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BEST AVAILABLE TECHNOLOGIES IN HOUSING

ITALIAN CASE STUDY

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1. SUMMARY AND CONCLUSIONS

The Italian case study has been carried out setting three scenarios as reference cases against which the new technologies were applied. The scenarios take into account the present Italian context in the household sector that, concisely, may be outlined as follow:

- the building stock is rapidly ageing (following the trend of the Italian population) and it is envisaged that the building older than 40 years (that is a critical threshold for what concern the retrofitting interventions) will constitute the 52% of the Italian stock up to 2020;
- the heating energy consumption has been directly proportional to number of households since the year seventies and hence, in the last 20 years, due to the decreasing growth of the population, has kept steadily constant; roughly it means that the increments of energy efficiency due to the houses built since the years eighties (that would be have designed on the base of the new Italian building regulatory norms) and to the renewal of the boiler stock, have been adsorbed by the growing heating demand due to the increasing of households;
- the majority of the heating systems (73% in 1998) are fired by naturals gas and this quote will slightly increase in the future (a maximum diffusion of approx. 80% is envisaged);
- the electric energy demand had a strong increase in the years seventies and eighties due to the diffusion of the basic domestic appliances and a stronger one is forecast at short-medium time due to the energy electric market liberalisation and the diffusion of air conditioners, heat pumps and other ancillary and leisure appliances (microwaves, electric ovens, computers, etc.);
- natural gas and electric energy (mainly produced by natural gas) will become in the next 20 years the most important energy sources for the household (and tertiary) sector;
- all this lead to the conclusion that the greater energy saving "reservoirs" of the household sector are represented by the existing building stock insulation interventions, renewal and energy efficiency improvement of the central and collective gas boilers, energy efficiency improvement of the electric final uses.

The scenarios and the new technologies have been built up and selected taking into account this frame and the Italian energy policy in this sector:

- Scenario 1 represents the continuation of current autonomous trends with no additional support in terms of legislation, grants or information campaigns.
- Scenario 2 represents the case in which energy efficient policies are pursued at the level at which they have been applied historically.
- Scenario 3 represents the best possible future case in which existing technologies are heavily promoted through both legislation and other campaigns.

The results obtained having used the MURE simulation capabilities shown that compared to a baseline in which unitary energy consumption remains constant (comparable with the trend over the last 25 years) the following savings are possible through the installation of energy saving technologies.

	% energy savings over baseline	
	2010	2025
Scenario 1 – Business as Usual	8.7%	16.3%
Scenario 2 – Policy Implementation	12.8%	23.5%
Scenario 3 – Best Available Technologies	18.6%	35.5%

Overall, the installation of higher efficiency gas and oil boilers will have the most significant impact on domestic energy consumption. This measure is also the one most likely to succeed as it could be implemented via the manufacturers, requiring no structural or behavioural changes at the level of the household.

Improved insulation, notably increased depth of loft insulation, cavity wall insulation and double glazing, can have a significant impact on overall energy consumption. However, retro-fitting of existing buildings is rarely cost-effective in energy saving terms except as part of a normal replacement/maintenance activity.

The technical potential from higher efficiency electric appliances is very high and requires little or no change in habits or comfort level on the part of the users. In this area in particular the market is trans-national and requires a concerted programme across, for example, the EU.

In addition, some further savings in primary energy can be achieved through the promotion of energy supply technologies. In Italy the alternative supply technologies most likely to produce savings are electric heat pumps and with lesser extent CHP-based district heating. Micro-CHP, with some contribution from photovoltaics, is not yet implemented in Italy but seems to have promising diffusion possibilities in the future.

2. BACKGROUND INFORMATION

2.1 Demographic trends: population ageing and low birth rates

Demographic trends in Italy, like to the other OECD countries, stress the population ageing, characterised by increasing average age and a large and rapid increase in the old-age dependency ratio[1].

The following table shows the over 65 years old population rates, calculated on the basis of residential population values.

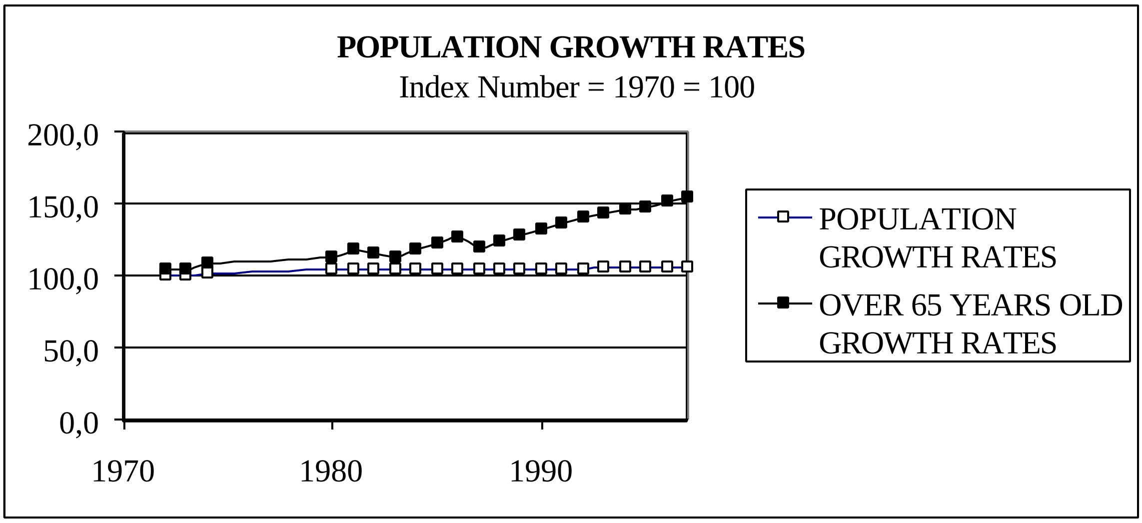
YEAR	TOTAL POPULATION (thousand of unit) **A**	OVER 65 YEARS OLD POPULATION (thousand of unit) **B**	% VALUES **B/A**
1971	54.073	6.102	11,3
1972	54.381	6.381	11,7
1973	54.751	6.660	12,2
1974	55.111	6.939	12,6
1980	56.434	7.217	12,8
1981	56.510	7.496	13,3
1982	56.579	7.357	13,0
1983	56.626	7.217	12,7
1984	56.652	7.496	13,2
1985	56.674	7.775	13,7
1986	56.675	8.054	14,2
1987	56.674	7.664	13,5
1988	56.688	7.889	13,9
1989	56.705	8.113	14,3
1990	56.737	8.427	14,9
1991	56.760	8.700	15,3
1992	56.960	8.928	15,7
1993	57.138	9.156	16,0
1994	57.269	9.271	16,2
1995	57.333	9.385	16,4
1996	57.461	9.645	16,8
1997	57.553	9.840	17,1

During about forty years the average annual rate of growth of population over 65 years old (+2,15) was growing faster than the average annual growth of population, equal to +0,2%.

On average, ratios of population over 65 years old were fewer than 12% in the first 70s, and more then 16% in the late 90s.

Taking the year 1970 as starting point, a more clear representation of ageing population in Italy is depicted in the following graph.

[1] The old-age dependency ratio refers to the ratio of the number of elderly (aged 65 and over) with the population in working age.

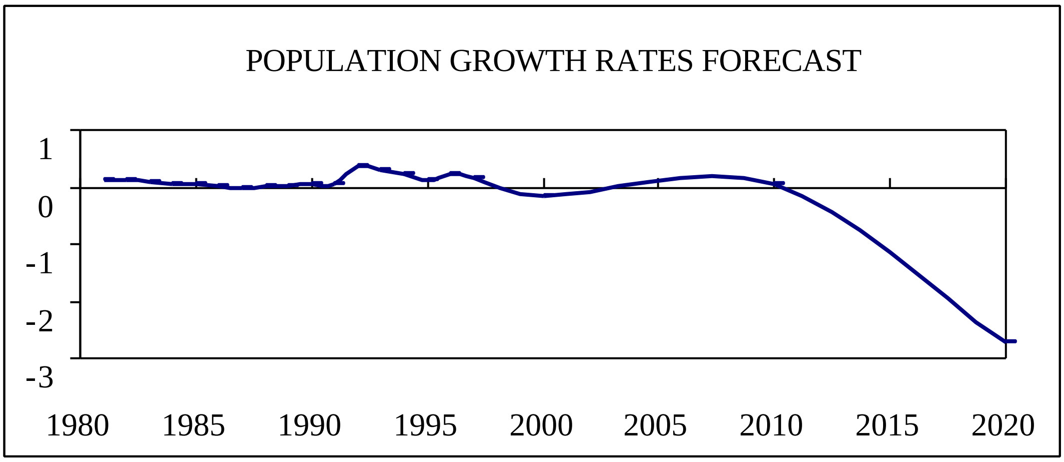


The index numbers values (1970=100) show:

- a slight growth of residential population (1997=105);
- a rapid growth of over 65 years old population in particular during last ten years, (1997=154).

