Measuring the ‘reality of the grid’

– the impact of energy transition on current measurement

Roland Bürger

A Senseleq White Paper

Measuring the ‘reality of the grid’

Abstract

There is a proverb in the Netherlands “Meten is weten”. A good translation would be “to measure is to know”, or more freely “the numbers tell the whole story”. The expression seems highly appropriate as we face the challenges of transitioning our energy sources from traditional sources to renewables. Without accurate measurement it is impossible to actually know what is happening in the grid. Only when we have the numbers will the picture become clean and a solution can be proposed to face these challenges.

From a general decarbonation target in most of countries, this whitepaper is describing the energy transition challenges in power grids and how it will impact the sub-station equipment including the conventional current transformer. This is followed by a discussion describing how a future-proof current transformer is expected to perform and concludes by suggesting the use of wide-range, universal, highly accurate current transformers based on zero flux technology.

An introduction to energy transition challenges on power grids

Today there is no debate on the urgency to reduce CO_2 emissions in all aspects of our life. Typically, in Europe there is a clear ongoing dynamic symbolized by the European Commission’s proposal to cut greenhouse gas emissions by at least 55% by 2030 sets Europe on a responsible path to becoming climate neutral by 2050[1]. One of the biggest parts is related to the electricity power generation with a challenging goal express in the Clean Energy for All Europeans Package to achieve 32% for renewable energy sources in the EU’s energy mix by 2030. Europe’s energy sector is shifting from a fossil fuel dominated and supply-centric model to a clean, digitalized and electrified consumer centric system with many distributed resources.

[1] https://ec.europa.eu/clima/eu-action/european-green-deal/2030-climate-target-plan_en

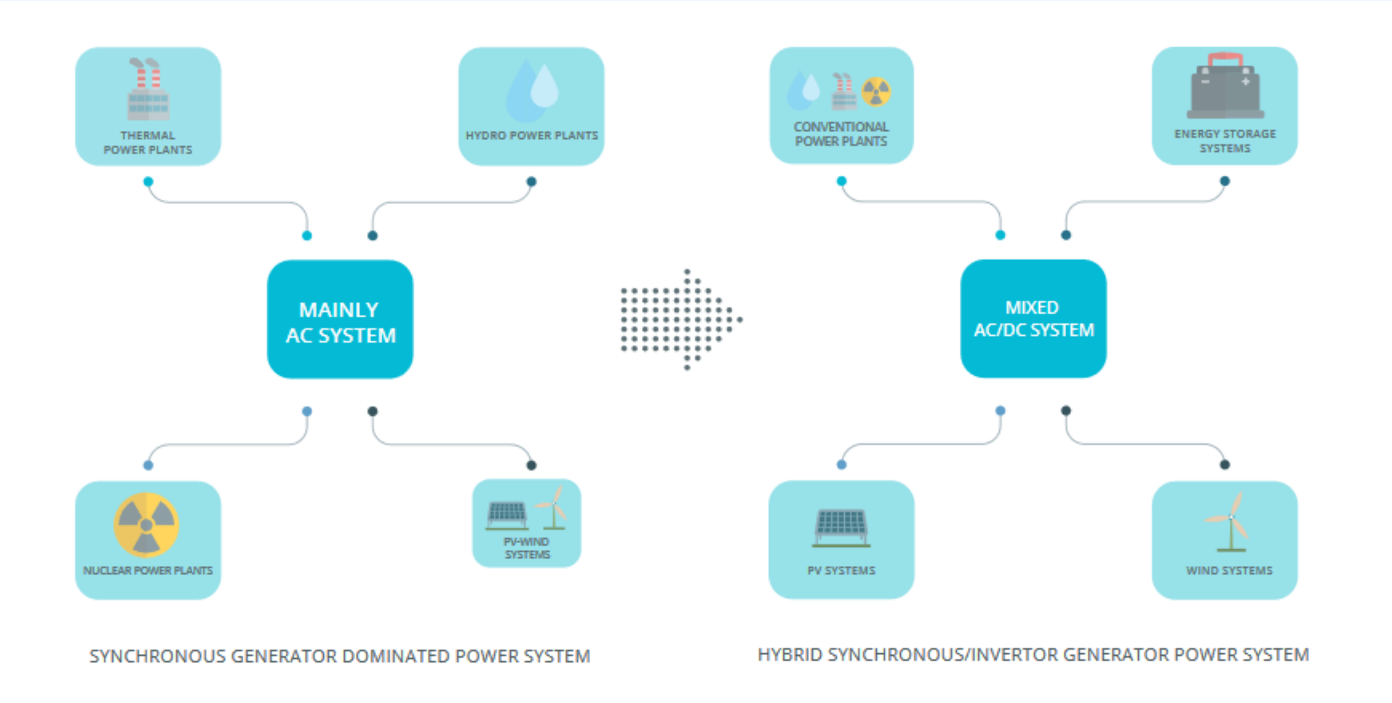

Figure 1: The logical result will be a significant increase of the power electronic converters connected to the HV and MV grids (see figure 2) with a strong impact on the power quality.

