

# Overcoming the inertia of building energy retrofit at municipal level: The Italian challenge

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## 1. Introduction

The reduction of climate change and the path to carbon neutral communities represent long lasting and urgent challenges for all the governments. The EU has approved the “Roadmap for moving to a competitive low carbon economy in 2050” (EU COM 112/2011) with the objective to reduce greenhouse gas emissions by 80–95% by 2050 in comparison to those of 1990. To reach this target it is very important to reduce the energy consumption and to drastically integrate renewable sources, looking especially at built environment. In fact, in Europe buildings are responsible of 41% of the total final energy consumption in 2010 (Odyssee, 2012), representing an important energy saving opportunity. New dwellings built in 2009 consumed 30% to 60% less than dwellings built in 1990 (Odyssee, 2012) and by 2021 all new buildings will be “nearly zero-energy buildings”, thanks to the Energy Performance of Buildings Directive (2010/31/EU). However, it should be noted that most EU countries extend their dwelling stock by less than 1% per year, so the impact of the new energy-efficient buildings is limited and policies to regulate the energy

performance of new buildings are not sufficient. The scientific community agrees about the need of operating on the already existing building stock. Nowadays it has roughly 25 billion m<sup>2</sup> of useful floor space (BPIE, 2011) with an average yearly energy consumption around 220 kWh/m<sup>2</sup> (Odyssee, 2012). Policies for increasing energy efficiency in buildings, in particular for space heating, are the central issue of this work. In fact, space heating accounts for 68% of end-use energy consumption while lighting and electrical appliances account for 15%, water heating for 12% and cooking for 4% (Odyssee, 2012). According to *Europe's buildings under the microscope* (BPIE, 2011), an ambitious renovation strategy is necessary to increase greatly the renovation rate of existing buildings. The actual renovation rate in Europe, estimated around 1%, must more than double to reach a complete renovation of the European building stock by 2050. This is technically feasible but “for policy makers the challenge only begins at this point. The question now is how to break the policy inertia and set the necessary policies in motion” (BPIE, 2011). As assessed by (BPIE, 2013b), some European State Member already have implemented policies and national plan to boost building renovation activities, but the regional and local level becomes increasingly important. As reported by the British Committee on Climate Change (UK CCC, 2012), local authorities could have a crucial role in reducing emissions to meet national carbon budgets and should develop

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**Table 1**  
main data about Italian municipalities.

Size of the municipalities Italian energy regulation	Less than 10,000 people – –	From 10,000 to 50,000 people – Compulsory energy manager	More than 50,000 people Compulsory energy plan Compulsory energy manager	Total
N. of municipalities	6,989	974	138	8,101
% on total municipalities	86%	12%	2%	
N. of inhabitants	18,631,613	18,745,510	19,618,621	56,995,744
% on total inhabitants	33%	33%	34%	
N. of households	10,026,838	8,503,362	8,761,793	27,291,993
% on total households	37%	31%	32%	
N. of residential buildings	5,823,508	3,606,202	1,796,885	11,226,595
% on total residential buildings	52%	32%	16%	
Buildings surface (m <sup>2</sup> )	935,634,130	796,586,519	775,428,454	2,507,649,104
% on total buildings surface	37%	32%	31%	

Source: <http://www.istat.it/>.

low-carbon plans. To achieve a full refurbishment of the European building stock, a proactive role of the local authorities and effective municipal energy plans are therefore necessary. The analysis of BPIE (2011) shows that, for the European building stock, it is possible to achieve in 2020 annual energy saving from 94 TWh (business-as-usual) to 527 TWh (best scenario) and in 2050 from 365 TWh (business-as-usual) to 2896 TWh (best scenario). However, these are only a technical potential and must be tackled with effective national and local energy plans. There are already several methodologies and tools devoted to the development of municipal energy plans, but, as summarized by Ma, Cooper, Daly, and Ledo (2012), “there is still a long way for building scientists and professionals to go in order to make existing building stock be more energy efficient and environmentally sustainable”. For instance, there are several methodologies to model energy consumption in the residential sector for space heating and cooling, domestic hot water, and appliances and lighting, as reviewed by Swan and Ugursal (2009). The aim of these methodologies is to evaluate the energy performance of a building stock and assess the potential energy saving using retrofitting measures. This potential saving should be considered as the maximum technical potential, since further analysis are needed in order to clarify how this potential could be achieved and to identify a robust approach to implementing retrofitting measures, as pointed out by Mata, Sasic Kalagasidis, and Johnsson (2013) and by recent researches carried out by the European Council for an Energy Efficient Economy.<sup>1</sup> The research here presented analyzes the reasons of the inertia of building energy retrofit at municipal level starting from the analysis of what hinders effective energy policies carried out by the public administration and what hinders the involvement of citizens and other stakeholders. For instance, in (EBC, 2013) they found several bottlenecks which often make the transition to energy efficiency difficult for cities and communities. For the municipalities the most prominent barriers are lack of knowledge, management, expertise, awareness and commitment. To exploit the local potential we have to move from exceptional best-case to common daily practice, making the energy planning process more smooth and effective, reducing barriers and providing a common basis for all municipalities. In this paper, we focus especially on improving the energy performance of the whole building stock, both public and private, in the Italian context. In Section 2.1 we describe the composition of Italian municipalities and of their building stock; in Section 2.2 we outline the barriers to effective municipal energy plan; in Section 2.3 we check these barriers in the Italian context; in Section 3 we portray possible solutions to overcome some of the non-technical barriers and we present an estimation of the energy savings deriving from

cost optimal retrofit interventions in relation to Italian residential buildings.

## 2. Material and methods

### 2.1. Italian building stock and municipalities

In Italy the importance of the building stock is recognized by the National Energy Strategy, a steering document that sets the guide-lines to reach the 2020 European objectives, with some remarks about the 2050 Roadmap. To tackle the building stock “actions regarding energy planning and sustainable urban development will be developed, in coordination with the concerned minister and local or territorial entities, with the objective to activate innovative planning frameworks of urban facilities and energy fluxes, efficiency in the networks, mobility and renovation of the building stock and public-private partnership” (SEN, 2013). In this section, we provide information for better understanding the main features of the building stock distributed in the Italian municipalities (Tables 1 and 2). An analysis of the consistency of national building, albeit preliminary and not exhaustive, is provided in the very recent Italian National Energy Efficiency Action Plan (PAEE, 2014). In Italy there are 13.6 million of buildings, of which 11.7 million (more than 87%) are residential buildings. Educational buildings are approximately 51,000, with a surface area equal to 73.2 million square metres; there are usually (about 60%) located in small municipalities (up to 20,000 inhabitants) and the majority (39%) have a surface area between 1,000 and 3,000 m<sup>2</sup>. Office buildings are approximately 65,000, with a surface area equal to 56.7 million square metres; 53% are located in small municipalities and about half of all office buildings is under 350 m<sup>2</sup>. Wholesale and retail trade buildings have a total surface area equal approximately to 63 million square metres, while there are 1,114 shopping centres with a Gross Leasable Area of 16 million square metres. There are 25,800 hotels, with a surface area equal to 48.6 million square metres; they are located mainly (64%) in small municipalities. There are 33,727 banks branches, usually located on the ground floor of other buildings. The buildings for the exclusive or predominant banking use are estimated at 1,469 units, with a surface area equal to 5.48 million square metres. There are approximately 700,000 buildings that are not used, because under refurbishment or because of poor safety condition. The Italian buildings are responsible of 36.7% of the total final energy consumption in 2012<sup>2</sup> and it is the only sector that has stable or even increasing energy consumption despite the economic crisis. In the residential sector more than two third of the energy consumption is for heating and the remaining third is split among electrical appliance (13.5%), cooking and domestic

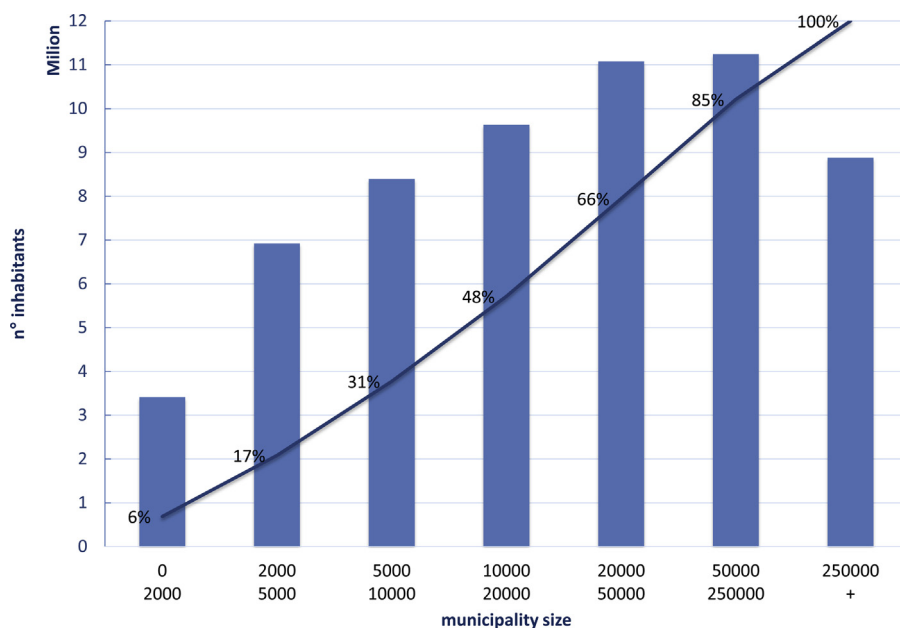
<sup>1</sup> [www.eceee.org](http://www.eceee.org).

<sup>2</sup> Data from: <http://dgerm.sviluppoeconomico.gov.it>.

**Table 2**  
focus on residential Italian buildings; distribution of small buildings and condominiums grouped by municipalities' sizes.