Over a long-term period, the effects of population ageing accompanying with low birth rates will determine a general reduction in the residential populations[2], unless increasing immigration flows will not offset it.

On the basis of available demographic projections[3] the immigration flows in Italy shouldn't offset the combined effects of population ageing and low birth rates; hence in the long-term period the residential population will decrease.



The graphic above clearly shows the decreasing trend of residential population during the period 2010-2020, with an average rate growth equal to –2,7%.

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[2] The population ageing has other important macroeconomic implications, for example, on pension system equilibrium and public and private savings flows.

[3] Istat, "Forecasts of resident populations by sex, age and region", Rome, 1997

With reference to housing sector, it is important to stress that population ageing could have a negative impact on the future growing rate for new dwelling.

2.2 Number, composition and characteristics of households

In Italy, during last ten years households with more generations living together showed a progressive reduction.

In the meantime, the households with only one generation, which composition is prevailing formed by singles and couples with no children was increasing, and their amount was respectively 21,3% and 19,6% of total households[4].

The overall result is a progressive household size decline, as depicted in the table below.

YEAR	POPULATION	MEDIUM NUMBER OF MEMBERS	HOUSEHOLD (thousand)
1988	57.504.691	2,9	19.829
1989	56.689.750	2,9	19.548
1990	56.854.742	2,9	19.605
1991	56.556.911	2,8	20.199
1992	56.960.300	2,7	20.879
1993	57.138.489	2,7	20.793
1994	57.268.578	2,9	20.020
1995	57.332.996	2,9	20.056
1996	57.460.977	2,9	20.088
1997	57.563.300	2,7	21.625
1998	57.612.600	2,7	21.644

During last ten years the average household size decreased from 2,9 members in 1988 to 2,7 members in 1998.

The forecast for 2020 set up a continuous reduction in the average household size[5] which a minimum value of 2,4 members in 2020.

YEAR	POPULATION	MEDIUM NUMBER OF MEMBERS	HOUSEHOLD (thousand)
2000	57.455.737	2,7	21.280
2005	57.601.837	2,6	22.155
2010	57.494.517	2,5	22.998
2020	55.939.123	2,4	23.308

[4] Istat, “Annual Report “, 1998, Rome
[5] “Energy in Europe”, Energy for a new century: The European Perspective”, July, 1990

About the future perspectives of housing sector, in the long-term period the number of households will increase, with a growing presence of households with singles, less children and more old-people.

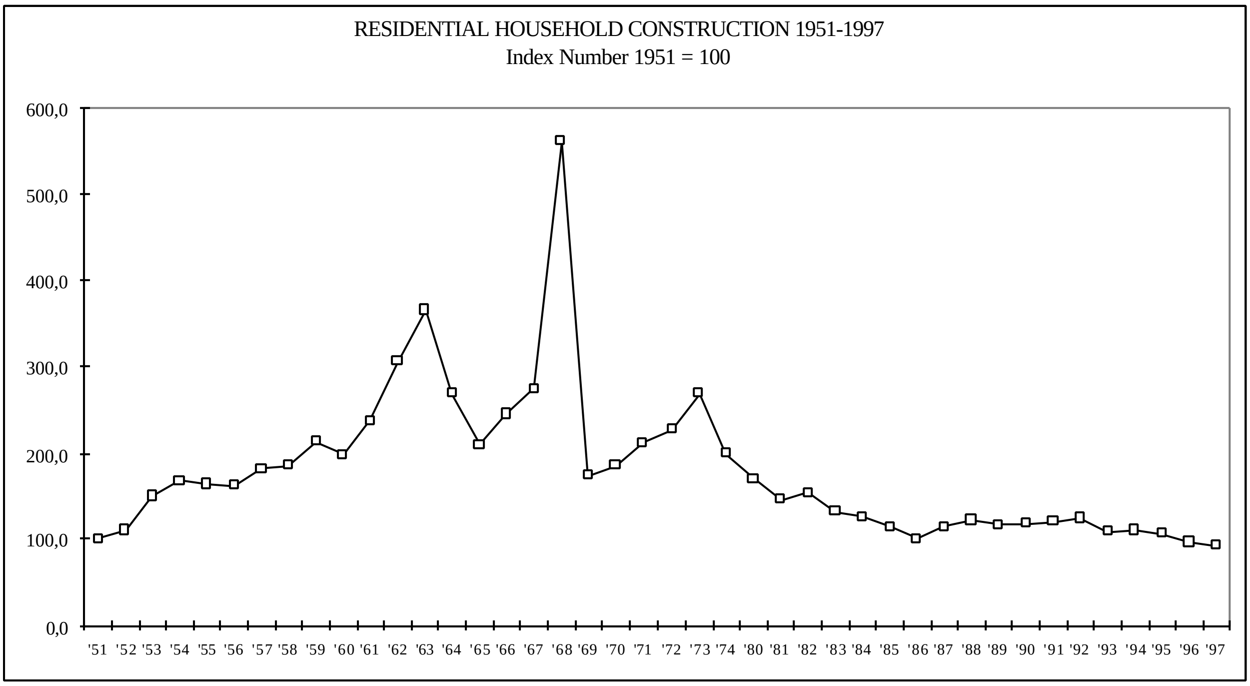
This can influence the characteristics of dwelling house, with a prevailing demand for dwelling house with an average and small dimension, i.e, from 1 to 15 dwellings.

Moreover, the new forms of urban development (urban sprawl, and decentralisation) will enforce the trend towards the construction of building with fewer dwellings.

3. HOUSING STOCK DEVELOPMENT

3.1 Historical trends

The following graph shows the residential households supply in the period between 1951 and 1997, with some lack of data for the second half of 70s.



The graphic allows to evidence two main phases of construction activity in Italy:

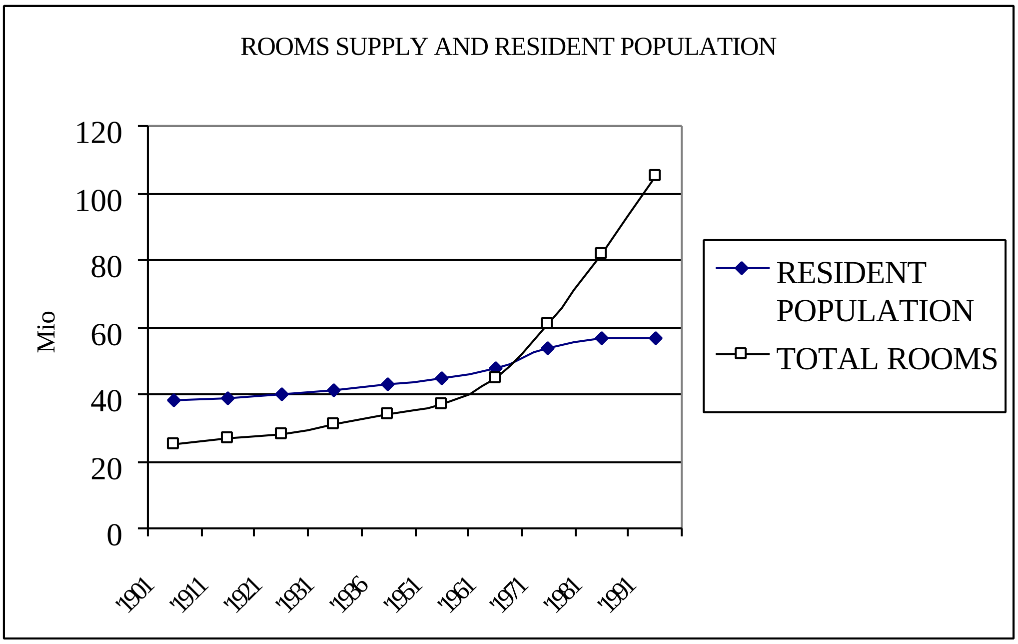
1. the phase characterised by a continuous growth, during 20 years, from 50s to 1970;

2. the phase starting from the 70s characterised by a slight but progressive reduction of construction activity.

