

# Demographic Shifts, Household Energy Needs and Vulnerability



Rossella Bardazzi and Maria Grazia Paziienza

## 1 Introduction

Structural changes in the population are bound to be intertwined with the energy transition in determining the evolution of household energy consumption. Most countries are characterized by shrinking total population, very fast ageing and smaller family size. These demographic shifts could enlarge the group of vulnerable individuals who are suffering from energy poverty. When studying the drivers of future energy demand, population dynamics represent a crucial factor (IEA 2017). Moreover, scholarly research has argued that energy consumption behaviour along the life cycle is shaped by cultural factors, considered as a set of social norms, energy practices and material culture and therefore different generations age with specific attitudes towards energy use (Stephenson et al. 2010; Stephenson 2018). Recent empirical studies have shown that age and generation effects on energy consumption are significant (Chancel 2014; Bardazzi and Paziienza 2017) and affect the future paths of energy consumption (Bardazzi and Paziienza 2020), although they are usually overlooked in the estimated long-run projections of energy use.

Population ageing and associated demographic changes mean, as a logical consequence, that the group of elderly people will become more and more influential in determining the future energy consumption. Most of the related literature agrees on the fact that an older population spends more time at home and is more concerned about health issues and comfort. Moreover, the increasing number of households and the decrease in family size contribute to this trend because of a higher number of

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appliances and a loss in the economies of scale. How are these trends going to affect the risk of falling into energy poverty?

In this chapter, we summarize how demographic changes are interlinked with energy transition with an analysis of the main issues related to changes in the composition and the age structure of the population and their expected effects on the future paths of energy consumption. Then we focus on the vulnerability to energy poverty of the elderly and on its main drivers concerning several dimensions related to the affordability of energy expenditures—affected by the disposable income and the price level—and the energy efficiency of buildings and residential equipment—influenced by the propensity to invest in energy efficiency improvements—. Last but not least, we investigate to what extent the condition of limited access to adequate energy services hampers the social activities of the ageing population as an additional facet of this multidimensional phenomenon. Finally, we present the estimates of residential energy demand elasticities for the Italian case to confirm low responsiveness of the electricity and natural gas consumption to the changes in income and prices as a further factor of energy vulnerability for the elderly population. Our conclusion is that, notwithstanding some specific conditions that have partially sheltered the seniors from the risk of energy poverty, the ongoing demographic shifts associated with the ageing of the ‘baby boomers’—less protected by the welfare system and more used to energy-intensive practices—will increase the energy vulnerability of the future old generations that should be targeted by specific public policies.

## 2 Population Trends: Some Features of Ageing

Demographic ageing within the European Union (EU) is likely to be of major significance in the coming decades. The population of the EU on 1 January 2021 was estimated at 447.2 million, older people (aged 65 or over) had a 20.8% share with an increase of 3 percentage points compared with 10 years earlier. Europeans are living longer and in better health: life expectancy has steadily increased, on average, by more than two years per decade since the 1960s. In the same period, the birth rates in the EU member states decreased although at a slower pace in the last two decades than previously. All these trends are transforming the age structure of the population with a demographic shift towards a much older population. This change is reflected in the age pyramids comparing the data of January 2021 with 2006 (Fig. 1). The base of the pyramid appears narrower, while the age classes above 50 years are larger due to the ageing of the ‘baby boomer’ cohorts. In 2021 more than 20% of the EU population was aged 65 and over, and this share is projected by Eurostat to reach more than 30% up to 2050 and stabilize to 2100, within a trend of shrinking population size.<sup>1</sup> Indeed, Europe’s population has grown consistently since 1960, but in the last decade the number of deaths has exceeded the number of births; therefore, without

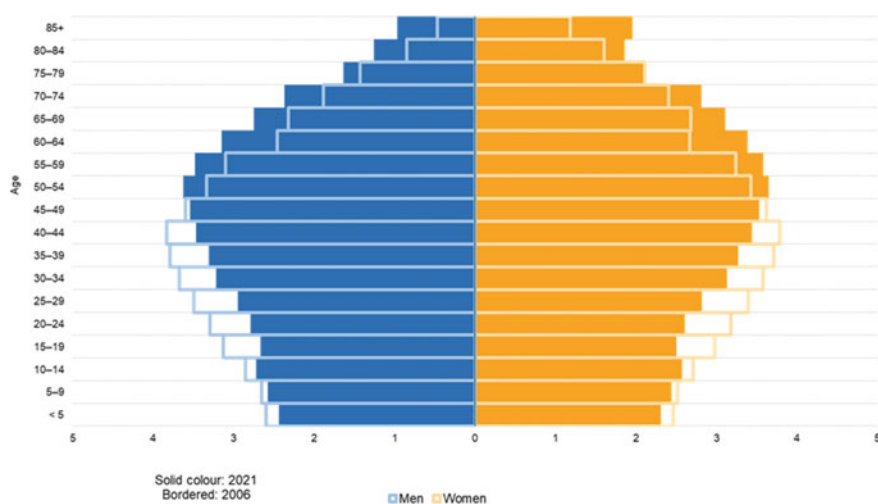
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<sup>1</sup> These figures are based on the Eurostat population projections database EUROPOP2019.

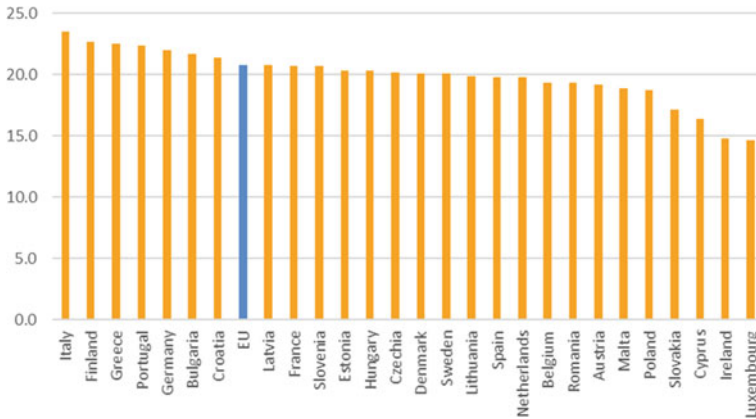
positive net migration, the population has already started to shrink. Eurostat projections state that the population will stabilize and reach a plateau before 2025 and then start to decline progressively after 2030, with an estimated decrease of around 7% by 2100.

This situation is heterogeneous across countries (Fig. 2), with Italy showing the highest share of elderly and therefore the highest median age (47.6 years compared with 44 years at the EU level). Population ageing is a global phenomenon, with the progress at different stages in various countries. For instance, the share of people aged 65 is particularly high in Japan (around 30%) while North America, Australia and South Korea have values slightly below the EU average (UN-DESA 2022).

