REGIONS & CITIES

Seismic and energy retrofit of buildings

20 October 2020

18th EUROPEAN WEEK of REGIONS and CITIES

05>09 OCTOBER 2020 | 12>16 OCTOBER 2020 | 19>22 OCTOBER 2020

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

Work in Progress

RESTART EUROPE Together

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European Committee of the Regions

European Commission

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

Work in Progress

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20 October 2020

European Commission
Joint Research Centre

Layout

- Action 1 – Technologies for seismic & energy upgrading
- Action 2 – Technologies for combined upgrading
- Action 3 – Methods to assess the combined upgrading
- Action 4 – Regional impact assessment & contributions to an action plan
- Action 5 – Stakeholders’ engagement

Action 1

Overview and classification of technologies for seismic strengthening and energy upgrading of existing buildings

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Technologies for seismic & energy upgrading

1.1: Building typologies needing upgrading

Identify representative classes of buildings regarding both seismic & energy performance

1.2: Technology options for seismic upgrading

Classify technologies in terms of expected seismic safety improvement, cost and disruption of service, use of raw materials, Life Cycle Analysis effects, and compatibility with energy upgrading technologies

1.3: Technology options for energy upgrading

Classify technologies in terms of expected energy efficiency improvement, cost and disruption of service, use of raw materials, Life Cycle Analysis effects, and compatibility with seismic strengthening technologies

Building typologies needing upgrading

Distribution of building typologies by year of construction

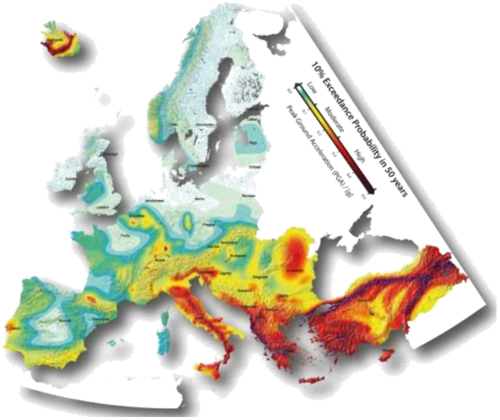
- 79% EU buildings built before 1991; 22 % before 1945
- Main EU typology: masonry; EL, CY, PT: RC

European climatic zones & seismicity

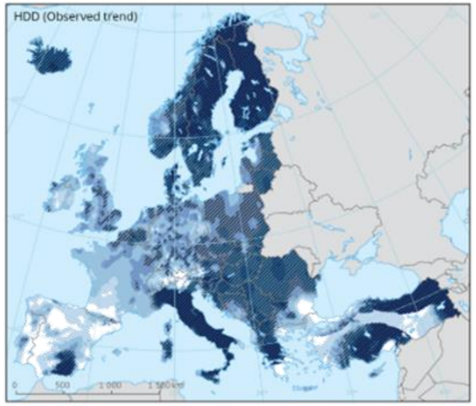
- Focus on regions in Bulgaria, Croatia, Greece, Italy and Romania

Building typologies most needing upgrading

Seismic zone	Climatic zone	Combined demand	Number of masonry buildings	% of masonry buildings
1-2	D-E-F	High	2,413,644	**33.4**
1-2	A-B-C	Medium	813,921	11.3
3-4	D-E-F	Medium	2,962,771	41.1
3-4	A-B-C	Low	1,022,432	14.2
Total			7,212,768	100.0



Giardini et al. (2014)



EEA (2019)

Technologies for seismic upgrading

Classification by structural typology: global, local

Classification by life cycle criteria: 17 criteria and definition of grade (1–5)

	LIFE CYCLE THINKING (LCT) CRITERIA	SCORE 1–5			
A	**Holistic - integrated compatible**	1	No compatible with holistic	5	Fully compatible
B	**Incremental Rehabilitation**	1	No compatible with Incr. Rehab	5	Fully compatible
C	**Disruption of the occupants / relocation**	1	Relocation of occupants	5	Minimum disruption/short-no downtime
D	**Disruption to the building, such as to the electrical/plumbing distribution systems**	1	No disruption to electrical/plumbing systems	5	No disruption to electrical/plumbing systems

Classification by cost of intervention, disruption time, compatibility with energy upgrading

- Construction cost breakdowns in 4 RC & 4 masonry retrofitted buildings (24 in total)
- Estimation of average construction cost
- Correction factors to adjust cost estimates to EU Member States
- Cost-effectiveness analysis exploring 3 alternative upgrading approaches on a selected RC building and qualitative assessment of life cycle criteria

Technologies for energy upgrading

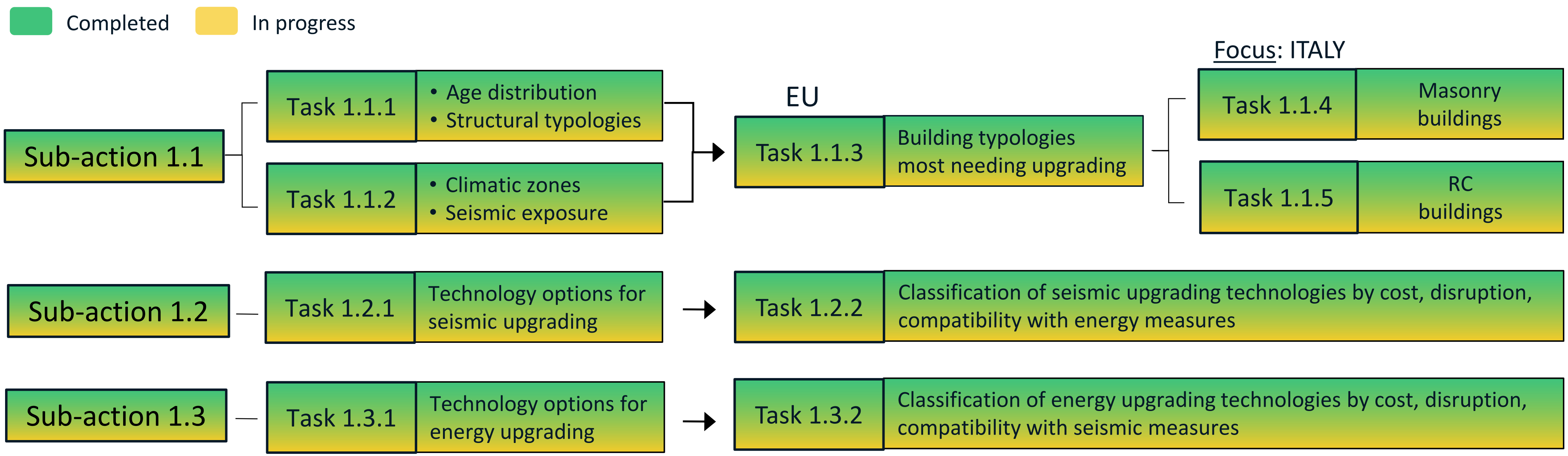
Classification by building typology

- 27 passive energy efficiency technologies (EETs) applicable to buildings' envelope
- Building typologies in 11 target countries of high and moderate seismicity
- Correlation of building typologies and EETs

