

ANALYSIS OF DISTRICT ENERGY SYSTEMS FOR INTEGRATION OF LOCAL ENERGY POTENTIALS IN FUTURE URBAN COMMUNITIES

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CONTENT

PART 1:

- CONTEXT
- PROBLEM STATEMENT
- METHODS AND TOOLS

PART 2:

- A SIMPLIFIED ENERGY BUILDING MODEL FOR URBAN TRANSFORMATION

CONTEXT

- CITIES CONSUME CLOSE TO 70% OF WORLD'S PRIMARY ENERGY AND ARE RESPONSABLE OF 75% OF WORLDWIDE CO₂ EMISSIONS. (IEA,2011)
- URBANIZATION PHENOMENA, ECONOMIC AND POPULATION GROWTH WILL PROBABLY INCREASE 2 -3 TIMES THE ENERGY DEMAND IN CITIES BY 2050 (UNEP,IEA 2011)
- SPECIALLY IN BUILDINGS AND INDUSTRIAL SECTORS, CURRENTLY THE MAIN CONSUMERS OF ENERGY IN CITIES. (IEA,2011)
- CITIES ARE BEING TRANSFORMED WITH A STRONG EMPHASIS ON **INCREASING THE EFFICIENCY OF THEIR ENERGY SYSTEMS.**

PROBLEM STATEMENT

PLANNING TO INCREASE THE EFFICIENCY OF AN URBAN ENERGY SYSTEM CONSIST ON THE STUDY OF 3 GROUP OF MEASURES: (Lund et al., 2012, Girardin et al., 2009, IEA, 2011 et al.)

1. BUILDING RETROFITS

- IMPROVEMENT OF BUILDING ENVELOPE
- IMPROVEMENT OF BUILDING SYSTEM

2. INFRASTRUCTURE UPGRADES

- NEW CONVERSION TECHNOLOGIES
- NEW SCHEMES FOR GENERATION, STORAGE AND DISTRIBUTION OF ENERGY
- INDIVIDUAL VS. DISTRICT SCALE CONFIGURATIONS

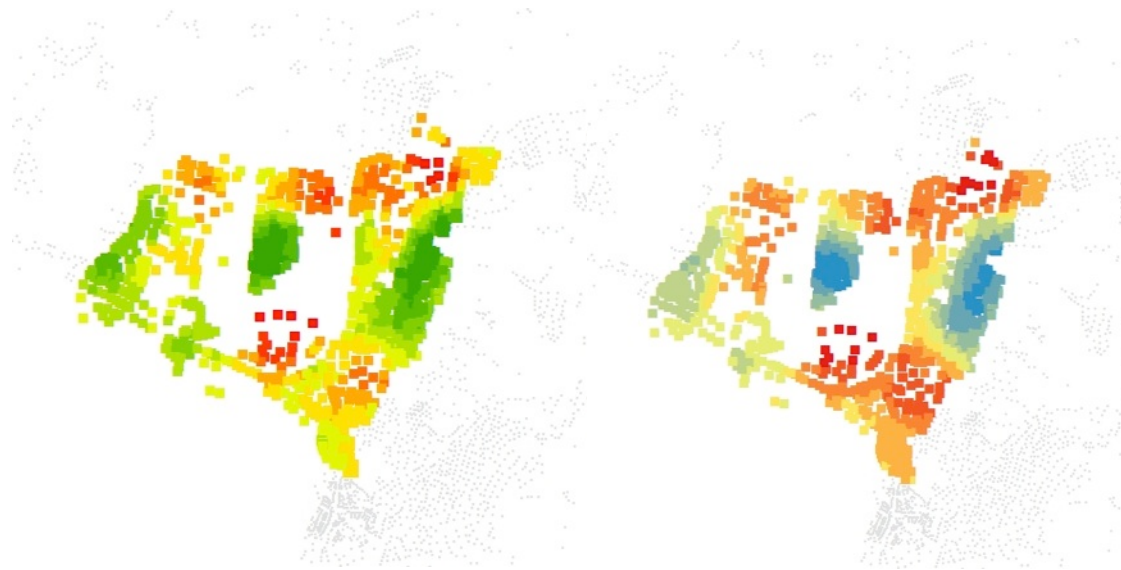
3. INTEGRATION OF LOCAL ENERGY SOURCES

- RENEWABLES (e.g. Solar, geothermal, wind etc...)
- SOURCES AND SINKS OF HEAT (e.g. Waste heat from industry, Datacenters etc..)

PROBLEM STATEMENT

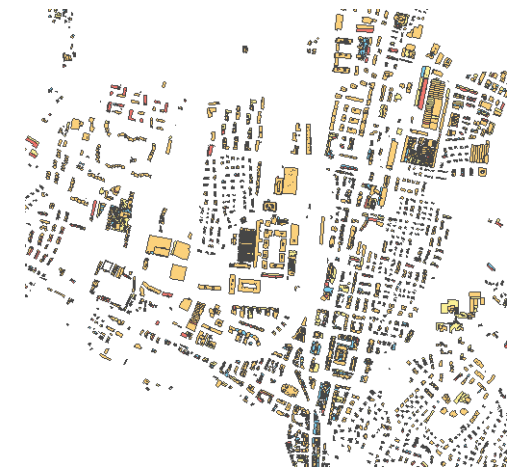
THE ASSESSMENT OF THOSE MEASURES REQUIRES THE SPATIO-TEMPORAL ANALYSIS OF ENERGY SERVICES AND RESOURCES AT QUALITATIVE AND QUANTITATIVE LEVELS.

SPATIAL



Electricity demand

Space Heating demand

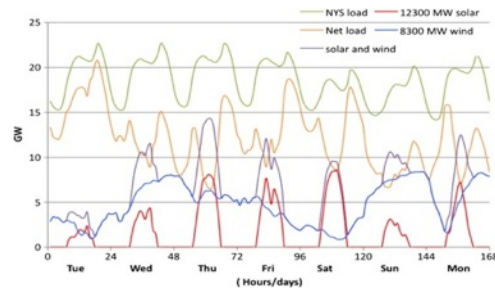


Solar radiation

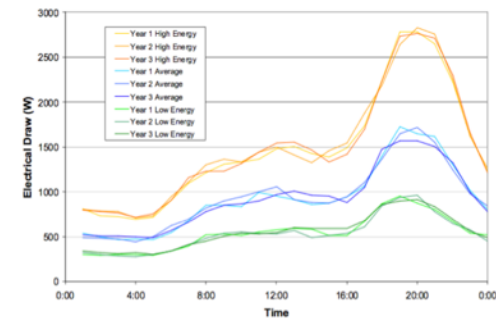
PROBLEM STATEMENT

THE ASSESSMENT OF THOSE MEASURES REQUIRES THE SPATIO-TEMPORAL ANALYSIS OF ENERGY SERVICES AND RESOURCES AT QUALITATIVE AND QUANTITATIVE LEVELS.

TEMPORAL



TECHNOLOGIES?
SYSTEMS?
OPERATION STRATEGY?



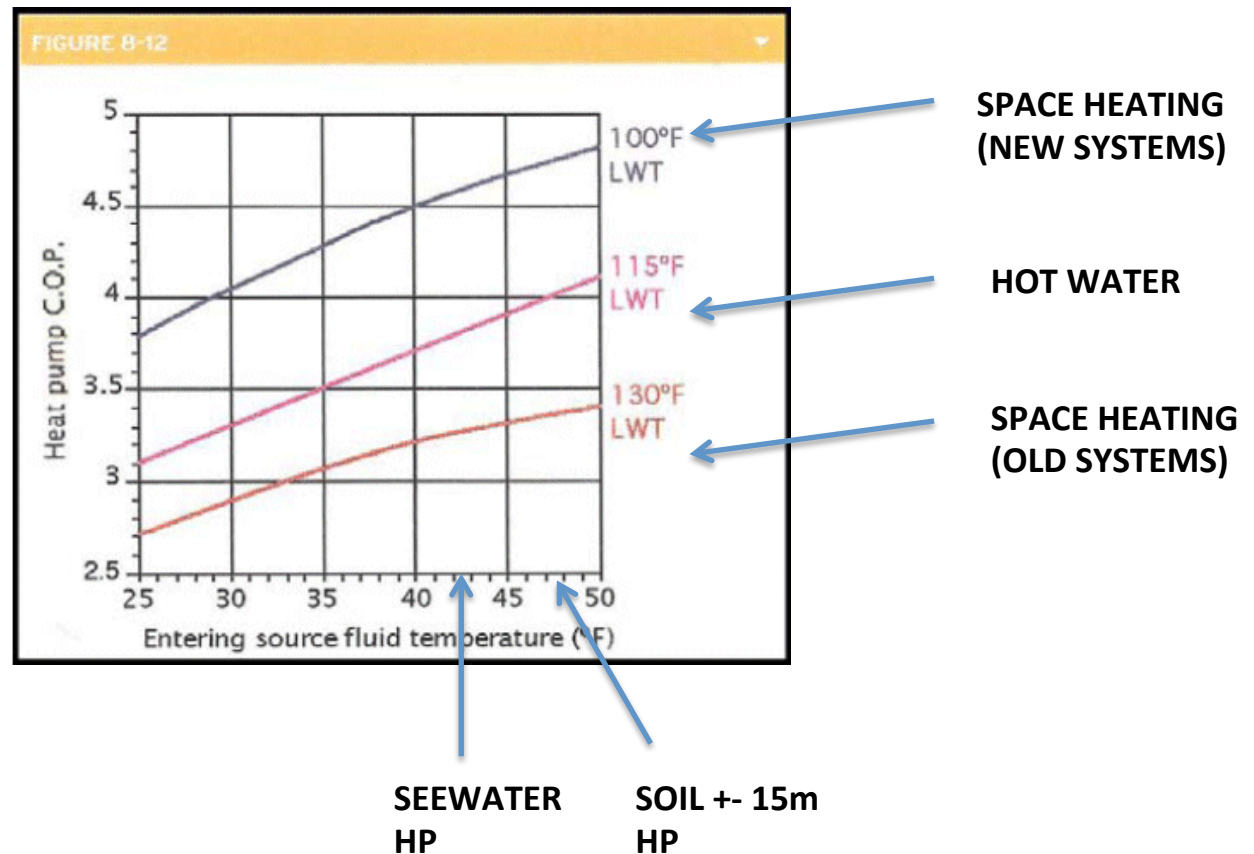
RESOURCES

ENERGY SERVICES

PROBLEM STATEMENT

THE ASSESSMENT OF THOSE MEASURES REQUIRES THE SPATIO-TEMPORAL ANALYSIS OF ENERGY SERVICES AND RESOURCES AT QUALITATIVE AND QUANTITATIVE LEVELS.

