# Building the future through Electrification and Digitalisation

## when AI-driven design meets electrification for zero-emission buildings

**26 November 2025 | 10:00 - 11:30 CET |**
**Teams webinar**

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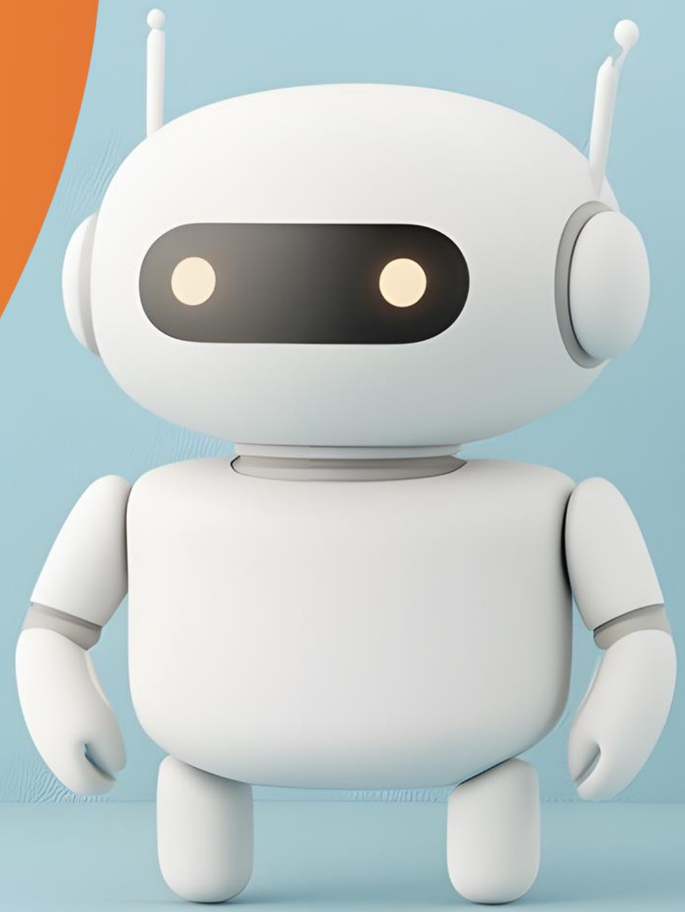
ZEBAI



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# Agenda

**10:00 - 10:05** - Welcome and Introduction to the webinar - **Francesca Genovesi**, **EHPA**

**10:05 - 10:10** - Introduction to META BUILD - **Nikos Dimitropolous**, **NTUA**

**10:10 - 10:20** - AI for planning and integration “Decarbonisation as a Service Approach’ - **Symeon Chorozoglou, NTUA**

**10:20 - 10:30** - Ensuring reliability and minimising downtime through AI/ML - driven solutions - **Marian Angeles Gallego de Santiago, CARTIF**

**10:35 - 10:40** - Introduction to ZEBAI - **Antonio LaTorre, UPM**

**10:40 - 10:50** - Introduction to ZEBAI tool - **Lorena Cruz, UPM**

**10:50 - 11:00** - Demonstration buildings and scalability potential - **Martjan den Hoed, GAF**

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# SPEAKERS



**Nikos Dimitropolous**
NTUA



**Symeon Chorozoglou**
NTUA



**Marian Angeles Gallego**
CARTIF



**Francesca Genovesi**
EHPA



**Antonio LaTorre**
UPM



**Lorena Cruz**
UPM



**Martjan den Hoed**
GAF

# Agenda

## Q&A and Panel Discussion : Modelling and AI for Industrial Sector and Circular Buildings

“Towards the digitalisation of the industrial sector with Digital Twin and Edge Computing”
**Lucia Royo, Electroingenium**

“Bridging innovation and market mechanism for decarbonised buildings”
**Dimitris Chatzigiannis, Heron Energy S.A**

“Low-carbon construction through circular materials: Introducing NeoCem’s calcined clay innovation”**Benjamin Constant, NéoEco**

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# PANELIST



**Lucia Royo**
Electroingenium



**Dimitris Chatzigiannis**
Heron Energy S.A



**Benjamin Constant**
NéoEco

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**Nikos Dimitropolous**
Senior researcher and R&D project manager at DSS Lab, NTUA

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# META BUILD

Nikos Dimitropolous



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# Content

Project Summary
Who we are
Background
Vision
Framework
Technologies
Demonstration Sites

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# Project Summary

Coordinator

**ICCS**

Insitute of Communications and Computer Systems

Powering the METAmorphosis of BUILDings towards a decarbonised and sustainable energy system

Title

HORIZON EUROPE, RIA – Research and Innovation Action

Funding

**38**

Participants

HORIZON-CL5-2023-D4-01

Call / Grant

Lifetime

**48** Months

01 Jan 2024 ⟶ 31 Dec 2028



# Who We Are

**38**
Participants

**13**
Countries

**6**
Pilots
Front Runners

**7**
Replication
Multipliers

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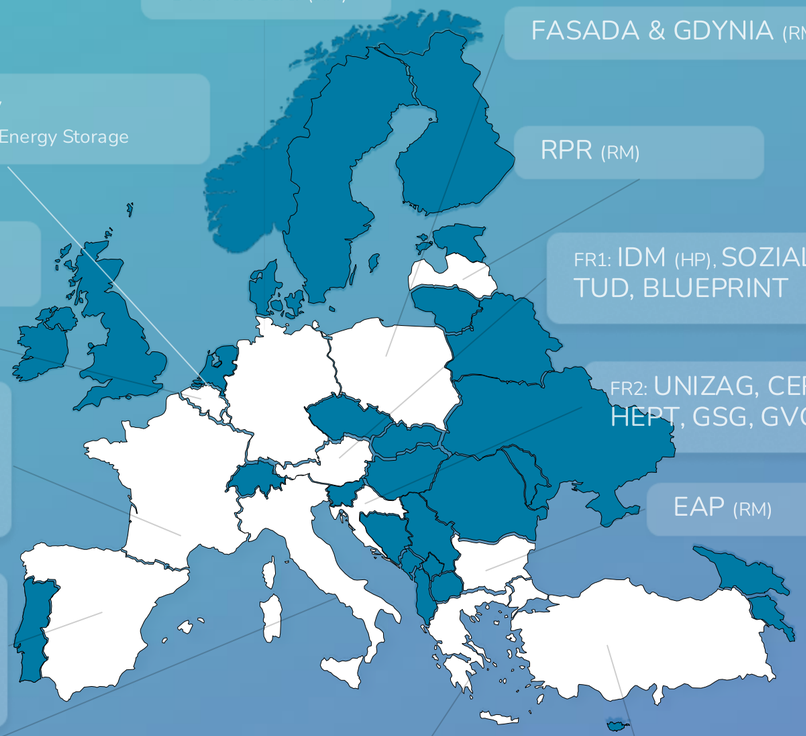


UNIPassau (RM)

FASADA & GDYNIA (RM)

ED Interoperability
CIRCULI-ION Energy Storage

RPR (RM)

EHPA & RAP
Networking & Policy Support

FR1: IDM (HP), SOZIALBAU, TUD, BLUEPRINT

FR2: UNIZAG, CER (HP) HEPT, GSG, GVG

ARTELYS Scalability
INETUM Exploitation
FR3: EDF, SAUTER, KM0 & ENOV, CAMPUS, HELEXIA (RM)

EAP (RM)

CARTIF Building Experts
FR6: TECNALIA (HP) VEOLIA (RM)
ENDEF (PVT)
ENETUM ES affiliated entity

ARCELIK HP in FR3

EURAC Scientific Coordinator
FR5: INNOVA (HP) & ANIMA

ICCS Project Coordinator
FR4: HOL, ZENITH, KLIMA THESS (RM)

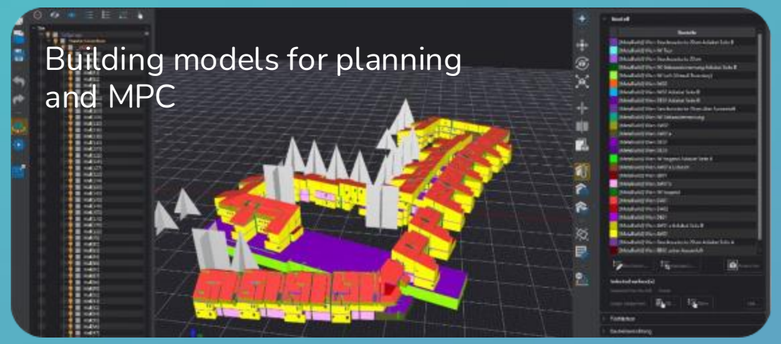



# Vision

- Integrate Renewable Energy Sources in building sector
- Electrify building thermal energy using Heat Pumps
- Optimise building energy systems performance
- Decarbonisation pathway of the building sector
- Enhance building digitalisation and intelligence

# Technology Framework

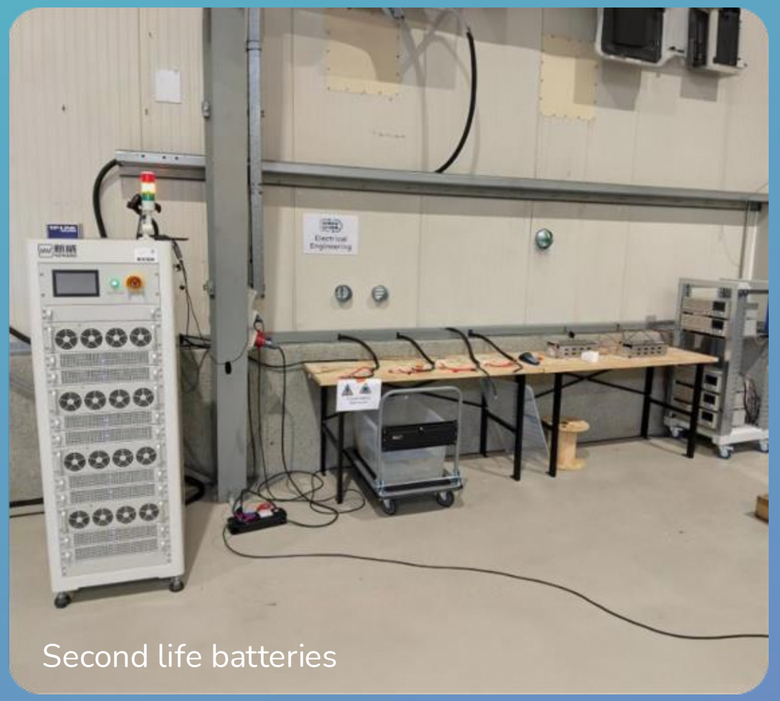


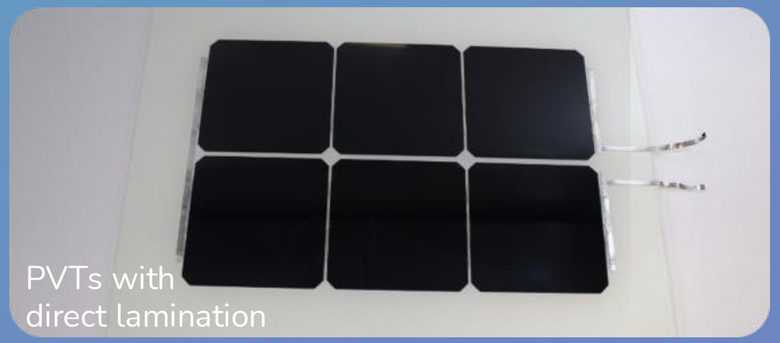


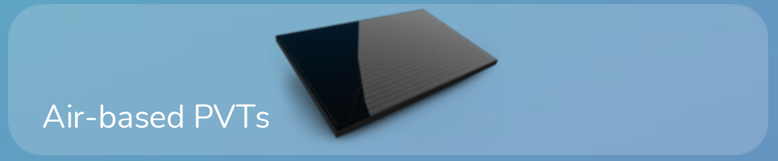




# Technologies












## DS 1: Viennese Multi-Family Row-House (2-storey)

Location: Vienna, Austria
Leading partner: IDM
Technology: R290 brine-to-water heat pump + PVs 200kW + Electric energy storage



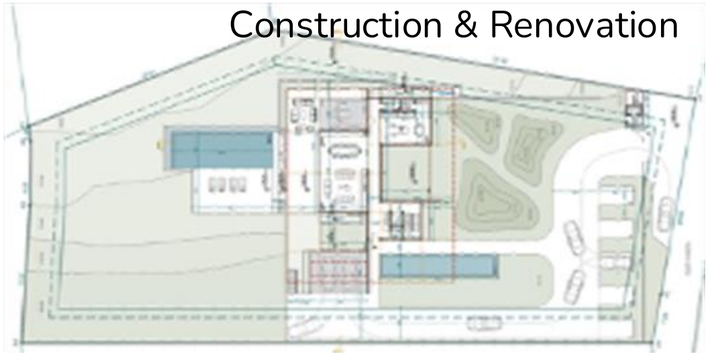

## DS 2: Residential Building, 130 apartments

Location: Velika Gorica, Croatia
Leading partner: HEPT
Technology: District-heating-connected HPs + Hybrid photovoltaic-thermal (PVT) technology + PV




## DS 3: Office complex in a historic peri-urban area

Location: Mulhouse, France
Leading partner: EDF
Technology: PV + HP DHN + BMS (Digital Twin solution)




## DS 4: 3-storey & 2-storey single houses

Location: Greece
Leading partner: ZENITH
Technology: HP+Rooftop PVs, IoT with DR tools




## DS 5: Multifamily building, 13 apartments

Location: Bolbeno, Trento, Italy
Leading partner: INNOVA
Technology: PVs + ATW HP + PCM Thermal ES in HPs ctrl + LT Emitters + radiant panels + Fan coils + Advance Energy Management on the Hydronic Plant




## DS 6: Office building, lab facilities & car parking

Location: San Sebastian, Spain Donostia-San
Leading partner: TECNALIA
Technology: DSHP + PVTs + Digital Twins

Hotel, University, Multi-Apartment Complex
Madrid, Segovia, Valladolid - Spain

Kindergarten
Gdynia - Poland

Multi-Appartment Building
Riga - Latvia

Sports Center, Kindergarten, Mensa Building
Passau - Germany

4 High schools, 1 Gym
Thessaloniki - Greece

Warehouse, Storage
Saint-Priest - Lyon France

Single Family Residential Building
Plovdiv - Bulgaria

# 7 Multipliers Replication Sites

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## Email

contact@meta-build.eu

## Newsletter

META BUILD Newsletter

## Website

www.meta-build.eu

## Social Media

Facebook
LinkedIn

# Thank You!

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**Symeon Chorozoglou**
Data Scientist and researcher at DSS Lab, NTUA

EPU N·T·U·A

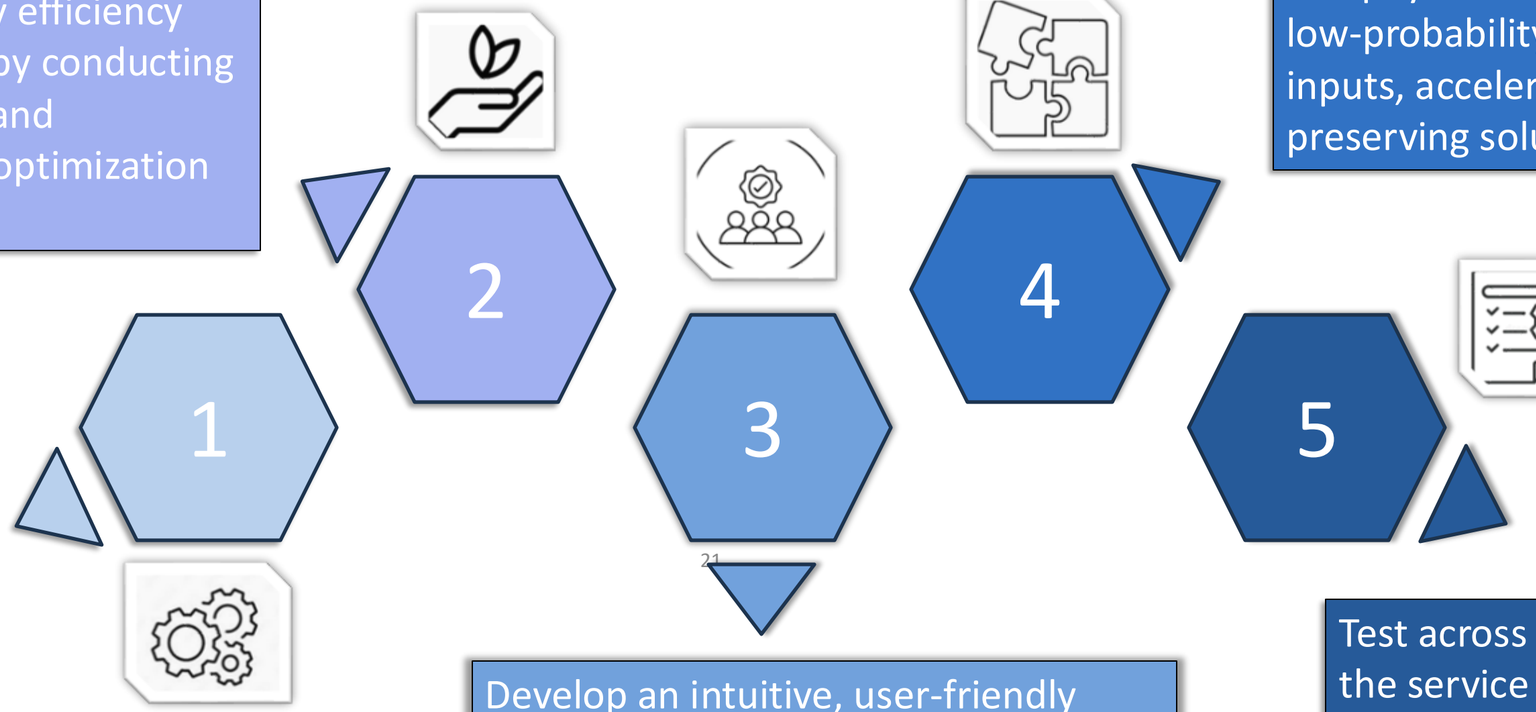
# Decarbonization as a service platform

Symeon Chorozoglou (NTUA)

# Objectives of the tool

Improve overall energy efficiency and operational costs by conducting baseline assessments and implementing proven optimization strategies

Minimize buildings $CO^2$ emissions by applying optimized energy interventions tailored for sustainability




Develop an intuitive, user-friendly platform that simplifies building management and enhances decision-making processes

Use physics-informed AI to screen out low-probability patterns for given inputs, accelerating the MILP while preserving solution quality

Test across pilots demonstrating that the service performs reliably in multiple contexts



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# Platform Overview and Architecture

