THE DISTRIBUTION NETWORKS AND THE LARGE DIFFUSION OF RENEWABLES POWER PLANTS: THE SITUATION OF ITALIAN ELECTRIC SYSTEM.

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ABSTRACT

In recent years the scenario of the Italian electricity system is characterized by the explosion of energy production from renewable sources and, in particular, of the distributed generation, which is revolutionizing the basic benchmarks of the electricity system as traditionally conceived.
The evolution of legislative and regulatory framework has encouraged this process by introducing various forms of incentive.
The exponential growth of connection requests to distribution network has determined a situation of potential saturation of the network in some areas of the country, necessitating urgent action plan for network strengthening and an increasingly close coordination with the TSO.
However, in some cases, the number of requests is so high that, even though providing distribution and transmission networks upgrades, the satisfaction of all connection requests risk to be impossible without lowering the efficiency of the whole electricity system.
The recent regulatory innovations come from this situation and introduce new instruments in order to streamline the phenomenon.
The high number of cases in which the connection works are designed and realized by the same applicant represents another critical aspect for the distribution network operator, that has no significant tools to control the connection process.
In this paper, distributed generation state of art in Italian electric system is presented.

AN OVERVIEW ON THE CURRENT SCENARIO IN ITALY

The last years have been characterized in Italy by a continuous legislative activity, under the pressure of two opposite forces, one with the goal of encouraging initiatives in renewable generation, the other with the aim to contain their growth, considered by someone as disproportionate.
The result is that the scenario is not always clear and stable.
In any case, national policies seem now to strongly encourage renewables sources, which remain one of the more remunerative areas for new investments, in years of economic and financial crisis.
Moreover, in regulatory terms, rules that have been recently introduced are very favorable for the connection of generators, mainly medium and small size, to the distribution networks. So there has been an explosion of requests, and consequently of connections, of medium and small size generators, which are more and more cost-effective than large size ones, thanks also to shorter and secure connection times. They have also less environmental impact, can benefit from simplified authorization processes, and have lower implementation costs.

The current Regulatory framework

Since 1st January 2009, procedural and economical modalities for connecting generators to the electrical networks at all voltage levels are defined by one paper, the already mentioned "TICA", published by Italian regulator (AEEG) with the 99/2008 Act.
TICA has fixed two different models of connection requests management and compensation, for HV connections, by one side, and for MV and LV connections by the other one.
Payment is on a lump-sum basis for the MV and LV connections, while for HV ones it depends specifically on the electrical installations needed to be built for the connection.
Relevant items are:

- possibility for the producers to design and realize the "network plants for the connection" (electrical installations to be built for the connection), for MV and HV connections;
- voltage level is fixed for ranges of production plant rated power, independently from the installations that have to be realized by network owner.

Especially for MV and LV connections, DSO has to respect the times prescribed by TICA for a large number of phases of connection procedure, for example:

- sending technical connection solutions with economic quotations,
- building the electrical installations for the connection,
- testing the electrical installations for the connection if they have been realized by the producer,
- activating the connection.

In the case of non-compliance of the prescribed times, DSO must pay automatic compensation to the producer.

The Technical Scenario

Since September 2008 the technical scenario is based on CEI 0-16 Standard, issued by Italian Electrotechnical Committee. It defines reference technical rules of connection of HV/MV users at distribution networks, and represents the fundamental guide for the design and the realization of HV and MV connections.
With respect to LV connections, at this time every utility has its own rules, but in 2011 a new Standard, written by a CEI workgroup, is expected.

How previously said, the regulatory framework defines generators rated power ranges that have to be connected to predefined voltage levels. Moreover, CEI 0-16 standard prescriptions must be applied.
So, with regards to new connections:

- P≤ 100 kW: connection to LV network is mandatory;
- 100 kW < P ≤ 200 kW: connection is possible to MV or LV network;
- 200 kW < P≤ 6.000 kW: connection to MV network is mandatory.

Of course, the DSO may realize new installations at higher voltage levels, if necessary: nevertheless, compensation paid by the applicant does not change, and bigger costs are in charge of the network owner.

