ELISE action
Webinar Series

Data-driven methodology for electricity characterisation of districts

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European Location Interoperability Solutions for e-Government

Enabling Digital Government through Geospatial and Location Intelligence

ISA²

What is ELISE?

A BIT OF HISTORY...

2004
IDABC: Interoperable Delivery of European eGovernment Services

2010
ISA: Interoperability solutions for public administrations

- **Actions**:
  - EULF
  - ARE3NA

2016
ISA²: Interoperability Solutions for European Public Administrations, Businesses and Citizens

- ELISE

2021
DIGITAL: Digital Europe Programme

ELISE builds upon the outcomes of the former ISA actions EULF and ARE3NA. It is the only action of the ISA² Programme, aiming to improve Digital Government through Location Interoperability.

WHAT?

ELISE stands for **E**uropean **L**ocation **I**nteroperability **S**olutions for e-Government. It is one of the more than 50 actions in the European Interoperability Programme ISA2

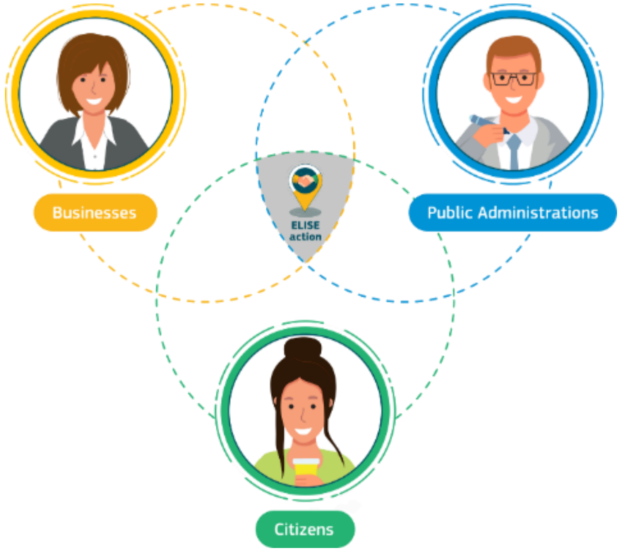
WHAT FOR?

To support Digital Government Transformation by making the best use of location data and technologies in an interoperable manner

FOR WHOM?

For all: citizens, businesses and public administrations

Location-enabled Digital Government Transformation



ELISE action objectives

ELISE action

Policy support

Supporting different policy initiatives at European and national levels

Emerging trends and technologies

Discovering how emerging trends and technologies enable more effective use of location data for policy and digital public services

Interoperable frameworks and solutions

Providing reusable interoperable cross-border and cross-sector frameworks and solutions for public administrations, business and citizens

Building a Knowledge base

Building a Geo-Knowledge base to inform and train stakeholders and promote the adoption of good practices and innovations in location data

ELISE outputs and topics

STUDIES

APPLICATIONS

FRAMEWORKS AND SOLUTIONS

GEO KNOWLEDGE BASE SERVICE

- Evolution of Spatial Data Infrastructures
- Support of data ecosystems
- Technologies for location -enabled innovation
- Collaboration models
- Spatial skills for Digital Government Transformation
- Location data privacy
- Improving access to spatial datasets
- Supporting cross-border and cross-sector data sharing
- Location intelligence for policy and digital public services
- Supporting innovation, growth and Return of Investment
- Managing data quality
- Supporting the creation of common EU public services

5 Years

SOME ACHIEVEMENTS

Active engagement of ISA² Member States

- Complemented the EIF and NIFO with an extensive location interoperability framework and state of play assessments
- Helped put the INSPIRE Directive into practice with tools for data providers and a strong focus on use cases
- Built an extensive community of European and international stakeholders
- Raised awareness on new approaches to location-enabled digital transformation
- Helped to assess the role of SDIs in evolving business models, e.g. data ecosystems, digital platforms.
- Assessed new policies (e.g. GDPR, European Data Strategy) and technologies (e.g. Artificial Intelligence, Blockchain, API...)
- Promoted and facilitated better links on location data between public and private actors
- Provided guidance on improving spatial awareness and analytical skills for best use of data

3 EIF Toolbox solutions

Aims of Knowledge Transfer

European Commission

Our speakers

Gerard Mor
Data Scientist - CIMNE (International Center for Numerical Methods in Engineering), and BEE Group (Building Energy and Environment Group)

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Group leader - CIMNE (International Center for Numerical Methods in Engineering), and BEE Group (Building Energy and Environment Group)

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The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

What we will cover today

1. Introduction to ELISE Energy & Location Applications
2. State of the art data-driven methodologies and technologies for electricity characterisation of districts
3. How these methodologies and technologies may support the business of start-up companies?
4. How these methodologies and technologies may support urban planning and energy efficiency policies of a Regional Government?
5. Urban energy simulation supporting the Local Digital Twins toolbox
6. Key messages, challenges and future outlook

Q&A

1

Introduction to ELISE Energy & Location Applications

ELISE has developed cross-border pilots and applications to test location data interoperability principles in the following sectors:

APPLICATIONS

MARINE

Supporting Member States in the management of Marine Strategy Framework Directive (MSFD) related spatial information

https://youtu.be/ROJqljr8aDU

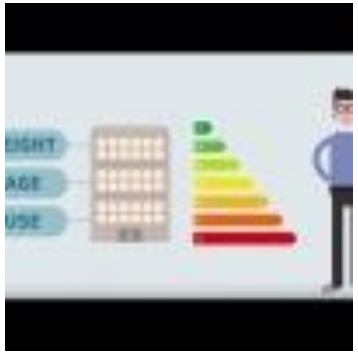
TRANSPORT

Developing and sharing best practices for the implementation of the Intelligent Transport Systems (ITS) Directive

https://www.youtube.com/watch?v=jnny5ATwTYE

ENERGY EFFICIENCY

Supporting public administrations, businesses and citizens engaged in energy policies' cycle



https://www.youtube.com/watch?v=Ftgy8uU9y2A

CULTURAL HERITAGE

Exploiting a pan-European gazetteer service

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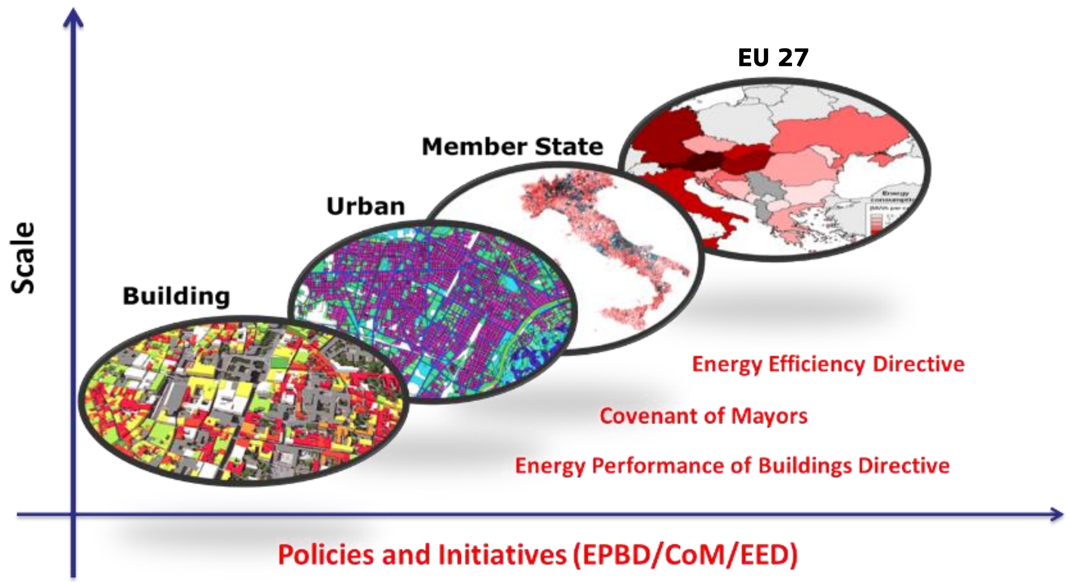
Location data interoperability principles and methodologies applied in the Energy Efficiency sector (1/3)

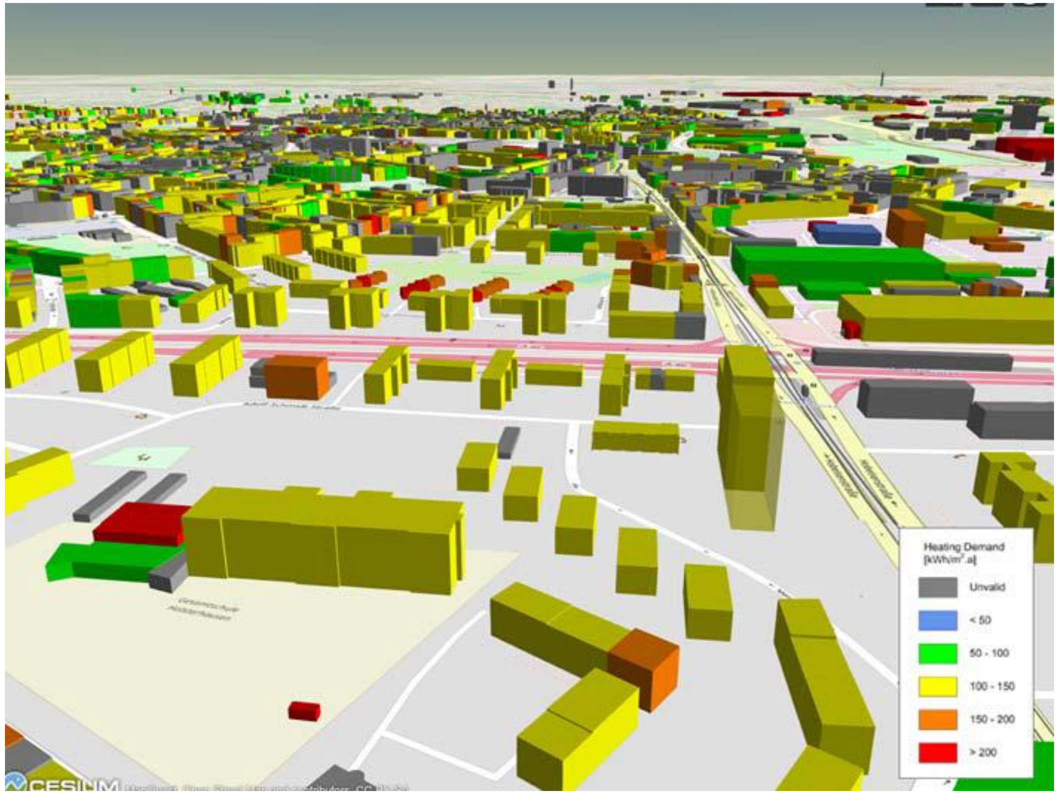


- To leverage location data at building level as an enabling factor to scale-up a set of methodologies to assess energy efficiency from local to district/city level and beyond.
- To use location-based data to support different types of stakeholders engaged in energy efficiency policies' cycle

