4RinEU

Reliable models for deep renovation

D6.1

WP6

Market and stakeholder analysis

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Foreword

Despite the low energy performances of the European building stock, the yearly renovation rate and the choice to perform a building deep renovation is strongly affected by uncertainties in terms of costs and benefits in the life cycle.

The project 4RinEU faces these challenges, offering technology solutions and strategies to encourage the existing building stock transformation, fostering the use of renewable energies, and providing reliable business models to support a deep renovation.

4RinEU project minimizes failures in design and implementation, manages different stages of the deep renovation process - from the preliminary audit up to the end-of-life - and provides information on energy, comfort, users' impact, and investment performance.

The 4RinEU deep renovation strategy is based on 3 pillars:

- *technologies* - driven by robustness - to decrease net primary energy use (60 to 70% compared to pre-renovation), allowing a reduction of life cycle costs over 30 years (15% compared to a typical renovation);
- *methodologies* - driven by usability - to support the design and implementation of the technologies, encouraging all stakeholders' involvement and ensuring the reduction of the renovation time;
- *business models* - driven by reliability - to enhance the level of confidence of deep renovation investors, increasing the EU building stock transformation rate.

4RinEU technologies, tools and procedures are expected to generate significant impacts: energy savings, reduction of renovation time, improvement of occupants IEQ conditions, optimization of RES use, acceleration of EU residential building renovation rate. This will bring a revitalization of the EU construction sectors, making renovation easier, quicker and more sustainable.

4RinEU is a project funded by the European Commission under the Horizon 2020 Programme and runs for from 2016 to 2020 (extended to 2021).

The 4RinEU consortium is pleased to present this report which is one of the deliverables from the project work.

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1. Executive Summary

1.1 Description of the deliverable content and purpose

In this deliverable analysis about market trends, experiences and actors are presented regarding the sectors of the products and services developed in the 4RinEU project.
The main sector which has been analysed is the renovation market for residential buildings. This is considered as the principal target market for the results of 4RinEU project. Therefore, trends and data about houses renovations have been presented and analysed at European level and particularly for 4 selected target countries: Norway, The Netherlands, Spain, and Italy.

Data about age of buildings and average renovation rates through Europe clearly show the need to accelerate renovation in construction sector, particularly concerning deep and major interventions.
The products and the analysis developed by 4RinEU project can provide an answer to these needs, offering a comprehensive set of solutions which can make possible and easier deep renovation projects.
Regarding the target countries, the analyses give dimensions and features of the residential buildings stock which can be considered more suitable and attractive to apply the 4RinEU solutions. The data demonstrate the relevance in term of quantity of multifamily buildings and apartment blocks, as well as of residential buildings owned by public or collective organizations. In countries like Norway we can see that multifamily buildings are frequent in larger cities, while rarer in the rest of the country; however, they represent a relevant part of the overall residential building stock. In all target countries the building stock features more suitable for the 4RinEU solutions have been confirmed.

The residential retrofit market has been analyzed focusing on the sectors suitable for the 4RinEU exploitable results. We saw that the project solutions can cover a wide range of the market segments involved in the renovation process: from all the activities concerning the renovation works - thanks to the high level of functional integration of the developed prefabricated wooden facades -, to consultancy and energy calculations services.

Particularly, features and contexts of the application of the prefabricated multifunctional façade system – PMFS (Exploitable Result 1) have been analysed and presented. So far the sector appears more advanced and active in new buildings projects, while the use of prefabricated wooden components for

envelope renovation is rare and appears as an innovative measure, even if technological solutions and application cases are available and reliable.
Geographic areas for market of prefabricated timber construction have been analysed. Usually, the selected timber construction companies are local-based due to several reasons (e.g. easy transportation of prefabricated components, low transport costs, knowledge of specific regulations, etc.), but companies able to work on larger geographical scale, such as national or European, can be identified. This resulted not only possible but also, in some cases, successful. This report indicates possible partnerships between wood construction companies and other entities to strengthen and spread their presence in different markets or geographical areas. These kinds of partnerships can base on different needs, such as commercial, technical, industrial and logistic, administrative, financial ones.
Some scaling up experiences have been presented in the field of wood construction companies. They can involve also real-estate corporations, public bodies owning or managing residential and non-residential buildings stock, umbrella organizations. Successful examples of scaling up process have been analyzed.

Market watching activities have been presented for the selected ERs. Main and similar players on the market have been considered and described, analysing their strategies with a focus on 4RinEU exploitable results. Innovativeness level of products and services developed within the project has been confirmed and underlined, compared to similar solutions on the market. For example, the ER1 - the wooden prefabricated multifunctional façade - represents a new product for the large common market since it suitable for buildings' renovations. The ER2 - the smart control for ceiling fan - stands out for the solid scientific base of its control algorithms and for the capability to upgrade existing ceiling fans.

Since the social housing sector represents a strategic field for the adoption of the 4RinEU solutions, analyses about it have been developed and presented. Some examples and figures through Europe have been presented to show extension, features, and potential opportunities.
If we consider the deep renovation market for social housing buildings and for other collectively owned or multi-families residential buildings, the following features, issues and opportunities can be recognized, particularly in relation to the deep renovation solutions developed in the 4RinEU project:

- Wide stocks with large number of buildings
- Relevant needs for renovations and maintenance
- Aggregation of demand - framework agreements
- Energy poverty
- Demolition or renovation

- Deep and integrated interventions
- Deep renovation vs. day-by-day maintenance needs
- Synergies between technologies and different ERs of the 4RinEU project
- Support to technical knowledges and design capacities of public and private entities
- Fire safety and other specific technical features
- Hub of solutions - aggregation (supply).

Concerning social housing, field observations show that the market sector offers specific opportunities, needs, and dimensions. Among the interesting points the following are worth to mention: (i) there is a potential large market, (ii) there could be opportunities related to demand aggregation and economies of scale both from supply both from demand side, and (iii) there are public funding schemes available.

2 Residential retrofit assessment

2.1 Global Market Sizes and Trends

Recent trends in energy consumption and energy-related carbon emissions for the global buildings and construction sector are varied, with increasing energy use but limited growth in buildings-related emissions. Buildings construction and operation accounted for 36% of global final energy use and 39% of energy-related carbon dioxide (CO_2) emissions in 2017 (Figure 1)[1]. The buildings and construction sector have the largest shares of energy and emissions, even when excluding construction-related energy use for transportation du to moving building materials to construction sites.

Therefore, the buildings and construction sector are key actors in the fight against climate change.

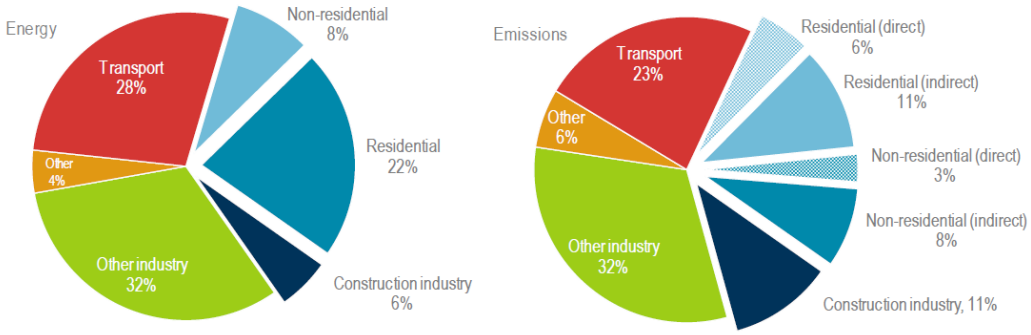


Figure 1. Share by sectors of the global total final energy use (left) and global CO2 emissions (source: Global Alliance for Buildings and Construction).

[1] Global Alliance for Buildings and Construction; 2018 Global Status Report - Towards a zero-emission, efficient and resilient buildings and construction sector; International Energy Agency, UN Environment et Al..

2.2 European Market Analysis

2.2.1 State of dwellings in Europe

In the European Union, most residential buildings were built before the introduction of thermal standards: in most EU countries, half of the residential stock was built without any thermal and energy standard requirements, which means before 1970. Anyway, there are differences between the various countries, given that in Italy, Sweden, and Denmark, for example, the percentage of dwellings built before 1980 in the overall stock is higher than 77%. On the contrary, in some other countries, such as Cyprus, Spain and Ireland, the share of new dwellings (built after 2000) is significant, as shown in Figure 2 (source: ENTRANZE project[2]).

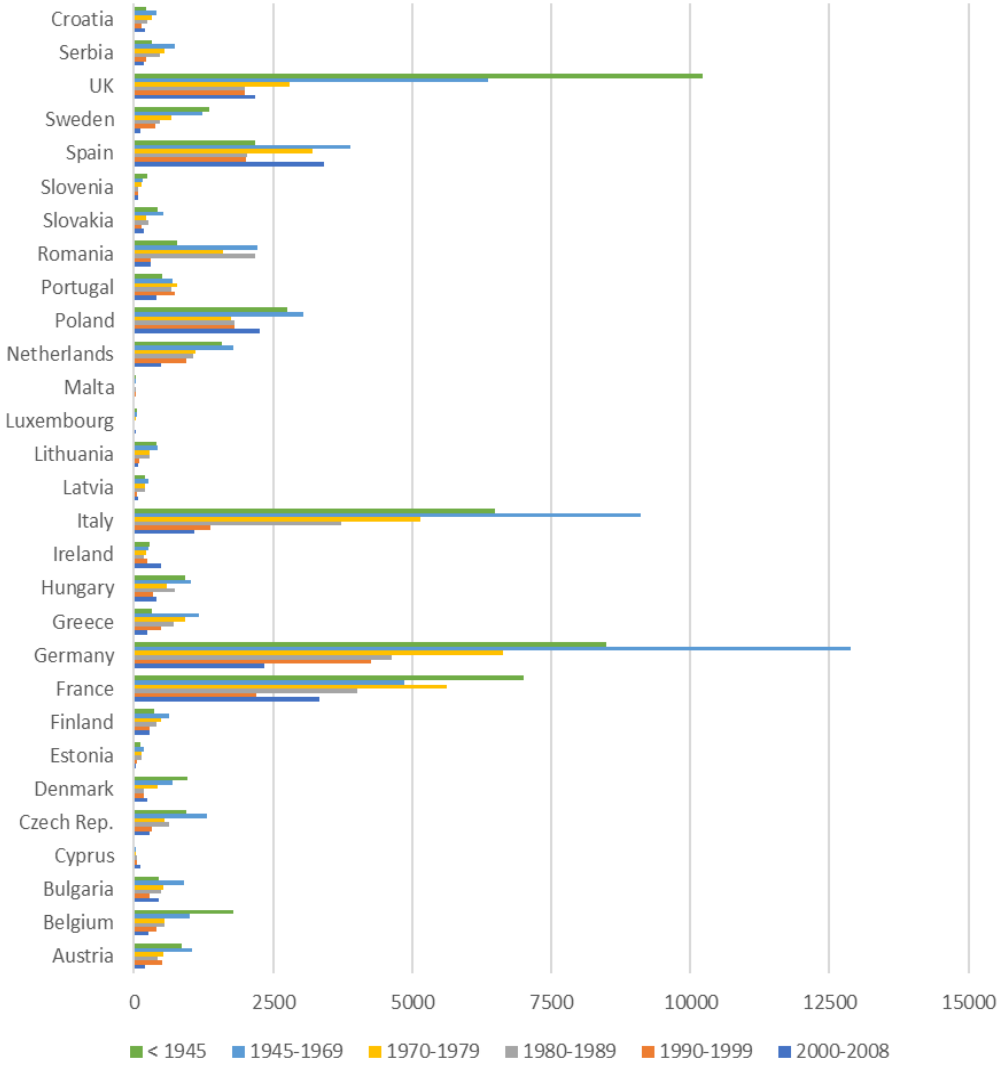


Figure 2. Dwellings according to construction date (source: ENTRANZE).

[2] https://www.entranze.eu/

The average age of existing buildings and the share of new buildings in the total stock are good indicators, that can describe the overall efficiency of the constructions, since the EU's thermal standards have progressively introduced increasingly ambitious targets.
Concerning the data on energy use, the ODYSSEE[3] database reports the consumption per dwelling, scaled to EU average climate with climatic corrections according to heating degree-days normalization method, as showed in Figure 3. The purpose of the climatic corrections is to leave out the influence of cold winter and are made only for the part of the final consumption corresponding to space heating. These data partly confirm the relationship between the age of the buildings and their consumption: in countries such as Spain with newly built homes, the final energy demand for space heating is less than 1 toe per dwelling (dw) per year, while in countries with more ancient residential buildings, such as Belgium, Croatia and Hungary are above 2 toe/dw.

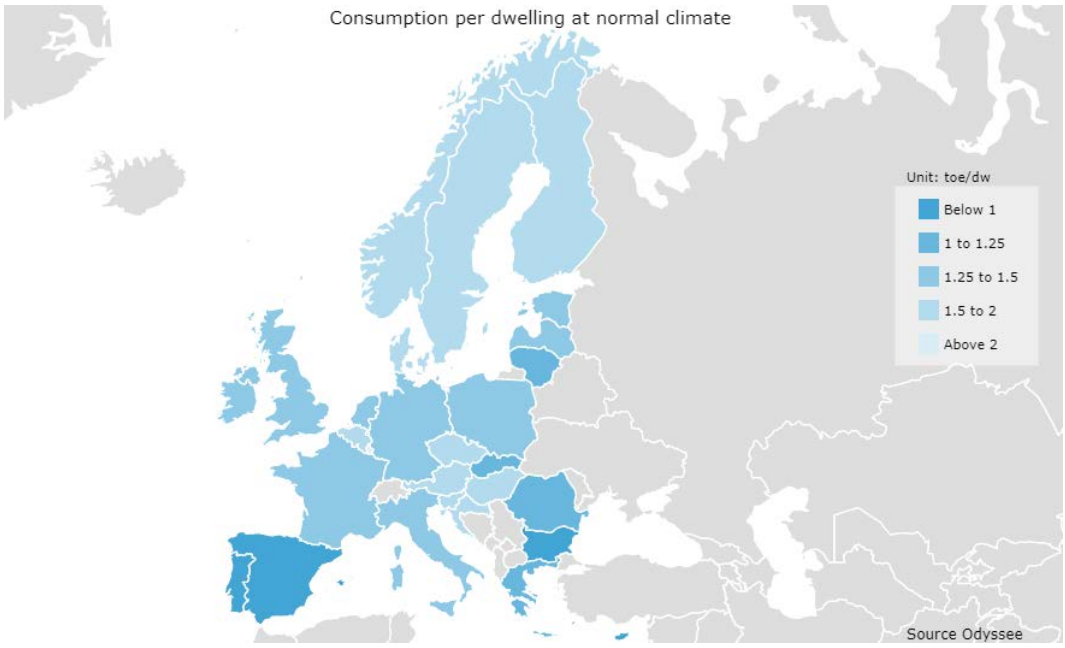


Figure 3. Final energy demand for space heating per dwelling (dw) with climatic correction (source: ODYSSEE)

Another aspect to consider is the typology of dwellings, and the share of single family houses and apartments in multifamily buildings. This data can be helpful to understand which renovation measures and of decision making and management processes can better suit the different type of buildings. The share across Europe varies a lot and it goes from Latvia and Estonia with a percentage of about 30% of

[3] http://www.odyssee-mure.eu/

single family houses, to UK, Greece, and Ireland with a percentage of more than 85% of single family houses (Figure 4).

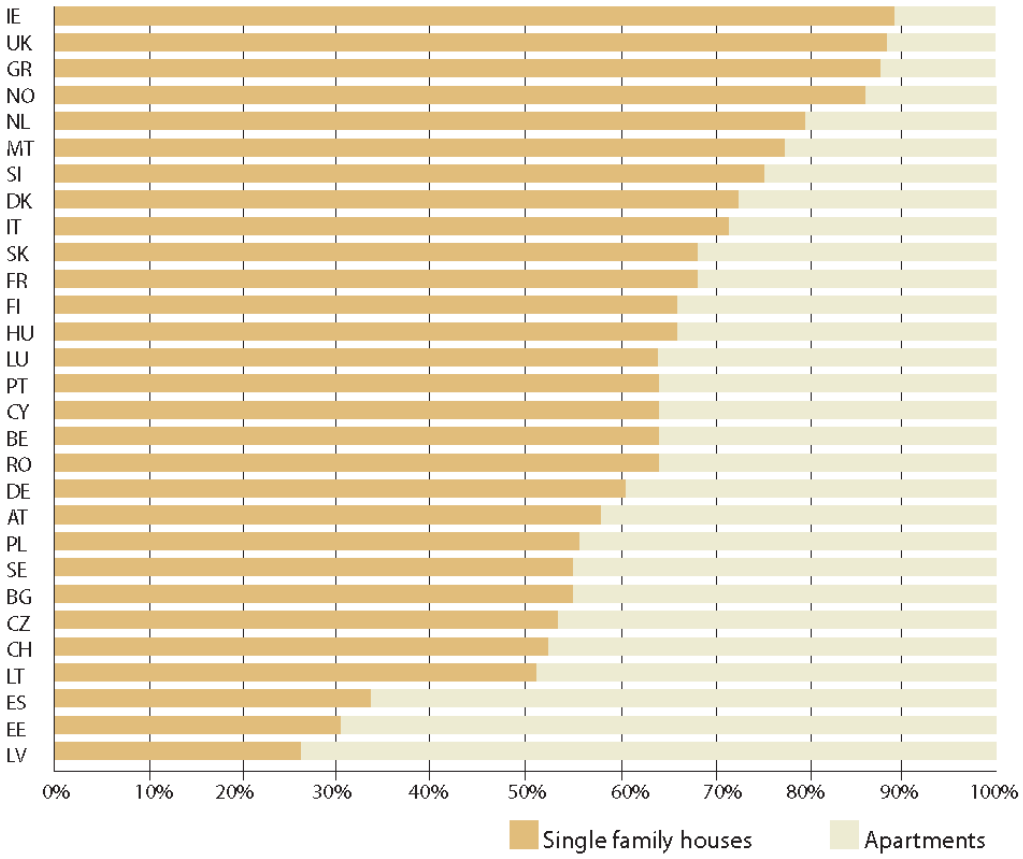


Figure 4. Single family and apartment buildings in Europe (source: BPIE Survey / values from Luxemburg, Portugal, Cyprus, and Belgium were estimated).

Furthermore, the average size of dwellings varies remarkably both between Countries and between typologies. For example, in the Netherlands, as shown in Figure 5, the average floor area for single family dwellings is about 115 m^2, while average floor area for apartments/multi-family dwellings is about 35 m^2. Instead, in Bulgaria there are no significative differences regarding the area, between the two types of dwellings and the average area is about 65 m^2.