Classification by unitary cost of intervention, disruption time, compatibility with seismic upgrading

- 20 seismic strengthening technologies (to check compatibility with 27 EETs)
- 11 indicators for the classification of EETs (e.g. cost, gain, env. impact etc.)
- Classification of EETs based on selected indicators
- Ranking of the EETs through multi-criteria decision making

Action 1: Next steps



- Detailed identification of building typologies in need for upgrading
- Country-based cost estimates; additional case studies; comparative evaluations
- Correlation of energy upgrading technologies with buildings typologies; ranking based on multi-criteria decision making

Action 2

Analysis of technologies for combined upgrading of existing buildings

Technologies for combined upgrading

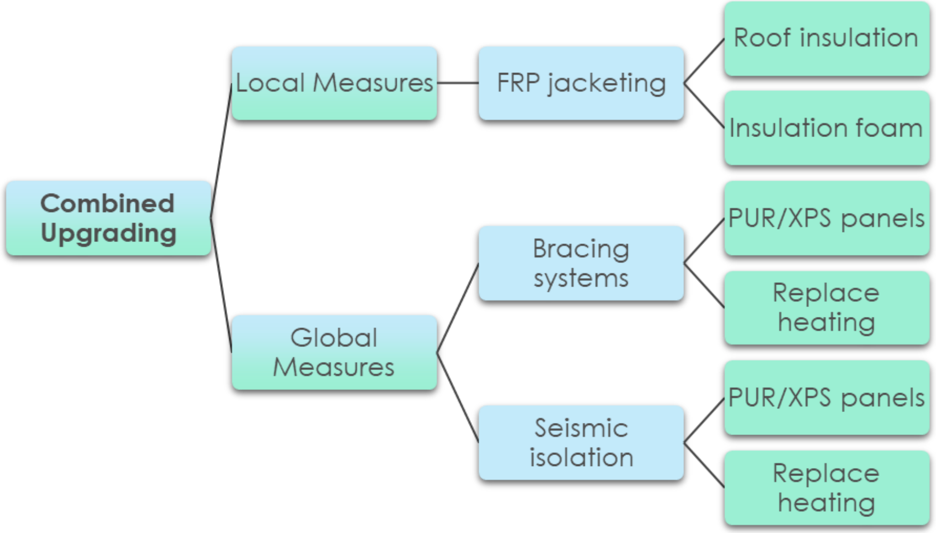
2.1: Technology options for combined upgrading of existing buildings

Review technologies for combined seismic and energy upgrading taking into account environmental effects in a life cycle perspective

2.2: Novel technology options for combined upgrading of existing buildings

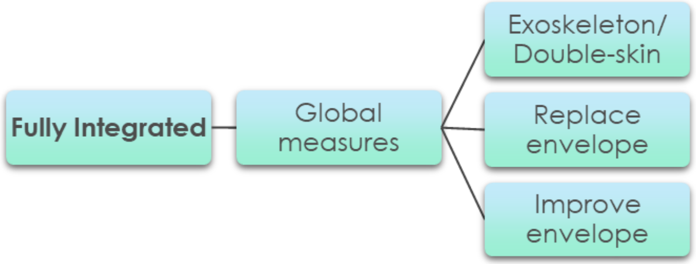
Analyse novel technologies for combined seismic and energy upgrading and compare to conventional ones – define needs for successful marketing (e.g. research and standardisation needs)

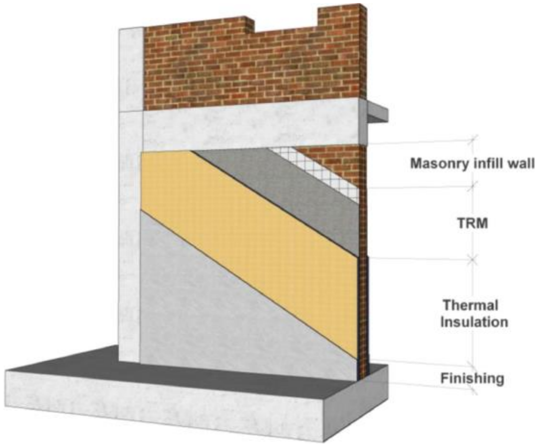
Technologies for combined upgrading



Invasiveness

- **Low:** Local seismic intervention from outside; e.g. FRP strengthening of joints plus thermal insulation of roof and window replacement
- **Medium:** FRP jacketing of columns (with partial infill demolition) plus layer of thermal insulation material inside the gap of infills
- **High:** global seismic upgrade plus application of thermal insulation material on façade and replacement of heating/cooling mechanical systems





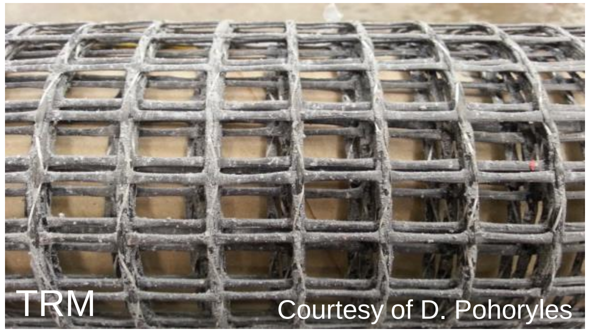
Improving envelope with TRM+Insulation

Pohoryles et al. (2020)

Novel seismic upgrading technologies

- **Local Measures**
  - RC jacketing
  - Steel jacketing
  - FRP/TRM jacketing
  - Hybrid jackets
- RC, infill, masonry, steel, timber
- **Global Measures**
  - Bracing systems
  - Addition of shear walls
  - Infill walls
  - Isolation & Energy dissipation

