ANNEX 1 – Upgrading the energy efficiency of the national building stock

1 Preamble

In accordance with Article 4 of Directive 2012/27/EU, this document provides an overview of the national building stock in Italy. It identifies the intervention criteria on the basis of the optimisation of the cost/benefit ratio. It then examines the technical, economic and financial barriers that hinder the implementation of energy efficiency measures in buildings, recommending actions aimed at improving the effectiveness of supporting instruments. Lastly, it estimates the expected energy savings by 2020 in the civil sector.

2 National building stock

Italy lies between the 35th and 47th parallel north, with an extensive coastline that stretches for around 7 458 km. The terrain is predominantly hilly (41.6 %), with some mountainous (35.2 %) and lowland areas (23.2 %); the average altitude is approximately 337 metres above sea level.

Due to its latitude, Italy's climate ranges from a Mediterranean subtropical climate in the south (where temperatures can exceed 40 °C in summer), to a continental temperate climate in the north (where temperatures can fall to -20 °C in winter). The climate is therefore extremely variable, as shown by the number of 'degree days', which range from 568 in Lampedusa (Province of Agrigento) to 5 165 in Sestriere (Province of Turin). The global solar radiation incident on a horizontal surface is also affected by the different latitudes in Italy, ranging from 1 214 kWh/m^2 for Ahrntal (Province of Bolzano) to 1 679 kWh/m^2 for Pachino (Province of Syracuse), with an average of 1 471 kWh/m^2 (0.127 toe/m^2). These data illustrate Italy's unique climate and the difficulties in defining clear building and technical standards and solutions that can be adapted to the diverse conditions. The design and implementation of the measures must therefore be carefully thought out by specialists. Furthermore, all stakeholders, including end users, must be involved in the process to achieve the energy saving targets prescribed by law.

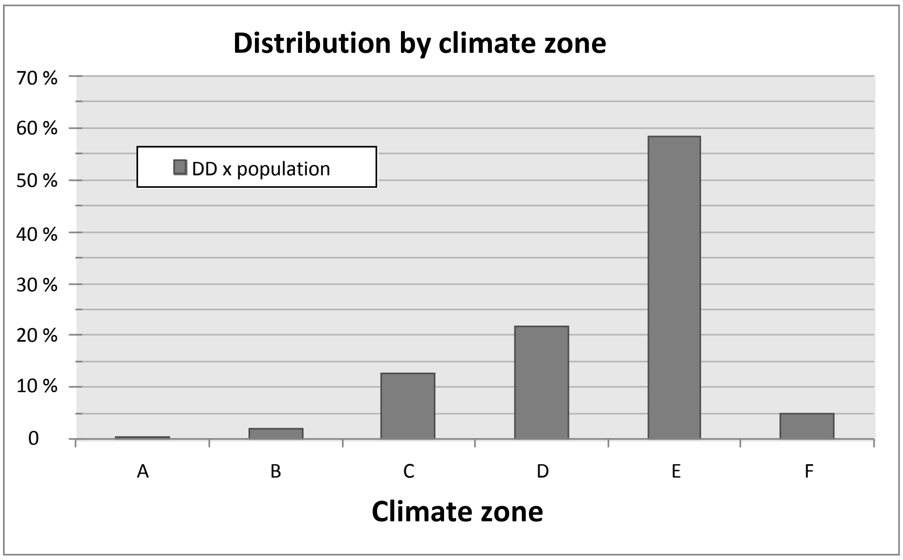
Table 1 lists Italy's climate zones and the number of municipalities in each one.

Table 1: Number of Italian municipalities by climate zone and 'degree days'

CLIMATE ZONE	DEGREE DAY (DD)	NUMBER OF MUNICIPALITIES	RESIDENT POPULATION	% RESIDENT POPULATION
A	DD ≤ 600	2	22 989	0.04 %
B	600 < DD ≤ 900	157	3 176 382	5.33 %
C	900 < DD ≤ 1 400	989	12 657 407	21.25 %
D	1 400 < DD ≤ 2 100	1 611	14 970 952	25.13 %
E	2 100 < DD ≤ 3 000	4 271	27 123 848	45.53 %
F	DD > 3 000	1 071	1 619 003	2.72 %

For the heating of existing buildings, national energy consumption can be considered proportional to the number of degree days multiplied by the population. Therefore, climate zone E, which is the most densely populated, has the highest percentage of consumption, while climate zone B has the lowest. Climate zone A, where only 0.04 % of the population lives (represented by only two municipalities), is excluded.

Figure 1: Distribution of population by climate zone



In 2015, final energy consumption totalled 116.4 Mtoe (excluding non-energy use), a 2.7 % increase on 2014. This was mainly due to the residential sector (+10 %) and tertiary sector (+4.9 %), which recorded consumption of 32.5 Mtoe and 15.4 Mtoe respectively. In the residential sector, this phenomenon was due to the climate factor[1], whereas in the tertiary sector, it was linked to the economic growth recorded in that sector. The structure of final energy consumption in 2015 illustrates the impact of the civil sector: this accounts for 41.1 % of total final consumption, up from 2014. The residential sector represents 27.9 % of this total, the service sector 13.2 %.

To conclude, the existing building stock is the sector with the highest potential for energy savings. However, the high investment costs pose a problem both for the government and the private sector.

For data on residential building stock, reference is made to the ISTAT 2011 census; for the non-residential sector, reference is made to the data contained in the CRESME and ENEA reports compiled during research into the national electrical system[2].

[1] Interestingly, 1 809 degree days were recorded in 2015, compared with 1 632 in 2014.
[2] Annual Implementation Plan (AIP) 2014 for the Programme Agreement between the Ministry of Economic Development and ENEA for research and development of general interest for the national electricity system.

2.1 Residential buildings

Italy has 12.2 million buildings intended for residential use, with more than 31 million dwellings. Over 60 % of this building stock is more than 45 years old (i.e. it predates Law No 373/1976[3], the first law on energy saving). Of these buildings, more than 25 % have annual consumption ranging from a minimum of 160 kWh/m^2 per year to over 220 kWh/m^2.

