Outline

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- Results
- Concluding remarks and way ahead

Goals

- Investigate households' **response to policies** aimed at reducing energy use and GHG emissions in buildings (30-40% of total energy use).

- Focus on **residential energy consumption of homeowners** (those most likely to undertake renovations) and on the "**energy-efficiency gap**".

- Look at **heating system** replacements, and at the effect thereon of monetary and non-monetary **incentives**, using data from an **original survey of Italian** homeowners.

- **Get around adverse selection and free riding issues**, by asking stated preference questions to those who weren't planning upgrades any time soon.

- Fit an **energy-efficiency renovations curve** that predicts the share of the population that will undertake these improvements for any given incentive level.

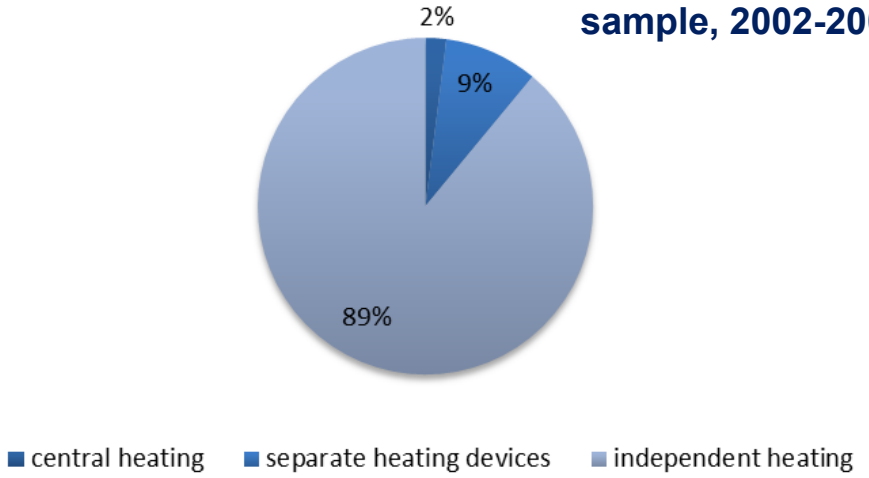
- Estimate the **CO_2 emissions saved and their cost-effectiveness**.

Background: Households characteristics

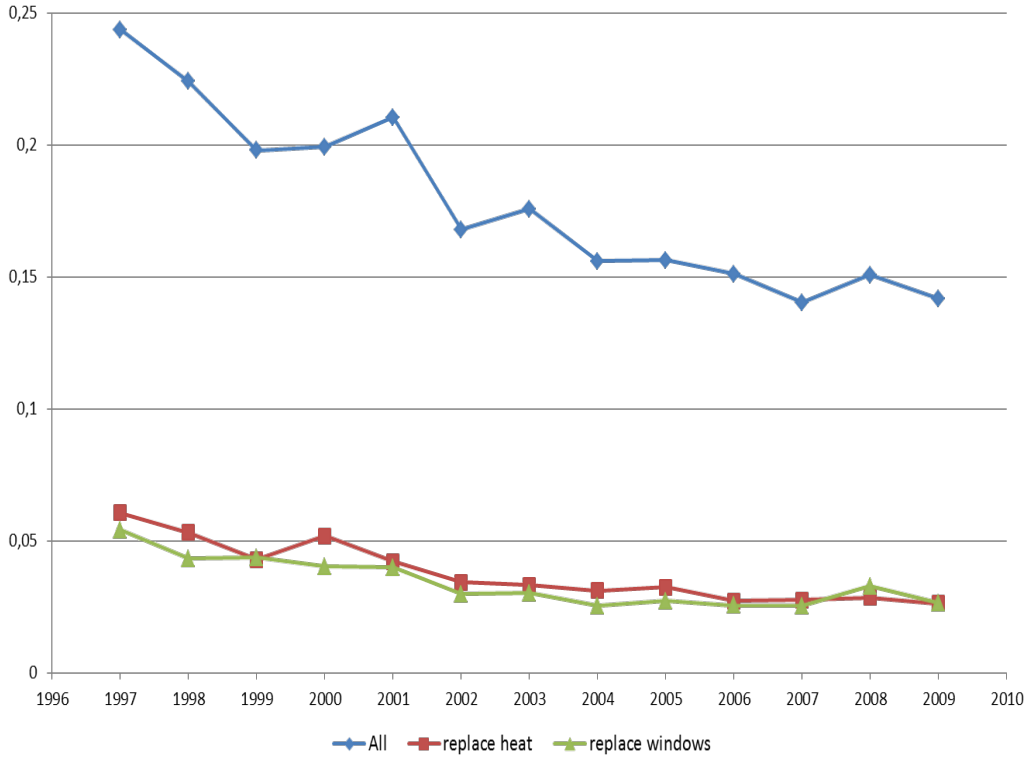
Italian Households Represented in the I-CEX (2009)

All households	homeowners		
	homeowners	SF homes + MF homes with own heating system	SF homes
24,609,438	18,269,200	15,141,900	6,004,640
As % of all households	74.2%	61.5%	24.4%

