



**Co-benefits of Plus Energy Buildings
in household and community level**

Cultural-E workshop
9:30 - 11:00 CET

**28 September 2022
Brussels and online**

European Sustainable
Energy Week
#EUSEW2022

Important information before we start



Your microphone will be muted and your camera will be off. If you would like to speak, please raise your hand and we will give you the floor



We will use Sli.do for real-time polls/ Q&A/ chat box. Further instructions will be give later

Important information
before we start



This workshop will be recorded

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Are you familiar with the Cultural-e project?

Yes



No



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Introduction to the project and outline of the workshop

Annamaria Belleri, project coordinator - EURAC



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870072

Climate and cultural-based solutions for Plus Energy Buildings



Main project objective:

to define modular and replicable solutions for residential Plus Energy Buildings (PEBs), accounting for climate and cultural differences, while engaging all key players involved in the building life cycle.


More info on our project website: <https://www.cultural-e.eu/>


Sign up to our bi-annual newsletter!

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What is a Plus Energy Building (PEB)?




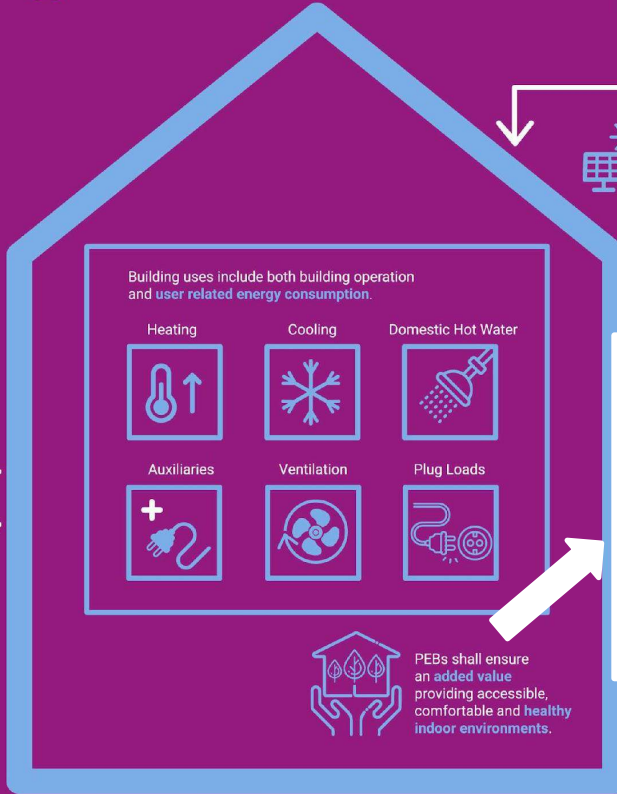
 A Plus Energy Building is an energy efficient building that produces more final energy than it uses via locally available renewable sources over a time span of one year*.

 Positive balance reached by ensuring a good dynamic matching between load and generation providing building flexibility.

+ generation ←

→ load -

 Positive balance reached by ensuring the lowest greenhouse gas emissions.



Energy generation shall be performed by renewable energy systems located within building footprint.

It can be extended to adjacent lots as long as there is a physical connection and direct control of renewable energy generation system.

Responsibility of the buildings relates

 PEBs shall ensure an added value providing accessible, comfortable and healthy indoor environments.

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PEB shall ensure an added value providing easy access to e-mobility.

How can PEB become the new building standard?



Put **user/households at the center** i) understanding user's needs and ii) guiding them towards better energy practices



Defining **viable and tailorable technology concepts**



Integrated climate and cultural approach that encompasses overall building configuration, technology selection, and user/systems interaction.



Define **viable business models** that include attractive financial mechanism and co-benefit evaluation

How to identify and evaluate co-benefits related to Plus Energy Buildings?

Guidelines for co-benefit evaluation



- to estimate the co-benefits associated with Plus Energy Buildings (PEBs) at household and community level
- to integrate the co-benefits associated with PEBs into business models and cost assessments
- to be presented within marketing strategies aimed at promoting the use and share of PEBs in the future



real estate agents, building occupants, policy makers and technology developers

Group of Interest



What is it? An External Advisory Board made of internationally renowned external experts on the topic in question.

