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Cost-effective energy savings potential of Italian residential building stock

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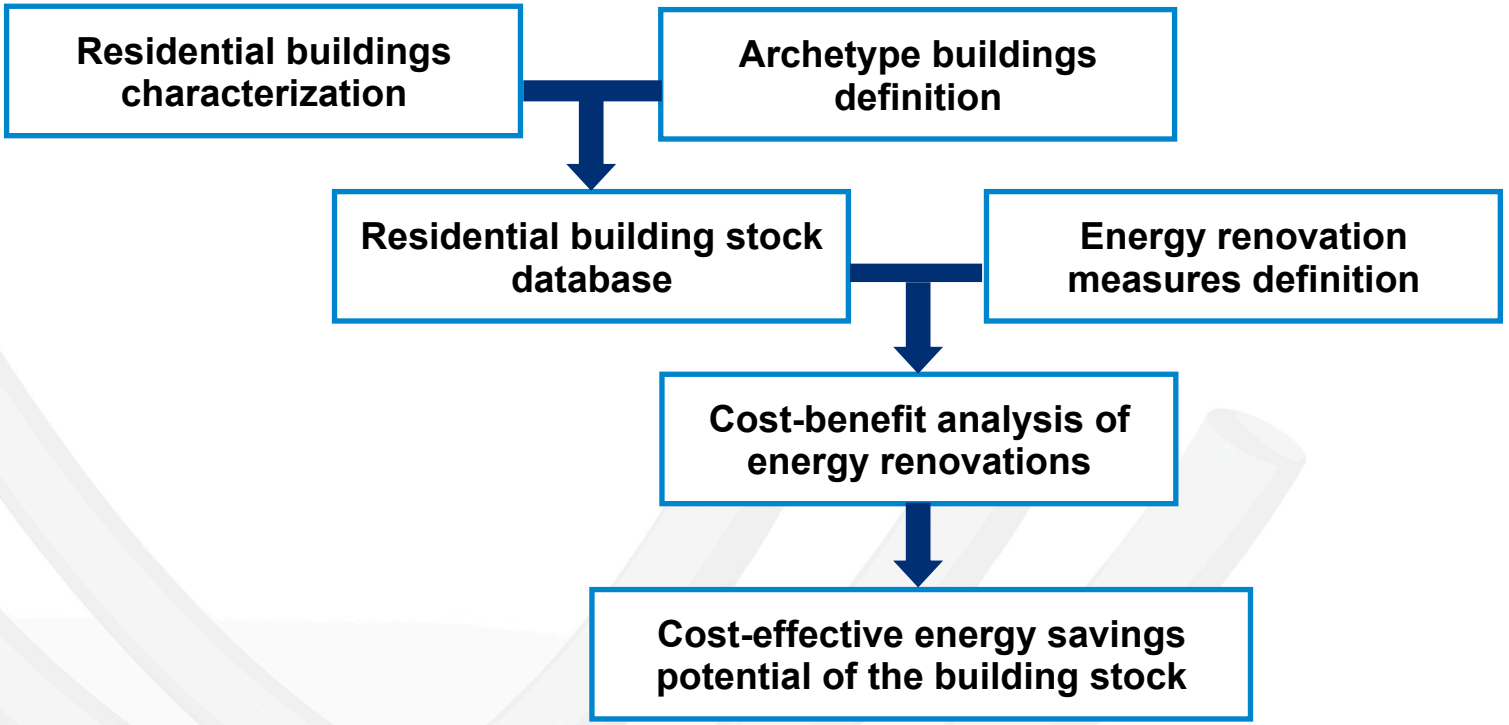
OBJECTIVE

To estimate the fraction of the residential building stock where energy renovations are now cost-effective with current technologies and conditions and to evaluate the corresponding potential energy savings.

Particularly we are interested in understanding how incentives affect this potential.

METHODOLOGY FRAMEWORK



METHODOLOGY AND ENERGY & COST CALCULATIONS

- Characterization of building stock is derived from ISTAT 2011 housing census.

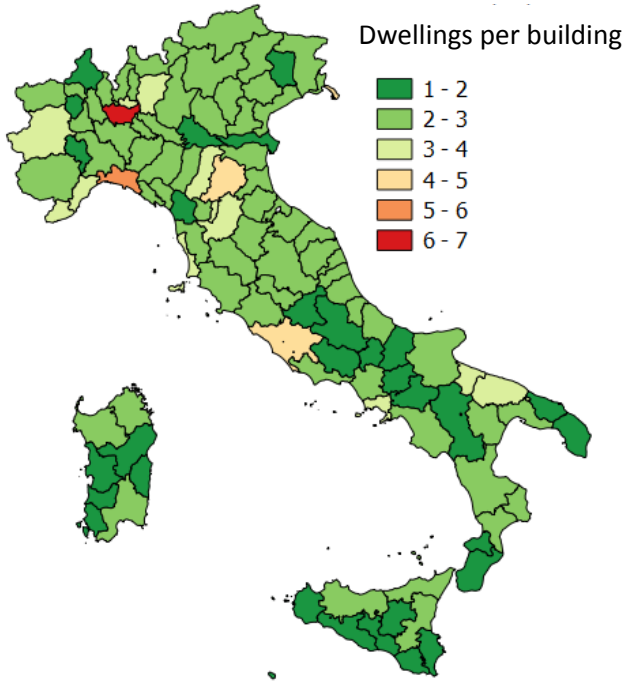
- Energy need is evaluated with hourly dynamic calculation method described in ISO 13790.
- Building technical systems performances are evaluated with UNI/TS 11300.
- A calibration of energy use is done on the actual consumption of a year chosen as representative of average climatic conditions.
- Calculated energy use has been compared with real consumption of over 200 buildings.

