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Metering and accounting solutions for heating and cooling, technical-economic feasibility and impact on energy efficiency: the Italian experience

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14th October 2020

Scope and research questions

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Scope of the research

- **Italian specific critical issues**
  1. Remote reading of thermal energy in Italy
  2. Energy poverty issues (compensation factors)
  3. Metering and accounting in centralized cooling systems
  4. Heating and cooling accounting policy

- **Impact of individual heat metering in residential buildings**
  5. Energy saving on Italian residential buildings
  6. Metrology and accuracy issues
  7. Cost/benefit analysis (Italian Thermo-technical Committee (CTI) Guidelines)
  8. Impact on Italian residential building stock

Italian specific critical issues

Giorgio Ficco

Associate Professor of Thermal and mechanical measurements

University of Cassino and Southern Lazio

#1 - Remote reading of thermal energy in Italy - EED article 9c implementation (metering)

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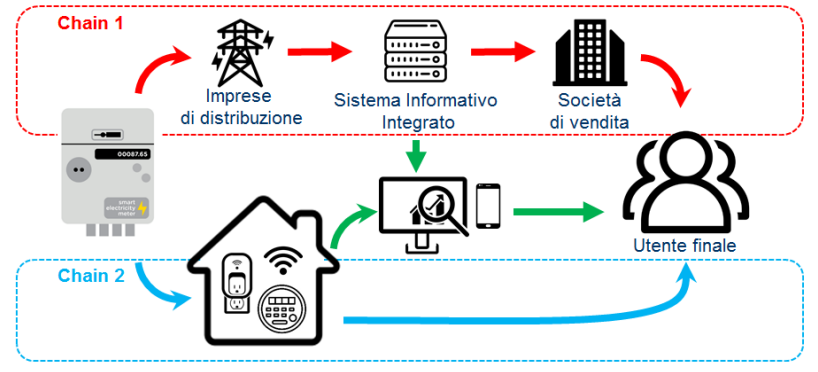
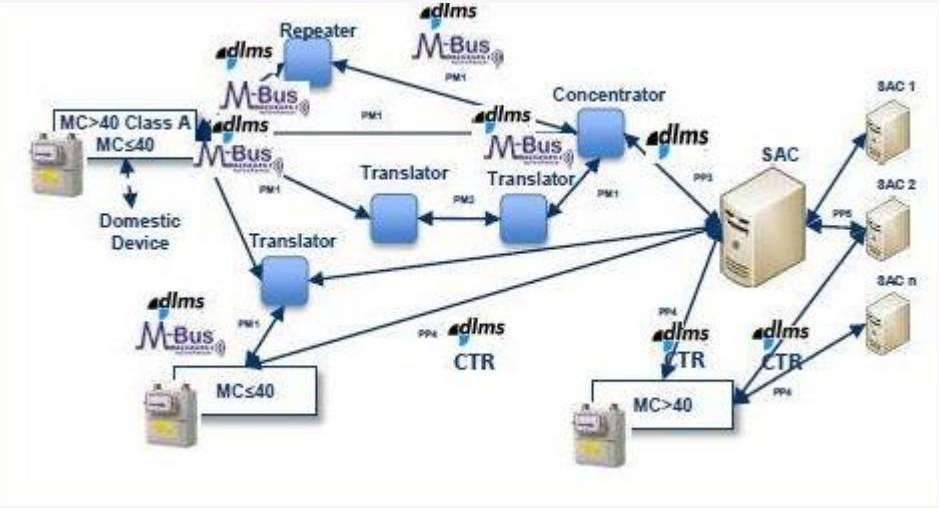
From Italian Legislative Decree 73/2020 (art. 9 sub *5 bis*)
"…*under cost-efficient conditions thermal heat metering and sub-metering devices (or indirect systems) installed after 25th Oct 2020 shall be remotely readable. Therefore by 1th Jan 2027 all these devices shall be remotely readable***".**

At metering level (i.e. District Heating supply) the Utility company should rely on the telecommunication infrastructures already available through:

a) power-line (electrical smart metering)
b) gas system (smart metering gas), namely point-multipoint or point to point (technical standard UNI-CIG 11291)





FOR A SUSTAINABLE FUTURE

#1 - Remote reading of thermal energy in Italy - EED article 9c implementation (submetering)

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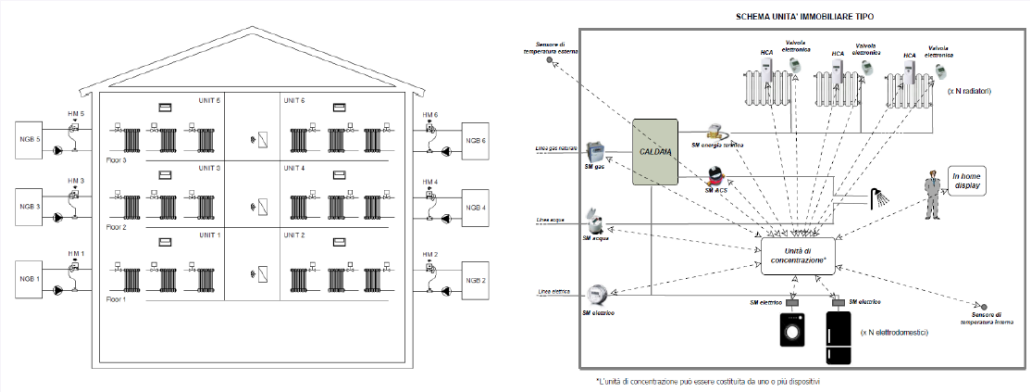
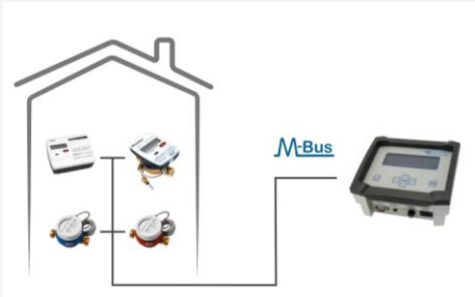
- At sub-metering level, In Italy no punctual remote measurement technology (e.g. walk-by, drive-by, wireless M-Bus, Wired M-Bus, Automatic Metering Reading - AMR), has been set mandatory by law, leaving the user the possibility of adopting the most appropriate in terms of costs and functionality;
- It is underlined that in the technical-economic assessment, the cheaper remote reading feature should be considered which fulfills the minimum number of readings required by law at the time of installation.