During the first phase, from 1950 to 1970, a deep process of urbanisation established and consequently the volume of housing supply increased 560 time the level of 1950.

During the second phase, from 70s to 1997, the demand of dwelling due to urbanisation processes was satisfied and the new household supplies progressively reduced.

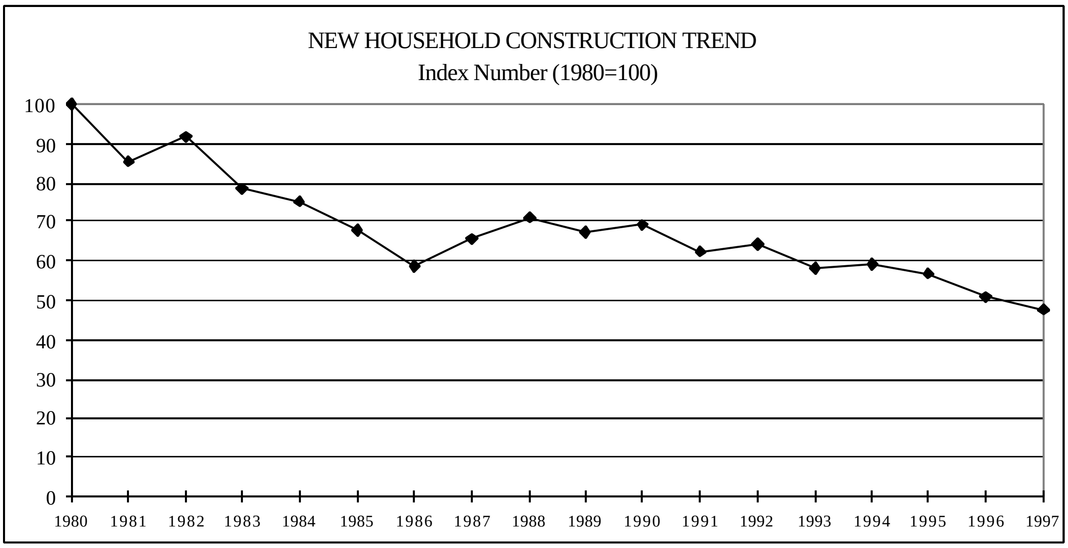
With reference to the total stock of rooms (new and old) the following graph shows the relationship with resident population during about one century, from 1901 to 1991.



A shortage of available rooms comparing to the residential population occurred in Italy from the beginning of the century to 1961. From 1961 to 1971 the gap was filled and started a period in which the supply of rooms was above the population level. In particular, from 1971 to 1991, the total stock of rooms increased by 3 time (from 37,3 to 105,1 million of room), while population increased only by 20%.

3.2 Forecasts of new dwelling: the effect of population ageing

During last twenty years, the new household construction trend decreased.



Assuming the 1980 as starting point, with new construction level equal to 100, the level of new household construction was equal to 69,2 in 1990, and to 47,8 in 1997.

A new dwelling construction forecast can be estimated on the basis of the correlation analysis with population ageing.

As explained above[6], growing population ageing could affect demographic trends and demand of new dwellings.

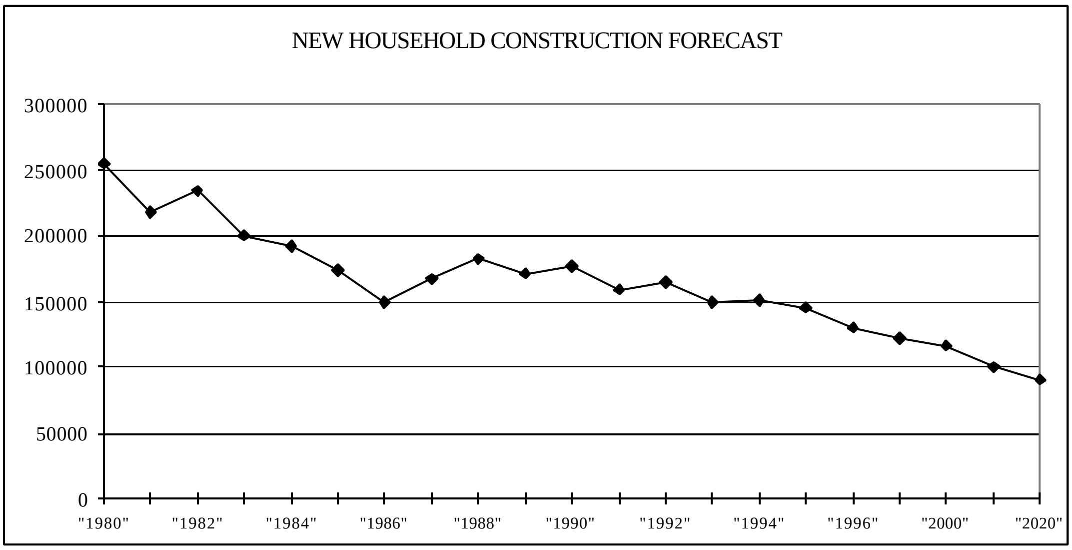
With reference to new dwelling construction trends, a high and negative coefficient of correlation (-0,85) has been found between population over 65 years old and new dwelling constructions trends during the period 1980-1997.

Owing to high negative correlation value with population ageing, a progressive reduction of new dwelling construction at the same pace of progressive population ageing should be assumed as hypothesis.

At 2000-2010-2020 year, the population over 65 years old will increase by respectively 4,9%, 13,8%, 10,5%.

These percentages are taken as reference values for decreasing the new dwelling construction pace. This means that, owing to population ageing the new constructions fall from 255,000 dwelling years of 1980 to less than 100,000 in 2020.

YEAR	NEW HOUSEHOLD	OVER 65 POPULATION
1980	255.040	7.217.481
1981	217.699	7.496.396
1982	233.763	7.356.721
1983	200.595	7.217.046
1984	192.386	7.495.961
1985	173.605	7.774.876
1986	149.421	8.053.792
1987	167.076	7.664.066
1988	181.515	7.888.527
1989	171.609	8.112.987
1990	176.448	8.426.600
1991	159.306	8.700.185
1992	164.069	8.928.066
1993	148.659	9.155.947
1994	150.941	9.270.674
1995	145.290	9.385.400
1996	129.968	9.644.533
1997	121.854	9.839.847



[6] See paragraph 1.1

3.3 *New dwelling types: the effect of household size reduction and new urbanisation models*

The effect of household size reduction and new urbanisation models (see below, par. 1.2) will probably cause an increasing demand for building with one or two dwelling houses and generally less spacious.

Between the last two Italian housing and population census of 1981 and 1991, the percentage value of new dwelling with one or two dwellings reduced slightly: from 45% in 1981 to 38% in 1991.

RESIDENTIAL BUILDING BY DWELLINGS - 1991 CENSUS -

	Before 1919	1919-1945	1946-1960	1961-1971	1972-1981	1982-1986	over1986	total
1dwelling	1.354.026	711.398	803.604	976.244	917.187	278.027	183.893	5.224.379
2 dwellings	506.474	289.998	457.107	686.988	533.649	116.506	71.293	2.662.015
>2 dwellings	1.068.992	769.466	1.794.211	2.790.129	1.951.946	726.553	412.864	9.514.161
total	2.929.492	1.770.862	3.054.922	4.453.361	3.402.782	1.121.086	668.050	17.400.555

RESIDENTIAL BUILDING BY DWELLINGS - 1981 CENSUS -

	Before 1919	1919-1945	1946-1960	1961-1971	1972-1975	1976-1880	over 1980	total
1dwelling	1.128.388	668.595	808.340	1.022.886	471.261	454.425	51.648	4.605.543
2 dwellings	400.233	258.913	420.408	627.305	259.394	223.054	22.505	2.211.812
>2 dwellings	1.010.845	835.302	1.865.122	2.690.398	875.946	821.280	71.125	8.170.018
total	2.539.466	1.762.810	3.093.870	4.340.589	1.606.601	1.498.759	145.278	14.987.373

But, with reference to recent data, the trend towards a reduction of building with more 1 or 2 dwellings is reducing.