EVOLUTION OF CONNECTION REQUESTS AND INCREASE OF DISTRIBUTED GENERATION ON ENEL'S NETWORK

In the following figures the increase of DG in terms of applications and connections at Enel network in the last few years is represented. Besides a rising sensibility on environmental aspects, strong incentives to renewable energy sources have given big attractiveness to this compartment. It is important to specify that data referred to year 2010 are still incomplete.

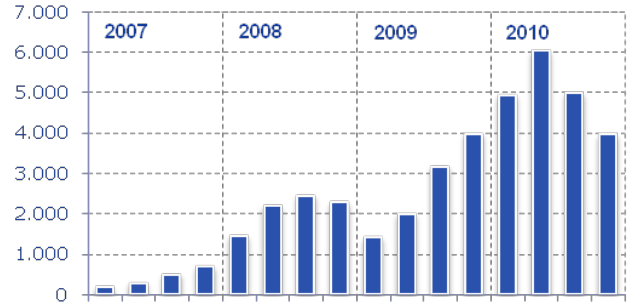

Fig 1: MV connection requests [No vs. quarters of the year]

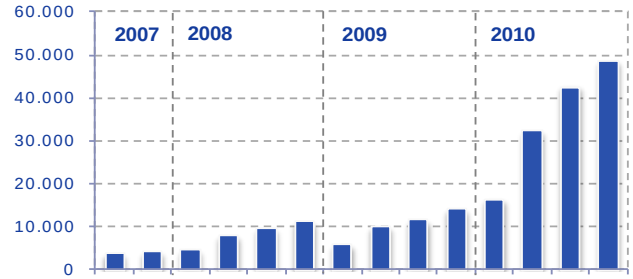

Fig 2: LV connection requests [No vs. quarters of the year]

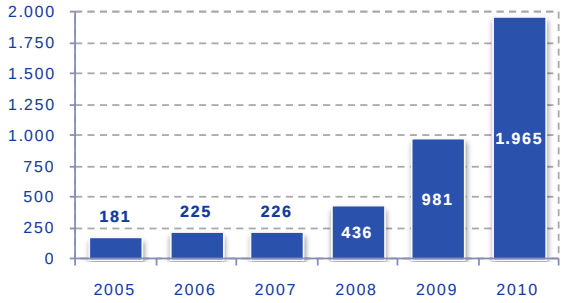

Fig 3: MV connections per year [No]

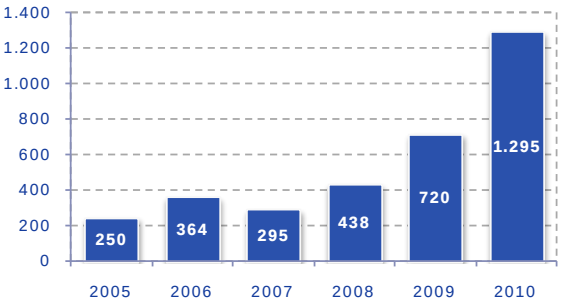

Fig 4: Connected generation power per year. MV network [MW]

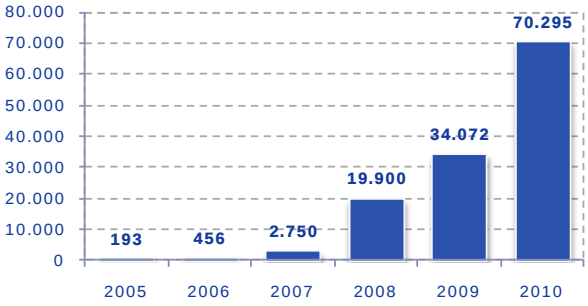

Fig 5: LV connections per year [No]

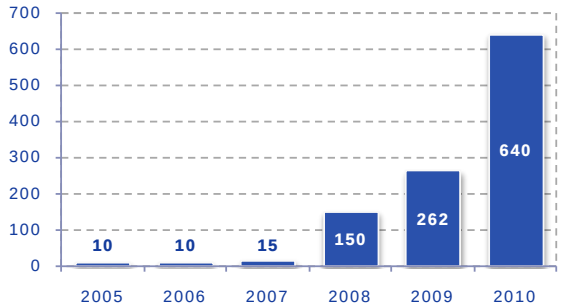

Fig 6: Connected generation power per year. LV network [MW]