#1 - Remote reading of thermal energy in Italy - EED article 9c implementation

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Problem statement

User feedback has been found to be non-effective in some cases and rebound effect has been observed among people living in retrofitted buildings if no information is given

Methodology

- Installation of remotely read metering and sub-metering devices in 3 case-study buildings (social housing)
- Administration of surveys for assessing energy use and user satisfaction
- Test of the feedback strategy tool on 28 end users, with periodical meetings

#1 - Remote reading of thermal energy in Italy - EED article 9c implementation

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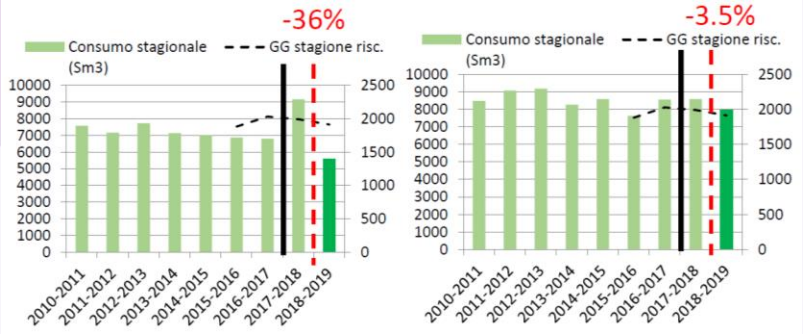
Results

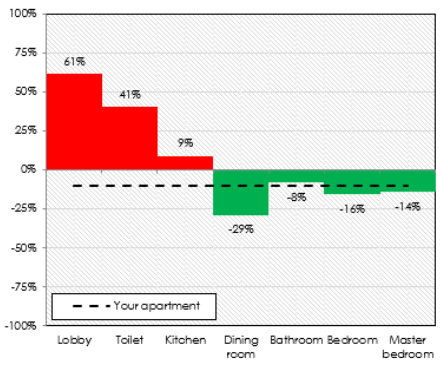
- ✓ **Performance indicators** and **personalized suggestions** on user energy consumption were **greatly appreciated** by the participants.
- ✓ **simple** and **immediate** information are preferable.
- ✓ **significant reduction** in energy consumption between before and after informative campaign



Informative sheets

Your energy consumption over this month...					Compared to your expected consumption...	
Lobby	124.7 kWh	9.5 *€	27.0 kgCO2		+61%	+ 3.6 €
Toilet	119.5 kWh	9.1 *€	25.9 kgCO2		+41%	+ 2.6 €
Kitchen	200.2 kWh	15.2 *€	43.3 kgCO2		+9%	+ 1.3 €
Dining room	276.9 kWh	21.1 *€	59.9 kgCO2		-29%	- 8.6 €
Bathroom	99.9 kWh	7.6 *€	21.6 kgCO2		-8%	- 0.7 €
Bedroom	158.8 kWh	12.1 *€	34.4 kgCO2		-16%	- 2.3 €
Master bedroom	375.1 kWh	28.6 *€	81.2 kgCO2		-14%	- 4.7 €
Total	**1355.1 kWh**	**103.2 *€**	**293.4 kgCO2**		**-10%**	**- 12.1 €**

Your energy performances over this month...

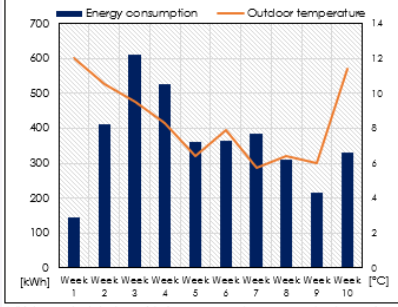


Energy savings tips...

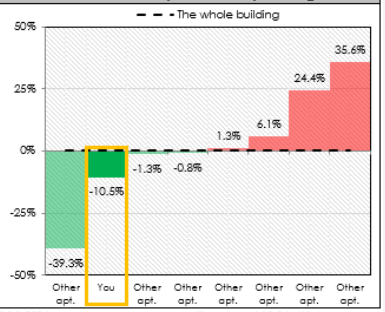
You are doing well!
Please, be shure to keep your energy saving over time by following these tips:

- ✓**Control the ventilation** of the entrance, the toilet and the kitchen: **10 minutes windows opening** are more than enough to have a complete room air change!
- ✓Heating the house too much hurts your health, your pockets and the earth: **19 °C is more than enough to guarantee your thermal comfort**. For each degree you save from 5 up to 10% on consumption.
- ✓Avoid obstacles in front of and above the radiators and, if possible, **install radiator reflectors** between the wall and radiator itself to prevent energy waste.
- ✓Shield the windows at night. By closing shutters and rolling shutters or by placing heavy curtains, heat losses towards the outside are reduced.

Your historical energy consumption...



A comparison with your neighbours...



* (Values calculated considering a seasonal average natural gas price of € 0.833/smc and an average calorific value of 10.94 kWh/smc)

On-going research

Providing the end-users with remote accessible **web applications** to monitor their consumption

#2 - Energy poverty issues (compensation factors)

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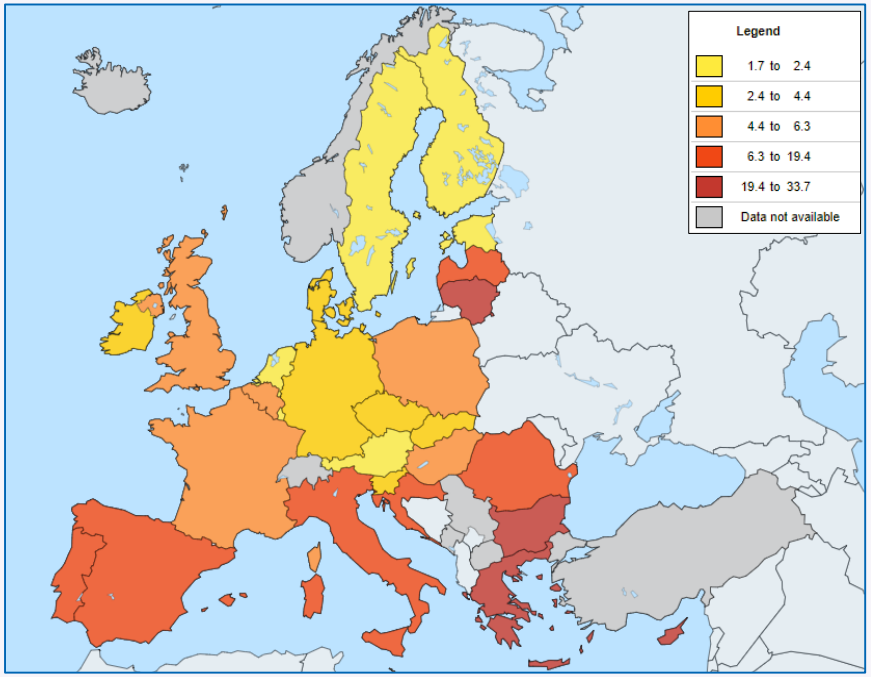
In Italy, **compensation** of energy costs **is not allowed**

- individual metering could lead to an increase in heating costs for some particularly disadvantaged apartments (low insulated attic or basements etc.);
- Social housing buildings are often old buildings with **poor thermal energy performances** and **obsolete heating systems**
- Low income tenants tend to reduce heating consumption regardless the presence of individual metering devices
- Heating costs often represent a great part of the users' income.