**Data Collection & Input**

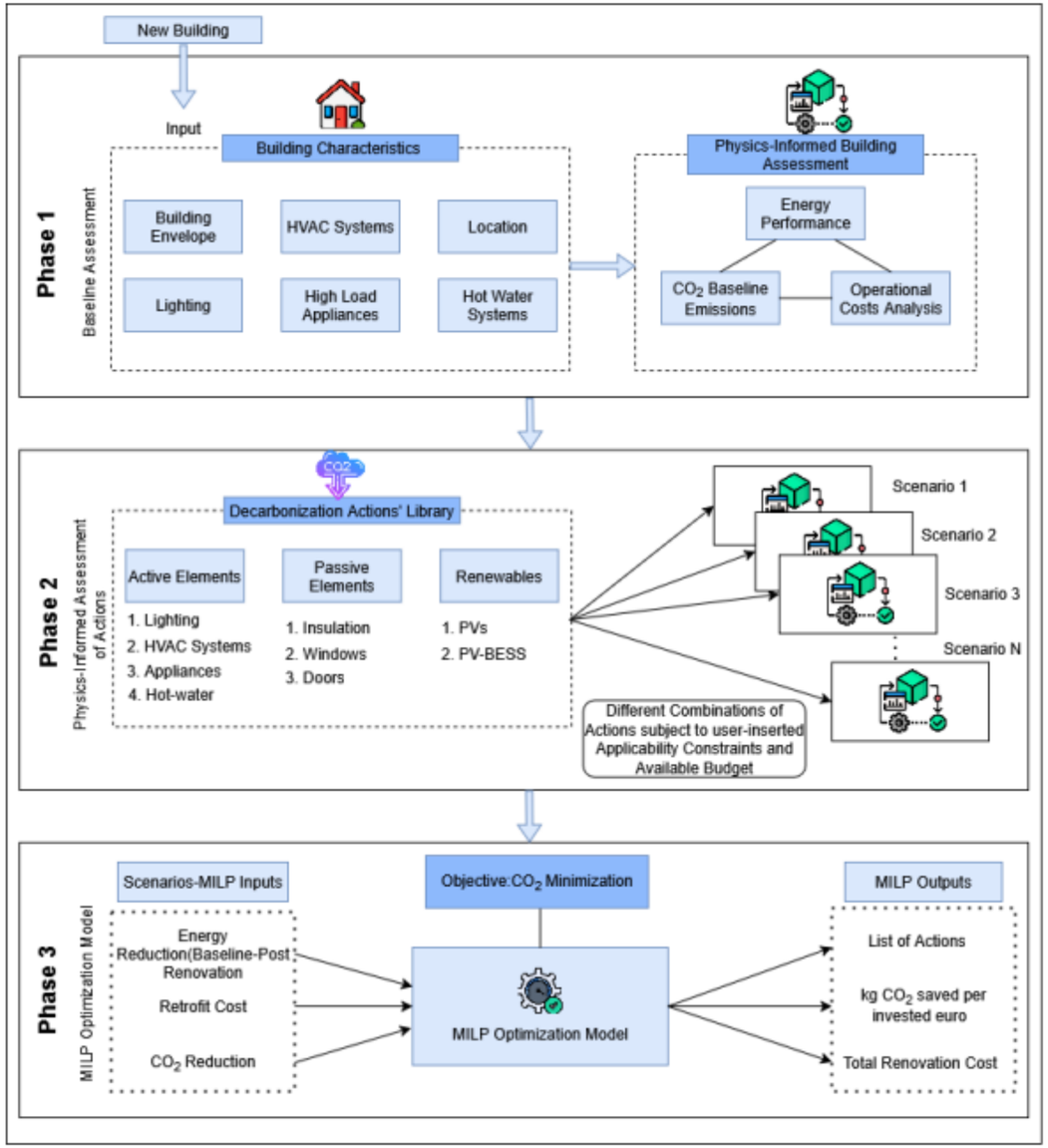
- Gathers detailed information on active elements such as HVAC systems, lighting, and renewable systems
- Collects data on passive elements including building envelope characteristics and insulation quality

**Baseline Assessment**

- Analyzes current energy performance and calculates baseline CO2 emissions
- Provides a clear understanding of the building's initial environmental impact through data-driven insights

**Decarbonization Strategy**

- Proposes tailored decarbonization actions based on the collected data
- Prioritizes interventions by assessing both energy performance improvements and potential emission reductions

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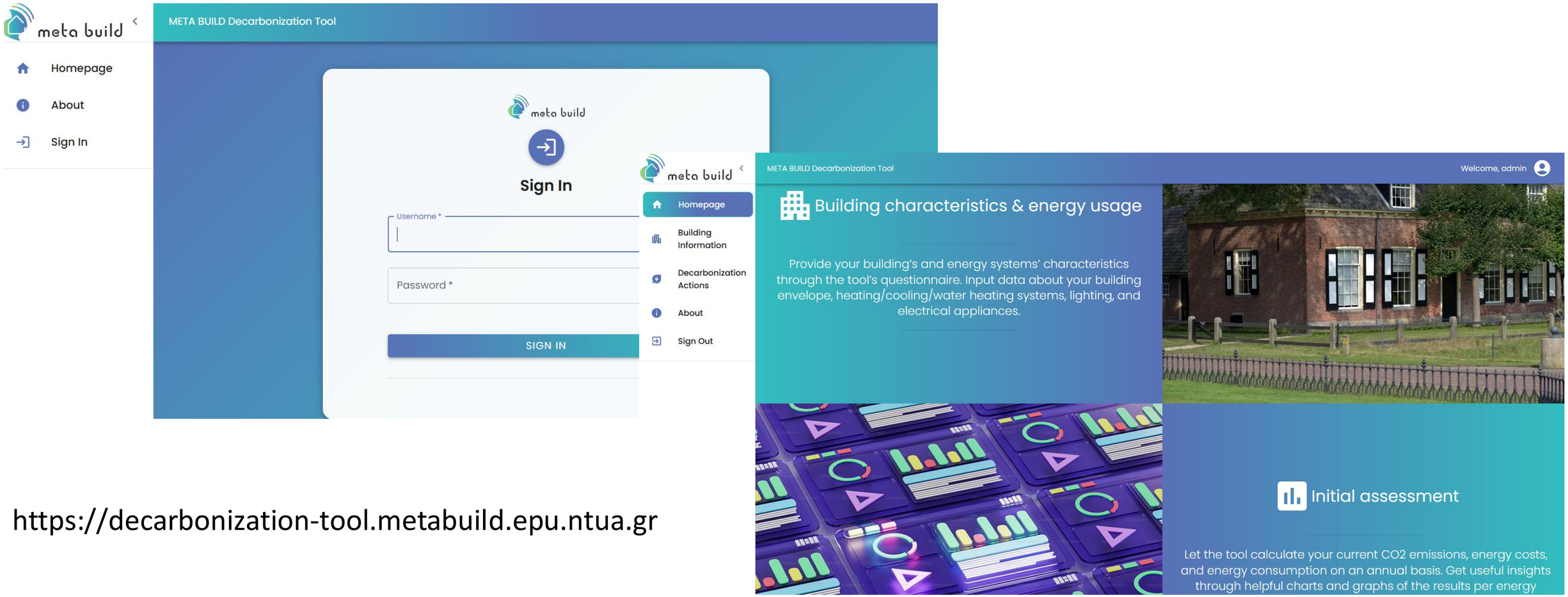
# Authentication and Home Page




https://decarbonization-tool.metabuild.epu.ntua.gr

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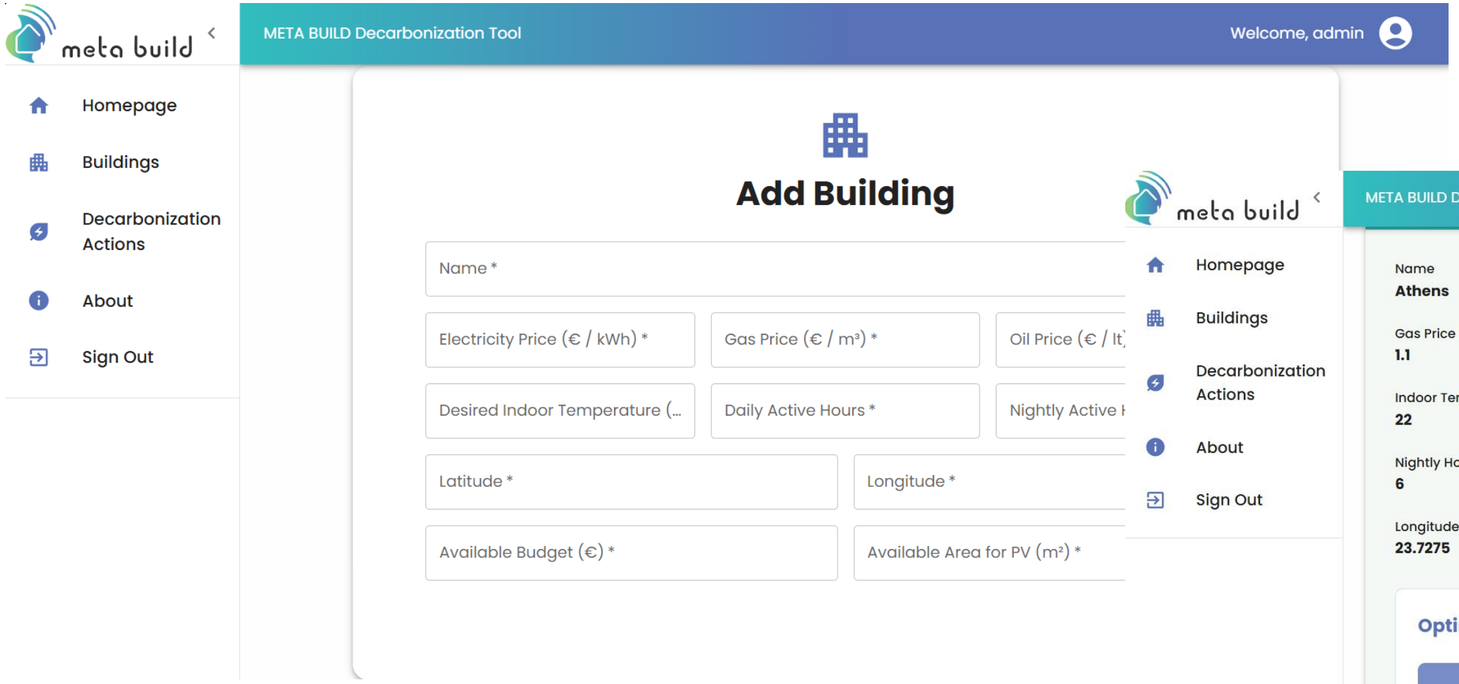
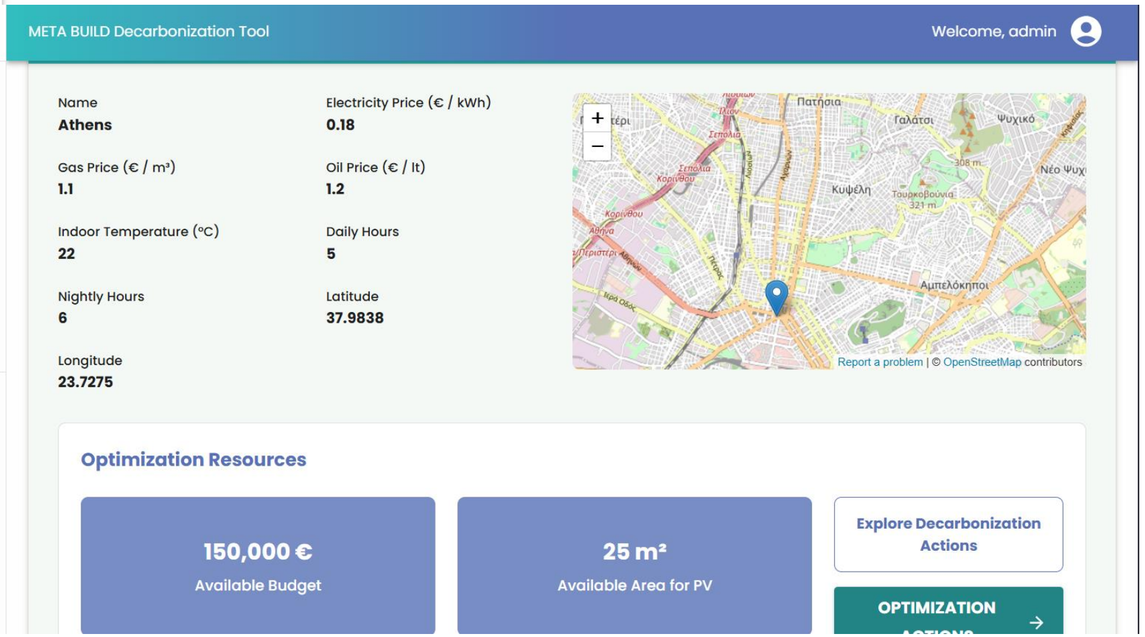
# Building’s General Information

## Building’s location and technical characteristics



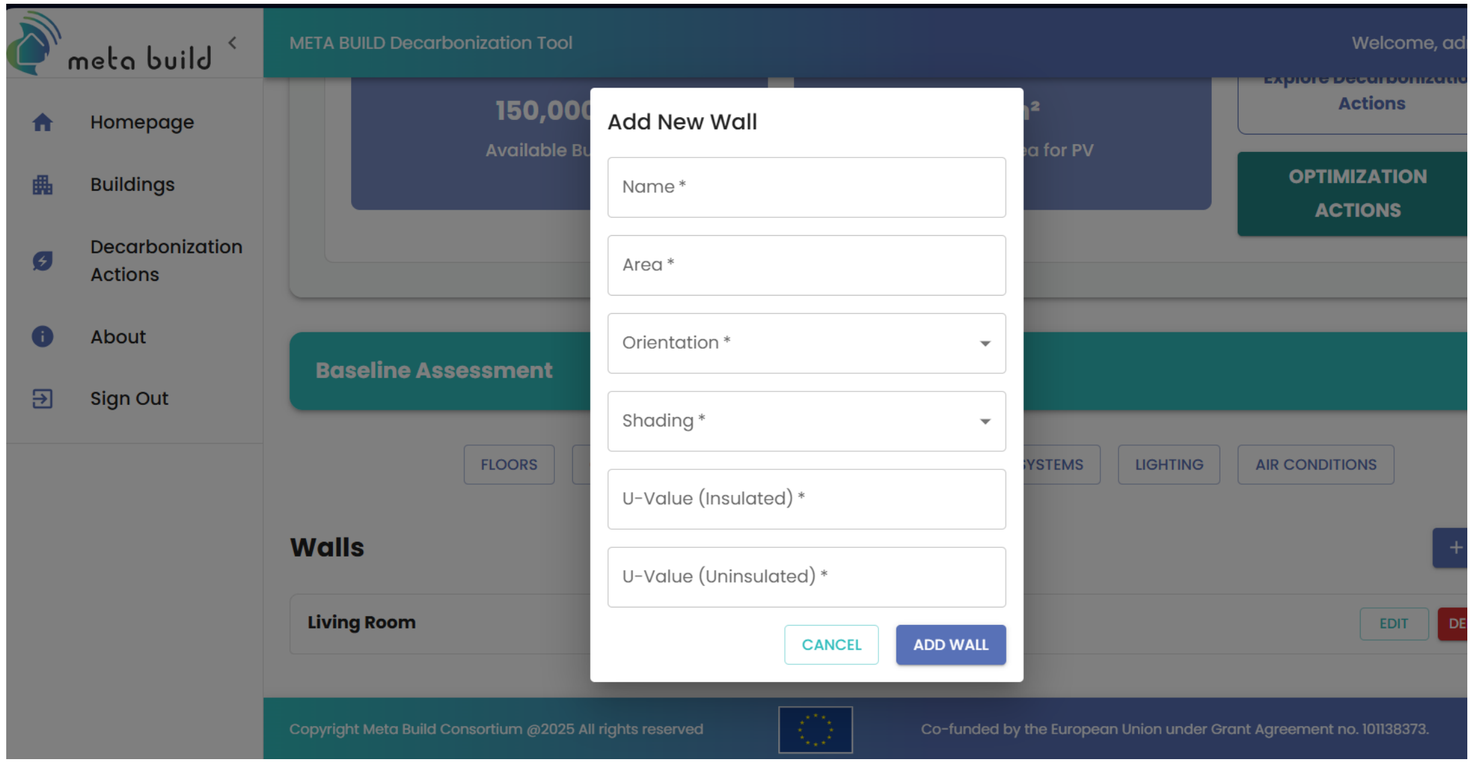

## Example Building in Athens



# Adding passive and active elements

Active and Passive Elements Examined:

- ❑ Building Envelope (walls, doors, ceilings, etc.)
- ❑ Heating systems
- ❑ Appliances (Oven, Microwave, etc.)
- ❑ Air-conditions
- ❑ Lighting Systems
- ❑ Elements' properties (U-values, occupancy hours, shadings)

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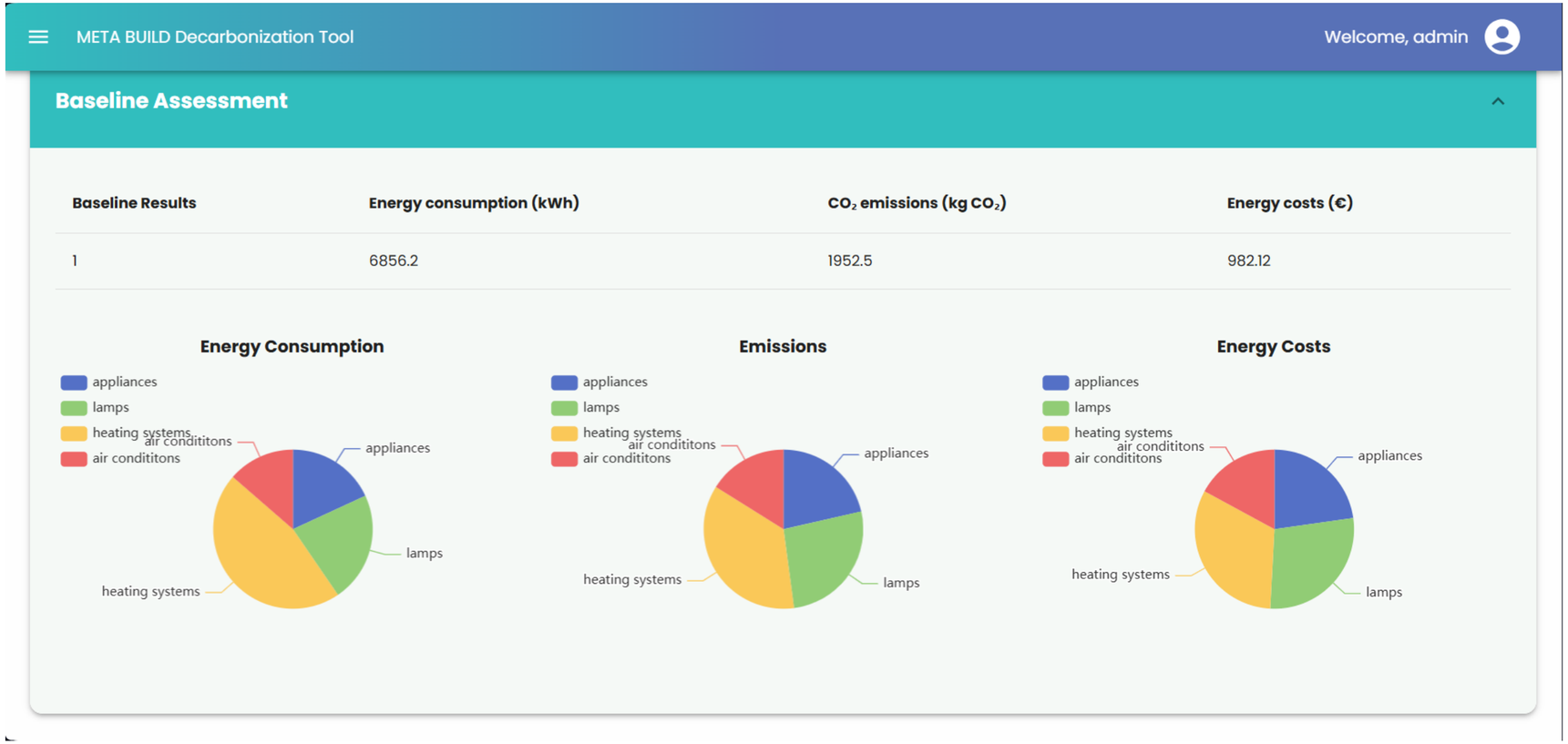
# Baseline Assessment of the Building

Metrics Examined:

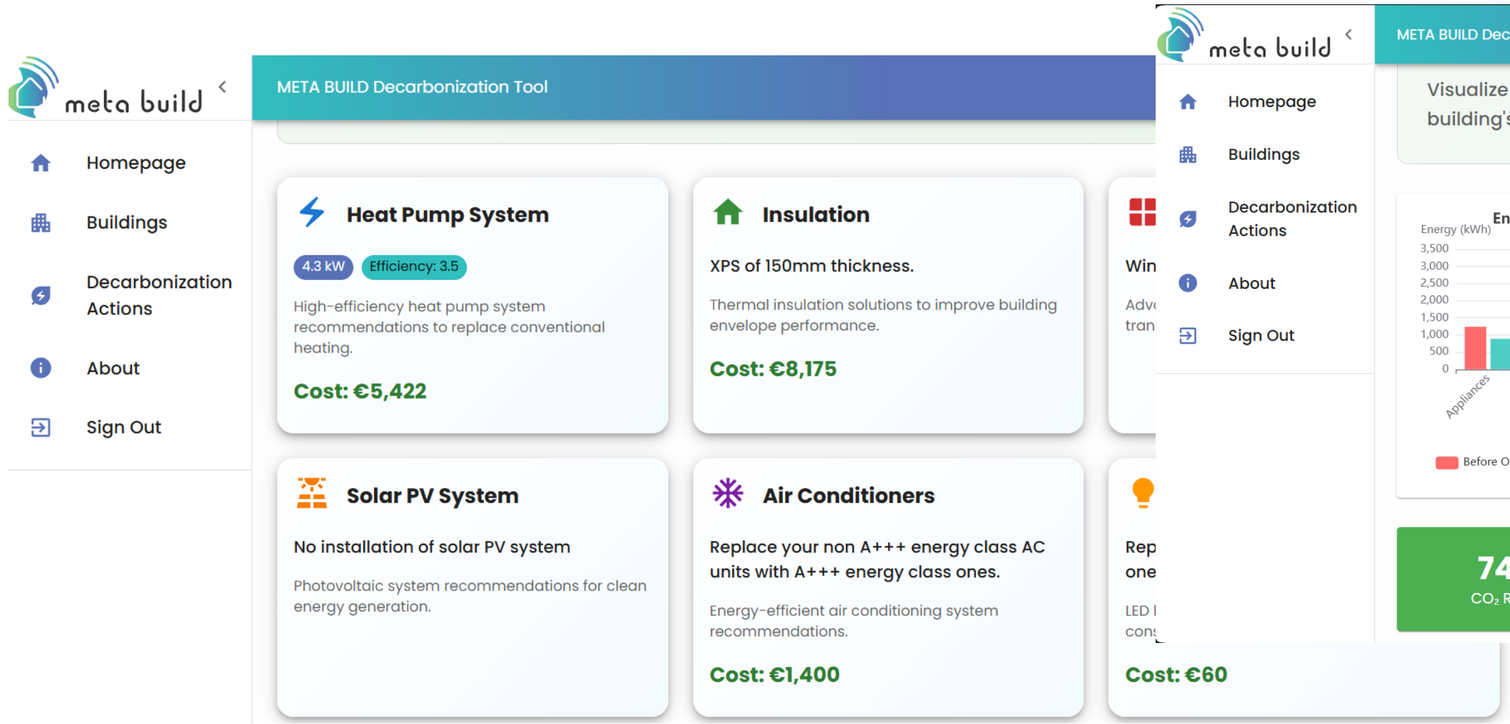
- Annual Energy Consumption
- Total $CO^2$ emissions
- Total Energy Costs
- Energy Consumption, Emissions, Costs per category

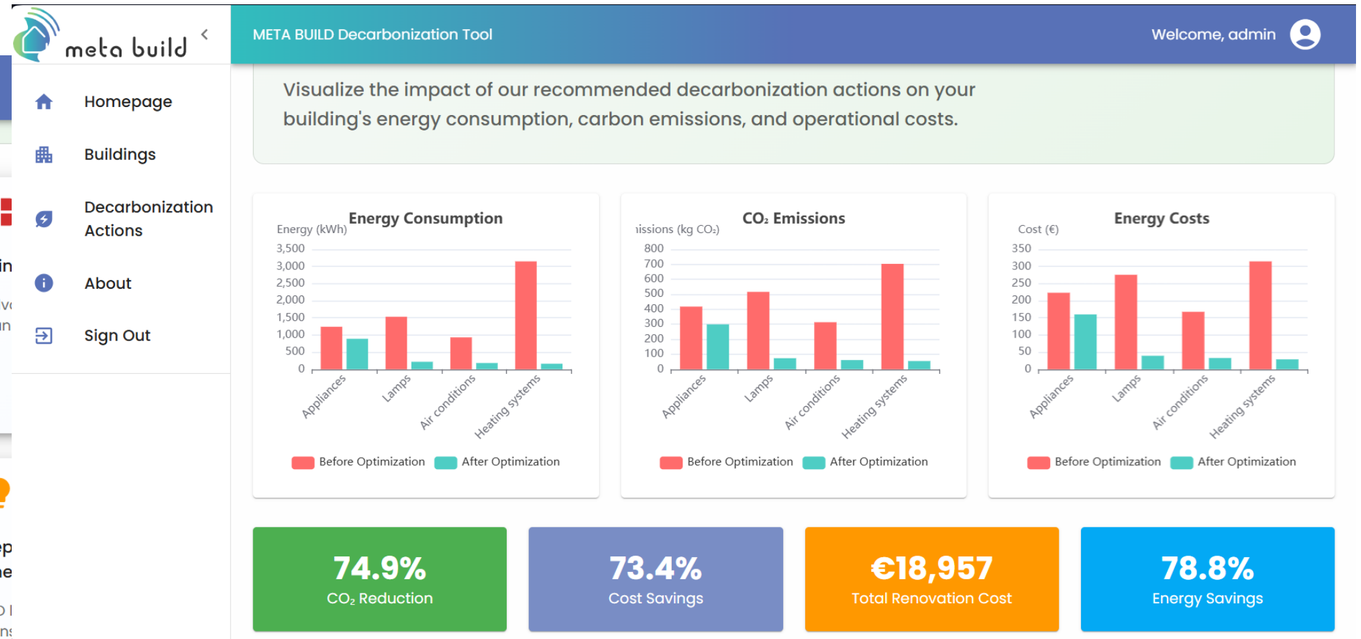


# Proposed Actions and Savings

- Propose prioritized replacement actions from the measure library (passive & active)
- Solve a mixed-integer linear program to minimize life-cycle $CO_2$ under budget, comfort, and feasibility constraints

- Calculate updated emissions and costs
- Compare pre- vs. post-renovation performance across $CO_2$, energy and cost



Symeon Chorozoglou (NTUA)

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**Marian Ángeles Gallego de Santiago,**
Senior Researcher and Project Manager
at CARTIF

CARTIF

# Ensuring reliability and minimising downtime through AI/ML-driven solutions

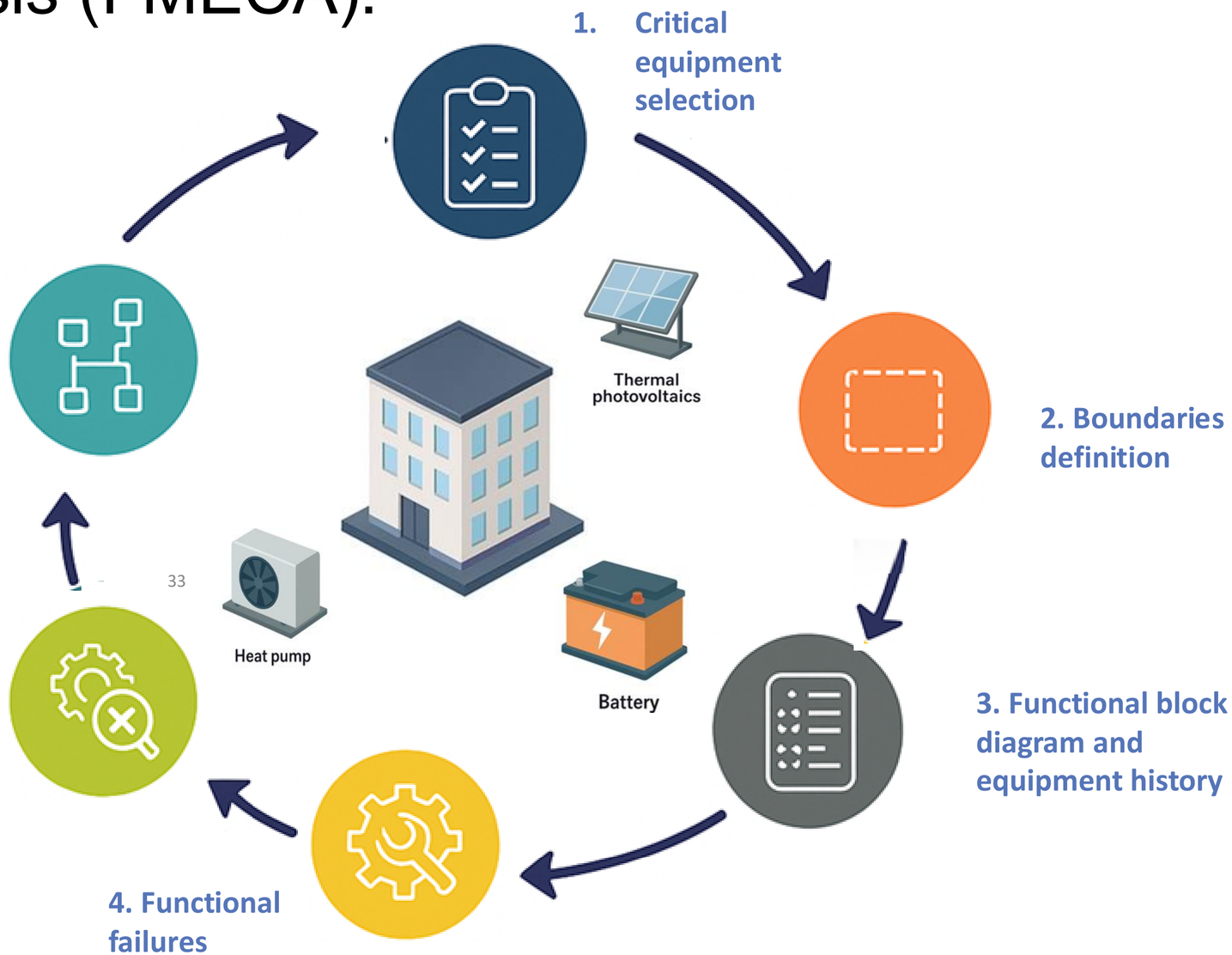
# Agenda

- Purpose of the work
- Description of Reliability Centered Maintenance (RCM) and Failure Mode, Effects, and Criticality Analysis (FMECA).
- RAM indicators
- AI approach
- Application to batteries

# Purpose of the work

- Ensure safe energy system operation for electrified buildings, guaranteeing **service continuity** and **reducing maintenance-related operational costs**.
- A **predictive maintenance tool** is being developed using a classical Reliability Centered Maintenance (**RCM**) approach and Failure Mode Effects and Criticality Analysis (**FMECA**).
- Focus set on f**ault prediction algorithms** for the electrified systems used in buildings (**PVT, HP, batteries**).
- The tool will incorporate **data-based** and **machine learning** prediction algorithms to estimate device states.

# Reliability Centered Maintenance (RCM) and Failure Mode, Effects, and Criticality Analysis (FMECA).



# RAM indicators

**Reliability:**
*"Probability that assets perform without failure over a given operating period."*

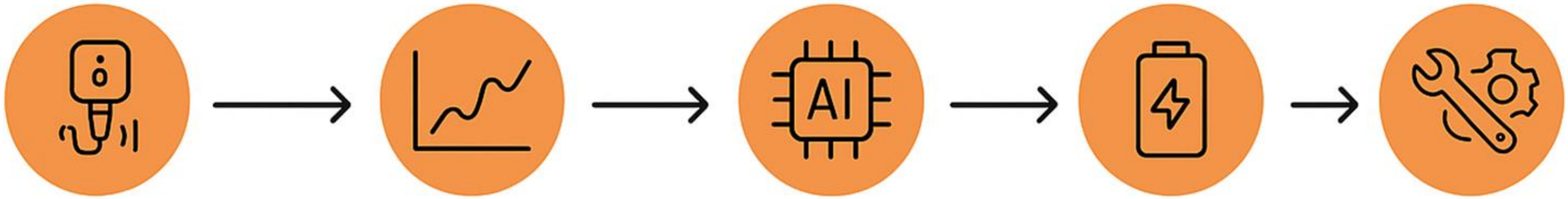
**Predictive Maintenance Performance:**
*"Using RAM metrics to prioritize assets, optimize inspection intervals and reduce unplanned downtime."*

**Availability:**
*"Percentage of time assets are in an operational state when needed."*

***Maintainability:***
*"Ease and speed with which assets can be restored after a failure."*



# AI approach




**Data acquisition**: Sensor measurements

**Model prediction:** Expected performance

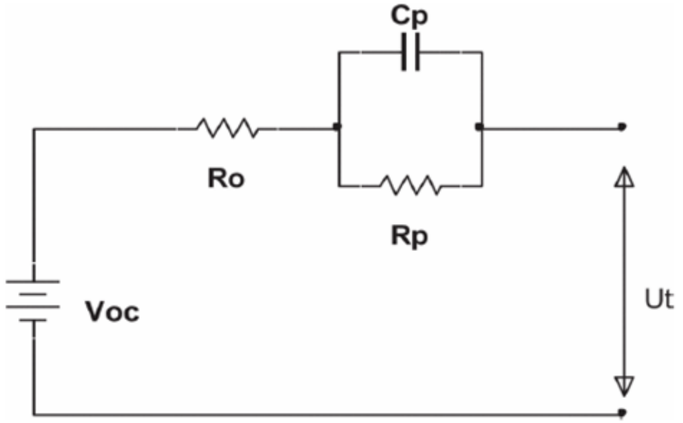
**AI detection:** Residual analysis & anomaly detection

**Fault diagnosis:** HP, PVT, batteries

**Maintenance feedback:** Improves model & reduces downtime

# Application to batteries: Thevenin model

Battery measured data:
- current,
- voltage,
- Etc.



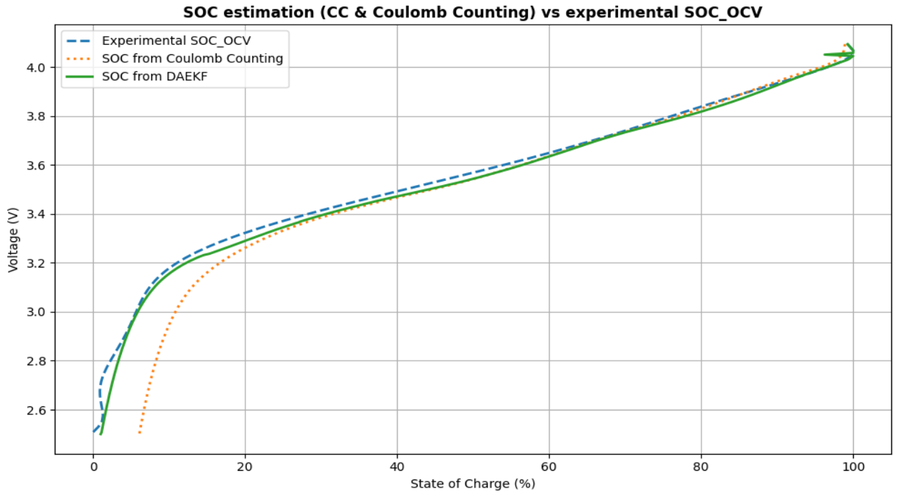

Estimated values:
- SOC
- Ohmic resistance
- SOH
- RUL

$R_0$: ohmic resistance
Rp: polarization resistance
Cp: equivalent capacitance, used to describe the transient response during charging and discharging cycles.
$V_{OC}$: open circuit voltage
$U_t$: terminal voltage

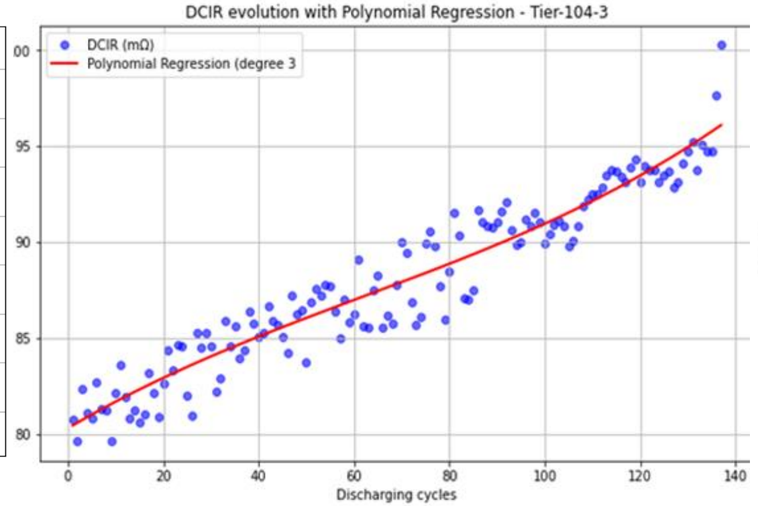
# Application to batteries: fault detection models

## State of Charge (SoC):

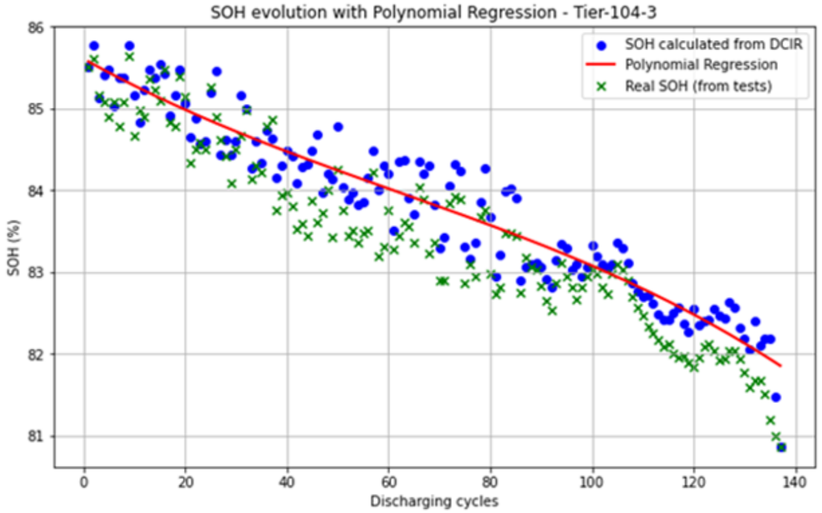
- Coulomb Counting method
- Dual Adapted Extended Kalman Filter




## Internal Resistance (R0)




## State of Health (SoH)

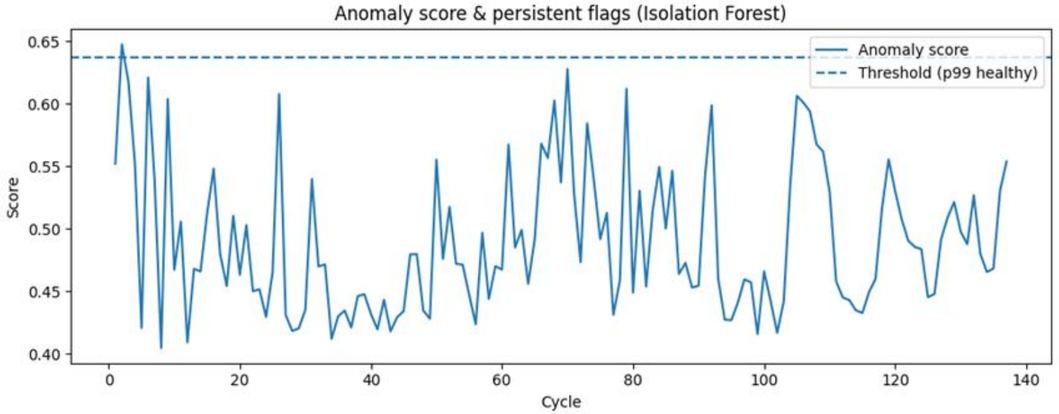


# Application to batteries: health estimation

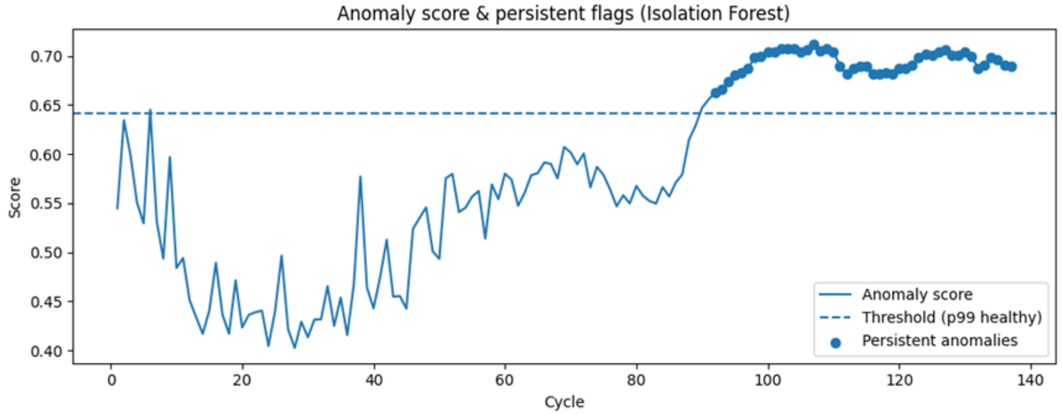
## Key Analysis Steps:

1. Residuals are calculated as differences between measured and predicted DCIR/SOH.
2. Rolling features (mean, std, slope) capture short-term behavior.
3. An Isolation Forest detects abnormal behavior based on deviations and trends.
4. A Health Index (HI) is derived from the anomaly score to quantify degradation.
5. An exponential model predicts the cycle where SOH drops below 80%, defining the estimated end of life.