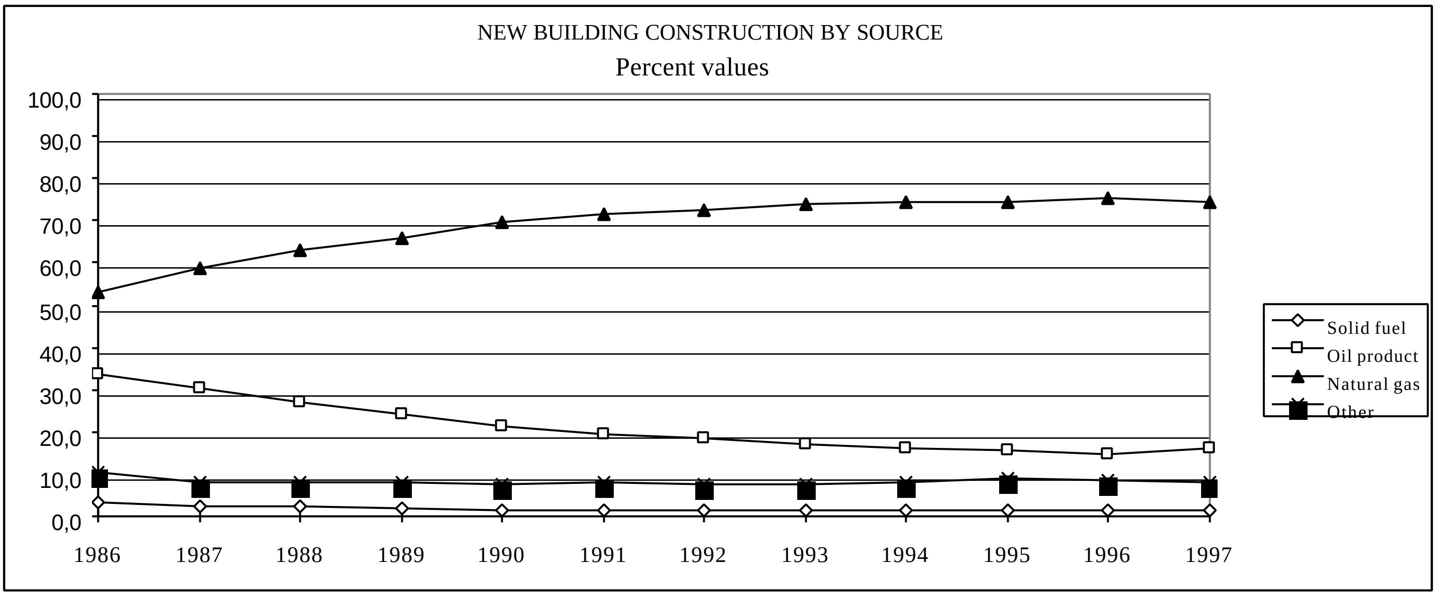
The following table shows the new building set up during the period 1990-1997, with the indication of number of dwellings.

	1dwelling	2 dwelling	from 3 to 15	from 16 to 30	over 30	total
1990	20.754	8.886	10.783	1.378	536	42.337
1991	20.347	8.345	10.955	1.302	502	41.451
1992	21.361	8.844	11.261	1.379	492	43.337
1993	19.773	8.058	10.451	1.223	443	39.948
1994	19.804	7.847	10.882	1.256	442	40.231
1995	19.002	7.296	10.351	1.216	394	38.259
1996	17.733	6.834	9.365	1.059	357	35.348
1997	16.001	6.051	8.784	1.044	332	32.212
Var. %	-22,9	-31,9	-18,5	-24,2	-38,1	-23,9

The trend towards a reduction of new dwelling construction was mainly related to the building with more of 30 dwellings (-38,1%), while the building of average dimension (from 3 to 15 dwellings) reported a slightly reduction (-18,5%).

3.4 New dwelling by energy source

The percentage of heating installations feed by gas in the new household during the period 1986-1997 increased steadily.



The percentage of heating installations feed by gas was 53% in 1986. The same percentage raised to 74,5% in 1997. Raising percentages of heating installations by gas was reported especially in the second half of 80s.

With reference to the other fuel types, the growing percentages of heating installation fuel by gas were in association with a strong reduction of heating installation feed by oil, which decreased by 34% in 1986 to 15% in 1977.

Forecast of fuel consumption in Italy at 2010 and 2020 for household and tertiary sector[7] can be used for assessing the new dwelling fuel consumption.

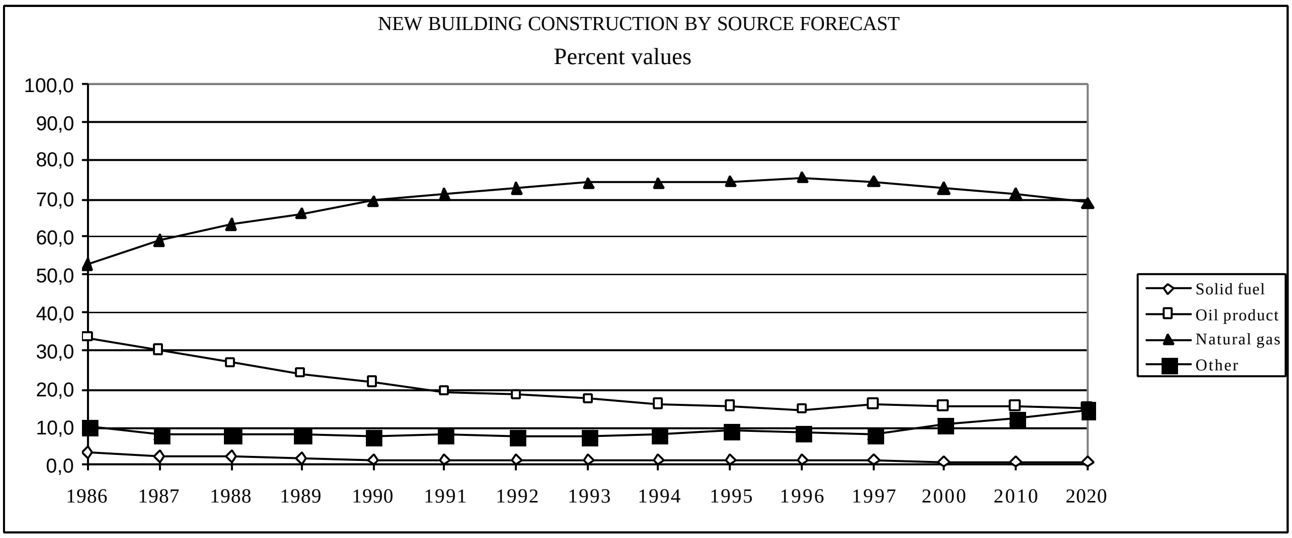
Tertiary and household -Mtoe-

	2010	2020
Natural gas	21,13	21,02
Oil product	3,45	2,23
Solid fuel	0,02	0
Electricity	12,35	14,86
Biomass	1,63	1,62
Total	38,58	39,73

In the next thirty years natural gas and electricity will be the most important sources of fuel, with a reduction of oil and solid fuel.