- Investments costs are mainly derived by national price lists and validated with recent renovation projects.
- Global cost calculation is performed according Delegated Regulation N°244/2012 and EN 15459.
- We consider tax credit incentive mechanism (65% of investment reimbursed over 10 years).

ITALIAN RESIDENTIAL BUILDING STOCK 1/2

60 millions of people
12 millions of residential buildings
31 millions of dwellings (24 millions dwellings occupied by resident persons)
2397 millions of m^2 of floor area (occupied dwellings)
62% of buildings are single-family houses
22% of occupied dwellings are in large multi-family buildings

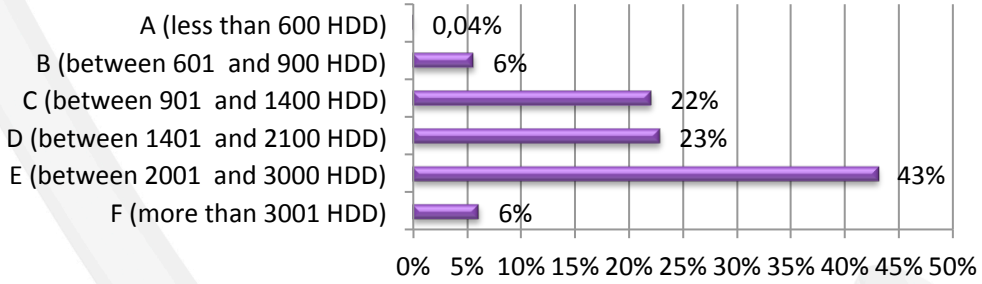
	Number of dwellings in the building					
	1	2	3-4	5-8	9-15	≥ 16
Residential buildings	62%	20%	9%	5%	2%	2%
Dwellings	21%	18%	15%	14%	12%	20%
Occupied dwellings	19%	17%	15%	14%	13%	22%

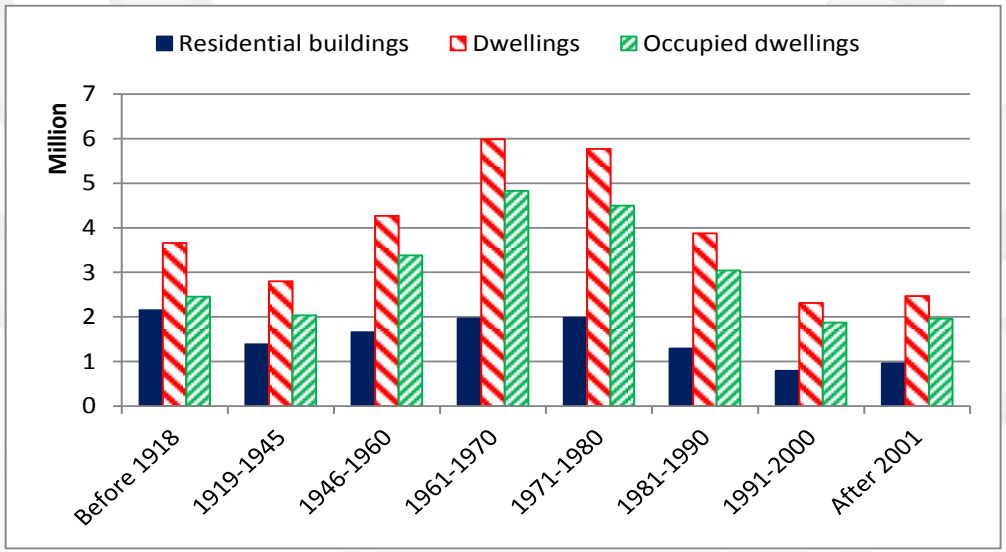


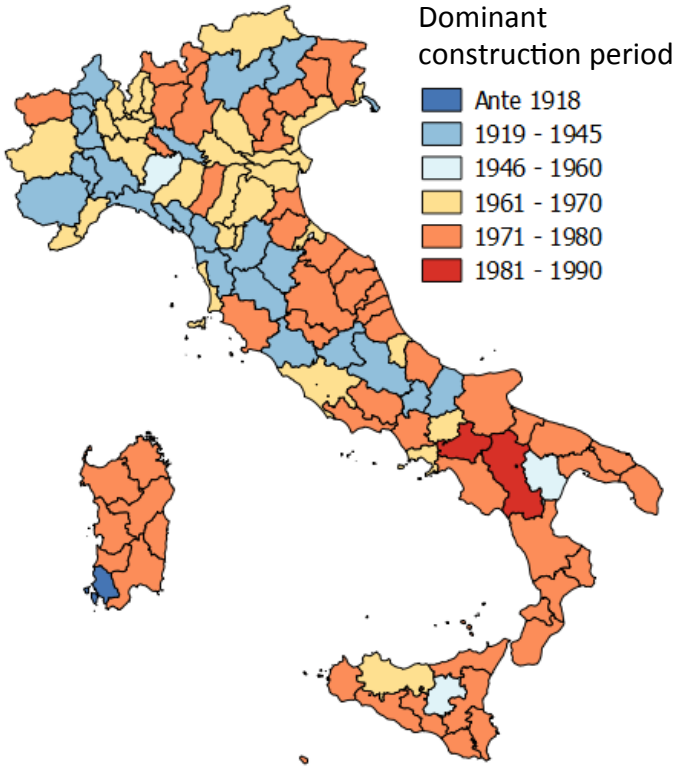
ITALIAN RESIDENTIAL BUILDING STOCK 2/2

43% of buildings are located in climate zone E
12% of buildings are located in extreme climate zones (A, B and F)
75% of buildings are built before 1980