Location data interoperability principles and methodologies applied in the Energy Efficiency sector (2/3)

- Buildings are responsible for the 40% of final energy consumption
- Over 75% of building stock is older than 25 years
- Averaged final energy consumption data: 185 kWh/m^2 for residential buildings and 280 kWh/m^2 for non-residential buildings
- Extensive renovation of buildings could cut 36% of their energy consumption by 2030

Location data interoperability principles and methodologies applied in the Energy Efficiency sector – <u>use cases</u> (3/3)

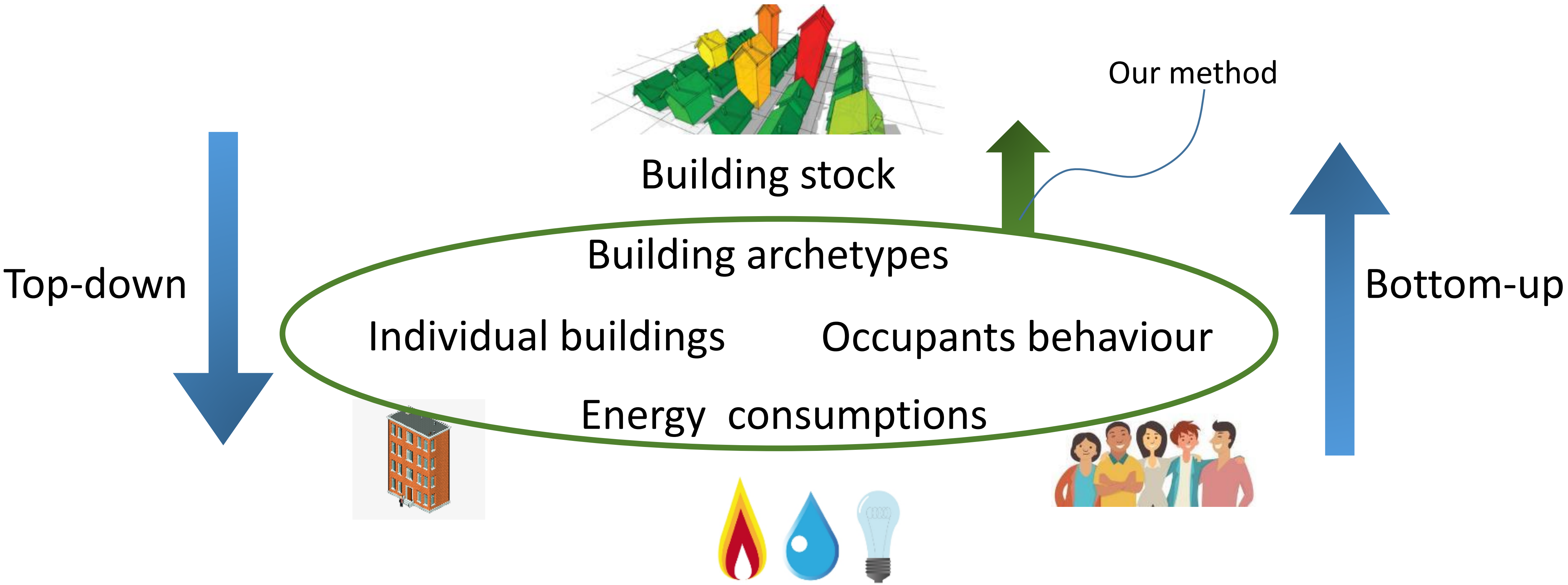


- Generalisation at EU level of a digital platform for public lighting being implemented in Italy in 8.000+ Municipalities
- Energy Performance Certificates (EPC) of Buildings harmonisation
- Harmonisation of SECAP (Sustainable Energy and Climate Action Plans), to support smart communities made by 100+ municipalities of the same Province, CoM signatories
- Harmonisation of energy simulations to assess the energy heat demand of buildings
- Assessment of energy performance of buildings using energy consumption data from smart meters.
- Role of geospatial information in a regional energy strategy

2

State of the art data-driven methodologies and technologies for electricity characterisation of districts

State of the art



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Data requirements

Case study source

- High frequency electricity consumption

datadis

- Building‘ area
- Building‘ uses

Sede Electrónica del Catastro

- Weather data

Dark Sky

Optional data requirements

Case study source

- Building‘ year of construction
- Building‘ volume

- Socioeconomic indicators
  - Amount of annual incomes and sources
  - Number of people per household
  - Gini index
  - Population age

