

## IMPACT OF THE ENFORCEMENT OF A TIME-OF-USE TARIFF TO RESIDENTIAL CUSTOMERS IN ITALY

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### ABSTRACT

*Flat tariff has always been the default condition for residential customers in Italy and only starting from July, 1st 2010, the Italian Authority for Electricity and Gas (AEEG) approved the entry into force of a mandatory time-of-use (ToU) tariff at two-part rate periods.*

*In order to assess the impact of the tariff in the short and medium term among Italian customers, R.S.E. has started a research project on residential loads and demand, in collaboration and under the patronage of AEEG.*

*The results of such analysis show that, even if there has been a limited shift of consumptions from peak hours to off-peak hours, the change in the behavior of the users is not negligible. Particular attention has been paid to the possible causes that have contributed to limit the amount of energy shifted from peak hours to off-peak hours and to analyse some possible solutions in order to make the tariff more effective.*

### INTRODUCTION

The most common billing method of electricity consumptions is flat rate, because it reduces to minimum the costs of metering and billing; the drawback is that customers are not prompted to adapt their consumptions in accordance to the scarcity or abundance of electricity.

On the opposite side there is real time rate: it allows the price signal to reach the customers in the correct way, but penalizes those customers who cannot move their consumptions.

Time-of-Use (ToU) tariffs are located in between because they provide for a number of time slots during which the price of electricity paid by the customers is determined in advance. This allows the “demand-response” among them but it offers some degree of protection to the customers who cannot modulate their electricity demand according to the price.

### ENTRY INTO FORCE OF THE TIME-OF-USE RATE

The Italian Authority for Electricity and Gas (AEEG) approved the entry into force of a mandatory Time-of-Use tariff among residential customers subject to the universal supply regime in Italy from July 1st 2010. It provides for variable electricity prices during the day: the price is higher during “peak hours” (the hours between 8 am and 7 pm on working days, also called F1 time slots) and lower during

“off-peak hours” (all the remaining hours, also called F2 and F3 time slots, which basically comprise nights and weekends). The AEEG established a 18-months transition period (until December 31st 2011): during such a period the price difference between peak and off-peak hours was limited (transitional ToU tariff) while, starting from January 1st 2012, it has become larger (final ToU tariff), based on the actual electricity market prices.

ToU tariff is more convenient than the flat tariff only if more than 2/3 (i.e. 66.67%) of the total consumption occurs during off-peak hours: such value represents an “indifference threshold”.

### THE MONITORING PROJECT

The entry into force of the Time-of-Use tariff has involved so far 20 millions of families, which are currently facing time-dependent prices of electricity.

In order to evaluate the impact of the ToU tariff on the Italian consumers, R.S.E. started a monitoring project [1]: it has involved a group of about 28,000 household users (the so-called “customer panel”, statistically representative of the Italian population subject to the universal supply regime) and has been acquiring their electricity consumption data with a monthly frequency, starting from July 2009 (i.e. one year prior to the introduction of the ToU tariff).

This paper shows the results of the analysis about how the consumption behaviour of the customers has been affected by the ToU tariff, considering in particular the shift from peak to off-peak hours.

### THE RESTRICTED CUSTOMER PANEL

In order to improve the significance of our study, we have selected a “restricted customer panel” and we have compared their behaviour in three different semesters:

- period P1: January 1st 2010 ÷ June 30th 2010;
- period P2: January 1st 2011 ÷ June 30th 2011;
- Period P3: January 1st 2012 ÷ June 30th 2012.

All the customers belonging to the “restricted customer panel” satisfy the following requirements during the whole monitored period:

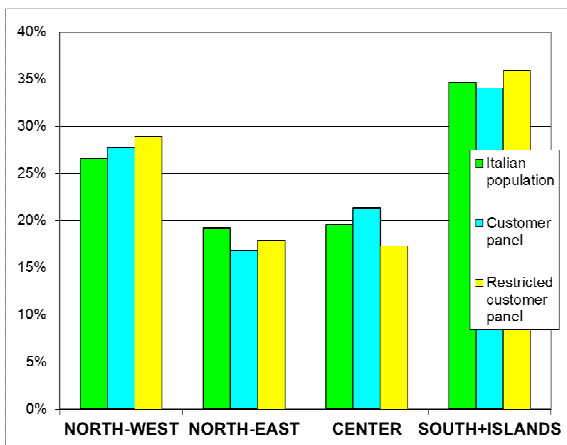
- they belonged to the “franchise market;
- they had no PV panels or other electricity generation systems;
- they were subject to the flat rate in the period P1, to the transitional ToU rate in P2 and to the final ToU tariff in P3;
- they underwent no variations in the contract.