Energy poverty in Europe



Population unable to keep home adequately warm by poverty status (% of population)

#3 - Metering and accounting in centralized cooling systems

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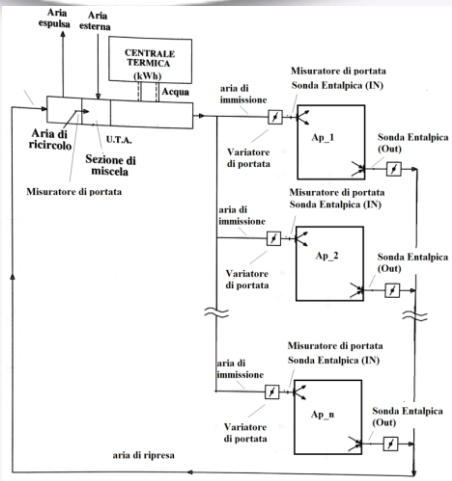
Problem statement

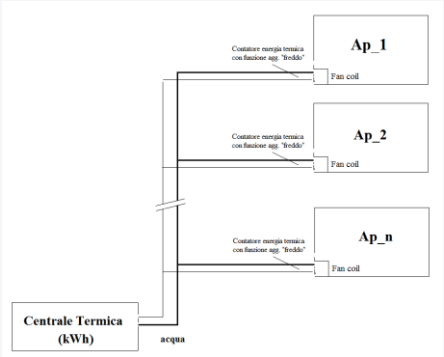
In Mediterranean regions cooling metering and submetering is crucial for achieving energy saving targets, both in residential and commercial buildings

Direct thermal energy meters for cooling applications are not regulated in MID directive

Indirect HCA are not applicable and other indirect systems are applicable only in few cases

Plant type	Possible accounting device	Applicable Technical Standard
Aeraulic (All-air systems)	Insertion flow meter (e.g. Wilson flow grid); Hentalpy probe (i.e. temperature and relative humidity)	ISO 7145:1982* ISO 3966: 2008 IEC 60751 UNI EN 12599:2012
All-water systems	Thermal energy meter	UNI EN 1434:2016
	Insertion time counters	UNI 11388:2015 UNI 9019:2013
Air and water systems	Mixed direct metering and indirect sub-metering	
Unitary refrigerant based systems	Volumetric Flow Meters Temp. and pressure sensors	





Methodology

- Analysis of the methods and devices available for cooling metering and submetering
- Field campaigns in residential and commercial buildings

#4 – Heating and cooling accounting policy

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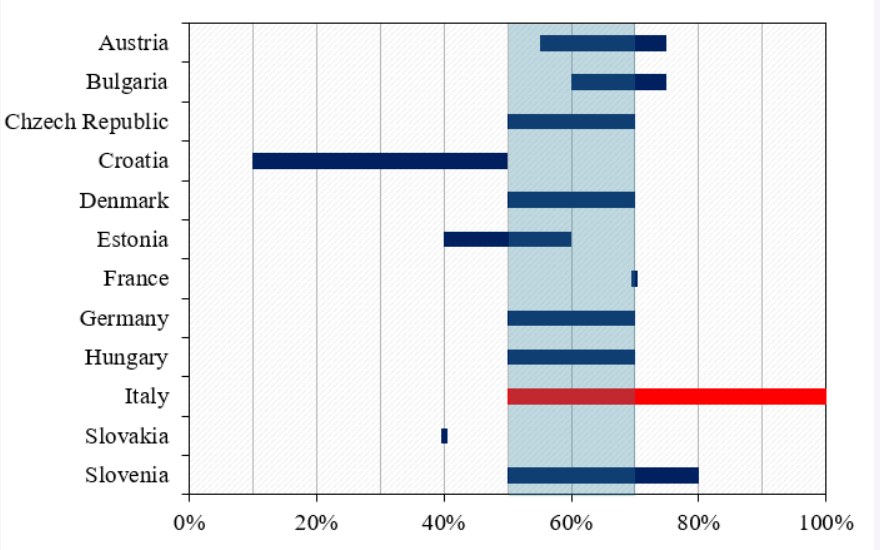
Problem statement

Existing heat cost allocation policies are based on equity and responsibility principles which are often conflicting and show limitations related to congruence with the EED objectives.

Methodology

- Analysis of the policies for allocating energy costs in EU (e.g. fixed proportionality, responsibility and fairness principles)
- Development of a new model for heat cost allocation:
  - based on the estimation of extra-consumptions due to building inefficiencies;
  - extra-consumptions are charged to all tenants in order to encourage energy efficient retrofit interventions;
  - application to a social housing building case study.



Range for variable share of heat cost allocation in some EU Member States

$$f_{ext,i} = \frac{HDD \cdot 0.024 \cdot \sum_j [(U_{com,j} - U_{com,j}^{ref}) \cdot b_j \cdot A_{com,j}]}{Q_{H,ls,i}}$$

#4 – Heating and cooling accounting policy

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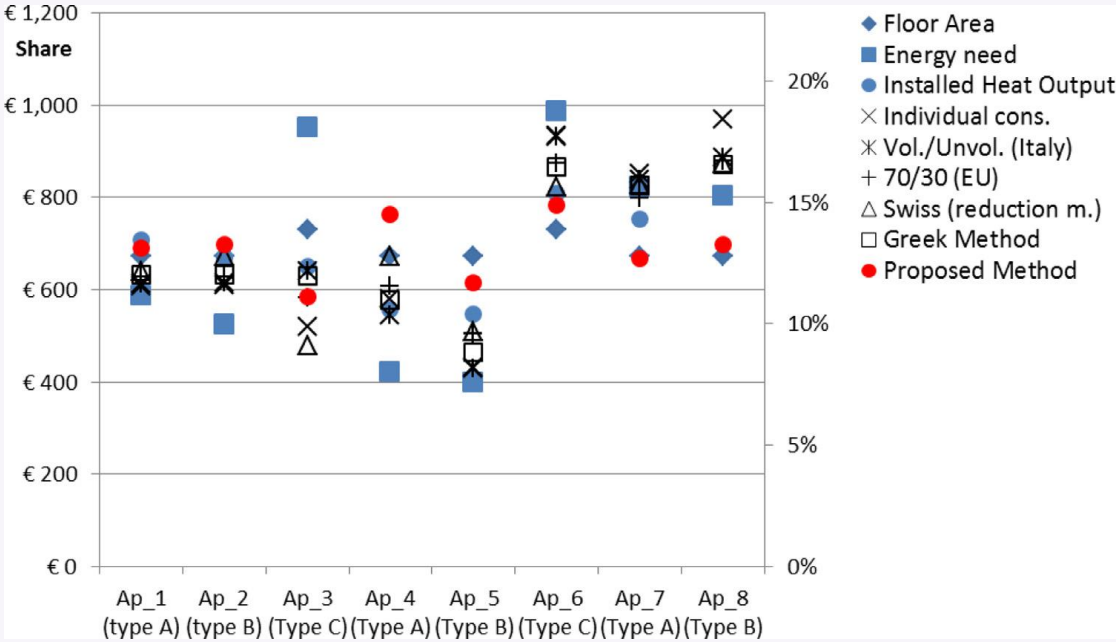
Main findings

