Pilot Project: Integrated Techniques for the Seismic Strengthening & Energy Efficiency of Existing Buildings

Previous/associated work: the SAFESUST project

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17 November 2020

Impact of sustainability and energy efficiency on building design and retrofit: SAFESUST

- A JRC Institutional WP as a part of Safe&Clean Construction
- A holistic approach to include safety and sustainability in design: SAFESUST approach
- The Sustainable Structural Design (SSD) method for design/retrofit of buildings

Life Cycle Analysis (LCA, from cradle to grave…)

Life Cycle Analysis (LCA, from cradle to grave)

Many LCA assessment procedures….

- Different criteria
- Lack interoperability
- Long and difficult

- Only a posteriori….

BREEAM

greenstar

SBTool

LEED

HQE CASBEE DGNB

How to match safety with sustainability?

The growing interests in achieving the environmental goals of the global agreements might be prevailing on other aspects of sustainability of buildings, such as seismic safety

How to optimize all performances?

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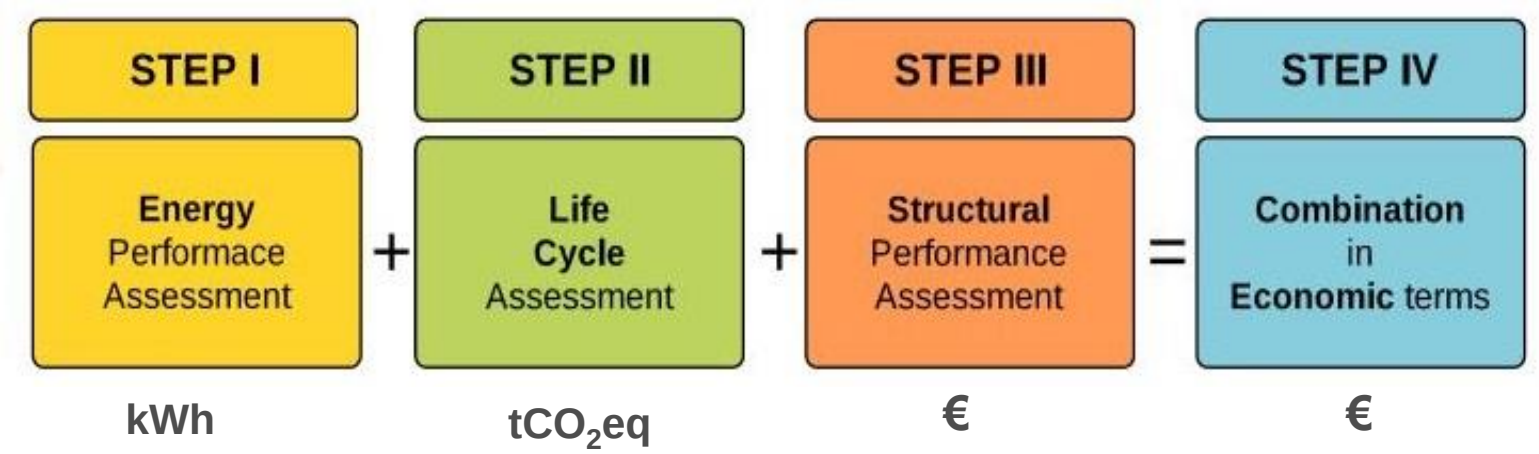
How to optimize all performances?

Sustainable Structural Design (SSD) **methodology**



- Energy performance is easily understood by owners, investors and decision makers.
- The advantages of energy upgrading can be measured in simple terms: reduction of operating costs, to be compared with investments.
- The first step of the method is the evaluation of the total expected energy consumption across the expected lifetime of the building.

Can we define a cost for safety?