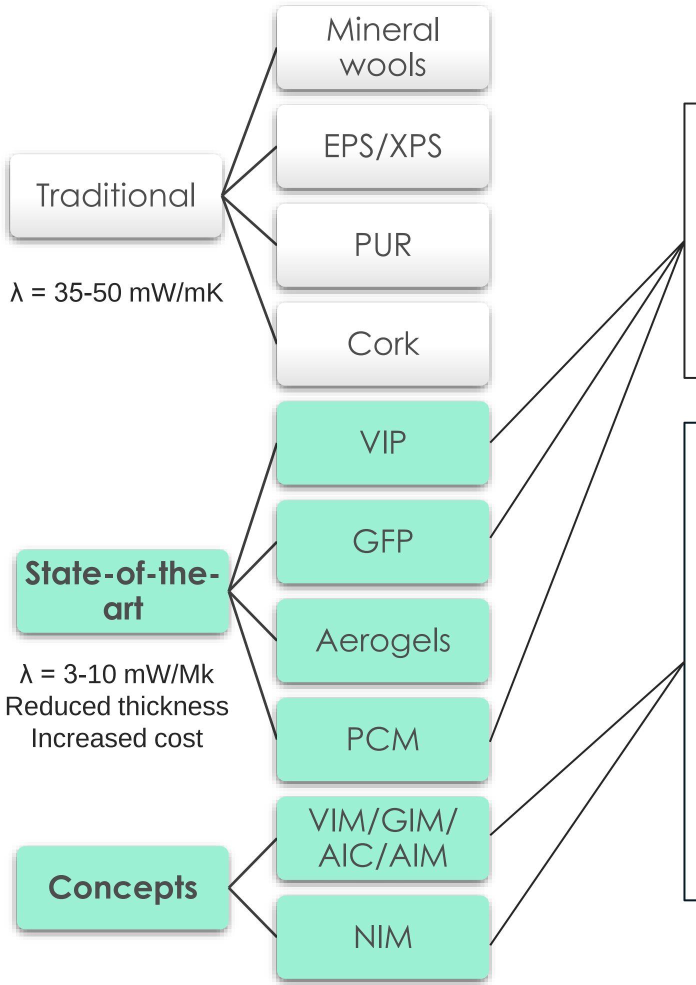
with high-performance materials



Coccia et al (2020)

European Commission

Novel thermal insulation materials



VIP: Vacuum Insulation Panels (VIP)

GFP: Gas-Filled Panels (GFP)

PCM: Phase Change Materials

Concepts for future thermal insulation

- Vacuum insulation materials (VIM)
- Gas insulation material (GIM)
- Aerogel incorporated in concrete (AIC) or mortars (AIM)
- Nano insulation materials (NIM)
  - External layers
  - Mixed in concrete
  - New material: NanoCon

Action 2: Next steps

Completed | In progress

Sub-action 2.1

- Task 2.1.1 – Technology options for combined upgrading → Task 2.1.2 – Analysis of technologies for combined seismic risk and energy inefficiency reduction (from ACTION 1 and market solutions)
- Task 2.1.1 – Technology options for built heritage

Sub-action 2.2

Seismic upgrading

- Task 2.2.1 – RC buildings
- Task 2.2.2 – Masonry buildings
- Task 2.2.3 – Steel and timber buildings

Seismic + Energy

- Task 2.2.4 – Advanced materials for combined upgrading

Energy upgrading

- Task 2.2.5 – Thermal insulation materials
- Task 2.2.6 – Smart buildings envelopes
- Task 2.2.7 – Window/ fenestration technologies
- Task 2.2.8 – Building Integrated Photovoltaics

- Additional combined upgrading technologies; review in terms of cost and environmental aspects; standardisation; masonry and heritage buildings
- Identification of novel seismic and energy upgrading technologies with potential for combined interventions
- Smart building envelopes for energy control; novel window/fenestration technologies; integrated photovoltaics

Action 3

Methodologies for assessing the combined effect of upgrading

Methods to assess the combined upgrading

3.1: State-of-the-art assessment methodologies

Review methodologies used to assess the improvement in seismic safety and energy/environmental performance

3.2: Proposed assessment methodology

Define a simplified method for the combined assessment of upgrading

3.3: Case studies

Investigate representative buildings' types retrofitted with combined upgrading technologies through implementing the simplified method

Existing methods & classification

Seismic vulnerability

- Seismic loss estimation methods (PBEE; HAZUS; AEBM)
- Method and tools for seismic vulnerability assessment (REDi™; RELi™2.0; Envision v3)

Energy/environmental

- Life Cycle Assessment (LCA) (ISO 14040/4:2006; SimaPro; GaBi; etc.)
- Life Cycle Energy Analysis (LCEA) (EnergyPlus)

Sustainability

- European and non-European rating system tools qualitative: e.g. BNB; BREEAM; Level(s); etc.
- Quantitative: SSD (SAFESUST)
- Building performance optimisation

Further classification

- Scope of assessment: new or existing building
- Considering essential indicators (energy use; climate change; natural disaster/seismicity) and relative importance
- Country where method is used
- Method effectiveness
- Readiness
- Ability to consider costs and disruption in use

Proposal of a novel method

GENERAL PRINCIPLES
- Sustainability principles
- Available legislations
- Life-Cycle performance

TECHNOLOGICAL CHARACTERISTICS
- Compatibility and feasibility
- Costs evaluations
- Incremental implementation

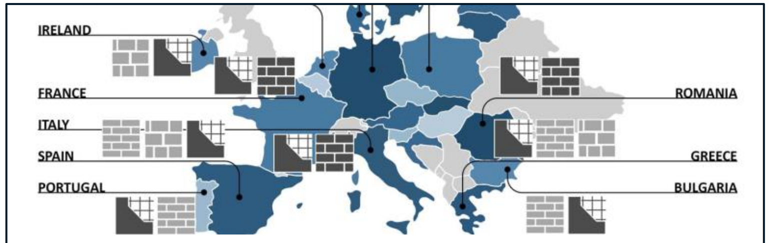
ENGINEERING COMPUTATION
- Site-dependent parameters
- Combined performance evaluation
- Dimensional scale of the application
- Simplification

STEP 1	STEP 2	STEP 3	STEP 4
Input information	Selection of techniques	Integrated design retrofit	Optimised solutions
Collect performance data and boundary conditions of existing building	Identify set of compatible and feasible energy and structural techniques	Retrofit design tool consisting of different stages	Carry out comparative quantitative assessment of energy-structural solutions

Case studies

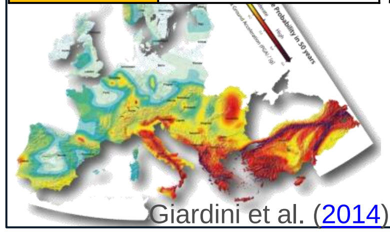
Monumental rubble masonry building
Residential brick masonry building
Residential reinforced concrete building
Public reinforced concrete building

