PROSPECT+

Capacity building for cities and regions - from learning to action!

SUSTAINABLE PLACES 2024

Fostering sustainable energy projects in cities and regions – lessons learnt and key takeaways from a peer-to-peer capacity building programme

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Sustainable Places 2024

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The PROSPECT+ project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101023271

TEESlab University of Piraeus Research Center

IEECP INSTITUTE FOR EUROPEAN ENERGY AND CLIMATE POLICY

Overview

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5. Inventory of sustainable energy measures and verification of achieved impacts
6. Barriers and Drivers in the implementation of local actions
7. Recommendations from Policy Dialogues, Replication webinars and other CoP activities
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The role of cities and regions in the Clean Energy Transition

- Cities are among the **major energy consumers**, being accountable for **70% of the global energy use** and consequently among the major GHG emitters.

- **Cities** and local authorities are **crucial actors** in the fight against climate change and in the way towards EU goal for **climate neutrality by 2050**.

- Due to their **proximity to citizens**, cities and local authorities may influence and take action on **several sectors.**

- Local and regional authorities often face **challenges** in several steps of projects planning, financing and implementation.

The role of cities and regions in the Clean Energy Transition

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Local governments often struggle with funding to implement their sustainable energy actions

Capacities inside the organisations – both in terms of resources and in terms of know-how also hinder initiation of actions

The PROSPECT+ project (1/3)

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The **PROSPECT+ project** has developed and implements a peer-to-peer capacity building programme for local/ regional authorities and energy agencies.

- **Increase capacities in financing sustainable energy plans** using innovative financing schemes
- **Enhance decision-making** of public authorities for them to be leaders in measures implementation
- Help public authorities and their agencies **profiting of the rich experience available**, taking inspiration from their peers
- To help use **synergies** by **linking public authorities** along with energy policy-makers, associations of planners, technical experts, financing bodies on sustainable energy, and local actors **in an intra-European network**

The PROSPECT+ project (2/3)

PROSPECT+

✓ 5 Thematic areas

Public Buildings

Private Buildings

Public Lightning

Transport

Cross-sectoral

✓ 5 Learning steps

Step 0

- **1 webinar for mentees**
- **2 webinars for mentors**

On project development, Financial maturity, and CBP training

Step 1

An **online session**

Participants get to know each other. The focus in on the mentors presenting their project.

Step 2

An **online session**

Presentation of mentee(s) projects and needs. Preparation for the physical meeting.

Step 3

Physical meeting

2 days of mentoring and knowledge exchange to address the needs of the mentees

Step 4

An **online follow-up meeting or call** on the implementation of mentees(s) project

BONUS!

Masterclass in Brussels

Workshop exclusive to the most advanced mentees

The PROSPECT+ project (3/3)

✓ 3 Learning methods

Peer Monitoring

1 mentor & 1 mentee

Study Visit

1 mentor & up to 5 mentees

Local Monitoring

1 mentor, up to 7 mentees

✓ On a variety of financing schemes

- **Energy Performance Contracting** (EPC)
- **Citizens Finance** (crowdfunding and cooperatives)
- **Internal Contracting** (intracting)
- **Soft Loans**
- **Revolving Funds**
- **Third Party Financing**
- **Incentives for e-mobility**
- **EE projects bundling**
- **Energy communities**
- **ELENA**
- **Green Bonds**
- **Guarantee Funds**

Progress of the capacity building programme (1/3)

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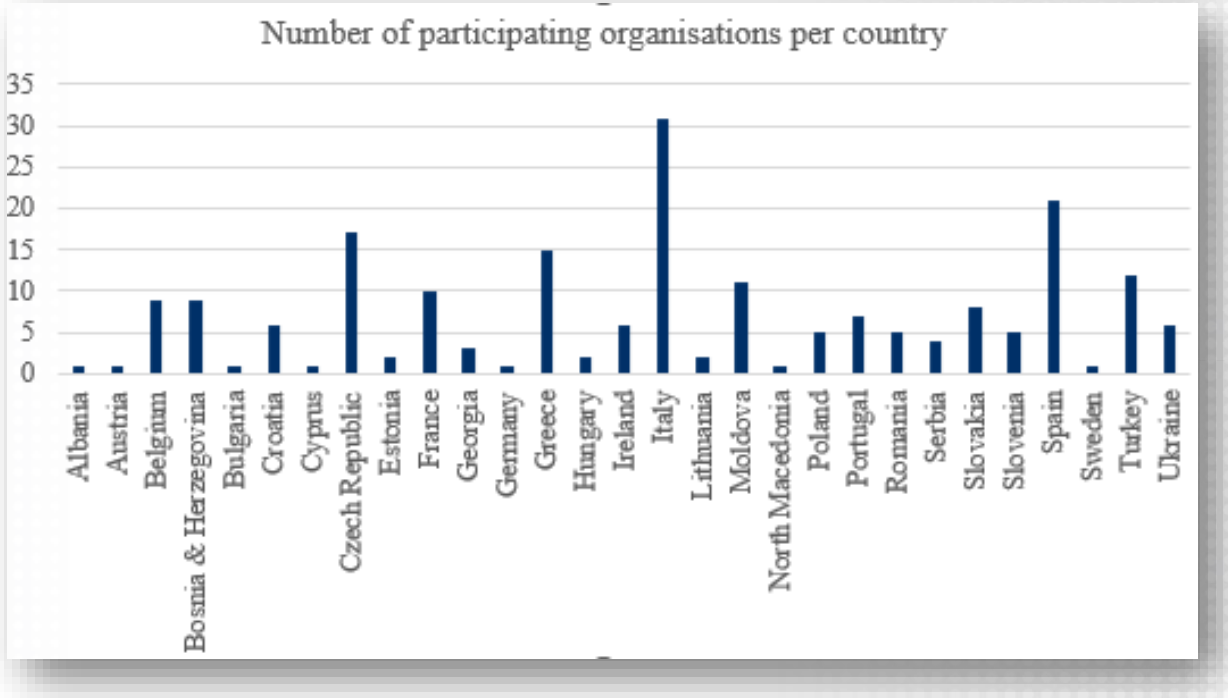
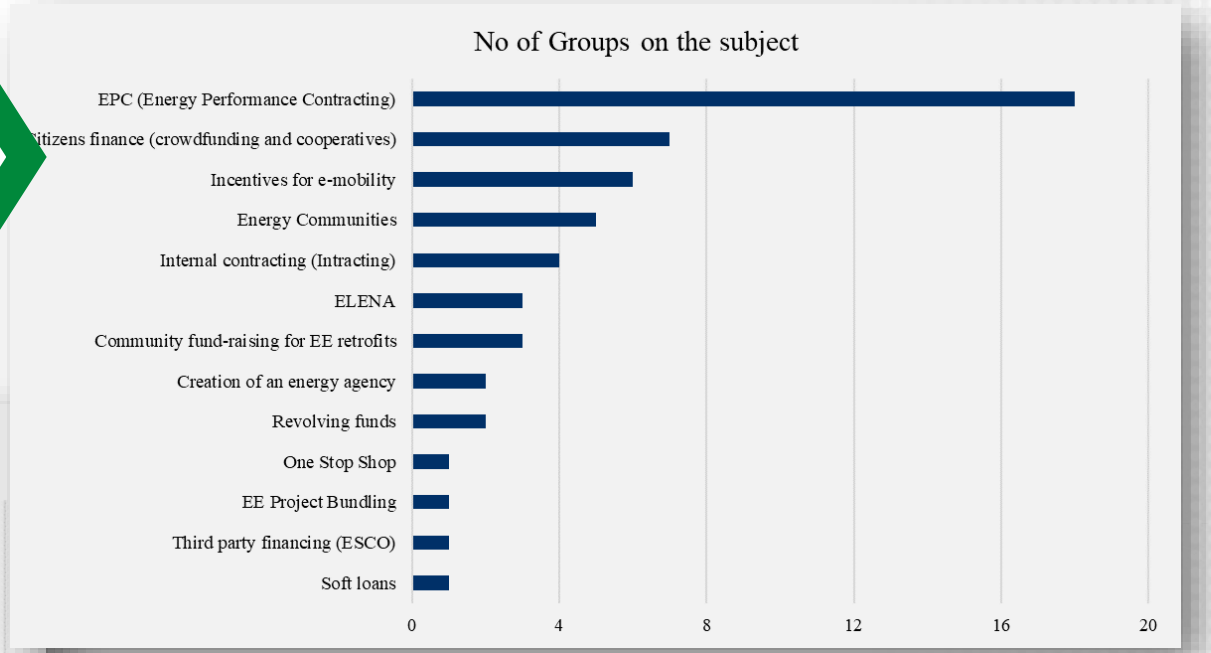
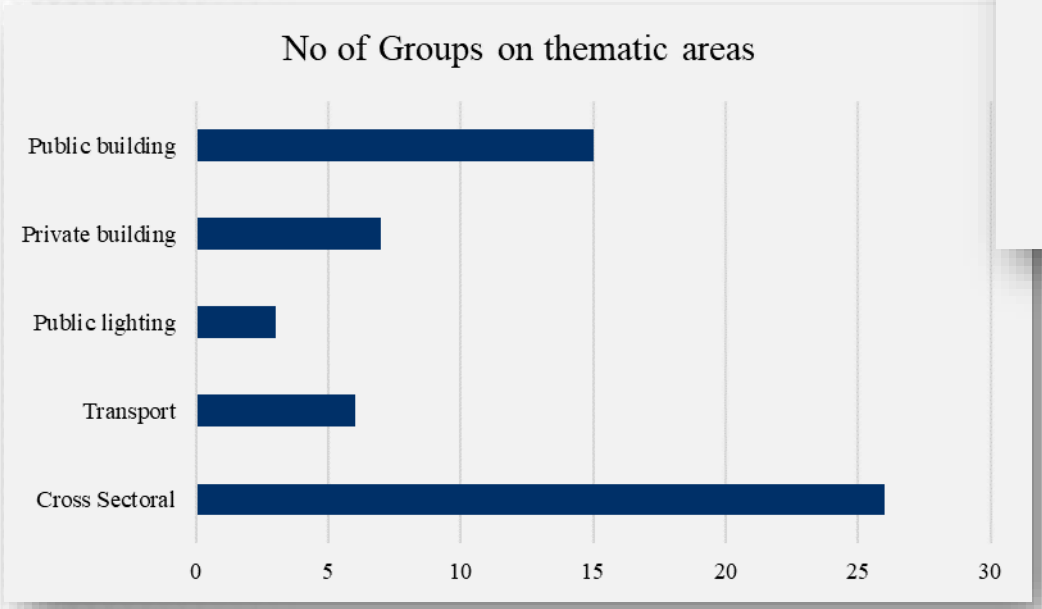
- **3** Learning Cycles (LCs) completed, **4th** LC is ongoing
- **32** finished learning groups, **22** learning groups ongoing
- Participants form **29** countries and **194** unique cities have joined the programme



Progress of the capacity building programme (2/3)

EPC the most popular financing scheme discussed





Cross sectoral the most popular thematic area

Progress of the capacity building programme (3/3)

~94% of participants satisfied with the overall quality of the PROSPECT+ CBP.

The majority of them are:

- ❑ Extremely willing to recommend the CBP to other local authorities.
- ❑ Planning or already have circulated the knowledge gained between their relevant colleagues.

Lessons learnt and key takeaways after the first three learning cycles (1/2)

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01 A dynamically evolving engagement effort closely aligned with the specific contexts of the local target audience will generally provide added value to the existing strategy.

02 The first three LCs met the expectation of the participants and on the whole, they had been successful in developing their capacities in shaping energy strategies and plans using innovative financing.

03 The first three LCs were actualised with a rather anticipated drop out ratio, which has been due to external factors.

Mentors' feedback

04 Replicability of PROSPECT+ activities depend on an added value/time & resources ratio – with clear added value for each learning hour mentees invest – and the continued exchange across mentees – where they are enabled to stay in the loop, being updated on the support networks available across the EU and regional levels

Lessons learnt and key takeaways after the first three learning cycles (2/2)

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Mentors' feedback

05 The project serves as a launching platform for mentors and mentees alike to initiate longer-term collaborations. Mentors expressed the interest in being part of a larger EU-level community to exchange practices with other mentors

Mentors' feedback

06 External mentors highlighted the advantage of local groups during the practices exchange (same language, context, governance structure).

Mentors' feedback

07 Mentors are very operational and promotion/dissemination activities is often overlooked. Additional efforts from the project consortium would support the visibility of study visits, local activities etc. beyond the project.

Mentors' feedback

08 Several mentors wish to be kept informed of their mentees' projects progress, and overall, of how many projects were implemented in which region/ thematic area etc.

Inventory of sustainable energy measures and verification of achieved impacts

Perform a quantitative verification of mentees' individual projects progress in relation to their energy efficiency measures (data collected until September 2024)

Project Performance Indicators (KPIs)	Achieved up to Sept 2024
Primary energy savings triggered by the sustainable project investments within its duration	3,084 GWh/year circa*
	64 Million EUR*
Renewable Energy production triggered by the project investments within its duration	385.14 GWh/year circa*
	5,34 Million EUR circa*

*The KPIs figures for Energy savings (Gwh/A), Savings (million EUR), CO2 reduction (tCO2/a), and RES production (GWh/a) are based on the actual figures declared by mentees in their respective Action Plans, in LC1—3 (figures for LC4 will be collected in December 2024).

Limitations:

- Increasingly low response rate (saturation of feedback required to mentees)
- Limited data based on actual mentees' implemented projects. Assumptions and calculations needed.

Barriers and Drivers in the implementation of local actions

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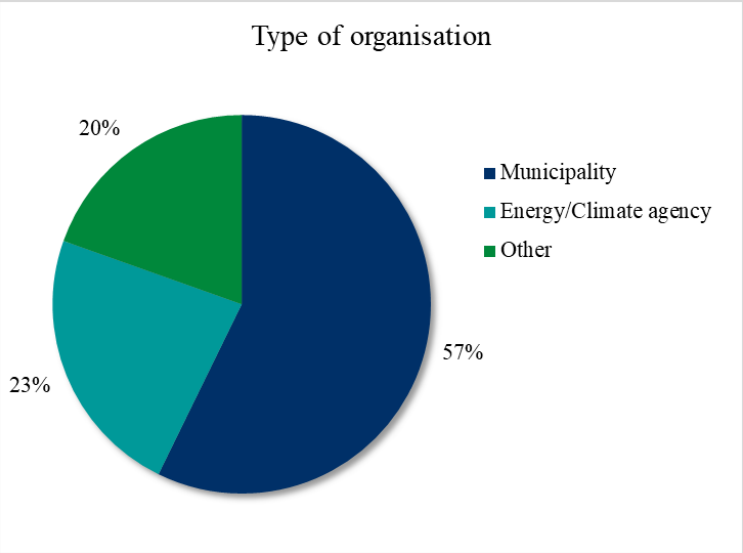
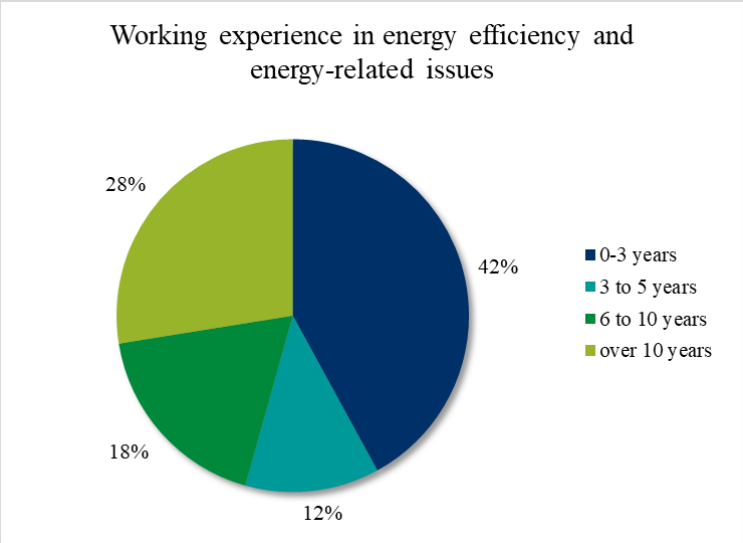
Perform a quantitative assessment of the factors that drive or hinter the implementation of sustainable energy action in cities and regions

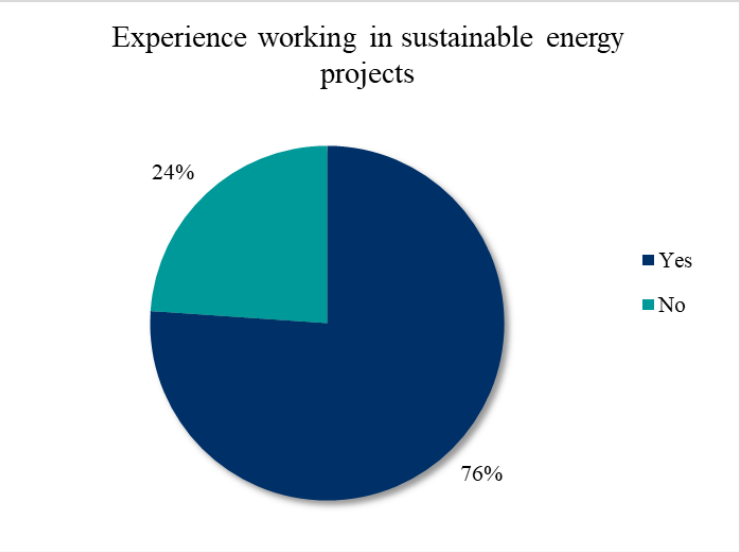
Methodological approach

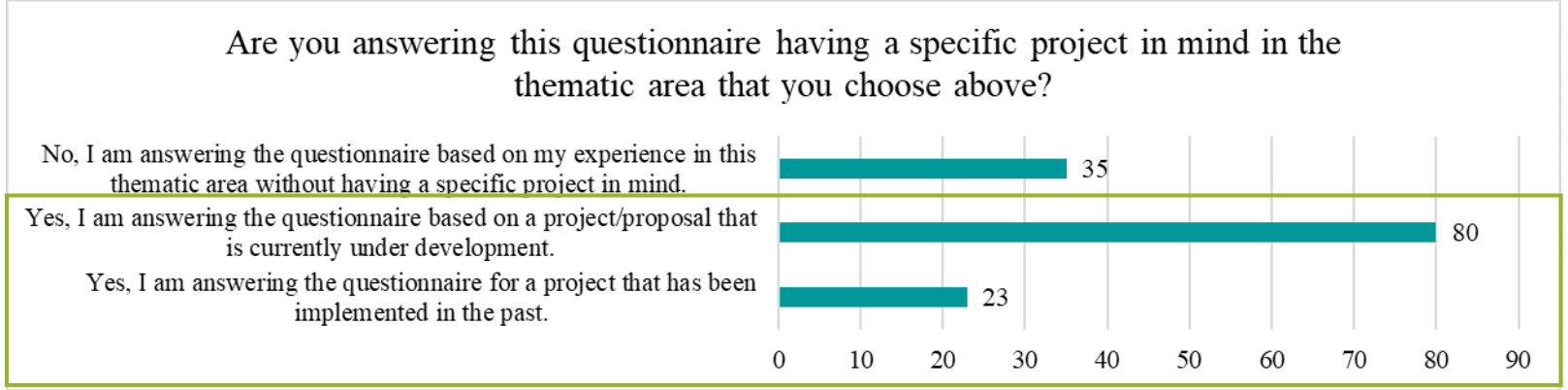
- Literature review & factors affecting the implementation of sustainable energy projects the in the five different thematic areas of PROSPECT+ → **50 factors** → 48 barriers, 17 drivers
- Allocation of the factors into six broad categories i.e, i. *economic & financial, ii. knowledge & informational, iii. social, cultural & behavioural, iv. policy & regulatory, v. institutional/ organizational, vi. technical & technological*
- Online survey using an assessment framework with two indices
- Analysis of the preliminary set of responses and identification of the ***most important positive and negative factors*** affecting the implementation of energy efficiency and other sustainable energy projects in cities and municipalities

Barriers and Drivers in the implementation of local actions Results (1/4)



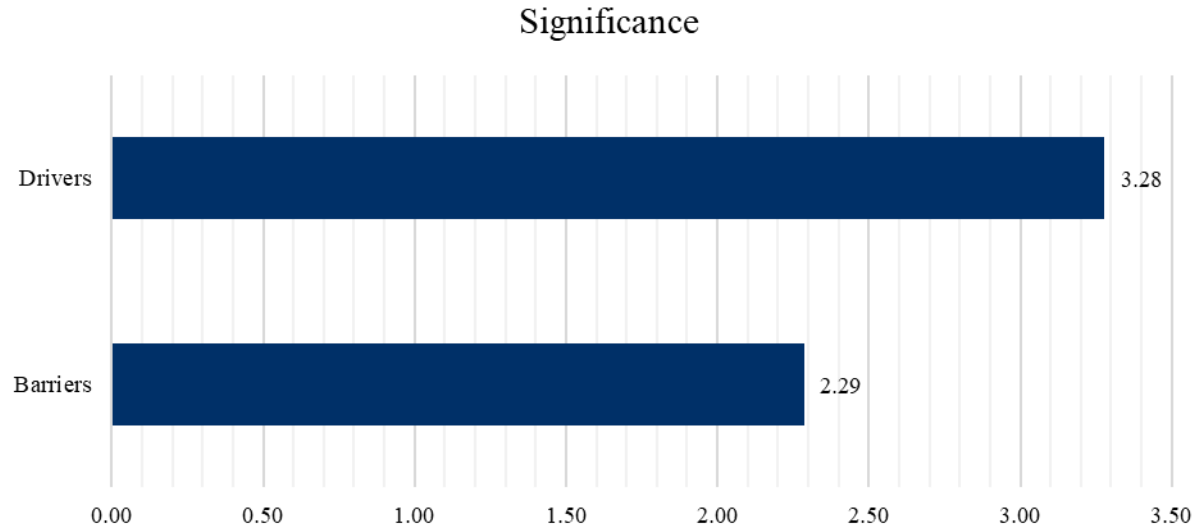






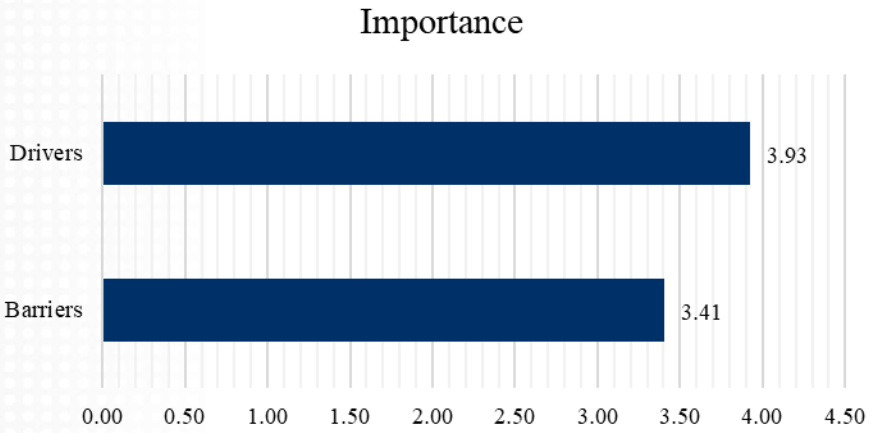
n = 138

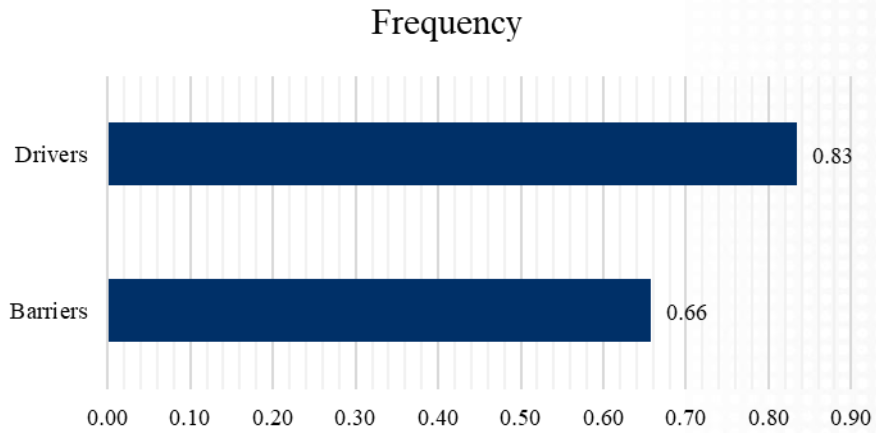
Barriers and Drivers in the implementation of local actions Results (2/4)



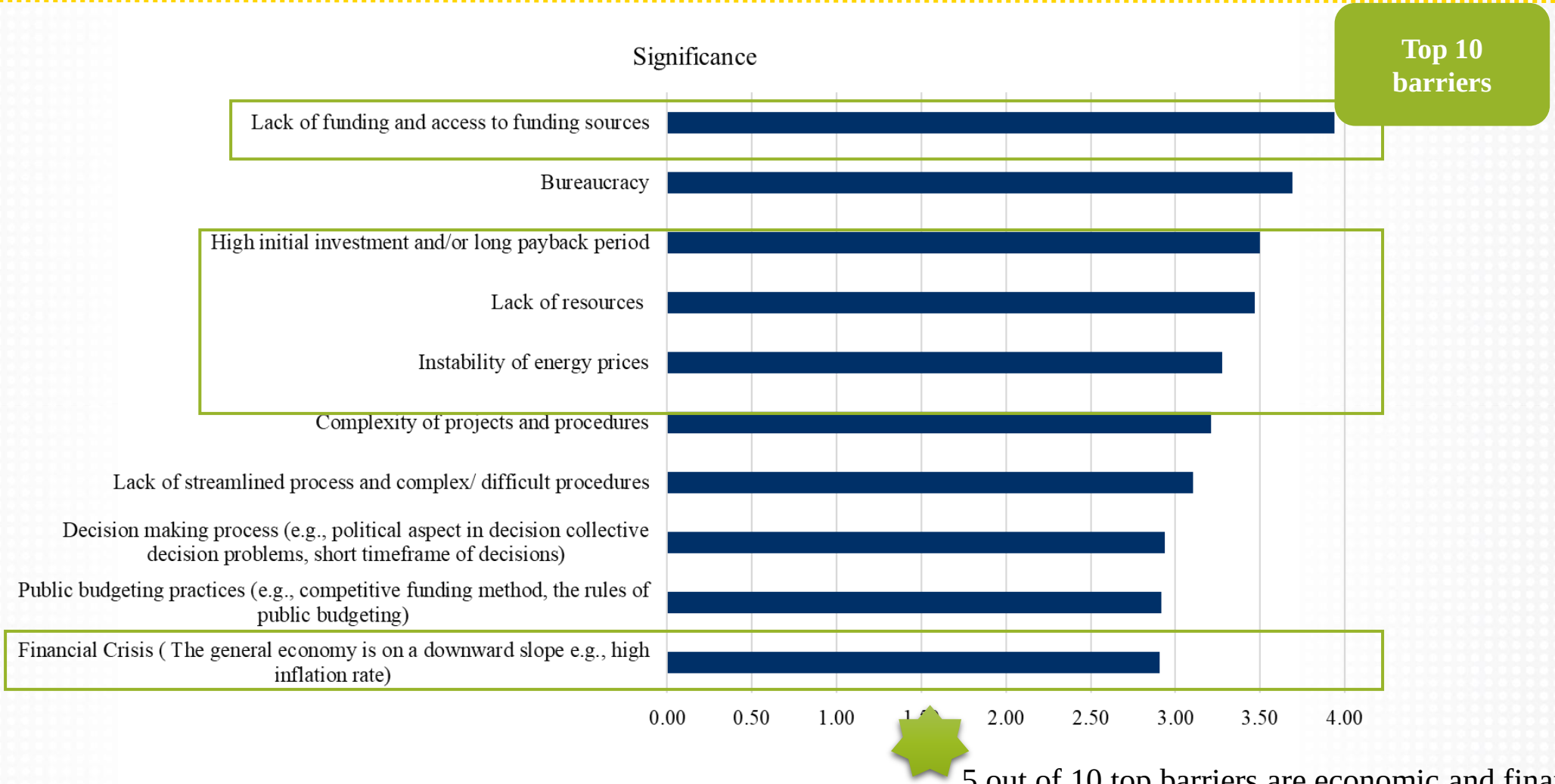
Significance
=
Frequency x Importance

n = 138





Barriers and Drivers in the implementation of local actions Results (3/4)



5 out of 10 top barriers are economic and financial

Barriers and Drivers in the implementation of local actions Results (4/4)

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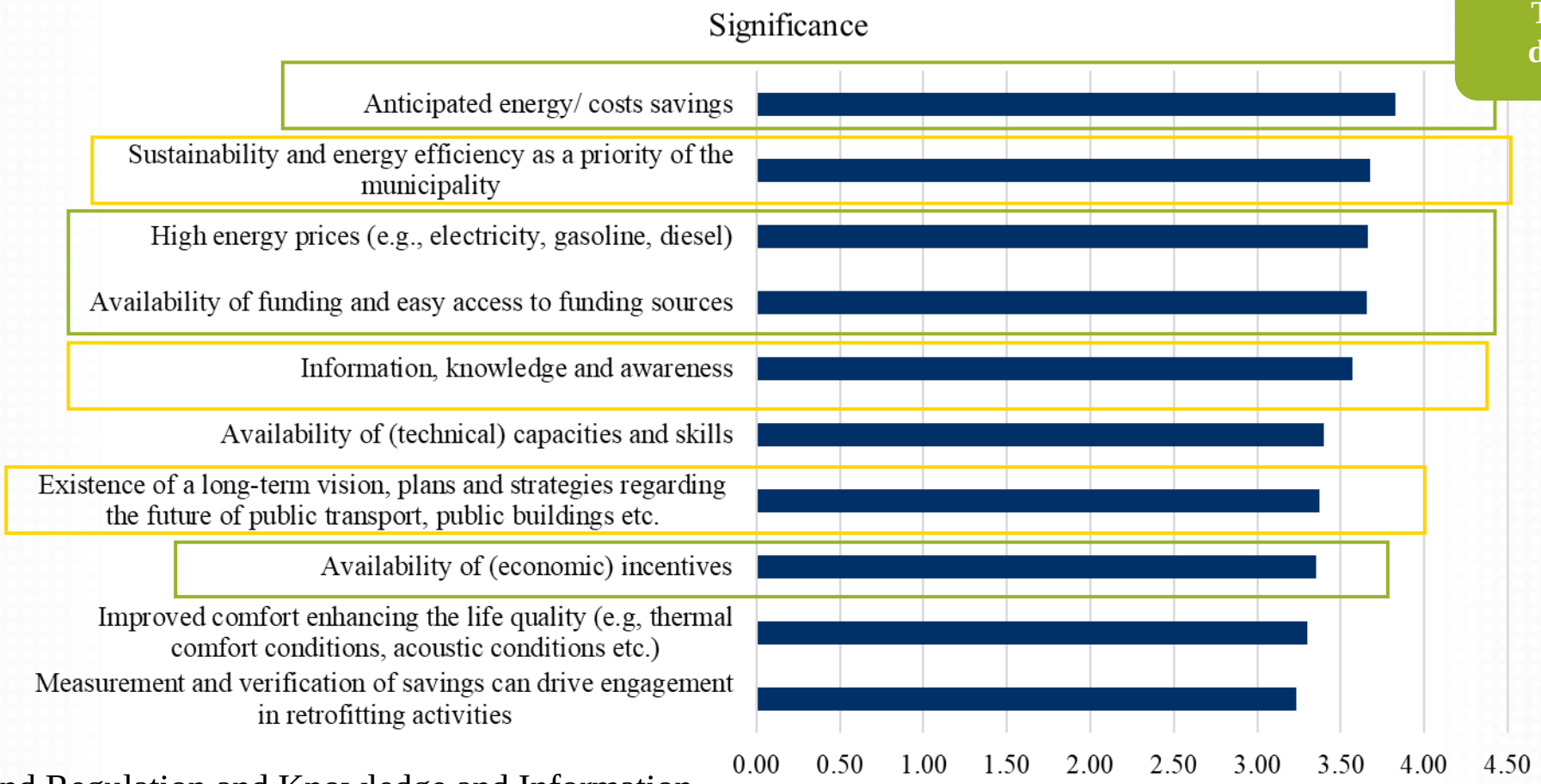
Top 10 drivers



Policy and Regulation and Knowledge and Information factors are also significant drivers

economic and financial factors also an important driver

Recommendations from Policy Dialogues, Replication webinars and other CoP activities (1/2)

PROSPECT+

PROSPECT+ Policy Dialogue webinar *Navigating New Reality in Financing for Local Energy Transition.* Over 100 attendees | 11 expert speakers. Presentations and recording available on PROSPECT+ website

- Beyond the PROSPECT+ scope: what LRAs need to implement energy projects without delays, (un)availability of subsidy programmes (dates, deadlines, ToRs), *efficiency* (how well inputs -funds, staff, time- are converted in outputs), risks mitigation.
- Experiences from the Netherlands: legal barriers in consumer credit regulations hinder energy-efficiency home renovations using EPC. This requires clarity & support from national and EU levels.
- Investors' perspective: the need for cities to recognise the potential of different financing models, including non-traditional ones like marketing and sponsorship opportunities; enforceable contracts; introduce city financial advisors?

