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BEHAVIOURAL ECONOMICS ANALYSIS OF INNOVATIVE TARIFFS: THE CASE OF ELECTRICITY

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To my parents, who are a constant source of encouragement.

To my sister, who is the cornerstone of all my successes.

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ABSTRACT

Nowadays, one of the main problems in the world is the air pollution caused by the emissions of the greenhouse gases (GHG), such as carbon dioxide, ozone, and nitrous oxide. These emissions are generated by several factors, including the energy sector, whose emissions due to electricity and heat, in 2016, constituted 42% of the total emissions with serious effects on climate change. In order to overcome the problem of the pollution there are essentially 4 types of "prevent actions": tax on CO_2, development of renewable energy, new tariff structures and nudge techniques.

This thesis focuses on the role of the new tariff structures in encouraging people to be more aware of their behaviours and aims to understand if the different pricing policies are able to modify customers' habits. Regarding this topic, literature suggests that the structure of tariffs would be one of the most efficient techniques to encourage customers to have a pro-environment behaviour. In fact, in a theoretical world, a rational individual would change his habits in according to the new tariff in order to gain a profit. However, in the last years the Behavioural Economics has highlighted that in the real world, people are characterized by some bias, including irrationality, which influence their decisions and make some new tariff structures ineffective. In this context it is important to look into the issue of consumer perception of tariff.

For this purpose, we carried out a lab experiment with a sample of 238 people in which we compared a linear tariff with two non-linear tariffs to analyse people's preferences and perceptions of the electricity tariffs. A second objective of the experiment was to investigate if people are able to adapt their choices once given the information necessary to adopt a more environmentally friendly behaviour.

The results confirm the main cognitive biases identifies in the literature and show both that consumers prefer the tariff with the simplest structure and that they are characterized by some bias which does not allow them to adapt their choices with the most profitable tariff.

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Chapter 1

THE ELECTRICITY SECTOR

In the last twenty years, the Italian electricity market has been pursuing, as the case of other European countries, a gradual liberalization process in order to make the markets of the different European States uniform.
The aim of this chapter is both outlining the expected benefits in Italy from the liberalization process and investigating if either these benefits can be actually achieved or if there are some barriers that prevent it to achieve market success.

1.1 History of electricity in Italy

For the first part of the last century, the most part of electricity was generated by a few firms (Edison; Sip (Iri); Sade; Centrale; Sme; Bastogi), which were characterised by financial autonomy and by ownership structures for both production and distribution. In 1945, 54,5% of electricity was generated by these firms, while the other part was produced by a multitude of small operators.
Over the years, the decrease in electricity demand, caused by the economic situation, and the shortage of investments, and the industrial fragmentation prompted some problems such as instability, inefficiency and bad quality of service. In order to overcome these problems, the Italian Authorities decided to promulgate "*Legge di Nazionalizzazione*"[1], an enactment whose aim was to nationalise most of the enterprises that had operated the electric services since as early as 1962 and unify the national electricity system. In this way, all the local operators became state-owned and were managed by ENEL: Ente Nazionale per l'Energia Elettrica.
Thus, up until 1999, the Italian electric power industry has been managed under a monopoly regime by ENEL, which had the task "*to ensure the*

[1] *Seduta Camera dei deputati del 26 giugno 1962*

availability of adequate electricity for quantity and price with minimum management costs to the needs of a balanced economic development of the country"[2].

In these thirty years, the ENEL monopoly has allowed the creation of economies of scale, which have favoured the development of the electricity grid and the improvement of the service quality and which have allowed almost all the Italian people to be served. These things facilitated a decrease in energy cost, at least up to the oil crisis, in the '70s (tab 1.1).

Table 1.1: Results of Enel first three years

	1963	1995	Variazione (%) (e variazione media annua, %)
Sviluppo linee elettriche (km)	360.000	>1.000.000	+178 (5,6)
Energia fatturata (TWh)	50	229	+358 (11)
Quota energia mezzogiorno (TWh)	10	72	+620 (19)
Potenza efficiente netta (MW)	13.000	54.000	+316 (9,9)
Produzione lorda (TWh)	48	191	+298 (9,3)
Rendimento netto termoelettriche (%)	32,8	37,7	+15 (0,47)
Perdite in rete (% P richiesta)	11,1	6,8	–39 (–1,22)
Popolazione non servita (Mpersone)	1,7	0,1	–94
Utenti/dipendente	192	296	+54 (1,68)
Costo kWh venduto (indice)	100	62	–38

Source: Lazzarin R. (2005)

Over the years, the scenario in which it was necessary to introduce ENEL changes and the conditions for continuing to keep the energy market under a national authority were lacking. So, in 1992, the ENEL monopoly was terminated and the d.l. 11 July 1992 turned the society into ENEL S.p.A. As a result, ENEL went from having immense property to having just the concession and all 100% of the shares were conferred to the Treasury Minister.

It should be noted that the end of the monopoly was caused by two events: the UE Directive 96/92/CE on the liberalization of the energy market and Bersani Decret[3].

The first one tried to impose some common rules about the energy market to the Union states: the first step was to define non-discriminatory conditions of access to the transport and distribution network while the second step was focused on the development of a competitive market. With regards to the

[2] *Legge n. 1643 del 6 dicembre 1962*

[3] *DL 79/99 del 16 marzo 1999, pubblicato nella Gazz. Uff. 31 marzo 1999, n. 75*

first step, it has been resolved by introducing the so called "*Third Party Access*" in the EU Directive and in the National agreements; about the second step, some work still needs to be done to reduce concentration in liberalized markets and redefine the rules and market institutions that provide the success of a competitive market.

According to Bersani Decret, it imposed on ENEL, among others things, both the production of only 50% of the whole energy consumed in Italy and the unbundling of the whole sector. In this way, the task of distributing electricity was conferred to TERNA so that all producers could have the same treatment in energy distribution.

The liberalization process has been gradual in the years, starting from the larger industrial customers up to all customers in 2007 (tab 1.2): 2007 was a revolutionary year for the electricity market, especially for the retail sector, since all the final customers, household and no-household, could begin choosing their supplier and in which segment of the retail sector they wanted to stay.

Table 1.2: The liberalization process in the years

1999	Only the largest firms
2000	Business customers with an annual consumption of at least 20GWh
2002	Business customers with an annual consumption of at least 9 GWh
2003	All customers with an annual consumption of at least 100 MWh
2007	All customers

The completion of the liberalization process is expected to be by the year 2020[4]. Until then, the market is composed of:

- *Free market*: In this segment, the clients can choose their supplier and switch it when they want
- *Protected market*: This is a transitory segment, which is destined to be abolished with the completion of the liberalization process. In this segment, the cost of providing is established by AEEGSI (Autorità per l'energia elettrica, il gas e l'acqua). This part of the

[4] *DL "Milleproroghe" n. 91/2018*

market includes all the domestic users and the firms connected to the low voltage grid which has less than 50 dependents and an annual turnover of less than 10 M€

- *Safeguard Market*: This segment includes all the final clients who are not in the free market and who are connected to the medium or high voltage, with more than 50 dependents or an annual turnover of more than 10 M€

Both Protected market and Safeguard market are characterized by Acquirente Unico (AU), an organization that purchases the energy supplied to the final users on the wholesale market and resells this energy to the local distribution companies present in these two segments.
The companies pay a price which on the one hand covers the costs incurred by the AU to purchase energy in the market and dispatch it and on the other hand includes a fee for the activities performed.

1.2 Types of contracts in the retail sector

The energy sector is composed of:

- *Generation sector*: It is the sector dedicated to the energy production
- *Transmission sector*: It is the transport sector and it provides the transportation of energy over long distances
- *Distribution sector*: It is the delivery sector, in which the electricity is delivered to the final customers

Connecting to the distribution sector there is the retail sector, which is composed of all the suppliers in charge of sales of energy in the final market. In this paragraph the focus is on this last sector and its structure, highlighting the concentration level and its consequences.

1.2.1 A general vision

As previously mentioned, the supply sector is composed of three sectors: the free market, the protected market and the safeguard market.

With regards to the data of the Authority (ARERA 2018), in 2017 the segment which counts the high number of companies is represented by the free market, in which there were 564 companies, 22 more than 2016. The protected market, instead, had 132 companies, while the safeguard had just two (tab. 1.3).

It is important to highlight that 2017 has confirmed the trend of the number of the companies operating in the retail sector has grown: the growth has been continuing since 2008, especially in the free market since the moment the number of companies which can operate in the safeguard market and in the protected market is established by the law.

Table 1.3: Number of firms operating in the three sectors

MERCATO	VENDITORI[(A)]	RISPONDENTI	DI CUI INATTIVE
Servizio di maggior tutela	132	128	-
Servizio di salvaguardia	2	2	-
Vendita ai clienti liberi	564	470	60

Source: ARERA. Indagine annuale sui settori regolati

Unbundling the total data, it should be noted that in 2017 the final customers were just less than 37 million, of which 29.5 million were domestic customers, while the other 7.5 million were non-domestic customers.

Focusing on the domestic sector, almost 11,4 million of these customers (38,6%) were in the free market, representing an increase of 11% on 2016, while 18.1 million (61,4%) were in the protected market, with a reduction of 8% compared to 2016.

The safeguard market results could be considered to be negligible because of the irrelevant number: in 2017 this sector grew by only 2000 customers.

The figures demonstrate that, even if the liberation process had started in 2007, the protected market includes almost 2/3 of the final customers, whilst the number has been decreasing in the years.

Regarding the non-domestic sector, it has increased in volume of energy bought from the final market, and reached 198.7 TWh in 2017 (in 2016 the volume was 196.9 TWh).

In this sector the consumptions have been increasing since 2015, even if the growth is slowing down: in 2015 the volume increased by 3.4%, in 2016 by 0.1% and in 2017 by 0.9%.

It should be noted that in 2017, in the non-domestic sector, the major volume was bought by customers connected to the medium voltage (98.304 GWh on 198.677GWh) while the volume bought by customers connected to the high voltage was 26.331GWh and, finally, the volume bought by customers connected to the low voltage was 74.042GWh, of which 22.3% bought in the protected market, 2.1% in the safeguard market and the other 75.7% in the free market (tab. 1.4; tab. 1.5; fig. 1.1).

Table 1.4: Final electricity sales by market and voltage (volume in GWh)

	2016				2017			
	MAGGIOR TUTELA	SALVA-GUARDIA	LIBERO	TOTALE	MAGGIOR TUTELA	SALVA-GUARDIA	LIBERO	TOTALE
VOLUMI								
Bassa tensione	52.693	1.481	77.617	131.791	49.979	1.520	80.294	131.793
Domestico	35.058		22.073	57.130	33.495		24.256	57.751
Non domestico	17.635	1.481	55.544	74.660	16.484	1.520	56.037	74.042
Media tensione		2.487	91.937	94.424		2.619	95.685	98.304
Alta/altissima tensione		257	27.576	27.833		169	26.162	26.331
TOTALE	52.693	4.224	197.130	254.047	49.979	4.309	202.140	256.428
PUNTI DI PRELIEVO								
Bassa tensione	23.338	83	13.867	37.288	21.455	85	15.249	36.789
Domestico	19.619		10.278	29.897	18.083		11.449	29.532
Non domestico	3.718	83	3.589	7.390	3.371	85	3.801	7.257
Media tensione		6,9	100	106		6,3	99	106
Alta/altissima tensione		0,02	1,0	1,1		0,02	1,0	1,0
TOTALE	23.338	90	13.968	37.395	21.455	91	15.349	36.895

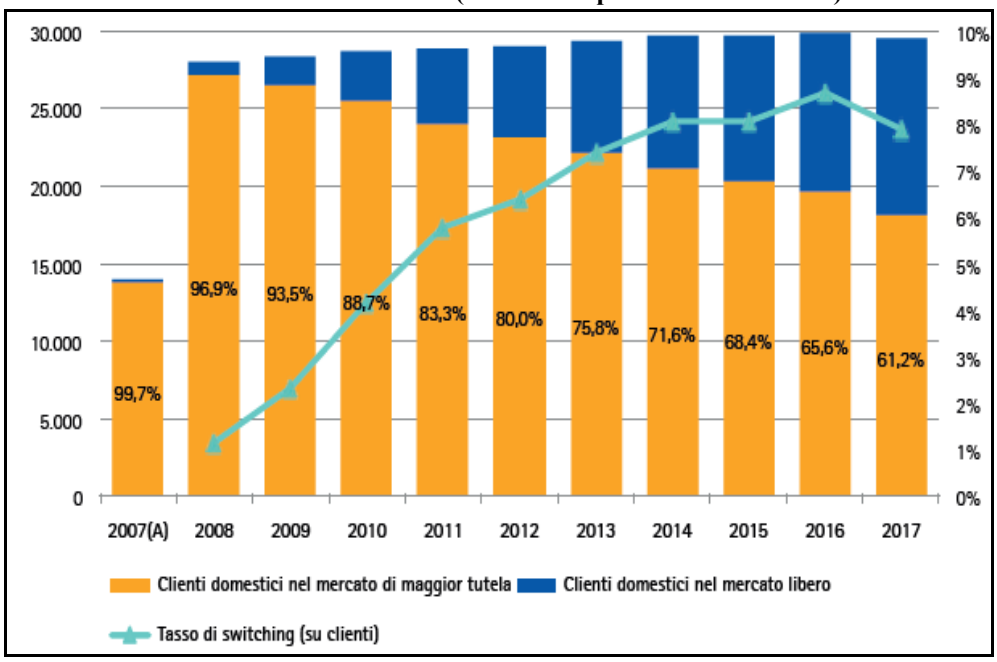
Source: ARERA. Indagine annuale sui settori regolati

Table 1.5: Final sales of electricity by market and type of customer

	VOLUMI			PUNTI DI PRELIEVO		
	2016	2017	VARIAZIONE	2016	2017	VARIAZIONE
Mercato di maggior tutela	52.693	49.979	-5,2%	23.338	21.455	-8,1%
Domestico	35.058	33.495	-4,5%	19.619	18.083	-7,8%
Non domestico	17.635	16.484	-6,5%	3.718	3.371	-9,3%
Mercato di salvaguardia	4.224	4.309	2,0%	90	91	1,9%
Mercato libero	197.130	202.140	2,5%	13.968	15.349	9,9%
Domestico	22.073	24.256	9,9%	10.278	11.449	11,4%
Non domestico	175.058	177.884	1,6%	3.690	3.901	5,7%
MERCATO FINALE	254.047	256.428	0,9%	37.395	36.895	-1,3%

Source: ARERA. Indagine annuale sui settori regolati

Figure1.1: N. of domestic customers who buy energy in the protected service and in the free market since 2017 (numbers expressed in thousands)



Source: ARERA. Indagine annuale sui settori regolati

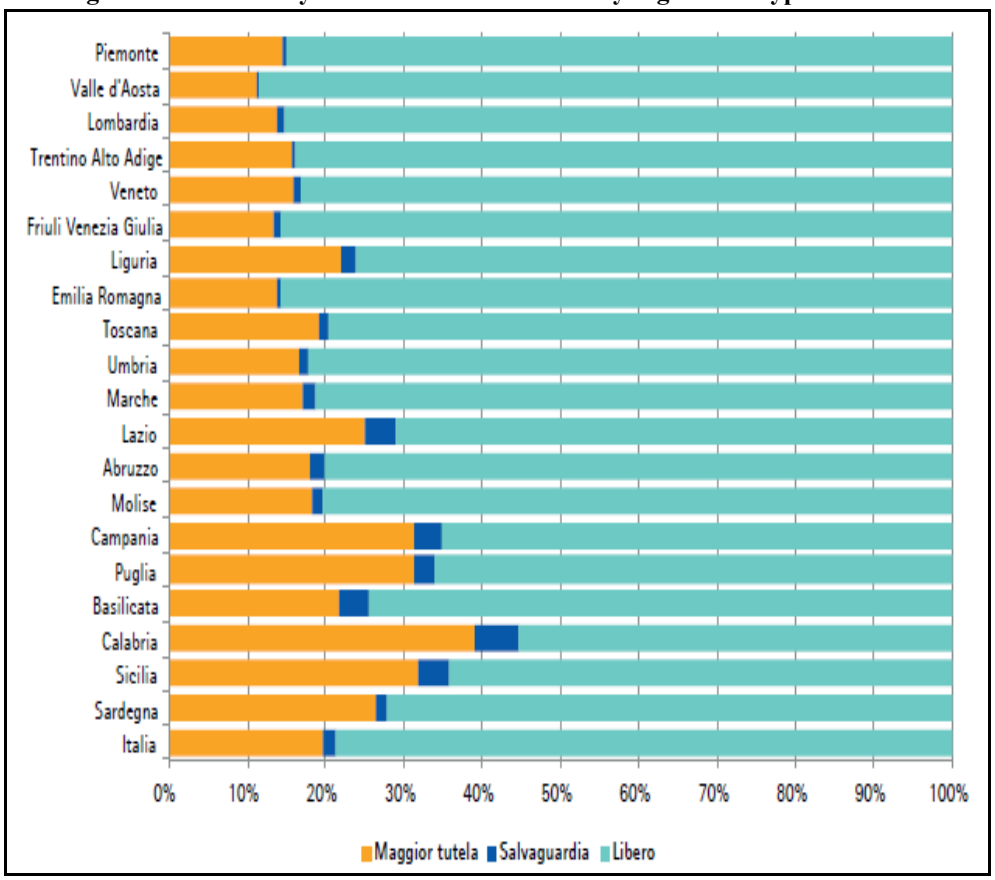
Focusing on the quantity of energy sold to the final users, it should be noted that the situation just described is different: the protected market consumes only the 19.5% of the total energy sold, which represented a reduction of 1.2% on 2016, while the free market consumes 78.8%, which represented an increase of 1.2% on 2016. The last 1.7% was consumed by the safeguard market, which is a marginalised market in this case too.

By carrying out a territorial analysis on the purchasing of energy on the final market, it should be observed that in 2017, 11 Italian regions (+3 in relation

to 2016) achieved the share of 80% energy bought from the free market. These regions were: Aosta Valley, Friuli Venezia Giulia, Umbria, Emilia Romagna, Lombardy, Piedmont, Trentino-South-Tyrol, Veneto, Marche, Molise e Abruzzo.

Furthermore, figures demonstrate that the regions of the south of Italy use more the protected market or the safeguard market. In particular, Calabria, it is the region which is less open to the free market, of which it bought only 55,5% of the energy (fig 1.2).

Figure 1.2: Electricity sales to the final market by region and type of market



Source: ARERA. Indagine annuale sui settori regolati

In the Italian electricity market, the incumbent operator is ENEL, which has a market share of about 37.5%: it sold to the final market 95734 GWh out of a total of 256.428 GWh. This market share marks a huge gap with the followers: Eni, which is the major competitor, has a market share of 4.5% and Edison, the second major follower, has a market share of 4.2% (tab. 1.6). It is important to highlight that the supremacy of ENEL is due not just to the household customers, but also to the no-household customers,

specially the final customers who are connected to the high voltage, that are the clients who require more energy power for unit.

Table 1.6: Energy sales of the various operators in the three market segments (sales in GWh)

GRUPPO	CLIENTI DOMESTICI	CLIENTI NON DOMESTICI			TOTALE	POSIZIONE NEL 2016
		BT	MT	AT/AAT		
Enel	41.699	30.173	16.938	6.924	95.734	1°
Eni	3.247	1.549	5.320	1.379	11.495	3°
Edison	1.051	1.751	5.236	2.555	10.592	2°
Hera	1.186	3.141	5.191	249	9.768	4°
Metaenergia	9	1.012	7.137	282	8.440	10°
A2A	1.653	2.198	2.945	245	7.042	6°
Axpo Group	54	1.552	3.550	1.628	6.784	5°
Iren	1.245	2.119	2.876	363	6.603	12°
E.On	271	1.562	3.178	920	5.931	9°
Acea	1.987	1.555	1.565	532	5.639	7°
Duferco	54	529	2.050	2.927	5.560	16°
Green Network	140	398	2.125	2.638	5.300	17°
CVA	122	1.378	2.968	112	4.579	13°
Eviva	61	1.979	2.012	123	4.175	14°
Dolomiti Energia	598	1.522	1.825	120	4.065	15°
Gala	29	1.212	2.665	144	4.050	8°
Sorgenia	202	1.269	2.207	142	3.819	11°
Repower	0	1.881	1.690	34	3.605	18°
Alperia	250	955	1.671	103	2.979	19°
Egea	48	465	2.328	138	2.979	20°
Altri operatori	3.845	15.842	22.828	4.774	47.290	-
TOTALE OPERATORI	57.751	74.042	98.304	26.331	256.428	-

Source: ARERA. Indagine annuale sui settori regolati

1.2.2 Protected market

As mentioned previously, the protected market is a transitory market which is for both all the domestic users who have not chosen to stipulate a contract in the free market and the small firms, which have fewer than 50 dependents and an annual turnover under 10 M€. This type of market includes also the public lighting.

The number of companies authorized to work in this market is established by the law.

The protected market was created at the beginning of the liberalization process in order to guarantee the families less well-off and the small firms. It should last until the year 2020, when the completion of the liberalization process is planned to take effect and this explains the constant decrease in the number of final users present in this market (tab. 1.7).

Table 1.7: Protected market by type of customer

TIPOLOGIA DI CLIENTE	VOLUMI			PUNTI DI PRELIEVO		
	2016	2017	VARIAZIONE	2016	2017	VARIAZIONE
Domestici	35.058	33.495	-4,5%	19.619	18.083	-7,8%
Residenti	30.859	29.760	-3,6%	15.048	14.052	-6,6%
Non residenti	4.199	3.735	-11,1%	4.572	4.031	-11,8%
Illuminazione pubblica	368	403	9,6%	18	20	9,4%
Altri usi	17.267	16.081	-6,9%	3.700	3.352	-9,4%
Fino a 16,5 kW	9.094	8.418	-7,4%	3.439	3.118	-9,3%
Oltre 16,5 kW	8.174	7.663	-6,3%	262	234	-10,5%
TOTALE	52.693	49.979	-5,2%	23.338	21.455	-8,1%

Source: ARERA. Indagine annuale sui settori regolati

The final users in this market can choose mainly between two main tariffs: "*Bioraria*" and "*Multioraria*". In both cases the electricity price depends on the moment in which the electricity is used and:

- In the case of bioraria there are only two time frames (8am-7pm energy is more expensive; 7pm-8am energy is less expensive)
- In the case of multioraria there are more than two time frames

In agreement with the data of the Authority (ARERA (2018)), focusing on the household users and carrying out a territorial analysis, the region which has the largest volume of energy consumed in this segment is Lombardy, that consumes 15,7% of the whole energy sold on the final market. At the opposite side, Molise and Aosta Valley are the two regions which consume less energy, due to their dimension too (tab. 1.8, tab. 1.9).

Table 1.8: Domestic customers in the protected market by type and region in 2017

REGIONI	RESIDENTI		NON RESIDENTI		TOTALI	
	VOLUMI	PUNTI DI PRELIEVO	VOLUMI	PUNTI DI PRELIEVO	VOLUMI	PUNTI DI PRELIEVO
Piemonte	1.841	996	196	298	2.037	1.294
Valle d'Aosta	51	27	22	39	73	66
Lombardia	4.808	2.377	449	459	5.257	2.835
Trentino Alto Adige	478	246	62	92	540	338
Veneto	2.707	1.175	241	256	2.948	1.430
Friuli Venezia Giulia	668	338	59	79	727	417
Liguria	724	436	129	220	853	657
Emilia Romagna	2.031	948	219	245	2.250	1.194
Toscana	1.792	857	280	263	2.072	1.120
Umbria	354	166	45	42	399	208
Marche	613	310	65	83	678	393
Lazio	2.651	1.258	408	340	3.060	1.597
Abruzzo	544	280	78	135	621	415
Molise	140	80	19	37	159	117
Campania	2.832	1.259	280	234	3.112	1.493
Puglia	2.153	996	311	316	2.464	1.312
Basilicata	256	141	28	46	284	188
Calabria	1.097	507	180	240	1.277	747
Sicilia	2.827	1.197	473	435	3.300	1.632
Sardegna	1.194	457	190	173	1.384	630
ITALIA	29.760	14.052	3.735	4.031	33.495	18.083

Source: ARERA. Indagine annuale sui settori regolati

Table 1.9: Domestic customers in the protected market by economic condition and consumption classes in 2017

CLASSI DI CONSUMO ANNUO	VOLUMI	PUNTI DI PRELIEVO	CONSUMI MEDI
Monoraria	354	213	1.661
0-1.000 kWh	29	88	332
1.000-1.800 kWh	60	44	1.377
1.800-2.500 kWh	70	33	2.112
2.500-3.500 kWh	79	27	2.904
3.500-5.000 kWh	57	14	4.050
5.000-15.000 kWh	49	7	6.807
> 15.000 kWh	11	0	32.827
Bioraria (obbligatoria o volontaria)	33.140	17.870	1.855
0-1.000 kWh	2.321	5.433	427
1.000-1.800 kWh	5.999	4.261	1.408
1.800-2.500 kWh	7.305	3.418	2.137
2.500-3.500 kWh	8.489	2.891	2.937
3.500-5.000 kWh	5.643	1.386	4.071
5.000-15.000 kWh	3.052	468	6.516
> 15.000 kWh	332	13	25.347
TOTALE	33.495	18.083	1.852

Source: ARERA. Indagine annuale sui settori regolati

Regarding the no-household customers in the protected market, about 90% of them use less than 10 MWh/year (tab. 1.10; fig. 1.3). In detail there are two main levels:

- <5 MWh/y: In this level there is 80,6% of the whole no-household population, which consumes about 19,6% of the whole sold energy
- 5 MWh/y - 10 MWh/y: this level includes l'8,8% of the entire no-household population and it's consumes 12,9% of the entire sold energy

In the case of no-household users, Lombardy is at the first position both for the number of final users (12.5%) and for volume of energy consumed (15.4%).

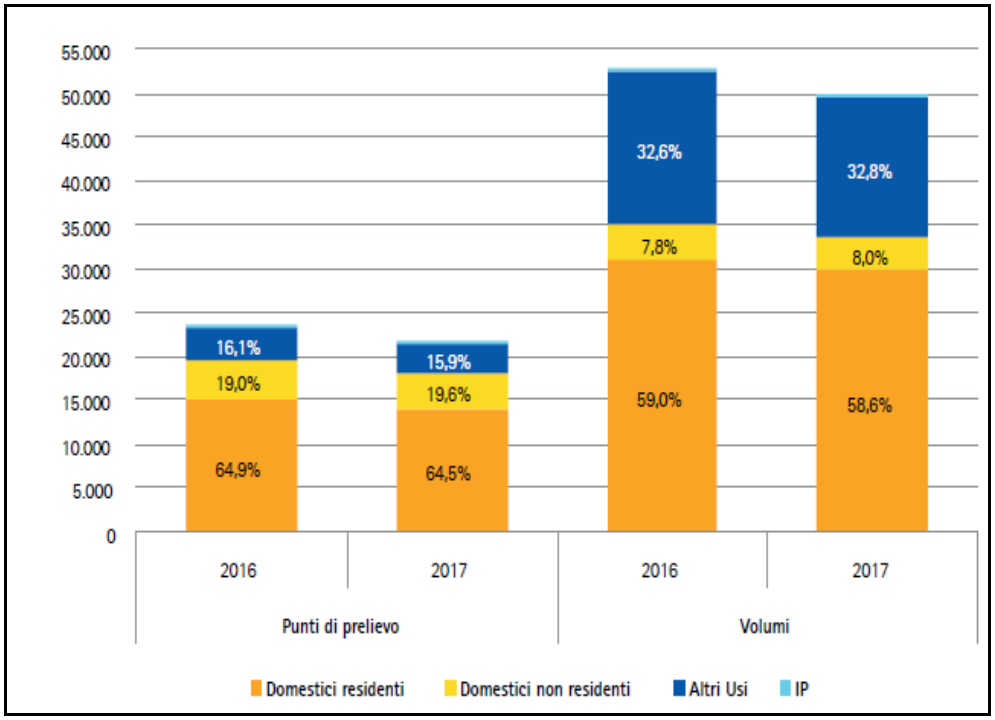
As regard the tariff, the common one is the multioraria, which is chosen by 98.1% of clients and concerns about 98.5% of the whole volume of sold energy. The second more common tariff is the monoraria, with 1.8% of clients and 1.3% of the total sold energy, while the bioraria tariff includes only about 0,2% of the final clients.

Table 1.10: No-household customers in the protected market by consumption level and power in 2017 (volume in GWh)

CLASSE DI CONSUMO	POTENZA FINO A 16,5 kW			POTENZA SUPERIORE A 16,5 kW			TOTALE	
	VOLUMI	PUNTI DI PRELIEVO	CONSUMO MEDIO	VOLUMI	PUNTI DI PRELIEVO	CONSUMO MEDIO	VOLUMI	PUNTI DI PRELIEVO
<5 MWh	3.057	2.661	1.149	89	42	2.137	3.146	2.703
5-10 MWh	1.845	266	6.941	223	30	7.490	2.068	296
10-15 MWh	1.085	89	12.127	313	25	12.509	1.398	114
15-20 MWh	751	44	17.202	368	21	17.517	1.119	65
20-50 MWh	1.525	55	27.862	2.345	72	32.532	3.870	127
50-100 MWh	141	2	58.984	2.195	32	68.770	2.337	34
100-500 MWh	11	0	144.883	2.009	12	161.073	2.021	13
500-2.000 MWh	2	0	769.239	108	0	717.005	110	0
2.000-20.000 MWh	0	0	12.178.600	12	0	3.932.155	12	0
20.000-50.000 MWh	-	-	-	1	0	30.303.588	1	0
TOTALE	8.418	3.118	2.700	7.663	234	32.737	16.081	3.352

Source: ARERA. Indagine annuale sui settori regolati

Figure 1.3: Consumption and customers in the protected market in 2017



Source: ARERA. Indagine annuale sui settori regolati

In regard to the service provision, the protected market is characterized by a high concentration that has been grown since 2016, even if the sector is including a high number of firms. In fact, a high number of operators does not mean that there is a high level of competition.

As reported by ARERA (2018), the incumbent firm in the sector is ENEL, whose market share was 86.5% in 2017, with 43.251 GWh out of the total of 49.979 GWh, is followed by Acea Energia, with a market share of 4.9%, while the least major competitor is A2A Energia with 3.1% (tab. 1.11). As previously mentioned, there is a deep gap separating ENEL and its followers also in this sector.

Table 1.11: First fifteen operators in the protected market in 2017 (volume in GWh)

RAGIONE SOCIALE	2017	QUOTA	POSIZIONE NEL 2016
Servizio Elettrico Nazionale	43.251	86,5%	1°
Acea Energia	2.441	4,9%	2°
A2A Energia	1.563	3,1%	3°
Iren Mercato	547	1,1%	4°
Dolomiti Energia	310	0,6%	5°
Hera Comm	228	0,5%	6°
Energiabasetrieste	195	0,4%	7°
Alperia Energy.	175	0,3%	8°
Cva Trading	105	0,2%	10°
Agsm Energia	96	0,2%	9°
AIM Energy	94	0,2%	11°
Amet	87	0,2%	12°
Asm Vendita E Servizi	49	0,1%	14°
Linea Più	47	0,1%	15°
Azienda Pubbliservizi Brunico	46	0,1%	16°
Altri esercenti	744	1,5%	-
TOTALE	49.979	100,0%	-

Source: ARERA. Indagine annuale sui settori regolati

In order to assess the effective degree of competition the C3 indicator is used, which is an indicator that gathers the market shares of the three major firms operating in the market (ENEL, Acea Energia, A2A). In this market, this indicator amounts to 94.5%, with an increase of 0.3% in 2016.

At the same time, another widely used indicator is the HHI:Herfindahl-Hirschman Index. This indicator takes values from 0 to 10000: the higher its value is, the lower its competition in the market. A value above 2500 points outlines a concentrated market. Focusing on the HHI, it was 7480 in 2016 while in 2017 it was 7525.

On the basis of these indicators, it may be concluded that the level of the concentration in this market is quite high.

1.2.3 Free market

In 2017, as reported by ARERA (2018), the free market increased by 9.9% compared with 2016 and the clients were about 15,3 million. This increase is due to the household customers, that increased by 11.4% with respect to 2016. Although, the increase in the number of clients is not linearly related with the volume of sold energy. In fact, even though the number of clients has increased in the years, the volume of sold energy has recorded some delays, especially in 2011 and in 2016 (tab. 1.12).

Table 1.12: Sellers' activity in the period 2011-2017 by sales class

	2011	2012	2013	2014	2015	2016	2017
Numero di esercenti in maggior tutela	137	136	136	136	135	131	132
Numero di venditori attivi	196	230	275	320	370	406	410
Oltre 10 TWh	3	2	3	2	3	3	2
5-10 TWh	9	8	7	7	7	6	8
1-5 TWh	19	23	23	23	26	23	21
0,1-1 TWh	63	56	60	66	63	70	73
Fino a 0,1 TWh	102	141	182	222	271	304	306
Volume venduto (TWh)	196,1	189,5	189,7	186,6	195,3	197,1	202,1
Oltre 10 TWh	70,9	55,4	62,6	53,4	62,4	62,9	61,1
5-10 TWh	63,0	59,5	45,0	48,4	45,8	39,0	51,6
1-5 TWh	34,4	50,0	56,7	58,7	60,7	64,8	57,9
0,1-1 TWh	25,7	21,8	22,2	22,7	22,4	25,8	26,5
fino a 0,1 TWh	2,0	2,8	3,1	3,3	3,9	4,6	5,1
Volume medio unitario (GWh)	1.000	824	690	583	528	486	493
Oltre 10 TWh	23.643	27.694	20.853	26.700	20.798	20.955	30.546
5-10 TWh	7.002	7.439	6.434	6.918	6.538	6.508	6.447
1-5 TWh	1.811	2.174	2.467	2.553	2.336	2.819	2.757
0,1-1 TWh	408	389	371	344	356	368	363
fino a 0,1 TWh	20	20	17	15	15	15	17

Source: ARERA. Indagine annuale sui settori regolati

In accordance with the increase of clients, the number of firms which operate in the free market has been increasing in the years, even if in 2017 the growth process reached the lost point.

Regarding the domestic sector, the different consumption levels have about the same percent. Although, the level characterized by the highest number of clients (24.6% of the total) is the one which has a consumption ranging from 1.000 to 1.800 KWh. On the opposite side the levels characterized by consumption over 5000 KWh have the lowest number of clients.

Focusing on the volume of energy purchased, the situation is different: the highest level is the one which has the consumption ranging from 2.500kWh/y to 3.500 kWh/y, with 26.7% of the total energy, while the two minor levels are the ones with consumption under 1.000 kWh (5.1%) and one with consumption over 15.000 kWh (1.1%). Finally, it should be noted that 86.7% of the volume of energy is bought by the total of the levels with consumption under 3.500 kWh/y (tab. 1.13).

Table 1.13: Domestic free market in 2017 by consumption class (volume in GWh and "*punti di prelievo*" in thousands)

CLASSE DI CONSUMO	VOLUMI	QUOTA	PUNTI DI PRELIEVO	QUOTA	CONSUMO MEDIO
< 1.000 kWh	1.230	5,1%	2.488	21,7%	494
1.000-1.800 kWh	3.979	16,4%	2.818	24,6%	1.412
1.800-2.500 kWh	5.169	21,3%	2.416	21,1%	2.139
2.500-3.500 kWh	6.468	26,7%	2.202	19,2%	2.937
3.500-5.000 kWh	4.544	18,7%	1.116	9,8%	4.070
5.000-15.000 kWh	2.603	10,7%	398	3,5%	6.547
> 15.000 kWh	263	1,1%	11	0,1%	24.979
TOTALE DOMESTICI	24.256	100,0%	11.449	100,0%	2.119
DI CUI CON CONTRATTO DUAL FUEL					
< 1.000 kWh	170	4,9%	336	20,1%	504
1.000-1.800 kWh	627	18,0%	443	26,4%	1.417
1.800-2.500 kWh	806	23,2%	378	22,5%	2.134
2.500-3.500 kWh	951	27,4%	324	19,3%	2.934
3.500-5.000 kWh	599	17,2%	148	8,9%	4.034
5.000-15.000 kWh	293	8,4%	46	2,7%	6.366
> 15.000 kWh	30	0,9%	1	0,1%	24.897
TOTALE CON CONTRATTO DUAL FUEL	3.475	100,0%	1.676	100,0%	2.073

Source: ARERA. Indagine annuale sui settori regolati

Focusing on the no-household sector, the clients were about 3.9 million, almost all connected to the low connection.

The volume bought by the customers connected to the low voltage was 39.7% of the total, which means there has been a slight increase compared with the 39.4% of 2016. On the other side, 47.3% has been purchased by the customers connected to the medium voltage and 12.9% by the customers connected to the high voltage (tab. 1.14). In this last case there has been a decrease compared with 14% of 2016.

Table 1.14: No-domestic free market in 2017 by voltage level

TIPOLOGIA DI CLIENTE	VOLUMI	DI CUI DUAL FUEL	PUNTI DI PRELIEVO	DI CUI DUAL FUEL
BT	56.037	1.413	3.801	79
MT	95.685	774	99	1
AT e AAT	26.162	10	1	0,01
TOTALE NON DOMESTICI	177.884	2.198	3.901	80

Source: ARERA. Indagine annuale sui settori regolati

As previously mentioned, in order to make an assessment about the level of concentration, it is not important if there are numerous firms operating in this market. By the moment this market is really variegated, it proceeds with a territorial analysis, using, as in the protected market, both the indicators C3 and HHI.

In reference to the indicator C3, as it is evidenced by ARERA (2018), it highlights the fact that the most concentrated regions are in the south of Italy, with the exception of Aosta Valley and Trentino-South-Tyrol, with results of a high level of concentration, with a C3 of, respectively, 85% and 78.2%. On the opposite side, Lombardy and Veneto are the two regions with the lowest C3 (respectively 32.6% and 37% in 2017) and, so, with the highest level of competition (tab. 1.15).

Table 1.15: Level of competition in the retailer sector in the free market measured by C3

REGIONE	NUMERO DEGLI OPERATORI		C3 SUL MERCATO TOTALE		% PUNTI DI PRELIEVO	
	2016	2017	2016	2017	2016	2017
Piemonte	231	243	36,3	35,5	49,1	67,2
Valle d'Aosta	95	122	88,3	85,0	73,9	83,2
Lombardia	277	300	29,2	32,6	63,4	62,6
Trentino Alto Adige	170	198	76,5	78,2	80,4	83,5
Veneto	221	243	32,7	37,0	50,2	56,4
Friuli Venezia Giulia	167	192	39,6	42,1	46,2	60,1
Liguria	203	220	42,7	44,0	66,3	70,2
Emilia Romagna	225	265	40,3	39,1	67,7	75,7
Toscana	221	253	35,5	37,8	64,3	68,3
Umbria	167	192	56,4	54,6	61,5	70,3
Marche	184	213	35,7	37,9	67,3	65,7
Lazio	235	261	44,3	45,6	58,3	70,8
Abruzzo	185	215	39,5	46,1	75,2	72,0
Molise	148	167	54,7	56,3	66,3	71,8
Campania	217	248	49,4	55,0	82,4	78,6
Puglia	226	238	48,9	55,9	67,9	76,9
Basilicata	160	184	53,3	54,4	82,1	80,9
Calabria	185	212	59,3	61,3	81,3	82,2
Sicilia	195	220	50,9	60,6	78,9	81,0
Sardegna	178	205	64,4	69,6	68,6	76,6

Source: ARERA. Indagine annuale sui settori regolati

Focusing on the operators, as for the protected market, the operator with the major market share is Enel, as in 2016. The market shares of ENEL increased from 20.7% of the 2016 to 25% in 2017 (and in 2015 were 17.9%) and sold 50.535 GWh out of the total of 202.140 GWh. But not all has remained the same: in 2017 Edison has taken over the second position with 5.7% of the market share, surpassing Edison, which resulted third with 5.2%.

From these data, the national level of concentration measured by C3 results 35.9%, marking an increase respect to the previously years, in which C3 was constant on about 33% (tab. 1.16).

Table 1.16: First twenty free market sales groups in 2017 (volumes in GWh)

GRUPPO	VOLUMI	QUOTA %	POSIZIONE NEL 2016
Enel	50.535	25,0%	1°
Eni	11.465	5,7%	3°
Edison	10.592	5,2%	2°
Metaenergia	8.440	4,2%	8°
Hera	7.179	3,6%	6°
Axpo Group	6.784	3,4%	4°
Iren	6.038	3,0%	11°
E.On	5.931	2,9%	7°
Duferco	5.560	2,8%	15°
A2A	5.431	2,7%	10°
Green Network	5.300	2,6%	17°
CVA	4.474	2,2%	13°
Eviva (ex Energetic Source)	4.175	2,1%	14°
Gala	4.050	2,0%	5°
Sorgenia	3.819	1,9%	9°
Dolomiti Energia	3.755	1,9%	16°
Repower	3.605	1,8%	18°
Acea	3.198	1,6%	12°
Egea	2.979	1,5%	19°
Alperia	2.804	1,4%	20°
Altri operatori	46.025	22,8%	-
TOTALE VENDITORI AL MERCATO LIBERO	202.140	100%	-

Source: ARERA. Indagine annuale sui settori regolati

It is evident, hence, that also in this market ENEL is the incumbent since it has the largest market share, which is significantly higher than that of its followers.

Although, compared with the protected market, it is clear that there are two different situations: while in the protected market the gap was of about 80%, in the free market the gap is roughly of 19%.

Furthermore, in the free market the gap is not widened by the growth of ENEL but it's widened by the followers' inefficiencies in selling: it is evident through the fact that in 2016 Edison was the leading follower with sales of 11.793 GWh on the final market while in 2017 the major follower was Eni with a selling of 11.465 GWh.

Regarding the HHI, in 2017, it increased from 623 in 2016 to 806. This value is mainly due to the growth of ENEL which is the major operator.

Even though there was an increase, the indicator is largely under the threshold of 1500, which is the limit upon which the market is considered middle concentrated.

It is possible to conclude that the level of concentration in the free market is low, even if rising.

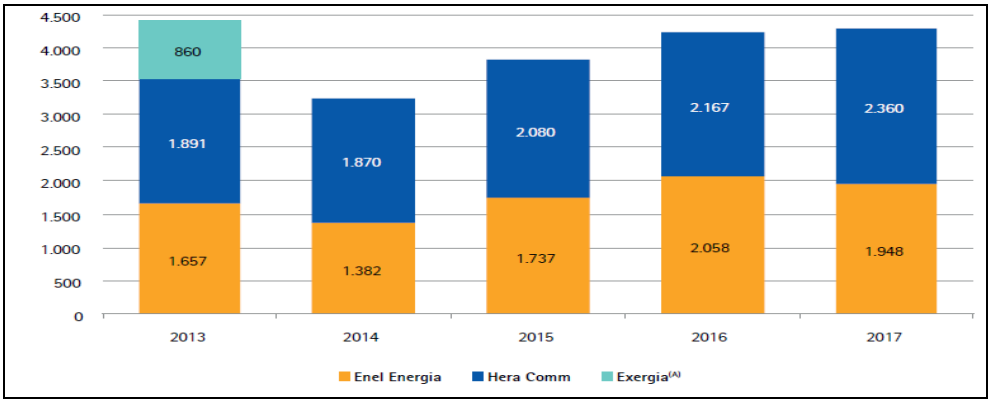
1.2.4 Safeguard market

As previously mentioned, the safeguard market includes both people connecting to the medium voltage and firms connected to the low voltage with more than 50 dependents or an annual turnover over 10M€ that had not stipulated a contract in the free market when the liberalization process began.

The arrangements for assigning the right to exercise in this segment takes place through an auction and allows the winning companies to provide the service for two consecutive years. About the biennium 2017-2018, the auction was won by Enel Energia and Hera Comm, that were the winners of the last auction too (biennium 2015-2016). This is the only one market in which ENEL is not the incumbent and, in 2017, its sales volume decreased of 5.3% (from 2.058 GWh in 2016 to 1948 GWh in 2017). On contrary, the sales volume of Hera Comm increased of 8.9%, from 2167 GWh in 2016 to 2360 GWh in 2017 (fig. 1.4).

In 2017 the regions which used mainly of the safeguard market were Campania, Lombardy, Sicily and Lazio: together these regions consumed 56% of the whole energy sold in this market.

Figure 1.4: Operators in the safeguard market



Source: ARERA. Indagine annuale sui settori regolati

1.2.5 The level of competition in the retail sector

In order to have an overall view about the level of competition in the retail sector, the following assessment uses all the figures of the previously paragraphs. In this way, it should be noted that in 2017 the level of competition in the retail sector decreased, even though there was a high number of companies operating.

As deducible from ARERA (2018), both the C3 indicator and the HHI show a worse level of concentration compared to 2016. Focusing on C3, the market shares of the three operators increased by 2.3% between 2016 and 2017, rising from 43.6% to 45.9%. Regarding the HHI, it has recorded an increase of 179 points, rising from 1342 in 2016 to 1521 in 2017, crossing the threshold of 1500 that, as previously mentioned, is the minimum value beyond which a sector is considered moderately concentrated.

As well as expected, ENEL is the incumbent in the entire sector: it is in the first position both for sold energy to the household customers (72.2%) and for sold energy to the no-household customers connected to the low voltage (40.8%). In the household sector, the main follower is Eni, whose market share is equal to 5.6%, while regarding the no-household sector, the main follower is Hera, whose market share is equal to 4.2%. As in the single markets, there is a deep gap between the incumbent and his major competitors.

As explained by Carlo Amenta et al. (2017), another way to analyse the level of concentration on the market is the switching rate: this can be considered as a measure of the sector competitiveness because a switch normally occurs either if there is a competitor that offers a better service or if there are more convenient offers. Moreover, a low switching rate could highlight the presence of barriers which do not allow the clients to change their supplier easily. The problem of the barriers is an added propensity to the inertia not to change, which is an intrinsic characteristic of the human behaviour. It could reinforce the dominance of the incumbent, as we explain in the last paragraph of this chapter.

In 2017, as reported by ARERA (2018) the electricity market recorded a switching rate equal to 10.3%, which implies that 3.8 million of people have

changed the supplier just once during the year. This rate points out an increase of about 83.000 users compared with 2016

Focusing on the volume of sold energy, the switching rate is 33% of the distributed energy.

