Best practices and Q&A session on Step-WISE Toolkit

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AGENDA

- INTRO STEPWISE TOOLKIT
- CASE STUDIES

1 – Application of the Stepwise Toolkit at the Urban Scale: PED Methodology and the EU +CityXChange

- Milan
- Udine
- Bologna
- Crispiano
- Rome

2 – Roadmap towards a Positive Energy District in the Industrial Zone of Padova

3 – Application of the Stepwise Toolkit at Building Level and EPBD Compliance Analysis

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Why we need the Step-wise Toolkit?

These tools facilitate the development of Clean Energy Transition Plans (CETs).

SECAP
Sustainable Energy and Climate Action Plan

LAEP
Local Area Energy Plan

SEAP
Sustainable Energy Action Plan

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What are the Clean Energy Transition Plans (CETs), and what do we need to demonstrate?

Strategic frameworks that outline how governments, organizations, or regions aim to achieve targets for clean energy usage, enhance energy efficiency, and reduce greenhouse gas emissions.

For instance, the Sustainable Energy and Climate Action Plan (SECAP):

- **Objective:** Achieve a reduction in greenhouse gas emissions by 2030.

Components:

- **Baseline Emission Inventory:** Identifies main emission sources.
- **Risk & Vulnerability Assessment:** Evaluates local climate risks.
- **Energy Actions:** Promotes energy efficiency and renewable energy. (so estimate the energy savings)
- **Climate Adaptation:** Enhances community resilience to climate change.
- **Monitoring:** Tracks progress and allows for plan adjustments.

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How can we demonstrate greenhouse gas emission reductions?

Which strategies we need to plan and implement?



One of the most accurate method is the use of the **Dynamic Energy Simulation of Buildings**



Dynamic building energy simulation refers to the use of computational models to predict and analyze the energy performance of buildings by creating a Digital Twin

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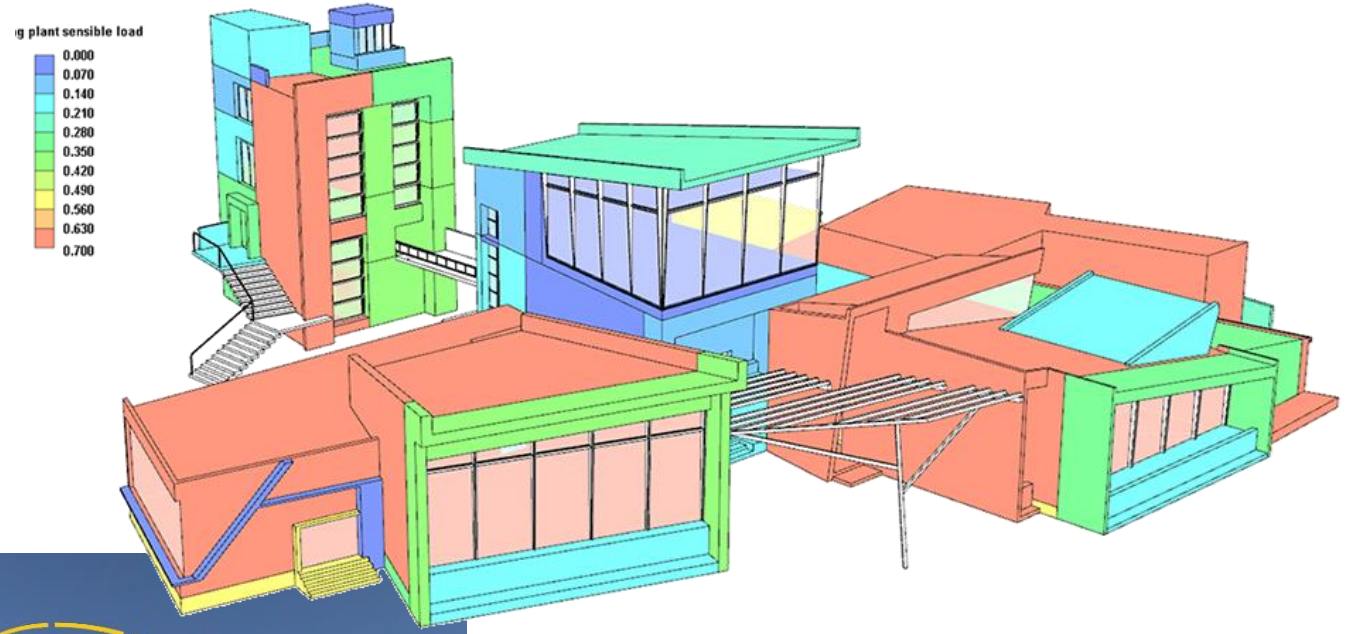
IES ICL
Intelligent Communities Lifecycle

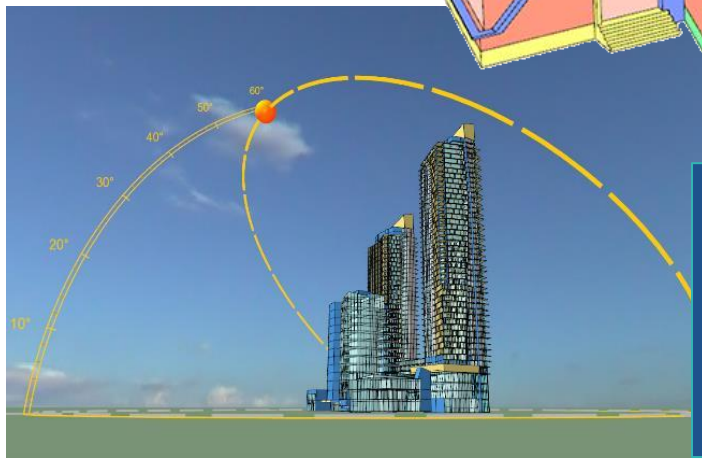


The Stepwise toolkit utilize the **Dynamic Energy Simulation**

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Virtual Environment (VE)

The Virtual Environment software is a suite of integrated building analysis tools that translate complex building physics and detailed dynamic thermal calculations.

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The pros and cons of dynamic energy simulation of buildings:

Pros:

1.Accurate Predictions: Models energy consumption realistically by considering dynamic factors.

2.Comprehensive Analysis: Identifies energy-saving opportunities.

3.Climate Adaptation: Evaluates building resilience to future climate conditions.

4.Policy Support: Helps meet regulatory and sustainability standards.

5.Stakeholder Engagement: Visualizations enhance communication with stakeholders.

Cons:

1.Complexity: Requires detailed data that can be difficult to obtain.

2.Resource Intensive: Time-consuming and may incur higher costs for software and training.

3.Uncertainty in Inputs: External factors can affect prediction reliability.

4.Steep Learning Curve: Requires specialized expertise to operate effectively.

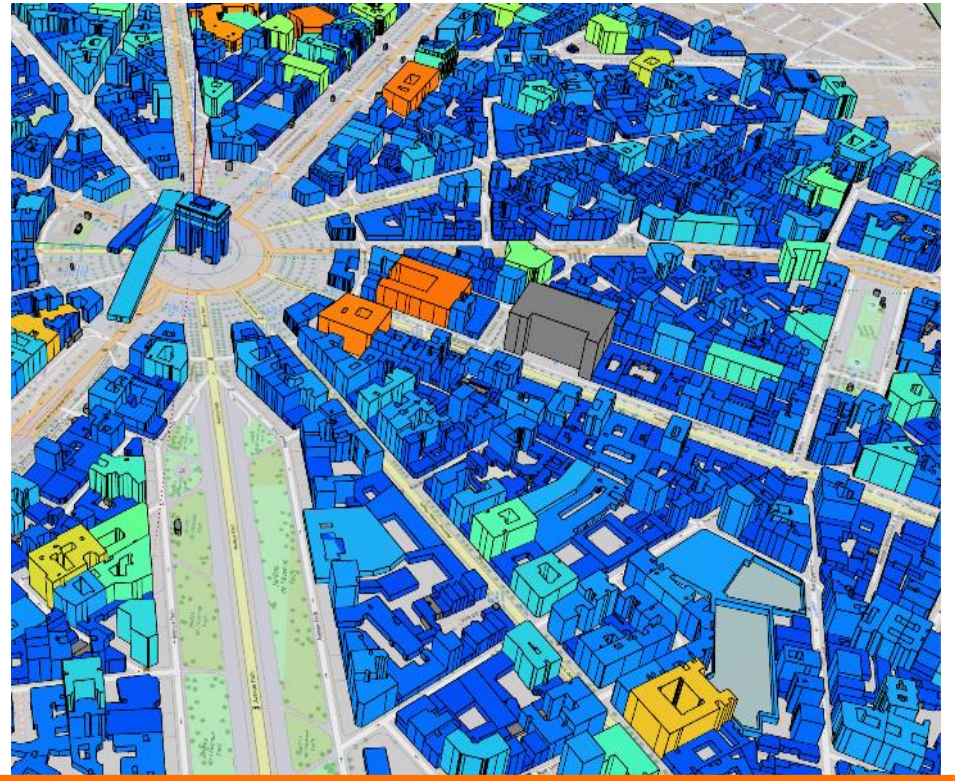
CROSS THESE BARRIERS (CONS)
IES Developed iCD

Step-WISE CO2

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iCD

Intelligent Community Design (iCD)

3D urban master planning tool that assist in creating baseline and apply retrofit scenarios at urban level .

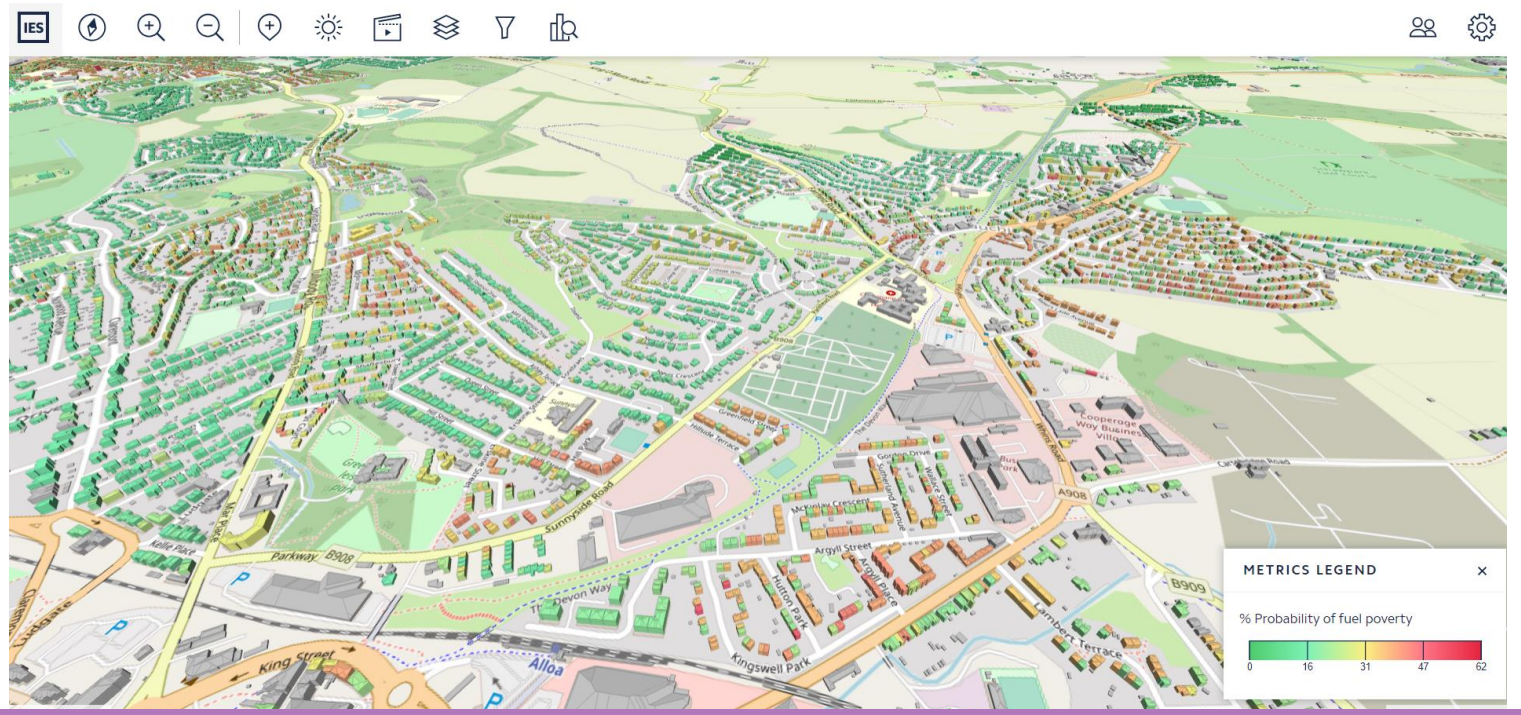
Step-WISE CO_2

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Collaboration Monitoring and Visualization Platform

iCM



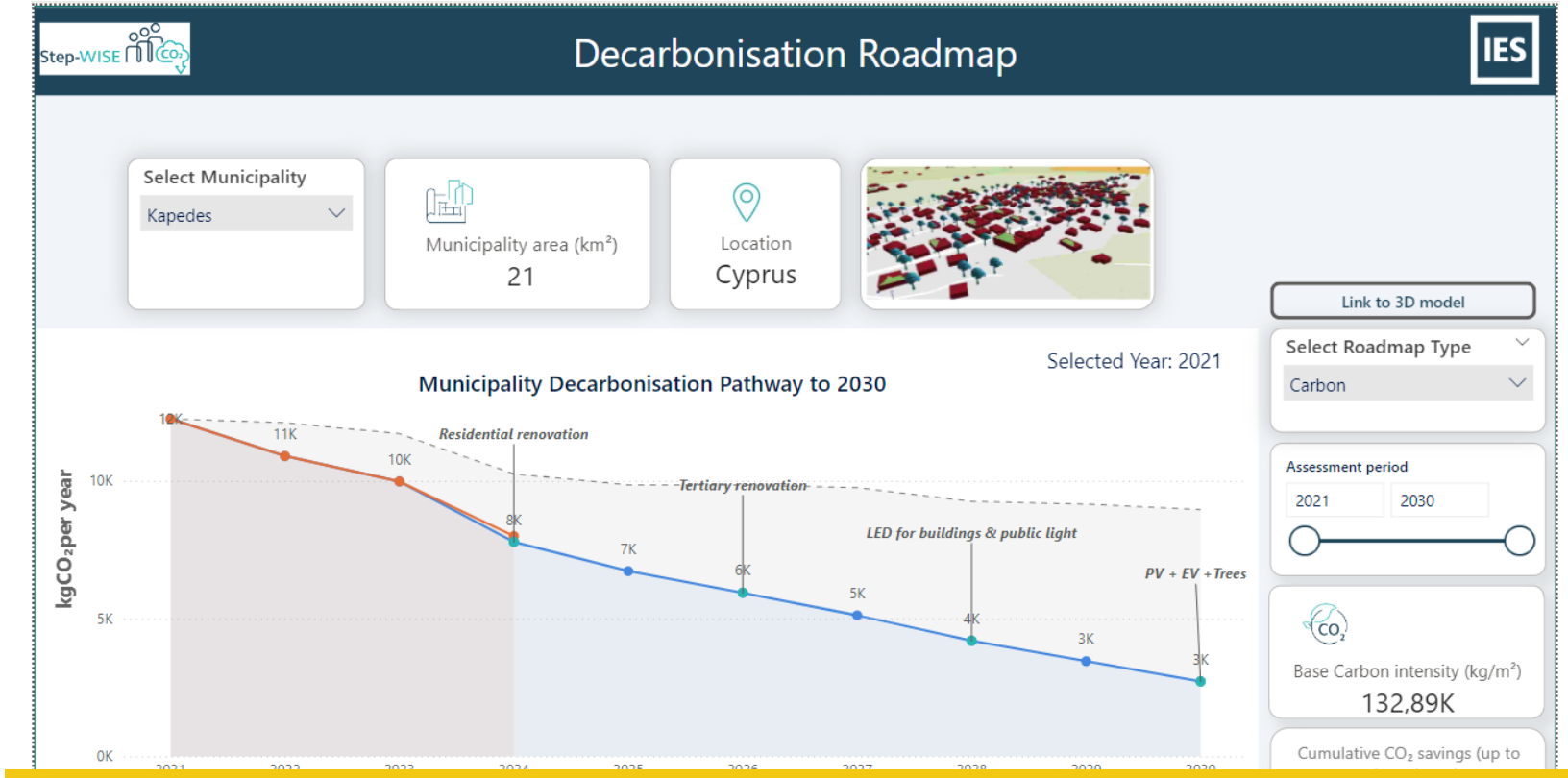
Provides 3D visualization and stakeholder engagement features

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Roadmap visualisation for the implementation of decarbonisation scenarios

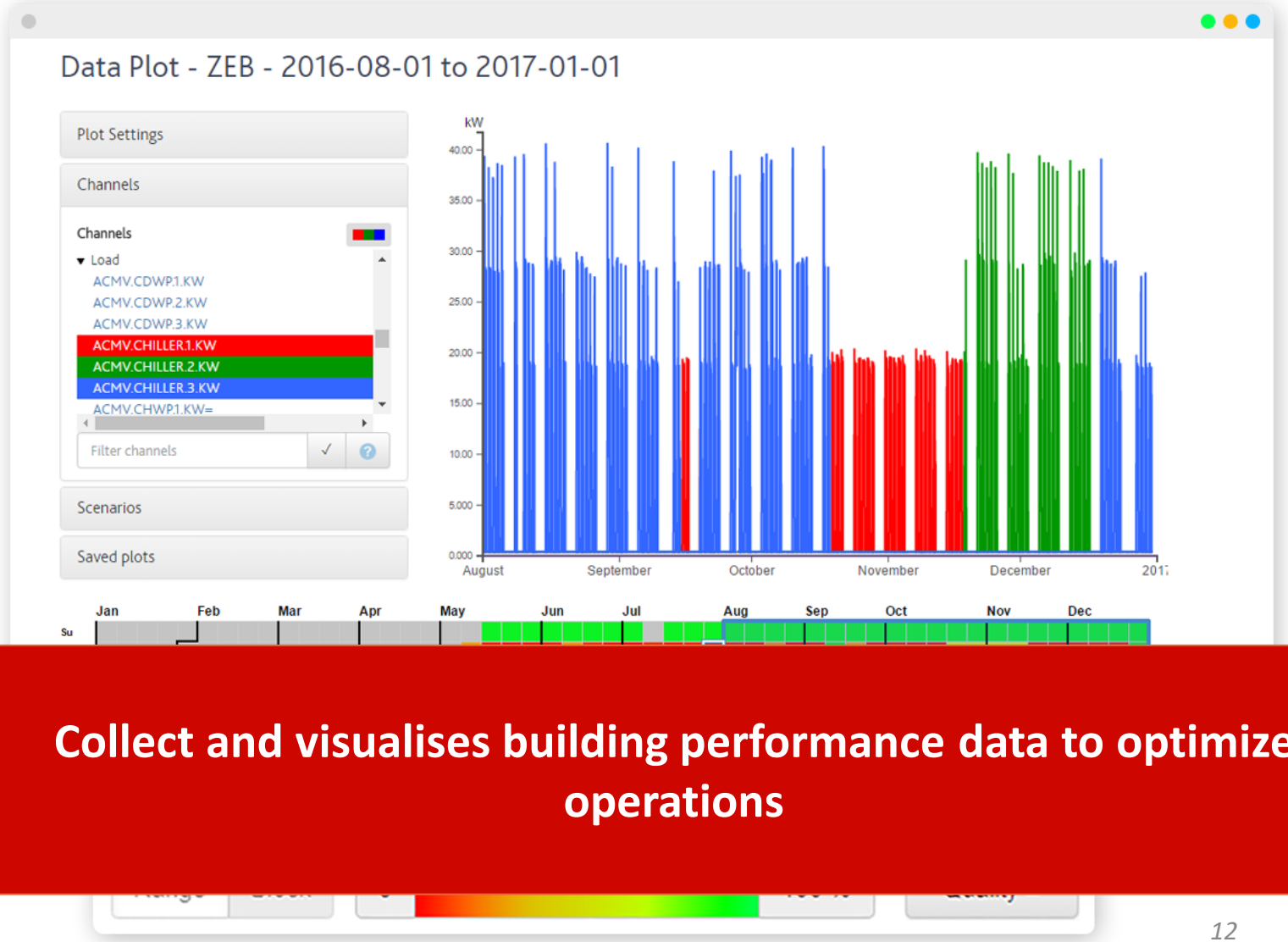
Power BI



Provides the visualisation of the Roadmap with the scenarios for the energy and CO2 emission reduction

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iSC

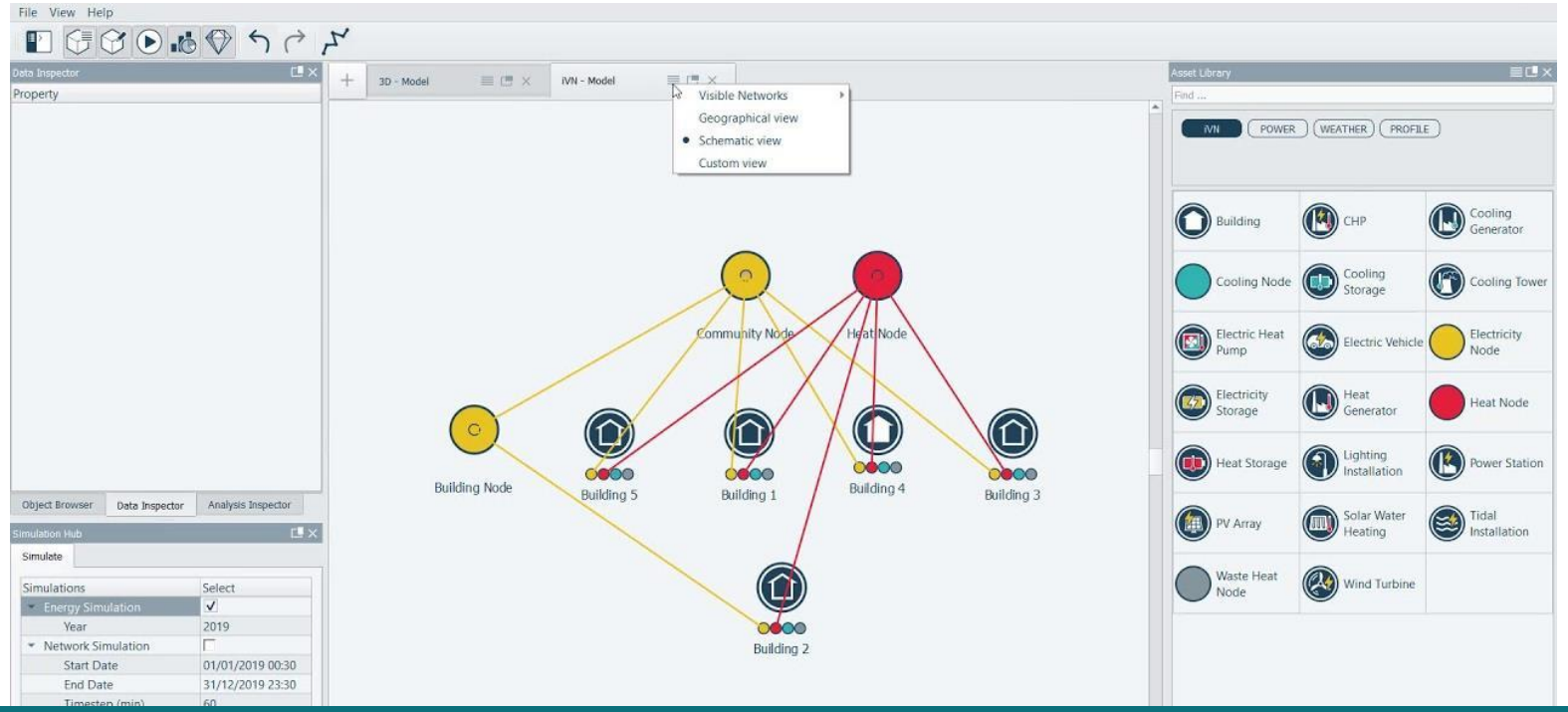
Intelligent Control and Analysis (iSCAN)

Collect and visualises building performance data to optimize operations

Step-WISE CO_2

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iVN

Intelligent Virtual Network (iVN)

The iVN is a network modelling and management tool that enable advanced analysis of local energy systems including district heating and storage

Application of the Stepwise Toolkit at the Urban Scale: PED Methodology and the EU +CityXChange