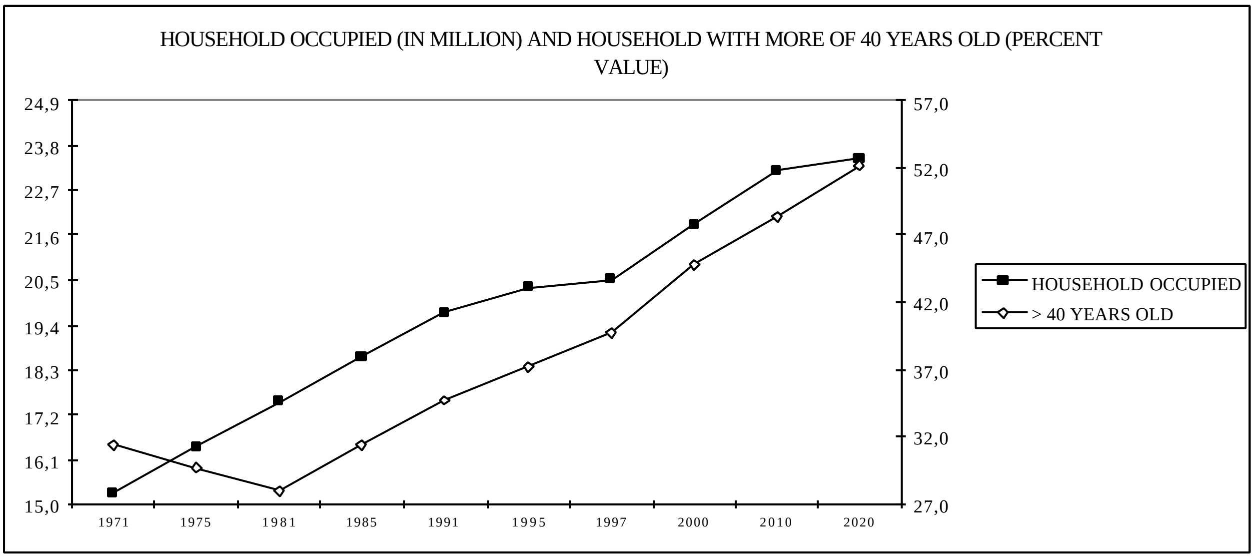
[7] Enea, "National Conference on Environment and Energy", Rome, 1998

Assuming these values as reference, the new dwelling will be feed prevailing by gas with an increasing role of electricity.



3.5 Stock building ageing and potential need of maintenance

The following graph and table show the stock-ageing forecast at 2020.



	HOUSEHOLD OCCUPIED	% > 40 YEARS OLD
1971	15.301.424	31,4
1975	16.421.588	29,7
1981	17.541.752	28,0
1985	18.638.833	31,4
1991	19.735.913	34,7
1995	20.344.872	37,2
1997	20.596.694	39,8
2000	20.713.674	44,8
2010	23.380.559	48,4
2020	23.848.171	52,2

The data clearly show that due to the combined effects of decreasing trend in new construction of dwelling and historical ageing of building constructed during last "boom economico" in the late 60s, the average age of more than 50% of occupied household in 2020 will be more than 40 years.

Public authorities are fully aware that if no incisive interventions will be undertaken, negative impacts on energy consumption level and public security will increased.

Recently, with the aim to offset building damages and improving overall energy efficiency, two main initiatives have been acted by National and Local government:

1. at National level, general fiscal benefits (up to 41%) for promoting maintenance and building restructuring activities;

2. at local level, i.e, Rome municipality, the establish of "building file" which collect the main information about "building age, structure, security regulation and static characteristics".

ACCORDING TO A RECENT SURVEY ABOUT THE STATE OF BUILDING STOCK IN ITALY[8], AT 1995 THE SITUATION IS THE FOLLOWING:

Household stock that requires to be urgently maintained (/000)

BUILDING > 40 YEARS OLD	BUILDING ERECTED DURING 1960s "ECONOMIC BOOM"	HISTORICAL BUILDING	TOTAL	% VALUE ON TOTAL STOCK 1995
770	680	535	1.985	9,8%

On the basis of these data, it is possible to envisage three possible retrofitting scenarios:

- In the first scenario, that assumes the current trends, the percentage of buildings involved in retrofitting interventions will approximately correspond to the stock which need urgent maintenance, according to the hypothesis that current fiscal benefits will be primarily used for the buildings in "worst" state. This allow to forecast that the 10% of the overall Italian stock could be retrofitted within the next ten year and another 10% (the next older stock) during the following 10 years, arriving to a total of 20% of the stock retrofitted up to 2020. It is important

[8] Censis, Press conference, 1999

to underline that in Italy the retrofitting interventions generally do not involve the energy or insulation aspects. Only in the very last years, the awareness that could be very useful to accompany the normal retrofitting interventions with insulation works is diffusing among the builders, the building professionals and the families itself. So of the above envisaged 20%, it could be "optimistically" envisaged that, up to 2020, the half will be subject of insulation interventions.

- The second scenario, that incorporates historic energy policy trends, forecast that some important decree regarding the building components certification and the building energy auditing, envisaged in the reference energy efficiency Italian law (law 9 of 1990) but still not applied, will be finally enter in force. This could allow to double the percentage presumed in scenario 1 (up to 2020);
- In scenario 3, in which existing technologies are supposed to be heavily promoted through both legislation and other campaigns, it is possible to dare to forecast a percentage as high as the 40%, that approximate the forecast percentage of building with more than 40 years old.

In figures, the % Stock involved by scenario will be

FIRST SCENARIO	SECOND SCENARIO	THIRD SCENARIO
10%	20%	40%

4. BEST AVAILABLE TECHNOLOGIES IN HOUSING

4.1 Energy Supply Technologies

As shown in paragraph 3.4, gas collective and central heating is the predominant form of space and water heating in Italy, being installed in approximately the 75% of homes. Of the total of the gas fired boilers, the little one (15-20 KW) used in central heating, represent approximately the 60%. The other main mean of heating are oil with 18%. The remainder are heated by solid fuel (mainly wood and wood products) which is steadily at the level of 7-8%.
This dominance of gas central heating leads to two important points for the potential to improve energy efficiency in heating;

1. Any significant improvement in the average efficiency of gas boilers on the market will have a strong impact on energy savings over a relatively short period (15-20 years).
2. New technologies that do not appear to the consumer as similar to gas central heating face substantial structural and behavioural barriers.

4.1.1 Improved boiler efficiency

In Italy there are not reliable statistics on the average annual efficiency of the heating boilers. Estimations based on surveys say that for a central heating boiler this figure is around 75% for gas and 70% for oil, although the efficiency of older boilers still in service can be as low as 50% or less. The best condensing boilers on the market currently achieve efficiencies of 91%, while the best non-condensing boilers reach 83%. Under the new Boiler Directive it is expected that the average efficiency of boilers on the market could reach 85%.

4.1.2 Heat pumps

Despite the technology having been developed for some time, there are very few applications of electric heat pumps in domestic dwellings in Italy. The limit to the diffusion of this technology has been, and still is, the price and the tariff structure of the electric energy. Indeed in Italy the majority of the households have a contract with the national electric utility (ENEL) that limit the installed power to 3 kW, because within this threshold the energy electric tariff is, for social reasons, highly discounted. This power threshold obviously impede the installation of devices as the electric heat pumps. But things are changing very rapidly and, due to the liberalisation of the electric market, it is possible to envisage, also at short term, a rapid diffusion of this technology, especially if used in combination with air conditioning devices (which stock is supposed to quadruplicate up to 2020 with respect the 1996 situation). Probably this technology will became the most strong competitor of the gas boilers and it is envisaged that could interest up to the 20% of the heating household market up to 2020.

4.1.3 Micro-CHP

Micro-cogeneration systems for domestic use are under development and expected to reach the market by 2005. Demonstration models have been able to generate between 20% and 40% of electricity demand for a 10% increase in gas demand. They are particularly economic in dwellings with a high heat-power ratio, that, for Italy, means big collective buildings in northern or mountain areas. Moreover all the problem related to the connection with the electric grid have to be still faced. The units are intended to be a straight replacement for a gas collective heating boiler in terms of size, noise and cost, so as to maximise their potential market.

4.1.4 CHP-based district heating

There are very few applications of CHP-based district heating in Italy (some in the north of Italy and one in Rome); Due to the general good climate conditions of central and southern Italy, and due to the high installation costs this technology is not really competitive in this country.

4.1.5 Solar hot water collectors

In Italy, solar systems can provide up to 70% of a household’s hot water during the year (and probably up to 80% in southern Italy). However, these systems have been on the market for over 25 years but have only achieved a tiny proportion of the heating market in that time. Whilst the cost of the solar panels has reduced dramatically over time, the relatively high maintenance costs can outweigh the savings achieved. It is unlikely that there will be any further significant reduction in system costs and more financial support is not expected in this technology. The total market is likely to remain low, with growth in a few niche areas such as swimming pool heating. Hence the use of solar hot water heating has not been included in the simulations.

4.1.6 Photovoltaics

Practically in Italy there are not photovoltaic installations (with the exception of some pilot plants). Peak domestic electricity consumption does not coincide with peak generating time and therefore either storage components or the potential to export to the grid is required. Current PV technology is too expensive for most applications, although it is expected that the cost of a module could be halved by 2010. However, in order to be economically viable for grid-connected domestic applications, the cost would need to reduce by a factor of 7-8.