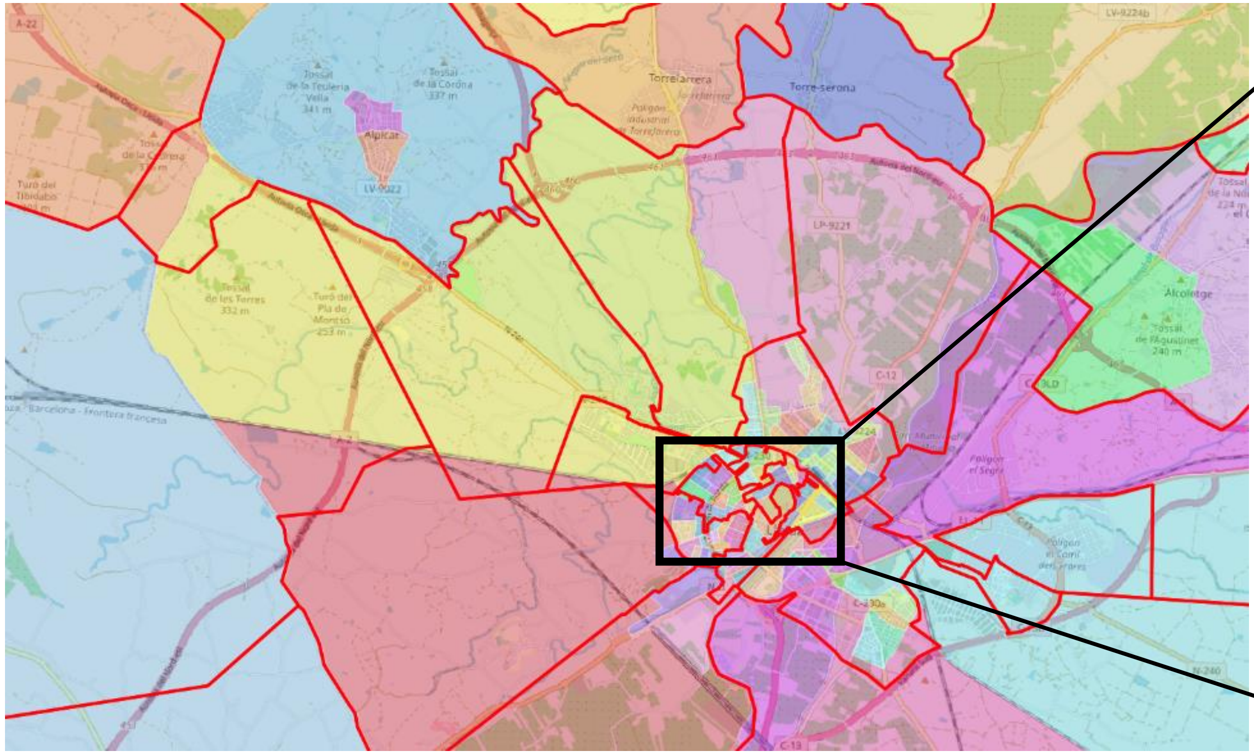
Sede Electrónica del Catastro

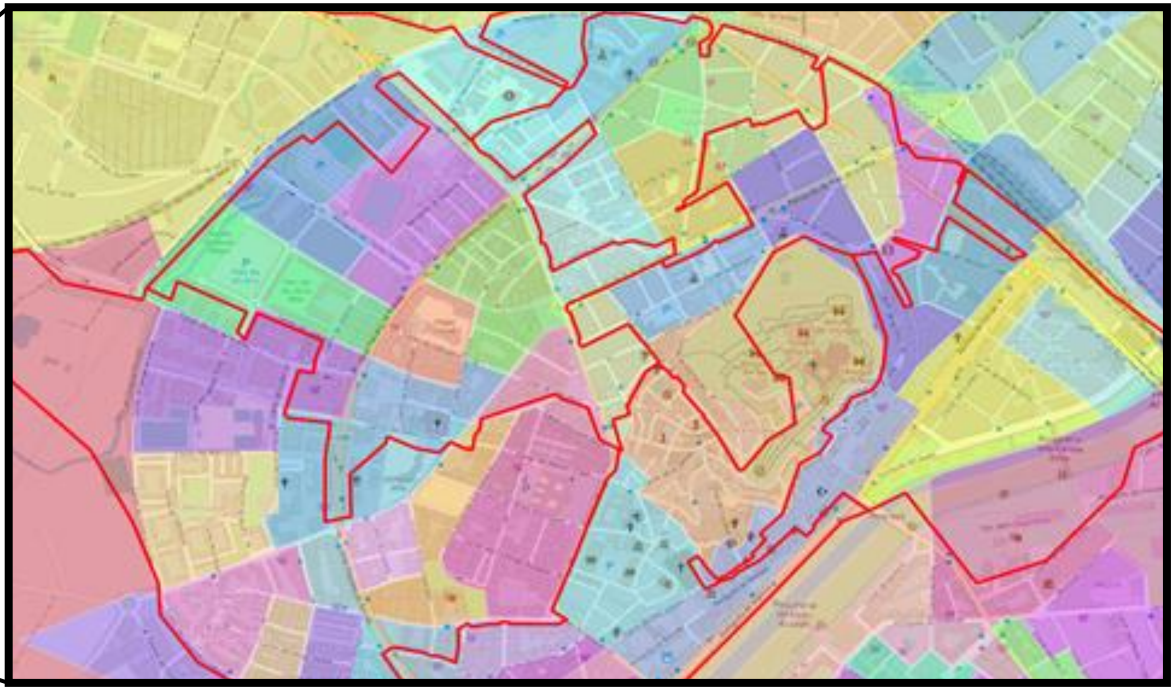
INE Instituto Nacional de Estadística

experimental

Geographical levels

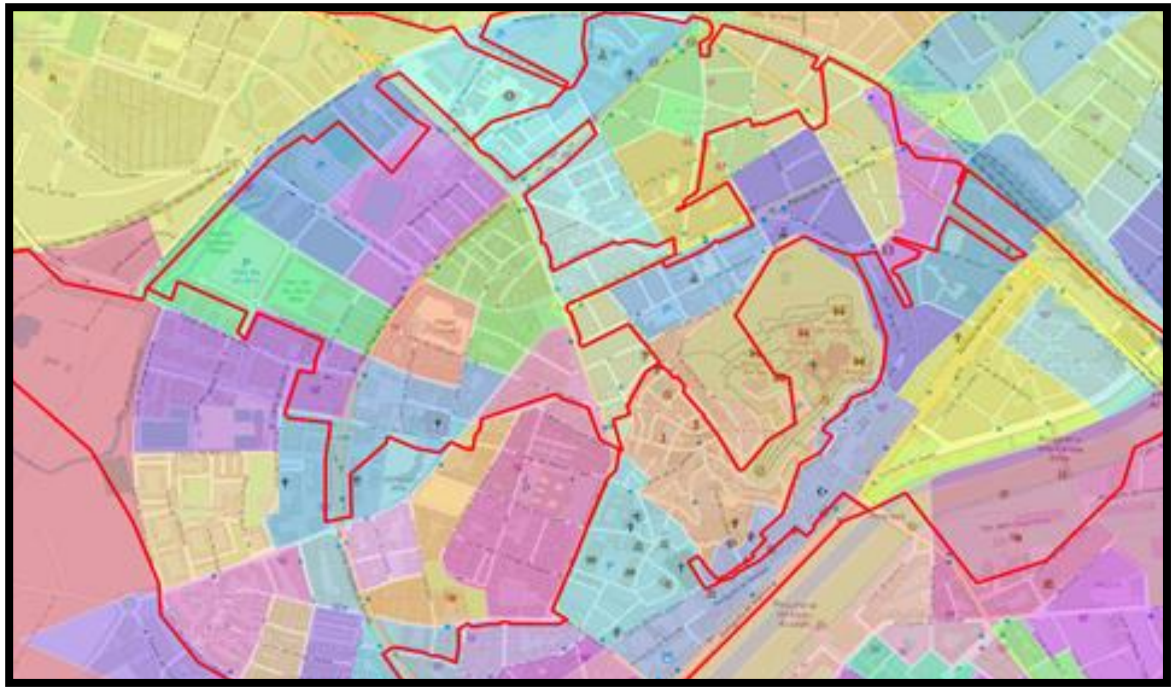
Case study: Postal code, census tract, building level



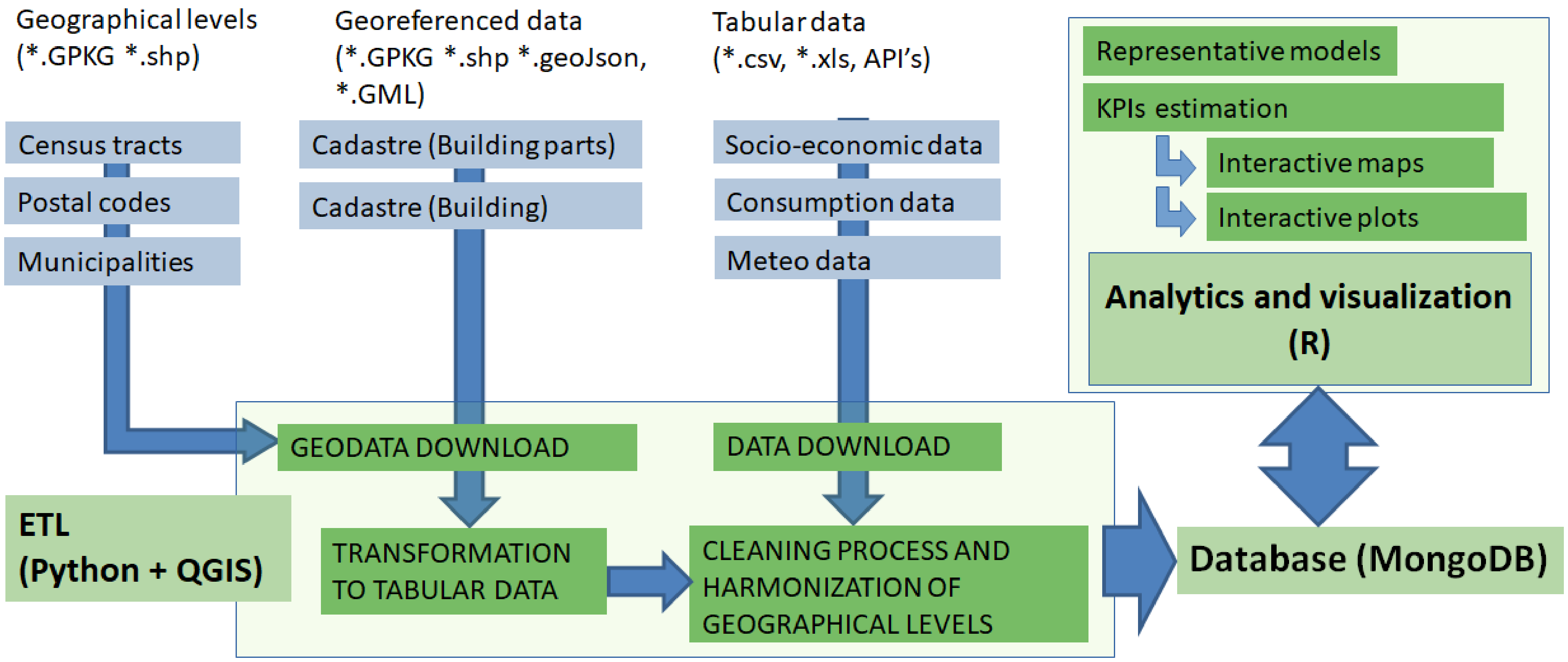


Geographical levels

- Electricity consumption
  - **Postal code** level
  - By economic sector and tariff
- Weather data
  - Estimated at certain **lat/lon**
- Cadaster
  - **Building level**
- Socioeconomic data
  - **Census tract level**



Methodology



Methodology steps

1. Reshape all data to postal code level
2. For each postal code:
   1. **Data cleaning** of the electricity consumption data
   2. **Inferring usage patterns** with clustering and classi
   3. Regression **model**
      - Output: Consumption/built area
      - Inputs: Calendar, usage patterns and weather features
   4. Disaggregate the electricity consumption to **baseload, heating, cooling and holidays terms**
3. Web application interface to visualise the results

Data cleaning

- Valid **consumption range** per contract, tariff and economic sector:

$$0 \leq Q_t^e \leq P_t^e \Delta t$$

- Data padding: **detect gaps**
- **Z-score** using a rolling window of two weeks

$$\frac{x - \bar{x}}{\sigma(x)} \geq 4$$

- Creation of an **all-contracts** synthetic **tariff and economic sector**

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Inferring usage patterns

- Based on **relative daily load curves** during:
    - March to May + September to November (No much weather dependence)
    - Avoid COVID-19 lockdown periods and holidays
- Using **Spectral clustering**
    - Alternatively, a Gaussian Mixture Model could be used
    - Kernel: Polynomial of degree=2
    - Best K: Gap in the eigenvalue spectrum
- Classification of non-clustered days using Multinomial logistic regression model and calendar features