Heating systems used by the homeowners in the sample, 2002-2009



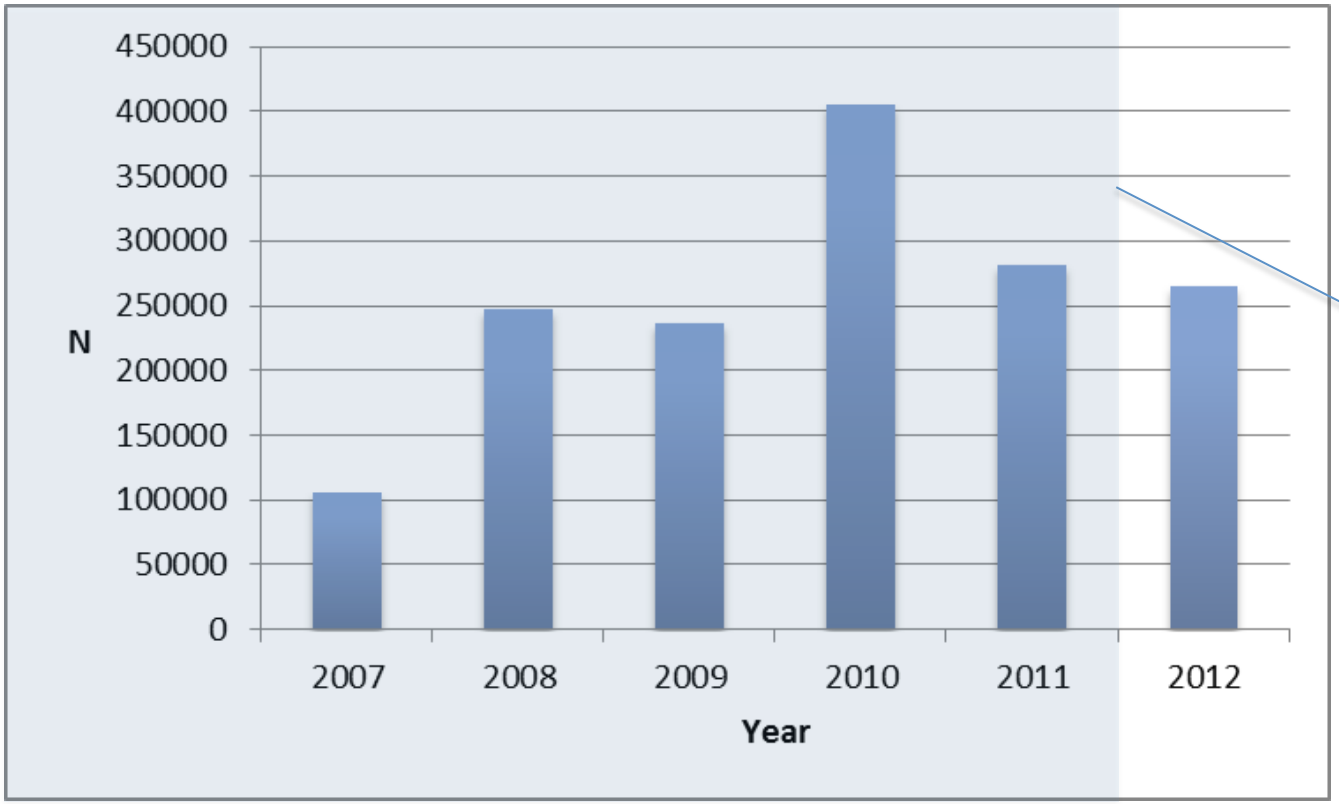
Annual Rates for Selected Home Renovations



Background: Incentives and efficiency renovations in Italy

A tax deduction policy for homeowners is in place in Italy since February 2007.

Income tax deductions of up to 55% (65% in 2014, 50% in 2015) of the cost of energy efficiency renovations or renewable energy sources in existing homes.



5.5% of all residental buildings in Italy (ENEA, 2012)

Number of filings received by ENEA per year, 2007-2012.

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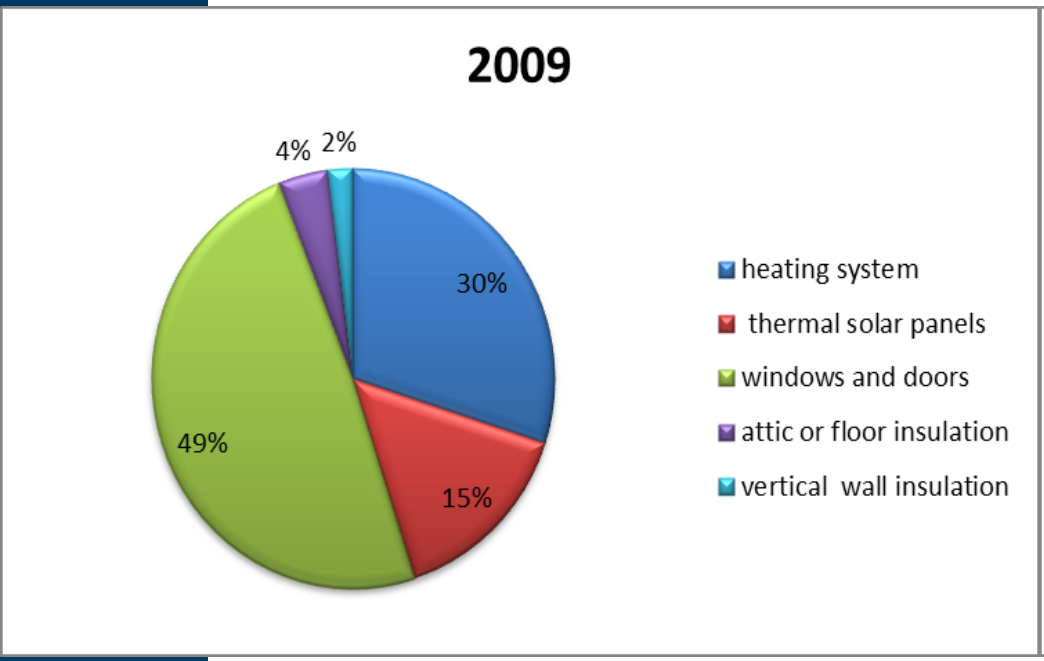
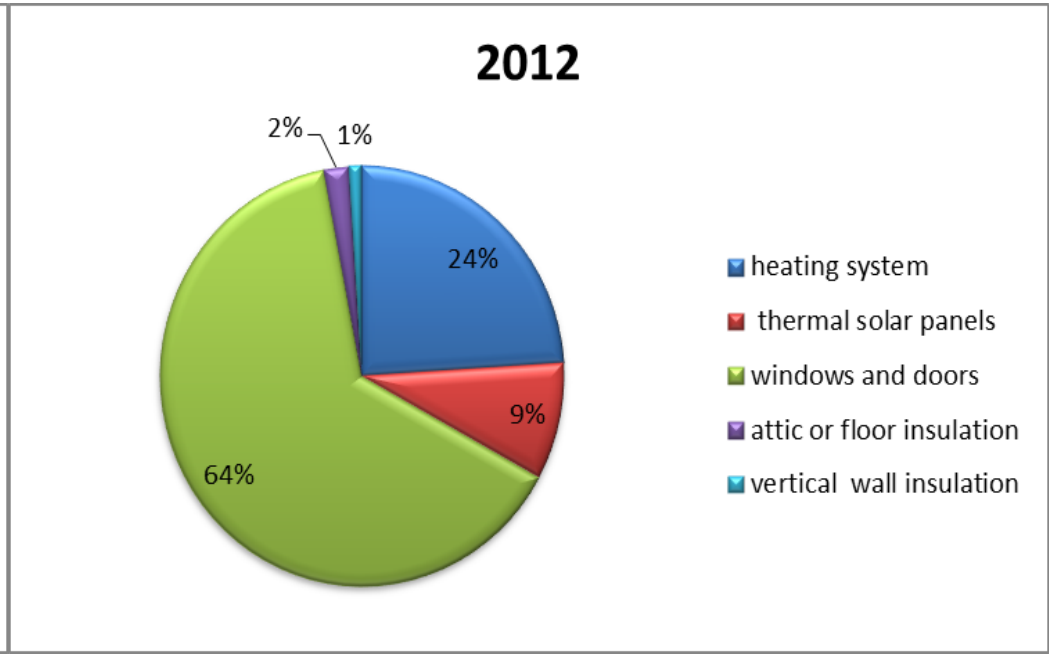
Background: Incentives and efficiency renovations in Italy





