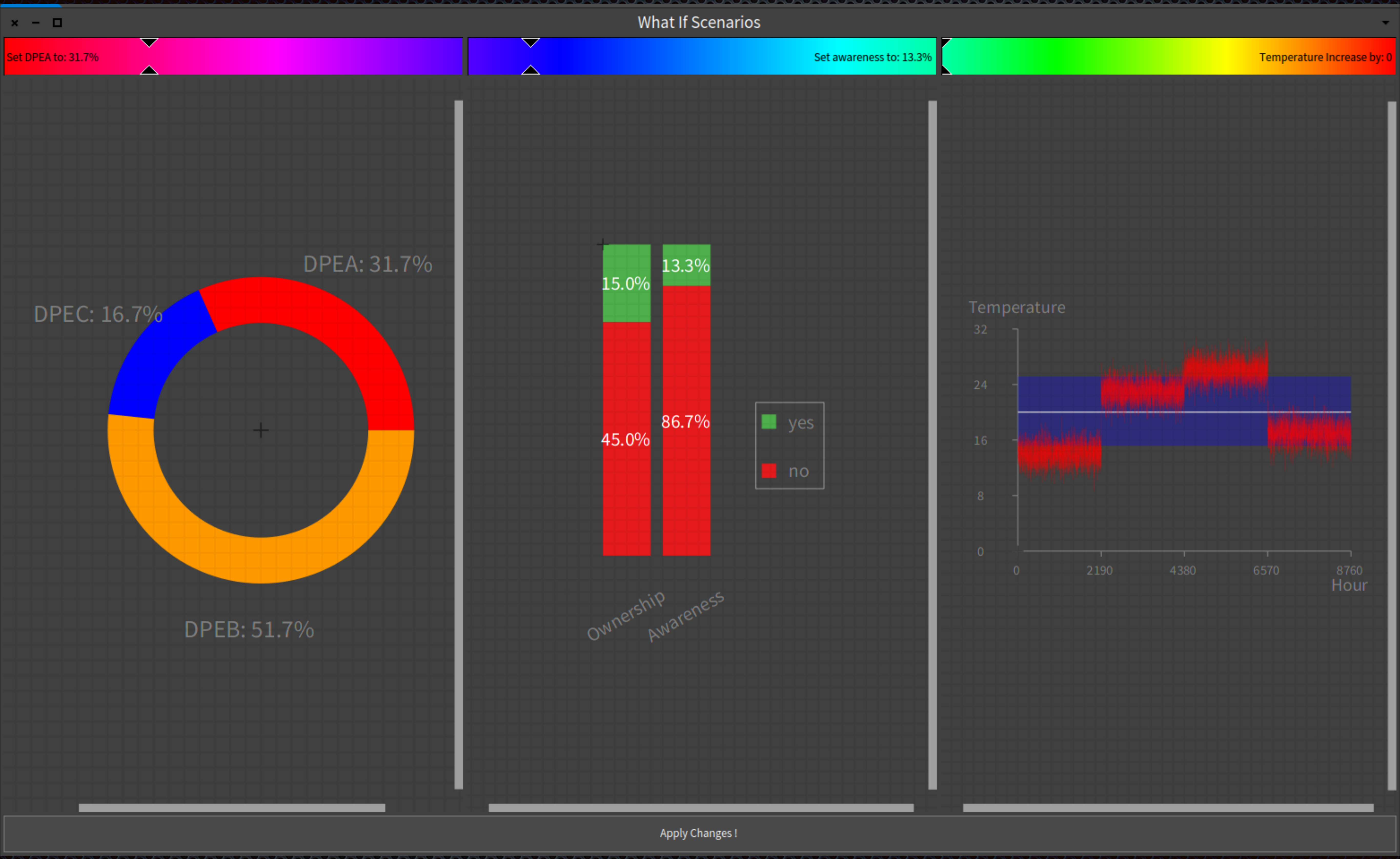
Input Figures (9): Structural / Social / Micro-Climate



Output Cons. Figures (4): Total / Structural / Social / Micro-Climate



What if Scenarios: 3 Examples (More for live sessions)



