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"GAS CONSUMPTION OF ITALIAN HOUSEHOLDS: INFLUENCING FACTORS AND PRICE ANALYSIS"

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Introduction

The cost of energy represents one of the most recurrent and substantial expenses for Italian families, and the cost of heating is certainly one of the most relevant items on the bill.
In Italy, 98.6% of families live in homes equipped with heating and hot water systems, of which 65.7% use autonomous heating systems, 17.1% use centralized systems, and the remaining 17.2% use individual appliances *(ISTAT data from 2022)*. On average, homes are heated for eight and a half hours a day, with variations of about an hour depending on the region (north, central, south) and the type of family.
Regarding the sources of energy for these systems, without any doubt, the most widespread is natural gas, both for heating (68%) and for the production of hot water (69.2%). This is due to its characteristics that make it an energy source not easily replaceable, as it offers ecological benefits for both the emissions generated by its transformation processes and its transportation through pipelines, which avoids traffic and further pollution. It also offers economic advantages compared to diesel and GPL.
Gas, and in particular its price, therefore plays a leading role in the Italian energy and economic sector. In recent years, the price of natural gas has undergone significant fluctuations with significant repercussions on users' wallets. The last two events that marked a significant variation in fuel prices in Italy are the pandemic and, above all, the war in Ukraine. This is due to the fact that, according to the latest ARERA report from 2021, net natural gas consumption in Italy has increased, while domestic production has decreased in the last year. Consequently, national imports have increased, and the supply of gas from foreign countries, particularly from Russia, has increased and now stands at around 95.5%.
Given the importance of gas in the national energy system and especially in the bills of Italian families and the recent increase in natural gas prices, the main objective of this paper is to analyse the relationship between Italian families' gas consumption and the factors that can influence this consumption such as climate, characteristics of the dwelling and the price of this energy source. In particular, the idea is to investigate to what extent the gas price influences family energy consumption, with the aim of identifying any relationships between the two phenomena.
The thesis begins in the first chapter by addressing a brief introduction to the gas market, the different phases of its supply chain, and the country's net imports. It continues with an analysis of historical trends in domestic gas consumption at the national level over the last 10 years. The chapter concludes with an analysis of the main factors that influence fuel consumption, such as climate and the thermal insulation of the housing unit.

The second chapter focuses on one of the variables considered in the previous chapter, namely the price of gas per cubic meter. The first part compares the price of gas in Italy with that of the European Union, drawing on data provided by Eurostat. Subsequently, the main instruments used by wholesalers to market gas and the markets in which it is bought and sold in Italy are analysed. The historical price trends of the raw material are then compared among the identified markets.

In the second part, the analysis focuses on the contracts applied to end customers in the liberalized market and compares them with those in the regulated market, examining the structure of the bill and how it has changed in recent times.

In the final part, gas prices are related to heating consumption, first at the national level and then based on the climatic zones (North, Central, and South). Furthermore, the price in the regulated market is correlated with the average consumption of a typical domestic consumer.

In the third and final chapter, the consumption and energy expenses of two condominiums in Padua are analysed in relation to the gas prices used for the purchased gas, based on data provided by an administrator in the area.

1. Gas market and consumption

1.1 Gas market introduction

Natural gas (CH4) is mostly composed of methane and today represents one of the largest sources of energy globally and nationally, despite being the last fossil fuel to establish itself on a global scale. The two main producers and exporters of gas in the world are Russia and the USA, which alone produce more than 40% of the world's gas.

Today, gas is used for various purposes, including domestic use for heating and hot water, industrial use for carrying out productive activities, for the production of electricity, and finally, it is used as fuel for cars and other vehicles.

Natural gas is the most widely used primary energy source in Italy, and the reasons for its diffusion are mainly three:

- Low emissions: the switch from a traditional oil-fired boiler to a more recent gas-fired one reduces CO_2 emissions by up to 55%, and in particular, PM10 emissions are significantly reduced, until they are eliminated *(Source: Uniper data 2014)*. Natural gas, in fact, produces between 25% and 40% less carbon dioxide than other fossil fuels for the same amount of energy produced. Moreover, gas condensing boilers can easily be integrated with systems that use renewable energy sources such as solar thermal panels;
- Higher energy efficiency: condensing boilers utilize the entire energy content of the fuel to transform it into heat. They reuse the thermal energy of the steam produced in the combustion process to preheat the cold water entering the boiler, and there is less heat dispersion;
- Reduced costs: in addition to being easily compatible with other renewable energy sources, which allows for a reduction in consumption, natural gas is extremely reliable and easy to install and repair. Even the price of the raw material itself, until a few months ago, was convenient compared to other energy sources. Furthermore, tax incentives are provided for these types of boilers.

Regarding the demand and supply of natural gas in Italy, according to data released by the Ministry of Ecological Transition[1], the country saw a net increase in gas consumption of 5.6 billion cubic meters (Gm^3) in 2021, reaching approximately 74.1 Gm^3. This represents an 8.1% increase compared to 2020, mainly driven by two factors: the economic recovery following the

[1] The Ministry of Ecological Transition is a department of the Italian government. It was formed in 2021 by the Draghi Cabinet, and replaced the Ministry of the Environment.

pandemic and the climate conditions that may have led to higher demand for gas for heating in the early part of the year.

In more detail, there was a significant increase in the residential sector, as shown in the figure1.1.1, which saw consumption rise to 17.7 Gm³, a 10.9% increase compared to 2020 and even 1.5 Gm³ higher than pre-pandemic levels in 2019.

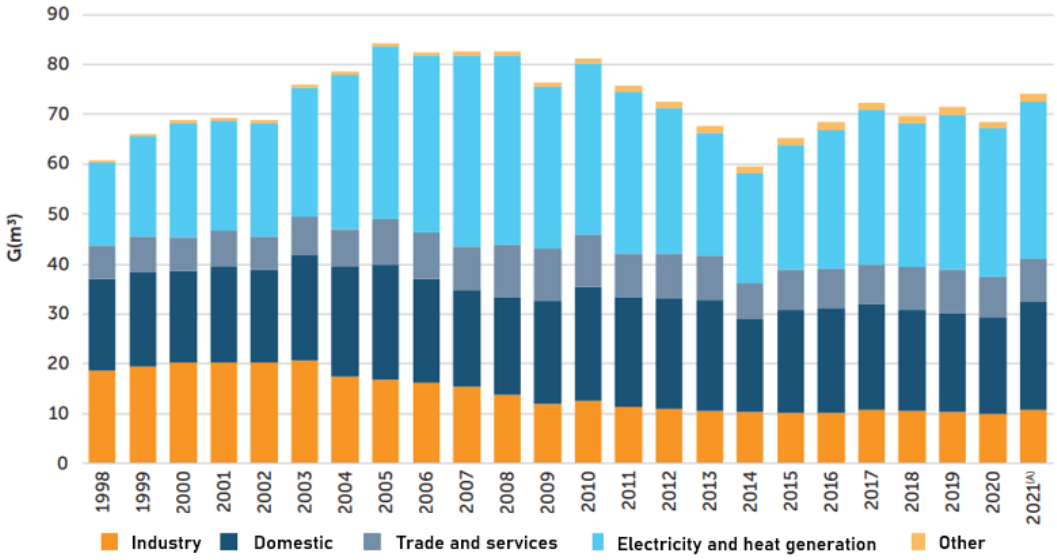


Figure 1.1.1 Natural gas consumption by sector. Source: Ministry of Ecological Transaction. National energy balance, various years.

To meet the increase in post-pandemic consumption in 2021, Italy saw its level of dependence on foreign countries, which is calculated as the ratio of net imports to the gross value of national consumption, increase by almost one percentage point and reach 93.5%. This is mainly due to three factors: the first is the decrease in already minimal national production, which in 2021 is about 3.3 billion cubic meters (16.7% less than the previous year); the second is the increase in imported gas volumes, which reached 73 Gm³; and the third and final factor is the increase in exports, which quadrupled compared to 2020, from 316 Mm³ to 1.5 Gm³ of gas. The reason for this last increase is that Italian gas, in the last part of the year, is the most cost-effective compared to gas that can be purchased at the TTF[2].

All these factors, combined with the increase in national consumption, have resulted in not only an increase in the level of dependence on foreign countries but also a decrease in the volume of gas stored, which has decreased by 1.6 Gm³. Taking into account all these data, gross national

[2] The TTF (Title Transfer Facility) is the main reference virtual market for gas trading in Europe which is based in Amsterdam, the Netherlands. This virtual platform brings together the producers of Natural Gas and the suppliers who buy it and resell it to end customers, citizens and businesses, in the countries where they operate.

consumption in 2021, excluding system consumption and network losses, was 76. Gm³, an increase of 7.3% compared to 2020 and 2.6% compared to pre-COVID levels.

1.2 The gas supply chain

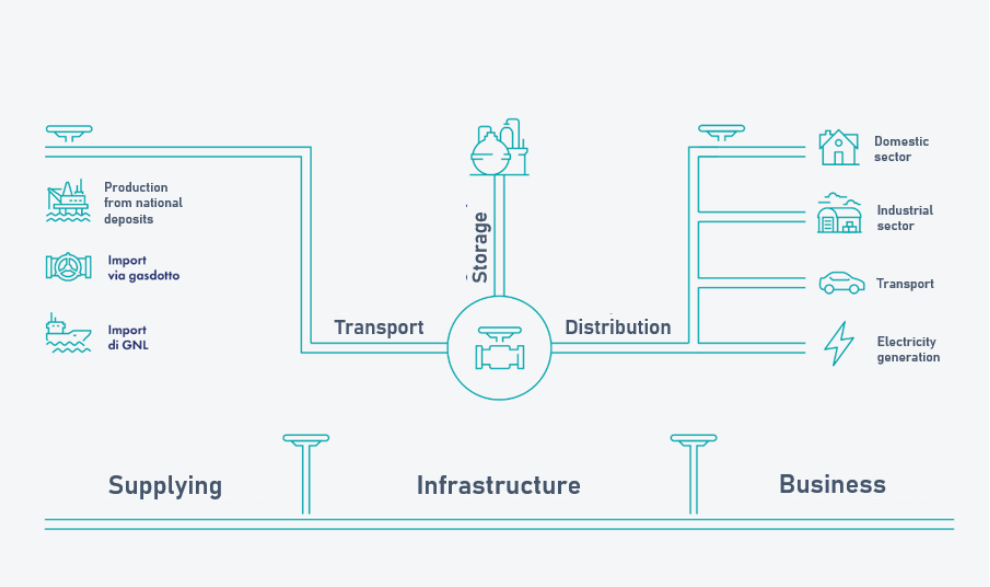


Figure 1.2.1 The natural gas supply chain in Italy. Source: Infogas, Proxigas.

All the steps involving the passage of gas from the extraction phase to its delivery to final customers are grouped together in the natural gas supply chain. In Italy, the gas system is mostly fueled by gas imported from foreign countries, which reaches the national network through pipelines with a total length of 41,000 km, and then arrives at the macro-consumption areas and finally at the regional networks for local distribution. Therefore, the natural gas supply chain refers to the gas production cycle and is divided into three main phases: supply, transportation (storage), and sale.

Regarding the first phase, which is the upstream one, there are two methods of supply: national production and importation from abroad. Based on the analyses carried out by the Ministry of Economic Development, in 2021, national production decreased compared to previous years, reaching around 3.3 billion cubic meters (Gm³) with a national coverage at a historic low of 4.4%. The 47% (1,630 Mm³) of the gas is extracted from onshore fields, while the remaining 53% (1,869 Mm³) is extracted from offshore fields. According to the National Mining Office for Hydrocarbons and Georesources, the proven gas reserves currently stand at around 39.9 Gm³ (a 10.5% decrease from the previous year's estimate), while the probable reserves are around 44.5 Gm³ (a 4.4% decrease from the estimate of the previous year). The quantities of

extractable gas in our country are destined to decrease and at the average extraction rate of the last few years, they could be depleted within the next 8 years, unless new investments are made to create new platforms and extraction points.

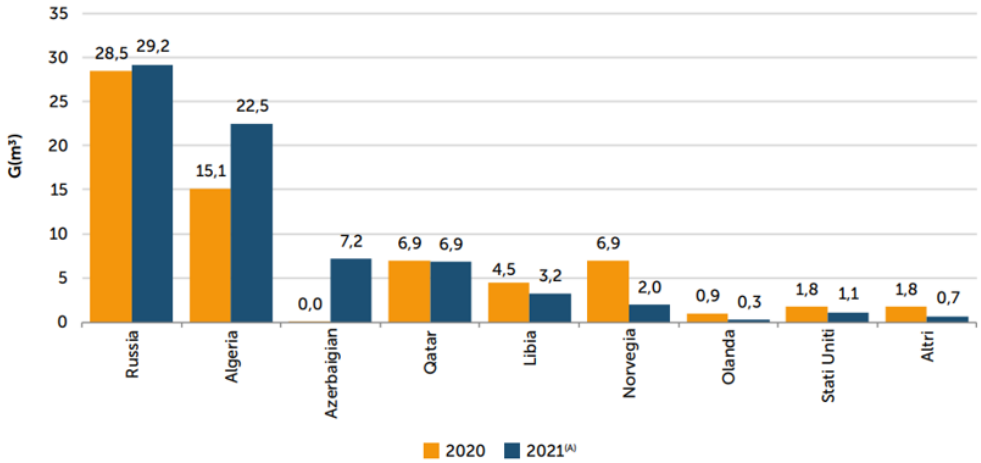
Regarding the main national producers of natural gas, despite the presence of 17 corporate groups, Eni is the top producer with an extracted gas quantity of 2.2 Gm³ and a national production share of 69.5% of the total.

The second method of supply is through importation from abroad. In fact, starting from the second half of the 1980s, Italy has become a net importer of natural gas. This means that imports, due to increased demand, have a greater impact than national production in meeting the country's needs.

The countries with the highest amount of gas supplied in the last two years are Russia (with 29.2 Gm³), Algeria (with 22.5 Gm³), and Azerbaijan (with 7.2 Gm³).

Gas is imported into Italy through two different methods: through pipelines with approximately 63 Gm3 (87%) and by ship (9.9 Gm3), first transforming the gas into LNG (Liquefied Natural Gas) and then re-converting it through regasification plants located in various parts of the peninsula.

The main importing company is Eni, which with its 34.3 Gm³ of imported gas, is the dominant operator in the market, while in second place is Edison with 11.1 Gm³ and in third is Azerbaijan Gas Supply Company Limited which imports gas through the new TAP[3] pipeline, which entered into operation at the end of 2020.



[3] The Trans Adriatic Pipeline is part of the Southern Gas Corridor, transporting natural gas to Europe from the Shah Deniz II field in Azerbaijan. Connecting with the Trans Anatolian Pipeline at the Greek-Turkish border, TAP crosses Northern Greece, Albania and the Adriatic Sea before coming ashore in Southern Italy to connect to the Italian natural gas network.

Figure 1.2.2 Gross imports of gas in the last two years by country. Source: Ministry of Ecological Transaction.

In the second phase, gas is injected into the network from various points scattered throughout the country and transported via the transmission network to reach the final customers' facilities. As for the injection of foreign gas into the network, there are 9 different points, 6 of which coincide with the gas pipelines (including TAP since 2020), while the remaining 3 are LNG terminals. The transmission network, owned 92.9% by Snam rete gas[4], is divided into primary, which involves the transportation of gas throughout the national territory, and secondary, which involves the transportation of gas locally branching off from the primary distribution arteries to end-users.

According to data collected by ARERA[5] in 2021, the volumes transported have increased by 6.8%, returning to pre-pandemic levels, highlighting an increase in national consumption. Finally, the transportation phase is functionally linked to storage activities, which involves storing gas in certain collection points, usually depleted fields, to compensate for demand fluctuations (commercial storage) and respond to situations of supply shortage/reduction or national system crises, such as extreme weather conditions or interruptions in gas pipeline supplies (strategic storage).

The last segment of the gas supply chain is the commercial activity, that is, the sale of the fuel to the end customer. A very important change occurred in this phase on January 1st, 2003, when the sector was liberalized[6], and the possibility of choosing one's own natural gas supplier in the free market or accessing the service of the protected gas market was introduced. Selling companies must be authorized by the Ministry of Economic Development. Since the introduction of the possibility of choice between the free market and the protected market regime, the percentage of switching, particularly for domestic customers, has been continuously increasing, and today the share of final consumption purchased on the free market is 67.8%. This positive trend of growth identifies an opening towards the final market that generates competition, bringing benefits to end customers who can obtain gas at a lower price.

4 Snam is Europe's leading operator in natural gas transport and storage, with an infrastructure enabling the energy transition. It ranks among the top ten Italian listed companies by market capitalization.

5 The Italian Regulatory Authority for Energy, Networks and the Environment (Autorità di Regolazione per Energia Reti e Ambiente, ARERA) is an independent body created under Italian Law No. 481 of 14 November 1995 for the purposes of protecting consumer interests and promoting the competition, efficiency and distribution of services with adequate levels of quality, through regulatory and control activities.

6 The liberalization of the gas market first began in 1998 with the EU's directive 98/30/EC, which was then replaced by the directive 2003/55/EC pursuing the goal of creating a single and competitive European market. In Italy, the opening of the gas market to competition started with the Order nr. 164/2000 (called "Decreto Letta"), which ratificated the directive 98/30/EC, breaking up the historical ENI's monopoly. The liberalization's process was completed in December 2002.

In 2021, according to the annual survey on energy sectors conducted by ARERA, approximately 75.5 Gm³ of gas were sold to 21.6 million customers, 18.4 of which were intended for self-consumption and 57 for sale. Overall, gas sales increased by 5% compared to 2020.

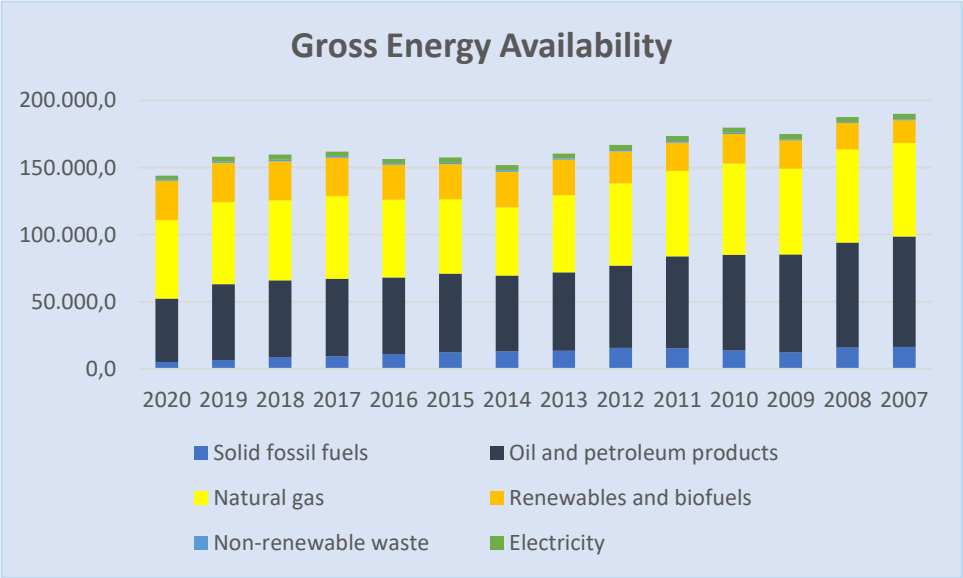
This is a brief overview of the gas production chain, how gas arrives from foreign countries to Italian households. The next paragraph analyses national consumption starting from Italian energy availability.

1.3 Consumption

1.3.1 National consumption

According to the Ministry of Ecological Transition, in 2021, Italy's gross energy availability was around 154,024 (ktoe[7]), with gas ranking first among the energy sources at 40.9%, followed by oil and petroleum products at 32.9%, and then renewable sources (19.5%), solid fuels (3.6%), and electricity (2.4%).

Of the 75.5 billion cubic meters of gas sold in 2021, an increase from the previous year, 30.2 Gm³ are attributable to consumption in the domestic sector, composed of residential and tertiary components, while the remaining 45.5 Gm³ of gas are destined for industry (10.8 Gm³) and the generation of electricity and heat (31.3 Gm³). In general, there has been a significant increase in consumption across all sectors.



[7] Tonne of oil equivalent (toe) is a unit of energy, defined as the amount of energy released by burning one tonne (1000 Kilograms) of crude oil.

Figure 1.3.1 Italy Gross Energy Availability Source: Self-created Graphic. Data from Eurostat, Energy database.

In the figure 1.3.1, which represents the national gross energy availability from 2007 to 2020, it is possible to observe how the percentage of gas, represented by the yellow bar, in satisfying the energy demand is continuously increasing over the years.

As every year, in 2021, the annual survey on energy sectors was carried out by ARERA. This consists of asking the companies that carry out the activity of selling gas wholesale or retail, listed in the Authority's operators register, to provide data on their sales. From this survey, which involved 485 retailers operating in the retail market, it emerged that the gas sold amounted to 57.04 Gm^3 to 24 million customers.

Geographically, these 57 Gm^3 are distributed unevenly throughout the national territory; in fact, 63.3% of them are sold in the North, 24.4% in the Central area, while the remaining 7.8 Gm^3 of gas are sold in the South and Islands.

The ratio between volumes consumed in the North and those in the other areas is on average 2.5 times those in the Centre and 4.6 times those in the South and Islands. Among the top 5 regions with the highest consumption, I found Lombardy, which alone consumes over a fifth of national volumes, with 12 Gm^3 of gas consumed, followed by Emilia-Romagna, with 8.1 Gm^3, Lazio with 6.1 Gm^3, Piedmont with 6 Gm^3, and finally Veneto with 5.3 Gm^3.

These marked differences in consumption, which have remained unchanged over the years, find an explanation mainly in the different climatic zones of the territory and the higher density of industrial activities.

