ENERGY EFFICIENCY OF RESIDENTIAL BUILDINGS: IS IT WORTHWHILE?

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SUMMARY

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- ☞ Foreword
- ☞ Key issue
- ☞ Methodology
- ☞ Case studies
- ☞ Estimates
- ☞ Results

summary

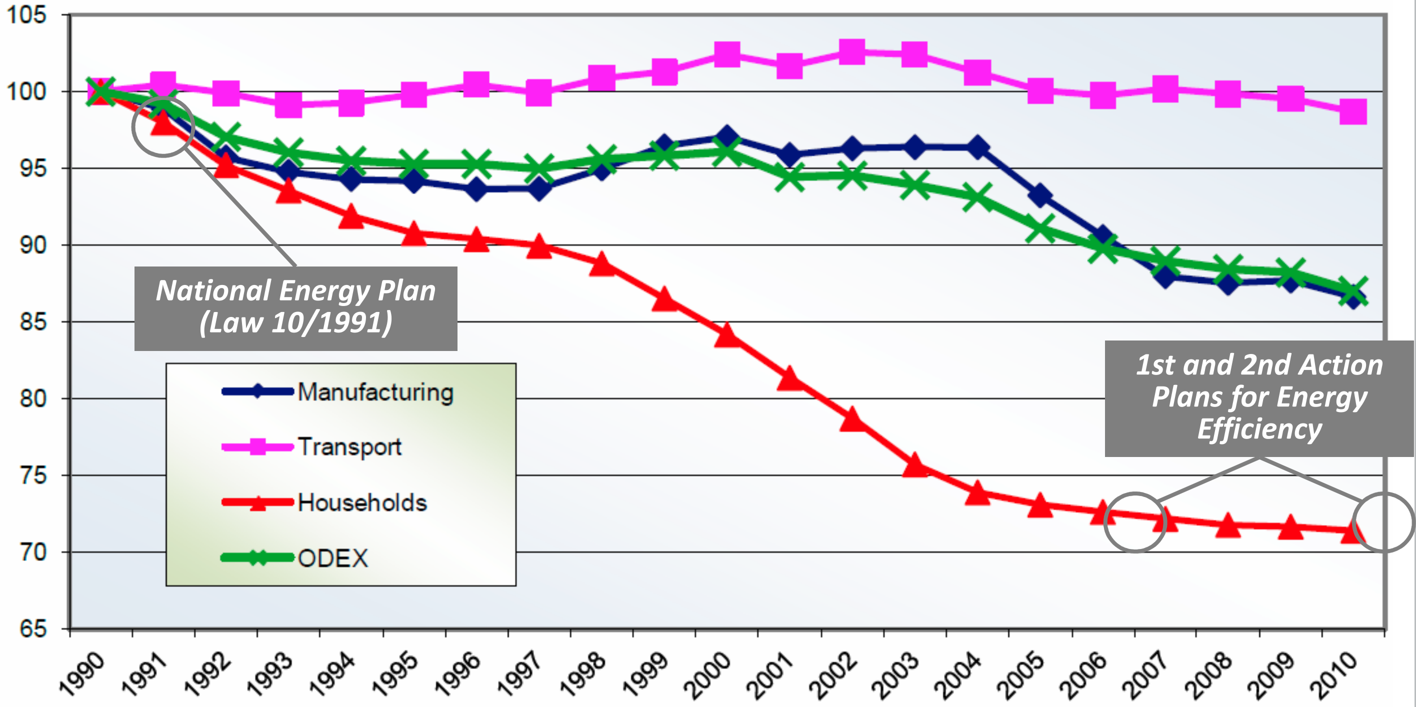
FOREWORD

- The buildings' energy efficiency is one of the main agenda items
  - **EU medium-term objective**
    - Reducing energy consumption of 20% by the year 2020
  - EU **long-term goal**
    - Low-carbon economy by the year 2050

FOREWORD

- **In Europe**
    - Considerable potential for improving the energy performance is identified in the construction sector
    - Current situation: perceived dichotomy between **ambitious goals** and partly **unsatisfactory results**
- In Italy
    - Several measures to improve the energy efficiency of buildings are being tested since at least two decades
        - Design solutions aimed at reducing energy losses
        - Use of construction materials with a better performance compared to the traditional ones
        - Building installations and systems of new conception
        - …