Making a distinction between household and no-household users, the families that have changed the supplier are about 7.9%, which corresponds to an energy share of 11.6%, while the no domestic users connected to the low voltage are 19,7%, which corresponds to an energy share of 34.1%.

These figures demonstrate that the volume of the switching rate has increased, even though the number of families which has made a switch has decreased.

1.3 The tariff structure

From the provisional data processed by Terna, the company that manages the transport of electricity, in 2017 the demand for energy amounted to 320.4 billion with an increase of 2% compared to 2016[5].

Since 2007, with the liberalization process, people have been choosing their tariff among several offers. In order to analyse the different offers, it is necessary to separate the clients based on their energy consumption (tab. 1.17) and then distinguish between household and no-household customers.

Table 1.17: Energy consumption classes

Consumption	I class	II class	III class	IV class	V class
MWh/y	<1.000	1.000-2.500	2.500-5.000	5.000-15.000	> 15.000

1.3.1 Domestic customers

In 2016, the Energy Authority established the new tariff reform[6], whose aim was to replace the progressive tariff structure with the non-progressive one by 2018.

[5] *https://www.ilsole24ore.com/art/impresa-e-territori/2018-01-19/energia-cosi-cambiamo-consumi-e-rinunciamo-petrolio 162158.shtml?uuid=AE2KgelD*

[6] *Deliberazione 22 dicembre 2016 782/2016/R/EEL da parte della autorità per l'energia elettrica il gas e il sistema idrico*

In this way, since 2018, all the domestic customers have the same non-progressive tariff structure for the network services, which divides the cost of distribution and commercialization, covered by the clients with a fixed part, and the cost of the transmission, that are the variable parts (c€/KWh).

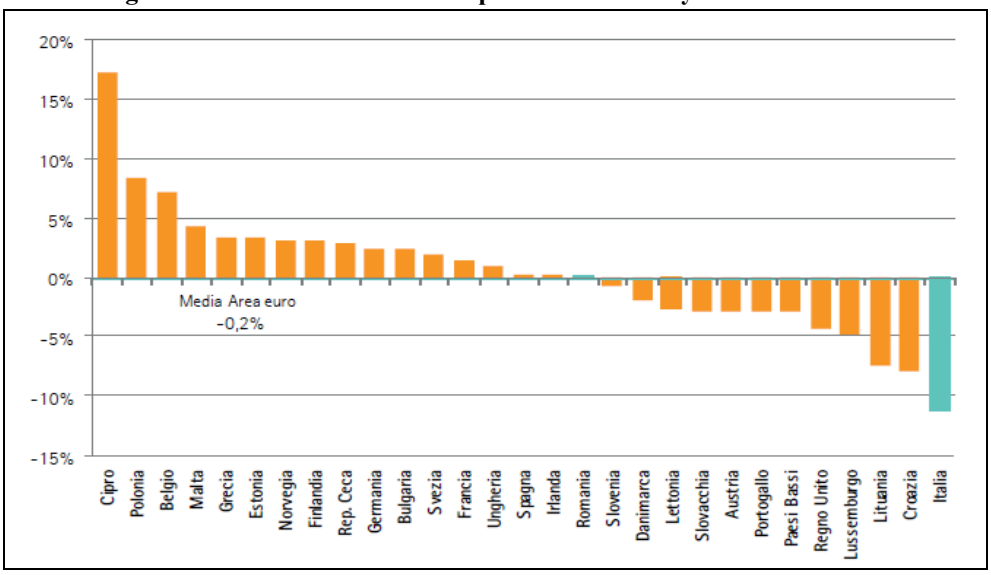
As reported by ARERA (2018), in 2017 the prices after the taxation of the first two classes recorded an increase of +9%, while there was some reduction from the third class onwards. The major reduction (about 20%) was recorded in correspondence to the IV class.

Making a comparison with Euro zone, it is highlighted that the prices for the first three classes, which represent 95.2% of the clients and consume 90.6% of the energy sold in the domestic sector, are lower than those in the Euro zone. On the opposite side, the clients who are not included in the first three classes are about 1.650.000 and they pay 8% more.

Focusing on the intermediate class, which includes consumption ranking from 2.500KWh/y to 5.000 KWh/y and represents the class with the highest energy share sold (38.3%), Italy records prices lower than those of the Euro area (-4%). This event is contrary to what happened the previous years.

It should be noted that for this class the Italian prices ante-tax have decreased about 11.2% compared with the previous year, even thought the gap with the Europe area is +4% (fig. 1.5; tab. 1.18; fig. 1.6).

Figure 1.5: Variation in the final prices of electricity for domestic use



Source: ARERA. Indagine annuale sui settori regolati

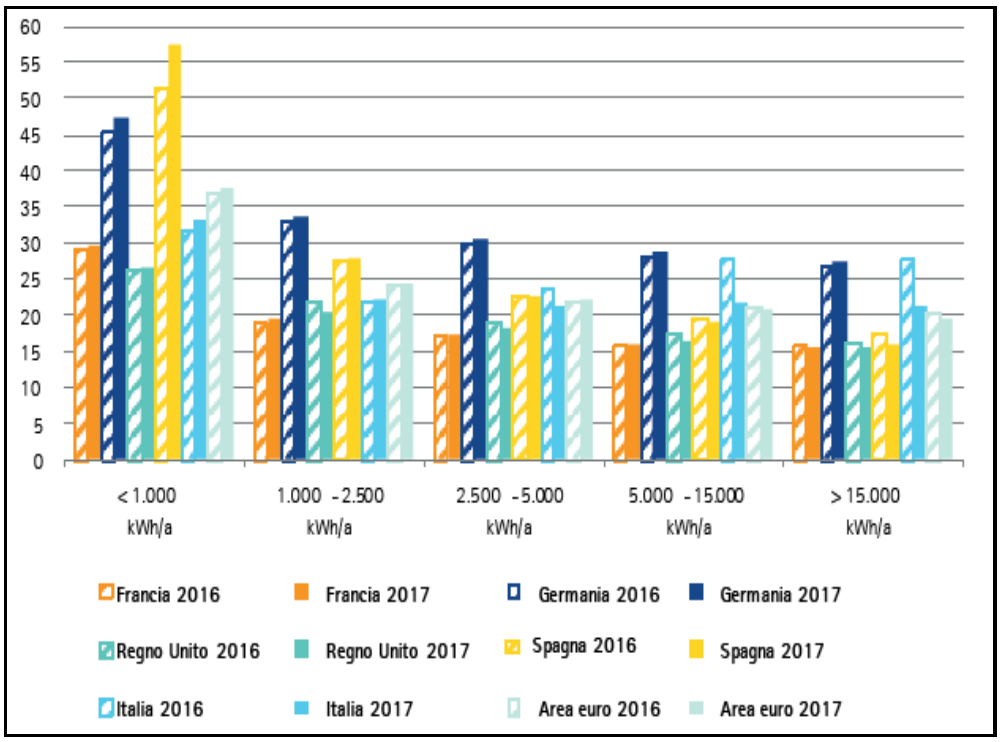
Table 1.18: Final electricity prices for domestic customers in 2017

	CONSUMATORI PER FASCIA DI CONSUMO ANNUO (kWh)									
	< 1.000		1.000-2.500		2.500-5.000		5.000-15.000		> 15.000	
	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI
Austria	20,98	37,15	14,23	23,83	12,20	19,64	10,94	17,26	10,03	15,69
Belgio	27,96	49,20	19,85	31,87	18,28	28,38	16,66	25,69	13,09	20,68
Bulgaria	8,23	9,88	8,11	9,73	8,08	9,69	8,07	9,68	7,98	9,58
Cipro	18,10	23,36	14,51	18,67	14,37	18,45	14,13	18,15	13,37	17,22
Croazia	17,05	20,01	11,01	13,18	10,12	12,16	9,72	11,70	9,42	11,36
Danimarca	15,33	37,43	11,53	32,68	9,63	30,30	8,60	23,69	8,34	21,63
Estonia	9,67	13,04	9,53	12,85	9,38	12,63	8,61	11,77	7,99	11,05
Finlandia	25,02	33,82	15,28	21,74	10,57	15,90	8,73	13,62	6,90	11,35
Francia	21,74	29,57	13,01	19,47	11,11	17,23	9,97	15,87	9,56	15,38
Germania	27,65	47,37	16,40	33,62	13,86	30,48	12,45	28,75	11,93	27,15
Grecia	15,66	22,62	11,86	17,96	11,15	17,78	10,97	20,58	10,25	18,96
Irlanda	29,83	41,64	22,56	30,01	18,56	23,30	16,28	19,65	13,92	16,15
Italia	23,95	32,95	15,72	22,00	13,29	21,11	12,48	21,78	11,29	21,18
Lettonia	13,02	19,00	10,85	16,37	10,42	15,84	10,01	15,35	10,22	15,61
Lituania	7,99	11,34	7,93	11,27	7,80	11,12	7,46	10,71	6,79	9,89
Lussemburgo	21,64	26,93	14,16	18,85	11,69	16,17	9,82	14,15	8,97	13,23
Malta	36,78	38,62	14,28	15,00	12,58	13,21	14,80	15,54	35,38	37,14
Paesi Bassi[(A)]	35,01	n.d.	16,50	10,57	11,49	15,59	8,13	17,26	n.d.	n.d.
Malta	13,47	18,94	11,07	15,96	10,26	14,54	9,46	13,31	9,41	13,12
Portogallo	17,29	38,81	11,82	24,71	10,93	22,57	10,57	21,74	10,55	21,30
Regno Unito	19,81	26,42	15,25	20,38	13,44	18,11	12,17	16,34	11,58	15,40
Cechia	22,54	27,40	15,93	19,42	11,97	14,63	9,50	11,63	8,66	10,64
Romania	9,16	12,53	9,22	12,59	9,08	12,44	8,89	12,21	8,56	11,82
Slovacchia	16,16	23,76	10,44	16,90	8,35	14,39	6,62	12,31	5,16	10,56
Slovenia	13,29	21,83	12,50	19,65	11,05	16,11	10,12	13,99	9,39	12,49
Spagna	44,94	57,16	21,81	27,73	17,59	22,37	15,00	19,07	12,39	15,75
Svezia	26,94	37,30	14,80	22,12	12,81	19,65	9,75	15,82	8,09	13,74
Ungheria	10,12	12,86	9,24	11,73	8,90	11,30	8,65	10,98	8,75	11,12
Norvegia	30,21	39,04	18,26	24,47	11,50	16,24	7,81	11,74	6,70	10,39
Unione europea	23,10	33,94	14,66	22,75	12,52	20,45	11,17	18,98	10,42	17,85
Area euro	25,00	37,66	15,14	24,30	12,76	21,89	11,44	20,71	10,65	19,54

(A) Nei Paesi Bassi è previsto uno sconto sul prezzo finale lordo che, per la prima classe di consumo, rende poco significativo il dato.

Source: ARERA. Elaborazione su dati Eurostat

Figure 1.6: Final prices of electricity for domestic use in the main European countries



Source: ARERA. Elaborazione su dati Eurostat

1.3.2 No-household users

As reported by ARERA (2018), the Italian no-household sector presents) higher prices than the rest of the euro zone in all the classes, an exception for the class characterized by the highest consumptions, whose gap, considered ante tax, with the euro area is zero. For the first three classes, instead, the gap is about 19% while for the following two it is about 25%.

Even thought the gap is still deep, it should be noted that in 2017, the gap of the prices ante tax decreased. For the first class, in 2016 there was the peak of the cost of energy, which marked a gap with the euro's area of +33%, while in 2017 the gap decreased to +12%.

Regarding the second class, the gap has decreased from +19% in 2016 to +13% in 2017. For the three following classes the decrease has been of, respectively, from +20% to +15%, from +24% to +19%, and from +28% to +25%.

The decrease of 2017 is in line with the trend that began in 2013: since this year the gap with the prices of the euro area is about halved.

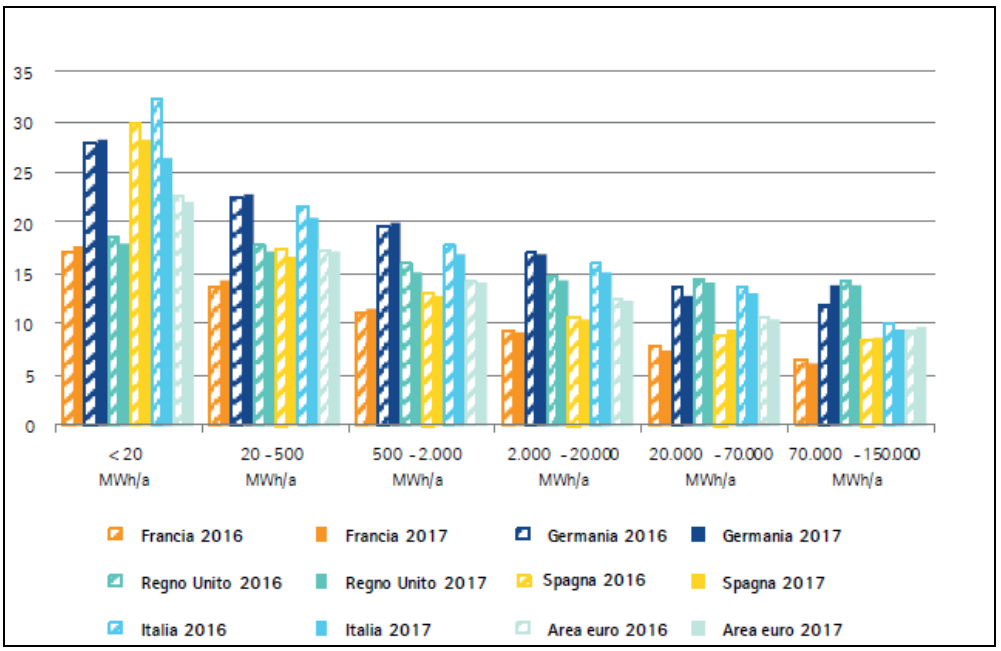
With regard to the prices after tax, it's highlighted that the gap for the first classes has decreased, in particular for the first class, in which the gap with euro area has decreased from +15% to +5%. A different situation characterizes the classes with highest consumption; the last class has increased the gap from +12% to 17% (tab. 1.19; fig. 1.7).

Table 1.19: Final energy prices for no-domestic customers in 2017

	CONSUMATORI PER FASCIA DI CONSUMO ANNUO (MWh)											
	< 20		20-500		500-2.000		2.000-20.000		20.000-70.000		70.000-150.000	
	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI	NETTI	LORDI
Austria	11,71	19,02	8,79	14,47	6,55	11,56	5,67	9,94	4,90	8,57	4,47	7,92
Belgio	15,73	25,87	11,80	18,84	7,80	13,41	6,75	11,09	5,51	8,63	5,01	7,18
Bulgaria	10,70	12,96	8,77	10,65	7,43	9,03	6,66	8,11	5,76	7,03	5,45	6,66
Cipro	16,22	20,68	14,63	18,82	12,67	16,51	11,81	15,48	11,05	14,40	10,30	13,67
Croazia	11,24	13,84	9,79	11,98	8,17	10,14	7,09	8,86	6,07	7,40	4,71	5,56
Danimarca	9,09	29,59	7,31	27,10	6,80	26,45	6,70	26,32	4,87	24,03	4,73	23,85
Estonia	9,64	13,36	7,90	11,27	7,09	10,30	6,17	9,18	5,59	8,44	5,35	8,16
Finlandia	8,17	11,01	7,62	10,32	6,01	8,33	5,74	7,99	4,53	6,48	4,40	6,33
Francia	11,56	17,68	9,04	14,44	7,01	11,50	5,88	9,18	5,26	7,45	4,76	6,14
Germania	12,07	28,08	9,87	22,92	7,74	19,88	6,37	16,93	4,76	12,89	4,45	13,69
Grecia	12,83	19,46	11,29	17,10	8,66	12,65	7,36	10,71	7,03	15,54	n.d.	n.d.
Irlanda	15,84	22,16	13,46	17,06	10,94	13,96	9,00	11,28	8,06	10,07	7,27	9,13
Italia	14,22	26,42	9,87	20,53	8,21	16,94	7,57	14,97	7,09	12,98	6,11	9,43
Lettonia	15,66	22,20	10,73	16,22	9,01	14,15	7,63	12,47	7,00	11,71	5,25	9,60
Lituania	10,01	13,84	7,95	11,38	6,91	10,12	6,07	9,08	5,40	8,23	n.d.	n.d.
Lussemburgo	10,81	14,51	8,73	10,83	7,08	8,61	5,96	7,08	3,93	4,29	n.d.	n.d.
Malta	23,52	24,69	15,50	16,27	13,93	14,63	12,11	12,71	10,34	10,85	9,81	10,30
Paesi Bassi	n.d.	n.d.	7,35	13,91	6,05	9,60	5,98	9,27	5,14	6,86	5,01	6,39
Polonia	13,50	19,11	9,92	14,18	7,19	10,70	6,16	9,39	5,60	8,63	5,07	7,58
Portogallo	12,86	24,67	10,69	18,82	8,36	14,10	7,72	12,76	6,69	10,73	6,43	10,06
Regno Unito	12,37	17,91	11,14	17,16	9,13	15,00	9,30	14,25	9,75	14,08	9,75	13,81
Cechia	16,49	20,08	11,41	13,94	6,88	8,46	6,15	7,57	6,03	7,43	6,36	7,82
Romania	8,37	11,44	7,67	10,65	6,50	9,26	5,93	8,58	5,26	7,64	5,17	7,51
Slovacchia	15,00	22,53	9,60	16,05	7,54	13,57	6,63	12,48	5,93	11,64	5,46	11,08
Slovenia	9,94	15,81	8,09	12,03	6,19	9,57	5,54	8,21	5,09	7,25	5,12	6,96
Spagna	22,12	28,14	13,11	16,67	9,96	12,67	8,28	10,53	7,40	9,42	6,84	8,70
Svezia	13,80	17,31	7,77	9,77	6,43	8,09	5,50	6,93	4,66	5,88	3,95	5,01
Ungheria	9,57	13,21	8,03	11,25	6,57	9,40	6,19	8,92	5,85	8,47	6,31	9,07
Norvegia	6,55	10,55	6,15	9,01	6,03	8,84	4,85	7,35	3,98	6,26	3,60	4,49
Unione europea	13,31	22,07	9,92	17,16	7,77	14,02	6,87	12,22	6,09	10,45	5,66	9,63
Area euro	13,60	23,66	9,97	18,10	7,80	14,72	6,72	12,59	5,75	10,39	5,24	9,44

Source: ARERA. Elaborazione su dati Eurostat

Figure 1.7: Final prices of electricity for no-domestic use in the main European countries



Source: ARERA. Elaborazione su dati Eurostat

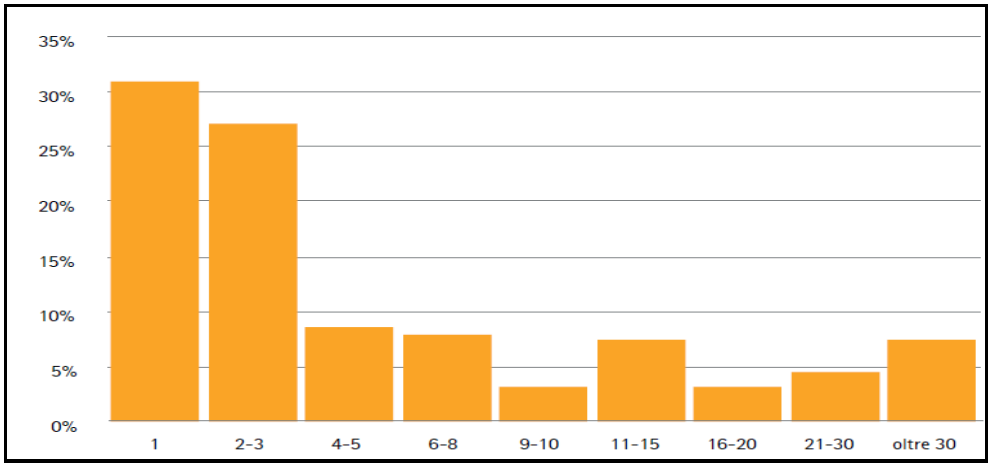
1.3.3 Free market

As reported by ARERA (2018), the operators in the free market can provide up to 14.5 offers to their potential household clients and up to 60.5 commercial offers to their no-household potential clients. The higher number of offers for no-household customers is given by the fact that the clients of this sector use more energy than household users and, then, they have particular requirements based on their activities. In this way, for the no-household clients there are more offers which try to meet their needs.

Although, it should be noted that about 1/3 of the suppliers offer only one commercial offer (that changes from supplier to supplier) and only 42% of the suppliers propose at least 4 or more commercial options (fig. 1.8).

It is highlighted that year by year the web is increasing its importance in the retail sector to reach all the potential clients, especially in the domestic sector, in which the offers purchasable on the web are 4.4.

Figure 1.8: Number of offers offered to customers by suppliers



Source: ARERA. Indagine annuale sui settori regolati

In detail, a research carried out by Bain & Company with Google[7] highlights that one Italian out of two chooses his supplier on the web. In 2015 there was an increase of 150% of clients which used the web to choose their supplier and in the next five years a further increase of 40% is expected. These figures show the importance of the web and how it could take on a key-role in the strategy of the companies to expand their share market.

Even with the importance of the web, ARERA (2018) highlights that there are still 21.3% of the Italian operators which do not offer any type of contract on the web. And 20% of the suppliers using the web, 20% offer the same number of contracts online and offline while the other 80% offer less on the web compared with the total of the offers.

Besides, the price plays a key-role in customers' decision. About 84% of the household clients have chosen a fixed price, which means that it does not change for all the period decided in the contract (ex 1 year or 2 years and so on), while 16% chose a variable price contract, which does mean the final price changes based on the cost of energy on the market.

However, it should be noted that the price is not the only feature influencing the customers' choice. In fact, the research carried out by Bain & Company, previously mentioned, shows 25% of the web researches on the energy

[7] *https://www.bain.com/it/about-bain/media-center/press-releases/italy/2019/luce-e-gas-piu-della-meta-dei-consumatori-italiani-sceglie-online-il-proprio fornitore/*

world are about offers on the electricity connected with products or services extra, such as air conditioning or furnaces. The sensibility of the clients about the energy world and the consequences of their actions has been increasing in these years. This is also shown by the fact that 60% of the customers know the difference between free market and protected market. It will be in the best interest of the suppliers to try to optimise the utility of the customers focusing not only exclusively on the price but also on the products and services connected with the energy world.

As showed by ARERA 2018, among the clients who have subscribed a fixed price contract, 46% have demanded the guarantee to have energy coming from renewable sources, while among the clients who have subscribed a variable price contract, 23.1% are interested in having some incentives and 16.1% demanded extra services (tab. 1.20).

Table 1.20: Percentage of customers who have signed a contract for the supply of electricity with additional services

SERVIZI AGGIUNTIVI	CONTRATTI A PREZZO FISSO	CONTRATTI A PREZZO VARIABILE
Garanzia di energia proveniente da fonte rinnovabile (offerta verde totale o percentuale)	45,7%	48,9%
Programma di raccolta punti (proprio o altrui)	45,0%	6,9%
Servizi energetici accessori (es. strumenti digitali e collaborativi per il controllo di consumi e costi energetici, strumenti per aumentare l'efficienza energetica, prestazioni professionali come assistenza telefonica, manutenzione impianti, assicurazione ecc.)	5,7%	16,1%
Omaggio o gadget	1,4%	23,1%
Vantaggi sull'acquisto di altri beni o servizi (es. sconti benzina, abbonamenti a riviste, ecc)	0,5%	3,6%
Altro non compreso tra le voci riportate sopra (specificare)	1,7%	1,4%
TOTALE	100%	100%

Source: ARERA. Indagine annuale sui settori regolati

In 2017, 1.7 million of household clients (14.6%) had a contract "*dual fuel*", a particular type of contract which allows them to have both electricity and gas by the same supplier. The total consumption of these users has been about 14.3% of the energy sold to the domestic users in the free market.

Regarding the diversification of the energy cost during the day, the majority of the clients stipulated the monoraria tariff is (63.2%), compared to the bioraria tariff (29.3%) or multioraria tariff (7.5%).
Focusing on the no domestic sector, the dual fuel contracts didn't have a deep diffusion: less than 80.000 are subscribed to this type of contract, which corresponds to 2.2TWh out of the total 177.9.

1.3.4 Protected market

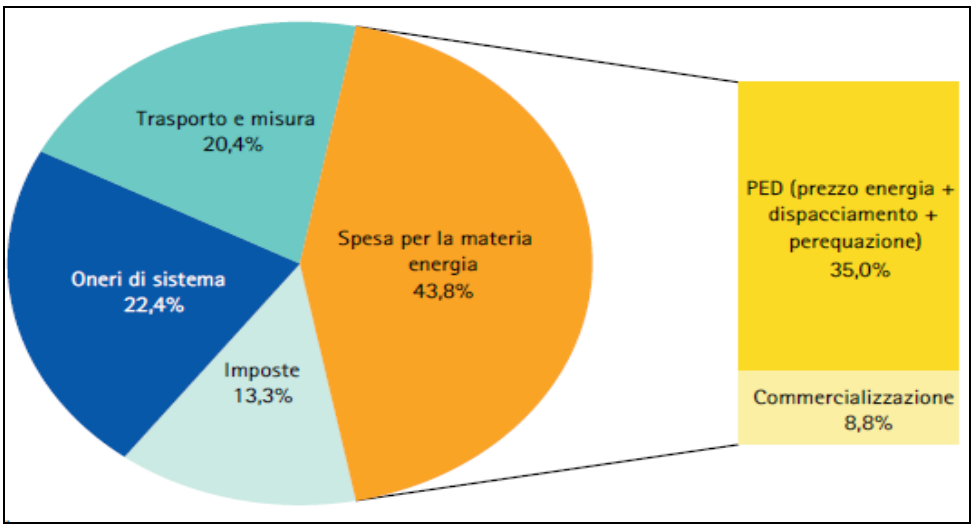
In the protected market the energy is bought by the AU, which buys it at more favourable market conditions and then resells to the companies. In this market the price is established by the authority ARERA. In detail, as showed by ARERA (2018) the price is composed of 4 main parts (fig. 1.9):

- *Cost for energy material*: this is the component which affects the final price more (about 45%) and it is dependent on the price on the wholesale market and, hence, on the cost of the primary materials from which it is making the energy (ex. Petroleum)
- T*axes*: they affect about 13% of the final price
- S*ystem costs*: they affect about 22% of the final price
- *Transportation and measure cost*: they affect about 20% of the final price

In the biennium 2015-2017 the prices had small fluctuations around the average value of 18.6 c€/KWh[8]. In the second semester of 2017, they had a sharp increase and then returned to just above the average value at the beginning of 2018 (Fig. 1.10).

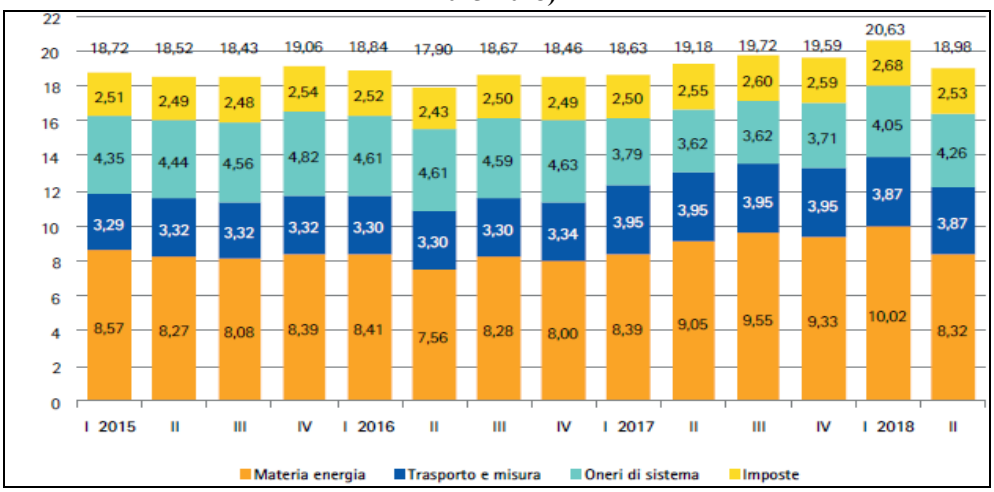
[8] *Istat monthly index on a resident domestic consumer with power equal to 3KW and consumption equal to 2,700 kWh*

Figure 1.9: Percentage composition of economic conditions for a consumer in the protected market with annual consumption equal to 2700 KWh and power equal to 3KW



Source: ARERA (2018)

Figure 1.10: Economic conditions for a domestic consumer in the protected market with annual consumption equal to 2700 KWh and power equal to 3KW (c€/KWh; 2015-2018)

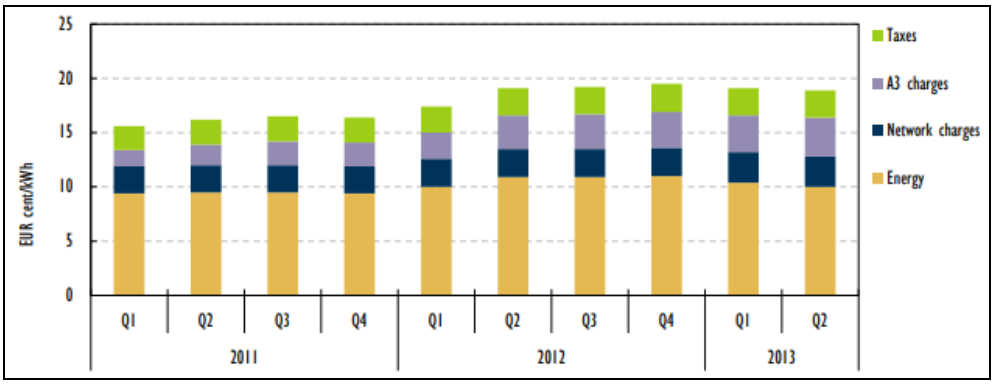


Source: ARERA (2018)

The system costs are composed of three parts (tab. 1.21). It is interesting to observe the increase of the component referred to the renewable sources. As reported by ARERA (2018), this component reached its highest value in 2015, amounting to the value of 4.82c€/KWh. This increase was substantially due to the government program which wanted to support the renewable energy. As highlighted by IEA (2016), in the years between 2011 and 2013 the component under consideration had a 50% increase, from 01.47/kWh to 03.64/kWh (fig. 1.11). This trend was reversed in 2017, with

a decrease of 25% (3.62c€/KWh) because of the interruption of the facilities for the firms characterized by a high energy consumption. These facilities were actuated again at the end of 2017, causing an increase of 0.55c€/KWh in 2018, as reported by ARERA (2018).

Figure 1.11: Evolution of retail tariff components over time, 2011- 2013



Source: MSE, country submission

Table 1.21: System cost in 2017 (milions of euro)

ALIQUOTA	DESCRIZIONE	GETTITO ANNUALE
A_2	Oneri per il finanziamento delle attività nucleari residue	187
A_3	Fonti rinnovabili e assimilate	12.405
A_4	Regimi tariffari speciali ferrovie	110
A_5	Finanziamento della ricerca	69
A_6	*Bonus sociale*	86
A_5	Agevolazioni imprese energivore	626
UC_4	Imprese elettriche minori	65
MCT	Misure di compensazione territoriale	48
UC_7	Efficienza energetica negli usi finali	688
	TOTALE	14.284

Source: ARERA. Elaborazione su dati CSEA

1.4 Liberalization

As previously mentioned, until the end of the '90s, Italy was characterized by a natural monopoly managed by ENEL. During these years it was evident that the conditions which had made the introduction of the natural monopoly necessary came to an end (the infrastructures were more efficient, almost the whole population was served and so on). In these years Italy started to develop the idea that liberalization was the best form to allow the

most efficient development for the energy market and it was an Italian aim as well as Europe's.

The reasons behind the liberalization process are to seek in the economics theory, which shows that social welfare can improve increasing the competition. The economics theory is based on some theoretical basis and it describes the way to reach the social best.

Theory suggests that in a world characterized by rational customers, perfect and costless flow of information and, finally, absence of externalities, the liberalization would be the best solution to obtain a freely competitive market and all its positive consequences. This idea can be deducted and explained in a concise but efficient way considering the benefits of the "*invisible hand*", a concept introduced for the first time by Adam Smith (1776). The notion of the invisible hand explains in which one measures the individuals, moved by the aim to getting more personal benefits, are forced by the invisible hand to behave as if they were worried about others. In this way, the liberalization would lead to the deletion of the barriers of entry, by making the entrance of the firms in the market easier and increasing the level of competition. The goals of liberalization are mainly three:

- To create a more dynamic market: the liberalization both in the generation and in the retail sector increases the level of competition between the companies. A high level of competition involves more different types of offers in order to offer the best tariff which meets the needs of customers, allowing suppliers to extend their own market share. The main consequence is a more dynamic market which can achieve also another type of goal: to avoid high consumptions in the "*peak-hours*" and to smooth the demand fluctuation during the day. In fact, an irregular demand fluctuation is a problem for the firms because of the marginal costs
- To decrease the tariff costs for the final users: The entry of major companies dictated by the removal of entry barriers and the intrinsic profitability of the sector in which demand is substantially rigid, would entail an increase in the level of competition that would give rise to a price war, which results in lower prices for the

benefit of end consumers, improving social welfare. In fact, if there is an efficient competitive market, the suppliers are forced to charge less or identical to their rivals, otherwise, if a supplier charges more than the market clearing price, all consumers will go to others with the lower price

- To increase the technological innovation and the quality of the service: in the energy market the competitors compete at a similar technologic level. The competition, hence, should lead to some major investments in technology in order to improve the infrastructure and the quality of the service in order to expand their own market shares

It is evident, hence, that in a perfect theoretical world, liberalization is a really important instrument to achieve the perfect competition and to obtain all its positive consequences just as described, including the decrease of the prices and the improvement of the social welfare.

1.4.1 Issues

Just as mentioned, the reasons behind the liberalization are deducted by a theory, but the real world is different from the theoretical one and it is also more complex. In concrete, hence, the aims of liberalizations could be hindered by plenty of problems. One of the first problems that hinders the achievement of the aims of liberalization is due to the irrationality of customers, as it is highlighted in the next chapter. Others amongst the most important are:

1. The presence of AU

   As highlighted by Amenta, C. et al. (2017), the protected market is a result which was reached after a large number of European suits and its legitimacy was recognized under two conditions:

   a) The protected prices have to be equivalent to the market prices
   b) The protected market has to be temporary

Regarding the first point, the AU works in the same way as a market operator. Although, the AU has an important characteristic that should not be underestimated: the condition offered by the protected market could discourage the clients by changing the supplier, leaving the protected market. In fact, just from the name up to the conditions which are characterized this type of market, it could elude customers into shifting to the free market, accepting a contract that, at least the name, that is not able to protect them.

This is a first form of lower efficiency in the market that hinders the achievement of the objectives of liberalization, taking into account inter alia that, precisely because of how structured, according to the definition given by Acer (2016) should be addressed only to those who actually need protection, while today it also includes SMEs and families that do not need economic protection.

As regards the second point, that is the transitory nature of the service, this is foreseen, as already said, by 2020. Until that date, however, the protected market represents a barrier of entry, as it has the prices of greater protection comparable to a price control system and, referring to what the Commission has said about regulated price regimes. Member States often cite an underperforming retail market or social protection needs as justification for price regulation. Social security policies can be used to increase vulnerability and non-vulnerable consumers alike. Therefore, other sustainable and precise measures should be explored to help Member States deregulate prices for end-users, as reported by EC (2015). Similarly, and with specific reference to the enhanced protection service in force in Italy, is reported by Acer (2016) that: "*Other forms of intervention setting price, such as the 'single buyer' (Single Buyer) and standard offer prices in Italy, 'Safety net regulation' in Belgium and 'Tariff Surveillance' in the Netherlands, may also have an impact on market competition*". Moreover: "*regulated prices (even when set above*

costs) can act as a focal point pricing which competing suppliers are able to cluster around inertia - can also considerably dilute competition" and "*standard offer prices in Italy are based on market conditions and do not distort competition among suppliers point for suppliers, be considered by consumers as a safer option than competing offer, and may reduce the propensity of consumers to seek better offers*", as reported by Acer (2015).

2. Basic condition: The offer must be higher than the demand

   As highlights by Giurickovic, E. (2014), in order to achieve the aim of reducing the prices of tariff, over a competitive environment, it is necessary to have the presence of a condition, without which the goal is not achievable: the offer must be higher than the demand.

   The problem is that the good which is placed on the energy market is a non-storable good and the only way to increase the production of this good, that is energy, would be creating new power generation plants, which need huge investments both in time and money.

   These investments not always are advantageous: they are high specific investments and this implicates plenty of risks due to the few alternative uses in different context from which they were designed. The only one solution to encourage companies to invest in new power generation plants would be to allow them a vertical integration to decrease the risks. But this solution, as previously mentioned, is not possible after Bersani Decree.

   So, this basic condition is quite hard to achieve and the best solution to overcome this problem is importation, but it is not able to solve the problem at all.

   This explains why in the period following Bersani Decree the expected results were not achieved.

   Focusing on the short period, the prices decreased, at least in the domestic sector. But from the 2005 onwards, as reported by

Giurickovic, E. (2014), the prices in Italy have been higher than those in Europe, with gap of also 20% (tab. 1.22).

Table 1.22: Electricity prices in Europe (€/kwh)

Paesi	Uso domestico												
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
GERMANIA	0,12	0,12	0,13	0,13	0,13	0,13	0,13	0,13	0,12	0,12	0,13	0,13	0,13
SPAGNA	0,12	0,12	0,11	0,11	0,11	0,10	0,09	0,09	0,09	0,09	0,09	0,09	0,09
FRANCIA	0,10	0,10	0,10	0,10	0,10	0,10	0,10	0,09	0,09	0,09	0,09	0,09	0,09
ITALIA	0,20	0,17	0,16	0,15	0,15	0,17	0,17	0,16	0,15	0,16	0,14	0,14	0,14
REGNO UNITO	0,11	0,10	0,10	0,09	0,09	0,10	0,10	0,10	0,11	0,10	0,10	0,10	0,08
EU 15	0,12	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,10	0,10	0,10	0,10	0,10

Paesi	Uso industriale												
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
GERMANIA	0,09	0,09	0,09	0,09	0,09	0,08	0,08	0,08	0,07	0,07	0,07	0,07	0,07
SPAGNA	0,09	0,09	0,08	0,07	0,08	0,07	0,06	0,06	0,06	0,05	0,05	0,05	0,05
FRANCIA	0,06	0,06	0,07	0,07	0,07	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05
ITALIA	0,09	0,07	0,07	0,06	0,06	0,07	0,07	0,06	0,07	0,09	0,08	0,08	0,08
REGNO UNITO	0,08	0,07	0,07	0,06	0,05	0,06	0,06	0,06	0,07	0,07	0,06	0,05	0,05
EU 15	0,08	0,08	0,07	0,07	0,07	0,07	0,07	0,06	0,06	0,06	0,06	0,06	0,06

Source: Giurickovic, E. (2014)

3. Information asymmetry

In order to allow competition, caused by liberalization, to lead to an effective benefit for the customers, it would be necessary for them to be able to actually understand which offers are the most convenient and what to do to maximise their utility (that is function of the prices as well as the extra services, as previously mentioned). However, this condition should not be reached: both the fear of finding long paperwork to face in order to change supplier and the fear of finding a contract at the end which does not lead to the expected benefits that make the cost in terms of time to sustain this research activity for the best offer, and does not equal the benefits. This explains the high value of the no-switcher percent among the domestic customers (fig. 1.12). In this way, there is another obstacle in the attempt to achieve the goals of liberalization: information asymmetry.

On this point, it should be noted that few years ago, Antitrust fined 6 million to some companies (such as ENEL and Eni) who had activated unsolicited supplies[9].

This sanction came due to the violation of the Consume Code and for the presence of information asymmetry about the offers.

As Basili, M. and Franzini, M. (2016) explain:

"*The existence of incomplete information and multiple alternatives that are not easily comparable determines the phenomenon known in behavioural economics as choice overload. This phenomenon has been observed in very different decision-making processes: from the choice of snack food to that of savings plans. In all cases where there is a high number of alternatives or when it is very difficult to examine the possible alternatives or, finally, when the information is incomplete or inaccurate, the choice of the consumer is not guided by an optimization process (maximization of utility), albeit in conditions of limited rationality, but by sub-optimal rules which include, according to Anglo-Saxon terminology, framing effect, anchoring effect, procrastination effect, endorsement effect etc. and that generally end with the application of default rules, i.e. automatic rules.*

The choice of the regime of greater protection is a default choice, so it is sub-optimal, but the conditions to overcome this situation without allowing energy retailers to make extra profits are onerous for consumers, both in terms of opportunity costs (time of search for the best contract) and direct costs (the average cost of the free market is currently higher).

So it could happen that, despite the continuous reduction in energy wholesale prices, retail prices increase due to asymmetries, distortions and market failures".

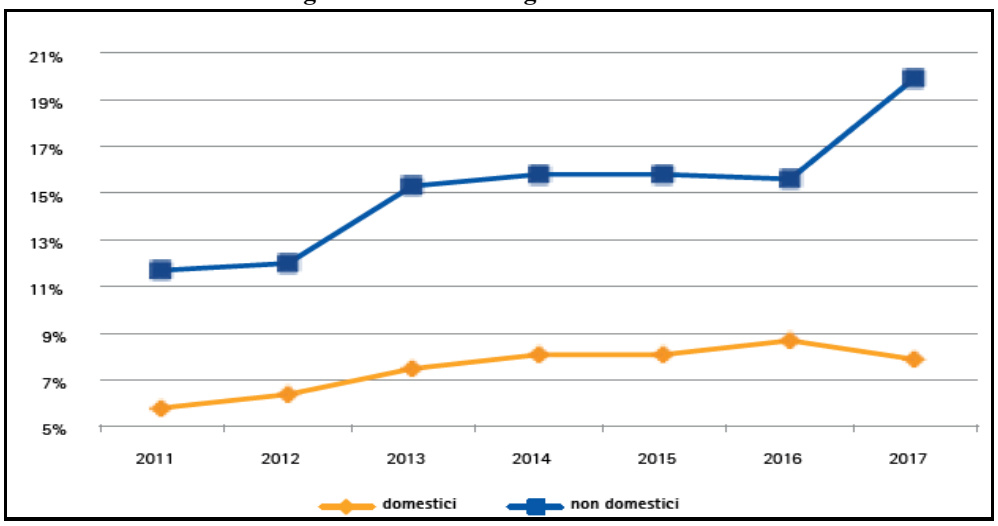
[9] *Bollettino 44/2015 del 06/12/2015, AGCM*

A possible solution could be achieved with the establishment of a telematic portal at the Aeegsi that allows consumers to compare the different offers. This is the proposal presented by Pitruzzella, former Antitrust president.

To overcome the information asymmetry problems and inform the final users about the advantages they could get with a switch would be desired to get the benefits expected by the free market.

As previously mentioned, moreover, that the switching rate is a parameter to understand if the market is open or not to the competition. In general, in Italy the switching rate has grown, especially in the no domestic sector.

Figure 1.12: Switching rate from 2012



Source: ARERA. Indagine annuale sui settori regolati.

4. The level of concentration

A further problem is the level of concentration characterizing the Italian market, which, as previously mentioned, is immensely high. The incumbent has a domestic market share of 73% and there are not any competitors that are able to challenge it.

The lack of a competitor as big as Enel is the most important problem: in both free market and protected market the followers have a deep gap of at least of 20%. And the problem is exacerbating by the fact that the owner of Enel is the state, which is also the owner of the only transmission grid (using Terna).

Then it becomes crucial to understand how to make the transition of the clients in the protected market to the free market when the liberalization process will end. As reported by Enrichetta, G. (2014) the three more valid options are:

a) Assigning clients in the protected market to different suppliers using auctions (this is the most valid alternative)
b) Assigning clients to the same supplier supplying them: this solution does not seem to meet the requirement to reduce the market share of the incumbent, which is needed to have an efficiency market. Indeed, this option will reinforce the position of incumbent of Enel, with the risk of not being able to oversee this company and understand when it will use market power to get a competitive advantage respecting the existing rules on the market. Furthermore, it should be noted that human beings are characterized by their laziness, as reported by Basili, M. and Franzini, M. (2016), and prefer the status quo to change, as it is highlighted by Bager, S., Mundaca, L. (2017). So, it can not be expected to have a spontaneous migration from the protected market to the free market in order to balance the level of concentration on the market
c) Assigning the clients to the safeguard market. This option is not realistic because the safeguard market is characterized by few clients. As it is structured, it could not accept all the clients of the protected market

Today the main discussion is still based on which option to focus on, even though the most accredited would seem to be the first because of two main factors: on the one hand, auctions would result in lower prices because we want to award interested customers substantially at the price rather than the extras. On the other hand the auction, due to the number of customers that it would bring within the boundaries of a specific company, could be the tool

sought in order to speed up the birth and development of competitors who would reach such dimensions as to be able to compete with Enel.

From what has just been analysed, it is clear how on one hand liberalization should lead to results that tend towards the optimum for welfare, but on the other hand there are many problems in the real world that hinder these achievements.

Moreover, it is fundamental to highlight that one of the main aims of the liberalization is to decrease the price of energy. One of the most intuitive consequences of the decrease of prices is an increase of consumptions. But this is in contrast with one of the most dangerous problems of our time: the climate change linked with the global warming. One of the ways used by the policy measures to fight this problem is to increase the price of the energy consumptions, thus to discourage customers to consume. It is evident, hence, the contrast between the purpose of liberalization and the goals of the policy measures of the last years in order to save the world.