- The Proposed methodology is effective in compensating for unfavourable conditions also highlighting how an energy retrofit could lower the energy bill
- Other methods in EU MSs are not always effective in guiding the consumer towards energy retrofit interventions
- The proposed method overcomes the contrast between equity and responsibility in heat cost allocation



Impact of individual heat metering in residential buildings

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Scope and research questions

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Scope of the research

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#5 - Energy saving in Italy

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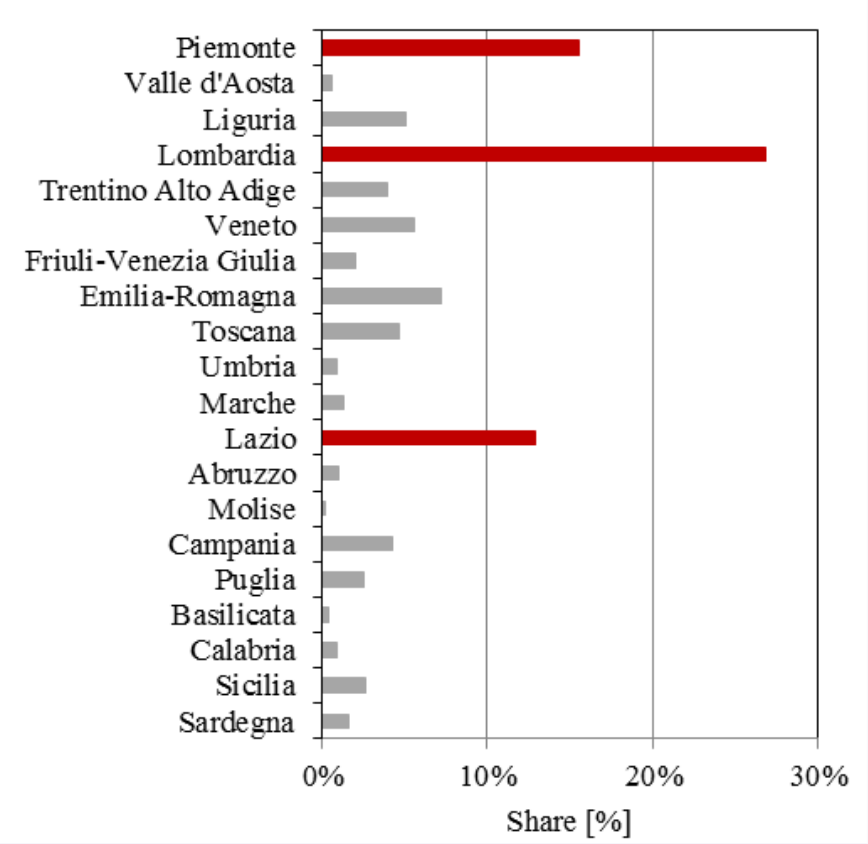
Problem statement

The literature on the energy saving of HAT systems is mainly related to continental climates and is affected by methodological issues (lacks in definition sample etc.)

Methodology

Experimental campaign carried out on 3050 dwellings in 50 buildings in three representative Italian regions subject to Heat Cost Allocator and Thermostatic Radiator Valves installation (two heating seasons at least).

Centralized heating systems in Italy



#5 - Energy saving in Italy

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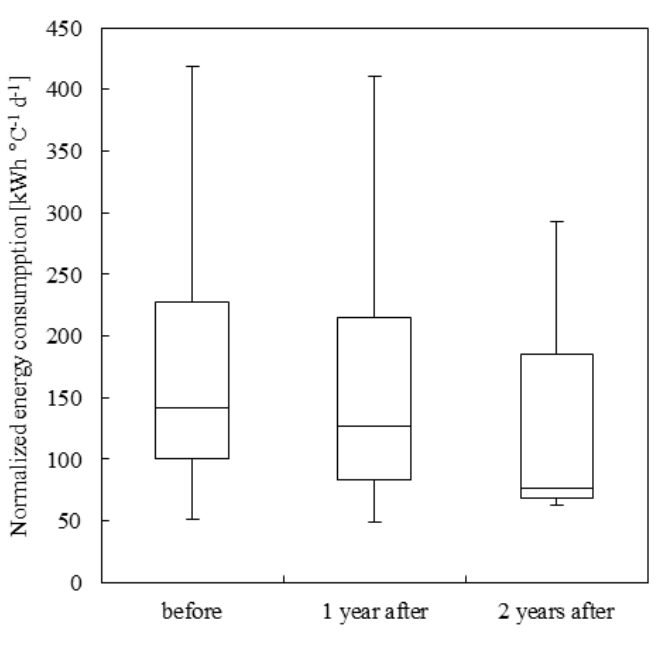
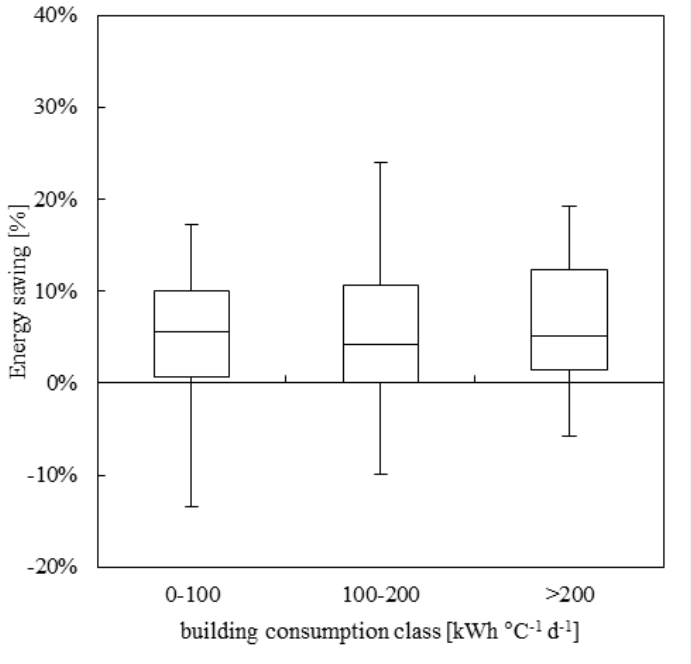
Main findings

Average energy saving of:

- about 8.7% one year after the installation,
- additional 2.3% the second year after the installation