This is the situation of the total, without distinction of sector, of national gas consumption and how it is distributed within the country; in the next paragraph, the domestic sector, which includes the consumption of households and condominiums, is analysed in detail.

1.3.2 Consumption in the domestic sector

As written in the previous paragraph, gas consumption in the domestic sector in 2021 was about 30 Gm^3, with more than 50% attributed to the residential sector with around 18 Gm^3, an increase compared to the previous three years.

To conduct the most detailed and reliable analysis possible, the data used was selected from the ARERA survey on the evolution of regulated sectors. This survey involves administering a questionnaire to companies listed in the operator registry that are involved in the distribution of natural gas, asking for data on their activity. There may be discrepancies between the quantities of gas distributed and the quantities of gas sold to the final retail market, and the reason lies in

the fact that there are normal statistical discrepancies due to the methods of data collection. Distribution data is collected from distribution companies, while sales data is transmitted by sales companies. Therefore, it is possible that even for the same customer, the distributor counts slightly different consumption compared to the seller, for example, because one of the sources uses the completeness basis (i.e., adds up the consumption made by the customer in the twelve months of the calendar year) and the other source uses the cash basis (i.e., adds up the consumption related to all invoices issued for that customer in the calendar year), both criteria being allowed in data collection.[8]

In the domestic customer category, each delivery point (hereinafter referred to as PDR) is included in the ownership of an end customer who uses natural gas to supply:

a) applications in premises used for family or collective housing, and annexes or areas related to the home used for studies, offices, laboratories, consulting rooms, cellars, or garages, provided that:

i. the use is carried out with a single PDR for the dwelling and residence or related premises;

ii. the PDR owner is a natural person.

b) a single building (single PDR) divided into several cadastral units (condominiums) where at least one room with uses similar to those referred to in the previous letter a) is present[9].

It is necessary to specify that even within the same domestic sector, there are different types of customers with different characteristics, needs, and, above all, different volumes of gas distributed.

In this regard, a first breakdown of customers consists of dividing them by use category. These categories coincide with those in force since 2013, defined by the resolution of May 31, 2012, 229/2012/R/gas, which introduces them with the aim of identifying the quantities of gas consumed by end customers that are not usually measured on a daily basis.

The usage categories analysed here are the first three, which coincide with: heating (code C1), cooking and/or production of hot water (C2), and heating + cooking and/or production of hot water (C3)."

The first category, heating, includes all customers with a gas consumption of more than 5000 smc[10], mainly consisting of centralized heating systems such as condominiums. Although the

8 Those informations are provided directly by supervisory office of ARERA. This is because during the data search I found some differences between gas sold and gas distributed.

9 This definition comes from the DCO 5/09 with reference to article 1, paragraph 3, of the law no. 125/07 and by directive 2003/55/CE.

10 Standard cubic meter is the unit of measurement of gas at standard levels of pressure and temperature. This is due to the fact that gas changes its volume as the temperature and pressure vary.

users in this category make up the smallest proportion of the three categories (about 2%), they consumed about one fifth of all distributed gas in 2021 (20.23%). An important indicator is the annual per capita consumption of 13,274 m3, an increase of 8% compared to the previous year.
The second type includes customers who use gas exclusively for cooking and/or producing domestic hot water, specifically those who consume less than 500 smc per year according to the regulation. The volume consumed and customer share are reversed compared to the previous category, as the gas distributed overall is 6.2% of the total, while the customer share is much higher at around 41%. The per unit consumption in 2021 was 200 m^3, a decrease compared to the previous year when it was around 231 m^3.
The third and last category, heating + cooking, is the most widespread among gas users, accounting for 55% of the total customer share. Furthermore, this category, with annual consumption ranging from 500 smc to 5000 smc, is the one that withdraws the largest amount of gas from the network, about 14.9 Gm^3, or 46.22% of the total volume. An important indicator is the annual per capita consumption of 1,126 m^3, an increase of almost 50 m^3 compared to the previous year.
A more precise breakdown divides customers based on gas consumption regardless of usage. There are 8 identified classes ranging from 0-120 m^3/year to over 1 million m3/year. The first four classes, 0-120, 121-480, 481-1560, and 1561-5000 m^3/year, are of greater interest to the residential sector, with particular attention to the 481-1560 m^3/year class, which accounts for 27.24% of the total volume.
This last class is the most numerous in terms of both customers and volume because it includes families or small businesses that use gas for both heating and hot water production or cooking. By combining these breakdowns into a single table, as shown in Figure 1.3.2.1, customers can be divided into measurement groups[11] based on usage category and withdrawal level.

[11] It is the part of the end customer's supply system which serves for shut-off, gas measurement and connection to the end customer's internal system; it includes a possible corrector of the measured volumes.

WITHDRAWAL LEVEL (m³/year)	MEASUREMENT GROUPS				VOLUMES			
	DOMESTIC	CONDOMINIUM FOR DOMESTIC USE	PUBLIC SERVICE ACTIVITIES	OTHER USES	DOMESTIC	CONDOMINIUM FOR DOMESTIC USE	PUBLIC SERVICE ACTIVITIES	OTHER USES
0-120	5.507,133	23,087	18,900	503,934	170	0	0,2	8
121-480	5.123,769	9,735	7,215	252,790	1.500	3	2	74
481-1.560	9.096,957	19,098	13,132	444,944	8.344	19	13	416
1.561-5.000	2.287,887	34,445	14,238	291,943	5.055	111	42	805
5.001-80.000	46,955	119,279	21,520	211,777	368	2.049	393	3.417
80.001-200.000	0,100	1,880	1,004	9,223	12	209	118	1.129
200.001-1.000.000	0,047	0,249	0,477	5,774	17	81	183	2.469
Oltre 1.000.000	0,009	0,004	0,128	1,683	36	5	337	4.889
TOTAL	22.062,857	207,777	76,614	1.722,068	15.503	2.476	1.088	13.207

Figure 1.3.2.1 Customer distribution and withdrawal breakdown by withdrawal range and usage (return points and measurement groups as of December 31, 2021 in thousands and withdrawal volumes in cubic meters). Source: ARERA, Annual report of energy sectors.

From this table, it can be inferred that per capita consumption for the domestic sector is consistent with the data obtained from partial breakdowns for both usage categories and withdrawal ranges, and corresponds to 703 m^3 for strictly residential use and 11,917 m^3 for condominiums. However, for a more precise data, further breakdowns of customers and volumes are necessary based on both sector and geographic area from which the data is obtained. The average per capita domestic consumption that emerges is quite varied territorially. In fact, per capita consumption in the North is 823 m^3, while in the South it is only 491 m^3, with the Centre in an intermediate situation at 619 m^3. Regional variations in gas withdrawals are mainly due to the climatic variability of the territory and the different degrees of methane distribution in various areas of Italy. Additionally, the table shows that the domestic category includes two different subcategories, condominium residential and strictly residential use, which alone comprise 22.2 million customers, or 92.5% of total customers and account for 55.7% of all distributed gas. Specifically, as previously mentioned, data emerges regarding strictly residential customers in the withdrawal range of 481-1560 m3/year, which includes families that use gas for heating and hot water. There are approximately 9 million customers with a consumption of 8.3 Gm^3 in 2021, and the unit consumption for this withdrawal range is 917 m^3/year. The consumption per capita for this withdrawal range over the last 10 years is illustrated in Figure 1.3.2.2.

Figure 1.3.2.2 Per capita consumption 481-1560 m3. Source: self-created graph. Data from ARERA, annual report 2012-2022.

1.4 The liberalization of gas

Since January 2003, as provided by the European Union, every household consumer can freely decide from which natural gas supplier and under what conditions to purchase natural gas for their needs; in particular, the liberalization of the gas market in Italy began with Legislative Decree no. 164 of May 23, 2000 (known as the "Letta Decree"). The consumer can choose to exercise this right and enter the "free market" where they are free to choose their supplier and contract, but above all they can change their offer based on what they consider more interesting and convenient. It should be noted, however, that the customer can only change the gas supplier and not the gas distributor[12]. If, on the other hand, the final consumer decides not to exercise this right, they remain in the regulated market and their gas bill will be calculated based on the supply economic conditions established by ARERA[13].

As a result of the application of this decree, two types of customers are created in two different types of markets, each with their own applied prices per cubic meter of gas. If we consider consumption in the "extended" domestic sector (families and condominiums) in 2021, out of 17 Gm^3, gas taken from the free market accounts for approximately 66% of the total, while the remaining 33% was taken from the regulated service. More specifically, 64% of the volumes of families and 85.2% of condominiums is purchased from the free market. These percentages are destined to grow until they reach 100% as, according to the analysis of switching activity

12 Distribution service operates with tariffs set by Authority.

13 The Authority's work focuses on ensuring the promotion of competition and efficiency in the energy sectors, as well as ensuring uniform availability and distribution of the services, for all regulated sectors and throughout the country. The Authority also establishes adequate levels of quality for services, certain and transparent tariff schemes based on predefined criteria, while promoting user and consumer protection.

in the natural gas sector conducted by ARERA, the number of customers who changed their contract in 2021 alone is 11.6%[14]. This value has been constantly increasing since 2018, as shown by the orange line in the figure 1.4.1, and could lead to the end of the regulated regime.

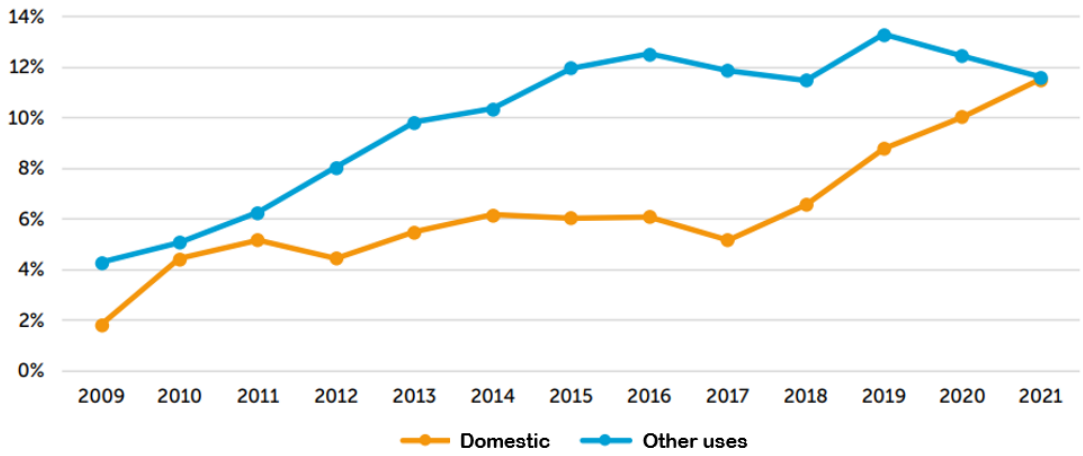


Figure 1.4.1 Switching rates of domestic customers and other uses since 2009. Source: ARERA, Annual report of energy sectors and SII.

To confirm this, in the following table, figure 1.4.2, the volumes and delivery points[15] are highlighted for comparison between the domestic sector in both the free market and the protected market in the years 2012 and 2021. While in 2012 the ratio of customers in the protected market to the free market was 4.9, in 2021 there has been a reversal of clientele that brings this ratio to 0.58.

Consumer sector	VOLUMES		Var 2021/2012	CLIENTS		Var 2021/2012
	2012	2021		2012	2021	
Protected market						
Domestic	13.900	5.510	-60,4%	16.520	7.414	-55,1%
Condominium for domestic use	1.623	357	-78,0%	135	48	-64,4%
Total	15.523	5.867	-62,2%	16.655	7.462	-55,2%
Free market						
Domestic	2.969	9.738	228,0%	3.337	12.753	282,2%
Condominium for domestic use	1.398	2.059	47,3%	61	132	116,4%
Total	4.367	11.797	170,1%	3.398	12.885	279,2%
Total	19.890	17.664		20.053	20.347	

Figure 1.4.2 Volumes and clients in protected market and free market in 2012 and 2021. Source: self-created table. Data from ARERA, Annual report 2012 and 2021.

[14] The analysis of switching activity in the natural gas sector includes data collected from transportation and distribution operators through the Annual Survey on Energy Sectors and data from the Integrated Information System (SII).

15 The delivery point is the border element between the distribution plant and the final customer's plant, where the distribution company delivers the natural gas for supply to the final customer.

In addition to the different volumes and customers in the two different types of markets, the average unit consumption also shows differences. In fact, in the free market, families have recorded a slightly higher per capita consumption, 764 m^3, compared to that found for families in the protected market with 743 m^3. In the case of residential condominiums, on the other hand, there is a much greater difference, as the average consumption in the free market is 15,583 m^3 while the average consumption in the protected service is about 7,412 m^3, half of that. One explanation for this difference could be due to the fact that the free market is more convenient than the protected market and given that the quantities of gas purchased for a condominium are much higher than those purchased by a standard family, the average consumption is affected accordingly.

1.5 Annual expenditure

The preceding paragraphs discuss gas consumption first on a national level, then on a sectoral level, and finally the consumption bands with particular reference to the 480-1560m^3 band in which families fall. In this paragraph, we address the topic of Italian households' energy spending, in order to aggregate the amounts of money spent to satisfy their domestic[16] needs alongside their consumption.

The annual report "The national energy situation" of the Ministry of Ecological Transition shows that the total energy expenditure spent by households[17] in 2021, which is divided into domestic and transportation use in the report, amounts to approximately 76 billion euros[18], with an increase of 17% compared to 2020 and 4.7% less than pre-pandemic levels. As shown in the figure 1.5.1, domestic energy spending, which is relevant to this paper, amounts to 44.08 billion euros in 2021 and is the highest in the 2018-2021 quadrennium, despite the total energy spending being lower than pre-pandemic levels.

16 The domestic use item includes: heating, cooling, hot water, kitchen use, lighting and appliance operation.
17 The estimates of the final energy consumption of the households presented here are made according to the definition of this sector in the National Accounts.
18 Measured using the Net domestic energy use for energy purposes (NDEU-energy) which represents the total energy consumption net of the energy that remains incorporated in the derived products in the transformation processes and of the energy used for non-energy purposes; therefore it expresses the measure of the energy consumed and no longer usable for any other energy purpose, including all the energy dissipated plus the loss of energy (from transformation and distribution). The indicator adopted by the European Commission for the calculation of energy use efficiency is based on the NDEU.

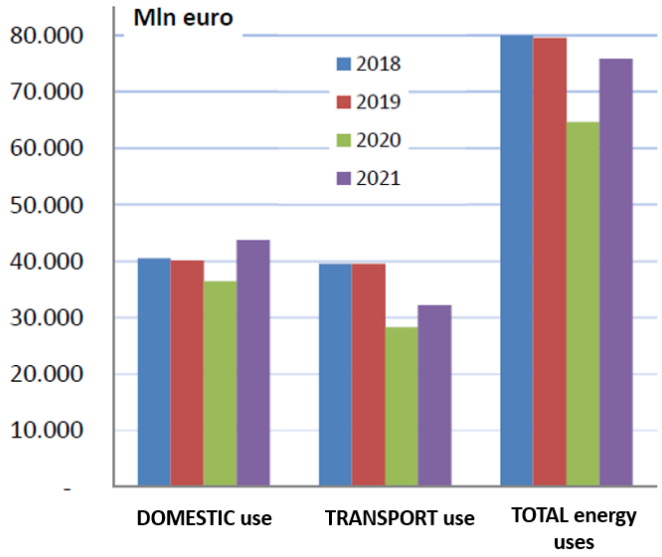


Figure 1.5.1 Energy products expenditure, for type of use. Years 2018-2021. Source: Istat, environmental accounts.

As mentioned earlier, the national domestic energy demand is mainly met with natural gas, which accounted for 52.5% in physical terms in 2021. In monetary terms, however, natural gas spending accounts for 41% and has a value of around 18 billion euros (see figure1.5.2).
Observing figures 1.5.1 and 1.5.2, an interesting data point emerges regarding gas prices. It can be seen from figure 1.5.2 that the quantity of gas consumed (expressed in ktep) has increased by 10.9%, while the spending on gas has increased by 34 percentage points. Since the value of energy consumption in monetary terms is obtained by multiplying the quantities consumed by the corresponding unit price, this means that gas prices increased significantly more in 2021 than the quantities consumed.

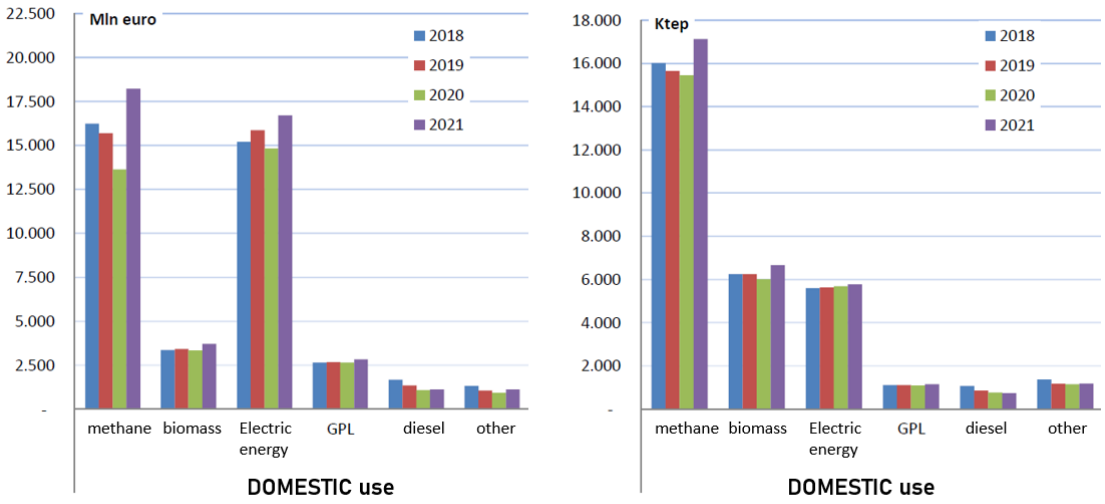


Figure 1.5.2 Energy use (ktep) and expenditure for energy products (millions of euros, at current prices) of households, by type of use and product - Years 2018-2021. Source: Istat, environmental accounts.

Regarding per capita spending, this has an irregular trend mainly determined by fluctuations in fuel prices, which in 2021 saw a surge, bringing the domestic usage indicator to levels 10 percentage points higher than pre-COVID ones. Based on GSE 2022 elaborations on ARERA, Istat and MISE data, it was calculated that a typical Italian family[19] consumes around 1400 cubic meters of natural gas and 2700 kWh of electricity to satisfy their household energy needs, and 1000 liters of fuel for transportation. In 2021, the spending for a typical family was 3,308 euros, approximately 10% of the average ISTAT family income, and 34% of this can be attributed to the gas bill (1139 euros).

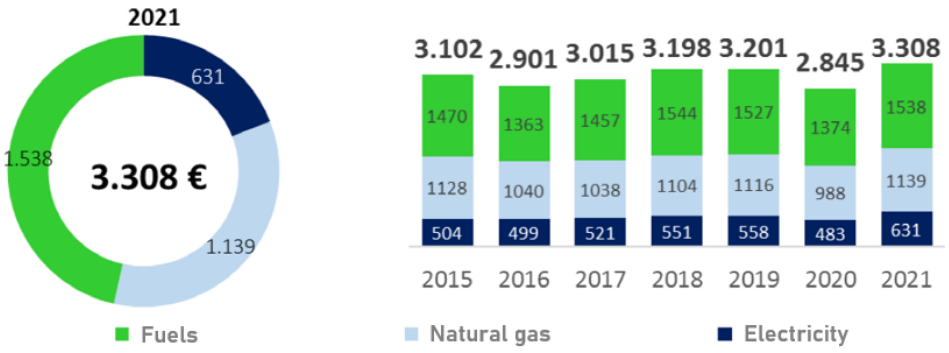


Figure 1.5.3 Trend of the annual energy expenditure of a typical family 2015-2021. Source: processing by GSE 2022, data from ARERA, Istat and MISE.

From the figure 1.5.3 it can be noted how in the last six years, a typical family's spending on gas fuel has remained between 30 and 40% of the total energy expenditure, with an average monetary value of around 1100 euros.

The typical family represents an important reference case throughout the national territory, but it is not entirely representative of the entire population. As stated in the previous paragraph and as will be seen in the following ones, there are several significant variations in consumption, influenced by the number of family members, climatic conditions, consumption habits, and the availability of alternative technologies and energy sources. Indeed, for families that use natural gas for cooking, hot water, and heating through autonomous systems, the main factor that

[19] The change in energy expenditure over the years is assessed on the basis of constant consumption attributed to the "typical" family identified by the standard consumption of electricity and gas conventionally adopted by ARERA and by the fuel consumption processed by the GSE on the basis of fuel expenditure by ISTAT 2017 households.

affects the gas bill is clearly the geographical and climatic location, which strongly determines heating consumption. Gas bills show a significant spending differential throughout the national territory, partly controlled by lower unit transport tariffs in the north of the country and fixed costs that have a greater impact on low-consumption users. Additionally, taxation in gas bills plays an important role in final spending (usually in the range of 30-40%), which is not homogeneous throughout the national territory (due to different regional additions applied) and dependent on consumption (excises and progressive surcharges).