This looks great on the paper but what does it means concretely for Transmission System Operators (TSOs) and Distribution System Operators (DSOs) in their daily power grid exploitation? In line with the 'European Green Deal', ENTSO-E[2] has established their view in the report Vision on Market Design and System Operation towards 2030[3].

One of the main conclusions is the transition of the power generation from a dominated synchronous system to a hybrid synchronous and invertors one (see figure 1). In addition, it will increase the electricity production volatility coming from the renewable energy intermittency.

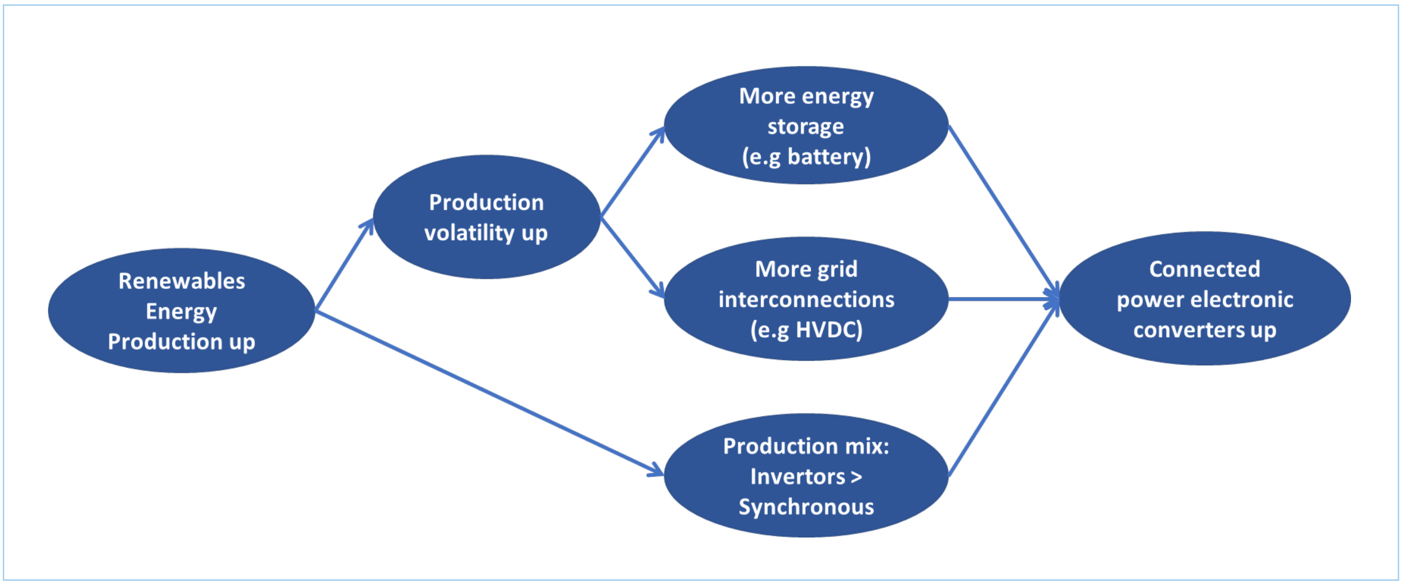

Figure 2: So what? How is this trend impacting the existing power grid and sub-station equipment? This is precisely the topic discussed in the next chapter.

[2] https://www.entsoe.eu/
[3] https://vision2030.entsoe.eu/

Power quality matters!

The multiplication of power electronic devices and its consequences on the power quality is already known for few years now in the low voltage area. Indeed, the presence of switch mode power supply, variable speed drives, UPS and divers power converters used at the electricity consumption level increased the power quality challenges. Therefore, we can expect to see the same consequences in the HV and MV grids as the following phenomena are becoming more and more common:

- Harmonic pollution in AC grids. Sub-harmonics, low harmonics, higher harmonics up to kHz can all impact load-ability, useful lifetime, operational efficiency, and the output accuracy of how transformers perform in the grid.
- DC pollution in AC grids. This is changing the load point and saturation status of power transformers, distribution transformers, and instrument transformers. This impacts load-ability, useful lifetime, operational efficiency, and the output accuracy of how transformers perform in the grid.
- Reduced useful lifetime of high voltage and medium voltage equipment. This is due to operational conditions which are not aligned with design specifications. This has also resulted in further development of condition monitoring systems and asset management platforms as well as proactive maintenance scheduling programs.
- Increased importance of power quality due to the increased cost of damage / loss of load to customers.

At the heart of power systems are measurement systems which facilitate the delivery of a true picture of what is happening in the grid. Hence the upgrade of current transformer technology is already a given. The following section explains this more fully.