The current state of residential building stock is shown below by period of construction (Table 2) and climate zone (Table 3).

Building period	***Number of buildings***	***%***
Pre-1918	1 832 504	15.0
1919-1945	1 327 007	10.9
1946-1960	1 700 836	14.0
1961-1970	2 050 833	16.8
1971-1980	2 117 651	17.4
1981-1990	1 462 767	12.0
1991-2000	871 017	7.1
Post-2001	825 083	6.8
Total buildings	*12 187 698*	*100*

[3] Rules for reducing energy consumption for heating in buildings.

Table 2 – Residential buildings in 2011 by period of construction

Table 3 – Residential buildings in 2011 by climate zone

Climate zone	***Number of buildings***	***%***
Climate zone A	*4 875*	*0.04*
Climate zone B	*699 573*	*5.74*
Climate zone C	*2 710 544*	*22.24*
Climate zone D	*2 858 016*	*23.45*
Climatic zone E	*5 191 960*	*42.60*
Climate zone F	*722 730*	*5.93*
Total	*12 187 698*	*100*

2.2 Non-residential buildings

Non-residential buildings have been grouped into the most widespread categories: schools, offices, shopping centres, hotels and banks.

Schools: nationwide, there are about 51 000 buildings entirely or partly reserved for use as schools. A total of 30 % of school buildings are concentrated in 10 provinces (the top three being Rome, Milan and Naples). More than half (51 %) are located in 24 provinces. About 29 % of schools are located in very small municipalities (up to 5 000 inhabitants), and roughly the same percentage in medium-small municipalities. The floor area of school buildings is 73.2 million m^2 and their total volume is about 256.4 million m^3. The largest share of school buildings (39 %) have a floor area between 1 000 and 3 000 m^2, with an average of 1 819 m^2. Some 43 % of school buildings can be broken down by floor area as follows: 16 % have a floor area between 751 and 1 000 m^2 (average 899 m^2), 14 % between 501 and 750 m^2 (average 631 m^2) and 13 % between 351 and 500 m^2 (average 435 m^2).

Offices: nationwide, there are about 65 000 buildings entirely or mainly for office use. A total of 30 % of office buildings are concentrated in 12 provinces (the top three being Milan, Rome and Turin), and 50 % are located in 26 provinces. About half (53 %) of schools are located in small and medium-sized municipalities (up to 20 000 inhabitants). Office buildings have a total floor area of 56.7 million m^2 and their volume is just under 200 million m^3. Most buildings are of a small size: about half do not exceed 350 m^2. A share of 32 % of the total floor area and volume (about 62 million m^3) is made up of just under than 1 200 large buildings (more than 5 000 m^2), mainly concentrated in Northern Italy.

Commercial sector

This sector refers to various commercial activities. It covers a wide range of building types, such as entire buildings (supermarkets, department stores, etc.), complexes (shopping centres, etc.), and building units (shops, boutiques, workshops, etc.). The total floor area in the commercial sector[4] amounts to around 165 million m^2, divided between shops and boutiques (99 million m^2 between 876 300 businesses), restaurants, pizzerias and bars (44 million m^2 and 261 600 businesses) and supermarkets (22 million m^2 and around 20 100 companies). The latter category can be divided into five sub-types, as detailed in **Error. Reference source not found.**

The percentage distribution of consumption varies according to the market sector, particularly outside the food industry. In shopping centres that sell electronics, for example, electrical consumption is higher than for other products.

In terms of energy end use, the most common energy carrier is electricity (about 70 %), as shown by national and European studies[5].

Table 4 – Distribution of the floor area of large supermarket chains and specific consumption

Type	Number of companies	Size	Specific consumption
Minimarket	5 636	1.6 million m^2	535 kWh/m^2/year
Supermarket	10 108	9.3 million m^2	585 kWh/m^2/year
Hypermarket	610	3.7 million m^2	525 kWh/m^2/year
Department store	2 067	2.7 million m^2	255 kWh/m^2/year
Large specialist store	1 685	5.1 million m^2	219 kWh/m^2/year

Hotels: nationwide, there are about 25 800 buildings entirely or mainly for use as hotels. Of these, 30 % are concentrated in six provinces, in order: Rimini, Bolzano, Venice, Naples, Trento and Rome. The top 17 provinces account for 50 % of all hotels in Italy. Moreover, 30 % of hotels are located in municipalities with a low population (up to 5 000 inhabitants) and 64 % in municipalities with up to 20 000 inhabitants.

[4] Information on the retail and hotel sectors was obtained from Nomisma Energia data processed by RSE SpA.
[5] EU Project CommONEnergy 2014.

In the last eight years, the average annual addition of new hotel buildings has been around 1.4 % of the existing stock.

Just over 1 in 5 buildings was built before 1919; the past 20 years have seen a decline in new buildings compared with earlier periods. The buildings have a total floor area of 48.6 million m^2 and a volume of more than 140 million m^3. The largest share of buildings is medium-large in size: almost 60 % are over 1 000 m^2. However, 43 % of floor areas and volumes (about 61 million m^3) are made up of 13 % of hotel buildings, i.e. 3 300 large buildings (more than 3 000 m^2). These are mainly concentrated in Northern Italy.

Banks: Italy has 76 banking groups, comprising 33 727 branches across the country. Many of these branches occupy portions of buildings, usually on the ground floor.

Buildings wholly or mainly for bank use number 1 469. Geographical concentration is fairly high: just over 30 % of those buildings are concentrated in only four provinces (Milan, Rome, Turin and Florence), while 50 % are distributed across the top 14 provinces. Also in terms of large geographical areas, distribution is not proportionate to the population: 58.2 % of buildings are located in Northern Italy, 22.2 % in Central Italy and 19.6 % in Southern Italy.