Another important major trend concerns the number and the size of households. According to the data from the Survey on Income and Living Conditions (EU-SILC), the average household in the EU consists of 2.3 people in 2021, steadily decreasing from 2.4 in 2010. As the average size goes down, the number of European households goes up: in 2021 there were 196,690 families with a 6% increase compared with ten years before. About 39% of all households consist of a single person: as population is ageing, a growing number of elderly is living alone. Member states such as the Scandinavian and the Baltic countries present shares of one-person households above 50%, while the Mediterranean and the Eastern countries rank below the average notwithstanding a significant population ageing. Differences in living arrangements of the elderly across countries could be due to the persistence of traditional family structures and cultural norms albeit in a context of demographic, social and economic change (UN-DESA 2020). However, in Western Europe and in the USA, multi-generational households have declined dramatically and most elderly live either alone or in a couple. As regards location in urban or rural areas, older people in the EU 27 are generally more inclined than the young to live in predominantly rural and



**Fig. 1** Population pyramids, EU 2006 and 2021 (% of the total population). *Source* EUROSTAT



**Fig. 2** Share of the population aged 65 years or over (%) (2021). *Source* EUROSTAT

intermediate regions (Eurostat 2020). Looking at the housing conditions, in the EU people aged 65 and over are more likely to live in under-occupied dwellings. While EU total households in 2021 have an average of 1.6 rooms per person (EU-SILC data), older people have an average of 2 rooms per person if living in couple and 3.3 rooms per person if living alone and they are more likely to be homeowners. Spain, Ireland, Belgium and the Netherlands show values above the average, while Central-Eastern countries are below.

These demographic shifts—namely a decrease in the population size, an increase in ageing and a reduction in household size with a change in the structure of the European population—are deemed to affect many dimensions of the economic system, including the use of energy and the green transition. For instance, the living arrangements of older people shape their demand for housing and for services and resources, including energy. When the number of households increases, there will be more appliances and lower efficiency of use per person because of lower economies of scale. In general, understanding these trends is relevant to meet the Sustainable Development Goals related to ending poverty (SDG 1), ensuring health and well-being (SDG 3) and ensuring access to affordable modern energy (SDG 7).

### 3 Long-Run Energy Forecasts and Population Dynamics

The design of models on long-term energy market developments is a daunting task. In addition to geopolitical instability and the economic growth of new areas of the world, technical factors such as climate change and technological innovation already pose extremely difficult challenges. The rapid evolution of demography in Europe discussed in the previous section—concerning a decrease in the total population and a change in age and family composition—adds a fundamental challenge because

modifications in population composition imply changes in aggregate behaviour. Indeed, recent surveys on the limits and prospects of development of energy models (Fodstad et al. 2022, Scheller et al. 2021) identify consumer behaviour as one of the least studied areas. As stated by Fodstad et al. (2022) “it can be expected that more complex theories about this behaviour—such as social practices and collective rather than individual decision making—will be attempted to be integrated into energy modelling”.<sup>2</sup> Research in psychology and sociology should contribute to better understand how energy practices interact with technological infrastructures and socioeconomic factors in shaping consumption behaviour, giving rise to a broader approach to overcome the usual dichotomies between technical, human and social perspectives in the study of energy trends and transitions. For all these reasons, the approaches to forecast energy demand on the basis of historical trends adopted in macro or micro-funded models with identical optimizing agents often turn out to be totally inadequate. Moreover, the impact of interactions between energy consumption choices and demographic changes is still underestimated.

By and large, total population growth has been associated with the idea of diminishing per capita resources and with an increase in total energy use and pollution (Club of Rome project and Meadows et al. 1972). In this framework an example is the IPAT class of models, which originated from an accounting formula proposed in the early 1970s, whose simplest version stresses the direct link between total population (P), energy use and the environment (I, impact), with the mediating role of ‘affluence’ (consumption levels and habits) and technology (T), so that  $I = P \cdot A \cdot T$ .<sup>3</sup> However, since the emergence of diverging trends in population dynamics among different areas of the world, researchers in Europe and East Asia have started to focus on population structural changes and their effect on energy forecasts. Assessing the effect of demographics on energy consumption is, nevertheless, far from being an easy task. Age is a multidimensional phenomenon, not only because of its correlation with other socio-demographic variables or life-cycle stages<sup>4</sup>—such as family size, income and residential preferences—but also because of its connection with a social dimension (Shove and Walker 2014). The first example of the new attention to the link between age and energy use comes from Liddle and Lung (2010).<sup>5</sup> By using aggregate data on 17 developed countries over the period 1960–2005, they find that the age effect is nonlinear, with the shares of the youngest and over 65 groups having a positive impact on environmental indicators while a high share of middle-aged group in the population shows a negative influence. More recently the nonlinear link between age and electricity use has been confirmed, among other results, by Estiri

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<sup>2</sup> Fodstad et al. (2022), p. 13.

<sup>3</sup> This sort of Malthusian idea was originally sketched in the book ‘Population Bomb’ written by P. Ehrlich in the late sixties. More specifically, according to Holdren (1991) an elastic relationship between population and energy consumption exists, implying a sort of diseconomy of scales at collective level when population is projected to increase.

<sup>4</sup> The study of the link of life cycle and energy consumption was pioneered by Fritzsche (1981).

<sup>5</sup> Liddle (2004) reviews evidence from cross-country macro-level studies and assesses that only when the level of disaggregation of an age group approximates the life-cycle behaviour are the results significant, although they are complex and nonlinear.

and Zagheni (2019) for the USA, Bardazzi and Paziienza (2017) for Italy and Belaïd et al. (2022) for France. They find an inverted U-shaped curve, peaking when the household head is about 50 years old and the family has reached its largest size and about its maximum income level. However, when considering heating needs the inverted U shape generally vanishes and a constant rise as householder age increases can be observed. These data confirm higher thermal comfort needs and more time spent at home by the elderly and specific electricity needs.

When considering the nonlinear age effect and change in population structures, long-run energy forecasts result more complex, because nonlinear age effects are interlinked with other socioeconomic variables. Indeed, the literature has identified several positive and negative drivers associated with the observed current changes in population structures. Among the main positive drivers—factors increasing energy use—are lower economies of scale due to smaller household sizes,<sup>6</sup> more time spent at home (and the need for heating and cooling comfort) and weaker attitudes to energy-saving investments and environmental protection.<sup>7</sup> Among the negative drivers are the supposed lower incomes of the elderly—a factor mitigating both energy demand and energy-saving investments—partially counterbalanced by a positive wealth effect. Factors linked to social norms and to energy culture (Stephenson 2018)—often captured by generational effects—can act in both ways, depending on the specific institutional and cultural context.

The combination of an ageing population, nonlinear age effect and the other drivers has generally been evaluated as leading to higher energy use. Zagheni (2011) considers several demographic characteristics (age structure, fertility and birth rates) to estimate the age-specific consumption profiles for key CO<sub>2</sub>-intensive goods. By combining these results with US population forecasts, he finds a small decrease in total CO<sub>2</sub> production in the USA in 2050 for a bundle of main consumption goods and an increase in consumption and CO<sub>2</sub> levels of energy products.<sup>8</sup> Similarly, Brounen et al. (2012) analyse the influence of dwelling characteristics and demographics on residential energy consumption in the Netherlands and combine their results with projections of future demographic trends up to 2030. As a result, the ageing of Dutch society and its increasing wealth combined with the nonlinear age effects produce forecasts of growing energy consumption. An interesting case study is Japan, where the shift in population composition has been evident since the eighties. As an example, Schröder et al. (2015) estimate that a 5% decline in average household size during the period 2005–10 in Japan resulted in a 3.5% increase in the household-sector energy demand. Using data at the prefecture level for the period 1990–2010, Ota et al. (2018) estimate that a 1% rise in the share of the elderly would result in a 0.8–1.1% reduction

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<sup>6</sup> On the long-term evolution of household size, see Bradbury et al. (2014) and Schröder et al. (2015).

<sup>7</sup> The economics literature usually assumes that elderly people are generally less concerned about climate change and are less likely to support climate-friendly policies. However, this kind of correlation is disputed in a part of the literature. Among others, Mingo et al. (2018) find that ageing and the level of education are significant and positive predictors of curtailment behaviours in Italy.