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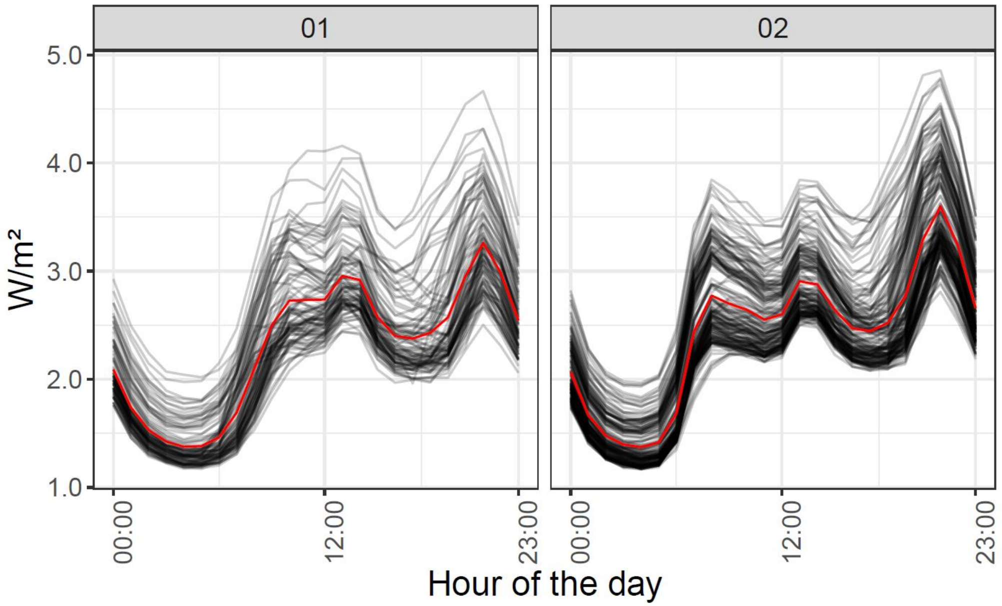
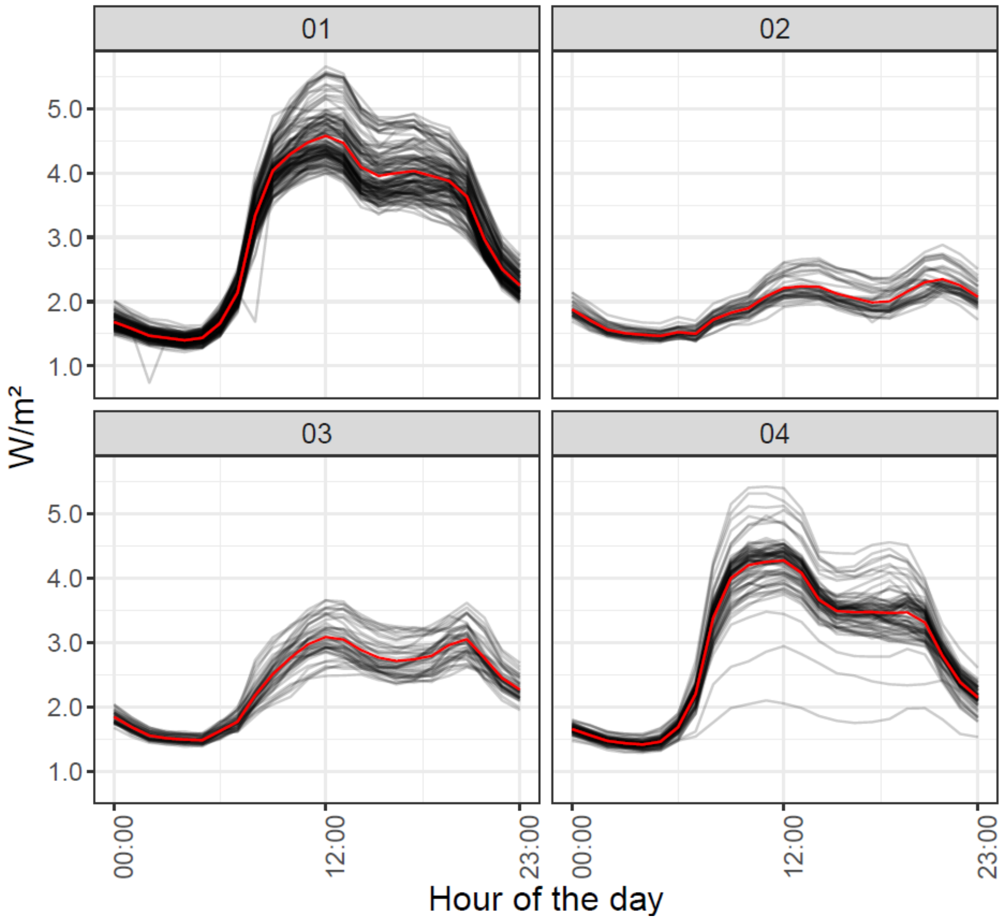
Inferring usage patterns





Modelling

- Penalised linear regression model
  - L1-regularisation

$$Q_t^e = (B_t \times s_t) + (H_t \times dh_t) + (C_t \times dh_t) + \varepsilon_t$$

baseload heating cooling

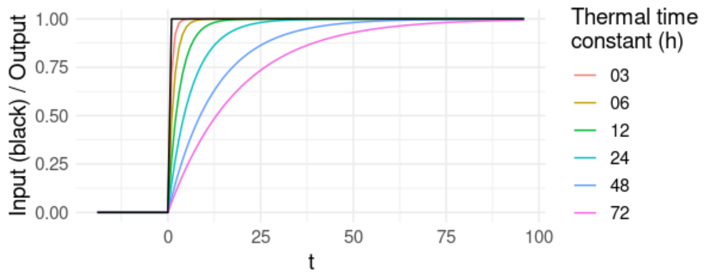
$$B_t = \omega_b + S_{N_d}(p_t^d) + S_{N_w}(p_t^w)$$

$$S_{N_d}(p_t^d) = \sum_{n=1}^{N_d} \omega_{b,d,n,cos} \cos(2\pi n p_t^d) + \omega_{b,d,n,sin} \sin(2\pi n p_t^d) \qquad p_t^d = \frac{dh_t}{24}$$

$$S_{N_w}(p_t^w) = \sum_{n=1}^{N_w} \omega_{b,w,n,cos} \cos(2\pi n p_t^w) + \omega_{b,w,n,sin} \sin(2\pi n p_t^w) \qquad p_t^w = \frac{wh_t}{168}$$

Modelling

Example of low-pass filter



$$H_t = \omega^{+}_{h,lp} T^{h,lp}_t + \omega^{+}_{h} T^{h}_t + \omega^{+}_{ah} A^{h}_t$$

$$C_t = \omega^{+}_{c,lp} T^{c,lp}_t + \omega^{+}_{c} T^{c}_t + \omega^{+}_{ac} A^{c}_t$$

$$T^{h,lp}_t = (T^{bal,c}_{dh_t} - T^{o,lp}_t) d_{s_t}$$
$$T^{h}_t = (T^{bal,h}_{dh_t} - T^{o}_t) d_{s_t}$$
$$A^{h}_t = W^{s}_t T^{h}_t d_{s_t}$$

$$T^{c,lp}_t = (T^{o,lp}_t - T^{bal,c}_{dh_t}) d_{s_t}$$
$$T^{c}_t = (T^{o}_t - T^{bal,c}_{dh_t}) d_{s_t}$$
$$A^{c}_t = W^{s}_t T^{c}_t d_{s_t}$$

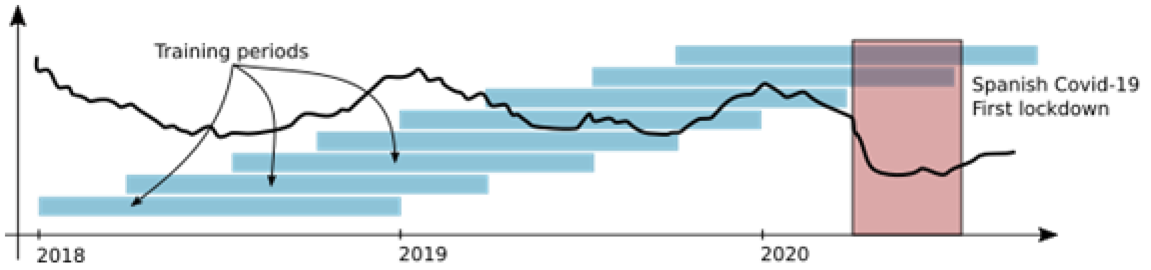
$$T^{o,lp}_t = \begin{cases} \alpha T^{o}_t & \text{if } t = 0, \\ \alpha T^{o}_t + (1-\alpha) T^{o,lp}_{t-1} & \text{if } t > 0. \end{cases}$$

$$\alpha = 1 - e^{-t_{sampling}/(2\pi\tau/24)}$$

$$d_{s_t} = \begin{cases} 1 & \text{if weather dependence in } s_t, \\ 0 & \text{if no weather dependence in } s_t. \end{cases}$$

Modelling

Training period:
75% training
25% validation
Days randomly distributed



Known terms and time series: Q^e, s, p^d, p^w, dh, wh, T^o, W^s and $t_{sampling}$.