Buildings per climate zone

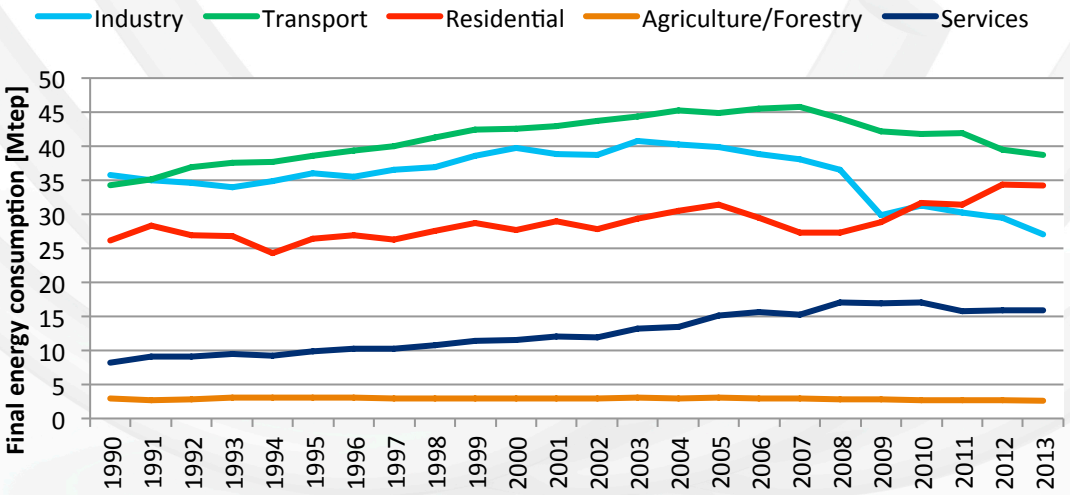


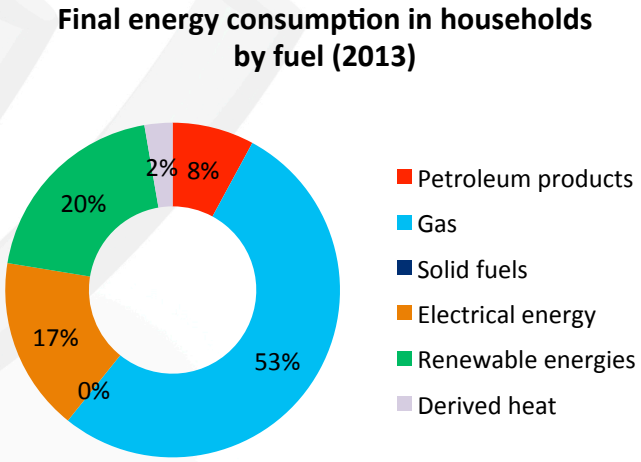




HOUSEHOLDS ENERGY CONSUMPTION

- Residential sector final energy consumption is growing, and currently is 28% of Italian total final energy consumption (34 Mtoe in 2013).
- Natural gas is the most used energy product.
- Final energy consumption per dwelling is 1.3 toe.
- Space heating is responsible of two third of final energy consumption.
- On average specific final energy consumption for space heating is 102 kWh/m^{2}year.
- Space cooling service is growing, but currently it is responsible of only 6% of households electricity consumption.





Source: EUROSTAT.

ARCHETYPES 1/2

140 archetypes (reference building representative of the building stock)

4 typologies:
Single-family buildings
Terraced houses and small size multi-family buildings (less than 9 housing units)
Medium size multi-family buildings (between 9 and 15 housing units)
Large size multi-family buildings (more than 15 housing units)

5 climate zone:
Ranging from B (between 600 and 900 HDD) to F (more than 3000 HDD)

7 construction periods (6 for renovations)**:**
Before 1918, 1918-1945, 1946-1960, 1961-1980, 1981-1990 (*law 373/76*), 1991-2006 (*law 10/91*), after 2006 (*L. decree 192/05*).

ARCHETYPES 2/2

Energy performance [kWh/m²year]							
Climate zone	**Building typologies**	**Construction periods**					
		Before 1918	*1919-1945*	*1946-1960*	*1961-1980*	*1981-1990*	*1991-2006*
B	*SF*	54	52	49	36	23	18
	TH	33	31	37	32	15	15
	MM	28	34	36	32	19	11
	LM	26	34	36	20	12	6
C	*SF*	100	97	93	70	47	35
	TH	67	63	74	65	32	30
	MM	56	70	72	64	38	24
	LM	55	69	72	42	25	16
D	*SF*	165	133	123	139	101	80
	TH	134	110	117	150	78	50
	MM	117	123	104	130	89	45
	LM	95	105	107	85	57	40
E	*SF*	250	227	195	184	120	84
	TH	201	197	165	210	92	65
	MM	178	186	164	163	104	60
	LM	145	157	156	119	69	56
F	*SF*	291	254	218	207	135	100
	TH	231	218	198	227	104	78
	MM	213	218	184	182	112	74
	LM	230	208	168	131	82	71

ENERGY RENOVATIONS

Selection criteria:

i. Widespread and common solutions.

ii. The aim is to reduce space heating and DHW production – No space cooling.

iii. No renovations requiring a radical modification of distribution and emission systems (too invasive).

iv. Access to tax credit incentive mechanism.