Size of the municipalities	Number of buildings	Number of buildings with less than 5 units	% of buildings with less than 5 units	Number of buildings with 5 units or more	% of buildings with more than 5 units
Less than 10,000 people	5,823,508	5,531,981	95%	291,527	5%
From 10,000 to 50,000 people	3,606,202	3,245,315	90%	360,887	10%
More than 50,000 people	1,796,885	1,322,855	74%	474,030	26%
Total	11,226,595	10,100,151	90%	1,126,444	10%

Source: <http://www.istat.it/>.



**Fig. 1.** Number of inhabitants per municipality size (classes defined by number inhabitants) with cumulative percentage.

Source: Data from ISTAT, National Census 2001.

hot water (16.5%) (Odyssee, 2012). The energy performance of the Italian building stock is scarce and not extensively investigated. For instance, in Lombardy Region, in the residential sector,<sup>3</sup> the average EPh (primary energy consumed for heating) for buildings built before 1976 is around 243 kWh/m<sup>2</sup>/year; it drops a little for buildings between 1977 and 1992 (206 kWh/m<sup>2</sup>/year) and between 1993 and 2006 (154 kWh/m<sup>2</sup>/year). The real enhancement took place in 2007 (98.67 kWh/m<sup>2</sup>/year) with continuous improvements; in 2012 EPh was 59 kWh/m<sup>2</sup>/year; the average EPh of new buildings is now a quarter of that of an existing building.

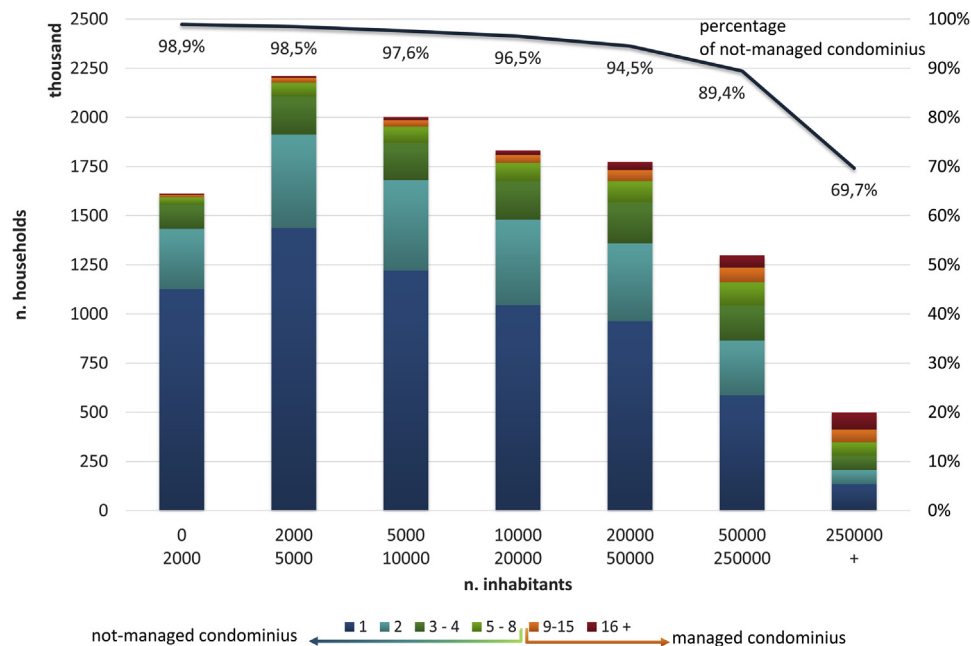
Indeed, the Italian building stock is quite old and not adequately refurbished. Data for the residential building stock<sup>4</sup> shows that 44% of the buildings were built before 1961, 45% of the buildings were built between 1961 and 1991, and 11% of the buildings were built between 1991 and 2011. For non-residential buildings data are scarce, only as a reference the estimates<sup>5</sup> tell that 53% of office buildings were built before 1971, 23% between 1972 and 1991, 25% after 1992. The educational building stock consists of older buildings: 90% were built before 1971, 4% between 1972 and 1991, 6% after 1992. In Italy, the majority of the dwellers own the house in which they live (76% of households). This implies that the building refurbishment interventions are rather frequent and ample: the 67% of the construction market consists of refurbishment of the existing stock. Nevertheless these interventions are mainly on technical systems or aesthetic enhancement and not

aimed at improving the building's energy performance (Cresme, 2012). The energy efficiency measures are carried out mainly when there is a failure or upgrade of the technical systems or the owners want to take advantage of government incentives. In fact, incentives for energy-saving measures have resulted in single interventions rather than a whole building approach (ENEA, 2013). In order to outline what mainly hinders effective energy policies for building energy retrofit, we focused on the municipal level since municipality administrations could modify the built environment using local plans and regulations. Data regarding municipalities and their buildings here presented derived from the National Census held in 2001 by the National Institute of Statistics (ISTAT). In Italy there are 8,092 municipalities, which are not homogeneous in land area or in number of inhabitants or dwellings. The majority (66%) of the Italians live in small and medium municipalities (up to 50,000 inhabitants) while the 15% live in twelve municipalities over 250,000 inhabitants, as shown in Fig. 1. The size of the municipality affects many environmental, economic and social aspects, i.e. the morphology of the urban space, the features of the buildings stock, the regulatory framework related to the built environment and the human and economic resources available at the administrative level for the technical offices. Overall in Italy the residential stock consists of 58% of single family houses, 32% of small building houses (up to 4 household), 5% of medium building houses (up to 8 household), and 5% of apartment buildings. As can be seen in Fig. 2, these percentages vary with the size of municipalities: in medium and small municipalities the large majority of the buildings have only one or two households. From the energy point of view, small buildings mean a high Surface to Volume ratio (called also Thermal envelope area to Heated volume ratio) and thus very likely high

<sup>3</sup> Data from: [http://www.energielombardia.eu/patrimonio\\_edilizio](http://www.energielombardia.eu/patrimonio_edilizio).

<sup>4</sup> Data from: <http://www.istat.it>.

<sup>5</sup> Data from: <http://www.buildingsdata.eu>.



**Fig. 2.** Number of households in building per municipality size (classes defined by number inhabitants) with cumulative percentage of not-condominium buildings. Source: Data from ISTAT, National Census 2001.

thermal dispersions. In Fig. 2 it is also plotted, as percentage, the rate of buildings that are single-family houses or not managed condominiums: in Italy there is the obligation of a building manager only for buildings with more than 8 owners (L. 220/2012). It is possible to note that only in big municipalities managed condominiums are significantly present (with a mean value of 32%). The building manager, who is responsible for the management and maintenance of the heating systems and for the building's energy certificate, could be involved by the local administrator as an actor in the energy policies, since he represents several owners. But it could be possible to extend his duties to the overall building efficiency and energy production, becoming an energy manager or working with him. In small buildings, this reference role is not mandatory, so the management is directly done by multiple owners. On the other hand, small buildings have fewer owners and thus fewer persons to come to an agreement about building's retrofit. Furthermore, small buildings mean a low density built environment (Fig. 2). Therefore, in small buildings it is possible to have greater surfaces available (i.e. in terms of available surface per people) for the integration of solar technologies and thus a higher coverage of the different final energy uses by renewable energy sources. The fact that the majority of the buildings are located in small and low-density municipalities underlines the vast potential in terms of reduction of the energy demand if the local administrations implement suitable and effective retrofit energy policies and actions.

### 2.1.1. The municipalities' role

The municipal energy plan is mandatory since 1991 (L 10/1991) for cities with more than 50,000 inhabitants. It is evident that this obligation encompasses only a small part of Italian municipalities, since only 142 of the 8,092 Italian municipalities (1.8%) have more than 50,000 inhabitants. The municipal energy plan involves the measurement of energy consumption of the city, grouped by sectors and the identification interventions for saving fossil fuels and for promoting the use of local renewable energy sources. To develop a municipal energy plan in Italy two guidelines are available (ENEA, 1997; ACEA, CISPEL, 1997), but they are not compulsory so it is possible to see plans different from each other and sometimes not comparable. Currently only 48 cities approved their energy plan

(ISTAT, 2012) and also in these cases it has rarely been possible to put in practice and to monitor the effects of the various measures suggested by the plans. Therefore, we can state that the energy plan, as it is, is not sufficient to challenge massive energy refurbishment. There is also another scarcely implemented obligation: the energy manager of local public administration. The national law (L 10/1991) set as mandatory the energy manager for municipalities with an annual consumption over 1,000 toe. In Italy, municipalities with more than 10,000 inhabitants generally exceed this target. However, among the 1,206 municipalities larger than 10,000 inhabitants only 112 have appointed the energy manager until now (FIRE, 2012). The lack of compulsive requirements, especially for small and medium municipalities, and the lack of coordination at national or regional level generate a shortage of detailed knowledge about the building stock. The situation is also aggravated by the long lasting economic crisis that has reduced funding availability of public administrations, and has drastically slowed investments in the buildings sector during the last years.

### 2.2. Barriers to the renovation of the building stock

In the previous sections, we outlined that the Italian and European building stock is old and has poor energy performance (BPIE, 2011) and that it is necessary an energy renovation plan. As clearly mentioned also in a recent seminar by ECEEE,<sup>6</sup> the European legal framework suggested an energy performance approach that was well implemented, but this positive effect is restricted by the often limited volume of construction. Efforts are needed in order to strengthen local and regional verification of national building codes and to accurately inform consumers of the energy performance of buildings for sale or rent, in combination with making full use of available financing.

Within the Entranze Project ([www.entranze.eu](http://www.entranze.eu)), has been carried out a literature review about the structure of key stakeholders, users and investors and their behaviour, preferences and

<sup>6</sup> [http://www.eceee.org/events/eceee\\_events/annual-policy-seminar-19-November-2014](http://www.eceee.org/events/eceee_events/annual-policy-seminar-19-November-2014).

interests, in order to analyze the most critical barriers to buildings retrofit. They underlined that the role of initial costs is dominant in most countries among housing owner-occupiers and they emphasized the role of grants in encouraging investments. In Italy, generally speaking these limits are mainly related to financial aspects, lack of information and skills, collective decision problems and uncertainty in measurement and verification,<sup>7</sup> but there are differences depending on the buildings' typologies (i.e. owner-occupied single-family homes; owner-occupied apartment buildings, social/professionally owned rental housing; public buildings).