QUALITATIVE



SCOPE

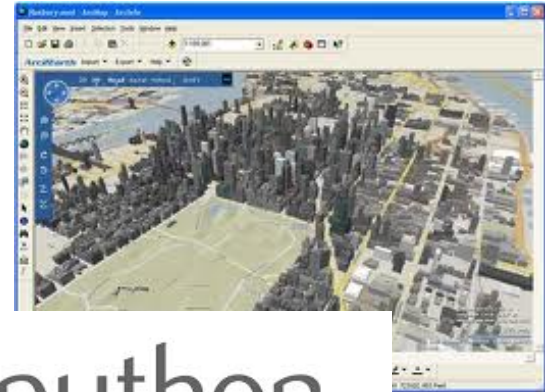
TO CONSTITUTE A MODEL OF ANALYS THAT.....

1. CHARACTERIZES SPATIO-TEMPORAL PATTERNS OF ENERGY CONSUMPTION AND SUPPLY IN URBAN AREAS.
2. IDENTIFIES THE OPTIMAL PENETRATION OF RESOURCES, AND OPTIMAL INFRASTRUCTURAL SOLUTIONS.
3. IS DETAILED ENOUGH BUT TARGETED TO BE USED IN PLANNING APPLICATIONS.

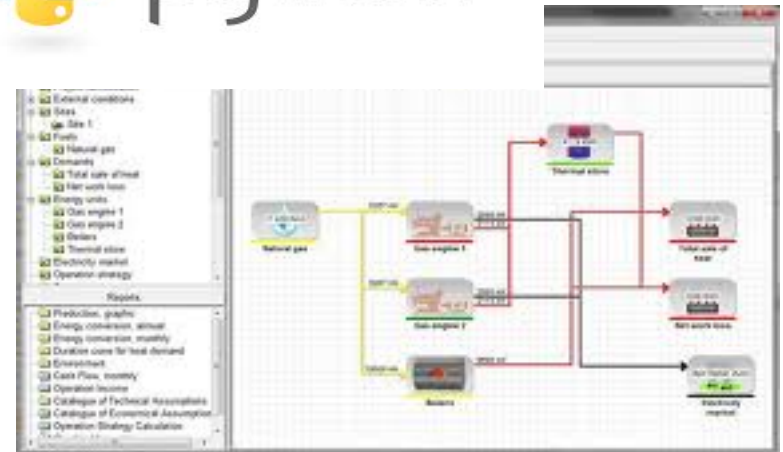
METHODS AND TOOLS

INTEGRATION OF URBAN PLANNING AND ENERGY SYSTEMS DESIGN PERSPECTIVES.

- SPATIAL AND TEMPORAL ANALYSIS WITH SUPPORT OF A GIS ENGINE: DATABASES AND STUDY OF CONSTRAINTS. **ARCGIS**



- ENERGY SYSTEMS OPTIMIZATION TOOL FOR PLANNING APPLICATIONS: **ENERGYPRO**



METHODS AND TOOLS

FASE I: CONSTITUTION OF A DEMAND MODEL

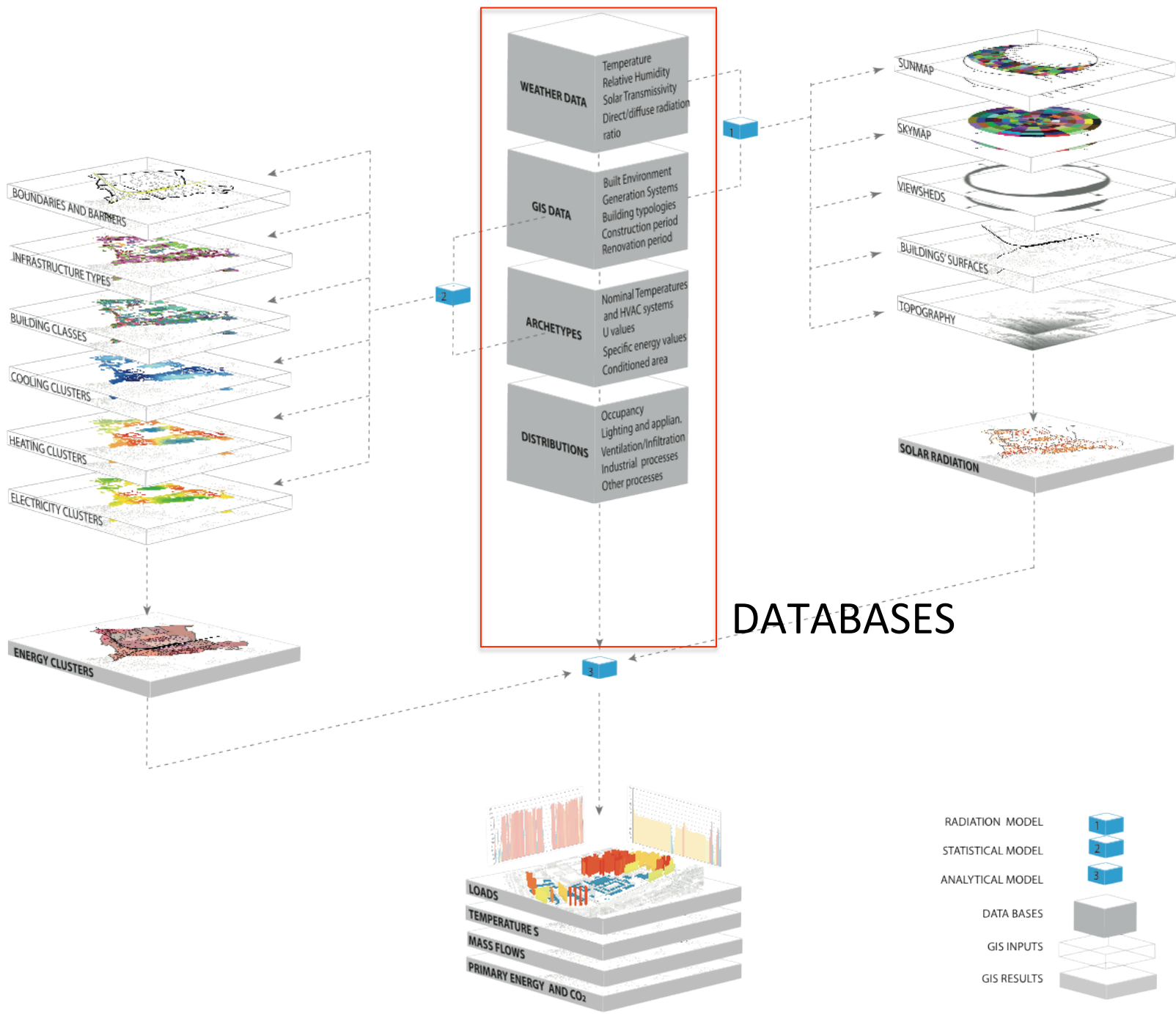
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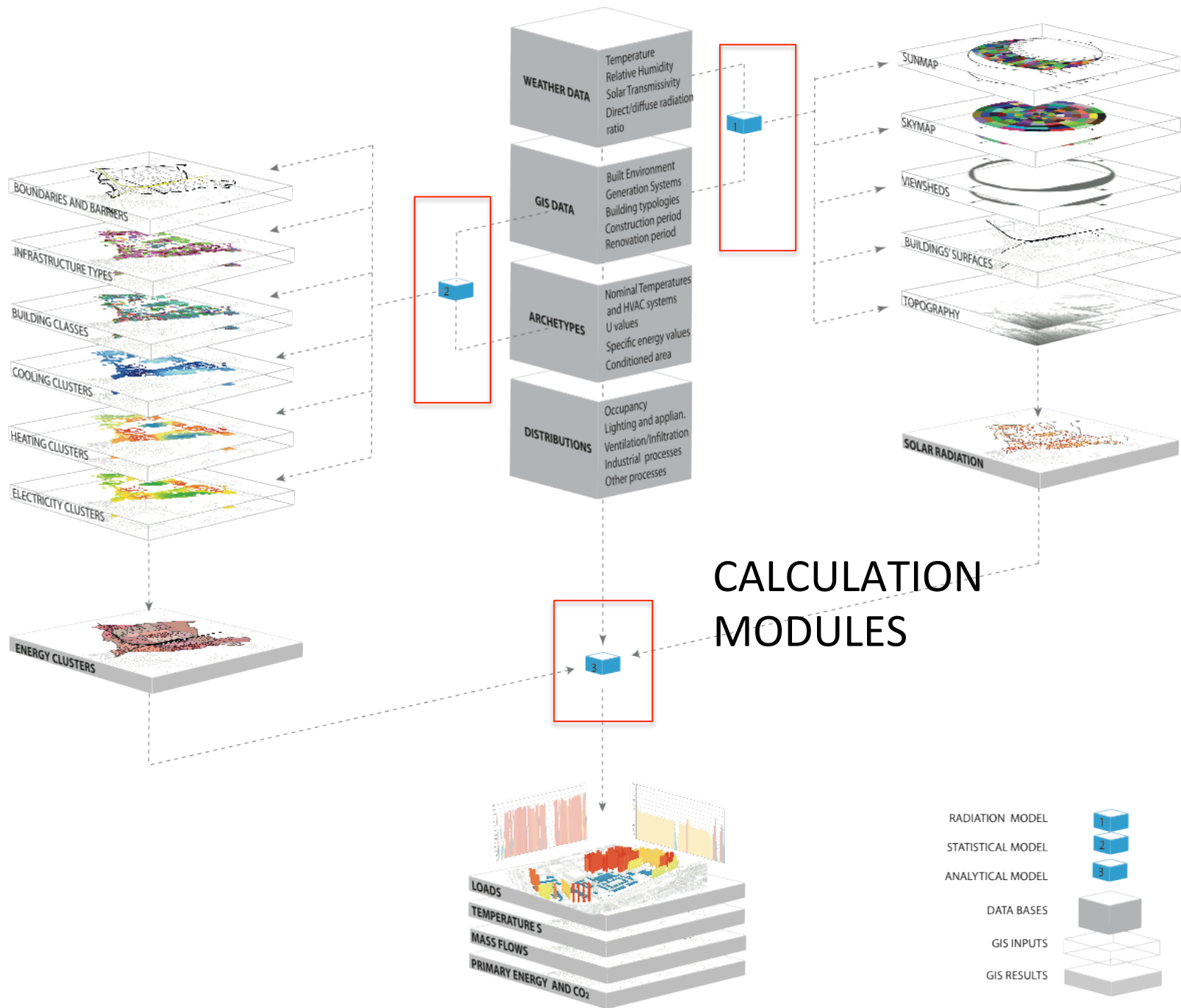
FASE II: CONSTITUTION OF A SUPPLY AND ENERGY SYSTEM OPTIMIZATION MODEL