Tax deduction filings in 2009 and in 2012, broken down according to the type of renovation.

Data

•Alberini et al. 2013 found a low rate of energy-efficiency renovations in the population (2-3% a year)

•That study informed the sampling frame of **our own survey**. We developed, tested and administered a survey questionnaire about

- •residential energy use,
- •the uptake of existing energy efficiency incentives,
- • the reasons for energy efficiency renovations funded through these incentives,
- •what the household would have done if the incentives hadn't been available.

•With households that did not do energy efficiency renovations in the last 5 years, and are not planning to do any in the next 5, **contingent behavior questions** are asked to find out whether the household would do them under (hypothetical) savings and incentives scenarios.

•Questionnaire administered on-line in May-June 2013 to a representative sample (3015 valid questionnaires).

Econometric approach

A homeowner will accept a subsidy if the offered incentive *X* is greater than his or her "reservation incentive," ***S**.** We do not observe a person's exact ***S**** ; we simply know whether it is above or below a certain value

$$S_i^* = \alpha + \varepsilon_i$$

ε is normally distributed with mean 0 and variance σ^2

α is the mean and median reservation subsidy

Simplest probit model

$$\Pr(\text{Renovation}) = \Pr(S_i^* \le X_i) = \Pr(\varepsilon_i / \sigma \le -\alpha/\sigma + (1/\sigma)\cdot X_i)$$

$$= \Phi\left(-\alpha/\sigma + X_i/\sigma\right)$$

Interval data model

$$\log L = \sum_{i=1}^{n} \log \ell_i$$

where

$$\ell_i = \Phi\left(-\alpha/\sigma + X_i^U/\sigma\right) - \Phi\left(-\alpha/\sigma + X_i^L/\sigma\right)$$

Virtual experiment and other determinants of S*

$$S_i^* = \alpha + \mathbf{z}_i\boldsymbol{\beta} + TREAT \cdot \gamma + \mathbf{w}_i\boldsymbol{\delta} + \varepsilon_i$$