Model Summary / Next steps

Structural/social/micro-climate input

======================================

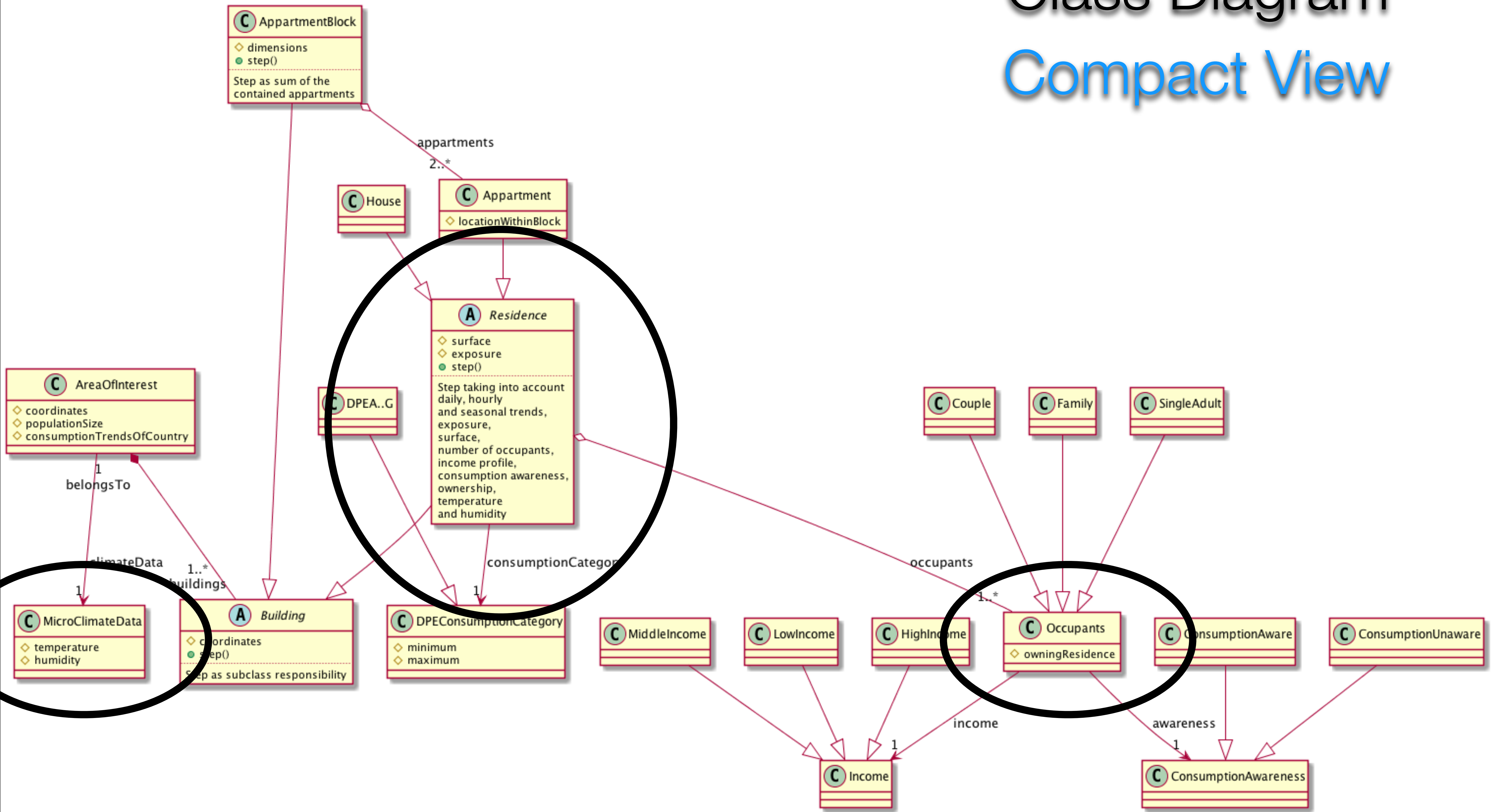
dpe
season
day
hour
temperature
humidity
exposure
(surface)
occupants
income
awareness
ownership