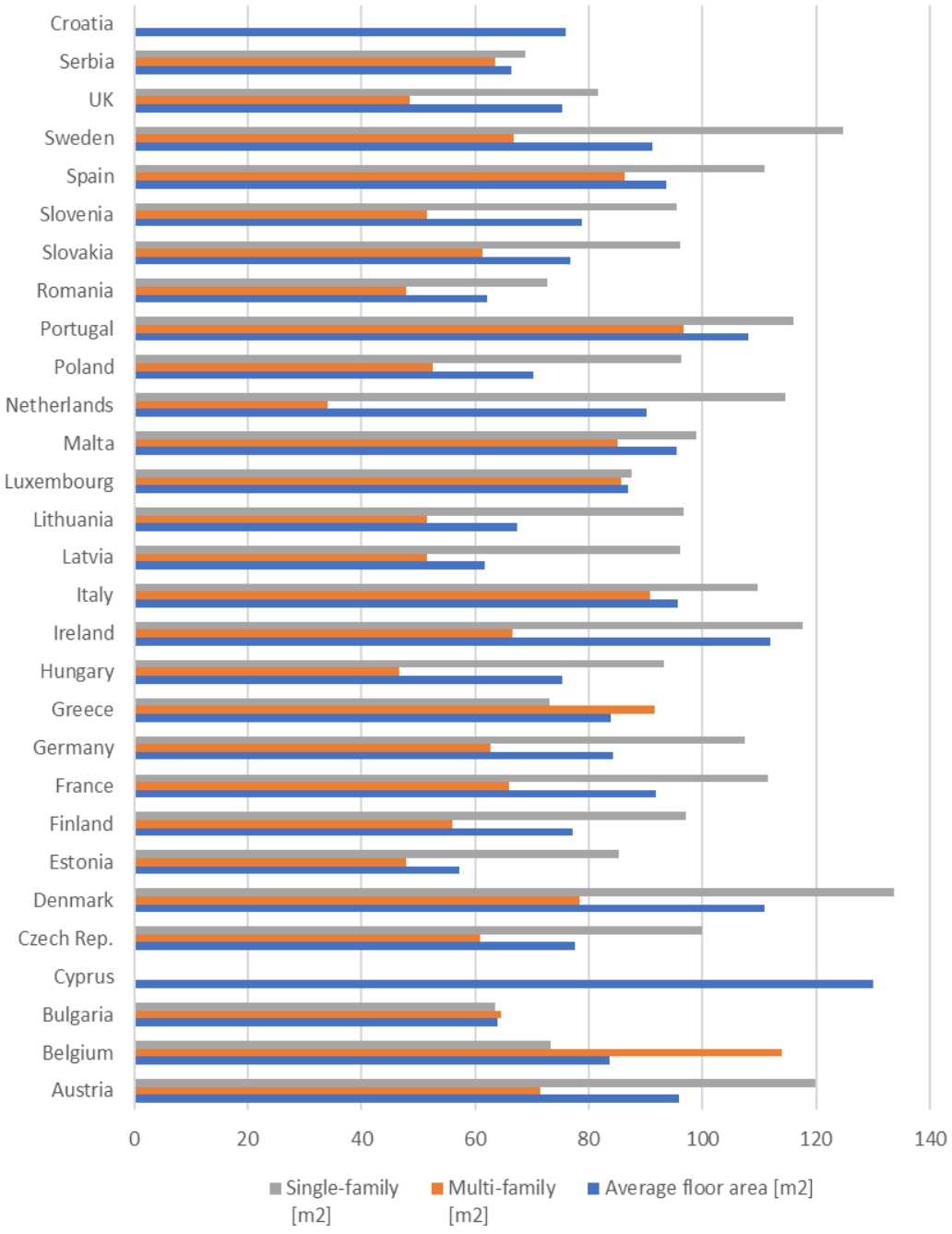


Figure 5. Average size of dwelling (source: ENTRANZE).

Another key factor which influences the willingness and ability to take actions on renovation measures is the question of tenure: Figure 6 shows that about 70% of European housing stock is owned, but these values vary widely from country to country and are around 50% in Austria and Germany and, conversely exceed 90% in Romania and Slovakia.

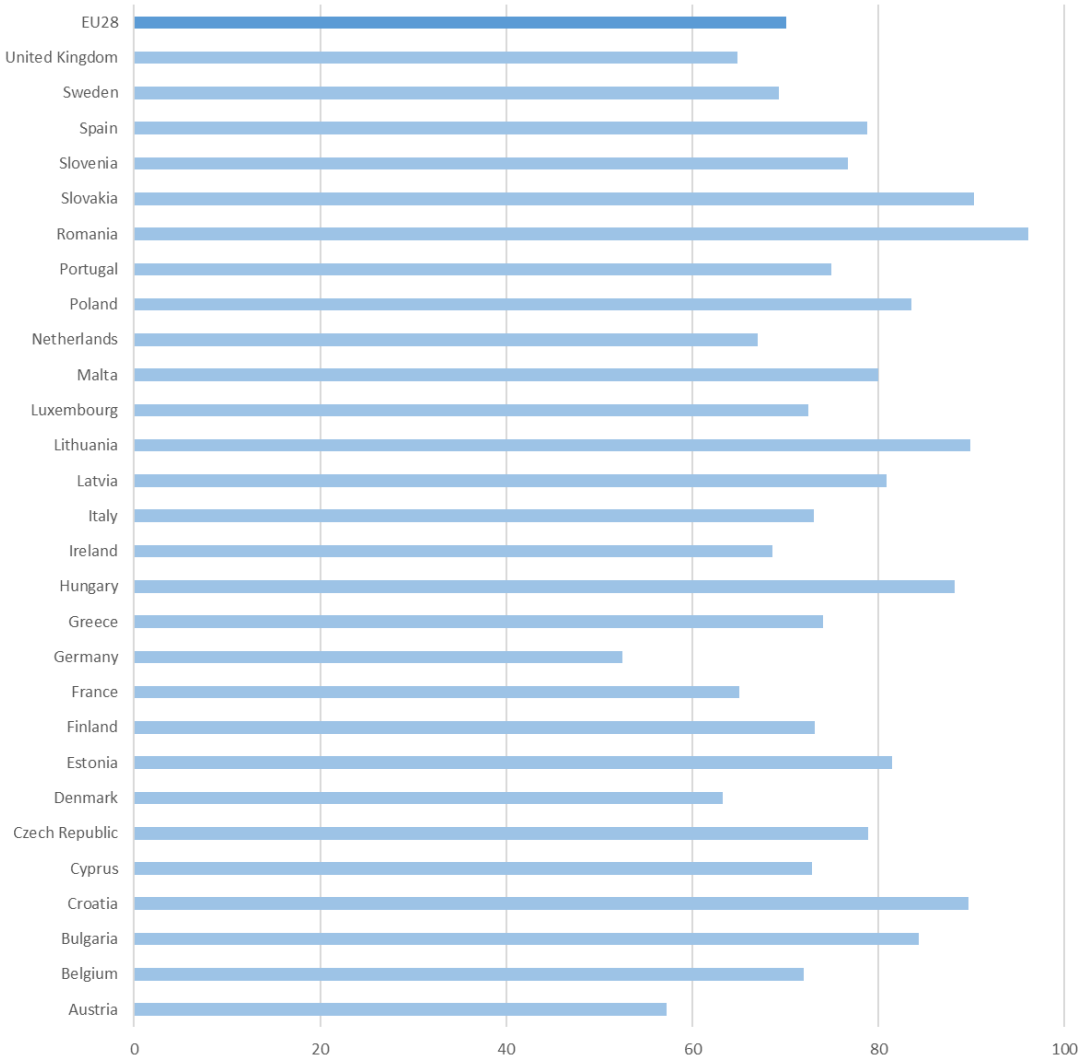


Figure 6. Percentage of residential properties
(source: EUROSTAT and national statistical institutes, for France this is an estimate).

Regarding the average total energy demand of residential buildings, in Figure 7, the consumption per dwelling, under normalised climate conditions, presents a constant and slow decreasing, and in 2015 the value is the value is only 6% lower than in 2010.

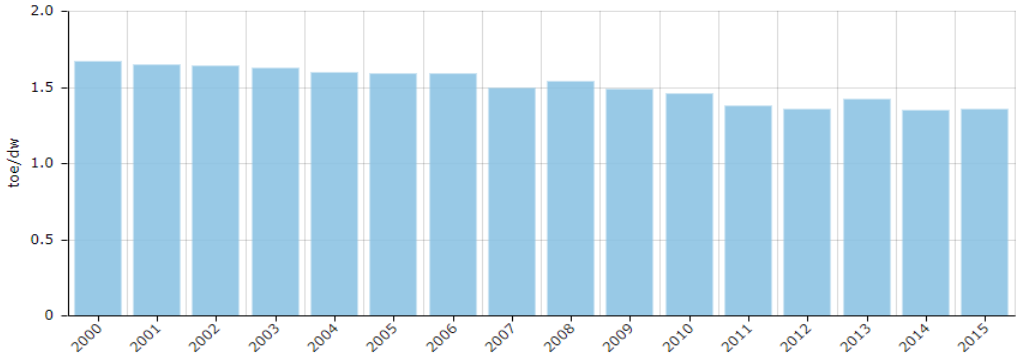


Figure 7. Total energy demand per dwelling (dw) at normal climate and trends (source: ODYSSEE).

Analysing deeper this data it appears that there are countries that are performing an important decrease in their energy consumption like Slovakia, United Kingdom, and Ireland, while other countries like Lithuania and Hungary are steady.
These energy consumptions are divided and analysed in Figure 8, where it is possible to see that in Sweden there is the highest share for electrical appliances and lighting (about 32%), then in Malta, Cyprus, Spain, Netherlands, Italy and Slovakia with a rate around 20%. In Baltic countries and Romania, the share of appliance is much lower than in the EU average (16% or below). Air conditioning still represents a marginal share of household consumption, except in Malta (almost 20%) and Bulgaria, Cyprus and Croatia.

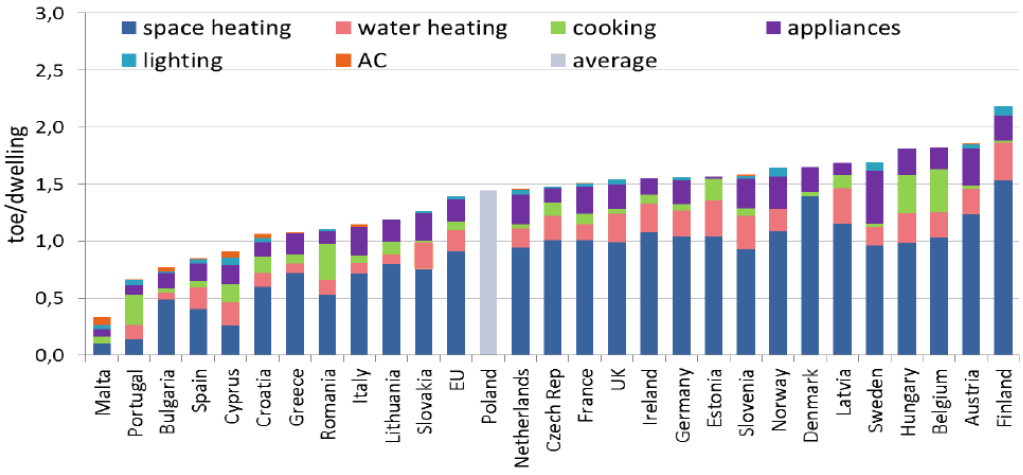


Figure 8. Breakdown of household energy use by end-use (2012) (source: ODYSSEE).

2.2.2 State of dwellings renovation in Europe

The European retrofit market is constantly growing at only about 1% renovation rate per year. Since 2010, the European legislation includes requirements for building renovation under specific conditions. The Energy Performance of Buildings Directive (EPBD) establishes minimum energy performance standards to be achieved whenever a building undergoes a major upgrade, while the Energy Efficiency Directive (EED) sets a 3% per year renovation rate of the total floor area of buildings owned and occupied by the central government. However, some individual Member States, regions and cities have gone further, introducing various forms of progressive renovation requirements. In addition to a lack of comprehensive information on the costs and savings of building renovations, there is little data on the numbers of renovations being undertaken, their depth, or indeed trends in renovation rates. Most estimates of renovation rates (other than those relating to single energy saving measures) are mainly between around 0,5% and 2,5% of the building stock per year. These rates typically reflect the activity of the past few years which in some cases are linked to special circumstances (e.g. the existence of a renovation programme) and therefore may not be of normal practice. In this work, it is assumed that the current prevailing renovation rate across Europe accounts for 1%.

The country yearly renovation rate represents in general the level of activity of the market related to building renovations in the construction sector, through Europe, and they can give an overall context for the market exploitation of the products, services and methodologies developed in the 4RinEU project.

*Table 1. Renovation rates across different Member States (annual % of building stock renovated; * general values given for the building stock, not specifically for the residential sector; + target value). Source: BPIE Survey*

Country	Renovation rate [%] Residential sector
AT	1,2 *
CY	0,9 *
CZ	2,4 (single family); 3,6 (multi-family)
FI	1-1,5 *
DE	0,7 *
HU	1,3
IT	1,2 *
LT	0,36
NL	3,5 +
NO	1,5
PL	2,5 (multi-family buildings)
PO	1,5 *
SL	2 *
CH	0,8-1 *

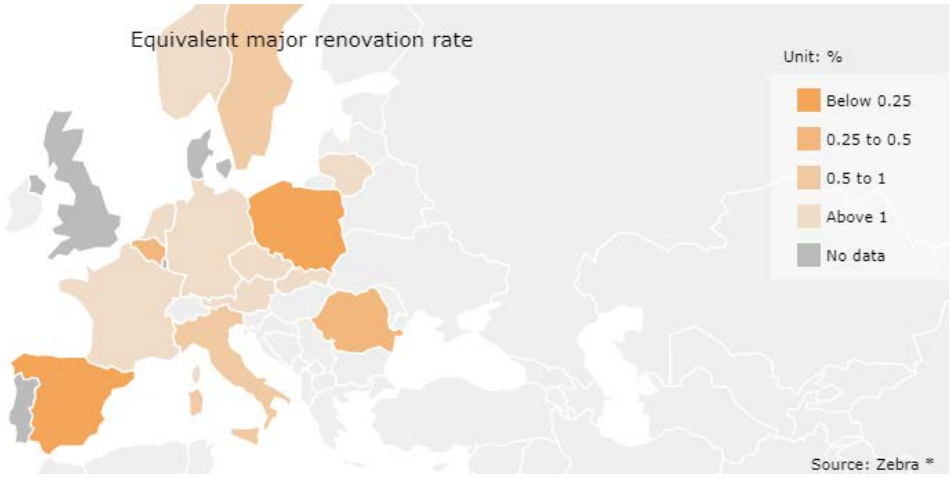


Figure 9. Equivalent major renovation rate (source: ZEBRA)

Equivalent major renovation methodology

In ZEBRA three renovations levels have been defined: "low", "medium" and "deep". However, their definition is different across countries and do not correspond to the same level of energy savings. Therefore, the data are hardly comparable. For that reason, ZEBRA developed an indicator of "major renovation equivalent" to ease comparisons.

Major renovations as defined in Article 2 of EPBD recast include interventions where the total investments relating to the envelope or its systems is higher than 25% of the building value, or deals with more than 25% of the building envelope surface. However, as Article 2 left each MSs to interpret and define differently major renovations, countries have chosen different ways to define and monitor them. Because of this lack of official European definition, the ZEBRA consortium assumes that with major renovations, a building's final energy demand for heating can be reduced by 50% to 80% (range depending on the country defined by national experts according to the current efficiency of the building stock).

The major renovation equivalent is based on assumptions on the type of measures considered for the different level of renovations and is determined by country. For example: the Dutch rate for medium level renovations also includes minor (light) measures. For Germany however, figures for minor (light) measures are not gathered and therefore are not considered in the renovation rates. The major equivalent renovation considering all renovation activities should therefore be higher than presented here. For each country, national experts defined the national renovation level and determined to which extent the allocated renovations fulfil / overfulfill the predefined major renovation level (expert guess).

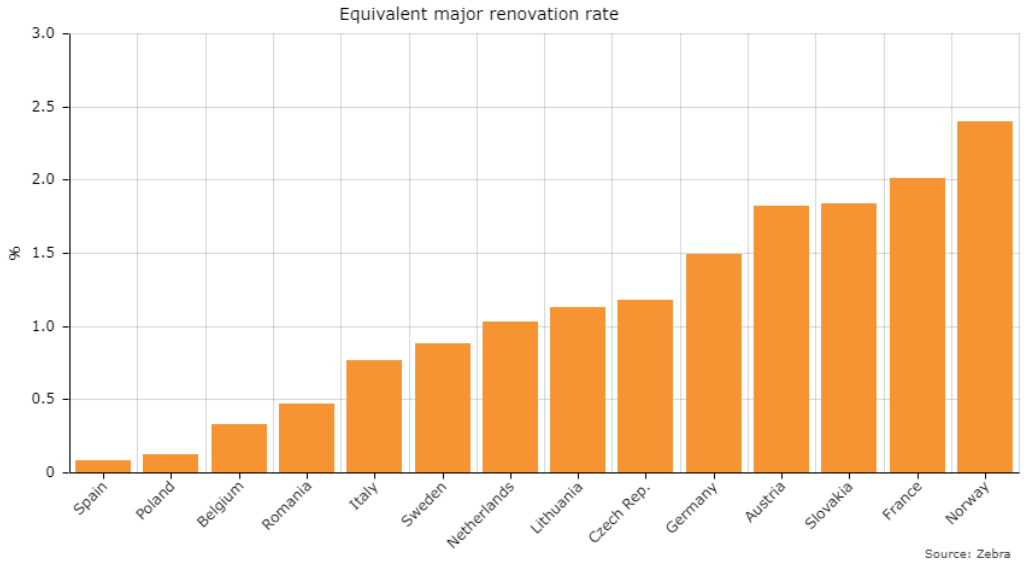


Figure 10. Annual equivalent major renovation rate in different countries (source: ZEBRA, EU Buildings Database4, 2016).

Major renovations and deep renovations are the types of interventions more suitable for the products and services developed in the 4RinEU project, since they are comprehensive and integrated set of solutions, aiming to ease and support the real implementation of actual high energy savings in buildings refurbishments. From the Figure 11 we can see that many EU countries are under the value of 1,5% of annual equivalent major renovation rate.

These represent markets where the 4RinEU solutions can help to increase the number and the quality of the refurbishment projects. While in the countries where the renovations rate is already higher, it could be easier or with higher potentiality to penetrate and spread for the 4RinEU solutions.

[4] https://ec.europa.eu/energy/en/eu-buildings-database

2.3 Target Country Market Analysis

Within the 4RinEU project, buildings located in Norway, The Netherlands, Spain, and Italy are going to be used for demonstration activities; additionally, a greater presence of partners and a desire for exploitation/commercialization is present in these countries. For these reasons, this market analysis examines the situation of the above-mentioned markets.

2.3.1 Norway

Some considerations can be developed regarding the existing buildings stock in Norway, particularly about the residential sector. This can give the base on the market context for building renovation. Many of the figures and graphs in the present chapter result from the official source SSB - Statistics Norway[5].
The Figure 12 depicts the buildings ownership typologies in the residential sector considering in average for the whole country ("Total Norway") and also separately for the four biggest cities in Norway ("4 cities": Oslo, Bergen, Trondheim, Stavanger) and for the rest of the country (Other Norway). Most residential buildings is owned by private people, this is true particularly outside from the four main cities, while considering larger cities the building private ownership is less frequent.

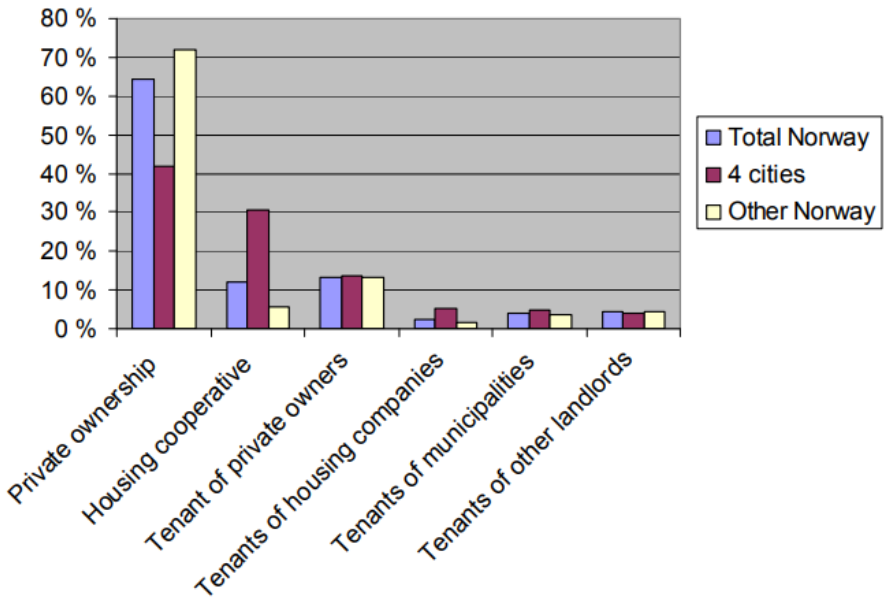


Figure 11. Percentage of dwellings by ownership type in 2001 ("4 cities" includes the four biggest cities in the country: Oslo, Bergen, Trondheim, Stavanger). Source: Thyholt et Al., 2019.

