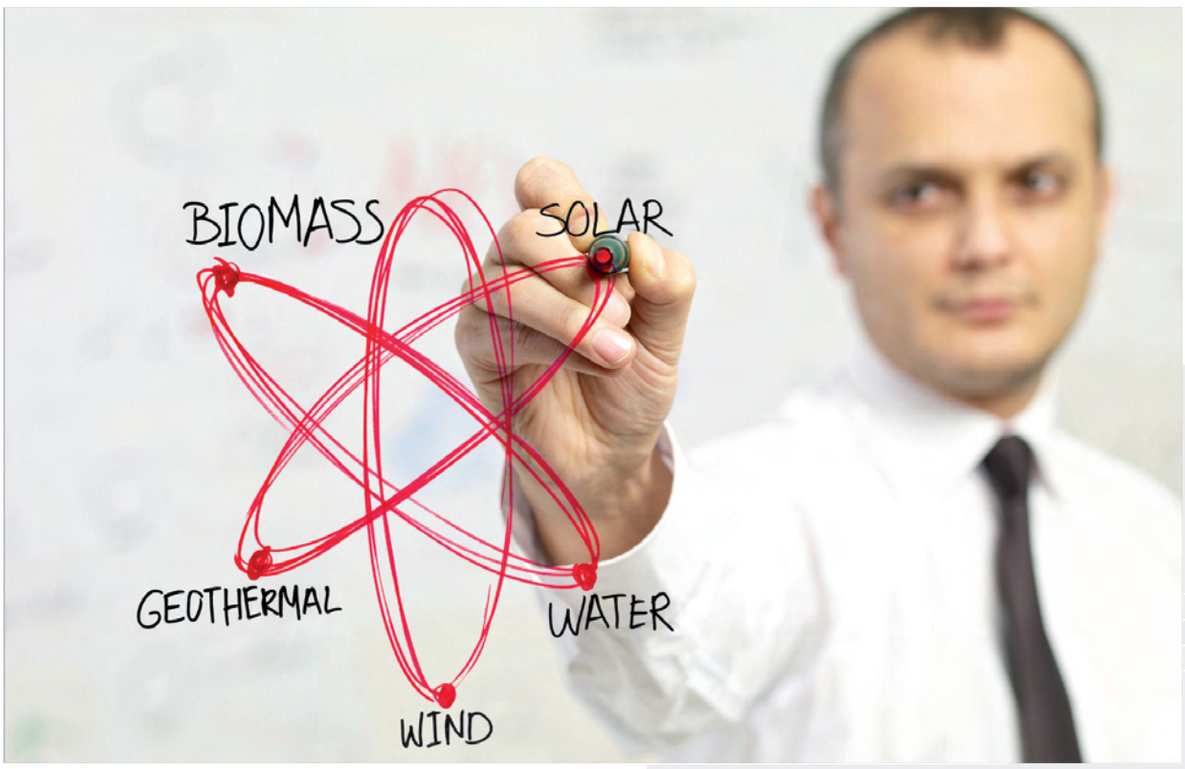
We take care of it.

a-eberle

LVRSys

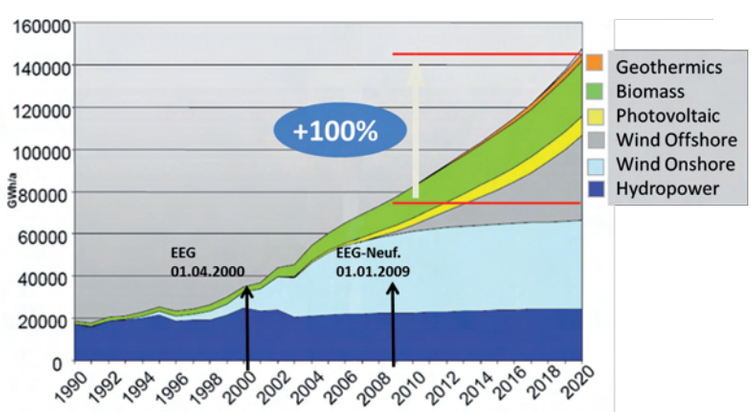
The right voltage is the key.