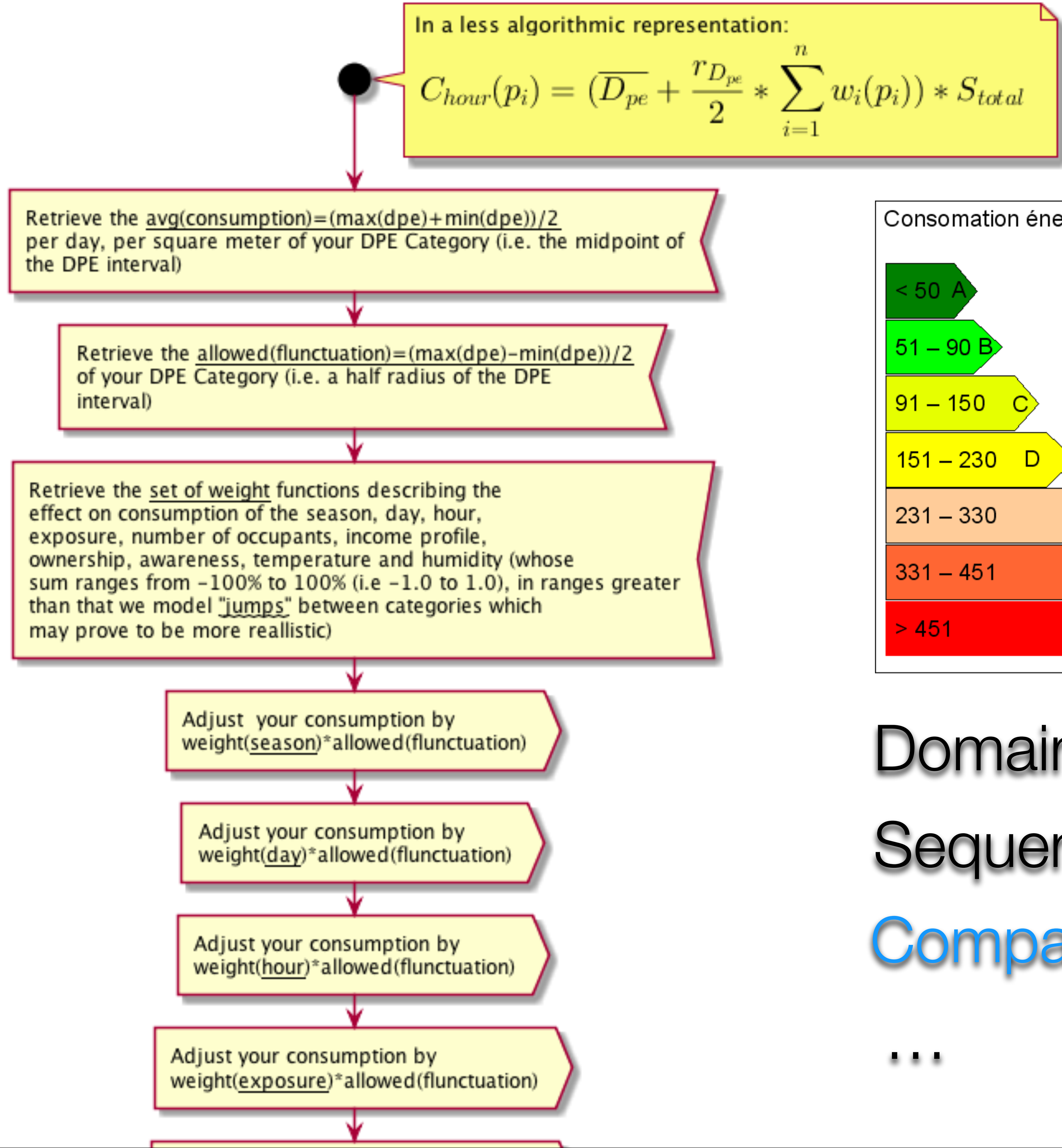
==

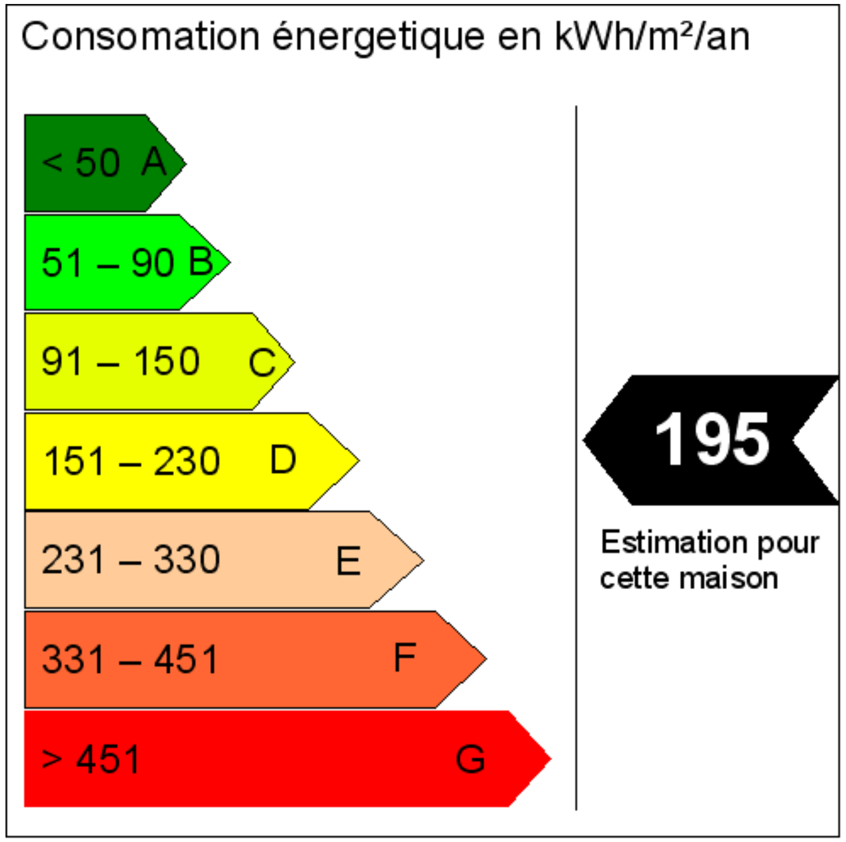
energy consumption simulation and output

- Calibration results
- UI/HCI experiments
- Stakeholder meeting
- Live interaction
- Abstractions/DSLs/Two-level UIs
- ...