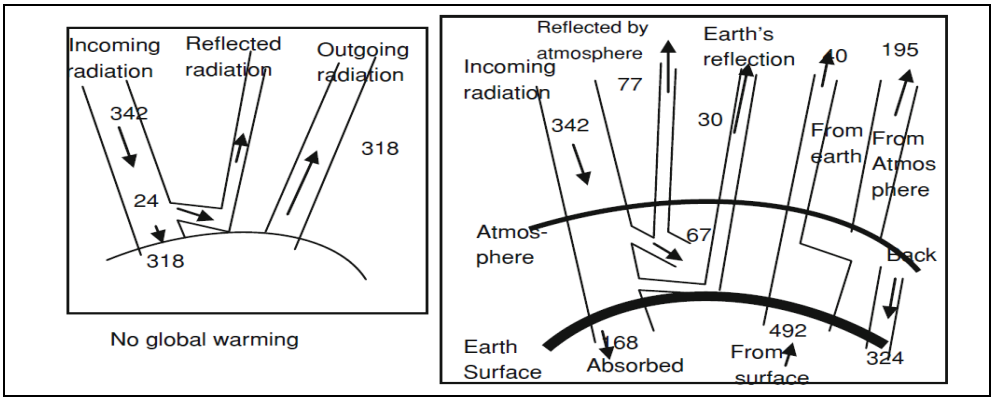
Chapter 2

GHG EMISSIONS AND THEIR CONSEQUENCES

Global warming problem and all the serious risks connected with climate changes, are one of the most important topics in almost all the discussions on energy and environment. Science has demonstrated that many of the causes behind climate changes are due to the greenhouse effect. This is a phenomenon caused by some gases which allow short wave radiations arriving from the sun to reach the Earth's surface but entrap the long waves radiations emitted by the Earth. Thus creating an effect similar to the greenhouse one, which traps heat to accelerate the growth of plants. In general, as reported by Bhattacharyya, C. S. (2011), the Earth's surface receives 342 Watts of solar radiations for every square metre (W/m2), and roughly 31% of these radiations is reflected back by clouds, atmosphere and the Earth's surface, while the rest is absorbed by the atmosphere and warms up the Earth's surface.

In order to maintain a stable climate it is important to balance the incoming energy with the outgoing energy, considering that any external factors (such as effects caused by human activities), can change the climate system also in a permanent way. In fact, the climate system has to adapt and adjust to maintain the balance even after some alteration in the solar radiation or in the Earth radiation, but some changes make more difficult to bring the balance back. An example are the effects in long-run produced by the greenhouse gases due to human activities, which are able to change the radiative forcing (fig. 2.1).

Figure 2.1: Earth's average energy balance



Source: IPCC (2001, Chap. 1, Fig. 1)

The term "*greenhouse gases*" (GHG) is referred to all the gases that produce and reinforce the phenomenon of the greenhouse effect, and the consequent climate change. This class of gases includes several gases as water vapour, ozone, nitrous oxide, chlorofluorocarbons, methane and, last but not least, carbon dioxide.

As it can be expected, the concentration of these gases has been raising since the industrial revolution because of human activities (tab. 2.1), and the negative effects, nowadays, continue to worsen the issue of global warming. This is due to one of the worst characteristics of these gases: from the moment they are created they survive for a long time, propagating their damage through the years. In this way, the whole world is still paying today for the negative effects of some gases produced many years ago.

Table 2.1: Changes in concentration of selected GHGs

Gas	Concentration in 1750 (ppm)	Concentration in 1998 (ppm)	Concentration in 2005 (ppm)
CO_2	278	365	379
CH_4	0.732	1.745	1.774
N_2O	0.270	0.314	0.319
SF_6	0	0.0042	0.0056
CF_4	0.040	0.080	0.074

Source: USEPA (2002) and IPCC (2007a)

Among all these gases, one of the most important and dangerous is CO_2. The levels of this gas started to be out of control from the first years of the new millennium. In fact, as reported by the IPCC (2007b), the atmospheric

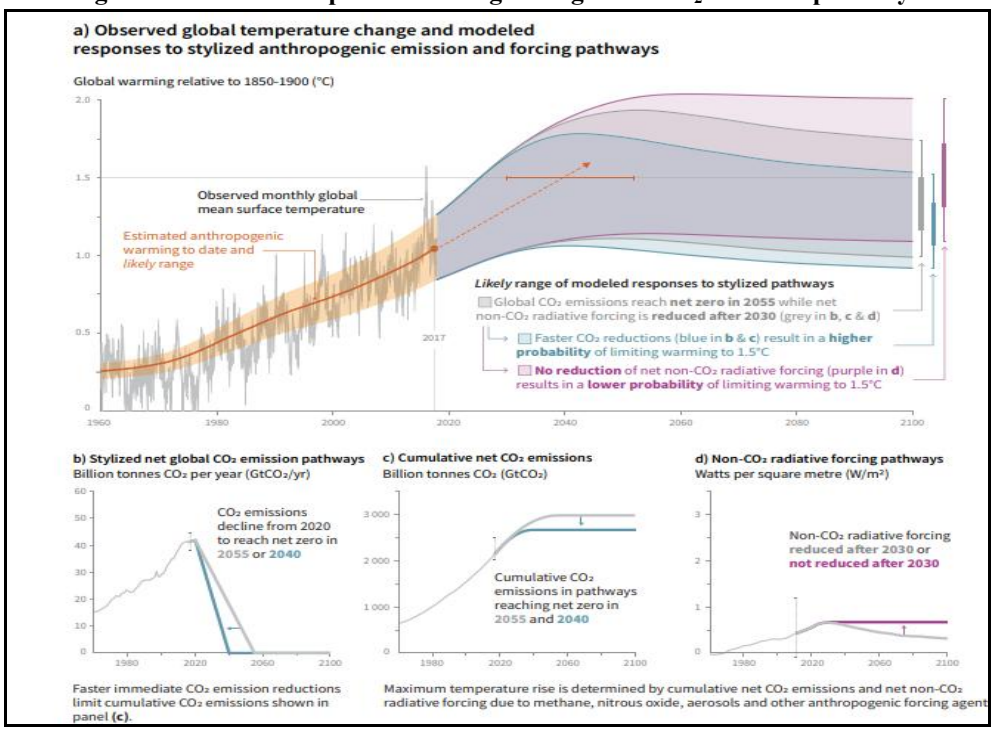
concentration of this anthropogenic greenhouse gas has reached the threshold of 379 ppm in 2005, exceeding the natural range over the last 650.000 years, which minimum was 180 ppm while the maximum was 300 ppm. Moreover, the problem is emphasized by the fact that the annual concentration growth rate of this gas has increased in few years. In fact, in the period between 1960-2005 the gas average was 1.4 ppm per year but focusing on the period between 1995-2005 the gas average was higher of 0.4 (1.9 ppm per year). The effects of this high concentration in the past are visible in the contemporary years: the decade between 2006–2015 was characterized by a temperature of 0.87°C higher than the average over the period between 1850–1900.

The main cause of the increasing atmospheric concentration of carbon dioxide seems to be the use of fossil fuel. But there are also some climate sceptics who make some valid points, such as the fact that the temperature increase rate has decreased in the last years (even if the reason could be the increasing temperature of the oceans), and that the climate change supporters are often its beneficiaries as wind turbines developers.

Even though the physic of climate is really complex and the climate science is a new branch of science, there are some evidences that led climate scientists to hypothesize a close relationship between the GHG emitted in the atmosphere and the global warming. In detail, with the use of sophisticated models, they have estimated that, if current trend continues, the sea level will rise of 26 up to 77 cm by 2100, as highlighted by IPCC (2018) because of the decline of snow and glacier in the mountains: the melting of glaciers will lead to an increase in the volume of the seas, causing an increase in sea levels of several meters for the next hundreds or thousands years. This phenomenon will have a huge impact on some ecosystems, both terrestrial and coastal, with the risk that some of them will be destroyed. Then another consequence predicted by scientists is that oceans temperatures will continue to increase during the years. Moreover, as reported by IPCC (2018), climate scientists have estimated that human activities have caused an increase of roughly 1.0°C of global warming above pre-industrial levels, and they estimated that this value will reach 1.5

°C between 2030 and 2052. But there are also other direct consequences to the increase of global warming. Some of these are the changes in the precipitation level in the different areas of the world. Thus likely there will be an increase in intensity and amount of heavy precipitation in some countries while in others there will be an increase of the frequency of droughts (fig. 2.2).

Figure 2.2: Global temperature change and global CO_2 emission pathways



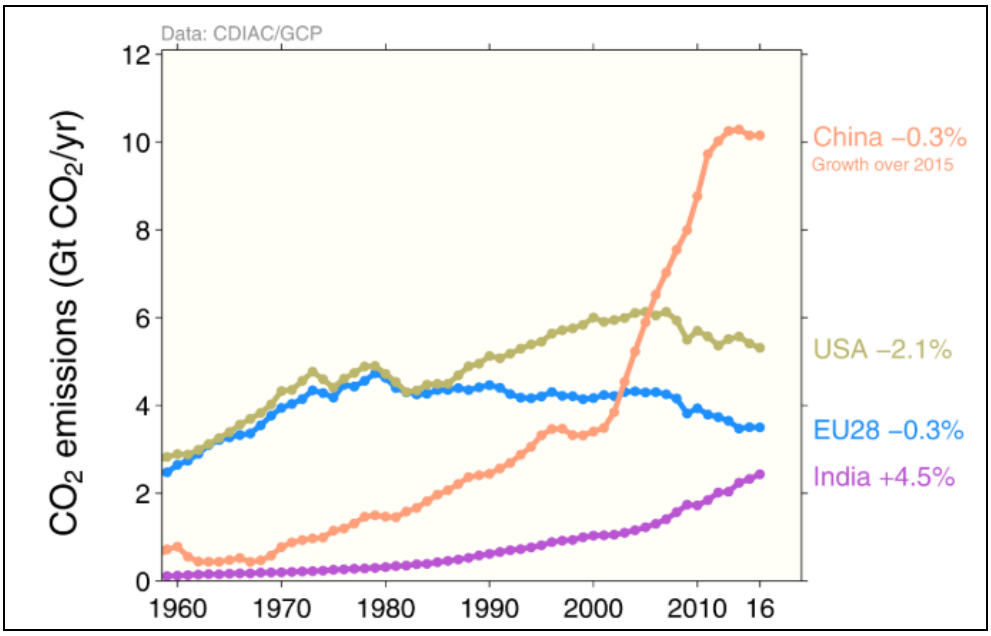
Source: IPCC (2018)

In order to control the greenhouse effect and to try to avoid or to limit these devastating events, some actions have to be taken, even if it seems to be really difficult. The difficulty is given by the fact that the greenhouse problem concerns the whole world, and all countries are causing bad effects in different ways and measures. In this way it is really difficult to find an agreement which meets all the needs of the various countries. There are many problems, but the most important thing is that, as previously mentioned, the effects of GHG will affect the world for a long period. So the problem which is facing the world today is caused by severe emissions of the past, and in this sense, it is difficult to understand who has the responsibility of it. This aim is really complex and, moreover, it is worsen

by the phenomenon of free-riding, meaning an opportunity or advantage that someone gets without having done anything to deserve it. This way some people do not take action to solve this problem because they think someone else will. Clearly, if everybody has this same way of thinking, even if it is could be possible to identify the responsible country for the past emissions, nobody would do the actions and attempts necessary to solve the problem.

It is also difficult to find a common solution because there are many countries which are evolving at different levels. An example would be China which represents a model of an economy in full growth. This growth drives China to have high energy consumption rates in order to keep production rates high. The consequence is higher emissions compared to the other countries in the world (fig. 2.3).

Figure 2.3: Fossil CO_2 emissions



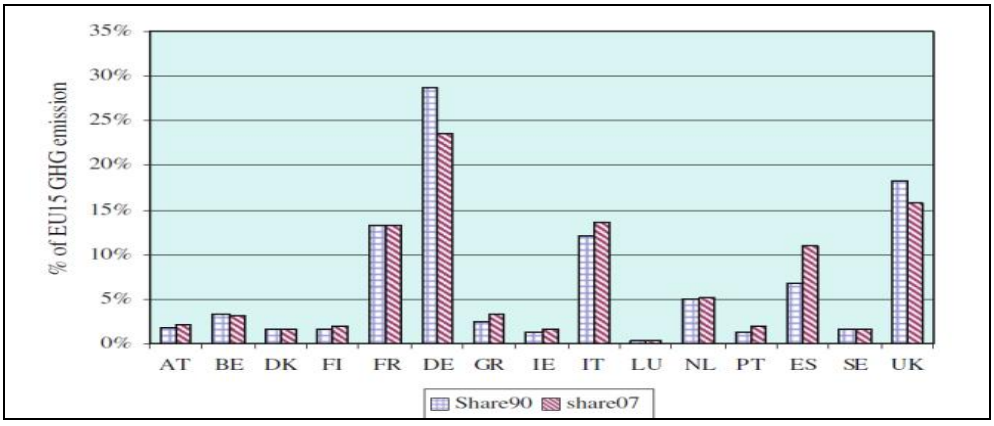
Source: Comitato Scientifico (Web Site)

Another difficulty in finding concrete and common solutions to face the problem of climate changes is represented by the behaviour of the States of the European Union. Although they are part of the same community, they have different priorities, and they lead to different solutions to face the problem.

This explains why, even if in the last years the emissions of GHG have been reduced in all the countries of the European Union, still the reduction is different from country to country.

Yet in the early years of the new millennium, as reported by Bhattacharyya, C. S. (2011), greenhouse gas emissions were significantly different between states according to their priorities and economies. The emissions generated by the European States were essentially due to 5 countries, which together reached about 75% of the GHG emissions in EU15. Among these five countries, those characterized by the highest level of emissions were Germany and the UK, which have contributed about 39% in 2007. Even though in the period between 1990-2017 they requested a decrease in the emissions, in 1990 the emissions were still 47%. Italy and France have also a high level of emissions, reaching roughly 13% each to the regional GHG emissions. The last country, characterized by an emission of 10%, is Spain. These were the 5 countries with the highest emissions (fig. 2.4).

Figure 2.4: EU15 GHG emission



Source: Bhattacharyya, C., S. (2011)

The actions of each State have continued to be different in the recent years even if the climate change is a famous topic. In this way there are States that are reducing their emissions while others are increasing them. This concept shows the GHG emissions generated by the energy consumption in Europe, in which, in the period between 2008-2016, was equal to 82% out of the total emissions, followed by the industrial processes (7.4%), and by the agricultural processes (6.5%), as reported by ISPRA in 2018.

As highlighted by Eurostat (2018), focusing on the GHG emissions generated by the energy consumptions in Europe, in 2017 there was an increase of 1.8% of carbon dioxide emissions from fossil fuel combustion compared with the previous year. In according to Eurostat, most of European Countries which have increased their emissions, such as Malta (+12.8%), Estonia (+11.3%), Bulgary (+8.3%), Spain (+7.4%) and Portugal (+7.3%). On the other hand, there are some countries which have decreased their emissions, such as Finland (-5.9%), Denmark (-5.8%), the UK (-3.2%), Ireland (-2.9%), Belgium (-2.4%) and Germany (-0.2%). This data confirms that Germany and the UK are continuing to decrease emissions in these years (tab. 2.2; fig. 2.5).

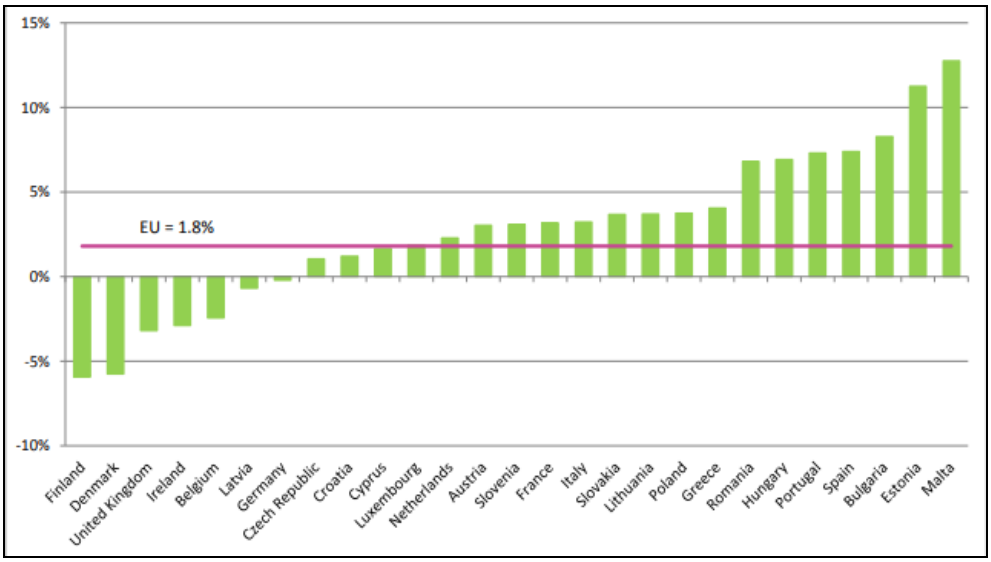
Table 2.2: Estimated CO_2 emissions from energy use

	Change 2017/2016	Share of EU total CO_2 emissions in 2017
EU*	**1.8%**	**100%**
Belgium	-2.4%	2.3%
Bulgaria	8.3%	1.5%
Czech Republic	1.0%	3.0%
Denmark	-5.8%	1.0%
Germany	-0.2%	23.0%
Estonia	11.3%	0.6%
Ireland**	-2.9%	1.2%
Greece	4.0%	2.1%
Spain	7.4%	7.7%
France	3.2%	10.0%
Croatia	1.2%	0.5%
Italy	3.2%	10.7%
Cyprus	1.7%	0.2%
Latvia	-0.7%	0.2%
Lithuania	3.7%	0.4%
Luxembourg	1.8%	0.3%
Hungary	6.9%	1.4%
Malta	12.8%	0.05%
Netherlands	2.3%	5.0%
Austria	3.0%	1.7%
Poland	3.8%	9.8%
Portugal	7.3%	1.5%
Romania	6.8%	2.1%
Slovenia	3.1%	0.4%
Slovakia	3.7%	0.8%
Finland	-5.9%	1.3%
Sweden	:	:
United Kingdom	-3.2%	11.2%

: Data under revision *Excluding Sweden **Include some Eurostat estimates

Source: EUROSTAT (2018)

Figure 2.5: Change in CO_2 emissions, 2017/2016 (estimated)



Source: EUROSTAT (2018)

Expanding the time frame for analyzing emissions and considering the total greenhouse gas emissions (thus not only those produced by energy consumption), it can be observed that, in general, all the countries of the European Union[10], have reduced their own total GHG emissions, even if in a different way. In general, the countries of the European Union characterized by the highest emissions show a decrease that began in 1990, except for Italy and Spain, whose emissions increased in 2005 and then realigned with the other European States. Despite the attempt to reduce the emissions, Germany remains the country with the highest emission per person, while the UK has been confirmed as the country with the largest reduction of emissions over the years (fig. 2.6).

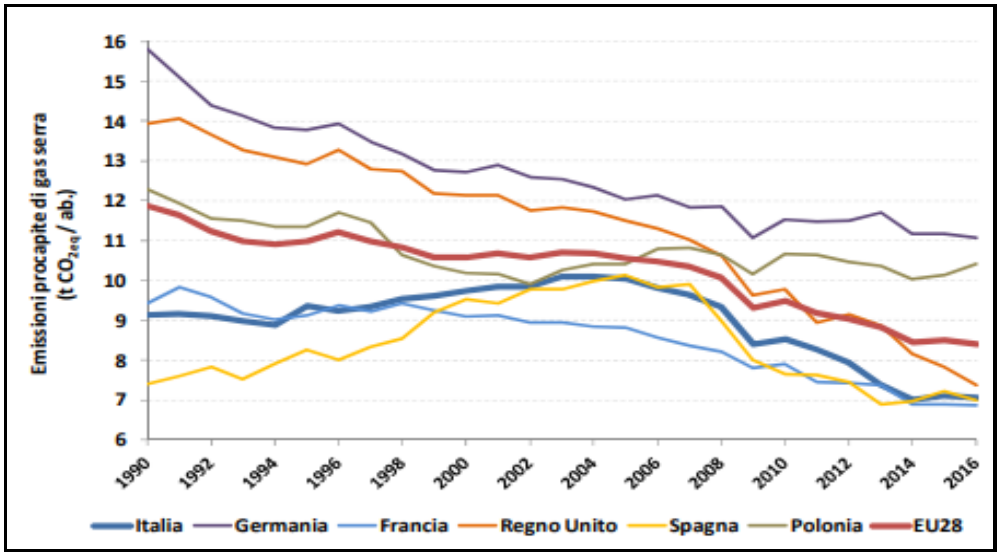
Focusing on the European per person consumption average (3.49 tep/ab), Italy, Spain and Poland are the countries characterized by the lowest consumptions. While Germany and France are the two countries in which consumption is over the average.

Since 2005 the consumptions have been reduced for many reasons, including the plant relocation. In general, since 2005 in the European Union

[10] *Geographical information: The European Union (EU) includes Belgium, Bulgary, the Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and the United Kingdom.*

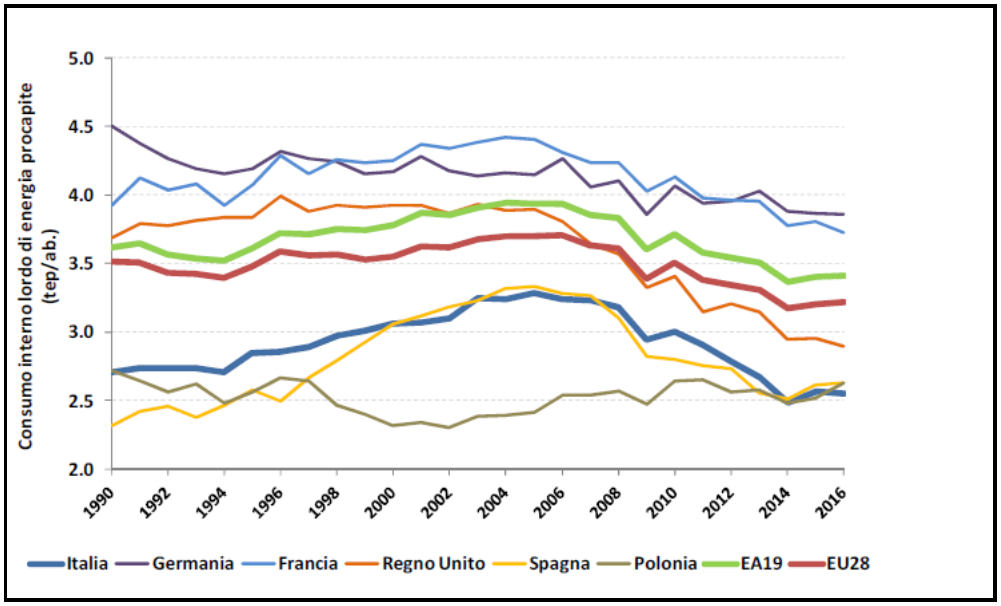
the reduction of the gross energy consumption was -13.2%, except for Poland that in 2016 recorded an increase of 8,9% (fig. 2.7).

Figure 2.6: Emissions per capita of GHG



Source: ISPRA (2018)

Figure 2.7: Trend of the gross domestic energy consumption per capita



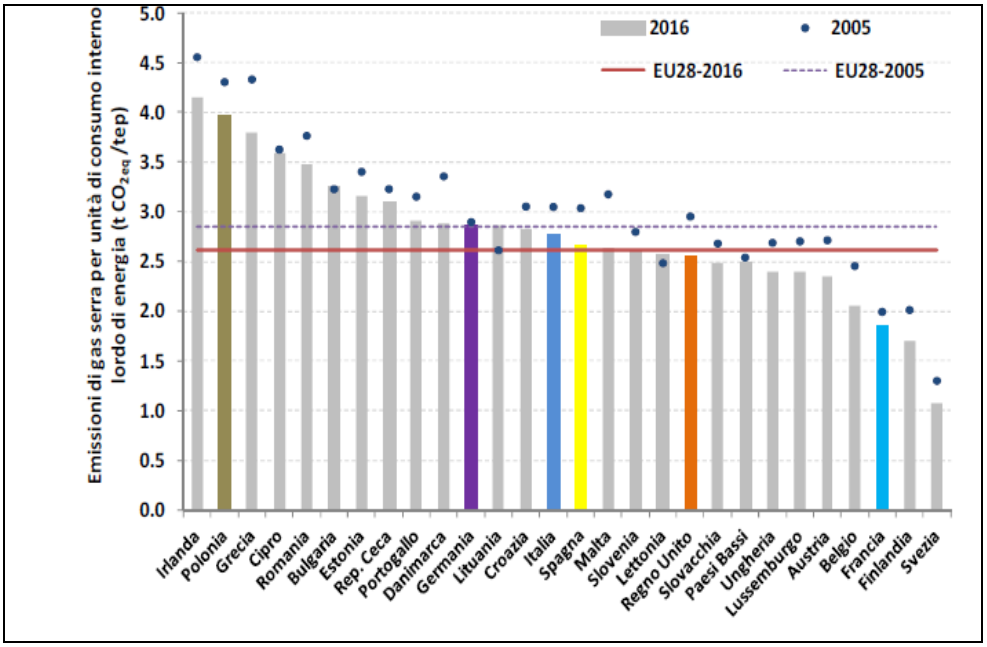
Source: ISPRA (2018)

Starting from 2015, the CO_2 emissions have been decreasing together with the consumptions. The reductions of the emissions are due to different factors: such as the technology innovation which allows to use fuel with a low quantity of CO_2, the renewable energy sources, the economic crisis

started in 2008 and the climate changes which influence the energy consumption.

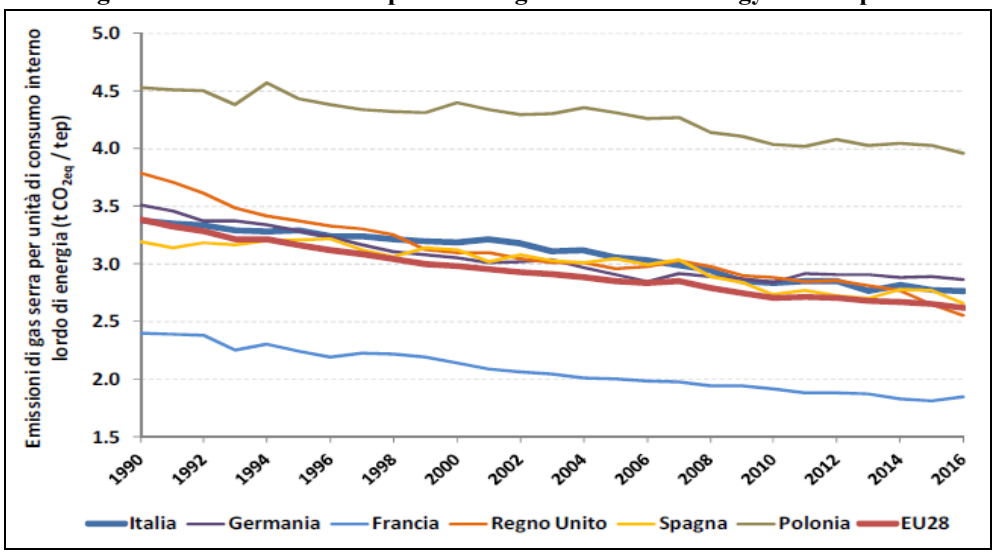
All these factors have caused a reduction of the emissions connected to the energy consumption in all the European States in the recent years compared with the first years of 2000 (fig. 2.8; fig. 2.9).

Figure 2.8: GHG emissions per unit of gross domestic energy consumption



Source: ISPRA (2018)

Figure 2.9: GHG emissions per unit of gross domestic energy consumption



Source: ISPRA (2018)

In order to understand the levels of emissions regarding Italy, and since consumptions and emissions are high connected, it is important to make an

assessment of the different sectors presented in the whole nation, focusing on consumptions that characterise every sector. In the following assessment only energy consumptions are taken in consideration, and their consequent emissions change from a sector to another. The sectors are characterized by variable consumptions which depends on the demand of the final users and the circumstances in which they work. The economic crisis of 2008 is an example: it had a really important role in changing the consumptions and, hence, the emissions. In addition to the economic crisis of 2008, there are others that influenced the energy consumptions, such as socio-political factors, climate changes and, finally, the introduction of renewable sources. Because of these different factors from 1990 to 2016, consumption in all sectors has not remained constant but had different trends depending on the circumstances that characterized the different periods (tab 2.3).

Table 2.3: Energy final consumption by sector (ktep)

Settore	1990	1995	2000	2005	2010	2015	2016
Industria	35.766	36.020	39.738	39.858	31.253	25.810	26.169
Trasporti	34.224	38.574	42.519	44.836	41.734	39.541	39.110
Residenziale	26.060	26.322	27.590	33.922	35.393	32.494	32.185
Servizi	8.174	9.817	11.542	15.053	16.979	15.391	15.440
Agricoltura	2.908	3.022	2.905	3.009	2.716	2.663	2.650
Pesca	200	230	259	313	224	188	221
Altro	379	593	166	162	160	143	155
Totale	**107.711**	**114.578**	**124.720**	**137.153**	**128.459**	**116.231**	**115.931**

Source: ISPRA (2018)

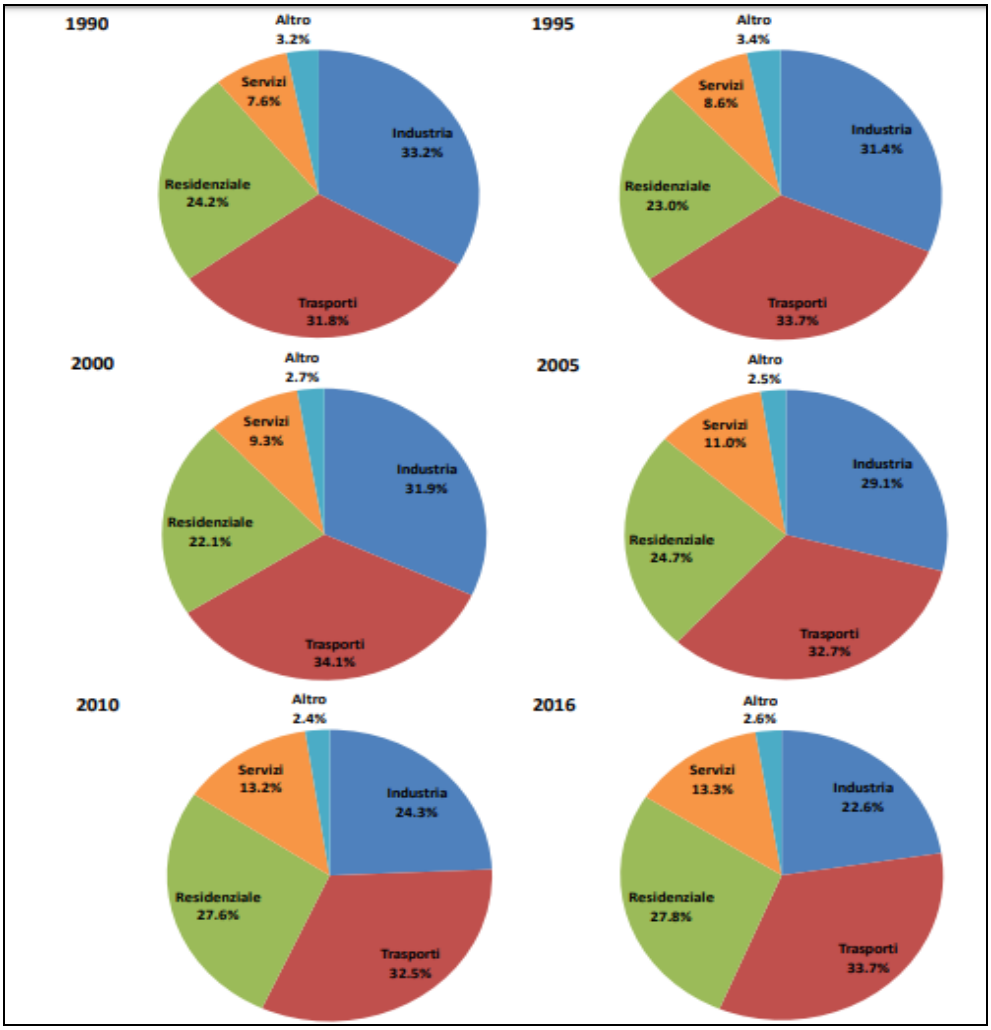
The two sectors that have required more energy in the past years were the industry and the transport sectors. Comparing the consumptions of 2016 with those of 2007, (that is the year before the crisis), a reduction in the final consumption of 31.2% for the industry sector, and of 14.5% for the transport one is evident, as reported by ISPRA (2018).

Always considering this time frame, there is also a reduction in consumption in the agriculture sector for 8.1% and fishing for a value of 24.9%. The reasons behind these reductions are mainly due to the 2008 economic crisis.

The residential sector, on the other hand, is a different area where there is a 0.5% decrease in consumption, but with large fluctuations that do not allow to understand whether these changes in consumption are due to the crisis or to other factors such as, for example, the different climatic conditions.

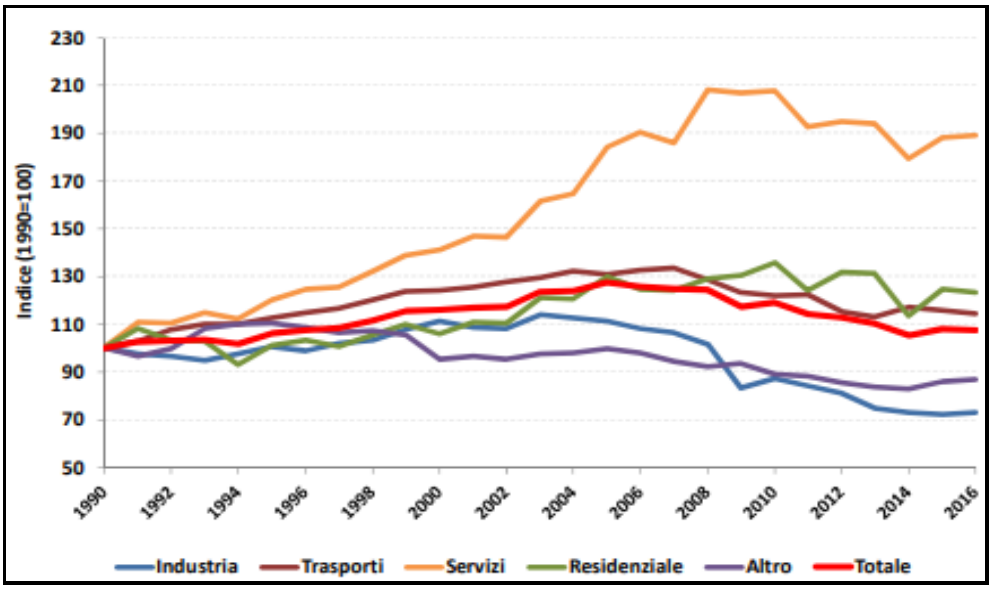
An analysis of final consumption from 1990 to 2016 shows an increase in consumption for services from 7.6% to 13.3%, while the industry has decreased from 33.2 in 1990 to 22.6% in 2016. Residential consumption is characterized by a strong oscillation but with a final increase, while the fishing and agricultural sectors have remained quite stable, with a fall since 2008 and then a gradual increase (fig. 2.10; fig. 2.11).

Figure 2.10: Subdivision of final energy consumption for the different sectors



Source: ISPRA (2018)

Figure 2.11: Annual variation of the final energy consumption

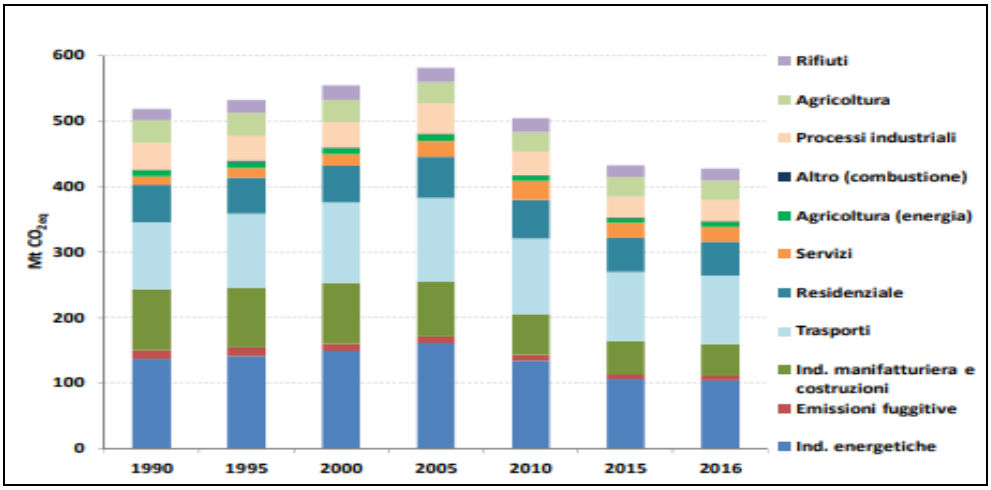


Source: ISPRA (2018)

As reported by ISPRA (2018), in accordance with consumption trends, the emissions trend also decreased from 2007 onwards, marking a national reduction of 17.5% compared to 1990 and of 26.3% compared to 2005. In general, the reduction in emissions occurred in all sectors.

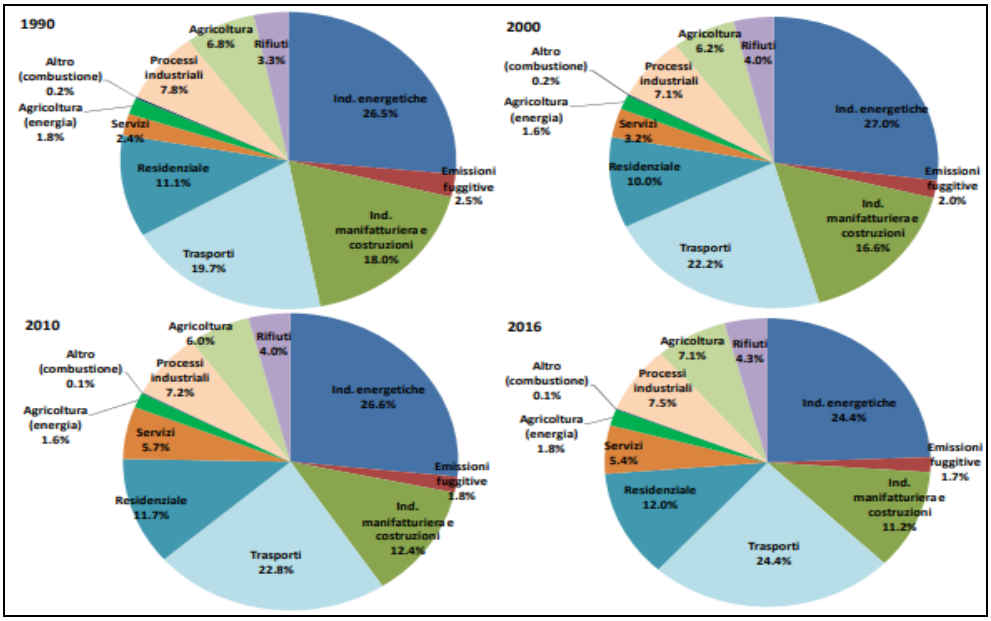
Analyzing each individual sector, it is evident that the manufacturing and construction industries have a 10% reduction in emissions from 1990 to 2005, and of 42.9% from 2005 to 2016. The transport sector, on the other hand, has a constant growth up to 2007, and then had a turnaround with a reduction in emissions in 2016 of 2.4% compared to 1990. The only sector that marks an increase in emissions is the civil sector. This sector is made of the residential and the services sectors. While the residential sector shows a 10.6% reduction in emissions, the service sector shows an increase of 89.1%, resulting in the entire civil sector emissions up to 7%. It should be noted as in 2016 the industry sector (which includes the manufacturing industry, the construction industry and the energy industry), with the transport and service sector, and the agriculture and fisheries sector represent 81.1% of the total national GHG emissions, down on the emissions of 2008, in which the percent was 83.1%, and the average value started from 1990, which is equal to 82.4% (fig. 2.12; fig. 2.13; fig. 2.14; tab. 2.4; tab. 2.5).

Figure 2.12: GHG emission by sector



Source: ISPRA (2018)

Figure 2.13: Allocation of GHG emission by sector



Source: ISPRA (2018)

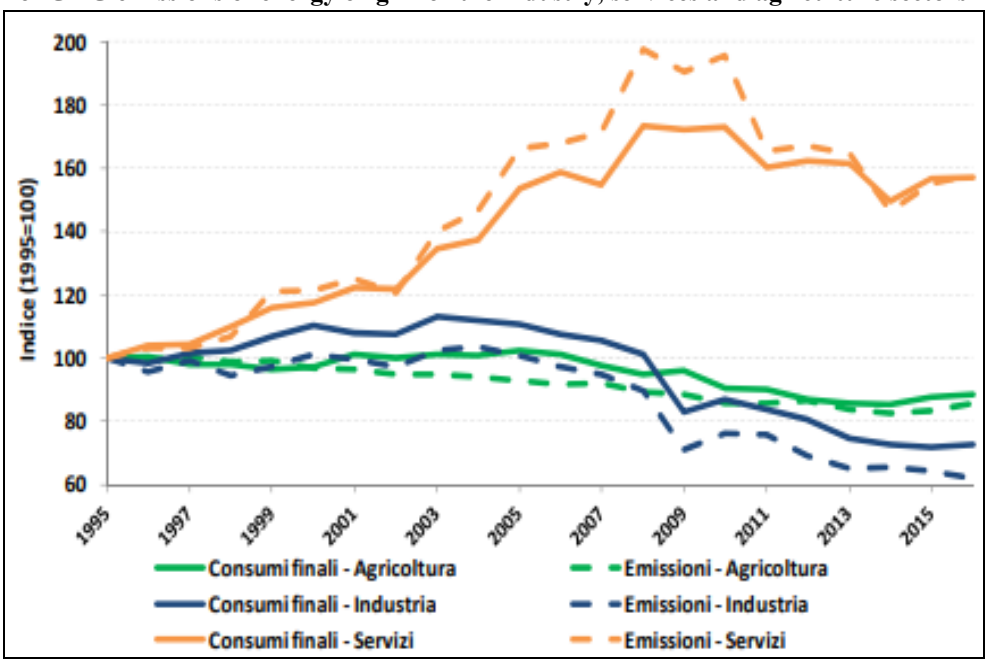
Table 2.4: GHG emission by sector (Mt CO_2eq)

Tabella 1.6 – *Emissioni di gas ad effetto serra per settore (Mt CO_{2eq}).*

Settori	1990	1995	2000	2005	2010	2015	2016	Δ %
				Mt CO_{2eq}				1990-2016
Industrie energetiche	137,2	141,7	149,5	161,3	134,0	105,8	104,4	-23,9%
Emissioni fuggitive	12,9	12,1	10,8	9,4	8,8	7,6	7,2	-43,9%
Industria manifatturiera e costruzioni	93,2	91,3	92,2	83,9	62,6	50,9	47,9	-48,6%
Trasporti	102,1	113,6	123,3	128,0	115,2	106,0	104,5	2,4%
Residenziale	57,5	54,7	55,7	62,4	58,9	51,2	51,5	-10,6%
Servizi	12,3	14,7	17,9	24,5	28,9	22,9	23,3	89,1%
Agricoltura e pesca (energia)	9,1	9,6	8,9	9,3	8,1	7,7	7,8	-14,8%
Altro (combustione)	1,1	1,6	0,9	1,3	0,7	0,5	0,5	-53,4%
Processi industriali	40,5	38,3	39,2	46,7	36,4	32,3	32,1	-20,7%
Agricoltura	35,1	35,0	34,3	32,1	30,1	29,4	30,4	-13,4%
Rifiuti	17,3	20,0	21,9	21,9	20,4	18,6	18,3	5,6%
LULUCF	-3,0	-21,6	-15,7	-27,5	-30,6	-35,3	-29,9	883,5%
Totale senza LULUCF	**518,4**	**532,6**	**554,5**	**580,9**	**504,0**	**432,9**	**427,9**	**-17,5%**

Source: ISPRA 2018

Figure 2.14: Percentage change with respect to 1995 of final energy consumption and of GHG emissions of energy origin for the industry, services and agriculture sectors



Source: ISPRA 2018

Table 2.5: Average annual variation in energy intensity (tep / M €) by production sector

	Variazione media annuale (%)			
Settori	**1995-2000**	**2000-2005**	**2005-2010**	**2010-2016**
Agricoltura	-2,5%	2,0%	-2,3%	-0,8%
Industria	0,7%	-0,6%	-3,2%	-2,1%
Servizi	1,3%	4,4%	2,2%	-1,7%
Totale	**0,4%**	**0,5%**	**-2,3%**	**-2,2%**

Source: ISPRA 2018

From what has been mentioned so far, starting from the analysis of comparisons between European countries and observing the analysis just made on Italy, it is clear that each country has its own history and its own priorities. The reasons that lead it to be characterized by a certain amount of emissions produced each year depended also on the sector analyzed. The consequence is that there are many difficulties to find an agreement between the different countries to solve or, at least, decrease the problem of the global warming. Focusing on the actions which can be taken, there are three main possible solutions:

1. *No actions*

   This solution assumes that humans adapt themselves to the climate change, doing only actions to adapt themselves to the

consequences of global warming, without any type of attempt to contrast the climate change. In order to accomplish this solution, the governments should take actions only to find solutions which limit the harms caused by the environment due to climate changes.

2. *Balance climate effects*

The idea in this case is to try to balance the effects of climate changes using technology. The basis of this logic is that technology has reached a status in which it is able to eliminate the carbon present in the atmosphere. As mentioned in the work Bhattacharyya C., S. (2011), it would be possible "*shooting iron particles in the atmosphere and fertilising the ocean with trace iron*" since "*the biological activity of the oceans could be increased by sprinkling iron on the ocean surface*".

Even if this idea seems to be a useful strategy in theory, it is really hard to put it into action because there are some limits, such as the cost of this operation since it needs a huge quantity of iron, and the difficulty of concretise the idea.

3. *Prevent actions*

This third solution considers actions that prevent GHG emissions. Compared with the other two solutions, this one is the one that has received the most attention by the public opinion and it is likely the best solution to apply to the energy sector.

The basic concept is decreasing the emissions coming by the fossil fuel, changing fuel, or decreasing the emissions, or even adopting other solutions in order to decrease the presence of emissions effects (e.g. planting new trees or installing some new technologies not able to disperse gas in the air and so on). In contrast to the actions to balance climate changes, it is really difficult to predict a priori the cost of these actions because it depends on many factors.

Anyway, this type of solution is the most common in many sectors and there are some useful actions that are possible to make in each sector (tab 2.6).

