GOSSEN METRAWATT

Safety through Competence

Stray Current Due to Harmonics – Myth or Reality?

Mains Quality

WÄGA Wärme-Gastechnik GmbH, a subsidiary of RMG by Honeywell located in Kassel, Germany, is an equipment manufacturer with an emphasis on technical gas systems. The company's offerings range from simple control cabinets for pressure reduction as well as large network transfer stations with volumetric measurement and control, right on up to complex project concepts consisting of several systems and network sub-segments.

In addition to turnkey gas pressure regulating and measuring systems for a great variety of applications, a further field of business involves the conceptualization and construction of natural gas filling stations. WÄGA has proven itself an innovative company in this respect.

In 2012, the responsible employees at WÄGA received an order from Energie- und Wasserversorgung Bruchsal GmbH (a power and water utility) for project engineering, installation and initial start-up of a natural gas filling station for the industrial park in Bruchsal, Germany. The customer is also the operating company.

The filling station was installed in order to meet rising demand generated by CNG vehicles (compressed natural gas) in the region. This was the first facility in Bruchsal for refueling CNG vehicles.

Considerable costs-savings result after switching from a diesel to a natural gas vehicle, and the cost difference is even greater for vehicles with gasoline engines (fuel costs only). Used as fuel, one kilogram of natural gas has an average energy content of approximately 13.3 kWh. A liter of gasoline (also approx. 1 kilogram) offers only 8.6 kWh. The fact that biogas from the region can be used, which is stored at decentralized locations, is a further positive aspect resulting from the use of natural gas.

Source: www.erdgas-mobil.de

A compressor is required in order to refuel the vehicles. The natural gas is taken from the gas transmission network and compressed by means of compressor. Normal transmission pressure for natural gas in German high pressure networks is less than 100 bar. Natural gas vehicles are refueled at filling pressures of up to 250 bar. High levels of compression make it possible to pump large amounts of gas into a small storage tank. High pressure levels are accomplished by means of step-by-step compression with a reciprocating compressor. The compressor at the natural gas filling station in Bruchsal is powered by a 3-phase, 110 kW electric motor. Gas with input pressures ranging from 4 to 14 bar is compressed to 250 bar by the unit. The upstream 110 kW frequency converter allows for variable motor speeds of 500 to 1300 rpm, and thus uniform, smooth operation of the system. The first systems of this type were equipped with a relatively simple compressor controller. The compressor was activated by means of a pressure switch inside the system's storage tank. When pressure dropped due to refueling of a vehicle and the resultant removal of gas from the storage tank, the compressor was started up by a common star-delta circuit. Making current due to activation represents a constant load for the upstream power supply network, the power infeed modules and the equipment itself. Additionally, the power infeed module had to be laid out for continuous making current, because the compressor quickly reached its filling pressure and was thus switched off again. This sequence could repeat itself as often as 20 times an hour. Compressor speed control is a time-tested method for compressing natural gas for transmission networks. The motor is decelerated with the help of a frequency converter so that its speed is matched to the actual load and thus the amount of gas currently being withdrawn from the system. Ideally, gas throughput through the compressor is constant over long periods of time. This concept is taken advantage of at the natural gas filling station in Bruchsal and makes it possible to significantly reduce the number of making and breaking operations. As a result, the mains are not subjected to loads due to high making current or peaks due to breaking energy, and uniform load is assured via the power infeed system. All in all, a significantly more harmonious procedure is achieved which is more gentle on the whole system involved.

