Mr. LUIGI FERRARIS

Chief Executive Officer and General Manager Terna

Luigi Ferraris has been the Chief Executive Officer and General Manager of Terna since May 2017.

From February 2015 to April 2017, he was Chief Financial Officer of the Poste Italiane Group, which he led through the process of privatisation and stock-market listing.

From October 1999 to January 2015, he was with the Enel Group, holding various top-management positions. These included Chief Financial Officer for the group from June 2009 to November 2014, Chairman of Enel Green Power in the same period, guiding the listing process, as well as Board member of the Chilean subsidiary Enersis and further on Manager of the Latin American area and, for the same company, CEO to January 2015. He was also on the Board of Directors of Endesa S.A., a Spanish subsidiary of the Enel Group as well as in other relevant subsidiaries.

1. What makes your energy system unique and different from any other?

A. For example, key characteristics: geographical features, system operation specifics, fuel & generation mix, compliance of market mechanisms with system control, network topology (extension, voltage levels etc.).

B. What is the impact of these peculiarities on your energy system management & control? What is the structure or hierarchy of your energy system management & control?

The Italian electricity system presents unique features stemming from from the intrinsic characteristics of the country such as its geographical configuration, which prevents Italy from being fully interconnected both at international (most of the interconnections are located at the north border) as well as national level (between regions and with the islands). Such conformation causes the intrinsic presence of bottlenecks, especially between North and South of Italy, thus leading to the necessity to split the electricity market in different areas, the so called “market zones” (North, Center-North, Center-South, South, Sicily, Sardinia).

Moreover, the electricity price in Italy is higher than in the neighbouring countries (mainly because of the different generation mix), and this leads to significant electricity import flows.

Furthermore, over the past ten years, renewable penetration in the generation mix has increased significantly, making the issue of security of supply more and more important and leading to new challenges for the electricity system.
Nowadays, Renewable Energy Sources (RES) cover 35% of the electricity demand. This growth did not occur homogeneously over the country, as RES technologies, especially wind farms, have been developed mainly in the South, a region abundant in primary resource but characterised by a less meshed grid and low electricity consumption.

In addition to the RES growth, the electricity demand decreased in the past few years due to a combination of the economic crisis and the adoption of energy efficiency measures, leading to a strong contraction of thermal power plants’ profits and, ultimately, to the progressive phase out of several thermal power plants (58 GW available in 2018 vs. 76 GW in 2013).

All these recent issues affecting the Italian electricity system make it challenging to ensure the security of supply. In this context, Terna is the sole transmission system operator (TSO) of the national high-voltage grid and its responsibilities include planning, design & construction, operation & maintenance of the transmission grid as well as managing the electricity system ("dispatching") – while guaranteeing security, reliability and efficiency.

2. What are the recent challenges that arise from the operation of your energy system?

How do you address them? What problems do they help to pinpoint (e.g. reliability and resiliency needs in the context of a highly decentralized and low carbon energy system)?

The main challenge faced by the Italian Electricity System is the continuous integration of non-programmable RES plants, also in consideration of the reduction of the available inertia traditionally provided by conventional power station and the intrinsic characteristics of the system, as already seen.

In fact, these factors impact negatively on the fundamental dimensions of safety, adequacy and efficiency of the Electricity System of which Terna is responsible. Some examples of situations which are increasingly difficult to manage include: network congestion, increase in hours and volumes of renewable overgeneration, increasing steepness of the evening residual load ramp, reduction of the adequacy of the System under stress conditions especially during extreme events (e.g. dry periods, heavy heat / cold waves), decrease in the regulating capacity of the voltage and frequency and decrease in short circuit power.

This context will become even more challenging in the coming years as described in all European and National energy scenarios. The proposed National Integrated Plan for Energy and Climate (PNIEC), recently transmitted by the Italian Government to the European Commission, foresees an increase of around 40 GW of renewable energy capacity by 2030 (of which around 30 GW of photovoltaic and 10 GW of wind) and the complete phase-out of coal by 2025 (7.2 GW).

Climate change is also significantly impacting on the management of the transmission network. The increasing intensity and severity of extreme weather events is already causing grid issues related to interruptions of the supply of electricity; main causes are ice / wet snow, wind storms, pollution, extreme heat waves.

To meet these challenges, Terna believes that it is necessary to implement a set of essential actions, coordinated and coherent with each other: network investments, digitalization, development of storage capacity, market evolution for the development of more effective long-term price signals and to foster participation of new distributed resources to the ancillary services market.

As an example, due to the problems of voltage regulation and maintenance of adequate levels of inertia deriving from the specificity of the configuration of the Italian electricity system, Terna has envisaged in its Development Plan to install synchronous compensators on its network in the central and southern areas, totalling around 3000 MVAr of reactive power.