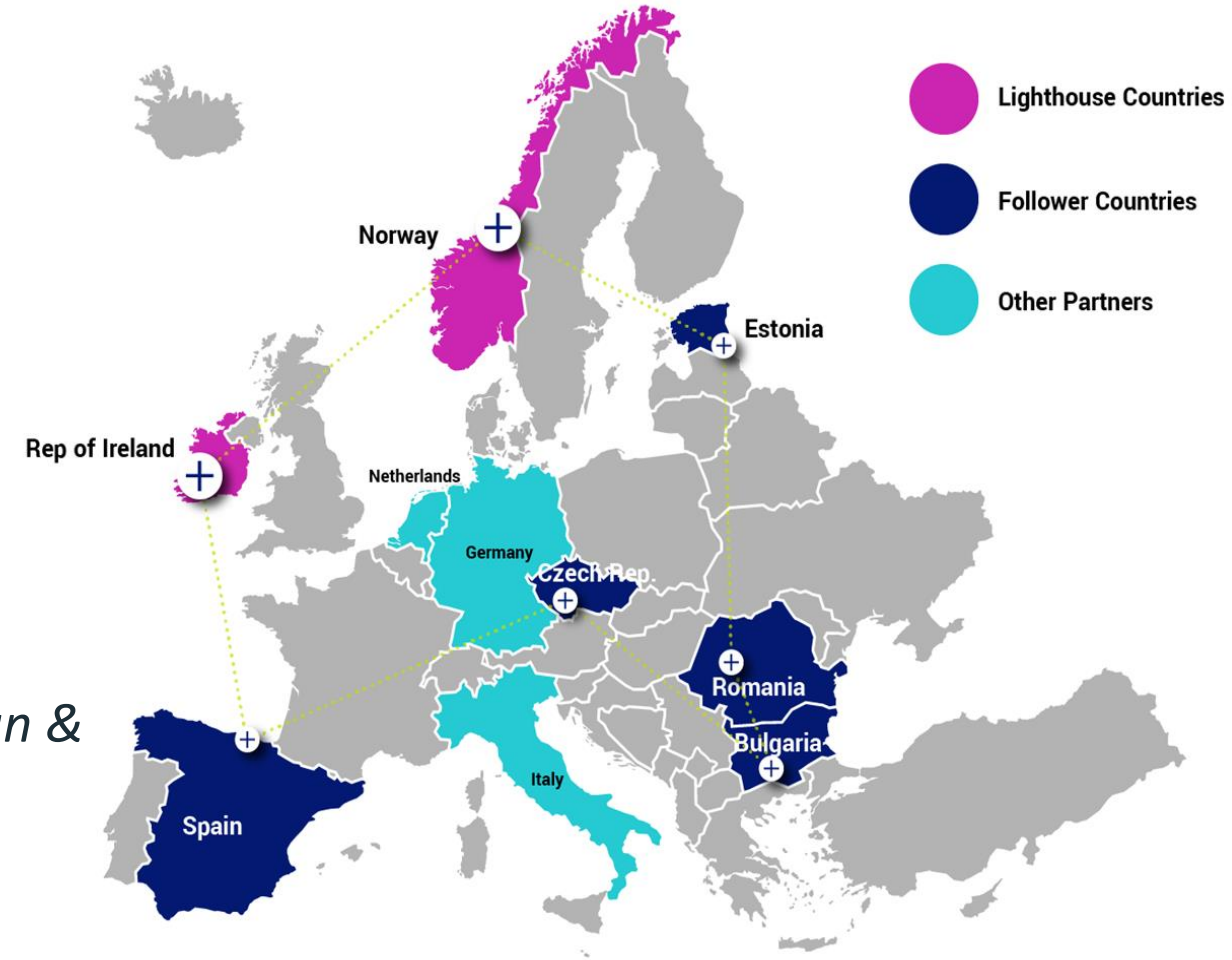
CASE STUDIES:
- Milan
- Udine
- Bologna (live demo)
- Crispiano
- Rome

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+CityxChange Project

- EU H2020 Grant funded
- *Nov 2018 to Oct 2023*
- *32 partner organisation's*
- *7 countries*
- *2 Lighthouse Cities – Trondheim & Limerick*
- *5 Follower Cites: Alba Iulia, Pisek, Võru, Smolyan & Sestao*



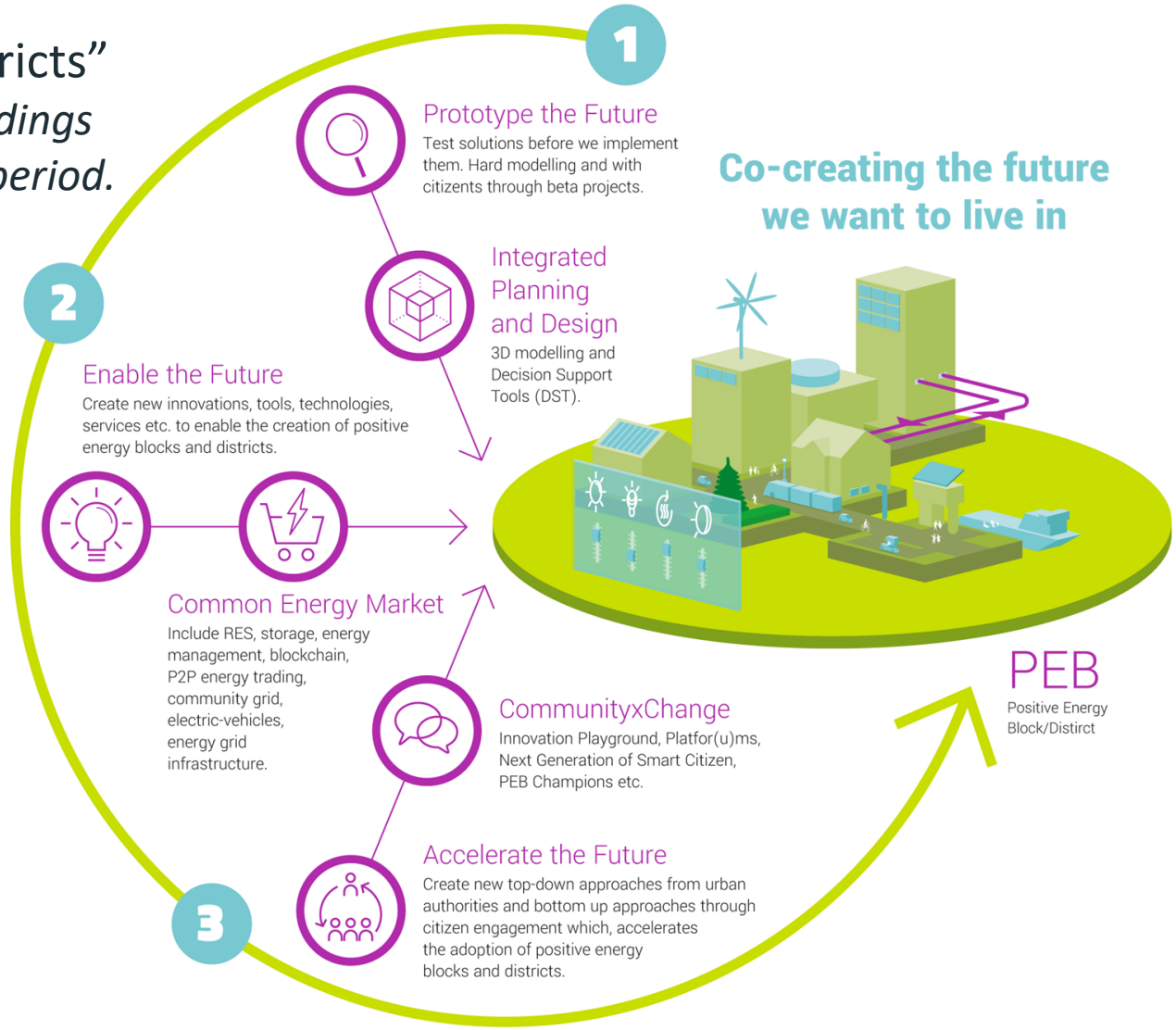
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Key Project Aims and Approach

Develop and deploy "Positive Energy Blocks and Districts"
**Positive Energy Block (PEB) is a group of three or more buildings that produce more energy than they consume in an annual period.*

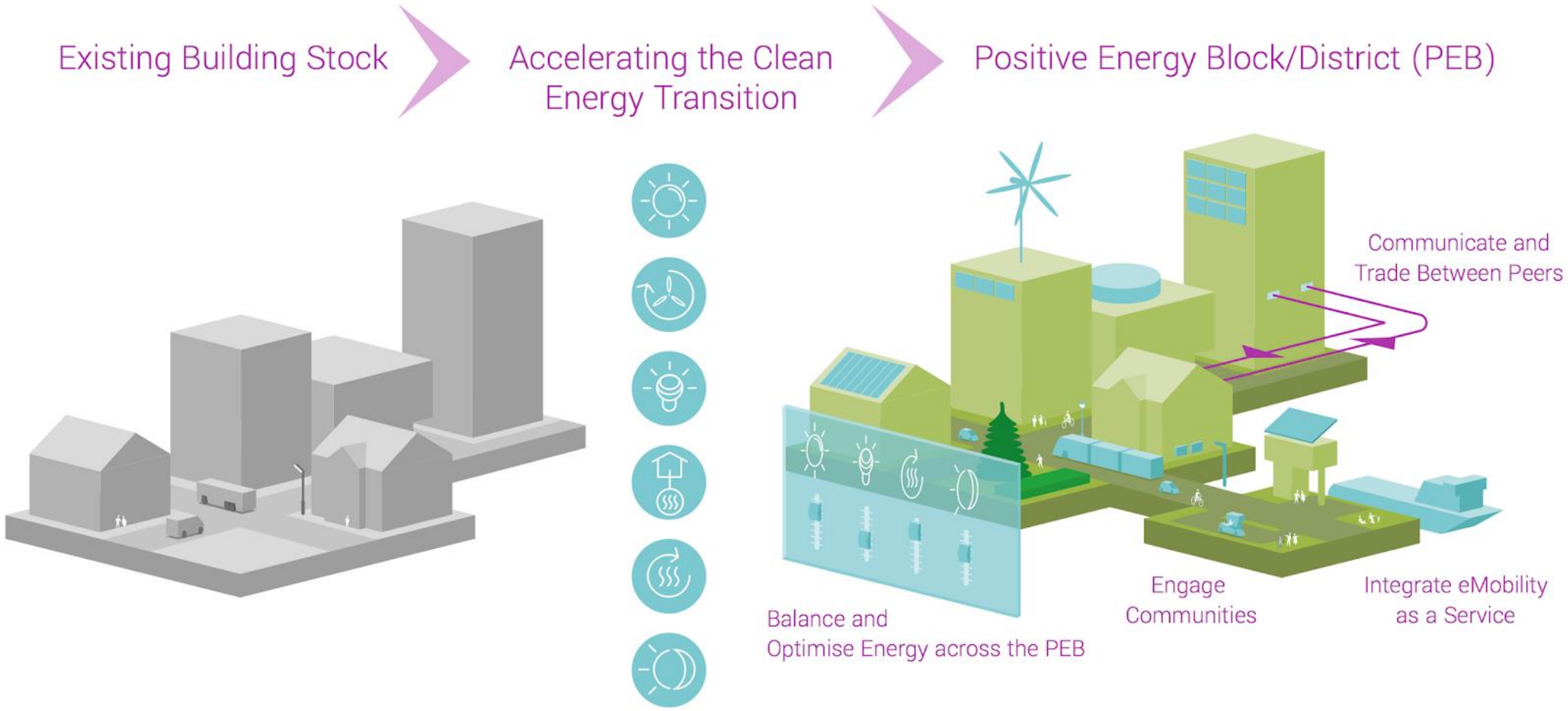
Scale these up as part of cities Net Zero plans for 2050



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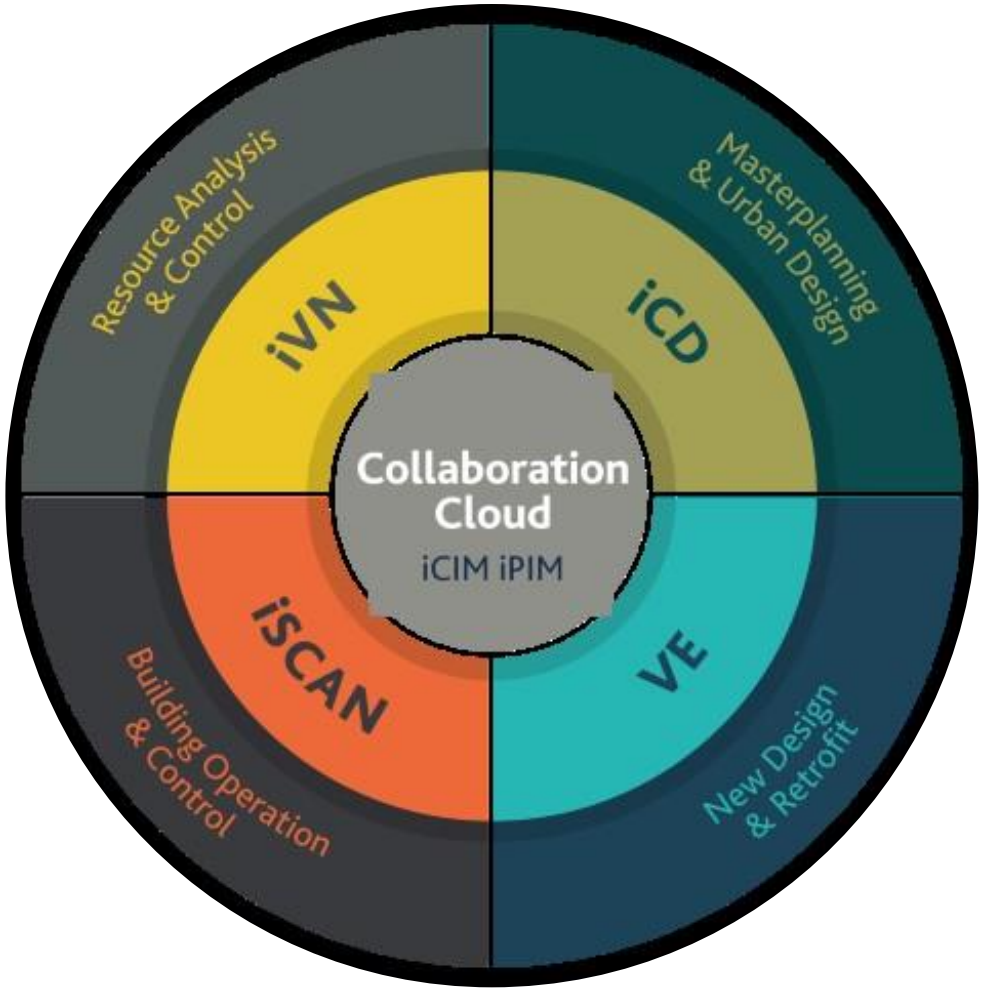
Positive Energy Blocks



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Intelligent Community Lifecycle (ICL)



The ICL is a platform to help create, plan, evaluate and manage the energy performance of a community now and into the future.

Creates dynamic 3D models that reflect real life performance.

Delivers resilience, cost savings and resource-efficiency for buildings, campuses, communities and cities.

- Connect, visualise & analyse any data from any source
- Fill data gaps using simulation
- Make informed decisions
- Create bespoke dashboards

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Cities – Overview and Starting Data

Bologna

Area: 140,86 km²
Inhabitants: 388 171

Buildings: 1080
Area: 7 750 218 m²
Inhabitants: ~ 23 000



- Shape (centro) and qgis file containing:
  - Number of floors
  - Year of construction
  - Building Type
  - Installed PV Capacity

Milano

Area: 181,67 km²
Inhabitants: 1 361 908

Buildings: 31
Area: 50 132 m²
Inhabitants: 97 841



- GeoJSON File containing:
  - Number of floors
  - Year of construction
  - Building Type

Udine

Area: 57,17 km²
Inhabitants: 97 841

Buildings: 10 (2 Schools, 1 Shopping mall, 7 Apartment blocks)
Area: 134 400 m²
Inhabitants: ~1000 (405 Apartments)



- Building's plans and sections
- Technical reports of the interventions
- Buildings' Energy Performance Certificates

Crispiano

Area: ~ 111 km²
Inhabitants: 13 770

Buildings: 7 (1 municipal building, 1 library, 2 schools, 2 offices, 1 sport center)
Area: ~ 16 000 m²
Occupancy: ~750 people/day



Building plans, survey reports, and energy requalification projects holding:
- Boulding geometry
- Envelope description
- Building type, Construction year

Roma

Area: 1 287,36 km²
Inhabitants: 2 746 639

Buildings: 155
Area: ~ 660 696 m²
Inhabitants: ~7610



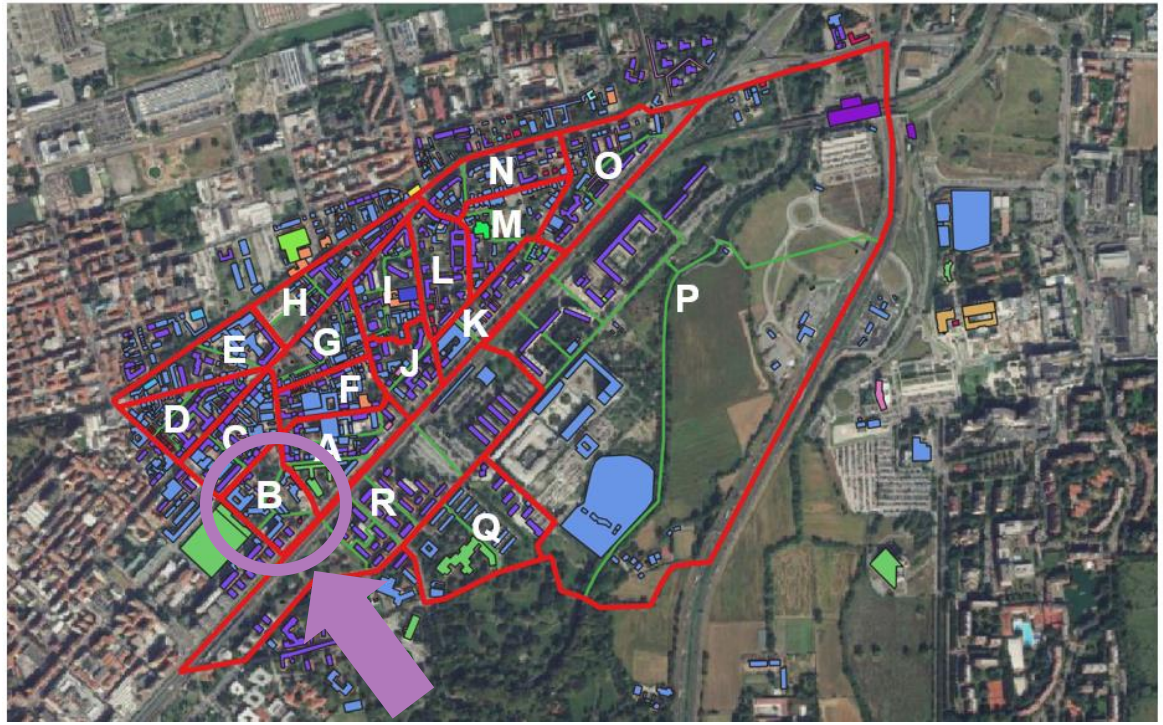
- GIS file containing:
  - Building Type
  - Number of floors
  - Roof Type
  - Potential roof area for PV

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Milano

Milan, Crescenzago area subject to redevelopment and the Reinventing Cities competition





- AREA CRESCENZAGO

- GeoJSON File containing:
  - Number of floors
  - Year of construction
  - Building Type

Started from a GIS File

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Milano

Milan, Crescenzago area subject to redevelopment and the Reinventing Cities competition

Milano: 181,67 km²

Inhabitants: 1 361 908



Specific area of interest: Area 1: 21300 m² (14 buildings); Area 2: 10950 m² (4 buildings)

Inhabitants: 97 841



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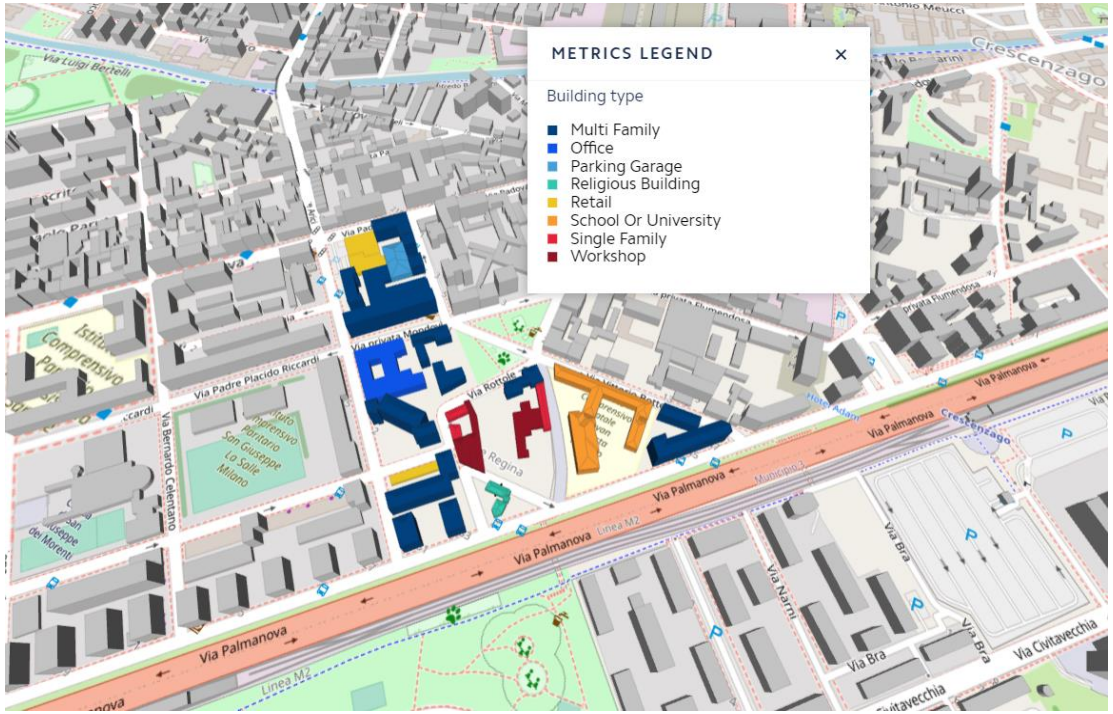
Milano - B

Model set up from iCD plugin in Sketchup:



Visualization from iCIM webpage

LINK ICIM



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- **ICL**

Once the information was obtained from the GIS file, it was supplemented with U-value data obtained from CENED (Energy Certification of Buildings).