Selected renovations (they represent about 97% of current energy renovations) **:**

A. Opaque envelope thermal insulation: external walls, roofs and floors (if possible).
B. Glazing system and shading devices.
C. Heating system renovation: condensing boiler and thermostatic valves.
D. Glazed flat-plate collectors with selective absorber surfaces (60% of DHW need)

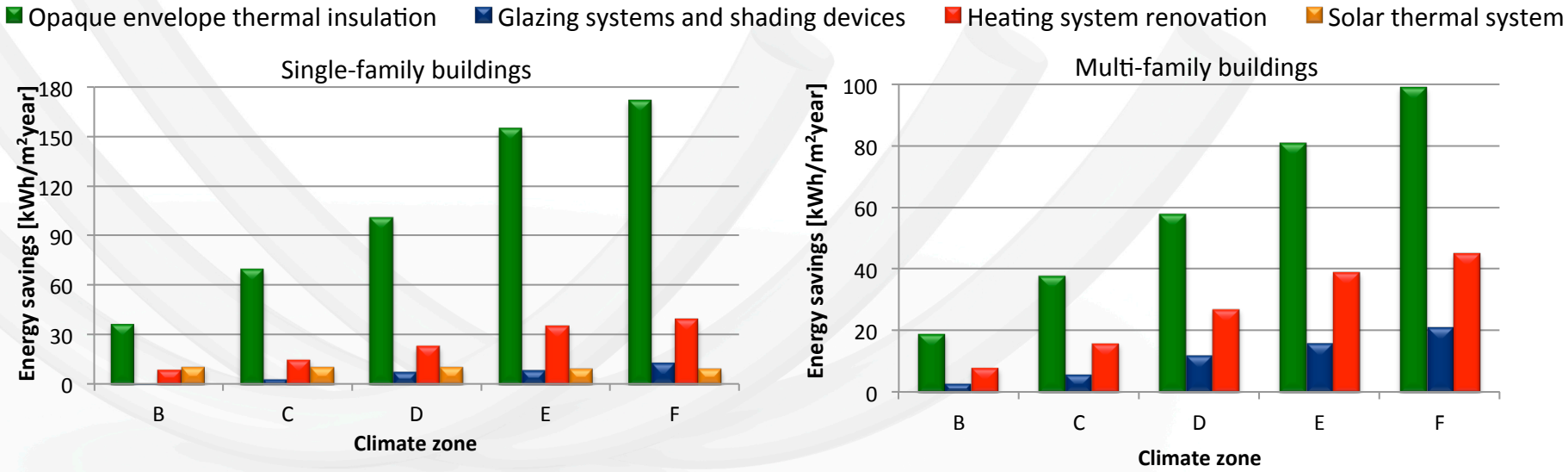
+ combination of these measures (A+B, A+B+C and A+B+C+D).

Climate zone	Target U-values				g-value	
	External walls	Roofs	Floors	Glazing systems	Without shading	With shading
B	0,41	0,32	0,46	2,4	0,67	0,23
C	0,34	0,32	0,40	2,1	0,67	0,23
D	0,29	0,26	0,34	2,0	0,67	0,23
E	0,27	0,24	0,30	1,8	0,50	0,18
F	0,26	0,23	0,28	1,6	0,50	0,18

Target values are set in order to access to tax credit incentive mechanism. To be noted that these values are very similar and sometimes lower (up to 15%) than those obtained in the cost-optimal methodology required by Directive 2010/31/EU.

INVESTMENT COSTS & ENERGY SAVINGS

Investment costs	Building typologies			
	Single-family houses	Terraced houses and small multi-family buildings	Medium multi-family buildings	Large multi-family buildings
Opaque envelope thermal insulation	290 €/m²	194 €/m²	193 €/m²	148 €/m²
Glazing systems and shading devices	73 €/m²	73 €/m²	74 €/m²	90 €/m²
Heating systems (single-family buildings)	34 €/m²			
Heating systems (central heating)		28 €/m²	25 €/m²	21 €/m²
Heating systems (autonomous heating)		43 €/m²	64 €/m²	51 €/m²
Solar thermal systems	41 €/m²			