3. How are market mechanisms embedded in your energy system management & control?

The Italian spot electricity market is divided into two macro-categories: "Energy Markets" and "Ancillary Services Markets".

The Energy Markets are operated by the Market Operator: Gestore dei Mercati Energetici (GME). In these markets, which include Day-Ahead Market (MGP) and Intraday Market (MI), generators and suppliers sell and buy electricity for every hour of the delivery day.

The outcome of the MGP market is the initial schedule of electricity for the delivery day (D). This schedule is defined at noon of the day before delivery (D-1) in one single session in which all bids and offers are cleared in the market. GME accepts offers/bids by merit order, taking into account the transmission limits notified by Terna. Accepted supply offers are remunerated at the zonal System Marginal Price. Accepted demand bids are remunerated at the National Single Price (PUN), calculated as the average of the zonal market prices weighted by the electricity demand.

The MI market allows the market operators to continuously adjust the initial schedule as defined by the MGP. The MI market takes place in seven sessions, two of them run in D-1, the remaining in the delivery day (D).

In the Ancillary Service Market (MSD), Terna purchases the resources required to manage the system, mitigate system constraints and balance the system in real time. Participation in the MSD is mandatory for plants with an installed capacity greater than 10 MVA and it is restricted to units that are authorised to supply ancillary services. In the MSD, Terna acts as a central counterparty and accepted offers are remunerated at the offered price (pay-as-bid).

The MSD consists of a scheduling phase (ex-ante MSD) and a Balancing Market (MB).

In the ex-ante MSD, consisting of a single session for presenting bids/offers and six scheduling substages, Terna accepts energy demand bids and supply offers to relieve residual congestions and to create reserve margins. In the MB, that takes place in six sessions closing one hour and a half before the delivery period, Terna accepts energy demand bids and supply offers to provide the service of secondary control and to balance energy injections and withdrawals into/from the grid in real time.

Moreover, in MSD, Terna accepts energy demand bids and supply offers to provide other ancillary services such as voltage regulation and primary control, that are mandatory offered by plants with an installed capacity greater than 10 MVA.

4. What are the main approaches to your energy system development

A. For example, key investment flows: networks, generation, modernization, renewables etc. Have these trends changed in the past 10 years?

The liberalization of the energy market, with the consequent unbundling of the activities of the electricity sector, was launched in Italy in 1999. The TSO is responsible for developing the National Electricity Transmission Grid, while the Distribution System Operators (DSOs) are responsible for the development of the distribution grid. Development of generating capacity is left to the market, as well as energy sale to final customers.

In the last 10 years, Terna has invested around 10 billion euros in the National Transmission Grid. Grid planning has followed different paths over the years. In particular, it is possible to identify at least three different phases: A first phase, from 2005 to 2010, has seen the development of extra-high voltage network (380 kV) to connect new CCGT plants as well as the development of sub-transmission grid, in order to improve the quality of the service and solve critical grid constraints.

During the second phase, from 2010 to 2014, several grid investments were needed in order to upgrade the high voltage network (120 - 150 kV) to allow the connection of utility scale renewable projects (wind and solar), as well as the construction of several electrical substations.
During the ongoing third phase and in connection with the phenomenon of “public opposition” and “nimby syndrome”, the focus on social and environmental issues is becoming increasingly important, and it dominates all aspects of grid development, starting from the initial planning. This is leading to a new approach: investments in grid development aim at optimizing the use of existing assets (e.g. dynamic thermal rating, use of high capacity

conductors), as well as adopting the newest advanced and environmental-friendly technical solutions (e.g. underground cables, HVDC). In addition, there is growing attention towards the concept of resilience, one of the central themes of the new energy / climate scenario. In this context, continuous discussion and search for optimal solutions together with local communities/stakeholders is becoming one of key aspects of grid planning activities.

C. What is the mechanism to support decision making for regulating investment flows in the industry?

Terna is directly responsible for grid development planning, which is carried out on the basis of long-term energy scenarios at European and National level. The ten-year Grid Development Plan is presented annually.

The Development Plan is approved by the Italian Ministry of Economic Development, after acquiring the opinions of all interested parties: the Italian Regulator (ARERA), the Ministry of the Environment and the Ministry of Cultural Heritage. ARERA verifies the coherence of the Development Plan with respect to the objectives set by the energy regulations in place, while the Ministry of the Environment and the Ministry of Cultural Heritage assess its environmental impacts.

Since 2005, Terna carries out a Cost/Benefit Analysis for all projects with a planned cost higher than 25€mn (from 2017 this threshold has been reduced to € 15m) on the basis of electrical, economic and environmental indicators, according to a methodology shared with the Regulator. The Cost / Benefit Analysis is based on static and probabilistic market and grid simulations. This analysis is carried out by comparing two sensitivities on the reference scenario: one with grid investment projects and one without any investments.