Domain Model
Class Diagram
Compact View





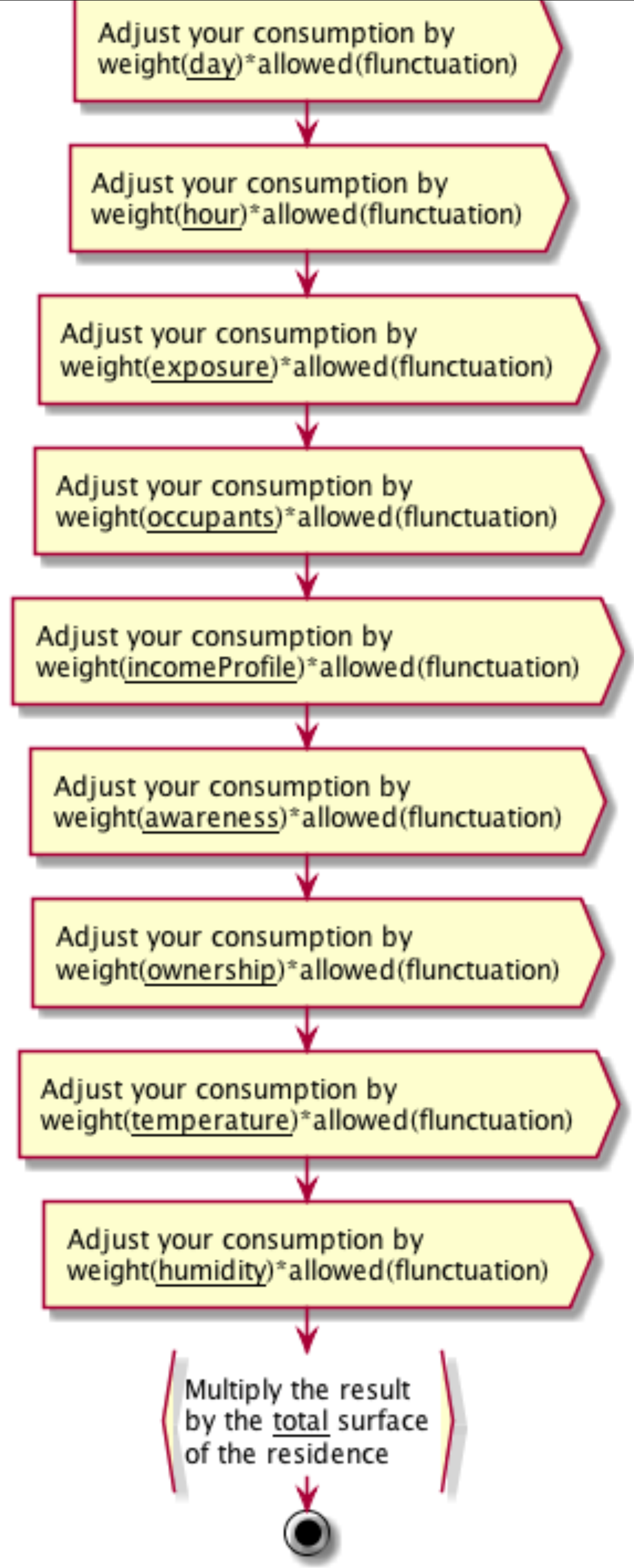


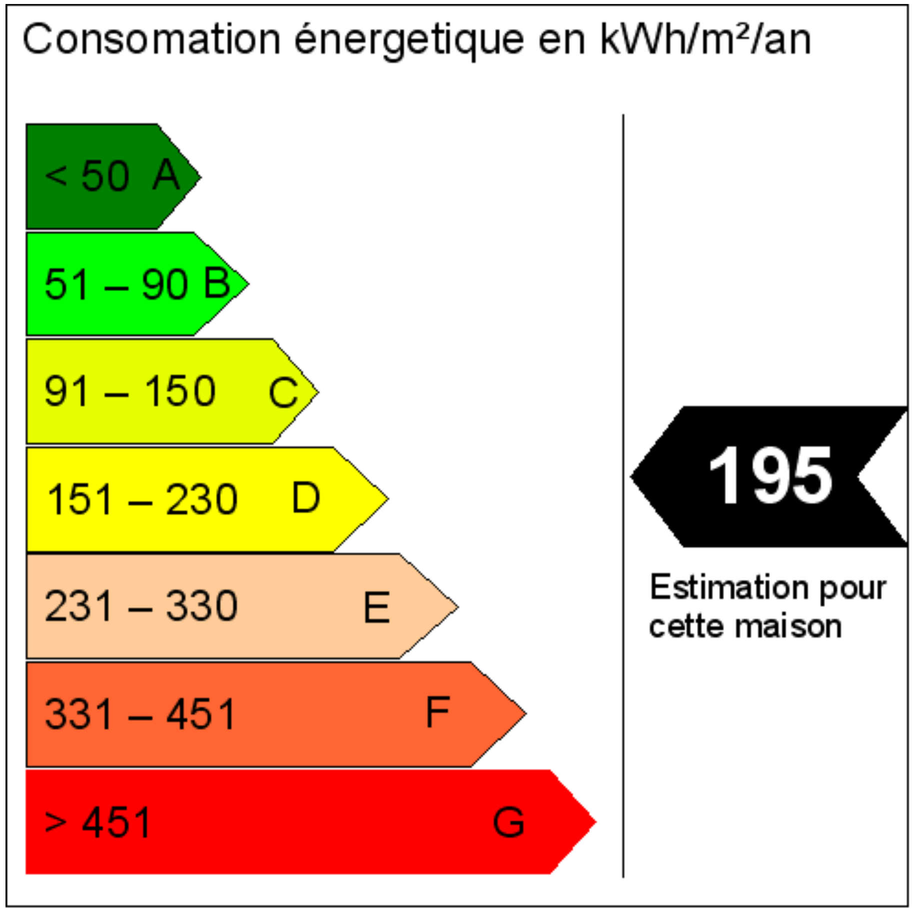
Domain Model

Sequence Diagram

Compact View

…