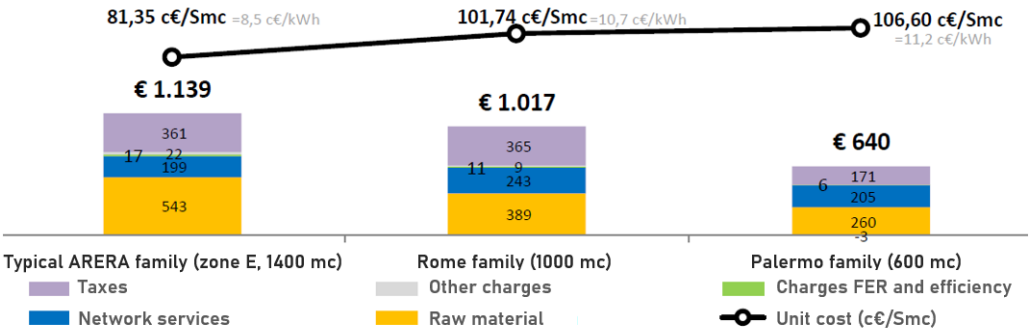


Figure 1.5.4 2021 Gas bill comparison between family in different climatic zones. Source: data from GSE 2022 and ARERA.

1.6 The most influential factors in gas consumption

The main purpose of this paper is to analyse the factors that affect or in some way influence the gas consumption of Italian households. However, before proceeding, it is necessary to make two clarifications. Firstly, it should be noted that there are a variety of different types of households with different characteristics and needs that may be affected by certain factors, such as the price of raw materials, or others, such as the size of the apartment or family habits. Secondly, it should be noted that the gas purchased from the distribution chain is used for various purposes within the home, and for each of these purposes there are various elements that affect consumption. As seen in previous paragraphs, there are different categories of gas users with different withdrawal ranges, and the reason for this is that households use gas either for heating and hot water production or only for the latter purpose. For this reason, some

consumers may modify their consumption based on certain factors, such as price, rather than remaining indifferent. Three main consumption purposes have been identified:

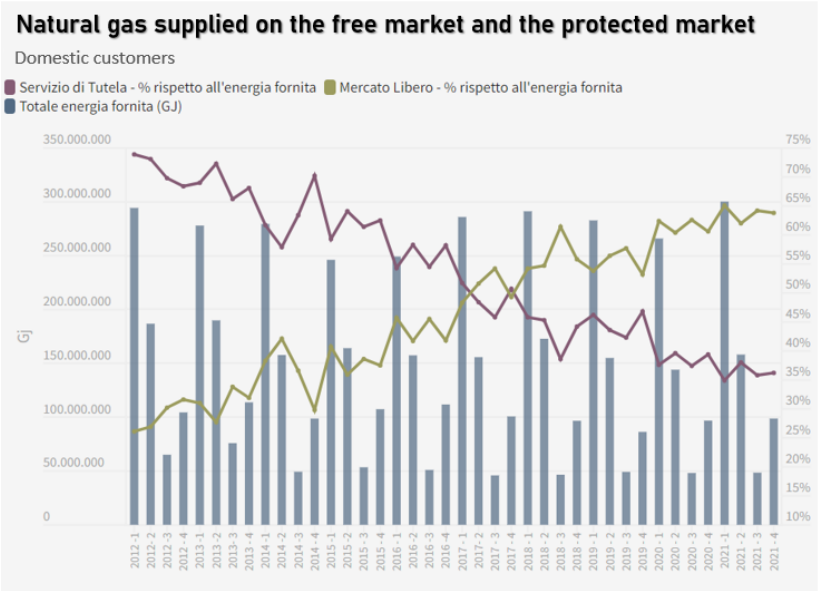
- Winter heating of the house: the highest percentage of gas consumption, on average around 80%, is dedicated to this purpose, and it is the purpose with the most parameters to take into account when calculating consumption. Some of these parameters may include: the energy class of the home, the efficiency of the heating system, the climatic zone to which it belongs, the size of the house, or the habits of the occupants;
- Production of domestic hot water (DHW). This accounts for about 10-15% of gas consumption and depends mainly on the number of people living in the apartment;
- Finally, cooking. The consumption for cooking does not have a significant impact on the gas bill as it represents only 5% of total consumption. For this purpose, as well, the variables to be taken into consideration are the number of family members and their daily habits.

The factors that will be analysed in the following paragraphs are those that have the greatest impact on the gas consumption of Italian households, mainly related to the heating of the home, as this accounts for over 80% of the final cost of the gas bill. The variables analysed include: climate, understood both as the climatic zone in which the dwelling is located and as a meteorological variable; the characteristics of the dwelling, such as its energy class, size, and whether it has auxiliary heating systems (solar panels); and finally, the price of gas. For the latter variable, which has the greatest impact on consumption variations, the second chapter is dedicated to comparing the prices of gas in the Italian market with domestic sector consumption analysed in the first part of the first chapter.

1.6.1 Climate

The climate undoubtedly has a significant impact on gas consumption, as heating homes and buildings represents the majority of gas consumption in households. During winter, when temperatures are lower, gas consumption increases as it is necessary to heat the rooms to maintain comfortable temperatures. Conversely, during milder seasons, gas consumption decreases as the outside temperature is already sufficiently warm and heating the rooms becomes less necessary. Therefore, inter-annual temperature variations directly determine the lesser or greater use of energy resources, with particular reference to the residential sector. This seasonality can also be observed in Figure 1.6.1.1, which shows the quantities of natural gas

supplied[20] in the free market and in the regulated service for the domestic sector and condominiums, values expressed in Giga Joules, reaching their maximum peaks in the winter months.



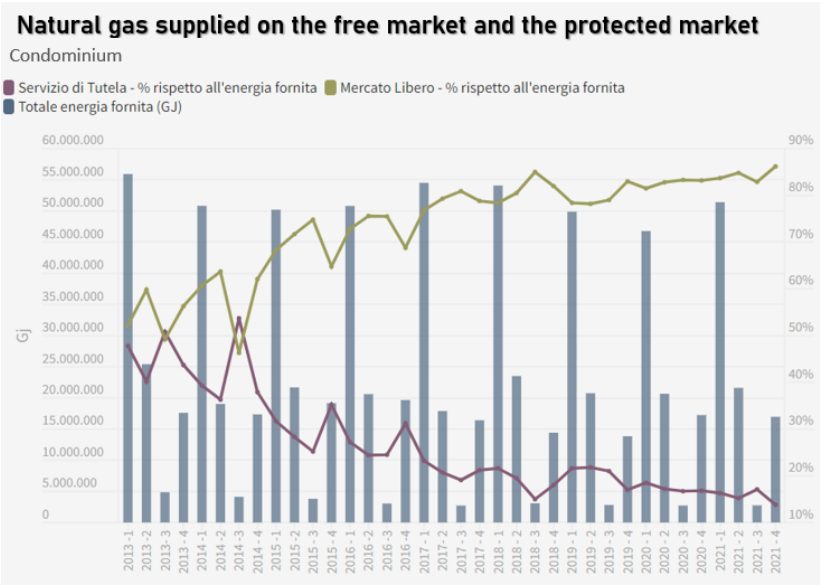


Figure 1.6.1.1 and 1.6.1.2 Natural gas supplied on the free market and the protected market (domestic costumers and condominium). Source: ARERA elaboration from data declared by operators pursuant to TIVG and retail monitoring.

20 Data from operators according to TIVG (an acronym for the integrated text of the sale of natural gas and gas other than natural gas distributed via urban networks) which regulates the protection service envisaged in the natural gas branch and the related supply conditions.

In addition to the time of year, ambient temperatures also vary depending on the geographical location within the national territory. As stated in paragraph 1.3.2, per capita consumption for households and condominiums provided by ARERA is not homogeneous throughout the peninsula, with the North consuming 823 m^3 while the South only consumes 491 m^3, with the Centre in an intermediate situation of 619 m^3.

In this regard, in order to classify different regions and reduce the energy consumption used for heating buildings, the so-called "climatic zones" were introduced by the D.P.R. n. 412 of August 26th, 1993. The Decree provides for a classification of different municipalities into six different climatic zones, which take into account the climate and they are calculated based on degree-days, i.e., the sum, for various days of the year, of the difference between indoor temperature and the average outdoor temperature: the higher the result of this operation, the more severe the climate in that area. An important advantage of this methodology is that, in addition to differentiating the territory based on a system of zones ranging from North to South, it also considers the altitude.

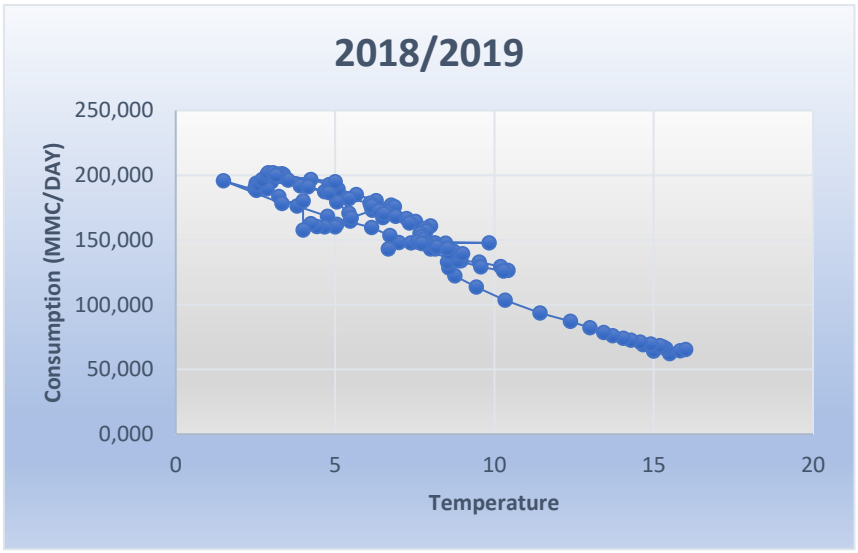
Finally, further evidence of the influence of climate on gas consumption can be obtained by observing the per capita consumption of the 480-1560 m^3 withdrawal range, represented in the figure 1.3.2.2, and the average minimum temperatures in Northern Italy[21] (figure 1.6.1.3), where consumption is highest and most affected by the influence of outdoor temperatures. It can be noted, in fact, that in the winter of 2014, average annual consumption dropped sharply from 928 m^3/year to 890 m^3/year. At the same time, from the historical trend of average minimum temperatures, 2014 appears to be the warmest year of the 9 selected, with a difference of about one degree compared to the previous year.

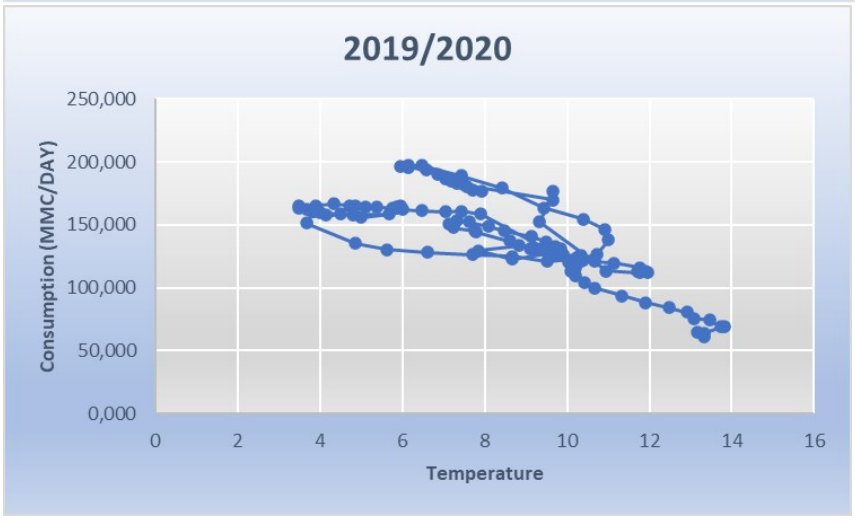
	2009	2010	2011	2012	2013	2014	2015	2016	2017
NORD	6,3	5,4	6,2	6,2	6,2	7,2	6,9	6,5	6,2

Figure 1.6.1.3 Minimum Temperature Weather Values of the Last 10 Years. Source: Ministry of Agriculture, of food sovereignty and forests.

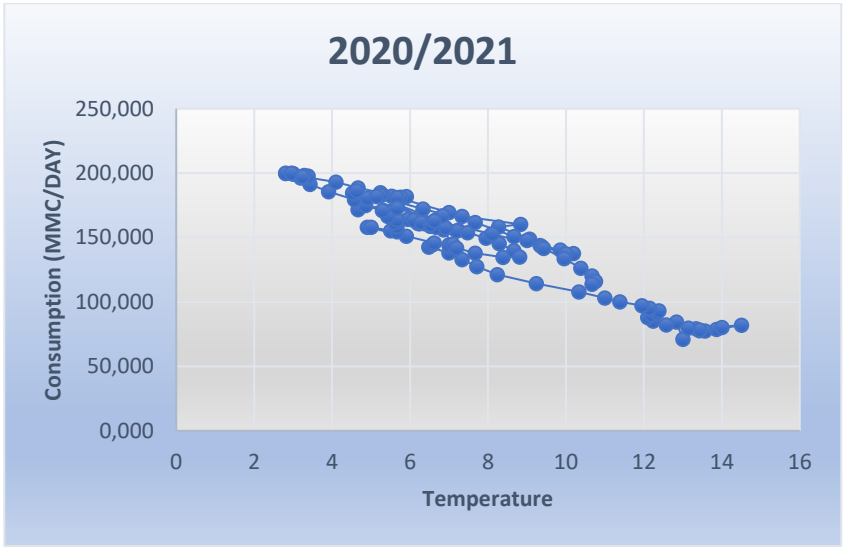
21 Data from Ministry of Agriculture, of food sovereignty and forests. Minimum Temperature Weather Values of the Last 10 Years.

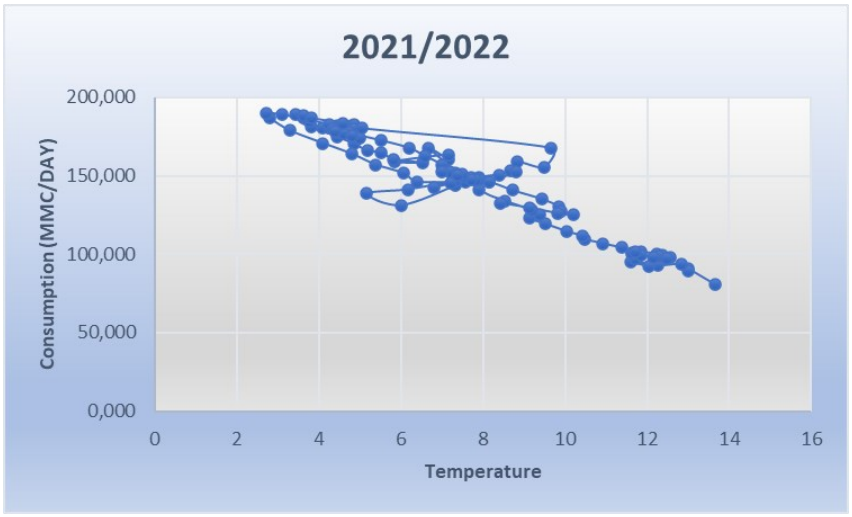
However, to truly understand whether Italians are saving on heating based on climate or not, it is not enough to compare daily consumption from one year to the next, but they must be compared with the daily temperatures of the same year. This is because lower temperatures recorded on the same day in different years systematically correspond to higher gas consumption. With the analysis conducted here, I'm trying to compare gas consumption for heating not on the same date, but at the same temperature. To do this, I conducted a graphical analysis in which I placed daily gas consumption, y-axis, and daily average temperatures, x-axis, on a Cartesian plane for the last four winter periods, from 2018 to 2022, considering the months from November to February.





Figures 1.6.1.4, 1.6.1.5, 1.6.1.6 and 1.6.1.7 Self-made graph. Ratio between daily average temperatures and daily gas consumption. Source: "Snam rete gas" and "il meteo.it" historical archive.





In this case, for the x-axis, I considered the historical trends provided by the "il meteo.it" historical archive of the temperatures obtained from the three different weather stations in Milan Linate, Rome Ciampino, and Bologna Borgo Panigale. In this way, I am able to understand the different climatic zones of the peninsula and therefore obtain measurements representative of average temperatures in Italy.

After calculating the daily average of the three locations, I performed another operation in which I calculated the weekly moving average of the average temperatures. The reason why I used the moving average is to avoid any temperature variations due to specific and short-term weather events that would substantially modify the results.

On the y-axis, daily consumption is represented in millions of cubic meters/days. The data was obtained from the SNAM rete gas archive, which deals with gas distribution throughout Italy, and in this case, the different daily distributions were also subjected to a weekly moving

average. With this method, I was able to eliminate the weekly variability of consumption, generated, for example, by the fact that many offices and some shops are closed on weekends. By comparing the trends of gas consumption for heating and the average temperatures recorded on those same days, between November 1st and February 28th of four years (between 2018 and 2021), the graphs show two different pieces of information, one expected while the other is very interesting.

Firstly, it can be noted that the growth of consumption proceeds with a rather linear trend with the variation of temperatures, which means that temperatures have a significant impact in the medium winter period.

Secondly, it can be observed that there is a certain inertia in consumption from one day to the next. In fact, once Italians turn on their heating for longer periods of time, even if the following days are slightly warmer, their consumption will tend to remain higher. This can be seen in the "loop" patterns of the curves, which demonstrate that in the very short term, consumption rises as temperatures drop, but then over a period of about a week, as temperatures rise, consumption decreases slightly but remains higher than it was ten days earlier, at the same temperature.

The conclusions that can be drawn from these analyses are that climate is an important, if not determining, factor in gas consumption throughout the calendar year, but in the short term it is not so influential. This suggests that there are other variables that impact consumption, and one of these is analysed in the next paragraph, in which the characteristics of a dwelling are examined to understand how much consumption varies depending on its energy class and size.

1.6.2 Building class energy

This paragraph describes the factors that can be defined as "fixed," meaning that they have a positive effect on gas consumption reduction, but do not vary from month to month or year to year, as they are characteristics or interventions made to the home that do not change over time. Normally, as the size of a building increases, the consumption to maintain the internal environment at the desired temperature also increases. The degree to which it increases depends on the variable cost per square meter, which in turn is influenced by the energy class of the home. The energy class is an evaluation of the energy performance of a building and is a rating scale that ranges from A4 (more efficient) to G (less efficient). In Italy, the classification of the energy class of homes has been discussed since 2005, starting with D.Lgs. n° 192/05 and subsequent legislative interventions. However, the scenario changed with DM n° 162/15, which introduced the new APE, or Energy Performance Certificate of the property, unique for all regions, with a uniform national methodology for calculating the energy class. The new

classification of building energy has introduced many different and complex changes, from the specifics of the performance of each individual energy service to the increased importance of factors related to the building envelope, which has become a central element in the overall calculation of the energy class. Each of these elements is analysed, and the results form the global energy performance index (EPgl), which measures the energy consumption of a real estate unit and is based on the ratio between the energy needed (expressed in kWh) to air-condition an apartment at 18°C and its net floor area (expressed in square meters).

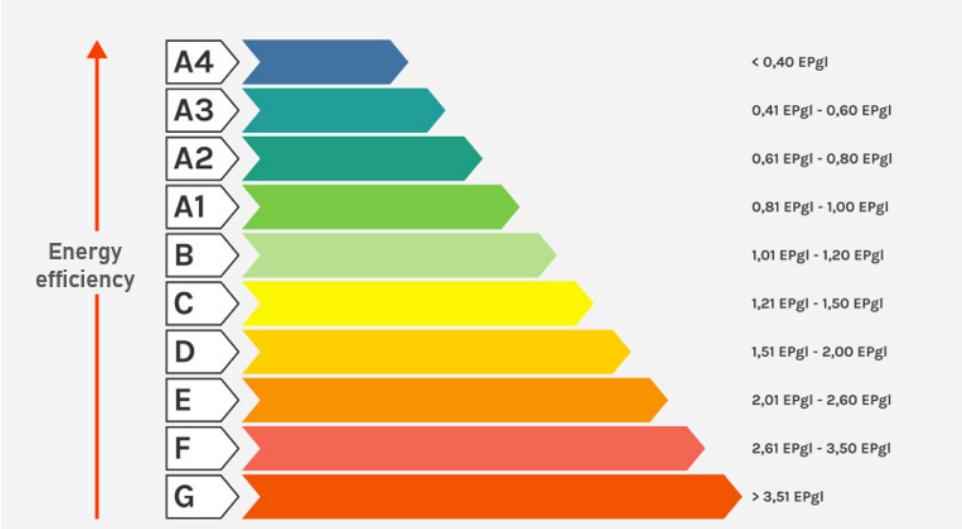


Figure 1.6.2.1 Energy classification buildings. Source: Aceaenergia.it.

To give some examples, buildings in energy classes A1, A2, A3, and A4 often use renewable energy sources, contributing to the reduction of greenhouse gas emissions. For heating and cooling, an energy-efficient system (condensing gas system) is present, combined with solar or photovoltaic systems.

On the other hand, buildings in energy classes E and F belong to those built between the 1970s and 1990s with traditional heating systems, but mainly without external or internal thermal insulation and outdated fixtures with high thermal dispersion.

A practical case analysed concerns a house built in the early 1970s of approximately 300 square meters, whose owner insulated the roof using the cellulose blowing technique, an economical and very efficient technique, as we will see. However, some considerations need to be made before analysing the data.

The first concerns the data collection period. Temperature measurements were taken, using a central unit equipped with four probes, during the winters of 2013/2014 and 2014/2015, from October 15th to April 15th. Despite the first part of winter 2014-2015 being warmer than the

previous year and the second part colder, the temperature delta between the two years never exceeded 2.4°C.

Furthermore, the measurements were taken at 4 am to avoid measurement errors due to external factors such as solar radiation or internal factors such as human activity, such as taking a shower, using the kitchen stove, or still-warm radiators.

The third and final consideration concerns the radiator settings, which were kept constant for both winters, while a calorie/kilowatt meter was used to record consumption.

The figure 1.6.2.2 shows how despite a difference in external temperatures between the two winters, the internal temperature of the house in the 2014/2015 year was always higher, up to a maximum of 3.3°C more.