<sup>8</sup> This result is based on a hypothesis of static technology with a fixed CO<sub>2</sub> content of electricity and natural gas.

in electricity consumption, while the impact on gas consumption is non-significant.<sup>9</sup> However, a balancing effect is expected due to the higher number of nuclear families, which will increase total electricity demand. They conclude that both effects must be considered to envisage the overall future pattern of energy demand. More recently, on the effect of shrinking household size, Wu et al. (2021) analyse the Chinese case, finding an elasticity of one household member to per capita electricity consumption around 20%, similar to the average value estimated in previous studies.<sup>10</sup> The use of pseudo-panels or pseudo-cohorts in this line of research has opened new perspectives, allowing the disentanglement of age and generational effects.<sup>11</sup> When looking inside overlapping generations, many studies—firstly marketing studies—have revealed that elderly people may have different consumption behaviour, depending on their cohort of birth.

As an example, Pampel and Hunter (2012) use cohort analysis to study changes in environmental concern over several decades, finding that the link between socio-economic variables and environmental attitude is nonlinear across cohorts. People belonging to different generations, characterized by orientations being shaped by common experiences (within the group) but different between generations, are carriers of changing perspectives on environmental protection and energy use.

In the economic literature it is possible to find several analyses of population composition shift that include cohort effects. Chancel (2014) estimates a clear cohort effect for energy use and CO<sub>2</sub> emissions in France, where the 1930–1955 cohort has been found consuming more than other cohorts. The author explains this finding with the interplay of an income factor (that particular generation experienced better life chances and therefore higher income), a technological factor and a behavioural factor (higher environmental concern of the younger generations and resistance of the baby boom generation to modifying its consumption patterns). Using US household data on total residential energy usage and a methodology based on pseudo-cohorts, Estiri and Zagheni (2019) confirm the existence of an increasing age-energy consumption profile but with a decrease–increase pattern for people younger than 39, with a peak around the age of 55. The positive rate of growth then slows down between 60 and 80 and accelerates again for the oldest cohort. They also find that in the warmer climate, the increase in energy demand at older ages intensifies, signalling the climate change may amplify the trend for an increasing demand. Inoue et al. (2022) estimate a positive impact on energy consumption from the pure ageing effect and from the downsizing of the average household in Japan. However, the cohort effect estimation shows that Japanese younger generations consume less energy than older ones because they live in smaller houses and practice more energy-efficient approaches. This cohort effect may partially offset the increasing factor caused by

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<sup>9</sup> Looking at the elasticity of energy to population changes, York (2007) projects a decrease in energy use as population structure changes also because the effect of ageing cannot completely counterbalance the projected total population shrink.

<sup>10</sup> See the comparison in Wu et al (2021)'s Table 8.

<sup>11</sup> Moreover, as we discuss in Sect. 4, the use of pseudo-panels allows a better understanding of price and income effects, since microdata on consumer consumption choices are not collected as panel.

pure age and household size components. A different consumption pattern has been observed for the Italian younger generations. Bardazzi and Paziienza (2020) find that the war and pre-war generations' energy consumption in Italy is lower than that of the post-war generations, implying that overall consumption can increase as society ages, even with decreasing population. Moreover, when disentangling the age and the cohort effect using the pseudo-panel dataset, they find a linear pure age effect also for electricity (consumption steadily increases with age) so that the nonlinear age effect vanishes, coming from two diverging cohort and age effects. The estimated increasing age effects and decreasing cohort effects (meaning that newer generations tend to adapt their demand more to thermal comfort standards and to new electrical appliances) overtake the population decrease the effect and therefore electricity demand is projected to increase by 2050. Due to the projected decline in the Italian population size, energy demand would decrease by 7% if no age and cohort effects were taken into account, whereas the projection with the estimated age and cohort effects results in a remarkable increase in the overall electricity demand by 2050.

## 4 Energy-Related Vulnerability of the Elderly

The importance of energy and environmental sustainability in ageing societies has attracted researchers' attention, although less than the topic would have deserved.

Indeed, in several countries, especially in the northern and colder areas, energy poverty has been placed within the context of overall poverty, so discharging the multidimensionality of this phenomenon and the complexity of its drivers.

Older persons have peculiar characteristics that affect all the drivers of energy consumption and therefore of energy poverty so putting them more frequently in a vulnerability area. Age does not in itself make individuals more vulnerable to climate risks—excluding extreme climate variation—, but nevertheless it is accompanied by a number of physical, political, economic and social factors that may do so, although the elderly cannot be considered a homogenous group.<sup>12</sup>

Following Bouzarovski and Petrova (2015), energy vulnerability originated from a set of six factors: besides the traditional triad of energy efficiency, prices and income affordability, there are other three important factors such as specific household needs, practices and the actual ability to invest for increasing efficiency. These three additional elements are in turn interrelated with the household socio-demographic characteristics (as for instance the size of the family and the presence of younger generations), health conditions, energy literacy and energy culture and household location (urban/rural location and climate among the most important). Last but not least, the wealth of the household—including, of course, home ownership—is of paramount importance for the investment incentive and the ability to invest.

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<sup>12</sup> See UN-DESA (2020).



The empirical literature generally supports the view that elderly households are more energy-intensive than other households on a per capita basis, making them more vulnerable. This is due, as previously discussed, to smaller household size (Cho et al. 2022), larger houses (more rooms per capita), more time spent at home and health-related problems. Other factors, among all energy cultures and accumulated wealth, may partially compensate and act as mitigating forces. As for the effects, the general binding constraint for other expenditures—such as an eat or heat dilemma—and health consequences of an inside temperature below the optimal values are among the most commonly studied.<sup>13</sup> Moreover, it is important to stress the negative consequences on social relations and friendship networks (Abeliansky et al. 2021), which are frequently associated with the energy poverty condition.

In the following, we review some data to assess whether and to what extent the elderly are more exposed to energy poverty in Italy. We will see that the composite effect of ageing population, welfare state structure and energy practices makes the elderly less disadvantaged than expected. Our investigation is constrained by data availability because data sources are far from being adequate as the original surveys have been designed for other purposes. Moreover, older persons (especially those 80 years of age and over) are often neglected in research and data collection, although they have peculiar consumption behaviour, needs and vulnerabilities. Indeed most statistical data, including those from Eurostat, do not distinguish between people over the age of 65, although in several countries the official retirement age is above that threshold.