The buildings have a total floor area of 5.48 million m^2 and a volume of just over 18.5 million m^3. About half the buildings are medium-large in size: 48 % are over 1 000 m^2. However, 62 % of floor area and volume (about 11.5 million m^3) is made up of just 16 % of bank-use buildings, i.e. 236 large buildings (each with floor area over 5 000 m^2), almost exclusively concentrated in Central and Northern Italy.

2.3 Estimating consumption

The estimates for calculating average consumption for the different intended uses were based on the distribution of buildings by climate zone and period of construction, as referred to in this chapter, as well as consumption data taken from statistical surveys on a representative set of buildings. This set was determined using a study that defined the representative sample of buildings for each intended use and the most common building type.

As an energy consumption indicator, kWh/m^2/year was used in relation to the useful floor area of the building. The indicator was harmonised by referencing the climate zone, intended use and building type. Unoccupied residential buildings (which account for some 22 % of the total) and partially used non-residential buildings were not included in the assessment of buildings and their useful floor area. Table 5 contains the average annual consumption indicators for each intended use[6].

Table 5 – Summary of intended use and average annual consumption indicator weighted by climate zone

Intended use	Electricity consumption [kWh/m^2 year]	Thermal consumption [kWh/m^2 year]
Single-family building	38	142
Multi-dwelling building	35	125
Schools	20	130
Offices	95	170
Hotels	110	150

[6] For the analysis, data from ISTAT, the Ministry of Economic Development, CRESME and ENEA were used.

3 Cost-effective measures and national savings potential

3.1 Assessment methodology for the cost-benefit ratio

Based on Directive 2010/31/EU (EPBD recast), Delegated Regulation (EU) No 244/2012[7] for the application of the comparative methodology, and the Commission Guidelines of 19 April 2012[8] accompanying the Regulation, the methodological framework was defined to determine the optimal energy requirements of buildings from a technical and economic viewpoint. The Member States are required to define the energy efficiency measures to be applied to residential and non-residential buildings by making reference to the results of applying that methodology (cf. Annex 1).

Regarding the provisions of Article 5 and Annex III of Directive 2010/31/EU, to define these measures a comparative methodology was applied for calculating the cost-optimal energy efficiency requirements. Measures that interact with each other (for example, the insulation of the building envelope affects the output and size of the technical installations) were combined in packages and/or variants.

The energy assessment was carried out by applying a simplified methodology in accordance with the technical specifications UNI/TS 11300:1-4. This was used to estimate the overall energy consumption for each building in the sample; to estimate the overall cost in the context of a new build or major renovation, the economic assessment was carried out in accordance with the standard UNI EN 15459.

For the assessments, reference was made to a conventional user and reference climate zone, so as to eliminate the effect of user behaviour or climate conditions on the final result. To that end, UNI/TS 11300 was used to define the 'standard' boundary conditions[9]. Regarding the thermal conditions of adjacent buildings or building units, UNI/TS 11300-1 requires, for all building categories (except for categories E.6(1) swimming pools, saunas and similar, E.6(2) gyms and similar and E.8 buildings used for industrial and craft activities and similar), a temperature of 20 °C in winter and 26 °C in summer. With regard to the management of a building installation system, a 'conventional' user is defined[10].

The energy efficiency measures taken into account made reference to various intended uses, as required by the recast Energy Performance of Buildings Directive (EPBD) and Directive 2012/27/EU. For the public and private sector, these concerned the 'residential, schools and offices' category; for the private sector only, hotels and shopping centres were also considered. For each intended use, the measures were assumed to have different efficiency levels:

- the first level indicated failure to meet the energy requirements in force;
- the second level indicated compliance with the energy requirements laid down in Legislative Decree No 192/2005, prior to the legislative amendments that entered into force on 1 October 2015;

[7] Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.
[8] Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012.
[9] With regard to climate data, UNI/TS 11300 refers to the standard UNI 10349 and Presidential Decree No 412/1993 (degree days).
[10] Annex E to UNI/TS 11300-1 reports the average daily factor of presence in air-conditioned premises, the correction factor for ventilation under reference conditions, and the overall average gains per unit of floor area.

– the subsequent levels indicated an improvement on the performance required by law.

For example, for measures to upgrade the energy efficiency of the building envelope, the first level considers a higher (i.e. worse) thermal transmittance value than the one prescribed by Annex C to Legislative Decree No 192/2005; the second level upgrades the building envelope to the standards prescribed by the Annex; and subsequent levels introduce further improvements.

For the application of the optimisation procedure, the following factors were defined:

– the energy efficiency measures to be considered;

– the energy saving options based on different solutions and/or several simultaneous measures;

– the energy savings achievable;

– the optimal costs of the measures[11].

Once the energy demand of the buildings was established, the package of measures was defined through an iterative calculation, which gave the cost-optimal level for that particular building category. More details on the methodology used can be found in Annex 1.

3.1.1 Building clustering model

The existing building stock is extremely varied in terms of type, construction, technical installations, geographical location, climate, etc. In order to establish a meaningful representation for this population, a method had to be found that would describe it according its various characteristics. Building categories were therefore defined, based on which a clustering model could then be generated. This model was then used to define additional models, parameters and criteria, as described below.

By defining a clustering model, the building stock could be presented in a meaningful and representative manner. Below are some of the aspects that informed the choice of criteria for creating a reference framework with which to assess the buildings and define the measures, together with the related priorities.

– The housing stock consists of a large number of buildings constructed before the Second World War (30.1 % of buildings). From the post-war period until the late 1990s, Italian building construction saw a sharp increase (around 70 % of buildings). During the last property cycle (post-2001), taller multi-storey buildings with larger plan dimensions were built (4.5 %). In general, the building stock was constructed at different times, and around 60 % consists of buildings constructed prior to the enactment of the first law on energy saving (Law No 373/1976). Many are subject to architectural and planning constraints.

