Today, the power supply of DC receivers from the AC network is most often implemented by power electronic converters - rectifiers (AC/DC), which convert AC to DC. In recent years, the demand for electricity has been significantly increasing, and new sources/receivers of energy have appeared in the system, such as wind farms, photovoltaic panels, fast chargers for electric car batteries or energy storage facilities. The power of systems is also growing and in order to reduce conduction losses, the voltage level is increased, which reduces the effective value of the conducted current. A similar trend is visible in today's power electronics, where the aim is to convert higher and higher voltages to increase the efficiency of electrical energy conversion.

In the case of rectifiers drawing energy from the medium voltage AC network (MVAC), two main solutions can be distinguished - reducing the voltage using a massive and expensive transformer operating at the network frequency, and then using low-voltage AC/DC converters. The second approach is to use a two-stage solution - first, a medium-voltage AC/DC rectifier is used to provide sinusoidal current from the network, and then an isolated DC/DC converter. Both of the aforementioned converters are switched at high frequency, which makes it impossible to achieve very high energy conversion efficiency, and at the same time, the reliability of such a solution is low.

The experience and previous work of the applicants concerning both converters enabling the conversion of medium voltages and AC/DC power electronic systems have shown that there is an alternative solution of an AC/DC converter cooperating directly with the medium voltage network, referred to as a quasi-single-stage system. This solution is similar to a two-stage AC/DC rectifier. However, a significant difference is that the rectifier is not switched with a high switching frequency, and the consumption of sinusoidal current from the network is ensured by appropriate control of the isolated DC/DC converter. Thanks to this, the power losses in the rectifier are significantly limited (higher energy conversion efficiency) and at the same time the reliability of such a solution is higher than that of a two-stage conversion. Moreover, in comparison with the second conventional approach, the problematic transformer is eliminated. On the other hand, the DC/DC stage is key to the correct operation of the entire rectifier, the operating conditions of which are very demanding for this type of converter.

Therefore, the aim of this work is to develop a quasi-single-stage AC/DC converter that allows direct cooperation with the MVAC network. The developed solution can then be successfully used in applications such as renewable energy sources, battery energy storage, fast chargers for electric car batteries or as an intermediary system between AC and DC networks, which will contribute to the development of flexibility and reliability of power systems.

The project work will be divided into three main areas: research on topologies and control methods of the AC/DC stage, research on topologies and control methods of the DC/DC stage, as well as on the assessment of operation in emergency states and reliability of the entire system. Thanks to this, it will be possible to find an optimal solution for the development of a PFC rectifier, as well as to ensure high reliability of the entire system. The first stage of research will focus on theoretical analyses, mathematical description and simulation verification of the proposed solutions. Then a scalable laboratory model of the PFC rectifier cooperating with the MVAC network will be built, which will enable confirmation of previous research and analyses, as well as a high degree of system reliability.

In the literature, only single works on quasi-single-stage conversion of electrical energy can be found, some of which were authored by the applicants. Moreover, these works concerned only systems operating at low voltages and powers. The innovativeness of the research will consist in the development of a quasi-single-stage PFC rectifier cooperating with the MVAC network, which has not been studied and analyzed by the scientific community so far. The team of applicants has significant experience in the development of power electronic converters operating in the medium voltage range, AC/DC converters, and isolated DC/DC converters. Therefore, the goals set in the project are possible to achieve.