The effects of the entry into force of a new electric tariff on Italian residential households equipped with a PV power plant

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Abstract
In 2016 Italy got a new electric tariff. This paper compares the old tariff to the new one and explains the details of the reformation process for two types of domestic end users who can be considered representatives of the whole Italian residential population equipped with a PV power plant.

The results show that the "traditional" solution (i.e. based on the use of fossil fuels for cooking, heating and producing hot water) is always more cost effective for a residential customer than the "all electric" one (i.e. in which electricity is used to satisfy all energy demands) with a PV power plant with the old tariff. On the contrary, the new tariff allows the "all electric" solution with a PV power plant to be both more energetically advantageous (taking primary energy consumption into account) and economically profitable than the "traditional" solution.

Introduction
The entry into force of the new electric tariff (with a flat price structure, except for a small portion of the taxes, called "Accise") for residential end users on January 1st, 2016 in Italy has the goals to overcome the progressive structure of the old tariff with respect to consumption (i.e. the higher is the consumption the higher is the price) and to adjust its components to the cost of the provided service. The price structure of the two tariffs are shown in Figure 1.

The structure of the new tariff is considered a way to stimulate end users' virtuous behaviours, by prompting them to switch from the traditional liquid or gaseous fossil fuels towards the electric vector in order to cover their domestic energy demands.

Taking this into account, an evaluation of the possible impact of the new tariff structure (both in terms of the annual cost of the energy consumption and in terms of primary energy savings and greenhouse gases emissions) has been made: it has involved two types of residential end users who decides to renovate his home without recurring to fossil fuels, thus going from a "traditional" home (i.e. based on the use of fossil fuels for cooking, heating and producing hot water) to a new "all electric" one (i.e. in which electricity is used to satisfy all energy demands) equipped also with a PV power plant, thus becoming a prosumer.

This paper illustrates the results of the analyses carried out with specific reference to two types of domestic end users, who can be considered representatives of the whole Italian residential population with equipped with a PV power plant. The analysis does not take into account the reward for PV production, in order to focus solely on the comparison between the old and the new tariff.

Methodology
The analysis has been carried out on a specific case study referring to a type of domestic end user, who can be considered representatives of the whole Italian residential population equipped with a PV power plant: it is a newly built or completely renewed detached house of 100 m^2, occupied by a fam-

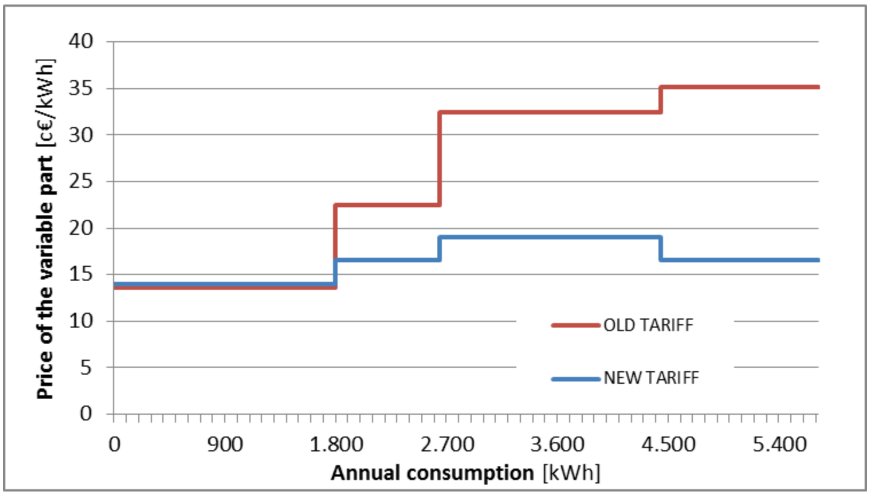

Figure 1. Comparison of the price of the variable part of the price between the old and the new tariff.

ily of 4 members, located in the Italian cold-temperate climate zone (zone E). The economic evaluation of the effects of the new tariff is made considering the following solutions to satisfy the demand of air conditioning and cooking and the production of hot water:

- "traditional" solution: it consists in the installation of a condensing boiler for heating and hot water production, with underfloor heating, of an air conditioning unit for cooling and of a gas stove for cooking (the total all-inclusive cost for the end user is equal to **€10,840**);
- "all electric" solution: it consists in the installation of a reversible heat pump for air heating, cooling and hot water production, with a fan coils unit, distribution system and of induction cooking plates. The cost of such a solution is higher than the cost of the "traditional" one (the total all-inclusive cost for the end user is equal to **€11,810**).