#5 - Energy saving in Italy

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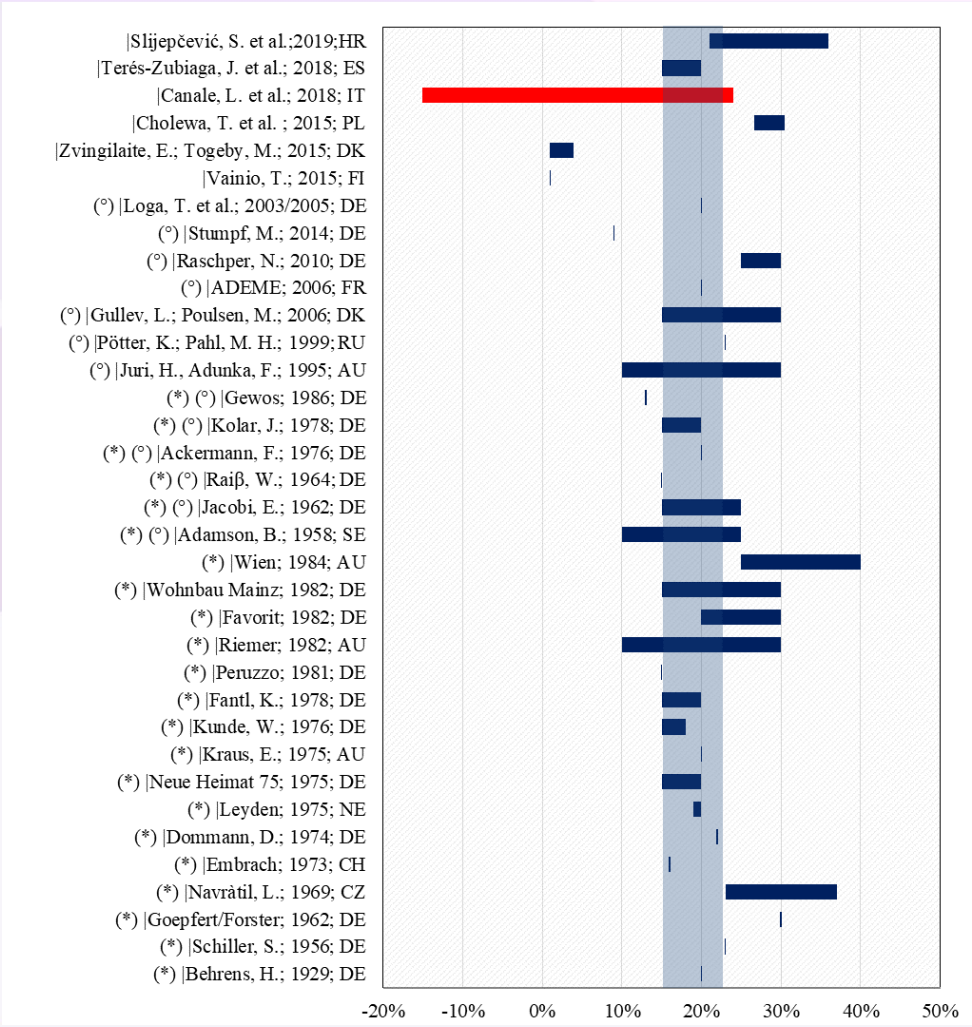

Comparison of italian results with energy savings (min-max) in other EU countries

#6 – Metrology and accuracy issues

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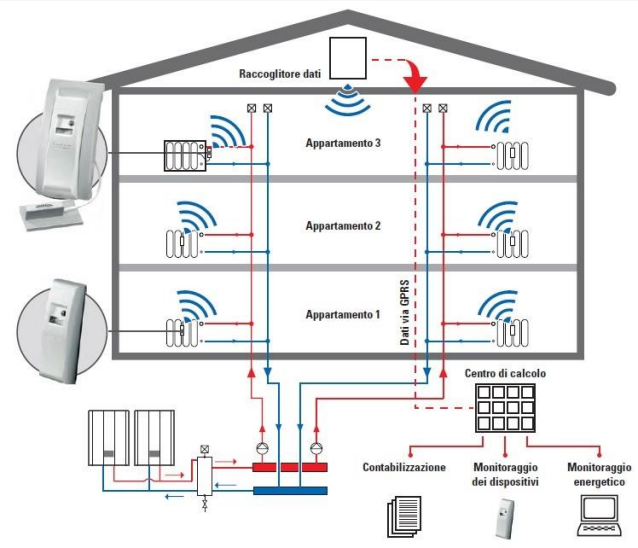
On-field tests

Problem statement

Despite the need of **consumers' protection**, neither legal metrology requirements are available for indirect accounting systems nor applicable technical standards specify the related **on-field maximum permissible errors**.

The high number of interconnected devices and the influence of installation and operative conditions on their on-field metrological performances could be significant



Methodology

→ A statistical model has been developed to estimate and predict the on-field reliability of heat accounting systems (3 different case studies)

→ Laboratory tests (INRIM)

#6 – Metrology and accuracy issues

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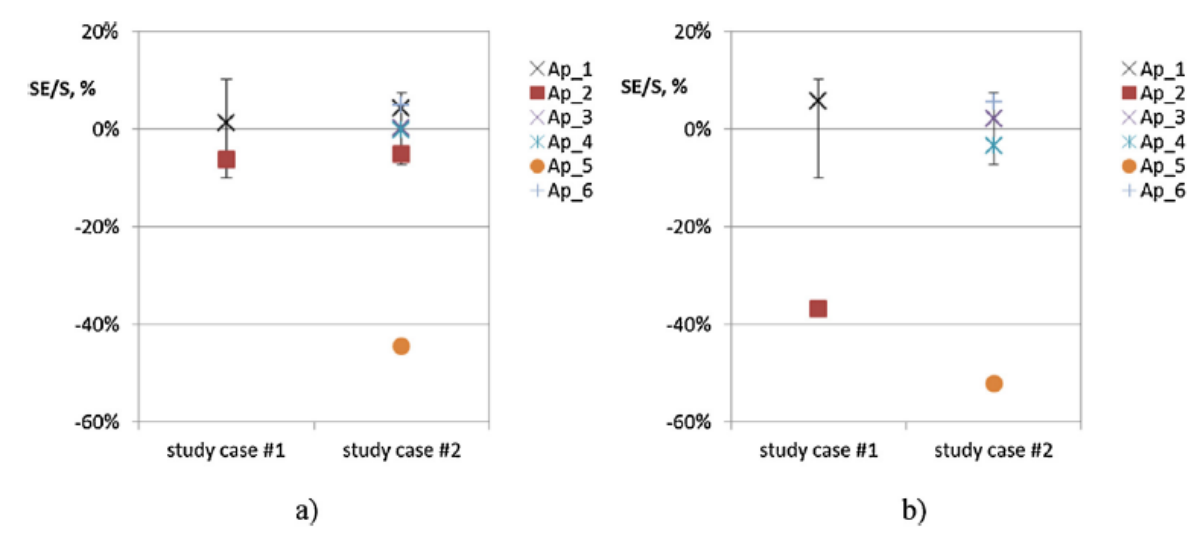
On-field tests