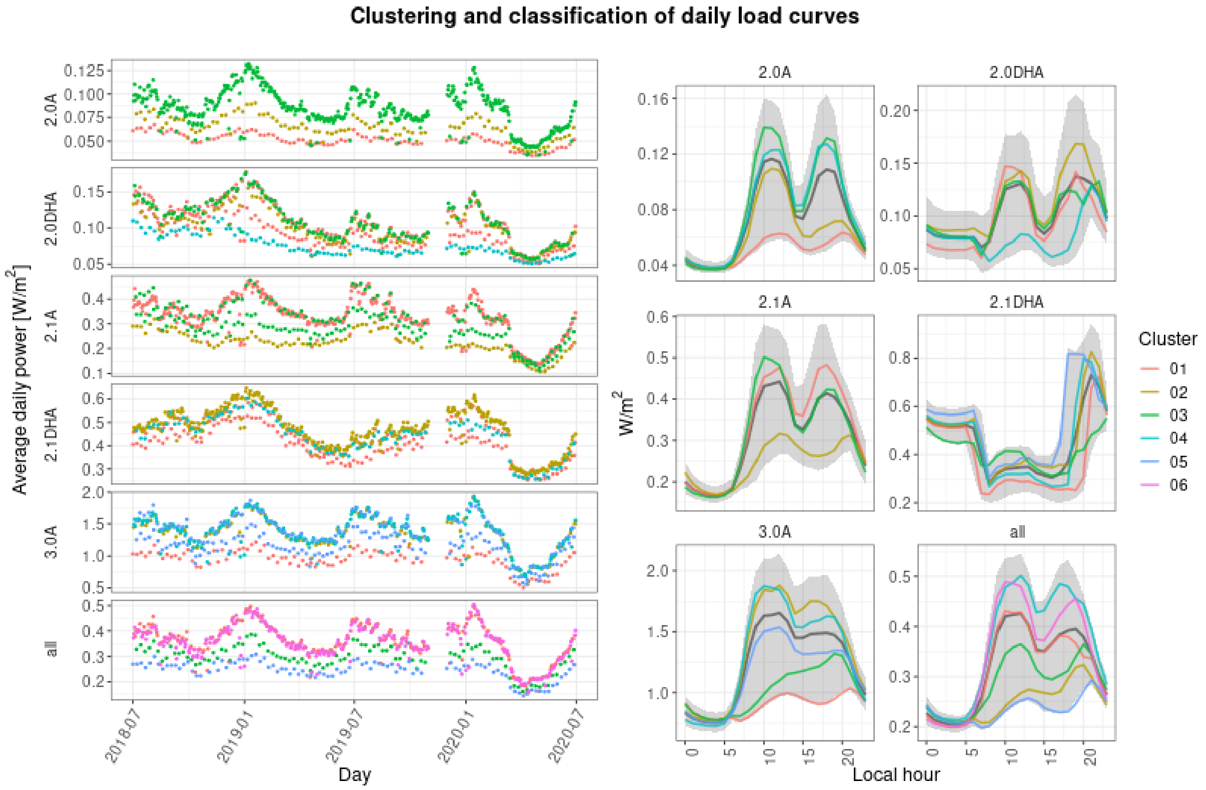
Unknown terms for each usage pattern: ω_b, $d_s(*)$, $\omega_{b,d,n,sin}$, $\omega_{b,d,n,cos}$, $\omega_{b,w,n,sin}$ and $\omega_{b,w,n,cos}$.

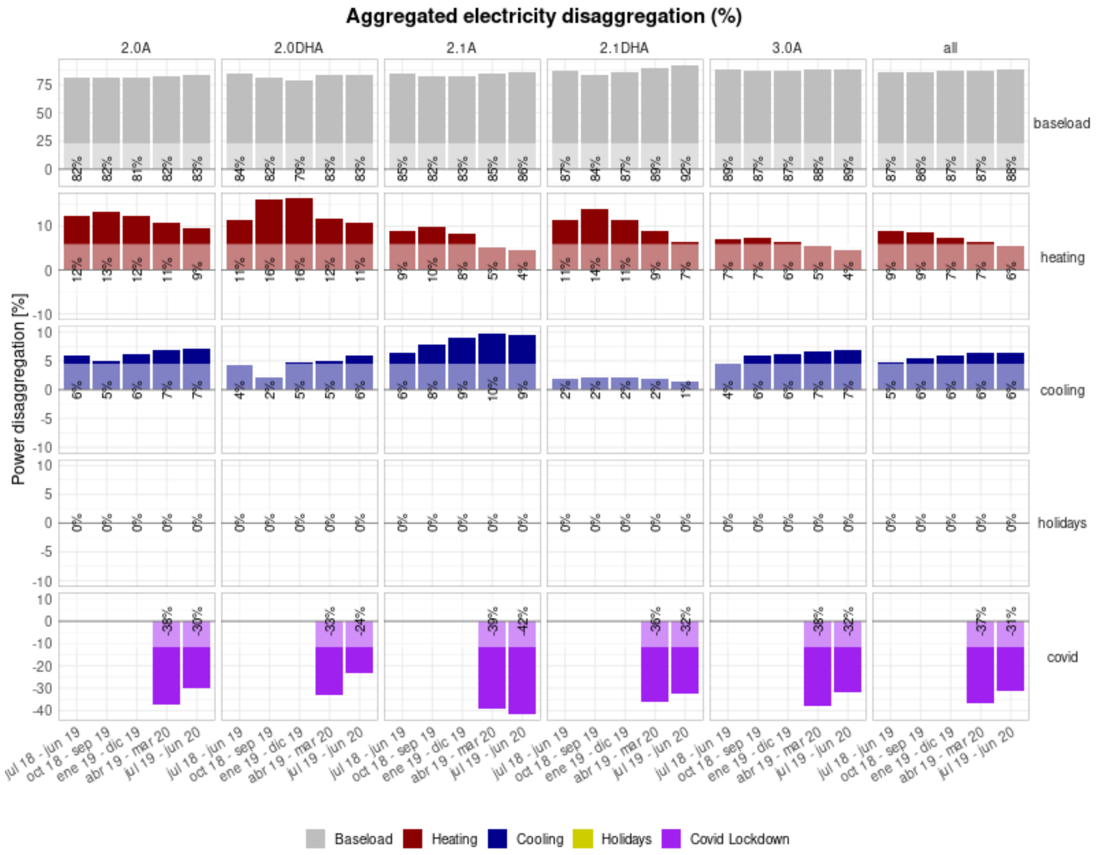
Unknown fixed terms: $\tau(*)$, N_d and N_w.

Unknown terms for each day part: $\omega^+_{h,lp}$, ω^+_h, ω^+_{ah}, $\omega^+_{c,lp}$, ω^+_c, ω^+_{ac}, $T^{bal,h}_{dh}(*)$ and $T^{bal,c}_{dh}(*)$.

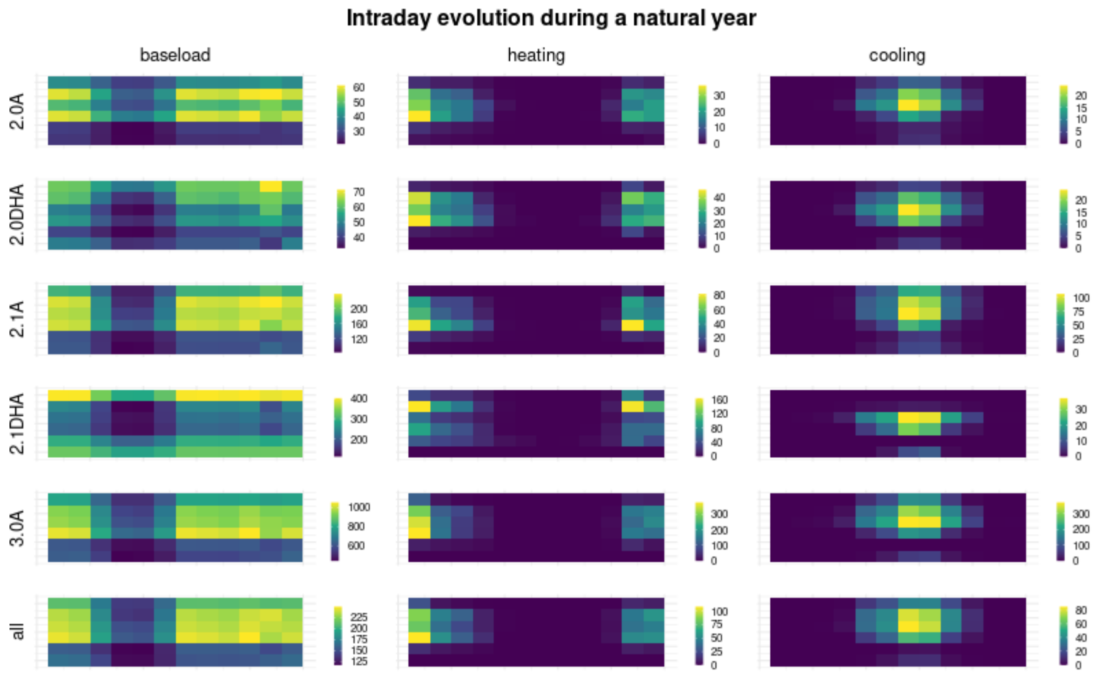
(*) Estimated using a genetic algorithm optimizer