Table 2.6: Mitigation options at the sector level

Sector	Option
Energy	Efficiency improvements for end-use appliances and energy supply technologies
	Improvements in transmission and distribution systems
	Switching to low carbon fuels and renewable energies
Transportation	Fuel efficiency improvements
	Fuel quality improvements
	System planning and demand management
	Switching to non-energy intensive modes
	Modal shifts and fuel switching (including bio-fuels and other alternatives)
Forestry	Better forest management and control of forest clearing
	Growing forests and re-forestation
	Re-use products and reduce demand
Agriculture/land use	Better fertiliser use practices and control systems
	Crops of large carbon sequestration capabilities
	Livestock management
	Use agro products as a fuel

Source: Bhattacharyya C., S. (2011)

Regarding the energy market, the actions used to fight global warming are almost all included in the "*prevent actions*". To date, the focus is on 4 types of prevent actions:

- Tax on CO_2
- Development of renewable energy
- New tariff structure
- Nudge

All these 4 actions could affect the retail sector, influencing the choices of customers. The idea is to find out which of these four actions is able to influence more clients, and lead them to have a more rational behaviour and more awareness about their impact on the environment.

Chapter 3

THEORY VS REALITY

As mentioned in the previous paragraph, one of the most important topics that is stressed in all the economic discussion in the world is how to limit, reduce or, even better, eliminate the problem of climate changes. This problem is often aggravated by both some economists' attempts to achieve optimal social welfare, and by some failures in people's behaviour.

Regarding the first point, an example is given by the liberalization of energy. It is clear that the liberalization process described in the first chapter has the aim, at least in theory, to lower tariffs, reducing the cost of them, so as to enable largest percentage of people to be able to access the use of electricity, and use more quantity of it. At the same time, however, the liberalization process could have a really negative impact on the environment, because a greater use of electricity leads to a higher GHG emissions and, hence, has a greater environmental impact, with the consequent worsening of the problem of global warming.

Regarding the second point, the problem is aggravated by the fact that in reality, people are different from those described by the theory and often they have some behaviours that are completely irrational. This brings forth negative consequences such as overconsumption and inflexibility over the period of the energy use. These behaviours sometimes lead people to do actions which worsen the problem of climate changes, rejecting the idea to invest in efficient energy. This fact forces policymakers to take actions adopting different measures, from time to time, to induce individuals to behave in the same way they should do if they were rational. The aim to limit the environmental impact was one of their priorities. Despite the actions of policymakers, often people persist on having irrational behaviours for different reasons, and thus the policies are not completely efficient.

Standard economic theories predict that customers are rational people who live in a world without asymmetric information, and who can use all the

information to maximize the utility of the goods that will be consumed. The customers' satisfaction is expressed by their willingness to pay for a particular good or their willingness to move from a particular situation to another. In the attempt to maximize their utility, "*economic*" people exclusively care about their own interests, and the only obstacle to achieve the highest level of utility is represented by the financial constraint. These kind of people are the so called homo economicus, as they are described by Thaler, the American economist who has been awarded with the 2017 Nobel prize, and Sunstein in 2008. In their book they say that "*if you look at economics textbooks, you will learn that homo economicus can think like Albert Einstein, store as much memory as IBM's Big Blue, and exercise the willpower of Mahatma Gandhi. Really*". But, the really relevant point is that they also add that "*the folks that we know are not like that. Real people have trouble with long division if they don't have a calculator, sometimes forget their spouse's birthday, and have a hangover on New Year's Day. They are not homo economicus; they are homo sapiens*".

What Thaler and Sunstein have stated, is not only in line with what was affirmed at the beginning of this paragraph, but it confirms as in the real world the "*homo economicus*" does not exist. There are plenty of behavioural barriers such as asymmetric information, inertia to stay in the status quo and so on, whose consequences are suboptimal choices, with overconsumption and underinvestment decisions. All these behavioural barriers have the consequences that many of the solutions found by the policymakers are inefficient, and that the problem of the negative impact of human actions on the environment is aggravated. This is mainly due to the fact that these behaviour barriers do not let people properly balance benefits and costs of their actions, therefore they are not able to make the right decisions.

It is important to consider that it is essential to find some efficient solutions and some environmental public policy interventions. Preserving and encouraging all factors and practices that can contribute to the quality of the environment on a long-term basis, promoting energy efficiency. It is

important, hence, to carry out a detailed examination of the main limitations characterizing people, in order to design appropriate policy responses.

3.1 Limitations of people

In order to design some appropriate policy responses, it is important to realise which are the main behavioural failures resulting from the irrationality of people that hinder the process of achieving the theoretical economic world. This was described by the standard economic theory and that marked a gap between the economic homo and the real one. Among those that are possible to find in literature, three are the main ones: "*Bounded rationality and the consequent algorithm*", "*inertia*" and "*inattention*".

3.1.1 Bounded rationality and the consequent algorithms

Consumers are characterized by cognitive limitations and this explains the trend to look for simplicity. The cognitive limitations do not allow people to properly balance benefits and costs of their actions. In order to maximise their own utility, especially in the most complex situations, customers use some mental shortcuts or heuristics which allow them to achieve a solution that is not always the best option. Regarding the electricity world, the attempt of customers to find the best solution by means of heuristics is due to complexity of energy tariffs. As it is explained by Wilson C. M. and Waddams Price C. (2010), consumers do not always get the desired earning and, in a significant percentage, consumers may find themselves losing a part of their surplus by making a change of contract. The work of Wilson C. M. and Waddams Price C., is based on two dataset from the UK electricity market, and it is focusing on the clients who have changed the supplier essentially to reduce their rates and, hence, to find a more profitable offer. Wilson C. M. and Waddams Price C. show that in the best of the cases a percentage between 17% and 32% end up choosing a more expansive supplier, losing money. Moreover, for the costumers who have been able to choose the cheapest supplier among all the alternatives (a percentage

between 8% and 20%), not one of these is able to appropriate of the whole earning but only of a percentage between 30% and 52%.

These results also highlight other critical issues that complicate the achievement of liberalization aims. The difficulty in gaining from a contract change and the costs of the switching, reduce the incentive for the clients to change the suppliers and decrease the effects of the competition, which, instead, should be the main aim of the liberalization.

In line with what the economic theory suggests, a solution to overcome this problem and to simplify customers' decision-making process, is to provide them with more information.

3.1.2 Inertia

Inertia is one of the intrinsic characteristics of all individuals that leads them to be reluctant towards changes, and to prefer habits even when the change could lead to a possible improvement or earning. And it is the uncertainty about earning (or improvement), one of the reasons that lead people not to easily take actions and decisions, that both require greater justification than inaction, and the fear of regretting the choices made. That means that people prefer remaining in their status quo, even if this leads to disadvantages.

Focusing on the electricity world to understand this limit, it is important to consider the results showed by Hartman R., Doane M. and Woo C. K. (1991). In their work they show how consumers' status quo might undermine economic rationality, "bias" consumer decisions. They prefer accepting risks, having a higher probability to run into interruptions in the electricity service (Willingness To Accept (WTA)), rather than leave the status quo (Willingness To Pay (WTP)).

Their experiment strongly confirms the irrationality of people and the importance of the effects of inertia (or status quo). Since they showed that the WTA and the WTP estimate how "*sample customers differ by an order of magnitude of four to one, larger than would be expected from any reasonable income effects*".

One of the main reasons at the basis of inertia, is the uncertainty about the future consequences of actions. In according with the work of Kahneman,

D., Tversky, A. (2000), the uncertainty reflects the fear of losing. This concept of "*loss aversion*" is a recurrent topic in literature as one of the main causes of the status quo. It has also been studied by Samuelson, W. and Zeckhauser, R. (1988), where, with some experiments, they explain the tendency of people to do nothing and stick to default options. The concept of "*loss aversion*" has also the consequence that people prefer to concentrate on not losing rather than gaining.

Another reason that explains the tendency to stay in the status quo rather than leave it, is the so called "endowment effect", namely the tendency of people to give greater value to the goods they already possess. And this is a limit to the achievement of the theoretical world described by economists since it is a violation of customer theory.

Other reasons behind inertia can be found in the difficulty of making a decision every time an individual has to choose among a variety of choices. The variety of choices means that it is more difficult to understand what is actually the best for us. And the choice in this case requires more effort since people prefer to avoid decisions and prefer doing nothing.

In order to reduce inertia it would be useful to suggest solutions that provide choices to be selected, and that may reduce as much as possible the uncertainty related to future consequences of our possible actions. With particular attention to the world of energy, it would be necessary to reduce the uncertainty related to future energy prices, so as to encourage investments in "*energy efficiency*".

To address inertia, a solution is suggested by the experiment carried out by Ebeling F. and Lotz S. (2015). The experiment is carried out using a method called "default effect" in which a contract, with some offers already sectioned, is offered to clients, and in the case customers do not want these selected offers, they have to deselect them.

The experiment, conducted in Germany, consisted in verifying whether the presence of selected offers modified the percentage of sale of the offers themselves. At this point, a group of people were given contracts with the selected offers, while another group was given contracts with unselected offers.

Focusing on selling offers related to renewable energy, the experiment highlighted how the contracts characterized by the "*default choice*", to have green energy, have increased the sales of renewable energy of about tenfold (69% in the opt-out case and 7.2% in opt-in case).

Apart from wanting to confirm the tendency of people to persist in the status quo, the experiment also allowed to assume that it is possible to exploit this inertia to direct customers towards a better personal and collective welfare.

3.1.3 Inattention

Even if customers were able to balance benefits and costs in a correct way, they would make some mistakes, because of an insufficient awareness about what they are doing. This lack of awareness can occur for several reasons, including a lack of attention on what they would do. This is due to the fact that getting information and using them to understand the consequences of their actions, requires time and effort.

Focusing on electricity, the phenomenon of "*inattention*" is shown in many works, including that of the ECME (Consortium of the European Commission) in 2010. In this work the attention is focused on the fact that 41% of consumers are not aware of the convenience of the tariff, while 53% do not know their energy usage.

In order to overcome the problem of inattention there are some strategies, from the social pressure to some economic strategies, as mediations on the bills.

In both cases the aim is to stimulate the philological side of people, increasing their attention and their interest on the impact of their actions on the environment.

"*Bounded rationality and the consequent algorithm*", "*inattention*" and "*altruism*", that have just been described, are three of the several limits which hinder to reach the theoretical economic world described by economists.

Another limit that has not been mentioned yet is altruism. This phenomenon differs sharply from what is described by the theory that "*homo economicus*" acts exclusively for its own financial interest. But in reality it

is not so. People often perform altruistic actions that can also involve a cost, and only the action in itself is the one that profits from it.

Another example that differs the real world from the one theorized by economists, is how information is presented: information is often fragmented and differs depending on who receives them based on how they are evaluated.

Including the main limitations that prevent the achievement of the world theorized by economists, it is now important to try to understand what are the possible policies that can be implemented by the policymaker, in order to limit climate changes by encouraging energy efficiency, despite the limits generated by peoples' irrationality. In order to reach this goal, it is important, on one hand, to outline some new policies so as to discourage all the behaviours that increase the impact of GHG on the environment: such as pricing CO_2 or outlining new tariffs that would discourage overconsumption. On the other hand, to encourage any action that leads to a respectful behaviour of the environment: such as stimulating renewable sources or putting tariffs, and that would lead to more awareness and responsible behaviours.

3.2 Possible solutions

3.2.1 Pricing CO_2

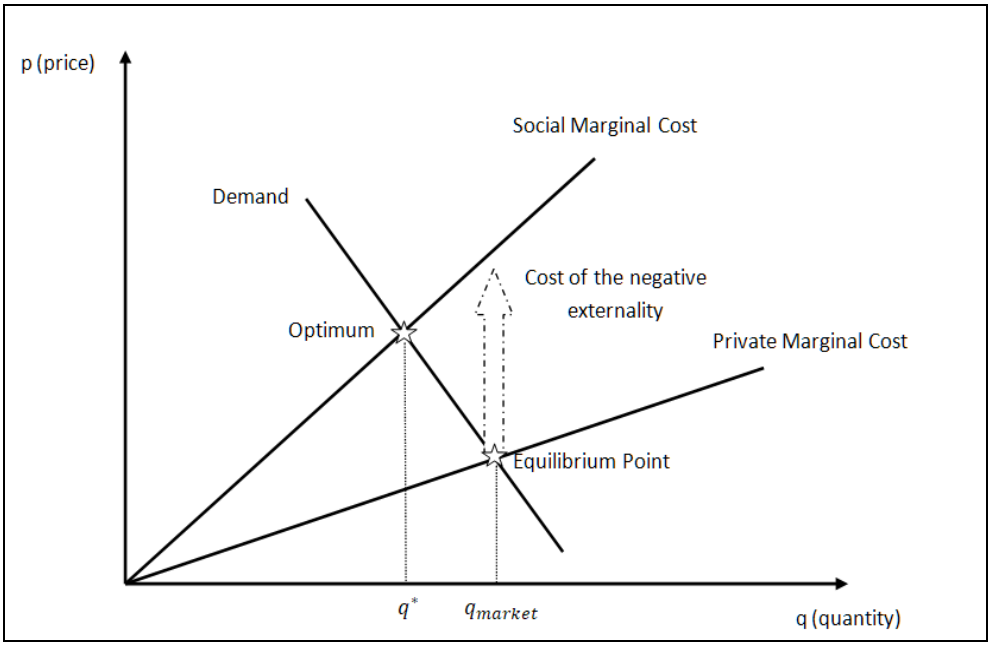
One of the first measures identified by economists to reduce GHG emissions in the environment is pricing CO_2 and other GHG emissions. The reasons behind these solutions is easily understood considering them as power producers. When they produce energy, they generate two types of marginal costs: the private marginal cost, the power producer has to extract the fuel and make the combustion; and the so-called negative externalities, which represent the future environmental damages. The sum of these two expenses entail the "*social marginal cost*".

To find a balance, it is necessary to analyse where the value deriving from the combustion of CO_2 intersects with the social marginal cost. Since the social marginal cost exceeds the private marginal cost, the result is that there

is an overconsumption compared to the optimal quantity. To correct this overconsumption it is necessary to make users pay more, in order to include external effects.

This is the justification behind the decision suggested by economists to tax CO_2 emissions (and GHG in general) (fig. 3.1).

Figure 3.1: Equilibrium and optimum CO_2 emissions



Source: Adapted from Thomas-Olivier Léauntier (2018)

There are two approaches for putting a price on carbon and they are:

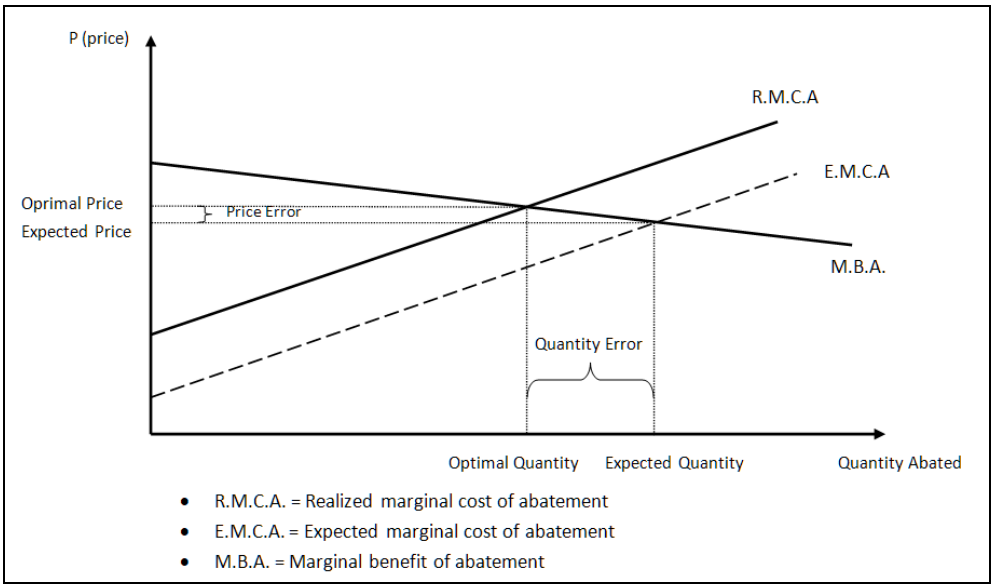
- *Pigovian tax*: which is a price intervention that puts a tax on every ton of CO_2 emitted and that allows users to decide the quantity of CO_2 to emit
- *The approach relies on tradable property rights*: this is a carbon market in which the policymakers decide a maximum quantity of emission volume that can be produced for a certain period, and the producers must comply with these emissions without departing, under penalty of high fines. Thus the maximum quantities of CO_2 emissions are determined and users decide the price for the permits

Both approaches are characterized by two common criticalities: being able to measure the amount of CO_2 emitted by each user; and quantify now what damage will cause in the future for each ton of CO_2. This latter problem, in

particular, is accentuated by the fact that in order to determine today the damage caused in the future by CO_2 emissions. It is necessary to have a physical model which connects CO_2 emissions to temperature, and to find also a coherent discount rate that allows to evaluate today's value of future costs.

These two problems are common to both approaches, and as we can see, the first one, the inclusion of a tax on emissions, would seem to be preferable as it is more powerful against uncertainties, as showed in an analyse conducted by Martin Weitzman, who is a professor of economy at Harvard University. In his experiment Weitzman, M. (1974), shows that when there is a mistake in setting the price of taxation, there is a smaller loss of surplus compared to mistakes made in setting the quantity (fig. 3.2).

Figure 3.2: Marginal cost and marginal benefit of abatement



Source: Adapted from Thomas-Olivier Léauntier (2018)

The approach that predicts a carbon pricing would also seem to be easier to apply rather than to set up an emission market. But it is important to underline that the carbon taxation would be effectively efficient if it was the same for all countries, while a different application causes the so called "*carbon leakage*" phenomenon. According to this phenomenon, taking as example two countries: if one applies a tax on coal and the other does not, the first will be economically disadvantaged, as it would risk having to

outsource its production in the country without taxation, with obvious repercussions in terms of productivity within its borders.

Furthermore, taxation on coal is a solution found by economists but not by politicians: they perfectly know that the benefits deriving from this policy against emissions are problems of the future, while costs are problems of the present, and politicians are chosen by their voters. This leads to be reluctant towards carbon pricing.

But the difficulties in applying this taxation are also due to different interests applied in various countries. As a matter of fact, some States have no interest in taxing emissions as they could benefit from a possible global warming (such as Russia and Canada), or, in any case, it is better for them to ignore the problem of climate change in favour of their growth (for example China and more generally all developing countries). Still others are the first to want an expansion of fuels (see, for example, Saudi Arabia).

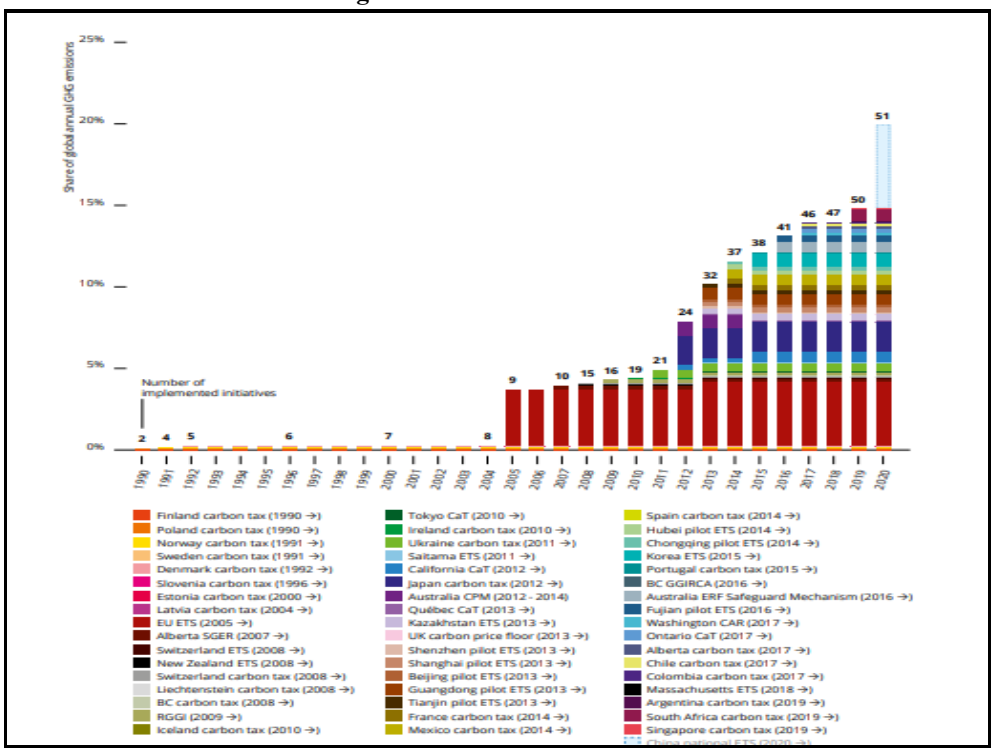
All these factors mean that the carbon pricing is not well seen if not by economists. Taxation, which would solve many problems if it would be the same for all nations, turns out to be different from nation to nation. In particular, in 2015, according to IEA data (2015), Europe was the region that taxed CO_2 emissions the most, and it priced 60% of its CO_2 emissions. Regarding the output price per unit, it should be noted that it is not stable as in the system of taxation, but rather as a market price that fluctuates. Among the European countries the first to introduce carbon pricing were the Nordic countries (tab. 3.1; fig. 3.3). The first in absolutely was Finland in 1990, followed by Norway and Sweden in 1991, and Denmark in 1992.

Table 3.1: Taxes as % of GDP, 1999

% of GDP	Sweden	Norway	Finland	Denmark
Energy taxes (excl. CO_2 taxes)	2.1	1.5	2.2	2.2
CO_2 taxes	0.7	0.6	0.4	0.4
SO_2 taxes	0.0	0.0	0.0	0.0
Total energy related taxes	2.8	2.1	2.6	2.6

Source: Bhattacharyya C. S. (2011)

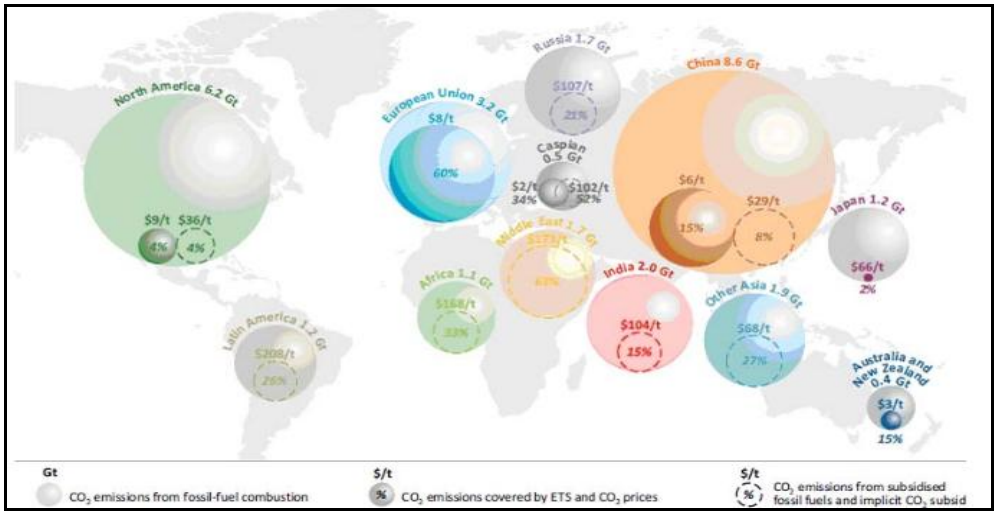
Figure 3.2.1: Regional, national and sub national carbon pricing initiatives: share of global emissions covered



Source: World Bank Group (2018)

On the other side there are regions like the Middle East where CO_2 emissions benefit from a subsidy. These subsidies have the main purpose of protecting domestic work by creating employment, even if this is at the expense of the climate changes (fig. 3.4).

Figure 3.4: Worldwide CO_2 emissions, subsidies and prices



Source: IEA(2015)

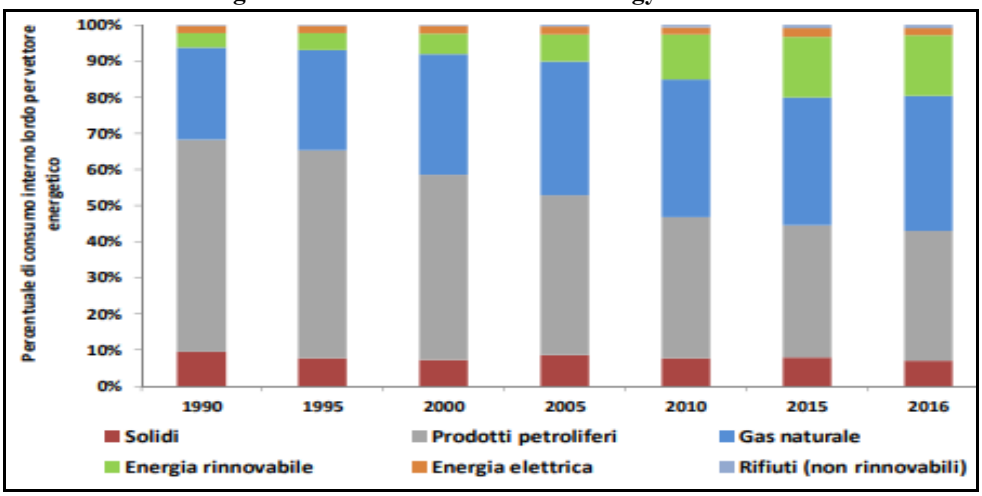
3.2.2 Renewable Energy Sources (RES)

Another perspective to face the problem of CO_2 and GHG emissions in the atmosphere is to focus on the development and use of renewable energy resources. Unlike what was said for pricing CO_2 and more generally GHG emissions, the sustainability of the development of renewable energy resources seems to be a solution appreciated by both politicians and public opinion.

The term "*renewable energy resources*" (RES), indicate all the resources that are inexhaustible in their duration as they self-regenerate. The main weakness of these resources is the uncertainty of the amount of energy that they can produce per unit of time, as they depend on natural and non-human factors. To understand this concept, we can think, for example, of photovoltaic panels: the amount of energy produced by these instruments depends on the amount of light they receive during daylight; while, in general, they do not work during night time.

The interest in this sector began to rise in the 1990s: as reported by ISPRA (2018), from 1990 up to 2007 there was an increase in the share of renewable sources that went from 4.2% to 9% of gross domestic consumption, reaching 16.8% in 2016 (fig. 3.5; tab. 3.2).

Figure 3.2.2: Trend over time of energy resources



Source: ISPRA (2018)

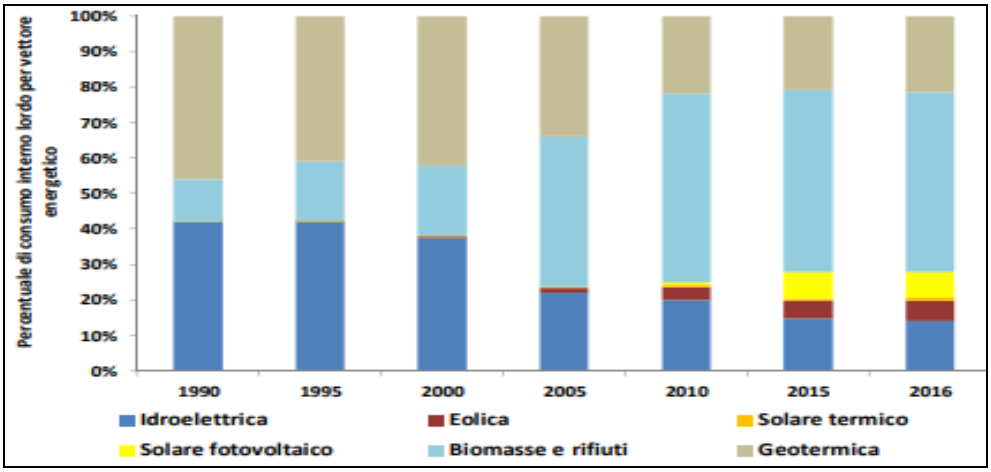
Table 3.2: Gross domestic consumption per energy source

Fonte	1990	1995	2000	2005	2010	2015	2016
Idroelettrica	2.719	3.249	3.800	3.101	4.395	3.916	3.648
Eolica	0	1	48	202	785	1.276	1.521
Solare termico	5	7	11	27	134	190	200
Solare fotovoltaico	0	1	2	3	164	1.973	1.901
Biomasse e rifiuti	777	1.294	1.993	5.983	11.611	13.445	13.177
Geotermica	2.971	3.167	4.259	4.791	4.776	5.469	5.571
Totale	**6.472**	**7.719**	**10.113**	**14.107**	**21.864**	**26.269**	**26.018**

Source: ISPRA (2018)

It should be pointed out that, in recent years, among the various forms of energy: solar, thermal and photovoltaic, wind power got significant value, and together they represent 13.9% of renewable energy consumption (fig. 3.6).

Figure 3.2.2: Relative share of renewable energy by source



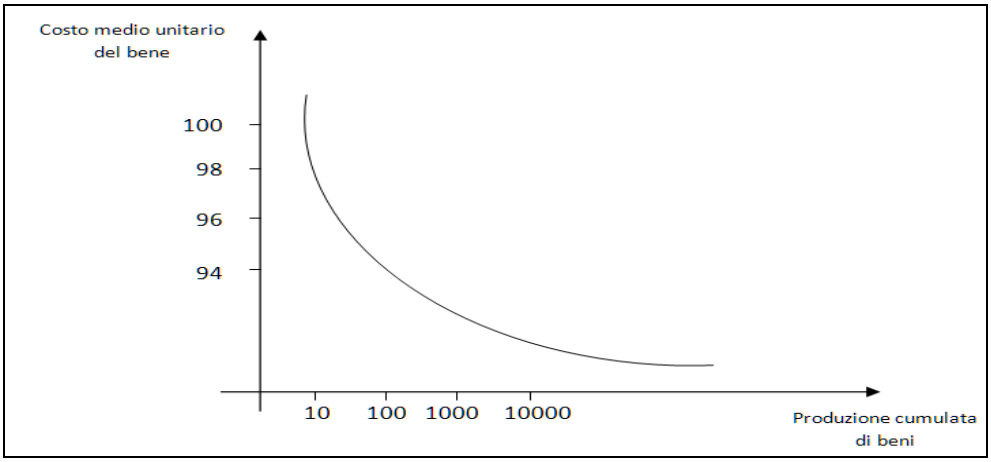
Source: ISPRA (2018)

Despite the considerable interest in this sector, it should be noted that it is a particularly recent one, it still has to be explored, and with deep research it could bring important news. The issue is that this sector is still in its initial phase of development. It led to an intense debate among economists whether it should be financed or not with state subsidies to allow it to develop.

There are many reasons for obtaining subsidies, even though some economists try to justify their doubts not approving them. Among the reasons in favour of subsidies, one is given by the externalities linked to learning economy (fig. 3.7). In learning economy there are regular and predictable reductions in the average unit costs of a product that occur as a

result of the increase in the production volume. The reason is that the development costs of a certain product are very high at the beginning, as it is necessary to make a massive investment in research and development in order to create the product and launch it on the market, and then over time the costs decrease. The decrease in costs derives from the skills accumulated over time by the company, skills that allow it to reduce costs, for example, in favour of a more efficient reallocation of resources.

Figure 3.2.2: Learning curve

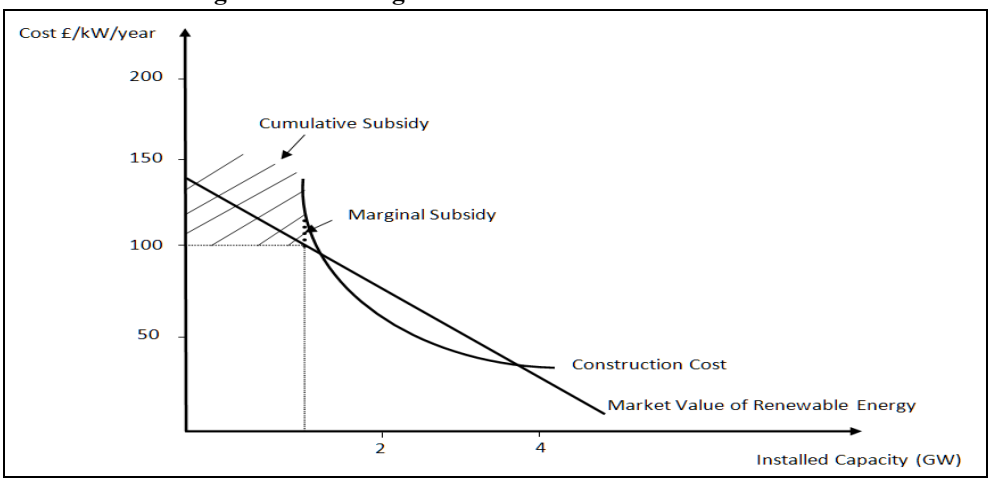


Starting from this concept, it is clear that all the companies that develop the first unit, which is the first mover to carry on the situation, find themselves at the beginning of the learning curve and, hence in the most expensive part, without the possibility of obtaining knowledge from other competitors. This, therefore, will lead them to develop units that will be more expensive than technologies that already are on the market. The problem arises when the first units are launched on the market, externalities are formed due to the fact that together, with the product on the market, the know-how of the first mover is also introduced. This know-how will be difficult to defend. Although there are different strategies to try to defend it for example patents. Competitors have different ways to completely or partially appropriate the know-how of the first mover and exploit it to their own advantage (e.g. reverse engineering, manufacturing similar units even if not equal and so on). This phenomenon discourages the first mover that will tend not to invest at a level that would be excellent at a social level, but it leads him to make an underinvestment, with a consequent loss of surplus

both for himself and for the general community. To try to avoid this behaviour it is necessary to give a subsidy that encourages the first mover to make an investment that is socially excellent.

Focusing on the aggregate learning curve (which indicates the costs for the installation of the units), and assuming that the market value of the aggregated units is linearly decreasing with a minor slope of the learning curve, the subsidy to a marginal Megawatt of RES capacity will be necessary whenever the cost for the installation of an asset, will be greater than the market value of the energy produced by the asset, while it will not be necessary when the market value of the asset is higher than the cost installation (fig. 3.8).

Figure 3.2.2: Marginal and cumulative RES subsidies



Source: Adapted from Thomas-Olivier Léauntier (2018)

The fact that the sector is still in the early stages leads to a second reason that can encourage subsidies, namely the fact that investment in the development of new technologies is a risky activity. The only certainty is that money is invested in the new technology but nothing is certain about the results. A government subsidy helps to reduce this risk, reducing development costs.

In addition, a further motivation in favour of subsidies is the willingness on the part of individual States to be energetically independent: investing in RES would lead to less dependence on imports of fuel from abroad and, therefore, greater energy security even if the main defect of these resources is their uncertainty on productivity that depends on time. This means that on

one hand there would be more energy independence, but on the other hand there would be a risk linked to the fact that this type of energy source is currently not easily manageable.

Although the reasons expressed in favour of subsidies have valid foundations, many economists are doubtful about it. In fact, some economists doubt that using the learning curve externalities to justify a production subsidy is a trump card. As a matter of fact, although it is true that externalities lead to an underinvestment, economists agree that this situation linked to the learning curve is typical of many other sectors that, however, do not enjoy subsidies. Furthermore, new technologies are financed mainly by investors who also finance other risky projects that do not have subsidies. Finally, other economists point out that energy security is put at risk by the uncertain energy production given by RES and by the lack, at least to date, of complementary instruments that allow to resolve, if not at least partially, this uncertainty.

In the face of all this, economists are not reluctant to grant subsidies, but tend to agree that subsidies should be given more for research and development rather than for production.

Different types of subsidies

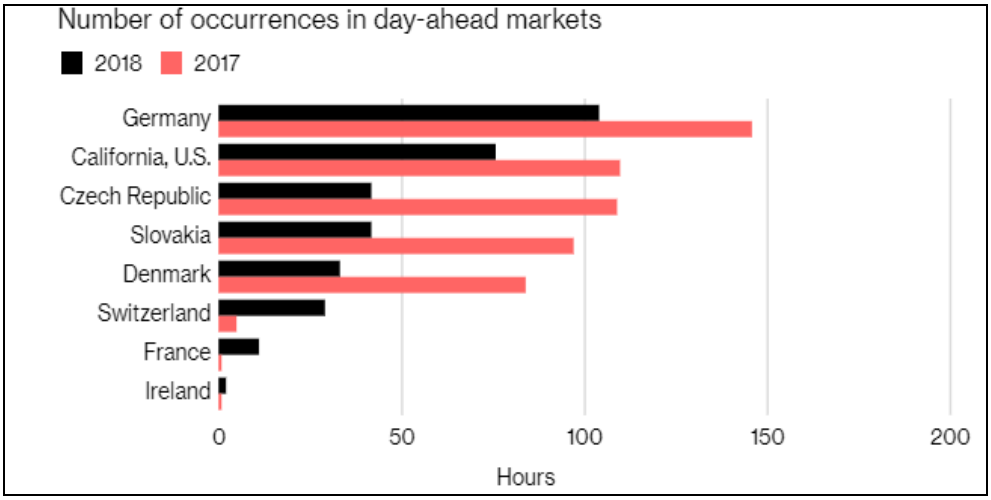
Over time, different approaches have been developed to support and, therefore, subsidize renewable resources. The first approach arrived in Europe was the feed-in tariff (FiT). This approach is essentially based on the local grid companies, that are forced to buy the energy from renewable generators at a fixed price and then resell that energy to retailers and then to final consumers, on which the purchase cost is added to the customers' bills. FiT has its peculiarity, precisely on the fixed price to which the local grid companies are obliged to buy energy. This price, at least initially, was administratively set with the advantage for the renewable generators of price security. Over time this support has been abandoned due to some critical points. A first limit to FiT is that, the guaranteed fixed price must be guaranteed to all companies that meet the requirements. Besides, in order to determine the fixed price, government officials rely on the costs of RES from official data, but also from surveys with manufacturers and developers

which tend to systematically overestimate their costs, raising the fixed price. Add to this, the fact that often the upgrade to a new value of FiT takes a long time, due to, as suggested by Léautier O. T. (2018b), lobbies that lengthen the bureaucratic times in order to be able to benefit with the new facilities of tariffs, calculated on old plants less efficient. It is clear how this approach results inefficient in giving a subsidy to RES. As reported by Léautier O. T. (2018b), the inefficiency of this support also emerges from an analysis carried out between 2004 and 2014 which highlighted how "*European taxpayers may have transferred somewhere between $ 50 billion and $ 100 billion of unjustified economic rent to the RES industry*" and, focusing on German customers, it was observed that "*the amount of subsidies ballooned: in 2016 to German retail customer paid around € 30 / MWh for the wholesale cost of energy and around € 60 / MWh for the RES subsidy*".

Another problem linked to FiT approach is given by the physical dispatch priority, namely the fact that the system operator must give priority to the outputs produced by RES, so that it is certain that the Megawatt-hours produced by RES are those actually sold.

As it can be expected, this type of sale has benefited RES companies because of the priority of spreading their output. On the other hand, it has created a general problem as these companies have the advantage of placing on the market their maximum capacity, regardless of the wholesale's spot price given that their revenues mainly depend on subsidies. This, combined with the problem that the energy produced by RES cannot be stored at present, has meant that even when the demand for energy is zero, there is a continuous supply with the consequent reduction in prices. There is a negative side of it: who produces has to pay to sell, and those who consume are paid to consume. Negative prices imply a decrease in net surplus and therefore a loss of value generated. Although it may seem only a theoretical risk, the phenomenon of negative prices has actually occurred in some European countries, including Germany and France, but also in countries outside Europe (fig. 3.9).

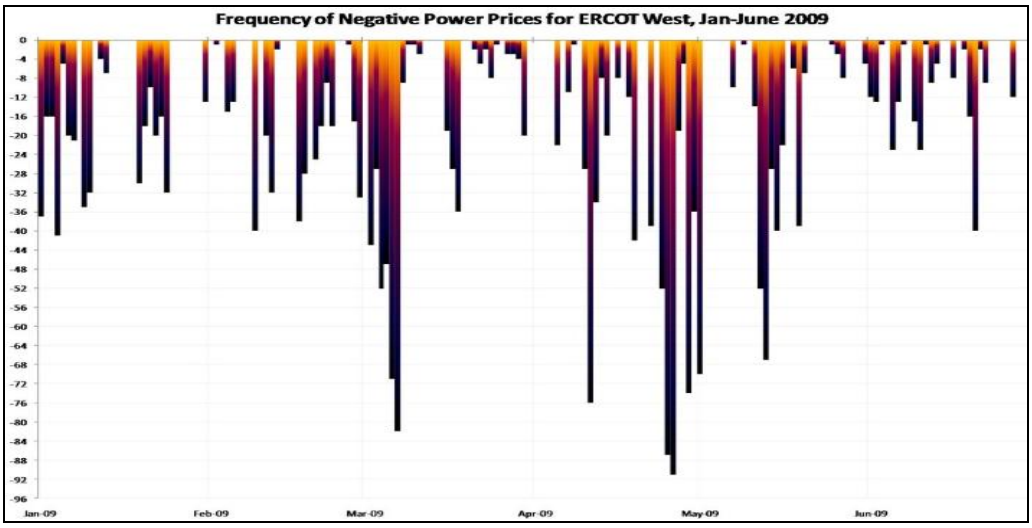
Figure 3.2.2: Negative Power Prices



Source: Epex Spot, Nord Pool, CAISO, SEMO and OTE

Outside Europe, there is a particular state in the U.S.A. that was most involved in this event: Texas. In the western part of Texas, in fact, the negative prices were verified for a third of the hours in the first semester of 2008 (Benedettini S. and Stagnaro C. (2014)) (fig. 3.10).

Figure 3.2.2: Negative prices: Frequency of negative prices for EROCT West, Jan-June 2009



Source*:* Giberson M. (2009)

It is reiterated once again that the problem of negative prices exist due to the combined effect of physical dispatch priority and subsidies. The first benefit causes RES producers to have priorities for their output, while the subsidies mean that this priority is used to market more energy than necessary, since it is cost-effective to operate until subsidies exceed in operating costs.

All this means that over time other solutions were sought to overcome the FiT subsidy. A first solution found was to always act in the manner described for the FiT approach but, instead of setting the price administratively, let the price originate from a market competition. This mechanism is called the "market-based approach" and it is a valid alternative to the FiT.

Another solution identified is feed-in premium (FiP). This approach is based on the fact that the producers sell their energy directly on the wholesale by applying a price increase that is an extra cost, most of the time determined competitively. This price increase will then be paid by final consumers. This approach leads producers to take on the risk of the market price and, therefore, become at least partly sensitive to the spot price. In any case, the problem of negative prices is not entirely overcome with FiP, as RES producers will produce and sell in the market until the wholesale spot price exceeds the opposite of FiP, as their revenue will be given, in the case of negative prices, from the incentive minus the market price.

A similar case, even if with different modalities, is what happens in the United States where for every MWh generated there is a renewable tax credit: in this case the subsidy is at the expense of the taxpayers.

Finally, a third method by which RES can be subsidized is an approach that focuses more on quantities than prices. According to this approach, it has been decided just how much renewable energy should be purchased by retailers from governments, but guidelines are not outlined on the conditions on how they should be purchased. In this way the generators will always have a guaranteed earning on the outputs but the price will again be determined through a market competition. Furthermore, in this way the government limits itself on checking the volumes of renewable energy that must enter the market, and not the prices at which it must be sold, thus having less difficulty controlling the amount of subsidies paid.

Problem linked to RES

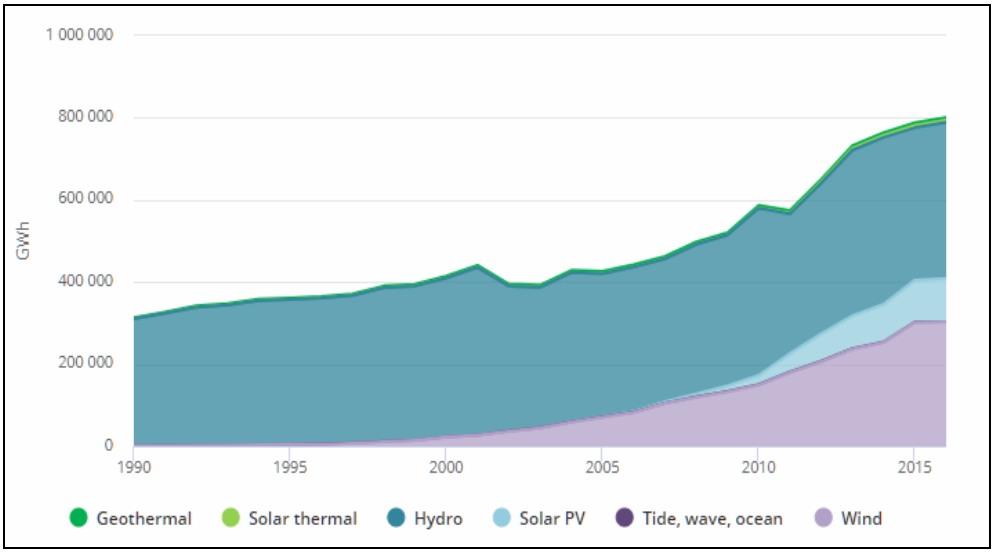
The main problem of RES is related to the impossibility of completely storing the created energy. This impossibility is accentuated by the fact that the production of electricity is variable over time, and it is based on

conditions that cannot be controlled by man. It is evident that, for example, a photovoltaic panel needs another resource that allows it to produce electricity, even during the night or when it is cloudy. Unfortunately, to date the development of energy does not give a lot of solutions, even if it must be said that the ways to store energy, at least partially, exist and are different: starting from batteries that can be of different types, such as lithium batteries or sulfur-ion batteries. The critical point of these methodologies of energy storage is given by the costs, but what is already happening, (and hopefully continue to allow an ever wider diffusion), is the reduction of costs and prices thanks to the economies of scale and learning. This is perhaps the main challenge for this sector which is in its early stages.