FASE III: ASSESSMENT AND VALIDATION IN SELECTED CASE STUDIES

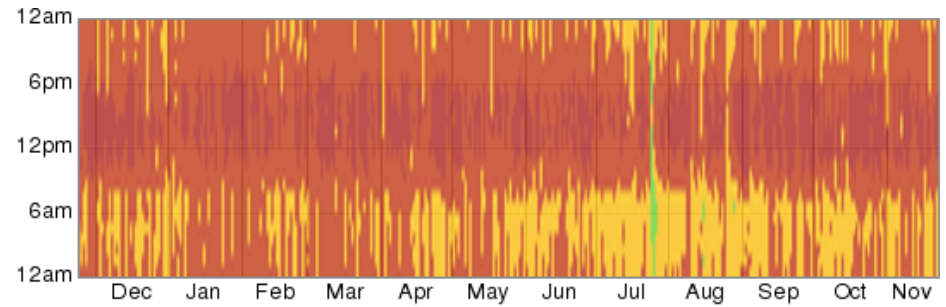
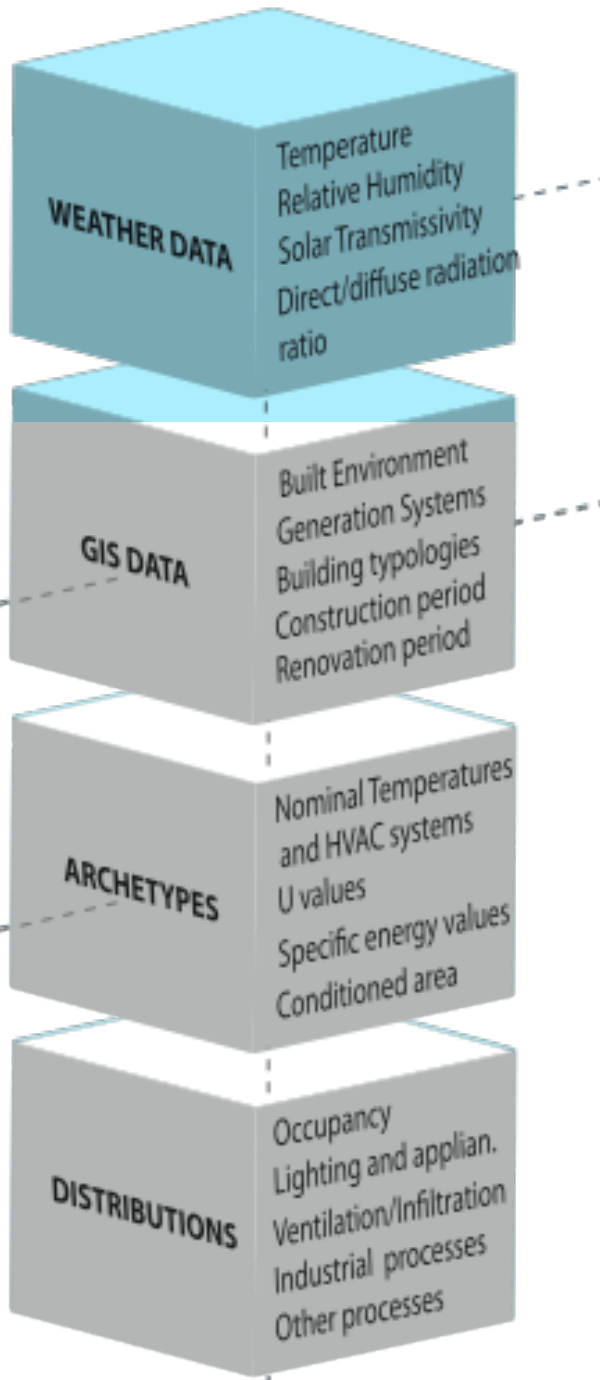
PART 2

A SIMPLIFIED ENERGY BUILDING MODEL FOR URBAN TRANSFORMATION

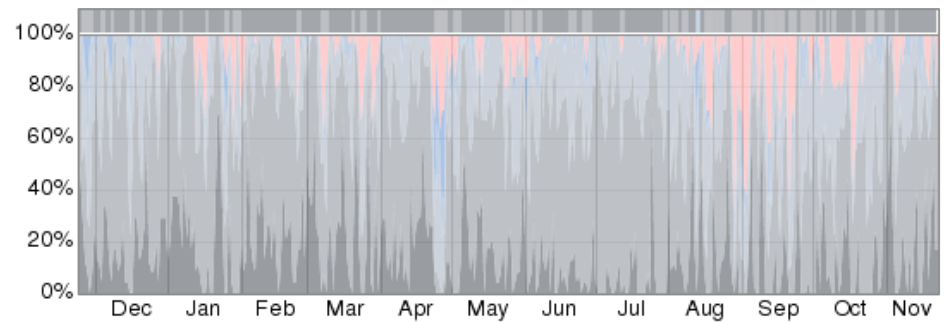




CONTENT



TEMPERATURE



DIRECT/DIFFUSE

CONTENT EXAMPLES

WEATHER DATA

- Temperature
- Relative Humidity
- Solar Transmissivity
- Direct/diffuse radiation ratio

GIS DATA

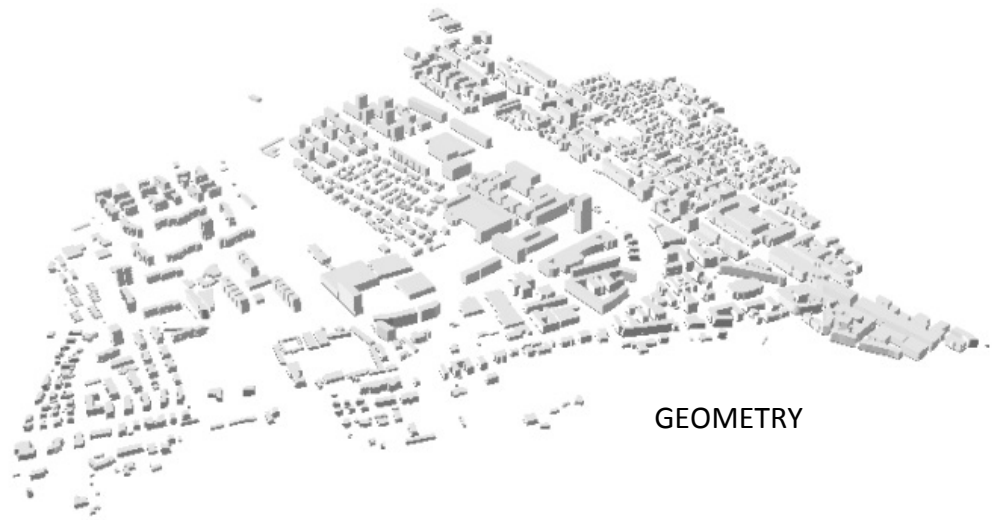
- Built Environment
- Generation Systems
- Building typologies
- Construction period
- Renovation period

ARCHETYPES

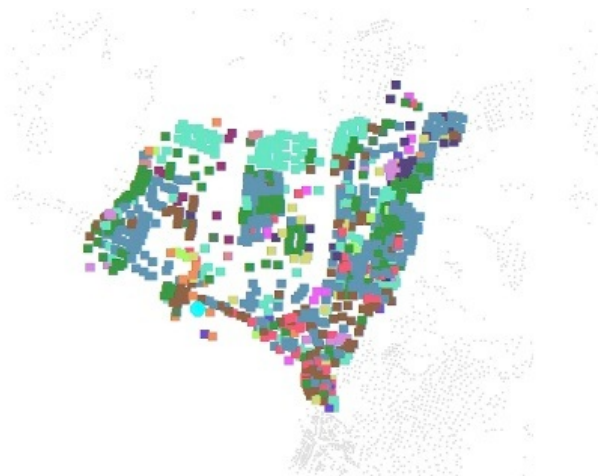
- Nominal Temperatures and HVAC systems
- U values
- Specific energy values
- Conditioned area

DISTRIBUTIONS

- Occupancy
- Lighting and applian.
- Ventilation/Infiltration
- Industrial processes
- Other processes



GEOMETRY



BUILDING TYPOLOGIES

TOPOGRAPHY

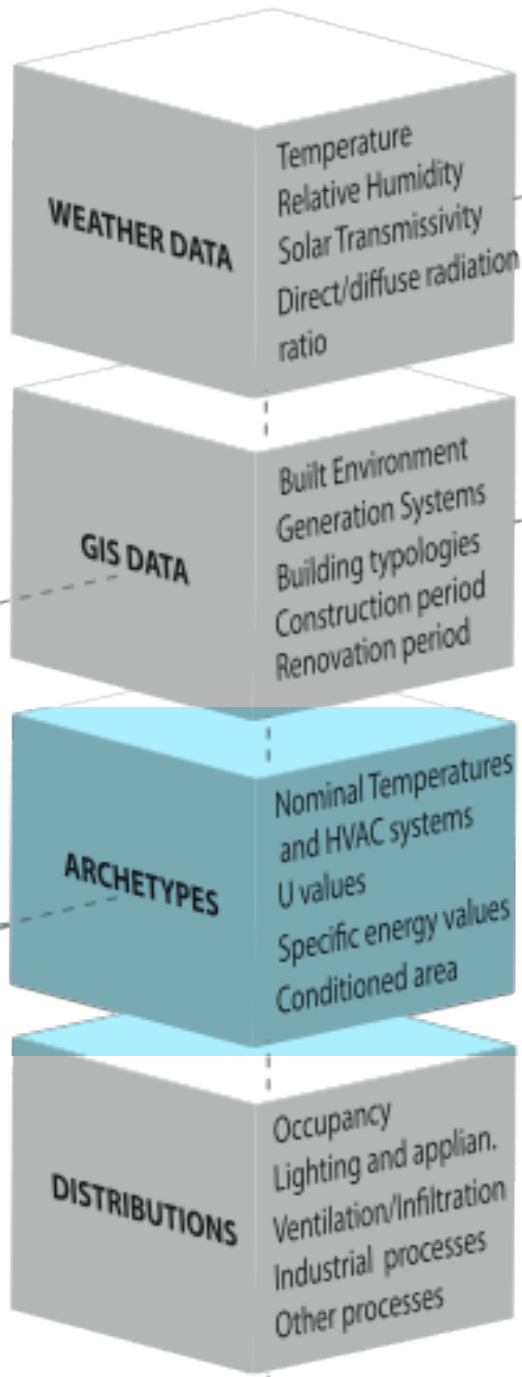
CONTENT EXAMPLES

Class	Period	Hs	Cm	Uw	Ur	Ub	Uwin
MDU1	1920	0.82	3	0.30	0.30	0.35	1.50
MDU2	1920-1970	0.82	2	0.30	0.30	0.35	1.50
MDU3	1970-1980	0.82	2	0.30	0.30	0.35	1.50
MDU4	1980-2005	0.82	2	0.30	0.30	0.35	1.50
MDU5	2005-2020	0.82	2	0.22	0.22	0.22	1.43
MDU6	2020-2030	0.82	2	0.18	0.18	0.18	1.24
MDU7	1920*	0.82	2	0.30	0.30	0.35	1.50
MDU8	1920-1970*	0.82	2	0.30	0.30	0.35	1.50
MDU9	1970-1980*	0.82	2	0.30	0.30	0.35	1.50
MDU10	1980-2005*	0.82	2	0.22	0.22	0.22	1.43