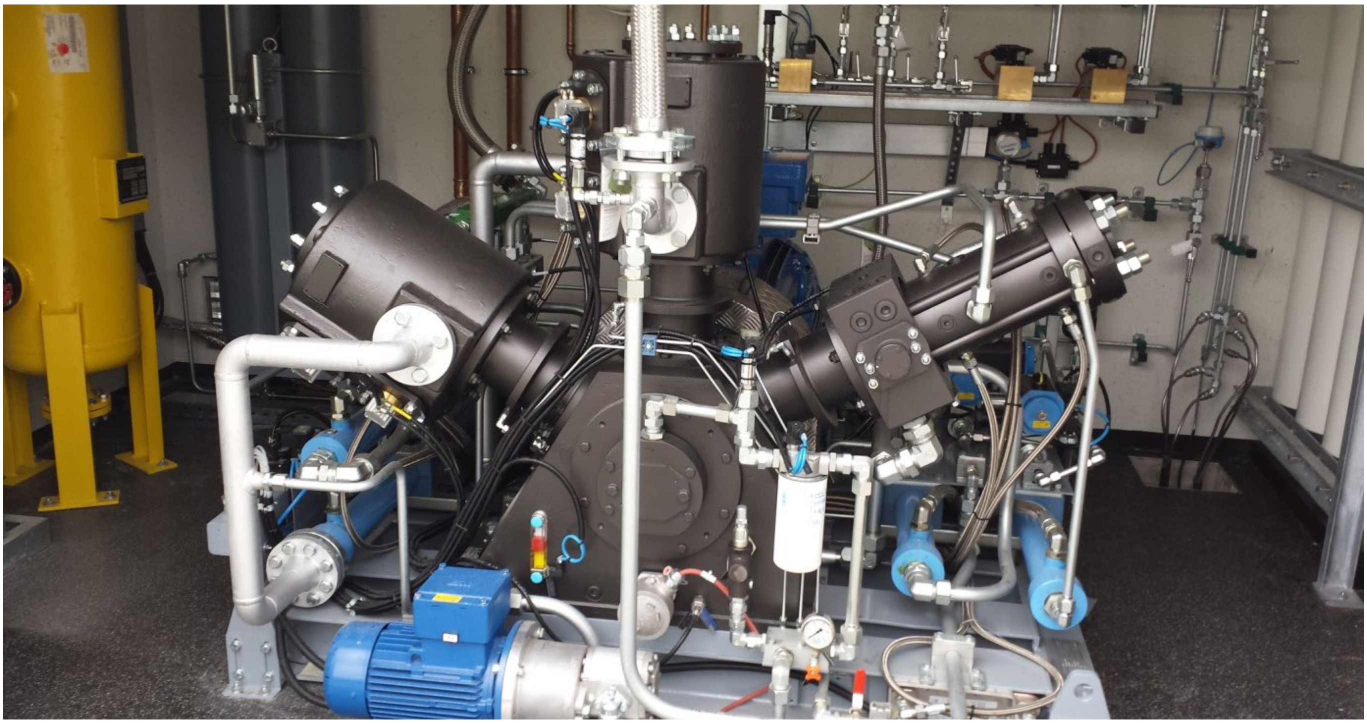

Figure 1: Compressor with Electric Motor

The system was installed according to plan and the compressor was started up for a test run at the natural gas network on schedule in the middle of September 2013. Primary power was supplied to the surrounding industrial park centrally via a feeding point, and thus via a transmission transformer. Due to the fact that the system was set up in an area with mixed zoning for both industry and commercial operations and a sensitive mains structure for power supply and distribution, Wäga decided to involve GOSSEN METRAWATT as a partner for the verification of possible system loads, as well as for expert technical assistance. While the compressor was being brought up to nominal speed with the frequency converter, examinations were conducted for undesirable system loads and mains pollution. Utilized frequency converter protective measures were taken into consideration during the course of comprehensive planning. Both a link reactor and a category C2 mains filter (for use in residential and industrial environments) were planned for and installed. After intensive measurements during which stray current was detected as a possible source of interference, the planned concept for increased protection requirements for the low-voltage distribution system was verified. Due to the fact that the complex measuring technology required to this end was available to neither the system installers nor the new owner, the measurements were performed by GOSSEN METRAWATT. In order to rule out all conceivable scenarios, several measurements were performed at the system (on the mains side). GOSSEN METRAWATT's Mavowatt 70 portable power disturbance analyzer was used for this purpose.