- Voltage regulation on local distribution transformers up to 1000 kVA
- Retrofit option for existing local distribution transformers
- Standard regulating range: ± 6% of rated voltage
- Independent regulation of the three-phase voltages (unbalanced compensation)
- Special version for voltage regulation on different feeders available
- Customer-specific construction designs
- Integrated power quality analysis according to EN 50160 or IEC 61000-2-2

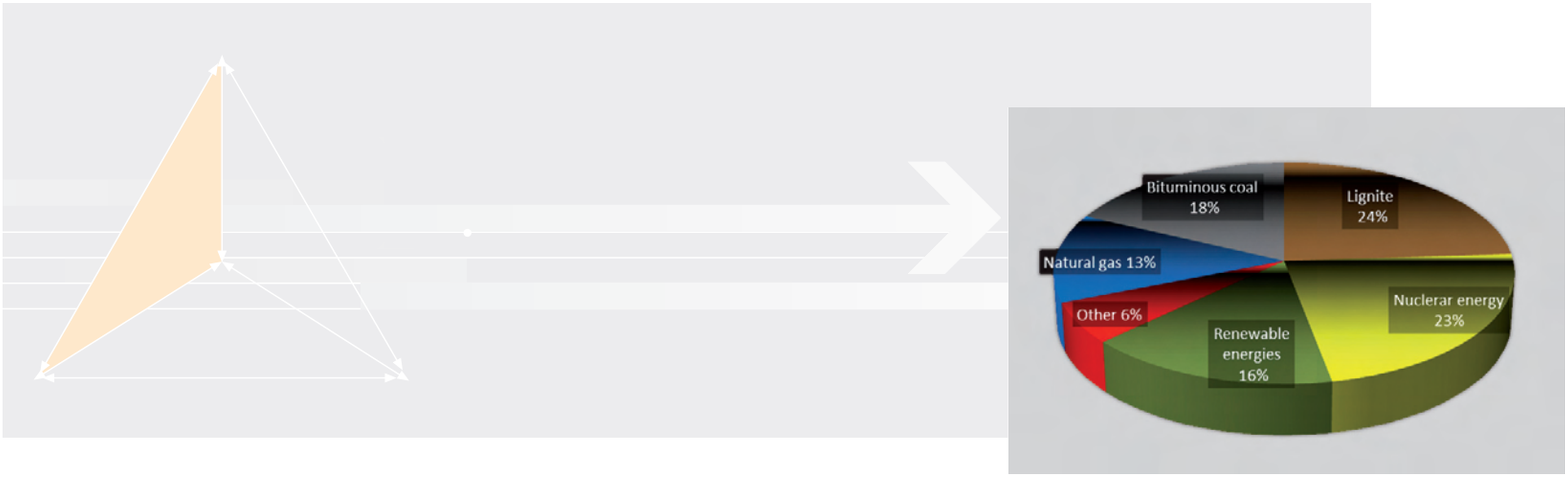


In 2000, the German Parliament reached a majority on gradually pulling out from nuclear energy. In the autumn of 2010, the Federal Government resolved to drastically extend the terms of the German nuclear power plants. Half a year later, shortly after the reactor catastrophe in Fukushima, Japan, the decommissioning of all German nuclear power plants was ordered by 2022.

The climate protection lobby in Germany is gaining momentum. The global temperature rise must not exceed 2°C against the pre-industrial level. Unacceptable consequences and risks are imminent if this is not achieved.



Energy policy reform demands new grids



Power generation according to energy carriers in Germany 2011/2012

In December 2007 the Federal Government published a comprehensive report on implementing the climate protection goals. The report proposes lowering carbon dioxide emissions by 40 percent lower than in 1990 by 2020. Coal fired power plants are already being closed down temporalily to meet this objective.