Impact on retail prices

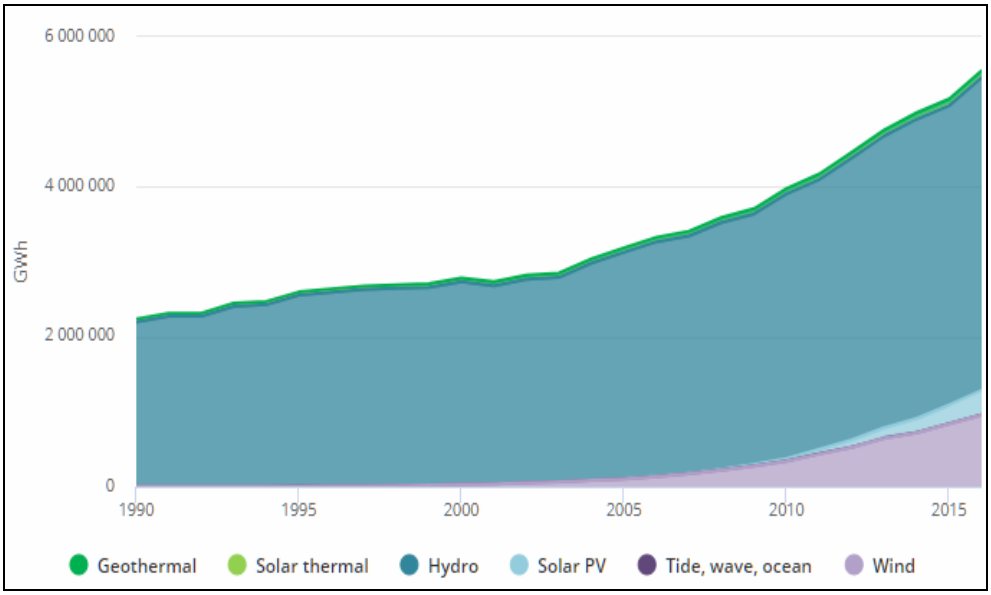
The various RES have rapidly increased and spread over the years both globally and at European level (fig. 3.11; fig. 3.12).

Figure 3.2.2: Electricity generation from renewable by source (EU28 1990-2016)



Source: IEA Electricity Information 2018

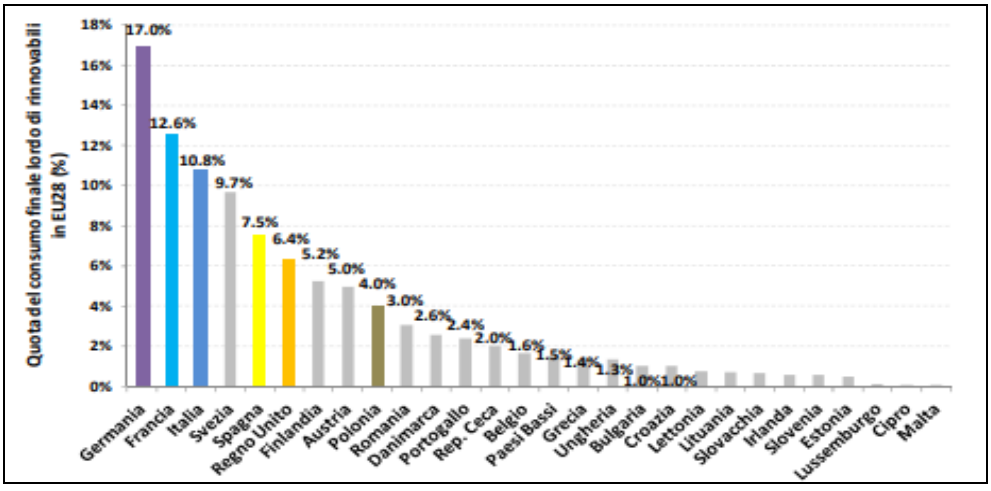
Figure 3.2.2: Electricity generation from renewable by source (World 1990-2016)



Source: IEA Electricity Information 2018

In particular, this spread has led to a greater gross domestic consumption of energy, deriving from renewable sources (fig. 3.13), with a reduction in costs. Spreading and reducing costs were certainly possible thanks to subsidies but, also thanks to the developers' ability to exploit economies of scale.

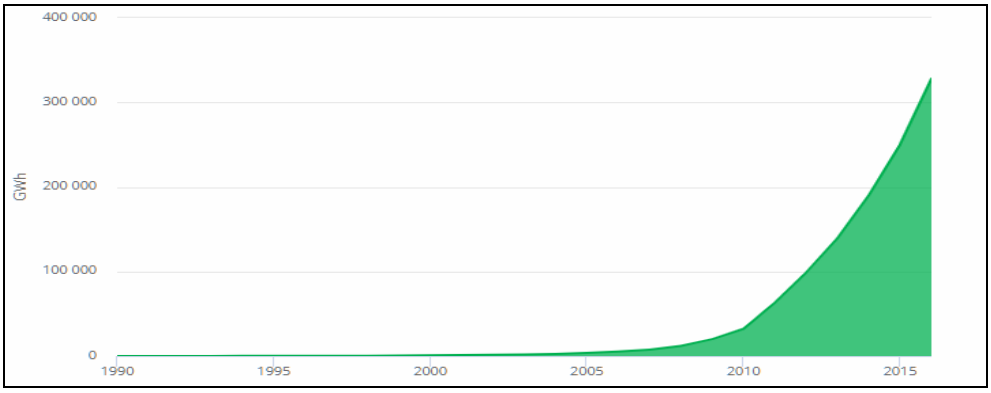
Figure 3.2.213: Share of gross final consumption of energy from renewable sources in EU28 (data 2016)



Source: ISPRA (2018)

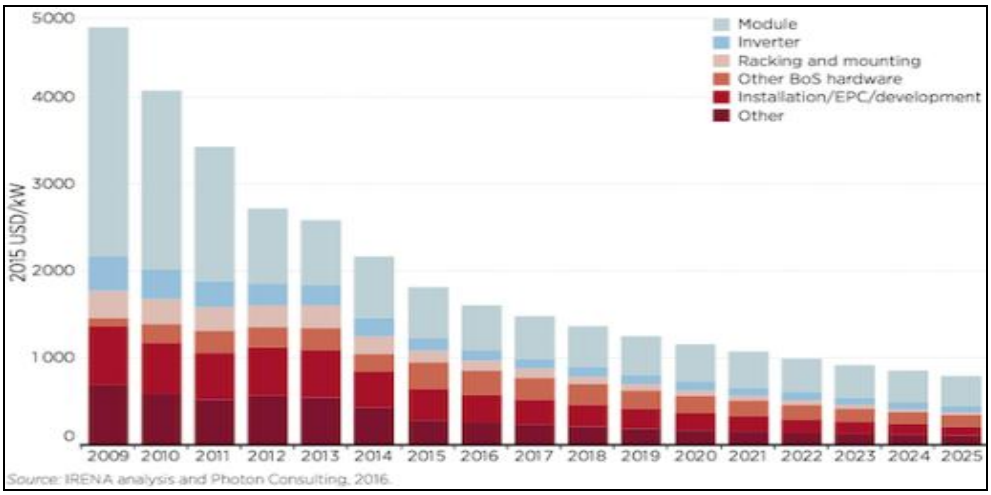
A significant example is the history of the costs of photovoltaic panels, which in 2016 had a cost less than half of that of 2009, thanks to an ever increasing diffusion of these resources (fig. 3.14; fig. 3.15).

Figure 3.14: Solar PV electricity generation (world 1990-2016)



Source: IEA Electricity Information 2018

Figure 3.2.2: Global weighted average total system costs breakdown of utility-scale solar PV system 2009-2025



Source: IRENA analysis and Photon Consulting 2016

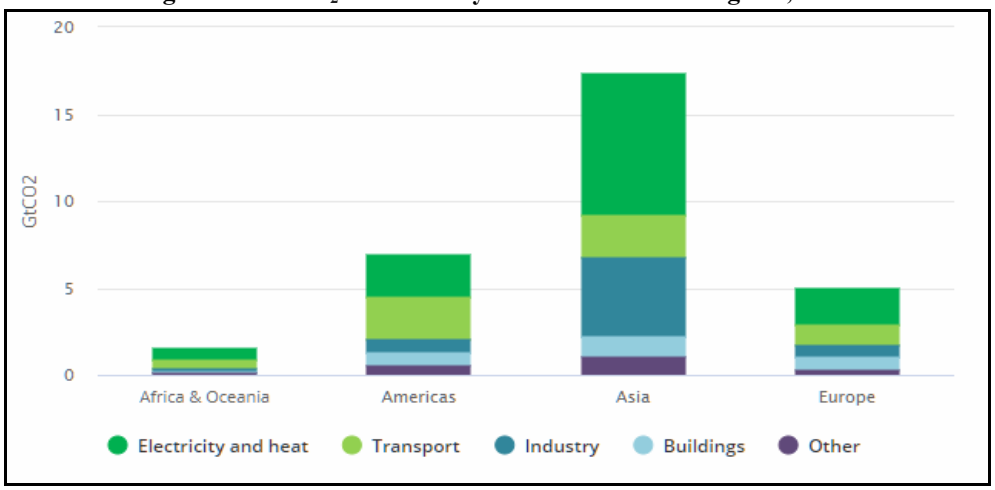
In particular, the diffusion of RES led, in the short run, to the abatement of the prices on the wholesale, since the RES are instruments with variable costs equal to zero. However, the same effect did not exist for retail prices, which increased due to subsidies. In fact, in all the previously analyzed subsidy cases, the higher price caused by the subsidy is generally added on the bill of the final consumer who, therefore, is ultimately the real financier of the development of RES.

3.2.3 Tariff schemes

GHG emissions are attributable to various factors, including the energy sector, whose emissions are a real emergency because of their size and the effects they have on climate change. As reported by IEA (2018), among the

different branches that make up the energy sector, the one that plays a major role is the power energy sector. The emissions due to electricity and heat in 2016 constituted 42% of the total emissions, mainly attributable to Asia that precisely (because of the electricity and heat generation), has produced emissions equal to ¼ of the global ones, and equal to 60% of the emissions produced by the power energy sector from all continents (fig. 3.16).

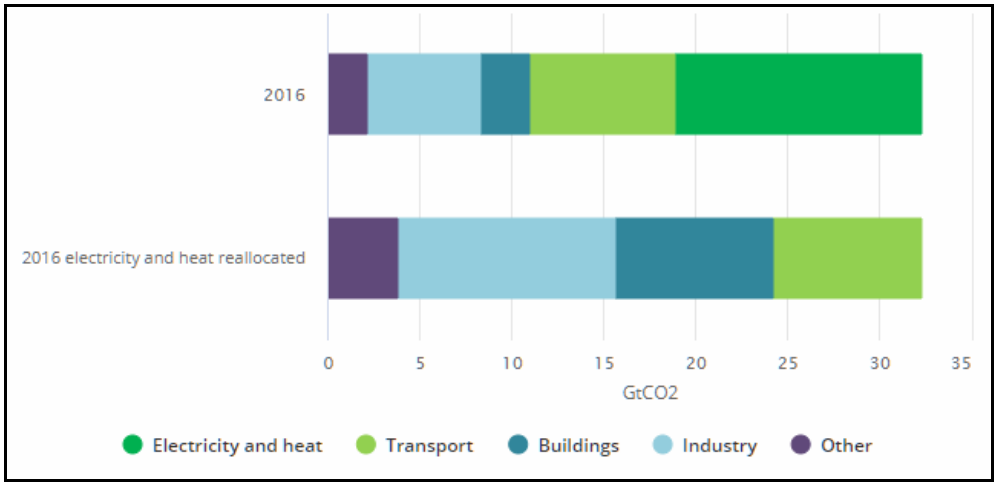
Figure 3.2.3: CO_2 emissions by sector for selected regions, 2016



Source: IEA (2018)

As it can be expected, electricity is used in various sectors, from industrial to transport. Allocating the emissions generated by electricity to consuming sectors, it is evidenced that industry is the largest emitter, followed by buildings and transports. It is also interesting to see how the building share increased from 8% to 27% out of the total (fig. 3.17).

Figure 3.2.3: Global CO_2 emissions by sector, 2016



Source: IEA (2018)

Since generating and consuming electricity is one of the main causes of global warming, it becomes essential to understand how to encourage individuals to induce them to have a more respectful and careful behaviour towards the environment. Changing their habits and starting to have greater attention to the positive effects of energy efficiency, would limit the negative externalities produced by their actions. In order to achieve these goals, they are experimenting with different tools, and one of these is trying to focus on people's economic interests.

One of the main aspects that characterizes the rational individual in economic theory that can also be found in real life is that every person when performing an action does so under a financial constraint, and acts for his own economic interest. There are some exceptions in some particular cases in real life, for example charity. The policymakers' efforts are not only focusing on this aspect, but are also focusing their efforts on encouraging individuals to adopt an attitude that is based on energy efficiency. Having a positive impact on the environment, emphasizes the advantages that people would have in their bills, and they would also have substantial savings.

In other words, what the policymakers are trying to do is to obtain a more positive environmental impact on people, starting from the awareness that each individual is interested in maximizing his benefits under a financial constraint. This theoretical conclusion is confirmed in real life by several studies conducted in the U.S.A., where it was clear that economic earning is the main driving force to induce behavioural changes, as reported by Rosenstock (2004).

Studies conducted in the U.S.A. are not the only experiments that have led to confirm this theory. Among others, it is important to highlight the studies conducted in Sweden, on the effect of feedback on households individual electricity use, which confirms the American results, as highlighted by Bartusch and Porathe (2011).

In this perspective, one of the techniques being studied and applied is that of trying to influence the behaviour of customers, through the tariffs applied to their consumption. The problem that persists, even in this case, is the irrationality that characterizes people, and that often leads them not to

behave in a coherent way with the tariffs imposed. This makes the application of such policies partially or completely useless. To overcome this problem it was decided to experiment with different types of dynamic tariffs, trying to understand which is the one that has the best results.

However, in order to stimulate a response, the use of dynamic tariffs is not only aimed at combating climate changes by reducing emissions but, also at generating advantages throughout the entire energy supply chain. A more energy-efficient behaviour on the part of customers, brings benefits to the environment and to the finances of the single users. It is also true that it allows for less infrastructure to generate and distribute energy in the peak time. In fact all the infrastructures are built to adequately respond to the demands of energy in peak time, namely the period in which demand reaches its maximum. The larger the infrastructure, the more sunk costs are needed. Therefore a more careful behaviour on the part of users would allow a lower cost related to the infrastructure. Furthermore, energy procurement costs would be reduced through lower peak prices. In fact, the prices for procuring energy increase in national energy demand. If it were possible to avoid peaks in demand, prices would never rise too much. Finally, with a more careful behaviour, failures in the distribution service would be reduced, such as the occurrence of blackouts.

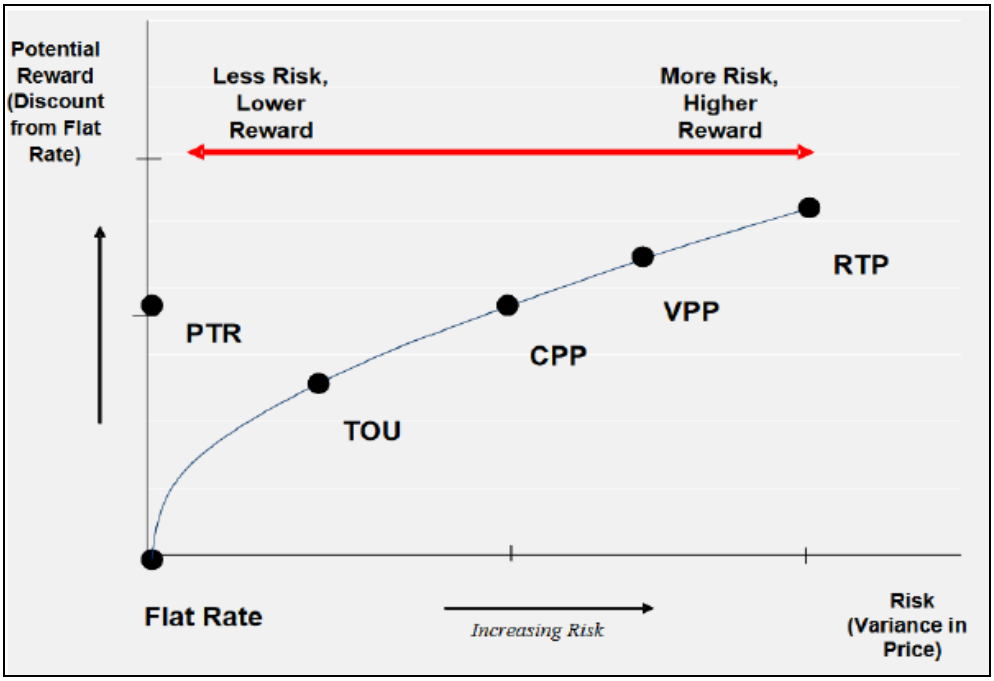
Following the liberalization in the retail market, the market began to offer different types of contracts and, thus, consumers had a greater chance of choosing the tariff that was closest to their needs, reducing electricity costs. The following are the main rates:

- *Flat tariff*: In this type of contract the price remains constant when energy is used (on-peak or off-peak). Since the price remains constant, there is no incentive on the part of the final consumer in changing his behaviour to shifting his energy consumption from on-peak periods to off-peak periods. Therefore this methodology represents the worst tariff structure. This is why alternatives have been created such as those that follow, in order to encourage behaviours that focus on energy efficiency, and create positive externalities on the environment

- *Seasonal tariff*: This type of tariff divides the rate according to whether the energy consumption occurs in the peak season, in which demand will be higher and therefore also the price will be higher; or in the off-peak season, in which demand will be lower and so the price will also be lower
- *Critical peak pricing* (CPP): This type of tariff foresees that prices are high during the peak hours and low during the rest of the day.
- *Time-of-use tariff* (ToU): This type of tariff requires that the price changes according to the period of the day in which the electricity is used: higher prices will be obtained in the periods established by the contract, in which a peak demand is expected (peak period), while prices will be lower in the periods of the day stable in the contract, in which demand is expected to decline (off-peak period)
- *Real-time pricing* (RTP): This type of tariff pervades that price changes in order to better reflect the actual cost of supply. Due to the difficulty of implementing this tariff, which involves the use of advanced technology devices that efficiently implement a dynamic pricing system, this tariff is little used, preferring rather a ToU

Analyzing these tariffs, Faruqui, A. et al. (2012) tries to make a trade-off between rewards, expressed in terms of economical savings on bills, and risks, expressed as the "*volatility of wholesale electricity markets*", since these two factors lead people to choose which tariff to select. Considering these two factors, hence, they identify that the scheme that allows the customer to have the maximum reward, is the real-time pricing as it is the one that is characterized by the maximum uncertainty. It is followed by variable peak pricing, critical peak pricing and time of use tariffs.
It is also worth highlighting how, on the other hand, flat rate tariffs do not give any risks to customers but at the same time do not offer any reward (fig. 3.18).

Figure 3.2.3: Risk-reward trade off in electricity time varying pricing structures



Source: Faruqui, A. et al. (2012)

These tariffs just described are some of the main dynamic tariffs adopted in order to achieve the aims described above. Unfortunately, in real life the effectiveness of these tariffs is not obvious, and it is linked both to the limits described above that characterize individuals, and to the different degree to which these limits influence the choices of users.

One of the first limits that most influences the success of a dynamic tariff is the risk aversion of people, which leads them to have a different propensity towards inertia. At the base of risk aversion is the concept of "*loss aversion*", that is the preference of people acting not to lose, rather than acting to earn.

In this aspect there is a whole literature and many experiments that want to investigate the irrational behaviour of people, starting from the awareness that loss aversion is an intrinsic characteristic of people that conditions their behaviour and actions.

One of the many examples is the experiment of Bager S. and Mundaca L. (2017), in which they begin the experiment stating that the work starts from the premise that "*the literature suggests that users perceive that, ceteris paribus, the potential losses or risks associated with change (e.g.*

improvements to their building's envelope) outweigh the financial benefits of energy savings, and consequently, they prefer the status quo".

It is important to emphasize that loss aversion does not simply affect individual's willingness to remain in the status quo, but has more general consequences and impacts on the environment that cannot be overlooked. As reported by Farsi M. (2010), in some experiments it is emphasized that loss aversion has a different influence on people's risk appetite, so that there is a different willingness to pay for energy-efficient systems.

Often the possible savings deriving from an energy efficient system are underestimated, due to the uncertainty of such savings, it is clear that the result will be a lower investment in efficient technologies. This concept is also highlighted by Attari S. Z. et al. (2010), that "*find that individuals systematically undervalue (by a factor of 2.8 on average) savings and favour conventional practices*".

In order to understand this concept it may be useful to introduce a further dynamic tariff, the "peak time rebate" (PTR), which provides that if customers reduce their consumptions during the peak period they are paid, otherwise they pay the existing rate. It is important to highlight that there are not discounts during off-peak periods. Referring to the work of Faruqui, A. et al. (2012), it is clear that this tariff approaches the flat rate from the point of view of risks as both rates do not present additional risks to customers, but differ in regards to the rewards. In consequence of the loss aversion, it is clear that the different time-varying tariffs do not perform equivalently. Since the PTR predicts that there are rebates if an individual reduces usage during critical peak hours otherwise the rate structure remains unchanged, without economic losses in the case of use in the peak period. This rate becomes more attractive compared to a ToU or even more than a CPP for many individuals more reluctant to the loss. This is due to the fact that consumers often focus on the worst case scenario, as explained by March, J. G. and Shapira, Z. (1987) and, hence, they perceive the rebates as an opportunity while the loss, in which they could incur with a CPP contract, as a "punishment". This leads people with a more pronounced loss aversion to prefer a PTR contract rather than a CPP or ToU one. Moreover,

individuals who have a more pronounced loss aversion, tend to prefer contracts in which there are more attributes that bring them advantages, regardless of the actual value that these attributes bring to them in terms of economic advantages. An example of this is reported by Letzler, R. (2007), which shows that a contract of the CPP type defined on the three periods (off-peak, on-peak and critical peak) in which two of the three attributes foresee a possible loss for the user, despite being two periods that account for less than 20% of all hours, people tend to reject it in favour of time invariant prices.

A second limit that influences the success of a dynamic tariff is the knowledge that individuals have about the benefits they can obtain by choosing a tariff instead of another. It should be emphasized, however, that these benefits can only be achieved if people behave rationally with the chosen tariff, in order to cover the costs of obtaining the necessary technologies to have the necessary information to reduce their consumption during the day.

The fact that benefits can be obtained by behaving rationally in relation to a specific dynamic tariff, thanks to the information available highlighted in the experiment of Bartusch C. et al. (2011), in which, taking a sample of households in Sweden, they verify the benefits deriving from operating in everyday life with a ToU tariff.

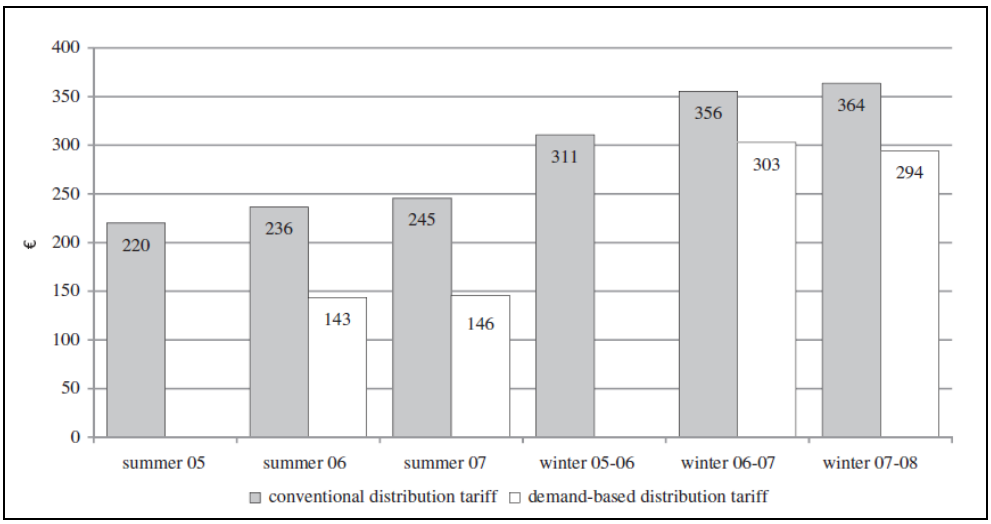
The experiment is structured in such a way to give a web based statistics service to a part of the sample analyzed, so that each households can have a feedback on its hourly electricity use of the previous day. Furthermore, the experiment is conducted with a demand-based tariff consisting of:

- A fixed access charge depending on fuse size
- Variable distribution charge, calculated on the average of the five highest meter reading in peak hours

The experiment shows that "*the customers as a whole have benefited economically from being charged according to the demand-based tariff as opposed to the conventional tariff. On average, costs of the households were 39.3% and 40.6% lower in the summer seasons and 14.8% and 19.1% lower*

in the winter seasons (..) than they would have been under the conventional tariff" (fig. 3.19).

Figure 3.2.3: Households' mean electricity costs as generated by the conventional and the demand-based distribution tariffs



Source: Cajsa Bartusch et al. (2011)

At the same time, the experiment underlined the participants' need to have technologies that allow them to be monitored more quickly and easily, compared to having to consult the website that was often found to be difficult to navigate and that provided data on to the previous day and not to those of the current day. What is therefore required by users, is the possibility of having a display that allows them to be continuously monitored. Furthermore, what has limited many users has been the lack of familiarity "*with the unit kilowatt and do have a poor sense of how much energy-related activities and electrical appliances affect demand*".

A fundamental aspect linked to the need to provide as much information as possible to users, in order to increase the possibility of success of the dynamic tariff, is to try to transmit a more detailed knowledge to users regarding the environmental impact, and positive externalities that they can generate through their more careful behaviour. In the work just mentioned it is highlighted as "*a survey of public knowledge and attitudes about energy issues, however, implies that environmental concerns tend to play an increasingly important role in households changing their behaviour in order to reduce their energy consumption*". This concept has also been taken up

by Burky S. et al. (2015), who shows that the discount requested by users to change tariffs and accept the risk of switching to a dynamic tariff, is less if they are aware of the environmental effects. In fact in his experiment he finds that users who have been informed about the environment and system advantages have had a 9.81% lower WTA (willingness to accept) for ToU.

In particular, what is emphasized is that the effectiveness of a dynamic tariff depends on how much attention is placed on the knowledge of the benefits for the environment and systems rising from this tariff. Furthermore, it should be emphasized that greater effectiveness of dynamic tariffs is accentuated even more if users find it easy to change and shift from one tariff to another. The greater is the automation of this shift, the better are the chances of persuading users to change.

Thus it is important that regulators and retailers understand customers' motivations and concerns, and move to address them through technology and information. Moreover if consumers understand the importance of smart metering, they would have a major diffusion of these instruments with the consequence of a reduction of the costs.

It is clear that, in order to improve the efficient effectiveness of dynamic tariffs, it is essential to provide users with more information, and also to allow them to effectively understand the reasons behind dynamic tariffs. In fact, in several experiments it has emerged that customers have different ideas about the reasons that led to the introduction of dynamic tariffs, some of which are deeply distorted. A clear example of this is given by Bartusch C. et al. (2011), in which many of the survey participants believed that the main reason for introducing the new tariffs was to make customers use less electricity in hours of high demand in the industrial sector or, as one respondent said, "*the utilities' primary motive is just to make more money*".

It is evidenced, as reported by the authors that the statement of this individual is a manifestation of a popular discontent based on "*a common misconception that the electricity retailer and the distribution system operator are one and the same company*".

The misunderstanding about the reasons behind the dynamic tariffs also arise in other experts, such as in the work conducted by Dütschke E. and Paetz A. G. (2013).

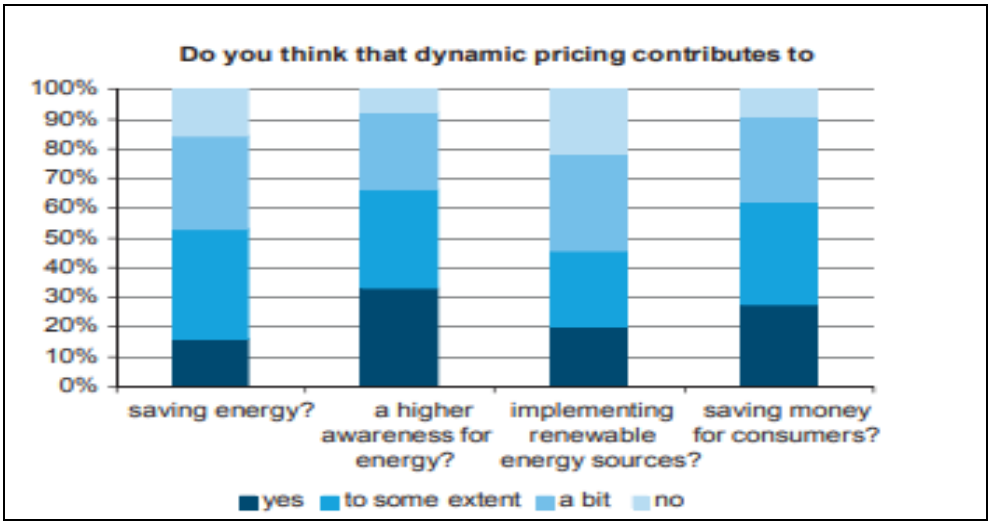
In their experiment it appears that only 53% of respondents believed that dynamic pricing might contribute to saving energy and only 67% agreed with the statement that "*dynamic pricing might be useful in enhancing awareness of energy use*".

Furthermore only 46% expected dynamic pricing might support the integration of renewable energy sources into the grid and only 63% believed that these tariffs helped to save money.

Finally, the fact that dynamic pricing does not bring a concrete advantage is emphasized by participants when interviewed on the question: "*whether they would prefer dynamic pricing or standard rate*". Only 25% expressed themselves in favour of dynamic pricing, while the remaining part, excluding a 6% who did not reply, expressed their support for the standard rate.

This, therefore, confirms that, in order to allow a better development of tariffs, it is necessary to provide more information to customers, in order to make them aware of the reasons behind the introduction of dynamic tariffs, so that individuals have a more inclined positive attitude towards these rates (fig. 3.20).

Figure 3.2.3: Evaluations of dynamic pricing programs



Source: Dütschke E. and Paetz A. G. (2013)

It is interesting to highlight an aspect of dynamic tariffs that can have a deep effect on users' decision on modifying their behaviour. Dynamic tariffs always have a fixed component (OH) which, depending on their size, can positively or negatively influence users. Referring to the experiment by De Filippo A. et al. (2017), it can be shown how the overheads, which are a decisive factor for achieving a positive profit, although, in some cases, they depress users from shifting (tab. 3.3).

Table 3.3: Effect of changing the fixed overhead costs

Table 5. Effect of changing the fixed overhead costs.

Competitor	Prices				% Switch					Profit
Tariff	o_j	p_0	p_1	p_2	k_0	k_1	k_2	k_3	k_4	(M€)
flat	100	324	281	325	71.4	71.7	70.9	73.5	73.9	6.67
flat	220	328	300	360	58.6	58.4	57.3	63.8	64.2	2.33
flat	250	334	312	363	52.2	52.0	50.7	58.0	58.5	1.40
flat	280	343	328	362	41.8	41.6	40.3	47.6	48.1	0.61
flat	340	–	–	–	–	–	–	–	–	–
two-price	100	334	273	316	71.3	71.3	70.8	73.5	73.8	6.54
two-price	220	338	293	351	57.9	57.8	56.9	63.5	63.9	2.21
two-price	250	344	305	353	51.0	51.0	50.0	57.4	57.9	1.30
two-price	280	353	323	352	39.3	39.6	39.0	46.2	46.9	0.53
two-price	340	–	–	–	–	–	–	–	–	–

Source: De Filippo A. et al. (2017)

In their experiment they tried to lower the fixed overhead costs from 250 k€/ GWh to 100, and then raise them up to 340. What they found was that the lower these costs were, the higher the shift percentage of profit margins were. So the new dynamic tariff becomes very competitive, while the overheads are higher, therefore it is more difficult to attract new customers as the new tariff will have lower profits, compared to the flat rate tariff, and thus will be less attractive.

3.2.4 The Nudge Theory

Another methodology that tries to face the problem of climate change and global warming is the "*nudge*" technique. It is a technique that seeks to take advantage of irrationalities and limitations of people, in order to induce them to make better decisions about everything concerning their interests, for the best of the entire community. Referring to the behavioural branch of the economy, the concept of "*nudge*" is exhaustively explained by Thaler H.

R. and Sunstein R. C. (2008), and it is defined as "*any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives*". Also defined as that technique which wants to "*push mildly or poke gently in the ribs especially with the elbow*"[11], the "*nudge*" technique is based on two premises. On one hand there are individuals often myopic and unable to make the best decision in terms of cost-benefits, and on the other hand, there are individuals that adopt solutions in order to direct them towards the best decisions. This is good for policymakers, who are defined as "*the architects*" in Thaler H. R. and Sunstein R. C.'s book. Starting from these concepts, the idea is to exploit the social context and the irrationality of people to try to achieve the desired aims in different fields. What is evident is that this technique becomes a very delicate one, as it leads people to specific goals decided by an architect, and therefore, it becomes fundamental that he acts for the common good. It is also important to underline how the nudge technique, on one hand pushes individuals to behave in a certain paternalistic way, and on the other hand it must not preclude, in any way, the possibility of choosing options other than those suggested. This way assuming a libertarian character, a fundamental characteristic for not becoming dictatorial.

One of the areas where the use of nudges can be useful is the liberalization of the electricity market. Focusing on Italy, it can be said that one of the main reasons why many individuals are still in the protected market regime, is that there are real consumers cognitive errors, which lead them to make less conscious choices, as reported by Rangone N. (2012). Therefore, they have not profited from the benefits of the liberalization process that began more than ten years ago.

Even in this case, however, nudges can interfere in favour of a better awareness and a better decision for users. It is evident that it is necessary to create a type of nudge that serves to overcome some limits that characterize people, due to lack of information. The nudge technique must, therefore, be

[11] *New York times magazine October 8, 2000, William Safire*

based on the dissemination of information, so as to educate consumers to have more awareness of what surrounds them. This way solving the problem of deficit information, and allowing them to navigate easier in the energy sector, but at the same time safeguarding their freedom of choice.

An example is the "*Portale Offerta*" system, a computer application created and managed by "*Acquirente Unico*", accessible via internet that allows people to obtain information on all commercial offers on the market, and to check which ones are the most suitable to meet their needs (fig. 3.21).

Figure 3.2.3: Web page of "portale offerte"

Source: Portale offerte official web site

This tool acts as a nudge because it simplifies the task of comparison and makes it easier to identify the commercial offers on the market, allowing consumers to have a greater awareness, and to limit the irrationality of people due to bound rationality and lack of information. It is clear, in fact, that in the presence of a reduced number of understandable options, individuals are able to rationally analyze all the attributes of the options, having a greater probability of choosing the one that best meets their interests.

Another example of nudge is the "*default option*", that are those choices that become effective if the individual does not deselect them. As previously mentioned, the default option exploits the bias of the status quo, in order to induce individuals to choose options that have a personal or collective welfare interest. In the example of the experiment described by Ebeling, F., & Lotz, S. (2015), the "*default option*" technique is used for encouraging people to choose contracts that promote the development of renewable

energy, thus obtaining a 69% increase in sales, with an opt-out choice compared to a 7.2% with an opt-in choice.

As can be seen from this example, the nudge, represented by the default option, induces people towards a specific decision that is a collective good. This way it covers a paternalistic aspect, but at the same time, it allows people to modify the options and choose the alternatives that they like the most, therefore maintaining a libertarian aspect.

The nudging is a technique that has aroused interest in various fields: from health, (whose global spending is growing to excess), to pollution or excessive energy consumption. This thesis is mainly focused on the last aspect, remembering however that many of the techniques that will be analyzed, can be used both in the energy consumption sector and in the other sectors.

Focusing on the aspect of energy consumption, due to the negative impact that this sector has on the environment, the attention will be mainly on the power sector. This is what causes more concern for the environmental aspect because of the high quantity of emissions it generates. The policymakers' goal is to achieve and to encourage more environmentally conscious behaviours in the electricity sector, through the use of nudges. And also to respond to the difficulties and limits that have prevented many dynamic tariff offers, analyzed in different experiments, so as to get the result desired. And, in particular, by means of nudges, this result is to be achieved without the need to directly affect the economic side of people.

Various techniques have been used, including that of "*framing*", which is a particular technique that suggests that the effectiveness of information does not depend on its content but on how it is presented. In this sense, for example, if you want to push people to buy energy-efficient products, it is worth letting them know how much is the earning they can expect, rather than letting them know the loss they would get by not buying them.

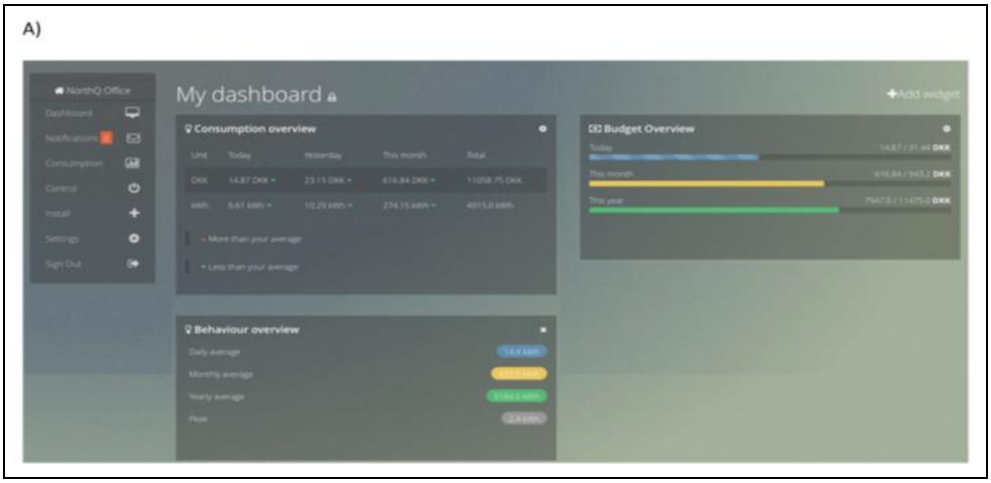
The "*framing*" concept can be associated with the loss aversion, so as to obtain advantages from the containing consumption point of view. The idea of loss aversion is that individuals are more likely to change their behaviour if they perceive that they can lose money rather than save it. Exploiting the

concepts of loss aversion and framing, together they can lead individuals to significantly decrease their consumption in peak periods.

This concept is well highlighted by Bagera S. and Mundacab L. (2017). They analyzed a group of homogeneous customers who performed an experiment in which they actually used and paid for their electricity. Customers were divided into two groups: one for the control and one for the intervention. Both groups were equipped with the meters that collected, stored and transmitted between the electricity supplier and the end user. People could access to all information only through a special software installed on their smartphones, tablets or computers.

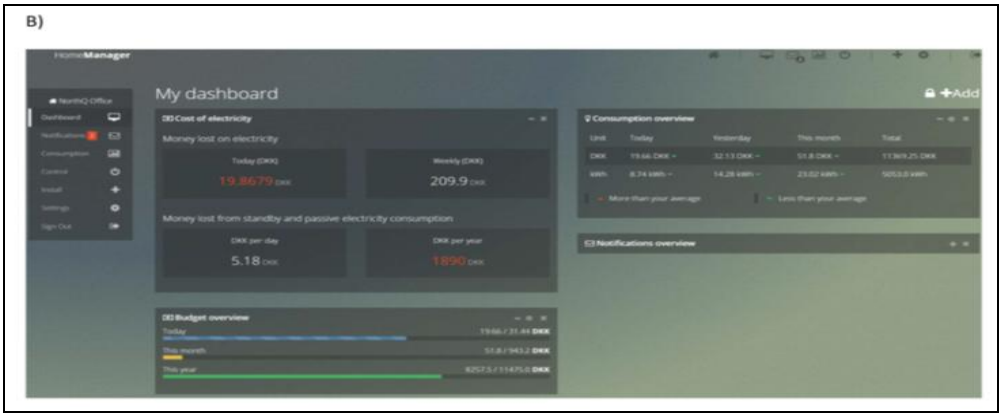
Moreover, both groups accessed the data control on the software but, for the purposes of the experiment, it was important to emphasize that only the intervention group received these information presented as a salient loss. The writing on the interface said: "*Money lost from electricity consumption*" followed by the monetary value (fig. 3.22a; fig. 3.22b).

Figure 3.2.3: Display without information presented as a salient loss



Source: Bagera S. and Mundacab L. (2017)

Figure 3.22b: Display with information presented as a salient loss



Source: Bagera S. and Mundacab L. (2017)

During the experiment the data was collected both in relation to the daily consumption (kWh) and to the overnight (standby) consumption (kWh / night).

The analysis of the change in consumption was made following two different approaches. In a first case the consumption was analyzed at the beginning of the experiment and at the end of it, comparing the average values (APPROACH A), while in a second case the consumption was analyzed calculating the average consumption during the entire experiment (APPROACH B).

What the experiment reached is that in the case of the first approach the reference group reduced their daily consumption by an average of 7%, while the intervention group by 18% (tab. 3.4). The second approach, on the other hand, has shown an increase in the daily electricity consumption for the reference group, and a decrease of 5% for the intervention group. Thus, a differential effect of −11% (APPROACH A) and −7% (APPROACH B) was found for the daily electricity consumption.

Regarding the standby consumption, with the first approach, the reference group marked a reduction of 3% while the intervention group of 28% (tab. 3.5). The second approach instead marked 3% increase for the reference group, compared to an average reduction of 13% for the intervention group. A differential effect of −25% (APPROACH A) and −16% (APPROACH B) was estimated (fig. 3.23).

Table 3.4: Daily average electricity use for households based on first comparative approach

	First week Average (kWh)	Mid-period week Average (kWh)	Last week Average (kWh)	Change in consumption (Δ%)
Intervention group (faming and salience)	5.72	4.88	4.68	−18
Reference group (No intervention)	5.10	–	4.72	−7

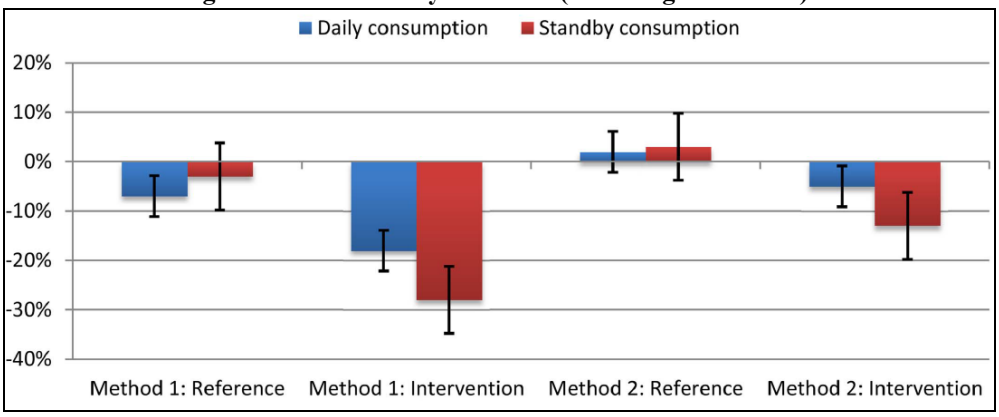
Source: Bagera S. and Mundacab L. (2017)

Table 3.5: Standby electricity use for households in based on first comparative approach

	First week Average (kWh)	Mid-period week Average (kWh)	Last week Average (kWh)	Change in consumption (Δ%)
Intervention group (framing and salience)	1.04	0.94	0.75	−28
Reference group (No intervention)	0.89	–	0.86	−3

Source: Bagera S. and Mundacab L. (2017)

Figure 3.2.3: Summary of results (including error bars)



Source: Bagera S. and Mundacab L. (2017)

In conclusion this experiment shows that framing (which is one of the most common nudge techniques), is able to exploit the limits (or irrationality) of individuals: such as the loss aversion, in order to reach goals of personal interest (shifting the use of electricity people save money), and of collective interest (shifting consumption from on-peak periods to off-peak periods produces advantages over the entire energy supply chain). It is also important to emphasize that, although the framing technique tends to influence people's behaviours, no coercion is made towards individuals, thus respecting the libertarian character typical of nudges.

In order to identify the most appropriate nudge technique, it is important to analyze which are the common problems that arise in certain situations. One

of the critical points raised in many experiments by participants, is the lack of tools that allow them to have an immediate and easy access to their consumption. Many individuals are not practical about how much they are consuming, or on how much their consumption has a more or less heavy impact on the environment: electricity is invisible and this prevents people from becoming fully aware, and many individuals are not familiar with the concept of MW/h.

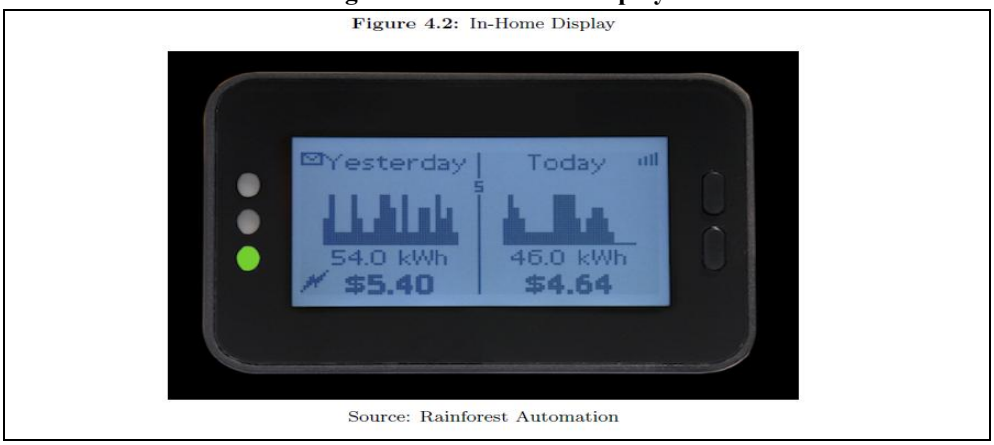
Trying to limit this phenomenon and helping people to become aware of their energy consumption, in 2004 the electricity sub-company Southern California Edison (SCE), gave consumers a small device. The aim of this device, called Ambient Orb, was to give visual feedback to customers on their consumption: depending on the amount of energy consumed, the device changed colour, from green, in case of optimal consumption, to red, in case of overconsumption. What was observed, was that this device was a very effective tool in encouraging people to have awareness of their consumption and reduce it. It is to highlight that the better monitoring of consumption involved a reduction of energy consumption of 40% in peak periods, according to the data. Also in this case, the Ambient Orb, which in this case acts as a nudge, induces people to regulate their consumption by making them aware of their possible overconsumption but, continues to maintain a libertarian character as it does not force any individual to modify their own behaviour (fig. 3.24).