FOREWORD



Source: Enea (2012), *Energy Efficiency Policies and Measures in Italy – Odyssee-Mure 2010 - Monitoring of EU and national energy efficiency targets*

http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-italy.pdf

KEY ISSUE

- Convenience of interventions
    - **Are the higher costs incurred during the construction or renovation offset by lower operating costs?**
- According to recent analysis
    - "only a few investments" suitable for residential buildings have "acceptable payback period and thus a positive cost-benefit profile"

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KEY ISSUE

- Several studies highlight modest results of investments aimed at improve the energy efficiency of residential or commercial buildings, both new construction as well as renovation
  - **Excessive investment** cost compared to **poor annual savings**
  - **Low internal rate of return**
  - **Need for public subsidies**
  - …

METHODOLOGY

- **Trade-off** between **short-term investments** and **monetary benefits in the medium to long term**

I	incremental **investment costs**
E'	**energy** supply **cost without improvement**
E''	energy supply cost **with** improvement
i	**energy inflation** rate
r	nominal **discount rate**
t, n	respectively **year** and **time horizon** of analysis

$$\mathrm{Npv} = \Sigma_{t=1..n}\, I_t \,/\, (1+r)^{t} - \Sigma_{t=1..n}\, [E'_t * (1+i)^{t} - E''_t * (1+i)^{t}] \,/ (1+r)^{t}$$

CASE STUDIES

- Three case studies
  - Located in Northern Italy
  - Within climate zone E, characterized by an amount of heating degree days in the range between 2,100 and 3,000
  - The **first case** concerns the **design of a single family house**
  - The **second and third case** concern the **refurbishment of public housing built in the mid-seventies**

CASE STUDIES

refurbishment of public housing built in the mid-seventies

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case studies

CASE STUDIES

- Case I
  A. Increase of insulating layers, beams and pillars covered with wood wool panels, reduction of thermal bridges
  B. Outer coat made of high density rock wool, ventilated roof with panels of wood fiber, elimination of thermal bridges
- Case II
  A. Floor and roof insulation by rock wool panels
  B. Wall insulation by rock wool panels
  C. Floor, roof and wall insulation by rock wool panels
- Case III
  A. Replacement of windows with double glazing
  B. Wall insulation by expanded polystyrene panels, roof insulation by mineral wool panels

ESTIMATES

investment; savings

Case	Intervention alternative	Built-up area	Investment cost	
		m2	*euro/m2*	*euro*
Case I	A) Medium thickness wall insulation	161	61	9.810
	B) Wall and roof insulation	161	153	24.596
Case II	A) Floor and roof insulation	7.037	65	458.069
	B) Wall insulation	7.037	126	884.449
	C) Floor, roof and wall insulation	7.037	191	1.342.518
Case III	A) Double glazing	9.408	96	903.168
	B) Wall and roof insulation	9.408	149	1.401.792

Case	Intervention alternative	Energy supply cost		Savings			
		base	alternative	base		alternative	
		euro/kWh		*euro/m2/y*	*euro/y*	*euro/m2/y*	*euro/y*
Case I	A) Medium thickness wall insulation	0,05	0,09	1,90	306	3,42	551
	B) Wall and roof insulation	0,05	0,09	3,60	580	6,48	1.043
Case II	A) Floor and roof insulation	0,05	0,09	0,95	6.685	1,71	12.032
	B) Wall insulation	0,05	0,09	0,60	4.222	1,08	7.599
	C) Floor, roof and wall insulation	0,05	0,09	1,10	7.740	1,98	13.932
Case III	A) Double glazing	0,05	0,09	2,85	26.813	5,13	48.263
	B) Wall and roof insulation	0,05	0,09	3,05	28.694	5,49	51.650