– Because they were built at different times, the buildings have different construction techniques: stone-built with iron or timber floors; entirely stone-built; stone- and brick-built; built from reinforced concrete and brick; built from reinforced concrete with prefabricated curtain walls; entirely built from reinforced concrete; timber construction; steel and glass construction; glass and steel curtain walls.

– Two main types of use have been identified: residential and non-residential. Residential buildings include detached and semi-detached houses, terraced houses,

[11] For the lifecycle assessment of building elements, reference is made to Annex 1 to EN 15459:2007.

blocks, high-rise buildings, etc.; non-residential buildings, in addition to their various configurations, encompass a wide range of uses with specific user profiles and needs (schools, offices, farm buildings, hotels, shopping centres, sports centres, etc.).

- The buildings are located in different climate zones and geographical regions, and so require specific energy efficiency measures.

Defining packages of standard measures to be carried out on the building envelope, installations or entire building (deep renovations) is therefore extremely difficult. Consequently, the first step of the methodology consisted of estimating:

- the number of residential and non-residential buildings to be refurbished;
- the provincial or sub-provincial geographical distribution;
- the size classes of these buildings;
- the representative types of building;
- the types of heating and lighting systems and the energy source used.

The model therefore consists of the following steps:

- definition of the reference buildings;
- definition of the energy efficiency measures to be applied to the reference buildings;
- calculation of the energy demand of the reference buildings, as modified by each of the energy efficiency measures considered;
- calculation of the overall cost[12] of the measures;
- sensitivity analysis;
- calculation of the cost-optimal levels.

3.1.2 Results of the application of the comparative methodology

By applying the comparative methodology[13], the optimal value of the primary energy (PE) performance index can be assessed for new and existing residential buildings (Table 6) and office buildings (Table 7) in climate zones B and E, taking into account the energy performance and costs of the measures[14]. This procedure defines the optimal energy performance requirements of the energy efficiency measures implemented, considering the investment costs for energy installations, maintenance and operating costs and any disposal costs. In addition, the potential[15] reduction in related consumption can also be calculated.

For climate zones B (climate with mainly summer demand) and E (mainly winter demand), the following types of buildings were selected:

- RMF: single-family house;
- RPC: small multi-apartment building;

[12] The term ‘overall cost’ means the cost associated with a new build or deep renovation, divided into various cost components: initial investment; maintenance; replacement; sale; residual cost.
[13] Application of the methodology for the calculation of cost-optimal levels of minimum energy performance requirements (Directive 2010/31/EU, Article 5), July 2013.
[14] To determine the population of buildings to be considered, the main criterion was current energy consumption.
[15] ‘Potential’ means the performance theoretically achievable, regardless of the current trend observed for renovations.

- RGC: large multi-apartment building;
- UFF: office buildings.

For each type, both the new building (NB) and renovations of two different existing buildings (E1 and E2) were considered. The results are given in Table 6 (residential) and Table 7 (offices). The optimal values are determined through the technical and economical optimisation of the various possible configurations. Annex 1 contains a flow chart for the optimisation procedure and the methodology employed. Note that the building codes also differentiate them by their typological and construction characteristics: for example, the code RPC defines a 'small multi-apartment' residential building, but the buildings RPC E1 and RPC E2 differ by year of construction, floor area/volume ratio, dispersing surface, heated volume and other factors that result in the assessments contained in Tables 6 and 7.

	BUILDING CODE	Overall cost [€/m^2]	PE optimal value [kWh/m^2]
CLIMATE ZONE E	RMF_E1	566	69.4
	RMF_E2	464	54.17
	RMF_N0	512	58.42
	RPC_E1	612	115.57
	RPC_E2	520	63.27
	RPC_N0	510	61.06
	RGC_E1	676	116.13
	RGC_E2	493	81.72
	RGC_N0	429	68.25
CLIMATE ZONE B	RMF_E1	420	46.14
	RMF_E2	374	43.1
	RMF_N0	359	31.3
	RPC_E1	466	93.41
	RPC_E2	418	54.1
	RPC_N0	419	50.81
	RGC_E1	541	81.22
	RGC_E2	439	69.13
	RGC_N0	346	46.97

Table 6 – Minimum overall cost and related optimal annual primary energy value of reference residential buildings

Table 7 – Minimum overall cost and related optimal annual primary energy value of reference office buildings

	BUILDING CODE	Overall cost [€/m^2]	PE optimal value [kWh/m^2]
CLIMATE ZONE E	UFF_E1	752	115
	UFF_E2	454	87
	UFF_N0	608	112
CLIMATE ZONE B	UFF_E1	669	79
	UFF_E2	406	116
	UFF_N0	502	68

3.2 Potential savings in the civil sector

This section summarises the results of the study on the potential savings in the civil sector. 'Potential savings' means the savings that would be achieved if all energy efficiency improvement measures having a favourable cost/benefit ratio and not yet implemented were carried out, irrespective of the spending capacity of the executing parties and the financial resources available under the energy efficiency promotion schemes, over a seven-year period. Clearly this potential is only theoretical, since the decision to execute the works does not depend on the cost/benefit ratio alone.

To assess the potential savings, the category of buildings was considered in relation to the distribution by climate zone and intended use (residential and non-residential). For data on residential building stock, reference is made to the ISTAT 2011 census; for the non-residential sector, reference is made to the data contained in the CRESME and ENEA reports compiled during research into the national electrical system[16].

As previously mentioned, the analysis of these subsets of buildings focused on those having the poorest energy performance.

Table 8 – Distribution by climate zone of residential and non-residential buildings

Type of building	Climate zone	Number of buildings	Values %
Residential	abc	3 412 000	28
	d	2 803 000	23
	ef	5 972 000	49
	Total	12 187 000	**100**
Non-residential			
Offices	abc	18 525	28
	d	18 265	28
	ef	28 210	44
	Total	**65 000**	**100**
Schools	abc	14 014	27
	d	12 976	25
	ef	24 914	48
	Total	**51 904**	**100**

3.2.1 Residential buildings

For the residential sector, the assessment concerned the existing building stock built between 1946 and 2005 (both single-family and multi-dwelling buildings), and included two types of renovation (complete and partial).