Figure 3.2.3: Southern California Edison's Energy Orb

Source: International society for optics and photonics

Another alternative solution to the Ambient Orb, to give a clear and easily accessible view to users, is the introduction of the In-Home Display (IHD). This tool is a device in the home connected to the smart meter, able to quickly analyze the real consumption of people, and transmit them on the display. The advantage of this tool is the fact that it allows users to avoid connecting to the app or to a website to see their consumption. The introduction of IHD was designed to respond to the difficulties highlighted by users during the experiments, in which it emerged that many costumers found it difficult to consult their consumption data via web or mobile app, and instead many people were activated to request display that shows instantaneous demand (fig. 3.25).

Figure 3.2.3: In-Home Display



Source: Rainforest Automation

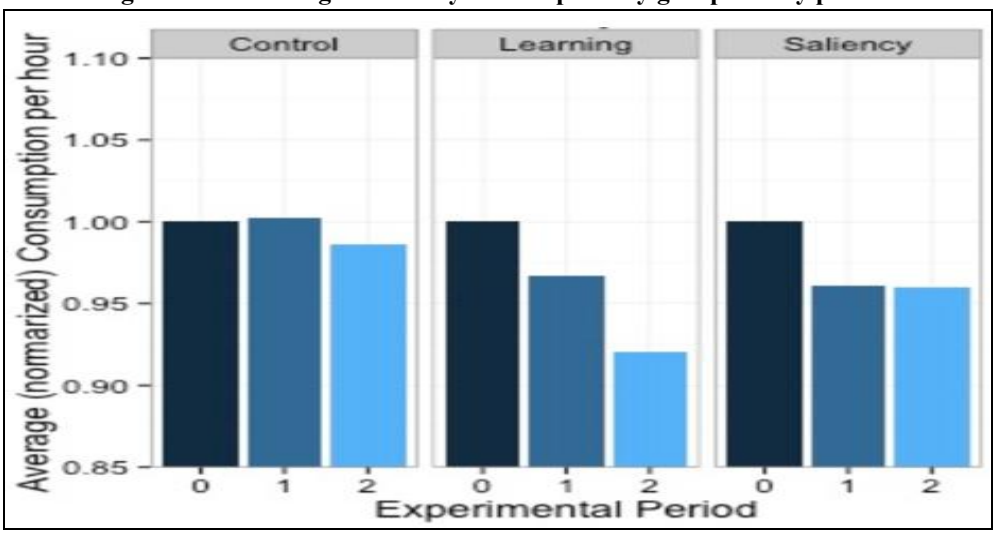
As demonstrated by Lynham et al. (2014), the fact of being able to see and becoming aware of an own consumption in real time helps save energy. The aim of his experiment was to try to understand if and how the installation of an In-Home Display could help save energy. At this point he conducted an experiment in which, he took 65 households in Honolulu that were randomly dived in three groups: one "*control group*" and two "*treatment groups*". Then, an IHD device was assigned only to the households who were in the "*treatment groups*". The presence of two treatment groups was due to the fact that one of the two, called the "*Saliency treatment group*", was given access to the IHD for the entire duration of the experiment, which lasted for 90 days. While the other group called "*the Learning treatment*

group", had access to the IHD only for the first 60 days. It should be emphasized that the experiment was designed this way to understand if the effective energy consumption reduction was attributed either by the "*learning effect*" or by the "*saliency effect*".

The results of the experiment has shown that people with IHD access have significantly reduced their use of electricity of 11% between 06.00 and 09.00 a.m., and between 06.00 and 09.00 p.m.. Despite this, the experiment also showed that the overall daily effect was not statistically significant. In fact people have reduced their consumption exclusively in these two time slots, without affecting consumption in the remaining hours of the day.

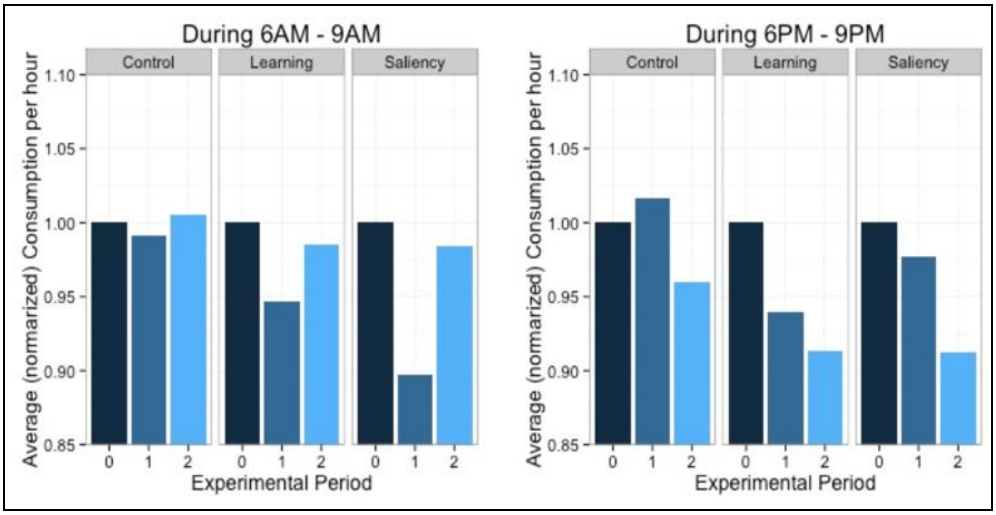
Another interesting aspect that emerged from this experiment was that the effect of IHD waned in time, because people became accustomed of having their consumption data at hand, therefore it was no longer a stimulus but a normality. From all of this we can also deduce that the reduction in energy consumption was given mainly by the "*learning effect*", rather than the constant remainder of electricity usage (fig. 3.26; fig. 3.27).

Figure 3.2.3: Average electricity consumption by group and by period



Source: Lynham et al. (2014)

Figure 3.2.3: Average electricity consumption in the morning and in the evening



Source: Lynham et al. (2014)

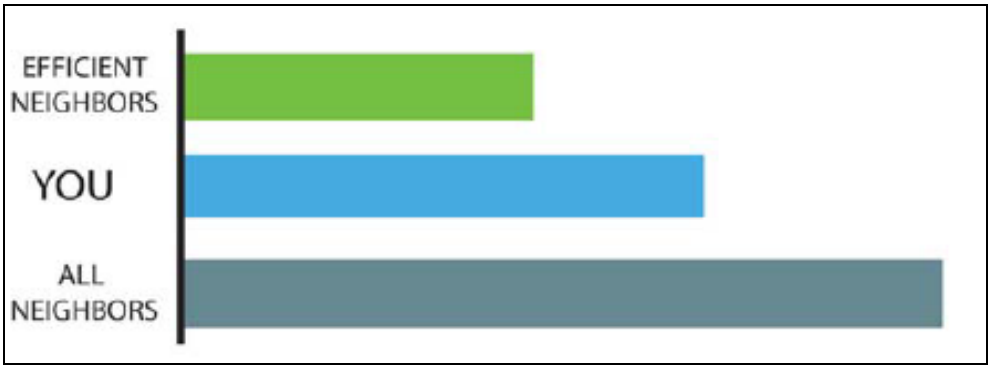
The fact that the presence of a real-time feedback (via SM or IHD) of the energy savings, is also evidenced by Derby S. (2006), in which he shows how savings are achieved in the range of 5–15%, especially for consumers with high bills. Moreover, as reported by Faruqui A. et al. (2010), several experiments conducted in the U.S.A. and Canada on assigning IHD tools, have shown the potential reduction in electricity consumption between 3 and 13%, and the fact that the interventions were more effective when users were provided with IHD feedback.

A further nudge technique among the most used, and which turns out to be one of the most effective is the "*social pressure*". This technique consists of putting people in "competition" in order to reach a certain behaviour. The result you will get is that, in order to be better than the others, people will work to change their behaviour so that they can stand out from the rest. This technique is based on two principles: firstly that individuals tend to learn information about each other, and secondly that social influences can deeply change their decisions. The motivations of these concepts are to be found in the social psychology that has shown that man is a conformist individual but, what is interesting, is that these two assumptions allow a starting point for generating "*nudge*".

In consequence it is possible to use this intrinsic characteristic of people so as to reduce electricity consumption. As reported by Thaler H. R. and

Sunstein R. C. (2008), in a study conducted on 300 households in San Marcos, California: all households were informed of their energy consumption in the previous weeks, and were also informed of the average consumption value by households in their neighbourhood (fig. 3.28). The effect was that the above-average energy users significantly reduced their consumption. In fact, the comparison with the other households had led them to change their behaviour in order to adapt to others, reducing their consumption.

Figure 3.2.3: Average consumption information



Source: Centre d'analyse stratégique (2011)

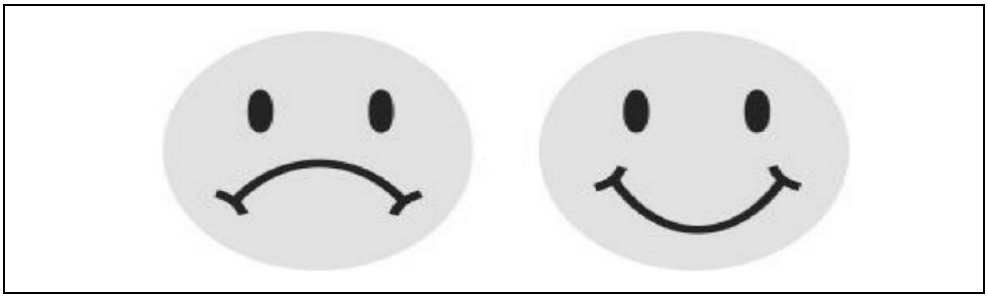
Unfortunately, however, there was also a negative effect, known as the "*boomerang effect*". Many households that had a below-average energy, ended up increasing their consumption. This effect is called boomerang because, remembering that, the nudge is implemented to obtain a behaviour that produces positive externalities to the community, we obtain an opposite result: the households that were doing better than the average, became aware of it and tended to increase their consumption, creating negative externalities for the community.

This leads to a fundamental conclusion, as reported by Thaler H. R. and Sunstein R. C. (2008), which is: "*If you want to nudge people into socially desirable behaviour, do not, by any means, let them know that their current actions are better than the social norm*".

A possible remedy for the boomerang effect is given by another nudge technique: it has been observed that giving positive feedback, such as a

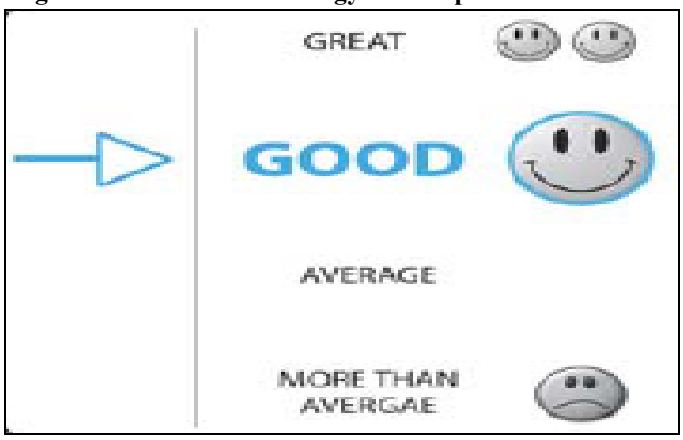
smiley face, to individuals who are behaving better than average, which their behaviour will remain constant making the boomerang effect definitively disappear. At the same time, by giving negative feedback to people characterized by the largest consumption of energy, like a happy emotion, their consumption will be drastically reduced (fig. 3.29; fig. 3.30).

Figure 3.29: Household energy consumption and emotions



Source: Wesley S. et. Al (2007)

Figure 3.30: Household energy consumption and emotions



Source: Centre d'analyse stratégique (2011)

As highlighted up to now, there are contexts in which both tariff and nudge instruments can be used in order to induce a reduction in energy consumption. The substantial difference is that in one case, unlike the other, economic incentives are used. There are, however, some situations in which dynamic tariffs have no effect, and nudges become the only useful tool, in achieving the desired goal, such as reducing electricity consumption. A typical example of a situation in which dynamic tariffs do not have any effect in energy consumption, is within the service sector. It is clear that within these environments the tariff solutions do not make any sense, since the employees who work in offices, for example, are not affected in any way

by a high or low bill. The only one who is harmed is the owner of the company.

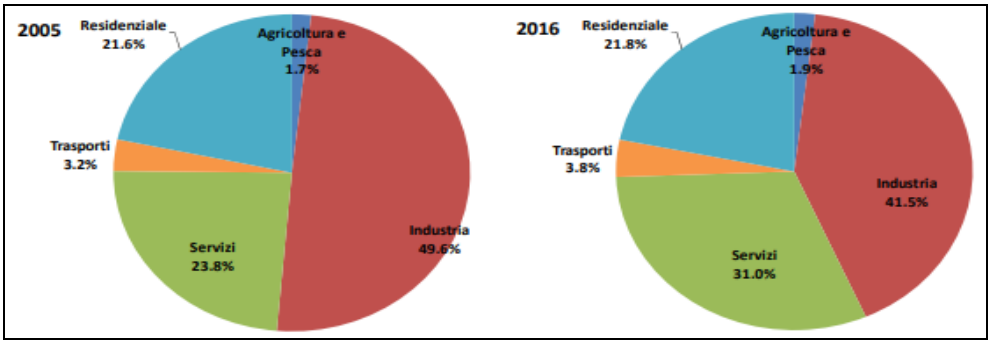
Since the service sector emissions are the ones who have the most important impact on the environment (tab. 3.6; fig. 3.31), it becomes important to understand how to act in order to reduce them.

Table 3.6: GHG emissions from electricity consumption by sector

Settori	2005	2010	2015	2016
	Mt CO_{2eq}			
Agricoltura e pesca	2,5	2,2	1,8	1,7
Industria	70,6	53,4	37,8	37,9
di cui da autoconsumo	*8,4*	*8,7*	*5,6*	*5,5*
Servizi	38,5	37,1	31,8	31,8
di cui trasporti	*4,6*	*4,1*	*3,4*	*3,4*
Residenziale	30,7	26,8	20,4	19,9
Totale	**142,3**	**119,5**	**91,8**	**91,2**

Source: ISPRA (2018)

Figure 3.31: Share of emissions from electricity consumption by sector



Source: ISPRA (2018)

At this point, Charlier C. et. Al (2018), proposed and experimented three different types of nudges in a field experiment.

The first technique he used is called "*moral appeal*". This technique aimed to emphasize the environmental impact that energy consumption entails. To adopt this approach in his experiment, each employee received some messages in which the advantages, that could bring a more environmentally friendly behaviour, were illustrated (fig. 3.32).

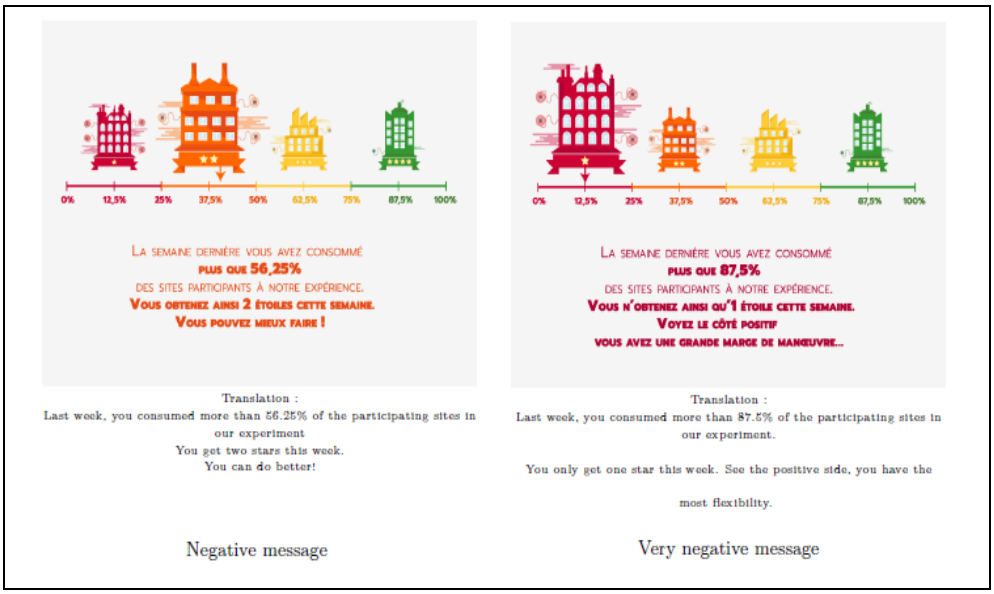
Figure 3.32: Moral appeal text message

Moral appeal message
Through our energy consumption, we contribute to global warming. **2016, record melting of arctic sea ice.** Be involved for change.
Through our energy consumption, we contribute to global warming. **One person moves every second for climatic reasons.** Be involved for change.
Through our energy consumption, we contribute to global warming. **The oceans will see "their acidity increase by about 170% compared to pre-industrial levels by 2100." Great coral reefs under threat!** Be involved for change.
Through our energy consumption, we contribute to global warming. **Between 2030 and 2050, it is expected that climate change will cause more than 250,000 additional deaths per year.** Be involved for change.

Source: Charlier C. et. Al (2018)

The second technique he experimented was the nudge called "*social comparison*". This nudge recalled the technique of creating a social competition, and more particularly, a "*peer pressure*". Therefore, generating a competitiveness among the different employees, making their results and actions public to the colleagues (fig. 3.33).

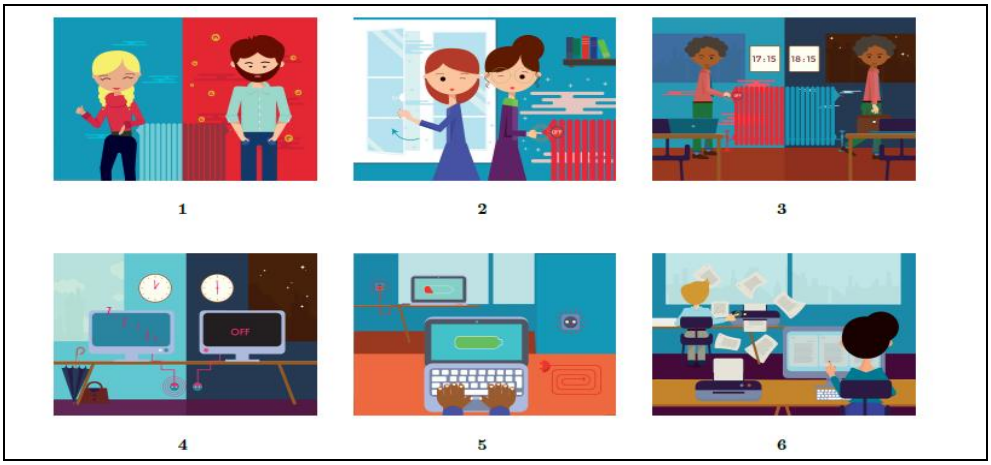
Figure 3.33: Four example of social comparison message



Source: Charlier C. et. Al (2018)

Finally the last technique analyzed was that of the "*stickers*". This technique informed employees about good practices for energy conservation through visual messages. In this case also, the aim was to induce people on having more respectful behaviours towards the environment, suggesting actions they could do to achieve this goal (fig. 3.34).

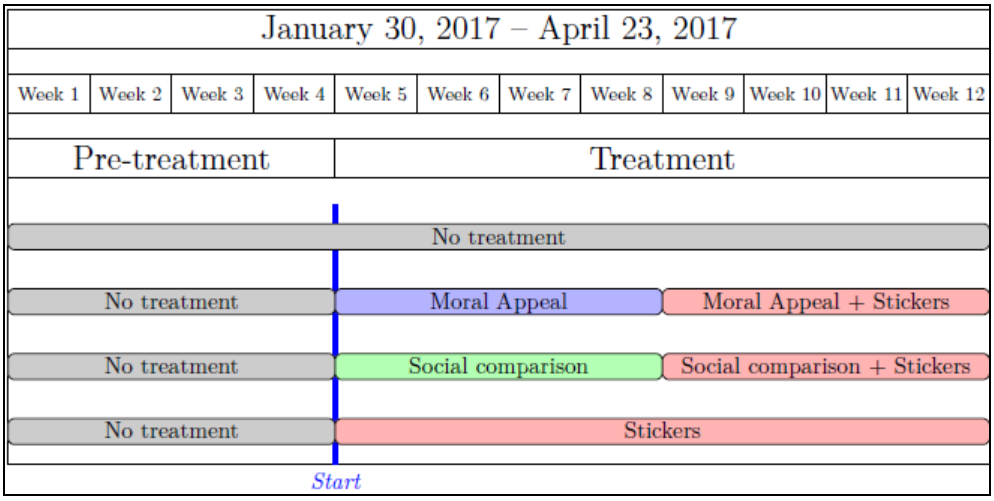
Figure 3.34: Some stickers



Source: Charlier C. et. Al (2018)

The experiment was conducted on 47 French companies sites, and focused on office employees. It was developed in such a way as to be able to analyze the effects of each individual nudge, at first considered separately from the others, and after in pairs to assess a possible complementarity (fig. 3.35).

Figure 3.35: Experimental design



Source: Charlier C. et. Al (2018)

What emerged from the experiment is that, unlike what happened with households, if individuals find themselves in workplaces such as the office, a single nudge has no significant effect. In particular, from the questionnaires carried out by the survey participants, it emerged that, regarding the "*moral appeal*", only 28% of 85% of participants who read the messages, thought that they did not have any real effect on their electricity consumption. As for the "*social comparison*", among the 98% of participants who have read emails, only 36% estimated that it had changed their electricity consumption. Finally, 90% of participants who have seen the "*stickers*", only 16% estimated that they have changed their electricity consumption.

This can also be justified with the concept of free riding. In this case, each employee does not feel forced to follow what is suggested by the nudge. In fact the final goal can be reached even without any effort by employees, while this is not possible for the households. To mitigate this effect, peer pressure intervenes, which causes people to confront each other. And, since people tend to conform to the mass, the effect of free riding is effectively mitigated when everyone knows what their colleagues are doing.

Another phenomenon highlighted by the experiment is that when the moral appeal and social comparison nudges are combined with the sticker ones, at that point they become effective. Considering which were the author's intentions, this result could be due to the fact that "*the moral appeal and*

social comparison nudges act more as means of creating awareness, while the stickers more likely act as a "reminder" of everyday actions for proper energy conservation. Indeed, the first two nudges raise individuals' awareness but do not necessarily give the means or the knowledge necessary to act and improve energy conservation". The consequence is that "*47% of the surveyed employees confronted with the moral appeal nudge and 32% of those subjected to the social comparison nudge estimated that stickers affected their electricity consumption*".

Finally it is still interesting to note that the experiment showed that individuals tended to be more influenced by "*social pressure*", when communicating with their colleagues about nudges.

What this experiment suggests is that, in all those sectors in which people are not given an economic incentive, it is important to identify the nudges which, even in pairs, allow a reduction in energy consumption. Taking into account the possible effect of free riding, which could eliminate most of the advantages deriving from nudges, it can be partially or completely eliminated through the peer/social pressure.

Chapter 4

Consumer perception of the electricity tariffs: an experimental study

As analysed in the previous chapter, from a theoretical point of view the literature suggests that the structure of tariffs is one of the most efficient techniques to influence people to have behaviour more respectful of the environment. In a theoretical world, a rational individual would change his daily actions in according to the new tariff in order to receive a profit or avoid a pecuniary loss. In the real world, however, there are some bias, such as the irrationality of individuals that hinder the success of this technique.

Furthermore, in order to create a tariff that provides benefits or penalties for the different behaviours, it is necessary to design a very articulated tariff structure. This means that the tariff is less comprehensible and, hence, less efficient.

Moreover, for the final electricity consumer, the choice of a tariff may be considered as a risky and often an uncertain decision. In fact normally consumers do not know ex ante the exact amount of electricity needed and, without this information, they are not able to predict the economic impact of the tariff choice.

It is clear that when people are insecure about future consumption trends, they prefer reject dynamic tariffs, especially if it is not easy correctly assess the benefits and costs due to the complexity of the tariff. This uncertainty about the future can lead to two opposite effects. On the one hand it can lead to the "insurance effect" (Lambrecht and Skiera 2006), that is a particular marked insecurity on how things will develop in the future. It leads people to have a negative perception of dynamic tariffs and to prefer flat tariffs. On the other hand, there is the "overestimation effect" (Lambrecht and Skiera 2006), typical of risk lover people. In this case, individuals believe, erroneously, that they can change their behaviour as they prefer and that, therefore, they will only enjoy the benefits of dynamic tariffs. Consequently,

they will have a better perception for dynamic tariff rather than for flat tariff.

It is evident how the perception of the tariff has a fundamental role in the decision-making choice of individuals. Therefore, it becomes important to look carefully into the issue of consumer perception of tariff.

In this context, the main objective of our experiment is to investigate people's preferences and perceptions of the electricity tariffs. Then, a second purpose is to investigate if people are able to adapt their choices once given the information necessary to adopt a more environmentally friendly behaviour.

Both our goals take into account the different characteristics linked to the dynamic tariffs presented, such as the complexity of the tariff or the risk associated with it, and the circumstances in which these tariffs should be applied. Thus, the characteristics of individuals, such as risk aversion, and the characteristics linked to the places where the tariffs could be applied, such as housing, are analyzed and considered.

4.1 Experimental design

The experiment was designated to be a "*lab experiment*" and it consists of 13 sessions which took place between September 2018 and June 2019 in the experimental laboratories of the Paris School of Economics (Laboratoire d'Economie Expérimentale de Paris, LEEP) and of the MSE (Maison des Sciences Economiques). We recruited 238 participants from the LEEP database in order to ensure that the sample was representative.

The experiment consists of two tests and a questionnaire. Regarding the questionnaire, it is characterized by:

1. *general questions*, which allows us to have some personal details of the participants and their intrinsic characteristics (risk aversion, preferences, etc.)
2. *"experimental" questions*, in which there is only one right answer. The aim of the analysis is to verify whether consumers understand the eco-friendly benefits derived from the electricity and water tariffs

At the end of the session each participant receives a share of money. This is the sum of two components:

- 5€ show-up fee for the availability given to take part in the experimental session
- A variable part that depends both on the quantity of correct answers provided to the "experimental" questions and on the result that each participant will get in the test for the assessment of risk aversion

The payment rules are communicated to the participants before the experiment starts and at the end of the session each of them is paid according to the rules shown at the beginning.
The experiment, lasting 60 minutes, begins with a welcome phase in which each participant is invited to take a seat in front of one of the screens in the lab and fill in an informed consent document. This document describes the rules under which the experiment is carried out and reminds both that the participants are volunteers and that the results will be analyzed in respect of their privacy and that they will remain anonymous.
Once this part is over, the experiment is developed on three other steps:

STEP I: In the first part of the session the aim is to understand the generalities of the participants. To this end, participants are asked questions in order to determine their socio-economic situation and to determine their average annual energy use.

STEP II: This second phase of the experiment consists of three moments. First of all the participants have to select some rates, on the basis of the preferences/personal knowledge. Then, the system provides them some information about the possibility to reduce energy consumption linked to an environment-friendly behaviour. After this explanation, participants are asked to answer the questions again. It allows us to verify if they are able to choose the most advantageous rate.

STEP III: In this third part of the experiment, the two tests are submitted to the participants: the first with the aim of understanding the risk attitude of the participants and the second to verify the participants' cognitive abilities.

Once these three steps have been completed, there is a conclusive phase in which the participants have to indicate the reasons that led them to choose a specific tariff rather than another.
After completing this last part, the participants are paid according to the rules established at the beginning of the session and the experiment ends.

4.1.1 The first phase

The first step is characterized by some questions that aim to identify both the socio-economic situation of the individual and the average annual use of electricity.
For the first objective, participants have to answer some questions about their age, sex, socio-professional category, household composition, zip code of the residence and the net monthly income of the household.
About the socio-professional category, they can choose one of the following categories:

- Employés (Employee)
- Profession intermediaries (Intermediate professions)
- Retraités (Retirees)
- Cadre et professions int. Superieures (Executive and intellectual professions)
- Etudiant (Student)
- Artisans, commerçants et chefs d'entreprise (Business owners, traders)
- Autres personnes sans activité professionnelle (Unemployed)
- Etudiant-salarié (Student with salary)

To achieve the second objective, participants have to answer another set of questions, such as:

- Household size
- Dwelling size
- Whether the dwelling is equipped with an independent electrical heating system or not

- Whether the dwelling is equipped with an electric hot water heater or not
- The frequency with which, during the week, the participant runs the dishwasher/ the washing machine/ the laundry dryer, if present, and whether these are new appliances or not
- Whether the dwelling is equipped with a chest or an upright freezer;
- Whether the dwelling is equipped with a vacuum cleaner
- Number of LCD TVs and plasma TVs
- Number of desktop computers and number of laptops

From these answers the average annual use of electricity is calculated using a calculator modelled on the basis of the one proposed by the EDF.

4.1.2 The second phase

The second phase of the experiment is the most important phase that focuses on the main goal of the research: to investigate the perception of individuals for the different types of electricity tariffs.

This second step can be divided into three phases. In the first phase of the analysis, participants were given a series of questions in pairs, from which they had to select their preferred alternatives (tab. 4.1).

Since there is no monetary incentive that influences the choice, this phase of the experiment allows us to understand what the real preferences of individuals are in relation to tariffs.

Table 4.1: Example of comparison between tariffs

Choice	Tariff 1	Tariff 2
Choice 1.1	Linear tariff with constant marginal price and without a fixed fee	Two-part tariff (fixed fee + linear price)
Choice 1.2	Two-part tariff(fixed fee + linear price)	Non-linear tariff (Increasing Block Tariff)
Choice 1.3	Non-linear tariff (Increasing Block Tariff)	Linear tariff with constant marginal price and without a fixed fee

All the electricity tariffs are calculated on the basis of the EDF standard rates (tab. 4.2) and an example is given for each proposed tariff during the session. In order not to influence the choice of the individual through the example, the components of the tariff have been chosen so that the final result is the same in all the tariffs. It is important to highlight this point since in this phase we want to investigate people's tariff perception and, hence, it is necessary not to condition the choices of people.

Table 4.2: EDF Standard rate

Subscribed power	Standard rate	
kVA	Fixed component (€/year)	Variable component (€/kWh)
3	56.07	0.16
6	96.50	0.14
9	111.35	0.15
12	172.78	0.15
15	199.95	0.15
18	228.56	0.15
24	491.85	0.15
30	594.30	0.15
36	698.64	0.15

Source: EDF

In particular, the examples to compare the tariffs, shown during the session, are the following (the examples consider an annual consumption of 4790 kWh):

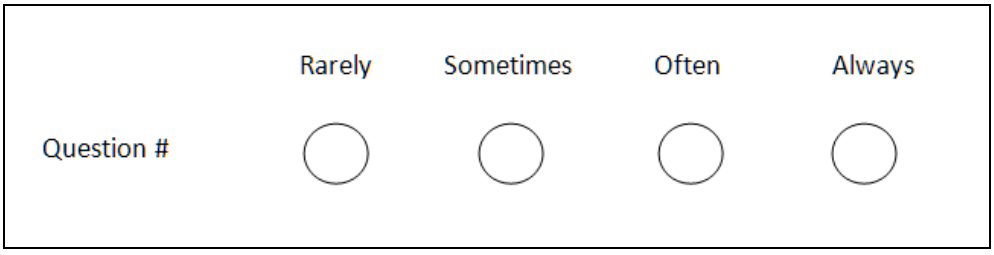
- Two-part tariff: fixed fee = 56.07€/year and variable component = 0.16 €/kWh. The resulting sum invoiced is 56.07+0.16*4790 = 822.47€
- Linear tariff with constant marginal price and without a fixed fee: fixed fee = 0 €/year and variable component called as p1= 0.1717€/kWh. The resulting sum invoiced is 0.1717*4790 = 822.47€
- Non-linear tariff: it is composed of two blocks: the first block goes from 0 to 2/3 of the total consumption, while the second block covers the remaining consumption. The tariff of the first block is computed as t1 = 2/3 * p1 = 0.1145€/kWh while the tariff of the

second block is computed as t2 = (1 + (2/3)) * p1 = 0.286€/kWh. The resulting sum invoiced, hence, is 0.1145 * 3193 + 0.286 * 1597 = 822.47€

After this first phase, pro-environmental behaviours are proposed to the participants and for each of them the maximum consumption reduction potential is expressed. Participants are asked to indicate for each behaviour if it is a behaviour that they are already used to carry out during their daily life and, in the case of an affirmative answer, the frequency with which they implement the behaviour in question.

To make everything easier, a non-comparative Itemized Rating Scale (fig. 4.1) with 4 possibilities is used to express the frequency with which each behaviour is carried out. The possibilities of the Itemized Rating Scale are: rarely, sometimes, often, and always.

Figure 4.1: Itemized Rating Scale



The proposed pro-environmental behaviours regarding the electricity world are the following:

- I decide to lower the thermostat of two degrees or I defrost the fridge and the freezer;
- I do not leave my appliances in stand-by mode so I switch them off when I do not use them;
- I decide to buy energy-saving light-bulbs rather than incandescent light bulbs;

What is important to note in the case of the third behaviour proposal is that, in order to adopt it, the participants should buy the "energy-saving light-bulbs", which implies a cost. This third behaviour therefore not only wants

to see the behaviour of people but also wants to test whether people are willing to invest money and efforts in order to achieve that energy saving.

Once this second phase is over, we move on to the third phase, in which participants are encouraged to give a correct answer in order to earn money. In particular, based on the answers given to phase two, the total potential consumption reduction is computed. The calculation is based on the potential reduction of consumption associated with each of the behaviours described above and on the basis of the frequency with which each participant declared to follow this behaviour, assuming that all participants, even if with minimal frequency, in this part of the experiment, adopt the proposed behaviours. Afterwards the participants are notified about both their total estimated consumption and their total consumption reduction potential. At this point the participants are re-proposed the pairs of tariffs proposed at the beginning of the experiment and are again asked to choose for each pair which tariff they consider most appropriate in order to reduce the energy bill. And in this phase they are economically incentivized to respond correctly because of for each correct answer, the participant receives a reward of 1€. At the same time, for each wrong answer, participants do not receive such reward.

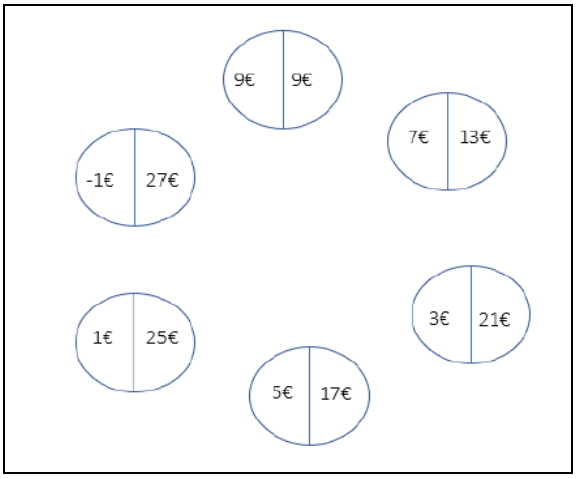
4.1.3 The third phase

The aim of the third step of the experiment is to investigate and identify the characteristics of the individuals. To this end, two types of test are carried out.

The first test focuses on identifying and measuring the subject's aversion to risk. To this end the test proposed by Eckel C.C. (a) et al. (2012) is used, which recalls the work presented by Eckel CC and Grossman PJ (2008). The test shows to the participants six different gambles, represented by a circle divided in half. Each gamble is composed of two playoff values: the low playoff is marked on the left and the high playoff is marked on the right. Both playoffs are equally likely to be drawn (fig. 4.2). Participants are asked to choose which of the six gambles shown would be willing to play. In the specific case of the experiment, the range of gambles includes a safe

alternative involving a sure payoff of €9 since both proposed playoffs have this value, while the riskiest gamble has two playoffs of values of € -1 and + € 27.

Figure 4.2: Risk attitude test



Source: Adapted from Eckel C. C. (b) et Al (2012)

At the end of the test a random extraction is made between the two playoffs constituting the gamble selected by the participant and the participant will win the sum determined by the draw.

The decision to use this approach comes from the desire to make the approach as precise and simple as possible.

Indeed, there would be more complex methods that would allow better accuracy in determining risk aversion, such as the experiment developed by Johnson et Al (2003) in which the experiment involving in more decisions between gables with probabilities ranging from 0.1 and 0.9. But, as demonstrated by Dave et al. (2010), greater complexity produces a higher probability of making mistakes. In fact, comparing two experiment, the first one based on Johnson studies and the other one based on those of Grossman, it is evidence that in the case of the experiment with more gambles, people requesting more clarification from the session staff while the experiment with less gambles and with a 50/50 of probability to gain a certain payoff appeared to be understood more quickly. Besides, there are other difficulties in the first experiment, such as the limited mathematical skill of people, which impede them to take the decision they really want.

In this way, in order to make the probability of error among the participants the minimum possible, the method described above was implemented.
The second test concerns the will to investigate the participant's rationality. To this end, a Cognitive Reflection Test (CRT) is proposed to all participants, namely a test that measures people's cognitive abilities, namely those skills that allow people to not give the first answer that comes instinctive but reflect on the correct answer (fig.4.3).

Figure 4.3: Cognitive ability test

(1) A bat and a ball cost 11€ in total. The bat costs 10€ more than the ball. How much does the ball cost? _____ cents
(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes
(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days

Source: Frederick S. (2005)

The CRT has been introduced by Frederick S. (2005) and it is based essentially on the fact that all the cognitive processes can be broken down into two categories:

- the “System 1” processes: these are the processes that occur spontaneously and intuitively and that do not require much attention
- the “System 2” processes: these are the processes that requires effort, concentration, reasoning and analysis

Both of these processes influence our behaviour, influencing our ability to make decisions and this is why CRT becomes a very useful tool for analyzing the tendency of people not to respond with the first reaction that comes to mind and then to evaluate the rationality of people in making decisions.

4.1.4 The conclusion phase

After completing the three steps of the experiment, in order to complete the session, participants are asked to answer a questionnaire about the choices that led them to select a specific rate.

In this case there are no monetary incentives and therefore the candidates are free to answer what actually pushed them to take a certain decision.

Also in this case a method was sought to make the investigation precise and simple. To this end, all participants are provided with a questionnaire to which they must answer each question using a Likert-type scale (fig. 4.4), composed of 5 symmetric points in which point 1 indicates strongly disagree and point 5 indicates strongly agree.

Figure 4.4: Example of likert-type scale

Molto d'accordo	Abbastanza d'accordo	D'accordo	Poco d'accordo	Per niente d'accordo
1	2	3	4	5

The decision to apply a scale of this type is given by the fact that it is one of the better ways in order to measure attitudes or opinions, as highlighted by Bowling (1997) and by Burns & Grove (1997). In fact these scales use fixed choice response formats and are designed to measure attitudes. They are ordinal scales that assume the strength/intensity of experience is linear and makes the assumption that attitudes can be measured.

The questions to which the participants must answer are the following:

- I chose the tariff that allows me to better forecast my future bills
- I chose the tariff that allows me to make savings on energy and water bills
- In everyday life, I seek to cut back on energy usage
- In everyday life, I seek to cut back on water usage
- I want to cut back on energy usage because I want to save money on my energy bills

- I want to cut back on energy usage because I want to avoid energy waste
- I want to cut back on energy usage because I want to participate in the fight against global warming
- I want to cut back on water usage because I want to save money on my water bills
- I want to cut back on water usage because I want to avoid water waste
- I want to cut back on water usage because I want to participate in the fight against drought
- When it comes to saving energy, I am willing to accept less comfort and I am willing to change my habits
- When it comes to saving water, I am willing to accept less comfort and I am willing to change my habits
- The efforts made must be accompanied by a reduction in the bill amount

4.2 Experimental Results

A data analysis was conducted to investigate two different situations: the electricity tariff perception of the participants and the ability of the participants to adapt to the most cost effective tariff.

Both the analysis consider the following variables:

1. *Sex*: the sample consisted of 162 females (68%) and 76 males (32%)
2. *Age*: the average age of the sample was 47 years. During the analysis, we created 3 dummies:
    - Dummy "*Under26*": it includes the youngest population of the sample
    - Dummy "*Middle-Age*": it includes all people who are more than 25 years and less than 65

- Dummy "O*ver64*": it includes the oldest participants of the sample

3. *Socio-professional category*: the sample was divided into 8 classes whose reference values are listed in the following table:

Socio-professional category	#	%
Employés	80	34%
Profession intermediaries	40	17%
Retraités	39	16%
Cadre et professions int. Superieures	29	12%
Etudiant	26	11%
Artisans, commerçants et chefs d'entreprise	10	4%
Autres personnes sans activité professionnelle	9	4%
Etudiant-salarié	5	2%

As can be seen, the socio-professional category "*Employès*" represents the highest percentage of the analysed population (34%) while, on the opposite side, the socio-professional category "*Etudiant-salarié*" is the one characterized by the lower percentage (2%).

4. *Consumption per person*: as regards the estimate of the annual electricity consumption, we used the knowledge about the composition of each household to calculate the consumption level per person, whose average value is about 2464 KWh, with a minimum recorded value of 913 KWh and a maximum recorded value of 6396 KWh. In order to analyse better and more efficiently this variable we created 3 dummies:
   - *High-consumption*: this dummy includes people who are characterized by a consumption level equal or higher than 5000 KWh/year

- *Middle-consumption*: this dummy includes people whose consumption levels are between 1500 KWh/y and 5000 KWh/y (excluding extremes)
- *Low-consumption*: this dummy includes people whose consumption level is equal or lower than 1500 KWh/year

5. *Revenue per person (revper)*: focusing on the net monthly income of the household, knowing the household composition, we can find the net monthly income per person, whose average value is 1653€, with a minimum registered value of 0€ and a maximum registered value of 4500€.

   We decided to carry out the examination of this variable divided the participants into two categories:

   - High-revenue: this dummy includes all the participants whose monthly revenue is more than 2000€
   - Low-revenue: this dummy includes all the participants whose monthly revenue is equal to or lower than 2000 €/month

6. *Risk aversion*: regarding the analysis of this variable we considered the results of the risk attitude test. We examined two different allocation of the sample.

   a) The first partition, as described in the literature, provides for:
      - Participants "risk averse", characterized by an high risk aversion level, who chose the gambles 9/9 or 7/13 or 5/17
      - Participants "risk lovers", who chose the gambles 3/21 or 1/25 or -1/27

   b) The second partition provides for:
      - Participants "risk averse", characterized by an high risk aversion level and who chose the gambles 9/9 or 7/13
      - Participants "risk moderate", characterized by a moderate risk aversion level and who chose the gambles 5/17 or 3/21
      - Participants "risk lovers", who chose the gambles 1/25 or -1/27

First of all, we carried out a general analysis on the data to determine whether there were significant correlations (tab. 4.3a; tab. 4.3b; tab. 4.3c; tab. 4.3d). It follows from this analysis that the variables characterized by a correlation with a significant level of 5% are:

- *"Middle-Age"* and *"High-Consumption"*
- *"Middle-Consumption"* and *"Risk-Moderate"*
- *"Low-Consumption"* and *"Risk-Moderate"*
- *"Cadre"* and *"High-Revenue"*
- *"Employes"* and *"High-Revenue"*
- *"Employes"* and *"Under26", "Middle-age", "Over64"*
- *"Retraites"* and *"Under26", "Middle-age", "Over64"*
- *"Etudiant"* and *"Under26", "Middle-age", "Over64"*
- *"Profint"* and *"Under26", "Middle-age"*
- *"Cadre"* and *"Under26", "Middle-age"*
- *"Etudiant-salarie"* and *"Under26"*
- *"Cadre"* and *"Sex"*
- *"Employes"* and *"Sex"*

The information relating to the correlation between the independent variables is important since a high correlation implies an imperfect collinearity. The main consequence of the imperfect collinearity is a lowering of the significance of the independent variables involved in the analysis. In this way, the independent variables could turn out to be significant in a simple regression and not significant in a multiple regression due to the correlation.

