White Paper

POWER CONVERSION

DC MICROGRIDS

Facing a growing electrical power demands in industrial manufacturing: how DC microgrids will help enhancing efficiency while reducing costs.

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PURPOSE

Introduction and background

The demand for electrical power in large industrial manufacturing plants, such as steel production facilities, is on the rise [1]. This increase is driven by the need for decarbonization, as large steel producers transition from CO2-intensive processes to electric processes with significantly lower CO2 emissions.

In addition to large power consumers like steel producers, many light manufacturing industries are also experiencing increased electrical power demands [2].

This growing demand necessitates enhanced power supply infrastructure, including transformers and medium voltage switchgears, which must be considered during the design and planning phases of new factories. Upgrading existing plants can be particularly challenging due to limited space and grid power availability.

Moreover, grid fees increase with higher power demands. For instance in Germany, grid fees increase linearly with the power demand of a factory [3]. The ratio varies among different distribution system operators (DSOs) and depends on the annual power consumption.

Considering this, it is evident that reducing power demand from the grid leads to lower grid fees and, consequently, lower overall electricity costs.

Electricity costs can generally be divided into two components:

1. Kilowatt-hour rate (€/kWh)
2. Maximum power intake (kW) and annual energy consumption (kWh/a)

Reducing electricity costs can be achieved by decreasing either energy consumption (kWh) or maximum power intake.

UPGRADING EXISTINGS FACTORIES

Challenges and solutions

Upgrading existing factories to meet increased power demands involves several challenges. These challenges stem from the need to accommodate a higher number of loads and machines, potentially leading to significant infrastructure changes. However, there are solutions to manage these demands without extensive upgrades.

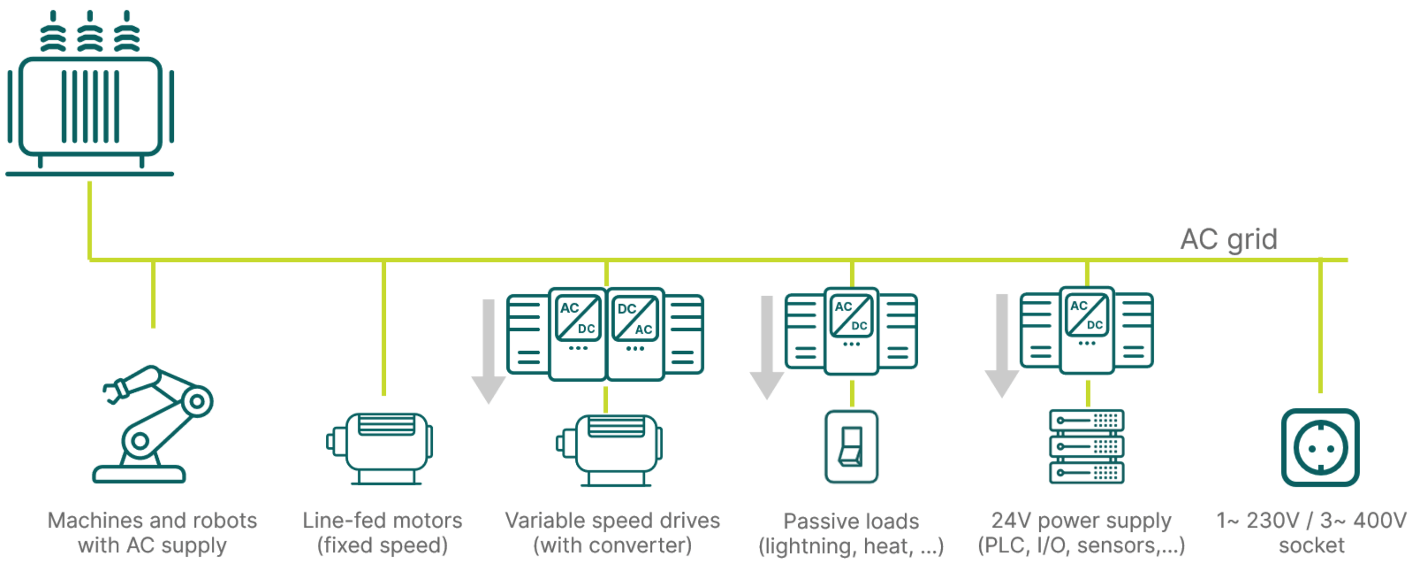
Typical factories consist of various electrical loads and machines essential for the manufacturing process.