ERP	ALER	H (M)	Fotovoltaico	Tipologia	ANNO_COSTR	CLASSE_ENE	ANNO	COMBUSTI_1	Tipo_Gen
NO	NO	29.73	NO	Edificio residenziale	1900	F	Prima 1919	GAS NATURALE	TELERISCALDAMENTO
NO	NO	5.611	NO	Edificio di terziario	1900		Prima 1919		
NO	NO		NO	Edificio trasformazione energia elettrica	1927		19-45	GAS NATURALE	
SI	NO	7.108	NO	Edificio residenziale	1927	G	19-45	GAS NATURALE	CALDAIE
SI	NO	6.688	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	7.13	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	6.966	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	7.078	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	7.046	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	6.865	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	6.958	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
SI	NO	6.89	NO	Edificio residenziale	1927		19-45	GAS NATURALE	CALDAIE
NO	NO	5.816	NO	Edificio residenziale	1935	F	19-45	GAS NATURALE	
NO	SI	15.27	NO	Edificio minore in muratura	1939	G	19-45	TELERISCALDAMENTO	TELERISCALDAMENTO
NO	SI	17.73	NO	Edificio residenziale	1939	G	19-45	TELERISCALDAMENTO	TELERISCALDAMENTO
NO	SI	4.21	NO	Edificio di terziario	1939	F	19-45	GAS NATURALE	TELERISCALDAMENTO
NO	SI	15.48	NO	Edificio residenziale	1941	F	19-45	GAS NATURALE	TELERISCALDAMENTO
SI	NO	4.846	NO	Edificio minore in muratura	1946		46-60		
NO	SI	17.03	NO	Edificio residenziale	1950	G	46-60	GAS NATURALE	TELERISCALDAMENTO
NO	NO	7.19	NO	Edificio residenziale	1950	G	46-60	GAS NATURALE	CALDAIE
NO	NO	17.7	NO	Edificio residenziale	1950	E	46-60	GAS NATURALE	CALDAIE
NO	NO	30.16	NO	Edificio residenziale	1960	E	46-60	TELERISCALDAMENTO	TELERISCALDAMENTO
NO	NO	30.04	NO	Edificio residenziale	1960	F	46-60	GAS NATURALE	TELERISCALDAMENTO
NO	NO	2.13	NO	Edificio minore in muratura	1960	A4	46-60	GAS NATURALE	CALDAIE

CENED Certificazione ENergetica degli EDifici

Construction era	Residential	Office	Parking garage	School or University	Workshop	Retail	Transportation	Hotel	Gymnasium
GlazingRatio									
<1930	11	10	6	-	6	-	-	-	-
1931-45	11	11	6	10	6	12	-	-	-
1946-60	13	12	6	-	6	12	6	-	-
1961-80	15	11	6	10	6	12	6	15	6
1981-90	14	13	-	-	-	12	-	-	-
1993-2006	14	-	-	-	-	-	-	-	-
>2006	15	-	-	-	-	-	-	-	-
Ext_Wall_U {W/m2K}									
<1930	1,3	10	1,3	-	1,3	-	-	-	-
1931-45	1,33	11	1,4	1,31	1,4	1,28	-	-	-
1946-60	1,35	12	1,4	-	1,4	1,35	1,4	-	-
1961-80	1,3	11	1,4	1,32	1,4	1,32	1,4	1,3	1,28
1981-90	1,11	13	-	-	-	1,15	-	-	-
1993-2006	0,64	-	-	-	-	-	-	-	-
>2006	0,3	-	-	-	-	-	-	-	-
Roof_U {W/m2K}									
<1930	1,4	1,4	1,4	-	1,4	-	-	-	-
1931-45	1,4	1,4	1,4	1,4	1,4	1,4	-	-	-
1946-60	1,4	1,4	1,4	-	1,4	1,44	1,4	-	-
1961-80	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4
1981-90	0,98	1,1	-	-	-	1,3	-	-	-
1993-2006	0,7	-	-	-	-	-	-	-	-
>2006	0,28	-	-	-	-	-	-	-	-
Ext_Wind_U {W/m2K}									
<1930	3,44	3,81	4,92	-	4,92	-	-	-	-
1931-45	3,54	3	4,95	4,43	4,95	4,92	-	-	-
1946-60	3,8	3,82	4,95	-	4,95	4,95	4,95	-	-
1961-80	3,82	4,02	5,23	5,28	5,23	4,95	5,23	3,82	3,82
1981-90	3,3	3,5	-	-	-	5,23	-	-	-
1993-2006	3,21	-	-	-	-	-	-	-	-
>2006	1,71	-	-	-	-	-	-	-	-

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CURIT
CATASTO IMPIANTI TERMICI
LOMBARDIA

	Building Type	Ventilation type	Infiltration	Generator cathegory	Emission System	Fuel Type	Heating Set point [°C]	DHW system
Hotel	E1 (3)	Natural	0,5	Boiler	Radiators	Natural gas	20	Gas Boiler
Multi Family	E1 (1)	Natural	0,5	Boiler	Radiators	Natural gas	20	Gas Boiler
Office	E2	Natural	0,5	Boiler	Fan coil	Natural gas	20	Electric Boiler
Parking Garage	E8	Natural	1,5	Boiler				
Retail	E5	Natural	1,5	Boiler	Fan coil	Natural gas	20	Electric Boiler
School or University	E7	Natural	1,5	Boiler	Radiators	Natural gas	20	Electric Boiler
Workshop	E8	Natural	1,5	Boiler	Radiators	Natural gas	18	Electric Boiler
Gymnasium	E6	Natural	1,5	Boiler	Radiators	Natural gas	18	Electric Boiler
Transportation	E8	Natural	1,5	Boiler	Radiators			
Single Family	E1 (1)	Natural	0,5	Boiler	Radiators	Natural gas	20	Gas Boiler
Police Station	E2	Natural	0,5	Boiler	Fan coil	Natural gas	20	Electric Boiler
Religious Building	E4 (2)	Natural	1,5	Boiler	Radiators	Natural gas	20	Electric Boiler
Performing Arts Teather	E4 (1)	Natural	1,5	Boiler	Radiators	Natural gas	20	Electric Boiler
Manufacturing	E8	Natural	1,5	Boiler	Radiators	Natural gas	18	Electric Boiler

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Milano– Intervention scenarios

BASELINE – Pre intervention

- External wall U = 1.3 ÷ 1.4 W/m2K
- Windows: U= 3.5 ÷ 5.22 W/m2K
- Un-insulated Roofs:
  U= 1.4 W/m2K
- Un-insulated Ground Floors:
  U=0.71 W/m^2K
- DHW: Gas Boiler | Electric boiler
- Heating: Central Heating Radiators. Natural Gas

PASSIVE MEASURES

Scenario 1:

- Ext Wall: 0.26 W/m2K
- Windows U= 1.3 W/m2K

ACTIVE MEASURES

Scenario 2: Substitution of heating system to Air source HP with COP=4 in all buildings

Scenario 3: Addition of PV panels on building's rooftops

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Milano– iCD Solar Assessment

PV ATTRIBUTES

- Inclination angle: 30 degrees
  Both for Flat and Hipped roof
- Panel size: 1x1.7 m
- Efficiency: 0.2
- Orientation: S, SE

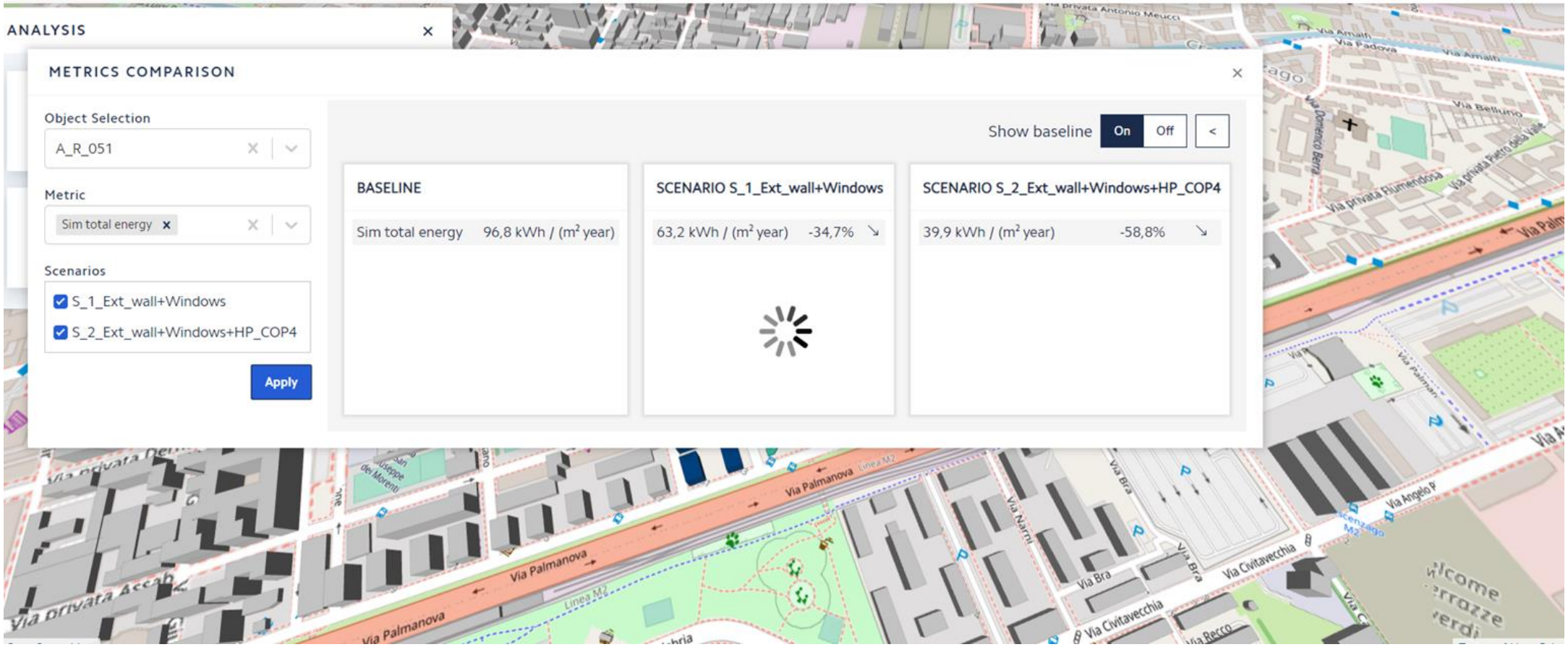
- **PV area: 3434 m2**
- **Total PV yield: 943 MWh**



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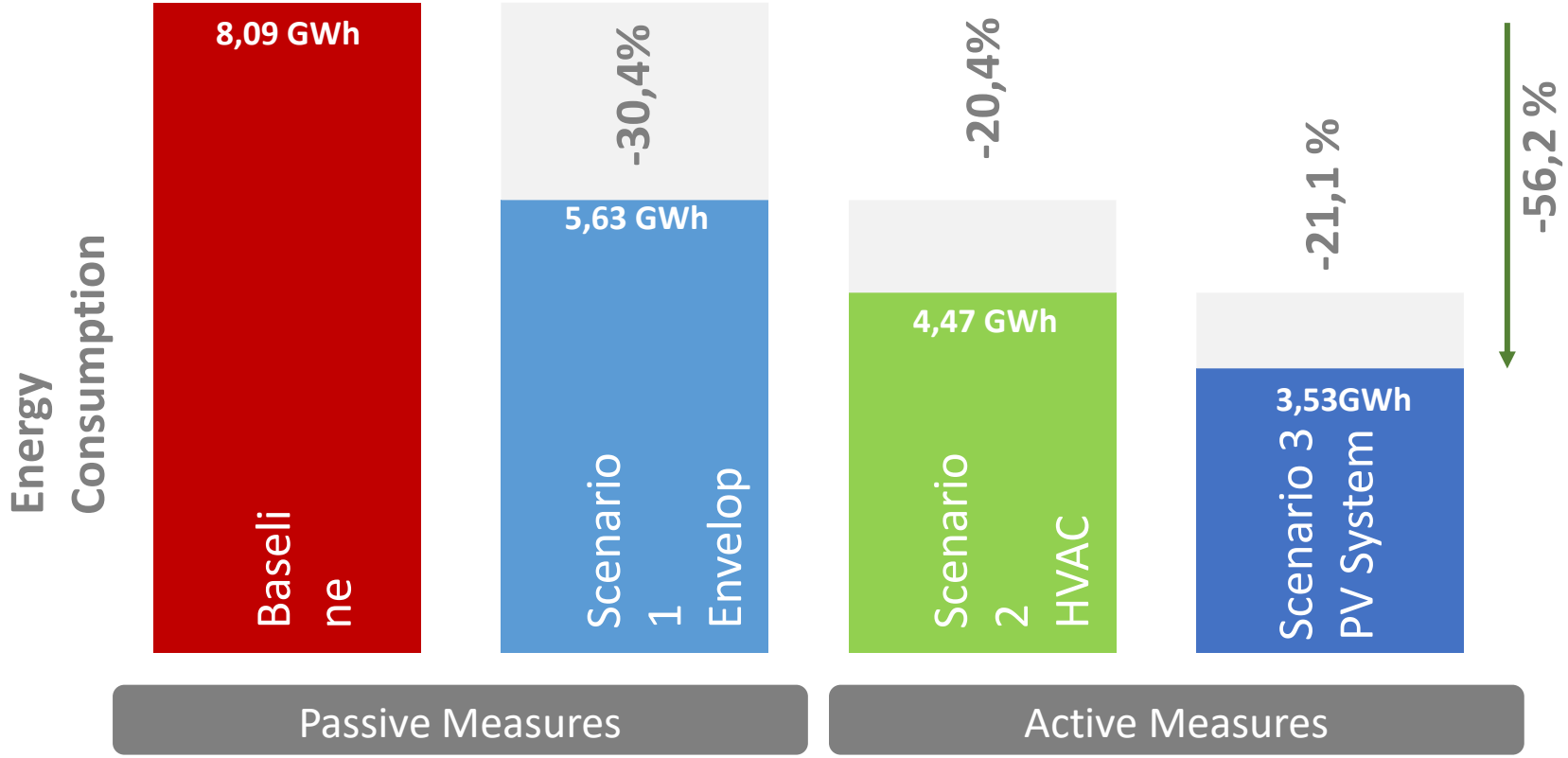
Milano - ICIM Metrics comparison



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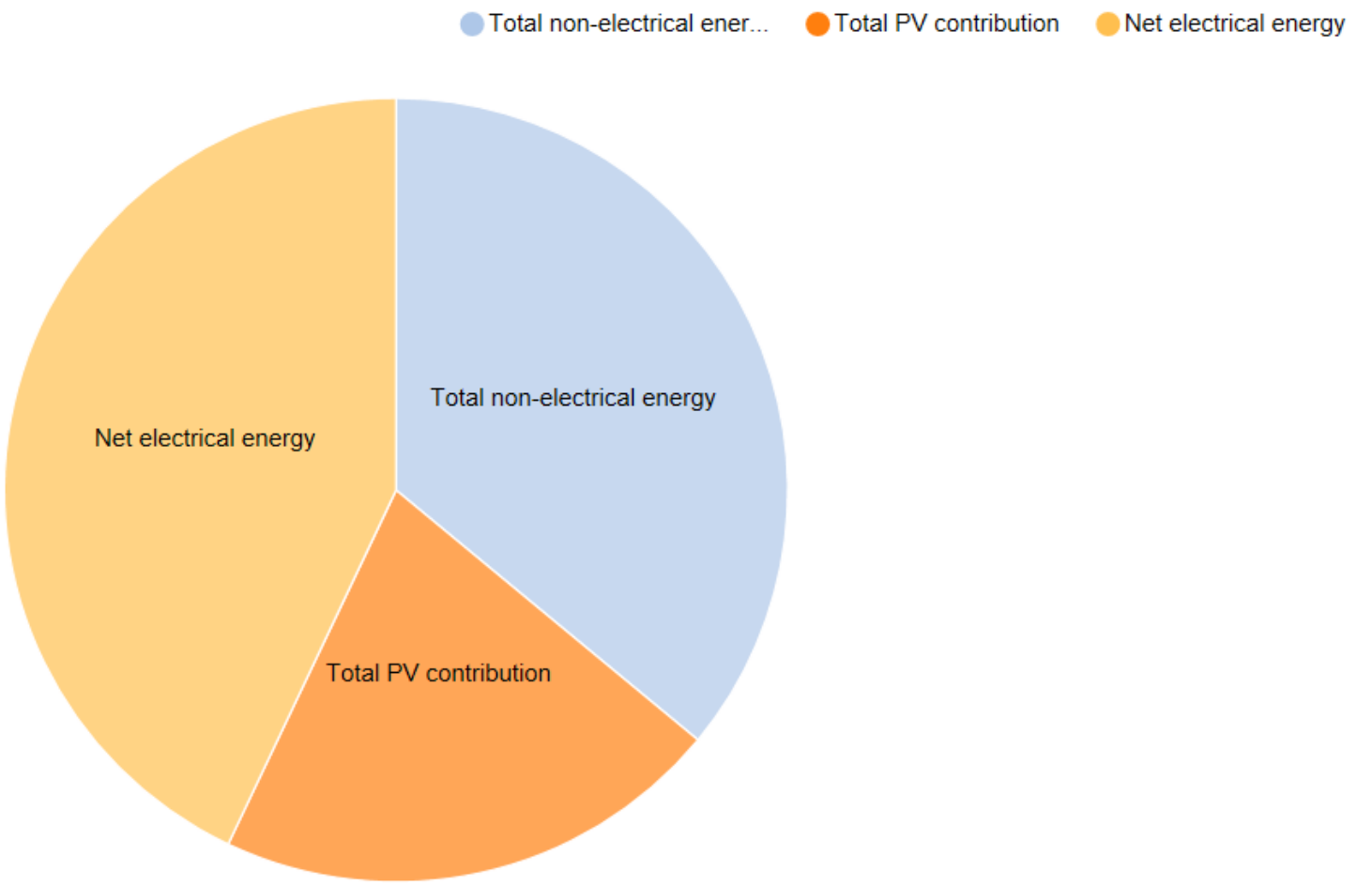
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Milano – PEB Methodology application



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Report: Annual PV contribution vs Total energy use



Total non-electrical energy
1.61 GWh

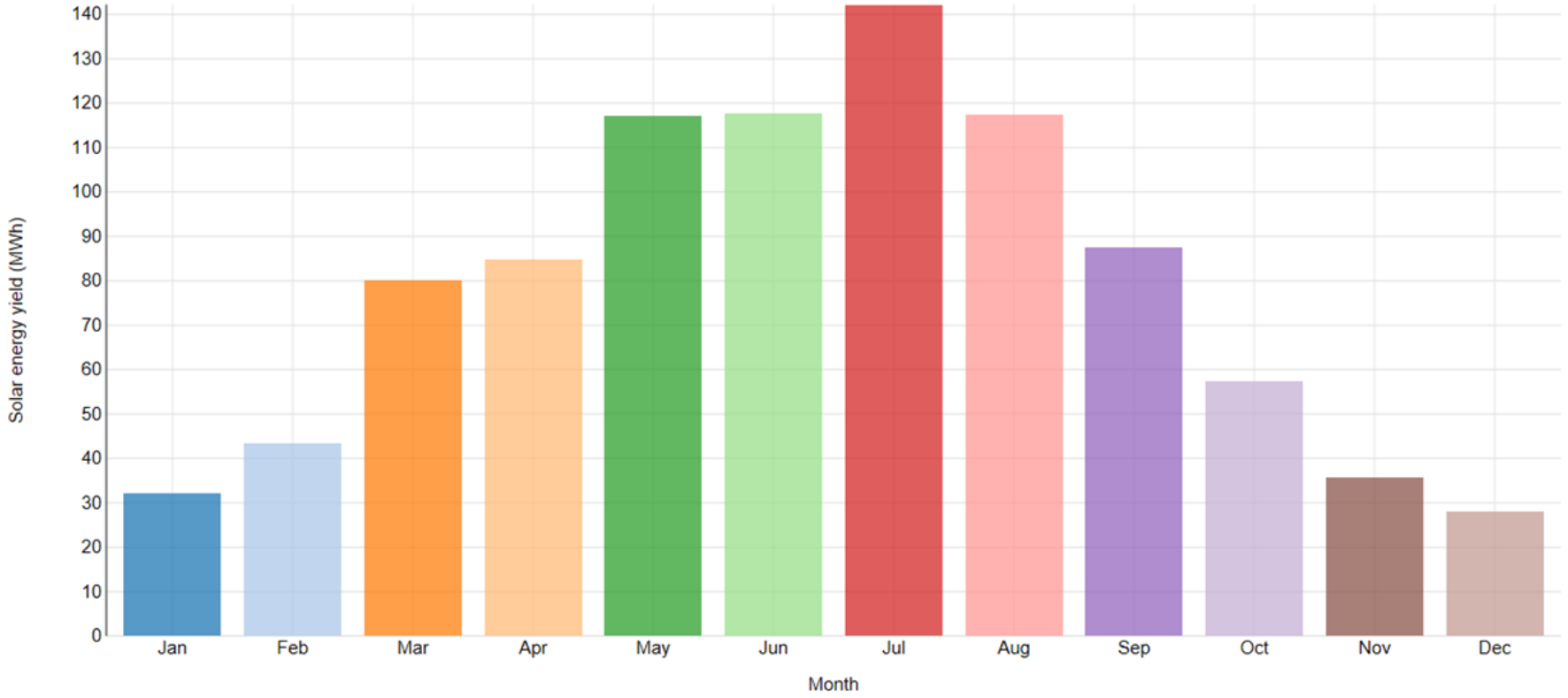
Total electrical energy
2.87 GWh

Total PV contribution
943 MWh

Balance electrical energy
1.92 GWh

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Milano - Monthly PV Electronic Yield



Total PV area
3,434 m²

Total PV yield energy
943 MWh

Site PV yield energy intensity
275 kWh/m²

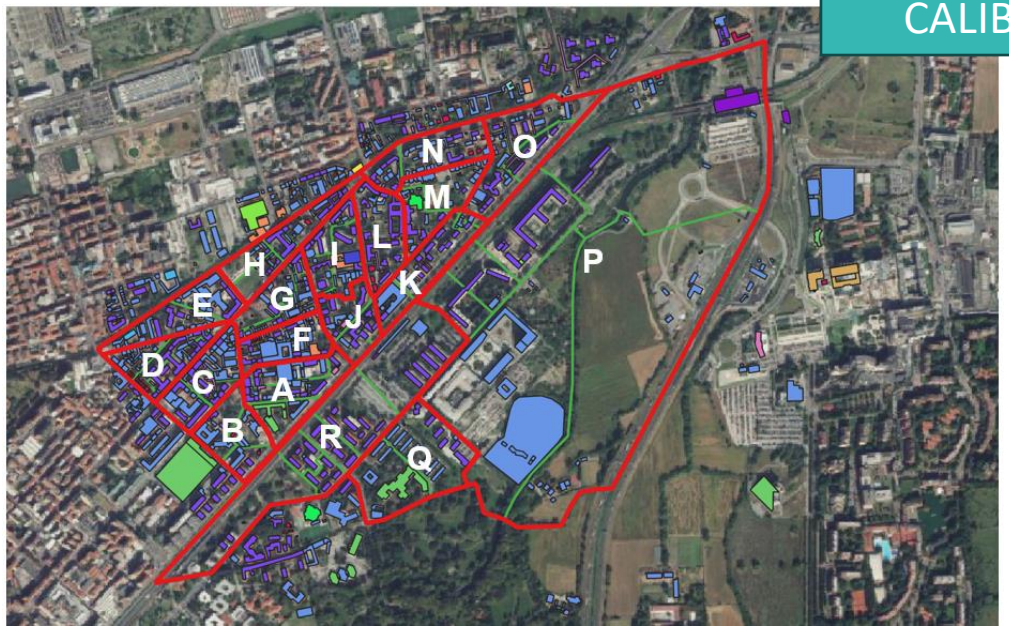
Workflow example – Energy simulation

Simulation of subareas → **Exporting results** → **Post-processing of results on excel, working on each individual area to have as final output:** → **Creation of files reporting all areas** → **Data processing to have for the entire area**

- The consumption in kWh per month for each building.
- The consumption by energy carrier for each area.

- Month-by-month comparison of final energy of heating with comparison by scenarios
- Month-by-month comparison of DHW final energy with comparion by scenarios
- Total primary energy divided by both renewable and non-renewable
- Comparison of total energy by scenario
- Comparison of total primary energy by scenario
- Comparison of CO2 emissions

CALIBRATION





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- SCENARIO 2025

Operational carbon neutrality

Requisiti minimi decreto 18456

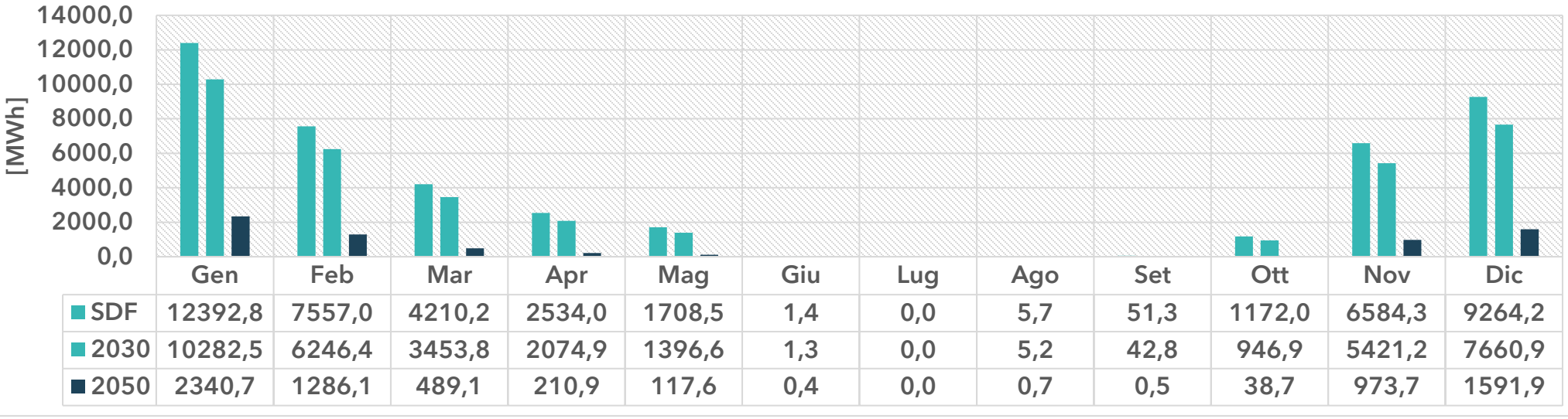
	External walls	Roof	Windows	Heating	DHW
Buildings <1930	No changes	U=0,24 W/m²K	U= 1,4 W/m²K	Condensing boiler (Natural Gas)	Boiler (Natural Gas)
Buildings >1930	U=0,28 W/m²K	U=0,24 W/m²K	U= 1,4 W/m²K	Centralized system →Ground source HP CoP 4 Standalone system → Air sourse HP CoP 3 (Electricity)	heatpump (Electricity)

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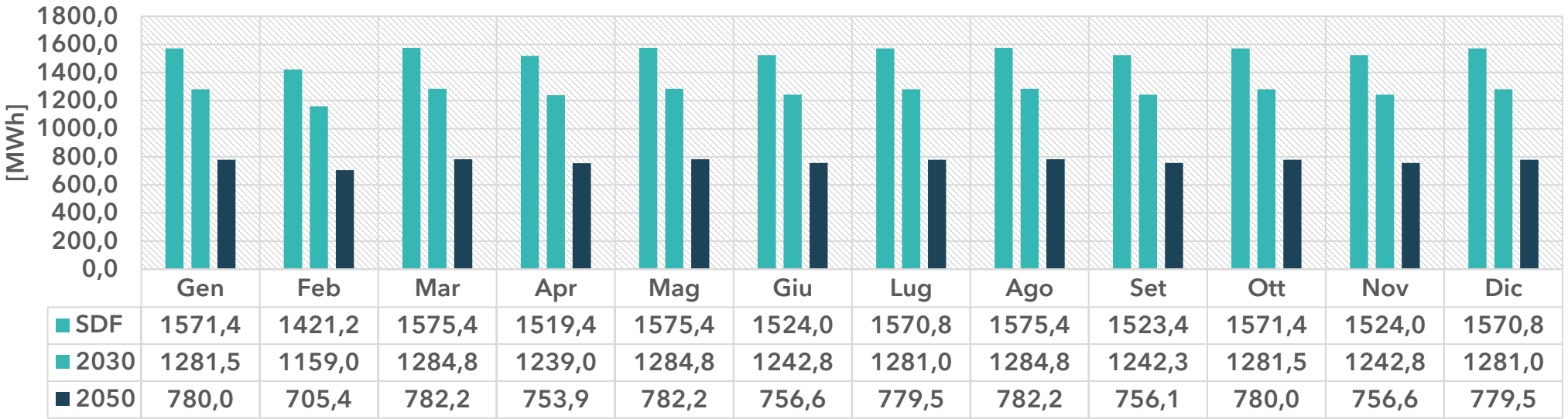
• Comparison– Heating/DHW