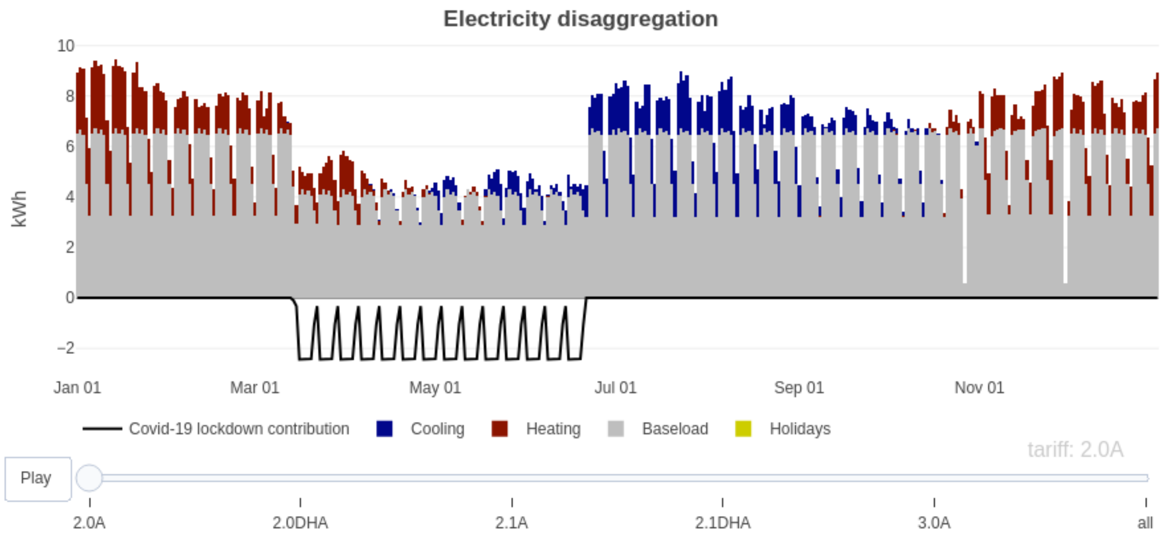
Disaggregation and consumption KPIs





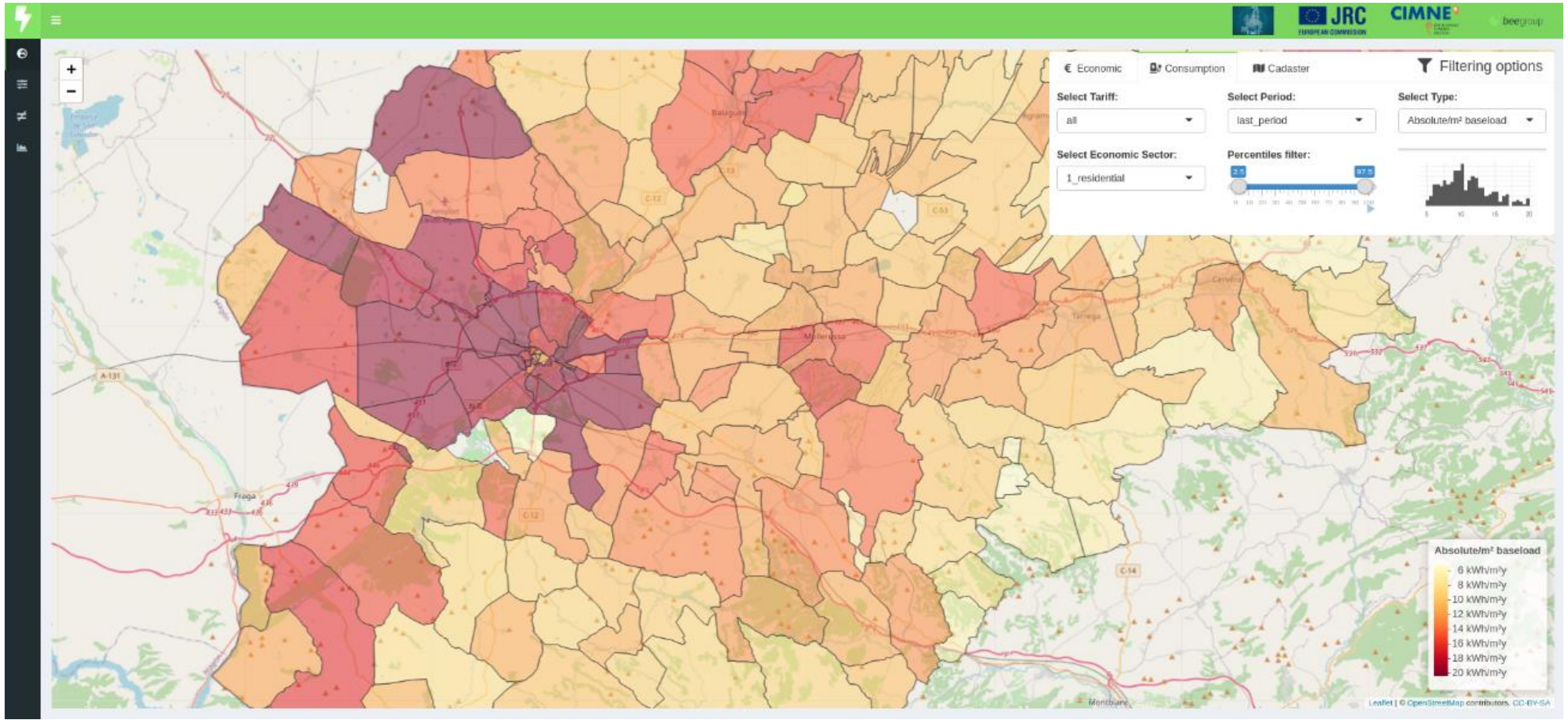
Disaggregation and consumption KPIs





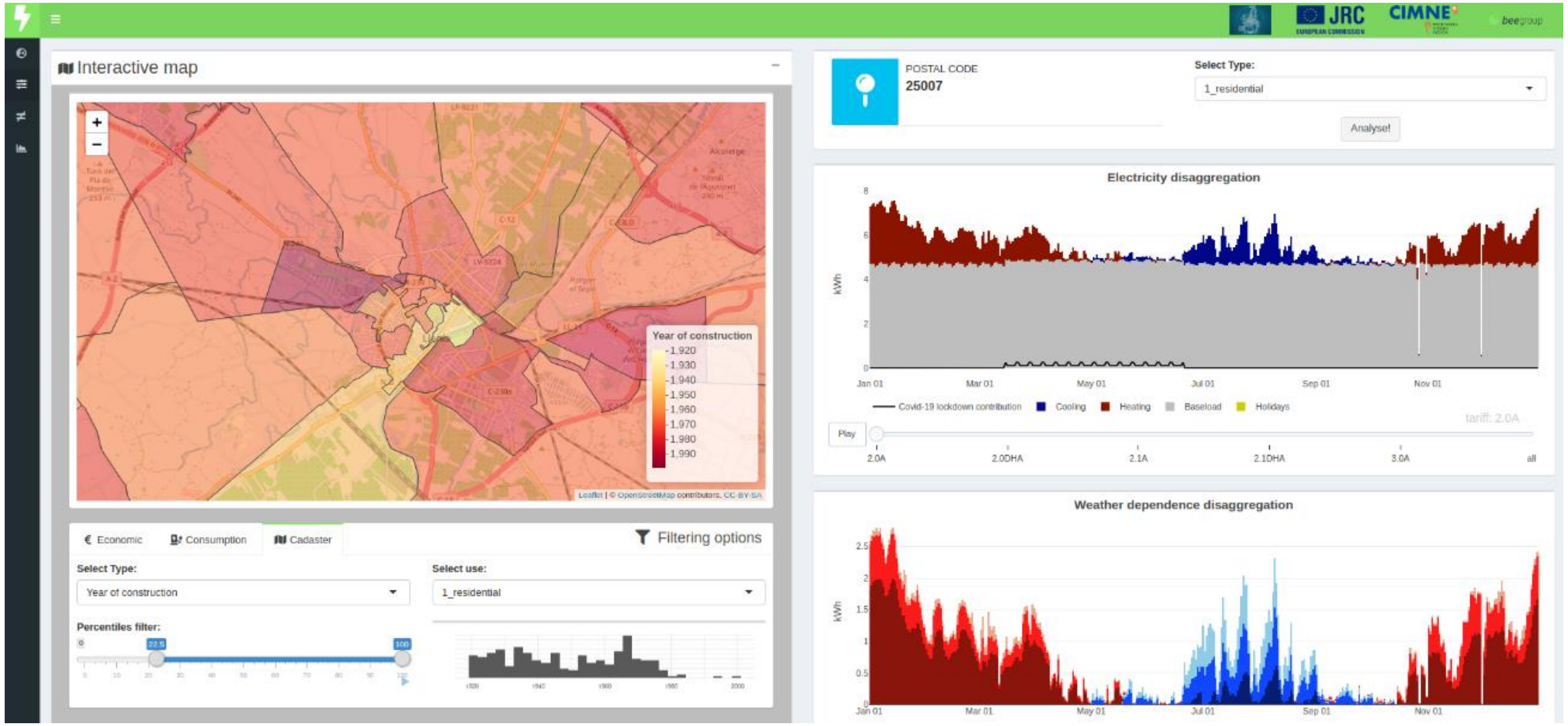
Web application / KPIs on a map

- All KPIs can be represented
- Filtering capabilities



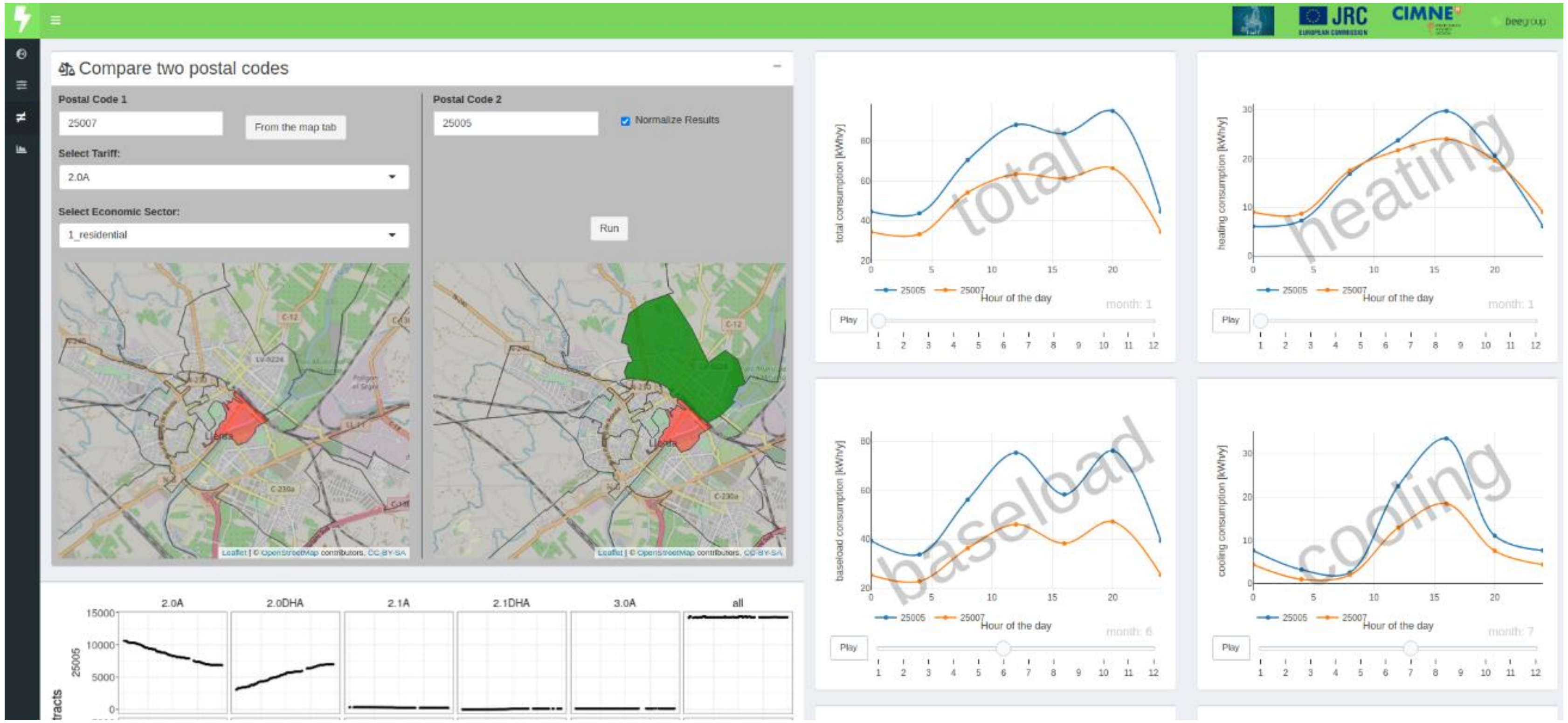
Web application / KPIs on detail

- **Dissagregation details** at each postal code, economic sector and tariff level.
- **Aggregated results** to understand tendencies in energy consumption



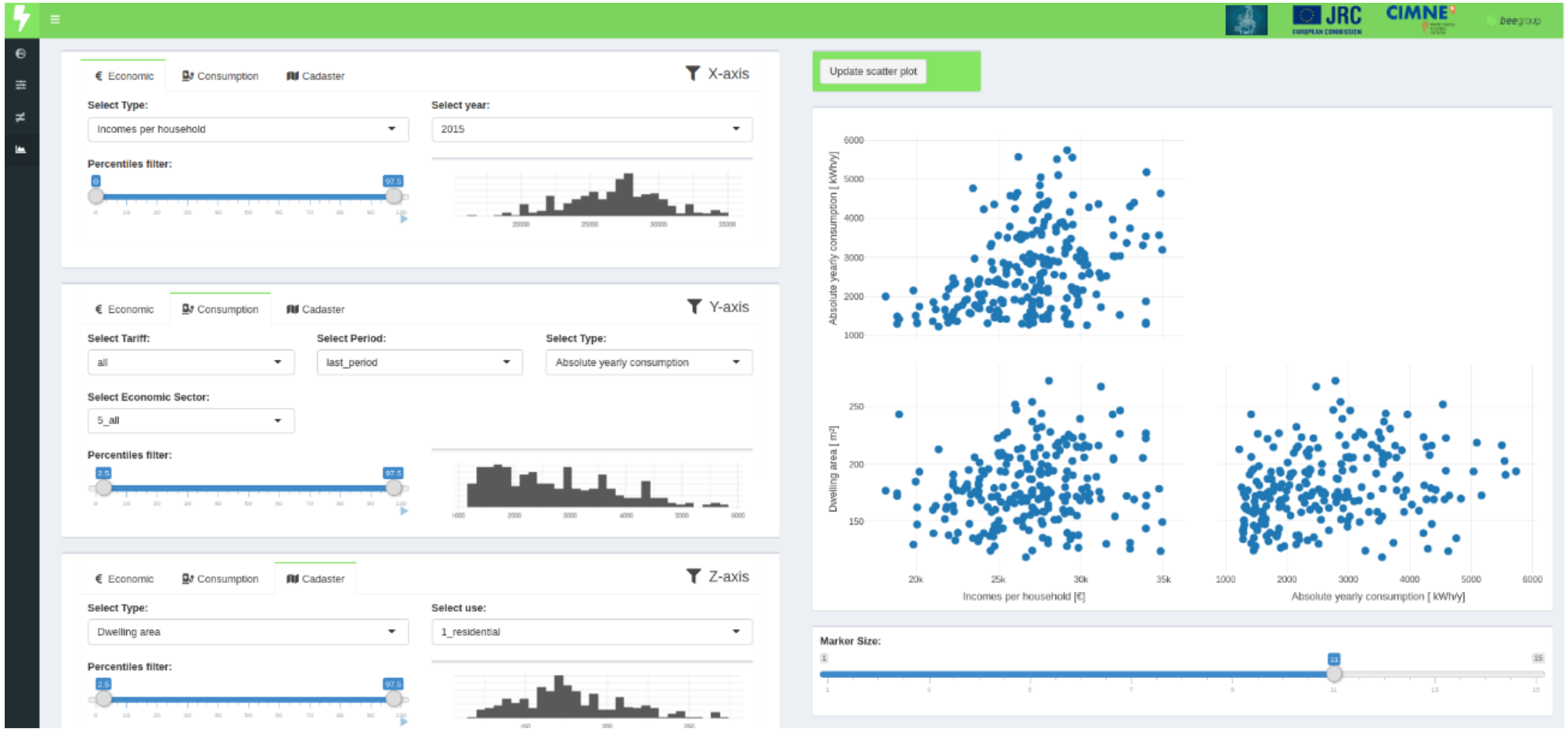
Web application / Benchmarking

- **Weather-normalised comparison** of the consumption KPIs between two different postal codes
- **Time-varying** benchmarking



Web application / KPIs correlation

- **Infer correlations** between diferent KPIs, either consumption, socioeconomic and cadaster



Conclusions

- Inference about buildings and their occupants in terms of energy consumption
  - User behaviour patterns
    - Useful to detect self-consumption potentiallities and occupancy patterns of buildings
  - Weather dependence
    - Useful for assessing the Energy Performance of Buildings
  - Baseload quantification
    - Useful for Energy Efficiency estimation of non-weather dependent consumptions

Conclusions

- Webapp functionalities:
  - KPIs in multiple types representations
  - KPIs filtering and correlation
  - Provides an interesting sandbox for testing visualisations

3

How these methodologies and technologies may support the business of start-up companies?

- **Added value:**
  - Emerging business models addressing the concept of "energy communities" may benefit from these data driven methodologies
  - District heating/cooling planning may need these tools to characterize the RES generation and the energy demand
  - Public administrations need these methods to take decisions in energy transition plans and in urban planning
  - Engineering and consultancy companies may require these data driven methods to substantiate their energy services

- **Challenges to market monetization:**
  - More effort on digitalization of thermal energy data sources is required (e.g. gas meters)