[5] https://www.ssb.no/en/boligstat/

As it could be expected, in the four main cities, the number of dwellings owned by larger entities is similar to the private ownership ones. This larger or collective entities are housing cooperatives, housing companies, municipalities. This can represent an interesting consideration for the market potential of solutions and strategies like the ones proposed by the 4RinEU project, since larger and collective building owners can be related to larger building stocks, more centralized decision process and responsibilities, larger buildings and buildings blocks.
Regarding dwellings owned by municipalities, the Figure 12 shows also that they are present in a small percentage (around 5%) but in homogeneous way on the four main cities and in the rest of the country.
The homogeneous distribution of dwellings owned by municipalities is a strategic information to develop common commercial strategies or policy measures related to the 4RinEU solutions, for larger regions or for the whole countries.
Indeed, decision makers from municipalities and from other public bodies could develop procedures, framework agreements, typical project requirements, etc. to spread deep renovations for residential buildings owned by municipality. This could consider features and methodologies related to the 4RinEU solutions. This kind of process could also happen in cooperation with other involved stakeholders (like umbrella organizations in the construction market, tenants' associations, etc.). This can also take advantage from the fact that the demo cases, where within the 4RinEU project a relevant deep renovation intervention has been completed, is owned by an organization of the Oslo Municipality.
From the side of the companies in the construction sector and for products and services related to the 4RinEU project, the dwellings owned by municipalities can represent and interesting market niche and this is confirmed by the statistics in the Figure 12.
Figure 13 represents the number of dwellings and their average energy use by construction period and building type, in Norway, until 2006. Considering the whole country, the building typology of detached and semidetached houses is more numerous in all the construction periods. Particularly this is evident for residential dwellings built between 1946 and 2000. However, flats in multi-dwellings buildings and apartments blocks are present in relevant quantities and they are not negligible. The average energy use per dwelling unit appears quite constants, with greater values for dwellings built in the period from 1921 to 1990. This could be affected by the sever climate conditions that characterized the country.

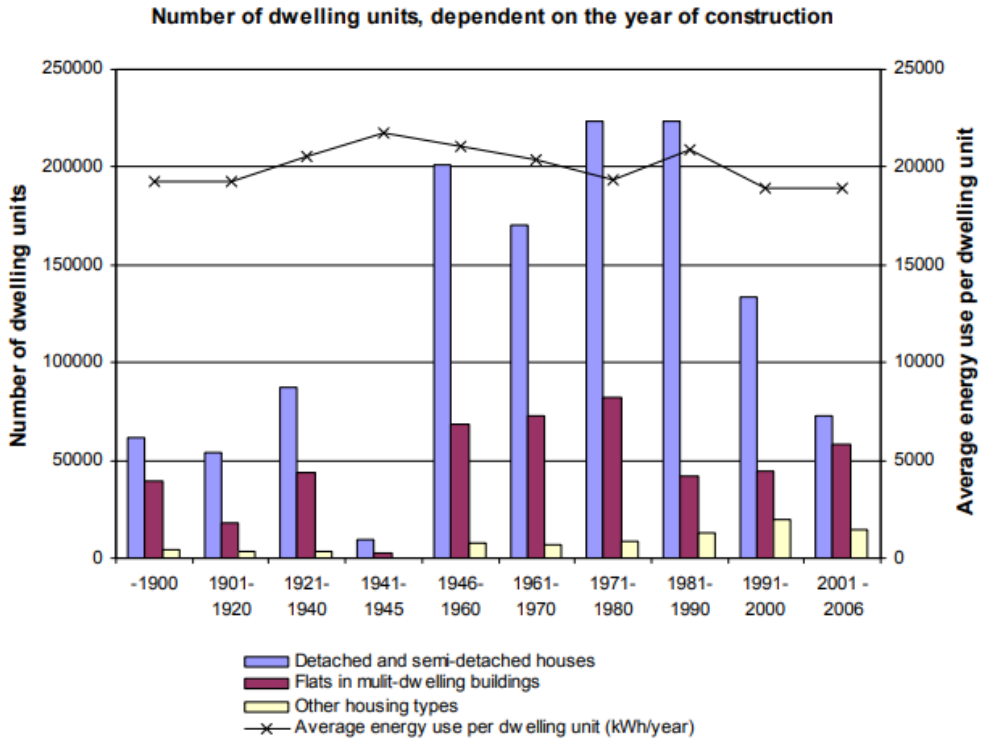


Figure 12. Number of dwellings and their average energy use by construction period and building type, in Norway. Source: Thyholt et Al., 2019.

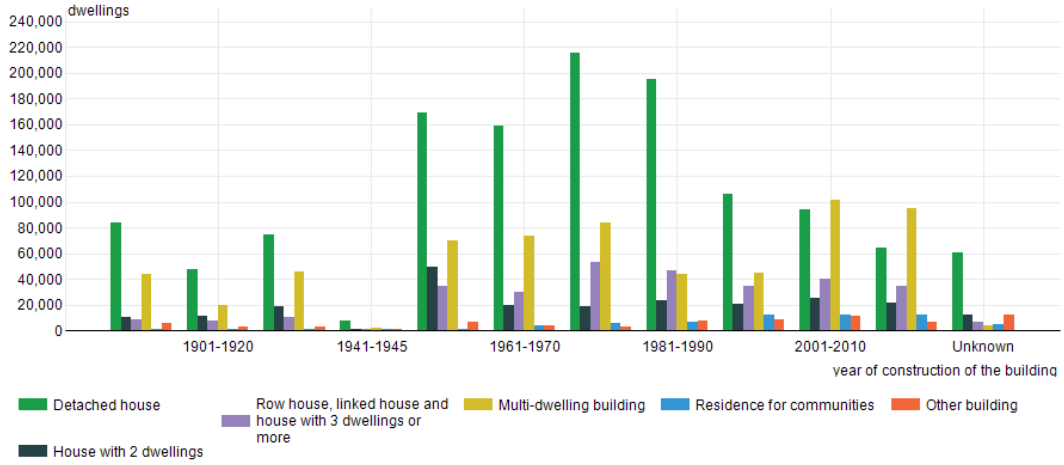


Figure 13. Number of dwellings by construction period and buildings type in Norway. Source: SSB.

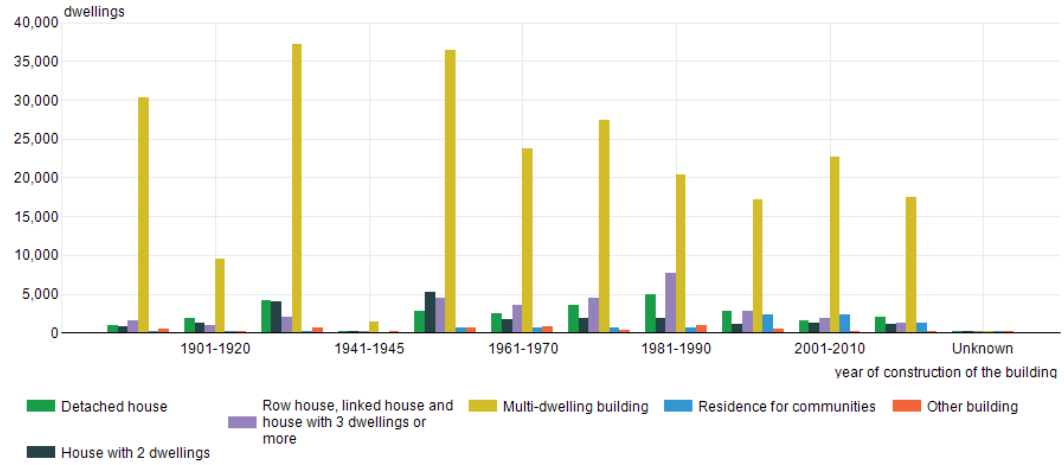


Figure 14. Number of dwellings by construction period and buildings type in Oslo. Source: SSB.

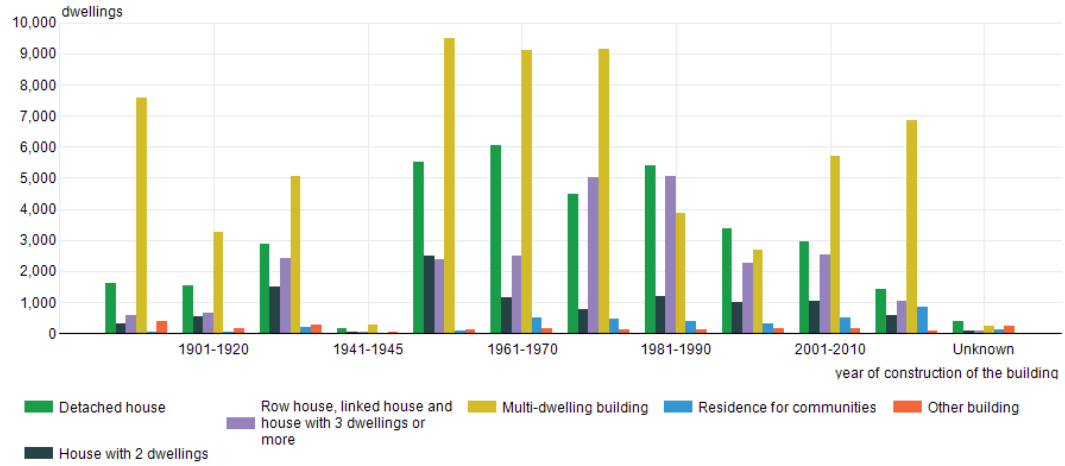


Figure 15. Number of dwellings by construction period and buildings type in Bergen. Source: SSB.

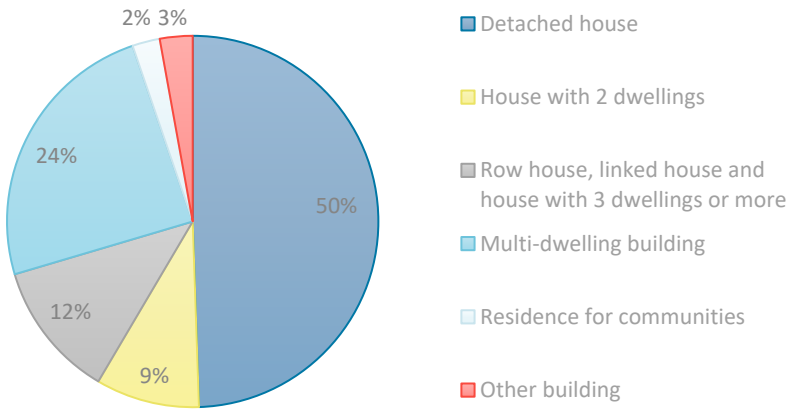


Figure 16. Percentage of dwellings by building type in Norway, 2019. Source: SSB.

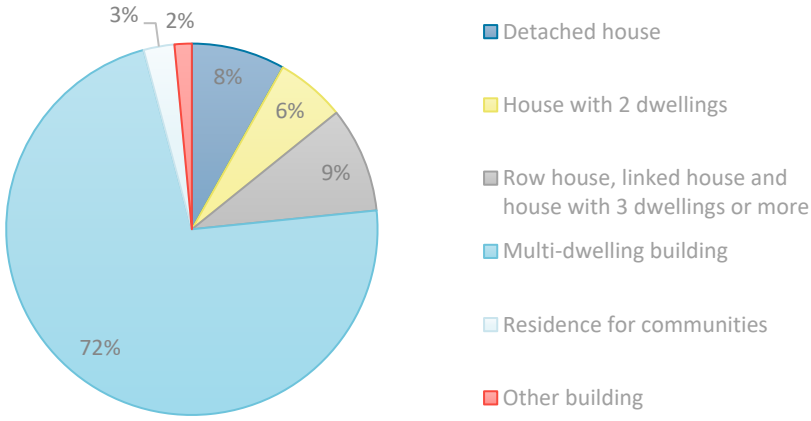


Figure 17. Percentage of dwellings by building type in Oslo, 2019. Source: SSB.

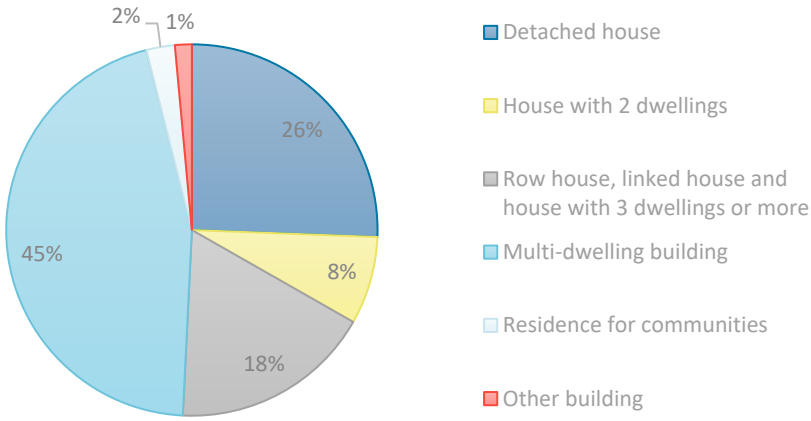


Figure 18. Percentage of dwellings by building type in Bergen, 2019. Source: SSB.

The Figure 14 represents the number of dwellings by construction period and buildings type in the country. Greater part has been built after the second world war, particularly between 1945 and 1990. In all periods before 2000, detached houses are the more numerous typologies, while in the last decades also multi-dwellings buildings represent a relevant part of the building stock. However multi-families buildings have been built in relevant quantities in all the considered periods. And, considering the Oslo municipality area (Figure 13), multi-dwelling buildings represent the most numerous typology in all the periods, and they correspond to an important number of buildings. Also in Bergen (Figure 16) we can see that larger buildings, like multi-dwelling buildings and row-houses, are relevant in the residential building stock. Oslo and Bergen represent the two largest cities for number of citizens in Norway: Oslo, with about 681 000 inhabitants, and Bergen, with about 272 000, counts together about the 18% of the Norwegian population. The Figure 17 summarizes the share of dwellings by the different building types, in 2019 in the whole country, where the 50% of the dwellings are detached houses, the 24% multi-dwellings buildings, followed by the other typologies. In Oslo (Figure 18), the context is different and the 72% are located in multi-dwellings buildings. In Bergen (Figure 19) we can see an intermediate situation, but with a greater part of dwellings in multi-families buildings (45% of the dwellings).
These kinds of figures can be representative of the northern Europe countries and of other contexts in Europe where we can see the greater part of the country characterized by low densities of population and some big cities, where the concentration is higher.

2.3.2 The Netherlands

Most of the Dutch dwellings are older than 40 years: as it is shown in Figure 20, the 64% of the stock was built before 1980. This bring to important needs for maintenance and renovation of the residential building stock.
The Figure 21 gives the percentages of dwelling types for private households (source: Netherlands' Housing Survey - WoON). We can see that terraced houses are the most numerous typologies with the 40%, followed by the flat / apartments blocks buildings with 32%. Therefore, the 72% percent of the private owned dwelling is located in terraced houses or in flats.
The ages and the typologies of the greater part of the residential building stock in the Netherlands can be interesting for the 4RinEU set of solutions.
Indeed, in this context the *Energiesprong* initiative started and is ongoing. This programme are mainly working on terraced houses, with an high level of integration of solutions and adopting prefabricated components, also wood based, and it has many common features with the 4RinEU approach and products. This represents a valuable example, both for technical both for financial and organizational point o view, to enhance deep renovations of buildings at large scale, also on terraced houses, in addition to apartments blocks and condominiums.

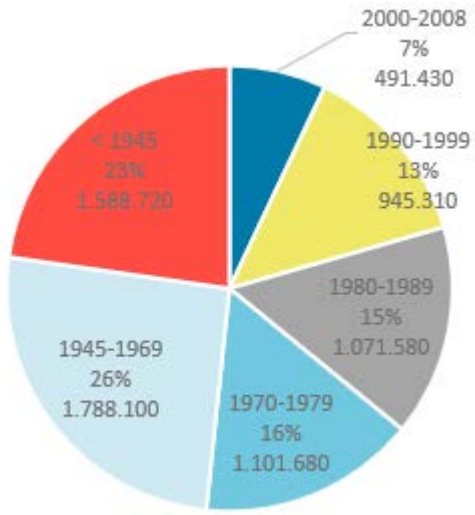


Figure 19. Percentage and number of dwellings by construction period in the Netherlands.

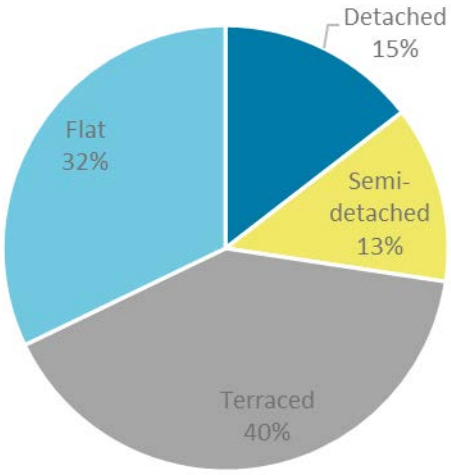


Figure 20. Dwelling types of private households in the Netherlands, 2015 (source: Netherlands' Housing Survey - WoON).

The overall annual renovation rate in the Netherlands for the residential sector results about 3,5%, as target value (source: BPIE), while the actual annual rate for major renovation can be considered around 1,1% (Source: ZEBRA, EU Buildings Database[6], 2016).

The Figure 21 shows the total final energy demand and the energy demand for space heating, which were slightly decreasing until 2017 and then remains more or less constant. The energy consumption trend follows the final energy demand for space heating, representing the great part of energy consumption in households.

[6] https://ec.europa.eu/energy/en/eu-buildings-database

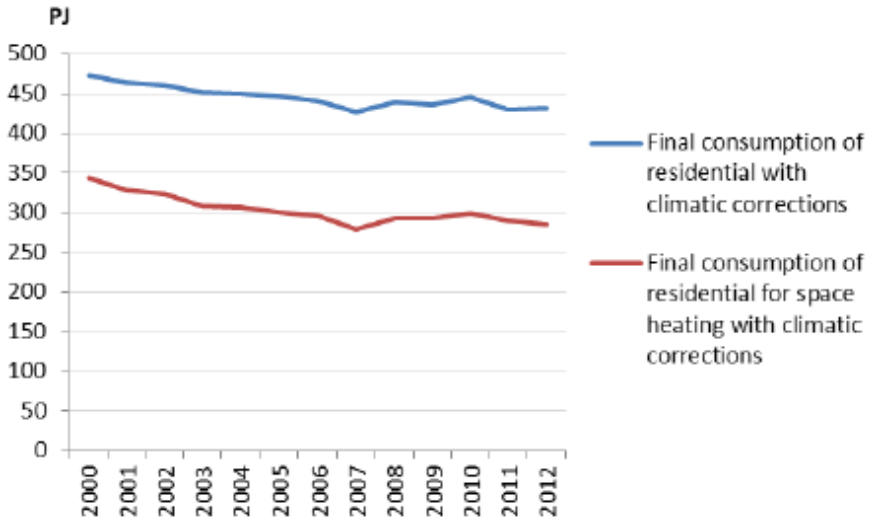


Figure 21. Total final energy demand and the energy demand for space heating (source: Odyssee).

2.3.3 Spain

In Spain there are about 9,8 million of buildings in the residential sector, of which more than 9,7 million are mainly or exclusively for housing and the others include also for other uses, as represented in Table 2. It also shows the relevant number of buildings with more than 4 dwellings.

Table 2. Number of buildings by number of included dwellings, in Spain (source: INE Organización Estadística en España, Censos de población y viviendas 2011).