- The “cost” associated to safety can be computed by adopting a Performance Based approach such as in the PEER method

$$G\,(DV) = \int_0^{\infty}\int\int G(DV|DM)\left|\frac{dG(DM|EDP)}{dDM}\right|\left|\frac{dG(EDP|IM)}{dEDP}\right| dIM\,dEDP\,dDM$$

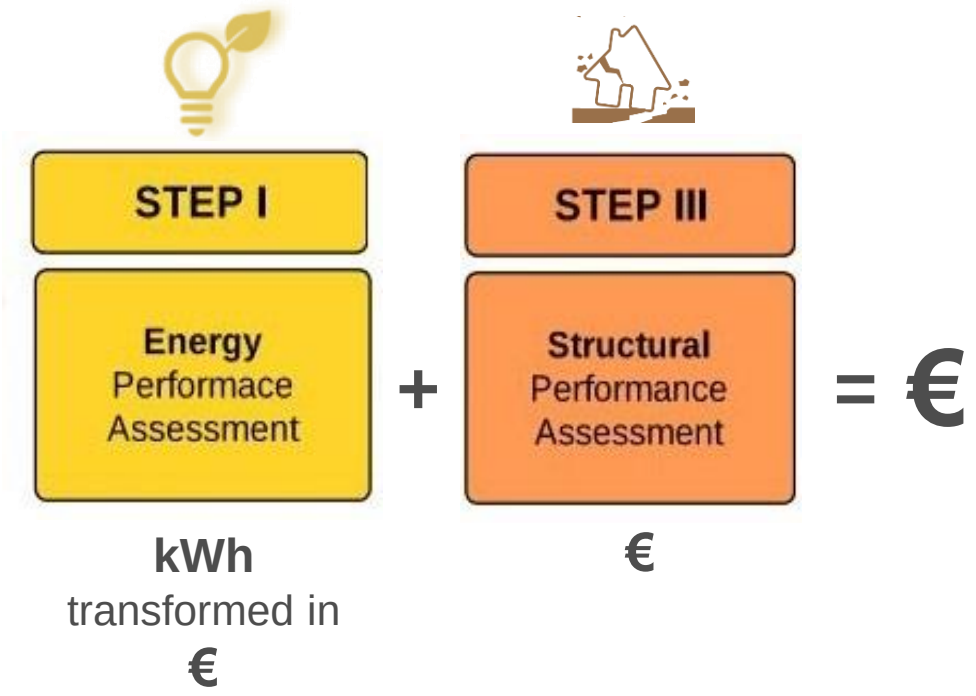
- The PEER method established a sound conceptual framework, but is by far too complicated to be used in practical design.

A Simplified Performance Based Assessment

- A set of limit states (minor damage, extensive damage, life safety…) is defined and the corresponding repair/replacement costs (possibly including downtimes) are evaluated
- A peak ground acceleration is associated to each limit state by a pushover curve
- The corresponding probability of exceedance is obtained by the return periods specified for the site by the design code
- The expected economic loss is the sum of the products of the probabilities of exceedance and the costs at each limit state

Reference: *Negro P., Mola E., A performance based approach for the seismic assessment and rehabilitation of existing RC buildings, Bulletin of Earthquake Engineering, 2017*

A total cost for the building



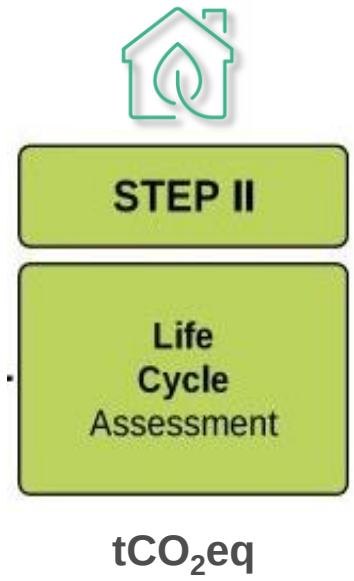
The cost of total expected energy consumption can be summed to the expected economic loss and compared to the investment for the construction cost or cost of upgrading

Reference: *Lamperti M., Loli A., Negro P., Balanced evaluation of structural and environmental performance in building design, Buildings, 2018.*

How about sustainability?