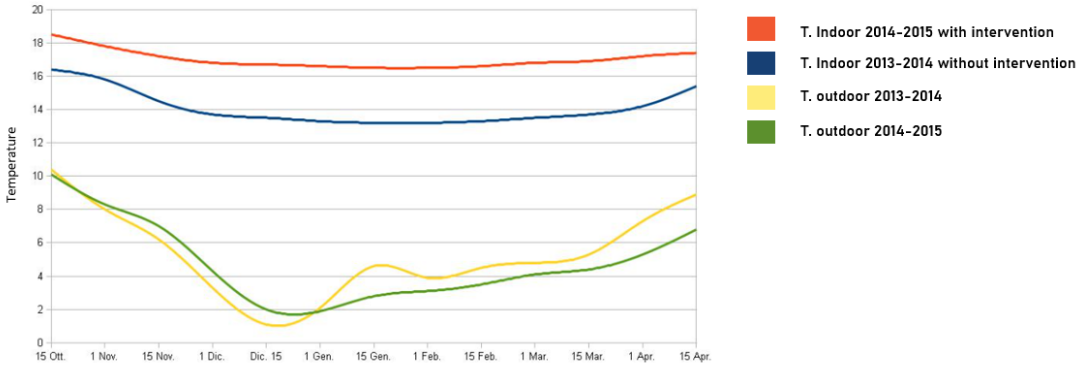


Figure 1.6.2.2 Comparison between indoor and outdoor temperatures winters 2013-2014 and 2014-2015. Source: customer of isolare.it.

This temperature difference inevitably translates into a rather high reduction in energy consumption, with peaks of over 30%. The reason is that even on the coldest days, the boiler turns off earlier as it has already reached the set temperature. From the figure 1.6.2.3 in which the energy consumption is expressed in kilowatt-hours (kWh), it can be seen that only in the month of January, 2100 kWh, or approximately 192 cubic meters of gas, were saved.

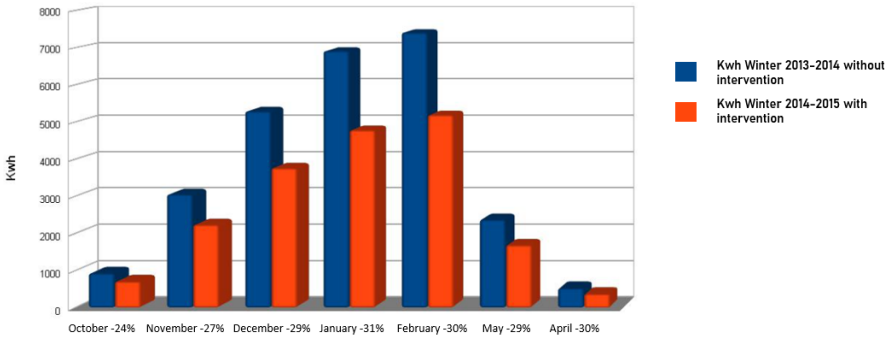


Figure 1.6.2.3 Heating consumption in kwh winter 2013-2014 and 2014-2015. Source: customer of isolare.it.

Another example of how the characteristics of a dwelling affect energy expenditure, and therefore gas consumption, is derived from the campaign conducted by "Legambiente", Civico 5.0. Civico 5.0 is an informal network composed of condominiums and has as its main objectives to create opportunities to develop a new, more sustainable way of living in condominiums, but above all to spread tools that can help families become less energy-intensive, reducing costs on their bills. In this regard, a database has been created with all the monitoring data from Italian condominiums conducted so far by the campaign, about 500 of them, each with an analysis of consumption and possible solutions to reduce expenses in the thermal, electrical, and indoor health sectors. In particular, for the thermal sector, thermographic analyses and simulations of energy efficiency investments have been carried out. Specifically, for the latter analysis, simulations have been conducted on potential savings resulting from interventions in insulating opaque surfaces, as they guarantee the best cost-effectiveness ratio. Insulation can be of two types: internal insulation, for individual housing units, or external insulation, for the entire facade of the condominium. To reflect the wide market range of insulation solutions in terms of thermophysical material parameters and other performance factors that influence the degree of efficiency of the result, three different simulations were performed for each cost range. The percentages of annual energy savings obtained after the work are strictly prudent and standard; they can increase depending on the severity of the initial state. The final results also depend on the climatic zone to which the building belongs and other technical and climatic-environmental factors. What emerged is that for an intervention involving internal insulation of a single housing unit with an average heating cost of 1000 euros, the potential savings range from a minimum of 13% to a maximum of 23% in the highest price range for the work. As for external insulation, the potential savings are calculated for the entire condominium as the intervention involves the entire external facade. In this case, the savings, for a building with an average annual cost of 17-20 thousand euros, range from a minimum of 30% to a maximum of 35%.

2 The Price of Gas: Market Dynamics and Its Impact on Household Consumption

2.1 Price: Europe vs Italy

In this chapter, the third macro factor that influences the gas consumption of Italian households will be analysed: the gas price. Before proceeding with the analysis of the price and how it affects bills, a comparison analysis is proposed with gross, net, and tax domestic prices applied in Italy and the Euro Area average, starting from Eurostat data.

Eurostat is the statistical office of the European Union, with the specific task of collecting data from the Member States' authorities and subsequently processing them for statistical purposes, promoting the harmonization process of statistical methodology among them, to provide the European Union with a high-quality statistical information service. Among the energy-related statistics, particularly for natural gas in identifying the prices charged to consumers in past years, two macro-categories have been introduced that divide consumers into domestic and industrial ones, and for each of them, the historical trend detected begins from the first half of 2003.

To have a uniform comparison between the various nations of the European Union, consumers are grouped into three different gas consumption classes[22]: less than 520 m^3, between 520 m^3 and 5,200 m^3, and greater than 5,200 m^3 annually. For simplicity, from now on, the first consumption class (520 m^3) will be identified as D1, while the second and third ones will be identified as D2 and D3, respectively.

In 2021, national prices for all three consumption classes were generally higher than the Euro Area average, although with different trends. More specifically, for the D1 class[23], there was a slight increase in gross prices (Italian average value of 129.38 c€/m^3) confirming a positive trend of an increase in the differential compared to the Euro Area, which has been steadily increasing since 2019 and currently stands at around 11%. In the previous 8 years (2011-2018), however, the price of Italian gas for this consumption bracket has always been more convenient than in other countries. The D2 class, which includes the largest share of customers and domestic consumption, has seen a slight decrease in the differential with the Euro Area average for gross prices (Italian average value of 90.30 c€/m3) compared to previous years, with a value around 12% in 2021. For the last class, which mostly includes centralized heating, there has been a sharp increase in gross prices (Italian average value of 86.01 c€/m3) compared to the Euro Area, with a differential of 21% compared to a +15% of the previous year.

In more detail, as can be seen from the figure 2.1.1, the net price for all consumption classes shows a positive differential, with particular reference to the D3 class where, after being negative in 2020 (-3%), it has returned to largely positive in 2021 (+20%). Taxes, conversely, follow the opposite trend and reduce their differential with the Euro Area average.

[22] The Eurostat consumption classes for domestic customers are defined on the basis of annual consumption intervals expressed in GJ. The limits of the intervals shown in the text have been translated into cubic meters based on a standard calorific value for greater readability and are rounded to the nearest whole value.

[23] Customers who use gas for cooking and hot water.

CONSUMPTION CLASS	NET PRICE	TAXES	GROSS PRICE
D1 CLASS (<520m3)	23%	-24%	11%
D2 CLASS (520 – 5200 m3)	14%	8%	12%
D3 CLASS(>5.200 m3)	20%	21%	21%

Figure 2.1.1 Difference between the Italian average and the European average in net price, taxes and gross price. Source: Eurostat.eu

From these data, it emerges that for each class, the two components, net price and taxes, have undergone different changes in the last year.

In the first class, the reduction of the tax component was not able to offset the significant increase in net prices, which had a significant impact on the increase in final gross prices, resulting in a 3.9% increase compared to a euro area average of 3.3% (Source: Eurostat). Similar trends were observed in class D3 but with much more pronounced values. In fact, only the increase in net price was 39.8%, while the reduction in the tax component was 10%. This caused the gross price for the third consumption bracket to increase by 16% compared to the previous year, from 74.13 c€/m3 to 86.01 c€/m3. Conversely, for class D2, the gross price increased slightly less (5.1%) compared to the euro area (6.2%). The reason for this different trend is that the opposite sign change of taxes was very similar to that of the third class, but the increase in net prices was much lower than in class D3, and therefore less impactful.

Further comparison can be made by looking at the prices of the main European countries (figure 2.1.2) and the Italian price for the lowest consumption class (129.38 c€/m3), including taxes, which remains lower, as in the past, only to the French one. In the second consumption class, the Italian price (90.30 c€/m3) is no longer the highest, as it was in 2020, being surpassed by the price practised in Spain. The Italian price (86.01 c€/m3) instead remains the highest in the third consumption class. The most affordable prices are still those in Germany in all classes. However, differentials between Italian prices and those of other countries have reduced in the first and second classes, while positive differentials in the third class have consolidated, increasing by +12% compared to France and Spain, and +7% compared to Germany.

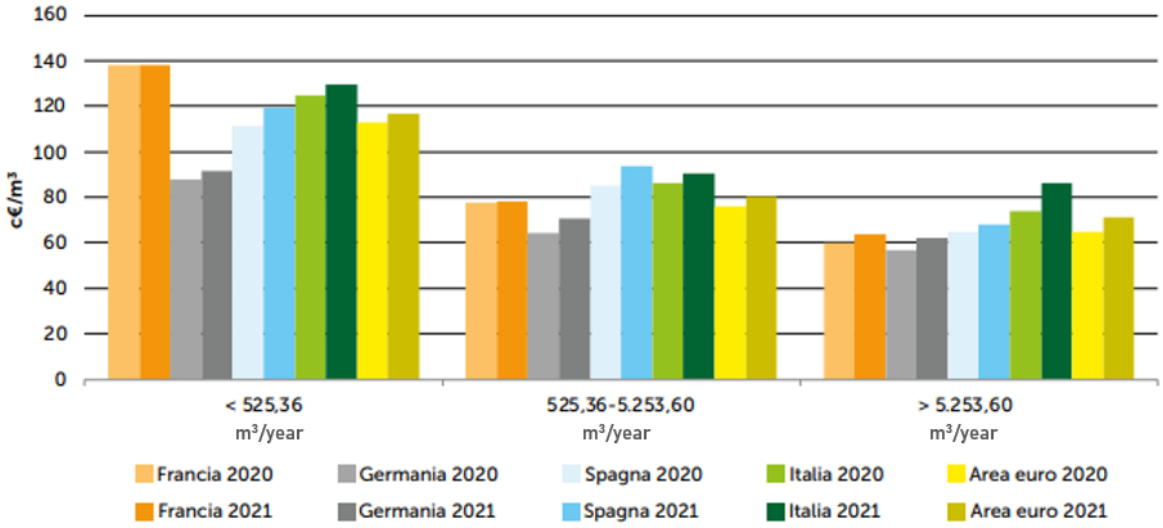


Figure 2.1.2 Natural gas gross prices for domestic use. Sources: ARERA, elaboration on Eurostat data.

2.2 *The Wholesale Gas Markets: An Overview of Pricing, Trading, and Market Dynamics*

2.2.1 Wholesale Gas Market Operators

To better understand how the final gas price is determined, it is useful to provide a brief explanation of who the primary gas buyers in Italy are and subsequently how the price of the purchased raw material is determined.

The gas, before being sold to the end customer in the retail market, is purchased by retailers from the wholesale market. Operators in this sector can be of three different types:

- Pure wholesaler, who is only engaged in gas wholesale;
- Pure seller, who sells gas exclusively to the end customer;
- And the mixed operator, who serves both the end market and wholesale.

In 2021, the wholesale market alone moved 285.1 billion cubic meters (Gm^3) of gas, which was supplied 57.9% by pure wholesalers and the remaining 42.1% by mixed operators (see figure 2.2.1.1). The quantities sold in the retail market, 57 Gm^3, were placed 32.9% by pure sellers and 67.1% by mixed operators.

OPERATORS	NUMBERS	FINAL MARKET	WHOLESALE MARKET	OF WHICH AT PSV	TOTAL
Pure wholesaler	86	-	165.133	147.429	165.133
Pure seller	381	18.785	-	-	18.785
Mixed operator	104	38.254	119.974	83.289	158.228
Inactive	43	-	-	-	-
TOTAL	614	57.039	285.107	230.718	342.146

Figure 2.2.1.1 Types of operators in the upstream gas market and gas volumes in millions of meters cubic. Source: ARERA.

As can be seen from the figure 2.2.1.2, companies operating in the wholesale market have two main sources of supply: imports and purchases at the PSV. The remaining gas is purchased from other retailers or the new platforms (M-GAS, P-GAS, and PB-GAS) of the gas exchange managed by the GME.

SOURCES OF SUPPLY	WHOLESALE MARKET OPERATORS					
	ENI	BIG	MEDIUM	SMALL	VERY SMALL	TOTAL
National production	4,8%	0,0%	0,0%	5,1%	6,7%	0,9%
Importation	78,8%	15,0%	10,1%	3,2%	0,0%	20,3%
Purchases from operators on the national territory	0,8%	1,2%	12,1%	27,7%	42,5%	7,1%
Purchases in storage	0,6%	0,0%	0,3%	2,5%	0,0%	0,3%
Purchases at PSV	14,0%	80,7%	74,0%	53,5%	45,1%	68,1%
Stock market purchases	1,1%	3,2%	3,6%	8,0%	5,7%	3,4%
TOTAL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Figure 2.2.1.2 Supplying Wholesalers in 2021. Big: with sales exceeding 10 G(m3); medium: with sales between 1and 10 G(m3); small: with sales between 0.1 and 1 G(m3); very small: with sales below 0.1 G(m3). Source: ARERA, Annual Energy Sector Survey.

In the figures 2.2.1.2 and 2.2.1.3 the company Eni (the largest seller in the sector) and market operators are represented based on sales volumes.

Table 2.2.1.3 illustrates the uses of gas by wholesale companies and highlights that the largest volumes of gas (on average 80%) are used for resale to other operators in the national territory through PSV. This percentage is highest (87.1%) for large entities, but it is also very relevant for medium-sized (78.2%) and Eni (73.2%) companies. Furthermore, the portion destined for the final market accounts for an average of 11.2%. This percentage has slowly decreased in recent years, but the reduction stopped in 2021, considering that in 2020 it was one percentage point lower. Among the classes of operators, it is the smallest ones that direct the largest share

of the gas intermediated towards final customers (43.9%), but it is also relevant for small companies (31.2%) and significant for medium-sized companies (15.6%).

SALES	WHOLESALE MARKET OPERATORS					
	ENI	BIG	MEDIUM	SMALL	VERY SMALL	TOTAL
To other sellers on the national territory	73,2%	87,1%	78,2%	60,1%	37,2%	80,0%
- referred to in storage	0,1%	0,0%	0,7%	4,6%	2,1%	0,4%
- referred to in PSV	75,8%	88,3%	85,8%	56,3%	33,0%	67,5%
To final customers	11,2%	3,7%	15,6%	31,2%	43,9%	11,2%
- of which corporately connected	17,5%	56,3%	28,9%	1,8%	5,8%	26,4%
Self-consumption	14,5%	5,9%	2,6%	0,9%	13,3%	5,4%
Stock market	1,1%	3,3%	3,6%	7,8%	5,7%	3,4%
TOTAL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Figure 2.2.1.3 Gas uses by wholesalers in 2021. Source: ARERA.

The procurement of entities operating in the final sales market is very similar to wholesale market operators, given that most of the observed companies are mixed operators common to both segments. In this regard, the following paragraphs present the two main markets where gas is traded by operators: the PSV and the Gas exchange.

2.2.2 Take or pay and spot contracts

Contracts are the main instruments used, by operators, to commercialize natural gas and they can be of two types:

- Take or pay. This type of long-term contract is characterized by a clause that explains the obligation for the buyer to pay, completely or partially, the minimum amount of gas agreed upon in the contract and, even in the case of lower or no withdrawal, to pay it anyway. However, to protect the buyer, flexibility mechanisms can be provided to recover the shortfall recorded in a subsequent period and mitigate risks related to demand fluctuations. The duration for these contracts is typically 20 to 30 years, and the price of the raw material is determined by the trend of oil prices, with a semi-annual update frequency. As a result, despite different sizes, characteristics, and dynamics, the gas and oil markets in Europe have a similar price trend;
- Spot. In contrast to the previous contracts, these contracts have an annual or shorter duration, and the prices subscribed are not linked to crude oil. The price is based on the classic supply-demand dynamics of the product. This type of contract, developed more

recently than ToP contracts, is subscribed in hubs (such as the PSV) and is more advantageous for the buyer.

According to the analysis of acquired contracts conducted by ARERA and reported in the annual report, in 2021, the large majority of natural gas imports to Italy come from multi-year contracts with variable maturities, although the share of medium and short-term contracts is in a slow but steady increase trend. The quantities underlying long-term contracts, i.e., those whose entire duration exceeds 20 years, are still predominant (66%). The incidence of contracts with a duration of less than five years (approximately 20%) and those with a duration between 5 and 20 years (14%) is tending to increase.

To have an overall picture of how the situation of import contracts may evolve, it is useful to consider the remaining life of these contracts. As shown in the figure, import contracts in force in 2021 expiring within the next ten years account for 52% of the total quantities, and those expiring within five years account for 23%. The contracts still valid whose remaining duration exceeds 15 years account for 40% of the total quantities.

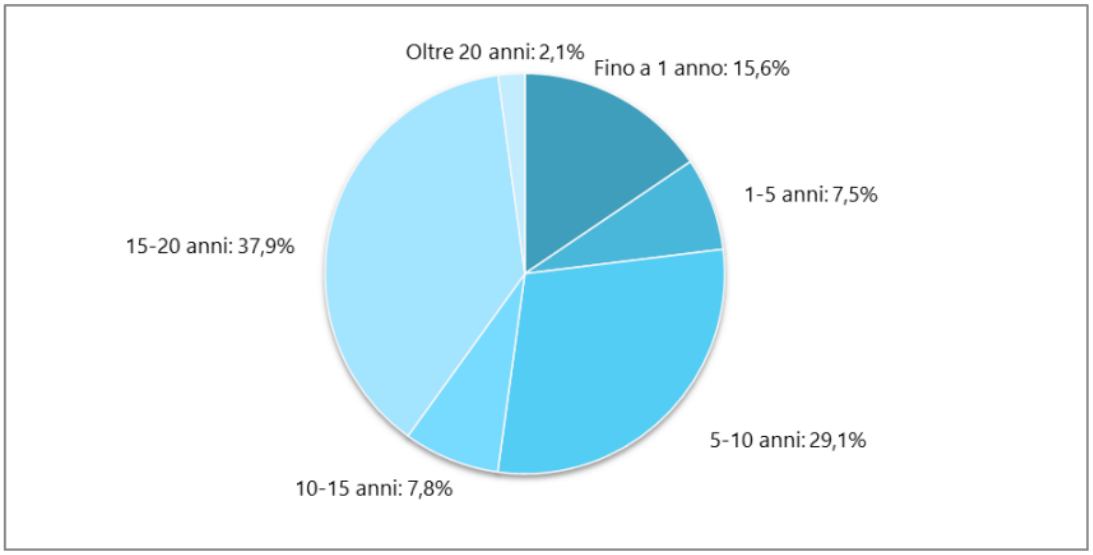


Figure 2.2.2.1 Percentage of contracts divided by residual duration. Source: Contracts monitoring report of procurement for the import of gas in Italy by ARERA.

Due to the prevalence of take or pay (ToP) contracts, Italy shows higher gas prices than other European countries, despite the constant increase of short-term contracts that is aligning Italian prices with those of other markets.

Both in Italy and across Europe, in the first decade of the 2000s, a process was initiated to promote competitive supply conditions as a means of reducing gas procurement costs. There was a gradual transition from a monopolistic system, in which gas procurement costs were

primarily determined by import costs of gas through long-term take or pay contracts indexed to liquid petroleum product prices, to a more competitive system.

The EU's Third Energy Package of 2009, implemented in Italy through DGLS 93/11, provided a significant stimulus for the gradual development of more competitive market conditions in the wholesale gas markets in Europe and Italy. Starting from 2011-2012, there has been a significant increase in commercial term trading on increasingly liquid and transparent hubs, and the prices formed on these markets showed significant advantages over long-term contract prices. The disparity between ToP contracts and spot prices has prompted traditional importers, particularly from countries better connected to European hubs, to renegotiate their long-term supply conditions, allowing, in some cases, the reformulation of rates with the introduction of a component linked to spot prices.

In Italy, the natural gas spot market is guaranteed by the Virtual Trading Point (PSV), see next paragraph. The prices generated in this market are linked to economic fundamentals and not international price quotes, as is the case for ToP contracts. With resolution 124/2013/R/gas, the Authority has therefore modified the methodology for calculating the economic supply conditions for gas protection service to ensure greater consistency with the new dynamics of gas price formation in the wholesale market. Since October 1, 2013, the natural gas procurement cost coverage component of a seller, previously calculated based on long-term contract price indicators through a basket of petroleum product prices, refers to the quotations of the most liquid forward markets, in Europe the TTF. The choice of referring to quotations taken from the TTF hub rather than national forward markets is due to the consideration of the different levels of liquidity, as market manipulation risks increase significantly in the presence of low liquidity. This consideration has led the Authority not to use the reference to the PSV products, maintaining the reference to TTF indexation, which was the most liquid trading platform in Europe. Over time, the national market has developed with prices gradually aligning with those of the TTF hub, and in July 2022 with resolution 374/2022/R/gas, the gas procurement cost coverage component (CMEMm) applied to customers still under protection is updated every month and published in the first few days of the following month and is equal to the monthly average of the PSV (day-ahead) daily price.

In the following paragraphs, I'll analyse the main virtual modes of gas transactions, as well as the hubs from which gas prices are influenced.