Most of these loads and machines are powered through a common AC bus (e.g., 400Vac) supplied by a step-down transformer. If the number of machines and loads increases (e.g., due to an upgrade of processing lines), the power intake from the grid might also increase.

This increase would necessitate a higher power rating of the step-down transformer and could lead to an upgrade of the entire feeder system.

Additionally, distribution system operators (DSOs) may not always have the capacity to enhance their power transmission capabilities, potentially prohibiting maximum power intake from the grid.

There are alternatives to upgrading the transformer, such as shifting high grid loads to balance peak power demand. However, this approach might not be applicable to all industrial processes.



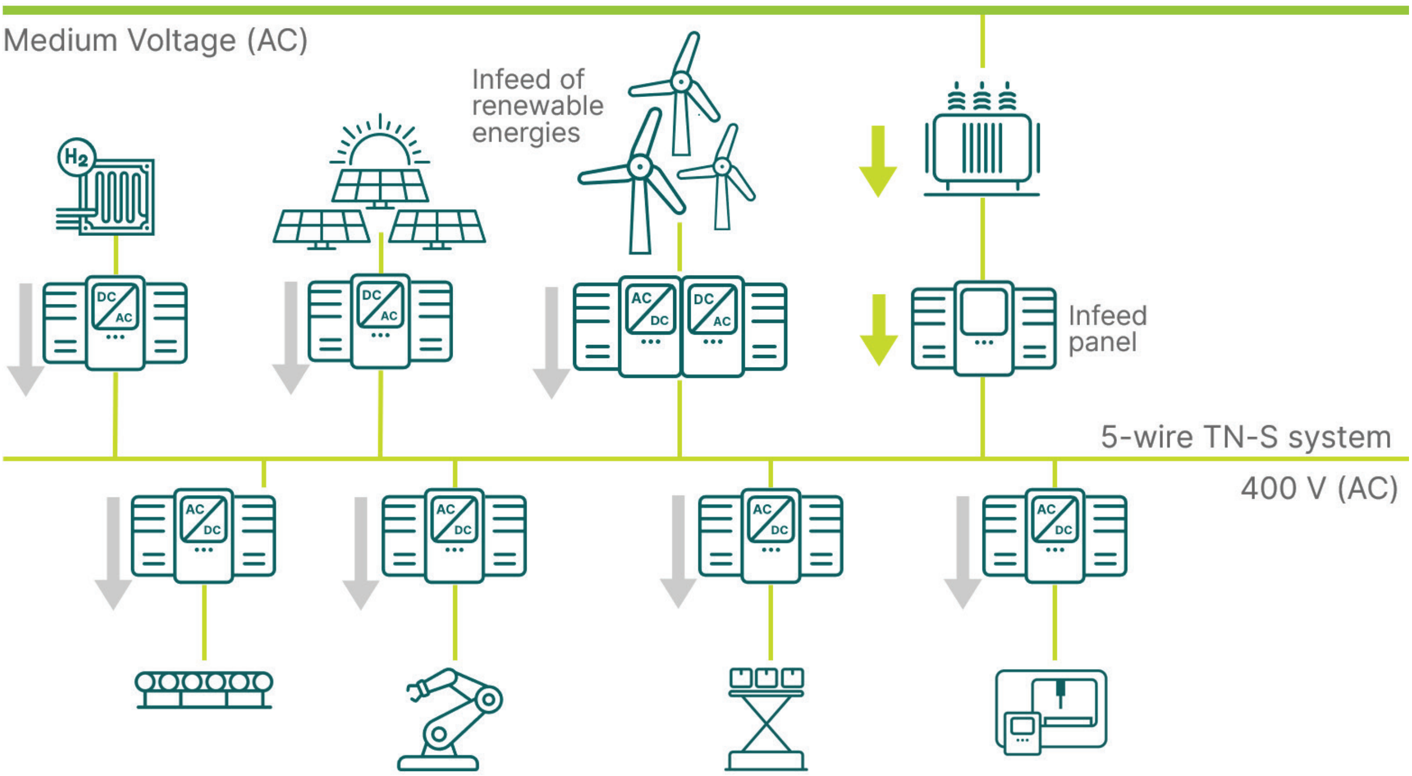
Evolving factory infrastructure