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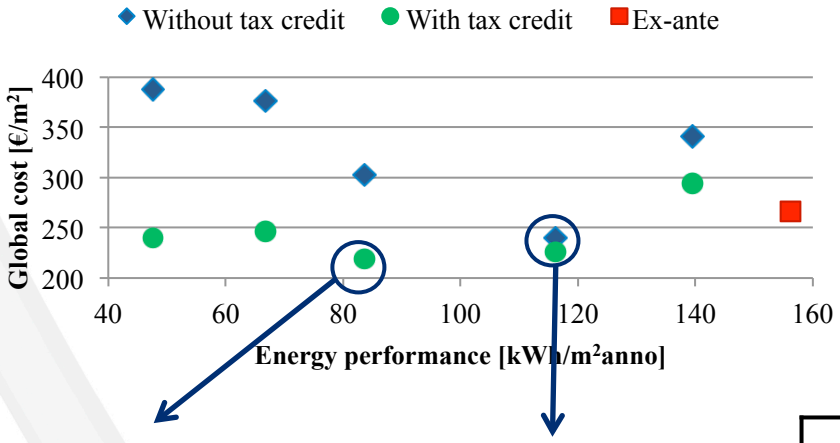
COST-OPTIMAL RENOVATIONS



Large multi-family building
Construction period: 1946-1960
Climate zone: E

Opaque envelope thermal insulation

Heating system renovation

Opaque envelope thermal insulation

Heating system renovation

None of the considered renovations

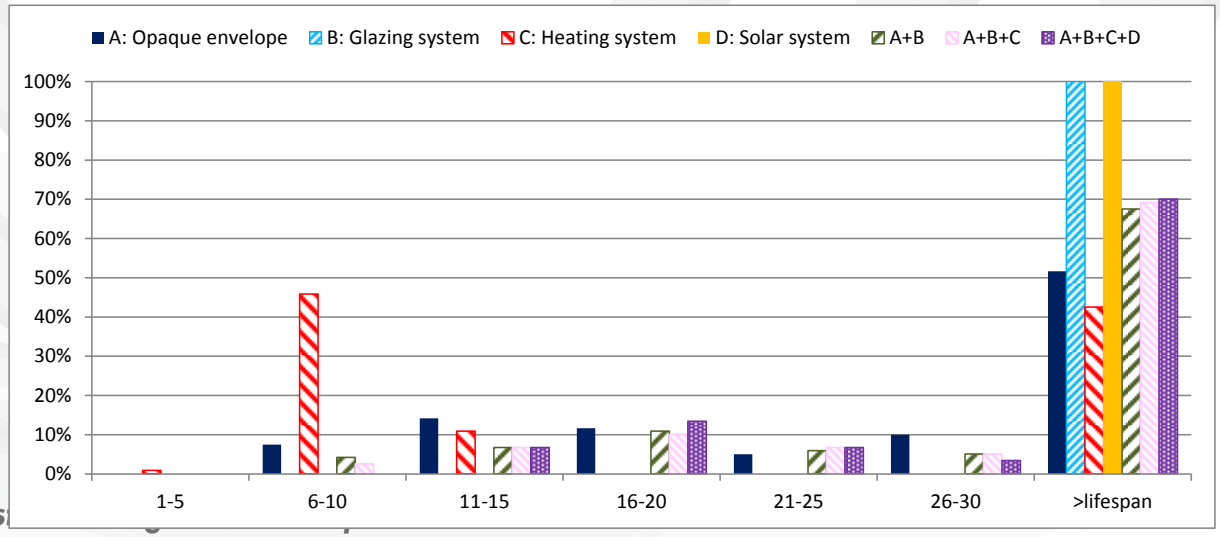
Cost-optimal renovations considering tax credit

Typology	Climate zone	Construction periods					
		before 1918	1919-1945	1946-1960	1961-1980	1981-1990	1991-2006
Single-family houses	B						
	C						
	D						
	E						
	F						
Terraced houses and small multi-family buildings	B						
	C						
	D						
	E						
	F						
Medium multi-family buildings	B						
	C						
	D						
	E						
	F						
Large multi-family buildings	B						
	C						
	D						
	E						
	F						

PAYBACK PERIODS

- Heating system renovation always has the shorter payback period.
- Payback periods for glazing systems and solar systems are longer than measure lifespan.

Climate zone	Heating system renovation				Opaque envelope thermal insulation			
	Without incentives		With tax credit		Without incentives		With tax credit	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
B	> lifespan	> lifespan	> lifespan	> lifespan	> lifespan	> lifespan	> lifespan	> lifespan
C	> lifespan	> lifespan	10	> lifespan	> lifespan	> lifespan	18	> lifespan
D	11	> lifespan	7	> lifespan	21	> lifespan	10	30
E	8	> lifespan	6	10	15	> lifespan	8	24
F	7	> lifespan	5	9	12	> lifespan	7	20