Heating



	Gen	Feb	Mar	Apr	Mag	Giu	Lug	Ago	Set	Ott	Nov	Dic
SDF	12392,8	7557,0	4210,2	2534,0	1708,5	1,4	0,0	5,7	51,3	1172,0	6584,3	9264,2
2030	10282,5	6246,4	3453,8	2074,9	1396,6	1,3	0,0	5,2	42,8	946,9	5421,2	7660,9
2050	2340,7	1286,1	489,1	210,9	117,6	0,4	0,0	0,7	0,5	38,7	973,7	1591,9

DHW



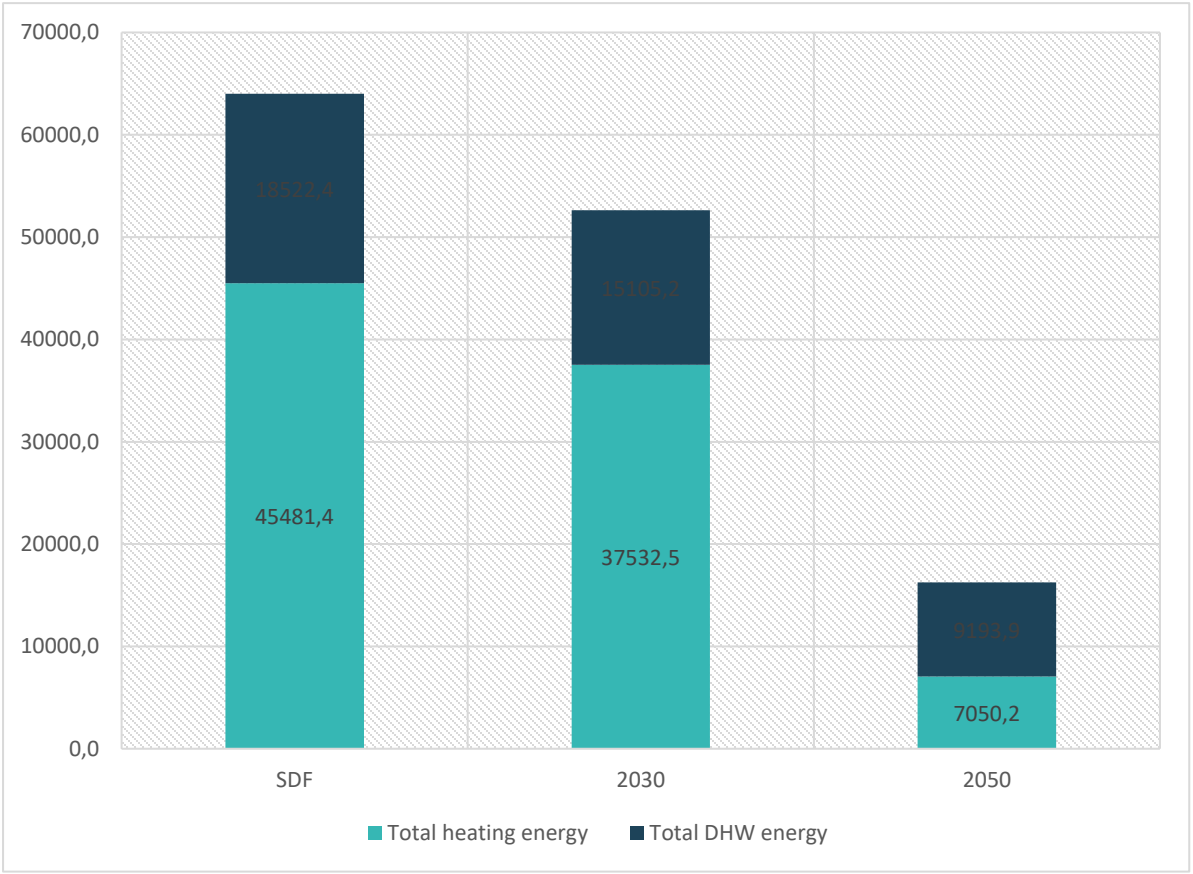
	Gen	Feb	Mar	Apr	Mag	Giu	Lug	Ago	Set	Ott	Nov	Dic
SDF	1571,4	1421,2	1575,4	1519,4	1575,4	1524,0	1570,8	1575,4	1523,4	1571,4	1524,0	1570,8
2030	1281,5	1159,0	1284,8	1239,0	1284,8	1242,8	1281,0	1284,8	1242,3	1281,5	1242,8	1281,0
2050	780,0	705,4	782,2	753,9	782,2	756,6	779,5	782,2	756,1	780,0	756,6	779,5

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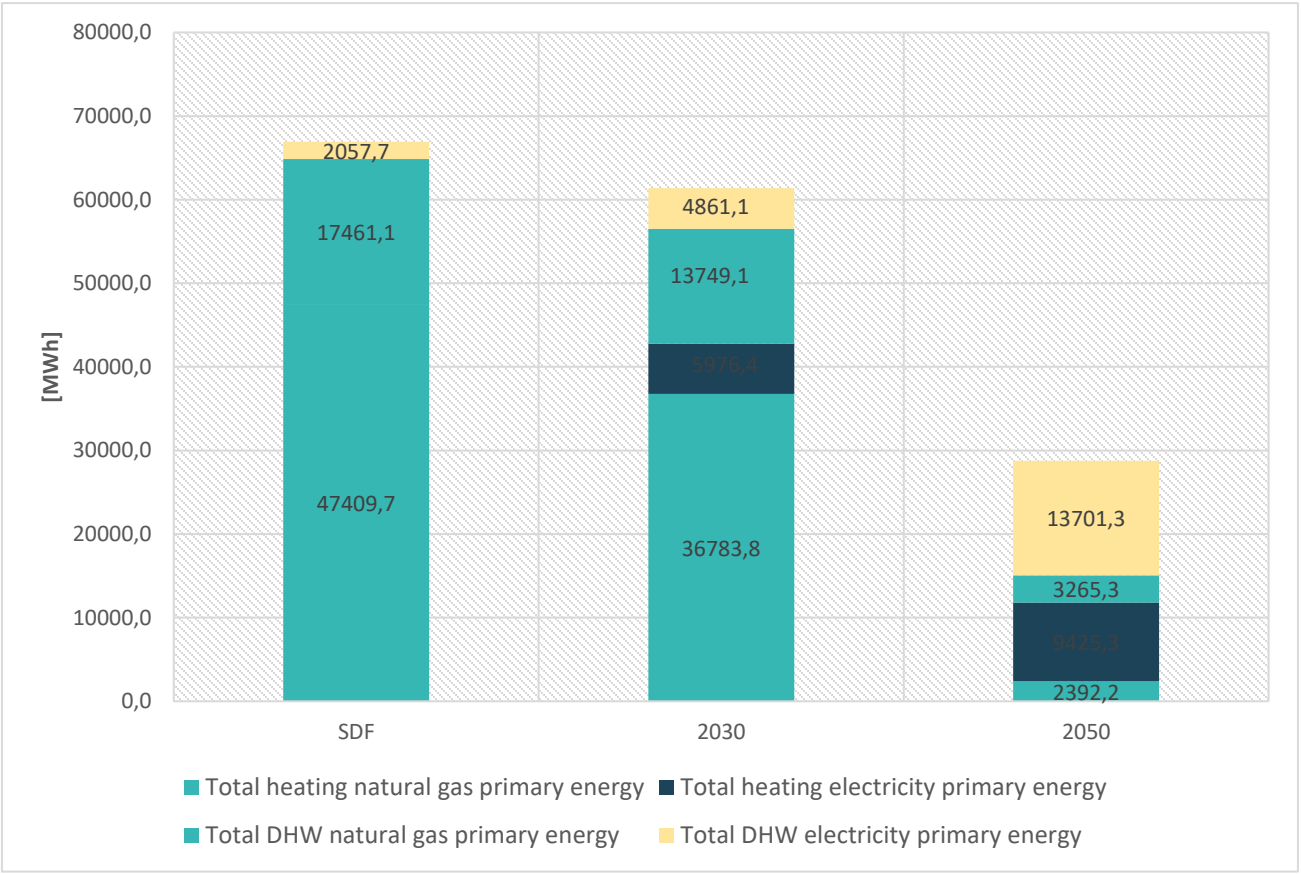
• Comparison– Energy / Primary energy

fattori di conversione	non renewable	renewable	total
gas naturale	1,05	0	1,05
energia elettrica	1,95	0,47	2,42

Total energy



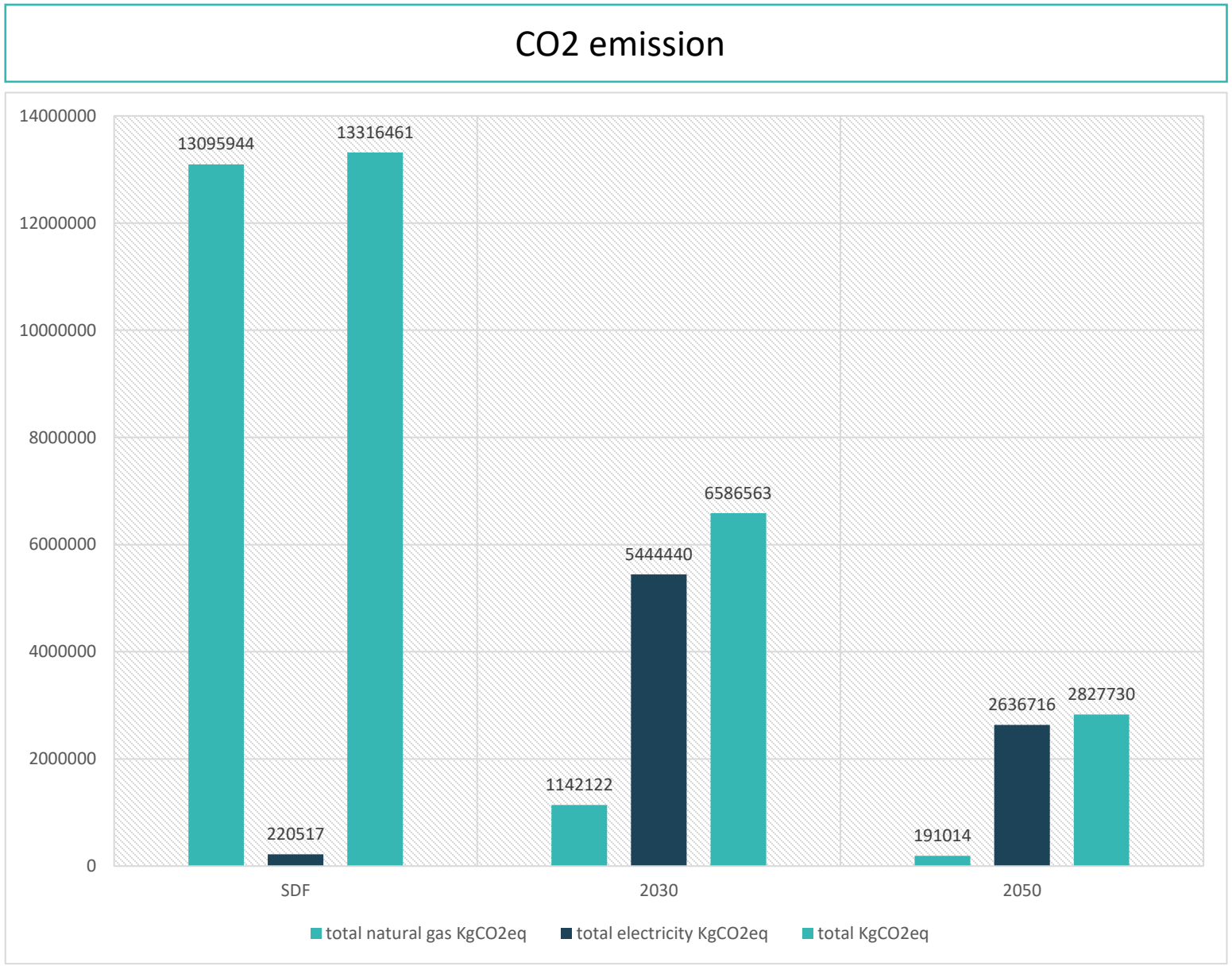
Total primary energy



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• Comparison – CO2 emission

fattori di conversione	
gas naturale [kgCO2eq/GJ]	56,077
energia elettrica [kgCO2eq/kWh]	0,247



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• Esempio workflow – Economic assessment

Creation of an excel file with the following characteristics for each building

- Object ID
- Name
- Total floor area (m2)
- Number of storeys
- GlazingRatio
- sup. Disperdente (*) [m2]
- sup finestrata (*) [m2]
- roof area [m2]
- Number of DHW HP
- Type of plant

Highlight the characteristics of each building for each scenario:

- wall insulation [W/m2K]
- roof insulation [W/m2K]
- windows insulation [W/m2K]
- DHW system
- Gen efficiency heating
- heating type of fuel

The excel file created reads if the characteristics are different between the two scenarios and calculates the cost of the intervention

The costs of the interventions have been calculated as follows for each building:

- Wall insulation = MITE cost [€/m2] * dispersing surface
- Roof insulation = MITE cost [€/m2] * footprint area
- Windows substitution = MITE cost [€/m2] * finished surface area (surface Dispersant*glazing ratio)
- DHW substitution (**)= Average price DHW HP [€] * n DHW HP per building (total floor area/average area served by a DHW HP)
- Heating HP (**) = HP price [€/kWt] * Thermal kW (sum of kWh per year/hours

The cashflows for the 2030 and 2050 scenarios have these assumptions:

- O&M costs of 1% of total plant intervention costs
- a percentage of costs saved due to the switch to electric
- an initial investment of 60% of the total cost
- a loan to cover the remaining part of the 10-year cost with an interest rate of 2%
- a tax break of 75% over 10 years

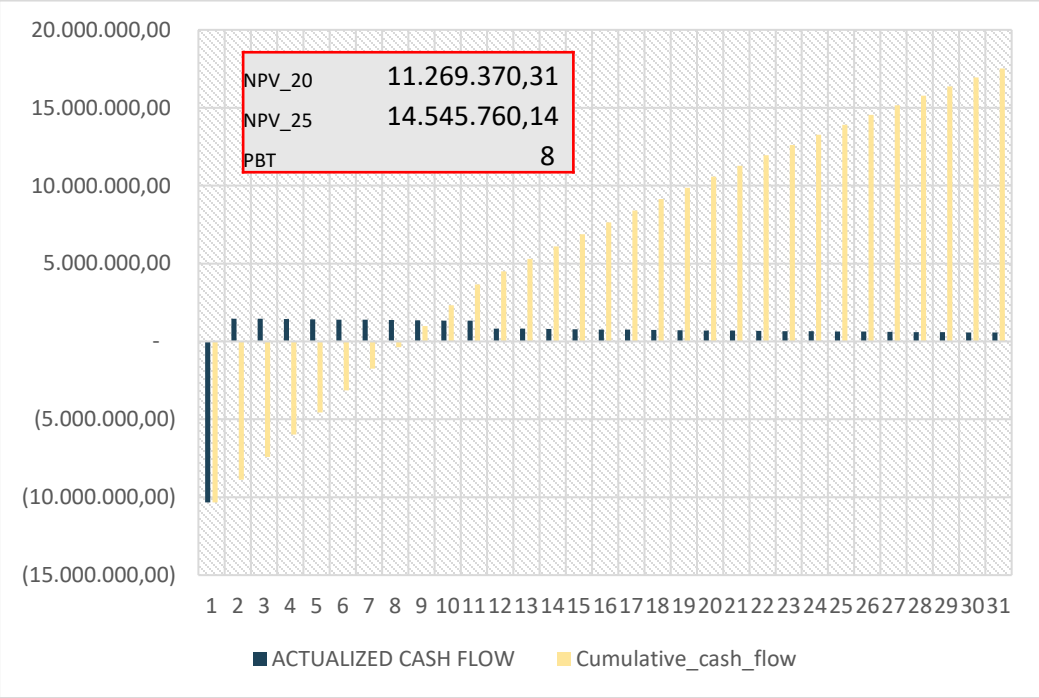
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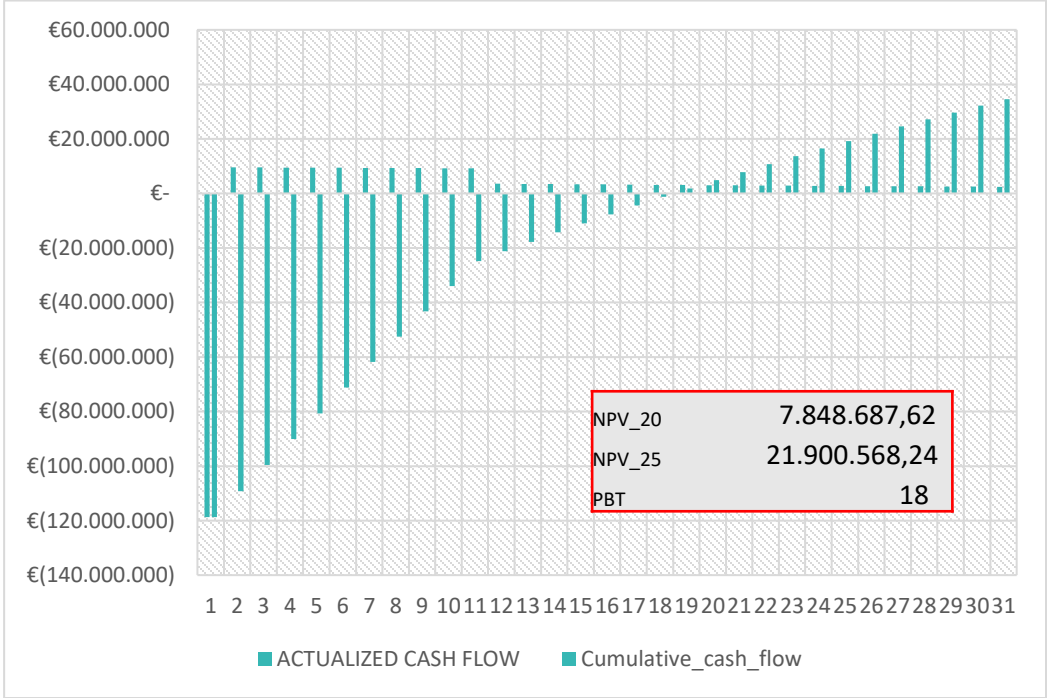
• Economic assessment

decreto MITE	
isolamento coperture	
copertura ventilata	300€/m2
pareti perimetrali	
esterno/diffusa	180€/m2
sostituzione chiusure trasparenti	
serramento	780€/m2
impianti di riscaldamento con caldaie ad acqaua a condensazione e/o generatori di aria alda a condensazione	
Pnon <= 35 kWt	240€/m2
Pnom > 35 kWt	216€/m2
impianti con pompe di calore	
aria/aria	€/kW 720t
geotermica	€/kW 2280t
ACS con pompa di calore	
con accumulo <= 150l	1200€
con accumulo >150l	1500€

2030



2050



Per il calcolo dei cashflow sono stati considerati
- costi di O&M dell 1% rispetto ai costi totali di intervento sugli impianti
- una percentuale di costi risparmiati dovuti al passaggio all'elettrico
- un investimento iniziale pari al 60% del costo totale
- un prestito per coprire la restante parte del costo di 10 anni con tasso di interesse al 2%
- un agevolazione fiscale del 75% in 10 anni

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Udine

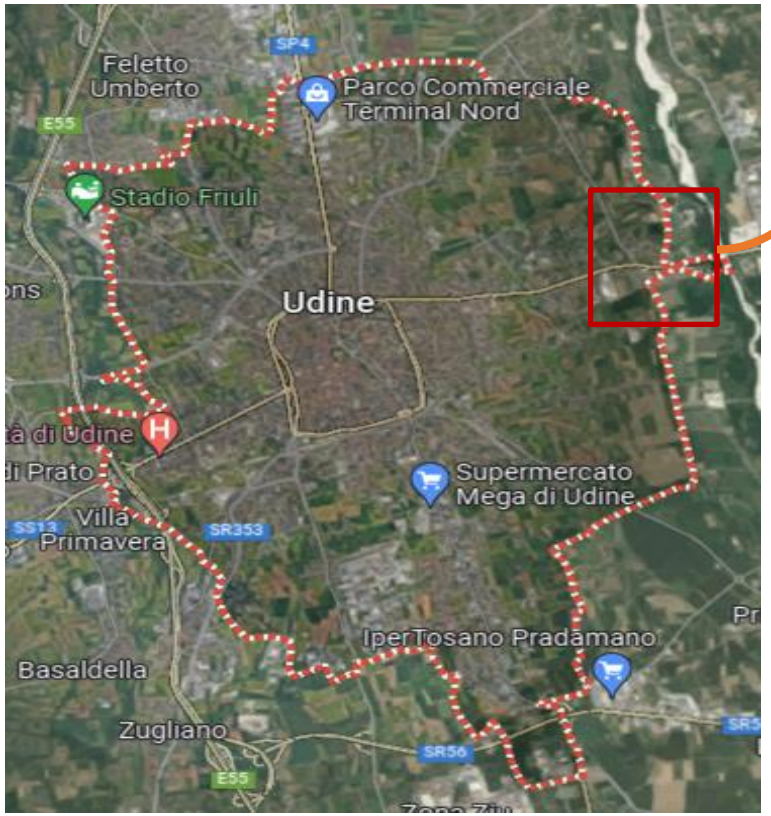
The municipality of Udine refurbished thanks to the SuperEcoBonus 110 incentive a residential area composed of condominiums of the ATER (Azienda Territoriale per l'edilizia residenziale di Udine) and some nearby facilities.