The “restricted customer panel” results to be composed of 8,427 customers. Table 1 shows a comparison among the average annual consumption of the customers composing the “restricted customer panel”, the “customer panel” and the residential customers belonging to the “franchise market” surveyed by AEEG in 2011: the values are similar in the three cases.

Average annual consumption [kWh]		
AEEG survey	Customer panel	Restricted customer panel
2,058	2,116	2,124

**Table 1: Comparison among the average annual consumption of residential customers belonging to the “restricted customer panel”, the “customer panel” and the “franchise market”.**

The geographical distribution of the “restricted customer panel” is shown in Figure 1, together with a comparison with the Italian population (as surveyed by the Italian National Institute of Statistics (ISTAT) [2]) and the “customer panel”: as we can see, the percentages in the different areas are quite similar.



**Figure 1: comparison between the geographical distribution of the Italian population, the “customer panel” and the “restricted customer panel”.**

In order to account for the different number of peak and off-peak hours, the consumptions in the different semesters have been normalized.

## RESULTS OF THE PROJECT

### Analysis of consumption allocation in the period P1

As for the analysis about the consumption allocation during the period P1 (January 2010 - June 2010), as it is shown in Table 2, the average percentage of consumption during off-

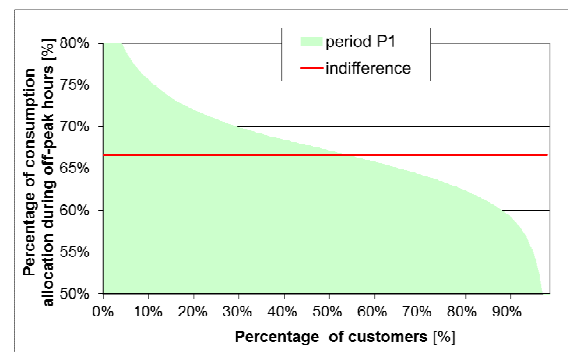
peak hours is about 66.87%, above the indifference threshold (66.67%) previously defined.

	Consumption allocated during peak hours [%]	Consumption allocated during off-peak hours [%]
January 2010	32.58%	67.42%
February 2010	33.92%	66.08%
March 2010	33.15%	64.85%
April 2010	32.60%	67.40%
May 2010	31.84%	68.16%
June 2010	32.71%	67.29%
<b>Average allocation in the period P1</b>	<b>33.13%</b>	<b>66.87%</b>

**Table 2: Monthly consumption allocation during peak and off-peak hours in the period P1.**

As for the distribution of customers around the “indifference threshold” during the period P1, we have calculated the percentage of customers whose consumptions were “concentrated in off-peak hours”: this means that at least 2/3 ( $\geq 66.67\%$ ) of the total consumptions occurred during off-peak hours, thus allowing the customers to save money with the ToU tariff with respect to the flat tariff.

Such customers represent about 55% of “restricted customer panel”, as it is shown in Figure 2.



**Figure 2: Distribution of the “restricted customer panel” around the “indifference threshold”.**

As we can see, most of the customers had already their consumption concentrated in off-peak hours in the period P1, even if there was no price signal.