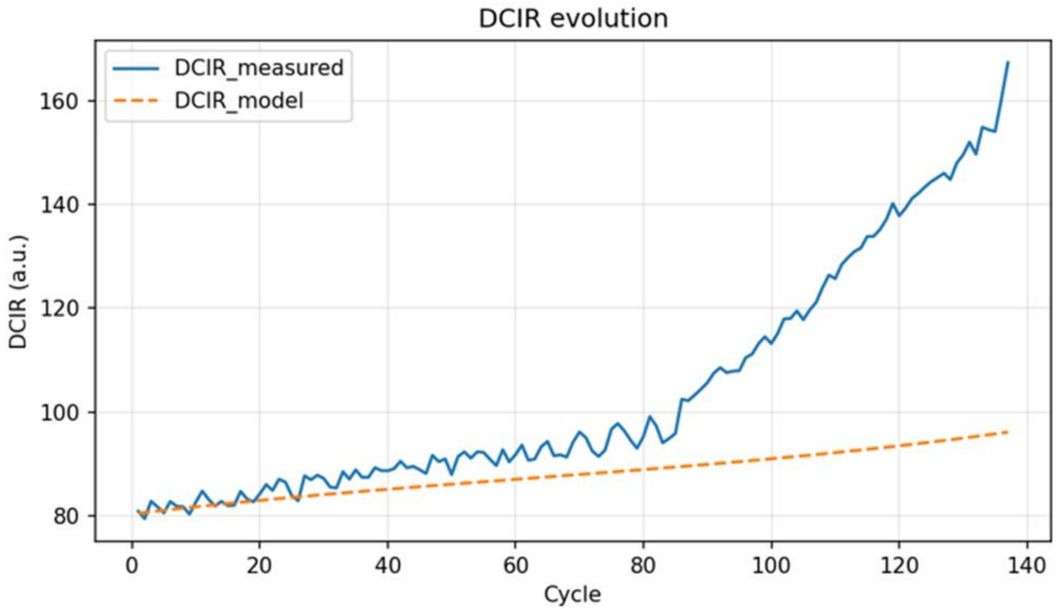
### Minimal battery degradation

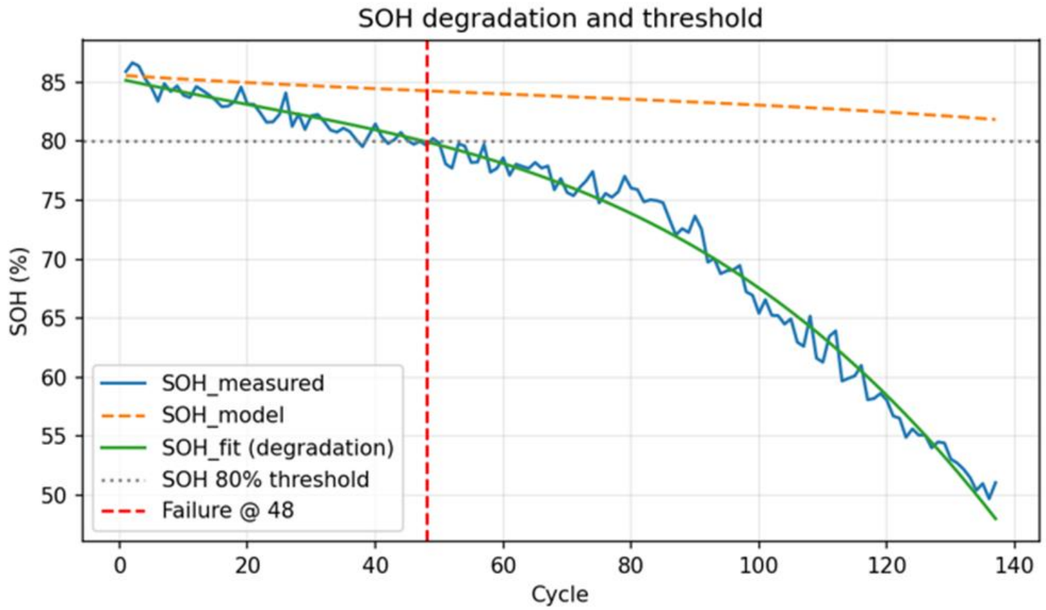



### Battery degradation (simulated data)



# Application to batteries: health estimation



Marian Gallego (CARTIF)

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**Antonio LaTorre**
Professor at the Universidad Politecnica de Madrid (UPM)

POLITÉCNICA

# ZEBAI: Evolutionary Algorithms for the design of Zero-Emission & cost-effective Buildings

Antonio LaTorre
Universidad Politécnica de Madrid

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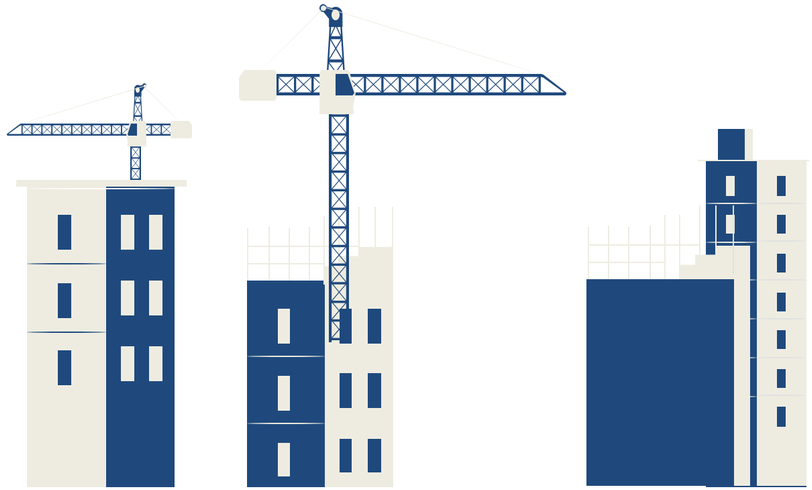
# Context and rationale of the ZEBAI Project

**25 %**

Of global CO2 emission are caused by construction industry



**2050**

Climate neutrality goal

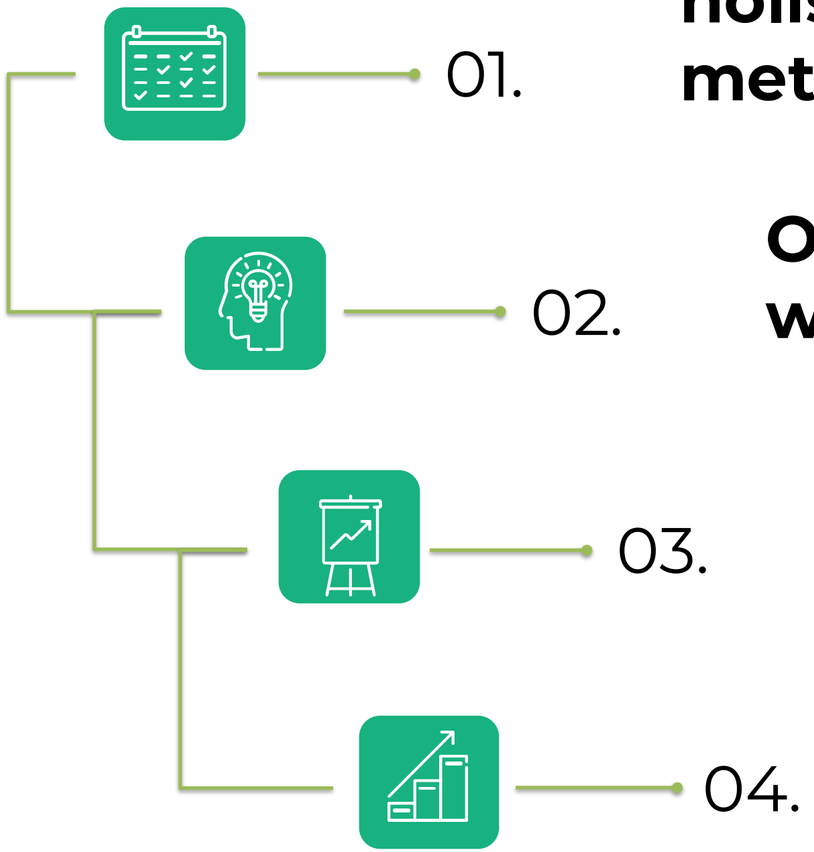
## Challenge

Current progress is too slow, most buildings aren't designed for efficiency, and focusing solely on one aspect (e.g. energy use) isn't enough.

## Solution

The key lies in multi-faceted approach that considers various aspects simultaneously. Effective solutions require collaboration among different stakeholders, recognising that isolated strategies won’t achieve lasting results.

# ZEBAI Project : key objectives



01. **Novel holistic methodology**

ZEBAI aims to develop a holistic methodology integrating several analyses and decision-making processes for building design, encompassing energy performance, environmental impact, indoor environmental quality, and cost-effectiveness.

02. **Optimisation with EAs**

Use Eas to optimise material selection, active and passive systems, making design faster, easier and more ecofriendly.

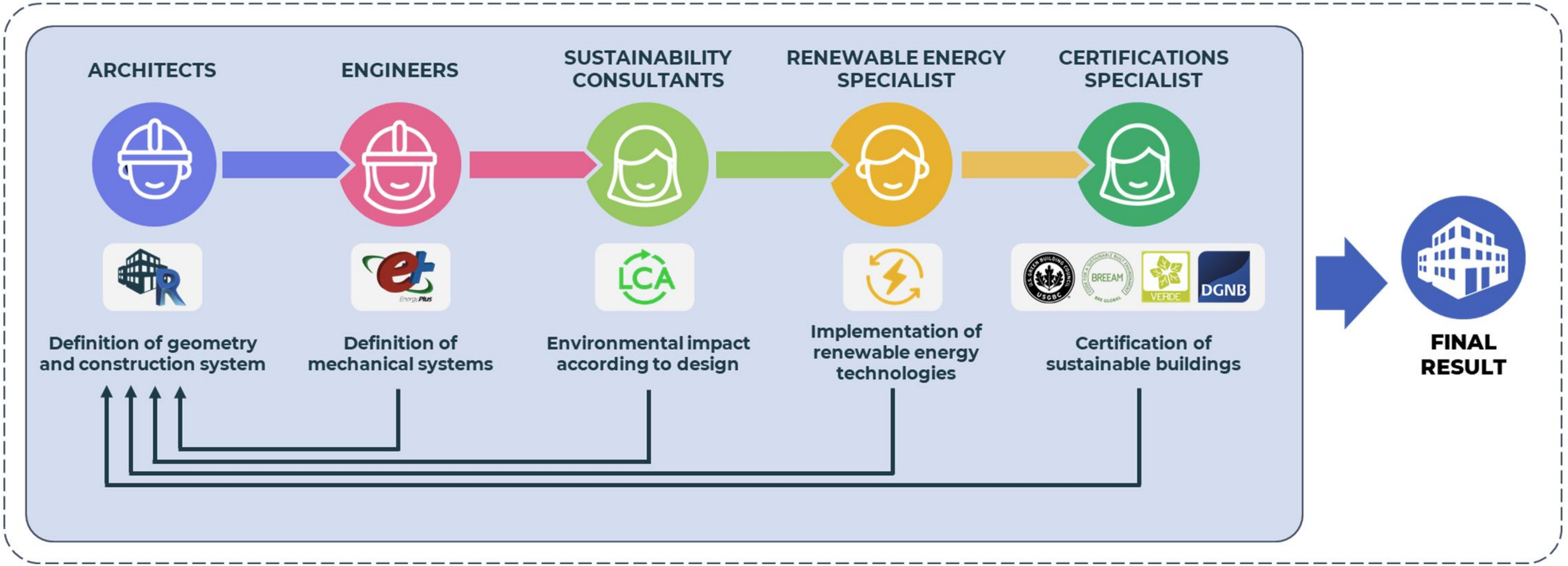
03. **Materials database**

ZEBAI will build a database of well-defined material and assess performances gaps to improve design accuracy.

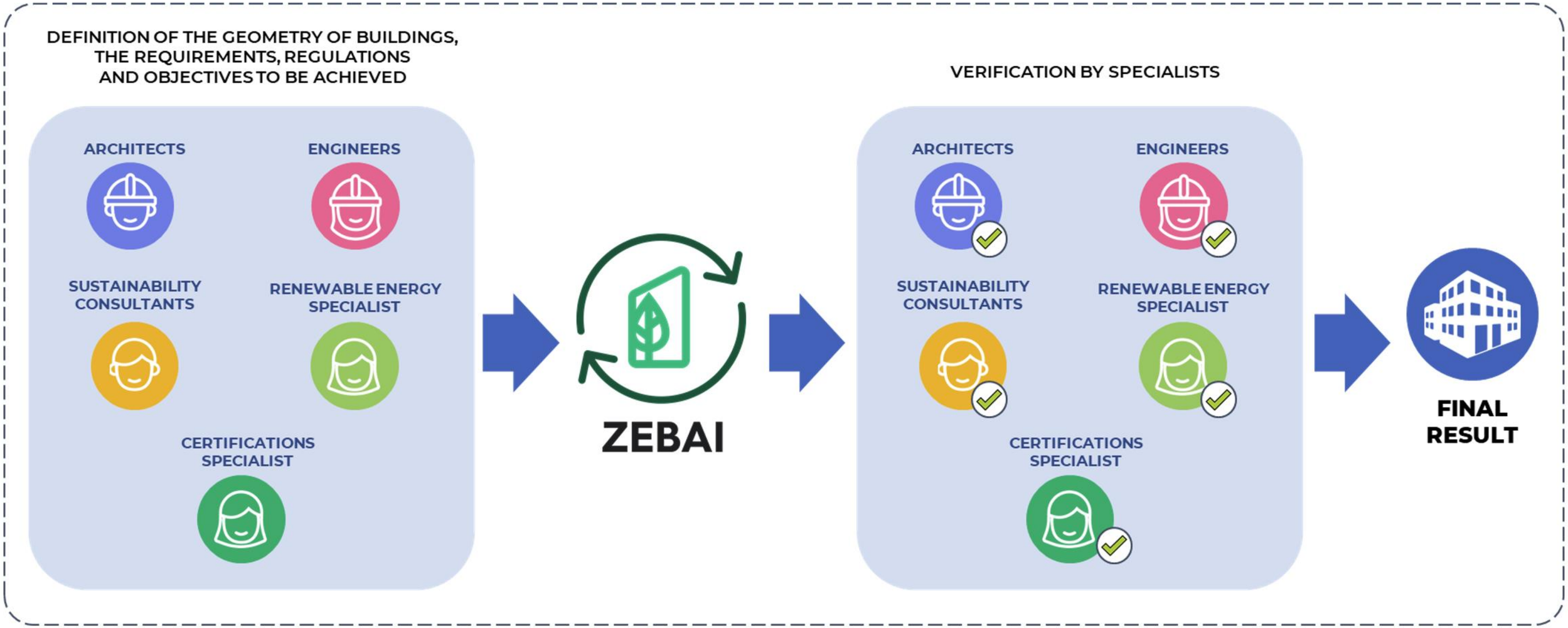
04. **Scalable zero energy buildings**

ZEBAI strives to optimise new architectural designs for scalable Zero Energy Buildings (ZEBs). These designs will be applicable across diverse climates, usages, and building patterns.

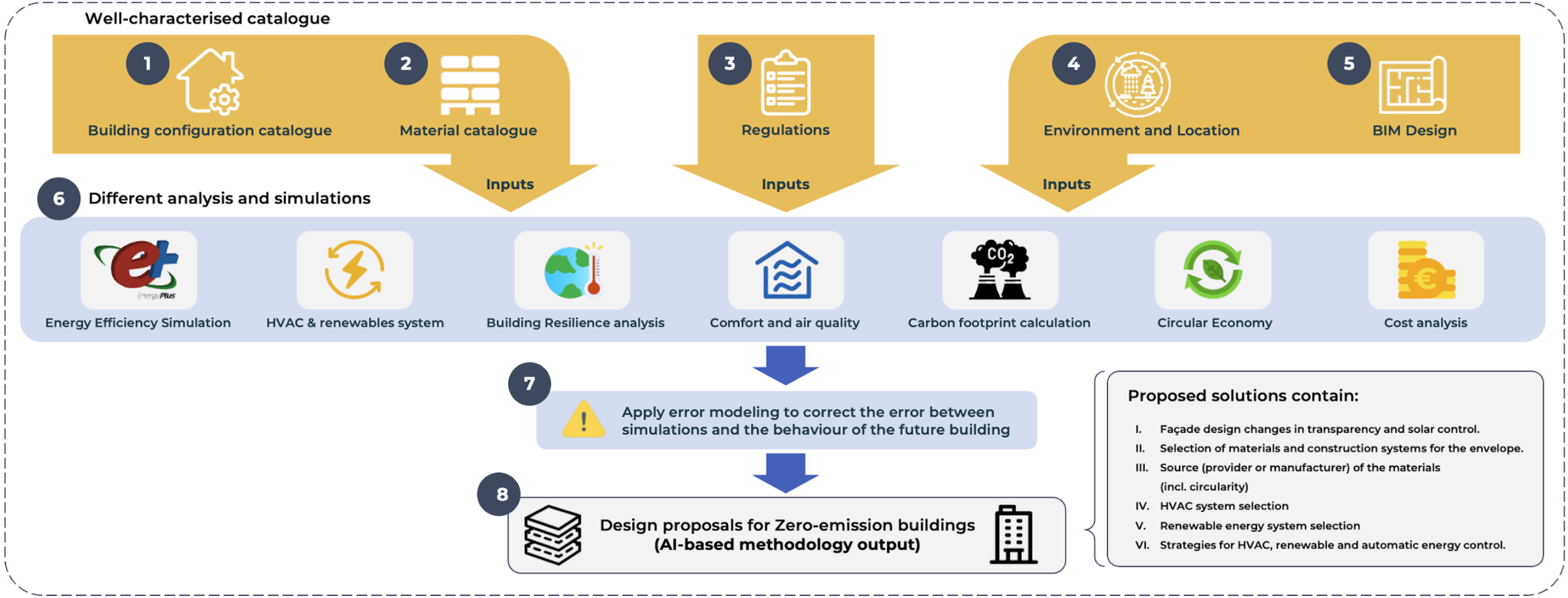
# Current design process of ZEBs



# ZEBAI Methodology



# Summary


Well-characterised catalogue
1
Building configuration catalogue
2
Material catalogue
3
Regulations
4
Environment and Location
5
BIM Design
Inputs
Inputs
Inputs
6
Different analysis and simulations
Energy Efficiency Simulation
HVAC & renewables system
Building Resilience analysis
Comfort and air quality
Carbon footprint calculation
Circular Economy
Cost analysis
7
Apply error modeling to correct the error between simulations and the behaviour of the future building
8
Design proposals for Zero-emission buildings
(AI-based methodology output)
Proposed solutions contain:
I. Façade design changes in transparency and solar control.
II. Selection of materials and construction systems for the envelope.
III. Source (provider or manufacturer) of the materials (incl. circularity)
IV. HVAC system selection
V. Renewable energy system selection
VI. Strategies for HVAC, renewable and automatic energy control.