What is the aim?

- providing guidance and feedback to a specific topic,
- create a network of expert to exchange about cutting edge research in the topic area

How to subscribe?

Online:

<https://docs.google.com/forms/d/e/1FAIpQLSdxrb-XeYui2yZUGo-7PUAf-02WvUxuJv3J5Cq9W33rBWht0q/viewform>

or by filling the form at the registration desk

Agenda



- 9:30 - 9:35 Brief introduction to the project and outline of the workshop
Annamaria Belleri, Eurac Research
- 9:35 - 9:40 Introduction to the Co-benefits from Plus Energy Buildings
Samar Thapa, Università Ca Foscari Venezia
- 9:40 - 10:00 Direct Costing methodology
Francesco Bosello, Università Ca Foscari Venezia
- 10:00 - 10:20 Discrete Choice Experiments methodology
Andrea Bigano, Mediterranean Centre for Climate Change
- 10:20 - 11:00 Discussion and Feedback

Thank you for your attention!



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Introduction to the Co-benefits of Plus Energy Buildings

**PEB co-benefit at household and society level: overview on
design of experiment and expected results**

Samar Thapa (UNIVE), Francesco Bosello (UNIVE), Andrea Bigano (CMCC), Aisling Sealy Phelan (CMCC), Anna Alberini (University of Maryland)

Workshop on Co-benefits of Plus Energy Buildings in household and
community level