COST-EFFECTIVE ENERGY SAVINGS POTENTIAL

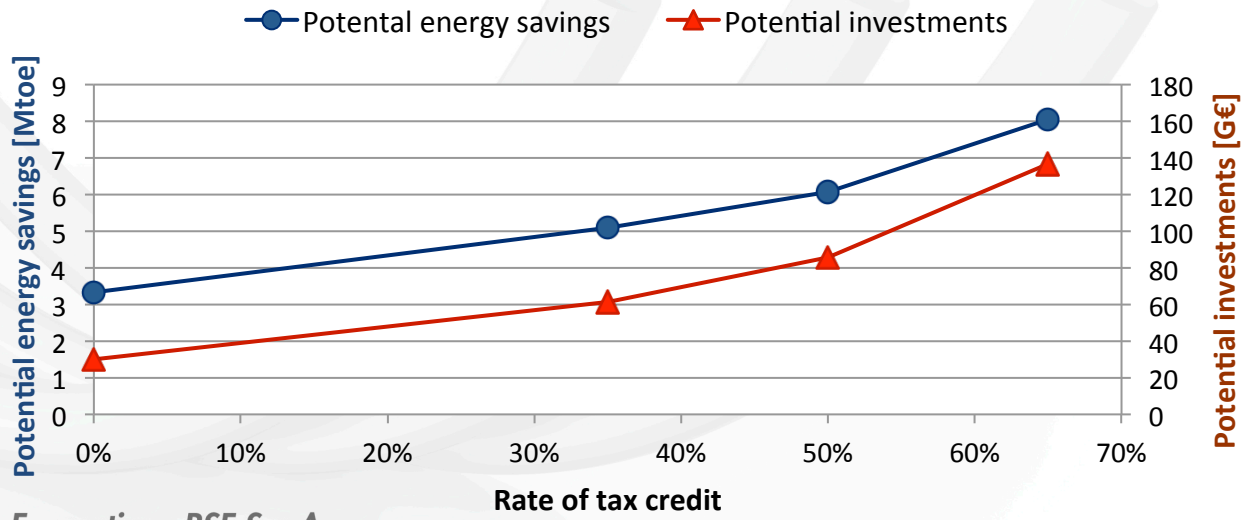
Cost-benefit analysis of energy renovations (archetypes)

Residential building stock database

Cost-effective energy savings potential

Energy renovations are cost-effective and have a payback period ≤ 15 years in 59% of the building stock. Assuming to select the cost-optimal renovation for each building, we found:

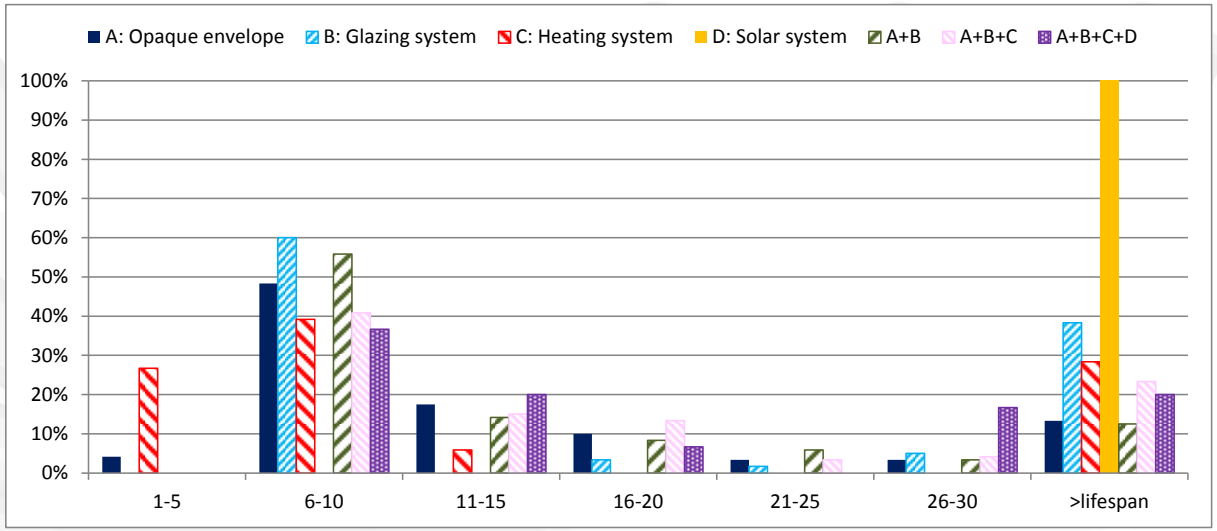
- 8 Mtoe energy savings (2020 target set in Italian NEEAP for all residential sector is 3.67 Mtoe)
- 19 Mt carbon savings
- 137 G€ investments



ENERGY RENOVATION OPPORTUNITY 1/2

Periodically buildings need refurbishments. If energy renovations are implemented when a refurbishment is needed, the cost effectiveness is enhanced (since some costs are already sustained).

So we compare basic refurbishment with energy renovations:
Façade renovation -> Opaque envelope thermal insulation
Simple double glazing -> efficient glazing system and shading devices
Traditional boiler -> condensing boiler and thermostatic valves



ENERGY RENOVATION OPPORTUNITY 2/2

We estimate that every year 150.000 building need a envelope refurbishment (façade), 500.000 buildings need to change the boiler and 300.000 buildings need to renovate the glazing system.

Assuming to implement energy renovations with payback periods ≤ 15 years, we can triple current investments and multiply by a factor of 10 the energy savings .

	Without incentives	With tax credit
Energy savings [ktoe/year]	257	427
Carbon savings [kt/year]	615	1023
Investments [G€/year]	3,7	11,9
Building stock involved per year	1,69%	3,61%

KEY MESSAGES

- Energy renovations with payback periods ≤ 15 years could be implemented in 59% of Italian residential building stock.
- Potential energy savings reach 8 Mtoe, i.e. 34% of current space heating and DHW energy use in residential buildings.
- Tax credit incentive mechanism is fundamental to promote building renovation, especially such renovation that require high investment and give more energy savings.
- Exploiting the opportunity of energy renovating buildings that already need a refurbishment, there is a potential of 427 ktoe/year and corresponding investment of 12 G€/year (three times current yearly investment in energy renovations).

Thank you for your attention!