# Thank You

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# Building the future through Electrification and Digitalisation

## when AI-driven design meets electrification for zero-emission buildings

meta build

ZEBAI



**26 November 2025**
**10:00 - 11:30 CET**

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**Lorena Cruz**
Researcher and Project Manager at the Universidad Politecnica de Madrid (UPM)

UNIVERSIDAD POLITÉCNICA MADRID

POLITÉCNICA

# ZEBAI

Innovative methodologies for the design of Zero-Emission and cost-effective Buildings enhanced by Artificial Intelligence

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# Context



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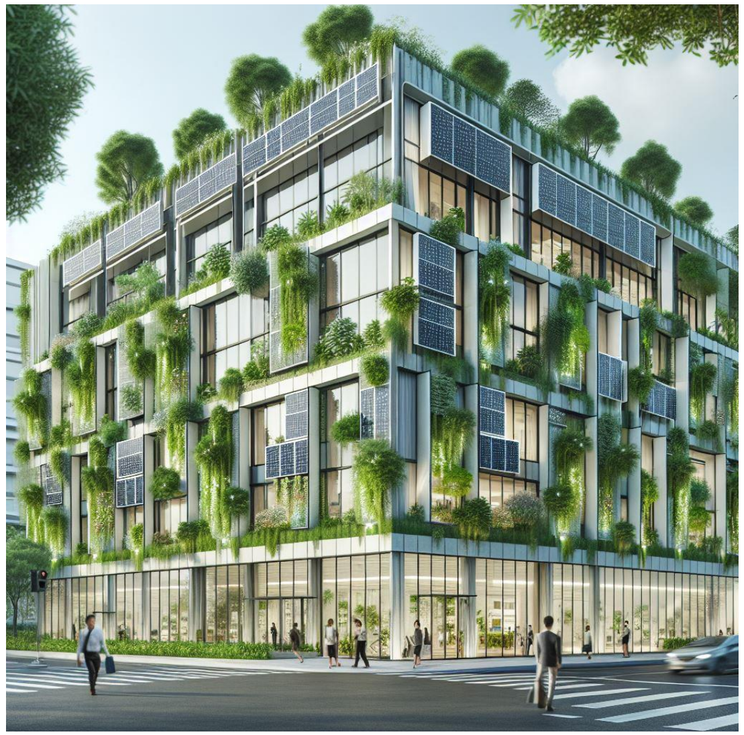
# Let’s explore some tools available on the market.



- For energy performance:
  - Energy plus
  - Design Builder
  - OpenStudio
- For LCA
  - OnceClick LCA
- For Cost:
  - Presto
  - Cype

**It’s difficult to find a tool that integrate all the analyses!**



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# Workflow steps



1. Model the building
2. Specify active/passive elements of the building
    a) Select materials for each constructive system
    b) Assign Window sizes
    c) Model the HVAC system
    d) Model the renewable system
    e) …
3. Run the simulation
4. Analyse the results



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**What if you want to find a better solution?**



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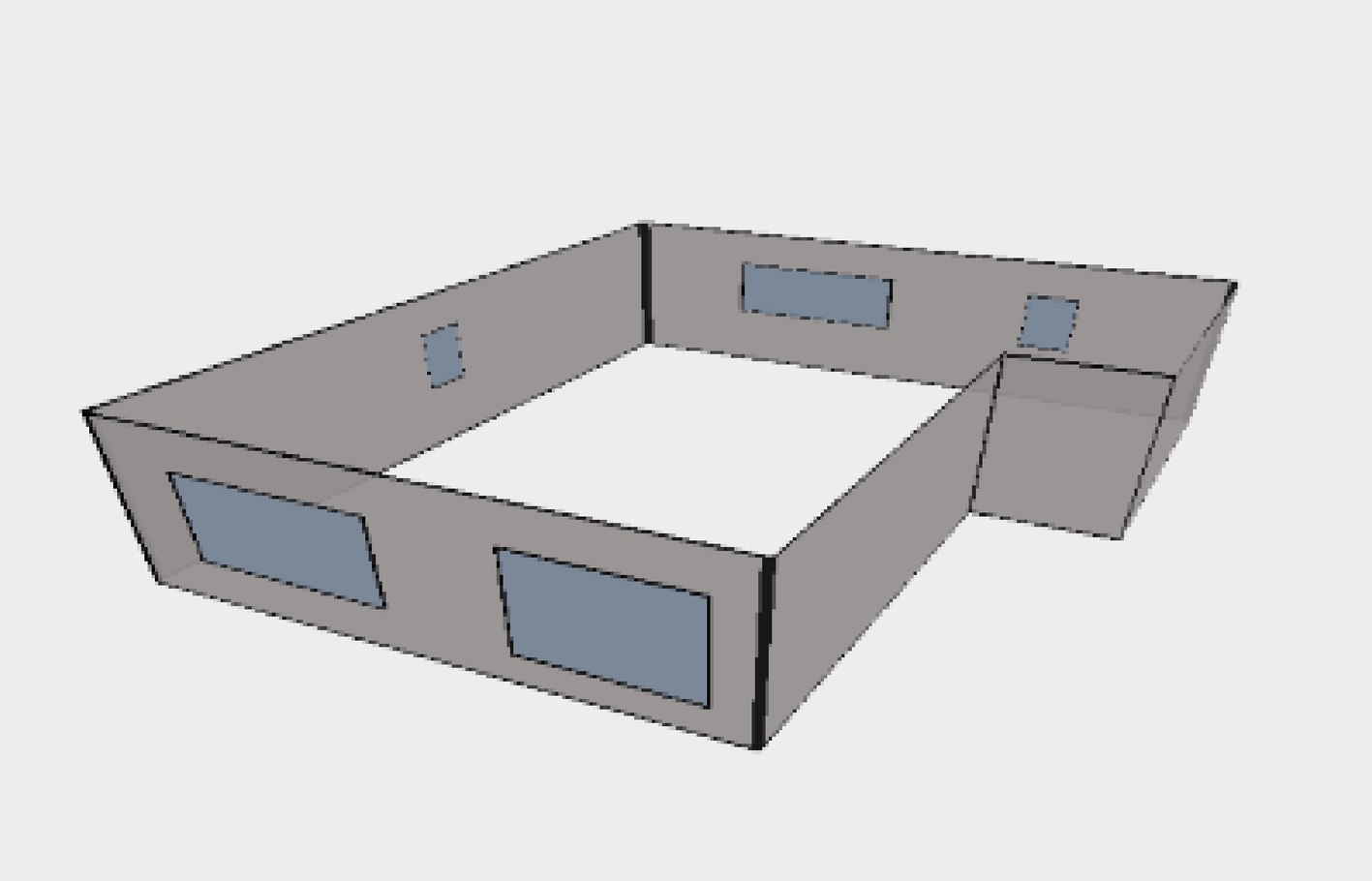



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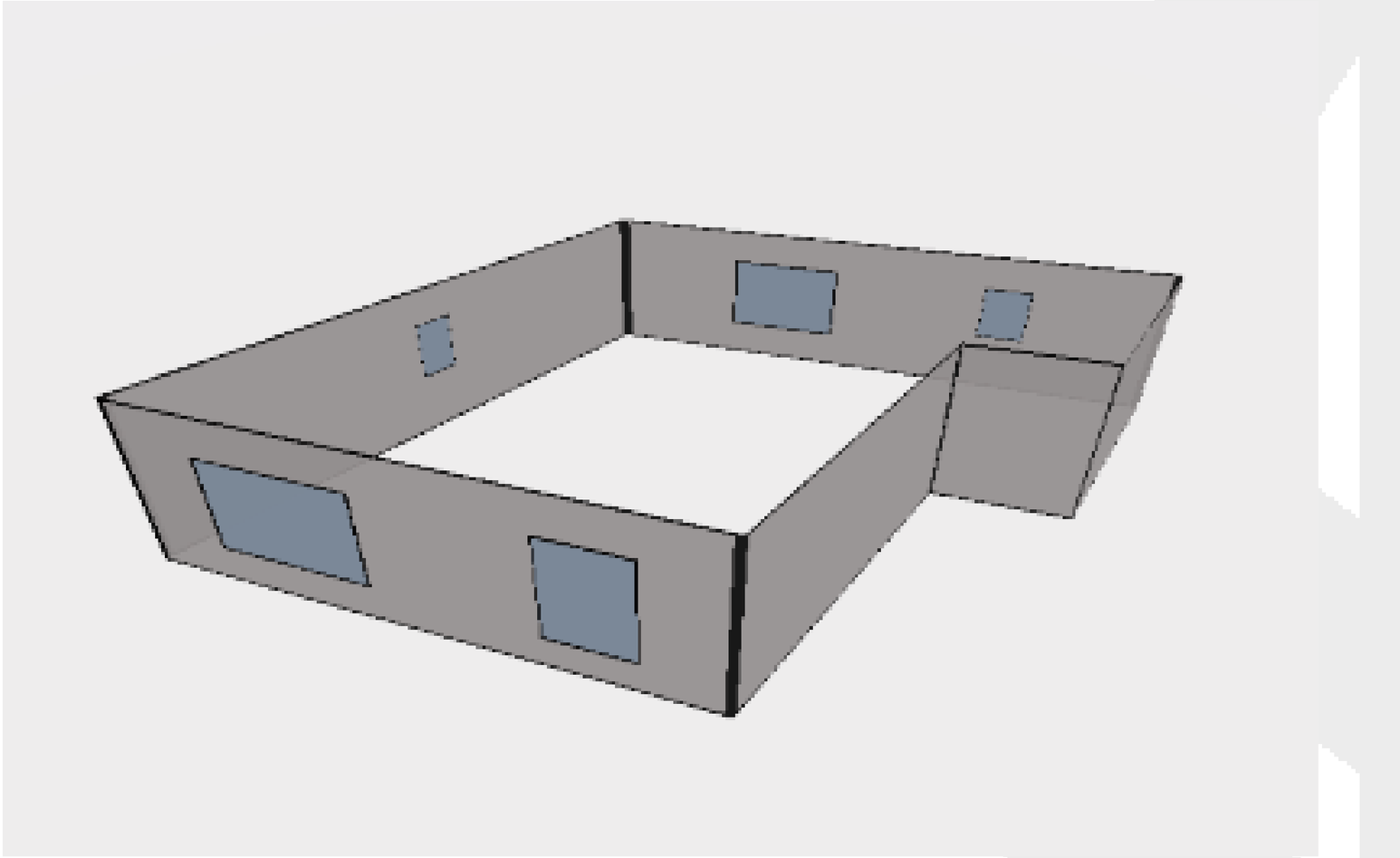
the European Union





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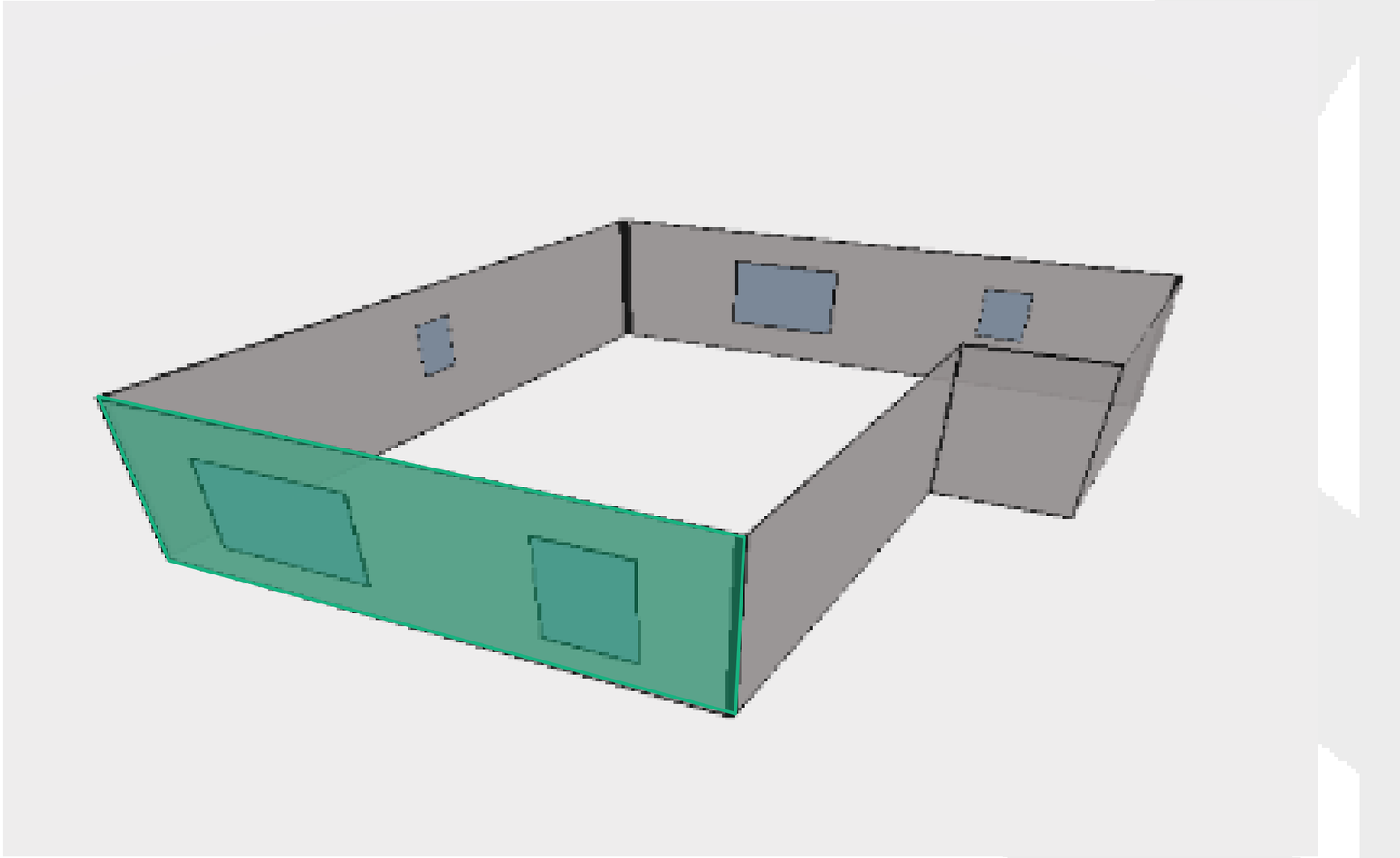
# Why ZEBAI tool?





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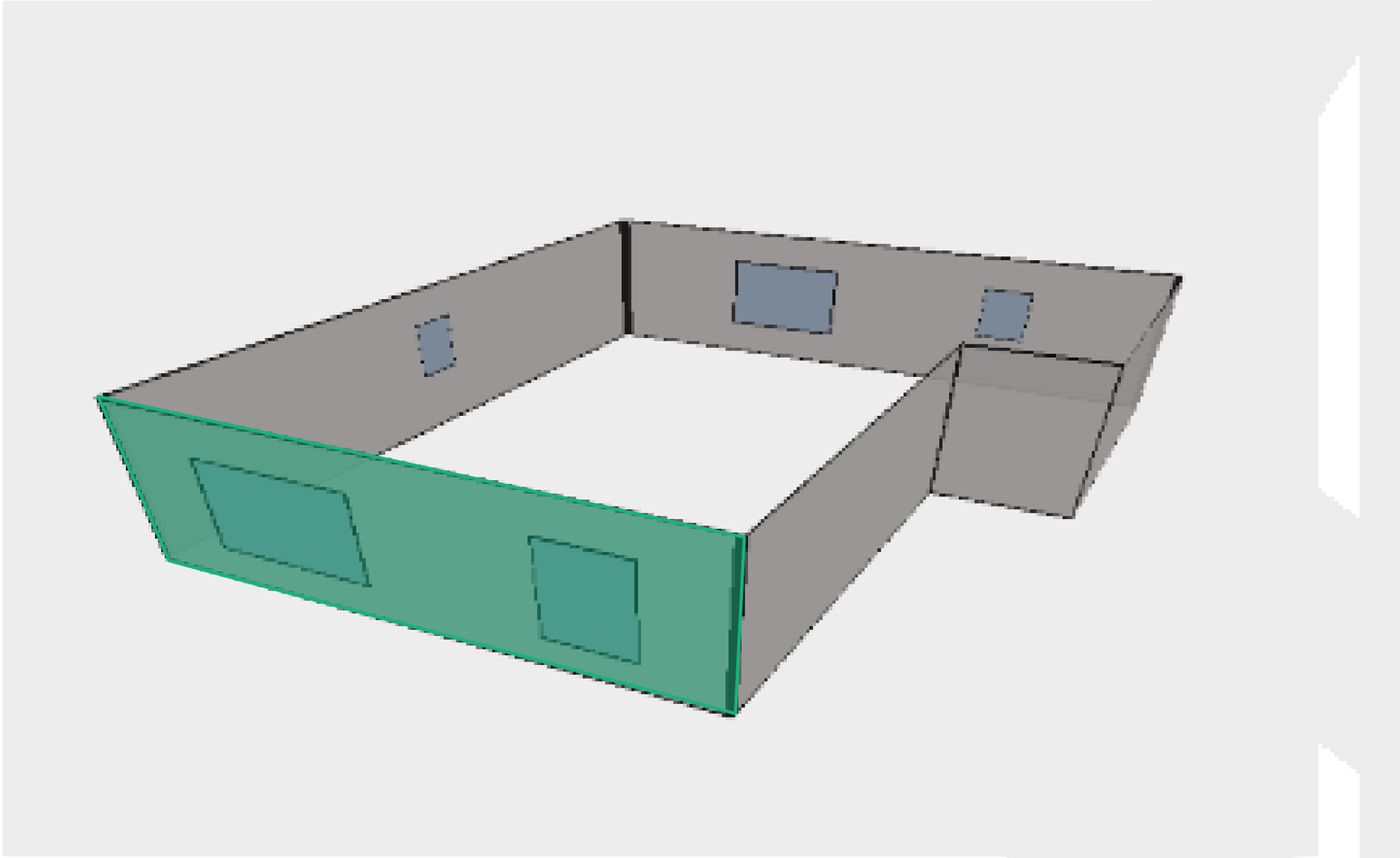

This is a long trial-and-error process!



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# What is the aim of the ZEBAI tool?

1. Model the building
2. Specify active/passive elements of the building
    a) Select materials for each constructive system
    b) Assign window sizes
    c) Model the HVAC system
    d) Model the renewable system
    e) …
3. Run the simulation
4. Analyse the results



**The goal is to make <u>this process</u> faster and automatically**



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# Why ZEBAI tool?



- Generate and evaluate multiple alternatives automatically.
- Consider the most important objectives (cost, energy, sustainability, comfort…)
- Find the best solutions.