Co-benefits, the definition

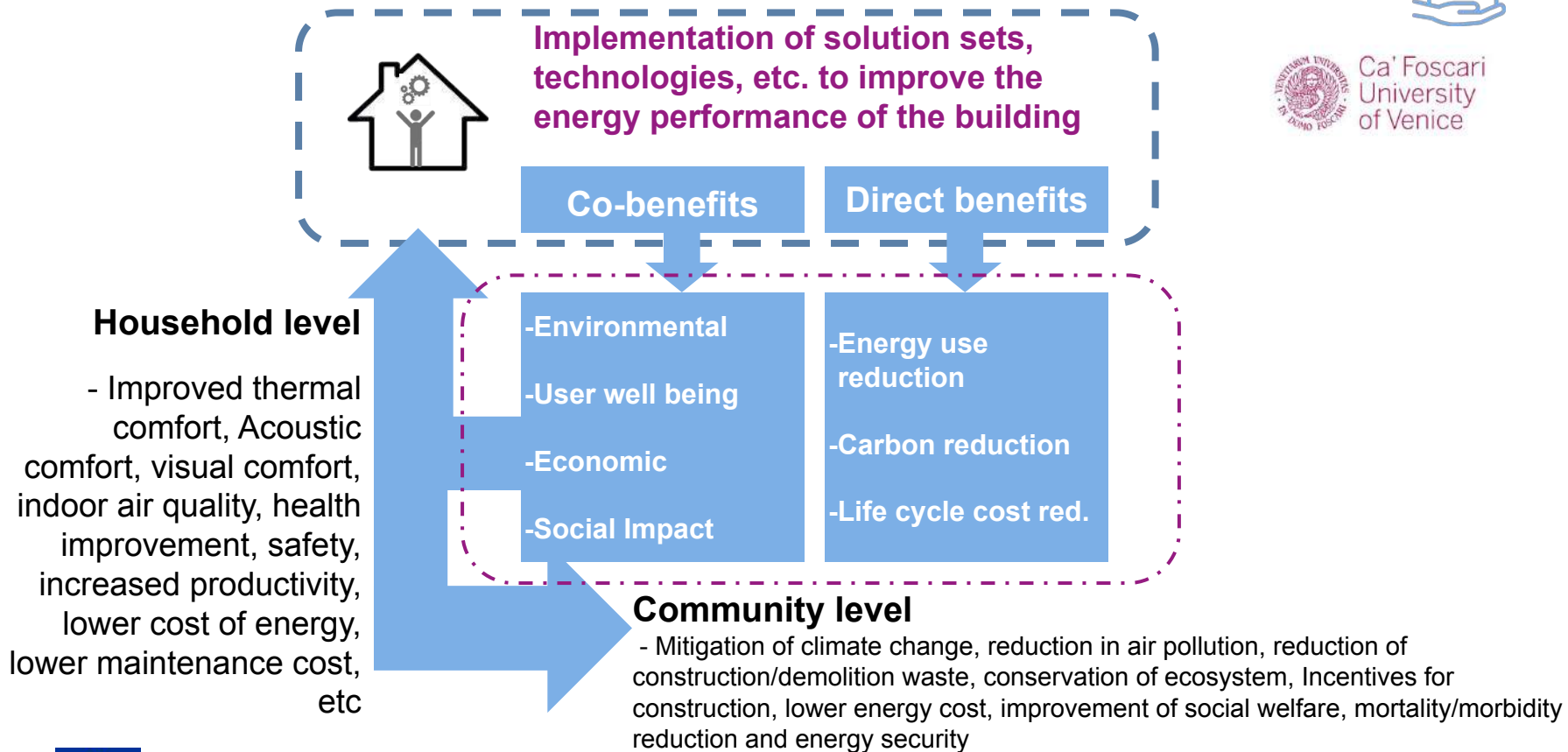


“The positive effects that a policy or measure aimed at one objective might have on other objectives, without yet evaluating the net effect on overall social welfare”

IPCC 5th Assessment Report (AR5)



Co-benefits of a Plus Energy Building



Cultural-E Task 5.2 and 5.3

Proposed Approach



What co-benefits?

Household Level

Community Level (that we interpret as «social»)

What Methods?

Some kind of «market or price» support for the evaluation exists

e.g.

- Energy savings from more e-efficient building
- ...

e.g.

- Emission savings from more e-efficient building
- More employment...

Direct costing

Value to the building «pricing» directly some of its features

No direct evaluation support from market transactions exists

e.g.:

- Welfare gains from high indoor air quality
- Welfare gains from better acoustic / thermal comfort
- Sense of satisfaction of living in a low environmental impact house...

Discrete Choice Experiment

Value to the building willingness to pay for some of its features



Thank you for your attention!



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Applying «direct costing» to evaluate co benefits of Plus Energy buildings