Critical issues in the connection process management

A critical aspect for the DSO, in Enel's experience, is related to the high number of applicants who decide to design and realize the "network plants for the connection", which are then going to become part of the distribution network after being tested by the DSO. This opportunity for

the applicants can create problems for the DSO, that has no significant tools to control the connection process: for example, the DSO can only specify some requirements for companies that build the connection works, but cannot require the use of its own qualified companies. Besides, TICA allows only short times for testing the connection works, especially taking into account the large number of installations to be tested.
Verification of projects for "network plants for the connection" prepared by applicants, frequently incomplete or not complying with Enel technical standard, often represents another critical aspect of the process.

TECHNICAL ISSUES

Reverse flow

The increase of DG is going to have a strong impact on the operation of electrical distribution network.
On the basis of measured data, more than 16% of Enel's primary substations already worked in 2009, for some times of the year, in reverse energy flow condition. The great amount of new connections requests will take this phenomenon to increase in the future.
These conditions are not optimal for a network designed to act as passive, with monodirectional flows.
Enel Distribuzione is already studying, and beginning to realize, important actions - on components, protections, automations, etc. - towards innovative network design and operational criteria, as described below.

System security and stability

The DG cannot be generally dispatched, and producers from renewable energy sources would always inject energy into the network. This can represent a problem, in the future, with the increase of DG on the distribution network. So it is important to prevent that the DG, connected to MV and LV networks, can be cause of electrical system instability.
When reverse energy flow occurs on HV/MV transformers, HV network sees them, and networks connected, as a generator, sometimes of high power that cannot be dispatched. Still now, there is no way to control, by the TSO, energy flowing from distribution network, and this can be dangerous when critical network conditions (caused by faults, outages, etc.) may eventually occur. So, it needs to plan the correct reserve given by traditional production.
Enel Distribuzione is now beginning to introduce new equipments and devices in MV installations, with the objective of enabling direct control of DG and the dispatchment of energy injected in distribution network.

Network planning

The increase of DG and of connection requests, often concentrated on small areas, have great influence on classical network planning criteria, for example in terms of complexity on load forecasting. Generators connected to distribution networks can be split in "distributed", when it is located nearby loads, or "dispersed" on the opposite case.
While distributed generation can help the network in terms of less losses (thanks to its closeness to loads) and less needs to improve the infrastructure (basically reducing peak network load), dispersed generation brings inefficiencies: distance between load and medium/small generation cause the need of high losses energy transmission service and low usefulness of the energy produced for the electrical system.

DISTRIBUTION NETWORK SATURATION

Impact on the new connection solutions

The increase of connection requests has led to a gradual saturation of the distribution network, with particular reference to the MV network, starting from some areas of the country. In these regions the most favorable basic conditions are concentrated, namely the presence of wind and sun in particular, facilitating the diffusion of photovoltaic power plants and wind farms. In some regions other factors have been too, such as local legislative actions.
This condition of potential network saturation, that is spreading on large parts of Italian country, has a growing impact on the definition of connection solutions for new generators, often requiring actions, even for small and medium size generators, on voltage network levels higher than those on which they are connected, with longer times for authorization and building. For example, the network plant for the connection of generators up to few MW can include:

- new MV lines
- new MV/HV transformers (inside existing substations or building new substations), called "DG collectors".

Coordination between the DSO and the TSO

The spread of DG is going to have a growing impact even on National Transmission Network (NTN). So the coordination between the DSO and the TSO has to be increasingly close and complex to ensure that, with the insertion of the DG on the distribution network, security and continuity of the electrical system are not compromised.
Since 2009 the coordination between Enel Distribuzione and the Italian TSO has consisted especially in continuous mutual exchange of data about requests and connections and, above all, in an increasing number of connection requests to NTN for new Enel MV/HV transformations.