  - The geographical scale of available data is too high (zip code)
  - There is a need for standard procedures to downscale data from the zip code to the district level
  - The market for added-value services based on geo-referenced data is not very clear
  - The energy services companies are showing interest but actually there is no direct link with their business models

4

How these methodologies and technologies may support urban planning and energy efficiency policies of a Regional Government?

First case study: **Department of vice-presidency, territory and digital policies of the Generalitat de Catalunya**

- Main objectives:

1. To develop and implement a georeferenced web environment able to gather, harmonize, visualize and provide KPIs for several use cases related to industrial parks, housing developments and residential districs
2. To validate the KPIs in the coastal area of Catalonia (Including Barcelona city)

First case study: **Department of vice-presidency,territory and digital policies of the Generalitat de Catalunya**

- Outcomes:

1. A web environment based on a QGIS backend and a map viewer, to graphically show the KPIs and the data analysis result
2. A set of statical learning tools designed to support the administration in generating land planning scenarios

First case study: **Department of vice-presidency,territory and digital policies of the Generalitat de Catalunya**

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First case study: **Department of vice-presidency,territory and digital policies of the Generalitat de Catalunya**

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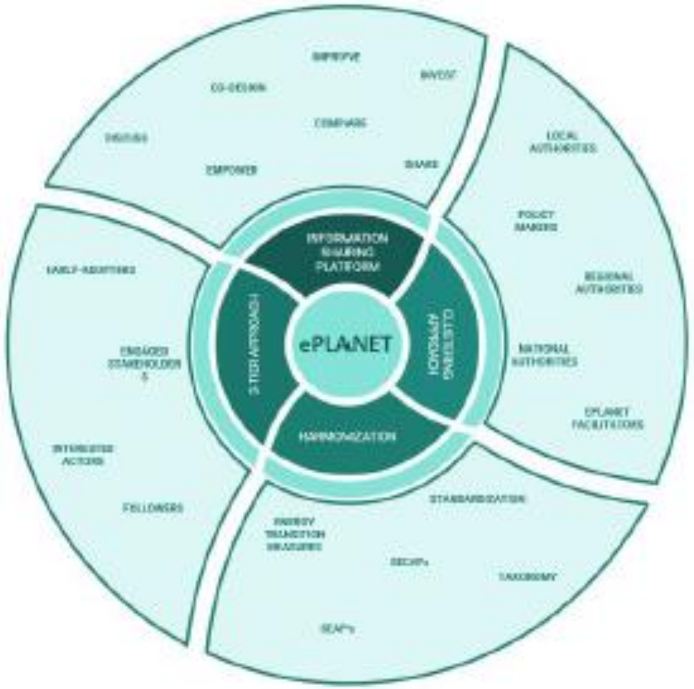
Second case study: **H2020-ePLANET: European Public Local Authorities' Network for driving the Energy Transition**

- **Objectives:**
  - To establish a transparent information **sharing framework among public authorities**
  - To deploy **multi-level working groups** of related to enable a collaborative approach in development and updating of **Energy Transition plans**
  - To enable digitalization of the energy transition plans