#### ***4.1 Energy Poverty in Older People and Its Drivers***

To assess the extent of the energy poverty diffusion among the elderly—specifically households with older householder—we analyse the three main consensual energy poverty indicators,<sup>14</sup> comparing Italy with the average EU situation. As for the EU situation (top panel of Fig. 3), we observe that on the average population aged 65 years and over is less likely to experience arrears in payments for a mortgage or rent and utility bills. In 2020, households in arrears were 9.1% of the total population EU 27, while the share was 4.4% for single individuals aged 65 and over and 3.9% for elderly couples (at least one aged 65 or more). On the other hand, these households experience higher difficulties in keeping their home adequately warm. This indicator is a widespread measure of energy poverty and it is explained by the energy inefficiency of buildings, relatively high energy costs and low income. At the EU level, 6.9% of households were unable to keep their homes adequately warm, rising to 9.4% for single adult aged 65 years and over, while elderly couples seem

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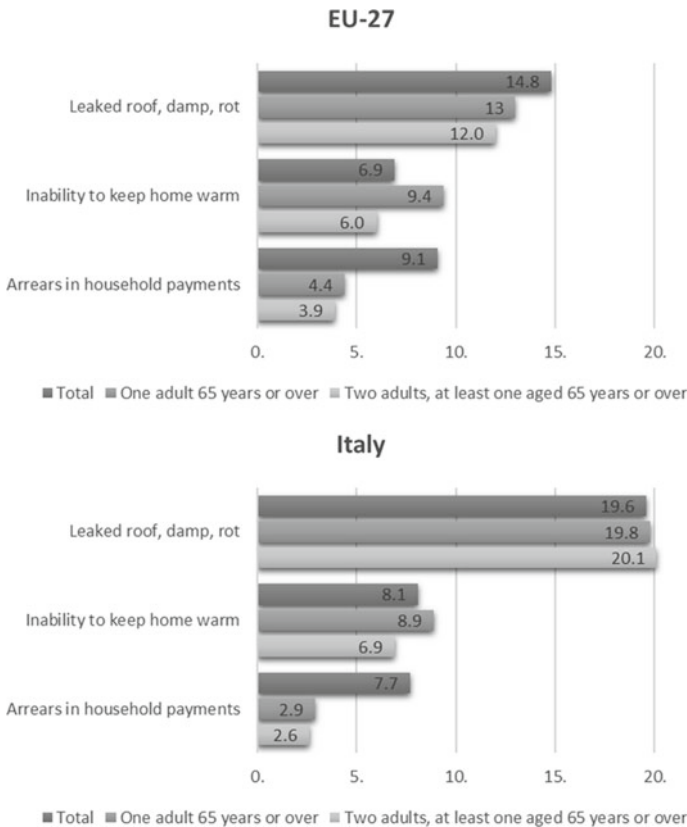
<sup>13</sup> Charlier and Legendre (2022).

<sup>14</sup> The huge debate on the efficacy of energy poverty indicators is outside the scope of this chapter. In this case we use the consensual approach indicators because they are easier to compare and more frequently updated.

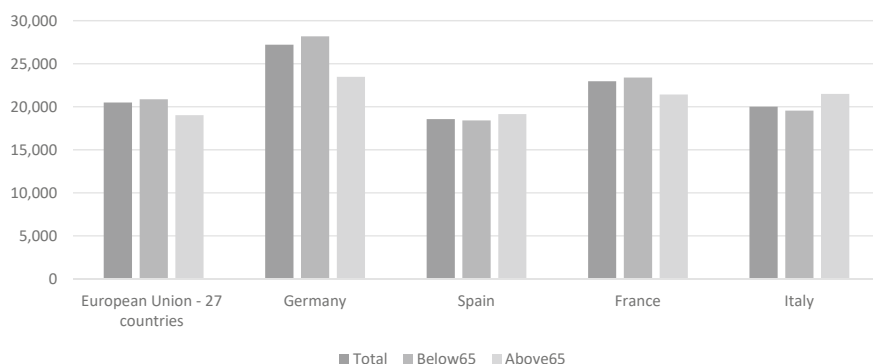
to cope better (6%). However, there is a lower share of older people compared with the whole population living in dwellings with a leaking roof, damp walls or rot in window frames or floors.

The Italian situation—shown in the bottom panel—presents a very high share of population claiming to live in deteriorated dwellings (with a leaking roof, damp walls or rot in window frames or floor), without significant variation by age groups. As for the possibility to experience arrears in housing-related payments, Italy shows a lower share than the EU and the same profile for the age group distribution. Finally, 8.1% of Italian families claim difficulties in keeping the house adequately warm, 1.2 percentage points above the EU average. However, within the same general age group profile, the solo households aged 65 and over exhibit a situation only slightly above the population average (8.9 compared to 8.1) and closer to the average when compared to the EU (9.4 and 6.9, respectively).

Turning our attention to the drivers of energy vulnerability mentioned above, in the following we present some evidence on how the elderly are characterized in relation



**Fig. 3** Energy poverty indicators, EU 27 and Italy (year 2020). *Source* Authors’ on EU-SILC data



**Fig. 4** Average income by age in selected countries (Euros) (2021). *Source* Authors' on EU-SILC data

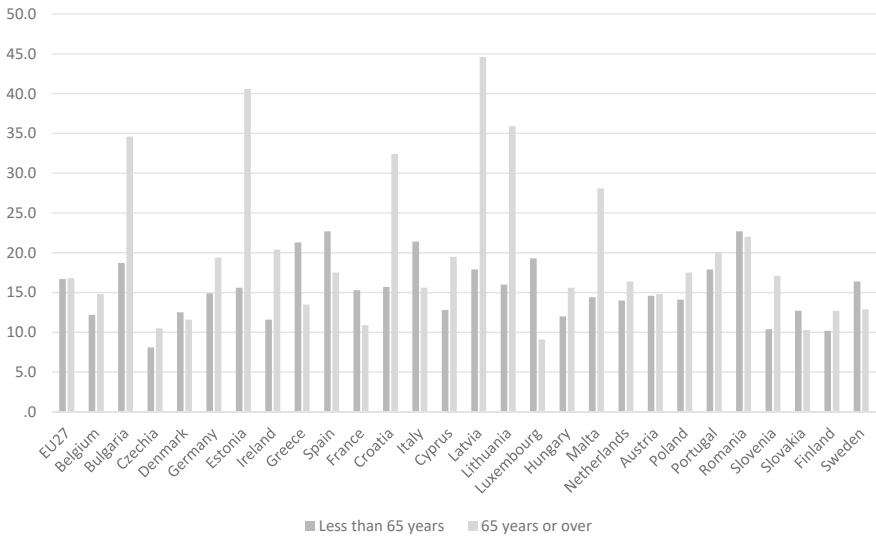
to several factors that affect the affordability of energy expenditure, the efficiency of their home and its improvement and other social practices deemed useful to identify energy poor households.

#### (a) **Energy affordability: the income level**

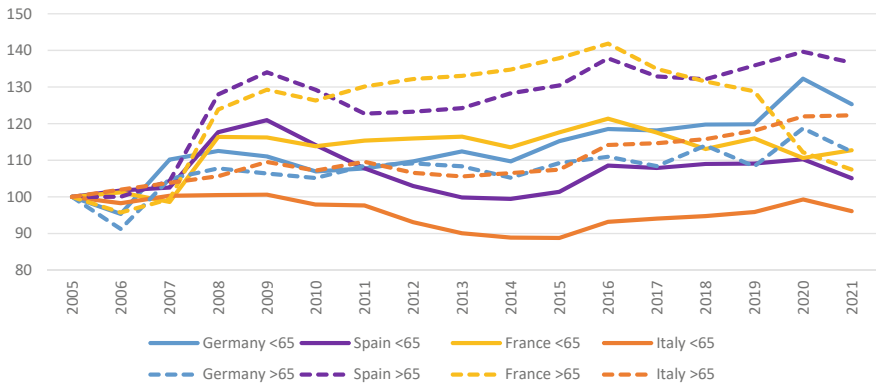
Although one would presume greater income vulnerability of the elderly, given their exit from the labour market, the characteristics of current pension systems—significantly skewed towards protecting the older generations—in the aftermath of the financial crisis have completely reversed the expectation in some countries. Figure 4 shows the average income by age group at the EU level and in selected member states: in Germany and France the average income for people below 65 years is higher than that of the other group. The reverse can be observed for Spain and Italy.