Other important contributions in clarifying the existing barriers to retrofit of existing building in European countries and also in Korea and Canada are reported in Emmert et al. (2013), Baek and Park (2012a), Baek and Park (2012b), Galvin (2012) and Gamtessa (2013), Hoicka, Parker, and Andrey (2014).

To focus on the European context with particular regard to the barriers for public administration at handling a local energy plan we analyzed the contributions of (BPIE, 2013a; Chmutina, Wiersma, Goodier, and Devine-Wright, 2014; Comodi et al., 2012; Dowson, Poole, Harrison, and Susman, 2012; EBC, 2013; Zanon and Verones, 2013).

After analysing the available literature, we focus on non-technical barriers that block or slow down the processes of local energy planning in the Italian context (Ballarini, Corgnati, and Corrado, 2014; Caputo, Costa, and Ferrari, 2013; Dall'O, Galante, and Pasetti, 2012).

Then, in order to better explore this topic, we checked our hypothesis preparing a questionnaire and sending directly to a selection of local administrations (see Section 2.3). Since the response rate was low, we also conducted some phone interviews with municipal technical offices, inquiring about the difficulties in compiling the questionnaire and about the barriers to undertake a local energy plan (see Section 3.1). We followed the schematic process of integrated energy planning presented by Mirakyan and De Guio (2013) as basis to depict identified actors and barriers in the various phases (Fig. 3). In *phase I: preparation and orientation* the main barriers are the lack of awareness about the energy problem, and the difficulties to set significant goals for the local governments, since they are not aware of their municipality's potentials. In *phase II: model design and detailed analysis* the data collection could be harder than expected. Moreover, the technical office, especially in small municipalities, may not have the expertise to collect and elaborate the data and then to develop an effective energy plan. In *phase III: prioritization and decision* the decision makers have to involve stakeholders and citizens in order to select the best strategies; without any specific expertise, the municipal offices may have several difficulties in managing a participatory process that lead to a shared consensus. *Phase IV: implementation and monitoring* is the most critical and often projects fail during this phase. Especially in these years of economic crisis, the lack of financial availability could stop the planned actions, so the local governments should have the ability to attract private and public funds. The propriety fragmentation of buildings, the willingness of owners or tenants to start refurbishment and the regulation framework are the main critical points. In the following sections we will mainly focus on the barriers of *Phase I* and *Phase II*, i.e. the barriers that particularly concern the public administrations as shown in Fig. 3.

## 2.2.1. Barriers to preparation and orientation phase

2.2.1.1. *Be aware of energy problem.* Chmutina et alii (Chmutina et al., 2014) found that environmental awareness and concern is a prominent driver to energy projects, especially for private

players, while stakeholders in the public sector are more influenced by the regulatory drivers. They also discovered that environmental awareness and concern could be instigated by the personal motivation of a project champion and by a variety of information sources about climate change and sustainability. As regards to regulatory drivers, in Italy only municipalities over 50,000 inhabitants are obliged to develop a municipal energy plan (L 10/1991). The majority of Italians (66%) live instead in medium and small municipalities where energy planning is up to the willingness of the public administration. By chance, there is a general concern in the local administration about the climate change and energy efficiency issues and also some willingness to take action. In fact, there are more than 1,000 Italian municipalities (more than 12% of the total) with innovative building code regarding energy efficiency and the use of renewable, as reported by Cresme and Legambiente (2013).

Further, in the Covenant of Mayors (www.covenantofmayors.eu), the European initiative that involve local and regional authorities into voluntary commitment for increasing energy efficiency and using renewable energy sources on their territories, Italy is placed first for the number of signatories, with currently 2410 municipalities involved (30% of all Italian municipalities).

However, this kind of involvement is often unproductive, as confirmed by an Italian study that analyses some case studies: "translating a rhetorical commitment to energy efficiency into effective policies and programmes is far from being straightforward" (Zanon and Verones, 2013).

The feeling is that public administrators and citizens are informed about energy problems but they do not have the necessary awareness and consciousness to face these problems in order to solve them.

2.2.1.2. *Set goals.* Linked to the scarce awareness of the energy problems and relevant opportunities, there are criticalities in goals setting. Local administrations are generally aware of the general European targets and so they are interested in reducing CO<sub>2</sub> emissions and in promoting REs integration. Usually they believe that energy efficiency measures applied to the building stock, i.e. those devoted to improve the envelope and heating systems performance, are strategic in order to reduce fossil fuels consumption and CO<sub>2</sub> emissions. However, often they are not able to identify realistic, suitable, affordable, and cost effective goals for their own municipalities.

If the goals are simply the same for all the municipalities, it could be onerous or unsuccessful for some municipalities and undemanding for others. In other terms, goals definition is indeed a critical point and implies a deep knowledge of the features of the local built environment.

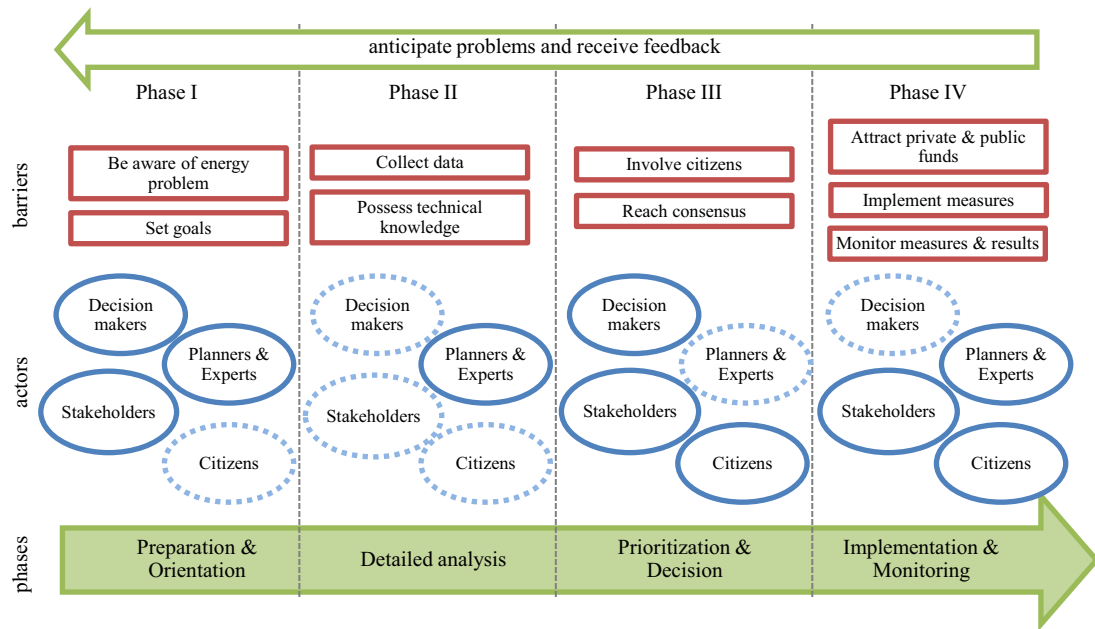
## 2.2.2. Barriers to detailed analysis phase

2.2.2.1. *Collect data.* In order to develop a detailed analysis (*Phase II*) it is necessary to collect several data about the local built environment from the energy point of view (see also Table 3). Unlike other countries, in Italy this step represents a great barrier, as reported in the technical literature and as recently assessed with four Italian municipalities with more than 100,000 inhabitants. Zanon and Verones (2013) underline an insufficient integration between energy and spatial planning and that actions and mechanisms are largely ineffective because of the multi-dimensional nature of energy issues. If this is true for large cities, it is expected that even more difficulties arise when a small municipality is involved.

2.2.2.2. *Possess technical knowledge.* A specific expertise is necessary to collect and analyze correctly data with the aim of defining energy saving goals and measures. Only in municipalities with

<sup>7</sup> [http://www.entranze.eu/files/downloads/D2\\_4/D2\\_4\\_Complete\\_FINAL3.pdf](http://www.entranze.eu/files/downloads/D2_4/D2_4_Complete_FINAL3.pdf).





**Fig. 3.** Schematic process of an integrated energy plan and principal barriers, based on (Mirakyan and De Guio, 2013); Actors in continuous frame: directly involved in the phase; Actors in dotted frame: scarcely involved in the phase.

**Table 3**  
structure of the questionnaire with aims and inquired data.

Level	Aims	Inquired data
Municipality	<i>Presence of energy awareness and policy</i>	Energy policies Energy office
General data	<i>Capability to gather general energy data about the municipality</i>	Number of inhabitants  Actual heating degree days (HDD) Energy consumption per sector (different classes of buildings, transportation, industry, agriculture etc.) and use (electricity and fuels) Energy production
Building stock data and supports	<i>Capability to gather specific energy data about the building stock</i>	Digital cartography with buildings geometry Buildings height Buildings number of floors Buildings roof shape Age of construction Regulatory constraints Usage of the buildings (residential, commercial, etc.) Construction materials (structure, envelope, windows) State of conservation Thermal transmittance of the envelope (U-value) Number of inhabitants per household Heating plant Renewable energy sources

mandatory energy plans or mandatory energy managers (see Section 2.1) we could expect some energy related expertise, but it is unlikely that other municipalities have such expertise. In most of cases, the municipal technical office has to manage all the issues related to the built environment, including energy issue. The competence to address issues related to energy is up to the profile and ethics of the technical staff of the single municipality.

### 2.3. Checking the assumed barriers

For a direct preliminary check of the assumptions about the barriers related to previously defined *Phase I* and *Phase II*, we carried out a survey among a sample of small to medium municipalities sending a questionnaire to the technical office. We selected a

sample among the 1,064 municipalities with 10,000–50,000 inhabitants in which 35% of the Italians live.