Replication webinar February 2024: greatest interest from local authorities, academia, NGOs and independent consultants. Topics: crowfunding and microloans, intracting and EPC.

Highlights: need for cooperation, effective knowledge exchange, diversify financial resources, urgent need to learn how to use new financial models

Policy Dialogues and webinars are conducted within the PROSPECT+ Community of Practice.

Recommendations from Policy dialogue consultations – initial findings (2/2)

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Overall, what is your opinion about what ?	
The **legislation/regulations (e.g. Public Procurement Law) in my country** need to be adapted if public authorities are to use such instruments.	**73.3%**
Public authorities need more capacity (knowledge and time to learn) to start using innovative financing options.	**96.7%**
The **perception of innovative financing instruments needs to change among our inhabitants**. We need to meet the expectations of the residents and they believe our role is to obtain subsidies.	26.7%
The **market needs to be more developed**: currently, there are not enough appropriate private partners.	**53.3%**
There needs to **be more advisory support provided to public authorities** which do not have experience with using the innovative financing instruments.	**63.3%**
There are **many public funding opportunities available, so using other instruments is not necessary**. Our needs are met in terms of access to capital.	6.7%
Return on Investment (ROI) and payback periods are not attractive enough compared to subsidies that are available to us.	23.3%
There are **strong concerns in my country about the transparency** of choosing private partners.	40%
The innovative financing instruments are not attractive because **there aren't appropriate policy incentives** available in our country.	13.3%
Public authorities need more incentives to start using innovative financing options - currently, there is **not enough motivation to change** how we finance projects.	36.7%
The **process of obtaining funds through such instruments is too long**.	16.7%
The process of obtaining funds through such instruments is **too complicated and too risky**.	40%
We have heard of many problems faced by public authorities that started using such instruments.	10%
We have not heard of projects in our country that used such instruments successfully.	13.3%
We believe **that sooner or later there will be more subsidies** available and we are willing to wait.	6.7%
The **current climate and energy targets are unrealistic for us**, given the extent of investments we would need to carry out, **regardless of the currently available funding/financing options**.	13.3%
Other	10%

Other key PROSPECT+ outcomes

PROSPECT+

01 Recommendations-Decision Matrix tool: assist LRAs navigating a range of innovative financing schemes

02 SYNERGISE+ tool: prioritization of Mitigation & Adaptation actions from SECAPs

03 Finance Readiness tool (soon online): facilitate assessment of projects' financial maturity and determines areas of improvement

04 Learning handbooks, tools GUIDELINES and manuals for replicability beyond project end

05 Replicable practices LIBRARY (mentors, mentees' experiences)

06 Continued policy dialogues, Community of Practice

The Policy dialogue will continue! **Contribute to the Policy feedback survey** - aimed at sharing public authorities positions and recommendations as well as flagging up barriers faced when trying to finance climate and energy related projects.

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Thank you!

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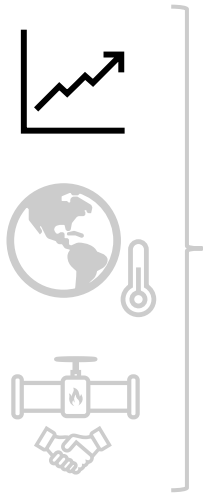
The PROSPECT+ project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101023271

Karlsruhe Institute of Technology

Validation of energy savings using the Smart Readiness Indicator through experiments in real buildings

Tristan Emich

Problem



Smart Building

Effects

Source: Destatis 2023: „Daten zur Energiepreisentwicklung“; Olk 2023: „Deutschland droht nach wie vor eine Gasmangellage“; Umweltbundesamt 2013: „Energiesparende Gebäude“; Bitkom 2024: „Klimaeffekte der Digitalisierung 2.0“; European Commission 2022: „Smart Readiness Indicator Schulungs-Diade“; Ramezani et al. 2021: „Application of smart readiness indicator for Mediterranean buildings in retrofitting actions“
: https://vito.be/en/news/towards-smarter-buidings-final-report-smart-readiness-indicator

Smart Readiness Indicator

Domain

Heating	10 Services
Cooling	10 Services
Domestic hot water	5 Services
Ventilation	6 Services
Lighting	2 Services
Electricity	7 Services
Electric vehicle charging	3 Services
Dynamic building envelope	3 Services
Monitoring & Control	8 Services

Impact

- Energy Efficiency
- Predictive maintenance
- Comfort
- Convenience
- Health and Wellbing
- Information for occupants
- Smart grid

Smart Readiness Indicator

Domain

Heating — 10 Services

H-1a	H-2a
H-1b	H-2b
H-1c	H-2d
H-1d	H-3
H-1f	H-4

Cooling — 10 Services
Domestic hot water — 5 Services
Ventilation — 6 Services
Lighting — 3 Services
Electricity — 7 Services
Electric vehicle charging — 3 Services
Dynamic building envelope — 3 Services
Monitoring & Control — 8 Services

Impact

Energy Efficiency

Predictive maintenance

Comfort

Convenience

Health and Wellbing

Information for occupants

Smart grid

Smart Readiness Indicator

Domain

Heating — 10 Services

H-2a

Level 0	Constant temperature control
Level 1	Variable temperature control depending on outdoor temperature
Level 2	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)
Level 3	-
Level 4	-

H-1f H-4

Cooling — 10 Services
Domestic hot water — 5 Services
Ventilation — 6 Services
Lighting — 2 Services
Electricity — 7 Services
Electric vehicle charging — 3 Services
Dynamic building envelope — 3 Services
Monitoring & Control — 8 Services

Impact

- Energy Efficiency
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Smart Readiness Indicator

Domain

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- Monitoring & Control — 8 Services

H-2a

Impact

		Energy Efficiency	Predictive maintenance	Comfort	Convenience	Health and Wellbing	Information for occupants	Smart grid
Level 0	Constant temperature control	0	0	0	0	0	0	0
Level 1	Variable temperature control depending on outdoor temperature	1	0	1	0	0	0	0
Level 2	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)	2	0	2	0	0	0	0
Level 3	-	-	-	-	-	-	-	-
Level 4	-	-	-	-	-	-	-	-

Smart Readiness Indicator

Domain

Heating — 10 Services

Impact

H-2a

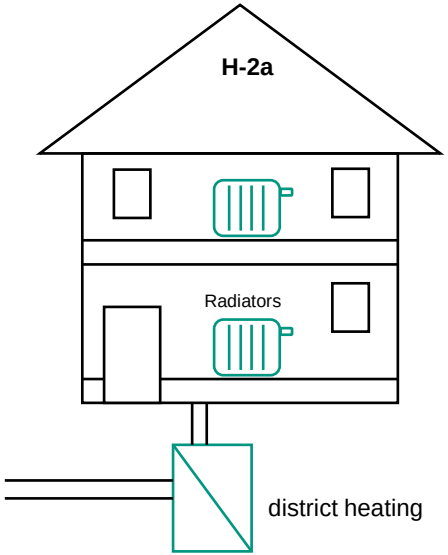
Level 0	Constant temperature control	0	0	0	0	0	0	0
Level 1	Variable temperature control depending on outdoor temperature	1	0	1	0	0	0	0
Level 2	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)	2	0	2	0	0	0	0
Level 3	-	-	-	-	-	-	-	-
Level 4	-	-	-	-	-	-	-	-

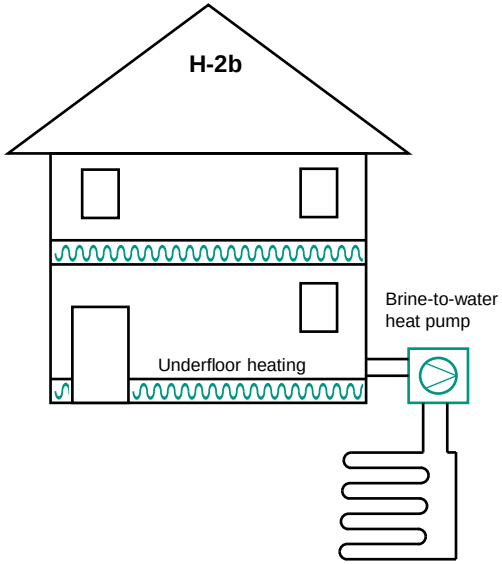
H-2b

Level 0	On/Off-control of heat generatori	0	0	0	0	0	0	0
Level 1	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)	1	0	1	0	0	0	1
Level 2	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	2	0	2	0	0	0	1
Level 3	Variable control of heat generator capacity depending on the load AND external signals from grid	2	0	2	0	0	0	3
Level 4	-	-	-	-	-	-	-	-

Method – Services

- H-2: Heat generator control
  - a: district heating
  - b: heat pumps





Quelle: Bettgenhäuser und Boermans 2011: „Umweltwirkung von Heizungssystemen in Deutschland; VDI 4645 2023: „Heizungsanlagen mit Wärmepumpen in Ein- und Mehfamilienhäusern“

Methodology – Variable

Independent variable

Functionality level (intelligent technology)

Dependent variable

Energy consumption

Disturbance variables

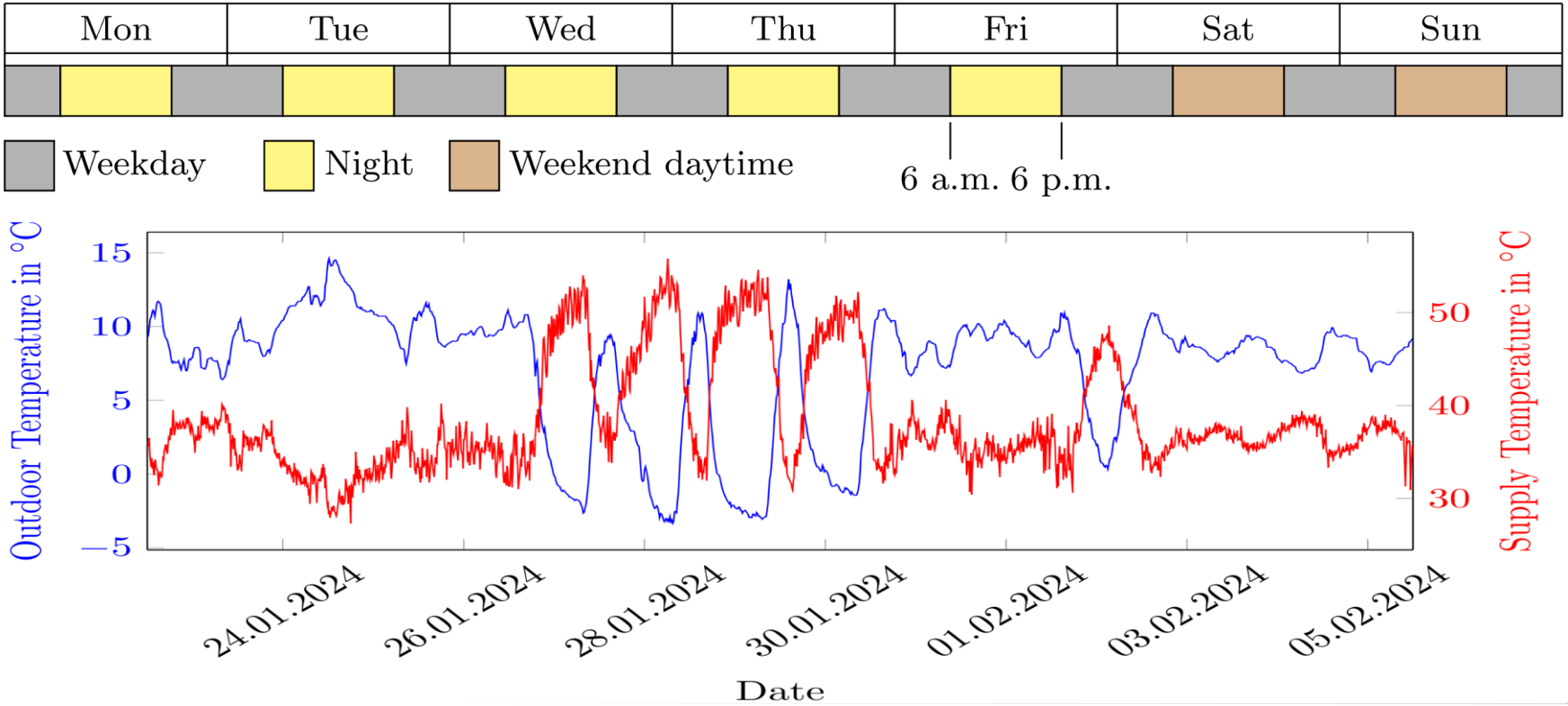
Use, weather

usage scenario

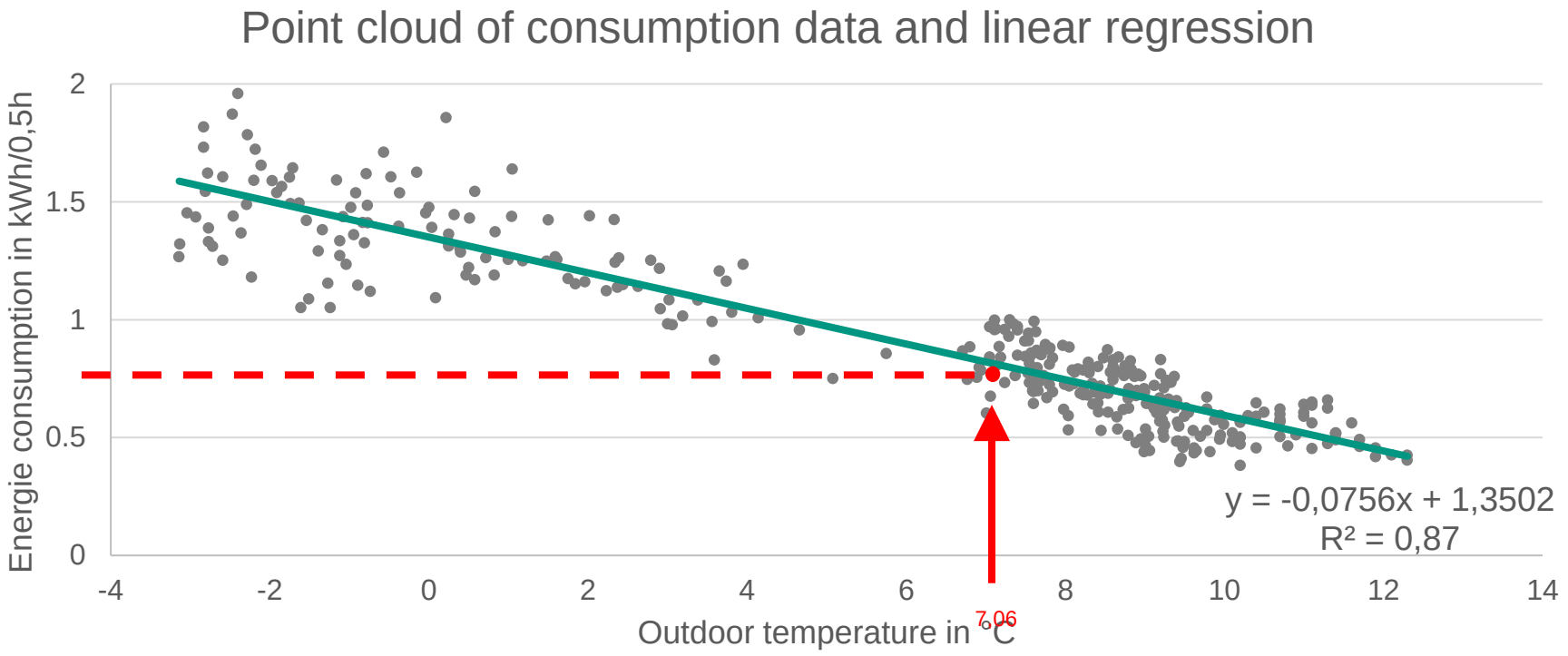
Normalisation

Quelle: Albers et al. 2009: „Methodik der empirischen Forschung“

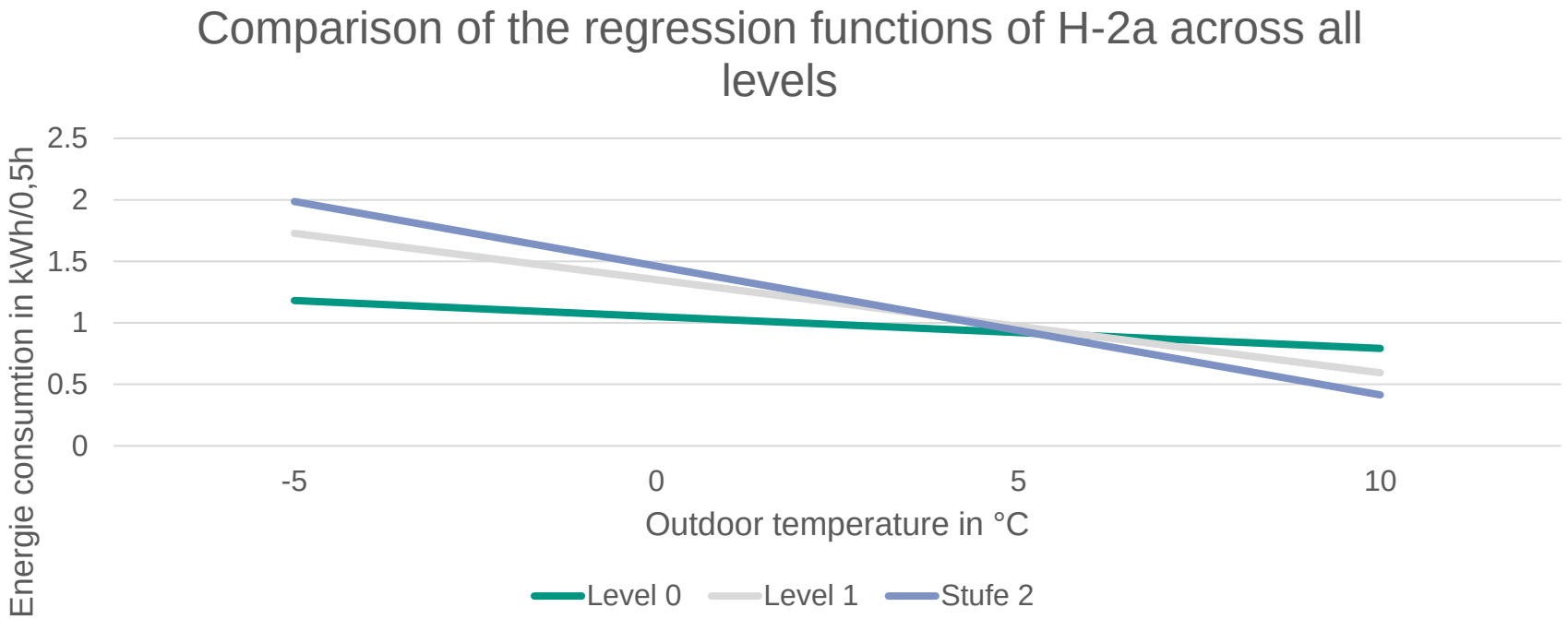
Experiment overview



Methodology – Evaluation



Results – Dependence on the temperature



Results – energy savings

Level	Impact Score Energy Efficiency	Beitrag Energieeffizienz zum SRI-Score	Energy saving according to ISO 52120	Measured energy savings	
				H-2a	H-2b
0	0	+0 %	0 %	0 %	0 %
1	1	+5,2 %	9 %	6 %	30,6 %
2	2	+10,3 %	26 %	16,8 %	36,1 %
3	2	+10,3 %	26 %	n. v.	30,6 %

H-2a

Level 0	Constant temperature control	0
Level 1	Variable temperature control depending on outdoor temperature	1
Level 2	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)	2
Level 3	-	-
Level 4	-	-

H-2b

Level 0	On/Off-control of heat generatori	0
Level 1	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)	1
Level 2	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	2
Level 3	Variable control of heat generator capacity depending on the load AND external signals from grid	2

Results - additional findings

Use

Comfort

Smart grid

Karlsruhe Institute of Technology

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Bildquelle: https://www.iai.kit.edu/RPE-LLEC.php#gallery

Design for circularity, a demonstration building – "Petite Maison"

SUSTAINABLE PLACES 2024

ArcelorMittal

Global Research and Development
24 September 2024

Jie YANG ArcelorMittal Global R&D, Esch-sur-Alzette, Luxembourg

About the project “Petite Maison”

- A demonstration building, located in Esch-sur-Alzette, Luxembourg, contributed to Esch2022, European Capital of Culture, by promoting the circularity of construction materials.
- Designed for disassembling /deconstruction and reuse, in steel-frame with prefabricated modular elements, incorporating the latest advancements from REDUCE on demountability and reuse of composite structures.
- Design, construction, use and deconstruction phases; QR codes were attached to reusable building components, linking them to a virtual database to facilitate future reuse.
- Reclaimed materials and components are presently stored at ArcelorMittal’s premises near the building site.

Petite Maison & Maison du Savoir

University of Luxembourg

About the project “REDUCE”

- REDUCE – *Reuse and Demountability using Steel Structures and the Circular Economy*, 07/2016 – 12/2019.
- Investigated the methodology and opportunities to design and facilitate the reuse of composite structures in steel frames.
- Opportunities for greater standardization, the quantification of whole-life benefits of the developed systems, and the use of Building Information Modelling were also investigated to encourage demountable design and reuse.
- Experimental, numerical, and analytical studies have been performed, providing better insight into the behaviour and design approaches of composite structures in demountable systems.
- Adaptable steel connections between beams and columns, and bolted connections between slabs and beams have been used in the “Petite Maison” project.

About the project “ADVANCE”

- ADVANCE – *Accompanying measure for Dissemination, Valorisation and Collaborative Exploitation of circularity of constructional steel products*, 09/2023 – 08/2025.

- Project objectives
  - Provide guidance for reuse of existing components or structures and design of new ones, introduce recommendations for product/waste status and material testing protocol for re-certification of steel products in the updated Recommendations for Reuse.
  - Support declaration of the environmental benefits of steel reuse implemented in the mobile LCA app and web tool.
  - Increase awareness about the alternative end-of-life options for constructional steel and steel-based products.
  - Identify the possibilities and roadmaps for scaling up the outcomes of the background projects beyond their original focus area.

- Project outcomes
  - European Recommendations for Reuse (ECCS publication).
  - 15 Factsheets.
  - Mobile/web LCA tool with BIM integration.
  - Workshops, online presentations, etc.

ADVANCE factsheets


Factsheet n° 10: S-Market, Urjala, Finland

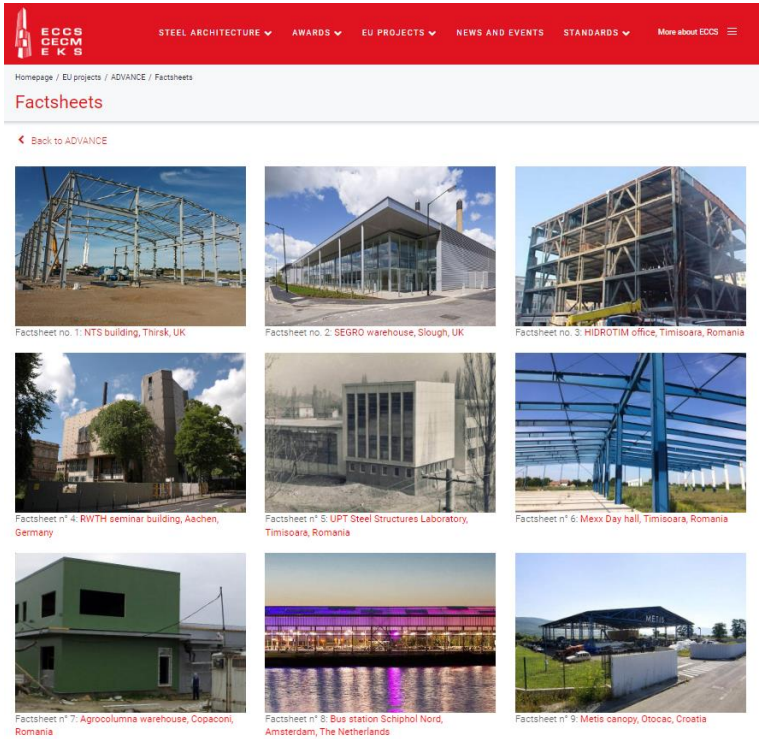

Factsheet n° 11: Reuse hall, Germany


Factsheet n° 12: Design for circularity – Petite Maison, Luxembourg


Factsheet n° 13: Reuse of steel sheet piles, Germany,


Factsheet n° 14: Deconstruction and reassembly of a hall, France


Factsheet n° 15: Deconstruction and relocation of four standard kit modules, Romania



Further details:
https://www.steelconstruct.com/eu-projects/advance/factsheets/

Circular design considerations

- Carbon optimization
  - The weight of the steel beams and columns were reduced about 24%, from 17.39 tons to 13.25 tons, by using a higher grade of steel (S355 to S460).

Petite Maison

Esch-sur-Alzette, Luxembourg

Circular design considerations

- Carbon optimization
- Prioritization of modular prefabricated elements with standardized details
  - Prefabricated concrete floor slabs in a uniform size, all steel beams in a uniform length, aligned with a structural grid of 1.35 meters.

Petite Maison

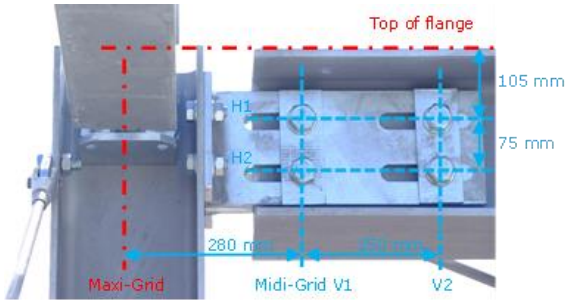
The axis of columns following a proposed standard grid

Circular design considerations

- Carbon optimization
- Prioritization of modular prefabricated elements with standardized details
  - Prefabricated concrete floor slabs in a uniform size, all steel beams in a uniform length, aligned with a structural grid of 1.35 meters.
  - Uniform steel sections for columns and primary beams, respectively, including identical bolt hole layouts.
  - All additional connected members (for example bracing, roof structure, etc.) used the existing pre-drilled holes in beams and columns
  - Adaptable steel connections, featuring standardized bolt hole layouts for bolts in both endplates and fin plates.
  - Concrete foundations are prefabricated and are designed to be removable and potentially reusable.

Petite Maison

Standardized details

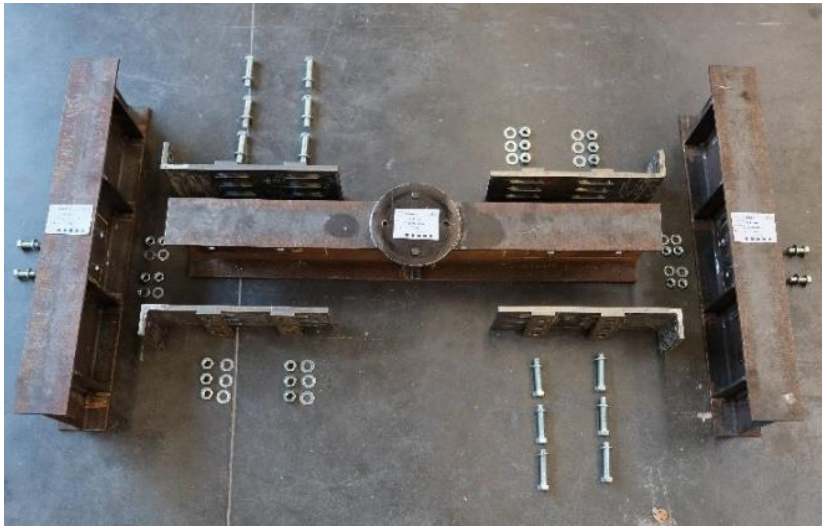


Circular design considerations

- Carbon optimization
- Prioritization of modular prefabricated elements with standardized details
- Consideration of member adaptability
  - Adaptable steel connections enable secondary beams to connect with primary beams as well as columns of various sizes within the same structural grid, enhancing the adaptability of these beams.