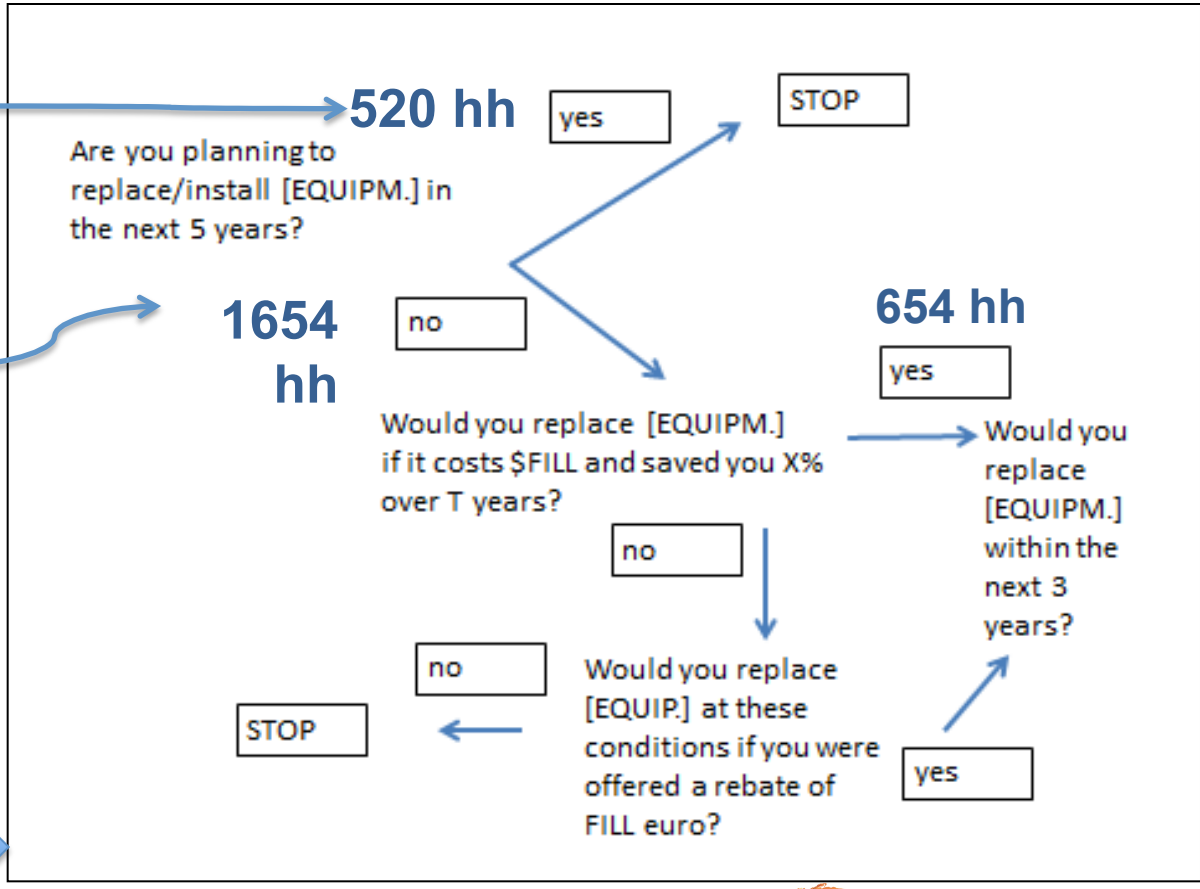
Questionnaire and Study Design

- Information related to recent and potential **future energy efficiency upgrades**
- **Technology** coverage
- Details about **existing equipment**
- For heating equipment bought in 2007 or later, we asked **about costs and government rebates or tax credits**
- Respondents' **attitude** about conservation and energy efficiency
- Respondents' **socio-demographic and economic** circumstances.

Sample grouping and structure of the hypothetical questions

- 841 households (27.89% of the sample) replaced their heating equipment between 2007 and the time of the survey.
- (17.25%) didn't change it in the last 6 years, but is planning to do so within the next 5 years.
- The remaining (54.86%) didn't change it in 2007-2013, and is not planning to change it in the next 5 years: exempt from free riding behavior!

- **We asked this last group about heating equipment replacement under well-specified hypothetical conditions.**



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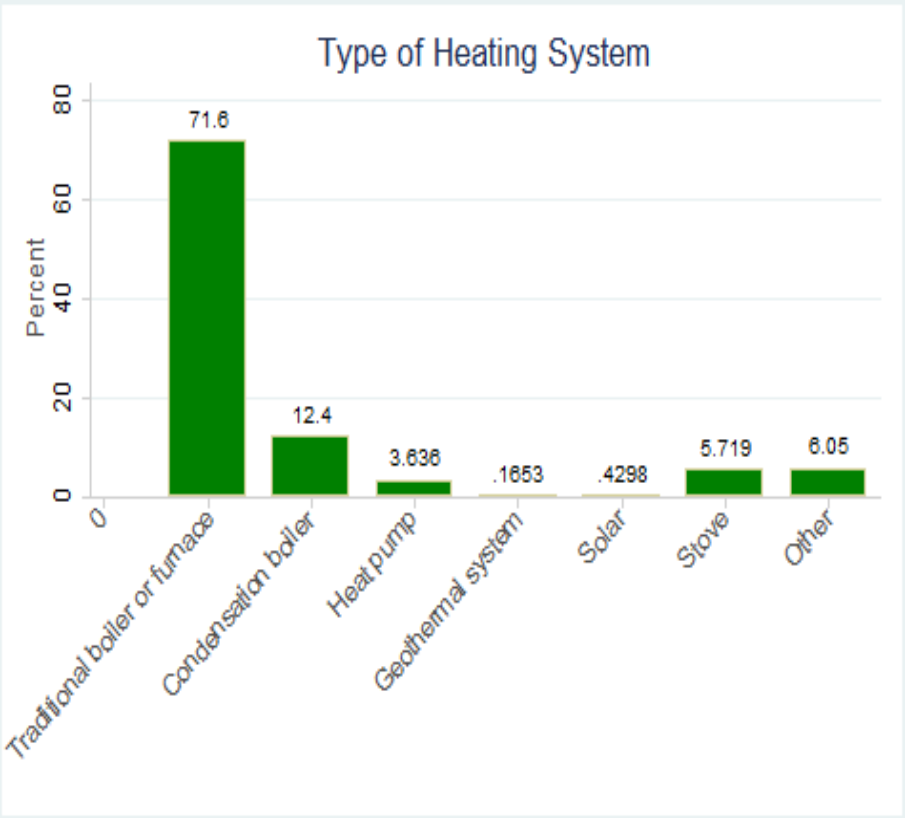
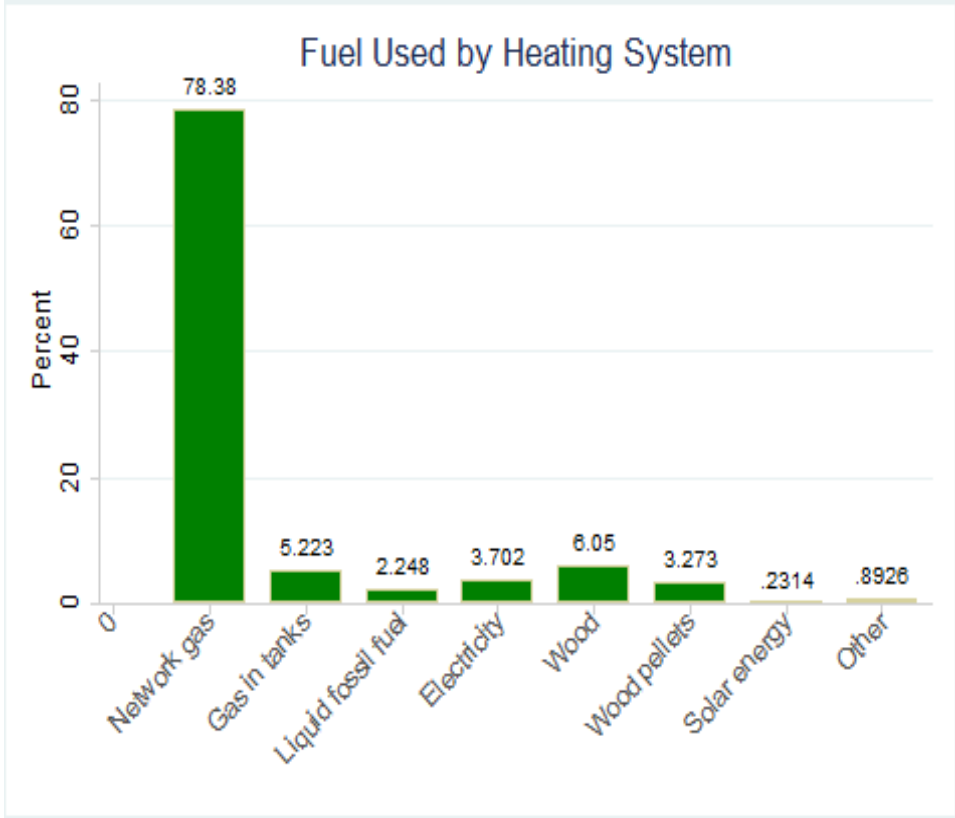
Data: Heating systems and fuels used in the sample