Starting from the 2018 Development Plan, Terna applies a new methodology for Cost / Benefit Analyses (CBA 2.0), which has partially revised the methodology and includes new indicators.

Among the various categories of benefits assessed in the analysis, some of the main ones are the increase in Social - Economic - Welfare (SEW), the reduction of “not supplied energy”, the integration of renewables and the environmental benefits associated with the implementation of the investment.

In the 2018 Development Plan, over 80% of the planned projects were subject to ACB 2.0 evaluation.

D. What business models and changes are necessary to ensure the economic viability of the energy system?

Energy systems characterized by a steady or slightly increasing demand coupled with a strong growth in intermittent renewables with a near-zero variable production costs, like the Italian market, require the formation of effective long-term price signals, in order to guarantee the financing of new capacity installation projects when and where needed. Examples of long-term signals are Power Purchase Agreements (PPAs) for renewables, Capacity Market for efficient and low-polluting thermal plants and long-term contracts through competitive procedures for storage systems and for the provision of ancillary services.

With particular reference to the new Italian Capacity Market, the final approval of the code by the Italian and European authorities is expected within the first half of 2019, with the simultaneous launch of the auctions for the delivery of capacity starting from 2022.

This will guarantee the adequacy of the system through an efficient and low-emission thermoelectric fleet, and the progressive transition of the energy sector towards decarbonisation without having negative impacts on the quality standards of the electricity service for citizens.

5. What is the mechanism to upgrade generation and networks in your energy system? Please elaborate.

As already mentioned, the development of the high-voltage grid in Italy is assigned to TERNA. The main drivers of the Development Plan include decarbonisation of the electricity system, market efficiency, security of supply, quality of service, resiliency, connecting new generation and consumption facilities and compliance with environmental and landscape constraints.

On the other hand, the development of new generators is market driven. In present market conditions, mechanisms to encourage investments in new generation capacity via long term price signals are strongly needed, such as the Power Purchase Agreement (PPAs) and the Capacity Market.

In any case, it is part of Terna's responsibilities to analyse and report the potential adequacy criticalities in the electricity system to the competent authorities and to propose solutions.

6. What are the regulatory problems SO faces in the industry? How do you address them?

The evolution of regulations in the energy sector has a strong and direct impact on Terna since around 90% of our revenues come from regulated activities.

Regulations in the energy sector are evolving substantially in Europe and, particularly, in Italy, due to the ongoing transition towards a decarbonised future.

The main regulatory issues for Terna can be summarized as follows:

- TheincreasingattentionofRegulatoryAuthoritiestowardsthecontainmentoffinaluserenergyprices

  and to the efficacy of the TSO remuneration mechanism, evolving from an input-based (CAPEX remuneration) to an output-based (performance remuneration) methodology. In many cases performance evaluation is very complex and time diluted.

- The strengthening of the regulatory framework harmonisation at European level, in an extremely variegated context in terms of electricity systems and markets (Clean Energy for All European Package and Network Code)
- The need to combine an increasingly decentralised and tangled electricity system with the univocal responsibility in ensuring security of supply, held by Terna.
- Theincreasingnecessitytocomplementthespotelectricitymarketbyprovidinglongtermpricesignals to support investments in new efficient and flexible generation to guarantee system adequacy.
- The evolution of the internal energy and ancillary services market through the increased participation of new distributed energy resources (demand response, small generation, electric vehicles,...).

Terna actively supports the evolution of regulatory framework through a continuous exchange with the institutional stakeholders, the sector associations and the public, in the light of its central role in the electricity system.

7. What is the role of Demand Response mechanism in your energy system?

What is your understanding of DR potential? In case DR is not introduced yet do you plan to introduce it?

The evolution of the energy sector towards a RES-dominated market, implies the need for the TSO to supply new flexible resources for ancillary services, such as demand, distributed generation, non-programmable renewable energy sources and storage, including electric vehicles.

To this regard, Terna launched a series of pilot projects in 2017 with the aim to extend the participation in ancillary services market to new resources, like demand response.

Previously, in fact, the only operative mechanism for demand response to provide ancillary services was the interruptibility scheme where demand units were remunerated to be ready to instantly cut off their consumption when required by Terna.

With the new pilot projects, demand units can supply tertiary reserve, intra-zonal congestions relief and real- time balancing services aggregated in Virtual Units, along with production units and storage. These aggregated units are managed by a new market entity, the Balance Service Provider (BSP), that is responsible for their performance in the ASM. As of today, about 600 MW of capacity are actively participating in the ASM.

Terna aims to launch new pilot projects to test the ability of new technologies in providing further ancillary services (for example to promote storage investments or to obtain voltage regulation from non-programmable RES) and to integrate the tested mechanism into the ancillary services market definitively.