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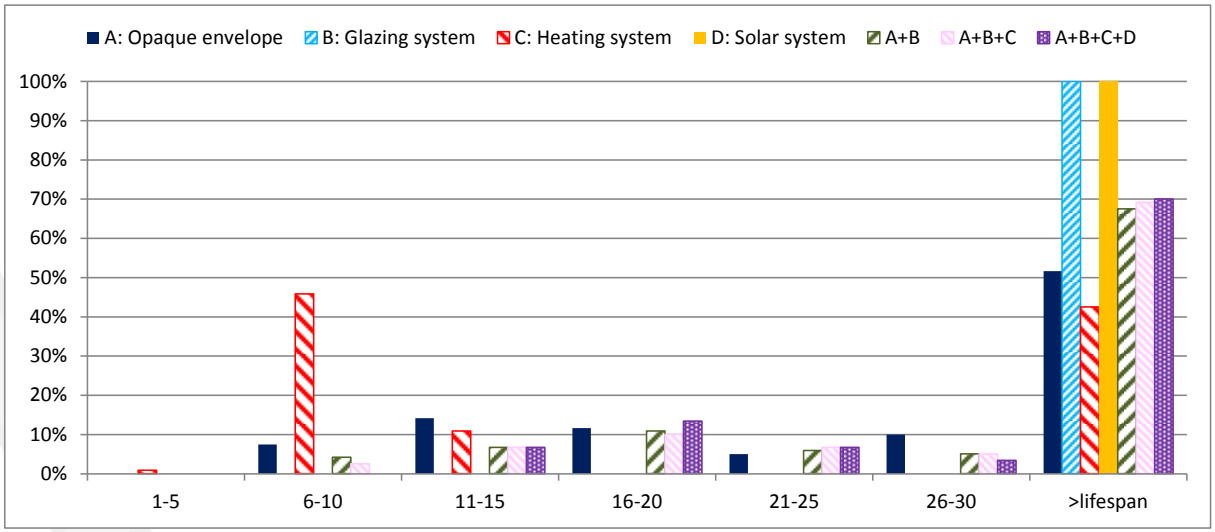
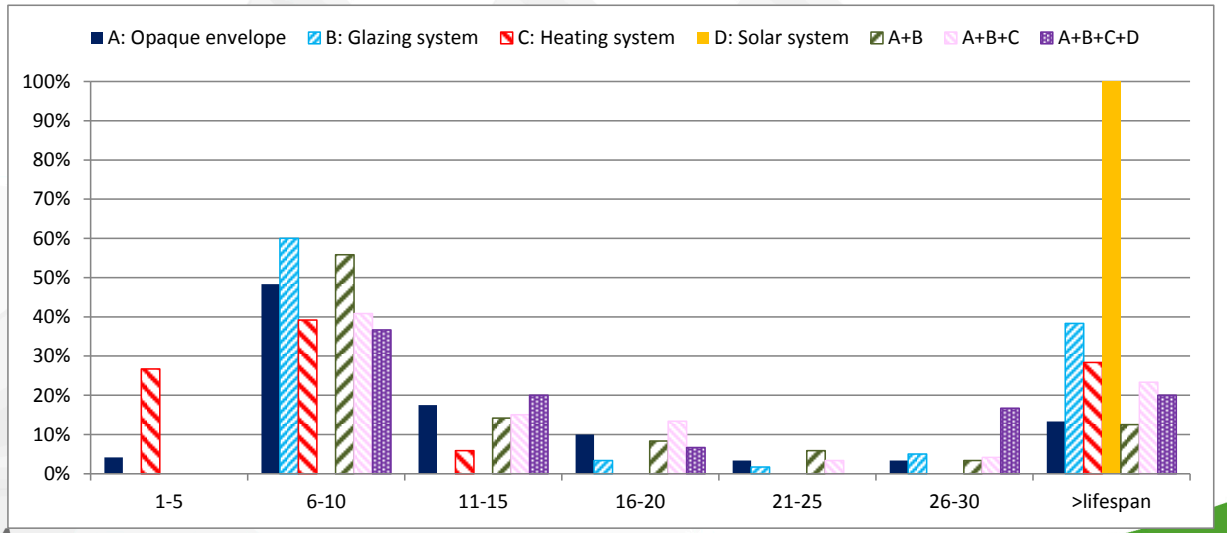
PAY-BACK PERIODS



Comparing energy renovation with "doing nothing"