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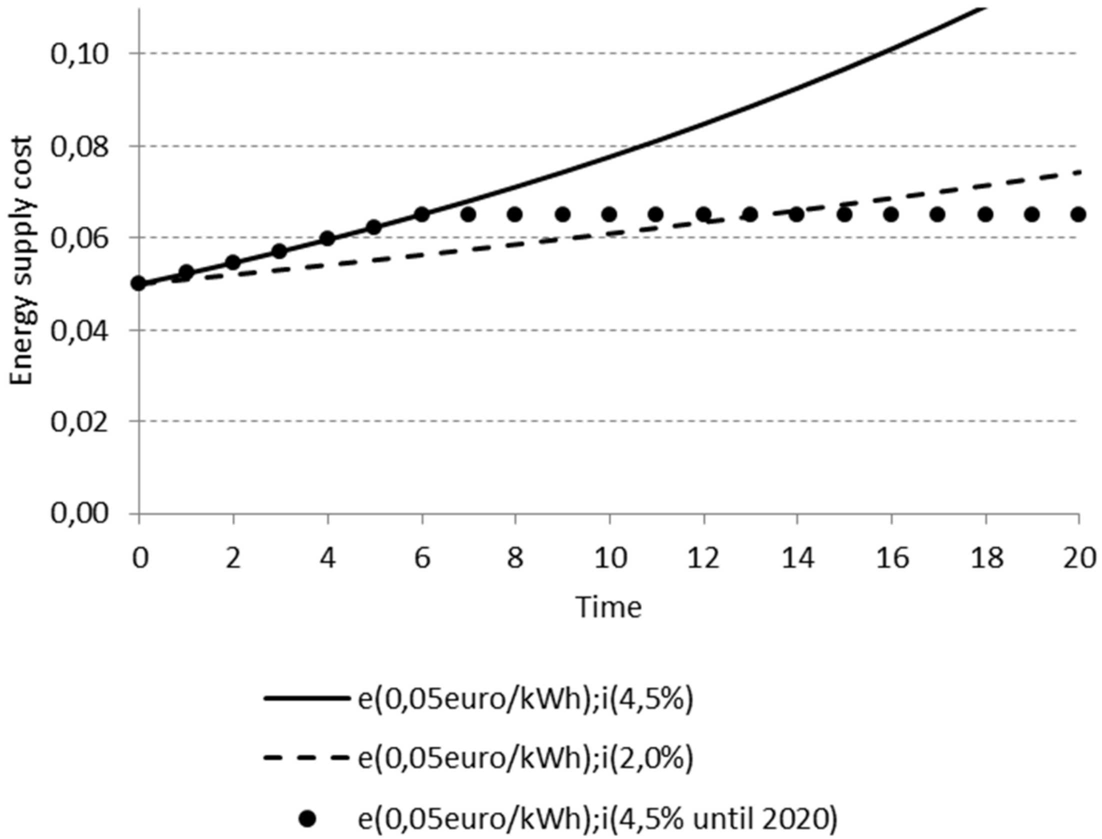
ESTIMATES

trend of energy costs



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estimates

ESTIMATES
discount rate

- The **discount rate** is estimated as the **opportunity cost of capital**, from the perspective of households
  - Capital owned: yield of alternative low-risk investments, e.g. those in government bonds
    - Minimum gross yield on government bonds over the past five years: 3%
  - Capital borrowed: interest rate charged by banks
    - Maximum annual percentage rate charged by banks on loans for house purchase over the same period: 5,5%
  - Mix of funding sources: weighted average cost of capital

RESULTS

- The empirical findings obtained in the present study confirm the doubts about the financial viability of measures to improve energy efficiency of buildings

Energy supply cost	0,05 euro/kWh				0,09 euro/kWh			
Energy inflation rate	2,0%		4,5%		2,0%		4,5%	
Discount rate	3,0%	5,5%	3,0%	5,5%	3,0%	5,5%	3,0%	5,5%
Case I								
A) Medium wall insulation	(1,9)	(4,1)	1,8	(1,9)	4,4	0,4	11,0	4,5
B) Wall and roof insulation	(9,6)	(13,8)	(2,7)	(9,5)	2,4	(5,2)	14,9	2,5
Case II								
A) Floor and roof insulation	(285,1)	(334,1)	(205,2)	(284,5)	(146,6)	(234,9)	(2,9)	(145,6)
B) Wall insulation	(775,2)	(806,1)	(724,7)	(774,8)	(687,8)	(743,5)	(597,0)	(687,1)
C) Floor, roof and wall insulation	(1.142,2)	(1.198,9)	(1.049,7)	(1.141,5)	(981,9)	(1.084,1)	(815,5)	(980,7)
Case III								
A) Double glazing	(209,2)	(405,8)	111,2	(206,8)	346,0	(7,8)	922,6	350,3
B) Wall and roof insulation	(659,1)	(869,5)	(316,3)	(656,6)	(65,0)	(443,6)	552,2	(60,4)