Potential consumption reduction was estimated taking into account the performance standards in force, the cost/benefit ratio and the feasibility of the following type of works:

[16] Annual Implementation Plan (AIP) 2014 for the Programme Agreement between the Ministry of Economic Development and ENEA for research and development of general interest for the national electricity system.

- thermal insulation of the building envelope (roof, floor/ceiling with a non-heated space, dispersing boundary opaque walls and reduction in thermal bridges);
- replacement of windows and doors (high energy performance windows and doors, insulation of roller blind boxes, shading elements);
- upgrading of the heating/cooling system controls (thermostatic valves, etc.);
- replacement of the heat generator (with condensing boilers or heat pumps, including geothermal pumps);
- installation of a home automation system;
- replacement or refurbishing of the lighting system (high-efficiency luminaries);
- use of renewable sources (thermal solar panels, photovoltaics).

The types of measures considered are as follows.

- Complete renovation: this concerns about 3.5 % of the buildings built in the period from 1946 to 2005 for single-family buildings and about 3 % of multi-dwelling buildings, for an annual floor area of about 51.6 million m^2. The potential for energy efficiency improvements in this category of buildings is greater in those built between 1946 and 1980, which have the poorest energy performance.
- Partial renovation: this mainly concerns individual apartments and common areas and technical systems of multi-dwelling buildings. It is estimated that effective action can be taken on about 4 % of buildings, for an annual floor area of some 118.5 million m^2. To estimate the achievable savings the various projects have been broken down by single-family and multi-dwelling buildings built between 1946 and 2005, with different consumption reduction percentages according to type of project.

The evaluations made lead to the potential energy savings achievable over a seven-year period (2014-2020), as illustrated in Table 9.

Table 9 – Consumption reduction potential by 2020 from works on residential buildings carried out from 2014

Type of building	Renovation scenarios on the building stock		Energy saving by type of project*					Total energy savings by 2020[17]	Total energy savings by 2020[24]
	Floor area covered	Floor area covered by renovation each year	Roof	External walls	Windows and external doors	Technical systems	Complete renovation		
		m^2	GWh/year					GWh/year	Mtoe/year
Single-family buildings	**Partial renovation**	39 407 808	221	132	83	265		4 907	0.43
	Complete renovation	26 551 030					2 230	15 610	1.34
Multi-dwelling buildings	**Partial renovation**	79 141 300	253	475	253	658		11 473	0.98
	Complete renovation	25 142 222					2 414	16 898	1.45

[17] The energy saving values given for the projects should be considered in isolation, since they cannot be aggregated.

Total	**170 242 360**		**48 888**	**4.20**

The estimated investments to achieve these potential savings amount to EUR 13.6 billion per year for complete renovation projects and EUR 10.5 billion per year for partial renovation projects. To estimate the investment costs to be incurred, a technical and economic assessment was carried out taking into account the different types of residential building located in climate zones A to F. This resulted in different assessments from the comparative methodology, based on 'typical' reference buildings located in two climate zones, B and E.

3.2.2 Non-residential buildings

For the non-residential sector, the analysis took into account buildings with specific uses (offices, schools, hotels, banks and shopping centres) for which the average energy consumption is 50 % higher than the benchmark. The potential savings achievable by 2020 were assessed based on that analysis.
The measures taken into account in assessing consumption reduction relate to:

- thermal roof insulation;
- thermal insulation of stilt floors or floors/ceilings bordering on unheated spaces and of heat-dispersing external walls (portion of wall below the window);
- replacement of existing windows with high-energy performance windows;
- upgrading of the heating/cooling system controls (thermostatic valves, etc.);
- replacement of the heat generator (especially for those still using diesel);
- use of high-efficiency heat recovery systems;
- installation of a home automation system or a BEMS (Building Energy Management System);
- replacement/refurbishing of the lighting system (high-efficiency luminaries);
- external solar screens, especially on south-facing sides of the building.

Complete renovations involve different combinations of the above-mentioned individual measures, depending on the climate characteristics of the zone in which the building is situated, the intended use and the cost/benefit ratio.

The floor area of the public and private buildings that can effectively be renovated each year has been estimated to be:

- 5.5 million m^2 for office use (about 2 000 buildings);
- 6.0 million m^2 for school use (about 3 800 buildings);
- 1.4 million m^2 for hotels (about 500 buildings);
- 2.3 million m^2 for shopping centres;
- 0.8 million m^2 for banks.

On this stock of buildings, several measures have been applied, differentiated by climate zone and applicability of the solutions, to achieve energy savings of 60 % in the public sector (offices and schools), 45 % in the private sector (offices, hotels, schools and banks) and 35 % in shopping centres. The difference in energy saving percentages between the public and private sector stems from the fact that public buildings were mainly constructed prior to 1980, and their baseline energy performance is therefore poorer. For shopping centres, the conservative estimates of 35 % savings is due to the fact that, on account of the type of building envelope, upgrading actions are mainly restricted to the technical systems.

The estimated investments for these projects amount to EUR 17.5 billion per annum, and should yield potential energy savings by 2020 of some 17 229 GWh/year, equivalent to 1.48 Mtoe/year (Table 10). To estimate the investments, given the widespread use of asbestos in buildings between the mid-1960s and the late 1970s, consideration was also given to remediation costs and costs of measures involving stabilisation works, such as the alteration of flat roofs for the installation of renewable energy sources. The percentage of these costs is estimated at about 20 %.