Comparing energy renovation with a "basic" refurbishment

ENERGY RENOVATION OPPORTUNITY

- Periodically buildings need refurbshments. If energy renovation is implemented

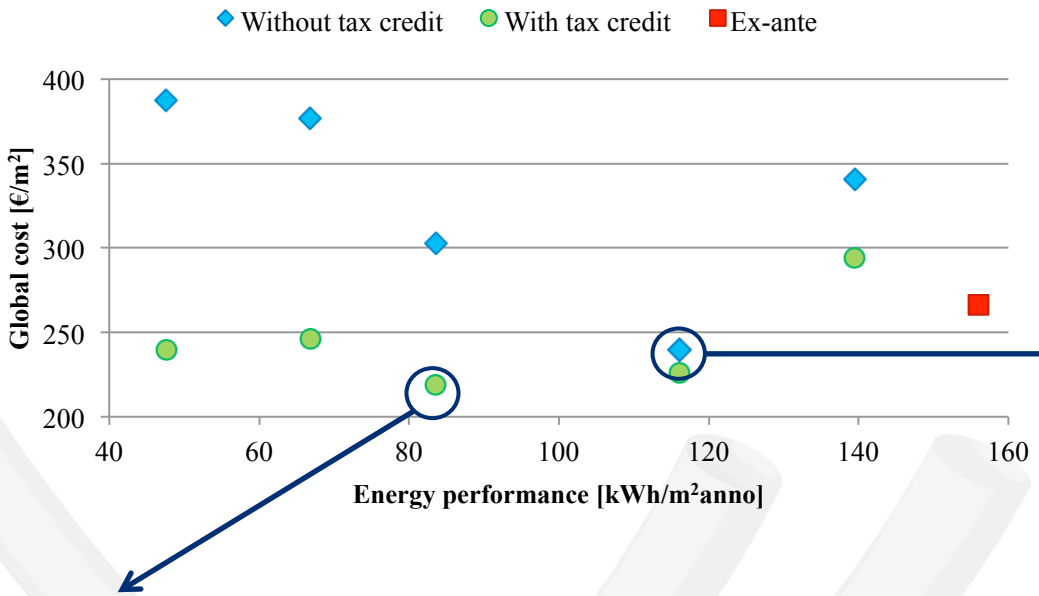
- We estimate that every year 150.000 building need a refurbishment (façade
- 500.000
- 300.000
-
- luate investment

Current rate of renovation

	Without incentives		With tax crediti (65%)	
	PBP ≤ 10	PBP ≤ 15	PBP ≤ 10	PBP ≤ 15
[ktoe/year]	144	257	393	427
[kt/year]	345	615	941	1023
G€/year]	1,3	3,7	9,8	11,9
involved per year	1,69%	2,47%	3,39%	3,61%

Finestre d'opportunità si presentano ogni anno per centinaia di migliaia di edifici. In particolare, si stima che la possibilità di una riqualificazione completa si verifichi ogni anno per circa 150 mila edifici (l'1,3% del nostro parco edilizio in termini di superficie). Focalizzandosi solo su alcune soluzioni specifiche, il numero di edifici interessati cresce ulteriormente: in particolare ogni anno , limitatamente al solo rinnovamento dell'impianto termico, l'occasione si presenta per circa mezzo milione di edifici, mentre per la sostituzione dei serramenti per oltre 300 mila edifici.

COST-OPTIMAL RENOVATION



Heating system renovation

Opaque envelope thermal insulation

INVESTMENT COSTS

- We evaluate investmentmost effective measure: final

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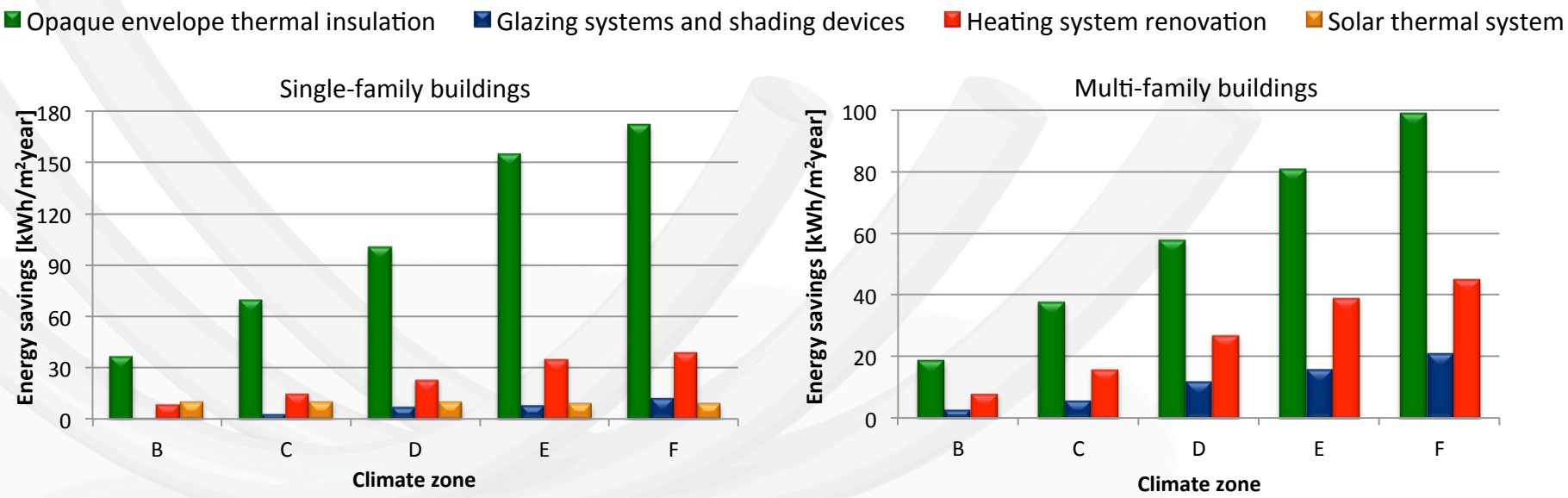
ENERGY SAVINGS

- Opaque envelope thermal insulation is the most effective measure: final energy use is about halved in multi-family buildings and could attain up to 70% in single-family ones.
- Heating system renovation reduces energy use by 15%-25% (more effective in multi-family builidngs).
- Glazing system and solar thermal system are less effective.



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