PROPERTIES OF BUILDING ENVELOPE

Class	Period	Esysh	tsh0	trh0	Esysc	tsc0	trc0
ADMIN1	1920	1	65	50	0	6	12
ADMIN2	1920-1970	1	65	50	3	6	12
ADMIN3	1970-1980	1	65	50	3	6	12
ADMIN4	1980-2005	1	65	50	3	6	12
ADMIN5	2005-2020	3	41.5	33.9	3	6	12
ADMIN6	2020-2030	3	39.6	32.3	3	6	12
ADMIN7	1920*	1	54.4	44.1	3	6	12
ADMIN8	1920-1970*	1	54.4	44.1	3	6	12
ADMIN9	1970-1980*	1	53.8	43.8	3	6	12
ADMIN10	1980-2005*	3	56.3	45.3	3	6	12

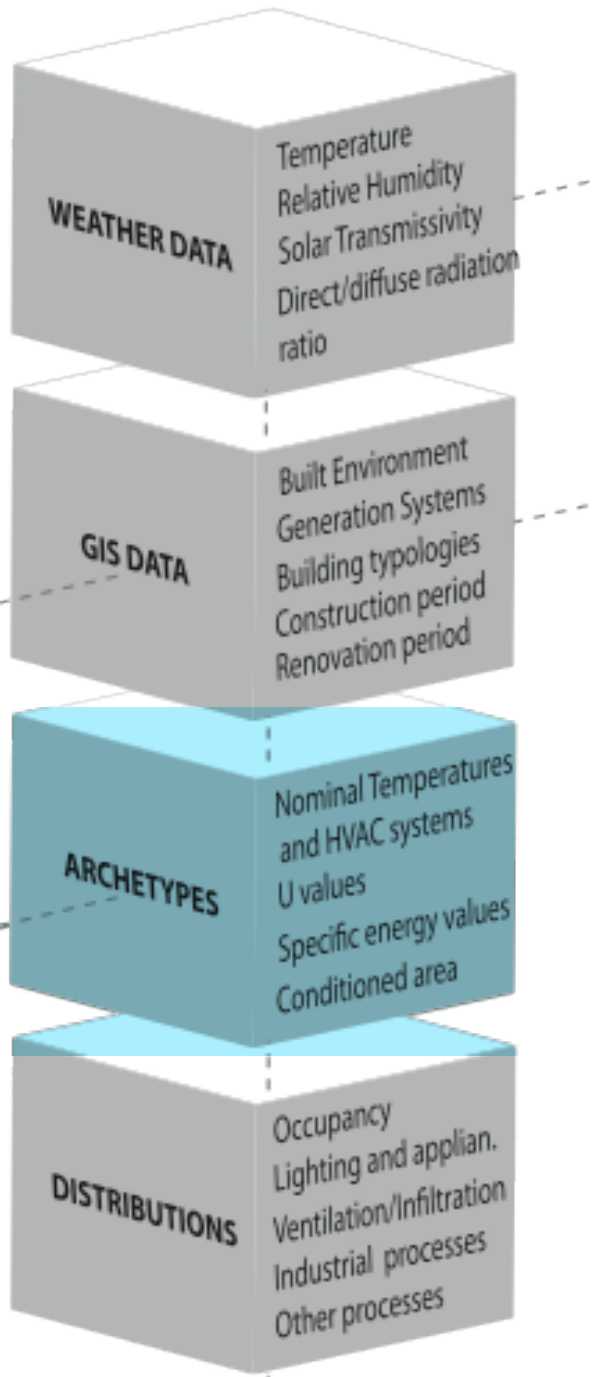
PROPERTIES OF HVAC SYSTEMS



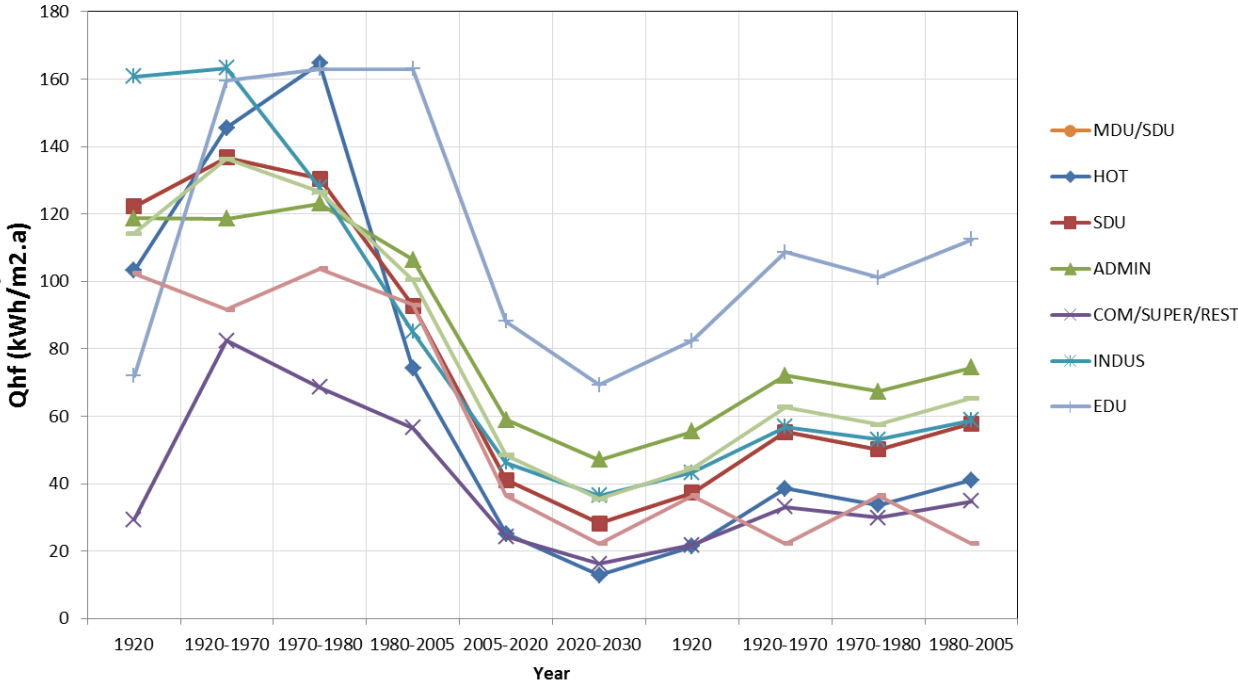
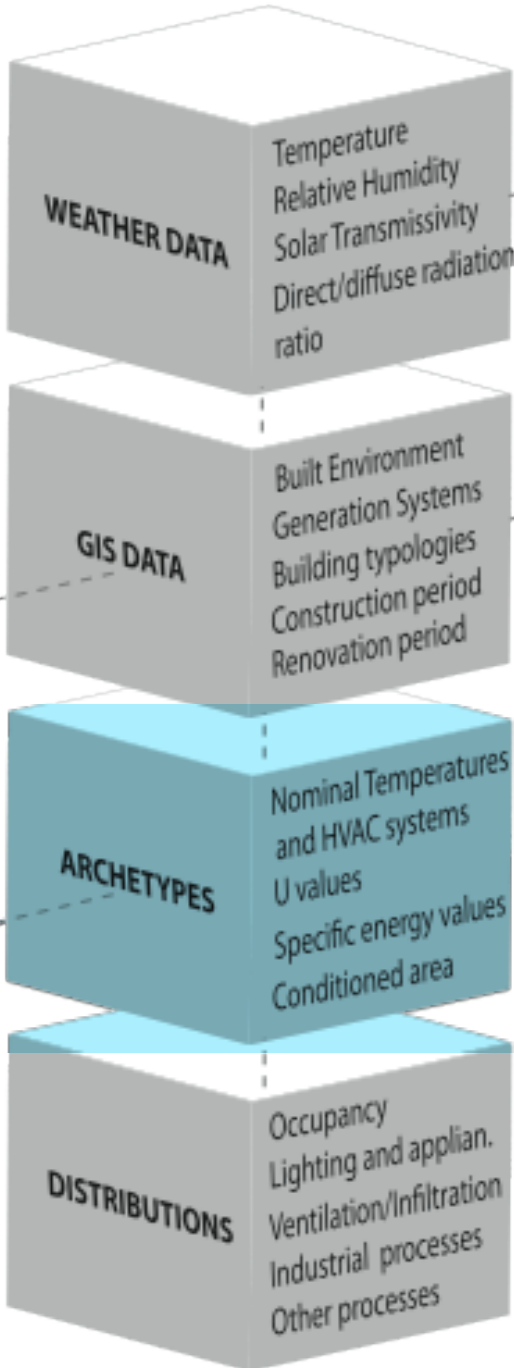
CONTENT EXAMPLES

Class	Period	q_k						E_k			
		hs	hp	w	cs	ci	cd	cp	al	d	p
INDUS1	1920	131	30	11	0.0	0.0	0.0	30	28	0	131
INDUS2	1920-1970	133	30	11	15.8	0.0	0.0	30	28	0	131
INDUS3	1970-1980	98	30	11	24.1	0.0	0.0	30	28	0	131
INDUS4	1980-2005	85	30	11	24.1	0.0	0.0	30	28	0	131
INDUS5	2005-2020	46	30	11	24.1	0.0	0.0	30	28	0	131
INDUS6	2020-2030	37	30	11	24.1	0.0	0.0	30	17	0	131
INDUS7	1920*	43	30	11	24.1	0.0	0.0	30	17	0	131
INDUS8	1920-1970*	57	30	11	24.1	0.0	0.0	30	17	0	131
INDUS9	1970-1980*	53	30	11	20.0	0.0	0.0	30	17	0	131
INDUS10	1980-2005*	59	30	11	18.5	0.0	0.0	30	17	0	131