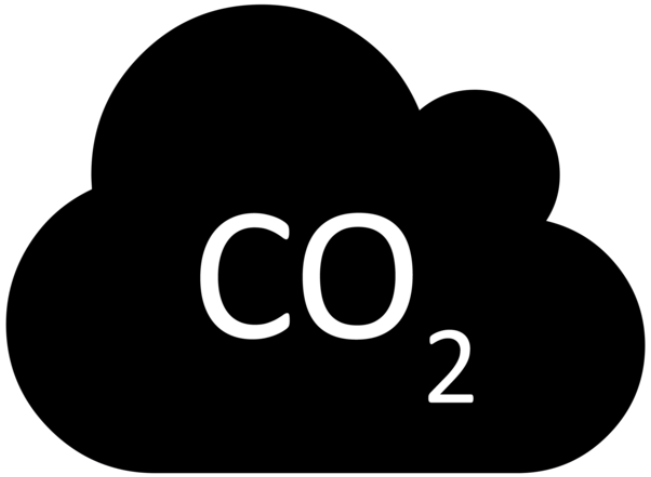
- Energy performance is related to environmental performance
- The cost of energy might (or might not) include a sort of environmental cost (carbon tax), but
- There is much more to sustainability than energy performance (embodied energy, raw material consumption, construction/demolition..)
- The latter might become dominant for nZEBs

Back to Life Cycle Analysis



The outcome of a LCA is typically expressed in terms of total equivalent CO_2 emissions across the whole life cycle of the buildings

A global performance indicator



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A global performance indicator

VS

(*Abhijit Tembhekar*, 2009 - CC BY 2.0, via Wikimedia commons)

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The *price* of Carbon

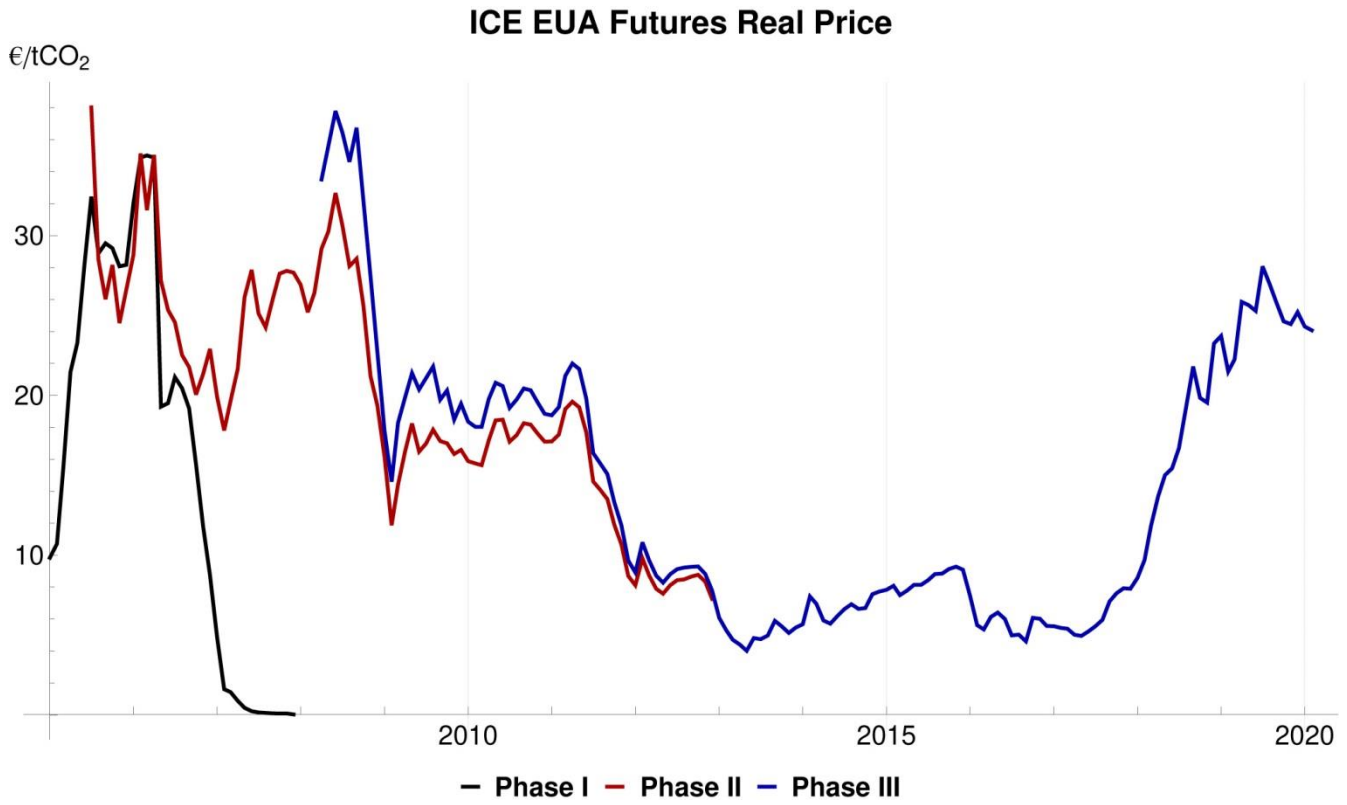
"*Carbon must have its price – because Nature cannot pay the price anymore*"