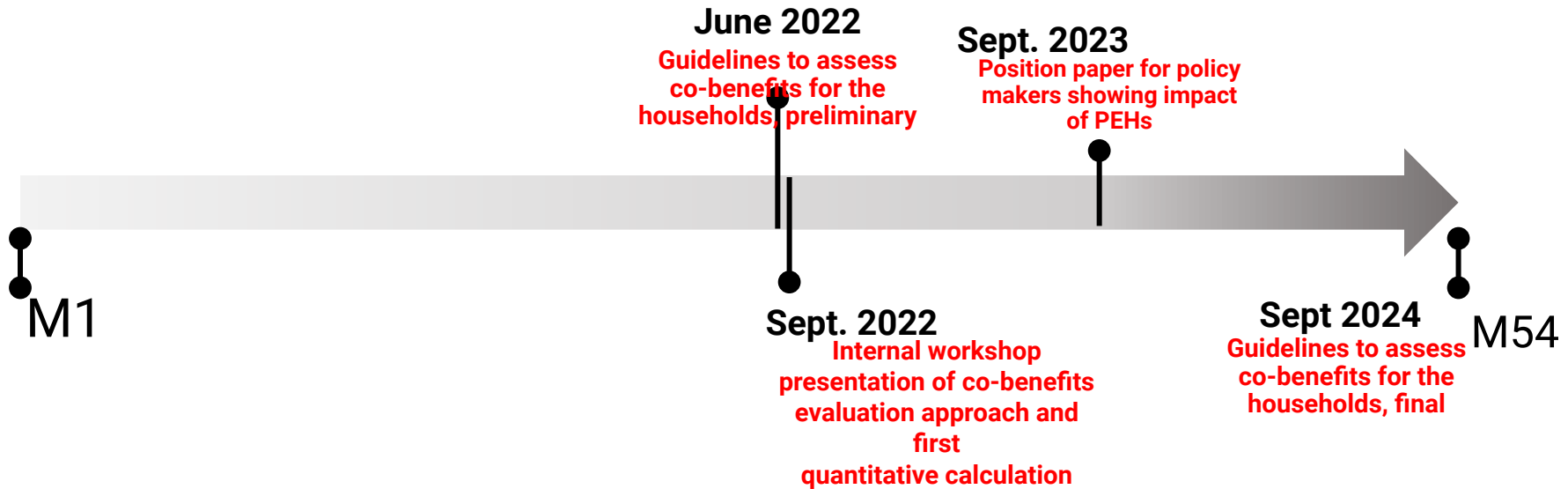
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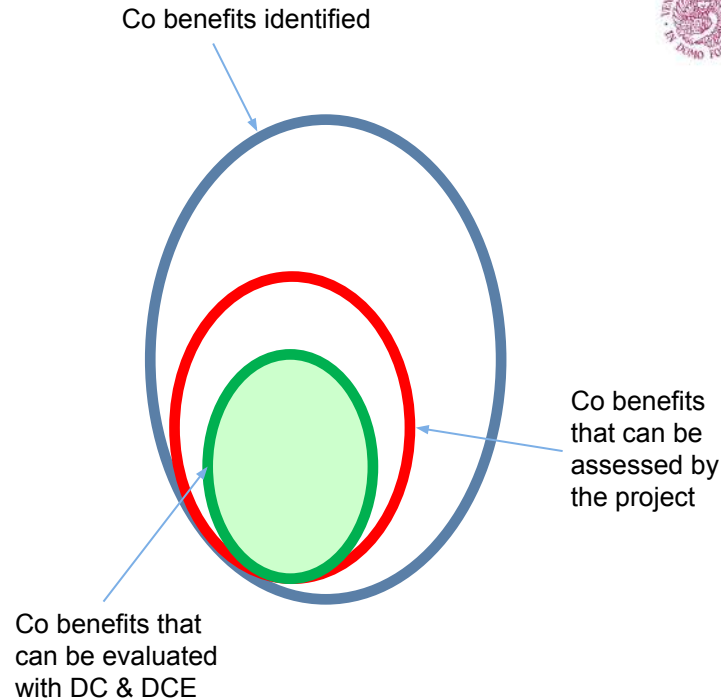
Timeline recap: Estimation of co-impacts at household and community level



What has been done

We selected what is suitable to an economic evaluation via direct costing and choice experiment from the list of benefits and co-benefits already identified in Cultural-E ;

We **interacted with partners** to define building references, select co-benefits suitable for DCE.



Applying direct costing: what is needed?

	E + Building (A)	Reference Building (say «Net 0» (B)	(A) - (B)
Material use by source	??	??	✓
Energy consumption	??	??	✓
GHG emissions	??	??	✓
Other emissions	??	??	↓

(A) - (B) is what we shall evaluate economically

The evaluation should be conducted over the life cycle...

Direct costing: which co benefits and how?