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Second case study: H2020-ePLANET: European Public Local Authorities' Network for driving the Energy Transition

- **Pilot sites:**

Region	Municipalities	Municipalities with SEAC
Girona	221	199
Crete	24	21
Zin	307	276

5

Urban energy simulation supporting the Local Digital Twins toolbox

European Commission

SOURCES

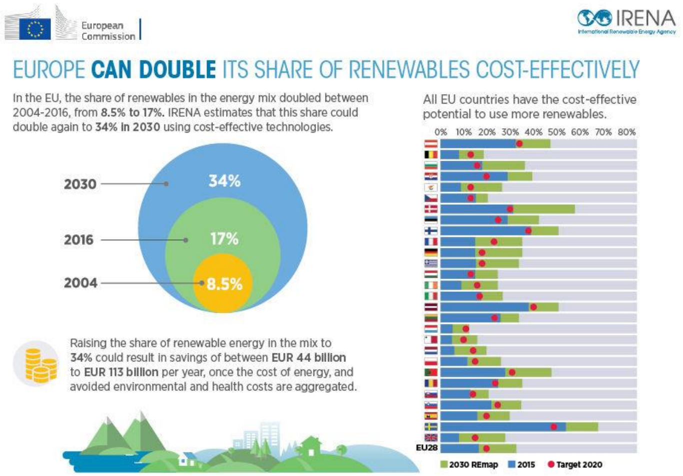
- Utilities
- Consumers
- Databases
- Simulation models

PURPOSE TODAY

- Billing, network control
- Cost control
- Building design
- Urban development

GEOLOCALISATION

- Intelligent networks
- Producers farms
- Decision making
- CO_2 footprint



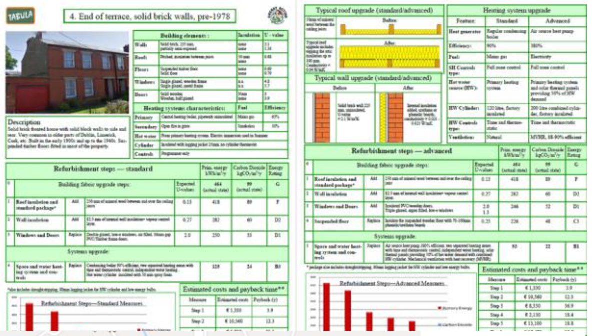
Georeferenced energy information

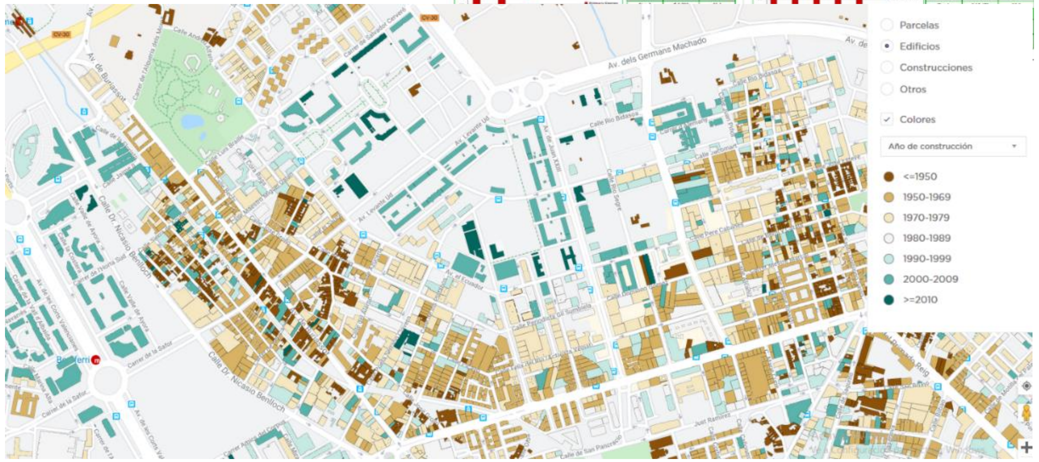
ISA[2]

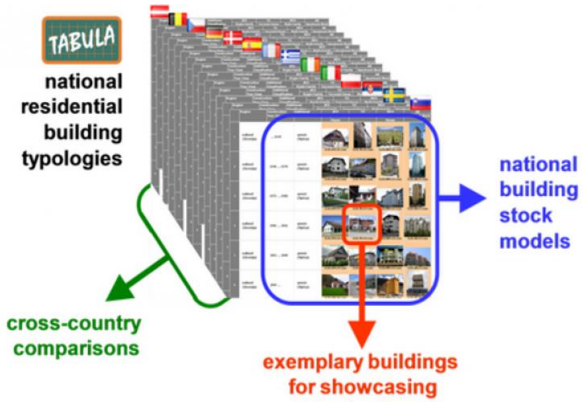
Energy data challenges

- **Data held by platform economy companies** is of high interest
- Appropriate **governance** - > multiple data sources and background
- **Organizational, legal and cultural challenges** (forthcoming Data Act)
- Stakeholders priorities
- Data quality

City/neighbourhood modelling







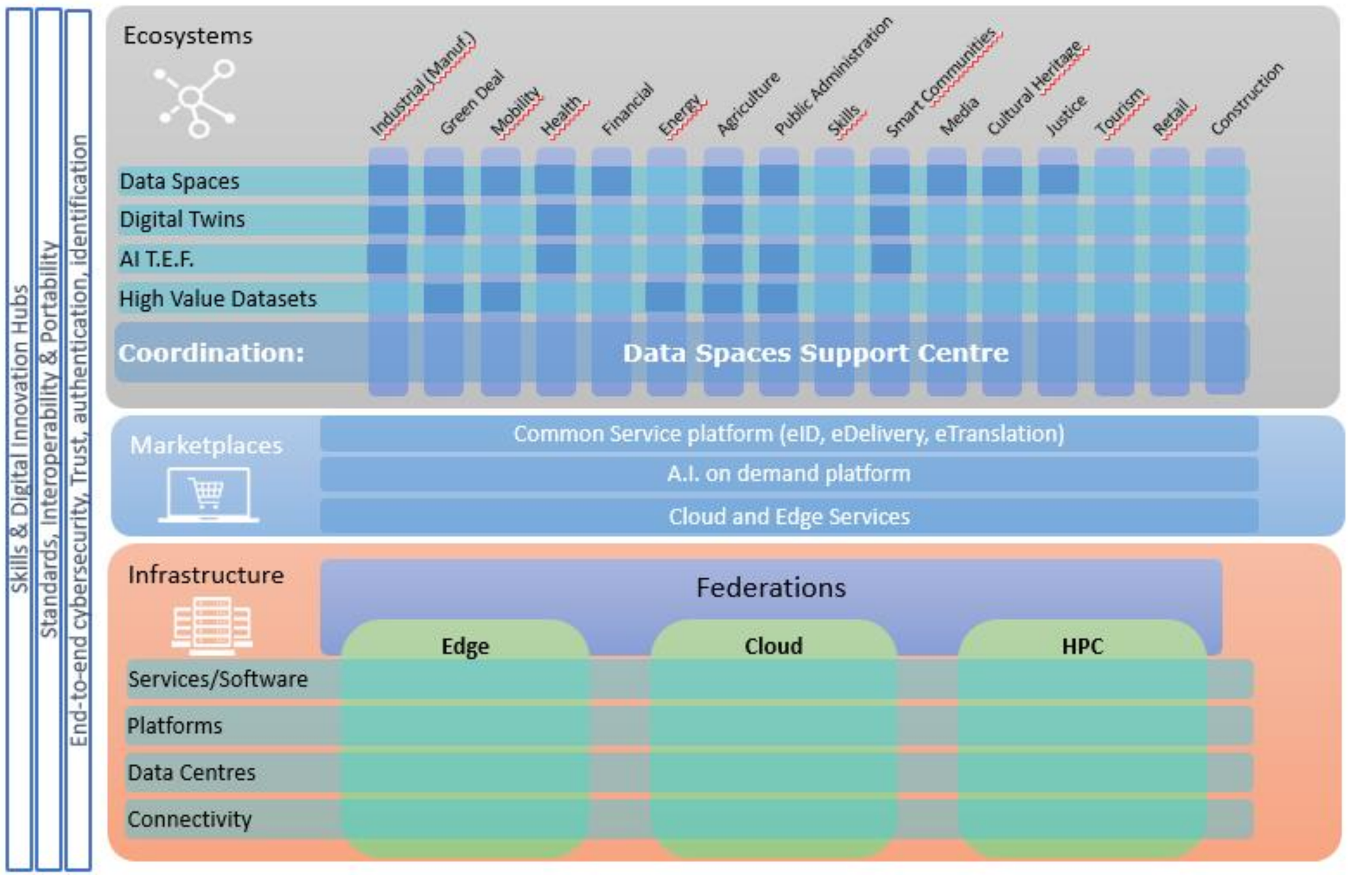
Companies’ challenges

- There is a need for **more clarity on the legislative framework**
- **Lack of interoperability** between different datasets
- Companies look for **scalable data sharing means** compatible with their business plans

Citizens’ challenges

- Energy **bill**, Energy **poverty**
- **Sustainability**

Next steps



DEP

Next steps

- B2G data sharing
  - Partnerships and ecosystems
  - EU Data Spaces
  - EU regulatory framework: Data Act, AI security
- EU Data Spaces for energy/Smart Communities
  - Energy transition
  - Data market ecosystem development
  - Carbon tax
  - Consumer farms…

6

Key messages, challenges and future outlook

- Downscale challenges: is it a matter of granularity of statistical and socio-economic data or of privacy issues related to energy consumption data or both?

- Future outlook: re-use of the methodology presented to support the implementation of the energy efficiency related actions of the Recovery and Resilience National Plans

Q&A

Thank you

Stay tuned

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