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# DEMO



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the European Union

# Project List

+ NEW PROJECT

| Edition Date | Name | Creation Date | BIM File |
|---|---|---|---|
| 08-08-2025 | client-app-buildings 1.json | 08-08-2025 | |
| 10-10-2025 | client-app-buildings-selection 1.json | 10-10-2025 | |
| 08-08-2025 | client-app-buildings.sevilla.json | 08-08-2025 | |
| 10-10-2025 | Sevilla | 10-10-2025 | |
| 25-11-2025 | Test 1 | 25-11-2025 | |

Development Build

ÚLTIMA HORA
Cuatro muertos...
Buscar
17:39
25/11/2025

# Thank You

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**Martjan den Hoed**
Architect, Director Information & Innovation at
GAF

Gortemaker Algra Feenstra

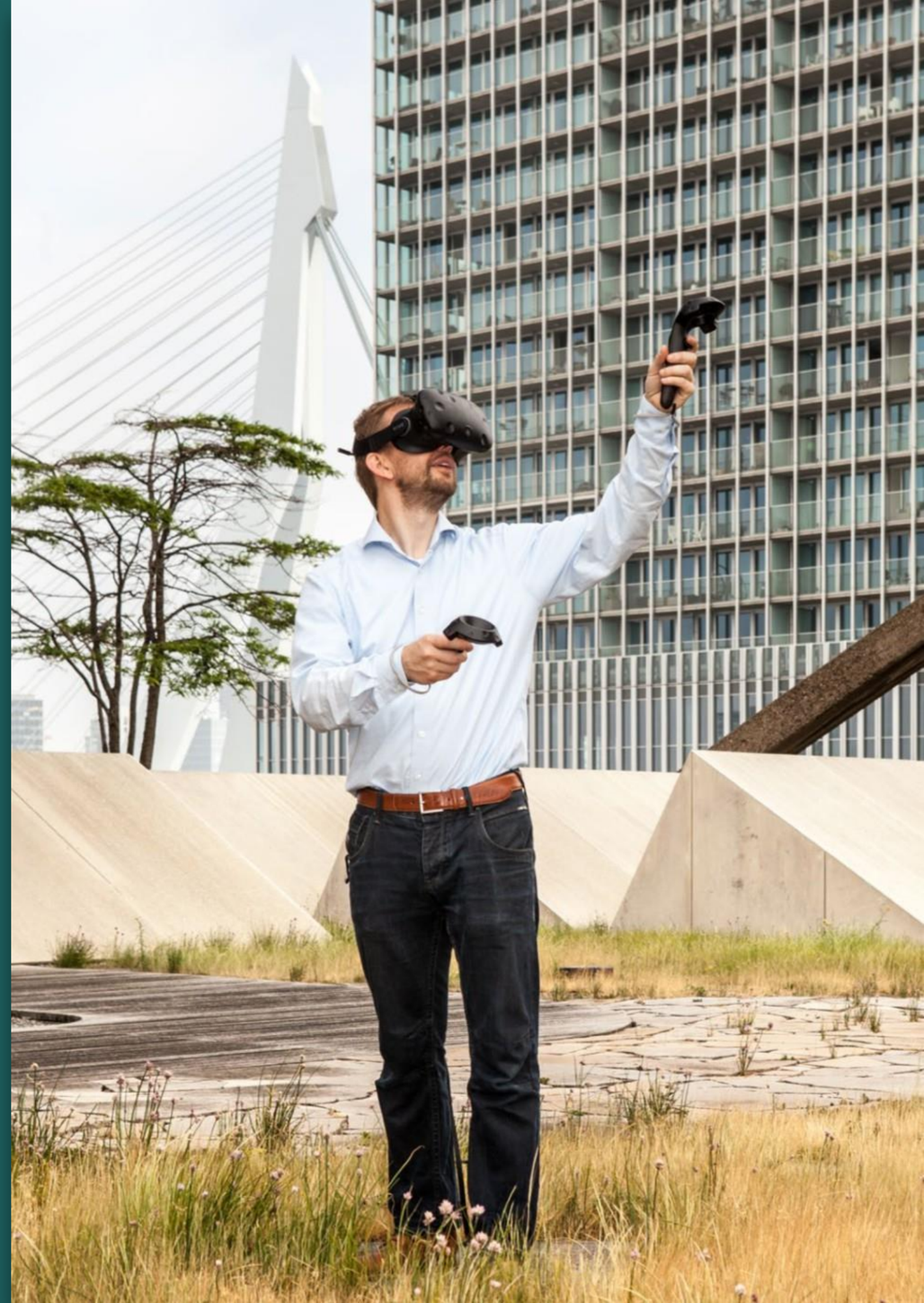
26 November
2025

# AI enhanced design process

meta build

Gortemaker
Algra
Feenstra

ZEBAI





# Martjan den Hoed

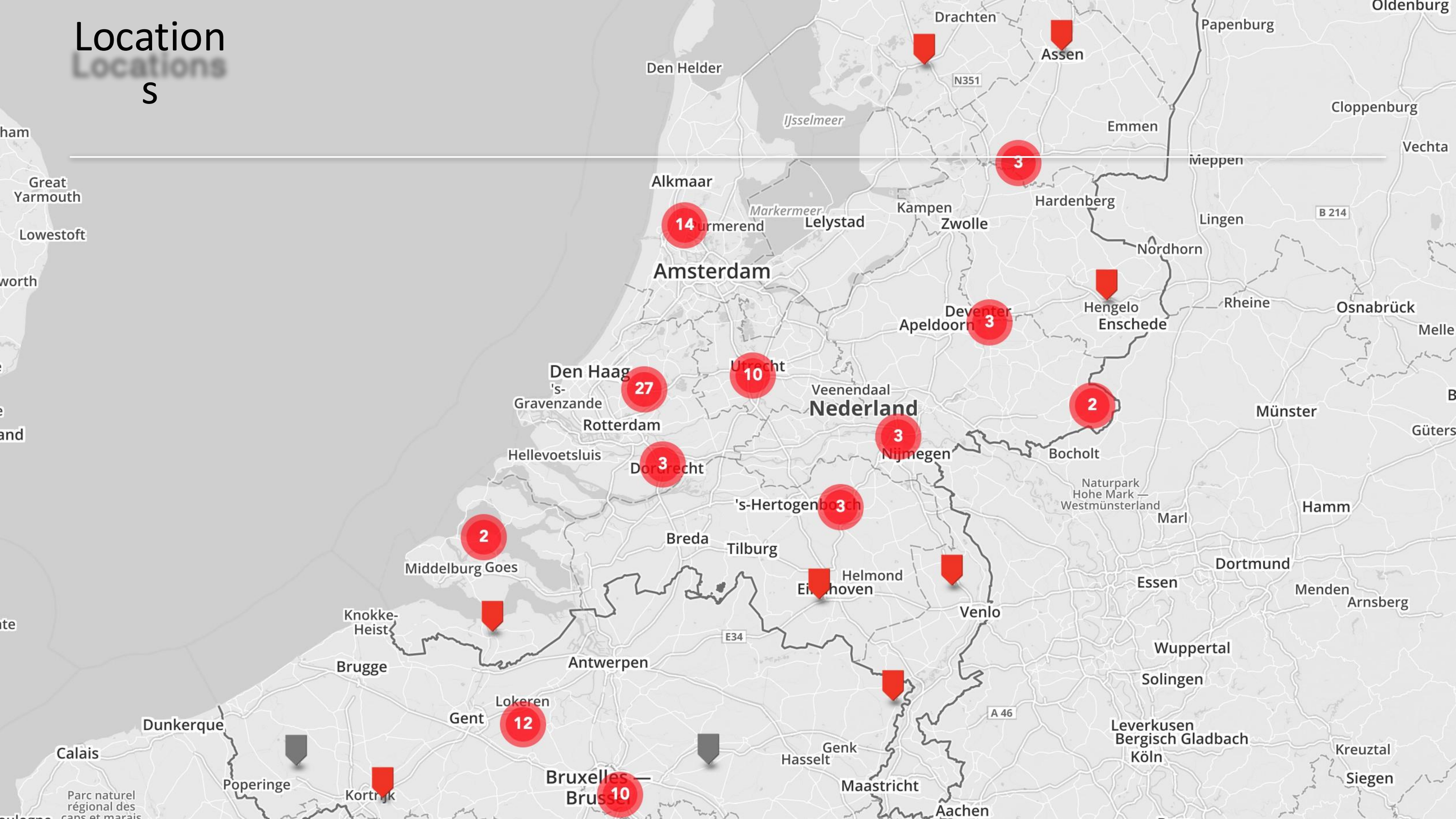
- Architect – MSc
- Director Innovation & Information

- Member of supervisory board Revit standards Member of board RevitGG
- married, father of 3

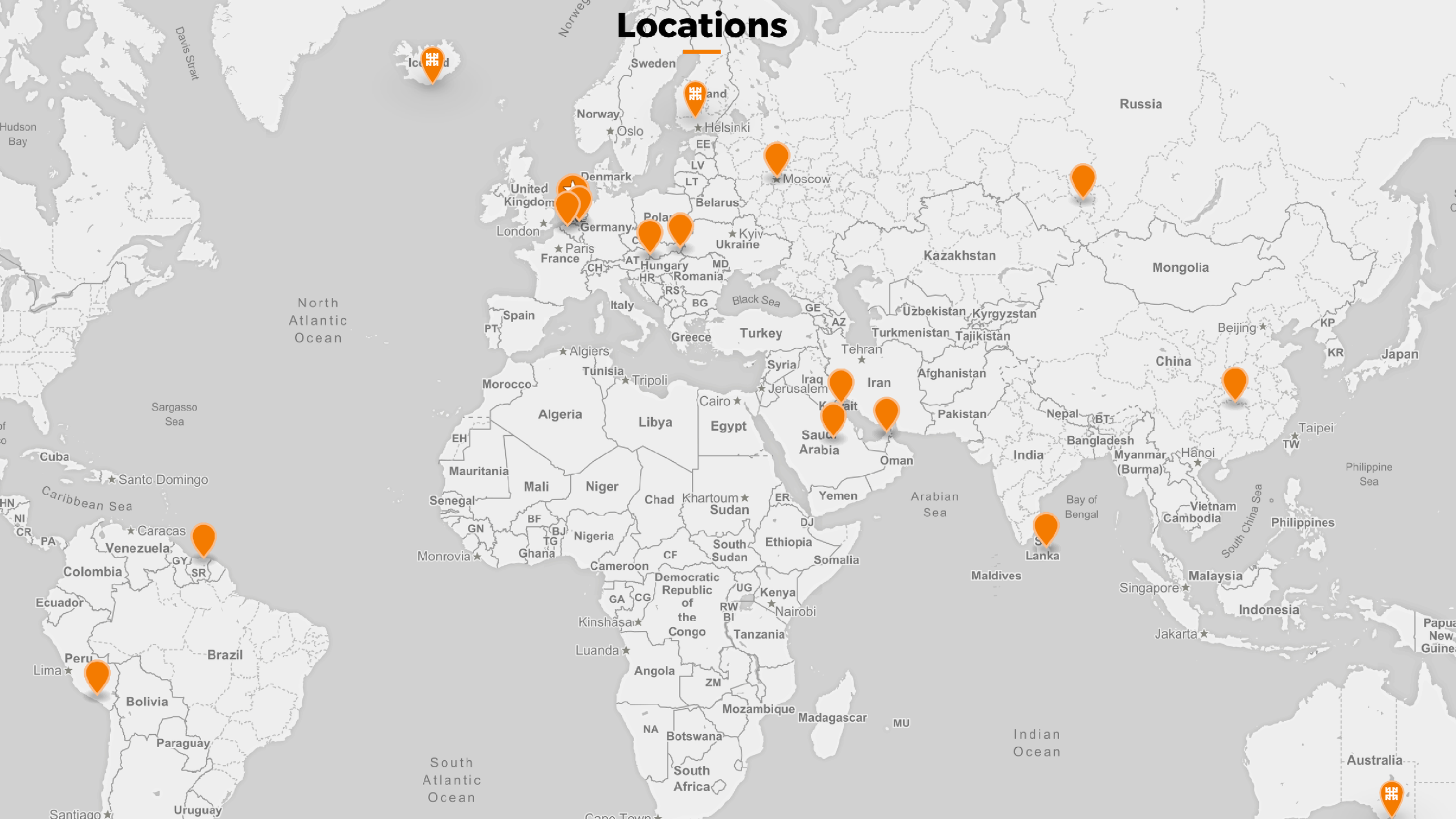
- Architecture
Development
Research

Gortemaker
Algra
Feenstra

# Location
Locations



# Locations


Davis Strait
Hudson Bay
North Atlantic Ocean
Sargasso Sea
Caribbean Sea
South Atlantic Ocean
Indian Ocean
Arabian Sea
Bay of Bengal
South China Sea
Philippine Sea
Sweden
Norway
Oslo
Helsinki
Russia
Moscow
Denmark
United Kingdom
London
Germany
Paris
France
Belarus
Kyiv
Ukraine
Poland
Hungary
Romania
Italy
Spain
Greece
Turkey
Black Sea
Kazakhstan
Uzbekistan
Kyrgyzstan
Turkmenistan
Tajikistan
Mongolia
Beijing
China
Japan
Taipei
Tehran
Iran
Iraq
Syria
Afghanistan
Pakistan
India
Nepal
Bangladesh
Myanmar (Burma)
Hanoi
Vietnam
Cambodia
Philippines
Malaysia
Singapore
Indonesia
Jakarta
Australia
Oman
Yemen
Saudi Arabia
Algeria
Libya
Egypt
Morocco
Tunisia
Algiers
Tripoli
Cairo
Jerusalem
Mauritania
Mali
Niger
Chad
Sudan
Khartoum
Nigeria
Ghana
Monrovia
Senegal
Cameroon
South Sudan
Ethiopia
Somalia
Kenya
Nairobi
Tanzania
Democratic Republic of the Congo
Kinshasa
Luanda
Angola
Zambia
Mozambique
Madagascar
Botswana
South Africa
Namibia
Cape Town
Maldives
Sri Lanka
Cuba
Santo Domingo
Caracas
Venezuela
Colombia
Ecuador
Peru
Lima
Brazil
Bolivia
Paraguay
Uruguay
Santiago

# Tea
# m





Holland Particle Therapy Centre


St. Antonius Ziekenhuis Utrecht


High Care


Ziekenhuis Bernhoven


Kindcentrum De Driehoek


Deventer Ziekenhuis


Verkeersleidingspost ProRail


SportResort Zilveren Schor


Sint-Aloysiuscollege


Parkeergarage St. Antonius Ziekenhuis Nieuwegein

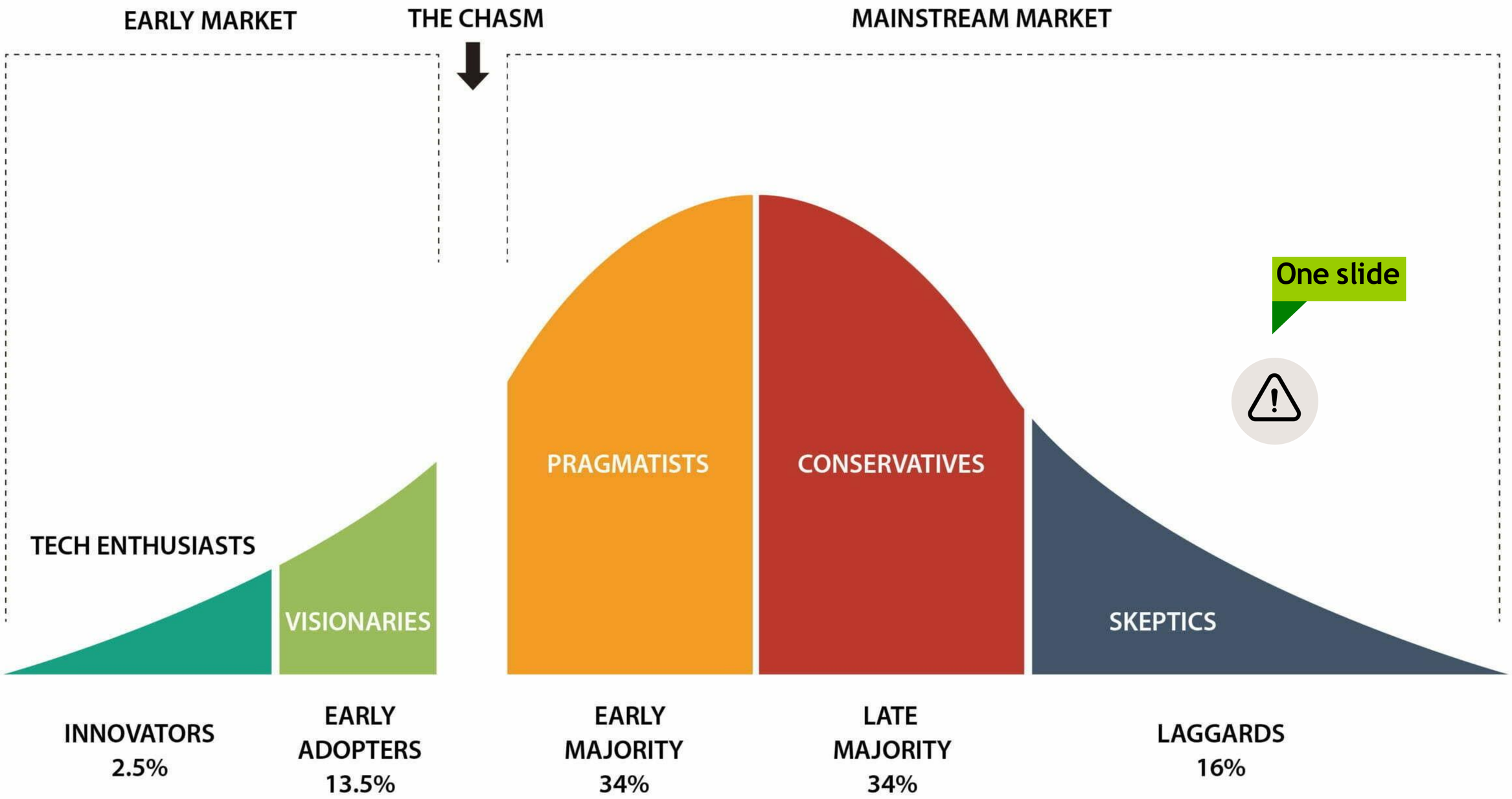

Algemeen Ziekenhuis Jan Portaels


Campusader UZ Gent

# Critical impacts of AI in Architecture




Gortemaker
Algra
Feenstra


EARLY MARKET
THE CHASM
MAINSTREAM MARKET
One slide
TECH ENTHUSIASTS
VISIONARIES
PRAGMATISTS
CONSERVATIVES
SKEPTICS
INNOVATORS
2.5%
EARLY
ADOPTERS
13.5%
EARLY
MAJORITY
34%
LATE
MAJORITY
34%
LAGGARDS
16%

# Critical Impacts of AI in Architecture



## Creativity & Standardization

Over-reliance on AI can lead to standardized designs, reducing creative freedom and design identity.

## Privacy & Data Bias

AI needs vast, often sensitive data, raising privacy risks and potential biases that may affect inclusivity.

## Job Shifts

Automation of basic tasks may limit entry-level opportunities, pushing architects toward data and software skills over traditional design.

## Environmental Costs

AI’s energy-intensive processing conflicts with sustainability goals in architecture.

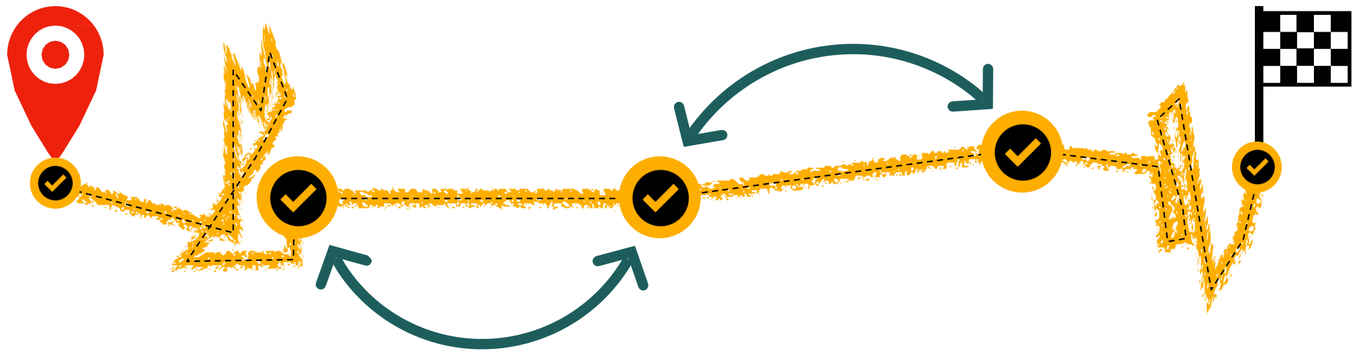
## Human-Centric Design Risks

AI lacks empathy, potentially overlooking user comfort and unique needs—crucial in healthcare projects.

## Ethical & Legal Issues

AI complicates accountability in design errors and raises ethical questions about decision-making in sensitive environments.