Table 10 – Consumption reduction potential by 2020 from complete renovation of non-residential buildings carried out from 2014

Buildings	Floor area covered by renovation each year	Total energy savings by 2020	Total energy savings by 2020
Type	**m^2**	**GWh/year**	**Mtoe/year**
Private offices	2 880 000	2 858	0.25
Public offices	2 640 000	3 881	0.33
Hotels	1 425 000	1 167	0.10
Private schools	1 000 000	617	0.05
Public schools	4 950 000	5 821	0.50
Banks	782 811	726	0.06
Shopping centres	2 289 163	2 159	0.19
Total	**15 966 974**	**17 229**	**1.49**

3.2.3 Total potential reduction in consumption by 2020

Table 11 summarises the total theoretical potential to reduce consumption by 2020 for works on residential and non-residential buildings. Overall, this amounts to 5.69 Mtoe/year. The total amount of resources to be mobilised over a seven-year period is more than EUR 290 billion.

Table 11 – Consumption reduction potential by 2020 from partial renovation of residential buildings and complete renovation of non-residential buildings carried out from 2014

Buildings	Floor area covered by renovation each year	Total energy savings by 2020	Total energy savings by 2020
Type	**m^2**	**GWh/year**	**Mtoe/year**
Residential	170 242 360	48 888	4.20
Non-residential	15 966 974	17 229	1.49
Total	**186 209 334**	**66 117**	**5.69**

3.3 Barriers to measures to improve the energy performance of buildings

Although the energy efficiency measures described are profitable, there are various impediments to this positive process being instigated voluntarily, especially in the case of minor works. The high initial investment costs, a frequent lack of awareness of the potential savings and difficulty in accessing incentives in many cases deter small-scale consumers. A brief analysis of the main technical and economic/financial barriers is provided below.

3.3.1 Technical and administrative barriers

Technical barriers cover several areas. Crucially, a regional variation exists in the implementation of procedures and requirements laid down in the planning tools that govern and regulate measures aimed at improving the energy efficiency of existing buildings, and the criteria for steering those measures toward innovative solutions.

Other issues concern the following processes:

- the management of the application procedure, which should be handled via websites accessible to individuals and businesses containing information on local planning restrictions;
- supporting documents for applications, which should be standardised and streamlined;
- administrative or preliminary costs, which should not discourage the use of energy efficient technology.

Simplifying the procedures is key, since this represents the bedrock of an environment conducive to investment, innovation and entrepreneurship. Actions to this effect will also speed up the harmonisation of planning tools for the implementation of measures on the ground. In this respect, the government digitisation process currently under way will play a vital role.

A key provision on simplification was introduced in Article 14(5) of Legislative Decree No 102/2014. This provides for the publication of guidelines to simplify and harmonise the application procedure for the setting up of energy efficient technical installations or mechanisms in residential and commercial property and for the use of renewables, and to harmonise the rules on energy performance certificates, accreditation requirements for certifying parties, and the system of checks and penalties. The new guidelines are expected to be issued in the coming months.

3.3.2 Economic and financial barriers

It has become considerably harder in recent years to obtain bank loans, especially for deep renovations. This is mainly due to the complexity of assessment and technical/economic approval of the project, the lengthy payback periods, the timing of payments, and the interest rates charged. In the case of projects implemented via an ESCO, the uncertainty of the future cash flows is another deterrent to the granting of funding. The lending process also remains highly conservative, given the limited experience and reluctance to finance energy efficiency projects based on cash flow, particularly where innovative incentive schemes are involved. This is partly due to the limited financial size of the projects (medium-small), which is of little interest to large financial institutions, but above all to the lack of project ‘models’. Added to this is the perceived high risk among the banks themselves, owing to the difficulty in calculating the actual costs of advanced or innovative technology, assessing unforeseen costs, and factoring in the significant fluctuations in energy costs, which affect the return on investment over time.

On the end-user side, the barriers are mainly access to credit, the interest rates charged and the lack of subsidised funding. In addition, the difficulties in accessing public funding and tax relief are even higher for innovative projects, regardless of the end-use sector.

Another issue is the separation of interests: the economic benefits and investment costs often go to different parties. In the residential sector, this situation typically occurs in the tenant-landlord relationship, where the landlord might make energy efficiency investments without reaping any direct benefit, other than increasing the value of the property, while the tenants could benefit from smaller utility bills, but have no interest in investing in a property they do not own and which they might leave a few years hence, before having recovered their investment.

In the case of works in public and private multi-owner buildings financed by ESCOs, there is a high risk of payment default, which discourages ESCOs in view of the possible problems in collecting their share of receivables from the energy savings achieved.

As a result of these issues, the bank loans and leasing – which are the most widely used instruments[18] for financing energy efficiency measures – currently available on the market have almost 'traditional' characteristics, hardly compatible with the nature of energy efficiency schemes. For example, banks will rely on the applicant's credit score as a decision-making criterion far more than the technical and economic merits of the project.

Overcoming these barriers is thus a priority for 'capturing' the maximum potential savings available. Some actions have already been taken, such as the extension of tax relief, the launch of the thermal energy account and the introduction of new energy saving targets through the white certificates mechanism. More generally, to overcome the barriers to the adoption of energy efficient solutions, it is crucial that instruments are rationalised and strengthened and that dedicated measures are put in place for each market segment and sector. The existing instruments have been or will be reinforced. In addition, new instruments will be introduced that set targets on the basis of both the potential to increase the energy efficiency of each consumption sector targeted, and the specific cost/benefit ratio of the instrument itself. Other opportunities were provided for in Legislative Decree No 102 of 4 July 2014, transposing Directive 2012/27/EU, which, to overcome the financial barriers described above, introduced the National Energy Efficiency Fund.

4 Assessment of the annual savings achievable by 2020 under existing instruments

While section 3.2 estimated the potential savings resulting from energy efficiency measures in residential and non-residential buildings, this section examines the savings achievable due to the regulatory or incentive-based policy measures currently in force, as covered in the Energy Efficiency Action Plan (EEAP) 2017.