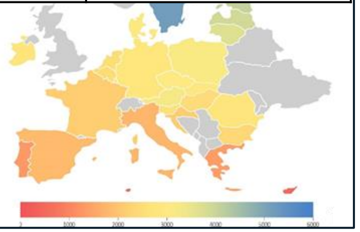
Seismic zone	Low – Moderate (L–M)	Low – Moderate (L–M)	Low – Moderate (L–M)	High – Moderate (H–M)	High – Moderate (H–M)	High – Moderate (H–M)
Climatic zone	A	B	C	A	B	C
Case study		X	X	Public RC building	Cultural heritage masonry building	



Seismic zone	Peak Ground Acceleration (PGA)
Low Moderate	PGA < 0,175 g
High Moderate	PGA ≥ 0,175 g

Climatic zone	Heating Degree Days (HDD)
A	HDD < 2200
B	2200 ≤ HDD ≤ 3500
C	HDD > 3500



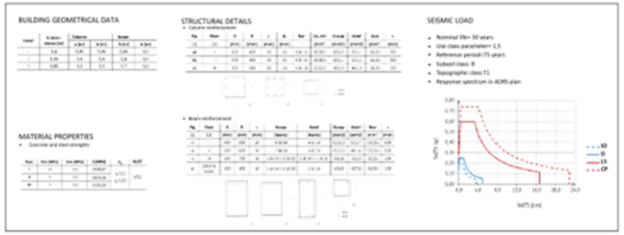


Giardini et al. (2014)

Pietro Santini RC building school

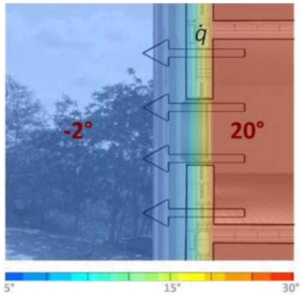
Retrofit technology (global)

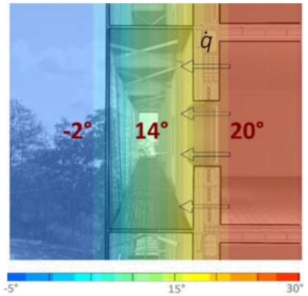
- Exoskeleton: X-shaped concentric bracing frames
- Double-skin envelope



Seismic assessment

- Increased lateral stiffness and strength after retrofit





Energy assessment

- 51% savings

Action 3: Next steps

Completed | In progress

Sub-action 3.1 — Task 3.1.1: Existing assessment methods of combined upgrading → Task 3.1.2: Classification of assessment methods by effectiveness, speed in implementation, ability to account for costs and disruption

Sub-action 3.2 — Task 3.2.1: Requirements for a novel/simplified method → Task 3.2.2: Proposal of a simplified method for combined assessment of building upgrading

Sub-action 3.3 — Task 3.3.1: Case-studies identification
→ Task 3.3.2: Standard methods application for independent assessment of seismic and energy upgrading
→ Task 3.3.3: Proposed simplified method application for combined assessment of retrofitted buildings

- Progress in optimisation of building performance; readiness; cost; disruption time
- Further refinement of requirements and steps of the proposed method
- Progress in identifying case studies and implementing standard methods for the independent evaluation of upgrading; implementation of the proposed method

Action 4

Regional impact assessment and contributions to an action plan

European Parliament (2020)

Regional impact assessment & contributions to an action plan

4.1: Priority regions

Rank EU regions based on seismic risk, energy performance of buildings, and socio-economic indicators

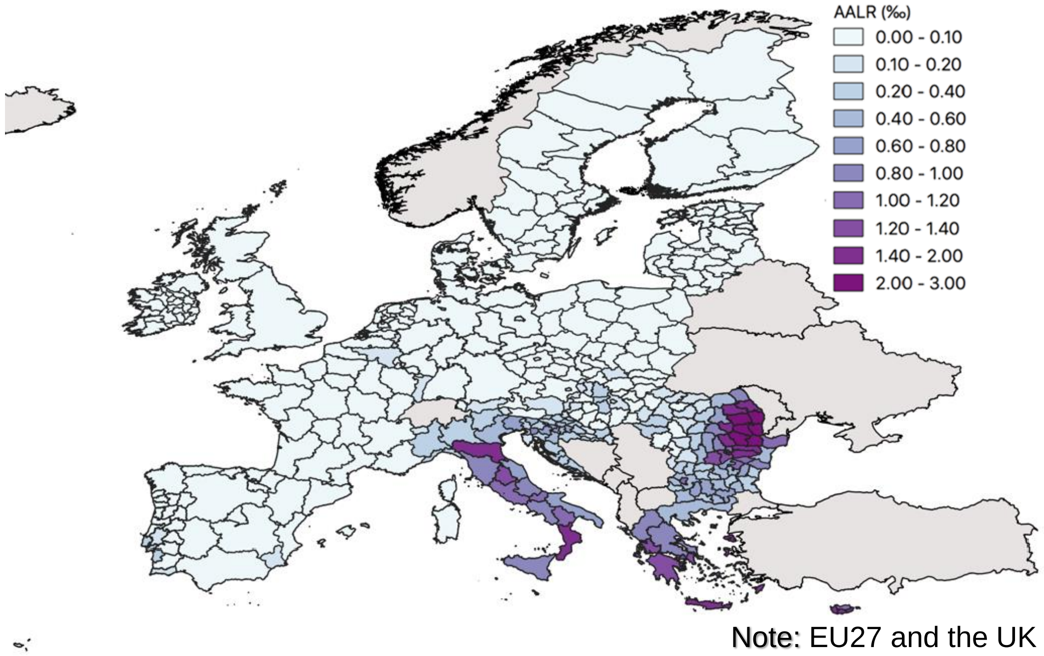
4.2: Implementing measures

Review legislation, incentives, guidance and standards prescribed in EU Member States regarding buildings’ retrofit

