

TOWARDS A SUSTAINABLE DISTRICT: A STREAMLINED LIFE CYCLE ASSESSMENT APPLIED TO AN ITALIAN URBAN DISTRICT

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CONTEXT



Cities (over 2/3 of the world's energy consumption and 70% of global CO₂ emissions) represent a **key challenge** in curbing greenhouse gas emissions and in taking adaptation and mitigation strategies



LCA is an accepted methodology for quantitative assessment of buildings over their whole life cycle



In the last 25 years, **LCA** has been increasingly used to assess the environmental impacts of construction products and buildings while it is still difficult to apply at **urban level**

CONTEXT

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2012_The municipality of Bologna started the process of moving toward a smart city

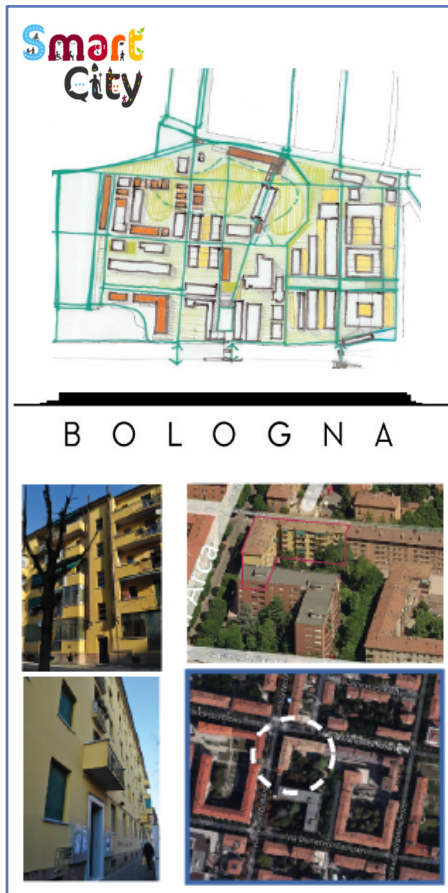


Bolognina neighbourhood : urban retrofitting intervention
(Department of Architecture at the University of Bologna)

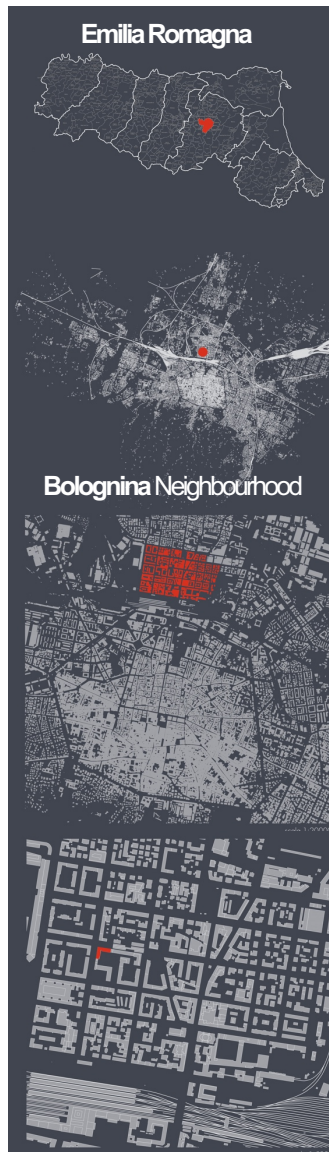
AIM

This work explores the application of a streamlined LCA on the urban district, main issues: buildings, energy, water and waste