The civil sector's contribution to the national targets is estimated at 4.9 Mtoe/year by 2020, including 3.67 Mtoe/year from the residential sector and 1.23 Mtoe/year from the non-residential sector. This estimate is based on consideration of the following factors:

- application of the new standards required by the EPBD for buildings and by the Ecodesign Directive for heating and cooling systems: the contribution to the total figure is estimated to be in the region of 1.6 Mtoe/year for residential buildings and 0.2 Mtoe/year for non-residential buildings;
- tax relief mechanism: this is estimated to yield a savings of 1.38 Mtoe/year of final energy in the residential sector;
- thermal energy account: this is estimated to save 1.47 Mtoe/year of final energy use, including 0.54 Mtoe/year in the residential sector and 0.93 Mtoe in the tertiary sector, both public and private;

[18] Over EUR 600 million disbursed during the period 2007-2013 (source: Energy Strategy Group, Milan Polytechnic).

- white certificates: while this scheme was designed with the industrial sector and infrastructure in mind, based on historical data white certificates are estimated to generate savings in the civil sector of 0.25 Mtoe/year of final energy, including 0.15 Mtoe/year in the residential sector and 0.1 Mtoe/year in the tertiary sector.

Table 13 illustrates the savings achieved during the period 2011-2016 for each economic sector as a result of the main policy measures in force: the comparison with the 2020 targets shows that the residential sector has nearly reached the target set, while there is a significant gap between the results obtained and the targets for the tertiary sector.

Table 13 – Annual energy savings achieved by sector during the period 2011-2016 and expected by 2020 (final energy, Mtoe/year)

Sector	White certificates	Tax relief*	Thermal energy account	Legislative Decree No 192/2005*	Eco-incentives and EU regulations*	Other measures**	Energy savings		Target achieved
							Achieved 2016	Expected by 2020	
Residential	0.59	1.56	-	0.91	-	0.02	**3.09**	**3.67**	**84.2 %**
Tertiary	0.13	0.02	0.003	0.05	-	-	**0.19**	**1.23**	**15.4 %**
Industry	1.84	0.03	-	0.09	-	-	**1.95**	**5.10**	**38.3 %**
Transport	-	-	-	-	1.13	0.04	**1.18**	**5.50**	**21.4 %**
Total	**2.56**	**1.60**	**0.003**	**1.05**	**1.13**	**0.07**	**6.41**	**15.50**	**41.4 %**

* Estimate for 2016.
** The residential sector includes savings from replacing large domestic appliances. The transport sector includes savings resulting from high-speed transport.
Source: ENEA processing of data from the Ministry of Economic Development, ISTAT, Gestore dei Servizi Energetici SpA, ENEA, FIAIP, GFK.

5 Conclusions

Italy already has a broad set of measures for the promotion of energy efficiency in buildings, described in detail in the EEAP 2017. By 2016, these measures had already achieved over 80 % of the savings target for 2020, particularly in the residential sector.

However, there are still potential savings to be tapped by implementing measures to overcome the barriers that limit investment in the energy-efficient renovation of buildings. This process is already under way, as evidenced by last year’s updates to the main instruments used to promote energy efficiency, including, for example, maintaining tax relief for energy efficiency improvements to common areas of multi-apartment buildings until 2021.

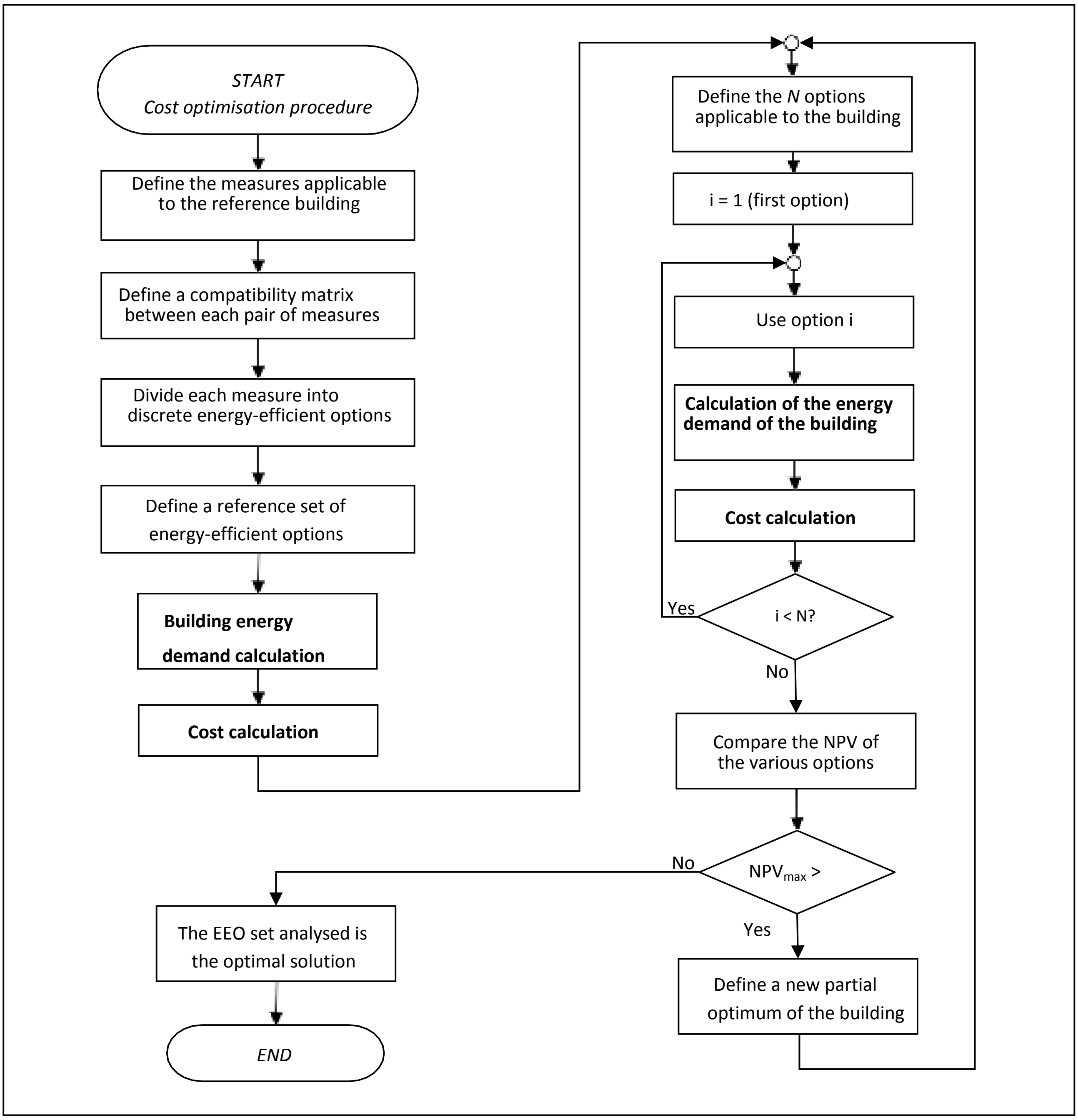
Together with new schemes, Italy remains committed to developing and refining its existing instruments for promoting energy efficiency in buildings.