In the past, grids were either AC (clean AC without much harmonic distortion or DC pollution), or DC (clean DC without AC harmonics). This is not the case anymore due to change in the nature of power generation, transmission, distribution, and application. Given this scenario, the question facing a highly polluted current flow is: 'what should nature of the new measurements be?'

Is it still enough to record a single value of peak or rms[4] current level, or must current transformers of the future deliver more information than just a number?

Current transformers of future

The previously mentioned ENTSO-E organization explained in their Innovation roadmap 2020-2030 report[5] the emerging needs and challenges to "enable secure operation of widespread hybrid AC/DC grids"; amongst which, the following apply to current transformers of future.

A future-proof CT is required that can measure a wide range of occurrences from extremely fast, high frequency phenomena to extremely low frequency DC phenomena. Only then can we truly know the 'reality of the grid'. When we can measure everything, we can understand it, prepare improvement plans and take corrective actions.

The new CT technology is expected to find more applications with different applications supported by one CT which is able to feed different IEDs (Intelligent Electronic Devices) with different functionalities – e.g. protection relays, accounting and metering, power quality including DC pollution and low / high kHz harmonics, digitalization over a wide range of currents 0A to kA, condition monitoring, etc. The new CT must be able to deliver the following specifications:

- Highly accurate AC and DC current measurement (exceeding existing accuracy classes) in a wide range of currents – milliamperes to multiple kiloamperes.
- DC measurements in AC grids / DC Pollution
- Power quality, Harmonics (sub-harmonics, inter-harmonics, supra harmonics, etc.)
- Extreme accuracy needed for a wide range of digitalization – which enables the same CT to be used for different applications
- Accounting / billing standards and certifications
- Able to be combined in a hybrid solution with existing inductive CT technology through a transition phase and for retrofit applications
- Robust and flexible
- Simplified and safe – to deliver more functionality without introducing any new safety risks

Is this possible, or just a utopian dream?

[4] root mean square (rms)
[5] https://www.entsoe.eu/publications/research-and-development/#rdi-roadmap-20202030

Universality comes from hybridization

In addition to the conventional current transformer principle there is a large diversity of current measurement technologies from the simple shunt to the complex electronic sensors like optical, Hall effect or Rogowski. However, none of them can cover all the emerging measurement needs described above except one: Zero-Flux. Indeed, this technology allows measurement from DC to few hundreds' kHz with a very high accuracy (ppm range) and robustness equal to CT.

Thanks to its Zero Flux universal measuring technology, Senseleq can provide a stable and reliable solution to solve the new measuring challenges.

The Senseleq solution includes three main components as follows:

- Ring core CT which provides the basic measurement of the primary current. The ring core can be delivered in cast resin set-up, in sub-assembly set-up for installation inside power transformers, or on a four-wheel solution for laboratories, etc.
- An analog electronic system reads the secondary current and injects back current into separate windings on the ring core. This approach is based on zero flux technology and makes sure that the core remains linear and accurate. This system includes a 19-inch rack solution and needs to be installed in an IP rated environment.
- Secondary cable between the ring core CT and the electronic system which provides the connection between the ring core windings – secondary winding, feedback winding, compensation winding, etc.

This CT can also be delivered in a hybrid configuration, including traditional existing inductive cores, because the active part of the CT is the same technology as a ring core CT; the new addition is the analog electronic system which manages the linearity of the core to provide high accuracy measurement across a wide range.

In a hybrid CT solution, the existing metering and protection cores are also delivered as with the existing ring core CT around the transformer bushing. Therefore, in addition to the existing inductive ring cores – in the same cast resin unit – Senseleq delivers the new sensor with its output analog current which can be used by the customer for special purpose DC measurements. By implementing the new technologies in a controlled manner, the continued safe operation of CTs is ensured.

The output signal of the analog electronic system will provide the output signal which will be fed into the IEDs[6]. This signal includes the entire spectrum of components - AC 50Hz, DC, harmonics up to 50kHz, etc., all at a high accuracy level.

Conclusion

Within the context of a major revolution for power grids for a self-adaption to achieve the carbon neutral objectives in 2050, there is a clear need for significant improvement of the existing infrastructure. Therefore, it is important to acknowledge that in addition to on-going investment in software applications, there is also a definite requirement to upgrade the technology used in high- and medium-voltage equipment as well.

The impact of the power electronic by increasing the power quality monitoring importance will reveal the urgency to change the existing approach by exploring new current measurement technology.

At Senseleq, thanks to our long-term experience in Zero-flux and conventional CT we are well-positioned to help TSOs and DSOs to try the challenge. So contact us!

[6] IED: Intelligent Electronic Device

Contact

Roland Buerger

Business Development

info@senseleq.com
Mobile: +49 179 7540018
Phone : +49 4187 9008877

Senseleq NV
Tukseweg 130,
8331 LH Steenwjik
Netherland