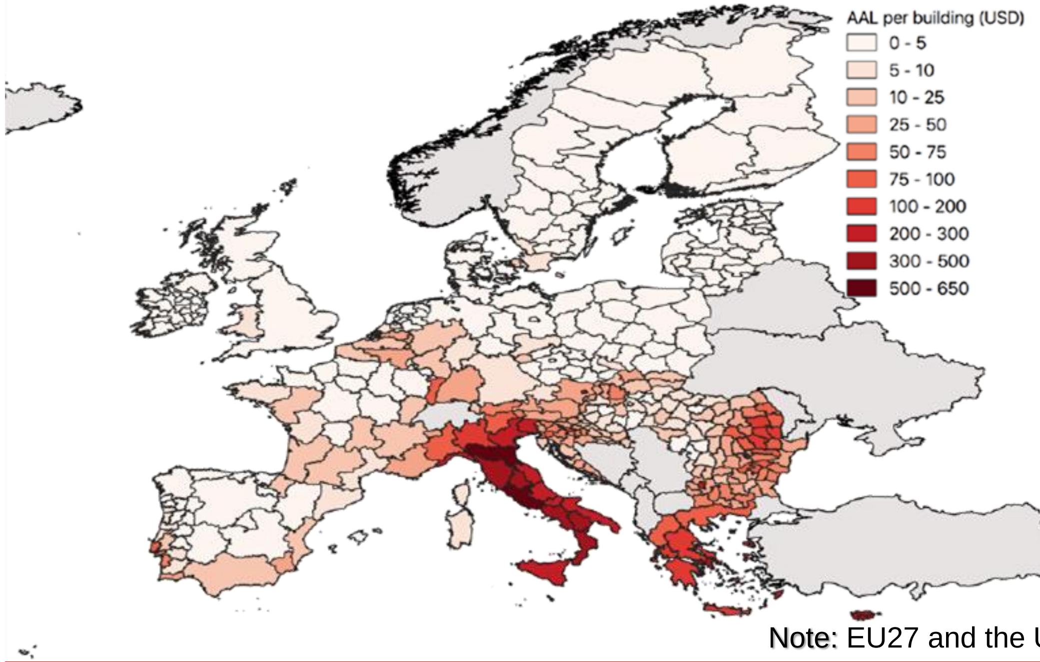
4.3: Scenarios for interventions

Define concurrent and non-concurrent intervention scenarios (considering also replacement) and assess scenarios at regional level in terms of seismic safety and energy efficiency

Seismic risk assessment



Note: EU27 and the UK



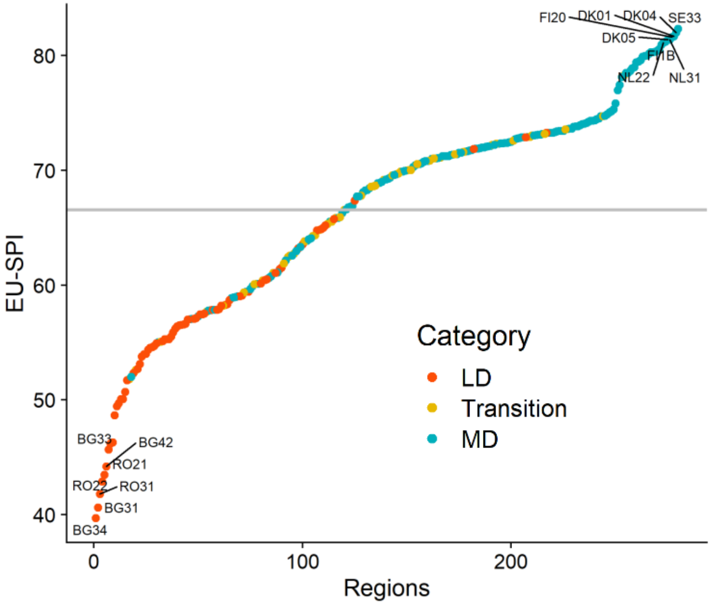
Note: EU27 and the UK

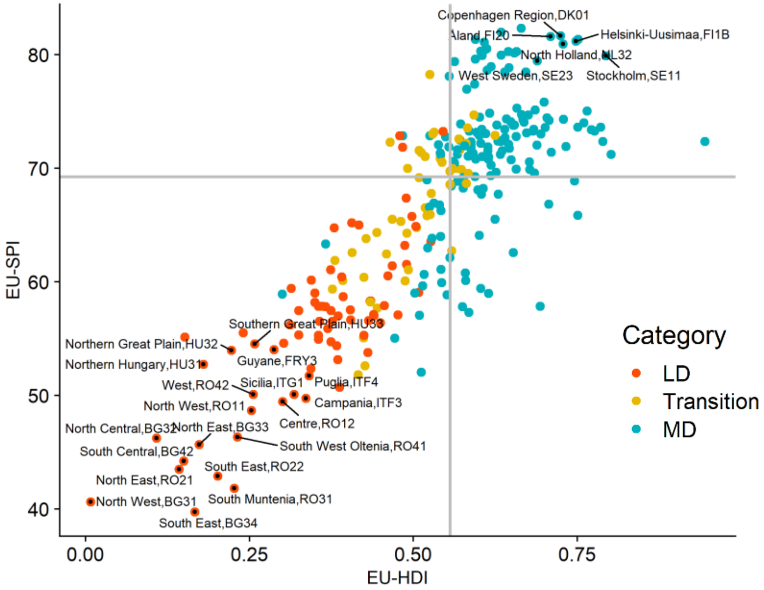
AALR
highlights regions with high losses compared to the exposure value

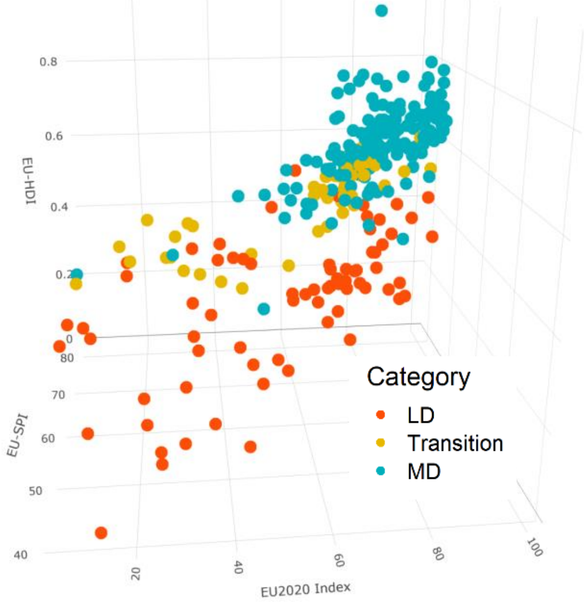
AAL per building
absolute loss normalised to exposure size

Socio-economic indicators & ranking

Regional ranking







Single composite indicator: MD are performing better than transition and LD regions