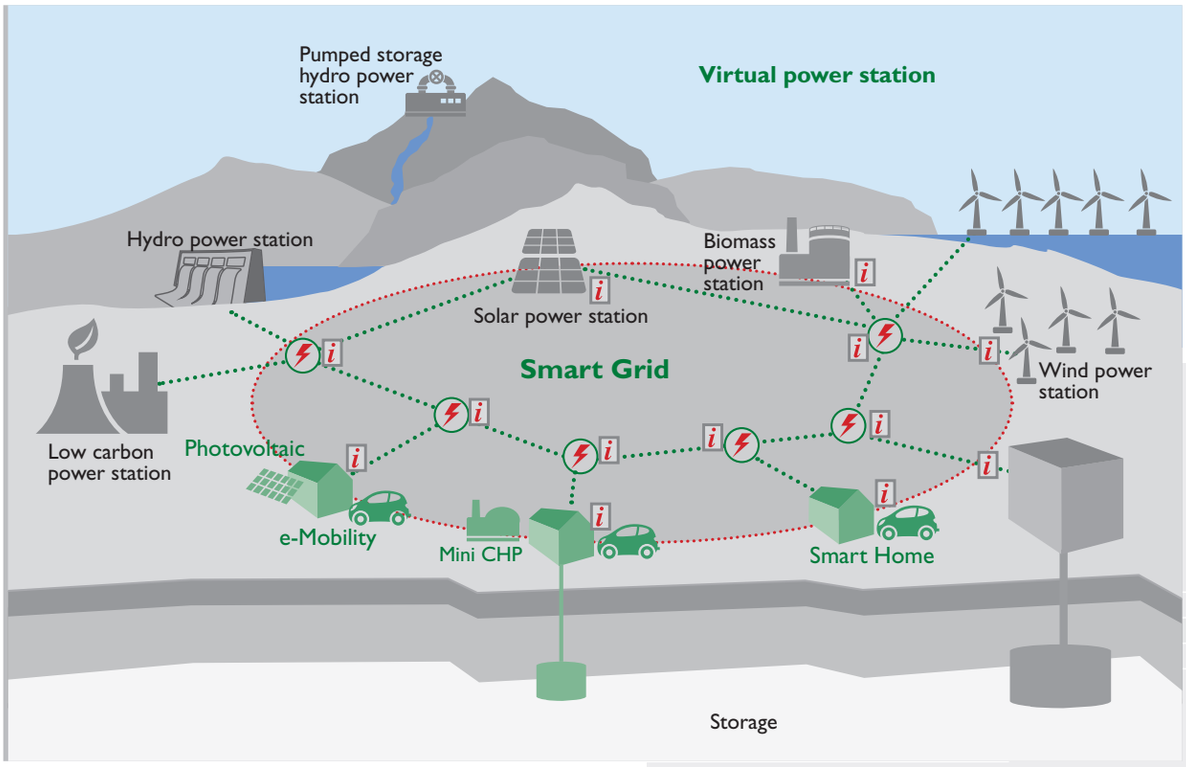
Currently, nuclear and coal power plants are still key elements of our energy supply, but they need to be steadily replaced.

Alternative solutions using wind power, solar energy, bioenergy and hydropower must be developed rapidly. Scenarios were developed to forecast the future of energy generation until 2020. Renewable energies are increasing according to the

- Federal Ministry for the Environment (BMU) by 30 percent;
- Renewable energies industry by 48 percent;
- Survey of the Federal states in Germany by 58 percent.

One thing is certain: Energy policy changes will lead to extreme changes of the networks.

YESTERDAY
Few centrally feeding large power plants
Flow of power always from generator to consumer
Regulation by adding or curtailing power plant output
Loads are primarily linear and ohmic-inductive
Conventional grid operation
TOMORROW
Many decentrally feeding small-scale power plants
Variable power flow
Regulating methods down to the low-voltage level
Loads are capacitive and non-linear
Grid dynamics increasingly play a central role (stability)



LVRSys

Growing integration of regenerative energy generators in low-voltage networks changes operating management drastically. Some possible negative results:

- Local voltage peaks
- Frequency variations
- Dynamic processes
- Degradation of voltage quality

The key characteristic variables of voltage are frequency and amplitude. The frequency is stable when energy generation and energy consumption are relatively balanced across the entire interconnected grid. Local voltage peaks can be regulated only on a local level.