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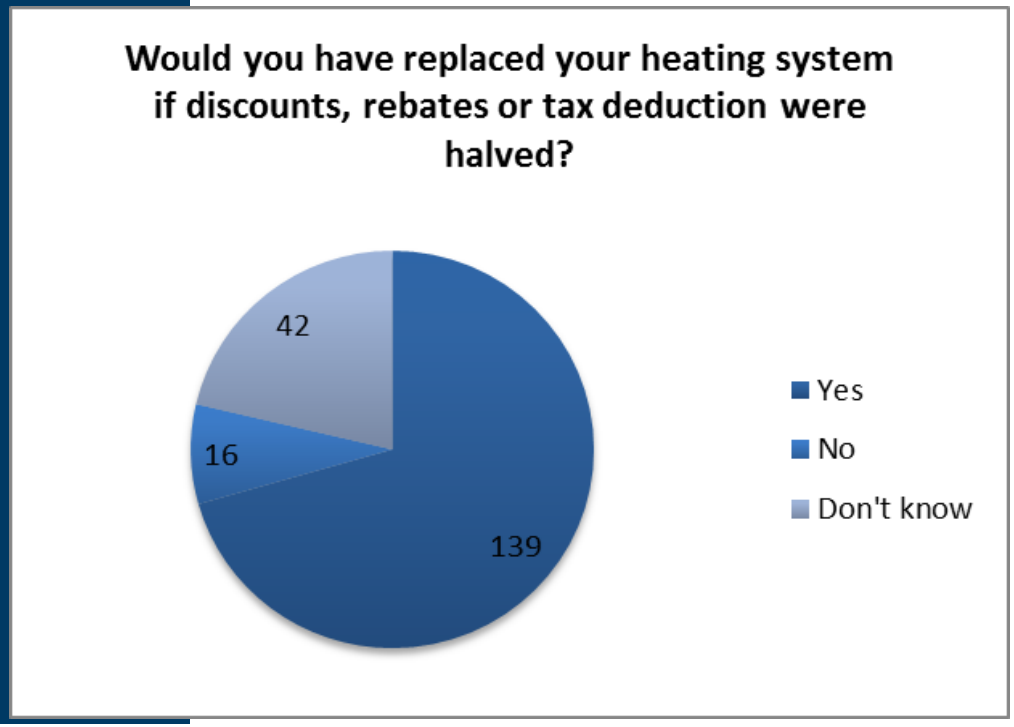
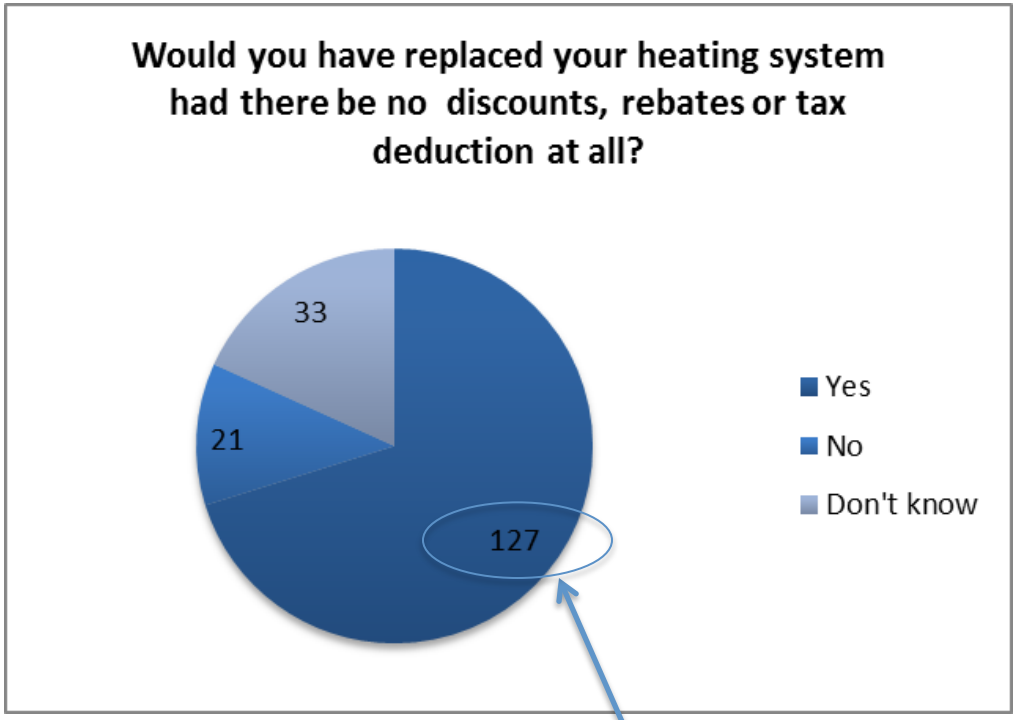
Data: The effect of public incentives

(244 households bought a new heating system in 2007 or later, 197 of which received a public incentive)





Free riders!