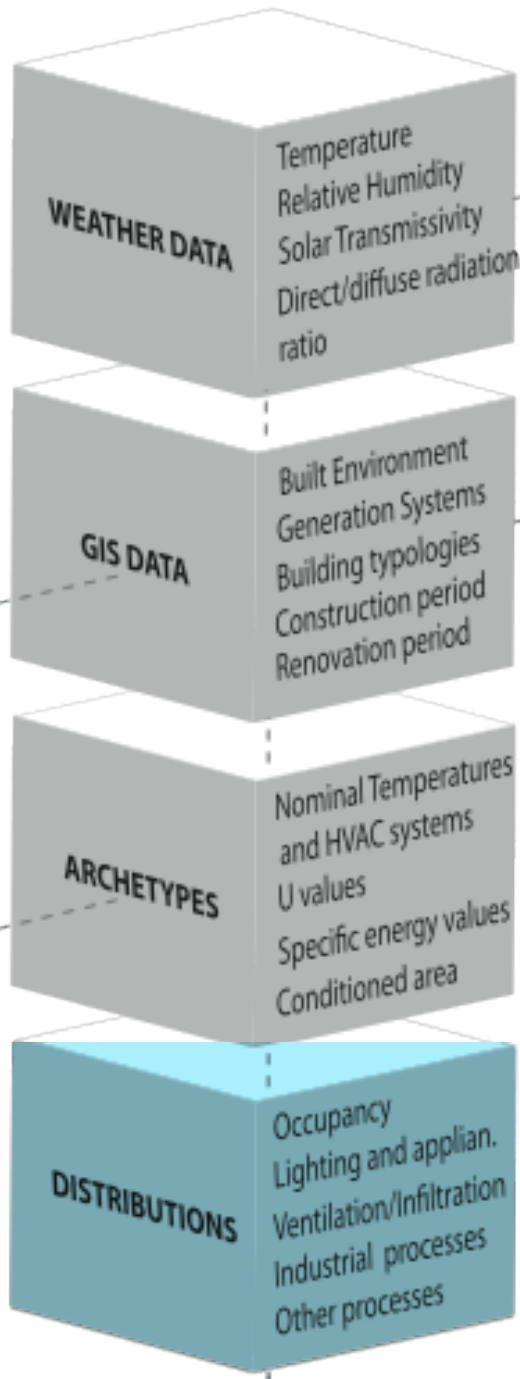
SPECIFIC ENERGY VALUES SWISS BUILDING STOCK - INDUSTRY



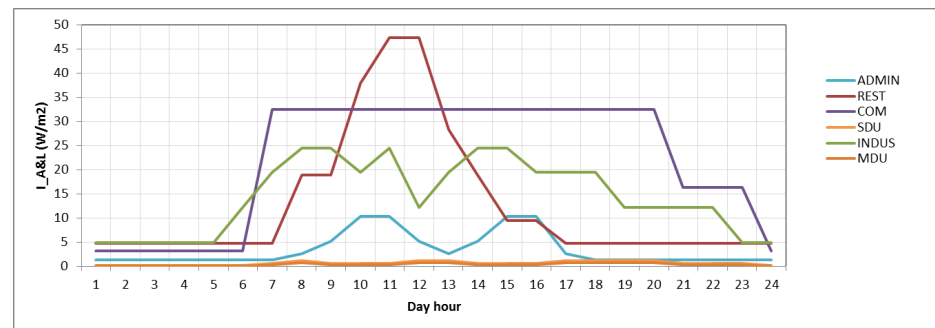
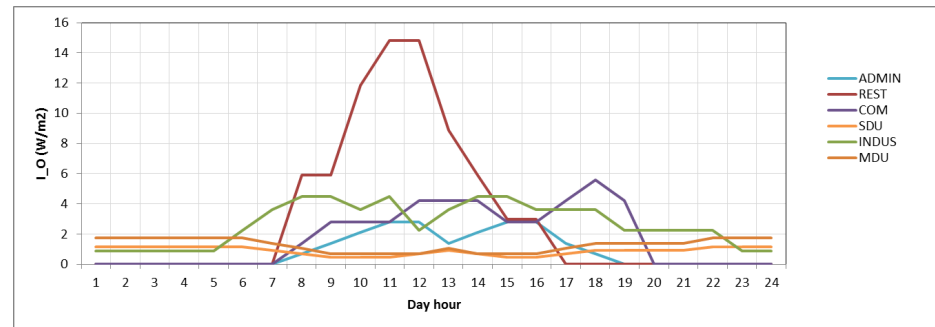
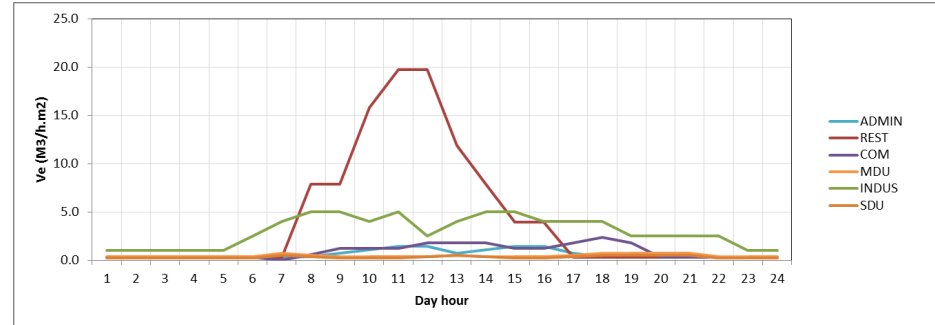
CONTENT EXAMPLES