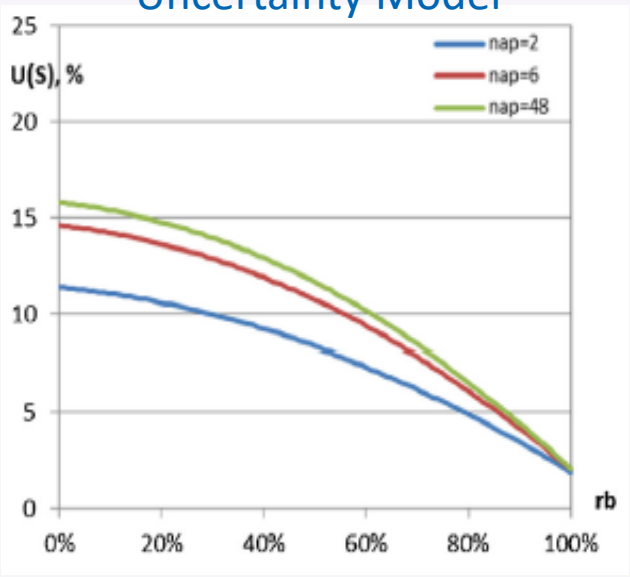
Main findings

→ Estimated Uncertainty variable between 10.1% and **11.7%** in a two-family house in **critical conditions**, between **2.7%** and 4.9% in a large building in **optimal conditions**.

Indirect vs Direct Measurement



Uncertainty Model



#6 – Metrology and accuracy issues

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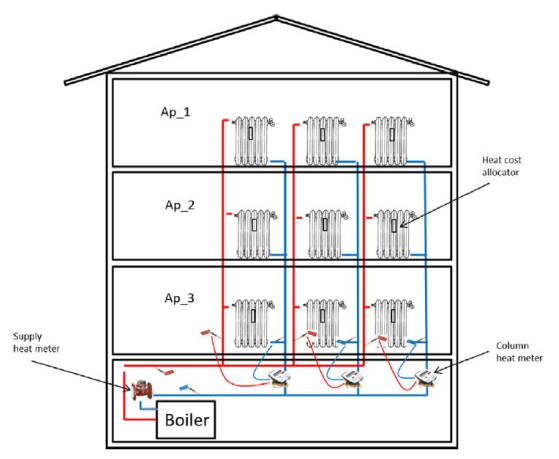
Laboratory tests

- → Hybrid method aimed at improving indirect heat accounting systems accuracy by installing a direct heat meter in each raising main
- → Improved accuracy at different conditions of occupancy and climate (warm, cold, very cold)



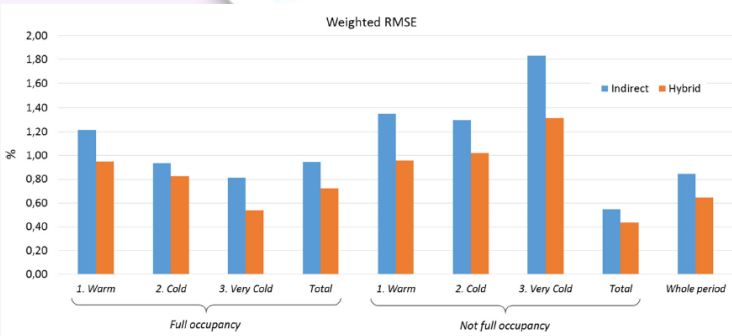


Fig. 6. *wRMSE* of indirect and hybrid methods.

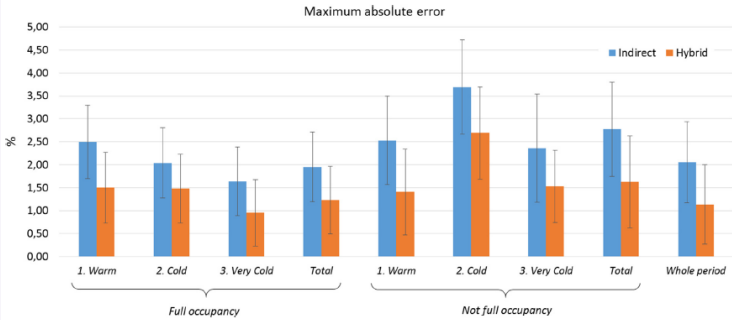


Fig. 7. Maximum error of indirect and hybrid methods.

#7 – Cost-benefit analysis

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Problem statement

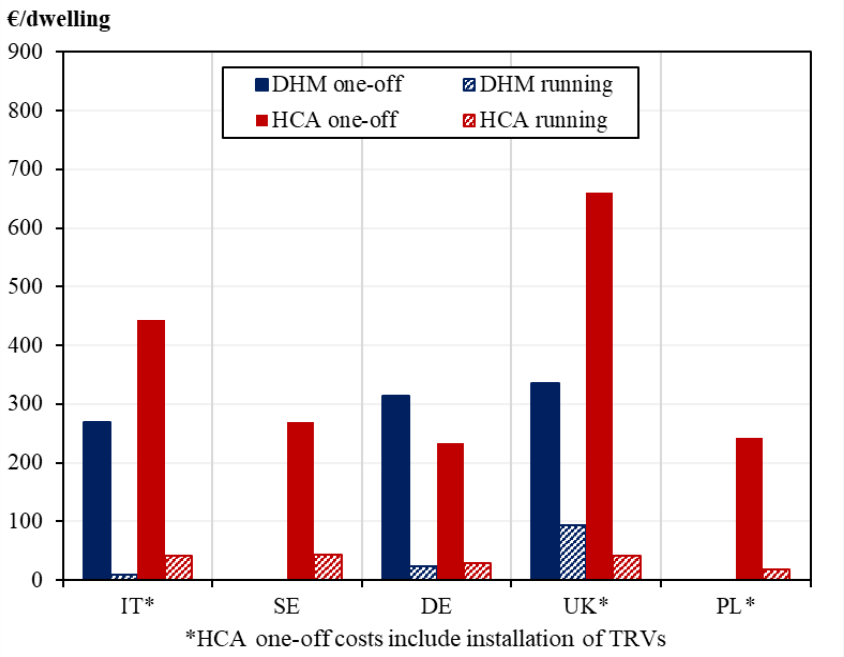
In Italy, the installation of heat accounting systems is mandatory only after technical and economical feasibility evaluation on single buildings.

A clear methodology to allow professionals evaluating cost-effectiveness is crucial.