Udine: 57,17 km²

Inhabitants: 97 841

Specific area of interest: 134 400 m² (2 Schools, 1 Shopping mall, 7 Apartment blocks)

Inhabitants: around 1000 (405 Apartments)





Starting from .cad drawings and Building data

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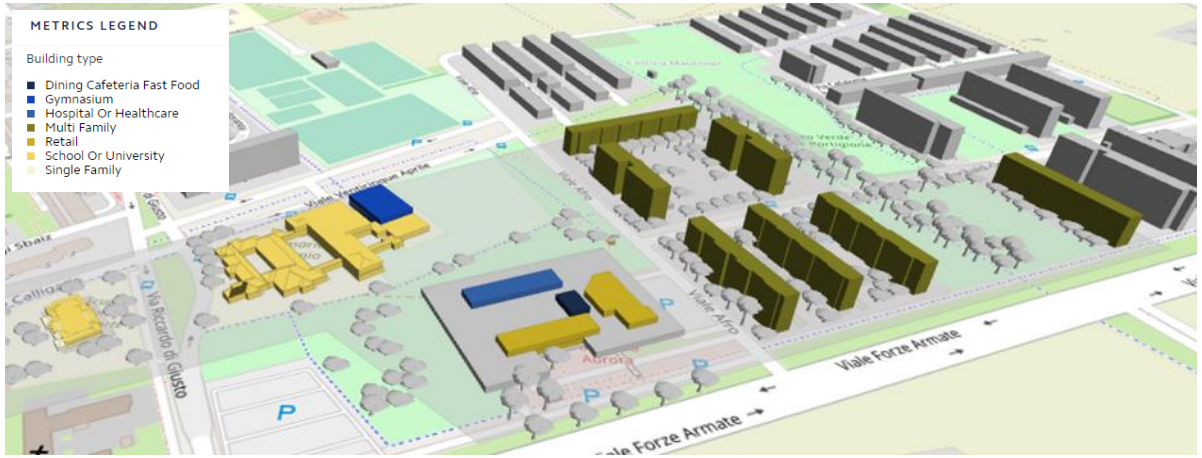
Udine

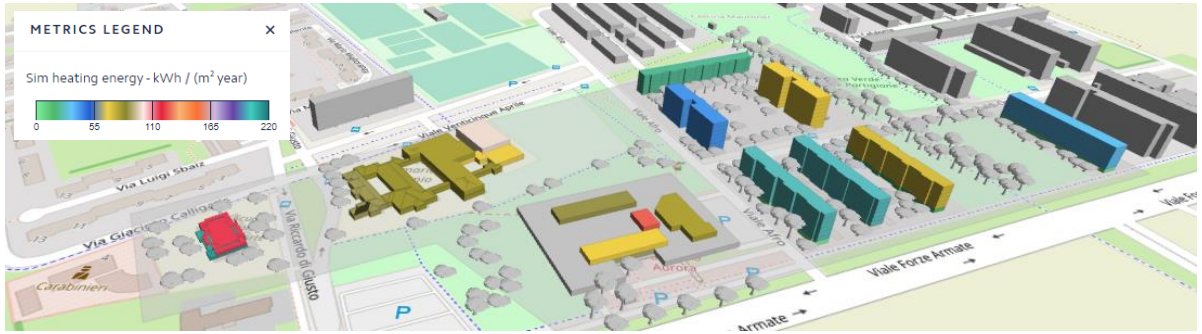
Model set up from iCD plugin in Sketchup:



Visualization from iCIM webpage

https://icim.iesve.com/trial/#/metrics-viewer/94cd0d00-635f-4631-b0ba-a4bb5bd76854

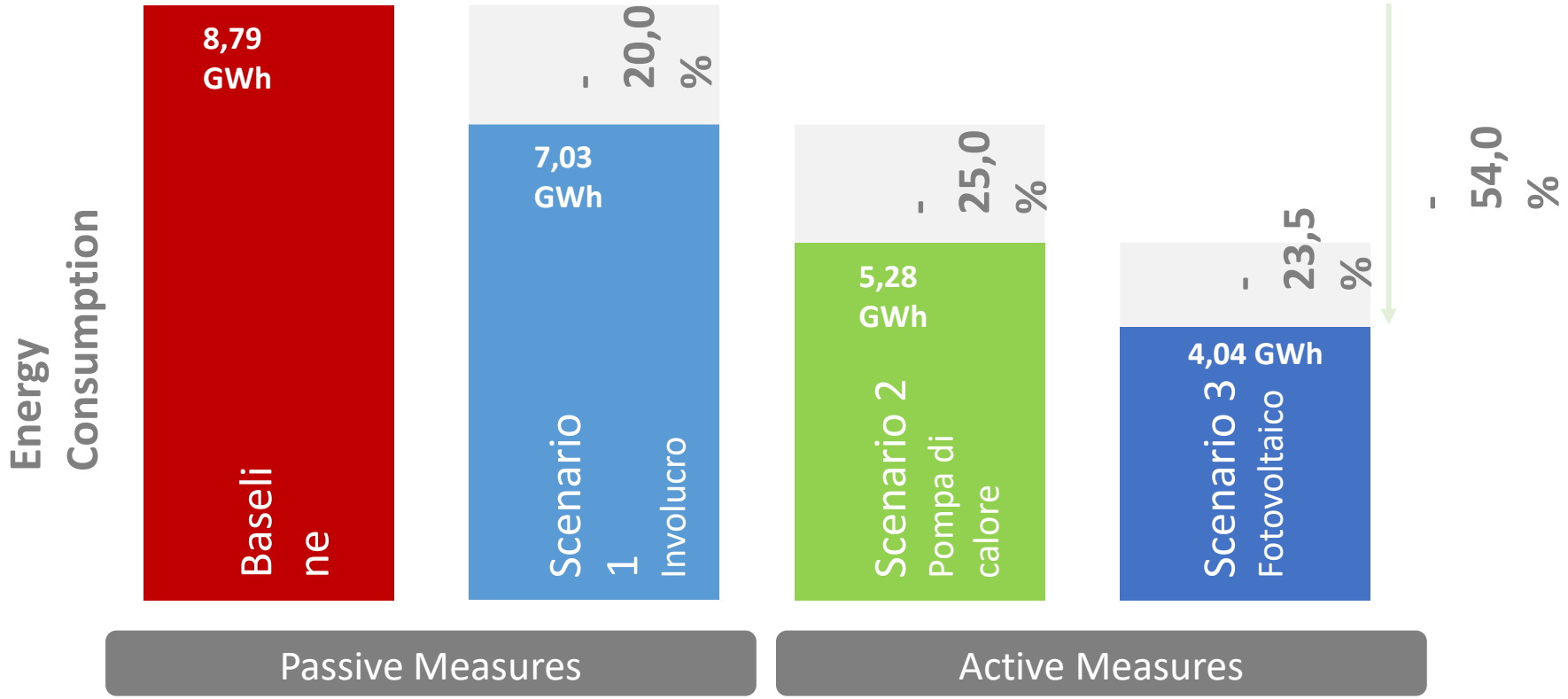




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Udine – PEB Methodology application



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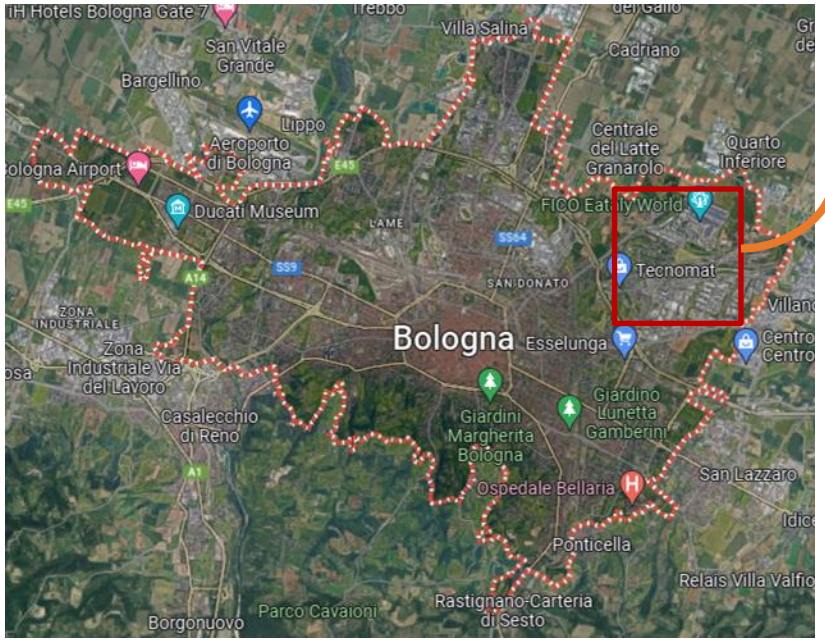
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Bologna

Pilastro-Roveri is the area studied in the Greta EU project, Green Energy Transition Actions. The intent was to make Pilastro - Roveri area an area pioneering the process of climate neutrality that cities and citizens are called to undertake by 2030.

Bologna: 140, 86 km²

Inhabitants: 388 171



Specific area of interest: 1080 Buildings (7 750 218,48 m²)

Inhabitants: around 23 000



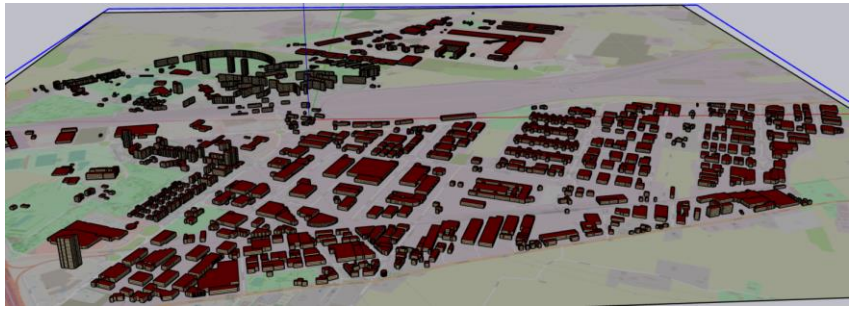
Starting from GIS FILE

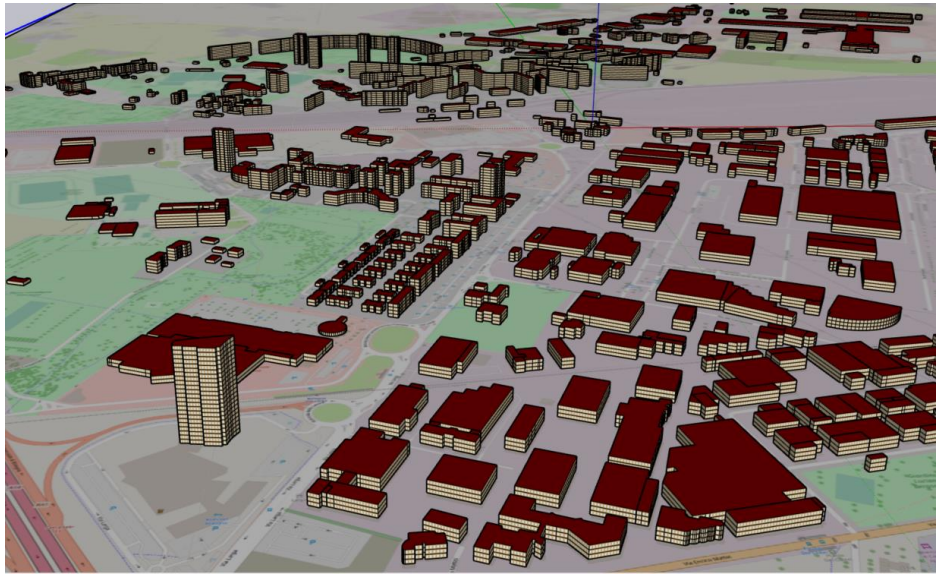
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Bologna – Neighborhood Pilastro Roveri

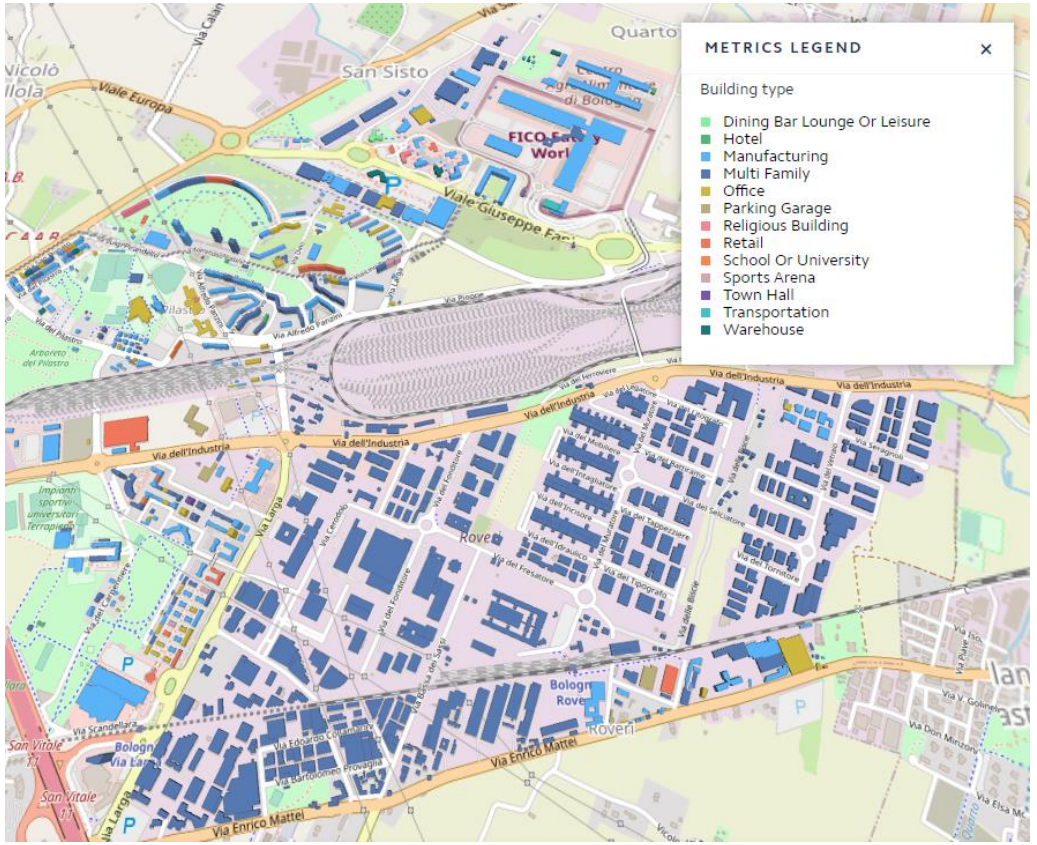
Model set up from iCD plugin in Sketchup:





Visualization from iCIM webpage

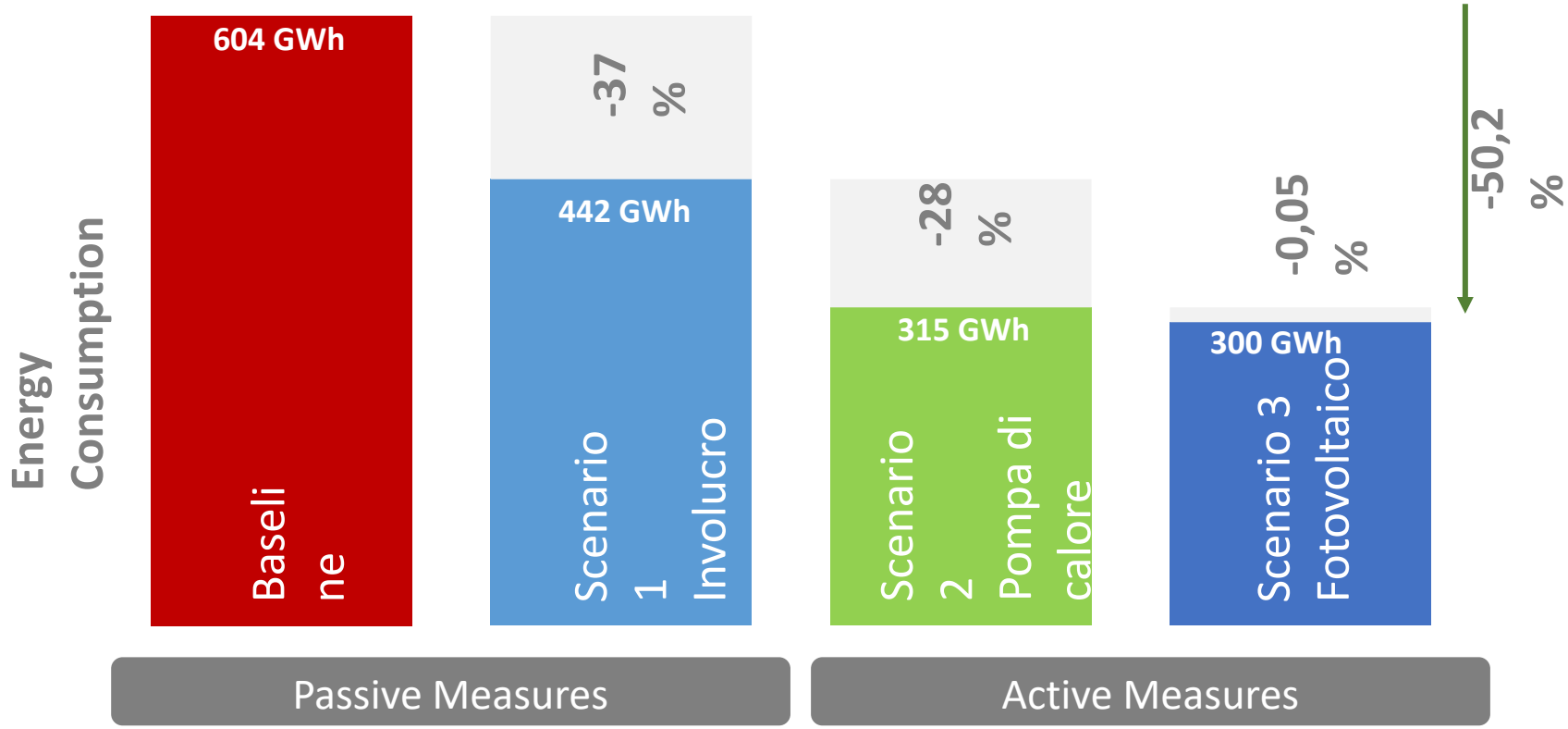
https://icim.iesve.com/trial/#/metrics-viewer/68127d7f-1323-4cab-8a9b-a727f97d6721


METRICS LEGEND
Building type
Dining Bar Lounge Or Leisure
Hotel
Manufacturing
Multi Family
Office
Parking Garage
Religious Building
Retail
School Or University
Sports Arena
Town Hall
Transportation
Warehouse
Quarto
San Sisto
Viale Europa
Viale Giuseppe Fanin
Via dell'Industria
Via Enrico Mattei
Via Larga
Via del Fresenore
Via del Frassinaro
Via del Fornasino
Via del Fondatore
Via del Fornace
Via del Fabbro
Via del Fattore
Via del Fienile
Via del Fiordaliso
Via del Fiorone
Via del Fiorista
Via del Fiume
Via del Fontanino
Via del Fornaio
Via del Fornello
Via del Fornitore
Via del Fotografo
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This project has received funding from the European Union's LIFE Programme for Research and Innovation under Grant Agreement no. 101120859

Co-funded by the European Union

Bologna Pilastro – PEB Methodology application



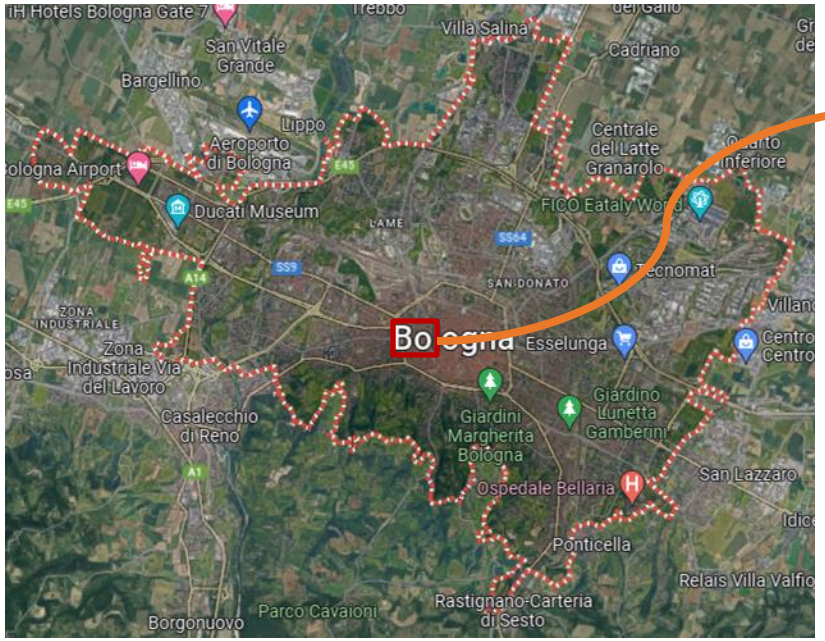
This project has received funding from the European Union's LIFE Programme for Research and Innovation under Grant Agreement no. 101120859

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Bologna – Centro

Bologna: 140, 86 km²

Inhabitants: 388 171



Specific area of interest: 54 Buildings (57 519 m²)

Inhabitants: around 1 000



Starting from Shape File

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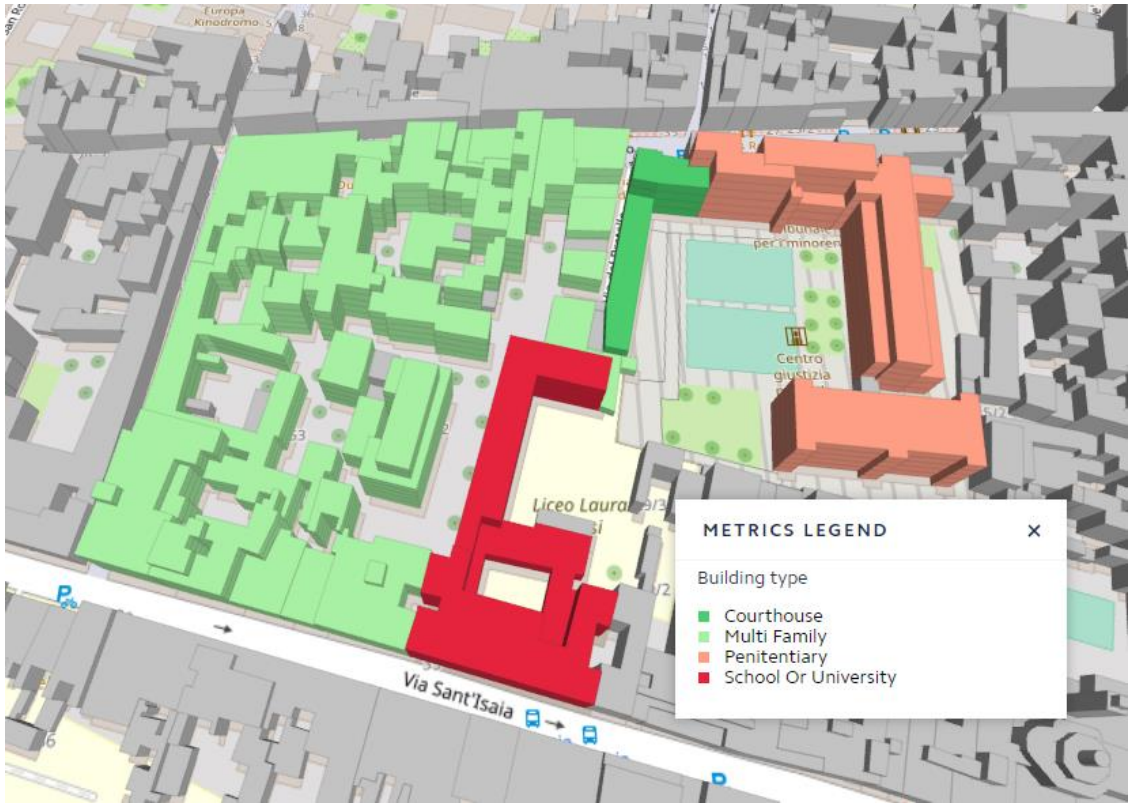
Bologna – Centro

Model set up from iCD plugin in Sketchup:



Visualization from iCIM webpage

LINK ICM

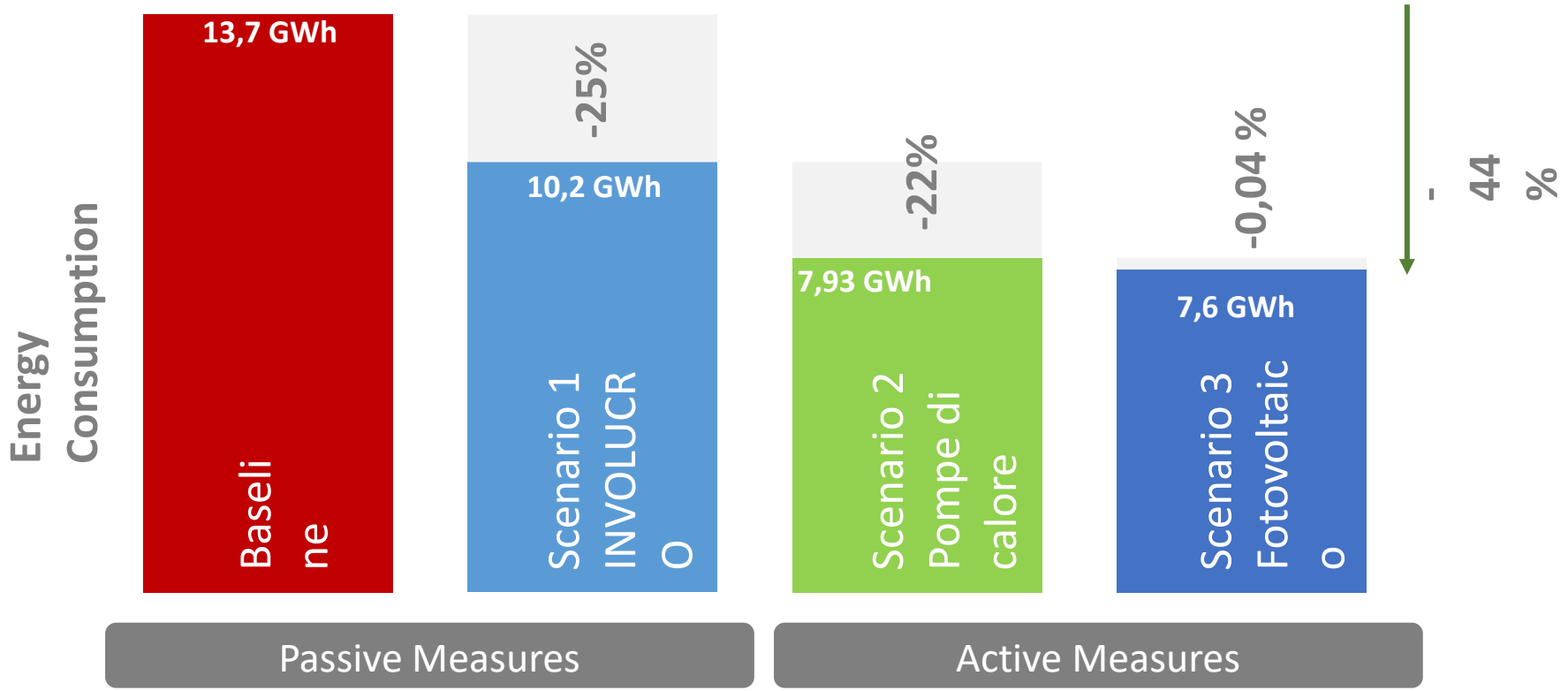


Building Type *(view from iCIM)*

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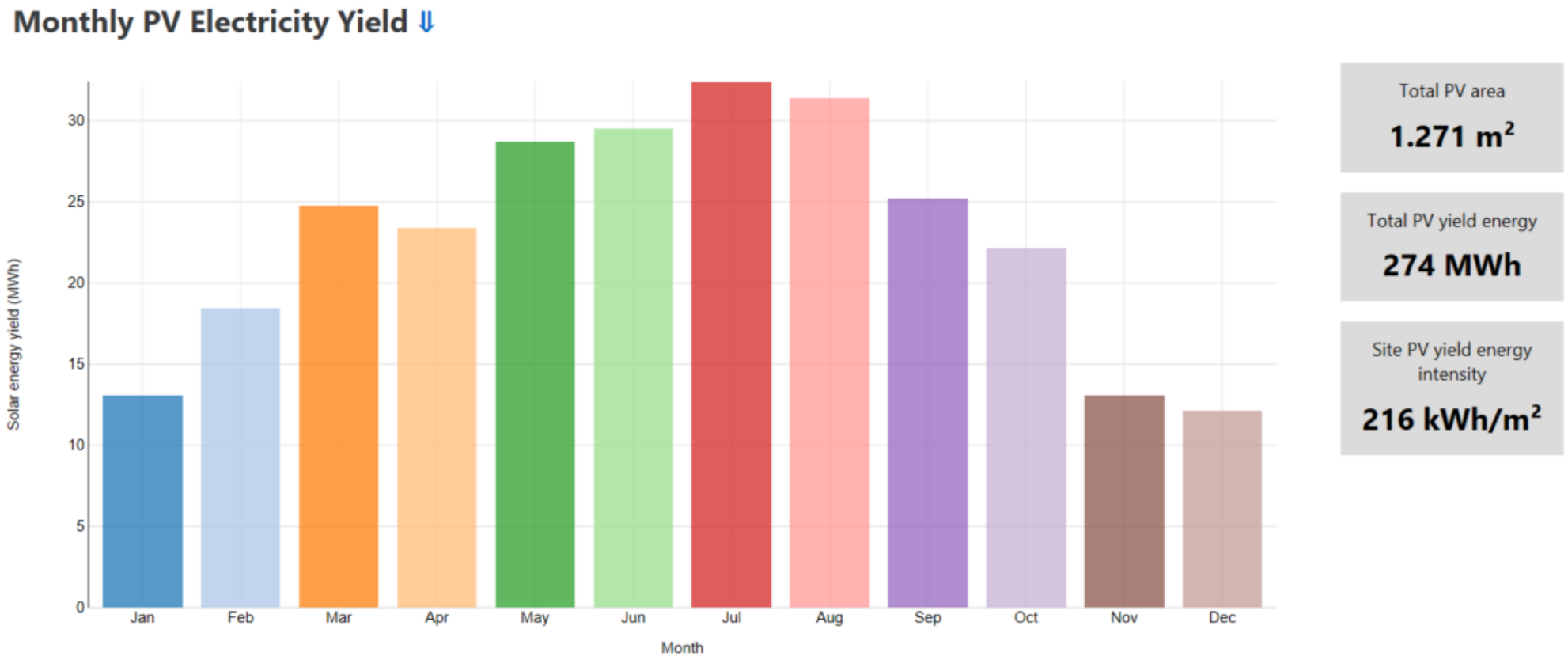
Bologna Centro – PEB Methodology application