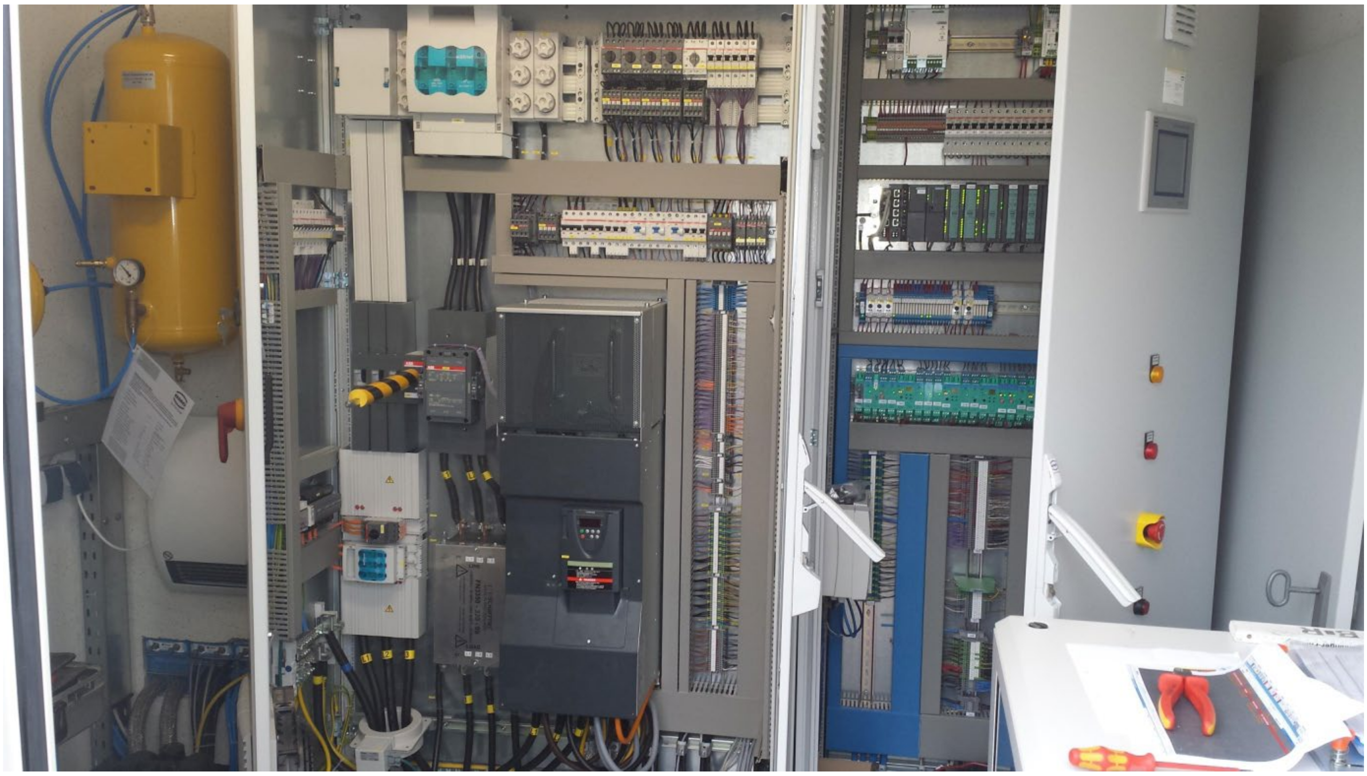

Figure 2: The Heart of the Compressor System, Control Cabinet with Frequency Converter

Measurement with the Mavowatt 70 revealed that the utilized frequency converter generated high discharge currents and fed them into the mains. This is by no means an unusual phenomenon, but rather an unavoidable fact. As a result of internal interference suppression measures and parasitic capacitances, modern frequency converters generate discharge currents of considerable magnitude within a broad frequency range.