Co-benefit	Indicator	Direct support for the assessment
Reduction of construction material and demolition waste.	Kg of various waste categories produced over the life cycle (Δ of a PEB wrt a NZEB).	Standard Waste Treatment Cost (from the literature, Vázquez-López et al., 2020)
Lower operational and maintenance costs.	Hours of operational and maintenance over the life cycle (Δ of a PEB wrt a NZEB).	Average market value of those services.
Mitigation of climate change.	Kg of CO2 equivalent emissions over the life cycle (Δ of a PEB wrt a NZEB).	The social cost of carbon (from the literature, Rennert & Kingdon 2019)
Employment creation.	Number of jobs over the life cycle (Δ of a PEB wrt a NZEB).	The average wage in the relevant economic sector. EUROSTAT data
Improvement of social welfare.	MWh of energy consumed over the life cycle (Δ of a PEB wrt a NZEB).	Translated in terms of reduced energy poverty □ assessing the effect of energy savings on the budget of households belonging to the lowest income deciles.
Reduction of air pollution.	Kg of particulate matter emitted over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of PM10 emissions or equivalent, €39.2. (CE Delft, 2018)
Reduced ozone depletion.	Kg of CFC equivalent substances emitted over the lifecycle (Δ of a PEB wrt a NZEB).	The external or social cost of emitting additional kg of CFC or equivalent, €30.40. (CE Delft, 2018)
Reduced formation potential of tropospheric ozone photochemical oxidants.	Kg of Ethen equivalent emissions over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of Photochemical oxidant formation is given as €1.15 per kg of non-methane volatile organic compounds (NMVOC) emitted. (CE Delft, 2018)
Reduced acidification potential.	Kg of Phosphate equivalent emitted over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of a unit of sulphur dioxide emissions is €4.97 per kg. (CE Delft, 2018)
Reduced eutrophication potential.	Kg of phosphate equivalent emitted over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of freshwater eutrophication is given as €1.86 per kg of phosphate equivalent (CE Delft, 2018)
Reduced abiotic depletion potential for non-fossil resources.	Kg of Antimony equivalent emitted over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of resource use, minerals and metals is given as €1.64 per kg of Sb equivalent. (Trinomics, 2020)
Reduced abiotic depletion potential for fossil resources.	Mj of energy use over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of fossil resource use is given as €0.0013 per Mj. (Trinomics, 2020)
Reduced water use.	M ³ of fresh water use over the life cycle (Δ of a PEB wrt a NZEB).	The external or social cost of water use is given as €0.00499 per m3 of water equivalent. (Trinomics, 2020)



A working example



Direct costing assessment of the Global Warming Potential (GWP) embedded in the warming/cooling/insulating technologies applicable to a Mediterranean “low rise” building, with:

NFA of 700 m², service life is 20 years.

The technology consists in a mix of: active window system (AWS Eurofinestra), a 200 m² photovoltaics system for energy generation, an 80 Kg stainless steel storage system, a 600 m² heating floor panel distribution system, a 1Kg-7kW heat pump Air-Water heating system, a 5000 m²/h mechanic ventilation system.

Source data are made available by the LCA developed in CULTURAL-E.

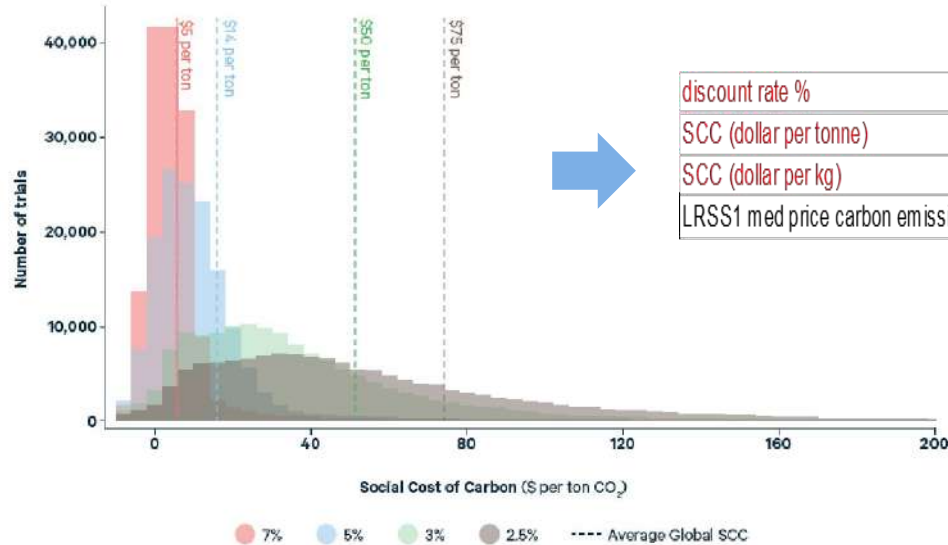
62.5 Tons of CO₂ equivalent embodied in their different production, waste and recycling phases