To look beyond the average figures, Fig. 5 shows the percentage of the population at risk of poverty by age in EU countries: in the EU average, the two shares are almost equal, but in most countries there is a significant difference between the two age groups. In particular, in many Eastern and new member countries (such as Malta, Cyprus and Croatia), a higher share of income vulnerability is noted for the elderly, while in Western and Mediterranean countries the situation is reversed. Italy, together with France, Spain, Greece and Sweden, shows a notable difference that favours the older population. Germany, on the contrary, shows a higher income vulnerability in the elderly.

Even more striking is the evolution of average equivalent income by age of the householder, illustrated with index numbers in Fig. 6 for four member countries. For three countries out of four—Italy, France and Spain—the increase in income for people aged 65 and over is always higher than that for the younger population. What is more, in Italy we observe an absolute decrease in disposable income for the younger generation whose level in 2021 is still below that of 2005.



**Fig. 5** At risk of poverty rate by age group (Cut-off point: 60% of median equivalised income after social transfers). *Source* Authors' on EU-SILC data



**Fig. 6** Mean equivalised net income by age group in selected countries (2005 = 100).<sup>15</sup> *Source* Authors' on EU-SILC data

**(b) Energy affordability: prices**

The general increase in energy prices is putting pressure on all households and probably can cause the shift to an energy poverty condition of many families in Europe. However, behind this general increase in prices there is a vulnerability factor for consumers that are becoming familiar with the increasing competition

<sup>15</sup> The mean equivalised net income in purchasing power standard is deflated using the Harmonized Index of Consumer Prices at the country level (base year 2015).

**Table 1** Energy efficiency in Building Stock (2013)

	Share of dwelling built after 2010 (%)	Energy consumption in residential per m <sup>2</sup> (kWh/m <sup>2</sup> )	Energy consumption for space heating in residential per m <sup>2</sup> (kWh/m <sup>2</sup> )
EU	2.8	182.9	123.9
Italy	1.8	172.7	128.7

Source EU Building Database

among energy services suppliers. In some member states, and particularly in Italy,<sup>16</sup> some consumers may be in the position of paying too high prices, even in non-extraordinary phases of international energy prices, such as the current one. This can happen because they have signed up for overpriced contracts with competitive energy supply companies pressed by door-to-door or telephone aggressive marketing practices. This vulnerability is particularly important to be tackled among older adults and foreigners with limited language skills. Contracts involving new price schemes and new services (such as the leasing of solar panels or a Renewable Energy Community plan) with potentially volatile charging arrangements could, in principle, be very hard to be fully understood and should generate the same need for protection, as the one usually considered for financial products with variable outcomes.

### (c) Energy Efficiency: the propensity to invest

Social concerns for the threats of climate change and the need to save energy have only recently spread in Italy, also in conjunction with an acceleration of public policies for investment in energy efficiency improvements. As an energy-dependent country, Italy exhibits low energy intensity, but the energy efficiency of the dwelling stock has been considered the weakest segment. Table 1 shows that the share of buildings built in recent years—presumably following higher energy efficiency standards—is very low in the European Union (2.8%) and even smaller in Italy (1.8%).

Moreover, notwithstanding a lower average residential energy consumption per square metre, Italy is characterized by higher energy consumption for space heating. This in spite of the milder climate, which means that there is ample room for further energy efficiency improvement.

Although the literature generally expects lower environmental concern and lower investment in energy efficiency for the elderly,<sup>17</sup> due to the shorter time horizon for the payback of the investment, Italian data present a different picture. In particular, Mingo et al. (2018) find that the subjective environmental concern is positively correlated with older age in Italy. We can also add that Italian older people exhibit a

<sup>16</sup> The competitive energy market in Europe has been designed by a complex set of directives and regulations, but the protection of vulnerable consumers is left to member states within a certain framework. In Italy the transition to a full competitive market is still problematic and the fully regulated contract regime (Mercato tutelato), which was originally scheduled to end in 2020, has been extended several times.

<sup>17</sup> See Abreu et al. (2020) for the Portuguese case.

**Table 2** Tax incentives for energy efficiency by income and age classes (2020)

	Income classes				
	<20.000	20.000–40.000	40.000–75.000	>75.000	Total
<i>Absolute number of investors</i>					
0–24	1,411	481	69	36	1,997
25–44	116,605	271,200	81,553	25,761	495,119
45–64	257,614	690,792	324,262	169,664	1,442,332
65–80	188,038	524,414	202,210	100,155	1,014,817
> 80	96,403	146,429	50,212	20,551	313,595
Total	660,071	1,633,316	658,306	316,167	3,267,860
<i>As a share of taxpayers</i>					
0–24	0.1%	0.5%	2.5%	3.8%	0.1%
25–44	1.7%	8.4%	18.3%	24.0%	4.6%
45–64	3.5%	12.4%	22.9%	31.3%	9.8%
65–80	4.0%	15.4%	27.7%	35.1%	11.2%
>80	2.9%	12.1%	23.1%	33.1%	6.5%
Total	2.8%	12.1%	23.4%	31.7%	7.9%

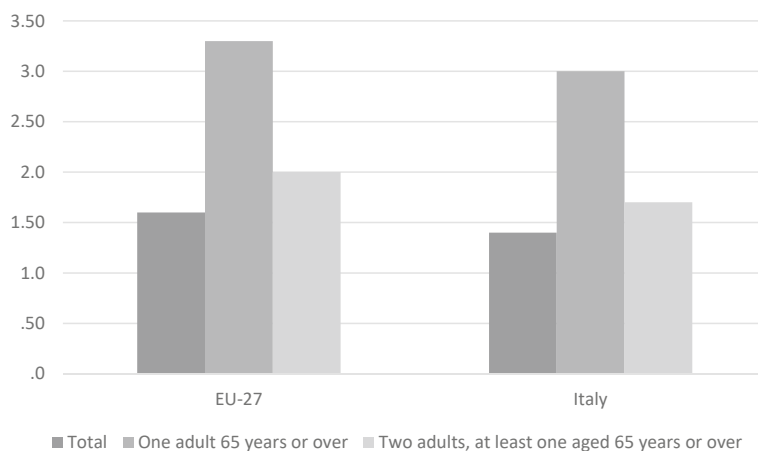
Source Italian Tax Authority

non-negligible elasticity to financial incentives. Since the 2008 crisis, Italian public funds<sup>18</sup> committed to increasing the efficiency of buildings have skyrocketed, mainly by using tax-related incentives. According to the data of the Italian Tax Authority, this generous incentive framework has prompted a 52% increase in the number of investors between 2016 and 2022 (from 2.1 million to 3.3 million). In this group, the number of investors over 65, for example, grew by 65% and that of the over 80 by 90%, reaching more than 300 thousands, 10% of the total investors in energy efficiency. Table 2 presents the total number of taxpayers benefitting from energy efficiency tax credits by income classes and as a percentage of total taxpayers (over 41 million in 2020). It is evident that the share of those claiming an energy-efficiency-related tax credit is higher among people aged 65 and above, whatever the income class they belong to.

#### (d) Energy efficiency: the residential space

Economies of scale in energy use are broadly linked to household size and average dwelling space to be heated and illuminated. The ordinary life-cycle pattern, as previously discussed, naturally decreases the household size as age increases, and the growing share of one-person households, observed in several Western countries

<sup>18</sup> Part of the funds came from EU Budget. Cohesion policy operational programmes allocated a budget of around €14 billion to improve the energy efficiency of buildings, equal to 4% of all 2014–2020 Cohesion policy funds. In addition, member states budgeted €5.4 billion for national co-financing, of which €2 billion for residential buildings. See European Court of Auditors (2020).