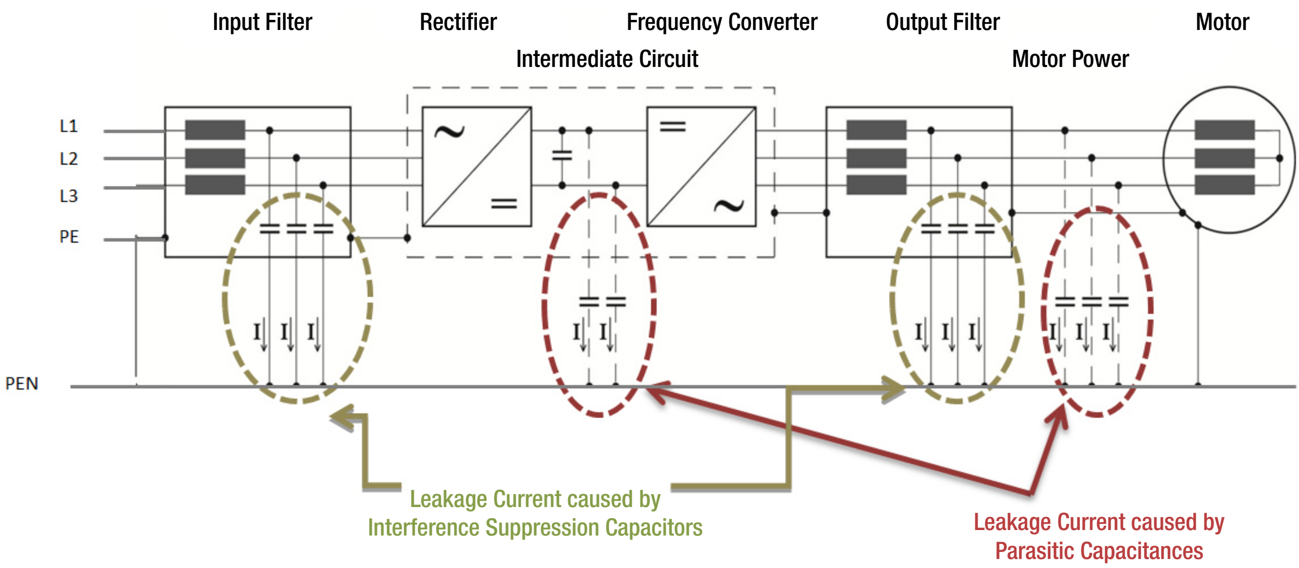

Figure 3: Layout of a Frequency Converter (source: "Achtung Ableitströme!", technical article by Herbert Blum)

Discharge current from the frequency converter is conducted by the protective conductor. Since line commutation was handled by just a single 4-wire cable (TN-C protection system), the discharge currents, along with reverse harmonic and operating current, added up to an effective value of 10.7 A.