### Analysis of consumption shift

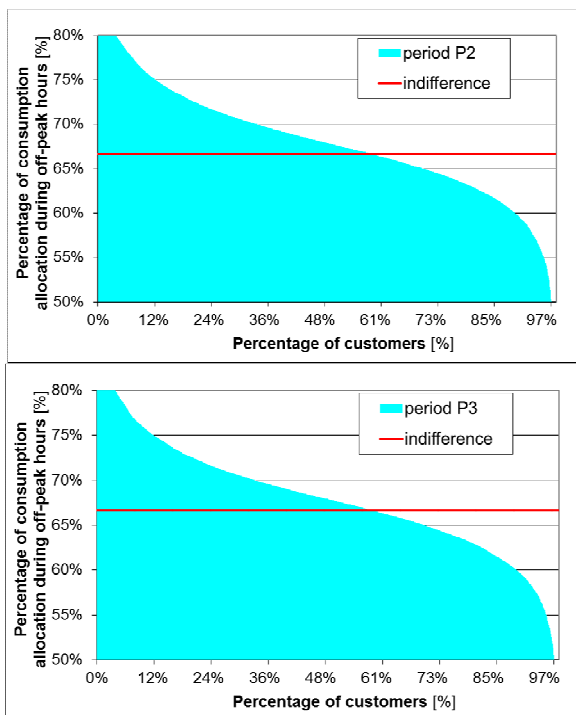
As for the evaluation of the variation of the consumption allocation between peak and off-peak hours among the different periods, Table 3 displays the percentage variation of the monthly average consumption allocation both from period P1 to P2 and from period P1 to P3.

As we can see, there has been a little shift of consumption from peak to off-peak hours in almost all the months of the period P2 and P3.

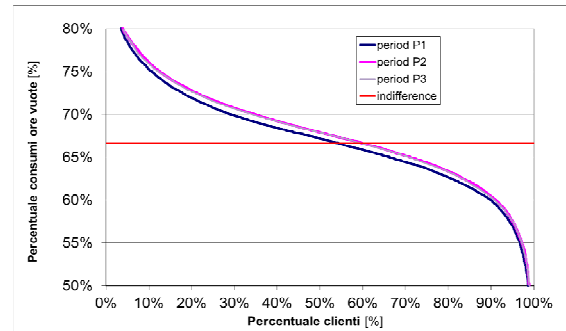
	Consumption shift from peak to off-peak hours [%]	Consumption shift towards off-peak hours [%]
January 2011-2010	-2.93%	2.93%
February 2011-2010	-0.17%	0.17%
March 2011-2010	-0.44%	0.44%
April 2011-2010	-0.53%	0.53%
May 2011-2010	-0.75%	0.75%
June 2011-2010	-0.11%	0.11%
January 2012-2010	-2.94%	2.94%
February 2012-2010	0.36%	-0.36%
March 2012-2010	-1.26%	1.26%
April 2012-2010	0.06%	-0.06%
May 2012-2010	-0.92%	0.92%
June 2012-2010	-0.38%	0.38%
<b>Monthly average</b>	<b>-0.90%</b>	<b>0.90%</b>

**Table 3: Monthly consumption shift towards peak and off-peak hours for the consumers belonging to the “restricted customer panel”.**

The percentage of consumers composing the “restricted customer panel” whose consumptions are “concentrated in off-peak hours” is about 59% both in the period P2 and P3: this means that there was an increase of about 4% with respect to the period P1.

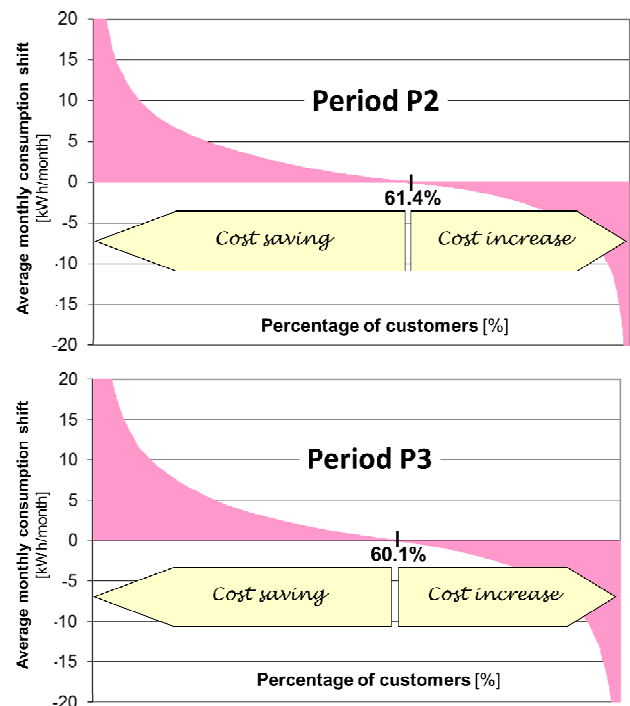


**Figure 3: Distribution of the “restricted customer panel” around the “indifference threshold” in period P2 and period P3.**