**Fig. 7** Average number of rooms per person by type of household (2021). *Source* Authors' on EU-SILC data

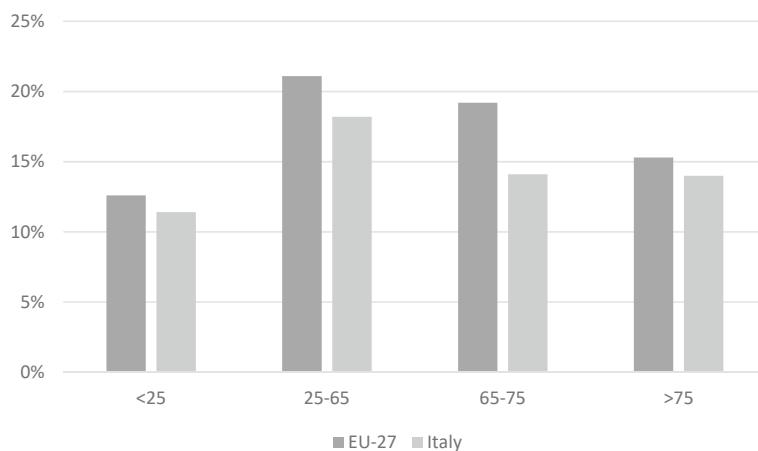
and East Asia, will exacerbate the phenomenon. With the shrinking household size, we can observe an increasing per capita space for which energy services are needed. Indeed, Fig. 7 shows that the average space—measured as rooms per person—is higher for one-person households aged 65 and over and for couples with at least one elderly person. However, the average home in Italy is smaller than in Europe for all types of families considered. This smaller residential space component can partially mitigate the ageing and the decreasing family size effects.

#### (e) **Additional factors: social practices**

In addition to the hampering of the health status (Charlier and Legendre 2022), energy poverty indirectly affects social activities, mental health and the general life satisfaction of household members (Welsch and Biermann 2017; Churchill et al. 2020). Middlemiss (2022) stresses that people in energy poverty report feelings of powerlessness and a lowered sense of agency and belonging in society. This effect is presumed even stronger in older adults where we observe a naturally decreasing sphere of physical mobility and social relations. On the contrary, a healthy ageing<sup>19</sup> would require to be able to take an active part in society and from a societal point of view healthy longevity can also reduce public expenditure in long-term care.

To investigate this particular vulnerability for older households we start by looking at the general EU situation. As expected, younger people usually have a strong preference to frequently go out for a meal or a drink, so that, on average, less than 15% of EU young people (with less than 25 years) declare that they cannot afford to get together with friends or family for drink/meal at least once month; this percentage

<sup>19</sup> The healthy ageing can be described as a “process of optimizing opportunities for physical, social and mental health to enable older people to take an active part in society without discrimination and to enjoy an independent and good quality of life”, see Healthy Aging Project (2007).



**Fig. 8** Persons who cannot afford to get together with friends or family (relatives) for a drink or meal at least once a month by age group (%) (2019). *Source* Authors' on EU-SILC data

is 11.4% for Italian youths (Fig. 8). For people more aged 65 and over, we can see that the share of those who cannot afford to go out for a drink/meal is lower than in working age and decreases for the older group. Italy shows the same pattern but the shares by age of those who declare they cannot afford social activity are always lower than in Europe.

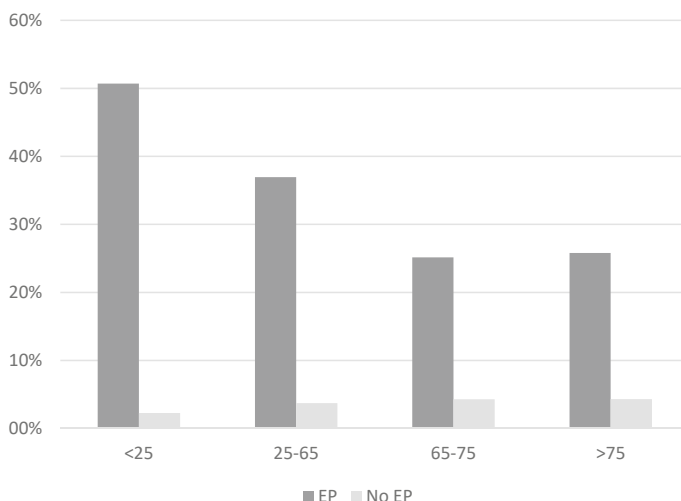
When we distinguish households in each age class according to a consensual indicator of energy poverty (Fig. 9), we observe a huge difference between the two groups. Those declaring the inability to keep the home warm also signal great difficulties in meeting friends and family members and this percentage reaches 50% for the younger group.

The same result has been confirmed by a recent survey on Italian households in energy poverty condition by Rugiero et al. (2022) who note "...a substantial divergence between respondents in conditions of non-discomfort (strongly oriented towards frequent family relations, assiduous frequenting of meeting places, systematic reading and information - also via the Internet -, participation in cultural events and training activities, travel and sporting activities) and respondents falling into classes of discomfort and vulnerability, who tend to be more isolated and less inclined to engage in activities that put them in contact with other actors in the local community. In particular, the energy poor are those who systematically participate less than others in all activities considered, in some cases to very modest proportions. They are closely followed by the energy vulnerable".<sup>20</sup>

Overall, this descriptive analysis draws a picture according to which in Italy the elderly, although suffering from health and social vulnerabilities due to age, are generally able to engage in practices to increase the energy efficiency of their homes and are shielded by welfare and pension systems that even after the financial crisis

<sup>20</sup> Our translation of the Italian text.





**Fig. 9** Persons who cannot afford to get together with friends or family (relatives) for a drink or meal at least once a month by age and Energy Poverty Indicator (%) (2019). *Source* Authors' on EU-SILC data

protected their income. To gain further insights on this issue, in the next section we propose an econometric analysis of Italian households' residential energy demand in order to estimate the responsiveness of demand by age group to changes in prices and income.

## 5 A Focus on Italian Household Energy Demand Elasticities

We focus on Italian residential energy consumption to analyse to what extent the elderly population has distinctive characteristics in its behaviour with respect to the affordability of energy use linked to income and prices. To exploit this issue, we use data collected through the Italian Household Budget Survey (IHBS) conducted annually by ISTAT. The main focus of the IHBS is on all the expenditures incurred in residential households to purchase goods and services along with socio-demographic characteristics of the household members. Our analysis uses annual observations of these independent cross-sections for the period 1997–2019 concerning demographic

characteristics and household expenditure for electricity and natural gas.<sup>21</sup> The original dataset is enriched with energy prices and tax components for the whole timespan. Nominal expenditures are converted to real values using commodity-specific price indexes (base year 2015). Moreover, to consider different demographic compositions, we use the square root of household size as an equivalence scale (as suggested by OECD). We build a pseudo-panel by grouping households on the basis of the age of the household head (between 25 and 85 years old), then means of all the relevant variables of the pseudo-household are computed for each year and cohorts are tracked over time according to the methodology already adopted in Bardazzi and Paziienza (2017, 2020).<sup>22</sup> This technique allows studying a dynamic phenomenon by following the same group of people over time when real panel data are not available.