Number of dwellings per building	Total number of buildings	Exclusively or mainly for residential use	Including also other uses
1	7.701.066	7.701.066	..
2	680.023	651.034	28.989
3	215.056	202.023	13.033
4	148.166	140.755	7.411
5 a 9	431.649	412.664	18.985
10 a 19	410.544	398.959	11.585
20 a 29	133.492	131.068	2.424
30 a 39	48.507	47.853	654
40 o más	46.282	45.577	705
Total	9.814.785	9.730.999	83.786

Fuente: INE. Censo de Población y Viviendas 2011

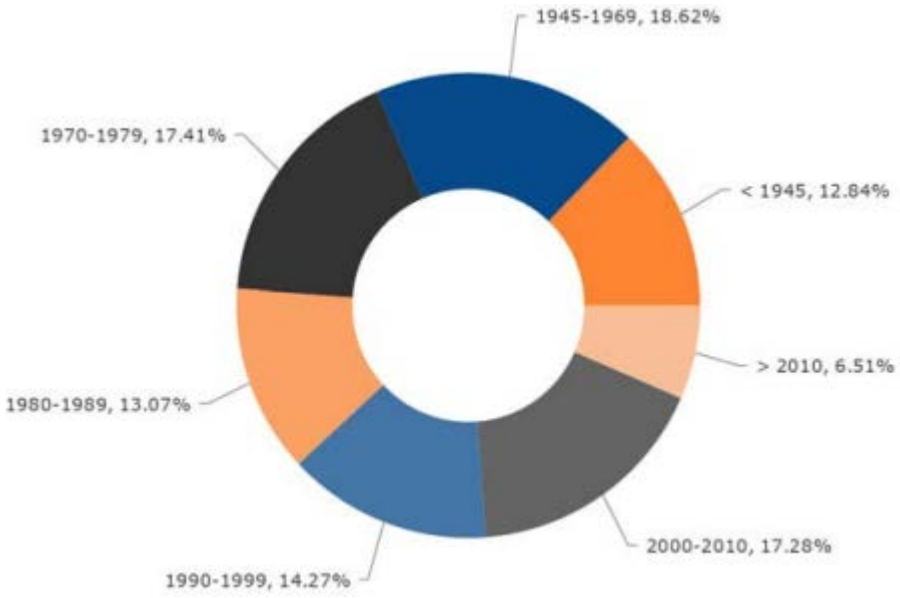


Figure 22. Percentage of residential buildings according to construction period, at 2014 in Spain (source: European Commission. EU Building Stock Observatory, 2016).

The 62% of residential buildings in Spain was built before 1990. It is a relevant amount of buildings with needs for maintenance and renovations.
However, the residential building stock present also an important portion of more recent buildings, with the 38% of them built after 1990 (Figure 23).
The residential sector energy demand in 2013 decreased by 3,3%, reaching 15.015 Ktoe, amounting to 18,6% of the total final energy consumption. Behind this evolution lay a contraction in electricity consumption (-3,4%), and in natural gas (-9,0%), which met 62,8% of Spanish household demands. Depending on the kind of energy sources that meet the demands of the residential sector, most of the energy demand (58%) was met with fuels, both of fossil and renewable origin (Figure 24) even if electricity increasingly gained ground until meeting 42% of the demand. This was so at the expense of the oil product contribution.

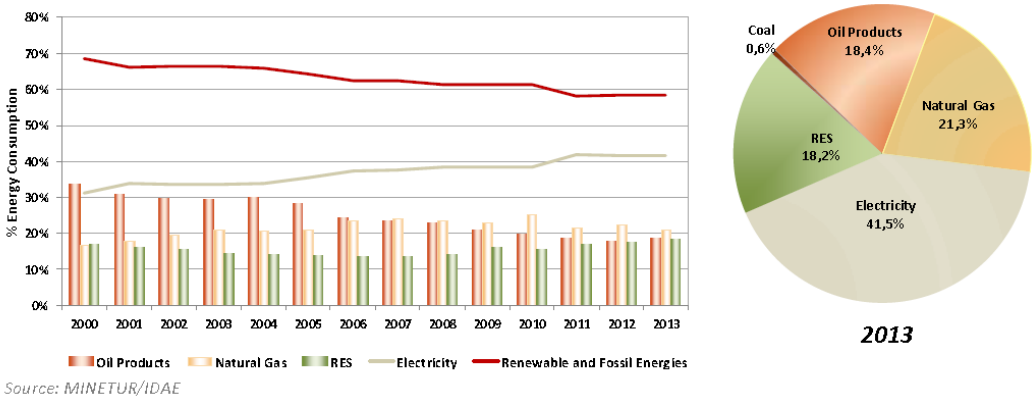


Figure 23. Structure of Energy Consumption of Households by Energy Sources in Spain, 2000-2013. Source: Energy Efficiency Trends and Policies in SPAIN - National Report for the ODYSSEE-MURE Project.

In any case, the prevalence of fuels accounts for the importance of thermal uses in this sector, among which the heating consumption stands out. This use concentrates over 40% of global energy demand in Spanish households (Figure 25), mostly met by fossil and renewable fuels and marginally, (7.4%) by electricity.

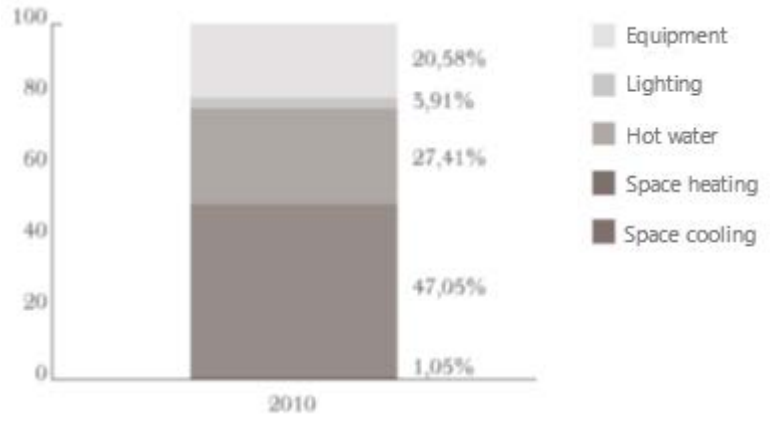


Figure 24. Share of final energy uses in residential sector in Spain (source: Ministerio de Industria, Turismo y Comercio Espana, Risultati di ricerca, Plan de Acción de Ahorro y Eficiencia Energética 2011-2020).

In the residential building stock in Spain, the annual rate for major renovation can be considered around 0,8%, according data of 2014 (Source: ZEBRA, EU Buildings Database).
In the last years, the most remarkable efficiency actions within the building sector have been those undertaken under the Action Plans of Energy Saving and Efficiency Strategy (E4). These measures have been essentially addressed to improve energy efficiency in buildings in general. There have been a large number of actions meant to boost the energy service market in the building sector, particularly the public ones, which were accompanied by an adaptation of the necessary legal frame to enhance this business model. At present all the promotion policies on energy efficiency have this kind of energy services contract as a reference, as way to achieve energy savings.

2.3.4 Italy

In Italy, most of the stock has been built in the years between the Second World War and 1991, the year in which the Italian law "Legge 10/91" was enacted. This law contains the rules for the implementation of the National Energy Plan on the rational use of energy, energy saving and renewable sources.
The data show that most of the buildings in Italy are older than 30 years and have poor characteristics than the current energy standards.
The trend is the same also focusing on residential buildings: in the image below, it is possible to see the peak of residential buildings constructed in the '50s,' 60s and '70s. Public and social housing, including the buildings owned by the former public

housing institute called IACP (*Istituto Autonomo Case Popolari*), represents a significant part of the residential stock: it is estimated that 90,000 units are present in Italy.

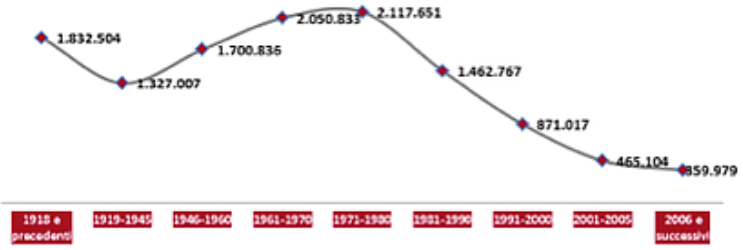


Figure 25. Number of residential buildings by age of construction. (Source: Ufficio Studi Gabetti.)

Entering in the analysis of energy consumption data to the residential level, as in Figure 27, in 2013 (and without significant changes in the previous decade) the energy consumption for air conditioning (heating and air-cooling) has absorbed about 75% of total consumption. The consumption of energy for lighting and for household appliances, has had a constant trend in the same period, slightly decreasing in recent years. In 2013, the consumption share was 10,9% for lighting and appliances, 8,5% for domestic hot water and 5,5% for kitchen use.

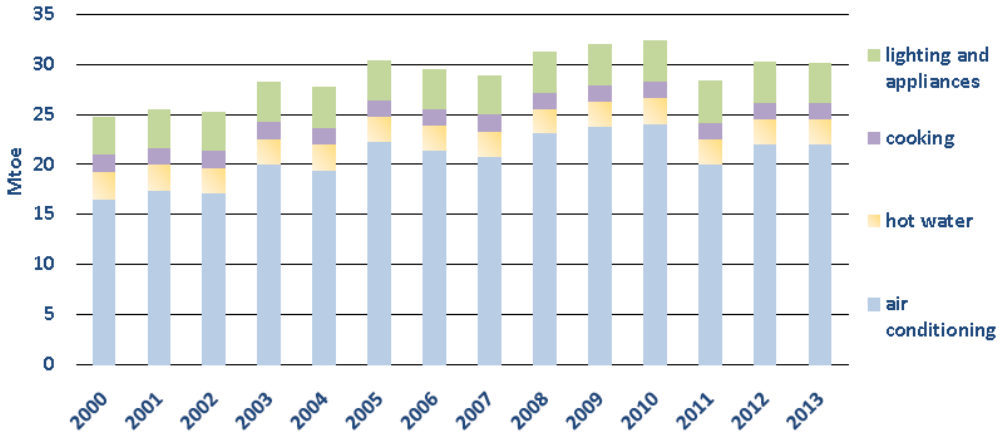


Figure 26. Energy consumption by type of end use in domestic consumption. (Source: Odyssee).

Considering the age of the Italian real estate, the construction market in recent years has moved on renovation projects to the detriment of new buildings.
And the trend inversion has already been under way for several years[7]. It should be underlined, however, that the trend reversal is mainly due to the decrease in investments in new buildings, rather than an increase in the renovation market and, in the last few years, also, the retrofit market has slowed down[8].

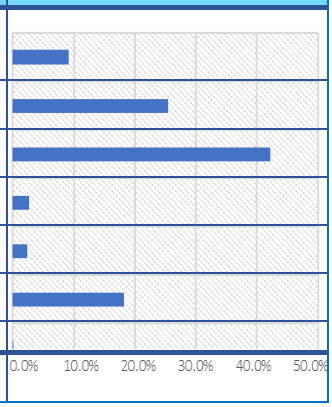
[7] Osservatorio congiunturale e previsionale ANIE ANIMA CRESME, 2015

[8] Osservatorio congiunturale e previsionale ANIE ANIMA CRESME, 2015

The Italian Governments are boosting the renovation market through tax deduction called "*Ecobonus riqualificazione energetica*": reductions of personal and income tax granted for actions improving the energy efficiency of existing buildings new standards required by the EPBD for buildings and by the Ecodesign Directive for space heating and cooling. In 2018 this tax reduction varies from the 50% of the tax reduction amount for some interventions such as condensing boilers and windows and doors replacements to 65% for other interventions e.g. solar panels, BMS, and heat pumps.
From the ENEA Annual Report of 2017 on the "*Ecobonus riqualificazione energetica*" it is possible to derive the breakdown of individual energy renovation measures, related to these tax deduction interventions. This report shows that the investments made in the three-year period 2014-2016 amount to approximately € 9,5 billion (Table 3): over 40% of the resources were allocated to the replacement of windows and doors; 25% of the insulation of floors and walls (e.g. ETICS) and about 9% of the reduction in energy needs for heating the entire building at a global level (data for 2016 are not yet consolidated).

Table 3. Investments per type of intervention (M€), years 2014-2016. Source: ENEA.

Year	2014	2015	2016	Tot.		Three-year investments 2014-2016 [%]
Type of intervention	**M€**	**M€**	**M€**	**n.**	**%**	
Reduction of energy requirements for heating the entire building	283,3	275,6	303,9	**862,9**	**9,1%**	
Improvement of thermal envelope performance (ETICS)	861,3	776,1	764,2	**2.401,6**	**25,4 %**	
Replacing windows and doors	1.345,5	1.296,0	1.355,5	**3.997,0**	**42,2 %**	
Installation of solar shading		100,4	148,4	**248,8**	**2,6%**	
Installation of solar panels	99,9	66,3	56,4	**222,6**	**2,4%**	
Replacement of winter air conditioning systems	476,4	574,0	671,0	**1.721,3**	**18,2 %**	
B.A.			9,2	**9,2**	**0,1%**	
Total	3.066,4	3.088,2	3.308,7	**9.463,3**	**100 %**	



The total amount of investments in 2016 related to these interventions amounted to over 3,3 billion euros (7% more than in 2015) although, in general, the annual share of residential buildings subjected to major renovations to Italian level stands at 0.77% [9] (2012 value). Although, financial measures to support deep renovation are in place and they can fund an interesting amount of the costs, in Italy major and deep refurbishment interventions are still not so spread in the market.
This is probably could be due also to lack of integrated solutions which can be installed easier, faster, with lower disturbance of the buildings occupants. These

[9] ZEBRA 2020 - Data tool. http://www.zebra-monitoring.enerdata.eu/overall-building-activities/equivalent-major-renovation-rate.html

aspects are addressed by the products and the methodologies developed in the 4RinEU project, which they can be particularly interesting also for the Italian market where deep renovations in residential buildings keep on to be financially supported with higher percentages of costs covering.

3 Residential retrofit market segmentation

The residential retrofit market is here analyzed focusing on the sectors suitable for the 4RinEU exploitable results. They can be subdivided into three main categories: technology products (ER1, ER2, ER3) software tools (ER4, ER5, ER8, ER10) and methodologies (ER6, ER7, ER9). These categories correspond to the three colors families of the following graphs, which represent the specific market sectors for each exploitable result.

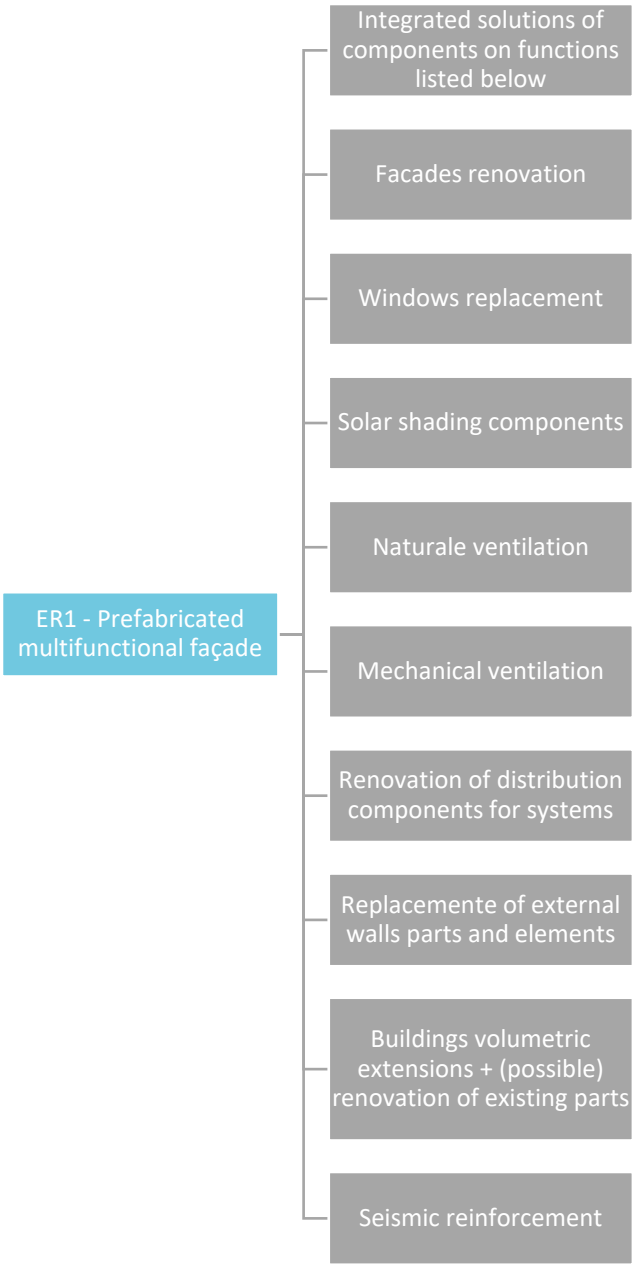


Figure 27. Main market segments related to the ER1.

The ER2 consists in a comprehensive set of algorithms for the optimized automatic control of ceiling fans. The result is an algorithm, but to be implemented in a technology product.

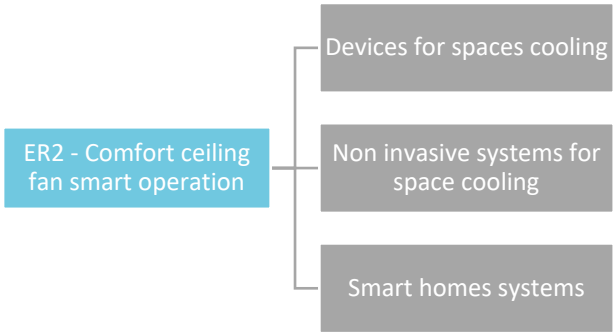


Figure 28. Main market segments related to the ER2.

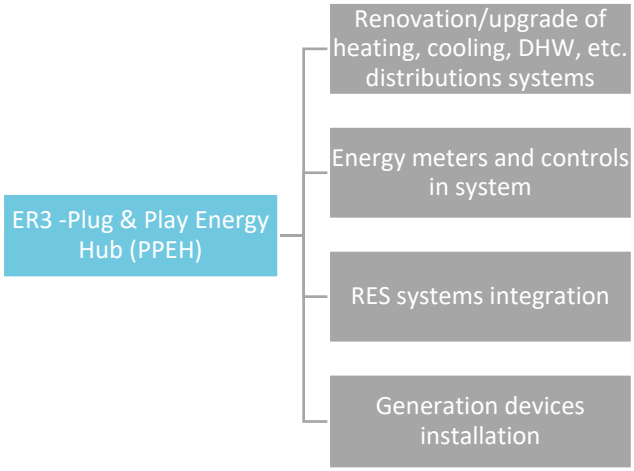


Figure 29. Main market segments related to the ER3.

Figure 30. Main market segments related to the ER4.

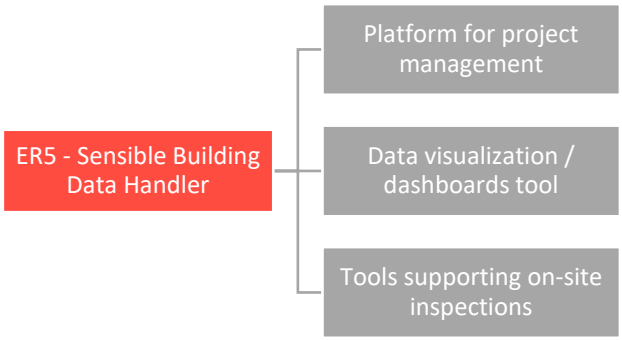


Figure 31. Main market segments related to the ER5.

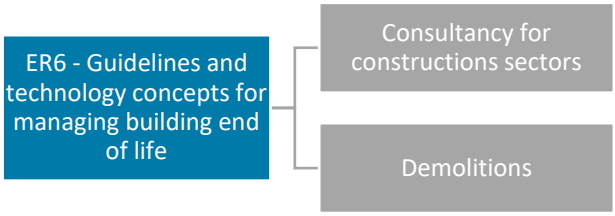


Figure 32. Main market segments related to the ER6.

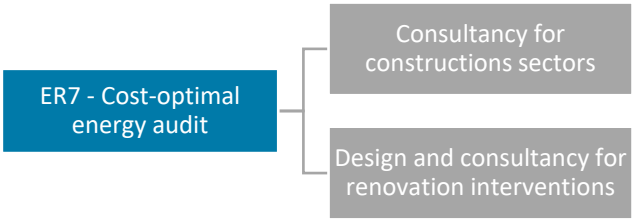


Figure 33. Main market segments related to the ER7.