Voltage maintenance in low-voltage networks

According to the European standard EN 50160, the low-voltage network may have a voltage tolerance of ± 10% of the rated voltage. According to BDEW decentral generating sources may raise the voltage by a maximum of three percent.

Four solutions have emerged for meeting these criteria

- **Network expansion**
- **Reactive power-capable inverters**
- **Regulated local distribution transformers**
- **Low-voltage regulation facility**

Some low-voltage networks must be expanded by laying cable: The short-circuit capacity of the networks is too low to be able to integrate additional decentral generating units. However, laying more cables is an ineffective and also expensive measure to solving voltage problems. A voltage increase of three percent is achieved, for example, when a decentral generating plant with an output of roughly 45 kW is connected to a low-voltage cable (150 mm^2, 500 m). However, the cable capacity would only then be utilized by 25 percent.

If the short-circuit capacity of the network is sufficiently dimensioned, the voltage increase can be attenuated or removed by much more favourable means.

Intelligent low-voltage networks

Power flow reversal and voltage increase at the local distribution transformer through photovoltaics

According to the German low-voltage directive VDE-AR-N 4105 inverter systems installed since January 2012 must provide reactive power. The voltage rise is prevented by supplying reactive power. This method is very effective for networks with a low R/X ratio (high-voltage and medium-voltage networks). An extreme amount of reactive power would need to be supplied on the low-voltage level for the effect of voltage lowering to be significant.

The regulation of the local distribution transformers increases the load level of the network since the voltage can be lowered centrally. Cable expansion can be largely avoided. Regulated local distribution transformers are three-phase operating equipment which cannot regulate unbalanced conditions. In contrast, low-voltage regulation systems adjust all three phases independently to compensate for unbalances. The regulator is not bound to the transformer but can also be installed on the different feeders in the depth of the network.

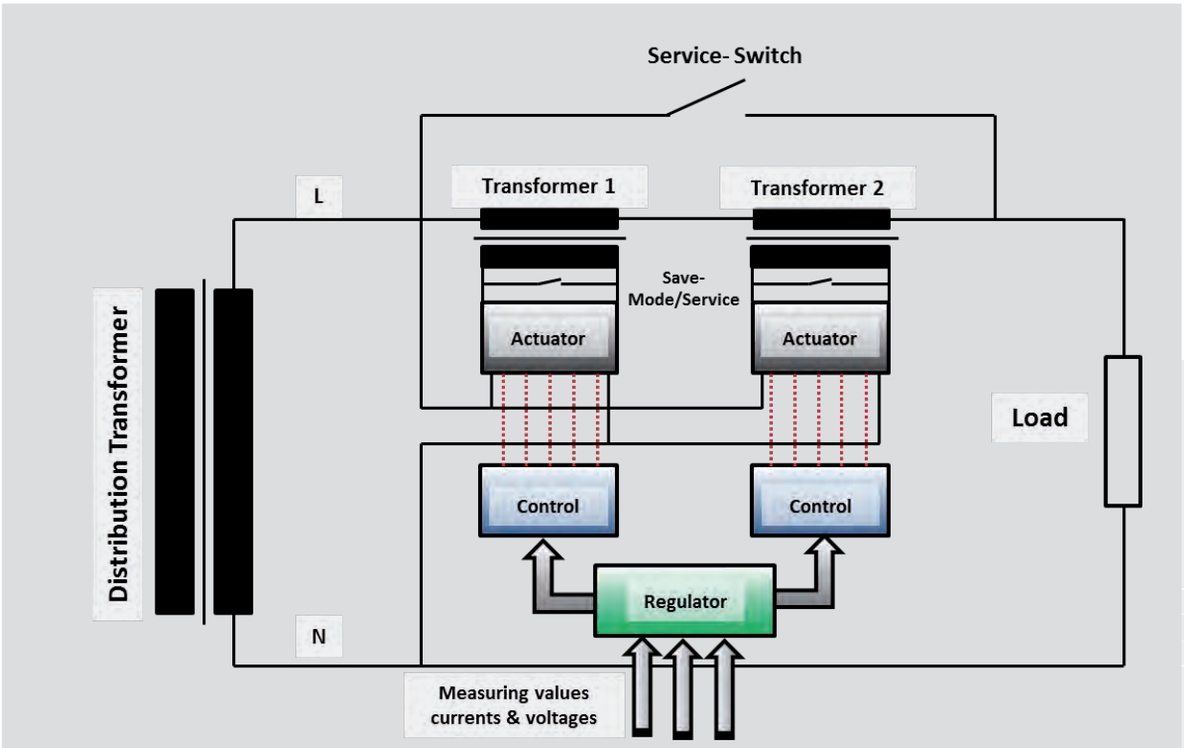
An overview of the systems mentioned:

Network expansion
+ Increases short-circuit capacity
- Most expensive measure
- Does not solve local voltage peaks
- Usually only a temporary solution

Reactive power-capable inverters
+ Cost-effective
- Not very effective in low-voltage networks
- Additional load on networks through reactive power
- Efficiency of generating systems drops

Regulated local distribution transformer
+ Improved utilisation of network
- Only three-phase regulation
- Existing local distribution transformer must be replaced

Low-voltage regulation facility
+ Existing local distribution transformer may continue to be used
+ Can also be used on the different feeders of the low-voltage network
+ Regulation of unbalances



LVRSys (Low-Voltage-Regulation System),
Single phase principle diagram

The low-voltage regulation system LVRSys regulates the output voltage by adding and selecting auxiliary transformers in series to the low-voltage level.

Regulator
The regulator determines the stage to be switched. The regulating algorithm can be adjusted according to customer preference.

Bus bar voltage
The regulator obtains voltage values from the bus bar which determines the stages.

Current regulation
The regulator obtains current values from the terminals of the bus bar. The line impedance initially determined allows taking the voltage into account via a calculation matrix. The customer can set a defined tolerance to avoid dynamics.

The regulator is idle if the voltage lies within the specified bandwidth. Regulation is active if the voltage lies outside the specified tolerance. For example, setting the tolerance to ± 5%, expands the regulating range by ± 6% to ± 11% of the rated voltage.

External measuring points
In this case the regulator obtains additional voltage measurements from critical network nodes. The stages determined in the regulator incorporate all nodes. No voltage point thus lies outside the specified limits.

Driver stage
The driver stage generates the signals for the power electronics. Electrically separate signals are distributed via logic from the stage to be switched, determined by the low-voltage regulator.

Actuator
Power semiconductors serve as actuators. They are extremely resilient and maintenance-free.

Safe-Mode/Service
In case of a fault or during maintenance of the power electronics, a contactor is activated which disables the auxiliary transformer. The local network can thus continue to operate without the regulator.

Service switch
In case of maintenance work on the transformer, the service switch becomes active and the local network is operated without the regulator.

LVRSys: the low-voltage regulation system

Adjustable tolerance band

LVRSys Product Features

- Low-voltage regulator up to 1000 kVA
- Three, two or single-phase versions
- Flexible standard regulating range of ± 6% or more in 1.5% increments
- Configurable voltage tolerance band and time behaviour
- Intelligent setpoint selection for min/max, average or priority methods
- Consideration of critical network nodes, e.g. power line communication, UMTS, radio or GPRS
- Algorithms for parallel operation of local distribution transformers available
- Integrated power quality analysis according to EN 50160 / IEC 61000-2-2 as well as fault recording.

Your sales partner

A. Eberle GmbH & Co. KG
Frankenstraße 160
90461 Nuremberg, Germany
Phone +49(0)911 628108-0
Fax +49(0)911 628108-99
e-mail info@a-eberle.de
web www.a-eberle.de

LVRSys_E_0412-nue