In this survey, we did not take into account municipalities with more than 50,000 inhabitants because for them the energy plan is mandatory by law, so we can expect a major awareness and competencies about energy issue and building stock features in these municipalities.

On the other hand, municipalities with a population below 10,000 inhabitants were not taken into account because, since they are too small, we can expect few availability of human and economic resource to be involved. Indeed, as mentioned before, these municipalities are not even obliged to appoint the energy manager (FIRE, 2012). Anyway, they should not be neglected since 31% of Italians live in municipalities with a population below 10,000 inhabitants.

The questionnaire was sent to municipalities all over Italy, first divided into two municipal size classes (10,000–20,000 and 20,000–50,000). We also divided the municipalities according to the sub-national geographic division used by Eurostat (i.e. North-West, North-East, Centre, South, and Islands). For the selection, we pick up the municipalities in proportion to the number of municipalities in each province.

In Table 3, we reported the aims and the data inquired about in the questionnaire. The scope of the first part is to understand the level of awareness of the municipality in energy and buildings issues and if energy policies or other pertinent initiatives were carried out. The second part inquires about the ability of the municipal offices to collect energy data regarding the entire municipality. The third part requires a better knowledge of the building stock, inquiring about data necessary to develop and apply an energy plan focused on promoting energy saving in buildings by retrofit.

To select the set of requested data we took into account the current development of the research in the national context. We compared the set of data adopted by three recent methodologies to assess the energy performance of the built environment and to simulate improved scenarios: a methodology to assess the energy performance of large building stock (Fracastoro and Serraino, 2011); a methodology to assess the potential energy savings by retrofitting residential building stocks (Dall'O' et al., 2012); and a methodology to define energy strategies in the building sector at urban scale (Caputo et al., 2013). In Table 4, we summarized the data and the sources used by the different methodologies. The main source of data for Fracastoro and Serraino (2011) is the National Census, integrated by energy standards and laws, literature and authors' assumptions. The methodology by Dall'O' et al. (2012) is based on detailed cartography and in situ surveys, integrated by energy standards and laws, literature and authors' assumptions. Caputo et al. (2013) elaborated detailed data from National Census in a Geographic Information Systems and defined building archetypes for simulating the actual and improved performance of the building stock. An analogous approach was recently followed by Ballarini et al. (2014) for defining and adopting reference buildings to assess the energy saving potentials of the residential building stock on the basis of the results of the European project TABULA.<sup>8</sup> We can state that, although there are differences and specificities, there is a common core of data adopted in the mentioned methodologies to characterize the energy efficiency of the building stock. We assume that this set of data is necessary for an energy building stock analysis, so we ask about it in the questionnaire. We would like to underline that we did not request the mentioned data but only if these data were available (i.e. easily and directly accessible) in the database commonly used and managed by the municipal technical office.

### 3. Results and discussion

The results of the questionnaire confirm us that, in small and medium Italian municipalities, there are several barriers to develop effective municipal energy plans. In the next sections, we present some possible solutions to overcome the detected barriers relevant to *Phase I (preparation and orientation)* and *Phase II (model design and detailed analysis)*.

#### 3.1. Results of the questionnaire

Unfortunately, the response rate to the questionnaire was very low: among 108 municipalities involved, just 10 partially answered

and only 4 completed the entire questionnaire. This was an important result, a clear sign of the lack of preparation of the municipal offices in facing energy issues related to the built environment. In order to improve the collected information, we conduct also some interviews to investigate better the energy problem at municipal level, calling the technical office. During the phone interviews, we asked why they were not able to compile the questionnaire, and which barriers represent the main obstacles in developing a building stock analysis and an energy balance. The outcome of the interviews allowed us to consolidate our reconnaissance of the main non-technical barriers. The following common problems were detected: dispersion of data among several municipal offices and other administrative entities; lack of coordination among the different offices, different archives systems for data and/or lack of digital archives; lack of a statistical office; lack of interest at decision-making level. The data scattering among several offices and other public entities could be overwhelming for smaller municipalities: they are not aware of data collected by other public entities and thus do not require nor use them. Further our questionnaire helped us in understanding which data are available for small-medium Italian municipalities and if these data are suitable to develop an effective municipal energy plan for the built environment. We here present the best and worst data availability found analysing the answers to our questionnaire, as depicted in Figs. 4 and 5. Data available are represented as green light; data not available are represented as red light; data that could be filled taking into account other sources are represented as yellow light, as depicted in Table 5. In particular, Fig. 4 is referred to the municipality with the best data availability, among those investigated by the questionnaire. It is the case of a relatively large municipality, with 36 thousand inhabitants, located in North-East Italy, a relatively wealthy region. In this case, it is possible to calculate the energy consumption for heating, while other information (e.g. the thermal transmittance of the envelope, information about the current heating systems and plants) could be approximated by statistical data at national or regional level, as reported in Table 5. A feasibility analysis of the retrofit measures could not be fully done because there are no data about the technical features and state of conservation of the building stock (e.g. materials, state of conservation, etc.). Further, there are no data about the roof surfaces (materials, orientation, and inclination). This is an important gap because the surfaces of the roofs, if correctly oriented and not shaded, can be employed for the integration of solar systems (thermal collectors or PV modules) in order to exploit the solar potential of the municipal built environment. Furthermore, there is an annual report on the energy consumption at municipal level, but no data about the energy production. Of course, energy sources and conversion systems can be estimated taking into account the national or regional energy system, but all these approximations compromise the comparison between the current situation and possible future improved scenarios.

On the contrary, Fig. 5 is referred to the municipality with the worst data availability, among those investigated by the questionnaire. It is clear that data are insufficient to develop a reliable building stock evaluation and an effective municipal energy plan, although some data could be filled with other sources of information. In particular, the lack of data about the energy consumption of the building sector and for the different final energy use does not permit to create a reference baseline.

It should be noted that these are the best and worst data available we found: other municipalities have different data availability, although of similar size. Some technical offices are not aware of the availability of data at national or regional level and do not collect data at municipal level. The capability to collect energy data depends on the individual local administration and the results are quite different.

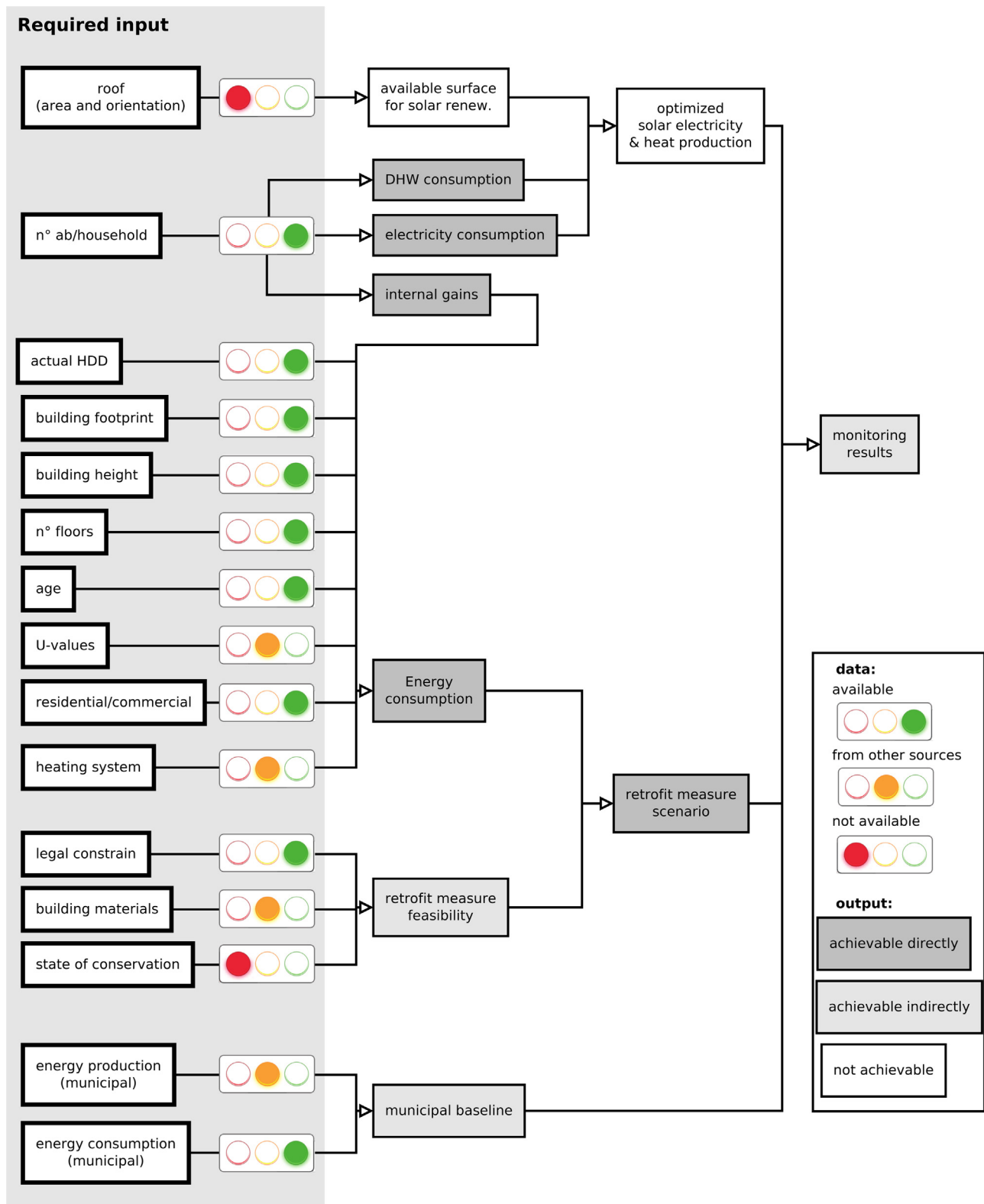
<sup>8</sup> [www.building-typology.eu](http://www.building-typology.eu).