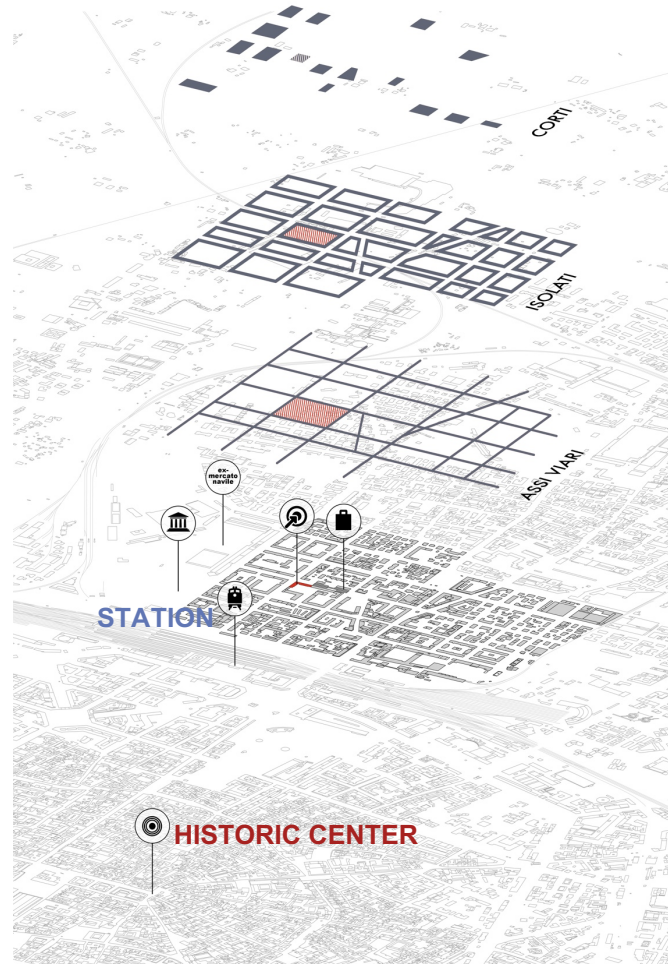
RESEARCH STEPS



1. Lacking of environmental indicators able to provide guidance in implementing the transition from a **sustainable** to a **smart city** framework;
2. Despite the complexity of applying at the urban level, LCA could provide a **robust method** to assess the environmental impact;
3. The strategic interventions in the **Bolognina** addressed 8 aspects of the built environment, from open space to energy consumption of the building stock;
4. Are the **smart city** solutions adopted in the case study also sustainable? Can we calculate the associated **environmental impacts** adopting the LCA method?



BOLOGNINA district



- came into being as a result of urban expansion to provide residence for the **working class** at the end of 19th century,
- represents an important **pivot** between the historical city centre and the surrounding outskirts

(functional activities of the open common area)

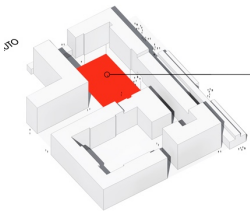
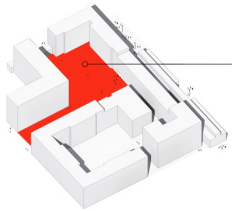
(renovation of the aged building stock)



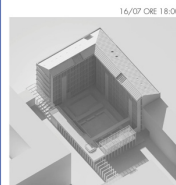
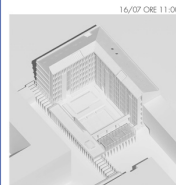
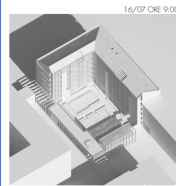
BOLOGNINA district

① Urban District Scale

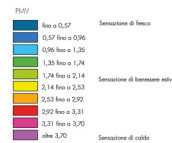
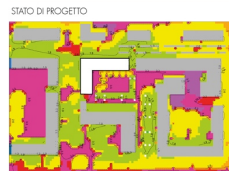
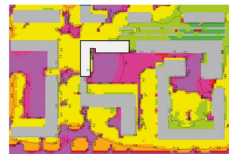
(functional activities of the open common area)



“reorganize and requalify the open spaces within the internal courtyards”