Net present value (euro x .000) of examined alternatives

RESULTS

- **Peculiar** empirical **findings**
  - **Marginal cost of complex interventions exceeds the marginal benefit** (alternatives characterized by lower investment are more affordable than those involving and combining different types of intervention)
  - **Energy supply costs** rising for a few years at first and then **stable in the long term** produces significant changes in the results: **several alternatives, feasible with a high energy inflation rate, become not convenient**

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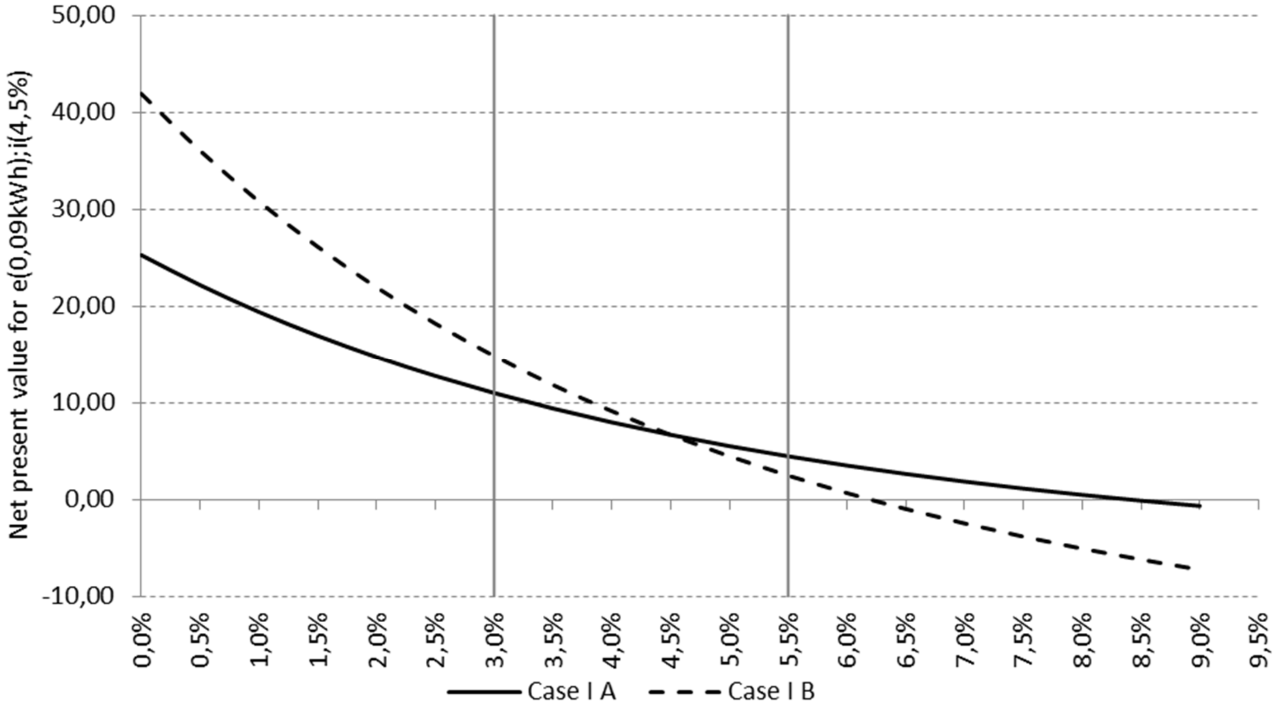
results

RESULTS

- Intersection of NPV's curves for alternatives characterized by different scale



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results

RESULTS

- **Investment in improving the energy efficiency** of buildings
  - Are still characterized by a **low financial feasibility**
  - Can be interpreted as a kind of "**hedge**" against the risk that the prices of energy supplies are subject to a strong upward trend in the coming years
- New "**energy efficiency paradox**“
  - **The measures to improve energy efficiency should reduce** both emissions of climate-altering gases and, in an efficient market, **the prices of energy supplies**
  - Nevertheless, **the wished reduction of energy prices acts as a disincentive to improve the performance of buildings**