Petite Maison

Adaptable steel connections linking a secondary beam to two primary beams



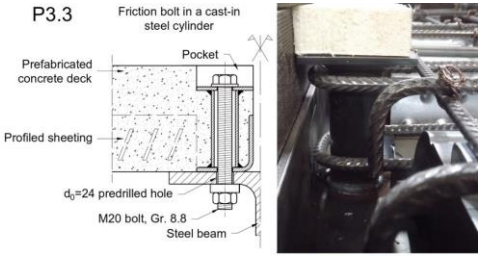
Circular design considerations

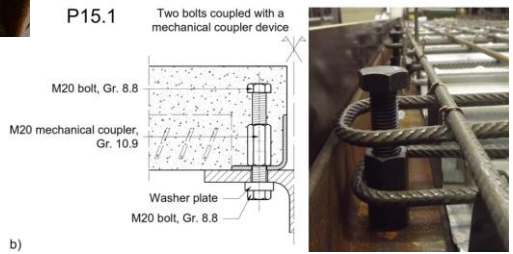
- Carbon optimization
- Prioritization of modular prefabricated elements with standardized details
- Consideration of member adaptability
- Designing for disassembly using bolted connections
  - Bolted connections have been favored within the structure: demountable shear connections between beam and slab, connections for beams, columns, bracings, and foundations, allowing for easier disassembly compared to welded connections. Welding was kept to an absolute minimum (only the base plate is welded to the column, nothing else).

Petite Maison

Prefabricated concrete slab

Embedded steel tube, welded plates with pre-drilled bolt hole, steel angle





Circular design considerations

- Carbon optimization
- Prioritization of modular prefabricated elements with standardized details
- Consideration of member adaptability
- Designing for disassembly using bolted connections
- Responsible sourcing of materials
  - Main building components are new materials with low environment impact inputs where possible, while non-loadbearing timber panels are reused materials.

Petite Maison

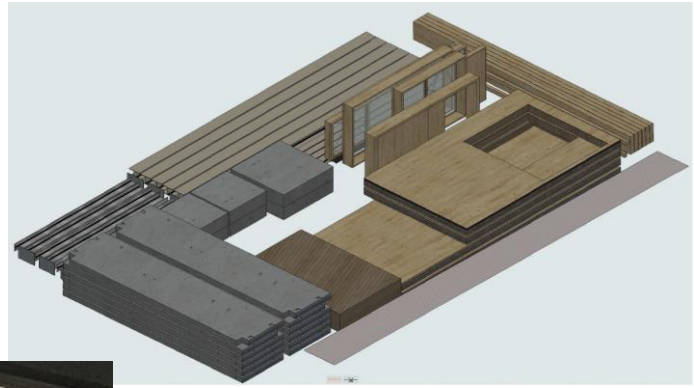
Esch-sur-Alzette, Luxembourg

Deconstruction

- Both digital and printed inventory catalogues are easily accessible. Each construction element underwent BIM modeling, followed by scanning and inventorying, with QR codes attached that link to a deconstruction platform jointly developed by LIST and BIM-Y. This platform provides detailed information on geometry, technical properties, and manufacturers.
- The same contractors are responsible for both the construction and deconstruction of the building. The deconstruction process closely mirrored the original construction sequence.
- A deconstruction procedure and storage plan, devised by Uni.Lu, facilitated efficient handling and organization throughout the deconstruction process.

Petite Maison

Reclaimed material, Storage space measuring 13.5 m × 6 m



2023-2025 ADVANCE
ACCOMPANYING MEASURE FOR DISSEMINATION, VALORISATION AND COLLABORATIVE EXPLOITATION OF CIRCULARITY OF CONSTRUCTIONAL STEEL PRODUCTS

UNIVERSITÉ DU LUXEMBOURG

ArcelorMittal

Reclaimed materials and components – damage and potential for reuse

- The steel sections within the steel frame were well-separated and in good condition: there was no visible degradation of galvanization, no signs of rust, and no visible deformation of the profiles. The steel sheets were unscrewed from the timber roof without any loss.
- It was necessary to cut notches to access the screw heads in timber frame and partitions; resulting in minor damages to the timber frame at the screw level. Several timber cladding boards were damaged due to nailing.
- The prefabricated concrete slabs and foundations were well salvaged, with some local damage observed in the concrete foundation blocks.
- Other salvaged materials included bolts, threaded rods, nuts, most of the insulation elements, plastic covering films, etc.
- To facilitate reuse, the connecting plates and bolts were reattached to the steel beams. Salvaged elements were labeled.

Petite Maison

Reclaimed materials and components

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Future reuse scenarios

- Future reuse scenarios are under consideration for the materials reclaimed from the Petite Maison project:
  - Relocation: the plan involves relocating and reconstructing the Petite Maison building using the same materials and components from within the project itself.
  - Extension: this approach involves accommodating reclaimed materials and components in the same layout of the original Petite Maison building, with extensions constructed using reclaimed materials sourced from other buildings or projects.
  - Adaptation to new layout: the possibility to design a one-family house on an existing empty plot in the city of Esch integrating the reclaimed materials has been studied. More similar elements are needed to complete the design.

Concluding remarks

- The Petite Maison stands as a pioneering demonstration project, illustrating the potential of new building construction to champion material circularity via a system that is de-constructable, modular, and reusable.
- Following deconstruction, a valuable stock of reusable building elements is generated, with high potential for future reuse.
- Deconstruction of buildings and salvaging their components are technically feasible, key aspects to this success are:
  - Early engagement during the design phase,
  - The incorporation of demountable systems alongside prefabricated and standardized elements and details,
  - Comprehensive inventory documentation,
  - Contractor familiarity with the building's structure,
  - Well-structured deconstruction procedure and storage plans.

Acknowledgement

The Petite Maison project was led and coordinated by architect Prof. Carole Schmit, with support from R&D specialist Dragos Ghioca, and in collaboration with Prof. Dr. Christoph Odenbreit at the University of Luxembourg.

This project has been made possible through the generous support and contributions of the following partners. The authors gratefully acknowledge their collaboration, support, and contributions to the Petite Maison project, upon which this case study is built: University of Luxembourg, Administration des Bâtiments Publics, Agora, Alwitra, Annen, ArcelorMittal, Betic Ingénieurs-Conseils, Béton Feidt, BIM-Y, Bois Brever, CDCL, CGDIS, Cimalux, Coatinc, DEG, DESA Ingénieurs-Conseils, EMBuild, Esch22, Fire Group SECO, Fonds Belval, frEsch.asbl, Gardula, GERI Management, Geri Securite Sante, Gru-Lux, Schreinerei Hoffmann, Lamesch, Icone, Leyendecker, Luxembourg Institute of Science and Technology, Luxinnovation, Luxlev, Mabilux, Manfred Scherf Holzfachhandel, Mersch Ingénieurs-paysagistes, Metrico, Modena Group, Paul Wurth – Geprolux, Prefalux, Polaris Architects, Reckinger, Restopolis, Rotor, Scherf, Schroeder & Associés, TWH - Trierer Werkzeughandel, Ville d'Esch-sur-Alzette, Wurth Shop Luxembourg.

The underlying scientific research leading to the Petite Maison project was part of the research project "REDUCE", which was funded by the European Commission, Research Fund for Coal and Steel under grant agreement No. 710040. The project partners included the Steel Construction Institute, University of Luxembourg, University of Bradford, Lindab, Tata Steel, Bouwen met Staal, Delft University of Technology, and AEC3.

This case study was prepared by Jie Yang, José Humberto Matias de Paula Filho from ArcelorMittal, with the support of Christoph Odenbreit, Shahin Sayyareh, András Kozma, and Carole Schmit.

The authors are grateful for the information and images provided by Schroeder & Associés regarding deconstruction.

Funded by the European Union

Reuse of steel sheet piles

- Factsheet published on the ECCS website.
- The modularity, compactness, and high stiffness of steel sheet piles, along with the available rental and buy-back business model, facilitate their reuse.
- Steel sheet piles are a top choice in temporary scenarios, such as cofferdams in water, linear excavations, and water retention.
- In temporary applications, steel sheet piles are often reused multiple times within the same project or for subsequent projects.
- Used sheet piles may also be applied in permanent applications.
- After long service lives, sheet piles can still be extracted from the soil, recycled, and serve as input for newly produced steel.
- This establishes a perfect cycle for the infinite use of steel, without any degradation of material properties.

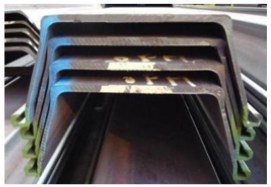
Reuse of Steel Case Study no. Xi

Reuse of steel sheet piles

Project summary

Project: Remediation of "Schwarze Pumpe" brownfield site, Spremberg, Germany
Project owner: LMBV GmbH
Design: Arge, CDM Smith
Contractors: Arge Lobbe / Bauer
Steel product: Sheet pile PU 22 [1] 14.0 m – 23.0 m S 355 GP 2,000 t
Steel manufacturer: ArcelorMittal
Construction cost: N/A

Reuse of steel sheet piles



Sheet piles can be applied in many fields, such as water transport solutions like quay walls, hazard protection solutions such as dams, mobility infrastructure solutions like rail and road bridges, tunnels, underground car parks, and environmental protection solutions such as polluted soil remediation. The modularity of steel sheet piles facilitates their reuse; they can be extracted from the ground at the end of their service life. In temporary applications, steel sheet piles are often reused multiple times in the same project or for subsequent projects. Steel sheet piles are top choice in temporary scenarios for example, cofferdams in water, linear excavations, water retention, complicated utilities installation and repairs, and limitation of settlement in nearby structures and services.

Temporary applications, such as excavation pits, have shorter life cycles, often under 2 years. Contractors commonly employ sheet piles for such purposes, with sections sometimes reused up to 10 times. Symmetric U-sections are particularly suitable for reuse due to their compactness and high stiffness. After each use, a portion (≤ 50 cm) is typically removed if deformations or damages from the installation process are observed at the head or toe. In addition, it is becoming increasingly accepted by project owners to install used sheet piles in permanent applications. After long service lives, the sheet piles can still be extracted from the soil, being recycled and serve as input for the newly produced steel. This establishes a perfect cycle for the infinite use of steel, without any degradation of material properties.

Thank you for your attention!

ArcelorMittal

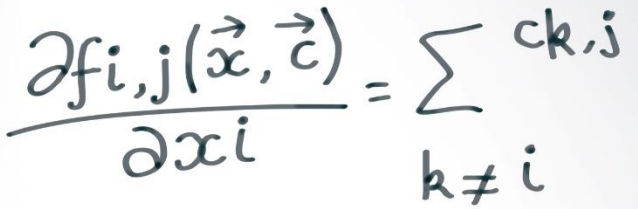
LIFE CYCLE ASSESSMENT OF AN UNDERGROUND CAR PARK'S RETAINING WALLS

Global Research and Development

06/06/2024

José Humberto M. de Paula Filho[a]

[a] ArcelorMittal Global R&D, Esch-sur-Alzette, Luxembourg



SUSTAINABLE PLACES 2024

Presentation Outline:

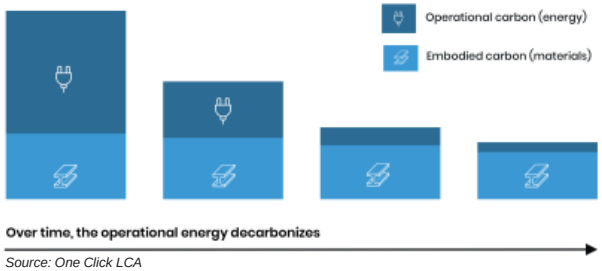
SUSTAINABLE PLACES 2024

1. INTRODUCTION
2. METHODOLOGY
3. RESULTS AND INTERPRETATION
4. CRITICAL REVIEW
5. CONCLUSION

INTRODUCTION:

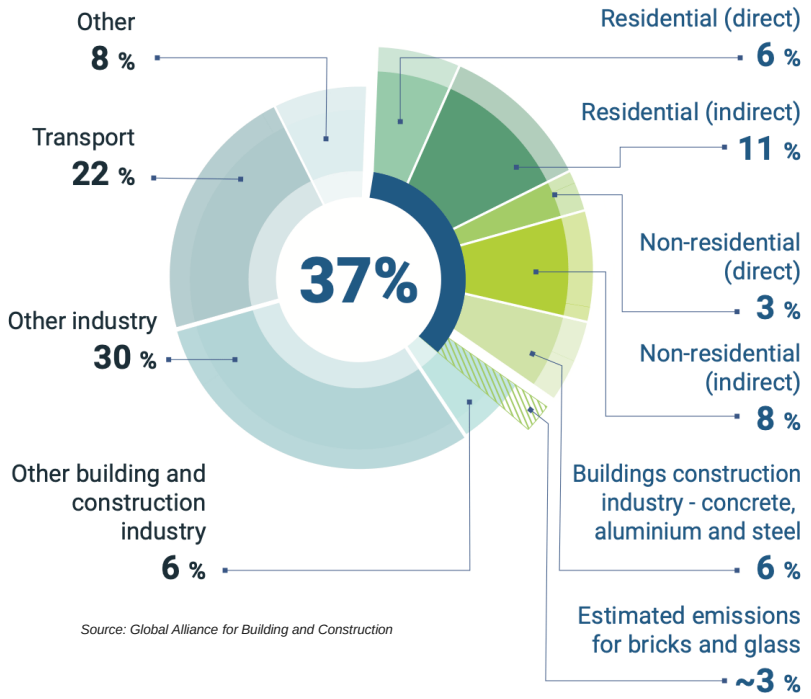
Environmental emergency

- 37% of the global share of energy-related CO_2e emissions were attributed to buildings and the construction sector.
- Efforts have been brought to reduce the operational carbon footprint of buildings by improving their energy efficiency



Source: One Click LCA

- Awareness has also been raised on embodied carbon. Emissions from materials and products must be urgently addressed to ensure constructions are optimized as low-carbon solutions.



Source: Global Alliance for Building and Construction

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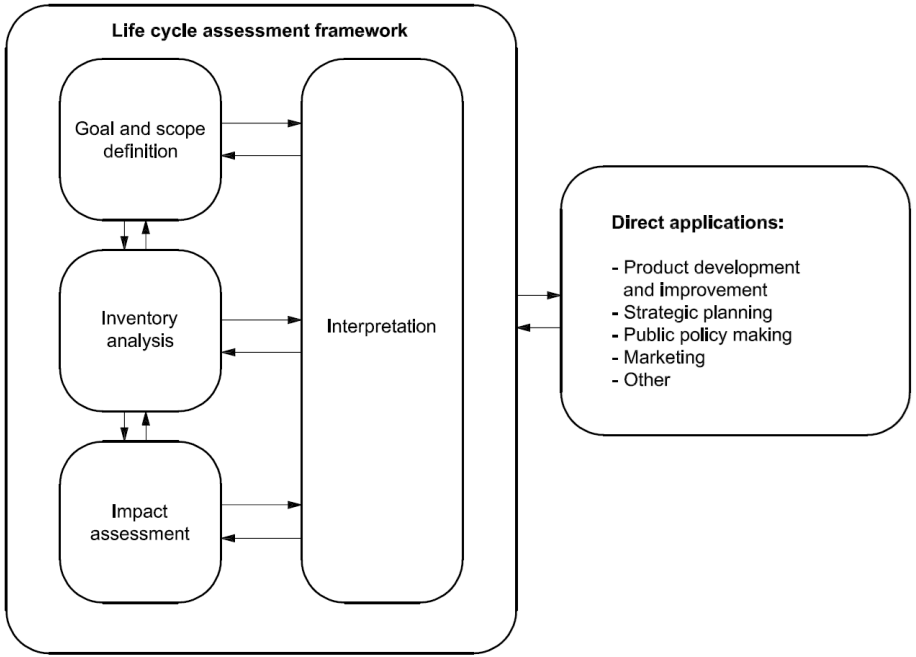
METHODOLOGY:

Life-cycle Assessment (LCA):

- LCA is a scientific and quantitative method for determining and assessing environmentally relevant processes.

- The ISO 14044 Environmental management — Life cycle assessment — Requirements and guidelines define the steps that shall be followed for LCA:
  - Goal and Scope;
  - Life Cycle Inventory (LCI)
  - Life Cycle Impact Assessment (LCIA);
  - LCA Interpretation;



Source: ISO 14040

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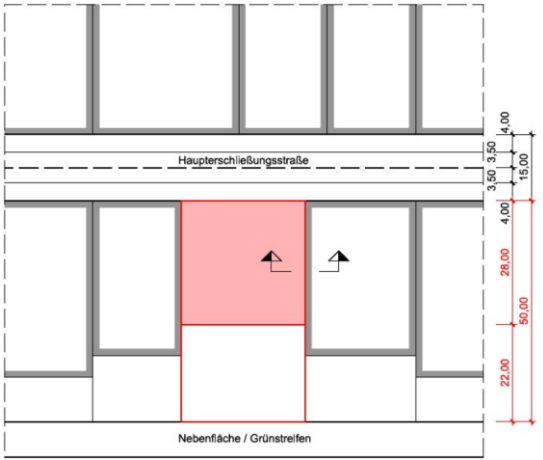
Goal and Scope:

- **Goal:**
  - The goal of this study is to assess the life cycle environmental impacts associated with four different types of retaining wall systems within the excavation pit of an underground car park. The study observes impacts over a 50-year analysis period at one location: Berlin, Germany.

- **Functional Unit:**

Functional unit	One retaining wall of a total length of 112 m spanning 2 underground levels for a total excavation height of 9,5 m over a 50-year analysis period. The excavation pit is squared-shaped with sides equal to 28 m.
Reference unit	One retaining wall with a total length of 112 m.
Location	Berlin (DE).
Quantification	Material content as defined by the design office GRBV.

Goal and Scope:



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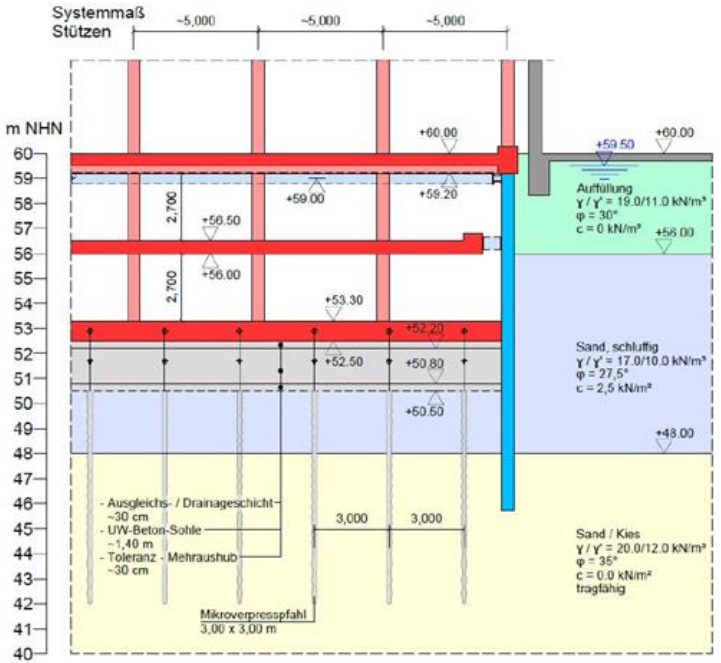
Goal and Scope:

- **Object of assessment (Product description):**
  - The structural design was conducted by the German design office GRBV Ingenieure im Bauwesen;
  - Four alternatives for retaining walls:
    - Permanent steel sheet pile (SSP) wall.
    - Temporary steel sheet pile wall in combination with a permanent reinforced concrete (RC) wall;
    - Permanent Secant Pile wall (RC);
    - Permanent Diaphragm wall (RC, also known as “slurry wall”).
  - The functional equivalency of these solutions is ensured by adopting the same boundary conditions such as design assumptions, building situation (neighbors), soil condition, safety requirements, and actions on the structure;
  - All the retaining wall solutions were designed to maximize their utilization ratio, ensuring the most economical solution for each specific case
  - The soil properties are typical for the Berlin region:



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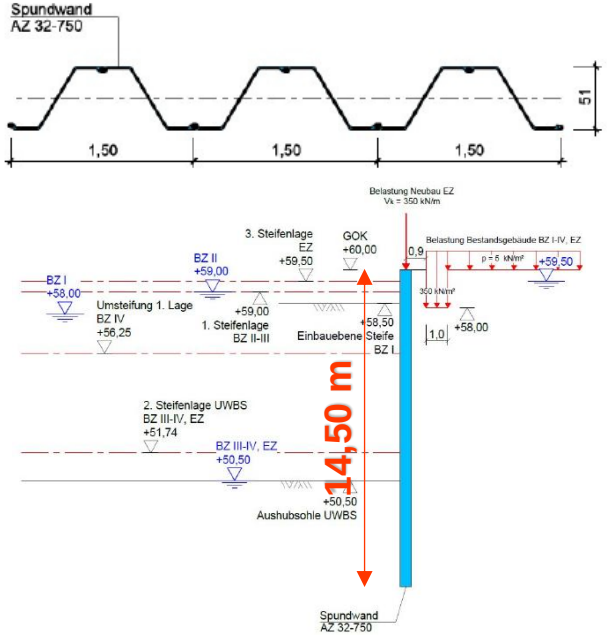
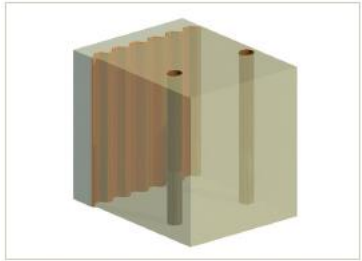
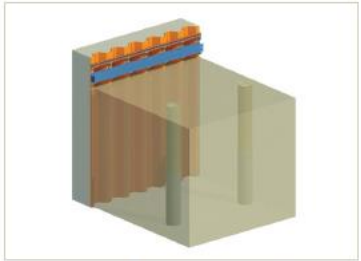
Goal and Scope:

- **Object of assessment (Product description):**
  - Permanent steel sheet pile wall (VARIANT 1)

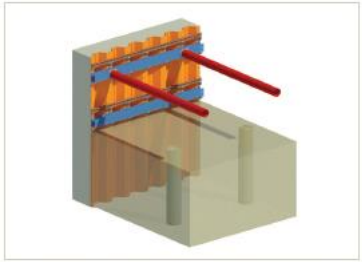




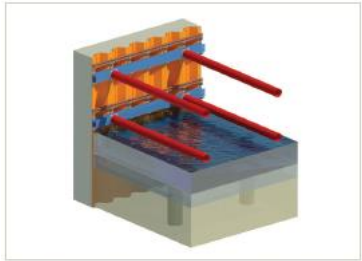
a. Steel sheet piles & piles for foundations installed



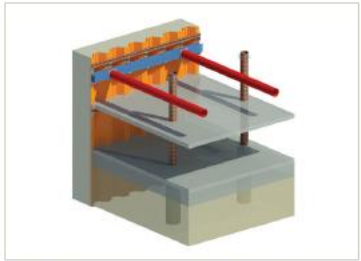
b. Excavation to level slightly below top strut



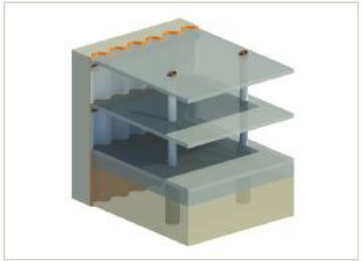
c. Installation of top strut, followed by excavation to level slightly below second strut



d. Installation of bottom strut, excavation under water, followed by bottom slab poured under water



e. Execution of permanent slab, followed by removal of lower strut



f. Execution of permanent slab (acting as strut) and removal of top strut

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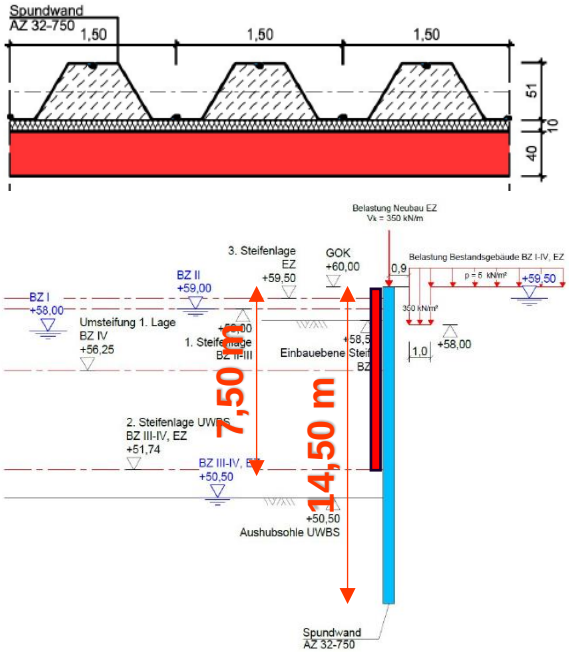
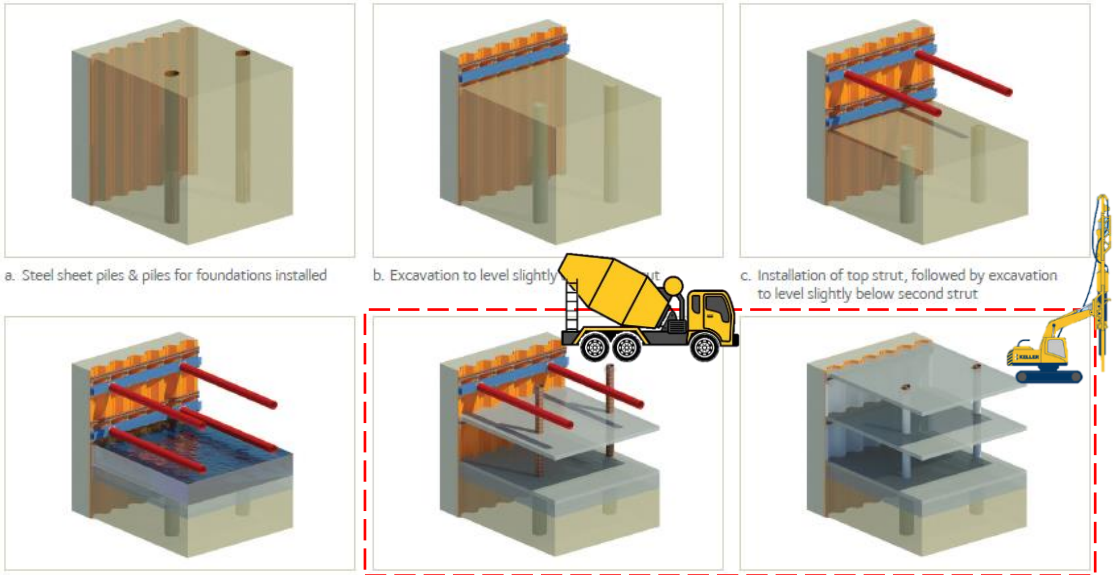
Goal and Scope:

- **Object of assessment (Product description):**
  - Temporary steel sheet pile wall in combination with a permanent reinforced concrete (RC) wall (VARIANT 2)





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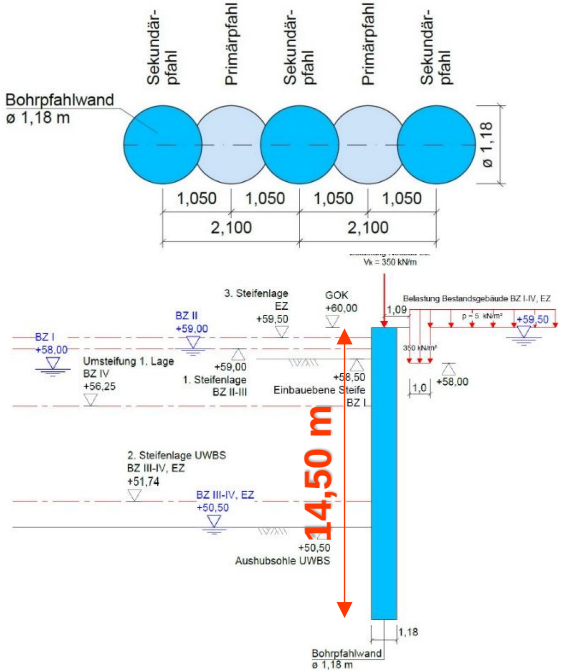
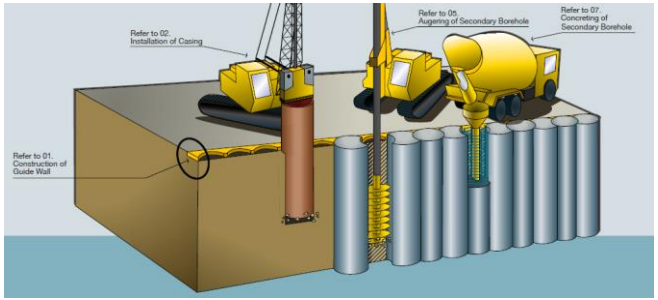
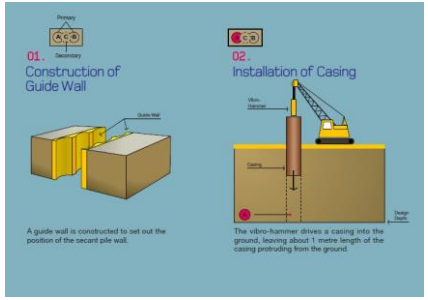
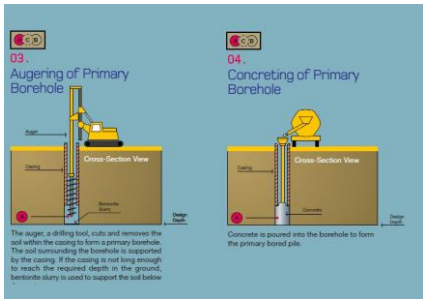
Goal and Scope:

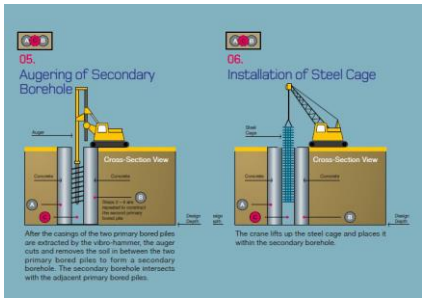
- **Object of assessment (Product description):**
  - Permanent Secant Pile wall (RC) (VARIANT 3)