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Bologna – Monthly PV Electricity Yield



Total PV area

1.271 m²

Total PV yield energy

274 MWh

Site PV yield energy intensity

216 kWh/m²

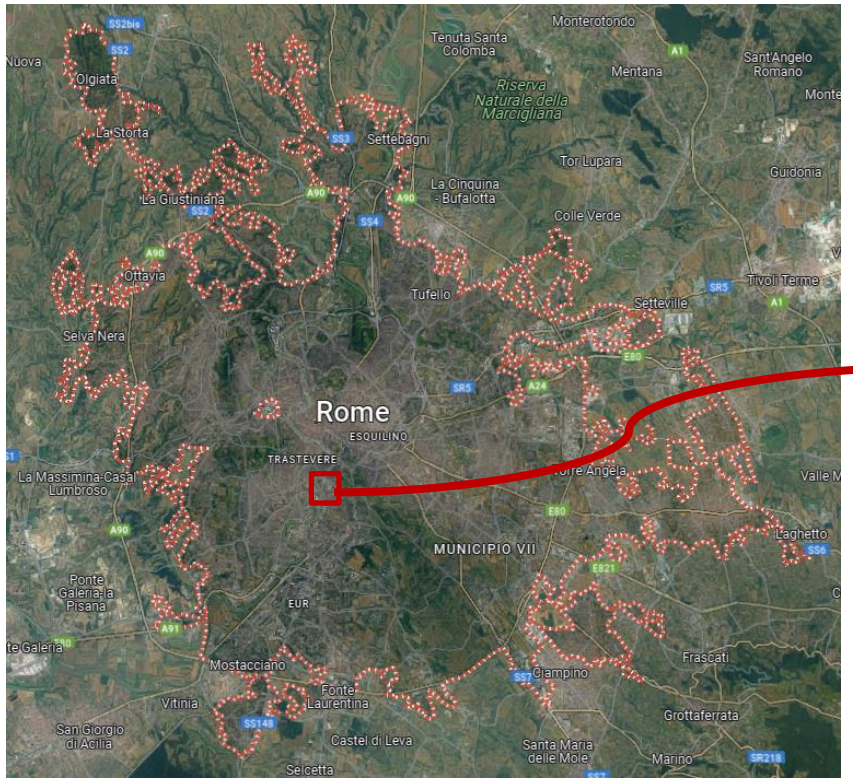
This project has received funding from the European Union's LIFE Programme for Research and Innovation under Grant Agreement no. 101120859

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Roma

Roma: 1 287,36 km²

Inhabitants: 2 745 777



Specific area of interest: around 660 696 m²

Inhabitants: around 7 610

Buildings: 155



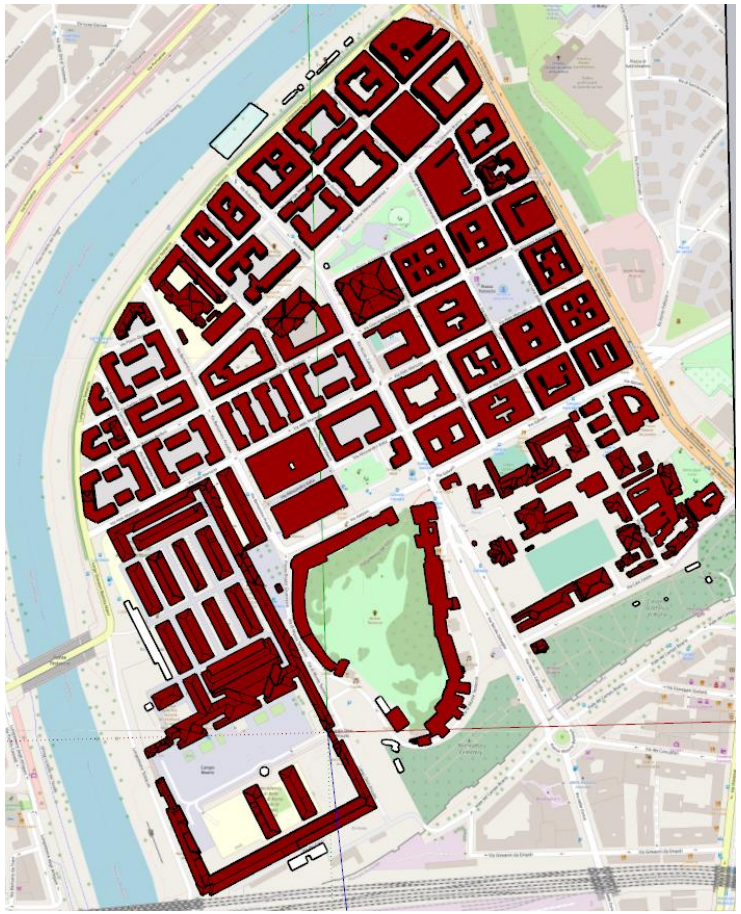
Starting from GeoJSON

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Roma

Model set up from iCD plugin in Sketchup:



Visualization from iCIM webpage

https://icim.iesve.com/trial/#/metrics-viewer/265cbfc3-153a-447d-a858-f6dbcfe5a816

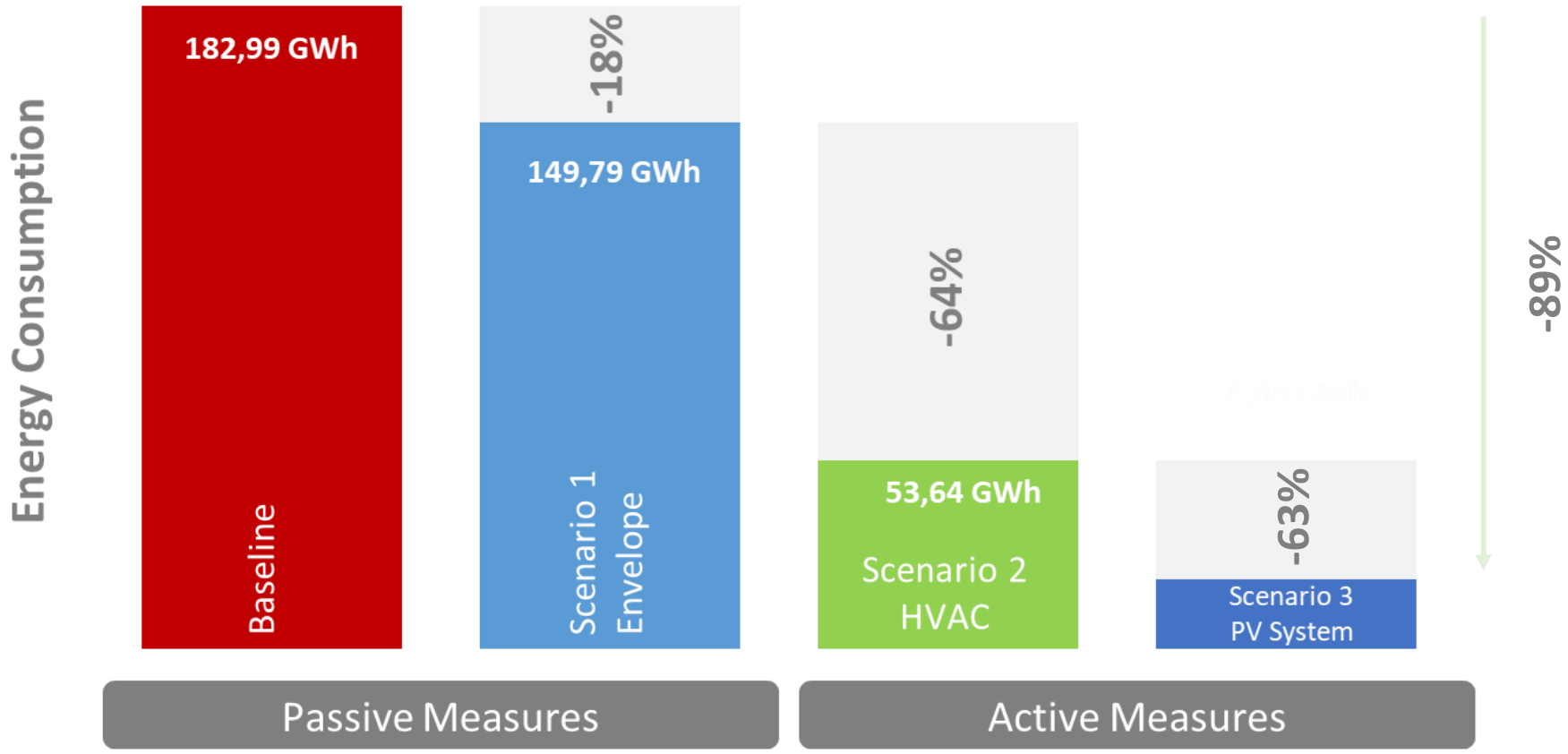




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Roma – PEB Methodology application



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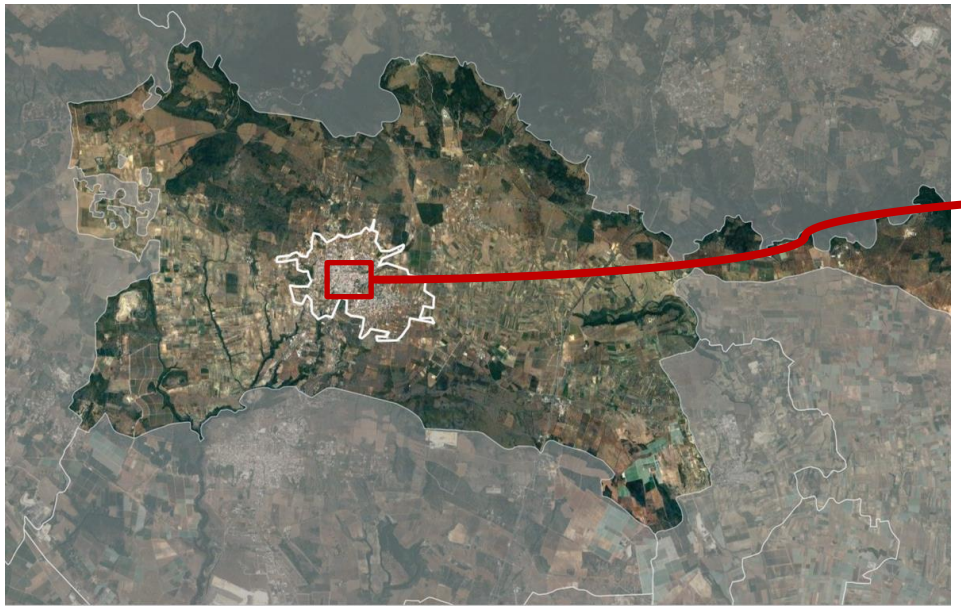
Co-funded by the European Union

Crispiano

Crispiano, Project of pilot sites

Crispiano: ~111 km²

Inhabitants: 13 770



Specific area of interest: ~ 16 000 m² (7 Buildings: 1 municipal building, 1 library, 2 schools, 2 offices, 1 sport center)
Occupancy: ~750 people/day



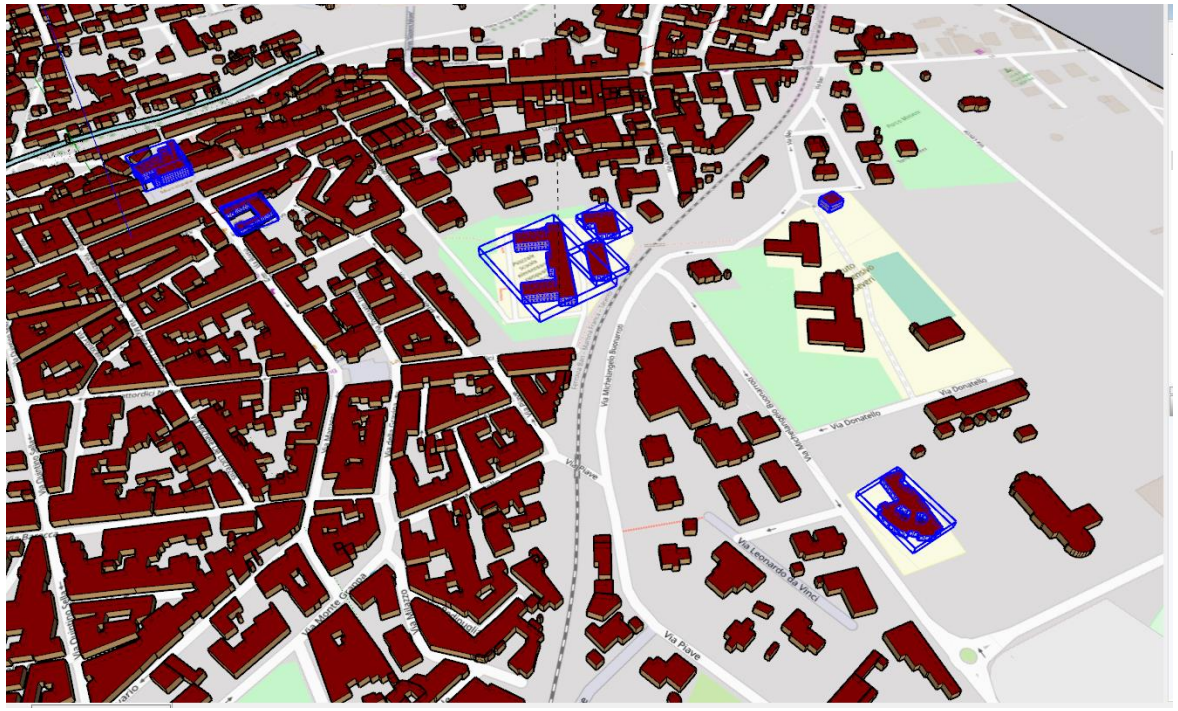
Starting from OSM

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Crispiano

Model set up from iCD plugin in Sketchup:



Visualization from iCIM webpage

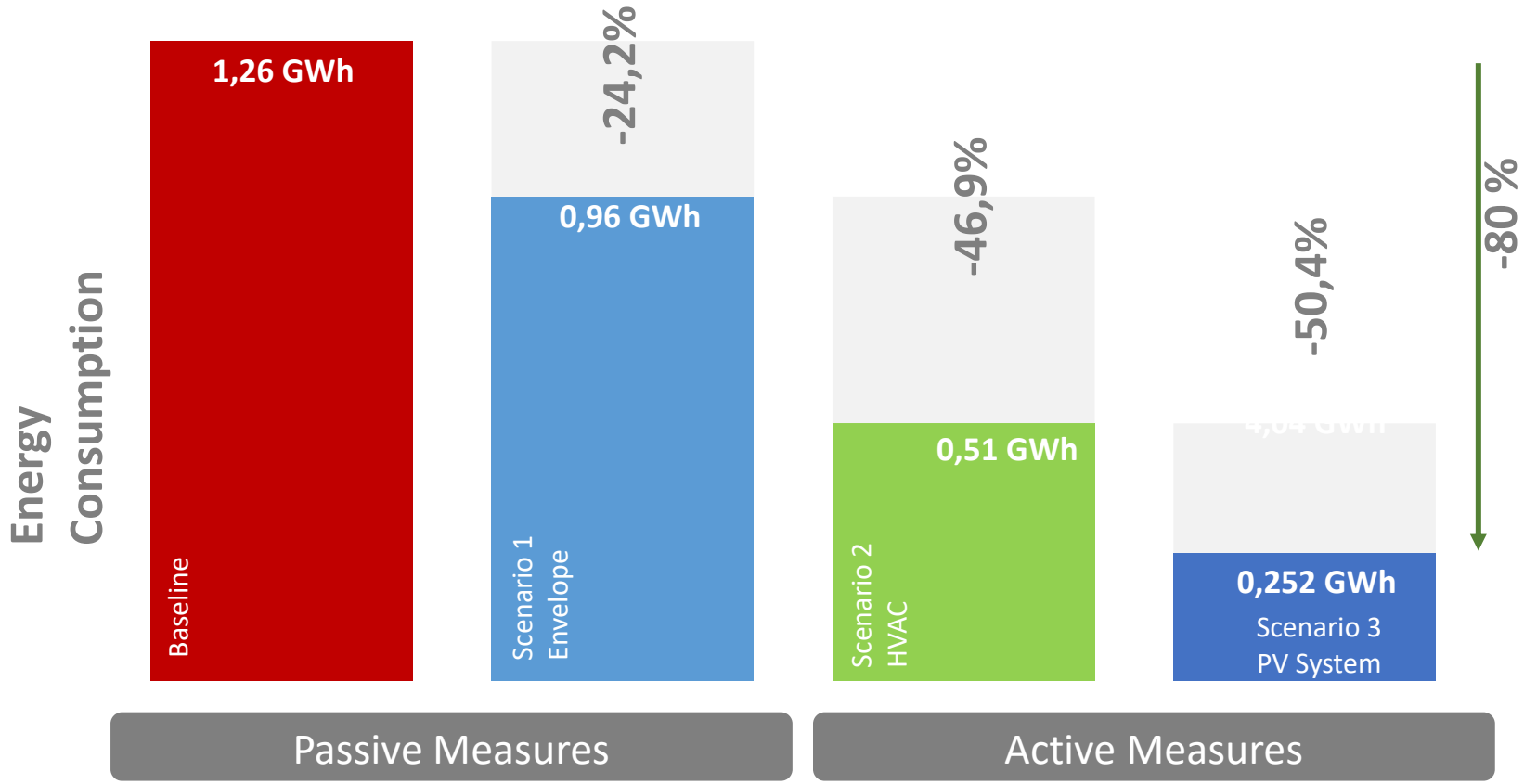
LINK ICM



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Crispiano – PEB Methodology application



2 – Roadmap towards a Positive Energy District in the Industrial Zone of Padova

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Roadmap towards a Positive Energy District in the Industrial Zone of Padova

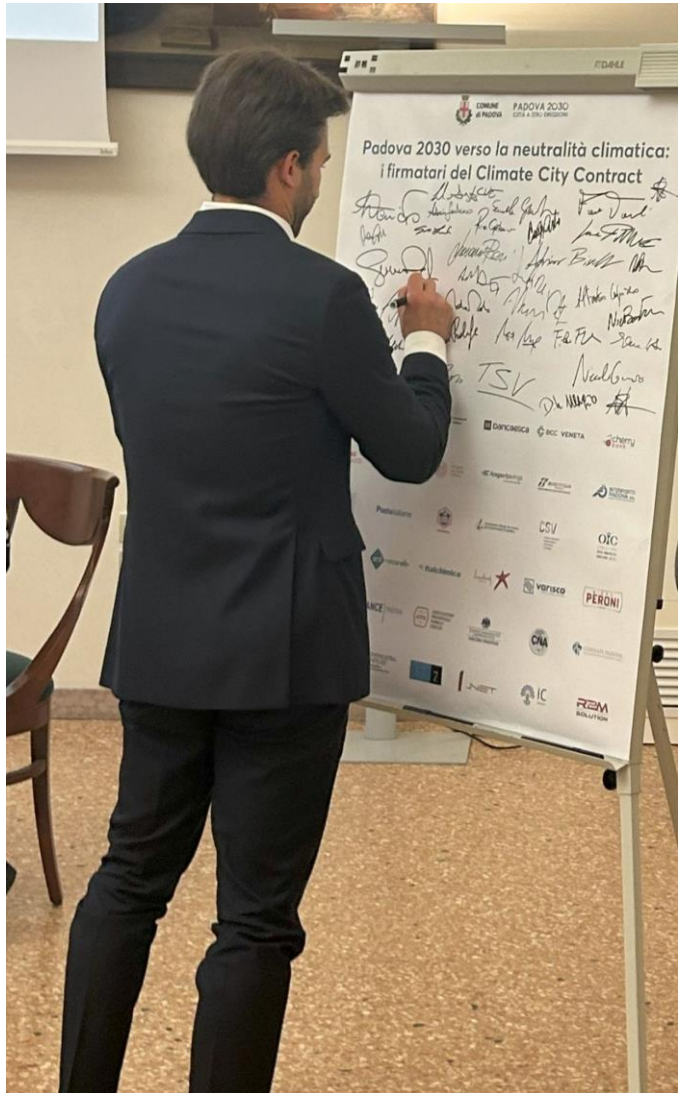
22 October 2025

Davide Quaggiotto | davide.quaggiotto@r2msolution.com

With the support of the European Union's Horizon 2020 research and innovation programme under grant agreement SCALABLE CITIES-202-PADOVA

Padova Climate City Contract

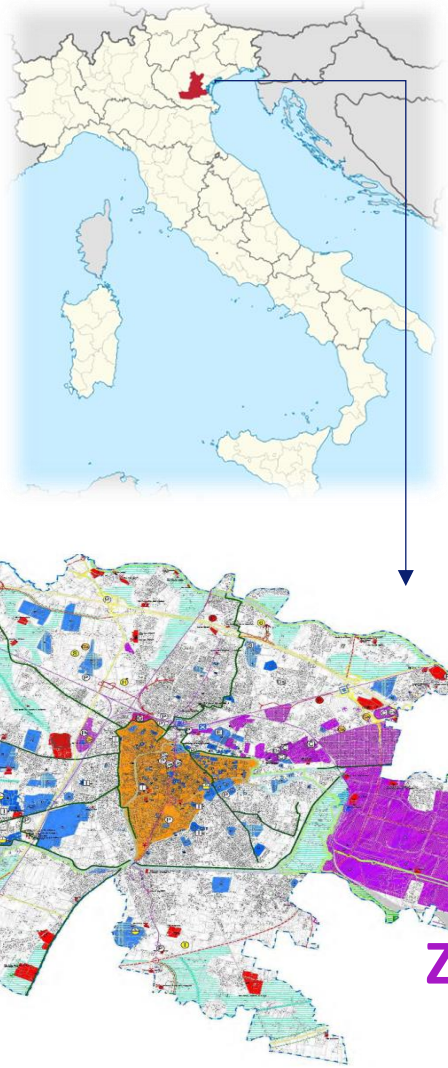




PADOVA 2030
CITTÀ A ZERO EMISSIONI

R2M Solution has signed the **Climate City Contract** of the city of **Padova**

+PADOVAxCHANGE objective



Development of a **Digital Twin (DT)** of the **Industrial Zone (ZI) of Padova** to **simulate decarbonization scenarios**, which include:

1. The **reduction of final electricity and gas consumption** through **energy efficiency measures**;
2. The increase in the production of **renewable energy** (photovoltaic) for the entire area;
3. The **recovery of waste heat** through a **district heating network**.