**Table 4**

Comparison between recent Italian methodologies on the use of data and sources for the characterization of the building stock.

Categories	Data	Fracastoro and Serraino (2011)		Caputo et al. (2013)		Dall'O' et al. (2012)	
		Raw data	Source	Raw data	Source	Raw data	Source
Geometry	Dipersing surface	Floor area	ISTAT national census	Floor area	Cartography	Floor area	Cartography
		Net floor height	<i>Derived</i>	Perimeter	Cartography	Perimeter	Cartography
		Contiguity	ISTAT national census	Height	Cartography	Height	<i>Derived</i>
	Net floor area	Floor area per room	ISTAT national census	Gross floor area	Cartography	Gross floor area	Cartography
		No. of rooms per household	ISTAT national census	Gross/net ratio	Authors	Gross/net ratio	Authors
		No. of household per building	ISTAT national census				
	Height	Floor area	ISTAT national census	–	Cartography	Number of floors	Cartography
		h/Af ratio by age	Authors			Floor height	Authors
	Heated volume	Net floor area	<i>Derived</i>	Net floor area	<i>Derived</i>	Net floor area	<i>Derived</i>
		Net floor height	<i>Derived</i>	Net floor height	<i>Derived</i>	Net floor height	<i>Derived</i>
Construction	Glazed area	Net floor area	<i>Derived</i>	Net floor area		Ag/Aw ratio	Sample survey
		Ag/Af ratio by age	Authors	Ag/Af ratio	D.M. 1975	Wall area	Cartography
	Roof area for renewables					Roof area	Cartography
						South exposition	Survey
	Age	–	ISTAT national census	–	ISTAT national census	–	Cartography
	U-values	Official U-values by age	UNI/TS 11300-1 laws 373/76 and 10/91	Official U-Values by age	UNI TS 11300-1 CNR 1982	Official U-values by age	UNI/TS 11300-1 laws 373/76 and 10/91
	Overall heating system efficiency	System efficiencies	UNI TS 11300-2	Heating system efficiencies	UNI TS 11300-2	Heating system efficiencies	UNI TS 11300-2
		Boiler efficiency	Literature	Cooling system efficiencies	UNI TS 11300-3	Systems' type	ISTAT national census
	State of conservation			Systems' type	ISTAT national census		
	Windows materials					–	In situ survey
Usage	Regulatory constraints					–	In situ survey
						–	Cartography
	Average indoor temperature	Conventional value	Authors	Conventional value	Authors	Conventional value	Authors
	Residential/commercial			Residential volume	ISTAT national census		Cartography
				Overall volume	Cartography		In situ survey
	Average number of air changes per hour	Technical standards	Authors	Technical standards	Authors	Technical standards	Authors
	Internal gains	Occupancy rate	Authors		Literature		
	DHW + cooking	Persons	ISTAT national census	–			
		Energy consumption per person [kWh/(pers year)]	Literature	–	UNI TS 11300-2	Energy consumption per person [kWh/(pers year)]	Literature
		Square metres per person	ISTAT national census			Square metres per person	ISTAT national census
Meteo	Electrical	Energy consumption per person [kWh/(pers year)]	Literature	–	Literature	Energy consumption per person [kWh/(pers year)]	Literature
		Square metres per person	ISTAT national census			Square metres per person	ISTAT national census
	Conventional DD	–	D.P.R. 412/1993	–	D.P.R. 412/1993	–	D.P.R. 412/1993
	Actual DD	Calculated	ARPA	Typical meterological year	Energy Plus database	Calculated	ARPA
	Clima		ARPA	Typical meterological year	Energy Plus database		ARPA
	Solar irradiance	–	ARPA	Typical meterological year	Energy Plus database	–	ARPA





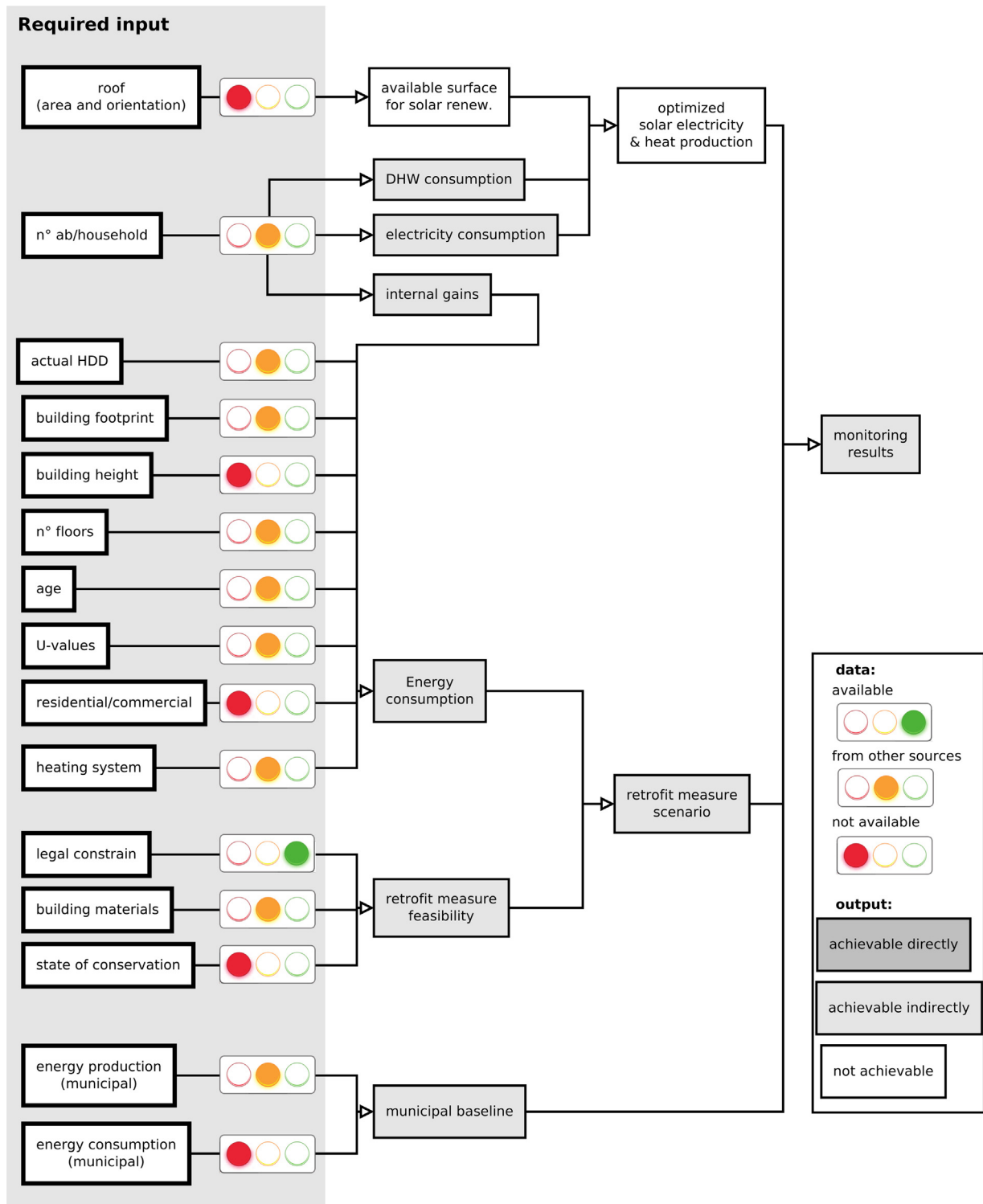
**Fig. 4.** Municipal energy model required input and possible output: data availability and output achievability in the best case.

### 3.2. Overcome barriers to preparation and orientation phase

#### 3.2.1. Be aware of energy problem

From the technical literature and from our survey we can state that among the local administrations there is a diffuse interest about the energy problem, but there is no real awareness of the

possible active role of their own municipality. The energy issue cannot be left to the willingness of the single local governments; there is a need for a better organization and coordination of the bodies involved in energy planning. The central (national) government should be more supportive, providing all the necessary information, resources and help to the local governments. More stability,



**Fig. 5.** Municipal energy model required input and possible output: data availability and output achievability in the worst case.

continuity, uniformity and coordination in rules, regulations, supports, and tools represent an urgent need. Support mechanisms should be optimized on the basis of the lessons learned in the past and economic-financial incentives must be better advertised along with the possibility to create new local activities and jobs.

Another help can concern the definition of a new model of mandatory municipal energy plan focused on possible, affordable, effective and monitorable (from the economic and environmental point of view) interventions. The new energy plan must arise

from consultations among local and central administrations, in order to make the plan effective. Economic and financial aspects are very important also in this phase, as pointed out in many references including also Theodoridou and Papadopoulos (2011) and Tommerup and Svendsen (2006).

### 3.2.2. Set goals

It is very important to define tailored objectives at municipal level. This is not possible in the absence of coherent problem

**Table 5**

Necessary data and possible source at different level; in light grey sources that may not be present.

	Data	Municipal sources	Regional sources	National sources
General data	Energy policies	Municipal legislation	Regional legislation	National legislation; ENEA
	Energy incentives	Municipal legislation	Regional legislation	National legislation; ENEA
	Inhabitants	Municipal register office		ISTAT: demograph statistics
	Official Degree Days			D.P.R. 412/1993
	Actual Degree Days		ARPA	
	Design temperatures		ARPA	D.P.R. 412/1993
Building stock	Municipal energy consumption	<i>Municipal energy plan [only &gt;50k inhab.]</i>		TERNNA
	Energy production			GSE; MiSE
	Building footprint	<i>Municipal planning office</i>	Region: planning office CTR (1:5000)	National Revenue Agency: Land Registry
	Building height	<i>Municipal planning office</i>		ISTAT: national census (no of floors)
	Construction age	<i>Municipal planning office</i>		ISTAT: national census
	Regulatory constraints	<i>Municipal urban plan</i>	Regional legislation	National legislation
	State of conservation			ISTAT: national census
	Building materials			ISTAT: national census (brick or concrete)
	Energy performance (Eph, U-values, heating systems, etc.)		Regional register of energy performance certificates	UNI TS 11300-1:2008
	Inhabitants per household	Municipal register office		ISTAT: national census
Renewable energy sources	Commercial/residential use	Municipal productive activities desk	Chamber of commerce: businesses cadastre	
	Heating systems	<i>Municipality [ &gt;40k inhab.]: heating plant cadastre</i>	<i>Province: heating plant cadastre [for munic. &lt;40k inhab.]</i>	ISTAT: national census (independent or centralized plant)
			Regional energy register	GSE

awareness and local energy data, since goals should be defined taking into account local peculiarities and reasonable efforts. The major risk is to correlate energy policy goals to political mandates and administrative duties with a limited duration.