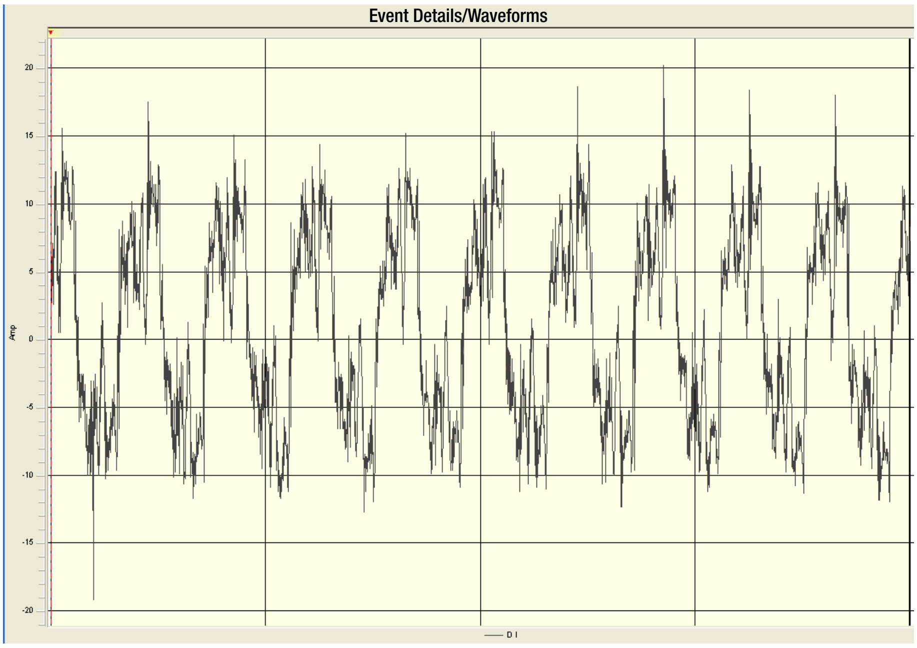

Figure 4: Waveform of PEN Current, Effective Value: 10.7 A

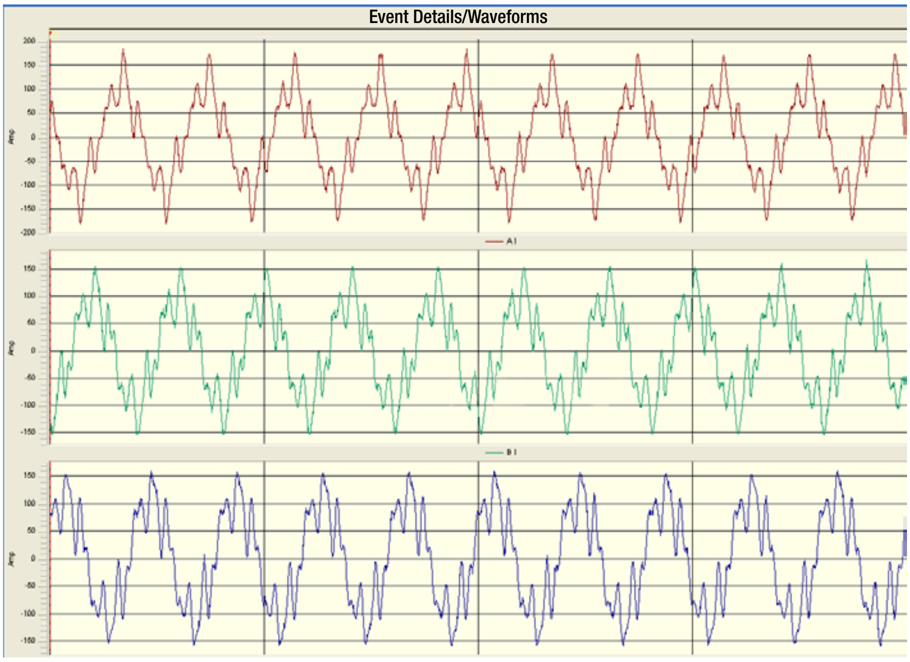

Figure 5: Characteristics Curves of Extracted Phase Currents

This current could also flow via other grounded, interconnected segments. These currents are known as stray current in technical jargon.

Under certain circumstances, stray current could also spread out via data cable shielding, in which case frequencies of 50 (fundamental harmonic) to 1250 Hz (25^{th} harmonic) are conceivable. Due to high signal strength with high-frequency components, interference could result for the transmitted/control signal, and thus interconnected power consumers as well. After reviewing and evaluating the measurement results together with the manufacturer of the frequency converter, the protection concept for the supply network, pursued already during the planning phase, was finally implemented. In order to assure maximum protection, it was decided to install a passive harmonic filter of the highest category (class C1 per EN 61800-3) between the frequency converter and the motor. The filter consists of series connected, damped capacitors. Resonant circuits of this type generate a “sink effect”, by means of which currents with undesired frequencies are quenched.

Figure 6: Passive Harmonic Filter

An additional series of measurements was subsequently performed by order of the installing company in cooperation with GOSSEN METRAWATT. As expected, installation of the filter had the desired effect, and the targeted goal of protecting the upstream distribution network was fulfilled.

Recordings confirm that amperage conducted by the PEN conductor was reduced and that the current waveform was significantly improved (see figure 7).