(President von der Leyen, State of the Union Address)

The *price* of Carbon

Cost of equivalent CO_2 emissions:

European Union Emission Trading System



(Nboccard, 2020 - CC BY-SA 4.0, via Wikimedia Commons)

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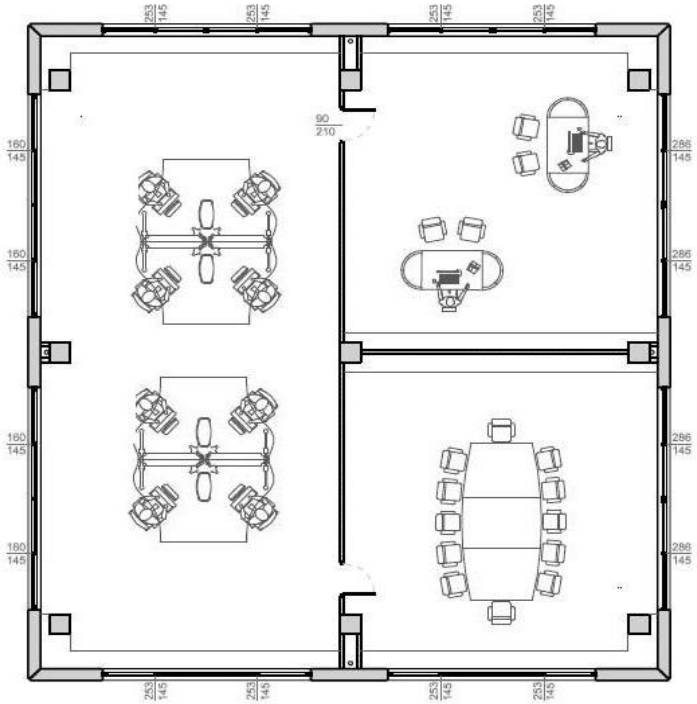
Application to a building

- Three storey building
- 15.62m × 16.87m in plan
- 2 spans of 7m in X and Y dir.
- 9.9m (3.5+3.2+3.2) height