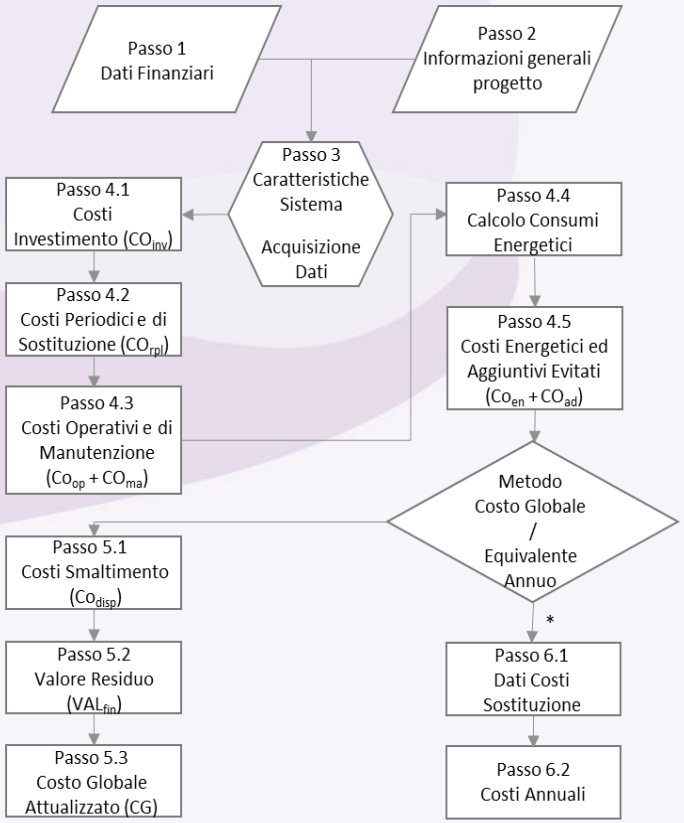
Actions

- ENEA and UNICAS developed “THIM Test – Viability Test Tool for Individual Heat Metering Beta”.
- **Italian Thermo-technical Committee (CTI) specific Guidelines based on EN 15459**
- The cost benefit analysis takes into account the cost of the **remote reading**

Reference costs in some states



#7 – Cost-benefit analysis



*procedura ammessa solo per relazioni redatte ante revisione EN 15459:2018

	Costi Globali	Simbolo	Applicabile (Si/No)
Costi Iniziali	Costi iniziali per Acquisizione Terreno - Acquisizione, preparazione, decontaminazione, ecc	CO_{inv}	No
	Costi iniziali di progettazione - Progettazione sistema contabilizzazione e termoregolazione - Direzione lavori		Si
	Costi iniziali (in situ) - Acquisto sistemi di contabilizzazione e termoregolazione (per esempio ripartitori walk-by, valvole termostatiche, detentori, ecc.) - Acquisto apparecchiature ausiliare1 (per esempio relativi alla sostituzione dei circolatori, valvole o dei sottocontatori in centrale termica) - Modifiche dell'impianto termico - Opere murarie ed eventuali smaltimenti materiali risulta - Installazione (smontaggio e rimontaggio valvole e detentori, eventuale lavaggio degli impianti, bilanciamento idraulico, modifica di circuiti elettrici) - Prove, collaudi e certificazione		Si
Costi Annuali	Costi Periodici e di Sostituzione (costi una-tantum) - Costi di sostituzione di componenti e sistemi per invecchiamento (se la vita media è minore al periodo di calcolo) - Costi di manutenzione straordinaria (e.g. controlli metrologici periodici se obbligatori)	CO_{rpl}	Si
	Costi di Manutenzione - Manutenzione ordinaria - Riparazione	CO_{ma}	Si
	Costi Operativi - Servizio di misura (riferito al costo di lettura walk-by) - Servizio bollettazione	CO_{op}	Si
	Costi Ristrutturazione	-	No
	Costi energetici (evitati) - costi evitati derivanti dal risparmio di energia - costi evitati derivanti dalla regolazione	CO_{en}	Si
	Costi aggiuntivi (o evitati) - detrazioni fiscali - incentivi minimi previsti dalla legge	CO_{ad}	Si
Costi Finali	Valore Residuo - Valore residuo degli impianti e dei componenti al termine dell'intervallo di calcolo	VAL_{fin}	Si
	Costi di smaltimento del sistema o del componente (laddove prevista).	CO_{disp}	Si

#8 – Impact on Italian building stock

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Problem statement

Lack of studies assessing the impact of individual metering policy (both in Italy and in EU).

Methodology

UBEMs (Urban Building Energy Models) are required to estimate the impact of energy policies and scenario analysis.

- Bottom-up building energy model developed, validated and calibrated to estimate the energy consumption of the Italian residential building stock:
- Analysis of statistical data about Italian regional building stocks (age, type, floor area, U etc.)
- «Building typologies» definition and assignment of thermo-physical and heating plant parameters
- Estimation of energy consumption (Asset Rating/Operational Rating) and model validation
- Economical feasibility assessment for each building typology defined
- Policy scenario definition (fiscal incentives)

#8 – Impact on Italian building stock

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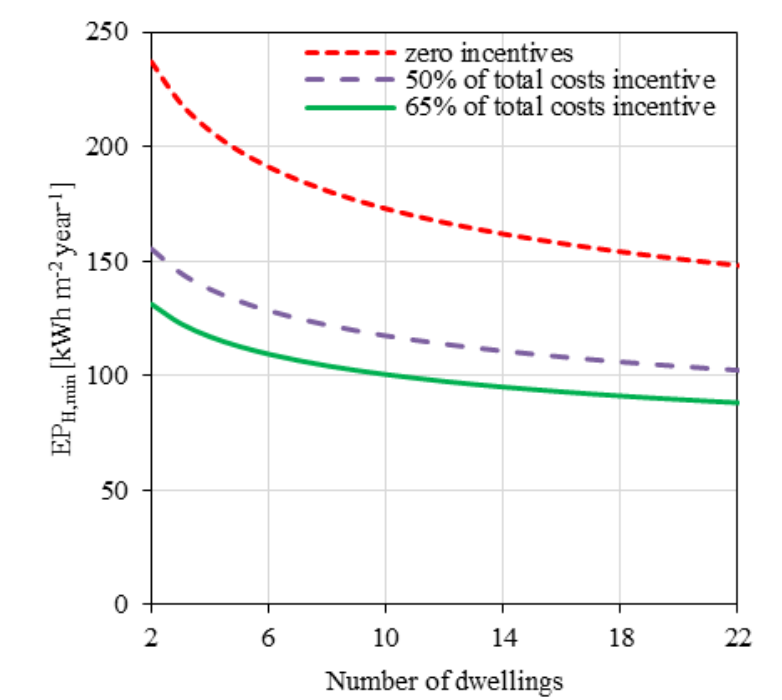
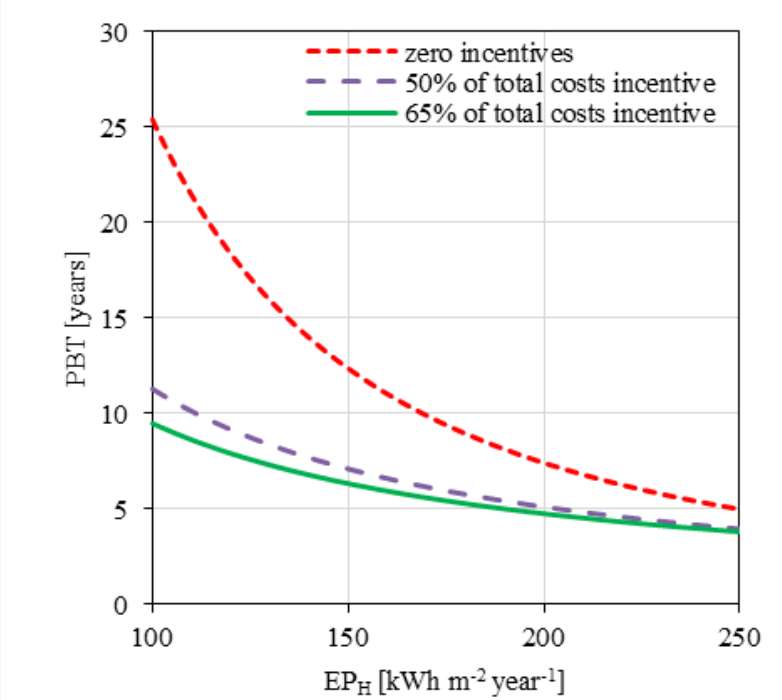
Application of economic feasibility analysis to typical Italian building typologies in three scenarios of fiscal incentives