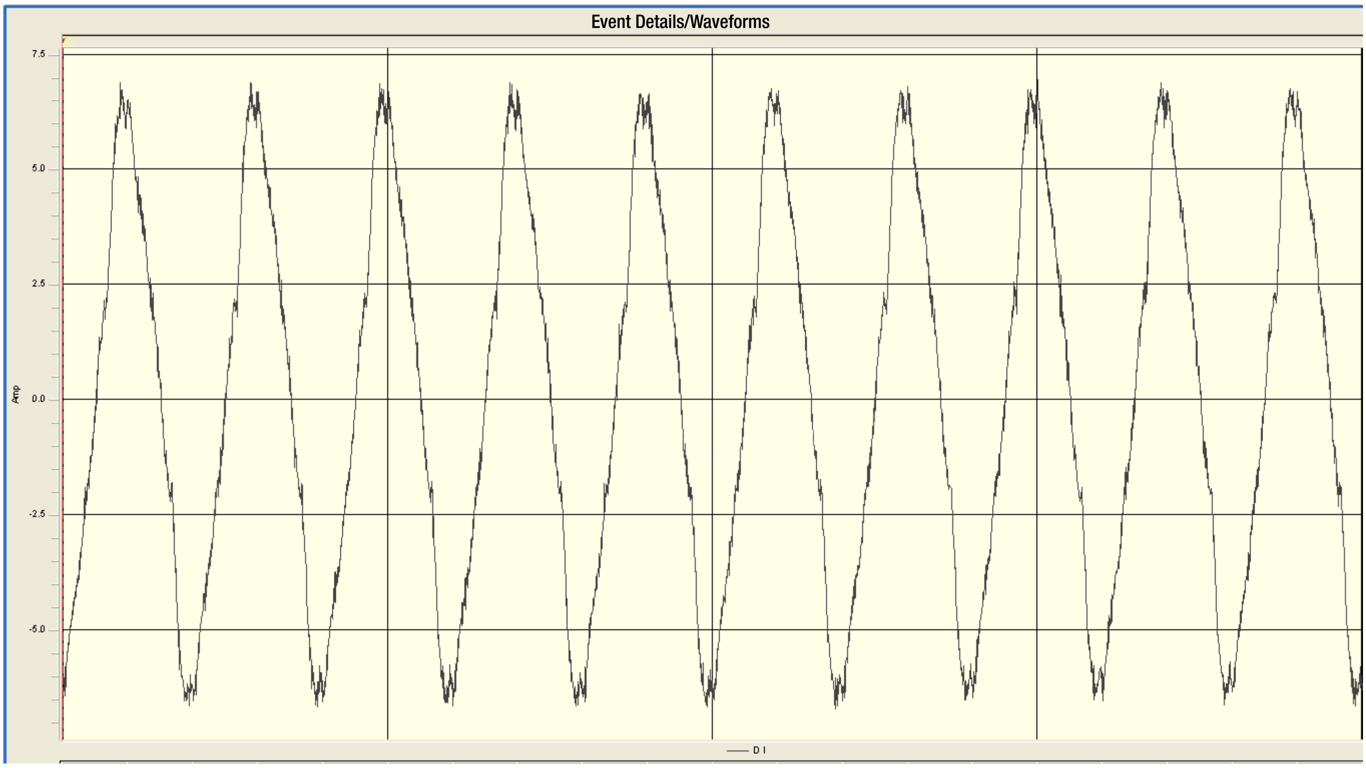

Figure 7: PEN Current After Additional Installation of Further Protective Measures, Effective Value: 4.26 A

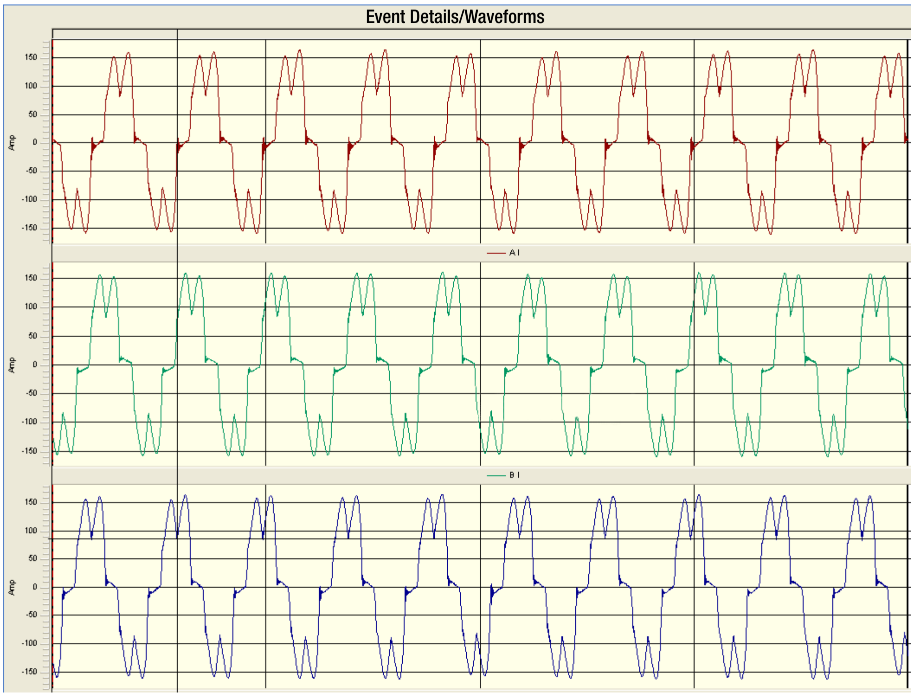

Figure 8: Characteristic Current Curves After Additional Installation of Further Protective Measures

Start-up of the filling station at the mains system ran smoothly, as expected. Ever since the filling station was started up on 9 November 2013, no failures or impairments of any power consumers or users within the transformer's supply network have been detected.

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