Location: ***Barcis (PN)***

PGA = 0.25 g

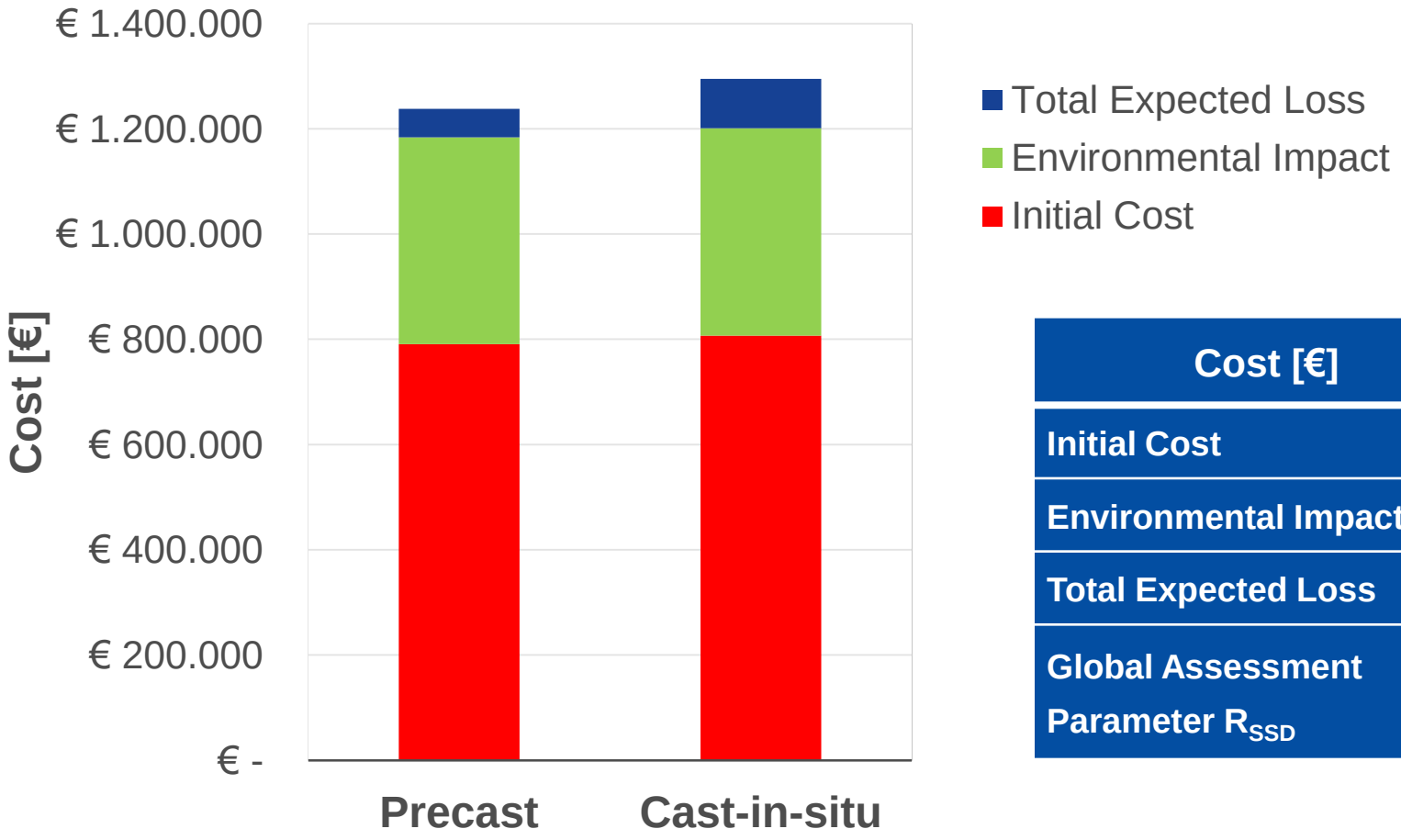
Zone F → U = 0.26 W/m^{2}K

Office occupancy

Service life 50 years

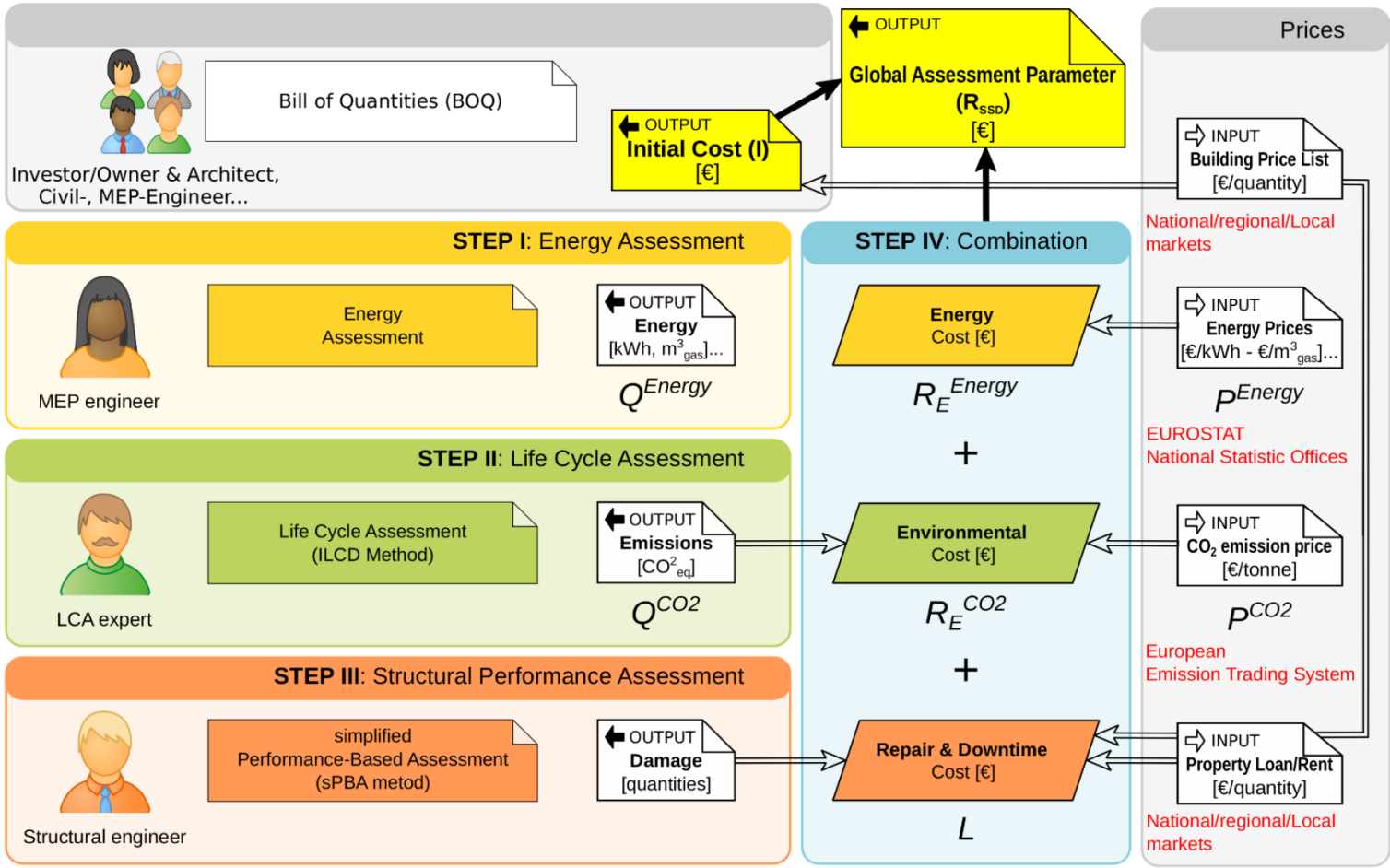
European Commission

Application to a building



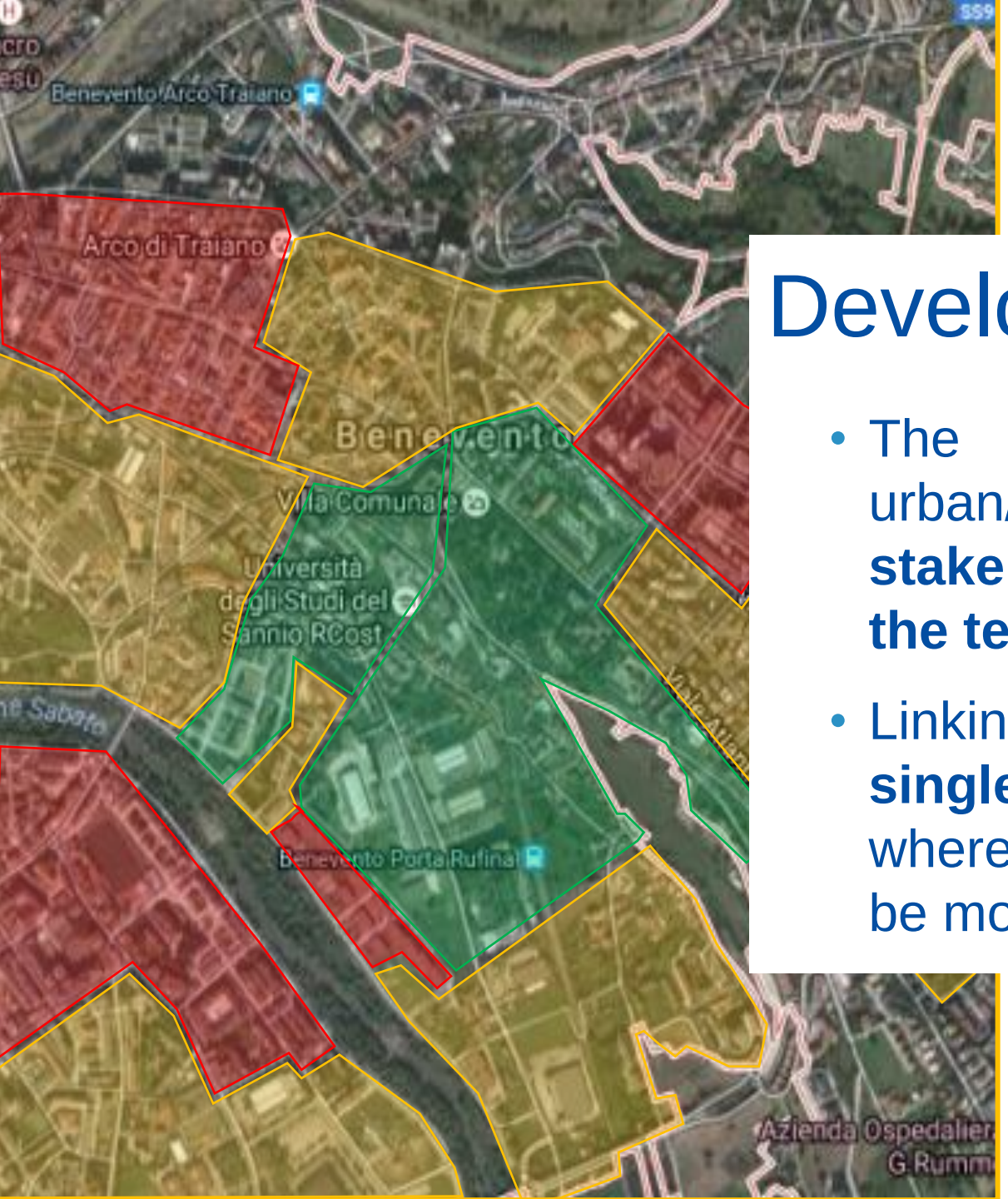
Cost [€]	Precast	Cast-in-situ
Initial Cost	790.530	807.055
Environmental Impact	393.218	394.054
Total Expected Loss	53.947	93.690
Global Assessment Parameter R_{SSD}	**1.237.695**	**1.294.799**

Costs as a common language….



(Lamperti et al, 2018)

Reference: *Lamperti Tornaghi M., Loli A., and Negro P., Balanced evaluation of structural and environmental performance in building design, Buildings, 8 (4), 52, 2018.*



Developments of the methodology

- The methodology can be used at urban/regional/national level for **supporting stakeholders** in addressing **policy projects on the territory**
- Linking all the buildings of a defined territory to **a single parameter** leads to identifying the areas where an intervention is more **urgent** and would be more **efficient**

Reference: *Caruso M.C., Lamperti M., Negro P. Applicability of the Sustainable Structural Design method at urban/regional/national level, Proc. 16ECEE, 2018.*

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Not only earthquakes

Structural safety
Higher live load requirements
Upgrading, transformations
Maintenance
Fire resistance
Climate change

SURECON:

A ROADMAP FOR A SUSTAINABLE INTEGRATED RETROFIT OF CONCRETE BUILDINGS

Reference: *A Roadmap for a SUstainable integrated REtrofit of CONcrete buildings, Iuorio, O. and Negro, P. editor(s), Publications Office of the European Union, Luxembourg, 2019. ISBN 978-92-76-23865-2*

Thank you

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