With the final goal of achieving a **positive energy district (PED)**

PADOVA 2030
CITTÀ A ZERO EMISSIONI

Padova Industrial Zone

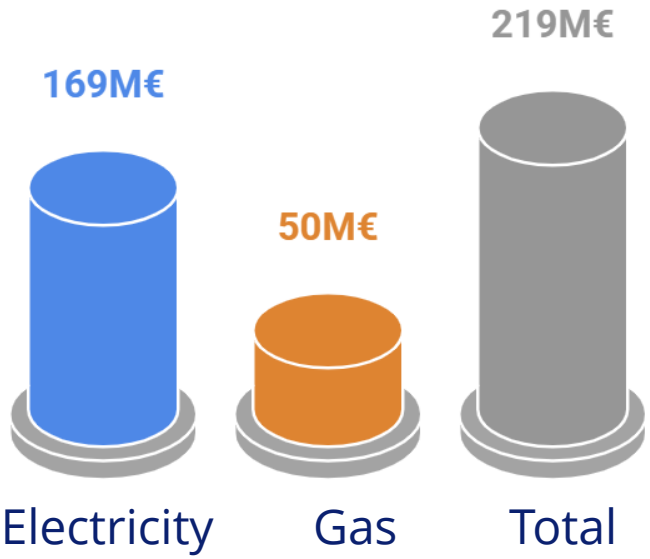
Final energy consumption [GWh]

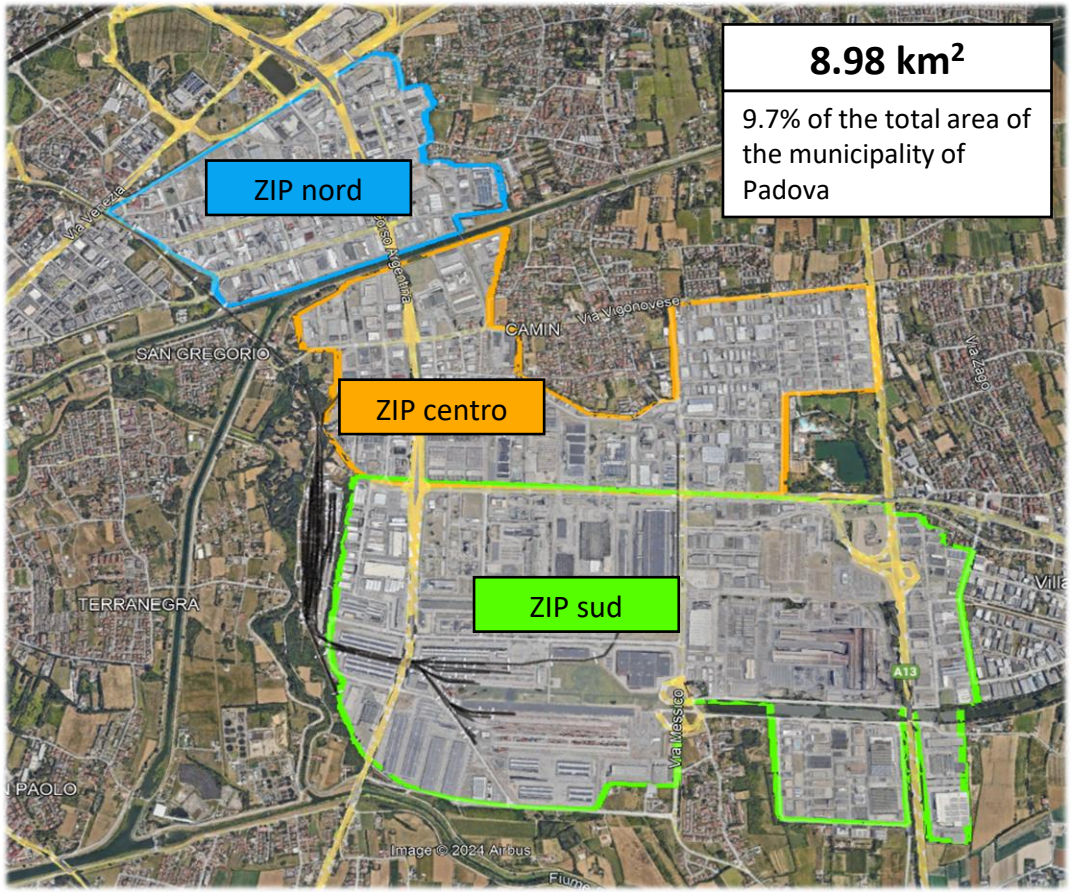
Year	TOT	Electric	Gas
2022	1290	724	565

Emissions [tCO2]

Year	TOT	Electric	Gas
2022	329000	214754	113873

Industrial Zone Bill





1 Data about the municipality of Padova
2 Calculated with annual CO2 shares and factors (ISPRA)
3 Equivalent to the emissions of approximately 183,000 cars in a year.
(15000 km/year, 120 gCO2/km)

Methodology

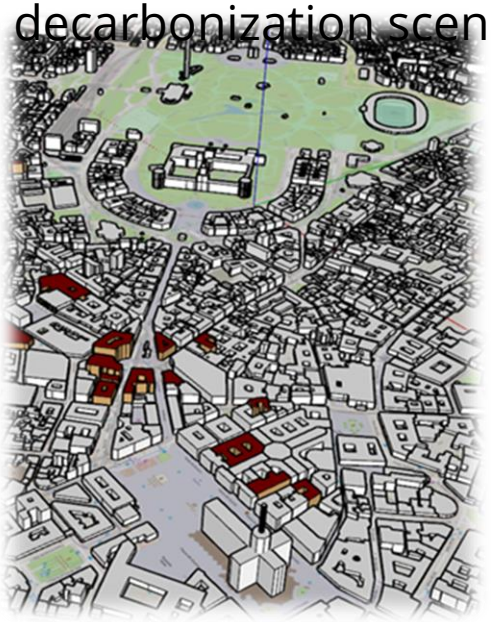
Tools

ICL - Intelligent Communities Lifecycle



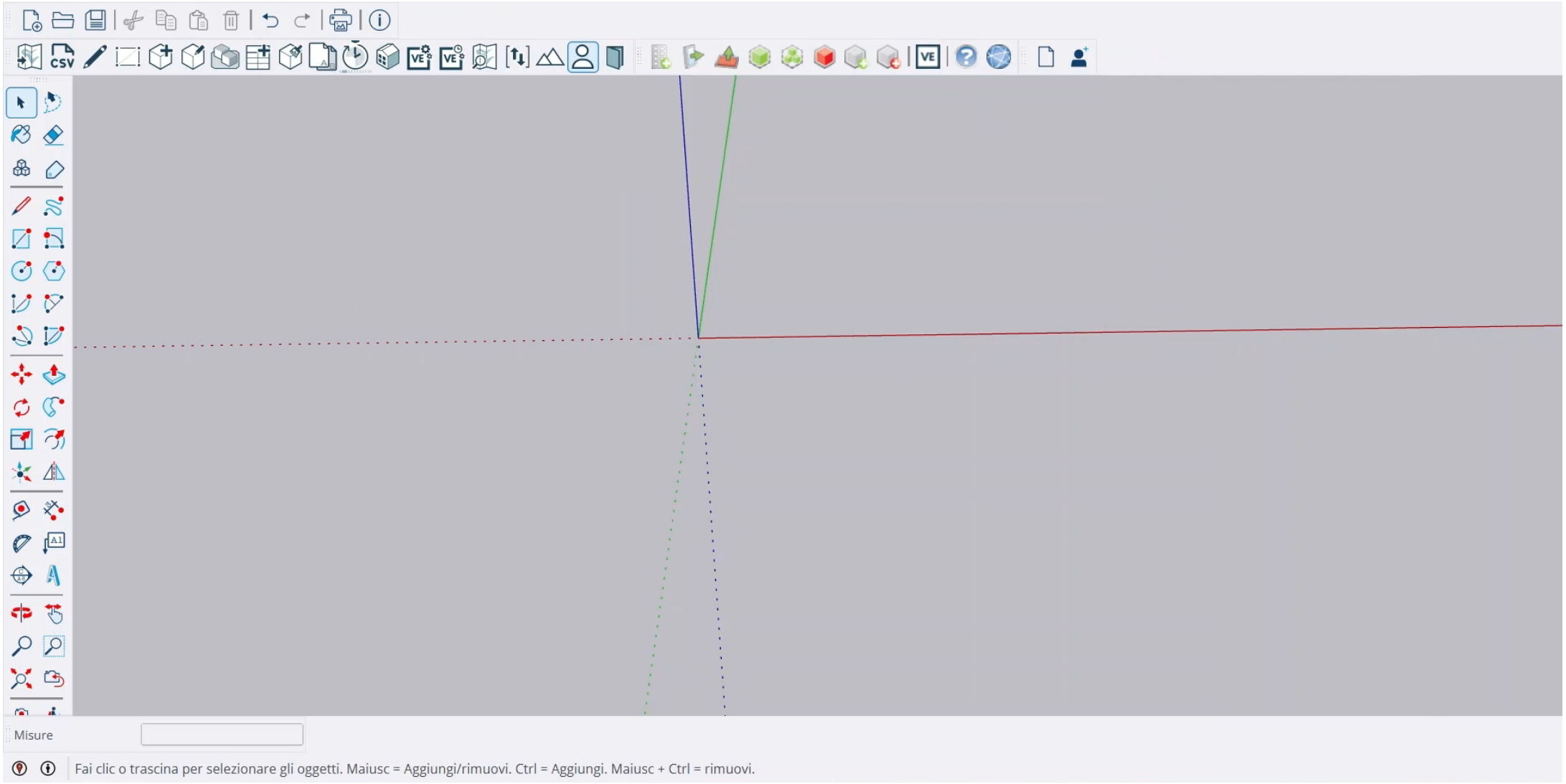
The ICL suite allows to plan and evaluate the energy performance of a **single building** or **urban district**

With iCD it is possible to develop dynamic 3D models of large districts, simulating decarbonization scenarios





Import geometry from OpenStreetMap (iCD)



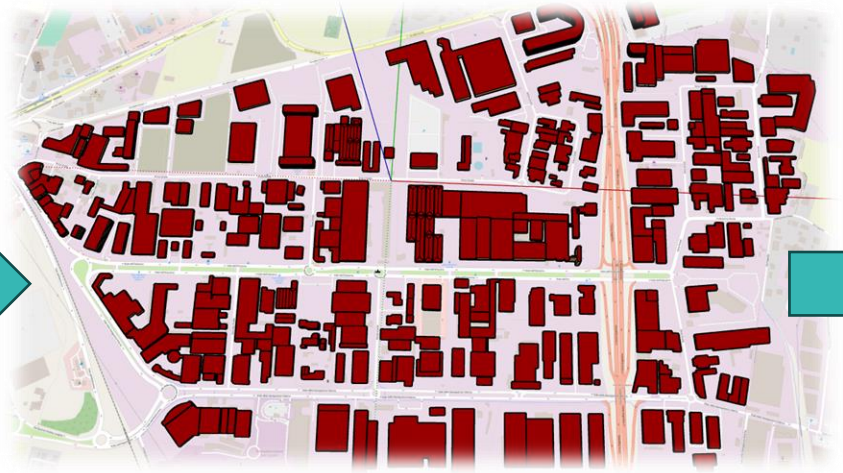
Digital Twin Development

Geometric data imported from **OpenStreetMap** and refined using **Google Earth** and **Lidar data** from the database of the Municipality of Padova

Baseline model



LIDAR Data
(Credit: Comune di Padova)



Digital twin for various retrofit scenarios



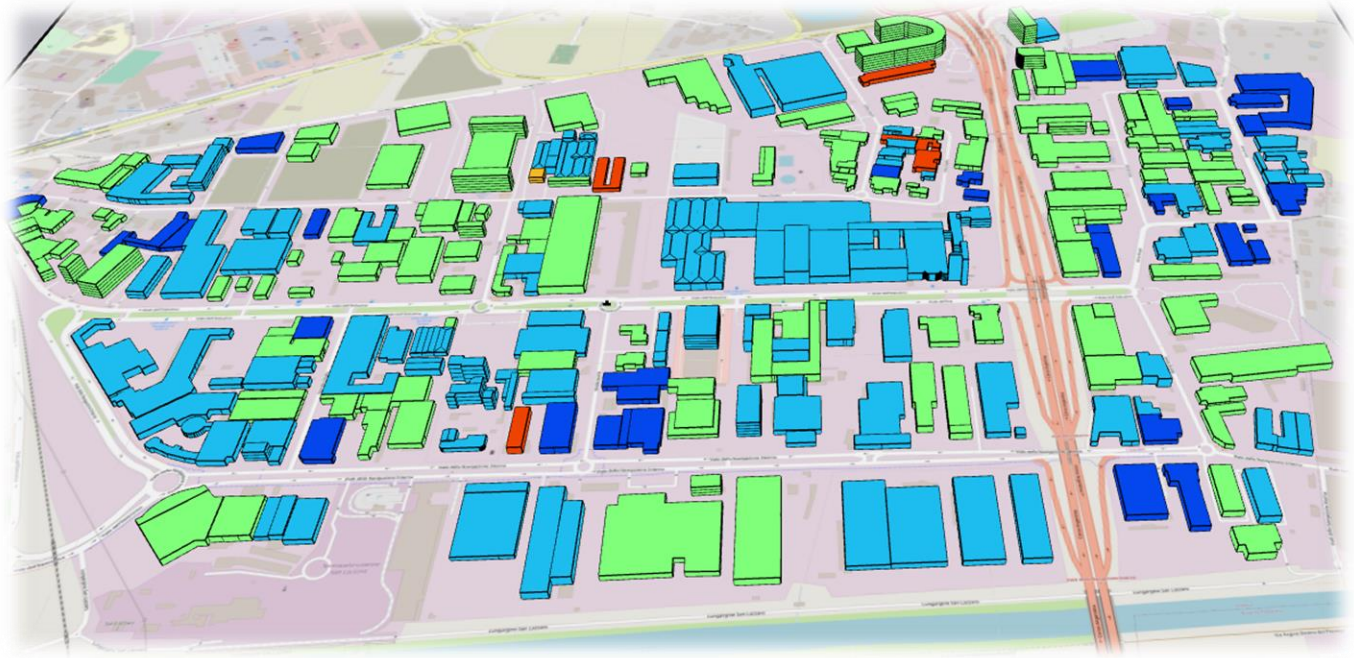
Digital twin for DHN



Definition of archetypes

Georeferenced data about the business activity of buildings provided by the Padova Chamber of Commerce

- Retail
- Logistics
- Offices
- Manufacturing



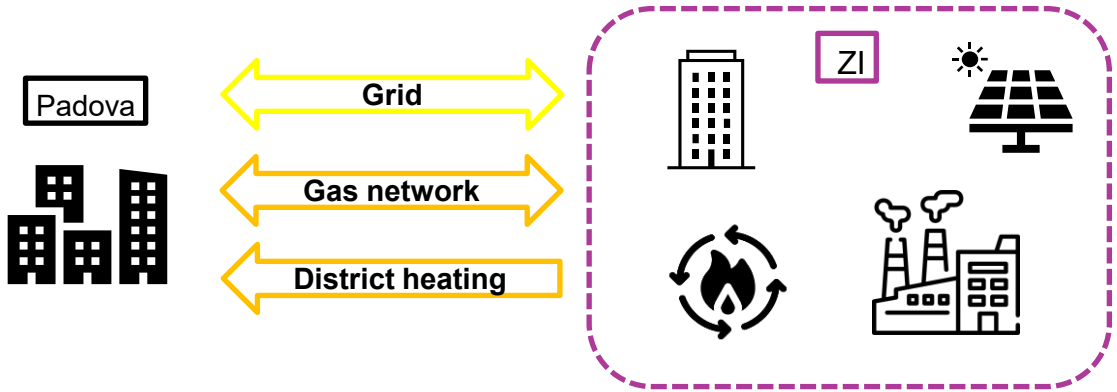
Italian statistical data on average consumption by type of industrial process (ISTAT)

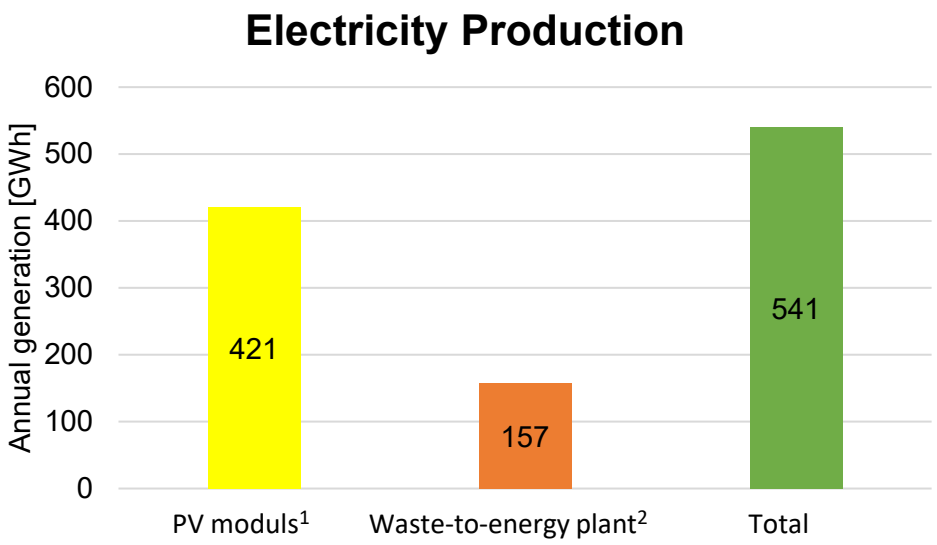
Decarbonisation scenarios

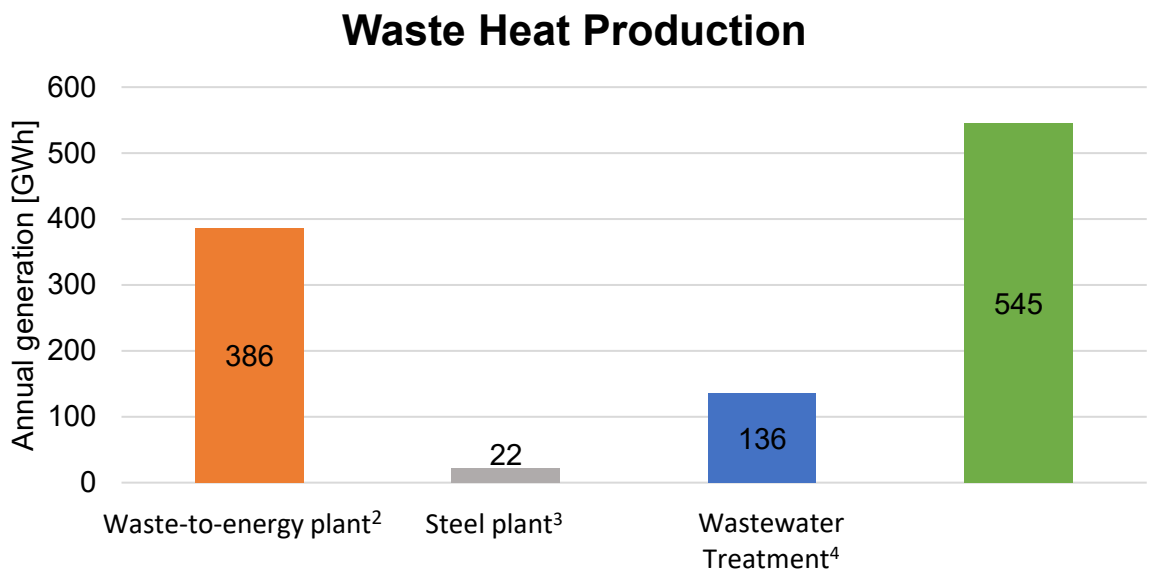
- 💡 Efficiency of lighting plants (LED)
- 🏠 Reduction of consumption for heating (insulation measures, window replacement)
- 🔌 Electrification of consumption for heating (HP)
- 🌞 Energy generation from renewable sources (photovoltaic)
- 🔥 Use of excess heat (district heating network)

Simulation results of decarbonisation scenarios

Internal energy generation Industrial Zone



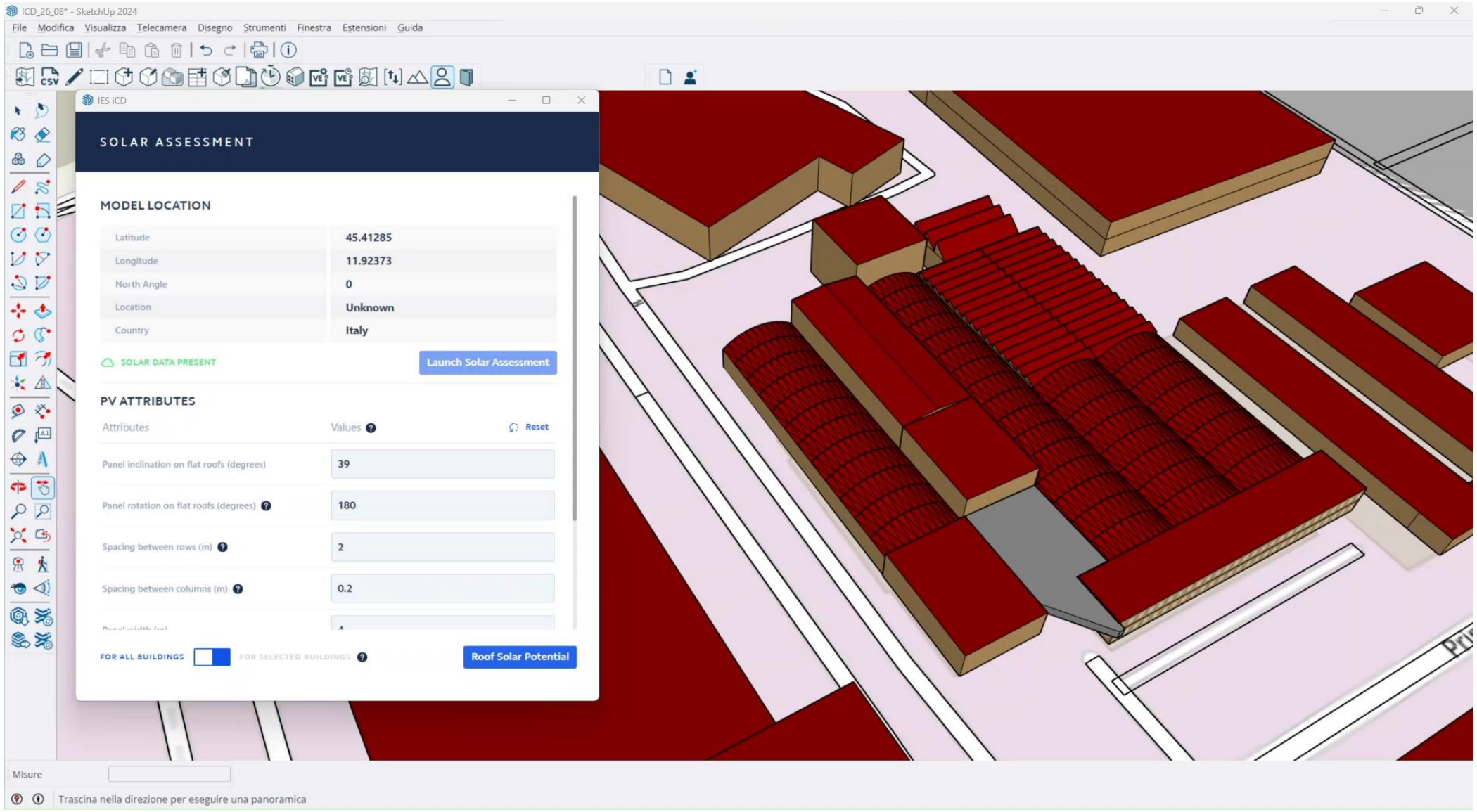




1 Considering an installed capacity of 316 MW (currently 20 MW)
2 Data HERAmbiente and sEEnergies

3 At a temperature of 95°C
4 At a temperature of 85°C with HP

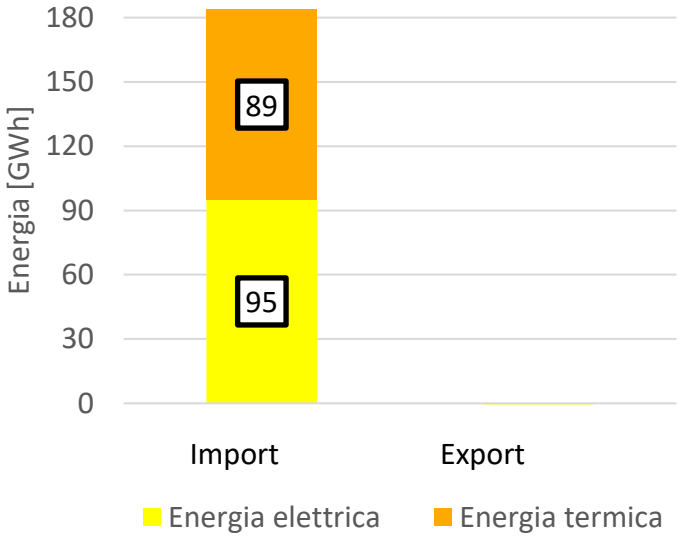
Potential of PV moduls



Roadmaps

PED

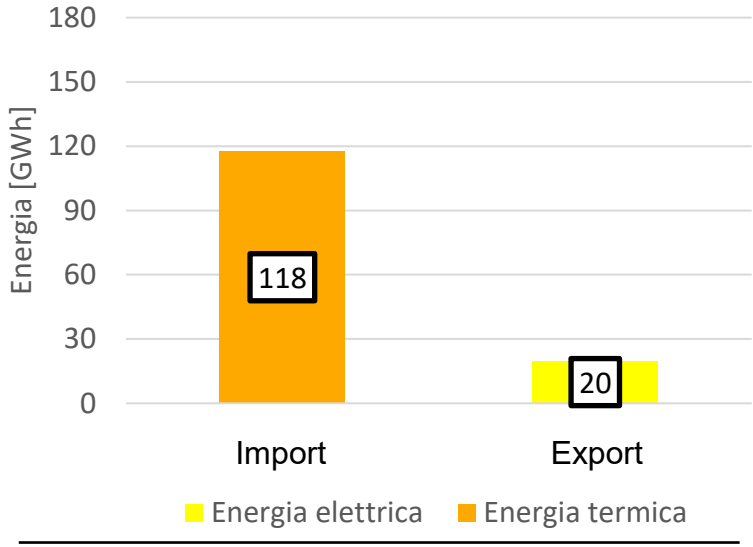




CAPEX (M€)	Annual bill savings (M€)	Payback (years)	Jobs generated*
1597	124	12.8	19402