Minimum Energy need and Pay-back time allowing economic feasibility





#8 – Impact on Italian building stock (Q10)

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Results

Scenario simulation

Table 7
Energy savings achievable through different fiscal policies and obligation approach [Mtoe].

Region		Fiscal policy 1 (0% incentives)		Fiscal policy 2 (50% incentives)		Fiscal policy 3 (65% incentives)	
		OR	AR	OR	AR	OR	AR
North	Piemonte	0.000	0.019	0.034	0.056	0.041	0.065
	Valle d'Aosta	0.002	0.003	0.004	0.004	0.004	0.004
	Liguria	0.000	0.004	0.003	0.015	0.006	0.017
	Lombardia	0.042	0.089	0.107	0.141	0.128	0.143
	Trentino Alto Adige	0.011	0.016	0.019	0.023	0.022	0.024
	Veneto	0.000	0.000	0.003	0.014	0.008	0.017
	Friuli-Venezia Giulia	0.000	0.000	0.000	0.002	0.002	0.005
	Emilia-Romagna	0.000	0.030	0.021	0.036	0.027	0.037
Center	Toscana	0.000	0.007	0.005	0.017	0.010	0.018
	Umbria	0.000	0.003	0.002	0.004	0.003	0.004
	Marche	0.000	0.001	0.001	0.004	0.002	0.005
	Lazio	0.000	0.012	0.006	0.037	0.014	0.043
	Abruzzo	0.000	0.000	0.000	0.002	0.000	0.003
South and Islands	Molise	0.000	0.000	0.000	0.001	0.000	0.001
	Campania	0.000	0.000	0.000	0.007	0.000	0.008
	Puglia	0.000	0.000	0.000	0.001	0.000	0.003
	Basilicata	0.000	0.000	0.000	0.001	0.000	0.001
	Calabria	0.000	0.000	0.000	0.000	0.000	0.000
	Sicilia	0.000	0.000	0.000	0.001	0.000	0.001
	Sardegna	0.000	0.000	0.000	0.001	0.000	0.002
Italy (Mtoe)	0.056	0.186	0.204	0.366	0.268	0.399	
Italy (share[a])		0.3%	0.9%	1.0%	1.7%	1.3%	1.9%

[a] Share referred to the total energy consumption for space heating in residential sector of 21.1 Mtoe estimated in 2015.

Thank you for your attention

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EU cost allocation rules

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Member state	Variable cost share Min.	Max.	Note	Compensation
Austria	55%	75%	Shares are defined through agreements between the energy company and users. If an agreement cannot be found, the energy cost is divided by 65% according to metered consumption and 35% by floor area.	Forbidden
Bulgaria	60%	75%	Heat cost allocation is performed by heat transmission companies, heat providers, or by qualified technicians. Compensation factors are rarely used.	Allowed
Croatia	10%	50%	–	Allowed
Czech Rep.	50%	70%	None should pay a share lower than −20% or higher than +100% of the building's average.	Mandatory
Denmark	50%	70%	Heat cost allocation is managed by the energy company or by the building owner.	Mandatory
Estonia	40%	60%	Fixed and variable costs shares are not specified in the current regulation. Typically, companies offering measurement and/or cost allocations systems and services provides also recommendations on heat cost sharing. Compensation factors are widely used.	Allowed
France	70%		Share for voluntary consumption is fixed by law. Compensation is allowed and managed by the condominium meeting	Allowed
Germany	50%	70%	The choice is agreed by the building owner in the rental contract with tenants. It is required that 70% of total cost is based on individual consumption.	Forbidden
Greece	Calculated case by case		Fixed energy costs are calculated as a function of the "indirect heat" delivered to the apartment through specific factors given by the Greek technical standard as a function of the dwelling's characteristics.	Allowed
Hungary	50%	70%	Heat costs allocation rules are defined only for district heating, no mention is done to similar rules for centralized heating systems. The condominium meeting can decide whether applying a different scheme, often with a detailed energetic calculation. Compensation is allowed and performed for single rooms in the dwelling.	Allowed
Italy	Minimum 70%		A detailed energy calculation performed by a qualified technician is required by law.	Forbidden
Latvia	Not regulated		There is not any obligation to adopt or not cost allocation rules based on actual consumption. Conversely, the choice of the calculation method is assigned to the condominium meeting. Compensation is allowed and performed by independent technicians.	Allowed
Lithuania	Not regulated		Apartment/building owners can decide the heat cost allocation method. The agreed method shall be authorised/validated by the National Commission for Energy Control and Prices.	Mandatory
Netherlands	Not regulated		If required by one or more tenant, a professional should be asked to check heat cost allocation performed by the service or heat company. The use of compensation factors is actually under discussion	Not applicable
Poland	Not regulated		It is currently under discussion the adoption of a min./max. range for variable heat consumption between 10 and 45%	–
Romania	Not regulated		It is currently under discussion the adoption of a share for variable heat consumption of 40%. Compensation is allowed and performed for single rooms in the dwelling.	Allowed
Slovakia	40%		Fixed by law, but adjustable to other ratio upon agreement	Allowed
Slovenia	50%	80%	Low and high consumptions per square meter in respect to the average are limited to 40% and 300% of the average itself, respectively. Compensations factors are allowed and estimated by independent technicians.	Allowed

User perception on heat accountind devices

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Questionnaires

A. Overall, I feel satisfied with the installation of thermostatic valves and sub-metering devices in my apartment

B. I do often adjust the temperature using the chrono thermostat

C. During periods of absence from the apartment, I set the thermostat temperature to minimum to save energy

D. I think the installation of thermostatic valves and sub-metering devices in my apartment is helping me save on my gas bill

E. The temperature in my apartment is often too high and I am forced to open the windows

F. The temperature in my apartment is often too low

G. I use alternative systems to heat my apartment (electrical heaters etc.)