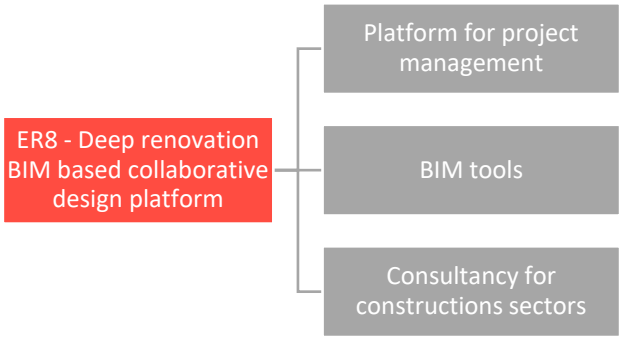


Figure 34. Main market segments related to the ER8.

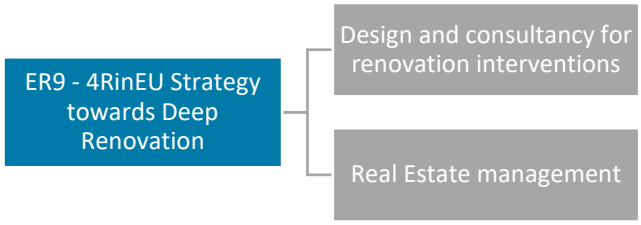


Figure 35. Main market segments related to the ER9.

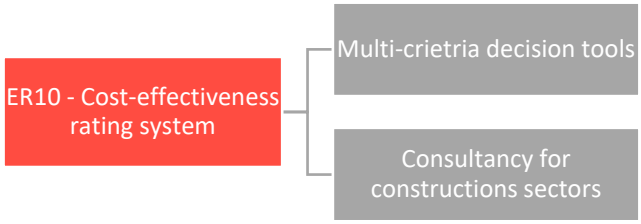


Figure 36. Main market segments related to the ER10.

3.1 Applications and synergies

A list of features and conditions, which represent limits or opportunities for the selected exploitable results, is presented here.
Hereafter particularly aspects related to the ER1 - Prefabricated multifunctional façade system (PMFS) - exploitable result ER 1 - are introduced. This allows for analysis about the specific results but also about the whole set of products developed in the project.
The other products deal with market sectors in the fields of manufacturing and electronic devices (like for the plug and play energy hub and its components and for the smart control system for ceiling fans) and in the field of software solutions for the construction sectors. These fields appear more mature and wider and will be deepen in the following chapters. Hereafter we focus on applications and experiences more related to the ER1 - Prefabricated multifunctional façade system (PMFS), particularly thinking on their use in the social housing sector and on other large buildings stocks having similar features. This sector is also relevant for the exploitation of the whole set of the 4RinEU developed products.

Market watching activities, also presented in the following chapter 2.2, show that wooden and timber construction sector is growing: in addition to the traditional applications, systems and products, the sector is also offering innovative processes, products and new ways to use wood based systems. The sector has a relevant importance in the industrialized and prefabricated off-site construction processes. Innovations can be seen in methodologies and systems for the off-site production, in wood-based materials, in new features of more common wooden components, in architectural and engineering solutions for projects[10].
A significant issue is that the sector appears more advanced and active in new buildings projects, while **the use of prefabricated wooden components for envelope renovation is not diffuse and it still appears as an innovative measure**.
On the contrary, PMFSs for renovation represent a mature family of products ready for the market, but so far their adoption is not so widespread. PFMs have been used successfully in significant renovations projects for multifamily buildings and schools in common interventions and in refurbishment cases studies supported by European research projects [Andaloro et Al, 2019], as described TES Energy Façade, iNSPiRe, SINFONIA, IEA ECBCS Annex 50 - Prefabricated Systems for Low Energy Renovation of Residential Buildings[11], Renew-School[12].
Even if the PMFSs adoption is not widespread in renovation, processes for off-site production and on-site mounting of the elements, there are several actions and

[10] https://woodinconstruction.net/25-cases.html
[11] https://www.iea-ebc.org/Data/publications/EBC_PSR_Annex50.pdf
[12] https://www.renew-school.eu/en/home/

features already commonly adopted in the timber construction sector for wooden components for homes, facades and roofs. In particular, the base technologies and materials, the procedures to measure dimensions and develop proper design details are already practiced.
So, the market and technological environment, on which the wooden multifunctional façade systems can base, is the sector of the wood and timber construction companies, even if focused on new buildings, so far. About this sector, the following features can be recognized at European level.

3.1.1 Geographic areas for market of prefabricated timber construction

In the usual practice, the selected timber construction companies are local because of several reasons: transportation easiness of prefabricated components and distance from factories, knowledge of specific regulation at local and national levels, knowledge of local language both for technicians both for craftsmen, commercial and overall stakeholders networks. The following levels and typologies of scale and size for prefabricated timber construction houses and components can be recognized.

- **Regional**
  (e.g. around 100 km far from the production site): it could be the more typical size for this kind of market and it could represent already relevant opportunities for quantities of projects, sales and revenues; this scale can represent common distances to transport typical prefabricated components without exceptional transport; it is the more common scale for commercial networks, particularly for small and medium enterprises.
- **National**
  (constraints related to language, national regulation, commercial network): some larger companies in the sector are active at national level or within more regions around their factories. This is more likely in countries which are not so extended, or which have not a large population. Working in its own country allow to deal easily with national language, typical organization and social features for building market and sites, national regulation and it does not need partnerships or synergies with third-parties organizations.
- **European**
  (import - export between different geographic areas and countries): commercial flows in this sector can be recognized between some regions and geographic areas located in different countries. This can happen from and between territories with well-established or with traditional industrial activities in the sector and regions where enterprises in this field grew or demand from the customer side is becoming greater. Commercial exchanges of prefabricated timber-based construction solutions are easier

between bordering countries, particularly but not only if they speak the same language or languages of the same family. Geographical areas and countries, where industrialized timber construction companies are more present and mature, generally are those showing also traditional presence in this field, we could recognize

- Alpine regions
- Forest regions in Austria and Germany
- Balkans countries
- Poland
- Baltic countries
- Scandinavia
- The Netherlands
- The Great Britain and Ireland
- Pyrenees regions

Some commercial cross-exchanges occur particularly within these regions and countries and within bordering areas. But exchanges happen also between not bordering countries. For example the 4RinEU partner Gumpp & Maier GmbH already delivering projects and components from Germany to the UK[13]. Exchanges occur also between Slovenia and Austria. And particularly the Baltic countries, mainly Estonia[14,15], are active with export activities towards many European areas (Figure 38 and Figure 39), as Scandinavian countries, the UK, Ireland, the Netherlands, Germany, Austria, Italy (particularly Northern).

Another example of construction **prefabricated components exported from a member state to the overall Europe** is represented by an Italian company, named Wood Beton S.p.A., who is following an agreement to deliver several hotel buildings for an international hotels brand, producing 3-dimensional prefabricated components, based on wood and concrete elements with preinstalled part of the systems. Prefabricated modules are built in their factories in the north of Italy to be then delivered to the construction sites, foreseen in Italy, Austria, Germany, France, the Netherlands, Denmark, Great Britain, Norway. Hereafter, further details on this experience are presented.

So, the sector shows commercial flows through Europe, even if it remains mainly local and national. It can be said that empowering an European market could bring to new opportunities, to larger sales volumes and to improving the overall competitiveness and technical capacity in the sector.

[13] https://www.gumpp-maier.de/files/sbyd_parkview_hub_ukphconf_2013.pdf
[14] https://iebn.ee/wp-content/uploads/2018/01/IEBN_EWHC_modular-houses-1.pdf
[15] https://www.puitmajaliit.ee/en

Nevertheless, actual and new markets at local level can offer positive features like a more environmentally sustainable production, avoiding longer transportation distances, which have not negligible impacts on life cycle assessment analysis, and with advantages for the local communities for job creation and employment stability.

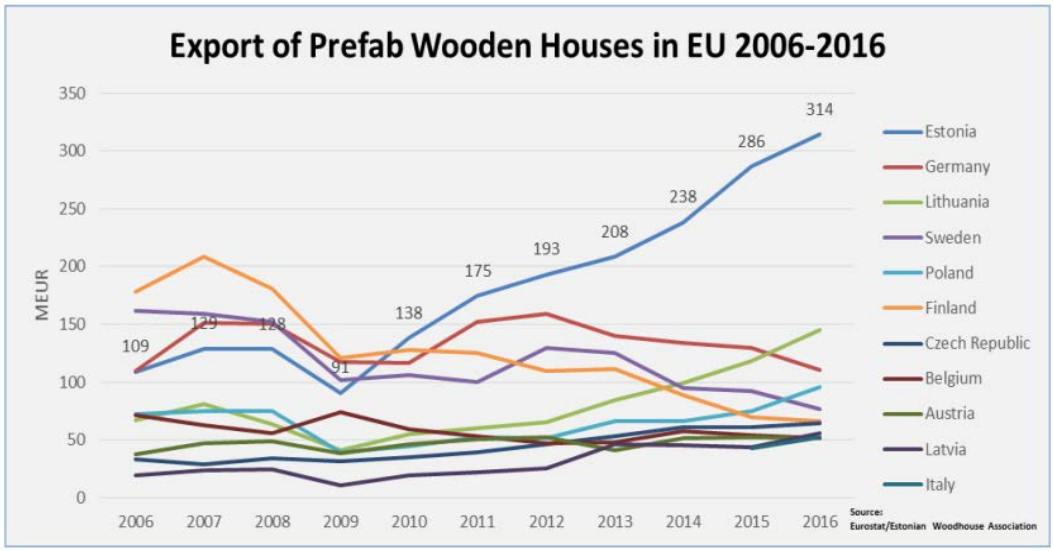


Figure 37. Export in millions of EUR of prefabricated wooden houses in Europe for period 2006-2016 (source: Estonian Woodhouse association).

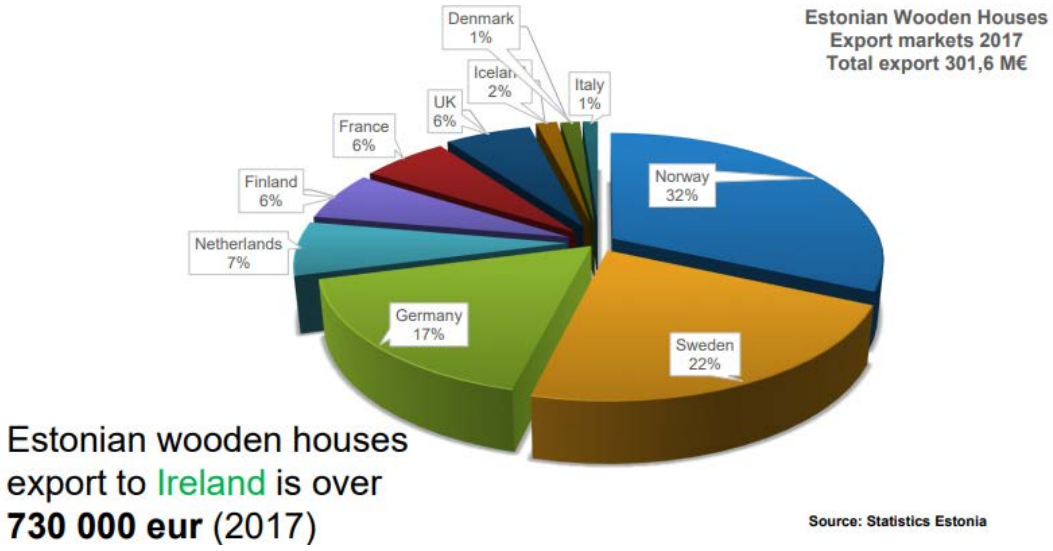


Figure 38. Export markets for Estonian timber house industry, in year 2017 (source: Estonian Woodhouse association).

3.1.2 Possible partnerships

In this context, different types of partnerships and synergies can be recognized between companies in the wooden construction sector and other entities on the market which can offer complementary features related to different countries contexts or different functions also in the same country. In this sector we could see the following kinds of partnerships.

Commercial
These could be partnerships between companies in the field of wooden construction and local or national partner to build and manage commercial networks. It could happen between entities/companies in different countries or in the same country. An example could be a foreign construction company who establish a partnership with a small or large entity in the field of real estate in another country, in order to have access to the residential construction sector in that area. This kind of partnership can be deployed also with other construction companies, or with engineering and architectural firms. It occurs mainly for new construction activities, but it could be possible also for refurbishment interventions with wooden components.

Technical
Technical partnerships could base on the needs to have support about local or national regulation in other geographical context respect the one where the wooden construction company has its own main site. Other advantages could be related to build synergies in different specialistic areas, for example between architectural design knowledges, systems design expertise, and the know-how related to wooden construction and renovation systems.

Construction, industrial, logistic
Other kinds of partnerships can be driven by needs of support on construction site, so a wooden construction company can be simple supplier of another construction company, which is not focused on wooden components, but which can act as main contractor. This relation can occasional and specific for a project or it can be repeated and structural for the activities of the two companies. This kind of partnerships could also aim to solve industrial needs or logistic issue, particularly for companies in different countries. This could be also the case where a wooden construction company established a partnership with other companies producing specific components to be installed in its facades, for example mechanical ventilation units, windows and solar shading devices, photovoltaic or solar thermal panels, etc. This kind of partnership could occur between two or more partners of the 4RinEU project. For example, it could be a partnership between Gumpp & Maier and Thermics Energie, in which Gumpp & Maier could optimize their products for the integration of hydraulic units provided by Thermics, they could specifically

cooperate for these purpose and so Thermics could became supplier for Gumpp & Maier. In addition, they could also place some kind of agreements for which Thermics could share its commercial network in Italy with Gumpp & Maier, facilitating new opportunities in the italian market for renovations and new buildings, where prefabricated solutions like Gumpp & Maier's ones can be successfully adopted, also integrating Thermics components.

Administrative
Partnership can be based also on the needs to have support about administrative and bureaucratic issues in new project contexts or in new countries for a wood construction company. This could be also support related to some kinds of official certification necessary in some contexts or for steps and requirements in a public tender procedure.

Financial
A wooden construction company could establish a partnership with other entities who provide financial sources, for a specific kind of projects or for specific investment to grown on the market. Partner could be more typical financial actors or they could be other industrial company, maybe larger ones, which want to invest in the sector. In addition, a ESCOs could be suitable for this kind of partnership.

It also possible that wooden construction companies from different countries (or different regions) establish together partnerships to build bigger and stronger entities on the market. This appears less likely, but possible. Generally, is more probable that a company acquire another one in order to grow or to have access to a wider market.

3.1.3 Scaling up experiences

In the present chapter, some examples are presented of experience on market where framework agreements, plans, initiatives allowed to scale up wooden construction interventions. Even if these examples are not directly related to the social housing sector, nevertheless they deal with prefabricated wooden element industries and public or private organizations, and they can be relevant to inspire the 4RinEu exploitation path. These examples could give idea also about possible extensions of interventions, and related economies of scales and quantities.

Private company and real estate corporation
We consider here possible partnerships, and related agreements, between companies in the wood construction sector and other entities, generally larger ones, in the real estate sector. This kind of partnership represents an interesting example of an industrial experience in the prefabricated wood construction sector,

which enlarged his market by mean of a specific framework agreement with another entities (in this case a private corporation). These agreements and related plans are specific buildings typology and intervention type, which are new construction of hotels buildings, and specific focus on a market segment, hotels in relevant location for travels like airport terminals and large train stations.
This is the case occurred to the Italian company Wood Beton, which put in place an agreement with the corporation Vastint Hospitality to deliver hotel buildings through Europe, characterized by fast construction times, thanks to the prefabricated wooden components from Wood Beton. The timber construction company planned its production in order to answer to the needs of hotel buildings for the Vastin Hospitality group. Wood Beton received also funds in order to enlarge their production site in Italy. Further details about this experience are presented in the following box.

A successful example of scaling up for a wood construction company: from local to international scale

In 2011, the timber construction company Wood Beton S.p.A.[16] received mandate from the corporation Vastint Hospitality B.V. to deliver hotel buildings through Europe, with a building system characterized by reduced time of construction and high quality.
Wood Beton is a company placed in the north of Italy, in Brescia district, active in the field of timber construction, mixed wood and concrete prefabricated elements, and prefabricated wooden houses. It was founded in 1989. In the recent years, the company also developed and sells prefabricated wooden façade elements for renovation of buildings both from thermal both for structural and seismic point of view.
Vastint Hospitality is a real estate company investing and developing hotels and student properties across Europe[17]. They also have agreements with hotels brand, like the one involved in the agreements with Wood Beton. Vastin Hospitality retains hotels buildings in their portfolio if investments, while the hotels are managed by third parties according franchising schemes. Vastint Hospitality is related to the same holding of IKEA, namely Inter IKEA Group[18], under the common ownership of the corporation Interogo Foundation.
Within these framework agreements between Wood Beton and Vastint Hospitality, the timber construction company developed a proper system to deliver hotels, with fast time of construction and proper quality. They adopt prefabricated wooden components, consisting of 3-dimensional elements, optimized in modules, with part of the systems integrated and preassembled. The larger buildings portions consist of wooden elements, while other smaller parts, like basements and stairwells, are in prefabricated concrete elements.
In 2014, Wood Beton deployed the first hotel, within this framework, close to the terminal of the Milano Malpensa airport. The hotel has 4 floors with a total surface of 5 000 m^2 and 162 hotel rooms.

[16] http://www.woodbeton.it/grandi-opere/hotel-moxy/
[17] https://vastint.eu/hospitality/about-us/
[18] https://vastint.eu/about-us/#our-history

After this first intervention, others followed and are following through Europe, according a plan of 50 hotels in 10 years, with a foreseen revenue of about € 50 million per year. Another example was the second hotel of this kind built in Italy, at the terminal of the other airport in Milano, Milano Linate, in 2017[19].
In the framework of this agreement, Vastint Hospitality, within the IKEA related holding, supporting the investments of Wood Beton to deploy a new factory site specific for the off-site prefabrication of the components for the hotels. The new factory has been opened in 2014 and it was added to other factory sites the company has in the north o Italy[20]. Sources indicated that IKEA related holding supported investment for the new industrial plants for about € 20 million.
Job positions created within these developments have been about 150 people started to work in the new factory[21].

Public bodies and umbrella organizations

Public entities, which own or manage buildings stocks, can establish framework agreements or official joint commitment documents with umbrella organizations of wood construction companies, in order to enhance high quality deep renovations of their buildings stock, adopting prefabrication techniques and aiming to real high levels of energy performance and environmentally sustainability. Common advantages from this are represented in the Figure 39.
A real example is represented by an experience started in 2014 in Italy: the Municipality of Milano established a framework agreement with the national umbrella organization of wooden industries, which include also many prefabricated timber construction companies[22]. The association is called FederlegnoArredo. In this framework, the Municipality committed to renovate and build new buildings for the schools of the city, adopting prefabricated wooden systems, with the aim to have renovated or new schools, with shorter time of construction and with higher energy performance and environmental sustainability levels. The umbrella organization gave general and technical support in planning and design activities by the Municipality.
From this, the city started the procedures for design and tender of interventions for around 10 school buildings. They started during 2015, some interventions are now completed some other are ongoing. They consist mainly in demolition of old school buildings and construction of new ones, adopting prefabricated wooden components, higher energy performance requirements (in some cases anticipating nZEB level according italian regulation), BIM method, and Building Monitoring and Control Systems installed. In addition, following the interventions related to this framework, the Municipality of Milano also renovated a school building reaching the nZEB level and deployed the process for the renovation of a kindergarten,

[19] https://www.infobuild.it/approfondimenti/ledilizia-off-site-di-wbfactory/
[20] http://www.woodbeton.it/il-gruppo/
[21] http://www.woodbeton.it/wp-content/uploads/2016/06/2014-10-28-Il-Giornale-di-Brescia.pdf
[22] https://www.federlegnoarredo.it/it/federazione/accordi-istituzionali/accordo-scuole-comune-di-milano

adopting prefabricated multifunctional wooden components: design an tender process have been completed. When the framework agreement was established, the Mayor of Milano declared that this kind of strategic agreement could be extended in future also for the social housing buildings stock. In this example, the umbrella organization of the timber construction companies gave external support to the Municipality, who committed to a strategic plan for renovate a specific typology of public buildings which are schools owned by the municipality. Then, basing on this the Municipality has proceed to deployed design and tender procedure according the regulation in force, selecting designers teams and companies who can develop and complete the planned interventions.