Evaluated using the concept of
SOCIAL COST OF CARBON



A working example

The Range of Values of the SCC



discount rate %	7	5	3	2.5
SCC (dollar per tonne)	5	14	50	75
SCC (dollar per kg)	0.005	0.014	0.05	0.075
LRSS1 med price carbon emissions	\$312.62	\$875.35	\$3,126.24	\$4,689.36

The direct costing method attaches to the technological mix an external cost due to its global warming potential, or said differently, to its originated climate change impact, of **\$312 to \$4689**.

Note that this is not yet a co-benefit measure. To translate the costs of carbon emissions into a co-benefit it is necessary to compare this value with what a NZEB can originate...

Source: Rennert & Kingdom (2019)

Thank you for your attention!



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Wir bauen, wo Stuttgart am schönsten ist

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Applying Discrete Choice Experiments to evaluate the co-benefits of Plus Energy Buildings

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DCE– the general plan



- Two countries, France and Germany, to capture heterogeneity across EU building stocks (climate, fuels, average age, national energy efficiency policies)
- Two samples of 1000 respondents each;
- Selection and possible clustering of relevant co-benefits;
- Definition of the questionnaire, including realistic ranges for attributes;
- Consider different kind of split samples (e.g. people who did upgrades in their home – in terms of efficiency, indoor comfort, etc. - vs. people who did not)
- Testing with laypersons and developers of nZEB/ Plus Energy Buildings (databases available)
- Administration of the questionnaire by a reputable survey company using Computer Assisted Web Interviewing (CAWI) procedures;
- Econometric analysis of collected data and WTP estimation.



Latest developments for DCE (discrete choice experiments)

- general section of the questionnaire
- First tentative identification of attribute levels and their realistic ranges (with WP5 partners)
- Considered expanding the scope of the energy balance and adaptability attributes.
- Considered refining the cost attribute to accommodate different types of dwellers.



Identifying Co-benefits: from clusters...

Indoor Air Quality Cluster
Indoor air quality
Health improvement
Improvement of health conditions / Reduction of work leave (smart working)
Reduction of psychological effects
Increase in productivity (smart working)
Building's real estate value Cluster
Easier to sell / rent at higher real estate prices
Increase in the value of the building
Energy consumption Cluster
Reduction of energy consumptions
Reduction of energy consumption costs
Lower cost of energy
Less need for energy subsidies
Reduction of dependence on fossil fuels

Indoor Comfort Cluster
Thermal comfort
Acoustic comfort
Visual comfort/quality of natural light indoor
Local Pollution reduction Cluster
Biodiversity protection
Environmental resources protection
Conservation of ecosystems
Energy security
Easy of use
Lower maintenance costs
Reduction of CO2 emissions
Resilience to climate change
Safety

...to (semi-final) selection

- **ENERGY BALANCE:** the difference between energy produced from renewable sources and energy consumed
- **Indoor Environmental Quality:** Indoor air quality (IAQ), thermal comfort, visual comfort and acoustic comfort)
- **ADAPTABILITY:** the ability of the building to adapt to user needs. It includes the control that a user can exercise over a technology and how the presence of this technology offers more possibilities to the user (columns then purchase of electric car, etc.)
- **PRICE** (investment cost and ordinary/extraordinary maintenance - O&M (LCC) , but also rental costs)



Questionnaire structure 1/3



Ice-breaking /general questions (Likert scale or multiple choice)

- Do you own or do you rent your main household dwelling
- Did you move in the last 10 years? (Includes leaving parents' house or student housing)
- Are you planning to move in the next 5 years?
- Tell us about
 - the main features of your place
 - your familiarity with energy efficiency
 - your familiarity with efficient buildings (NZEB /Plus Energy)
 - your familiarity with energy districts/communities
- your own experience with energy efficiency practices in buildings
- any public financial support you may have received to install renewable energy in your home
- your interest in joining a positive energy district sharing renewable energy—as a supplier or simply user of such energy



Questionnaire structure 2/3



Tell us about your familiarity with co-benefits, in terms of:

- natural light in your home
- air quality in your home
- indoor air quality issues you may have experienced in your home (mildew, dampness, odours etc.)
- your experiences with blackouts or brownouts in the last 12 month
- your awareness about the share of energy inputs (natural gas, oil, coal) that must be imported
- your expectations about having to cut down heating or delivery delays or interruptions.