Further, a methodology to verify and monitor the achievement of the goals should accompany the goals definition from the beginning. Affordable intermediate milestones should be also precisely indicated.

The national burden sharing decree (D.M. 2012) quantifies the intermediate and final goals that each Region must achieve in order to reach national targets for 2020 in terms of share of energy from renewable sources. However, the regional goals are not enough: for an effective local energy planning it is also necessary to define the municipal goals. A project leads by three Regional Authorities (<http://www.factor20.it>) considers the mandatory regional objectives set by the national burden sharing decree (D.M. 2012) and the real opportunities of the territories, developing tailored municipal goals. If the results of the testing phase are satisfactory, the methodology (Factor20, 2012) could be applied to the other Italian municipalities. A similar approach is also needed with regard to energy efficiency goals, which are now neglected.

As suggested in (EBC, 2013), it is important to establish a set of supporting indicators in order to compare targets and achieved results to national or average values and to benchmark other municipalities. For example, as city-wide key indicators related to the municipal energy performance, the following can be suggested: electricity per capita ( $\text{kWh}_{\text{el}}/\text{cap}$ ); thermal energy per capita ( $\text{kWh}_{\text{th}}/\text{cap}$ ); and tonnes of equivalent carbon dioxide per capita ( $\text{t CO}_2\text{eq}/\text{cap}$ ). Referring to buildings, the following indicators can be considered: thermal energy per floor area ( $\text{kWh}_{\text{th}}/\text{m}^2$ ) and electricity per floor area ( $\text{kWh}_{\text{el}}/\text{m}^2$ ). Further indicators can be adopted in order to verify the economic effectiveness of energy and  $\text{CO}_2$  emissions savings and the willingness to pay.

### 3.3. Overcome barriers to detailed analysis phase

#### 3.3.1. Collect data

The data collection seems the most engaging barrier because of the dispersion of data among several municipal offices and other

administrative entities and the lack of interoperability among the data collection systems. The need to make data of building stock sharable, accessible and compatible for different scopes and by different offices is very urgent. This barrier can be overcome with a concerted effort at the national and local levels, gathering all the needed data into a new Municipal Energy Model (MEM).

We imagine this MEM as a template able to collect real data about energy and public and private building stock and to create effective policies for an operative refurbishment. The description of the proposed MEM can be found in Section 3.4.

An example of effort in data collection is the Homes Energy Efficiency Database (HEED): the Government of United Kingdom developed a data-framework that draws together data on energy efficiency retrofits in approximately 13 million homes. This high quality data-framework helps the UK Government to develop and monitor ambitious energy retrofit programmes such as the Green Deal (DECC, 2010). In a recent work, Hamilton, Steadman, Bruhns, Summerfield, and Lowe (2013) describe the data and the policy implication of such detailed database. They underline that HEED is not the product of a large omnibus survey or a concerted monitoring and reporting exercise, but offers a repository and framework for a range of disparate activities that are centred on home energy efficiency.

The need of a data collection framework in Italy originates from the fact that data about building energy efficiency are scattered among several authorities and are often not uniform. In this context many sources of data are available, such as:

- ISTAT, Italian National Institute of Statistics;
- National Revenue Agency (also collect data for building cadastre and land values);
- GSE Operator of Energy Systems, state-owned company which promotes and supports renewable energy sources;
- AEEG Regulatory Authority for Electricity and Gas;
- ARPA, Regional Agency for Environmental Protection;
- Regional register of energy performance certificates.

Many data come from national sources, with a low level of detail, but at first rough data can be collected and then they can be gradually refined with new data sources. For instance, U-values and other energy performance data (e.g. heating energy demand and heating consumption) could be derived from energy performance certificates or estimated with different methodologies, for buildings that have not yet an energy performance certificate. Currently Italian regional authorities are in charge to update the register of energy performance certificates. Unfortunately, the implementation of the regional registries is not complete, since only 11 regional authorities out of 21 have an operating register (CTI, 2013). Further, the methodology for the energy certification is different among the several regions and the reliability of certificates is not guaranteed because monitoring activities are still in an experimental phase (CTI, 2013).

In future, thanks to smart metering, data about final energy consumption in buildings will be increasingly detailed and data accessibility will be more widespread, following the open data policy. In fact, the European Commission conveyed its policies with *Open data: An engine for innovation, growth and transparent governance* (COM 2011, n. 882) and, on smart metering, with *Preparations for the roll-out of smart metering systems* (2012/148/EU).

Further, in the Italian context there are already some initiatives to expand the data availability, such as that of the initiative by Authority for Electricity and Natural Gas (AEEG, 2013) to incentivise pilot projects for multi-service smart-metering, so it will be possible to know the consumption of electricity, water, and natural gas.

As example of good practice a platform set up by Lombardy Region (<http://www.energielombardia.eu>) can be mentioned. The scope is to collect in a single platform data about energy consumption in all the sectors and for all the final uses, buildings energy performance (envelopes and systems), and integration of renewable sources (Cestec, 2012). These data are available at municipal level and derive from several regional databases; the most complete and updated are: SIRENA, Information system for energy and environment (<http://sirena.finlombarda.it>); CENED, Register of buildings' energy certificate (<http://www.cened.it>); and CURIT, Register of heating plants (<http://www.curit.it>).

### 3.3.2. Possess technical knowledge

Argyriou, Fleming, and Wright (2012) find that senior leadership, cross departmental collaboration, interdisciplinary work, and a critical mass of local administration personnel would be factors of success in tackling climate change at the local level. The study underlines the importance of expertise sharing between local authorities in sustainable energy development.

In order to start this virtuous path, we suggest that all municipalities should have a mandatory office dedicated to climate and energy issues. In Italy, the energy manager is already compulsory for public administration with an annual consumption over 1,000 toe but currently only 10% of the compelled municipalities have an energy manager. We suggest to enforce the law and extend it to all municipalities, also increasing the scope and expertise of the energy manager.

A reform and an upgrade of the existing technical office can accompany this process, since energy is a multidisciplinary issue. The technical office should be enriched by energy and statistics expertise. These competencies are very important, as highlighted by our interviews. Of course, this reform implies efforts in terms of human and economic resources, information and training.

### 3.4. Suggestions and tools for more effective energy policies

In the previous sections we stated that national energy policies so far undertaken are giving results too slow and that it is

possible to overcome the barriers of the local administration by completing some policies already in place and creating some new policies. Our proposal is schematized in Fig. 6. It should be noted that to tackle the energy issue in buildings effectively and renovate the building stock adequately it is necessary a combined top-down and bottom-up strategy. The central government must act as leader and coordinator and must ensure that local administrations have adequate information on the energy issue and knowledge about support mechanisms. The central government should encourage local administrations to act on their territory, through local energy plans, to achieve shared goals. With a deeper knowledge of the territory, it is possible to ask each municipality to meet a goal tailored to its real potential in terms of energy saving, acting also on the building stock retrofit. The regional administration could monitor and compare results obtained in different municipalities helping to find best practices and to avoid unsuccessful or non-effective interventions. The definition and calculation of precise indicators such as, public and private cost of avoided toe or of avoided tonne of CO<sub>2</sub> emissions could support the evaluation of the effectiveness of the undertaken interventions to improve energy efficiency in buildings. This is particularly useful in the present context due to the long lasting economic and financial crisis.

On the other hand, the local administration, in the early phases, must involve citizens, building manager and owners, energy savings companies (ESCOs), and other stakeholders. Indeed, in order to make the energy planning pragmatic and effective, it is important to address the barriers for the last two phases (*Phase III: Prioritization & Decision and Phase IV: Implementation & Monitoring*). These phases are strictly connected to Phase I and Phase II while feedback effects are also possible. Our future work will focus on the last two phases, but we can already say that the proposed framework, with a new Municipal Energy Model and a new energy office, is useful not only for the first and second phases, but also for the last phases.

In order to set up an effective energy planning at local scale it is first necessary to carry out a preceding phase (pre-phase). The purpose of the pre-phase is to improve data availability and management in every Italian municipality, with an effort at national or regional level. Energy and building stock data that are actually scattered among several sources, as described in Table 5, must be collected and organized. With a national framework, it will be possible to provide an up to date energy and environmental baseline for each Italian municipality. With a better knowledge of energy and building stock, it is possible to ask each municipality to meet a goal tailored to its real potential in terms of energy saving and exploitation of renewable energy sources. With a common framework, it is also possible to monitor and compare results obtained in different municipalities.

To exploit this pre-phase and start an effective local energy plan, there is the need of more expertise at the local level. We thus propose a reform of the municipal technical office, which include a mandatory energy office to deal with the energy issue at municipal scale. As already mentioned, there is a national law (L 10/1991) that oblige some municipality to appoint an energy manager, but does not oblige all municipalities and it is scarcely implemented. The same law define the tasks of the energy manager, which can be briefly resumed as the quantification of energy consumption, the optimization of energy supply and the promotion of good practices. The field of action concerns the energy directly consumed in public buildings and not a broader action on the entire municipality. We suggest to enlarge the operation of the energy manager in the framework of the mentioned energy office, dealing both with the energy consumed directly by the local administration (public buildings), and with the energy consumed within the municipality.