The annual energy demands are shown in Table 1[1,2] while in Table 2[3] you can find the annual consumption of natural gas (m^3) and of electric energy (kWh). In order to go from the energy demand to the consumption it is necessary to use the efficiency, SCOP[4] and SEER[5] of the respective appliance: in particular it is necessary to divide the energy demand by such parameters[6].

Table 3 displays the operating costs of the "traditional" vs. the "all electric" solution in the above described case study with the old and new tariff.

As you can see, the operating costs of the "all electric" solution are higher than those of the "traditional" solution with the old tariff; the opposite situation occurs with the new tariff, thus showing that the new tariff tends to encourage the use electric technologies in order to efficiently satisfy the user's needs for heating, air conditioning, hot water production and cooking.

Therefore, in the case of the new tariff, it is possible to calculate the payback time of the extra investment cost of the *"all electric"* solution with respect to the *"traditional"* one (Δcost = €970), thanks to the lower operating costs of *"all electric"* solution (annual savings = €716): such a payback time is equal to about 1.3 years. We have chosen the payback time as the only economic parameter as it is easily understandable by the end user, without recurring to more complex models.

Analysis with a PV power plant

PV POWER PLANT ON BOTH "TRADITIONAL" AND "ALL ELECTRIC" SOLUTION

We now move to evaluate the convenience of the installation of a PV power plant to (partially) cover the electric energy demand in both the "all electric" and "traditional" solution. The respective yearly demands of electric energy are those defined in Table 2 and, for convenience, they are summarized in Table 4.

The analysis is performed considering two possible sizes of the PV power plant: 3 kWp and 6 kWp. The additional assumptions for the economic evaluation are summarized below:

- electric energy production of 3,600 kWh per year for the 3 kWp PV power plant and 7,200 kWh per year for the 6 kWp power plant;
- annual degradation rate of PV power plant energy production performance equal to 1 %;
- discount rate equal to 4 %;
- tax deductions of 50 % on the cost of investment (purchase and installation) of the PV power plant, equally distributed over a period of 10 years.

In this first version of the study we do not take into consideration the possibility of reducing the amount of available power

1. "Demand" means the amount of energy required to satisfy the heating/cooling/hot water/cooking requirements of the end user i.e. the amount of energy to be produced by the generator in order to satisfy such requirements.

2. "Default consumption" means the electricity consumption of all electric devices in the house excluding those related to heating, air conditioning and hot water production.

3. In order to calculate the consumption of natural gas in kWh, it is necessary to multiply the consumption of natural gas in m^3 by the gas calorific value (about 9.6 kWh/m^3).

4. SCOP stands for Seasonal Coefficient Of Performance.

5. SEER stands for Seasonal Energy Efficiency Ratio.

6. The values of efficiencies used in the calculation (90 % for heating and 85 % for hot-water production for the condensing boiler, 55 % for the gas stove, 90 % for the induction cooking plates), SCOP (3.3 for heating and 3 for hot water production for the reversible heat pump) and SEER (3,3 for cooling for the air conditioning unit and 3.1 for the reversible heat pump) were determined in RSE experimental facilities based on the testing of real appliances.

Table 1. Annual energy demands of the house.

Default consumption [kWh_e]	Heating demand [kWh_t]	Hot water demand [kWh_t]	Cooling demand [kWh_f]	Cooking demand [kWh_t]	Total demand of the house [kWh_t]
3,200	17,650	2,300	2,508	705	26,363

Table 2. Annual consumption of natural gas (m^3) and of electric energy (kWh).

	Default consumption	Heating Consumption		Hot water consumption		Cooling consumption		Cooking consumption		Annual Total consumption	
	Electricity [kWh]	Gas [m^3]	Electricity [kWh]	Gas [m^3]	Electricity [kWh]	Gas [m^3]	Electricity [kWh]	Gas [m^3]	Elect. [kWh]	Gas [m^3]	Elect. [kWh]
“Traditional” solution	3,200	2,043	–	282	–	–	760	134	–	418	3,960
“All electric” solution	3,200	–	5,348	–	767	–	809	–	783	–	10,908

Table 3. Operating costs of the “traditional” solution vs the “all electric” solution.

“Traditional” Solution [€/year]		“All electric” Solution [€/year]		Δoperating costs “traditional” *vs.* “all electric” solution [€/year]
Old tariff	915 (electric) 1,952 (gas)	Old tariff	3,493 (electric)	-626
New tariff	766 (electric) 1,952 (gas)	New tariff	2,002 (electric)	+716

in the presence of a PV power plant, which would make the operating costs of the “all electric” solution lower.

The values of the payback times for the installation of the PV power plants with the old and new tariffs are shown in Table 5.