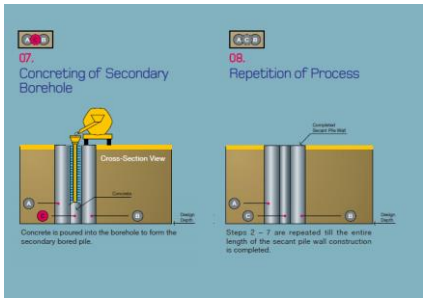












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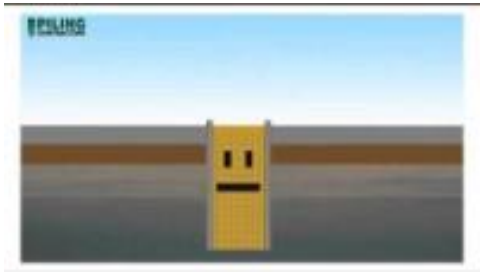
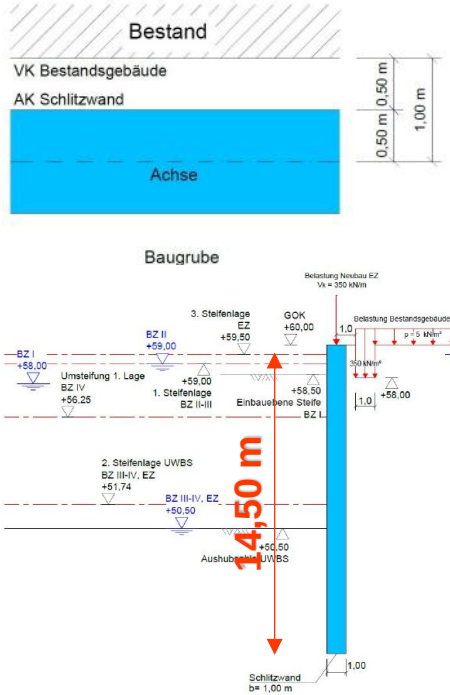
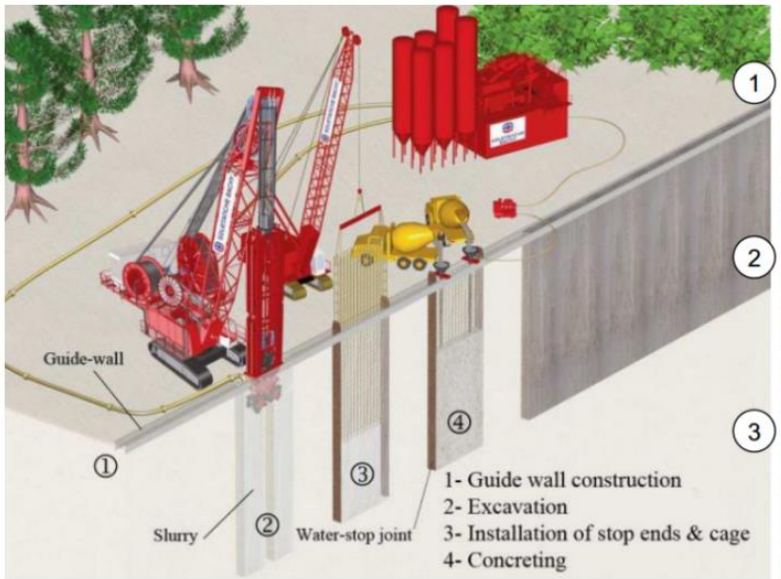
Goal and Scope:



- **Object of assessment (Product description):**
  - Permanent Diaphragm wall RC (VARIANT 4)





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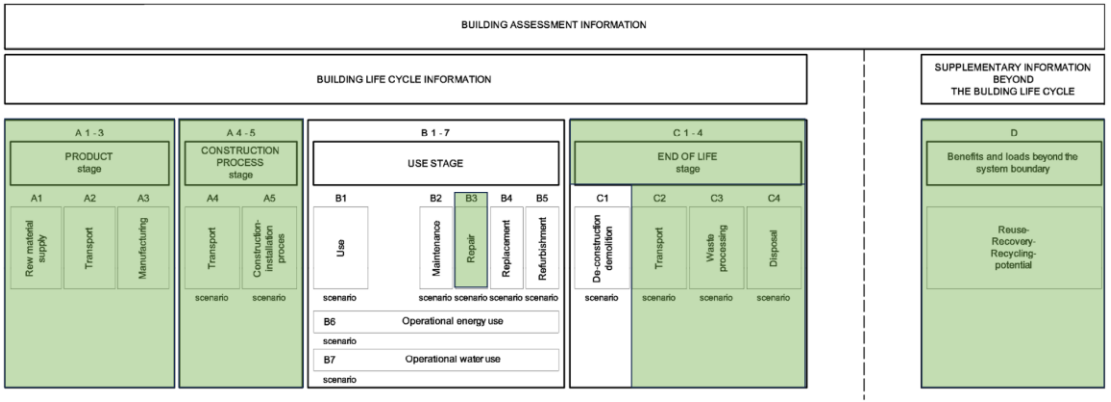
Goal and Scope:

- **System Boundaries:**
  - The EN 15978 set out a common life cycle model for construction works. The life cycle model includes modular definitions for the life cycle stages, allowing each stage to be compared in isolation with other projects.
  - Product Stage – A1-A3;
  - Construction Process Stage – A4-A5;
  - Repair B3;
  - End of Life – C2-C4
  - Benefits and loads outside the systems boundaries – D.



Source: EN 15978

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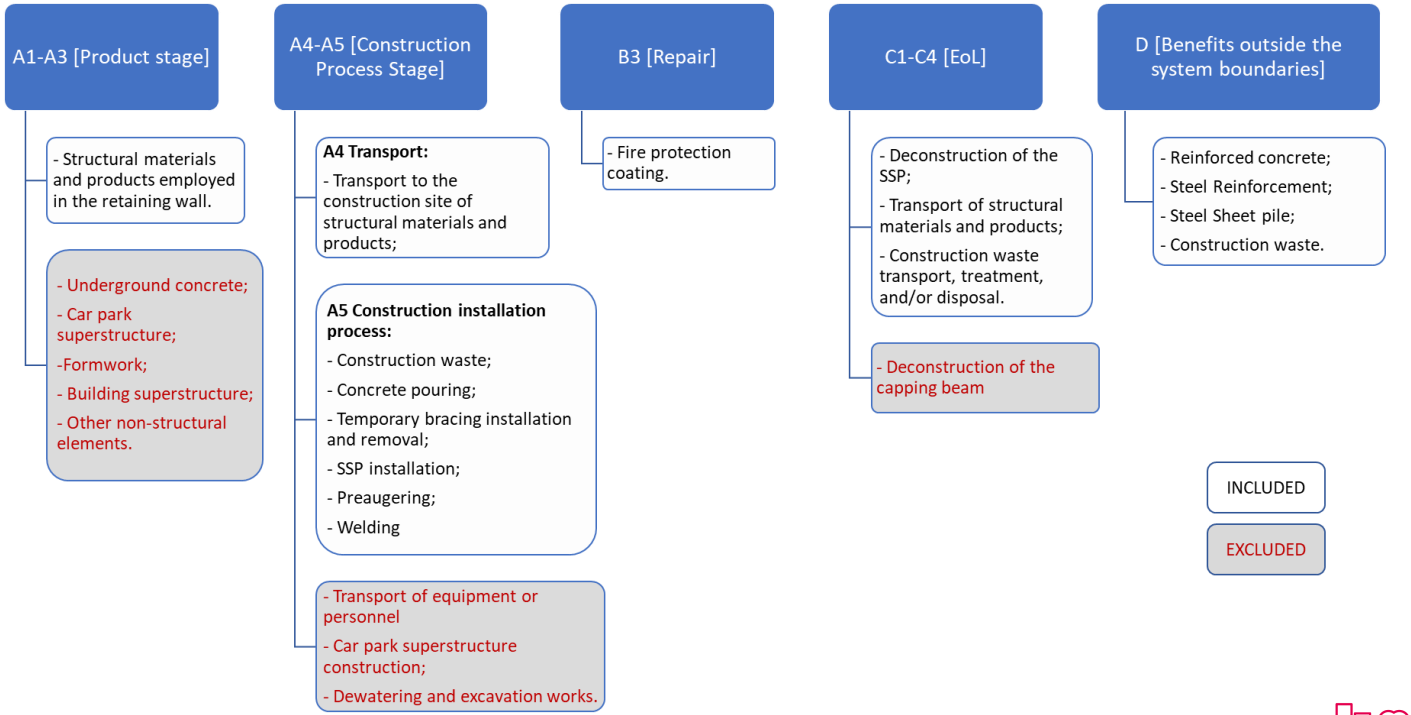
Goal and Scope:

- **System Boundaries Permanent steel sheet pile wall (VARIANT 1):**



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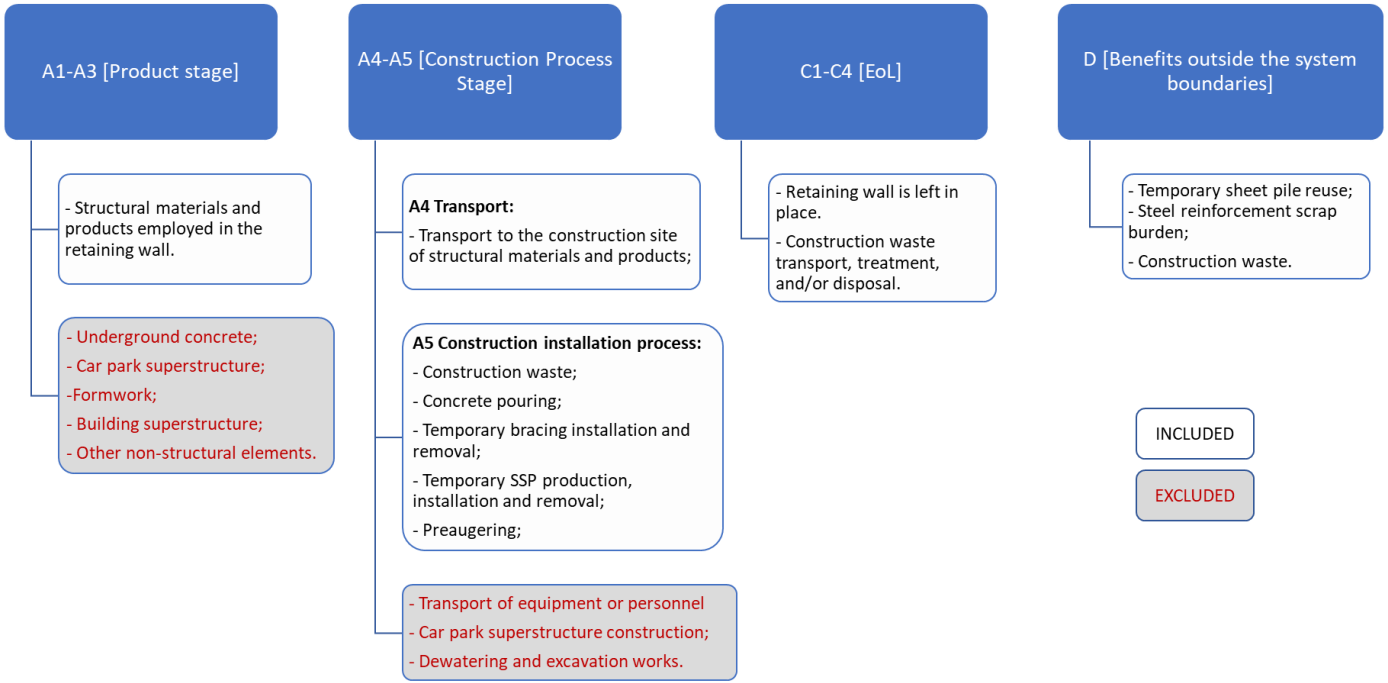
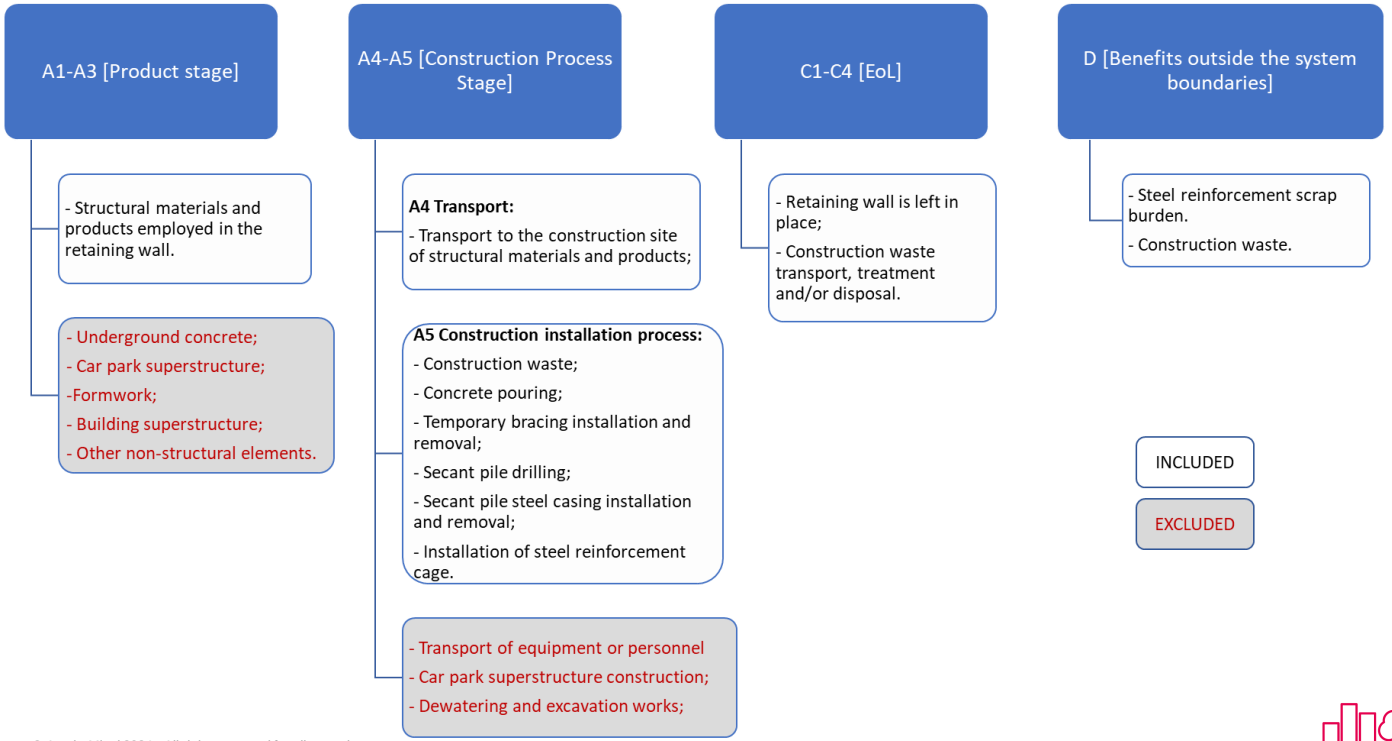
Goal and Scope:

- **System Boundaries Temporary steel sheet pile wall (VARIANT 2):**



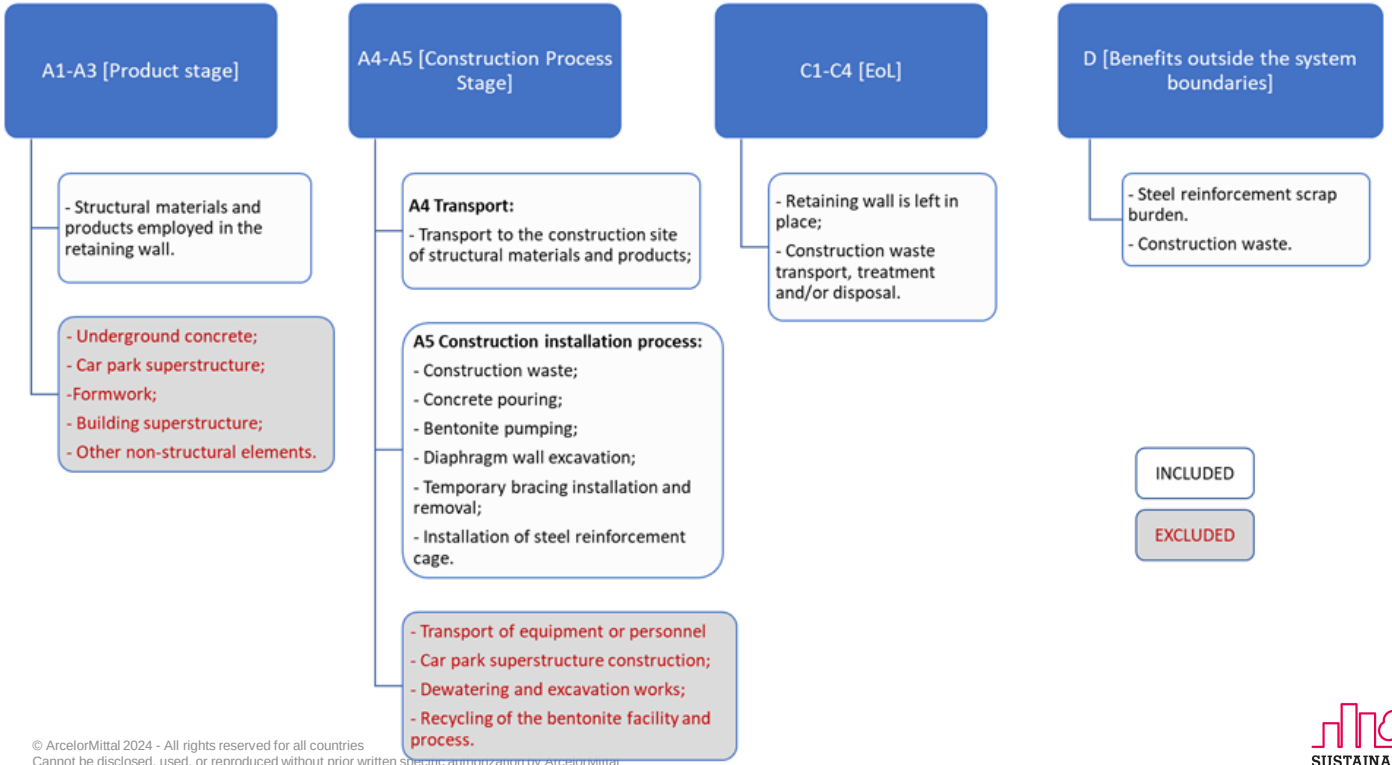
Goal and Scope:

- **System Boundaries Permanent Secant Pile wall (VARIANT 3):**



Goal and Scope:

- **System Boundaries Permanent Diaphragm wall (VARIANT 4):**



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Goal and Scope:

- **Time coverage:**
  - The study represents a hypothetical initial construction in 2024 and continued use of the retaining wall for 50 years.
- **Technology Coverage:**
  - Technologies are representative of Germany and Europe for manufacturing the structural materials, and the construction of the retaining wall. Current technologies have been applied to future repair and deconstruction activities.
- **Geographical Coverage:**
  - Design assumptions, background data on environmental impacts, and life cycle assessment scenarios were intended to represent a retaining wall construction in Berlin Germany. The results of this study are only applicable to the location, the boundary conditions and LCA scenarios considered.

- **Allocation**
  - Co-product allocation was not necessary for the foreground processes, as there are no co-products known or considered in the construction of the retaining wall.
  - For all background data used in the model, the standard allocation assumptions of the used datasets were maintained.
- **Cut-off criteria:**
  - No cut-off criteria were applied in this study.

Goal and Scope:

- **Selection of Life Cycle Impact Assessment Methodology and Types of Impacts:**

Impact category	Indicator	Unit	Model
Climate change - total	Global Warming Potential total (GWP-total)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - fossil	Global Warming Potential fossil fuels (GWP-fossil)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - biogenic	Global Warming Potential biogenic (GWP-biogenic)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Climate change - land use and land use change	Global Warming Potential land use and land use change (GWP-luluc)	kg CO_2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013
Ozone Depletion	Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq.	Steady-state ODPs, WMO 2014
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H^+ eq.	Accumulated Exceedance, Seppälä et al. 2006, Posch et al., 2008
Eutrophication aquatic freshwater	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater)	kg P eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication aquatic marine	Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-marine)	kg N eq.	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe
Eutrophication terrestrial	Eutrophication potential, Accumulated Exceedance (EP-terrestrial)	mol N eq.	Accumulated Exceedance, Seppälä et al. 2006, Posch et al.
Photochemical ozone formation	Formation potential of tropospheric ozone (POCP);	kg NMVOC eq.	LOTOS-EUROS, Van Zelm et al., 2008, as applied in ReCiPe
Depletion of abiotic resources - minerals and metals	Abiotic depletion potential for non-fossil and metals resources (ADP-elements)	kg Sb eq.	CML 2002, Guinée et al., 2002, and van Oers et al. 2002.
Depletion of abiotic resources - fossil fuels	Abiotic depletion potential for fossil resources (ADP-fossil)	MJ, net calorific value	CML 2002, Guinée et al., 2002, and van Oers et al. 2002.
Water use	Water (user) deprivation potential, deprivation-weighted water consumption (WDP)	m^3 world eq. deprived	Available WAter REmaining (AWARE) Boulay et al., 2016

Goal and Scope:

- **Assumptions:**
  - **Transport A4**

Material/Product	leg 1		leg 2	
	Distance (km)	Type	Distance (km)	Type
Ready-mix concrete	30	Truck, 32 t payload	-	-
Steel sheet piles	790	Truck, 20-26 t	-	-
Temporary steel sheet piles	659	Truck, 20-26 t	-	-
Steel plates	2209	Bulk Carrier Coast	316	Rail transport
Welding material	370	Truck, 20-26 t	-	-
Fire protection coating	110	Truck, 20-26 t	-	-
Temporary bracings	2209	Bulk Carrier Coast	316	Rail transport
Steel rebars	600	Truck, 20-26 t	-	-
Sealing material: Beltan	790	Truck, 20-26 t	-	-
Drilling template foam	430	Truck, 20-26 t	-	-
Bentonite	200	Truck, 20-26 t	-	-
Exterior wall insulation	430	Truck, 20-26 t	-	-

Goal and Scope:

- **Assumptions:**
  - **Construction A5**

Material wastage scenarios

Material	Wastage	Source
Ready-mix concrete	4%	[11]
Steel sheet piles	1%	ArcelorMittal
Steel plates	3,3%	[11]
Fire protection coating	2%	[12]
Temporary bracings	3,3%	[11]
Steel reinforcement (rebars)	4,85	[11]
Drilling template foam	4%	[11]
Exterior wall insulation	4%	[11]

Material assembly scenarios

Material	Unit	Type	Quantity	Source
Installation – steel sheet piles	l/t	Diesel	11,22	[13]
Removal – steel sheet piles	l/t	Diesel	8,77	[13]
Installation/removal – temporary bracings	MJ/kg	Diesel	0,0511	[14]
Installation/removal – struts	MJ/kg	Diesel	0,0511	[14]
Installation – reinforcement cage	MJ/kg	Diesel	0,0511	[14]
Excavation – diaphragm wall panels	l/m	Diesel	2,12	[15]
Preaugering – steel sheet piles	l/m	Diesel	2,5	ArcelorMittal
Drilling and casing placement – secant pile	l/m	Diesel	3,375	[16]
Pumping – ready-mix concrete	MJ/m^3	Diesel	128,40	Betie[17], SNBPE [18]
Pumping – bentonite solution	MJ/m^3	Diesel	128,40	INIES - FR
Welding – plates	kWh/m	Electricity	2,40	[19]

Goal and Scope:

- **Assumptions (use stage):**

  - **Repair B3**
    - Fire protection coating: The scenario assumed was that 25% of the fire protection coating requires reapplication every 25 years.

  - **Corrosion Steel Sheet Pile:**
    - The corrosion rate adopted was 0,01 mm/year, as per EAU 2020. The estimated steel loss due to corrosion is 12,09 tons for VARIANT 1.

Goal and Scope:

- **Assumptions:**
  - **EOL C1-C4**

    - **Different EOL assumptions were attributed to each retaining wall solution. They were:**
      - Permanent steel sheet pile wall (VARIANT 1) is recovered and recycled in its EOL (50 years);

Material/Product	Recycling %	Downcycling %	Reuse %	Landfilling %	Left in Place %
Sealing material: Beltan	-	-	-	100	-
Hot rolled steel heavy plates	93	-	7	-	-
Steel reinforcement: capping beam	95	-	-	5	-
Ready-mix concrete C30/37: capping beam)	-	75	-	25	-
Fire protection coating	-	-	-	100	-
Permanent steel sheet pile	100	-	-	-	-
Permanent steel sheet pile (corroded steel)	-	-	-	-	100
Temporary bracings	-	-	100	-	-

Goal and Scope:

- **Assumptions:**
  - **EOL C1-C4**

    - **Different EOL assumptions were attributed to each retaining wall solution. They were:**
      - The temporary steel sheet pile in (VARIANT 2) is to be reused in a total of 6 uses with the remaining retaining reinforced concrete wall structure left in place in its EOL;

Material/Product	Recycling %	Downcycling %	Reuse %	Landfilling %	Left in Place %
Sealing material: Beltan	-	-	-	100	-
Ready-mix concrete C30/37: exterior wall	-	-	-	-	100
EPS insulation: exterior wall	-	-	-	-	100
Temporary steel sheet pile	18	-	80	2	-
Steel reinforcement: exterior walls	-	-	-	-	100
Temporary bracings	-	-	100	-	-

Business practice				
Input				
initial length		14,30	m	
cut		0,50	m	
min length		11,60	m	
% recycle vs landfill/lost		90%		
		reuse	**recycle**	**landfill/lost**
sheet pile is used 5 times		**81,74%**	**16,44%**	**1,83%**
total [m] →	78,30	64,00	12,87	1,43
# lifecycle	Installed (m)	reuse (m)	recycle (m)	landfill/lost (m)
1	14,30	13,80	0,45	0,05
2	13,80	13,30	0,45	0,05
3	13,30	12,80	0,45	0,05
4	12,80	12,30	0,45	0,05
5	12,30	11,80	0,45	0,05
6	11,80	0,00	10,62	1,18

Goal and Scope:

- **Assumptions:**
  - **EOL C1-C4**

    - **Different EOL assumptions were attributed to each retaining wall solution. They were:**
      - The reinforced concrete secant (VARIANT 3) pile is assumed to be left in place in its EOL;

Material/Product	Recycling %	Downcycling %	Reuse %	Landfilling %	Incineration & energy recovery	Left in Place %
EPS Insulation: drilling template foam	-	-	-	-	100	-
Ready-mix concrete C20/25: drilling template	-	-	-	-	-	100
Ready-mix concrete C25/30: secant pile	-	-	-	-	-	100
Steel reinforcement: drilling template	-	-	-	-	-	100
Steel reinforcement: secant pile cage						100
Temporary bracings	-	-	100	-	-	-

Goal and Scope:

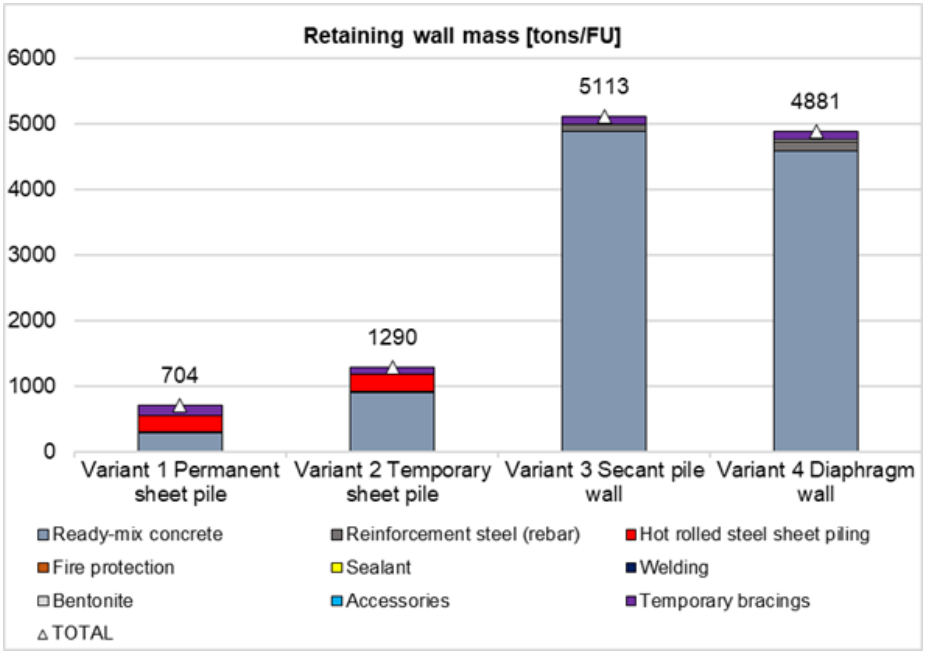
- **Assumptions:**
  - **EOL C1-C4**

    - **Different EOL assumptions were attributed to each retaining wall solution. They were:**
      - The reinforced concrete secant (VARIANT 3) pile is assumed to be left in place in its EOL;

Material/Product	Recycling %	Downcycling %	Reuse %	Landfilling %	Incineration & energy recovery	Left in Place %
EPS Insulation: drilling template foam	-	-	-	-	100	-
Ready-mix concrete C20/25: drilling template	-	-	-	-	-	100
Ready-mix concrete C25/30: diaphragm wall	-	-	-	-	-	100
Bentonite mixture	-	-	-	100	-	-
Steel reinforcement: drilling template	-	-	-	-	-	100
Steel reinforcement: diaphragm wall cage	-	-	-	-	-	100
Temporary bracings	-	-	100	-	-	-

Life Cycle Inventory (LCI):

- **Material consumption of the retaining walls**



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Life Cycle Inventory (LCI):

- **Energy and transport – Datasets:**

Energy	Dataset name	Source	Compliance system name	Year	Geography	Version	Upstream database
Diesel	Excavator 100kW	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Electricity	Electricity for building operation 2020	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi