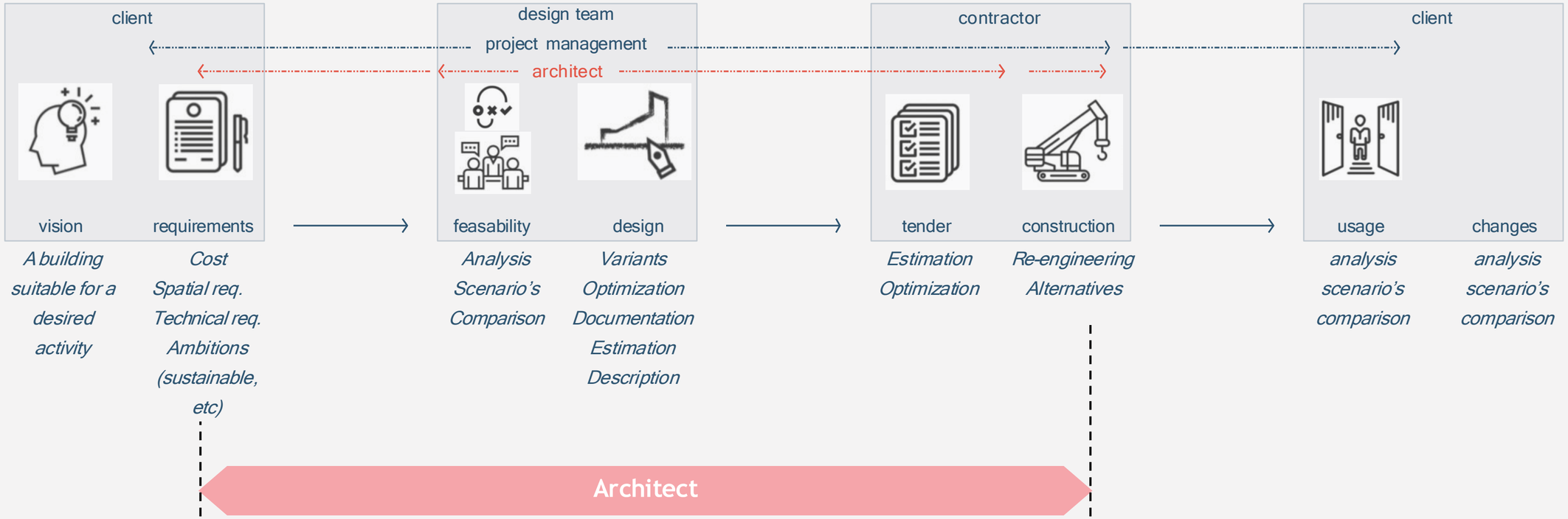
# AI enhanced design process



A car cannot (yet) perform a 100% autonomous drive,
but it can handle parts of the route.

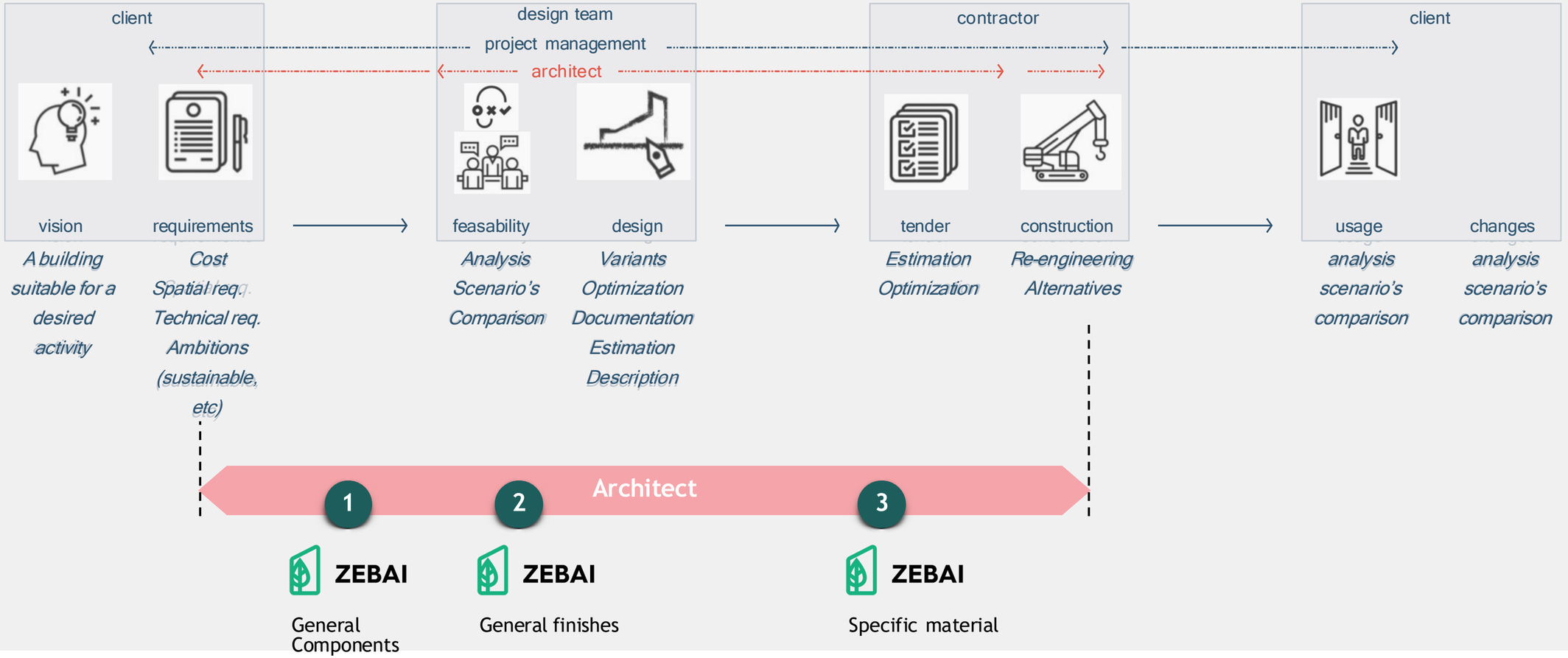
# Design phases

> rough steps: from an idea to a building



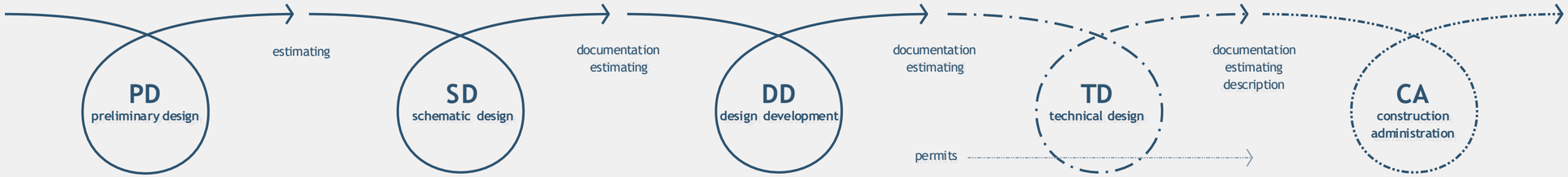
# Design phases

> rough steps: from an idea to a building



# Design phases

> Different phases within the design process

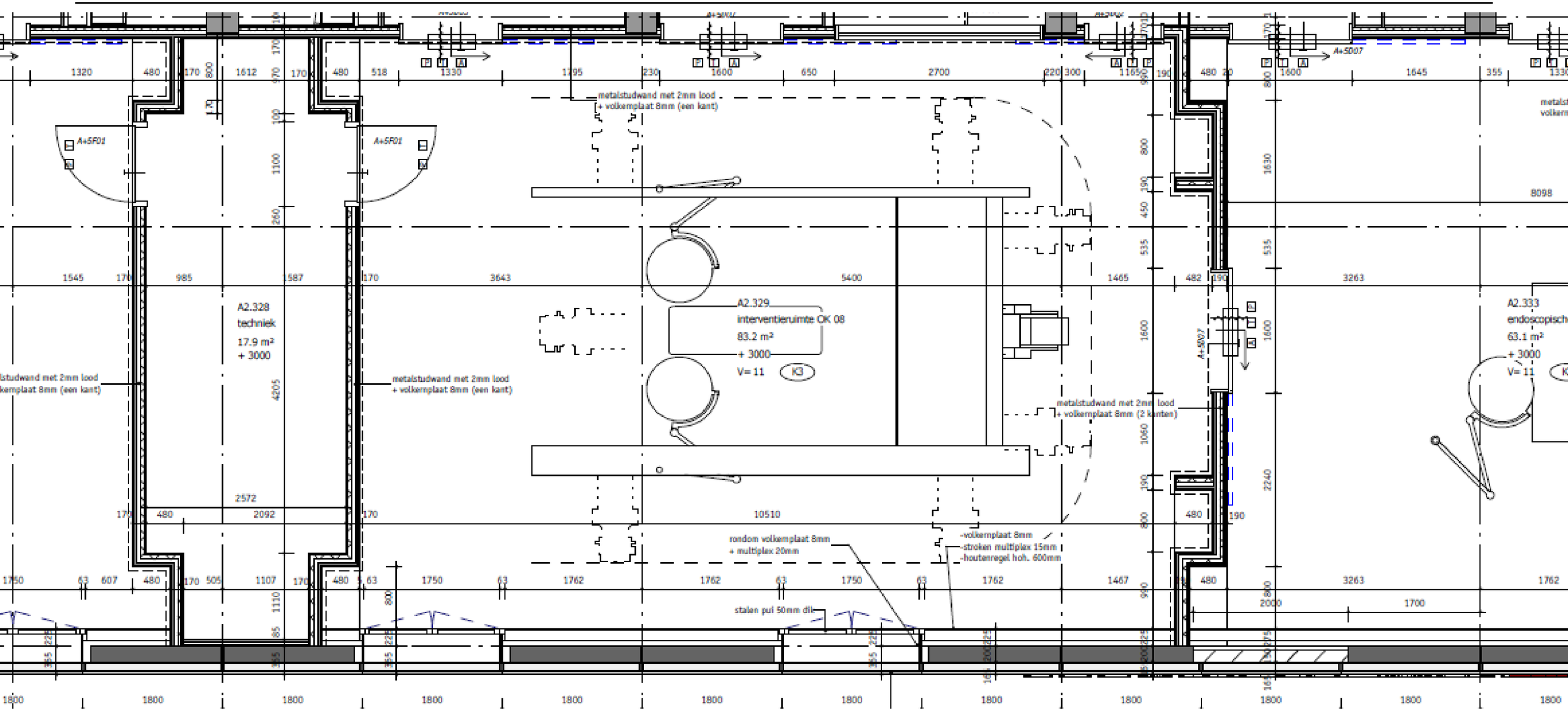



| PD | SD | DD | TD | CA |
|---|---|---|---|---|
| *Massing studies*<br>*Location / orientation*<br>+<br>***Building methodology***<br>+<br>*Spatial relations between the main components* | *spatial relationships within the main components*<br>+<br>***Typicals design solutions***<br>+<br>***rough materialisation (typology)*** 1 | *Detailed layouts*<br>+<br>***Product selection***<br>+<br>***materialisation (color, property)*** 2 | *Focus on detailed product specific sollutions*<br>+<br>***materialisation (product, finish)*** 3 | *Updating design BIM to an As-Built BIM*<br>***(actual products)*** |
| ZEBAI level of detail > | *stone/ceramic/wood* | *blue stone (granite/marble)* | *azul aran granite glossy* | *blue bahia granite* |