Table 4.3a: Correlation table (sig 0.05)

	Highre~e	Highco~n	Middle~n	Lowcon~n	Under26	Middle~e	Over64	Sexe	risklo~r	Risklo~r	Riskmo~e	Riskav~e
Highrevenue	1.0000											
Highconcum~n	-0.0064 0.9215	1.0000										
MiddleCons~n	-0.0779 0.2312	-0.3265* 0.0000	1.0000									
Lowconsump~n	0.0843 0.1950	-0.1910* 0.0031	-0.8654* 0.0000	1.0000								
Under26	-0.1040 0.1094	0.1052 0.1056	-0.0079 0.9032	-0.0475 0.4655	1.0000							
MiddleAge	0.1225 0.0592	-0.1399* 0.0309	0.0229 0.7254	0.0504 0.4389	-0.6142* 0.0000	1.0000						
Over64	-0.0572 0.3793	0.0780 0.2304	-0.0213 0.7433	-0.0192 0.7682	-0.1547* 0.0169	-0.6847* 0.0000	1.0000					
Sexe	-0.0863 0.1847	-0.1040 0.1094	0.0431 0.5084	0.0104 0.8729	-0.1030 0.1129	0.0318 0.6258	0.0554 0.3950	1.0000				
risklover	0.0116 0.8584	0.0226 0.7282	0.0510 0.4336	-0.0650 0.3183	-0.0330 0.6121	0.0440 0.4998	-0.0245 0.7068	0.0869 0.1813	1.0000			
Risklover	0.0216 0.7399	0.0134 0.8375	0.1101 0.0902	-0.1214 0.0615	-0.0115 0.8595	0.0951 0.1434	-0.1084 0.0951	0.0603 0.3547	0.6951* 0.0000	1.0000		
Riskmoderate	0.0005 0.9935	-0.0236 0.7170	-0.1353* 0.0370	0.1530* 0.0182	-0.0398 0.5407	-0.0093 0.8865	0.0484 0.4569	-0.0192 0.7683	0.1561* 0.0159	-0.4083* 0.0000	1.0000	
Riskaverse	-0.0204 0.7545	0.0094 0.8850	0.0232 0.7220	-0.0291 0.6554	0.0472 0.4683	-0.0789 0.2253	0.0551 0.3971	-0.0377 0.5623	-0.7825* 0.0000	-0.5439* 0.0000	-0.5439* 0.0000	1.0000

Table 4.3b: Correlation table (sig 0.05)

	Artisan	Cadre	Employes	Retrai~s	Etudia~e	Etudiant	Profint	Autre	Highre~e	Highco~n	Lowcon~n	Middle~n
Artisan	1.0000											
Cadre	-0.0780 0.2305	1.0000										
Employes	-0.1490* 0.0215	-0.2651* 0.0000	1.0000									
Retraites	-0.0927 0.1539	-0.1649* 0.0108	-0.3150* 0.0000	1.0000								
Etudianret~e	-0.0307 0.6377	-0.0546 0.4020	-0.1042 0.1087	-0.0649 0.3191	1.0000							
Etudiant	-0.0733 0.2597	-0.1305* 0.0444	-0.2492* 0.0001	-0.1550* 0.0167	-0.0513 0.4308	1.0000						
Profint	-0.0941 0.1477	-0.1674* 0.0097	-0.3198* 0.0000	-0.1990* 0.0020	-0.0658 0.3118	-0.1574* 0.0151	1.0000					
Autre	-0.0415 0.5239	-0.0738 0.2565	-0.1411* 0.0296	-0.0878 0.1772	-0.0290 0.6558	-0.0694 0.2861	-0.0891 0.1706	1.0000				
Highrevenue	0.1143 0.0785	0.3057* 0.0000	-0.1792* 0.0056	-0.0300 0.6453	-0.0869 0.1813	-0.1158 0.0746	0.1172 0.0710	-0.1177 0.0700	1.0000			
Highconcum~n	-0.0562 0.3879	0.0539 0.4080	-0.1200 0.0646	0.1078 0.0971	-0.0393 0.5460	0.1211 0.0621	-0.0309 0.6351	-0.0532 0.4137	-0.0064 0.9215	1.0000		
Lowconsump~n	-0.0604 0.3539	0.0069 0.9162	0.0021 0.9748	0.0214 0.7425	0.0818 0.2085	-0.0781 0.2299	0.0132 0.8396	0.0455 0.4852	0.0843 0.1950	-0.1910* 0.0031	1.0000	
MiddleCons~n	0.0868 0.1819	-0.0341 0.6006	0.0593 0.3626	-0.0756 0.2451	-0.0587 0.3671	0.0134 0.8373	0.0031 0.9623	-0.0166 0.7989	-0.0779 0.2312	-0.3265* 0.0000	-0.8654* 0.0000	1.0000

Table 4.3c: Correlation table (sig 0.05)

	Artisan	Cadre	Employes	Retrai~s	Etudia~e	Etudiant	Profint	Autre	Sexe	Under26	Middle~e	Over64
Artisan	1.0000											
Cadre	-0.0780 0.2305	1.0000										
Employes	-0.1490* 0.0215	-0.2651* 0.0000	1.0000									
Retraites	-0.0927 0.1539	-0.1649* 0.0108	-0.3150* 0.0000	1.0000								
tudianret~e	-0.0307 0.6377	-0.0546 0.4020	-0.1042 0.1087	-0.0649 0.3191	1.0000							
Etudiant	-0.0733 0.2597	-0.1305* 0.0444	-0.2492* 0.0001	-0.1550* 0.0167	-0.0513 0.4308	1.0000						
Profint	-0.0941 0.1477	-0.1674* 0.0097	-0.3198* 0.0000	-0.1990* 0.0020	-0.0658 0.3118	-0.1574* 0.0151	1.0000					
Autre	-0.0415 0.5239	-0.0738 0.2565	-0.1411* 0.0296	-0.0878 0.1772	-0.0290 0.6558	-0.0694 0.2861	-0.0891 0.1706	1.0000				
Sexe	-0.1261 0.0521	-0.2132* 0.0009	0.1821* 0.0048	0.1084 0.0951	-0.0882 0.1751	-0.0779 0.2310	-0.0055 0.9331	0.0413 0.5261	1.0000			
Under26	-0.0140 0.8300	-0.1388* 0.0324	-0.1835* 0.0045	-0.1649* 0.0108	0.2141* 0.0009	0.7343* 0.0000	-0.1331* 0.0402	-0.0738 0.2565	-0.1030 0.1129	1.0000		
MiddleAge	0.0325 0.6174	0.1680* 0.0094	0.3112* 0.0000	-0.4227* 0.0000	-0.1094 0.0922	-0.4255* 0.0000	0.1966* 0.0023	0.1202 0.0641	0.0318 0.6258	-0.6142* 0.0000	1.0000	
Over64	-0.0278 0.6693	-0.0821 0.2067	-0.2201* 0.0006	0.6815* 0.0000	-0.0608 0.3501	-0.1454* 0.0249	-0.1232 0.0578	-0.0823 0.2057	0.0554 0.3950	-0.1547* 0.0169	-0.6847* 0.0000	1.0000

Table 4.3d: Correlation table (sig 0.05)

	Artisan	Cadre	Employes	Retrai~s	Etudia~e	Etudiant	Profint	Autre	risklo~r	Risklo~r	Riskmo~e	Riskav~e
Artisan	1.0000											
Cadre	-0.0780 0.2305	1.0000										
Employes	-0.1490* 0.0215	-0.2651* 0.0000	1.0000									
Retraites	-0.0927 0.1539	-0.1649* 0.0108	-0.3150* 0.0000	1.0000								
Etudianret~e	-0.0307 0.6377	-0.0546 0.4020	-0.1042 0.1087	-0.0649 0.3191	1.0000							
Etudiant	-0.0733 0.2597	-0.1305* 0.0444	-0.2492* 0.0001	-0.1550* 0.0167	-0.0513 0.4308	1.0000						
Profint	-0.0941 0.1477	-0.1674* 0.0097	-0.3198* 0.0000	-0.1990* 0.0020	-0.0658 0.3118	-0.1574* 0.0151	1.0000					
Autre	-0.0415 0.5239	-0.0738 0.2565	-0.1411* 0.0296	-0.0878 0.1772	-0.0290 0.6558	-0.0694 0.2861	-0.0891 0.1706	1.0000				
risklover	0.0177 0.7864	-0.0846 0.1934	-0.0114 0.8611	0.0487 0.4544	-0.0759 0.2437	0.0295 0.6503	0.0154 0.8137	0.0388 0.5512	1.0000			
Risklover	0.0508 0.4352	-0.0682 0.2950	0.0354 0.5866	-0.0077 0.9063	-0.0290 0.6559	0.0137 0.8332	0.0100 0.8782	-0.0296 0.6498	0.6951* 0.0000	1.0000		
Riskmoderate	-0.0877 0.1777	0.0451 0.4888	-0.0626 0.3363	0.0674 0.3006	-0.0290 0.6559	-0.0160 0.8064	-0.0148 0.8206	0.1161 0.0739	0.1561* 0.0159	-0.4083* 0.0000	1.0000	
Riskaverse	0.0339 0.6031	0.0212 0.7448	0.0250 0.7013	-0.0549 0.3993	0.0534 0.4124	0.0021 0.9747	0.0044 0.9462	-0.0795 0.2217	-0.7825* 0.0000	-0.5439* 0.0000	-0.5439* 0.0000	1.0000

4.2.1 Tariff perception analysis

In order to investigate the electricity tariff perception, we individually considered each pair of tariffs described in the "Objectives of the experiment" chapter. For each single pair, we considered the choice of the tariff as the dependent variable, denominated "*choice*", and the six variables previously mentioned as the independent variables. Furthermore, for each couple we carried out both the singular regression with every independent variable and the multiple regressions, which include more independent variables. Since the dependent variable "c*hoice*" is dichotomous, we used the logistic regression.

Linear tariff vs two part tariff

The aim of the comparison between a linear tariff, with constant marginal price and without a fixed fee, and a two-part tariff structure is to investigate the aversion to fixed part tariff. As highlighted by the data, choices expressed by the participants indicate a high propensity to choose a linear tariff, selected by 155 participants (65%), over a more complex non-linear structure, selected by 83 participants (35%) (fig. 4.5a; fig. 4.5b) regardless of the variables considered.

Figure 4.5a: Linear tariff vs Two part tariff

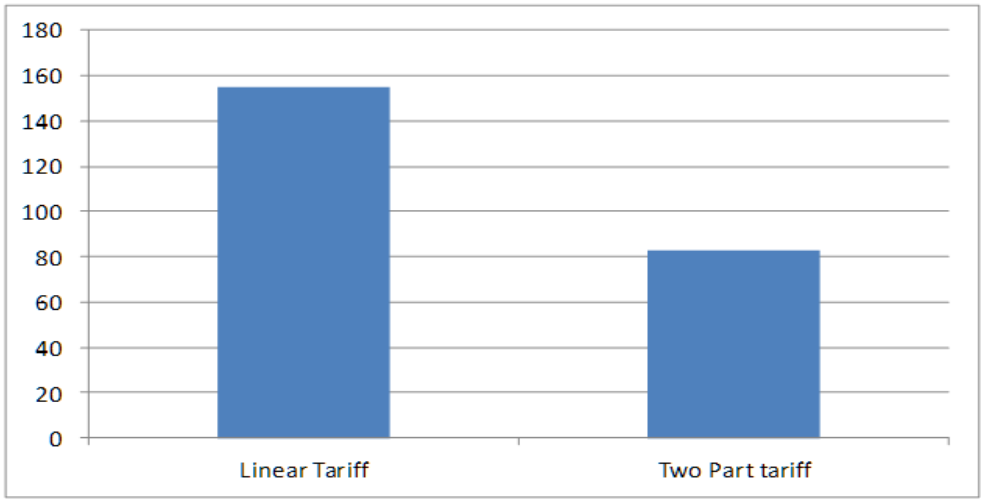
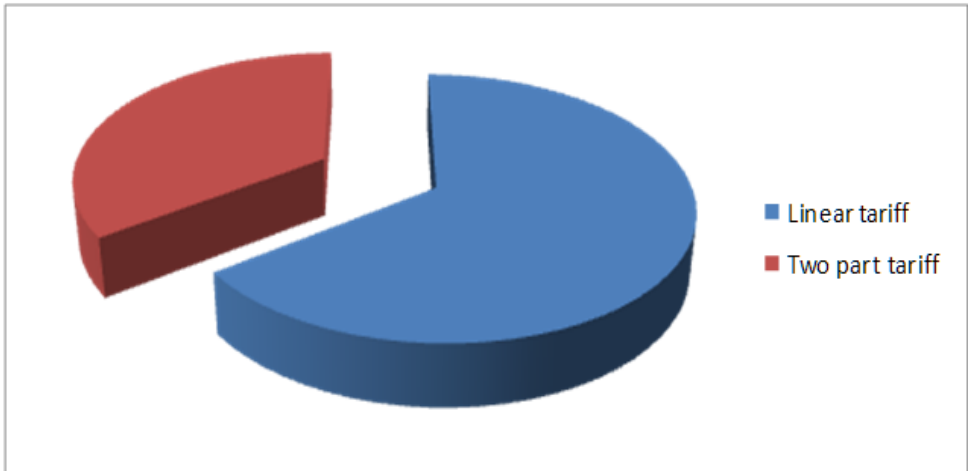


Figure 4.5b: Linear tariff vs Two part tariff



First of all we analysed the variable "*socio-professional category*". The study highlights that the choice of the linear tariff is prevalent among most of the socio-professional categories, especially the one denominated "*Artisans, commerçants et chefs d'entreprise*" (90%). The only two categories which selected the linear tariff with a lower percentage of 50% are "*Etudiant-salarie*" (20%) and "*Autres personnes sans activité professionnelle"* (44%) (fig. 4.6; tab. 4.4).

Figure 4.6: Distribution of the linear tariff preference

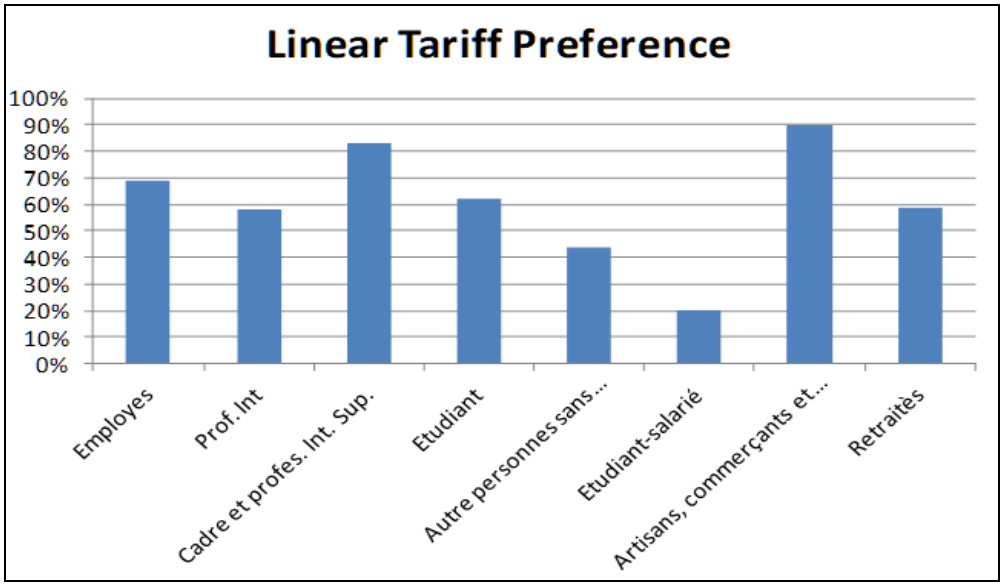


Table 4.4: Distribution of choices for linear tariff (variable socio-prof-cat)

Socio-professional category	#	%
Artisans, commerçants et chefs d'entreprise	9/10	90%
Cadre et professions int. Superieures	24/90	83%
Profession intermediaires	23/40	58%
Employés	55/80	69%
Etudiant	16/26	62%
Retraités	23/39	58%
Autres personnes sans activité professionnelle	4/9	44%
Etudiant-salarié	1/5	20%

At the same time, the linear tariff appears to be preferred to the two part tariff even when analysing the variable "*revenue per person*". In particular, both the participants in the category "*high-revenue*" and in the category "*lower-revenue*" opted for the linear tariff with a percentage higher than 50%. However, it is interesting to highlight that the linear tariff was selected with a larger percentage by the participants with a higher rate, namely them whose monthly revenue is more than 2000€. In fact the participants characterized by a revenue more than 2000€/month are roughly 26% (62/238) and among them 80.6% (50/62) selected the linear tariff while only the remaining 19.4% (12/62) chose the two part tariff. On the other side, the participants characterized by a revenue equal to or lower than 2000 €/month are 74% of the sample (176/238) and 59.7% (105/176) of them opted the linear tariff while the remaining 40.3% (71/176) selected the other one (tab. 4.5).

Table 4.5: Distribution of choices (variable revenue-per person)

	Linear tariff	**Two part tariff**
High-revenue (26%)	80.6% (50/62)	19.4% (12/62)
Low-revenue (74%)	59.7% (105/176)	40.3% (71/176)

Besides, considering the variable "*consumption-per-person*", the study shows that even in this case the majority of the sample discarded the two part tariff. In fact regarding people in the category "h*igh-consumption*", who are 6.7% (16/238) of the sample, only 12.5% (2/16) chose the non-linear tariff while as regards the participants in the category "*middle-consumption*", who are 59.7% (142/238) of the sample, the percentage is higher (35.9% (51/142)) but it is still below 50%. Finally, also the participants in the category "l*ow-consumption*", who are 33.6% (80/238) of the sample, selected the two part tariff with a rate below 50% (37.5% (30/80)) (tab. 4.6).

Table 4.6: Distribution of choices (variable consumption-per-person)

	Linear tariff	**Two part tariff**
High-consumption (6.7%)	14 (87.5%)	2 (12.5%)
Middle-consumption (59.7%)	91 (64.1%)	51 (35.9%)
Low-consumption (33.6%)	50 (62.5%)	30 (37.5%)

We can observe that the linear tariff is preferred to the two part tariff even when we consider the other variables. In particular, taking into account the variable "*sex*" we can observe that for both males and females, more than 50% of the participants have selected the linear tariff. In particular, the linear tariff was chosen by 62% (101/162) of female and 71% (54/76) of male while the two part tariff was selected by 38% (61/162) of female and 29% (22/76) of male (tab. 4.7).

Table 4.7: Distribution of choices (variable sexe)

	Linear tariff	Two part tariff
Male (32%)	54 (71%)	22 (29%)
Female (68%)	101 (62%)	61 (38%)

Similarly to the variable "*sex*", the results show that in all the 3 age categories (under26, middle-age, over64), more than 50% of participants opted for the linear tariff (tab. 4.8). In particular, we can observe that the linear tariff was selected by:

- 58.6% (17/29) of people under 26, who are 12.2% (29/238) of the sample
- 66.1% (115/174) of the participants in the "*middle-age*" category, who are 73.1% (174/238) of the sample
- 65.7% (23/35) of the participants over 64, who are 14.7% (35/238) of the sample

Table 4.8: Distribution of choices (variable age)

	Linear tariff	Two part tariff
Under26 (12.2%)	17 (58.6%)	12 (41.4%)
Middle-Age (73.1%)	115 (66.1%)	59 (33.9%)
Over64 (14.7%)	23 (65.7%)	12 (34.3%)

Finally, we analysed the variable "*risk*". Even in this case, regardless of which risk allocation we consider, the linear tariff is the most preferred.
Considering the risk allocation a), described previously, we can observe that among the "*risk-averse*" participants, who are 54.2% (129/238) of the sample, 67% of them (86/129) selected the linear tariff while only the remaining 33% (43/129) chose the two part tariff. Regarding the "*risk-*

lover" participants, who are 45.8% (109/238) of the sample, 63% of them (69/109) opted for tariff 1 while the remaining 37% (40/109) selected tariff 2 (tab. 4.9).

Table 4.9: Distribution of choices (variable risk; allocation a)

	Linear tariff	**Two part tariff**
Risk averse (54,2%)	86 (67%)	43 (33%)
Risk lover (45.8%)	69 (63%)	40 (37%)

In the same way, analysing the risk allocation b), we observe (tab. 4.10) that the participants continue to prefer the linear tariff, which was selected by:

- 65% (65/100) of the "*risk-averse*" participants, who are 42% (100/238) of the sample
- 67% (46/69) of the "*risk-moderate*" participants, who are 29% (69/238) of the sample
- 64% (44/69) of the "*risk- lover*" participants, who are 29% (69/238) of the sample

Table 4.10: Distribution of choices (variable risk; allocation b)

	Linear tariff	**Two part tariff**
Risk averse (42%)	65 (65%)	35 (35%)
Risk moderate (29%)	46 (67%)	23(33%)
Risk lover (29%)	44 (64%)	25 (36%)

For the purpose of analysing the joint effect of several independent variables on the dependent variable, we carried out some multiple regressions. Each multiple regression considers some variables that are not-correlated each other with a statistical level of 5%. The reason behind this decision is to overcome the problem of the imperfect collinearity.

In the light of this study, we can notice that the dependent variable "*choice*" is influenced by many variables. First of all we can observe that the dependent variable is influenced by the revenue with a significant level of

1%. The results show that higher is the monthly revenue and greater is the propensity to select tariff 1, rejecting tariff 2 with the fixed cost (tab. 4.11a). Besides, the multi regressions demonstrate that there are some significant differences between some socio-professional categories (Tab. 4.11c; tab. 4.11d). These results are valid both when we consider the dummies of the variable "*risk*" in the multi-regression and whether we consider the dummies of the variable "*consumption-per-person*". Consequently, we can affirm that there is a significant tendency to choose tariff 1 by:

- "*Cadre et professions int. Superieures*" compared to "*Autres personnes sans activité professionnelle*" (CI = 95%).
- "*Cadre et professions int. Superieures*" compared to "*Profession intermediaires*" (CI = 95%).
- "*Cadre et professions int. Superieures*" compared to "*Retraites*" (CI = 95%).
- "*Cadre et professions int. Superieures*" compared to "*Etudiant-salarié*" (CI = 95%).
- "*Artisans, commerçants et chefs d'entreprise*" compared to "*Etudiant-salarié*" (CI = 95%).
- *"Artisans, commerçants et chefs d'entreprise"* compared to "*Autres personnes sans activité professionnelle"* (CI = 90%)
- *"Artisans, commerçants et chefs d'entreprise" compared to "Profession intermediaires" (*CI = 90%).
- *"Cadre et professions int. Superieures"* compared to *"Etudiant" (*CI = 90%)
- *"Artisans, commerçants et chefs d'entreprise" compared to "Retraites"* (CI = 90%)
- *"Employés" compared to "Etudiant-salarié"* (CI = 90%)

Finally, we can observe that more is the consumption level per person and higher is the tendency to discard tariff 2, with a significant level of 10% (tab. 4.11a; tab. 4.11b).

Table 4.11a: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice
Highrevenue	1.046***	0.995***	1.015***	1.013***	0.997***	0.996***
	(0.361)	(0.360)	(0.358)	(0.358)	(0.360)	(0.360)
Sexe	-0.272	-0.356	-0.320	-0.327	-0.344	-0.350
	(0.310)	(0.309)	(0.307)	(0.307)	(0.310)	(0.310)
Lowconsump~n	-1.485*					
	(0.801)					
MiddleCons~n	-1.335*					
	(0.785)					
Under26		-0.319			-0.313	-0.306
		(0.530)			(0.530)	(0.532)
MiddleAge		-0.0789			-0.0668	-0.0675
		(0.398)			(0.398)	(0.401)
risklover			-0.140		-0.141	
			(0.280)		(0.280)	
Risklover				-0.0593		-0.0563
				(0.335)		(0.338)
Riskmoderate				0.0660		0.0570
				(0.337)		(0.338)
_cons	1.896**	0.746*	0.684**	0.622**	0.793*	0.732
	(0.783)	(0.435)	(0.292)	(0.310)	(0.446)	(0.456)
N	238	238	238	238	238	238
chi2	15.17	11.11	10.96	10.82	11.37	11.21
p	0.00436	0.0253	0.0120	0.0287	0.0446	0.0821

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.11b: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Cadre	-0.729		0.709	1.263**	2.864**	1.180*	1.228**	1.697**
	(1.166)		(0.551)	(0.597)	(1.225)	(0.646)	(0.591)	(0.834)
Employes	-1.438	-0.709		0.554	2.155*	0.472	0.520	0.988
	(1.082)	(0.551)		(0.414)	(1.147)	(0.482)	(0.403)	(0.714)
Retraites	-1.992*	-1.263**	-0.554		1.601	-0.0827	-0.0347	0.434
	(1.108)	(0.597)	(0.414)		(1.169)	(0.531)	(0.464)	(0.751)
Etudianret~e	-3.593**	-2.864**	-2.155*	-1.601		-1.684	-1.635	-1.167
	(1.542)	(1.225)	(1.147)	(1.169)		(1.198)	(1.166)	(1.305)
Etudiant	-1.910*	-1.180*	-0.472	0.0827	1.684		0.0481	0.517
	(1.134)	(0.646)	(0.482)	(0.531)	(1.198)		(0.526)	(0.792)
Profint	-1.958*	-1.228**	-0.520	0.0347	1.635	-0.0481		0.469
	(1.104)	(0.591)	(0.403)	(0.464)	(1.166)	(0.526)		(0.745)
Autre	-2.426*	-1.697**	-0.988	-0.434	1.167	-0.517	-0.469	
	(1.252)	(0.834)	(0.714)	(0.751)	(1.305)	(0.792)	(0.745)	
Lowconsump~n	-1.467*	-1.467*	-1.467*	-1.467*	-1.467*	-1.467*	-1.467*	-1.467*
	(0.809)	(0.809)	(0.809)	(0.809)	(0.809)	(0.809)	(0.809)	(0.809)
MiddleCons~n	-1.492*	-1.492*	-1.492*	-1.492*	-1.492*	-1.492*	-1.492*	-1.492*
	(0.793)	(0.793)	(0.793)	(0.793)	(0.793)	(0.793)	(0.793)	(0.793)
Artisan		0.729	1.438	1.992*	3.593**	1.910*	1.958*	2.426*
		(1.166)	(1.082)	(1.108)	(1.542)	(1.134)	(1.104)	(1.252)
_cons	3.684***	2.955***	2.246***	1.692**	0.0907	1.774**	1.726**	1.258
	(1.315)	(0.905)	(0.814)	(0.801)	(1.368)	(0.829)	(0.830)	(1.033)
N	238	238	238	238	238	238	238	238
chi2	20.66	20.66	20.66	20.66	20.66	20.66	20.66	20.66
p	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143	0.0143

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.11c: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	Choice	Choice	Choice	Choice	Choice	Choice	Choice	Choice
Cadre	-0.650	-0.675			0.767	0.762	1.184**	1.206**
	(1.164)	(1.166)			(0.548)	(0.549)	(0.591)	(0.591)
Employes	-1.416	-1.436	-0.767	-0.762			0.418	0.444
	(1.082)	(1.083)	(0.548)	(0.549)			(0.406)	(0.407)
Retraites	-1.834*	-1.880*	-1.184**	-1.206**	-0.418	-0.444		
	(1.103)	(1.107)	(0.591)	(0.591)	(0.406)	(0.407)		
Etudianret~e	-3.626**	-3.611**	-2.977**	-2.937**	-2.210*	-2.175*	-1.792	-1.731
	(1.540)	(1.539)	(1.223)	(1.223)	(1.147)	(1.145)	(1.169)	(1.167)
Etudiant	-1.728	-1.758	-1.079*	-1.084*	-0.312	-0.322	0.105	0.122
	(1.129)	(1.130)	(0.637)	(0.637)	(0.470)	(0.470)	(0.518)	(0.519)
Profint	-1.900*	-1.927*	-1.250**	-1.253**	-0.483	-0.491	-0.0658	-0.0470
	(1.102)	(1.103)	(0.588)	(0.587)	(0.401)	(0.401)	(0.457)	(0.458)
Autre	-2.415*	-2.501**	-1.765**	-1.826**	-0.999	-1.065	-0.581	-0.620
	(1.250)	(1.259)	(0.834)	(0.836)	(0.714)	(0.721)	(0.746)	(0.749)
risklover	-0.134		-0.134		-0.134		-0.134	
	(0.283)		(0.283)		(0.283)		(0.283)	
Risklover		-0.202		-0.202		-0.202		-0.202
		(0.372)		(0.372)		(0.372)		(0.372)
Riskaverse		-0.154		-0.154		-0.154		-0.154
		(0.346)		(0.346)		(0.346)		(0.346)
Artisan			0.650	0.675	1.416	1.436	1.834*	1.880*
			(1.164)	(1.166)	(1.082)	(1.083)	(1.103)	(1.107)
_cons	2.266**	2.356**	1.616***	1.682***	0.850***	0.920***	0.432	0.476
	(1.065)	(1.093)	(0.502)	(0.537)	(0.275)	(0.341)	(0.357)	(0.385)
N	238	238	238	238	238	238	238	238
chi2	16.13	16.23	16.13	16.23	16.13	16.23	16.13	16.23
p	0.0405	0.0622	0.0405	0.0622	0.0405	0.0622	0.0405	0.0622

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.11d: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Artisan	3.626**	3.611**	1.728	1.758	1.900*	1.927*	2.415*	2.501**
	(1.540)	(1.539)	(1.129)	(1.130)	(1.102)	(1.103)	(1.250)	(1.259)
Cadre	2.977**	2.937**	1.079*	1.084*	1.250**	1.253**	1.765**	1.826**
	(1.223)	(1.223)	(0.637)	(0.637)	(0.588)	(0.587)	(0.834)	(0.836)
Employes	2.210*	2.175*	0.312	0.322	0.483	0.491	0.999	1.065
	(1.147)	(1.145)	(0.470)	(0.470)	(0.401)	(0.401)	(0.714)	(0.721)
Retraites	1.792	1.731	-0.105	-0.122	0.0658	0.0470	0.581	0.620
	(1.169)	(1.167)	(0.518)	(0.519)	(0.457)	(0.458)	(0.746)	(0.749)
Etudiant	1.898	1.853			0.171	0.169	0.686	0.743
	(1.192)	(1.190)			(0.515)	(0.515)	(0.783)	(0.789)
Profint	1.727	1.684	-0.171	-0.169			0.515	0.573
	(1.166)	(1.164)	(0.515)	(0.515)			(0.744)	(0.750)
Autre	1.211	1.110	-0.686	-0.743	-0.515	-0.573		
	(1.308)	(1.310)	(0.783)	(0.789)	(0.744)	(0.750)		
risklover	-0.134		-0.134		-0.134		-0.134	
	(0.283)		(0.283)		(0.283)		(0.283)	
Risklover		-0.202		-0.0482		-0.202		-0.202
		(0.372)		(0.338)		(0.372)		(0.372)
Riskaverse		-0.154				-0.154		-0.154
		(0.346)				(0.346)		(0.346)
Etudianret~e			-1.898	-1.853	-1.727	-1.684	-1.211	-1.110
			(1.192)	(1.190)	(1.166)	(1.164)	(1.308)	(1.310)
Riskmoderate				0.154				
				(0.346)				
_cons	-1.360	-1.255	0.538	0.444	0.366	0.429	-0.149	-0.145
	(1.120)	(1.147)	(0.428)	(0.436)	(0.348)	(0.395)	(0.689)	(0.686)
N	238	238	238	238	238	238	238	238
chi2	16.13	16.23	16.13	16.23	16.13	16.23	16.13	16.23
p	0.0405	0.0622	0.0405	0.0622	0.0405	0.0622	0.0405	0.0622

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Two part tariff vs increasing block tariff

The participants had to choose between two non-linear tariffs. The aim of the comparison between a two-part tariff structure with fixed cost and a increasing block tariff is to investigate if the fixed cost influences the choice of the participants, also when it is compared with a non-linear tariff, as the increasing block tariff.

Data shows that the sample is divided down the middle: 114 participants (48%) selected the two part tariff, while 124 participants (52%) opted for the increasing block tariff (fig. 4.7a; fig. 4.7b).

It should be noted that the lack of a large majority for one of the two tariffs is independent of the variables analysed.

Figure 4.7a: Two part tariff vs increasing block tariff

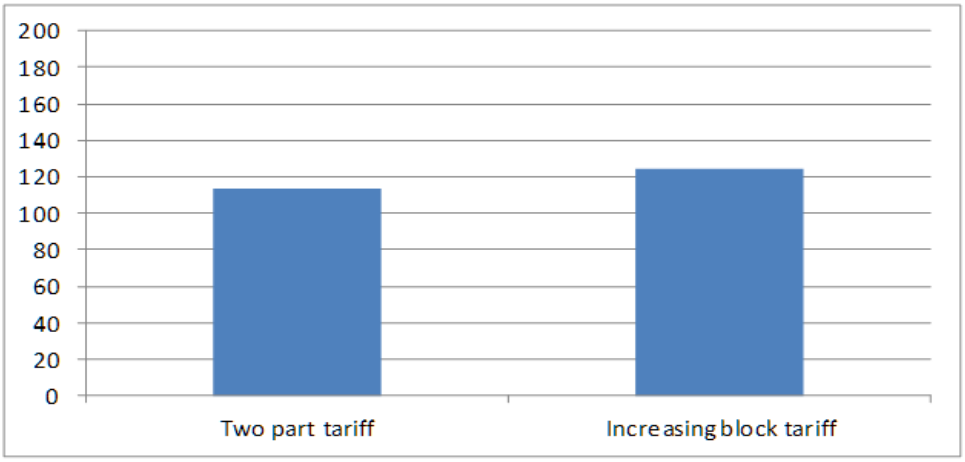
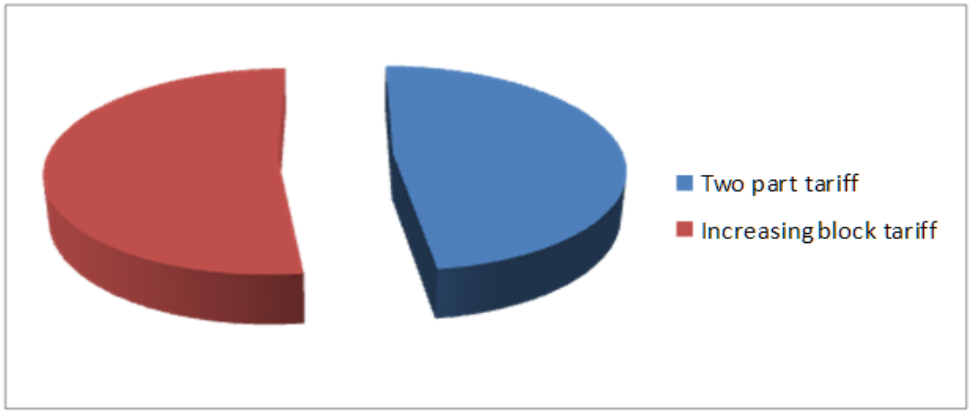


Figure 4.7b: Two part tariff vs increasing block tariff



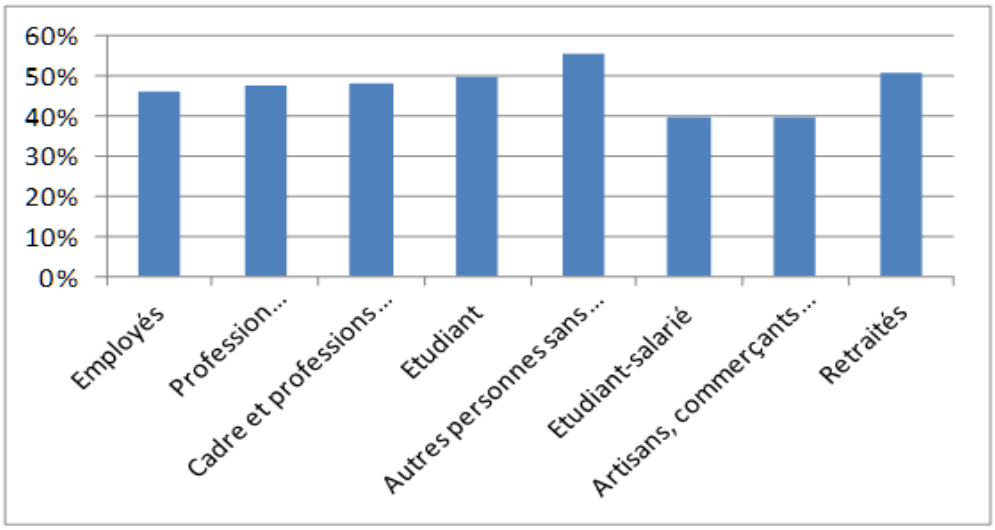
We started the analysis considering the variable "*socio-professional category*". The study points out that each socio-professional category is

divided into two nearly equal groups in the choice of the tariff. The choice of the two part tariff is prevalent among the two categories denominated "*Autres personnes sans activité professionnelle*" (55.5%) and "*Retraités*" (51%). On the other hand, the choice of the increasing block tariff is dominant among the two categories denominated "*Etudiant-salarié*" (60%) and "*Artisans, commerçants et chefs d'entreprise*" (60%) (tab. 4.12; fig. 4.8).

Table 4.12: Distribution of choices for linear tariff (variable socio-prof-cat)

Job	#	%
Employés	37/80	46%
Profession intermediaires	19/40	47.5%
Cadre et professions int. Superieures	14/29	48%
Etudiant	13/26	50%
Autres personnes sans activité professionnelle	5/9	55.5%
Etudiant-salarié	2/5	40%
Artisans, commerçants et chefs d'entreprise	4/10	40%
Retraités	20/39	51%

Figure 4.8: Distribution of the two-part tariff preference



Besides, the results show that the sample is divided into two early equal parts taking also into account the variable "*sex*". In fact we can observe that 46% (75/162) of female chose the two part tariff while 54% (87/162) selected the increasing block tariff while, regarding the male, 51% (39/76) chose two part tariff while 49% (37/76) opted for the increasing block tariff (tab. 4.13).

Table 4.13: Distribution of choices (variable sexe)

	Two part tariff	**Increasing block tariff**
Male (32%)	39 (51%)	37 (49%)
Female (68%)	75 (46%)	87 (54%)

We obtained the same results analysing the variable "*age*" and its categories. In particular, analysing the 3 dummies described previously, we can see that regarding people under 26, 55.2% (16/29) selected the two part tariff while the remaining 44.8% (13/29) chose the other one. As concerns people in the category "*middle-age*", 46.6% (81/174) selected the two part tariff while 53.4% (93/174) chose the increasing block tariff. Finally people considering people in the category "*over64*", 48.6% (17/35) of them chose the two part tariff while the remaining 51.4% (18/35) opted the increasing block tariff (tab. 4.14).

Table 4.14: Distribution of choices (variable age)

	Two part tariff	**Increasing block tariff**
Under26 (12.2%)	16 (55.2%)	13(44.8%)
Middle-Age (73.1%)	81 (46.6%)	93 (53.4%)
Over64 (14.7%)	17 (48.6%)	18 (51.4%)

Moreover, analysing the dummies of the variable "*consumption-per-person*", previously mentioned, no category is able to select a tariff in a large majority, except for the category "h*igh-consumption"*. In fact, regarding people in the category "h*igh-consumption*", only 31.3% (5/16) selected the two part tariff while the remaining 68.7% (11/16) chose tariff 2.

Considering the other two categories, we can observe that in the category "*middle-age*" 52.1% (74/142) of the participants selected the two part tariff, while in the category "*low-consumption*", the two part tariff was chosen by 43.8% (35/80) of people (tab. 4.15).

Table 4.15: Distribution of choices (variable consumption-per-person)

	Two part tariff	**Increasing bock tariff**
High-consumption (6.7%)	5 (31.3%)	11 (68.7%)
Middle-consumption (59.7%)	74 (52.1%)	68 (47.9%)
Low-consumption (33.6%)	35 (43.8%)	45 (56.2%)

Furthermore we analysed the variable "*risk*", considering the dummies obtained by the two different risk allocations of the sample previously described. Even in this case the study demonstrates that in both the case there is not a majority in the choice of the tariff (tab. 4.16).

In particular, considering the allocation a) we can observe that among the "*risk averse*" participants, 44% of them (57/129) selected the two part tariff in contrast to 52% (57/109) of the "*risk lover*" participants, while 56% (72/129) opted for the increasing block tariff in contrast to 48% (52/109) of the "*risk lover*" participants.

Table 4.16: Distribution of choices (variable risk; allocation a)

	Two part tariff	**Increasing bock tariff**
Risk averse (54,2%)	57 (44%)	72 (56%)
Risk lover (45.8%)	57 (52%)	52 (48%)

On the other hand, analysing the partition b) we can see that among the "*risk-averse*" participants, 43% (643/100) of them selected the two part tariff in contrast to 55% (38/69) of the "*risk-moderate*" participants and 48% (33/69) of the "*risk lover*" participants, while 57% (57/100) chose the increasing block tariff, in contrast to 45% (31/69) of the "*risk-moderate*" participants and 52% (36/69) of the "*risk lover*" participants (tab. 4.17).

Table 4.17: Distribution of choices (variable risk; allocation b)

	Two part tariff	Increasing bock tariff
Risk averse (42%)	43 (43%)	57 (57%)
Risk moderate (29%)	38 (55%)	31 (45%)
Risk lover (29%)	33 (48%)	36 (52%)

Finally, analysing the two categories "*high-revenue*" and "*low-revenue*" previously mentioned, it appears that, as concerns the participants characterized by a revenue more than 2000€/month, exactly 50% (31/62) selected the two part tariff. On the other side, considering the participants characterized by a revenue equal to or lower than 2000 €/month, 47.2% (83/176) selected the two part tariff while the remaining 52.8% (93/176) chose the increasing block tariff (tab. 4.18).

Table 4.18: Distribution of choices (variable revenue-per person)

	Two part tariff	Increasing bock tariff
High-revenue (26%)	50% (31/62)	50% (31/62)
Low-revenue (74%)	47.2% (83/176)	52.8% (93/176)

In conclusion, we carried out some multiple regressions in order to analyse the joint effect of several independent variables on the dependent variable. For the reason outlined in the previous paragraph, each multiple regression considers some variables that are not-correlated each other with a statistical level of 5%.

Afterwards, we carried out some multiple regressions in order to analyse the joint effect of several independent variables on the dependent variable. For the reason outlined in the previous paragraph, each multiple regression considers some variables that are not-correlated each other with a statistical level of 5%.

We can notice that the dependent variable is not influenced by any independent variables with a significant level of 1% or 5%. The only statistically significant result, with a significant level of 10%, is the

difference in the tariff choice between the participants in the category "*middle-consumption*" and the participants in the category "*high-consumption*".

This conclusion suggests that people in the category "*middle-consumption*" have a higher propensity to select the two part tariff compared to people in the category "*high-consumption*" (tab. 4.19a; tab. 4.19b; tab. 4.19c; tab. 4.19d).

Table 4.19a: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice
Highrevenue	0.122	0.130	0.0894	0.0919	0.125	0.129
	(0.300)	(0.300)	(0.298)	(0.298)	(0.301)	(0.302)
Sexe	-0.241	-0.171	-0.227	-0.199	-0.205	-0.175
	(0.284)	(0.282)	(0.282)	(0.281)	(0.284)	(0.284)
Lowconsump~n	0.577					
	(0.589)					
MiddleCons~n	0.926					
	(0.569)					
Under26		0.241			0.241	0.271
		(0.508)			(0.509)	(0.512)
MiddleAge		-0.102			-0.120	-0.108
		(0.372)			(0.374)	(0.377)
risklover			0.344		0.353	
			(0.263)		(0.264)	
Risklover				0.206		0.222
				(0.316)		(0.318)
Riskmoderate				0.487		0.503
				(0.316)		(0.317)
_cons	-0.702	0.0436	-0.111	-0.174	-0.0815	-0.164
	(0.564)	(0.405)	(0.269)	(0.288)	(0.417)	(0.429)
N	238	238	238	238	238	238
chi2	4.350	1.358	2.348	3.025	3.158	3.896
p	0.361	0.852	0.503	0.554	0.676	0.691

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.19b: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Cadre	0.486		0.159	-0.152	0.346	-0.0780	0.0803	-0.233
	(0.752)		(0.440)	(0.497)	(0.993)	(0.549)	(0.494)	(0.773)
Employes	0.328	-0.159		-0.311	0.187	-0.237	-0.0785	-0.391
	(0.687)	(0.440)		(0.399)	(0.946)	(0.462)	(0.391)	(0.711)
Retraites	0.639	0.152	0.311		0.498	0.0741	0.232	-0.0804
	(0.730)	(0.497)	(0.399)		(0.975)	(0.515)	(0.457)	(0.751)
Etudianret~e	0.141	-0.346	-0.187	-0.498		-0.424	-0.265	-0.578
	(1.127)	(0.993)	(0.946)	(0.975)		(1.006)	(0.972)	(1.138)
Etudiant	0.564	0.0780	0.237	-0.0741	0.424		0.158	-0.155
	(0.764)	(0.549)	(0.462)	(0.515)	(1.006)		(0.513)	(0.788)
Profint	0.406	-0.0803	0.0785	-0.232	0.265	-0.158		-0.313
	(0.723)	(0.494)	(0.391)	(0.457)	(0.972)	(0.513)		(0.746)
Autre	0.719	0.233	0.391	0.0804	0.578	0.155	0.313	
	(0.937)	(0.773)	(0.711)	(0.751)	(1.138)	(0.788)	(0.746)	
Lowconsump~n	0.623	0.623	0.623	0.623	0.623	0.623	0.623	0.623
	(0.597)	(0.597)	(0.597)	(0.597)	(0.597)	(0.597)	(0.597)	(0.597)
MiddleCons~n	0.977*	0.977*	0.977*	0.977*	0.977*	0.977*	0.977*	0.977*
	(0.577)	(0.577)	(0.577)	(0.577)	(0.577)	(0.577)	(0.577)	(0.577)
Artisan		-0.486	-0.328	-0.639	-0.141	-0.564	-0.406	-0.719
		(0.752)	(0.687)	(0.730)	(1.127)	(0.764)	(0.723)	(0.937)
_cons	-1.314	-0.828	-0.987	-0.676	-1.173	-0.750	-0.908	-0.595
	(0.863)	(0.639)	(0.601)	(0.597)	(1.080)	(0.632)	(0.631)	(0.882)
N	238	238	238	238	238	238	238	238
chi2	4.857	4.857	4.857	4.857	4.857	4.857	4.857	4.857
p	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.19c: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Cadre	0.388	0.263			0.115	0.0588	-0.0677	-0.101
	(0.748)	(0.751)			(0.436)	(0.437)	(0.494)	(0.494)
Employes	0.273	0.205	-0.115	-0.0588			-0.183	-0.159
	(0.686)	(0.687)	(0.436)	(0.437)			(0.393)	(0.394)
Retraites	0.456	0.364	0.0677	0.101	0.183	0.159		
	(0.723)	(0.726)	(0.494)	(0.494)	(0.393)	(0.394)		
Etudianret~e	0.0960	-0.00834	-0.292	-0.272	-0.177	-0.213	-0.359	-0.372
	(1.124)	(1.123)	(0.988)	(0.991)	(0.944)	(0.945)	(0.973)	(0.973)
Etudiant	0.408	0.348	0.0201	0.0849	0.135	0.144	-0.0475	-0.0158
	(0.758)	(0.759)	(0.543)	(0.544)	(0.453)	(0.454)	(0.508)	(0.509)
Profint	0.315	0.246	-0.0726	-0.0172	0.0426	0.0416	-0.140	-0.118
	(0.721)	(0.723)	(0.491)	(0.491)	(0.389)	(0.390)	(0.452)	(0.453)
Autre	0.615	0.459	0.227	0.196	0.342	0.255	0.159	0.0952
	(0.934)	(0.943)	(0.771)	(0.773)	(0.710)	(0.716)	(0.746)	(0.749)
risklover	0.316		0.316		0.316		0.316	
	(0.264)		(0.264)		(0.264)		(0.264)	
Risklover		0.190		0.190		0.190		0.190
		(0.316)		(0.316)		(0.316)		(0.316)
Riskmoderate		0.453		0.453		0.453		0.453
		(0.319)		(0.319)		(0.319)		(0.319)
Artisan			-0.388	-0.263	-0.273	-0.205	-0.456	-0.364
			(0.748)	(0.751)	(0.686)	(0.687)	(0.723)	(0.726)
_cons	-0.566	-0.529	-0.178	-0.265	-0.293	-0.324	-0.111	-0.164
	(0.662)	(0.663)	(0.384)	(0.402)	(0.255)	(0.271)	(0.348)	(0.364)
N	238	238	238	238	238	238	238	238
chi2	2.348	2.933	2.348	2.933	2.348	2.933	2.348	2.933
p	0.968	0.967	0.968	0.967	0.968	0.967	0.968	0.967

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.19d: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Artisan	-0.0960	0.00834	-0.408	-0.348	-0.315	-0.246	-0.615	-0.459
	(1.124)	(1.123)	(0.758)	(0.759)	(0.721)	(0.723)	(0.934)	(0.943)
Cadre	0.292	0.272	-0.0201	-0.0849	0.0726	0.0172	-0.227	-0.196
	(0.988)	(0.991)	(0.543)	(0.544)	(0.491)	(0.491)	(0.771)	(0.773)
Employes	0.177	0.213	-0.135	-0.144	-0.0426	-0.0416	-0.342	-0.255
	(0.944)	(0.945)	(0.453)	(0.454)	(0.389)	(0.390)	(0.710)	(0.716)
Retraites	0.359	0.372	0.0475	0.0158	0.140	0.118	-0.159	-0.0952
	(0.973)	(0.973)	(0.508)	(0.509)	(0.452)	(0.453)	(0.746)	(0.749)
Etudiant	0.312	0.357			0.0928	0.102	-0.207	-0.111
	(0.999)	(0.998)			(0.506)	(0.506)	(0.780)	(0.785)
Profint	0.219	0.255	-0.0928	-0.102			-0.300	-0.213
	(0.971)	(0.971)	(0.506)	(0.506)			(0.744)	(0.749)
Autre	0.519	0.468	0.207	0.111	0.300	0.213		
	(1.139)	(1.143)	(0.780)	(0.785)	(0.744)	(0.749)		
risklover	0.316		0.316		0.316		0.316	
	(0.264)		(0.264)		(0.264)		(0.264)	
Risklover		0.190		0.190		0.190		0.190
		(0.316)		(0.316)		(0.316)		(0.316)
Riskmoderate		0.453		0.453		0.453		0.453
		(0.319)		(0.319)		(0.319)		(0.319)
Etudianret~e			-0.312	-0.357	-0.219	-0.255	-0.519	-0.468
			(0.999)	(0.998)	(0.971)	(0.971)	(1.139)	(1.143)
_cons	-0.470	-0.537	-0.158	-0.180	-0.251	-0.282	0.0487	-0.0692
	(0.916)	(0.923)	(0.415)	(0.423)	(0.342)	(0.353)	(0.688)	(0.707)
N	238	238	238	238	238	238	238	238
chi2	2.348	2.933	2.348	2.933	2.348	2.933	2.348	2.933
p	0.968	0.967	0.968	0.967	0.968	0.967	0.968	0.967

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Increasing block tariff vs Linear tariff

The participants had to choose between an increasing block tariff and a linear tariff, with constant marginal price and without a fixed fee. This comparison aims to investigate if there is an aversion to the increasing block tariff.