Transport	Dataset name	Source	Compliance system name	Year	Geography	Version	Upstream database
Truck, 32 t payload	Ready-mix concrete C20/25; C20/25[a)]	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Truck, 20-26 t	Truck	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Bulk Carrier Coast	Bulk carrier coast	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Rail transport	Rail Transport	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi

Life Cycle Inventory (LCI):

- **Material and Products – Datasets (Environmental Product Declaration):**

Product/Material	Dataset name	Source	Compliance system name	Year	Geography	Version	Upstream database
VARIANT 1							
AZ 32/750 Hot rolled steel sheet piles	EcoSheetPile™ Plus – Steel Sheet Piles from ArcelorMittal Europe – Long Products	[21]	EN 15804+A2	2023	RER	S-P-11071	GaBi
Ready-mix concrete C30/37 capping beam	Ready-mix concrete C30/37	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel rebars capping beam	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi
VARIANT 2							
Rented AZ 32/750 Sheet Piles	EcoSheetPile™ Plus – Steel Sheet Piles from ArcelorMittal Europe – Long Products	[21]	EN 15804+A2	2023	RER	S-P-11071	GaBi
Ready-mix concrete C30/37: exterior wall	Ready-mix concrete C30/37	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel rebars: exterior walls	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi

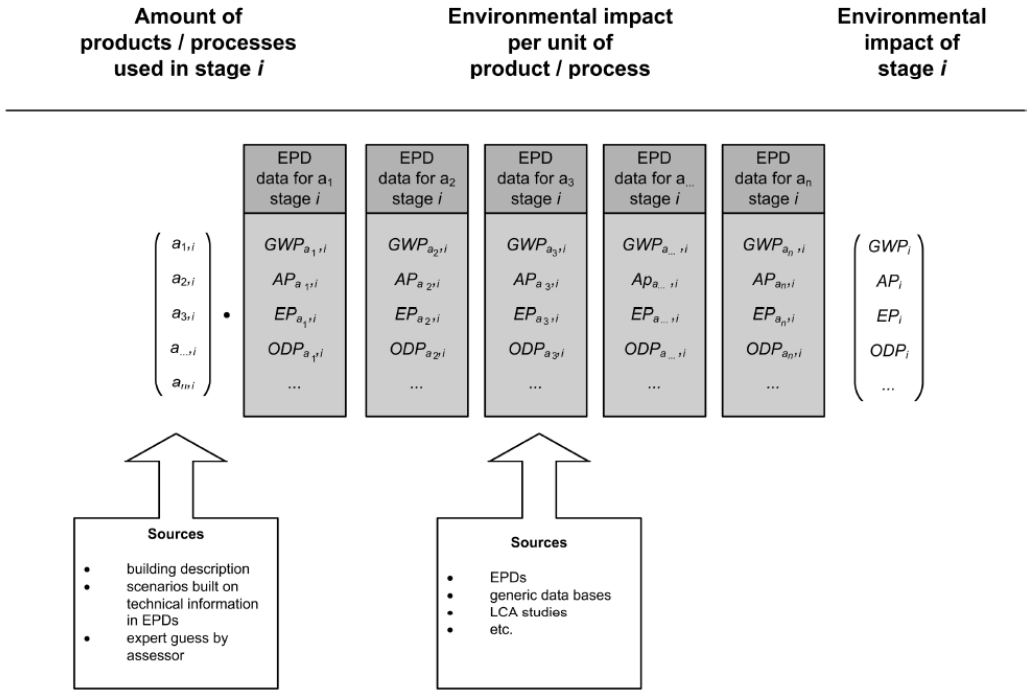
Life Cycle Inventory (LCI):

- **Material and Products – Datasets (Environmental Product Declaration):**

Product/Material	Dataset name	Source	Compliance system name	Year	Geography	Version	Upstream database
VARIANT 3							
Ready-mix concrete C20/25: drilling template	Ready-mix concrete C20/25; C20/25	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel rebars: drilling template	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi
Ready-mix concrete C25/30: secant pile wall	Ready-mix concrete C20/25; C20/25	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel reinforcement: secant pile cages	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi
VARIANT 4							
Ready-mix concrete C20/25: drilling template	Ready-mix concrete C20/25; C20/25	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel rebars: drilling template	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi
Bentonite: bentonite mixture	Bentonite {DE} | market for bentonite | No transport | Cut-off	Ecoinvent	EN 15804+A2	2021-2022	DE	3.9.1	Ecoinvent
Ready-mix concrete C25/30: diaphragm wall	Ready-mix concrete C20/25; C20/25	Ökobaudat	EN 15804+A2	2022	DE	20.23.050	GaBi
Steel reinforcement: diaphragm wall cages	Betonstahl in Ringen und Betonstabstahl Badische Stahlwerke GmbH	[24]	EN 15804+A2	2022	DE	EPD-BSW-20210265-CBA1-DE	GaBi

Life Cycle Impact assessment (LCIA):

- **Calculation matrix & GWP emission factors:**



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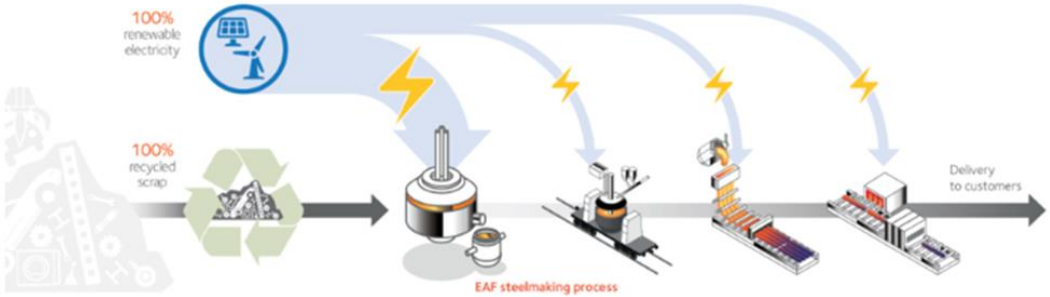
Life Cycle Impact assessment (LCIA):

- **XCarb™:**
  - ArcelorMittal's XCarb™ initiative, which emphasizes recycled and renewably sourced steel, is centered around the Electric Arc Furnace (EAF) route.
  - This approach involves using 100% recycled material combined with 100% renewable electricity.

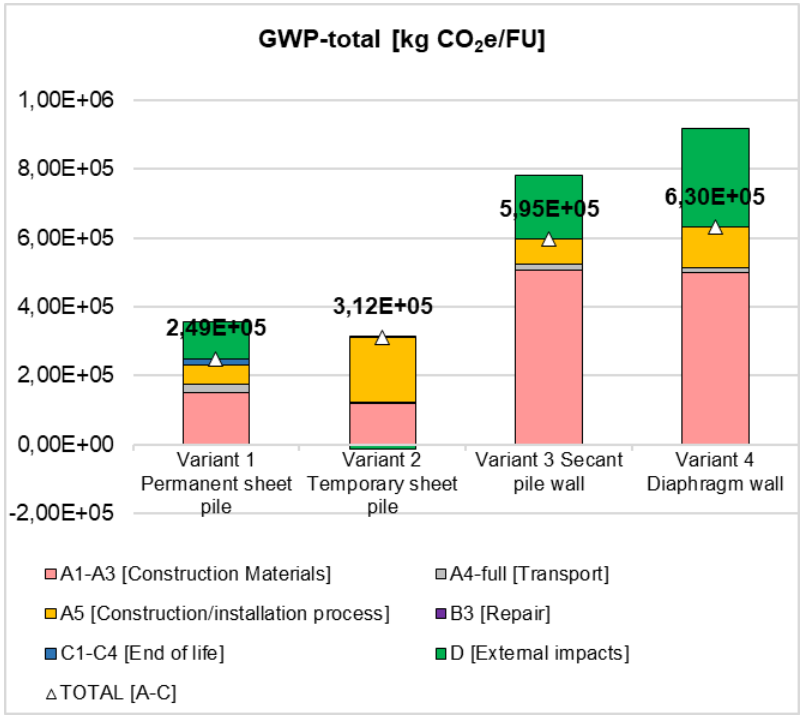


Material/Product	XCarb™ A1-A3 $kgCO_2e/kg$	WorldSteel association $kgCO_2e/kg$	Reduction %
Hot Rolled Steel Sections (Steel sheet piles)	0,370	1,91 (global production)	82,72

RESULTS AND INTERPRETATION:

Results and Interpretation:

- The results are presented in terms of FU (112 m) of the retaining wall.



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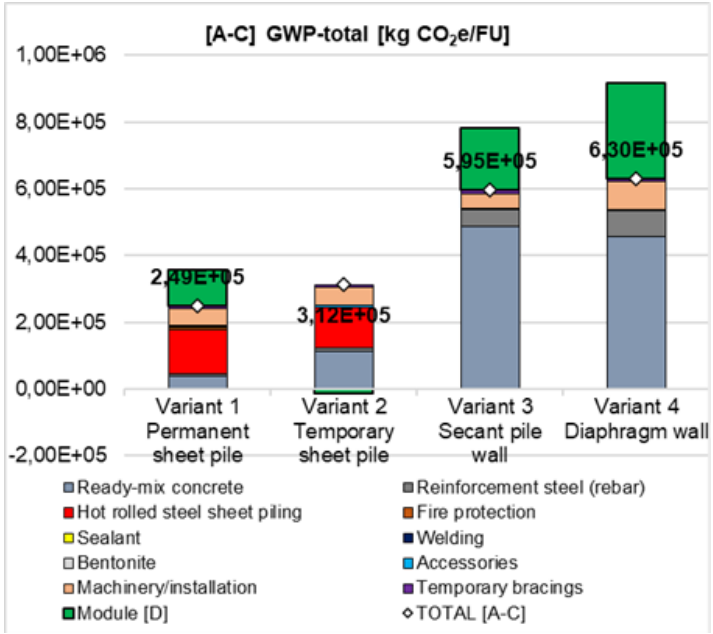

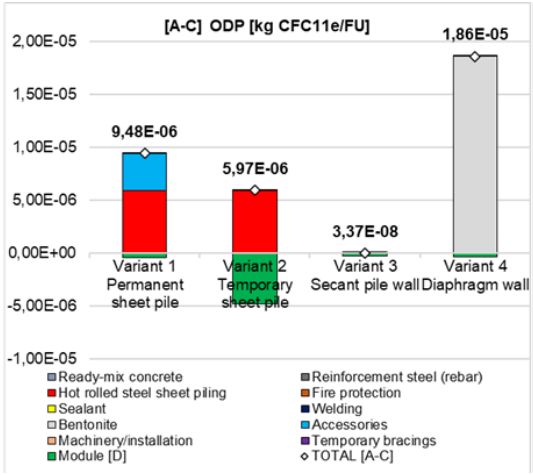

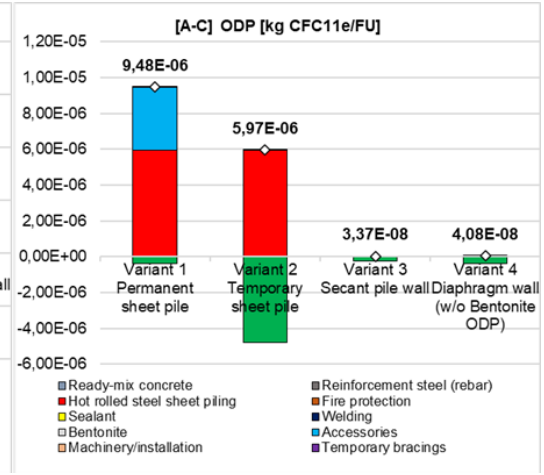

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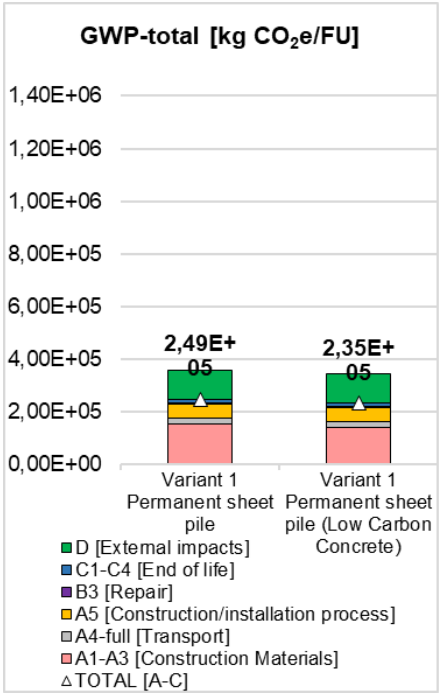
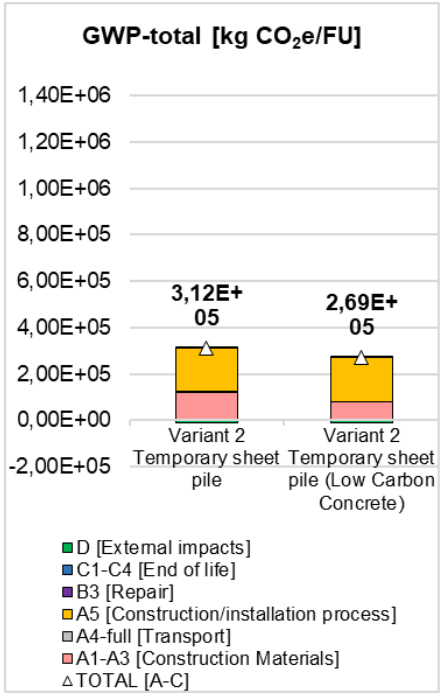
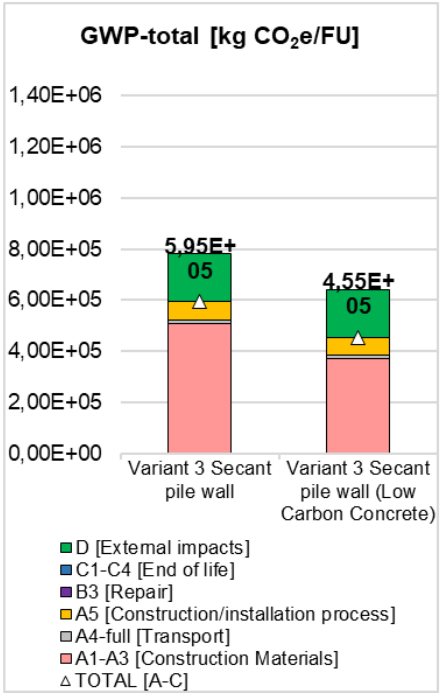
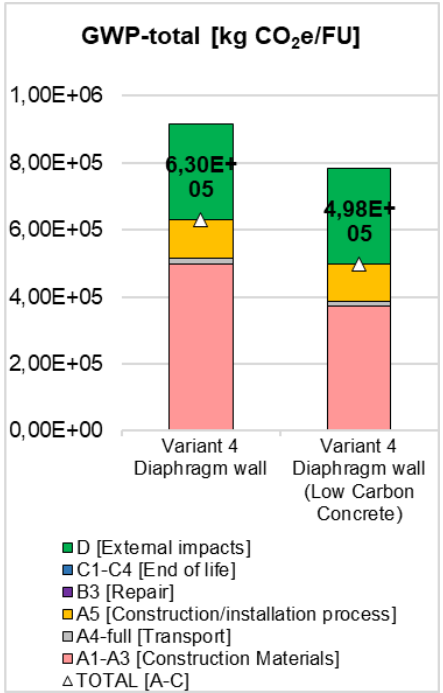
Sensitivity analysis “Low carbon emission ready-mix concrete”:

- The results are presented in terms of FU (112 m) of the retaining wall.









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CRITICAL REVIEW:

Critical review:

- As the results are intended to be used in comparative assertions to be disclosed to the public (i.e. conferences, fairs, brochures, and leaflets) a critical review process is necessary so the study is compliant with ISO standards.

- ArcelorMittal commissions iPoint-systems gmbh to set up a review panel and conduct a panel review of this comparative LCA study with reference to EN 15978, and ISO 14040/44

Martina Prox
(Chair)

iPoint-systems GmbH
Max-Brauer-Allee 50
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Dr. Matthias Buchert

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Rheinstraße 95
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Dr. Bastian Wittstock

Ramboll Deutschland GmbH
Jürgen-Töpfer-Straße 48
22763 Hamburg

"The critical reviewers would like to thank the ArcelorMittal project team for their great openness and acceptance of the critical review panel's comments and suggestions. In the panel's view, this constructive attitude has contributed to the very high quality of this LCA study…".

"Concluding, the reviewers see the LCA methodology consistently applied, and the conclusion and interpretation taken by the authors are justified under the goal and scope of the study. Sensitivity analyses support the interpretation of the results in an adequate manner, allowing the reader to be confident in the robustness of results presented."

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CONCLUSIONS:

Conclusions:

- The LCA results reveal that VARIANT 1 and VARIANT 2 offer environmental advantages over their life cycle when compared to VARIANT 3 and VARIANT 4. This can be attributed to their lower material consumption compared to VARIANT 3 and VARIANT 4.
  - A comparison between VARIANT 1 and VARIANT 3 reveals that the total retaining wall mass can be reduced by up to 86%.
  - Additionally, the use of 100% recycled steel sheet piles manufactured with 100% renewable electricity further contributes to the reduction of environmental impacts.
- For the global warming potential impact assessment indicator VARIANT 1 and VARIANT 2 result in lower GWP-total compared to VARIANT 3 and VARIANT 4.
  - Specifically, GWP-total is reduced by up to 60% when comparing VARIANT 1 with VARIANT 4 over their total lifetime (A-C).
  - The majority of GWP-total savings are related to lower impacts attributed to the production of materials and products.
- Furthermore, the investigation into the use of low-carbon emission concrete demonstrated a reduction in environmental impacts, particularly for VARIANT 3 and VARIANT 4, as these variants exhibited higher consumption of ready-mix concrete.
- Datasets with different upstream databases (GaBi and Ecoinvent) were used. This combination of databases introduces the potential for significant uncertainties in the LCIA of certain environmental indicators, such as ODP.

SUSTAINABLE PLACES 2024

THANK YOU!!

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Retabit

SUSTAINABLE PLACES 2024

24 September

A Data-Driven Platform for Sustainable Building Renovation Plans

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ARC Engineering and Architecture La Salle
Ramon Llull University, Spain

Proyecto PID2020-115936RB-C21
Financed by the Ministry of Science and Innovation of Spain

Building renovation across scales and domains

DATA

Climate

Urban amenities

EPC

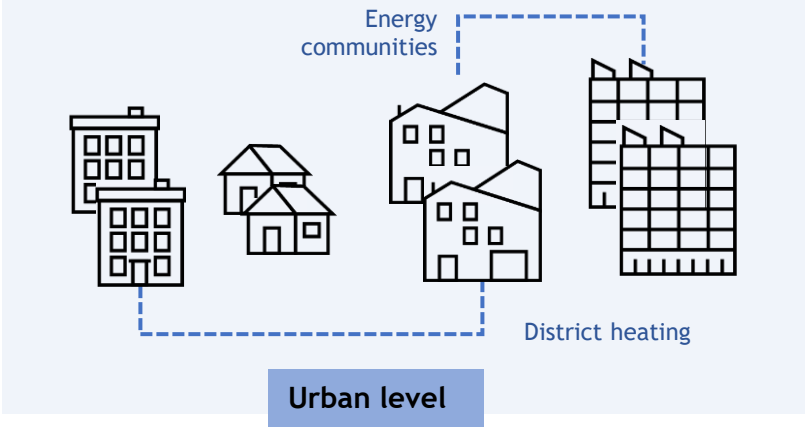
Cadastre

Income

Planning regulations

Building status

…..

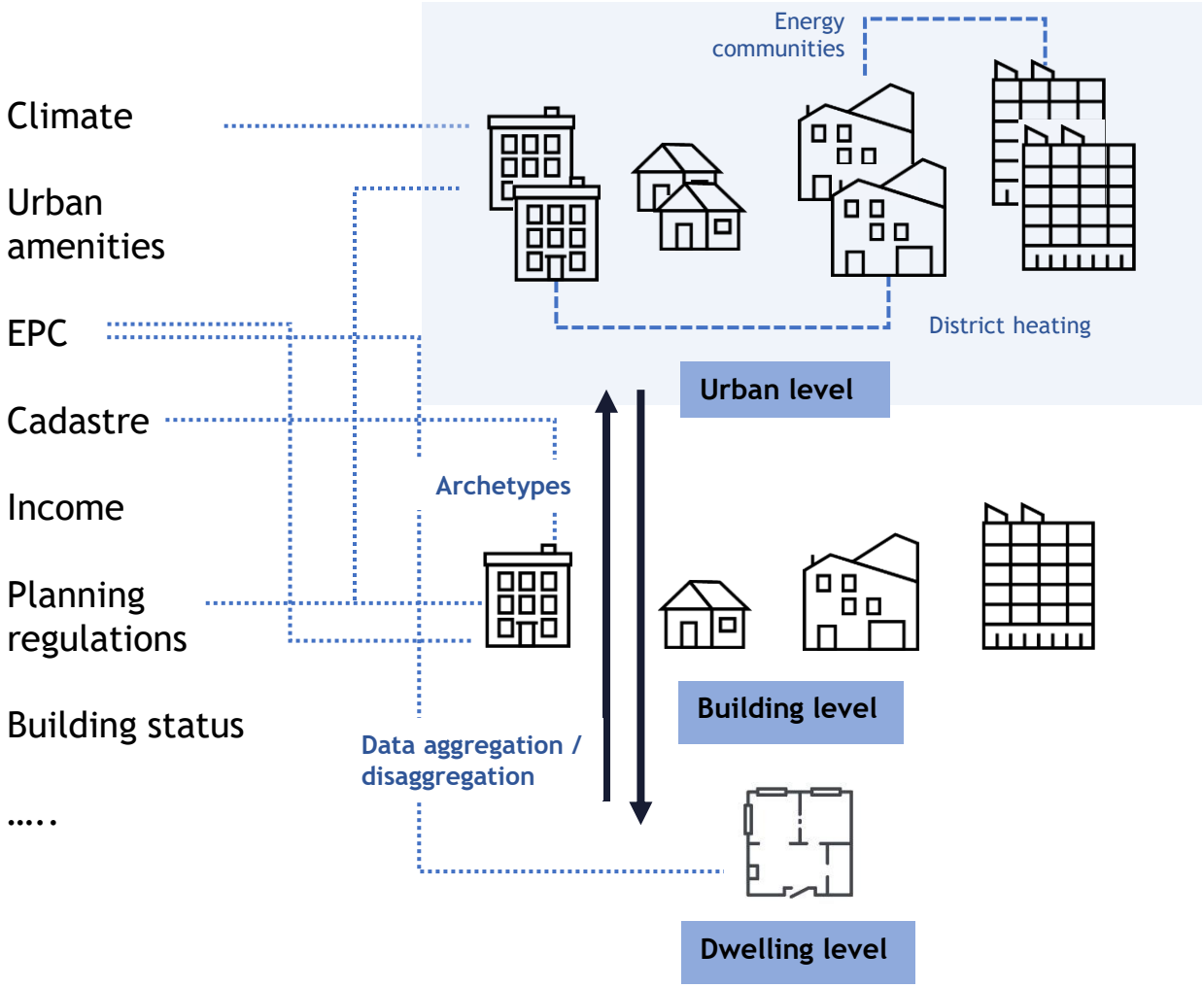


From a sustainable development perspective, building renovation encompasses multiple scales and domains.

It is not solely about the building itself, nor is it only about energy.

Building renovation across scales and domains

DATA



To gain a comprehensive understanding of which buildings to renovate in a city or region, data must be gathered across multiple domains and scales.

The data is often dispersed, heterogeneous, and varies in granularity.

Building renovation across scales and domains

DATA

Climate

Urban amenities

EPC

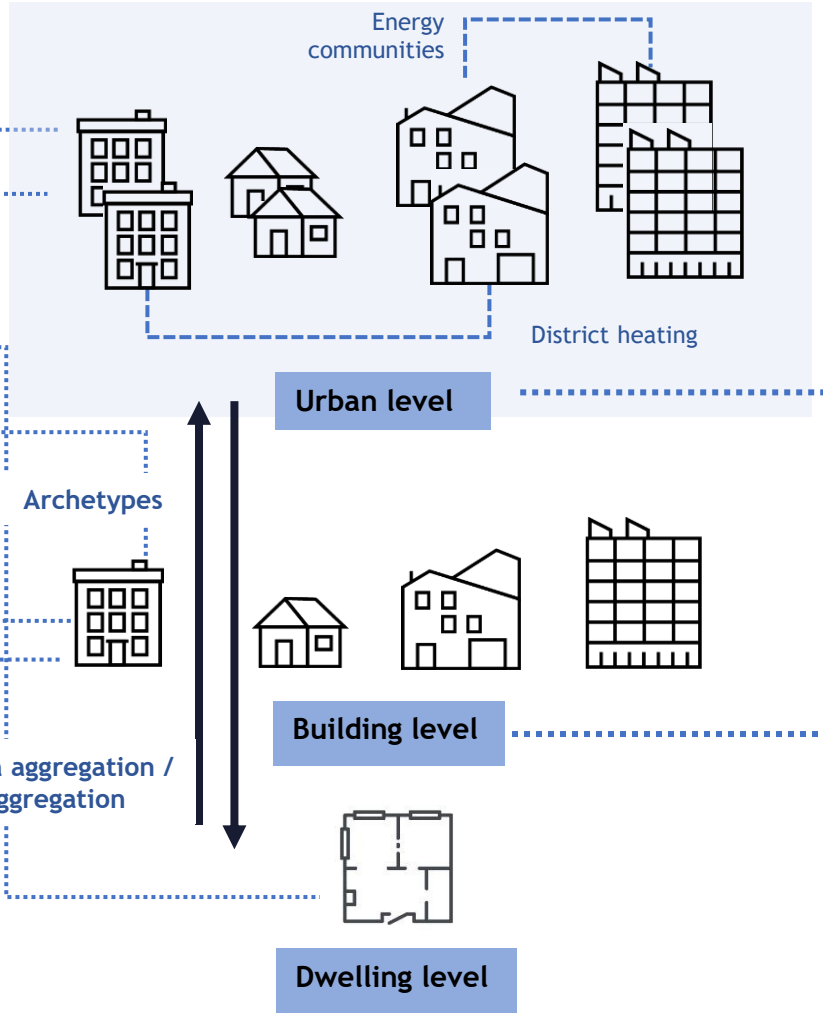
Cadastre

Income

Planning regulations

Building status

…..



Buildings are the object of the renovation. However, the objectives and impact of the renovation transcends the building scale

INTERVENTIONS

Building stock renovation:

- **Stakeholders:** local administrations, financial institutions
- **Instruments:** Planning programmes, incentives, UBEM,…
- **Objectives:** Reducing carbon emissions in accordance with the EU objectives

Building renovation:

- **Stakeholders:** Building owners, housing associations
- **Instruments:** EPC, RP, energy audits, BIM
- **Objectives:** Minimum EPC label class F by 2030 for residential buildings

Building renovation across scales and domains

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EPC

Cadastre

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Planning regulations

Building status

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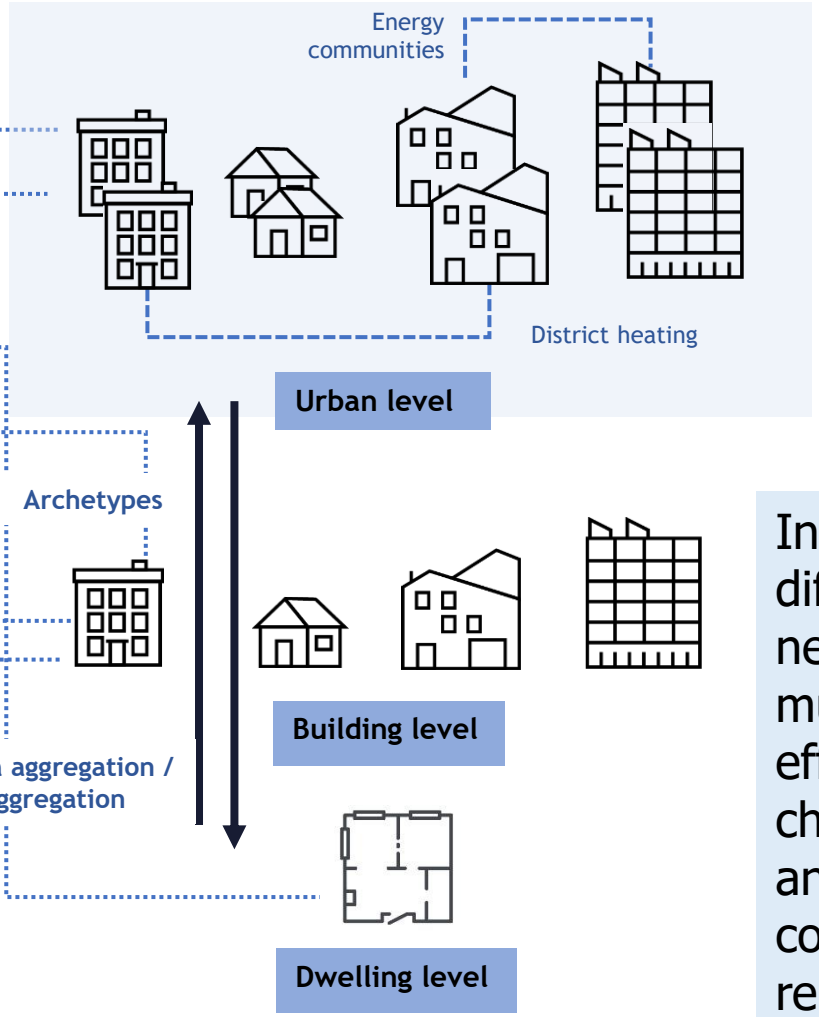

INDICATORS

Energy Performance Certificate

Energy poverty

Median household income

Percentage of rented housing

Indicators combine data from different scales (buildings, neighborhoods, cities) and multiple domains (energy efficiency, building status and characteristics, social impact, and economic factors) to offer a comprehensive view of the renovation process.