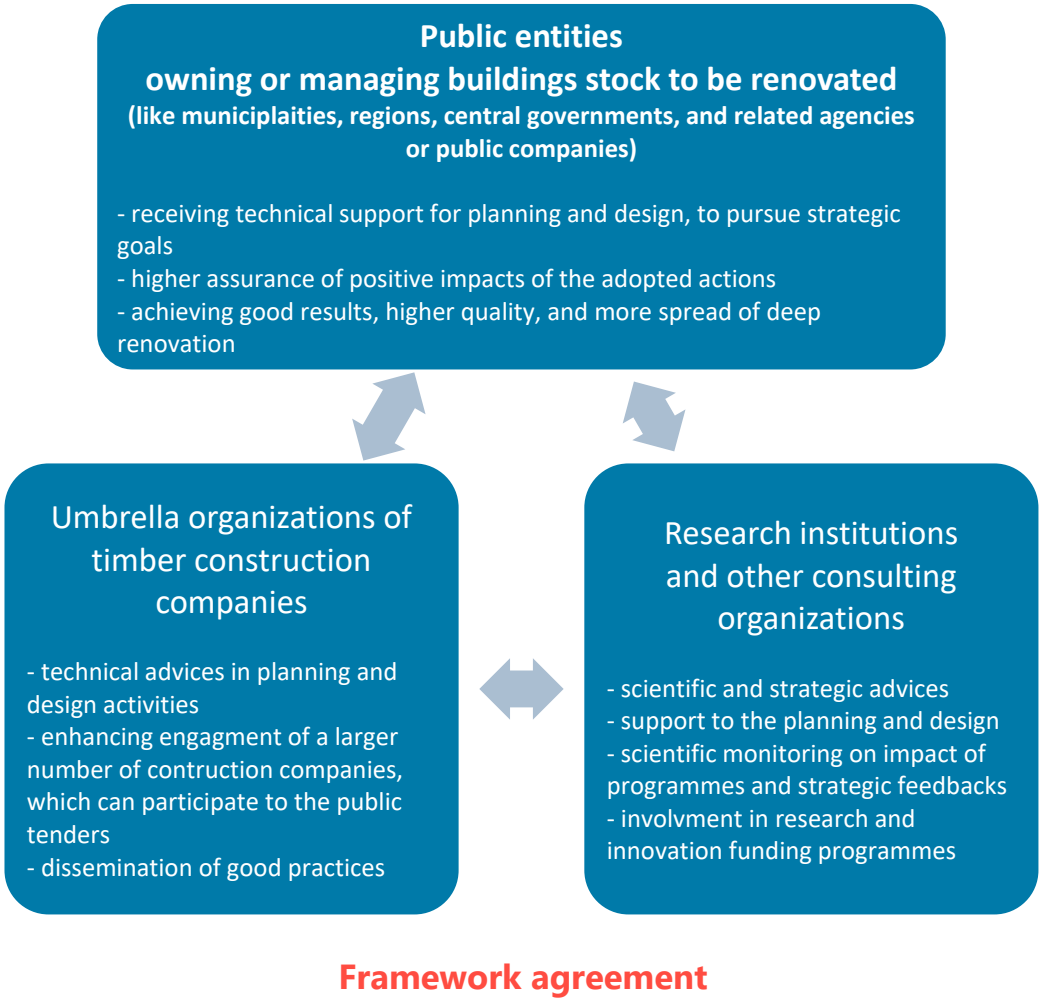


Figure 39. Scheme of relations in a framework agreement between public bodies, umbrella organizations and research institutions, to enhance the deep renovations in the buildings stocks managed by the considered public body.

This kind of agreements can involved also research institutions, like universities and research centres, or other consulting organizations, with the aim to improve the technical, scientific and innovative elements of the actions.

Open technical guidelines from large companies

Companies in the wood construction sector, in addition to provide materials, components or projects, can also make available technical guidelines in order increase knowledge and confidence in the related solutions.

For example, the following experience can be recognized: Stora Enso is a large company producing wood based materials, like timber construction elements, cross-laminated timber components, wooden cladding and decking, but also other products derived by wood, like paper and paperboard, packaging solutions, lignin, bio-composites, pellets, and others[23]. Stora Enso is publicly listed on the Helsinki and Stockholm stock exchanges and has about 26 000 employees in more than 30 countries.

In the field of timber construction elements, they made available on-line technical guidelines[24] to design and build residential multi storey buildings and offices buildings with systems based on their wooden components[25]. Guidelines are comprehensive, giving technical information on many aspects (architectural, technological, acoustic, structural, etc.) and can represent a good source for designers, contractors, but also for building owners to start to find answers to common questions and doubts about wooden construction systems. These publications, open access available on their web pages, seems to have the main goal to improve confidence in wooden construction systems, in order to support the main scope of the company, which is to enlarge its market and to make its volume sales grow.

3.1.4 Environmental sustainability: trends and opportunities

On the market, wooden components for new buildings or renovation can benefit from a good reputation from the point of view of the environmental sustainability, we could call a good "green" reputation. Often, this can represent the truth, since wooden base materials show sustainable features in themselves: renewable and recyclable material, low energy production processes (no need of high temperature processes or melting passages, etc.).

However, going into deeper analysis, some aspects can consider better to assure an actual sustainability. If we consider a multifunctional prefabricated wooden system, further considerations can be done on its sustainability about source of wooden materials (forests sustainable management and transportation distances),

[23] https://www.storaenso.com/

[24] https://www.storaenso.com/en/products/wood-products/building-concepts/residential-multi-storey

[25] https://www.storaenso.com/-/media/documents/download-center/documents/product-brochures/wood-products/residential-multistorey-buildings--design-manualfinal-20160620version-14en.pdf

but also about environmental features of sealing materials, glue materials, paintings, plaster and cement layers, thermal insulation, quantities and source of metallic elements, etc.
These aspects are often not considered in an environmental sustainability evaluation of a prefabricated wooden components, nor they are communicated to the potential customers. Sometimes it could be brought to unexpected results, positive or negative. However, they could represent interesting points on which companies can make the difference from sustainability point of view respect their competitors on the market, going deeper from a green reputation towards more actual and recognizes environmental features. Some customers segments, regulation requirements, or environmental certification protocols for buildings are asking more about this.
About source of wooden material, available for products in the market are sustainable forestry certification schemes like the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC), and others less adopted. They certify forests which are source for paper and wood products.
Their aim is to balance environmental, social and economic benefits in forest management, and they provide a framework for stakeholders to evaluate this.
Considerations which can include also other materials used can be developed considering the specific technical sheets, or environmental product declaration (EPD) or information from life cycle assessment (LCA) databases, or performing LCA analysis for the considered projects or for typical case studies of application for the considered product.

3.1.5 Multifunctional renovations

Products of multifunctional prefabricated facades for building renovation offer in itself the integration of several functions, thanks to the fact that different components families can be integrated in the prefabricated façade unit: for example

- thermal insulation layers
- water and air tightness elements
- exterior claddings, windows
- solar shading devices
- mechanical ventilation units
- vents and ducts
- pipes and other hydraulic components
- electrical cables
- solar thermal and photovoltaic panels.

This is proven in the 4RinEU demo cases and in many other applications of this kind of systems.
Together with the advantages related to the prefabrication and the environmental sustainability for the main materials, the multifunctionality can represent a real strength for this kind of solutions, particularly within the goals of a deep renovation of buildings: one measures can include many solutions needed for the interventions.
The chance to integrate different functions and related varied products can encourage soft or closer partnerships between wooden construction companies, which provide the specific components.
Multifunctionality can also deal with further aspects and goals of a renovation intervention in a building, which can allow to reach retrofit aims in different relevant areas, in one unique intervention. These improvements can deal with the following aspects

- Buildings volumes extensions
- Structural and seismic reinforcements
- Aesthetic improvements of a facade

3.1.6 Building typologies and features in public or association owned residential buildings

- Shape and geometry
- Number of floors (1-2 floors, 3 floors and more)
- Typologies
- Period of construction: materials and energy performance
- Examples from target countries social housing building stock
- Climate zones in Europe

- Other building typologies suitable for renovation with prefabricated wooden multifunctional components

- Schools and educational buildings
- Hotels
- Hospitals
- Offices

3.2 Competence Analysis for Different Technologies

The chapter presents gathered information about main features and selected competitors who offer products similar to the project exploitable results. .
Many information has been collected and used for the analysis developed in the other deliverable of the WP6. Part of this information is reported and analysed in the present document.

Table 2.1 Brief Description of ER 1 main players and players typologies

COMPANY TYPOLOGIES	DESCRIPTION
Prefabricated facades with metal components	Some companies in the field of prefabricated components based on metal elements and structures produce also prefabricated facades modules. These generally are self-supported, insulated, including claddings and glass and windows elements. It's not common to have integrated mechanical ventilation units, air ducts or other pipes. This kind of companies can also produce prefabricated three-dimensional modules. It seems not common to see metal panels bi-dimensional components and three-dimensional components, based on metal structures, in projects where they are applied on an existing facade. More often they can replace the existing components, or they can be used in new construction projects. Often this kind of companies offer also consulting and design services in order to develop proper solutions for customers. They can also deliver services for installation, directly by their staffs of by their partners. Examples of products lines and related companies in this field are: QBISS ONE by Trimo https://www.trimo-group.com/en/products/facades-and-walls/qbiss-one COMFORT-LINE by Komo- Modular https://www.koma-modular.cz/en/comfort-line BENCHMARK by Kingspan https://www.kingspan.com/gb/en-gb/products/architectural-facade-systems
Prefabricated wooden components	This sector is emerging among the European countries. The companies produce different typologies of prefabricated wooden panels for walls, floors and roofs. Generally walls and facades components includes timber structure (frame elements or cross laminated timber panels), thermal insulations and other construction layers, windows and related solar shading devices, claddings. Sometimes also components for HVAC systems can be integrated

	(mainly electrical pipes, hydraulic pipes), while integration of larger systems components (e.g. mechanical ventilation units, air ducts, heat pumps units) does not represent a common practice, and it but an advanced solution. This kind of companies can also produce prefabricated three-dimensional modules. It seems not common to see their panels bi-dimensional components and three-dimensional components, based on metal structures, in projects where they are applied on an existing facade. More often, they can be used in new construction projects or they can replace the existing components. These aspects represent a potential path for the 4RinEU ER1 in order to gather interest on the market. Companies in this field can cover the following works, which can offer synergies for joint interventions (e.g. volume extension + renovation of existing facades): • Renovation - installing components upon existing ones • Renovation - replacing existing facade walls • Seismic reinforcements • Extension - volumetric extension or roof extension • New constructions Gumpp & Maier https://www.gumpp-maier.de/ Rubner Gruppe https://www.rubner.com/en/haus/ Wolf House https://www.wolfhaus.it/en/ Woodbeton http://www.woodbeton.it/

Table 2.2 Brief Description of ER 2 main players

COMPANIES / PRODUCT LINES	DESCRIPTION
Big Ass Fans	This company produces ceiling fans and other kind of fans, for both industrial environments, buildings spaces in office, commercial, educational, and residential contexts. They also produce ceiling fans for large spaces. They developed and integrated a specific control system, called *SenseME* (trademark registered) already available on the market. The control system includes voice control capabilities and smart thermostat integration, for indoor applications.

	According the information available on the company website, the *SenseME* system can offer the following features.
	• Temperature and humidity sensors, connected with fan via Bluetooth, constantly monitor the environment at your level and adjust fan speed to maintain the set conditions, while an onboard occupancy sensor automatically turns the fan and optional LED on and off.
	• Bluetooth remote and Wi-Fi mobile app controls, called *Haiku* mobile app.
	• The mobile app is free and supported by Android and iOS mobile devices.
	• The mobile app allows to change fan speed, light levels, and preference settings.
	• Possible integration with Amazon Alexa, Google Assistant, and Ecobee smart sensors and thermostats.
	• Possible settings are
	  • seasonal settings - Smarter Heating and Smarter Cooling,
	  • in the Smarter Cooling mode, the user sets their selected temperature, and the fan automatically adjusts to find the most comfortable fan speed,
	  • in the Smarter Heating mode, automatically the fan work to recirculate heat in the space by increasing in speed when the user exits the room, then when the user comes back to the room, the fan slows,
	  • Connection with smart thermostats,
	  • Schedules settings,
	  • Whoosh (trademark registered) Mode: silently varies fan speed to mimic cooling natural breezes,
	  • Sleep Mode: responds to changing conditions to provide customized comfort all night long,
	  • Functionality of grouping multiple fans in the same space for synchronized operation,
	  • Manual speed control,
	  • Manual light control,
	  • Motion sensor, to sense occupancy in the room,
	  • Temperature and humidity sensor.
	
	It seems not available further details about controls algorithms.

Hunter Fan	The company produce a wide range of ceiling fans models, including also smart-ceiling fans line of products, with Wi-Fi connection, Amazon Alexa, Google Home Assistant, Apple HomeKit enabled. The main capabilities seem to allow to control fan speed and lighting level (if lighting source is integrated) via a proper app for smart-phones. No further information is given about specific control logics and implemented algorithms.

Fanimation	They produce ceiling fans in different models and also an electronic module that can be sold separately and applied on existing ceiling fans, even from other companies. It is called FanSync (trademark registered) and it allows communication via Wi-Fi and Bluetooth, so control via users' voice or via smartphone app is possible. It is compatible with the main smart home devices, like Amazon Echo, Google Home, Nest, Ecobee, and others.3
Fantasia Ceiling Fans	They produce different typologies of ceiling fans. It seems to be an example of company using common remote control, and not innovative ones-
Vortice	The company produce a wide range of products in the filed of ceiling fans and in general for mechanical ventilation. They are cooperating with EURAC in order to implement and developed industrial prototypes of devices adopting the control algorithms under development in the 4RinEU project, as ER2. For this, agreements about intellectual property management are under discussion between EURAC and the company. The company is commercially active in 90 countries all over the word.

Company	WiFi or Bluetooth connection	Smart home assistants connection	Trade market registered for control	Specific algorithm for control	R&D scientific evidences	Upgrade of existing fans
Big Ass Fans	●	●	●	●		
Hunter Fan	●	●				
Fanimation	●	●	●			●
4RinEU - ER2	●			●	●	●

Figure 40. Innovative features summary matrix of some smart control solutions for ceiling fans.

Table 2.3 Brief Description of ER 3 main players

COMPANIES / PRODUCT LINES	DESCRIPTION
HM Trend by Stiebel-Eltron	It is a prefabricated hydronic module thought for the connection of heat pumps to heating and domestic hot water loops towards the buildings spaces. In the same box, it includes an heating expansion vessel 24 litres, heating/DHW diverter valve, an electronic control unit with a display for user, safety valve, emergency/booster heater. It aims to simplify the integration of heat pumps into the hydraulic system. Energy meters devices seem not included, nor chance to connect and control different heat sources on the primary side (e.g. boilers, solar thermal system, etc.) in addition to or in parallel with the heat pump. Stiebel-Eltron also produces other preassembled hydronic control panels including different functions, such as temperature control for the loops of domestic hot water, high temperature heating, low temperature heating, with integrated connections, mixing and control components, energy meters.
Hydronic control panels by Eagle Mountain	They produce prefabricated hydronic panels with control devices included, for residential and commercial applications. The panels are custom designed and assembled off-site. All panels arrive pre-wired and ready for installation at the building site. Panel drawings and wiring diagrams can be delivered in advance of the panel shipment. A single power supply operates all equipment on the panel, so electrical installation is simplified. Since the design is customized, different components can be included for piping, connections, metering, controls, etc., and different heating systems and heat sources can be connected and controlled (e.g. heat pumps, gas boilers, biomass boilers, solar thermal, etc.). In the public technical documentations, nothing is mentioned about standard solution for controls and related communication protocols and requirements. An useful service offered by the company is an on-line form where potential customers can answer a questionnaire in order to receive a quotation for an hydronic panel suitable for their specific needs (http://www.eagle-mt.com/radiantmax/control_panels.php). The company is based in the United States of America.
R-Ready by Vortex	It's a prefabricated hydronic module allowing to receive heating from one source (primary loop, without storage tank) and to provide heat to space heating loop and to DHW loop. The module includes a hydraulic pump for the primary loop (towards energy generation) and a heat exchanger between primary and secondary loops.

	Models are available for different heat power and so with different pipes diameters. As standard solution, it seems it doesn't include energy meters and other electronic control devices. Only one heat source can be connected. But it seems that the company offers customized solutions and variants. The company is based in Canada.
HMC Hydronic Modules Corp by Yates	They offer custom prefabrication of modules for water pumping, heat transfer, and controls. They offer also support and services for maintenance. Customized design allows for integration of different components and heat sources.
Caleffi Hydronic Solutions	In their products catalogue, Caleffi offers a range of different models for hydronic modules with the following functionalities: space heating and DHW, space heating for building zones (apartments, units, etc.), pumping and control of water flow for heating.
TA-SHUNT by IMI Hydronic Engineering	TA-SHUNT is a range of prefabricated modules for control loops, coupling primary loops (towards heat / cool generator) to secondary loops. TA-SHUNT is suitable in heating and cooling systems such as radiator systems, floor heating systems, ventilation heat exchangers and heat re-cycling systems. In the standard products line only one heat / cool source can be connected. Different schemes for connection and controls are available in the catalogue.
HPS Controls	They offer Hydronic Pump Zone Control Stations, which are hydronic modules with the functionality of pumping. They include hydraulic pumps for primary loop and hydraulic pumps for secondary loops (for example for 3 or 4 building zones or loops). Different typical layouts are available (for example right or left connection pipes, etc.)
HydroNex by Watts	Hydronex modules are prefabricated hydronic modules produced in five varieties, according their own specific functionalities and consequent layout: respectively the different typologies are • Condensing boiler panel • Primary panel • Distribution panel • Zone panel • Specialty panel The five panels types can be used alone or in combination, in order to answer to the different needs.
Plug & Play Energy Hub By Thermics Energie	First Prototypes of the Domestic Hot Water (DHW) module, capable to integrate different heat sources and to optimise their use thanks to the implemented control algorithms. Certified energy meters are included.

	The module can communicate with common building management and control systems according the open protocol Modbus. The most valuable aspects to using an Energy Meter with ModBus board driver is the possibility to measure not only the thermal energy but also other important values like, for example, instant power, flow, inlet and outlet temperature. These values give the controller important parameters to manage module's behaviour and to collect important information about thermal energy consumption, issues, amount of used water and many others parameters. Normally, the Energy Meters obtain this information with a long refresh rate to saving battery energy, in the Plug&Play Energy Hub's case the accounting component uses electricity grid, for these reasons Thermics Energie worked a lot with the supplier to custom the component to achieve the goals.

Some points of interest have been listed here below:

- Optimized design
- Standard vs. customized design and features
- One or multi-heat sources
- Open vs. close controls and communication
- Energy metering
- Controls devices set
- Operating variables and states monitoring
- Controls algorithms for different aims (RES and different heat sources integration, etc.)

Table 2.4 Brief Description of ER 4 framework main players / typologies.

COMPANIES / PRODUCT LINES	DESCRIPTION
Energy calculation software tools - semi-steady-state or with simplified models	These kind of software tools allow for calculations on energy balance in buildings. They use steady-state or semi-steady state models, generally with monthly calculation periods, or they can implement also simplified dynamic calculation models. The implemented calculation methods are often based on the standards at national, european and international level. In the framework of buildings energy performance calculation generally the following aspects are considered: energy demand for main uses (space heating and cooling,, ventilation, domestic hot water, electricity demand for lighting and other uses, etc.) and the main systems typologies are considered also RES ones, such as solar thermal and solar photovoltaic systems.