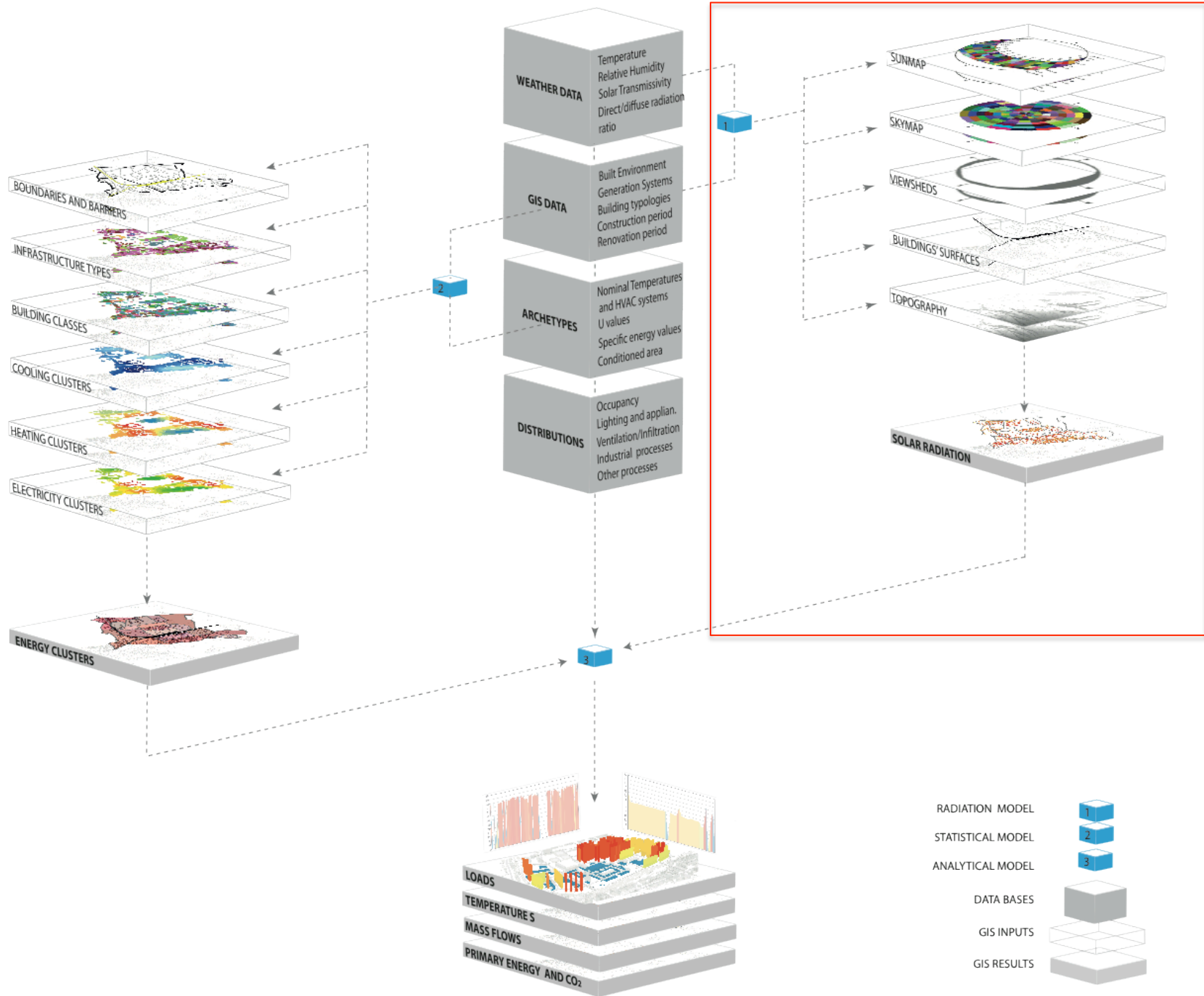


SPECIFIC ROOM HEATING YEARLY CONSUMPTION

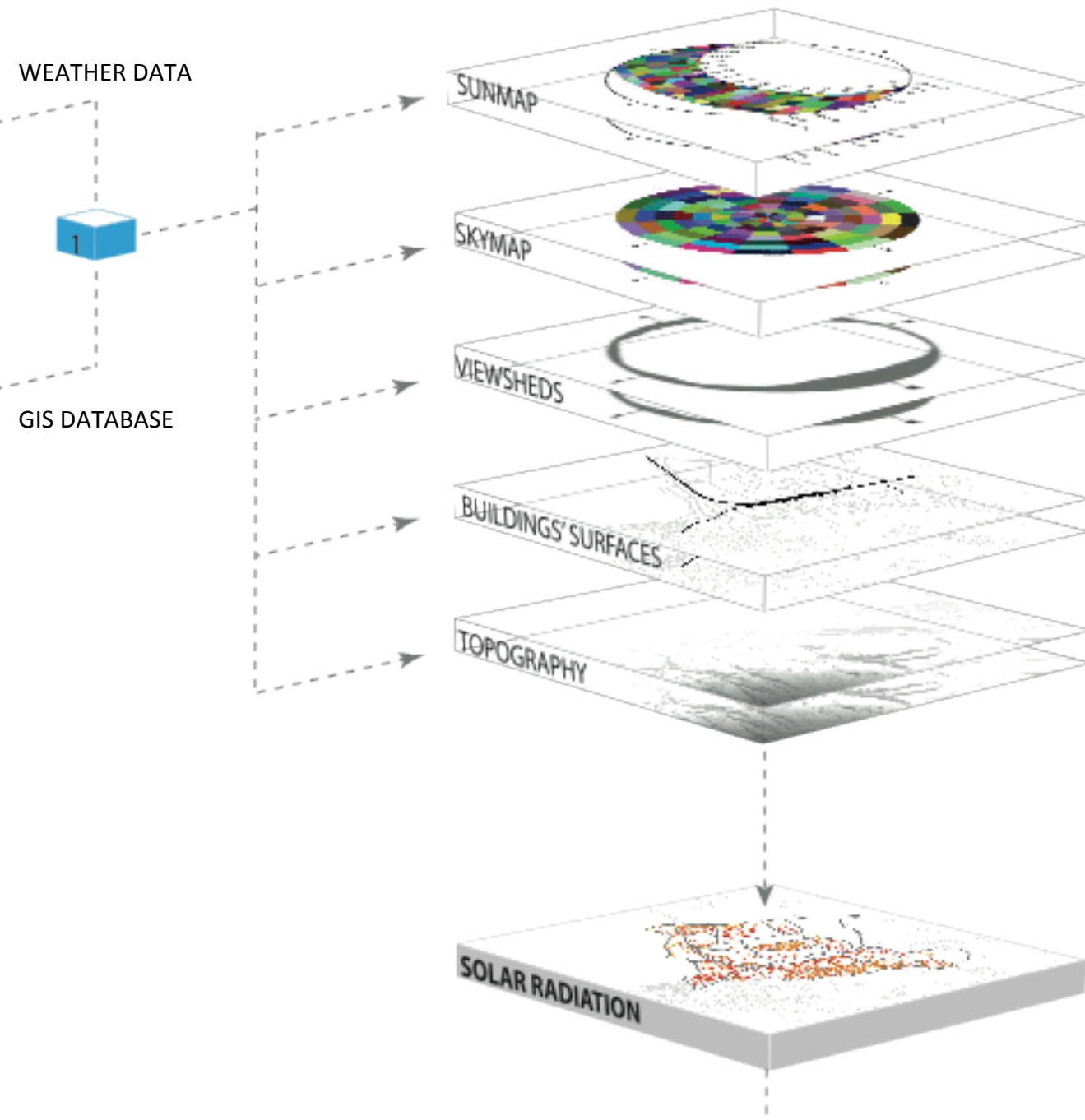


CONTENT EXAMPLES

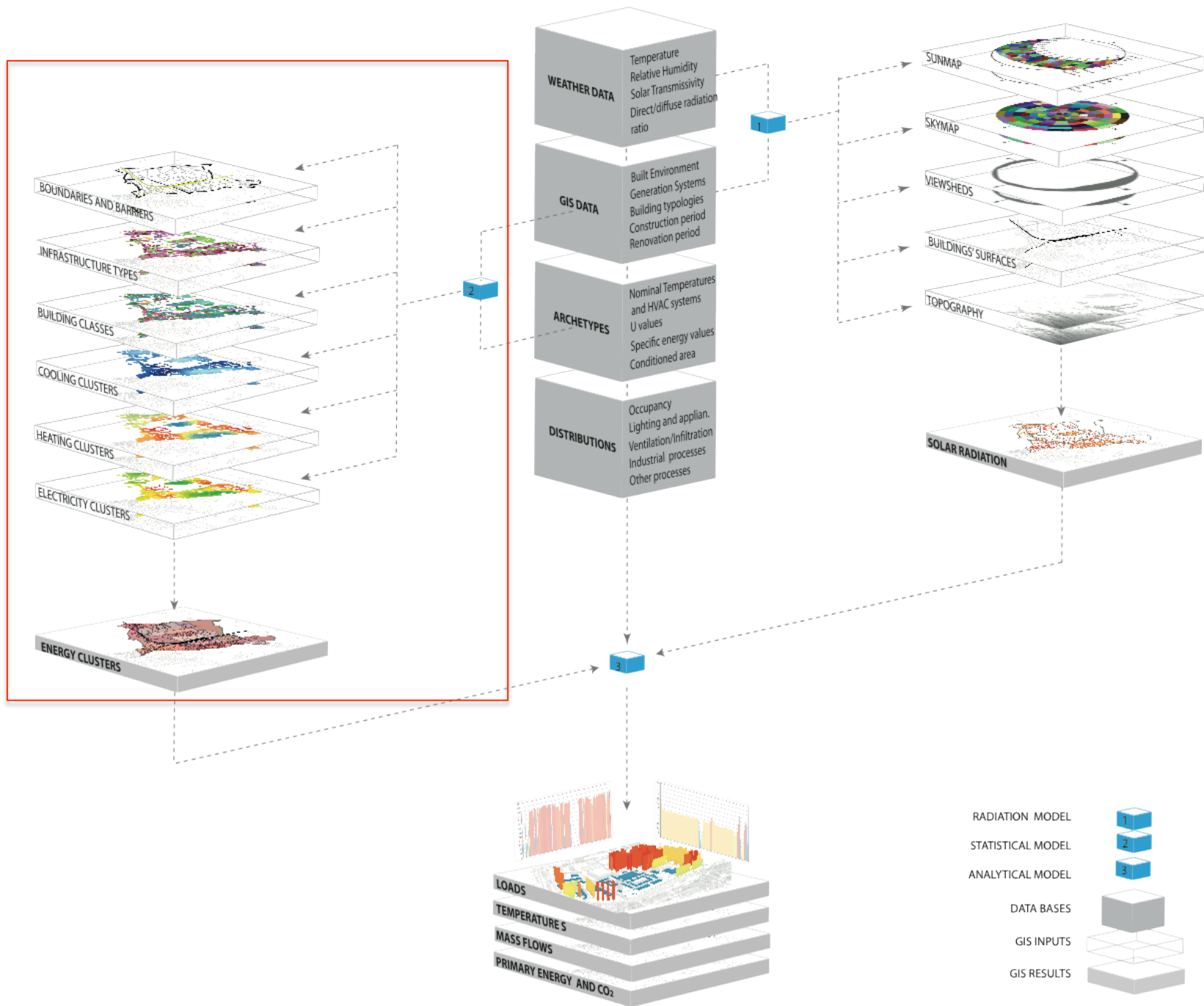




SOLAR RADIATION MODULE



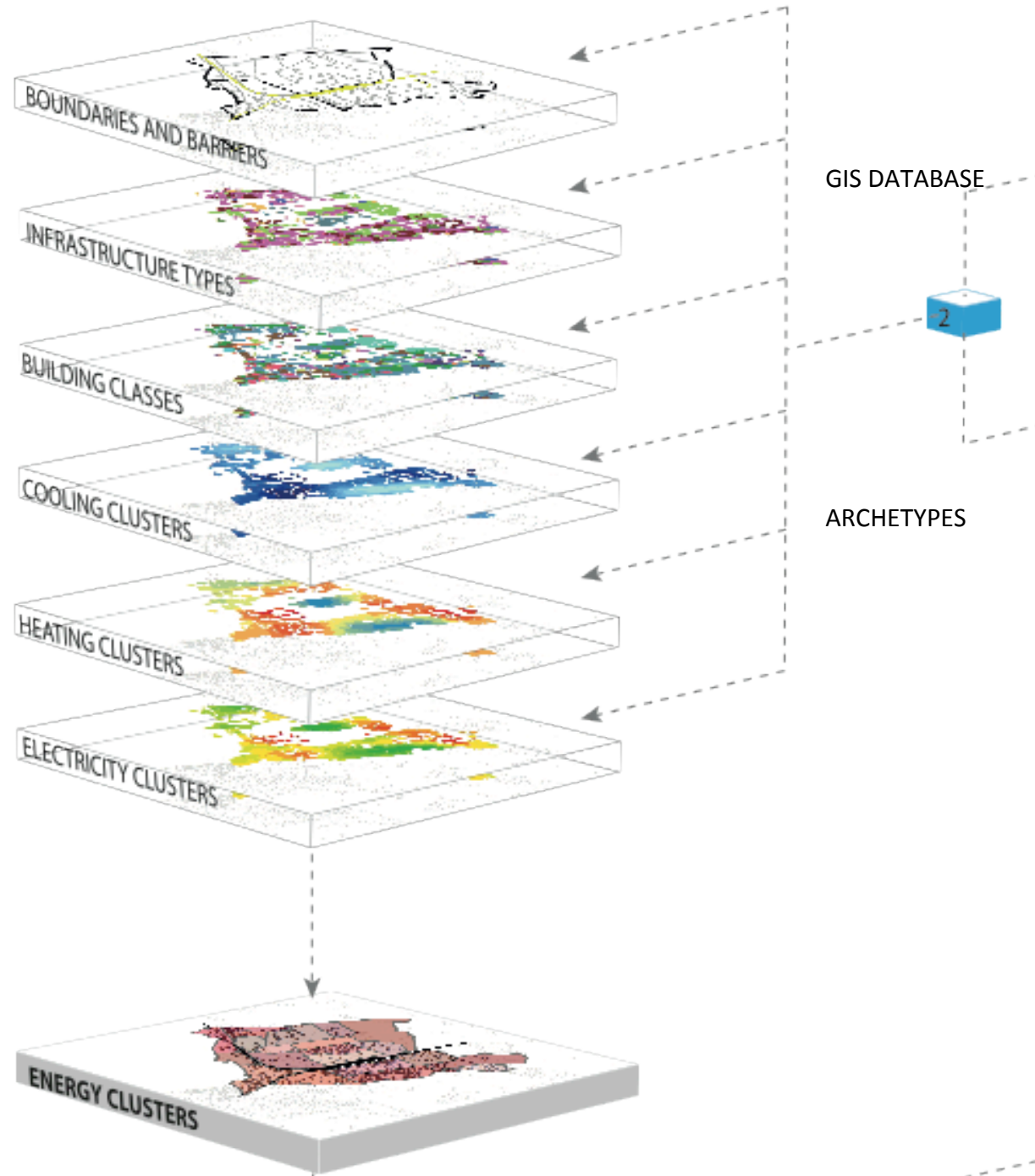
Calculation of solar Isolation in vertical surfaces of buildings



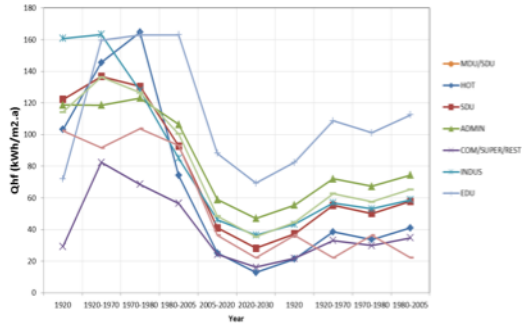
STATISTICAL MODULE

Statistically-driven
calculation of energy
demand in a building
basis

Statistically significant
clustering of buildings
with similar energy
systems



STATISTICAL MODULE



ARCHETYPES
ENERGY VALUES (q in kWh /m2)