INTERVENTIONS

Building stock renovation:

- **Stakeholders:** local administrations, in the context of a SECAP
- **Instruments:** Planning programmes, incentives, UBEM,…
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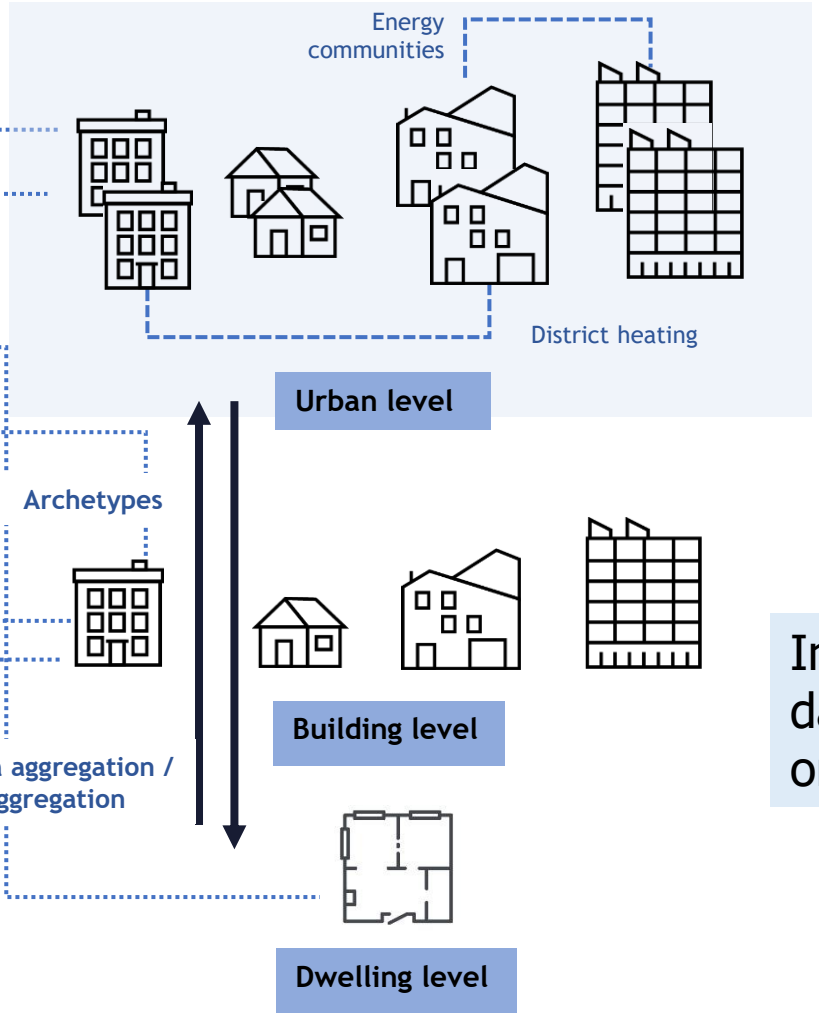

INDICATORS

Energy Performance Certificate

Energy poverty

Median household income

Percentage of rented housing

Indicators rely on the available data, directly adopted in its original form and/or processed.

INTERVENTIONS

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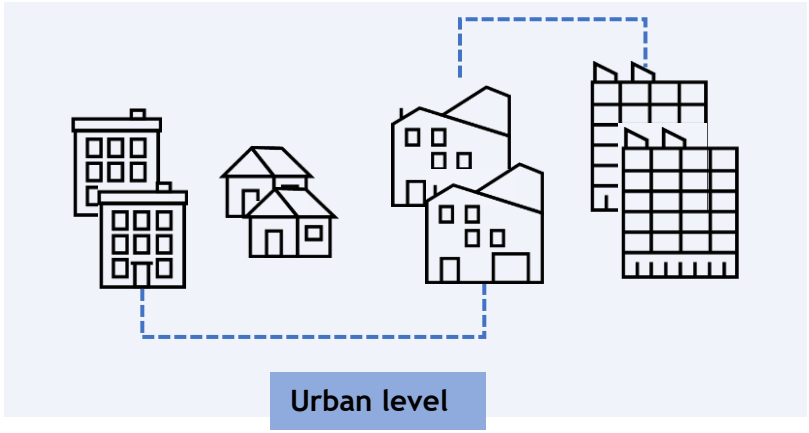
Building renovation across scales and domains



Building renovation's impact on urban sustainability

Measures to be applied to buildings

Data, indicators and objectives need to be interlinked……

DATA

- Income
- Building status
- EPC

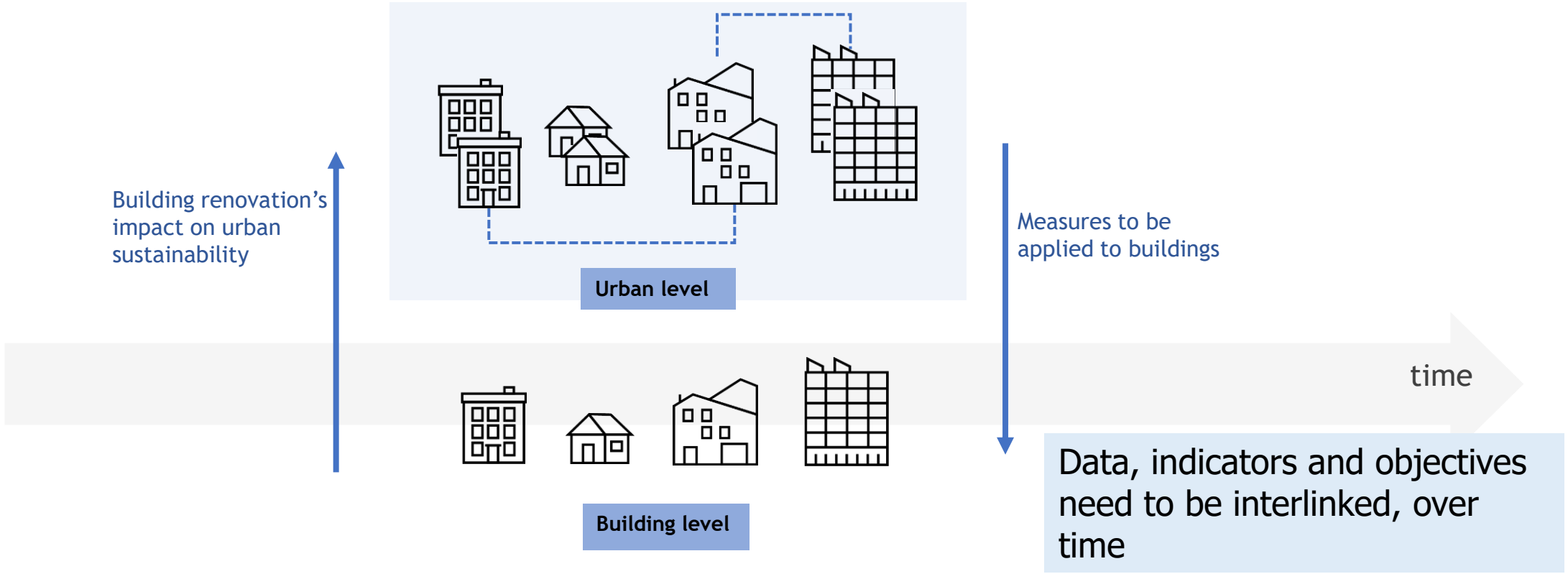
INDICATORS

- Energy efficient and energy recovering homes
- Median household income
- Population income below 60 average

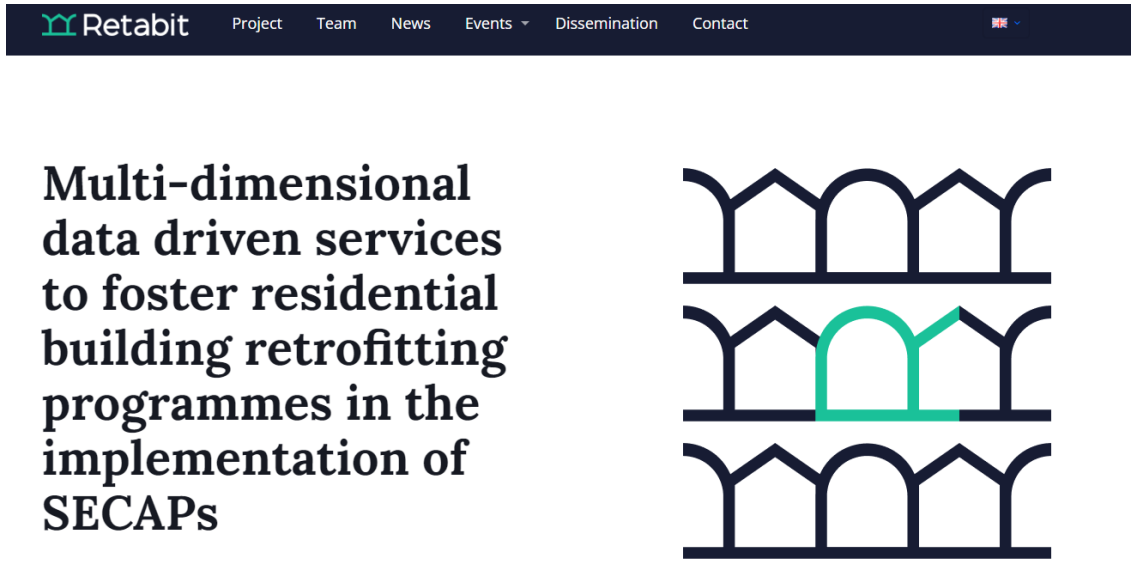
OBJECTIVES

Reducing carbon emissions in accordance with the EU

Building renovation across scales and domains



Retabit research project



Retabit is a project co-financed by the Spanish Ministry of Science and Education, 2021-2024 carried out by the research group ARC La Salle-URL (coordinator) and the Catalonia Institute for Energy Research (IREC)

https://retabit.es

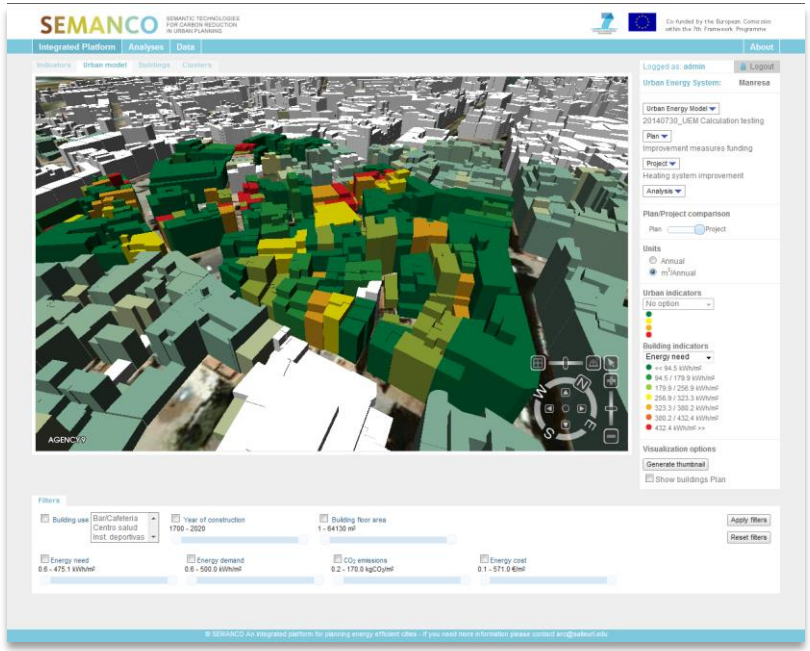
A data-driven service platform which facilitates multiple stakeholders involved in building retrofitting:

1. To find out buildings within a municipality to be renovated, based on the available data and using a combination of multisectorial indicators

2. To propose building retrofitting measures using building archetype to simulate their impact

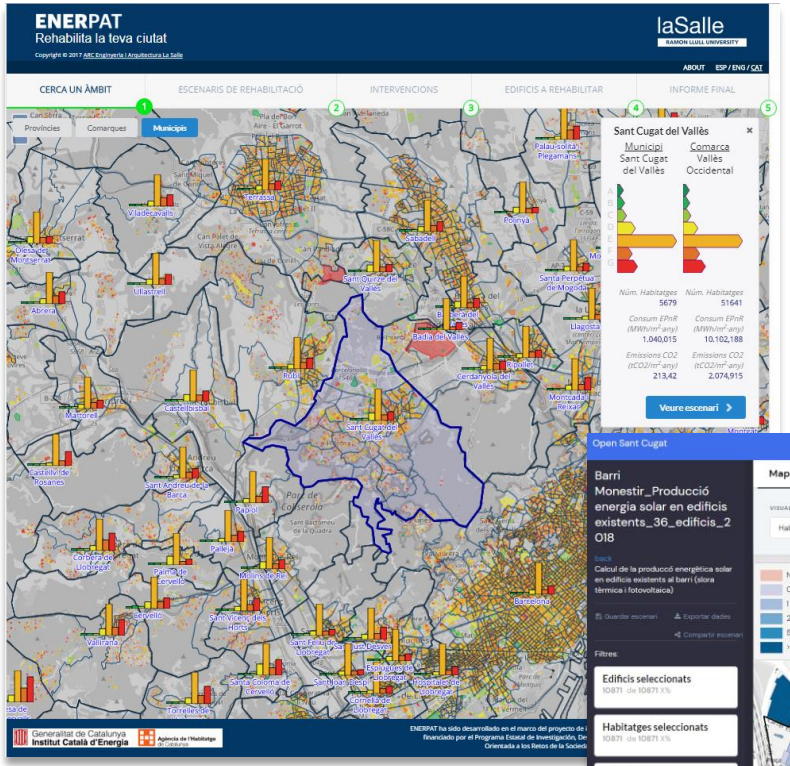
Previous projects – ARC Engineering and Architecture

SEMANCO Semantic Tools for Carbon Reduction in Urban Planning (2011-14)



https://www.semanco-project.eu

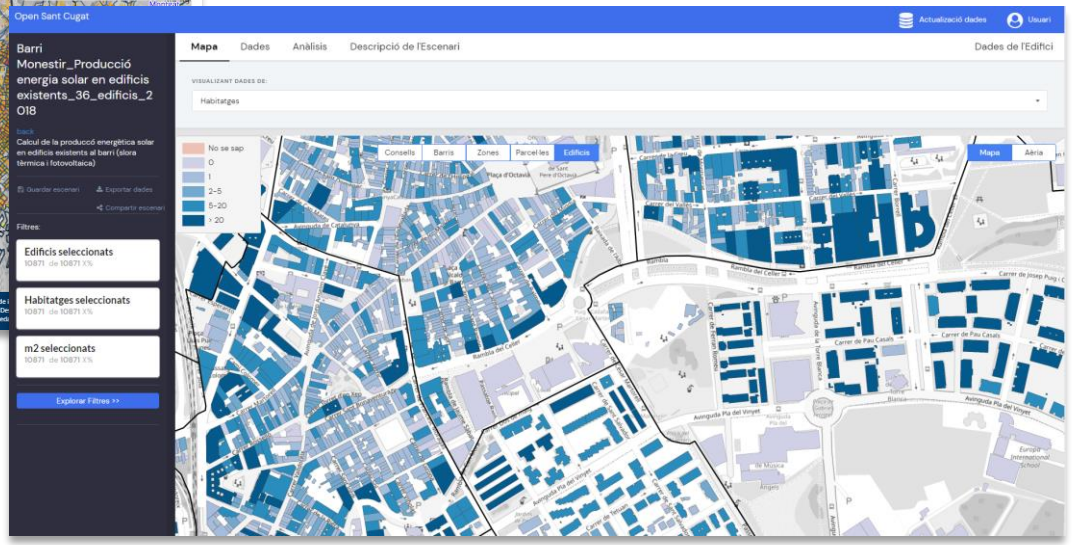
ENERPAT Building retrofitting at municipal scale (2014-17)



https:// www.enersi.es/enerpat

https://es.slideshare.net/slideshow/care4climateleandromadrazopublishedpdf/253088328

Open Data Sant Cugat - Integration of city data with open data sources (2017-19)



Retabit platform

Data

Climate

Urban amenities

EPC

Cadastre

Income

Planning regulations

Building status

…..

Indicators

Primary Energy Consumption

Heating Energy Consumption

CO2 Emissions

PV potential generation

Energy renovation residential buildings

Median houshold income

House Price

Average renting Price compared to family income

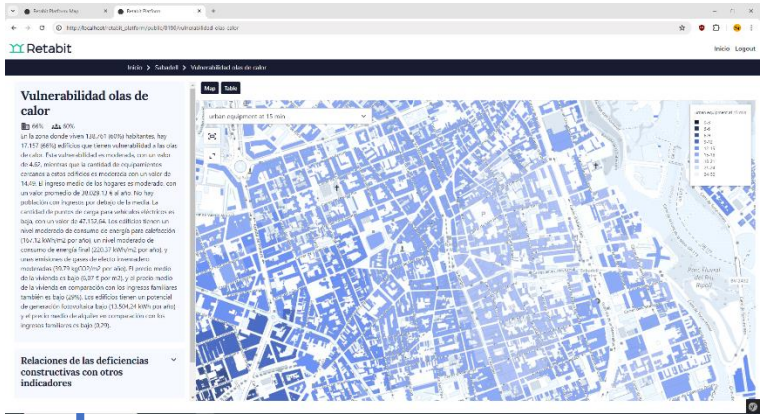
Urban equipment at 15 minutes

Green area surfaces

Vulnerability to heatwaves and temperatura rise

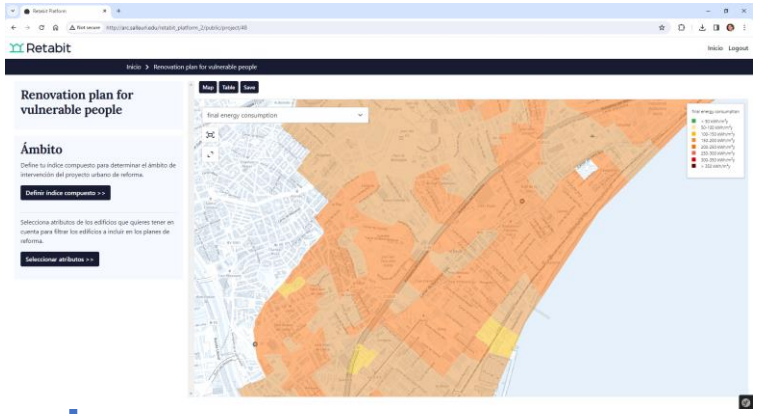
Accessibility to bike lanes

Buildings to renovate



Which buildings to renovate taking into account multiple domains and scales - integrating multiple data sources

Renovation plans



Which measures to apply to improve baseline conditions - applying archetypes

RETABIT research project

- *EPC database*
- *Cadastre database*
- *Open Street Maps*
- *Land Cover*
- *Weather data*
- *House rental prices*
- *National Statistics*
- *Other databases*
- *Possible Pilot surveys*

Energy

Primary Energy Consumption

Heating Energy Consumption

CO2 Emissions

PV potential generation

Energy renovation residential buildings

Socioeconomic

Median household income

House price

Average renting price compared to family income

Environment

Vulnerability to heatwaves and temperature rise

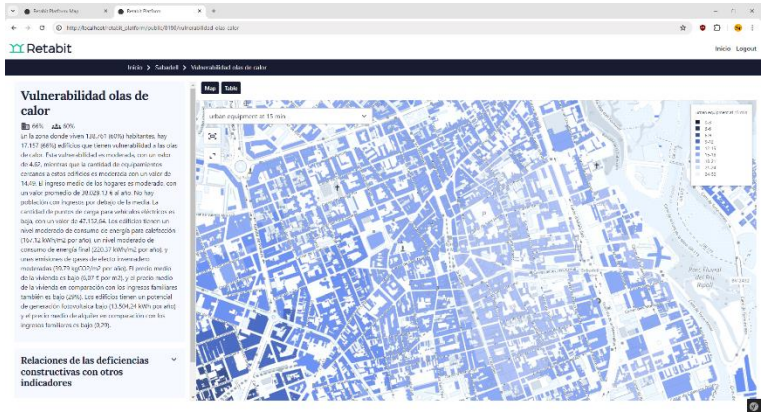
Urban equipment at 15 minutes

Green area surfaces

Accessibility to bike lanes

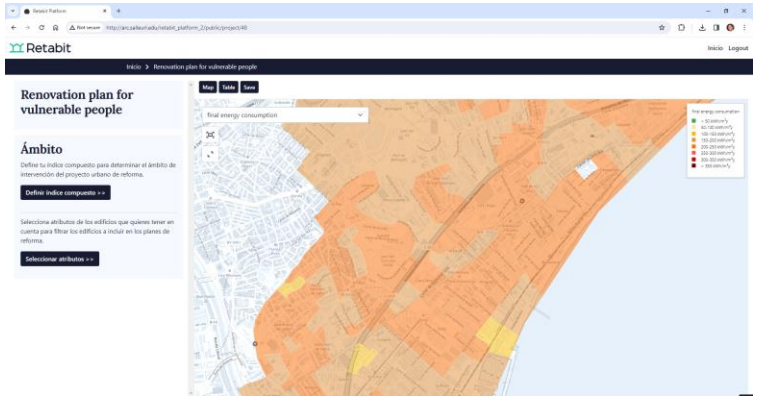
Buildings to renovate

Which buildings to renovate considering multiple domains and scales - integrating multiple data sources



Renovation plans

Which measures to apply to improve baseline conditions - applying archetypes



Energy indicators

KPI	*Heating Energy Consumption*
Scale Possibilities	Building Urban (Aggregation)
Data source	Energy Performance Certificates, Cadastre
SDG - SECAP Asspciation	SDG 7, 11, 12 Mitigation

Definition:

Heating energy consumption of a building considering all types of energy.

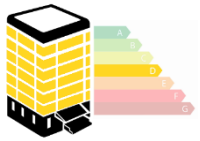
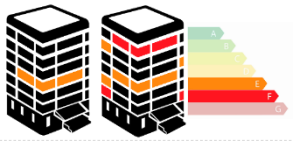
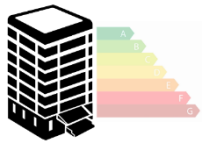
Use:

Evaluate the heating energy consumed by the buildings.

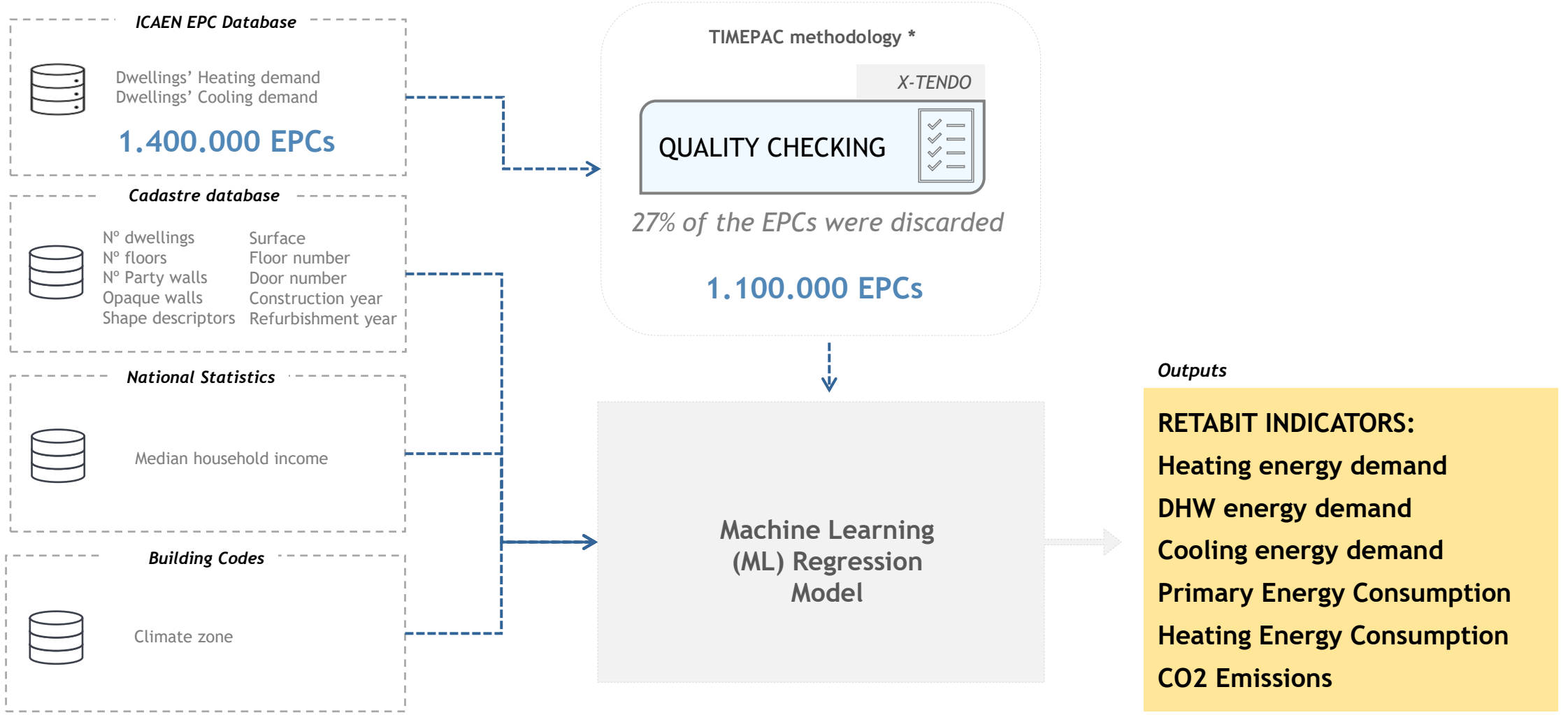
Rule for calculation:

- Energy simulation of the archetype
- Associate the archetype to each geo-referenced building
- Kwh/m2y x m2

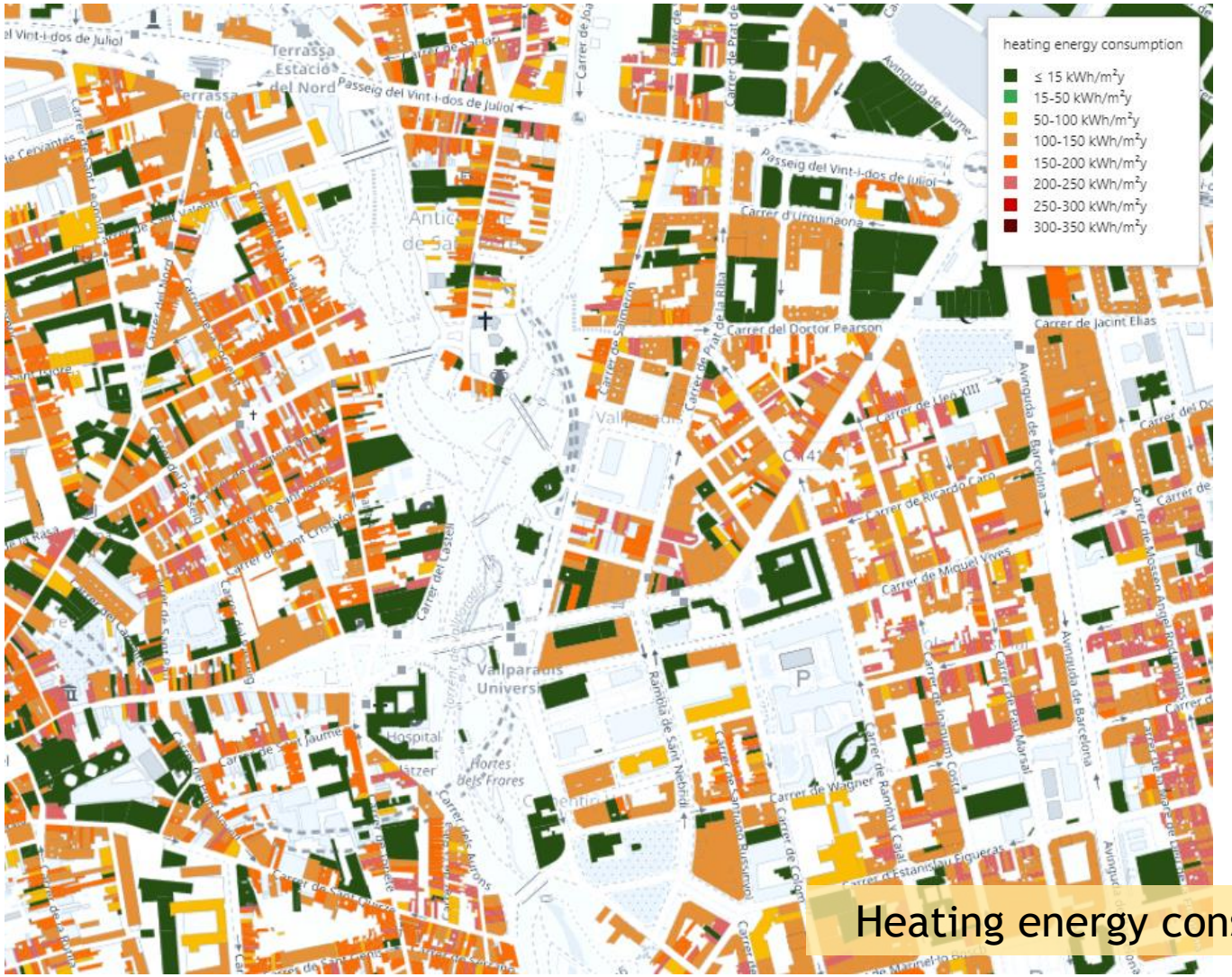
Energy indicators

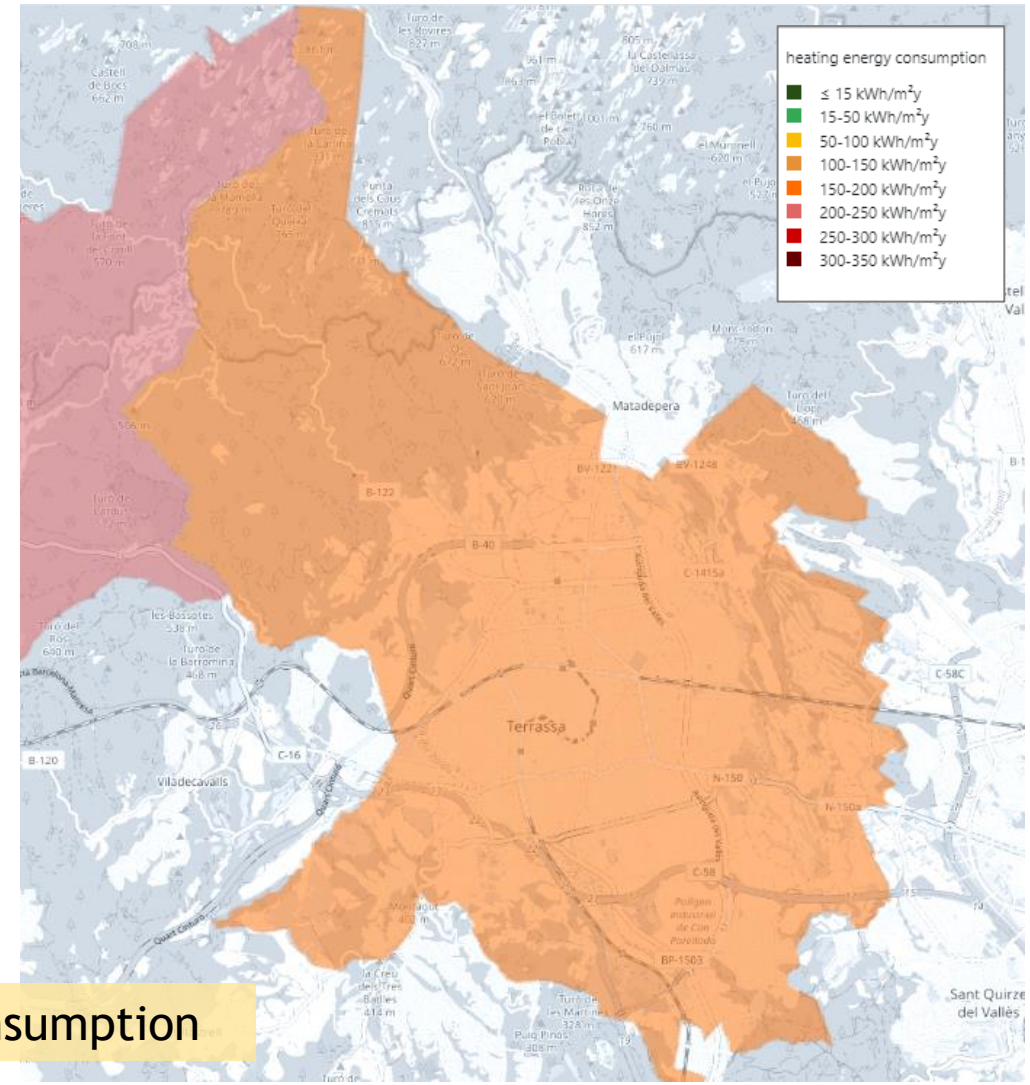
Build park scenarios	*EPC data from ICAEN data source*	*Retabit database* — *Actions for energy KPIs development*
	Buildings' data	The EPC data → Retabit KPIs
	Dwellings' data	1. Estimation of unknown EPCs 2. **Median** value → Retabit KPIs
	No Data	1. Estimation of EPCs. 2. **Median** value → Retabit KPIs

Energy indicators



Energy indicators





Heating energy consumption

Multidimensional indicators

KPI	*Median Household income*
Scale Possibilities	Building (de-escalation) Urban (Aggregation)
Data source	National Institute of Statistics
SDG - SECAP Asspciation	SDG 1, 10 Mitigation

Definition:

Median household income per building.