Pairs of indicators: Positive and strong correlation

Multiple composite indicators: More informed results for groups of regions

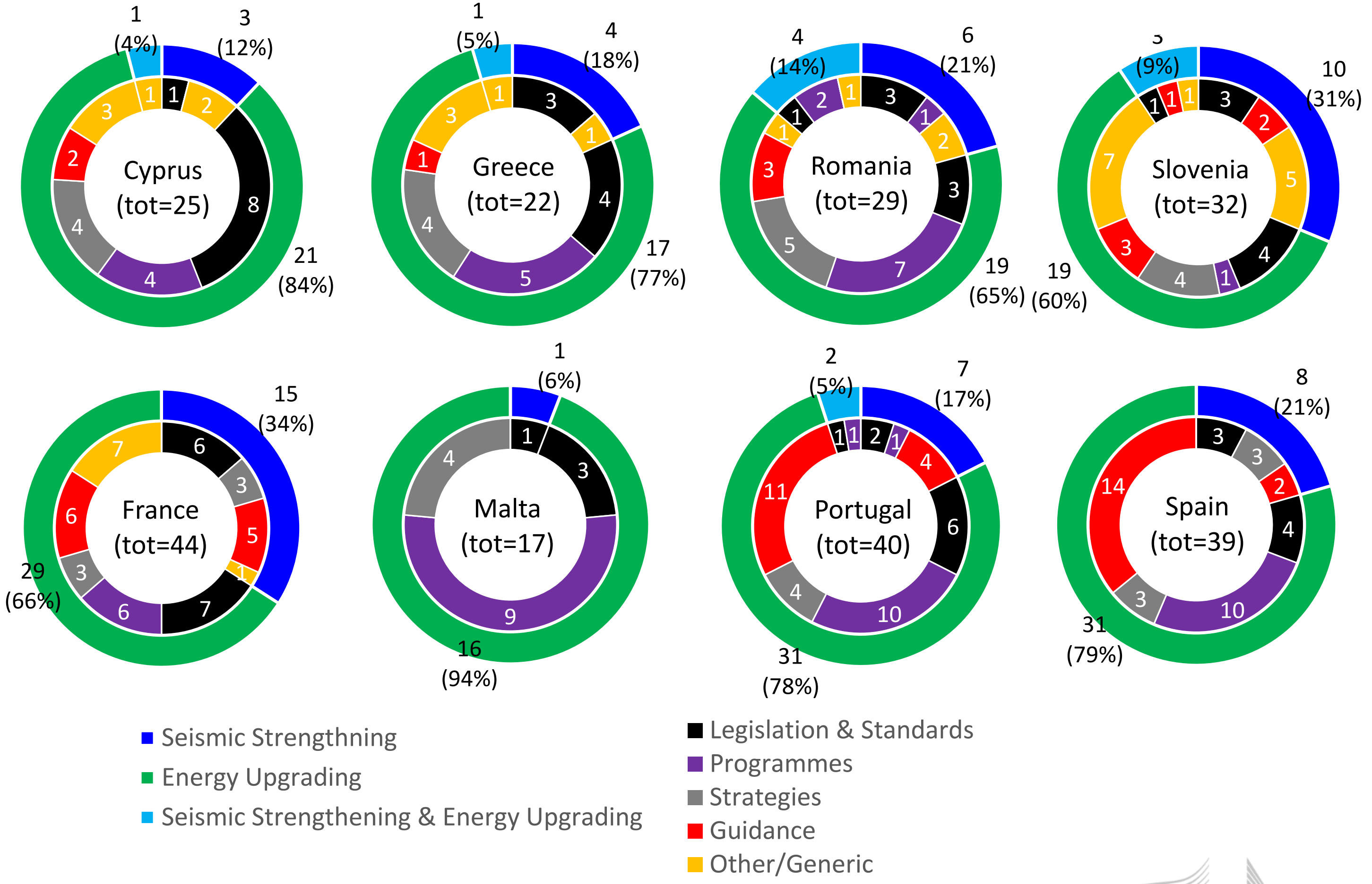
Note: corresponding to the EU28 - to be updated

European Commission

Implementing measures

Assessment of measures

- Various “energy” strategies and programmes with elevating demands
- Lack of “seismic” and “joint” measures – less public awareness
- Engagement of hard-to-reach groups: building as a whole, service interruption, consent
- Cost issues (e.g. non-regulated prices); scarce data
- Seismic insurance schemes in France, Spain, Portugal



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Scenarios for intervention in Italy

Definition of intervention scenarios →

- based on seismic and energy demand
- potential extent of field of application

SCZ	Intervention Scenario
SCZ1	Comprehensive concurrent seismic and energy upgrading; possible demolition/reconstruction
SCZ2a	Seismic upgrading with minor energy efficiency upgrading
SCZ2b	Energy upgrading with minor seismic upgrading
SCZ3	Minor (or none) seismic and energy upgrading

SCZ	Seismic Zone	Climate Zone	No. of buildings (x10^6)	No. of buildings (%)	Population (x10^6)	Population (%)
SCZ1	1-2	D-E-F	3.84	31.47%	19.13	31.64%
SCZ2a	1-2	A-B-C	1.55	12.74%	8.00	13.23%
SCZ2b	3-4	D-E-F	4.96	40.70%	25.18	41.66%
SCZ3	3-4	A-B-C	1.84	15.09%	8.14	13.47%
		Total	12.19	100.00%	60.45	100.00%

Detailed intervention scenarios by

- Building typologies
- Retrofit technologies
- Cost, etc..

Action 4: Next steps

Sub-action 4.1

- Task 4.1.1 – Regional seismic risk assessment: selection of data and methodology → Task 4.1.2 – Perform risk assessment - (georeferenced database) → Task 4.1.3 – Priority regions for intervention
- Task 4.1.4 – Socio-economic indicators identification and method for including in impact analysis → Task 4.1.5 – Indicators collection and archive (georeferenced database)

Sub-action 4.2

- Task 4.2.1 – Italy → Task 4.2.2 – Review and assess of implementing measures → Task 4.2.3 – Proposal of implementing measures for action plan
- Task 4.2.4 – Austria, Germany, Hungary, Slovakia and Sweden → Task 4.2.5 – Review and assess of implementing measures → Task 4.2.6 – Proposal of implementing measures for action plan
- Task 4.2.7 – Bulgaria, Cyprus, Greece, Croatia, Romania and Slovenia → Task 4.2.8 – Review and assess of implementing measures → Task 4.2.9 – Proposal of implementing measures for action plan
- Task 4.2.10 – Spain, France, Malta and Portugal → Task 4.2.11 – Review and assess of implementing measures → Task 4.2.12 – Proposal of implementing measures for action plan