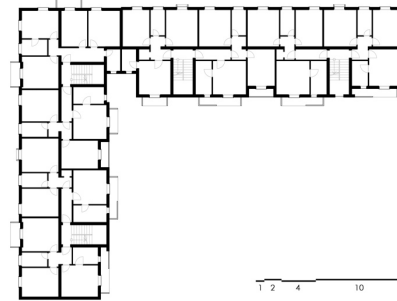
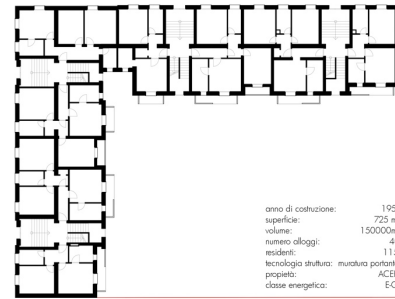
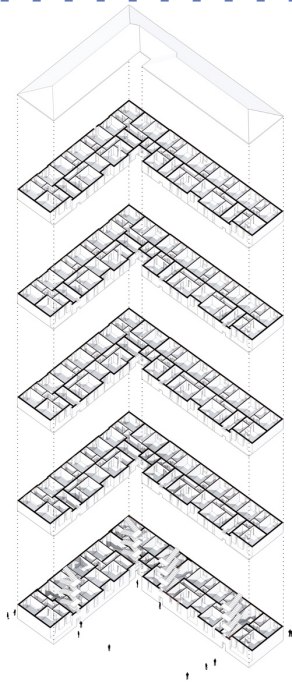
ENVI.met software



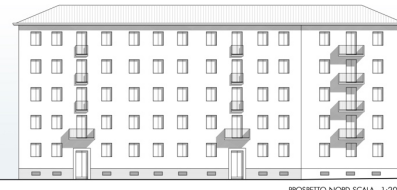
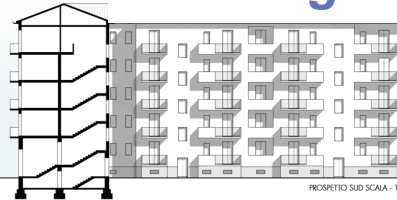
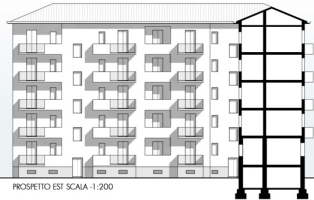
- heat island effect,
- air flow dynamics
- and vegetation related benefits



Mitigation strategies in Bolognina



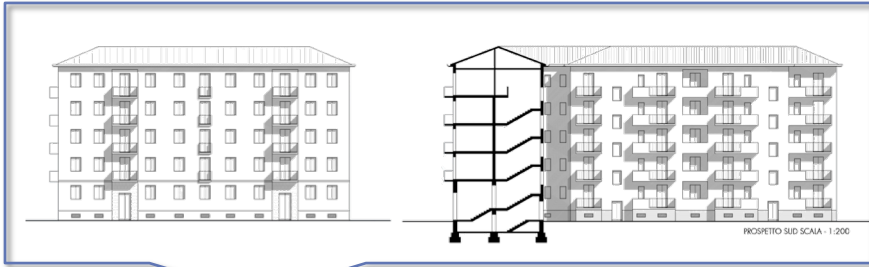
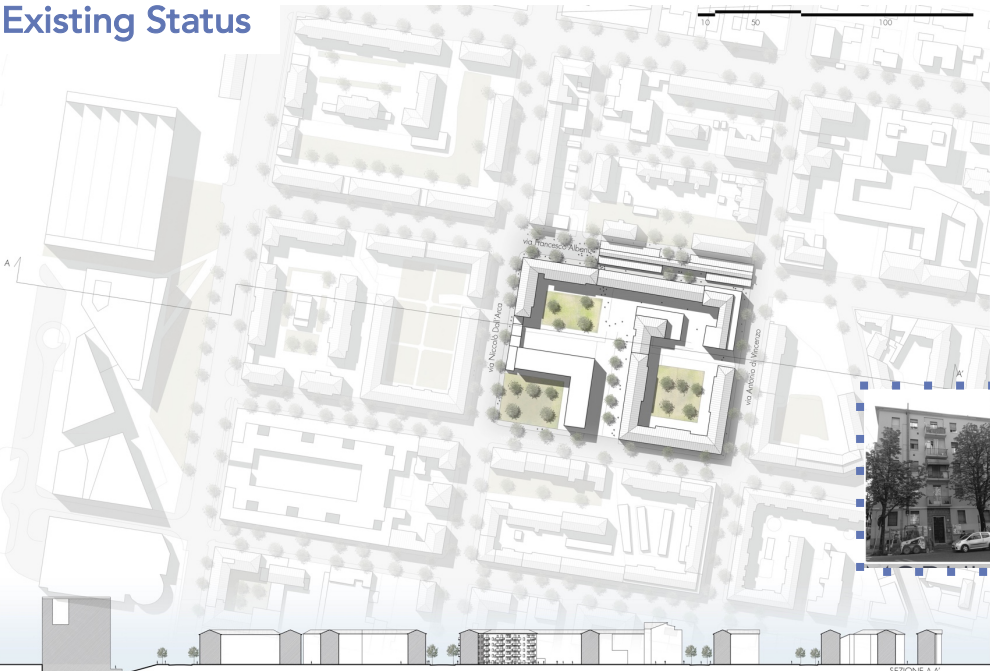
Building level