	Generally goals and models are not focused explicitly on environmental sustainability, passive solutions (like natural ventilation and ventilative cooling) nor on the assessment of the match between on site energy generation and the building energy demand.
Energy dynamic simulation software tools	These kinds of solutions include comprehensive software which implement dynamic calculation models for energy valance in buildings. They considered in detailed way all the aspects listed here above and more. Calculation method take into account dynamic behaviours and allows for comprehensive results. Often, they include also more detailed calculation models about natural ventilation. Some of these products offer templates and fixed framework for calculations, some others are more flexible, and can be used in more open way, for example in definition of calculation equations, rules, systems to be simulated.
Software tools for specific systems or implementing specific models	These are software tools thought for calculations related to specific systems or aspects about energy and comfort performance in buildings. They can be more detailed or simplified. They are often used for design or assessment of them. For example, on the market, different kind of software are available for calculations about one or more of these aspects: solar thermal systems, photovoltaic systems, demand response optimization, natural ventilation in buildings spaces, indoor lighting design, etc.
Energy calculation tools related to BIM software as plugins	Some of the main software to develop BIM models now allows also for energy performance calculation. This often happens thanks to proper plugins to be installed in the software itself or thanks to software ad service available on web platform linked to the considered BIM software. They can perform calculations for the overall energy balance of the building (mainly on energy need or final energy demand for heating and cooling) or they can focus on other aspects like indoor lighting or natural ventilation. Since the main goals of the BIM software is not energy calculation sometimes the calculation methods are simplified or not explicitly described in detail.
Early-RENo - 4RinEU ER4	The software, developed in the framework of the 4RinEU project, has extended name: Early design methodology for RES best use in renovation process. It allows for calculation about daylighting, photovoltaic systems, natural ventilation, solar thermal systems. It implements detailed calculation models, allowing for frequent time steps calculations. It's specifically thought for calculation to assess and better define early design choices. It focused on RES and passive solutions (ventilate cooling and natural ventilation, daylighting to check transparent surfaced dimensions). About photovoltaic systems, the software allows to optimize the PV

	modules and disposition on the building envelope, targeting optimization of matching between electrical energy generation and filled in electrical energy demand profile and the optimization of economic indicators about this.

Table 2.5 Brief Description of ER 7 framework main players / typologies.

COMPANIES / PRODUCT LINES	DESCRIPTION
Guidelines	Guidelines and methodological framework for energy audit in buildings. National level (Member States)- Methodological frameworks, sometimes theoretical and not applied to demo cases, that can be shown. The 4RinEU audit protocol could references to some of these guidelines, underling advantages and benefits.
Audit services for buildings	Audit services for buildings provided by third parties bodies / organization recognized for certification. They could be less specific. Other related services can be offer together or in completion (e.g. with environmental certification schemes and pre-assessment, …). In the framework of this kind of service, there could be also audit services provided by small and medium engineering and architectural firms.
Software tools for energy audits in buildings	Software tools for energy auditing in buildings. Often as functionality in tools for energy certification or energy balance calculation. Generally, they appear rigid and close in the defined framework and without the chance of performing questionnaires for occupants.
Software tools to manage audits	Software tools to manage audits in general, not specific for buildings nor for buildings renovation.
Software tools based on ISO 50001	Software tools based on ISO 50001 and energy management They can be used also for auditing in buildings.
Cost-optimal energy audit - 4RinEU ER7	Specific for deep energy renovation projects. Focused firstly on social housing buildings (but not only) Synergies and best use of surveys, measurements, modelling (auditing + M&V protocol) Also aim of reducing 'pre-bound' and 'rebound' effect on energy use in buildings. Considering also of fuel poverty issue. 2 levels: Preliminary and Detailed. high replicability and cost effective energy, comfort, and IAQ user centric (owners / tenants / occupants): checklists and questionnaires

3.3 Key Market Drivers and Challenges

If we consider the deep renovation market for social housing buildings and for other collectively owned or multi-families residential buildings, the following features, issues and relevant opportunities can be recognized, particularly in relation to the deep renovation solutions developed in the 4RinEU project.

- Wide stocks with large number of buildings
- Relevant needs for renovations and maintenance
- Aggregation of demand - framework agreements
- Energy poverty
- Demolition or renovation
- Deep and integrated interventions
- Deep renovation vs. day-by-day maintenance needs
- Synergies between technologies and different ERs of the 4RinEU project
- Support to technical knowledges and design capacities of public and private entities
- Fire safety and other specific technical features
- Hub of solutions - aggregation (supply)

These aspects are considered hereafter, presenting related examples, which can give idea of dimensions and trends within the European market.

The 4RinEU solutions and the whole related methodology for renovations are particularly suitable and profitable for deep and integrated interventions since they offer multifunctional features and high level of integration of components and functions.
Anyway, of course 4RinEU solutions can be adopted also in partial or not deep renovations.
In the construction market, deep and major renovations could offer advantages from financial point of view, in many financial schemes available in the Member States, the percentage of refunded costs or the maximum amount of funding increase with the level of the energy performance or with the energy savings, which are achieved (e.g. deeper renovations, higher level of energy performance, better energy certification label achieved with the renovation). For these reasons, the 4RinEU solutions can be more suitable to reach higher level of funding or better conditions in financial schemes, since they integrate several and comprehensive functions and they can allow to achieve higher energy performance levels. One

example is the prefabricated multifunctional facade developed in the 4RinEU project, which can integrated in one solution all or part of these aspects: thermal insulation of opaque and transparent building envelope surfaces, details and solutions for airtightness, devices and components for mechanical ventilation, solar shading, RES systems. This represents a comprehensive package to achieve higher energy saving through refurbishment interventions, and so higher support from the available financing scheme.
Furthermore, the 4RinEU solutions can allow and higher quality checks and assurance, thanks to off-site prefabrication, to an overall methodology and the software tools, made available from the project. This can also help to control and reduce risks associated to renovation interventions (delays in completions, lack of quality, lack of performances) giving better conditions for customers and final users satisfaction and in the framework of some financial schemes, like preferential loans and EPC.

When multi-family residential buildings are owned by social housing organizations or by real estate actors, they can be grouped in large buildings stocks including thousands of residential units. For example, this is the case of the housing organization participating as partners to the 4RinEU project.
With large assets of buildings, it could be profitable to apply certain forms of **aggregation of renovation projects**, to benefit from economies of scale [BPIE.2018]. Organizations owning or managing large buildings stocks could plan renovation interventions on a large amount of buildings and according medium and long periods. This can be difficult, since requires adequate budget and economic and financial plan and adequate technical and administrative capacities in the owning organizations. But it could be possible with legal instrument like **framework agreements** and related tenders for this.
The 4RinEU solutions and methodologies can be suitable for this kind of frameworks, thanks to features related to prefabrication and industrialization of the renovation interventions and thanks to a comprehensive set of solutions and methods.

Often, financial instruments foresee that funding or repayment happen in a certain time period in future with instalments, as for example loans or in different way with EPC schemes, or with part of the funding amount in the taxation cycle, for example for the next 5 or 10 years. This lasting in time allows to assess interventions costs through life cycle cost and **global cost analysis**. These can be also useful to evaluate repayments on long periods and considering evaluation and **monetisation of multiple benefits** from deep renovations, consisting in costs savings not only for energy but also in other undirect relevant issues, like environmental sustainability and atmospheric emission reduction, better health and comfort conditions for occupants, job creation, etc. These could be relevant

also when the considered buildings or buildings stocks are owned by public entities, which deal also with societal issues and related expenditures.

The 4RinEU solutions are suitable for all building typologies and kinds of ownerships, however multi-dwellings buildings owned by large organizations or by collective entities can better take advantage from the 4RinEU, for their dimensions and features and for more centralized decision processes. Also for these aspects, the 4RinEU consortium decided to focus on the market of renovation of social housing buildings, due to their features and also to the social relevance if this market segment.
In order to give an idea of the dimensions and potentiality related to the **social housing sector** in Europe, hereafter some examples and related figures are presented.
For example, the figure below shows the numbers related to the apartments in social housing buildings in main cities in Italy. It gives for each of the considered city (first column on the left) the numbers of the citizens in the city, apartments / dwellings in social housing buildings, the number occupants in them, the percentage of citizens of the city living in these social housing settlements. This example can be considered as representative for all the main cities in Italy (main towns in districts and regions). In big cities around the 10% of the citizens live in social housing buildings, which generally are owned and managed by municipalities, municipal dedicated organizations, or regional public organizations, generally with branches at district level. Both municipalities both dedicated regional bodies are generally total public organization with large dimensions and relevant budget, which of course have to be used in order to deal with a great amount of needs and issue, both related to maintenance and buildings renovation both to the primary need of homes for low income citizens.
The figure below shows for some of the main cities in Italy, taken as example, the relevant dimensions of the building stocks in the social housing sector and thus the related actual and potential market for deep renovation integrated solutions or single products, like the ones developed in the 4RinEU project.

	City population	Social housing dwellings	Occupants	%
ROMA	2.872.021	69.496	159.841	5,6%
MILANO	1.337.155	76.817 Aler e MM	176.679	13,2%
NAPOLI	978.399	42.097	96.823	9,9%
TORINO	896.773	31.200	71.760	8,0%
BOLOGNA	386.181	11.850	27.255	7,1%

Figure 41. Numbers related to the apartments in social housing buildings in main cities in Italy (Source: MM S.p.A, Milano - 2015)

Considering deeply the city of Milano as suitable example of large cities in Italy and, with some differences in the contexts, in Europe, the following figure shows location and extension of social housing settlements in the overall city of Milano, which counts about 1,3 million of citizens. The maps in Figure 24, related to the different construction periods, show that the larger part of the social housing building stock have been built after 1946. Several and large settlements can be recognized, and they include a large number of buildings. These are all multifamily residential buildings and they are all owned by public organizations. Particularly, reflecting the whole Italian context, the social housing buildings in Milano (figure below) are in part owned by the Municipality of Milano and managed by the municipality owned company MM S.p.A.[26], and in part owned by the regional public organization called ALER. As we said, this is the typical scheme we can recognize in the whole country in Italy, and it could be similar to schemes of public ownership and management of large social housing buildings stock in other European countries. So, Italy has few public organizations which are responsible for the management and the related investment of large amounts of buildings.

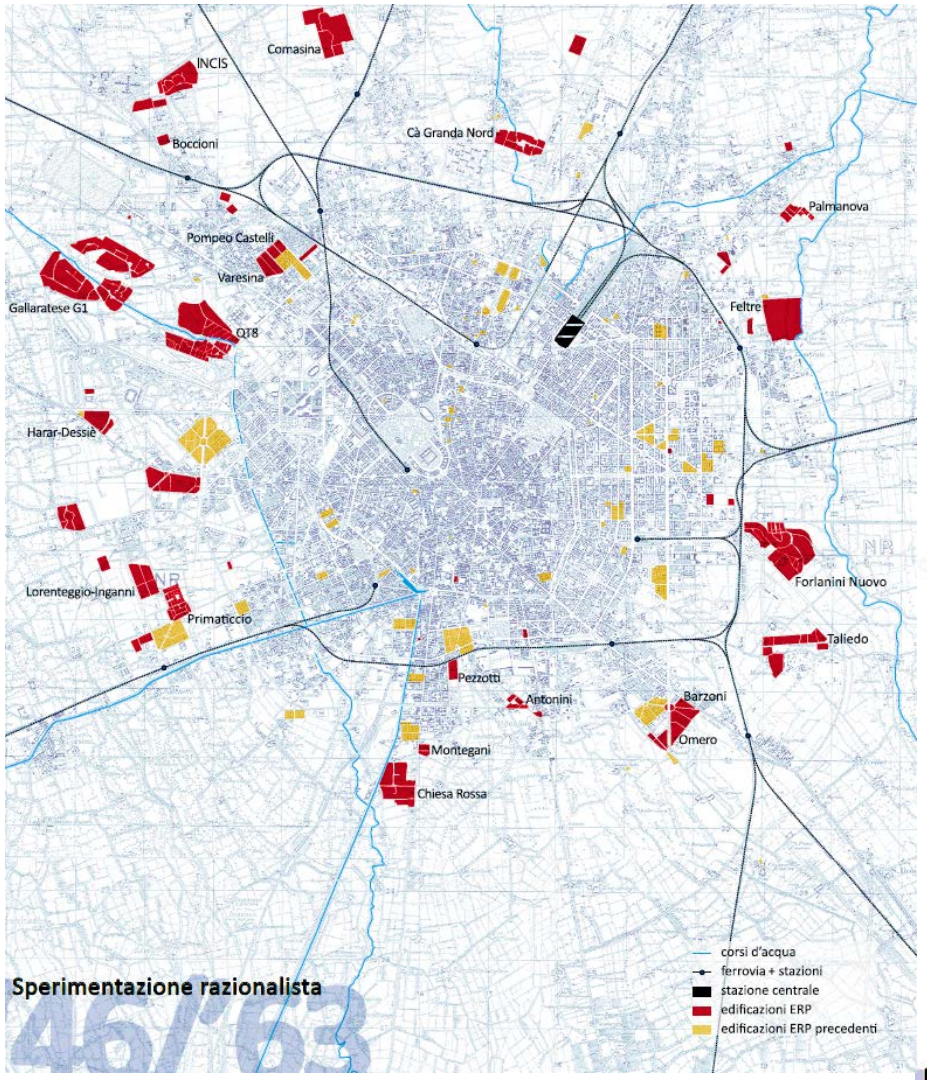
The Figure 25 shows only some examples of the buildings' typologies in the social housing settlements in Milano. Different shapes, dimensions, heights, and other features can be recognized. These represent only a part of the large variety in the features of the buildings stock. However, **some typologies are replicated** in different buildings of the same settlement or of different settlements in the city. It

[26] MM S.p.A is company owned but the Municipality of Milano. It acts as the technical branch of the Municipality, managing water supply and sewerage systems for the city, subway infrastructures and other transportation infrastructures, and social housing buildings owned by the Municipality.

is quite common that the same building typologies is fully replicated in a building block, which can include two or more multifamily buildings. This can represent a relevant advantage in order to replicate the same renovation project to more than one building in their blocks and settlements. This could bring to projects optimization, also from costs point of view, to applied economies of scales in refurbishments interventions.

Social housing stock in Europe represents a clear market opportunity for the products and solutions developed in the 4RinEU project, due to the recurrence of the typologies and the large number of buildings.
This is valid particularly for building stock were large multifamily dwellings are present and widespread, for examples in large cities and also in medium towns contexts, like in the case of Milano and other similar contexts in Europe.

Coming back to the example of the Milano context, many of the building typologies show suitable features for the 4RinEU products and solutions, for instance number of floors up to about 5, regular shapes and modular geometries, unique building blocks ownerships. Whole other typologies are only partially suitable for these kinds of solutions, since they have greater heights, more complex shapes, or historical features for older buildings (i.e. build before 1940), which are not the majority.



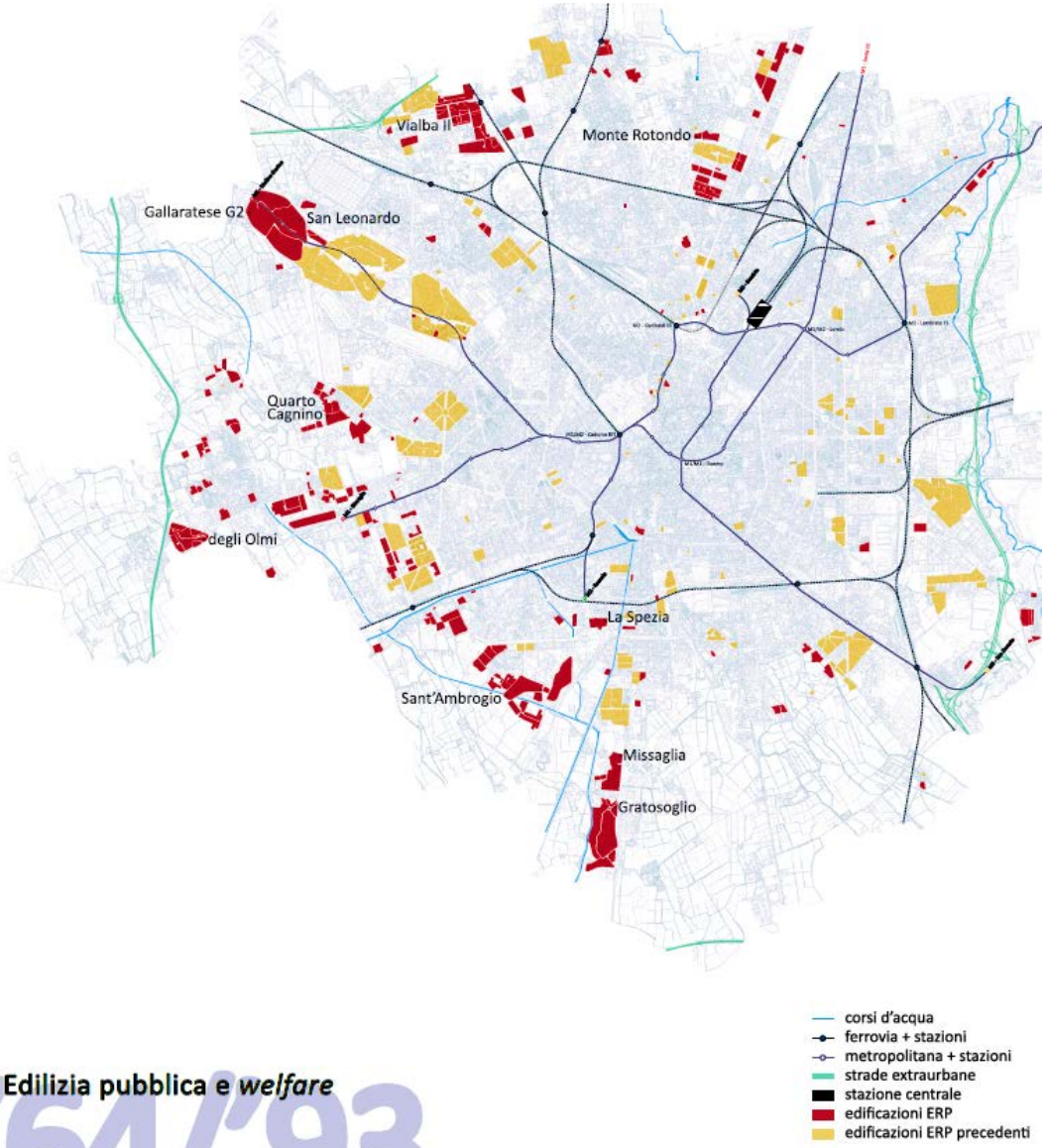


Figure 42. Location and extension of social housing settlements in the overall city of Milano: (left) in brown settlements built before 1946 and in red in period 1946-1963, (right) in brown before 1964 and in red in period 1964-1963 (source: Pasqui, Lettini, Gambirasio, Politecnico di Milano - 2010).


88.quartiere San Siro


78.quartiere Quarto Oggiaro


79.quartiere Missaglia


75.quartiere Gallaratese


91.quartiere Giambellino Lorenteggio


73.quartiere Chiesa Rossa


82.quartiere Ponte Lambro


68.Vialba case minime

Figure 43. Examples of some of the different typologies of social housing buildings in Milano.

	2015	2016	2017	Totale
Manutenzione ordinaria	€ 6.000.000	€ 7.500.000	€ 6.000.000	€ 19.500.000
Manutenzione Straordinaria	€ 37.804.931	€ 51.750.000	€ 70.800.000	€ 160.354.931

Figure 44. Allocated budget for maintenance and renovation of the municipality owned social housings in Milano, in period 2015-2017 (source: MM S.p.A).

In order to give an idea of possible quantities related to the market of refurbishments in social housing buildings stocks, hereafter some other figures from Milano are presented. Of course, public or private budget for social housing maintenance and renovation vary from the specific political context and economic conditions in place in the considered locations, but the here presented example can give information on possible market opportunities.
The city of Milano, with around 1,3 million of citizens, shows about 76.800 dwellings in social housing sector, of which about 37.000 are owned by the Municipality and manged by the MM company. In the 3 years 2015, 2016 and 2017 the total budget allocated by MM for building renovation interventions ("Manutenzione Straordinaria") was about € 160.350.000 and for common maintenance interventions ("Manutenzione ordinaria") of about € 19.5000.000, distributed in the 3 years as in figure here below. These amounts includesalso 9 interventions of deep renovation, with a budget higher than € 1 million each interventions and 1 intervention of demolition and reconstruction of 2 buildings for € 17,9 million. This represent an interesting market, even if considered only for a city.