It is estimated that the technical potential for domestic PV systems could be 2,600 GWh/year generated by 2010 and over 13,000 GWh/year by 2025. However, a realistic market potential would be less than 0.5% of this.

4.2 Appliance Technologies

The energy consumption of domestic electric appliances has been rising steadily since 1970 through a combination of increased ownership and increased usage patterns. With no improvement in the efficiency of products on the market, appliances energy consumption could increase by over 25% by 2025. In recent years however, the labelling and minimum standards introduced across the EU have lead to a reduction in some unitary consumptions, notably cold appliances. Further reductions are expected as a result of voluntary agreements among manufacturers.

4.2.1 Cold appliances

Cold appliances include refrigerators, fridge-freezers and freezers, which together consume around 20% of domestic appliance electricity. Between 1970 and 1987 the total electricity consumption of cold appliances increased fourfold, but since then this growth has virtually stopped due to a significant improvement in efficiency of new devices. As table 3 shows, there is still a considerable potential for further savings largely through the introduction of vacuum insulation panels.

Table 3 Annual Consumption of Cold Appliances

Appliance	Average annual consumption kWh/yr		
	In Stock	New	Best (2010)
Refrigerator	370	365	225
Freezer	474	440	350

4.2.2 Wet appliances

Wet appliances include washing machines and dishwashers. The energy consumption of this group has risen dramatically over the last 25 years due mainly to increased ownership, but also to patterns of increased usage per household. Together they account for 14.3% of electric appliance energy consumption.

However, ownership of washing machines is reaching saturation levels although dishwasher ownership is expected to increase by around 40-50% by 2010.

A number of factors determine the annual energy consumption of wet appliances; number of cycles and the temperature of the cycle used can play a more significant role than the technological performance of the machine. The average wash temperature has been decreasing and this trend is expected to continue.

Table 4 Annual Consumption of Wet Appliances

Appliance	Average annual consumption kWh/yr	
	In Stock	Best (2010)
Washing machine	296	200
Dishwasher	445	300

4.2.3 Cooking appliances

In Italy the majority of households use gas for cooking, however the number of appliance as electric ovens, and microwaves is steadily growing. Together the electric cooking uses account for 3.6% of electric appliance energy consumption.

Improvements in the energy efficiency of ovens are possible through better insulation, controls and the use of low emissivity surfaces and for microwaves, a reduction in stand-by power.

4.2.4 Recreational appliances

This category includes televisions, videos and home office equipment. Recreational appliances account for 13% of electric appliances energy consumption. Ownership of recreational appliances has increased enormously over the last 25 years, which has had a related impact on energy consumption, despite improving efficiency. The trend in ownership is likely to continue as saturation levels are unlikely to be reached for some time. In addition, increasing ownership of satellite and digital decoders will tend to add to the energy consumption in this group.

The greatest potential for savings comes from a reduction in stand-by power, which could be reduced by as much as 90%.

Table 6 Annual Consumption of Recreational Appliances

Appliance	Average annual consumption kWh/yr	
	In Stock	Best (2010)
TV	277	38

4.2.5 Lighting

Lighting is the largest single energy consuming appliance, accounting for 13% of the appliances total. Lighting energy consumption is directly related to comfort factors, and the number of light fittings per household has been steadily increasing. Almost no efficiency improvements were possible until the introduction of compact fluorescent lightbulbs (CFLs) in the early 1990s. The very high cost of these has been a major barrier to market penetration, but it is now estimated that around 15% of household own at least one.

The energy savings predicted are based on the assumption that by 2010 80% of lightbulbs will have been replaced with CFLs, which consume 25% of the energy of a conventional bulb.

4.2.6 Electric water heating

Around 17% of households use electricity as their main energy source for water heating. Electricity used for water heating has halved since 1975 due to the growth in gas uses and this decline is expected to continue, although more slowly.

While the heating element can be considered as 100% efficient, over 25% of the energy consumed is lost during storage and distribution of the hot water. The technologies available to reduce these standing losses are improved insulation, intelligent controls and the use of dual-element heaters.

5. MURE SCENARIOS' DESCRIPTION

In order to define reference base cases whereby a simulation of best available technologies can be implemented, three scenarios have been defined:

- a first "business as usual" scenario where the existing trend in current energy policies is taking as reference, without considering additional political, legislative or normative effects;
- a second scenario where future trends in energy policies are based on historic policy trends that should introduce some improvement, i.e through voluntary agreement development;
- a third scenario aiming to simulate the application of best available technology.

The following table summarises the main scenario characteristics with reference to building shell, sanitary hot water and electric appliances.

	Scenario 1	**Scenario 2**	**Scenario 3**
Building shel			
Existing houses	Italian regulatory law in 1980s	As Scenario 1	As Scenario 1
Existing houses	Existing autonomous trends continued (e.g. double glazing, cavity wall insulation)	Existing autonomous trends continued (e.g. double glazing, internal panels for individual housing, cavity wall insulation for collective housing)	As Scenario 2
Heating equipment	Development according to European Boiler Directive	Only low-temperature boilers or better admitted	Enhanced introduction of condensing boilers
Electric appliances	Improvement only for appliances with minimum standards (cold appliances). Little impact of energy labels	Minimum standards for all appliances or equivalent through ambitious voluntary agreements and active strategy to promote energy consumption labels.	Best available technology for all appliances

It can be noted that in Italian case the building insulation parameters for new buildings are the same in the three scenarios. Insulation parameters roughly refer to building codes in the Italian regulatory law issued in the 1980s.

This is because the recent Italian law, that refers to the building shell-heating equipment, as a whole, obliges the designers to set the building heating demand below a given energy level stated depending on the climate situation.

The above mentioned scenarios represent reference base cases for the impact analysis of energy supply technologies.

The energy supply technologies considered in Italian case are the following:

- Heat pumps
- Photovoltaics
- Cogeneration-based district heating
- Micro-Cogeneration
- Gas heat pumps

6. MURE SCENARIOS' IMPLEMENTATION

In this section for each scenario the indication of technologies involved, with their corresponding technical parameters and penetration rates, are described and the energy impacts in terms of energy savings are provided.

It is important to underlined that the annual rates used to forecast the diffusion of the selected technologies, draw a "quasi-S" curve along the considered period and assure that all the involved stocks are interested by the selected technologies up to 2025.

6.1 Scenario 1

Scenario 1 was set up using the following parameters.

6.1.1 Space heating (insulation)

Cavity Wall Insulation applied to Old and Intermediate Individual and Collective Dwellings

Average u-value of walls;	Old dwellings	0.89 W/m2K
	Intermediate dwellings	0.48 W/m2K
% stock involved;	10%	

Annual Penetration rates (% values)

1995-2005	2005-2010	2010-2015	2015-2020	2020-2025
5	10	25	15	5

Double glazing applied to Old and Intermediate Dwellings

Average u-value of windows;	Old dwellings	2.09 W/m2K
	Intermediate dwellings	2.09 W/m2K
% stock involved;	10%	

6.1.2 Sanitary Hot Water

Gas heating equipment replaced with new technologies (electric system) with the following average seasonal efficiencies

		Reference	New
Combined system	Gas	54%	70%
Combined system	Oil	45%	70%
Separated system	Gas	70%	85%

Annual penetration rates all 7% based on an average lifetime of 15 years.

6.1.3 Appliances

Cold appliances only replaced to minimum standards using the following data;

Appliance	Annual Unitary Consumption (kWh/year)	Annual Penetration Rate
Refrigerators	337	7%
Freezers	422	7%

Minimum standards applied to cold appliances as in scenario 1 on the assumption that this would be at 20% of the difference between the current average and the best technically possible.

6.1.4 Reference Scenario 1: Trends in consumption levels

The following table depicts the energy consumption trend up to 2025 for Scenario1. Since Scenario1 is characterised by current energy policies without further improvements, the impacts comparing to the baseline energy consumption trend are low: -4.3% in 2025.

The baseline energy consumption scenario considered here is related to Household sector.

Scenario 1 Energy Consumption (ktoe)

	1995	2005	2010	2015	2020	2025
Baseline	22,547	24,335	24,840	25,034	25,135	25,261
Heating	0	105	252	414	442	447
Sanitary Hot Water	0	167	287	371	430	472
Appliances	0	33	66	100	134	169
Scenario 1 Consumption	22,547	24,030	24,235	24,149	24,129	24,173

6.2 Scenario 2

Scenario 2, which represents the evaluation of future trends in energy policy based on historic policy trends, was set up using the following parameters.