Residential buildings have inadequate performance levels:

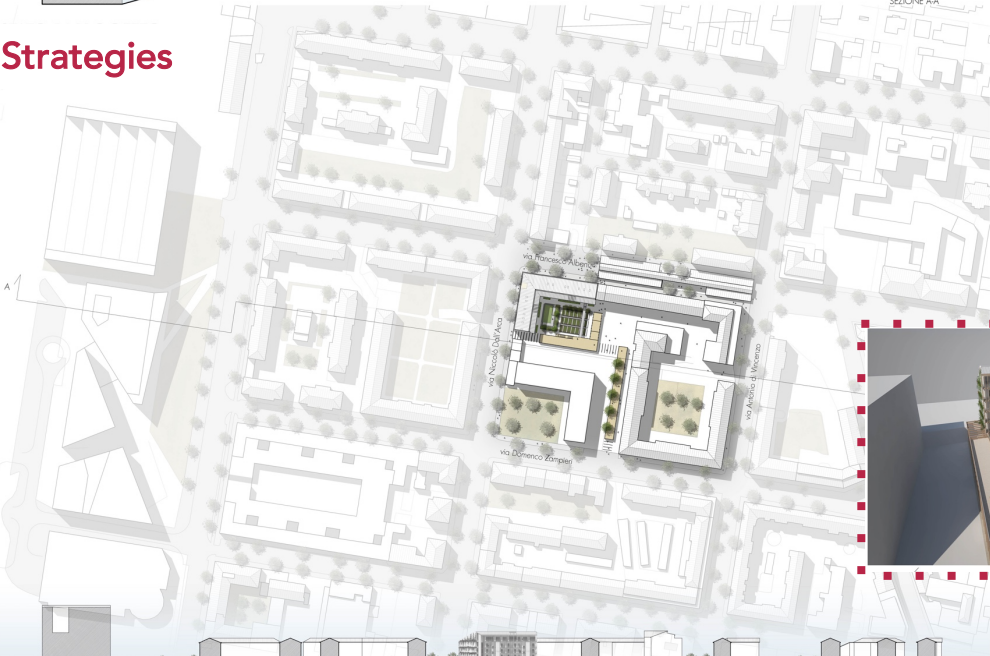
- 70% of the rooms have **lower surface areas** compared to existing legal limits;
- 20% are **under-sized** by more than 70%;
- the **indoor comfort levels** (exposure to sunlight and ventilation) are at critical levels;
- **energy consumption** is very high