As you can see, the new rate causes an extension in the payback times of the installation of the PV power plant with respect to those obtained with the old tariff.

However, it is interesting to note that, with the new tariff, the payback time of the PV power plant in a house with a “all electric” solution is approximately equal to the one which would occur with the old tariff in the same house with a “traditional” solution (8.6 years vs. 6.9 years with a 3 kWp PV power plant; 8.2 years vs. 7.7 years with a 6 kWp PV power plant); this shows that the new tariff keeps the convenience of the PV power plant at the same level of the situation occurring with the old tariff provided that the electric energy consumption of the house is increased through the adoption of energy efficient technologies (heat pumps, induction cooking) which make use of electric energy as the only energy vector to satisfy the energy demands of the house.

Changing the annual electric energy consumption of the house and the size of the installed PV power plant, there is a variation in the payback time of the PV power plant; in par-

Table 4. Annual demands of electric energy (kWh).

	Annual Total consumption of electric energy [kWh]
“Traditional” solution	3,960
“All electric” solution	10,908

Table 5. Payback times for the installation of the PV power plants in the analysed cases.

	Payback time [years]	
3 kWp PV power plant	Old tariff	New tariff
“Traditional” solution	6.9	9.3
“All electric” solution	4.5	8.6
6 kWp PV power plant	Old tariff	New tariff
“Traditional” solution	7.7	10.8
“All electric” solution	4.3	8.2

ticular, going from the old to the new tariff, there is an increase in payback time of PV power plant, as shown in Figure 2: the increase is approximately equal to 2 years for values of consumption less than 4,000 kWh/year, about 3 years for values of consumption of about 8,000 kWh/year and stabilize around four years for values of consumption more than 8,000 kWh/year.

PV POWER PLANT ONLY ON THE "ALL ELECTRIC" SOLUTION

The next step is the comparison of the financial benefits of the "traditional" solution without a PV power plant with the "all electric" solution equipped with a PV power plant partly satisfying the electric energy consumption of the house.

The configuration and the cost of "traditional" and the "all electric" solutions, as well as the PV power plant and the annual electric energy demands, are the same of the analysis shown in the previous paragraphs. The economic evaluation of the two solutions is made by considering:

- Δ(investment cost) between the "all electric" solution equipped with a PV power plant and the "traditional" solution without a PV power plant, as the investment costs of the former solution is higher than those of the latter one;
- Δ(annual operating) cost between the "traditional" solution and the "all-electric" solution equipped with a PV power plant, as the operating costs of the former solution are higher than those of the latter one with both the new and old tariff. Such savings obtained by the end user are discounted over the entire technical life of the equipment installed.

The payback times are shown in Table 6. As you can see, the adoption by a residential end user of the "all electric" solution equipped with a 3 kWp PV power plant, instead of a "traditional" solution, is not profitable with the old tariff as the extra investment cost of the "all electric" with PV solution with respect to the "traditional" one is not recovered within the technical life of the installed technologies; on the contrary, the value of the payback time is about five years with the new tariff.

The "all electric" solution with a 6 kWp PV power plant is, on the other hand, profitable with both the old and new tariff, even if such a profitability is higher with the new tariff with respect to the old tariff (the payback time is, respectively, 6 and 7 years). Therefore, in the analysed cases the new tariff makes the "all electric" solution equipped with a PV power plant more convenient than the "traditional" solution without a PV power plant.

Conclusions

It is quite common for those end users who have the possibility to install a PV power plant in their home to also meet the appropriate logistic and spatial requirements to adopt a solution exclusively based on electric energy for their needs of air conditioning, hot water production and cooking.

The old tariff for household end users, although generally more favourable than the new tariff towards the installation of a PV power plant (as a result of its progressive structure with respect to consumption), was not supporting the *"all electric"* solution. Therefore, the end users were particularly encouraged to install a PV power plant in order to partially cover their con-