8. In recent years traditional approaches in the industry are strongly influenced by new technologies. How does your energy system management & control adapt to these changes?

The integration of a large number of renewable plants that cannot provide ancillary services in the Electricity System today requires an evolution of the technologies used for the management of the network and for the management of the large amount of necessary data .

Examples of technologies already used to manage the network are the Dynamic Thermal Rating (DTR) and the Phasor Measurement Units (PMUs) that allow, respectively, a more efficient use of the network in areas where there are major problems of grid congestion and real-time monitoring of the conditions of the electricity system in order to identify and implement countermeasures in case of system stress events.

Moreover, to further increase the flexibility of the Electricity System, new technologies are being studied and evaluated such as the Flexible Alternating Current Transmission Systems (FACTS) based on power electronics, which allow to increase the transmission capacity and/or to improve security management of the Electrical System.

In addition to the use of “hardware” technologies, the growing complexity of the Electrical System implies the need for a strong development of the "software” and IT technologies necessary for real-time management of large amounts of data coming from the field, decision support and process automation (e.g. advanced analytics, forecasting algorithms, machine learning).

In this respect, our 5 years strategic plan includes more than 600 M€ of investments in digital assets:

- connectivity, optical fibres, hedge computing and data storage capabilities, new technologies to monitor distributed energy resources

- digitalization of substations
- improving our predictive maintenance capabilities
- implementing new algorithms based on machine learning / artificial intelligence for real time system operation
- redesign of system operation tools (SCADA, control and defence system).

9. Integration of new resources into conventional energy mix is widely discussed at present. Is it

of high priority to you?

1. **What types of new resources have you adopted already?**
2. **How do you address the issue of system operation & management with these new types integrated into your energy system?**
3. **What innovative solutions do you choose to promote in order to address the future challenges (e.g. Storage, Smart Inverters etc.)?**

The integration of RES in Electricity Systems to enable the energy transition towards a more sustainable model is a topic of fundamental priority at a global level. In fact, the study conducted by the Intergovernmental Panel on Climate Change (IPCC) in October 2018 officially announced an overheating of the planet in the range of 0.8 ÷ 1.2 °C, with an expected trend of +0.2 °C per decade.

The energy transition is for Terna an absolute priority but also a clear opportunity. In fact, thanks to its central position in the Electricity System, the TSO is the most suitable player within the energy sector to hold a leading role in the energy transition.

Around 30 GW of solar and wind power plants are already integrated into the Italian Electricity System (for reference, Italian historical peak load is around 60 GW). These generation technologies are essentially intermittent and dependant from the availability of the primary resource. Therefore, these technologies cannot guarantee a continuous production and might not be available at times of system stress. Moreover, most of these plants are connected to medium and low voltage networks, which are not directly controlled by the TSO.

To ensure the safe integration of an additional 40 GW of renewables by 2030, as foreseen by the energy scenarios described above, it is necessary to implement innovative solutions.

To guarantee enough flexibility of the Electricity System, Terna believes that it is necessary to develop an adequate storage capacity, both hydroelectric and electrochemical (in the PNIEC, around 6 GW of storage are envisaged by 2030). Terna is at the forefront of research on electrochemical storage, having launched since 2012 an important experimentation to investigate and validate the technological solutions able to provide the ancillary services necessary to guarantee the safety of the system and to support the integration of the RES.

To continue guaranteeing the security of the Electricity System with an increasing decentralization of resources (today already the power of the connected power plants on medium and low voltage networks represents around 25% of the total), Terna is developing an Observability Model of this generation, based on direct measurements of a sample of installations, historical data and environmental data. This will allow the estimate of distributed generation in real time, allowing the integration of such information in the control and defence systems.

10. The concept *'Power System of the Future*' is gaining increasing acceptance in the world energy industry. How do you approach this concept?

The Clean Energy Package presented by European Commission set new targets for the EU for 2030: a binding renewable energy target of at least 32% and energy efficiency target of at least 32.5%, to decarbonise the energy sector.
To achieve such ambitious goals, it will be necessary to act following these three key guidelines: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers. In addition, it will be fundamental to develop a proper regulatory framework and to implement a future-proof market design.

Terna believes it is of the utmost importance to act soon and simultaneously on different key areas: investing in grid development, fostering new storage systems (both hydro pumped and electrochemical) for the integration of RES technologies, developing long-term price signals (PPAs and Capacity Market) to encourage new generation capacity, building new hardware and software technologies to manage increasing volumes of data and integrating distributed energy resources in the electricity markets.

In such scenario, the national Transmission System Operator, third and independent party to market dynamics, plays a central and extremely delicate role, as to get a low-carbon emission economy while ensuring reliability, quality and security in line with the current standards is absolutely feasible but not obvious at all.

look forward to continuing our professional dialogue in the future!