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In our most recent experience, off-line simulation tools that are decoupled from the distribution company's management system are becoming meaningless. The implementation of the models becomes slower and the ability to obtain simulation parameters to represent the real state of the network is greatly reduced. Moreover, the validation of the simulations is also much more complex.

From this point of view, bringing together different simulation models under the umbrella of the so-called digital twins and connecting them to the real-time management systems of the distributors, so that mathematical models can be generated in real time or off-line but in an automated and fast way, is vital.

To date, simulations have been carried out using specialised software packages that are completely disconnected from the company's management systems, the process of obtaining data for modelling means that in many cases by the time the model has been implemented, the state of the network has already changed, and in most cases the data is scattered across different departments and its collection is extremely complex. When it comes to validating the results, the complexity is also very important because although in many cases the company has data from sensors in the field such as transformer station supervisors or smart meters, superimposing this data on the data generated with mathematical models is not trivial. The problem becomes more acute as we move to lower voltage levels and is particularly acute at low voltage where the quality of the data is often quite poor.

The development of so-called digital twins and their use for operational and planning decisions is part of a very deep digital transformation process that affects all levels of electricity distribution companies.

The concept of the digital twin is relatively abstract and can be understood in radically different ways depending on the scope of application. We tend to think of the concept of a digital twin as a digital representation of a physical asset, or to put it more compactly, a digital twin is a digital replica of a physical system. This definition is not wrong, but it is incomplete and certainly does not allow us to understand how a digital twin can be used within a distribution network management platform. According to this definition, any mathematical model of the network could be called a digital twin of the network, and this is not true.

The concept of digital twin must consider in an integral way 1) the physical system 2) the digital representation of it and 3) the bidirectional transfer of data between both systems.
Only in this way it is possible to take advantage of a digital twin as the core of the future network operating system. On the one hand, the physical system must be parameterized in such a way that it can be digitally reproduced in the form of a mathematical model. In the case of mechanical systems, this parameterization would imply for example the knowledge of weights, dimensions of the different components. In the case of distribution networks, it will be necessary to know the parameters that define the lines, nodes, network infrastructure and devices connected to it as well as its different controls.

Within the large set of parameters necessary to digitally define an electrical network, there are some static parameters with little or no variability, such as the position of the different network elements. In other cases, such as the switches that make up the topological layout of the network, although their position may vary over time, the number of maneuvers is very limited. Other parameters such as the control commands of certain devices that use converters or even the active and reactive power data consumed or injected at each point of the network vary with a very small latency.

Here it is necessary to define the link between the physical layer and the data layer. This means, which sensors or sources of information are necessary to obtain each type of parameter and to go even further by separating the parameters into those that must be measured and those that can be estimated within the digital twin. For example, it is reasonable to think that we want to measure each of the consumptions in the network, but it would be impossible to measure the voltage or current at each point of the network considering the thousands of kilometres of cables that compose it. However, the digital twin could be used to estimate this information from a minimum set of measurements that makes the system observable, and this would be a simple case of integration of the physical layer, the data layer, and the communications between the two. The digital twin can be used also to filter bad data or detect outliers or uncommon behaviours.

We have discussed about the physical layer and its sensorization as well as the bidirectional communication system with the digital representation of the physical system, but what do we mean by digital representation of the physical system? Normally, we refer to a set of mathematical and simulation models that reproduce the behaviour of the physical system and that, given certain inputs, can reproduce the outputs accurately enough to allow us to make decisions with guarantees about the actions to be carried out on the physical system. As far as power systems are concerned, this set of mathematical models includes those that allow us to solve load flows, state estimations, thermal models, control models, topological estimation models, among others.

Once we can perform data-driven decisions making use of the digital twins, the latency of the decisions can be optimized looking again to the physical and communication layers. (More sensors, AI, communication 5G…). Although these technologies that improve the processes and systems in the company are considered in many cases core, they are in fact enabling technologies that pivot around the digital twin, which is the real core of the data driven decision.