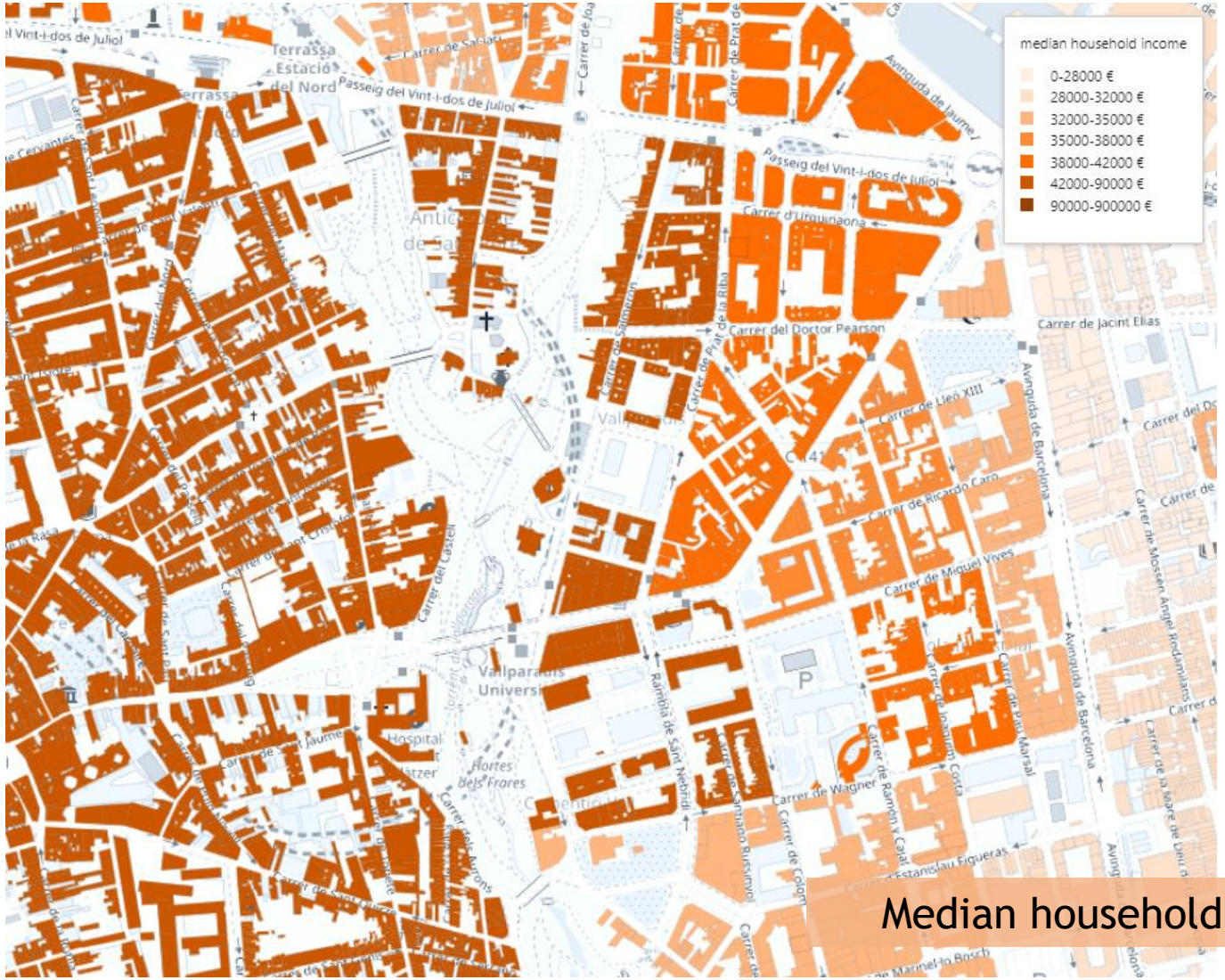
Use:

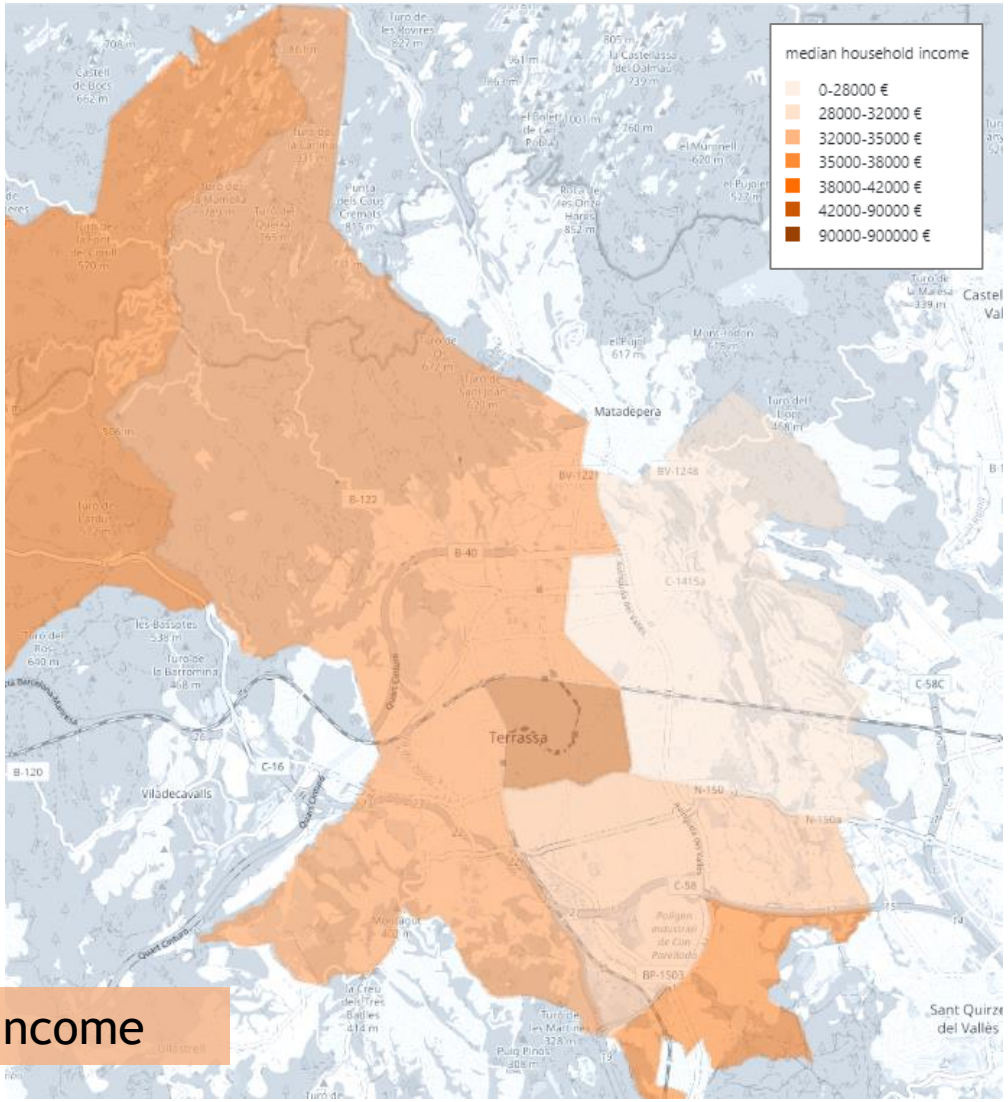
Evaluate economic situation of the population.

Rule for calculation:

- Gathering economic data per census unit.
- Associate the data to each building within the census unit.
- The same data is applied to all buildings within the same census unit (sensitive data protection)

Multidimensional indicators





Median household income

Environmental indicators

KPI	*15 – Minutes City*
Scale Possibilities	Building Urban (Aggregation)
Data source	Open Maps (geo-located data)
SDG – SECAP Asspciation	SDG 3, 4, 10, 11, 13 Mitigation

Definition:

Equipments within 15 minutes far away from the building.

Use:

Evaluate proximity, accessibility and quality of life.

Rule for calculation:

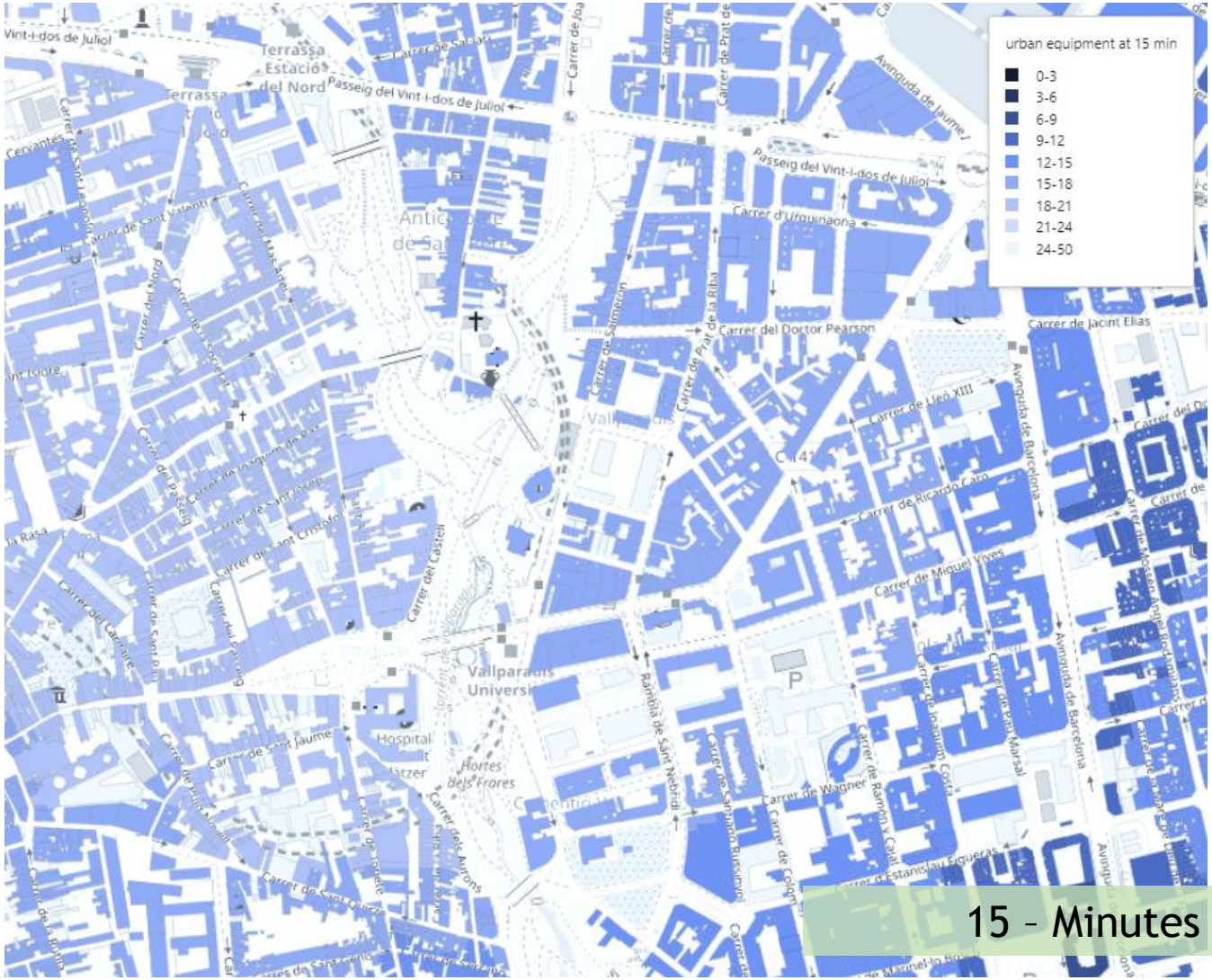
- Geo-referenciation of all care, education, provisioning, entretainment and transport categories services.
- Limitation of the minutes > Transformation to Meters
- Selection and count of the services > Limit: Meters/service

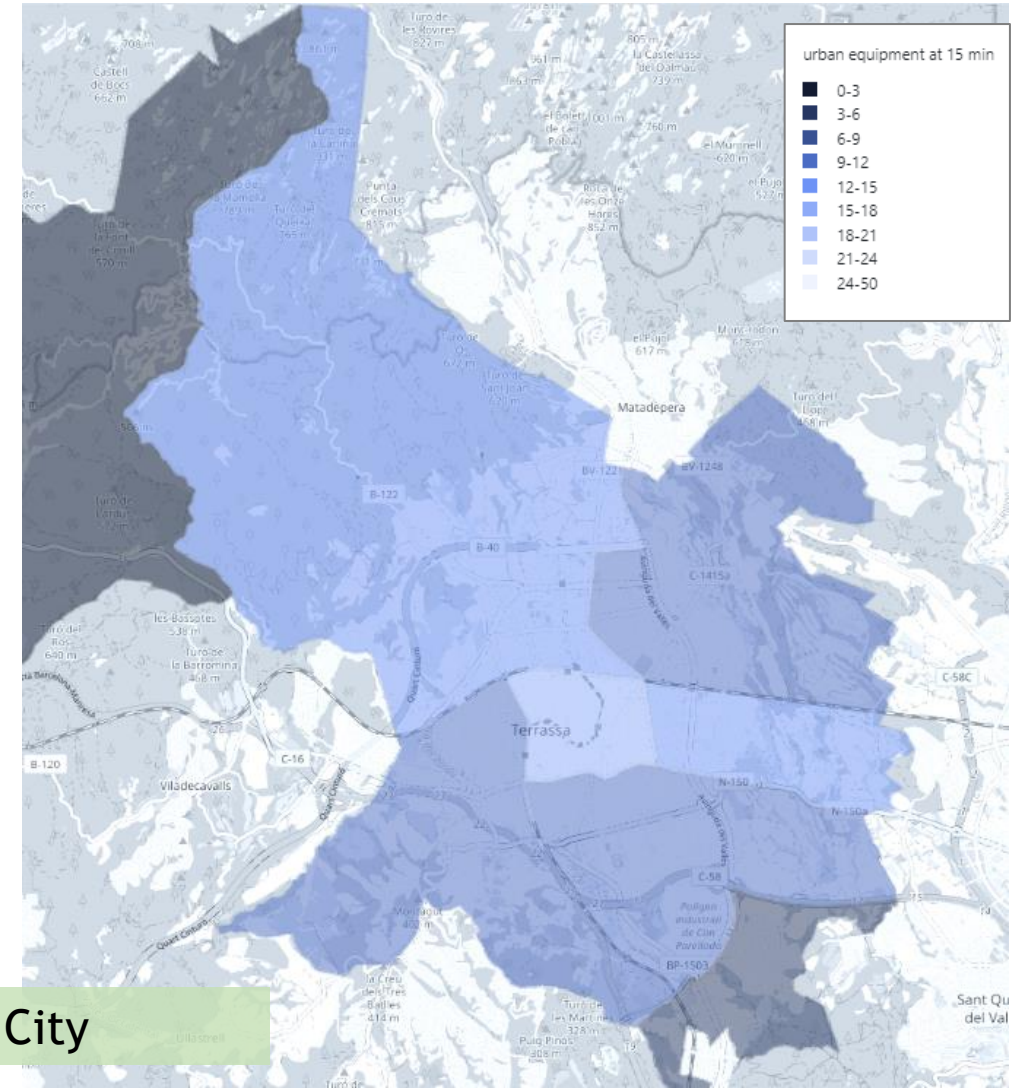
Environmental indicators

KPI	*15 - Minutes City*
Scale Possibilities	Building Urban (Aggregation)
Data source	Open Maps (geo-located data)
SDG - SECAP Asspciation	SDG 3, 4, 10, 11, 13 Mitigation

Function	Category	Minutes	Meters
Care	Health	10	850
Care	Social Services	15	1225
Care	Day centers	10	850
Education	Preschool Education	5	475
Education	Primary education	5	475
Education	Secondary education	10	850
Provisioning	Supermarkets	10	850
Provisioning	Markets	10	850
Provisioning	Fresh food	5	475
Provisioning	Daily non-food	5	475
Provisioning	Catering	5	475
Provisioning	Miscellaneous services	5	475
Entertainment	Shows	10	850
Entertainment	Libraries	15	1225
Entertainment	Civic centers	10	850
Entertainment	Children playgrounds	5	475
Entertainment	Sports facilities	10	850
Entertainment	Squares and parks >1000m2	5	475
Entertainment	Squares and parks > 10000m2	5	475
Transport	Metro stations	10	850
Transport	Bus stations	5	475
Transport	Night bus	10	850
Transport	Trains stations	10	850
Transport	Bike stations	5	475
Transport	Bike lanes	5	475

Environmental indicators





15 - Minutes City

Environmental indicators

KPI	*Vulnerability degree against heatwaves and temperature rise*
Scale Possibilities	Building Urban (Aggregation)
Data source	Land cover, Weather data, Cadastre, National Statistics
SDG - SECAP Asspciation	SDG 3, 11, 13 Mitigation

Definition:

Value (from 0 to 9) of vulnerability resulting from comfort decrease within the buildings due to heat island effect.

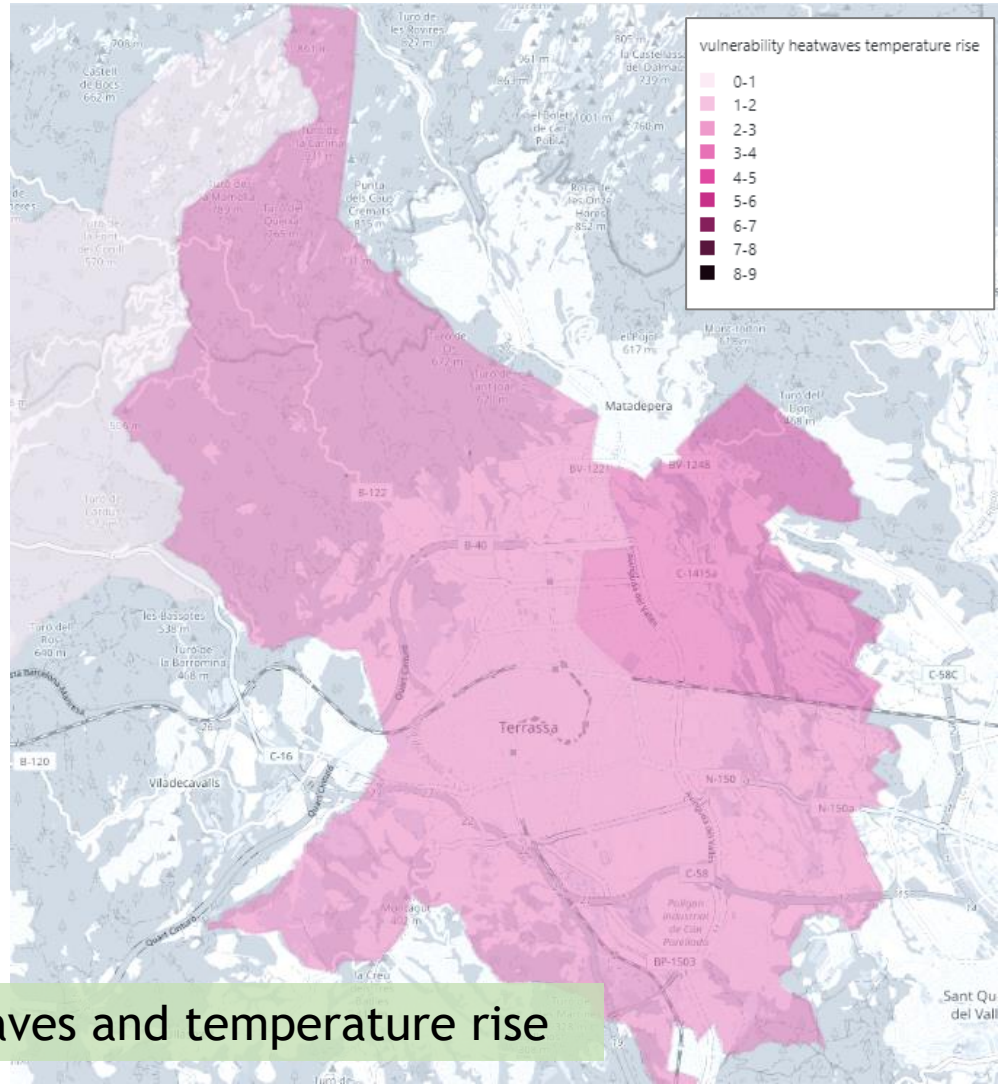
Use:

Evaluate resilience and quality of life.

Rule for calculation:

- **Sub-KPI 1:** Calculation of temperature increase projection (1 to 3)
- **Sub-KPI 2:** Evaluation of population density (1 to 3)
- **Sub-KPI 3:** Evaluation of green areas and building conservation status (1 to 3)
  - **Sub-KPI 3.1:** Green areas (1 to 3)
  - **Sub-KPI 3.2:** Building conservation status (1 to 3)
- **KPI:** Combination of the scale of each sub-KPI

Environmental indicators



Vulnerability degree against heatwaves and temperature rise

Barcelona

A continuación, se muestran los distintos aspectos sociales, económicos, sostenibles y medio ambientales que se pueden tener en cuenta para la rehabilitación del parque edificado. Esta perspectiva integral permite considerar no solo la infraestructura física, sino también su impacto en el bienestar social, el desarrollo económico, la preservación del medio ambiente y la viabilidad a largo plazo de las comunidades urbanas.

Vulnerabilidad olas de calor

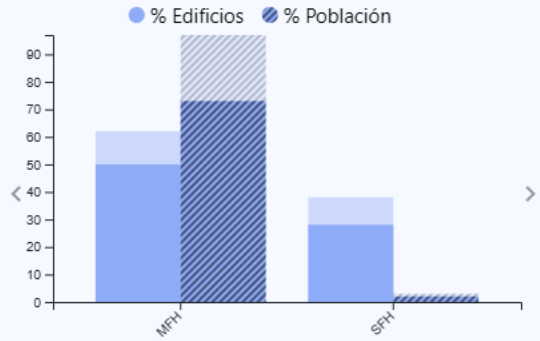
78% 76%

En un área donde viven 1.223.262 (76%) habitantes, se encuentran 47.751 (78%) edificios que tienen vulnerabilidad a las olas de calor. La cantidad de zonas verdes cercanas es baja (6 hectáreas), pero en un radio de 15 minutos a pie se pueden encontrar una gran cantidad de equipamientos urbanos (20) y un carril bici completamente accesible (100%). El potencial de generación fotovoltaica es bajo (9.006,59 kWh por año), pero el número de viviendas energéticamente eficientes y recuperadoras de energía es alto (el 94% de las viviendas). En la zona no hay población con ingresos inferiores al 60% de la media.

Ver más

Características de los edificios

Uso del edificio



Indicadores relacionados

Superficies de zonas verdes

Viviendas energéticamente eficientes y recuperadoras de energía

Equipamiento urbano a 15 minutos caminando

Consumo final de energía

Edificios eficientes

3% 4%

En la zona donde viven 61.463 (4%) habitantes, existen 1.894 (3%) edificios que destacan por su alta eficiencia energética.

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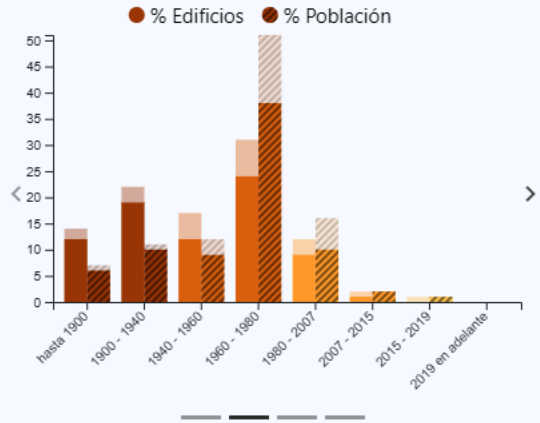
Ver más

Características de los edificios

Año de construcción



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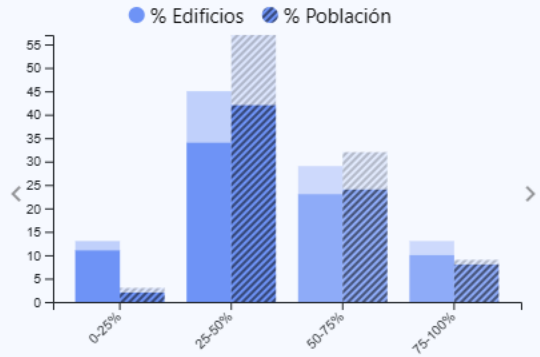
Ver más

Características de los edificios

Porcentaje de ocupación



Indicadores relacionados

Superficies de zonas verdes

Viviendas energéticamente eficientes y recuperadoras de energía

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Consumo final de energía

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Características de los edificios

Uso del edificio

Indicadores relacionados

Consumo final de energía

Indicador seleccionado

Precio medio alquiler comparado ingresos familiares

M P R

Precio medio alquiler comparado ingresos familiares

Porcentaje (%) de la renta bruta de los hogares más el saldo de transferencias corrientes (impuestos sobre la renta o el patrimonio, cotizaciones sociales, prestaciones sociales y otras), dedicado al pago del alquiler de la vivienda, determinado mediante el cálculo del valor medio de las unidades del edificio

Indicadores

-- Económico indicators --

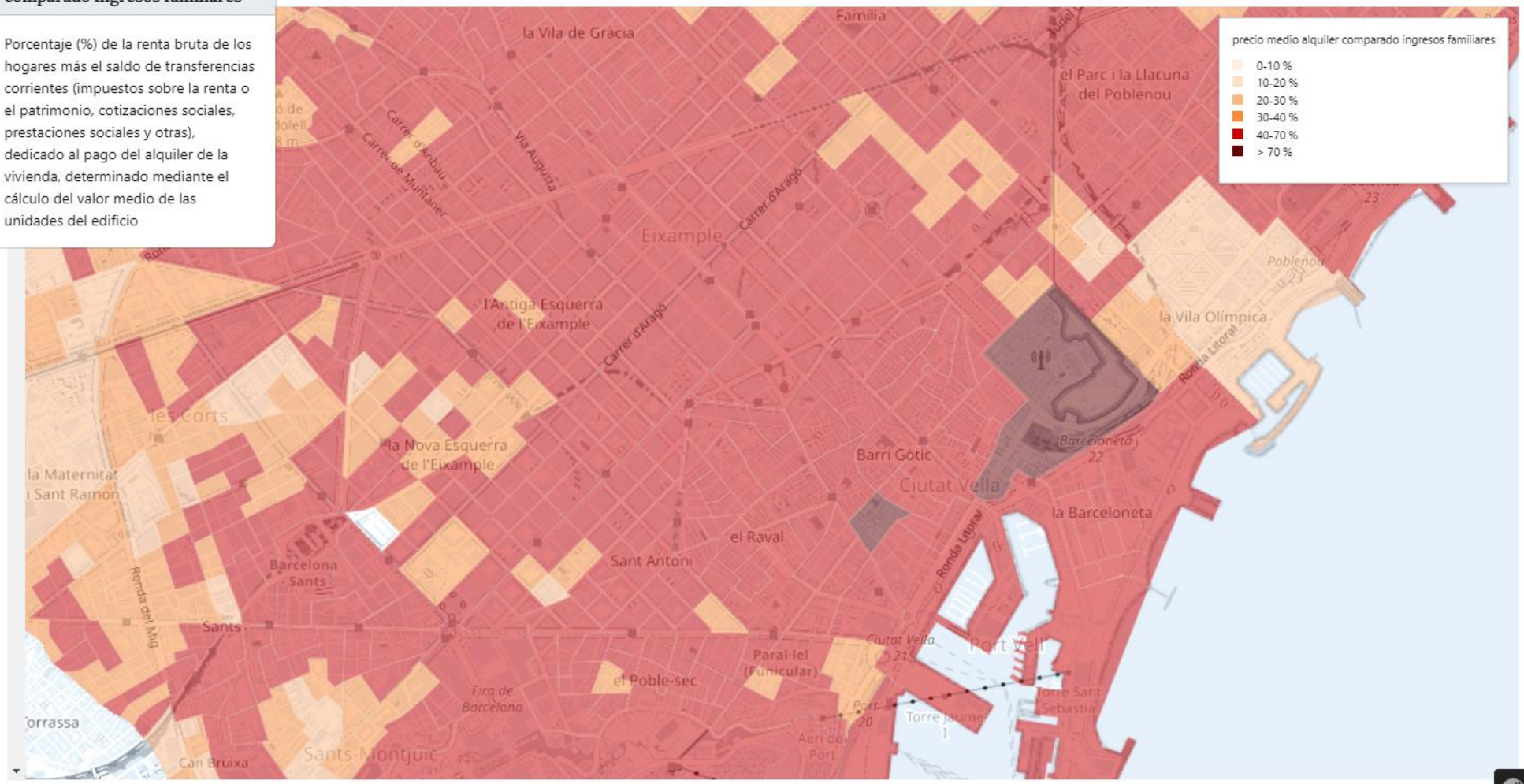
Precio medio alquiler comparado ingresos familiares