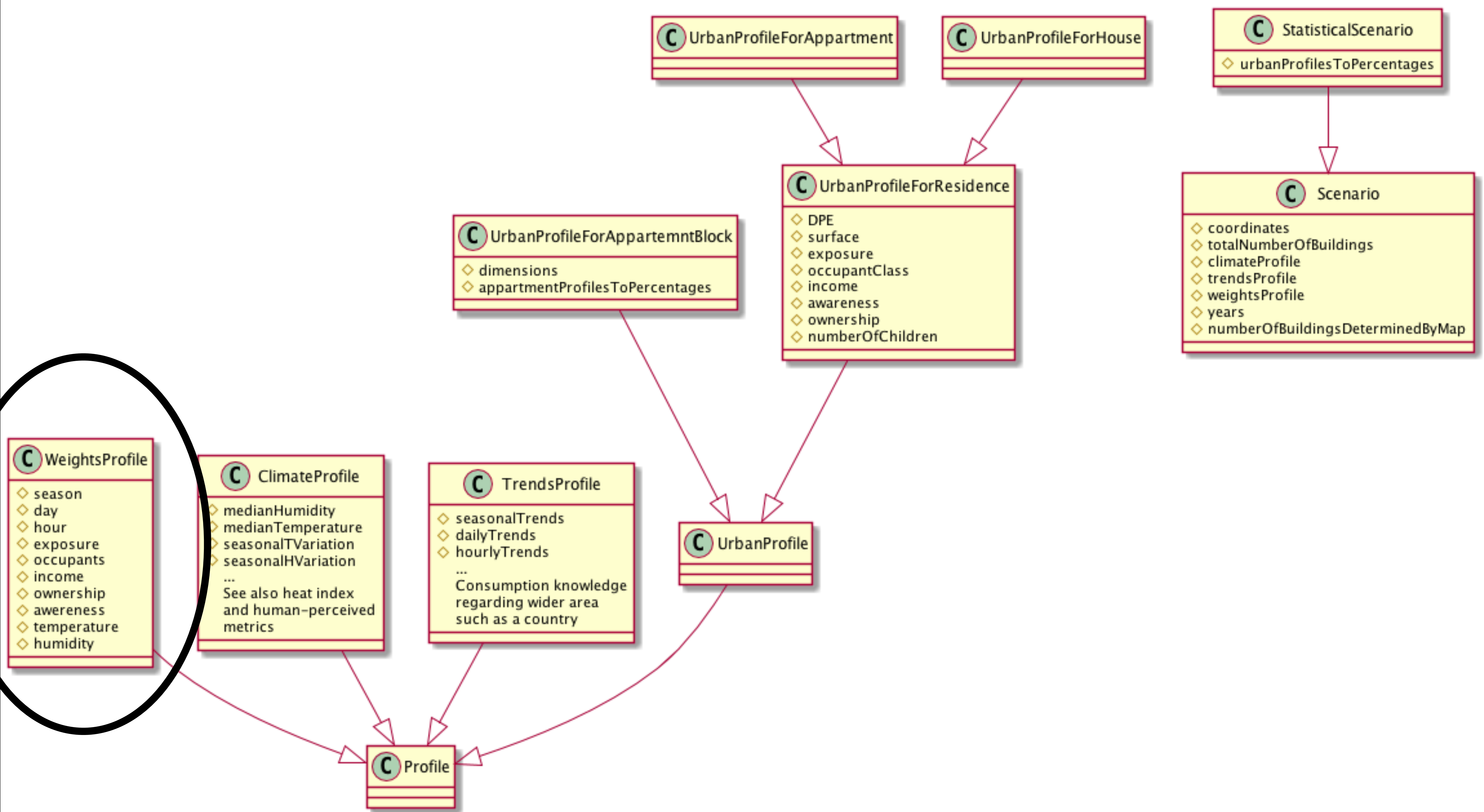
Domain Model

Sequence Diagram

Compact View

...

Scenario / Profiles UML



Survey / Ground-truth / Parameter fitting

Target Case-study: Agile Survey Geranium (V. Kolb)