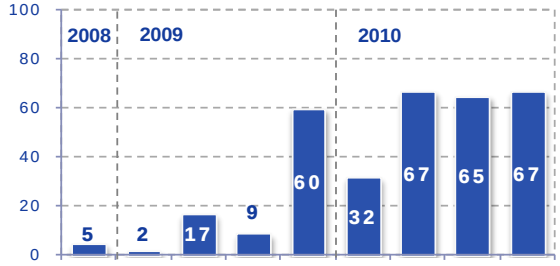

Fig 7: Connection requests to TSO for new MV/HV transformations necessary for DG [No vs. quarters of the year]

The DG Collector

In areas with potential saturation of network, DG Collectors allow to connect an higher number of medium and small size distributed generators.
DG Collector is a HV/MV transformer, or a new primary substation, designed and built to work in energy uprising condition, with energy flowing almost steadily from MV to HV network. The location must be as near as possible to the barycentre of the area in which DG develops.
The first 4 new primary substations for DG connections have been already realized in Puglia by producers, coming into operation in December 2010 - January 2011 after the necessary test phases executed by Enel Distribuzione.

New methods and criteria in Enel MV installations

New MV networks are now designed and realized by Enel Distribuzione with criteria that allow an optimal management of the DG, based on these characteristics:

- real time measures and control of the energy injected by generators, by means of an innovative protection and control system installed;
- dispatchability of the DG.

For these purposes, remote controlled MV switchers and optic fibres are installed along the MV network..

THE NEW SCENARIO SINCE 2011

Legislative news

Since 1st January 2011 a progressive reduction of tariffs has begun in Italy for solar energy, as a result of a new legislative decree. In 2011 this reduction proceeds in steps of about 6-7% (depending on the type of the power plant) every 4 months. In the next years it will take place annually.
Another important aspect of the new scenario is an increasing and spreading promotion of integrated solar panels (public and private roofs covered with PV panels, for example) and also of small wind turbines.
Finally, new guidelines about authorization procedures have been issued by the Government, with the objective of standardizing the procedures themselves. Till now there are different local authorization procedures required for power plants and for their connection works.

Regulatory news

Since 1st January 2011 there are some relevant modifications of the above mentioned TICA, thanks to the 125/2010 Act, published by Italian regulator (AEEG).
The most important ones are:

- the introduction of "critical areas", based on parameters that consider network saturation levels. AEEG provided a financial guarantees mechanism in order to take into account the reserved power in these areas;
- the introduction of "open seasons", that the DSO may open in a critical area for a period of 3 months, during which it is possible to analyze all the new requests;
- coordination arrangements between applicants, to allow the management of common technical solutions (design, authorization process, realization of new connection works).

Actions taken by Enel

Enel Distribuzione took into account the new regulatory scenario publishing, in December 2010, the updated edition of the "Guide to the connections at Enel Distribuzione electrical network". It contains in particular:

- new procedural modalities for connections, in accordance with the modifications of TICA;
- how technical solutions for connection are chosen, if necessary scheduling some upgrades of the electrical distribution network, that will be realized by Enel;
- a technical guide for HV and MV connections, and technical rules for LV connections;
- how to design and realize network installations by users, and Enel's trial criteria.

Moreover, Enel published the "critical areas" in which open season have started on 1st January. They are shown in the figure below.

Fig 8: "Critical areas" for Enel's network

CONCLUSIONS

The increase of DG in the Italian distribution networks has shown the problems that are determined on network planning and operation. The current trend of new DG requests in Italy is toward small and medium size plants, and in the new scenario this trend will probably increase, thanks to new legislative developments and to decreasing installation costs.
This has led Enel to develop technical solutions to the current network and new network structures, in order to keep high technical standards of quality in the electrical service even in the new operation as an active network.

REFERENCES

[1] Fabio Cazzato, Simone Botton, 2009, "Connection of Distributed Generation to Enel's network in the transition period from passive network sto Smartgrids", *CIRED 20th International Conference on Electricity Distribution*.
[2] Alberto Cerretti, Simone Botton, Sergio Sartore, 2007, "I problemi del gestore della rete di distribuzione", *AEIT conference on distributed generation*.