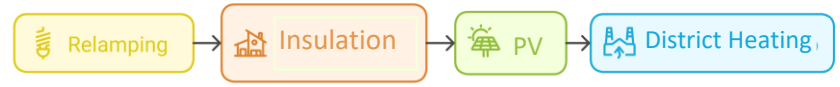
PED

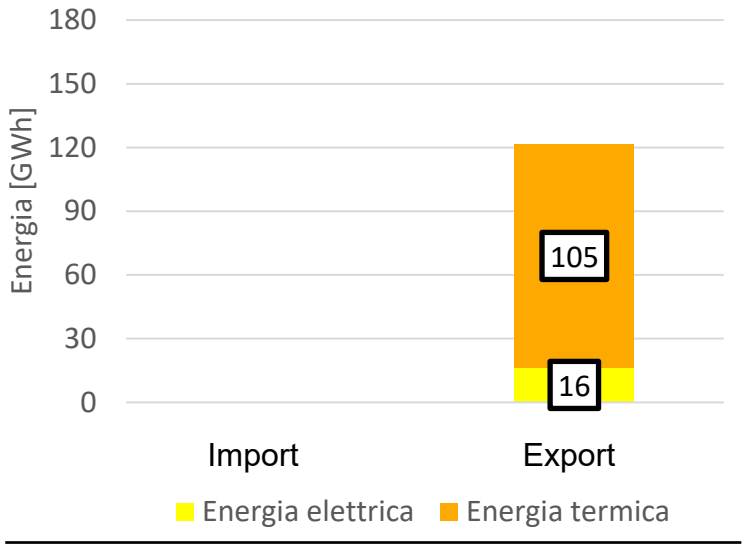




CAPEX (M€)	Annual bill savings (M€)	Payback (years)	Jobs generated*
496	209	2.4	6021

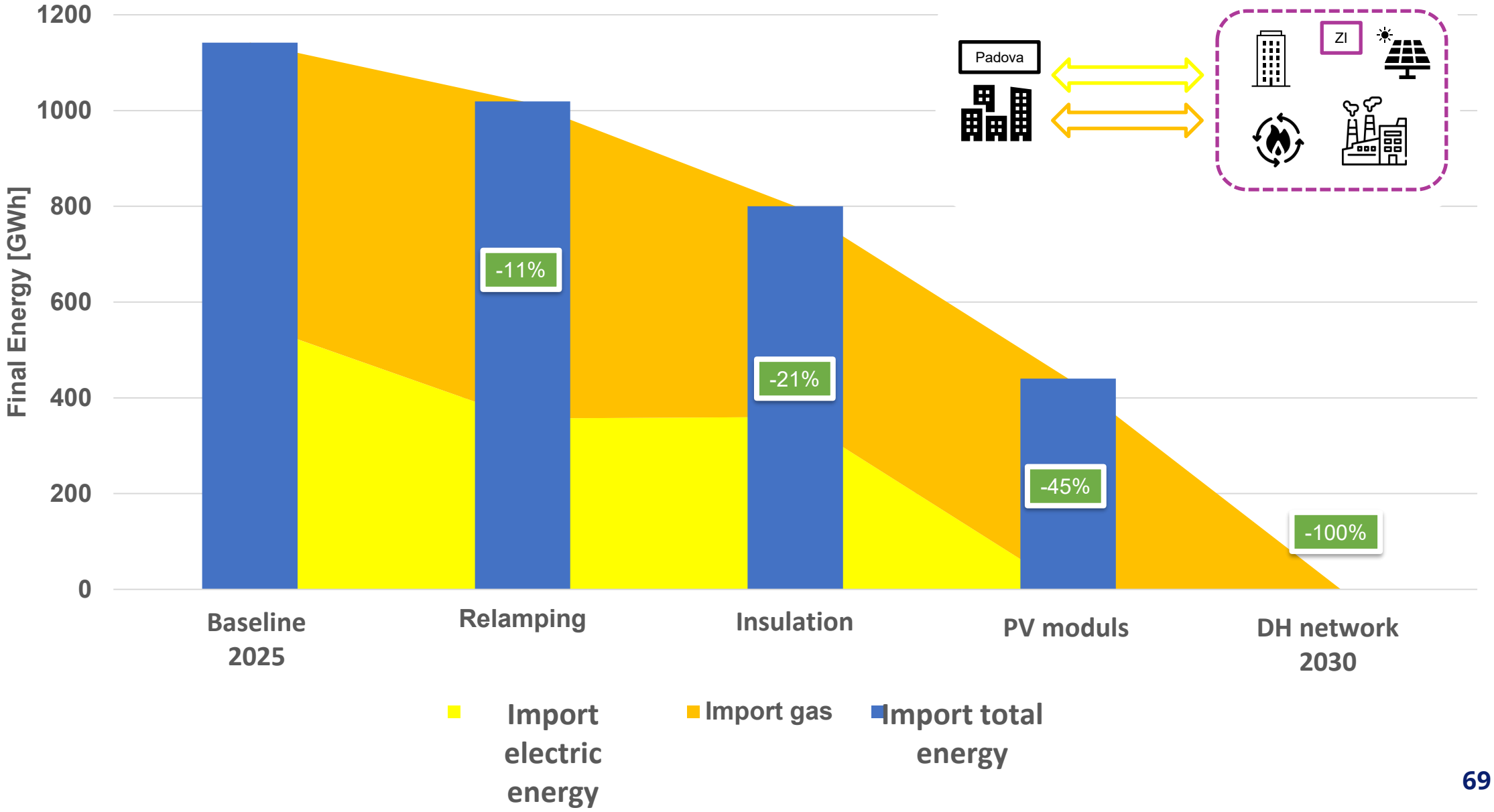
PED

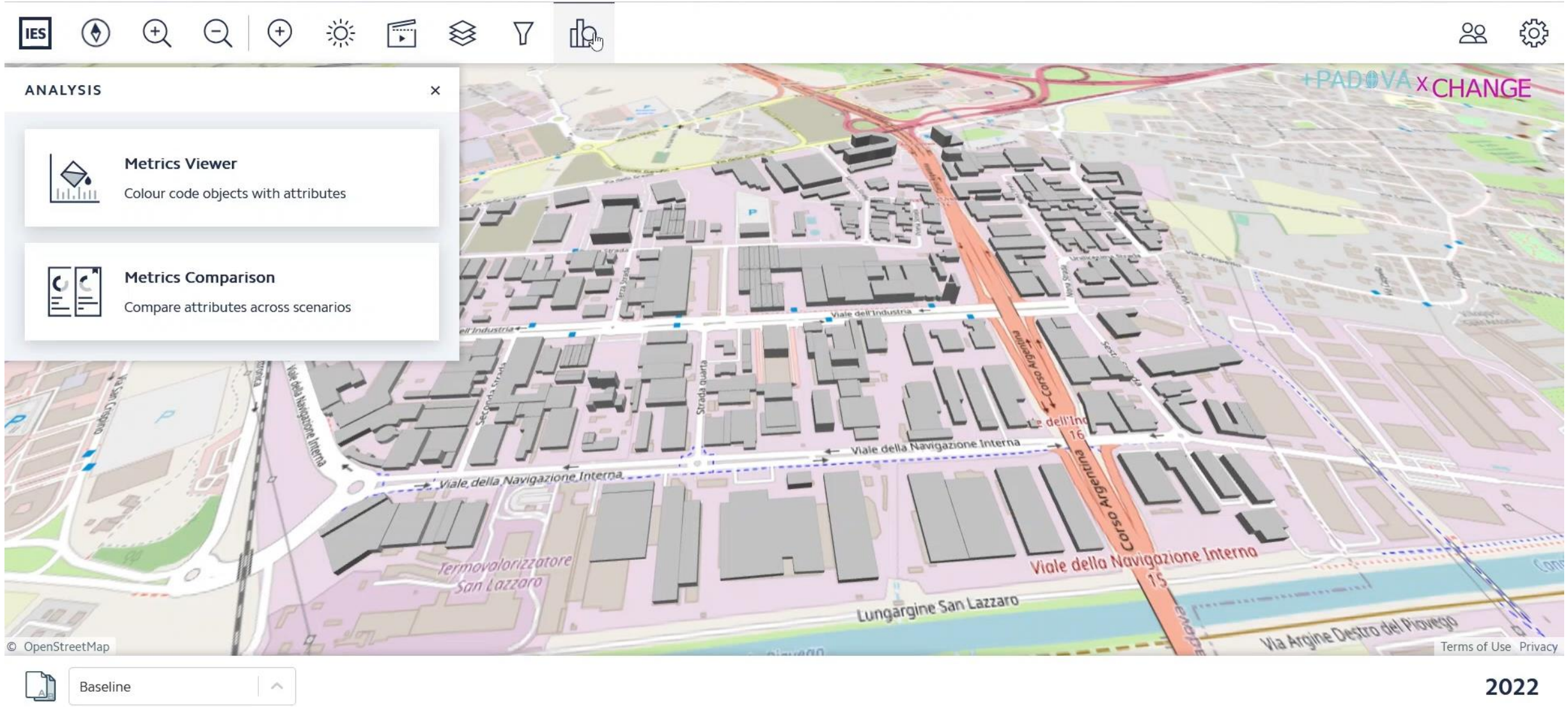




CAPEX (M€)	Annual bill savings (M€)	Payback (years)	Jobs generated*
1510	219	6.75	18349

Roadmap PED


1200
1000
800
600
400
200
0
Final Energy [GWh]
-11%
-21%
-45%
-100%
Padova
ZI
Baseline 2025
Relamping
Insulation
PV moduls
DH network 2030
Import electric energy
Import gas
Import total energy


ANALYSIS
Metrics Viewer
Colour code objects with attributes
Metrics Comparison
Compare attributes across scenarios
+PADOVA X CHANGE
Viale della Navigazione Interna
Viale dell'Industria
Corso Argentina
Strada quarta
Termovalorizzatore San Lazzaro
Lungargine San Lazzaro
Via Argine Destro del Piovego
© OpenStreetMap
Terms of Use
Privacy
Baseline
2022

This project has received funding from the European Union's LIFE Programme for Research and Innovation under Grant Agreement no. 101120859

Co-funded by the European Union

Thank you

Davide Quaggiotto | davide.quaggiotto@r2msolution.com

With the support of the European Union's Horizon 2020 research and innovation programme under grant agreement SCALABLE CITIES-202-PADOVA

3 – Application of the Stepwise Toolkit at Building Level and EPBD Compliance Analysis

This project has received funding from the European Union's LIFE Programme for Research and Innovation under Grant Agreement no. 101120859

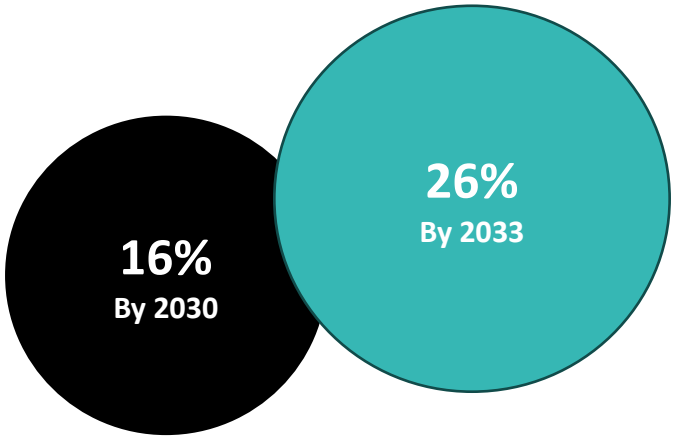
Co-funded by the European Union

CASE STUDY 2: URBAN MODELING - MUNICIPAL BUILDINGS

- **New EPBD Directive**
- Decarbonization of the building stock by 2050
- Tackling energy poverty for a just transition to climate neutrality
- Disincentive to the use of fossil fuels and incentive to install renewable sources
- Sustainability throughout the entire life cycle of buildings

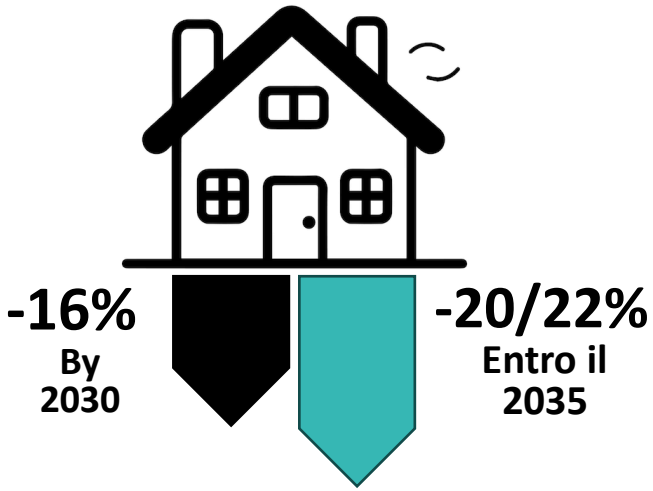
NON-RESIDENTIAL BUILDINGS
MINIMUM ENERGY EFFICIENCY STANDARDS

Building renovation with low performance



RESIDENTIAL BUILDINGS

Energy consumption reduction targets



ZERO EMISSIONS TARGET

- ☑ **From 2030** all new residential buildings
- ☑ **From 2028** all public buildings
- ☑ **From 2050** the entire heritage of existing buildings

OTHER OBLIGATIONS

- ☑ **From 2026** photovoltaic obligation on the roofs of new public and non-residential buildings

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CASE STUDY 2: URBAN MODELING - MUNICIPAL BUILDINGS

OBJECTIVES

















🎯 Objective

Use IES ICD to carry out Simplified Energy Audits.

📌 Purpose

🏛️ Generate Energy Audits for municipal buildings

💡 Identify and propose energy efficiency scenarios

🤝 Provide a simulation of the EPC Contract for the implementation of the works

💬 Motivation

Traditional analyses of this type require very long times, in-depth inspections and several weeks for modeling.

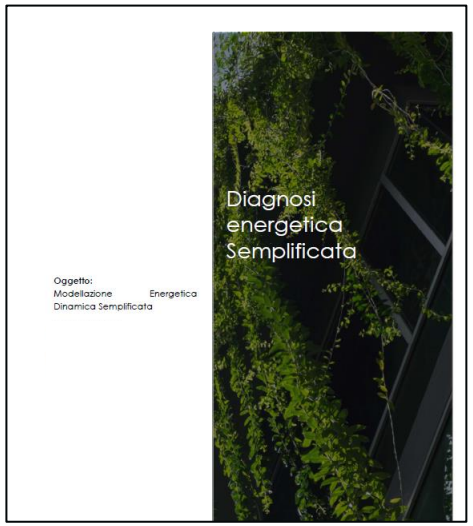
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CASE STUDY 2: URBAN MODELING - MUNICIPAL BUILDINGS

RESULTS

GEOMETRIA							DATI IES GEOMETRIA								VERIFICHE GEOMETRIA						
VIA	Deser.	AREA NETTA RISC.	AREA NETTA ILLUMIN.	AREA LORDA RISC.	VOLUME NETTO RISC.	VOLUME LORDO RISC.	AREA LORDA IES	AREA LORDA RISCALDATO IES	SUPERFICIE ORIZZONTALE DI BASE	SUPERFICIE ORIZZONTALE DI COPERTURA	SUPERFICIE FINESTRATA	NUMERO PIANI	AREA LORDA ILLUMINATA	VOLUME LORDO IES	VOLUME LORDO RISCALDATO IES	% Errore rispetto a sup illuminata	% Errore rispetto a sup riscaldata	% Errore volume riscaldato	Consumo gas naturale	Consumo energia termica	Baseline Energia Primaria	
[...]	[...]	m2	m2	m2	m3	m3	m2	m2	m2	m2	m2		m2	m3	m3	%	%	%	Smc	kWh	kWh	
P.zza Vittorio Emanuele II	UFFICI	1355.3	1689.8	1653.1	5035.3	6328	2076.6	1833.7	795.34	805.23	123	3	2061.10	7546.6	7182.2	1%	-9.8%	-3.5%	11231	107704	302494	
Via D. G. Minzoni, 3	SALA CONSILIARE - UFFICIO	123.7	124.1	145	507.2	681.5	159.73	145.53	159.73	0	50.5	1	145.47	702.81	640.33	9%	-0.4%	6.4%	384	3679	5971	1
Via D. G. Minzoni, 44	UFFICIO	49.8	65	60.4	198.7	276.6	78.51	61.091	78.51	0	2.7	1	78.84	329.74	256.62	0%	-1.1%	7.8%	-	-	-	
Via D. G. Minzoni	UFFICIO - SCUOLA	120.1	120.1	150.3	475.2	679.5	151.92	151.92	96.115	97.21	8	2	150.30	653.26	653.26	1%	-1.1%	4.0%	-	-	-	3
Via D. G. Minzoni	UFFICIO	675.8	1101.5	1013.6	3074.6	4071.2	1386.9	1013.4	1136.4	1162	130.8	2	1274.81	6042.6	4449.2	8%	0.0%	-8.5%	34486	330723	502736	7



Scenario 2																			
Descrizione scenario	Consumo totale annuo elettrico IES VE	Consumo totale annuo gas IES VE	Consumo totale annuo IES VE	Energia elettrica e termica prodotta da fonti rinnovabili	Fabbisogno energetico totale	Risparmio energetico IES VE	Risparmio energetico percentuale	TEP totale consumo energetico	Risparmio TEP percentuale	Emissioni CO2 totale	Risparmio CO2 percentuale	Costo Totale Energia considerando PV	Risparmio Costo Totale Energia considerando PV	Risparmio Economico percentuale considerando PV	CAPEX	Totale Conto termico 2.0	Totale Conto termico 3.0	Ritorno dell'Investimento CT 2.0	Ritorno dell'Investimento CT 3.0
	(kWh/anno)	(kWh/anno)	(kWh/anno)	(kWh/anno)	(kWh/m*anno	(kWh)	(%)	(TEP)	(%)	(kgCO2e)	(%)	(|)	(|)	(%)	(|)	(|)	(|)	(anni)	(anni)
Serramenti	94177.20	94842.10	189019.30	0.00	91.02	9571.40	5%	25.78	2%	46562.34	3%	34864.62	538.34	2%	83141.90	41570.95	41570.95	69.48	69.48
Serramenti	1147.00	4628.20	5775.20	0.00	36.16	842.30	13%	0.61	11%	1261.71	12%	836.61	93.92	11%	34135.50	17067.75	17067.75	>75	>75
Serramenti	561.70	2495.60	3057.30	0.00	38.94	38.60	1%	0.32	1%	663.70	1%	436.88	4.58	1%	1825.07	912.53	912.53	>75	>75
Serramenti	2807.20	15164.30	17971.50	0.00	118.30	675.60	4%	1.83	3%	3855.37	3%	2502.72	80.14	3%	5407.60	2703.80	2703.80	33.74	33.74
Serramenti	73372.70	123509.80	196882.50	0.00	141.96	10662.00	5%	24.35	3%	46200.16	4%	33048.72	1214.00	4%	88414.32	44207.16	44207.16	36.41	36.41
Serramenti	32751.40	55479.90	88231.30	0.00	78.51	2617.30	3%	10.90	0%	20632.14	2%	14793.34	58.85	0%	57793.76	28896.88	28896.88	>75	>75
Relamping	3612.50	3286.10	6898.60	0.00	28.43	313.30	4%	0.96	7%	1715.68	6%	1235.61	101.36	7%	3417.78	0.00	1367.11	33.72	20.23
Serramenti	35658.80	128411.90	164070.70	0.00	74.08	28580.20	15%	17.72	12%	36130.41	14%	24173.78	3390.27	12%	344734.72	100000.00	172367.36	72.19	50.84
Solaio Copertura	1189.50	17813.80	19003.30	0.00	88.54	1735.90	8%	1.76	8%	3911.28	8%	2411.39	205.92	8%	22745.35	11372.68	11372.68	55.23	55.23
Serramenti	10586.60	23640.80	34227.40	0.00	62.82	8535.00	20%	4.02	15%	7830.03	18%	5458.85	1012.45	16%	83209.50	41604.75	41604.75	41.09	41.09
Solaio Copertura + Fotovoltaico	2684.40	19059.80	29846.40	23286.86	12.41	16372.36	72%	-2.22	200%	-2230.42	147%	-2309.98	5958.52	195%	86537.22	27940.89	27940.89	9.83	9.83
Fotovoltaico	33592.10	165784.00	199376.10	71417.91	81.44	71417.91	36%	7.20	65%	22073.84	49%	10181.32	17307.45	64%	94016.42	0.00	0.00	5.25	5.25
Solaio Copertura + Fotovoltaico	32195.80	91741.30	123937.10	42635.14 30516.85	48.79	161390.59	62%	0.24	99%	6348.10	86%	613.22	28880.57	98%	296678.21	94282.64	94282.64	7.01	7.01
Fotovoltaico	60566.90	354466.10	415033.00	73326.85 30099.17	75.50	103428.03	18%	22.50	46%	58334.91	34%	31300.83	25933.72	45%	147976.54	0.00	0.00	5.71	5.71
Serramenti	27402.90	24578.70	51981.60	0.00	88.86	7764.50	13%	7.24	8%	12944.79	11%	9786.65	921.05	9%	49236.23	24618.11	24618.11	26.73	26.73
Serramenti	14451.70	0.00	14451.70	0.00	68.38	425.80	3%	2.70	3%	4234.35	3%	3623.64	106.77	3%	11889.37	5944.98	5944.98	55.68	55.68
Fotovoltaico	24047.90	95542.10	119590.00	62109.08	37.31	62109.08	52%	1.11	91%	7956.50	70%	1769.99	15573.33	90%	92189.50	0.00	0.00	5.92	5.92
Fotovoltaico	2939.60	11893.80	14833.40	75572.85	-32.89	75572.85	507%	-12.55	891%	-18884.00	673%	-16785.54	18949.26	676%	110380.86	0.00	0.00	5.83	5.83
Fotovoltaico	171.40	630.60	802.00	2744.97	-29.00	2744.97	342%	-0.43	534%	-627.94	458%	-570.50	688.28	594%	4009.28	0.00	0.00	5.83	5.83
Fotovoltaico	230.80	2707.70	2938.50	2086.36	18.11	2086.36	70%	-0.10	136%	15.44	38%	-129.03	523.14	133%	3013.54	0.00	0.00	5.76	5.76
Fotovoltaico	83.00	944.70	1027.70	4477.40	-32.82	4477.40	436%	-0.74	864%	-1098.62	615%	-989.80	1122.67	945%	6289.18	0.00	0.00	5.60	5.60
Serramenti	9072.00	26950.30	36022.30	0.00	40.03	1754.80	5%	4.02	4%	8048.16	4%	5471.66	208.16	4%	29364.88	14982.44	14982.44	71.98	71.98
Serramenti	13155.40	21850.90	41006.30	0.00	42.59	3636.40	13%	5.46	13%	9982.71	16%	7395.08	1143.10	13%	20278.51	10139.26	10139.26	8.87	8.87

🏢 **Buildings Analyzed**
23 Municipal Buildings

🛠️ **Activity**

🧱 Energy Modeling

⚙️ Simulation of Efficiency scenarios (Economic and Financial)

RESULTS: The simplified approach has made it possible to reduce the time to 2 weeks of work, significantly reducing time and resources, while maintaining a maximum error of 10%

BENEFITS FOR THE INSTITUTION

Quick estimate of national incentives (e.g. Thermal Account 3.0).

- It improves competitiveness for access to PNRR funds and other calls.
- Optimized planning: priorities, times, resources.

Thank you

Alessandro Piccinini [IES]

General Assembly

22/05/2024