2.2.3 PSV

The PSV is a virtual Hub, which is conceptually located between the entry points and exit points of the national gas pipeline network, where it is possible to carry out exchanges and transfers of gas introduced into the network itself. The particularity of this Hub is that, being virtual, it is not associated with any physical node and therefore is a market, with particular trading mechanisms, open to competition among competitors. Its importance, both in terms of volumes traded and number of contracts, has grown over time.

In more detail, the PSV, managed by Snam Rete Gas, allows for various types of transactions, ensuring their accounting. The transactions that can be recorded are both those based on bilateral contracts, known as Over counter (OTC) and those carried out in regulated markets managed by GME. Furthermore, since September 2015, contracts managed by third-party exchanges[24] can also be recorded on the PSV, i.e., transactions executed on exchanges managed by entities other than GME. Thanks to these last two types of transactions, the PSV has played an increasingly important role in the Italian gas market.

To operate within the platform, it is necessary to be a subscriber, i.e., to meet certain requirements and have signed an adherence form committing to respect certain conditions[25]. In 2021, the number of subscribers was 233, a number that is constantly increasing, and of these, 49 among those who carried out transfers or acquisitions are traders, i.e., subscribers who are not users of the transport system.

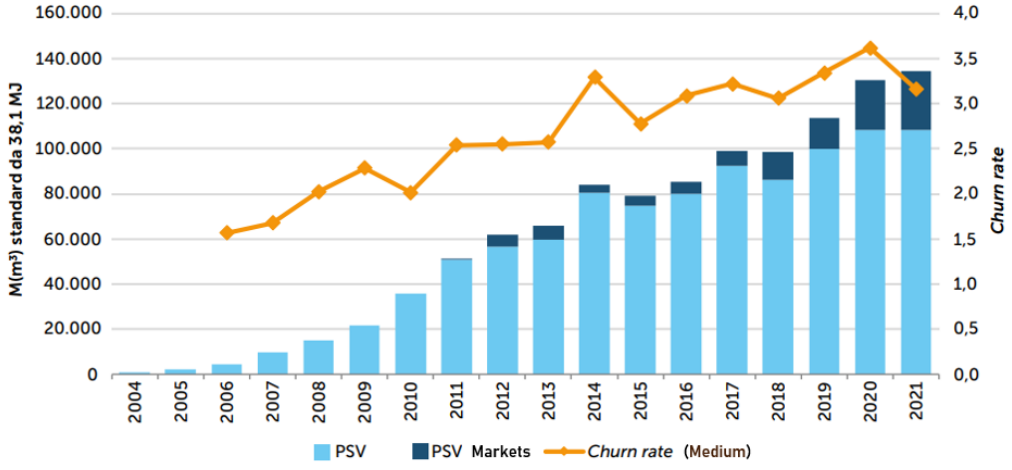


Figure 2.2.3.1 Transaction volumes at PSV and churn rate. Source: Snam Rete Gas.

[24] Third stock exchange means the operator of a regulated foreign market, where derivative financial instruments are traded. Those instruments provide for physical delivery and the guarantee of the transactions concluded on this market are regulated through a clearing house (i.e. the third party that assumes the risk of counterpart).

[25] Approved by the Authority with resolution 147/2017/R/gas of 16 March 2017.

In the figure 2.2.3.1, the volumes of gas traded at PSV, expressed in M(m^3), from 2004 to 2021 are shown. As can be seen, they are constantly increasing over the years. Under the label "PSV," the redeliveries resulting from daily and multi-day OTC trades are grouped, while under the label "PSV markets," the trades registered at PSV resulting from transactions on centralized markets are grouped. The orange line represents the churn rate, a synthetic indicator that measures the average number of times in which the commodity, in this case, gas is traded between the moment of sale and the physical delivery. The indicator, which has different calculation methodologies, has been calculated by comparing the total volumes traded at PSV to the value of registrations that result in physical delivery. The more liquid the market is, the more this value increases.

2.2.4 Gas exchange

The gas exchange is also a virtual trading place where the operator, GME[26], acts as a counterparty to transactions and offers registered members specific services to reduce financial risks through Clearing House[27] and bank guarantees. The price is set through an auction mechanism for the purchase/sale of standardized products. Thus, GME acts as a central counterparty, providing operators with the exchange of weekly, monthly, quarterly, or yearly gas batches. Subsequently, it records on the PSV the transactions made on the futures market as a registered operator, triggering the delivery of the volume to the network.
With the decree of the Ministry of Ecological Transition of 18th March 2010, the first core of the exchange was created, with the establishment of the P-Gas platform. The P-GAS is a trading platform for the exchange of natural gas, which also offers gas quotas for subjects bound by law. To operate on P-GAS, operators must be authorized to carry out transactions on the Virtual Trading Point (PSV). In this core, GME does not have a counterparty role but only that of the platform manager. As summarized in the figure 2.2.4.1, P-gas is divided into three sections:

- the Import section offers gas quotas under Article 11(2) of Law 40/07, as well as other quotas different from those under Articles 11(1) and 11(2) of Law 40/07;
- the rates section offers gas quotas due to the state under Article 11(1) of Law 40/07;

[26] The Energy Markets Operator is the company responsible for the organization and management of the electricity market, as well as the environmental markets, the gas markets and the administration of the energy accounts platform.
[27] An independent organisation responsible for ensuring the smooth functioning of a futures exchange. It assumes the role of counterparty of the concluded transactions, guaranteeing the success of the same even in the event of default by one of the two parties.

- the ex D.lgs. 130/10 section is where adhering investors can offer quantities of gas made available by associated virtual stores, within the virtual storage service's methods provided for by the Authority for Electricity, Gas, and the Water System (ARERA) Deliberation 67/2012/R/GAS.

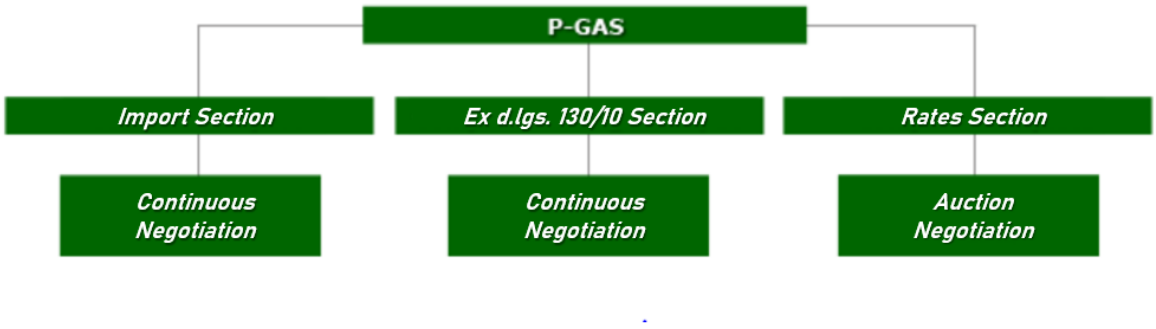


Figure 2.2.4.1 The P-GAS sections. Source: mercatoelettrico.org

Also in October 2010, the M-Gas was born, in which GME organizes and manages the natural gas market, within which authorized operators to carry out transactions on the Virtual Trading Point (PSV) can buy and sell natural gas quantities for immediate delivery and gas quantities on a forward basis, functional also to gas system balancing.

In this market, GME acts as the central counterparty for transactions concluded by operators. M-GAS is divided into:

1) The Spot Gas Market (MPGAS) is composed of:
   a. The Day Ahead Gas Market (MGP-GAS). Negotiations on MGP-GAS take place according to continuous negotiation methods and, only for the system gas procurement section (AGS section), whose session is held on gas day G-1, according to auction negotiation methods. For MGP-GAS negotiations, purchase and sale gas offers are selected relating to the three successive days starting from the day the negotiation session opens. For AGS section negotiations, purchase and sale gas offers are selected for the following day from the day the negotiation session takes place;
   b. The Intraday Gas Market (MI-GAS). Negotiations on MI-GAS take place according to continuous negotiation methods and, only for the system gas procurement section (AGS section), whose session is held on day G, according to auction negotiation methods. For MI-GAS negotiations, purchase and sale gas offers are selected for the gas day in question and the following day. For the negotiations of the AGS sector, offers to

purchase and sell gas are selected for the same day on which the trading session takes place;

c. Market for locational products (MPL). The MPL operates according to auction trading methods. MPL sessions only take place at the request of Snam Rete Gas. In this market, Snam Rete Gas sources quantities of gas needed to manage physical needs located within the balancing zone or any expected deviations between total network inputs and withdrawals from authorized users;

d. Organized market for gas trading in storage (MGS). The MGS operates according to auction trading methods. On the MGS, offers to purchase and sell gas in storage can be negotiated by authorized users and Snam Rete Gas.

2) Gas futures market (MT-GAS). The MT-GAS operates according to continuous trading methods. Many trading books are organized on the MT-GAS, each for each type of negotiable product, referring to different delivery periods, within which offers to purchase and sell gas are selected. The types of negotiable products are defined in the Technical Operating Regulations (DTF).

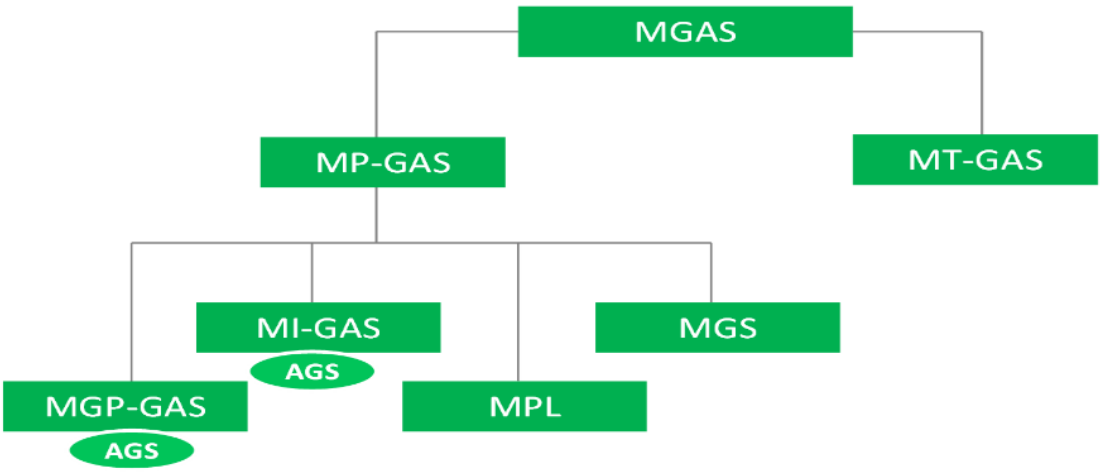


Figure 2.2.4.2 The M-Gas sections. Source: mercatoelettrico.org

2.2.5 TTF

The title transfer facility (TTF) is the Dutch gas trading exchange and it is a major hub for buying or selling gas. Customers who want to trade in gas must first take out a TTF subscription with Gastransport. The TTF, like PSV, is a virtual marketplace where the gas that has already been injected into the GTS transport system can be traded. It was established in 2003 in order to promote gas trading in one marketplace, increasing the liquidity of gas trading. This Dutch

gas trading exchange has greatly expanded over the last few years and is now the largest on the European mainland. On the TTF, the amount of gas traded comes to more than 14 times the amount of gas consumed in the Netherlands. Gas prices on the Dutch wholesale platform have become important reference prices for Europe.

2.2.6 *Prices compared*

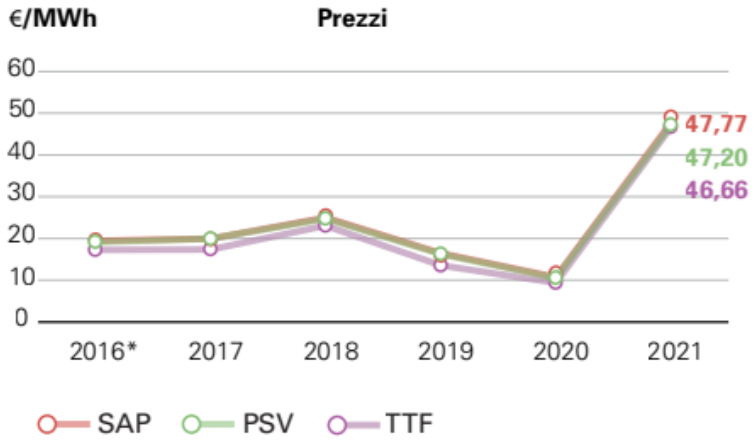


Figure 2.2.6.1 Gas raw material prices. GME annual report, 2022.

In Figure 2.2.6.1, the average prices of the gas raw material are shown, compared between SAP, PSV, and TTF over the last 6 years, and it is possible to notice how the two Italian indicators follow a very similar trend to TTF.

In a national and international context characterized by strong imbalances in supply and demand, natural gas prices show upward pressure and increased volatility on all trading floors. In particular, in 2021, on the spot gas markets managed by GME, prices rise everywhere to historic highs, ranging from 45.66 €/MWh of MGS to 46.70 €/MWh of the continuous trading sector of MI-GAS, remaining closely correlated with the PSV price (47.2 €/MWh), even in their monthly trends. Because of its increased liquidity, the weight of the continuous trading of MGP-GAS in determining the System Average Price (SAP)[28] increases, with its value reaching 47.77 €/MWh, expanding the spread with the PSV to 0.56 €/MWh (+0.40 €/MWh).

In Figure 2.2.6.2, the monthly trends of PSV and TTF prices for the years 2020 and 2021 are shown. It is immediately noticeable that the price surge began in June 2021, indicating a marked increase in volatility, to the last quarter of the year and it is characterized by exogenous

[28] The SAP is the average of the prices recorded on the MGP-GAS and the MI-GAS with weighted continuous trading their respective pairings.

conditions of strong instability, including delays in the start of Nord Stream and the slowdown in gas supplies from Russia due to the Russia-Ukraine crisis.

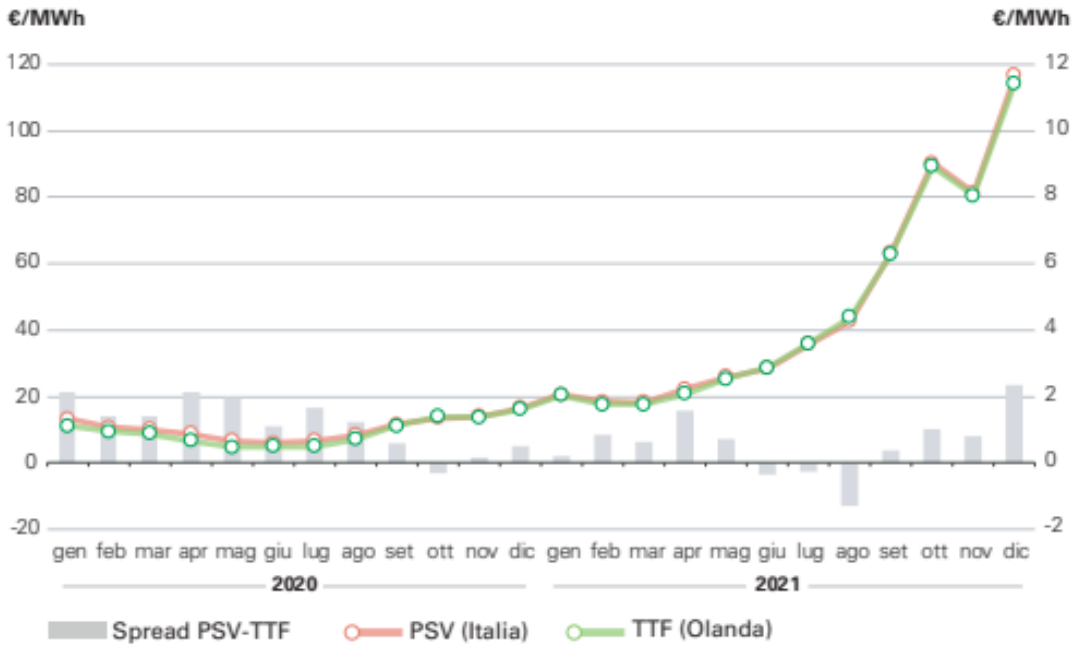


Figure 2.2.6.2 TTF and PSV trend, 2020 and 2021. Source: GME annual report, 2022.

Regarding the TTF-PSV price difference, the greater oscillation of prices is also reflected in higher variability of the PSV-TTF spread, which decreased in 2021 to a historic low of 0.6 €/MWh (it was 1.63 €/MWh in 2020). Throughout 2021, in fact, the differential between the two quotations (represented by the grey bars) recorded several inversions of its sign, positive first, negative during the summer period (especially in August: -1.2 €/MWh), and finally, again positive and higher than 2 €/MWh in December. In general, in terms of frequency, in 2021 the share of sessions in which the Italian price was lower than the Dutch one significantly increased, with a higher percentage in the three summer months and a lower one in the spring months and in December.

A final consideration is relating to the monthly trend of gas demand in Italy. As can be seen from the graph, the demand decreases in the summer months and then increases in the early winter months, suggesting a decrease in prices during periods of lower demand. Referring back to the figure, while in 2020 the monthly price trend followed a normal demand trend, in 2021 this did not happen. After a brief decline in March and April, the price sharply spike vertically in an exponential manner until the last month of the year. The reason is that starting from the summer of 2021, there was an increase in the TTF gas price due to the recovery of the economy and therefore consumption after the COVID-19 pandemic. Additionally, many other geopolitical and large-scale factors have impacted the gas price. In conjunction with the

autumnal increase in European consumption, there was a decrease in gas deliveries to Europe from Russia and Norway, with an increase in deliveries to more profitable Asian markets, which raised the European gas price.

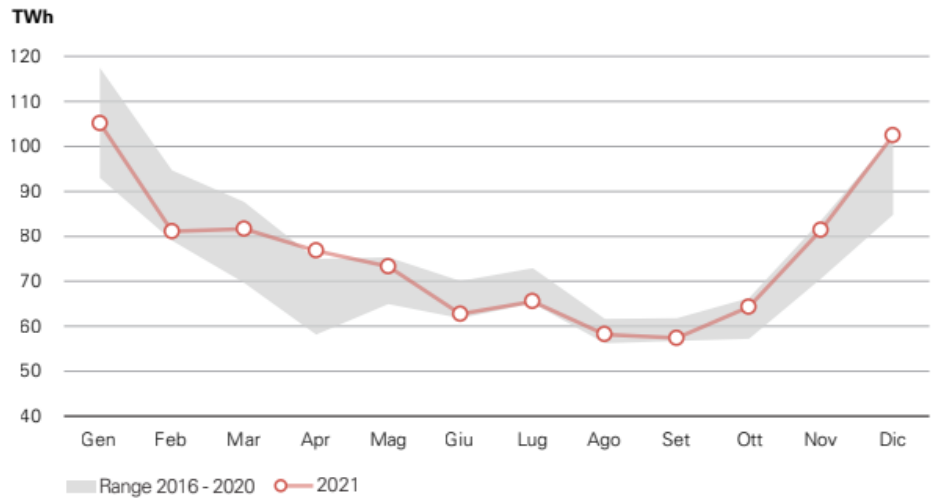


Figure 2.2.6.3 The monthly trend of natural gas demand in Italy. Source: GME annual report, 2022.

2.3 Contracts in the free market

Within the gas market, as stated in the previous paragraphs, there are various consumers with different needs and, above all, different annual gas consumption. It is precisely for this reason that companies operating in the free market offer their customers a variety of commercial offers that can vary based on the additional services attached to them, price calculation methodologies, or sales contract indexation. Among these, since 2017, there are the PLACET offers *(Prezzo Libero A Condizioni Equiparate di Tutela)*, which, as will be seen in the next paragraph, are a mix between the free market and the regulated market, as they are offers with prices freely determined by the seller but with contract conditions defined by the Authority.

According to a 2021 survey conducted by ARERA, the average number of commercial offers that each gas seller is able to propose to their customers is approximately 11.8 for domestic customers and 5.8 for condominiums with domestic use. For these contracts, there can be two types of prices: fixed price or variable price. In the free market, approximately 72.7% of domestic customers have subscribed to a fixed-price contract[29] in 2021, while the remaining 27.3% prefer variable-price contracts, where the price changes according to the times and modalities established by the contract itself. For condominiums, on the other hand, as can be

[29] The price does not change for at least one year from time of subscription.

seen from the figure 2.3.1, the values are completely reversed, with a clear prevalence of variable-price contracts. This is because, regarding the procurement cost component of the gas price, variable-price contracts are less advantageous for all types of customers, but the differential that can be obtained with a fixed-price contract is much larger for condominiums that purchase larger quantities of fuel.

CONTRACTS	DOMESTIC CUSTOMERS		CONDOMINIUMS	
	QUOTA	PRICE c€/m³	QUOTA	PRICE c€/m³
Fixed price contracts	72,7%	43,73	27,9%	34,63
Variable price contracts	27,3%	48,12	72,1%	41,12
TOTAL CUSTOMERS	100%	45,09	100%	41,21

Figure 2.3.1 Contracts for the supply of gas on the free market in 2021 by type of price and average price. Price is referred to procurement costs. Source: ARERA.

The proposed commodity price for customers with variable-price contracts includes different indexation methods. The most common one is linked to the components established by the Authority for the economic conditions of the supply of the protected service, while other commonly used methods are linked to the trends in gas prices at TTF and PSV. From the table 2.3.2, it emerges that the average price in 2021 for the indexation method based on the components established by the Authority (42.36 c€/m3) is more advantageous compared to the average of indexed contracts (48.12 c€/m3). Conversely, for both indexation methods based on the trends of the virtual hubs (TTF and PSV), the average value applied to the procurement component (56.07 c€/m3 and 62.40 c€/m3, respectively) is higher than the average.