For studying the interaction of demographic shifts in Italian population and the use of energy we select the units of the pseudo-panel according to three broad age classes of the householder (up to 35 years old, between 35 and 64, 65 and over) and we refer to these categories as ‘young’, ‘adult’ and ‘elderly’. For each group, we estimate log–log demand equations (Appendix A) where the left-hand-side variable is either the average consumption of electricity in kilowatt-hours (kWh) or of natural gas in cubic metres. Our main variables of interest are disposable income and energy prices as we aim to investigate how responsive is residential energy demand to these ‘affordability’ indicators and how vulnerable are the different age groups.

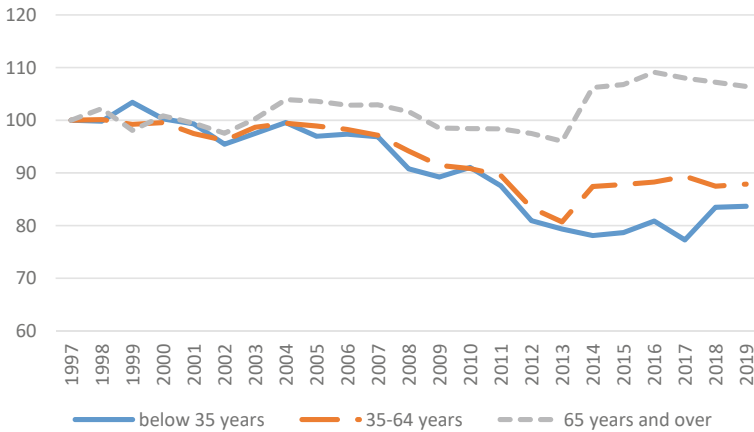
Concerning prices, we use the average regional gross price of electricity and natural gas. There is a debate in the literature (Alberini and Filippini 2011) about whether the marginal or the average price is the most appropriate variable in a demand model. As our data are cohort averages, we assume that the potential for the average price to be endogenous—as the average price depends on the quantity consumed in the presence of block pricing schemes—is mitigated by the aggregation of many different individual and local pricing levels, as supported by some empirical studies (Shin 1985; Ito 2014).

As regards household income, the Italian Budget Survey only collects data on total expenditure and not on disposable income, therefore we use the adult equivalent total expenditure in real terms to represent the spending capacity of households. To confirm that this variable is a good proxy of the income trends that we have discussed in the previous section, in Fig. 10 we represent the long-run trends of the equivalent total expenditure in real terms (base year 2015) as index numbers per age group of the householder. The widening gap we have observed between the elderly and the rest of the Italian population in Fig. 6 is confirmed by the household budget microdata.

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<sup>21</sup> The survey is based on a harmonised international classification of expenditure items (Classification of Individual Consumption by Purpose—Coicop). The design of the survey was revised in 2014 when a new HBS replaced the old HBS which was carried out between 1997 and 2013. The data used in this chapter are linked between the two types of survey by means of a correspondence analysis of each variable of interest performed by the authors.

<sup>22</sup> Some assumptions are implicit in building the pseudo-panel. Although migration, ageing and death can change the composition of cohort population over time, here they are assumed to be constant. Moreover, cohorts are defined by the age of the head, therefore the age of the other family members is not considered as a factor influencing consumption decisions.



**Fig. 10** Mean equalised total expenditure by age group (1997 = 100). *Source* Authors' on IHBS data

In particular, here we have further split the households with heads below 35 years and those between 35 and 64 that are the groups used in the regression analysis. The data show that since the 2008 financial and economic crisis it is the younger group of households that has suffered more in terms of real spending capacity which in 2019 is still well below that one of 1997.

Other control variables in the estimated equations include socio-demographic characteristics (the educational level, the family size) and climatic conditions represented by the heating and cooling degree days. Although other variables such as the occupational status of the family members, the dwelling characteristics and the heating and cooling appliances are relevant for energy consumption at the household level, these cannot be considered in our model because they lose heterogeneity in the cohort data.

Table 3 shows the descriptive statistics of the variables at the aggregate level for the whole period. When relevant, statistics by age group are presented. As expected, the average consumption of electricity by age mimics the inverted U shape usually estimated in the empirical literature, while natural gas use increases with age. As mentioned in the previous sections, the average family size reflects the life cycle of the head with a maximum age between 35 and 64 years. Finally, the educational qualification attained is lower the older the cohort.

Our estimation results are presented in Tables 4 and 5 for electricity and natural gas, respectively. In each table, different columns refer to the coefficients of the model estimated for each age group and their associated robust standard errors, obtained using OLS.

Focusing on the affordability issue of energy consumption, our main parameters of interest are the total expenditure (as a proxy of disposable income) and the price elasticities that provide information on the responsiveness of household energy demand to changes in income and prices. All the coefficients have the expected sign and are

**Table 3** Descriptive statistics

Variable	Mean	Std. Dev	Min	Max
Electricity average adult equivalent consumption (kWh)	1398.93	215.11	718.38	2117.63
hh aged less than 35 years old	1303.09	223.85	718.38	2117.63
hh aged between 35 and 64 years old	1433.32	200.33	925.84	1805.82
hh aged 65 years old and over	1426.25	206.02	856.40	1765.56
Natural gas adult equivalent consumption (cubic metre)	455.46	93.03	0.00	1324.72
hh aged less than 35 years old	382.57	108.89	0.00	1324.72
hh aged between 35 and 64 years old	456.90	68.23	288.76	639.12
hh aged 65 years old and over	514.57	64.94	340.27	639.12
Average adult equivalent total expenditure (2015 euros)	20,621.92	3192.117	7206.155	91,255.34
hh aged less than 35 years old	20,855	4784	7206	91,255
hh aged between 35 and 64 years old	21,909	1633	18,253	25,754
hh aged 65 years old and over	18,432	1949	14,243	22,380
Average household size	2.4	0.6	1.0	4.0
hh aged less than 35 years old	2.0	0.3	1.0	4.0
hh aged between 35 and 64 years old	2.9	0.3	2.0	3.7
hh aged 65 years old and over	1.8	0.2	1.4	2.3
Average educational level (0 = no education; 5 = PhD)	0.10	0.06	0.00	0.30
hh aged less than 35 years old	0.12	0.08	0.00	0.30
hh aged between 35 and 64 years old	0.13	0.05	0.03	0.28
hh aged 65 years old and over	0.05	0.02	0.00	0.14
Average price of electricity per kWh (euros)	0.260	0.085	0.193	0.605
Average price of natural gas per cubic metre (euros)	0.762	0.159	0.555	1.000
Heating Degree Days	1903.16	115.80	1631.87	2162.84
Cooling Degree Days	225.85	65.75	127.45	409.64

Source Authors' on IHBS data

statistically significant with few exceptions. Our results indicate that electricity use is sensitive to income changes with demand elasticity larger for households whose head is in the 'young' and 'adult' groups (0.378 and 0.385, respectively) while it is not significantly different from zero for the elderly. On the contrary, income elasticities of natural gas use are higher than electricity and households with head aged below 35 show a very elastic natural gas demand. Also in this case, the elderly households demand is not statistically sensitive with respect to their spending capacity.