Existing Status

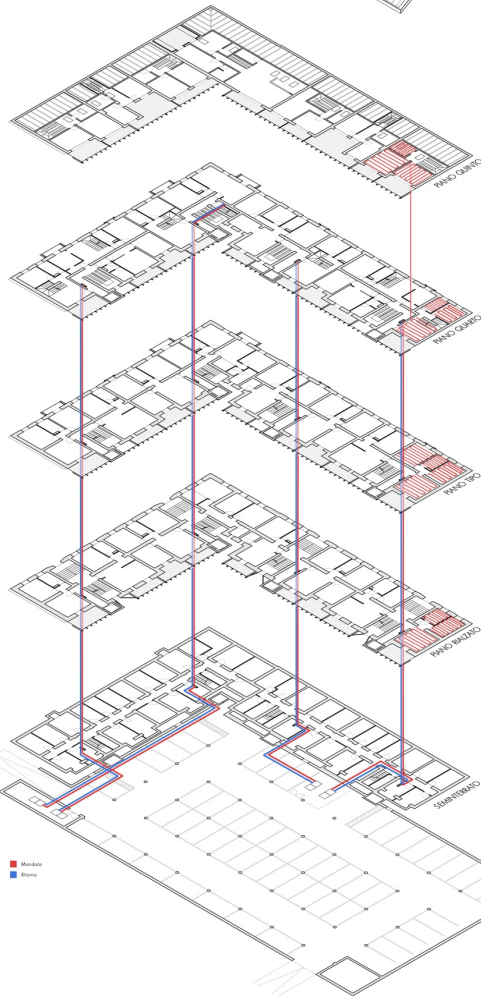
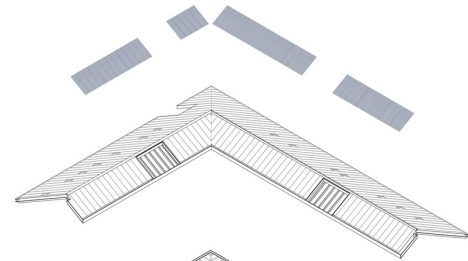


strategies to improve the daylight comfort and ventilation

Strategies



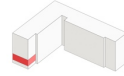
Schema impianti



VALUTAZIONE DELLA PRESTAZIONE ENERGETICA

Stato di fatto - alloggio A1

Impianti autonomi, caldaie a gas
Riscaldamento + ACS
Impianto di raffrescamento: assente



Dati dimensionali alloggi

Superficie utile riscaldata: 41 m²
Volume lordo riscaldato: 123 m³
Superficie dipendente: 55,5 m²

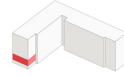
Prestazioni fabbricato - fabbisogni energia termica utile
Riscaldamento: 98,2 kWh/m²
Raffrescamento: 53 kWh/m²
ACS: 18,3 kWh/m²

Prestazioni edificio

Fabbisogni energia primaria
EP_{tot,cal} = 0 kWh/m² EP_{tot,ref} = 128 kWh/m²
EP_{cal,cal} = 0 kWh/m² EP_{cal,ref} = 0 kWh/m²
EP_{cal,cal} = 0 kWh/m² EP_{cal,ref} = 23 kWh/m²
EP_{cal,cal} = 0 kWh/m² EP_{cal,ref} = 151 kWh/m²

Progetto - alloggio A1

Impianti centralizzati, pompe di calore
Riscaldamento/Raffrescamento/ACS



Dati dimensionali alloggi

Superficie utile riscaldata: 35 m²
Volume lordo riscaldato: 105 m³
Superficie dipendente: 51 m²

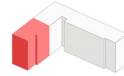
Prestazioni fabbricato - fabbisogni energia termica utile
Riscaldamento: 21,5 kWh/m²
Raffrescamento: 30 kWh/m²
ACS: 18,3 kWh/m²

Prestazioni edificio

Fabbisogni energia primaria
EP_{tot,cal} = 15 kWh/m² EP_{tot,ref} = 7 kWh/m²
EP_{cal,cal} = 10 kWh/m² EP_{cal,ref} = 18 kWh/m²
EP_{cal,cal} = 17 kWh/m² EP_{cal,ref} = 5 kWh/m²
EP_{cal,cal} = 42 kWh/m² EP_{cal,ref} = 30 kWh/m²

Progetto - blocco 1

Impianti centralizzati, pompe di calore
Riscaldamento/Raffrescamento/ACS



Dati dimensionali alloggi

Superficie utile riscaldata: 621 m²
Volume lordo riscaldato: 2839 m³
Superficie dipendente: 1172 m²