Indexing type of the sales contract	Domestic costumers		Condominiums	
	Quote	Price c€/m3	Quote	Price c€/m3
With a discount on one of the established components by the Service Authority of protection	56,4%	42,36	73,3%	38,31
Indexing at TTF price	34,2%	56,07	13,7%	46,92
Indexing at PSV price	5,9%	62,40	9,4%	62,35
Other indexing (e.g. GME, Brent)	3,5%	42,02	3,6%	39,54
TOTAL	100%	48,12	100%	43,63

Figure 2.3.2 Variable price contracts for the supply of gas in the free market in 2021 by type of indexation and average price. Source: table self-made, data from ARERA.

Contracts for gas supply in the liberalized market can also differ based on the presence of additional services attached to the offer, which result in a different price per cubic meter of gas. These services are available for both fixed-price and variable-price contracts and a direct consequence of adding services to the offer is an increase in the price component that covers procurement and sales costs. However, nearly 40% of customers in 2021, who subscribe to a fixed-price contract, are willing to pay a slightly higher price (approximately 3 c€/m3) to participate in a loyalty program as an additional service. On the contrary, for customers with variable-price contracts, the trend is not to add any services to their contract, with about 80% of customers without any additional services.

2.3.1 PLACET offers

All operators who work on the end market are obliged, as established by law no. 124/2017, to offer households at least one fixed-price supply proposal, and one variable-price supply proposal, and since August 2017, they are obligated to include the PLACET offer in their package of commercial proposals. In the PLACET offer, prices are freely determined but with contract conditions defined by the Authority.

Indeed, these offers have uniform price structures, which are established by the Authority and are non-negotiable. This characteristic, along with standard contract conditions and the exclusion of any additional services to the supply of natural gas, makes PLACET offers easily comparable among themselves.

Regarding contract conditions, these are always defined by the Authority and are non-negotiable, unlike the contract conditions of other offers in the liberalized market, which are proposed by the seller and partially modifiable, while respecting the regulation of the Authority. As for prices, sellers have a certain freedom in establishing the economic conditions of the offer, but with some limitations. The conditions must be renewed every 12 months, and within three months of the expiration of these conditions, the seller must inform the customer about the new conditions that will apply from the thirteenth month.
Regarding the types of offers, every retailer must offer two types of PLACET offers: one with a fixed price and one with a variable price. For this latter type of offer, the price is indexed to the TTF determined each quarter as the arithmetic average of the quarterly OTC forward quotations related to the respective quarter at the TTF hub.

2.4 Bill structure

The bill provides a concise overview of the amounts to be paid for different expense items. The expense items indicated on all bills in the summary are:

- expense for natural gas material;
- expense for transportation and meter management;
- expense for system charges;
- taxes.

In general, both for the free market and the regulated market, the last three components remain unchanged; the only one that changes is the first component, which relates to procurement costs. The structure of a typical bill for a customer in the regulated market is then analysed.
The first item encompasses all invoiced amounts related to the various activities carried out by the seller to provide natural gas to the end customer. The price is updated monthly and consists of a fixed fee (euro/year) which is part of the price expressed in euro/year and is paid to have an active delivery point, even in the absence of consumption and an energy component expressed in euro/cubic meter, which includes all amounts to be paid in proportion to consumption. The component included in the fixed fee is the retail commercialization component (QVD), which represents the amount to cover the fixed costs incurred on average by a sales company to perform customer commercial management activities.
Regarding the energy component, it further includes two other components: the gas raw material component called CMEM and the procurement component (CCR).

The CCR, expressed in euro/cubic meter, corresponds to the costs that sellers must incur to supply their customers and protect customers from the risks of significant price fluctuations (caused, for example, by exceptional winter temperatures or variations in overall gas demand). The CMEM is the most significant component in calculating the price of gas per cubic meter and corresponds to the expected cost of purchasing gas to be resold to customers. With the 374/2022/R/gas resolution, the value of this variable, previously calculated based on the trend of the TTF price until July of last year, is now updated monthly based on the monthly average of the PSV (day-ahead) price.

The second expense item, for transportation and meter management, is also composed of a fixed fee and an energy component. It includes the invoiced amounts for the various activities that allow sellers to deliver natural gas to end customers. The tariffs are updated every quarter and include the components: distribution and measurement tariff and transport tariff components (Qt), commercial quality (RS) and equalization (UG1).

The expense for system charges includes the invoiced amounts related to fees aimed at covering costs related to activities of general interest for the gas system, which are paid by all end customers of the gas service. The tariffs are updated according to the needs for cost coverage and are usually reviewed every quarter. For this item as well, the components are divided into a fixed fee, UG2, and an energy component, RE, UG3.

Finally, the last major item, taxes, includes sub-items related to consumption tax (excise duty), regional surcharge, and value-added tax (VAT). Excise duty is applied to the quantity of gas consumed, and the tax rate increases if certain annual consumption thresholds (tiers) are exceeded. The regional surcharge is applied to the quantity of gas consumed and is autonomously determined by each region within the limits set by law. VAT is applied to the total amount of the bill. For civilian uses, the tax rate prescribed by tax legislation is 10% for the first 480 cubic meters/year consumed and 22% for all other consumption and fixed fees.

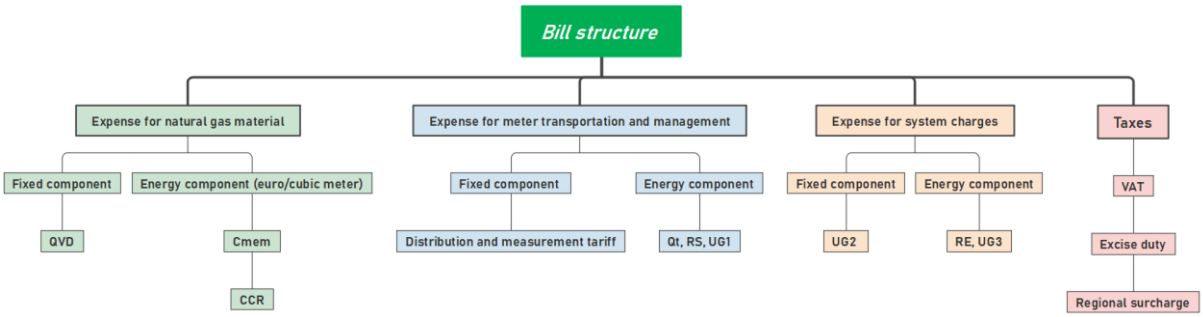


Figure 2.4.1 Bill structure. Scheme self-made, data from ARERA.

2.5 *The price structure for the typical domestic customer: some examples*

Starting from the structure of the bill described in the previous paragraph and integrating ISTAT and ARERA data on consumer price trends, it is possible to develop a trend analysis of the average economic conditions30 for the supply of the typical domestic customer. By typical domestic customer, we mean a subject with an annual consumption of 1400 m^3 and equipped with an autonomous heating system. The trend shown in Figure 2.5.1 presents prices that have been derived using a national average value for all locally variable components, except for distribution, for which the value of the north-eastern area is employed, as it has the greatest impact.

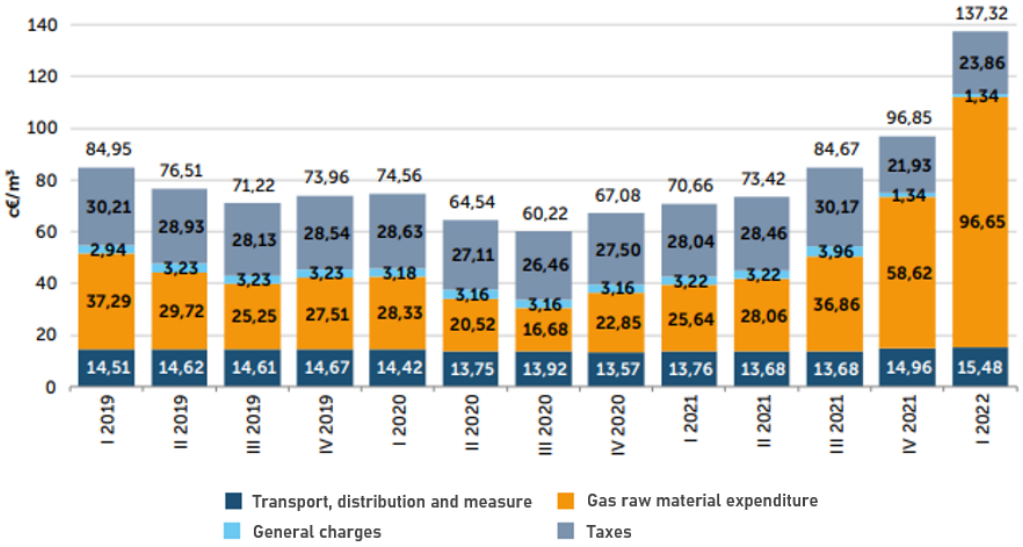


Figure 2.5.1 Natural gas prices for a typical domestic consumer from 2019 to 2022. Source: ARERA.

As can be observed from the figure 2.5.1 and the graph 2.5.2, the dynamics of the overall price strongly depend on the trend of the gas raw material component, which represents a significant percentage of the total value paid by the consumer. In January 2022, it constitutes 70% of the price with a value of approximately 96.65 c€/m^3 (figure 2.5.2). The method of calculating the procurement component price, as extensively explained in the previous paragraphs, has been progressively updated since 2013, replacing the reference to oil prices resulting from long-term contracts with prices obtained from short-term gas markets (spot markets). Thanks to the new calculation system introduced in 2013 and the progressive contraction of international gas

[30] Introduced with resolution 4 December 2003, n. 138, and currently governed by attachment A (TIVG) of resolution ARG/gas 64/09.
Selling companies are obliged to offer these conditions to households alongside their offers for the free market.

demand, there has been a systematic reduction in the price for the typical consumer until the first half of 2016. Subsequently, after a period of growth, in the second quarter of 2019, there was a new reversal of the trend, attributed to the economic slowdown and the sharp drop in wholesale market prices following the onset of the pandemic. As a consequence, there were significant reductions in the procurement component of the raw material, which halved its value in 2020, and the overall price returned to a value of approximately 60 c€/m^3. Later, there was an economic recovery that drove energy demand to levels exceeding supply capacities, resulting in tensions and significant price increases in international energy markets. The gas raw material component reflected this evolution, increasing by about six times in just over a year, while the overall price (135.6 c€/m^3 in January 2022) became more than doubled compared to the 2020 minimum. These increases would have been even higher if the Government and the Authority had not implemented reductions in the system charges and taxes components.

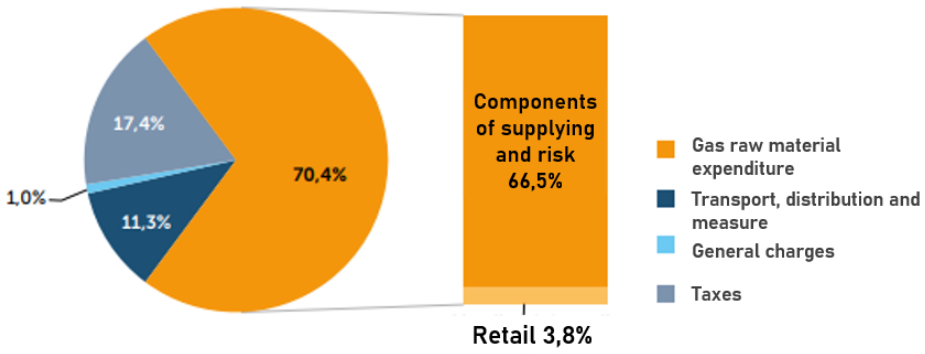


Figure 2.5.2 Percentage composition of natural gas price for a typical domestic consumer as of January 1st, 2022. Source: Arera.

As of January 1st, 2023, the reference price of gas for the typical Italian household stands at 99.37 c€/m^3. This value has decreased compared to the previous month, but it still doesn't fully counteract the high price levels reached in the past year. The gas expenditure for the household in the period February 2022 to January 2023 amounts to approximately 1,769 euros, which is 36% higher compared to the equivalent 12-month period of February 2021 to January 2022.

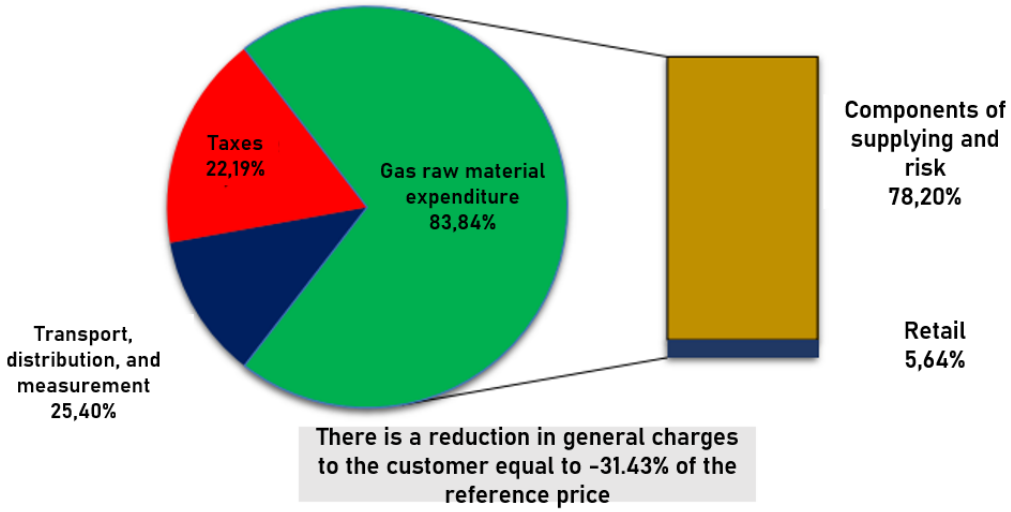


Figure 2.5.3 Percentage composition of natural gas price for a typical domestic consumer as of January 1st, 2023. Source: Arera.

In Figure 2.5.3, the percentage compositions of the price to which the typical customer is subjected under the regulated regime in January 2023 are expressed. The 99.37 c€/m3 are divided as follows:

- *Expenditure for natural gas supply*. It can be split in 77.72 c€/m3, accounting for 78.20% of the total bill, for natural gas procurement and related activities, and 5.60 c€/m3, 5.64% of the total, for retail sales;
- *Expenditure for transport and meter management.* 25.24 c€/m3, 25.40% of the total, for distribution, measurement, transportation, distribution equalization, and quality services;
- *Expenditure for system charges.* -31.24 c€/m3, -31.43% of the total bill, for general system charges, resulting in a reduction effect for the end-user;
- *Taxes.* 22.05 c€/m3, 22.19% of the total, including excise taxes (15.38%), regional surcharge (2.04%), and VAT (4.76%).

An important consideration is regarding the third component, expenditure for system charges, which is negative and thus has a reducing effect on the end-user. This is because, to counteract the increase in energy costs, ARERA has eliminated general system charges from the second quarter of 2022, and for consumers with consumption below 5000 smc/year, the UG2 component has been set as negative. The UG2 component ensures that the amounts paid by customers through the Commercialization component are equal to those incurred by sales companies for customers served under market conditions and customers served under the

regulated regime. These decisions in favour of the customer have also been confirmed by the 2023 budget law and will remain in effect until July 2023.

2.6 Comparison between free and protected market

An important consideration concerns the end of the regulated market. With the quarter[31] aid decree, the government has decided to extend the end of price protections for gas, originally scheduled for January 1, 2023, to the same date set for the electricity market, which is January 10, 2024. The reason for this extension, despite the increasing switching rate in recent years, is to introduce elements of gradualness to accompany the transition process towards the free market, also through adequate auction mechanisms. The reason to switch to the free market is that the latter offers several advantages in favour of the end consumer. These include:

- Greater choice options. In the free market, consumers have access to a wide range of suppliers and commercial offers. This means they can compare prices, contract conditions, and additional services offered by different suppliers, to find the offer that best suits their needs. In the regulated market, on the other hand, the option has always been limited to a single supplier and tariffs set by the Authority;
- Competitive prices. In the free market, competition among suppliers drives the search for lower prices. Suppliers in the free market can freely set the prices of their offers, seeking to attract customers by offering more affordable rates or discounts. In the regulated market, prices are determined by ARERA and may not fully reflect the competitive dynamics of the market;
- Personalized services. In the free market, as seen in the previous paragraph, suppliers can offer additional services to their customers, such as technical assistance, online bill management, loyalty programs, or specific promotions. These services can add value to the offer and meet the specific needs of consumers;
- Contractual flexibility. In the free market, consumers have more opportunities to negotiate contract conditions, such as contract duration or payment terms. They can also choose between fixed or variable price contracts, depending on their preferences and the perceived risk associated with gas price fluctuations;
- Innovation and new technologies. In the free market, suppliers are incentivized to introduce innovations and adopt new technologies to improve the efficiency and quality

[31] The new quater aid decree was passed by Council of Ministers on November 10, 2022 and it provides for a sum of 9.1 billion euros to mitigate high energy costs and inflation.

of services offered. This can result in more competitive offers and a better experience for consumers.

To understand whether and how much the offers available in the free market are more advantageous compared to those in the regulated market, the annual expenditure that a customer could have incurred by choosing from the monthly offers available on the Offer Portal since January 2020 was analysed. The Offer Portal is a public website, managed by the Integrated Information System Manager (SII), where domestic customers, households, and small businesses can compare and choose natural gas offers free of charge. The sample chosen for this analysis, conducted by ARERA, considers the typical domestic customer located in Milan with an annual consumption of 1,400 Smc and using natural gas for cooking, hot water, and heating, while the comparison elements considered are all the monthly variable price offers available on the Offer Portal in the last three years (Figure 2.6.1).

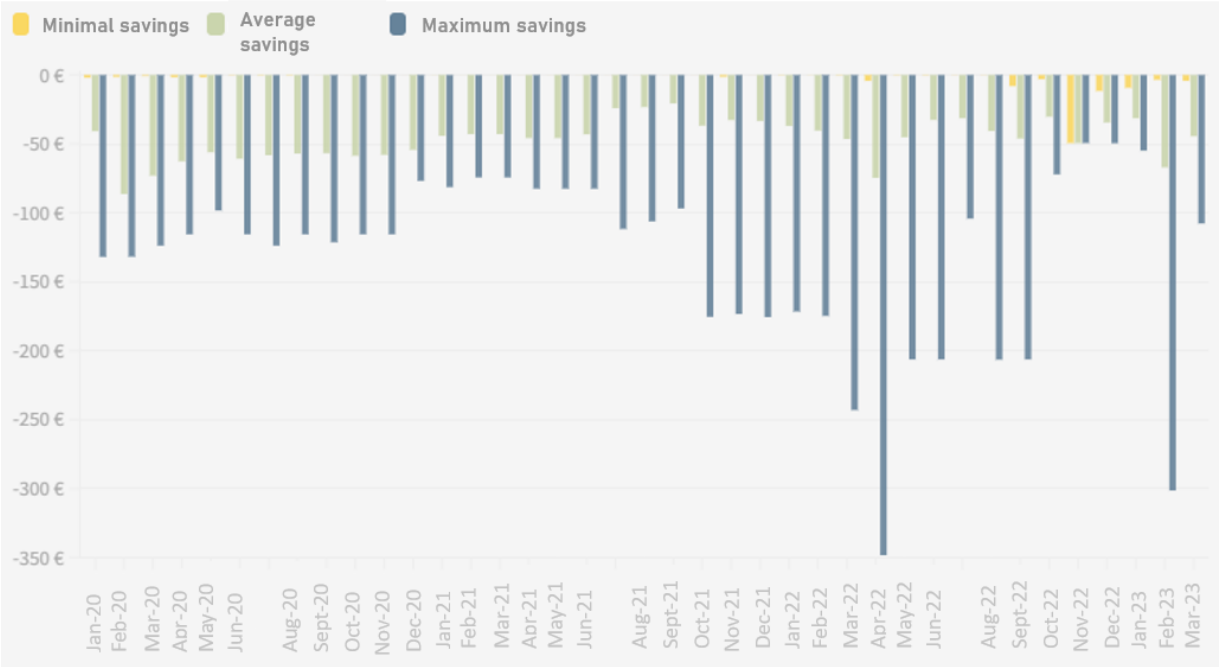


Figure 2.6.1 Possible savings in the free market compared to the protected market. Source: ilPortaledelleofferte.it

From this analysis of the offers available on "ilportaledelleofferte.it" every month, it emerged that the annual gas expenditure for those who turn to the free market is generally higher than those who use the regulated market. However, numerous offers in the free market are more cost-effective, and the potential savings are depicted in the figure 2.6.1 where the maximum savings are shown, considering the best offer of the current month on the Offers Portal, and the average savings, considering the total of the most convenient offers available in the free market.

It is important to clarify that each seller in the free market can determine the validity period of each offer published on the Portal based on their commercial assessments and wholesale market conditions at the time of publication, while the economic conditions of the regulated service are updated quarterly and remain unchanged throughout the valid quarter. Consequently, the assessment of potential savings in the free market compared to the regulated conditions can be influenced not only by the different characteristics in terms of contractual conditions applied in the free market compared to the regulated services but also by the asynchrony of the cyclicity of updates to the regulated conditions with the commercial campaigns of individual sellers, who are more flexible in responding to market conditions.

2.7 Relationship between price and gas consumption

This paragraph focuses on the analysis of natural gas consumption in relation to the price paid per cubic meter, a fundamental aspect in the energy context. In particular, the first part examines the relationship between the average domestic consumption over the past 10 years (data from ARERA) and the average annual prices, including taxes, during the same period (prices obtained from Eurostat). The subsequent part of the paragraph analyses the consumption trends, also about price, divided based on the climatic zones of residents, with three macro zones identified: North, Central, South, and Islands. The paragraph then proceeds to analyse the trends of the two consumption categories classified by Eurostat as D1, gas used for cooking and hot water, and D2, gas also used for heating, in relation to the average annual prices applied to each category. Finally, a more detailed comparison is made between the quarterly gas prices applied to customers in the regulated market and the average domestic consumption of a typical family. The first graph (Figure 2.7.1) examines two variables: national per capita domestic consumption expressed in cubic meters per year, without any class or location distinction, and the average annual weighted price of natural gas.