As further example, the social housing building stock managed by the 4RinEU partner **Agencia de l'Habitatge de Catalunya** (AHC) can be considered to derive numbers from another relevant region in Europe. AHC manages 688 residential blocks, corresponding to 13.924 apartments for about 835.440 m^2 of residential floor surface. This are all residential dwellings and located in buildings 100% managed by AHC. The organization manages also other additional dwellings in co-owned buildings with private or other public organizations. The average renovation rate in period 2015-2019 is about 4,9 % and it includes mainly interventions on facades. In addition to this, the demo case, selected in the 4RinEU project, consists of about 900 m^2 of residential floor surface.
Table 9 shows value of the total yearly floor surface of renovated buildings and the related yearly renovation rates respect the overall building stocks of AHC. Relevant quantities and related market opportunities can be recognized. We can see also that the amount of interventions, and so the yearly renovation rate, varies year by year and it depends by time to manage and launch the design and works procedures, by the budget allocation, and by other constraints.

Table 6. Total yearly floor surface of renovated buildings and related yearly renovation rates, in the social housing buildings stock of Agencia de l'Habitatge de Catalunya (AHC) (source:AHC).

year	total floor surface of renovated buildings [m^2]	renovate rate [%]
2015	55 700	6,7 %
2016	2 474	0,3 %
2017	89 549	10,7 %
2018	22 800	2,7 %
2019	33 291	4,0 %

Table 7. Number of apartments by construction periods in the social housing buildings stock of Agencia de l'Habitatge de Catalunya (AHC) (source:AHC).

Typologies	Year of Construction	Apartments	Building regulations
Typology 1	Between 2006/2010	4.382	CTE 2006
Typology 2	Between 2005/1980	6.568	Regulation NBE-CT-79
Typology 3	Between 1979/1970	949	-
Typology 4	Between 1969/1960	357	-
Typology 5	Between 1959/1950	205	-
Typology 6	Between 1949/1930	180	-
Unclassified	Unknown	1.283	-

The Table 10 represents the number of dwellings, managed by AHC, divided by period of construction. We can see that, even if the greater part of them were built after 1980, a large amount was built before.

We already said that dealing with large buildings stocks, like ones owned and managed by social housing organizations or by real-estate companies or housing associations, could allow for **aggregation of demand** for renovations and of related projects for interventions. This could bring to larger **economies of scale** with greater discounts in offers for renovations works and materials, with final costs reductions. Dealing with large stocks of buildings means also to tackle the issue of financial resources to achieve maintenance and renovation interventions. This represents a primary step to develop actions in order to answer to numerous and relevant needs for renovations. For this, in the market of renovations of social housing it could be relevant to **combine different financial sources**, as

- own budget from the managing organizations,
- private funds from financial (e.g. from banks or financial institutions) or technical mechanisms (e.g. from ESCO procedures),
- other local, national and European funds.

Combining different financial funding scheme can help to start wide opportunities in the market of renovations of the social housing buildings, and, at the same time, answering to the related social needs. For this, hereafter some examples of large

interventions of renovations of social housing stocks combining different financial schemes are presented.

We present here an interesting example of **demand aggregation for the renovation of social housing buildings** and of a profitable combination of different financial instruments: this happened in the framework of the **EnerSHIFT projects**, focusing on energy renovation of a good number of social housing buildings in Liguria region in Italy. EnerSHIFT is a project of typology Coordination and Support Action funded by the European Commission in the framework of the programme Horizon 2020 - Project Development Assistance. The budget, funding at 100% by the European Commission in the EnerSHIFT project, has been of about € 970 000, that project consortium used for technical, administrative and legal assistance in order to develop tenders and to started renovation works in **76 social housing buildings (about 3.000 apartments) in about 15 municipalities** of Liguria region, for a total investment of about € 14,5 million. So, the ratio between the funds from the EnerSHIFT Horizon2020 project and the total investment for renovations is about 1:15. The foreseen energy retrofit interventions are about boilers replacements and building envelope renovation, with energy savings at least of 45%. In order to cover the investments of € 14,5 million the public organizations involved combined 3 different financial schemes: (i) European regional Development Fund (ERDF), (ii) energy performance contracts (EPC) with ESCOs, (iii) public subsidies from national state called "Conto Termico". At the end, for constraints in use of the ERDF, 2 different public tenders for renovation works have been published. The first one according EPC schemes for ESCOs, for a total amount of about € 21 million (VAT excluded) including renovation works, heating systems managements services and energy carriers delivering for the next 12-13 years. In addition, the second tender with a total amount of about € 6,2 million, covered with about € 3,5 million from ERDF and 2,7 for the public organization owning the social housing stock in Liguria. This second tender covered renovation works without other ESCO services.
The EnerSHIFT project duration has been of 48 months from February 2016 to January 2020, and it prepared the renovation works that started during 2019.

Another interesting project is **LEMON - Less Energy More OpportuNities**, funded in the Horizon2020 programme, supporting renovation works for 622 apartments in social housing buildings in Emilia Romagna region in Italy, for a total amount of about € 15 million. They combined EPC schemes with ESCOs, European regional development fund (ERDF - POR-FESR in the figure below), and) public subsidies from national state (GSE - Conto Termico in the figure below), according the exemplifying scheme in the figure here below (source: www.progettolemon.it, www.lemon-project.eu).

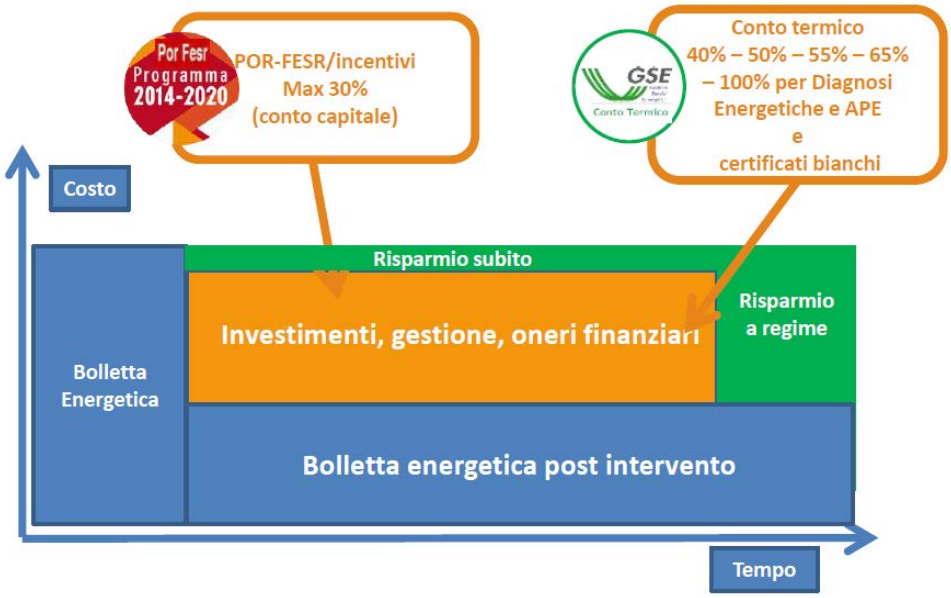


Figure 45. Example of financial schemes for energy renovation of social housing, combining EPC with ESCO, European Regional Development funds (POR-FESR in Italian) and national public subsidies (GSE-Conto Termico) - source: LEMON project.

In this market segment, a problem, that occurs to low-income people and families, is the so called fuel poverty or **energy poverty** [BPIE.2016], which can be exemplified by three main issues: (i) inability to keep homes adequately warm, (ii) living in a dwelling with bad or dangerous construction components (e.g. a leaking roof, rot windows and damp walls or ceilings), (iii) and arrears on payment of utility bills. This is for sure a relevant issue from social point of view, but because it's an urgent problem, solving it can bring to opportunities related to job creation, energy and comfort performance improvement, and other market increasing.

Particularly in social housing buildings, in some cases, due to the fact that buildings energy performance is poor and occupants' incomes can be low, tenants and households can pay higher amount for energy bills than for rent the dwelling. It's possible that they cannot manage to pay the bills or that they pay with delays, leaving the public or private bodies owning the buildings to bear the costs. So, energy costs must be partially covered by the budget of the public or private organization that owns the apartments. Improving the energy performance of buildings allows to reduce the costs due to energy bills, reducing the phenomenon of arrears in utility bills, thus allowing building owners to repay the investments made for renovations or to make available part of the budget for this. Analysis on financial sources from savings could mobilise investments in renovations.

These direct financial advantages related to buildings renovations in social housing sector are coupled to undirect ones and to social advantages like health issues due to cold homes, better indoor thermal comfort, Job creation, social inclusion (e.g. by renovated poor districts), reduction of CO2 emissions.

Dealing with the social housing sector, it also relevant to consider **demolition or refurbishment** alternatives. Technical assessment of building suitability for refurbishment or demolition are often based on models of building performance. Decisions are also based on a series of performance and cost indicators. Estimating the costs and impacts of refurbishment or demolition is complex, especially where non-monetary costs and benefits have to be assigned a value.
The energy performance of a building is an important consideration when deciding to demolish or renovate, and it has a big impact on the health of residents and the cost of their energy bills. Energy is also used to manufacture building materials, for construction, demolition, reusing, recycling etc. Reducing carbon emissions associated with the built environment means reducing the emissions associated with the whole lifecycle of the building.
Case studies demonstrate that even older, poorly insulated structures, known as hard to treat in buildings, can be retrofitted to achieve high energy efficiency standards. In these cases, residents have been able to stay in their homes avoiding costs and disruption of temporarily housing people elsewhere. Other factors that should be taken into consideration are performance gaps and behaviour of the residents as they can affect final energy consumption.
Improving the quality of social housing stock is essential to reduce health inequalities in Europe. Refurbishment can deliver improvements in housing quality at a faster rate than demolition and rebuilding of social housing, but issues such as ventilation and indoor air quality can be complex to address in refurbishment.

The type of examples, which have been reported, and the related numbers shape the size of the potential market at local, regional and national levels for each member states. Acting in the refurbishment and deep renovation of social housing buildings deals with large building stocks owned by few large organizations, which are public, in many case, or private. The numbers showed in this chapter can orientate on the market dimension and on possible opportunities related to medium- and long-term planning of the interventions, aggregation of the demand for deep renovations, possible economies of scale.
In addition, the age of construction and energy poverty bring to urgent needs for maintenance and renovation of social housing, in many regional contexts in Europe, also from societal point of view.

4 Stakeholder Analysis

Project Management Institute (2001) defines the stakeholders as: "individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion."
A more concise definition of the stakeholders would be: "*those groups or individuals with whom the organization interacts or has interdependencies…any individual or group who can affect or is affected by the actions, decisions, policies, practices or goals of the organization*". (Carroll, 1993).

Divided in:

- **Internal Stakeholders** to the organization, who are the team members of the project or those who provide for the financing of it.
- **External Stakeholders** like the people affected by the project in some significant way.

The list of stakeholders in a construction project is often long and includes the owners and facility users, project management, team members, facilities managers, designers, shareholders, public administration, workers, subcontractors, services suppliers competitors, banks insurance companies, media, community representative, neighbours, general public, clients, regional development agencies. Each one of them have a potential influence on one or more phases of of a renovation project

Table 8. Grouping of Stakeholders: External and Internal for the 4RinEU project.

External		Internal	
Public	**Private**	**Supply Side**	**Demand Side**
Regulatory Agencies	Local Residents	Architects	Client
Local Government	Local Landowners	Engineers	Financiers
National Government	Others	Principle Contractors	Client's Employees
Public Agencies		Trade Contractors	Client's Customer
		Materials	Client's Suppliers
		Suppliers	

Table 9. Roles of Project Stakeholders.

Stakeholder Group	Objectives and Roles
Client	The client can be public or private. The main difference between a private construction project and a public project is that the client and the beneficiary are the same in private construction project and in the reconstruction housing project the main initiator is the beneficiary and benefit accrues to the communities affected
Consultant	Provides the consultancy advice for the project on designing, evaluating the cost, technical issues/advice (engineering advice electrical, civil etc.).
Contractor	Engage in actual construction according to the designs, specifications, contract documents communicated by the relevant parties
Funding body/Sponsor	Ensures that the funds are utilized for the purpose and the sponsor makes sure that used according to the planned budget and time schedule. Ensures that deliverables are delivered on time at the specified and approved cost.
Municipalities/Land Owners	Provides the land on which construction work is carried out. Their support is important for the timely purchase, planning, execution and completion of the construction project.
Surrounding Communities	Their support, influence, interest in the project is important and must be assessed.
Politicians	The support of the politicians is important in project construction as they are the leaders of the communities surrounding the project. They influence and they have power.
Government and other Authorities such as counties	Ensure that the construction project is carried out according to laid down regulations and requirements.

Stakeholders can also be classified as primary and secondary (Carroll and Buchholtz, 2006)[27].Tthe primary stakeholders are a group of people whose continued participation in the project is important for the survival of the project organization. Whereas, secondary stakeholders are those who may be able to influence the organization or the organization may influence them. Primary stakeholders could be contractors who provide services (e.g. contractors, subcontractors, consultants).Secondary stakeholders usually have an indirect or

[27] https://pdfs.semanticscholar.org/3e01/a7a11d060b84a5bcc013911367c696af01fb.pdf

secondary relationship with an organization without having contracted responsibility.

Classification of project Stakeholder

There is a number of reasons why it is necessary to classify stakeholders:

- to provide a strong sense of stakeholder impact on projects when considering the other alternative concurrence to develop appropriate responses to manage them,
- to assess how each stakeholder group is likely to enforce its expectation on the project, whether these groups have the means to do so based on the power they possess,
- the likely impact of stakeholder expectations on project strategy.

Hereafter, the project stakeholders are categorized according the scheme of the power/interest matrix, where the following groups can be recognized.

Stakeholders with "Low Influence" and "High Interest" can be helpful in decisions making and giving insightful opinions. The second group is those with "High Influence" and "High Interest" This group is important and are critical stakeholders who must be managed closely. A third group is the minor group with "Low Influence" and "Low Interest". This group requires minimal effort to manage and are least in priority and requires monitoring. The fourth group with "High Influence" and "Low interest" are those who need to be either kept engaged in the project or kept informed or both.

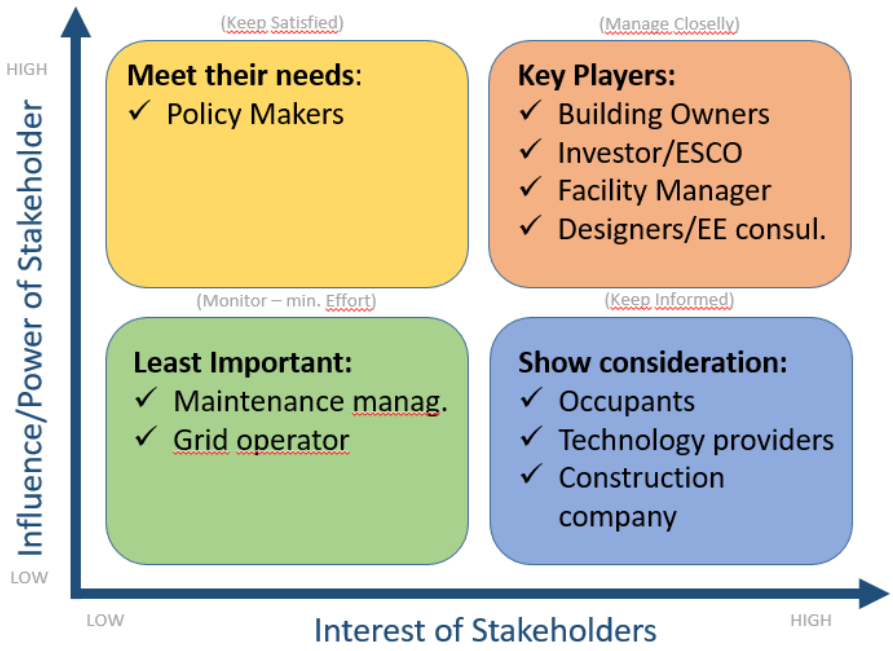


Figure 46. Power/interest matrix of the main stakeholders of the project.

Managing Stakeholders

From this we can recognized the Four Levels of stakeholder management, suitable for the activities of exploitation-oriented dissemination and communication about the project.

Table 10. The four Levels of stakeholder management.

	Low Stake/Importance	High Stake/Importance
High Interest	Keep satisfied Interest protected: These Stakeholders can be helpful in giving insightful opinions. (Involve)	Key players Maintain good relations: These Stakeholders are critical and requires close collaboration (Collaborate)
Low Interest	Minimal effort: Least priority Stakeholders. Monitor them (Inform)	Keep informed: If you cannot get them engaged and interested, keep them informed (Consult)

List of stakeholders

- Building owners
  - Public Associations
  - Private Associations
  - Private owners
- Investors
  - Holdings
  - Developers
  - Public companies in the field of housing
- Facility Managers
- Designers
  - Architects
  - City planners/ urbanists
- Consultants
  - MEP engineers
  - Structural engineers
- Occupants
  - Private owners
  - Consortiums / Associations
- Technology providers
  - Façade fabrication companies
  - PV sellers
  - Heating systems

    - Fans producers
- Construction companies
    - MEP installers
    - General contractors
    - Façade installers
- ESCOs
- Policy makers and public bodies
    - Municipalities
    - Government (Regional, National)
    - NGO organizations
    - Social care organizations
- Maintenance Managers
- Grid operators

5 Conclusions

The needs for renovation of the European building stock are well known, and already included in the agenda of the European and national institutions.
Estimates of renovation rates (other than those relating to single energy saving measures) range mainly between 0.5% and 2.5% of the building stock per year. These rates typically reflect the activity of the past few years which in some cases are linked to special circumstances during those years (e.g. the existence of a renovation programme) and therefore may not be of normal practice. It can be assumed that the current prevailing renovation rate across Europe is about 1%. Deep renovations represent only a part of it, which can be smaller or bigger depending by the country. The market needs an acceleration.

The solutions developed within 4RinEU project are suitable for all building typologies and ownerships, however multi-dwellings buildings owned by large organizations or by collective entities can benefit more from 4RinEU outcomes, due to their dimensions and features, and to their more centralized decision processes. For these aspects, the 4RinEU consortium decided to focus on the market of renovation of social housing buildings, due to their features, and due to the social relevance if this market segment.
Analysis presented in the first chapter about the existing housing stock in Europe and in some target countries, taken as representative, shows the relevance in quantities of multi-dwellings buildings and larger owner entities, in different countries and context.

The refurbishment activities and particularly the deep renovations involve many market segments, different actors and stakeholders.
The solutions and overall methodology developed in the 4RinEU project can be applied in many different contexts and type of interventions, and they represent a comprehensive set of products and knowledges.
Considering the market related to the first 4RinEU exploitable result the prefabricated multifunctional wooden façade components (PMFS), market watching activities show that wooden and timber construction sector is growing: in addition to the traditional applications, systems and products, the sector is also offering innovative processes, products and new ways to use wood based systems. The sector has a relevant importance in the industrialized and prefabricated off-site construction processes. Innovations can be seen in methodologies and systems for the off-site production, in wooden based materials, in new features of more common wooden components, in architectural and engineering solutions for projects.

The sector appears active in new buildings projects, while the use of prefabricated wooden components for the renovation of building envelopes is rare and it still appears as an innovative measure.
PMFSs for refurbishment represent a mature family of products that can be used on the market, but so far their adoption is not so widespread, even if they have been used successfully in significant renovations projects for multifamily buildings and schools in common interventions and in refurbishment cases studies supported by research projects.
This market is often local, but several commercial flows happen also throughout Europe.
Valuable scaling up experiences are presented in this document: some examples can be recognized in interesting experience involving private companies and real estate corporations, public bodies and umbrella organizations, large companies developing open technical guidelines.
These examples could be disseminated through the main stakeholders' network of the project in order to increase the awareness about potentialities in the analysed sectors.

As far as social housing is concerned, field observations show that the market sector shows relevant opportunities, needs, and dimensions. Some of the interesting points are that it is a potential large market, there could be opportunities related to demand aggregation and economies of scale both from supply both from demand side, there are public funding schemes available.

Innovative and peculiar features of the project exploitable results have been presented in relation to some competitors and other similar products available on the market in the same fields. This shows interesting features and good potential for the products developed in the 4RinEU project.

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