Incorporating energy sources such as batteries or solar panels into the existing factory infrastructure, creating a microgrid, can be an effective way to reduce power consumption when upgrading facilities.

As illustrated in the figure below, many conversions from DC voltages (e.g., from PV panels, batteries or fuel cells) to AC voltage and vice versa are required. Additionally, variable speed drives typically include an AC/DC/AC conversion.

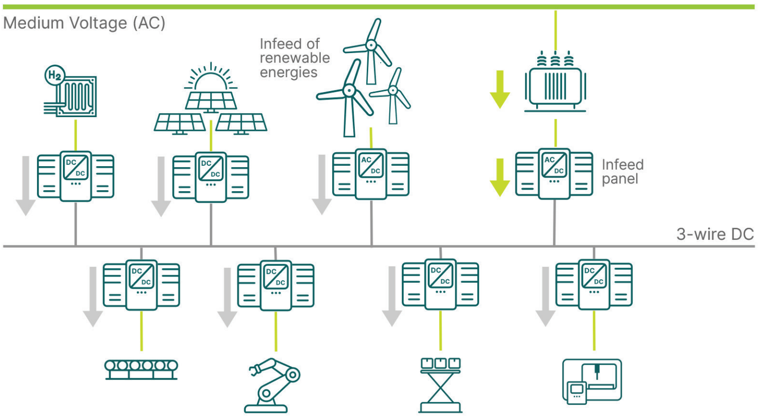
These multiple conversion steps onto an AC grid add complexity and result in electrical losses within the factory infrastructure, ultimately increasing the cost of electricity.

> "Direct current from renewable energies can be easily integrated into production and ... makes an important contribution to greater energy and resource efficiency."
>
> *Prof. Dr. Holger Borcherding*
> *iFE - Institute Future Energy*



BENEFITS OF DC GRID VS. AC GRID

Implementing a DC grid as a replacement for conventional AC grids can eliminate the above-mentioned conversion stages.