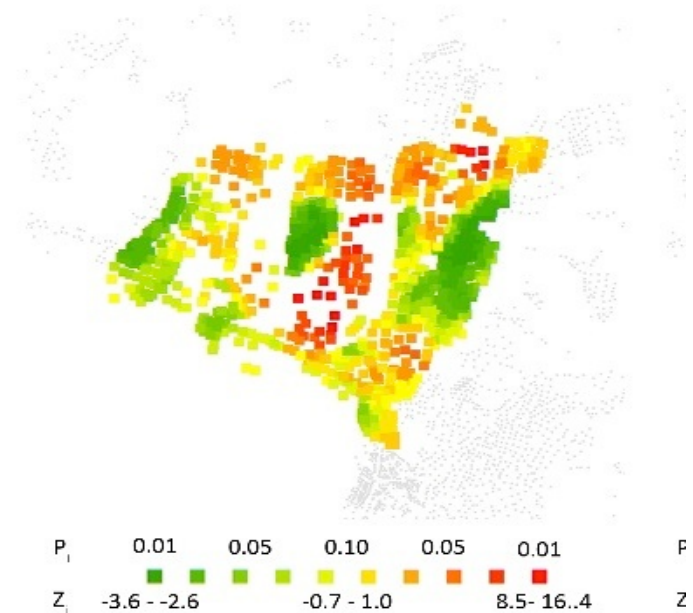
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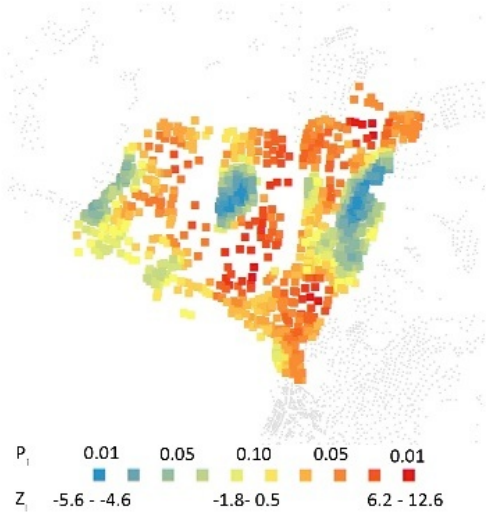
BUILDING TYPES
% OF CLASS
HEATED AREA (Ae)

$$E_i = Ae_i * \sum_{j=1}^n q_{k,j} * \%class_{j,i}$$

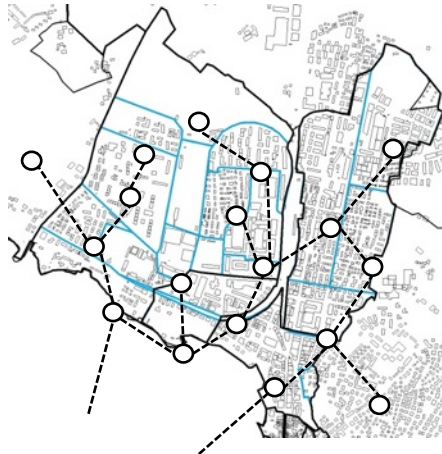
$$G_i^* = \frac{\sum_{x=1}^n w_{i,j(dc)} x_j - \bar{x} \sum_{j=1}^n w_{i,j(dc)}}{S \sqrt{\frac{n \sum_{j=1}^n w_{i,j(dc)}^2 x_j - (\sum_{j=1}^n w_{i,j(dc)})^2}{n-1}}}$$



STATISTICAL MODULE

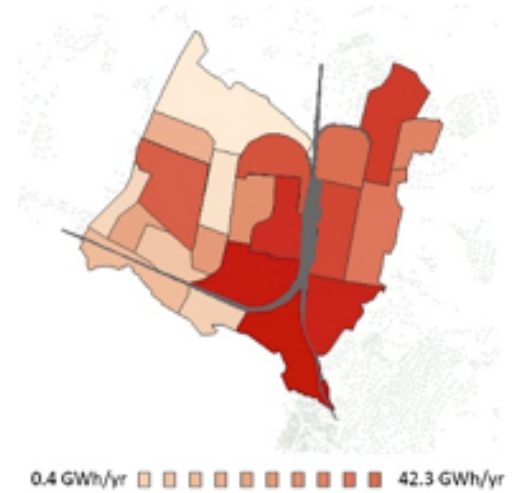


HOT SPOT ANALYSIS

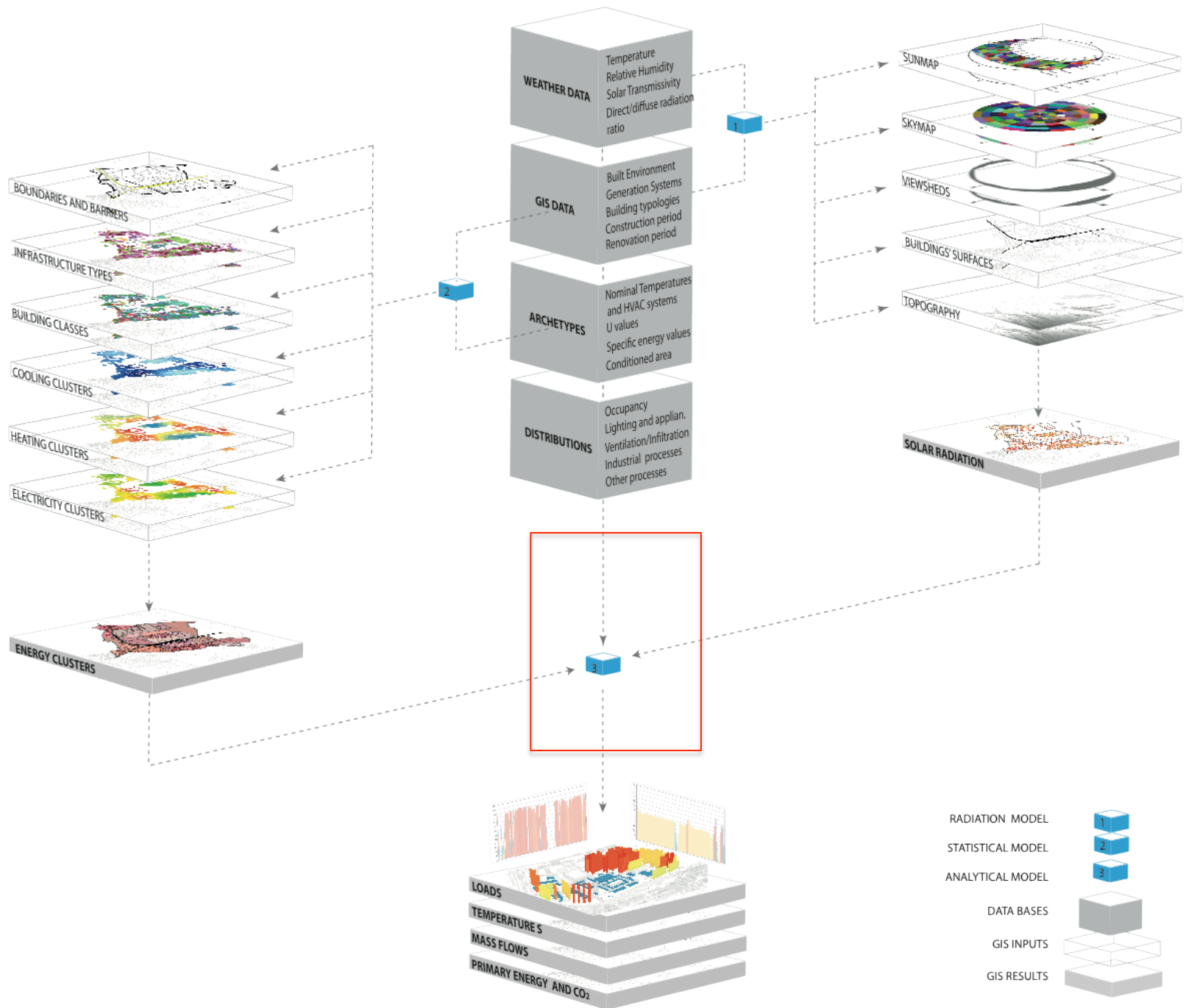


NODE-LINK ANALYSIS

ADVANTAGES OF CLUSTERING



STUDY OF SOLUTIONS
IN A ZONE BASIS



ALL DATABASES RELATING
PROPERTIES OF BUILDINGS AND
HVAC

CLUSTERS AND
STATISTICAL YEARLY
DEMANDS

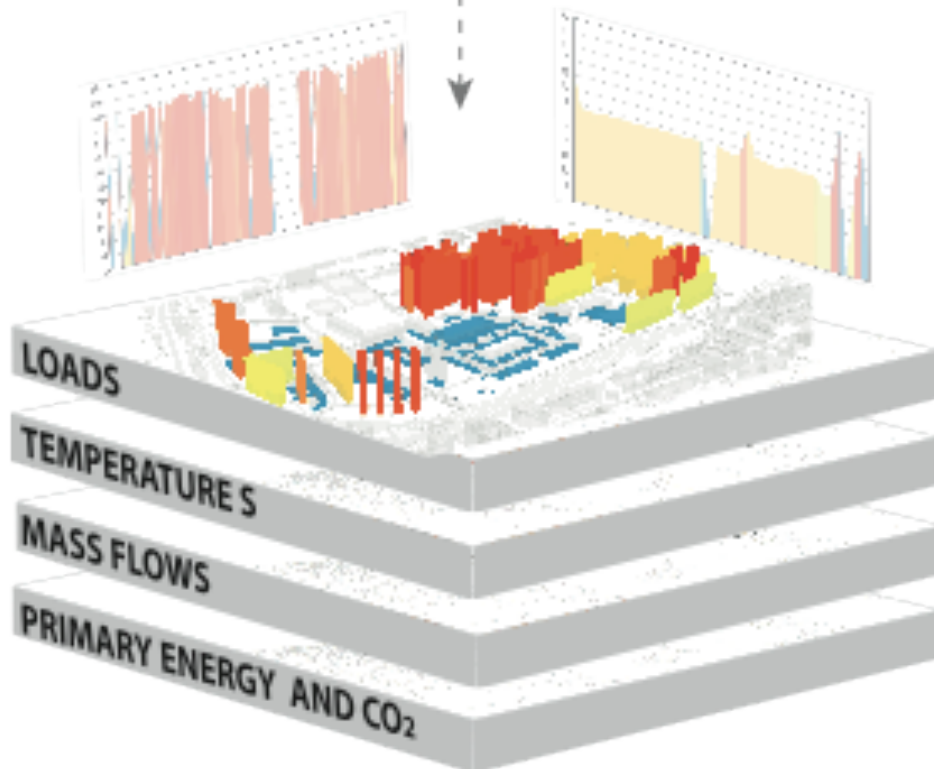


SOLAR RADIATION IN BUILDINGS
SURFACES SURFACES

ANALYTICAL MODULE

ENGINE for Dynamic modeling
of energy loads in buildings
according to EN Standards.