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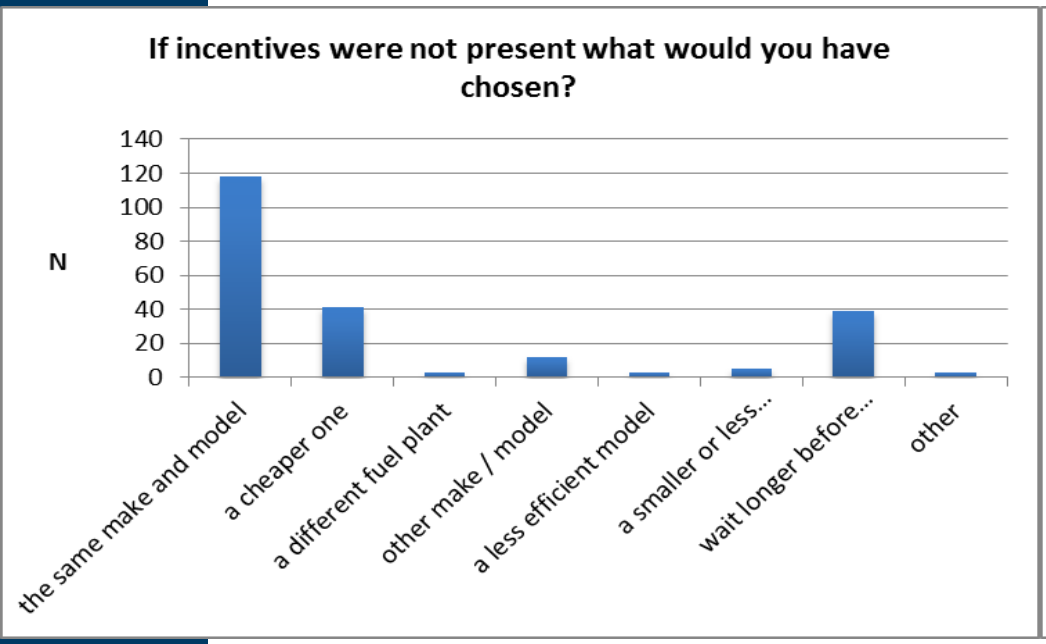
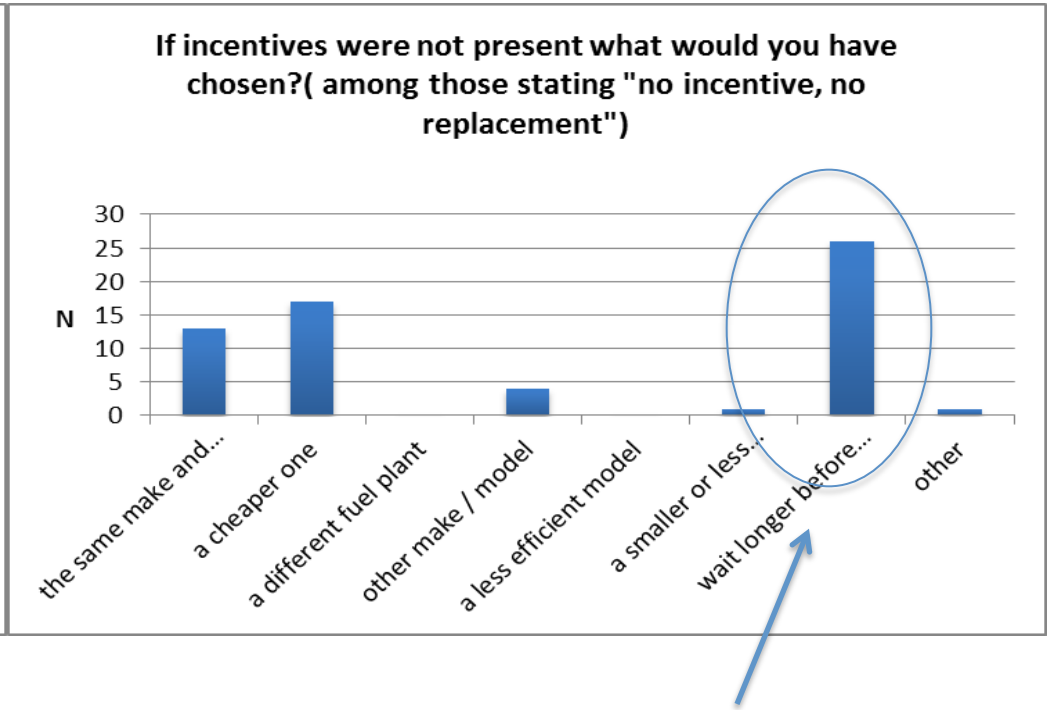
Data: The effect of public incentives





Incentives speed up transition to higher efficiency for 50% of those who didn't free ride.

Not true in general: The reported age of replaced heating system is 17.28 year vs. 16.61 years among incentive recipient and non-recipient (statistically, the same).

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Results: Reasons for changing the heating system in 2007-2013. N=841 respondents who changed their heating systems in 2007-2013

Reason		received rebates or tax credits		Test of the null that there is no difference across groups
	All	yes	no	T statistic
the previous one was broken	32.58	26.23	35.17	-2.61
the previous one was old	35.79	43.03	33.83	2.74
the previous one was inadequate	17.84	20.08	16.92	1.06
I wanted a heating system that worked better	18.31	25.41	15.41	3.16
I wanted a heating system with better energy efficiency	16.29	26.23	12.22	4.48
I was doing other home renovations	13.67	18.44	11.72	2.39
I was or am thinking of selling this house	0.59	1.23	0.33	1.2
I wanted to change the type of heating system or the fuel	9.27	12.29	8.04	3.78
I was offered a good deal	4.16	4.51	4.02	0.31
rebates or tax credits were available	9.27	31.15	0.33	10.34
I wanted to help reduce CO_2 and pollution emissions	7.49	15.57	4.19	4.62
this was the least expensive system that was eligible for tax credits or rebates	0.95	1.64	0.67	1.1
I wanted to save on the heating bills	20.1	25.81	17.75	2.51
I expected the energy prices to increase	1.43	1.23	1.51	-0.32

Results: **interval-data models: b**asic specifications. Respondents who did not change their heating equipment in 2007-2013 and are not planning a change within the next 5 years.