Prestazioni fabbricato - fabbisogni energia termica utile
Riscaldamento: 27 kWh/m²
Raffrescamento: 29 kWh/m²
ACS: 18,3 kWh/m²

Prestazioni edificio

Fabbisogni energia primaria
EP_{tot,cal} = 19 kWh/m² EP_{tot,ref} = 8 kWh/m²
EP_{cal,cal} = 9 kWh/m² EP_{cal,ref} = 16 kWh/m²
EP_{cal,cal} = 19 kWh/m² EP_{cal,ref} = 6 kWh/m²
EP_{cal,cal} = 47 kWh/m² EP_{cal,ref} = 30 kWh/m²

Emissioni di CO₂

Stato di fatto

Emissioni di CO₂: 74.292 kgCO₂/anno

Emissioni equivalenti di CO₂

barili petrolio/anno: 4,32

auto/anno: 40,82

alberi/anno: 2971,68

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alberi/anno: 2971,68

Progetto

Emissioni di CO₂: 33.020 kgCO₂/anno

Emissioni equivalenti di CO₂

barili petrolio/anno: 0,89

auto/anno: 18,14

alberi/anno: 1320,82

alberi/anno: 1320,82

alberi/anno: 1320,82

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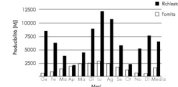
alberi/anno: 1320,82

alberi/anno: 1320,82

alberi/anno: 1320,82

Produttività fotovoltaica

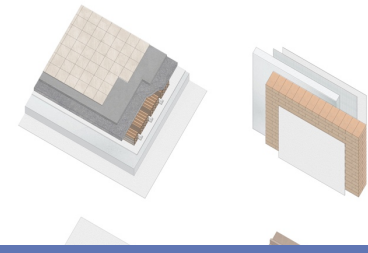
(1 MJ = 0,28 kWh)
Pannelli fotovoltaici per zona di calcolo: 24
Fattore di potenza di picco: 0,150 kW/m²



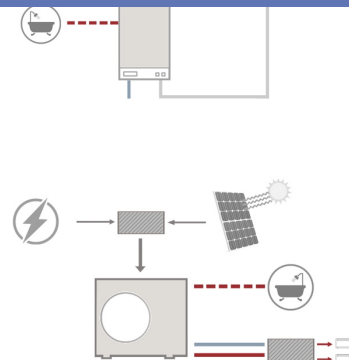
Mitigation strategies for Bolognina

energy efficiency labelling

building envelope insulation



from
Class F
(160 kWh/m² year)
to
Class A4
(16,96 kWh/m² year)



BOLOGNINA district



Bolognina neighbourhood

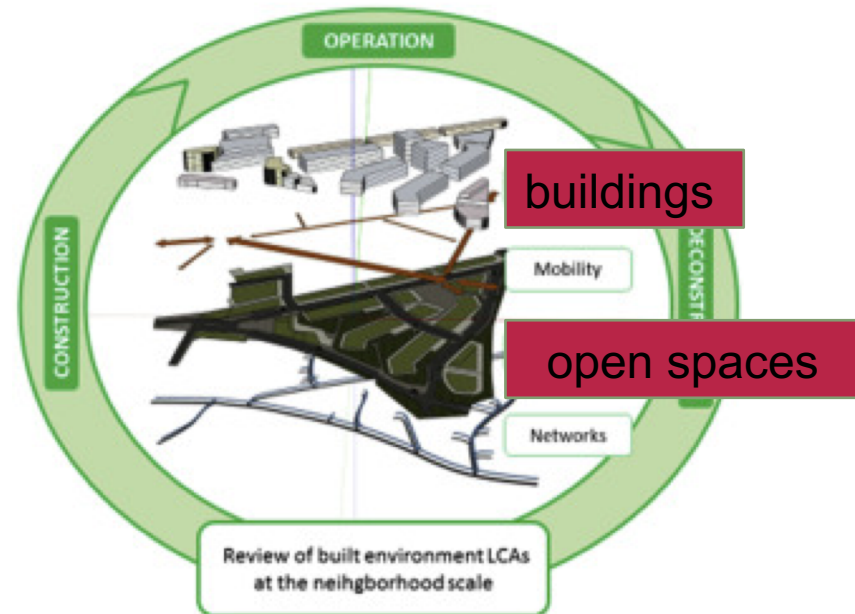
(Department of Architecture of the University of Bologna)