Sub-action 4.3

- Task 4.3.1 – Intervention scenarios for EU building stock upgrading: Concurrent - Non-concurrent - Demolition and new construction (georeferenced database) → Task 4.3.2 – Impact analysis of five intervention scenarios (based on Task 4.1.1) (georeferenced database)

Focus: ITALY

- Task 4.3.3 – Intervention scenarios for Italian building stock → Task 4.3.4 – Data on retrofitted buildings in Italy

Completed | In progress

Action 5

Stakeholders’ engagement

Stakeholders’ engagement

5.1: Involvement of stakeholders during the project

- Involve stakeholders in enquires on relevant measures, technologies and methodologies
- Organise workshops

5.2: Dissemination and outreach

Achieve visibility of project results, awareness of the need for further measures at European level, and support the follow-up action plan by means of:

a) public communication material

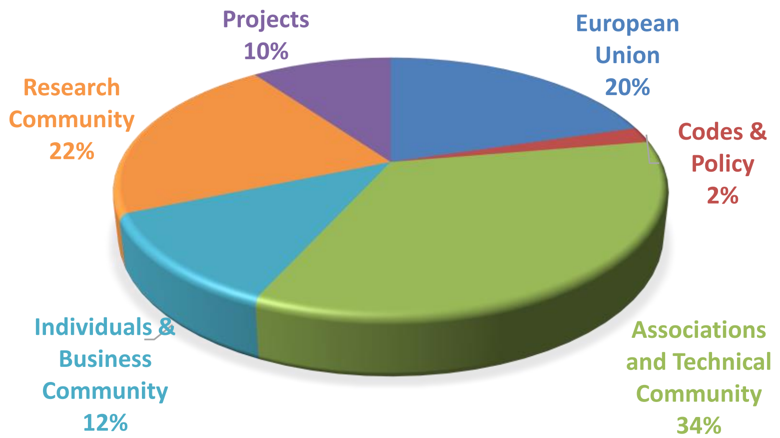
b) a web platform (including a technical area/repository)

c) technical and science for policy reports

Communication strategy

Midterm workshop: 16–19 November 2020

Day 1	16 November 2020
European Pilot Project: Integrated techniques for the seismic strengthening and energy efficiency of existing buildings	
Regional impact assessment and contributions to an action plan	
Day 2	**17 November 2020**
Overview and classification of technologies for seismic strengthening and energy upgrading of existing buildings	
Day 3	**18 November 2020**
Analysis of technologies for combined upgrading of existing buildings	
Day 4	**19 November 2020**
Methodologies for assessing the combined effect of upgrading	
Conclusions, recommendations and further steps	



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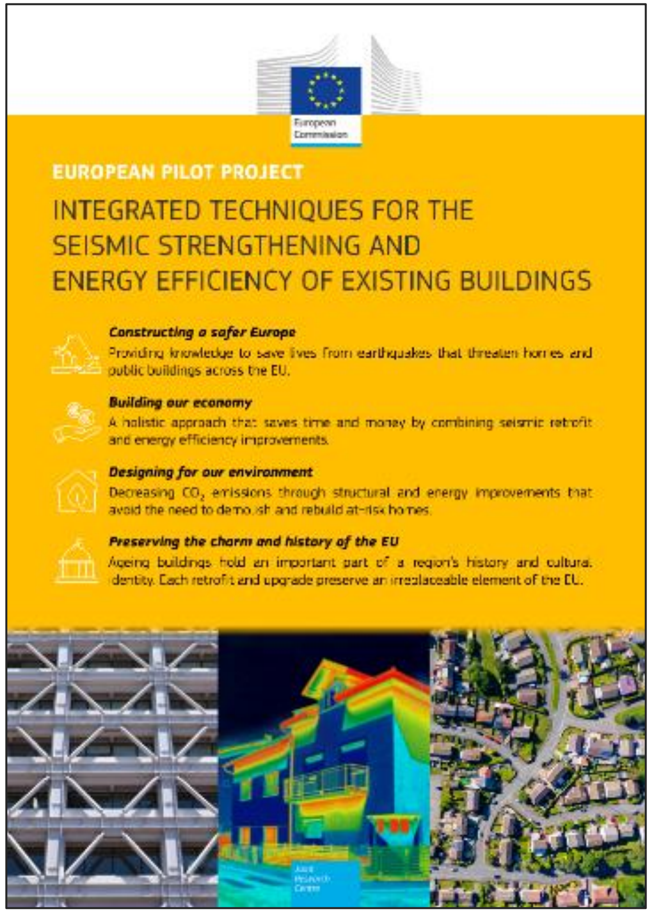
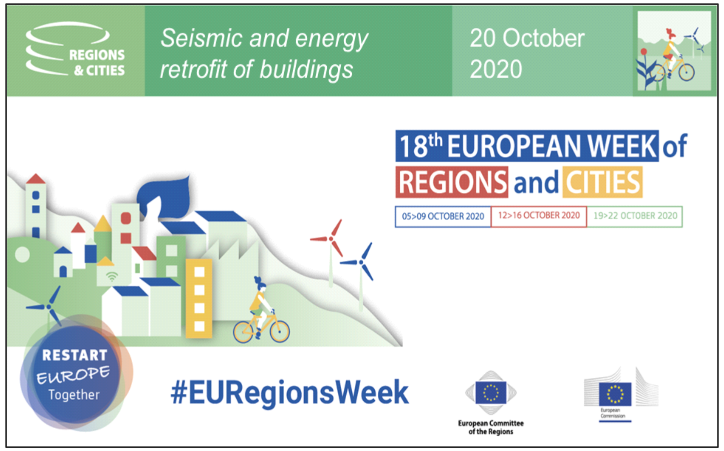
Dissemination material & activities





DRMKC(2020)