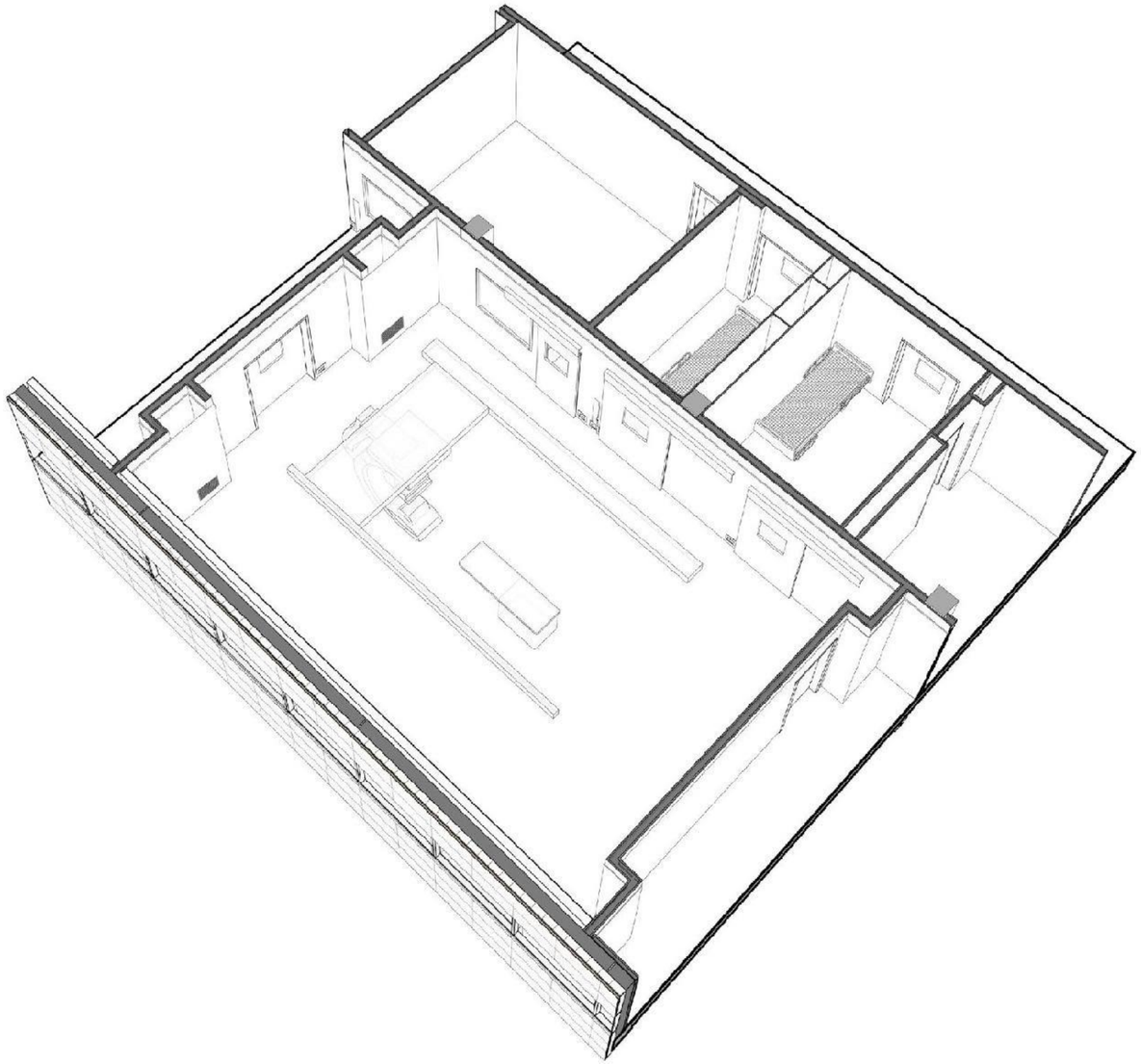
# End user meetings



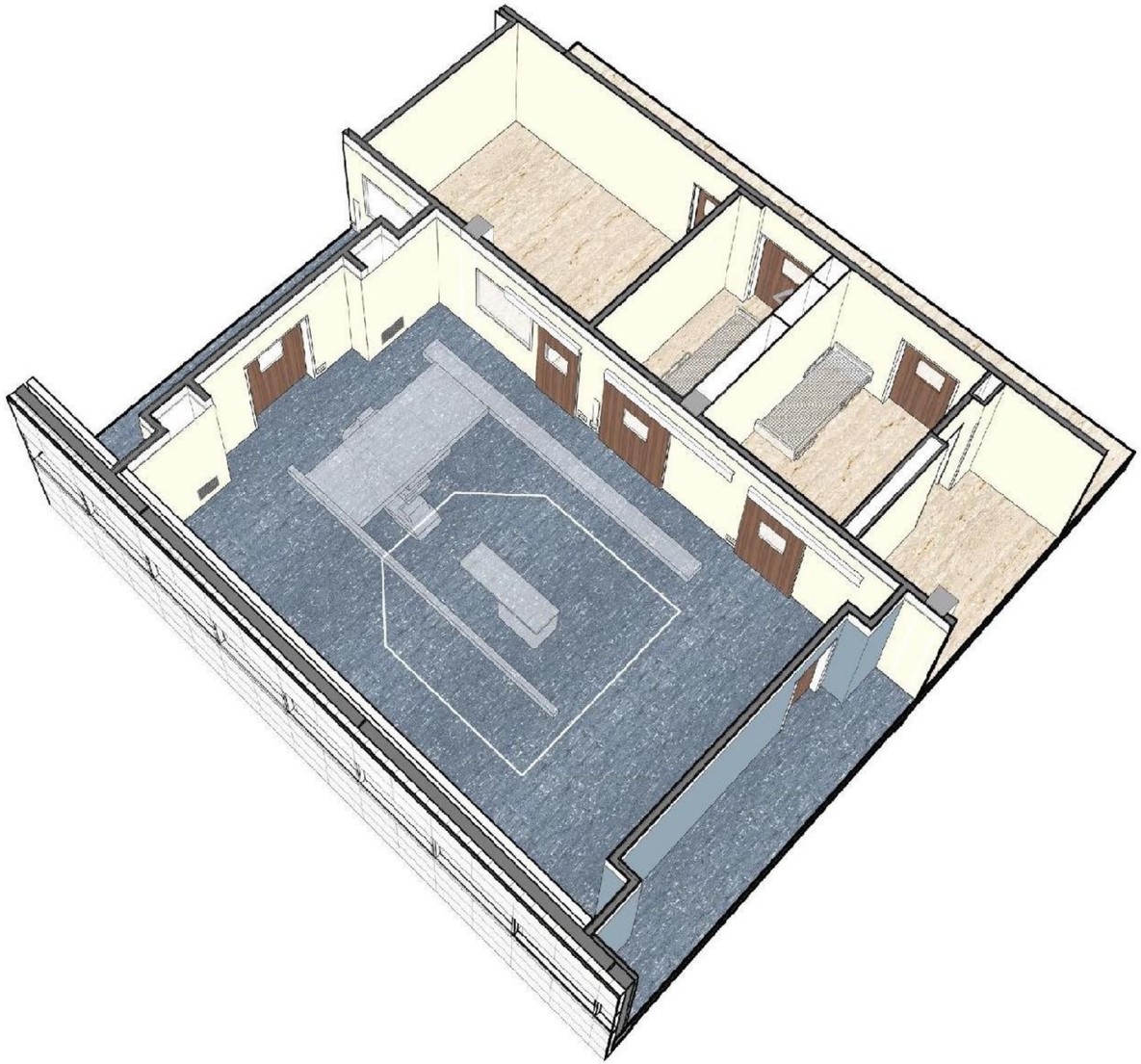
# Workflow - BIM to experience



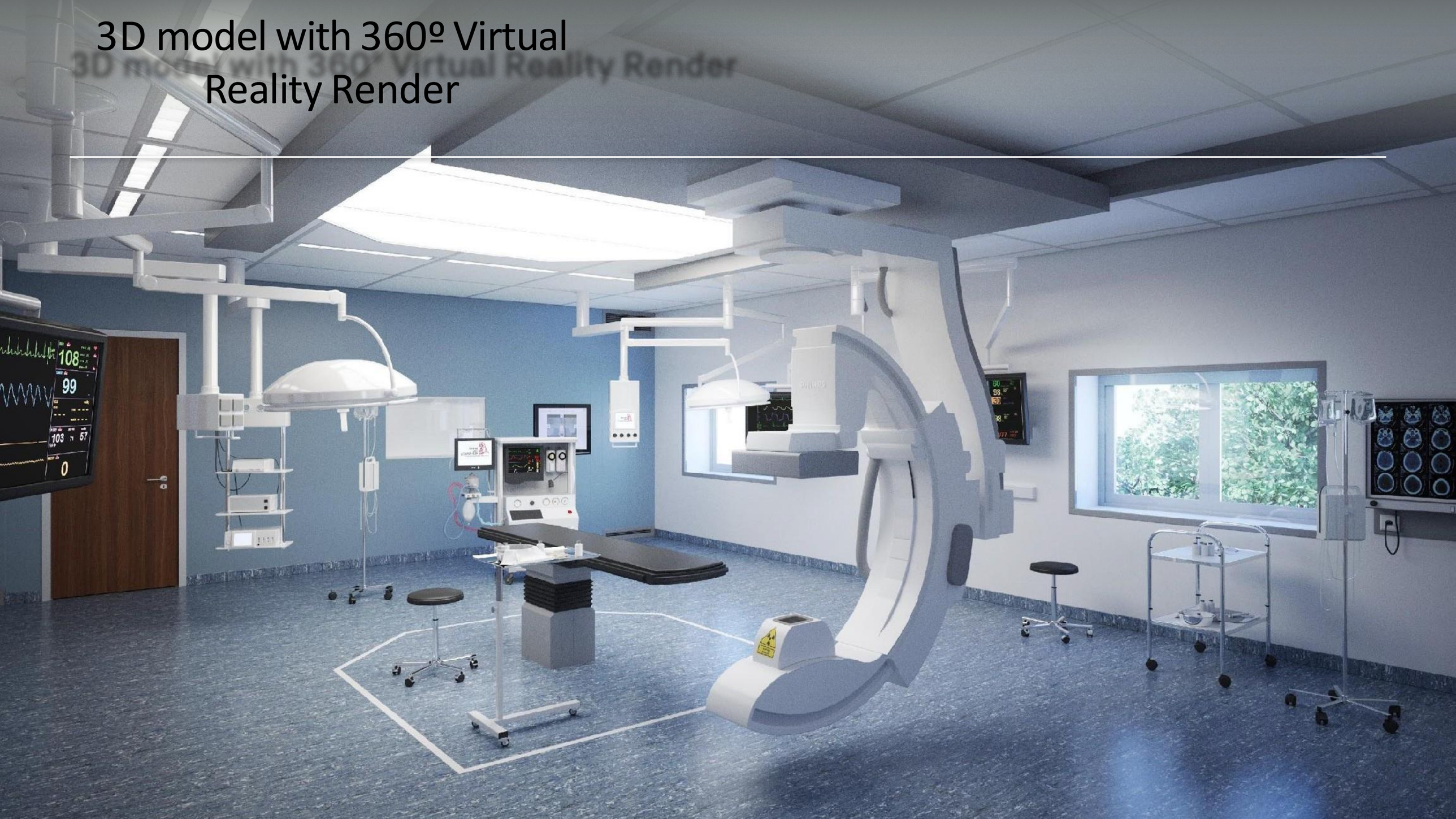
# 3D model



# 3D model with materials



# 3D model with 360º Virtual Reality Render

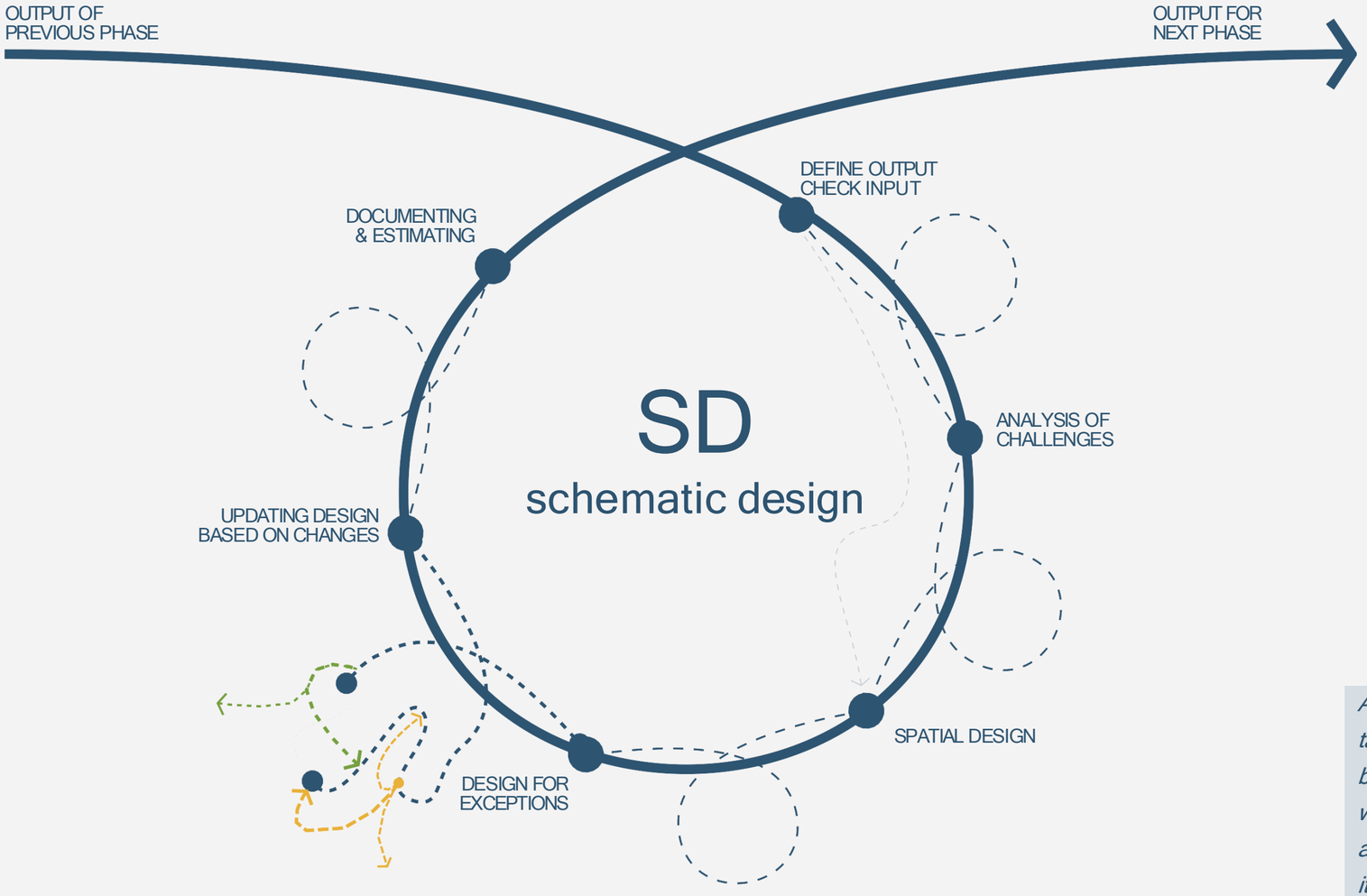


# VR with stakeholders



# The design process

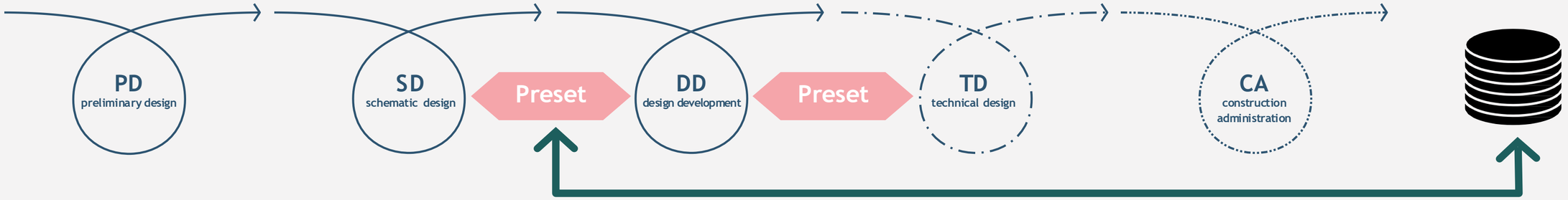
> A collection of various subprocesses



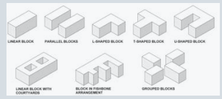

*A typical design phase takes 3 months and has biweekly meetings in which design questions are answered in an often iterative and non-lineair process*

# ZEBAI tool implementation

> Which possibilities are there per design phase




*Assist in the choice for:*
- *Building typology incl. span/grid*





*concrete / steel / wood & cores / walls / columns*

*Assist in the choice for:*
- *Facade typology*
- *Other material typologies*



*curtain wall / panel vs Masonry*

*Assist in the choice for:*
- *Facade design (open/close/shading)*
- *Better material types and colors/finishes*



*Curtain wall vs white vs black roofing*

*Assist in the choice for:*
- *Better products to use as reference in description*



*concrete column vs CLT walls*

*Assessing changes:*
- *Proposed changes*
- *Design vs constructed*

*concrete column vs CLT walls*

**ZEBAI** can help set the criteria for the next phase

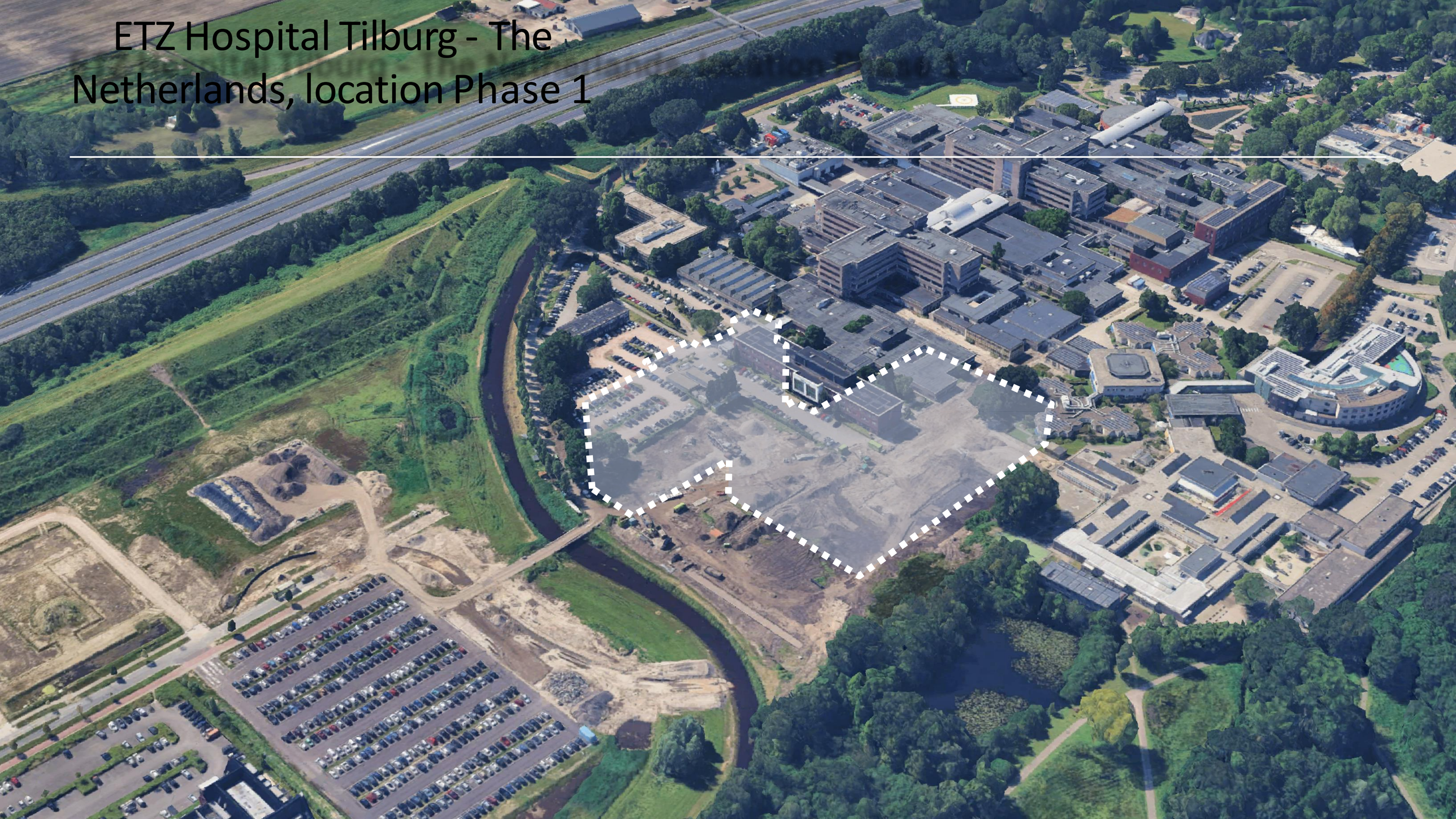
# Our ZEBAI Use Case

Gortemaker
Algra
Feenstra

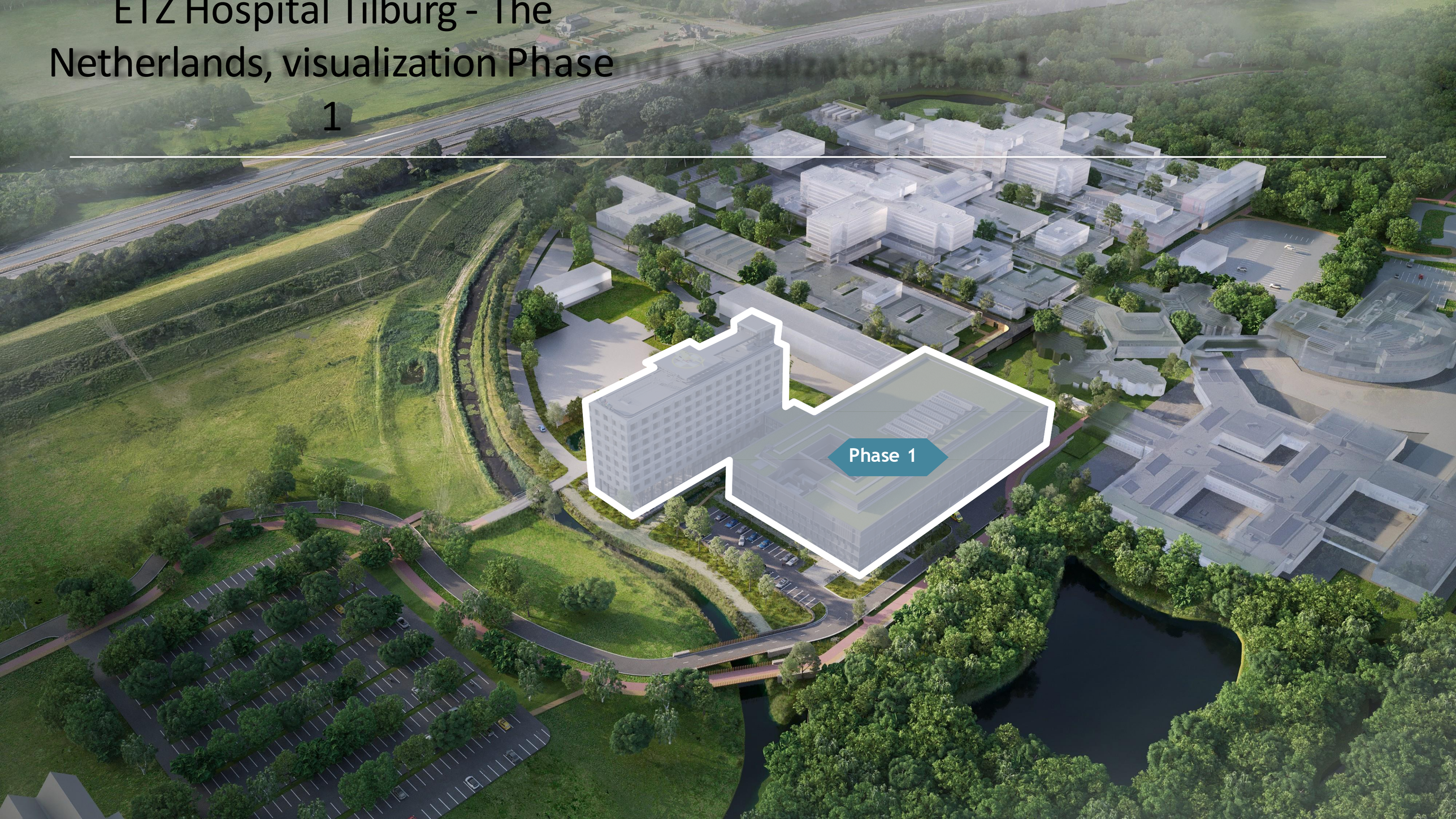
# ETZ Hospital Tilburg - The Netherlands



# ETZ Hospital Tilburg - The Netherlands, location Phase 1



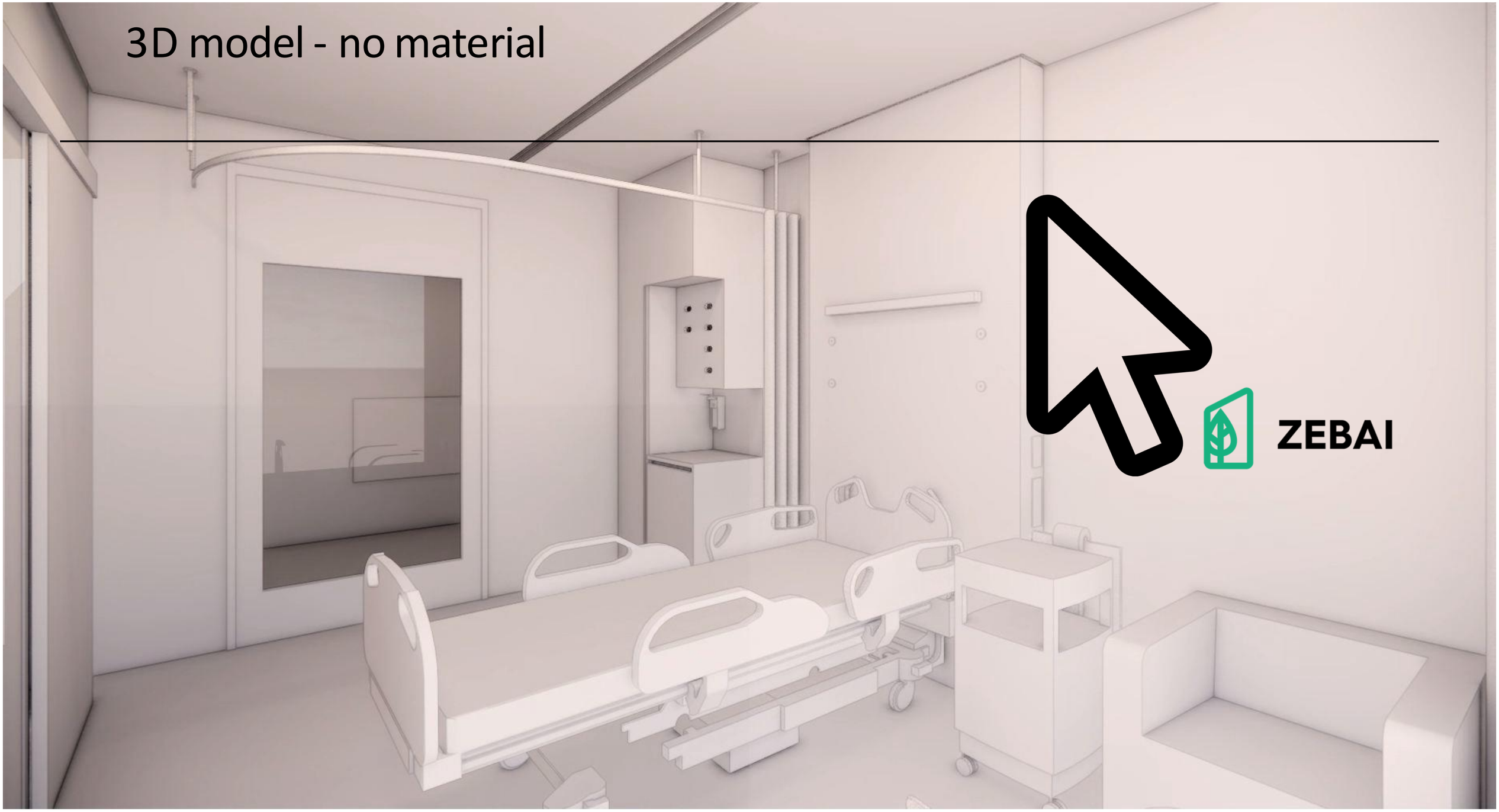
# ETZ Hospital Tilburg - The Netherlands, visualization Phase 1



# ETZ Hospital Tilburg - The Netherlands, visualization Phase 2



# 3D model - no material



# 3D model - visualized



# 3D model - visualized



# ETZ Hospital Tilburg - The Netherlands, visualization Phase 1 & 2



# ETZ Hospital Tilburg - The Netherlands, visualization future development



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Research



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# PANELIST



**Lucia Royo**
Electroingenium



**Dimitris Chatzigiannis**
Heron Energy S.A



**Benjamin Constant**
NéoEco