With a consistent database and the proper expertise at the local level, it is possible to think of an advanced tool to collect energy information and manage effective local energy plan. We propose a

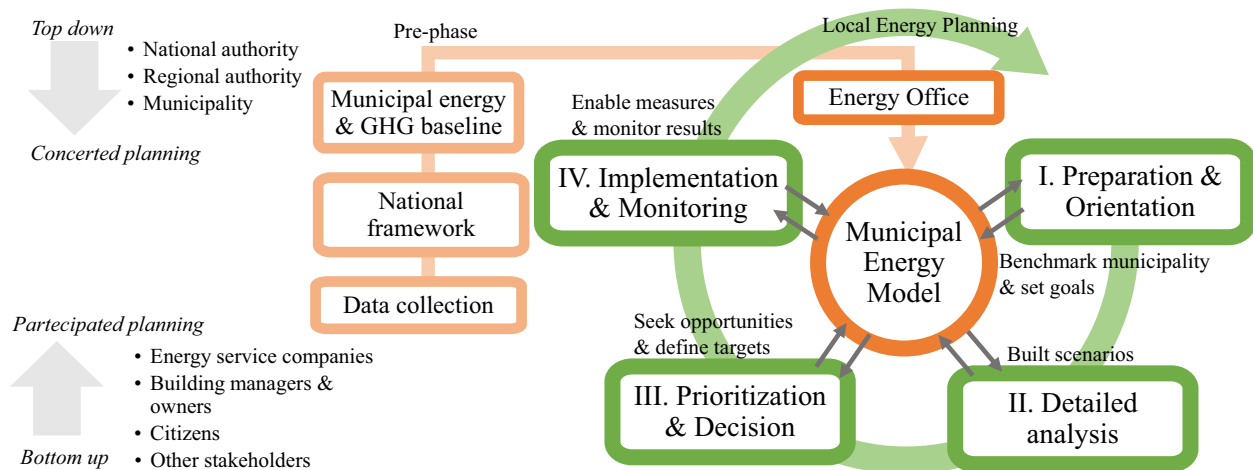


Fig. 6. Scheme of proposed policies in a new local energy planning process.

new Municipal Energy Model (MEM), able to give a geo-referenced representation of the state of the entire building stock of the municipality, with information about energy consumption, production, and features. As already mentioned, information could be rough at the beginning and then they can be gradually refined when new sources of data are available, such as the new possibilities by smart metering and open data policies.

The energy office may use the MEM in each energy planning phases both to provide support and to modify the model according to the feedback received. In the *Preparation & Orientation* phase, the MEM could be used to benchmark the municipality and set feasible goals targeted on the municipality. In the second phase the model could be very useful to depict a detailed analysis of the building stock and to propose plausible scenarios. During the *Prioritization & Decision* phase, the MEM allows to give transparent information to all stakeholders about the building stock and the possibility to renovate it. Using the MEM to seek the real opportunities for energy measures, it is possible to define reachable targets with the involvement and consensus of citizens and other stakeholders. In the last phase the technical office could update the MEM according to the measures actually implemented, thus having a timely control on the progress of the energy plan and the actual results. When a local energy planning cycle is finished, we will be left with an updated Municipal Energy Model, ready for the next planning cycle.

### 3.5. Why overcome the barriers?

Drastic programmes and actions are required at global and local level in order to control climate change and relative effects, increase of urban population, migration, increase of global energy demand and non-renewable energy resources depletion, global economic and financial crisis.

The analysis of BPIE (2011) shows that, for the European building stock, it is possible to achieve in 2020 annual energy saving from 94 TWh (business-as-usual) to 527 TWh (best scenario) and in 2050 from 365 TWh (business-as-usual) to 2896 TWh (best scenario). However, this is only a technical potential and must be tackled with effective national and local energy plan.

A deep evaluation of the current energy efficiency policy framework forwards 2020 targets and beyond was recently developed by the European Commission 2014.<sup>9</sup>

In Italy the annual potential energy saving expected by the National Energy Efficiency Action Plan (PAEE, 2014) from the refurbishment of the building stock in 2020 is 48.9 TWh for the residential buildings and around 17.2 TWh for non-residential buildings.

Starting from data reported in Tables 1 and 2 and taking into account the results recently published in the framework of Entranze Project ([www.entranze.eu](http://www.entranze.eu)), we tried to give an idea of the energy saving potential related to the Italian residential buildings (Tables 6 and 7). We obtained the mentioned results on the basis of the following assumptions:

- we considered the “single house” building type reported in Entranze Project as representative for Italian residential buildings with 1 to 4 units;
- we considered the “apartment block” building type reported in Entranze Project as representative for Italian residential buildings with 5 units or more;
- among the locations analyzed in Entranze Project, we took into account the climatic conditions of Rome as representative of the Italian climate (conservative hypothesis, because the Italian mean climatic conditions are colder than those in Rome);
- we roughly calculated the potential energy savings and the economic performances taking into account the overall heated surface corresponding to the buildings of the two categories (single house or apartment block) and representing the results grouped by municipalities' sizes.

In Tables 6 and 7, we consider the costs of base refurbishment (base renovation of the building/HVAC technologies for aesthetical/obsolescence/safety reasons without specific energy efficiency aims) and the costs of cost optimal refurbishment (improved refurbishment, taking into account technologies for cost optimal interventions), as defined in Pietrobon et al. (2013). We show the extra-cost as difference between these two costs. We did the calculations considering both the investment costs and the global costs, again as defined in Pietrobon et al. (2013). The results of Table 7 in terms of energy saving represent the maximum theoretical energy saving we can reach acting on all the residential buildings and following a cost optimality approach instead of a “physiological” refurbishment. Further, we are aware of the level of approximation of the obtained results and we will study more precisely the energy and economic potential in the following improvement of our research. Despite of this, looking at Table 7 we can underline the importance of introducing more effective retrofit measures in small and medium municipality. This confirms our initial

<sup>9</sup> [http://ec.europa.eu/energy/efficiency/studies/doc/2014\\_report\\_2020-2030\\_en\\_policy\\_framework.pdf](http://ec.europa.eu/energy/efficiency/studies/doc/2014_report_2020-2030_en_policy_framework.pdf).



**Table 6**

Estimation of primary energy and costs of refurbishment in residential buildings.

Building typologies defined in <a href="http://www.entranze.eu">www.entranze.eu</a>			
Single house		Apartment block	
Estimated net primary energy by base refurbishment (1), kWh/m <sup>2</sup> y	193	Estimated net primary energy by base refurbishment (1), kWh/m <sup>2</sup> y	157
Estimated net primary energy by cost optimal refurbishment (2), kWh/m <sup>2</sup> y	41	Estimated net primary energy by cost optimal refurbishment (2), kWh/m <sup>2</sup> y	70
Global extra-cost of retrofit, €/m <sup>2</sup>	−127	Global extra-cost of retrofit, €/m <sup>2</sup>	−173
Extra-cost of retrofit, investment cost €/m <sup>2</sup>	115	Extra-cost of retrofit, investment cost €/m <sup>2</sup>	53

Elaborations by the authors starting from data reported in Pietrobon et al. (2013).

**Table 7**

Estimated performance of the retrofit actions sorted by municipalities' sizes.

	Municipalities' size			Total
	Less than 10,000 people	From 10,000 to 50,000 people	More than 50,000 people	
Estimated net primary energy by base refurbishment, kWh/m <sup>2</sup> y	192	190	184	
Estimated net primary energy by cost optimal refurbishment, kWh/m <sup>2</sup> y	43	44	49	
Estimated primary energy savings, GWh/y	139,481	116,186	104,924	360,591
Estimated primary energy savings in 30 years, MTOE	359	299	270	927
Global extra-cost of retrofit, €/m <sup>2</sup>	−129	−132	−139	
Extra-cost of retrofit, investment cost €/m <sup>2</sup>	112	109	99	
Total global extra-cost of retrofit, M€	−121,163	−104,985	−108,024	−334,171
Total extra-cost of retrofit, investment cost M€	104,708	86,689	76,553	267,950

hypothesis about the importance of developing effective regulatory and planning measures also for small-medium municipalities.

The negative values of the global extra-cost of Table 7 mean economic benefits. Certainly the expected economic benefits can represent an important challenge to overcome the inertia given by the crisis at least in the long term.

#### 4. Conclusions

Municipalities have a very important role in this framework since significant results can be obtained by the improvement of their energy systems towards more sustainable paradigms. To that end, retrofit interventions oriented to drastically decrease the energy demand in the building stock seem to be the more cost-effective and efficient measures. In this framework, as acknowledged by the European Union through several directives and initiatives, the role of the local public administrations is fundamental. The Italian regulative framework follows the European regulatory framework, but it is more complicated and instable. This has dangerous effects, especially at municipal scale. Indeed, there is no common model or obligation about energy planning and knowledge of the features of the building stock.

Furthermore, as depicted in Section 2.1, also the built environment is highly fragmented, with the majority (66%) of the Italians living in small and medium municipalities (up to 50,000 inhabitants) and with the large majority of buildings (more than 90%) with less than 8 households.

From the Italian experience of the last two decades, we learned that often even good plans find difficulties in achieving and monitoring results. Hence, we analyzed the barriers to develop an effective municipal energy plan: we analyze in Section 2.2 the first two phases (i.e. *preparation and orientation*; *detailed analysis*), that directly concern the municipal administrations and we checked them in Section 2.3. Taking into account the available technical literature and the results of questionnaire we sent to a sample of small and medium Italian municipalities, we have presented in Section 3 some policies and tools to overcome these barriers.

Although the suggestions we present in this paper may seem obvious, in Italy the implementations of these policies can deeply change the approach of municipal energy planning. In fact, a

correct and updated knowledge of the features of the built environment could help in developing achievable and cost effective plans and interventions, taking into account local conditions and pertinent targets. Our future work is to develop a new GIS tool (provisionally called “Energy Scout”) that can help in immediately identifying the most promising areas to be involved in the process of energy renovation and in simulating possible energy scenarios. A clear knowledge of the regulation framework and of the available incentives can contribute in overcoming the non-technical barriers and attracting potential investors and stakeholders. The proposed Municipal Energy Model and the renovation of the municipal technical office are the basis for this new Energy Scout tool, which can support in matching the interests of buildings owners, ESCOs, and other potential investors. This could bring important results from the economic, energy, and environmental point of view, especially if accompanied by a scrupulous monitoring of the expected goals.