HLM (Rent)			Owners	
rennovated	new	new	social housing	private
32	19	11	9	16

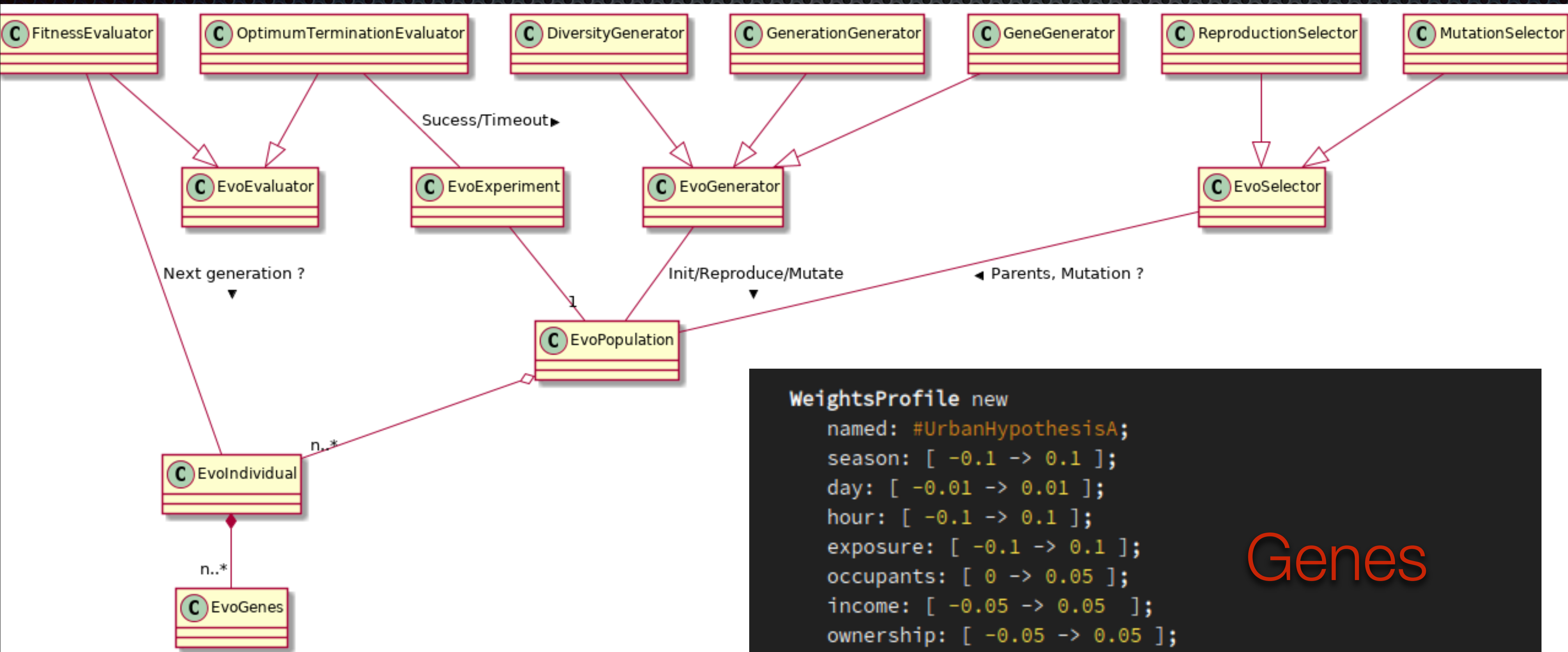
87 residences surveyed (a population of 228 inhabitants) as a proxy of 186 residences in total

***Simulation Goal:* Fit parameters from larger area / population (St. Eloi) to calibrate consumption output**

Parameter Approximation through Genetic Algorithms

Input: $Population_{size}$, $Problem_{size}$, $P_{crossover}$, $P_{mutation}$
Output: S_{best}
Population $\leftarrow$ `InitializePopulation`($Population_{size}$, $Problem_{size}$);
`EvaluatePopulation`(Population);
$S_{best} \leftarrow$ `GetBestSolution`(Population);
while $\neg$`StopCondition`() **do**
    Parents $\leftarrow$ `SelectParents`(Population, $Population_{size}$);
    Children $\leftarrow \emptyset$;
    foreach $Parent_1$, $Parent_2$ $\in$ Parents **do**
        $Child_1$, $Child_2$ $\leftarrow$ `Crossover`($Parent_1$, $Parent_2$, $P_{crossover}$);
        Children $\leftarrow$ `Mutate`($Child_1$, $P_{mutation}$);
        Children $\leftarrow$ `Mutate`($Child_2$, $P_{mutation}$);
    end
    `EvaluatePopulation`(Children);
    $S_{best} \leftarrow$ `GetBestSolution`(Children);
    Population $\leftarrow$ `Replace`(Population, Children);
end
return S_{best};