	(A) simplest		(B) design variables only		(C) total savings, discount rate=0		(D) same as (C) but keep those who don't report heating expenses		(E) same as (C) but discount future savings at 5% rate	
	Coeff	t stat	Coeff	t stat	Coeff	t stat	Coeff	t stat	Coeff	t stat
Const	361.92	8.83	1420.64	7.28	608.86	8.98	627.83	9.28	618.10	8.97
FILL1_1 duration			-23.05	-2.68						
FILL1_2 saving			-25.58	-6.67						
Totsavings					-0.1096	-7.05				
totsavings2 (recoded to 0 if missing)							-0.1135	-7.3		
DK heating cost X 10% savings X T							20.78	2.06		
DK heating cost X 20% savings X T							22.42	2.09		
DK heating cost X 30% savings X T							2.94	0.28		
DK heating cost X 40% savings X T							16.13	1.41		
totsavings3 (discounted at 5%)									-0.1742	-7.04
Sigma	1385.25	17.03	1357.56	17.07	1312.36	15.65	1332.77	17.10	1312.44	19.04
N	1654		1654		1339		1654		1339	
log likelihood	-1614.99		-1585.64		-1287.85		-1558.06		-1288.2	
LR test chi square of the null that all slopes are zero			58.52		64.61		113.68		63.90	
p value			less than 0.00001		less than 0.00001		less than 0.00001		less than 0.00001	

Mean and median

High St. Dev.

Internally valid responses

Robustness checks

Results: **interval-data models**: additional specifications. Respondents who did not change their heating equipment in 2007-2013 and are not planning to change it within the next 5 years.

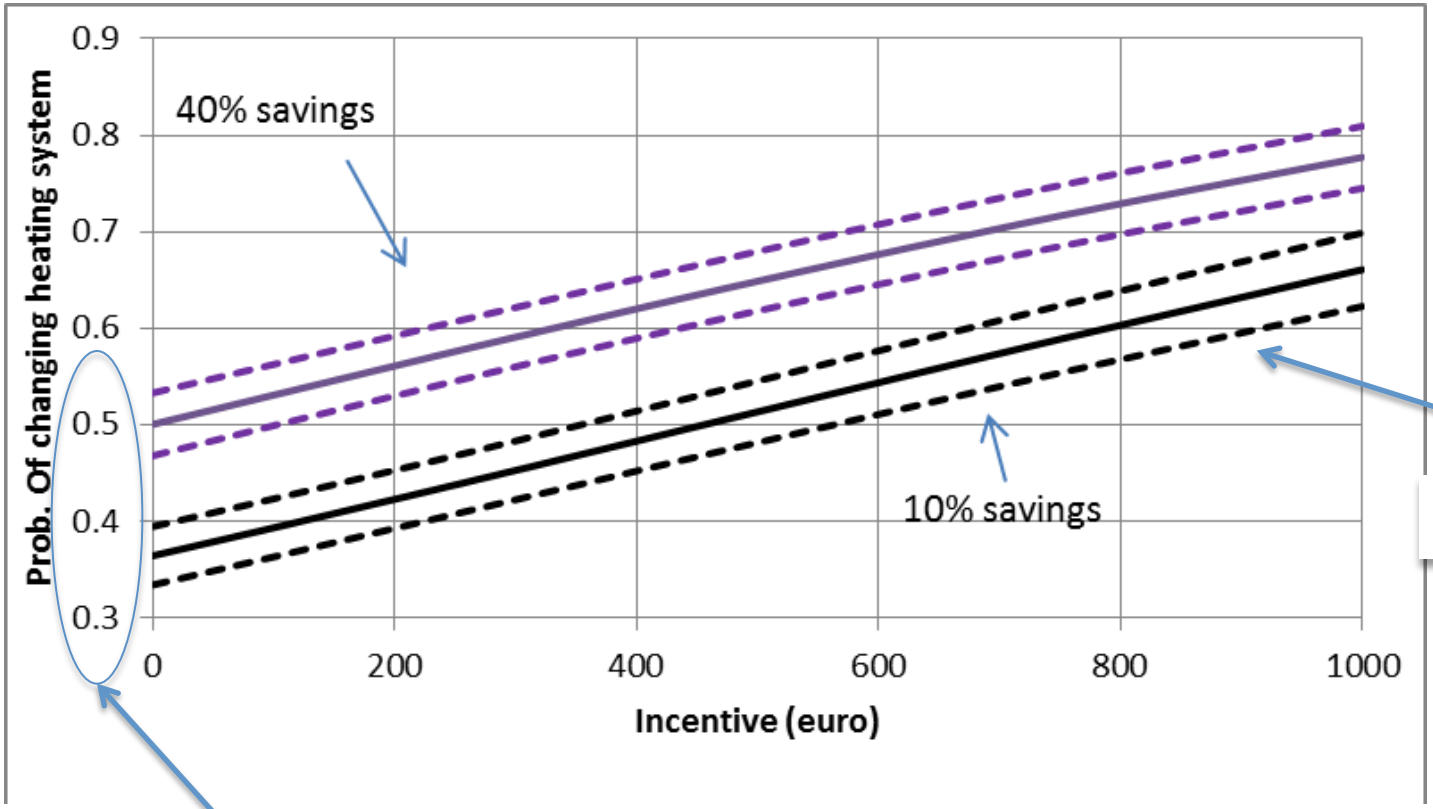
	(A) CO_2 emissions reminder		(B) add age of the heating system		(C) add education		(D) add household income	
	coeff	t stat	coeff	t stat	coeff	t stat	coeff	t stat
Const	785.55	5.35	790.14	3.77	845.7681	3.99	635.7565	2.75
Totsavings	-0.1097	-7.06	-0.1099	-7.03	-0.11019	-7.05	-0.1061	-6.79
treatment (1=no reminder, 2=reminder)	-118.67	-1.38	-118.85	-1.38	-110.517	-1.28	-95.3166	-1.11
age of current heating system (recoded to 0 if missing)			0.1059	0.01	-0.71697	-0.06	-2.02974	-0.18
age of current heating system missing dummy			-10.86	-0.06	-19.7026	-0.12	-61.0202	-0.36
some college					-186.33	-1.39	-166.413	-1.24
college degree or graduate studies					58.4347	0.4	87.35839	0.59
income below 30,000 euro/yr							210.463	1.92
income information missing							421.6875	2.44
Sigma	1311.55	15.65	1311.53	15.65	1	5	1305.556	15.6542
N	1339		1339		1339		1339	
log likelihood	-1286.89		-1286.88		-1285.42		-1387.85	
LR test chi square of the null that all slopes are zero	66.52		66.54		69.47		64.61	
p value	less than 0.00001		less than 0.00001		less than 0.00001		less than 0.00001	