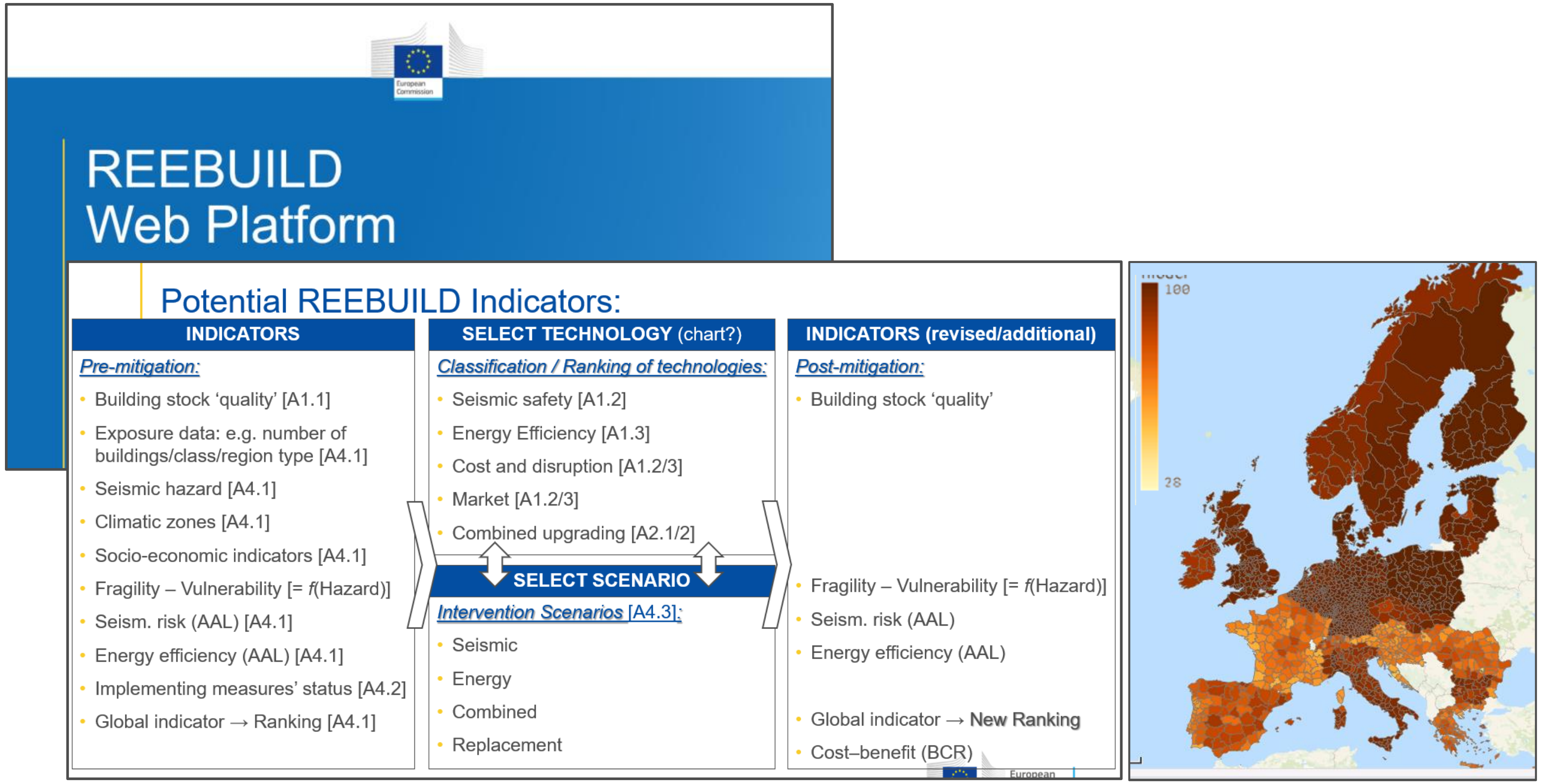
+ Pilot Project video (under preparation)

European Commission

Web platform

Sections

- Home
- About
- Actions
- Policy
- News & Events
- Library / Repository
- Software & Tools
- Contact



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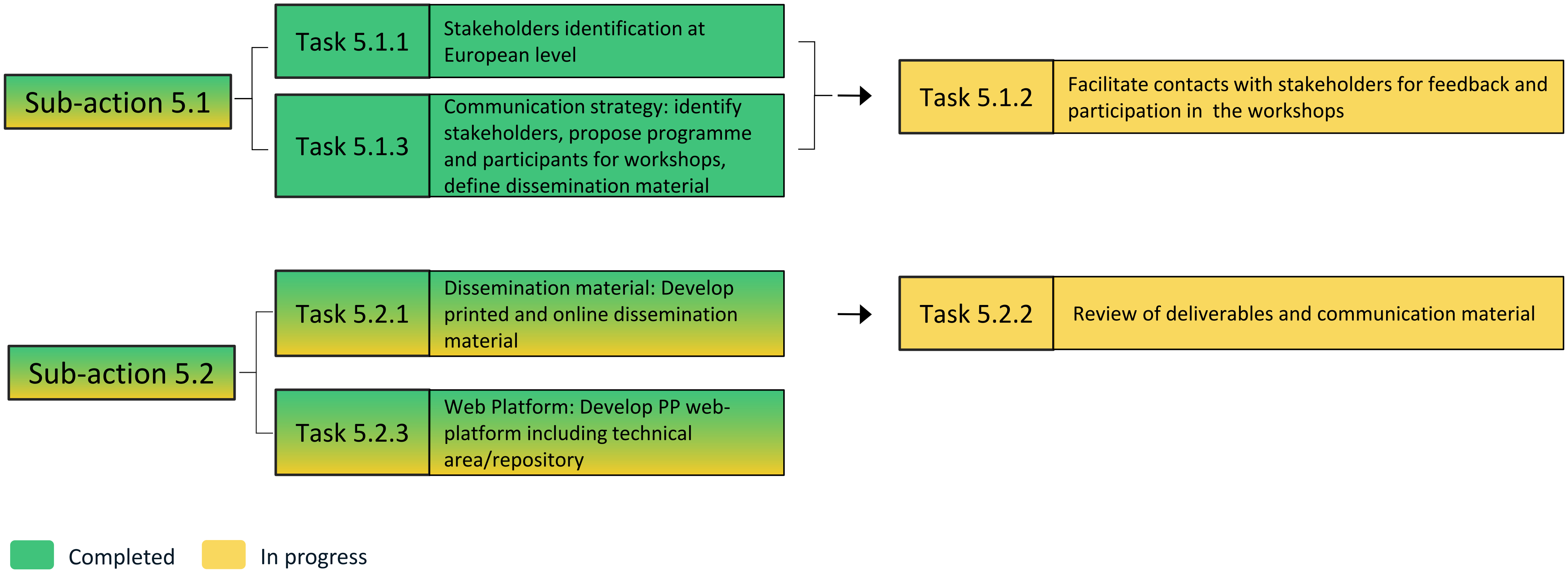
Action 5: Next steps



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