Price elasticities are negative but all below 1 in absolute value for both fuels. For electricity, older households show the lowest value compared with families in

**Table 4** Estimation results: electricity

	Under 35 years	35–64 years	65 years and over
Total expenditure (log)	0.378*** (0.052)	0.385*** (0.023)	0.051 (0.041)
Electricity price (log)	-0.765*** (0.025)	-0.816*** (0.012)	-0.653*** (0.012)
Educational level	-0.043*** (0.011)	-0.132*** (0.022)	0.014 (0.013)
Family size	-0.100** (0.045)	0.054 (0.049)	0.228*** (0.027)
Heating Degree Days	0.559*** (0.062)	0.459*** (0.016)	0.320*** (0.018)
Cooling Degree Days	0.009 (0.010)	0.014*** (0.004)	0.037*** (0.005)
Time	0.040*** (0.003)	0.045*** (0.001)	0.034*** (0.001)
Constant	-2.538** (0.893)	-2.261*** (0.295)	2.561*** (0.440)
R <sup>2</sup>	0.84	0.83	0.92
N	362	713	459

\*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$

the previous phases of the life cycle, showing that their natural gas demand is more rigid to changes in its own price with respect the electricity use. In general, our price elasticities are larger than those estimated for residential electricity demand in Italy by Dicembrino and Trovato (2013) on monthly data for the period 2000–2012 (-0.013) but they are consistent with results obtained by Faiella and Lavecchia in Chapter 7 of this volume (short-term price elasticity of electricity -0.36 and heating -0.40) on the same data used here. This evidence supports the general finding in the literature that estimated elasticities based on panel data tend to be higher than those estimated on aggregate time series and on cross-sections (Labandeira et al. 2017).

Within a framework of relatively better income performance of the elderly compared to the younger population, our estimates show a lower responsiveness of residential energy consumption (electricity and natural gas) to the changes in income and prices. This can be partly explained by a relatively restrained attitude that characterizes the energy consumption of the current elderly (those born before 1955), as shown by estimates of generational effects (Bardazzi and Pazienza 2017, 2020), and partly by relatively less squeezable and, generally speaking, less flexible needs. This relatively more rigid energy demand is a source of additional vulnerability, as generally highlighted by the empirical literature.<sup>23</sup> However, as for Italy,

<sup>23</sup> Estimations by cohorts, not shown in this chapter, confirm for the older generations (born before 1950s) lower income elasticities and higher price elasticities especially for natural gas demand.

**Table 5** Estimation results:  
natural gas

	Under 35 years	35–64 years	65 years and over
Total expenditure (log)	1.763*** (0.188)	0.253** (0.111)	0.077 (0.180)
Natural gas price (log)	−0.216 (0.227)	−0.405*** (0.057)	−0.248*** (0.061)
Educational level	0.342*** (0.046)	−0.186*** (0.031)	−0.040 (0.042)
Family size	−0.084 (0.274)	0.095 (0.069)	0.572*** (0.172)
Heating Degree Days	0.618 (0.365)	0.407*** (0.075)	0.413*** (0.080)
Cooling Degree Days	0.077 (0.046)	−0.072*** (0.011)	−0.128*** (0.015)
Time	0.024*** (0.007)	0.061*** (0.002)	0.052*** (0.003)
Constant	−17.949*** (3.225)	−2.206 (1.413)	−0.010 (2.139)
R <sup>2</sup>	0.39	0.70	0.78
N	362	713	459

\*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$

we can expect remarkable changes due to the different generational consumption behaviour (especially for the baby boomers) and for the long-run effect of welfare reforms.

## 6 Conclusions

The fast ageing process and the persistent inequality among European countries make it crucial to provide projections to take action on the many economic and social critical issues. Total population is shrinking in almost all EU countries, within remarkable age and household composition effects. These demographic shifts, characterized by a decrease in household size, could enlarge the group of vulnerable individuals who are suffering for deprivations and energy poverty in particular. At the same time, the need to speed up the energy transition path makes it urgent to consider different attitudes and capability towards new technologies and energy efficiency investments for an older and smaller population.

The link between population and energy consumption has long been considered straightforward, and projections of world population growth—the 'population bomb' effect—have long raised alarms about the availability of per capita energy resources. It was not until the first signs of a decline in total population that the age and household

size effects were taken into account. However, it is now recognized that the age effect is not linear and depends not only on the life cycle but also on energy cultures and the relative wealth position of different contingent age groups. Ageing certainly coincides with a situation of increased vulnerability that needs to be taken seriously when tackling deprivation and energy poverty in particular. Being elderly means that one's income is decoupled from general economic growth, that one has health problems, that it is more difficult to keep up with technological progress, including the provision of energy services, and that one often lives in a small household and in a large house, thus losing economies of scale in energy consumption. Many indicators of income vulnerability and energy poverty signal the higher incidence on the elderly, especially among single households at the EU level. However, the elderly are far from being a homogeneous group. In some European countries—including Italy—the slow economic growth, longer and healthier life courses and welfare system may have protected part of the current older generations with respect to the younger cohorts. In Italy the current older part of the population is characterized by an energy culture still shaped by hard times—the war and the oil shock of the seventies—resulting in an energy-saving attitude. At the same time, on average, the welfare system has sheltered their income and wealth so they also have a positive attitude towards the energy-saving investments. Therefore, the lower responsiveness of residential energy consumption (electricity and natural gas) to the changes in income and prices with respect to the younger population can be interpreted with a relatively better income and wealth situation and a persistent energy-saving attitude. However, the challenges the EU faces to reach the ambitious energy transition targets and the progressive changes in the welfare system will put more hardship on elderly people in the future. Moreover, the baby boomer generation will become old in the next decades with a different lifestyle characterized by higher thermal comfort standards and more electrical appliances. At the same time, the welfare systems are likely to offer lower protection and guarantees to preserve their long-term financial sustainability. All these factors could concur to a higher risk to be exposed to energy vulnerability for the future generations of senior citizens.

## **Appendix A: Construction of the Pseudo-Panel and the Model**

To construct the pseudo-panel for our analysis, we use data from cross-sections for the years 1997–2019 and select households whose head is between 18 and 85 years old. This truncation eliminates those above 85 to avoid a selectivity problem.

The definition of cohorts creates a trade-off between the number of cohorts and the number of observations per cohort. On the one hand, if the number of cohorts is too small, there is a risk of grouping in the same cell households with heterogeneous behaviour. On the other hand, if a large number of cohorts is chosen to preserve variability within the pseudo-panel, it is possible to obtain cells with a very low

number of observations, and the cohort means are inaccurate estimates of the true means of the cohort population, thus leading to inconsistent estimators (Verbeek 2008). Moreover, the criteria for the definition of cohorts are also important. Cohorts should be built according to characteristics that are invariant over time and observed for all individuals in the survey, such as date of birth, gender or region.

Consequently, for the construction of the pseudo-panel we take into account these considerations and perform the following steps. After trimming extreme and unreliable values we compute the pseudo-household means of all the relevant variables according to the age of the householder and year. Finally, the large quantity of original data is reduced to a total of about 1534 cells with an average cohort size of 350 households that allows to neglect measurement errors of population means (Verbeek 2008).

To estimate the effects of different covariates on pseudo-household energy demand we consider a set of variables including energy prices, real income and some demographic characteristics. Since we apply the model to a pseudo-panel, all the variables must be averaged by cohort  $c$  at time  $t$ , and the model can be parsimoniously written in matrix form as:

$$y = \alpha + W\varphi + \varepsilon, \quad (1)$$

where  $y$  is the stacked vector of cohort mean observations and  $W$  is a matrix of time-varying covariates, including fuel prices, household total expenditure in real terms (as a proxy for income), some control characteristics like the householder's educational level and household size and the climatic conditions measured with the heating and cooling degree days. When we control for variables that change over time, we want to see the extent to which the life cycle and generational behaviour of variable  $y$  are explained by these variables. Equation (1) constitutes the basis for our analysis.

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