**Figure 4: Distribution of the “restricted customer panel” around the “indifference threshold”.**

Figure 3, similarly to Figure 2, shows the distribution of the customers around the “indifference threshold” indicated by the red line: these graphs are compared in Figure 4. As for the average monthly consumption shift for each customer in the period P2 and P3 with respect to the period P1, it can be positive if it occurs from peak to off-peak hours or negative if it goes in the opposite direction. The results are shown in Figure 5.



**Figure 5: Customers distribution according to their average monthly consumption shift between peak and off-peak hours in the period P2 and P3.**

About 61.4% and 60.1% of customers of the “restricted customer panel” have shifted their consumption to off-peak hours, respectively, in the period P2 in P3 with respect to the period P1; the average amount of shift is about 1.53 kWh/month. Thus the price signal provided by the ToU tariff has prompted in some ways most of residential customers to modify their habits. We now calculate the variation of the monthly average

expense in the period P2 and P3 as the difference between:

- the electricity bill the customer would have paid in P2 and in P3 if his/her consumptions had been billed with a flat tariff;
- the electricity bill that the customer has actually paid in P2 and P3 with the ToU tariff.

The average monthly saving is equal to about 1.1 c€/month for each customer. It may seem quite low, but it must be compared with the maximum saving that a customer could hypothetically achieve in a month by concentrating his/her whole consumption during off-peak hours: it would be about 29 c€/month. More realistically, assuming a consumption allocation during off-peak hours equal to 70%, the average monthly saving would be about 2.8 c€/month.

## CONCLUSION

The results show that there has been an average shift of consumptions of about 1% in the period after the introduction of the mandatory ToU tariff; we can find two reasons which have prevented a larger shift to occur:

- consumption allocation during off-peak hours was very slightly above the “indifference threshold” even before the introduction of the ToU tariff;
- the price signal conveyed to the customers was low in comparison to other ToU tariff experiences in other countries [3], due to the tiny price difference between peak and off-peak hours.

The overall savings achieved by all the residential customers in the period July 2010 – June 2012 can be estimated around 6.45 M€. However, the change in the behaviour of the Italian users is not negligible because about 60% of the restricted customers panel have moved their consumptions according to the price signal provided by the ToU tariff. This means that the ToU tariff has been capable of shaping the habits of Italian residential customers to a certain extent.

There are some aspects of the ToU tariff which may be improved, such as the allocation of the hours of the day to the peak and off-peak sets. In fact, due to the recent huge penetration of photovoltaic generation (about 17 GW in January 2013) in the Italian power system, electricity market prices during the hours belonging to the F1 peak time slot decreased, while prices during the first hours of the evening increased, so that some of the hours belonging to the off-peak F2 and F3 time slots have, on average, prices higher than some of the peak hours, thus not providing the correct price signal to the customers.

To tackle this problem, the AEEG has recently published a consultation document [4]: it proposes either the introduction of an intermediate group of hours between peak and off-peak hours or a different composition of the two times periods

of the current ToU tariff. The “Critical peak pricing” is another approach which can make the price signal more effective, allowing a more significant shift from peak to off-peak hours with respect to ToU tariff [5][6]; substantial interventions on the measurement system would, however, be necessary.

Improving both the previous aspects, will make the ToU tariff more effective, giving more flexibility to the customers and encouraging them to shift their consumptions to the periods of the day in which the price is lower.

Finally, we can state that the ToU tariff has contributed to improve the efficiency of the whole Italian power system, moving a percentage of the residential consumptions from peak hours to off-peak hours; in particular, it has shown how customers are capable to shape their energy consumptions in order to face time-dependent electricity costs, a first step towards their active participation in the smart grids.

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