6.2.1 Space heating (insulation)

Cavity Wall Insulation applied to Old and Intermediate Collective Dwellings

Average u-value of walls;	Old dwellings	0.48 W/m2K
	Intermediate dwellings	0.51 W/m2K
% stock involved;	20%	

Cavity Wall Insulation applied to Old and Intermediate Individual Dwellings

Average u-value of walls;	Old dwellings	0.45 W/m2K
	Intermediate dwellings	0.45 W/m2K
% stock involved;	20%	

Slope roof unpracticable insulation applied to Old collective Dwellings and slope

Average u-value of walls;	Old dwellings	0.35 W/m2K
% stock involved;	20%	

Slope roof panel inner side insulation applied to Old and Intermediate collective and individual Dwellings and slope

Average u-value of walls;	Old dwellings	0.31 W/m2K
% stock involved;	20%	

Double glazing applied to Old and Intermediate Dwellings

Average u-value of windows;	Old dwellings	2.09 W/m2K
	Intermediate dwellings	2.09 W/m2K
% stock involved;	20%	

Annual Penetration rates (% values)

1995-2005	2005-2010	2010-2015	2015-2020	2020-2025
5	10	25	15	5

6.2.2 Sanitary Hot Water

Gas heating equipment replaced with new technologies (electric system) with the following average seasonal efficiencies

		Reference	New
Combined system	Gas	54%	70%
Combined system	Oil	45%	70%
Separated system	Gas	70%	85%

Penetration rates all 6.7% based on an average lifetime of 15 years.

6.2.3 Appliances

Cold appliances only replaced to minimum standards using the following data;

Appliance	Annual Unitary Consumption (kWh/year)	Annual Penetration Rate
Refrigerators	337	7%
Freezers	422	7%
Washing machines	276	9%
Dishwashers	404	9%
Television	151	10%

Penetration rates are based on an average lifetime of appliances.

6.2.4 Reference Scenario 2: Trends in consumption levels

The following table depicts the energy consumption trend up to 2025 for Scenario2. Comparing to Scenario1, the Scenario2 impacts' on energy consumption savings are slightly higher: -7.7% in 2025 against –4.3 (Scenario1).

Scenario 2 Energy Consumption (ktoe)

	1995	2005	2010	2015	2020	2025
Baseline	22,547	24,335	24,840	25,034	25,135	25,261
Heating	0	252	605	993	1060	1072
Sanitary Hot Water	0	167	287	371	430	472
Appliances	0	82	165	250	334	420
Scenario 2 Consumption	22,547	23,834	23,783	23,420	23,311	23,297

6.3 Scenario 3

Scenario 3 represents the evaluation of future trends in energy policy based on the applications of best available technologies. It was set up using the following parameters.

6.3.1 Space heating (insulation)

Cavity Wall Insulation applied to Old and Intermediate Collective Dwellings

Average u-value of walls; Old dwellings 0.48 W/m2K

	Intermediate dwellings	0.51 W/m2K
% stock involved;	40%	

Cavity Wall Insulation applied to Old and Intermediate Individual Dwellings

Average u-value of walls;	Old dwellings	0.45 W/m2K
	Intermediate dwellings	0.45 W/m2K
% stock involved;	40%	

Annual Penetration rates (% values)

1995-2005	2005-2010	2010-2015	2015-2020	2020-2025
5	10	25	15	5

Double glazing applied to Old and Intermediate Dwellings

Average u-value of windows;	Old dwellings	2.09 W/m2K
	Intermediate dwellings	2.09 W/m2K
% stock involved;	40%	

Slope roof unpracticable insulation applied to Old collective Dwellings and slope

Average u-value of walls;	Old dwellings	0.35 W/m2K
% stock involved;	40%	

Slope roof panel inner side insulation applied to Old and Intermediate collective and individual Dwellings and slope

Average u-value of walls;	Old dwellings	0.31 W/m2K
% stock involved;	40%	

6.3.2 Sanitary Hot Water

Gas heating equipment replaced with new technologies (electric system) with the following average seasonal efficiencies

		Reference	New
Combined system	Gas	54%	75%
Combined system	Oil	45%	75%
Separated system	Gas	70%	90%

Penetration rates all 6.7% based on an average lifetime of 15 years.

6.3.3 Appliances

Cold appliances only replaced to minimum standards using the following data:

Appliance	Annual Unitary Consumption (kWh/year)	Annual Penetration Rate
Refrigerators	225	7%
Freezers	350	7%
Washing machines	200	9%
Dishwashers	300	9%
Television	38	10%

Penetration rates are based on an average lifetime of appliances.

6.3.4 Reference Scenario 3: Trends in consumption levels

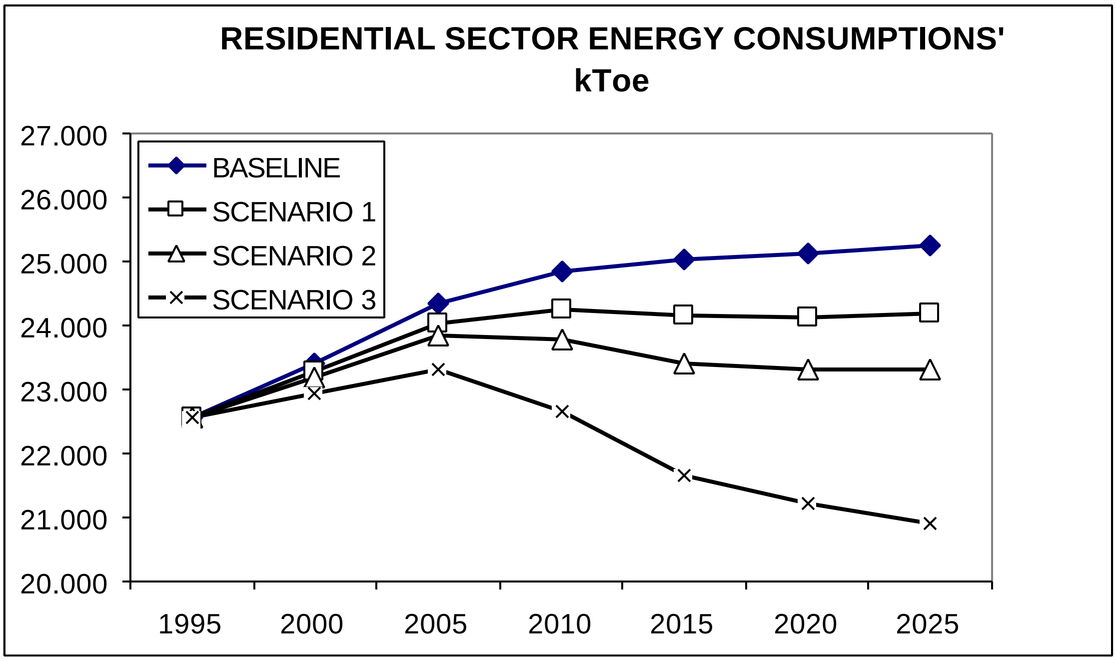
The following table depicts the energy consumption trend up to 2025 for Scenario3. The impacts' on energy consumption savings are equal to -13.9% in 2025.

Scenario 3 Energy Consumption (ktoe)

	1995	2005	2010	2015	2020	2025
Baseline	22,547	24,335	24,840	25,034	25,135	25,261
Heating	0	502	1204	1977	2111	2135
Sanitary Hot Water	0	172	295	382	444	486
Appliances	0	336	678	1024	1370	1719
Scenario 3 Consumption	22,547	23,325	22,663	21,651	21,210	20,921

7. SUMMARY OF SCENARIOS

The following graph compares the baseline energy consumption in residential sector with energy consumption relating to the three scenarios above mentioned.



It can be shown that the applications of best available technologies in Scenario 3, and in particular its high implementation rate (40% of total household stock) allow saving more energy: about 4,300 kToe in 2025.

In the second scenario the energy saving amount to about 3,200 kToe, (with 20% of total household involved) while in the first scenario the amount is equal to 2,300 ktoe (10% of total household involved).

Since the first two scenarios represent the implementation of current and historical trends in energy policies, it must be stressed that the achieving of relevant energy saving in the Italian context must be obtained through marked energy policies, in particular in the field of heating insulation.