Questionnaire structure 3/3



- Section on Discrete Choice Experiments
- ideally in three versions, depending on actual cost of surveys
 - Renters: price attribute in terms of Δ in rents
 - Owners - stayers: price attribute in terms of Δ in renovation costs
 - Owners - movers: price attribute in terms of Δ in real estate prices
- Section on Socio-demographic questions
 - Household composition and age of its members
 - Education
 - Employment
 - Income



Choice card example

Which do you prefer: would you prefer to stay with the current situation (option 1), or would you go for option 2, or option 3? Please keep in mind that if you choose to stay with the current situation, you get no additional benefits in terms of comfort or air quality or ability of the house to accommodate other needs such as more precise remote controlling of the indoor conditions or the ability to recharge an electric vehicle in your parking lot, no savings in energy consumption, and your household would not face any additional costs.

- Option 2
- Option 3
- neither – I prefer the current situation

	Attribute 1 (e.g. Thermal comfort)	Attribute 2	Attribute 3	Attribute ...	Attribute N-1	Attribute N (Costs)
Option 1	Base	Base	Base	Base	Base	Base
Status quo						
Option 2	Good	Excellent	Excellent	Base	Excellent	$\Delta = X\%$
Option 3	Good	Excellent	Base	Excellent	Base	$\Delta = Y\%$

Attribute levels to be described to respondents through clear text and visual aids

The issue of the cost attribute

- The identification of the cost attribute is crucial and problematic:



- it drives WTP
- It varies with categories of responders

- We propose to have three different versions of choice cards for renters, stayer-owners and mover-owners, as respondent will realistically envisage the cost categories they are likely to face.

- Most likely, the respondents will be either renters or stayers-owners, hence we'll need to go in most cases for variations in rents or in renovation costs.

- In any case pre-testing is crucial to determine the most suitable format for this attribut



Next Steps for DCE

- Finalise all refinements of the questionnaire
 - assess the state of the housing market at this unusual time and determine whether it is a good time to ask people to answer questions about the potential purchase of a home
 - assess whether renters appreciate energy efficiency and the opportunity to participate in a PED, or the split incentive problems renders interferes with these incentives
 - consider supplementing DCE with alternate valuation methods
- Start pre-testing
- Finalise the choice of the survey company and launching the survey



Thank you for your attention!



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Time for an interactive poll

Go to the website sli.do and insert the code
#Co-benefits
or scan the QR code in the next slide with your phone





In your opinion, what is more cost-efficient overall?

performing a deep energy efficiency renovation in an existing building



don't know / not sure



upgrading an already efficient building (e.g. class A) to Plus Energy performance levels



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What is the most appealing feature of Plus Energy Buildings for resident households? (It is possible to select multiple options)

the negligible energy costs



the indoor comfort



the idea of contributing to decarbonising the planet



the extra security stemming from self generated energy and the access to energy districts



other (please specify in the chat)



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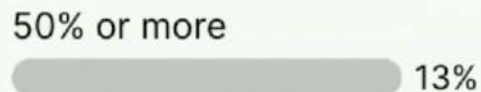
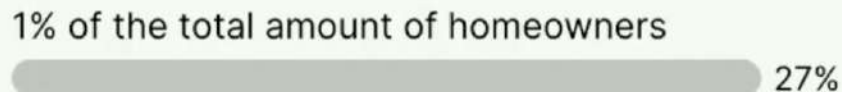
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What do you think will be the rate of PEB homeowners in 10 years from now?



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Thank you for joining us today



More information can be found at
<https://www.cultural-e.eu/>



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