LCA at urban level



key features of the neighbourhood



Lotteau M *et al.* 2015 Critical review of LCA for the built environment at the neighborhood scale *Building and Environment* **93** pp 165-178

Functional unit (UF)

as the quantified performance of a product system that is used as the reference unit for the LCA and for comparability among assertions (ISO 14040-14044:2006).

This assessment is referred to dimensional characteristic of the typical block of Bolognina urban district, namely **8910 m²** of open area, about **190 unit housing** with **10879 m²** of living spaces and **475 inhabitants**

Boundaries and Life Cycle stages

(EN 15804:2012+A1:2013, "Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products")

i) Product stage

(raw materials extraction, manufacturing);

ii) Construction phase

(transport, building and infrastructures construction);

iii) Use phase

(operation and maintenance)

and

vi) Deconstruction phase

(End of Life: recycling, landfill, re-use, etc).

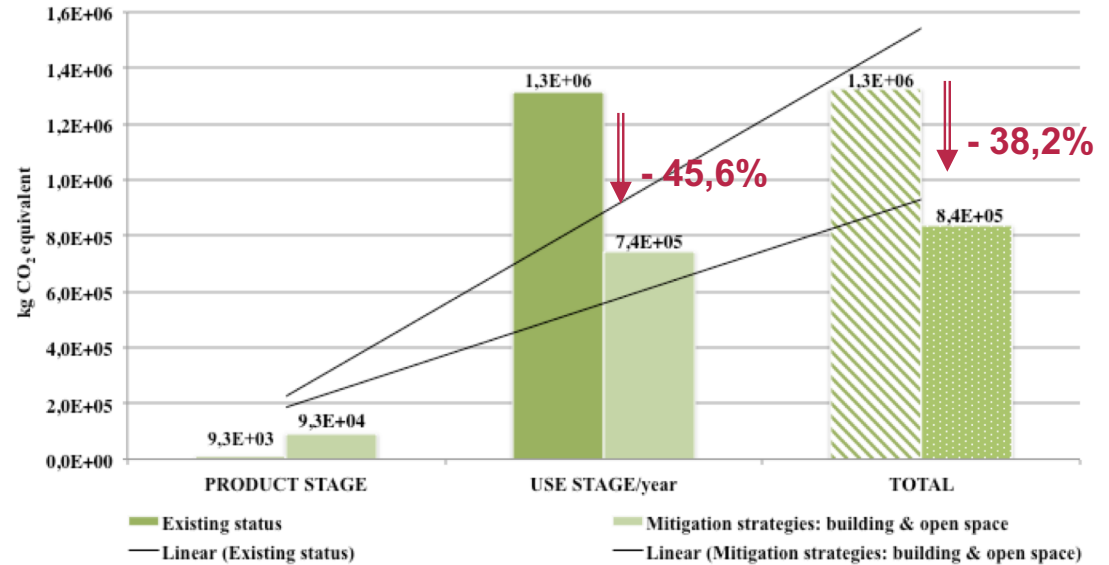
Assumption Life Cycle Inventory (LCI)

The foreground flows are principally represented by real data collected during **site visits**, **interviews** and re-calculations based on **appropriate software** (e.g energy related retrofit of buildings). Whenever primary data were not available, regional and national references sources were considered