#### References

- 2010/31/EU. (2010). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast). *Official Journal of the European Union*.
- ACEA, CISPE. (1997). *Il Piano Energetico Ambientale Comunale. Linee metodologiche in applicazione della legge 10/91 art. 5 comma 5*. A cura dell'istituto di Ricerche Ambiente Italia. Milano: Edizioni Ambiente srl.
- AEEG. (2013). *Procedura e criteri di selezione degli investimenti ammessi alla sperimentazione di soluzioni di telegestione multi-servizio di misuratori di gas naturale di classe minore o uguale a G6 e di altri servizi di pubblica utilità*. Autorità per l'Energia Elettrica e il Gas.
- Argyriou, I., Fleming, P., & Wright, A. (2012). Local climate policy: Lessons from a case study of transfer of expertise between UK local authorities. *Sustainable Cities and Society*, 5, 87–95.
- Ballarini, I., Corgnati, S. P., & Corrado, V. (2014). Use of reference building to assess the energy saving potentials of the residential building stock: The experience of TABULA project. *Energy Policy*, 68, 273–284.
- Baek, C.-H., & Park, S.-H. (2012). Changes in renovation policies in the era of sustainability. *Energy and Buildings*, 47, 485–496.
- Baek, C.-H., Park, S.-H., Baek, C., & Park, S. (2012). Policy measures to overcome barriers to energy renovation of existing buildings. *Renewable and Sustainable Energy Reviews*, 16, 3939–3947.
- BPIE. (2011). *Europe's buildings under the microscope: A country-by-country review of the energy performance of buildings*. Buildings Performance Institute Europe (BPIE). ISBN: 9789491143014. <http://www.bpie.eu>
- BPIE. (2013a). *A guide to developing strategies for building energy renovation*. Buildings Performance Institute Europe (BPIE). ISBN: 9789491143076. <http://www.bpie.eu>



- BPIE. (2013b). *Boosting building renovation: An overview of good practices*. Buildings Performance Institute Europe (BPIE). <http://www.bpie.eu>
- Caputo, P., Costa, G., & Ferrari, S. (2013). A supporting method for defining energy strategies in the building sector at urban scale. *Energy Policy*, 55, 261–270.
- Cestec. (2012). *PASSE: Una piattaforma aperta al dialogo*. Milan. <http://www.enerialombardia.eu>
- Chmutina, K., Wiersma, B., Goodier, C. I., & Devine-Wright, P. (2014). Concern or compliance? Drivers of urban decentralised energy initiatives. *Sustainable Cities and Society*, 10, 122–129. <http://dx.doi.org/10.1016/j.scs.2013.07.001>
- Comodi, G., Cioccolanti, L., Polonara, F., & Brandoni, C. (2012). Local Authorities in the Context of Energy and Climate Policy. *Energy Policy*, 51, 737–748. <http://dx.doi.org/10.1016/j.enpol.2012.09.019>
- Cresme, & Legambiente. (2013). *L'innovazione energetica in edilizia – Rapporto ONRE 2013*.
- Cresme. (2012). *Città, mercato e rigenerazione 2012. Analisi di contesto per una nuova politica urbana*. Milan.
- CTI. (2013). *Attuazione della certificazione energetica degli edifici in Italia*. Comitato Termotecnico Italiano Energia e Ambiente. <http://www.cti2000.eu>
- Dall'O, G., Galante, A., & Pasetti, G. (2012). A methodology for evaluating the potential energy savings of retrofitting residential building stocks. *Sustainable Cities and Society*, 4, 12–21.
- DECC. (2010). *The green deal – A summary of the Government's proposals* Ref: 10D/996 published 9-12-2010. UK Department of Energy & Climate Change. <https://www.gov.uk/government/publications/the-green-deal-a-summary-of-the-governments-proposals>
- D.M. 2012. Decreto Ministeriale del 15 marzo 2012: Definizione e quantificazione degli obiettivi regionali in materia di fonti rinnovabili e definizione delle modalità di gestione dei casi di mancato raggiungimento degli obiettivi da parte delle Regioni e delle Province autonome (c.d. Burden Sharing). *Gazzetta Ufficiale* n. 78 del 2-04-2012.
- Dowson, M., Poole, A., Harrison, D., & Susman, G. (2012). Domestic UK retrofit challenge: barriers, incentives and current performance leading into the Green Deal. *Energy Policy*, 50, 294–305. <http://dx.doi.org/10.1016/j.enpol.2012.07.019>
- Emmert, S., van de Lindt, M., & Luiten, H. (2013). *BarEnergy: Barriers to changes in energy behaviour among end consumers and households*. [www.barenergy.eu](http://www.barenergy.eu)
- ENEA. (1997). *Dipartimento Energia, Unità Piani Energetici Territoriali*. Frascati, Roma: Guida per la pianificazione energetica comunale.
- ENEA. (2013). *Rapporto Annuale sull'Efficienza Energetica 2012*. Rome: Unità Tecnica Efficienza Energetica ENEA. [www.ufficienzaenergetica.enea.it](http://www.ufficienzaenergetica.enea.it)
- Energy in Buildings and Communities (EBC) Annex 51. (2013). *Case studies and guidelines for energy efficient communities: A guidebook on successful urban energy planning*. Fraunhofer IRB Verlag.
- EU COM 112. (2011). *A Roadmap for moving to a competitive low carbon economy in 2050*. Brussels: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions n°112.
- Factor20. (2012). *PROGETTO FACTOR 20 – FASE PA2 DELIVERABLE 6: Ripartizione obiettivi a livello locale in Regioni F20*. Milan: Forwarding demonstrative ACTIONS On a Regional and local scale to reach EU targets of the European Plan20/20/20. [www.factor20.it](http://www.factor20.it)
- FIRE. (2012). *Presenza, rappresentatività e ruolo dei responsabili per l'uso razionale dell'energia in Italia*. Rome: Federazione Italiana per l'uso Razionale dell'Energia. [www.fire-italia.org](http://www.fire-italia.org)
- Fracastoro, G. V., & Serraino, M. (2011). A methodology for assessing the energy performance of large scale building stocks and possible applications. *Energy and Buildings*, 43, 844–852.
- Galvin, R. (2012). German Federal policy on thermal renovation of existing homes: A policy evaluation. *Sustainable Cities and Society*, 4, 58–66.
- Gamtesa, S. F. (2013). An explanation of residential energy-efficiency retrofit behavior in Canada. *Energy and Buildings*, 57, 155–164.
- Hamilton, I. G., Steadman, P. J., Bruhns, H., Summerfield, A. J., & Lowe, R. (2013). Energy efficiency in the British housing stock: Energy demand and the homes energy efficiency database. *Energy Policy*, 60, 462–480.
- Hoicka, C. E., Parker, P., & Andrey, J. (2014). Residential energy efficiency retrofits: How program design affects participation and outcomes. *Energy Policy*, 65, 594–607.
- ISTAT. (2012). *Indicatori ambientali urbani 2011*. Rome. [www.istat.it](http://www.istat.it)
- L. 10/1991. Legge 9 gennaio 1991. n. 10: Norme per l'attuazione del Piano energetico nazionale in materia di uso razionale dell'energia, di risparmio energetico e di sviluppo delle fonti rinnovabili di energia. *Gazzetta Ufficiale* n.13 del 16-1-1991 – Suppl. Ordinario n. 6.
- L. 220/2012. Legge 11 dicembre 2012. n. 220, Modifiche alla disciplina del condominio negli edifici. *Gazzetta Ufficiale* n. 293 del 17-12-2012.
- Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and Buildings*, 55, 889–902.
- Mata, E., Sasic Kalagasidis, A., & Johnsson, F. (2013). Energy usage and technical potential for energy saving measures in the Swedish residential building stock. *Energy Policy*, 55, 404–414.
- Mirakyan, A., & De Guio, R. (2013). Integrated energy planning in cities and territories: A review of methods and tools. *Renewable and Sustainable Energy Reviews*, 22, 289–297.
- Odyssee. (2012). *Energy Efficiency Trends in Buildings in the EU*. Lessons from the ODYSSEE MURE project. <http://www.odyssee-indicators.org>
- PAEE, 2014. Piano d'Azione Italiano per l'Efficienza Energetica. Approved on July 17th 2014. published on *Gazzetta Ufficiale* n. 176, 31-7-2014.
- Pietrobon, M., Armani, R., Zangheri, P., & Pagliano, L. (2013). *Report on Cost/Energy curves calculation* Report in the frame of the IEE project ENTRANZE. [www.entranze.eu](http://www.entranze.eu)
- SEN. (2013). *Strategia Energetica Nazionale: per un'energia più competitiva e sostenibile*. Ministero Sviluppo Economico.
- Swan, L. G., & Ugursal, V. I. (2009). Modeling of end-use energy consumption in the residential sector: A review of modeling techniques. *Renewable and Sustainable Energy Reviews*, 13, 1819–1835.
- Theodoridou, I., & Papadopoulos, A. M. (2011). Statistical analysis of the Greek residential building stock. *Energy and Buildings*, 43, 2422–2428.
- Tommerup, H., & Svendsen, S. (2006). Energy savings in Danish residential building stock. *Energy and Buildings*, 38, 618–626.
- UK CCC. (2012). *How local authorities can reduce emissions and manage climate risk*. Committee on Climate Change. [www.theccc.org.uk](http://www.theccc.org.uk)
- Zanon, B., & Veronesi, S. (2013). Climate change, urban energy and planning practices: Italian experiences of innovation in land management tools. *Land Use Policy*, 32, 343–355.