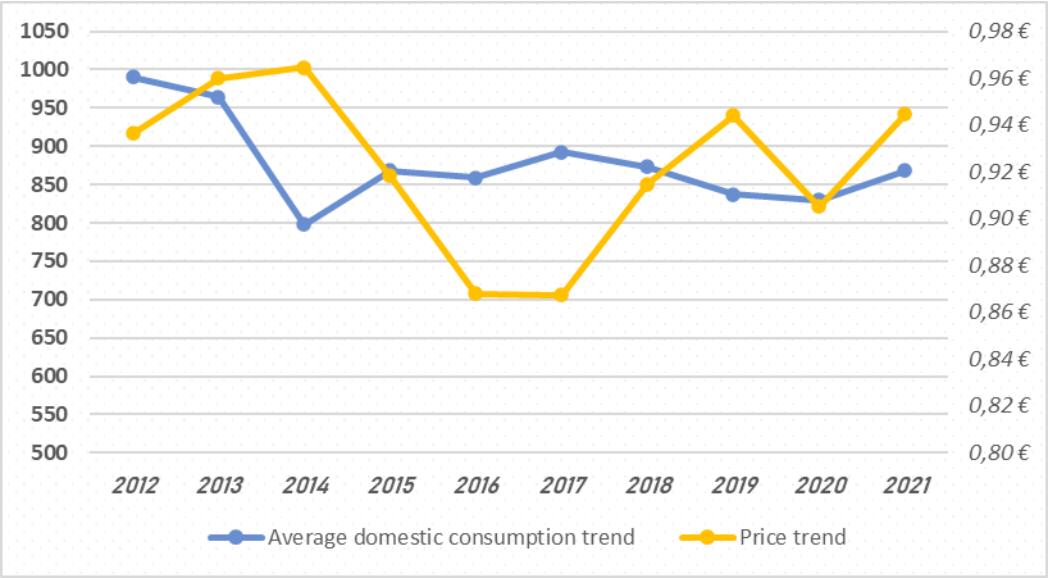


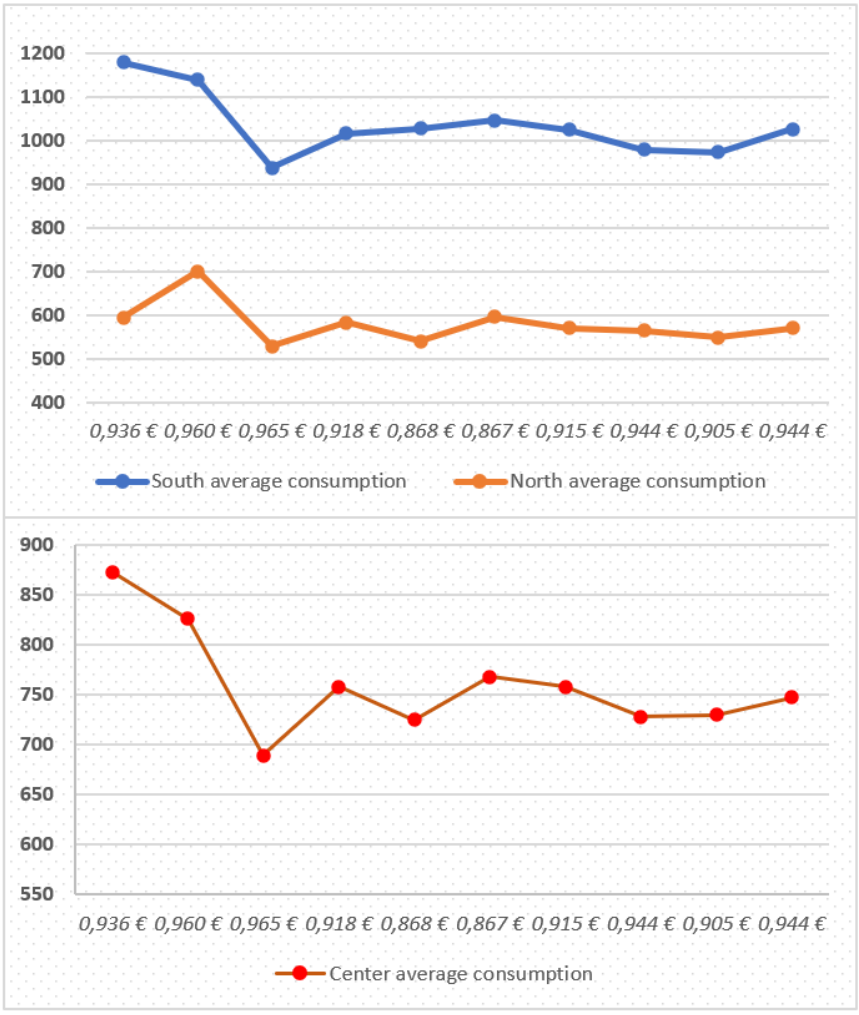
Figure 2.7.1 Price and average domestic consumption annual trend. Sources: self-made graph, data from Eurostat and Arera.

Regarding the first variable, consumption values are derived from the annual retail analysis conducted by ARERA, which received responses from 614 companies including wholesalers and retailers. The results of this survey are shown in Figure 2.7.1 under the category of national per capita consumption and represented by the blue line.

For the second variable, the data source is the database provided by Eurostat. As mentioned in the first part of this chapter, consumers are divided into classes (D1, D2, D3) by Eurostat based on the amount of gas consumed, and a different price is assigned to each category. For this analysis, only classes D1 and D2 were considered, which include all customers with consumption below 5000 m^3 annually. The prices for each category were calculated by averaging the average prices, including taxes, recorded in the first and second semesters of the reference year by Eurostat. Subsequently, in order to relate a single price to the annual domestic consumption expressed in the first variable, a weighted average was calculated across different gas consumption ranges. To do this, the percentage of volumes consumed by domestic customers with consumption below 500 m^3/year (considering the first two ranges identified by ARERA, 0-120 and 121-480 m^3) and the percentage with consumption between 500 and 5000 m^3/year (i.e., the consumption ranges 481-1560, 1561-5000) were calculated for each year. These two percentages were then multiplied by the reference prices of classes D1 and D2. Finally, since the values are expressed in Euros per gigajoule, they were converted to Euros per cubic meter (smc).

In Figure 2.7.1, the average consumption (left column) and average prices (right column) for the years 2012 to 2021 are represented. The first observation that can be made relates to the correlation between the two lines, i.e., as the gas price increases, the average consumption tends

to decrease. However, as discussed in the first chapter, consumption can be influenced by various factors, and for some years, an increase in price corresponds to an increase in consumption. This was the case in the biennium 2020-2021, where the recovery of the economy after the onset of the pandemic led to increased consumption despite the price increase. Looking closer, it can be noted that the highest positive price variation in the decade under consideration occurred from 2017 to 2018, with an increase of 4.72 cents/euro (5.44%). The variation in average consumption, on the other hand, was -19 m^3/year, corresponding to -2.13%, roughly half compared to the price variation. In the period between 2013 and 2014, despite an increase of only 0.5 cents/euro (practically unchanged), average consumption decreased by 17 percentage points (-166 m^3/year). This drastic reduction in consumption despite the nearly unchanged price can be attributed to the exceptionally high average winter temperature recorded in that year (the highest of the decade under consideration). Similarly, between the years 2014-2015, with a further decrease in average winter temperatures, per capita consumption recorded the highest increase of the decade with an increase of 70 m^3/year (8.77%) despite a decrease in the price of only 4.8 percentage points.



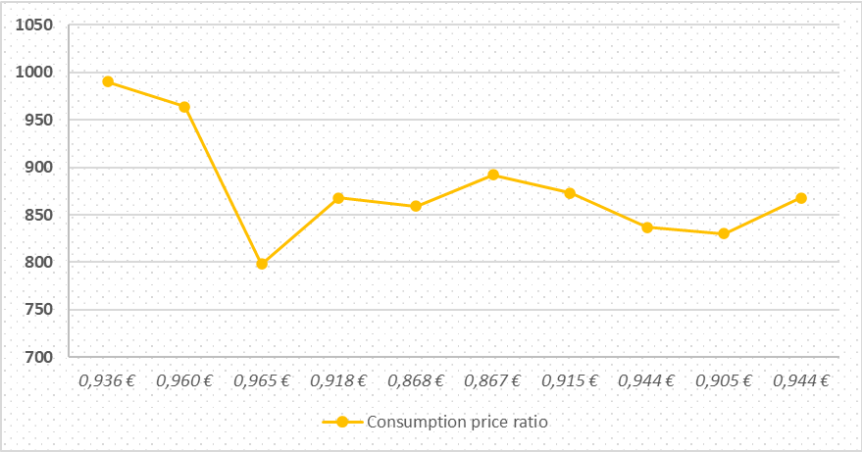


Figure 2.7.2 and 2.7.3 National, north centre and south consumption price ratio. Sources: self-made graphs, data from Eurostat.

In Figures 2.7.2 and 2.7.3, the average domestic consumption is represented, divided into the three different identified climatic zones: North, Central, and South. For each of these graphs, the consumption variable has been related to the average annual price derived from the previous graph. If we consider the period 2017-2018, which experienced the most significant positive price variation of 5.44%, it can be observed that the average consumption for the three zones decreased by different percentages. While there was not a significant difference in percentage for consumption in the North and Central regions, 2.10% respectively in the North and 1.30% in the Central, the Southern macro zone saw a decrease of 25 m^3/year, equivalent to 4.19%, which is twice as much as the North. Similarly, throughout the considered decade, the variations in average consumption in the South tend to be more pronounced compared to other regions of the country when prices change. This may indicate that average consumption is more sensitive to price variation. One reason for this could be the temperature difference between the two regions. In the South, temperatures, especially in winter, are milder, allowing for an easier reduction in consumption compared to the North. Another reason could be attributed to the calculation of the national average price, which involved a weighted average across consumption ranges within the two price classes, D1 and D2. The D1 class, which includes prices applied to customers with annual consumption below 520 m^3, exhibits absolute price variations higher than those in the D2 class. Due to the milder temperatures in the South, there is a higher proportion of customers belonging to the first two consumption ranges identified by ARERA (0-120 m^3 and 121-480 m^3), resulting in a greater impact from the price increase in the D1 class.

Finally, by observing the figures related to average consumption in the North, South, and at the national level, it is noticeable that the trend in average consumption in the North closely resembles the national trend. This is because the national average is highly influenced by the

large amount of gas consumed in colder temperature zones. Additionally, when looking at Figure 2.7.2, it can be observed that consumption variations are more pronounced, creating a less "harmonious" and less specular line compared to the price line, unlike the consumption line in the North. This occurs precisely because there is a greater impact of D1 prices in the South, which, as previously mentioned, has recorded more significant absolute variations over the decade.

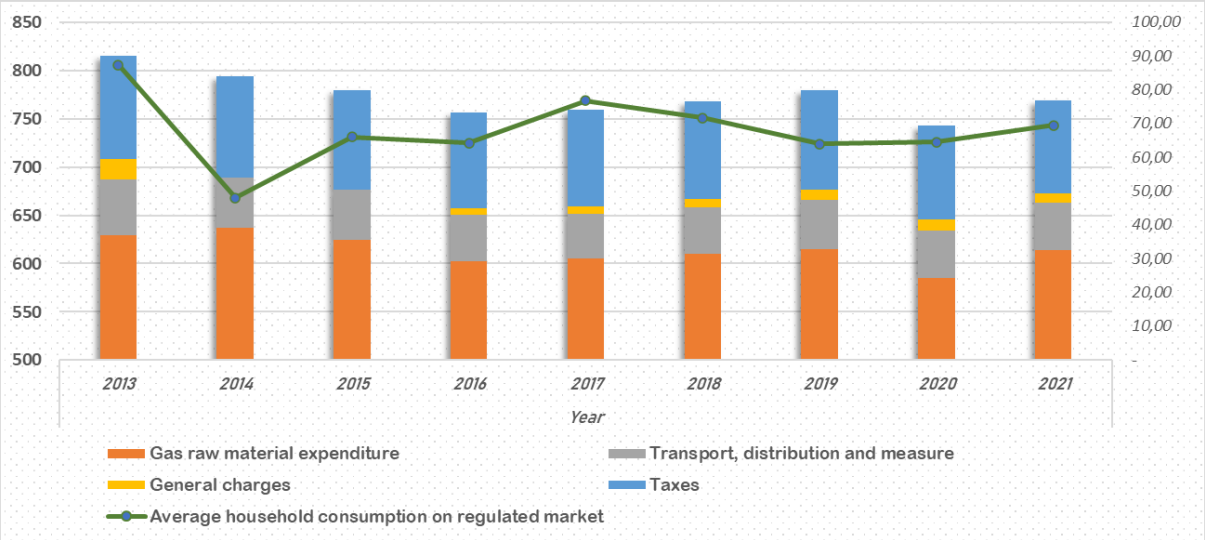


Figure 2.7.4 Average household consumption on the regulated market in m3/year and prices on the regulated market expressed in c€/m3. Sources: self-made graph, data from Eurostat and Arera.

An additional analysis was conducted by examining the values of average household consumption in the strict sense[32] for those who purchase gas through a contract in the regulated market, and the prices of natural gas for a typical residential consumer under regulated conditions. Regarding the first variable, the average consumption values were obtained by using data from ARERA and dividing the total volumes sold in the regulated market and in the strictly residential sector by the number of customers in the respective sector. As for the second variable, similar to the average price between D1 and D2 in the previous analysis, a weighted average was calculated. While previously the price was calculated by multiplying the gas quantities, divided by withdrawal ranges, by the corresponding reference prices, in this case, the total gas quantities consumed by the residential sector each quarter have been multiplied by the corresponding prices at which the gas was sold in the regulated market. The reason for this calculation is that the gas price component covering the natural gas procurement costs (CMEMm) was updated every three months until October 2022. To obtain a more accurate

[32] Considering only families without condominiums.

annual average price, it was weighted by the quantities of gas consumed in the respective quarter. Furthermore, the price was decomposed into its different components, and a weighted average was calculated for each component using the same methodology explained earlier.

In Figure 2.7.4, the trend of average household consumption for Italian families is represented by the green dashed line, while the stacked columns represent the different components that constitute the final price. The first thing that can be immediately noticed is that in the year 2014, similar to the previous graphs, there is a clear reduction in both consumption and prices. Once again, the most likely explanation can be attributed to the increase in average temperatures, especially during the winter period. A second observation can be made in the biennium 2018-2019, where there was the highest percentage decrease in consumption, 3.6%, excluding the decline in 2014, accompanied by the second highest increase in price, 4.25 percentage points. On the contrary, at the end of 2016, there was a decrease in the regulated market price by 8.39%, but it was not accompanied by an increase in consumption; in fact, consumption even decreased by 0.82%. From these latter two observations, it can be deduced that the average family that relies on the regulated market for gas purchases tends to quickly respond to price increases by reducing consumption, and responds more cautiously to price reductions, which are not immediately followed by an increase in consumption as one might expect. A similar trend was observed in the first chapter when analysing the external temperature variable, where on two distinct days but with the same temperatures, consumption tends to be higher after a pattern characterized by a decrease in temperatures followed by a momentary reduction. Finally, the columns highlight that taxes and the cost of raw materials constitute a significant influence on the determination of the final price. While tax values remained very similar over the decade with minor fluctuations, the raw material expense component has decreased or increased significantly over time and it has had a significant impact on the trend of the final price applied to the customer.

3 Gas in Condominiums: A Case Study

The second chapter examined the important variable of gas price and its impact on the energy consumption of Italian households. In this chapter, a more specific analysis is conducted regarding the variations in consumption and energy expenditure in a condominium context, considering the corresponding price fluctuations to obtain a real validation of the previous results. It will be of particular interest to observe how residents in a centralized heating system condominium react to gas price fluctuations and whether such variations have a significant impact, either positive or negative, on their energy consumption behaviours. The data for the following analysis were kindly shared by a study based in Padua that manages several condominiums scattered throughout the Veneto region. The requested information pertains to gas consumption, both involuntary and voluntary, total energy expenses incurred, and the price paid per cubic meter. The ultimate objective is to verify if the conclusions drawn during the previous chapter also find confirmation in the reference sample case.

3.1 The National Situation of Condominiums

Before proceeding with the actual analysis, it is appropriate to provide some information and regulatory references to contextualize and explain certain methodologies for determining and allocating condominium costs.

At the national level, the residential condominium sector consumed 2.4 (Gm^3) in 2021 (an increase compared to the previous year) out of the total market volume of 57 Gm^3, with approximately 210,000 condominiums scattered throughout the peninsula and an average annual consumption of 11,917 cubic meters. Similar to households, condominium consumption varies significantly depending on the climatic zone in which the building is located. This can be observed from the average consumption reported by ARERA, which indicates an average consumption of 12,936 m^3 in the North, 10,099 m^3 in the Central region, and 5,241 m^3 in the South. In fact, the North accounts for 79.9% of the national volumes, while the rest is predominantly purchased in the Central region (17.7%). In practice, this usage is much lower in the South, where centralized heating systems are not common, as evidenced by the purchasing volumes representing only 2.4% of the national total and having a ratio of 1 to 33 compared to consumption in the North.

Regarding the gas purchasing market, 85.2% of condominiums buy from the liberalized market, a percentage that has been steadily increasing in recent years, with an average consumption of 15,583 m^3 per unit. This consumption is more than double compared to the protected service,

which amounts to 7,412 m^3. This market differentiation is destined to disappear as of January 10, 2024, when the regulated market will come to an end in condominiums as well. All customers who have not yet switched to the free market will not experience a supply disconnection, but will automatically transition to a Gradual Protection Service, which involves being assigned a supplier and prices determined through auctions. Another aspect that differentiates residential condominiums from households is the average number of contracts offered by gas suppliers, which is 5.8 compared to the 11.8 offered to residential customers. Additionally, a higher percentage of condominium customers, 72.1%, opt for variable pricing for their supply contracts, with an average price of 41.12 c€/m^3 for the raw material component. In contrast, 27.3% of residential customers choose variable pricing, with an average price of 48.12 c€/m^3 for the supply cost component.

Similar to residential customers, the main types of indexing used for variable-price contracts adopted by condominiums include a discount on one of the components established by the authority for protected services (73.3% of customers with variable contracts), indexing to the TTF (13.7%), and indexing to the PSV (9.4%).

3.2 Condominiums with Centralized Heating Systems: Functionality and Regulatory Overview

Centralized heating in a condominium refers to a heating system in a building that consists of three different components:

- a heat generation system, such as a boiler, condensing boiler, or gas heat pump;
- an internal distribution network within the condominium;
- heating devices (radiators, fan heaters, underfloor, ceiling, or wall radiant panels, or diffusers for distributing heated air from treatment units) and control and potential metering equipment.

With the legislative decree no. 73, which modifies the legislative decree no. 102 of 2014, the implementation of Directive (EU) 2018/2002 amending Directive 2012/27/EU has been carried out. In line with Article 9 of the Directive, legislative decree no. 102 of 2014 establishes that in order to promote energy consumption reduction, the allocation of expenses for heat, cooling, or domestic hot water consumption for each housing unit should be based on effective consumption.

Starting from 2016, all centralized boilers must be equipped with heat metering valves, which allow for tracking the consumption of each individual housing unit. This system enables the

fair division of energy expenses among condominium owners according to their respective consumption.

Furthermore, all radiators in each apartment must be equipped with valves for heat regulation, ranging from level 1 (lowest) to level 5. This allows each condominium owner to adjust the heating within their own apartment and manage their consumption.

The national regulations specify the temperature range for centralized heating, which ensures proper building warmth while reducing energy waste, and it is set between 20 and 22 degrees Celsius.

The dates for turning on the heating system and the maximum duration are also determined nationally, based on regional needs, as stipulated by Law No. 10 of 09/01/1991. This law divides Italy into six different zones, assigning a letter from A to F based on external temperatures.

3.3 How Consumption is Allocated: Methods and Considerations

According to the guidelines provided by ENEA in the document "Allocation of Expenses for Thermal Energy Consumption in Condominiums," consumption allocation applies to condominiums supplied by a centralized heating or cooling source. A condominium refers to a building with at least two individual housing units exclusively owned by co-owners of the common areas. In order to assign each housing unit a proportionate share of the expenses based on individual consumption, a direct or indirect metering system can be utilized.

Direct metering systems allow individual users to directly determine their voluntary energy consumption (usually expressed in kWh) through individual thermal energy meters, without the need for additional measurements or estimations. If direct metering is not technically feasible or cost-effective, an indirect method can be employed. Indirect metering systems enable individual users to indirectly determine their voluntary energy consumption by counting the energy allocation units[33] in all housing units. Typically, a thermal energy meter at the outlet of the centralized boiler is used to measure the total useful energy consumed, while heat allocators or heat totalizers (both compliant with European standards) can be used to measure the allocation units.

According to Legislative Decree No. 102/2014, the allocation of expenses for heating, cooling, or domestic hot water must be based on "actual consumption." The decree establishes both a total voluntary expense share related to the actual voluntary consumption of all condominium

[33] Energy Allocation Units are not expressed in physical quantities, but are proportionate to the consumption of thermal energy through specific coefficients.

owners and a total involuntary expense share due to distribution system losses. In the case of direct metering, the share of voluntary consumption is calculated by determining the ratio between the sum of all individual energy consumptions and the measurement of energy output from the heat generator, while the total share of involuntary consumption is obtained by difference. Conversely, with the indirect method, where the shares cannot be directly measured, they must be estimated. In practice, useful calculations are provided through allocation units to determine the percentage of total voluntary consumption allocation. The percentage of involuntary consumption can be estimated based on the UNI 10200 technical standard or, alternatively, by the appointed professional. Generally, the share of involuntary consumption determined using this method can range from 20% to 30% of the total consumption.