- + accounting for system losses,
auxiliary loads
- + Calculation of fresh water
based on standard values
- + TRNSyS HVAC systems. To
model temperature assuming a
constant flow.



COMPARISON WITH MEASURED DATA



Mean error per energy service

4% to 20%

Other models:

33% to 103%

Rager et al., 2013 [26 in CitySim [27] and the traditional energy signature models [2] respectively.

SOME APPLICATIONS

KTI PROJECT INDUCITY:

SUSTAINABLE TRANSFORMATION OF AN INDUSTRIAL CITY QUARTER



SIEMENS



HSR
HOCHSCHULE FÜR TECHNIK
RAPPERSWIL
FHO Fachhochschule Ostschweiz



ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



NSSI

Natural and Social Science Interface

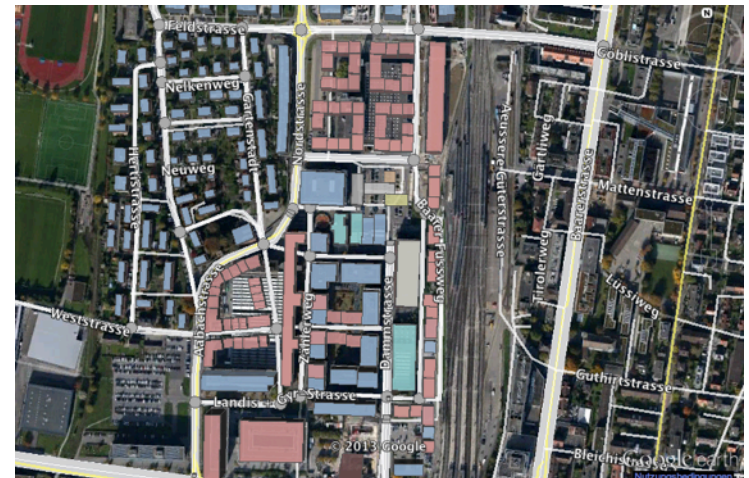


SuAT

Architecture & Sustainable Building Technologies
Prof. Dr. Anno Schlüter

SOME APPLICATIONS

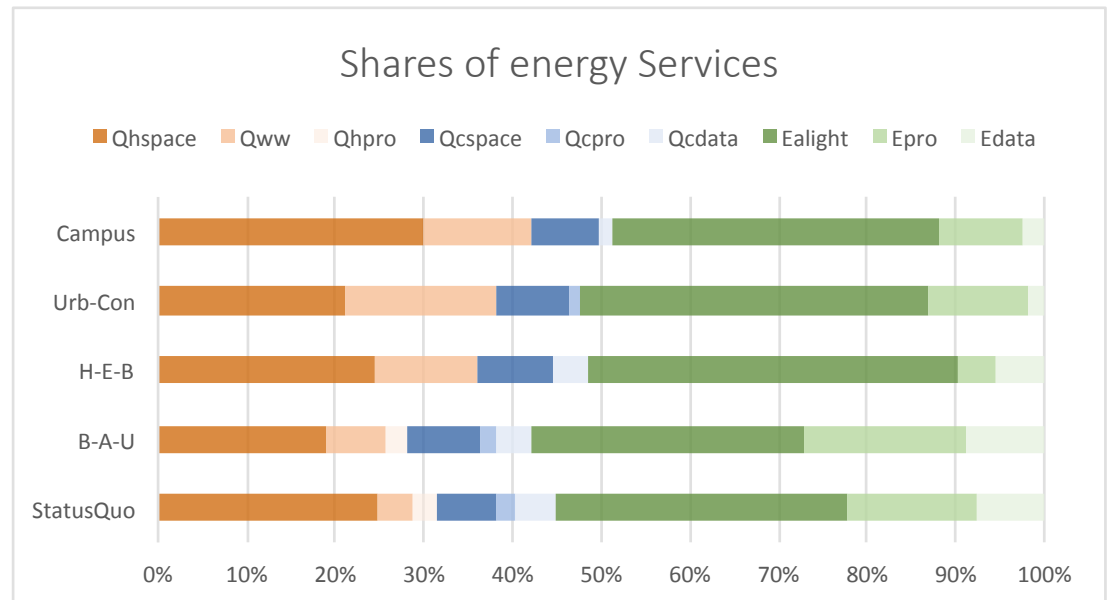
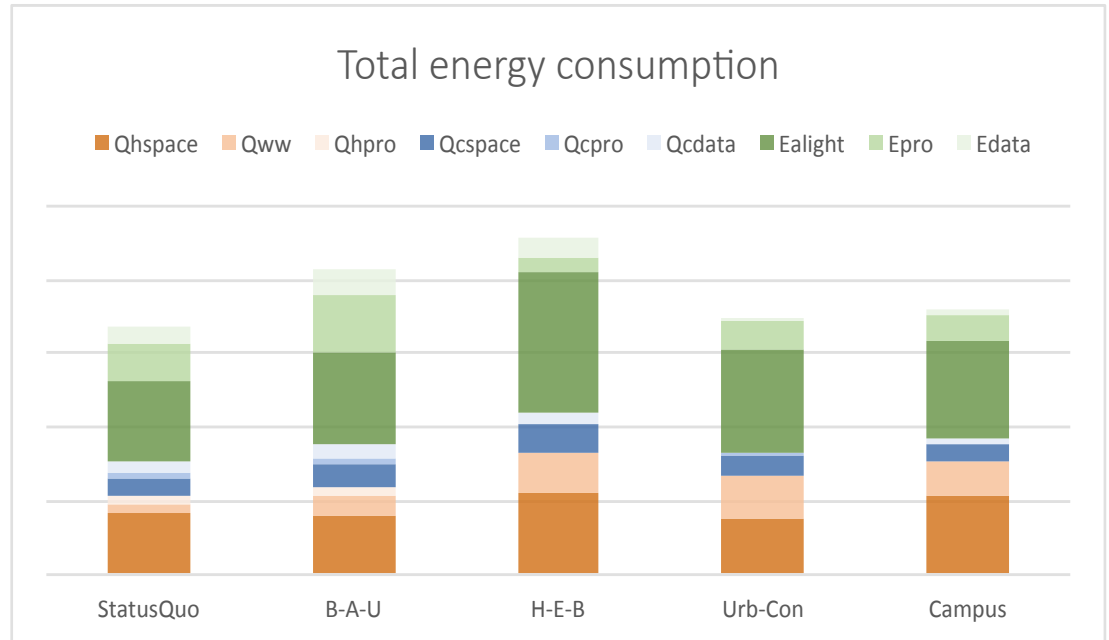
FOUR SCENARIOS WITH DIFFERENT BUILDING TYPOLOGIES AND INDUSTRIES.



SOME APPLICATIONS

Are the planned retrofit measures
Effective from scenario to
scenario?

Could there exist synergies for use
of waste heat?

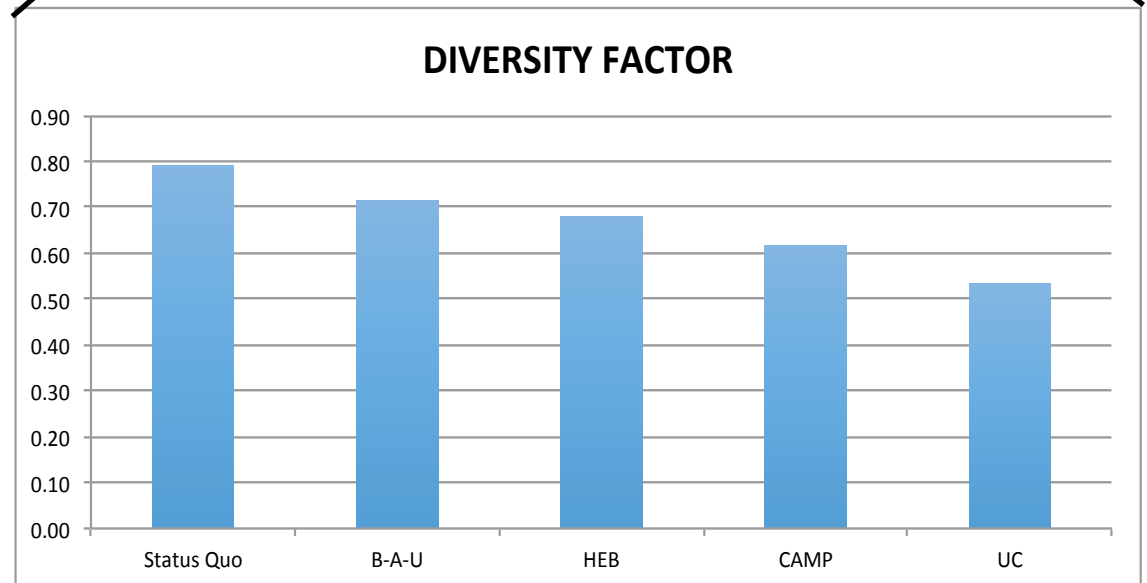
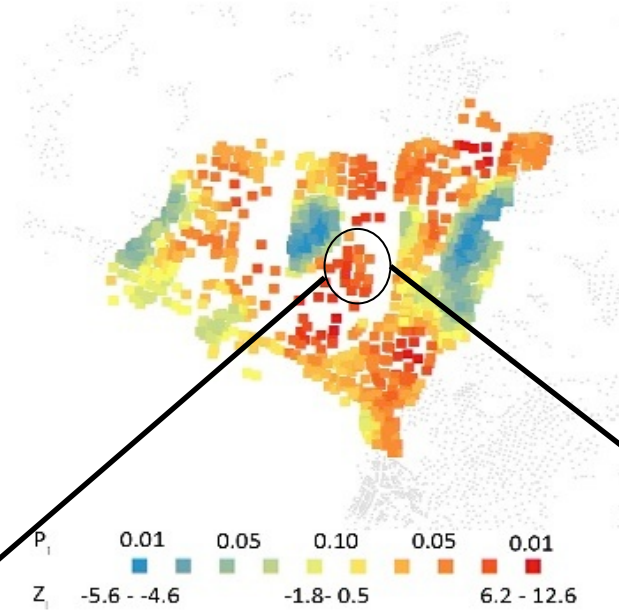


SOME APPLICATIONS

Which scenario would benefit in terms of capacity installed, the use of a district heating network?

What happens if I connect other zone from the surroundings?

What happens if I connect other zone from the surroundings?



CONCLUSIONS

A new model for description of spatio-temporal patterns of energy demand is introduced.

An emphasis is given to describe those characteristics necessary to assess new technologies for conversion of energy.

Its simple, presents high accuracy, but still has to be furthermore validated.

Its applications rely widely in the fields of urban and energy planning.

FUTURE WORK

To run more case studies to validate furthermore the model.

To publish and open-source part of the material.

To develop an energy system optimization model.