8. THE ENERGY SUPPLY TECHNOLOGIES

Additional policies and interventions through technological supply of new technologies have been simulated for each scenario.

The list of new technologies implemented and the parameters used for the simulations are given below.

District Heating

CHP-based district heating with an average efficiency of 90% and a primary energy coefficient of 80% was applied to 15% of individual housing and collective housing.

Gas Heat Pumps

Gas heat pumps with an average coefficient of performance of 2,7 were applied to 20% of all dwellings.

Micro CHP

Micro CHP with an average efficiency of 60% (expressed as ratio between the CHP thermal output and the fossil fuel consumed) was applied to 5% of collective dwellings.

Photovoltaics

It was assumed that where PV is installed it would provide the 5% of the electricity requirements of the dwelling. The technology was not expected to have any measurable impact on the market before 2010 and thereafter would have a penetration rate of 0.2% per year of the total number of dwellings

Annual Penetration Rates

Annual penetration rates for the technologies above (except Micro CHP, only for individual dwellings and Photovoltaics) were the same as used in the baseline scenarios for improved boiler efficiencies.

	1995-2005	2005-2010	2010-2015	2015-2020	2020-2025
Individual	5	10	25	15	5
Collective	5	10	25	15	5

9. IMPACT OF ENERGY SUPPLY TECHNOLOGIES

In the following tables are depicted the impacts in terms of energy savings the technologies described in paragraph 4:

Energy Savings of the New Technologies (ktoe)

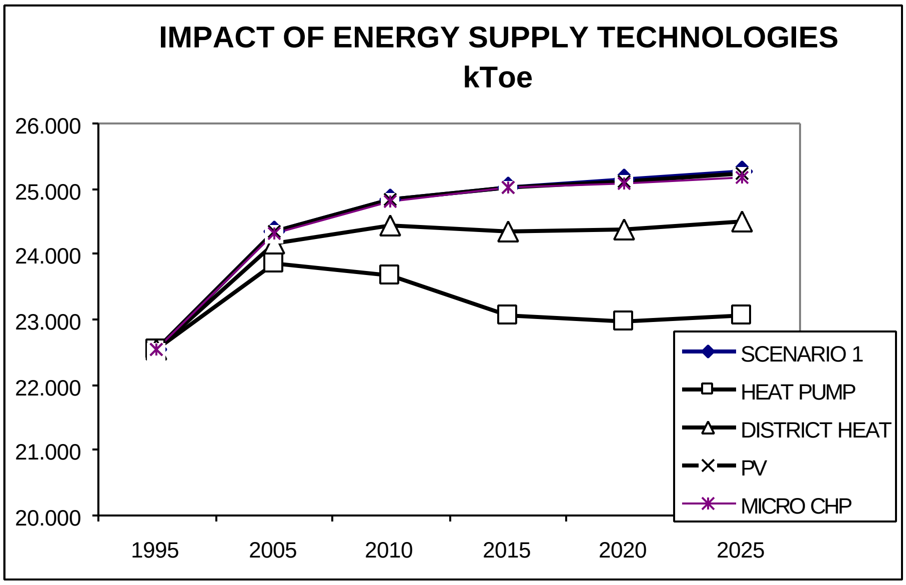
Gas Heat Pump	2005	2010	2015	2020	2025
Scenario 1	467	1154	1982	2152	2188
Scenario 2	611	1514	2608	2836	2884
Scenario 3	698	1724	2953	3204	3256
Micro CHP					
Scenario 1	13	20	23	48	78
Scenario 2	8	12	14	29	46
Scenario 3	6	10	11	24	39
District Heating					
Scenario 1	160	400	691	752	765
Scenario 2	227	558	952	1031	1047
Scenario 3	290	723	1222	1319	1338
PV					
Scenario 1,2,3	2	4	7	9	12

In terms of energy savings, heat pumps implementation allows reducing energy consumption in more incisive way (data in final energy, in primary energy, taking into account the rather low Italian energy primary coefficient – 0,33 – the real savings are practically reduced of one third. By the way the emission situation should improve given the more controlled emission outputs from the power stations)

The impact of CHP based on district heating envisage one Mtoe of savings up to 2025 in the second scenario and something more in the third one. The success of this technology is linked to the development of the electric market liberalisation. In fact it is important to note that the utilities will be obliged to sell electric energy produced with a minimum of 2% coming from renewable energies and that this proportion does not include electricity produced with co-generation systems.

The contribution of micro CHP is little given the small stock involved considered (at the present there are not reliable information that allow to envisage a less pessimistic scenario). Nevertheless the technology seems to be promising, should the problem linked to maintenance and grid connection be solved in the future.

The impacts of photovoltaic is minimal and confined to some niche markets.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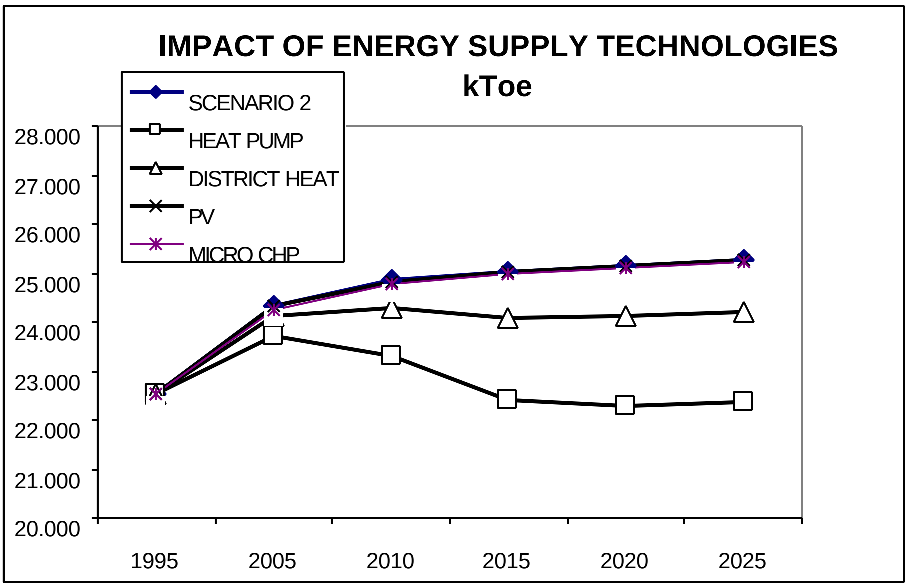
HEAT PUMP
DISTRICT HEAT
PV
MICRO CHP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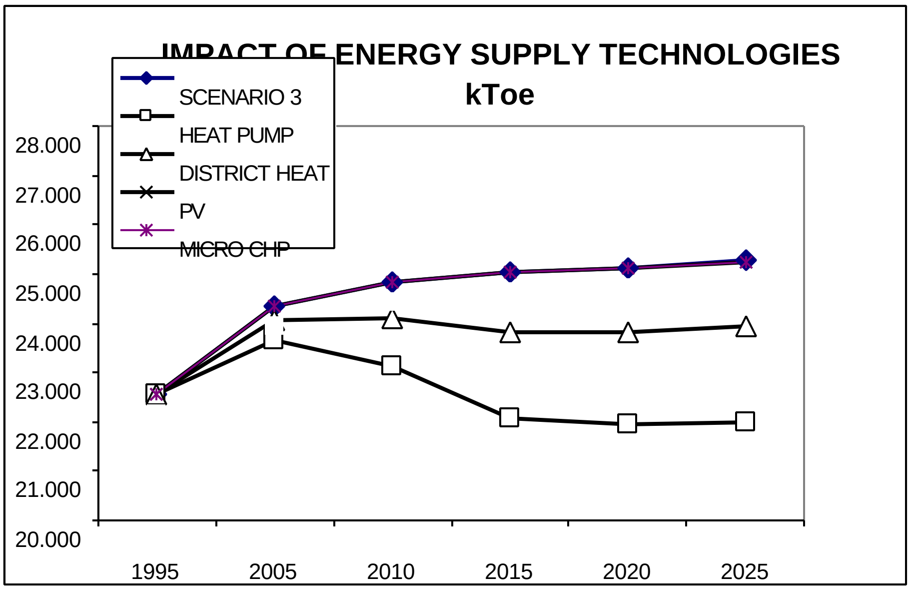
IMPACT OF ENERGY SUPPLY TECHNOLOGIES
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