After identifying the total voluntary and involuntary shares, the next step is to allocate each condominium owner's portion of the total involuntary share. This share is distributed among the housing units based on thousandths (millesimal) approved in the assembly, and the methods for determining the thousandths can vary but are predetermined by law and cannot be arbitrarily chosen by the condominium assembly. There are three criteria for allocating the involuntary consumption based on thousandths:

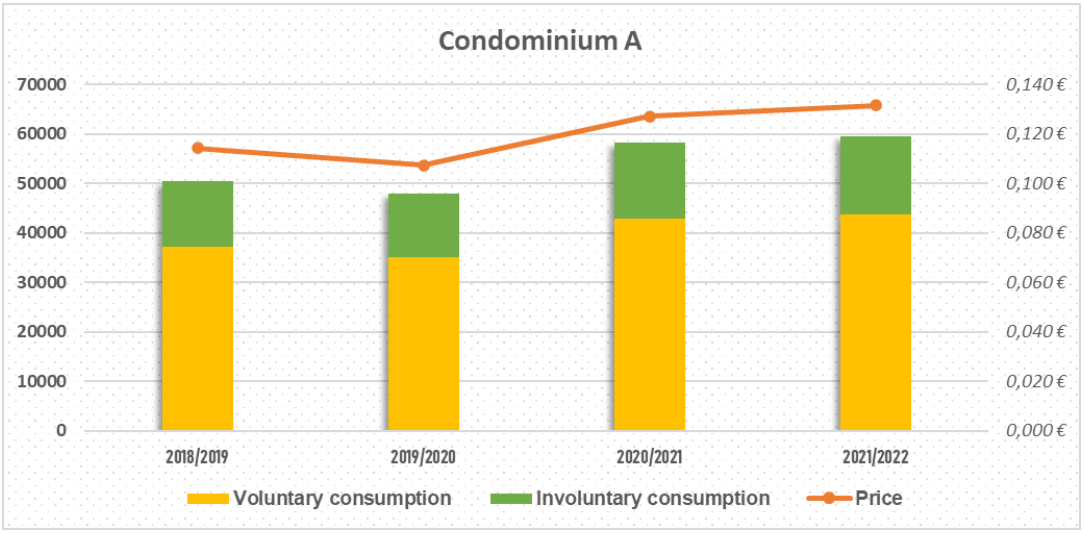
- surface area thousandths: the simplest method where thousandths are calculated based on the total surface area of each housing unit;
- Power thousandths: thousandths are calculated based on the total thermal power installed in each housing unit. This method is particularly useful when apartments have heating devices with significantly different power outputs for the same surface area;
- demand thousandths: thousandths are calculated based on the ideal energy demands of each housing unit.

For each proposed calculation methodology, the cost attributed to each condominium owner will differ, which means the calculation can either favour or disadvantage the owner of the housing unit.

3.4 Case Study Examined

For my analysis, I examined the consumption and price trends of two condominiums, hereinafter referred to as A and B, with centralized heating systems located in the Padua area over the past 4 years. Both structures utilize an indirect methodology for cost allocation, and heat allocation units (HUs) were used to calculate the voluntary shares. As for the determination of the involuntary share, there is a difference in the percentage applied to the calculation. Condominium A has an involuntary share of 26.5%, while Condominium B has an involuntary

share of 25%. Furthermore, the allocation of involuntary energy and maintenance expenses is divided into thousandths based on the surface area criterion.



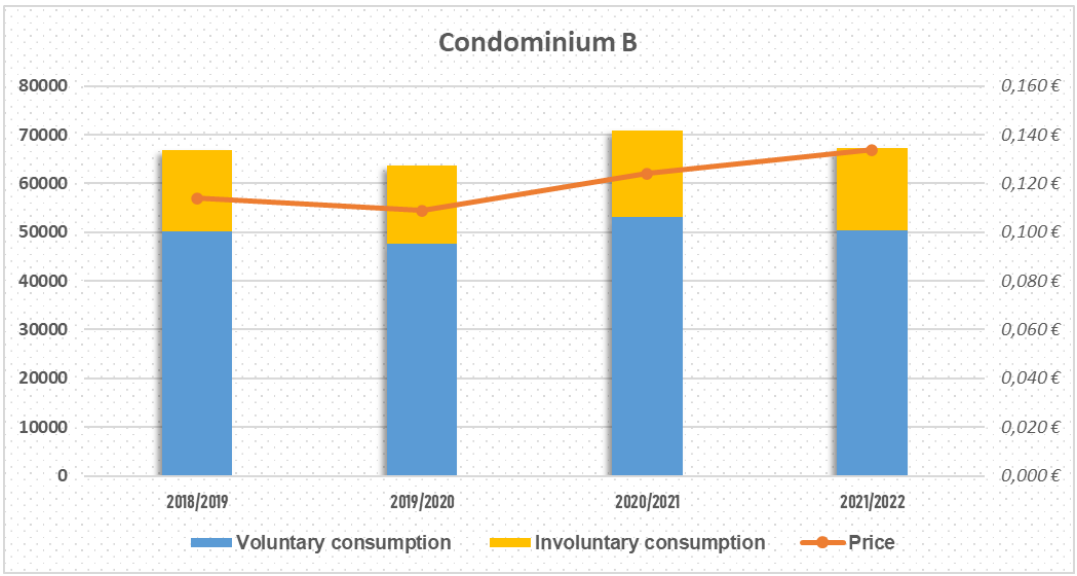


Figure 3.4.1 and 3.4.2 Price and consumption trends of two condominiums in Padua. Sources: graphs are self-made and data are from Building Manager in Padua. Consumptions are expressed in kWh and prices in Euro/kWh.

In Figures 3.4.1 and 3.4.2, the total annual consumption is presented in column format, divided into voluntary and involuntary shares for condominiums A and B respectively, covering the period 2019-2022. The orange line represents the average annual prices applied to gas per kilowatt-hour. The first thing to note is that both graphs show a price trend similar to the weighted average prices discussed in the previous chapter, with a decrease from 2019 to 2020, followed by an increase from 2020 to 2021. Similarly, the annual consumption follows the national average, with a reduction in 2020 despite the price decrease, followed by a new increase in 2021. One key difference between the two complexes is observed in the year 2022,

where the increase in raw material prices corresponds to two different reactions. Condominium A, despite a price increase of 3.43%, experiences a 2.08% increase in consumption. On the contrary, in 2022, Condominium B reduces its consumption by 5.07% in response to a price increase of 7.87%. When considering the trends of individual residential units, in Condominium A, 25% of units reduced their consumption in 2022, while the remaining 75% increased theirs. In Condominium B, however, the percentages are reversed, with 75% of the condominium owners reducing their consumption in response to the price increase.

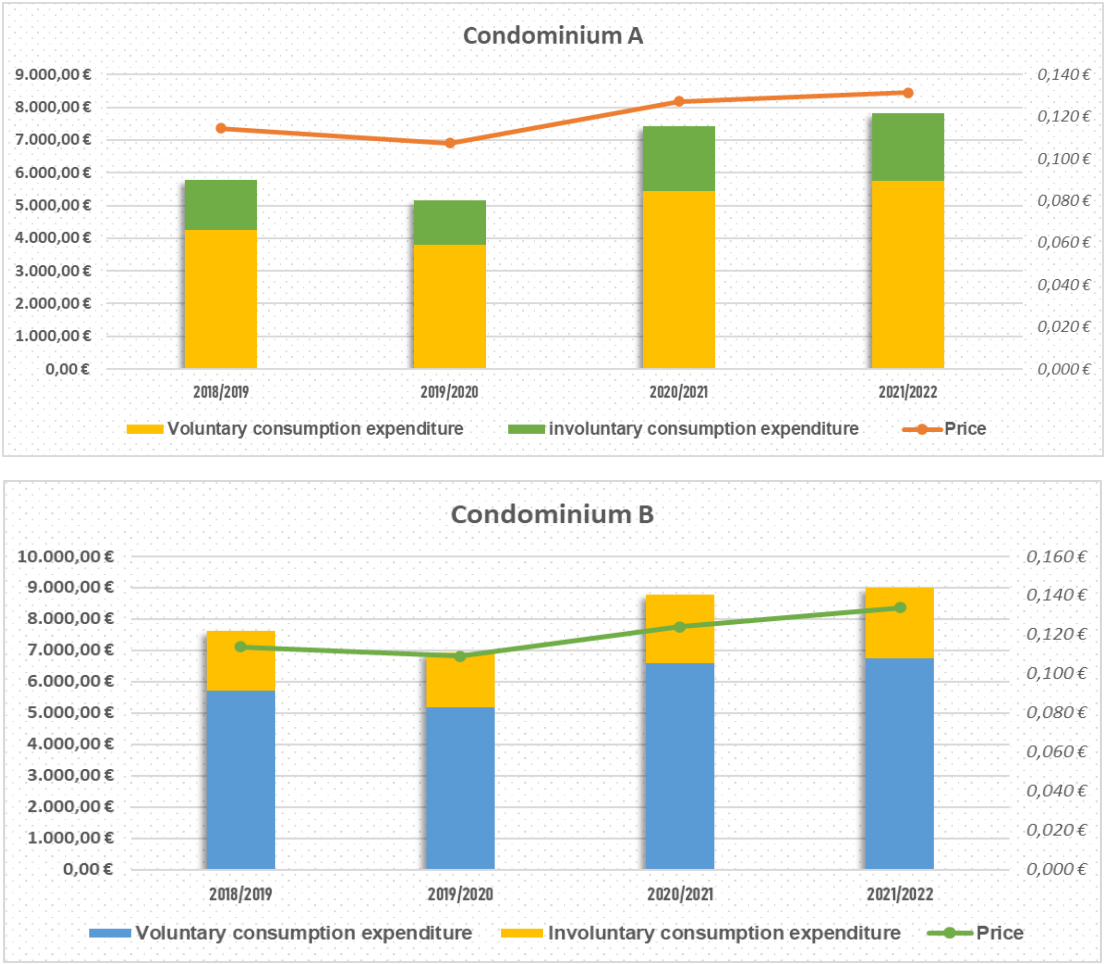


Figure 3.4.3 and 3.4.4 Price and total energy expenditure trends of two condominiums in Padua. Sources: graphs are self-made and data are from Building Manager in Padua. Energy expenditures are expressed in euro and prices in Euro/kWh.

In Figures 3.4.3 and 3.4.4, the total energy expenses, obtained by summing up the voluntary and involuntary expenditures, are represented in stacked columns along with the price trend. While the expense trend aligns with the consumption trend for Condominium A, for Condominium B, an increase of approximately 2.4% in energy expenditure is observed in 2022,

despite a 5.07% reduction in consumption. This indicates that the reduction in consumption was not able to offset the price increase, and even though the condominium owners tried to limit expenses by consuming less gas, their bills still increased by 2.5%. By comparing the variations in consumption, total expenditure, and prices for each year, it can be noted that for both condominiums during the period 2019-2020, the gas expenditure decreased by a greater percentage, 9.72% for Condominium A and 7.63% for Condominium B, compared to the annual consumption. The main reason for this is indeed the decrease in gas prices. In the 2020-2021 biennium, the same trend occurs but with reversed signs, meaning that the consumption increases while the energy expenditure shows a greater percentage increase, with a significant expense variation of 39% for Condominium A, compared to a consumption variation of 21.63%.

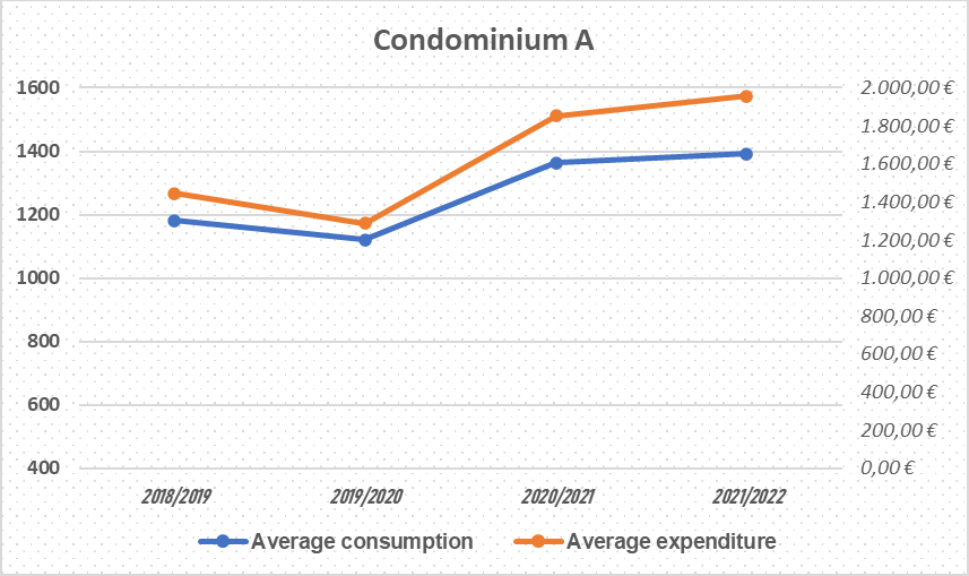
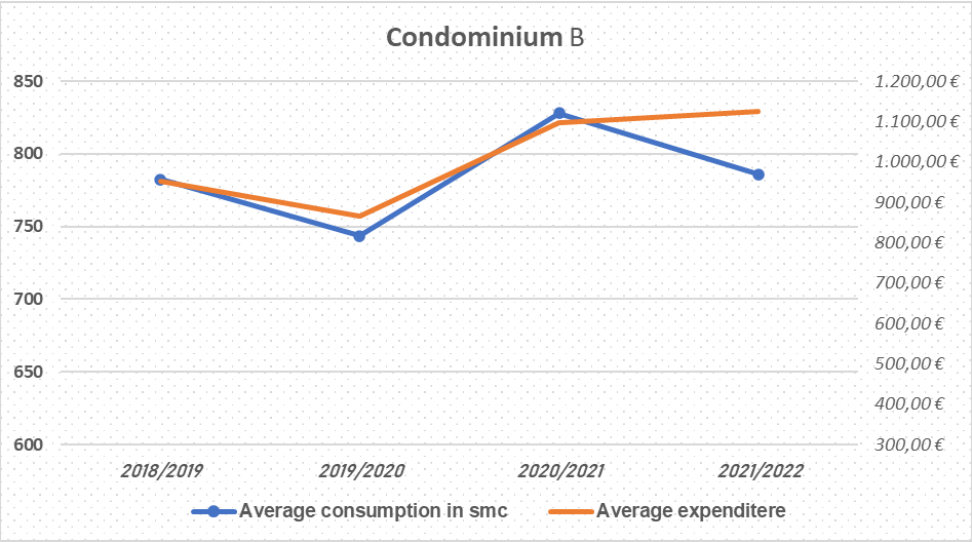


Figure 3.4.5 and 3.4.6 Average consumption and average expenditure, from 2019 to 2022, of two condominiums in Padua. Sources: graphs are self-made and data are from Building Manager in Padua.



As the final analysis, represented in Figures 3.4.5 and 3.4.6, the average annual consumption and average annual heating expenses were calculated for both condominiums. What emerges is that the per capita consumption of Condominium A (Figure 3.4.5), which 2022 amounts to 1391 m^3/year, is slightly higher in absolute value compared to the average consumption in the northern region obtained in the previous chapter, but shows a very similar trend. As for the per capita expenditure of Condominium A, amounting to 1956 euros in 2022, although following a similar trend, it is consistently higher than the national average in all years. This is because both the average consumption and the gas purchase price are higher than the values obtained in the first and second chapters. On the other hand, Condominium B, in addition to presenting similar trends in terms of expenditure and consumption compared to national values, has absolute values much more in line with the national averages, with, for example, a mean expenditure of 1124 euros/year and an average consumption of 786 m^3/year in 2022. Finally, observing the trend of the lines in the biennium 2021-2022, as demonstrated in the previous analysis, it can be noticed that for Condominium A, both per capita consumption and average energy expenditure follow the same direction, while for Condominium B, the dashed lines follow the opposite trend.

Conclusions

After analysing the gas market and natural gas consumption by Italian households, divided by sector and withdrawal levels, the first chapter examined some of the factors that most influence the trends in such consumption. In the second chapter, the price factor was analysed in more detail. In the first part, the price of Italian gas was compared with the European average for each consumption class, D1, D2, and D3. The findings showed that in 2021, the first class, with consumption below 520 m^3, and the third class, with consumption above 5200 m^3, experienced a higher gross price increase than the European average, reaching 129.38 c€/m^3 and 86.01 c€/m^3, respectively. On the other hand, the second class, with annual consumption between 520 m^3 and 5200 m^3, had a smaller price increase compared to the European average, reaching a value of 90.30 c€/m^3. In general, two common elements among the three classes are the increase in net price differentials and the reduction in tax differentials compared to the average values in the euro area. These results are particularly evident in the D2 class, where the net price increase was offset by the reduction in taxes, making the gross gas price slightly more competitive than the previous year at the European level.

Following the comparison with the European Union, to provide a more complete picture of price trends, the types of operators who buy and sell gas in the market were described, and the two main instruments through which these exchanges occur, namely take-or-pay contracts and spot contracts, were analysed. Briefly analysing the evolution of the gas trading sector over the past 15 years and the current contractual situation in Italy, it emerged that wholesale gas market operators and consequently retailers have progressively updated the mechanism for determining the costs of gas procurement by introducing price calculation dynamics based on the supply and demand logic of spot markets such as TTF and PSV. Building on this information, the main virtual markets where gas is traded were presented, namely the PSV for the Italian market and the TTF for the European market, as well as the regulated gas market managed by the GME. The price trend of the raw material in recent years was recorded for each of the three markets, and what emerged was a very similar trend, with the TTF price consistently slightly lower. In 2021, the average recorded prices were 47.77 €/MWh for SAP, 47.20 €/MWh for PSV, and 46.66 €/MWh for TTF. Furthermore, a significant price increase has been observed since June 2021, mainly due to the post-pandemic increase in demand and the decrease in supply due to the Russia-Ukraine crisis. After analysing how the price of the gas raw material component is determined, the different types of offers available on the free market were examined along with regulated market offers, and they were compared. It emerged that thanks in part to government incentives, which will eliminate the possibility for consumers to source gas from the regulated

market starting in 2024, households have been switching their energy supply contracts to the free market for several years. Among the reasons that drive consumers to make this choice, in addition to potential price savings, there are several factors, such as the possibility of establishing a fixed gas price that will remain unchanged for 12-18 months, or the option to add additional services to the offer, such as loyalty programs or specific promotions. Finally, to conclude the section on market offers, the typical structure of a gas bill for an average consumer in the regulated market was analysed, including how the four main components - raw material costs, transportation and meter management costs, system costs, and taxes - billed on the invoice have changed in recent years. Among these components, the raw material gas cost is certainly the most significant, accounting for over 70% of the total expenditure, and between the third quarter of 2020 and the first quarter of 2022, it increased by about six times, raising the gross gas price from 60.22 c€/m^3 to 137.32 c€/m^3.

The last part of the chapter focuses on analysing the relationship between natural gas consumption and price. In the first analysis, the national average domestic consumption was compared with the weighted average price between the consumption classes of D1 and D2. It emerged that as the price increases, consumption tends to decrease, although to varying degrees. However, there were exceptions in some years, such as in the 2020-2021 period when both prices and consumption increased due to the post-pandemic economic recovery. In the second analysis, the average consumption in the three climatic macro-zones of the peninsula - North, Central, and South - was considered and compared with the average price values from the previous analysis. Surprisingly, consumption in the South was found to be more sensitive to price, experiencing higher average consumption variations compared to the North and the Center. The most likely causes could be either the presence of a milder climate that allows for lowering the thermostat temperature in case of price increases or the price calculation methodology used for the analysis, which does not consider the presence of multiple consumers belonging to the D1 consumption class that experiences higher absolute price variations. In the last analysis, the average consumption of a typical family purchasing gas in the regulated market and the market prices set by the authority quarterly were considered. A common variation among the three analyses concerns the years 2013-2014, where consumption significantly decreased despite the price reduction, due to the increase in average annual temperatures. The findings from this last analysis indicate that the raw material gas cost component has a significant influence on the trend of the final price, and consumers react more quickly and significantly to positive price variations by reducing their consumption. Conversely, in the case of negative variations, consumers tend not to adjust their consumption as promptly and markedly as in the opposite case.

The first final consideration that can be drawn from these analyses is that gas consumption for heating in Italian households is strongly influenced by seasonal external temperatures, which, especially in the north, lead to a sharp increase in consumption during winter periods. As for daily/weekly temperatures, it has been observed that as they decrease, there is a corresponding increase in consumption, while in the case of a positive variation and therefore milder temperatures for a short period of time, there is not a corresponding reduction in consumption as in the opposite case.

Secondly, the characteristics of the dwelling, such as the energy class, level of insulation, and type of boiler, can contribute to a reduction in annual energy expenditure ranging from 13 to 30%.

Lastly, regarding price fluctuations, a different consumption response has been noted depending on the sign of the price variation. In fact, with some exceptions for the 2020-2021 biennium, as the gas price increases, the response of a typical family is a reduction in consumption, although with varying percentages depending on the climatic zone. On the other hand, in the case of a price reduction, there is often no corresponding reduction in consumption as in the opposite case, demonstrating that consumers are less sensitive to negative price fluctuations.

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del DIPARTIMENTO DI SCIENZE ECONOMICHE E AZIENDALI "MARCO FANNO"

presso l'Università degli Studi di Padova

sessione secondo periodo, appello unico anno accademico 2022/23

dovendo sviluppare una tesi/prova finale dal titolo:

Gas consumption of italian households: influencing factors and price analysis

con relatore il Prof. Forni Lorenzo

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