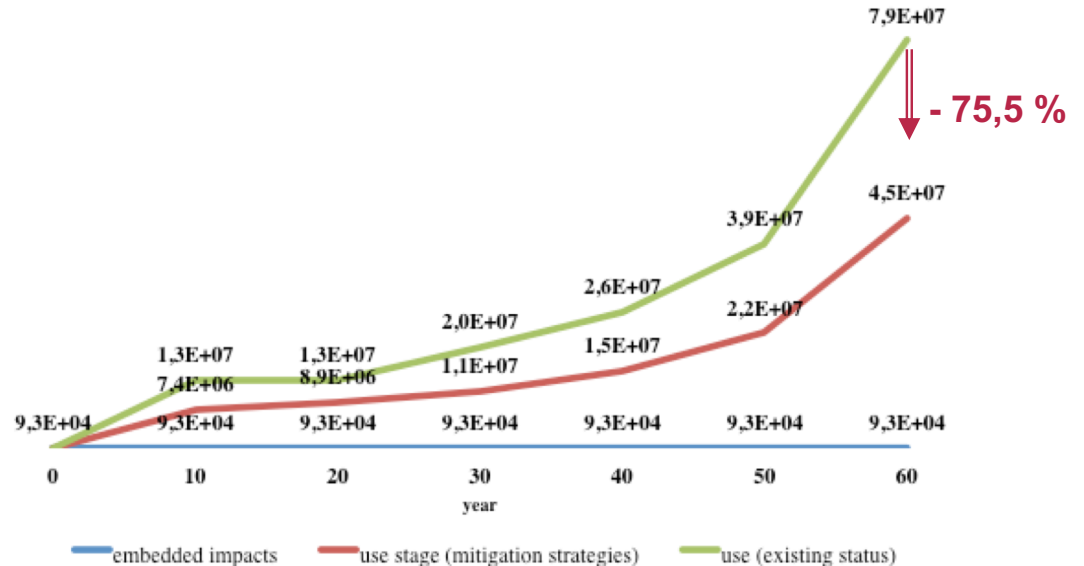
e.g. water consumers m³/inhabitant in Bologna from Hera, multi-utility company that provides water and energy services in the Bologna municipality

Foreground flows Output and Waste				
	Electricity	Natural gas	Water	Waste
Reference unit	m ² of living space	m ² of living space	m ³ / inhabitant	m ³ / inhabitant
Typology of data	Primary data	Primary data	Secondary data (source: Hera*)	Secondary data (source: ISPRA**)
*Multi-utility company that provides water and energetic services in the Bologna municipality) Italian **Institute for Environmental Protection and Research)				

Comparative assessment related to **Global Warming Potential** (kg CO₂ equivalent) between **existing status** and **mitigation strategies** of the block of Bolognina neighbourhood in **1 year**

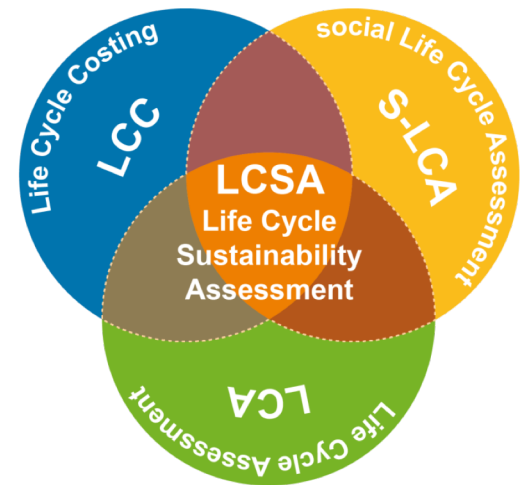


Comparative assessment related to **Global Warming Potential** (kg CO₂ equivalent) between existing status and mitigation strategies of the block of Bolognina neighbourhood **during entire Life Cycle of Building**



CONCLUSIONS

- ◆ This study present the results of a simplified application of LCA on urban block scale, explaining the **potential of this methodology** in the evaluation of the environmental performance of the built environment at the urban scale;
- ◆ Next step will be extend the evaluation to **cover all** other **life cycle** stages of the built environment;
- ◆ However, further researches are necessary to broaden the evaluation and to assess the **three pillar of sustainability** throughout a life cycle sustainability assessment.



THANKS FOR YOUR ATTENTION!

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