Población con ingresos inferiores al 60% de la media

Precio de la vivienda

Ingresos familiares medios

-- Energía indicators --



Indicador seleccionado

Ingresos familiares medios

R P M

Precio medio alquiler comparado ingresos familiares

Población con ingresos inferiores al 60% de la media

Precio de la vivienda

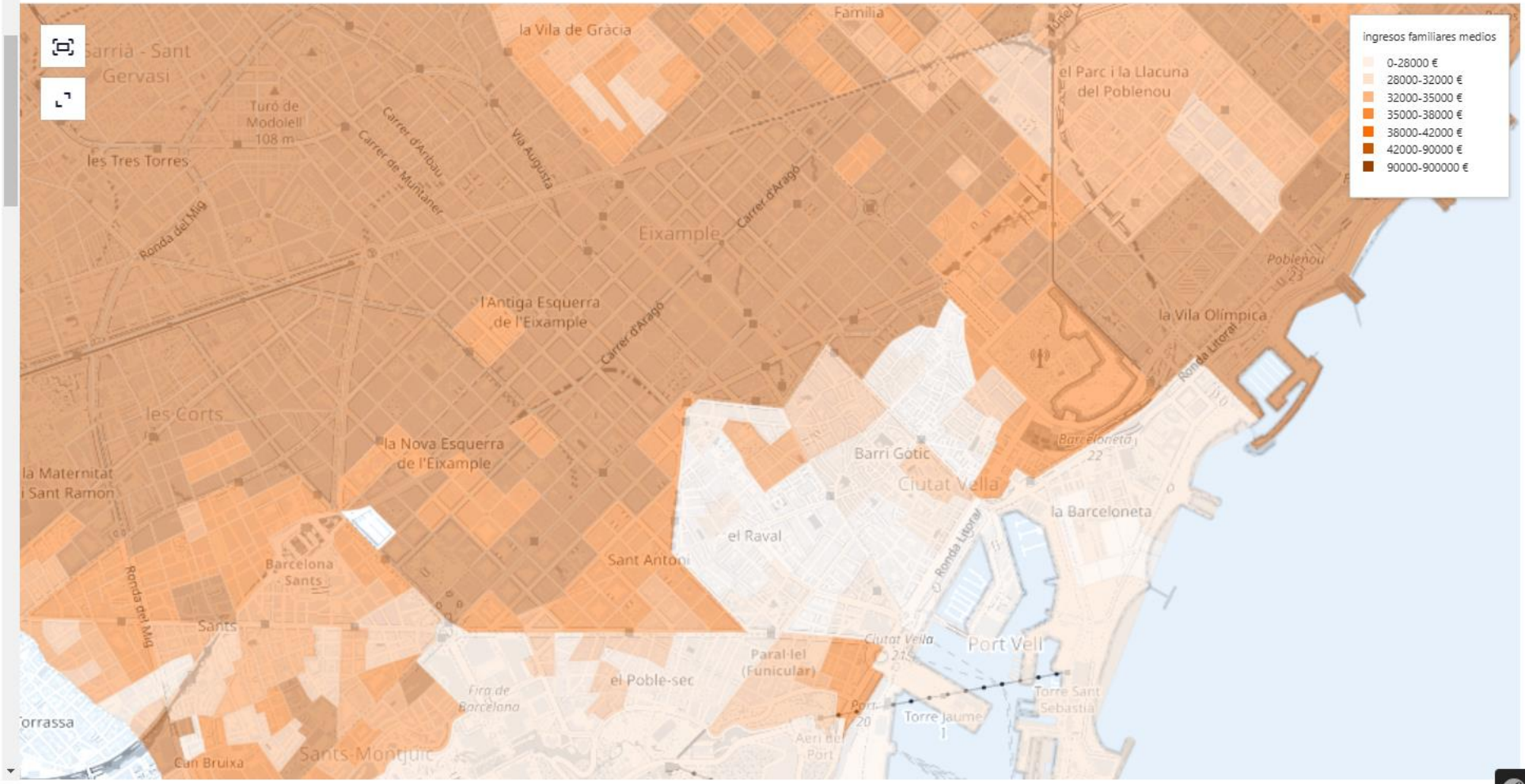
Ingresos familiares medios

-- Energía indicators --

Viviendas energéticamente eficientes y recuperadoras de energía

Potencial de generación solar fotovoltaica

Map Table



Indicador seleccionado

Potencial de generación solar fotovoltaica

M P R

recuperadoras de energía

Potencial de generación solar fotovoltaica

Viviendas energéticamente eficientes y recuperadoras de energía

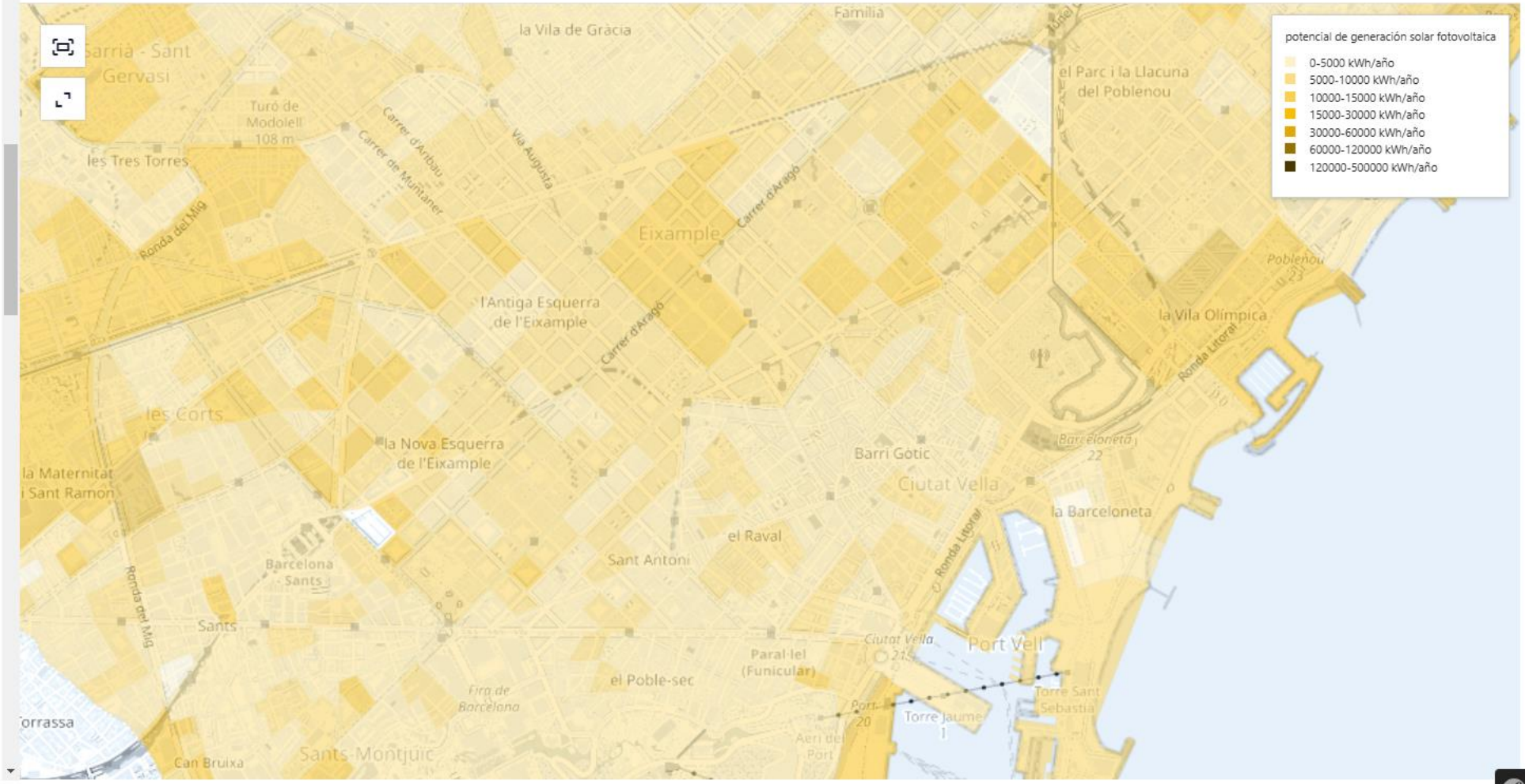
Consumo de energía de calefacción

Emisiones de gases de efecto invernadero

Consumo final de energía

-- Social indicators --

Map Table



Indicador seleccionado

Superficies de zonas verdes

R? M

Consumo de energía de calefacción

Emisiones de gases de efecto invernadero

Consumo final de energía

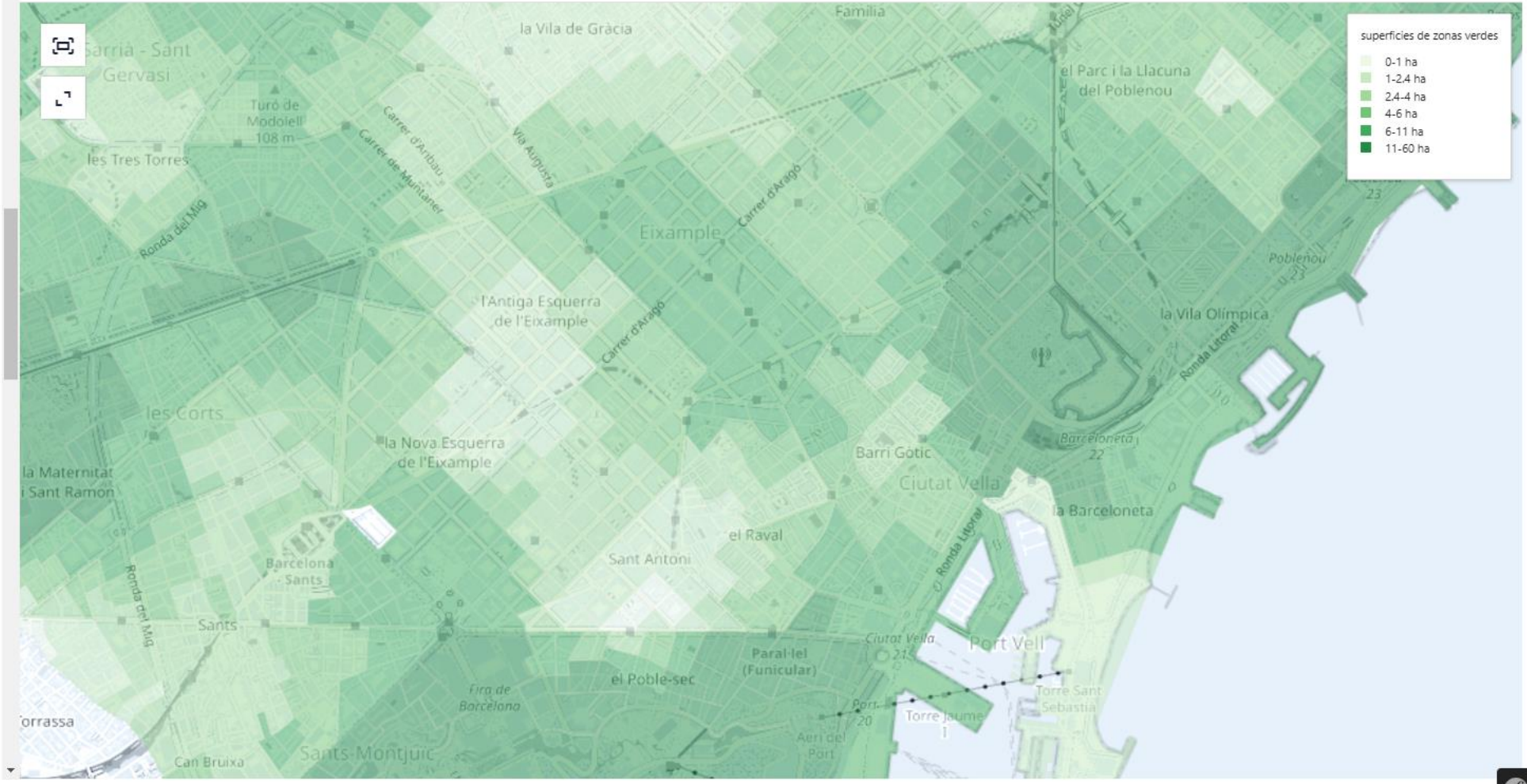
-- Social indicators --

Superficies de zonas verdes

Equipamiento urbano a 15 minutos caminando

Vulnerabilidad olas de calor y aumento de la temperatura

Map Table



Indicador seleccionado

Vulnerabilidad olas de calor y aumento de la temperatura

R P M

Superficies de zonas verdes

Equipamiento urbano a 15 minutos caminando

Vulnerabilidad olas de calor y aumento de la temperatura

Acceso al carril bici

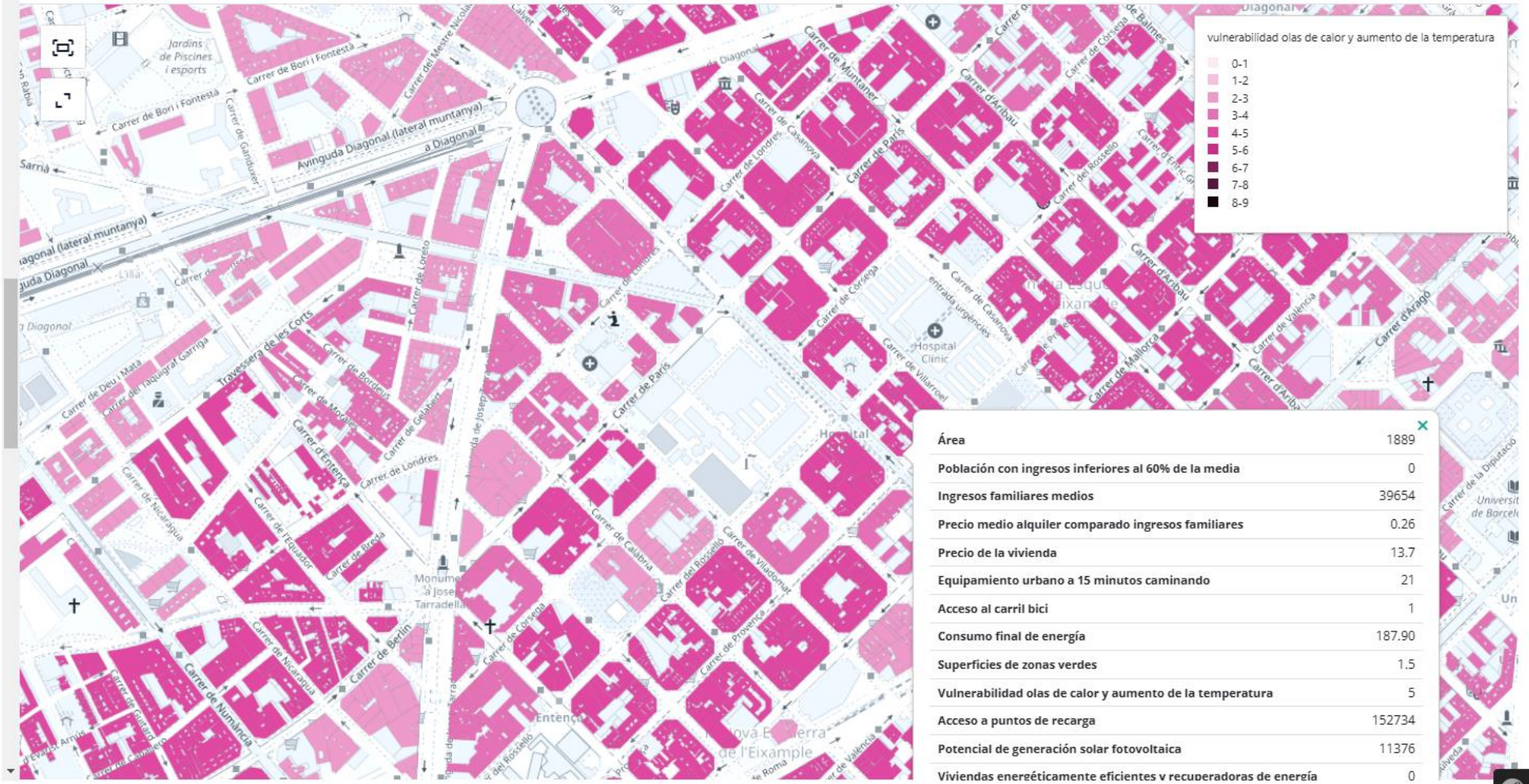
Acceso a puntos de recarga

Uso del edificio

% Edificios % Población

90 80 70

Map Table



Área	1889
Población con ingresos inferiores al 60% de la media	0
Ingresos familiares medios	39654
Precio medio alquiler comparado ingresos familiares	0.26
Precio de la vivienda	13.7
Equipamiento urbano a 15 minutos caminando	21
Acceso al carril bici	1
Consumo final de energía	187.90
Superficies de zonas verdes	1.5
Vulnerabilidad olas de calor y aumento de la temperatura	5
Acceso a puntos de recarga	152734
Potencial de generación solar fotovoltaica	11376
Viviendas energéticamente eficientes y recuperadoras de energía	0

Indicador seleccionado

Consumo de energía de calefacción

M R

recuperadoras de energía

Potencial de generación solar fotovoltaica

Viviendas energéticamente eficientes y recuperadoras de energía

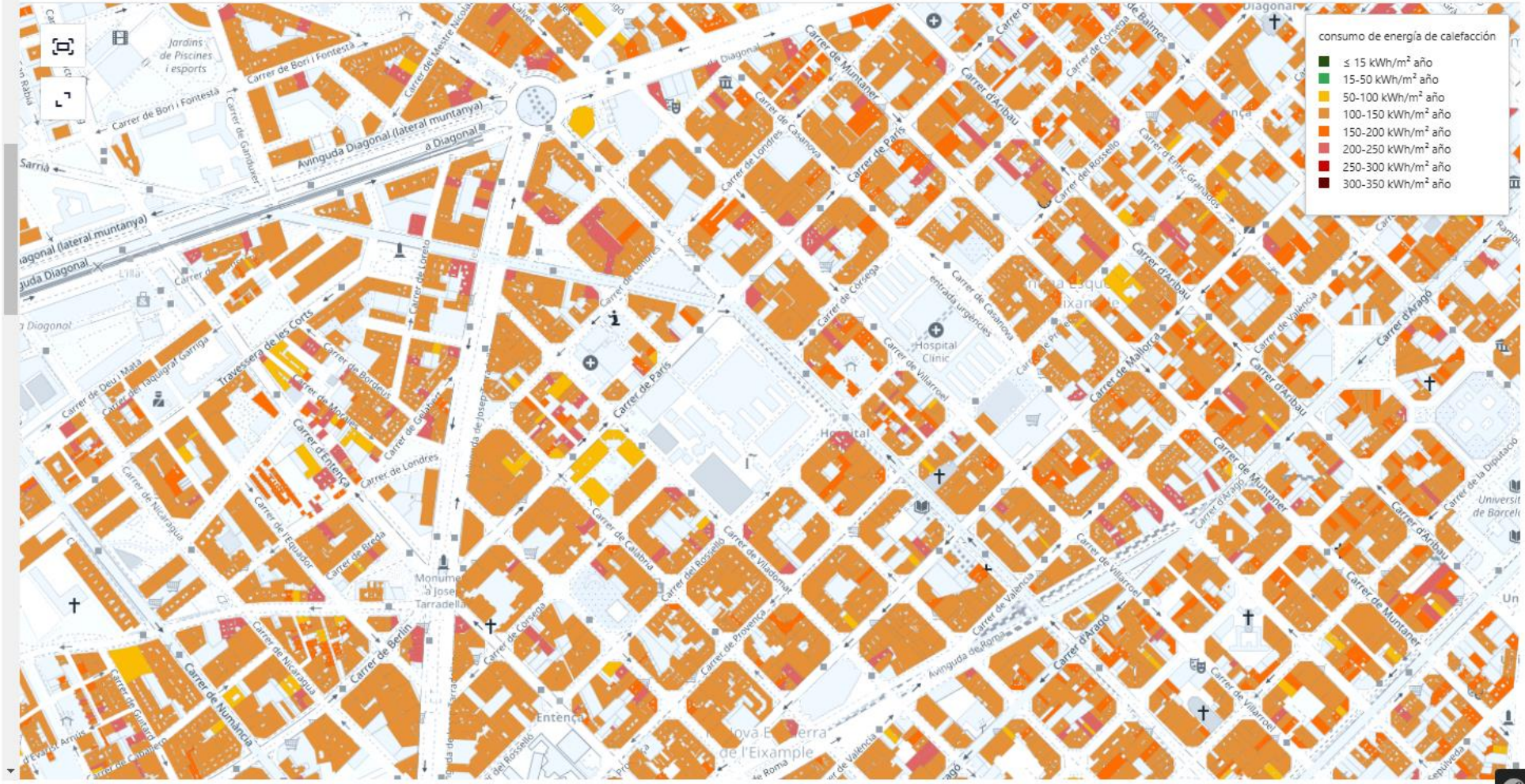
Consumo de energía de calefacción

Emisiones de gases de efecto invernadero

Consumo final de energía

-- Social indicators --

Map Table



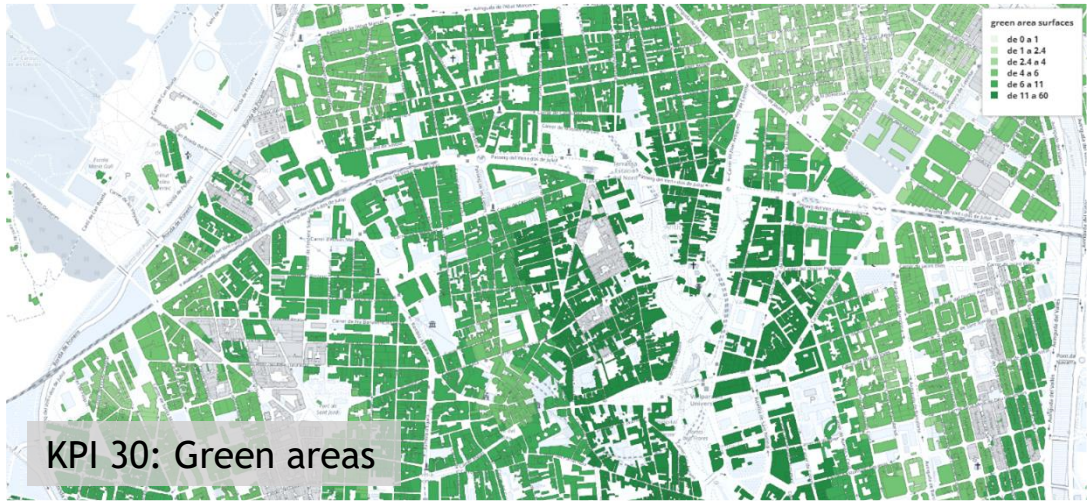
Identifying buildings for large-scale renovation plans

Where are the areas where vulnerable inhabitants live in non-efficient buildings within an urban context that do not enhance energy efficiency?

Identifying buildings for large-scale renovation plans

KPI 20: Median household income

KPI 37: Heating demand

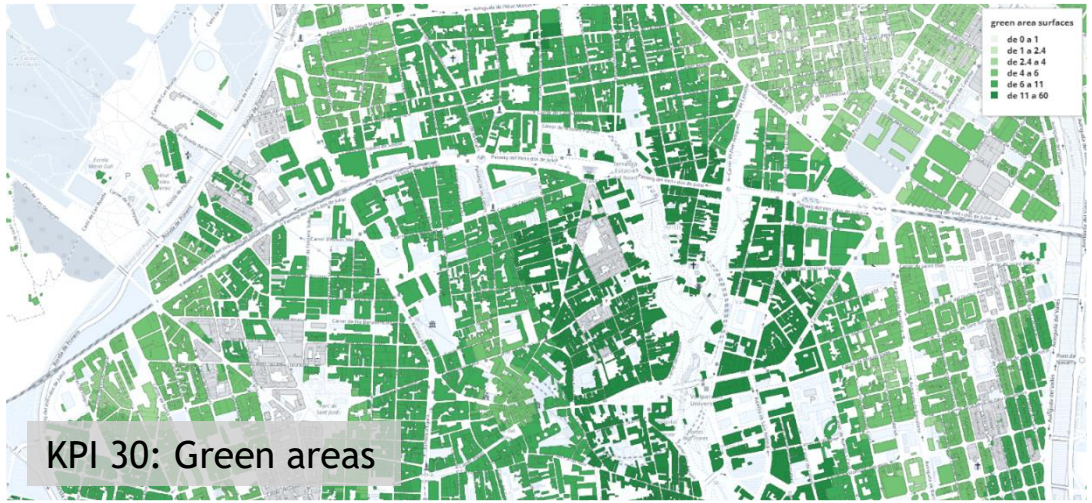


KPI 30: Green areas

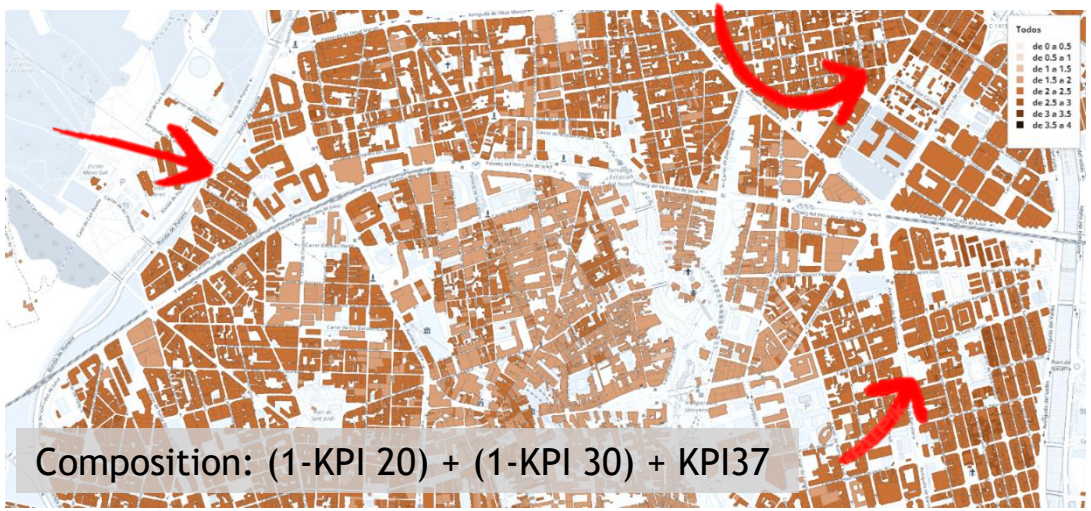
Identifying buildings for large-scale renovation plans

KPI 20: Median household income

KPI 37: Heating demand



KPI 30: Green areas



Composition: (1-KPI 20) + (1-KPI 30) + KPI37

Test test

(1) Definir ámbito (2) Definir Proyecto (3) Evaluar

Viviendas 684400 (58 %)
Habitantes 1585939 (58 %)

Indicador seleccionado

Indicador compuesto

Define tu índice compuesto para determinar el ámb
intervención del proyecto urbano de reforma.

Definir índice compuesto

vulnerable people non efficient buildings

Año de construcción

Área

Porcentaje de ocupación

Uso

Crear/editar el indicador compuesto para el plan de reforma

Puedes crear un propio indicador diseñado para el propósito de tu plan de reforma. Este indicador combinará varios indicadores que te ofrece la plataforma RETABIT.

Nombre del indicador compuesto

Selecciona indicadores con IA

Describe los datos que estás buscando y la IA te devolverá la mejor selección de indicadores posible a tu búsqueda.

Where are the areas where vulnerable inhabitants live in non-efficient buildings within an urban context that do not enhance energy efficiency?

Buscar

Indicadores disponibles

- Viviendas energéticamente eficientes y recuperadoras de energía
- Equipamiento urbano a 15 minutos caminando
- Acceso al carril bici
- Vulnerabilidad olas de calor y aumento de la temperatura
- Acceso a puntos de recarga

Indicadores seleccionados

- Ingresos familiares medios
- Consumo final de energía
- Superficies de zonas verdes

Test test

Edificios 20094 (33 %)
Viviendas 684400 (58 %)
Habitantes 1585939 (58 %)

(1) Definir ámbito | (2) Definir Proyecto | (3) Evaluar Proyectos

Indicador seleccionado

Indicador compuesto

Define tu índice compuesto para determinar el ámbito de intervención del proyecto urbano de reforma.

Definir índice compuesto

vulnerable people non efficient buildings

Año de construcción

Área

Porcentaje de ocupación

Uso

Map | Data

Take Aways

- A holistic perspective to address sustainability goals through building renovation: going **beyond** urban **energy** modelling.
- The RETABIT Platform has been developed for analyzing Spanish municipalities, with potential for broader European application.
- To this end, three main needs arise:
  - Adequate data **granularity**: to ensure reliability of analysis avoiding assumptions or inaccuracies.
  - **Standardization** of KPIs: to align global goals with renovation actions and address issues with adequate measures.
  - Use of **Composite Indicators:** To provide a comprehensive approach through a single index, leveraging Artificial Intelligence tools without oversimplifying intricate data.

Retabit

SUSTAINABLE PLACES 2024

If you would like more information, please contact us at

alvaro.sicilia@salle.url.edu
leandro.madrazo@salle.url.edu

Thanks for your attention!

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