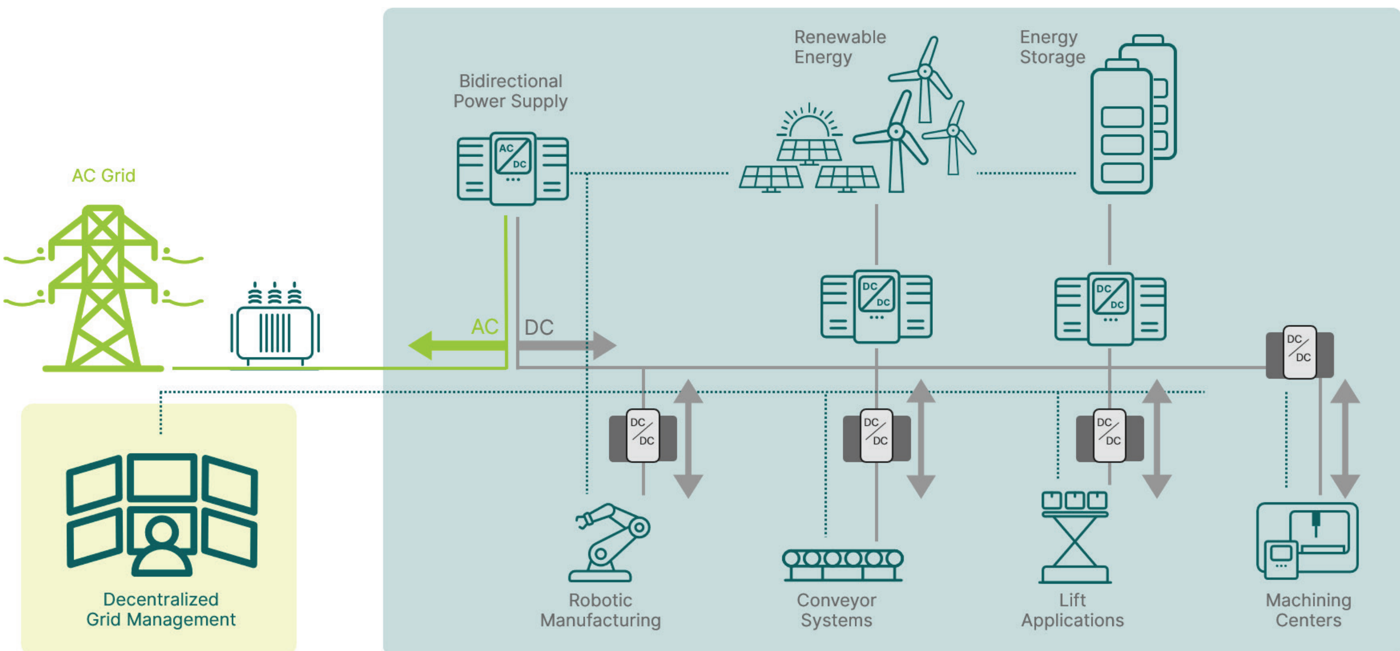
Potential DC grid for a factory.

With fewer conversion stages, the overall efficiency of the factory can be increased. Studies on larger commercial buildings have demonstrated an overall efficiency improvement of 2-5% [4].

Additionally, variable frequency drives can inject energy from the mechanical load back into the DC grid during braking without the need og an additional active front end. The number of phases and cable cross-sections in a DC grid is reduced compared to a conventional AC grid [5]. Up to 55% less copper is required to transmit the same power, and cable losses are reduced by approximately 45%.

One challenge in designing a DC microgrid system is selecting the appropriate DC grid voltage level. Unlike AC grids, DC grid voltage levels are not yet standardized. Some recommendations are provided in [6], however, DC voltage ranges must be carefully chosen for different loads and sources. Selecting a single supplier for the DC/DC and DC/AC conversion can minimize interfaces and simplify the coordination of the non-standardized DC grid voltage levels.

Power Conversion's converter platform LV8 offers a comprehensive set of DC/DC and DC/AC converter systems suitable for operation on a common DC grid. It allows to connect variable speed drives to the DC grid through a wide range of DC/AC converter systems. Moreover, battery energy storage and PV can be integrated into a common DC grid via high-power DC/DC converters. This integration can be achieved without managing different DC link voltage levels from various converter systems or platforms. Here, the LV8 is a high-power converter platform, and supplying lower power to loads and consumers must be done with third-party converter platforms. These converters can also be integrated into an overall DC microgrid system with an overlaying DC grid control.



Integrated LV8 platform system solution.

SUMMARY

Upgrading existing factory with new manufacturing lines can lead to an increased power consumption of the factory.

To avoid additional investment in the feeder system and additional operating expenses a separate grid inside the factory (microgrid) can be established. This microgrid might be either AC or DC, whereas DC microgrids provide a better overall efficiency. This requires a modular and flexible converter system suitable to connect DC/DC and DC/AC converters on a common DC grid. GE Vernova´s Power Conversion LV8 platform is already able to meet the requirements for both AC and DC microgrids and simplifies the design of a DC microgrid tremendously.

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About Power Conversion, a GE Vernova business

We apply the science and systems of power conversion to help drive the electric transformation of the world's energy infrastructure. Designing and delivering advanced motor, drive and control technologies that help improve the efficiency and decarbonization of energy-intense processes and systems, helping to accelerate the energy transition across marine, energy and industrial applications.

We are a at the heart of electrifying tomorrow's energy.

GEA25524_ DC Microgrids_WP_DC Microgrids_EN_20240723