Non–monetary incentives ineffective

Equipment age Irrelevant

Expected signs but mixed significance

Results: energy-efficiency renovation curve

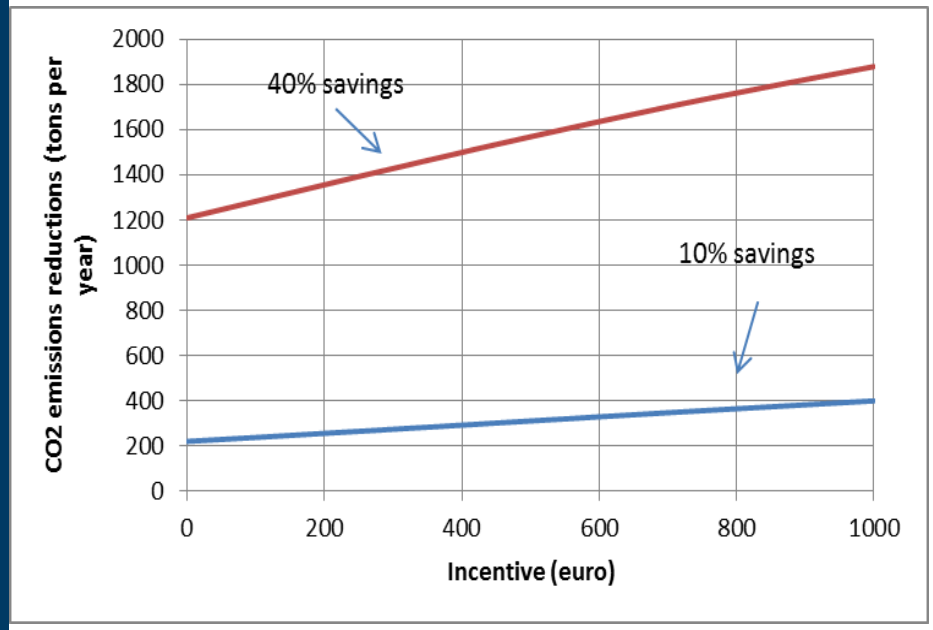


Virtually Linear

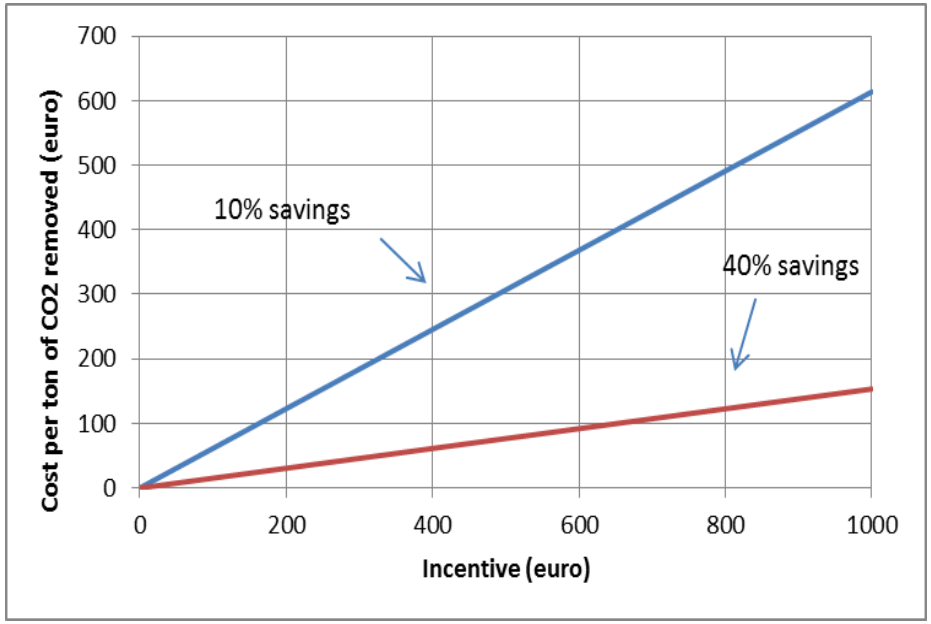
No need of incentives for a substantial share of homeowners

Energy-efficiency renovation curve (share of the population that would take the offer and replace the heating system), and 95% confidence bands, as a function of the incentive offer.

Results: cost efficiency of CO_2 emissions reduction



CO_2 emissions reduction curve



Cost per ton of CO_2 removed

Conclusions

- The responses to our survey are internally valid: Replacement are more likely when savings are larger and experienced over a longer horizon, and in presence of rebates.
- Each $100 increase in the incentive raises the likelihood of replacing the heating system by 3 %. The reminder about CO_2 and climate change had little effect. This is potentia useful for effective policy targeting.
- The associated cost per ton of CO_2 removed are reasonable, but only when the energy and emissions reductions are large and the subsidy is small.
- When the subsidy is of the size typical of the Italian program for the cost of the heating system posited to the respondent in the questionnaire, the cost per ton of CO_2 emissions avoided is relatively high—even under the "best case" assumptions and without questioning whether respondents would truly behave as they say they would.

With 40% savings and a rebate of €1000, equivalent to the 55% tax credit program in Italy, the cost per ton of CO_2 removed is **€279**, about ten times the typical social cost of carbon figures used in UK (£25 per ton CO_2)

Work in progress

- Developed and tested a **conjoint choice experiment** on the public's preferences for policies that reduce CO_2 emissions from homes and buildings. The questionnaire is currently being administered on-line to 1000 randomly selected participants of the wave 1 survey.
- We look also at thermal insulation renovations, given uncertainty about the most cost effective type of investment.
- Moreover we explore energy literacy and consumption from private transport and electrical appliances.

Thank you!

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PURGE is a collaborative project funded by the EC's 7th Framework Programme under GA No. 265325