To that end, revising the National Energy Strategy will be crucial ahead of the preparation of the Climate and Energy Plan, which will leverage the potential energy savings in the civil sector as a key to achieving the environmental targets by 2030.

Appendix 1 – Optimisation methodology

An optimisation macro has been developed that interfaces with spreadsheets for the calculation of energy demand (UNI/S 11300-1, 2, 3, 4) and overall cost. An auxiliary spreadsheet links each package of measures identified by the optimisation procedure to all input data necessary to describe the reference building and perform the calculations.

Optimisation procedure flow chart



The optimisation methodology considers discrete energy efficient options (for example, different levels of thermal insulation), applied one at a time to obtain a new partial 'optimised building' for each calculation step.

The starting point of the iterative optimisation calculation is a reference package of energy-efficient options; the present value of each series of energy-efficient options is defined in relation to the reference set. Next, the procedure identifies a series of configurations (packages of measures) that represent 'partial optimums'. To progress from one partial optimum to the next, all the parameters that characterise the levels of each energy-efficient measure will be changed one at a time. Of all the configurations tested, the next partial optimum is the one that offers the greatest reduction in overall cost.

Classification of packages of measures to be applied to various building clusters

For an estimate of the measure, consideration was given to the actual applicability of the energy-efficient measures, the cost/benefit ratios and the modularity of operations concerning:

a. the building envelope: reference was made to the standard parameters prescribed by Legislative Decree No 192/2005, as amended, which involve the insulation of the building envelope, the replacement of doors and windows, screening elements, etc.;
b. thermal and electrical installations: integrated projects were considered such as the replacement of the existing thermal installation with a new high efficiency system, where necessary, and the implementation of a BEMS to manage the entire electrical system of the building, with the integration and installation of renewable energy sources.

The following measures were assessed for their potential to reduce consumption:

- thermal insulation of the building envelope;
- thermal insulation of the roof;
- thermal insulation of stilt floors or floors/ceilings bordering on unheated spaces and of heat-dispersing external walls (portion of wall below the window, roller blind boxes, etc.);
- replacement of existing windows with high-energy performance windows;
- upgrading of the heating/cooling system controls (thermostatic valves, etc.);
- replacement of the heat generator (especially of those still using diesel);
- installation of a home automation system or a BEMS;
- replacement/refurbishing of the lighting system (high-efficiency luminaries);
- external solar screens, especially on south-facing sides of the building.

The projects considered are defined as a mix of combinations that take into account both the climate characteristics at the building's location, and the type and intended use.

For this assessment, considering the interaction between the different measures (such as the insulation of the building envelope, which affects the output and size of technical systems), the measures were combined into 'packages'. The aim was to create synergy in order to achieve more realistic results (in terms of cost and energy performance) than would be achievable with individual measures.

The energy efficiency projects considered were divided into different categories depending on the building type. These were then assessed according to the energy efficiency of the measures (EEM) and cost/benefit factor, by reference to the performance standards prescribed by the regulations in force and improvements for the application of Decree-Law No 63/2013.

By way of example, Table A.1 lists the projects considered for the category of 'existing non-residential buildings'.

Table A.1 – Projects for the definition of technology 'packages'

No	Energy efficiency of the measures	Parameter	Symbol
1	External wall insulation (external layer)	Thermal transmittance [W/(m^{2}K)]	U_p
2	Thermal insulation of external walls with blown cavity insulation	Thermal transmittance [W/(m^{2}K)]	U_p
3	Roof insulation	Thermal transmittance [W/(m^{2}K)]	U_r
4	Slab insulation	Thermal transmittance [W/(m^{2}K)]	U_f
5	Doors and windows	Thermal transmittance [W/(m^{2}K)]	U_w
6	Shading systems	Total solar energy transmittance g_{gl}	g_{gl}
7	High-efficiency chiller units	Energy efficiency index in design conditions	EER
8	High-efficiency heating system	Generation efficiency	η_{gn}
9	High-efficiency hot water systems	System performance at 100 % load	$\eta_{gn,Pn,W}$
10	Heating and hot water systems	Generation efficiency	η_{gn}
11	Heat pump for heating system and cooling and hot water production	Coefficient of performance	COP
		Energy efficiency index in design conditions	EER
12	Solar thermal energy	m^2 of solar captors	m^2
13	Solar photovoltaic	Installed peak power	kWp
14	High-efficiency heat exchangers	Heat exchanger efficiency	η_r
15	Intelligent control and management systems	Regulation and control efficiency	η_{ctr}
16	Installed lighting power density	Installed lighting power density (W/m²) (UNI EN 15193)	PN
17	Lighting control systems	Factor of dependency on occupation (UNI EN 15193)	F_o