Parameter Approximation through Genetic Algorithms

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    occupants: [ 0 -> 0.05 ];
    income: [ -0.05 -> 0.05  ];
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    awareness: [ -0.1 -> 0.1 ];
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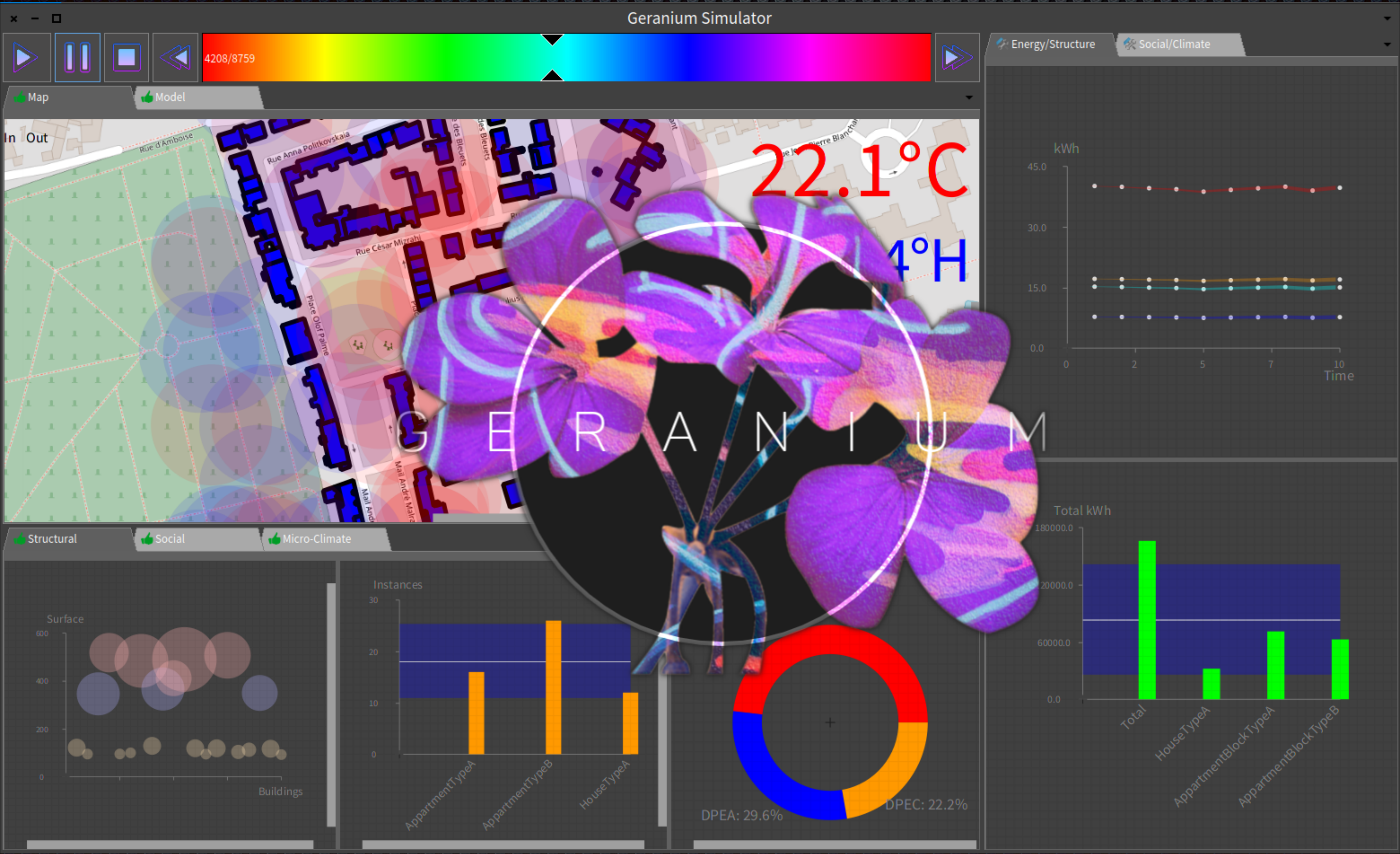
    humidity: [ -0.09 ->  0.04 ].
```

Genes

Thank you



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