As highlighted by the data, choices expressed by the participants indicate a high propensity to opt for a linear tariff, selected by 155 participants (65%), over a more complex non-linear structure, selected by 83 participants (35%) (fig. 4.9a; fig. 4.9b).

Figure 4.9a: Two part tariff vs linear tariff

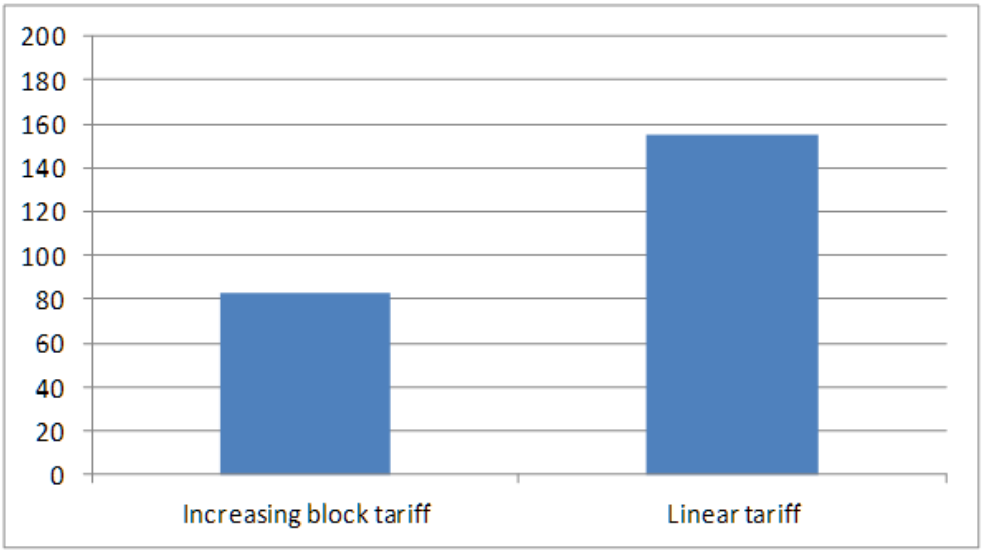
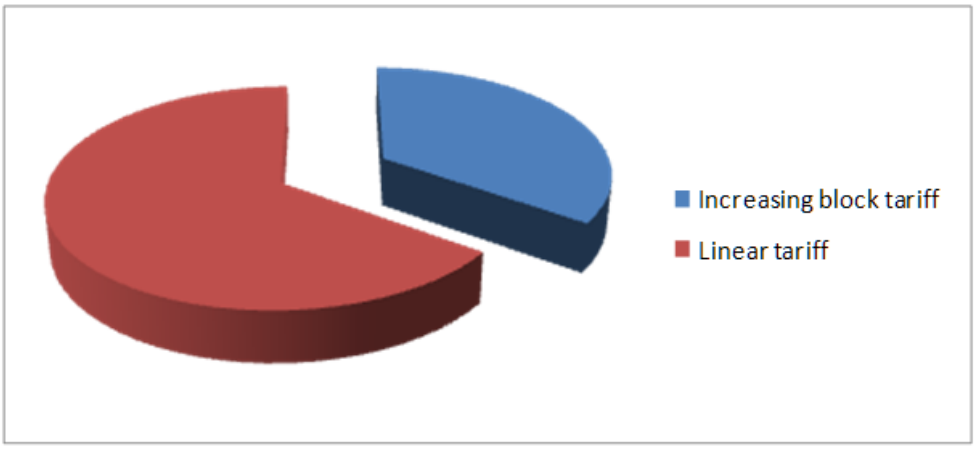


Figure 4.9b: Two part tariff vs linear tariff



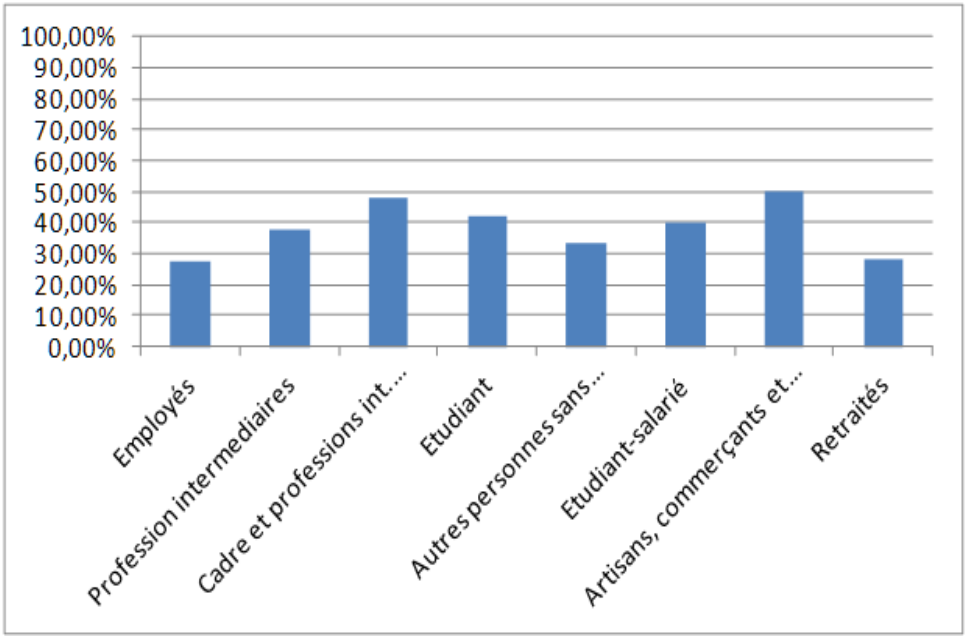
As illustrated in the paragraph "*Linear tariff vs two part tariff*", even in this comparison the linear tariff is largely preferred by the participants regardless of the variable considered.

The first variable we analysed was the variable "*socio-professional category*". The study indicates (tab. 4.20; fig. 4.10) that the choice of the linear tariff is prevalent among all the categories with the exception of the category "*Artisans, commerçants et chefs d'entreprise*" and the category "*Cadre et professions int. Superieures*". In these two categories, the sample is divided into two equal parts.

Table 4.20: Distribution of choices for linear tariff (variable socio-prof-cat)

Job	#	%
Employés	22/80	27.5%
Profession intermediaires	15/40	37.5%
Cadre et professions int. Superieures	14/29	48%
Etudiant	11/26	42%
Autres personnes sans activité professionnelle	3/9	33%
Etudiant-salarié	2/5	40%
Artisans, commerçants et chefs d'entreprise	5/10	50%
Retraités	11/39	28%

Figure 4.10: Distribution of the two-part tariff preference



In the same way, the results show that the linear tariff appears to be preferred to the two part tariff even when analysing the variable "revenue per person". In fact we can see that the participants of both the categories (high-revenue and low-revenue) are characterized by a strong propensity to reject the non-linear tariff. In particular, as concern the participants characterized by a revenue more than 2000€/month, exactly 40.3% (25/62) selected the increasing block tariff while the other 59.7% (37/62) chose the linear one. On the other side, considering the participants characterized by a revenue equal to or lower than 2000 €/month, 33% (58/176) selected the

non-linear tariff while the remaining 67% (118/176) chose the linear tariff (tab. 4.21).

Table 4.21: Distribution of choices (variable revenue-per person)

	Increasing block tariff	**Linear tariff**
High-revenue (26%)	40.3% (25/62)	59.7% (37/62)
Low-revenue (74%)	33% (58/176)	67% (118/176)

We can observe that the linear tariff is preferred to the two part tariff even when we consider the other variables. In particular, taking into account the variable "*sex*" we can observe that for both males and females, more than 50% of the participants selected the linear tariff. In particular, 64% (104/162) of female chose the linear tariff while 36% (58/162) selected the increasing block tariff. Regarding the male, 67% (43/76) opted for the linear tariff while 33% (25/76) chose the non-linear one (tab. 4.22).

Table 4.22: Distribution of choices (variable sexe)

	Increasing block tariff	**Linear tariff**
Male (32%)	25 (33%)	43 (67%)
Female (68%)	58 (36%)	104 (64%)

Furthermore, analysing the data we can affirm that also considering the variable "*age*" and its 3 dummies described previously, the linear tariff continues to be preferred to the non-linear one, regardless of the category analysed (tab. 4.23). In fact we can see that the linear tariff was selected by:

- 58.6% (17/29) of the participants under 26
- 63.8% (111/174) of the participants aged between 26 and 64 years
- 77.1% (27/35) of them over 64

Table 4.23: Distribution of choices (variable age)

	Increasing block tariff	Linear tariff
Under26 (12.2%)	12 (41.4%)	17(58.6%)
Middle-Age (73.1%)	63 (36.2%)	111 (63.8%)
Over64 (14.7%)	8 (22.9%)	27 (77.1%)

In addition, the study demonstrates that also the results obtained analysing the variable "*consumption-per-person*" follow this trend. In fact, in all the 3 categories of this variable (high-consumption, middle-consumption and low-consumption), more than 50% of participants discarded the increasing block tariff.

In particular, the non-linear tariff recorded the highest percentage of choice in the category "h*igh-consumption*", where 43.8% (7/16) of the participants selected the increasing block tariff. As regards the percentage of the non-linear tariff choice in the other two categories, we can observe that in the "*middle-consumption*" the percentage drops to 32.4% (46/142), while in the category "l*ow-consumption*" the percentage falls to 37.5% (30/80) (tab. 4.24).

Table 4.24: Distribution of choices (variable consumption-per-person)

	Increasing block tariff	Linear tariff
High-consumption (6.7%)	7 (43.8%)	9 (56.2%)
Middle-consumption (59.7%)	46 (32.4%)	96 (67.6%)
Low-consumption (33.6%)	30 (37.5%)	45 (62.5%)

Finally, we analysed the variable "*risk*". Even in this case, regardless of which risk allocation we consider, the linear tariff appears to be the most preferred.

Considering the risk allocation a), described previously, we can observe that among the "*risk averse*" participants, 38% of them (49/129) selected tariff 1

while 62% (80/129) chose tariff 2. Regarding the "*risk lover*" participants, 31% of them (34/109) selected tariff 1 while the remaining 69% (75/109) preferred tariff 2 (tab. 4.25).

Table 4.25: Distribution of choices (variable risk; allocation a)

	Increasing block tariff	**Linear tariff**
Risk averse (54,2%)	49 (38%)	80 (62%)
Risk lover (45.8%)	34 (31%)	75 (69%)

Considering the partition b) (tab. 4.26), the linear tariff was selected by:

- 61% (61/100) of the "*risk averse*" participants,
- 30.5% (21/ 69) of the "risk-moderate" participants
- 33% (23/69) of the "*risk lover*" participants

Table 4.26: Distribution of choices (variable risk; allocation b)

	Increasing block tariff	**Linear tariff**
Risk averse (42%)	39 (39%)	61 (61%)
Risk moderate (29%)	21 (30.5%)	48 (69.5%)
Risk lover (29%)	23 (33%)	46 (67%)

Finally, we analysed the joint effect of several independent variables on the dependent variable considering some multi regressions. For the reason outlined in the previous paragraph, each multiple regression considers some variables that are not-correlated each other with a statistical level of 5%.
From this investigation, we can observe that the dependent variable is not influenced by any independent variables with a significant level of 1% or 5%. The only statistically significant result, with a significant level of 10%, is the difference in the tariff choice between the participants who are under 26 and the participants who are over 64. (CI = 10%). This conclusion highlights that the increasing block tariff, namely the non-linear tariff, is positively influenced if people are less than 26 years (tab. 4.27a; 4.27b; 4.27c; 4.27d).

Table 4.27a: Multiple regressionswith variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice
Highrevenue	0.321	0.340	0.342	0.343	0.342	0.343
	(0.308)	(0.311)	(0.307)	(0.307)	(0.313)	(0.313)
Sexe	0.185	0.209	0.189	0.168	0.236	0.216
	(0.299)	(0.301)	(0.298)	(0.298)	(0.302)	(0.302)
Lowconsump~n	-0.316					
	(0.560)					
MiddleCons~n	-0.518					
	(0.540)					
Under26		0.935*			0.931*	0.928*
		(0.558)			(0.558)	(0.559)
MiddleAge		0.634			0.642	0.653
		(0.435)			(0.435)	(0.437)
risklover			-0.322		-0.325	
			(0.277)		(0.279)	
Risklover				-0.267		-0.309
				(0.329)		(0.332)
Riskmoderate				-0.387		-0.373
				(0.334)		(0.336)
_cons	-0.426	-1.447***	-0.703**	-0.647**	-1.326***	-1.273***
	(0.536)	(0.474)	(0.284)	(0.302)	(0.481)	(0.491)
N	238	238	238	238	238	238
chi2	2.526	4.579	2.724	2.872	5.952	6.105
p	0.640	0.333	0.436	0.579	0.311	0.412

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.27b: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Cadre	-0.153		0.868*	0.885*	0.359	0.235	0.422	0.607
	(0.739)		(0.451)	(0.517)	(0.992)	(0.547)	(0.497)	(0.803)
Employes	-1.020	-0.868*		0.0180	-0.509	-0.632	-0.446	-0.261
	(0.683)	(0.451)		(0.441)	(0.951)	(0.477)	(0.413)	(0.752)
Retraites	-1.038	-0.885*	-0.0180		-0.527	-0.650	-0.464	-0.279
	(0.734)	(0.517)	(0.441)		(0.986)	(0.536)	(0.487)	(0.797)
Etudianret~e	-0.512	-0.359	0.509	0.527		-0.123	0.0631	0.248
	(1.119)	(0.992)	(0.951)	(0.986)		(1.006)	(0.974)	(1.158)
Etudiant	-0.388	-0.235	0.632	0.650	0.123		0.186	0.371
	(0.754)	(0.547)	(0.477)	(0.536)	(1.006)		(0.520)	(0.819)
Profint	-0.575	-0.422	0.446	0.464	-0.0631	-0.186		0.185
	(0.716)	(0.497)	(0.413)	(0.487)	(0.974)	(0.520)		(0.781)
Autre	-0.760	-0.607	0.261	0.279	-0.248	-0.371	-0.185	
	(0.954)	(0.803)	(0.752)	(0.797)	(1.158)	(0.819)	(0.781)	
Lowconsump~n	-0.182	-0.182	-0.182	-0.182	-0.182	-0.182	-0.182	-0.182
	(0.575)	(0.575)	(0.575)	(0.575)	(0.575)	(0.575)	(0.575)	(0.575)
MiddleCons~n	-0.442	-0.442	-0.442	-0.442	-0.442	-0.442	-0.442	-0.442
	(0.555)	(0.555)	(0.555)	(0.555)	(0.555)	(0.555)	(0.555)	(0.555)
Artisan		0.153	1.020	1.038	0.512	0.388	0.575	0.760
		(0.739)	(0.683)	(0.734)	(1.119)	(0.754)	(0.716)	(0.954)
_cons	0.390	0.238	-0.630	-0.648	-0.121	0.00215	-0.184	-0.369
	(0.836)	(0.614)	(0.585)	(0.587)	(1.067)	(0.607)	(0.610)	(0.894)
N	238	238	238	238	238	238	238	238
chi2	7.892	7.892	7.892	7.892	7.892	7.892	7.892	7.892
p	0.545	0.545	0.545	0.545	0.545	0.545	0.545	0.545

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.27c: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Cadre	-0.113	-0.0208			0.875*	0.917**	0.822	0.848
	(0.737)	(0.740)			(0.450)	(0.451)	(0.517)	(0.517)
Employes	-0.988	-0.938	-0.875*	-0.917**			-0.0528	-0.0690
	(0.682)	(0.683)	(0.450)	(0.451)			(0.436)	(0.437)
Retraites	-0.935	-0.869	-0.822	-0.848	0.0528	0.0690		
	(0.727)	(0.731)	(0.517)	(0.517)	(0.436)	(0.437)		
Etudianret~e	-0.491	-0.415	-0.378	-0.394	0.497	0.523	0.444	0.454
	(1.116)	(1.115)	(0.988)	(0.990)	(0.950)	(0.950)	(0.985)	(0.985)
Etudiant	-0.312	-0.269	-0.199	-0.248	0.676	0.669	0.623	0.600
	(0.749)	(0.750)	(0.547)	(0.547)	(0.471)	(0.471)	(0.534)	(0.535)
Profint	-0.520	-0.471	-0.407	-0.450	0.467	0.467	0.415	0.398
	(0.714)	(0.715)	(0.497)	(0.497)	(0.413)	(0.413)	(0.484)	(0.485)
Autre	-0.681	-0.566	-0.568	-0.545	0.307	0.372	0.254	0.303
	(0.951)	(0.961)	(0.802)	(0.804)	(0.752)	(0.758)	(0.793)	(0.796)
risklover	-0.280		-0.280		-0.280		-0.280	
	(0.281)		(0.281)		(0.281)		(0.281)	
Risklover		-0.222		-0.222		-0.222		-0.222
		(0.333)		(0.333)		(0.333)		(0.333)
Riskmoderate		-0.374		-0.374		-0.374		-0.374
		(0.342)		(0.342)		(0.342)		(0.342)
Artisan			0.113	0.0208	0.988	0.938	0.935	0.869
			(0.737)	(0.740)	(0.682)	(0.683)	(0.727)	(0.731)
_cons	0.140	0.126	0.0270	0.105	-0.848***	-0.812***	-0.795**	-0.743*
	(0.649)	(0.651)	(0.385)	(0.405)	(0.277)	(0.292)	(0.381)	(0.396)
N	238	238	238	238	238	238	238	238
chi2	7.728	8.011	7.728	8.011	7.728	8.011	7.728	8.011
p	0.460	0.533	0.460	0.533	0.460	0.533	0.460	0.533

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.27d: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) Choice	(2) Choice	(3) Choice	(4) Choice	(5) Choice	(6) Choice	(7) Choice	(8) Choice
Artisan	0.491	0.415	0.312	0.269	0.520	0.471	0.681	0.566
	(1.116)	(1.115)	(0.749)	(0.750)	(0.714)	(0.715)	(0.951)	(0.961)
Cadre	0.378	0.394	0.199	0.248	0.407	0.450	0.568	0.545
	(0.988)	(0.990)	(0.547)	(0.547)	(0.497)	(0.497)	(0.802)	(0.804)
Employes	-0.497	-0.523	-0.676	-0.669	-0.467	-0.467	-0.307	-0.372
	(0.950)	(0.950)	(0.471)	(0.471)	(0.413)	(0.413)	(0.752)	(0.758)
Retraites	-0.444	-0.454	-0.623	-0.600	-0.415	-0.398	-0.254	-0.303
	(0.985)	(0.985)	(0.534)	(0.535)	(0.484)	(0.485)	(0.793)	(0.796)
Etudiant	0.179	0.146			0.209	0.201	0.369	0.297
	(1.001)	(1.000)			(0.515)	(0.516)	(0.813)	(0.818)
Profint	-0.0295	-0.0557	-0.209	-0.201			0.161	0.0952
	(0.974)	(0.973)	(0.515)	(0.516)			(0.781)	(0.786)
Autre	-0.190	-0.151	-0.369	-0.297	-0.161	-0.0952		
	(1.161)	(1.164)	(0.813)	(0.818)	(0.781)	(0.786)		
risklover	-0.280		-0.280		-0.280		-0.280	
	(0.281)		(0.281)		(0.281)		(0.281)	
Risklover		-0.222		-0.222		-0.222		-0.222
		(0.333)		(0.333)		(0.333)		(0.333)
Riskmoderate		-0.374		-0.374		-0.374		-0.374
		(0.342)		(0.342)		(0.342)		(0.342)
Etudianret~e			-0.179	-0.146	0.0295	0.0557	0.190	0.151
			(1.001)	(1.000)	(0.974)	(0.973)	(1.161)	(1.164)
		(0.342)		(0.342)		(0.342)		(0.342)
Etudianret~e			-0.179	-0.146	0.0295	0.0557	0.190	0.151
			(1.001)	(1.000)	(0.974)	(0.973)	(1.161)	(1.164)
_cons	-0.351	-0.289	-0.172	-0.143	-0.380	-0.345	-0.541	-0.440
	(0.916)	(0.922)	(0.421)	(0.429)	(0.352)	(0.363)	(0.724)	(0.743)
N	238	238	238	238	238	238	238	238
chi2	7.728	8.011	7.728	8.011	7.728	8.011	7.728	8.011
p	0.460	0.533	0.460	0.533	0.460	0.533	0.460	0.533

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

4.2.2 Ability to adapt

In the second part of the data analysis we took into consideration questions about water and electricity to investigate the customer's ability to choose the most profitable tariff. As described in the paragraph "*Experiment design*", the attendees faced this part of the experiment with the information about a new total annual consumption. This new value is composed by the annual consumption and their total consumption reduction potential. The first one is estimated by the system thanks the questions participants answered at the beginning of the experiment. The second one is estimated by the system assuming that all the participants adopt the proposed pro-environment behaviours suggested during the session.

In a theoretical world, we expected that, thanks the information of the new consumption level, a rational person should be able to estimate the cost of the future bill for each tariff and, hence, to choose the more profitable tariff. It is important to remember that in this part of the experiment the participants were incentivised to answers in the correct way.

The analysis shows a general inability of people to adapt their preference towards the most profitable tariff. In fact, the average of correct answers is 2.9 out of 6.

We divided the sample in two groups:

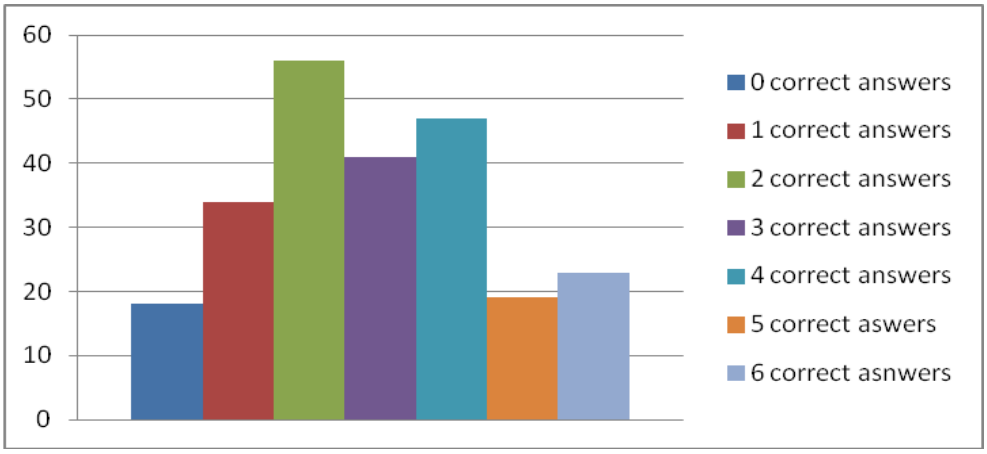
- Participants able to modify their choices ("*ability-to-adapt*"): in this group there are people that answered correctly to at least 5 questions
- Participants unable to modify their choices ("*inability-to-adapt*"): in this group there are people that answered correctly less than 5 questions

The participants of the first group, who were able to adapt their answers to the new information, were 42 (18%). In particular, 19 answered correctly to 5 questions while the others 23 answered correctly to 6 questions. The remaining 82% of the sample (196/238) answered correctly less than 5 questions. More precisely, 24% of the sample, namely ¼ of the participants,

answered in a correct way to only 2 questions and 8% of the participants were not able to select the correct tariff even once (fig. 4.11).

It is interesting to highlight that the percentage of participants unable to adapt their choices is higher than them able to select the correct tariff regardless of the variables considered.

Figure 4.11: Distribution of correct answers



To begin we analysed the variable "*socio-professional category*".

Here below are the results of the different socio-professional categories in detail:

- **Category**: *Artisans, commerçants et chefs d'entreprise*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	0	1	4	1	1	1	2
%	0%	10%	40%	10%	10%	10%	20%

- **Category**: *Cadre et professions int. Superieures*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	2	1	7	7	5	2	5
%	7%	3%	24%	24%	3%	3%	17%

- **Category**: *Employes*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	5	13	17	15	21	5	4
%	6%	16%	21%	19%	26%	6%	5%

- **Category**: *Retraites*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	4	5	10	7	8	4	1
%	10%	13%	26%	18%	21%	10%	3%

- **Category**: *Etudiant-Salarie*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	2	1	1	0	0	0	1
%	40%	20%	20%	0%	0%	0%	20%

- **Category**: *Etudiant*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	1	6	5	1	4	4	5
%	4%	23%	19%	4%	15%	15%	19%

- **Category**: *Profession intermediaires*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	4	4	10	9	7	3	3
%	10%	10%	25%	23%	18%	8%	8%

- **Category**: *Autres personnes sans activité professionnelle*

Correct answers	**0/6**	**1/6**	**2/6**	**3/6**	**4/6**	**5/6**	**6/6**
#	0	3	2	1	1	0	2
%	33%	22%	11%	11%	11%	0%	22%

We can observe that the category characterized by a high percentage of people unable to select the correct tariff in according with the new information. In particular, the category characterized by the highest percentage of correct answers is "*Etudiant*" (34%) while the category characterised by the highest percentage of mistakes is "*Employes*" (11%).

Similarly to the variable "*socio-professional category*", considering the variable "age", we can see that in all the 3 categories (under26, middle-age, over64), more than 50% of participants are not able to use the new information to choose the most economically advantageous tariff. In fact the results show that regarding people who are under 26, only 37.9% (11/29) are able to select at least tariffs correctly while, as concerns people in the category "*middle-age*", the percentage sharply drops to 15% (26/174). Finally, considering people who are over 64, the percentage falls to14.2% (5/35) (tab. 4.28).

Table 4.28: Distribution of choices (variable age)

	Ability to adapt	**Inability to adapt**
Under26 (12.2%)	11 (37.9%)	18 (62.1%)
Middle-Age (73.1%)	26 (15%)	148 (85%)
Over64 (14.7%)	5 (14.2%)	30 (85.8%)

The situation does not change analysing the variable "*consumption-per-person*" (tab. 4.29). In fact the participants who selected at least 5 tariffs correctly are:

- 31.3% (5/16) in the category "*high-consumption*"
- 17% (24/142) in the category "*middle-age*"
- 16.3% (13/80) in the category "*low-consumption*"

Table 4.29: Distribution of choices (variable consumption-per-person)

	Ability to adapt	**Inability to adapt**
High-consumption (6.7%)	5 (31.3%)	11 (68.7%)
Middle-consumption (59.7%)	24 (17%)	118 (83%)
Low-consumption (33.6%)	13 (16.3%)	67 (83.7%)

We can observe that the inability to adapt the choices in according to the new consumption information is prevalent among the participants even when considering the other variables. In particular, analysing the variable "s*ex*" we can observe that for both males and females, more than 50% of the participants is not able to adapt to the more economic advantageous tariff. In particular, 84.6% (137/162) of female results unable to adapt while 15.4% (25/162) is able to select at least 5 correct tariffs. Regarding the male, 77.6% (59/76) is unable to adapt its choices while 22.4% (17/76) chose at least 5 right answers (tab. 4.30).

Table 4.30: Distribution of choices (variable sexe)

	Ability to adapt	**Inability to adapt**
Female	25 (15.4%)	137 (84.6%)
Male	17 (22.4%)	59 (77.6%)

Furthermore the results show that the inability of the participants to select the most cost economically advantageous tariff is dominant even when analysing the variable "*consumption-per person"* and its two categories "h*igh-revenue*" and "*low-revenue*". In particular, as concern the participants characterized by a revenue more than 2000€/month, the participants who selected at least 5 tariff correctly are 22.6% (14/62) of the sample. On the other side, considering the participants characterized by a revenue equal to

or lower than 2000 €/month, the percentage of people able to select more than 4 tariff correctly drops to 15.9% (28/176) (tab. 4.31).

Table 4.31: Distribution of choices (variable revenue-per person)

	Ability to adapt	**Inability to adapt**
High-revenue (26%)	22.6% (14/62)	77.4% (48/62)
Low-revenue (74%)	15.9% (28/176)	84.1% (148/176)

Finally, we analysed the variable "*risk*".

Analysing the partition a) we found that the "*risk-averse*" group and the "*risk-lover*" group are both characterized by a high rate of people unable to adapt.

Among the "*risk-averse*" participants, 83% of them (107/129) is unable to answer more than 4 questions correctly while the remaining 17% (22/129) selected at least 5 right answers. Regarding the "*risk-lover*" participants, 81.7% of them (89/109) selected less than 5 correct answers while the remaining 18.3% (20/109) selected at least 5 right answers (tab. 4.32).

Table 4.32: Distribution of choices (variable risk; allocation a)

	Ability to adapt	**Inability to adapt**
Risk lover	20 (18.3%)	89 (81.7%)
Risk averse	22 (17%)	107 (83%)

Taking into consideration the partition b), among the "*risk-averse*" participants, 84% (84/100) selected less than 5 correct answers while 16% (16/100) of them selected at least 5 correct answers. As concern the "risk-*moderate*" participants, 54 (78.3%) participants are unable to select more than 4 correct answers while the participants who answered at least 5 answers correctly were 15 (21.7%). Finally, regarding the "*risk-lover*" participants, 81% (58/69) of the participants selected less than 5 right answers while 19% of them (11/69) showed the ability to adapt their choices in according with the new information about the annual consumption level (tab. 4.33).

Table 4.33: Distribution of choices (variable risk; allocation b)

	Ability to adapt	**Inability to adapt**
Risk lover	11 (19%)	58(81%)
Risk moderate	15 (21.7%)	54 (78.3%)
Risk averse	16 (16%)	84 (84%)

Afterwards, in order to analyse the joint effect of several independent variables on the dependent variable "*ability-to-adapt*", we carried out some multiple regressions. Each multiple regression analyses some variables that are not-correlated each other with a statistical level of 5%.

We can see a significant result analysing the difference "*ability-to-adapt*" skill between some socio-professional categories. Analysing the multi regressions (tab. 4.34c, 4.34d) composed by the socio-professional categories and the dummies of the variable "*risk*", independently from the allocation of the risk considered, we can affirm that there is a great tendency to adapt the choice correctly with the new information by:

- "*Etudiant*" compared to "*Employes*" (CI=99%)
- "*Etudiant*" compared to "*Retraites*" (CI = 95%)
- "*Etudiant*" compared to "*Profession intermediaires*" (CI = 90%)

Besides, the study show that, if we consider the risk allocation b) in the multi-regression (tab. 4.34c choice (2)), people in the category "*Artisans, commerçants et chefs d'entreprise*" have a stronger ability to adapt their choices compared to the them in the category "*Employes*", with a significant level of 10%. At the same time, if we consider the risk allocation a) in the multi-regression (tab. 4.34c choice (3)) people in the category "*Cadre et professions int. superieures*" answered correctly to more questions compared to the participants in the category "*Employes*", with a significant level of 10%.

Moreover the multi regressions highlight that the ability to choose the new tariff correctly in according with the new information is positively influenced if the participants are less than 26 (tab. 4.34a) while is not

influenced in a statistically way by the level of the consumption (tab. 4.34a; tab. 4.34b).

Table 4.34a: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) abilitytoa~t	(2) abilitytoa~t	(3) abilitytoa~t	(4) abilitytoa~t	(5) abilitytoa~t	(6) abilitytoa~t
Highrevenue	0.416	0.563	0.393	0.400	0.562	0.569
	(0.373)	(0.384)	(0.370)	(0.370)	(0.384)	(0.385)
Sexe	-0.379	-0.316	-0.438	-0.423	-0.330	-0.308
	(0.357)	(0.363)	(0.355)	(0.354)	(0.365)	(0.365)
Lowconsump~n	-0.821					
	(0.627)					
MiddleCons~n	-0.731					
	(0.592)					
Under26		1.290**			1.296**	1.353**
		(0.625)			(0.627)	(0.633)
MiddleAge		-0.0289			-0.0308	0.000170
		(0.533)			(0.533)	(0.537)
risklover			0.125		0.159	
			(0.344)		(0.352)	
Risklover				0.0135		0.0453
				(0.431)		(0.441)
Riskmoderate				0.383		0.464
				(0.402)		(0.413)
_cons	-0.715	-1.692***	-1.428***	-1.506***	-1.756***	-1.889***
	(0.580)	(0.562)	(0.337)	(0.368)	(0.584)	(0.608)
N	238	238	238	238	238	238
chi2	4.438	10.93	2.903	3.836	11.14	12.34
p	0.350	0.0273	0.407	0.429	0.0488	0.0548

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.34b: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) abilitytoa~t	(2) abilitytoa~t	(3) abilitytoa~t	(4) abilitytoa~t	(5) abilitytoa~t	(6) abilitytoa~t	(7) abilitytoa~t	(8) abilitytoa~t
Cadre	-0.383		0.860	0.800	0.161	-0.479	0.550	0.0259
	(0.823)		(0.565)	(0.650)	(1.206)	(0.604)	(0.623)	(0.917)
Employes	-1.243	-0.860		-0.0598	-0.698	-1.338**	-0.310	-0.834
	(0.778)	(0.565)		(0.605)	(1.177)	(0.552)	(0.568)	(0.878)
Retraites	-1.183	-0.800	0.0598		-0.638	-1.278**	-0.250	-0.774
	(0.853)	(0.650)	(0.605)		(1.225)	(0.637)	(0.658)	(0.942)
Etudianret~e	-0.544	-0.161	0.698	0.638		-0.640	0.388	-0.136
	(1.323)	(1.206)	(1.177)	(1.225)		(1.203)	(1.207)	(1.377)
Etudiant	0.0957	0.479	1.338**	1.278**	0.640		1.028*	0.504
	(0.813)	(0.604)	(0.552)	(0.637)	(1.203)		(0.612)	(0.911)
Profint	-0.933	-0.550	0.310	0.250	-0.388	-1.028*		-0.524
	(0.824)	(0.623)	(0.568)	(0.658)	(1.207)	(0.612)		(0.918)
Autre	-0.409	-0.0259	0.834	0.774	0.136	-0.504	0.524	
	(1.062)	(0.917)	(0.878)	(0.942)	(1.377)	(0.911)	(0.918)	
Lowconsump~n	-0.686	-0.686	-0.686	-0.686	-0.686	-0.686	-0.686	-0.686
	(0.653)	(0.653)	(0.653)	(0.653)	(0.653)	(0.653)	(0.653)	(0.653)
MiddleCons~n	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699
	(0.618)	(0.618)	(0.618)	(0.618)	(0.618)	(0.618)	(0.618)	(0.618)
Artisan		0.383	1.243	1.183	0.544	-0.0957	0.933	0.409
		(0.823)	(0.778)	(0.853)	(1.323)	(0.813)	(0.824)	(1.062)
_cons	-0.151	-0.534	-1.393**	-1.334*	-0.695	-0.0552	-1.084	-0.560
	(0.918)	(0.681)	(0.678)	(0.685)	(1.274)	(0.649)	(0.713)	(1.003)
N	238	238	238	238	238	238	238	238
chi2	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75
p	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.34c: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) abilitytoa~t	(2) abilitytoa~t	(3) abilitytoa~t	(4) abilitytoa~t	(5) abilitytoa~t	(6) abilitytoa~t	(7) abilitytoa~t	(8) abilitytoa~t
Cadre	-0.282	-0.406			0.931*	0.885	0.789	0.784
	(0.817)	(0.825)			(0.561)	(0.563)	(0.649)	(0.649)
Employes	-1.214	-1.290*	-0.931*	-0.885			-0.142	-0.101
	(0.776)	(0.781)	(0.561)	(0.563)			(0.596)	(0.598)
Retraites	-1.071	-1.190	-0.789	-0.784	0.142	0.101		
	(0.840)	(0.850)	(0.649)	(0.649)	(0.596)	(0.598)		
Etudianret~e	-0.509	-0.584	-0.226	-0.178	0.705	0.706	0.563	0.605
	(1.318)	(1.320)	(1.201)	(1.204)	(1.176)	(1.177)	(1.222)	(1.223)
Etudiant	0.211	0.139	0.494	0.545	1.425***	1.430***	1.283**	1.329**
	(0.804)	(0.809)	(0.601)	(0.603)	(0.544)	(0.545)	(0.632)	(0.636)
Profint	-0.885	-0.969	-0.603	-0.563	0.328	0.321	0.186	0.220
	(0.820)	(0.826)	(0.622)	(0.623)	(0.567)	(0.568)	(0.653)	(0.655)
Autre	-0.411	-0.604	-0.129	-0.199	0.802	0.686	0.660	0.585
	(1.058)	(1.077)	(0.915)	(0.920)	(0.877)	(0.887)	(0.934)	(0.939)
risklover	0.101		0.101		0.101			
	(0.352)		(0.352)		(0.352)			
Risklover		0.0136		0.0136		0.0136		0.0136
		(0.438)		(0.438)		(0.438)		(0.438)
Riskmoderate		0.422		0.422		0.422		0.422
		(0.416)		(0.416)		(0.416)		(0.416)
Artisan			0.282	0.406	1.214	1.290*	1.071	1.190
			(0.817)	(0.825)	(0.776)	(0.781)	(0.840)	(0.850)
riskaverse							-0.101	
							(0.352)	
_cons	-0.898	-0.898	-1.180***	-1.304***	-2.112***	-2.188***	-1.869***	-2.087***
	(0.713)	(0.719)	(0.452)	(0.485)	(0.391)	(0.416)	(0.507)	(0.540)
N	238	238	238	238	238	238	238	238
chi2	9.584	10.71	9.584	10.71	9.584	10.71	9.584	10.71
p	0.295	0.296	0.295	0.296	0.295	0.296	0.295	0.296

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 4.34d: Multiple regressions with variables that are not-correlated each other with a statistical level of 5%

	(1) abilitytoa~t	(2) abilitytoa~t	(3) abilitytoa~t	(4) abilitytoa~t	(5) abilitytoa~t	(6) abilitytoa~t	(7) abilitytoa~t	(8) abilitytoa~t
Artisan	0.509	0.584	-0.211	-0.139	0.885	0.969	0.411	0.604
	(1.318)	(1.320)	(0.804)	(0.809)	(0.820)	(0.826)	(1.058)	(1.077)
Cadre	0.226	0.178	-0.494	-0.545	0.603	0.563	0.129	0.199
	(1.201)	(1.204)	(0.601)	(0.603)	(0.622)	(0.623)	(0.915)	(0.920)
Employes	-0.705	-0.706	-1.425***	-1.430***	-0.328	-0.321	-0.802	-0.686
	(1.176)	(1.177)	(0.544)	(0.545)	(0.567)	(0.568)	(0.877)	(0.887)
Retraites	-0.563	-0.605	-1.283**	-1.329**	-0.186	-0.220	-0.660	-0.585
	(1.222)	(1.223)	(0.632)	(0.636)	(0.653)	(0.655)	(0.934)	(0.939)
Etudiant	0.720	0.723			1.097*	1.108*	0.623	0.744
	(1.196)	(1.196)			(0.605)	(0.607)	(0.902)	(0.913)
Profint	-0.376	-0.385	-1.097*	-1.108*			-0.474	-0.365
	(1.207)	(1.207)	(0.605)	(0.607)			(0.917)	(0.925)
Autre	0.0976	-0.0203	-0.623	-0.744	0.474	0.365		
	(1.382)	(1.389)	(0.902)	(0.913)	(0.917)	(0.925)		
risklover	0.101		0.101		0.101		0.101	
	(0.352)		(0.352)		(0.352)		(0.352)	
Risklover		0.0136		0.0136		0.0136		0.0136
		(0.438)		(0.438)		(0.438)		(0.438)
Riskmoderate		0.422		0.422		0.422		0.422
		(0.416)		(0.416)		(0.416)		(0.416)
Etudianret~e			-0.720	-0.723	0.376	0.385	-0.0976	0.0203
			(1.196)	(1.196)	(1.207)	(1.207)	(1.382)	(1.389)
_cons	-1.407	-1.482	-0.687	-0.759	-1.783***	-1.867***	-1.309	-1.502*
	(1.121)	(1.132)	(0.449)	(0.466)	(0.476)	(0.496)	(0.827)	(0.859)
N	238	238	238	238	238	238	238	238
chi2	9.584	10.71	9.584	10.71	9.584	10.71	9.584	10.71
p	0.295	0.296	0.295	0.296	0.295	0.296	0.295	0.296

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Chapter 5

CONCLUSION

One of the main aims of the policy makers is to investigate customer's behaviour in order to design policies that are effective in the reduction of the consumptions and in the shift of the use of energy from the peak hours to the no-peak hours.

The contribution of the behavioural economics is essential to reach these goals, because it highlights the bias that influence customer's choices and the reasons behind the sub-optimal decisions of people.

In this context, the experiment we carried out in the last months it is significant because our results are consistent with the main cognitive biases identifies in the literature. In particular we could verify that consumers, involved in the lab experiments, constantly preferred the tariff with the simplest structure. They avoided pricing instruments containing a fixed cost and increasing block-pricing structures.

The revealed preference for the linear tariff could be the result both of the risk aversion attitude of some subjects and the perception of the risk associated with the non-linear tariff. At the end of the session, the participants could explain their choices answering to some closed questions. The majority of subjects indicated a choice oriented towards the tariff that gave them the perception of being more profitable (tab. 5.1).

Table 5.1: Explanation of choices

Variable	Obs	Mean	Std. Dev.	Min	Max
easier	238	3.827731	1.289256	1	5
prevedereb~a	238	4.092437	1.067286	1	5
savemoney	238	4.554622	.6712603	1	5

This result confirm the possibility that a tariff characterized by an easier structure gives the perception of being more profitable and, hence, less risky.

We want to highlight that the results of the risk aversion test, that affirms that the population examined is divided down the middle (46% risk lover (109) vs. 54% risk-averse (129)), are partially denied by the tariff choices of the same participants. In fact, the two non-linear tariffs analysed are considered more risky compared with the linear tariff analysed in the experiment. In particular, the two part tariffs are considered more risky due to the obligation to sustain a fixed cost regardless of the number of units consumed, without the security of being able to return from this cost thanks to the reduction of the variable part. Regarding the increasing block pricing structures, the major risk consists of the possibility to remain "*blocked*" in a higher price bock even if the consumption is just a little bit more of the limit consumption that characterised the previous block.

This is the reason why people are more willing to choose the linear tariff, which guarantees them to pay only costs that are directly related to the amount of consumption, considered less risky.

Since the two non-linear tariffs are sensed as more risky, it could be expected that people, who were in the category "*risk lover*", would choose the non-linear tariff. Indeed, people who are risk-lover (46% of the sample) would be encouraged to choose the non-linear tariff, "betting" on their ability to be able to reduce consumption in order to exploit the lower cost of the variable part or to remain in the cheapest block. However, the results of the category "*risk lover*", resulted by the partition a) described previously, show a significant different situation. In fact the outcomes show that the non-linear tariffs were chosen only by about 35% of them (40/109 in the case of "*linear tariff*" vs. "*two part tariff*" and 34/109 in the case of "*linear tariff*" vs. "*increasing block tariff*").

Moreover, the results of the test session confirm that when we compare the two non-linear tariffs, there are not independent variables able to influence the choice of people and the sample is split into two equal groups. The

reason behind this phenomenon could be that people are not able to fully understand and balance properly the benefits and the risks of the two tariffs, independently by their age, sex, job or revenue. Moreover, the perception of the risk associated with both the non-linear tariff is such as not to bring a majority in terms of preference of one or the other tariff.

Finally, the results about the ability of participants to adapt their choices to select a more profitable tariff confirm some cognitive biases identified also in the literature, such as the irrationality of people and the tendency to prefer the status quo. These cognitive bias might be the reason behind the inability to choose the best tariff. Choosing the optimal decision is not easy. People, who are characterized by the bounded rationality constraints, look for easier methods to reach the best result or they seem to be inclined to the status quo, preferring not to change answer even in the case of potential gains.

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