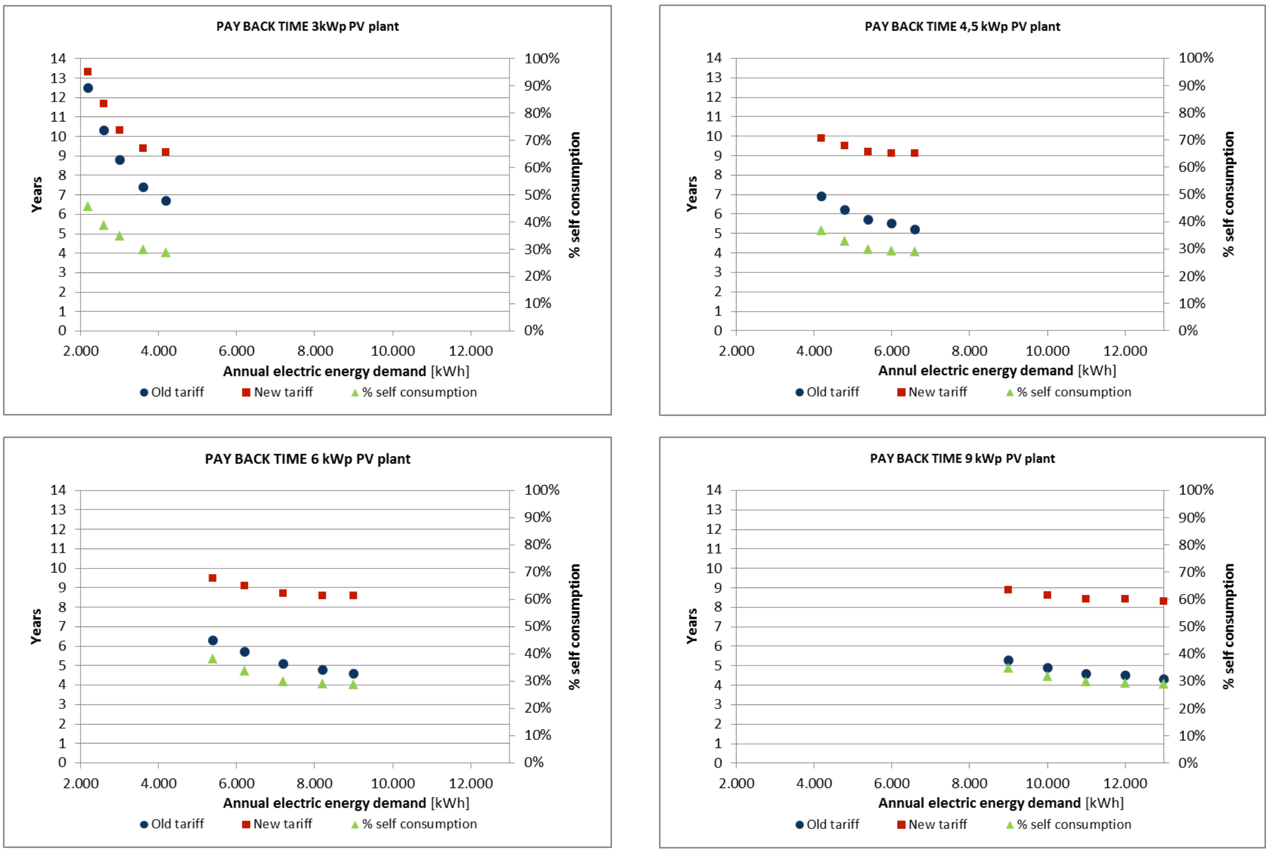

Figure 2. Payback times for the installation of different sizes of PV power plants with different electric energy demands of the house (% self consumption means the personal consumption of self-generated electric energy through the PV power plant).

Table 6. Payback times for the installation of the PV power plants in the analysed cases.

	Payback time [years]	
	Old tariff	New tariff
"traditional" solution *vs.* "all electric" solution with a 3 kWp PV power plant	> technical life	5
"traditional" solution *vs.* "all electric" solution with a 6 kWp PV power plant	7	6

sumption, but less supported towards the adoption of such *"all electric"* solution.

The new domestic tariff, although a little less favourable than the old one towards the installation of a PV power plant (due to its flat price structure), makes the adoption of the *"all electric"* solution more convenient with respect to the old progressive tariff: such a conclusion is supported by the analyses described in this paper, in line with the goals of the tariff reformation declared by the AEEGSI.

The analyses also show that the profitability of a PV power plant is higher with the old tariff than with the new tariff for consumptions larger than 2,000 kWh/year. This occurs because the old tariff has a progressive structure and therefore the PV production cuts the consumptions falling in the slots with the highest price, while, with the new tariff, due to its flat price structure, the same consumptions have a lower cost. However, despite longer payback times, the PV power plant installation is still a fruitful investment, with acceptable payback time for residential end users.

Finally, despite the above-mentioned extension of the values of payback times of PV power plants going from the old to the new tariff, the choice of the "all electric" solution equipped with a PV power plant is both more energetically and economically convenient than the "traditional" solution with the new tariff with respect to the old tariff, thus providing an overall benefit to the whole Italian energy system. The new tariff therefore supports efficient solutions based on the electric vector combined with the production of electric energy using PV power plants, in line with the goals of the tariff reform undertaken by the AEEGSI.

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